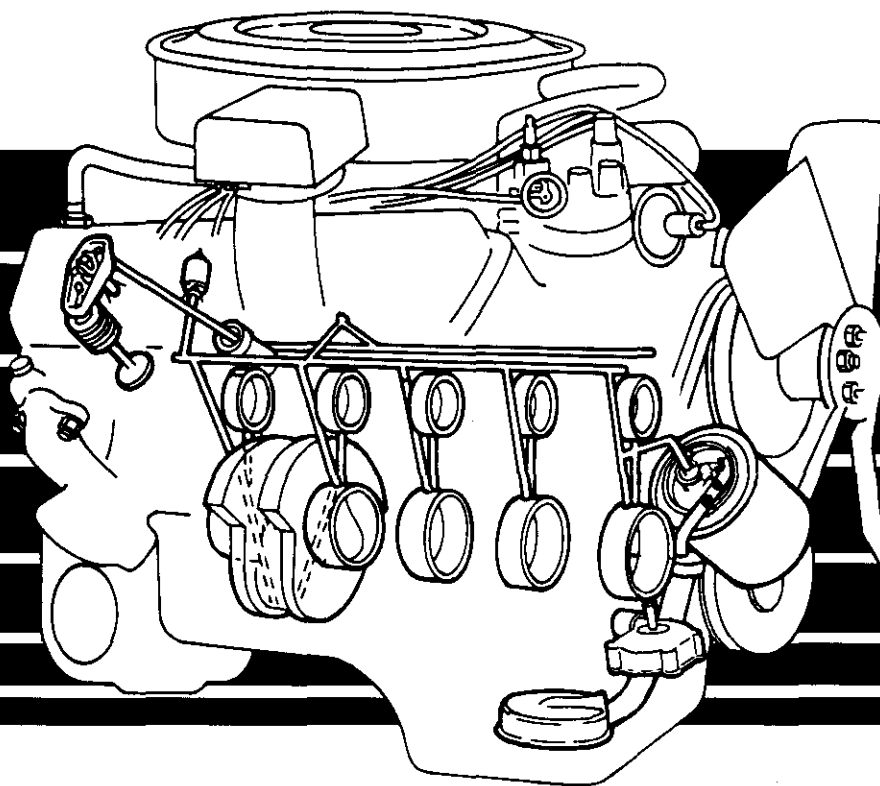


*Ford*

**Power  
Products**

# **LSG 875 SERVICE MANUAL**



PPO-194 208-86

# Introduction

In general, this manual covers the servicing of the engine and associated standard equipment. In many cases, engines are supplied with accessories and equipment that are unique to the application. If service information is ever required on such unique accessories or equipment it is suggested that the Power Products Operations of Ford Motor Company be contacted. The proper information will either be forwarded or the Service Technician will be advised where it can be obtained.

The information in this manual is grouped in sections according to the type of work being performed. The various sections are indicated in the index. In addition, each section is subdivided to include topics such as diagnosis and testing, cleaning and inspection, overhaul, removal and installation procedures, disassembly and assembly procedures, and service specifications.



**Power Products Division  
Geometric Results Incorporated  
19855 W. Outer Drive  
Dearborn, MI 48124**

*The descriptions and specifications contained in this manual were in effect at the time the book was released for printing. Geometric Results Incorporated reserves the right to discontinue models at any time, or change specifications of design, without notice and without incurring obligation.*

**NOTE:** *The recommendations and suggestions contained in this publication are made to assist the distributor in improving his distributorship parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.*

## **IMPORTANT SAFETY NOTICE**

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles as well as the personal safety of the individual doing the work. This Shop Manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools, and parts for servicing vehicles, as well as in the skill of the individual doing the work. This Manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from the instructions provided in this Manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

## **NOTES, CAUTIONS, AND WARNINGS**

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific operation. If you have a manual transmission, it should be in REVERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific operation. Place wood blocks (4" x 4" or larger) to the front and rear surfaces of the tires to provide further restraint from inadvertent vehicle movement.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts, when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind the head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

# 7.5 Liter Engines

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## Part 1 — Basic Engine

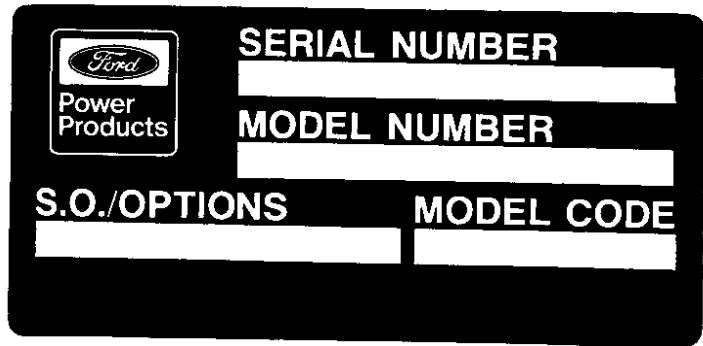
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# Part 1 — Basic Engine

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## INDUSTRIAL AND IRRIGATION IDENTIFICATION

An Identification Plate is affixed to each engine. The plate contains the engine serial number which identifies this unit from all others. Next is the engine model number and S.O. or special options which determines the parts or components required on this unit. Use all the numbers when seeking information or ordering replacement parts for this engine.



## MARINE IDENTIFICATION

All Marine Engines have a white tape engine code label located on the front of the left rocker arm cover. A typical label and an explanation of the codes are shown below.

If this tag is destroyed or painted over, it will be very difficult to distinguish between the various levels of engines; that is, for example, to distinguish between the 460 standard output and low output or even standard rotation versus reverse rotation.

DENOTES PLANT SOURCED TO PRODUCE ENGINES

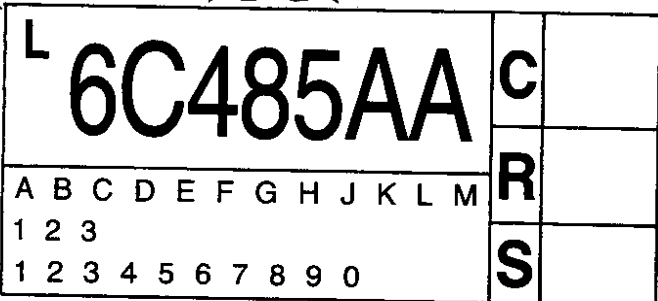
- D — DEARBORN ENGINE PLANT
- L — LIMA ENGINE PLANT
- C1 — CLEVELAND ENGINE PLT 1
- C2 — CLEVELAND ENGINE PLT 2
- W1 — WINDSOR ENGINE PLT 1
- W2 — WINDSOR ENGINE PLT 2

BASIC MARINE ENGINE CODE NUMBER

- |                                   |                         |
|-----------------------------------|-------------------------|
| 1986                              | 1985                    |
| 6C485AA 460-4V (STD.)             | 5C485AA (STD.)          |
| 6C484AA 460-4V (REV.)             | 5C484AA (REV.)          |
| 6C486AA 61 460-4V (STD.) SKI-BOAT | 5C486AA (STD.) SKI-BOAT |

ENGINE BUILD DATE

"A TO M" MONTH — A IS JANUARY AND M IS DECEMBER.  
 SECOND LINE 123 IS TEN DIGIT OF DAY OF MONTH  
 THIRD LINE 1 TO 0 IS ONE DIGIT OF DAY OF MONTH  
 CORRECT LETTER OR DIGIT IS "MARKED-OUT":  
 TO INDICATE BUILD DATE



## DESCRIPTION AND OPERATION

The 7.5 liter (460 CID) V-8 Engine is a light-weight cast iron design with a bore of 4.36 inches and a stroke of 3.85 inches.

### MANIFOLDS

The cast iron intake manifold is an exhaust gas heated design with eight mounting bolts per side. Coolant is discharged from the engine through the outlet housing at the right front of the intake manifold.

The intake manifold contains two sets of air-fuel mixture passages which have round ports. All passages are of nearly equal length to assure more even mixture distribution to the cylinders. The upper set of passages feeds cylinders 1, 4, 6 and 7 from the right primary and secondary bores of the carburetor. Exhaust gases flow through the crossover passage below the carburetor mounting pad to provide the initial heat for vaporization of the air-fuel mixture.

Filtered air for use in automatic choke is heated in a heat chamber at the crossover passage of the intake manifold. This air is drawn from the air cleaner through the air inlet tube, and is directed to the automatic choke through the air outlet tube.

The cast iron exhaust manifolds are the conventional runner type. The hot and cold air intake shroud is mounted on the right exhaust manifold. Two engine lifting brackets are incorporated with the exhaust manifolds.

### CYLINDER HEADS

Cylinder head assemblies have rail type rocker arms individually mounted on threaded studs. Combustion chambers are cast in an advanced wedge (quench) design with more rounded contours. Valves are canted at angles so their heads will conform to these contours. Intake and exhaust ports are round in cross section. The valve arrangement from front to rear is E-I-E-I-E-I-E-I for the left cylinder head, and I-E-I-E-I-E-I-E for the right cylinder head.

The cylinder head gasket used on all marine engines is the composition-type with a stainless steel core and should be installed dry, that is, without any sealer.

### CYLINDER BLOCK

The cast iron cylinder block has five main bearings. All oil passages are closed with pipe plugs. Main bearings are of intermediate copper-lead material with an oil groove only in the upper half. Crankshaft end thrust is controlled by the flanges of the center main bearing.

Cylinders are numbered from front to rear with 1 through 4 on the right bank and 5 through 8 on the left bank. Each slipper skirt autothermic piston has two compression rings and an oil control ring. The upper compression ring has a moly-filled groove and the lower compression ring has a scraper groove. The oil control ring assembly consists of a stainless steel expander spacer separating chrome-plated steel rails. Pressed-in piston pins and strap-type caps with overplated copper-lead alloy bearings are used with the connecting rods.

All 460 marine engines are available in either standard or reverse rotation, except for the "Ski Boat." The 460 Ski Boat engine is standard rotation only. The firing order is different between reverse and standard rotation. Standard rotation is 1-5-4-2-6-3-7-8. Reverse rotation is 1-8-7-3-6-2-4-5. The crankshaft is precision cast, nodular alloy and has five main bearings.

Two crankshaft assemblies are used on marine engines depending upon whether the engine is standard or reverse rotation. The knurling must throw oil toward the slinger.

A two-piece split lip-type rear oil seal is used for service on marine engines. They are color coded, yellow for use with a standard rotation crankshaft and red for use with a reverse rotation crankshaft.

The 460 engines have cast pistons with the notch, for assembly.

The cylinder front cover is die cast aluminum. The standard marine 460 engines use a cast iron front cover while the "Ski Boat" engines use the aluminum front cover. Mounted on it are the water pump (all marine engines except the 460 "Ski Boat" engine use a marine bi-rotational water pump with a stainless steel external bypass tube, left hand water inlet, and no heater inlet. The "Ski Boat" engine uses a standard automotive water pump) with bonded ceramic seal contact face. The oil pump is mounted at the lower left front of the block and is driven by the distributor through an intermediate 5/16 inch hex driveshaft.

## DESCRIPTION AND OPERATION (Continued)

### VALVE TRAIN

The camshaft is supported by five bearings pressed into the block. It is driven at one-half crankshaft speed by the timing chain and sprockets. The camshaft sprocket is positioned by a dowel in the forward face of the front camshaft bearing journal. Camshaft end play is controlled by a thrust plate attached to the front of the cylinder block. An eccentric cam for fuel pump actuation is attached to the front face of the sprocket. A helical accessory drive gear is machined in the camshaft directly behind the front journal to drive the distributor and oil pump. (There are two camshafts available for the 460 marine engines depending upon whether the engine is standard rotation or reverse rotation.)

Hydraulic valve lifters ride directly on the camshaft lobes and transmit the thrust of the lobes to the push rods which actuate the valve train.

When a valve is closed, the related push rod is in its lowest position and the lifter assembly is on the base circle of the cam lobe. The valve lifter plunger spring expands, forcing the plunger upward. This force is transmitted to the rocker arm through the push rod, causing solid contact between the valve end of the rocker arm and the valve stem.

As the valve lifter plunger spring expands to move the plunger upward, the volume of the compression chamber in the bottom of the lifter body is increased. Oil, supplied at full lubrication system pressure through the oil gallery passages in the cylinder block unseats the disc type check valve in the bottom of the lifter and enters the compression chamber to fill the increased volume. The check valve closes when the chamber is filled.

As the camshaft rotates, the lifter body is raised by the cam lobe. The oil in the compression chamber, being incompressible, acts as a solid member and transfers the lifting force to the plunger and push rod. Because of the load im-

posed on the plunger by the push rod, the oil in the compression chamber is subjected to increased pressure. This causes a slight leakage out of the chamber past the walls of the plunger. The leakage flow is known as the calibrated leak-down rate and is controlled by precise matching of valve body and plunger during original assembly of the valve lifter. Consequently, individual hydraulic valve lifter components are not interchangeable.

When the high point of the cam rotates past the foot of the valve lifter body, the lifter is forced downward by the push rod as the valve (intake or exhaust) returns to its seat in the cylinder head. This reduces the force on the lifter plunger and allows the plunger to be raised once again by the plunger spring. Engine oil is forced into the compression chamber to replace that which leaked out, priming the lifter for its next operating cycle.

Hydraulic force and plunger spring action in the valve lifter take up all clearances in the valve train mechanism to maintain zero valve lash.

The push rods are tubular steel with ball ends. Each push rod receives oil from a disc-type metering valve in the push rod cup at the top of the valve lifter. The oil enters and leaves the push rod through holes in both ball ends to independently lubricate each rocker arm.

The rocker arms each have a hole in their push rod end for lubrication. Each rocker arm is pedestal mounted. The rocker arm pivots on a spherical fulcrum. A bolt retains the rocker arm and fulcrum on the head.

Intake and exhaust valves are of forged alloy steel with chrome plated stems. Both intake and exhaust valves are the free turning type. Because the valves are canted, they open obliquely into the combustion chambers, in the direction of gas flow, to improve engine breathing. Pockets are cast in the piston heads to provide clearance at top dead center for full valve opening.

## DESCRIPTION AND OPERATION (Continued)

### LUBRICATION SYSTEM

Oil from the bottom of the sump in the front of the oil pan is drawn into the oil pump through the pump inlet tube and screen assembly. The positive displacement rotor type oil pump is driven by an intermediate drive shaft from the distributor. The pump forces the oil through the engine's lubrication system. A spring-loaded relief valve in the pump limits the maximum pump output pressure, returning any excess oil flow to the intake side of the pump.

The pressurized oil flow from the pump passes through a Motorcraft full-flow oil filter before it enters the engine lubrication galleries. A relief valve in the filter permits oil to bypass the filter if the high capacity element becomes clogged.

From the filter, the oil flows through a passage to the right main oil gallery. Before reaching the right main oil gallery, some oil is diverted into a narrower vertical cross passage leading up to the No. 1 camshaft bearing and down to the No. 1 main bearing. Oil from the top of the cross passage flows through the oil hole in the camshaft bearing to lubricate the bearing surfaces. Some oil is conveyed through a groove in the bearing to a passage that lubricates the distributor shaft pilot bearing. The rest of the oil is squeezed out between the front and rear edges of the camshaft bearing and journal. Oil from the front of the bearing is directed through slots in the hub of the camshaft sprocket and drips onto the timing chain and fuel pump eccentric cam for lubrication. It then drains into the forward end of the oil pan.

Oil in the right main oil gallery is routed to the main bearings, the hydraulic valve lifters for the right cylinder bank of the engine, and through a crossover passage to the left main oil gallery which supplies the hydraulic valve lifters for the left cylinder bank of the engine. A passage at the rear of the right main oil gallery leads to the sending unit for the low oil pressure warning light on the instrument panel.

Oil passages are drilled in the cylinder block from each main bearing to the camshaft bearing above it. After lubricating the camshaft bearings, the oil drains into the oil pan.

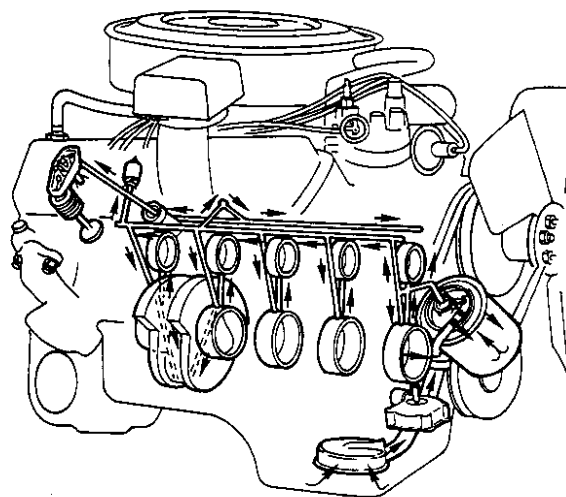
In addition to supplying oil for the camshaft bearings, the main bearing lubrication system also lubricates the connecting rod bearings through grooves in the upper halves of the main bearings and passages drilled in the crankshaft.

#### ON SKI BOAT ENGINES ONLY:

The level of the engine oil in the crankcase is indicated on a dipstick inserted in a tube extending downward and slightly rearward from the top right side of the cylinder front cover. The lower portion of the dipstick enters the surface of the oil supply near the right front corner of the oil pan.

#### ON STANDARD MARINE, INDUSTRIAL, AND IRRIGATION ENGINES:

The dipstick and tube are mounted on the right hand side of the engine and extends into the oil pan.



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### OIL (ENGINE) — HEALTH WARNING

**THE AMERICAN PETROLEUM INSTITUTE (API) HAS ANNOUNCED THAT CONTINUOUS CONTACT WITH USED MOTOR OIL HAS CAUSED SKIN CANCER IN LABORATORY MICE. THE EFFECTS OF USED MOTOR OIL ON HUMANS HAS NOT BEEN ESTABLISHED. IT IS RECOMMENDED, HOWEVER,**

**THAT AS A PRECAUTIONARY MEASURE, HUMANS PROTECT THEIR SKIN BY WASHING WITH SOAP AND WATER AFTER COMING IN CONTACT WITH USED MOTOR OIL.**

Ford Motor Company will be adding warnings to its oil cans. This warning does not apply to fresh motor oil.

## DESCRIPTION AND OPERATION (Continued)

### POSITIVE CRANKCASE VENTILATION SYSTEM

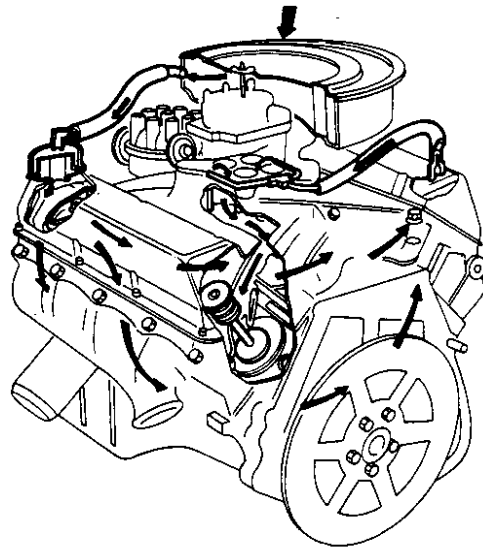
The 460 V-8 engine has a closed type, positive ventilation system. This system draws blow-by vapors from the crankcase and discharges them into the intake manifold to be burned in the combustion chambers of the engine. The closed positive crankcase ventilation system also prevents the discharge of any crankcase fumes to the atmosphere, as an air pollution control measure.

Clean ventilating air, taken from the air cleaner, flows through a hose to the oil filler cap on the front of the valve rocker arm cover. The oil filler cap is sealed at the filler opening to prevent the entrance of atmospheric air.

From the oil filler cap, the air enters the rocker arm chamber. Then it moves down past the push rods into the crankcase. The ventilating air then flows to the rear of the crankcase and up to the rear section of the valve rocker arm cover, sweeping any combustion by-product fumes along with it. The vapor-laden air enters a spring-loaded regulator valve, which regulates the amount of airflow to meet changing operating conditions. The air is then drawn to the intake manifold through the crankcase vent hose.

The regulator valve operates by sensing intake manifold vacuum through the crankcase

vent hose. At idle, intake manifold vacuum is high, overcoming the pressure of the valve spring. The valve moves to the low-speed operation position where only a minimum of ventilating airflow passes out of the valve. As manifold vacuum decreases with an increase in engine speed and/or power output, the spring forces the pin to the full open position to increase the flow of ventilating air.

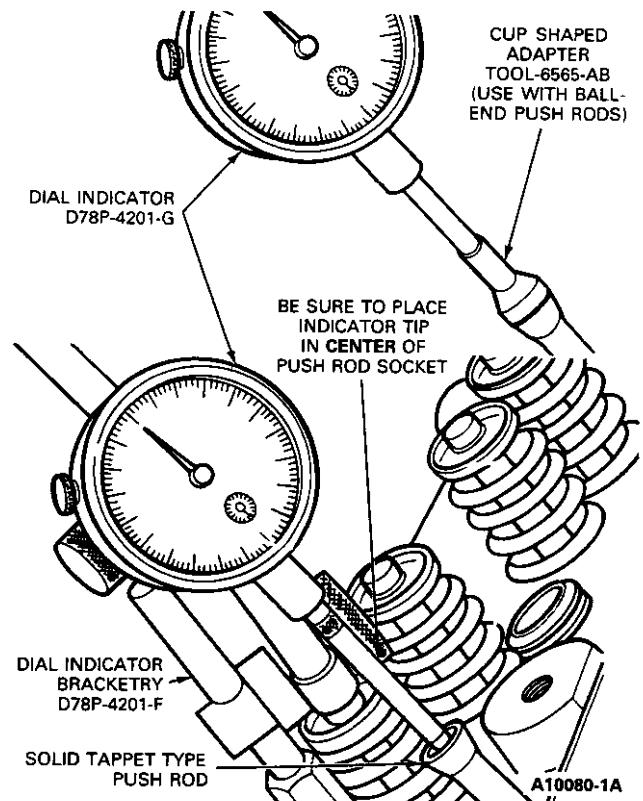


## DIAGNOSIS AND TESTING

### CAMSHAFT LOBE LIFT

Check the lift of each lobe in consecutive order and make a note of the readings.

1. Remove the air cleaner. Remove valve rocker arm cover.
2. Remove the valve rocker arm shaft assembly(ies) and install a solid, tappet-type push rod in the push rod bore of the camshaft lobe to be checked or use the adapter for ball end push rods.
3. Make sure the push rod is in the valve lifter socket. Install a dial indicator so that the actuating point of the indicator is in the push rod socket (or the indicator ball socket adapter is on the end of the push rod) and in the same plane as the push rod movement.
4. Connect an auxiliary starter switch in the starting circuit. Crank the engine with the ignition switch OFF. Bump the crankshaft over until the tappet or lifter is on the base circle of the camshaft lobe. At this point, the push rod will be in its lowest position.
5. Zero the dial indicator. Continue to rotate the crankshaft slowly until the push rod is in the fully raised position.
6. Compare the total lift recorded on the indicator with specifications.
7. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until the indicator reads zero. **If the lift on any lobe is below specified wear limits, the camshaft and the valve lifters operating on the worn lobe(s) must be replaced.**
8. Remove the dial indicator and auxiliary starter switch.
9. Install the rocker arm shaft assembly as detailed under Removal and Installation.
10. Install the valve rocker arm cover and the air cleaner.



### COMPRESSION TEST

#### COMPRESSION GAUGE CHECK

1. Be sure the crankcase oil is of the correct viscosity and make sure that the battery is properly charged. Operate the engine for a minimum of 30 minutes at 1200 rpm, or until the engine is at normal operating temperature. Turn the ignition switch off; then remove all the spark plugs.
2. Set the carburetor throttle plates in the **wide open position**.
3. Install a compression gauge in No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. Using the auxiliary starter switch, crank the engine (with the ignition switch OFF) at least five compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder as was required to obtain the highest reading on the No. 1 cylinder.

## DIAGNOSIS AND TESTING (Continued)

### TEST CONCLUSION

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75% of the highest. Refer to the following example.

Seventy-five percent of 140, the highest cylinder reading, is 105. Therefore, cylinder No. 7 being less than 75% of cylinder No. 3 indicates an improperly seated valve or worn or broken piston rings.

If one or more cylinders read low, squirt approximately one (1) tablespoon of engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on these cylinders.

1. If compression improves considerably, the piston rings are at fault.
2. If compression does not improve, valves are sticking or seating poorly.

3. If two adjacent cylinders indicate low compression pressures and squirting oil on the pistons does not increase the compression, the cause may be a cylinder head gasket leak between the cylinders. Engine oil and/or coolant in the cylinder could result from this problem.

It is recommended that the following quick reference chart be used when checking cylinder compression pressures. The chart has been calculated so that the lowest reading number is 75% of the highest reading.

### EXAMPLE

After checking the compression pressures in all cylinders, it was found that the highest reading obtained was 196 psi. The lowest pressure reading was 155 psi. The engine is within specifications and the compression is considered satisfactory.

Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI
134	101	174	131	214	160
136	102	176	132	216	162
138	104	178	133	218	163
140	105	180	135	220	165
142	107	182	136	222	166
144	108	184	138	224	168
146	110	186	140	226	169
148	111	188	141	228	171
150	113	190	142	230	172
152	114	192	144	232	174
154	115	194	145	234	175
156	117	196	147	236	177
158	118	198	148	238	178
160	120	200	150	240	180
162	121	202	151	242	181
164	123	204	153	244	183
166	124	206	154	246	184
168	126	208	156	248	186
170	127	210	157	250	187
172	129	212	158		

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## DIAGNOSIS AND TESTING (Continued)

### HYDRAULIC VALVE LIFTER

Dirt, deposits of gum and varnish and air bubbles in the lubricating oil can cause hydraulic valve lifter failure or malfunction.

**Dirt, gum and varnish can keep a check valve from seating and cause a loss of hydraulic pressure.** An open valve disc will cause the plunger to force oil back into the valve lifter reservoir during the time the push rod is being lifted to force the valve from its seat.

Air bubbles in the lubricating system can be caused by too much oil in the system or too low an oil level. Air may also be drawn into the lubricating system through an opening in a damaged oil pick-up tube. Air in the hydraulic system can cause a loss of hydraulic pressure.

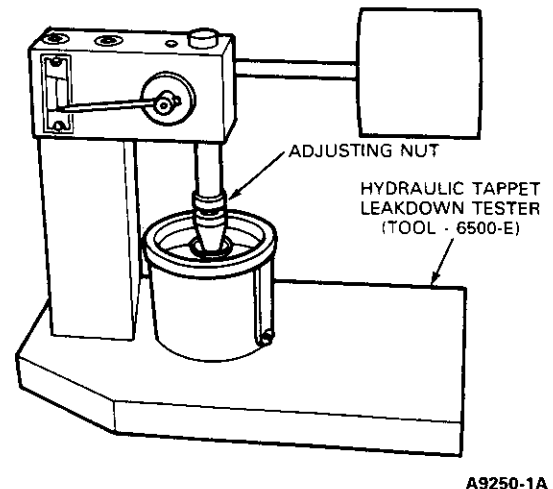
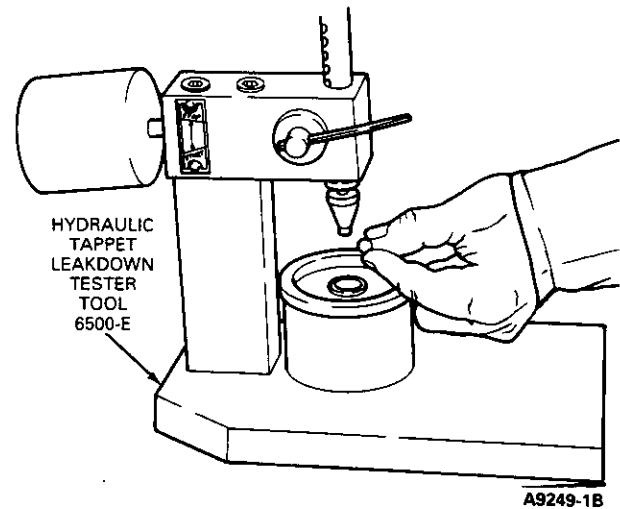
Assembled valve lifters can be tested with Tool 6500-E to check the leak-down rate. The leak-down rate specification is the time in seconds for the plunger to move the length of its travel while under a 50 lb. load. Test the valve lifters as follows:

1. Disassemble and clean the lifter to remove all traces of engine oil. Lifters cannot be checked with engine oil in them. Only the testing fluid can be used.
2. Place the valve lifter in the tester with the plunger facing upward. Pour hydraulic tester fluid into the cup to a level that will cover the valve lifter assembly. The fluid can be purchased from the manufacturer of the tester. Do not use kerosene, for it will not provide an accurate test.
3. Place a 5/16 inch steel ball in the plunger cup.
4. Adjust the length of the ram so that the pointer is 1/16 inch below the starting mark when the ram contacts the valve lifter plunger to facilitate timing as the pointer passes the start timing mark.

Use the center mark on the pointer scale as the stop timing point instead of the original stop timing mark at the top of the scale.

5. Work the valve lifter plunger up and down until the lifter fills with fluid and all traces of air bubbles have disappeared.
6. Allow the ram and weight to force the valve lifter plunger downward. Measure the exact time it takes for the pointer to travel from the start timing to the stop timing marks on the tester.

7. A valve lifter that is satisfactory must have a leak-down rate (time in seconds) within the minimum and maximum limits specified.
8. If the valve lifter is not within specifications, replace it with a new lifter. It is not necessary to test a new lifter before installing it in the engine.



## DIAGNOSIS AND TESTING (Continued)

### POSITIVE CLOSED-TYPE VENTILATION SYSTEM

A malfunctioning closed crankcase ventilation system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making carburetor adjustments. **The removal of the crankcase ventilation system from the engine will adversely affect the fuel economy and engine ventilation with resultant shortening of engine life.** To determine whether the loping or rough idle condition is caused by a malfunctioning crankcase ventilation system, perform the following test.

### CRANKCASE VENTILATION REGULATOR VALVE TEST

Install a known good regulator valve (PCV) in the crankcase ventilation system.

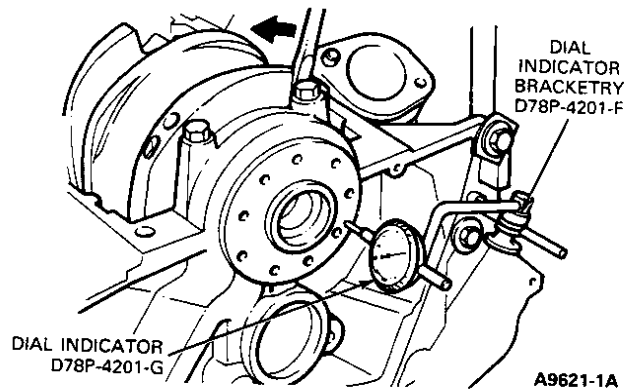
Start the engine and compare the engine idle condition to the prior idle condition.

If the idle condition is found to be satisfactory, use the new regulator valve and clean the hoses, fittings, etc.

If the loping or rough idle condition remains when the good regulator valve is installed, the crankcase ventilation regulator valve is not at fault. Check the crankcase ventilation system for restriction at the intake manifold or carburetor spacer. If the system is not restricted, further engine component diagnosis will have to be conducted to find the malfunction.

### CRANKSHAFT END PLAY

1. Force the crankshaft toward the rear of the engine.
2. Install a dial indicator so that the contact point rests against the crankshaft flange and the indicator axis is parallel to the crankshaft axis.
3. Zero the dial indicator. Push the crankshaft forward and note the reading on the dial.
4. If the end play exceeds the wear limit, replace the thrust washers. If the end play is less than the minimum limit, inspect the thrust bearing faces for scratches, burrs, nicks, or dirt.



### FLYWHEEL FACE RUNOUT

Install a dial indicator so that the indicator point bears against the flywheel face. Turn the flywheel making sure that it is full forward or rearward so that crankshaft end play will not be indicated as flywheel runout.

If the clutch face runout exceeds specifications, remove the flywheel and check for burrs

between the flywheel and the face of the crankshaft mounting flange. If no burrs exist, check the runout of the crankshaft mounting flange. Replace the flywheel or machine the crankshaft-flywheel mounting face sufficiently to true up the surface if the mounting flange runout exceeds specifications.

## DIAGNOSIS AND TESTING (Continued)

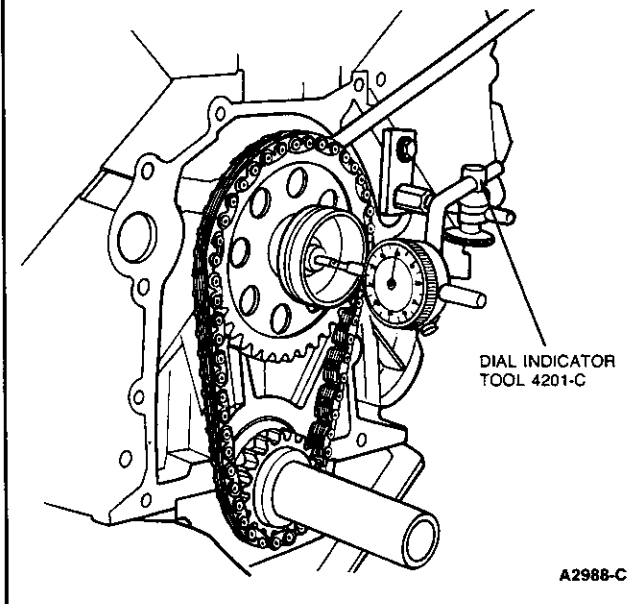
### CAMSHAFT END PLAY

Prying against the aluminum-nylon camshaft sprocket, with the valve train load on the camshaft, can break or damage the sprocket. Therefore, the rocker arm adjusting nuts must be backed off, or the rocker arm and shaft assembly must be loosened sufficiently to free the camshaft. After checking the camshaft end play, adjust the valve clearance.

Push the camshaft toward the rear of the engine. Install a dial indicator so that the indicator point is on the camshaft sprocket attaching screw. Zero the dial indicator. Position a large screwdriver between the camshaft gear and the block. Pull the camshaft forward and release it. Compare the dial indicator reading with specifications.

If the end play is excessive, check the spacer for correct installation before it is removed. If the spacer is correctly installed, replace the thrust plate.

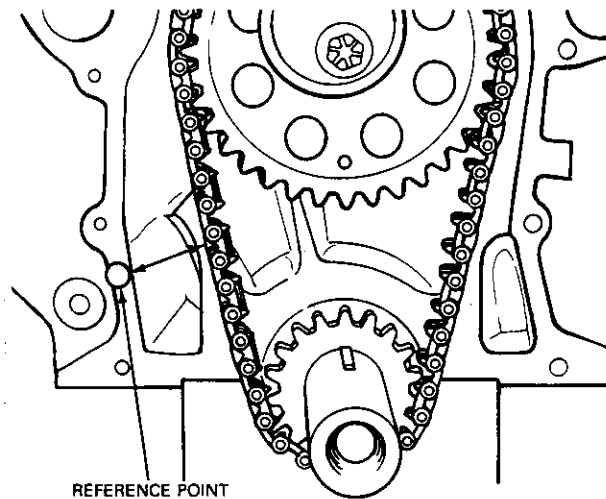
Remove the dial indicator.



### TIMING CHAIN DEFLECTION

1. Rotate the crankshaft in a counterclockwise position (as viewed from the front) to take up the slack on the left side of the chain.
2. Establish a reference point on the block and measure from this point to the chain.
3. Rotate the crankshaft in the opposite direction to take up the slack on the right of the chain. Force the left side of the chain out with the fingers and measure the distance between the reference point and the chain. The deflection is the difference between the two measurements.

If the deflection exceeds specifications, replace the timing chain and sprockets.



## CLEANING AND INSPECTION

The cleaning and inspection procedures are for a complete engine overhaul; therefore, for partial engine overhaul or parts replacement, follow the pertinent cleaning or inspection procedure.

### INTAKE MANIFOLD

#### Cleaning

Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent and dry it with compressed air.

#### Inspection

Inspect the manifold for cracks, damaged gasket surfaces, or other defects that would make it unfit for further service. Replace all studs that are stripped or otherwise damaged. **Remove all filings and foreign matter that may have entered the manifold as a result of repairs.**

### EXHAUST MANIFOLDS

#### Cleaning

Remove all gasket material from the manifolds.

#### Inspection

Inspect the cylinder head joining flanges of the exhaust manifold for evidence of exhaust gas leaks.

Inspect the manifolds for cracks, damaged gasket surfaces, or other defects that would make them unfit for further service.

### VALVE ROCKER ARM

#### Cleaning

Clean all the parts thoroughly. Make sure all oil passages are open.

Make sure the oil passage in the push rod end of the rocker arm is open.

#### Inspection

Inspect the pad at the valve end of the rocker arm for indications of scuffing or abnormal wear. If the pad is grooved, replace the rocker arm. **Do not attempt to true this surface by grinding.**

### PUSH RODS

#### Cleaning

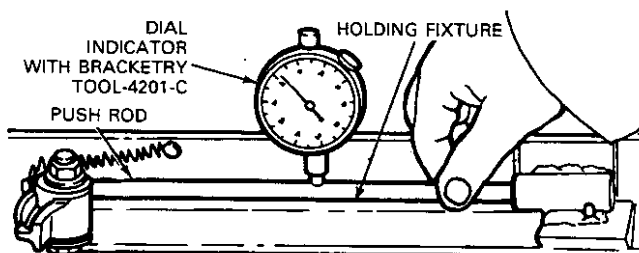
Clean the push rods in a suitable solvent. Blow out the oil passage with compressed air.

#### Inspection

Check the ends of the push rods for nicks, grooves, roughness or excessive wear. Make sure the oil passage in the push rod is open and clean.

The push rods can be visually checked for straightness while they are installed in the engine by rotating them with the valve closed. They also can be checked with a dial indicator.

If the push rod is visibly bent, it should be replaced.



A9623-1A

## CLEANING AND INSPECTION (Continued)

### CYLINDER HEADS

#### Cleaning

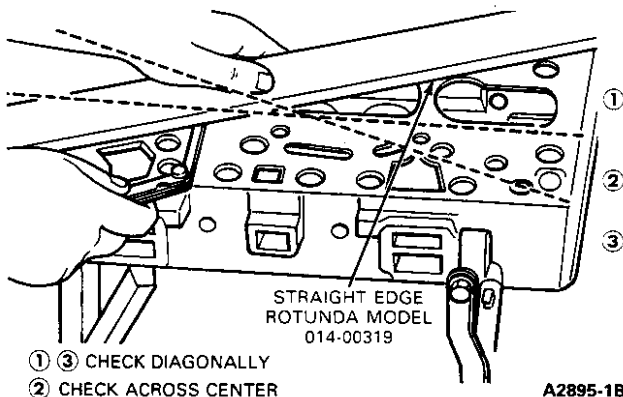
With the valves installed to protect the valve seats, remove deposits from the combustion chambers and valve heads with a scraper and a wire brush. Be careful not to damage the cylinder head gasket surface. After the valves are removed, clean the valve guide bores with a valve guide cleaning tool. Use cleaning solvent to remove dirt, grease and other deposits. Clean all bolt holes. Remove all deposits from the valves with a fine wire brush or buffing wheel.

#### Inspection

Check the cylinder head for cracks and inspect the gasket surface for burrs and nicks. Replace the head if it is cracked.

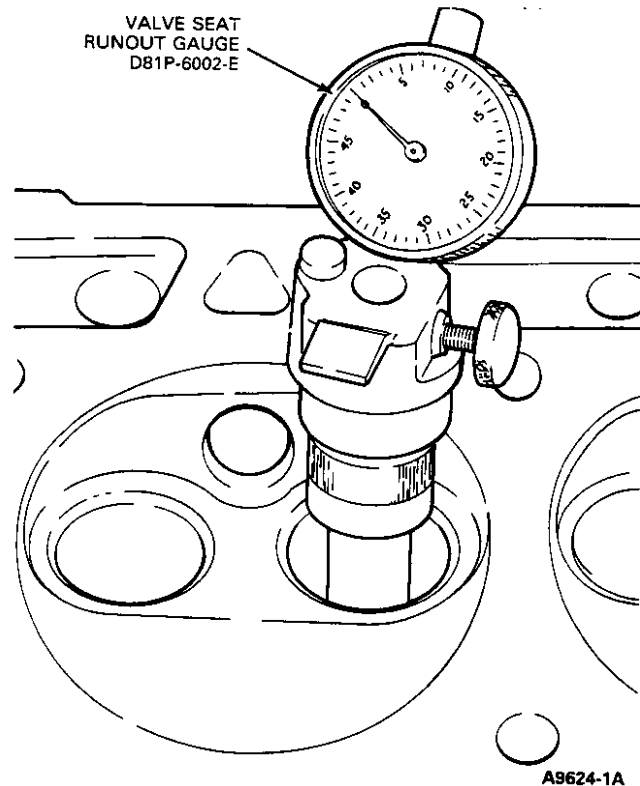
The following inspection procedures are for a cylinder head that is to be completely overhauled. For individual repair operations, use only the pertinent inspection procedure.

When a cylinder head is removed because of gasket leaks, check the flatness of the cylinder head gasket surface for conformance to specifications. If necessary to refinish the cylinder head gasket surface, **do not plane or grind off more than 0.254mm (0.010 inch).**



Check the valve seat runout with an accurate gauge. Follow the instructions of the gauge manufacturer. If the runout exceeds the wear limit, reface the valve and valve seat. Measure the valve seat width. Reface any valve seat whose width is **not within specifications.**

Inspect the valve face and the edge of the valve head for pits, grooves, scores or other



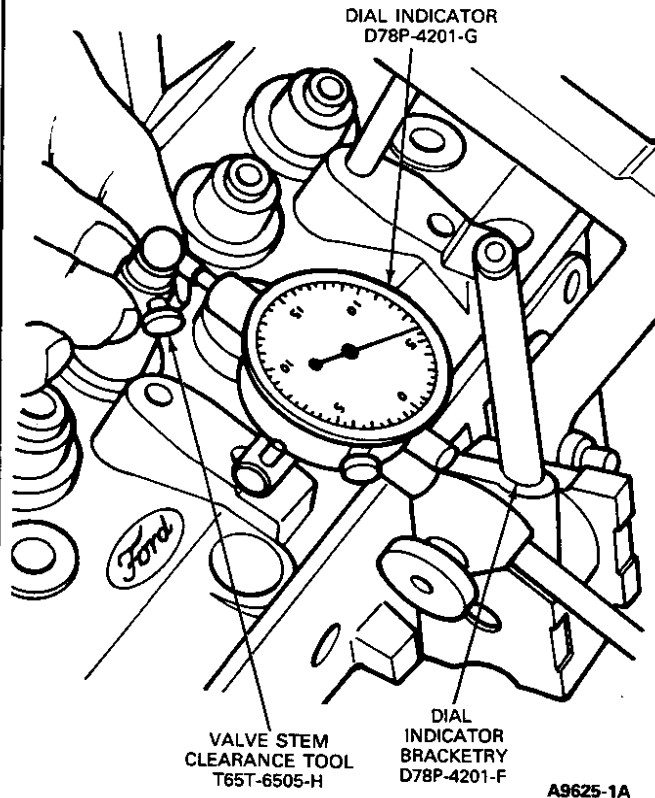
damage. Inspect the stem for a bent condition and the end of the valve head for pits, grooves, scores or other wear. Inspect the stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for signs of burning, erosion, warpage and cracking. Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged. **Do not discard sodium-cooled valves with other scrap metal in scrap bins. If a sodium-cooled valve is accidentally broken and the sodium exposed, it will react violently upon contact with water resulting in fire and explosion due to chemical action. Therefore, these valves should be handled with care and disposed of by being buried in the ground in an area not subjected to excavation.**

Inspect the valve spring, valve spring retainers, locks and sleeves for wear or damage. Discard any visually damaged parts.

Check the valve stem to valve guide clearance of each valve in its respective valve guide with the tool shown or its equivalent. Use a flat end indicator point.

## CLEANING AND INSPECTION (Continued)

Install the tool on the valve stem until it is fully seated, and tighten the knurled set screw firmly. Permit the valve to drop away from its seat until the tool contacts the upper surface of the valve guide.



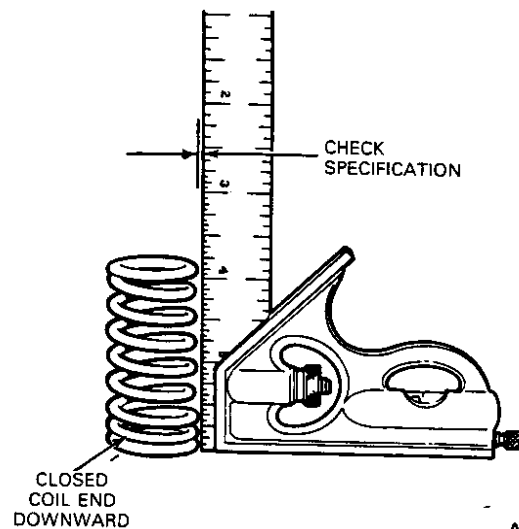
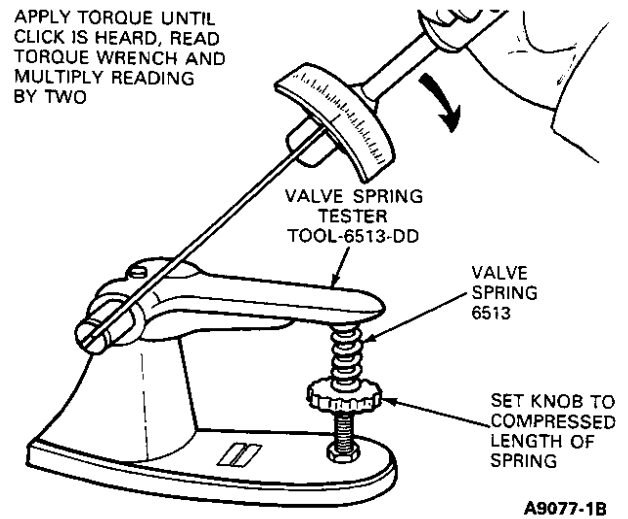
Position the dial indicator with its flat tip against the center portion of the tool's spherical section at approximately 90 degrees to the valve stem axis. Move the tool back and forth in line with the indicator stem. Take a reading on the dial indicator without removing the tool from the valve guide upper surface. Divide the reading by two, the division factor for the tool.

Check the springs for proper pressure at the specified spring lengths (Tool 6513-DD). Weak valve springs cause poor engine performance. Replace any spring not within specifications.

Check each spring for squareness using a steel square and a flat surface. Stand the spring and square on end on the flat surface. Slide the

spring up to the square. Revolve the spring slowly and observe the space between the top coil of the spring and the square. The out-of-square limits are  $5/64$  inch.

Follow the same procedure to check new valve springs before installation. **Make certain the proper spring (color coded) is installed.**



## CLEANING AND INSPECTION (Continued)

### HYDRAULIC VALVE LIFTERS

The valve lifter assemblies should be kept in proper sequence so that they can be installed in their original position. Inspect and test each lifter separately so as not to intermix the internal parts. **If any part of the lifter assembly needs replacing, replace the entire assembly.**

#### Cleaning

Thoroughly clean all the parts in cleaning solvent and wipe them with a clean, lint-free cloth.

#### Inspection

Inspect the parts and discard the entire lifter assembly if any part shows pitting, scoring, galling or evidence of non-rotation. Replace the entire assembly if the plunger is not free in the body. The plunger should drop to the bottom of the body by its own weight when assembled dry.

Assemble the lifter assembly and check for freeness of operation by pressing down on the push rod cup. The lifters can also be checked with a hydraulic tester to test the leak-down rate. Follow the instructions of the test unit manufacturer.

### CRANKSHAFT VIBRATION DAMPER AND SPACER

#### Cleaning

Clean the oil seal contact surface on the crankshaft damper or spacer with solvent to remove any corrosion, sludge or varnish deposits. Excess deposits that are not readily removed with solvent may be removed with crocus cloth. Use crocus cloth to remove any sharp edges, burrs or other imperfections which might damage the oil seal during installation or cause premature seal wear. **Do not use crocus cloth to the extent that the seal surface becomes polished. A finely polished surface may produce poor sealing or cause premature seal wear.**

#### Inspection

Inspect the crankshaft damper or spacer oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

### TIMING CHAIN AND SPROCKETS

#### Cleaning

Clean all parts in solvent and dry them with compressed air.

Lubricate the timing chain with engine oil before installing it on the engine.

#### Inspection

Inspect the chain for broken links. Inspect the sprockets for cracks and worn or damaged teeth. Replace all the components of the timing chain and sprocket assembly if any one item needs replacement.

Inspect the fuel pump drive eccentric for scores, nicks and excessive wear. If the eccentric is scored, replace it.

### CAMSHAFT

#### Cleaning and Inspection

Clean the camshaft in solvent and wipe it dry. Inspect the camshaft lobes for scoring and signs of abnormal wear. Lobe wear characteristics may result in pitting in the general area of the lobe toe. This pitting is not detrimental to the operation of the camshaft; therefore, the camshaft should not be replaced unless the lobe lift loss has exceeded 0.005 inch.

The lift of the camshaft lobes can be checked with the camshaft installed in the engine or on centers. Refer to Camshaft Lobe Lift.

Check the distributor drive gear for broken or chipped teeth. Replace the camshaft if this condition exists.

## CLEANING AND INSPECTION (Continued)

### CRANKSHAFT

#### Cleaning

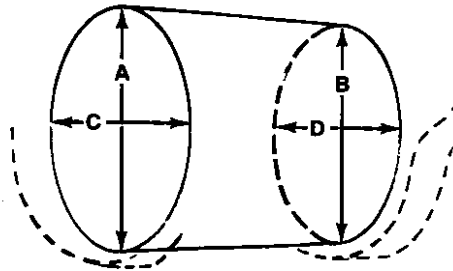
Handle the crankshaft with care to avoid possible fractures or damage to the finished surfaces. Clean the crankshaft with solvent, then blow out all oil passages with compressed air.

#### Inspection

Inspect the main and connecting rod journals for cracks, scratches, grooves or scores. Inspect the crankshaft oil seal surface for nicks, sharp edges or burrs that might damage the oil seal during installation or cause premature seal wear.

A VS B = VERTICAL TAPER  
C VS D = HORIZONTAL TAPER  
A VS C AND B VS D = OUT-OF-ROUND

CHECK FOR OUT-OF-ROUND AT EACH END OF JOURNAL

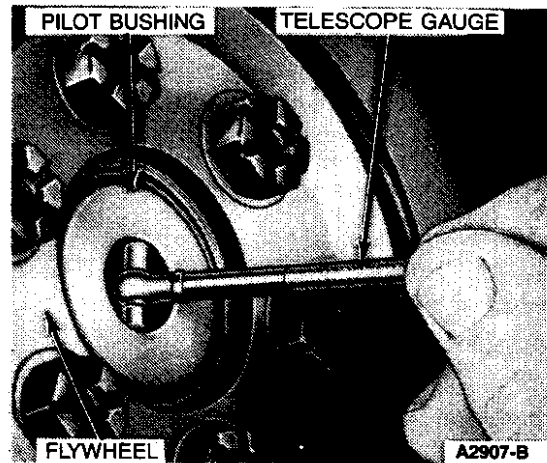


A2901-B

Measure the diameter of each journal in at least four places to determine an out-of-round, taper or undersize condition.

Check the fit of the clutch pilot bushing in the bore of the crankshaft. The bushing is pressed into the crankshaft and should not be loose. Inspect the inner surface of the bushing for wear or a bell-mouth condition. Check the ID of the bushing. Replace the bushing if it is worn or damaged or the ID is not within specifications.

Inspect the pilot bearing (ball bearing) when so equipped, for roughness, evidence of overheating or loss of lubricant. Replace it if any of these conditions are found.



A2907-B

### FLYWHEEL

#### Inspection

Inspect the flywheel for cracks, heat check, or other damage that would make it unfit for further service. Machine the friction surface of the flywheel if it is scored or worn. If it is necessary to remove more than 0.045 inch of stock from the original thickness, replace the flywheel.

Inspect the ring gear for worn, chipped, or cracked teeth. If the teeth are damaged, replace the ring gear.

With the flywheel installed on the crankshaft, check the flywheel face runout, following the procedure under Diagnosis and Testing.

## CLEANING AND INSPECTION (Continued)

### CONNECTING RODS

#### Cleaning

Remove the bearings from the rod and cap. Identify the bearings if they are to be used again. Clean the connecting rod in solvent, including the rod bore and the back of the inserts. **Do not use a caustic cleaning solution.** Blow out all passages with compressed air.

#### Inspection

The connecting rods and related parts should be carefully inspected and checked for conformance to specifications. Various forms of engine wear caused by these parts can be readily identified.

A shiny surface on either pin boss side of the piston usually indicates that a connecting rod is bent.

Abnormal connecting rod bearing wear can be caused by either a bent connecting rod, worn or damaged crankpin, or a tapered connecting rod bore.

Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb the action of the entire piston, rings, and connecting rod assembly and may be the cause of excessive oil consumption.

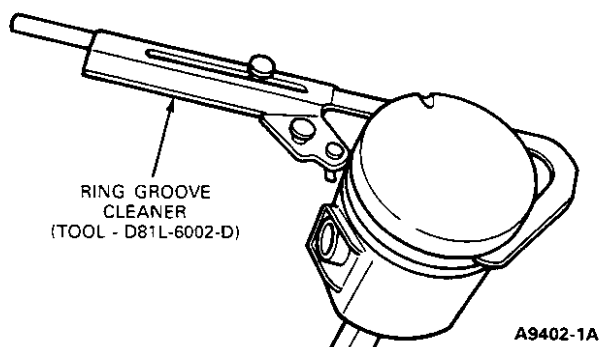
Inspect the connecting rods for signs of fractures and the bearing bores for out-of-round and taper. If the bore exceeds the recommended limits and/or if the connecting rod is fractured, it should be replaced. Check the ID of the connecting rod piston pin bore. If the pin bore in the connecting rod is larger than specifications, install a 0.002 inch oversize piston pin. First, prefit the oversize piston pin to the piston pin bore by reaming or honing the piston. Then, assemble the piston, piston pin and connecting rod following the procedures for assembly. **It is not necessary to ream or hone the pin bore in the connecting rod. Replace damaged connecting rod nuts and bolts. Check the connecting rods for bend or twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. If the bend and/or twist exceeds specifications, the connecting rod must be straightened or replaced.**

### PISTONS, PINS AND RINGS

#### Cleaning

Remove deposits from the piston surfaces. Clean gum or varnish from the piston skirt, piston pins and rings with solvent. **Do not use a caustic cleaning solution or a wire brush to clean pistons.**

Clean the ring grooves with a ring groove cleaner. Make sure the oil ring slots (or holes) are clean.



#### Inspection

Carefully inspect the pistons for fractures at the ring lands, skirts and pin bosses, and for scuffed, rough or scored skirts. If the lower inner portion of the ring grooves has a high step, replace the piston. The step will interfere with ring operation and cause excessive ring side clearance.

Spongy, eroded areas near the edge of the top of the piston are usually caused by detonation or pre-ignition. A shiny surface on the thrust surface of the piston, offset from the centerline between the piston pin holes, can be caused by a bent connecting rod. Replace pistons that show signs of excessive wear, wavy ring lands or fractures or damage from detonation or pre-ignition.

Check the piston to cylinder bore clearance by measuring the piston and bore diameters. Refer to the specifications for the proper clearance. Refer to Cylinder Block Inspection for the bore measurement procedure. **Measure the OD of the piston with micrometers approximately 2 1/4 inches below the dome and at 90 degrees to the piston pin bore.** Check the ring side clearance following the procedure under Fitting Piston Rings in this section.

Replace pistons pins showing signs of fracture, etching or wear. Check the piston pin fit in the piston and rod. Refer to Piston and Connecting Rod Assembly.

Check the OD of the piston pin and the ID of the pin bore in the piston. Replace any piston pin or piston that is not within specifications.

Replace all rings. Check the end gap and side clearance. **Rings should not be transferred from one piston to another regardless of mileage or hours.**

# CLEANING AND INSPECTION (Continued)

## MAIN AND CONNECTING ROD BEARINGS

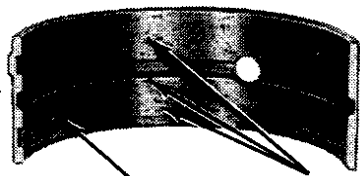
### Cleaning

Clean the bearing inserts and caps thoroughly in solvent, and dry them with compressed air. **Do not scrape gum or varnish deposits from the bearing shells.**

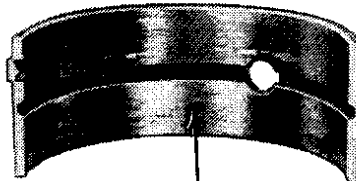
### Inspection

Inspect each bearing carefully. Bearings that have a scored, chipped, or worn surface should

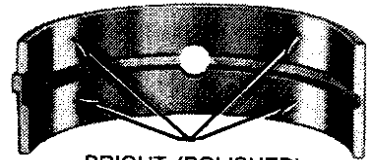
be replaced. Typical examples of unsatisfactory bearings and their causes are shown in the example. The copper-lead bearing base may be visible through the bearing overlay. This does not mean that the bearing is worn. It is not necessary to replace the bearing if the bearing clearance is within recommended limits. Check the clearance of bearings that appear to be satisfactory with Plastigage as detailed under Main and Connecting Rod Bearings.



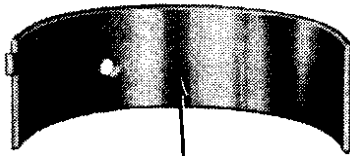
SCRATCHES  
DIRT IMBEDDED INTO BEARING MATERIAL  
SCRATCHED BY DIRT



OVERLAY WIPED OUT  
LACK OF OIL

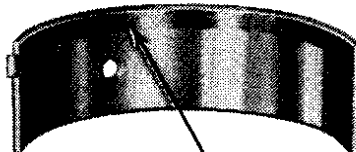


BRIGHT (POLISHED) SECTIONS  
IMPROPER SEATING



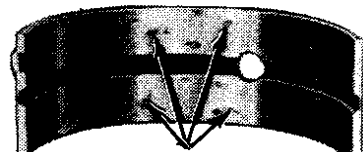
OVERLAY GONE FROM ENTIRE SURFACE

TAPERED JOURNAL



RADIUS RIDE

RADIUS RIDE



CRATERS OR POCKETS

FATIGUE FAILURE

## CLEANING AND INSPECTION (Continued)

### CYLINDER BLOCK

#### Cleaning

After any cylinder bore repair operation, such as honing or deglazing, clean the bore(s) with soap or detergent and water. Then, thoroughly rinse the bore(s) with clean water to remove the soap or detergent, and wipe the bore(s) dry with a clean, lint-free cloth. Finally, wipe the bore(s) with a clean cloth dipped in engine oil. If these procedures are not followed, rusting of the cylinder bore(s) may occur.

If the engine is disassembled, thoroughly clean the block with solvent. Remove old gasket material from all machined surfaces. Remove all pipe plugs that seal oil passages; then clean out all the passages. Blow out all passages, bolt holes, etc., with compressed air. Make sure the threads in the cylinder head bolt holes are clean. Dirt in the threads may cause binding and result in a false torque reading. Use a tap to true up threads and to remove any deposits. Thoroughly clean the grooves in the crankshaft bearings and bearing retainers.

#### Inspection

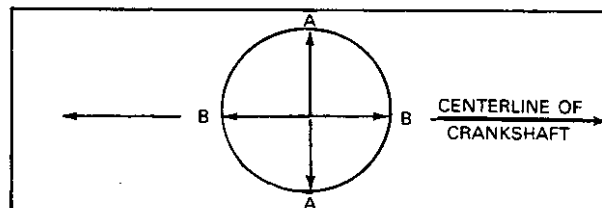
After the block has been thoroughly cleaned, check it for cracks. Minute cracks not visible to the naked eye may be detected by coating the suspected area with a mixture of 25% kerosene and 75% light engine oil. Wipe the part dry and immediately apply a coating of zinc oxide dissolved in wood alcohol. If cracks are present, the coating will become discolored at the defective area. Replace the block if it is cracked.

Check all machined gasket surfaces for burrs, nicks, scratches and scores. Remove minor imperfections with an oil stone.

Replace all expansion-type plugs that show evidence of leakage.

Inspect the cylinder walls for scoring, roughness, or other signs of wear. Check the cylinder bore for out-of-round and taper. Measure the bore with an accurate bore gauge following the instructions of the manufacturer. Measure the diameter of each cylinder bore at the top, middle and bottom with the gauge placed at right angles and parallel to the centerline of the engine. **Use only the measurements obtained at 90 degrees to the engine centerline when calculating the piston to cylinder bore clearance.**

Refinish cylinders that are deeply scored and/or when out-of-round and/or taper exceed the wear limits. If the cylinder walls have minor surface imperfections, but the out-of-round and taper are within limits, it may be possible to remove the imperfections by honing the cylinder walls and installing new service piston rings providing the piston clearance is within specified limits.



A - At Right angle to center line of engine  
B - Parallel to center line of engine

**Top Measurement:** Make 12.70mm (1/2 inch) below top of block deck

**Bottom Measurement:** Make within 12.70mm (1/2 inch) above top of piston - when piston is at its lowest travel (B.D.C)

**Bore Service Limit:** Equals the average of "A" and "B" when measured at the center of the piston travel.

**Taper:** Equals difference between "A" top and "A" bottom.

**Out-of-Round:** Equals difference between "A" and "B" when measured at the center of piston travel.

Refer to Specification tables at end of each engine section.

A4165-1G

### OIL PAN

#### Cleaning

Scrape any dirt or metal particles from the inside of the pan. Scrape all old gasket material from the gasket surface. Wash the pan in a solvent and dry it thoroughly. Be sure all foreign particles are removed from below the baffle plate.

#### Inspection

Check the pan for cracks, holes, damaged drain plug threads, and a loose baffle or a damaged gasket surface.

Inspect for damage (uneven surface) at the bolt holes caused by over-torquing the bolts. Straighten surfaces as required. Repair any damage, or replace the pan if repairs cannot be made satisfactorily.

## CLEANING AND INSPECTION (Continued)

### OIL PUMP

#### Cleaning

Wash all parts in a solvent and dry them thoroughly with compressed air. Use a brush to clean the inside of the pump housing and the pressure relief valve chamber. Be sure all dirt and metal particles are removed.

#### Inspection

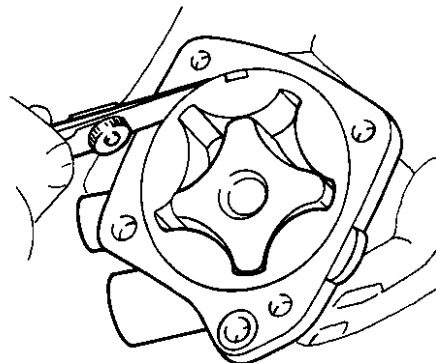
Refer to the specifications for clearances and wear limits.

Check the inside of the pump housing and the outer race and rotor for damage or excessive wear.

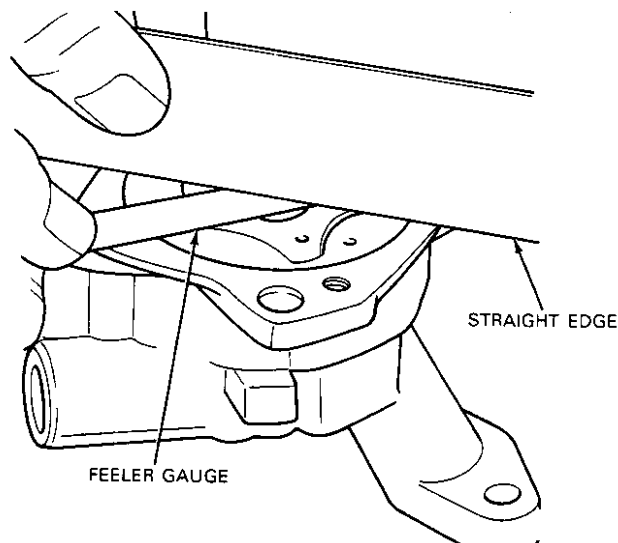
Check the mating surface of the pump cover for wear. If the cover mating surface is worn, scored or grooved, replace the cover.

Measure the outer race to housing clearance. Then check the clearance between the outer race and the rotor lobes.

With the rotor assembly installed in the housing, place a straight edge over the rotor assembly and the housing. Measure the clearance (rotor end play) between the straight edge and the rotor and outer race. **The outer race, shaft and rotor are replaceable only as an assembly.** Check the drive shaft to housing bearing clearance by measuring the OD of the shaft and the ID of the housing bearing. Inspect the relief valve spring for a collapsed or worn condition. Check the relief valve spring tension. If the spring tension is not within specifications and/or the spring is worn or damaged, replace the spring. Check the relief valve piston for scores and free operation in the bore.



A1026-C



A1027-B

### POSITIVE CLOSED-TYPE CRANKCASE VENTILATION SYSTEM

#### Cleaning

**Do not attempt to clean the crankcase ventilation regulator valve; it should be replaced at the specified maintenance interval.** The oil filler cap and oil separator should be cleaned at the proper maintenance interval. Re-

move the cap and the oil separator and wash them in a low-volatility, petroleum-base solvent. Shake the cap dry and install them. Clean the crankcase ventilation system connection(s) on the intake manifold by probing with a flexible wire or bottle brush. Clean the hoses, fittings, tubes and associated hardware with a low-volatility, petroleum-base solvent and dry with compressed air.

## OVERHAUL

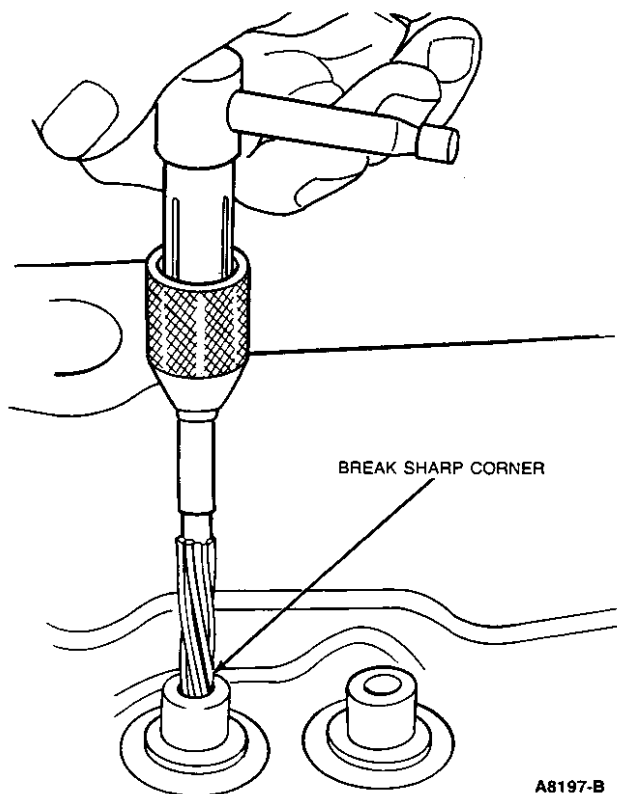
### CYLINDER HEAD

Replace the head if it is cracked. **Do not plane or grind more than 0.254mm (0.010 inch) from the cylinder head gasket surface.** Remove all burrs or scratches with an oil stone.

### REAMING VALVE GUIDES

If it becomes necessary to ream a valve guide to install a valve with an oversize stem, a reaming kit is available which contains the following reamer and pilot combinations: a 0.003-inch OS reamer with a standard diameter pilot, a 0.015-inch OS reamer with a 0.003-inch OS pilot, and a 0.030-inch reamer with a 0.015-inch OS pilot.

When going from a standard size valve to an oversize valve always use the reamer in sequence. **Always reface the valve seat after the valve guide has been reamed, and use a suitable scraper to break the sharp corner (ID) at the top of the valve guide.**



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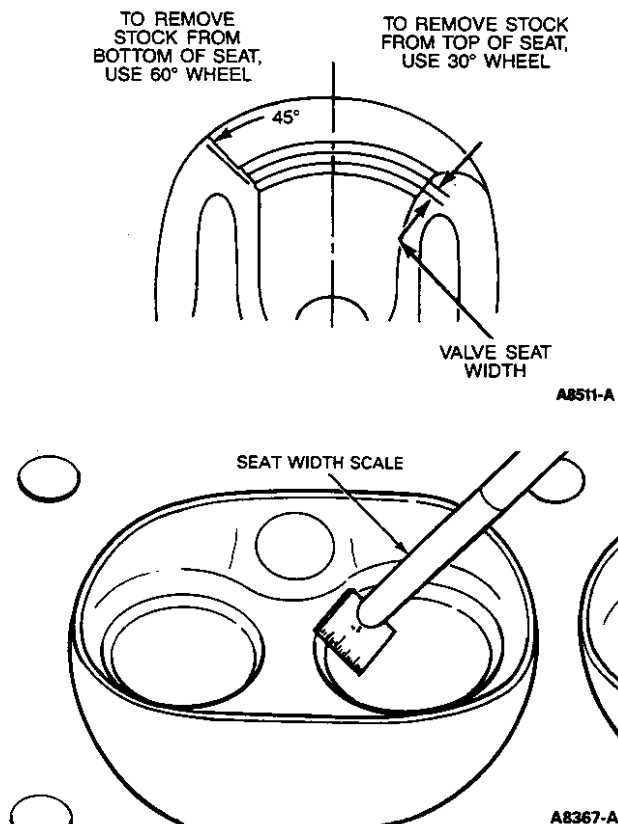
### REFACING VALVE SEATS

Refacing the valve seat should be closely coordinated with the refacing of the valve face so that the finished seat and valve face will be concentric and the specified interference fit will be maintained. This is important so that the valve and seat will have a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

Grind the valve seats of all engines to a true 45 degree angle. Remove only enough stock to clean up pits and grooves or to correct the valve seat runout. After the seat has been refaced, use a seat width scale or a machinist scale to measure the seat width. Narrow the seat, if necessary, to bring it within specifications, and center it on the valve face.

If the valve seat width exceeds the maximum limit, remove enough stock from the top edge and/or bottom edge of the seat to reduce the width to specifications, and center.

On the valve seats of all engines, use a 60 degree angle grinding wheel to remove stock from the bottom of the seats (raise the seats) and use a 30 degree angle wheel to remove stock from the top of the seats (lower the seats).



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The finished valve seat should contact the approximate center of the valve face. It is good practice to determine where the valve seat contacts the face. To do this, coat the seat with Prussian blue and set the valve in place. Rotate the valve with light pressure. If the blue is transferred to the center of the valve face, the contact is satisfactory. If the blue is transferred to the top edge of the valve face, lower the valve seat. If the blue is transferred to the bottom edge of the valve face, raise the valve seat.

## OVERHAUL (Continued)

### VALVES

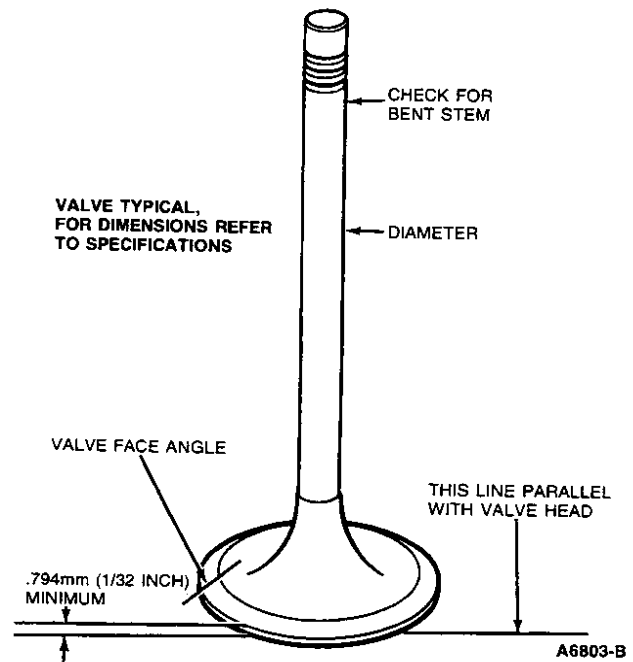
Minor pits, grooves, etc., may be removed. Discard valves that are severely damaged, if the face runout cannot be corrected by refinishing or stem clearance exceeds specifications. **Discard any excessively worn or damaged valve train parts.**

### REFACING VALVES

The valve refacing operation should be closely coordinated with the valve seat refacing operations so that the finished angles of the valve face and of the valve seat will be to specifications and provide a compression-tight fit. Be sure that the refacer grinding wheels are properly dressed.

Under no circumstances should the faces of aluminized intake valves be ground or the valves lapped in as this will remove the diffused aluminum coating and reduce the valve's wear and heat resistant properties. If the valve faces are worn or pitted it will be necessary to install new valves and to resurface the valve seats or, alternatively, lap the seats using dummy valves. The exhaust valves may be lapped in or the faces ground if required.

If the valve face runout is excessive and/or to remove pits and grooves, reface the valves to a true 44 degree angle. Remove only enough stock to correct the runout or to clean up the pits and grooves. If the edge of the valve head is less than 1/32 inch thick after grinding, replace the valve as the valve will run too hot in the engine. **The interference fit of the valve and seat should not be lapped out. Remove all grooves or score marks from the end of the valve stem, and chamfer it as necessary. Do not remove more than 0.010 inch from the end of the valve stem.**



If the valve and/or valve seat has been re-faced, it will be necessary to check the clearance between the rocker arm pad and the valve stem with the valve train assembly installed in the engine.

### SELECT FITTING VALVES

If the valve stem to valve guide clearance exceeds the wear limit, ream the valve guide for the next oversize valve stem. Valves with oversize stem diameters of 0.003, 0.015 and 0.030 inch are available for service. **Always reface the valve seat after the valve guide has been reamed. Refer to Reaming Valve Guides.**

### CAMSHAFT REPAIR

Remove light scuffs, scores or nicks from the camshaft machined surfaces with a smooth oil stone.

## OVERHAUL (Continued)

### CRANKSHAFT

Dress minor scores with an oil stone. If the journals are severely marred or exceed the wear limit, they should be refinished to size for the next undersize bearing.

### REFINISHING JOURNALS

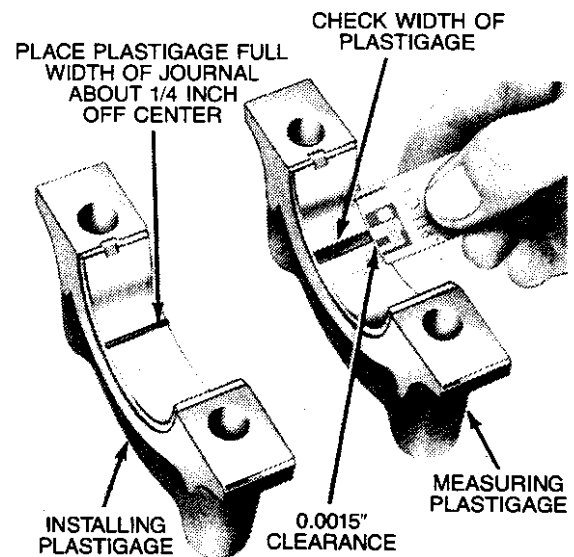
Refinish the journals to give the proper clearance with the next undersize bearing. If the journal will not clean up to maximum undersize bearing available, replace the crankshaft.

Always reproduce the same journal shoulder radius that existed originally. Too small a radius will result in fatigue failure of the crankshaft. Too large a radius will result in bearing failure due to radius ride of the bearing.

After refinishing the journals, chamfer the oil holes; then polish the journal with a No. 320 grit polishing cloth and engine oil. Crocus cloth may also be used as a polishing agent.

### FITTING MAIN OR CONNECTING ROD BEARINGS WITH PLASTIGAGE

1. Clean crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear. **When replacing standard bearings with new bearings, it is good practice to fit the bearing to minimum specified clearance.** If the desired clearance cannot be obtained with a standard bearing, try a 0.002 inch undersize in combination with a standard bearing to obtain the proper clearance.
2. If fitting a main bearing in the chassis, **position a jack under counterweight adjoining bearing which is being checked. Support crankshaft with jack so its weight will not compress Plastigage and provide an erroneous reading.**
3. Place a piece of Plastigage on bearing surface across full width of bearing cap and about 1/4 inch off center.
4. Install cap and torque bolts to specifications. Do not turn crankshaft while Plastigage is in place.
5. Remove cap. Using Plastigage scale, check width of Plastigage at widest point to get minimum clearance. Check at narrowest point to get maximum clearance. Difference between readings is taper of journals.
6. If clearance exceeds specified limits, on the connecting rod bearings, try a 0.002 inch undersize bearing in combination with the standard bearings. Bearing clearance must be within specified limits. If 0.002 undersize



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main bearings are used on more than one journal, be sure they are all installed in cylinder block side of bearing. If standard and 0.002 inch undersize bearings do not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.

7. After bearing has been fitted, remove Plastigage and apply light coat of engine oil to journal and bearings. Install bearing cap. Torque cap bolts to specifications.
8. Repeat procedure for remaining bearings that require replacement.

## OVERHAUL (Continued)

### PISTONS, PINS AND RINGS

#### FITTING PISTONS

Pistons are available for service in standard sizes and the oversizes shown in the parts book.

The standard size pistons are color coded red or blue, or have 0.0025 O.S. stamped on the dome. Refer to the Specifications for standard size piston dimensions.

Measure the cylinder bore and select the piston to assure the proper clearance. When the bore diameter is in the lower one-third of the specified range, a red piston should be used. When the bore diameter is in the middle one-third a blue piston should be used. When the bore diameter is in the upper one-third, the 0.0025 O.S. piston should be used.

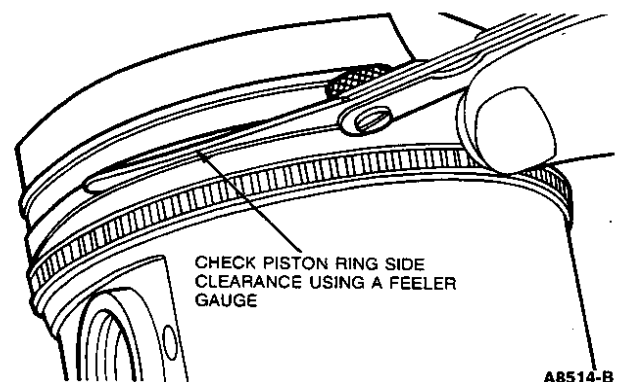
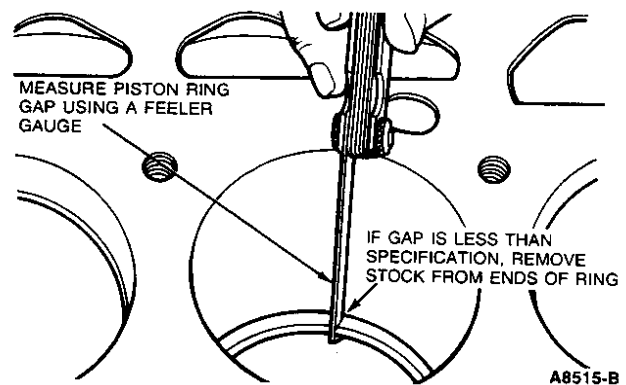
Measure the piston diameter to ensure that the specified clearance is obtained. It may be necessary periodically to use another piston (red or blue) that is either slightly larger or smaller to achieve the specified clearance. **If none can be fitted, refinish the cylinder to provide the proper clearance for the piston. When a piston has been fitted, mark it for assembly in the cylinder to which it was fitted. If the taper, out-of-round and piston to cylinder bore clearance conditions of the cylinder bore are within specified limits, new piston rings will give satisfactory service. If new rings are to be installed in a used cylinder that has not been refinished, remove the cylinder wall glaze (refer to Cylinder Block, Refinishing Cylinder Walls). Be sure to clean the cylinder bore thoroughly.**

1. Calculate the size piston to be used by taking a cylinder bore check. Follow the procedures outlined under Cleaning and Inspection.
2. Select the proper size piston to provide the desired clearance (refer to the specifications). The piston should be measured 2 1/4 inches below the dome and at 90° to the piston pin bore.
3. Make sure the piston and cylinder block are at room temperature (70 degrees F). **After any refinishing operation allow the cylinder bore to cool, and make sure the piston and bore are clean and dry before the piston fit is checked.**

#### FITTING PISTON RINGS

1. Select the proper ring set for the size cylinder bore.
2. Position the ring in the cylinder bore in which it is going to be used.

3. Push the ring down into the bore area where normal ring wear is not encountered.
4. Use the head of a piston to position the ring in the bore so that the ring is square with the cylinder wall. **Use caution to avoid damage to the ring or cylinder bore.**
5. Measure the gap between the ends of the ring with a feeler gauge. If the ring gap is less or greater than the specified limits, try another ring set.
6. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. **If the lower land have high steps, the piston should be replaced.**



#### FITTING PISTON PINS

The piston pins are selected to give the correct fit in the piston pin bore and bushing in the connecting rod. Pistons are only supplied in service complete with the piston pin, to ensure the correct fit. The piston pins should not be interchanged.

## OVERHAUL (Continued)

### VALVE ROCKER ARM

If the pad at the valve end of the rocker arm has a grooved radius, replace the rocker arm. **Do not attempt to true this surface by grinding.**

### PUSH RODS

Following the procedures under Push Rod Inspection, check the push rods for straightness.

If the runout exceeds the maximum limit at any point, discard the rod. **Do not attempt to straighten push rods.**

## CYLINDER BLOCK

### REFINISHING CYLINDER WALLS

Honing is recommended for refinishing cylinder walls **only** when the walls have minor scuffs or scratches, or for fitting pistons to the specified clearance. The grade of hone to be used is determined by the amount of metal to be removed. Follow the instructions of the hone manufacturer. If coarse stones are used to start the honing operation, leave enough material so that all hone marks can be removed with the finishing hone which is used to obtain the proper piston clearance.

Cylinder walls that are severely marred and/or worn beyond the specified limits should be refinished. **Before any cylinder is refinished, all main bearing caps must be in place and tightened to the proper torque so that the crankshaft bearing bores will not become distorted from the refinishing operation.**

Refinish only the cylinder or cylinders that require it. All pistons are the same weight, both standard and oversize; therefore, various sizes of pistons can be used without upsetting engine balance.

Refinish the cylinder with the most wear first to determine the maximum oversize. If the cylinder will not clean up when refinished for the maximum oversize piston recommended, replace the block.

Refinish the cylinder to within approximately 0.0015 inch of the required oversize diameter. This will allow enough stock for the final step of honing so that the correct surface finish and pattern are obtained.

For the proper use of the refinishing equipment, follow the instructions of the manufacturer. Only experienced personnel should be allowed to perform this work.

Use a motor-driven, spring pressure-type hone at a speed of 300-500 rpm. Hones of grit

sizes 180-220 will normally provide the desired bore surface finish of 15/32 RMS. When honing the cylinder bores, use a lubricant mixture of equal parts of kerosene and SAE No. 20 motor oil. Operate the hone in such a way as to produce a cross-hatch finish on the cylinder bore. The cross-hatch pattern should be at an angle of approximately 30 degrees to the cylinder bore. After the final operation in either of the two refinishing methods described and prior to checking the piston fit, thoroughly clean and oil the cylinder walls. Mark the pistons to correspond to the cylinders in which they are to be installed. When the refinishing of all cylinders that require it has been completed and all pistons are fitted, thoroughly clean the entire block and oil the cylinder walls.

### REPAIRING SAND HOLES OR POROUS ENGINE CASTINGS

Porosity or sand hole(s) which will cause oil seepage or leakage can occur with modern casting processes. A complete inspection of engine and transmission should be made. If the leak is attributed to the porous condition of the cylinder block or sand hole(s), repairs can be made with metallic plastic (Part No. C6AZ-19554-A). **Do not repair cracks with this material.** Repairs with this metallic plastic must be confined to those cast iron engine component surfaces where the inner wall surface is not exposed to engine coolant pressure or oil pressure, for example:

1. Cylinder block surfaces extending along the length of the block, upward from the oil pan rail to the cylinder water jacket but not including machined areas.
2. Lower rear face of the cylinder block.
3. Intake manifold casting.
4. Cylinder head, along the rocker arm cover gasket surface.

## OVERHAUL (Continued)

The following procedure should be used to repair porous areas or sand holes in cast iron:

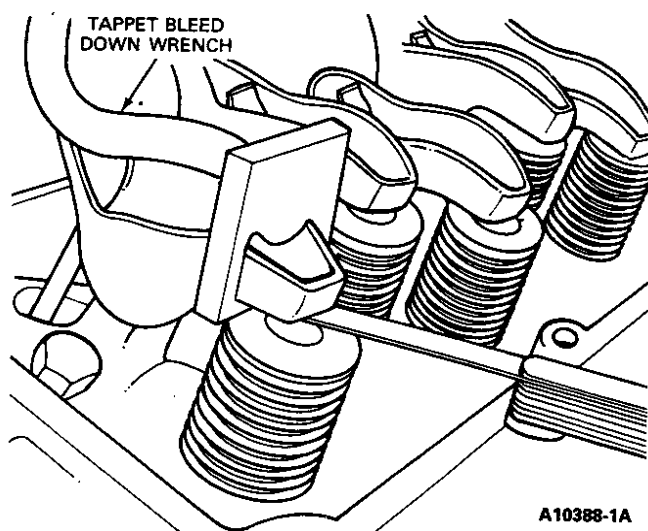
- a. Clean the surface to be repaired by grinding or rotary filing to a clean bright metal surface. Chamfer or undercut the hole or porosity to a greater depth than the rest of the cleaned surface. Solid metal must surround the hole. Openings larger than 1/4 inch should not be repaired using metallic plastic. Openings in excess of 1/4 inch can be drilled, tapped and plugged using common tools. Clean the repair area thoroughly. Metallic plastic will not stick to a dirty or oily surface.
- b. Mix the metallic plastic base and hardener as directed on the container. Stir thoroughly until uniform.
- c. Apply the repair mixture with a suitable clean tool (putty knife, wood spoon, etc.) forcing the epoxy into the hole or porosity.
- d. Allow the repair mixture to harden. This can be accomplished by two methods: heat cure with a 250 degree watt lamp placed 10 inches from the repaired surface, or air dry for 10-12 hours at temperatures above 50 degrees F.
- e. Sand or grind the repaired area to blend with the general contour of the surrounding surface.
- f. Paint the surface to match the rest of the block.

## ADJUSTMENTS

### VALVE CLEARANCE

The valve arrangement on the left bank is E-I-E-I-E-I and on the right bank is I-E-I-E-I-E-I-E.

A 1.52mm (0.060 inch) shorter push rod or a 1.52mm (0.060 inch) longer push rod are available for service to provide a means of compensating for dimensional changes in the valve mechanism.



Valve stem to valve rocker arm clearance should be within specifications listed at the end of this Section. With the hydraulic tappet completely collapsed, repeated valve reconditioning operations (valve and/or valve seat refacing) will decrease the clearance to the point that if not compensated for, the hydraulic valve tappet will cease to function and the valve will be held open.

To determine whether a shorter or a longer push rod is necessary, make the following check:

1. Install an auxiliary starter switch. **Crank the engine with the ignition switch Off until the No. 1 piston is on TDC after the compression stroke.**
2. With the crankshaft in the positions designated in Steps 3, 4 and 5, position the hydraulic tappet compressor Tappet Bleed Down Wrench T71B-6513-B or equivalent on the rocker arm. Slowly apply pressure to bleed down the hydraulic tappet until the plunger is completely bottomed. Hold the tappet in this position and check the available clearance between the rocker arm and the valve stem tip with a feeler gauge. If the clearance is less than specifications, install a shorter push rod. If the clearance is greater than specifications, install a longer push rod.

## ADJUSTMENTS (Continued)

3. With the No. 1 piston on TDC at the end of the compression stroke as shown in POSITION NO. 1, check the following valves:

No. 1 Intake No. 1 Exhaust

No. 3 Intake No. 4 Exhaust

No. 7 Intake No. 5 Exhaust

No. 8 Intake No. 8 Exhaust

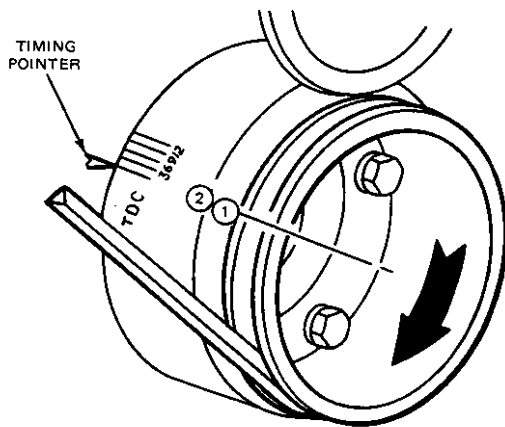
4. After checking the spacing on these valves, rotate the crankshaft 360 degrees to POSITION NO. 2 then check the following valves:

No. 2 Intake No. 2 Exhaust

No. 4 Intake No. 3 Exhaust

No. 5 Intake No. 6 Exhaust

No. 6 Intake No. 7 Exhaust



POSITION 1—NO. 1 AT TDC AT END OF COMPRESSION STROKE.  
 POSITION 2—ROTATE THE CRANKSHAFT 360 DEGREES  
 (ONE REVOLUTION) CLOCKWISE FROM POSITION 1.

A7908-1A

## REMOVAL AND INSTALLATION

### CRANKCASE VENTILATION SYSTEM

#### Removal

1. Disconnect the crankcase vent front hose from the air cleaner.
2. Remove the air cleaner and intake duct assembly. If so equipped, disconnect the oil filler pipe hose from the left rocker arm cover.
3. Disconnect the crankcase vent rear hose from the carburetor spacer, at the front of intake manifold. Pull the hose and PCV valve out of the valve rocker arm cover. Remove the PCV valve from the vent hose.

#### Installation

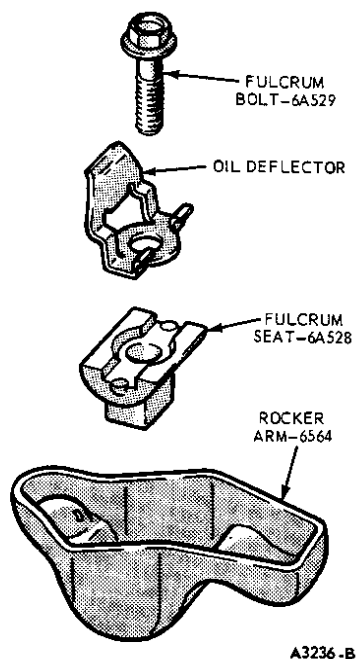
1. Insert the PCV valve into the grommet in the valve rocker arm cover. Connect the crankcase vent hose to the hot idle compensator and the PCV valve and the carburetor spacer or intake manifold.
2. Install the air cleaner and intake duct assembly. If so equipped, connect the oil filter pipe hose to the left rocker arm cover.
3. Connect the crankcase vent front hose to the air cleaner and the oil filter tube.
4. Start the engine and check for leaks.

## REMOVAL AND INSTALLATION (Continued)

### VALVE ROCKER ARM COVER AND ROCKER ARM

#### Removal

1. Remove the air cleaner and intake duct assembly.  
If a right cylinder head rocker arm is to be removed, remove the crankcase ventilation PCV valve from the valve rocker arm cover.
2. Disconnect the spark plug wires from the spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent and position the wires out of the way.
3. Remove the valve rocker arm cover(s).
4. Remove the valve rocker arm bolt, oil deflector, fulcrum seat and rocker arm.



#### Installation

1. Apply Ford Polyethylene Grease D0AZ-19584-A or equivalent to the top of the valve stems, the rocker arm and fulcrum seats.

2. Position the No. 1 piston on TDC at the end of the compression stroke, (POSITION 1 in illustration) and install the rocker arm, fulcrum seat, oil deflector and bolt on the following valves:

No. 1 Intake No. 1 Exhaust

No. 3 Intake No. 8 Exhaust

No. 7 Intake No. 5 Exhaust

No. 8 Intake No. 4 Exhaust

Position the crankshaft in POSITION 2 and install the rocker arm, fulcrum seat, oil deflector and bolt on the following valves:

No. 2 Intake No. 2 Exhaust

No. 4 Intake No. 3 Exhaust

No. 5 Intake No. 6 Exhaust

No. 6 Intake No. 7 Exhaust

**Be sure that the fulcrum seat base is inserted in its slot on the cylinder head before tightening the fulcrum bolts.** Tighten the fulcrum bolt to 25-33 N·m (18-25 ft-lb). Adjust the valve clearance following the procedures under adjustments in this Section.

3. Clean the valve rocker arm cover(s) and the cylinder head gasket surface(s). Position the gasket in the cover, making sure that the gasket tangs are secured in the notches in the cover.
4. Position the cover(s) on the cylinder head(s). Make sure the gasket seats evenly all around the head. Install the bolts. The cover is tightened in two steps. Tighten the bolts to 7-8 N·m (5-6 ft-lb). Two minutes later, tighten the bolts to the same specifications.

If the right cover was removed, install PCV valve.

Install the air cleaner and intake duct assembly.

5. Connect the spark plug wires.
6. Start the engine and check for leaks.

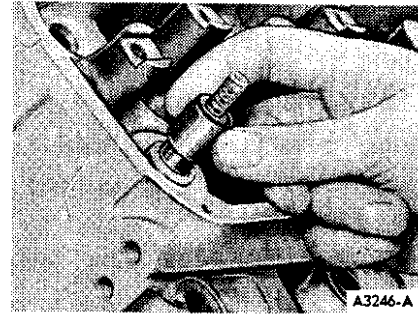
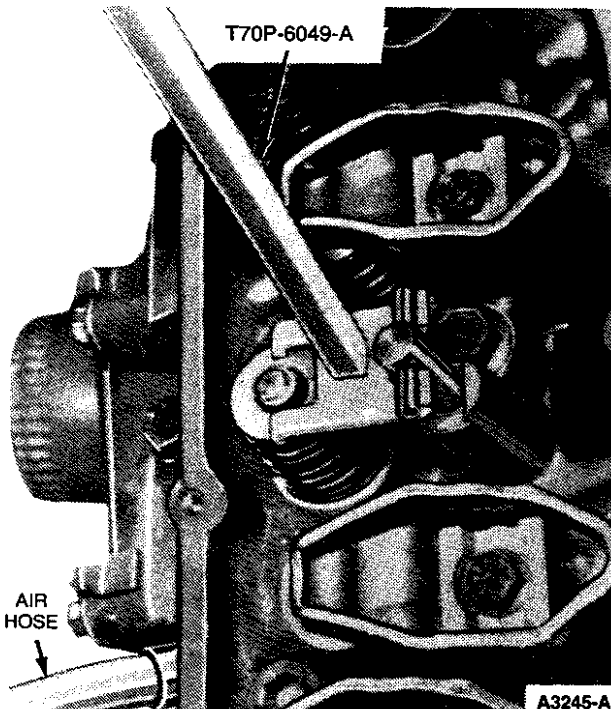
## REMOVAL AND INSTALLATION (Continued)

### VALVE SPRING, RETAINER AND STEM SEAL

Broken valve springs or defective valve stem seals or retainers may be replaced without removing the cylinder head if valve or valve seat is not damaged.

#### Removal

1. If defective spring, retainer, or seal is on right side of engine, remove air cleaner and intake duct assembly. Remove PCV valve and hose from right valve rocker arm cover. If defective spring, retainer, or seal is on left side of engine, remove oil filler cap and ventilation hose from left valve rocker arm cover and position out of way.
2. Remove valve rocker arm cover(s) and applicable spark plug(s).
3. Remove valve rocker arm bolts, oil deflectors, fulcrum seats, rocker arms, and push rods from affected cylinder(s).
4. Install air line with adapter in spark plug hole. Turn on air supply to hold valves closed.
5. Install Tool T70P-6049-A and compress valve spring. Remove retainer locks, spring retainer, and spring. Remove and discard valve stem seal. **If air pressure fails to hold valve in closed position, valve damage affecting sealing is indicated. Remove and inspect cylinder head assembly.**



6. Wrap rubber band, tape or string around end of valve stem to prevent valve from dropping into cylinder when air pressure in cylinder is shut off if piston is at bottom of cylinder. Shut off air pressure.
7. Inspect valve stem for damage. Rotate valve, checking tip for eccentric movement. Move valve up and down through normal travel in valve guide and check for binding. **If valve is damaged, cylinder head must be removed for repairs.**

#### Installation

1. If valve proves satisfactory, hold valve closed and turn on air pressure in cylinder.
2. Lubricate the valve stems with heavy engine oil. Install new valve stem seal. Set spring and retainer over valve stem. Compress valve spring and install retainer locks. Release spring and remove tool.
3. Shut off air pressure and remove air line and adapter. Install spark plug.
4. Apply Ford Polyethylene Grease D0AZ-19584-A to tip of valve stem and each end of push rod. Install push rod. **Be sure lower end of push rod is seated in valve lifter.**
5. Lubricate fulcrum seats and sockets with Ford Polyethylene Grease D0AZ-19584-A or equivalent.
6. Lubricate the push rod socket, fulcrum seat and the valve pad of the rocker arm with heavy engine oil.
7. Install the rocker arms and rocker arm covers using the procedure and sequence given under Rocker Arm Installation. If the right cover was removed, install PCV valve.
8. Install the spark plug and connect the spark plug wires.
9. Install the air cleaner and intake duct assembly.
10. Connect the automatic choke heat chamber air inlet hose.

## REMOVAL AND INSTALLATION (Continued)

### INTAKE MANIFOLD

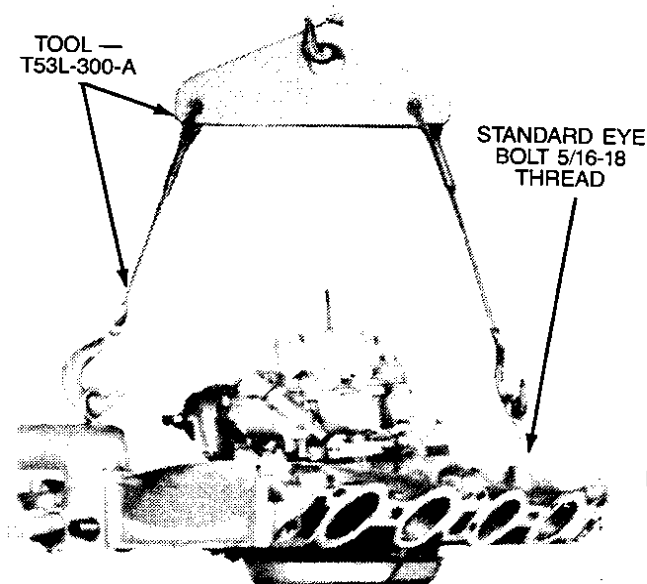
#### Removal

1. Drain cooling system. Remove air cleaner.
2. Disconnect radiator upper hose at engine.
3. Loosen water pump by-pass hose clamp at intake manifold.
4. Disconnect PCV valve and hose at right valve rocker arm cover.
5. Disconnect wires at spark plugs using Spark Plug Wire Remover T74P-6666-A or equivalent. Remove wires from brackets on valve rocker arm covers. Disconnect coil high tension lead at coil and remove distributor cap and wires as an assembly.
6. Disconnect distributor vacuum line at carburetor. Remove distributor and vacuum line as an assembly.
7. Disconnect throttle linkage at carburetor. Remove bolts holding throttle linkage bell crank, remove linkage springs, and position linkage out of way.
8. Disconnect fuel line at carburetor.
9. Disconnect wiring harness at coil battery terminal, engine temperature sending unit, oil pressure sending unit, and other connections as necessary. Disengage wiring harness from three clips at left valve rocker arm cover bolts, and position wiring harness out of way.
10. Remove coil and bracket assembly.
11. Remove attaching bolts and nuts and remove intake manifold and carburetor as an assembly. **If necessary to pry manifold away from cylinder heads, do not damage gasket sealing surfaces.**

12. Remove and discard intake manifold gaskets and seals.
13. If manifold is to be further disassembled, remove coolant outlet housing, gasket, and thermostat. Remove automatic choke heat tubes, carburetor, spacer, and gaskets. Remove engine temperature sending unit. Discard all gaskets.

Remove all gasket material from the machined surfaces of the manifold. Clean the manifold in a suitable solvent and dry it with compressed air.

Inspect the manifold for cracks, damaged gasket surfaces, or other defects that would make it unfit for further service. Replace all studs that are stripped or otherwise damaged. Remove all filings and foreign matter that may have entered the manifold as a result of repairs.



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## REMOVAL AND INSTALLATION (Continued)

### Installation

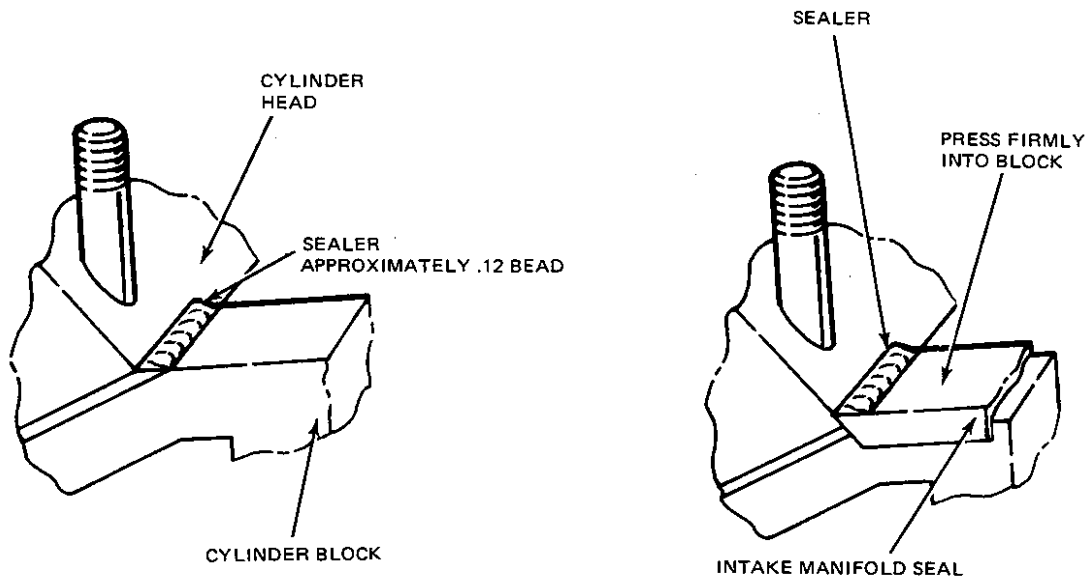
1. If intake manifold assembly was disassembled, install coolant outlet housing, new gasket, and thermostat. Install carburetor, spacer, new gaskets, automatic choke heat tubes. Coat threads with electrical conductive sealer and install water temperature sending unit.
2. Clean mating surfaces of intake manifold, cylinder heads, and cylinder block. Use a solvent such as Ford Spot Remover (B7A-19521-A) or similar degreasing agent.
3. Apply a 3.2mm (1/8 inch) diameter bead of silicone rubber sealer (D6AZ-19526-A or equivalent) in and along the joint, the full width of the cylinder block seal mounting surface (4 corners).
4. Install the cylinder head to manifold gaskets and the front and rear intake manifold to cylinder block seals. Apply a 1.6mm (1/16 inch) bead of sealer at the outer end of each intake manifold seal for the full width of the seal.

**NOTE: This sealer sets up within 15 minutes after application, so assembly should proceed promptly.**

5. Carefully lower intake manifold into position over four studs in ends of cylinder heads. **When intake manifold is in place, run finger around seal area to be sure seals are**

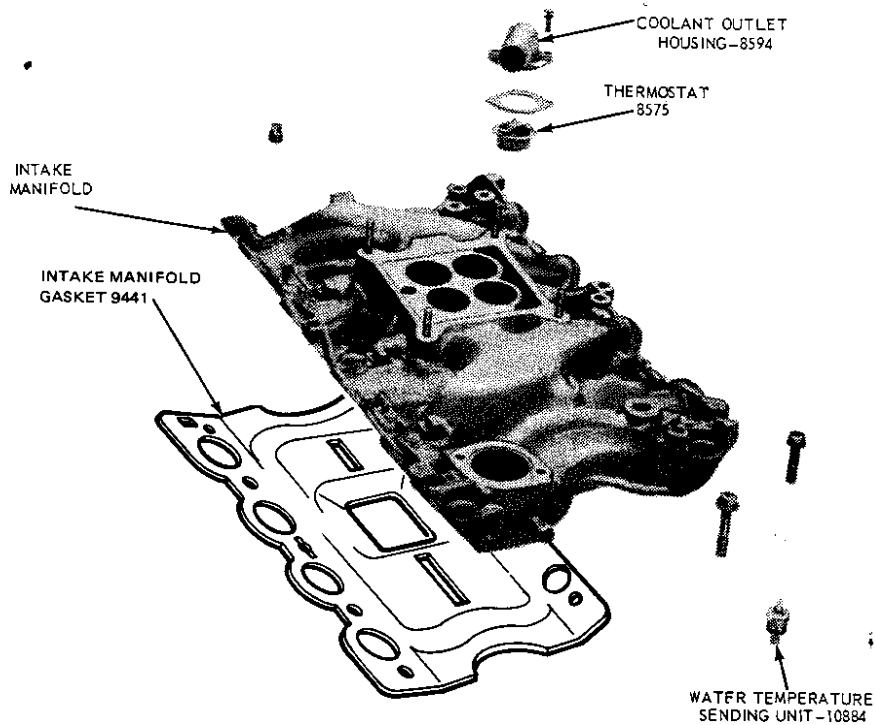
**in place. If seals have shifted, remove manifold and reposition seals.**

6. Be sure intake manifold gaskets are properly aligned. Then install attaching bolts and nuts snugly to manifold. Tighten bolts and nuts in sequence to specifications to compress gaskets and seals. Then repeat sequence, tightening bolts and nuts to same specifications.
7. Install water pump by-pass hose to intake manifold fitting.
8. Connect radiator upper hose to coolant outlet housing.
9. Rotate crankshaft damper until No. 1 piston is at TDC at end of compression stroke. Position distributor in block with rotor at No. 1 firing position and points open. Install hold down clamp.
10. Connect PCV valve and hose to right valve rocker arm cover.
11. Connect fuel line to carburetor.
12. Install coil and bracket assembly to intake manifold.
13. Fit wiring harness into clips at inboard edge of left valve rocker arm cover and connect to all terminals.
14. Position throttle linkage on manifold. Attach throttle linkage bell crank. Install linkage springs and connect linkage to carburetor.

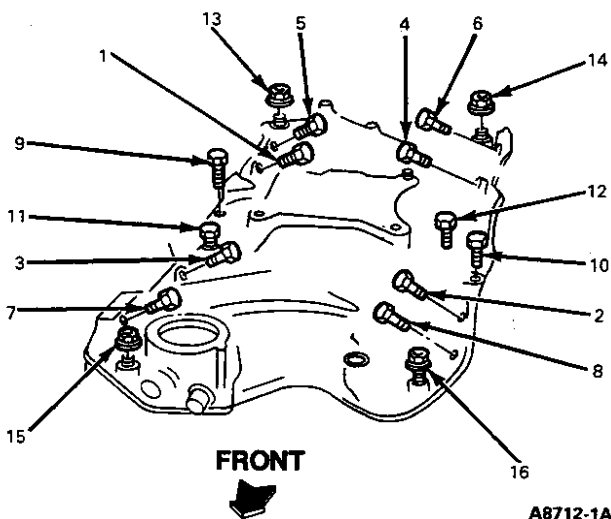


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## REMOVAL AND INSTALLATION (Continued)



A2944-E



15. Secure distributor cap to distributor. Connect spark plug wires to spark plugs and fit wires into brackets on valve rocker arm covers. Connect coil high tension lead to coil.
16. Fill the cooling system.
17. Start engine. Check and adjust ignition timing. Connect distributor vacuum line.
18. Operate engine at fast idle and check for coolant leaks. Re-check coolant level and refill as necessary.
19. Allow engine to reach normal operating temperature, then re-tighten the manifold attaching nuts and bolts to specifications.
20. Check and adjust carburetor idle speed and mixture as required. Install air cleaner and intake duct assembly.

## REMOVAL AND INSTALLATION (Continued)

### VALVE TAPPET

The following procedure is applicable for removing one or all of the valve tappets. Before replacing a hydraulic valve tappet for noisy operation, be sure the noise is not caused by improper valve clearance or by worn rocker arms and/or push rods.

#### Removal

1. Remove intake manifold and carburetor as an assembly, following instructions under Intake Manifold.
2. Remove the valve rocker arm covers. Loosen the rocker arm bolts and turn rocker arms to one side.
3. Remove the push rods in sequence.
4. Remove the valve tappets with a magnet. Place them in a rack in sequence. If the tappets are stuck in bores, use plier-type tool T70L-6500-A to remove them. Rotate tappet back and forth to loosen them from gum or varnish deposits. Refer to cleaning, inspection and testing procedures earlier in this section.

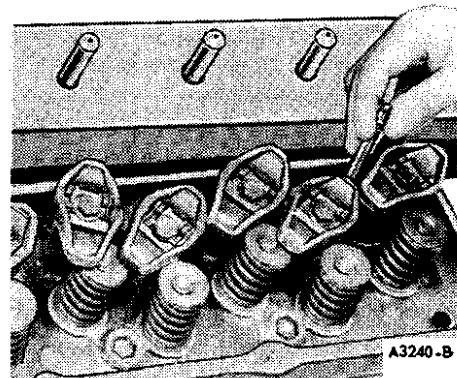
#### Installation

1. Clean the outside of valve tappets. Tappets and bores are to be lubricated with heavy engine oil before installation. Install the tappets in their original bores. Check any new tappet for free fit in bore to which it is to be installed.
2. Install push rods in original positions. Apply Ford Polyethylene grease D0AZ-19584-A or equivalent to valve stem tips and push rod ends.
3. Position the rocker arms over the push rods and tighten the bolts following the procedure under Valve Rocker Arm Installation.
4. Install rocker arm covers following procedure under Rocker Arm and Cover Installation.
5. Install intake manifold and carburetor, following the instructions under Intake Manifold.

### CYLINDER HEADS

#### Removal

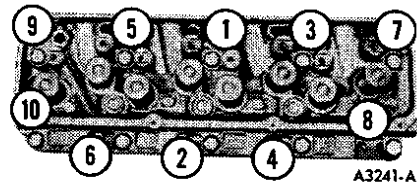
1. Remove intake manifold and carburetor as an assembly, following procedure under Intake Manifold Removal.
2. Loosen alternator attaching bolts and remove bolt attaching alternator bracket to right cylinder head.
3. Remove valve rocker arm covers. Remove rocker arm bolts, rocker arms, oil deflectors, fulcrums and push rods in sequence so they can be installed in their original positions.
4. Remove cylinder head attaching bolts. Lift cylinder heads and exhaust manifolds as assemblies from cylinder block with a hoist. **If necessary to loosen cylinder head gasket seal, pry at forward corners of cylinder heads against casting bosses provided on cylinder block. Do not damage machined surfaces of head or block. Discard cylinder head gasket.**
5. If disassembly or machining of cylinder head is required, remove exhaust manifold.



## REMOVAL AND INSTALLATION (Continued)

### Installation

1. Clean cylinder head, intake manifold, valve rocker arm cover, and cylinder block gasket surfaces. If cylinder head was removed for cylinder head gasket replacement, check flatness of cylinder head and block gasket surfaces. If exhaust manifold was removed, coat cylinder head and manifold port areas with film of graphite grease and install manifold and gasket to cylinder head.
2. Position new cylinder head gaskets on block over dowels. Do not apply sealer to head gasket surfaces. Place cylinder heads on block and install attaching bolts (longer bolts in lower row of bolt holes). Tighten all cylinder head attaching bolts in sequence in three steps to specifications. **When this procedure is used, it is not necessary to re-tighten bolts after extended operation.**
3. Clean and inspect push rods, one at a time. Clean the oil passage in the push rods with a suitable solvent, and blow out with compressed air.
4. Install push rods in original positions. Apply Ford Polyethylene grease D0AZ-19584-A or equivalent to valve stem tips and push rod ends.
5. Lubricate and install the rocker arms following the procedure under Valve Rocker Arm Installation. **Be sure lower ends of push rods remain seated in valve lifters.**
6. Install intake manifold and carburetor assembly, following procedure under Intake Manifold Installation.
7. Perform valve clearance adjustment, as detailed under Valve Clearance Adjustment, only if necessary.
8. Apply oil-resistant sealer to one side of new valve rocker arm cover gaskets. Lay cemented side of gaskets in place in covers. Install covers.
9. Install bolt attaching alternator bracket to right cylinder head. Adjust alternator drive belt tension to specifications and tighten alternator attaching bolts.
10. Fill cooling system as necessary.
11. Start engine and check for leaks.
12. Check and adjust carburetor idle speed and mixture as required.



## EXHAUST MANIFOLD

### Removal

1. Remove attaching bolts and washers, and remove exhaust manifold(s), lifting bracket(s) and spark plug wire heat shields.

Inspect the cylinder head joining flanges of the exhaust manifold(s) for evidence of exhaust gas leaks.

Inspect the manifold(s) for cracks, damaged gasket surfaces, or other defects that would make them unfit for further service.

### Installation

1. Clean mating surfaces of exhaust manifold(s) and cylinder head(s). Apply light film of graphite grease to exhaust manifold(s).
2. Position spark plug wire heat shields and exhaust manifold(s) on cylinder heads. Install attaching bolts and washers, starting at fourth bolt hole from front of each manifold. Position lifting bracket under bolts at third exhaust port from front of engine. Tighten bolts to specifications, working from center of manifold to both ends.
3. Place new gasket(s) on inlet pipe(s). Position inlet pipe(s) to manifold(s). Install attaching nuts and tighten to specifications.
4. Start engine and check for exhaust leaks.

## REMOVAL AND INSTALLATION (Continued)

### WATER PUMP

#### Removal

1. Drain cooling system.
2. Remove bolts attaching fan assembly to water pump and remove fan.
3. Loosen the alternator pivot bolt. Remove the two attaching bolts and spacer. Remove the belt, then rotate the bracket out of the way.
4. Disconnect the lower hose.
5. Loosen the by-pass hose clamp at the pump.
6. Remove remaining water pump attaching bolts and remove water pump from cylinder front cover. Remove separator plate from water pump. Discard gaskets.

#### Installation

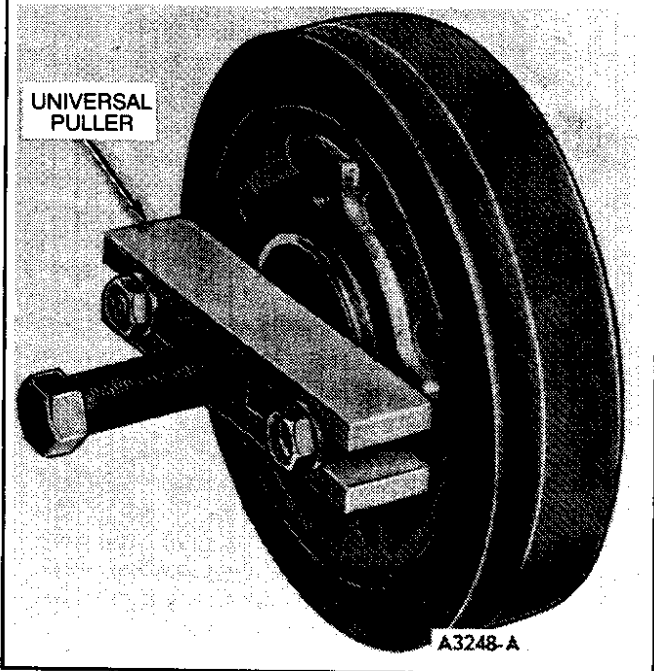
1. Remove any gasket material from water pump, cylinder front cover and separator plate mating surfaces.
2. Position new gaskets coated on both sides with water-resistant sealer.
3. Position water pump on cylinder front cover and install only those bolts not used to attach alternator bracket to water pump. Tighten bolts to specifications.
4. Connect lower hose and by-pass hose to water pump.
5. Place the water pump pulley on the pump.
6. Lower the fan into position. Install the fan attaching bolts and the shroud attaching bolts. Tighten the bolts to specifications.
7. Rotate the alternator bracket into position and install the two attaching bolts and spacer. Adjust the belt tension and tighten the attaching bolts to specification.
8. Fill the cooling system.
9. Start the engine and check for leaks.

### CYLINDER FRONT COVER AND TIMING CHAIN

#### Removal

**Cylinder front cover oil seal replacement is recommended whenever the cover has been removed.**

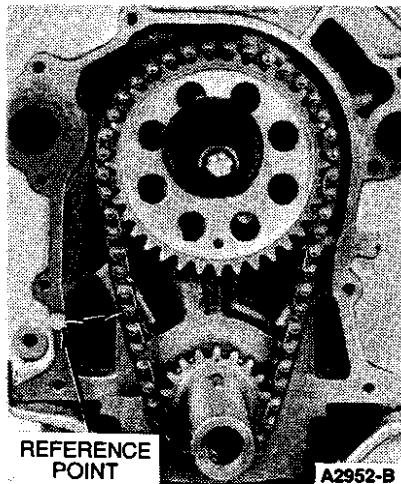
1. Drain cooling system and crankcase.
2. Remove bolts attaching fan to water pump shaft. Remove fan.
3. Disconnect upper and lower hoses at engine.
4. Remove radiator.
5. Loosen alternator attaching bolts to relieve tension on drive belt. Remove drive belts with water pump pulley.
6. Remove the crankshaft pulley from the vibration damper.
7. Remove bolt and washer attaching crankshaft damper. Remove crankshaft damper with a puller. Remove spacer. Remove Woodruff key from crankshaft.



## REMOVAL AND INSTALLATION (Continued)

8. Loosen by-pass hose at water pump.
9. Disconnect and plug fuel inlet line at fuel pump. Disconnect fuel line to carburetor at fuel pump. Remove fuel pump.
10. Remove bolts attaching cylinder front cover to cylinder block. Using a thin-bladed knife, cut the oil pan seal flush with cylinder block face prior to separating the cover from the cylinder block. Remove cylinder front cover and water pump as an assembly. Discard cylinder front cover gasket and oil pan seal.
11. If new cylinder front cover is to be installed, remove water pump and install it and a new gasket on the new front cover.
12. Check timing chain deflection by rotating the crankshaft in a counterclockwise direction to take up the slack on the left side of the chain. (All directions are as viewed from the front of the engine.)

Establish a reference point on the block and measure from this point to the left side of the chain.



Rotate the crankshaft in the opposite direction to take up the slack on the right side of the chain. Force the left side of the chain out with the fingers and measure the distance between the reference point and the chain. The deflection is the difference between the two measurements.

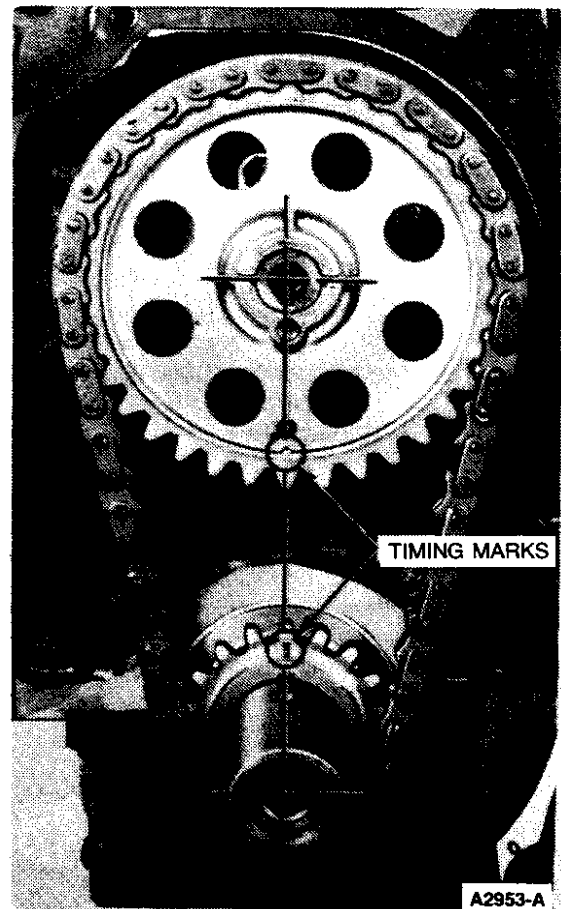
If the deflection exceeds specifications, replace the timing chain and sprockets.

13. If the timing chain and sprocket are to be removed, crank the engine until timing marks are aligned.
14. Remove camshaft sprocket cap bolt, washer, two-piece fuel pump eccentric and front oil slinger. Slide timing chain and sprockets forward, and remove as an assembly.

Refer to Page 1-15 for cleaning and inspection procedures.

### Installation

1. Assemble the timing chain and sprockets so sprocket timing marks point directly toward each other. Install the chain and sprockets as an assembly to crankshaft and camshaft. Verify proper alignment of timing marks after installation. Install front oil slinger.
2. Install the fuel pump eccentric, camshaft sprocket cap bolt and washer. Tighten cap screw to specifications. Lubricate timing chain with engine oil.
3. Coat the gasket surface of the oil pan with sealer. Cut and position the required sections of a new seal on the oil pan. Apply sealer at the corners.
4. Coat the gasket surfaces of the block and cover with sealer, and position a new gasket on the block.
5. Position the cylinder front cover on the cylinder block. Use care when installing the cover to avoid seal damage or possible mislocation.

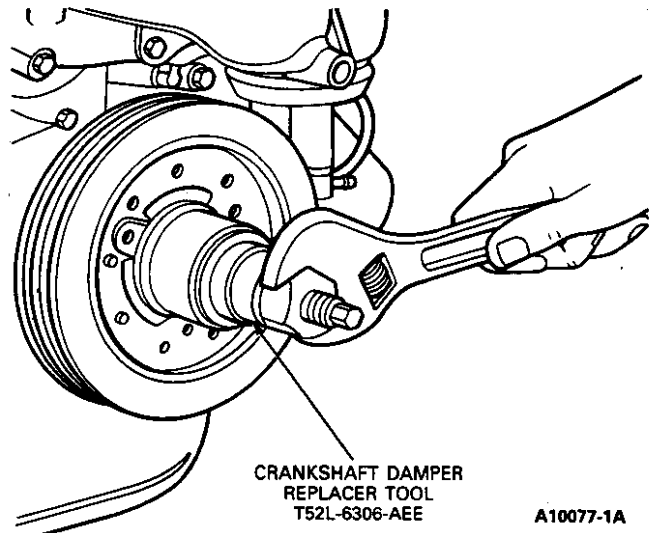
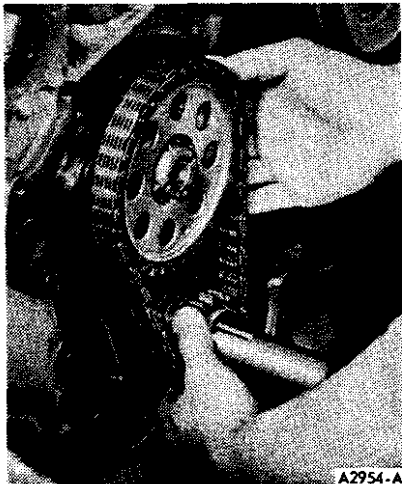
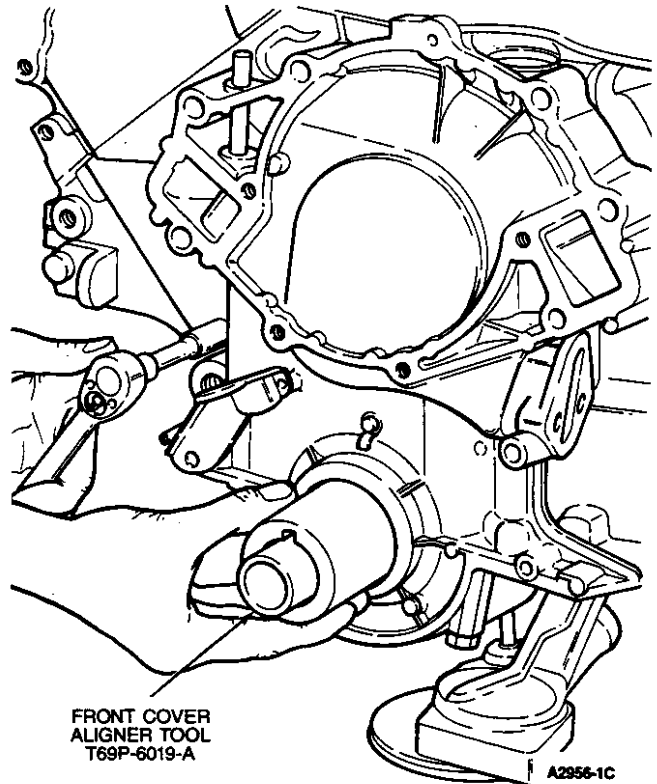


## REMOVAL AND INSTALLATION (Continued)

6. Install the cylinder front cover to seal alignment tool into proper position. It may be necessary to force the cover downward in a manner to slightly compress the pan seal. This operation can be facilitated by using a suitable tool at the attaching bolt hole locations.
7. Coat the threads of the attaching bolts with oil-resistant sealer and install the screws.
8. While pushing in on the alignment tool, tighten the oil pan to cover attaching bolts to specifications. Remove alignment tool. Tighten the cover to cylinder block attaching screws.
9. Apply white lead and oil mixture to front of crankshaft for damper installation.
10. Position crankshaft damper Woodruff key and install crankshaft spacer and damper. Install damper attaching screws and washer. Tighten to specification.
11. Install the crankshaft pulley.
12. Coat new fuel pump gasket with oil-resistant sealer and place on fuel pump. Install fuel pump. Connect fuel lines to fuel pump.
13. Install water pump pulley and all drive belts.
14. Position radiator and install attaching bolts. Connect radiator upper and lower hoses at engine. Connect oil cooler lines.
15. Position the fan on the water pump and install and tighten the attaching bolts.
16. Adjust belt tension to specifications. Tighten alternator attaching bolts.
17. If any of the coolant entered the oil pan when separating the cylinder front cover from the block, the crankcase should be

drained and refilled with the proper grade and quantity of engine oil before starting the engine.

18. Fill and bleed the cooling system. Fill the crankcase to the correct level with the recommended oil.
19. Run engine at fast idle and check for coolant and oil leaks. Adjust ignition timing and curb idle speed to specifications.



## REMOVAL AND INSTALLATION (Continued)

### FRONT OIL SEAL

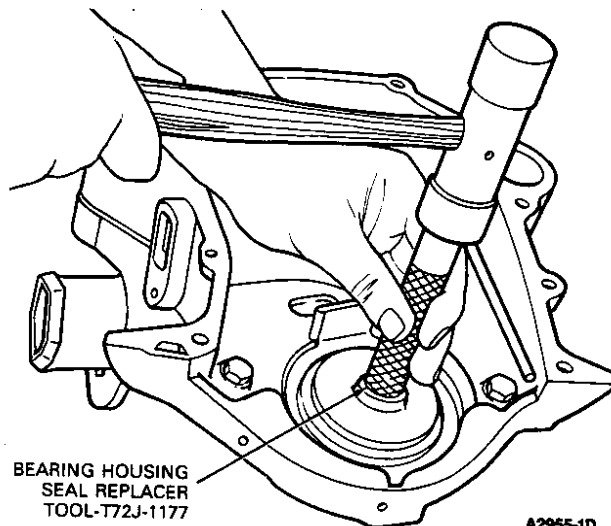
#### Removal

Replacement of the front oil seal is recommended whenever the cylinder front cover is removed.

1. Drive out the old seal with a pin punch. Clean the seal recess in the cylinder front cover.

#### Installation

1. Coat a new seal with grease. Install the seal with Tool T72J-1177. After installation, be sure seal spring remains in proper position.



A2955-1D

### CAMSHAFT

The exploded view shows the camshaft and related parts.

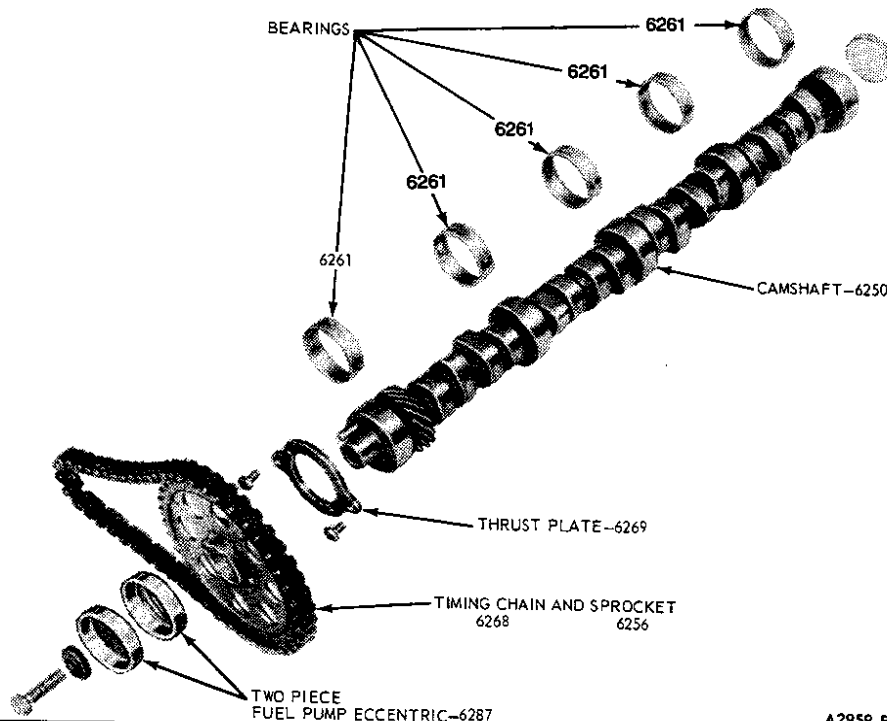
#### Removal

1. Remove timing chain and sprockets, following procedure under Cylinder Front Cover and Timing Chain. Check timing chain deflection before removal.
2. Remove the intake manifold and carburetor as an assembly, following the instructions under Intake Manifold.
3. Remove valve rocker arm covers. Back off all rocker arm bolts, turn rocker arms side-

ways, and remove the push rods in sequence.

4. Remove the valve tappets with a magnet and place them in a rack in sequence. If the tappets are stuck in bores, use plier-type Tool (T52T-6500-DJD or 6500-D) to remove them. Rotate the tappet back and forth to loosen it from gum or varnish deposits.
5. Remove the camshaft thrust plate attaching bolts, and carefully remove the camshaft from the front of engine. **Do not damage the camshaft bearings.**

Refer to Page 1-15 for cleaning and inspection procedures.



A2959-B

## REMOVAL AND INSTALLATION (Continued)

### Installation

1. Oil the camshaft journals and apply Ford Polyethylene grease D0AZ-19584-A or equivalent to the cam lobes. Carefully slide the camshaft into position.
  2. Install camshaft thrust plate. Check camshaft end play. If end play is excessive, replace the camshaft thrust plate.
  3. Install timing chain, sprockets, oil slinger and cylinder front cover as detailed under Cylinder Front Cover and Timing Chain.
  4. Clean the tappets externally. Lubricate the tappets and tappet bores with engine oil before installing them. Lubricate the push rod ends with Ford Polyethylene grease D0AZ-19584-A or equivalent. Install the valve tappets and push rods in their original positions.
  5. Install intake manifold and carburetor, following the procedure under Intake Manifold.
  6. Rotate the crankshaft damper until No. 1 piston is at TDC at the end of compression stroke. Position the distributor in the block with the rotor at No. 1 firing position and points just starting to open. Install the hold down clamp.
  7. Apply Ford Polyethylene grease D0AZ-19584-A or equivalent to valve stem tips. Position rocker arms over push rods and tighten bolts following the procedure under Valve Rocker Arm Installation. Adjust valve clearance if necessary.
  8. Clean the valve rocker arm covers and cylinder head gasket surfaces. Apply oil-resistant sealer to one side of the new cover gaskets.
- Lay the cemented side of gaskets in place in the covers.
9. Position the covers on the cylinder heads and make sure that gaskets seat evenly. Install cover attaching bolts and tighten to specifications. Two minutes later, tighten bolts to same specifications.
  10. Connect the radiator upper hose.
  11. Connect the fuel line to the carburetor.
  12. Install the coil and bracket assembly to intake manifold.
  13. Install the throttle linkage.
  14. Engage engine wiring harness in clips on left cylinder head and connect all wire terminals. Connect PCV valve and hose to right valve rocker arm cover.
  15. Install the distributor cap and connect the coil and spark plug wires.
  16. Place the water pump pulley and drive belts in position. Position the fan assembly to water pump shaft and install and tighten the attaching screws to specification.
  17. Adjust the tension of drive belts to specifications and tighten attaching screws.
  18. Fill and bleed the cooling system. Run engine at fast idle and check for leaks.
  19. Adjust the ignition timing and connect distributor vacuum line.
  20. Check and adjust the carburetor idle speed and mixture as required after engine temperature has stabilized. Adjust transmission linkage, if necessary. Install the air cleaner and intake duct.

### CORE PLUGS

#### Removal

To remove a large core plug, drill a 12.70mm (1/2-inch) hole in the center of the plug and remove with an impact Slide Hammer T59L-100-B, T50T-100-A or equivalent, or pry it out with a large drift punch. On a small core plug, drill a 6.35mm (1/4-inch) hole in the center of the plug and pry it out with a small pin punch. Clean and inspect the plug bore.

Prior to installing a core plug the plug bore should be inspected for any damage that would

interfere with the proper sealing of the plug. If the bore is damaged it will be necessary to true the surface by boring for the next specified oversize plug.

Oversize (OS) plugs are identified by the OS stamped in the flat located on the cup side of the plug.

Coat the plug and/or bore lightly with an oil-resistant (oil galley) or water-resistant (cooling jacket) sealer and install it following the procedure for cup type or expansion type below:

## REMOVAL AND INSTALLATION (Continued)

### Installation

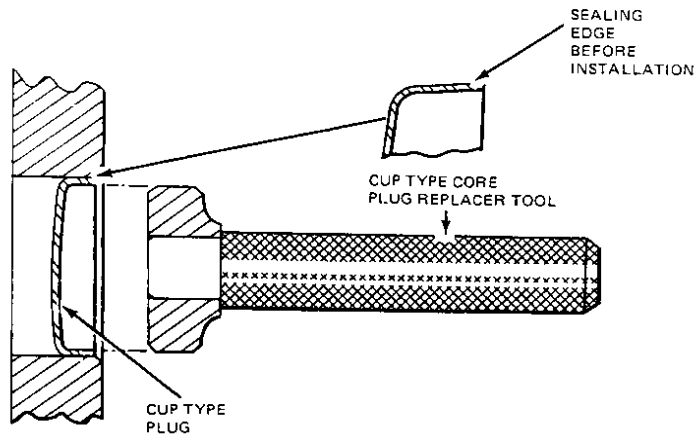
#### Cup Type

Cup-type core plugs are installed with the flanged edge outward. The maximum diameter of this plug is located at the outer edge of the flange. The flange on cup-type plugs flares outward with the largest diameter at the outer (sealing) edge.

**It is imperative to pull the plug into the machined bore by using a properly designed tool.** Under no circumstances is the plug to be driven into the bore using a tool that contacts the flange. This method will damage the sealing edge and will result in leakage and/or plug blow out.

The flanged (trailing) edge must be below the chamfered edge of the bore to effectively seal the plugged bore.

**If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.**



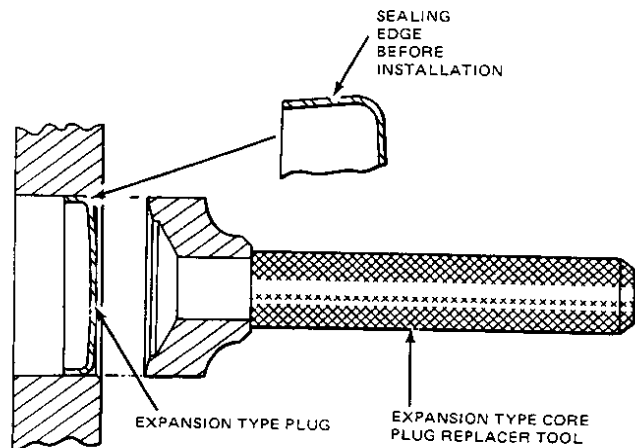
#### Expansion-Type

Expansion-type core plugs are installed with the flanged edge inward. The maximum diameter of this plug is located at the base of the flange with the flange flaring inward.

**It is imperative to push or drive the plug into the machined bore using a properly designed tool.** Under no circumstances is the plug to be driven using a tool that contacts the crowned portion of the plug. This method will expand the plug prior to installation and may damage the plug and/or plug bore.

When installed the trailing (maximum) diameter must be below the chamfered edge of the bore to effectively seal the plugged bore.

**If the core plug replacing tool has a depth seating surface, do not seat the tool against a non-machined (casting) surface.**



## REMOVAL AND INSTALLATION (Continued)

### OIL PAN

#### Removal

1. Disconnect the battery ground cable.
2. Drain the crankcase.
3. Remove the oil filter.
4. Remove the oil pan attaching bolts and remove the pan. It may be necessary to rotate the crankshaft to provide clearance between the pan and crankshaft throws or counterweights.
5. Refer to cleaning and inspection procedures. Check the gasket surface for damage caused by over-tightened bolts. Straighten the surface as required to restore original flatness.

#### Installation

1. Clean the gasket surfaces of the block and oil pan. Coat the block surface and the oil

pan gasket surface with oil-resistant sealer. Position the oil pan gaskets on the cylinder block.

2. Position the oil pan front seal on the cylinder front cover. **Be sure that the tabs on the seal are over the oil pan gasket.**
3. Position the oil pan rear seal on the rear main bearing cap. **Be sure that the tabs on the seal are over the oil pan gasket.**
4. Hold the oil pan in place against the block and install a bolt, finger tight, on each side of the oil pan. Install the remaining bolts. Tighten the bolts from the center outward in each direction to specifications.
5. Install a new oil filter.
6. Connect the battery ground cable.
7. Fill the crankcase. Start the engine and check for leaks.

### OIL PUMP

#### Removal

1. Remove the oil pan following the procedure under Oil Pan Removal.
2. Remove the oil pump mounting bolts and remove the pump from the cylinder block.

#### Installation

1. Prime the oil pump by filling the inlet port with engine oil. Rotate the pump shaft to distribute oil within the pump body.
2. Install the distributor intermediate shaft in the oil pump rotor shaft.

3. Insert the intermediate shaft into the distributor shaft hex bore. Make certain that the intermediate shaft is properly seated. Do not force the pump into position if it will not seat readily. The intermediate shaft hex may be misaligned with distributor shaft. To align, rotate the intermediate shaft until it can be seated. Secure the oil pump to cylinder block and tighten the screws to specifications.
4. Install the oil pan and related parts following procedure under Oil Pan Installation.

### CRANKSHAFT REAR OIL SEAL

A split-lip type crankshaft rear oil seal is provided for servicing 460 engines. The complete seal is replaced without removing the crankshaft.

#### Removal

1. Remove the oil pan and the oil pump (if required).
2. Loosen all the main bearing cap bolts, thereby lowering the crankshaft slightly but not to exceed 1/32 inch.

3. Remove the rear main bearing cap, and remove the oil seal from the bearing cap and cylinder block. On the block half of the seal use a seal removal tool, or install a small metal screw in one end of the seal, and pull on the screw to remove the seal. **Exercise caution to prevent scratching or damaging the crankshaft seal surfaces.**
4. Remove the oil seal retaining pin from the bearing cap if so equipped. **The pin is not used with the split-lip seal.**

## REMOVAL AND INSTALLATION (Continued)

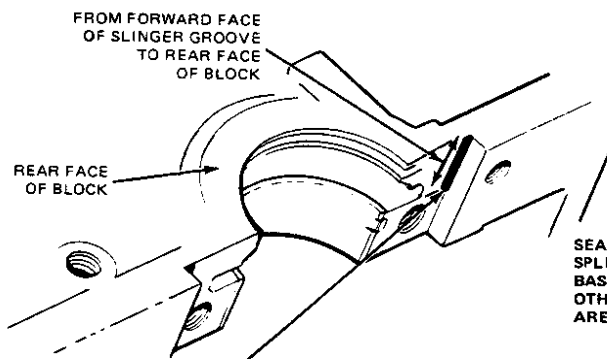
### Installation

1. Carefully clean the seal groove in the cap and block with a brush and solvent.
2. Dip the split lip-type seal halves in clean engine oil.
3. Carefully install the upper seal (cylinder block) into its groove with undercut side of seal toward the FRONT of the engine, by rotating it on the seal journal of the crankshaft until approximately 1/8 inch protrudes below the parting surface.

**Be sure no rubber has been shaved from the outside diameter of the seal by the bottom edge of the groove. Do not allow oil to get on the sealer area.**

4. Tighten the remaining bearing cap bolts and torque to specifications.

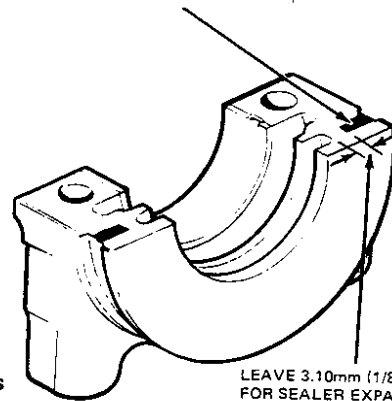
5. Install the lower seal in the rear main bearing cap with undercut side of seal toward the FRONT of the engine, allowing the seal to protrude approximately 1/8 inch above the parting surface to mate with the upper seal when the cap is installed.
6. Apply an even 1.588mm (1/16 inch) bead of RTV Silicone Rubber Sealer D6AZ-19562-B or equivalent, to the areas shown, following the procedure given in the illustration. **Do not apply sealer to the area forward of the side seal groove. Install the rear main bearing cap. Torque the cap bolts to specifications.**
7. Install the oil pump and oil pan. Fill the crankcase with the proper amount and viscosity oil.
8. Operate the engine and check for oil leaks.



APPLY 1.58mm (1/16 IN) DIA. BEAD OF D6AZ-19562-A (OR B) SEALER IN SHADED AREA OF CYLINDER BLOCK PRIOR TO ASSEMBLY OF BEARING CAP—(BOTH SIDES)  
DO NOT PERMIT SEALER TO GET ON I.D. OF SPLIT LIP SEAL

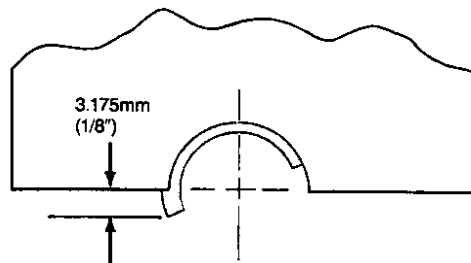
**NOTE: WHEN APPLYING RUBBER SILICONE ALWAYS USE THE BEAD SIZE SPECIFIED AND JOIN THE COMPONENTS WITHIN 15 MINUTES OF APPLICATION. AFTER THIS AMOUNT OF TIME THE SEALANT BEGINS TO "SET UP" AND ITS SEALING EFFECTIVENESS MAY BE REDUCED.**

APPLY 1.58mm (1/16 IN) DIA. BEAD OF D6AZ-19562-A (OR B) SEALER AS INDICATED ON BEARING CAP (BOTH SIDES)

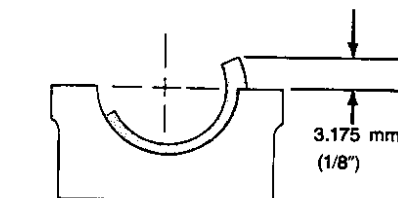


LEAVE 3.10mm (1/8 IN) GAP FOR SEALER EXPANSION

A3724-2F



SEAL HALVES TO PROTRUDE BEYOND PARTING FACES THIS DISTANCE TO ALLOW FOR CAP TO BLOCK ALIGNMENT



REAR FACE OF REAR MAIN BEARING CAP AND CYLINDER BLOCK

VIEW LOOKING AT PARTING FACE OF SPLIT, LIP-TYPE CRANKSHAFT SEAL

INSTALL SEAL WITH LIP TOWARDS FRONT OF ENGINE

FRONT OF ENGINE



A2639-C

## REMOVAL AND INSTALLATION (Continued)

### MAIN BEARINGS

Main and connecting rod bearing inserts are selective fits.

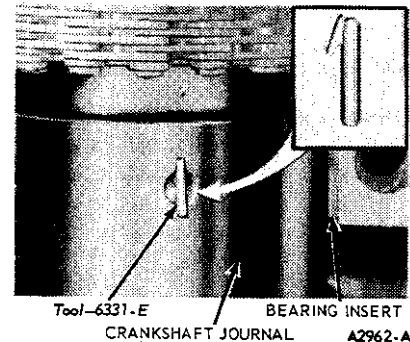
Selective fit bearings are available for service in standard size, 0.001 and 0.002 inch under-size. Undersize bearings (0.010, 0.020 and 0.030 inch), which are not selective fit, are available for use on crankshaft journals that have been refinished.

#### Removal

1. Drain the crankcase. Remove the oil level dipstick. Remove the oil pan and related parts, following the procedure under Oil Pan Removal.
2. Remove the oil pump.
3. Replace one bearing at a time, leaving the other bearings securely fastened. Remove the main bearing cap to which new bearings are to be installed.
4. Insert the upper bearing removal tool (Tool 6331-E) in the oil hole in the crankshaft.
5. Rotate the crankshaft in the direction of engine rotation to force the bearing out of the block.
6. Clean the crankshaft journals. Inspect journals and thrust faces (thrust bearing) for nicks, burrs or bearing pickup that would cause premature bearing wear.

#### Installation

1. To install upper main bearing, place plain end of bearing over shaft on locking tang side of block and partially install bearing so Tool 6331-E can be inserted in oil hole in crankshaft. With Tool 6331-E in oil hole, rotate the crankshaft in the opposite direction of engine rotation until the bearing seats itself. Remove the tool.



A2962-A

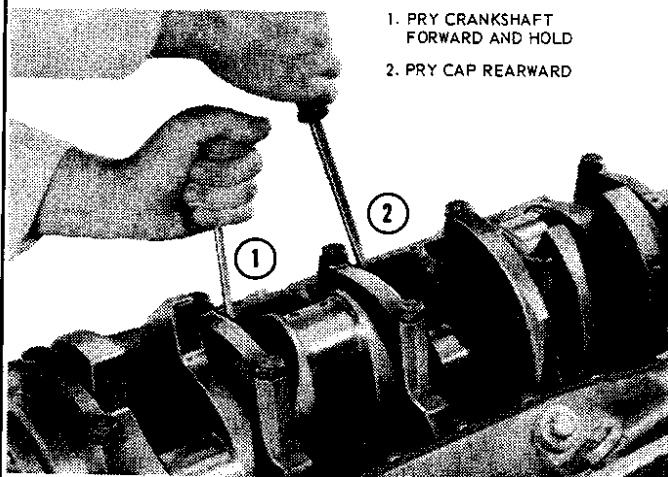
## REMOVAL AND INSTALLATION (Continued)

2. Fit the main bearings as detailed on Page 1-23 under Fitting Bearings with Plastigage.
3. After the bearing has been fitted, apply light coat of engine oil to journal and bearings. Install the bearing cap. Tighten the cap bolts to specifications.
4. Repeat the procedure for remaining bearings that require replacement.
5. If the rear main bearing is to be replaced, remove the rear main bearing cap. Remove and discard the rear oil seal.
6. Clean rear journal oil seal groove and mating surfaces of block and rear main bearing cap.
7. Install the new seal.
8. Seal the rear main bearing cap. After sealing, install the rear main bearing cap and tighten cap bolts to specifications.

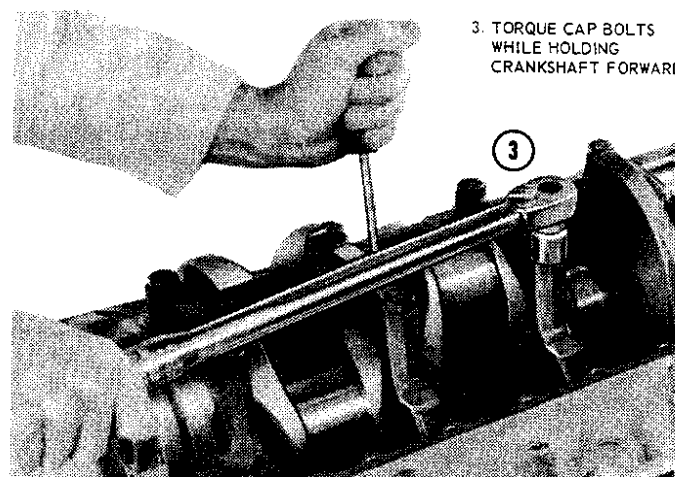
9. If the thrust bearing cap (No. 3 main bearing) has been removed, install it as follows:

Install the thrust bearing cap with the bolts finger-tight. Pry the crankshaft forward against the thrust surface of the upper half of bearing. Hold the crankshaft forward and pry thrust bearing cap to rear. This aligns thrust surfaces of both halves of bearing. Retain forward pressure on crankshaft. Tighten cap bolts to specifications.

10. Clean the oil pump inlet tube screen. Prime the oil pump by filling the inlet opening with oil and rotating the pump shaft until oil emerges from the outlet opening. Install the oil pump.
11. Install the oil pan following procedure under Oil Pan Installation.
12. Fill the crankcase. Start the engine and check for oil pressure. Operate the engine at fast idle and check for oil leaks.



1. PRY CRANKSHAFT FORWARD AND HOLD
2. PRY CAP REARWARD



3. TORQUE CAP BOLTS WHILE HOLDING CRANKSHAFT FORWARD

A2964-A

## CONNECTING ROD BEARING

### Removal

1. Follow steps 1 and 2 under Main Bearing Removal.
2. Turn the crankshaft until connecting rod to which new bearings are to be fitted is down. Remove the connecting rod cap. Remove the bearing inserts from rod and cap.
3. Be sure the bearing inserts and bearing bore in connecting rod and cap are clean. Foreign material under inserts will distort bearing and cause a failure.
4. Clean the crankshaft journal. When replacing standard bearings with new bearings, it is good practice to fit the bearing to minimum specified clearance.

## REMOVAL AND INSTALLATION (Continued)

### Installation

1. Fit connecting rod bearings as detailed on Page 1-23 under Fitting Bearings with Plastigage.
2. Install the bearing inserts in the connecting rod and cap with tangs in the slots provided.
3. Apply a light coat of engine oil to the journal and bearings. Pull the connecting rod assembly down firmly on the crankshaft journal.

4. Install the connecting rod cap. Be sure the connecting rod bolt heads are properly seated in the connecting rod. Tighten the nuts to specifications.
5. Repeat the procedure for the remaining connecting rods that require new bearings.
6. To complete installation, follow instructions under Main Bearing Installation.

Refer to Page 1-17 for cleaning and inspection procedures.

## PISTONS AND CONNECTING RODS

### Removal

1. Drain the cooling system and crankcase. Remove the intake manifold, cylinder heads, oil pan and oil pump, following procedures in this section.
2. Remove any ridge and/or deposits from upper end of cylinder bores as follows:

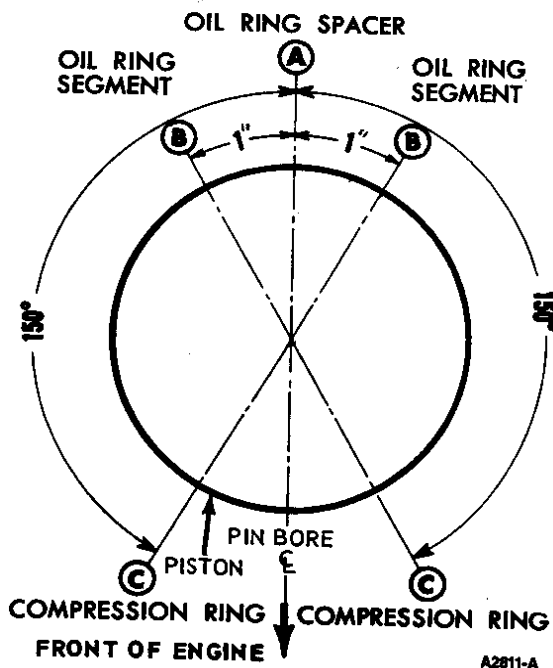
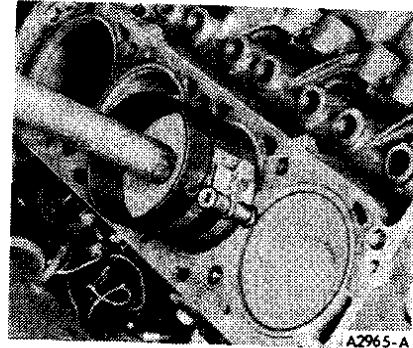
Turn the crankshaft until the piston to be removed is at bottom of its travel. Place a cloth on top of the piston to collect cuttings. Remove any ridge and/or deposits from the upper end of the cylinder bore. Remove the cylinder ridge with a ridge cutter. Follow instructions furnished by tool manufacturer. **Never cut into ring travel area in excess of 1/32 inch when removing ridges.** Repeat the procedure at the remaining cylinders.

3. Make sure that all connecting rod caps are marked so they can be installed in their original positions.
4. Turn the crankshaft until the connecting rod being removed is down.
5. Remove the connecting rod nuts and cap.
6. Push the connecting rod and piston assembly out through the top of the cylinder with the handle end of a hammer. **Avoid damage to the crankshaft journal and cylinder wall when removing the piston and rod.**
7. Remove the bearing inserts from the connecting rod and cap.
8. Install the cap on the connecting rod from which it was removed.

## REMOVAL AND INSTALLATION (Continued)

### Installation

1. If new piston rings are to be installed, remove the cylinder wall glaze. Follow instructions as detailed on Page 1-25.
2. Oil the piston rings, pistons and cylinder walls with light engine oil. **Be sure to install pistons in the same cylinders from which they were removed or to which they were fitted. Connecting rods and bearing caps are numbered from 1 to 4 in the right bank, and 5 to 8 in the left bank, beginning at the front of the engine. Numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one block or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number.**
3. Make sure that ring gaps are properly spaced around circumference of piston.
4. Install piston ring compressor on piston and push in with hammer handle until it is slightly below top of cylinder. Be sure to guide connecting rods while tapping them into position to avoid damaging crankshaft journals. **Install piston with indentation notch in piston head toward front of engine.**
5. Check clearance of each bearing, following procedure under Fitting Connecting Rod Bearings.



6. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings.
7. Turn the crankshaft throw to the bottom of the stroke. Push the piston all the way down until the connecting rod bearing seats on the crankshaft journal.
8. Install the connecting rod cap. Be sure connecting rod bolt heads are properly seated in the connecting rod. Tighten the nuts to specifications.
9. After the piston and connecting rod assemblies have been installed, check the side clearance between the connecting rods on each crankshaft journal.
10. Disassemble, clean and assemble the oil pump. Clean the oil pump inlet tube screen, and oil pan and the block gasket surfaces.
11. Prime the oil pump by filling the inlet port with engine oil and rotating the pump shaft to distribute oil within the housing. Install the oil pump. Install the oil pan, following the procedure under Oil Pan Installation.
12. Install the cylinder heads, following instructions under Cylinder Head Installation.
13. Install the intake manifold, following instructions under Intake Manifold Installation.
14. Fill and bleed the cooling system. Fill the crankcase to the correct level with the specified engine oil.
15. Start the engine and adjust the ignition timing. Connect the distributor vacuum line.
16. Operate the engine at fast idle and check for oil and coolant leaks. With the engine temperatures stabilized, adjust the engine curb idle speed and mixture.
17. Install the air cleaner.

## REMOVAL AND INSTALLATION (Continued)

### CRANKSHAFT

To perform the following operation, it is necessary to install the engine on a work stand.

The exploded view shows the crankshaft and related parts.

#### Removal

1. Disconnect the wires from the spark plugs. Remove the spark plugs to allow easy rotation of crankshaft.
2. Remove the fuel pump and the oil filter. Slide water pump by-pass hose clamp toward the water pump.
3. Remove the crankshaft pulley from the vibration damper.
4. Remove the bolt and washer from the end of the crankshaft. Install a puller on the crankshaft vibration damper and remove damper and spacer. Remove Woodruff key.
5. Remove the cylinder front cover and water pump as an assembly. Check the timing chain deflection. Remove the timing chain sprockets and key.
6. Invert the engine on a work stand. Remove the flywheel and the engine rear cover plate. Remove the oil pan and gasket. Remove the oil pump.
7. Make sure that all bearing caps (main and connecting rod) are marked so they can be installed in their original locations.

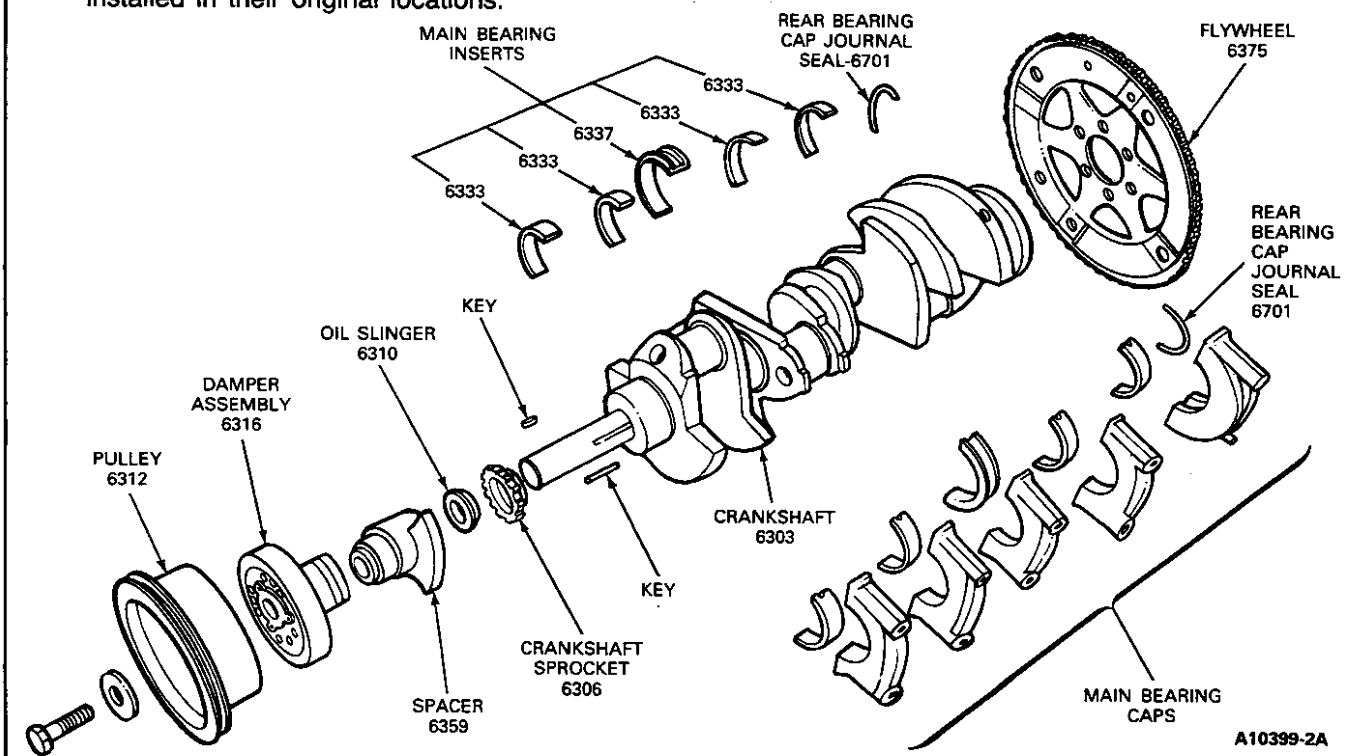
Turn the crankshaft until the connecting rod from which the cap is being removed is down, then remove the bearing cap. Push the connecting rod and piston assembly up into the cylinder. Repeat this procedure until all connecting rod bearing caps are removed.

8. Remove the main bearing caps.
9. Carefully lift the crankshaft out of the block so thrust bearing surfaces are not damaged. **Handle the crankshaft with care to avoid possible fracture or damage to finished surfaces.**

Refer to Page 1-16 for cleaning and inspection procedures. Clean the crankshaft damper.

#### Installation

1. Remove the rear journal oil seal from the block and rear main bearing cap.
2. Remove the main bearing inserts from the block and bearing caps.
3. Remove the connecting rod bearing inserts from the connecting rods and caps.
4. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearing. Be sure that bearing inserts and bearing bores are clean. Foreign material under inserts will distort the bearing and cause failure.
5. Place the upper main bearing inserts in the bores with tang in slot.



A10399-2A

## REMOVAL AND INSTALLATION (Continued)

6. Install lower main bearing inserts in bearing caps.
7. Clean the rear journal oil seal grooves and mating surfaces of the block and rear main bearing cap.
8. Install a new rear main bearing oil seal in the block and cap.
9. Carefully lower the crankshaft into place. **Be careful not to damage bearing surfaces.**
10. Check the clearance of each main bearing.
11. After bearings have been fitted, apply a light coat of engine oil to journals and bearings. Install a new seal in the rear main bearing cap and install the rear main bearing cap. Install all bearing caps except thrust bearing cap (No. 3 bearing). **Be sure that main bearing caps are installed in original locations.** Tighten the bearing cap bolts to specifications.
12. Install the thrust bearing cap with bolts finger-tight.
13. Pry the crankshaft forward against thrust surface of upper half of bearing.
14. Hold crankshaft forward and pry thrust bearing cap to rear. This aligns thrust surfaces of both halves of bearing.
15. Retain forward pressure on the crankshaft. Tighten cap bolts to specifications.
16. Force the crankshaft toward the rear of the engine.
17. Check the crankshaft end play.
18. Install new bearing inserts in the connecting rods and caps. Check the clearance of each bearing.
19. After the connecting rod bearings have been fitted, apply a light coat of engine oil to the journals and bearings.
20. Turn the crankshaft throw to the bottom of its stroke. Push the piston all the way down until the rod bearing seats on the crankshaft journal.
21. Install the connecting rod cap. Be sure that connecting rod bolt heads are properly seated in connecting rod. Tighten nuts to specifications.
22. After piston and connecting rod assemblies have been installed, check side clearance between connecting rods on each connecting rod crankshaft journal.
23. Install timing chain and sprockets, oil slinger, cylinder front cover, spacer and crankshaft damper as detailed in Cylinder Front Cover and Timing Chain Installation.
24. Install the engine rear cover plate. Position flywheel on crankshaft flange. Install and tighten the bolts to specifications.
25. Clean the oil pan, oil pump and oil pump screen. Prime the oil pump by filling inlet port with engine oil and rotating pump shaft to distribute oil within housing. Install oil pump and oil pan by following procedures under Oil Pan and Oil Pump Installation.
26. Install the oil filter and fuel pump, and connect the fuel lines.
27. Install the spark plugs and connect the spark plug wires.

## REMOVAL AND INSTALLATION (Continued)

### CAMSHAFT BEARINGS

Camshaft bearings are available pre-finished to size for standard and undersize journal diameters.

#### Removal

1. With engine removed and placed in a work stand, remove the camshaft, flywheel, and crankshaft, following the appropriate procedures in this part. Push pistons to top of cylinders.
2. Remove the camshaft rear bearing bore plug. Remove camshaft bearings.

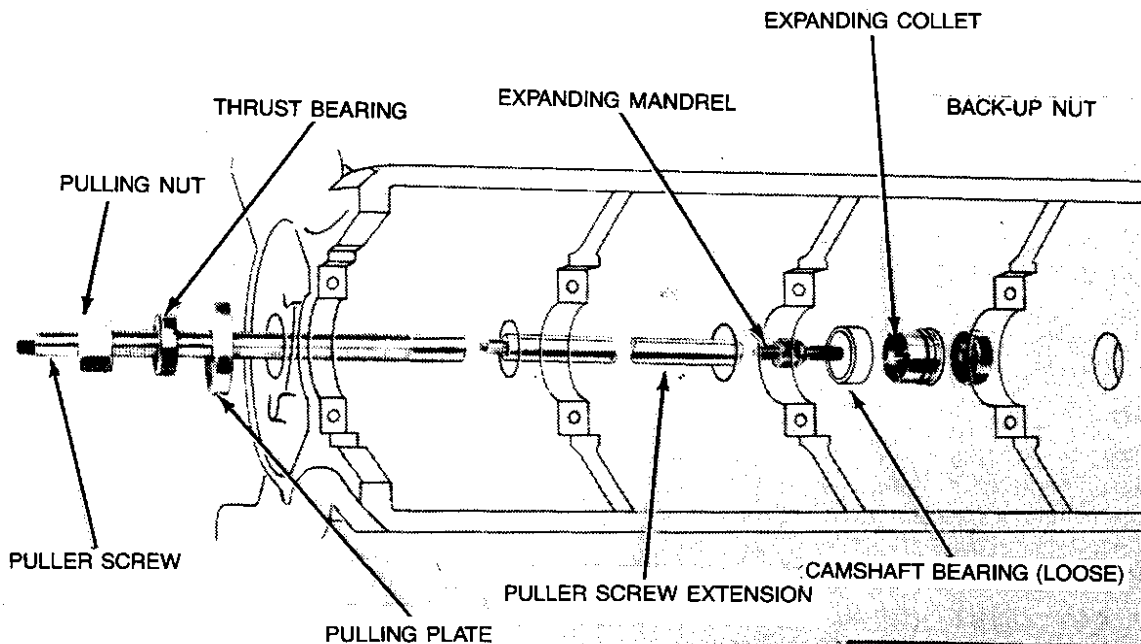
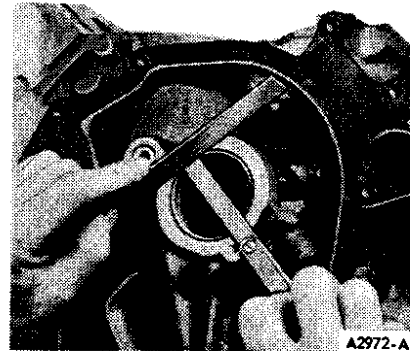
#### Installation

1. Select the proper size expanding collet and back-up nut and assemble on expanding mandrel. With the expanding collet collapsed, install the collet in the camshaft bearing and tighten back-up nut on expanding mandrel until collet fits camshaft bearing.
2. Assemble the puller screw and extension (if necessary) and install on expanding mandrel. Wrap a cloth around threads of the puller screw to protect the front bearing or journal. Tighten pulling nut against the thrust bearing and pulling plate to remove camshaft bearing. Hold a wrench on the end of puller screw to prevent it from turning.
3. Repeat the procedure for each bearing. To remove the front bearing, install puller screw from rear of cylinder block.

4. Position new bearings at bearing bores, and press in place with the tool shown in the illustration. Be sure to center the pulling plate and puller screw to avoid bearing damage.

**Failure to use correct expanding collet can cause severe bearing damage.** Align oil holes in bearings with oil holes in cylinder block before pressing them into block. Be sure front bearing is installed specified distance below front face of cylinder block.

5. Install core plug.
6. Install the camshaft, crankshaft, flywheel and related parts, following appropriate procedures in this part, except do not check connecting rod and main bearing clearances.



TOOL - T65L-6250-A

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## REMOVAL AND INSTALLATION (Continued)

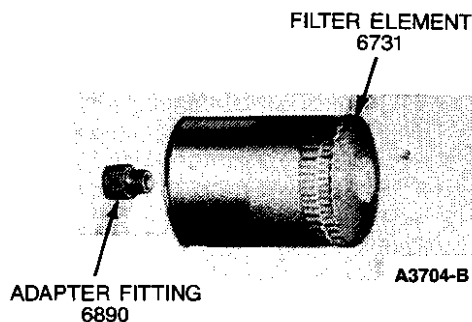
### OIL FILTER

#### Removal

1. Place a drip pan under the filter. Unscrew the filter from the adapter fitting and clean the adapter recess. Clean the oil filter gasket surface.

#### Installation

1. Coat the gasket on a new filter with oil. Place the filter on the adapter fitting. Hand tighten the filter until the gasket contacts the sealing surface, then tighten 1/2 turn more.
2. Operate the engine at fast idle and check for oil leaks. If oil leaks are evident, perform the necessary repairs to correct the leakage. Check the oil level and fill the crankcase to the correct level.



## DISASSEMBLY AND ASSEMBLY

When installing nuts or bolts that must be tightened refer to specifications. Oil the threads with light engine oil. **Do not oil threads that require oil-resistant or water-resistant sealer.**

### CYLINDER HEAD

#### Disassembly

1. With cylinder head removed from engine, remove rocker arm bolts, oil deflectors, fulcrum seats, and rocker arms. Remove exhaust manifolds and spark plugs.
2. Clean carbon from combustion chambers before removing valves.
3. Compress valve springs. Remove spring retainer locks and release springs. Remove retainers, springs, stem seals, and valves. Discard stem seals.

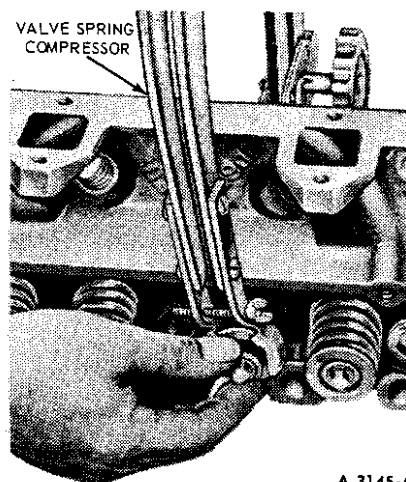
Clean and inspect cylinder head(s) and related components, using pertinent procedures in this section.

Refer to Page 1-21 and 1-22 for repair procedures for cylinder heads and valves.

#### Assembly

Lubricate all valves, valve stems and valve guides with engine oil. The valve tips are to have Ford Polyethylene grease D0AZ-19584-A or equivalent applied. The lubricant is to be applied before installation.

1. Install each valve in port from which it was removed or to which it was fitted. Install new stem seal on each valve.
2. Set valve spring and retainer over valve stem. Compress spring and install retainer locks.



3. With dividers, measure assembled height of valve spring from surface of spring pad on cylinder head to underside of spring retainer. Check dividers with accurate scale. If assembled height exceeds specifications, install spacer(s) below spring to reduce height to recommended dimension. **Reducing assembled height below specifications can cause spring breakage and rapid wear of cam lobe.**
4. Coat the fulcrum seats and sockets with Ford Polyethylene grease D0AZ-19584-A. Make certain that the rocker arm bolts are in a serviceable condition before installing them. Install rocker arms, fulcrum seats, oil deflectors and bolts as detailed under Valve Rocker Arm Installation.
5. Install exhaust manifolds and spark plugs.

## REMOVAL AND INSTALLATION (Continued)

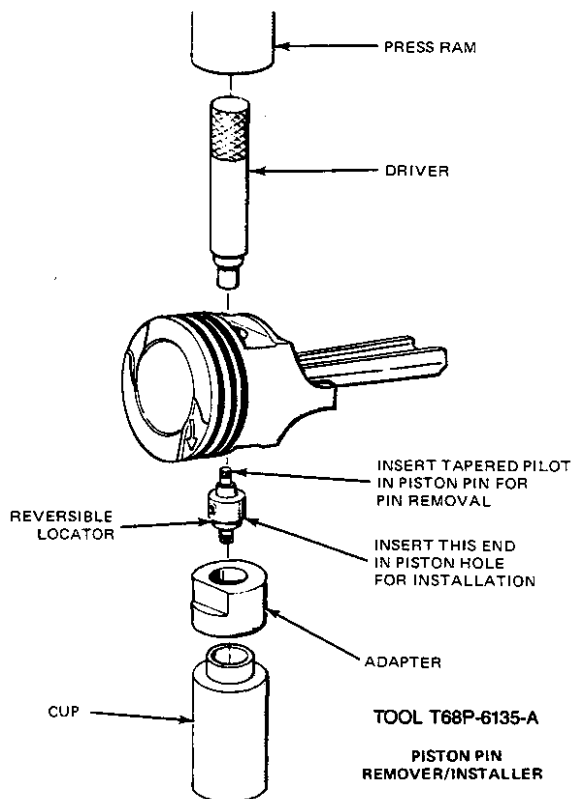
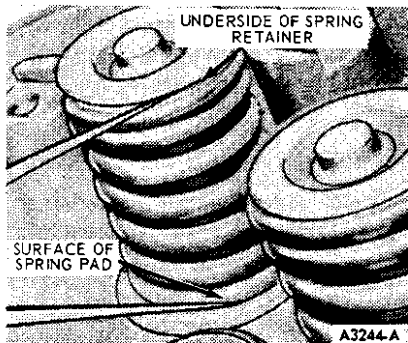
### PISTON AND CONNECTING ROD

#### Disassembly

1. Remove the bearing inserts from the connecting rod and cap.
2. Mark the pistons to assure assembly with same rod and installation in the same cylinders from which they were removed.
3. Using an arbor press and the tool shown in the illustration, press the piston pin from the piston and connecting rod. Remove the piston rings.

Refer to Page 1-17 for cleaning and inspection procedures.

Refer to Page 1-45 for repair procedures.

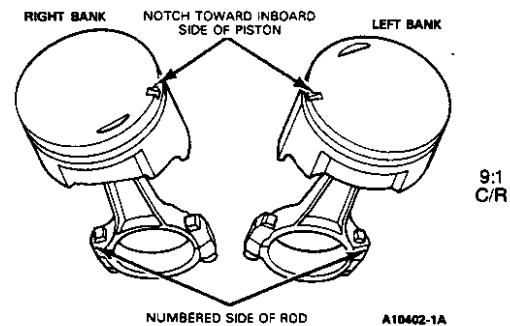
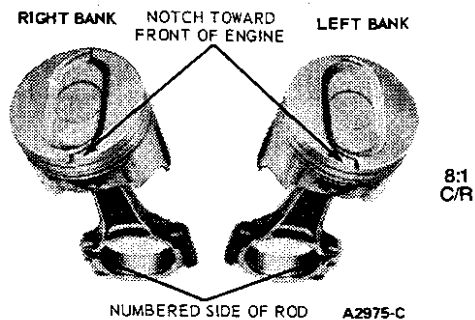


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#### Assembly

Check the fit of a new piston in the cylinder bore before assembling piston and piston pin to connecting rod. Piston pin bore of connecting rod and diameter of piston pin must be within specifications.

1. Apply a light coat of engine oil to all parts. Assemble the piston to the connecting rod with the cylinder number side of the connecting rod and indentation notch in piston positioned in illustration.



2. Start the piston pin in the piston and the connecting rod. Using an arbor press, press the piston pin through the piston and connecting rod until the end of pin is 1/16 inch to 1/8 inch below chamfer of the pin bore in the piston.
3. Check the end gap of all piston rings. End gap must be within specifications. Follow the instructions contained on piston ring package and install the piston rings.
4. Check the ring side clearance of compression rings with a feeler gauge inserted between the ring and the lower land. Feeler gauge should slide freely around the ring circumference without binding. Any wear will form a step at the inner portion of the lower land. If the lower lands have high steps, replace the piston.
5. Be sure the bearing inserts and bearing bore in the connecting rod and cap are clean. Foreign material under the inserts will distort the bearing and cause failure. Install bearing inserts in connecting rod and cap with tangs fitting in slots provided.

## REMOVAL AND INSTALLATION (Continued)

### OIL PUMP

#### Disassembly

1. Remove the four screws and washers securing the oil pump cover to the oil pump.
2. Remove the oil pump outer rotor and rotor shaft assembly from the oil pump housing.

Refer to Page 1-20 for cleaning and inspection procedures.

#### Assembly

1. Install the outer rotor and rotor shaft in the housing. **Be sure that the identification mark on the outer rotor is on the same side as the identification mark on the inner rotor. These parts are matched sets and should only be replaced as an assembly. Fill the housing with engine oil for priming purposes.**

### CYLINDER ASSEMBLY

#### Disassembly

1. Mount the old engine in a work stand and remove all the parts not furnished with the new cylinder assembly, following the procedures given under Removal and Installation.
2. Remove the four cylinder head locating dowels and the block drain plugs.
3. Remove the old cylinder assembly from the work stand.

#### Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder assembly in a work stand and install the cylinder head locating dowels and block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder assembly, following the procedures given under Removal and Installation.
4. Check all assembly clearances and correct as necessary.

### CYLINDER BLOCK

Before replacing a cylinder block, determine if it is repairable. If so, make the necessary repairs, following the procedures given on Page 1-25.

#### Disassembly

1. Mount the old engine in a work stand and completely disassemble it, following the procedures given under Removal and Installation.
2. Remember to ridge-ream the cylinder bores before removing piston assemblies.
3. Remove the cylinder head locating dowels and the block drain plugs.

#### Assembly

1. Clean the gasket and seal surfaces of all serviceable parts and assemblies.
2. Position the new cylinder block in a work stand and install the cylinder head locating dowels and the block drain plugs.
3. Transfer all serviceable parts removed from the old cylinder block, following the procedures given under Removal and Installation.
4. Check all assembly clearances and correct as necessary.

## Part 2 — Ignition System

SUBJECT	PAGE	SUBJECT	PAGE
<b>IDENTIFICATION</b> .....	2-01	<b>CLEANING AND INSPECTION (Cont'd)</b>	
<b>SOLID STATE IGNITION</b>		Spark Plugs .....	2-18
<b>DESCRIPTION</b> .....	2-01	Ignition Wires .....	2-18
<b>ADJUSTMENTS</b>		Ignition Coil .....	2-18
Initial Ignition Timing .....	2-04	<b>PRESTOLITE DISTRIBUTORS</b>	
<b>DIAGNOSIS AND TESTING</b> .....	2-04	<b>(MARINE AND IRRIGATION ENGINES)</b>	
<b>REMOVAL AND INSTALLATION</b>		<b>DESCRIPTION AND OPERATION</b>	
Distributor .....	2-15	Adjustments and Repairs .....	2-20
Stator Assembly .....	2-16	Breaker Points and/or Condensor .....	2-20
Diaphragm Assembly .....	2-16	Breaker Plate and Sub-Plate .....	2-20
Distributor Cap, Adapter and Rotor .....	2-16	Cam and Centrifugal Advance Weights .....	2-21
Ignition Wires .....	2-17	Distributor .....	2-21
Spark Plugs .....	2-17	<b>MAJOR REPAIR OPERATIONS</b>	
<b>CLEANING AND INSPECTION</b>		Bench Disassembly .....	2-22
Distributor Assembly .....	2-17	Bench Assembly .....	2-23
Distributor Cap and Rotor .....	2-17		

### IDENTIFICATION

The distributor assemblies can be identified through the information stamped on a metal tag attached to the distributor by a diaphragm assembly attaching screw.

<b>E2TZ</b>	←	PREFIX
<b>12127</b>	←	BASIC PART NUMBER
<b>ABA</b>	←	SUFFIX

### SOLID STATE IGNITION DESCRIPTION

The solid state ignition is the Duraspark II breakerless type. It is equipped with a vacuum and centrifugal advance to control ignition timing.

The distributor provides a signal to the ignition module which controls the timing of the spark at the spark plugs. The signal is generated as the armature, attached to the distributor shaft, rotates past the stator assembly. The rotating armature causes fluctuations in a magnetic field produced by the stator assembly magnet. These fluctuations induce a voltage in the stator assembly pick-up coil. This signal is connected to the ignition module by the wiring harness.

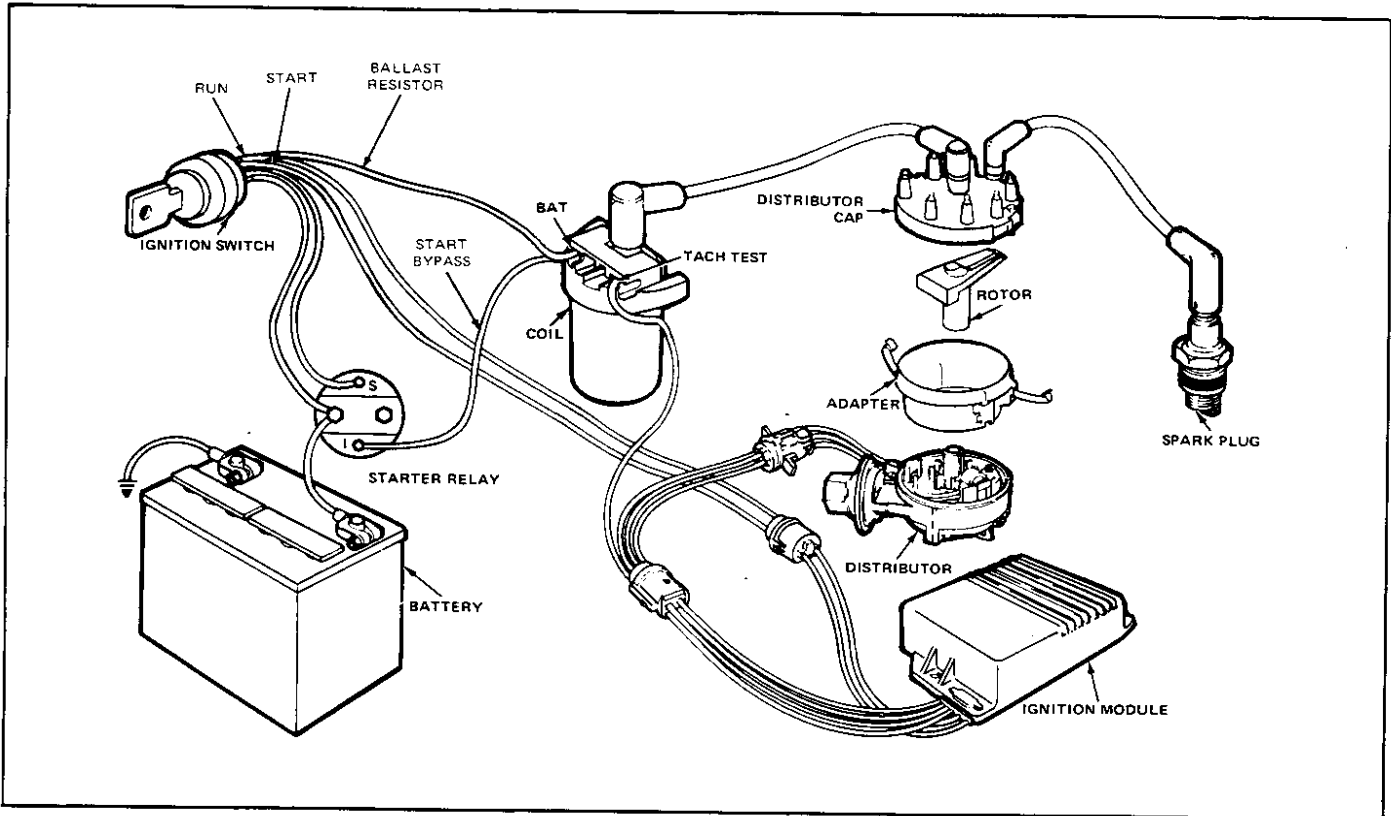
The occurrence of the signal to the ignition module, in relation to initial spark timing, is controlled by centrifugal and vacuum mechanisms. The centrifugal advance mechanism controls spark timing in response to the engine RPM. The vacuum mechanism controls spark timing in response to engine load.

The centrifugal advance mechanism varies the relationship of the armature to the stator assembly. The sleeve and plate assembly, on which the armature is mounted, rotates in relation to the distributor shaft. This rotation is caused by centrifugal weights moving in response to engine

RPM. The movement of the centrifugal weights change the initial relationship of the armature to the stator assembly by rotating the sleeve and plate assembly ahead of its static position on the distributor shaft. This results in spark advance. The rate of movement of the centrifugal weights is controlled by calibrated springs.

The vacuum spark control mechanism provides spark advance. The diaphragm assembly also varies the armature to stator relationship to provide spark advance. In this case the stator assembly position is changed by means of vacuum applied to the diaphragm assembly. Vacuum applied to the diaphragm assembly causes the diaphragm and attached diaphragm rod to move, compressing the advance spring, which controls the rate of spark advance. This movement of the diaphragm rod, which is attached to the stator assembly, causes the stator assembly to move with respect to the armature. This changes the initial armature to stator assembly relationship established during initial timing set, causing spark advance. The stator assembly is mounted on the lower plate assembly which, along with the diaphragm assembly, is attached to the distributor base.

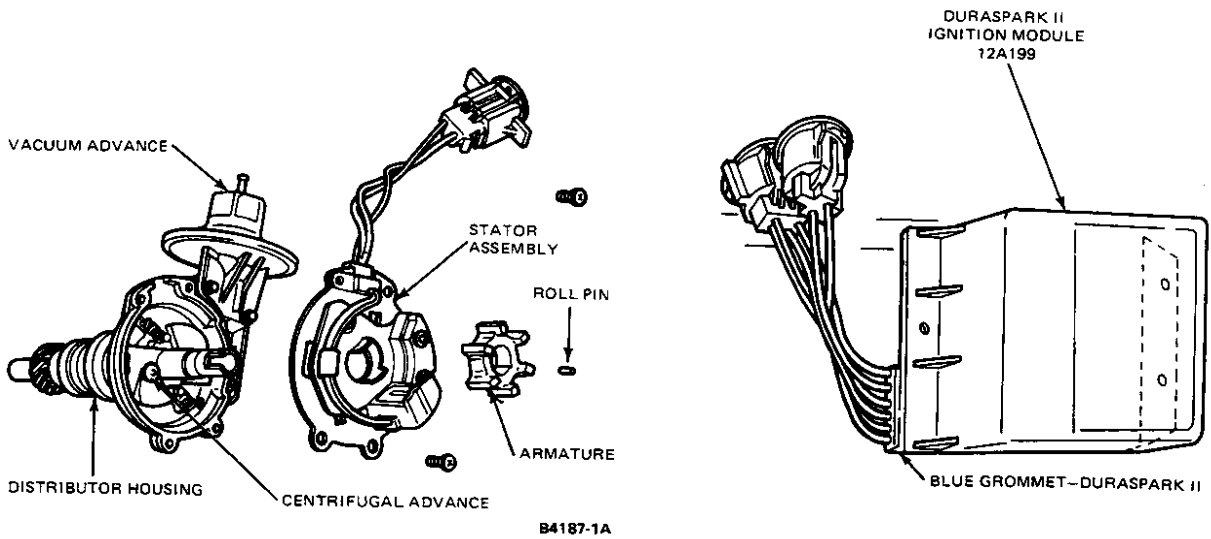
DESCRIPTION (Continued)



The Duraspark II ignition module is shown. The standard base part number for this module is 12A199.

The ignition module performs the function of turning off current flow through the ignition coil in

response to a control signal. In the Duraspark II ignition system this control signal comes from the distributor stator assembly.



**DESCRIPTION (Continued)**

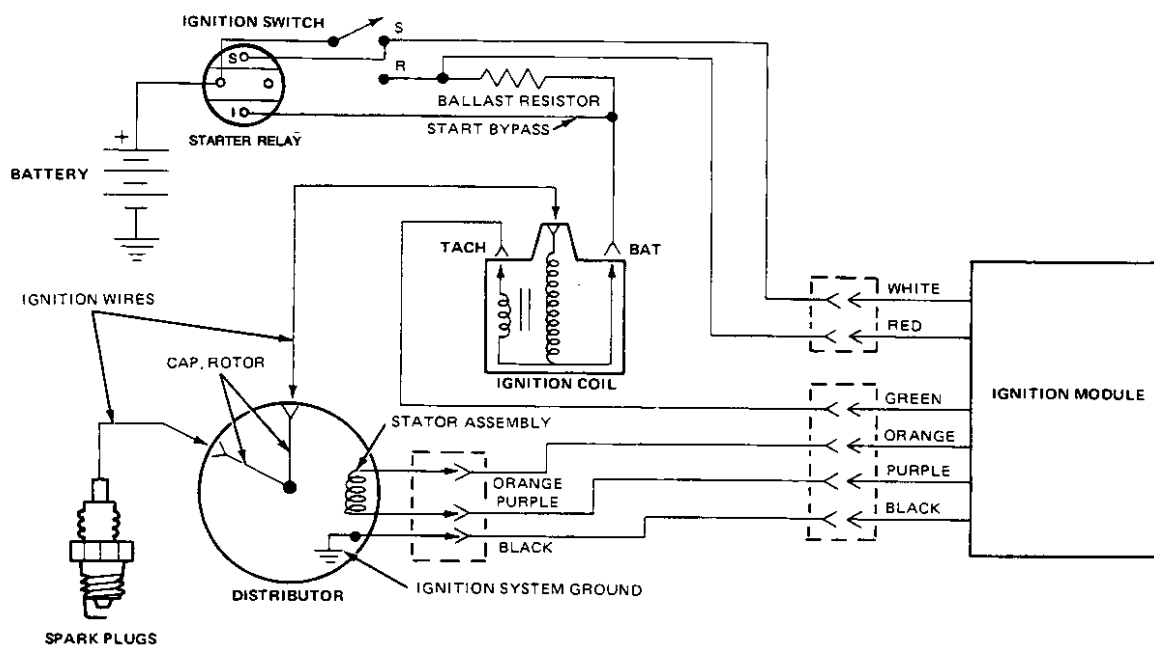
The Duraspark II ignition system consists of a primary and a secondary circuit.

The primary circuit consists of the:

1. Battery
2. Ignition Switch
3. Ballast Resistor — Start Bypass (Wires)
4. Ignition Coil Primary Winding
5. Ignition Module
6. Distributor Stator Assembly

The secondary circuit consists of the:

1. Battery
2. Ignition Coil Secondary Winding
3. Distributor Rotor
4. Distributor Cap
5. Ignition Wires
6. Ignition Switch
7. Ballast Resistor — Start Bypass (Wires)
8. Spark Plugs



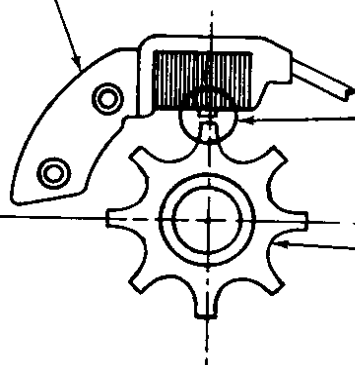
## DESCRIPTION (Continued)

With the ignition switch in the Run position, primary circuit current flows from the battery, through the ignition switch, the ballast resistor, the ignition coil primary (BATTERY), the ignition module (GREEN wire), and back to the battery through the ignition system ground in the distributor (BLACK wire). This current flow causes a magnetic field to be built up in the ignition coil. When the poles on the armature and stator assembly align, the ignition module turns the primary current off, collapsing the magnetic field in the ignition coil. The collapsing field induces a high voltage in the ignition coil secondary winding. The ignition coil wire conducts the high voltage to the distributor where the cap and rotor distribute it to the appropriate spark plug.

A timing circuit in the ignition module turns the primary current back on after a short period of time. High voltage is produced each time the magnetic field is built up and collapsed.

The RED ignition module wire provides operating voltage for the ignition module's electronic components in Run mode. The WHITE wire provides voltage for the ignition module during Start mode. Bypass provides increased voltage for the ignition coil during Start mode.

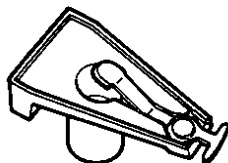
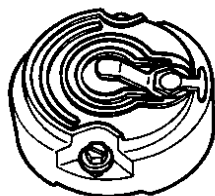
STATOR  
ASSEMBLY



ALIGNMENT OF  
ARMATURE AND  
STATOR ASSEMBLY  
POLES

ARMATURE

B3509-1B



B4283-1B

## ADJUSTMENTS

Ignition system adjustments are limited to initial timing and spark plug gap on Duraspark II systems.

### INITIAL IGNITION TIMING

The timing marks and their locations are illustrated on page 2-18.

For checking and adjusting the ignition timing with a scope refer to the scope manufacturer's instructions. To check and adjust the timing with a timing light, proceed as follows:

1. Clean and mark the specified timing mark with chalk or white paint.
  2. Disconnect the vacuum line and plug the disconnected vacuum line.
  3. Connect a timing light to the No. 1 cylinder spark plug wire. Connect a tachometer to the engine.
  4. Start the engine and reduce the idle speed to 600 RPM to be sure that the centrifugal advance is not operating.
  5. Direct the timing on the timing marks. The light should flash just as the notch on the pulley lines up between the 4 and 8. Check specifications for correct initial ignition timing.
  6. If the timing is not to specification, loosen the distributor retaining bolt and rotate the distributor body until the marks are in line.
- Ignition timing is advanced by counter-clockwise rotation of the distributor body, while clockwise rotation retards timing.
7. Tighten distributor retaining bolt and connect vacuum hose.
  8. To determine if the advance mechanism is functioning, accelerate the engine while watching the timing mark with the timing light. The notch on the crankshaft pulley should advance as engine RPM increases.
  9. Disconnect the timing light.

## DIAGNOSIS AND TESTING

Procedures for ignition system diagnosis and testing are shown in the tests on the following pages.

## DIAGNOSIS AND TESTING (Continued)

### Checkout

- Visually inspect the engine compartment to ensure all vacuum hoses and spark plug wires are properly routed and securely connected.
- Examine all wiring harnesses and connectors for insulation damage, burned, overheated, loose, or broken conditions.
- Be certain the battery is fully charged.
- All accessories should be Off during diagnosis.

### Equipment

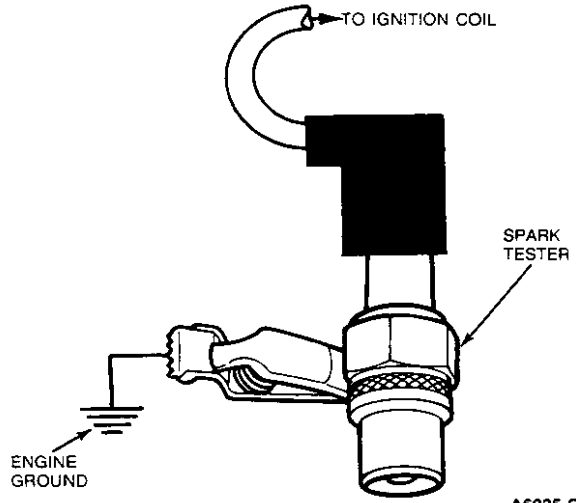
Obtain the following test equipment or an equivalent:

- Spark Tester, Special Service Tool D81P-6666-A.

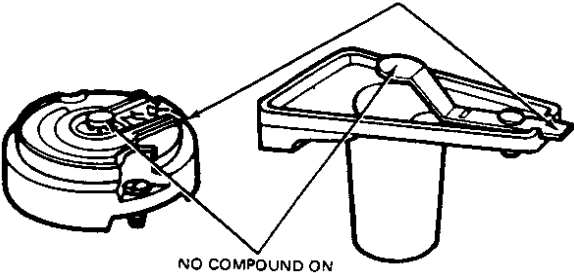
- Digital Volt-Ohmmeter Rotunda 014-00407.
- Small straight pins (2).

### Notes

- All wire colors referred to in this part relate to the colors of the ignition module wires. When working with a wiring harness, the wires must be traced back to the ignition module for proper color identification.
- When instructed to inspect a wiring harness, both a visual inspection and a continuity test should be performed.
- When making measurements on a wiring harness or connector, it is good practice to wiggle the wires while measuring.

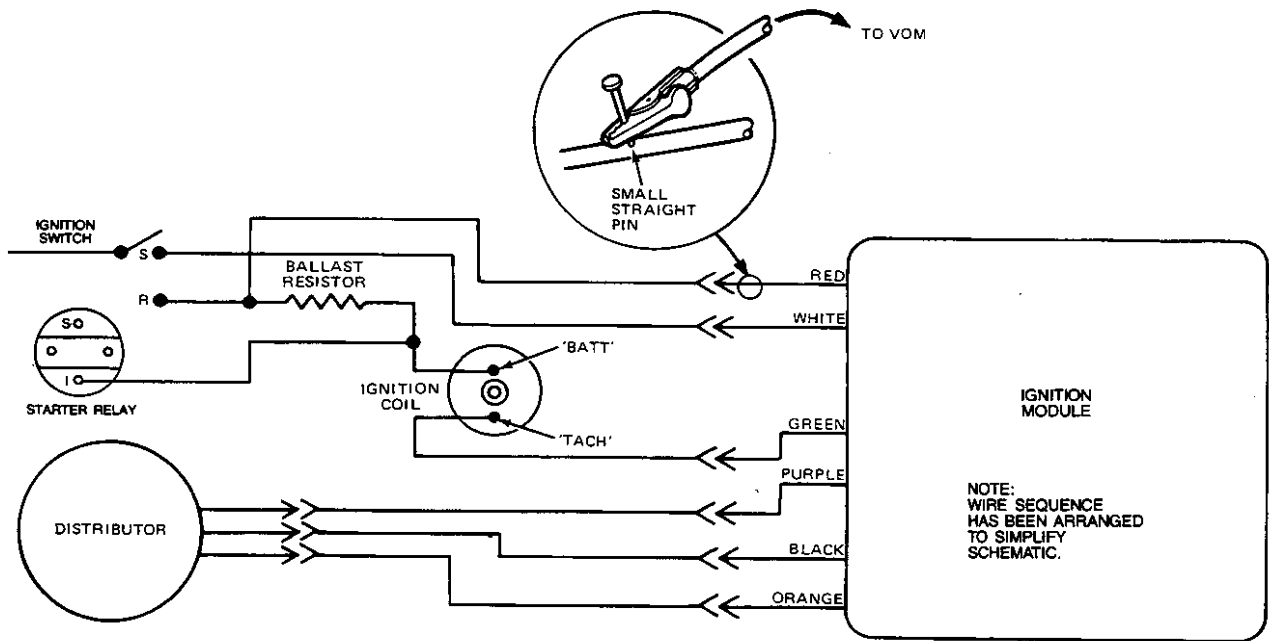
TEST STEP		RESULT	ACTION TO TAKE
1	START CIRCUIT		
<ul style="list-style-type: none"> <li>• Connect spark tester between ignition coil wire and engine ground.</li> <li>• Crank engine using ignition switch.</li> </ul>  <p style="text-align: right;">A6025-C</p>		Sparks	GO to 2.
		No Sparks	<p>MEASURE resistance of ignition coil wire. Replace if greater than 5,000 ohms per inch.</p> <p>INSPECT ignition coil for damage, carbon tracking.</p> <p>CRANK engine to verify distributor rotation.</p> <p>GO to 5.</p>

## DIAGNOSIS AND TESTING (Continued)

TEST STEP		RESULT	ACTION TO TAKE
2	<p><b>RUN CIRCUIT</b></p> <ul style="list-style-type: none"> <li>• Turn ignition switch from Off to Run to Off position several times.</li> <li>• Spark should occur each time switch goes from Run to Off position.</li> <li>• Remove spark tester, reconnect coil wire to distributor cap.</li> </ul> <p>COAT COMPLETE SURFACE OF ROTOR BLADE TIP WITH SILICONE COMPOUND — 1/32" THICK*</p>  <p>NO COMPOUND ON THIS SURFACE</p> <p><b>*DO NOT USE SILICONE COMPOUND ON MULTIPOINT ROTOR.</b></p> <p>A6027-B</p>	<p>Sparks</p>	<p>INSPECT distributor cap, adapter, rotor for cracks, carbon tracking, lack of silicone compound.</p> <p>CHECK for roll pin securing armature to sleeve in distributor.</p> <p>CHECK that ORANGE and PURPLE wires are not crossed between distributor and ignition module.</p>
		<p>No Sparks</p>	<p>GO to 3.</p>

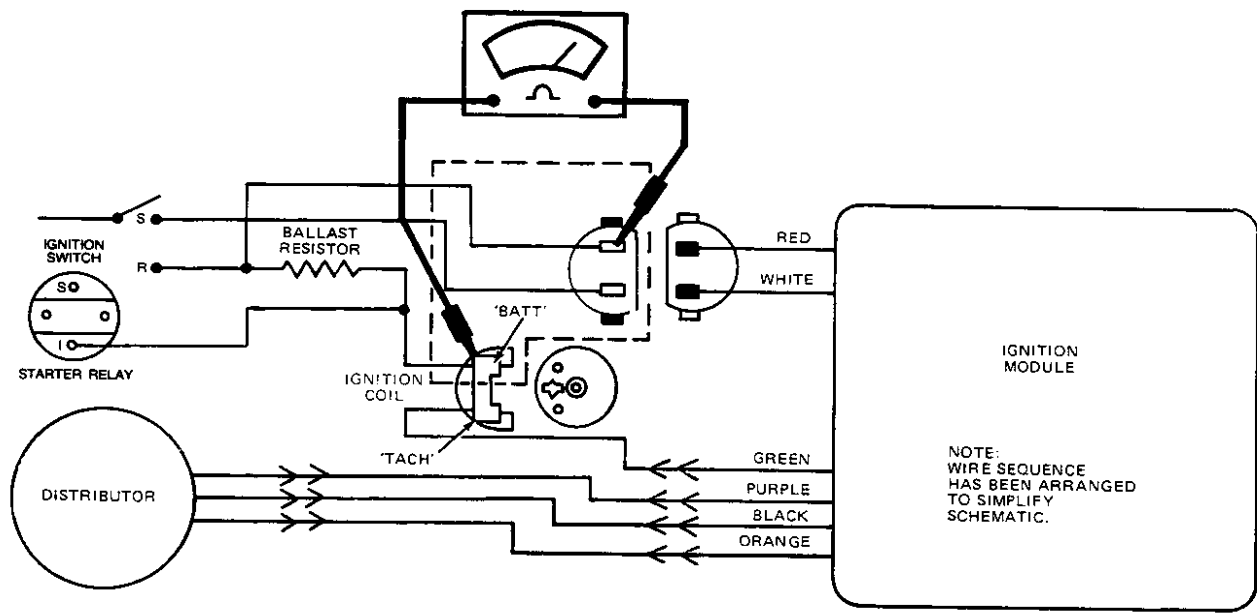
**DIAGNOSIS AND TESTING (Continued)**

TEST STEP		RESULT	ACTION TO TAKE
3	MODULE VOLTAGE	90 percent of battery voltage or greater	GO to 4.
		Less than 90 percent of battery voltage	Refer to wiring diagram. Inspect wiring harness between module and ignition switch.  Worn or damaged ignition switch.



**DIAGNOSIS AND TESTING (Continued)**

TEST STEP		RESULT	ACTION TO TAKE
4	BALLAST RESISTOR	0.8 to 1.6 ohms	Problem is either intermittent or not in ignition system. GO to 5.
	<ol style="list-style-type: none"> <li>1. Separate and inspect ignition module two wire connector with RED and WHITE wires.</li> <li>2. Disconnect and inspect ignition coil connector.</li> <li>3. Measure ballast resistor between BATT terminal of ignition coil connector and wiring harness connector mating with RED module wire.</li> <li>4. Reconnect all connectors.</li> </ol>	Less than 0.8 or greater than 1.6 ohms	Replace ballast resistor.



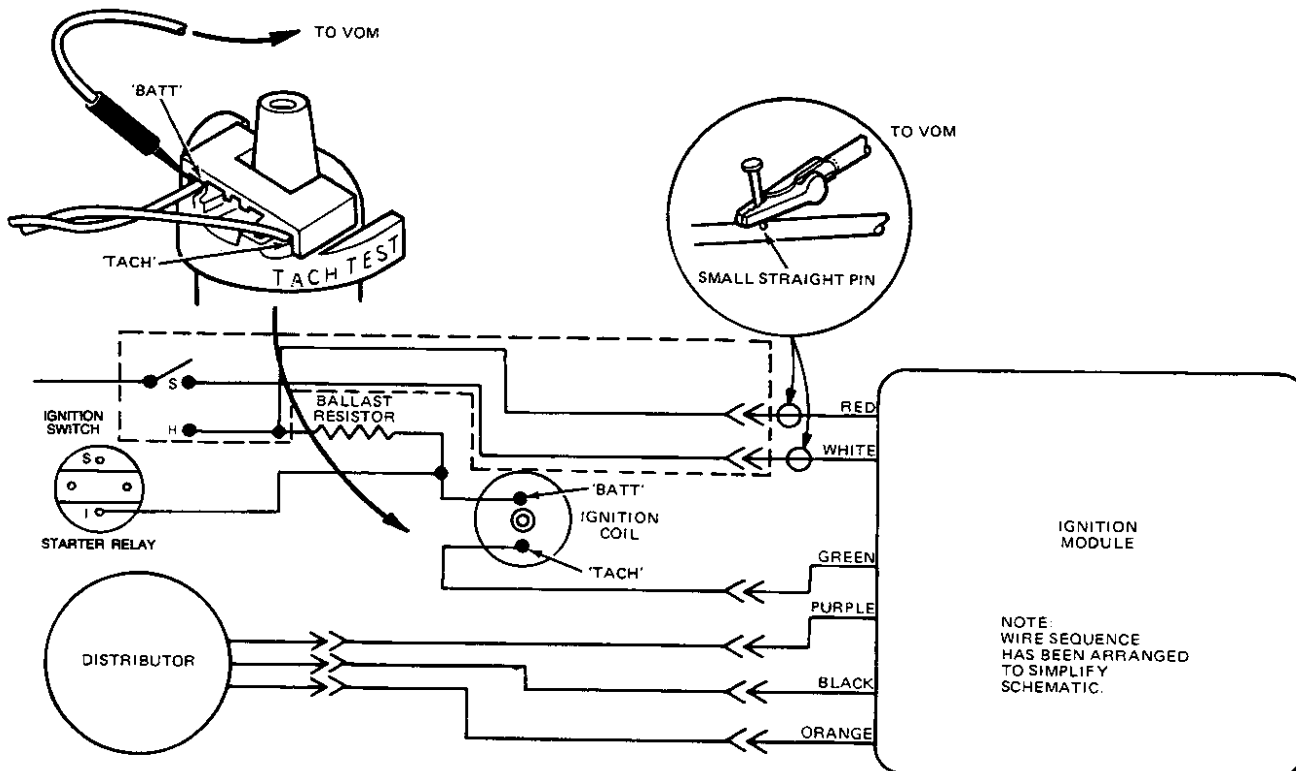
A6379-A

**DIAGNOSIS AND TESTING (Continued)**

TEST STEP		RESULT	ACTION TO TAKE
5	<b>SUPPLY VOLTAGE CIRCUITS</b>  1. Remove SPARK TESTER, reconnect coil wire to distributor cap. 2. Disconnect cable from starter relay to starter motor. 3. Carefully insert small straight pins in RED and WHITE module wires. <b>CAUTION: Do not allow straight pins to contact electrical ground.</b> 4. Measure battery voltage. 5. Following table below, measure voltage at points listed with ignition switch in position shown. <b>NOTE</b> • Attach negative (-) VOM lead to distributor base. • Wiggle wires in wiring harness when measuring.	90 percent of battery voltage or greater	Test result OK. GO to 6.
		Less than 90 percent of battery voltage	Refer to wiring diagram. Inspect wiring harness and connector(s) in faulty circuit(s). Worn or damaged ignition switch.

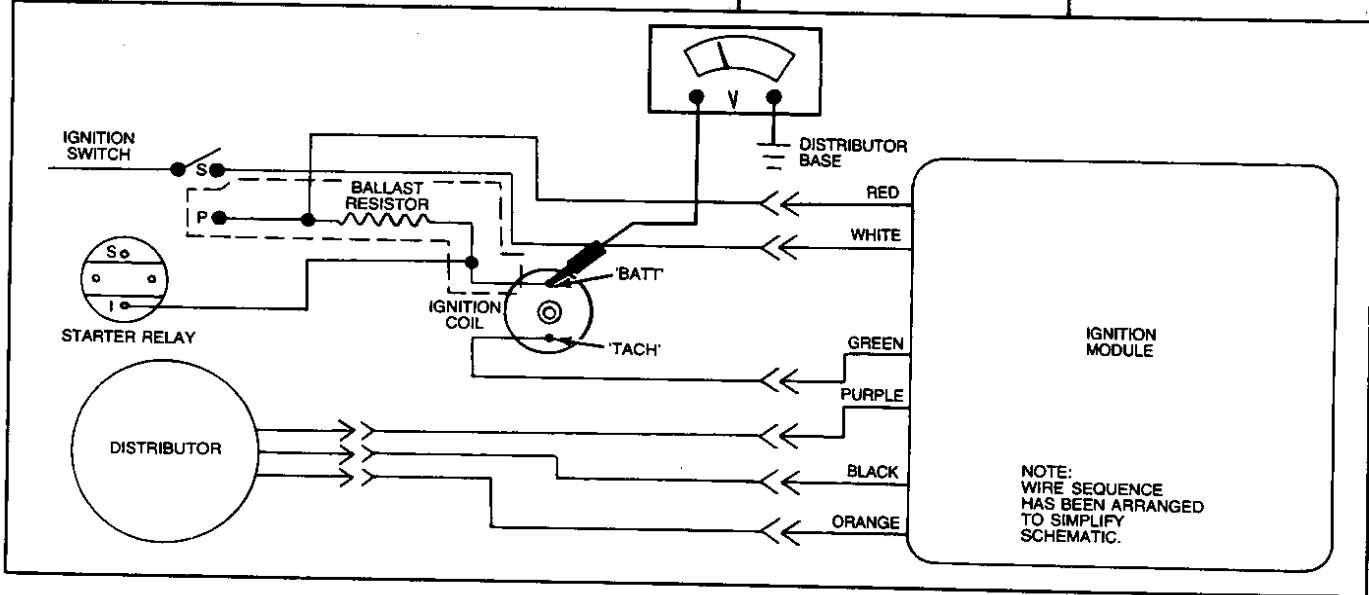
WIRE/TERMINAL	CIRCUIT	IGN. SWITCH POSITION
RED	RUN	RUN
WHITE	START	START
"BATT" TERMINAL IGNITION COIL	BALLAST RESISTOR BYPASS	START

6. Turn ignition switch to Off position.
7. Remove straight pins.
8. Reconnect any cables/wires removed from starter relay.

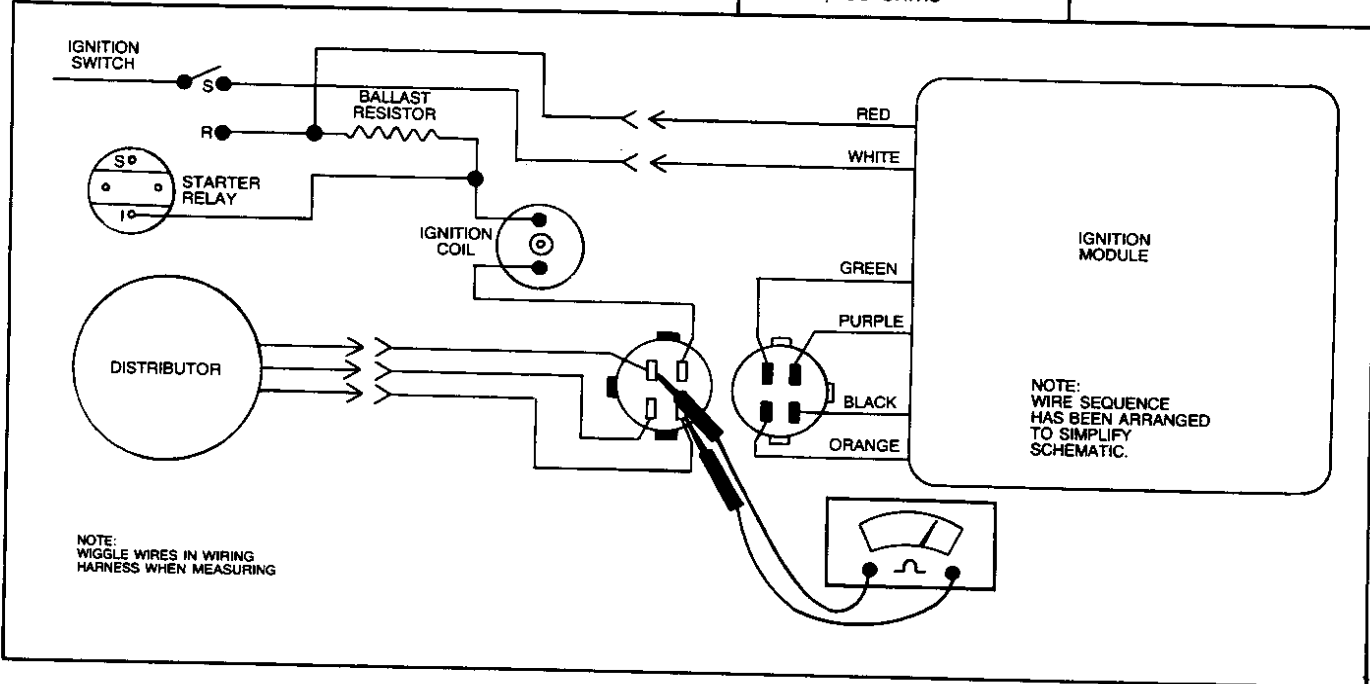


**DIAGNOSIS AND TESTING (Continued)**

TEST STEP	RESULT	ACTION TO TAKE
<p><b>6</b> IGNITION COIL SUPPLY VOLTAGE</p> <ol style="list-style-type: none"> <li>1. Attach negative (-) lead of VOM to distributor base.</li> <li>2. Turn ignition switch to Run position.</li> <li>3. Measure voltage at BATT terminal of ignition coil.</li> <li>4. Turn ignition switch to Off position.</li> </ol>	6 to 8 volts	GO to 7.
	Less than 6 volts or greater than 8 volts	GO to 12.

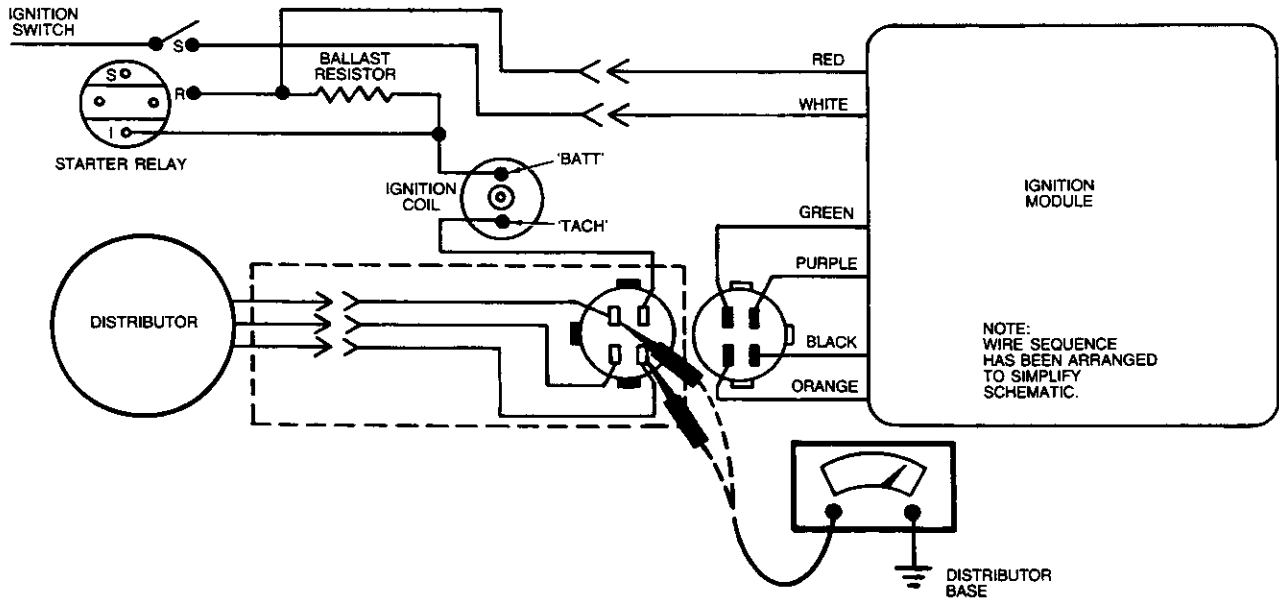


TEST STEP	RESULT	ACTION TO TAKE
<p><b>7</b> DISTRIBUTOR STATOR ASSEMBLY AND WIRING HARNESS</p> <ol style="list-style-type: none"> <li>1. Separate ignition module four wire connector. Inspect for dirt, corrosion, and damage.</li> <li>2. Measure stator assembly and wiring harness resistance between wiring harness terminals mating with ORANGE and PURPLE module wires.</li> </ol>	400 to 1,300 ohms	Test result OK. GO to 8.
	Less than 400 or greater than 1,300 ohms	GO to 11.

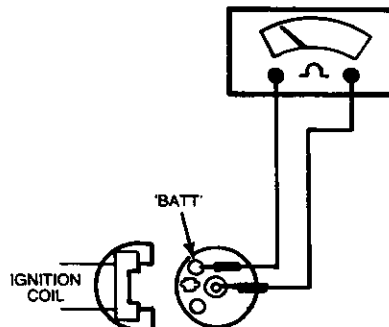


**DIAGNOSIS AND TESTING (Continued)**

TEST STEP	RESULT	ACTION TO TAKE
<p><b>8</b> DISTRIBUTOR STATOR ASSEMBLY WIRING HARNESS</p> <ol style="list-style-type: none"> <li>1. Attach one VOM lead to distributor base.</li> <li>2. Alternately measure resistance between wiring harness terminals mating with ORANGE and PURPLE module wires and ground.</li> <li>3. Reconnect four wire connector.</li> </ol>	<p>Greater than 70,000 ohms</p>	<p>Test result OK. GO to 9.</p>
	<p>Less than 70,000 ohms</p>	<p>Inspect wiring harness between module connector and distributor, including distributor grommet.</p>

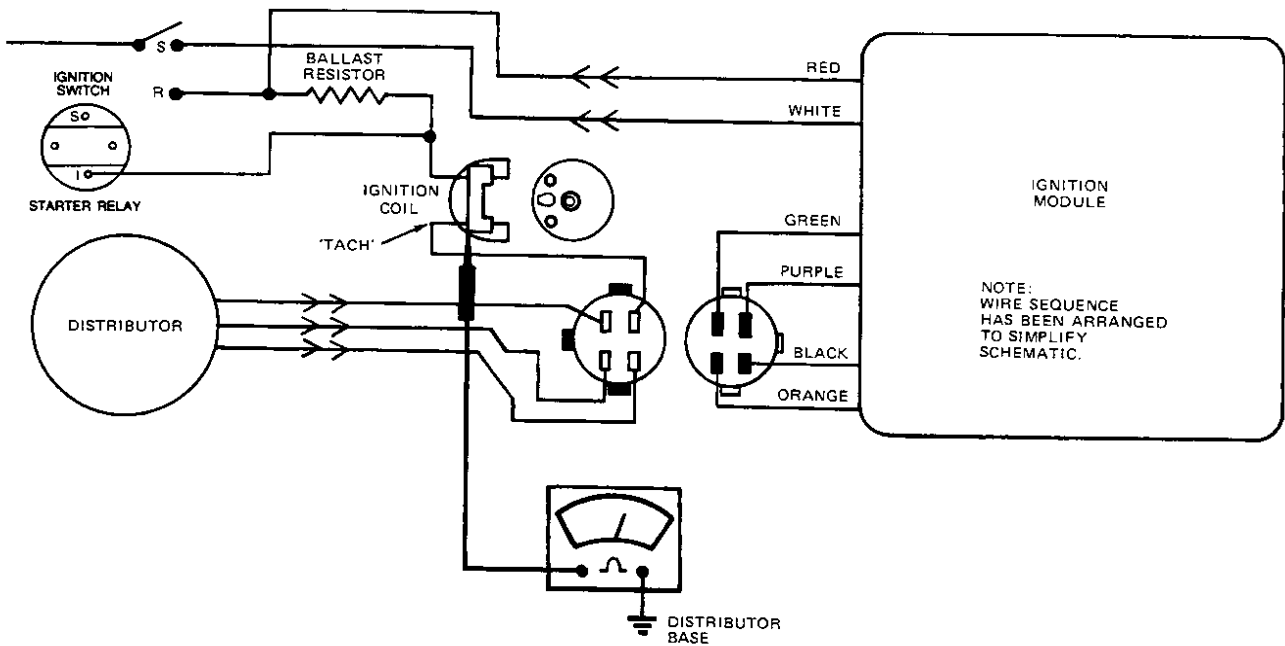


TEST STEP	RESULT	ACTION TO TAKE
<p><b>9</b> IGNITION COIL SECONDARY RESISTANCE</p> <ol style="list-style-type: none"> <li>1. Disconnect and inspect ignition coil connector and coil wire.</li> <li>2. Measure secondary resistance from BATT terminal to high voltage terminal.</li> <li>3. Reconnect ignition coil wire.</li> </ol>	<p>7,700 to 10,500 ohms</p>	<p>Test result OK. GO to 10.</p>
	<p>Less than 7,000 ohms or greater than 10,500 ohms</p>	<p>Replace ignition coil.</p>



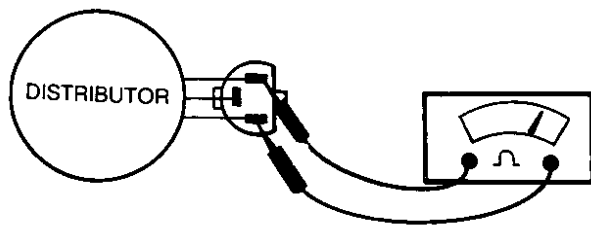
**DIAGNOSIS AND TESTING (Continued)**

TEST STEP	RESULT	ACTION TO TAKE
<b>10</b> MODULE TO COIL WIRE		
1. Separate and inspect ignition module four wire connector and ignition coil connector from coil. 2. Connect one lead of VOM to distributor base. 3. Measure resistance between TACH terminal of ignition coil connector and ground. 4. Reconnect ignition module and coil connectors.	Greater than 100 ohms	Replace ignition module.
	100 ohms or less	Inspect wiring harness between ignition module and coil.

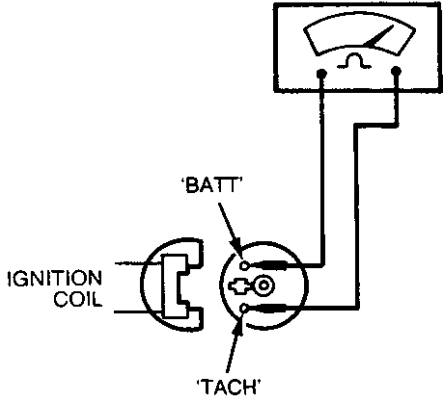
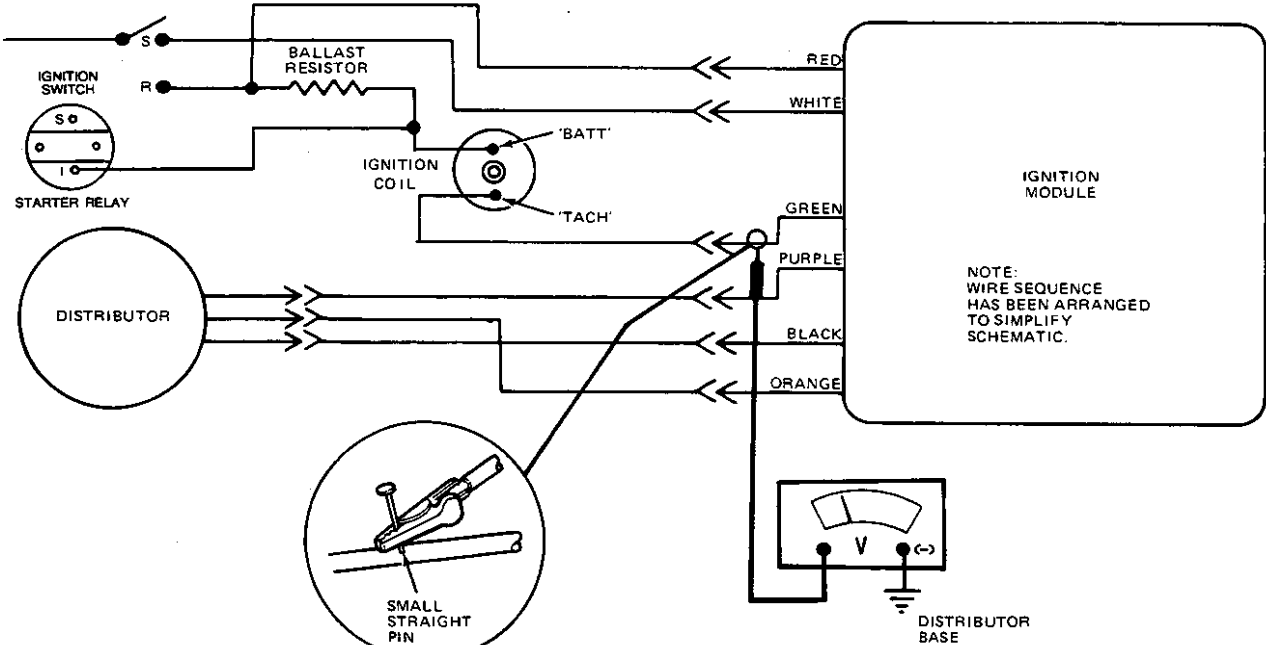


A6366-C

TEST STEP	RESULT	ACTION TO TAKE
<b>11</b> DISTRIBUTOR STATOR ASSEMBLY		
1. Separate distributor connector from harness. Inspect for dirt, corrosion, and damage. 2. Measure stator assembly resistance across ORANGE and PURPLE wires at distributor connector. 3. Reconnect distributor and module connectors.	400 to 1,000 ohms	Test result OK. Inspect wiring harness between distributor and ignition module.
	Less than 400 or greater than 1,000 ohms	Replace stator assembly.

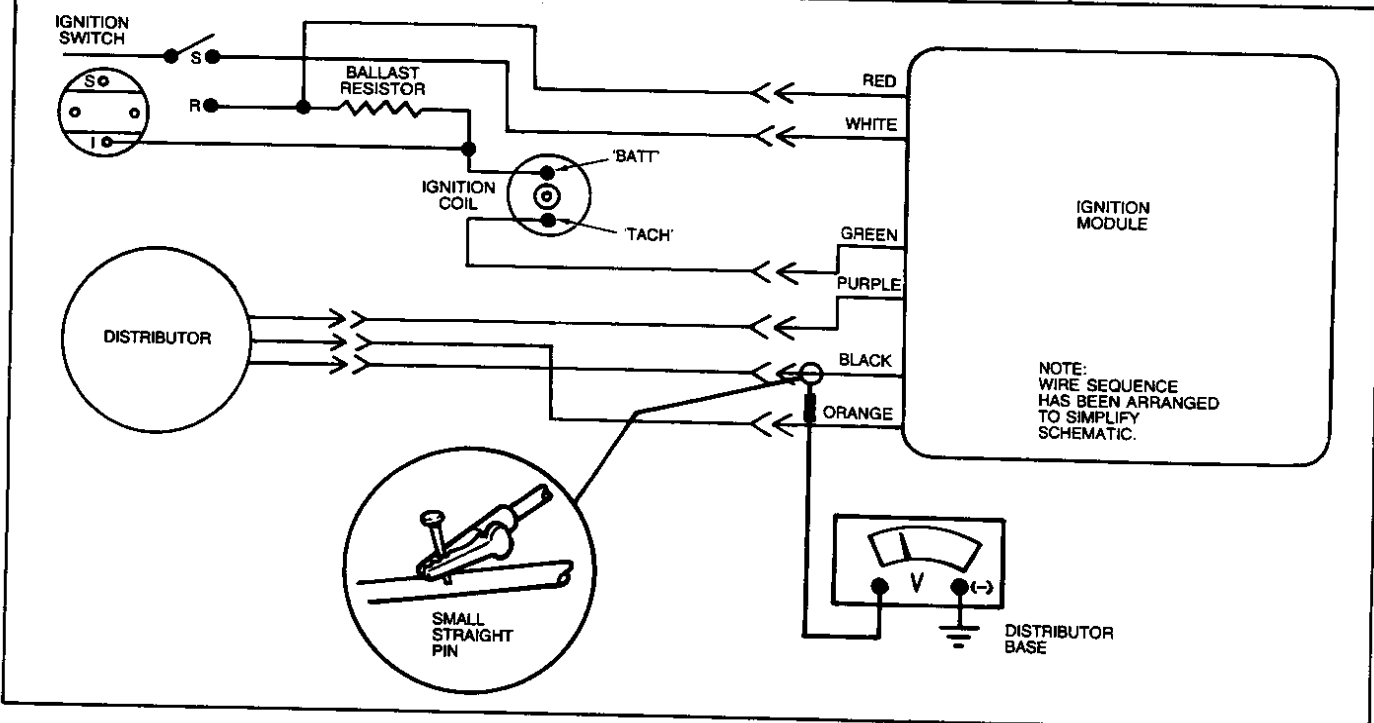


**DIAGNOSIS AND TESTING (Continued)**

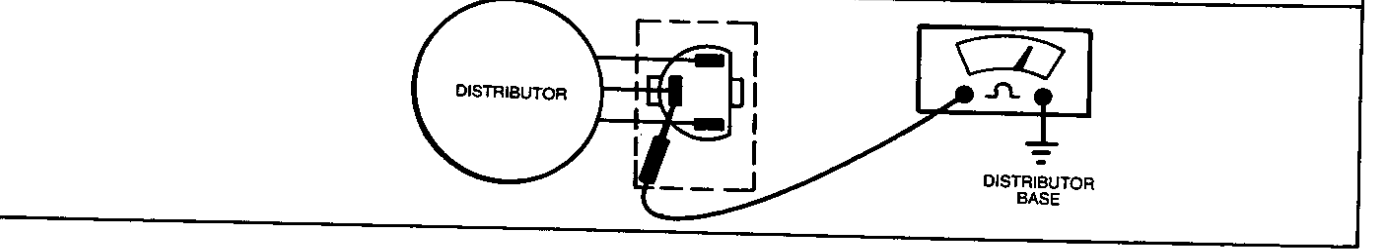
TEST STEP	RESULT	ACTION TO TAKE
<p><b>12</b> IGNITION COIL PRIMARY RESISTANCE</p> <ol style="list-style-type: none"> <li>1. Disconnect ignition coil connector.</li> <li>2. Measure primary resistance from BATT to TACH terminal.</li> <li>3. Reconnect ignition coil connector.</li> </ol> 	<p>0.8 to 1.6 ohms</p>	<p>Test result OK. GO to 13.</p>
	<p>Less than 0.8 or greater than 1.6 ohms</p>	<p>Replace ignition coil.</p>
<p><b>13</b> PRIMARY CIRCUIT CONTINUITY</p> <ol style="list-style-type: none"> <li>1. Carefully insert small straight pin in module GREEN wire.</li> </ol> <p><b>CAUTION: Do not allow straight pin to contact electrical ground.</b></p> <ol style="list-style-type: none"> <li>2. Attach negative (-) VOM lead to distributor base.</li> <li>3. Turn ignition switch to Run position.</li> <li>4. Measure voltage at GREEN module wire.</li> <li>5. Turn ignition switch to Off position.</li> <li>6. Remove straight pin.</li> </ol>	<p>Greater than 1.5 volts</p>	<p>GO to 14.</p>
	<p>1.5 volts or less</p>	<p>Inspect wiring harness and connectors between ignition module and coil.</p>
 <p>NOTE: WIRE SEQUENCE HAS BEEN ARRANGED TO SIMPLIFY SCHEMATIC.</p>		

**DIAGNOSIS AND TESTING (Continued)**

TEST STEP	RESULT	ACTION TO TAKE
<b>14</b> GROUND CIRCUIT CONTINUITY		
1. Carefully insert small straight pin in module BLACK wire. <b>CAUTION: Do not allow straight pin to contact electrical ground.</b> 2. Attach negative (-) VOM lead to distributor base. 3. Turn ignition switch to Run position. 4. Measure voltage at BLACK wire. 5. Turn ignition switch to Off position. 6. Remove straight pin.	Greater than 0.5 volt	GO to 15.
	0.5 volt or less	Replace ignition module.



TEST STEP	RESULT	ACTION TO TAKE
<b>15</b> DISTRIBUTOR GROUND CIRCUIT CONTINUITY		
1. Separate distributor connector from harness. Inspect for dirt, corrosion, and damage. 2. Attach one lead of VOM to distributor base. 3. Measure resistance by attaching other VOM lead to BLACK wire in distributor connector. <b>NOTE: Wiggle distributor grommet when measuring.</b>	Less than one ohm	Test result OK. Inspect wiring harness and connectors between distributor and ignition module.
4. Reconnect distributor connector.	Greater than one ohm	Inspect ground screw in distributor.



## REMOVAL AND INSTALLATION

### DISTRIBUTOR

#### Removal

1. Remove distributor cap. Position it and ignition wires to one side.
2. Disconnect and plug diaphragm assembly hose(s).
3. Separate distributor connector from wiring harness.
4. Rotate engine to align stator assembly pole and any armature pole.
5. Scribe a mark on distributor body and engine block to indicate position of distributor in engine, and position of rotor.
6. Remove distributor holddown bolt and clamp.
7. Remove distributor from engine. Do not rotate engine while distributor is removed.

#### Installation

1. If engine was rotated while distributor was removed:
  - a. Rotate engine until No. 1 piston is on compression stroke.
  - b. Align timing marks for correct initial timing.
  - c. Install distributor with rotor pointing at number one terminal position in cap, and armature and stator assembly poles aligned.
  - d. Make sure oil pump intermediate shaft properly engages distributor shaft. It may be necessary to crank engine after distributor gear is partially engaged in order to engage oil pump intermediate shaft and fully seat distributor in block.
  - e. If it was necessary to crank engine, again rotate engine until No. 1 piston is on compression stroke and align timing marks for correct initial timing.
  - f. Rotate distributor in block to align armature and stator assembly poles and verify rotor is pointing at No. 1 cap terminal.
  - g. Install distributor holddown bolt and clamp; do not tighten.
2. If engine was not rotated while distributor was removed and original distributor is being replaced:
  - a. Position distributor in engine with rotor and distributor aligning with previously scribed mark. Armature and stator assembly poles should also align, if distributor is fully seated in block and properly installed. Crank engine if necessary to fully seat distributor in block.
  - b. Install distributor holddown bolt and clamp; do not tighten.
3. If engine was not rotated while distributor was removed and new distributor is being installed:
  - a. Position distributor in engine with rotor aligned with previously scribed mark. If necessary, crank engine to fully seat distributor.
  - b. Rotate engine until timing marks for correct initial timing align and rotor is pointing at No. 1 one cap terminal.
  - c. Rotate distributor in block to align armature and stator assembly poles.
  - d. Install distributor holddown bolt and clamp; do not tighten.
4. If in steps 1-3 above the armature and stator assembly poles cannot be aligned by rotating distributor in block, pull distributor out of block enough to disengage distributor gear and rotate distributor shaft to engage a different distributor gear tooth and re-install distributor. Repeat steps 1-3 as necessary.
5. Connect distributor to wiring harness.
6. Install distributor cap and ignition wires. Check that ignition wires are securely connected to distributor cap and spark plugs.
7. Set initial timing to specification.
8. Tighten distributor holddown bolt to specification.
9. Recheck initial timing. Readjust if necessary.
10. Connect diaphragm assembly hose.

**REMOVAL AND INSTALLATION (Continued)****STATOR ASSEMBLY****Removal**

1. Remove distributor cap and rotor.
2. Separate distributor connector from wiring harness.
3. Using small gear puller or two screwdrivers, remove armature from sleeve and plate assembly. Use caution to avoid loss of roll pin.
4. Remove two screws retaining lower plate assembly and stator assembly to distributor base. Note there are two different screws.
5. Remove lower plate assembly and stator assembly from distributor.
6. Remove E-clip, flat washer and wave washer securing stator assembly to lower plate assembly and separate stator assembly from lower plate assembly. Note installation of wave washer.

**Installation**

1. Place stator assembly on lower plate assembly and install wave washer (outer edges up), flat washer and E-clip.
2. Install stator assembly/lower plate assembly on distributor base, being sure to engage pin on stator assembly in diaphragm rod.
3. Install two retaining screws in proper locations and tighten to specification.
4. Note there are two locating notches in armature. Install on sleeve and plate assembly with unused notch and new roll pin.
5. Connect distributor to wiring harness.
6. Replace distributor rotor and cap. Check that ignition wires are securely connected to cap and spark plugs.
7. Check initial timing.

**DIAPHRAGM ASSEMBLY****Removal**

1. Disconnect diaphragm assembly vacuum hose.
2. Remove diaphragm assembly attaching screws (2) and identification tag.
3. Disengage diaphragm rod from stator assembly pin and remove diaphragm assembly.

**Installation**

1. Adjust new diaphragm assembly per instructions included in carton.
2. Engage diaphragm rod with stator assembly pin.
3. Attach diaphragm assembly and identification tag to distributor base with two attaching screws and tighten to specification.
4. Ensure diaphragm rod is properly engaged with stator assembly pin.
5. Connect vacuum hose.

**DISTRIBUTOR CAP, ADAPTER AND ROTOR****Removal**

1. Remove the secondary wires.
2. Unclip the distributor cap and lift straight off the distributor.
3. Using a screwdriver, loosen the adapter attaching screws and remove the adapter.
4. Loosen the screws attaching the rotor to the distributor and remove the cap, if necessary.

**Installation**

1. If previously removed, position the distributor rotor with the square and round locator pins matched to the rotor mounting plate. Tighten screws to specification.
2. Install adapter in position and tighten attaching screws to specification.
3. Install the cap, noting the square alignment locator, and fasten the clips.
4. Install secondary wires, noting correct locations on the distributor cap.

## REMOVAL AND INSTALLATION (Continued)

### IGNITION WIRES

The ignition wires include the spark plug wires connecting the distributor cap to the spark plugs and the ignition coil wire connecting the distributor cap to the high voltage terminal of the ignition coil.

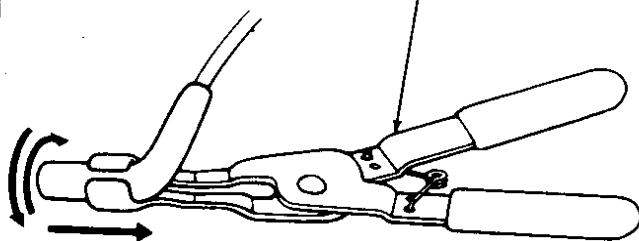
These wires are designed to reduce radio interference caused by high voltage discharges in the ignition system.

For testing, use an ohmmeter and check resistance from terminal in cap to spark plug terminal. Do not, under any circumstances, puncture an ignition wire with any type of probing device.

#### Removal

When removing wires from spark plugs, use Tool T74P-6666-A or equivalent. Grasp and twist the spark plug wire boot back and forth, then pull the wire off the plug. Do not pull directly on the spark plug wire, or it may separate from its terminal inside the spark plug wire boot.

SPARK PLUG WIRE  
REMOVAL TOOL  
T74P-6666-A  
OR EQUIVALENT



TWIST & PULL

B3496-1C

#### Installation

Whenever an ignition wire is removed from a spark plug or ignition coil or distributor cap terminal, silicone compound must be applied to the spark plug wire boot before it is reconnected. Using a small clean tool, lightly coat the entire inner surface of the boot with Ford Silicone Dielectric Compound (D7AZ-19A331-A or equivalent).

1. Attach each wire to proper terminal of distributor cap. Be certain wires are fully seated on terminals.
2. Remove wire separators from old wire set and install them on new set in approximately same position.
3. Connect wires to proper spark plugs. Install ignition coil wire. Be certain all wires are fully seated on terminals.

### SPARK PLUGS

#### Removal

1. Remove spark plug wire from spark plug, using Tool T74P-6666-A or equivalent with a twisting-pulling motion. Do not pull directly on spark plug wire.
2. Inspect spark plug wires for physical damage. Replace as necessary.
3. Clean area around each spark plug port with compressed air.
4. Remove spark plug.

#### Installation

1. Set spark plug gap to specification.
2. Install spark plug and tighten to specification.
3. Coat the inside of the spark plug wire boot with silicone compound and install on spark plug.

## CLEANING AND INSPECTION

### DISTRIBUTOR ASSEMBLY

Clean distributor using compressed air. Make sure no metal chips adhere to stator assembly. Inspect distributor to be certain all components are securely attached and stator assembly moves freely. Check that sleeve and plate assembly rotates freely on distributor shaft.

### DISTRIBUTOR CAP AND ROTOR

Wipe the distributor cap and rotor with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air.

Examine for cracks, carbon tracking, dirt or missing carbon button in cap. Replace as necessary. Review Distributor Cap and Rotor Installation and Removal.

**CLEANING AND INSPECTION (Continued)**

**SPARK PLUGS**

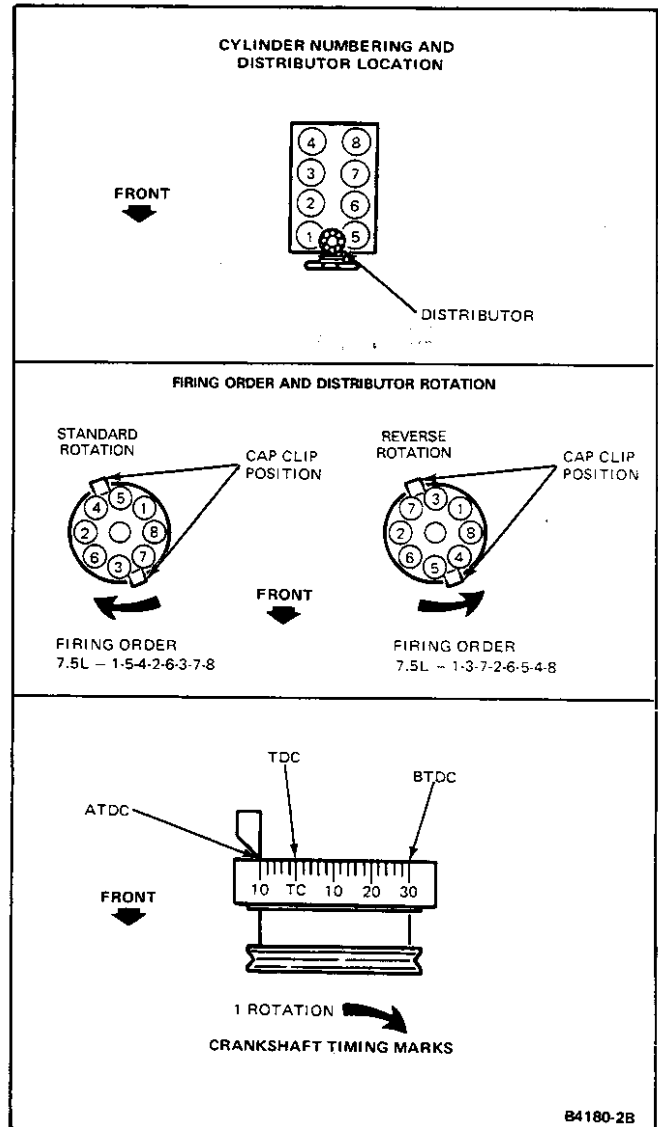
Examine the spark plug for cracked ceramic insulator and condition of firing end. Refer to page 02-19 for various conditions and actions.

**IGNITION WIRES**

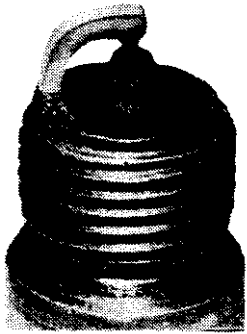
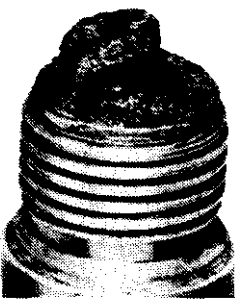
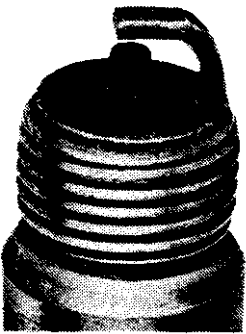
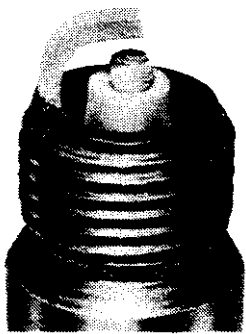

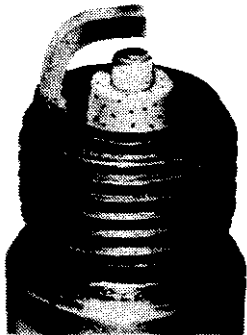
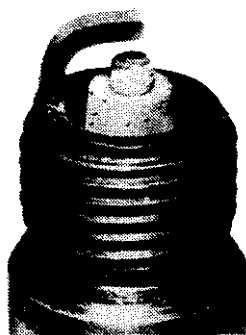
Without removing wires, inspect for visible damage such as cuts, pinches, cracked or torn boots. Replace as necessary.

**IGNITION COIL**

Wipe coil tower with a clean cloth dampened with soap and water. Remove any soap film and dry with compressed air. Inspect for cracks, carbon tracking and dirt.



## CLEANING AND INSPECTION (Continued)

<p style="text-align: center;"><b>GAP BRIDGED</b></p>  <p>IDENTIFIED BY DEPOSIT BUILDUP CLOSING GAP BETWEEN ELECTRODES.</p> <p>CAUSED BY OIL OR CARBON FOULING. REPLACE PLUG, OR, IF DEPOSITS ARE NOT EXCESSIVE, THE PLUG CAN BE CLEANED.</p>	<p style="text-align: center;"><b>OIL FOULED</b></p>  <p>IDENTIFIED BY WET BLACK DEPOSITS ON THE INSULATOR SHELL BORE ELECTRODES.</p> <p>CAUSED BY EXCESSIVE OIL ENTERING COMBUSTION CHAMBER THROUGH WORN RINGS AND PISTONS, EXCESSIVE CLEARANCE BETWEEN VALVE GUIDES AND STEMS, OR WORN OR LOOSE BEARINGS. REPLACE THE PLUG.</p>	
<p style="text-align: center;"><b>CARBON FOULED</b></p>  <p>IDENTIFIED BY BLACK, DRY FLUFFY CARBON DEPOSITS ON INSULATOR TIPS, EXPOSED SHELL SURFACES AND ELECTRODES.</p> <p>CAUSED BY TOO COLD A PLUG, WEAK IGNITION, DIRTY AIR CLEANER, DEFECTIVE FUEL PUMP, TOO RICH A FUEL MIXTURE, IMPROPERLY OPERATING HEAT RISER OR EXCESSIVE IDLING. CAN BE CLEANED.</p>	<p style="text-align: center;"><b>NORMAL</b></p>  <p>IDENTIFIED BY LIGHT TAN OR GRAY DEPOSITS ON THE FIRING TIP.</p>	<p style="text-align: center;"><b>PRE-IGNITION</b></p>  <p>IDENTIFIED BY MELTED ELECTRODES AND POSSIBLY BLISTERED INSULATOR. METALIC DEPOSITS ON INSULATOR INDICATE ENGINE DAMAGE.</p> <p>CAUSED BY WRONG TYPE OF FUEL, INCORRECT IGNITION TIMING OR ADVANCE, TOO HOT A PLUG, BURNT VALVES OR ENGINE OVERHEATING. REPLACE THE PLUG.</p>
<p style="text-align: center;"><b>OVERHEATING</b></p>  <p>IDENTIFIED BY A WHITE OR LIGHT GRAY INSULATOR WITH SMALL BLACK OR GRAY BROWN SPOTS AND WITH BLuish-BURNT APPEARANCE OF ELECTRODES.</p> <p>CAUSED BY ENGINE OVERHEATING, WRONG TYPE OF FUEL, LOOSE SPARK PLUGS, TOO HOT A PLUG, LOW FUEL PUMP PRESSURE OR INCORRECT IGNITION TIMING. REPLACE THE PLUG.</p>	<p style="text-align: center;"><b>FUSED SPOT DEPOSIT</b></p>  <p>IDENTIFIED BY MELTED OR SPOTTY DEPOSITS RESEMBLING BUBBLES OR BLISTERS.</p> <p>CAUSED BY SUDDEN ACCELERATION. CAN BE CLEANED IF NOT EXCESSIVE. OTHERWISE REPLACE PLUG.</p>	

## PRESTOLITE DISTRIBUTORS (MARINE & IRRIGATION ENGINES) DESCRIPTION AND OPERATION

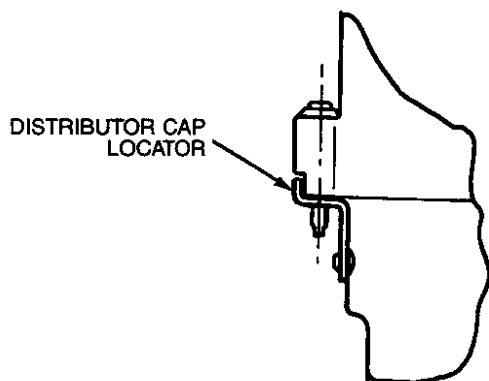
The centrifugal advance distributor is a straight mechanical-type unit. A governor-type centrifugal advance is located below the stationary breaker plate. Two centrifugal weights cause the cam to advance or move ahead with respect to the distributor drive shaft the rate of advance is controlled by two calibrated springs.

### ADJUSTMENTS AND REPAIRS

#### BREAKER POINTS AND/OR CONDENSER

##### Removal

1. Remove the distributor cap and the rotor. Note distributor cap locator.



2. Disconnect the primary and the condenser wires from the breaker point assembly.

3. Remove the breaker point assembly and condenser retaining screws. Lift the breaker point assembly and condenser out of the distributor.

##### Installation

1. Place the breaker point assembly and the condenser in position and install the retaining screws.
2. Align and adjust the breaker point assembly.
3. Connect the primary and condenser wires to the breaker point assembly.
4. Install the rotor and the distributor cap. Cap must be properly positioned on locator.

#### BREAKER PLATE AND SUB-PLATE

##### Removal

1. Remove the distributor cap and rotor.
2. Working from the inside of the distributor, pull the primary wire through the opening out of the distributor.
3. Remove the sub-plate attaching screws and lift the assembly from the distributor.

##### Installation

1. Place the breaker plate assembly in position in the distributor.
2. Install the sub-plate hold down screws.
3. Insert the primary wire in the distributor. Install the breaker points and the condenser. Connect the primary wire and the condenser wire to the breaker point terminal.
4. Install the rotor and the distributor cap.

## PRESTOLITE DISTRIBUTORS (MARINE & IRRIGATION ENGINES) DESCRIPTION AND OPERATION (Continued)

### CAM AND CENTRIFUGAL ADVANCE WEIGHTS

#### Removal

1. Remove the breaker plate and sub-plate from the distributor.
2. **Mark one of the distributor weight springs and its brackets. Also mark one of the weights and its pivot pin.**
3. Carefully unhook and remove the weight springs.
4. Lift the lubricating wick from the cam assembly. Remove the cam assembly retainer and lift the cam assembly off the distributor shaft. Remove the thrust washer.
5. Lift the weights out of the distributor.

#### Installation

1. If the weights were removed, fill the grooves in the weight pivot pins with distributor cam lubricant (C4AZ-19D530-A).

Position the weights in the distributor (**the marked weight is placed on the marked pivot pin**) and install the weight retainers.

2. Place the thrust washer on the shaft.
3. Fill the grooves in the upper portion of the distributor shaft with distributor cam lubricant (C4AZ-19D530-A).
4. Install the cam assembly. **Be sure that the marked spring bracket on the cam assembly is near the marked spring bracket on the stop plate.**

Place a light film of distributor cam lubricant (C4AZ-19D530-A) on the distributor cam lobes. Install the retainer and the wick. Oil the wick with SAE-10W engine oil.

5. Install the weight springs. **Be sure that the marked spring is attached to the marked spring brackets.**
6. Install the plate assembly.
7. Install the primary wire in the distributor. Connect the primary and condenser wires to the breaker point terminal.
8. Adjust the breaker point gap or dwell as required.

### DISTRIBUTOR

#### Removal

1. Remove the air cleaner. Disconnect the primary wire from the coil. Remove the distributor cap.
2. Scribe a mark on the distributor body and the cylinder block indicating the position of the body in the block, and scribe another mark on the distributor body indicating the position of the rotor. These marks can be used as guides when installing the distributor in a correctly timed engine.
3. Remove the distributor hold down bolt and clamp. Lift the distributor out of the block.

**Do not rotate the crankshaft while the distributor is removed, or it will be necessary to time the engine.**

#### Installation

1. If the crankshaft was rotated while the distributor was removed from the engine, it will be necessary to time the engine. Rotate the crankshaft until No. 1 piston is on TDC after the compression stroke. Align the TDC mark on the timing pointer with the timing pin on the crankshaft damper. Position the distributor in the block with the rotor at the No. 1 firing position.

**Make sure the oil pump intermediate shaft properly engages the distributor shaft. It may be necessary to crank the engine with the starter, after the distributor drive gear is partially engaged to engage the oil pump intermediate shaft.**

**Install, but do not tighten, the retaining clamp and bolt. Rotate the distributor to advance the timing to a point where the breaker points are just starting to open. Tighten the clamp.**

2. If the crankshaft has not been moved, position the distributor in the block with the rotor aligned with the mark previously scribed on the distributor body and the marks on the distributor body and cylinder block in alignment.
3. Install the distributor cap.
4. Connect the primary wire to the coil.
5. Check the ignition timing with a timing light and adjust to specifications.
6. Install the air cleaner.

## MAJOR REPAIR OPERATIONS

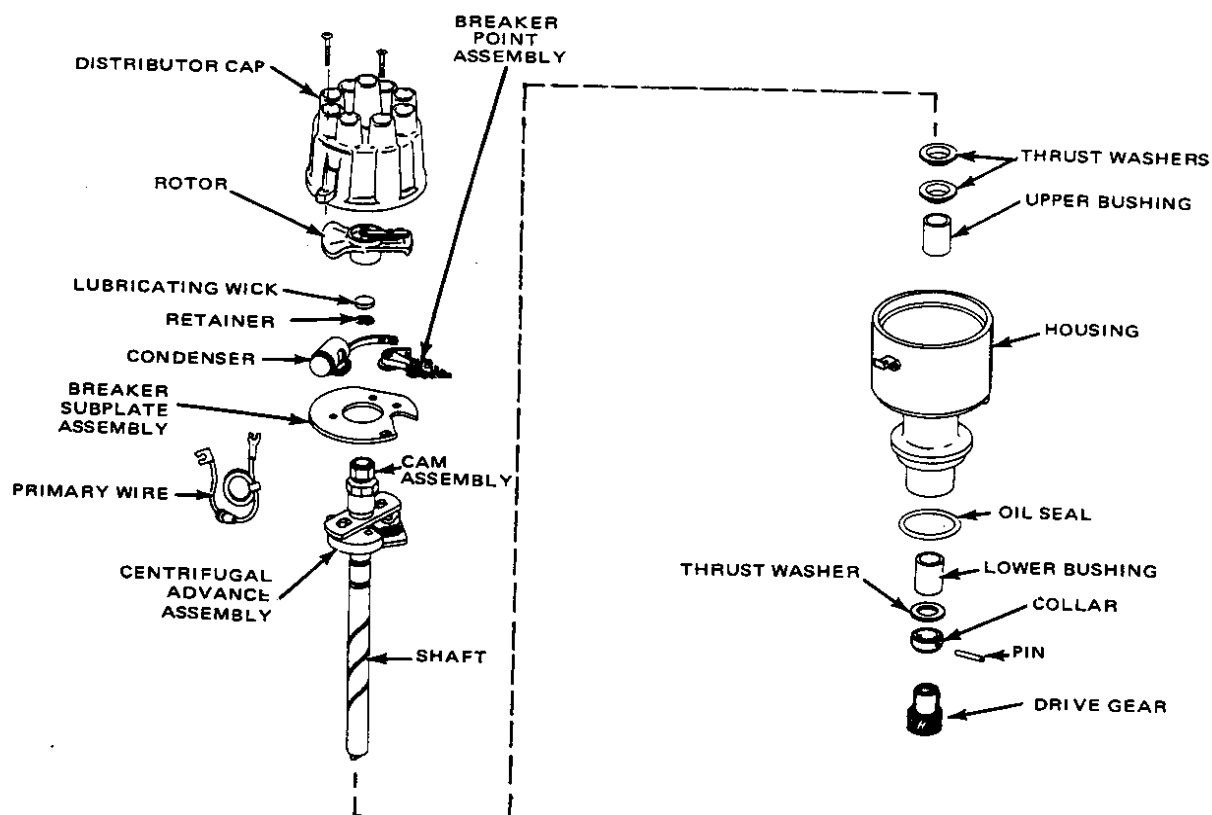
To perform the operations in this section, it will be necessary to remove the distributor from the engine and place it in a vise.

### BENCH DISASSEMBLY

Refer to the illustration for the location of parts.

### CONVENTIONAL IGNITION SYSTEM DISTRIBUTOR

1. Remove the rotor.
2. Disconnect the primary wire, the jumper strap, and the condenser wire from the breaker point assemblies.
3. Remove the retaining screws from the breaker point assemblies and condenser. Lift the breaker point assembly and the condenser out of the distributor.
4. Working from the inside of the distributor, pull the primary wire through the opening in the distributor.
5. Remove the breaker point and condenser plate retaining screws and lift the plate out of the distributor.
6. Mark one of the distributor weight springs and its brackets. Also mark one of the weights and its pivot pin.
7. Carefully unhook and remove the weight springs.
8. Lift the lubricating wick from the cam assembly. Remove the cam assembly retainer and lift the cam assembly off the distributor shift. Remove the thrust washer.
9. Lift the weights out of the distributor.
10. If the gear and shaft are to be used again, mark the gear and the shaft so that the pin holes can be easily aligned for assembly. Remove the gear roll pin and then remove the gear.
11. Remove the shaft collar roll pin.
12. Invert the distributor and place it on a support in a position that will allow the distributor shaft to clear the support plate and press the shaft out of the collar and the distributor housing.
13. Remove the distributor shaft upper bushing.
14. Remove the distributor shaft lower bushing.



## MAJOR REPAIR OPERATIONS (Continued)

### BENCH ASSEMBLY

#### ORIGINAL SHAFT AND GEAR

1. Oil the new upper bushing, and install it on the bushing replacer tool. Then install the upper bushing. When the tool bottoms against the distributor base, the bushing will be installed to the correct depth.
2. Burnish the bushing to the proper size.
3. Invert the distributor and install the lower bushing in a similar manner.
4. Oil the shaft and slide it into the distributor body.
5. Place the collar in position on the shaft and align the holes in the collar and shaft, then install a new pin.
6. Check the shaft end play with a feeler gauge placed between the collar and the base of the distributor. If the end play is not within limits, replace the shaft and gear.
7. Press the gear on the shaft, using the marks made on the gear and shaft as guides to align the pin holes.
8. Remove the distributor from the press. Install the gear retaining pin.
9. Position the distributor in a vise. Fill the grooves in the weight pivot pins with distributor cam lubricant (C4AZ-19D530-A).
10. Position the weights in the distributor (**the marked weight is placed on the marked pivot pin**) and install the weight retainers.
11. Place the thrust washer on the shaft.
12. Fill the grooves in the upper portion of the distributor shaft with distributor cam lubricant (C4AZ-19D530-A).
13. Install the cam assembly. **Be sure that the marked spring bracket on the cam assembly is near the marked spring bracket on the stop plate.**  
Place a light film of distributor cam lubricant (C4AZ-19D530-A) on the distributor cam lobes. Install the retainer and the wick. Saturate the wick with SAE 10W engine oil.
14. Install the weight springs. **Be sure that the marked spring is attached to the marked spring brackets.**

15. Place the breaker point and condenser plate in position and install the retaining screws.
16. Working from the inside of the distributor, push the primary wire through the opening in the distributor housing.
17. Place the breaker point assembly and the condenser in position and install the retaining screws.
18. Align and adjust the breaker point assembly.
19. Connect the primary wire and the condenser wire to the breaker point assembly.
20. Install the rotor and the distributor cap.
21. Check and adjust (if necessary) the centrifugal advance mechanism.

#### NEW SHAFT AND GEAR

The shaft and gear are replaced as an assembly. One part should not be replaced without replacing the other.

1. Follow steps 1, 2, 3 and 4 under "Installing Original Shaft and Gear Conventional Ignition System Distributor."
2. Insert a .024-inch feeler gauge between the collar and distributor base. Slide the collar on the shaft. While holding the collar in place against the distributor base, drill a 1/8-inch hole through the shaft using the hole in the collar as a pilot. Remove the feeler gauge.
3. Position the gear on the end of the shaft. Install the assembly in a press.
4. With the backing screw on the support tool tightened enough to remove all end play, press the gear on the shaft to the specified distance from the bottom face of the gear to the bottom face of the distributor mounting flange. Drill a 1/8-inch hole through the shaft using the hole in the gear as a pilot.
5. Remove the distributor from the press. Install the collar retaining pin and the gear retaining pin.
6. On a conventional ignition system distributor, complete the assembly by following steps 10 thru 21 under "Bench Assembly Original Shaft and Gear."

**MAJOR REPAIR OPERATIONS (Continued)****MECHANICAL OPERATION**

1. Turn the switch to the SET position.
2. Adjust the SET TACH control so that tachometer pointer is on the SET line.
3. Turn the switch to the SYNC position and check to make sure that the drive chuck is securely tightened on the distributor shaft.
4. Turn the motor switch to the left for 8 cylinder setting.
5. Adjust the speed control to vary the distributor speed between 400 and 4000 engine rpm, or at the maximum speed of the engine on which the distributor is used. Erratic or thin faint flashes of light preceding the regular flashes as the speed of rotation is increased can be due to weak breaker arm spring tension or binding of the breaker arm on the pivot pin.
6. Operate the distributor at approximately 2500 engine rpm and move the protractor scale so that the zero degree mark on the scale is opposite one of the neon flashes. The balance of all the flashes should come within 1 degree, plus or minus, evenly around the protractor scale. A variation larger than 1 degree or erratic or wandering flashes may be caused by a worn cam or distributor shaft or a bent distributor shaft.

**DWELL ANGLE**

1. Turn the switch to the CAM position. Operate the distributor at about 1000 rpm.
2. Turn the test selector switch to the cam angle position and operate the distributor at approximately 1000 engine rpm.
3. Adjust the breaker point gap until the dwell angle is to specifications.

**DISTRIBUTOR SPARK ADVANCE TEST**

The spark advance is checked to determine if the ignition timing advances in proper relation to engine speed and load.

1. Check the contact dwell. If the contact dwell or the breaker point gap is not within specifications, adjust the breaker points.
2. Check the breaker arm spring tension and adjust it, if necessary.

**CENTRIFUGAL ADVANCE**

1. Set the test set to 0 degree advance and the initial rpm setting listed in the specifications.
2. Operate the distributor in the direction of rotation and slowly increase the rpm to the setting specified for the first advance reading listed in the specifications.

If the correct advance is not indicated at this rpm, stop the distributor and bend one spring adjustment bracket to change its tension. Bend the adjustment bracket away from the distributor shaft to decrease advance (increase spring tension) and toward the shaft to increase advance (decrease spring tension). After the adjustment is made, identify the bracket.

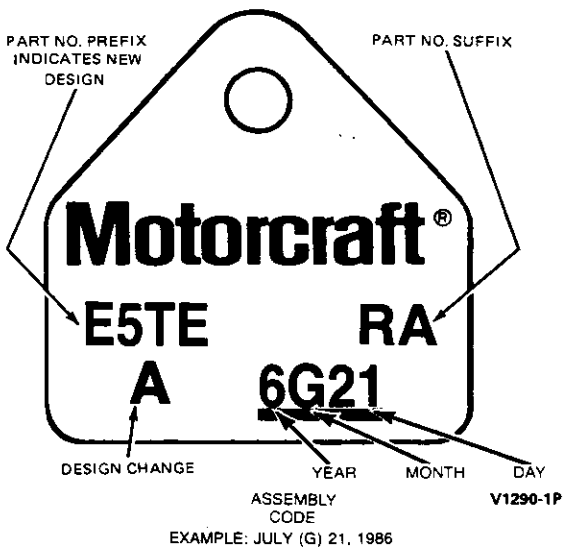
3. After an adjustment has been made to one spring, check the minimum advance point again.
4. Operate the distributor at the specified rpm to give an advance just below the maximum. If this advance is not to specifications, stop the distributor and bend the other spring bracket to give the correct advance.
5. Check the advance at all rpm settings listed in the specifications. Operate the distributor both up and down the rpm range.

# Part 3 — Fuel System

SUBJECT	PAGE	SUBJECT	PAGE
<b>IDENTIFICATION</b> .....	3-01	<b>MODEL 2300 2-V CARBURETOR (Cont'd)</b>	
<b>DESCRIPTION</b> .....	3-01	Adjustments .....	3-09
<b>DIAGNOSIS AND TESTING</b>		Removal and Installation .....	3-12
General Information .....	3-02	Disassembly and Assembly .....	3-13
Charts .....	3-02	Cleaning & Inspection .....	3-15
Pressure and Capacity (Volume) Testing .....	3-04	<b>MODEL 4160 CARBURETOR SYSTEMS</b>	
<b>REMOVAL AND INSTALLATION</b>		Primary Systems .....	3-20
Fuel Pump Assembly .....	3-04	Secondary Systems .....	3-26
<b>MODEL 2300 2-V CARBURETOR</b>		Secondary Fuel Metering Systems .....	3-26
Description .....	3-05	Service Procedures .....	3-28
Carburetor Systems .....	3-06	Carburetor Adjustments .....	3-34

## IDENTIFICATION

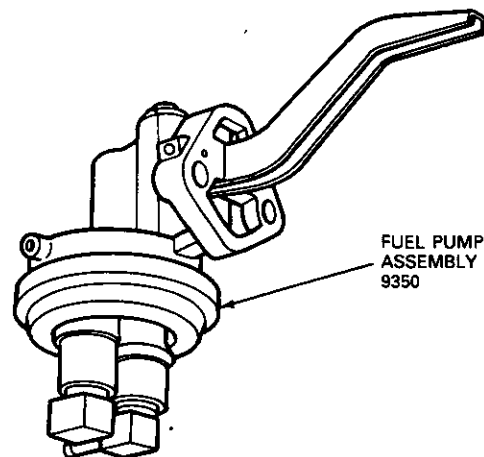
The carburetor identification tag is attached to the body of the carburetor. The basic part number for all carburetors is 9510. To procure replacement parts, it is necessary to know the part number prefix and suffix.



## DESCRIPTION

The fuel pump is bolted to the left side of the cylinder front cover. It is mechanically operated by an eccentric bolted to the end of the camshaft. The pump rocker arm riding against the eccentric provides the diaphragm up and down pumping motion.

The fuel pump cannot be disassembled for repairs and must be replaced if testing indicates it is not within performance specifications.



V5424-1A

**WARNING: DO NOT SMOKE OR CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE PERSONAL INJURY.**

## DIAGNOSIS AND TESTING

### GENERAL INFORMATION

Water and dirt that accumulate in the fuel tank can cause a restricted fuel line or filter and malfunction of the fuel pump or carburetor. Condensation, which is the greatest source of water entering the fuel tank, is formed by moisture in the air when it strikes the cold interior walls of the fuel tank.

If the accumulation of dirt and water in the filter is excessive, the fuel tank should be removed and flushed, and the line from the fuel pump to the tank should be blown out.

Air leakage in the fuel inlet line can cause low fuel pump pressure and volume.

A restricted fuel tank vent can cause low fuel pump pressure and volume and can result in collapsed inlet hoses or a collapsed fuel tank.

Low pressure is the most likely fuel pump trouble that will affect engine performance. Low pressure will cause a lean mixture and fuel starvation at high speeds.

Dirt accumulation in the fuel and air passages, improper idle adjustments, and improper fuel level are the major sources of carburetor troubles.

CONDITION	PROBABLE CAUSE
Low Fuel Pump Pressure	<ul style="list-style-type: none"> <li>● Diaphragm stretched or leaking.</li> <li>● Fuel pump diaphragm spring is weak.</li> <li>● Cam eccentric worn or undersize.</li> <li>● Fittings loose or cracked.</li> <li>● Fuel pump screen clogged.</li> <li>● Fuel line cracked or broken.</li> <li>● Fuel pump valves seating improperly.</li> <li>● Dirt in fuel tank and/or lines.</li> <li>● Fuel tank vent restricted.</li> <li>● Diaphragm ruptured.</li> </ul>
Low Fuel Pump Volume with Normal Pressure	<ul style="list-style-type: none"> <li>● Fuel filter clogged.</li> <li>● Fuel pump to carburetor inlet line obstructed, crimped or leaks.</li> <li>● Restriction in fuel supply line to fuel pump.</li> </ul>
Fuel Pump Leaks	<ul style="list-style-type: none"> <li>● Diaphragm defective. Fittings loose.</li> </ul>
Fuel Pump Leaks Oil	<ul style="list-style-type: none"> <li>● Fuel pump retaining bolts loose.</li> <li>● Mounting gasket defective.</li> </ul>
Fuel Tank and/or Inlet Line Hoses Collapsed	<ul style="list-style-type: none"> <li>● Fuel tank vent restricted.</li> </ul>
Flooding or Leaking Carburetor	<ul style="list-style-type: none"> <li>● Cracked carburetor body.</li> <li>● High fuel level or float setting.</li> <li>● Fuel inlet needle not seating properly or worn needle and/or seat.</li> <li>● Excessive fuel pump pressure.</li> </ul>
Hard Starting	<ul style="list-style-type: none"> <li>● Improper starting procedure causing a flooded engine.</li> <li>● Improper carburetor fuel level.</li> <li>● Improper idle adjustments.</li> <li>● Sticking or incorrectly seating fuel inlet needle.</li> <li>● Incorrect fuel pump pressure.</li> <li>● Dirty air cleaner element.</li> </ul>
Stalling	<ul style="list-style-type: none"> <li>● Incorrect idle fuel mixture.</li> <li>● Engine idle speed too slow.</li> <li>● Dirt, water or ice in fuel filter.</li> <li>● Fuel lines restricted or leaking air.</li> <li>● Fuel tank vent restricted.</li> <li>● Leaking intake manifold or carburetor gaskets.</li> <li>● Carburetor icing (cold, wet or humid weather).</li> <li>● Incorrect throttle linkage adjustment to carburetor.</li> <li>● Clogged air bleeds or idle passages.</li> <li>● Defective fuel pump.</li> <li>● Excessive looseness of throttle shaft in bore(s) of throttle body.</li> </ul>

## DIAGNOSIS AND TESTING (Continued)

CONDITION	PROBABLE CAUSE			
Rough Idle	<ul style="list-style-type: none"> <li>● Incorrect idle mixture adjustment.</li> <li>● Idle adjusting needle(s) grooved, worn, or otherwise damaged.</li> <li>● Idle air bleeds restricted.</li> <li>● Accelerating pump discharge check valve not seating properly.</li> </ul>			
Poor Acceleration	<ul style="list-style-type: none"> <li>● Idle air or fuel passages restricted.</li> <li>● Idle discharge holes restricted.</li> <li>● Excessive dirt in air cleaner.</li> <li>● High or low float setting.</li> </ul> <ul style="list-style-type: none"> <li>● Poor acceleration complaints fall under one of three headings: the engine is sluggish on acceleration, the engine stalls when accelerated, or the engine hesitates or develops a flat spot when accelerated. Poor acceleration is caused by either an excessively lean or rich mixture on acceleration and/or defects of improper adjustments in the ignition system.</li> </ul> <table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>A LEAN MIXTURE CAN BE CAUSED BY:</p> <ul style="list-style-type: none"> <li>● Low fuel pump pressure.</li> <li>● Sticking fuel inlet needle.</li> <li>● Low fuel level or float setting.</li> <li>● Restriction in main fuel passage.</li> <li>● Air leak between the carburetor and the manifold caused by loose mounting bolts or defective gasket.</li> <li>● Air leak at the throttle shaft caused by a worn throttle shaft.</li> </ul> </td> <td style="width: 50%; vertical-align: top;"> <p>A RICH MIXTURE CAN BE CAUSED BY:</p> <ul style="list-style-type: none"> <li>● High fuel level or float setting.</li> <li>● Fuel inlet needle not seating properly or worn needle and/or seat.</li> <li>● Excessively dirty air cleaner.</li> <li>● Incorrect accelerating pump stroke adjustment.</li> <li>● Restricted air bleeds.</li> <li>● Worn or damaged main metering jet.</li> <li>● Accelerating pump outlet valve not seating properly.</li> </ul> </td> </tr> </table>		<p>A LEAN MIXTURE CAN BE CAUSED BY:</p> <ul style="list-style-type: none"> <li>● Low fuel pump pressure.</li> <li>● Sticking fuel inlet needle.</li> <li>● Low fuel level or float setting.</li> <li>● Restriction in main fuel passage.</li> <li>● Air leak between the carburetor and the manifold caused by loose mounting bolts or defective gasket.</li> <li>● Air leak at the throttle shaft caused by a worn throttle shaft.</li> </ul>	<p>A RICH MIXTURE CAN BE CAUSED BY:</p> <ul style="list-style-type: none"> <li>● High fuel level or float setting.</li> <li>● Fuel inlet needle not seating properly or worn needle and/or seat.</li> <li>● Excessively dirty air cleaner.</li> <li>● Incorrect accelerating pump stroke adjustment.</li> <li>● Restricted air bleeds.</li> <li>● Worn or damaged main metering jet.</li> <li>● Accelerating pump outlet valve not seating properly.</li> </ul>
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Inconsistent Engine Idle Speed	<ul style="list-style-type: none"> <li>● Incorrect throttle linkage adjustment to carburetor.</li> <li>● Governor not adjusted properly or faulty.</li> <li>● Binding or sticking throttle linkage.</li> <li>● Sticking carburetor throttle shaft.</li> </ul>			
Surging Above Idle Speed	<ul style="list-style-type: none"> <li>● Excessive looseness of throttle shaft in bores of throttle body.</li> <li>● Incorrectly installed throttle plates.</li> <li>● Sticking fuel inlet needle.</li> </ul>			
Surging Above Idle Speed	<ul style="list-style-type: none"> <li>● Clogged main jets.</li> <li>● Improper size main jets.</li> <li>● Low fuel level or float setting.</li> <li>● Low fuel pump pressure or volume.</li> </ul>			
Reduced Power Output	<ul style="list-style-type: none"> <li>● Clogged fuel filter or fuel pump filter screen.</li> <li>● Distributor vacuum passage clogged.</li> </ul>			
Reduced Power Output	<ul style="list-style-type: none"> <li>● Float setting too high or too low.</li> <li>● Fuel pump pressure too low.</li> <li>● Improper size or obstructed main jets.</li> <li>● Restricted air bleeds.</li> </ul>			
	<ul style="list-style-type: none"> <li>● Restriction in main fuel passages.</li> <li>● Excessive dirt in air cleaner.</li> <li>● Throttle plate not fully open.</li> <li>● Faulty choke operation.</li> <li>● Improper throttle linkage or governor adjustment.</li> </ul>			

## DIAGNOSIS AND TESTING (Continued)

### PRESSURE AND CAPACITY (VOLUME) TESTING

To determine that the fuel pump is in satisfactory operating condition, tests for both fuel pump pressure and fuel pump capacity (volume) should be performed.

The tests are performed with the fuel pump installed on the engine and the engine at normal operating temperature at idle speed.

**Before the tests, make sure the replaceable fuel filter has been changed within the recommended maintenance interval. When in doubt, install a new filter.**

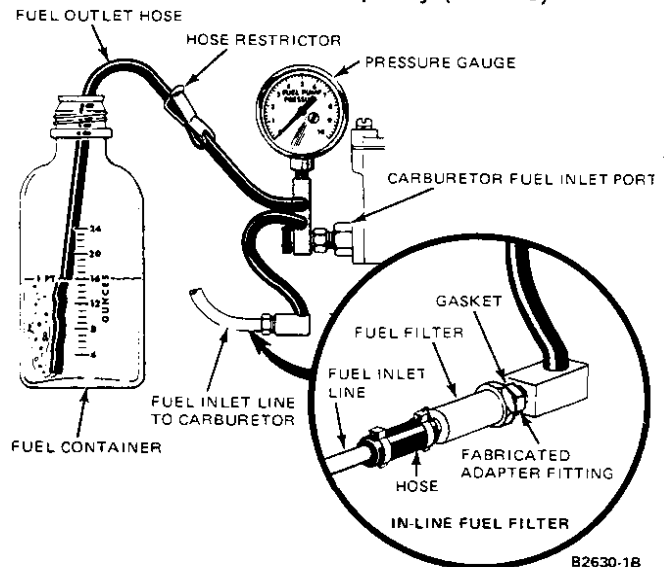
#### Pressure Tests

Refer to the fuel pump specification and note the fuel pump pressure and capacity (volume) design tolerances.

1. Remove the air cleaner assembly. Disconnect the fuel inlet line or the fuel filter at the carburetor. **Use care to prevent combustion due to fuel spillage.**
2. Connect a pressure gauge, a restrictor and a flexible hose between the fuel filter and the carburetor. **NOTE: Inside diameter of smallest passage in test flow circuit must not be smaller than .220.**
3. Position the flexible fuel outlet hose and the restrictor so the fuel can be discharged into a suitable graduated container.
4. Before taking a pressure reading, operate the engine at the specified idle RPM and vent the system into the container by opening the hose restrictor momentarily.
5. Close the hose restrictor, allow the pressure to stabilize, and note the reading. (Refer to the Specifications in Part 8).

If the pump pressure is not within specifications, and the fuel lines and filter are in satisfactory condition, the pump should be replaced.

If the pump pressure is within specifications, perform the tests for fuel capacity (volume).



#### Capacity (Volume) Test

With the fuel pump pressure within specifications, test the capacity (volume) as follows:

1. Operate the engine at the specified idle RPM.
2. Open the hose restrictor and expel the fuel into the container, while observing the time required to expel one pint. Close the restrictor. One pint or more of fuel should be expelled within the specified time limit.

If the pump volume is below specifications, repeat the test using an auxiliary fuel supply and a new fuel filter. If the pump volume meets specifications while using the auxiliary fuel supply, check for a restriction in the fuel supply from the tank and for the tank not venting properly.

## REMOVAL AND INSTALLATION

### FUEL PUMP ASSEMBLY

#### Removal

1. Disconnect the inlet and outlet lines at the fuel pump.
2. Remove the pump attaching screws, then remove the pump and the gasket. Discard the gasket.

#### Installation

1. Remove all the gasket material from the mounting pad and pump flange. Apply oil-resistant sealer to both sides of a new gasket and to the threads on the attaching bolts.
2. Position the new gasket on the pump in position against the mounting pad. Make sure the rocker arm is riding on the camshaft eccentric. (Turn the engine over until the fuel pump eccentric is on the low side of the stroke.)
3. Press the pump tight against the pad, install the attaching screws and alternately tighten them to specifications.
4. Connect the fuel inlet and outlet lines.
5. Operate the engine and check for leaks.

## MODEL 2300 2-V CARBURETOR

### DESCRIPTION

The Model 2300 2-V carburetor has four main assemblies. They are the main body, throttle body, metering block and the fuel bowl.

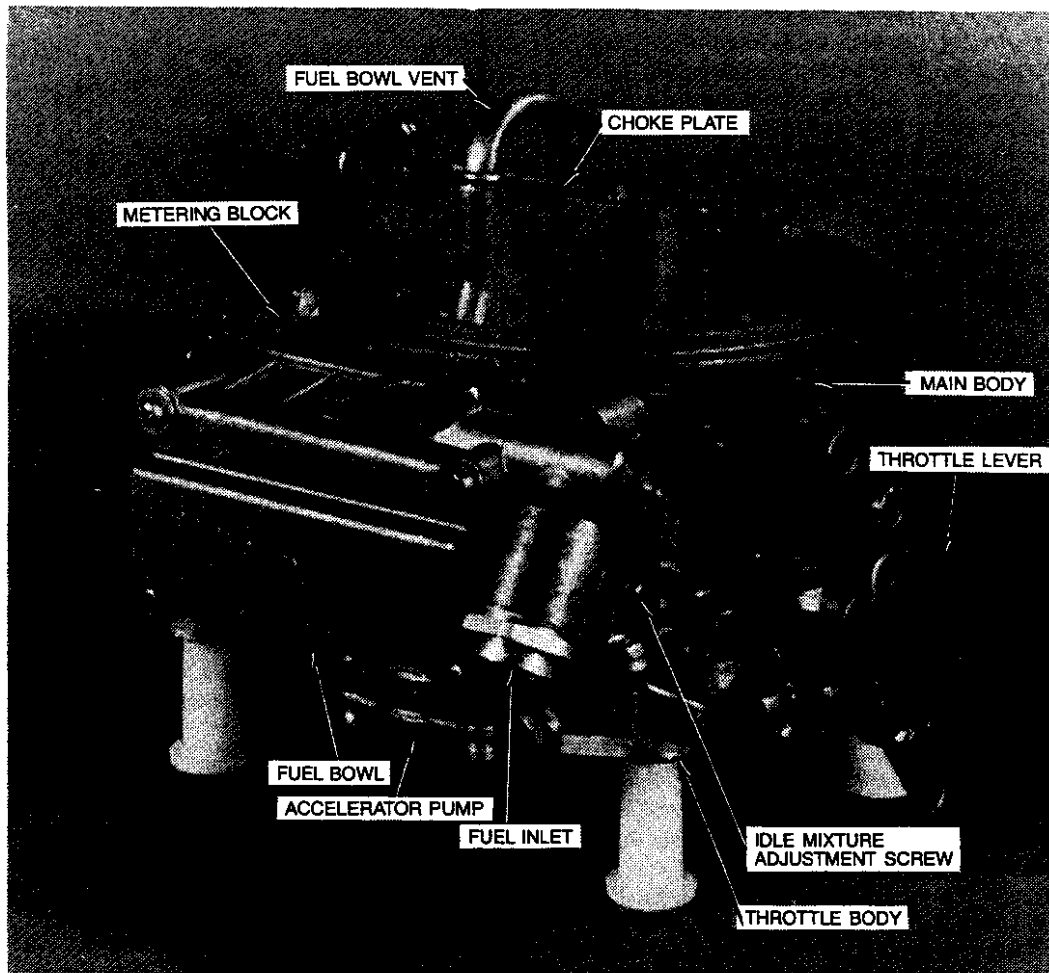
The air horn assembly is part of the main body. On top of the air horn is the choke plate, and below the choke plate are the primary and booster venturis. Within the venturis are the main and accelerating pump discharge nozzles. On the side of the main body is the choke assembly.

Found below the main body is a separate assembly called the throttle body. Located inside the throttle body are the throttle plates and throttle shaft. The throttle lever is connected to the

throttle shaft. Connected to the throttle body is the accelerating pump operating lever and the idle speed adjustment screw.

The metering block is connected to the side of the main body. Inside the metering block are the main jets, the power valve, and the various fuel and air passages and restrictions. The idle mixture adjusting screws are found on the side of the metering block.

Connected to the metering block on the main body is the fuel bowl assembly. Inside the fuel bowl are the fuel inlet screen, fuel inlet needle and seat assembly, float and lever assembly, and accelerating pump. Found on some models are a sight plug and an adjusting nut for the float level.



## MODEL 2300 2-V CARBURETOR (Continued)

### CARBURETOR SYSTEMS

The Holley Model 2300 two-barrel carburetor uses four systems to provide carburetion. Together these four systems vaporize and meter fuel into the proper air/fuel mixture for every mode of engine operation. The four systems are: idle, accelerating pump, main metering and power system. Two other systems, fuel inlet and choke, supplement these systems.

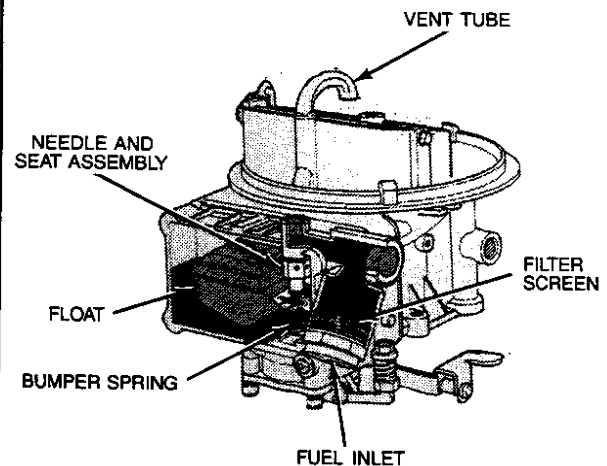
The two-barrel system can be thought of as two carburetors working for the same purpose. Each barrel can be thought of as a single carburetor by itself. Each system works identical to its counterpart in the other barrel.

The idle system provides a reasonably rich mixture for smooth engine idling speed and a transfer system that is in operation during low speeds. The main metering system provides the proper mixture for normal cruising conditions. The accelerator pump system mechanically supplies additional fuel during acceleration. The power enrichment system provides a richer mixture when high power output is desired. Each of these systems is constantly supplied with fuel by the fuel inlet system.

A choke system provides a rich mixture to start the engine when cold and a slightly richer than normal mixture for cold engine operation. The 2300 carburetor is equipped with a manual choke or an electrically heated automatic choke.

### FUEL INLET SYSTEM

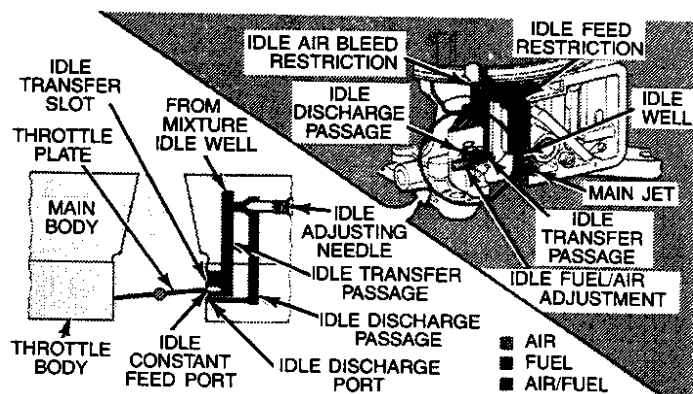
All fuel enters the fuel inlet through pressure supplied by the fuel pump. Fuel passes from the fuel inlet through the filter screen, past the needle and seat assembly, and into the fuel bowl. As the fuel level in the fuel bowl rises, so does the float level in the fuel bowl rises, so does the float assembly. But as the float rises it tends to close the needle and seat assembly, restricting the amount of fuel flowing into the fuel bowl. As the fuel is used, the float drops and the needle valve leaves the seat, allowing more fuel to enter the fuel bowl, but only enough fuel to raise the float to its proper level. A bumper spring is placed under the float hinge to stabilize the movement of the float assembly. The fuel bowl is vented internally through the vent tube.



### IDLE FUEL SYSTEM

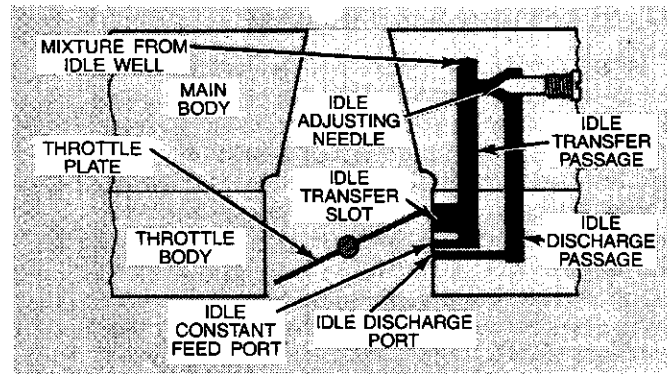
From the fuel bowl, fuel flows through the main jet into a small, angular, horizontal idle feed passage that leads to a vertical idle well passage. Flowing up this idle well passage, fuel passes through the idle feed restriction. After this passage, the fuel flows through another horizontal passage and at the end of this passage is mixed with incoming air from the idle air bleed. The air/fuel mixture then flows down another vertical passage to the bottom of the main body, where it splits into two directions. One direction goes to the idle discharge passage, the other to the idle transfer passage and constant feed port. The mixture flowing down the passages leading to the idle discharge passage flows past the pointed tip of the idle mixture adjustment needle screw. From here, the air/fuel mixture goes down a short passage in the main body and down another passage into the throttle body, where it is discharged in the throttle bore below the closed throttle plate. In the passages leading to the idle transfer passage and constant

feed port, the air/fuel mixture flows unrestricted. The mixture exits through the idle constant feed port. When the throttle plate is closed, no fuel is discharged through the idle transfer slot. At this point the function of the transfer slot is to act as an air bleed directly above the idle constant feed port and to further lean out the air/fuel mixture.



## MODEL 2300 2-V CARBURETOR (Continued)

As more engine speed is desired, the movement of the accelerator linkage causes the throttle plate to open. When the throttle plate is opening, the idle transfer slot is exposed to manifold vacuum, causing fuel to be discharged from the transfer slot. As the throttle plate opens more, engine speed increases, thus increasing the air flow through the carburetor. The air flow is increased further by the effect of the venturi. With the resulting increases in air flow, the main metering system comes into operation with idle system tapering off. Thus a smooth, gradual transition is made from idle to operating speeds.

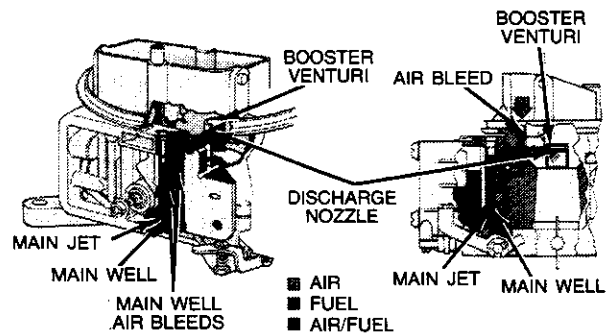


### MAIN METERING SYSTEM

In the main metering system, with the throttle partly opened, fuel flows from the fuel bowl through the main jet. The main jet meters the fuel into the main well. From the main well, fuel flows past the main well air bleeds, where it becomes mixed with air. The air/fuel mixture continues up the main well, passing through horizontal passages in the body, and exiting through a horizontal channel to the discharge nozzle in the booster venturi. The air/fuel mixture is now mixed with the incoming air.

Filtered air enters through the high speed air bleed in the air horn of the main body, and then enters the main metering body through interconnecting passages. Because the air/fuel mixture is lighter than liquid fuel, it responds faster to changes in venturi vacuum and vaporizes more

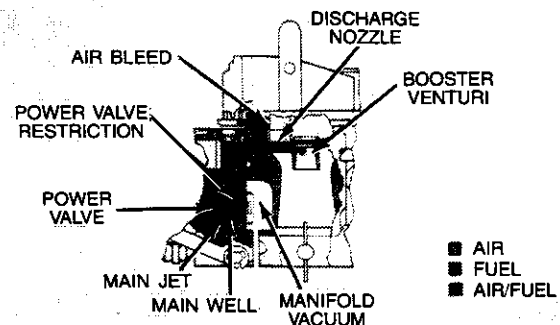
easily when discharged into the airstream. The amount of air/fuel mixture flowing to the intake manifold is regulated by the throttle plate position, which also regulates the engine speed and power output.



### POWER FUEL SYSTEM

During high power operation, the increased air flow down the air horn tends to lean out the air/fuel mixture. Additional fuel is required to enrich the air/fuel mixture. The needed additional fuel is supplied by the power fuel system, which is regulated by manifold vacuum. Vacuum to actuate the power valve, found in the metering block, is supplied through passages in the throttle body and main body. At idle speed or under normal load, the vacuum supplied to the power valve is sufficient to overcome the spring pressure acting on the power valve diaphragm; thus the vacuum holds the power valve closed. At high speed operation, manifold vacuum drops; thus the spring in the power valve forces the valve to open, allowing fuel to flow. The path of the fuel is through the power valve, then through the diagonal restrictions in the metering block, and finally into the main well, where it joins the main fuel flow and enriches the mixture.

When engine speed is reduced, manifold vacuum once again increases. This vacuum acts on the power valve diaphragm to overcome spring pressure. The power valve then shuts off the added supply of fuel which is no longer required.

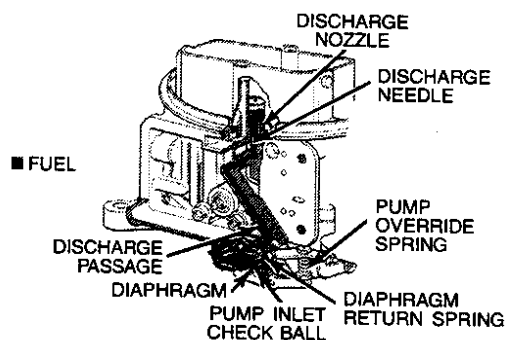


## MODEL 2300 2-V CARBURETOR (Continued)

### ACCELERATING PUMP SYSTEM

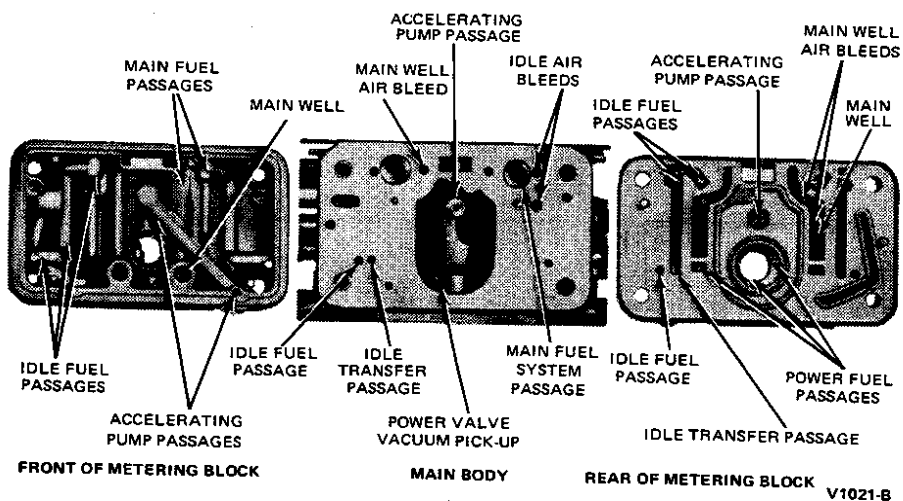
When the throttle plates are opened suddenly as during quick acceleration, the air flow down the venturi responds almost immediately and is rapidly increased. Fuel responds more slowly to this increased air flow since it is heavier than air. This difference in response must be compensated for or a too-lean mixture would result and the engine would hesitate. The accelerating pump system corrects this problem. It mechanically supplies fuel until the other metering systems are able to supply enough fuel to maintain a proper mixture.

The accelerating pump is a diaphragm-type pump which is located in the bottom of the fuel bowl. When the throttle is opened, the pump linkage is actuated by a cam on the throttle lever, and forces the pump diaphragm upward. When the diaphragm moves up, fuel pressure forces the pump inlet check ball, or valve, onto its seat, preventing fuel flow back into the fuel bowl. The diaphragm pressure also forces fuel through a short passage in the fuel bowl, and into the long, diagonal passage in the metering body. It then flows into the main body passage to the pump discharged chamber. Fuel pressure causes the discharge needle to unseat and fuel is discharged into the venturi.



When the accelerator is moved rapidly the throttle plates go to the wide-open position, the pump override spring is compressed and allows the full pump travel, by applying pressure to maintain the pump discharge. Without this pump override spring, the pump linkage would be bent or broken because fuel, being a liquid, is essentially incompressible.

As the throttle moves to the closed position, the accelerating pump linkage returns to its original position and the diaphragm return spring pulls the diaphragm back to its original position. The pump inlet check ball is again unseated and fuel flows from the fuel bowl into the accelerating pump chamber.



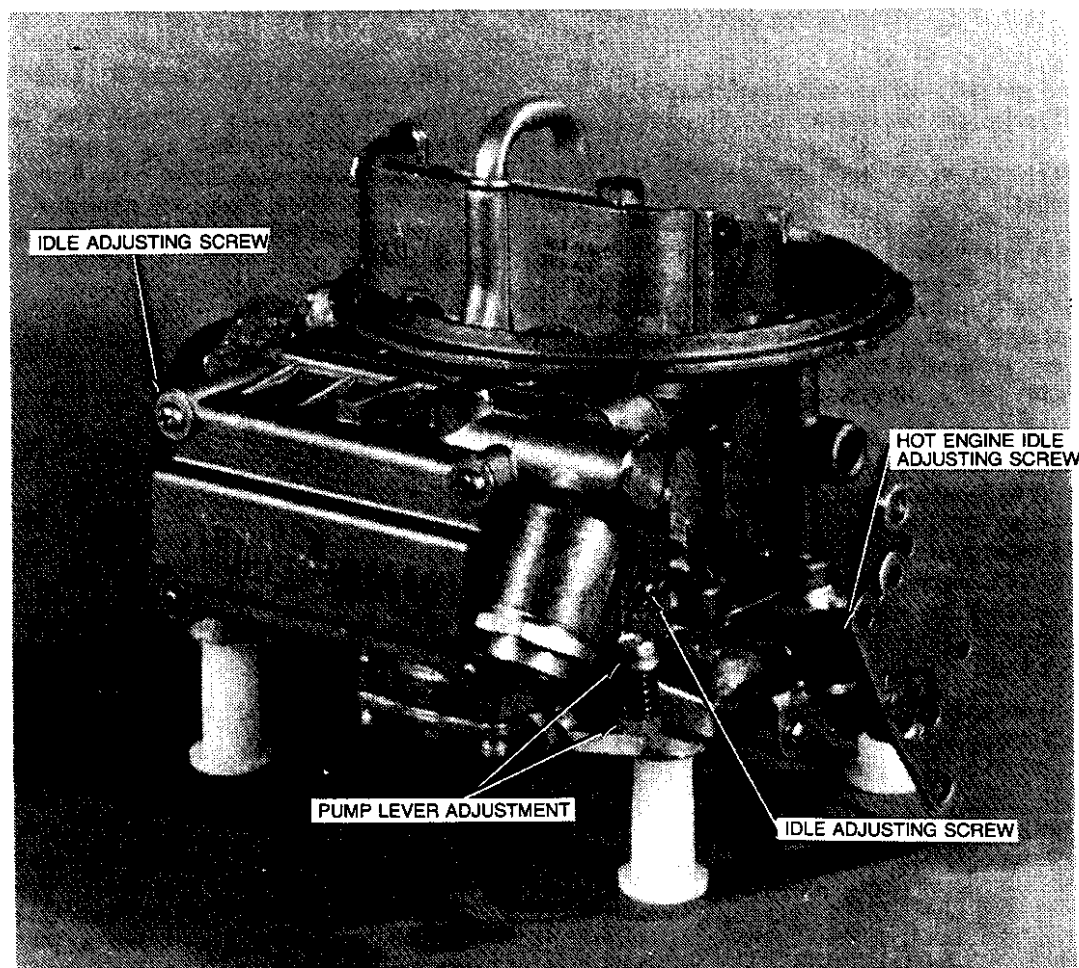
**MODEL 2300 2-V CARBURETOR (Continued)****ADJUSTMENTS****IDLE MIXTURE ADJUSTMENT**

Connect tachometer to engine; tachometer should have 1% to 2% accuracy and an expanded scale of 0-1000 RPM or 400-800 RPM.

1. Adjust idle mixture screws fully in until they are lightly seated. Back them out 1-1/2 revolutions. This will provide sufficient adjustment to be able to start the engine.
2. Be sure the engine is thoroughly warmed up. Adjust the curb idle speed to specification by turning the throttle stop screw "in" to

raise idle speed, or "out" to decrease idle speed.

3. Turn the idle mixture adjustment screws inward until the engine speed begins to drop due to a lean mixture. Next, turn the screws outward until the engine speed begins to drop due to an excessively rich mixture. Then turn the screws inward to a point between these two extremes to obtain maximum engine smoothness and RPM.
4. Reset idle speed to specifications.
5. Recheck idle mixture adjustment and reset if necessary.



## MODEL 2300 2-V CARBURETOR (Continued)

### ERRATIC ENGINE IDLE

If the engine idle is erratic or rough after correct idle adjustment, check the following items:

1. Recheck spark plugs and spark plug wires. Be sure all cylinders are firing. A missing cylinder or occasional misfire will turn an engine that is a minor emitter into a gross emitter.
2. Check for vacuum leaks (vacuum lines or manifold).

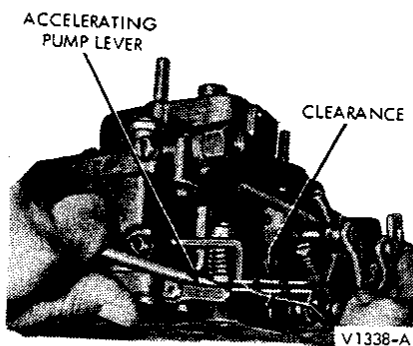
### LOW IDLE SPEED ADJUSTMENT

With engine at correct operating temperature and condition as in above procedure and curb idle adjusted to specifications, proceed as follows:

1. Set the low idle speed to specifications by adjusting the low idle speed adjusting screw.

### ACCELERATING PUMP LEVER ADJUSTMENT

1. Using a feeler gauge and with the throttle plates in the wide open position, there should be .015 inch clearance between the accelerating pump operating lever adjustment screw head and the pump arm when the pump arm is depressed manually.
2. If adjustment is required, loosen the adjusting screw lock nut and turn the adjusting screw in to increase the clearance and out to decrease the clearance. **One half turn of the adjusting screw is equal to approximately 0.015 inch.** When the proper adjustment has been obtained hold the adjustment screw in position with a wrench and tighten the lock nut.
3. Perform an accelerating pump stroke adjustment, if required.



### ACCELERATING PUMP STROKE ADJUSTMENT

The accelerating pump stroke has been set to help keep the exhaust emission level of the en-

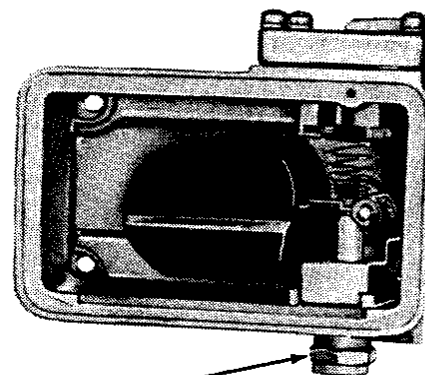
gine within the specified limits. The additional holes provided for pump stroke adjustment are for adjusting the stroke for specific engine applications. **The stroke should not be changed from the original setting.**

If the pump stroke has been changed from the specified setting, refer to the following instructions to correct the stroke to specifications.

If a change in the adjustment is required, make certain the proper hole (top or bottom) in plastic accelerating pump cam, located behind the throttle lever, is properly aligned (indexed) with the numbered hole (top or bottom) in the throttle lever before installing the retaining screw.

### FUEL LEVEL FLOAT ADJUSTMENT — DRY

On the externally adjusted fuel inlet needle and seat, the dry float adjustment is a preliminary fuel level adjustment only. The final adjustment (Fuel Level Float Adjustment — Wet) must be performed after the carburetor is installed on the engine.



TURN ADJUSTING NUT UNTIL FLOAT IS PARALLEL WITH TOP OF BOWL (HOLDING BOWL UPSIDE DOWN)

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On the internally adjusted fuel level, the dry adjustment is the only one made. With the fuel bowl and float assembly removed, adjust the float so that the float is parallel to the fuel bowl, with the top of the fuel bowl inverted.

On the externally adjusted fuel inlet needle and seat, turn the adjusting nut to make the adjustment.

On the internally adjusted fuel level, bend the float arm to make the adjustment.

With the fuel bowl and float assembly removed, adjust the float so that the float is parallel to the fuel bowl, with the top of the fuel bowl inverted.

## MODEL 2300 2-V CARBURETOR (Continued)

### FUEL LEVEL ADJUSTMENT — WET

The fuel pump pressure and volume must be to specifications prior to performing the following adjustments.

1. Operate the engine to normalize engine temperatures and place the engine on a flat surface, as near level as possible. Stop the engine and remove the air cleaner, if it was not previously removed.
2. Check the fuel level in each fuel bowl separately. **Place a suitable container below the fuel level sight plug in the fuel bowl to collect any spillover of fuel. Carefully remove the fuel level sight plug and gasket.**
3. If the fuel level is satisfactory, install the sight plug.
4. If the fuel level is too high, drain the fuel bowl and refill it. To drain the fuel bowl, loosen one lower retaining bolt from the fuel bowl and drain the fuel into a suitable container. Check the fuel level again before altering the float setting. **This will eliminate the possibility of foreign material causing a temporary flooding condition. Install the bolt and the fuel level sight plug, and start the engine to fill the fuel bowl. After the fuel level has stabilized, stop the engine and check the fuel level.**

**If the fuel level is still too high, it should first be lowered below specifications and then raised until it is just at the lower edge of the sight plug opening. If the fuel level is too low, it is only necessary to raise it to the specified level. Follow the procedure under To Lower Fuel Level or To Raise Fuel Level, whichever is applicable.**

#### To Lower Fuel Level

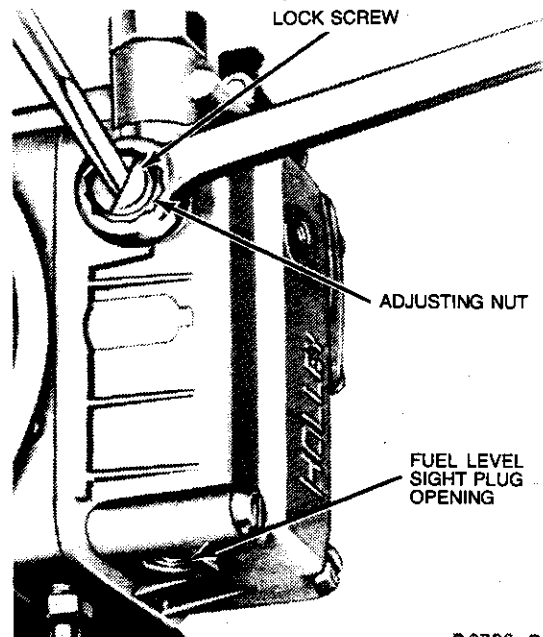
1. With the engine stopped, loosen the lock screw on top of the fuel bowl just enough to allow rotation of the adjusting nut underneath. **Do not loosen the lock screw or attempt to adjust the fuel level with the sight plug removed and the engine running because the pressure in the line will spray fuel out and present a fire hazard.**
2. Turn the adjusting nut approximately 1/2 turn in to lower the fuel level below specifications (1/6 turn of the adjusting nut, depending on the direction of rotation, will raise or lower the float assembly at the fuel level sight plug opening 3/64 inch).
3. Tighten the lock screw and install the fuel level sight plug. Start the engine. After the fuel level has stabilized, stop the engine and

check the fuel level at the sight plug opening. The fuel level should be below specified limits. If it is not, repeat the previous steps, turning the adjusting nut an additional amount sufficient to lower the fuel below the specified level.

4. Loosen the lock screw and turn the adjusting nut out in increments of 1/6 turn or less until the correct fuel level is achieved. After each adjustment, tighten the lock screw, install the fuel level sight plug, and then start the engine and stabilize the fuel level. Check the fuel level at the sight plug opening. Install the sight plug and gasket.
5. Install the air cleaner if other carburetor adjustments are not required.

#### To Raise Fuel Level

1. With the engine stopped, loosen the lock screw on top of the fuel bowl just enough to allow rotation of the adjusting nut underneath. **Do not loosen the lock screw or attempt to adjust the fuel level with the sight plug removed and the engine running because the pressure in the line will spray fuel out and present a fire hazard.**
2. Loosen the lock screw and turn the adjusting nut out in increments of 1/6 turn or less until the correct fuel level is achieved. After each adjustment, tighten the lock screw, install the fuel level sight plug, and then start the engine and stabilize the fuel level. Check the fuel level at the sight plug opening. Install the sight plug and gasket.
3. Install the air cleaner if other carburetor adjustments are not required.



## MODEL 2300 2-V CARBURETOR (Continued)

### REMOVAL AND INSTALLATION

#### CARBURETOR

##### Removal

1. Remove the air cleaner. Remove the throttle rod from the throttle lever. Disconnect the choke control cable, hand throttle control cable, the distributor vacuum hose and the fuel line.
2. Disconnect the governor throttle control lines or rod at the carburetor (if applicable).
3. Remove the carburetor retaining nuts and lockwashers, then remove the carburetor. Remove the spacer from the manifold.

##### Installation

1. Be sure all old gasket material is removed from the manifold heat riser flange, then place the spacer in position on the manifold. Position the carburetor on the manifold and install the lockwashers and nuts. Tighten the nuts alternately to specification.
2. Connect the throttle rod. Connect the choke control cable. **Be sure the end of the choke cable is bent downward to prevent interference with the bottom of the air cleaner. This interference will restrict opening of the choke plate.** Connect the hand throttle control cable, the distributor vacuum hose, the fuel line, and the governor lines or control rod. Adjust the idle speed, the primary and secondary fuel level, and the idle fuel mixture.

#### FUEL BOWL AND GASKET METERING BLOCK AND GASKET

##### Removal

1. Remove the fuel inlet line and vacuum line.
2. Place a suitable container under the fuel bowl and drain the bowl by loosening one of the lower fuel bowl retaining screws. Remove the container.
3. Remove the four fuel bowl retaining screws.
4. Remove the fuel bowl, gasket and baffle, and metering block and gasket. **Discard the gaskets.**

##### Installation

1. If the fuel bowl or metering block is being replaced, transfer the parts.
2. Position the **new** metering block gasket on the dowels on the back of the metering block.
3. Lay the metering block in place on the main body.
4. Position the baffle and **new** fuel bowl gasket on the metering block.

5. Place the fuel bowl on the metering block. Use **new** compression gaskets on the bowl retaining screws; then install and tighten the screws.

#### POWER VALVE AND GASKET

##### Removal

1. Remove the fuel bowl and metering block.
2. Using a socket wrench, remove the power valve and gasket.
3. **Discard the gasket.**

##### Installation

1. Place a **new** gasket on the specified power valve.
2. Using a socket wrench, install the power valve and gasket.
3. Install the fuel bowl and metering block.

#### MAIN JET

1. Remove the fuel bowl and metering block.
2. Use a jet wrench to remove and install jets.
3. Install the fuel bowl and metering block.

#### ACCELERATING PUMP DIAPHRAGM

##### Removal

1. Remove the fuel bowl and metering block.
2. Remove the accelerating pump cover, diaphragm and spring.

##### Installation

1. Place the spring and diaphragm in the accelerating pump chamber. The diaphragm must be positioned so that the diaphragm disc protrudes from the fuel bowl.
2. Install the cover screws finger tight.
3. Make sure the diaphragm is centered; compress the diaphragm with the pump operating lever and tighten the cover screws.

#### FLOAT

##### Removal

1. Using needle nose pliers, remove the float retainer.
2. Slide the float off the shaft.
3. Remove the spring from the float.

##### Installation

1. Install the float spring on the float.
2. Slide the float on the shaft.
3. Install the float retainer.

## MODEL 2300 2-V CARBURETOR (Continued)

### FUEL INLET NEEDLE AND SEAT

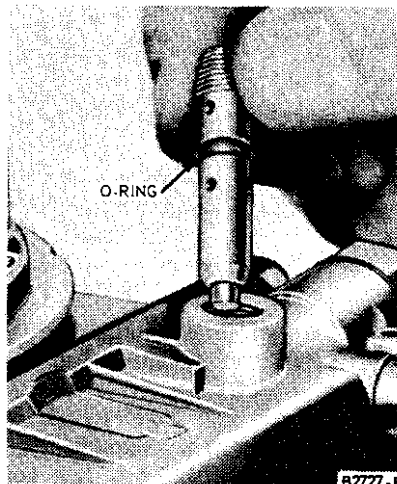
#### Removal

The fuel inlet needle and seat assembly can be replaced without removing the fuel bowl.

1. Remove the air cleaner.
2. Remove the fuel level adjustment lock screw and gasket. Turn the adjusting nut out and remove the adjusting nut and gasket. Remove the fuel inlet needle and seat assembly. **Do not disassemble the fuel inlet needle and seat assembly. They are matched parts and are serviced as an assembly.**

#### Installation

1. Position the fuel inlet needle and seat assembly in the fuel bowl.
2. Position the adjusting nut gasket and nut on the fuel inlet needle and seat assembly. Align the flat on the ID of the nut with the flat on the OD of the fuel inlet needle and seat assembly.



3. Install the fuel level adjustment lock screw and gasket.
4. Adjust the fuel level.

## DISASSEMBLY AND ASSEMBLY

### DISASSEMBLY

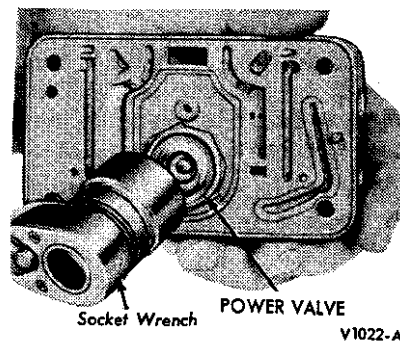
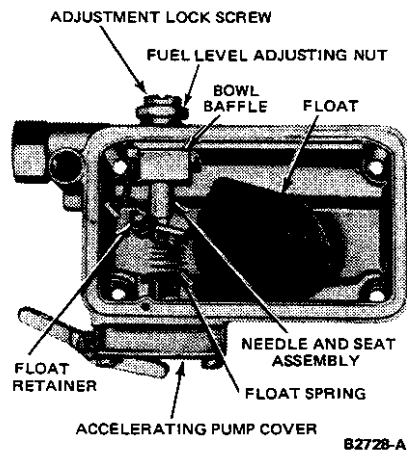
To facilitate working on the carburetor and to prevent damage to the throttle plates, install bolts about 2 1/4 inches long of the correct diameter through the carburetor attaching bolt holes with a nut above and below the flange (or install carburetor legs).

Use a separate container for the component parts of the various assemblies to facilitate cleaning, inspection and assembly.

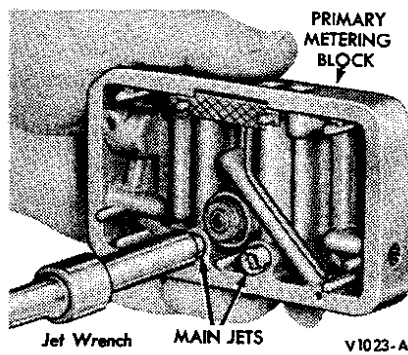
The following is a step-by-step sequence of operations for completely overhauling the carburetor; however, certain components of the carburetor may be serviced without disassembling the entire unit. For a complete carburetor overhaul, follow all the steps. To partially overhaul the carburetor or to install a new gasket kit, follow only the applicable steps.

#### Fuel Bowl and Metering Block

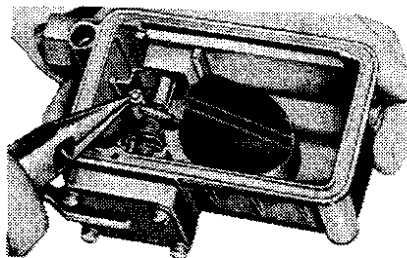
1. Remove the fuel bowl and gasket, and the metering block and gasket. Discard the gaskets.
2. Using a socket wrench, remove the power valve and gasket. Discard the gasket. Using a jet wrench, remove the main jets.



## MODEL 2300 2-V CARBURETOR (Continued)



3. Remove the fuel level adjustment lock screw and gasket. Turn the adjusting nut counterclockwise and remove the lock nut and gasket, and the fuel inlet needle and seat assembly. **Do not disassemble the fuel inlet needle and seat. They are matched, and are replaced as an assembly.**
4. Using needle nose pliers, remove the float retainer.
5. Slide the float off the shaft. Remove the spring from the float.
6. Remove the fuel level sight plug and gasket. Remove the fuel inlet fitting, gasket, and filter screen.
7. Invert the fuel bowl and remove the accelerating pump cover, diaphragm, and spring. The accelerating pump inlet ball check is not removable.



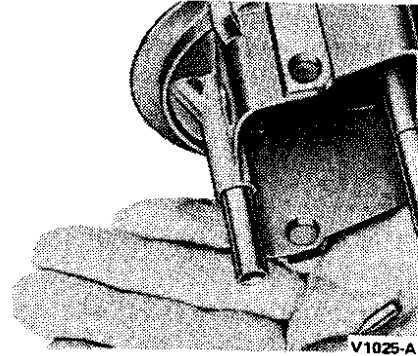
### Main Body

1. Invert the carburetor and remove the throttle body from the main body. Disconnect the choke rod from the choke control shaft lever assembly by pushing the rod toward the main body and releasing it from the lever. Discard the throttle body gasket.
2. Remove choke rod and seal. Unless the choke valve is bent or damaged, **DO NOT** remove.

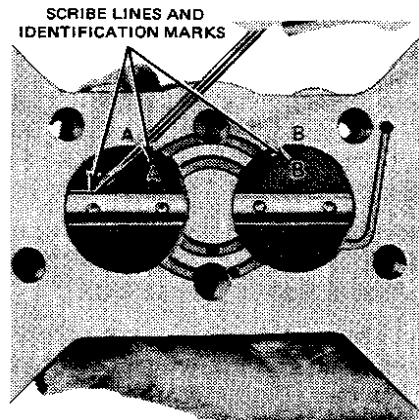
**NOTE:** The choke plate screws are staked to prevent loosening and care is necessary to avoid breaking or stripping the threads in the choke shaft. If necessary to remove plate, re-

move staking with a file before loosening screws.

3. Remove the accelerating pump discharge nozzle from the main body.
4. Invert the main body and let the accelerating pump discharge needle fall into the hand. Remove the throttle operating shaft housing back-up plate and gasket.



5. If it is necessary to remove the throttle plates, lightly scribe both throttle plates along the throttle shaft and mark each throttle plate and its corresponding barrel to insure proper installation. Remove the throttle plates. Remove the retainer from each end of the shaft. Slide the throttle shaft out of the throttle body.



### Throttle Operating Shaft Housing

1. Remove the engine idle speed adjusting screw and spring. Remove the fast idle adjusting pin and screw.
2. Loosen the throttle lever screw. Remove the throttle lever retaining pin. Remove the throttle lever and the accelerating pump cam. Remove the throttle pick-up lever and swivel assembly.
3. Remove the throttle shaft retainer and slide the throttle shaft out of the housing.

## MODEL 2300 2-V CARBURETOR (Continued)

### CLEANING AND INSPECTION

#### CARBURETORS

**WARNING: DO NOT SMOKE, CARRY LIGHTED TOBACCO OR OPEN FLAME OF ANY TYPE WHEN WORKING ON OR NEAR ANY FUEL RELATED COMPONENT. HIGHLY FLAMMABLE MIXTURES ARE ALWAYS PRESENT AND MAY BE IGNITED, RESULTING IN POSSIBLE HUMAN INJURY.**

Dirt, gum, water or carbon contamination in the carburetor or the exterior moving parts of the carburetor are often responsible for unsatisfactory performance. For this reason, efficient carburetion depends upon careful cleaning and inspection.

The cleaning and inspection of only those parts not included in the carburetor overhaul repair kit are covered here. All gaskets and parts included in the repair kit should be installed when the carburetor is assembled and the old gaskets and parts should be discarded.

Wash all parts in clean commercial carburetor cleaning solvent, except all electrical components, the rubber or solid nitrophenyl carburetor float (if so equipped), the accelerator pump diaphragm and the power valve. If a commercial solvent is not available, denatured alcohol may be used.

Rinse the parts in kerosene to remove all traces of the cleaning solvent, and then dry them with compressed air. Wipe all parts that can not be immersed in solvent with a clean, soft, dry cloth. Be sure all dirt, gum, carbon and other foreign matter are removed from all parts.

Check the metal float(s) (if so equipped) for leaks by holding it under water that has been

heated to just below the boiling point. Bubbles will appear if there is a leak. If float leaks, replace it. Replace the float if the arm needle contact point is grooved. If the float(s) is serviceable, polish the needle contact surface of the arm with crocus cloth or steel wool. Replace the float shaft(s) if it is worn.

Force compressed air through all passages of the carburetor. **Do not use a wire brush to clean any parts, or a drill or wire to clean out any openings or passages in the carburetor.** A drill or wire may enlarge the hole or passage, changing the calibration of the carburetor.

Check the choke shaft for grooves, wear, and excessive looseness or binding. Inspect the choke plate for nicked edges and for ease of operation. Free the shaft and plate, if necessary.

Check the throttle shaft(s) in its bore for binding, or excessive looseness. Check the throttle plate(s) for burrs which prevent proper closure.

Inspect the main body, throttle body and metering block, accelerating pump cover, and the secondary diaphragm housing (Holley 4-V carburetor) for cracks.

Replace all screws and nuts that have stripped threads. Replace all distorted or broken springs.

Inspect all gasket mating surfaces for nicks and burrs. Repair or replace any parts that have a damaged gasket surface.

Inspect the main and accelerating pump discharge nozzles and idle restrictions. If any of the openings are blocked, open them with compressed air.

Always replace fuel filter (external) when installing the carburetor.

## MODEL 2300 2-V CARBURETOR (Continued)

### ASSEMBLY

Make sure all holes in the new gaskets have been properly punched and that no foreign material has adhered to the gaskets. Make sure the accelerating pump diaphragm is not torn or cut. An exploded view of the carburetor is shown in this section.

#### Throttle Operating Shaft Housing

Refer to the exploded view for proper location of parts.

1. Slide the throttle operating lever and shaft assembly into the housing. Install the accelerating pump cam in the throttle lever. Position the pick-up lever and swivel assembly on the shaft.
2. Aligning the retaining pin hole in the throttle lever and shaft, position the throttle lever on the shaft. **Be sure the throttle lever can be rotated from the full open position to the full closed position. Install the throttle lever retaining pin. Install the throttle lever screw.**
3. Install the engine idle speed adjusting screw and spring. Install the fast idle adjusting pin and screw.

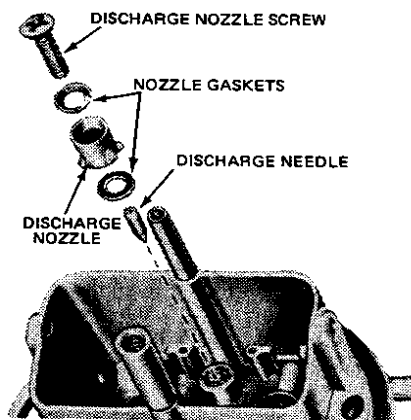
#### Throttle Body

Refer to exploded view for the correct locations of the parts.

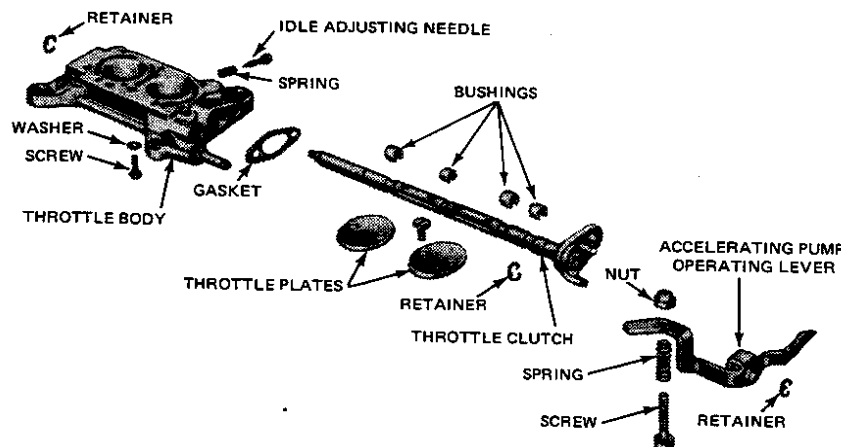
1. If the throttle plates were removed, position the bushings on the throttle shaft and slide them into the throttle body. Install the retainer on each end of the shaft. Referring to the lines scribed on the throttle plates, install the plates in their proper location with the screws snug, but not tight. Close the throttle plates and hold the throttle body up to the light. Little or no light should show between

the throttle plates and the throttle bores. If the throttle plates are properly installed and there is no binding when the throttle shafts are rotated, tighten and stake the throttle plate screws.

2. Position the throttle operating shaft housing back-up plate assembly on the throttle body by sliding them over the clutch lever on the throttle shaft.
3. Insert the throttle operating housing attaching screws in the housing. Slide the housing gasket over the screws.
4. Open the throttle plates and install the throttle operating housing on the throttle body. **If the housing is correctly installed, the throttle lever will close the throttle plates, but will not open them.**
5. Install the accelerating pump lever on the throttle body.
6. Install the idle adjusting needles and springs. Turn the needles in gently until they touch the seat, then back them out 1-1 1/2 turns.



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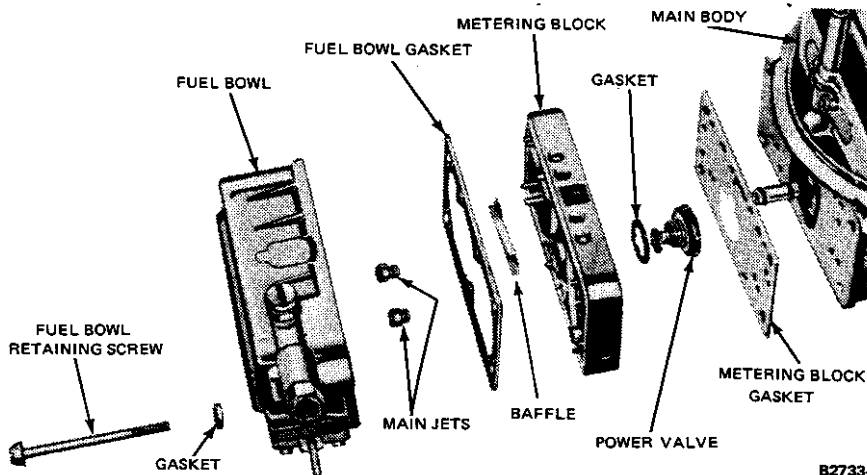
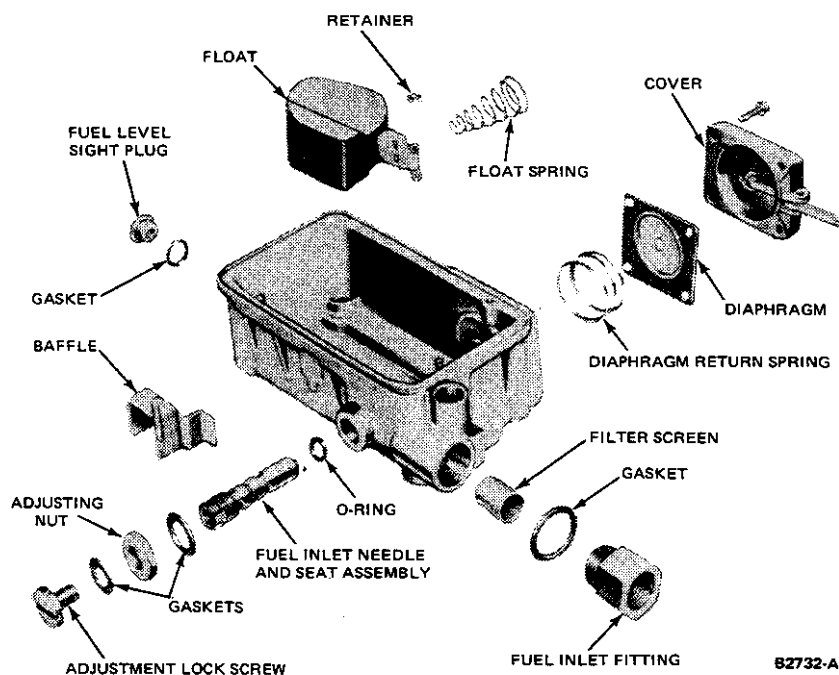


B2731-B

## MODEL 2300 2-V CARBURETOR (Continued)

### Main Body

- Drop the accelerating pump discharge needle into the well. Seat the needle with a brass drift and a light hammer. Make sure it is free. Position the accelerating pump discharge nozzle gasket and nozzle in the main body; then install the attaching screw and gasket.
- Place the choke rod seal in the groove located on the underside of the carburetor air cleaner flange.
- Working from the underside of the carburetor air cleaner flange, slide the choke rod (with the small upset end of the top) through the opening in the main body and rod seal.
- Place the air horn poppet valve in position on the main body. From inside the air horn, insert the pins through the main body and
- poppet valve, install the spring, spring seats, and retainers.
- Position the choke plate shaft in the air horn. Position the choke rod in the choke plate shaft lever and over the spring.
- Position the choke plate poppet valve over the retaining screws, then position the choke plate on top of the poppet valve.
- Place the spacers over the screws, then position the flat spring over the screws so that the curved portion is down. Install the attaching nuts.
- Invert the main body and position the gasket on the main body. Place the throttle body in position on the main body sliding the choke rod into the choke rod lever as the throttle body is placed into position. Install the throttle body to main body screws and lockwashers.

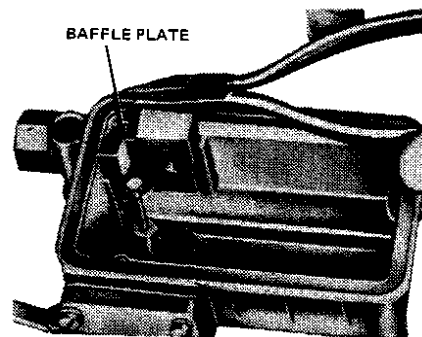


## MODEL 2300 2-V CARBURETOR (Continued)

### Fuel Bowl and Metering Block

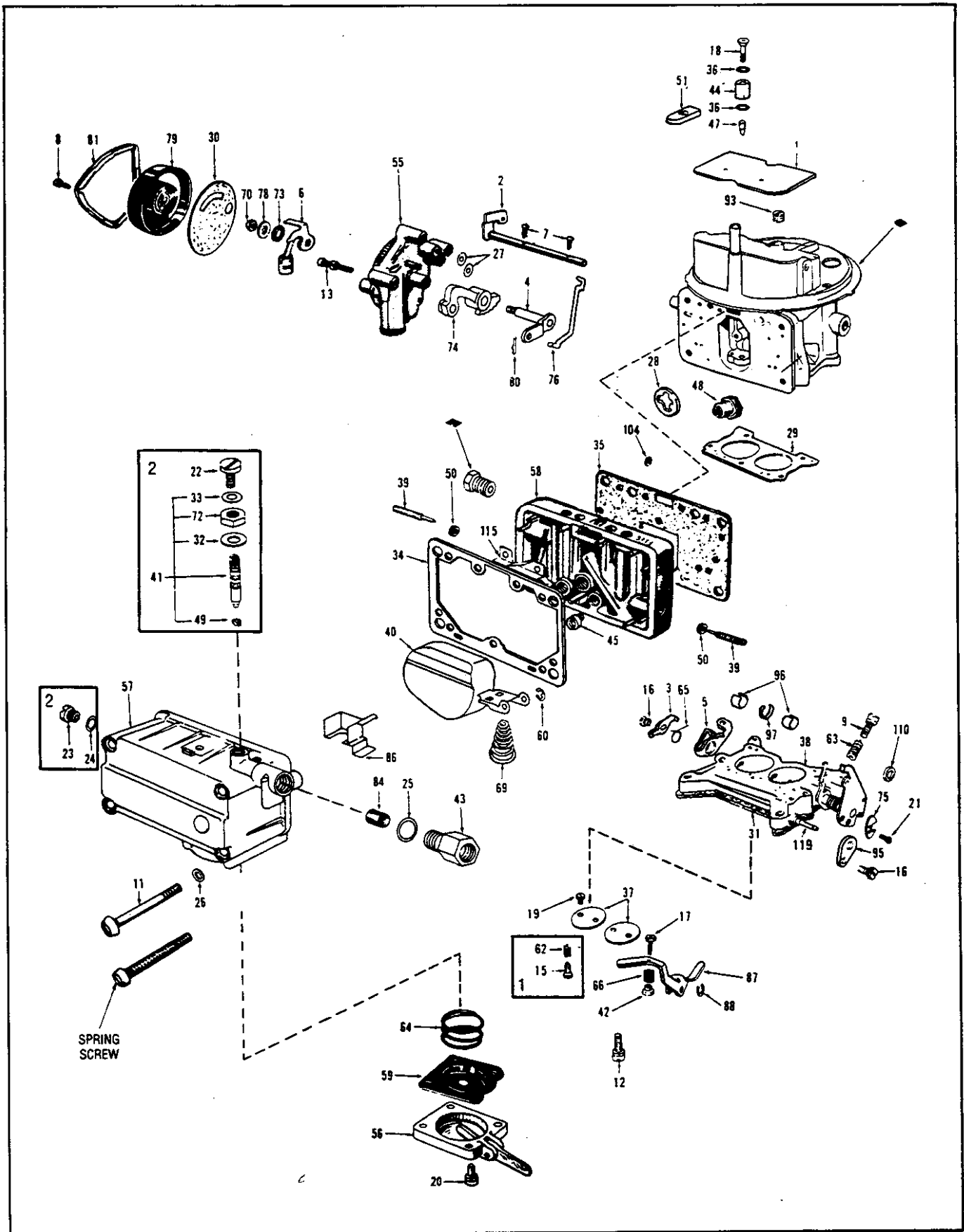
Refer to exploded view for the correct location of the fuel bowl parts.

1. Place the accelerating pump diaphragm spring and diaphragm in the accelerating pump chamber. The diaphragm must be positioned so that the large end of the lever disc will be against the operating lever. Install the cover with the screws finger tight. Make sure the diaphragm is centered, then compress the diaphragm with the pump operating lever and tighten the cover screws.
2. Install the fuel level sight plug and gasket.
3. Install the fuel inlet filter screen, gasket and fitting.
4. Slide the baffle plate on the ridges in the fuel bowl.
5. Install the float spring on the float, slide the float on the shaft and install the float retainer.
6. Apply petroleum jelly to a new O-ring seal and slide it on the fuel inlet needle and seat assembly.
7. Position the fuel inlet needle and seat assembly in the fuel bowl through the top of the bowl. Position the adjusting nut gasket and nut on the fuel inlet needle and seat. Align the flat on the ID of the nut with the flat on the OD of the fuel inlet needle and seat assembly.
8. Adjust the float so that the top of the float is parallel with the top of the fuel bowl with the fuel bowl inverted (see Adjustment).
9. Install the fuel level adjusting lock screw and gasket.
10. Using a socket wrench, install the power valve and a new gasket. **Be sure to install the correct power valve. Refer to the specifications for the correct identification number. The number is stamped on a flat on the base of the valve.** Using a jet wrench, install the main jets.
11. Position the metering block gasket on the dowels on the back of the metering block. Lay the metering block in place on the main body. Position the baffle on the metering block, then position the fuel bowl gasket on the metering block. Place the attaching screws and new compression gaskets in the fuel bowl. Lay the bowl in place on the metering block. Tighten the screws.



B 2734-A

### MODEL 2300 2-V CARBURETOR (Continued)



# TYPICAL NOMENCLATURE

Index Number	Part Name	Index Number	Part Name	Index Number	Part Name
1	Choke Plate	30	Choke Therm. Housing Gasket	62	Fast Idle Cam Lev. Scr. Spring
2	Choke Shaft Assembly	31	Flange Gasket	63	Throttle Stop Screw Spring
3	Fast Idle Pick-up Lever	32	Fuel Valve Seat Adj. Nut Gskt.	64	Pump Diaphragm Return Spring
4	Choke Hsg. Shaft & Lev. Assy.	33	Fuel Valve Seat Lock Scr. Gskt.	65	Fast Idle Cam Lev. Spring
5	Fast Idle Cam Lever	34	Fuel Bowl Gasket	66	Pump Oper. Lev. Adj. Spring
6	Choke Therm. Lev., Link & Piston Assembly	35	Metering Body Gasket	69	Float Spring
7	Choke Plate Screw	36	Pump Discharge Nozzle Gasket	70	Choke Thermostat Shaft Nut
8	Therm. Hsg. Clamp Screw	37	Throttle Plate	72	Fuel Valve Seat Adj. Nut
9	Throttle Stop Screw	38	Throt. Body & Shaft Assy.	73	Choke Therm. Lever Spacer
11	Fuel Bowl to Main Body Screw	40	Float & Hinge Assy.	74	Fast Idle Cam Assembly
12	Throt. Body Scr. & L. W.	41	Fuel Inlet Valve & Seat Assy.	76	Choke Rod
13	Choke Hsg. Scr. & L. W.	42	Pump Oper. Lev. Adj. Scr. Fitting	78	Choke Therm. Shaft Nut L. W.
15	Fast Idle Cam Lever Screw	43	Fuel Inlet Fitting	79	Thermostat Housing Assembly
16	Fast Idle Cam Lev. & Throt. Lev. Screw & L. W.	44	Pump Discharge Nozzle	80	Choke Rod Retainer
17	Pump Oper. Lev. Adj. Screw	45	Main Jet	81	Thermostat Housing Clamp
18	Pump Discharge Nozzle Screw	47	Pump Discharge Needle Valve or Check Ball Weight	84	Filter Screen Assembly
19	Throttle Plate Screw	48	Power Valve Assembly	86	Baffle Plate
20	Fuel Pump Cov. Assy. Scr. & L. W.	49	Fuel Valve Seat "O" Ring Seal or Gasket	87	Pump Operating Lever
21	Pump Cam Lock Scr. & L. W.	50	Idle Needle Seal	88	Pump Operating Lev. Retainer
22	Fuel Valve Seat Lock Screw	51	Choke Rod Seal	93	Air Adapter Hole Plug
23	Fuel Level Check Plug	55	Choke Hsg. & Plugs Assy.	95	Throttle Lever
24	Fuel Level Check Plug Gasket	56	Fuel Pump Cover Assy.	96	Throttle Shaft Bearing
25	Fuel Inlet Fitting Gasket	57	Fuel Bowl & Plugs Assy.	97	Throttle Shaft Brg. (center)
26	Fuel Bowl Screw Gasket	58	Main Metering Body & Plugs Assy.	104	Diaphragm Link Retainer
27	Choke Housing Gasket	59	Pump Diaphragm Assembly	105	Air Vent Rod Spg. Retainer
28	Power Valve Body Gasket	60	Float Spring Retainer	110	Throt. Link Connector Pin Washer
29	Throttle Body Gasket	61	Air Vent Retainer	115	Metering Body Vent Baffle
				119	Pump Oper. Lever Stud

## MODEL 4160 CARBURETOR SYSTEMS

### PRIMARY SYSTEMS

#### FUEL INLET SYSTEM

The fuel inlet system consists of a fuel bowl, fuel inlet fitting, fuel inlet needle and seat and a float assembly. A float screen or filter is usually installed in the inlet fitting.

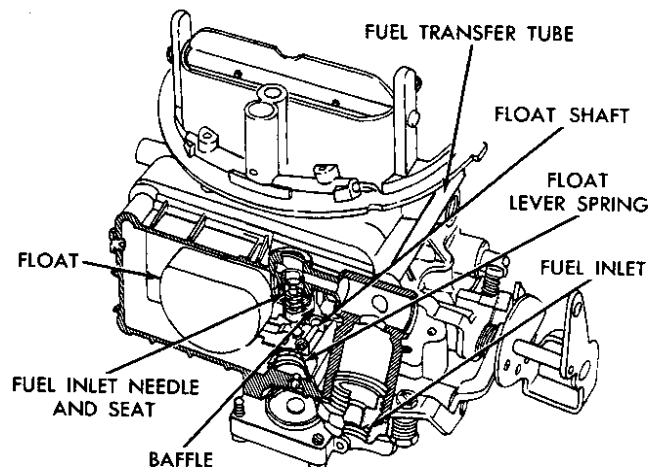
**CAUTION:** Where there is no filter in the inlet fitting, an inline filter must be used to prevent malfunction due to dirty fuel.

Many different types of floats have been used. Early production used side hinged rectangular brass floats. There were two different versions of this float. Later production used a half moon brass float or a nitrophyl (cellular plastic material) float.

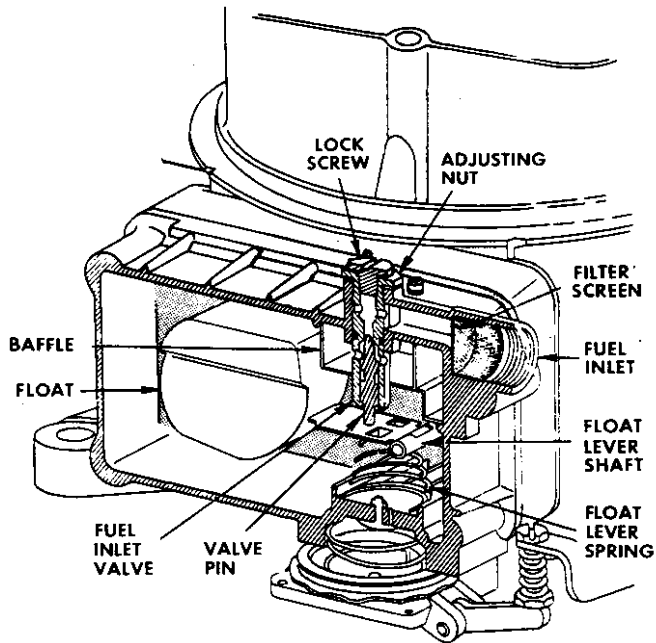
The fuel inlet valve (needle and seat) and the float assembly must maintain the fuel level at the prescribed specification.

**NOTE:** The basic fuel metering systems are calibrated to deliver the proper mixture only when the fuel is adjusted to the correct level.

A float bumper spring is installed under the float level in many applications to stabilize the float movement.



## MODEL 4160 CARBURETOR SYSTEMS (Continued)



With the externally adjustable needle and seat the fuel level can be adjusted (to the bottom of the threads in the sight plug hole) without removing any other part of the carburetor.

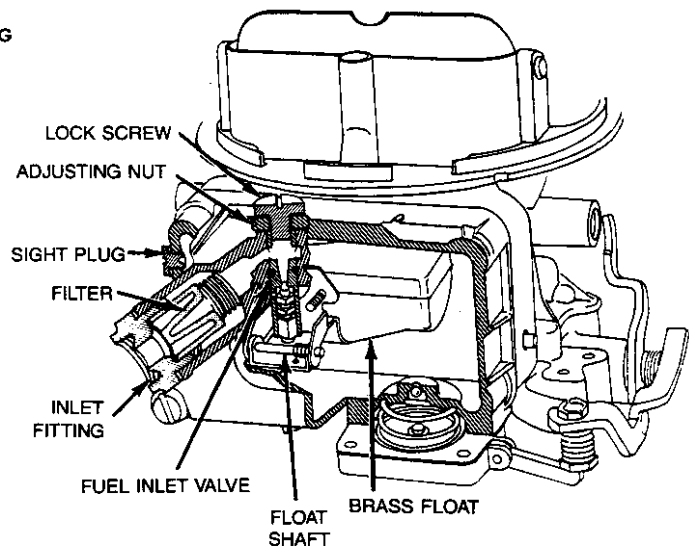
To adjust an internal needle and seat it is necessary to remove the carburetor from the engine.

The fuel bowl is vented internally to the air horn by a vent tube in the carburetor body.

On the standard 4V units a fuel transfer tube transfers fuel from the primary fuel inlet fitting to

the secondary fuel bowl. The transfer tube is sealed at either end with an "O" ring.

**NOTE:** When adjusting the fuel level on the secondary side of the 4V units, it is necessary to run the engine for two or three minutes to stabilize the fuel level. A very small amount of fuel is used from the secondary side at idle and it is easy to make a false (low) adjustment of the fuel level. If there is any question about the level, loosen a lower bowl screw and drain a small amount of fuel into a pan. Tighten the bowl screw and let the bowl refill to the adjusted level. After attaining the correct level, install and retighten the sight plugs.

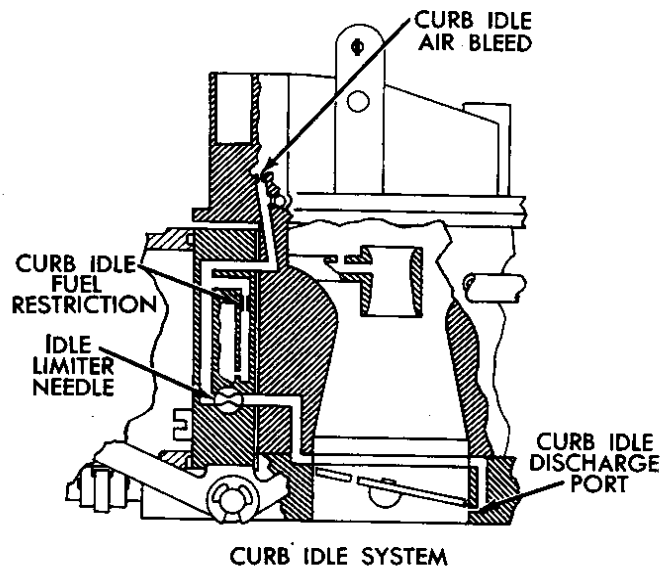


# MODEL 4160 CARBURETOR SYSTEMS (Continued)

## IDLE SYSTEM

An idle system supplies the air fuel mixture to operate the engine at idle and low speeds. Idle fuel enters the system through the main jet into the main well. Some applications include an idle tube in the main well to meter the fuel. Other applications use a horizontal passage from the main well to the idle well and an idle channel restriction for metering purposes. The restriction has been installed in several different locations.

In either type, air enters the idle air bleed and mixes with the fuel after the fuel flows through the idle tube or restriction. At curb idle the throttle valves are almost closed. This creates a high vacuum below the throttle valve with near atmospheric pressure above the valve. As the throttle valves are opened the transfer slot is progressively exposed to vacuum and the air-fuel emulsion is also discharged from the transfer slot. The air-fuel mixture from the idle passage

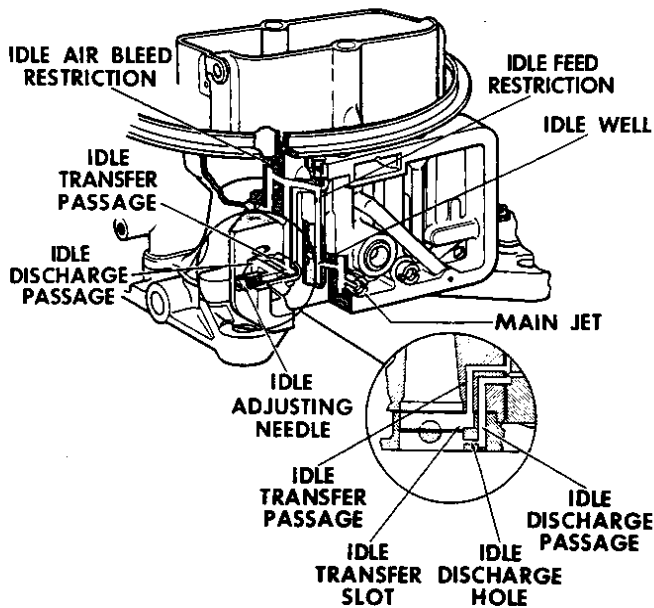


CURB IDLE SYSTEM

and the transfer slot supplies the necessary fuel to operate the engine at lower speeds and loads.

A low pressure or partial vacuum is created in the booster venturi and the main metering system starts to flow. This moderate opening (transition) of the throttle is commonly called "tip in." When the throttle valves are opened, the accelerator pump system mechanically squirts raw fuel into the venturi to prevent a stumble until the mixture from the main metering system "catches up" with the increased air flow. (This supplementary fuel requirement is needed more during rapid throttle openings.)

A hesitation or "sag" at tip in is one of the most common carburetor problems. A low fuel level, a partially clogged idle tube or restriction gummed-up air bleeds or a manifold leak can cause a "sag" during tip in. Any problem in the accelerator pump system will also cause a problem.



## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### MAIN METERING SYSTEM (PRIMARY)

The main metering system on both models discussed in this section are very similar.

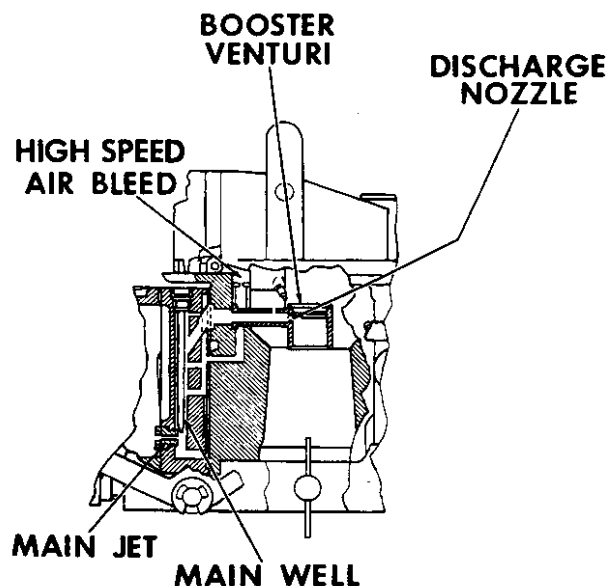
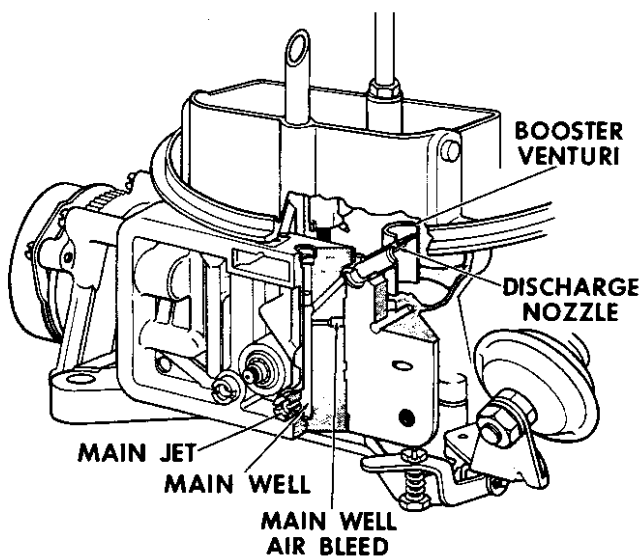
At higher speeds the vacuum is increased at the main discharge nozzle in the center of the booster venturi.

This vacuum or pressure differential causes fuel to flow through the main metering jet into the main well. The fuel moves up the main well past one or more air bleed holes from the main airwell. These air bleed holes are supplied with the filtered air from the "high speed" air bleeds

in the air horn. The mixture of fuel and air moves up the main well and through a channel to the main discharge nozzle in the booster venturi.

Many booster venturi have tabs or projections which assist in providing unique distribution of the air-fuel mixture in the intake manifold as required for certain engines.

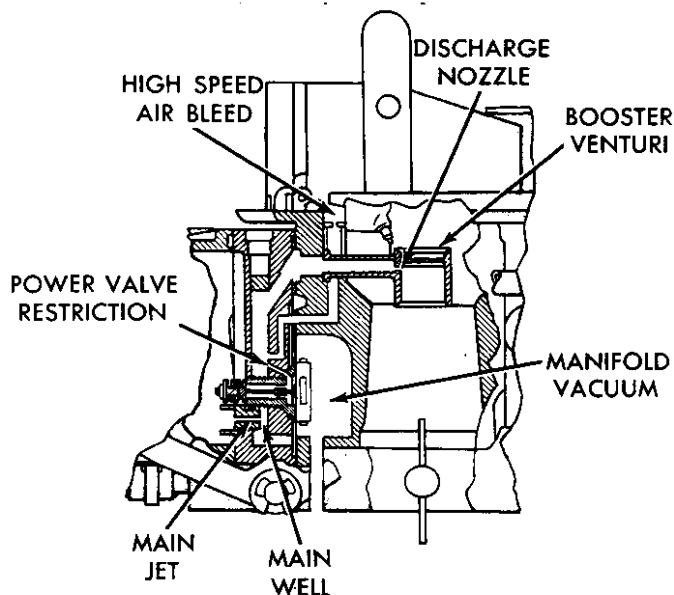
The booster venturi in this series of carburetors are not replaceable, although many carburetors use separate booster castings that are permanently installed in the main body casting.



### POWER ENRICHMENT SYSTEM (PRIMARY)

During high speed or heavy load operation, when manifold vacuum is low, the power system provides added fuel for power operation. A vacuum passage in the throttle body transmits vacuum to the power valve vacuum chamber in the main body. All of the power valves used in this series of carburetors are actuated by a vacuum diaphragm. Manifold vacuum is applied to the vacuum side of the diaphragm to hold it closed at idle and normal moderate load conditions.

When manifold vacuum drops below the power valve's calibration, the power valve spring opens the valve to admit additional fuel. This fuel is metered by the power valve channel restrictions in the metering body. The fuel flows through the restrictions into the main well and is added to the fuel flowing from the main metering jets.



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## MODEL 4160 CARBURETOR SYSTEMS (Continued)

There are many power valve variations, differentiated by size of valves and fuel passages, as well as a wide range of vacuum settings.

When servicing a carburetor the power valve supplied in the repair kit or the valve listed in the service parts list should be used. Each power valve is stamped with the vacuum setting, (example: 65 would indicate the valve would operate at 6.5 inches of vacuum). A manufacturing code is also stamped on the valve.

**NOTE: It is very important that the proper gasket is used on the valve and the valve be torqued to 100 in. lb. (Many valves are considered faulty because fuel leaks around the gasket and through the threads.) A sudden**

**change in idle characteristic or sudden stalling due to idle richness can result from a leaking power valve diaphragm. The power valve diaphragm should be tested on a distributor test machine vacuum system or with a hand vacuum pump equipped with a piece of rubber tubing that will cover the diaphragm side of the valve.**

Contrary to many technician's belief that backfiring ruptures power valves, we find it extremely difficult to create a failure by backfire. In reviewing reported instances of severe backfiring on vehicles (which usually turn out to be caused by ignition problems) power valve diaphragm failures are seldom found.

### ACCELERATING PUMP SYSTEM

During acceleration the air flow through the carburetor responds almost immediately to the increased throttle opening. Since fuel is heavier than air, it has a slower response. The accelerator pump system mechanically supplies fuel until the other fuel metering systems can once again supply the proper mixture.

The diaphragm type pump is located in the bottom of the primary fuel bowl.

Locating the pump in the bottom of the fuel bowl assures a more solid charge of fuel (fewer bubbles).

When the throttle is opened, the pump linkage, actuated by a cam on the throttle lever, forces the pump diaphragm up. As the diaphragm moves up, the pressure forces the pump inlet check ball or valve onto its seat, thereby preventing the fuel from flowing back into the fuel bowl.

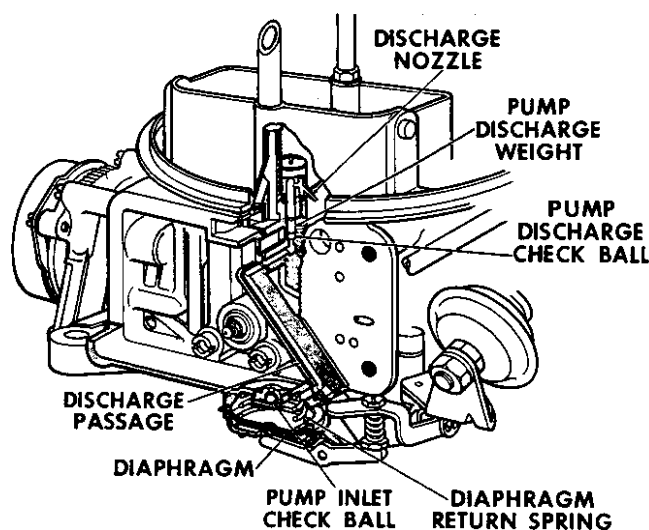
The fuel passes through a short passage in the fuel bowl into the long diagonal passage in the metering body. It next goes into the main body passage and then the pump discharge chamber. The pressure of the fuel causes the discharge valve to raise and fuel is then discharged into the venturi.

The pump override spring is an important part of all accelerator pump systems. When the accelerator is moved rapidly to the wide open position, the override spring is compressed and allows the full pump travel. The spring applies pressure to maintain the pump discharge. Without the spring the pump linkage would be bent or broken due to the resistance of the fuel which is not compressible.

As the throttle moves toward the closed position, the linkage returns to its original position and the diaphragm return spring forces the diaphragm down. The pump inlet check valve is moved off its seat and the diaphragm chamber is refilled with fuel from the fuel bowl.

There are many variations in the accelerator pump system. First, there are different capacity pump diaphragms and covers. There are a variety of pump cams and there are two locating holes in each cam. Most applications use a ball intake check valve. Several later applications use a plastic "umbrella" type intake valve.

Accelerator pump delivery rate is important and is controlled by the pump cam, linkage, the override spring and the size of the discharge holes.



## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### CHOKE SYSTEMS

The choke system provides the richer mixture required to start and run a cold engine. A fully or partially closed choke valve creates a vacuum below the valve so that fuel is discharged from both the idle and main metering systems. Closing the choke plate results in greater enrichment. The richer mixtures are needed because the cold fuel will not vaporize readily and much of the fuel condenses on the walls of the cold intake manifold.

The integral choke has the bimetal assembly and vacuum piston housing mounted on the carburetor. In this model the heat required to operate the bimetal is supplied from an intake manifold cross-over tube or a heat stove mounted on or in the exhaust manifold.

Some of these systems may use an electric heating element to assist and speed up choke "come off" time to meet tighter emission requirements.

A fast idle cam and linkage permits higher engine RPM when the engine is cold. An unloader tab is provided on the throttle lever which mechanically opens the choke plate when the throttle lever is held at the wide open position. This permits the operator to relieve an over-choked or flooded condition. Some applications may delete the fast idle cam feature.

Electric chokes, where the bimetal assembly is heated only by an electrical resistor are becoming more popular for certain applications.

Hand operated chokes are used on many special applications.

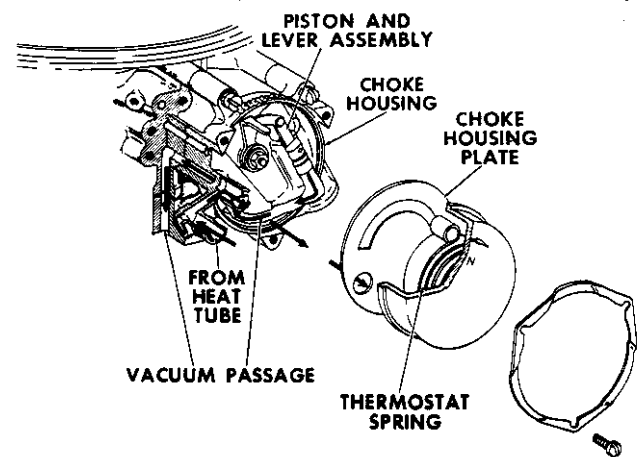
### INTEGRAL AUTOMATIC CHOKE

When the accelerator pedal is depressed and released the choke thermostatic spring pushes the choke valve to a fully or partially closed position and the fast idle cam to a corresponding fast idle position. A cold engine at lower temperatures will allow the choke valve to close completely and the fast idle cam to move to its top step.

A manifold vacuum passage through the carburetor body is connected to the bottom end of the choke piston cavity. When the engine starts, the vacuum acting on the bottom of the choke piston, opens the valve to a predetermined position established by the "choke piston travel adjustable stop." This initial vacuum opening is called the "choke qualifying dimension," "vacuum break," "vacuum kick" or "vacuum pull down."

The choke plate may open further under increasing airflow conditions.

The choke heat tube, usually asbestos covered, connects the heat source with the heat tube connection of the choke housing. After the piston is pulled down to its stop, a vacuum bypass slot or hole in the center of the piston is opened up and increased hot air is circulated in the housing to further heat the bimetal spring. As the spring warms up, its tension on the choke shaft will be relaxed and allow the choke valve to open gradually to the wide open position. The choke bimetal cover has index marks and an arrow indicating the lean direction. Different applications require different settings. When the engine first starts, the fast idle cam can be "kicked down" to a lower step and speed by tapping the throttle lever lightly.



## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### ELECTRIC CHOKES

Electric chokes function somewhat similarly and require nearly the same hardware as integral systems, except for the bimetal cover assembly. The electric choke differs in bimetal cover assembly design. A resistor is built into the cap assembly and provides a direct heat supply for the bimetal. This type of choke system may be adjusted for choking duration on the engine by readjusting or repositioning the index setting of the bimetal cap. During carburetor design the rate of temperature increase is varied slightly by changing airflow thru the cap by means of a restriction in the manifold vacuum passage. The primary means of substantially altering choking time is by changing the bimetal temperature rate or resistance (number of coils in the resistor). This choke system may be used

with aftermarket intake manifolds not incorporating a heat tube.

**NOTE: Care must be taken to properly connect to the basic 12V supply and not to ignition or coil, which have reduced voltage during operating conditions. A low voltage will not open the choke completely. The ignition firing efficiency would additionally be impaired if choke voltage were taken here.**

### HAND OPERATED CHOKES

The most important hand choke problem to watch for is to be sure that the choke will open and close properly. If the knob on the choke cable is too close to the instrument panel, the engine vibration will have a tendency to pull the choke valve partly closed. This creates a rich condition at higher speeds.

## SECONDARY SYSTEMS

### VACUUM SYSTEMS SECONDARY OPERATION

At lower speeds the secondary throttle valves remain closed, allowing the engine to maintain proper air-fuel velocities and distribution for lower speed, light load operation. When engine demand increases to a point where additional breathing capacity is needed, the vacuum controlled secondary throttle valves begin to open automatically.

Vacuum from one of the primary venturi and one of the secondary venturi is channeled to the top of the secondary diaphragm. The bottom of the diaphragm is open to atmospheric pressure. At higher speeds and higher primary venturi vacuum, the diaphragm, operating through a rod and secondary throttle lever, will commence to open the secondary throttle valves. This action will start to compress the secondary throttle valves. This action will start to compress the secondary diaphragm spring.

As the secondary throttle valves open further a vacuum signal is created in the secondary venturi. This additional vacuum assists in opening the secondary throttle valves to the maximum designed opening. The secondary opening rate is controlled by the diaphragm spring and the size of the vacuum restrictions in the venturi.

When the engine speed is reduced, venturi vacuum decreases and the diaphragm spring starts to push the diaphragm down to start the closing of the secondaries. Closing the primary throttle valves moves the secondary throttle connecting link.

Most production applications have a ball check and bypass bleed installed in the diaphragm passage. The ball permits a smooth even opening of the secondaries, but lifts off the inlet bleed to cause rapid closing of the secondaries when the primary throttle valves are closed.

**CAUTION: No attempt should be made to convert vacuum operated secondaries to mechanical operation. Bolts or screws should never be installed in the slot in the secondary throttle lever.**

### SECONDARY FUEL METERING SYSTEMS

#### FUEL INLET SYSTEMS

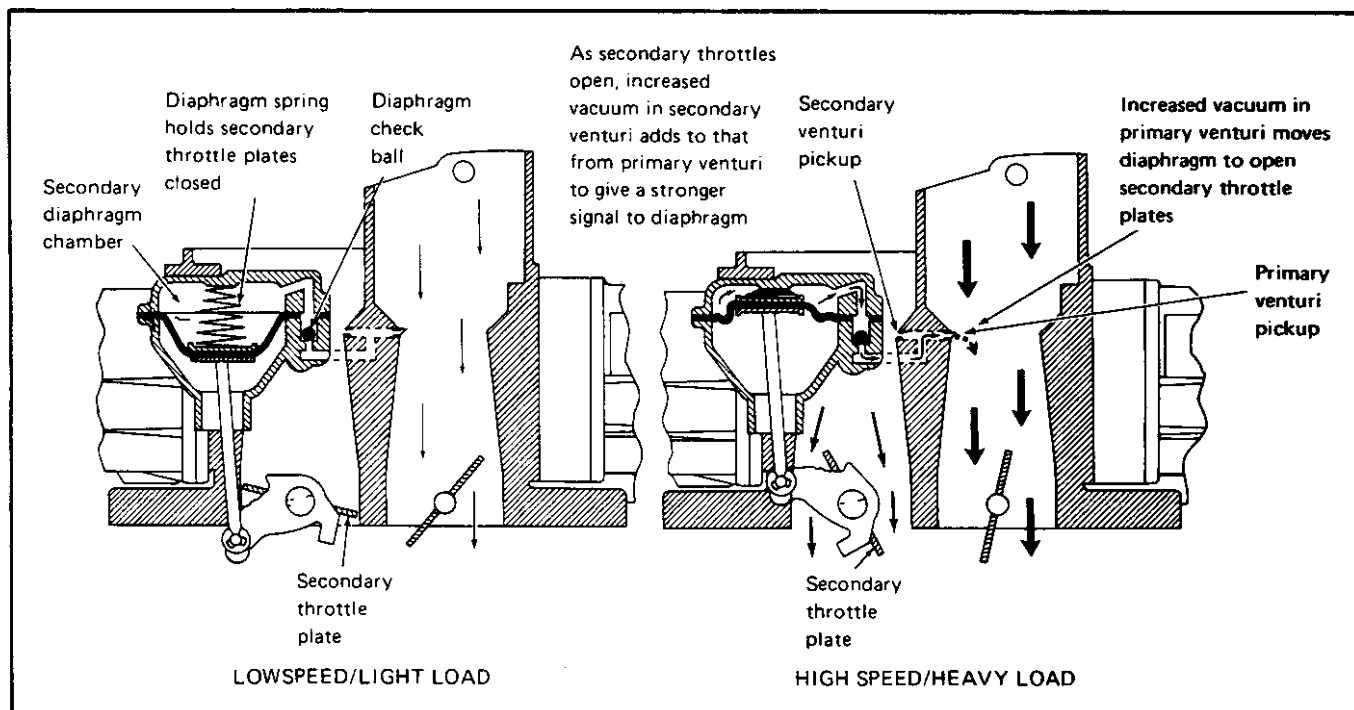
All secondary systems in these models have a separate fuel bowl. Fuel is usually supplied to the secondary bowl by a transfer tube from the primary fuel inlet fitting. Some models have bowls with center hinged floats which use exterior plumbing.

The secondary fuel bowl is equipped with a fuel inlet valve and float assembly similar to the primary side.

The specified fuel level on the secondary side is usually slightly lower than the primary side.

**NOTE: Some applications include a balance tube which vents vapors and excess fuel back to the primary bowl. The secondary fuel inlet system is calibrated to deliver the proper mixture to the other systems only when the fuel is at the specified level.**

### MODEL 4160 CARBURETOR SYSTEMS (Continued)



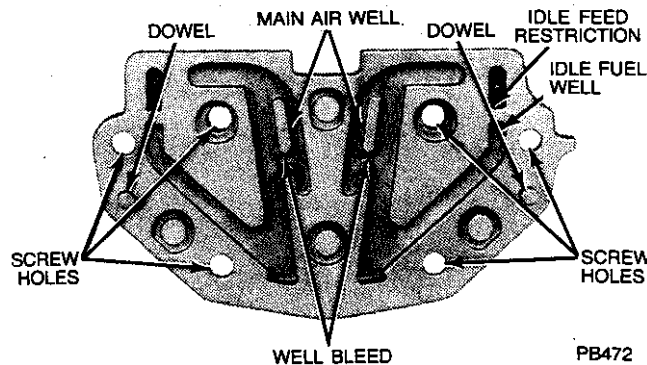
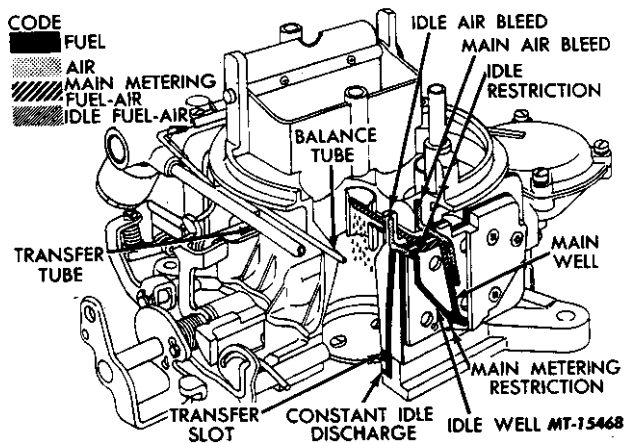
### SECONDARY FUEL METERING SYSTEM

The 4160 model secondary metering body (plate) is enclosed within the fuel bowl. The metering body is attached to the carburetor body with six clutch head screws.

Fixed main metering restrictions are located in the bottom of the metering body. Fuel for the idle and idle transfer system as well as fuel for the main metering system enters the main well through these restrictions. Idle fuel wells branch

off of each main well. Fuel travels up the idle well through an idle restriction where it is mixed with air entering through the secondary idle air bleeds. Air enters the main well through the secondary high speed air bleeds.

The air and fuel emulsion is discharged out of the secondary nozzles located in the booster venturi. The secondary transfer and main metering system are only operative when the secondary throttle valves are opened.



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## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### SERVICE PROCEDURES

Dirt, dust, water and gum and varnish deposits are some of the main causes of poor carburetor operation.

All parts **except** the secondary diaphragm should be thoroughly cleaned in suitable solvent or commercial carburetor cleaner, then inspected for wear or damage.

All restrictions and channels should be blown out with air.

Experienced technicians develop their own order or method of disassembly. It is probably best for a beginner to break the carburetor down

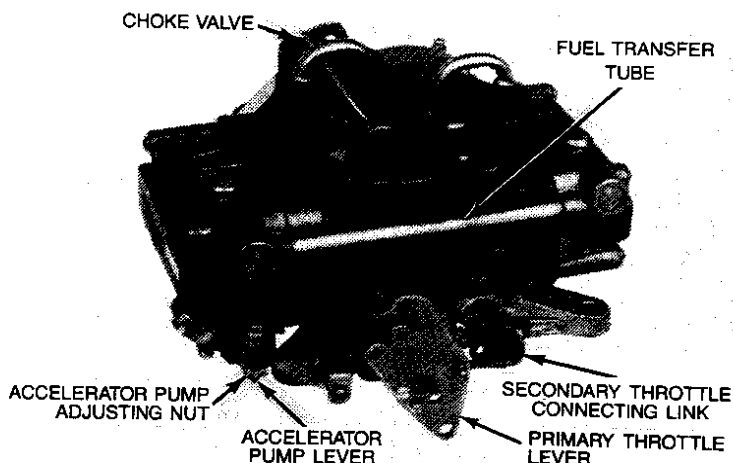
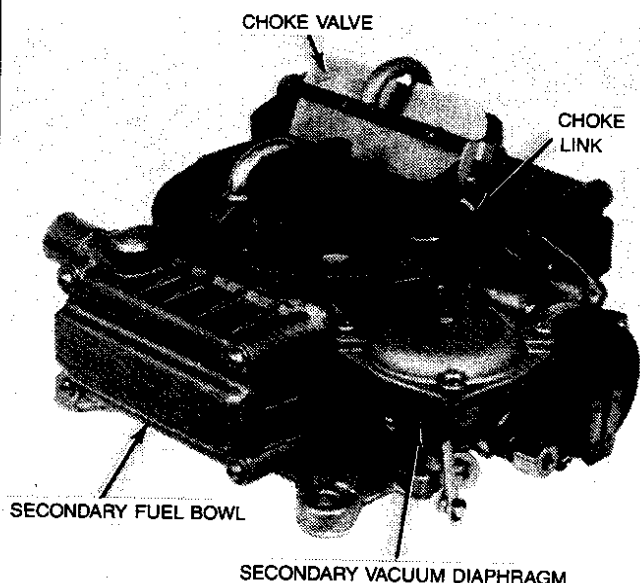
into subassemblies, keeping the related parts together. The most important tool or asset of any carburetor repairman is a keen sense of observation.

**NOTE:** Before disassembling any carburetor in this series place the carburetor on a suitable stand or legs. Legs can be made from four two-inch cap screws and eight nuts. Screw one nut on each cap screw about one inch from the end. Place in the mounting holes and install the other nut on the top. This procedure prevents nicks or damage to the throttle valves or shafts.

### DISASSEMBLY

Many carburetors do not have all the hardware noted in the following Steps.

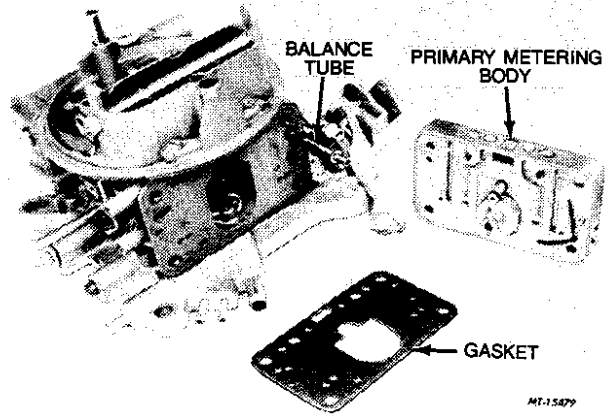
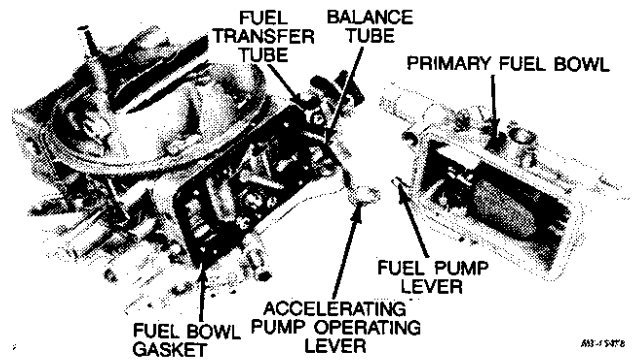
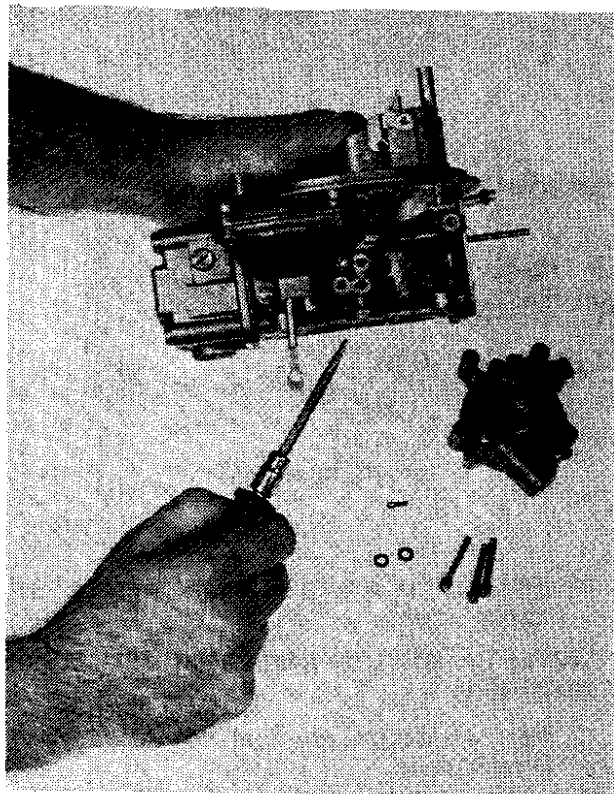
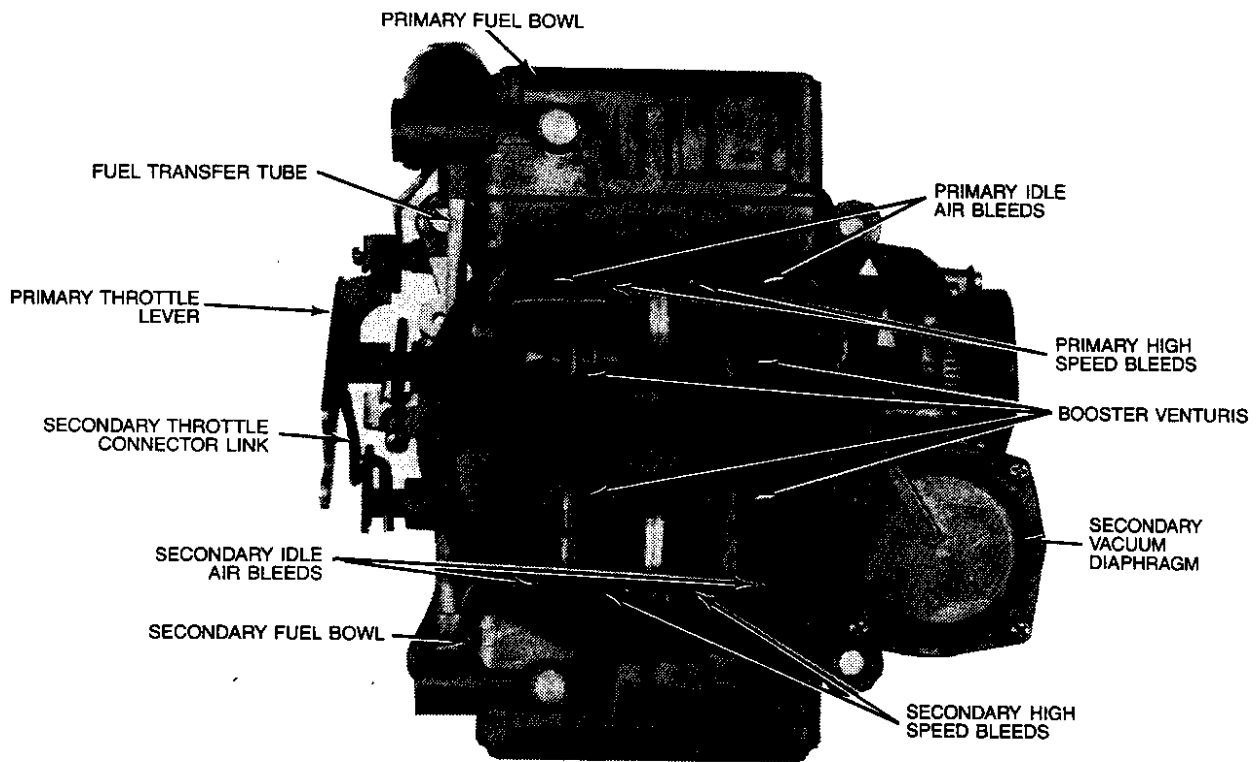
1. Remove integral choke assembly and fast idle cam (if used).
2. Remove choke fast idle lever screw and lever, remove "E" clip, fast idle cam and lever (if used).
3. Remove secondary vacuum diaphragm assembly from carburetor body (if used).
4. Remove four fuel bowl screws and primary fuel bowl assembly by sliding straight off transfer tube.
5. Remove primary metering body by sliding straight off dowels or balance tube.
6. Remove power valve using 1" wrench or power valve socket. Remove power valve



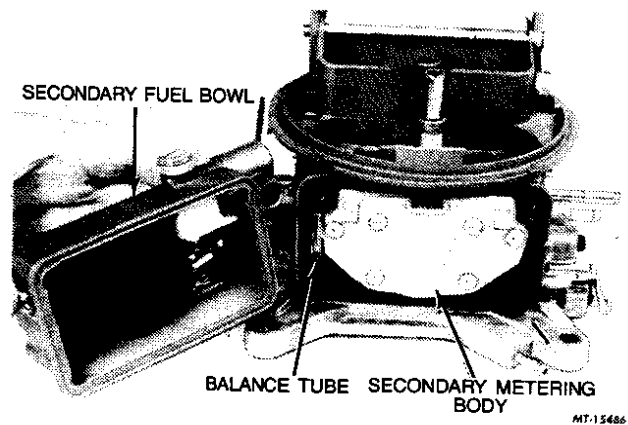
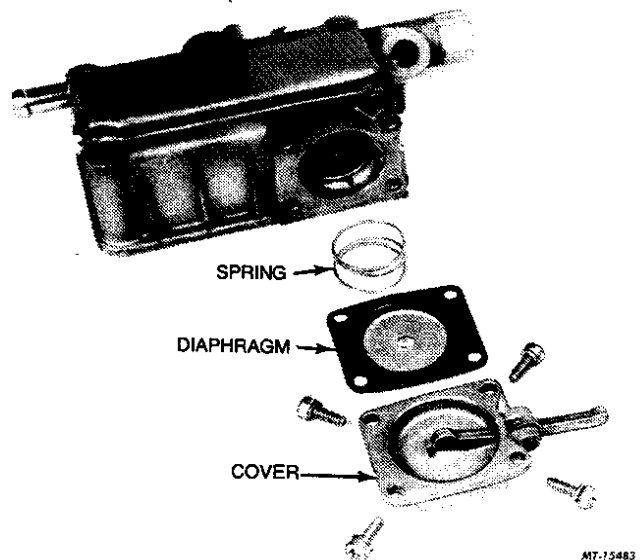
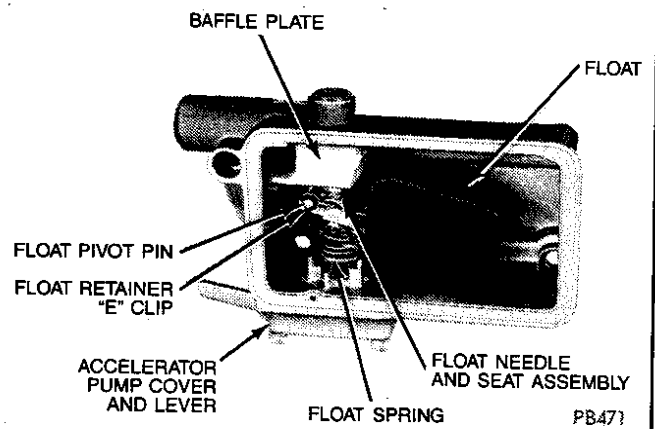
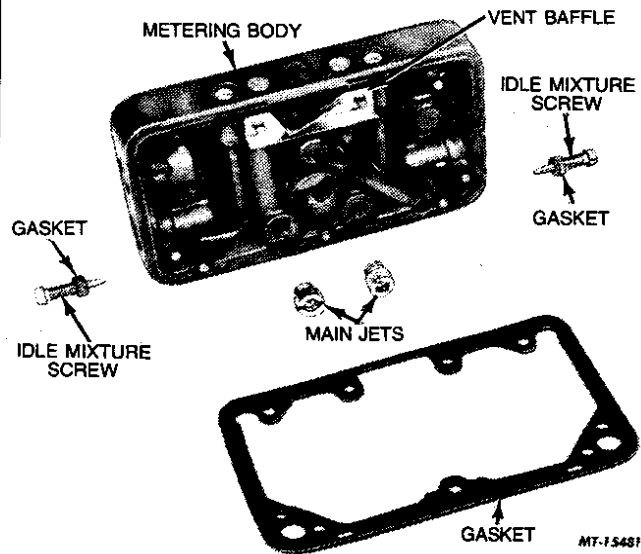
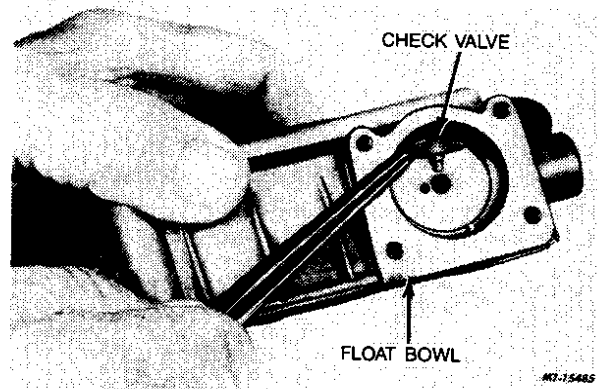
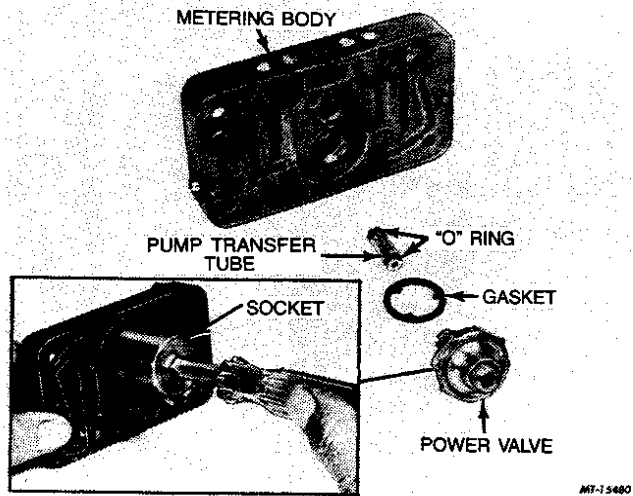
gasket and pump transfer tube with "O" rings (if used) from metering body.

7. Remove gasket and main metering jets using 3/8 inch wide screwdriver or proper jet socket.
8. Turn idle limiter caps "clockwise" to stops, remove caps by prying off of idle mixture screws (if used). **(NOTE: Be careful not to bend screws.)** Count and record exact number of "clockwise" turns to seat each screw lightly. The same number of turns must be maintained from the seat upon re-installation. Remove screws and gaskets from metering body. Remove vent baffle.
9. Remove screws attaching accelerator pump cover to fuel bowl. Remove cover and carefully remove pump diaphragm and spring.
10. Remove fuel inlet fitting with screen or filter and gasket.
11. Remove float retainer "E" clip, then slide float and spring out of float chamber. Remove baffle, fuel inlet valve and seat. **Discard gasket.**

# MODEL 4160 CARBURETOR SYSTEMS (Continued)



MODEL 4160 CARBURETOR SYSTEMS (Continued)



12. Remove the plastic accelerator pump inlet check valve.

**NOTE:** The ball type inlet check valve is not removable.

13. Remove secondary fuel bowl from carburetor body.

**NOTE:** Disassembly of the secondary fuel bowl is similar to the primary bowl.

The fuel inlet baffles are not interchangeable.

## MODEL 4160 CARBURETOR SYSTEMS (Continued)

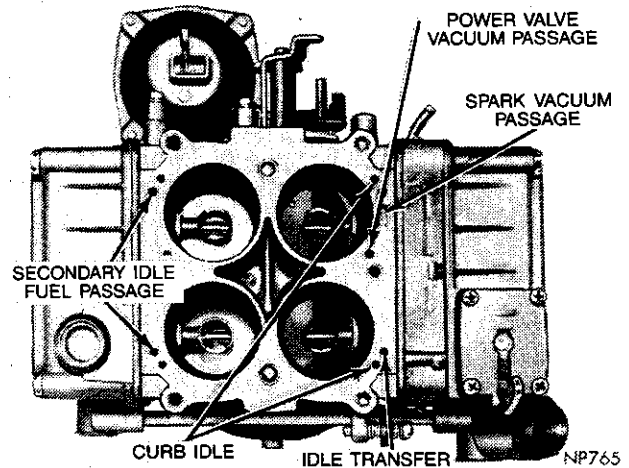
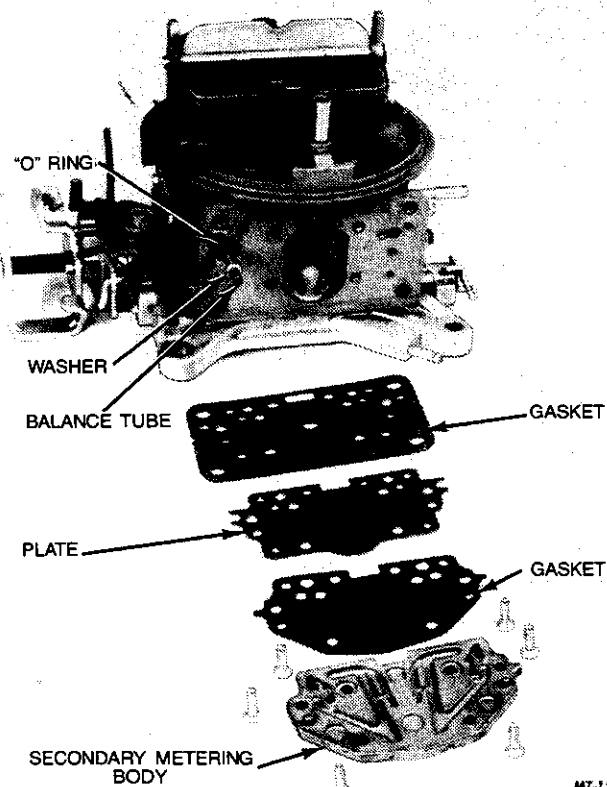
14. Remove secondary metering body plate and gaskets from main body.

**NOTE:** A clutch head screwdriver must be used. Do not attempt to make one from a regular screwdriver. Remove balance tube washers and "O" ring (if used).

15. Remove choke rod and seal. Unless the choke valve is bent or damaged, DO NOT remove.

**NOTE:** The choke valve screws are staked to prevent loosening and care is necessary to avoid breaking or stripping the threads in the choke shaft. If necessary to remove valve, remove staking with a file before loosening screws.

16. Remove pump discharge nozzle retaining screw, then lift out discharge nozzle. Remove gaskets from nozzle (top and bottom),



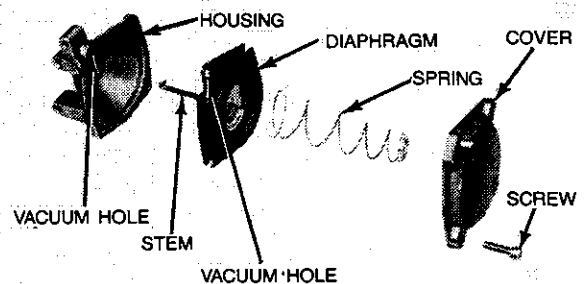
invert carburetor and drop out pump discharge needle from discharge passage.

17. Invert carburetor and remove the throttle body attaching screws. Remove the throttle body and gasket. Remove accelerator pump operating lever, adjusting screw and spring, low idle speed screw and spring, curb idle speed screw and spring, and secondary connecting rod.

**CAUTION:** If the throttle valves are nicked or damaged, it will be necessary to install a new throttle body or obtain a new carburetor.

18. Disassemble the secondary diaphragm.

**CAUTION:** Loosen four screws carefully and free up cover to prevent catching edges of diaphragm in cover screws.



## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### CLEANING

Carburetor parts cleaning is covered on page 3-15.

**NOTE:** Cleaning, proper assembly, the use of the correct parts, proper torquing of all screws and correct adjustments are necessary to achieve correct carburetor service.

### ASSEMBLY

#### Primary Metering Body

1. Install idle mixture screw gaskets in passages. Use head of screw to push into place.

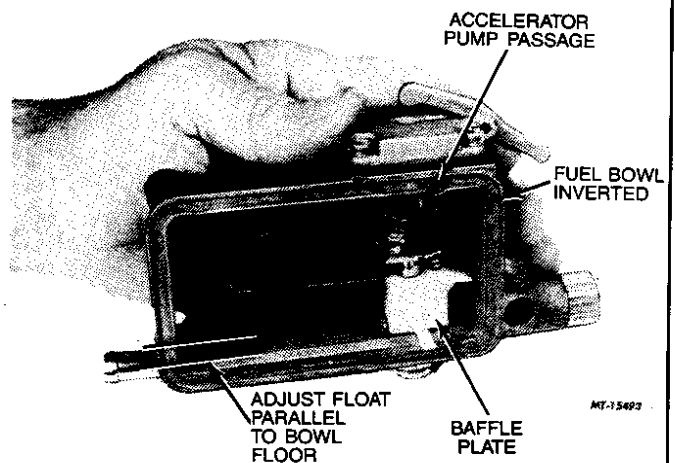
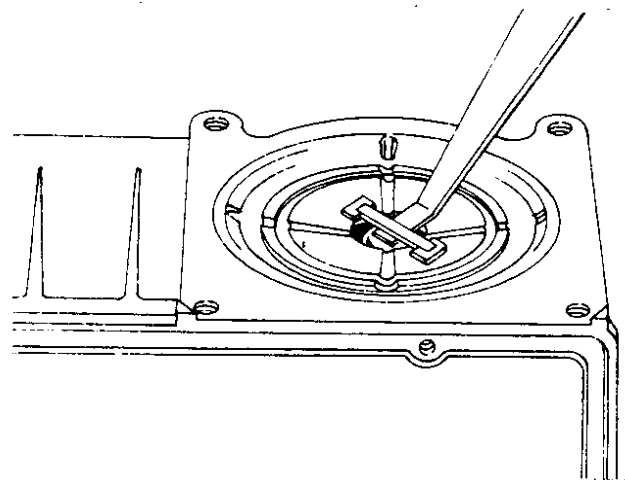
**NOTE:** Inspect mixture screws. If the tapered portion is grooved or ridged, a new mixture screw should be installed to insure ability to maintain the correct idle mixture. Turn screws in lightly against their seats. Back each screw out the exact number of turns recorded during disassembly.

2. Install a new gasket on power valve and install with proper wrench or socket. Torque to 100 in. lbs.
3. Install main metering jets using proper screwdriver or jet wrench.
4. Install fuel baffle (if used). Press metering body and fuel bowl gasket down firmly on the dowels.

**CAUTION:** Be sure you are using the correct metering body gasket and that bowl gasket is not covering the accelerator pump passage.

#### Primary Fuel Bowl

1. Install plastic accelerator pump check valve in fuel bowl (if used).
2. If ball type, check ball clearance under retaining bar is proper.
3. Install pump diaphragm return spring, diaphragm and pump cover. Be sure diaphragm is centered and contact button is toward pump lever in cover. Install four attaching screws and tighten evenly.
4. Install gasket on fuel inlet seat and install in fuel bowl.
5. Tighten securely with proper wrench.
6. Install fuel inlet needle.



7. Slide the inlet baffle into the grooves.
8. Install float spring (if used) on float lever and then install the assembly on the float shaft. Be sure spring is properly located on fuel bowl floor. Install the float retainer. Adjust float parallel to bowl floor. If an adjustment is necessary, carefully bend float tang until proper adjustment has been obtained using care not to nick or damage portion of tang which contacts needle.

#### Secondary Fuel Bowl

Assemble the secondary fuel bowl by following Steps 4 through 8 under assembly primary fuel bowls.

## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### MAIN BODY

1. Place a new gasket on throttle body, then lower main body down on throttle body.

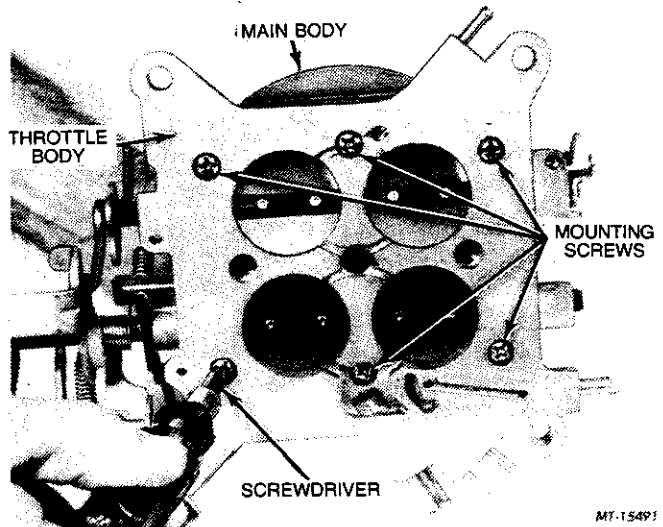
**NOTE: Be sure the gasket fits the throttle body and main body.**

2. Hold assembly together, invert assembly and install attaching screws.

**CAUTION: Primary throttle bores must be on primary venturi side (choke side).**

Install levers, springs and screws into throttle body. Torque attaching screws evenly in stages to 50 in. lb.

3. Install accelerator pump discharge needle or ball and weight (if used) in pump discharge passage under choke valve.
4. Install pump discharge nozzle gasket on nozzle screw, install nozzle, second gasket and install assembly in position. Tighten screw securely.
5. Install a new secondary metering body (plate) to main body gasket followed by the metering body (plate). Install six clutch head



MT-15493

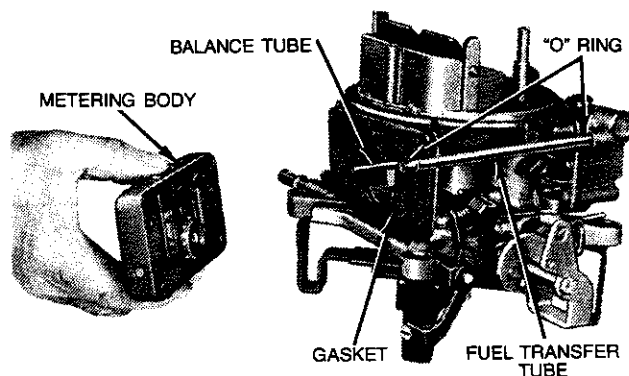
screws. Tighten evenly and securely with a proper clutch head screwdriver.

6. Position balance tube so that only 1" extends beyond the secondary metering body.

### FUEL BOWLS AND METERING BODY

1. If metering body and bowl gaskets were not installed previously under No. 4, describing assembly primary metering body, do so now. Press gaskets down firmly on dowels, not only to hold them in place but to prevent bowl gasket from interfering with the float.
2. Install eight bowl screw gaskets on the screws. NOT IN THE RECESSES.

**NOTE: This prevents shearing off gasket fibers which could enter the fuel bowl and partially stop up a main metering jet.**



NP756A

3. Carefully install primary metering body over balance tube (if used) and press firmly on dowels.
4. Install fuel bowl on metering body, positioning pump lever in proper position over pump operating lever.  
Carefully install four bowl screws and gaskets and torque all bowl screws evenly in stages to 45 in. lb.
5. Install a new "O" ring on the extreme end of each end of fuel transfer tube. Apply Vaseline lightly on "O" ring and install transfer tube into opening in primary fuel bowl. The "O" ring will roll into proper position as tube is installed.
6. Carefully slide secondary fuel bowl on fuel transfer tube and seat on gasket. Install four bowl screws and gaskets and torque evenly in stages to 25-30 in. lb.
7. Install accelerator pump discharge needle or ball and weight (if used) in pump discharge passage (in air horn).
8. Install pump discharge nozzle gasket on nozzle screw, install nozzle, second gasket and install assembly in position. Tighten screw securely.

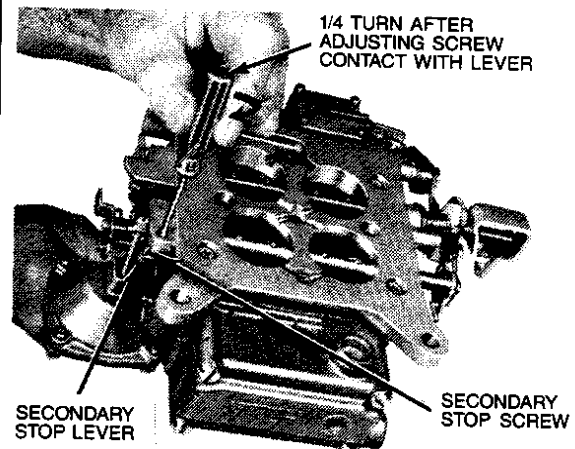
## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### SECONDARY DIAPHRAGM

1. Position diaphragm in lower housing so that the diaphragm vacuum hole is aligned with vacuum hole in lower cover.
2. Install diaphragm return spring with small end snapped over button in cover.
3. Stand diaphragm stem and lower housing in a socket or support to keep the diaphragm in position as the spring and cover are installed.
4. Align vacuum port in cover with port in housing. Install cover and four cover screws. Tighten securely.
5. Check diaphragm by pressing in on stem and placing finger over port. Diaphragm should stay in retracted position.
6. Install new gasket in vacuum passage recess in diaphragm housing. Engage diaphragm in secondary lever. Install housing on carburetor body, install screws and tighten securely.

### ADJUSTING SECONDARY THROTTLE STOP (IF USED)

Back the secondary throttle stop screw out until the secondary throttle valves are closed in the throttle bore. Turn the screw in (clockwise) until it just touches the stop on the lever, then give it an additional 1/4 turn.

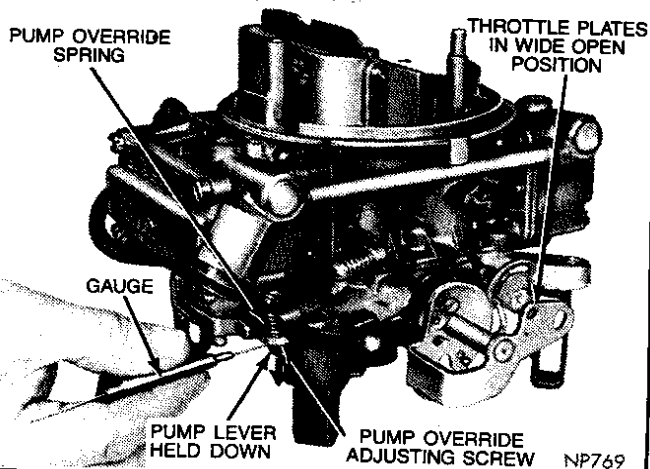


NP774A

### CARBURETOR ADJUSTMENTS

#### CHECKING ACCELERATOR PUMP LEVER CLEARANCE

1. With throttle plates held wide open and the pump lever held down, it should be possible to insert a .015 in. min. — 0.062 in. max. gauge between adjusting nut and lever.
2. If adjustment is necessary, adjust pump override screw until correct clearance has been obtained.
3. There must be no free movement of pump lever when throttle lever is at curb idle.



NP769

### INTEGRAL CHOKE ADJUSTMENTS

#### Choke Qualifying

Remove choke thermostat housing cover (plastic).

A paper clip (.030 to 0.036 dia.) must be bent to provide an end no longer than 1/8 inch. The bent end of the clip should be inserted into the piston bore until the end of the bore slot is hooked. Move the piston and levers (bimetal lever must be in contact with piston lever adjusting tab) in a choke closing direction until the edge of the piston slot engages the end of the paper clip. The resulting choke valve opening (clearance to the air horn wall) may then be adjusted by bending the piston lever adjusting tab.

#### CHOKE BIMETAL ADJUSTMENT

Set choke bimetal cover to specifications.

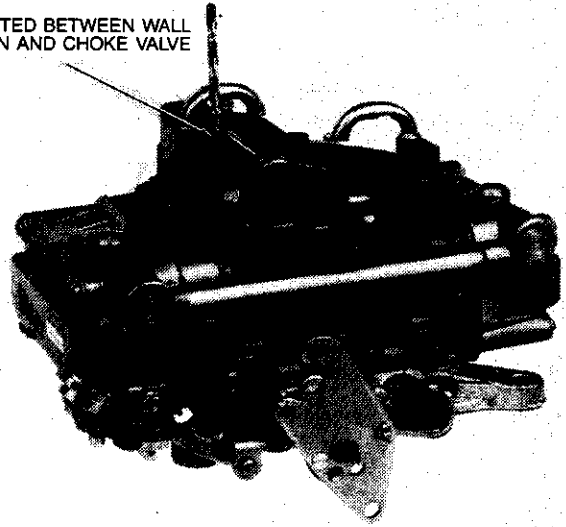
## MODEL 4160 CARBURETOR SYSTEMS (Continued)

### CHOKE UNLOADER ADJUSTMENT

The choke unloader is a mechanical device that partially opens the choke at wide open throttle. It is used to eliminate choke enrichment during cranking of an engine. Engines which have been flooded or stalled by excessive choke enrichment can be cleared by use of the unloader. Adjust the system as follows:

1. Qualify the choke control lever, if necessary.
2. Hold the throttle valves in the wide open position. Insert the specified drill shank or gauge between the upper edge of the choke valve and inner wall of air horn.
3. With a finger lightly pressing against the choke control lever or plate, a slight drag should be felt as the gauge is withdrawn. If an adjustment is necessary, bend the indicated throttle lever tang until correct opening has been obtained.

DRILL INSERTED BETWEEN WALL OF AIR HORN AND CHOKE VALVE



### CURB IDLE ADJUSTMENT

Connect tachometer to engine, tachometer should have 1 1/2 to 2 1/2 accuracy and an expanded scale of 1-1000 R.P.M. or 400-800 R.P.M.

1. Adjust the idle mixture screws fully in until they are lightly seated. Back them out 1 1/2 revolutions. This will provide sufficient adjustment to be able to start the engine.
2. Be sure the engine is thoroughly warmed up. Adjust the curb idle speed to specification by turning the throttle stop screw "in" to increase idle speed, or "out" to decrease idle speed.
3. Turn the idle mixture adjustment screws inward until the engine speed begins to drop due to a lean mixture. Next, turn the screws outward until the engine speed begins to drop due to an excessively rich mixture. Then, turn the screws inward to a point between these two extremes to obtain maximum engine smoothness and rpm.
4. Reset idle speed to specifications.
5. Recheck idle mixture adjustment and reset if necessary.
6. Disconnect tachometer from engine.

### ERRATIC ENGINE IDLE

If the engine idle is erratic or rough after correct idle adjustment, check the following items:

1. Recheck spark plugs and spark plug wires. Be sure all cylinders are firing. A missing

cylinder or occasional misfire will turn an engine that is a minor emitter into gross emitter.

2. Check for vacuum leaks (vacuum lines or manifold).

### LOW IDLE SPEED ADJUSTMENT

With engine at correct operating temperature and condition as in above procedure and curb idle adjusted to specifications, proceed as follows:

1. Set the low idle speed to specifications by adjusting the low idle speed adjusting screw.

### FAST IDLE ADJUSTMENT

1. Remove air cleaner.
2. Attach tachometer.
3. With engine off and at normal operating temperature, transmission in neutral, open throttle, and close the choke.
4. Close throttle, then release choke to place fast idle screw on highest speed step. Move fast idle cam until screw drops down to second step of the cam against the first step shoulder.
5. Without touching throttle, start engine, allow engine speed to stabilize and observe tachometer. Engine should operate at specified fast idle speed. Readjust fast idle screw if necessary.

## MODEL 4160 CARBURETOR SYSTEMS (Continued)

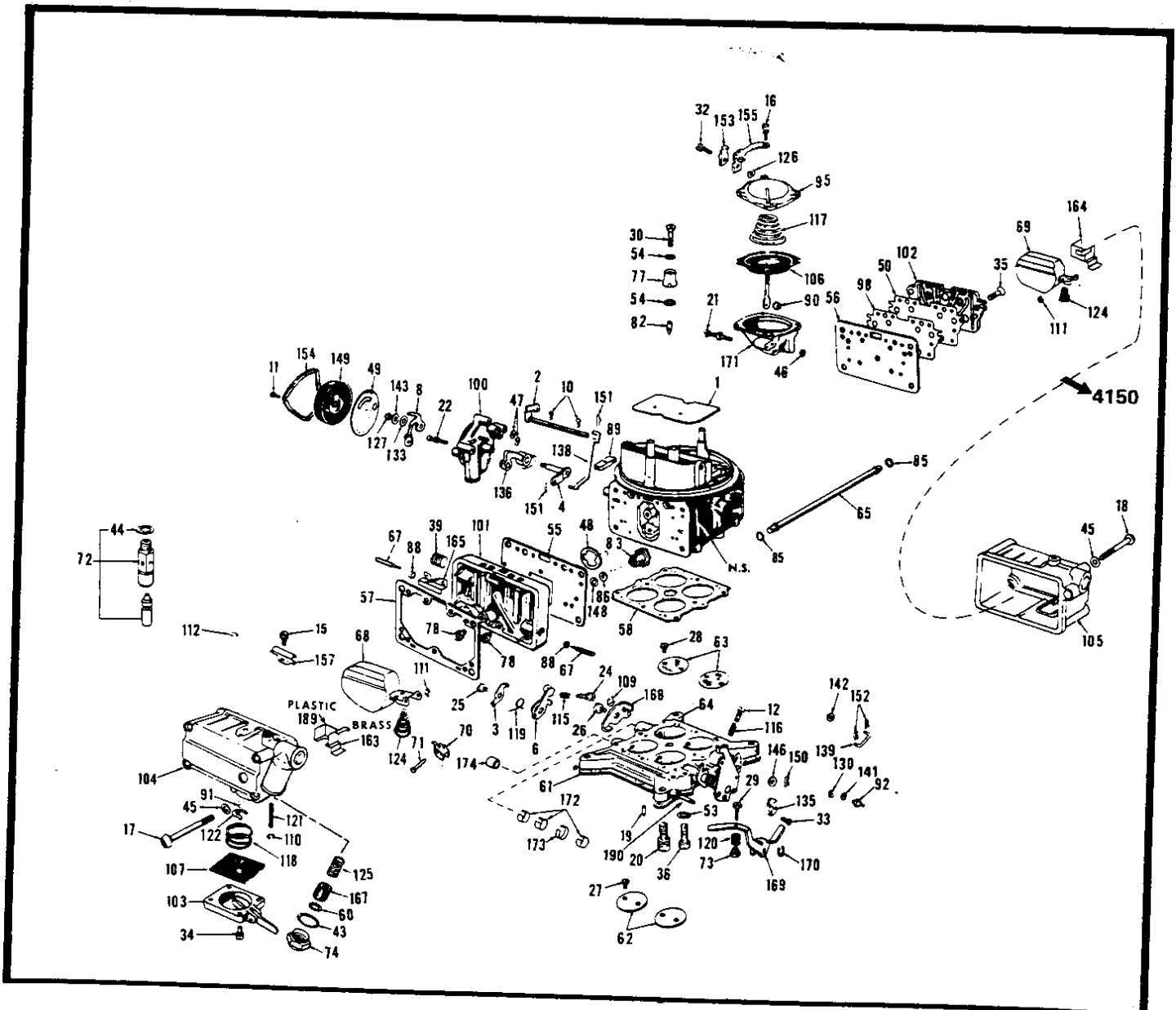
### IDLE ADJUSTMENT PROCEDURE WITH ANALYZER

There are a number of infra-red and ultra-violet exhaust gas analyzers in use in all parts of the country. Instructions for use of this equip-

ment varies by test equipment manufacturer. It is recommended that the various equipment manufacturer's instructions be followed for all idle adjustments.

## EXPLODED VIEW

### MODEL 4160



## TYPICAL NOMENCLATURE

Index Number	Part Name	Index Number	Part Name	Index Number	Part Name
1	Choke Plate	60	Fuel Inlet Filter Gasket	118	Diaphragm Return Spring
3	Fast Idle Pick-up Lever	61	Flange Gasket	119	Fast Idle Cam Lever Spring
4	Choke Housing Shaft & Lever Assy.	62	Throttle Plate — Primary	120	Pump Lev. Adj. Screw Spring
8	Choke Therm. Lev., Link & Piston Assembly	63	Throttle Plate — Secondary	122	Pump Inlet Check Ball Ret. Spring
10	Choke Plate Screw	64	Throt. Body & Shaft Assembly	124	Float Spring — Pri. & Sec.
11	Therm. Housing Clamp Screw	65	Fuel Line Tube	125	Fuel Inlet Filter Spring
12	Throttle Stop Screw	67	Idle Adjusting Needle	127	Choke Thermostat Shaft Nut Throttle Lever Ball Nut
15	Air Vent Clamp Screw & L. W.	68	Float & Hinge Assy. — Primary	132	Fuel Valve Seat Adj. Nut
16	Sec. Diaph. Assy. Cov. Scr. & L. W.	69	Float & Hinge Assy. — Secondary	133	Choke Thermostat Lever Spacer
17	Fuel Bowl to Main Body Screw — Primary	73	Pump Lever Adjusting Screw Fitting	135	Pump Cam
18	Fuel Bowl to Main Body Screw — Secondary	77	Pump Discharge Nozzle	138	Choke Rod
19	Diaph. Lever Adjusting Screw	78	Main Jet — Primary	139	Throttle Connecting Rod
20	Throt. Body Screw & Lock Washer	82	Pump Discharge Needle Valve	141	Throttle Lev. Ball Nut Washer
21	Diaph. Hsg. Assy. Scr. & L. W.	83	Power Valve Assy. — Primary	143	Choke Shaft Nut Lock Washer
22	Choke Housing Screw & L. W.	85	Fuel Line Tube "O" Ring Seal	149	Therm. Hsg. Assy. — Complete
26	Diaph. Lev. Assy. Scr. & L. W.	88	Idle Needle Seal	150	Throt. Connector Pin Retainer
27	Throt. Plate Screw — Primary	89	Choke Rod Seal	151	Choke Rod Retainer
28	Throt. Plate Screw — Secondary	90	Diaphragm Housing Check Ball — Sec.	152	Throt. Connecting Rod Cotter Pin
29	Pump Lever Adjusting Screw	91	Pump Inlet Check Ball	154	Thermostat Housing Clamp
30	Pump Discharge Nozzle Screw	92	Throttle Lever Ball	157	Air Vent Rod Clamp
33	Pump Cam Lock Screw	95	Sec. Diaphragm Housing Cover	161	Filter Screen
34	Fuel Pump Cov. Assy. Scr. & L. W.	98	Secondary Metering Body Plate	163	Baffle Plate — Primary (Brass)
35	Secondary Metering Body Screw	99	Air Vent Cap	164	Baffle Plate — Secondary
36	Throt. Body Screw — Special	100	Choke Hsg. & Plugs Assembly	165	Metering Body Vent Baffle
44	Fuel Valve Seat Gasket	101	Main Metering Body & Plugs Assy. — Primary	167	Fuel Inlet Filter
45	Fuel Bowl Screw Gasket	103	Fuel Pump Cover Assembly	168	Diaphragm Lever Assembly
46	Sec. Diaphragm Housing Gasket	104	Fuel Bowl & Plugs Assy. — Primary	169	Pump Operating Lever
47	Choke Housing Gasket	106	Secondary Diaph. & Rod Assy.	170	Pump Operating Lever Retainer
49	Choke Thermostat Housing Gasket	107	Pump Diaphragm Assembly	171	Secondary Diaphragm Housing
50	Sec. Metering Body Plate Gasket	109	Secondary Diaphragm Assembly	172	Throt. Shaft Brg. Pri. & Sec. (Ribbon)
53	Throt. Body Screw Gasket	110	Air Vent Rod Spring Retainer	173	Throt. Shaft Brg. Pri. & Sec. (Ribbon)
54	Pump Discharge Nozzle Gasket	111	Float Retainer	174	Throt. Shaft Bearing — Pri. (Solid)
55	Metering Body Gasket — Primary	112	Air Vent Valve Retainer	189	Baffle Plate — Primary (Plastic)
56	Metering Body Gasket — Secondary	113	Choke Control Lever Retainer	***	Fuel Valve Clip
57	Fuel Bowl Gasket	115	Fast Idle Cam Lever Screw Spring	190	Pump Oper. Lever Stud
58	Throttle Body Gasket	116	Throttle Stop Screw Spring	72	Inlet Needle and Seat
		117	Secondary Diaphragm Spring		



## Part 4 — Charging System

SUBJECT	PAGE	SUBJECT	PAGE
<b>DESCRIPTION AND OPERATION</b>		<b>REMOVAL AND INSTALLATION</b>	
Alternator .....	4-01	Removal .....	4-13
Regulator .....	4-03	Installation .....	4-13
Application .....	4-03	<b>DISASSEMBLY AND ASSEMBLY</b>	
<b>DIAGNOSIS</b>		Disassembly .....	4-14
Normal Charge Indicator Light .....	4-04	Cleaning and Inspection .....	4-16
Normal Charge Ammeter .....	4-04	Assembly .....	4-17
Isolating the Problem .....	4-04	<b>ADJUSTMENTS</b>	
<b>TESTING</b>		Drive Belt .....	4-18
Battery .....	4-05	Belt Tension .....	4-18
Charging System Tests .....	4-06		
Bench Tests .....	4-11		

### DESCRIPTION AND OPERATION

#### ALTERNATOR

**Industrial Engines use either a Motorcraft or a Motorola alternator. Most of this section applies to the Motorcraft alternator, because the Motorola unit is serviced by Motorola.**

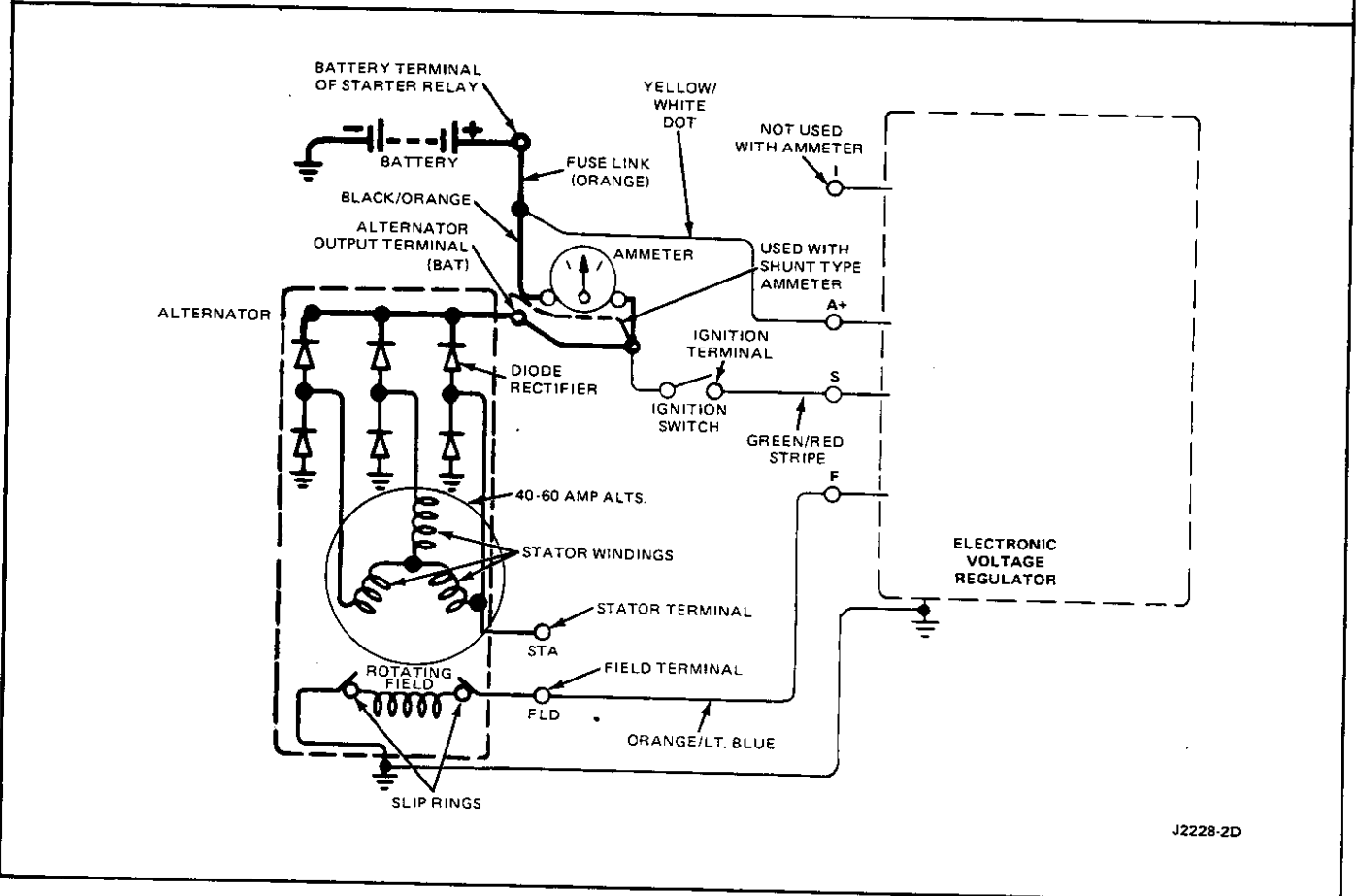
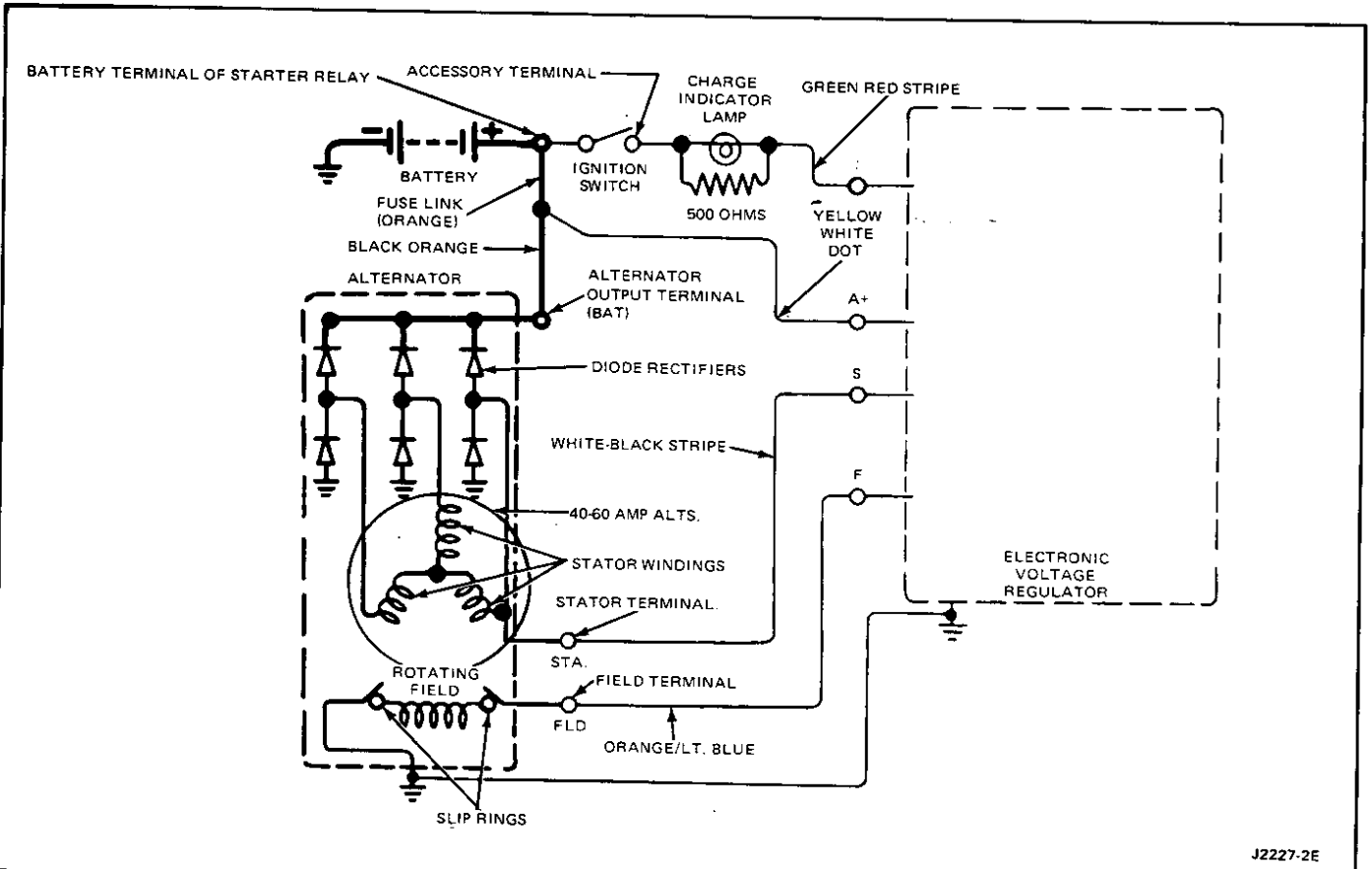
The alternator is belt driven from the engine. Current is supplied from the alternator-regulator system to the rotating field of the alternator through two brushes and two slip rings.

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

The warning lamp control circuit passes current to the warning lamp when the ignition switch is in the Run position and there is no alternator voltage at terminal S. When the voltage at S rises to a pre-set value, current is cut off to the warning lamp. This circuit is not included in the regulator for vehicles equipped with an ammeter rather than the warning lamp.

**WARNING: MARINE ALTERNATORS ARE EXTERNAL IGNITION PROTECTED. WHEN REPAIRING OR REPLACING THESE UNITS, USE ONLY PARTS OR ASSEMBLIES DESIGNATED FOR THIS PURPOSE. TO SUBSTITUTE AUTOMOTIVE PARTS OR ASSEMBLIES, WHICH APPEAR SIMILAR AND WILL FUNCTION, VOIDS THE EXTERNAL IGNITION PROTECTION AND GREATLY INCREASES THE DANGER OF IGNITING A COMBUSTIBLE MIXTURE, RESULTING IN POSSIBLE PERSONAL INJURY.**

# DESCRIPTION AND OPERATION (Continued)



## DESCRIPTION AND OPERATION (Continued)

A 500 ohm, 1/4 watt resistor is connected across the terminals of the lamp at the instrument cluster in vehicles equipped with an indicator warning lamp.

The switching circuit receives voltage from the ignition switch through the warning lamp control circuit on vehicles equipped with an indicator

warning lamp or through terminal S on vehicles equipped with an ammeter. With an input voltage present, the switching circuit turns on the voltage control circuit, which in turn controls the output circuit. When the ignition switch is Off, the output circuit remains open and no current flows to the alternator field.

### REGULATOR

The electrical charging systems incorporate a new electronic voltage regulator. These regulators are 100 percent solid state, consisting of transistors, diodes, and resistors. The working functions are achieved using electronic components arranged in basically three circuit divisions as follows: the output stage, the voltage stage, and the solid state relay.

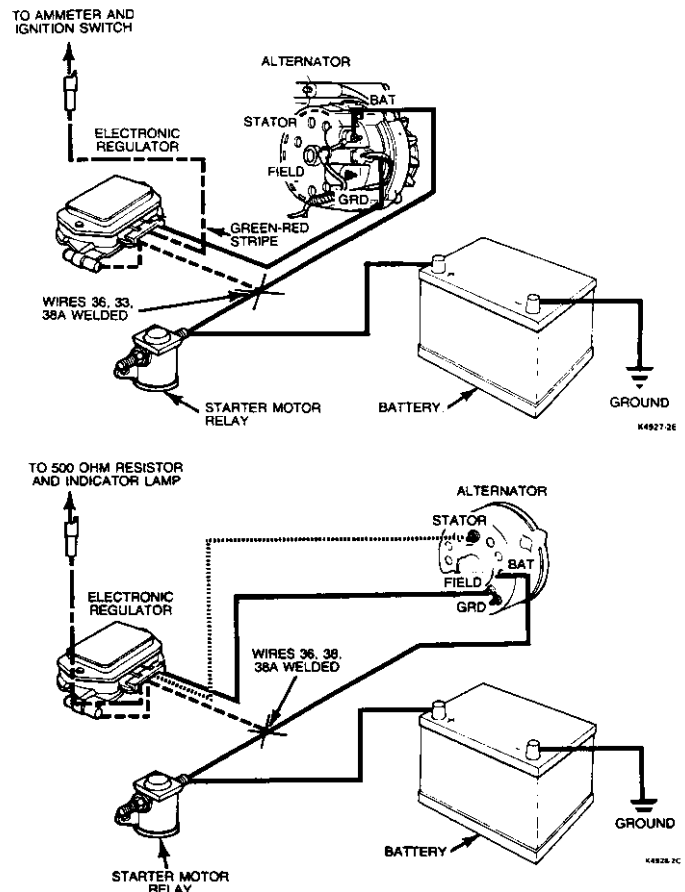
The new regulator will be released under two separate part numbers with color codes. The units will look alike, but are not interchangeable with the new regulator wiring harness connector plugs.

One of these units will be used on vehicles equipped with an ammeter, the other on vehicles equipped with an alternator warning indicator lamp. The regulators are calibrated and preset by the manufacturer. No readjustment is required or possible on these units.

The new solid state regulators being used in conjunction with other new components in the charging system that must be properly matched to prevent damage to the charging system are as follows:

1. A new alternator with higher field current requirement.
2. A new warning indicator lamp shunt resistor.
3. The alternator to regulator wiring harness is changed to incorporate a new regulator connector plug. The new plug is designed so that

the connector will not index with the regulator terminals when the wrong regulator is inadvertently installed in the vehicle.



### APPLICATION

Whenever the system components are being replaced, the following precautions should be followed so that the charging system will work properly and components will not be damaged.

1. Always use the proper alternator in the system being serviced. Older model alternators, if used in the present system, will have a slightly reduced output.
2. Never use an electro-mechanical regulator in the new charging system. The connector plug

on the new system wiring harness will not index properly with the electro-mechanical regulator.

3. The electronic regulators are color coded for proper installation. Always use the black color coded regulator in systems which use the warning lamp indicator. The blue color coded regulators must be used in ammeter gauge systems.
4. The charging system uses a 500 ohm resistor on the back of the instrument cluster on units with a warning indicator lamp. Do not replace this item with the 15 ohm resistance wire.

## DIAGNOSIS

Troubleshooting or diagnosis is required before actual repairs can be made in the electrical system. Even where an obvious fault makes the replacement of a unit necessary, you must still find out why the unit failed. When a trouble is diagnosed correctly, unnecessary repairs are prevented, the time the engine is out of service will be decreased, and the repairs that are made will be permanent.

Before performing charging or starting 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 or no charge, alternator warning lamp does not come on 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 alternator, regulator and engine. Inspect for evidence of arcing.
3. Check the alternator belt tension using belt tension gauge T63L-8620-A, Model 210019 or equivalent and tighten to specification (if necessary).

### NORMAL CHARGE INDICATOR LIGHT

With ignition switch off . . . alternator light is off.

With ignition switch on (engine not running) . . . alternator light is on.

With ignition switch on (engine running) . . . alternator light is off.

1. If the charge indicator light does not come on with the ignition key in the On position and the engine not running, disconnect the wiring plug connector at the regulator and connect a jumper wire from the I terminal of the regulator

wiring plug to the negative battery post cable clamp.

2. If the charge indicator light does not go on, check the bulb for continuity and replace (if burned out).
3. If the bulb is not burned out, an open circuit exists between the ignition switch and the regulator.
4. Check the 500 ohm resistor across the charge indicator lamp. Engines equipped with an ammeter will not have a resistor.

### NORMAL CHARGE AMMETER

With ignition switch off and no electrical load . . . ammeter should show 0 or center scale.

With ignition switch on and engine running . . . needle deflects towards charge and re-

turns toward center scale in two steps (fully charged battery).

With ignition switch off and lights on . . . ammeter should show between 0 and discharge scale.

### 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 the proper state of charge. The battery must be operating properly before the other areas of the electrical system can perform normally.

## TESTING

### BATTERY

**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.**

**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) NOR 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 temperatures.**

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 holddowns and heat shields and inspect for broken or cracked case or cover. If worn or damaged, loose or broken post, or cracked case or cover, replace battery.

### 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 °F	Minimum Acceptable Load Voltage
70 (or above)	9.6
60	9.5
50	9.4
40	9.3
30	9.1
20	8.9
10	8.7
0	8.5

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

### CAPACITY TEST

A high rate discharge tester 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.

## TESTING (Continued)

### STATE OF CHARGE — MAINTENANCE-FREE BATTERIES

Read the battery open circuit terminal voltage with a digital voltmeter capable of reading 1/100 of a volt. If the open circuit voltage of the battery is below 12.40 volts and the battery has passed the capacity test, charge the battery.

## CHARGING SYSTEM TESTS

### MOTOROLA

The following tests are made with the alternator on the engine with output and regulator connections maintained to the alternator except as noted in Tests 3 and 5. The field lead and voltage regulator are disconnected for these tests.

#### CAUTION:

- DO NOT disconnect alternator output lead while alternator is operating.
- DO NOT disconnect voltage regulator while alternator is operating.
- DO NOT ground field terminal.
- Check battery condition. Use a fully charged battery when testing alternator.
- Disconnect ground cable of battery when removing and installing the alternator.

All readings indicated are for correct operation.

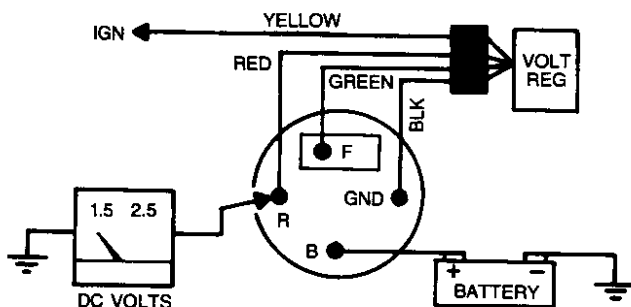
### Test 1 — Ignition On — Engine Not Running

Correct voltage at regulator terminal is approximately 1.5 to 2.5 volts. This test evaluates excitation circuit.

If voltage at regulator terminal is:

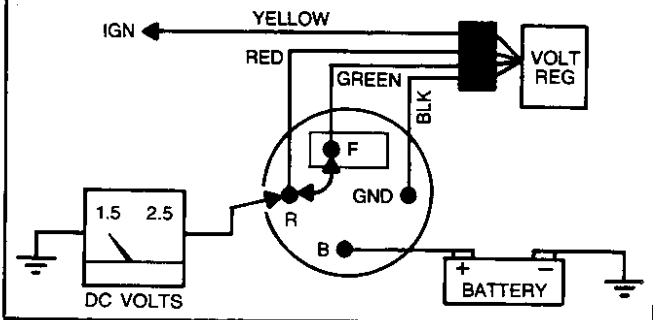
- 5.0 to 7.0 volts = open rotor (field circuit)
- .75 to 1.1 volts = grounded rotor circuit
- 8.5 to 10.0 volts = open in regulator's load circuit
- 0 volts = open ignition switch or excitation resistor

If test results are uncertain, go to Test 2.



### Test 2 — Ignition On — Engine Not Running

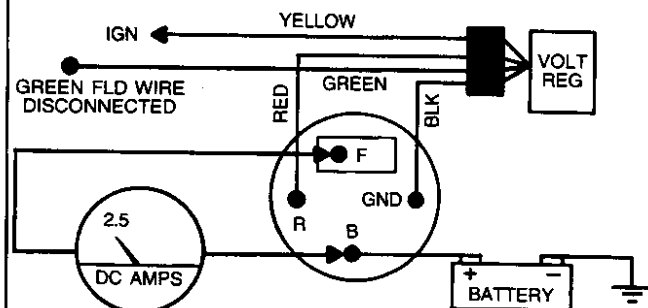
The voltage regulator may be bypassed with a short jumper between the regulator and field terminals. If jumper provides approximate correct voltage, fault is in the regulator. No change from high voltage indicates that the defect is in the brush or rotor circuit.



### Test 3 — Field Draw Test — Ignition Off

This test evaluates complete field circuit, independent of voltage regulator. Circuit is through brushes, slip rings, field coil to ground. Current should be 2 to 2.5 amps. If less than this, check brushes and slip rings. It is desirable to use a field rheostat in series with meter for protection of the meter. If field is shorted, excessive current would flow through meter and possible damage would result.

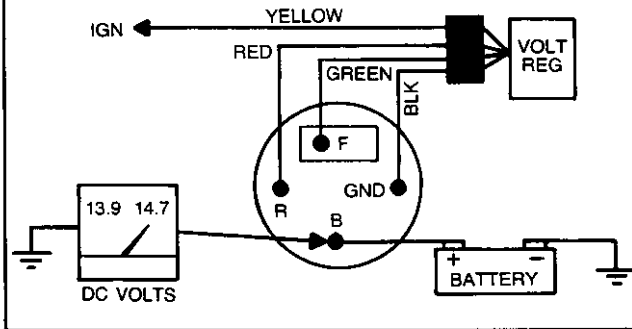
**NOTE: On integral regulator units, remove regulator to disconnect field connection. Regulator and ground terminals to remain connected.**



## TESTING (Continued)

### Test 4 — Ignition On — Engine Running at Fast Idle

Voltage indicated is usually 13.9 to 14.7 volts depending on regulator ambient temperature. High voltage may be due to a poor ground connection. If ground connection is not faulty, regulator will require replacement.

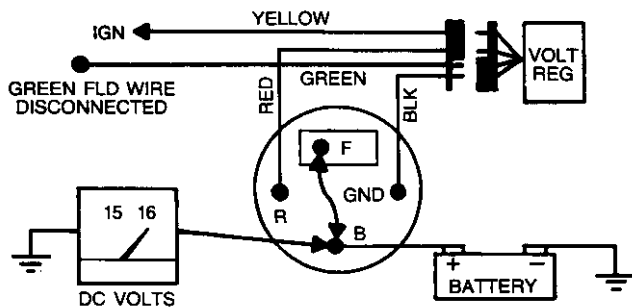


### Test 5 — Field Term Disconnected Voltage Regulator Plug Disconnected Battery Terminal Shorted to Field Terminal

#### Ignition On — Engine Running at Idle

This test isolates defect to either the alternator or regulator. If voltage at auxiliary terminal rises to 15-16 volts now, when it did not in Test 4 with regulator connected, then defect is in regulator and it should be replaced. If voltage does not rise at auxiliary terminal, defect is in alternator stator or rectifier diodes, if field circuit checked out properly. For defects in stator or diodes, remove alternator.

**NOTE:** On integral regulator units, remove regulator completely.



## MOTORCRAFT

When performing charging system tests with a voltmeter, turn off all lights and electrical components.

**CAUTION:** Be sure field terminal connector is installed on the "Field" terminal stud at alternator and not the ground stud.

Always disconnect the connector plug from the regulator before checking alternator output with test probes or a jumper wire.

Always disconnect the connector plug from the regulator before removing the regulator mounting screws. Removing the connector from an un-grounded regulator with the ignition switch on will destroy the regulator.

Never attempt to polarize or test the alternator by grounding the field circuit, as this will destroy the regulator.

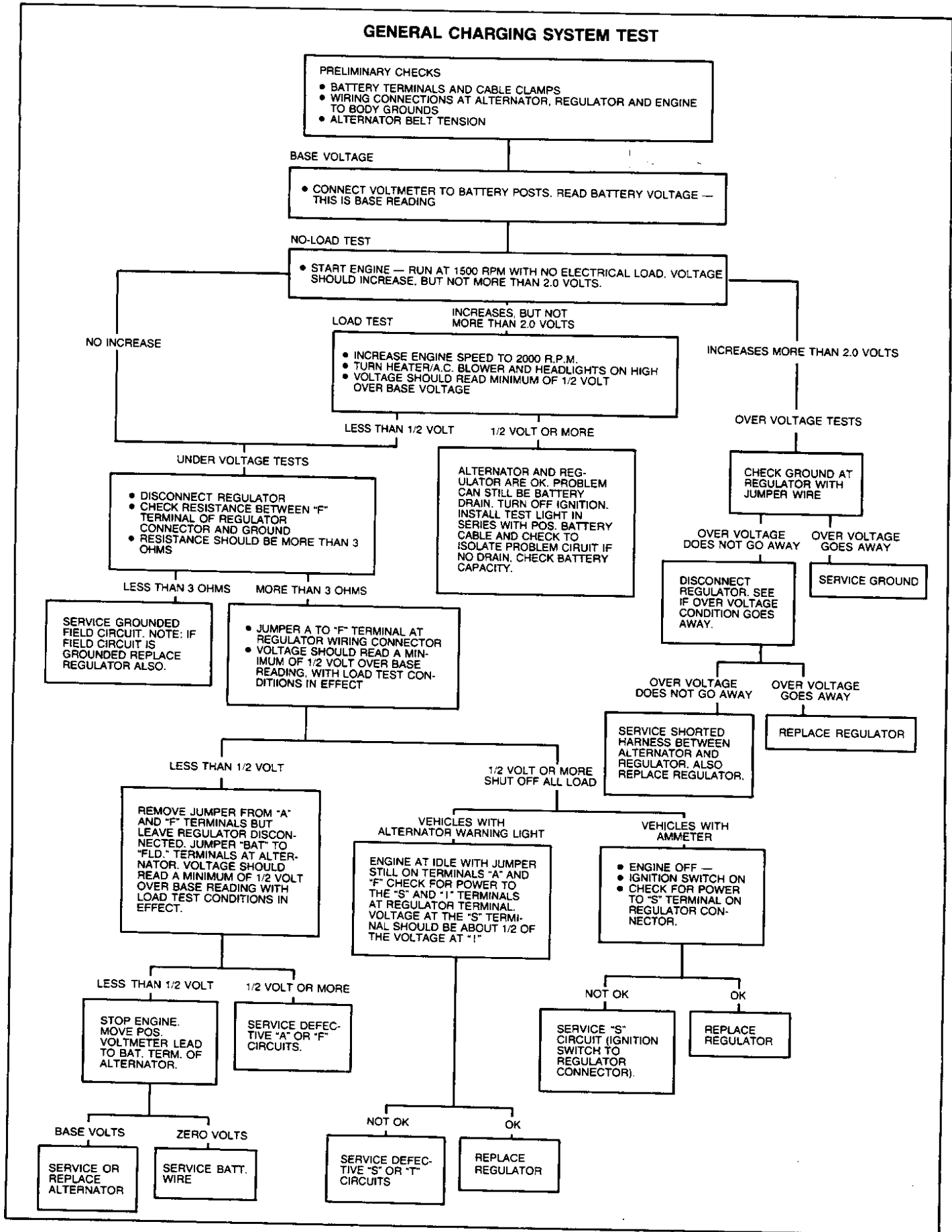
### Base Voltage Test

1. With ignition off and no electrical load on, connect the negative lead of the voltmeter to the negative battery cable clamp.
2. Connect the positive lead of the voltmeter to the positive battery cable clamp.
3. Record the battery voltage reading shown on the voltmeter scale (base voltage).

### No Load Test

1. Connect a tachometer to the engine.
2. Start the engine and increase speed to approximately 1500 RPM. With no other electrical load, the voltmeter pointer should move upward (increase), but not more than 2 volts above the base voltage (first recorded battery voltage reading above). The reading should be taken when the voltmeter pointer stops rising. It may take a few minutes to reach this point. If the voltage increases to proper level, perform Load Test. If the pointer continues to rise, perform the Over Voltage Tests. If the voltage does not rise to proper level, perform the Under Voltage Tests.

TESTING (Continued)



CHECK GROUND AT REGULATOR WITH JUMPER WIRE

DISCONNECT REGULATOR. SEE IF OVER VOLTAGE CONDITION GOES AWAY.

SERVICE GROUND

SERVICE SHORTED HARNESS BETWEEN ALTERNATOR AND REGULATOR. ALSO REPLACE REGULATOR.

REPLACE REGULATOR

**REMOVE JUMPER FROM "A" AND "F" TERMINALS BUT LEAVE REGULATOR DISCONNECTED. JUMPER "BAT" TO "FLD." TERMINALS AT ALTERNATOR. VOLTAGE SHOULD READ A MINIMUM OF 1/2 VOLT OVER BASE READING WITH LOAD TEST CONDITIONS IN EFFECT.**

LESS THAN 1/2 VOLT      1/2 VOLT OR MORE

STOP ENGINE. MOVE POS. VOLTMETER LEAD TO BAT. TERM. OF ALTERNATOR.

BASE VOLTS      ZERO VOLTS

SERVICE OR REPLACE ALTERNATOR

SERVICE BATT. WIRE

SERVICE DEFECTIVE "A" OR "F" CIRCUITS.

**VEHICLES WITH ALTERNATOR WARNING LIGHT**

ENGINE AT IDLE WITH JUMPER STILL ON TERMINALS "A" AND "F" CHECK FOR POWER TO THE "S" AND "I" TERMINALS AT REGULATOR TERMINAL. VOLTAGE AT THE "S" TERMINAL SHOULD BE ABOUT 1/2 OF THE VOLTAGE AT "I"

NOT OK      OK

SERVICE DEFECTIVE "S" OR "I" CIRCUITS

REPLACE REGULATOR

**VEHICLES WITH AMMETER**

- ENGINE OFF —
- IGNITION SWITCH ON
- CHECK FOR POWER TO "S" TERMINAL ON REGULATOR CONNECTOR.

NOT OK      OK

SERVICE "S" CIRCUIT (IGNITION SWITCH TO REGULATOR CONNECTOR).

REPLACE REGULATOR

## TESTING (Continued)

### Load Test

1. With the engine running, turn the heater or air conditioner blower motor on (high speed) and headlights on high beam.
2. Increase the engine speed to approximately 2000 RPM. The voltmeter should indicate a minimum of 0.5 volt above the base voltage. If not, perform the Under Voltage Tests described below.

If the above tests indicate proper voltage readings (1/2 volt open circuit above base), the charging system is operating normally. Proceed to the tests below if one or more of the readings are different than shown above and use a test light to check for battery drain.

### Over Voltage Tests

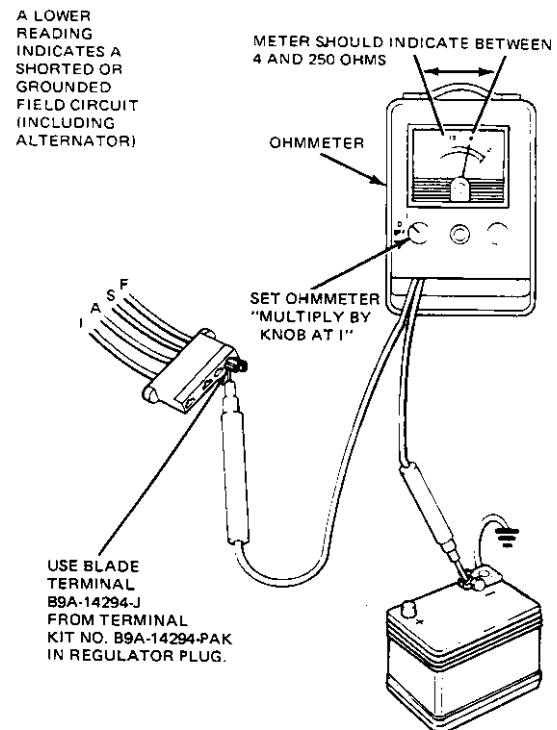
1. If the voltmeter reading indicates more than 2.0 volts above base voltage, connect a jumper wire between the regulator base and alternator frame. Repeat the No Load test. If over voltage condition disappears, check ground connections on alternator, regulator and from engine to firewall and to battery. Clean and tighten connections securely.
2. If over voltage condition still exists, disconnect the regulator wiring plug from the regulator and repeat the No Load test.
3. If over voltage condition disappears (voltmeter reads battery base voltage), replace voltage regulator.
4. If over voltage still exists with the regulator wiring plug disconnected, check for short between "A" and "F" in the wiring harness plug and service as required. Replace the regulator and connect the regulator wiring plug to the regulator.

### Under Voltage Tests

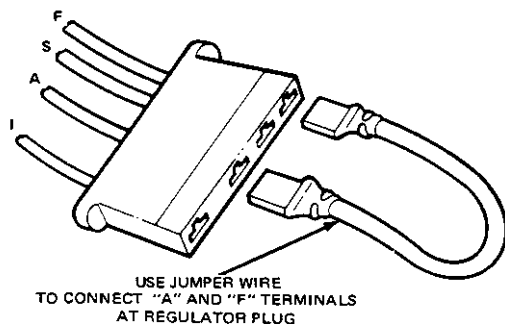
1. If the voltage does not indicate more than 1/2 volt above base voltage, disconnect wiring plug from regulator and connect an ohmmeter from "F" terminal of plug to ground. Meter should indicate more than 2.4 ohms. If less than 2.4 ohms is indicated, service grounded field current in wire or alternator and repeat Load Test above.
2. If ohmmeter indicates more than 2.4 ohms connect jumper wire from "A" to "F" terminals of regulator plug. Repeat Load Test above. If voltmeter now indicates more than 1/2 volt above base voltage, service wiring to regulator or regulator.
3. If the voltmeter still indicates under voltage, remove the jumper wire from the regulator plug and leave the plug disconnected from the

regulator. Connect a jumper wire to the FLD and BAT terminals on the alternator and repeat the Load Test. If the voltmeter now indicates more than 1/2 volt above the base voltage, perform S and I Circuit Test and service the wiring harness from the alternator to the regulator.

4. If the voltmeter still indicates under voltage, stop the engine and move the positive voltmeter lead to the alternator BAT terminal.
5. If the voltmeter now indicates the base voltage reading, service the alternator. If the voltmeter indicates zero volts, service alternator to starter relay wire.

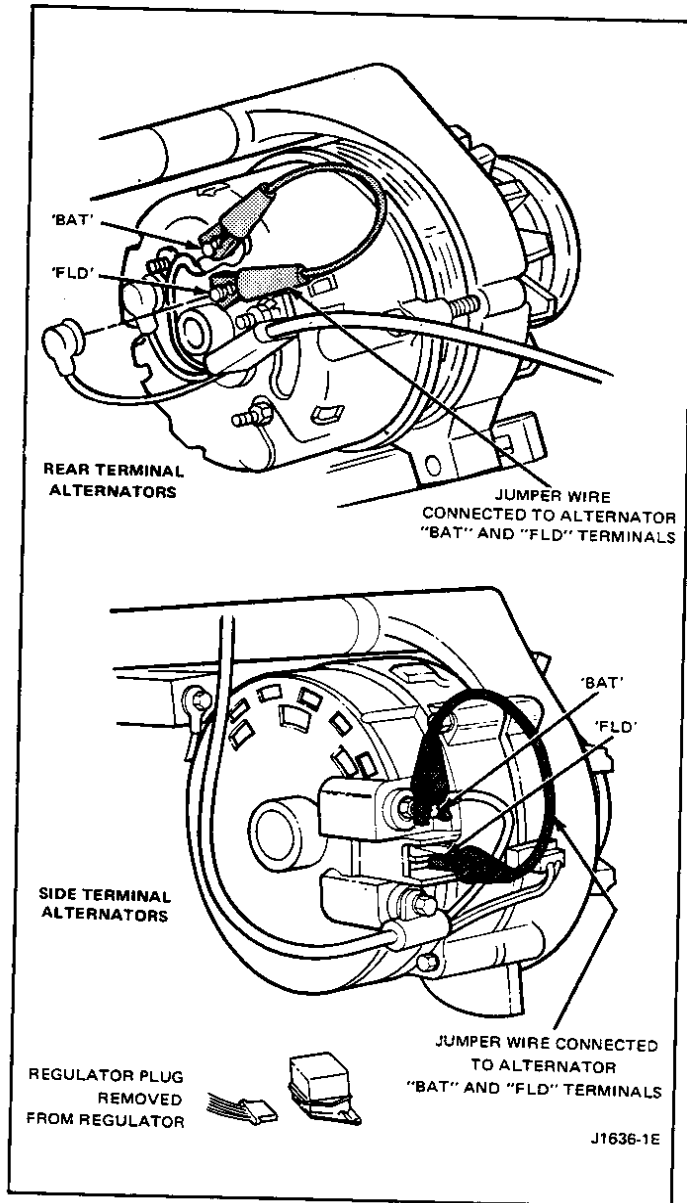


J1633-1D



J1635-1A

## TESTING (Continued)



### Regulator S and I Circuit Tests S-Circuit with Ammeter

1. Connect the positive lead of the voltmeter to the S terminal of the disconnected regulator wiring plug and negative lead of voltmeter to battery ground terminal. Then, turn the ignition switch to the On position. DO NOT start the engine. No voltage should be indicated with ignition switch Off.
2. The voltmeter should indicate battery voltage.
3. If there is no voltage reading, service the S wire lead from the ignition switch to the regulator wiring plug.
4. Connect the positive voltmeter lead to the positive battery cable terminal, connect regulator wiring plug to regulator and repeat the Load Test.

### S and I Circuit — With Indicator Light

1. Disconnect the regulator wiring plug and install a jumper wire between the "A" and "F" terminals.
2. With the engine idling, connect the negative voltmeter lead to the battery ground terminal and the positive lead of the voltmeter to the S terminal and then to the I terminal of the regulator wiring plug. The voltage of the S circuit should read approximately one-half of the I circuit.
3. If no voltage is present, service the wiring circuit. Reconnect the positive voltmeter lead to the positive battery cable terminal.
4. Then, remove the jumper wire from the regulator wiring plug and connect the wiring plug to the regulator. Repeat the Load Test.

## TESTING (Continued)

### BENCH TESTS

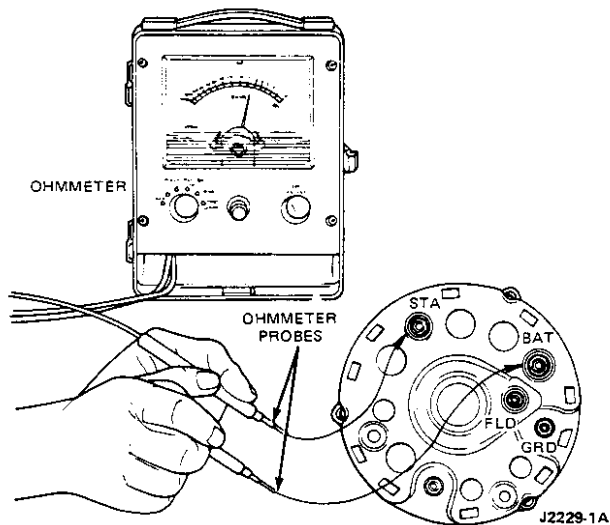
After the general charging system diagnosis has isolated the problem to the alternator, remove it from the vehicle for bench testing and service, or replacement. Refer to Alternator Removal and Disassembly in this section.

#### Rectifier Short or Grounded and Stator Grounded Test

These tests are performed with an ohmmeter (Rotunda 50-0010 or equivalent). Set the "Multiply By" knob at 1 and calibrate the ohmmeter as directed.

**CAUTION: Digital meters cannot be used to perform these rectifier tests.**

1. Contact one ohmmeter probe to the alternator BAT terminal (terminal with red insulator) and the other probe to the STA terminal (terminal with black insulator). Then, reverse the ohmmeter probes and repeat the test. Normally there will be no needle movement in one direction, indicating the rectifier diodes are being checked in the reverse current direction and are not shorted. A low reading with the probes reversed indicates that rectifier positive diodes are being checked in the forward current direction. Using the referenced tester, the low reading should be about 6 ohms but may vary if another type of tester is used. A reading in both directions indicates a bad positive diode, a grounded positive diode plate or a grounded BAT terminal.

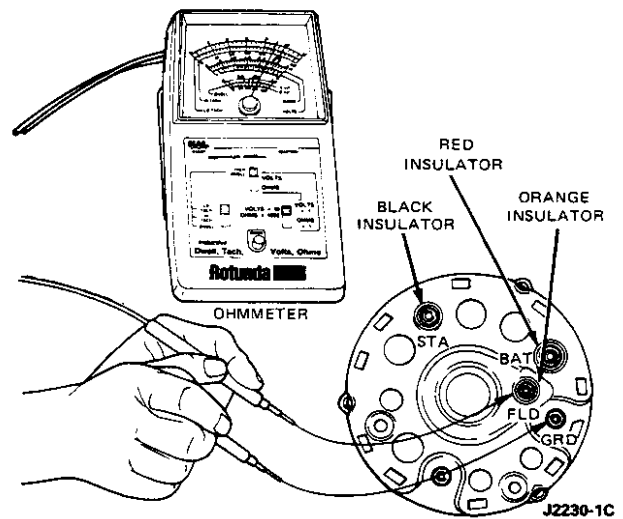


2. Perform the same test using the STA and GND terminals. A reading in both directions indicates either a grounded stator winding, a bad negative diode, a grounded stator terminal, a grounded positive diode plate, or a grounded BAT terminal.
3. If there is no needle movement with the probes in one direction and a high resistance (significantly over 6 ohms) in the opposite direction, for either test, a bad connection exists between the stator lead terminal and the stator bolt head.

#### Field Open or Short Circuit Test

This test is performed with an ohmmeter. Set the ohmmeter "Multiply By" knob at 1 and calibrate the ohmmeter as directed inside the instrument cover.

1. Contact the alternator field terminal with one probe and the ground terminal with the other probe. Then, spin the alternator pulley. The ohmmeter reading should be between 2.4 and 100 ohms and should fluctuate while the pulley is turning.
2. An infinite reading (no meter movement) indicates an open brush lead, worn or stuck brushes or a bad rotor assembly.
3. An ohmmeter reading less than 2.4 ohms indicates a grounded brush assembly, a grounded field terminal or a bad rotor.



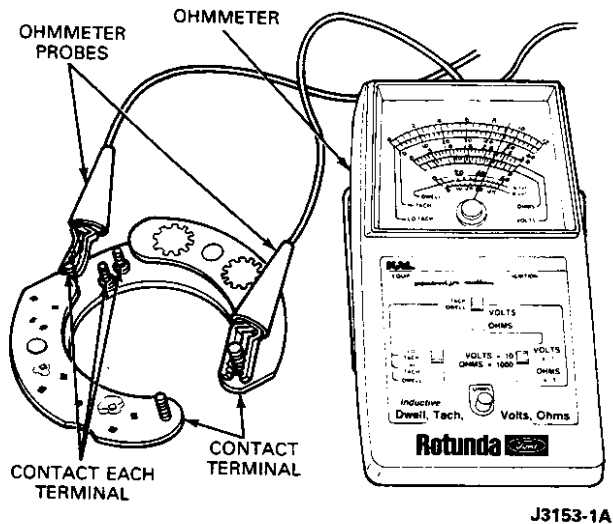
## TESTING (Continued)

### Diode Test

Remove the rectifier assembly from the alternator. Set the ohmmeter "Multiply By" knob at 1 and calibrate the meter as directed.

**CAUTION: Digital meters cannot be used to perform these diode tests.**

1. To test one set of diodes, contact one probe to the terminal bolt and contact each of the three stator lead terminals with the other probe. Reverse the probes and repeat the test. All diodes should show a low reading of about 6 ohms in one direction and an infinite reading (no needle movement) with the probes reversed. The low reading may vary with the type of tester used. This reading may be checked against a good rectifier if it is available.



2. Repeat the preceding tests for the other set of diodes except that the other terminal screw is used.
3. If the meter readings are not as specified, replace the rectifier assembly.

### Stator Coil Grounded Test

These tests are made to determine if the stator coil is operating properly. Remove the stator from the alternator and disconnect from the rectifier assembly (refer to Disassembly procedure in this section). Set the ohmmeter "Multiply By" knob at 1000.

1. Connect the ohmmeter probes to one of the stator leads and to the stator laminated core.

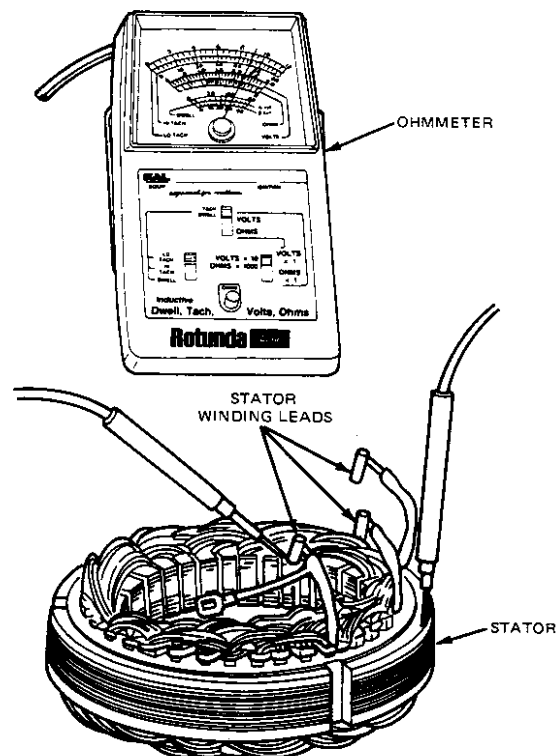
Be sure that the probe makes a good electrical connection with the stator core. The meter should show an infinite reading (no meter movement).

2. If the meter does not indicate an infinite reading (needle moves), the stator winding is shorted to the core and must be replaced.
3. Repeat this test for each of the stator leads. Do not touch the metal probes or stator leads with the hands. Such contact will result in an incorrect reading.

### Stator Coil Open Test

This test determines if there is an open stator circuit. Disconnect the stator from the rectifier assembly. Set the ohmmeter "Multiply By" knob at 1.

1. Connect one ohmmeter probe to a stator phase lead and touch the other probe to another stator lead. Check the meter reading.



2. Repeat this test with the other two stator lead combinations. If no meter movement occurs (infinite resistance) on a lead paired with either of the other two leads, that phase is open and the stator should be replaced.

## TESTING (Continued)

### Rotor Open or Short Circuit Test

Remove the rotor from the alternator. Set the ohmmeter "Multiply By" knob at 1 and calibrate the meter as directed.

1. Contact each ohmmeter probe to a rotor slip ring. The meter reading should be 2.0 to 3.5 ohms.
2. A higher reading indicates a damaged slip ring solder connection or a broken wire.
3. A lower reading indicates a shorted wire or slip ring. Replace the rotor if it is damaged and cannot be serviced.
4. Contact one ohmmeter probe to a slip ring and the other probe to the rotor shaft. The meter reading should be infinite (no deflection).
5. A reading other than infinite indicates the rotor is shorted to the shaft. Inspect the slip ring soldered terminals to be sure they are not bent and not touching the rotor shaft or that excess solder is not grounding the rotor shaft or coil connections to the shaft. Replace the rotor if it is shorted and cannot be serviced.

## REMOVAL AND INSTALLATION

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**WARNING: KEEP 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 FIFTEEN MINUTES. IF ACID IS SWALLOWED, DRINK LARGE QUANTITIES**

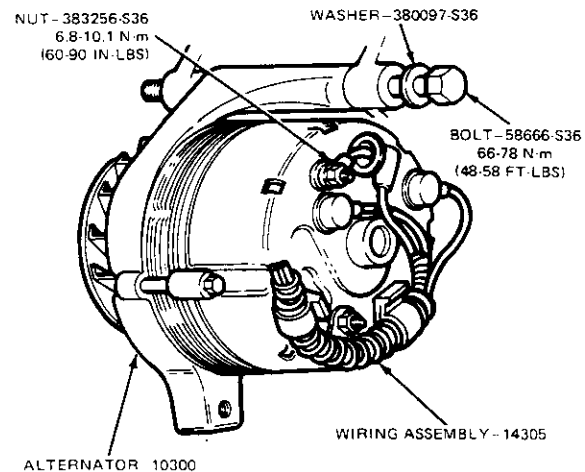
**OF MILK OR WATER, FOLLOWED BY MILK OF MAGNESIA, A BEATEN EGG, OR VEGETABLE OIL. CALL A PHYSICIAN IMMEDIATELY.**

### REMOVAL

1. Disconnect the ground cable from the battery.
2. Loosen the alternator pivot bolt and remove the adjustment arm-to-alternator bolt.
3. Disengage the alternator drive belt from the drive pulley.
4. Disconnect the wiring terminals from the back of the alternator. The stator and field wiring terminals are the push-on type. The push-on type terminal should be pulled straight off the terminal to prevent damage.
5. Remove the alternator pivot bolt.
6. Remove the alternator.

### INSTALLATION

1. Position the alternator on the engine.
2. Install the alternator pivot bolt and adjuster bolt.
3. Connect the wiring terminals to the back of the alternator.
4. Install the drive belt over the alternator drive pulley.
5. Adjust the belt to specification.
6. Connect ground cable to battery.



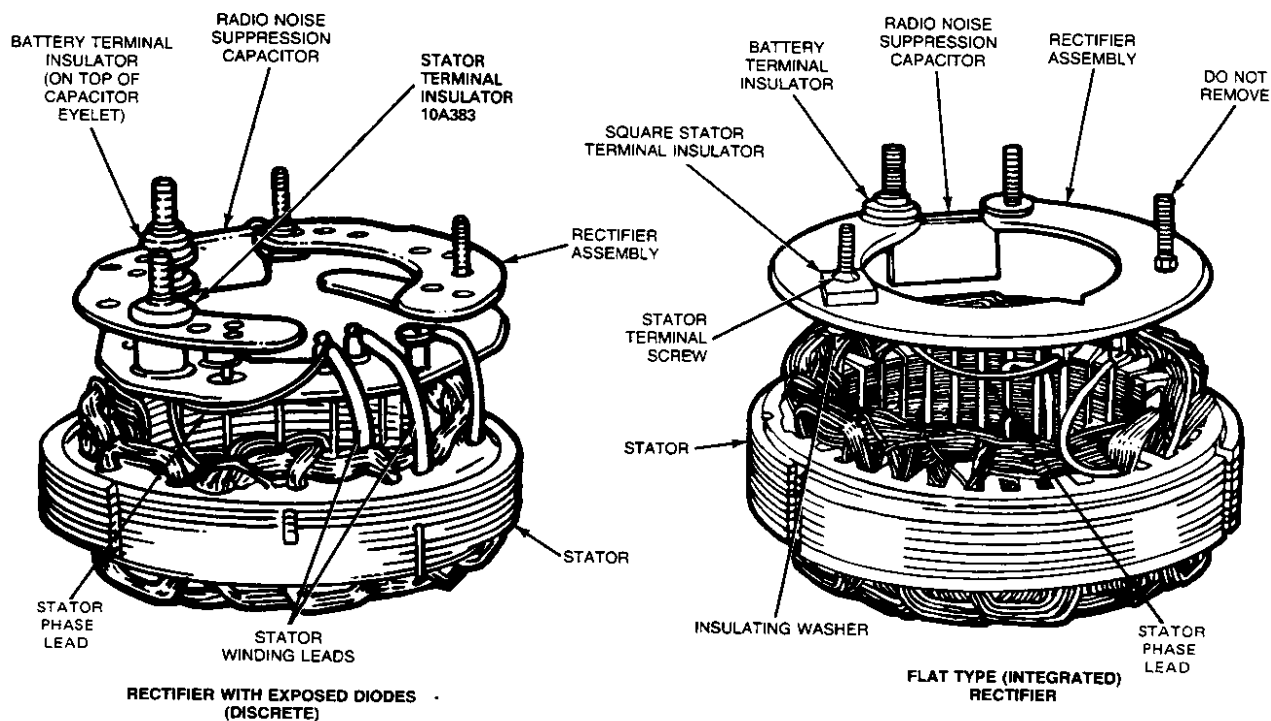
## DISASSEMBLY AND ASSEMBLY

### DISASSEMBLY

**NOTE: All of the following disassembly steps may not be necessary to perform a particular test or repair. Perform only those steps that apply in your case.**

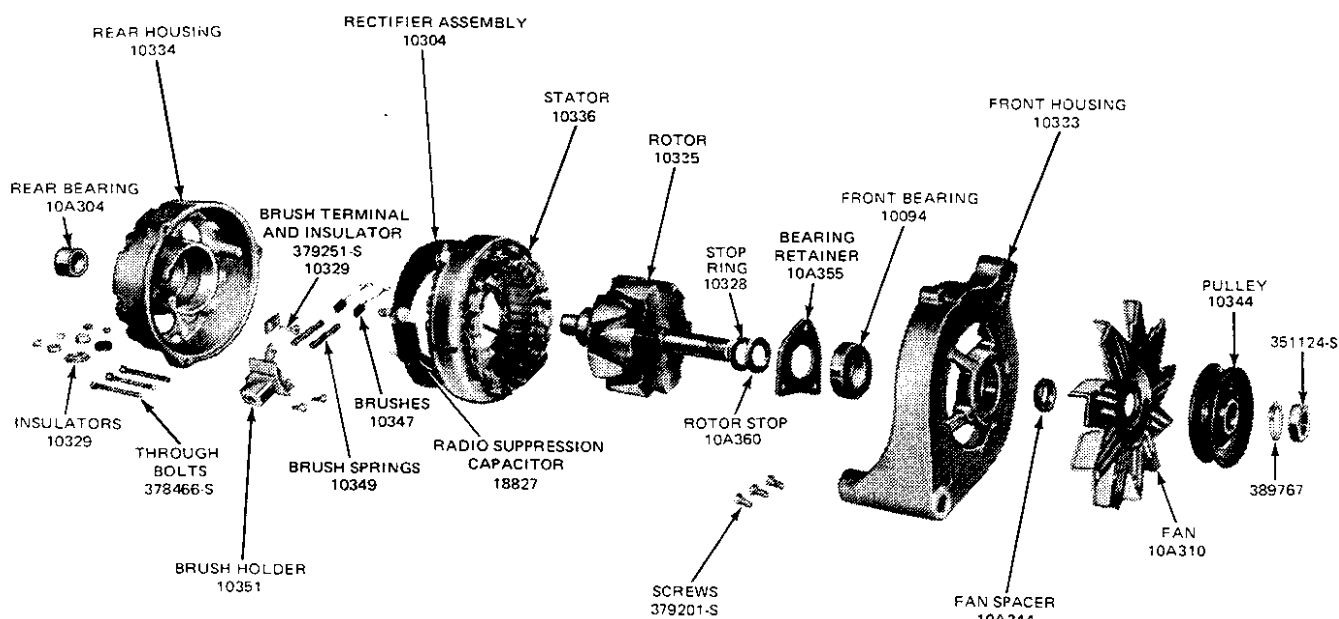
The rear terminal alternator will have one of two types of rectifier assembly. One is a flat design with built-in diodes. The other type is a stacked design with exposed diodes. Procedural steps affected by the differences in the rectifiers will be noted.

1. Scribe a line across the end housings and stator frame for alignment reference during assembly.
2. Remove the three housing through bolts.
3. Separate the front housing and rotor assembly from the stator and rear housing assembly. It may be necessary to tap the front housing with a plastic tipped hammer to loosen the front housing from the stator frame.
4. Remove the brush springs from the brush holder in the rear housing.
5. Remove the nuts, washers and insulators from the terminals on the back of the rear housing. Note the color and location of the insulators for assembly reference.
6. Remove the stator and rectifier assembly from the rear housing.
7. Remove the screws attaching the brush holder to the rear housing.
8. Remove the brush holder, the brushes and the brush terminal insulator from the rear housing.
9. Using a suitable arbor press, remove the bearing from the rear housing. Support the housing close to the bearing boss to prevent damage to the housing.
10. Clamp the front housing in a vise with protective jaws.
11. Remove the drive pulley retaining nut from the rotor shaft using Removal/Installation Tool, T65P-10300-B or equivalent.
12. Remove the lockwasher, drive pulley, fan and fan spacer from the rotor shaft.
13. Remove the rotor from the front housing and remove the housing from the vise.
14. Remove the front bearing spacer from the rotor shaft. Do not remove the stop ring from the rotor shaft unless it is damaged.
15. Remove the screws attaching the bearing retainer to the front housing and remove the retainer.
16. Remove the bearing from the front housing. If the bearing will not slide out, remove it using a suitable arbor press. Support the housing close to the bearing boss to prevent damage to the housing.

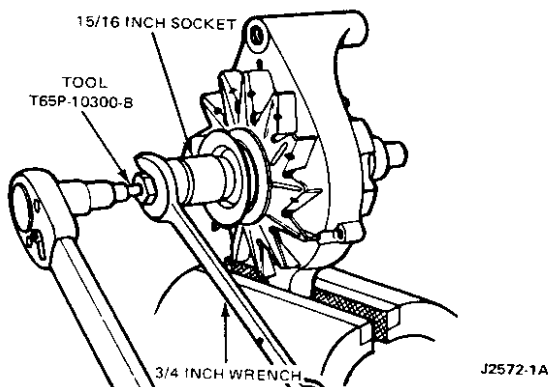


STATOR AND RECTIFIER ASSEMBLIES

## DISASSEMBLY AND ASSEMBLY (Continued)



J1166-20



J2572-1A

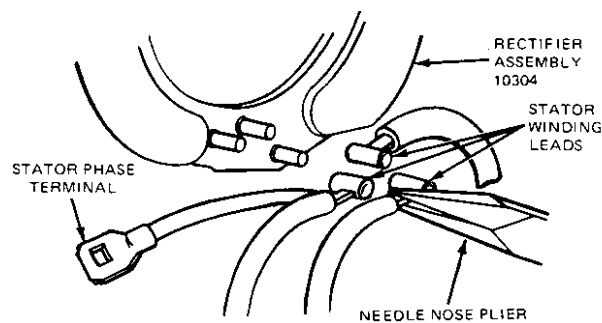
17. Remove the radio suppression capacitor and the battery terminal insulator from the rectifier assembly.
18. Using a 100 watt soldering iron, unsolder the stator leads from the rectifier assembly. Do not allow the soldering iron to overheat the rectifier. When removing the rectifier assembly from the alternator, do not cut the stator lead wires. Unsolder the stator terminals from the molded circuit board terminals and with needle nose pliers pull stator lead terminals upwards from the rectifier assembly. While the terminals are still hot, shake the molten solder from the terminals.

19. Disconnect the stator phase lead from the rectifier assembly as follows:

Flat type (integrated) rectifier — Remove the stator terminal screw by pressing it straight out of the rectifier. Do not turn the terminal screw during removal. Turning the screw during removal will destroy the serrations cut into the rectifier to hold the terminal screw in position.

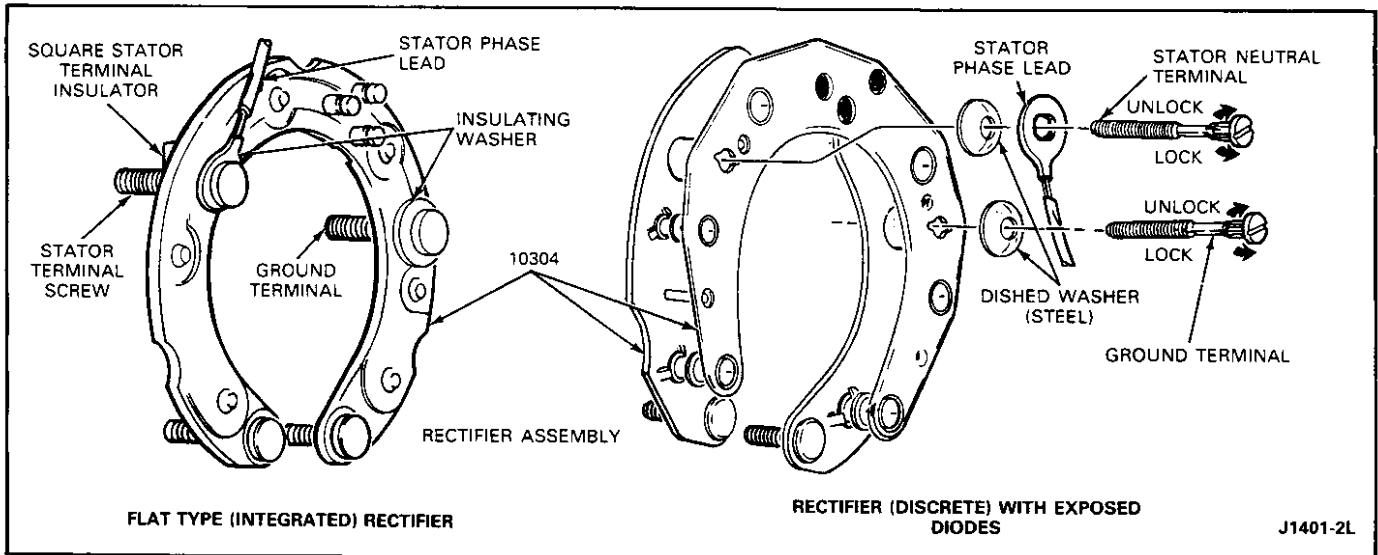
Exposed diode (discrete) rectifier — Remove the stator terminal screw by turning it 1/4 turn to unlock it from the rectifier assembly.

20. If necessary, the ground terminal can be removed from the rectifier assembly by following the appropriate procedure outlined in Step 19.



J2232-1B

## DISASSEMBLY AND ASSEMBLY (Continued)



### CLEANING AND INSPECTION

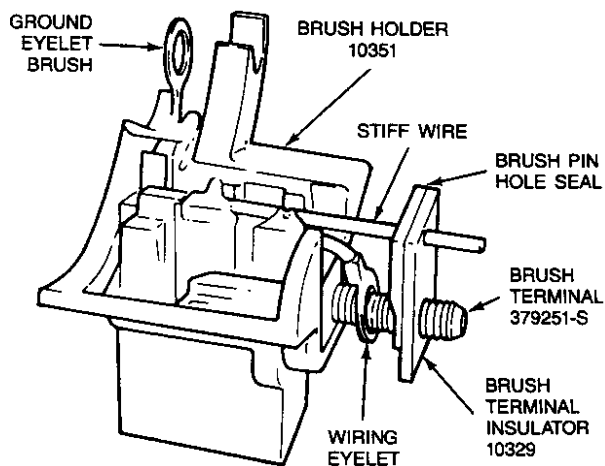
**CAUTION:** When rebuilding a high temperature 60 AMP alternator, use only high temperature rectifier assembly and bearings. Use of standard parts will result in alternator failure.

1. Wipe the rotor, stator and bearings with a clean cloth. Do not clean these parts with solvent.
2. Rotate the front bearing on the drive end of the rotor shaft. Check for any scraping noise, looseness or roughness. Look for excessive lubricant leakage. If any of these conditions exist, replace the bearing.
3. Inspect the rotor shaft rear bearing surface for roughness or severe chatter marks. Replace the rotor assembly if the shaft is not smooth.
4. Place the rear bearing on the slip ring end of the rotor shaft and rotate the bearing. Make the same check for noise, looseness, or roughness as was made for the front bearing. Inspect the rollers and cage for damage. Replace the bearing if these conditions exist, or if the lubricant is lost or contaminated.
5. Check the pulley and fan for excessive looseness on the rotor shaft. Replace any pulley or fan that is loose or bent out of shape.
6. Check both the front and rear housing for cracks, particularly in the webbed areas and at the mounting ear. Replace damaged or cracked housing.
7. Check all wire leads on both the stator and rotor assemblies for loose or broken soldered connections and for burned insulation. Resolder poor connections. Replace parts that show signs of burned insulation.
8. Check the slip rings for nicks and surface roughness. Nicks and scratches may be removed by turning down the slip rings. Do not go beyond the minimum diameter of 31 mm (1.22 inches). If the rings are badly damaged, replace the rotor assembly.
9. Replace the brushes if they are worn shorter than 6.35 mm (1/4 inch).

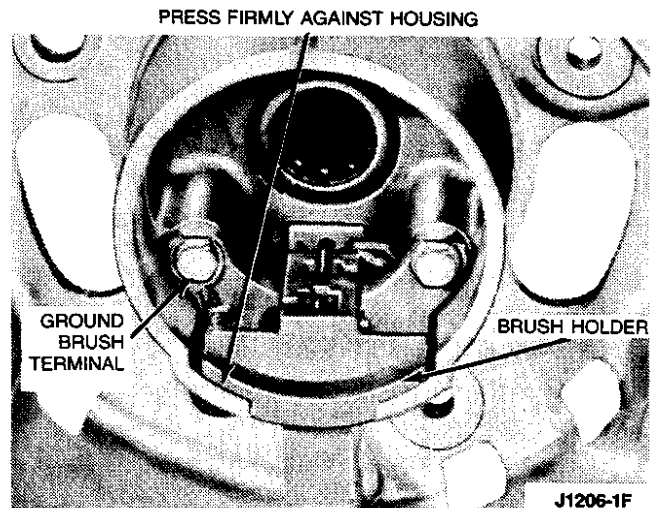
## DISASSEMBLY AND ASSEMBLY (Continued)

### ASSEMBLY

1. Install the bearing in the front housing. Press on the outer race only.
2. Position the bearing retainer on the front housing and install the attaching screws. Tighten the screws to 2.8-4.5 N·m (25-40 in-lb).
3. If the stop ring was removed from the rotor shaft, install a new ring by sliding it over the end of the shaft and into the groove. Do not open the ring with snap ring pliers as permanent deformation of the ring will result.
4. Install the bearing spacer on the rotor shaft with the recessed slide against the stop ring.
5. Install the rotor in the front housing and clamp the housing in a vise.
6. Install the fan spacer, fan, drive pulley lock-washer and nut on the rotor shaft. Tighten the nut to 82-135 N·m (60-100 ft-lb) using Removal/Installation Tool, T65P-10300-B or equivalent.
7. Remove the rotor and housing assembly from the vise.
8. Support the rear housing close to the bearing boss to prevent damage to the housing and install the bearing using a suitable arbor press. Press the bearing into the bore until it is flush with the housing.
9. Position the brush wiring eyelet over the brush terminal and install the brush terminal insulator.



10. Install the springs and brushes in the brush holder. Hold the brushes against spring tension by inserting a piece of stiff wire through the brush holder.



11. Position the brush holder in the rear housing and install the attaching screws. Tighten the screws to 1.9-2.8 N·m (17-25 ft-lb). Press the brush holder firmly against the housing while tightening the screws. Make sure the ground brush wiring eyelet is positioned under the screw before tightening.
12. Connect the stator phase lead to the rectifier assembly as follows:

Flat type (integrated) diode rectifier — Position the stator terminal insulator and the stator phase lead on the rectifier assembly. Insert the terminal screw and press into position. The screw should be pressed in far enough to keep the phase lead terminal from moving.

Rectifier with exposed diodes (discrete) — Position the stator phase lead and dished washer on the rectifier assembly. Insert the terminal screw and lock into place by rotating 1/4 turn.

13. If the ground terminal was removed from the rectifier assembly, it can be installed by pressing or turning as outlined in the appropriate procedure in Step 12.
14. Before soldering stator leads to rectifier, make sure that the insulator sleeves are in place. Wrap the stator winding leads around the terminals of the rectifier assembly and solder them, using a 100 watt soldering iron and resin core electrical solder. Do not allow the soldering iron to overheat the rectifier assembly. Press the sleeves on the terminals before rectifier soldering.
15. Install the radio suppression capacitor and battery terminal insulator on the rectifier assembly.
16. Install the insulator on the stator terminal screw.

## DISASSEMBLY AND ASSEMBLY (Continued)

17. Align the terminal screws on the rectifier assembly with the holes in the back of the rear housing and install the stator rectifier assembly in the rear housing. Make certain the terminal insulators are seated in their recesses.
18. Install the external insulators, washers and nuts on the terminals. The insulators are color coded as follows:
  - Black on the stator (STA) terminal. Tighten nut to 2.8-3.9 N·m (25-35 in-lb).
  - Red on the battery (BAT) terminal. Tighten nut to 3.4-6.2 N·m (30-55 in-lb).
  - Orange on the field (FLD) terminal. Tighten nut to 2.8-3.9 N·m (25-35 in-lb).
19. Wipe the rear end bearing surface of the rotor shaft with a clean, lint-free rag.
20. Position the rear housing and stator assembly over the rotor and align the scribe marks made during disassembly.
21. Seat the machined portion of the stator core into the stop in both end housings and install the housing through bolts. Tighten the bolts to 4.1-6.7 N·m (35-60 in-lb).
22. Remove the wire holding the brushes.

**CAUTION: This step is important so that regulator will not be damaged.**

## ADJUSTMENTS

### DRIVE BELT

The fan drive belt should be properly adjusted at all times. A loose drive belt can cause improper alternator, fan and water pump operation. A belt that is too tight places a severe strain on the water pump and alternator 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 belt 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 alternator mounting bolts and move the alternator adjusting arm bolts. Move the alternator toward or away from the engine until the correct tension is obtained. Remove the gauge.
3. Tighten the alternator adjusting arm bolt and the mounting bolts. Install the tension gauge and check the belt tension.

## Part 5 — Starting System

SUBJECT	PAGE	SUBJECT	PAGE
<b>DESCRIPTION AND OPERATION</b> .....	5-01	<b>TESTING (Cont'd.)</b>	
<b>TESTING</b>		Starter No-Load Test .....	5-04
Road Service .....	5-02	Armature Open Circuit Test .....	5-04
Jump Starting .....	5-02	Armature and Field Grounded	
On Vehicle Testing .....	5-02	Circuit Test .....	5-04
If Starter Cranks Slowly .....	5-02	<b>REMOVAL AND INSTALLATION</b> .....	5-05
If Starter Does Not Crank But		<b>DISASSEMBLY AND ASSEMBLY</b>	
Starter Relay Operates (Clicks) .....	5-03	Disassembly .....	5-05
If Starter Does Not Crank and		Cleaning and Inspection .....	5-05
Relay Chatters or Does Not Click .....	5-03	Assembly .....	5-08
If Starter Spins (Humming Noise)		Starter Drive Replacement .....	5-08
But Does Not Crank Engine .....	5-03	Brush Replacement .....	5-09
Starter Load Test .....	5-03	Armature Replacement .....	5-09
Bench Tests .....	5-04		

### DESCRIPTION AND OPERATION

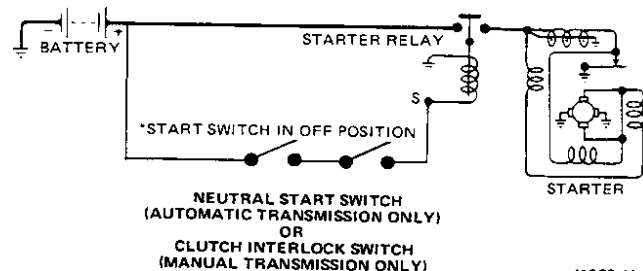
The starting system includes the starter motor with an integral positive-engagement drive, the battery, a remote control starter switch (part of the ignition switch), the neutral-start switch (used with automatic transmissions), the starter relay, starter interlock switch (used with manual transmission), and heavy circuit wiring.

Turning the ignition key to the Start position actuates the starter relay through the starter control circuit. The starter relay then connects the battery to the starter.

Vehicles equipped with an automatic transmission have a neutral-start switch in the starter control circuit. This prevents operation of the starter on vehicles with an automatic transmission if the selector lever is not in the N (NEUTRAL) or P (PARK) position.

When the starter is not in use, one of the field coils is connected directly to ground through a set of contacts. When the starter is first connected to the battery, current flows through the grounded field coil, actuating a movable pole shoe. The pole shoe is attached to the starter drive plunger lever and thus the drive is forced into engagement with the flywheel ring gear.

When the movable pole shoe is fully seated, it opens the field coil grounding contacts and the starter is then in normal operation. Normal field current is used to maintain the movable pole shoe in the fully seated position during the time that the starter is cranking the engine.



**WARNING: MARINE STARTERS ARE EXTERNAL IGNITION PROTECTED. WHEN REPAIRING OR REPLACING THESE UNITS, USE ONLY PARTS OR ASSEMBLIES DESIGNATED FOR THIS PURPOSE. TO SUBSTITUTE AUTOMOTIVE PARTS OR ASSEMBLIES, WHICH APPEAR SIMILAR AND WILL FUNCTION, VOIDS THE EXTERNAL IGNITION PROTECTION AND GREATLY INCREASES THE DANGER OF IGNITING A COMBUSTIBLE MIXTURE, RESULTING IN POSSIBLE PERSONAL INJURY.**

## TESTING

### ROAD SERVICE

On road service calls or cases of a starter that will not crank the engine or a starter that cranks very slowly, a booster battery may be connected to the 12-volt system. If the engine still will not turn with the booster connected, refer to the following tests:

#### TO JUMP START (NEGATIVE GROUNDED BATTERY)

**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) NOR 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 temperatures.**

**CAUTION: To prevent damage to electrical or lighting components during jump starting, the following procedure must be followed:**

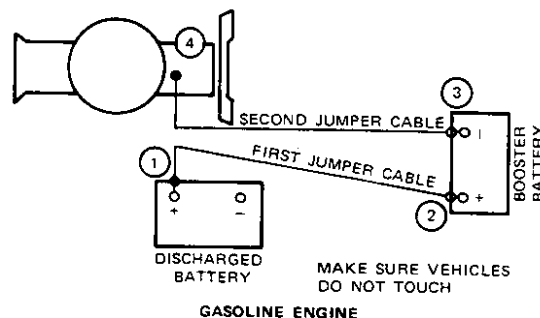
1. Turn all lamps off before and during jump starting.
2. Turn on heater blower motor to remove transient voltage.
3. Shield eyes. Use safety goggles or similar eye protection.
4. Connect ends of one cable to positive (+) terminal of discharged battery and the other end to the positive (+) terminal of the booster battery.
5. Connect one end of the other cable to negative (-) terminal of "good" battery.
6. Connect other end of cable to engine bolthead or similar good contact spot on the vehicle being started (NOT to negative (-) terminal of battery).
7. Make sure jumper cables are not in the way of moving engine parts.
8. Start engine of vehicle with the booster battery and run at moderate speed.
9. Start engine of vehicle with discharged battery. Follow starting procedure described in owner's manual.
10. To prevent damage to other electrical components on vehicle being started, make certain that engine is at idle speed before disconnecting jumper cables.
11. Remove cable from engine block before disconnecting cable from battery positive terminal. Lamps may now be turned on.

### ON VEHICLE TESTING

#### IF STARTER CRANKS SLOWLY

1. **BATTERY** — Use jumper cables per instructions. If this corrects problem, check condition of battery, recharge or replace if necessary. Clean battery posts, cable lugs and tighten.
2. **CABLES** — If the above does not correct the problem, clean and tighten connections at starter, relay and battery ground on engine. Eyelet terminals should not be easily rotated by hand. Also check for short to ground.
3. **STARTER** — If the above does not correct the problem, replace starter.

MAKE CONNECTIONS IN NUMERICAL ORDER (DISCONNECT IN REVERSE ORDER 4, 3, 2, 1)



## TESTING (Continued)

### IF STARTER DOES NOT CRANK BUT STARTER RELAY OPERATES (CLICKS)

1. BATTERY — Use jumper cables, check battery, etc. as above.
2. CABLE — Clean and tighten connections at starter and relay. Make sure wire strands are secure in eyelets.
3. STARTER — If the above does not correct the problem, replace starter.

### IF STARTER DOES NOT CRANK AND RELAY CHATTERS OR DOES NOT CLICK

1. BATTERY — Use jumper cables, check battery, etc. as above.
2. RELAY — Remove push-on connector from relay (red w/blue stripe wire) and make sure connection is clean and secure. Make sure relay bracket is grounded.

If connections are good, check operation by jumping with push-on connection off and transmission in PARK or NEUTRAL. Jumper above described terminal to relay main terminal (BAT side) or battery positive post. If this corrects problem, check ignition switch, neutral switch and wiring in start circuit for open or loose connections.

If jumper across relay does not correct problem, replace relay.

### IF STARTER SPINS (HUMMING NOISE) BUT DOES NOT CRANK ENGINE

STARTER — Remove and check armature shaft for corrosion, clean or replace. If no corrosion, repair starter or replace the starter drive.

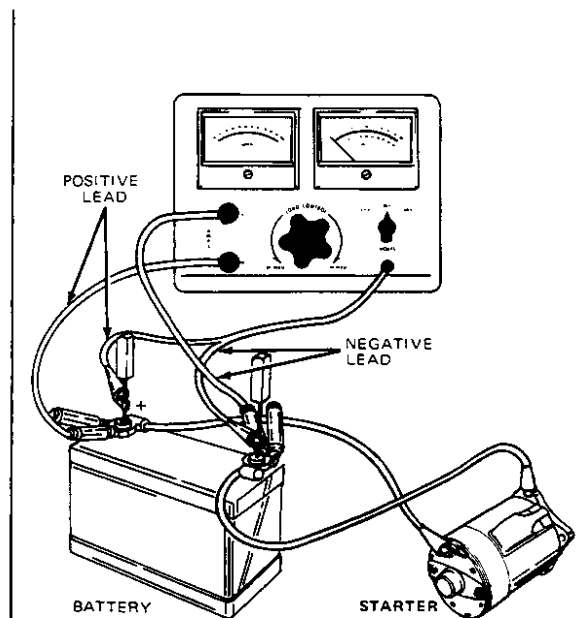
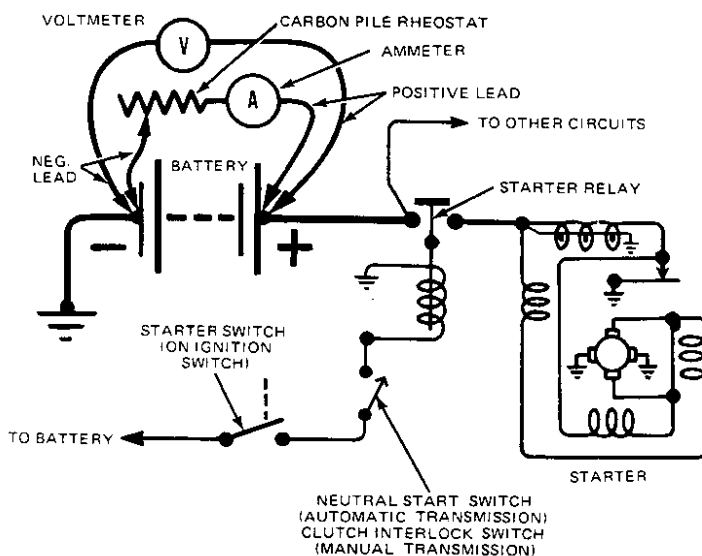
### STARTER LOAD TEST

Conduct this test if the starter cranks slowly and a comparison of the current output with specifications is desired.

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 the push-on connector "S" at the starter relay and by connecting the remote control starter switch from the positive battery terminal to the "S" terminal of the starter relay.

Stop cranking the engine. Then reduce the resistance 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. (Refer to Specifications at the end of this section.)



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## TESTING (Continued)

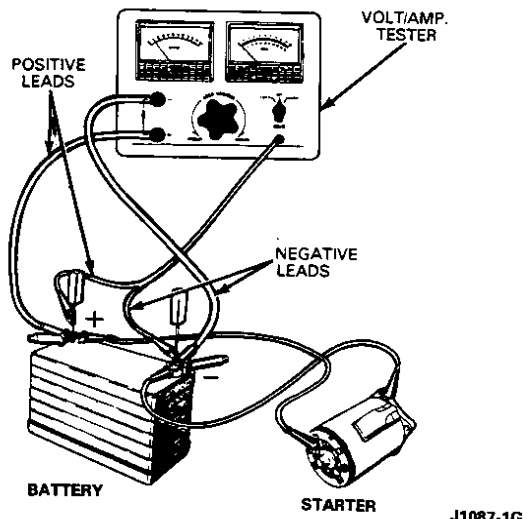
### BENCH TESTS

#### STARTER NO-LOAD TEST

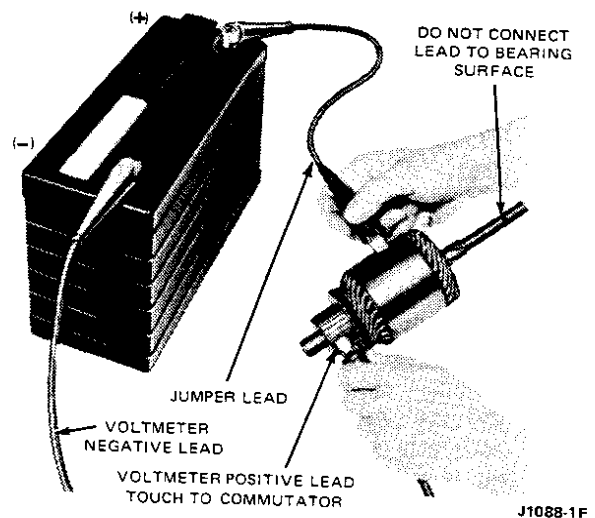
The starter no-load test will uncover open or shorted windings, rubbing armature, and bent armature shaft.

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.



Grounded field windings can be detected by making the connections as shown. If the voltmeter indicates any voltage, the field windings are grounded.



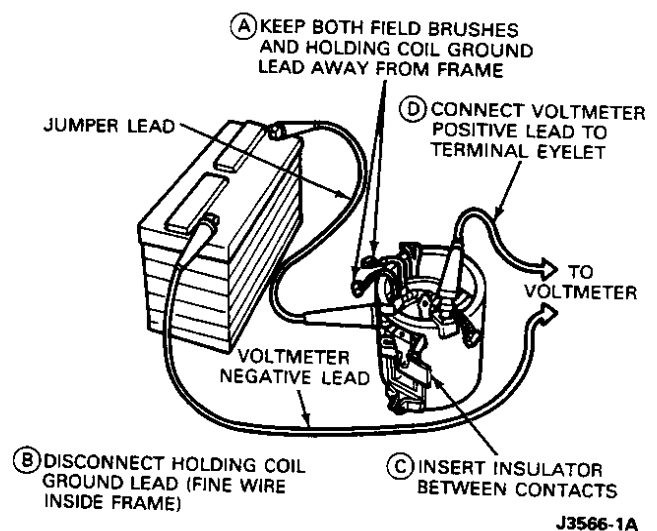
#### ARMATURE OPEN CIRCUIT TEST

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

This test will determine if the winding insulation has been damaged, permitting a conductor to touch the frame or armature core.

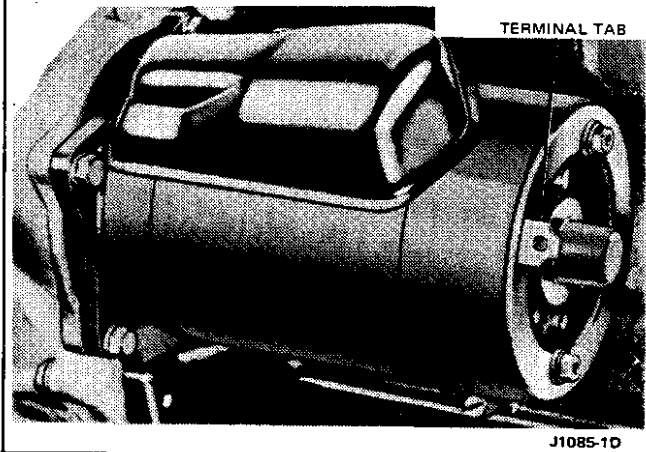
To determine if the armature windings are grounded, make the connections as shown. If the voltmeter indicates any voltage, the windings are grounded.



## REMOVAL AND INSTALLATION

### REMOVAL

1. Disconnect the negative battery cable.
2. Raise the vehicle on a hoist.
3. Disconnect the starter cable at the starter terminal.
4. Remove the starter mounting bolts. Remove the starter assembly.



### INSTALLATION

1. Position the starter assembly to the flywheel housing, and start the mounting bolts.
2. Snug all bolts while holding the starter squarely against its mounting surface and fully inserted into the pilot hole. Tighten the bolts to 21-27 N·m (15-20 ft-lb).
3. Connect the starter cable.
4. Lower the vehicle. Connect negative battery cable to battery. Check the operation of the starter.

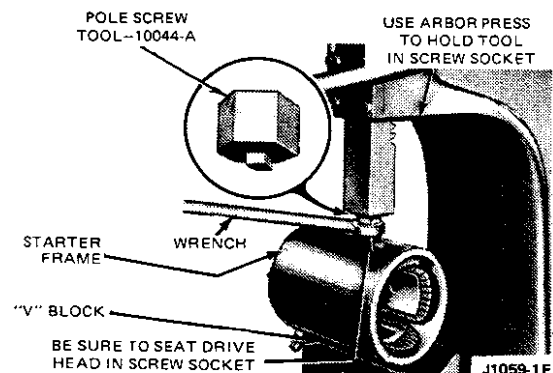
## DISASSEMBLY AND ASSEMBLY

Use the following procedure when it becomes necessary to completely overhaul the starter. The figure on page 5-06 illustrates a disassembled starter.

### DISASSEMBLY

1. Remove the cover screw, cover, and through bolts.
2. Remove the pivot pin retaining the starter gear plunger lever and remove the lever, the starter drive end housing, and lever return spring.

3. Remove the stop ring retainer. Remove and discard the stop ring retaining the starter drive gear to the end of the armature shaft, and remove the starter drive gear assembly.
4. Remove the brush end plate and insulator assembly.
5. Remove brushes from plastic brush holder and lift out brush holder. Note location of brush holder with respect to end terminal.
6. Remove the two screws retaining the ground brushes to frame. (The 4-inch starter has copper rivets.)
7. On the field coil that operates the starter drive gear actuating lever, bend the edges on the field coil retaining sleeve and remove the sleeve and retainer.
8. Remove the three coil retaining screws using an arbor press. The arbor press prevents the wrench from slipping out of the screw. Cut the field coil connection at the switch post lead and remove the small diameter ground wire from the upper tab riveted to frame. Remove pole shoes and coils from frame.

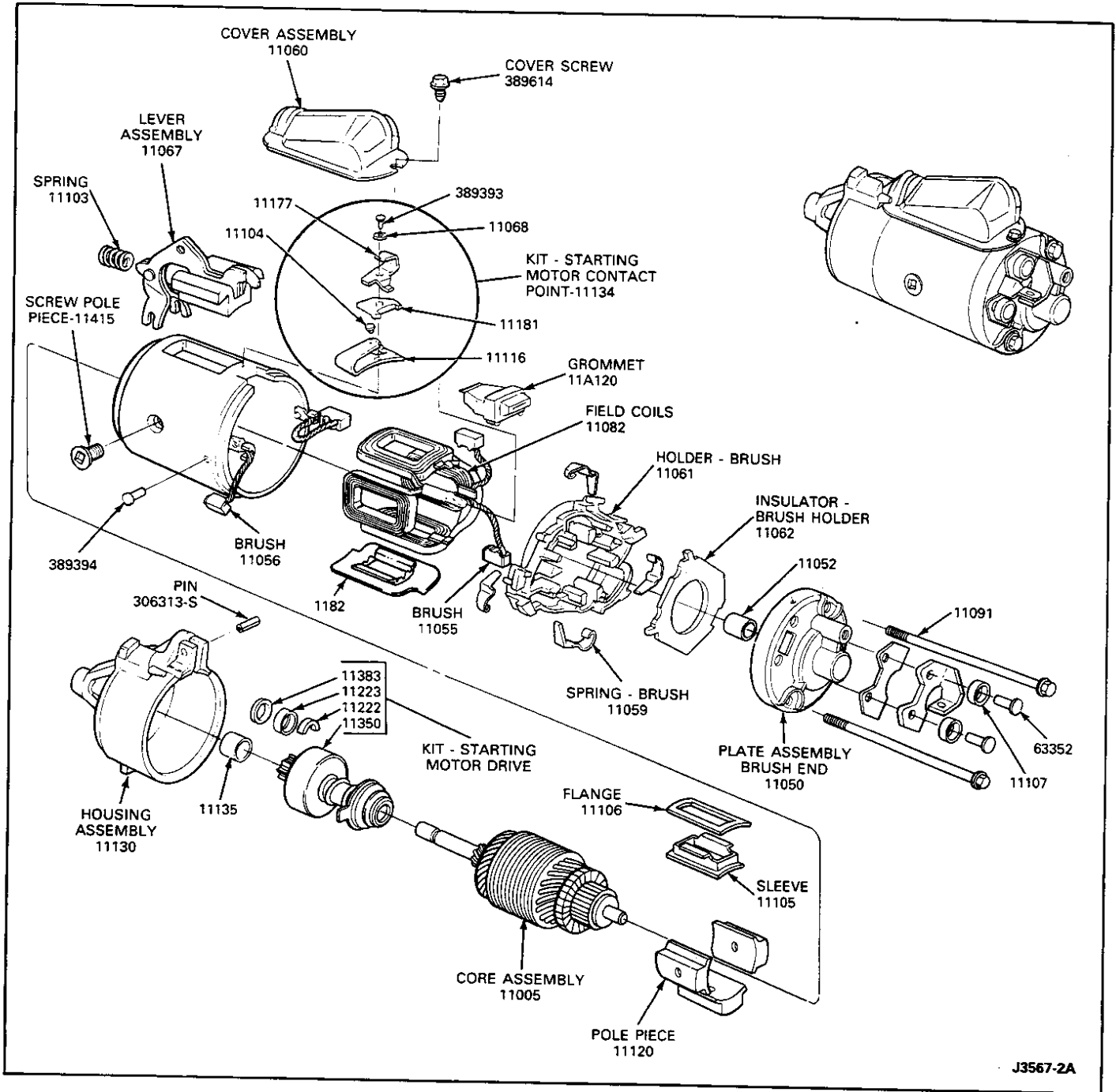


9. Cut the positive brush leads from the field coils, as close to the field connection point as possible.

### CLEANING AND INSPECTION

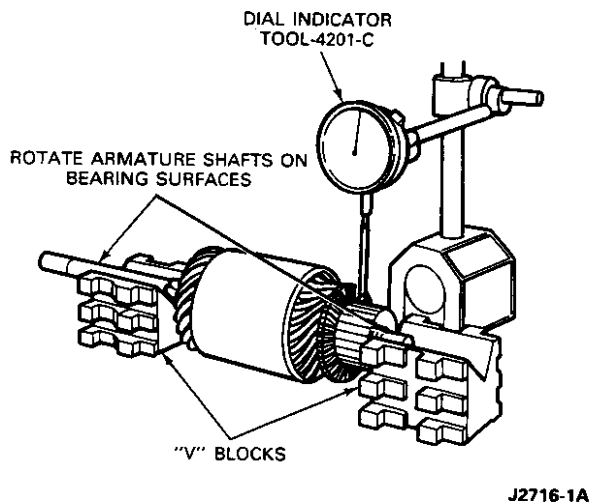
1. Use a brush or air to clean the field coils, armature, commutator, armature shaft, brush end plate, and drive end housing. Wash all other parts in solvent and dry the parts.
2. Inspect the armature windings for broken or burned insulation and unsoldered or open connections.
3. Check the armature for open circuits and grounds.

# DISASSEMBLY AND ASSEMBLY (Continued)

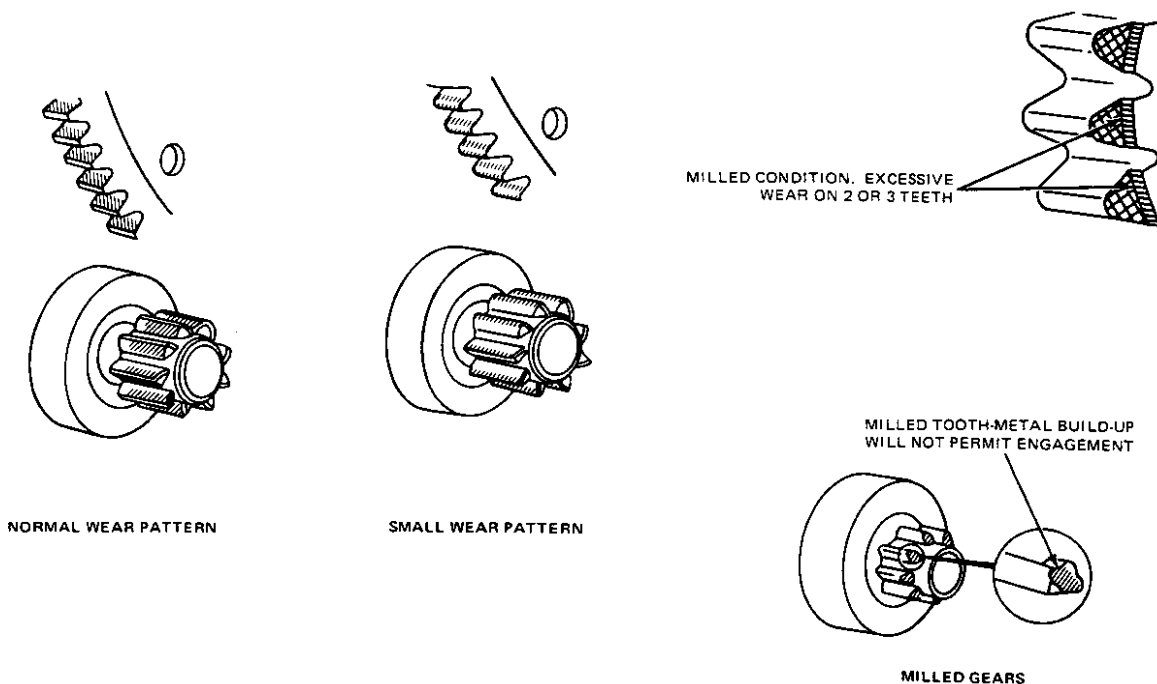


## DISASSEMBLY AND ASSEMBLY (Continued)

4. Check the commutator for runout using Dial Indicator TOOL-4201-C. Inspect the armature shaft and the two bearings for scoring and excessive wear. If the commutator is rough, or more than 0.127mm (0.005 inch) out-of-round, turn it down.



5. Check the plastic brush holder for cracks or broken mounting pads. Replace the brushes if worn to 6.35mm (1/4 inch) in length. Check the field brush connections. A brush kit and contact kit are available. All other assemblies are to be replaced rather than repaired.
6. Examine the wear pattern on the starter drive teeth. The pinion teeth must penetrate to a depth greater than one-half the ring gear tooth depth, to eliminate premature ring gear and starter drive failure.
7. Replace starter drives and ring gears having milled, pitted or broken teeth or that show evidence of inadequate engagement.

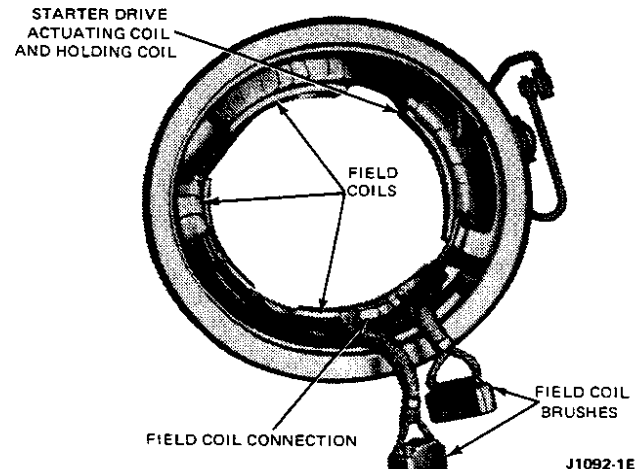


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## DISASSEMBLY AND ASSEMBLY (Continued)

### ASSEMBLY

1. Position the three coils and pole pieces, then install the attaching screws. As the pole shoe screws are tightened, strike the frame several sharp blows with a soft-faced hammer to seat and align the pole shoes, then stake the screws.
2. Install the remaining coil and retainer and bend the tabs to secure the coils to the frame.
3. Position the new insulated field brushes lead on the field coil terminal. Install the clip provided with the brushes to hold the brush lead to the terminal. Solder the lead, clip, and terminal together, using rosin core solder. Use a 300 watt iron.
4. Check for continuity and grounds in the assembled coils.
5. The coil which is around the retaining sleeve is to be grounded by positioning the small diameter wire leading from it, under the copper tab held by the rivet which attaches the contact to the frame.
6. Attach the ground brushes to the starter frame with the screws. (4.0-inch starter has copper rivets.)
7. Apply a thin coating of Lubriplate 777 or equivalent on the armature shaft splines. Install the starter motor drive gear assembly to the armature shaft and install a new retaining stop ring. Install a new stop retainer.
8. Install the armature in the starter frame.
9. Partially fill the drive end housing bearing bore with Grease ESB-M1C.63-A or equivalent (approximately 1/4 full). Position the starter drive gear plunger lever to the frame and starter drive assembly.



10. Position the starter drive plunger lever return spring and the drive end housing to the frame. Install brush holder, insert brushes and springs. Install brush holder insulator.
11. Position end plate to frame, align plate locator with frame slot. Install and tighten the through bolts to 6.21-8.47 N·m (55-75 in-lb). Do not pinch brush leads when installing end plate. Install pivot pin.
12. Position the drive gear plunger lever cover on the starter and fasten with the cover screw in the frame.
13. Check the starter no-load current draw.

### STARTER DRIVE REPLACEMENT

1. Remove the starter drive plunger cover.
2. Remove the pivot pin retaining the starter drive plunger lever.
3. Loosen the through bolts enough to allow removal of the drive end housing and the starter drive plunger lever return spring and lever.
4. Remove the drive gear stop ring retainer and stop ring from the end of the armature shaft and remove the drive gear assembly.
5. Apply a thin coating of Lubriplate 777, or equivalent on the armature shaft splines. Install the drive gear assembly on the armature shaft and install a new stop ring.
6. Position the starter gear plunger lever on the starter frame. **Be sure that the plunger lever properly engages the starter drive assembly.**
7. Install a new stop-ring retainer. Partially fill the drive end housing bearing bore with Grease ESB-M1C.63-A or equivalent (approximately 1/4 full). Position the starter drive plunger lever return spring and drive end housing to the starter frame, and then tighten the through bolts to 6.21-8.47 N·m (55-75 in-lb). Install pivot pin.
8. Position the starter drive plunger lever cover on the starter. Tighten the attaching screw.

**DISASSEMBLY AND ASSEMBLY (Continued)****BRUSH REPLACEMENT**

Replace the starter brushes when they are worn to 6.35mm (1/4 inch). Always install a complete set of new brushes.

1. Remove the two through bolts from the starter frame.
2. Remove the brush end plate, brush springs and brushes from the holder.
3. Remove the ground brush attaching screws or rivets from the frame and remove the brushes.
4. Cut the insulated brush leads from the field coils, as close to the field connection point as possible.
5. Check the plastic brush holder for cracks or broken mounting pads. Replace if necessary.
6. Position the new insulated field brushes lead on the field coil connection. Position and crimp the clip provided with the brushes to hold the brush lead to the connection. Solder the lead, clip, and connection together, using a 300 watt iron and rosin core solder.
7. Install the ground brush leads to the frame with the attaching screws or rivets.
8. Install brush holder and insert brushes in holder and install brush springs. Positive brush leads should be positioned in their respective slots in the brush holder to prevent potential grounding.
9. Install the brush end plate. Be sure end plate insulator is positioned properly on the end plate.
10. Install the two through bolts to the starter frame and tighten to 6.21-8.47 N·m (55-75 in-lb).
11. Secure the starter in a vise and connect the starter to a battery to check its operation.

**ARMATURE REPLACEMENT**

1. Remove starter drive plunger lever cover retainer screw and remove cover.
2. Remove the through bolts, the drive end housing, plunger lever and the drive plunger lever return spring, brush end plate. Remove brushes and lift out brush holder.
3. Remove the pivot pin retaining the starter gear plunger lever.
4. Remove the armature. If the starter drive gear assembly is being reused, remove the stop ring from the end of the armature shaft, and remove the drive.
5. Place the drive gear assembly on the new armature with a new stop ring.
6. Install the armature in the starter frame.
7. Position the drive gear plunger lever to the frame and drive gear assembly.
8. Partially fill the drive end housing bearing bore with Grease ESB-M1C.63A or equivalent (approximately 1/4 full). Position the drive plunger lever return spring, the drive end housing to the starter frame. Be sure that the stop ring retainer is seated properly in the drive housing.
9. Install brush holder and insert brushes in holder and install brush springs. Positive brush leads should be positioned in their respective slots to prevent grounding.
10. Install the brush end plate (be certain end plate insulator is positioned properly on end plate).
11. Install the two through bolts to the starter frame and tighten to 6.21-8.47 N·m (55-75 in-lb). Install pivot pin.
12. Install starter drive plunger lever cover and tighten retaining screw.
13. Check the starter no-load current draw.



# Part 5a—Starter, Permanent Magnet

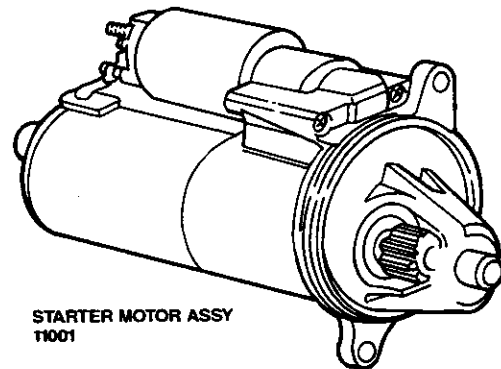
SUBJECT	PAGE	SUBJECT	PAGE
<b>DESCRIPTION AND OPERATION</b>		<b>DISASSEMBLY AND ASSEMBLY (Cont'd.)</b>	
Jump Starting .....	5a-02	Cleaning and Inspection .....	5a-09
Road Service .....	5a-02	Starter Drive Replacement .....	5a-11
Sequence of Operation .....	5a-01	<b>REMOVAL AND INSTALLATION</b>	
<b>DIAGNOSIS AND TESTING</b>		Starter Motor .....	5a-07
Bench Tests .....	5a-06	<b>SPECIAL SERVICE TOOLS</b> .....	
System Inspection .....	5a-03	<b>SPECIFICATIONS</b> .....	
<b>DISASSEMBLY AND ASSEMBLY</b>			5a-11
Armature Replacement .....	5a-11		

## DESCRIPTION AND OPERATION

The function of the starting system is to crank the engine at a speed fast enough to permit the engine to start. Heavy cables, connectors, and switches are used in the starting system because of the large current required by the starter while it is cranking the engine. The amount of resistance in the starting circuit must be kept to an absolute minimum to provide maximum current for starter operation. A discharged or damaged battery, loose or corroded connections, or partially broken cables will result in slower than normal cranking speeds, and may even prevent the starter from cranking the engine.

The starting system includes the permanent magnet gear-reduction starter motor with a solenoid-actuated drive, the battery, a remote-control starter switch (part of the ignition switch), the starter relay, the heavy circuit wiring, and may include starter lock out devices.

Typical Starter Shown

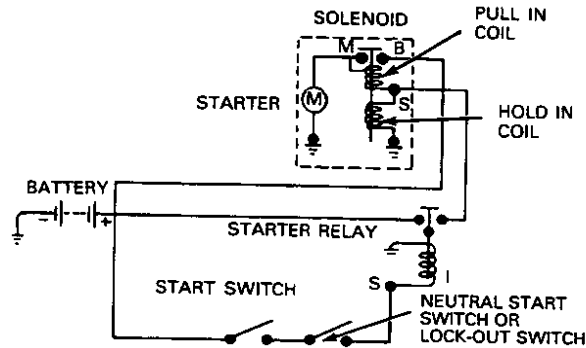


### Sequence of Operation

1. The ignition switch is turned to the START position.
2. A remote starter relay is energized, which provides voltage to the starter solenoid. The starter solenoid is energized, creating a magnetic field in the solenoid coil.
3. The iron plunger core is drawn into the solenoid coil.
4. A lever connected to the drive assembly engages the drive pinion gear to the flywheel ring gear.
5. When the iron plunger core is all the way into the coil, its contact disc closes the circuit between the battery and the motor terminals.
6. The current flows to the motor, and the drive pinion gear cranks the flywheel and the engine crankshaft.
7. As current flows to the motor, the solenoid pull-in coil is bypassed.
8. The hold-in coil keeps the drive pinion gear engaged with the flywheel.

## DESCRIPTION AND OPERATION (Continued)

9. The gear remains engaged until the ignition switch is released from the START position.



An overrunning clutch in the drive assembly protects the starter from excessive speeds during the brief period before the driver releases the ignition switch from the START position (as the engine starts).

## Road Service

For cases of a starter that cranks the engine very slowly, connect a 12-volt booster battery to the system.

## Jump Starting

To avoid damage to the vehicle and battery or the possibility of personal harm, follow these instructions and precautions:

**WARNING: 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: KEEP 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 FIFTEEN 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.**

**WARNING: DO NOT DISCONNECT THE BATTERY OF THE VEHICLE TO BE STARTED. DISCONNECTING THE BATTERY COULD DAMAGE THE VEHICLE'S ELECTRONIC SYSTEM.**

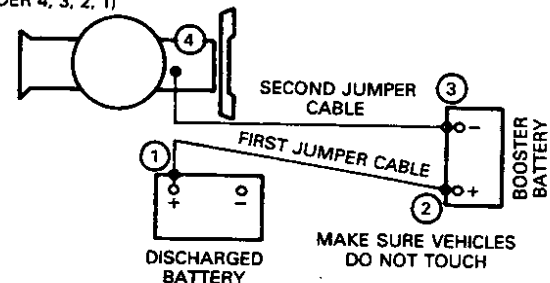
## Negative Grounded Battery

**WARNING: TO AVOID ANY POSSIBILITY OF INJURY, USE PARTICULAR CARE WHEN CONNECTING A BOOSTER BATTERY TO A DISCHARGED BATTERY.**

1. Position vehicles so jumper cables will reach, being careful that vehicles do not touch.
2. Make jumper cable connections.
  - Connect one end of first jumper cable to positive (+) terminal of discharged battery and other end of positive (+) terminal of booster battery.
  - Connect one end of second jumper cable to negative (-) terminal of booster battery. Connect other end to an engine bolthead or good metallic contact spot on engine of equipment to be started, NOT TO NEGATIVE (-) BATTERY TERMINAL.

## JUMP STARTING

MAKE CONNECTIONS IN NUMERICAL ORDER (DISCONNECT IN REVERSE ORDER 4, 3, 2, 1)



**WARNING: MAKING THE FINAL CABLE CONNECTION COULD CAUSE AN ELECTRICAL SPARK NEAR THE BATTERY AND COULD CAUSE AN EXPLOSION. REFER TO WARNING AT THE BEGINNING OF THE JUMP STARTING PROCEDURE.**

**CAUTION: When servicing starter or performing other underhood work in the vicinity of the starter, be aware that the heavy gauge battery input lead at the starter solenoid is "electrically hot" at all times.**

**Be sure to disconnect battery negative cable before servicing starter.**

- Make sure jumper cables are not in way of moving engine parts.
  - Start engine of vehicle with good battery. Run engine at a moderate speed.
  - Start engine of vehicle with discharged battery. Follow starting instructions in the Owner Guide.
3. Completely discharged batteries may require an electrical load to initialize charging.

**DESCRIPTION AND OPERATION (Continued)**

4. Remove cables in exact REVERSE sequence.  
Begin by removing cable from engine of vehicle that had discharged battery.

If the starter does not turn the engine over, even with the booster battery attached, refer to On-Vehicle Testing.

**DIAGNOSIS AND TESTING****System Inspection**

**CAUTION:** When disconnecting the plastic hardshell connector at the solenoid "S" terminal, grasp the plastic connector and pull lead off. DO NOT pull separately on lead wire.

**WARNING:** WHEN SERVICING STARTER OR PERFORMING OTHER WORK IN THE VICINITY OF THE STARTER, BE AWARE THAT THE HEAVY GAUGE BATTERY INPUT LEAD AT THE STARTER SOLENOID IS "ELECTRICALLY HOT" AT ALL TIMES.

Be sure to disconnect battery negative cable before servicing starter.

1. Inspect starting system for loose connections.
2. If system does not operate properly, note condition and continue diagnosis using the symptom chart.

**WARNING:** WHEN WORKING IN AREA OF THE STARTER, BE CAREFUL TO AVOID TOUCHING HOT EXHAUST COMPONENTS.

**Symptom Chart**

CONDITION	POSSIBLE SOURCE	ACTION
Starter solenoid does not pull-in and starter does not crank (Audible click may or may not be heard).	<ul style="list-style-type: none"> <li>● Open fuse.</li> <li>● Low battery.</li> <li>● Defective remote relay.</li> <li>● Open circuit or high resistance in external feed circuit to starter solenoid.</li> <li>● Defective starter.</li> </ul>	<ul style="list-style-type: none"> <li>● Check fuse continuity.</li> <li>● Refer to appropriate battery service manual.</li> <li>● Go to Test B.</li> <li>● Go to Test A.</li> <li>● Replace starter. See removal and installation procedure.</li> </ul>
Unusual starter noise during starter overrun.	<ul style="list-style-type: none"> <li>● Starter not mounted flush (cocked).</li> <li>● Noise from other components.</li> <li>● Ring gear tooth damage or excessive ring gear runout.</li> <li>● Defective starter.</li> </ul>	<ul style="list-style-type: none"> <li>● Realign starter on transmission bell housing.</li> <li>● Investigate other powertrain accessory noise contributors.</li> <li>● Refer to appropriate engine manual.</li> <li>● Replace starter. See removal and installation procedure.</li> </ul>
Starter cranks but engine does not start.	<ul style="list-style-type: none"> <li>● Problem in fuel system.</li> <li>● Problem in ignition system.</li> <li>● Engine related problem.</li> </ul>	<ul style="list-style-type: none"> <li>● Refer to appropriate fuel system manual.</li> <li>● Refer to appropriate ignition system manual.</li> <li>● Refer to appropriate engine manual.</li> </ul>
Starter cranks slowly.	<ul style="list-style-type: none"> <li>● Low battery.</li> <li>● High resistance or loose connections in starter solenoid battery feed or ground circuit.</li> <li>● Ring gear runout excessive.</li> <li>● Defective starter.</li> </ul>	<ul style="list-style-type: none"> <li>● Refer to appropriate battery manual.</li> <li>● Check that all connections are secure.</li> <li>● Refer to appropriate engine manual.</li> <li>● Replace Starter. See removal and installation procedure.</li> </ul>

**DIAGNOSIS AND TESTING (Continued)**

CONDITION	POSSIBLE SOURCE	ACTION
Starter remains engaged and runs with engine.	<ul style="list-style-type: none"> <li>Shorted ignition switch.</li> <li>Battery cable touching solenoid 'S' terminal (defective or mispositioned cable).</li> <li>Defective starter.</li> </ul>	<ul style="list-style-type: none"> <li>Refer to appropriate ignition system manual.</li> <li>Replace or relocate cable and replace starter.</li> <li>Replace starter. See removal and installation procedure.</li> </ul>

FPP01

**Evaluation Procedure 1**

**CAUTION:** Remove plastic safety cap on starter solenoid and disconnect hardshell connector at solenoid "S" terminal as described under "Removal and Installation" in this section.

**CHECK STARTER MOTOR — TEST A**

TEST STEP		RESULT	ACTION TO TAKE
<b>A1</b>	<b>CHECK FOR VOLTAGE TO STARTER</b>		
	<ul style="list-style-type: none"> <li>Key OFF. Transmission in Neutral.</li> <li>Check for voltage between starter B+ terminal and starter drive housing.</li> <li>Is voltage OK? (12-12.45V)</li> </ul>	Yes No	GO to A2. CHECK wire connections between battery and starter solenoid and the ground circuit for open or short.
<b>A2</b>	<b>CHECK STARTER MOTOR</b>		
	<ul style="list-style-type: none"> <li>Key OFF. Transmission in Neutral.</li> <li>Connect one end of a jumper wire to the starter B+ terminal and momentarily touch the other end to solenoid 'S' terminal.</li> <li>Does starter crank?</li> </ul>	Yes No	CHECK connections from output of fender apron relay to 'S' terminal for open or short. Defective starter. REPLACE starter.

FPP02

**Evaluation Procedure 2**

**CHECK RELAY — TEST B**

TEST STEP		RESULT	ACTION TO TAKE
<b>B1</b>	<b>CHECK FENDER APRON RELAY</b>		
	<ul style="list-style-type: none"> <li>Key in START. Transmission in Neutral.</li> <li>Is case ground OK?</li> </ul>	Yes No	GO to B2. REPAIR ground. GO to B2.

## DIAGNOSIS AND TESTING (Continued)

CHECK RELAY — TEST B (Continued)		
TEST STEP	RESULT	ACTION TO TAKE
<b>B2</b> CHECK VOLTAGE AT REMOTE RELAY START TERMINAL <ul style="list-style-type: none"> <li>● Key in START. Transmission Neutral.</li> <li>● Check for voltage between relay start terminal and case ground.</li> <li>● Is voltage OK? (12-12.45V)</li> </ul>	Yes No	GO to <b>B3</b> . Open circuit or high resistance exists in external circuit wiring or components. Check the following: <ul style="list-style-type: none"> <li>— All circuit connections including plastic hard-shell connector at solenoid "s" terminal to make sure it is not broken or distorted.</li> <li>— Ignition switch.</li> <li>— Neutral switch or manual lever position sensor.</li> </ul>
<b>B3</b> CHECK OUTPUT TERMINAL VOLTAGE <ul style="list-style-type: none"> <li>● Key in START. Transmission in Neutral.</li> <li>● Check for voltage at output terminal of remote relay.</li> <li>● Is voltage OK?</li> </ul>	Yes No	REFER to Starter System Diagnosis in this section. Defective remote relay. REMOVE and REPLACE relay.

FPPO3

**Starter Load Test**

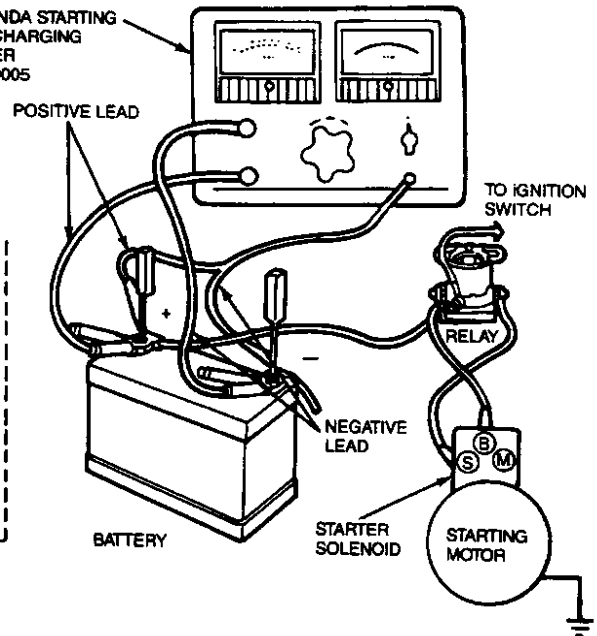
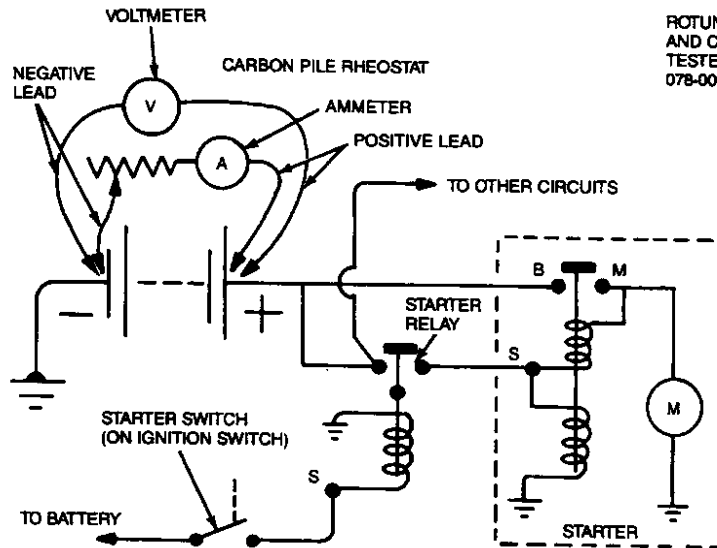
Conduct this test if the starter cranks slowly and it is desired to compare current to specifications.

1. Connect Rotunda Starting and Charging Tester 078-00005 or equivalent. Make sure that current is not flowing through ammeter and heavy-duty carbon pile rheostat portion of circuit (rheostat at maximum counterclockwise position).

2. Place transmission or transaxle in NEUTRAL. Crank engine with ignition off, and determine exact reading on voltmeter. This test is accomplished by disconnecting push-on connector S at starter relay and by connecting a remote control starter switch from positive battery terminal to S terminal starter relay.

## DIAGNOSIS AND TESTING (Continued)

- Stop cranking engine, and reduce resistance of carbon pile until voltmeter indicates same reading as that obtained while starter cranked the engine. The ammeter will indicate starter current draw under load. Check this with value listed in Specifications.



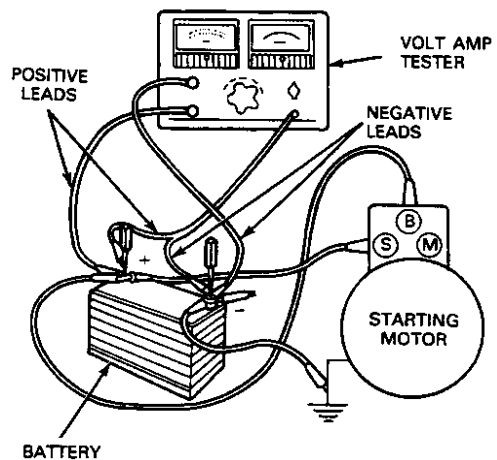
### Bench Tests

#### Starter No-Load Test

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

- Make test connections with Rotunda Starting and Charging Tester 078-00005 or equivalent cables connected to starter, large enough to carry high current (the same as in the vehicle). The starter will run at no-load. Be sure that no current is flowing through ammeter (rheostat at maximum counterclockwise position). Determine exact reading on voltmeter.

**CAUTION: Make sure that the starter is securely mounted in bench vise while energizing, as starter will move or jump.**



(CONVENIENT GROUND ON STARTER SUCH AS MOUNTING EAR ON CASTING.)

**DIAGNOSIS AND TESTING (Continued)**

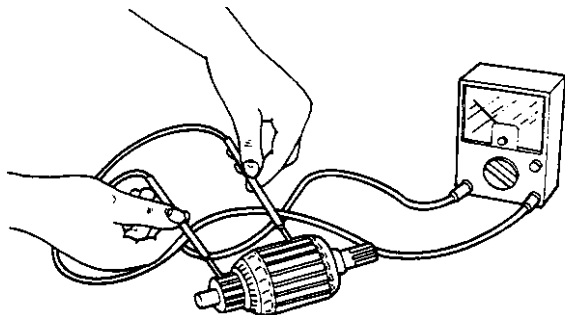
2. Disconnect starter from battery. Then, reduce resistance of rheostat until voltmeter indicates same reading as that obtained while starter was running. The ammeter will indicate starter no-load current draw. Refer to Specifications for a comparative value.
3. If current exceeds specification, check for rubbing armature, bent shaft, binding bearings, or shorts in armature, or brush assembly.

**Armature Open Circuit Test**

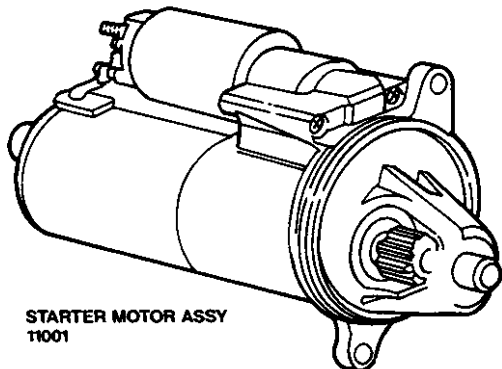
An open circuit armature may sometimes be detected by examining the commutator for evidence of burning. A burn spot on the commutator is caused by an arc formed every time the commutator segment, connected to the open circuit winding, passes under a brush.

**Grounded Armature Test**

This test will determine if the winding insulation has been damaged, permitting a conductor to touch the frame or armature core. To determine if the armature windings are grounded, check with a VOM as shown. Infinite resistance indicates a normal condition.

**Starter Solenoid Test**

Make sure that the solenoid is isolated electrically from the motor. Using a VOM, check for continuity between S terminal and M terminal, and between S terminal and ground (frame). If there is no continuity, the wire is broken and the solenoid should be replaced.



STARTER MOTOR ASSY  
11001

**REMOVAL AND INSTALLATION****Starter Motor****Removal**

**WARNING: WHEN SERVICING STARTER OR PERFORMING ANY MAINTENANCE IN THE AREA OF THE STARTER, NOTE THE HEAVY GAUGE INPUT LEAD CONNECTED TO THE STARTER SOLENOID IS HOT AT ALL TIMES. MAKE SURE THE PROTECTIVE CAP IS INSTALLED OVER THE TERMINAL AND IS REPLACED AFTER SERVICE.**

1. Disconnect the negative battery ground cable.
2. Disconnect starter cable and push-on connector from starter solenoid.

**CAUTION: When disconnecting hardshell connector at S-terminal, grasp the plastic shell and pull off. Do not pull on wire. Be careful to pull straight off to prevent damage to the connector and S-terminal. If any part of the connection is damaged, replace the damaged components.**

3. Remove upper bolt with a 3/8 inch drive ratchet, swivel socket and a 22 inch long extension. Access is in front of and along side of the right-hand front engine mount.
4. Remove lower bolt.

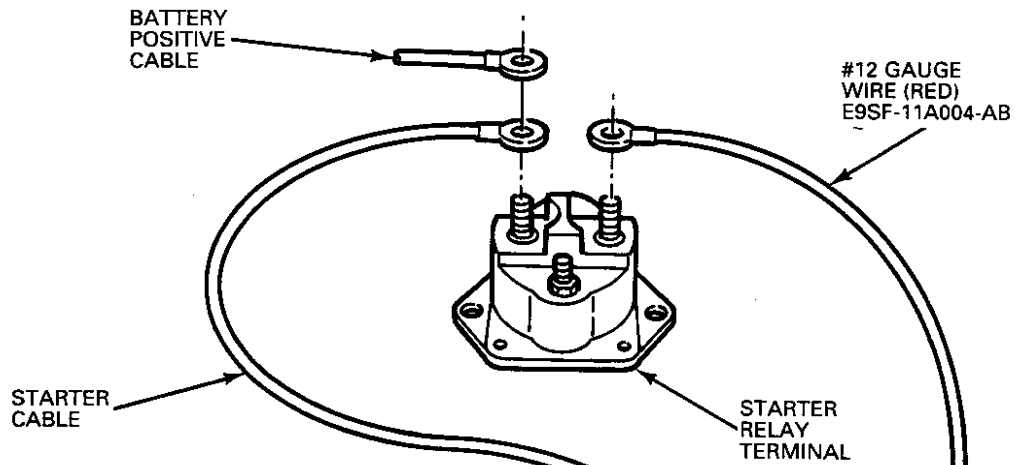
**Installation**

1. Position starter motor to engine and install upper and lower bolt finger-tight.
2. Tighten the upper bolt to 21-27 N·m (15-20 ft·lb). Access to upper bolt is with a 3/8 inch drive ratchet, swivel socket and a 22 inch long extension. Access is in front of and along side of the right-hand front engine mount.
3. Tighten the lower bolt to 21-27 N·m (15-20 ft·lb).
4. Connect starter solenoid connector. Be careful to push straight on and make sure connector locks in position with a notable click or detent.
5. Install starter cable nut to starter terminal. Tighten to 9-13 N·m (80-120 in·lb).
6. Replace red solenoid safety cap.
7. Connect negative battery ground cable.

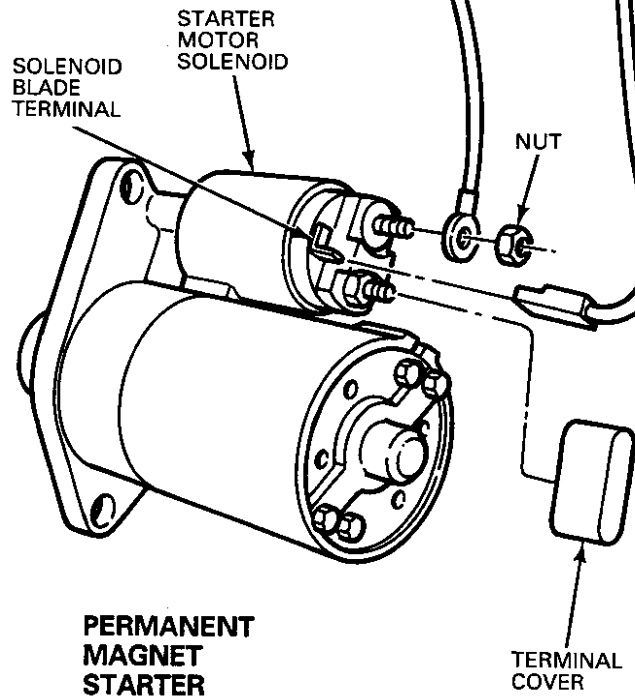
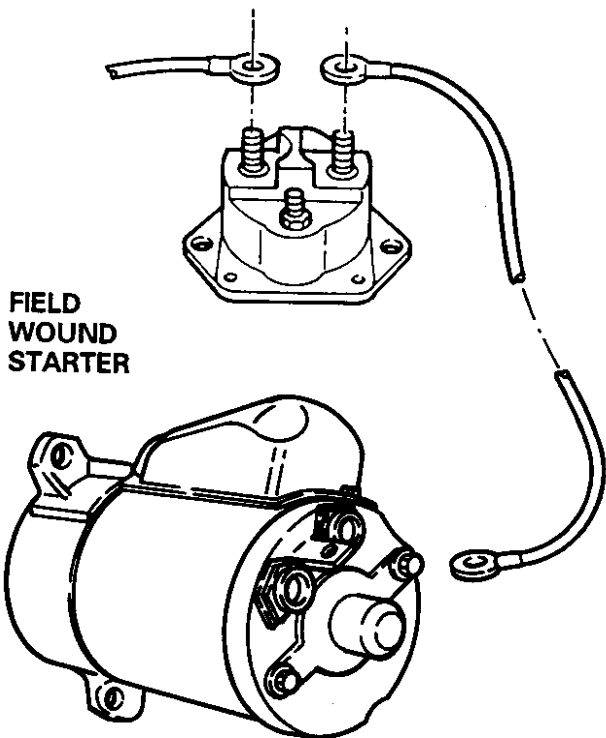
**Wiring**

It is recommended that wiring service kit F2PZ-11K162-A be used, which includes a 70 inch long #12 gauge wire, a terminal nut, a terminal cover, four tie wraps and insulation instructions.

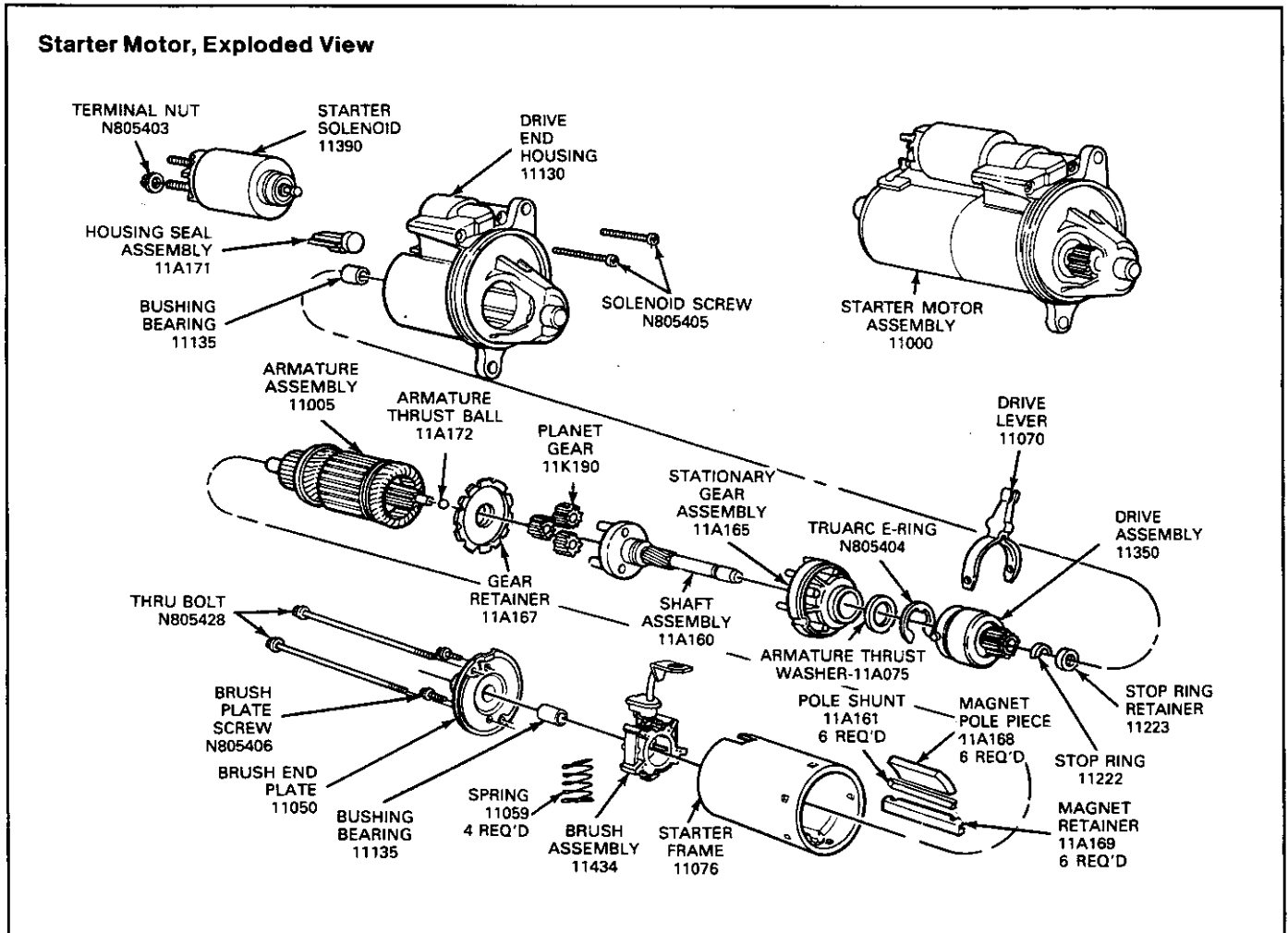
REMOVAL AND INSTALLATION (Continued)



**CAUTION:** A jumper wire must not be installed between the large round electrical terminal and the solenoid blade terminal at the starter, to avoid use of the # 12 wire. If done, voltage is generated to the solenoid by the spinning starter after release of the start key or button, causing the starter to remain engaged, resulting in failure.



## DISASSEMBLY AND ASSEMBLY

**Disassembly**

1. Remove positive brush connector from solenoid motor (M) terminal.
2. Remove solenoid retaining screws and solenoid.
3. Remove through-bolts and separate drive end housing from motor frame. Remove housing seal assembly from drive. Remove drive and gear assembly from drive end housing.
4. Remove drive lever from drive assembly. Remove stop ring and retainer from driveshaft, then remove drive assembly from shaft. Push C-ring off driveshaft, and separate gear assembly from driveshaft.
5. Remove brush plate screws and brush end plate from motor frame. Remove brush assembly and push armature out of frame.

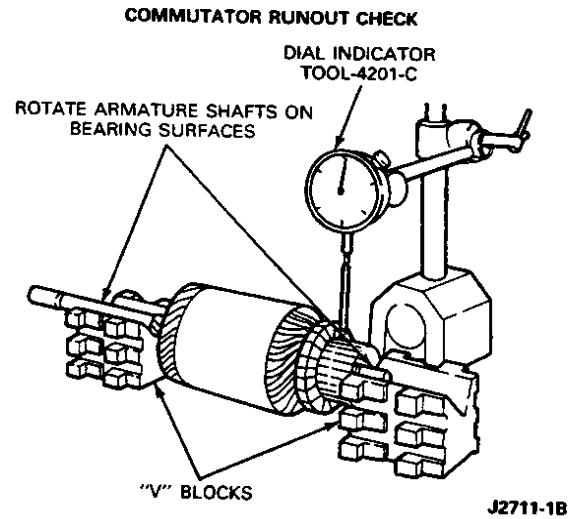
**Cleaning and Inspection**

**CAUTION: DO NOT WASH THE DRIVE BECAUSE THE SOLVENT WILL WASH OUT THE LUBRICANT CAUSING DRIVE TO SLIP. USE A BRUSH OR COMPRESSED AIR TO CLEAN THE DRIVE, ARMATURE, BRUSH, AND GEAR ASSEMBLIES, DRIVE END HOUSING, POLE PIECES AND PLANET GEARS. WASH ALL OTHER PARTS IN SOLVENT AND DRY.**

1. Inspect armature windings for broken or burned insulation and unwelded or open connections.
2. Check armature for open circuits, shorts and grounds. Check for pole rub or rub on magnetic shunts.

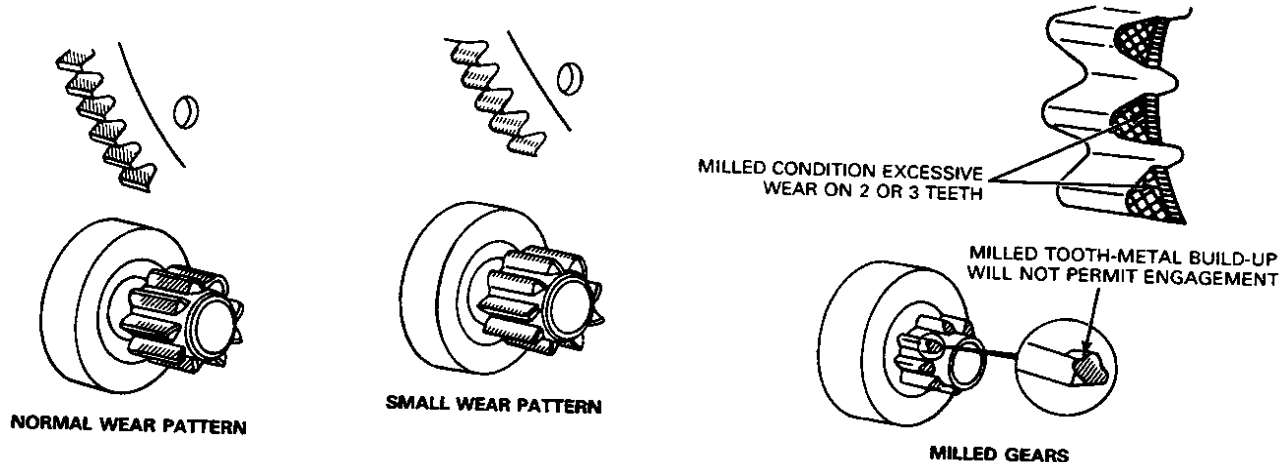
### DISASSEMBLY AND ASSEMBLY (Continued)

3. Check commutator for runout. Inspect armature shaft and two bearings for scoring and excessive wear with Dial Indicator TOOL-4201-C or equivalent. If commutator is rough, or more than 0.12mm (.005 inch) out of round, it must be replaced.



4. Examine gears, spline on driveshaft, and drive pinion for chipped, broken or worn conditions. Replace if required.

#### PINION AND RING GEAR WEAR PATTERNS



#### Assembly

1. Install armature assembly in starter frame. Apply a thin coating of ESF-M1C2 18-A Grease or equivalent low temperature grease on both ends of armature shaft and spline. Install brush assembly ensuring brushes fit over commutator. Apply grease to bearing bore in brush end plate. Push back grommet onto frame and attach brush end with brush plate screws. Tighten to 2.3-3.4 N-m (20-30 in-lb).
2. Apply grease to driveshaft spline and place stationary gear assembly over driveshaft. Install armature thrust washer and push C-ring onto driveshaft. Place drive assembly onto shaft and install stop ring and retainer. Attach drive lever to drive assembly.
3. Grease and install planet gears.
4. Apply grease into drive end housing bearing bore (approximately one-quarter full). Install drive gear assembly into housing, making sure to line up bolt holes in gear assembly and housing. Place gear retainer over gear assembly. Install housing seal assembly into drive end housing.
5. Position starter frame to housing and install through-bolts. Tighten to 5.0-9.5 N-m (45-84 in-lb).
6. Correctly position solenoid to housing ensuring that solenoid plunger is attached through drive lever (bottom solenoid terminal (M) should have a metal strip attached to it). Tighten solenoid bolts to 5.1-9.6 N-m (45-85 in-lb).
7. Attach positive brush connector to solenoid (bottom terminal). Tighten nut to 9-13 N-m (80-120 in-lb).

**DISASSEMBLY AND ASSEMBLY (Continued)**

8. Check that starter no-load current draw is within specification. Refer to Bench Tests.

**Starter Drive Replacement**

1. Remove positive brush connector from solenoid motor (M) terminal. Remove solenoid retaining screws and remove solenoid.
2. Remove through-bolts and separate motor assembly drive end housing. Remove housing seal from drive end housing. Remove drive gear assembly from housing and detach drive lever.
3. Remove stop ring and retainer from driveshaft and then remove drive assembly.
4. Apply a thin coating of ESF-M1C218-A Grease or equivalent low temperature grease on driveshaft spline. Install new drive gear assembly on driveshaft. Install new stop ring and retainer. Attach drive lever.
5. Partially fill drive end housing bearing bore with grease (approximately one-quarter full). Install drive gear assembly in housing, making sure to line up bolt holes in gear assembly and housing.
6. Install lever support and housing seal in drive end housing.
7. Position starter frame to housing and install through-bolts. Tighten to 5.0-9.5 N·m (45-84 in-lb).
8. Install solenoid. Refer to Assembly.

**Armature Replacement**

1. Remove positive brush connector from solenoid motor (M) terminal.
2. Remove through-bolts and separate motor from gear assembly and drive end housing.
3. Remove brush end plate screws, brush end plate and brush assembly from starter frame. Remove armature from frame.
4. Install new armature in frame. Apply a thin coating of ESF-M1C218-A Grease or equivalent low temperature grease on both ends of armature shaft and pinion.
5. Install brush assembly. Using tool, make sure that brushes fit over commutator. Push black grommet onto frame. Apply grease to bearing bore in brush end plate and attach to starter frame.
6. Position starter frame to gear assembly and drive end housing and install through-bolts. Tighten to 5.0-9.5 N·m (45-84 in-lb).
7. Attach positive brush connector to solenoid (bottom terminal). Tighten nut to 9-13 N·m (80-120 in-lb).
8. Check that starter no-load current draw is within specification. Refer to Bench Testing.

**SPECIFICATIONS****TORQUE SPECIFICATIONS**

Description	N·m	Lb·In
Solenoid Bolt	5.1-9.6	45-85
M Terminal Nut	9.0-13.5	80-120

(Continued)

**TORQUE SPECIFICATIONS (Cont'd)**

Description	N·m	Lb·In
B Terminal Nut	9.0-13.5	80-120
Through-Bolt	5.0-9.5	45-84
Mounting Bolt	20.3-27	15-20 (Lb·Ft)
Brush Plate Screw	2.3-3.4	20-30

Starter Motor						Starter Brushes					
Motor Diameter		Current Draw Under Normal Load	Normal Engine Cranking Speed	Min. Stall Torque @ 5 Volts		Max. Load	No Load	Mfg. Length		Spring Tension	
mm	Inches	Amps	RPM	N·m	Lb·Ft	Amps	Amps	mm	Inches	N	oz.
78	3	140-200	200-250	14.7	11.0	800	70 ± 10	16.8	0.66	18	64

Maximum Commutator runout is 0.12mm (0.005 inch) Maximum starting circuit voltage drop (battery positive terminal to starter terminal) at normal engine temperature is 0.5 volt.

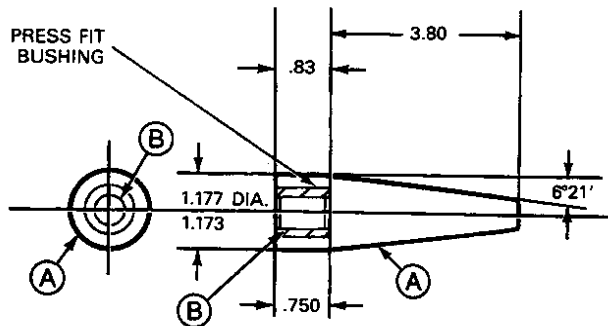
**SPECIAL SERVICE TOOLS**

Tool Number	Description
TOOL-4201-C	Dial Indicator

**ROTUNDA EQUIPMENT**

Tool Number	Description
078-00005	Starting and Charging Tester

**TOOL TO ASSEMBLE BRUSH HOLDER TO ARMATURE**



BRUSH HOLDER ASSEMBLY

- (A) MANDREL  
MAT'L: MICAATA LL221  
TAN-TYPE FBL  
STK: 13/8 DIA. + ▲-LG  
(1) REQ'D
- (B) BUSHING  
UNIVERSAL HEADLESS TYPE  
PRESS FIT BUSHING  
CAT. NO. GS-93  
.471/.472 I.D. .7518 O.D. .750 LG.  
(1) REQ'D

# Part 6 — Governors

SUBJECT	PAGE	SUBJECT	PAGE
DESCRIPTION AND OPERATION .....	6-01	ADJUSTMENTS .....	6-02
TROUBLESHOOTING .....	6-02		

## DESCRIPTION AND OPERATION

### MECHANICAL GOVERNOR — BELT DRIVEN

Belt driven governors come in several versions. The constant speed type is adjusted to operate at one fixed speed. The governor spring is connected between the spring lever and the speed adjusting lever. Spring tension, thus engine RPM, are adjusted by the speed adjusting screw.

The governor throttle lever has a flexible knee-action lever which allows the engine to be idled at a lower speed for starting and for standby service.

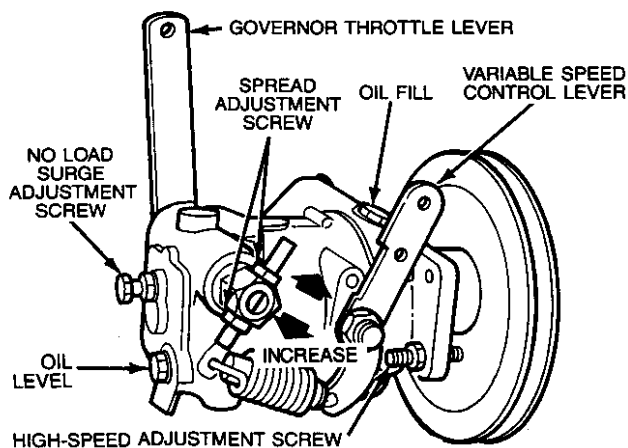
The variable speed type allows engine governor operation from idle to a maximum setting. The variable speed lever is actuated by the throttle cable, which in turn adjusts the spring tension and engine speed.

The throttle is generally a solid arm, but in some cases may contain the flexible knee-action joint for special applications.

The belt driven governor must be driven by the engine at a fixed ratio. The governor pulley size and belt arrangement are determined by the engine application and the speed at which it is to be governed.

Slippage of the belts would permit the engine to run faster than the governor, thus permitting overspeed of the engine.

Tightening the drive belt too tight can cause early failure of the governor bearings. The belt tension should be set to specification with a belt tension gauge.



## TROUBLESHOOTING

### MECHANICAL GOVERNOR

To troubleshoot a governor with a full load surge, first increase the spread between full and no-load. If this does not help, shorten the throttle rod two or three turns. Then check for an excessively rich or lean fuel/air mixture at the carburetor. Also look for vacuum leaks.

There are two other conditions that can cause this problem which should be checked. They are excessively loose throttle rod ball joints or throttle rod binding or rubbing.

No-load surge at maximum RPM can be eliminated with the surge adjustment screw providing the no-load and full load is properly set.

Engine overspeed on accelerating can be caused by excessive friction in the carburetor linkage, throttle shaft and/or accelerator pump, if so equipped. The throttle rod may also be bending or rubbing, or the drive belt(s) may be slipping. These should be checked before making the adjustments.

If the engine overspeeds on removal of the load, try backing out the no-load surge adjustment screw one or two turns. If that doesn't correct the problem, shorten the throttle rod two or three turns. Also check for an excessive amount of oil in the governor.

When the governor does not respond to load changes, adjust the throttle rod to the proper length. If problems still exist, back out the no-load screw and adjust it per instructions.

Look for bent or fractured flyweights in the governor possibly caused by insufficient lubrication or overspeeding.

## ADJUSTMENTS

### PRELIMINARY CHECKS

#### MECHANICAL GOVERNORS

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.

## ADJUSTMENTS (Continued)

### Oil Level

Remove the oil 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 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 the belt tension tool on the drive belt and check the tension.
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 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 1/32 to 1/16 inch wide.
3. If adjustment is necessary, loosen the control rod ball joint lock nuts, 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 lock nuts.

### SPREAD ADJUSTMENT

Proper governor operation requires a difference between full-load and no-load governed speed. This is called spread or sensitivity. Too small an RPM spread between the two speeds will cause governor hunting and surging. Too large a spread will cause low response to a load.

The normal RPM speed is 5 to 10 percent. This means if the desired full-load RPM is 2000 RPM, the no-load RPM can be 2100 to 2200 RPM.

The spread adjustment is the eyebolt type. Adjustment is made with the eyebolt that attaches the spring to the variable speed lever.

To increase the spread, loosen the locknut and turn the adjusting nut counterclockwise until the engine speed decreases approximately 150 RPM; then tighten the locknut.

To decrease the spread, loosen the locknut and turn the adjusting nut clockwise until engine speed increases approximately 150 RPM. Tighten the locknut.

Recheck governor operation under full load and no-load conditions.

### RPM ADJUSTMENT

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

Disengage engine load and loosen the locknut on the governor high speed stop screw. The location of this screw will vary from governor to governor. Slowly pull the throttle to the desired maximum engine speed and adjust the high speed stop screw to maintain this speed.

The low speed adjustment is made with the low speed adjustment screw, if the governor is so equipped, or with the carburetor idle speed adjustment screw.

Move the hand throttle or variable speed lever to the closed position. Turn the adjustment screw in or out until you can maintain the desired speed.

### NO-LOAD SURGE ADJUSTMENT

One other adjustment that you may need to make is the no-load surge adjustment. It is set at the factory and rarely requires changing. If necessary, this adjustment can be used to prevent hunting and surging at no-load speeds, provided the RPM spread adjustment is set properly.

To make the adjustment, increase the engine speed with the hand throttle to 75 RPM lower than the maximum no-load desired control RPM. Then loosen the no-load surge adjustment screw locknut and turn the screw inward until 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.**

# Part 7 — Cooling

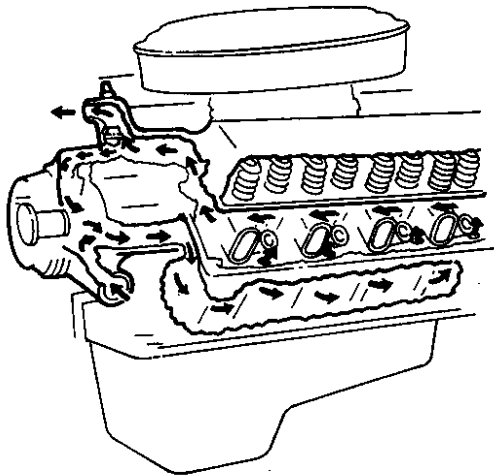
SUBJECT	PAGE	SUBJECT	PAGE
<b>DESCRIPTION AND OPERATION</b>		<b>ADJUSTMENTS</b>	
Coolant (Industrial) .....	7-01	Drive Belt .....	7-03
<b>TESTING</b>		Belt Tension .....	7-03
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		Cooling System .....	7-04

## DESCRIPTION AND OPERATION

The cooling system is a series-parallel flow. Coolant flow is from the radiator to the water pump through passages in the front cover (both sides) to the cylinder block. Flow continues through the block to the rear and up through the deck or head faces, then forward through the cylinder heads to the water crossover at the front of the intake manifold, through the water outlet (thermostat housing) and to the top of the radiator.

The flow with the thermostat closed is through the by-pass hose to the suction side of the water pump.

**NOTE: The cooling system may change on marine engines as they are marinized. The water pump may be deleted on ski boat engines.**



A5505-1A

### COOLANT (INDUSTRIAL)

Correct coolant level is essential for maximum circulation and adequate cooling. In addition, for the cooling system to perform its function, it must receive proper care. This includes keeping the radiator fins clean and a periodic inspection of the cooling system for leakage.

Use care when removing the pressure cap to avoid injury from escaping steam or hot water.

When the cooling system is drained, fill the system with specified coolant.

All coolant added should be the specified mixture of Ford permanent anti-freeze and water. If

Ford Permanent Anti-Freeze is not available, another reputable permanent anti-freeze may be used and diluted with an equal quantity of water.

Ordinary tap water may be used in an emergency except in areas where the water is known to be exceptionally hard or to have a high alkali content. The cooling system should be drained and flushed and the proper mixture of anti-freeze added as soon as possible, however.

To avoid possible overheating in very hot weather, do not use mixtures with more than 50 percent anti-freeze except in areas where anti-freeze protection below -35 degrees F is required. In this case, refer to the coolant mixture chart on the Ford Permanent Anti-Freeze container.

A standard ethylene glycol hydrometer can be used to check the protection level of the long-life coolant.

To prevent damage to the cooling system during periods of below freezing ambient temperature, when water or anti-freeze is added to the supply tank, always operate the engine at fast idle for 30 minutes before letting the engine set in the OFF position for prolonged periods. This will allow a uniform mixture throughout the cooling system and prevent damage by freezing, when sufficient anti-freeze is used.

### DRAINING AND FILLING THE SYSTEM

To prevent loss of anti-freeze when draining the radiator, attach a hose on the radiator drain cock and drain the coolant from the radiator into a clean container.

To drain the radiator, open the drain cock located at the bottom of the radiator and remove the radiator or supply tank cap. The cylinder block is drained by removing the drain plugs located on both sides of the block.

To fill the cooling system, install the cylinder block drain plug(s) and close the radiator drain cock.

After the initial fill, the coolant level will drop approximately 1 quart after the engine has been operated about 20 minutes at 2000 rpm. This is due to the displacement of entrapped air. Refill radiator as required.

## TESTING

### PRESSURE TEST

It is recommended that a cooling system pressure test gauge be used to properly test the system for:

- a. Blown or leaking cooling system sealing gaskets.
- b. Internal or external cooling leakage.
- c. Pressure cap malfunction.

Some modification of existing pressure testers may be required in order to use this procedure.

1. Shut the engine off. **To prevent loss of coolant and to avoid the danger of being burned, place a cloth over the cap and rotate the cap slowly counterclockwise to first stop and allow pressure to escape completely. Then, turn cap again slowly counterclockwise to remove.**
2. After the cooling system pressure has been released, remove the radiator cap, wet the rubber sealing surface and re-install cap tightly on the radiator.
3. Disconnect the electrical connector from the engine temperature sending unit and remove the temperature sending unit from the manifold.  
  
With the radiator cap installed, only a small amount of coolant will be lost when the sending unit is removed.
4. Install an adapter fitting tightly (3/8 N.P.T. male thread on one end, and a hose connection on the other end to accommodate the tester hose) into the intake manifold or cylinder head in place of the sending unit.
5. Remove the radiator overflow hose from the retainer clips. **Make sure the hose is firmly installed on the radiator overflow tube and is in good condition.** Insert the free end of the overflow hose into a container of water.
6. Attach the pressure pump and gauge to the adapter fitting and pressurize the cooling system until bubbles are observed in the water container. Discontinue pumping when bubbles appear.

When the bubbles cease, read the pressure gauge. The gauge reading is the pressure relief of the cap and should be within specifications. If the pressure reading exceeds the specified limit, replace the radiator cap.

7. If bubbles continue and the pressure drops below 10 psi for engines with a 13 psi system, or below 5 psi for a 7 psi system, the radiator cap is not holding pressure. Release pressure and wash cap in clean water to dislodge any foreign matter from the valves. Check the rubber sealing surface of the cap and also the cap sealing surface in the radiator neck. Inspect the cam lock flanges on both sides of the filler neck for maximum cap engagement.
8. Re-check the cooling system as outlined in Step 6. If the cap still does not hold pressure, the cap is damaged and must be replaced. Recheck system after a new cap is installed to assure that the system will now hold pressure.
9. If the bubbles in the water container cease and the radiator cap is within pressure specifications, observe gauge reading for approximately two minutes. Pressure should not drop during this time.
10. If pressure drops, check for leaks at engine to radiator hoses, by-pass hose, thermostat housing gasket, etc. Any leaks which are found must be corrected and the system rechecked.
11. If the system holds pressure, remove the radiator cap to release the pressure; then, re-install the cap.
12. Remove the adapter from the manifold or cylinder head and reinstall the temperature sending unit. Check coolant level and replenish, if necessary, with the correct coolant solution.

### THERMOSTAT TEST

It is good practice to test new thermostats before installing them in the engine.

Remove the thermostat and immerse it in boiling water. Replace the thermostat if it does not open more than 1/4 inch.

If the problem being investigated is insufficient heat, the thermostat should be checked for leakage. This may be done by holding the thermostat up to a lighted background. Light leakage around the thermostat valve (thermostat at room temperature) is unacceptable and the thermostat should be replaced. It is possible, on some thermostats, that a slight leakage of light at one or two locations on the perimeter of the valve may be detected. This should be considered normal.

## ADJUSTMENTS

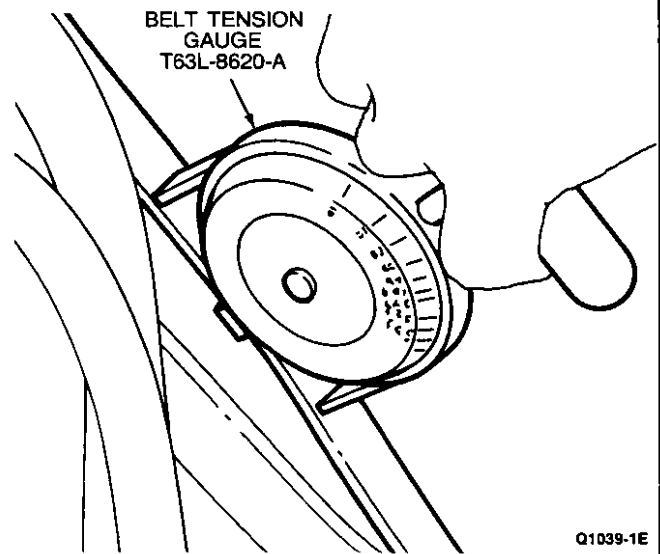
### DRIVE BELT

The fan drive belt should be properly adjusted at all times. A loose drive belt can cause improper alternator, fan and water pump operation. A belt that is too tight places a severe strain on the water pump and alternator 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 alternator mounting bolts and move the alternator adjusting arm bolts. Move the alternator toward or away from the engine



until the correct tension is obtained. Remove the gauge.

3. Tighten the alternator adjusting arm bolt and the mounting bolts. Install the tension gauge and check the belt tension.

### THERMOSTAT REPLACEMENT

**Do not attempt to repair the thermostat. It should be replaced if it is not operating properly. Check the thermostat before installing it, following the procedure under Thermostat Testing.**

#### Removal

1. Drain the cooling system so that the coolant level is below the thermostat.
2. Remove the water outlet housing retaining bolts. Bend the upper hose upward and remove the thermostat and gasket.

#### Installation

1. Clean the water outlet housing gasket surfaces. Coat a new water outlet housing gas-

ket with water-resistant sealer. Position the water outlet housing gasket on the intake manifold opening.

2. Install the thermostat in the intake manifold opening with the copper pellet or element toward the engine and the thermostat flange positioned in the recess. If the thermostat is improperly installed, it will cause a retarded flow of coolant.
3. Position the water outlet housing against the intake manifold. Install and torque the retaining bolts to specifications.
4. Fill and bleed the cooling system. Operate the engine until normal operating temperature is reached; then check the coolant level and check for leaks.

## CLEANING AND INSPECTION

### COOLING SYSTEM

To remove rust, sludge and other foreign material from the cooling system, use either FoMoCo Regular Cooling System Cleanser or in severe cases use Heavy Duty Cleanser. Removal of such material restores cooling efficiency and avoids overheating.

In severe cases where cleaning solvents will not properly clean the cooling system for efficient operation, it will be necessary to use the pressure flushing method.

Various types of flushing equipment are available. If pressure flushing is used, make sure the cylinder head bolts are properly tightened to prevent possible water leakage into the cylinders.

**Always remove the thermostat prior to pressure flushing.**

**A pulsating or reversed direction of flushing water flow will loosen sediment more quickly than a steady flow in the normal direction of coolant flow.**



## SPECIFICATIONS (Continued)

CAMSHAFT AND BEARINGS (Cont'd.)	CONNECTING ROD BEARINGS (Cont'd.)
Marine — Intake ..... 285 Exhaust ..... 290 Maximum Allowable Lobe Lift Loss ..... 0.005 Bearing Inside Diameter ..... 2.1258-2.1273 Camshaft Bearing Location — No. 1 Bearing ..... 0.040-0.060* Timing Chain Deflection — Maximum ..... 0.500	Allowable ..... 0.0008-0.0025 Wall Thickness Standard ..... 0.0757-0.0762
*Distance in inches that the front edge of the bearing is installed toward the rear from the front face of the cylinder block.	<b>PISTONS</b>
<b>CRANKSHAFT AND FLYWHEEL</b>	Piston Diameter* — Coded Red ..... 4.3585-4.3591 Coded Blue ..... 4.3597-4.3603 0.003 Oversize ..... 4.3609-4.3615 Piston to Cylinder Bore Clearance ..... 0.0022-0.0030 Piston Pin Bore Diameter ..... 1.0402-1.0405 Ring Groove Width, Compression Top ..... 0.080-0.0815 Compression Bottom ..... 0.080-0.0815 Oil Ring ..... 0.188-0.189
Main Bearing Journal Diameter ... 2.9994-3.0002 Main Bearing Journal Runout — Maximum ..... 0.002 Main Bearing Journal Out-of-Round — Maximum ..... 0.0006 Main Bearing Journal Taper — Maximum ..... 0.0005 Inch Connecting Rod Journal Diameter 2.4992-2.5000 Connecting Rod Journal Out-of-Round — Maximum ..... 0.0006 Connecting Rod Bearing Journal Taper — Maximum ..... 0.0006 Per Inch Thrust Bearing Journal Length ..... 1.124-1.126 Crankshaft Free End Play ..... 0.004-0.008 Service Limit ..... 0.012	*Measured at the piston pin bore centerline at 90° to the pin bore.
<b>MAIN BEARINGS</b>	<b>PISTON PIN</b>
Crankshaft Clearance Desired ..... 0.0008-0.0015 Allowable No. 1 ..... 0.0008-0.0020 No. 2, 3, 4, 5 ..... 0.0008-0.0025 Wall Thickness Standard ..... 0.0955-0.0960	Piston Pin Diameter — Standard .. 1.0398-1.0403 0.001 Oversize ..... 1.0410-1.0413 Piston Pin Length ..... 3.290-3.320 Piston Pin to Piston Clearance ... 0.0002-0.0005 Piston Pin to Connecting Rod Bushing Clearance ..... Interference Press Fit
<b>CONNECTING ROD</b>	<b>PISTON RINGS</b>
Piston Pin Bore I.D. Standard ..... 1.0386-1.0393 Piston Pin Bore Out-of-Round and Taper . 0.0004 Bearing Bore Diameter ..... 2.6522-2.6530 Bearing Bore Out-of-Round and Taper ... 0.0004 Connecting Rod Length — Center to Center ..... 6.6035-6.6065 Twist Total Difference — Maximum ..... 0.024* Bend Total Difference — Maximum ..... 0.012* Side Clearance ..... 0.010-0.020 Service Limit ..... 0.023	Top Compression Ring Width ..... 0.077-0.078 Bottom Compression Ring Width .... 0.077-0.078 Top Compression Ring Side Clearance ..... 0.0025-0.0045 Service Limit ..... 0.006 Bottom Compression Ring Side Clearance ..... 0.0025-0.0045 Service Limit ..... 0.006 Oil Ring Side Clearance ..... Snug Top Compression Ring Gap Width ... 0.010-0.020 Bottom Compression Ring Gap Width ..... 0.010-0.020 Oil Ring Gap (Steel Rail) ..... 0.010-0.035 NOTE: Ring gap may exceed these specifications when measurement is made in block.
*Pin bore and crankshaft bearing bore must be parallel and in the same vertical plane within the specified total difference at ends of an 8-inch long bar measured 4 inches on each side of rod.	<b>OIL PUMP</b>
<b>CONNECTING ROD BEARINGS</b>	Relief Valve Spring Tension — (Lbs. @ Specified Length) ..... 20.6-22.6 @ 2.490 Drive Shaft to Housing Bearing Clearance ..... 0.0015-0.0030 Relief Valve Clearance ..... 0.0015-0.0030 Rotor Assembly End Clearance ..... 0.001-0.004 Outer Race to Housing Clearance (Radial) ..... 0.001-0.013 Inner to Outer Rotor Tip Clearance ..... 0.012
Bearing to Crankshaft Clearance Desired ..... 0.0008-0.0015	

**SPECIFICATIONS (Continued)**

**TORQUE LIMITS — 7.5L (460 CID) V-8 ENGINE**

**NOTE:** All values are in N·m (ft-lbs) unless otherwise noted. Oil threads with engine oil. The standard torque limits listed below are applicable for all functions not listed in the special torque chart.

1/4-20	5/16-18	5/16-24	3/8-16	3/8-24	7/16-14	7/16-20	1/2-13	9/16-18
8-12 (6-9)	17-24 (12-18)	19-27 (14-20)	30-43 (22-32)	37-51 (27-38)	61-77 (45-57)	55-81 (40-60)	75-81 (55-60)	116-162 (85-120)

**PIPE THREADS**

1/8-27	1/4-18	3/8-18	1/2-14
7-11 (5-8)	17-24 (12-18)	30-44 (22-23)	34-47 (25-35)

Item	Torque		Item	Torque		
	N·m	(ft-lbs)		N·m	ft-lbs	
Camshaft Sprocket — Gear to Camshaft	55-61	40-45	Oil Filter to Adaptor or Cylinder Block	1/2 turn after gasket contacts sealing surface — oil gasket		
Camshaft Thrust Plate to Cylinder Block	13-16	9-12	Oil Inlet Tube to Pump	17-24	12-18	
Connecting Rod Nut	55-61	45-50	Oil Inlet to Main Bearing Cap Nut	30-43	22-32	
Cylinder Front Cover — 5/16"	17-24	15-21	Oil Pan Drain Plug	21-33	15-25	
Cylinder Head Bolts in Sequence	Step 1	108	80	Oil Pan to Cylinder Block	1/4" 10-12	7-9
	Step 2	149	110	5/16" 13-14	9-11	
	Step 3	177-189	130-140			
Damper to Crankshaft	95-122	70-90	Oil Pan Baffle Nut	30-43	22-32	
Distributor Clamp Down	24-33	17-25	Oil Pump to Cylinder Block	30-43	22-32	
Carburetor Mounting Stud	20 Max.	15 Max.	Pulley to Damper Bolt	48-67	35-50	
Carburetor Attaching Nuts	17-20	12-15	Rocker Arm Bolt to Cylinder Head	25-33	18-25	
Fuel Pump to Front Cover	26-36	19-27	Spark Plug to Cylinder Head	7-13	5-10	
Flywheel to Crankshaft	103-115	75-85	Valve Rocker Arm Cover	7-8	5-6	
Main Bearing Cap Bolts or Stud Bolt	129-142	95-105	Water Outlet Housing	14-20	10-15	
Manifold to Cylinder Head — Intake in Sequence	30-43	22-32	Water Pump to Front Cover	20-28	15-21	
			Alternator Bracket to Water Pump — Bolt	44-61	35-50	
Intake Manifold Vacuum Fittings	8-13	6-10	Alternator Pivot Bolt	62-77	45-57	
Manifold to Cylinder Head — Exhaust	38-44	28-33	Alternator Adjusting Arm to Water Pump Bolt	48-67	35-50	
Oil Filter Insert to Cylinder Block/Adaptor	62-74	45-55	Alternator Adjusting Arm to Alternator Bolt	33-60	24-40	
Oil Filter Adaptor to Cylinder Block	55-67	40-50				

IGNITION SYSTEM	IGNITION SYSTEM (Cont'd.)
Initial Spark Advance — BTDC ..... 10°	Average Draw
Gear Location Dimension —	Engine Stopped ..... 4.5
Distributor* ..... 4.031-4.038	Engine Idling ..... 2.5
*(Distance from bottom of Mounting Flange to bottom of Gear).	Ballast Resistor — Ohms ..... 1.30-1.40 (25°F)
Shaft End Play — Distributor ..... 0.024-0.035	Spark Plug Gap (inches) ..... .032-.036
<b>BREAKER POINT TYPE</b>	<b>SOLID STATE</b>
Breaker Arm Spring Tension (ounces) ..... 17-21	Coil
Contact Spacing ..... .014-.019	Primary Resistance
Dwell Angle at Idle Speed ..... Marine, 31°	(Ohms) ..... 1.15-1.25 (75°F.)
Condenser	Secondary Resistance
Capacity — Microfarads ..... 0.21-0.25	(Ohms) ..... 7700-10500 (75°F.)
Minimum Leakage — Megohms ..... 10	Amperage Draw
Maximum Series Resistance Ohms ..... 1	Engine Stopped ..... 4
Coil	Engine Idling ..... 5
Primary Resistance — Ohms .. 1.40-1.54 (75°)	Ballast Resistor (Ohms) ..... 0.8-1.6 (75°F.)
Secondary Resistance —	Stator Assembly Resistance
Ohms ..... 7600-8800 (75°)	(Ohms) ..... 400-1000
	Spark Plug Gap (Inches) ..... 0.045-.034

**SPECIFICATIONS (Continued)**

**INDUSTRIAL DISTRIBUTOR (E3TZ-BAA)?**

CENTRIFUGAL ADVANCE. Set the test stand to 00° at 250 rpm and 0 inches of vacuum.

rpm (Distributor)	Advance (Degrees)	Vacuum (Inches of Mercury)
500	0-2-1/2	0
750	4-6	0
1000	6-1/2-8-1/2	0
1500	8-10-1/2	0
2000	10-12-1/2	0

VACUUM ADVANCE. Set the test stand at 0° at 1000 rpm and 0 inches of Hg.

rpm (Distributor)	Advance (Degrees)	Vacuum (Inches of Mercury)
1000	0-1-1/2	5
1000	6-9	10
1000	6-9	15
1000	6-9	20

**MARINE DISTRIBUTOR (E5JL-EA) & FA (IBM-7020-B&C)**

CENTRIFUGAL ADVANCE. Set the test stand to 00° at 250 rpm and 0 inches vacuum.

rpm (Distributor)	Advance (Degrees)	Vacuum (Inches of Mercury)
500	0	0
750	4-6-1/2	0
1000	6-7-1/2	0
1500	8-1/2-10-1/2	0
2000	11-13	0

FUEL SYSTEM	COOLING SYSTEM
Fuel Pump Static Pressure @ 500 rpm .. 6.0-8.0 Minimum Fuel Pump Volume Flow @ 500 rpm ..... 1 Pint/20 Sec. Eccentric Total Lift ..... 0.602-0.622	Thermostat Low Temperature ..... Opens 157°-164°F Fully Open — 184°F High Temperature ..... Opens 188°-195°F Fully Open — 212° Drive Belt Tension ..... New — 140 Lbs. Used — 100 lbs. (any belt operated over 10 minutes)

## SPECIFICATIONS (Continued)

CARBURETORS	D7JL F	D9JL C	E0JL DA	E6JL FB	E6JL FC
<b>Carburetor Size</b> Throttle Bore Diameter Primary – Secondary –	1.562 –	1.562 –	1.686 1.686	1.686 1.686	1.686 1.686
<b>Fuel System</b> Fuel Level (Wet) Float Level (Dry)	② ③ ①	② ③ ①	② ③ ①	② ③ ①	② ③ ①
<b>Main Metering System</b> Main Jet Primary – Secondary – Power Valve Timing④ Idle Mixture Screw (Primary Setting)	563 – – 5-7 1-1/2	563 – – 5-7 1-1/2	731 – .089 5-7 1-1/2	731 – .089 5-7 1-1/2	ST. 743 – .089 5-7 1-1/2
<b>Accelerator Pump System</b> Capacity – C, C/10 Strokes Pump Rod Location	22-32 #2	22-32 #1	17-27 #2	30-40 #2	30-40 #2
<b>Idle Speed</b> Curb Idle RPM Fast Idle RPM	550-575 1500	550-575 1500	550-575 1500	550-575 1500	550-575 1500
<b>Choke</b> Cover Setting Dechoke Choke Qualifying Secondary Throttle Opening⑤ Heater – Ohms	– – .270 – –	– – .270 – –	Index .300 .140 1/4 10 ohms @ 140°C	Index .300 .140 1/4 10 ohms @ 140°C	One Notch Rich .270-.330 10 ohms @ 140°C
Supplier Supplier I.D. Number Carburetor Model	Holley R-7996A 2300	Holley R-8970 2300	Holley R-9394 4160C	Holley R-50399A 4160C	4160C
Air Cleaner Studs (Flame Arrester)	30 in-lbs		Throttle Plate and Secondary Plate Screws – Stake		10 in-lbs
Air Horn/Main Body Screws	10 in-lbs		Fuel Inlet Seat		10 in-lbs
Choke Housing Screws	5 in-lbs		Main Jet		10 in-lbs
Choke Plate Screws	6 in-lbs		Power Valve		100 in-lbs
Fast Idle Cam Nut	10 in-lbs		Pump Discharge Nozzle Screw		15 in-lbs
Fuel Inlet Screen Nut	60-in lbs		Fuel Bowl Screws (Standard (Spring Type)		45 in-lbs
Pump Diaphragm Cover Screws	5 in-lbs				1/4 Turn Return
Secondary Shaft Nut	10 in-lbs				

### NOTES:

- ① Parallel with Float Bowl Floor (bowl inverted).
- ② 1/2" Primary 5/8" Secondary.
- ③ Use Kent Model Gauge #10193.
- ④ Manifold vacuum reading in inches of mercury.
- ⑤ Turns open, from the closed position.

### FUEL

Gasoline 87 Octane  $\left( \frac{R+M}{2} \right)$

## SPECIAL SERVICE TOOLS

Call Owatonna Tool Company at 1-800-533-5338.  
Ask for the Ford Order Desk.



# METRICS

<b>SUBJECT</b>	<b>PAGE</b>	<b>SUBJECT</b>	<b>PAGE</b>
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English/Metric Conversion Chart .....	5	Hex Nuts .....	3
Introduction .....	1	Studs .....	3
Nomenclature for Bolts .....	2	Tapping Screws .....	3
		Thread Forming Screws .....	3
		U-Nuts .....	3
		Torque Conversion Chart .....	6

## INTRODUCTION

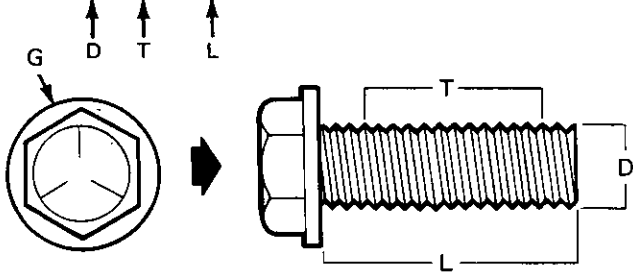
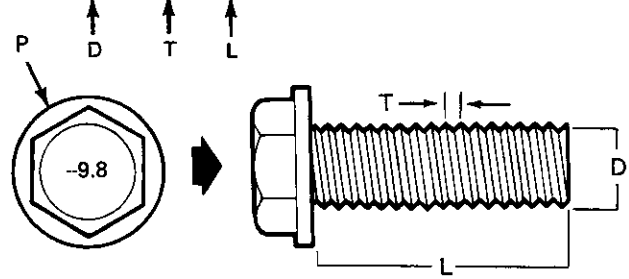
Most threaded fasteners are covered by specifications that define required mechanical properties, such as tensile strength, yield strength, proof load and hardness. These specifications are carefully considered in initial selection of fasteners for a given application. To assure continued satisfactory vehicle performance, replacement fasteners used should be of the correct strength, as well as the correct nominal diameter, thread pitch, length, and finish.

Most original equipment fasteners (English system or metric) are identified with markings or numbers indicating the strength of the fastener. These markings are described in the pages that follow. Attention to these markings is important in assuring that the proper replacement fasteners are used.

Further, some metric fasteners, especially nuts, are colored blue. This metric blue identification is in most cases a temporary aid for production start-up, and color will generally revert to normal black or bright after start-up.

English system and metric system fasteners are available through your Ford Parts and Service operation.

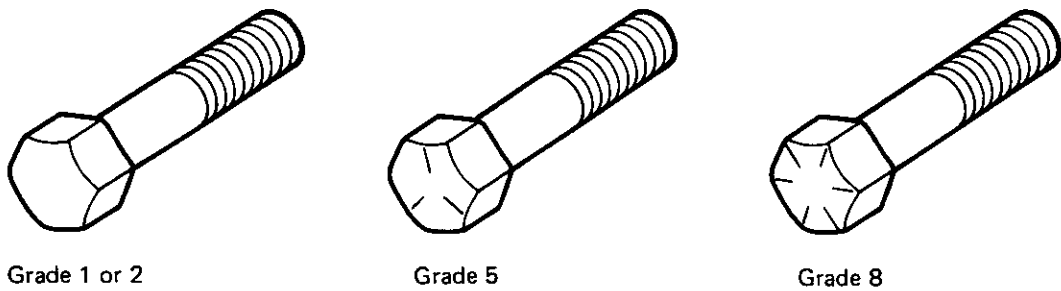
# NOMENCLATURE FOR BOLTS

(ENGLISH) INCH SYSTEM		METRIC SYSTEM	
<b>Bolt, 1/2-13x1.25</b> 		<b>Bolt M12-1.75x25</b> 	
D- Nominal Diameter (inches)	L- Length, (inches)**	D- Nominal Diameter (millimeters)	P- Property Class* (bolt strength)
G- Grade Marking (bolt strength)	T- Thread Pitch (thread/inch)	L- Length (millimeters)**	T- Thread Pitch (thread width crest to crest mm)

\*The property class is an Arabic numeral distinguishable from the slash SAE English grade system.  
 \*\*The length of all bolts is measured from the underside of the head to the end.

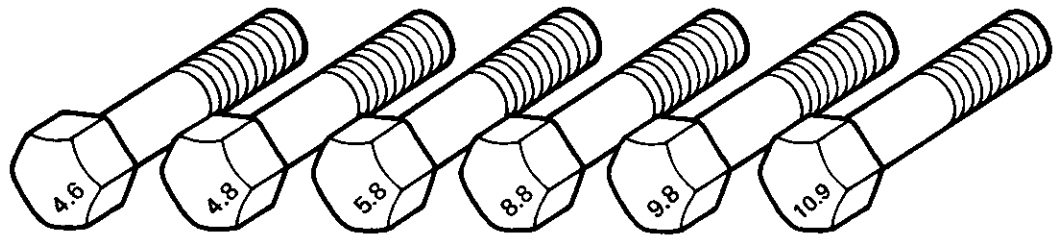
## BOLT STRENGTH IDENTIFICATION

### (ENGLISH) INCH SYSTEM




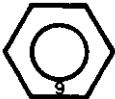

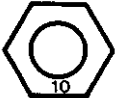
(English) Inch bolts - Identification marks correspond to bolt strength - increasing number of slashes represent increasing strength.

### METRIC SYSTEM



Metric bolts — Identification class numbers correspond to bolt strength - increasing numbers represent increasing strength. Common metric fastener bolt strength properties are 9.8 and 10.9 with the class identification embossed on the bolt head.

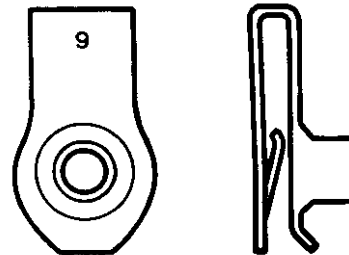
# HEX NUT STRENGTH IDENTIFICATION

(ENGLISH) INCH SYSTEM		METRIC SYSTEM	
Grade	Identification	Class	Identification
Hex Nut Grade 5	 3 Dots	Hex Nut Property Class 9	 Arabic 9
Hex Nut Grade 8	 6 Dots	Hex Nut Property Class 10	 Arabic 10
Increasing dots represent increasing strength.		May also have blue finish or paint daub on hex flat. Increasing numbers represent increasing strength.	

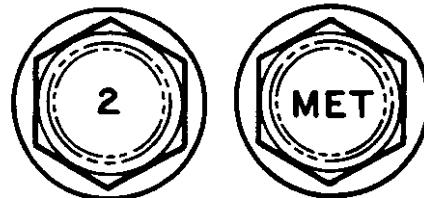
## OTHER TYPES OF PARTS

Metric identification schemes vary by type of part, most often a variation of that used of bolts and nuts. Note that many types of English and metric fasteners carry no special identification if they are otherwise unique.

–Stamped “U” Nuts



–Tapping, thread forming and certain other case hardened screws



–Studs, Large studs may carry the property class number. Smaller studs use a geometric code on the end.



CLASS  
9.8

CLASS  
8.8

## DECIMAL AND METRIC EQUIVALENTS

Fractions	Decimal In.	Metric mm.	Fractions	Decimal In.	Metric mm.
1/64	.015625	.397	33/64	.515625	13.097
1/32	.03125	.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.478
1/8	.125	3.175	5/8	.625	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.250	6.35	3/4	.750	19.05
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.54	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.500	12.7	1	1.00	25.4

# ENGLISH METRIC CONVERSION

	multiply	by	for equiv. no. of:
ACCELERATION	Foot/sec <sup>2</sup>	0.304 8	meter/sec <sup>2</sup> (m/s <sup>2</sup> )
	Inch/sec <sup>2</sup>	0.025 4	meter/sec <sup>2</sup>
TORQUE	Pound-inch	0.112 98	newton-meters (N-m)
	Pound-foot	1.355 8	newton-meters
POWER	horsepower	0.746	kilowatts (kw)
PRESSURE or STRESS	inches of water	0.249 1	kilopascals (kPa)
	pounds/sq. in.	6.895	kilopascals (kPa)
ENERGY or WORK	BTU	1 055.	joules (J)
	foot-pound	1.355 8	joules (J)
	kilowatt-hour	3 600 000.	joules (J=one W's)
		or 3.6 x 10 <sup>6</sup>	
LIGHT	foot candle	10.76	lumens/meter <sup>2</sup> (lm/m <sup>2</sup> )
FUEL PERFORMANCE	miles/gal	0.425 1	kilometers/liter (km/l)
	gal/mile	2.352 7	liters/kilometer (l/km)
VELOCITY	miles/hour	1.609 3	kilometer/hr. (km/h)
LENGTH	inch	25.4	millimeters (mm)
	foot	0.304 8	meters (m)
	yard	0.914 4	meters
	mile	1.609	kilometers (km)
AREA	inch <sup>2</sup>	645.2	millimeters <sup>2</sup> (mm <sup>2</sup> )
	foot <sup>2</sup>	6.45	centimeters <sup>2</sup> (cm <sup>2</sup> )
	yard <sup>2</sup>	0.092 9	meters <sup>2</sup> (m <sup>2</sup> )
VOLUME	yard <sup>2</sup>	0.836 1	meters <sup>2</sup>
	inch <sup>3</sup>	16 387.	mm <sup>3</sup>
		16.387	cm <sup>3</sup>
	quart	0.016 4	liters(1)
	quart	0.946 4	liters
	gallon	3.785 4	liters
yard <sup>3</sup>	0.764 6	meters <sup>3</sup> (m <sup>3</sup> )	
MASS	pound	0.453 6	kilograms (kg)
	ton	907.18	kilograms (kg)
	ton	0.907	tonne (t)
FORCE	kilogram	9.807	newtons (N)
	ounce	0.278 0	newtons
	pound	4.448	newtons
TEMPERATURE	degree fahrenheit	(1°F 32) 1.8	degree Celsius

# TORQUE CONVERSION

NEWTON METERS (N·m)	POUND-FEET (LB.-FT.)
1	0.7376
2	1.5
3	2.2
4	3.0
5	3.7
6	4.4
7	5.2
8	5.9
9	6.6
10	7.4
15	11.1
20	14.8
25	18.4
30	22.1
35	25.8
40	29.5
50	36.9
60	44.3
70	51.6
80	59.0
90	66.4
100	73.8
110	81.1
120	88.5
130	95.9
140	103.3
150	110.6
160	118.0
170	125.4
180	132.8
190	140.1
200	147.5
225	166.0
250	184.4

POUND-FEET (LB.-FT.)	NEWTON METERS (N·m)
1	1.356
2	2.7
3	4.0
4	5.4
5	6.8
6	8.1
7	9.5
8	10.8
9	12.2
10	13.6
15	20.3
20	27.1
25	33.9
30	40.7
35	47.5
40	54.2
45	61.0
50	67.8
55	74.6
60	81.4
65	88.1
70	94.9
75	101.7
80	108.5
90	122.0
100	135.6
110	149.1
120	162.7
130	176.3
140	189.8
150	203.4
160	216.9
170	230.5
180	244.0