

# Chapter Ten

## MerCruiser 470, 485, 488, 170MR and 190MR

This chapter covers the MerCruiser 224 cid 4-cylinder engine variously designated as 470, 485 and 488. The 1985 470 and 488 models were redesigned as 170MR and 190MR respectively to indicate the use of the new style gear housing. All models of this engine are essentially the same, differing primarily in camshaft profile and valve train specifications.

The cylinders are numbered 1-2-3-4 from front to rear. Engine firing order is 1-3-4-2.

Rocker arms are retained by individual threaded bolts. A simple ball pivot valve train is used, with camshaft motion transferred through the hydraulic lifters to the rocker arms by pushrods.

The crankshaft is supported by 5 main bearings. The No. 3 bearing takes the thrust. Crankshaft rotation is counterclockwise when seen from the drive unit end of the engine.

The chain-driven camshaft rotates directly in the aluminum cylinder bores and is located above the crankshaft in the engine block.

The oil pump is located on the bottom front of the block on the starboard side and is driven by the distributor shaft.

Specifications (Table 1 and Table 2) and tightening torques (Table 3 and Table 4) are at the end of the chapter.

### ENGINE SERIAL NUMBER

The engine serial number is stamped on a plate mounted on the front left side of the engine block next to the heat exchanger (Figure 1).

This information identifies the engine and indicates if there are unique parts or if internal

changes have been made during the model run. It is important when ordering replacement parts for the engine.

If the serial number plate and/or model decals are missing, check the cylinder head stamp (Figure 2) and color of the valve spring to determine the engine model:

- a. MCM 470/170MR—stamped “0” or no stamp in cylinder head. Single coil valve springs with an orange stripe.
- b. MCM 485—stamped “5” in cylinder head. Valve springs with internal dampener have red/green or blue/white stripes.
- c. MCM 488/190MR—stamped “8” in cylinder head. Valve spring use an external dampener and green stripes.

### SPECIAL TOOLS

Where special tools are required or recommended for engine overhaul, the tool numbers are provided. While these tools can sometimes be rented from rental dealers, those carrying a “J” prefix can be purchased from Kent-Moore, Inc., 28635 Mound Road, Warren, Michigan 48089. Tools carrying a “T” prefix can be purchased from Owatonna Tools, Inc., Attn: Ford Order Desk, Owatonna, MN. 55060. Part numbers with a “C” prefix are from Mercury Marine.

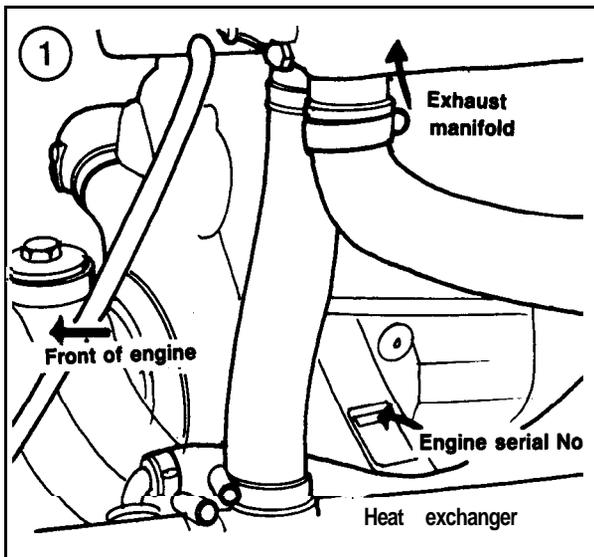
### REPLACEMENT PARTS

Various changes are made to automotive engine blocks used for marine applications. Numerous

part changes are required due to operation in fresh and salt water. For example, the cylinder head gasket must be corrosion-resistant. Marine engines use head gaskets of copper or stainless steel instead of the standard steel used in automotive applications. Brass expansion or core plugs must be used instead of the steel plugs found in automotive blocks.

Since marine engines are run at or near maximum rpm most of the time, the use of special valve lifters, springs, pistons, bearings, camshafts and other heavy-duty moving components is necessary for maximum life and performance.

For these reasons, automotive-type parts should not be substituted for marine components. In addition, Mercury recommends that only Quicksilver parts be used. Parts offered by other manufacturers may look alike, but may not be manufactured to Mercury's specifications. Any damage resulting from the use of other than Quicksilver parts is not covered by the Mercury Marine warranty.



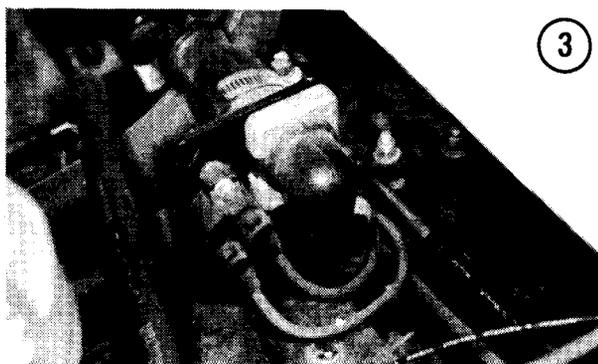
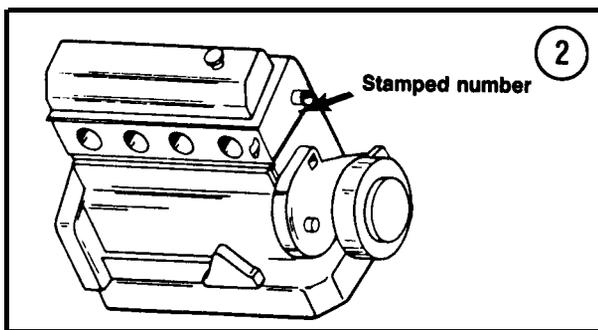
**REMOVAL**

Some service procedures can be performed with the engine in the boat; others require removal. The boat design and service procedure to be performed will determine whether the engine must be removed. In some installations, it may be necessary to remove the stern drive unit first. See Chapter Fourteen.

**WARNING**

*The engine is heavy, awkward to handle and has sharp edges. It may shift or drop suddenly during removal. To prevent serious injury, always observe the following precautions.*

- 1. Never place any part of your body where a moving or falling engine may trap, cut or crush you.**
- 2. If you must push the engine during removal, use a board or similar tool to keep your hands out of danger.**
- 3. Be sure the hoist is designed to lift engines and has enough load capacity for your engine.**
- 4. Be sure the hoist is securely attached to safe lifting points on the engine.**
- 5. The engine should not be difficult to lift with a proper hoist. If it is, stop lifting, lower the engine back onto its mounts and make sure the engine has been completely separated from the boat.**



1. Remove the engine hood cover and all panels that interfere with engine removal. Place to one side out of the way.
2. Disconnect the negative battery cable, then the positive battery cable. As a precaution, remove the battery from the boat.
3. Disconnect the throttle cable at the carburetor. If necessary, remove cable from anchor plate.
4. Disconnect the instrument panel wiring harness connector plug from the harness receptacle (Figure 3, typical).

5. Disconnect the fuel lines at the fuel pump (Figure 4). Plug the fuel lines to prevent leakage.
6. Disconnect the brown and black (shift interlock) wires from the shift plate terminal block.
7. Disconnect the red and black power trim pump motor wires at the engine.
8. Disconnect the trim indicator sender wires (if so equipped).
9. Disconnect the water inlet hose. Open the engine drain valve(s) and drain all water from the block.
10. Disconnect the exhaust elbow bellows (Figure 5).
11. Disconnect the drive unit shift cable from the J clamp on the flywheel housing.
12. Disconnect the intake manifold vacuum hose, if so equipped.
13. Disconnect any accessories connected to the engine that will interfere with removal.
14. Attach a lifting bracket to the engine lifting eyes. Connect the bracket to an engine hoist and elevate it enough to remove all slack.

*NOTE*

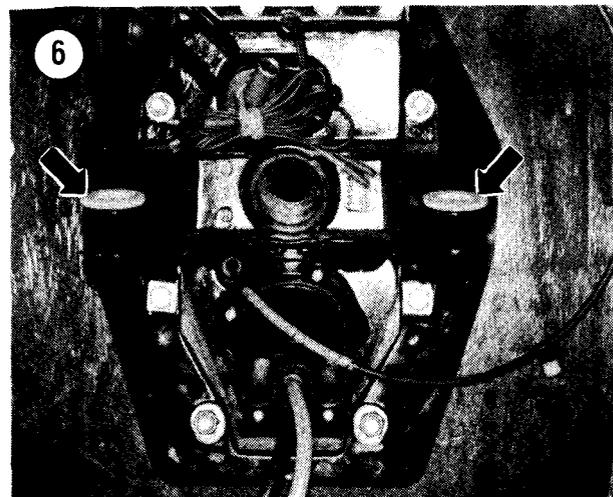
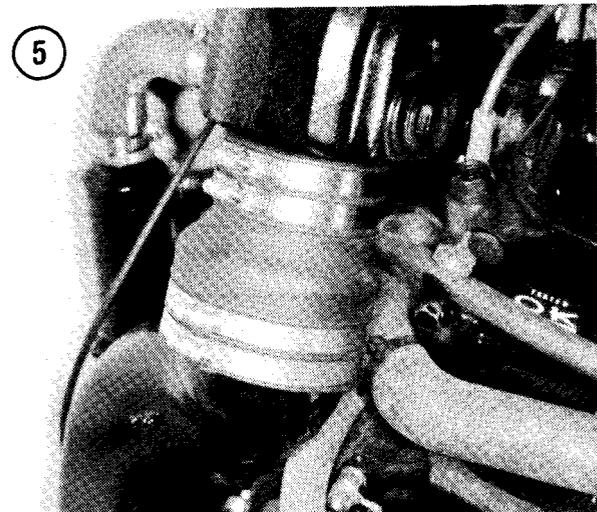
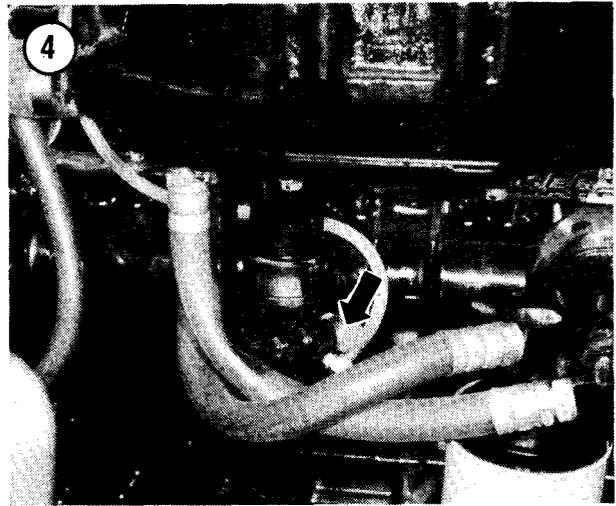
*At this point, there should be no hoses, wires or linkage connecting the engine to the boat or stern drive unit. Recheck this to make sure nothing will hamper engine removal.*

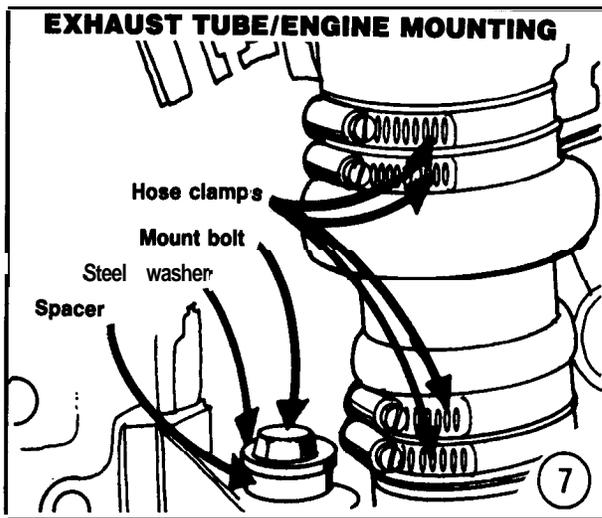
15. Remove the front and rear engine mounting bolts.
16. Slide the engine forward sufficiently to disengage it from the drive shaft assembly.
17. Remove the engine from the boat with the hoist.

### ENGINE INSTALLATION

Engine installation is the reverse of removal, plus the following.

1. Coat the engine coupling splines with Universal Joint Lubricant (part No. C-92-74058).
2. It may be necessary to rotate the crankshaft slightly to align the engine coupling splines with the drive shaft. You may also rotate the drive shaft by placing the **outdrive** in forward gear and rotating the propeller.
3. Install the front engine mount bracket.
4. Position a large fiber washer on top of the inner transom plate mounting brackets (Figure 6). Position the special split lockwasher inside the fiber washer.





5. Position engine over the transom plate mounting brackets. Install hose clamps over the rubber exhaust elbow bellows, then fit bellows over the exhaust manifold outlet and tighten the clamps securely. See Figure 7.

**CAUTION**

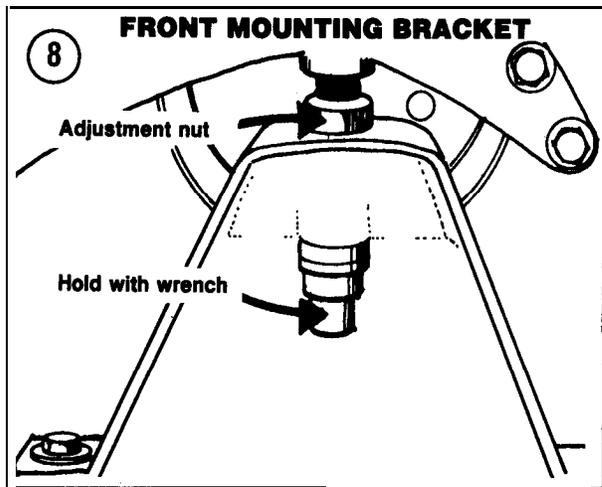
*Elastic stop nuts should never be used more than twice. It is a good idea to replace such nuts with new ones each time they are removed. Never use worn-out stop nuts or non-locking nuts.*

6. Install steel washers and spacers on the mounting bolts, then insert bolts down through the rear engine mounts, washers and mounting brackets. See Figure 7. Install elastic stop nut on bolts and tighten to specifications (Table 3 or Table 4).

7. Turn adjusting nuts in front mounting bracket until bracket rests solidly on the mount location in the boat. See Figure 8. Install mount to boat:

**CAUTION**

*If the alignment tool specified in Step 8 is not available, take the boat to a MerCruiser dealer for proper alignment. Drive shaft/coupling spline misalignment can cause serious damage.*

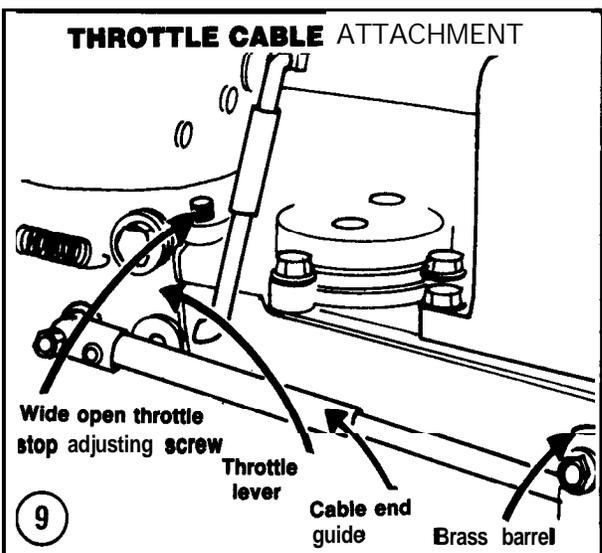


8. Coat the solid end of alignment tool part No. C-9 1-48247 with multi-purpose lubricant and insert it from outside the boat through the gimbal bearing. Index the bearing and drive shaft with the engine coupling splines. If indexing is difficult, loosen the front mount and raise or lower the engine with the hoist as required to permit indexing with no resistance.

9. Tighten all fasteners to specifications (Table 3 or Table 4). Remove the alignment tool.

10. Refer to Figure 9 and connect the throttle cable as follows:

- a. Move remote control to neutral gear, idle position.
- b. Connect cable end guide to throttle lever with flat washer and nut.
- c. Holding throttle cable behind the brass barrel, push it toward the throttle lever. Adjust barrel to align with anchor stud, then connect barrel to stud with flat washer and nut.
- d. Make sure throttle valves are wide open when remote control is in full-forward position, then turn wide-open throttle stop adjusting screw clockwise until it just touches the throttle lever.
- e. Tighten set nut securely, return control to neutral gear, idle position and make sure that idle stop screw rests against the stop.



10. Fill the engine with an oil recommended in Chapter Four.
11. Fill the cooling system. See Chapter Twelve.
12. Adjust the drive belts. See Chapter Thirteen.

### DISASSEMBLY CHECKLISTS

To use the checklists, remove and inspect each part in the order mentioned. To reassemble, go through the checklists backwards, installing the parts in order. Each major part is covered under its own heading in this chapter, unless otherwise noted.

#### Decarbonizing or Valve Service

1. Remove the rocker arm cover.
2. Remove the intake and exhaust manifolds.
3. Remove the rocker arm assembly.
4. Remove the cylinder head.
5. Remove and inspect the valves. Inspect valve guides and seats, repairing or replacing as required.
6. Assemble by reversing Steps 1-5.

#### Valve and Ring Service

1. Perform *Decarbonizing or Valve Service*.
2. Remove the oil pan.
3. Remove the pistons with the connecting rods.
4. Remove the piston rings. It is not necessary to separate the pistons from the connecting rods unless a piston, connecting rod or piston pin needs repair or replacement.
5. Assemble by reversing Steps 1-4.

#### General Overhaul

1. Remove the engine from the boat.
2. Remove the flywheel.
3. Remove the engine mount brackets and oil pressure sending unit from the engine.
4. If available, mount the engine on an engine stand. These can be rented from equipment rental dealers. The stand is not absolutely necessary, but it will make the job much easier.
5. Check the engine for signs of coolant or oil leaks.
6. Clean the outside of the engine.
7. Remove the distributor. See Chapter Thirteen.
8. Remove all hoses and tubes connected to the engine.
9. Remove the fuel pump. See Chapter Eleven.
10. Remove the intake and exhaust manifolds.
11. Remove the thermostat. See Chapter Twelve.

12. Remove the rocker arm assemblies.
13. Remove the crankshaft pulley/vibration damper and timing case cover. Remove the timing gear and sprockets.
14. Remove the camshaft.
15. Remove the cylinder head.
16. Remove the oil pan and oil pump.
17. Remove the pistons and connecting rods.
18. Remove the crankshaft.
19. Inspect the cylinder block.
20. Assemble by reversing Steps 1- 18.

### ROCKER ARM COVER

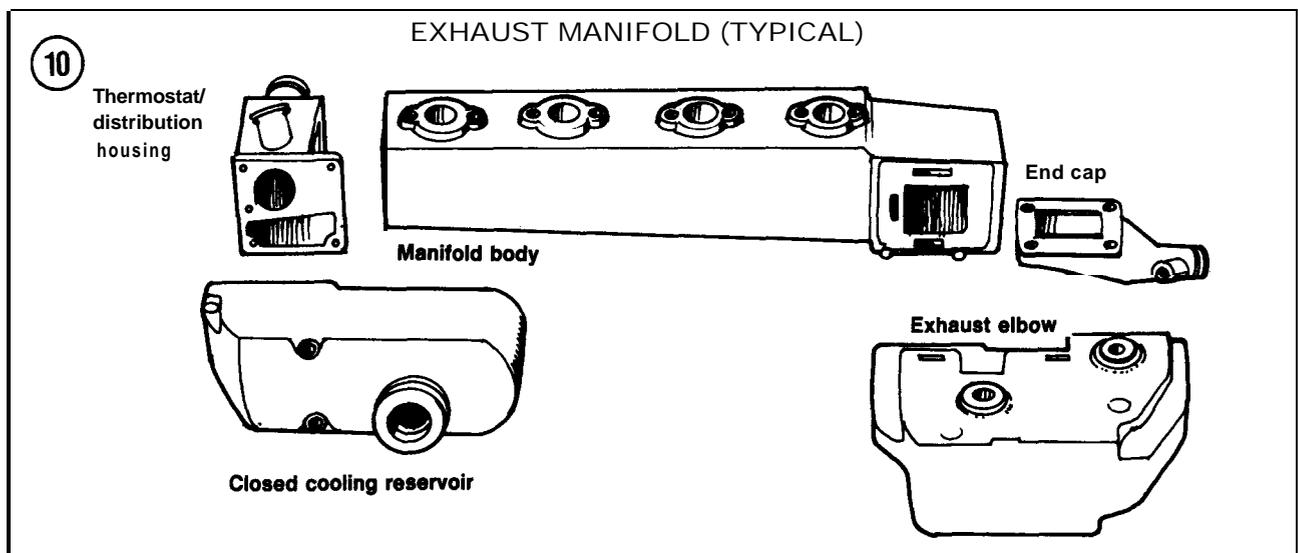
#### Removal/Installation

1. Remove the crankcase vent hose from the rocker arm cover.
2. Unclip or detach any wires or wire looms attached to the rocker arm cover.
3. Remove the cover attaching screws and washers. Tap the rocker arm cover with a plastic mallet to break the gasket seal. Remove the rocker arm cover.
4. Clean any gasket residue from the cylinder head and rocker arm cover with degreaser and a putty knife.
5. Coat one side of a new gasket with an oil-resistant sealer and install sealer-side down in the rocker arm cover. Gasket tabs must engage cover notches.
6. Install the cover on the cylinder head.
7. Install the attaching screws and washers. Tighten to specifications (**Table 2**).
8. Install the crankcase vent hose in the rocker arm cover.

### INTAKE MANIFOLD

#### Removal/Installation

1. Disconnect the negative battery cable.
2. Disconnect the choke cover wire and fuel pump vent tube at the carburetor.
3. Disconnect the fuel line at the carburetor. Plug the line to prevent leakage.
4. Disconnect the throttle cable at the carburetor and remove the return spring.
5. Remove the water hoses from the manifold.
6. Disconnect the crankcase breather hose at the flame arrestor.
7. Support the intake manifold. Remove manifold fasteners and engine wire harness retaining clamps.
8. Remove the manifold assembly with carburetor attached. Discard the manifold gasket.



9. Clean all gasket residue from the cylinder head and manifold mating surfaces with degreaser and a putty knife.

10. Coat a new manifold gasket with Perfect Seal (part No. C-92-34227) or equivalent. Position gasket to cylinder head.

11. Install intake manifold. Tighten fasteners to specifications (**Table 2**) working from the center to the ends. The remainder of installation is the reverse of removal.

#### Inspection/Cleaning

1. Remove carburetor from manifold. Check manifold for cracks or distortion. Replace as required.

2. Check mating surfaces for nicks or burrs. Small burrs may be removed with an oilstone.

3. Place a straightedge across the manifold mating surface. If there is any gap between the mating surface and straightedge, measure it with a feeler gauge. Measure from end to end and corner to corner.

4. The mating surface should be flat within 0.006 in. per foot of manifold length. If not, replace the manifold.

5. Check manifold for stripped or damaged studs, drain plug and stud hole threads. Repair or replace as required.

### EXHAUST MANIFOLD

#### Removal/Installation

1. Drain both engine coolant systems. See Chapter Five.

2. Disconnect the temperature sending unit lead at the thermostat housing.

3. Disconnect all hoses and exhaust bellows from the manifold.

4. Drain the engine crankcase. See Chapter Four.

5. Unscrew the oil dipstick tube at the oil pan fitting. Remove the bracket attaching bolt. Remove the oil dipstick tube.

6. Support the exhaust manifold. Remove the manifold attaching fasteners.

7. Remove the manifold assembly from the engine. Discard the gasket.

8. Installation is the reverse of removal. Use a new gasket.

#### Disassembly/Reassembly

**Figure 10** shows the major subassemblies of the exhaust manifold.

1. Remove the closed cooling reservoir from the thermostat/distribution housing.

2. Remove the thermostat.

3. Remove the thermostat/distribution housing from the manifold assembly.

4. Remove the temperature sender and brass plug from the distribution housing.

5. Disconnect and remove exhaust elbow from manifold. Discard the gaskets.

6. Remove end cap from aft end of manifold. Discard the gasket.
7. Assembly is the reverse of disassembly. Use new gaskets and wipe temperature sender/brass plug threads with Perfect Seal (part No. C-92-34227) or equivalent. Tighten manifold attaching fasteners to specifications (**Table 3** or **Table 4**).

### Inspection/Cleaning

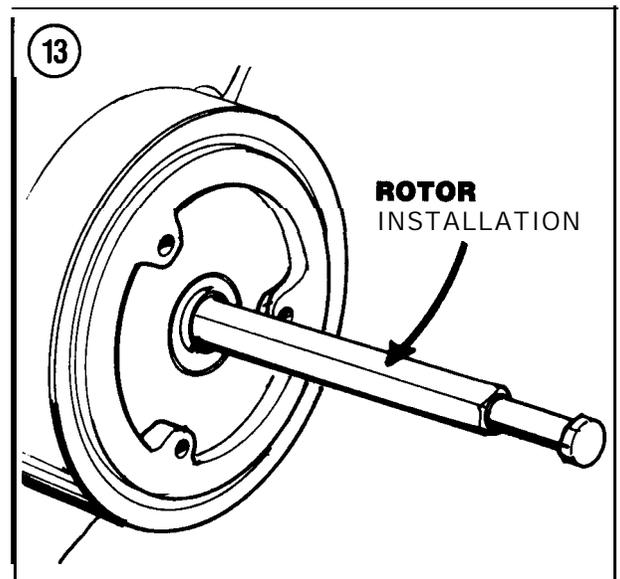
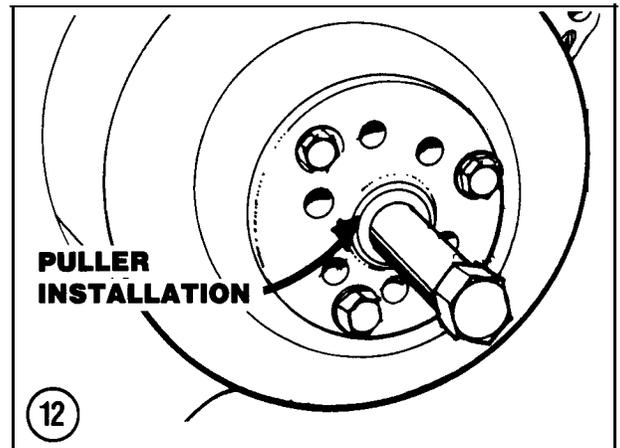
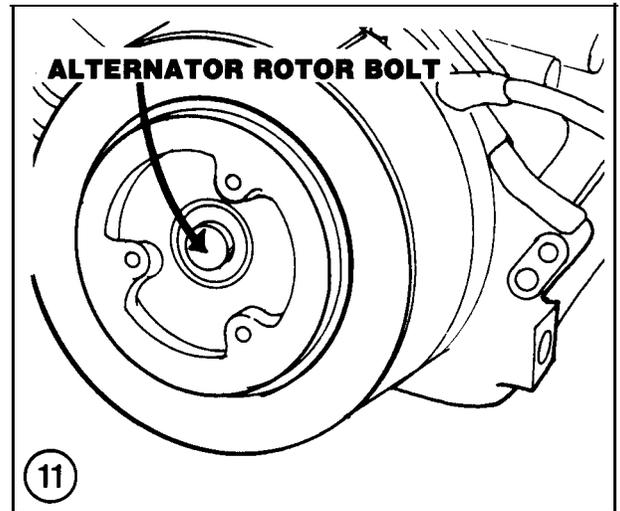
1. Inspect engine exhaust ports for signs of rust or corrosion. Replace manifold if such signs are found.
2. Clean all gasket residue from manifold mating surfaces.
3. Remove pipe plugs from manifold and elbow. Check water passages for clogging.

## ALTERNATOR ROTOR/STATOR

### Rotor Removal/Installation

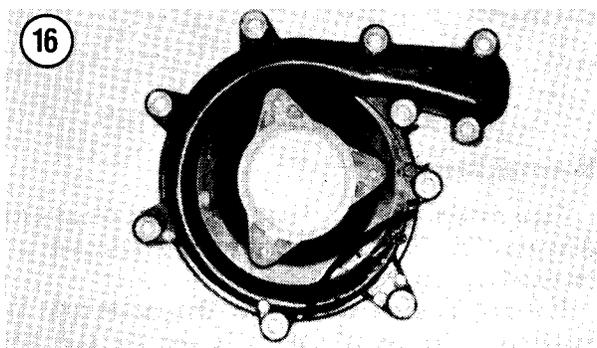
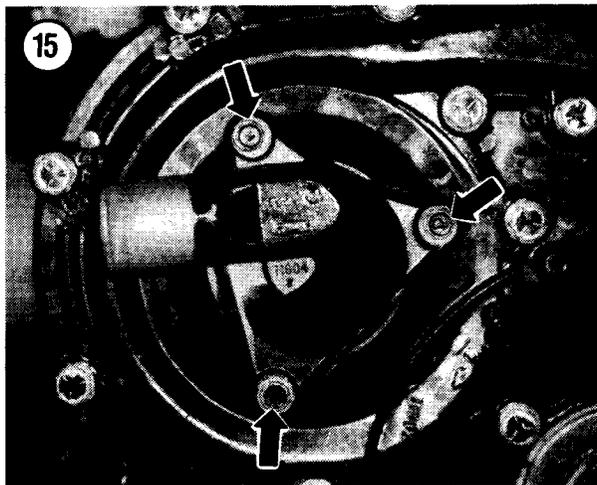
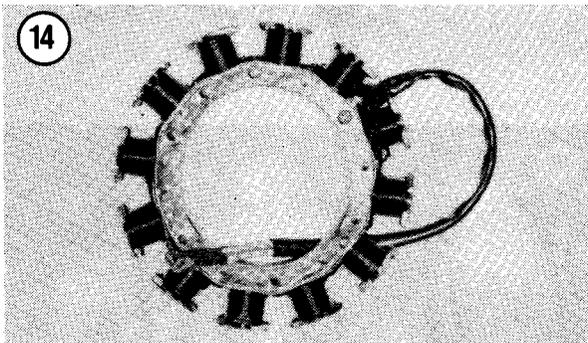
On some installations, it may be necessary to remove the front engine mount assembly before attempting to remove the rotor.

1. Remove alternator drive belt. See Chapter Thirteen.
2. Remove bolt and washer from center of rotor (**Figure 11**).
3. Apply grease to end of puller (part No. J-6978-04). Install puller to rotor hub as shown in **Figure 12** and remove rotor.
4. Lubricate seal lip and inside of rotor surface where seal rides with Multipurpose Lubricant (part No. C-92-63250) or equivalent.
5. Make sure rotor locating key is properly installed in crankshaft groove.
6. Lubricate end of crankshaft and ID of rotor assembly with Quicksilver Lubricant No. 3 or equivalent.
7. Position rotor on crankshaft end and align rotor key slot with crankshaft key.
8. Install tool part No. J-21058-8 on end of crankshaft. See **Figure 13**. Hold center shaft of tool with a wrench and turn outer shaft with a second wrench and turn outer shaft with a second wrench until rotor bottoms out on crankshaft.
9. Install bolt with washer in center of rotor and tighten to specifications (**Table 3** or **Table 4**).
10. Install and adjust alternator drive belt. See Chapter Thirteen.



**Stator Removal/Installation**

1. Remove alternator rotor as described in this chapter.
2. Disconnect stator electrical leads from rectifier.
3. Remove stator wire harness from clamp.
4. Remove stator attaching screws. Remove stator (Figure 14).
5. Installation is the reverse of removal. Output wires must face toward cover recess. Wipe



attaching screw threads with Perfect Seal (part No. C-92-34227) or equivalent and tighten to specifications.

**FRONT COVER AND SEALS**

**Removal/Installation**

This procedure can generally be performed without removing the engine from the boat, provided you are careful in cutting the oil pan seal in Step 6. If the engine is out of the boat, remove the oil pan as described in this chapter as a first step and omit those steps describing oil pan gasket cutting and replacement.

1. Remove the alternator rotor and stator as described in this chapter.
2. Remove the 2 screws holding the front of the oil pan to the front cover.
3. Remove the water inlet housing (Figure 15).
4. Remove the pump impeller cover (Figure 16).

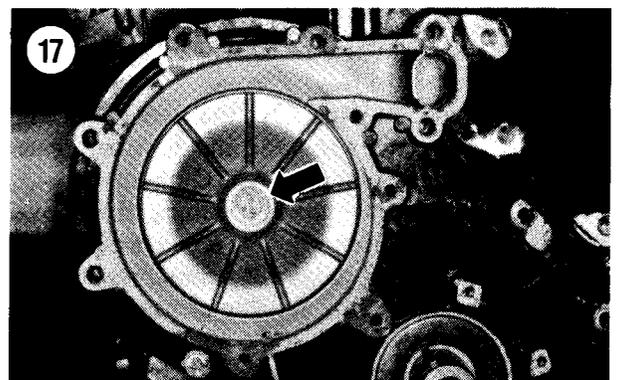
**CAUTION**

*If the impeller fastener is a nut (early models), the fastener has left-hand threads. If the impeller fastener is a bolt (late models), the fastener has right-hand (standard) threads. Be certain to turn the impeller fastener the correct direction in Step 5.*

5. Remove the impeller fastener (Figure 17). On early models, turn the nut clockwise to remove. On late models, turn the bolt counterclockwise to remove. Remove the impeller assembly.

**CAUTION**

*On early models, the impeller shaft is screwed into the camshaft (left-hand threads) and is removable. On late models, the impeller shaft is part of the camshaft and is not removable.*



6. On early models with a nut securing the impeller, unscrew the impeller shaft from the camshaft by turning it clockwise (left-hand threads). *Do* not attempt to remove the impeller shaft on late models with a bolt securing the impeller.

7. Use a sharp X-acto knife to cut the oil pan seal flush with the cylinder block face:

8. Remove the front cover bolts. Remove the cover (Figure 18), cover gasket and cut portion of the oil pan seal. Discard the cover gasket. Retain the pan seal segment for use as a template in Step 16.

9. Support the cover and drive out the crankshaft oil seal and both water pump shaft seals (arrows, Figure 18).

10. Clean the gasket mounting surfaces on the block and cover with degreaser and a putty knife.

11. Coat the OD of new water pump shaft and front cover oil seals with Perfect Seal (part No. C-92-34227) or equivalent, taking care that sealer does not touch seal lips.

12. Support the underside of the cover and install each seal with the lips facing away from the engine block. Press **first** water pump seal in cover until it bottoms. Fill cavity between seals with Multipurpose Lubricant (part No. C-92-63250) or equivalent, then press second seal in until it is flush with the cover surface.

13. Install new crankshaft seal with lip facing engine block. Press in place until seat bottoms out. Lubricate lip with multipurpose lubricant.

14. Position a new front cover seal on the cylinder block dowel pin. Install front cover to block.

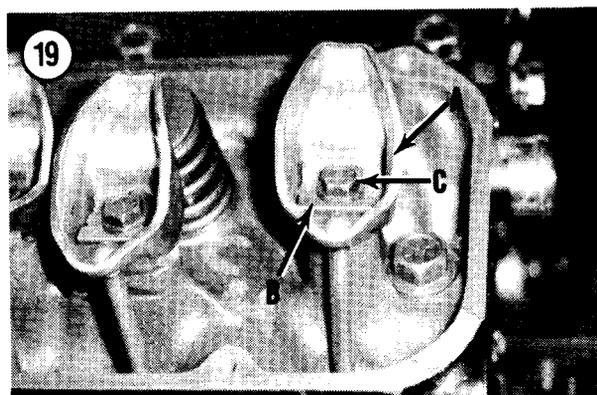
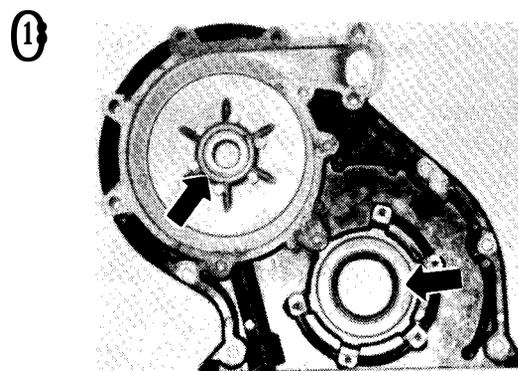
15. Wipe front cover bolt threads with Perfect Seal or equivalent and install bolts. Tighten to specifications (Table 3 or Table 4).

16. Use the cut portion of the oil pan seal as a template and cut a matching section from a new seal for use in Step 17.

17. Install the cut portion of seal to the bottom of the front cover, inserting the seal tips into the cover holes.

18. Apply a  $\frac{1}{8}$  in. bead of room temperature vulcanizing (RTV) sealer along the joint on each side where the oil pan meets the block.

19A. Early models-Apply Loctite Retaining Compound 680 to the threads of the impeller shaft (camshaft end). Lubricate the shaft with Quicksilver 2-4-C Marine Lubricant, then insert it into the front cover seals and screw it securely into the camshaft (left-hand threads). Install the water pump impeller onto the impeller shaft. Use a suitable grease to hold the flat washer in place against the impeller. Install the cupped washer with its concave side facing the im-



PELLER. Install and tighten the impeller nut (left-hand threads) to 40 ft.-lb.

19B. Late models-Install the water pump impeller onto the front of the camshaft. Install the lockwasher and flat washer on the impeller bolt. Apply Loctite 271 to the threads of the impeller bolt, then install (right-hand threads) the bolt and washers. Tighten the bolt to 15 ft.-lb.

20. Install water pump cover with a new gasket. Coat bolt threads with Perfect Seal or equivalent and tighten bolts to specifications (Table 3 or Table 4).

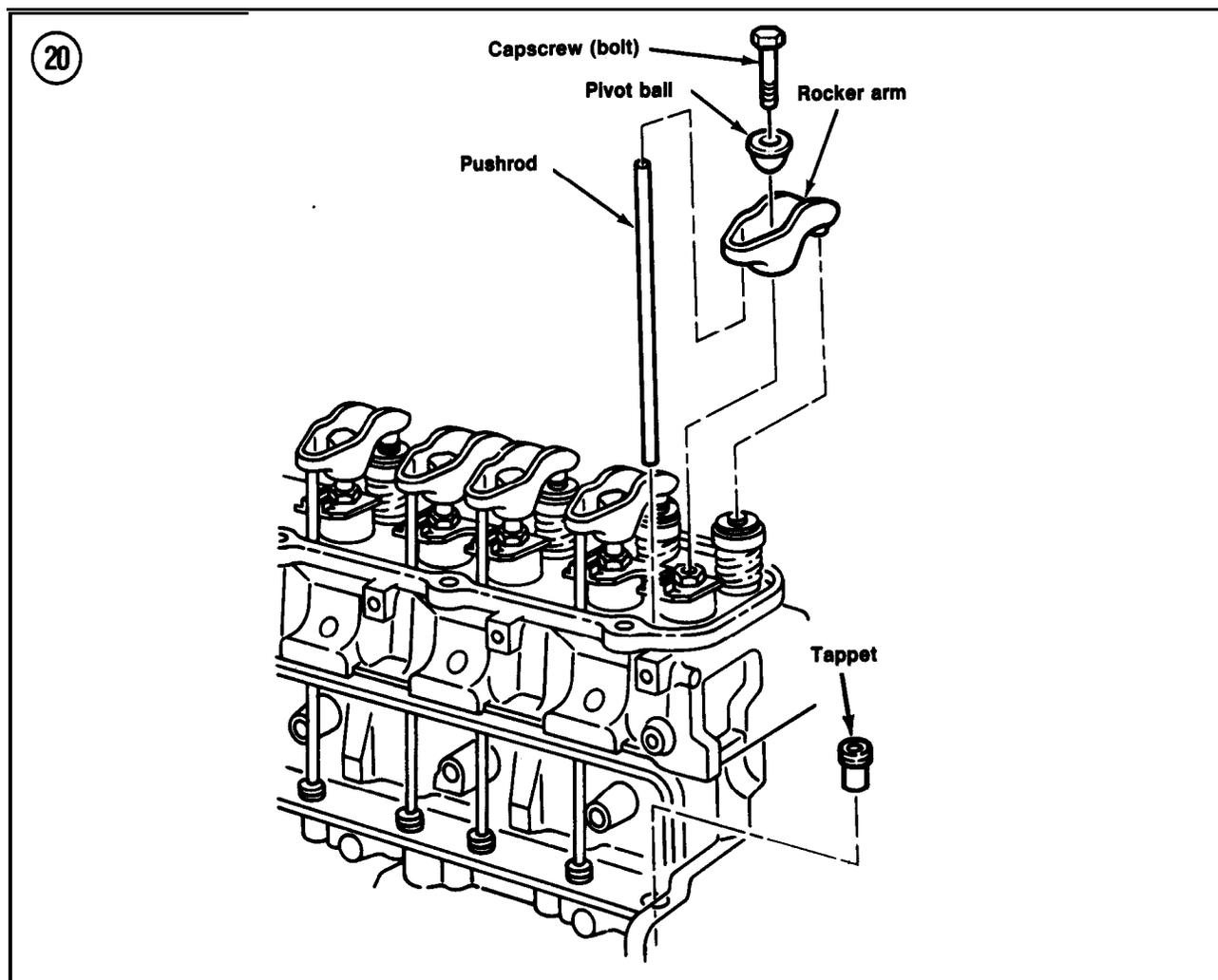
21. Install alternator **stator** and rotor as described in this chapter.

## ROCKER ARM ASSEMBLIES

### Removal/Installation

Each rocker arm (A, Figure 19) moves on its own fulcrum (B). The rocker arm and fulcrum are retained by a bolt (C).

It is not necessary to remove the rocker arm for **pushrod** replacement; simply loosen the bolt and



move the arm away from the **pushrod**. Refer to **Figure 20** for the complete removal procedure.

1. Remove the rocker arm cover as described in this chapter.
2. Remove each rocker arm bolt, fulcrum, rocker arm and **pushrod**.
3. Place each rocker **arm/pushrod** assembly in a separate container or use a rack to keep them separated for reinstallation in the same position from which they were removed.

#### NOTE

*When installing new valve lifters, rocker arms or rocker arm fulcrums, coat the contact surfaces with engine oil or Molykote (part No. C-92-55049).*

4. Install the pushrods, making sure that each fits into its lifter socket.

5. Install the rocker arms, fulcrums and bolts.

6. Rotate the crankshaft to position one cylinder at TDC. Tighten that cylinder's rocker arm bolts to specifications (**Table 3** or **Table 4**). Repeat this step for each remaining cylinder.

7. Install the rocker arm cover as described in this chapter.

#### Inspection

1. Clean all parts with solvent and use compressed air to blow out the oil passages in the pushrods.
2. Check each rocker arm, fulcrum, bolt and **pushrod** for scuffing, pitting or excessive wear. Replace as necessary.
3. Check **pushrods** for straightness by rolling them across a flat, even surface such as a pane of glass. Replace **pushrods** that do not roll smoothly.

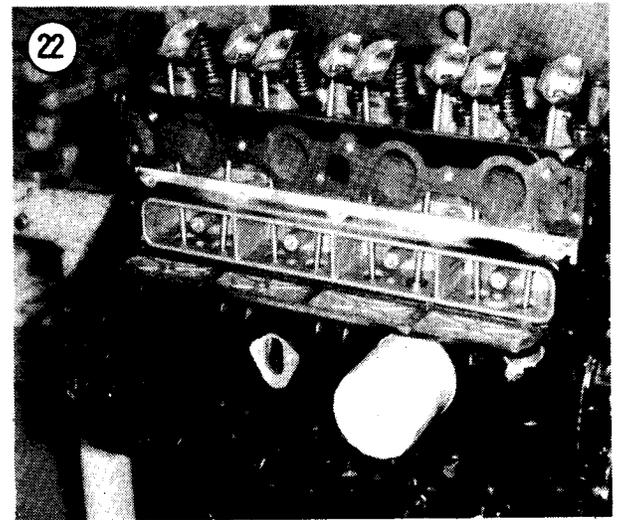
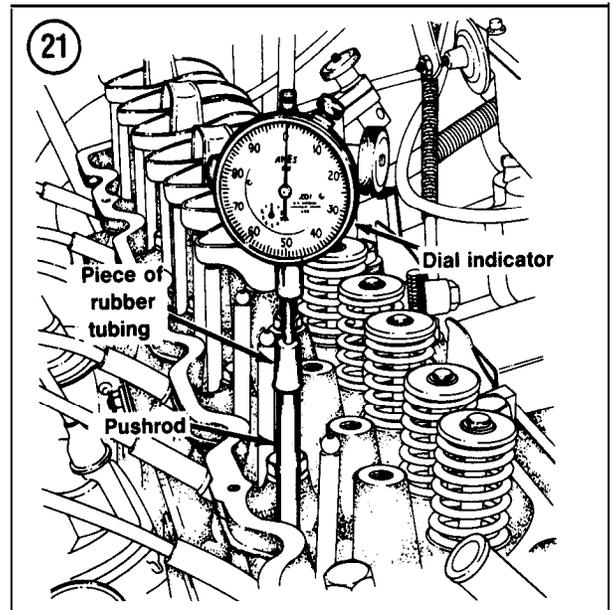
4. If a **pushrod** is worn from lack of lubrication, replace the corresponding lifter and rocker arm as well.

### CAMSHAFT

#### Lube Lift Measurement

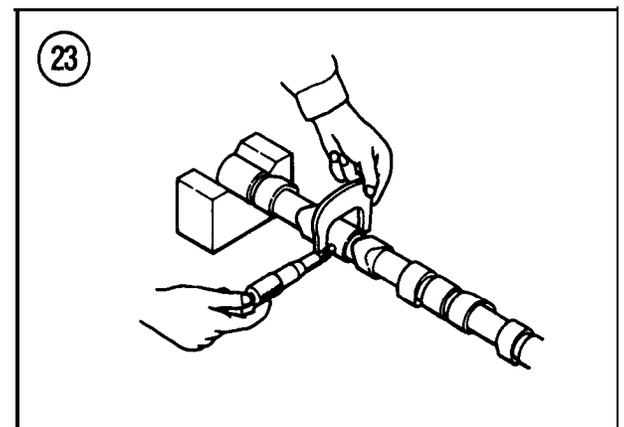
Camshaft lobe lift can be measured with the camshaft in the block and the cylinder head in place. The lifters must be bled down slowly or the readings will be incorrect.

1. Remove the rocker arm covers as described in this chapter.
2. Remove the rocker arm assemblies as described in this chapter.
3. Remove the spark plugs.
4. Install a dial indicator with a ball socket adapter to fit over the **pushrod**. See **Figure 21**.
5. Turn the crankshaft in the normal direction of rotation until the valve lifter seats on the heel of the cam lobe. This positions the **pushrod** at its lowest point.
6. Zero the dial indicator, then slowly rotate the crankshaft until the **pushrod** reaches its maximum travel. Note the indicator reading and compare to specifications (**Table 1** or **Table 2**).
7. Repeat Steps 4-6 for each **pushrod**. If all lobes are within specifications, reinstall the rocker arm assemblies as described in this chapter.
8. If one or more lobes are worn beyond specifications, replace the camshaft as described in this chapter.
9. Remove the dial indicator and reverse Steps 1-3.



#### Removal/Installation

1. Crank the engine over until the No. 1 piston is at the top of its compression stroke. The timing mark on the pulley/damper will align with the TDC mark on the timing chain cover and the distributor rotor terminal will point to the No. 1 spark plug terminal in the distributor cap. Remove the distributor. See Chapter Thirteen.
2. Remove the rocker arm cover as described in this chapter.
3. Remove the front cover as described in this chapter.
4. Remove the fuel pump. See Chapter Eleven.
5. Remove the **pushrod** cover (**Figure 22**) and discard the gasket.



6. Remove the rocker arm assemblies as described in this chapter.
7. Remove the valve lifters and place in a rack or other container in the order removed so they may be reinstalled in their original locations.
8. Remove the timing chain and sprockets as described in this chapter.
9. Remove the camshaft thrust plate.
10. Carefully withdraw the camshaft from the front of the engine to avoid damage to the camshaft bores in the block.
11. Installation is the reverse of removal. Coat the camshaft lobes with Lubriplate or equivalent and the journals with heavy engine oil before reinstalling in the block. Check camshaft end play as described in this chapter.

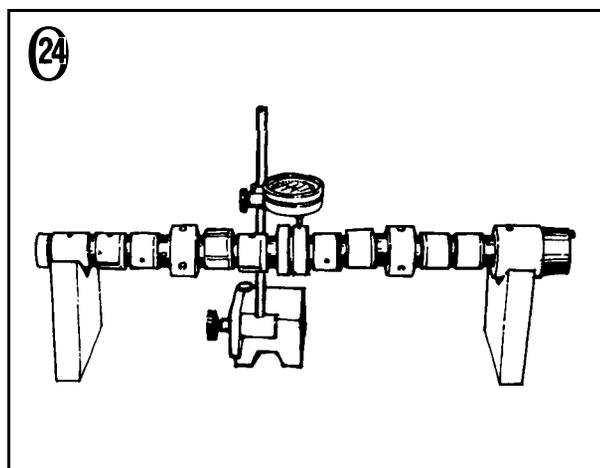
### Inspection

1. Check the journals and lobes for signs of wear or scoring. Lobe pitting in the toe area is not sufficient reason for replacement, unless the lobe lift loss is excessive.
2. Check each valve lifter for signs or wear, pitting or scoring. Replace as required.

### NOTE

*If you do not have precision measuring equipment, have Step 3 done by a machine shop.*

3. Measure the camshaft journal diameters with a micrometer (Figure 23). If any journal exceeds 0.001 in. out-of-round, replace the camshaft.
4. Suspend the camshaft between V-blocks and check for **warpage** with a dial indicator. See Figure 24. Replace if reading is greater than 0.002 in.



5. Check the distributor drive gear for excessive wear or damage.
6. Check camshaft gear and thrust plate for wear or damage.
7. Carefully inspect the seal contact area on the impeller shaft. If any grooves are noted in this area, proceed as follows:
  - a. Early models (impeller secured with a nut)—Replace the impeller shaft.
  - b. Late models (impeller secured with a bolt)—Replace the camshaft assembly.

### End Play Measurement

End play is checked with the sprockets and timing chain installed.

1. Install a dial indicator with its indicator plunger contacting the camshaft gear face.
2. Pry camshaft back and forth using a large screwdriver behind the camshaft gear. Note the dial indicator reading.
3. If end play reading is not within specifications (Table 1 or Table 2), replace the thrust plate.

### Bearing Installation

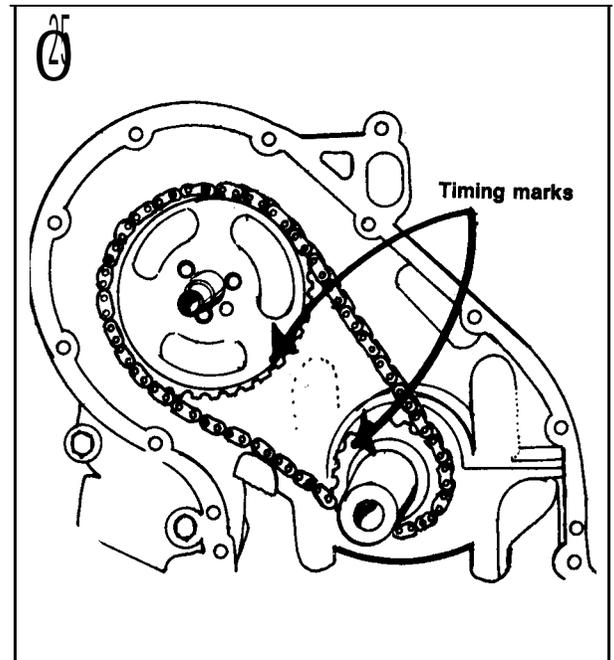
The camshaft rotates directly in its bores in the aluminum cylinder block. Bearings are not normally used but if one or more bore surfaces become scratched or damaged, all bores should be enlarged to 2.2495-2.2510 in. diameter and bearings installed. Bearing installation kit (part No. T65L-6250-A) must be used. Enlarge bore diameters and install bearings according to procedure included with installation kit.

## TIMING CHAIN AND SPROCKETS

### Removal/Installation

1. Remove the front cover as described in this chapter.
2. Rotate the crankshaft clockwise (as seen from front of engine) to take up the slack on the left side of the chain.
3. Pick a convenient reference point on the engine block and measure from that point to the chain.
4. Rotate the crankshaft counterclockwise to take up the slack on the right side of the chain. Force the left side of the chain outward with your fingers, then measure the distance between the reference point and the chain.

5. Subtract the smaller measurement from the larger one. If the difference or deflection exceeds one inch, replace the chain.
6. Now rotate the crankshaft until the sprocket timing marks are aligned. See **Figure 25**.
7. Remove the chain tensioner (A, **Figure 26**).
8. Remove the 3 camshaft sprocket screws (B, **Figure 26**).
9. Pull sprockets and chain forward as an assembly and remove from the camshaft and crankshaft. Disassemble the chain and sprockets.
10. Assemble the chain and sprockets with the sprocket timing marks aligned (**Figure 25**).
11. Install the sprocket/chain assembly to the crankshaft and camshaft. Make sure the timing marks remain aligned, then install the camshaft sprocket screws and tighten to specifications (**Table 3** or **Table 4**).
12. Install chain tensioner, then lubricate chain, tensioner and sprockets with engine oil.
13. Install front cover as described in this chapter.



### Cleaning and Inspection

1. Clean all parts in fresh solvent and blow dry with compressed air, if available.
2. Check chain for worn or broken links.
3. Check sprockets for cracks, scores, nicks or worn or damaged teeth.
4. Check tensioner for excessive wear or damage. If chain deflection is within specifications in Step 5 of *Removal/Installation* but tensioner does not touch the chain, replace the tensioner.
5. Inspect tensioner grooves for excessive wear and replace as required.
6. Place tensioner on a flat surface and measure to the highest point on its top. If not at least 1 1/4 in., replace the tensioner.

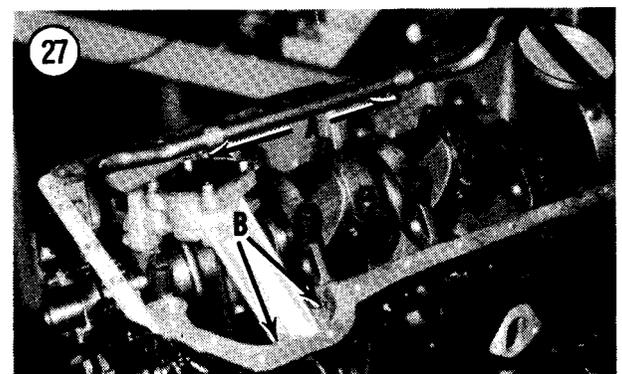
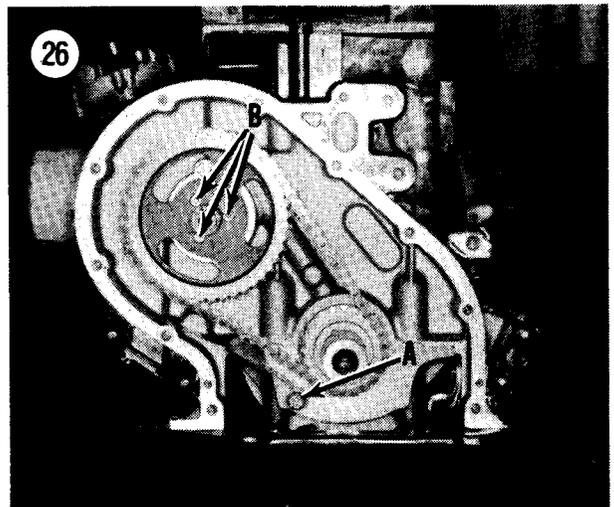
### OIL PAN

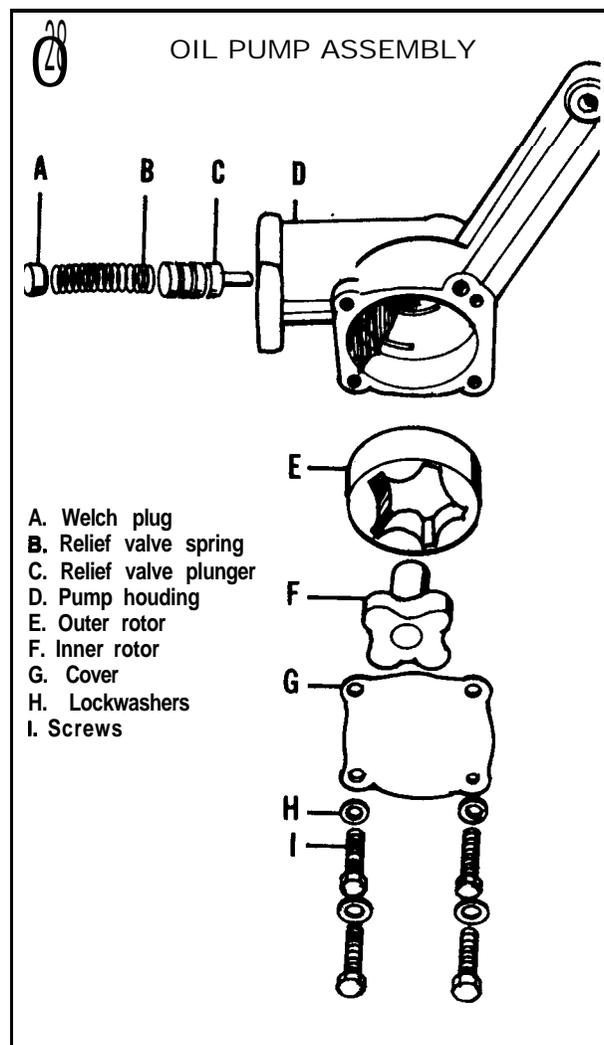
#### Removal

1. Remove the engine as described in this chapter.
2. Place a 6-quart container under the oil pan drain plug. Remove the plug and let the crankcase drain.

#### NOTE

*A modification kit is available from marine dealers to assist in draining the oil when the engine is in the boat. This kit can be installed on any engine oil pan when the engine is removed for service.*





3. Unscrew the oil dipstick tube fitting at the oil pan. Remove the dipstick tube retaining clamp at the block. Remove the dipstick tube.
4. If mounted in an engine stand, rotate the engine 180° to place the oil pan in an upright position.
5. Remove the oil pan attaching capscrews and washers. Remove the oil pan.
6. Remove and discard the oil pan gasket and the rear main cap seals.

### Inspection

1. Remove all gasket residue from the oil pan flanges and crankcase side rails with degreaser and a putty knife.
2. Clean the pan thoroughly in solvent.
3. Check the pan for dents or warped gasket surfaces. Straighten or replace the pan as necessary.

### Installation

1. Install the rear seals on the rear main bearing cap.
2. Coat the block side rails and oil pan flange with Perfect Seal (part No. C-92-34227) or equivalent. Apply additional sealer on rear main cap seals and area where timing cover mates with block.
3. Position a new gasket on the cylinder block gasket surface.
4. Carefully place the oil pan in position. Make sure the gasket and seals are not misaligned and install a pan attaching capscrew with washer finger-tight on each side of the block.
5. Install the remaining capscrews with washers and tighten all to specifications (Table 3 or Table 4). Work from the center outward in each direction. When all pan capscrews are tightened, retorquer a second time.
6. Install the engine in the boat as described in this chapter and fill the crankcase with oil recommended in Chapter Four.

## OIL PUMP

### Removal/Installation

1. Remove the oil pan as described in this chapter.
2. Remove the nut and stud/nut holding the oil pump pickup brackets in place (A, Figure 27).
3. Remove the oil pump attaching bolts (B, Figure 27). Remove the oil pump.
4. To install, align the pump gear shaft slot with the distributor drive shaft.
5. Install pump to block. Tighten pump and bracket attaching bolts to specifications (Table 3 or Table 4).
6. Install the oil pan as described in this chapter.

### Disassembly/Assembly

Refer to Figure 28 for this procedure.

1. Remove the 2 bolts holding the pickup tube to the pump body. Remove the pickup tube, retaining flange and O-ring.
2. Remove the cover screws, lockwashers, cover and gasket. Discard the gasket.
3. Remove inner and outer rotors from the body.
4. Remove pressure regulator welch plug, spring and valve.
5. Oil all parts thoroughly before reassembly.
6. Assembly is the reverse of disassembly. Index gear identification marks, install a new cover gasket and rotate pump drive shaft by hand to check for smooth operation.

### Inspection

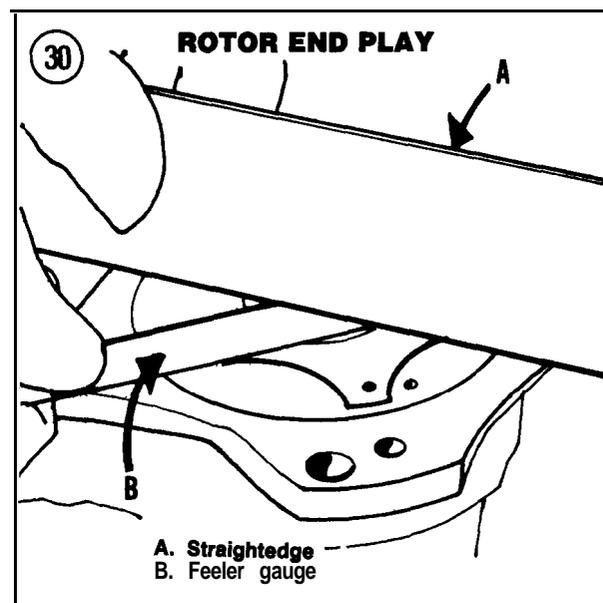
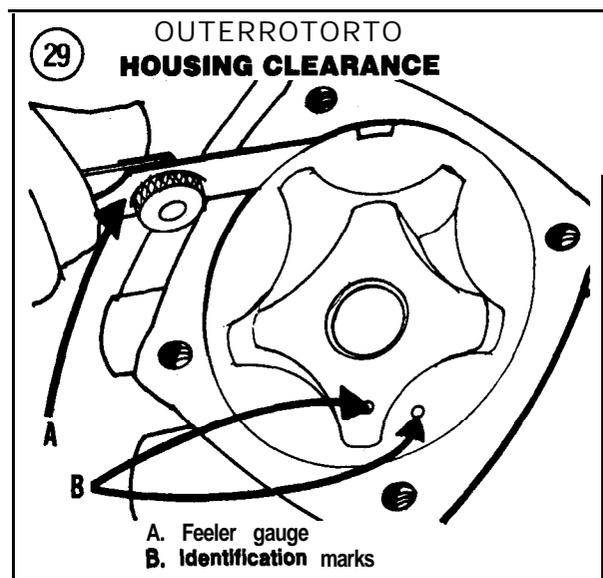
1. Clean all parts thoroughly in solvent. Brush the inside of the body and the pressure regulator chamber to remove all dirt and metal particles. Dry with compressed air, if available.
2. Check the pump body and cover for cracks or excessive wear.
3. Check the pressure regulator valve for a proper fit.
4. Check the pump gears for damage or signs of excessive wear.
5. Check the drive gear shaft-to-body fit for excessive looseness.
6. Check the inside of the pump cover for wear that could allow oil to leak around the ends of the gears.
7. Install inner and outer rotors in pump body. Measure outer rotor race to housing clearance (**Figure 29**). Replace the pump body if the clearance exceeds 0.0125 in.
8. Place a straightedge across the pump rotors and measure any gap with a feeler gauge (**Figure 30**). If clearance exceeds 0.005 in., replace the pump body.

### CYLINDER HEAD

#### Removal

Perform Steps 1-8 if engine is in boat. If engine has been removed from boat, begin with Step 9.

1. Remove the intake and exhaust manifolds as described in this chapter.
2. Open the engine block drain valve(s) and allow the water to drain.
3. Disconnect the fuel line support clamps. Remove the fuel line.
4. Disconnect the cooling hoses at the water distribution housing.
5. Disconnect the temperature sending lead and remove the water distribution housing.
6. Disconnect and remove ignition coil.
7. Remove circuit breaker bracket and engine lifting eye.
8. Disconnect all spark plug cables. Remove the spark plugs.
9. Remove the rocker arm cover as described in this chapter.
10. Loosen the rocker arms and rotate them to one side. Remove the **pushrods** and identify each for reinstallation in their original position.
11. Loosen the cylinder head bolts, working from the center of the head to the end in each direction.



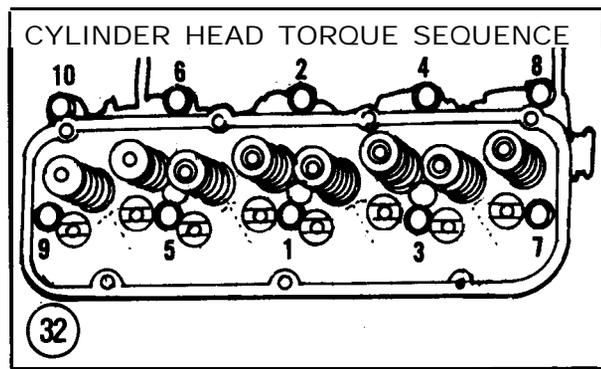
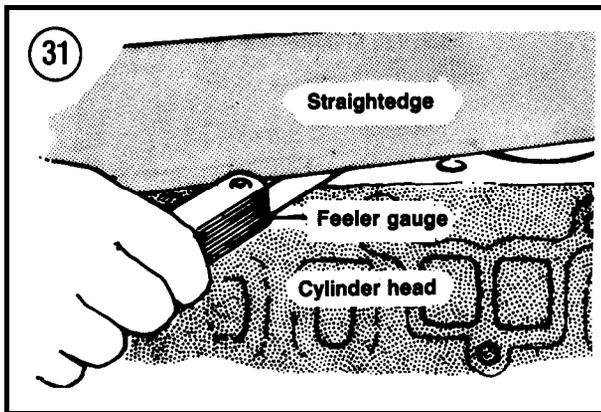
12. Remove the head bolts. Tap the end of the head with a plastic hammer to break the gasket seal. Remove the head from the engine.

#### CAUTION

*Place the head on its side to prevent damage to the spark plugs or head gasket surface.*

13. Remove and discard the head gasket.
- #### Decarbonizing

1. Without removing the valves, remove all deposits from the combustion chambers, intake



ports and exhaust ports. Use a fine wire brush dipped in solvent or make a scraper from hardwood. Be careful not to scratch or gouge the combustion chambers.

2. After all carbon is removed from the combustion chambers and ports, clean the entire head in solvent.
3. Clean away all carbon on the piston tops. Do not remove the carbon ridge at the top of the cylinder bore.
4. Remove the valves as described in this chapter.
5. Clean the **pushrod** guides, valve guide bores and all bolt holes. Use a cleaning solvent to remove dirt and grease.
6. Clean the valves with a fine wire brush or buffing wheel.

#### Inspection

1. Check the cylinder head for signs of oil or water leaks before cleaning.
2. Clean the cylinder head thoroughly in solvent. While cleaning, look for cracks or other visible signs of damage. Look for corrosion or foreign material in the oil and water passages. Clean the

passages with a stiff spiral brush, then blow them out with compressed air.

3. Check the cylinder head studs for damage and replace, if necessary.
4. Check the threaded rocker arm bolt holes for damaged threads. Replace if necessary.
5. Check the cylinder head-to-block surface for **warpage** with a straightedge and feeler gauge (Figure 31). Compare to specifications (Table 1 or Table 2). If gap exceeds specifications, have the head resurfaced by a dealer or a machine shop.

#### CAUTION

*If head resurfacing is required, do not remove more than 0.010 in. Replace the head if a greater amount must be removed to correct warpage.*

#### Installation

1. Make sure the cylinder head and block gasket surfaces and bolt holes are clean. Dirt in the block bolt holes or on the head bolt threads will affect tightening torque.
2. Recheck all visible oil and water passages for cleanliness.

#### CAUTION

*Do not use steel automotive-type gaskets. Use only MerCap replacement head gaskets in Step 3.*

3. Fit a new MerCap head gasket on the cylinder block. The stamped word FRONT should face the block and be toward the front of the engine.
4. Install the cylinder head to the block. Wipe the head bolt threads with Perfect Seal (part No. C-92-34227) and install finger-tight.
5. Tighten head bolts to 55 ft.-lb. one at a time following the sequence shown in Figure 32.
6. Repeat Step 5 to tighten head bolts to 90 ft.-lb., then to 130 ft.-lb.

#### CAUTION

*Retorque head bolts to 130 ft.-lb. after engine has reached its maximum operating temperature when reinstalled in the boat. This will prevent possible poor engine performance, a blown head gasket, burned valves and other engine problems.*

7. If engine is in boat, reverse Steps 1-10 of **Removal** in this chapter. If engine is out of boat, reverse Step 9 and Step 10 of **Removal** to complete installation.

### VALVES AND VALVE SEATS

Some of the following procedures must be done by a dealer or machine shop, since they require special knowledge and expensive machine tools. Others, while possible for the home mechanic, are difficult or time-consuming. A general practice among those who do their own service is to remove the cylinder head, perform all disassembly except valve removal, then take the head to a machine shop for inspection and service. Since the cost is low relative to the required effort and equipment, this is usually the best approach, even for experienced mechanics. The following procedures are given to acquaint the home mechanic with what the dealer or machine shop will do.

#### Valve Removal

Refer to **Figure 33** for this procedure.

1. Remove the cylinder head as described in this chapter.
2. Remove the rocker arm assemblies as described in this chapter.
3. Compress the valve spring with a compressor tool like the one shown in **Figure 34**. Remove the retainer locks and release the spring tension.
4. Remove the valve spring retainer, spring and seal. Discard the seal.

#### CAUTION

*Remove any burrs from the valve stem lock grooves before removing the valves or the valve guides will be damaged.*

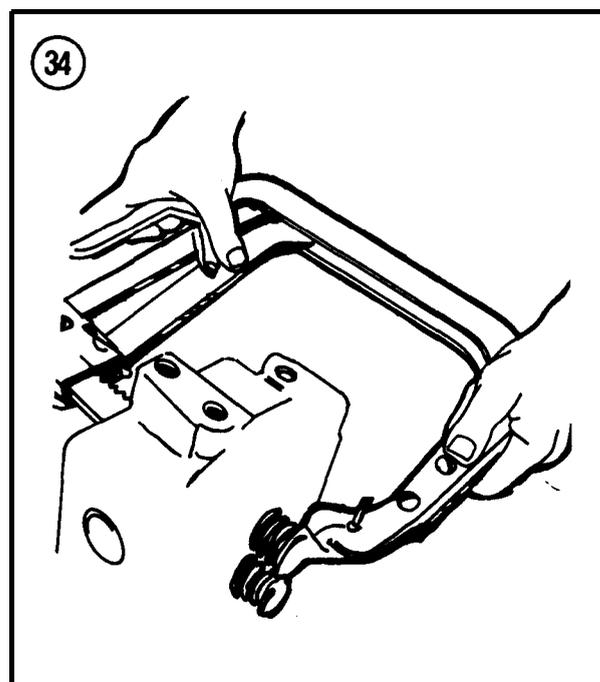
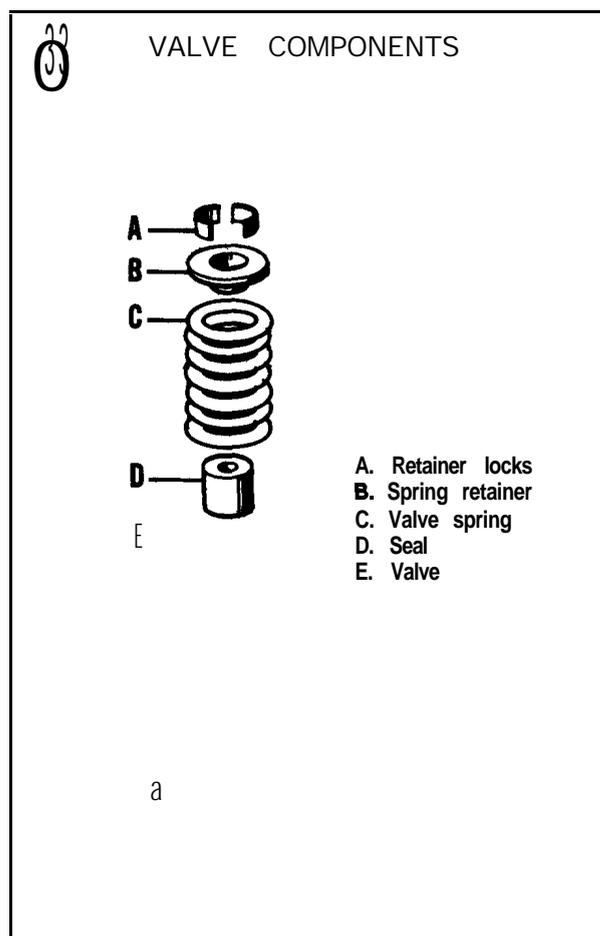
5. Remove the valve and repeat Step 3 and Step 4 on each remaining valve.
6. Arrange the parts in order so they can be returned to their original positions when reassembled.

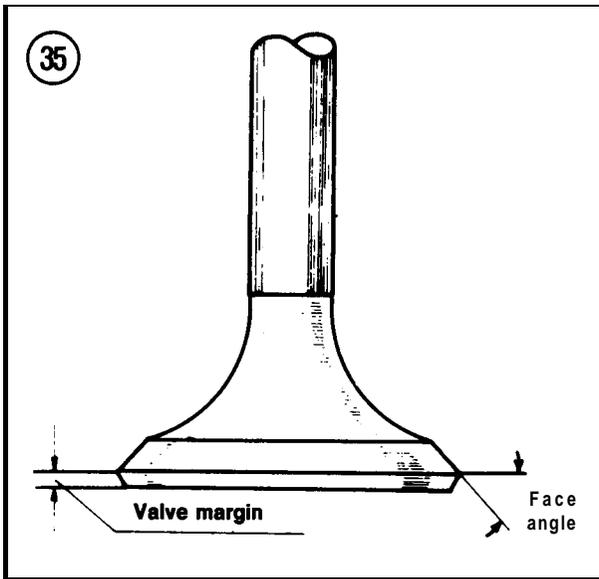
#### Inspection

1. Clean the valves with a fine wire brush or buffing wheel. Discard any cracked, warped or burned valves.
2. Measure valve stems at the top, center and bottom for wear. A machine shop can do this when the valves are ground. Also measure the length of each valve and the diameter of each valve head.

#### NOTE

*Check the thickness of the valve edge or margin after the valves have been ground. See **Figure 35**.*





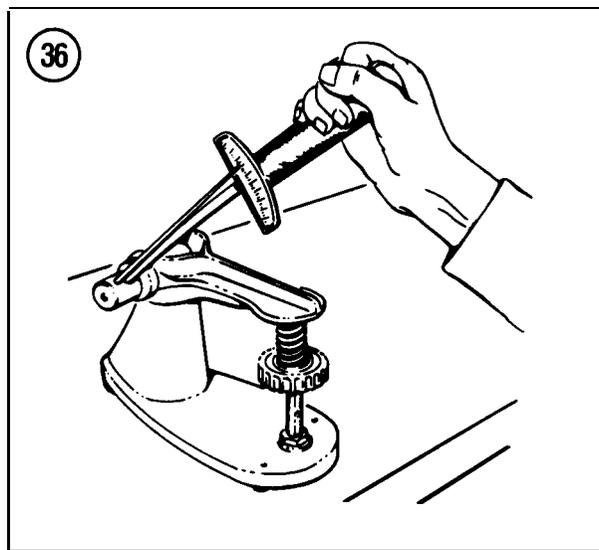
Any valve with a margin of less than 1/32 in. should be discarded.

3. Remove all carbon and varnish from the valve guides with a stiff spiral wire brush.

**NOTE**

The next step assumes that all valve stems have been measured and are within specifications. Replace valves with worn stems before performing this step.

4. Insert each valve into the guide from which it was removed. Holding the valve just slightly off its seat, rock it back and forth in a direction parallel with the rocker arms. This is the direction in which the greatest wear normally occurs. If the valve stem rocks more than slightly, the valve guide is probably worn.

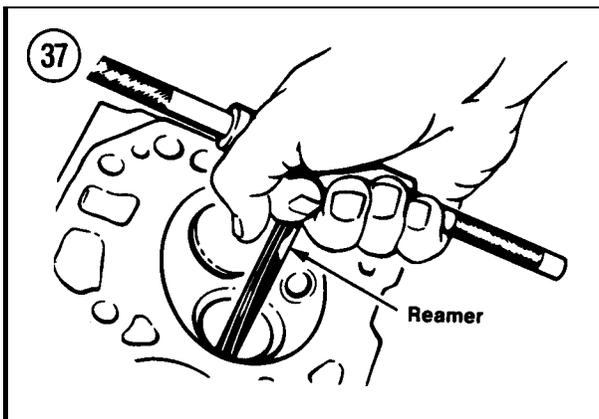


5. If there is any doubt about valve guide condition after performing Step 4, have the valve guide measured with a valve stem clearance checking tool. Compare the results to specifications (Table 1 or Table 2) according to engine. Worn guide must be reamed for the next oversize valve stem.

6. Test the valve springs under load on a spring tester (Figure 36). Replace any weak springs.
7. Check each spring on a flat surface with a steel square. Slowly revolve spring 360° and note the space between the top of the coil and the square. If it exceeds 5/16 in. at any point, replace the spring.
8. Inspect the valve seat inserts. If worn or burned, they must be reconditioned. This is a job for a dealer or machine shop, although the procedure is described in this chapter.

**Valve Guide Reaming**

Worn valve guides must be reamed to accept a valve with an oversize stem. Reaming must be done by hand (Figure 37) and is a job best left to an experienced machine shop. The valve seat must be refaced after the guide has been reamed.



**Valve Seat Reconditioning**

1. Cut the valve seats to the specified angle (Table 1 or Table 2) with a dressing stone. Remove only enough metal to obtain a good finish.
2. Use tapered stones to obtain the specified seat width when necessary.
3. Coat the corresponding valve face with Prussian blue dye.

4. Insert the valve into the valve guide.
5. Apply light pressure to the valve and rotate it approximately 1/4 turn.
6. Lift the valve out. If it seats properly, the dye will transfer evenly to the valve face.
7. If the dye transfers to the top of the valve face, lower the seat. If it transfers to the bottom of the valve face, raise the seat.

### Valve Installation

#### NOTE

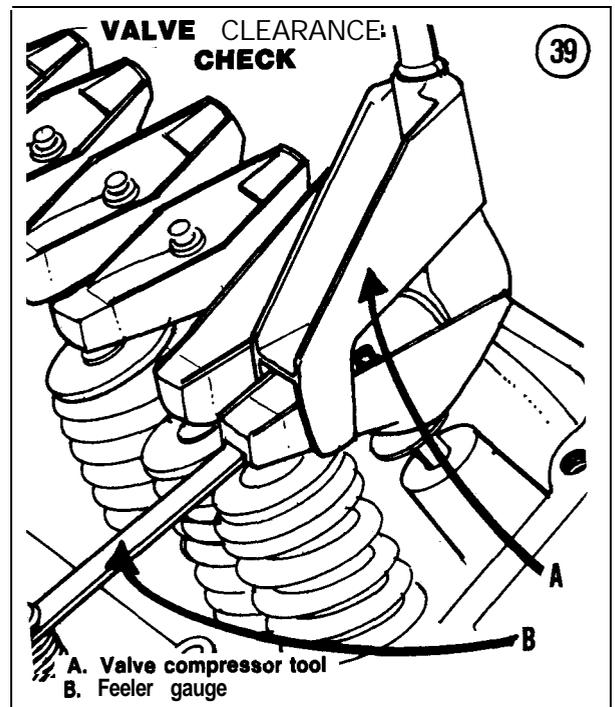
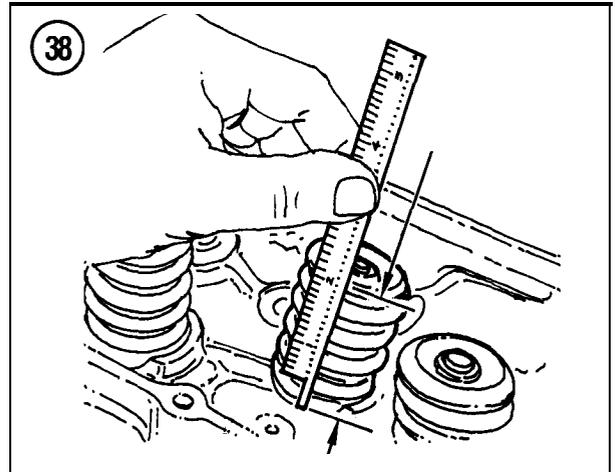
*Install all parts in the same positions from which they were removed.*

1. Lubricate the valve stems and guides with Quicksilver Engine Oil Supplement (part No. C-92-33365- 1).
2. Install each valve in the port from which it was removed.
3. Install new oil seals on each valve stem.
4. Install the valve spring over the valve, then install the spring retainer.
5. Compress the spring and install the locks. Make sure both locks seat properly in the upper groove of the valve stem.
6. Measure the installed spring height between the top of the valve seat and the underside of the spring retainer. See **Figure 38**. If height is greater than specifications (**Table 1** or **Table 2**), install an extra spring shim seat about 1/16 in. thick and remeasure the height.

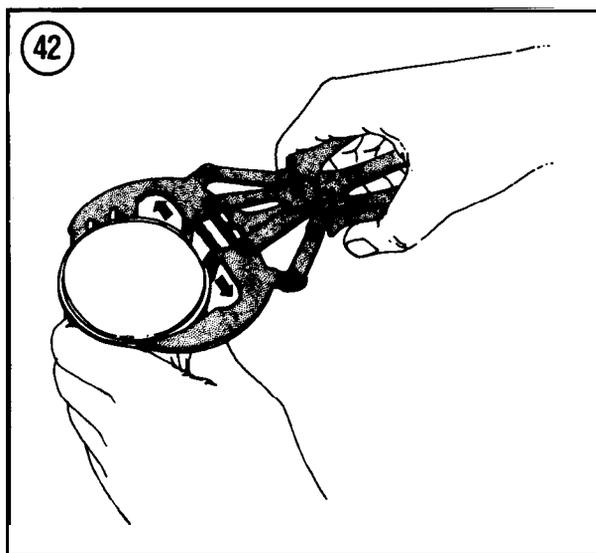
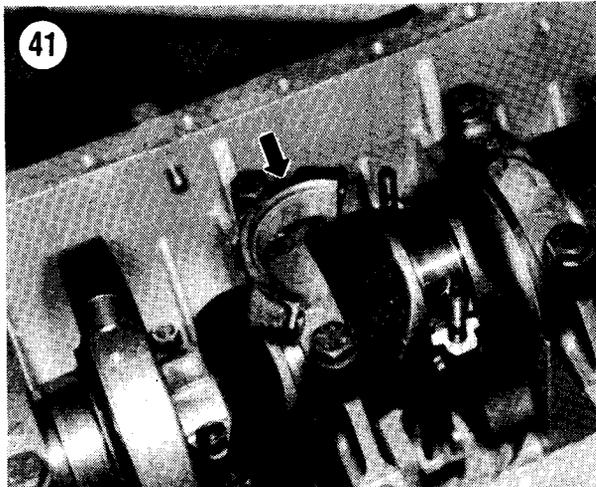
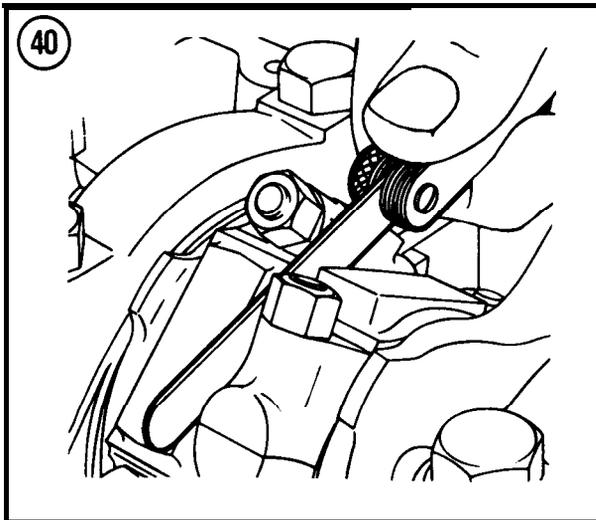
### Valve Clearance

Clearance should be checked whenever the valve face/seat is ground, valve stem is ground, head and/or block surface is milled or valve train becomes noisy. Valves are not adjustable but proper clearance can be maintained by installing the appropriate length **pushrod**. Use the following procedure to determine if **pushrod** replacement is necessary.

1. Remove rocker arm cover as described in this chapter.
2. Rotate the crankshaft until the pulley notch aligns with the zero mark on the timing tab. This positions the No. 1 cylinder at TDC. This position can be verified by placing a finger on the No. 1 rocker arms as the pulley notch nears the zero mark. If the valves are moving, the engine is in the No. 4 firing position. Rotate the crankshaft pulley one full turn to reach the No. 1 firing position.



3. With the valve fully closed and lifter completely collapsed, install special tool part No. T71 1P-6513A as shown in **Figure 39**. Check clearance between valve stem and rocker arm with a feeler gauge and compare to specifications (**Table 1** or **Table 2**).
4. If clearance is not within specifications, check for worn valve train components. If worn components are not present, install a **pushrod** of the length required to bring valve clearance within specifications. See your dealer for **pushrod** selection.



## PISTON/CONNECTING ROD ASSEMBLY

### Piston Removal

1. Remove the engine as described in this chapter.
2. Place a 6-quart container under the oil pan and remove the drain plug. Let the crankcase oil drain.
3. Remove the intake and exhaust manifolds as described in this chapter.
4. Remove the cylinder head as described in this chapter.
5. Remove the oil pan and oil pump as described in this chapter.
6. Remove the flywheel housing, coupler and flywheel as described in this chapter.
7. Pack the cylinder bore with clean shop rags. Remove the carbon ridge at the top of the cylinder bore with a ridge reamer. These can be rented for use. Vacuum out the shavings, then remove the shop rags. Repeat this step for each cylinder.
8. Rotate the crankshaft so the connecting rod is centered in the cylinder bore.
9. Measure the clearance between each connecting rod and the crankshaft journal flange with a feeler gauge (Figure 40). If the clearance exceeds specifications (Table 1 or Table 2), replace the connecting rod during reassembly.
10. Remove the nuts holding the connecting rod cap. Lift off the cap, together with the lower bearing insert (Figure 41).

#### NOTE

*If the connecting rod caps are difficult to remove, tap the studs with a wooden hammer handle.*

11. Use a wooden hammer handle to push the piston and connecting rod from the bore.

#### NOTE

*Mark the cylinder number on the top of each piston with quick-drying paint. Check for cylinder numbers or identification marks on the connecting rod and cap. If they are not visible, make your own.*

12. Remove the piston rings with a ring remover (Figure 42).

### Piston Pin Removal/Installation

The piston pins are press-fitted to the connecting rods and hand-fitted to the pistons. Removal requires the use of a press and support stand. This

is a job for a dealer or machine shop equipped to fit the pistons to the pins, ream the pin bushings to the correct diameter and install the pistons and pins on the connecting rods.

### Piston Clearance Check

Unless you have precision measuring equipment and know how to use it properly, have this procedure done by a machine shop.

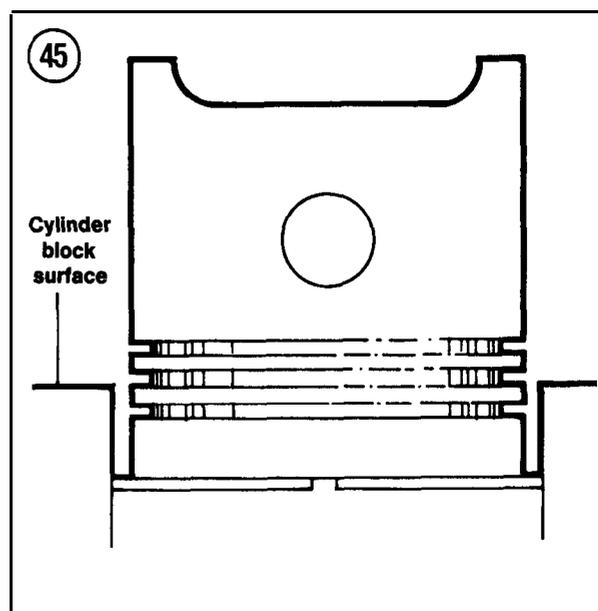
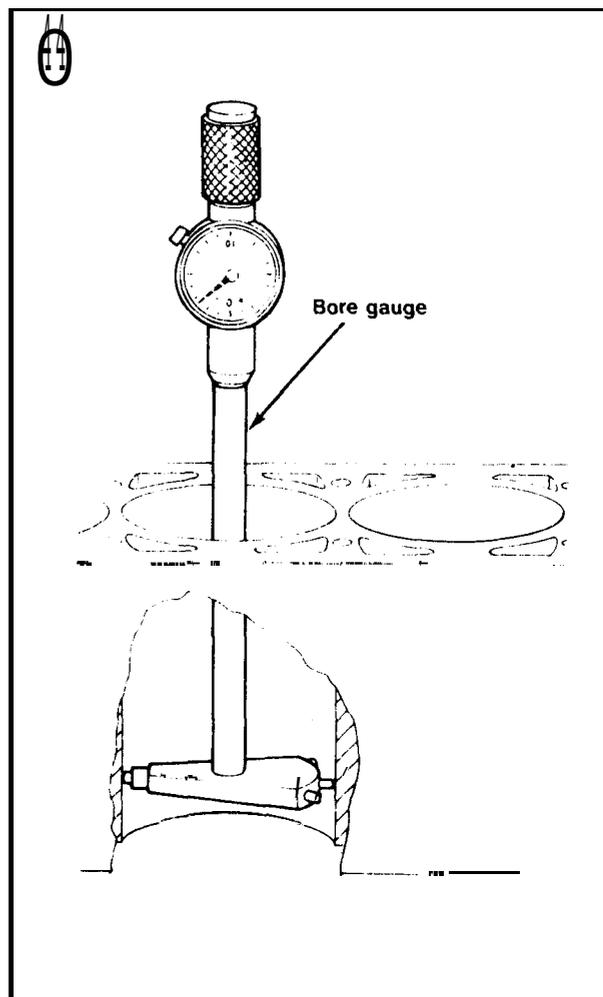
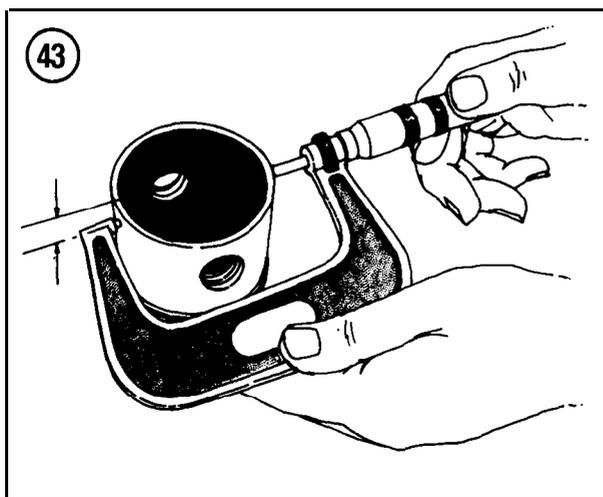
1. Measure the piston diameter with a micrometer (**Figure 43**). Measure just below the rings at right angles to the piston pin bore.
2. Measure the cylinder bore diameter with a bore gauge (**Figure 44**). Measure at the top, center and bottom of the bore, in front-to-rear and side-to-side directions.
3. Subtract the piston diameter from the largest cylinder bore reading. If the difference exceeds specifications (**Table 1** or **Table 2**), the cylinder must be rebored and oversized pistons installed.

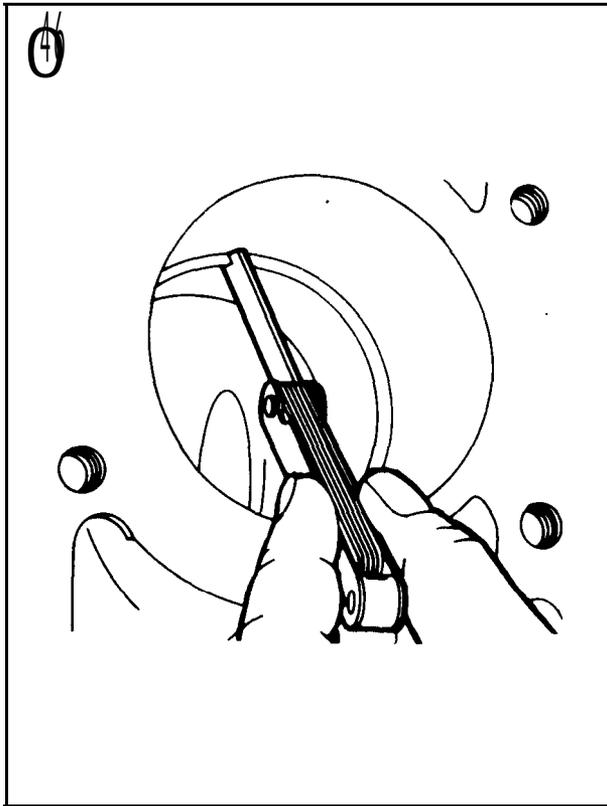
### Piston Ring Fit/Installation

1. Check the ring gap of each piston ring. To do this, position the ring at the bottom of the ring travel area and square it by tapping gently with an inverted piston. See **Figure 45**.

#### NOTE

*If the cylinders have not been rebored, check the gap at the bottom of the ring travel, where the cylinder is least worn.*





2. Measure the ring gap with a feeler gauge as shown in **Figure 46**. Compare with specifications. If the measurement is not within specifications (**Table 1** or **Table 2**), replace the rings as a set.

3. Check the side clearance of the compression rings as shown in **Figure 47**. Place the feeler gauge alongside the ring all the way into the groove. If the measurement is not within specifications (**Table 1** or **Table 2**), either the rings or ring grooves are worn. Inspect and replace as necessary.

4. Using a ring expander tool (**Figure 48**), carefully install the oil control ring, then the compression rings.

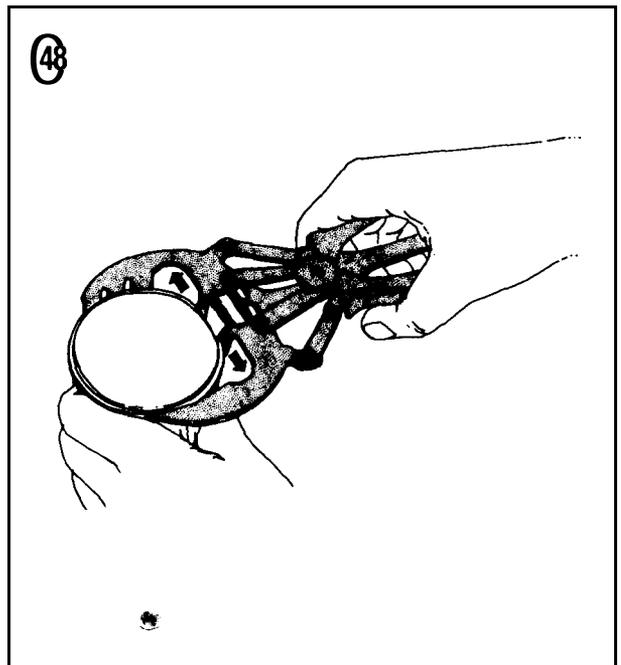
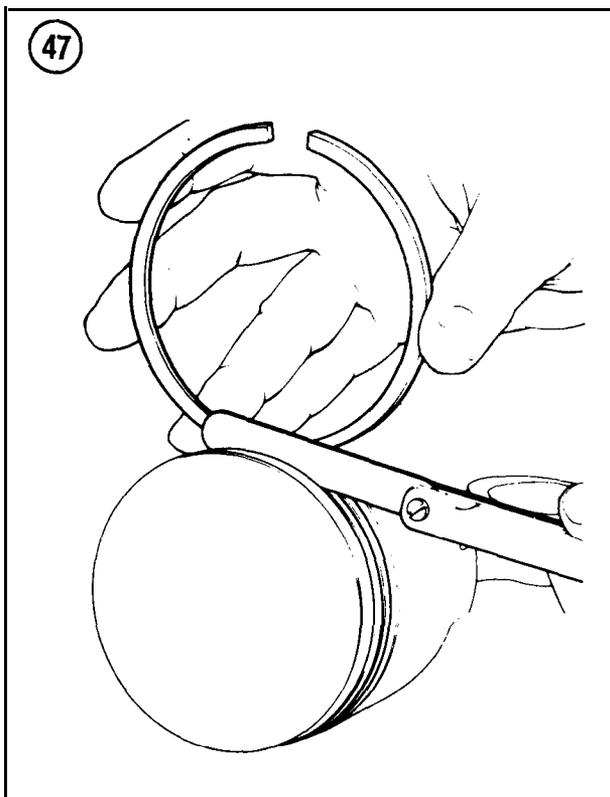
**NOTE**

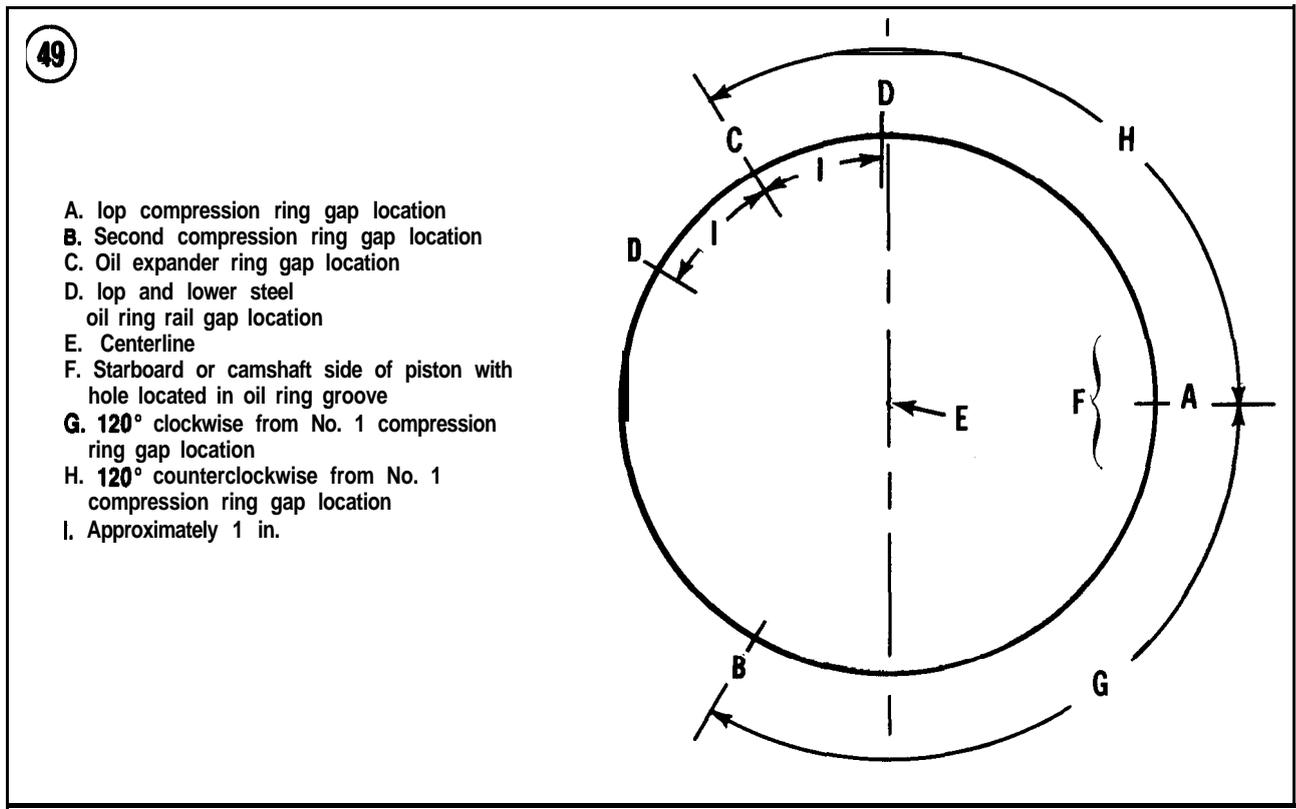
*Oil rings consist of 3 segments. The wavy segment goes between the flat segments to act as a spacer. Upper and lower flat segments are interchangeable.*

5. Position the ring gaps as shown in **Figure 49**.

**Connecting Rod Inspection**

Have the connecting rods checked for straightness by a dealer or machine shop. Connecting rods can spring out of alignment during shipping or handling. When installing new connecting rods, have them checked for misalignment before installing the piston and piston pin.





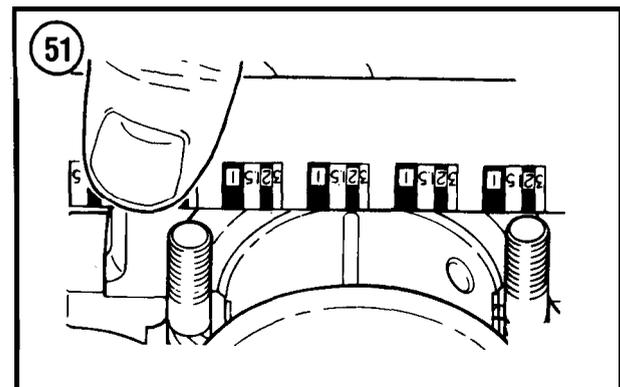
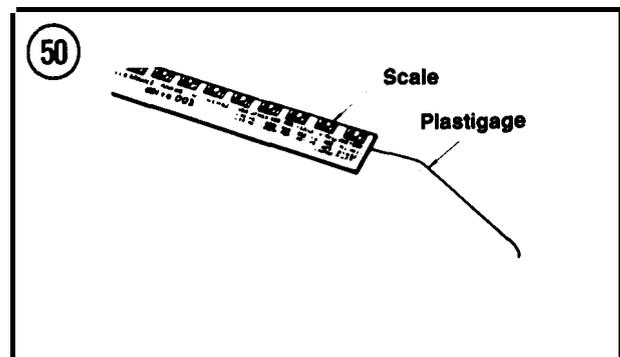
### Connecting Rod Bearing Clearance Measurement

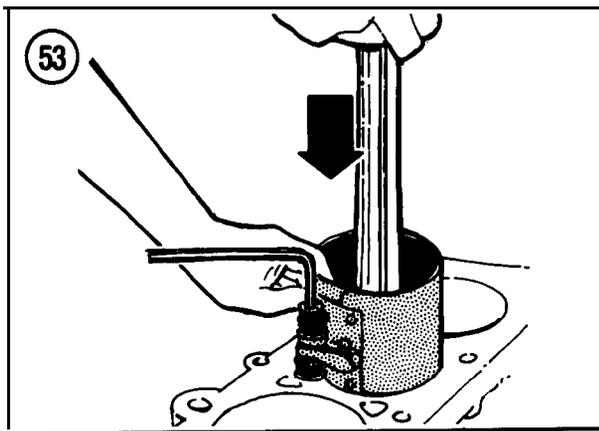
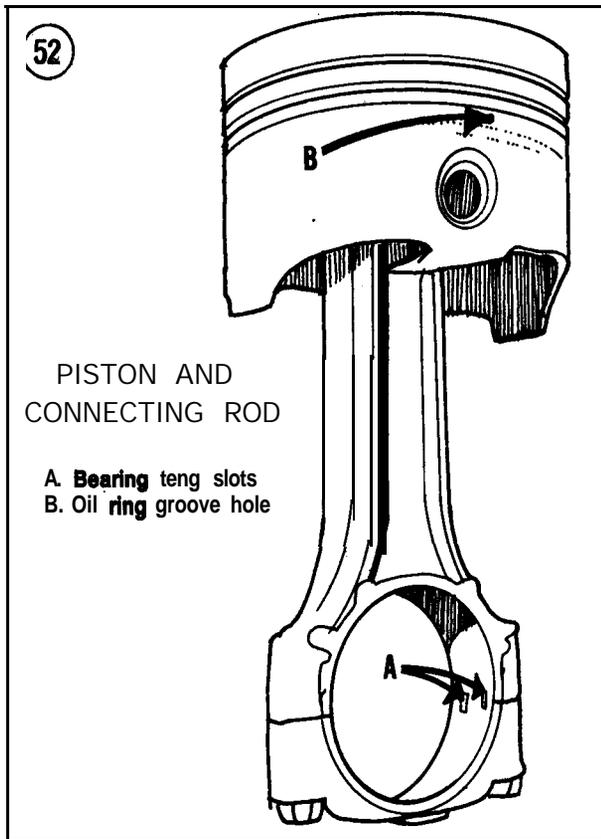
1. Place the connecting rods and upper bearing halves on the proper connecting rod journals.
2. Cut a piece of Plastigage the width of the bearing (Figure 50). Place the Plastigage on the journal, then install the lower bearing half and cap.

#### NOTE

*Do not place Plastigage over the journal oil hole.*

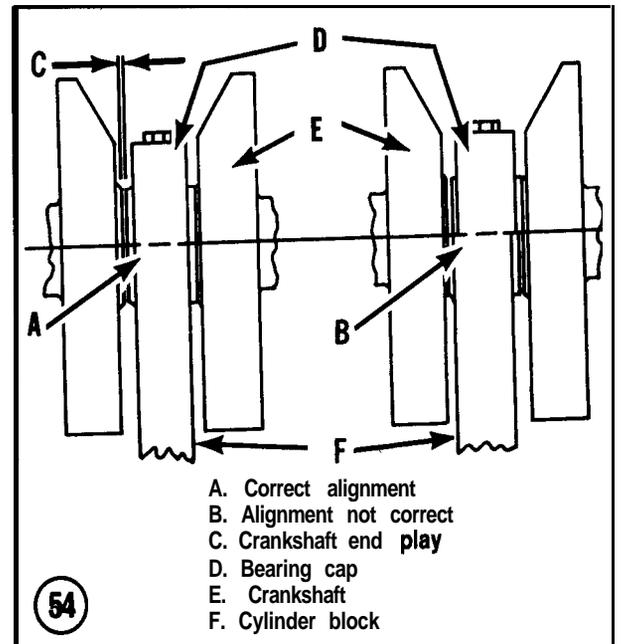
3. Tighten the connecting rod cap to specifications (Table 3 or Table 4). Do not rotate the crankshaft while the Plastigage is in place.
4. Remove the connecting rod cap. Bearing clearance is determined by comparing the width of the flattened Plastigage to the markings on the envelope. See Figure 51. If the clearance is excessive, the crankshaft must be reground and undersize bearings installed.





**Installing Piston/Connecting Rod Assemblies**

1. Make sure the pistons are correctly installed on the connecting rods. The rod bearing tangs should be on the same side as the hole in the piston oil ring groove. See Figure 52.
2. Make sure the ring gaps are positioned as shown in Figure 49.



3. Slip short pieces of hose over the connecting rod studs to keep them from nicking the crankshaft. Tape will work if you do not have the right diameter hose, but it is more difficult to remove.
4. Immerse the entire piston in clean engine oil. Coat the cylinder wall with oil.
5. Install the piston/connecting rod assembly in its cylinder as shown in Figure 53. Make sure the number painted on the top of the piston before removal corresponds to the cylinder number.
6. Clean the connecting rod bearings carefully, including the back sides. Coat the journals and bearings with clean engine oil. Place the bearings in the connecting rod and cap.
7. Remove the protective hose or tape and install the connecting rod cap (Figure 41). Make sure the rod and cap marks align. Tighten the cap nuts to specifications (Table 3 or Table 4).
8. Check the connecting rod big-end play as described under *Piston Removal*.

**CRANKSHAFT**

**End Play Measurement**

1. Pry the crankshaft to the front of the engine with a large screwdriver.
2. Measure the crankshaft end play between the front of the No. 3 main bearing and the crankshaft thrust surface with a feeler gauge. See Figure 54. Compare to specifications (Table 1 or Table 2).

3. If end play is excessive, replace the No. 3 main bearing. If less than specified, check the bearing faces for imperfections.

### Removal

1. Remove the engine as described in this chapter.
2. Remove the flywheel housing, coupler and flywheel as described in this chapter.
3. Mount the engine on an engine stand, if available.
4. Invert the engine to bring the oil pan to an upright position.
5. Remove the oil pan and oil pump as described in this chapter.
6. Remove the front cover and timing chain as described in this chapter.
7. Remove the spark plugs to permit easy rotation of the crankshaft.
8. Check rod caps for cylinder number identification. Mark caps, if necessary.
9. Rotate the crankshaft to position one connecting rod at the bottom of its stroke.
10. Remove the connecting rod bearing cap and bearing (A, **Figure 55**). Move the piston/rod assembly away from the crankshaft.
11. Repeat Step 9 and Step 10 for each piston/rod assembly.
12. Unbolt the main bearing caps (B, **Figure 55**) and remove with bearing inserts.

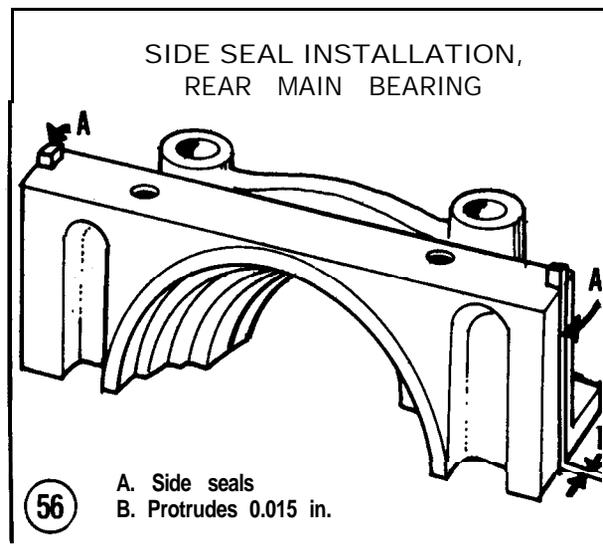
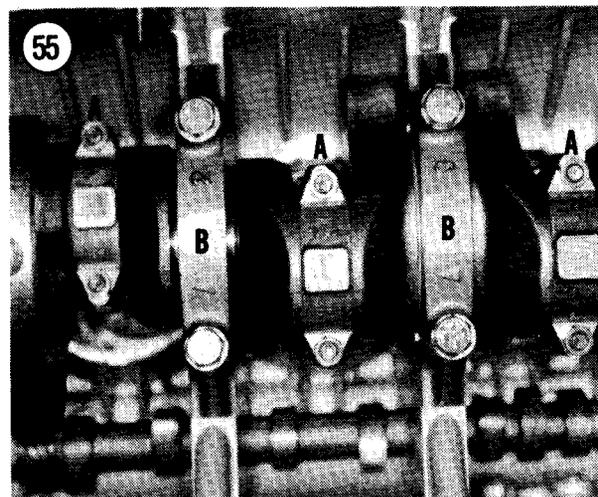
#### NOTE

*If the caps are difficult to remove, lift the bolts partway out, then pry the caps from side to side.*

13. Check the caps for identification numbers or marks. If none are visible, clean the caps with a wire brush. If marks still cannot be seen, make your own with quick-drying paint.
14. Carefully lift the crankshaft from the engine block. Lay the crankshaft, main bearings and bearing caps in order on a clean workbench.
15. Remove the main bearing oil seal from the cylinder block and rear bearing cap.

### Inspection

1. Clean the crankshaft thoroughly with solvent. Blow out the oil passages with compressed air.
2. Check the main and connecting rod journals for scratches, grooves, scoring or cracks. Check oil seal surface for burrs, nicks or other sharp edges which might damage a seal during installation.



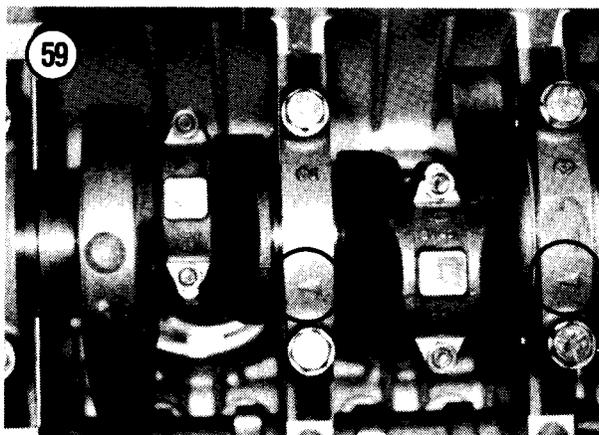
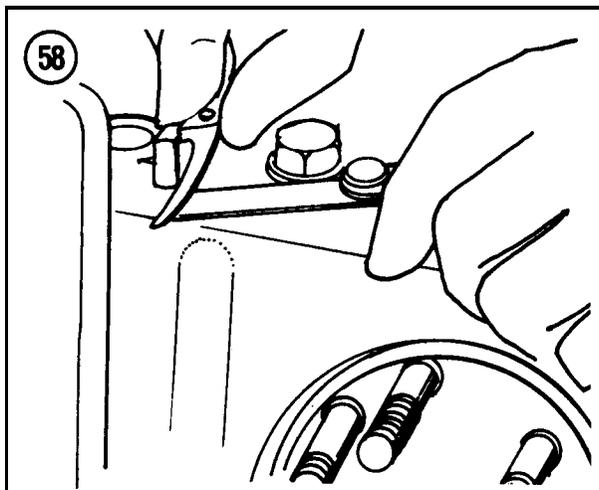
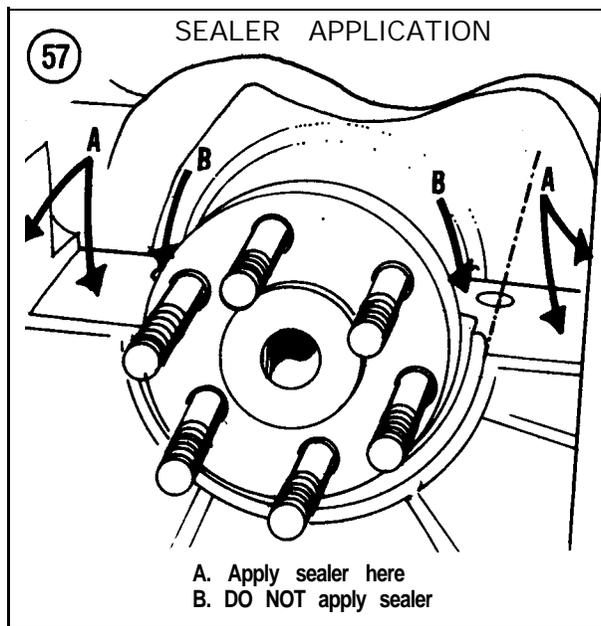
#### NOTE

*If you do not have precision measuring equipment and know how to use it, have a machine shop perform Step 3.*

3. Check all journals and crankpins against specifications for out-of-roundness and taper. If necessary, have the crankshaft reground and install new undersize bearings.

### Main Bearing Clearance Measurement

Main bearing clearance is measured with Plastigage in the same manner as connecting rod bearing clearance, described in this chapter. Excessive clearance requires that the bearings be replaced, the crankshaft be reground or both.



### Installation

1. Install the main bearing inserts in the bores with their tabs engaging the slots provided in the block.
2. Install the main bearing inserts in the bearing caps. Insert tabs must engage slots in caps.
3. Carefully lower the crankshaft into position in the block.
4. Slightly stretch new rear main bearing side oil seal and install in groove at each side of rear main cap, with seal end protruding 0.015 in. from block side of cap. See Figure 56.

### NOTE

*Do not apply Perfect Seal beyond centerline of bolt holes toward crankshaft in Step 5. See Figure 57.*

5. Apply Perfect Seal (part No. C-92-34227) to area on cylinder block where rear main cap fits, as shown in Figure 57.
6. Apply Perfect Seal to outside face of side seals on rear main cap.
7. Install rear cap, making sure that the side seal does not move upward in the cap groove. When cap is fully installed, the end of the seal should still protrude from the block side of the cap.
8. Install cap bolts and tighten to specifications (Table 3 or Table 4).
9. Using a 0.015 in. feeler gauge as shown in Figure 58, cut each side seal so it will protrude 0.015 in. above the bottom of the cap.
10. Install main bearing caps with their arrows pointing toward the front of the engine. See Figure 59.
11. Tighten all except the No. 3 bearing cap to specifications (Table 3 or Table 4).
12. Pry crankshaft toward front of engine, then toward the rear to align the thrust bearing and crankshaft thrust surfaces.
13. Torque No. 3 bearing cap to specifications (Table 3 or Table 4).
14. Measure crankshaft end play as described in this chapter.
15. Reverse Steps 1-10 of *Removal* in this chapter.

### FLYWHEEL HOUSING, COUPLER AND FLYWHEEL

#### Removal/Installation

1. Remove the engine as described in this chapter.
2. Remove attaching parts from flywheel housing. Remove the housing.

3. Remove the coupler retaining nuts and washers. Remove the coupler.
4. Unbolt and remove the flywheel.
5. To install, align offset holes in flywheel with crankshaft studs and position flywheel on studs.
6. Fit drive coupling on studs. Install washers and locknuts. Tighten nuts to specifications (**Table 3** or **Table 4**).
7. Install flywheel housing. Install attaching parts to housing.

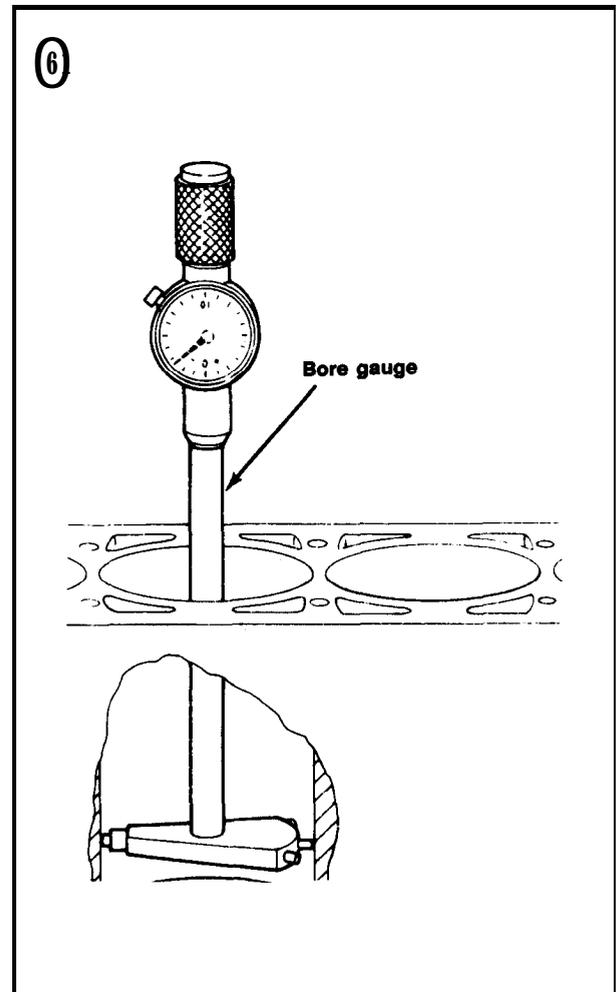
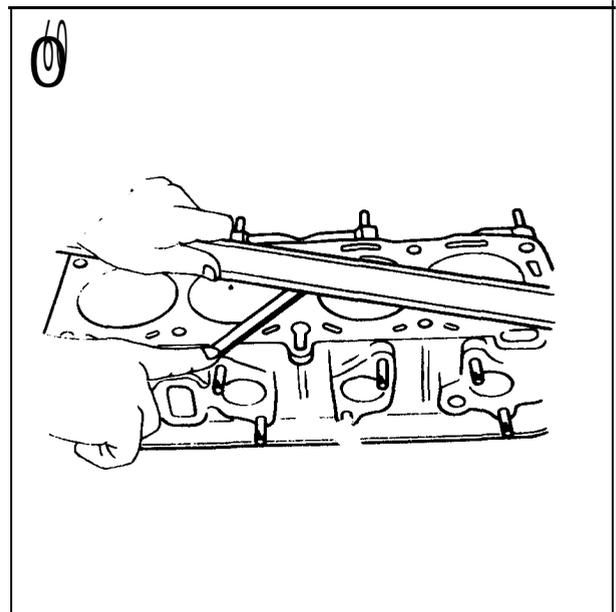
### Inspection

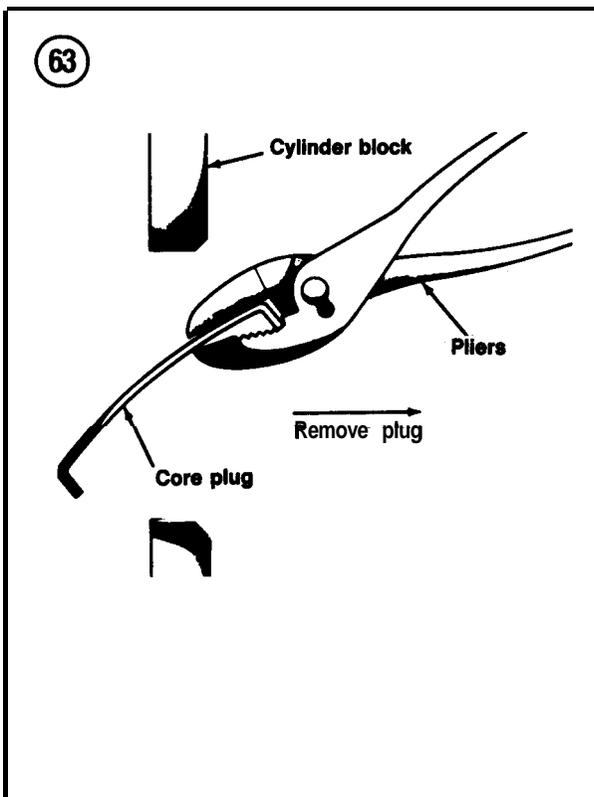
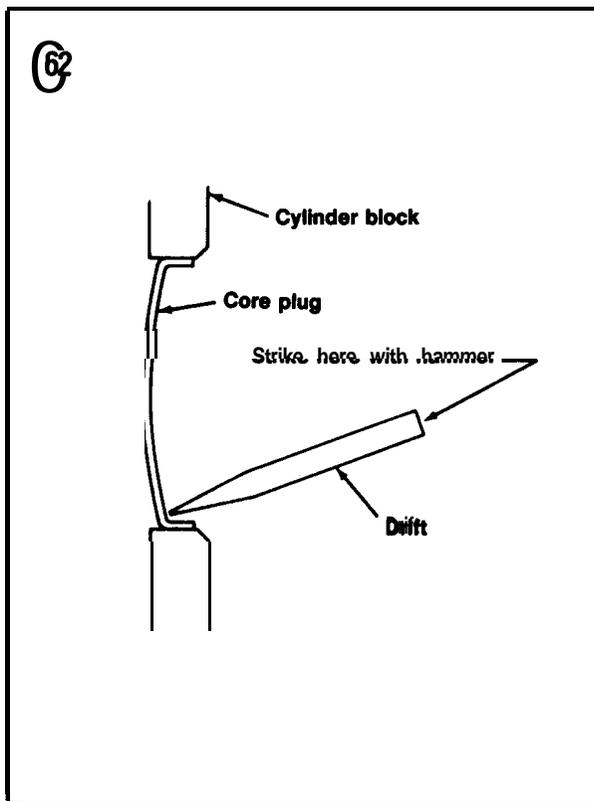
1. Visually check the flywheel surfaces for cracks, deep scoring, excessive wear, heat discoloration and checking.
2. Have the face **runout** checked with a dial indicator and compare to specifications.
3. Check surface flatness with a straightedge and feeler gauge.
4. Inspect the ring gear teeth for cracks, broken teeth or excessive wear. If severely worn, check the starter motor drive teeth for similar wear or damage. Replace as indicated.
5. Check coupling splines for signs of wear caused by a lack of sufficient lubrication when installed.
6. Check hub bond. If sheared or pulled loose from flywheel, engine and drive are misaligned. Replace flywheel.

## CYLINDER BLOCK

### Cleaning and Inspection

1. Clean the block thoroughly with solvent. Remove any gasket residue from the machined surfaces. Check all core plugs for leaks and replace any that are suspect. See *Core Plugs* in this chapter. Remove any plugs that seal oil passages. Check oil and coolant passages for sludge, dirt and corrosion while cleaning. If the passages are very dirty, have the block boiled out by a machine shop. Blow out all passages with compressed air. Check the threads in the head bolt holes to be sure they are clean. If dirty, use a tap to true up the threads and remove any deposits.
2. Examine the block for cracks. To confirm suspicions about possible leak areas, use a mixture





of one part kerosene and 3 parts engine oil. Coat the suspected area with this solution, then wipe dry and immediately apply a solution of zinc oxide dissolved in wood alcohol. If any discoloration appears in the treated area, the block is cracked and should be replaced.

3. Check flatness of the cylinder block deck. Place an accurate straightedge on the block. If there is any gap between the block and straightedge, measure it with a feeler gauge. Measure from end to end and from corner to corner, as shown in Figure 60.

4. Measure the cylinder bores with a bore gauge (Figure 61) as described in Step 2, *Piston Clearance Check* in this chapter. If the cylinders exceed maximum tolerances, they must be rebored. Reboring is also necessary if the cylinder walls are badly scuffed or scored. Before boring, install all main bearing caps and tighten the cap bolts to specifications in Table 3 or Table 4.

### CORE PLUGS

Check the condition of all core plugs in the block and cylinder head whenever the engine is out of the boat for service. If any signs of leakage or corrosion are found around one plug, replace them all.

#### Removal/Installation

#### CAUTION

*Do not drive core plugs into the engine casting. It will be impossible to retrieve them and they can restrict coolant circulation, resulting in serious engine damage.*

1. Tap the bottom edge of the core plug with a hammer and drift. Use several sharp blows to push the bottom of the plug inward, tilting the top out (Figure 62).
2. Grip the top of the plug with pliers. Pull the plug from its bore (Figure 63) and discard.
3. Clean the plug bore thoroughly to remove all traces of the old sealer.
4. Apply a light coat of Loctite Stud N' Bearing Mount or equivalent to the plug bore.
5. Install the new core plug with an appropriate size driver or socket. The sharp edge of the plug should be at least 0.02 in. inside the lead-in chamfer.

Table 1 470,488 AND 488 ENGINE **SPECIFICATIONS**

<b>Type</b>	<b>Inline 4-cylinder</b>
<b>Displacement</b>	224 cid
<b>Cylinder numbering (front to rear)</b>	1-2-3-4
<b>Firing order</b>	1-3-4-2
<b>Cylinder bore</b>	
Out-of-round	0.0005 in. max.
Taper	0.0005 in. max.
<b>Piston clearance</b>	0.0020-0.0037 in.
<b>Piston rings</b>	
Groove clearance	
Top compression	0.0025-0.0040 in.
2nd compression	0.0025-0.0040 in.
Oil	0.0011-0.0065 in.
<b>Gap</b>	
Top compression	0.010-0.020 in.
2nd compression	0.010-0.020 in.
Oil	0.010-0.025 in.
<b>Piston pin</b>	
Diameter	1.0399-1.0402 in.
Clearance	<b>0.0004-0.0006</b> in.
Fit in rod	<b>0.0006-0.0016</b> Interference
<b>Crankshaft</b>	
Main journal diameter	2.7472-2.7482 in.
Main journal taper	0.0002 in. max.
Main journal out-of-round	0.0002 in. max.
Main bearing clearance	0.0009-0.0031 in.
End play	0.006-0.010 in. max.
<b>Crankpin diameter</b>	2.4979-2.4989 in.

(continued)

Table 1 470,485 AND 488 **ENGINE** SPECIFICATIONS (continued)

<b>Crankpin taper</b>	0.0002 in. max.
<b>Crankpin out-of-round</b>	0.0002 in. max.
<b>Connecting rod</b>	
Bearing clearance	0.0009-0.0031 in.
Side clearance	0.0050-0.0120 in.
<b>Camshaft</b>	
470 lobe lift	
Intake	0.278 in.
Exhaust	0.290 in.
485 lobe lift	
Intake	0.287 in.
Exhaust	0.310 in.
488 lobe lift	
Intake	0.287 in.
Exhaust	0.299 in.
Lobe wear limit	0.009 in.
Journal diameter	2.1242-2.1248 in.
Bore diameter	2.1258-2.1288 in.
Clearance	<b>0.0010-0.0026</b> in.
<b>Runout</b>	0.001 in. max.
<b>Cylinder head</b>	
Gasket surface flatness	0.003 in. in any 8 in. or 0.007 in. overall
<b>Valves</b>	
Lifter	Hydraulic
Rocker arm ratio	<b>1.73:1</b>
Collapsed tappet gap	0.075-0.175 in.
470, 488 face angle	<b>44°</b>
485 face angle	
Intake	29.5"
Exhaust	44.5"
(continued)	

Table 1 470,488 AND 488 **ENGINE SPECIFICATIONS** (continued)

470, 488 seat angle	45"
485 seat angle	
intake	30"
Exhaust	45"
Seat runout	0.002 in. max.
Seat width	<b>0.060-0.080</b> in.
Stem clearance	0.0010-0.0027 in.
<b>Valve springs</b>	
Free length	
470, 485	2.03 in.
488	2.18 in.
Pressure	
470, 485	
Closed	78-84 lb. @ 1.81 in.
Open	<b>240-265</b> lb. @ 1.33 in.
<b>488*</b>	
Closed	90-100 lb. @ 1.88 in.
Open	255-275 lb. @ 1.38 in.
Installed height ( $\pm 1/32$ in.)	
470,485	1.80-1.82 in.
488	1.88 in.
. Test pressure with damper assembled.	

Table 2 **170MR/190MR ENGINE SPECIFICATIONS**

Cylinder bore Diameter	<b>4.3602-4.3609</b> in. (110.749-110.787 mm)
Out-of-round Production	0.0005 in. (0.0127 mm) max.
Service	0.0015 in. (0.0381 mm) max.
Taper Production	0.0005 in. (0.0127 mm) max.
Thrust side	0.0005 in. (0.0127 mm) max.
Relief side	0.003 in. (0.078 mm) max.
Service	0.005 (0.1 mm) max.
Cylinder head flatness	0.005 (0.1 mm) max.
Cylinder block Deck height <sup>1</sup> Production	<b>10.255-10.265</b> in. <b>(260.477-260.731)</b> mm
Service	10.240 in. (260.098 mm) min.
Main bearing bore diameter Production	2.9417-2.9429 in. (74.7191-74.7497 mm)
Service	2.9435 in. (74.7849 mm) max.
Hydraulic lifter bore diameter Production	<b>0.875-0.876</b> in. (22.225-22.250 mm)
Service	0.878 in. (22.301 mm) max.
Camshaft bore diameter	<b>2.1258-2.1278</b> in. <b>(53.995-54.046)</b> mm
Piston clearance	NA
Piston rings Groove side clearance	
Compression	0.0025-0.0040 in. (0.07-0.10 mm)
Oil	<b>0.0011-0.0065</b> in. (0.03-0.15 mm)
Gap Compression	0.010-0.020 in. (0.25-0.50 mm)
Oil	0.010-0.025 in. ( <b>0.25-0.60</b> mm)
Piston pin Diameter	1.0399-1.0402 in. <b>(26.413-26.421)</b> mm
Clearance	<b>0.0004-0.0006</b> in. (0.0102-0.0152 mm)
Fit in rod	<b>0.0006-0.0016</b> in. <b>(0.0152-0.0406)</b> mm
Crankshaft Main journal Diameter	2.7472-2.7482 in. <b>(69.779-69.804)</b> mm
Taper Production	0.0002 in. (0.0051 mm) max.
Service	0.0005 in. (0.0127 mm) max.
Out-of-round Production	0.0002 in. (0.0051 mm) max.
Service	0.0005 in. (0.0127 mm) max.

(continued)

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Table 2 **170MR/190MR** ENGINE SPECIFICATIONS (continued)

Main bearing clearance	
Production	0.0009-0.0035 in. <b>(0.0229-0.0889 mm)</b>
Service	0.001-0.0035 in. (0.0254-0.0889 mm)
Rear seal area diameter	
Production	3.748-3.752 in. <b>(95.1992-95.3008 mm)</b>
Service	3.745 in. (95.123 mm) min.
Timing sprocket inside diameter <sup>2</sup>	
Production	1.380-1.381 in. (35.052-35.077 mm)
Service	1.379 in. (35.028 mm) min.
End play	<b>0.006-0.010</b> in. (0.15-0.25 mm)
Connecting rod journal	
Diameter	2.4979-2.4989 in. (83.447-83.472 mm)
Taper	
Production	0.0002 in. (0.0051 mm) max.
Service	0.0005 in. (0.0127 mm) max.
Out-of-round	
Production	0.0002 in. (0.0051 mm) max.
Service	0.0005 in. (0.0127 mm) max.
Rod bearing clearance	
Production	0.0009-0.0031 in. <b>(0.0228-0.0787 mm)</b>
Service	0.001-0.003 in. (0.03-0.07 mm)
Rod side clearance	0.005-0.012 in. (0.15-0.30 mm)
Alternator rotor front oil seal diameter	
Production	1.873-1.877 in. (47.5742-47.8758 mm)
Service	1.871 in. (47.5234 mm) min.
Camshaft	
Journal diameter	2.1238-2.1248 in. (53.9445-53.9899 mm)
Clearance	<b>0.001-0.0026</b> in. <b>(0.0254-0.0660 mm)</b>
Lobe lift	
Intake	0.287 in. (7.2898 mm) max.
Exhaust	0.290 in. (7.3880 mm) max.
End play	0.002-0.005 in. <b>(0.06-0.10 mm)</b>
Runout	0.001 in. (0.0254 mm) max.
Valve System	
Lifter type	Hydraulic
Rocker arm ratio	<b>1.73:1</b>
Valve lash	0.110-0.210 in. (2.8-5.3 mm)
Face angle	<b>44°</b>
Seat angle	45°
Seat runout	0.002 in. (0.051 mm)

(continued)

Table 2 **170MR/190MR** ENGINE SPECIFICATIONS (continued)

<b>Seat width</b>	
Intake and exhaust	0.060-0.080 in. (1.524-2.032 mm)
<b>Stem clearance</b>	
Production	0.0010-0.0027 in. (0.0254-0.0686 mm)
<b>Service</b>	
Intake	0.0037 in. (0.0940 mm)
Exhaust	0.0052 in. (0.1321 mm)
<b>Valve spring</b>	
Free length	2.18 in. (55 mm)
Installed height	1.86 in. (47 mm)
<b>Pressure <sup>3</sup></b>	
Closed	90-100 lb. @ 1.86 in. (122-136 N @ 47 mm)
Open	255-275 lb. @ 1.36 in. (346-372 N @ 35 mm)
<b>Damper</b>	External

1. Measure from center of main bearing bore to top of cylinder block.  
 2. Crankshaft is tapered; take measurement @ rear half of sprocket area on crankshaft.  
 3. Test springs with damper installed.

Table 3 470, 485 AND 488 TIGHTENING TORQUES

Fastener	in.-lb.	ft.-lb.
Alternator rotor-to-crankshaft		50
<b>Camshaft</b>		
Extension shaft		60
Sprocket screws	150	
Thrust plate	115	
Carburetor flange bolts		20
Chain tension bolt		20
<b>Connecting rod cap nuts</b>		40
Coupling-to-flywheel		60
Cylinder head bolts		130
Distributor clamp		15
Flywheel housing-to-block		30
Front cover bolts		15
Front mount-to-block		50
Impeller cover		15
Impeller nut (early models)		40
Impeller bolt (late models)		15
Main bearing cap		55
Manifold-to-head		25
<b>Oil pan</b>		
Screws	130	
Drain plug		20
<b>Oil pump</b>		
Cover	120	
To block		25
Pickup-to-pump		20
Pickup tube-to-block nuts		20

(continued)

If

Table 3 470, 485 AND 488 **TIGHTENING TORQUES** (continued)

Fastener	in.-lb.	ft.-lb.
Rocker arm cover	90	
Rocker arm <b>capscrew</b>		20
Side cover		15
Spark plugs		15
Starter motor		60
Stator-to-front cover	45	
Water pump cover		15

Table 4 **170MR/190MR TIGHTENING TORQUES**

Fastener	in.-lb.	ft.-lb.	N-m
<b>Alternator rotor</b>		75	102
Camshaft			
Impeller stud (see notes 1 and 2)		15	20
Thrust plate	115		13
Sprocket screws	150		17
Carburetor mounting bolt		20	27
Chain tightener bolt		20	27
Connecting rod cap		40	54
Coupler/flywheel		30	41
Cylinder head bolts <sup>3</sup>		130	176
Distributor clamp		15	20
Exhaust manifold		25	34
Flywheel housing to block		30	41
Front mount to block		50	66
Intake manifold		25	34
Impeller and cover <sup>4</sup>		15	20
Main bearing cap		55	75
Oil pan			
Attaching screws	130		15
Drain plug		20	27
Oil pump			
Cover	120		14
Pickup		20	27
To block		25	34
Oil tube to block		20	27
Rocker arm cover	90		10
Rocker arm <b>capscrew</b>		20	27
Side cover		15	20
Spark plugs		15	61
Starter motor		60	5
Stator-to-front cover	45		20
Water pump cover		15	20
<p>1. Left-hand thread.  2. Use Loctite 35.  3. Torque in 3 stages with valves closed. Retorque after first start-up.  4. Late models have left-hand thread.  5. Torque with valves closed.</p>			