1530, 1630, 1725, 1925, TC25, TC25D, TC29, TC29D, TC33, TC33D REPAIR MANUAL

CONTENTS

SECTION 1
ENGINE SYSTEMS

CONTENTS

GENERAL INFORMATION

DESCRIPTION AND OPERATION

This chapter describes the engine overhaul and repair procedures of the Models 1530, 1630, 1725, 1925, TC25, TC29, TC33, TC25D, TC29D, and TC33D tractors. Repair procedures are essentially the same for all models except as noted in the repair procedures.

The tractors are equipped with three-cylinder in-line engines. They are all four cycle, overhead valve, liquid cooled engines. The engines are identified by a code, 1, cast into the lower right side of the cylinder block.

NOTE: Numeric value, 2, under the Engine Code indicates displacement of the engine in liters.

Engine Identification	Tractor Model	Engine Power Hp (Kw)
J843	1530	25 (18.7)
J843	1630	27.3 (20.5)
J843	1725	29 (21.6)
N843	1925	34 (25.5)
J843	TC25	25 (18.7)
J843	TC25D	25 (18.7)
J843	TC29	29 (21.6)
J843	TC29D	29 (21.6)
N843	TC33	33 (24.6)
N843	TC33D	33 (24.6)

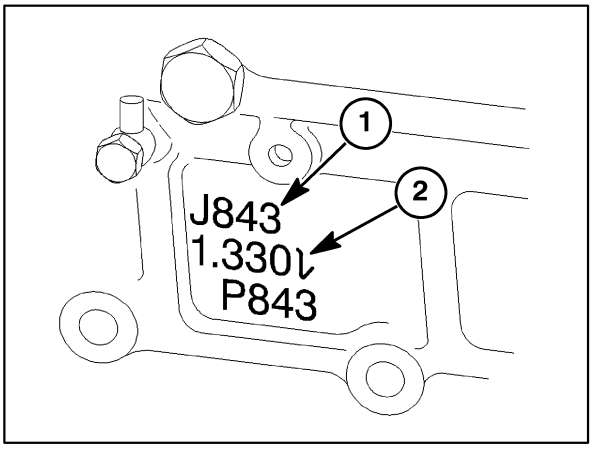

Figure 1-1

CYLINDER HEAD AND VALVE TRAIN COMPONENTS

The cylinder head incorporates the valve assemblies, rocker arms, rocker shaft, push rods, and lifters. A swirl chamber located between the injector assembly and the main combustion chamber of the cylinders provides improved starting and greater fuel efficiency. Initial combustion starts in the precombustion chamber and as the expansion occurs a strong swirl pattern is created in the main combustion chamber for more complete combustion of the air-fuel mixture. The air intake manifold is separate from the cast aluminum valve cover on all these engines. The exhaust manifold is bolted on the left-hand side of the cylinder head on each of the models. Cylinder heads have integral valve guides. Standard size valves only are used. Figure 1-2 provides a cut-away front view of an engine.

CYLINDER BLOCK ASSEMBLY

The cylinder block assembly contains the pistons, connecting rods, crankshaft, timing gears, and engine oil pump. The crankshaft is supported on four main bearings. The front bearing is positioned in a bore in front of the block. The second, third, and fourth bearings are split liners located in holders bolted to the block. The camshaft is supported on two ball bearings located on each end of the block. Figure 1-3 provides a cutaway side view of the engine.

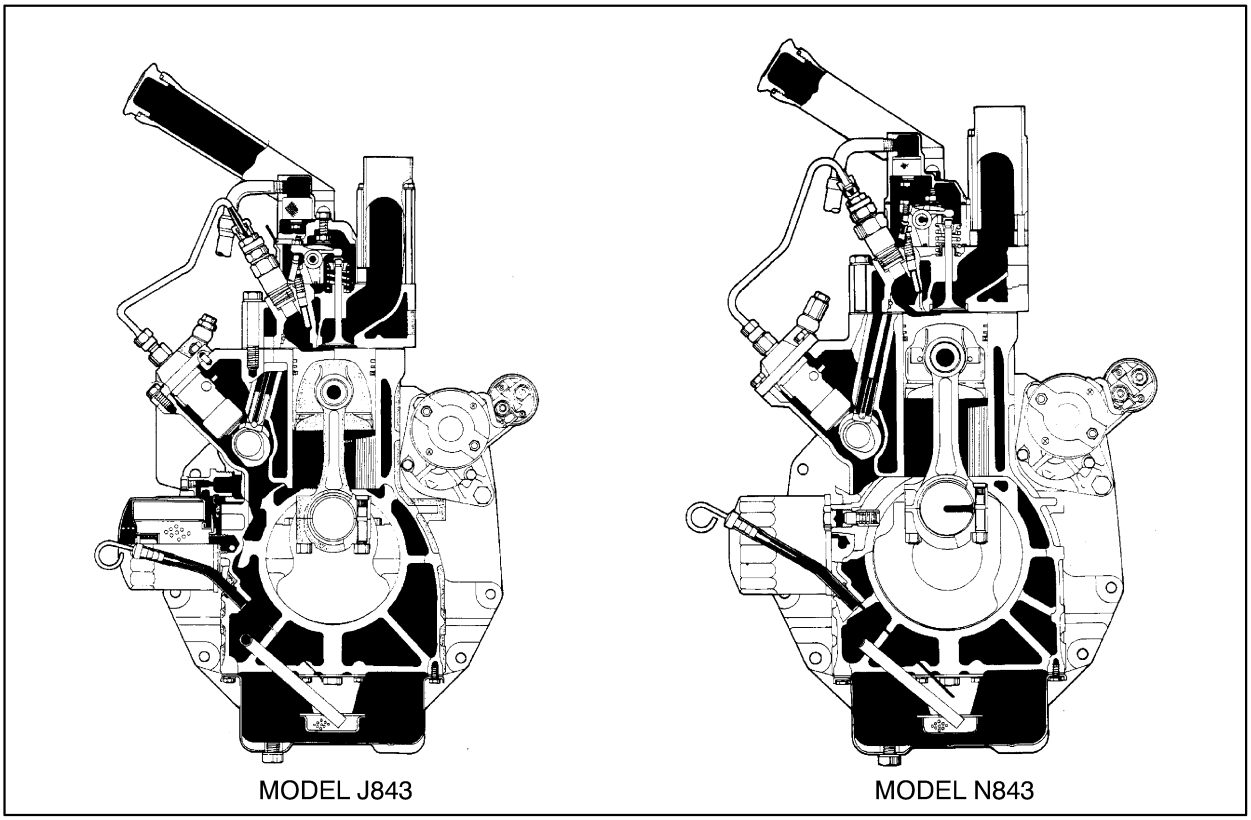

Figure 1-2

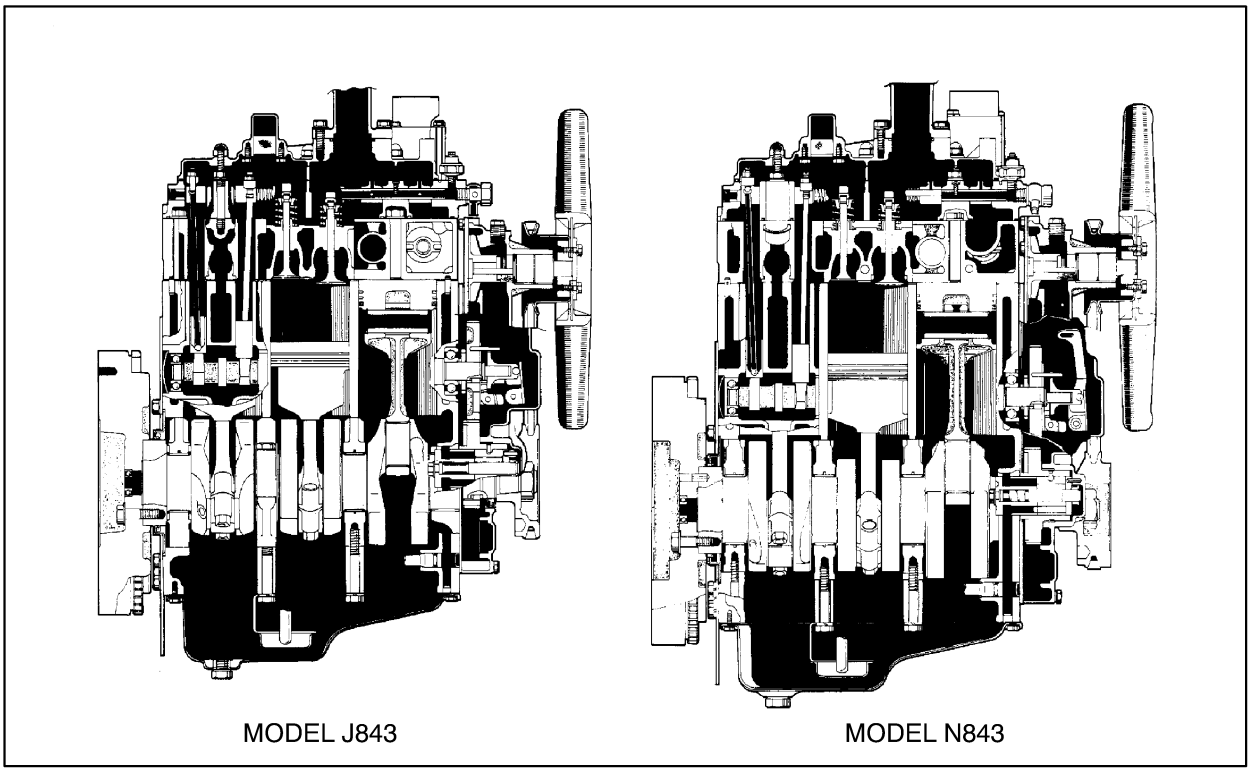

Figure 1-3

ENGINE OVERHAUL

ENGINE DISASSEMBLY

1. Turn coolant tap bolt, 1, counterclockwise to drain fluid. Remove the radiator assembly. See “Radiator Removal”, discussed later in this section.

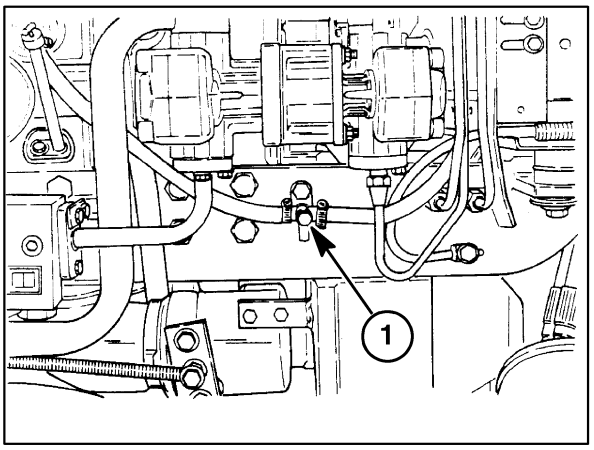

Figure 1-4

2. Remove the air cleaner assembly, 1, along with the air cleaner hoses. Push in on assembly, 1, and turn counterclockwise to remove.

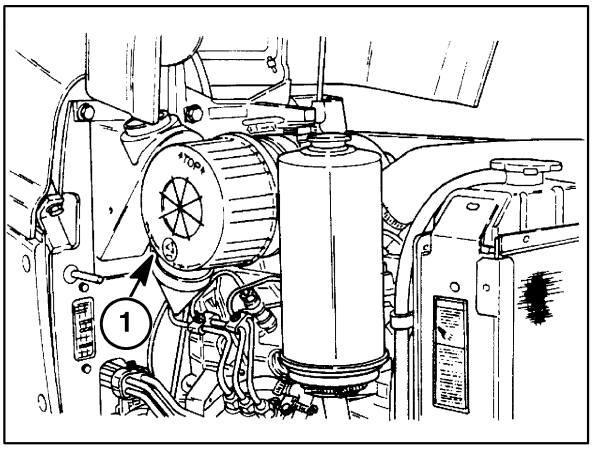

Figure 1-5

3. Remove bolts, 1, for final removal of air cleaner assembly.

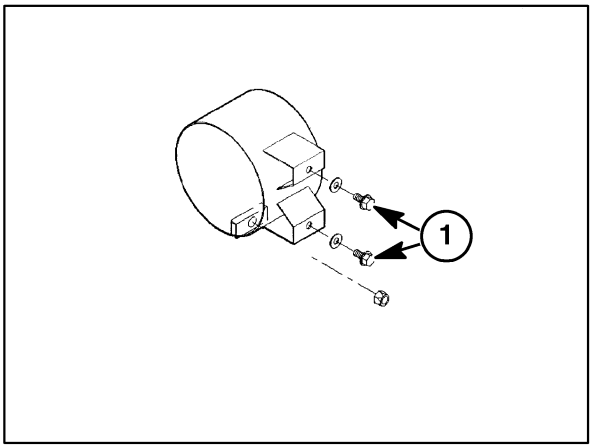

Figure 1-6

4. Remove the exhaust muffler, 1, and manifold assembly, 2. Loosen bolt, 3, and bolt, 4, Figure 1-8, to remove exhaust muffler. Loosen six bolts, 5, to remove exhaust manifold.

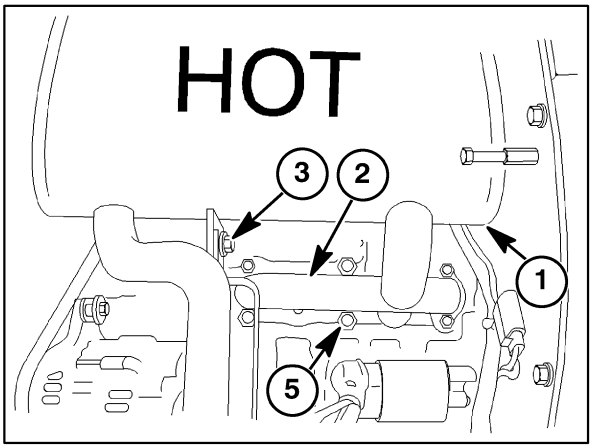

Figure 1-7

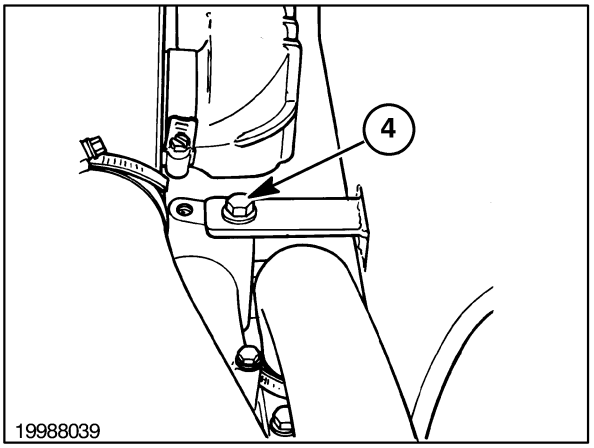

Figure 1-8

FUEL INJECTOR AND GLOW PLUG REMOVAL

1. Clean all dirt and oil from the injectors and surrounding areas.
2. Disconnect the fuel lines, 1, from the injectors and cap all openings.
3. Remove the injector fuel leak-off line, 3.
4. Remove the injector assemblies, 2.
5. Remove the glow plug bus connector, 5, and remove the glow plugs, 4.

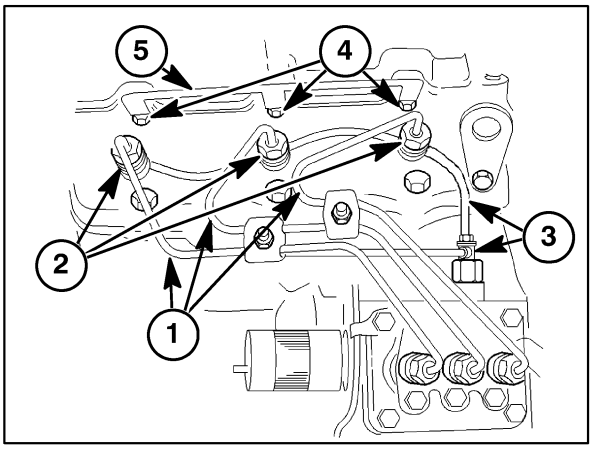

Figure 1-9

OIL PRESSURE SWITCH

Remove the oil pressure switch, 1.

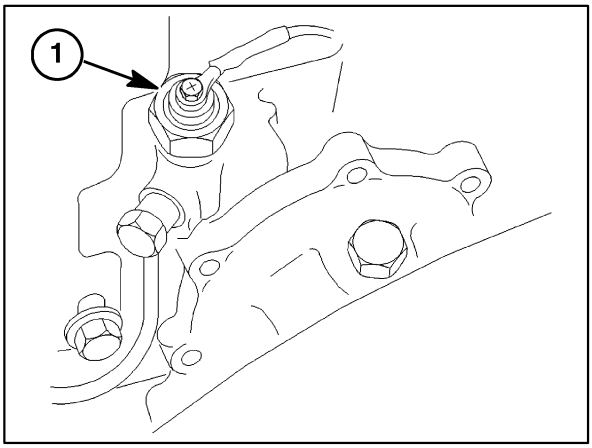

Figure 1-10

TEMPERATURE SENDING SWITCH AND ALTERNATOR REMOVAL

1. Remove the temperature sending switch, 1, from the front of the cylinder head.
2. Loosen the alternator mounting bolts, 2, and remove the V-belt, 3, from the drive pulley.
3. Disconnect the alternator wires from the back of alternator, 4.
4. Remove the alternator mounting bolts, 2, and remove the alternator.

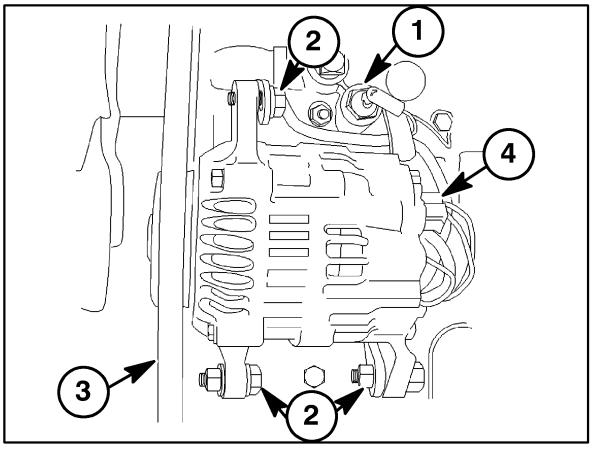

Figure 1-11

FAN, WATER PUMP, AND EXTERNAL OIL TUBE REMOVAL

1. Remove the fan and water pump assembly. See “Fan Removal” and “Water Pump Removal” discussed later in this section.
2. Remove the external oil transfer tube banjo bolt, 1, from the front of the cylinder head. Figure 1-12 illustrates the 25 and 30 Series and Figure 1-13 illustrates the TC models.

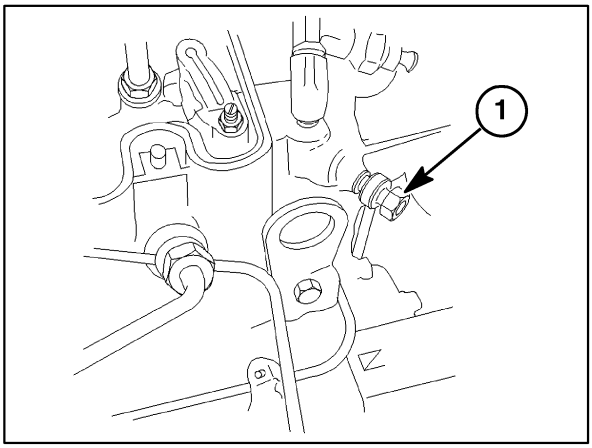

Figure 1-12

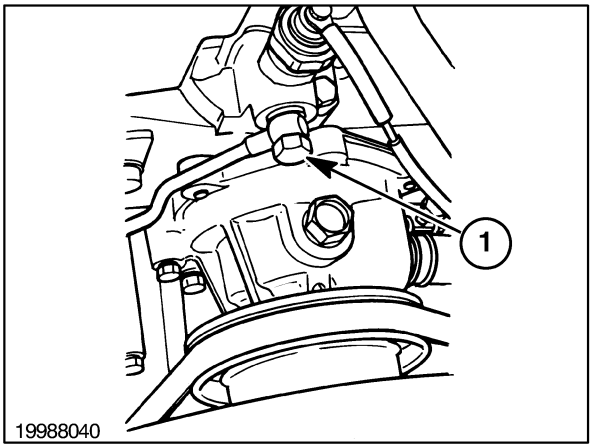

Figure 1-13

AIR INLET MANIFOLD REMOVAL

Remove the six retaining bolts, 1, and remove the air inlet manifold assembly, 2.

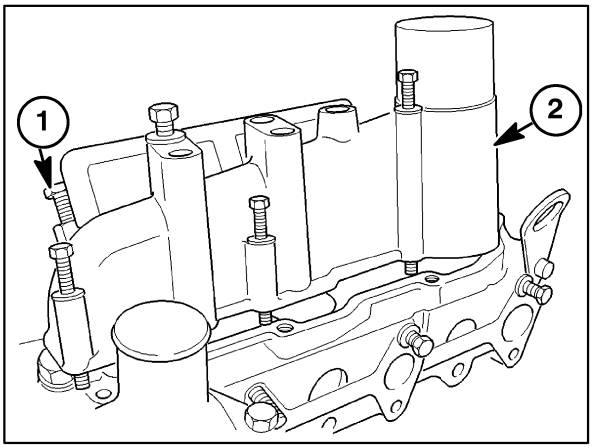

Figure 1-14

VALVE COVER REMOVAL

Loosen the three bolts, 1, to remove the valve cover, 2.

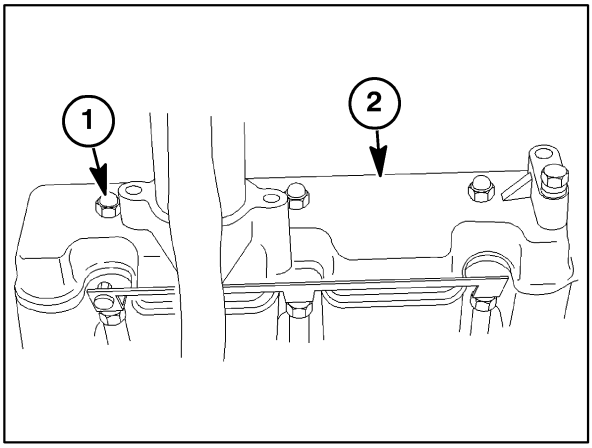

Figure 1-15

ROCKER ARM SHAFT AND SUPPORT BRACKET REMOVAL

Remove the rocker arm shaft and support bracket as an assembly, 1.

NOTE: Alternately loosen the rocker support bolts a turn at a time to prevent distorting the rocker shaft.

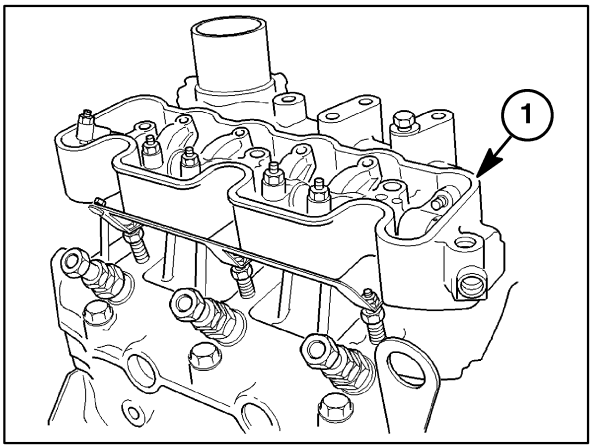

Figure 1-16

CYLINDER HEAD REMOVAL

1. Remove the valve stem caps, 1, and push rods, 2.

   NOTE: Keep all valve components in separately marked containers for re-assembly in their original location.

2. To remove the cylinder head, remove the cylinder head bolts, 3, by alternately loosening a half turn at a time to prevent warping the head.

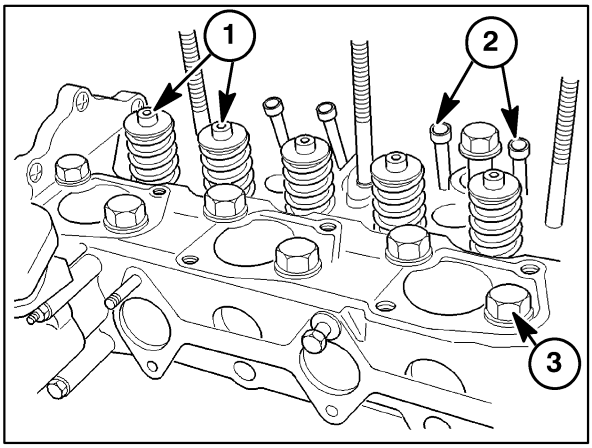

Figure 1-17

VALVE TAPPET REMOVAL

Remove the valve tappets, 1, from the machined bore in the cylinder block.

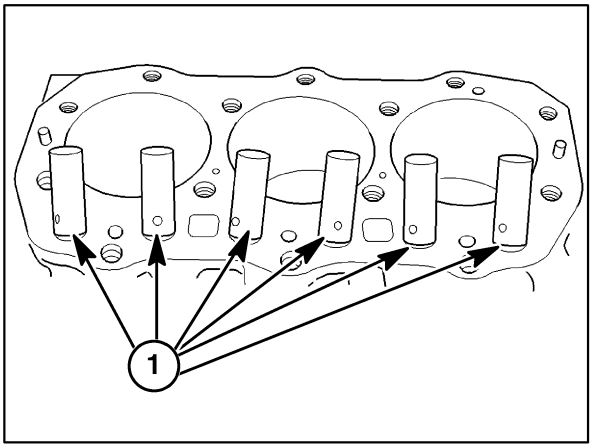

Figure 1-18

FUEL SHUTOFF SOLENOID REMOVAL

Remove the wire connector and unscrew the fuel shutoff solenoid, 1.

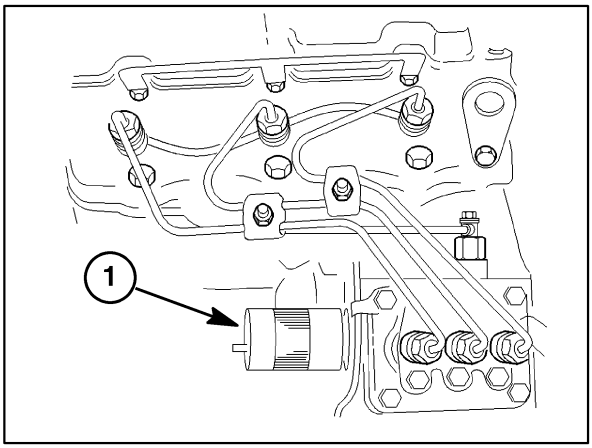

Figure 1-19

ENGINE TIMING GEAR COVER, TIMING GEARS, AND CAM SHAFT

Timing Gear Cover Removal

1. Drain the engine crankcase oil.
2. Remove the crankshaft pulley.
3. Disconnect the throttle control rod at the injection pump.
4. Loosen the four injection pump mounting bolts, 2, and raise the injection pump, 3, enough to remove the spring pin, 1, and separate the governor link from the control rack. Remove the injection pump.

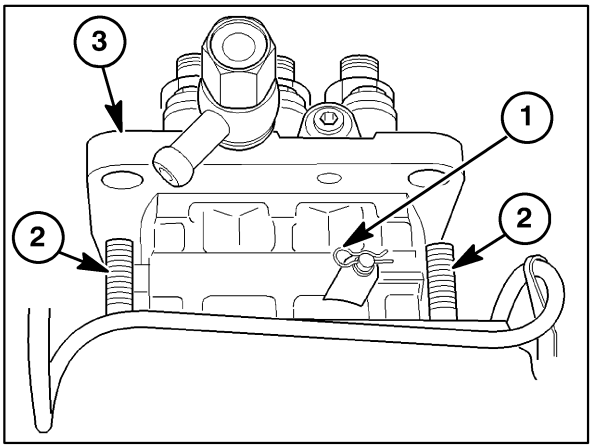

Figure 1-20

5. Remove the power steering pump reservoir tank dipstick-filler cap, 2.

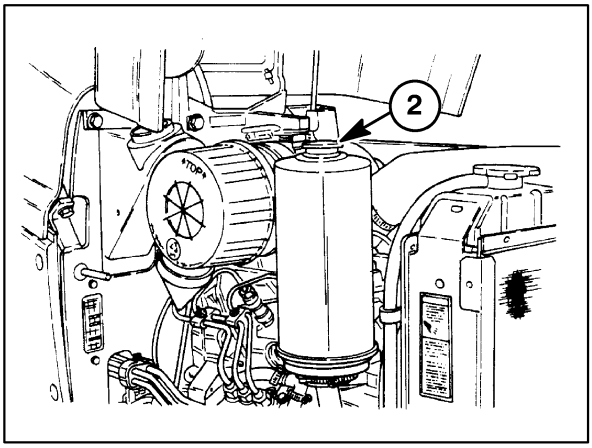

Figure 1-21

6. Remove the reservoir drain plug, 3, and drain the hydraulic fluid out of the reservoir tank, 1, into a suitable container.

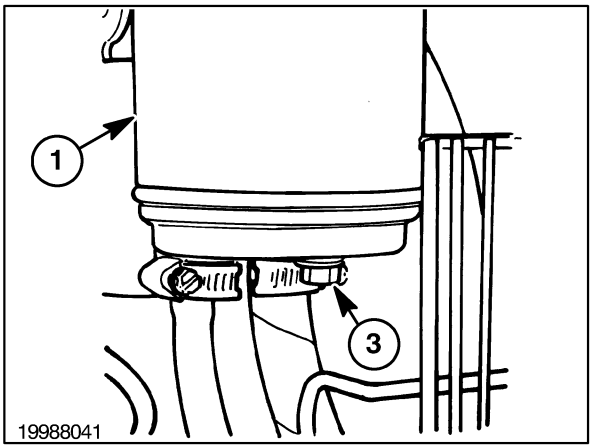

Figure 1-22

7. Loosen the hose clamp, 2, on the suction tube, 3, and remove the suction hose from the steering pump, 5.
8. Remove the pressure tube, 1, from the bottom of the steering pump.
9. Remove the through bolts, 4, and remove the steering pump from the front cover. Cap the lines and pump openings.

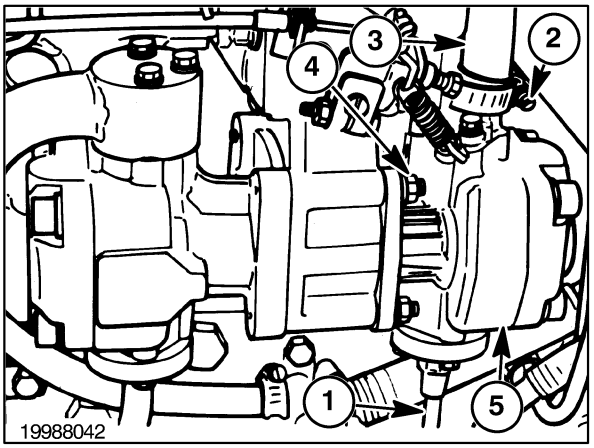

Figure 1-23

10. Remove retaining nut and washer, 1. Pull crankshaft pulley, 2, off of crankshaft, 3.

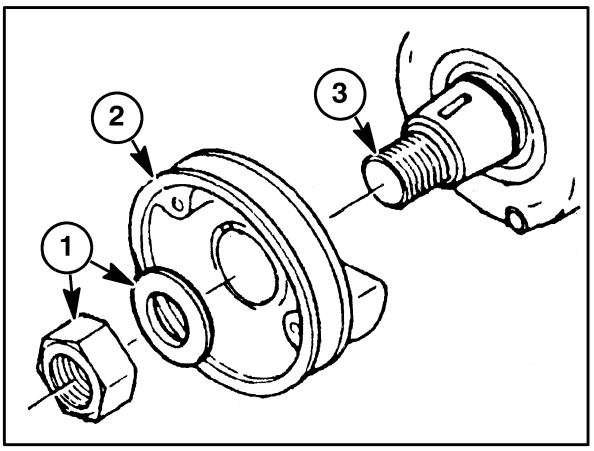

Figure 1-24

11. Remove the retaining bolts, 1, and lift the cover, 2, off the locating dowels.

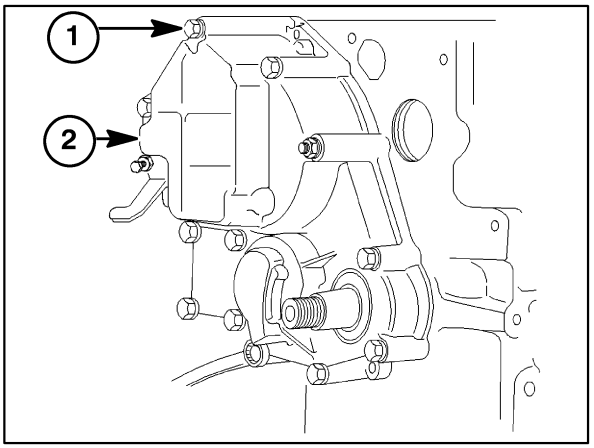

Figure 1-25

Timing Gears and Camshaft Removal

1. Remove retaining ring, 1, and remove the idler gear, 3, and oil pump assembly, 2.

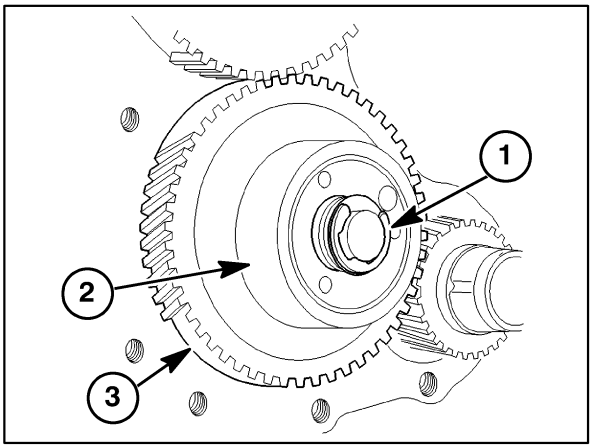

Figure 1-26

2. Remove the two bolts, 1, securing the keeper plate, 3. One must be accessed using the access hole, 2, in the cam gear.
3. Slide the camshaft and gear out of the camshaft bore.

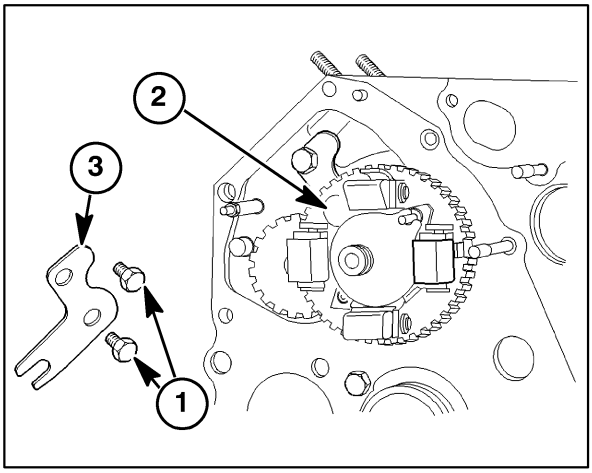

Figure 1-27

Oil Sump Removal

1. Remove the oil sump retainer bolts, 1.
2. Remove the oil sump and discard gasket.

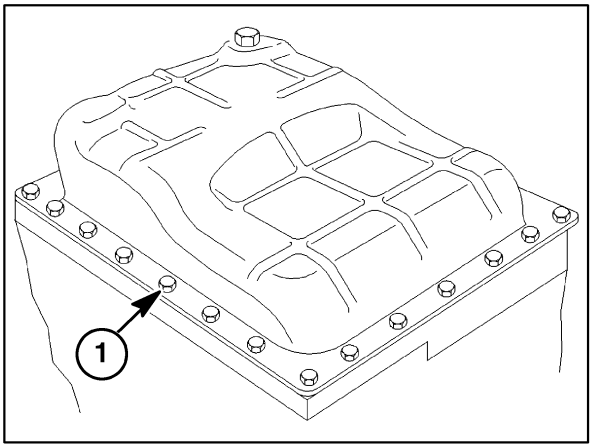

Figure 1-28

Oil Suction Pipe and Strainer Removal

1. Remove the two retaining bolts, 1.
2. Remove the oil strainer, 2, and rotate the oil suction pipe, 3, out of its bore. Remove from the front side of the block.

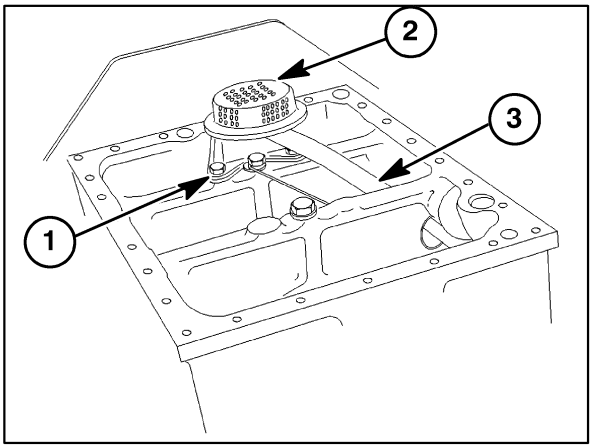

Figure 1-29

Connecting Rods, Bearings, and Pistons, Rings Removal

1. Remove the two bolts, 1, retaining the connecting rod caps, 2.
2. Remove the connecting rod caps and lower half of connecting rod bearing.
3. If necessary, remove any ridge from the top of the cylinder bores using a suitable ridge reamer.

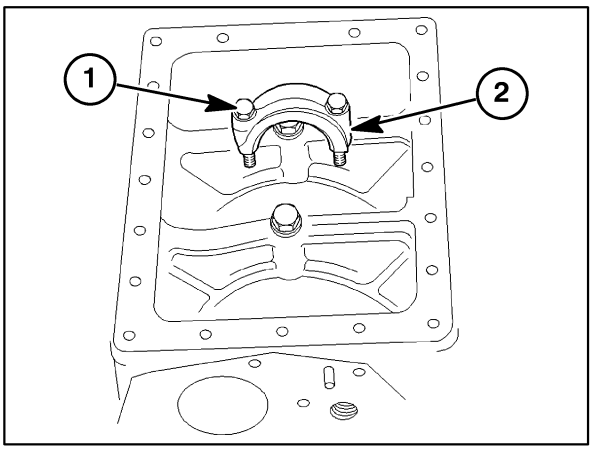

Figure 1-30

4. Push the piston and connecting rod out of the cylinder block.
5. Replace the connecting rod cap to the piston assembly it was removed from. Keep together in cylinder sequence.

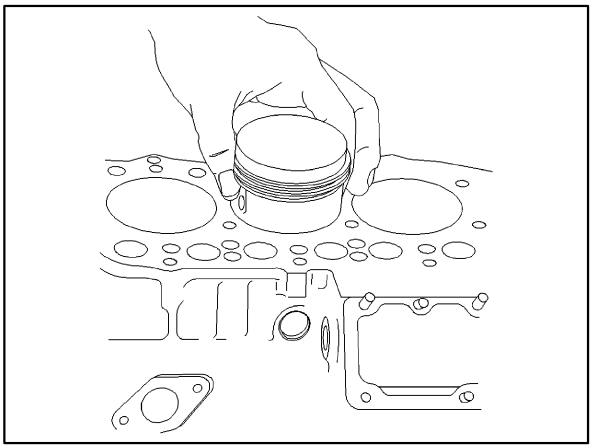

Figure 1-31

Flywheel Removal

1. Loosen the flywheel retaining bolts.
2. Using a brass drift and hammer, tap the end of the crankshaft, 1, to loosen the flywheel, 2, from the shaft.

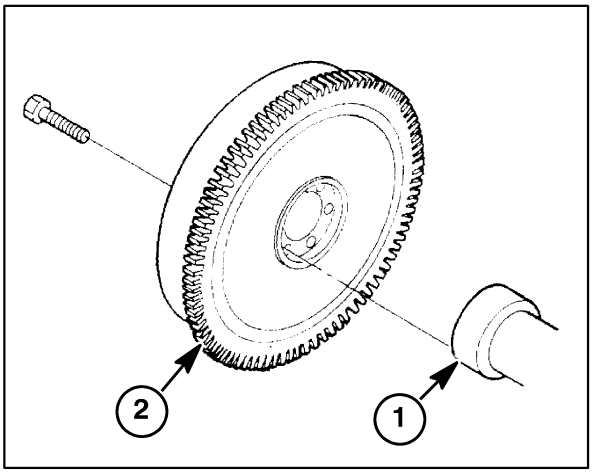

Figure 1-32

Backplate and Oil Seal

1. Remove the backplate retaining bolts and remove the backplate.
2. Remove the rear oil seal, 1.

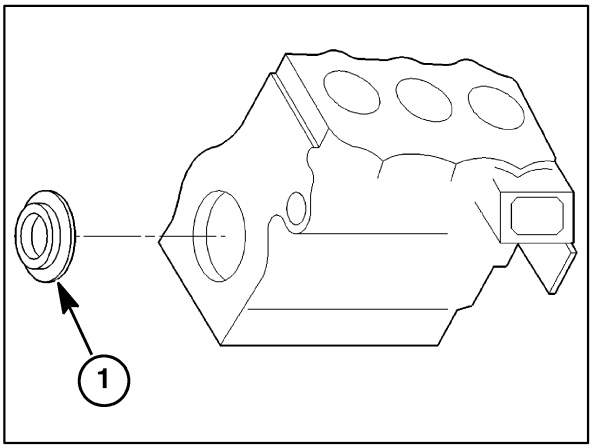

Figure 1-33

Crankshaft and Main Bearings Removal

1. Remove the crankshaft bearing holder retaining bolts, 1.
2. Slide the crankshaft and main bearing assembly through the rear of the engine.

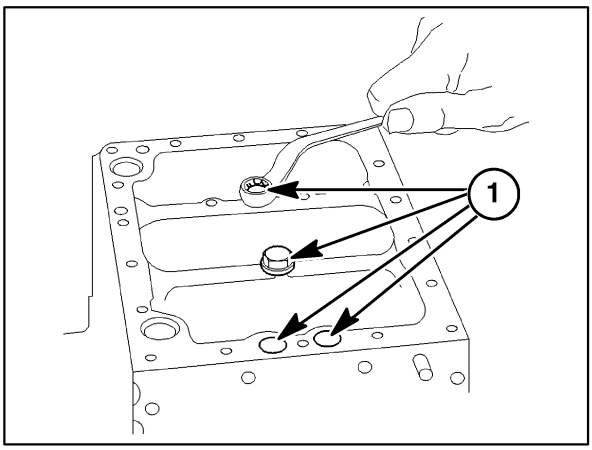

Figure 1-34

DISASSEMBLY, INSPECTION, FITS, CLEARANCES, AND ASSEMBLY OF COMPONENT ASSEMBLIES

CYLINDER HEAD DISASSEMBLY

1. Clean the cylinder head and remove any carbon deposits from around the valve heads.
2. Use a valve spring compressor and remove the valve spring retainer locks, 1, spring, 2, and spring retainer, 3, from each valve, 4.
3. Remove the valves and place the valve components together in separately marked containers for reassembly in their original position.

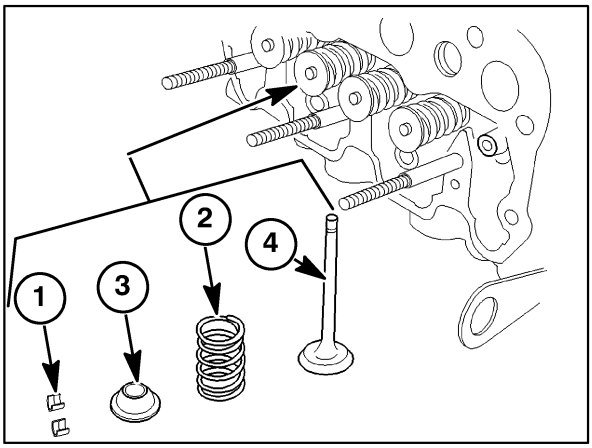

Figure 1-35

CYLINDER HEAD INSPECTION AND REPAIR

1. Clean all carbon deposits from the combustion chamber and valve ports using a wire brush and scraper.
2. Clean all dirt and residue from the gasket surface using care not to scratch or nick the machined surface.
3. Clean the cylinder head in solvent and air dry.
4. Inspect the head for cracks or damage in the following areas:
   - Valve ports
   - Valve seats, 2
   - Prechamber, 3
   - External cracks in the water jackets, 1
5. Inspect the gasket surfaces for scratches or nicks, which could cause leakage.
6. Examine the core hole plugs for rust or signs of leakage. If a plug shows signs of damaging rust or leakage, replace all plugs in the head.
7. Inspect the prechamber for carbon deposits and looseness. Remove any carbon deposits found. If prechamber is found to be loose, cylinder head may be warped.

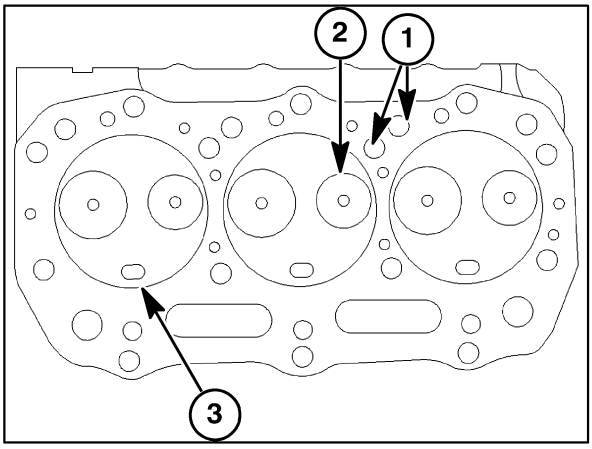

Figure 1-36

8. Use a straight edge and a feeler gauge and check the cylinder head for warp lengthwise, crosswise, and diagonally.

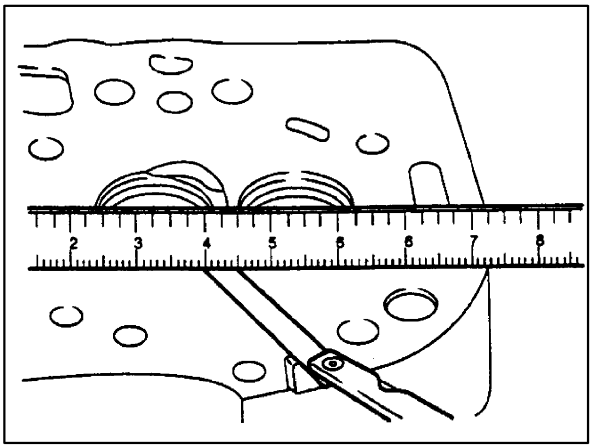

Figure 1-37

VALVE SEATS

1. Correct Valve Seat Width and Location
2. Correct Valve Head Margin N843
   0.7 - 1.0 mm (0.027 - 0.039″)
3. 45° Valve Seat Angle

Examine the valve seats and surface the seat if damaged. Valve seat grinding requires that the seat be ground to the correct width and properly positioned. A valve that extends too deep into the combustion area will result in valve burning. If the valve is recessed too deep into the head it will cause a rapid build-up of carbon deposits.

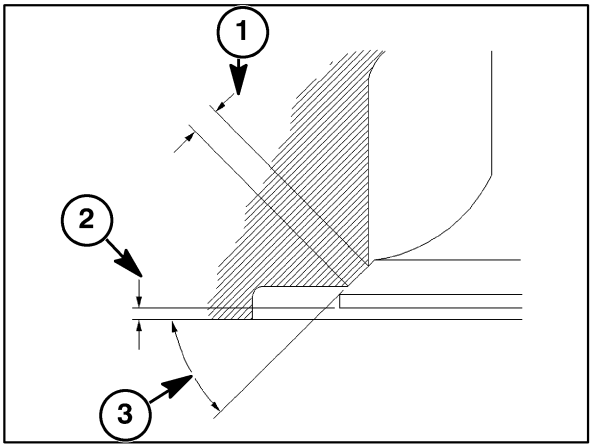

Figure 1-38

1. Check the seat for surface defects. Use a 45° stone if necessary to reface. Grind away only enough material to provide a smooth even seat.

   1. Seat angle - 45° Stone
   2. Lower Seat Location - 15° Stone
   3. Raise Seat Location - 75° Stone

2. Check the seat width. If necessary, use a 15° stone to lower the seat contact point and use a 75° stone to raise the seat contact point.

   NOTE: Refacing the seat should always be coordinated with refacing of the valve to ensure a compression tight fit.

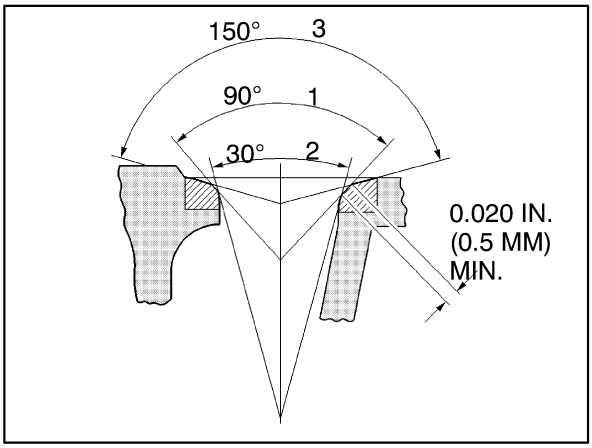

Figure 1-39

VALVES

1. Margin Too Thin
   Min. 0.5 mm (0.02″)
2. Bent Valve
3. Pitting
4. Indented
5. Wear or Nicking
6. Burned

1. Clean all deposits from the valves using a soft wire brush. Inspect the condition of the valves and discard any that are badly burned, cracked, or bent.

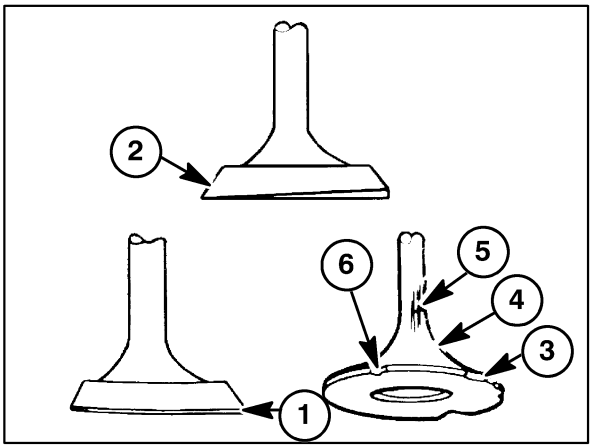

Figure 1-40

2. Using a micrometer, measure the valve stem at points “A,” “B,” and “C.”

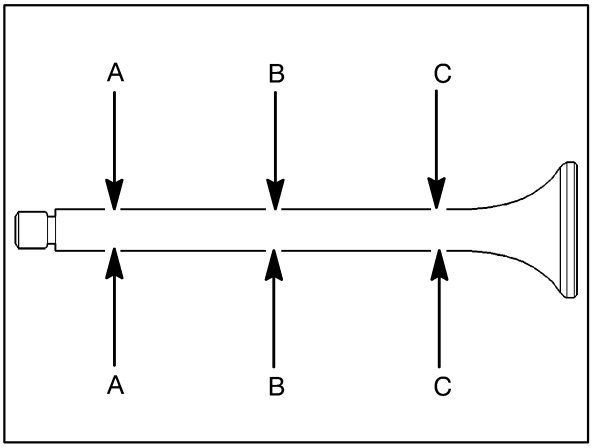

Figure 1-41

1. 45° Angle Seat
2. Minimum Valve Margin

3. If inspection indicates that the valve may be reused, the valve should be ground.
4. After grinding the valve and seat, check to ensure the seat contacts the center of the valve face. Using Prussian Blue, lightly coat the valve seat, place the valve in position and rotate the valve slightly while holding a light pressure against the valve. If the blue is transferred to the center of the valve face, the contact is correct.

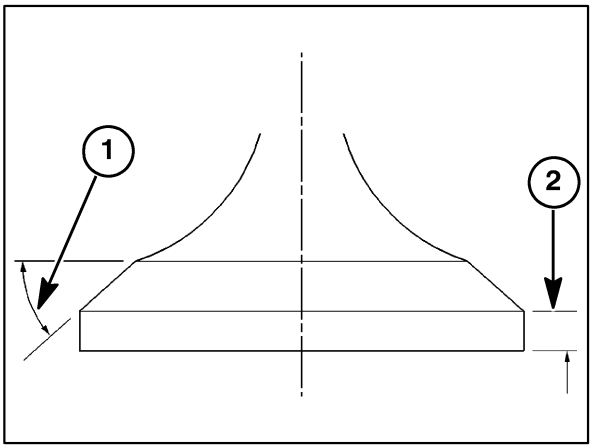

Figure 1-42

5. If Prussian Blue is not available, mark the valve face or seat, 1, with a soft lead pencil. Rotate the valve slightly in the seat. The penciled lines will be broken at the seat contact area.

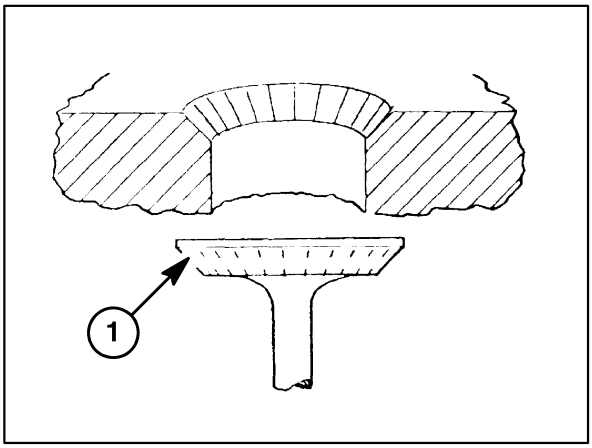

Figure 1-43

VALVE GUIDES

Thoroughly clean the valve guides before attempting to check internal wear.

1. Using a telescoping gauge and micrometer, measure the valve guide bore at the top and bottom wear points, 1.

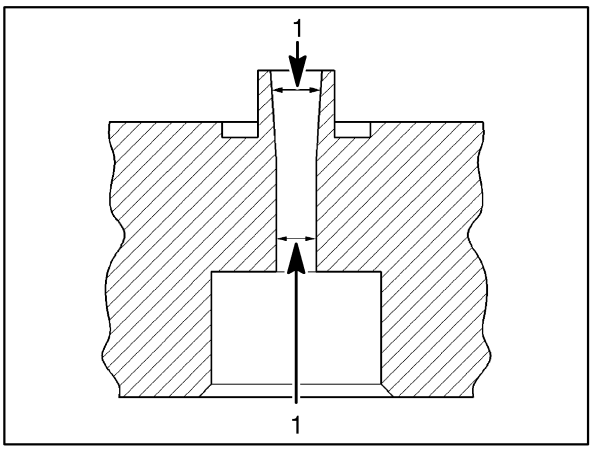

Figure 1-44

2. Determine the valve stem to valve guide clearance, 1, by subtracting the valve stem diameter from the valve guide diameter. Replace valves if the clearance, 1, is more than 0.2 mm (0.008″), intake valves, or 0.25 mm (0.010″), exhaust valves.
3. Replace the cylinder head if excessive clearance is determined and the valves have met all specified measurement requirements. See “Specifications,” discussed later in this section.

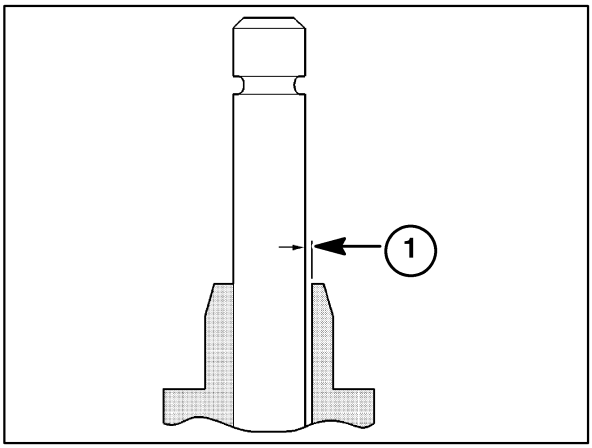

Figure 1-45

VALVE SPRINGS

1. Place the valve springs on a flat surface. Measure the free length of the spring and squareness. Replace springs that do not meet the following specifications (all models):

Max. Out of Square	Min. Free-Length
2.0 mm (0.079″)	33.5 mm (1.319″)

2. Place the springs in a suitable spring load tester and measure the spring load rating. Replace springs that do not meet the following specifications (all models):

Standard	Maximum
8.1 kg (17.86 lbs.) at 30.4 mm (1.197″)	7 kg (15.43 lbs.) at 30.4 mm (1.197″)

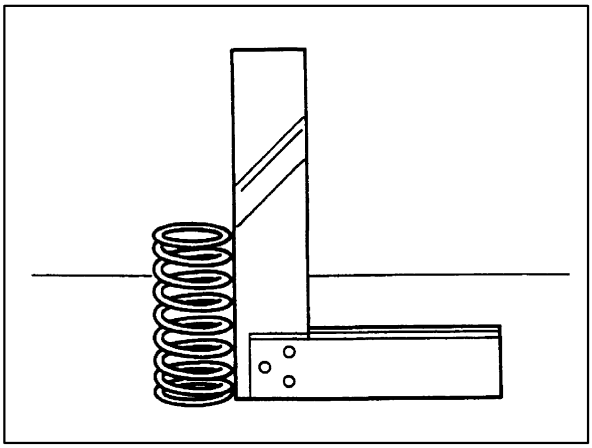

Figure 1-46

ROCKER ARMS

1. Setscrew
2. Rocker Arm
3. Shims
4. Spring
5. Rocker Arm Shaft

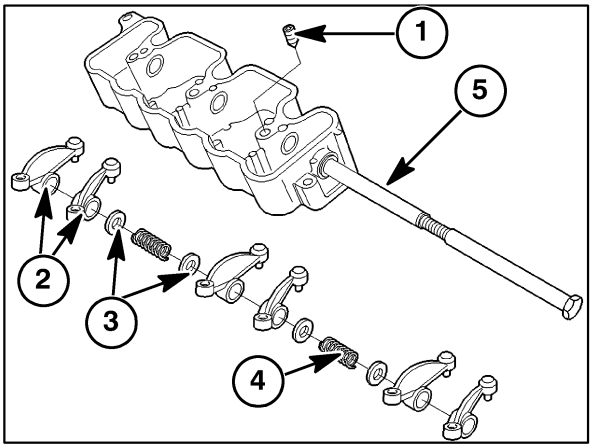

Figure 1-47

1. Remove setscrew, 1, that secures the rocker arm, 2, to the support.
2. Remove the plug from the rear of the rocker shaft support.
3. Thread an 8 mm bolt into the rear end of the rocker shaft and slowly withdraw the rocker shaft while at the same time removing the rocker arms and springs.
4. Inspect the rocker arms and shaft for wear or damage. Check the adjusting screws for damaged threads or excessive wear.
5. Check the valve stem contact area for pitting or excessive wear. Slight wear patterns may be removed using a fine grit oil stone.

6. Using an outside micrometer, measure the wear points, 1, on the rocker shaft. Replace the rocker shaft if the wear at any point exceeds 0.2mm (0.008″).

   NOTE: Lube holes, one set on bottom of rocker shaft at 180° from set screw hole and 90° from the rocker hole.

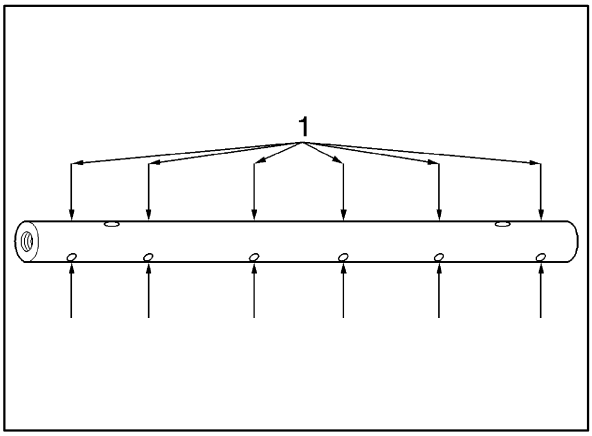

Figure 1-48

7. Using a telescoping gauge and micrometer, measure the inside of the rocker arm. Replace rocker arms having a bore diameter exceeding 11.57 mm (0.456″). Replace the rocker shaft and/or rocker arm if the rocker arm to shaft clearance exceeds 0.2 mm (0.008″).

   NOTE: Rocker arms have no bushings and only one lube hole.

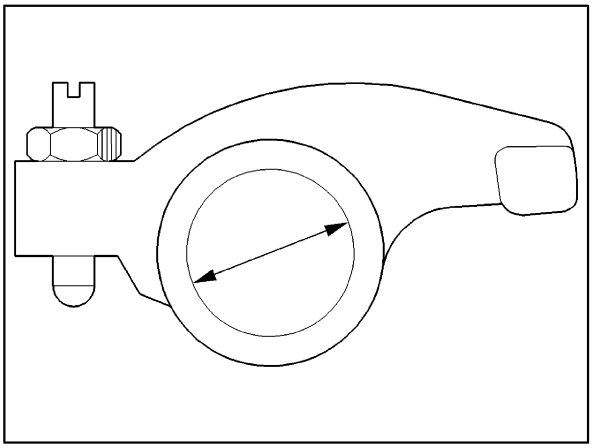

Figure 1-49

PUSH RODS

1. Check the push rods for straightness by rolling on a flat surface. Replace rods that are bent.
2. Inspect the ends of the push rods for excessive wear. If any push rod is worn, the corresponding lifter and rocker arm should also be inspected for excessive wear.

CYLINDER HEAD ASSEMBLY

1. Insert each valve in the guide from which it was removed and lightly lap the valve to be sure of an even seat around the valve face. Remove the valve and remove all traces of lapping compound.
2. Install new intake valve seals on the valve guides using a suitable driver.
3. Using a spring compressor, assemble the valves, springs, retainers, and keepers.

CYLINDER BLOCK

1. Inspect the cylinder block top face for cracks, damage, and warping in the same way as for the cylinder head. Replace the cylinder block if warp is greater than 0.12 mm (0.005″).
2. Visually inspect the cylinder bore. There should be no scoring, rust, or corrosion.
3. Using a telescoping gauge in line with the crankshaft, measure the inside diameter of the top of the bore (approximately 1.0 mm [0.39″] Model 1530, 1630, 1725, TC25, TC25D, TC29, and TC29D and 1.5 mm [0.59″] Model 1925, TC33, and TC33D below the top of the block).
4. Repeat this measurement at right angles to the crankshaft at the same distance.
5. In line with the crankshaft at the bottom of the bore, measure (approximately 100 mm [3.9″] Model 1530, 1630, 1725, TC25, TC25d, TC29, and TC29D and 117 mm [4.6″] Model 1925) from the top of the cylinder.
6. Repeat this measurement at right angles to the crankshaft at the same distance.
7. If any of the measurements taken indicate worn or damaged cylinder bores, the cylinders must be bored and oversize pistons installed, or replace the block. Pistons are available in 0.5 mm (0.020″) and 1.0 mm (0.40″) oversize. Bore and hone the cylinder to obtain a piston wall clearance of 0.038 - 0.064 mm (0.0015 - 0.0025″).

   NOTE: If the cylinder bore measures 85.19 mm (3.354″) replace the block.

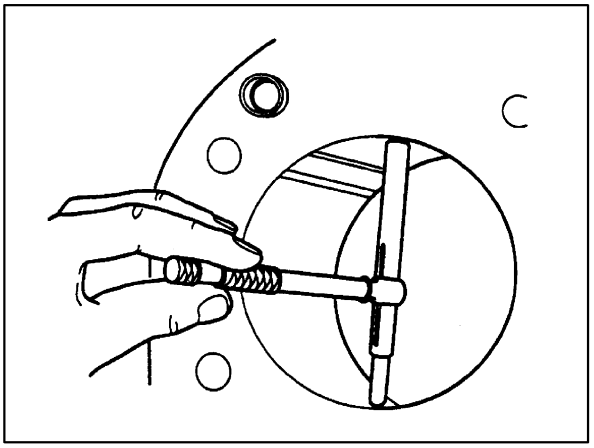

Figure 1-50

PISTONS, PISTON RINGS, AND CONNECTING RODS DISASSEMBLY AND INSPECTION

Pistons

1. Remove the piston rings using a piston ring tool.

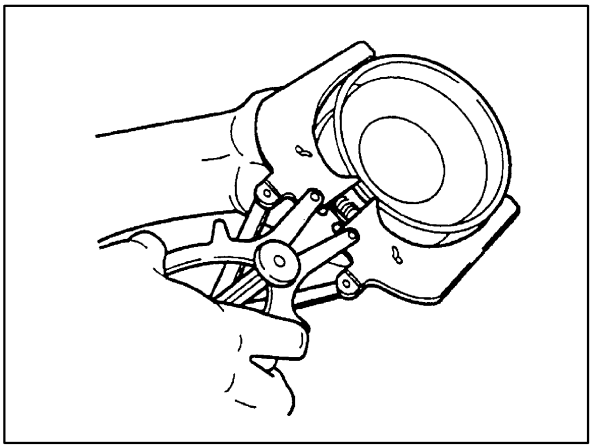

Figure 1-51

2. Remove the wrist pin, 1, retaining rings and drive the wrist pin out of the piston using pin remover Tool No. NH 01585, 2.

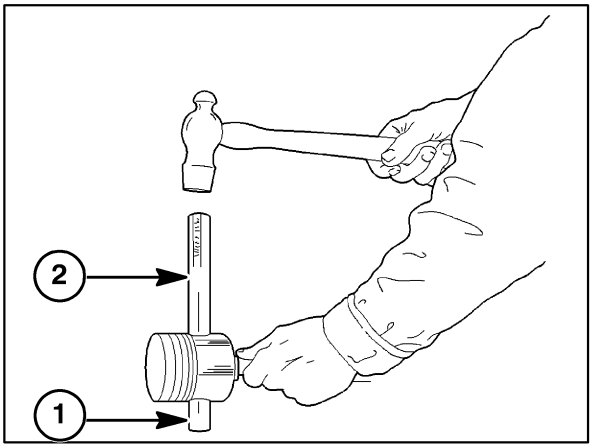

Figure 1-52

3. Wash the pistons and connecting rods in a suitable solvent and air dry.
4. Using a groove cleaner, remove the carbon deposits from the ring grooves. Be careful to avoid cutting any metal from either side or the bottom of the grooves.

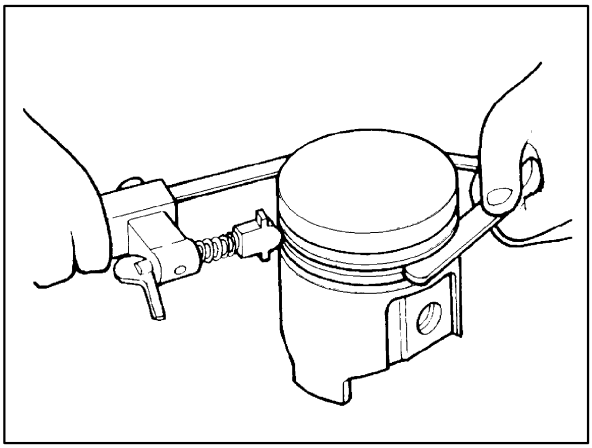

Figure 1-53

5. Inspect the piston ring lands for excessive wear. Use a new ring, 1, and feeler gauge, 2, to check the ring side clearance. Replace pistons having a ring side clearance exceeding the following dimensions:

Compression Ring	Oil Control Ring
0.25 mm (0.010″)	0.15 mm (0.006″)

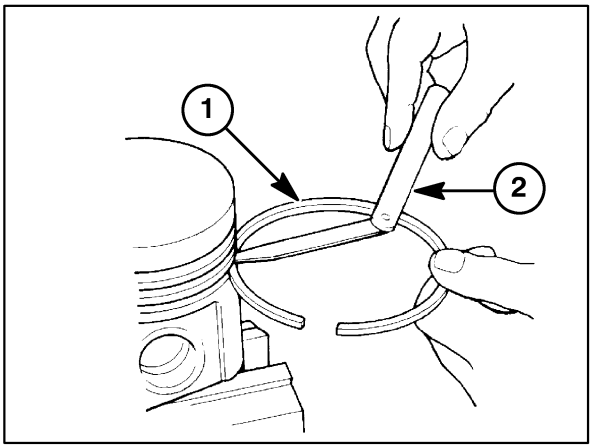

Figure 1-54

6. Using a micrometer, check the piston diameter at 90 degrees from the wrist pin bore. Replace pistons that are worn to less than the following dimensions:

Model	Wear Limit
All	83.7 mm (3.3″)

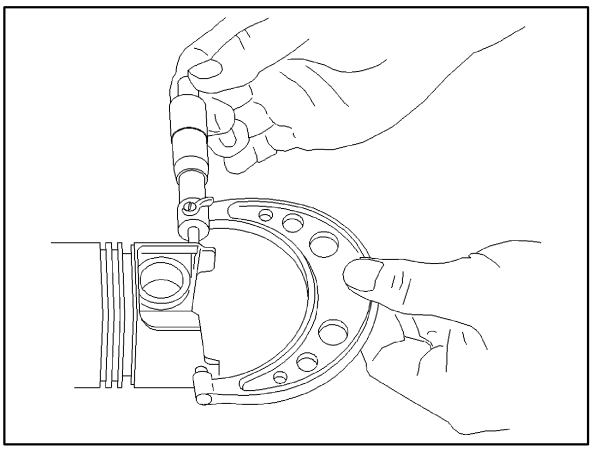

Figure 1-55

7. Using a telescoping gauge and a micrometer, measure the piston pin bore and the wrist pin diameter. Replace piston and/or wrist pins that exceed the following limits:

   Bore Diameter: 28.0 mm (1.102″)

   Pin Diameter: 27.98 mm (1.101″)

   Clearance: 0.02 mm (0.0008″)

   In some instances the wrist pin diameter may be equal to or slightly larger than the wrist pin bore. This interference fit is normal.

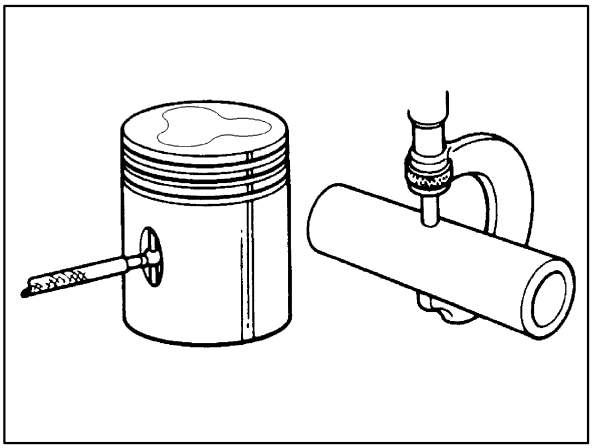

Figure 1-56

Piston Rings

1. Position the piston rings, 1, one at a time, in the cylinder to the lowest point of travel. Use an inverted piston to square the ring in the bore.
2. With a feeler gauge, 2, measure the ring gap.

   The ring is shown at the top of its travel for clarity.
3. Replace worn rings with end gap clearance in excess of 1.0 mm (0.039″).

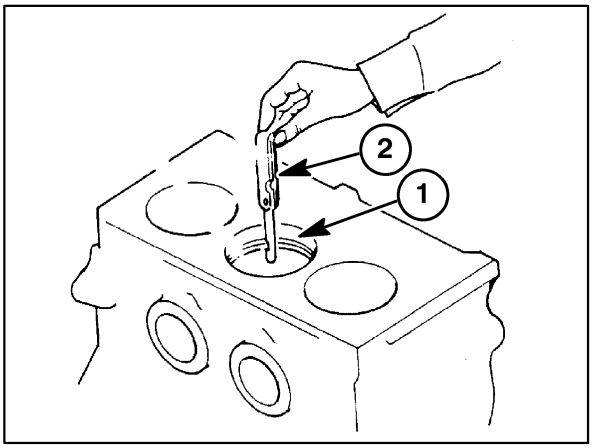

Figure 1-57

Connecting Rods

1. Check the connecting rods for damage and alignment. Place each rod in an alignment fixture to check for bent or twisted condition.
2. Straighten or replace rods that are bent or twisted more than the following dimensions:

   Max. Bend: 0.15 mm (0.0059″) per 100 mm (3.94″)

   Twist: 0.2 mm (0.0078″) per 100 mm (3.94″)

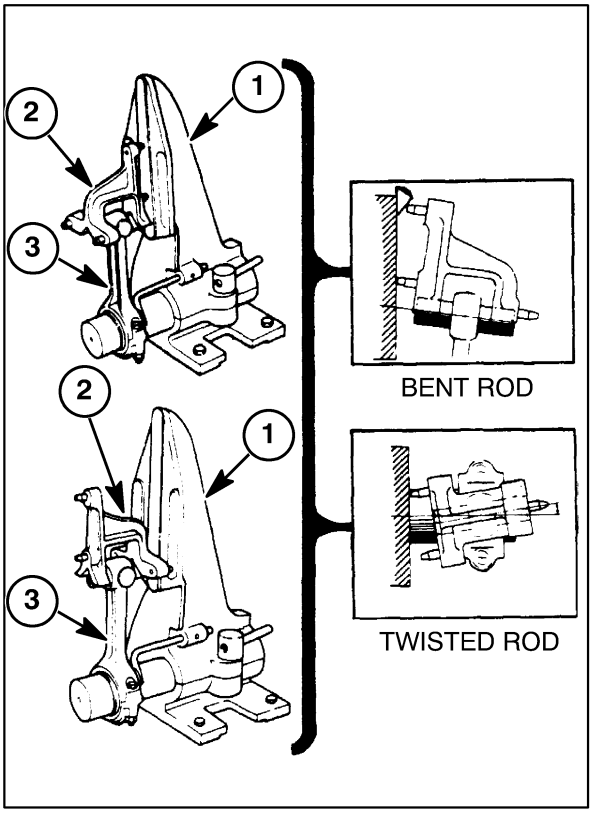

Figure 1-58

1. Alignment Fixture
2. Gauge
3. Connecting Rod

3. Using a telescoping gauge and a micrometer, measure the inside diameter of the connecting rod wrist pin bushing.
4. Replace bushings measuring more than the following:

Model	Max. Inside Diameter
1530	25.0 mm (0.984″)
1630	25.0 mm (0.984″)
1725	25.0 mm (0.984″)
1925	28.08 mm (1.106″)

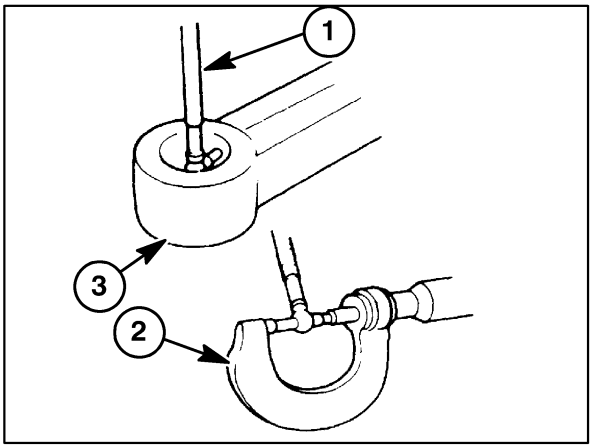

Figure 1-59

1. Hole Gauge
2. Micrometer
3. Connecting Rod

5. Remove and install the connecting rod wrist pin bushings using a suitable driver and press a new bushing into the rod bore.
6. Ream and hone the bushing to the following finish size.

Pin to Bushing Clearance

Std.	Max.
0.010 - 0.025 mm (0.00039″ - 0.00098″)	0.08 mm (0.0031″)

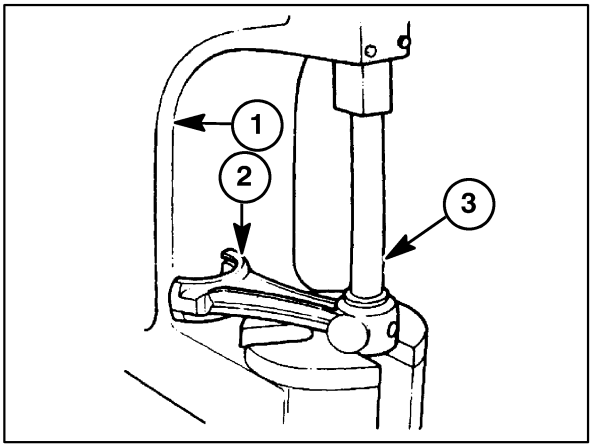

Figure 1-60

1. Press
2. Connecting Rod
3. Bushing Driver

7. When installing a new piston pin bushing, use the hole in the rod and drill a lube hole in the new bushing.

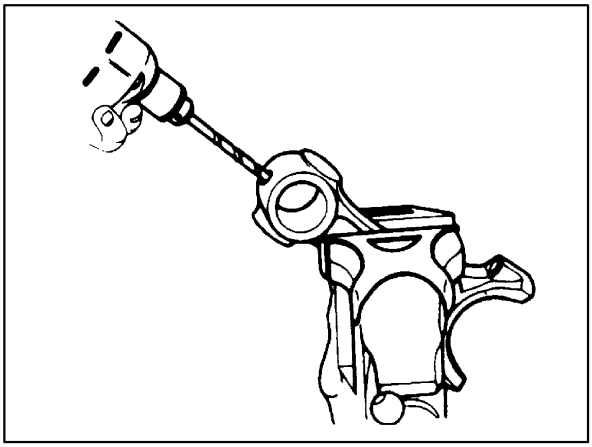

Figure 1-61

8. Install the connecting rod on the crankshaft and measure the play in shaft direction. If the play is more than 0.7 mm (0.028″) replace the connecting rod.

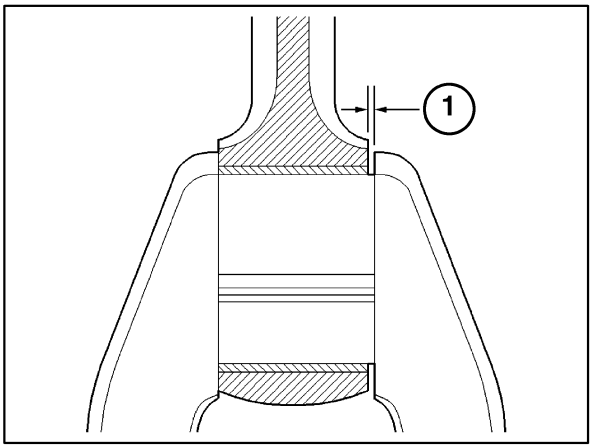

Figure 1-62

1. Side Clearance Check 0.7 mm (0.028″) Max.

Connecting Rod Bearing Oil Clearance Check

1. Remove oil or foreign matter from the bearing and crankshaft.
2. Cut a piece of plastigauge, 1, to the same width as the bearing. Place it on the crankshaft. Avoid the oil hole.
3. Install the rod cap and torque to 49.0 - 53.9 N·m (36.2 - 39.8 ft lbs).
4. Remove the rod cap and measure the width of the flattened plastigauge using the plastigauge scale.
5. The width of the widest flattened plastigauge is the minimum clearance and the width of the narrowest plastigauge is the greatest clearance. Select the proper size bearing liners to obtain the correct clearance. See “Specifications” later in this section.

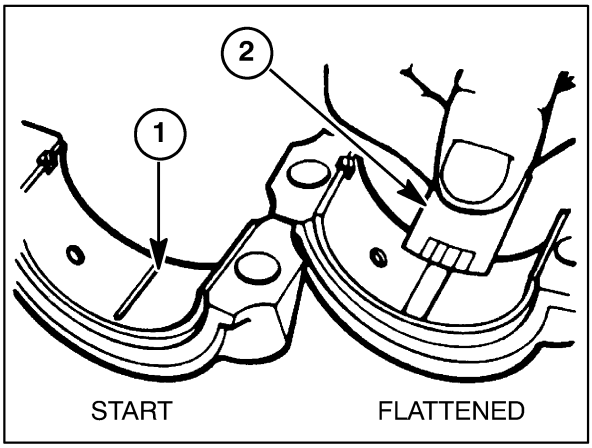

Figure 1-63

1. Plastigauge
2. Bearing Clearing Check

PISTONS, RINGS, AND CONNECTING ROD ASSEMBLY

1. Assemble the pistons and connecting rods with the matching marks, 1, on the rods on the same side as the trade name “SHIBAURA,” 2, embossed on the inside of the piston skirt. Install the piston pin, and retaining rings.

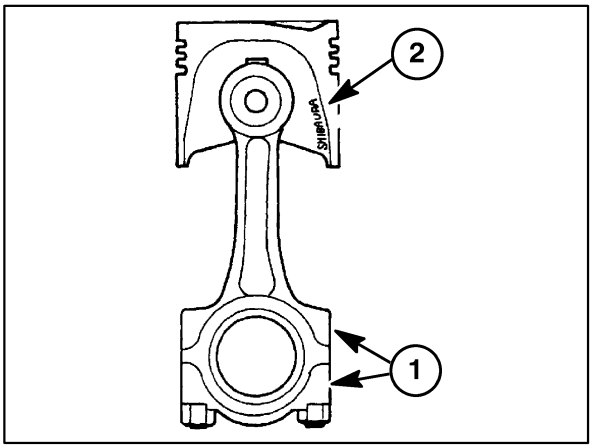

Figure 1-64

2. Using a suitable ring expander tool, install the piston rings positioning the ring gaps at approximately 120 degrees from each other. Install the third (oil ring) first as follows:

   Put the expander ring, 1, into position in its groove.

   Fit the upper side rail, 2, on top of the expander. Insert the end of the side rail into the groove and hold it in position with the thumb. Slide the rail into position with the other thumb.

   Fit the lower side rail, 3, in a similar manner.

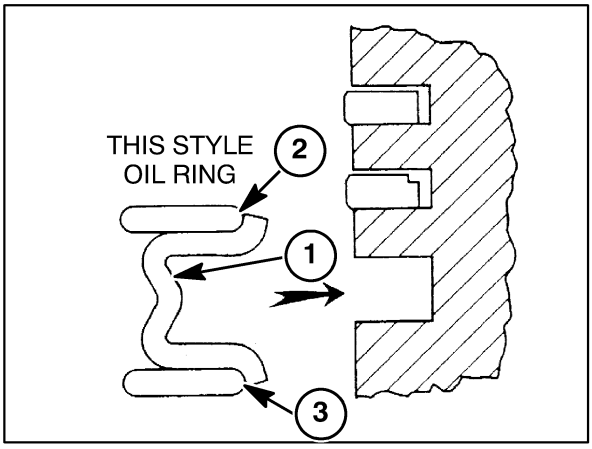

Figure 1-65

CRANKSHAFT

Main Bearing and Thrust Washer Removal and Inspection

1. Remove the two retaining bolts from the bearing holders, 1.
2. Remove the bearing holders and bearing liners, 2.
3. Position a piece of plastigauge across the full width of the bearing liners.
4. Install the bearing holder and tighten the bolts to 49.0 - 53.9 N·m (36.2 - 39.8 ft lbs).

   NOTE: Do not permit the bearing holder to rotate, even the slightest amount.
5. Remove the bearing holders and measure the width of the flattened plastigauge using the gauge printed on the plastigauge package.
6. Replace components or grind the crankshaft to the next oversize bearing as required to obtain the correct clearance. See “Specifications” later in this section.
7. Check the thrust washer for wear, poor contact, burning, or other defects. Using a micrometer measure the washer thickness. If washer thickness is not within allowable limits or found to be defective, the washers must be replaced.

Standard Thickness:	2.95 mm-3.0 mm (0.116″-0.118″)
Allowable Limit:	2.8 mm (0.11″)

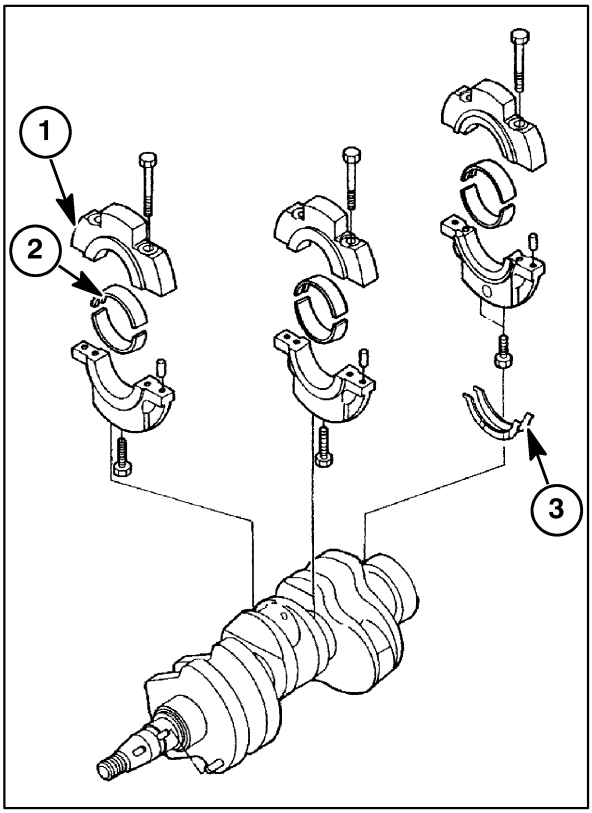

Figure 1-66

1. Holder
2. Main Liner
3. Thrust Bearing

Crankshaft Inspection

1. Inspect the crankshaft gear teeth for wear or damage and replace if necessary.

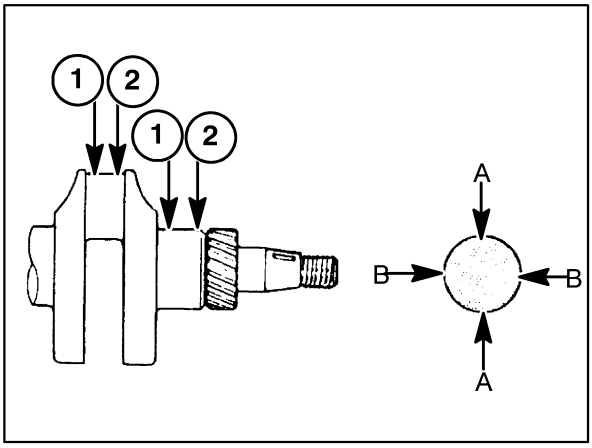

Figure 1-67

A. Taper Readings: 1 vs. 2
B. Out-of-Round Readings: A vs. B