FORD

Service Manual

Tractors
TW-10, TW-20, TW-30

42001030

Reprinted

REPAIR MANUAL
for
TW-10, TW-20 and TW-30
TRACTORS

Ford Tractor Operations

Ford Motor Company

SE 3734

Printed in U.S.A.

FOREWORD

This manual provides information for the proper servicing of the Ford TW-10, TW-20 and TW-30 Tractors. The information is essential for all mechanics and will be especially meaningful to those who have attended the Training Programs for the TW-10, TW-20 and TW-30 Tractors. We recommend therefore, that this manual be readily available for reference at all times.

The manual is grouped into parts, each containing chapter divisions. The chapters contain such information as general operating principles, detailed inspection and repair procedures, and full specifics regarding trouble shooting, specifications, and special tools. Whenever possible, the special tools are illustrated performing their specific operations. Any reference made in the manual to right, left, front, rear, top or bottom, is as viewed facing the direction of forward travel from the driver's seat.

The material contained in this manual was correct at the time the manual was approved for printing. Ford policy is one of continuous improvement and the Ford Motor Company reserves the right to discontinue models at any time or change specifications or design without notice and without incurring obligation.

Ford Tractor Operations
Ford Motor Company

SAFETY PRECAUTIONS

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

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

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PART 1
ENGINE SYSTEM

Chapter 1
ENGINE AND LUBRICATION SYSTEM

1. DESCRIPTION AND OPERATION

The engine described in this manual is a six cylinder diesel "in-line" type with direct fuel injection and overhead valve design. The displacement amounts to 401 cu. in. (6580 cc), the bore to 4.4 in. (111.76 mm) and the stroke to 4.4 in. (111.76 mm). Because of the bore and stroke dimensions it is referred to as a square engine.

This part of the manual deals with the disassembly, inspection, repair, and assembly of the engine, lubrication system and the cooling system.

CYLINDER HEAD ASSEMBLY — INCLUDING VALVE TRAIN COMPONENTS

The cylinder head assembly incorporates the valves, valve springs, and rotators. The valve rocker arm shaft assembly is bolted to the cylinder block, through the head. The intake and exhaust manifolds are bolted to the head. The intake manifold is on the right side of the engine, and the exhaust manifold is on the left side.

Valve guides are an integral part of the cylinder head, and valves with oversize stems are available for service. Special replaceable cast alloy valve seats are pressed into each valve port of the cylinder head. The alloyed steel exhaust valves are fitted with positive valve rotators. Intake valves use umbrella-type seals while the exhaust valves use a square section O-ring. The push rods are high tensile strength steel with oil-cushioned sockets, and locate inside the tappet. The tappets are cast cylindrical, chill-hardened iron. Valve lash is maintained by self-locking adjusting screws.

The camshaft is supported by five replaceable bearings. The camshaft is driven by the camshaft drive gear which is in mesh with the camshaft gear. Camshaft thrust is controlled by a plate secured to the block and located between the camshaft gear and the front journal of the camshaft.

The cylinder head is designed with the entire face flat and uses six evenly spaced headbolts per cylinder. The fuel injectors are mounted outside the rocker cover and the combustion chamber is in the head of the piston.

MANIFOLDS

The aluminum alloy intake and two part cast iron exhaust manifolds are on opposing sides of the cylinder head providing better heat distribution in the head with less heat being transferred to the intake manifold. Tractors are equipped with an exhaust expansion manifold and a vertical exhaust system. The intake manifold is connected through tubing to the air cleaner. The intake manifold is provided with a tapped hole for installation of an ether cold starting air kit. Another tapped hole is provided for the air cleaner restriction gauge.

NOTE: *On tractors where cold start equipment is not fitted, the plug assembled in the manifold should remain securely assembled at all times. Considerable damage to the cylinder bores could result from its absence. The cylinder bores can also be damaged by grit and other foreign matter passing through the air cleaner hose connections if they are not properly secured.*

CYLINDER BLOCK ASSEMBLY

The cylinder block is alloy cast iron with heavy webbing and deep cylinder skirts. The block features full length water jackets for cooling the cylinders. Cylinder arrangement is vertical in-line with the cylinders numbered from 1 to 6, starting at the front of the block. The firing order is 1-5-3-6-2-4.

The oil pan sump is heavy cast iron. The oil filler tube and the dipstick are both located on the right side of the engine.

The oil pan is attached to the bottom of the cylinder block and is the sump for the lubrication system. The engine front cover is attached to the front engine adapter plate forming a cover for the timing gears.

The crankshaft gear is keyed and press fitted on the front of the crankshaft. The crankshaft gear drives the camshaft drive gear which is attached to the front of the cylinder block. The camshaft drive gear drives the camshaft gear and the injection pump drive gear.

The camshaft gear is attached to the front of the camshaft by a bolt, lock washer, a flat washer, and a spacer. The gear is keyed to the camshaft to maintain the position of the gear and drive the shaft.

All the timing gears can be checked by observing the timing punch marks on the gears. The crankshaft is supported in the cylinder block by seven main bearings.

The fifth bearing is a flanged thrust bearing which controls crankshaft end play.

A slinger is machined on the rear of the crankshaft to direct oil away from the rear seal. The rear seal is a circular lip-type rubber seal that fits into a pocket machined into the cylinder block and rear main bearing cap. The cap also has two composition side seals. There is also a rear plate gasket to assist in sealing the rear bearing.

The engine pistons have a continuous skirt around the entire piston. Each piston has three compression rings and one oil control ring, the top compression ring is a keystone ring.

The piston is connected to the crankshaft by a heavy I-beam connecting rod. The crankshaft end of the connecting rod has an insert-type bearing. The piston end of the connecting rod has a replaceable bronze bushing. The piston pin is a free-floating steel pin held in place in the piston by two snap-rings, (circlips).

LUBRICATION SYSTEM

A gear rotor-type oil pump, driven from the crankshaft through an idler gear, is mounted on the front cover plate. It takes oil from the deepest part of the oil pan through an filter screen and pumps the oil into the lubrication system. A spring-loaded relief valve in the pump body limits the maximum pressure in the system by directing excess oil back to the intake side of the pump.

Oil flows from the pump to a replaceable cartridge external filter. A relief valve in the filter permits oil to bypass a clogged filter, thereby maintaining oil flow to the engine at all times.

Oil flows from the filter to the main oil gallery, which runs the length of the cylinder block and intersects the tappet chambers. The main oil gallery also supplies oil to all the crankshaft main bearings and to the connecting rod journals by way of the crankshaft. Camshaft bearings receive oil by means of drilled passages from the main bearings.

The camshaft drive gear bushing is pressure-lubricated through a drilled passage from the front main bearing and has spiral grooves to direct oil toward the outside of the gear. The gear has small oil passages machined on both sides which allows the oil to exhaust. The timing gears are splash-lubricated from the pressure-lubricated camshaft drive gear and the fuel injection pump overflow.

Cylinder walls and pistons are splash-lubricated by the crankshaft on the TW10. Piston pins are splash-lubricated on the TW10; pressure-lubricated on the TW20 and 30 tractors. An intermittent flow of oil is fed to the valve rocker arm shaft assembly through a drilled passage in the cylinder block at the No. 1 camshaft bearing which indexes with a hole in the cylinder head. From the head, the oil flows up around the No. 1 rocker arm support bolt to the rocker shaft. The oil from the shaft flows through drilled holes in each rocker arm to lubricate the valve end and the adjusting screw end of the rocker arm. Oil from the ball ends of the rocker arms flows down the push rods and assists in lubricating the tappets and push rods. Excess oil drains into the push rod chamber through the push rod holes in the cylinder head and then back to the oil pan sump through cored openings in the block.

A heat exchange manifold is mounted on the left side of the engine block. The engine oil is cooled by water as it is pumped through the exhange manifold. Two screw-on oil filters attached to the manifold filter the engine oil.

2. CYLINDER HEAD, VALVES AND RELATED PARTS

The cylinder head can be removed from the engine for service with the engine installed in the tractor.

A. REMOVAL

1. Remove the pre-cleaner and the fuel tank cap.

2. **TW10 and 20:**
   Remove the two side panels, three radiator grille panels and the hood panel, Figure 1.

3. **TW10:**
   Muffler — Unbolt the muffler pipe from the exhaust manifold and remove the muffler, muffler support bracket and muffler pipe from the tractor.

   Air Cleaner — Remove the air intake pipe at the intake manifold and at the radiator bracket flange and remove from the tractor.

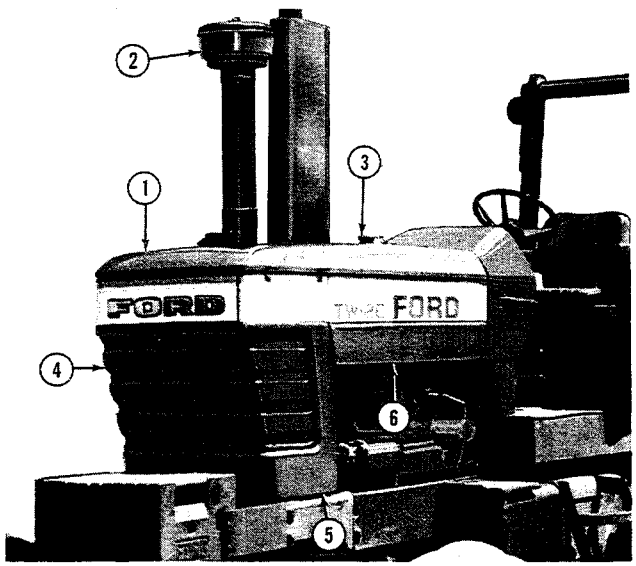


Figure 1
Sheet Metal

1. Hood Panel
2. Pre-Cleaner
3. Fuel Cap
4. Front Grille
5. Side Grille
6. Side Panel

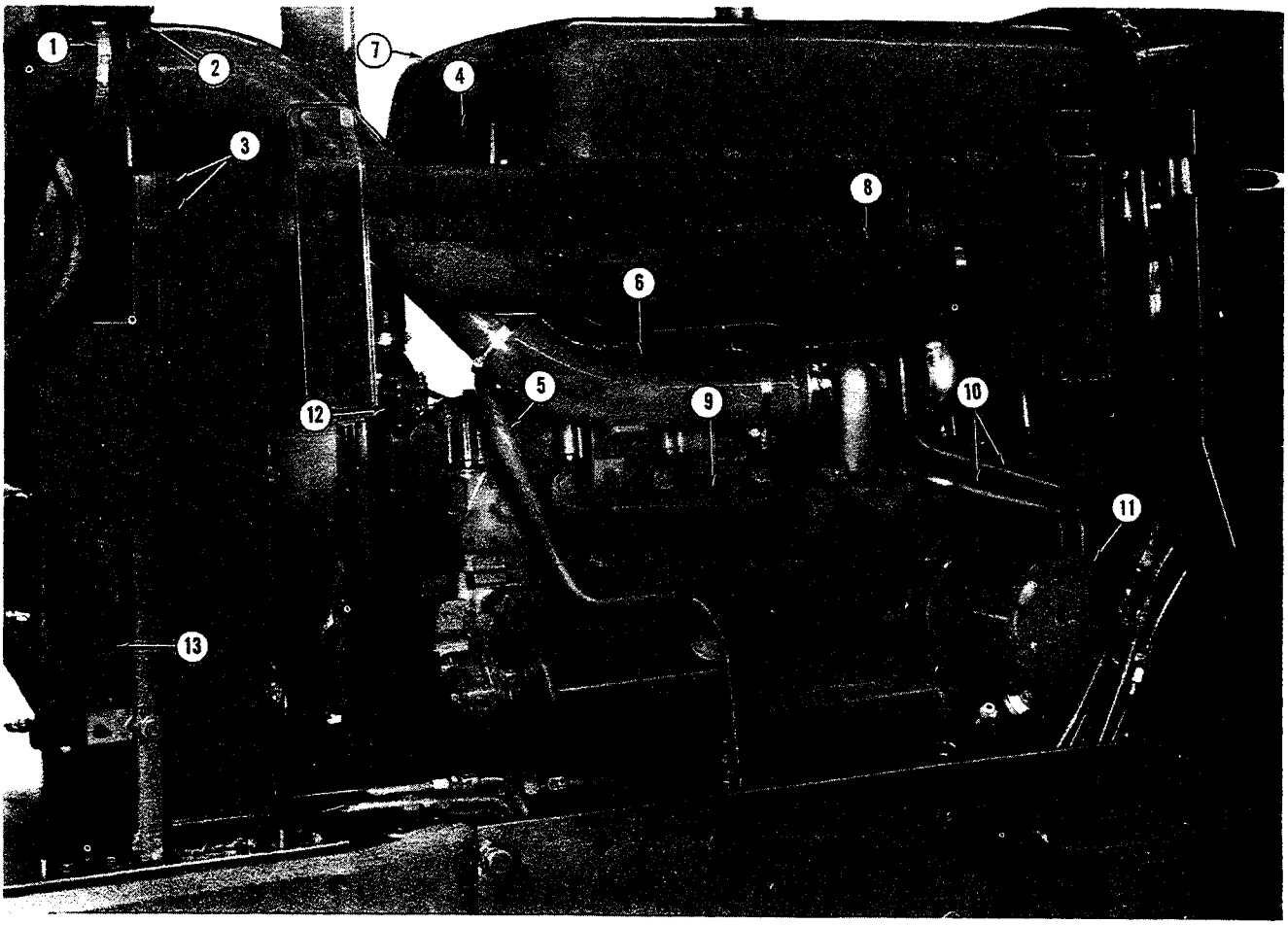


Figure 2
Access to Engine

1. Air Cleaner Clamp
2. Flange Bolts
3. Fuel Tank Bracket Bolts
4. Muffler Support Bracket
5. Breather Tube
6. Turbo-to-Muffler Tube
7. Main Fuel Tank
8. Air Intake Tube
9. Exhaust Manifold
10. Turbo Lube Tubes
11. Engine Oil Filter (Spin-On)
12. Thermostat Housing
13. Hydraulic Oil Cooler

TW20:
Muffler — Remove the muffler. Remove the heat shield from the muffler-to-turbocharger tube. Remove the tube, Figure 2.

Air Cleaner — Remove the air intake pipe from the turbocharger to the radiator support. Remove the intake manifold hose, Figure 3.

Turbocharger — Remove the turbocharger oil lines. Remove the 4 bolts attaching the turbocharger to the exhaust manifold. Remove two turbocharger oil cooler bracket bolts. Remove the turbocharger. Plug all turbocharger openings to prevent the entry of dirt. See Figure 2.

4. **TW 10 and 20:**
   Shut off the fuel at the main fuel tank, Figure 3.

5. Disconnect the wiring harness at the alternator and air intake sensor. Remove the harness from the fuel tank bracket.

6. Remove eight bolts that attach the main fuel tank support brackets to the tractor, Figure 3.

7. Using a sling, remove the fuel tank and brackets from the tractor, Figure 4.

8. Remove the fan brace.

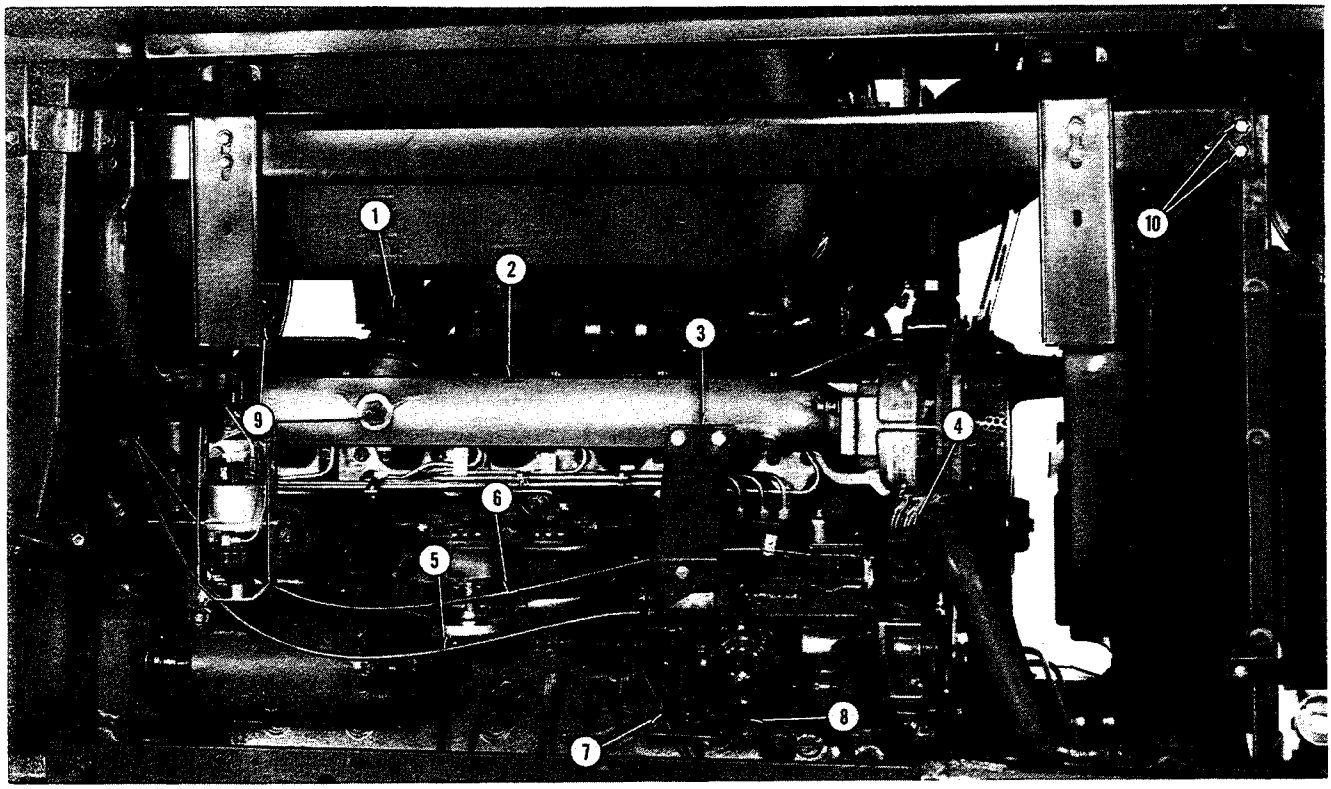


Figure 3
Engine Access (TW20)

1. Intake Manifold Hose
2. Intake Manifold
3. Support Bracket
4. Oil Filler Cap
5. Fuel Shut-Off Cable
6. Throttle Cable
7. Engine Oil Dipstick
8. Fuel Line
9. Fuel Shut-Off Valve
10. Fuel Tank Support Bolts

TW30:

1. Remove the two side panels, grille and hood panel, Figure 5.

   Air Cleaner — Remove 4 mounting bolts, aspirator hose and air cleaner to turbocharger tube. Remove the air cleaner, Figure 6.

   Intercooler — Remove the grille support (11), Figure 6. Remove the air cleaner-to-turbo tube and hose. Disconnect the intercooler-to-turbo tube. Disconnect the aspirator hose. Remove the intercooler assembly (8 bolts).

   Turbocharger — Remove the exhaust hose clamp. Remove the air intake clamp. Remove two oil tubes. Remove the turbocharger assembly (6 bolts). See Figure 7.

2. Remove the intercooler support bracket at the rear of the engine, Figure 8.

3. Remove the support bracket, fan and alternator bracket and water pump as required, Figure 9. Remove the water hoses.

ALL TRACTORS

4. Remove the 12 exhaust manifold bolts, the exhaust manifold and gasket.

5. Remove the cold start (ether) unit and the fuel delivery lines. Plug the fuel line, injector and fuel pump openings to prevent the entry of dirt.

6. Remove 14 intake manifold bolts, the intake manifold and gasket, Figure 3.

7. Remove the breather tube from the rocker cover.

8. Drain the engine coolant.

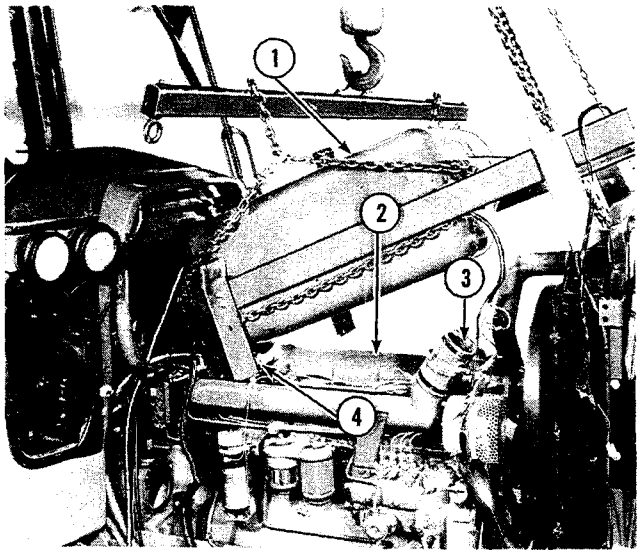


Figure 4
Access to Cylinder Head

1. Main Fuel Tank
2. Valve Cover
3. Intake Manifold Air Inlet
4. Fuel Shut-Off Valve

9. Remove the fuel filters and lines from the engine. Plug all openings to prevent the entry of dirt.

10. Remove the rocker arm cover and gasket.

11. Remove the injector leak-off line at No. 6 cylinder.

12. Remove the two nuts from each injector. Remove the injectors. If the injectors cannot be removed by hand it may be necessary to pry them out. Keep the area clean to avoid fouling the injectors with dirt.

13. Visually check the push rods for straightness by rotating them with the valve closed. Loosen the rocker arm shaft bolts evenly and remove the assembly from the tractor, Figure 10.

    NOTE: *Do not remove the rocker arm shaft retaining bolts unless it is necessary to disassemble the rocker arm shaft.*

14. Remove the valve push rods from their holes in the cylinder head and arrange them in a rack in the order in which they were removed. It is important that the rods are installed in the same bores during reassembly.

15. Loosen and remove the cylinder head retaining bolts evenly, working from the ends to the center of the head, and carefully lift the cylinder head from the block.

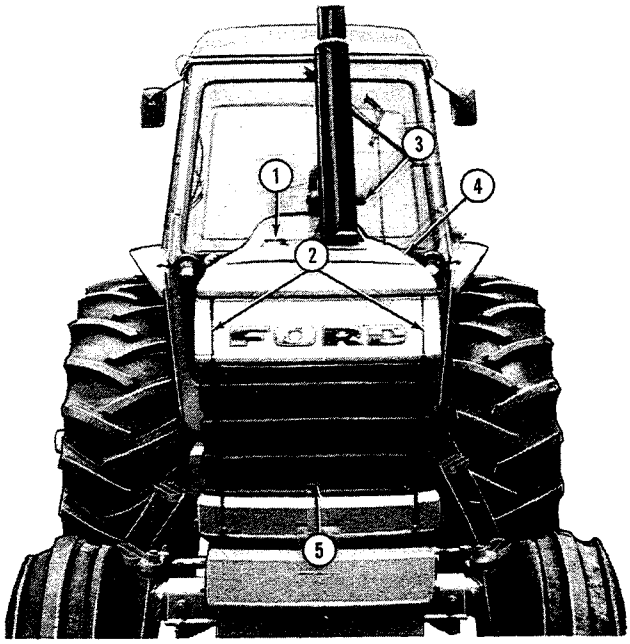


Figure 5
Sheet Metal (TW30)

1. Fuel Tank Cap
2. Side Panels
3. Pre-Cleaner
4. Hood Panel
5. Grille

B. DISASSEMBLY

1. Before removing the valves from the cylinder head, clean all carbon deposits from the valve heads.

2. Position the valve spring compressor over the valve and spring, as shown in Figure 11, and compress the spring.

   Intake Valves: Remove the retainer locks, spring retainer, spring, and valve stem seal. The parts are shown in Figure 11.

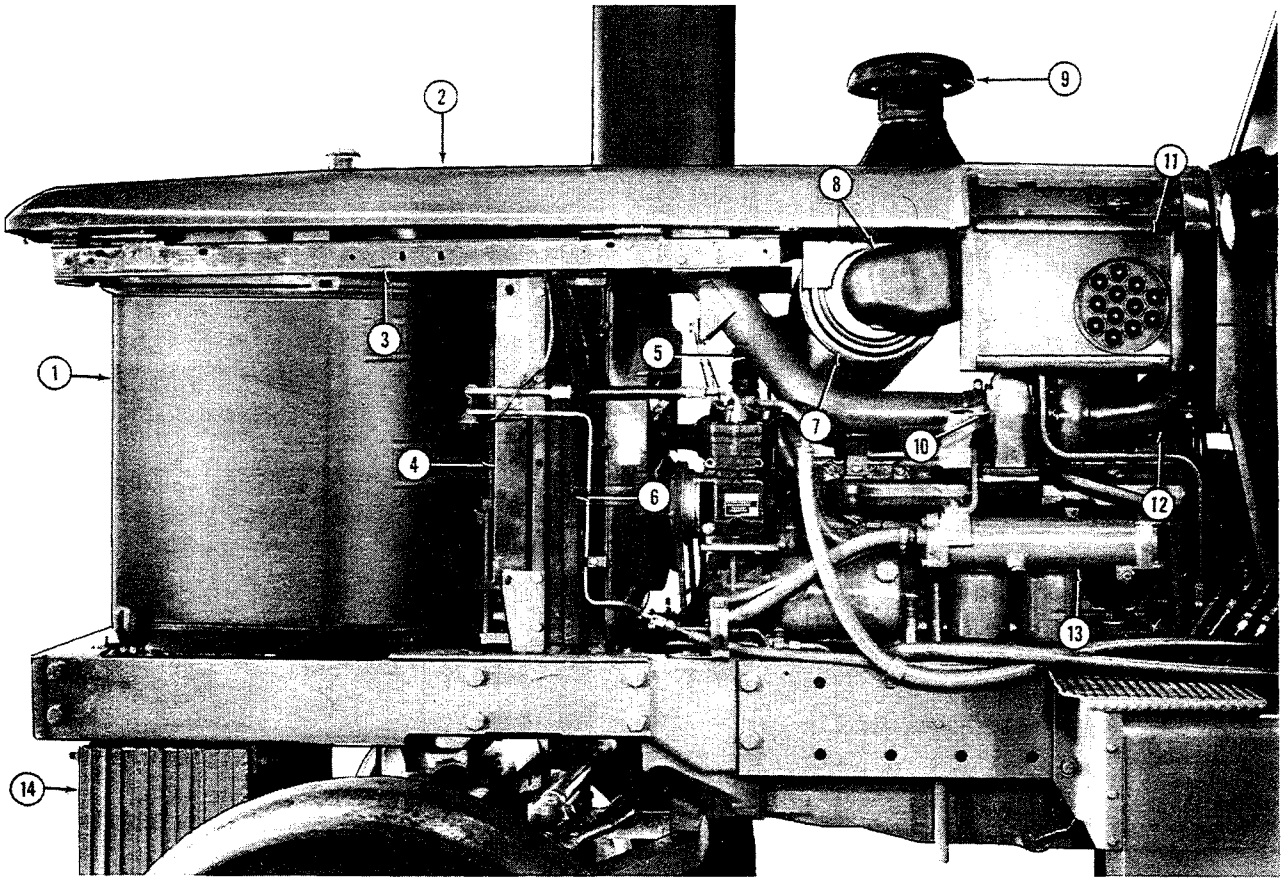


Figure 6
Engine Access (TW30)

1. Fuel Tank
2. Hood Panel
3. Side Panel Rail
4. Oil Cooler
5. Turbo Exhaust Tube
6. Radiator
7. Air Cleaner
8. Air Cleaner-to-Intercooler Tube
9. Pre-Cleaner
10. Tubrocharger
11. Grille Support (Intercooler)
12. Intercooler-to-Turbo Tube
13. Engine Oil Filter
14. Front Weights

Exhaust Valves: Remove the retainer locks, the seal from its groove, and the valve rotator and spring. The parts are shown in Figure 13.

3. Lift the valves from the cylinder head and place them in a numbered rack so they can be reinstalled in their respective guides. Keep the exhaust valve rotators with the valves from which they were removed.

C. CLEANING

1. After the valves are removed, clean the valve guide bores with a valve guide cleaning tool.

2. Remove all dirt, grit, and grease from the cylinder head with cleaning solvent.

NOTE: *Be sure to remove any injector washers that may have remained in the bores.*

D. INSPECTION AND REPAIR

1. Inspect the cylinder head for cracks, nicks, or burrs. Install a new head if necessary. Remove all burrs or nicks from the gasket surface.

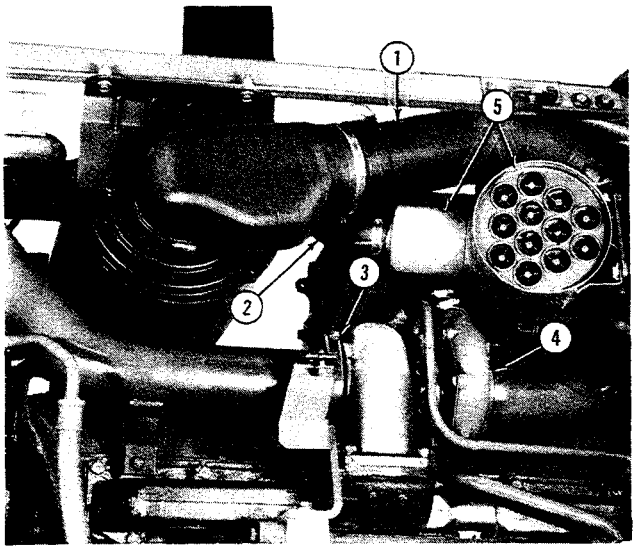


Figure 7
Turbocharger and Intercooler

1. Air Cleaner-to-Turbo Tube
2. Aspirator Tube
3. Exhaust Clamp and Tube
4. Air Cleaner-to-Turbo Tubes and Clamps
5. Intercooler

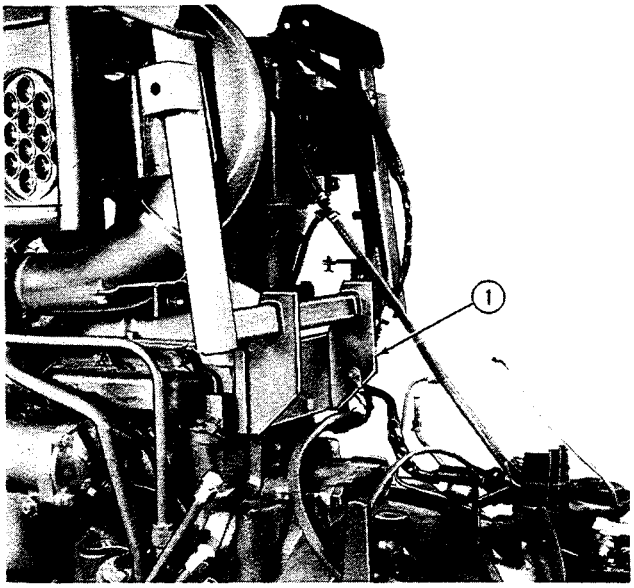


Figure 8
Engine Access

1. Intercooler Support Bracket

2. With a straight edge and feeler gauge, check the flatness of the cylinder head, as shown in Figure 14. Specifications for flatness are 0.006 in. (0.15 mm) maximum overall, or 0.003 in. (0.76 mm) in any six inches (152.40 mm).

NOTE: *If the cylinder head face is not within the flatness specification, it may be skimmed providing the depth from the lower face of the valve seat insert to the cylinder head face after skimming is not less than 0.117 in. (2.97 mm).*

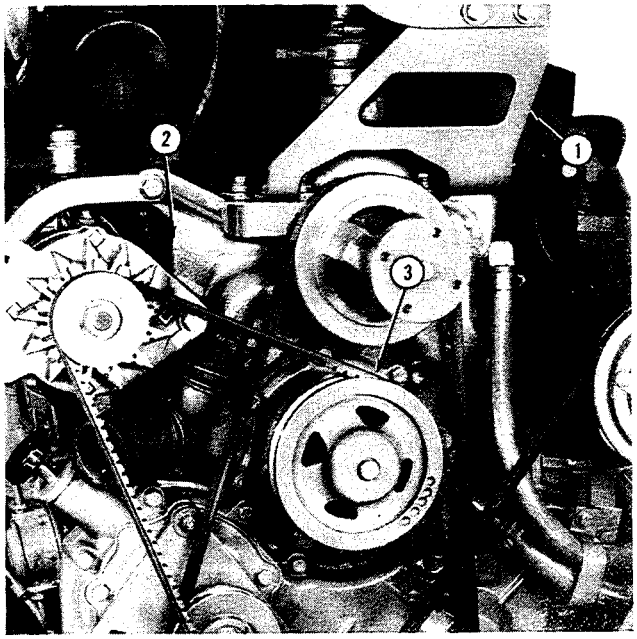


Figure 9
Engine Access

1. Bracket
2. Fan and Alternator Bracket
3. Water Pump

3. If the head has been skimmed, determine that all the head bolts will bottom. Place the cylinder head, less gasket, on the block and install and finger tighten all the head bolts (rocker arm shaft supports and washers should be used under the long bolts). Using a feeler gauge, check the clearance between the underside of the head bolts and the cylinder head rocker arm support. If the clearance is 0.010 in. (0.254 mm) or greater for any bolt, use a 1/2" x 13 UNC-2A thread tap and increase the tap depth. The head bolts should be marked so they are reinstalled in the hole which they were checked.

IMPORTANT: *Valve seat inserts of 0.010 in. (0.254 mm) and 0.020 in. (0.508 mm) oversize diameter have been fitted to some cylinder heads in production. Heads having oversize inserts fitted are stamped with the following identification marking S010 OS and S020 OS on the exhaust manifold side of the cylinder head in line with the valve seat.*

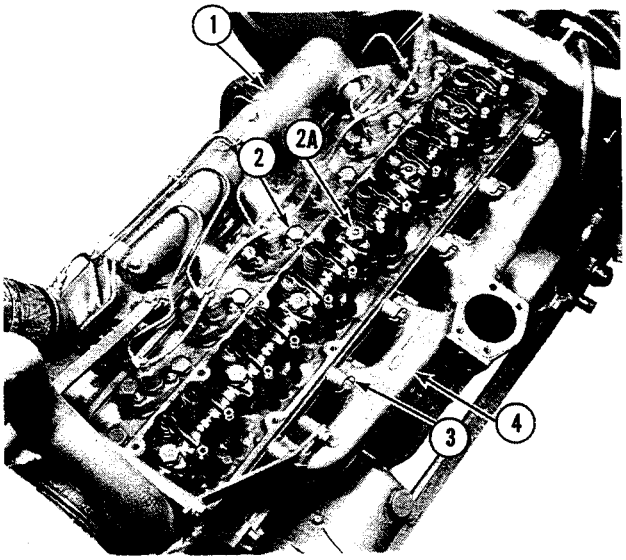


Figure 10
Top View of Engine

1. Intake Manifold
2. Head Bolt
2A. Head/Rocker Arm Bolt
3. Lock Tab
4. Exhaust Manifold

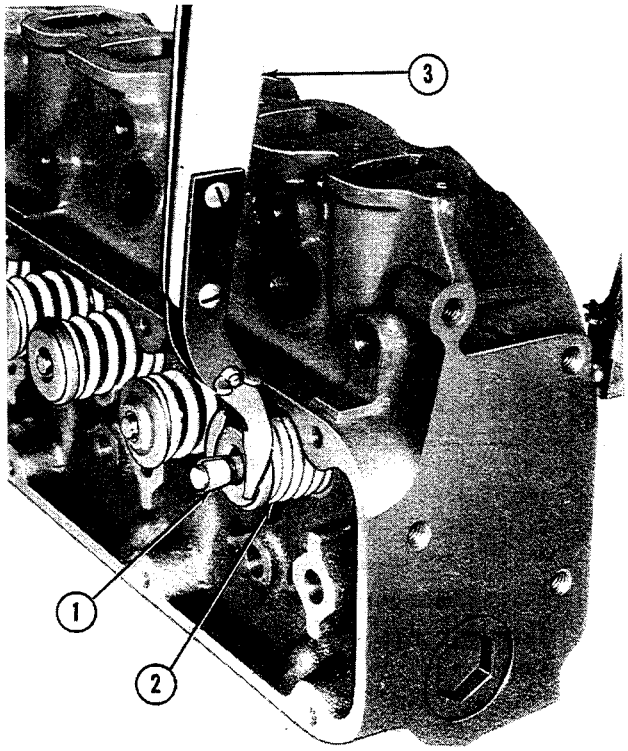


Figure 11
Removing Valves

1. Retainer Locks
2. Valve Spring
3. Valve Spring Compressor

4. The intake and exhaust valve ports in the cylinder head are equipped with removable valve seat inserts. Remove and replace inserts that are cracket or loose, or that show excessive wear.

5. To install a larger insert than originally fitted, machine the counter bore for the seat in the cylinder head to the dimensions in Table 1, page 12. The insert must be thoroughly chilled in dry-ice before installation.

6. Measure the width of the valve seats, Figure 15, and reface the seats if they do not meet the specifications shown in Figure 17.

7. Measure the concentricity of the valve seat with a suitable gauge, as shown in Figure 16, or with Prussian Blue. If the valve seat runout exceeds .0015 in. (.0381 mm) reface the seat.

   NOTE: *Reface the valve seat and face at the same time so the finished measurements correspond to Figure 17.*

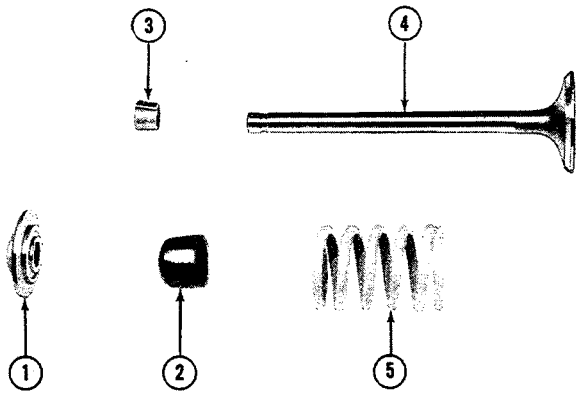


Figure 12
Intake Valve Assembly

1. Retainer
2. Seal (TW10 Only)
3. Retainer Locks
4. Intake Valve
5. Spring

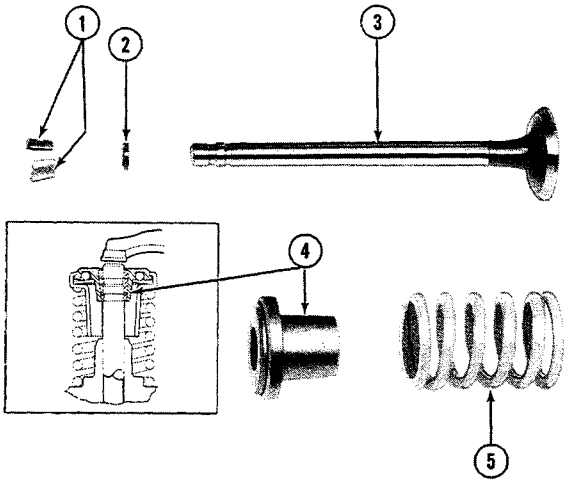


Figure 13
Exhaust Valve Assembly

1. Retainer Locks
2. Seal
3. Exhaust Valve
4. Rotator
5. Valve Spring

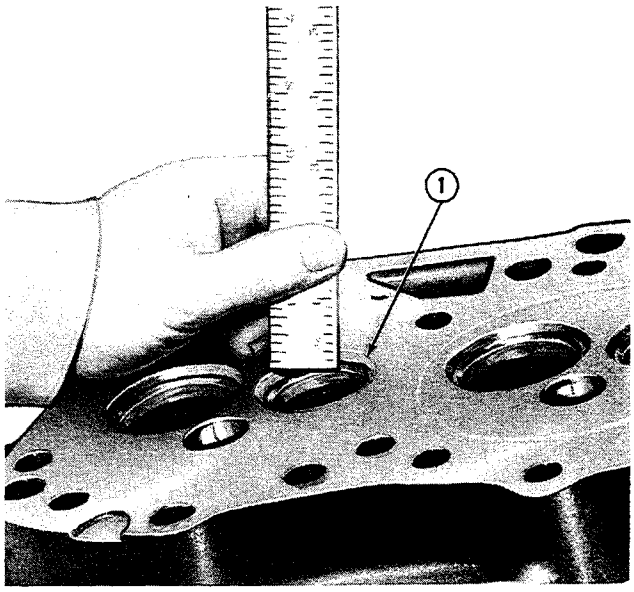


Figure 15
Measuring Valve Seat Width

1. Valve Seat

Remove only enough stock from the seat to clean up the pits and grooves, or to correct the seat runout. After refacing, the seat should measure 3/32 in. (2.38 mm) ± 1/64 in. (0.40 mm). If the refaced seat exceeds this width, narrow the seat by removing stock from the top or bottom of the seat. See Step 8. If the seat measures less than this width, widen the seat.

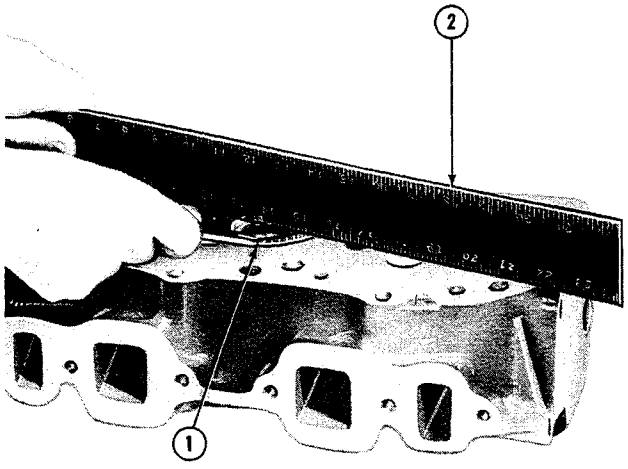


Figure 14
Measuring Cylinder Head Flatness

1. Feeler Gauge
2. Straight Edge

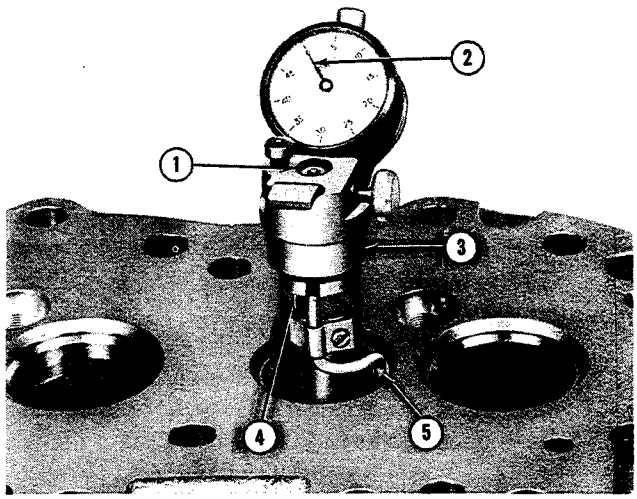
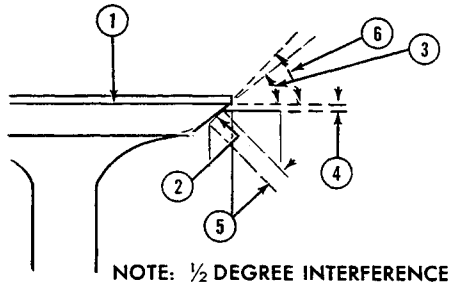


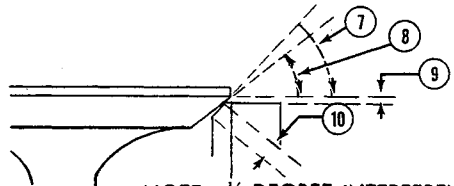
Figure 16
Checking Valve Seat Concentricity

1. Tighten Pilot
2. Set Dial at "0"
3. Valve Seat Concentricity Gauge
4. Rotate Sleeve Clockwise and Read Dial
5. Set Point to Ride on Valve Seat Face



NOTE: ½ DEGREE INTERFERENCE ANGLE BETWEEN VALVE SEAT AND FACE

FORD TW 10 INTAKE AND EXHAUST VALVES
FORD TW 20 AND 30 EXHAUST VALVES



FORD TW 20 AND 30 INTAKE VALVES

NOTE: ½ DEGREE INTERFERENCE ANGLE BETWEEN VALVE SEAT AND FACE

Figure 17
Valve Face and Seat Angles

1. Valve Face
2. Valve Seat
3. Valve Face Angle — 44-1/2°
4. 1/32" (.79 mm)
5. Seat Width 3/32" (2.38 mm)
6. Valve Seat Angle — 45°
7. Valve Seat Angle — 30°
8. Valve Face Angle — 29-1/2°
9. 1/16" (1.59 mm)
10. Seat Width—3/32" ± 1/64" (2.38 ± .40 mm)

8. Rotate a new or refaced valve lightly in the seat, using Prussian Blue. If the blue is transferred to the valve face 1/16 in. (1.59 mm) below the upper edge of the valve face, the contact is satisfactory. If the blue is transferred to the valve face above or below this point, raise or lower the seat as follows.

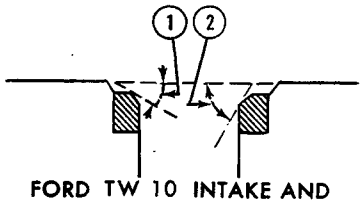
   FORD TW10 INTAKE, FORD TW20 AND TW30 EXHAUST VALVES

   Lower the valve seat by removing stock from the top of the seat with a 30° grinding wheel. Raise the seat by removing stock from the bottom of the seat with a 60° grinding wheel. See Figure 18.

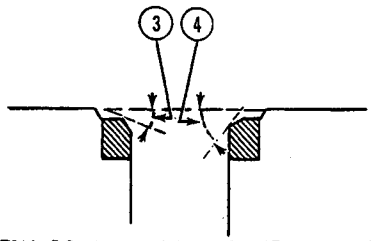
FORD TW20 AND 30 INTAKE VALVES

Lower the valve seat by removing stock from the top of the seat with a 15° grinding wheel. Raise the seat by removing stock from the bottom of the seat with a 45° grinding wheel. See Figure 18.

IMPORTANT: Some cylinder heads may have one or more 0.003 in. (.0762 mm) or .015 in. (0.381 mm) oversize valve guides and valves installed. The exhaust manifold side of the cylinder head opposite these valves will be stamped "03" or Y003 OS; "15" or V015 OS as appropriate.



FORD TW 10 INTAKE AND EXHAUST VALVES,
FORD TW 20 AND 30 EXHAUST VALVES



TW 20 AND 30 INTAKE VALVES

Figure 18
Dressing Valve Seats

1. 30°
2. 60°
3. 15°
4. 30°

9. Valve stem-to-guide clearance tolerances are as follows. Intake valves, 0.0010-0.0045 in. (0.0245-0.114 mm); exhaust valves, 0.0020-0.0055 in. (0.0508-0.0139 mm).

   Measure stem-to-guide clearance with a telescoping gauge and micrometer, Figure 20. If not within tolerances, or if excessive oil consumption is indicated, replace the affected guides.

   Valves with oversize stems are available for service. If it is necessary to ream valve guides to in-

stall valves with oversize stems, use Valve Reamer Kit, SW502, and ream guides in steps, first using the small reamer and standard diameter pilot. The kit contains the following reamer and pilot combinations.

Reamer Diameter	Pilot Diameter
0.003 in. (0.0762 mm) oversize	Standard Diameter
0.015 in. (0.3810 mm) oversize	0.003 in. (0.0762 mm) oversize
0.030 in. (0.7620 mm) oversize	0.015 in. (0.3810 mm) oversize

NOTE: *Always reface the valve seat after reaming the valve guide.*

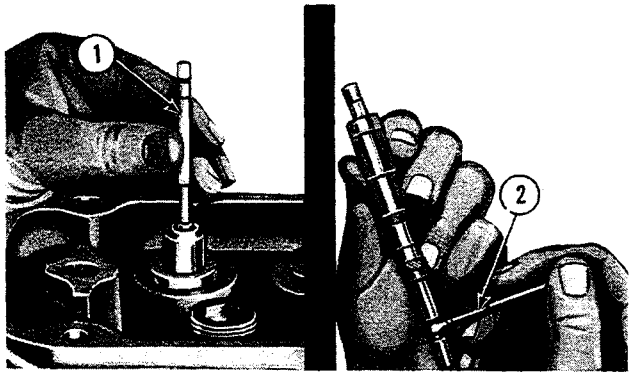


Figure 19
Measuring Valve Guide

1. Telescope Gauge
2. Micrometer

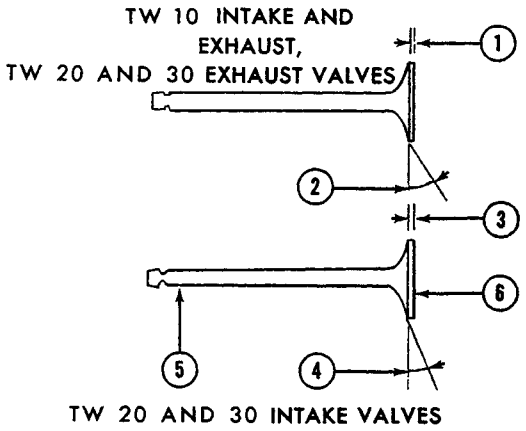


Figure 20
Critical Valve Measurements and Inspection Checks

1. 1/32" (.79 mm) Minimum
2. 44-1/2°
3. 1/16" (1.58 mm)
4. 29-1/2°
5. Check for Bent Stems and Correct Diameter
6. Check Maximum Valve Face Run-Out

TABLE 1

Insert Oversize	Exhaust Valve Insert	Intake Valve Seat Insert
	Counterbore Diameter in Cylinder Head	
0.010 in. (0.254 mm)	1.607/1.608 in. (40.82/40.84 mm)	1.907/1.908 (43.44/43.46 mm)
0.020 in. (0.508 mm)	1.617/1.618 in. (41.07/41.10 mm)	1.917/1.918 (43.69/43.72 mm)
0.030 in. (0.762 mm)	1.627/1.628 in. (41.33/41.36 mm)	1.927/1.928 (43.95/43.97 mm)

VALVES AND PUSH RODS

A. INSPECTION

The critical inspection points of the valves are shown in Figure 17. Inspect the valve face and the edge of the valve head for pits, grooves, scores, or other defects. Inspect the stem for a bent condition and the end of the stem for grooves or scores. Check the valve head for cracks, erosion, warpage, or burn. Minor defects such as small pits or grooves, can be removed. Check the valve tip for pits or grooves and replace the valve if such a condition exists. Discard valves that are severely damaged.

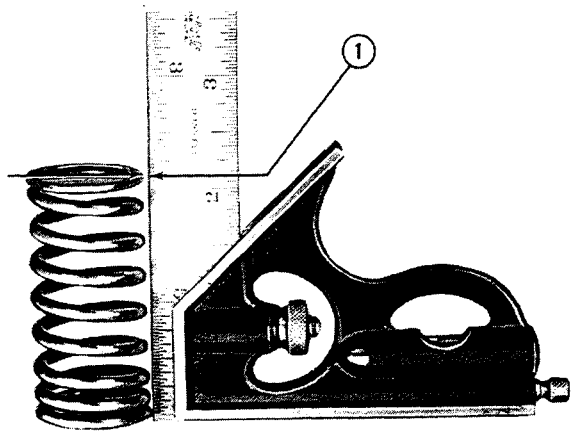


Figure 21
Checking Valve Spring Squareness

1. Not More Than 1/16" (1.59 mm)

Discard any valve springs that show signs of erosion or rust. Check each valve spring for squareness, such as shown in Figure 21. Discard valve springs that are out of square in excess of 1/16 in. (1.59 mm).

Check specified free length and loaded height of the valve springs. Weak valve springs cause poor engine performance. If the free length is less than 2-5/32 in. (54.8 mm), add one 0.030 in. (0.76 mm) spacer between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended dimensions of 2-1/8 in. - 2-3/16 in. (53.9-55.6 mm).

Check the valve spring retainer locks to be sure they are in good condition. Rotate the exhaust valve positive rotator to be sure it is not binding or excessively worn. Install new rotators if necessary.

Check the ends of the push rods for nicks, grooves, roughness, or excessive wear. If the push rods were not straight when checked in Step 19 of "Removal," or if any of the above wear conditions exist, install new rods. Do not attempt to straighten push rods.

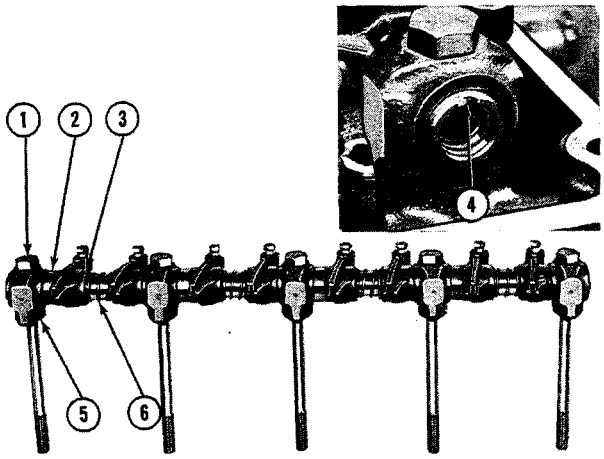


Figure 22
Rocker Arm Shaft

1. Bolt
2. Spacer
3. Rocker Arm
4. Notch
5. Rocker Arm Shaft Support
6. Spring

B. REFACING VALVES

The valve refacing operation should be closely coordinated with the valve seat refacing operating so the finished angle of the valve is 1/2° less than the valve seat to provide an interference angle for better seating, Figure 17. Adjust the refacing tool to obtain a face angle of 44-1/2° or 29-1/2° as shown in Figure 18.

Remove only enough stock to clean up the pits and grooves. Check the edge of the valve head, if less than 1/32 in. (0.79 mm) margin, install a new valve, Figure 22.

Remove all grooves or score marks from the valve tip, then chamfer as necessary. Do not remove more than 0.010 in. (0.25 mm) from the tip.

ROCKER ARMS AND SHAFT

A. DISASSEMBLY

To disassemble the rocker shaft assembly, remove the bolts that attach the rocker shaft to the cylinder head from the rocker shaft supports, Figure 22.

B. INSPECTION

1. Inspect the rocker arm adjusting screws and the push rod ends of the rocker arms for stripped or worn threads.
2. Check the ball end of the screws for nicks, scratches, or excessive wear.
3. Check the rocker arm locating springs and spacers for breaks or other damage.
4. Inspect the pad and insert end of the rocker arm for roughness or grooves, or excessive wear. If any of the above conditions exist, install new parts.
5. Check the rocker arm and rocker shaft diameters. If the diameter exceeds the specifications, page 86, install a new part. If the shaft meets specifications, clean it thoroughly in solvent. Make sure the oil passages are clean of obstructions.

C. INSTALLATION

1. Reassemble the rocker arm and shaft assembly as shown in Figure 22.
2. Coat the rocker arm shaft with engine oil prior to assembly. Lubricate the valve pads on all rocker arms.
3. The rocker shaft has an identification groove at one end of the shaft. Position the mark upward and use this end as the front of the shaft. This puts the oil holes and grooves in the shaft facing down.
4. Start reassembly from the rear of the shaft by first positioning a rocker arm support with the notch on the support to the right of the shaft facing forward.
5. Be sure the springs and spacers are in their correct position, as shown in Figure 23, then proceed with the assembly.

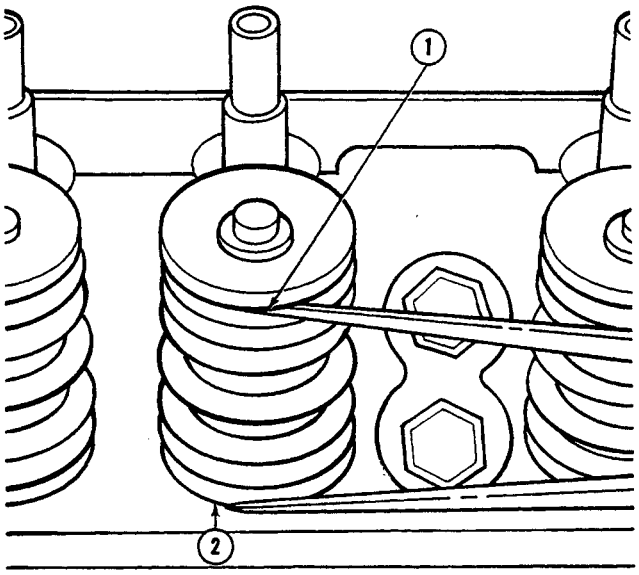


Figure 23
Checking Valve Spring Assembled Height
1. Underside of Spring Retainer
2. Surface of Spring Pad

CYLINDER HEAD

A. ASSEMBLY

1. Insert each valve in the guide bore from which it was removed and lap it in position to give an even seat around the valve. On completion of this operation remove the valve and carefully clean the lapping compound from the valve seat and seat insert.
2. Lubricate all moving parts with engine oil prior to installation. Refer to Figures 12 and 13 for reference to parts of the intake and exhaust valves.
3. Insert each valve in the guide bore from which it was removed or to which it was fitted. Position a new valve seal over each intake valve (on the TW10 only) and guide.
4. Install the valve springs over the valve guides.

5. On intake valves, compress the springs and spring retainer as shown in Figure 12, and install the retainer locks. On exhaust valves, compress the spring and the valve rotator. Be sure to install the rotator onto the valve from which it was removed.

6. On exhaust valves install the new sealing ring into the second groove from the top of the valve stem and install the retainer locks.

CHECKING VALVE SPRING ASSEMBLED HEIGHT

Measure the assembled height of the valve spring from the surface of the cylinder head spring pad to the underside of the spring retainer. Use dividers, Figure 23.

If the assembled height is greater than the specified limit, install .030 in. (0.76 mm) spacers between the cylinder head spring pad and the valve spring to bring the assembled height to the recommended dimension, listed below.

NOTE: *Do not install spacers unless necessary. Use of spacers in excess of recommendations will result in overstressing the valve springs and overloading the camshaft lobes.*

VALVE SPRING ASSEMBLED HEIGHT —
1-23/32 — 1-25/32 in.
(43.6 — 45.2 mm)

B. INSTALLATION

1. Place a new head gasket on the cylinder block, then carefully position the cylinder head on the gasket. Two dowels are on the top of the cylinder block at opposite corners to aid in positioning the cylinder head and gasket.

2. Lubricate the cylinder head bolts and install them finger tight.

3. Install the valve push rod with the cupped end up in the holes in the cylinder head from which they were removed. Be sure the ball ends of the push rods are seated in the tappet sockets.

4. Position the rocker shaft assembly on the cylinder head, the long cylinder head bolts and washers in the respective holes. Refer to Figure 10. Make sure that the ball ends of the rocker arm adjusting screws are seated in the cupped end of the push rods.

5. Tighten 9/16 in. cylinder head bolts in the sequence shown in Figure 24. Tighten in two steps:
   (a) 140 lbs. ft. (190 Nm)
   (b) 160 lbs. ft. (217 Nm)

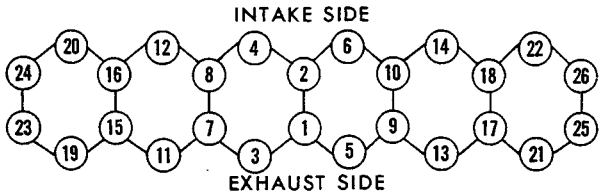


Figure 24
Cylinder Head Tightening Sequence

NOTE: *The cylinder head bolts should be torqued only when the engine is cold.*

6. Rotate the engine and set the valve lash, Figure 25, to the specified limits, page 85.

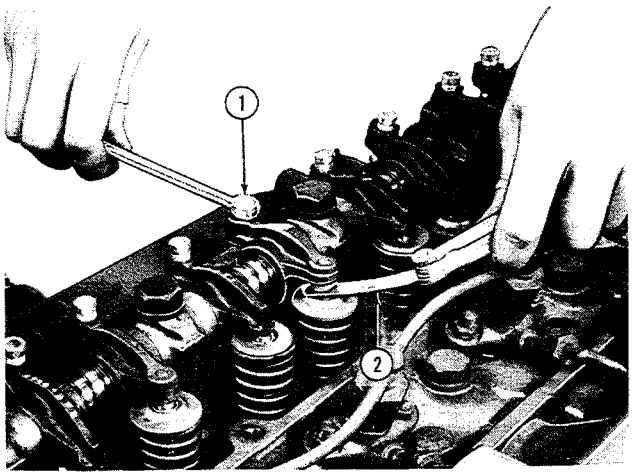


Figure 25
Adjusting Valve Lash

1. Adjusting Screw
2. Feeler Gauge

7. Install a new seat washer in each injector bore in the cylinder head. Position new cork seals over the injectors.

8. Install each injector into the cylinder head and over the two studs, as shown in Figure 11. Install the nut on each stud and tighten progressively to the specified torque, page 92.

9. Using new copper washers, install the injector leak-off line.

10. Install a new gasket and the intake manifold onto the cylinder head. Secure the manifold with the bolts and lock washers and tighten the bolts to the specified torque, page 92.

11. Attach the fuel filters to the manifold with two bolts and flat washers, and connect the fuel lines.

12. Connect the injector lines to the injection pump and to the injectors. Position the clamps on the injector lines in the same position from which they were removed.

13. Connect cold start equipment where fitted.

14. Position a new exhaust manifold gasket on the cylinder head and install the exhaust manifold, as shown in Figure 6. Use new lock tabs and tighten th bolts to the specified torque, page 92. Bend the lock tabs to retain the bolts.

TW10 and TW20:

15. **Ford TW10:** Bolt the muffler, with a new gasket installed, to the exhaust manifold.

    Ford TW20: Bolt the turbocharger, with a new gasket installed, to the exhaust manifold. Install the oil pressure and return lines to the turbocharger and engine.

16. Connect the upper radiator hose to the cylinder head.

17. Fill the radiator with coolant.

18. Install the rocker cover, installing a new gasket, and tighten the bolts to the specified torque, page 92. Connect the ventilating tube.

19. Lift the air cleaner and support assembly into place and attach with the hardware previously removed.

20. **Ford TW10:** Attach the muffler to the air cleaner support assembly and connect the air intake tube to the intake manifold.

    Ford TW20: Connect the exhaust extension to the turbocharger exhaust outlet and attach it to the air cleaner support assembly. Connect the air intake tube to the inlet side of the turbocharger and the air cleaner.

21. Install the fuel tank assembly, Figure 10.

22. Turn on the fuel.

23. Position the wiring harness in the clips on the support brace and connect the harness at the alternator and air intake restrictor valve.

24. Install the top hood panel and the pre-cleaner.

25. Install both hood side panels and the radiator grille panel(s).

26. Bleed the fuel system as described in Part 2, "FUEL SYSTEM". Start the engine.

TW30

27. Bolt the turbocharger and new gasket to the exhaust manifold. Install the oil lines between the turbocharger and the engine. Install the water pump if removed. Use a new gasket.

28. Install the thermostat — fan hub housing. Attach the radiator hose and heater hose, Figure 9.

29. Install the intercooler support bracket at the rear of the engine, Figure 8.

30. Install the intercooler, Figure 7.

31. Connect the intercooler-to-turbo tube. Connect the aspirator hoses.

32. Install the air cleaner. Connect the air cleaner-to-turbo tube.

33. Attach the grille support, Figure 6.

34. Install the hood panel, grille and side panels, Figure 1.

3. ENGINE FRONT COVER AND TIMING GEARS

Engine front cover and timing gear service operations can be performed after separating the front axle assembly from the engine, transmission, and rear axle assembly, as outlined in Part 9, "COMPONENT REMOVAL".

CRANKSHAFT PULLEY REMOVAL

1. Remove the fan and water pump belts. Remove the bolt and washer from the crankshaft pulley, Figure 26, using puller No. 518 and Shaft Protector No. 625-1, as shown in Figure 22. To use the puller for this purpose, 7/16" x 14 UNC bolts have to be used and the slots in the puller enlarged.

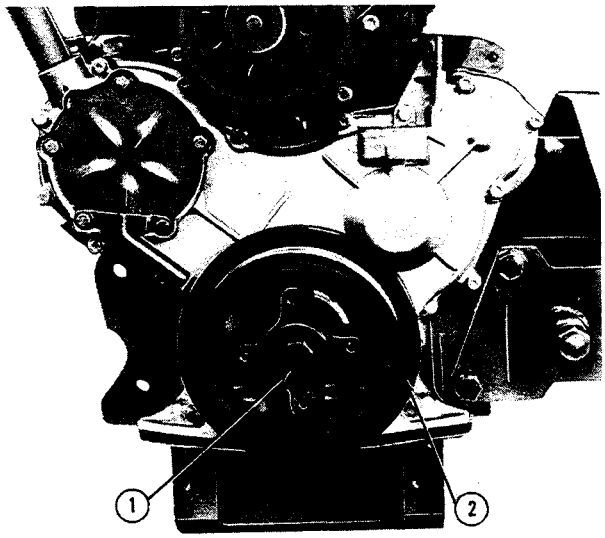


Figure 26
Crankshaft Pulley

1. Pulley Bolt
2. Crankshaft Pulley

2. Check the pulley belt grooves to be sure the surfaces are smooth and the flanges are not cracked or broken.

3. Check the shaft spacer in the area that contacts the front oil seal to be sure it is free of scratches or grooves that may cause oil leakage past the seal. Clean the seal contact surface with solvent and polish with crocus cloth prior to installation.

FRONT COVER REMOVAL

1. Drain the engine oil, and remove the oil pan.

2. Remove the front cover-to-front engine plate bolts and note the position of the fan mounting.

3. Remove the alternator front mounting bracket bolt.

4. Carefully pry the front cover off the dowel pins and remove it.

5. Remove the oil slinger.

6. Clean all the gasket material from the front cover and from the front engine plate.

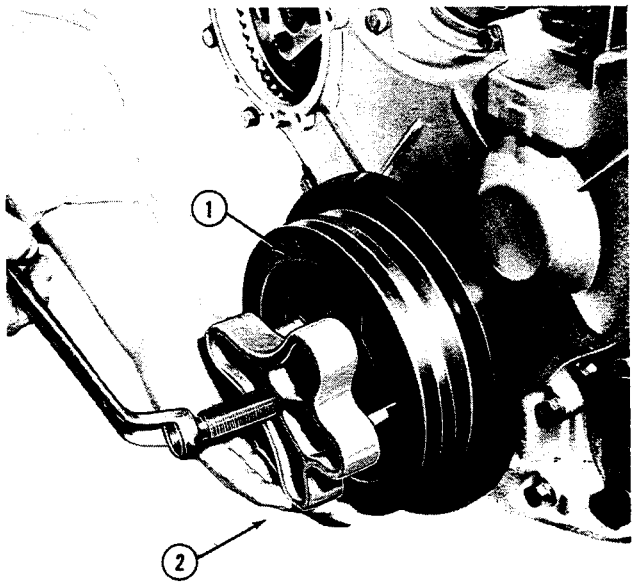


Figure 27
Removing Crankshaft Pulley

1. Crankshaft Pulley
2. 518 Pulley

FRONT COVER CRANKSHAFT SEAL REMOVAL

The front cover oil seal should be removed and a new seal installed every time the front cover is removed.

1. Drive out the old oil seal and dust seal with a punch. Be careful not to damage the cover.

2. Thoroughly clean the seal bore in the cover.

3. Insert the dust seal in the seal bore before installing the oil seal. Coat the new oil seal with petroleum jelly and install the seal as shown in Figure 28. To install the seal, use Step Plate No. 630-16 and a driver handle. Drive the seal in until it is fully seated in the seal bore. Check after installation to be sure the spring is properly positioned in the seal.

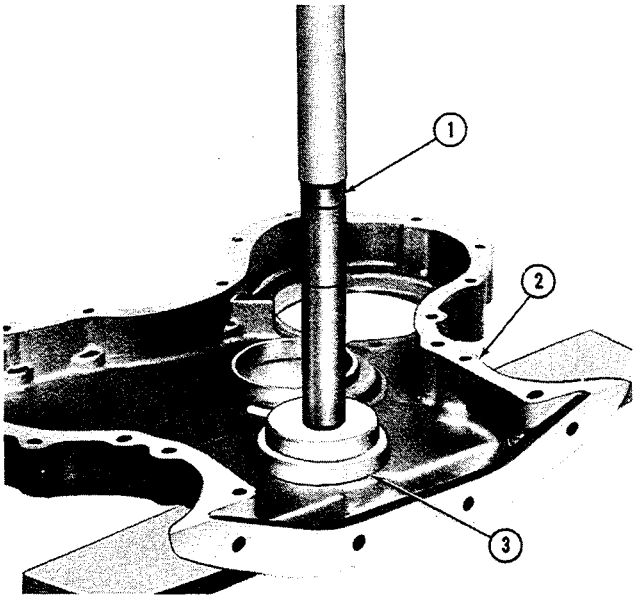


Figure 28
Installing Front Cover Seal

1. Driver
2. Engine Front Cover
3. 7536 Seal Installer

CHECK TIMING GEAR BACKLASH

1. The timing gears are shown in Figure 29. The gears are correctly assembled when the timing marks on the gear teeth line up, as shown in the illustration, with the No. 1 piston on TDC.

2. Check the backlash of the gears with a dial indicator or a feeler gauge, as shown in Figure 30.

3. Check between the camshaft drive gear and camshaft gear as shown, and also between the injection pump gear and camshaft drive gear. Also check between the crankshaft gear and camshaft drive gear.

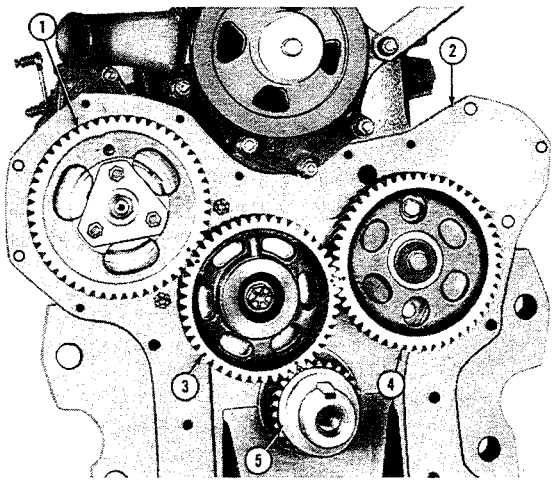


Figure 29
Timing Gears

1. Injection Pump Gear
2. Front Cover Plate
3. Camshaft Drive Gear
4. Camshaft Gear
5. Crankshaft Gear

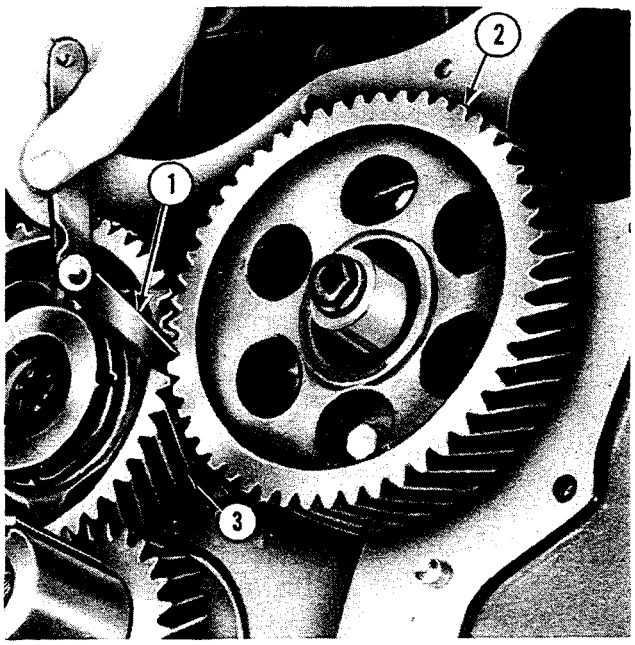


Figure 30
Checking Timing Gear Backlash

1. Feeler Gauge
2. Camshaft Gear
3. Camshaft Drive Gear

4. Check the backlash at four equidistant points on the gears.

5. If the backlash is within specifications, page 86, the gears are suitable for reinstallation. If not, install new gears.

INJECTION PUMP GEAR

A. REMOVAL

1. Turn the crankshaft until the camshaft gear is in the approximate timed position, Figure 31.

2. Remove the three attaching bolts that retain the injection pump gear, Figure 31, to the pump adapter plate and remove the gear.

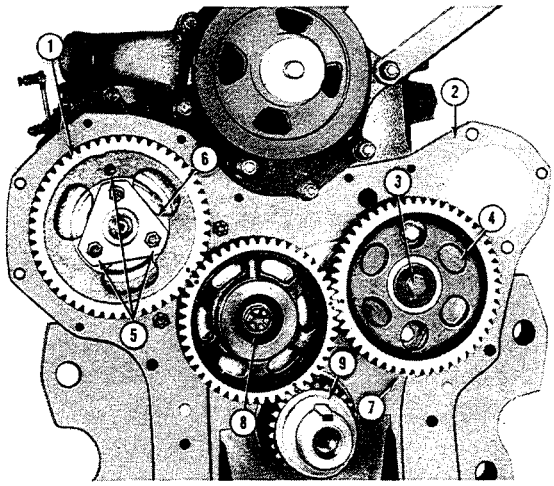


Figure 31
Engine Front Cover Removed

1. Injection Pump Gear
2. Front Cover Plate
3. Retaining Bolt
4. Washer
5. Attaching Bolts
6. Adapter Plate
7. Camshaft Gear
8. Self-Locking Bolt
9. Slinger

B. CLEANING AND INSPECTION

1. Clean the gear in solvent.

2. Inspect gear teeth for scores and nicks and the condition of the teeth contact pattern.

3. Use a carborundum stone to remove minor gear teeth imperfection. If gear teeth wear or damage is severe install a new gear.

C. INSTALLATION

1. Time the engine before installing the injection pump gear. To do this remove the camshaft drive gear, place No. 1 piston at top dead center and reinstall the camshaft drive gear in mesh and the timing marks aligned to the other gears as shown in Figure 31. Tighten the camshaft drive gear adapter bolt to the specified torque, page 92.

2. Install the new injection pump gear on the pump adapter plate, with the timing mark aligned.

3. Install the three bolts and the adapter plate and tighten to the specified torque, page 92.

CAMSHAFT DRIVE GEAR AND ADAPTER

A. REMOVAL

1. Remove the self-locking bolt that retains the camshaft drive gear and adapter to the cylinder block.

2. Remove the adapter and camshaft drive gear. Refer to Figure 32.

B. CLEANING AND INSPECTION

1. Clean the gear and adapter in solvent.

2. Inspect gear teeth for scores and nicks and the condition of the teeth contact pattern. Use a carborundum stone to remove minor gear teeth imperfections. If tooth wear or damage is severe install a new gear.

3. Check the adapter oil passage, Figure 33, to be sure that it is clear.

4. Inspect the camshaft drive gear bushing, Figure 33, for wear, nicks or burns, and install a new gear if any of these conditions exist.

5. If excessive backlash, page 86, existed in the gears when checked, install a new gear.

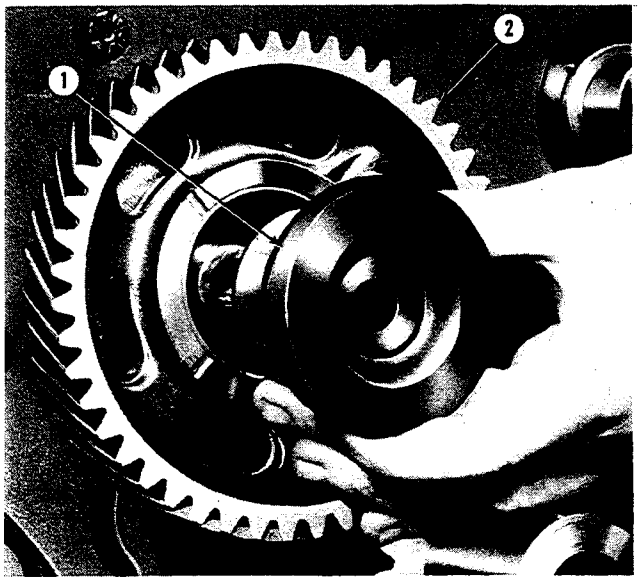


Figure 32
Removing Camshaft Drive Gear Adapter

1. Adapter
2. Camshaft Drive Gear

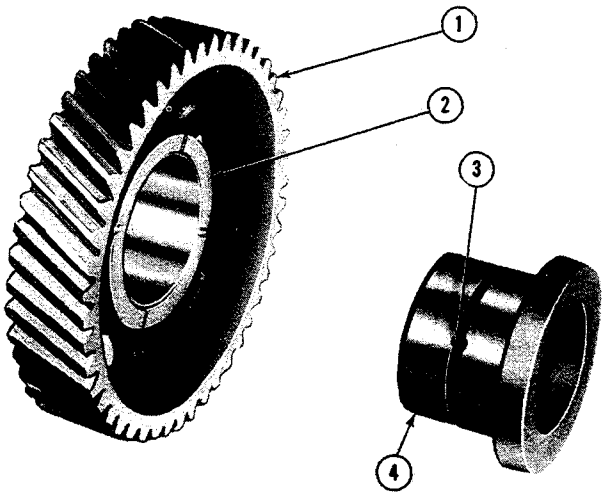


Figure 33
Camshaft Drive Gear and Adapter

1. Camshaft Drive Gear
2. Bushing
3. Oil Passage
4. Adapter

C. INSTALLATION

1. Install the gear and adapter in mesh with the timing marks aligned.

2. Install the adapter self-locking bolt and tighten the bolt to the specified torque, page 92.

CRANKSHAFT GEAR

The crankshaft gear should only be removed if it shows signs of wear or chipping.

A. REMOVAL

1. Remove the crankshaft gear with Crankshaft Gear Remover-Replacer, No. SW 501 with Insert SW 501-1, or Remover No. CPT 6040, as shown in Figure 34.

B. CLEANING AND INSPECTION

1. Clean the gear in cleaning solvent.

2. Inspect the gear teeth for scores and nicks, and the condition of the teeth wear pattern.

3. Check the crankshaft keyway to be sure it is in good condition.

4. Check the key. If there is any evidence of distortion or chipping, use a new key when installing the gear. Install a new gear if wear or damage is evident.

C. INSTALLATION

1. Drive the key into the keyway until it is seated.

2. Install the crankshaft gear with Crankshaft Gear Remover-Replacer No. SW 501 with Insert SW 501-1, or Replacer No. CT 6069, as shown in Figure 34.

CAMSHAFT GEAR

A. REMOVAL

1. Remove the retaining bolt and washer, Figure 31.

2. Remove the camshaft gear from the end of the shaft.

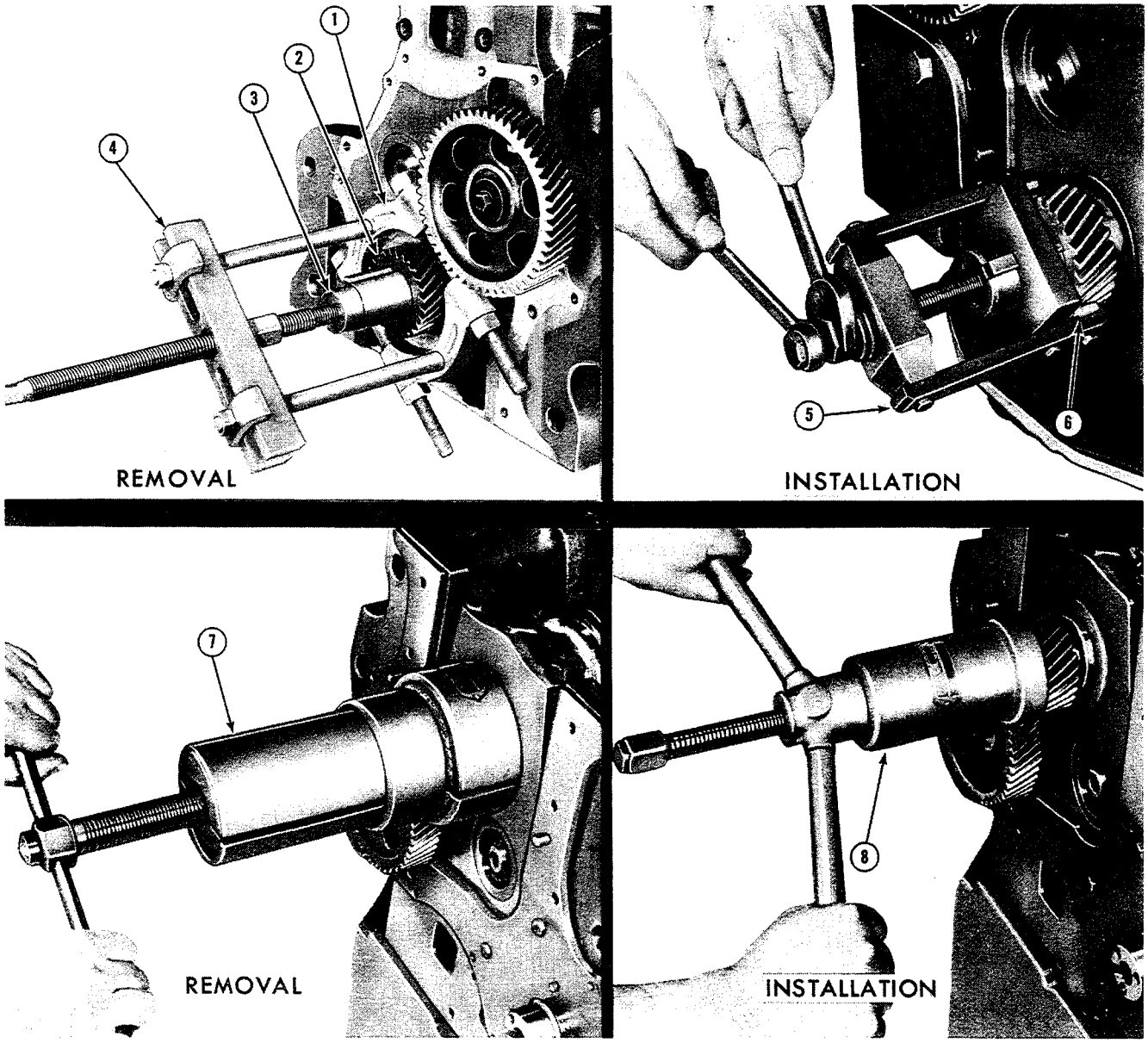


Figure 34
Removing and Installing Crankshaft Gear

1. Tool No. 951
2. Crankshaft Gear
3. Tool No. 625-1
4. Tool No. 927
5. Remover - Replacer SW 501
6. Insert SW 501-1
7. Remover CPT 6040
8. Replacer CT 6069

B. CLEANING AND INSPECTION

1. Clean the gear in solvent.

2. Inspect gear teeth for scores and nicks, and the condition of teeth wear pattern.

3. Check the keyway and key on the end of the camshaft. If the key is damaged, install a new key before installing the gear. Use a carborundum stone to remove minor gear teeth imperfections. If tooth wear or damage is severe install a new gear.

C. INSTALLATION

1. Install the camshaft gear spacer.
2. Install the key in the camshaft keyway.
3. Install the camshaft gear, with timing marks aligned, the flat washer, lock washer, and bolt, and tighten to the specified torque, page 92.

TIMING THE GEARS

When removing or installing any of the timing gears, be sure that the timing marks line up correctly, as shown in Figure 31. The No. 1 piston must be at T.D.C. on the firing stroke when the timing marks are aligned.

The power steering pump drive gear does not require timing.

FRONT COVER INSTALLATION

1. Position a new gasket on the engine front adapter plate.
2. Install the oil slinger dish out, Figure 31.
3. Install the front cover, being sure the cover aligns with the dowel pins.
4. Install the front cover-to-front engine plate bolts and tighten to the specified torque, page 92.
5. Install the oil pan with new gasket and tighten bolts to the specified torque, page 92.
6. Install the alternator support front mounting bolt.
7. Refill the crankcase with the proper grade and quantity of oil.
8. Replace the filler cap.

CRANKSHAFT PULLEY INSTALLATION

1. Lubricate the crankshaft pulley spacer, align the keyway in the spacer with the crankshaft keyway and slide it back as far as it will go.
2. Lubricate the pulley hub and align the keyway in the pulley with the key in the end of the crankshaft. Tap the pulley onto the crankshaft.
3. Install the flat washer and bolt and tighten the bolt to the specified torque, page 92.

4. OIL PAN AND OIL PUMP

OIL PAN

A. REMOVAL

IMPORTANT: *Take care when removing the oil pan because of its weight. Use a jack or sling to support the pan.*

The oil pan on the Ford TW10, 20 and 30 Tractors can be removed by replacing the cylinder block-to-front support bolts one at a time with 8-inch long bolts. The purpose of installing these bolts is to safely allow the front support assembly to be eased forward approximately 1-1/2 inches (38.1 mm) to facilitate removal of the two sump front bolts.

1. Drain the engine oil and remove the engine oil level dipstick.
2. Support the tractor with a jack under the transmission and a hoist or crane at the front support and radiator assembly.
3. Remove both hood side panels.
4. Remove the pre-cleaner from the air intake tube.
5. Remove the top hood panel and the radiator grille panel(s).
6. Drain the engine coolant.
7. Remove all lines and hoses between the radiator/coolers/condenser and the engine. This includes (1) air intake tube, (2) coolant hoses, (3) oil cooler lines, (4) air conditioner lines, (5) hydraulic oil hoses, and (6) power steering oil lines.

8. Remove the main fuel tank front support bolts.

9. Remove the two bolts that attach each side frame member to the front support.

10. Move the front support assembly forward sufficient to remove the front oil pan bolts and oil pan.

11. Remove the two bottom transmission-to-engine attaching bolts.

12. Support the oil pan. Remove the 31 attaching bolts and lock washers holding the pan to the engine. Refer to Figure 35.

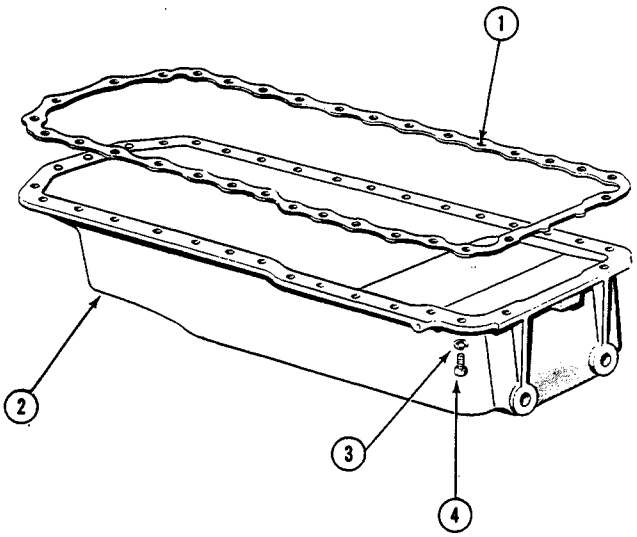


Figure 35
Oil Pan

1. Gasket
2. Oil Pan
3. Lockwasher
4. Attaching Bolt

B. CLEANING AND INSPECTION

1. Scrape all dirt and metal particles from the inside of the pan.

2. Scrape all gasket material from the gasket surface.

3. Wash the oil pan in a solvent and dry thoroughly.

4. Check the pan for cracks, holes, damaged drain plug threads, or a nicked or warped gasket surface.

5. Repair any damage, or install a new pan if repairs cannot be made.

C. INSTALLATION

To install the oil pan to an engine installed in a tractor, reverse the procedure on page 22, paying attention to the following points.

1. Be sure that the gasket surfaces on the oil pan and block are clean.

2. Position the gasket on the cylinder block and apply a thin film of gasket sealer on the gasket, front cover, and the oil pan.

3. Hold the pan against the block and install a bolt in each corner of the oil pan. Tighten the bolts by hand so they are finger tight.

4. Install the remaining bolts and tighten the rear bolts first. Then, tighten from the middle outward in each direction to the specified torque, page 92.

5. Assemble the front of the tractor to the engine. Install the two bottom engine-to-transmission bolts and spacers, if equipped.

6. Install the oil level dipstick, tighten the drain plug, and fill the crankcase with the proper grade and quality engine oil.

7. Start the engine and check for oil leaks.

OIL PUMP

A. REMOVAL

1. Remove the oil pan.

2. Remove the two front pump mounting bolts, two rear delivery tube mounting bolts and one pickup tube support bolt, Figure 36. Remove pump assembly with dowels and pickup tubes.

B. DISASSEMBLY

1. Remove 4 bolts from backplate of pump assembly.

2. Remove both tubes, screen and backplate.

3. Remove idler gear.

4. Remove outer rotor.

5. Remove drive gear by hand or with a hydraulic press.

6. Remove relief valve spring and cap, Figure 37.

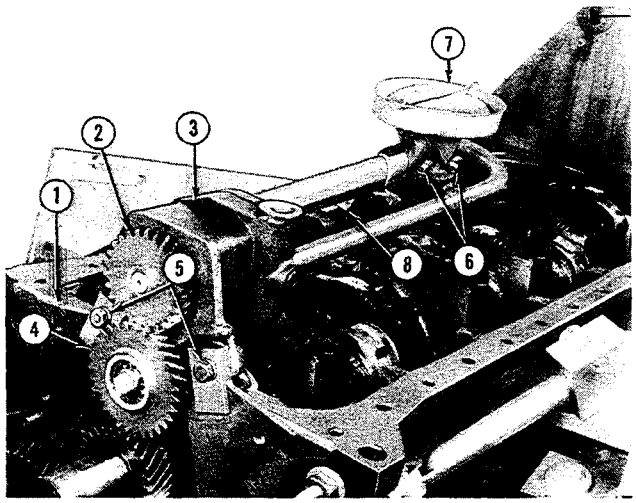


Figure 36
Oil Pump

1. Oil Pump Support Plate
2. Oil Pump Drive Gear
3. Oil Pump Housing
4. Idler Gear
5. Front Support Bolts
6. Rear Support Bolts
7. Oil Pump and Screen
8. Support Bolt

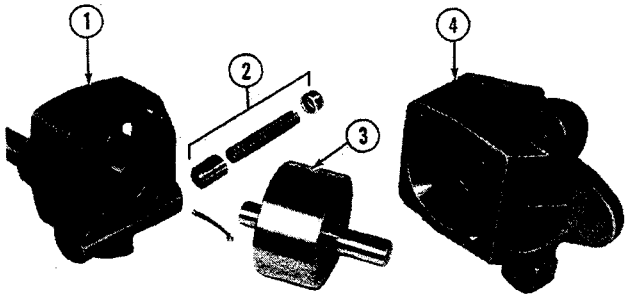


Figure 37
Oil Pump

1. Pump Cover
2. Relief Valve
3. Rotor and Shaft

C. CLEANING AND INSPECTION

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

2. Check the inside of the pump cover for wear and score marks. Inspect both rotors for wear or score marks. Replace as required. Check idler gear bearing for binding. Inspect both gears for wear and pitting.

3. With the rotor and shaft assembly installed in the pump body, place a straight edge over the rotor and shaft assembly and the pump body. Measure the clearance between the straight edge and the inner rotor and shaft assembly and between the straight edge and the outer rotor, Figures 38 and 39. If the measurement is not within specifications, page 92, install a new rotor assembly.

NOTE: *The shaft and rotor are serviced only as an assembly.*

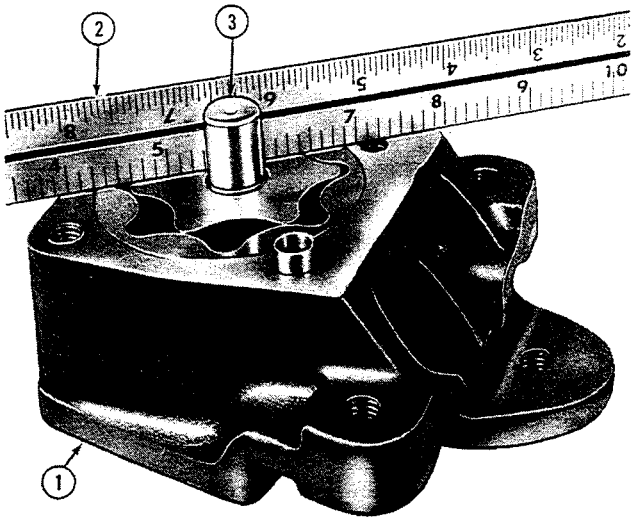


Figure 38
Checking Oil Pump Clearance

1. Pump Body
2. Straight Edge

4. Measure the rotor-to-housing clearance by inserting feeler blades between the rotor and the housing. Take the measurements at four places, 90° apart. If the measurements are not within specifications, page 92, install a new rotor

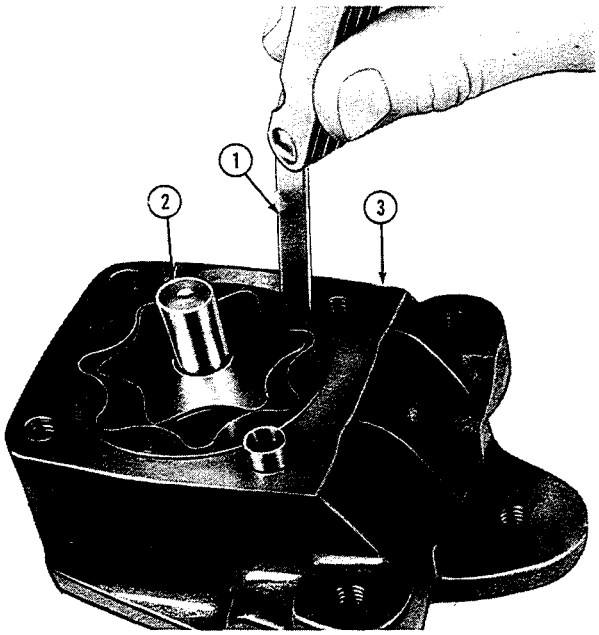


Figure 39
Checking Oil Pump Clearance

1. Feeler Gauge
2. Rotor and Shaft
3. Pump Body

assembly. Remeasure clearances with the new rotor assembly in the pump body. If the measurements are still not within specifications install a new pump body.

5. Check the relief valve spring tension. If the spring tension is not within specifications, page 92, install a new spring.

6. Check the relief valve for score marks and be sure it is free to move within the bore.

D. ASSEMBLY

The oil pump assembly is shown in Figure 37.

1. Oil all the parts thoroughly.

2. Install the oil pressure relief valve and spring, and drive in a new plug.

3. Install inner rotor in the pump body and press on drive gear with key. Install outer race in pump body. The rotor, shaft and outer race are serviced as an assembly. Both parts must be replaced together.

4. Install the pump cover plate and pickup tube assembly, and tighten four bolts to the specified torque.

5. Install the screen assembly, delivery tube, gaskets and O-ring.

E. INSTALLATION

1. Prime the pump by filling the inlet port with clean engine oil. Rotate the pump drive gear and shaft to distribute oil in the pump body.

2. Install the pump assembly, tube and clamp on engine.

The engine oil filters should be serviced every 300 hours on a TW10 tractor, every 150 hours on TW20 and every 200 hours on the TW30 tractors. Operate the engine until it reaches normal operating temperature, then drain the engine oil from the pan and the oil cooler. Replace the oil filter elements. Fill the crankcase with oil of the correct grade and specification.

5. CONNECTING RODS, BEARINGS, PISTONS, RINGS, CYLINDER BLOCK AND SLEEVES

PISTON AND CONNECTING ROD ASSEMBLY

A. REMOVAL

1. Remove the cylinder head assembly as outlined on page 3.

2. Remove the oil pan.

3. Remove the oil pump assembly as outlined on page 22.

4. If necessary, remove the ridge from the top of each cylinder with a cylinder ridge reamer or a hand scraper, Figure 40. (Ridge removal is not necessary when reboring or if the old pistons are not to be used. However, it may be necessary to remove a ridge in order to remove an old piston.)

When removing the cylinder ridge do not cut down into the ring travel more than 1/32 inch (0.793 mm). It is possible to cut so deeply into the cylinder wall and so far down into the ring travel that reboring, or the installation of a new engine block is necessary. Do not attempt to remove and reuse a piston from a cylinder with an excessive ridge. Forcing the piston past the ridge may break the lands on the piston or the ridge.

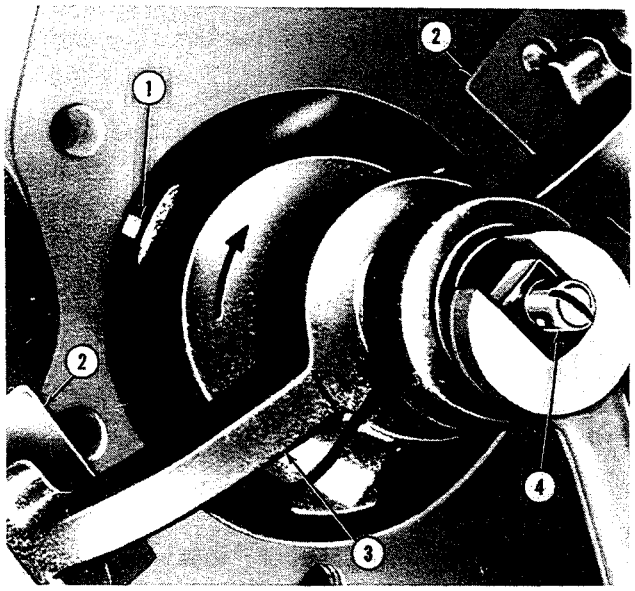


Figure 40
Removing Cylinder Ridge

1. Cutter Blade
2. Shoe
3. Reamer
4. Adjusting Screw

5. Remove the nuts from the connecting rod bearing cap bolts of the piston that is at the bottom of its stroke. Remove the rod bearing cap and liner, Figure 41, from the rod. Push the piston and rod assembly away from the crank pin and remove the bearing liner from the rod. Push the rod and piston assembly out of the top of the cylinder with the handle end of a hammer. Be careful not to scratch the crank pin or the cylinder. Turn the crankshaft to bring each piston to the bottom of its stroke and repeat this procedure. Keep the bearing caps and liners with their respective connecting rods.

6. Remove the piston rings from the pistons with a piston ring expander or other suitable means. See Figure 42.

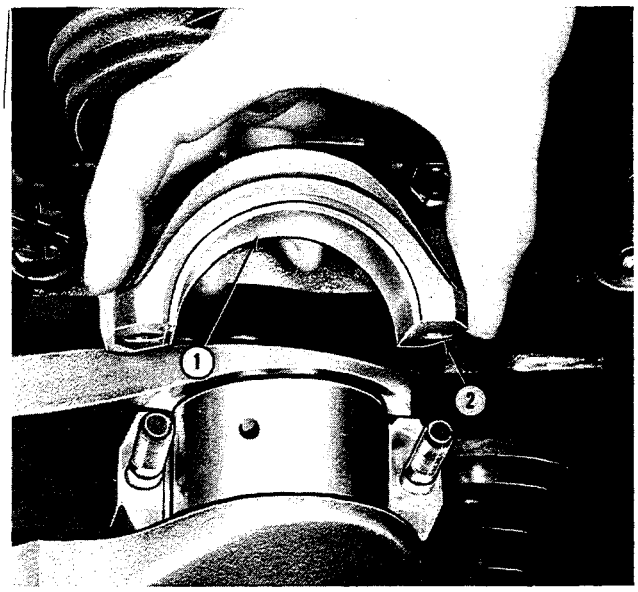


Figure 41
Removing Connecting Rod Bearing Cap

1. Bearing Liner
2. Rod Bearing Cap

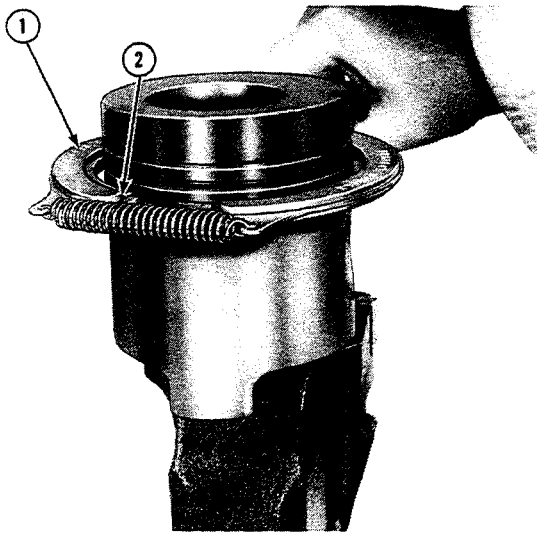


Figure 42
Removing Piston Ring

1. Piston Ring Expander
2. Piston Ring

B. DISASSEMBLY

1. Remove the piston pin snap ring (circlip) from each side of the piston and remove the pin.

2. Identify each piston to be sure it will be assembled to the rod from which it was removed.

C. CLEANING

Clean the piston ring grooves with a piston ring groove cleaner, Figure 43. Be careful not to scratch or remove metal from the groove sides. Place the piston assembly in liquid cleaner, if available, to soften carbon and lead deposits. Clean the rod bore and the back of the connecting rod bearing liners thoroughly. Dry the parts with compressed air. Do not use a wire brush.

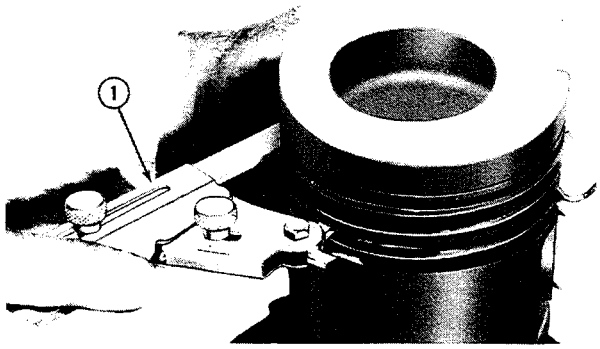


Figure 43
Cleaning Piston Ring Grooves
1. Piston Ring Groove Cleaner

D. INSPECTION

CONNECTING RODS

1. Inspect the connecting rods for signs of damage and the bearing bores for out-of-round and taper. If the bore exceeds the recommended limits or is damaged, install a new connecting rod.

2. Check the connecting rod nuts and bolts. Replace any part that shows signs of wear or damage. Always use new connecting rod bearing cap nuts.

3. Check piston pin bushings for wear or damage. Measure outside diameter of piston pin and inside diameter of piston pin bushing. If bushing is damaged, or if the measurements indicate that a clearance between the bushing and the pin is not between 0.0005-0.0007 in. (0.0127-0.0178 mm), the bushings must be removed.

   NOTE: *If a new piston pin bushing is installed, it must be reamed to provide the clearance above.*

4. A shiny surface on the pin boss side of the piston will usually indicate that a connecting rod is bent. Abnormal connecting rod bearing wear is also an indication of bent connecting rods. Twisted connecting rods will not create an easily identifiable wear pattern, but badly twisted rods will disturb the action of the entire piston assembly. Refer to page 29, under "Connecting Rod Alignment."

CONNECTING ROD BEARINGS

1. If the bearing liners are scored, have the flash overlay wiped out, show fatigue, failure, or are badly scratched, as shown in Figure 44, install new bearing liners.

2. If the bearing liners appear to be serviceable, keep them with their respective rods for reassembly in the engine. If the clearance exceeds the specified limits, page 88, new bearings must be installed. Undersize connecting rod bearings are available in 0.002 in. (0.0508 mm), 0.010 in. (0.254 mm), 0.030 in. (0.762 mm), and 0.040 in. (1.016 mm) for service. If new bearings are required, follow the procedure covered on page 29 for fitting.

PISTONS

1. Inspect pistons for damage and wear at the ring grooves, piston skirt and piston pin bosses.

2. Check for wear at the top ring by measuring the ring groove with a 1/8 in. - 150 "keystone" gauge. If the shoulders of the gauge contact the face of the piston, Figure 45, the groove is worn beyond serviceable limits and the piston must be replaced. If the special gauge is not available, insert a new keystone ring in the groove and place a 0.006 in. feeler gauge between the top of the ring and the ring groove. If the feeler gauge can be inserted to the depth of the ring, the groove is excessively worn and the piston should be replaced.

3. Check all other piston ring grooves with a new ring and feeler gauge, Figure 46. The grooves should have the clearances shown on page 90. Replace pistons with excessive clearance.

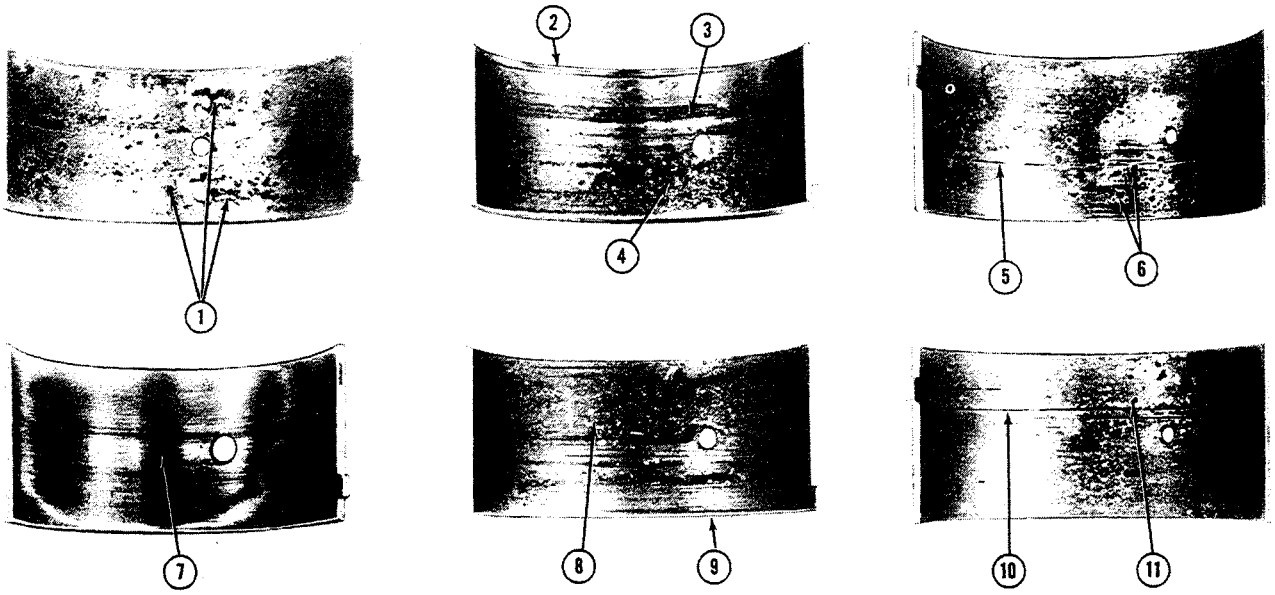


Figure 44
Typical Defective Bearings

1. Craters or Pockets
2. Radii Ride
3. Scratches
4. Dirt
5. Scratches
6. Imbedded Dirt
7. Overlay Worn Out
8. Fatigue Failure
9. Radii Ride
10. Scratches
11. Imbedded Dirt

4. Replace pistons with excessive skirt clearance, wavy wing lands, fractures, and pistons that shown damage from detonation.

5. Replace worn or damaged piston pins. Always use new piston pin snap rings (circlips) when replacing piston pins.

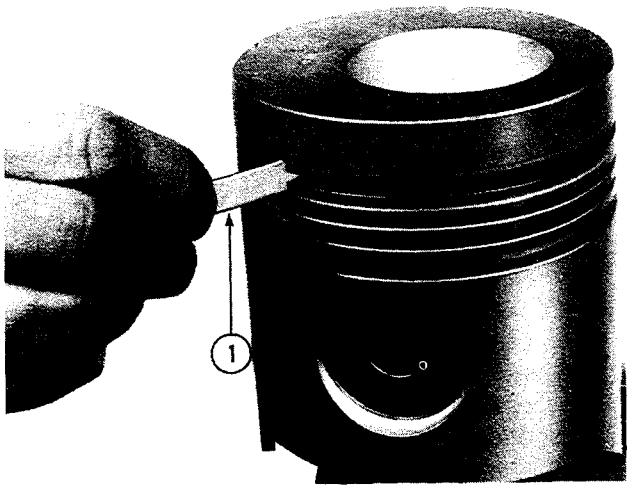


Figure 45
Checking Top Ring Groove

1. Keystone Gauge

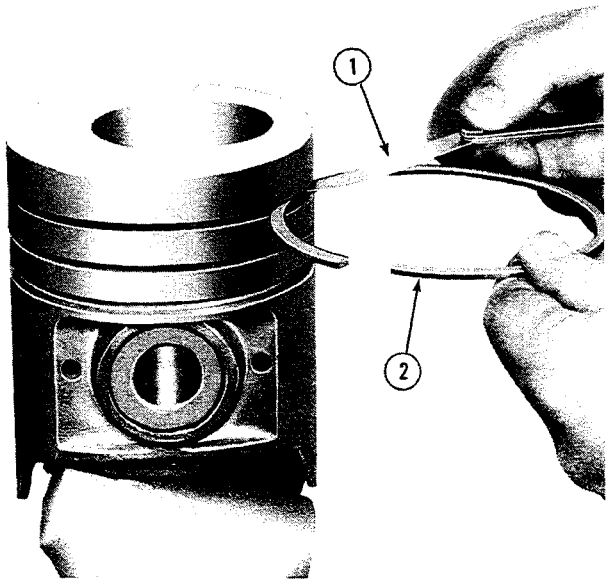


Figure 46
Checking Ring Side Clearance

1. Feeler Gauge
2. Piston Ring

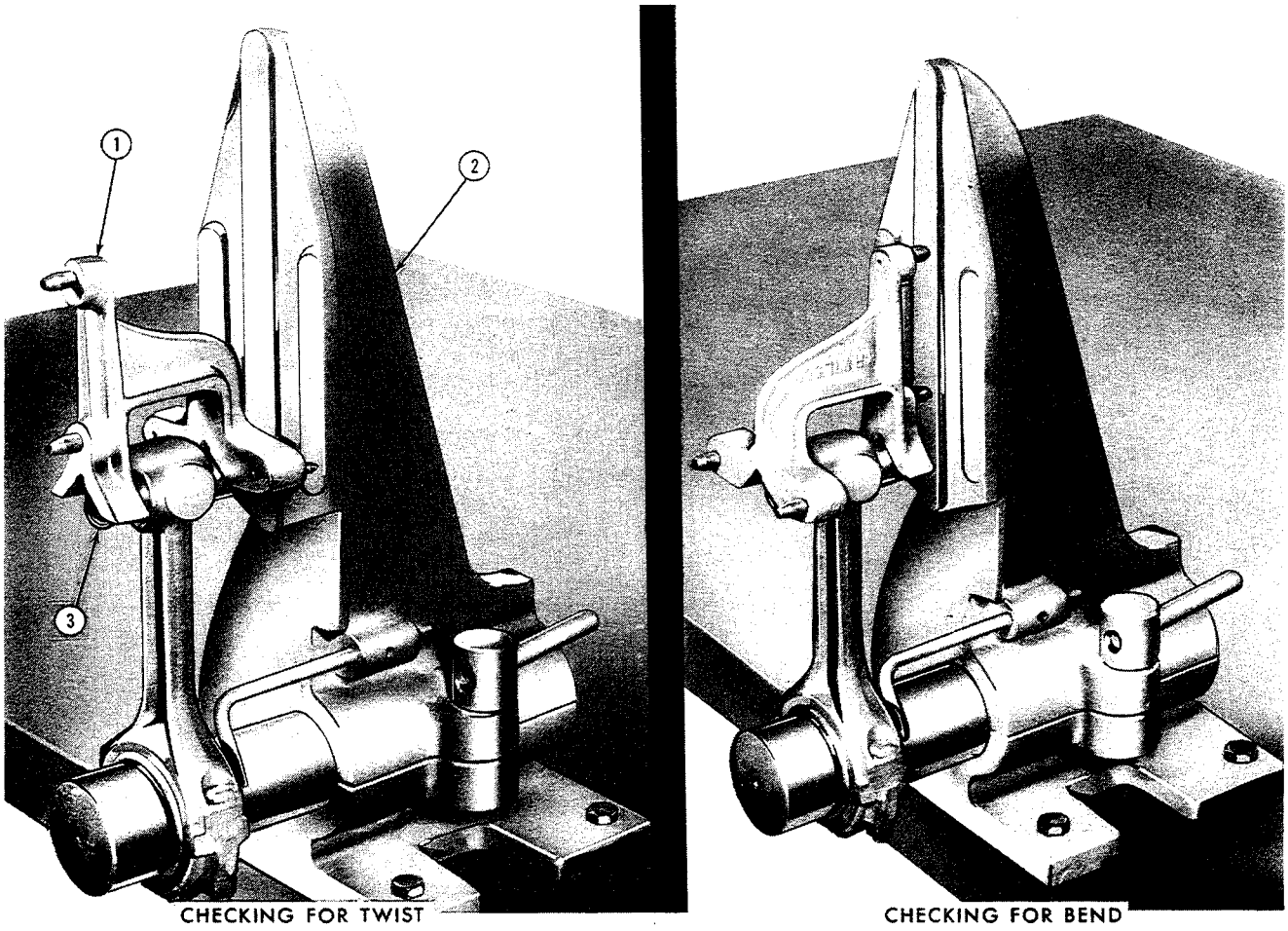


Figure 47
Connecting Rod Alignment

1. Alignment Gauge
2. Connecting Rod Aligner
3. Piston Pin

CONNECTING ROD ALIGNMENT

1. Place each connecting rod in an alignment fixture, as shown in Figure 47.

2. If the connecting rod is twisted more than 0.0120 in. (0.3048 mm), or bent more than 0.0040 in. (0.1016 mm), install a new rod.

E. REPAIR

CONNECTING ROD BUSHING

1. Remove the connecting rod bushing from the connecting rod with Driving Mandrel No. 815 Adapter No. T-809, and an arbor press, Figure 48.

2. Clean the connecting rod bore and make sure there are no burrs or scratches in the bore. Line up the oil feed hole of the bushing to that of the connecting rod and press the new bushing into the connecting rod, using the same bushing tool used for removal. The bushing should not protrude from either side of the rod.

3. **TW10**: Using the hole in the top of the connecting rod as a guide, drill a 3/64 inch (1.21 mm) diameter hole in the bushing, Figure 49.

TW20 and 30:

1. Using a long 5/32 in. (4.1 mm) drill, drill from the crankshaft end of the rod, through the bottom half of the pin bushing. See Figure 50.

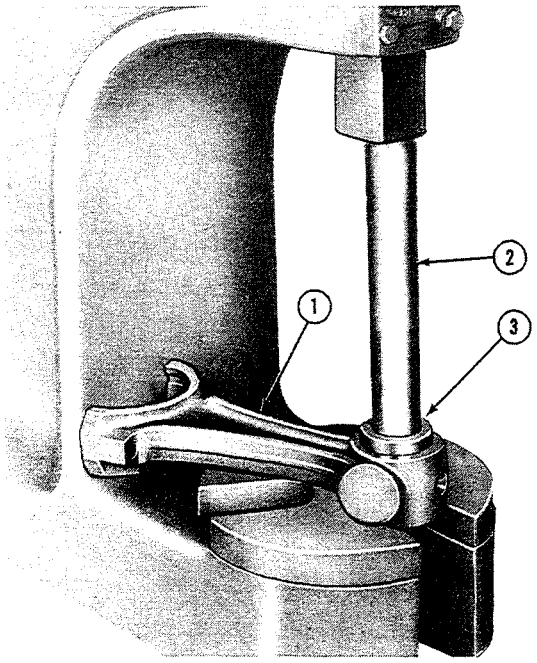


Figure 48
Removing and Installing Connecting Rod Bushings

1. Connecting Rod
2. No. 815 Mandrel
3. T – 809 Adapter

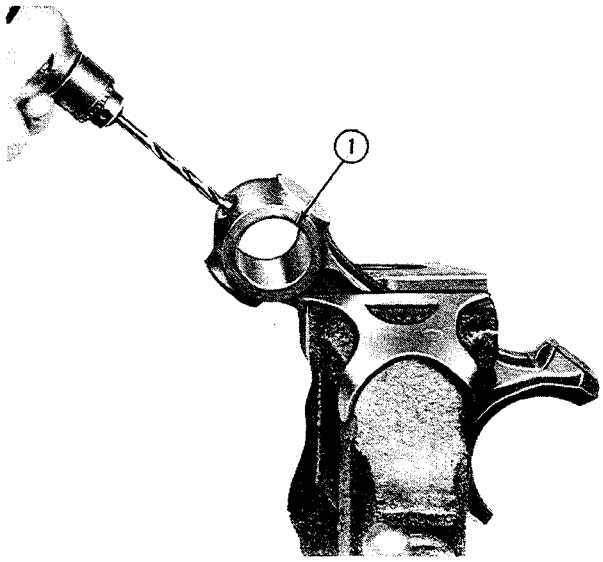


Figure 49
Drilling Connecting Rod Bushing – TW10

1. Connecting Rod Bushing

2. Using a 3/64 in. (1.19 mm) drill, drill through the top of the rod and through the top of the bushing, Figure 50.

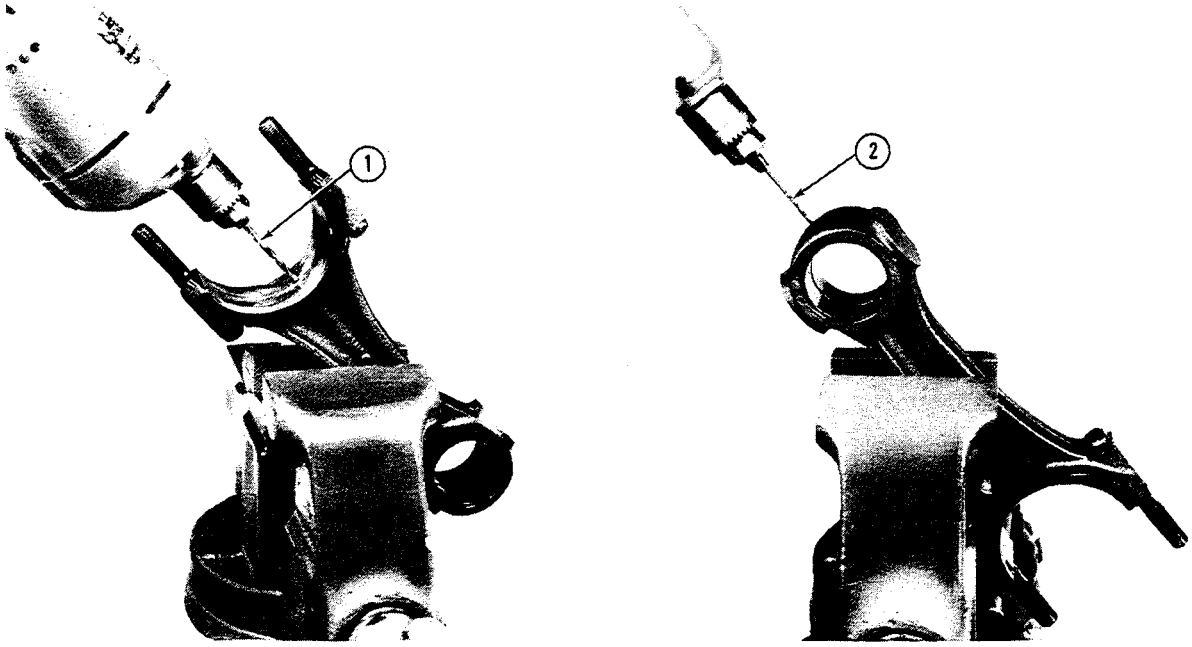


Figure 50
Drilling Connecting Rod Bushings—TW20 and 30

1. 5/32" Drill
2. 3/64" Drill

3. Remove burrs and metal chips from the rod before fitting the piston pin.

4. Using a spiral expansion reamer, ream the bushing in the connecting rod to obtain the correct bushing-to-pin clearance.

FITTING PISTONS

1. Pistons are available in both standard and oversize to fit all engines. New pistons should be installed if the clearance exceeds the specified limits.

2. The cylinder bores must be checked for taper and out-of-round before fitting a piston, as outlined on page 34, under "A. Cylinder Block Inspection."

3. Before installing a piston and new rings in a used block, remove the high polish on the cylinder wall to aid ring seating. This is done by passing a hone lightly through the cylinder bore a few times. Do not hone more than enough to rough up the polish. After honing, bores should be washed with hot water and detergent, then rinsed in cold water and dried thoroughly. The bores should then be oiled to prevent rusting.

4. Using a bore gauge (or inside micrometer) check and record the cylinder bore diameter in a crosswise direction as shown in Figure 51.

5. With an outside micrometer, check and record the "W" diameter of the piston to be fitted, Figure 52.

6. Subtract the piston diameter from the bore diameter. The resultant figure should be within the clearance given in the Specification section.

7. If the resultant figure is greater than the clearance given in Specifications, try another piston. If none can be fitted, rebore the cylinder to the next oversize. If the clearance is less than specified, hone the bore until the desired clearance is obtained.

NOTE: *Dimension "W" is not the point of largest diameter of the piston, but it is the datum from which bore clearances are calculated.*

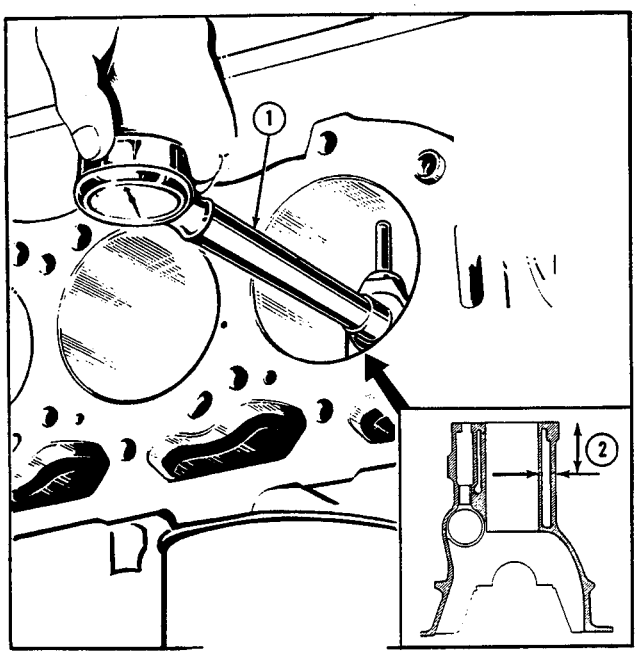


Figure 51
Cylinder Bore Grading Depth

1. Bore Gauge
2. Depth Measurement

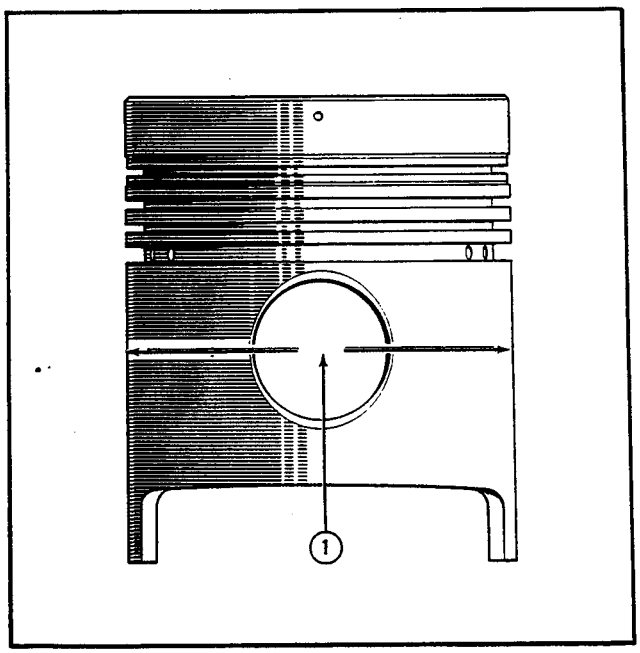


Figure 52
Piston Grading Diameter

1. Dimension "W"

FITTING PISTON RINGS

1. Before installing new rings on a piston, the rings should be checked for proper ring gap. Each ring should be fitted and checked in the cylinder in which it is going to be used. Each ring should be marked accordingly after the cylinders have been checked and reconditioned as required. Push the ring down into the cylinder bore to the lowest unworn portion of the cylinder, using the head of a piston so that the ring is square with the cylinder wall.

   NOTE: *When positioning the piston ring inside the cylinder for checking ring gap, be careful not to damage the ring or the cylinder bore.*

2. Check the gap (see Specifications) between the ends of the ring with a feeler gauge, Figure 53. It is important that all rings have at least the minimum gap clearance to provide for the expansion that occurs when the engine warms up to operating temperature; otherwise, the ring ends may butt together and cause scuffing, scoring, or ring breakage.

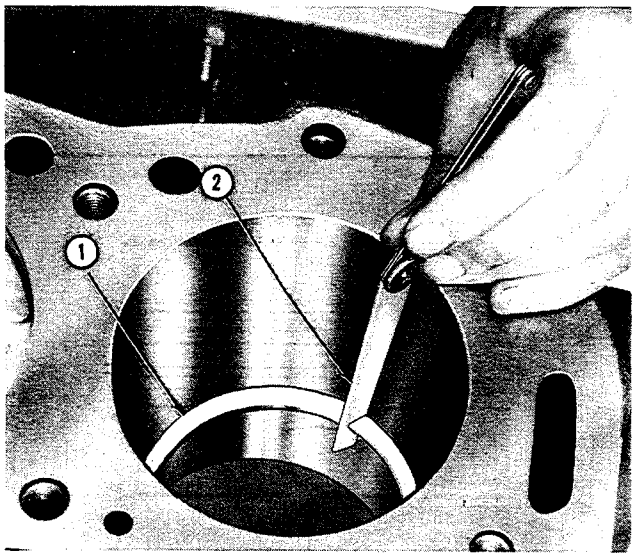


Figure 53
Checking Piston Ring Gap

1. Ring
2. Feeler Gauge

3. New rings should also be checked for side clearance in the grooves of the piston on which they are to be installed. See page 33.

INSTALLING PISTON RINGS

NOTE: *When installing the piston rings, it is recommended that a piston ring expander be used as shown in Figure 43. This tool will prevent over-expansion of the ring, and will expand the ring to a true circle to avoid distortion. The rings supplied in Service Ring Kits differ from the standard size rings used in production. Because of the differences the following points should be noted when installing new sets of rings, whether they be standard or oversize.*

1. Production Piston Ring Set — consists of:

   3 Compression Rings
   1 Oil Control Ring
   1 Oil Control Ring Expander (Coiled)

   TOP COMPRESSION RING
   Bright chrome finish, "Keystone" ring.

   2ND COMPRESSION RING
   Bright chrome finish, step on inside diameter. Assemble with step facing upwards.

   3RD COMPRESSION RING
   Dull black finish, step on inside diameter. Assemble with step facing upwards—no expander behind ring, Figure 54.

   OIL CONTROL RING
   Install either way upwards with slotted expander behind ring, Figure 54.

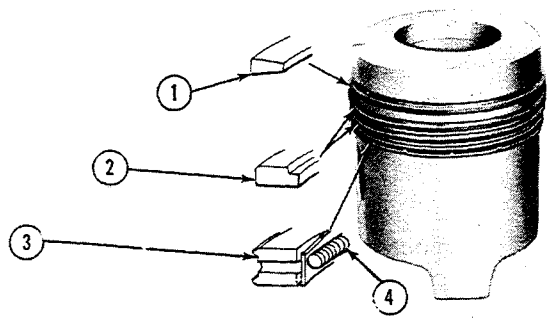


Figure 54
Fitting Piston Ring

1. Keystone Ring
2. Compression Rings (2)
3. Oil Control Ring
4. Coil Type Expander

2. Service type Set — consists of:

   3 Compression Rings
   1 Oil Control Ring
   1 Oil Control Ring Expander (Coiled)

   TOP COMPRESSION RING
   Bright chrome finish, Keystone Ring.

   2ND COMPRESSION RING
   Bright chrome finish, step on inside diameter. Assemble with step facing upwards.

   3RD COMPRESSION RING
   Dull black finish, step on outside diameter, facing downwards and non-slotted expander behind ring.

   OIL CONTROL RING
   Install either way upwards with expander behind ring.

3. Space the rings on piston as follows:

   Coil-Type Expander —
   Position gap in line with piston dome identification mark, Figure 54.

   Oil Control Ring —
   Position gap 90° from piston dome identification mark.

   Lower Compression Ring —
   Position gap 180° from oil control ring gap.

   Remaining Compression Rings —
   Position gap 120° intervals from lower compresssion ring.

PISTON ASSEMBLY

1. Lubricate all parts generously with engine oil during assembly. All parts of the piston and connecting rod assembly are shown in Figure 56. Use the illustration for reference during assembly.

2. Assemble the piston to the connecting rod with the notch on the piston crown and the pip on the connecting rod in line as shown in Figure 55. If a piston is used the connecting rod piston pin bushing may have to be reamed or replaced to provide the specified pin-to-bushing clearance (when properly fitted the pin should rotate snugly in both the rod and piston). Before installing the piston in the block be sure the piston pin retainers are fully seated in the piston grooves.

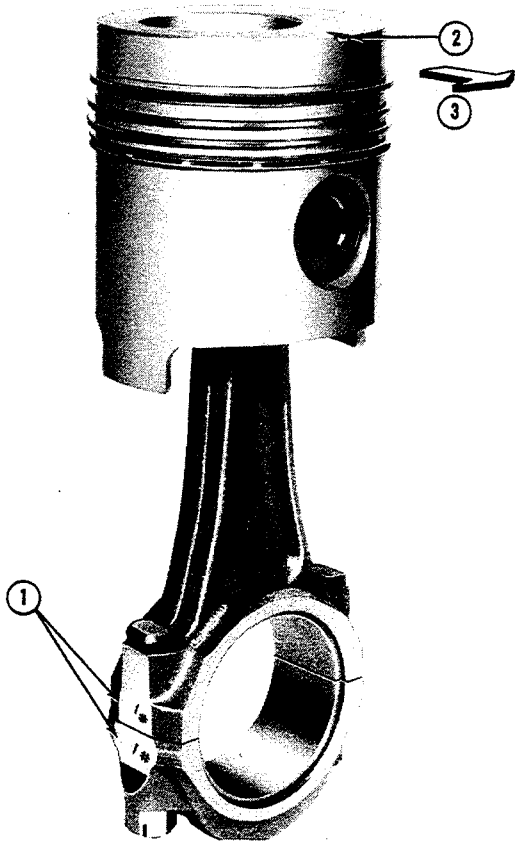


Figure 55
Positioning Piston with Connecting Rod
1. Connecting Rod and Cap Numbers
2. Notch on Piston
3. Notch to Front of Engine

F. INSTALLATION

1. Turn the crankshaft to position the No. 1 crankpin at the bottom of its stroke.

2. Liberally lubricate the No. 1 piston with engine oil. Compress the rings with a Piston Ring Compressor as shown in Figure 57. Install the bearing liner in the connecting rod.

3. Position the piston and rod assembly in the cylinder block with the identification mark on the piston facing the front of the engine.

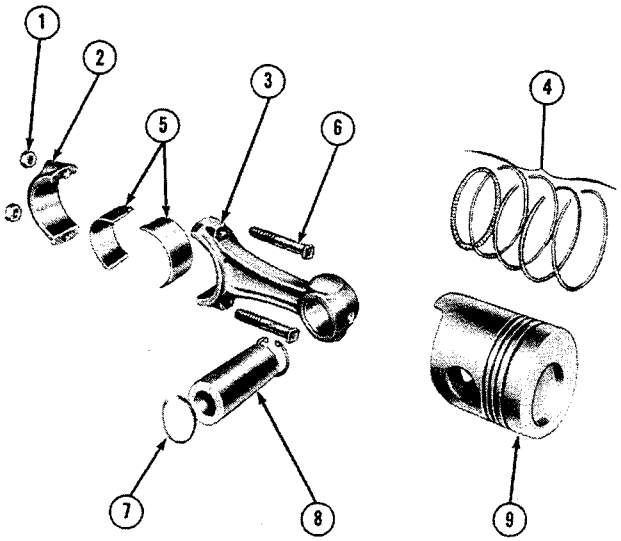


Figure 56
Piston and Connecting Rod Assembly

1. Nut
2. Cap
3. Connecting Rod
4. Piston Rings
5. Bearings
6. Bolt
7. Pin Retainer
8. Piston Pin
9. Piston

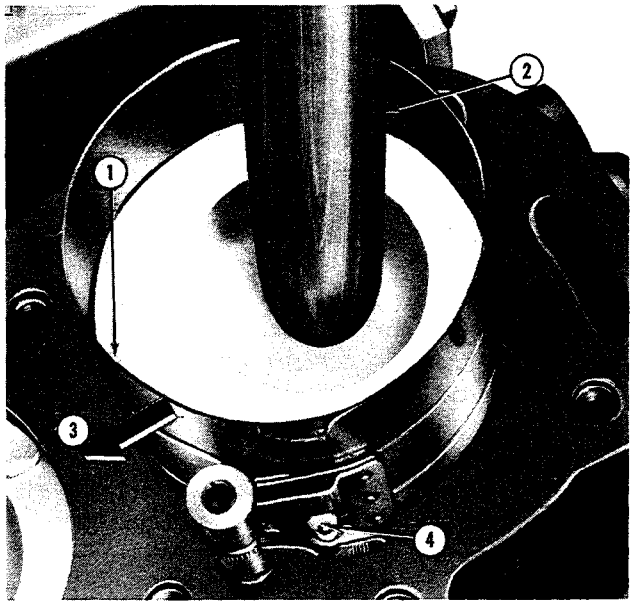


Figure 57
Installing Piston and Connecting Rod

1. Identification Notch
2. Hammer Handle
3. Assemble with Notch Forward
4. Piston Ring Compressor

4. Tap the piston into the cylinder bore with the handle end of a hammer, Figure 57, until the connecting rod bearing liner is seated on the crankpin. Be careful not to damage the cylinder wall or the bearing journal with the connecting rod or rod bolts.

5. Having insured correct liner clearance, refer to page 44, "Fitting Main and Connecting Rod Bearings." Lubricate the crankpin and liners and install the bearing cap on the rod with the number on the cap on the same side as the number on the rod. Install new nuts and tighten to the specified torque, page 92.

6. Install the remaining pistons and rods in the same manner, each time checking the bearing clearance.

7. Install the oil pump and the oil pan as outlined on page 22.

8. Install the cylinder head as outlined on page 15.

9. Fill the crankcase with oil and the radiator with coolant.

10. Start the engine and check for leaks.

CYLINDER BLOCK

The following is the procedure for inspection and repair of the cylinder block.

A. INSPECTION

1. Inspect the core plugs for evidence of rust. Rust indicates leakage and new plugs should be installed. Remove the defective plugs. Apply sealer to the new plugs and install them securely.

2. Inspect and measure the cylinder bores for waviness, scratches, scuffing, out-of-round, wear, and taper. A wavy cylinder wall has a series of parallel lines or rings worn around the