# Index

## Reconditioning Procedures (Section 8)



# General Information

The 4.5" bore, V8 (Direct Injection) Engine can be reconditioned to provide performance characteristics comparable to a new engine. The reconditioned engine will operate satisfactorily if certain reconditioning precautions are observed.

Performance and oil control comparable to a new engine can be obtained only if the necessary machining is done to the required Specifications. Cylinder block reconditioning requires an automatic honing machine to control size, surface finish and cross hatch pattern of the cylinder bores. A manually operated hone does not give satisfactory results and is not recommended.

To facilitate reconditioning, pistons and rings are available 0.51 mm (.020 in) and 1.02 mm (.040 in) oversize.

Connecting rods and main bearings are available 0.25 mm (.010 in), 0.51 mm (.020 in) and 1.27 mm (.050 in) undersize.

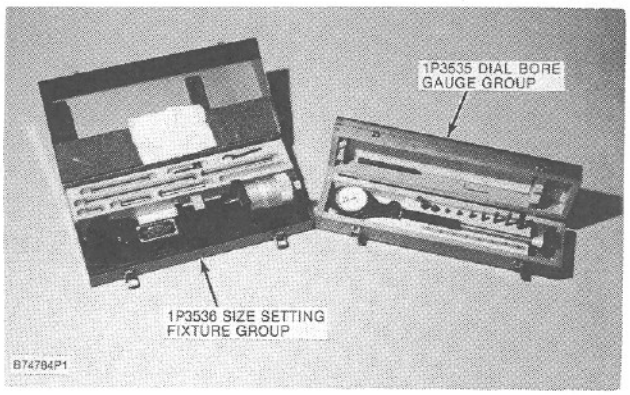
Main bearings are available with a 0.25 mm (.010 in) oversize outside diameter. These bearings are for cylinder blocks that have had the bore for the main bearings bored oversize.

# Basic Block

## Cylinder Block Honing

The following preliminary check is essential to determine if honing is necessary, and if so, the size to hone.

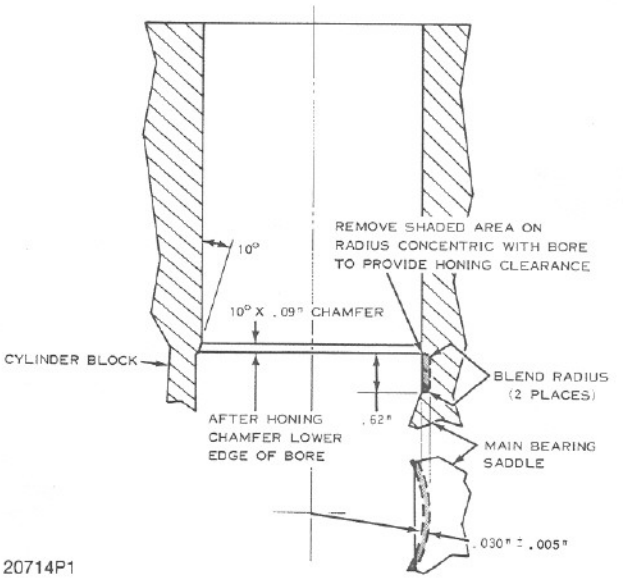
Measure all cylinder bores during disassembly using the 1P3537 Bore Gauging Group. This Group includes a 1P3535 Dial Bore Gauge Group and a 1P3536 Size Setting Fixture Group. The bore gauging group provides more accurate measurement than other methods, such as inside micrometers. When setting the gauge, always be sure the gauge pin has sufficient travel to measure the points of maximum wear in the bore. In a cylinder bore, maximum wear is usually across the diameter perpendicular to the crankshaft centerline, either at the top or bottom of ring travel. Normal wear usually will not exceed 0.51 mm (.020 in); however, if bore wear is greater than 0.51 mm (.020 in), hone the block 1.02 mm (.040 in) oversize. The fact that the block can be honed both 0.51 mm (.020 in) and 1.02 mm (.040 in) oversize will allow a block to be reconditioned twice under normal wear conditions. The standard bore size is 114.300 to 114.338 mm (4.5000 to 4.5015 in).




1P3537 Bore Gauging Group

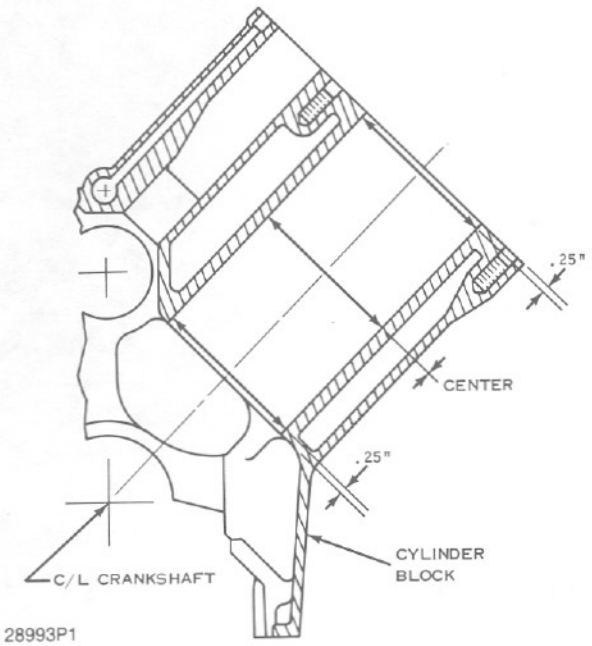
When reconditioning an engine, the bore size is the determining factor as to the necessity of honing the bores. If bores are worn 0.15 mm (.006 in) more than the standard size, the block should be honed. However, additional service may be obtained without honing if wear does not exceed the maximum wear limit of 0.216 mm (.0085 in).

Before honing, inspect the bottom of each cylinder bore adjacent to the main bearing saddle or web. Some of the saddles may overlap the edge of cylinder bores enough to interfere with honing. Where overlap exists, machine a relief in the saddle to provide clearance for the honing tool. The radius of the relief must be concentric with the cylinder bore and 0.76 ± 0.13 mm (.030 ± .005 in) larger than the bore radius. The relief extends 15.7 mm (.62 in) beyond the bottom of the bore, as shown. This provides adequate clearance for honing.




Relief In Saddles And Chamfer After Honing

When honing, check bore size at several locations in the length of the bore and around the circumference. Specifically measure at points perpendicular to the crankshaft centerline at locations 6.4 mm (.25 in) from each end and at center of bore. These three specific locations are primary gauge points during and after honing.




Primary Gauging Points

When honing cylinder blocks, maintain the specific dimensional surface finish and cross hatch tolerances to obtain satisfactory oil control. The tolerances specified are virtually the same as those used for original bore finish at the factory, and can be obtained with an automatic honing machine such as the Sunnen CK-10. This machine has been evaluated and found to give satisfactory results.

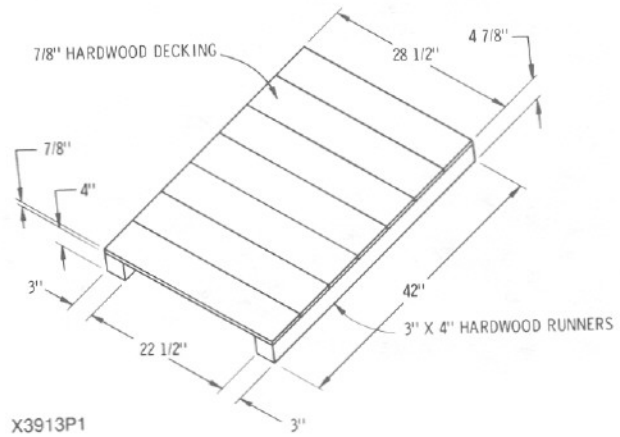
The Sunnen CK-10 machine is available from Sunnen Products Company, 7910 Manchester Avenue, St. Louis, Missouri, 63143.

Due to the cost of suitable honing equipment, it may be more expedient to have the honing done by a shop equipped with a Sunnen CK-10 or equivalent.

## Transit Preparation

The following Steps can prevent damage to the block in transit to a shop.

1. Completely disassemble, but do not clean block. The residual oil on the surface will prevent rust.
2. Enclose the block in an industrial plastic bag and position it with the oil pan surface on a suitable wood pallet or equivalent. Dimensions of a suitable wood pallet are shown.




Transporting Pallet

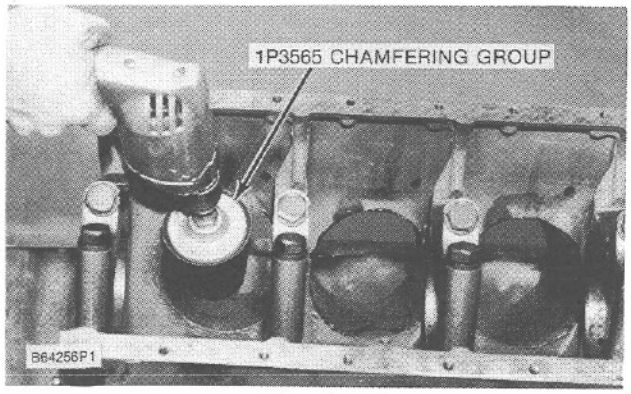
3. Cover the block with 12.7 mm (½ in) thick plywood or equivalent, and band block to the pallet.
4. Follow similar instructions when block is returned. To prevent rust, the block should not be cleaned after honing; the film of honing oil provides ample protection from rusting.

NOTE: If blocks are stored for any length of time, clean and anti-rust after honing.

## Cleaning Procedure

After honing is completed, and before assembling the engine, the cylinder block must be cleaned and prepared according to the following instructions.

1. If not previously removed, the camshaft bearings must be removed to permit thorough cleaning of the oil passages. To remove the bearings, see the topic Camshaft Bearings Removal And Installation.
2. Use 1P3565 Chamfering Group, remove the sharp corner at the bottom of the cylinder bores as shown. This is essential to prevent scuffing the piston skirts. This chamfer should be approximately 10° × 2.3 mm (10° × .09 in).




Chamfering Bore

NOTICE

Avoid damage to the cylinder bore surface or any other parts.

3. Use the 1P5580 Brush Group and a strong detergent and water solution to clean the following areas of the block.

A. Main oil gallery and supply passage. Use the 1P5572 or 1P5573 Brush and stroke several times while rotating the brush.

B. Camshaft bearing oil passages. Use the 1P5571 Brush and stroke several times while rotating the brush.

C. Cylinder bores. Use the 1P5574 Brush and stroke each bore for one minute while rotating the brush at 1000 rpm.

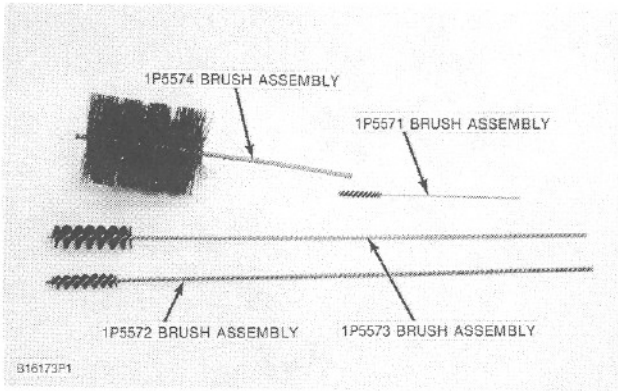
NOTICE

Incomplete cleaning will result in piston seizure or rapid wear of cylinder bores, pistons and rings. Only thorough rotary brushing with a strong detergent and water solution satisfactorily removes abrasive particles.

4. To clean the piston cooling jets, use a #50 drill or a length of 1.78 mm (.070 in) wire and push through the jet. Be sure the groove in the main bearing bores and the counterbores for piston cooling jets are clean and free of debris.

5. Thoroughly clean the cylinder block in an agitator-type cleaning tank. This type of cleaning should follow the brushing of the cylinder bores but is not sufficient by itself for cleaning.

6. Coat all machined surfaces immediately after cleaning with engine oil (SAE 30). Keep the block covered to exclude dirt until assembled.




1P5580 Brush Group

## Remove and Install Piston Cooling Jets

Use a 3/16 in diameter punch approximately 305 mm (12 in) long to remove the piston cooling jets. Put the punch in the engine cylinder bore and drive the piston cooling jet into the main bearing bore.

Use a FT1542 Driver to install the piston cooling jets in the main bearing bores. After installation check the orifice size in the piston cooling jet. A #50 drill or a length of 1.78 mm (.070 in) diameter wire must pass through the jet.

| SUNNEN CK-10 MACHINING DATA | | | |
|---|---|---|---|
| **Item** | **Rough** | **Semifinish** | **Finish** |
| 0.51 mm (.020 in) oversize bore | 114.694 ± 0.03 mm (4.5155 ± .001 in) | 114.770 ± 0.013 mm (4.5185 ± .0005 in) | 114.821 ± 0.013 mm (4.5405 ± .0005 in) |
| 1.02 mm (.040 in) oversize bore | 115.202 ± 0.03 mm (4.5355 ± .001 in) | 115.278 ± 0.013 mm (4.5385 ± .0005 in) | 115.329 ± 0.013 mm (4.5405 ± .0005 in) |
| Cylinder length | 203.2 mm (8 in) | 203.2 mm (8 in) | 203.2 mm (8 in) |
| Hone head | CK-3000 | CK-3000 | CK-3000 |
| Stroke scale | 69.9 mm (2.75 in) | 69.9 mm (2.75 in) | 69.9 mm (2.75 in) |
| Stroke length setting | 203.2 mm (8 in) | 203.2 mm (8 in) | 203.2 mm (8 in) |
| Rotation speed (rpm) | 125 | 125 | 125 |
| Strokes per minutes | 49 | 49 | 37 |
| Feed ratchet | 14 | 14 | 14 |
| Top over stroke | 9.53 mm (.375 in) | 9.53 mm (.375 in) | 9.53 mm (.375 in) |
| Stone | EHU-123 | EHU-525 | JHU-625 |
| Load meter | 85 | 75 | 40 |
| Stock removal rate per minute | 0.13 mm (.005 in) | 0.064 mm (.0025 in) | 0.051 to 0.064 mm (.0020 to .0025 in) |
| Honing-per each 0.03 mm (.001 in) stock removal, advance feed | 0.03 mm (.001 in) | 0.08 mm (.003 in) | 0.08 mm (.003 in) |
| Surface finish (micro-inches) | – | – | 12-20 |
| NOTE: Mount cylinder block on .675″ riser plates. Use 42″ long bar, move clamps and riser blocks to extreme ends of carriage. | | | |

| SPECIFICATIONS AND TOLERANCES | | | |
|---|---|---|---|
| **Dimension Location** | **Standard Size** | **0.51 mm (.020") Oversize** | **1.02 mm (.040") Oversize** |
| Cylinder bore-finished | 114.300 to 114.338 mm (4.5000 to 4.5015 in) | 114.821 ± 0.013 mm (4.5205 ± .0005 in) | 115.329 ± 0.013 mm (4.5405 ± .0005 in) |
| **Allowable wear limit | 114.45 mm (4.506 in) | 114.96 mm (4.526 in) | – – |
| Maximum wear limit | 114.53 mm (4.509 in) | 115.03 mm (4.529 in) | 115.54 mm (4.529 in) |
| Surface finish (micro-inches) | 12 to 20 | 12 to 20 | 12 to 20 |
| Crosshatch included angle | 140 to 150 | 138 to 150 | 138 to 150 |
| Rough hone | – | 114.694 ± 0.03 mm (4.5155 ± .001 in) | 115.202 ± 0.03 mm (4.5355 ± .001 in) |
| Semifinish hone | – | 114.770 ± 0.013 mm (4.5185 ± .0005 in) | 115.278 ± 0.013 mm (4.5385 ± .0005 in) |
| ***Top ring gap new | 0.572 ± 0.190 mm (.0225 ± .0075 in) | 0.572 ± 0.190 mm (.0225 ± .0075 in) | 0.572 ± 0.190 mm (.0225 ± .0075 in) |
| **Allowable wear limit | 1.14 mm (.045 in) | 1.14 mm (.045 in) | 1.14 mm (.045 in) |
| Maximum wear limit | 1.40 mm (.055 in) | 1.40 mm (.055 in) | 1.40 mm (.055 in) |
| ***Oil ring gap-new | 0.508 ± 0.254 mm (.0200 ± .0100 in) | 0.508 ± 0.254 mm (.0200 ± .0100 in) | 0.508 ± 0.254 mm (.0200 ± .0100 in) |
| **Allowable wear limit | 0.97 mm (.038 in) | 0.97 mm (.038 in) | 0.97 mm (.038 in) |
| Maximum wear limit | 1.14 mm (.045 in) | 1.14 mm (.045 in) | 1.14 mm (.045 in) |
| Top ring vertical clearance in groove-new | 0.076 to 0.140 mm (.0030 to .0055 in) | 0.076 to 0.140 mm (.0030 to .0055 in) | 0.076 to 0.140 mm (.0030 to .0055 in) |
| **Allowable wear limit | 0.28 mm (.011 in) | 0.28 mm (.011 in) | 0.28 mm (.011 in) |
| Maximum wear limit | 0.36 mm (.014 in) | 0.36 mm (.014 in) | 0.36 mm (.014 in) |
| Oil ring vertical clearance in groove-new | 0.025 to 0.076 mm (.0010 to .0030 in) | 0.025 to 0.076 mm (.0010 to .0030 in) | 0.025 to 0.076 mm (.0010 to .0030 in) |
| **Allowable wear limit | 0.15 mm (.006 in) | 0.15 mm (.006 in) | 0.15 mm (.006 in) |
| Maximum wear limit | 0.20 mm (.008 in) | 0.20 mm (.008 in) | 0.20 mm (.008 in) |

* Tolerance includes out-of-round, taper and any other irregularities. Take final measurements with blocks stabilized to room temperature. Finished bore must clean up to 100%.

** Allowable wear limit is the suggested wear limit for a general overhaul. However, additional service may be obtained without honing the block if wear does not exceed maximum wear limits. (Cylinder bore wear is measured at the top and bottom of ring travel.)

*** To be measured in unworn area of bore.

NOTE: When the size of the cylinder bores exceeds the maximum wear limit of 115.545 mm (4.5490 in) replacement of the cylinder block or installation of cylinder sleeves is necessary.

| TIGHTENING PROCEDURE FOR THE BOLTS FOR MAIN BEARING CAPS |
| --- |
| **Tightening Procedure** |
| 1. Put 2P2506 Thread Lubricant on bolt threads and washer face.<br>2. Tighten to 40 ± 4 N•m (30 ± 3 lb ft).<br>3. Put a mark on each bolt and cap.<br>4. Tighten bolts from mark an added 120° ± 5°. |

## Main Bearing Bores

With the main bearing caps installed and tightened to the torque given in the chart Tightening Procedure For The Bolts For Main Bearing Caps, check main bearing bore size using the 1P3537 Gauging Group. If the main bearing bore is not within 94.171 ± 0.038 mm (3.7075 ± .0015 in), replace the main bearing cap. It is necessary to line bore the replacement caps. See the topic Line Boring Main Bearing Cap.

When installing main bearings caps on a reconditioned engine use new bearing cap bolts and washers.

## Main Bearing Cap Guide Width

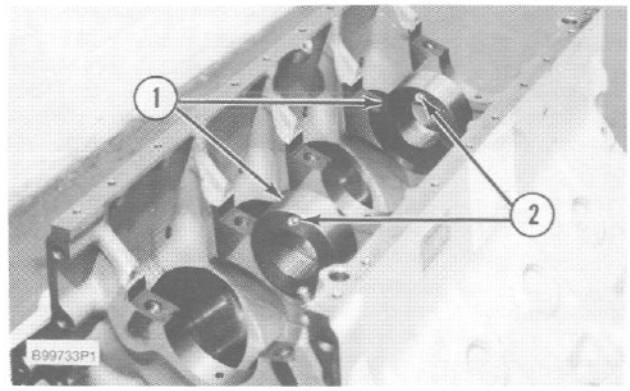
Check the width of the main bearing cap guide. The guide width of a new cap is 166.624 ± 0.018 mm (6.5600 ± .0007 in). Replace main bearing caps that are less than the minimum width of 166.573 mm (6.5580 in). It is necessary to line bore the replacement service caps. See the topic Line Boring Main Bearing Cap.

When installing main bearing caps on a reconditioned engine, use new main bearing cap bolts and washers.

## Line Boring Main Bearing Caps

When reconditioning a block, and one main bearing cap is replaced, line bore the replaced cap. If it is necessary to replace more than one cap, it is recommended that all of the main bearing bores be line bored. See the topic Line Boring Main Bearing Bores.

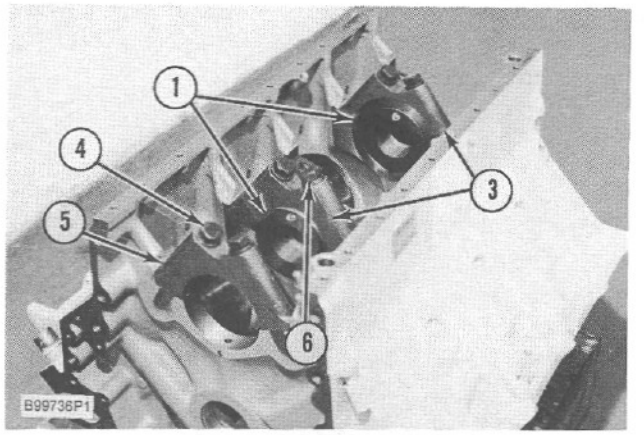
Clean bearing caps and saddles. Remove all nicks from pan rail. Plug oil holes in block with grease to prevent chips from entering oil passages.




Centering Rings In Block
(1) Centering Rings. (2) Oiler.

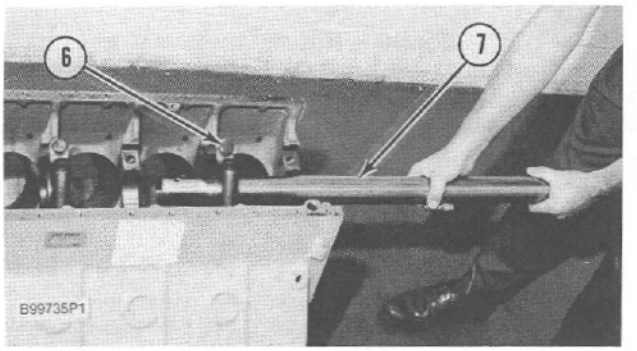
Place 1P2344 Centering Rings (1), with oiler (2) up, on each side of the cap being replaced. For an end cap, place 1P2344 Centering Rings (1) in the second and fourth main bearing bores.

Mark new cap to correspond with number of saddle and install the new unbored cap (5). Mark cap and saddle "OS" for oversize next to location number. Tighten the unbored cap bolts (4) to the torque shown in the chart Tightening Procedure For The Bolts For Main Bearing Caps. Place the original bearing caps (3) over the centering rings (1). Tighten the original bearing cap bolts (6) hand tight.



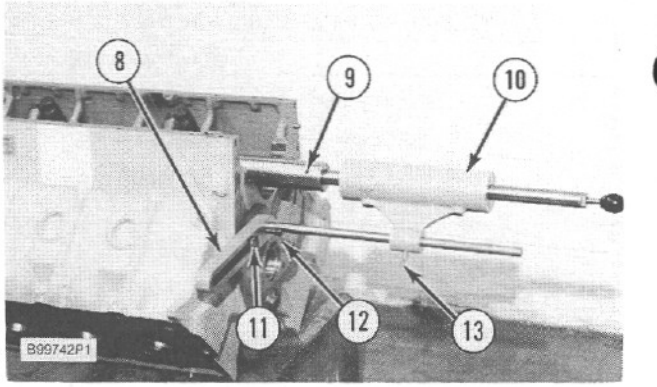

Centering Rings Installed
(1) 1P2344 Centering Rings. (3) Original bearing caps. (4) Bolts (two). (5) Unbored cap. (6) Bolts (four).

Oil boring bar (7) and insert it through centering rings (1). Tighten bolts (6) to a minimum of 25 N•m (20 lb ft) and a maximum of 70 N•m (50 lb ft) while spinning boring bar (7) to check for binding. Centering rings (1) must be seated in bearing saddles after tightening.



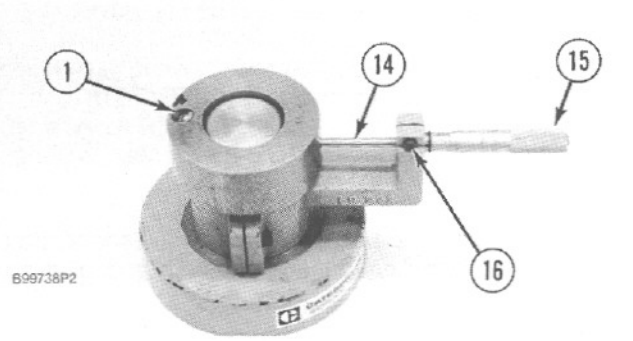

Installing Boring Bar
(6) Bolts (four). (7) 1P2352 Boring Bar.

Bolt torsion bar assembly (8) loosely to opposite end of block from which boring bar will be driven. Install feed assembly (10) into boring bar and tighten setscrew (9). Slide feed assembly (10) onto torsion bar assembly (8) and tighten bolt (11). Tighten bolt (12) finger tight. Boring bar must slide in and out freely after these tightening operations. Tighten thumbscrew (13).




Feed Assembly Installed
(8) 1P2369 Torsion Bar Assembly. (9) Setscrew. (10) 5P2981 Feed Assembly. (11) Bolt. (12) Bolt. (13) Thumbscrew.

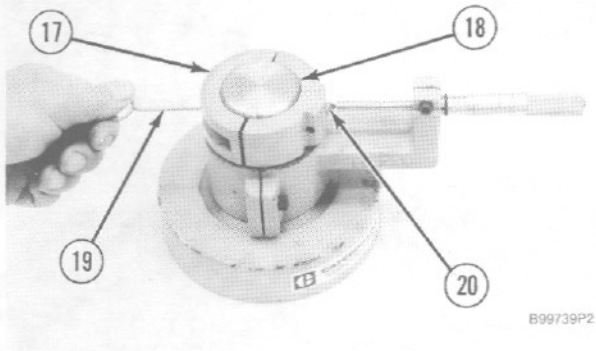
To set tool in tool holder. Set micrometer (15) to 94.171 mm (3.7075 in). Place centering ring (1) on 1P2370 Micrometer Bracket Assembly. Move micrometer (15) until spindle (14) contacts centering ring (1). Tighten bolt (16). Back off micrometer thimble and recheck micrometer setting. Repeat above steps until micrometer setting is accurate.




Setting Micrometer
(1) 1P2344 Center Ring. (14) Micrometer spindle. (15) Micrometer. (16) Bolt.

Place tool holder (17) on the 1P2370 Micrometer Bracket Assembly. Align mark on tool holder (17) with hole in shaft (18). Place tool bit (20) in tool holder (17) and set the micrometer 1.78 mm (.070 in) less than the finish bore diameter of 94.425 ± 0.013 mm (3.7175 ± .0005 in). Turn the bracket assembly arm until micrometer spindle aligns with tool bit (20). Adjust tool bit (20) by pushing it with the 9S8521 Rod (19) until tip of tool bit (20) touches micrometer spindle.

NOTICE
Do not sweep micrometer spindle across tool bit.

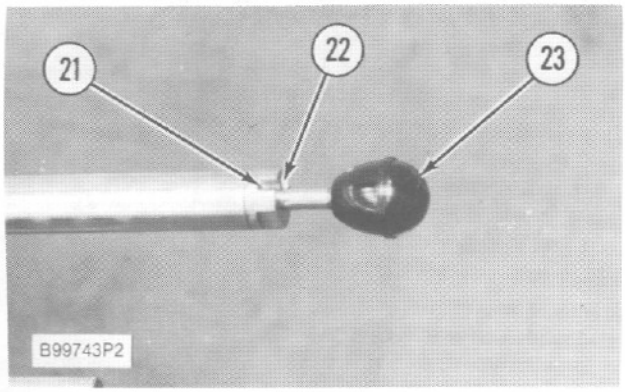



Setting Tool Bit
(17) 1P2366 Tool Holder Assembly. (18) Shaft. (19) 9S8521 Rod. (20) Tool bit.

Use a maximum of 0.64 mm (.025 in) rough cuts and 0.25 mm (.010 in) finish cuts.

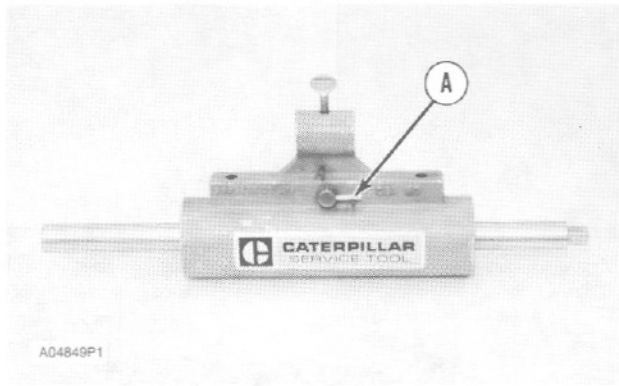
Wipe boring bar and tool holder clean. Place tool holder on the boring bar, with tool bit cutting edge facing the direction of rotation. Assemble the tool holder by placing lower half over the bolts, slide into slot and tighten bolts. Slide boring bar in until tool is approximately 3.0 mm (.12 in) from the bore. Compare tool cutting tip with bore surface while turning bore bar by hand, to insure correct tool setting.

Set feed mechanism into feed by turning knob (23) until pin (22) drops into slot (21).



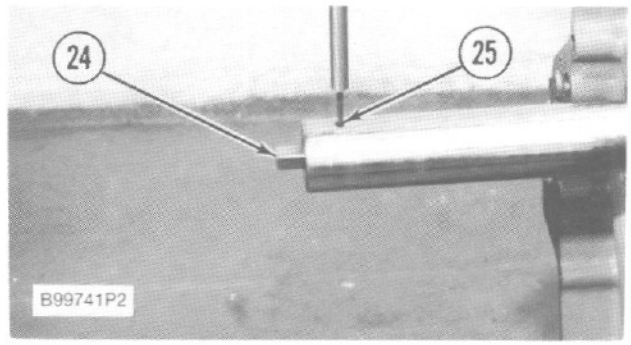

Feed Engaged
(21) Slot. (22) Pin. (23) Knob.

NOTE: To set the feed mechanism into feed on later units, turn lever (A) up (the direction of arrow).



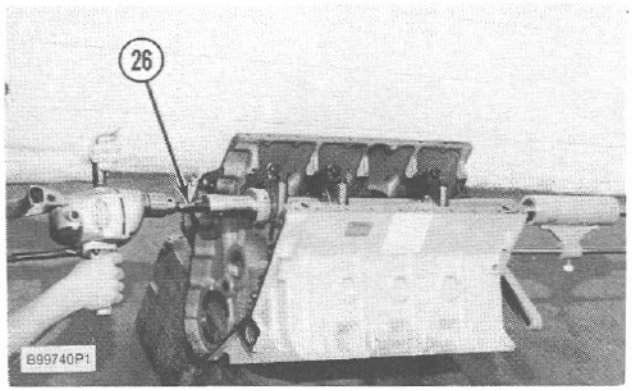

Later Feed Mechanism
(A) Lever.

Place adapter (24) into boring bar and tighten setscrew (25).



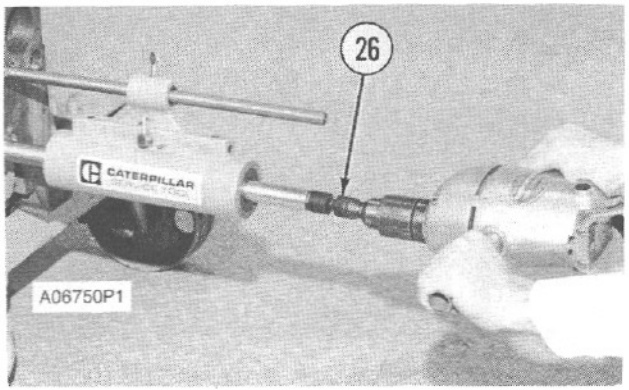

Adapter Installed
(24) 1P2364 Adpater. (25) Setscrew.

Apply layout bluing to the bearing cap and bearing bore. Oil the centering rings. Do not use lubricant on the cutter. Use a one-half inch electric drill with universal joint (26) to feed tool through the bore. Service main bearings with 0.25 mm (.010 in) oversize outside diameter are available to permit the bore to be bored oversize. Bore the bore to 94.425 ± 0.013 mm (3.7175 ± .0005 in).




Boring Bearing Bore
(26) 1P2363 Universal.

NOTE: If you use the later feed mechanism, the tool can be driven from either the boring bar or the feed mechanism.

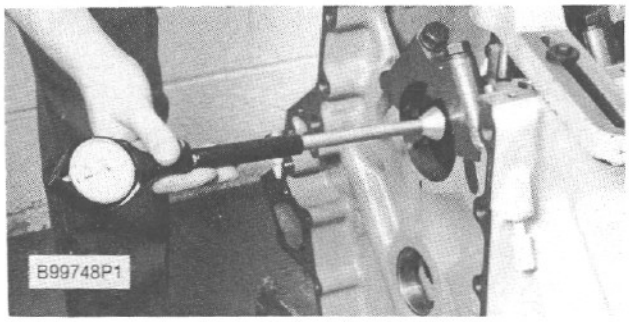



Driving Through Feed Mechanism
(Typical Example)
(26) 1P2363 Universal

The bluing applied to the bearing bore indicates the condition of the bore at the correct bore size. If bluing shows an out of round condition, check the largest diameter (indicated by remaining bluing) in relation to the smallest diameter (indicated by lack of bluing). The difference of the two must not exceed 0.025 mm (.0010 in).

If bluing indicates a step in the joint face, measure the diameter at the step in relation to the smallest diameter. A step of 0.013 mm (.0005 in) on one or both sides is permissible. A maximum of 0.025 mm (.0010 in) over the nominal finish bore diameter is permissible if within the described limits.

To check the bore diameter, set the 1P3535 Dial Bore Gauge to 94.425 mm (3.7175 in).




Checking Bore
(Typical Example)

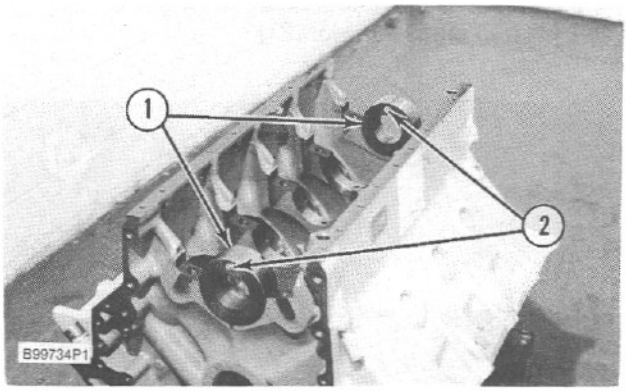
## Line Boring Bearing Bores

Line bore all main bearing bores if bearing caps or saddles are distorted.

Clean bearing caps and saddles. Remove all nicks from pan rail. Plug oil holes in block with grease to prevent chips from entering oil passages.

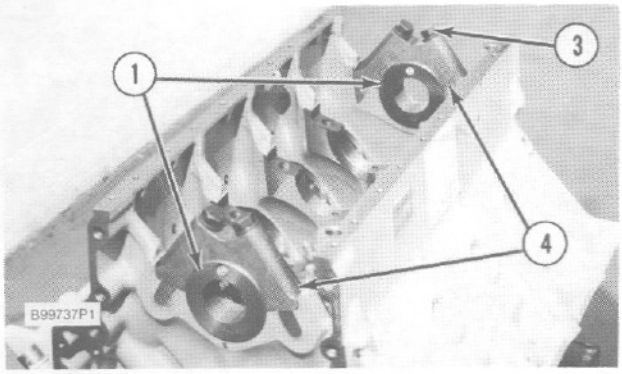
Place 1P2344 Centering Rings (1), with oiler (2) up, at each end of block. If an end bore is distorted, use the next good bore.

NOTE: There must be two good bores for locating centering rings.

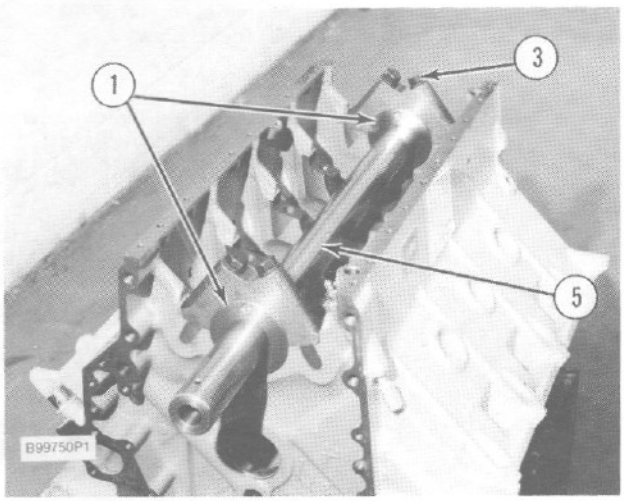



Centering Rings In Block
(1) 1P2344 Center Rings. (2) Oiler.

Place original bearing caps (4) over the centering rings (1). Tighten bolts (3) hand tight.



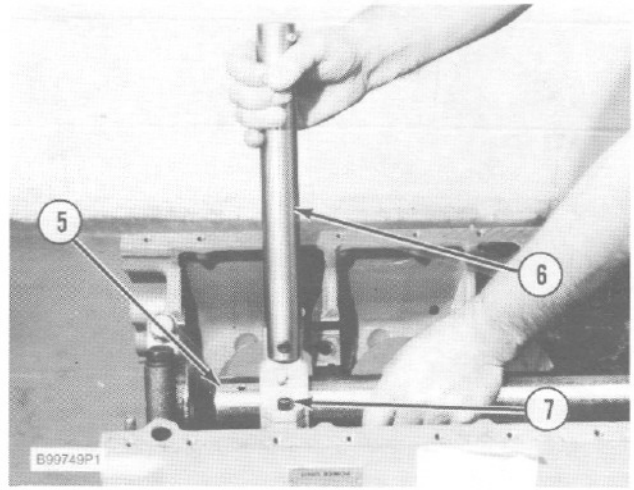

Centering Rings Installed
(1) 1P2344 Centering Rings. (3) Bolts (four). (4) Bearing caps.




Boring Bar Installed
(1) 1P2344 Centering Rings. (3) Bolts (four). (5) 1P2352 Boring Bar.

Oil boring bar (5) and insert it through centering rings (1). Tighten bolts (3) to a minimum of 25 N•m (20 lb ft) and a maximum of 70 N•m (50 lb ft) while spinning boring bar (5) to check for binding. Centering rings (1) must be seated in bearing saddles after tightening.

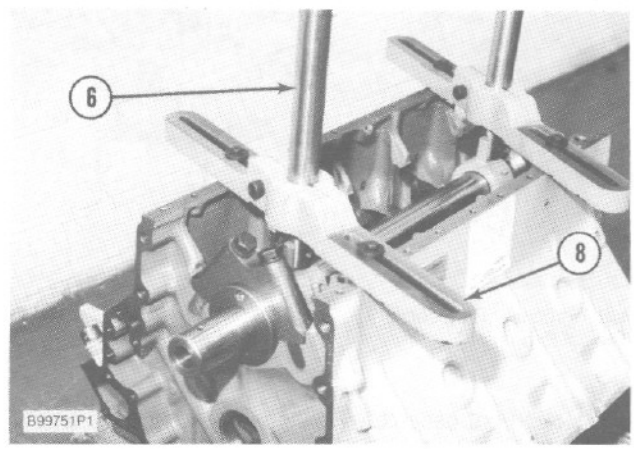
Slide boring bar (5) out of one end of block and install bearing assemblies (6) on boring bar (5). Slide boring bar (5) back through centering ring. Adjust bearing by tightening bolt (7) until bar begins to bind, then back off until boring bar (5) spins easily.




Installing Bearing Assemblies
(5) 1P2352 Boring Bar. (6) 1P2373 Bearing assembly (two).
(7) Bolt.

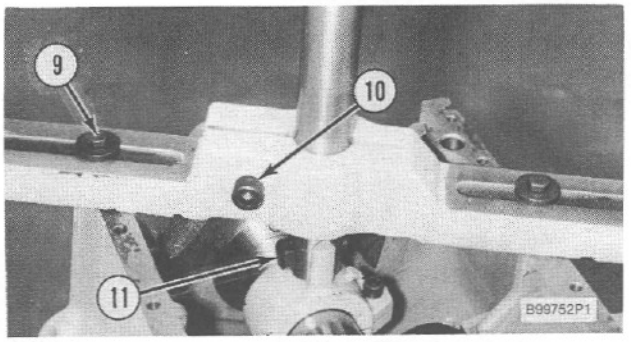
Install bridge assemblies (8) over bearing assemblies (6). Position bridge assemblies (8) on block as shown with thicker portion up.

NOTE: Bridge assemblies must be on block as shown for tool holder clearance at each bore.




Bridge Assemblies Installed
(6) 1P2373 Bearing Assembly (two). (8) 1P2343 Bridge Assembly (two).

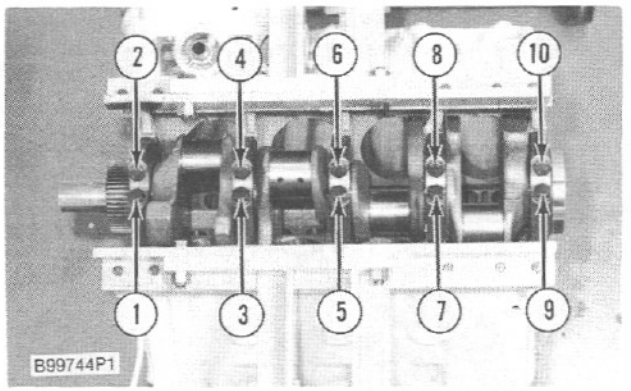
Tighten bolts (9) finger tight. Tighten bolt (10) lightly. Tighten bolt (11). Loosen, then tighten bolts (9) and bolt (10). Spin boring bar (5) during all tightening operations. Repeat above procedure if boring bar (5) binds.




Bolt Location
(9) Bolt (two). (10) Bolt. (11) Bolt.

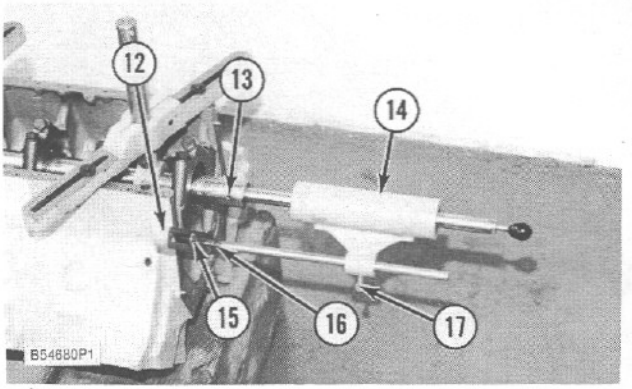
Remove original bearing caps and centering rings. Mark new caps to correspond with numbers on saddle and install new service caps. Mark caps and saddles "OS" for oversize next to location number.

Be sure to install new bolts. Put engine oil on bolt threads and washer face. Tighten bolts in number sequence to 40 ± 4 N•m (30 ± 3 lb ft), put a mark on each bolt and cap. Tighten all bolts by number from mark an additional 120 ± 5°.



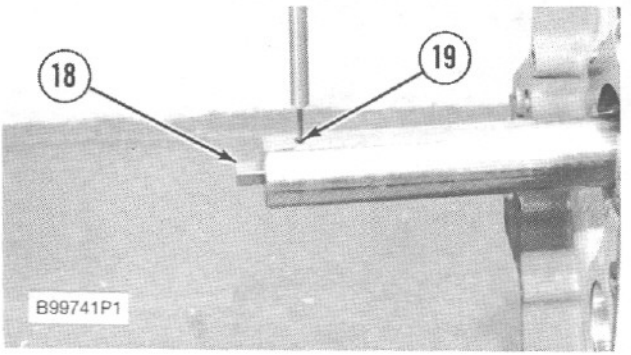

Bolt Tightening Sequence
(Typical Example)

Bolt torsion bar assembly (12) loosely to opposite end of block from which boring bar will be driven. Install feed assembly (14) into boring bar and tighten setscrew (13). Slide feed assembly (14) onto torsion bar assembly (12) and tighten bolt (15). Tighten bolt (16) finger tight. Boring bar must slide in and out freely after these tightening operations. Tighten thumbscrew (17).



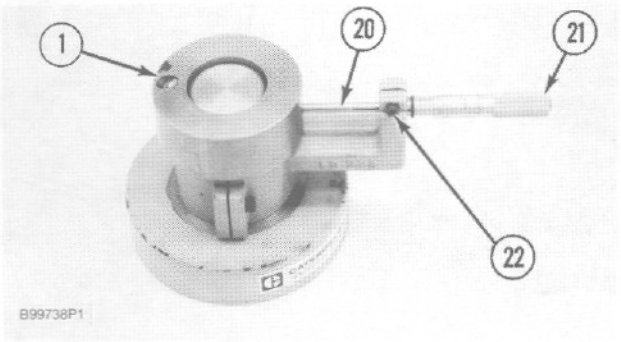

Feed Assembly Installed
(12) 1P2369 Torsion Bar Assembly. (13) Setscrew. (14) 5P2981 Feed Assembly. (15) Bolt. (16) Bolt. (17) Thumbscrew.

Place adapter (18) into boring bar and tighten setscrew (19).




Adapter Installed
(18) 1P2364 Adapter. (19) Setscrew.

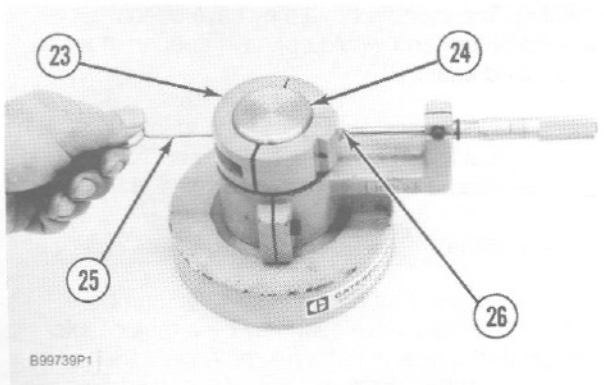
Put tool in tool holder, set micrometer (21) to 94.171 mm (3.7075 in). Place centering ring (1) on the 1P2370 Micrometer Bracket Assembly. Move micrometer (21) until spindle (20) contacts centering ring (1). Tighten bolt (22). Back off micrometer thimble and check micrometer setting. Repeat above steps until micrometer setting is accurate.




Setting Micrometer
(1) 1P2344 Centering Ring. (20) Micrometer spindle.
(21) Micrometer. (22) Bolt.

Place tool holder (23) on the 1P2370 Micrometer Bracket Assembly. Align mark on tool holder (23) with hole in shaft (24). Place tool bit (26) in tool holder (23) and set the micrometer 1.78 mm (.070 in) less than the finish bore diameter of 94.425 ± 0.013 mm (3.7175 ± .0005 in). Turn the bracket adjustment arm until micrometer spindle aligns with tool bit (26). Adjust tool bit (26) by pushing it with the 9S8521 Rod (25) until tip of bit (26) touches micrometer spindle.

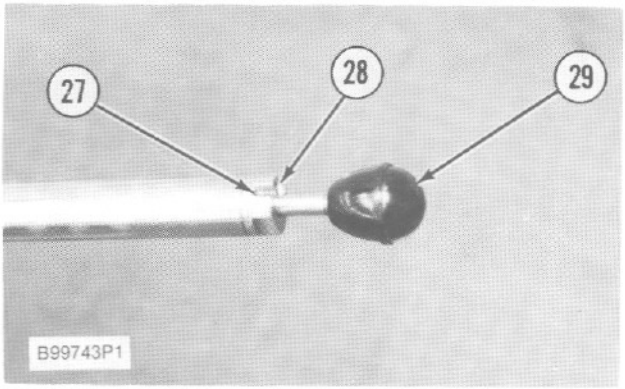
NOTICE
Do not sweep micrometer spindle across tool bit.




Setting Tool Bit
(23) 1P2366 Tool Holder Assembly. (24) Shaft. (25) 9S8521 Rod.
(26) Tool bit.

Use a maximum of 0.64 mm (.025 in) for rough cuts and 0.25 mm (.010 in) for finish cuts.

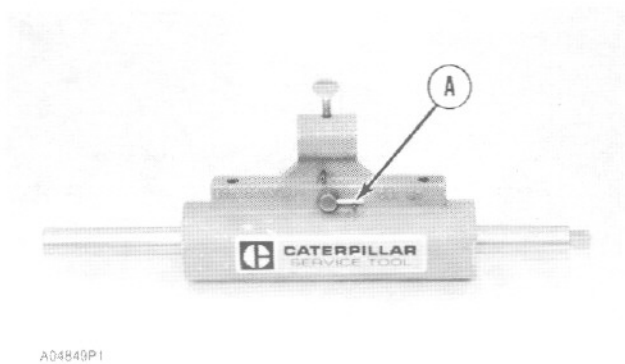
Wipe the boring bar and tool holder clean. Place tool holder on the boring bar, with tool bit cutting edge facing the direction of rotation. Assemble the tool holder by placing lower half over the bolts, slide into slot and tighten bolts. Slide boring bar in until tool is approximately 3.0 mm (.12 in) from the bore. Compare tool cutting tip with bore surface while turning boring bar by hand, to insure correct tool setting.




Feed Engaged
(27) Slot. (28) Pin. (29) Knob.

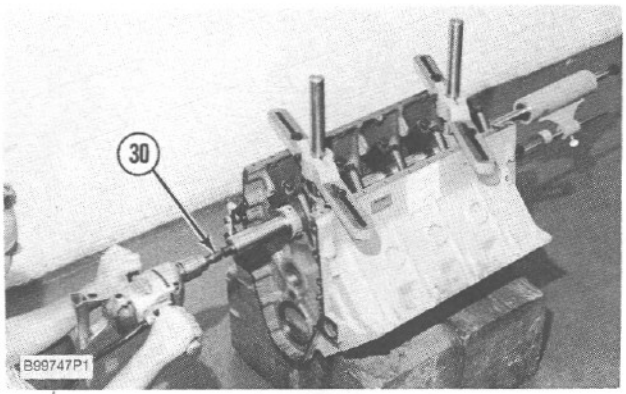
Set feed mechanism into feed by turning knob (29) until pin (28) drops into slot (27).

NOTE: To set the feed mechanism into feed on later units, turn lever (A) up (the direction of arrow).

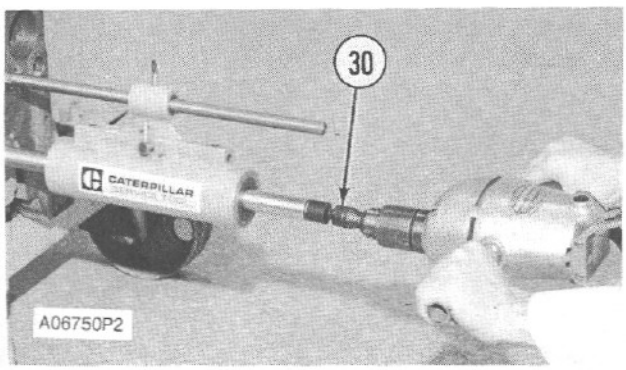



Later Feed Mechanism
(A) Lever.

Oil the bearing assemblies. Do not use lubricant on the cutter. Use one-half inch electric drill with universal joint (30) to feed the tool through the bores. Service main bearings with 0.25 mm (.010 in) oversize outside diameter are available to permit bores to be bored oversize. Bore block to 94.425 ± 0.013 mm (3.7175 ± .0005 in).

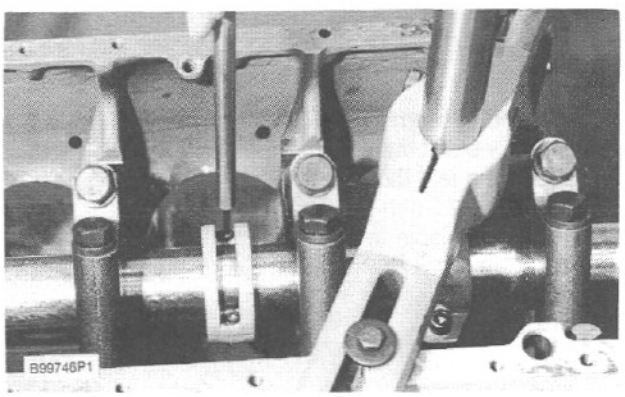



Boring Block
(30) 5P1630 Universal.



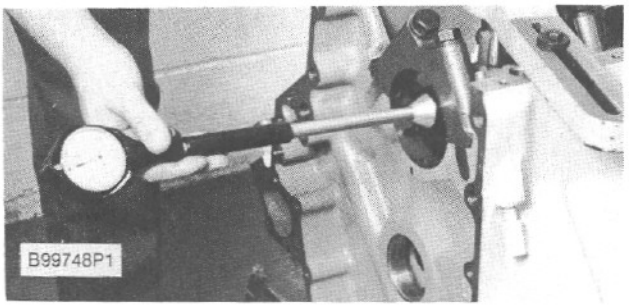

Driving Through Feed Mechanism
(Typical Example)
(30) 5P1630 Universal.

NOTE: If you use the later feed mechanism the tool can be driven from either the boring bar or the feed mechanism.




Positioning Tool Holder

When boring, if bearing assemblies interfere or tool does not reach next bore, reposition tool holder on boring bar.




Checking Bore

To check bores, set the 1P3535 Dial Bore Gauge to 94.425 mm (3.7175 in).

## Cylinder Head and Valve Components

Check cylinder head for cracks before reconditioning.

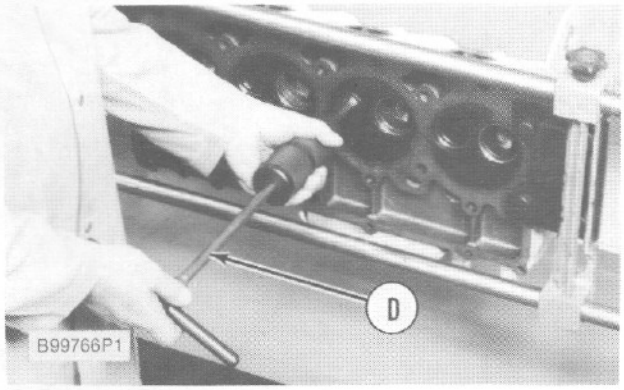
Flatness of the cylinder head should be within 0.15 mm (.006 in) total, and a maximum of 0.08 mm (.003 in) for any 152.4 mm (6.00 in) span. A maximum stock removal of 0.25 mm (.010 in) is permissible when resurfacing the head.

Always check the thickness of a cylinder head before resurfacing. The cylinder head may have been resurfaced before and would not have enough stock to be resurfaced again.

To check the thickness of a cylinder head, measure through the fuel injection nozzle holes at each end of the cylinder head. For the correct thickness of the cylinder head, see the topic Cylinder Head in the Specifications.

The valve seat insert for the exhaust valve can be replaced. The intake valve seat may be a replaceable seat insert or the seat may be machined into the cylinder head. When the seat for a non-replaceable intake valve has been machined to the limits, the cylinder head can be bored (machined) for a valve seat insert. See, Specification for dimensions given.

To remove the intake and exhaust valve seats that have replaceable inserts, use the 8S7170 Valve Seat Insert Puller Group.




Removing Exhaust Valve Seat Insert

Freeze the intake or exhaust valve seat inserts and use the 8S7170 Valve Seat Insert Puller Group to install inserts into head. Be sure bores are clean, free of burrs, and the insert has a good press fit into the bore.

After inserts are installed, grind the seat face of the insert to be sure it is flat, has the correct angle, and is in alignment with the bore in the valve guide.

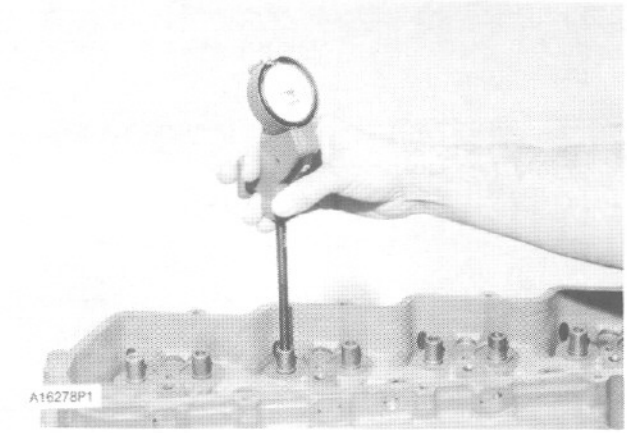
For specifications, see VALVE GRINDING SPECIFICATIONS CHART.

NOTE: Replace intake and exhaust valve seat inserts when valve seat width or valve head-to-cylinder head face cannot be machined to the correct specification. For specifications, see VALVE GRINDING SPECIFICATIONS CHART.

Clean valve guides of all carbon and oil, using the 5P7176 Brush and a solvent.

The valve guides are cast in the cylinder heads. Check each valve guide bore size 19.1 mm (.75 in) deep from each end. The bore size is 9.512 ± 0.013 mm (.3745 ± .0005 in) and the maximum size worn is 9.550 mm (.3760 in). Valve guides worn more than the maximum wear size, can be restored by original tolerances through knurling.

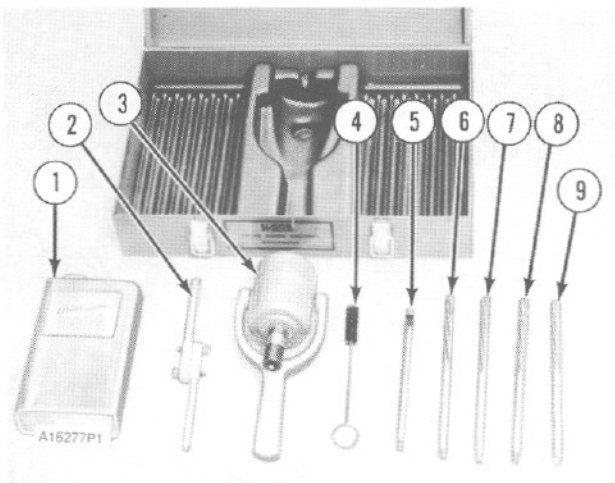
Use the 5P3536 Valve Guide Gauge Group to check the bore of the valve guides. Special Instruction, Form No. GMG02562 gives complete and detailed instructions for use of the 5P3536 Valve Guide Gauge Group.




Using 5P3536 Valve Guide Gauge Group

NOTE: If valve guide bore is larger than 9.68 mm (.381 in), knurling may not restore the guide to original tolerances.

The following procedure can be used to knurl valve guide bores using the 5P5170 Knurling Group:




5P5170 Knurling Group
(1) 5P5178 Lubricant. (2) 5P5187 Tap Wrench. (3) 5P5177 Speed Reducer (7 to 1). (4) 5P5176 Brush. (5) 5P5175 Knurling Arbor. (6) 5P5171 Reamer (.371 in). (7) 5P5172 Reamer (.372 in). (8) 5P5173 Reamer (.373 in). (9) 5P5174 Reamer (.374 in).

1. Clean and buff head, guides and valves. Check valve stem diameter. The intake valve stem diameter is 9.462 ± 0.013 mm (.3725 ± .0005 in) and the minimum size worn is 9.423 mm (.3710 in). The tapered stem exhaust valve has a stem diameter of 9.436 ± 0.013 mm (.3715 ± .0005 in) at the keeper end of the stem, and 9.411 ± 0.013 mm (.3705 ± .0005 in) at the head end of the stem. The minimum size worn is 9.373 mm (.3690 in).

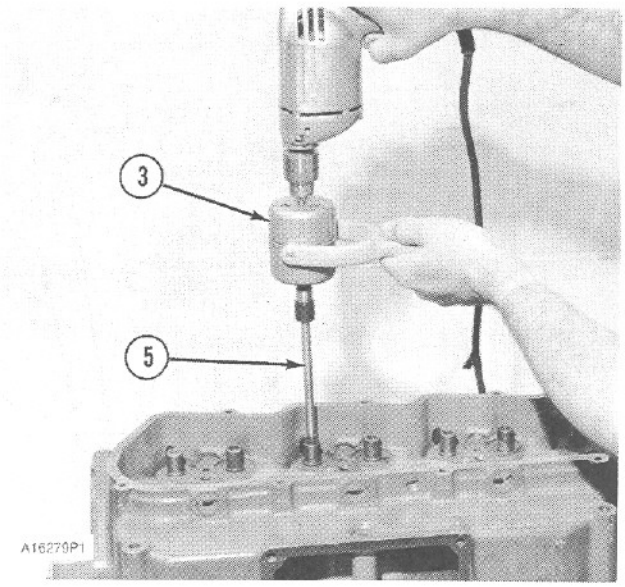
2. Place head on the FT806 Cylinder Head Bench or 8S6691 Cylinder Head Stand with rocker arm side toward you.

NOTE: Use FT967 Adapter Plates to mount head on FT806 Cylinder Head Bench.

3. Dip the 5P5176 Brush (4) into the 5P5178 Lubricant (1) and run the brush through the guide.

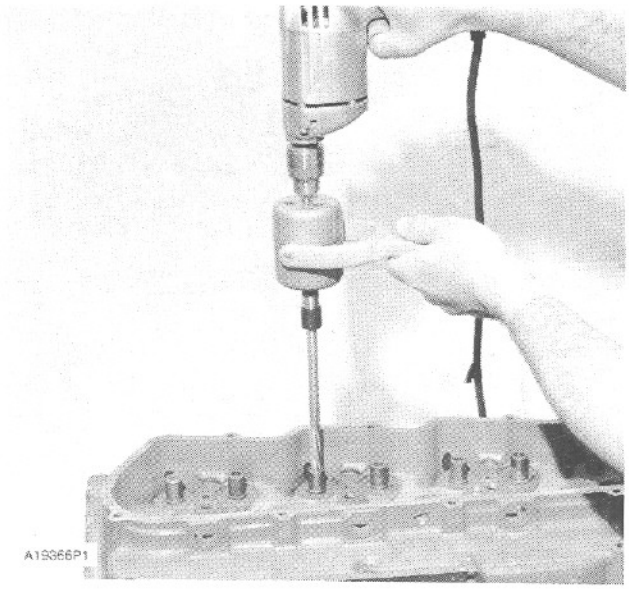
NOTE: The 5P5178 Lubricant is specially formulated for knurling cast iron guides and will prolong arbor life. If not available, use only Black Sulfur cutting oil or parafin base oil.

4. Dip the 5P5175 Knurling Arbor (5) into the 5P5178 Lubricant just prior to knurling. Use the 5P5177 Speed Reducer (3) and a ¼ inch electric drill (1200 to 1600 rpm recommended) to drive the arbor. Hold the speed reducer and drill firmly during knurling. Do not push or guide arbor during knurling.




Knurling Guide
(3) 5P5177 Speed Reducer. (5) 5P5175 Knurling Arbor.

5. Select the reamer that is closest to the size of the valve stem that is to be used and ream the guide using the speed reducer and ¼ inch electric drill. Push firmly to ream.




Reaming Guide

NOTE: It is not necessary to use lubricant for reaming.

6. Clean the valve guides with brush and solvent.

7. Install the valve. It is permissible to use a maximum force of 27 N (6 lb) with no oil to install the valve. Should valve not fit, use next size larger reamer and ream as in Step 5.

8. Thoroughly clean the valve guide bores after knurling.

The following procedure may be used to knurl valve guide bores using the United Tool Process:

1. Clean and buff head, guides and valves. Check valve stem diameter. The intake valve stem diameter is 9.462 ± 0.013 mm (.3725 ± .0005 in) and the minimum size worn is 9.423 mm (.3710 in). The tapered stem exhaust valve has a stem diameter of 9.436 ± 0.013 mm (.3715 ± .0005 in) at the keeper end of the stem, and 9.411 ± 0.013 mm (.3705 ± .0005 in) at the head end of the stem. The minimum size worn is 9.373 mm (.3690 in).

2. Place head on the FT806 Cylinder Head Bench or 8S6691 Cylinder Head Stand with spring end of valve guides toward you.

NOTE: Use FT967 Adapter Plates to mount head on FT806 Cylinder Head Bench.

3. Select the drill jig that corresponds in size to the valve guide. Use the 3/16 in drill and stop in a slow speed drill. Drill an offset hole in guide 3.2 to 4.8 mm (⅛ to 3/16 in) deep (hole to be drilled on exhaust manifold side of guide).

4. Using the proper size knurling tool and wheel, insert tool into guide and place wheel edge in offset notch. Place one drop of lubricant in each offset notch before knurling, and one drop on wheel after installing wheel in knurling tool. Use straight hex blade provided to match knurling tool and adapter in speed reducer. Hold outer shell of reducer from turning and start drill. Follow the rotating tool with slight pressure through the guide.

NOTICE

**Use the mechanical speed reducer for all knurling and reaming as excessive speed and torque destroys tools. If possible, use a drill with a no load speed of 600 rpm.**

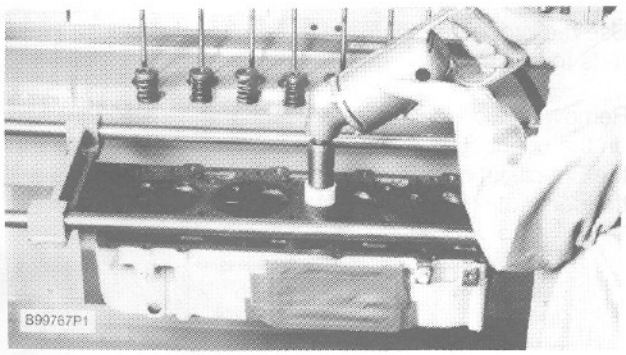
5. After knurling all guides, and before reaming, try valve in each end of guides. They should not fit into guides. If valves will go in either end of guides, the guides must be knurled again using the next size wheel. Ream the guides with a .374 in reamer before knurling. Repeat knurling and reaming process until valves will not fit into guides.

6. Ream valve guide bores to 9.512 ± 0.013 mm (.3745 ± .0005 in). To ream valve guide bore use a .374 in reamer. The reamer will ream the bore 0.013 to 0.020 mm (.0005 to .0008 in) over the size marked on the reamer.

7. After reaming, clean guides thoroughly before checking valve guide bore size.

8. Before installing valves, clean valve guide bores with the 1P5571 Brush and a strong detergent. Stroke each bore several times with the brush rotating to remove all dirt and loose chips.

After the valve guides are knurled, the valves and valve seats must be ground to provide proper sealing. For valve grinding specifications, see VALVE GRINDING SPECIFICATIONS CHART.




Grinding Valve Seats

| VALVE GRINDING SPECIFICATIONS | | |
|---|---|---|
| Seat Angle | 45 ½° ± ½° | 30 ½° ± ½° |
| Valve Head Diameter | 45.82 ± 0.13 mm (1.804 ± .005 in) | 53.19 ± 0.13 mm (2.094 ± .005 in) |
| Seat Width (Maximum) | 2.67 mm (.105 in) | 3.05 mm (.120 in) |
| Seat Outside Diameter (new) | 44.07 ± 0.13 mm (1.735 ± .005 in) | 52.23 ± 0.13 mm (2.045 ± .005 in) |
| Seat Outside Diameter (maximum) | 44.70 mm (1.760 in) | 52.45 mm (2.065 in) |
| Angle to Grind Insert to Reduce Seat Maximum Diameter | 15° | 15° |
| Valve Face Angle | 45° ± ¼° | 30° ± ¼° |
| Valve Lip Thickness (new) | 1.60 mm (.063 in) | 2.31 mm (.091 in) |
| Valve Lip Thickness (minimum) | 1.27 mm (.050 in) | 1.78 mm (.070 in) |
| Valve Head Diameter | 45.82 ± 0.13 mm (1.804 ± .005 in) | 53.19 ± 0.13 mm (2.094 ± .005 in) |
| Maximum Distance Valve Head to Cylinder Head Face (Closed Valve) | 2.16 mm (.085 in) | 1.73 mm (.068 in) |
| Minimum Distance Valve Head to Cylinder Head Face Closed Valve) | 1.27 mm (.050 in) | 0.91 mm (.036 in) |

## Valve Springs

Check valve springs with the 8S2263 Valve Spring Tester. Springs not meeting Specifications should be replaced.

| VALVE SPRING SPECIFICATIONS | | |
|---|---|---|
| Item | 9N5495 Spring | 9N5496 Spring |
| Length-test force applied | 42.47 mm (1.672 in) | 45.47 mm (1.790 in) |
| Test force | 91.2 ± 9.0 N (20.5 ± 2 lb) | 185.0 ± 18.0 N (41.6 ± 4 lb) |
| Use again minimum load at length under test force | 81.9 N (18.4 lb) | 166 N (37.3 lb) |
| Length of spring at valve open position | 27.23 mm (1.072 in) | 30.23 mm (1.190 in) |
| Use again minimum load at valve open position | 295 N (66.3 lb) | 600 N (135 lb) |
| Free length after test | 48.77 mm (1.920 in) | 51.77 mm (2.038 in) |
| Outside diameter | 26.67 mm (1.050 in) | 39.62 mm (1.560 in) |
| Spring must not be bent more than | 1.70 mm (.067 in) | 1.80 mm (.071 in) |

# Connecting Rods

## Piston Pin Bearing Removal And Installation

The 5P8639 Press Group and the 6V6100 Tool Group are used to remove and install the piston pin bearings in the connecting rods. Use the procedure that follows to remove and install the piston pin bearing from the connecting rod.

Remove the crankshaft bearing from the large end of the connecting rod and install the cap on the rod.

Put the connecting rod in an oven and get the temperature of the rod to 204°C (400°F).

Put the 6V4819 Spacer in the counterbore of the base plate. Be sure the spacer is in the bore straight and is against the bottom of the counterbore. Put the connecting rod, with the part number up, on the base plate so that the post assembly is in the center of the piston pin bearing.

Install the pin for the large end of the connecting rod in the center of the bearing bore. Put the 5P8653 Adapter over the post assembly and into the piston pin bearing. Make sure the alignment hole in the adapter is in line with the hole in the base plate. Install the 5P8641 Clamp Bar and the clamp pin on the large end of the connecting rod.

Put a new piston pin bearing on the 5P8653 Adapter. The bearing joint must be in alignment with the hole in the adapter. Put the 5P8645 Push Adapter, with the tapered side down, on the post assembly and on top of the 5P8653 Adapter. Make sure the alignment hole in the push adapter is in alignment with the bearing joint and the holes in the 5P8653 Adapter and the base plate.

Put the pusher on the 5P8645 Push Adapter and use the press to push the old bearing out and the new bearing in. Use the press until the push adapter makes full contact with the connecting rod. Remove the tools and the connecting rod from the press group.

NOTE: The piston pin bearing must be bored (machined to size) before the connecting rod can be used.

## Check for Connecting Rod Distortion

The 5P2050 Connecting Rod Checking Fixture is used to check for bearing bore center-to-center distance and for piston pin bearing bore to crankshaft bearing bore alignment. The checking fixture can be used to check connecting rods with or without the piston pin bearing installed.

To check connecting rods that are to be reconditioned, the fixture must first be adjusted to the correct bearing bore center-to-center distance. Use a connecting rod of known length (master rod) for adjustment.

Remove the connecting rod bearing and install the cap on the connecting rod and tighten the nuts as shown in the SPECIFICATIONS. Remove the piston pin bearing from the connecting rod.

Put the 5P2041 Pin Mandrel in the piston pin end of the master rod. Install the 5P2013 Plunger Extension on the plunger of the 5P2053 Crank Mandrel. Install the 5P2051 Position Arm on the end of the crank mandrel. Put the crank mandrel in the crankshaft bearing bore of the master rod. Move the position arm so it is in alignment with the centerline of the pin mandrel. Turn the actuator knob on the end of the crank mandrel and tighten the mandrel in the rod.

Put the master connecting rod on the checking fixture. Move the dial indicator holder until both indicators show approximately 0.25 mm (.010 in) less than one complete revolution. Turn the dial face of each indicator until the hand is on zero.

Remove the connecting rod from the fixture; turn the rod 180° horizontally and put the rod on the fixture again. If the dial indicators read zero, the fixture is adjusted correctly. If there is a different reading on the dial indicators, move the dial face one-half the distance between zero and the reading. Remove the master rod from the fixture and remove mandrels from the master rod.

The checking fixture is now adjusted to check connecting rods for reconditioning.

Use the procedure that follows to inspect connecting rods to check if they are acceptable for reconditioning.

Remove the connecting rod bearing and install the cap on the connecting rod and tighten the nuts as shown in the Specifications. Remove the piston pin bearing from the connecting rod.

Put the 5P2041 Pin Mandrel in the piston pin bearing bore. Put the 5P2053 Crank Mandrel with 5P2013 Plunger Extension and 5P2051 Position Arm in the crankshaft bearing bore. Move the position arm in alignment with the centerline of the pin mandrel. Turn the actuator knob on the crank mandrel and tighten the mandrel in the rod.

Put the connecting rod on the checking fixture. Make a record of the readings on each of the dial indicators. Add the two readings and divide by two. The result is the average difference from the master connecting rod bearing bore center-to-center distance. The allowable difference for rods that are acceptable for reconditioning is ± 0.10 mm (± .004 in).

Leave the connecting rod in the checking fixture and check for both bores parallel. Make a record of the readings for both dial indicators. The total difference between indicator readings is the bores parallel dimension. The maximum allowable dimension is 0.15 mm (.006 in) for rods that are acceptable for reconditioning.

A check can also be made to check for connecting rod twist. Push one end of the pin mandrel against the locating surface behind it. Use a thickness gauge on the opposite end to check the clearance between the mandrel and the locating surface. Check both ends of the mandrel in this way for clearance. The amount of clearance is the twist in the rod. The maximum allowable twist is 0.30 mm (.012 in) for rods that are acceptable for reconditioning.

## Boring Piston Pin Bearing

After new piston pin bearings are installed in the connecting rods, use the 5P3550 Connecting Rod Boring Machine to bore the piston pin bearings to the correct size.

Install the cap on the connecting rod (do not install the bearings). Tighten the nuts as shown in the Specifications.

Put the 5P2010 Mandrel on the spindle. Install nut and actuator, and tighten to hold mandrel in position. Install 5P2013 Plunger Extension on the plunger. The plunger must be in the up position within ± 3°. Loosen the spindle carrier, and use the handle on top to adjust the bearing bore center-to-center dimension. Move the carrier until the vernier scale reads 195.24 ± 0.03 mm (7.687 ± .001 in). This is the correct scale dimension to get a bearing bore center-to-center dimension of 200.66 ± 0.03 mm (7.900 ± .001 in). Tighten the carrier in this position.

Put the connecting rod in position on the mandrel, with the boss on the pin end of the rod towards the left. Turn the actuator until the connecting rod is tight on the mandrel.

Install 5P3552 Bushing in the front bracket. Push the locating arbor through the front bushing. Put 5P3541 Locating Bushing, with the large dimension of the diamond shape horizontal, on the locating arbor. Slide the locating arbor through the connecting rod and into the rear bushing. Slide the locating bushing into the rod. Push the locating rods until they are against the connecting rod, and tighten the rods firmly. Remove the locating arbor end bushing.

Fasten the 5P2023 Tool Bit Setting Gauge to the boring bar. Be sure the contact point of the indicator is against the boring bar. Adjust the indicator so the revolution counter and the hand are at zero. Move the tool bit setting gauge so that the contact point is against the cutting edge of the tool bit. Fasten the gauge in this position. Loosen the screw that holds the tool bit. Make an adjustment to the tool bit until the indicator reads 4.750 mm (.1881 in). Tighten the screw that holds the tool bit and recheck the setting.

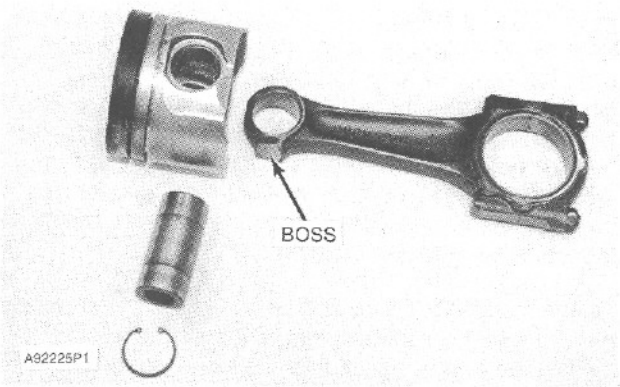
Put the boring bar through the connecting rod and into the rear bushing. Install the front bushing over the boring bar and into the bracket. Install 5P4777 Torsion Bracket on the rear of the boring machine. Put 5P4778 Feed Cylinder so the shaft goes through the rear bushing and into the boring bar. Tighten the setscrew in the boring bar to hold the feed cylinder shaft. Adjust torsion bracket and feed cylinder so the boring bar moves smoothly in rear bushing.

NOTE: Put the feed lever on the feed cylinder in the OPEN position before moving the boring bar.

With the feed lever in the OPEN position, move the boring bar until the tool bit is 3.2 mm (.13 in) from the bearing in the connecting rod. Put the feed lever in the CLOSED position and tighten the thumbscrew on the cylinder against the torsion bracket shaft. Install 5P2055 Flexible Adapter in the front of the boring bar and fasten an electric drill to the adapter. Put oil on the boring bar at the front and rear bushings. Start the drill and let the feed cylinder pull the boring bar through the bearing. Use a slow feed rate and do not push on the drill.

Check the bearing bore with a new piston pin. If the fit is too tight, do the boring operation again with the SAME tool bit setting.

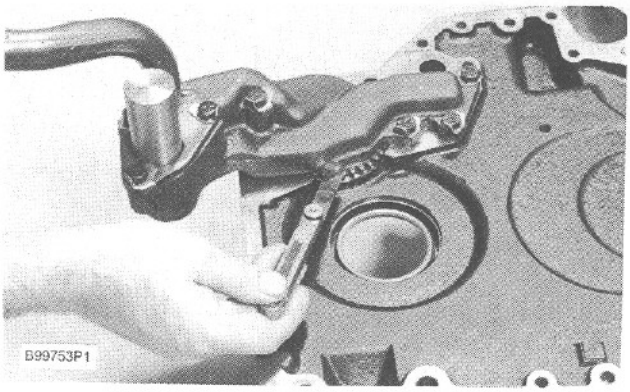
Install the connecting rod into the piston with the boss on the rod on the same side as the crater in the piston.




Connecting Rod And Piston

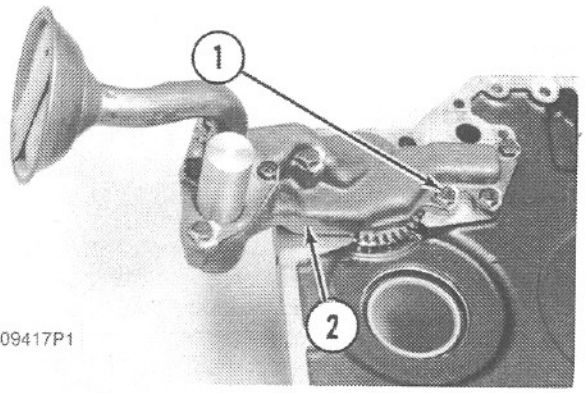
## Oil Pump

Check oil pump end clearance. End clearance is 0.069 to 0.135 mm (.0027 to .0052 in) new.

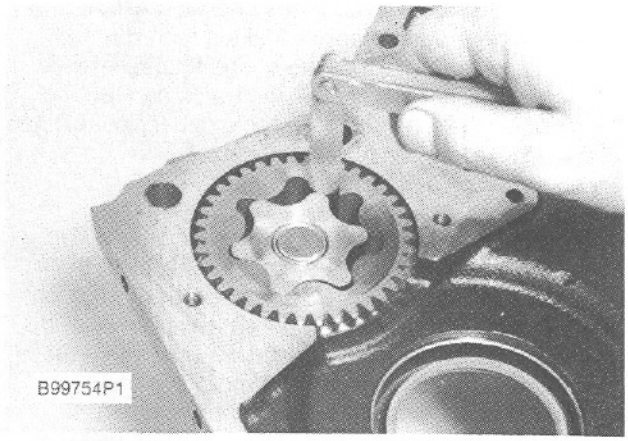



Checking End Clearance

Remove oil pump cover mounting bolts (1). Remove oil pump cover (2).



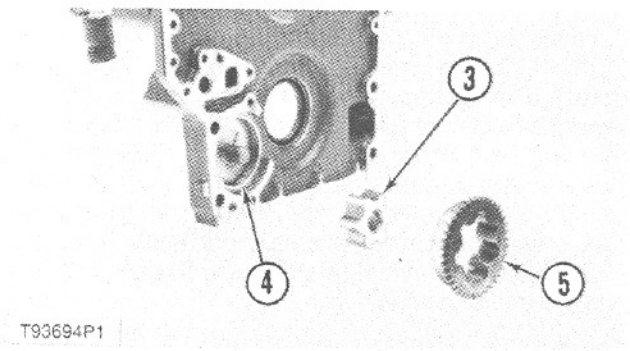

Oil Pump
(1) Bolts (four). (2) Oil pump cover.



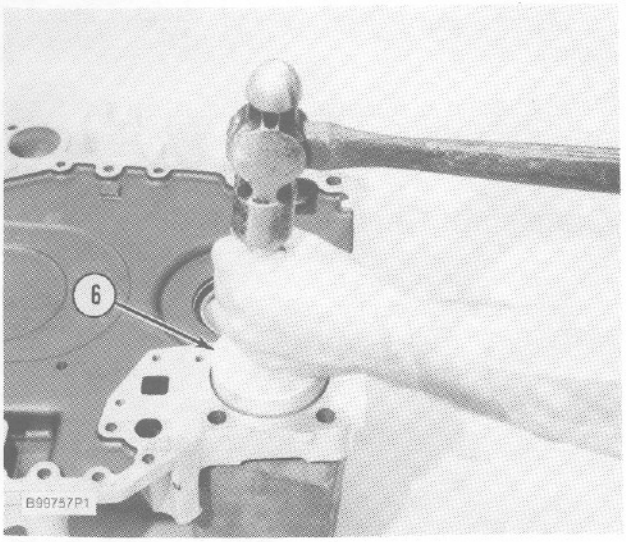

Checking Rotor Tip Clearance

Check oil pump rotor tip clearance. Rotor tip clearance is 0.05 to 0.20 mm (.002 to .008 in). Maximum rotor tip clearance is 0.28 mm (.011 in).

Remove outer rotor (5) and inner rotor (3). Check size of bearing (4). Size of bearing (4) is 71.224 ± 0.056 mm (2.8041 ± .0022 in). Replace bearing if necessary. Use an 8S2285 Driver (6) to install the bearing. For the correct location of bearing junction, see the topic Oil Pump in the Specifications.




Rotors Removed
(3) Inner rotor. (4) Bearing. (5) Outer rotor.




Installing Bearing
(6) 8S2285 Driver.

Clean all parts thoroughly before installing. Oil all component parts before installing. Install inner rotor (3), outer rotor (5), cover (2), mounting bolts (1) and locks. Tighten bolts to 24 ± 7 N•m (18 ± 5 lb ft) and secure with locks.

## Crankshaft

Reconditioning of these crankshafts can be done by grinding the "journals" (bearing surface on the crankshaft for the connecting rod bearings and main bearings) 0.25 mm (.010 in), 0.51 mm (.020 in) or 1.27 mm (.050 in) "undersize" (smaller than the original size).

The diameter of the "journals" for the connecting rod bearings is 69.840 ± 0.015 mm (2.7496 ± .0006 in). The diameter of the "journals" for the main bearings is 88.887 ± 0.015 mm (3.4995 ± .0006 in). The minimum permissible diameter of the "journals" for the connecting rod is 69.814 mm (2.7486 in). The minimum permissible diameter for the "journals" for the main bearings is 88.862 mm (3.4985 in). Measure each "journal" in several places around the diameter to find the maximum wear point. If the diameter of any "journal" is smaller than the minimum permissible diameter, grind all of the "journals." Before a crankshaft is ground, check to be sure the crankshaft is not bent. To check for a crankshaft that is bent, place crankshaft main bearing journals 2 and 4 on 5P8637 V-Blocks. Use a dial indicator and check the runout (total indicator reading) for main bearing journals 1, 3 and 5.

The maximum total indicator reading is 0.13 mm (.005 in) for each journal. If the total indicator readings is more than 0.13 mm (.005 in) the crankshaft must be straightened before it is ground. Make reference to Guideline for Reusable Parts Procedure To Measure Bent Crankshafts, Form No. SEBF8030.

Another procedure must be used to determine if a bent crankshaft can be straightened.

Place the crankshaft main bearing journals 1 and 5 on 5P8637 V-Blocks. Use a dial indicator and check the runout (total indicator reading) of the center main bearing journal. If the total indicator reading is more than 1.27 mm (.050 in) the crankshaft cannot be straightened.

If the total indicator reading is less than 1.27 mm (.050 in), the crankshaft can be straightened. Before the crankshaft is straightened it must be heated to 177 to 232°C (350 to 450°F). Make reference to Guideline For Reusable Parts Procedure To Straighten Bent Crankshafts, Form No. SEBF8040.

With the crankshaft installed in the cylinder block, check the end play for the crankshaft. End play for the crankshaft is 0.08 to 0.25 mm (.003 to .010 in). Maximum permissible end play for the crankshaft is 0.36 mm (.014 in).

NOTE: If end play for the crankshaft is more than the maximum permissible end play, check the crankshaft thrust bearing.

### Crankshaft Grinding Specifications

The dimensions and finish for grinding crankshafts are as follows:

Diameter (A) for connecting rod bearing journals is:

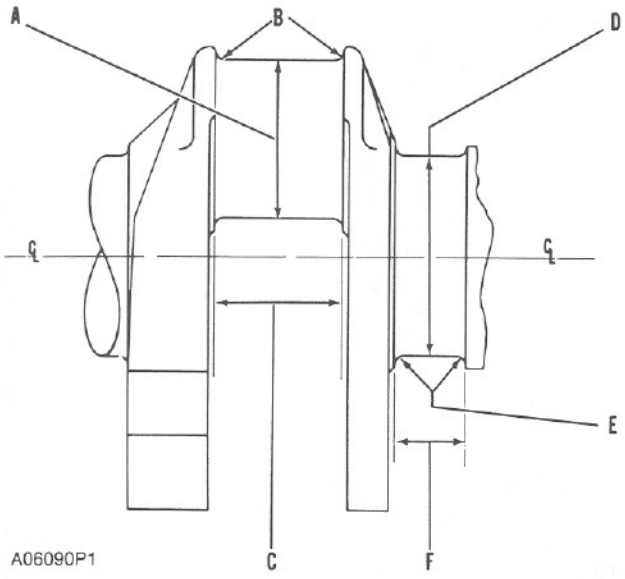
| | |
|---|---|
| 0.25 mm (.010 in) Undersize ..... | 69.586 ± 0.015 mm (2.7396 ± .0006 in) |
| 0.51 mm (.020 in) Undersize ..... | 69.332 ± 0.015 mm (2.7296 ± .0006 in) |
| 1.27 mm (.050 in) Undersize ..... | 68.570 ± 0.015 mm (2.6996 ± .0006 in) |

Surface finish must be 0.25 micrometers (10 microinches) or less.

Radius (B) must be 2.54 ± 0.25 mm (.100 ± .010 in).

Surface finish must be 1.6 micrometers (63 microinches) or less.

The radius must blend smoothly with the newly machined journals.




Dimensions For Grinding
(A) Diameter of connecting rod bearing journals. (B) Radius on connecting rod bearing journals. (C) Width to grind journals for the connecting rods. (D) Diameter of main bearing journals. (E) Radius on main bearing journals. (F) Width to grind journals for the main bearings.

Width (C) is 58.77 ± 0.08 mm (2.314 ± .003 in)

Diameter (D) for main bearing journals is:

0.25 mm (.010 in) Undersize ..... 88.633 ± 0.015 mm (3.4895 ± .0006 in)

0.51 mm (.020 in) Undersize ..... 88.379 ± 0.015 mm (3.4795 ± .0006 in)

1.27 mm (.050 in) Undersize ..... 87.617 ± 0.015 mm (3.4495 ± .0006 in)

Surface finish must be 0.25 micrometers (10 microinches) or less.

Radius (E) must be 2.41 ± 0.25 mm (.095 ± .010 in).

Surface finish must be 1.6 micrometers (63 microinches) or less.

The radius must blend smoothly with the newly machined journals.

Width (F) is 31.95 ± 0.05 mm (1.258 ± .002 in) for number 4 main bearing journal. Surface finish on the thrust faces of the number 4 main must be 0.45 micrometers (18 microinches) or less.

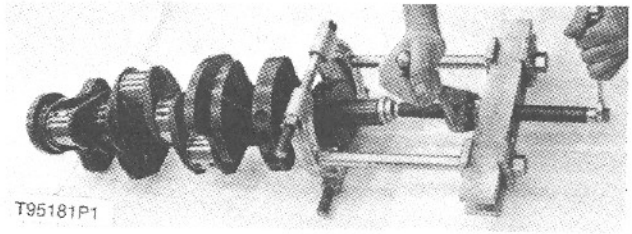
Width (F) is 32.21 + 0.51 − 0.25 mm (1.268 + .020 − .010 in) for number 2, 3 and 5 main bearing journals.

There is no width (F) for number 1 main bearing journal.

When grinding a crankshaft, no material can be removed from the crankshaft webs or counterweights.

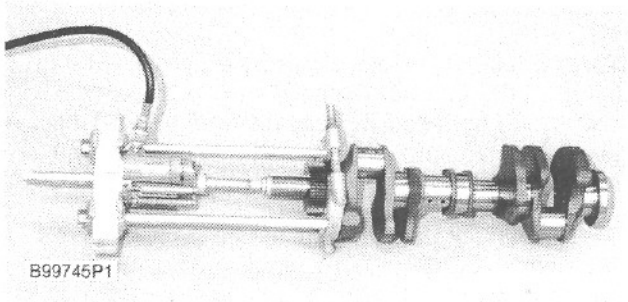
## Crankshaft Gear Removal

Remove the gear using a 8B7548 Push Puller, 8B7551 Bearing Pulling Attachment, 8B7561 Step Plate, and 8H684 Ratchet Box Wrench.




Pulling Crankshaft Gear

The 1P0820 Hydraulic Puller Group can also be used to pull gear from crankshaft. Tools required are 1P0820 Hydraulic Puller Group, 8B7551 Bearing Pulling Attachment, 8B7549 Puller Legs (two), 8B7561 Step Plate, 3H0465 Plate (four), 1B4207 Nut (two) and 6V9061 Pump Group.



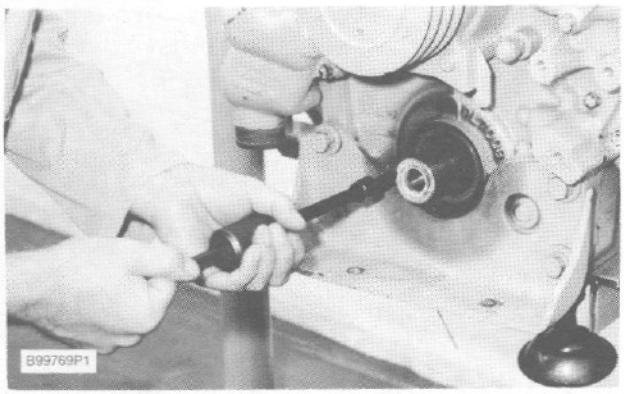

Using Hydraulic Puller

## Crankshaft Gear Installation

1. Install the key in keyway of crankshaft. Remove all burrs from key and keyway inside of crankshaft gear.
2. Heat gear to 260°C (500°F) maximum.
3. Install gear on crankshaft with timing mark on gear facing front of crankshaft.

## Crankshaft Front Oil Seal Removal

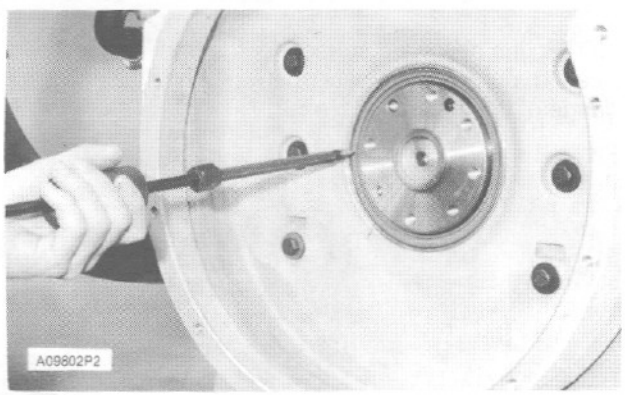
Remove the crankshaft from pulley. Use the 1P3075 Puller Group to remove the crankshaft front oil seal.




Removing Front Oil Seal
(Typical Example)

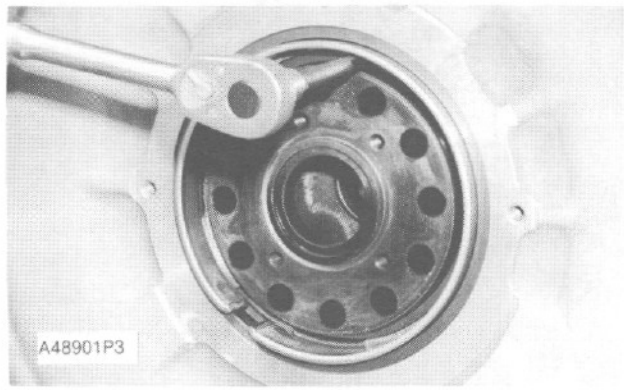
## Remove Crankshaft Rear Seal and Wear Sleeve

Remove the crankshaft rear oil seal with the 1P3075 Puller Group.




Removing Rear Oil Seal

Install a 5P7338 Distorter Ring from the 5P7318 Wear Sleeve Distorter Group, in the rear seal bore. Install 5P7312 Distorter between distorter ring and wear sleeve. Turn the distorter until the edge of the tool makes a flat place (crease) in the wear sleeve. Do this in two or more places until the wear sleeve is loose. Remove the tools and wear sleeve.

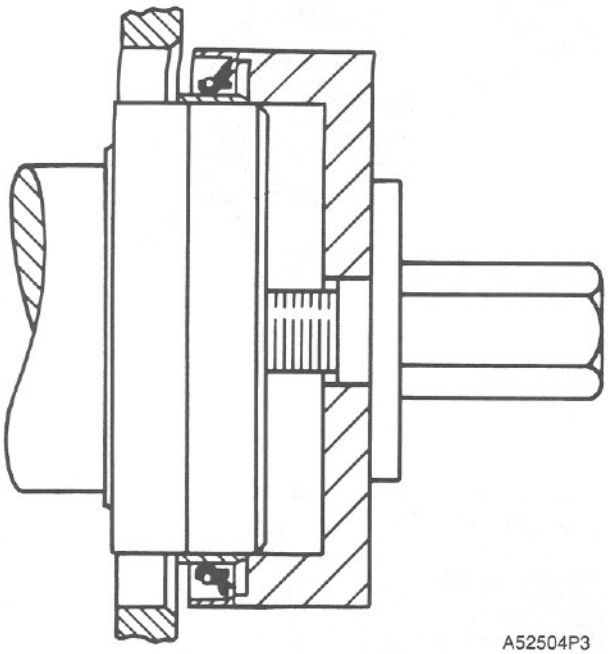



Removing Rear Wear Sleeve
(Typical Example)

## Install Crankshaft Rear Seal and Wear Sleeve (Lip Type Seal)

The crankshaft rear seal and wear sleeve must be installed at the same time. Clean the wear sleeve inside diameter and the crankshaft outside diameter and put 6V1541 Quick Cure Primer on the surfaces. Put 9S3265 Retaining Compound on the outside diameter of the crankshaft and the inside diameter of the wear sleeve. Install 5P0290 Locator on the rear of the crankshaft. Put a sealer on the outer metal case of the seal.

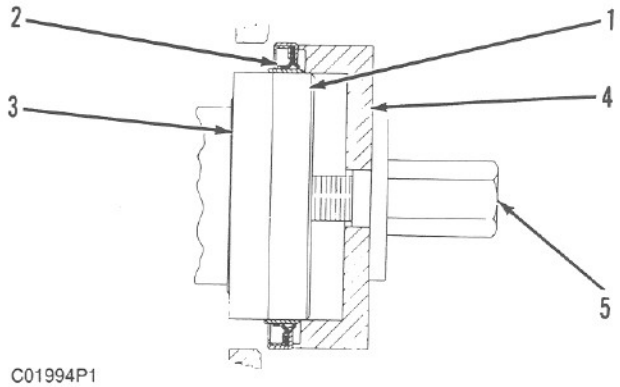
Put the wear sleeve and seal in position on the locater, with the outside diameter bevel on the wear sleeve away from the crankshaft. Be sure the lip of the seal is toward the engine. Put 5P7293 Installer in position on the locater. Put clean engine oil on the face of the nut and install it on the locater. Tighten the nut until the installer will not longer move.




Installing Crankshaft Rear Seal And Wear Sleeve

## Install Crankshaft Rear Seal and Wear Sleeve (Hydrodynamic)

NOTE: New seal groups must be installed dry (no lubrication). Seal groups that have been separated must not be used. Only new seal groups are acceptable for installation.




Seal And Wear Sleeve Installation
(1) Locator. (2) Seal group. (3) Crankshaft. (4) Installer. (5) Nut.

1. Install the crankshaft rear seal and wear sleeve assembly with tooling as follows:

   a. Install locator (1) in position on the crankshaft.

   b. Use 6V1541 Quick Cure Primer to clean outer *diameter of the crankshaft flange and the inside* diameter of the wear sleeve.

   c. Put 9S3265 Retaining Compound on the outside diameter of the crankshaft and the inside diameter of the wear sleeve.

   d. Put seal group (2) on locator (1). Put installer (4) on locator (1). Put lubrication on the face of washer and nut (5). Install and tighten nut (5) until installer (4) comes in contact with locator.

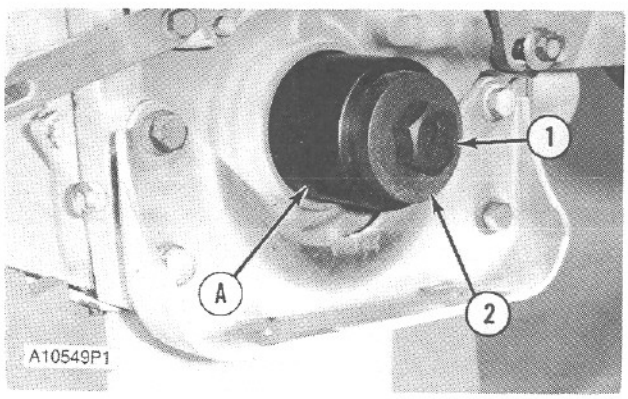
   e. Remove tooling, and check the wear sleeve and seal for correct installation.

## Crankshaft Front Oil Seal Installation

1. Put the seal over the short end of the 5P4194 Installer Assembly (A). Put a sealer on the outer diameter of the seal metal shell. The lip of the seal must be toward the inside of the engine.

2. Put the seal and installer assembly (A) in position on the end of the crankshaft. Install bolt (1) and washer (2) that hold the crankshaft pulley in place. Tighten bolt (1) until the installer assembly (A) makes contact with the crankshaft gear.

NOTE: If a new wear surface for the front seal is needed, put 5P4230 Spacer between the seal and flange of the installer assembly.

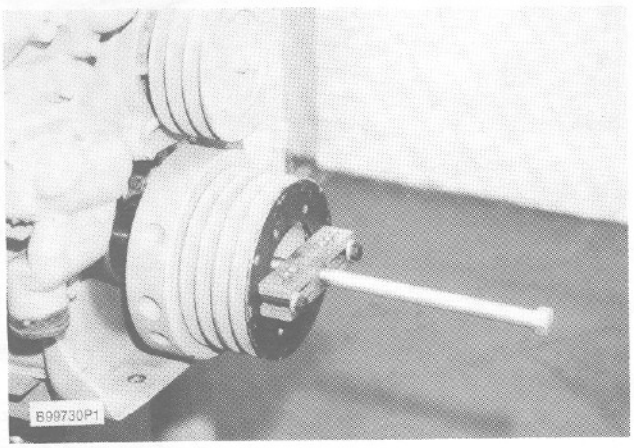



Installing Front Oil Seal
(1) Bolt. (2) Washer. (A) 5P4194 Installer Assembly.

3. Put engine oil on the lip of the seal before installing the pulley.

## Crankshaft Pulley Removal

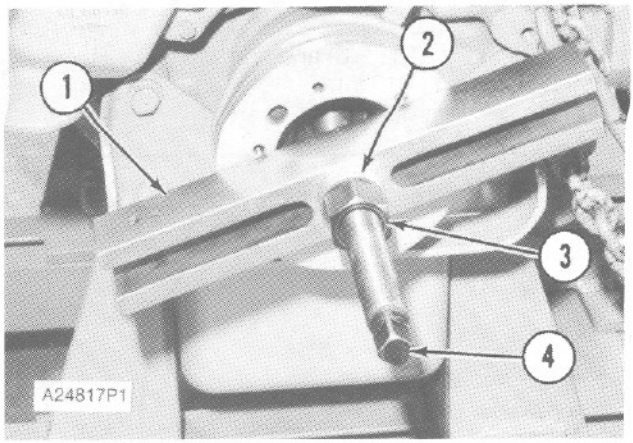
1. Remove pulley retaining bolt and washer.
2. Remove the pulley using a 5F7465 Puller Assembly, 8B7560 Step Plate, two 5M2894 Washer, and two 0S1571 Bolts.




Pulley Removal
(Typical Example)

## Crankshaft Pulley Installation

1. Lubricate lip of crankshaft front oil seal and the sealing surface of crankshaft pulley with engine oil (SAE 30).
2. To install pulley, start pulley on crankshaft. Put screw (4) from the 8B7548 Push Puller into the crankshaft until it bottoms out. Put cross bar (1) from the 8B7548 Push Puller onto screw (4). Install washer (2) and nut (3) onto screw (4). Hold screw (4) and turn nut (3) to press pulley onto crankshaft. When installed, the pulley hub will contact the crankshaft gear.
3. Remove the tool setup. Install the pulley retaining bolt and washer. Tighten the pulley retaining bolt to the torque shown in the specifications.




Installing Pulley
(1) Crossbar. (2) Washer. (3) Nut. (4) Screw.

# Camshaft

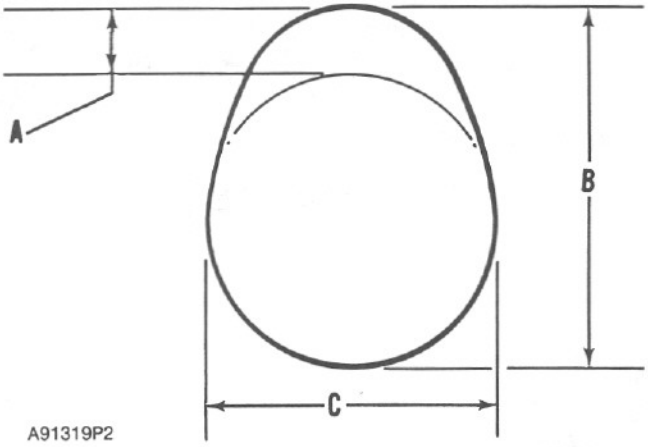
Inspect the camshaft for wear or damage. There must be no pits or scuffing on the surface of the camshaft lobes. If damage is found on a camshaft lobe, inspect the valve lifter for that lobe for damage. Check the diameter of the camshaft bearing journals and the camshaft lobe height.

Camshaft bearing journals have a diameter of 63.500 ± 0.013 mm (2.5000 ± .0005 in) and the minimum diameter worn is 63.424 mm (2.4970 in).

To find lobe lift (A) of camshaft, use the following procedure:

1. Measure lobe height (B) of one exhaust and one intake lobe.
2. Measure base circle (C) of one exhaust and one intake lobe.
3. Subtract base circle (C) dimension (STEP 2) from lobe height (B) dimension (STEP 1). The difference is actual lobe lift (A).
4. The specified (new) lobe lift (A) is:
   Camshaft used with roller lifters.
   (a) Exhaust lobe ..... 9.40 mm (.370 in)
   (b) Intake lobe ..... 9.33 mm (.367 in)
   Camshaft used with flat face lifters.
   (c) Exhaust lobe ..... 9.40 mm (.370 in)
   (d) Intake lobe ..... 9.06 mm (.357 in)

5. The maximum permissible difference between actual lobe lift (STEP 3) and specified lobe lift (STEP 4) is 0.25 mm (.010 in).




Camshaft Lobe
(a) Lobe lift. (b) Lobe height. (c) Base circle.

With camshaft installed in the cylinder block, check end play. End play with new components should be 0.18 ± 0.08 mm (.007 ± .003 in). The maximum permissible end play is 0.51 mm (.020 in).

## Valve Lifters

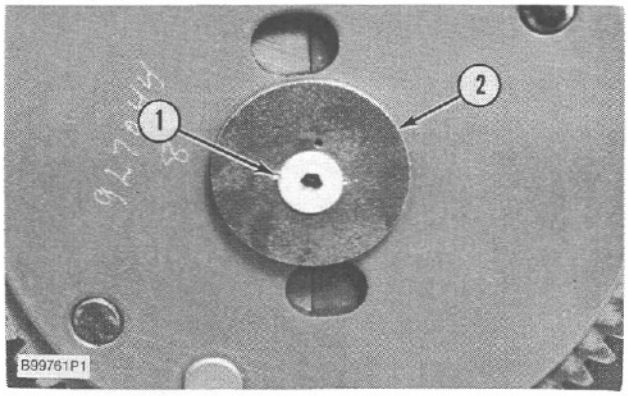
Inspect lifters for wear or damage. The roller must turn freely in the lifter. There must be no deep scratches (grooves) on the side of the lifter body, and there can be no pits or scuffing on the wear surface of the roller.

If the lifters do not have wear or damage, the lifter can be used again with a used camshaft.

NOTE: New lifter guide springs must be installed anytime the lifters are removed from the lifter bores.

## Camshaft Gears

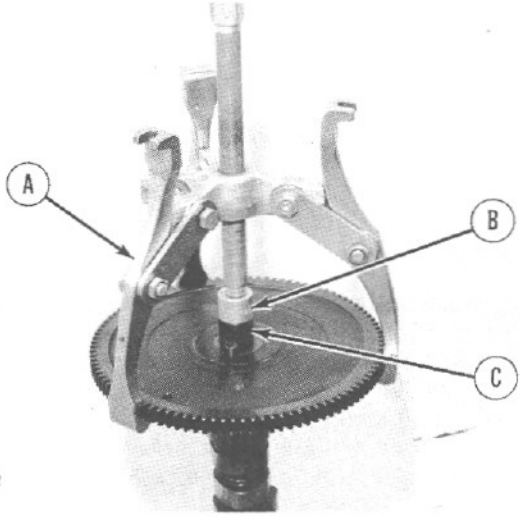
1. Remove screw (1) and washer (2) from end of camshaft.




Removing Timing Advance Retaining Screw
(1) Screw. (2) Washer.

2. Remove timing advance unit from the camshaft.

3. Install puller (A), with spacer (C) over the shaft in the camshaft. Put spacer (B) on spacer (C) as shown and remove the gear from the camshaft.




Removing Gear
(Typical Example)
(A) 1P2321 Puller. (B) 8S5579 Spacer. (C) 9S9155 Spacer.

To install the gear use the following procedure:

1. Heat the gear to a temperature of approximately 204°C (400°F) before installing on the camshaft.

NOTICE
Do not heat the gear with a torch. Do not heat the gear to a temperature of more than 315°C (600°F). Heating the gear with a torch or to a temperature of more than 315°C (600°F) may cause the two drive dowels for the automatic timing advance to loosen and come out of the gear.

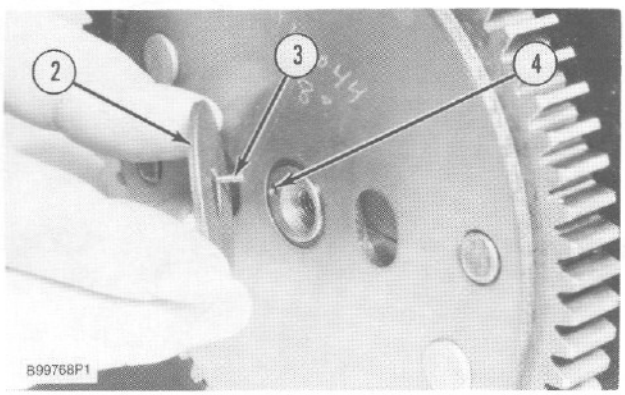
2. Align slot in gear hub with the pin in the camshaft. Install the gear on the camshaft with timing mark on gear aligned with timing mark on crankshaft gear. Be sure the gear is completely seated against the shoulder of the camshaft.

NOTICE
Do not drive the gear on the camshaft.

3. Align holes in weights with dowels in gear and install the automatic timing advance.

4. Align pin (3) in washer with hole (4) in camshaft and install washer (2).

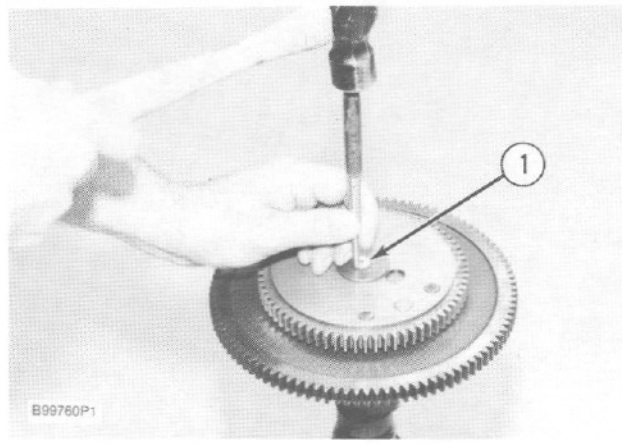
5. Install screw (1) and tighten to 7.9 ± 0.6 N•m (70 ± 5 lb in). Stake screw in two places.




Installing Washer
(2) Washer. (3) Pin. (4) Hole.

NOTICE
Stake screw (1) carefully. Heavy blows on washer or screw can force the shaft extension too far into the camshaft and eliminate all end clearance.

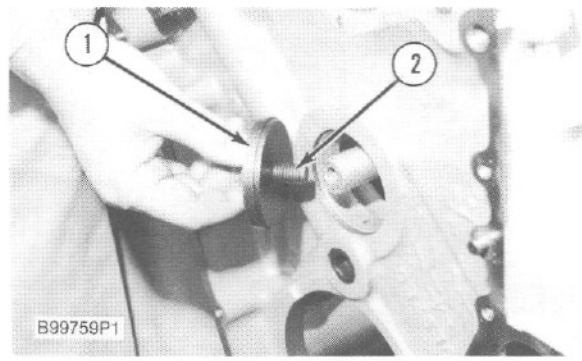
6. After screw (1) is staked, the gear and weight assembly requires 0.08 to 0.94 mm (.003 to .037 in) end clearance to prevent binding against the washer, camshaft end or camshaft gear.




Staking Screw
(1) Screw.

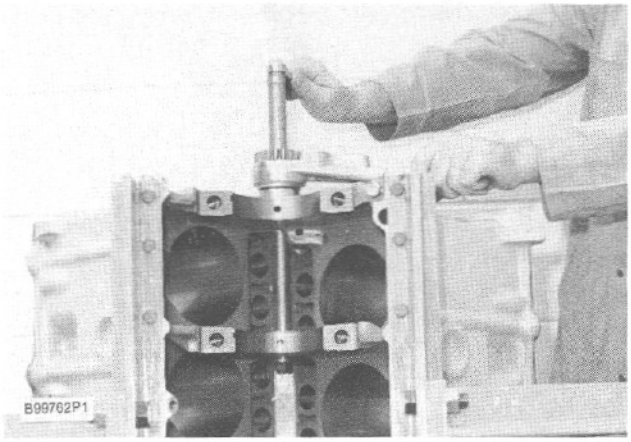
## Camshaft Bearings Removal and Installation

Remove camshaft bearings using the 1P5544 Washer (1) and 0S0509 Bolts (2), from the 1P5545 Adapter Group, in conjunction with the 8S2241 Camshaft Bearing Removal and Installation Group, and the 8H0684 Ratchet Box Wrench.



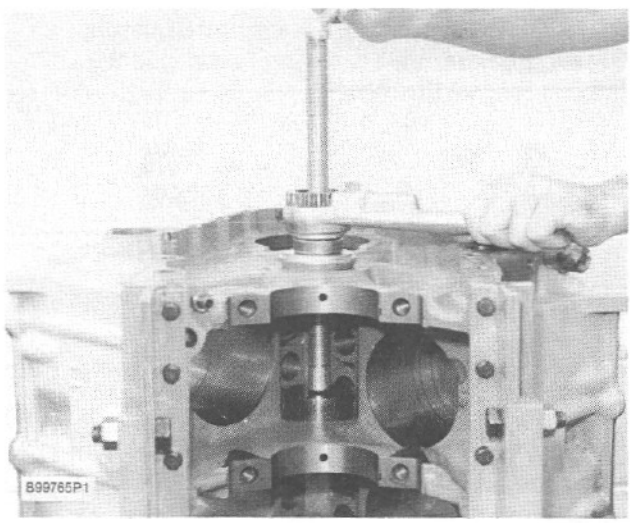

Installing Washer
(1) 1P5544 Washer. (2) 0S0509 Bolt.

With removal tools installed on cylinder block, remove bearings.




Removing Camshaft Bearings

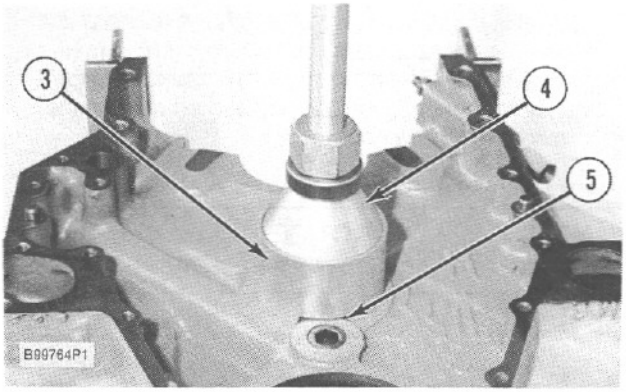
Use the 1P5545 Adapter Group in conjunction with the 8S2241 Camshaft Bearing Removal and Installation Group, and the 8S0684 Ratchet Box Wrench to install camshaft bearing.




Installing Camshaft Bearings

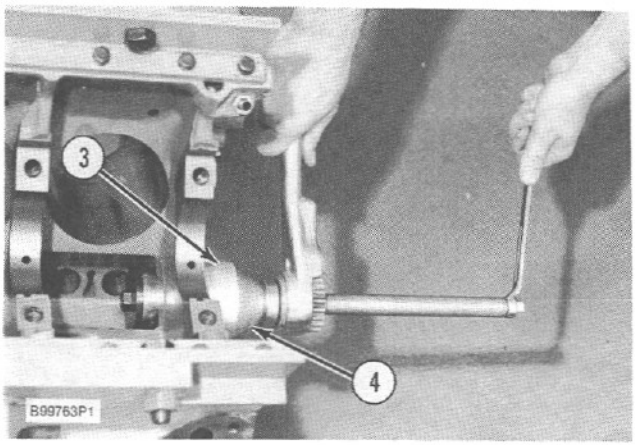
The 1P5545 Adapter Group pilots in the camshaft bearing bore and also pilots the bearing into the bore. This insures bearing alignment. Install bearings from chamfered side of the bore and align oil hole in bearings with oil holes in cylinder block.

To install the camshaft front bearing, it is necessary to machine a notch in the 8S8289 Tube (3) for clearance of the boss that projects above the camshaft bearing bore. Machine the notch 38.1 mm (1.50 in) wide, 9.5 mm (.37 in) deep, with a 3.2 mm (.13 in) radius or chamfer in the corners and on the edges.




Notch In Tube
(3) 8S8289 Tube. (4) 8S8288 Cone. (5) Notch.

Invert the 8S8288 Cone (4) and install it in the 8S8289 Tube (3) for installation of the camshaft front bearing.




Installing Camshaft Front Bearing
(3) 8S8289 Tube. (4) 8S8288 Cone.

# Engine Test Procedure

## Lubrication for a Rebuilt Engine

It is very important for a rebuilt engine to have "adequate" (needed) lubrication during the first seconds of operation. A "dry start" (without needed lubrication) on a rebuilt engine can cause bearing damage.

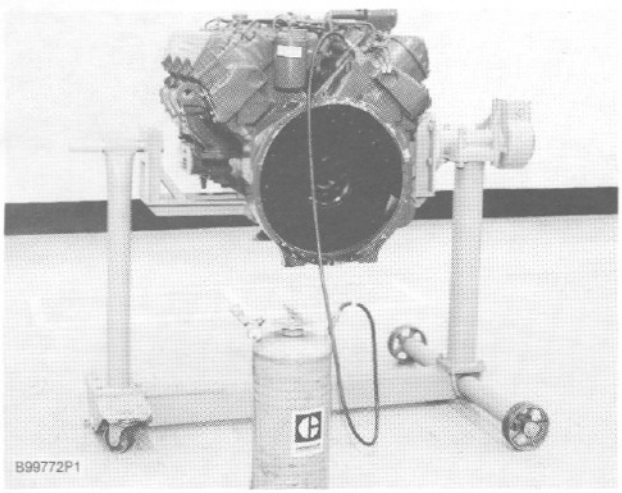
When an engine is rebuilt with new parts, oil is put on each part as it is installed. This is generally enough lubrication for engine start-up. However, this lubrication may not be enough or may be lost if the rebuilt engine is placed in storage for any length of time.

When a factory assembled short block assembly is installed, the oil used at the factory has to give this needed lubrication. However, the factory oil application can flow off the parts in a short block during storage or shipment. As a result the parts in a rebuilt engine will not have "adequate" lubrication at startup.

To prevent the possibility of a "dry start" and bearing damage during the first seconds of running, use the 1P0540 Flow Checking Tool Group, and shop air pressure to pressure lubricate (fill the main oil passage with oil under pressure) all rebuilt engines.

## Procedure for Pressure Lubrication

1. Clean the tank of the 1P0540 Flow Checking Tool Group thoroughly.
2. Put approximately one gallon of engine oil in the tank.
3. Connect the tools to the engine as shown. The tap shown is connected to the main oil passage.




Pressure Lubrication
(Using the 1P0540 Flow Checking Tool Group)
(Typical Example)

**⚠ WARNING**

**If shop air is used, set the tank regulator to the minimum kPa (psi) setting. If air pressure is too high, fittings and hoses can be blown off or the tank can explode causing personal injury. Do not exceed 415 kPa (60 psi) air pressure in the tank.**

4. Add air pressure to the tank. Set the regulator at 240 ± 35 kPa (35 ± 5 psi). Although the tank does have a hand pump, it is difficult to get enough air pressure to do the job with the hand pump. Therefore, use of the shop air is recommended.
5. Let the one gallon of engine oil flow into the oil passage under pressure.

When filling the crankcase, put in one gallon of oil less than the recommendation in the Operation And Maintenance Guide, if engine has received this pressure lubrication application. Also if the engine is not going to be used for a long time, do the above procedure again before the first starting.

If shop air is not available for charging the tank, the hand pump may be used to get the minimum required pressure.

NOTICE

**Do not use the same 1P0540 Flow Checking Tool Group for both "pressure lubrication application" and for checking fuel flow. Incorrect cleaning is probable if the tool is used for both fuel and lube oil. Even a minute amount of dirt in the fuel system can cause nozzle failure.**

## Initial Operation After Engine Reconditioning

The quality of oil control components used in Caterpillar engines is such that, following engine reconditioning (with Caterpillar Service Parts), only an initial operational check is necessary before continued operation in normal service.

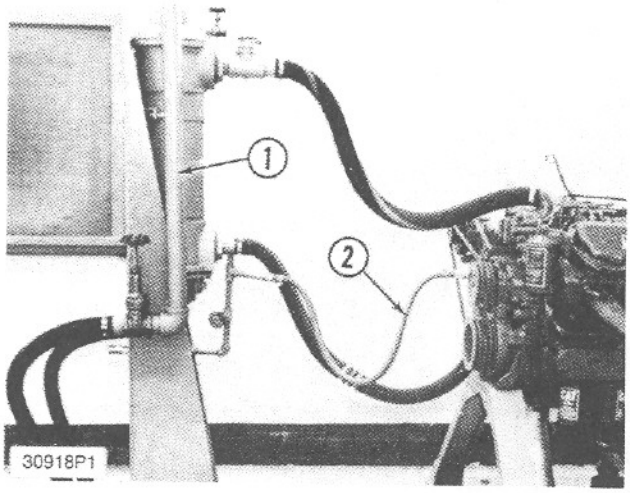
The purpose of this initial operation check is to: insure that the engine has been assembled properly; determine if proper pressures and temperatures are maintained in the lubrication, cooling and fuel systems; correct any leaks; perform necessary adjustments (such as valve clearance, governor high and low idle speeds, etc.); check the power setting of the engine.

To provide a safe, uniform initial operational check, the following procedure is recommended:

1. Motor engine at cranking speed until oil pressure is observed.
2. Operate engine for 10 minutes at low idle.
3. Operate engine for 15 minutes at half-load and ¾ rated speed.
4. Operate engine for 30 minutes at rated load and speed.

## Dynamometer Test Precaution

To avoid possible engine damage while testing on a dynamometer, the thermostats must be installed and the shunt line connected as shown.




Shunt Line Connected To Engine
(Typical Example)