

## PISTON

### Removal

1. See Section [3.9 TOP END OVERHAUL, DISASSEMBLY](#), steps 1-11 and 15-29.

### Disassembly

#### Piston Rings, Removal

#### ⚠ WARNING

**Always wear proper eye protection when removing the compression rings. Slippage may propel the ring with enough force to cause eye injury.**

1. Carefully remove first and second compression rings using the proper piston ring expander (Snap-On PRS8).
2. Using your fingers, remove the top and bottom oil rails from the third ring groove. Remove the expander spring.
3. Discard the piston rings.

### Cleaning and Inspection

#### Cleaning

#### CAUTION

**Do not sand blast or glass bead blast pistons. Bead blasting rounds off ring lands and will result in oil contamination leading to accelerated wear.**

1. To remove all carbon and combustion deposits, soak the pistons in a special detergent that will not corrode aluminum. Maintain the temperature of the cleaning solution well below 212° F. (100° C.).
2. Thoroughly rinse the pistons and dry with moisture free compressed air.
3. Clean the oil drain holes leading from the oil control ring groove to the underside of the piston crown. Run a small bristle brush through the passageways to ensure their cleanliness, but be careful not to damage or enlarge the holes. Do not use a wire brush.
4. Verify that all other oil holes are clean and open.

#### CAUTION

**Exercise care to avoid scratching the sides of the piston ring grooves.**

5. Thoroughly clean the three piston ring grooves of all carbon deposits. A broken compression ring properly ground to a sharp chisel-like edge may be used for this purpose.

6. Using Magnaflux Dye Penetrant, inspect the piston for surface cracks. Pay special attention to the area around the pin bores, ring lands and oil drain holes beneath the piston crown. If no cracks are found, thoroughly wash piston to remove traces of dye.

### Inspection

1. Lightly oil a good piston pin and insert it into the piston pin bore to feel for the proper interference fit. The pin should slide in and out without binding, but also without pivoting or rocking. Replace piston and/or pin if clearance exceeds 0.0008 in. (0.020 mm).
2. Carefully inspect the pistons for damage or excessive wear. Discard pistons with cracked, broken or bent ring lands. Check the piston skirt for cracks, gouges, deep scratches or heavy scoring. Check the piston heads for evidence of burning, etching or melting. Look for marks or imprints caused by contact with valves. Pistons with superficial wear marks, minor scratching or mild scoring may continue to be used.
3. Run your index finger around the edge of the piston crown to feel for dings, nicks or burrs. Lightly file the edge of the crown to remove any defects.

#### CAUTION

**Worn ring grooves result in high oil consumption and blow-by of exhaust gases. Blow-by of exhaust gases contaminates the engine oil supply with acids and leaves sludge in the crankcase. It also reduces engine efficiency by weakening the combustion seal necessary for efficient transfer of energy to the piston.**

4. Measure the piston ring side clearance as follows:
  - a. Insert the edge of a new ring into the piston ring groove. Insert a feeler gauge between the upper surface of the ring and the ring land. See [Figure 3-86](#).



**Figure 3-86. Measure Piston Ring Side Clearance**



**Figure 3-87. Measure Early Style Piston for Running Clearance**

- b. Since the grooves wear unevenly, repeat this check at several locations around the piston groove circumference.
- c. Discard the piston if the side clearance of either compression ring exceeds 0.0045 in. (0.11 mm). Discard the piston if the oil control ring side clearance exceeds 0.010 in. (0.25 mm).
5. Measure the running clearance on fully coated early style pistons as follows:

**NOTE**

*Check the piston clearance in the cylinder in which the piston will run. The torque plates must be installed on the cylinder and it must be deglazed and suitable for continued service.*

- a. Holding outside micrometer, measure piston skirt diameter across the thrust faces (perpendicular to pin bore). Start below the bottom ring land and move micrometer towards bottom of skirt. Micrometer will be loose, then tight (about 1/2 inch from bottom), and then loose again. See lower frame of Figure 3-87.
- b. Measure the piston skirt at the tightest spot and then transfer that measurement to the dial bore gauge.

**NOTE**

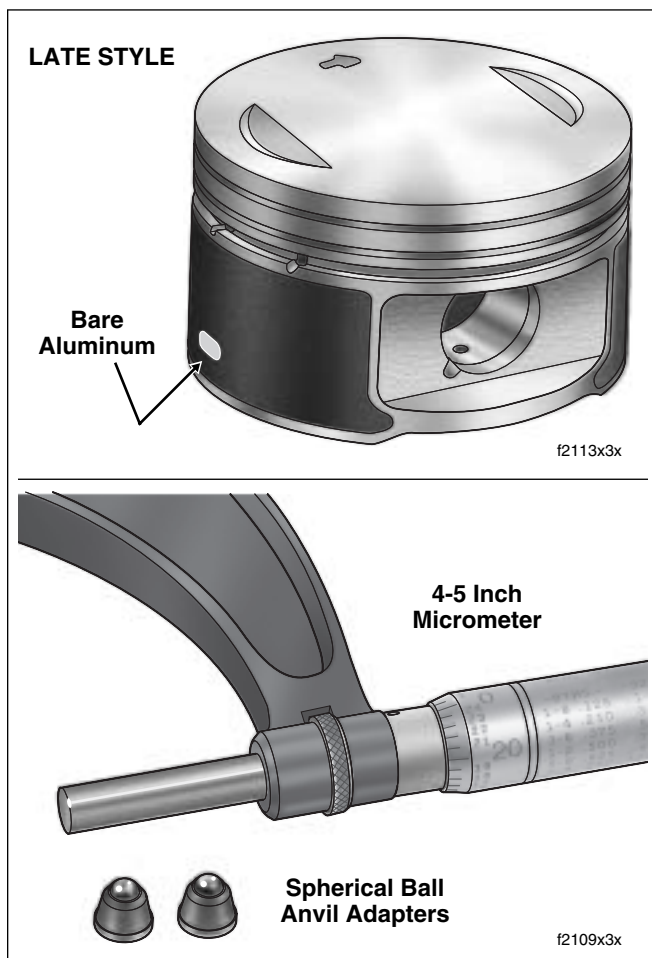
On late style pistons, the measurement is taken on the bare aluminum to avoid measuring errors. An oval-shaped opening is present on each side of the piston for proper placement of the micrometer. See upper frame of Figure 3-88. Since the oval openings are too small for a standard flat anvil micrometer, which would result in measuring errors, use a 3-4 inch blade or ball anvil style micrometer, or a 4-5 inch micrometer with spherical ball anvil adapters. See lower frame of Figure 3-88.

- c. Using a grease pencil, mark the top, middle and bottom of the piston ring travel zone in the cylinder bore. Measure at markings in cylinder parallel and perpendicular to crankshaft.

**CAUTION**

**Do not check piston running clearance immediately after honing or deglazing cylinder. Since heat will cause measurements to vary by as much as 0.0002 inch (0.005 mm), both piston and cylinder must be at room temperatures.**

- d. Replace piston and/or cylinder if running clearance exceeds 0.003 in. (0.076 mm).



**Figure 3-88. Measure Late Style Piston for Running Clearance**



Figure 3-89. Measure Ring End Gap

## Assembly

### Piston Rings, Installation

#### NOTE

Always use **new** piston rings. Piston rings take a definite set and must not be reused if the engine has been operated. Always deglaze (or hone) the cylinder before installing new rings. Ring sets are available to fit oversize pistons.

1. Before placing each ring on the piston, perform the following check.

#### CAUTION

Insufficient ring end gap may cause the ends to abut at engine operating temperatures, resulting in ring breakage, cylinder scuffing and/or piston seizure.

#### CAUTION

Excessive ring end gap results in high oil consumption and blow-by of exhaust gases. While blow-by contaminates the oil supply and leaves sludge in the crankcase, it also reduces engine efficiency by weakening the combustion seal necessary for efficient transfer of energy to the piston.

2. Insert the new ring into the cylinder, square it in the bore using the top of the piston and measure the ring end gap with a feeler gauge. See Figure 3-89. Do not use the ring if the end gap does not fall within the following specifications.

Table 3-8. Ring End Gap

| Ring Type              | Ring End Gap                              |
|------------------------|---|
| Top compression ring   | 0.010 in. (0.25 mm) - 0.020 in. (0.51 mm) |
| 2nd compression ring   | 0.014 in. (0.36 mm) - 0.024 in. (0.61 mm) |
| Oil control ring rails | 0.010 in. (0.25 mm) - 0.050 in. (1.27 mm) |

#### NOTE

Ring end gap dimensions also apply to oversize rings. Replace ring if end gap exceeds specification. If end gap is under specification, filing is permissible.

3. Use compressed air to remove any dirt or dust that may have settled in the oil drain holes and piston ring grooves.
4. Install piston rings as follows:
  - a. Apply clean H-D 20W50 engine oil to three piston ring grooves.
  - b. Install expander spring into third ring groove. Spiral bottom oil rail into space below expander spring positioning the gap 90 degrees from the gap in the expander spring. Spiral top oil rail into space above expander spring positioning gap 180 degrees from the gap in the bottom oil rail.

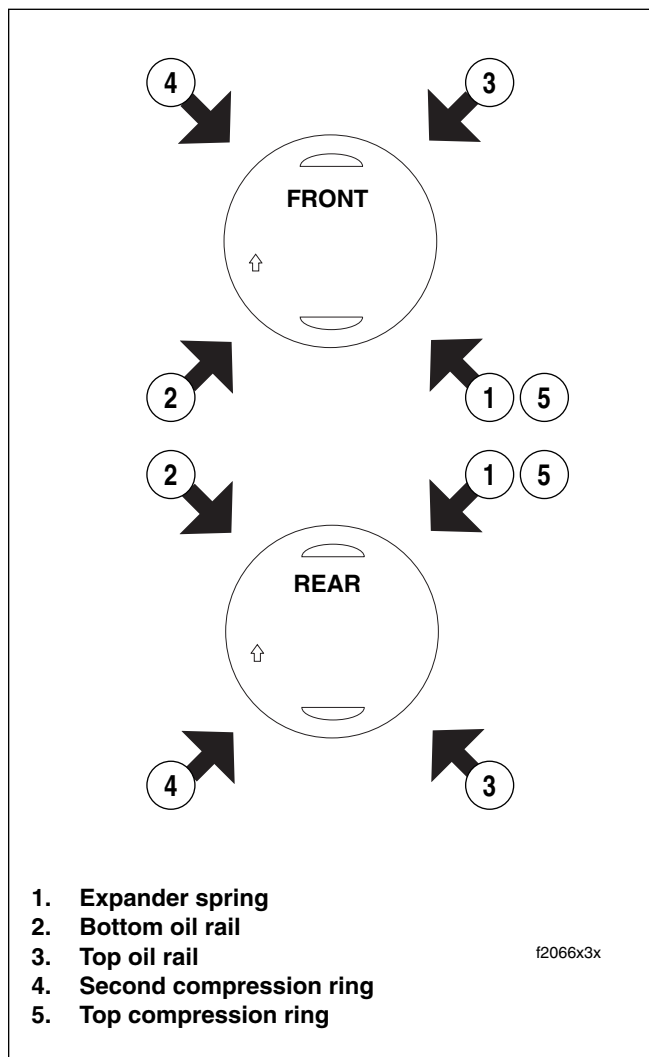


Figure 3-90. Piston Ring Gap Alignment

**CAUTION**

Use the proper piston ring spreader to prevent excessive ring twist and expansion. Over expansion may cause the ring to crack opposite the ring gap. Damaged or distorted rings result in blow-by of exhaust gases, increased oil consumption and lower service life on valves and other components.

**CAUTION**

Installing the second compression ring upside down will cause oil to be scraped up into the combustion chamber resulting in excessive oil consumption and low service life on valves and other components.

- c. Using the proper piston ring expander (Snap-On PRS8), carefully install the second compression ring making sure that the dot (punch mark) near the ring gap faces the piston crown. Rotate the ring so the gap is 90 degrees from the gap in the top oil rail.
- d. Carefully install the top compression ring using the proper piston ring expander (Snap-On PRS8). Rotate the ring so the gap is 180 degrees from the gap in the second compression ring.
- e. Rotate the three piston rings using the palms of both hands. The rings must rotate freely without sticking.
- f. Verify that the ring gaps are still properly staggered. See [Figure 3-90](#).

**Installation**

1. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 1-24 and 29-39.

# NOTES

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## UPPER CONNECTING ROD

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-11 and 15-29.

### Disassembly/Assembly

#### NOTE

Service of connecting rods is limited to replacement of the upper bushing. Damage to connecting rods or lower bushing service requires replacement of the flywheel assembly.

### Upper Connecting Rod Bushing

#### Removal

#### NOTE

Replace the upper rod bushing if the piston pin to rod bushing clearance exceeds 0.002 inch (0.051 mm).

#### CAUTION

Place clean shop towels in and around the crankcase bore to prevent chips and shavings from falling into the crankcase.

1. Obtain the CONNECTING ROD CLAMPING TOOL (HD-95952-33B) and proceed as follows:
  - a. Slide clamp over connecting rod so that slots engage cylinder head studs. See Figure 3-92. Exercise caution to avoid scratching or bending studs.
  - b. With the knurled side up, install threaded cylinders (HD-95952-1) onto studs to secure position of clamp.
  - c. Alternately turn each clamp thumbscrew a few turns to gradually fix position of connecting rod. Turning only one thumbscrew will move rod off-center, while tightening second thumbscrew can cause rod to flex or bend.
2. Obtain the CONNECTING ROD BUSHING REMOVER/INSTALLER (HD-95970-32D) and proceed as follows:
  - a. Sparingly apply graphite lubricant to threads of rod to prolong service life and ensure smooth operation.
  - b. Slide receiver cup (HD-95984-99) onto threaded rod with the closed side facing hex nut.
  - c. Insert threaded rod through upper rod bushing.
  - d. Slide remover side of driver (HD-95986-99) down threaded rod. The driver is stamped to ensure proper orientation.
  - e. Slide Nice bearing and flat washer down threaded rod until it contacts driver.

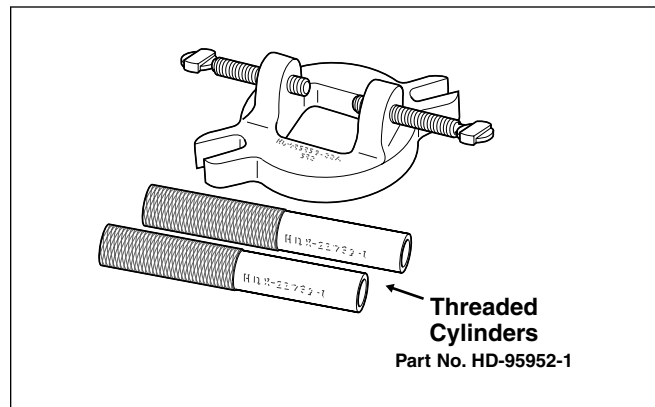


Figure 3-91. Connecting Rod Clamping Tool (Part No. HD-95952-33B)

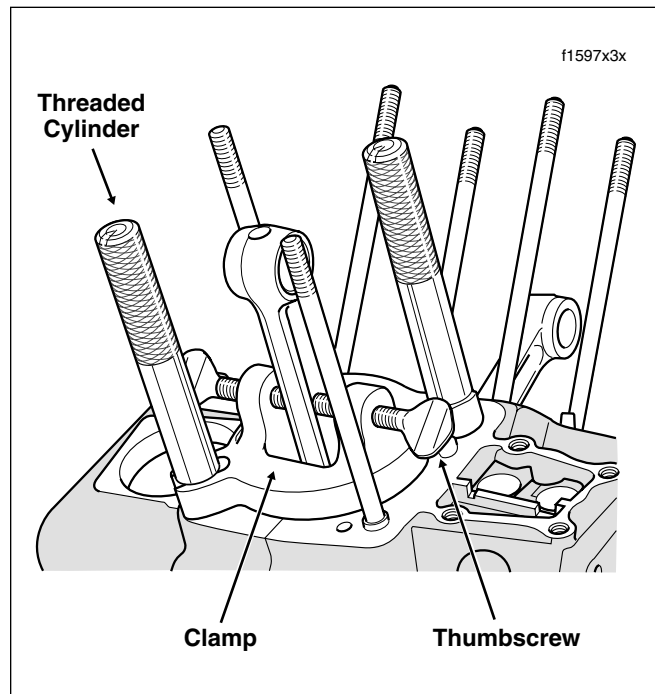


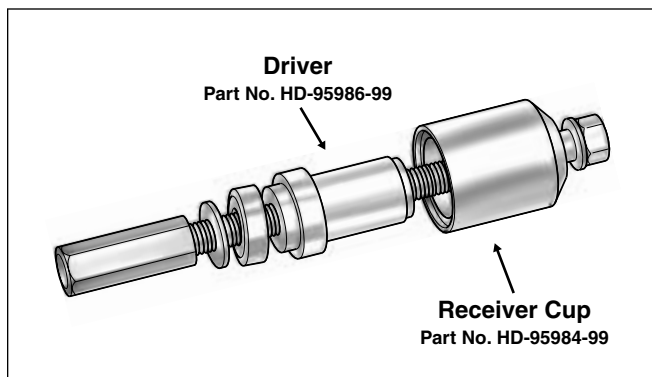
Figure 3-92. Install Connecting Rod Clamping Tool

- f. Thread the hex cylinder onto rod until assembly is snug. See upper frame of Figure 3-94.
- g. Holding nut at end of threaded rod with a 5/8 inch box wrench, turn hex cylinder with a 5/8 inch socket until bushing is free.
- h. Unthread hex cylinder from rod. Remove flat washer, Nice bearing and driver. Remove threaded rod from bushing bore.
- i. Remove bushing from receiver cup and discard.

### Installation

1. Obtain the CONNECTING ROD BUSHING REMOVER/INSTALLER (HD-95970-32D) and proceed as follows:



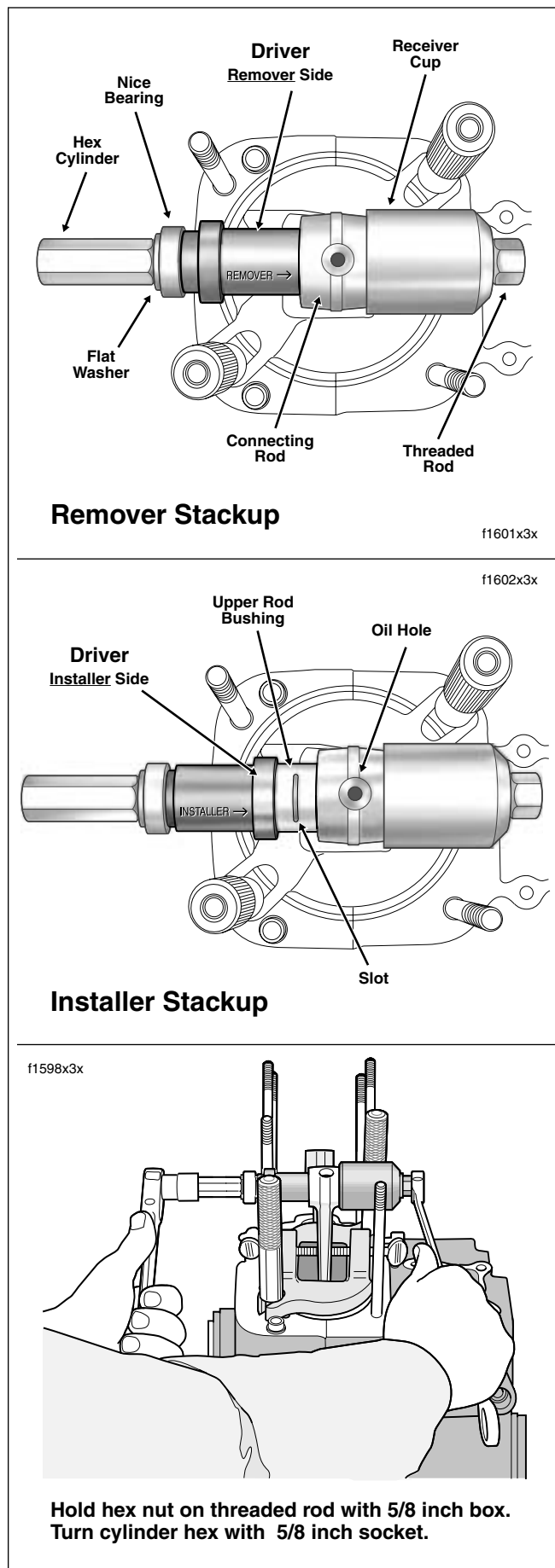


**Figure 3-93. Connecting Rod Bushing Remover/Installer (Part No. HD-95970-32D)**

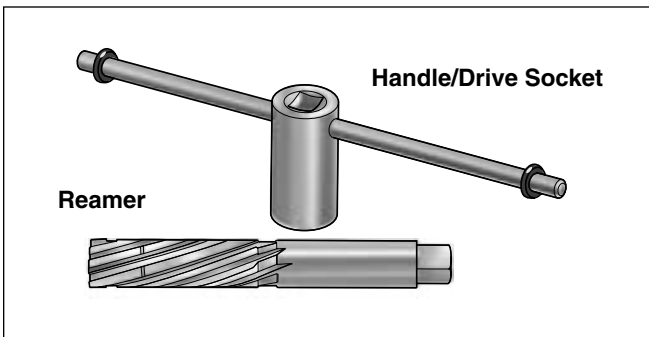
- Slide receiver cup (HD-95984-99) onto threaded rod with the closed side facing hex nut.
- Insert threaded rod through upper rod bushing bore.
- Slide **new** bushing down threaded rod. Start bushing into bore. Verify that center of slot in bushing is aligned with oil hole at top of rod. Also, be sure that bushing is square in bore and not cocked. See center frame of [Figure 3-94](#).
- Slide installer side of driver (HD-95986-99) down threaded rod until shoulder contacts bushing. The driver is stamped to ensure proper orientation.
- Slide Nice bearing and flat washer down threaded rod until it contacts driver.
- Thread the hex cylinder onto rod until assembly is snug.
- Holding nut at end of threaded rod with a 5/8 inch box wrench, turn hex cylinder with a 5/8 inch socket until collar on driver bottoms against connecting rod. See lower frame of [Figure 3-94](#).
- Unthread hex cylinder from rod and remove flat washer, Nice bearing and driver. Remove threaded rod from bushing bore, but exercise caution to avoid scratching or gouging bushing.

## Reaming Upper Rod Bushing

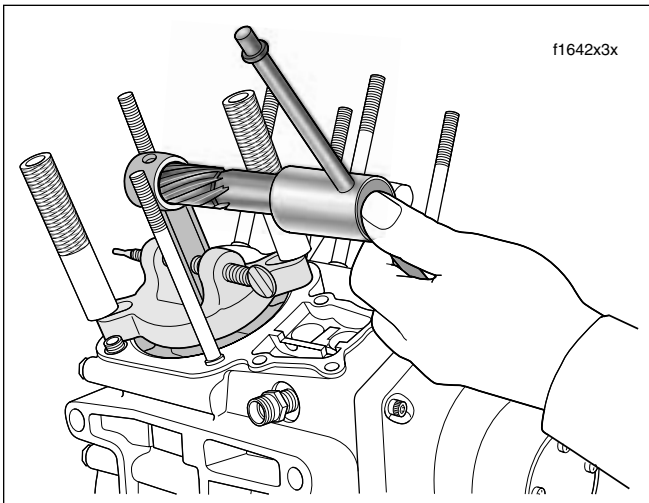
- Obtain the CONNECTING ROD BUSHING REAMER (HD-42318) and REAMER HANDLE/DRIVE SOCKET (HD-43645). Proceed as follows:
  - Carefully insert bit of reamer into upper connecting rod bushing. Do not apply lubricant to reamer or bushing. Ream the bushing dry or cut will not be accurate.
  - Install handle/driver socket on reamer lug. See [Figure 3-96](#).
  - Placing thumb on drive socket, apply slight pressure on reamer while rotating handle/driver socket in a clockwise direction.



**Figure 3-94. Remove/Install Connecting Rod Bushing**



**Figure 3-95. Connecting Rod Bushing Reamer (Part No. HD-42318) and Handle/Drive Socket (Part No. HD-43645)**



**Figure 3-96. Ream Connecting Rod Bushing**

#### CAUTION

For best results, do not push on reamer or apply pressure to the reamer handle. While excessive pressure results in a rough cut, bushing bore will be tapered if pressure is not centrally applied.

- d. Continue rotating handle/driver socket until entire bit has passed through bushing and shank of reamer rotates freely in the bore.

#### CAUTION

Never back reamer out of connecting rod or bushing will be damaged.

- e. Remove handle/driver socket, and carefully pulling on bit, draw shaft of reamer out of connecting rod bushing.

#### CAUTION

Abrasive particles can damage machined surfaces and plug oil passageways possibly resulting in engine failure.

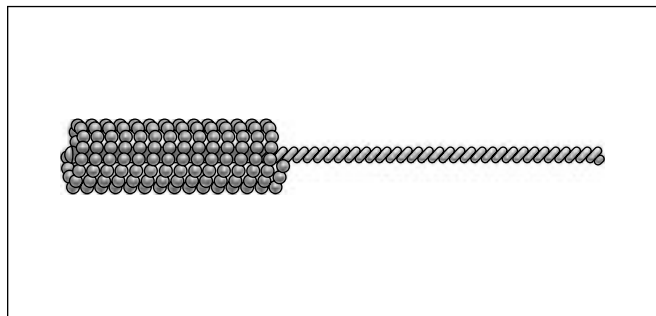
2. Using contact cleaner or cleaning solvent, thoroughly wipe upper connecting rod and bushing of any metal shavings or debris.

## Honing Upper Rod Bushing

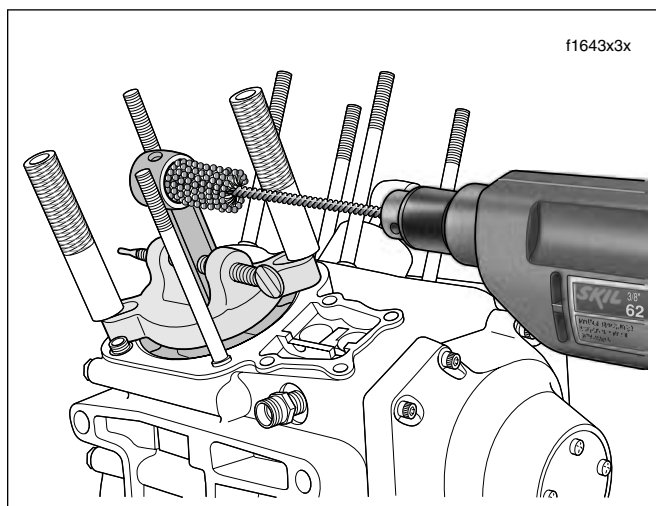
1. Obtain the CONNECTING ROD BUSHING HONE (HD-42569) and REAMER LUBRICANT (HD-39964). Proceed as follows:
  - a. Install hone in a high speed electric drill.
  - b. Apply reamer lubricant to finishing stones of hone and inside of upper connecting rod bushing.
  - c. Start finishing stones of hone into bushing.
  - d. Activating the drill, move the entire length of the finishing stone arrangement forward and backward through the bushing bore for 10 to 12 complete strokes. See [Figure 3-98](#). Work for a crosshatch pattern of approximately 60°.

#### CAUTION

Abrasive particles can damage machined surfaces and plug oil passageways possibly resulting in engine failure.



**Figure 3-97. Connecting Rod Bushing Hone (Part No. HD-42569)**



**Figure 3-98. Hone Connecting Rod Bushing**



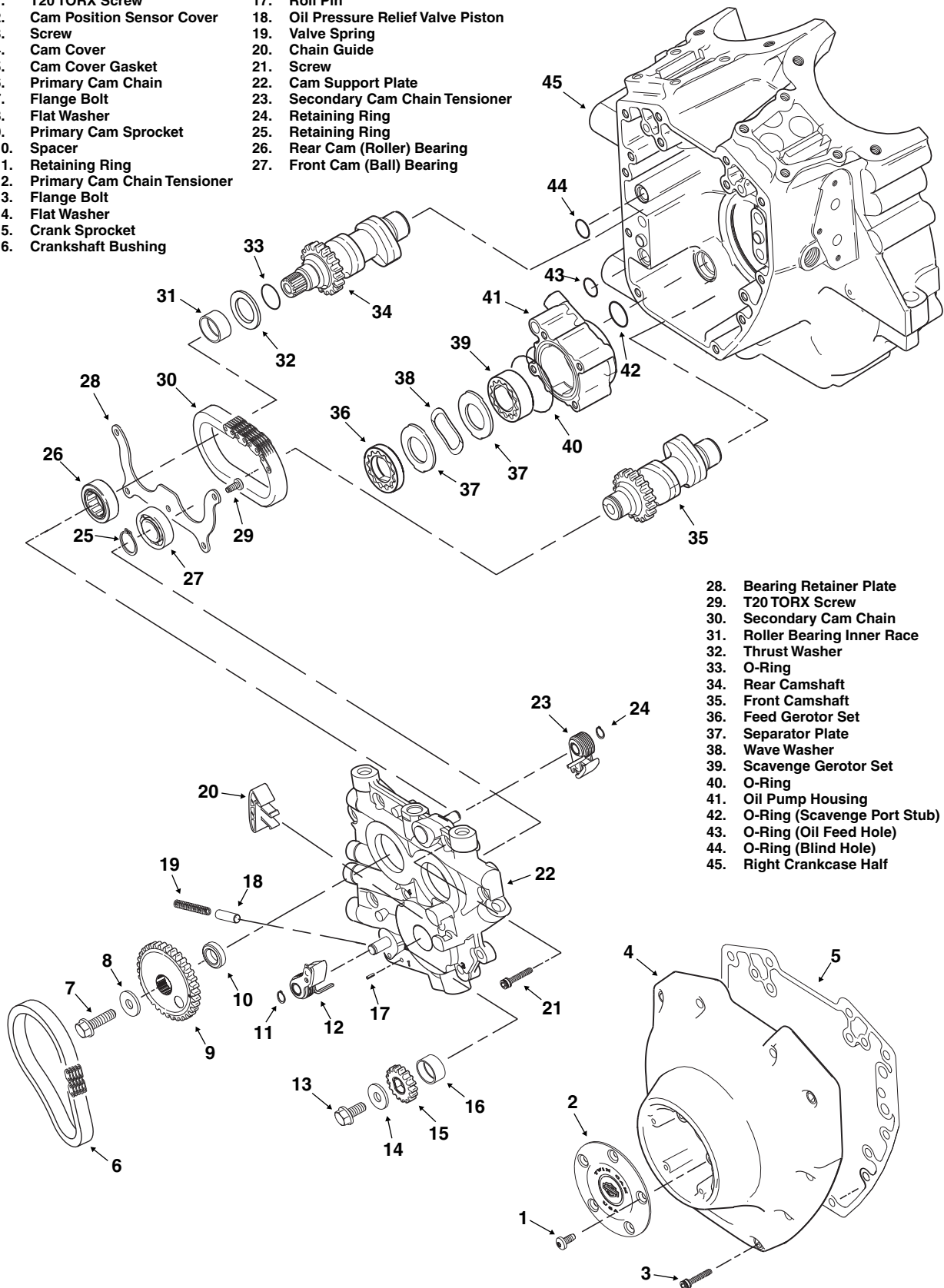
2. Using contact cleaner or cleaning solvent, thoroughly wipe upper connecting rod and bushing of any metal shavings or debris. Continue wiping until a clean cloth shows no evidence of dirt or debris.
3. Lightly oil a good piston pin and insert it into the upper connecting rod bushing bore to feel for the proper interference fit. The pin should slide in and out of the bushing without binding, but also without pivoting or rocking.
4. Remove shop towels exercising caution that shavings, chips and other debris do not fall into crankcase.

## Installation

See Section [3.9 TOP END OVERHAUL](#), [ASSEMBLY](#), steps 1-24 and 29-39.

**Legend:**

- |                                 |                                      |
|---------------------------------|--------------------------------------|
| 1. T20 TORX Screw               | 17. Roll Pin                         |
| 2. Cam Position Sensor Cover    | 18. Oil Pressure Relief Valve Piston |
| 3. Screw                        | 19. Valve Spring                     |
| 4. Cam Cover                    | 20. Chain Guide                      |
| 5. Cam Cover Gasket             | 21. Screw                            |
| 6. Primary Cam Chain            | 22. Cam Support Plate                |
| 7. Flange Bolt                  | 23. Secondary Cam Chain Tensioner    |
| 8. Flat Washer                  | 24. Retaining Ring                   |
| 9. Primary Cam Sprocket         | 25. Retaining Ring                   |
| 10. Spacer                      | 26. Rear Cam (Roller) Bearing        |
| 11. Retaining Ring              | 27. Front Cam (Ball) Bearing         |
| 12. Primary Cam Chain Tensioner |                                      |
| 13. Flange Bolt                 |                                      |
| 14. Flat Washer                 |                                      |
| 15. Crank Sprocket              |                                      |
| 16. Crankshaft Bushing          |                                      |



f2413x3x

**Figure 3-99. Cam Support Plate/Oil Pump Assemblies (Exploded View)**

## BOTTOM END

### CAM SUPPORT PLATE

#### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-11.

#### NOTE

When removing the cam support plate, it is not necessary to disturb the lifter assemblies if a method is devised to prevent the hydraulic lifters from dropping into the cam compartment. One such method is provided in the following step. Leaving the lifter assemblies intact simplifies the procedure, since the lifter cover, gasket, anti-rotation pin and hydraulic lifters can be left in place.

2. Fashion lifter holding tool as follows:
  - a. Obtain a large binder clip (available at any office supply store). Squeeze wireforms to remove from binder clip. See upper frame of Figure 3-100.
  - b. Compress wireform slightly and insert free ends into outer and inner lifter cover bores so that legs engage walls of both hydraulic lifter sockets. See lower frame of Figure 3-100.
3. See Section 3.10 BOTTOM END OVERHAUL, DISASSEMBLY, steps 1-14.

#### Disassembly/Assembly

#### CAUTION

Do not pull the retention pins from the primary or secondary cam chain tensioners with the chains and sprockets removed. With 35-40 pounds of spring pressure behind the tensioner, allowing it to accelerate through its full length of travel will cause spring stretching and/or cracking of the tensioner shoe, damage which requires replacement of the assembly. Furthermore, if the tensioner should contact fingers or other parts of the hand, minor or moderate injury may occur.

#### NOTE

If the retention pins interfere with cleaning or service procedures, hold the retracted cam chain tensioner with the CAM CHAIN TENSIONER UNLOADER (HD-42313), pull the retention pin and ease the assembly into the unloaded position.

#### Crankshaft Bushing

##### Removal

1. Obtain the CRANKSHAFT BUSHING REMOVER/INSTALLER (HD-42315).

2. Center support tube under ram of arbor press.
3. Center crankshaft bushing in cam support plate over support tube. Be sure that the primary cam chain side of the cam support plate is facing upward.

#### CAUTION

If the crankshaft bushing is pressed out the primary cam chain side, the bore will be damaged by the knurled edge of the bushing. Damage to the bore requires replacement of the cam support plate.

4. Insert remover side of driver into crankshaft bore so that shoulder on tool is seated on edge of bushing. See upper frame of Figure 3-102.
5. Press on driver until collar of tool contacts cam support plate. Remove bushing from support tube and discard.

#### Installation

1. Obtain the CRANKSHAFT BUSHING REMOVER/INSTALLER (HD-42315).
2. Center support tube under ram of arbor press.

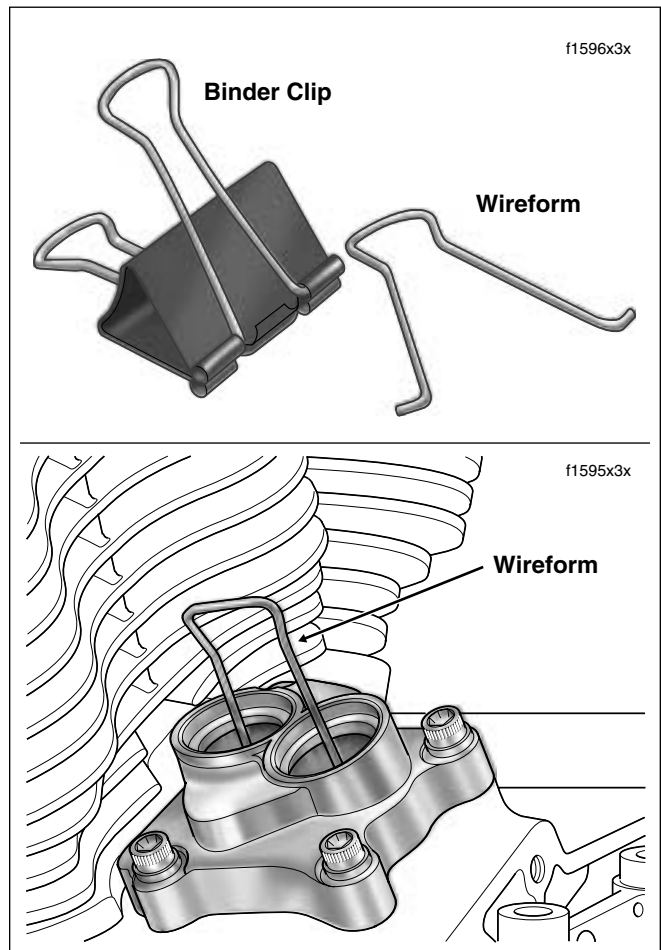
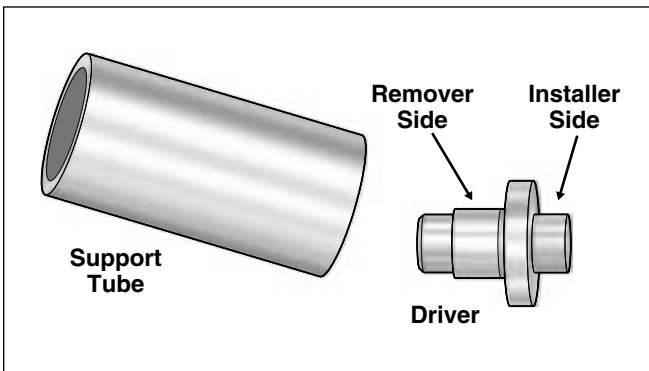


Figure 3-100. Fashion Tool to Hold Hydraulic Lifters



**Figure 3-101. Crankshaft Bushing Remover/Installer (Part No. HD-42315)**

3. Turn cam support plate over so that secondary cam chain side is facing upward.
4. Start **new** bushing into bore with the knurled edge top-side. Be sure that hole in bushing is aligned with oil hole in bushing bore.

#### CAUTION

If the crankshaft bushing is pressed in from the primary cam chain side, or from the secondary cam chain side with the knurled edge of the bushing down, the bushing bore will be damaged. Damage to the bore requires replacement of the cam support plate.

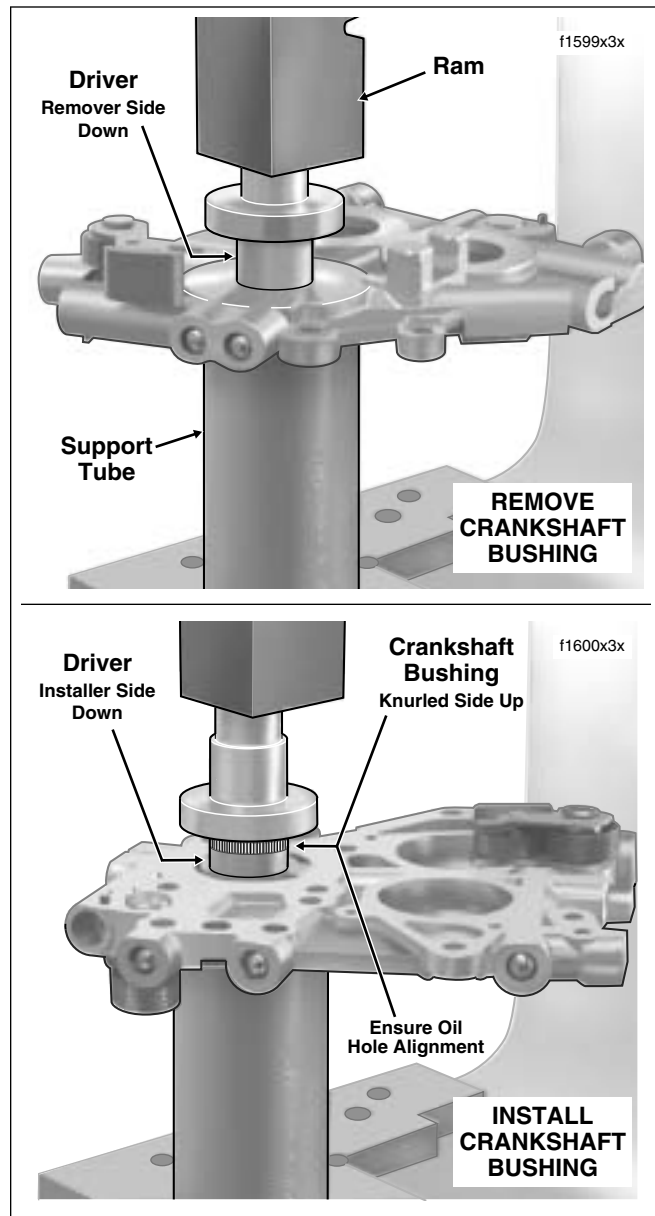
5. Center crankshaft bushing bore over support tube.
6. Insert installer side of driver into bushing. See lower frame of [Figure 3-102](#).
7. Press on driver until collar of tool makes firm contact with cam support plate.
8. Ream the crankshaft bushing following the directions below.

## Reaming Crankshaft Bushing

#### NOTE

A **new** crankshaft bushing must be reamed for proper size and alignment. If crankcase halves are not split, ream the bushing using a spare right case half to avoid further engine disassembly.

1. Slide cam support plate onto two ring dowels in crankcase flange.
2. Install six allen head socket screws (1/4 x 1 inch) to secure cam support plate to crankcase flange. Alternately tighten screws until snug.
3. Obtain the CRANKSHAFT BUSHING REAMER (HD-42316) and REAMER HANDLE/DRIVE SOCKET (HD-43645). Proceed as follows:



**Figure 3-102. Remove/Install Crankshaft Bushing in Cam Support Plate**

- a. From flywheel compartment side, carefully insert tapered end of reamer pilot into crankshaft bearing until it stops. See left frame of [Figure 3-104](#).
- b. Slide reamer through pilot starting bit into crankshaft bushing in cam support plate. Do not apply lubricant to reamer or bushing. Ream the bushing dry or cut will not be accurate.
- c. Install handle/driver socket on reamer lug. See right frame of [Figure 3-104](#).
- d. Placing thumb on drive socket, apply slight pressure on reamer while rotating handle/driver socket in a clockwise direction.

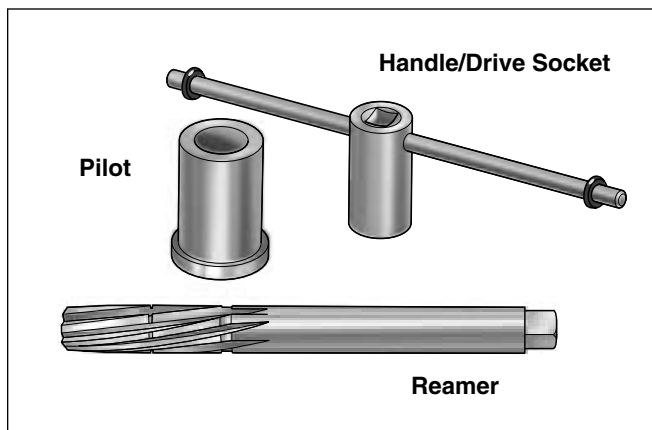


Figure 3-103. Crankshaft Bushing Reamer (Part No. HD-42316) and Handle/Drive Socket (Part No. HD-43645)

#### CAUTION

For best results, do not push on reamer or apply pressure to the reamer handle. While excessive pressure results in a rough cut, bushing bore will be tapered if pressure is not centrally applied.

- e. Continue rotating handle/drive socket until entire bit has passed through bushing and shank of reamer rotates freely in the bore.

#### CAUTION

Never back reamer out flywheel side of crankcase or crankshaft bushing will be damaged.

- f. Remove handle/drive socket, and carefully pulling on bit, draw shaft of reamer out of bushing on cam side of crankcase.
  - g. Remove pilot from crankshaft bearing. Tap on pilot using a soft rubber mallet, if necessary.
4. Remove the allen head socket screws to release the cam support plate from the crankcase flange.

#### CAUTION

Abrasive particles can damage machined surfaces and plug oil passages possibly resulting in engine failure.

5. Thoroughly flush right crankcase half and cam support plate in cleaning solvent to remove any metal shavings or debris. Blow dry with compressed air.

## Camshafts/Camshaft Bearings

### Removal

1. Place cup of CAM CHAIN TENSIONER UNLOADER (HD-42313) over spring coil of secondary cam chain tensioner positioning finger on tool between tensioner and shoe. See Figure 3-105. Rotate tool in a counterclockwise direction inserting retention pin through hole in boss on primary cam chain side of cam support plate. Pin engages hooks on tensioner to hold it in the retracted position. For best results, place cam support plate in a vise using brass jaw inserts to prevent casting damage.

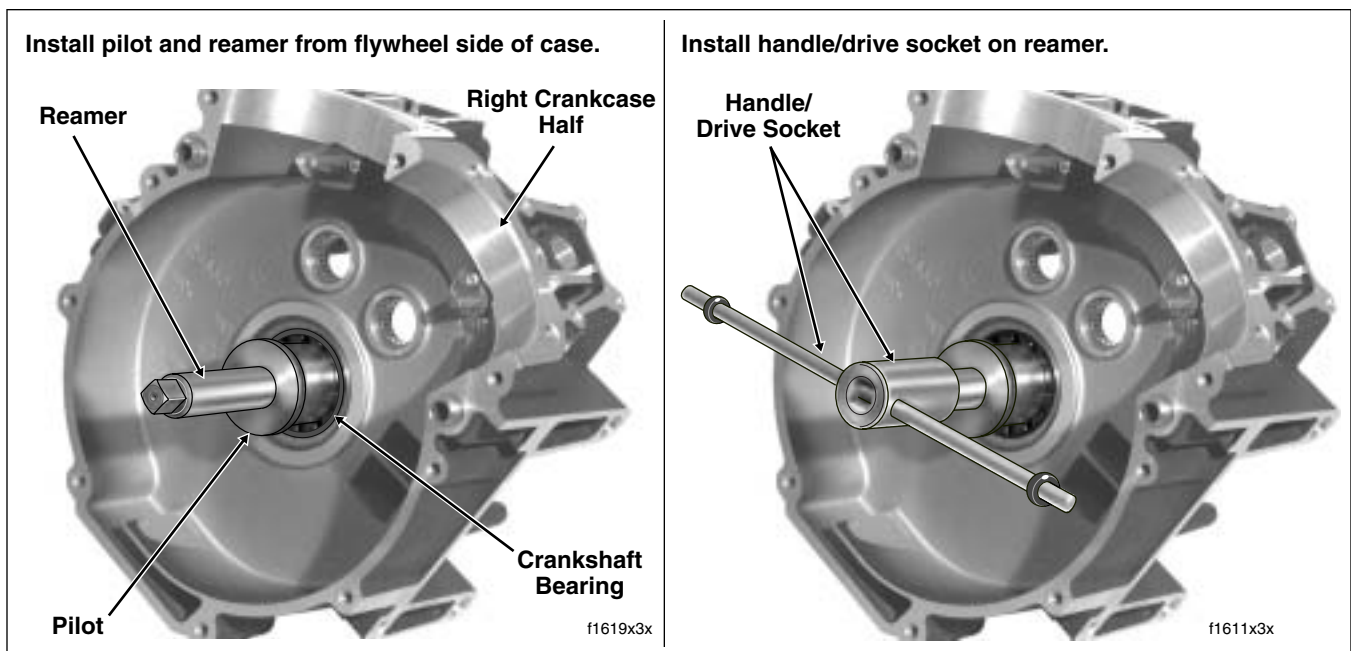


Figure 3-104. Ream Crankshaft Bushing

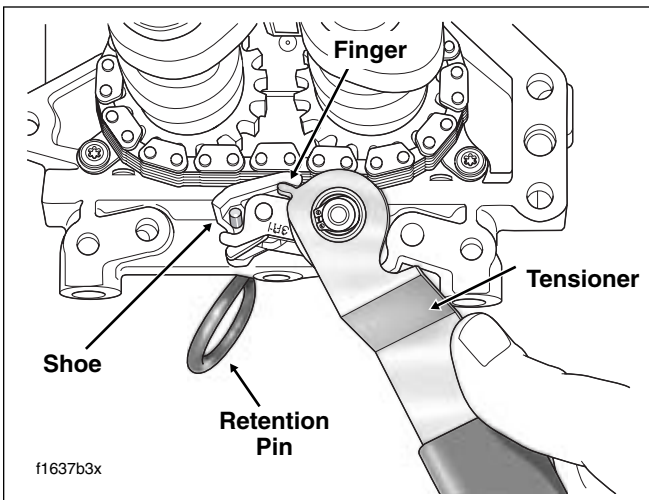


Figure 3-105. Retract Secondary Cam Chain Tensioner

### ⚠ WARNING

Always wear proper eye protection when removing retaining rings. Use the correct retaining ring pliers. Verify that the tips of the pliers are not damaged or excessively worn. Slippage may propel the ring with enough force to cause eye injury.

2. Remove retaining ring from groove at end of front camshaft. Discard retaining ring.
3. Remove four T20 TORX screws to free bearing retainer plate from inboard side of cam support plate.
4. Using a colored marker, mark one of the links of the secondary cam chain. Maintaining the original direction of rotation during assembly may prolong service life of chain.
5. With the primary cam chain side facing upward, place cam support plate on parallel blocks under ram of arbor press.
6. Obtain the CAMSHAFT/CAMSHAFT BEARING REMOVER/INSTALLER (HD-43644). See Figure 3-106.

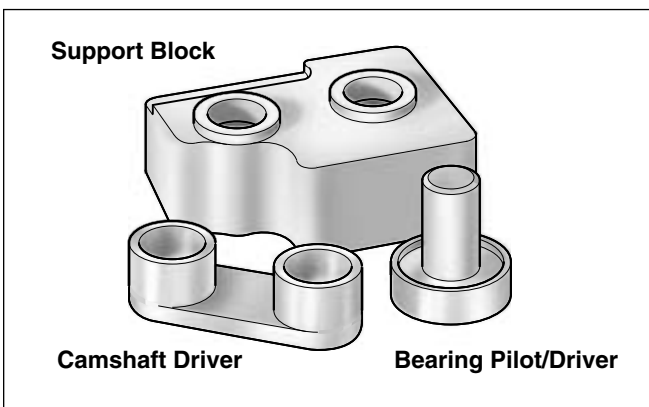
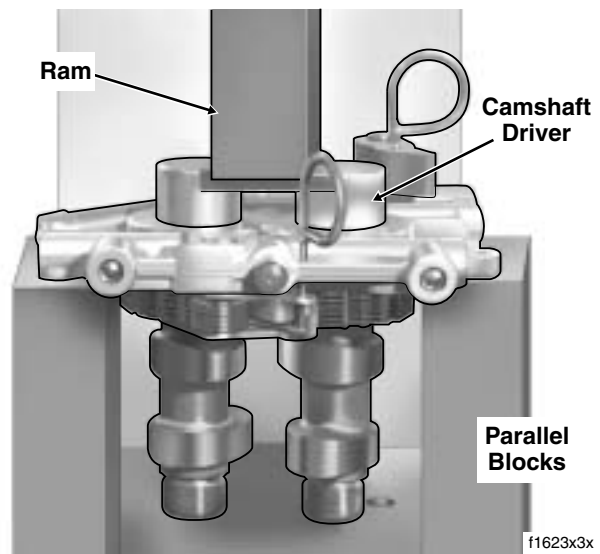


Figure 3-106. Camshaft/Camshaft Bearing Remover/Installer (Part No. HD-43644)

Press out camshafts (with bearings).



Remove bearing from front camshaft.

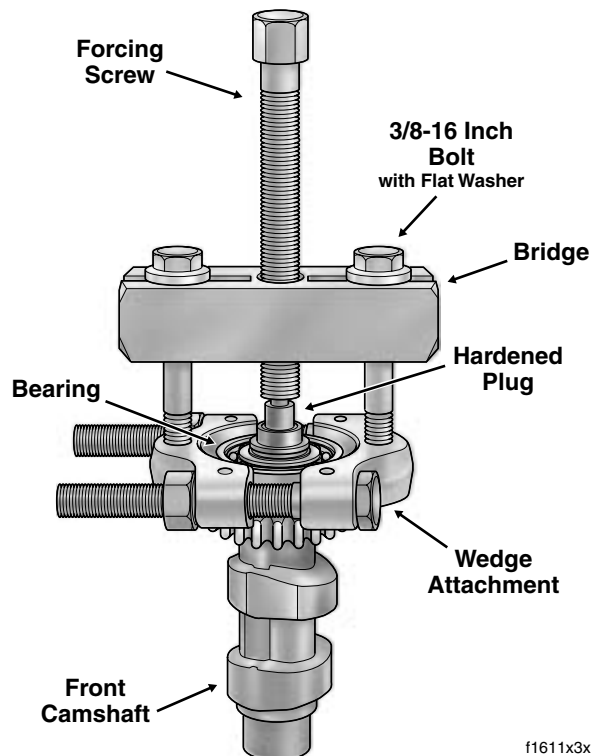
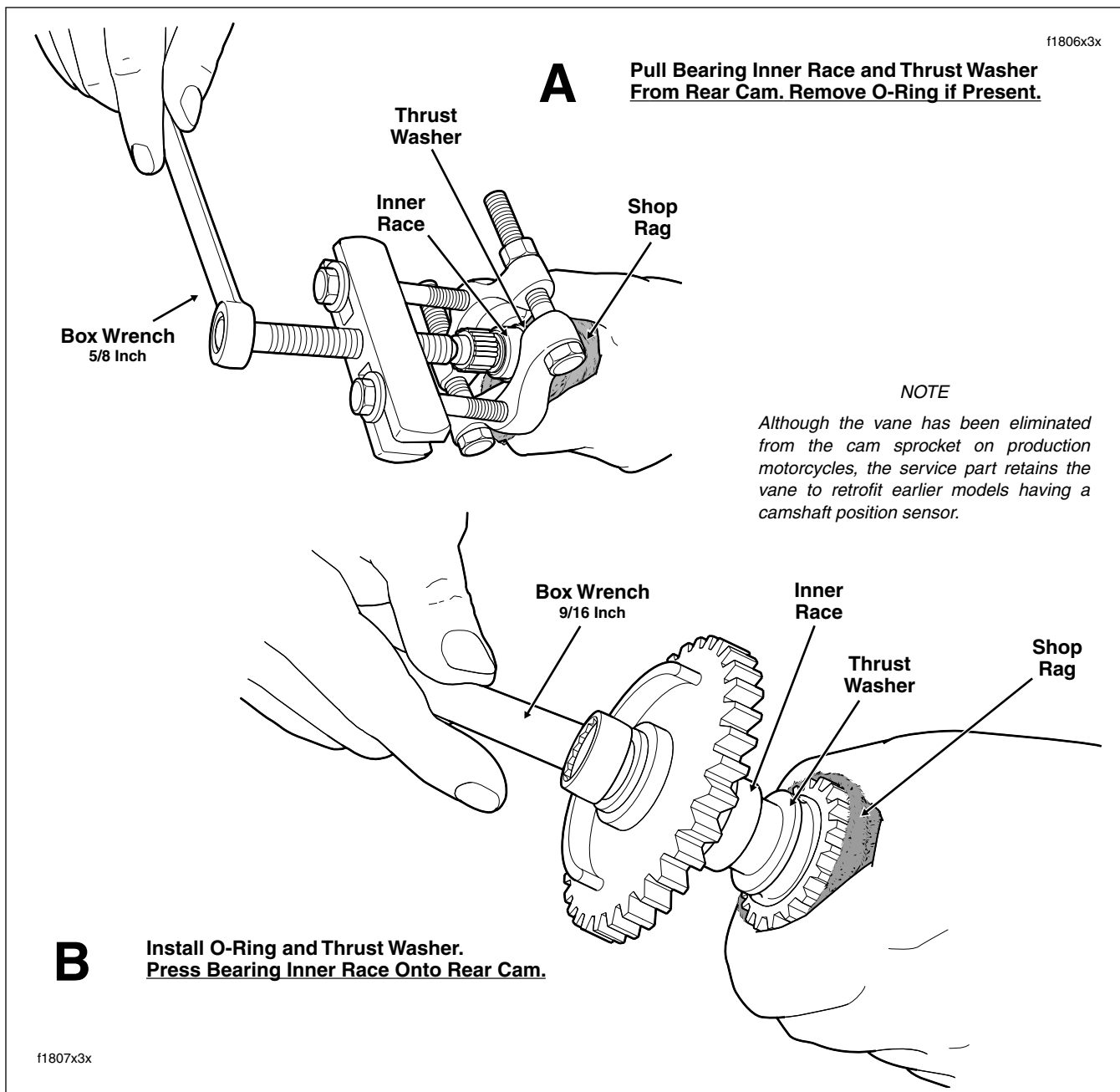


Figure 3-107. Remove Camshafts/Front Cam Bearing

### CAUTION

Since the bearing fit to the camshafts is tighter than its fit in the support plate, any attempt to remove the camshafts without the bearings will result in damage to the cam support plate and bearing retainer plate, if installed.





**Figure 3-108. Remove/Install Bearing Inner Race (With O-Ring and Thrust Washer) Onto Rear Camshaft**

### CAUTION

Cam bearings may be a loose fit in the cam support plate. To avoid possible damage, be aware that camshaft and bearing assemblies may drop out at start of press procedure.

7. Fit cups of camshaft driver over ends of front and rear camshafts, so that contact is made with the bearing inner races. Centering driver under ram at a point midway between the camshafts, simultaneously press both
8. Remove secondary cam chain from cam sprockets.
9. If reusing front camshaft, remove bearing as follows:
  - a. Position WEDGE ATTACHMENT (HD-95637-46B) on inboard side of front camshaft bearing and turn hex nuts an equal number of turns to draw halves of wedge together.

camshafts (with attached bearings) from the cam support plate. See upper frame of [Figure 3-107](#).

- b. Obtain two 3/8-16 inch bolts 3-1/2 inches long (with flat washers). Install flat washers on bolts. Obtain bridge, forcing screw and hardened plug from MAINSHAFT BEARING INNER RACE PULLER/INSTALLER (HD-34902B).
- c. Slide one bolt into channel on each side of bridge so that flat washer is between bridge and bolt head. Thread bolts into wedge attachment an equal number of turns.
- d. Sparingly apply graphite lubricant to threads of forcing screw to prolong service life and ensure smooth operation. Start forcing screw into center hole of bridge.

### CAUTION

**Failure to use hardened plug may result in damage to forcing screw and/or camshaft.**

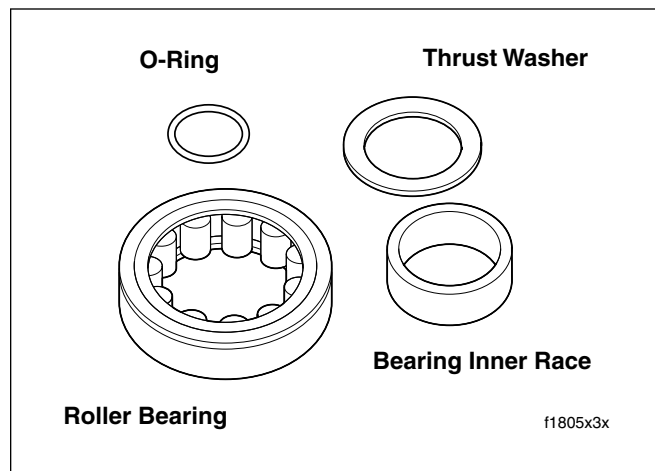
- e. Place cupped side of hardened plug against end of camshaft. Thread forcing screw into bridge until the steel ball at the end of the screw makes firm contact with hardened plug.
  - f. Verify that the tool assembly is square so that the bearing is not cocked during removal. See lower frame of [Figure 3-107](#). Turn forcing screw until bearing is pulled free of camshaft. Discard bearing.
10. If reusing rear camshaft, remove roller bearing assembly as follows:
- a. Slide roller bearing from end of rear camshaft. Since bearing is a loose fit on cam, no pressing tools are required.
  - b. Install tools as you would to remove the bearing from the front camshaft, but position cup of wedge inboard of the thrust washer.
  - c. Wrap a shop rag around camshaft to get a firm grip and also to protect hand from sharp edges of sprocket.
  - d. Using a 5/8 inch box wrench, turn forcing screw until bearing inner race and thrust washer are pulled free of camshaft. See A of [Figure 3-108](#). A light interference fit allows the parts to be removed with little effort. Discard inner race and thrust washer.
  - e. If present, remove O-ring from grinding relief groove in camshaft. Groove is on the splined end between the machined area and the secondary cam sprocket. Discard O-ring.

### NOTE

*Since the O-ring is not used in production, it will only be found if the cams were serviced at the dealer level.*

## Installation

1. Obtain new rear cam roller bearing kit (Part No. 8983). See [Figure 3-109](#).



**Figure 3-109. Rear Cam Roller Bearing Kit (P/N 8983)**

2. Install O-ring, thrust washer and bearing inner race onto rear camshaft as follows:
  - a. To properly locate thrust washer, first install O-ring in grinding relief groove. Groove is on the splined end between the machined area and the secondary cam sprocket. Exercise caution to avoid stretching or breaking the O-ring. Since the O-ring is not sold separately, damage will require purchase of a new roller bearing kit.

### CAUTION

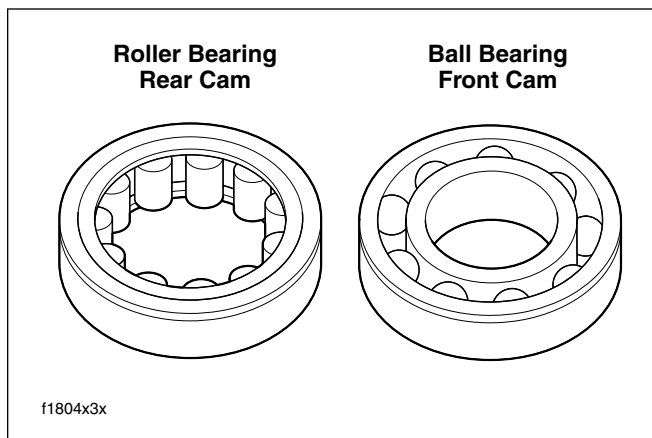
**The thrust washer will be offset to one side if the O-ring is not installed in the grinding relief groove. Damage to the bearing cage can occur if the thrust washer is not properly centered.**

- b. Slide thrust washer down rear camshaft until centered over O-ring in grinding relief groove.
- c. Slide bearing inner race down rear camshaft until contact is made with shoulder of machined area.
- d. Install primary cam sprocket spacer and sprocket on camshaft and secure using thicker flat washer and long flange bolt.

### NOTE

*If not enough of the splined shaft is exposed to install the sprocket, leave out the spacer and proceed to step 2(e). Once the bearing inner race has been started onto the machined area, remove the flange bolt, washer and sprocket, and then reassemble using the spacer. Repeat step 2(e) to fully install bearing inner race.*

- e. Wrap a shop rag around camshaft to get a firm grip and also to protect hand from sharp edges of sprocket. Using a 9/16 inch box wrench, turn flange bolt in a clockwise direction. Bearing inner race is fully installed when it makes firm contact with the thrust washer. See B of [Figure 3-108](#).



**Figure 3-110. Cam Bearings**

- f. Verify that the thrust washer is locked in place and cannot be rotated. If necessary, install shaft in vise using brass jaw inserts, and further tighten flange bolt until the desired result is achieved.
- g. Remove flange bolt, flat washer, sprocket and spacer.

#### CAUTION

**Always install new bearings. Only use genuine Harley-Davidson bearings. Reusing old bearings or using bearings from a supplier other than Harley-Davidson will result in engine damage.**

3. Obtain the CAMSHAFT/CAMSHAFT BEARING REMOVER/INSTALLER (HD-43644).
4. With the secondary cam chain side facing upward, place cam support plate on support block, so that outer races of bearings are properly supported. Note that one corner of the support block is contoured to accommodate the chain guide blocks cast into the front of the support plate.
5. Center **new** bearing over bearing bore with the lettered side up. Slide pilot shaft of bearing driver through bearing into hole of support block.

#### NOTE

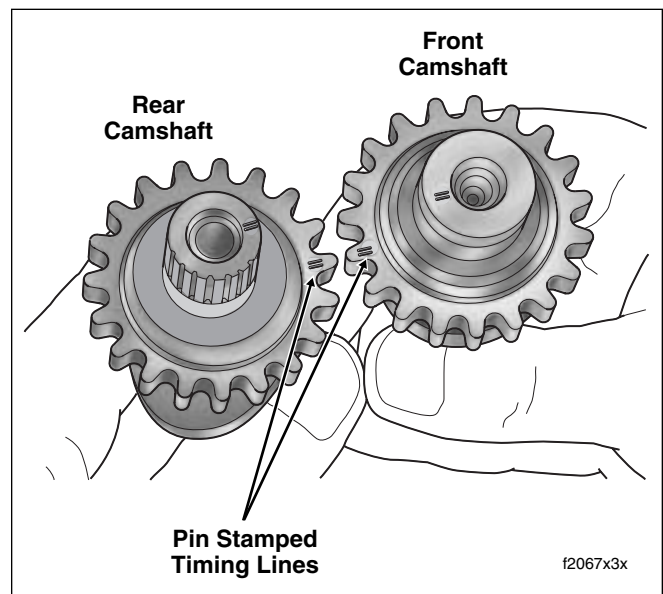
*Be aware that the front and rear cam bearings are not interchangeable. The rear bearing is the roller type, while the front is the ball bearing kind. See [Figure 3-110](#).*

6. Center bearing driver under ram of arbor press. Press on driver until bearing makes firm contact with counter-bore in cam support plate. See upper frame of [Figure 3-112](#). Repeat steps to install second bearing.

#### NOTE

*Bearings may be a press to loose fit. If deemed necessary, clean bearing OD and apply Loctite Low Strength Threadlocker 243 (Blue) before installation, but exercise caution to avoid getting compound on rollers or bearing ID.*

7. Apply a small dab of Loctite Medium Strength Threadlocker 243 (blue) to threads of four bearing retainer plate screws. Using a T20 TORX drive head, secure bearing retainer plate to cam support plate. Tighten screws to 20-30 **in-lbs** (2.3-3.4 Nm) in a crosswise pattern. Verify that hole in retainer plate is properly aligned with secondary cam chain oiler.
8. Place cam support plate back on support block, if removed. Block properly supports inner races of bearings as camshafts are installed.
9. Align pin stamped timing lines on teeth of secondary cam sprockets (outboard faces). See [Figure 3-111](#). Using a colored marker, carefully mark the timing line locations on the inboard side of the sprocket teeth. These marks are needed to observe proper orientation of the camshafts when they are pressed into the bearings.
10. Place the secondary cam chain around the sprockets of both the front and rear camshafts. To maintain the original direction of rotation, be sure that the colored mark placed on the chain link during disassembly is facing opposite the cam support plate during installation.
11. Orient the camshafts so that they are positioned on opposite ends of the chain, and then verify that the colored marks placed on the inboard side of the sprocket teeth are still in alignment.
12. Maintaining the position of the camshafts on the chain with the colored marks in alignment, place the sprocket ends of the camshafts into the bearings.



**Figure 3-111. Align Timing Lines on Teeth of Camshaft Sprockets**

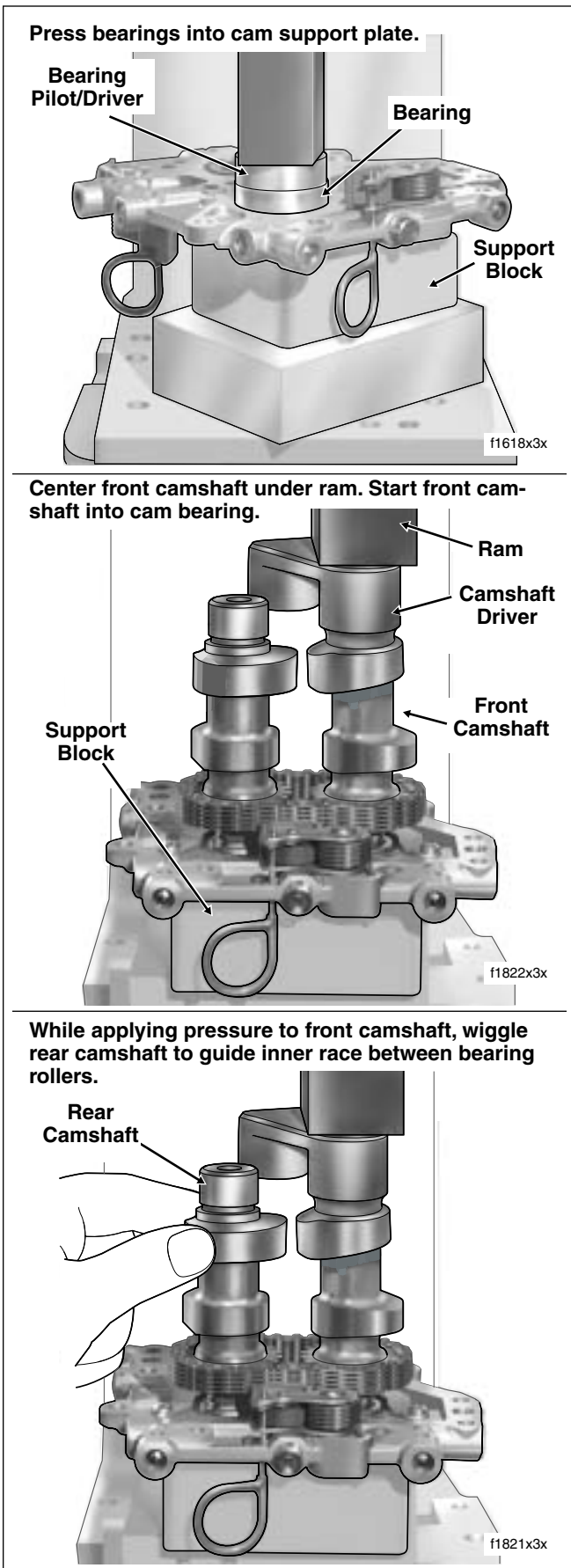


Figure 3-112. Install Cam Bearings/Camshafts

## NOTE

Do not mix camshafts during the press procedure. The rear camshaft, which can be identified by the splined shaft, must go into the roller bearing at the rear of the cam support plate.

13. Place cup of camshaft driver over end of front camshaft only.

## CAUTION

Verify that splined end of rear camshaft has been started into support block. Damage to the camshaft and/or support block can occur if end of camshaft catches top of block during the press procedure.

## NOTE

To reduce the likelihood of such contact occurring, use 7/8 inch drill bit to enlarge rear cam bore in support block. For best results, radius top inside edge of bore after drilling.

## CAUTION

Be sure that the tensioner shoe is clear of the secondary cam chain during the press procedure. Contact can result in damage that requires replacement of the tensioner assembly.

14. Center end of front camshaft under ram and slowly apply pressure to driver just to start front camshaft into bearing ID. See center frame of [Figure 3-112](#).

## CAUTION

If rear camshaft is not properly aligned, edge of installed inner race can catch on bearing rollers. Bearing damage can result if contact occurs during the press procedure.

15. Slowly apply pressure to driver on front camshaft, while wiggling rear camshaft as necessary to guide inner race between bearing rollers. See lower frame of [Figure 3-112](#).
16. When inner race on rear cam is started into roller bearing, apply pressure to driver until front camshaft is fully seated. If necessary, keep finger pressure at top of rear camshaft to ensure that assembly remains square and inner race moves to installed position in roller bearing.
17. Since the pin stamped timing lines on the secondary sprockets cannot be observed once the camshafts are pressed into the bearings, note that the outboard ends of the shafts have a second set of timing lines (although they may be somewhat difficult to see). Using a straight-edge, verify that these timing lines are in alignment. See [Figure 3-113](#). If they are not, then the camshafts must be removed and reinstalled (with a new bearing set).

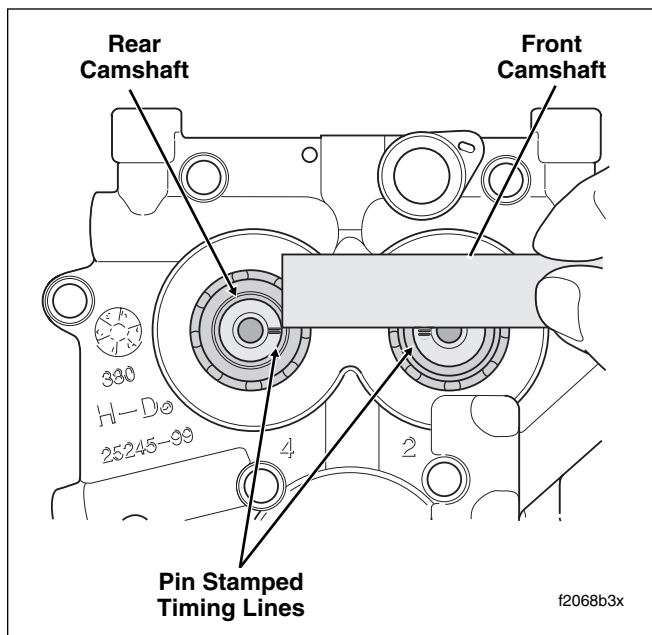


Figure 3-113. Verify Alignment of Timing Lines on Ends of Camshafts

### ⚠ WARNING

Always wear proper eye protection when installing retaining rings. Use the correct retaining ring pliers. Verify that the tips of the pliers are not damaged or excessively worn. Slippage may propel the ring with enough force to cause eye injury.

18. With the sharp edge out, install **new** retaining ring in groove at end of front camshaft.

## Cam Chain Tensioners

### Removal

### ⚠ CAUTION

Do not pull the retention pins from the primary or secondary cam chain tensioners with the chains and sprockets removed. With 35-40 pounds of spring pressure behind the tensioner, allowing it to accelerate through its full length of travel will cause spring stretching and/or cracking of the tensioner shoe, damage which requires replacement of the assembly. Furthermore, if the tensioner should contact fingers or other parts of the hand, minor or moderate injury may occur.

1. If retracted, hold the cam chain tensioner with the CAM CHAIN TENSIONER UNLOADER (HD-42313), pull the retention pin and ease the assembly into the unloaded position.

### ⚠ WARNING

Always wear proper eye protection when removing retaining rings. Use the correct retaining ring pliers. Verify that the tips of the pliers are not damaged or excessively worn. Slippage may propel the ring with enough force to cause eye injury.

2. Remove retaining ring from groove in tensioner post. Discard retaining ring.
3. Slide cam chain tensioner assembly from post disengaging spring pin from hole in cam support plate.

### Installation

1. Slide cam chain tensioner assembly onto post inserting spring pin into hole in cam support plate.

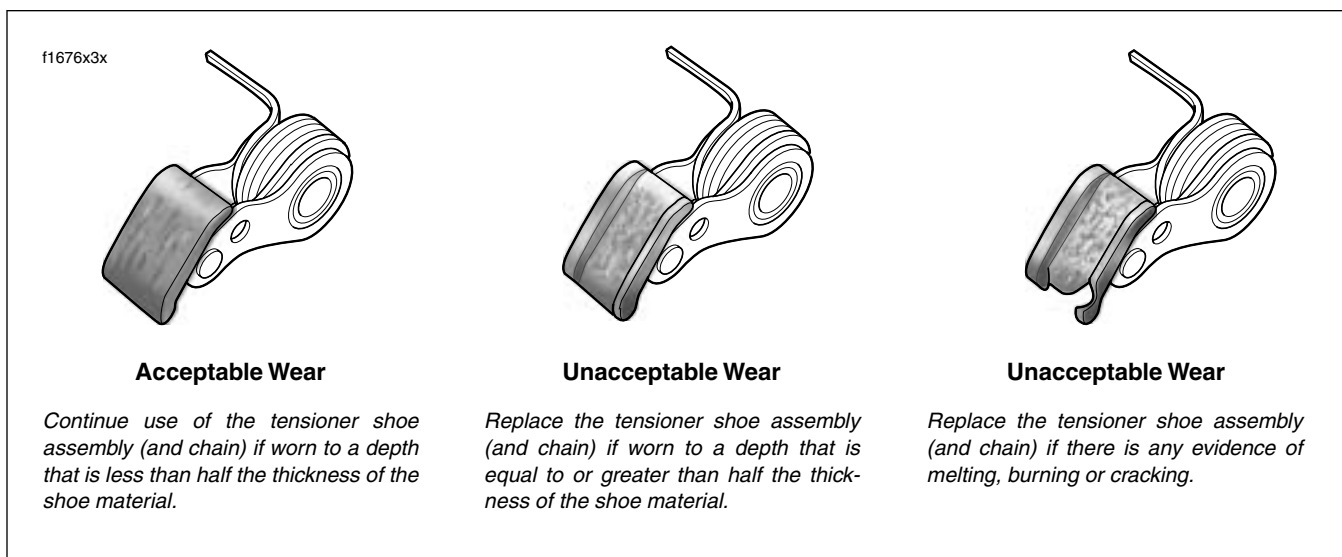
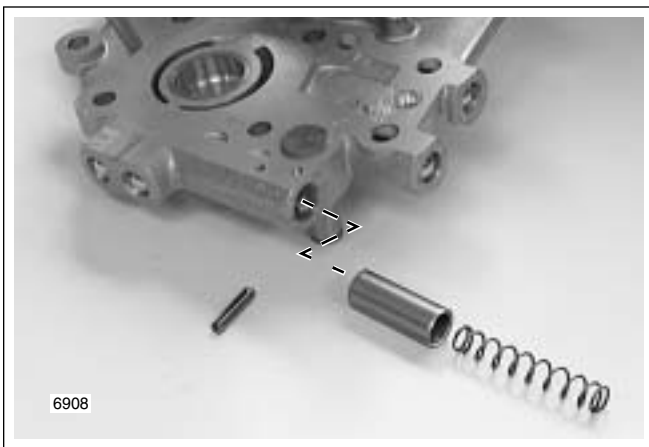


Figure 3-114. Cam Chain Tensioner Shoe Wear





**Figure 3-115. Oil Pressure Relief Valve Assembly**

### ⚠ WARNING

**Always wear proper eye protection when installing retaining rings. Use the correct retaining ring pliers. Verify that the tips of the pliers are not damaged or excessively worn. Slippage may propel the ring with enough force to cause eye injury.**

2. With the sharp edge out, install **new** retaining ring in groove of post. Verify that the ring is fully seated in the groove.
3. If retracted prior to disassembly, place cup of CAM CHAIN TENSIONER UNLOADER (HD-42313) over spring coil of cam chain tensioner assembly. Retract the tensioner inserting a retention pin through hole in boss on the **primary cam chain side** of cam support plate.

## Oil Pressure Relief Valve

### Removal

1. Before removal, see INSPECTION on this page.
2. Remove primary cam chain tensioner assembly. See CAM CHAIN TENSIONERS, REMOVAL.
3. Secure the cam support plate in a vise with access to the roll pin. Be sure to install a pair of brass jaw inserts in the vise to avoid damage to the casting.
4. Using a 1/8 inch punch with a small hammer, carefully tap roll pin from pin hole in cam support plate. Discard roll pin.
5. Remove spring and piston from bypass port.

### Installation

1. Secure the cam support plate in a vise. Install a pair of brass jaw inserts to avoid damage to the casting.
2. Lubricate piston with clean H-D 20W50 engine oil. Slide piston into bypass port with the open side facing outward.

3. Slide spring into bypass port until seated in open side of piston.
4. Start **new** roll pin into hole in cam support plate. Compress spring using the blade of a small screwdriver.
5. Holding spring compressed, tap roll pin into cam support plate until it approaches pin hole on opposite side.
6. Remove screwdriver to release spring. Verify that spring is straight and square in bore.
7. Using a 1/8 inch punch with a small hammer, carefully tap roll pin until flush with casting.
8. Install primary cam chain tensioner assembly. See CAM CHAIN TENSIONERS, INSTALLATION, in this section.

### Inspection

1. Inspect oil pressure relief valve as follows:

#### NOTE

*If diagnosing low oil pressure, start with step 1(a). If diagnosing high oil pressure, then begin with step 1(b).*

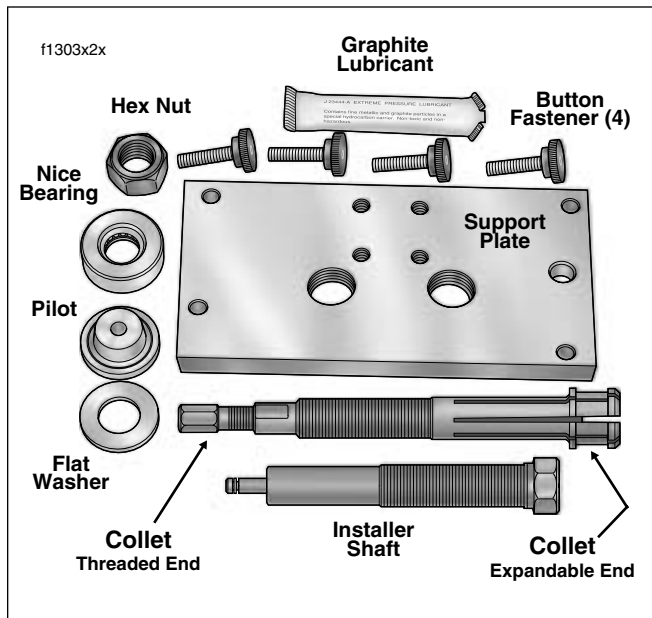
- a. Measure distance from edge of cam support plate to inboard side of piston. Insert straight stiff wire into unplugged hole outboard of roll pin until it bottoms, and then mark and measure wire. With piston fully seated in the bore, depth should be approximately 2.25 inches (57.15 mm). If it is not, continue with step 1(b).
- b. Remove oil pressure relief valve. See OIL PRESSURE RELIEF VALVE, REMOVAL, on this page.
- c. Inspect spring for stretching, kinking or distortion.
- d. Inspect piston and bore for burrs, scoring or other damage. Look for steel particles or aluminum chips. Replace cam support plate and piston if any of these conditions are found.
- e. Install piston in bore and measure running clearance. If running clearance exceeds 0.003 inch (0.076 mm), install new piston and remeasure. Replace cam support plate if running clearance still exceeds specification.

## Cam Needle Bearings

### Removal

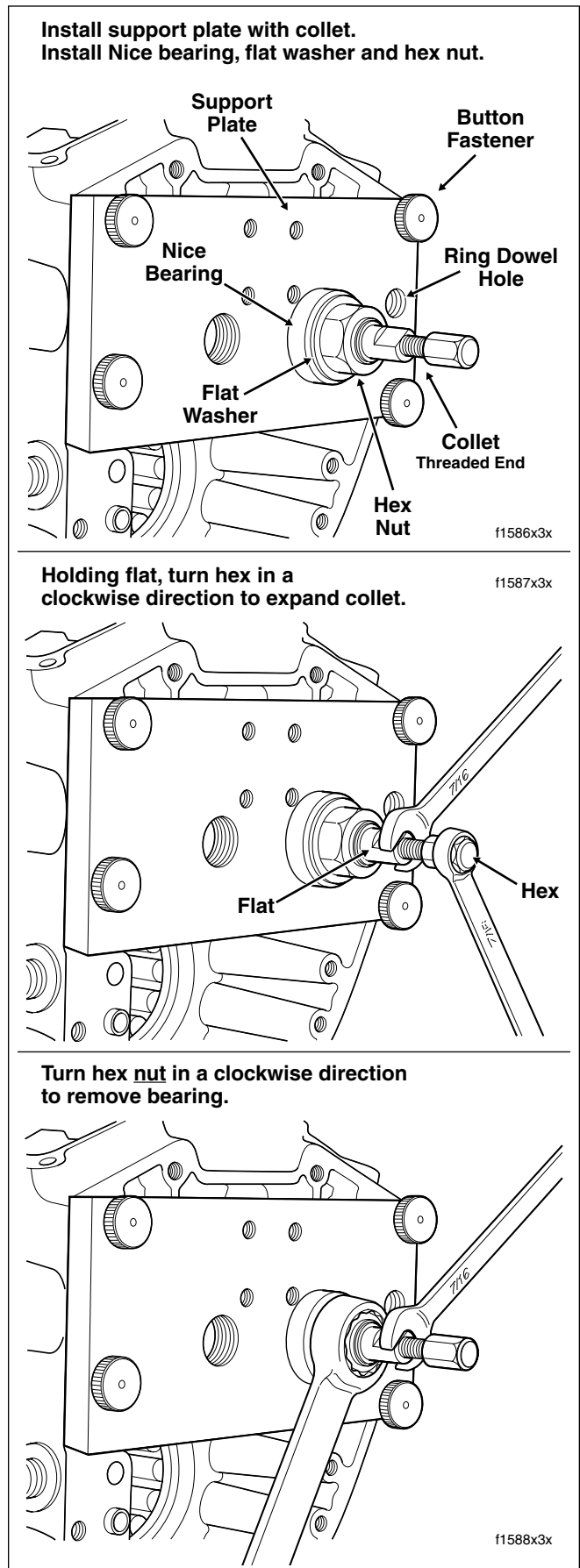
1. Obtain the CAMSHAFT NEEDLE BEARING REMOVER/INSTALLER (HD-42325A).
2. Remove four button fasteners from threaded holes in support plate, if installed. See [Figure 3-116](#).
3. Sparingly apply graphite lubricant to threads of collet to prolong service life and ensure smooth operation.
4. Slide collet through support plate so that threaded end exits stamped side of plate.





**Figure 3-116. Camshaft Needle Bearing Remover/Installer (HD-42325A)**

5. Aligning two large holes in support plate with needle bearing bores, hang right side of plate on ring dowel in crankcase flange.
6. Align four holes at corners of support plate with threaded holes in crankcase flange. Install button fasteners in these holes to secure support plate to crankcase. See upper frame of [Figure 3-117](#).
7. Center expandable end of collet in bearing bore and slide Nice bearing and flat washer on threaded end. Start hex nut on threaded end.
8. Push expandable end of collet through bearing bore into flywheel compartment. Feel for inside edge of needle bearing using end of collet and then back off slightly.
9. Holding collet to prevent lateral movement, finger tighten hex nut until Nice bearing contacts support plate.
10. Using a 7/16 inch open end wrench, hold flat on collet to prevent rotation. Using a second 7/16 inch open end wrench, expand collet by turning hex at end of shaft in a clockwise direction. See center frame of [Figure 3-117](#). Expandable end of collet makes contact with needle bearing ID.
11. Using a 15/16 inch open end wrench, turn hex nut in a clockwise direction until bearing is free. If necessary, hold flat on collet to prevent rotation. See lower frame of [Figure 3-117](#).
12. Remove four button fasteners and pull support plate from crankcase.
13. Holding flat on collet, turn hex at end of shaft in a counterclockwise direction to close collet. Remove and discard needle bearing.

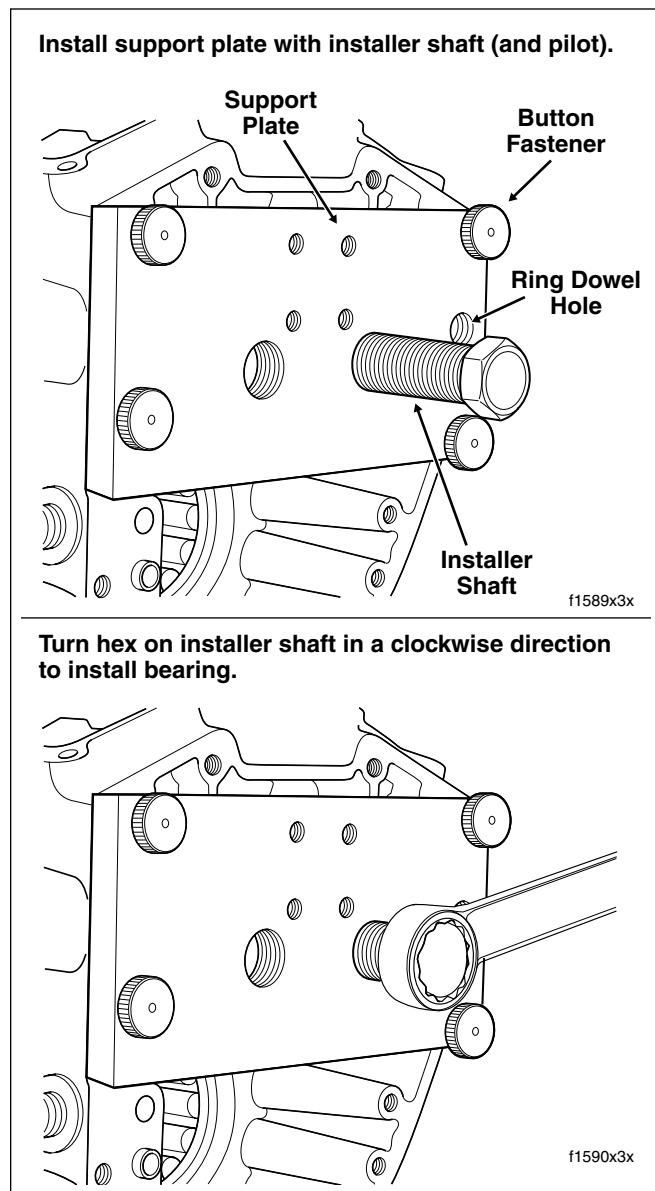


**Figure 3-117. Remove Cam Needle Bearing**

14. Remove hex nut, flat washer and Nice bearing from threaded end of collet. Pull collet from support plate.
15. Return to step 1 to remove second needle bearing.

### Installation

1. Obtain the CAMSHAFT NEEDLE BEARING REMOVER/INSTALLER (HD-42325A).
2. Sparingly apply graphite lubricant to threads of installer shaft to prolong service life and ensure smooth operation.
3. Thread installer shaft into stamped side of support plate until threads begin to emerge from opposite side.
4. Install pilot at end of installer shaft.
5. Place **new** needle bearing on pilot with lettered side facing shoulder.
6. Aligning two large holes in support plate with needle bearing bores, hang right side of plate on ring dowel in crankcase flange.
7. Align four holes at corners of support plate with threaded holes in crankcase flange. Install button fasteners in these holes to secure support plate to crankcase. See upper frame of [Figure 3-118](#).
8. Using 15/16 inch open end wrench, turn hex at end of installer shaft in a clockwise direction until resistance is felt. See lower frame of [Figure 3-118](#).
9. Turn end of installer shaft in a counterclockwise direction until pilot is free of needle bearing bore.
10. Remove four button fasteners and pull support plate and installer shaft from crankcase.
11. Remove pilot from installer shaft. Unthread installer shaft from support plate.
12. Return to step 1 to install second needle bearing.
13. Thread four button fasteners into threaded holes in support plate to prevent loss.



**Figure 3-118. Install Cam Needle Bearing**

### Installation

1. See Section [3.10 BOTTOM END OVERHAUL, ASSEMBLY](#), steps 12-29.
2. Remove wireforms to release hydraulic lifters.
3. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 29-39.

## OIL PUMP

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-11.

#### NOTE

When removing the cam support plate, it is not necessary to disturb the lifter assemblies if a method is devised to prevent the hydraulic lifters from dropping into the cam compartment. One such method is provided in the following step. Leaving the lifter assemblies intact simplifies the procedure, since the lifter cover, gasket, anti-rotation pin and hydraulic lifters can be left in place.

2. Fashion lifter holding tool as follows:
  - a. Obtain a large binder clip (available at any office supply store). Squeeze wireforms to remove from binder clip. See upper frame of Figure 3-100.
  - b. Compress wireform slightly and insert free ends into outer and inner lifter cover bores so that legs engage walls of both hydraulic lifter sockets. See lower frame of Figure 3-100.
3. See Section 3.10 BOTTOM END OVERHAUL, DISASSEMBLY, steps 1-15.

### Cleaning and Inspection

1. Clean all parts in a non-volatile cleaning solution or solvent.

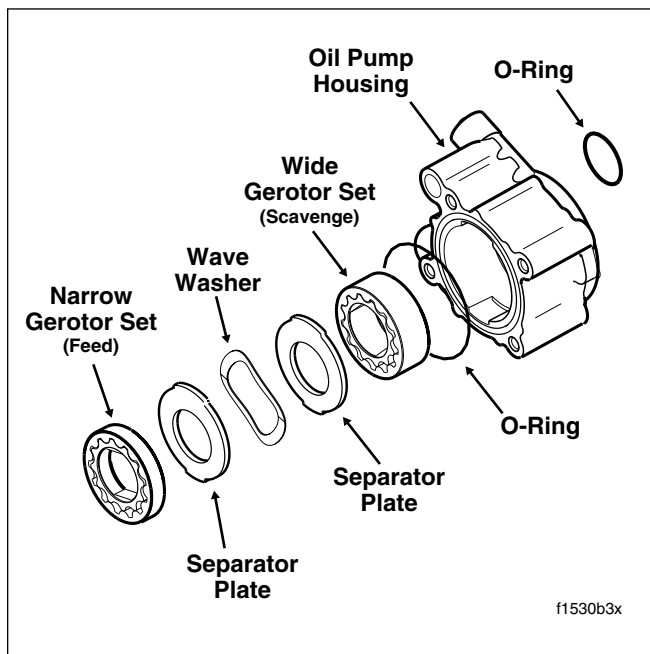


Figure 3-119. Oil Pump Assembly

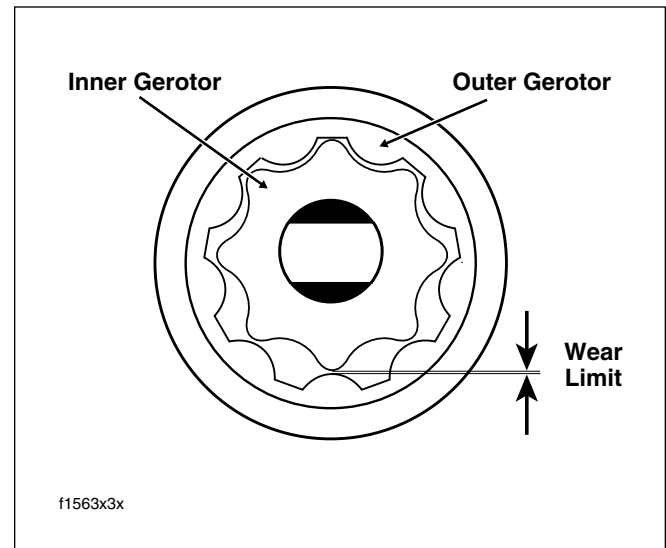


Figure 3-120. Measure Gerotor Sets for Wear

2. Thoroughly dry all parts with low pressure compressed air. Verify that all oil passages are clean and open.
3. Look for scoring, gouging or cracking caused by foreign material that may have passed through the oil pump.
4. Look for grooves or scratches on the cam support plate, which serves as the outboard side of the oil pump.
5. Check for excessive wear or damage on lobes of outer gerotors and between lobes on inner gerotor.
6. Mesh pieces of one gerotor set together as shown in Figure 3-120. Use a feeler gauge to determine clearance between tips of lobes on inner and outer gerotors. The maximum allowable clearance is 0.004 inch (0.10 mm). Replace gerotor set if clearance exceeds specification. Inspect second gerotor set in the same manner.
7. Measure thickness of inner gerotor of one set with a micrometer. Measure the outer gerotor of the same set. Replace the gerotor set if the difference exceeds 0.001 inch (0.025 mm). Inspect second gerotor set in the same manner.
8. Assemble the oil pump. Verify that feed gerotors stand proud of the oil pump surface 0.0215-0.0305 inch (0.546-0.775 mm). If measurement is less than 0.0215 inch (0.546 mm), remove feed gerotor set and reassemble using **new** wave washer. Repeat measurement and replace oil pump body if still not within specification.

### Installation

1. See Section 3.10 BOTTOM END OVERHAUL, ASSEMBLY, steps 11-29.
2. Remove wireforms to release hydraulic lifters.
3. See Section 3.9 TOP END OVERHAUL, ASSEMBLY, steps 29-39.

## Legend:

f2070x3x

1. Crankshaft Bearing
2. Ring Dowel
3. Cam Needle Bearing
4. Oil Inlet Fitting
5. Oil Outlet Fitting
6. Crankcase Breather Fitting
7. Right Crankcase Half
8. O-Ring
9. Piston Jet
10. T20 TORX Screw
11. Lock Ring
12. Sprocket Shaft Bearing
13. O-Ring
14. Ring Dowel
15. Plug
16. O-Ring
17. Oil Filter Mount
18. Oil Filter Adapter
19. Flat Washer
20. Bolt
21. Lockplate
22. Oil Filter
23. Crankcase Bolt
24. Ring Dowel
25. O-Ring
26. Left Crankcase Half
27. Thrust Washer
28. Oil Seal
29. Sprocket Shaft Spacer

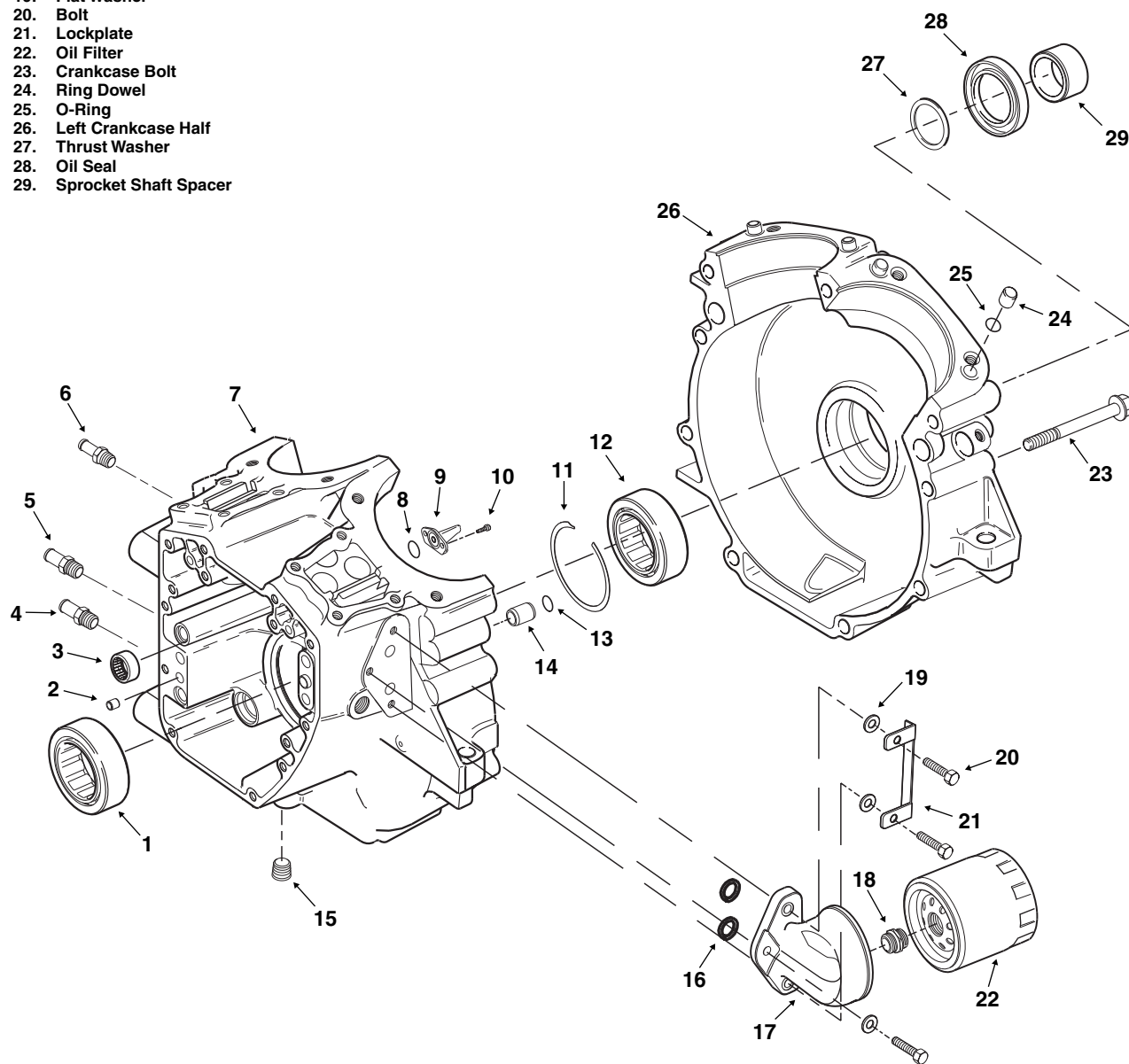


Figure 3-121. Crankcase Assembly (Exploded View)

## CRANKCASE

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-29.
2. See Section 3.10 BOTTOM END OVERHAUL, DISASSEMBLY, steps 1-18.

### Disassembly/Assembly

#### RIGHT CRANKCASE HALF

#### Crankshaft Bearing

##### Removal



Never move or lift the crankcase by grasping the cylinder studs. The crankcase is too heavy to be carried in this manner and may be dropped. Dropping the crankcase may result in parts damage and minor or moderate injury.

1. See Figure 3-122. Obtain CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER PILOT/DRIVER (B-45655) and CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER SUPPORT TUBE (HD-42720-5).
2. Place support tube on hydraulic press table with the "A" end up. The ends of the support tube are stamped "A" and "B" to ensure proper orientation.
3. With the outboard side of the right crankcase half facing upward, position crankshaft bearing bore over support tube.

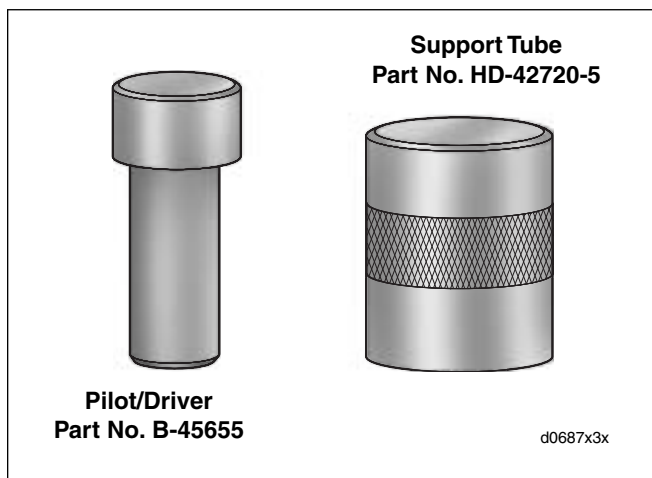


Figure 3-122. Crankshaft/Sprocket Shaft Bearing Pilot/Driver and Support Tube

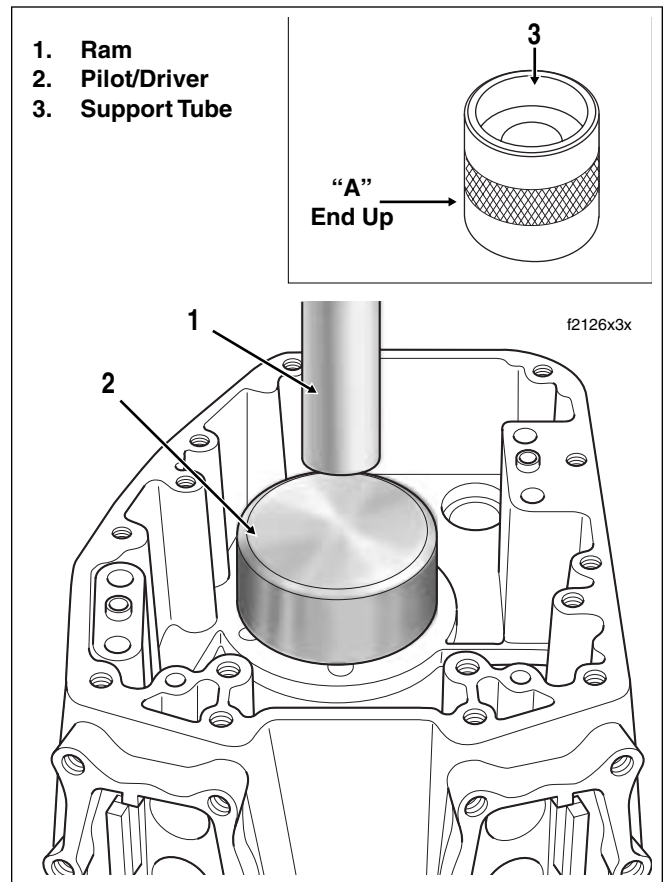


Figure 3-123. Remove Crankshaft Bearing

4. Slide pilot/driver through bearing into support tube.
5. Center pilot/driver under ram of press. Apply pressure to pilot/driver until bearing is free. See Figure 3-123.
6. Remove right crankcase half, pilot/driver and bearing from support tube. Discard bearing.

##### Installation

1. See Figure 3-122. Obtain CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER PILOT/DRIVER (B-45655) and CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER SUPPORT TUBE (HD-42720-5).
2. Turn support tube over so that the "B" end is up. The ends of the support tube are stamped "A" and "B" to ensure proper orientation.
3. With the outboard side of the right crankcase half facing upward, position crankshaft bearing bore over support tube.
4. Obtain **new** crankshaft bearing and apply a thin film of clean engine oil to O.D.

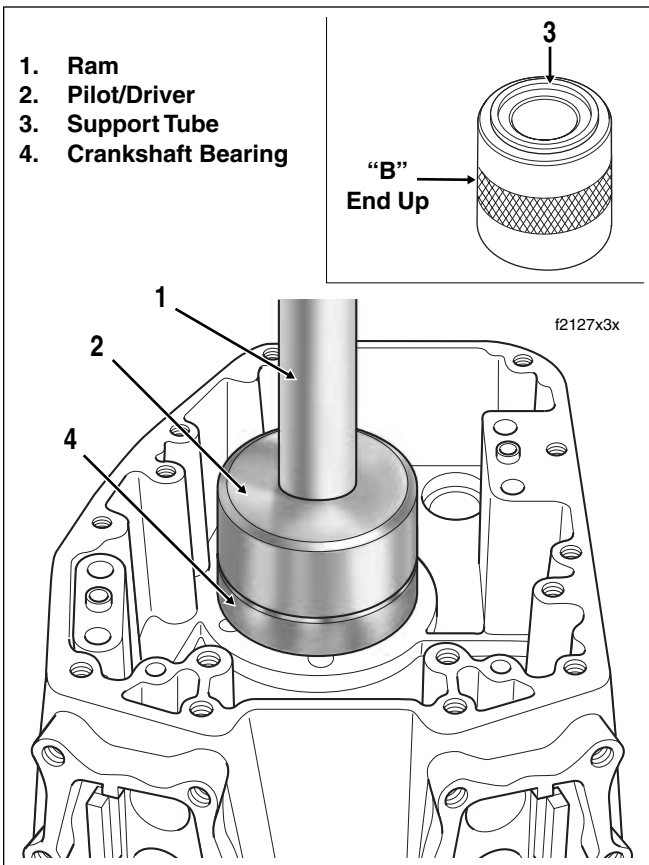


Figure 3-124. Install Crankshaft Bearing

5. Start crankshaft bearing into bore with the lettered side up. Lubricate leading edge of bearing before placement.
6. Slide pilot/driver through bearing into support tube.
7. Center pilot/driver under ram of press. Apply pressure to pilot/driver until resistance is felt and bearing bottoms in support tube. See [Figure 3-124](#).
8. Remove pilot/driver and right crankcase half from support tube.

## Piston Jets

### Removal

1. Remove two T20 TORX screws to free piston jet from crankcase.
2. Remove O-ring from groove in mounting flange of jet. Discard O-ring.

## Installation

### CAUTION

O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.

1. Install **new** O-ring in groove of jet mounting flange. Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation.
2. Apply Loctite Low Strength Threadlocker 222 (purple) to threads of two T20 TORX screws.
3. With the jet pointed upward, install TORX screws to secure piston jet to crankcase. Tighten screws to 25-35 **in-lbs** (2.8-4.0 Nm).

## LEFT CRANKCASE HALF

### Sprocket Shaft Bearing

#### Removal

### CAUTION

Never move or lift the crankcase by grasping the cylinder studs. The crankcase is too heavy to be carried in this manner and may be dropped. Dropping the crankcase may result in parts damage and minor or moderate injury.

### WARNING

Do NOT rotate left crankcase half in the engine stand so the stator mount flange (sprocket shaft side) is facing up or the flywheel assembly will drop to the floor. Dropping the flywheel assembly may result in parts damage and minor or moderate injury.

1. Holding flywheel assembly so that it does not drop out of left crankcase half, rotate cradle so that engine is upright and crankshaft and sprocket shaft are horizontal.
2. Carefully slide flywheel assembly out of left crankcase half.
3. Remove left crankcase half from engine stand and move to bench area. Remove thrust washer from outboard side of crankcase by pulling it past the oil seal. Set thrust washer aside for inspection or reuse.
4. Using a suitable drift, tap oil seal from bearing bore. Discard oil seal.



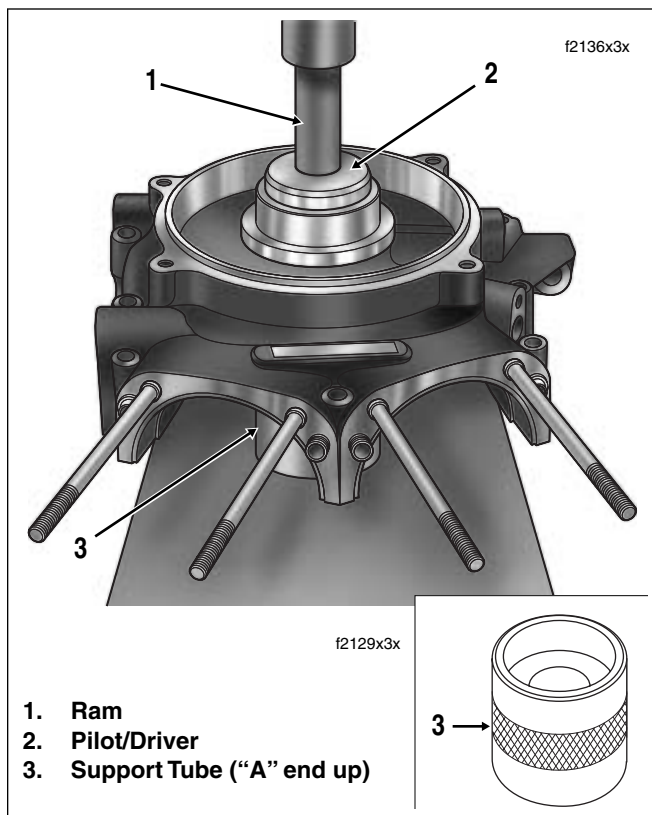


Figure 3-125. Remove Sprocket Shaft Bearing

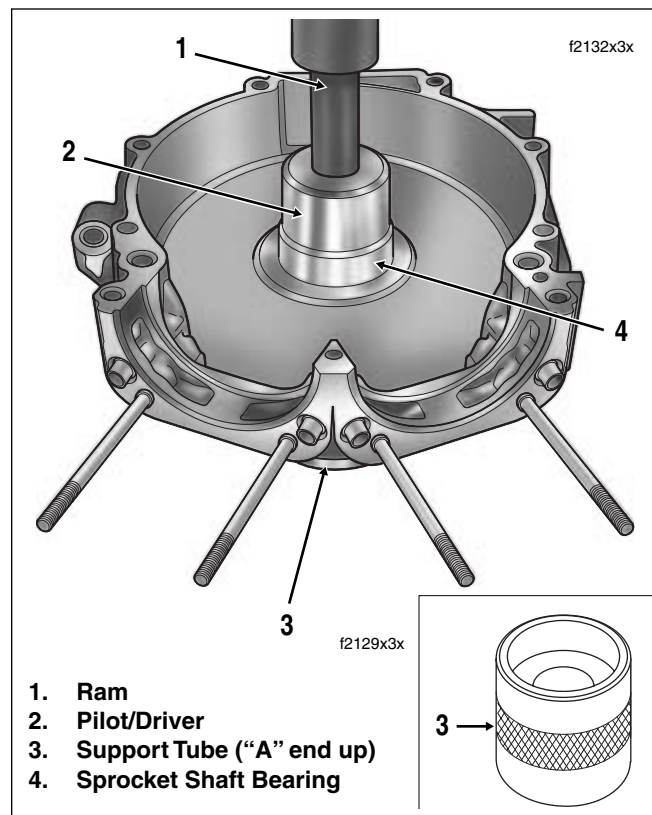


Figure 3-126. Install Sprocket Shaft Bearing

5. See [Figure 3-122](#). Obtain CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER SUPPORT TUBE (HD-42720-5) and CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER PILOT/DRIVER (B-45655).
6. Place left crankcase half on work bench with inboard side of facing upward.
7. Using the tip of a flat blade screwdriver, carefully lift end of lock ring out of groove in bearing bore. Working the screwdriver around the edge, lift the lock ring up and out of the groove. Be careful not to damage the lip of the groove during removal.
8. Place support tube on hydraulic press table with the "A" end up. The ends of the support tube are stamped "A" and "B" to ensure proper orientation.
9. With the outboard side of the left crankcase half facing upward, position sprocket shaft bearing bore over support tube. See [Figure 3-125](#).
10. Slide pilot/driver through bearing into support tube.
11. Center pilot/driver under ram of press. Apply pressure to pilot/driver until bearing is free.
12. Remove left crankcase half, pilot/driver and bearing from support tube. Discard bearing.

## Installation

### CAUTION

Never move or lift the crankcase by grasping the cylinder studs. The crankcase is too heavy to be carried in this manner and may be dropped. Dropping the crankcase may result in parts damage and minor or moderate injury.

1. See [Figure 3-122](#). Obtain CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER SUPPORT TUBE (HD-42720-5) and CRANKSHAFT/SPROCKET SHAFT BEARING REMOVER/INSTALLER PILOT/DRIVER (B-45655).
2. Place support tube on hydraulic press table with the "A" end up. The ends of the support tube are stamped "A" and "B" to ensure proper orientation.
3. With inboard side of the left crankcase half facing upward, position sprocket shaft bearing bore over support tube.
4. See [Figure 3-126](#). Obtain **new** sprocket shaft bearing and apply a thin film of clean engine oil to O.D.
5. Start sprocket shaft bearing into bearing bore with the lettered side down. Lubricate leading edge of bearing before placement.

6. Slide pilot/driver through bearing into support tube.
7. Center pilot/driver under ram of press. Apply pressure to pilot/driver until bearing lightly bottoms in the bore.
8. Remove left crankcase half and pilot/driver from support tube.
9. Place left crankcase half on work bench with inboard side of facing upward.
10. Obtain **new** lock ring and work into groove in bearing bore. Be careful not to damage the lip of the groove during installation. Verify that lock ring is fully seated in the groove.

**NOTE**

*If lock ring will not fit into groove, bearing bore may not have been properly cleaned and/or bearing may not be fully seated in the bore.*

## Sprocket Shaft Bearing Inner Race

### Removal

1. If reusing flywheel, remove bearing inner race and thrust washer as follows:
  - a. Obtain FLYWHEEL SUPPORT FIXTURE (HD-44358). See Figure 3-127. Install brass jaws or shop towels around teeth of vise to prevent damage to tool. Clamp tool in vise with the round hole top-side.
  - b. Insert crankshaft end through hole resting flywheel assembly on fixture. Slide knurled locating pin down slot in tool to engage crank pin hole. Hand tighten locating pin.
  - c. Slide hold-down clamp down slot to engage inboard side of right flywheel half, and then hand tighten knurled nut at bottom to secure. Repeat step to secure hold-down clamp on opposite side of flywheel.

**NOTE**

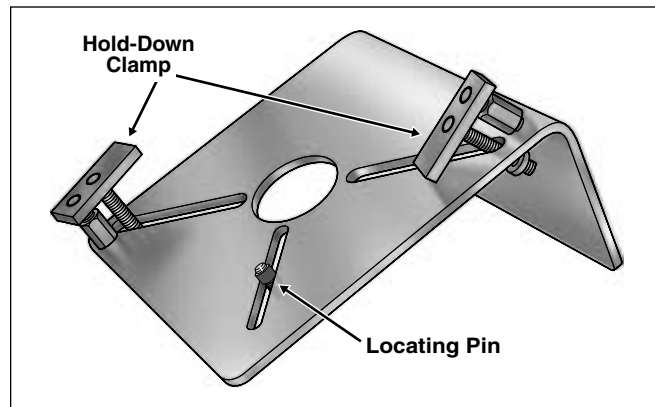
*For proper clamping force, hold-down clamp must not be tilted. Rotate hex on outboard stud until clamp is level.*

- d. Position WEDGE ATTACHMENT (HD-95637-46B) on inboard side of thrust washer and turn hex nuts an equal number of turns to draw halves of wedge together.

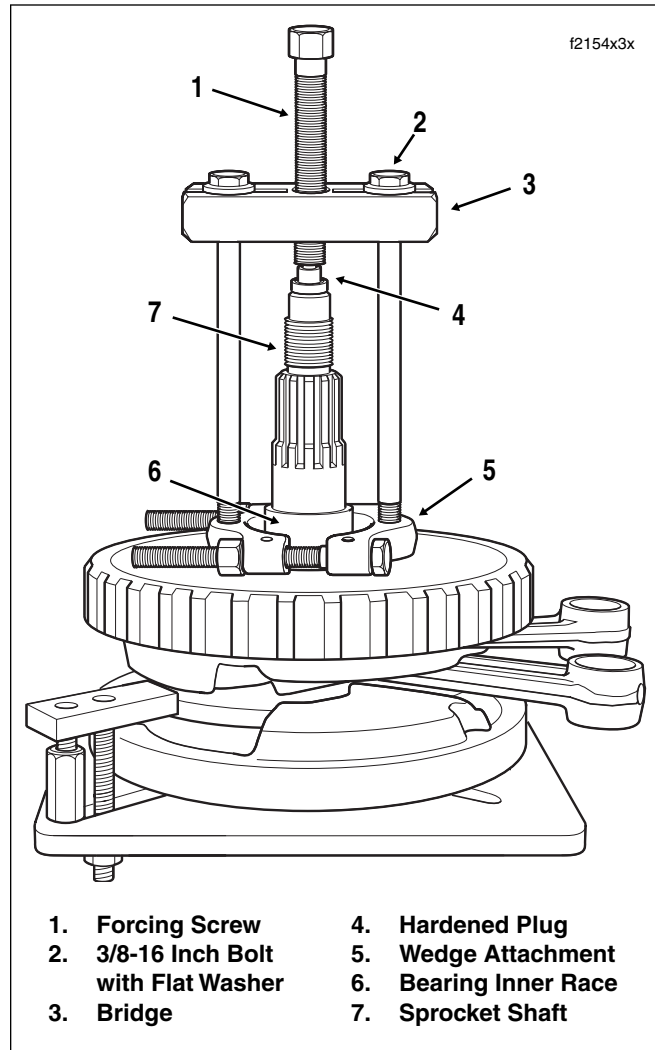
**CAUTION**

**Install wedge attachment only so far as necessary to ensure positive contact with thrust washer. Installing tool with more contact than absolutely necessary will result in damage to flywheel.**

- e. Obtain two 3/8-16 inch bolts 6-1/2 inches long (with flat washers). Install flat washers on bolts. Obtain bridge, forcing screw and hardened plug from MAINSHAFT BEARING INNER RACE PULLER/INSTALLER (HD-34902B).

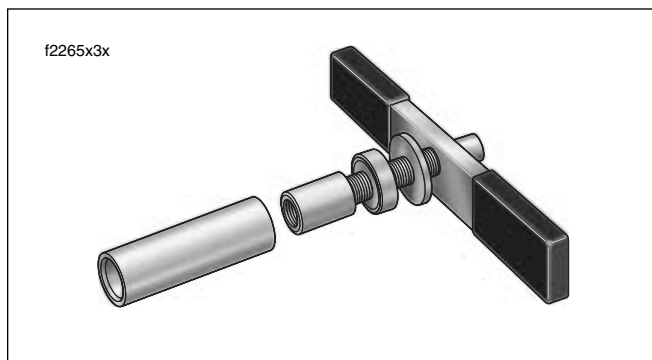


**Figure 3-127. Flywheel Fixture (Part No. HD-44358)**



**Figure 3-128. Remove Inner Race From Sprocket Shaft**

- f. Slide one bolt into channel on each side of bridge so that flat washer is between bridge and bolt head. Thread bolts into wedge attachment an equal number of turns.



**Figure 3-129. Sprocket Shaft Timken Bearing Cone Installer (Part No. HD-97225-55B)**

- g. Sparingly apply graphite lubricant to threads of forcing screw to prolong service life and ensure smooth operation. Start forcing screw into center hole of bridge.

#### CAUTION

**Failure to use hardened plug may result in damage to forcing screw and/or sprocket shaft.**

- h. Place cupped side of hardened plug against end of sprocket shaft. Thread forcing screw into bridge until the steel ball at the end of the screw makes firm contact with hardened plug.
- i. Using the Robinair Heat Gun (HD-25070), uniformly heat the bearing inner race for about 30 seconds using a circular motion.

#### NOTE

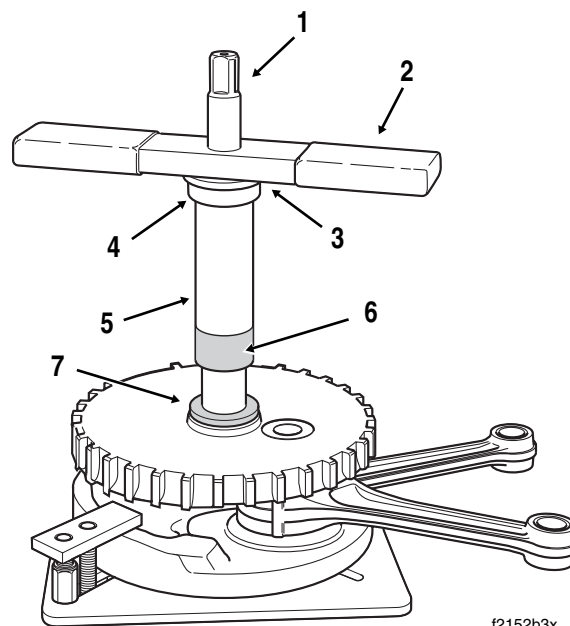
*To facilitate removal without heat, apply a light penetrating oil to shaft and leading edge of bearing inner race.*

#### WARNING

**Never use both heat and penetrating oil. Use only one or the other. Excessive heat can cause the penetrating oil to ignite resulting in flames or fire. Inadequate safety precautions can result in death or serious injury.**

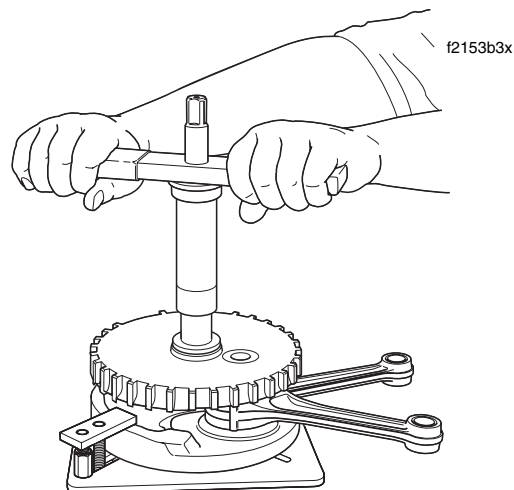
- j. Turn forcing screw until thrust washer and bearing inner race move approximately 1/8 inch (3.2 mm).
- k. Turn hex nuts an equal number of turns to separate halves of WEDGE ATTACHMENT.
- l. After bottoming thrust washer on shaft, reposition WEDGE ATTACHMENT (HD-95637-46B) on inboard side of bearing inner race. Turn hex nuts an equal number of turns to draw halves of wedge together.

#### 1. Install Thrust Washer and Bearing Inner Race On Sprocket Shaft. Assemble Tool.



f2152b3x

#### 2. Press Bearing Inner Race Onto Sprocket Shaft.



f2153b3x

- |                 |                  |
|-----------------|------------------|
| 1. Pilot Shaft  | 5. Sleeve        |
| 2. Handle       | 6. Inner Race    |
| 3. Flat Washer  | 7. Thrust Washer |
| 4. Nice Bearing |                  |

**Figure 3-130. Press Inner Race Onto Sprocket Shaft**

#### CAUTION

**Install wedge attachment only so far as necessary to ensure positive contact with bearing inner race. Installing tool with more contact than absolutely necessary will result in damage to flywheel.**

f2266x3x

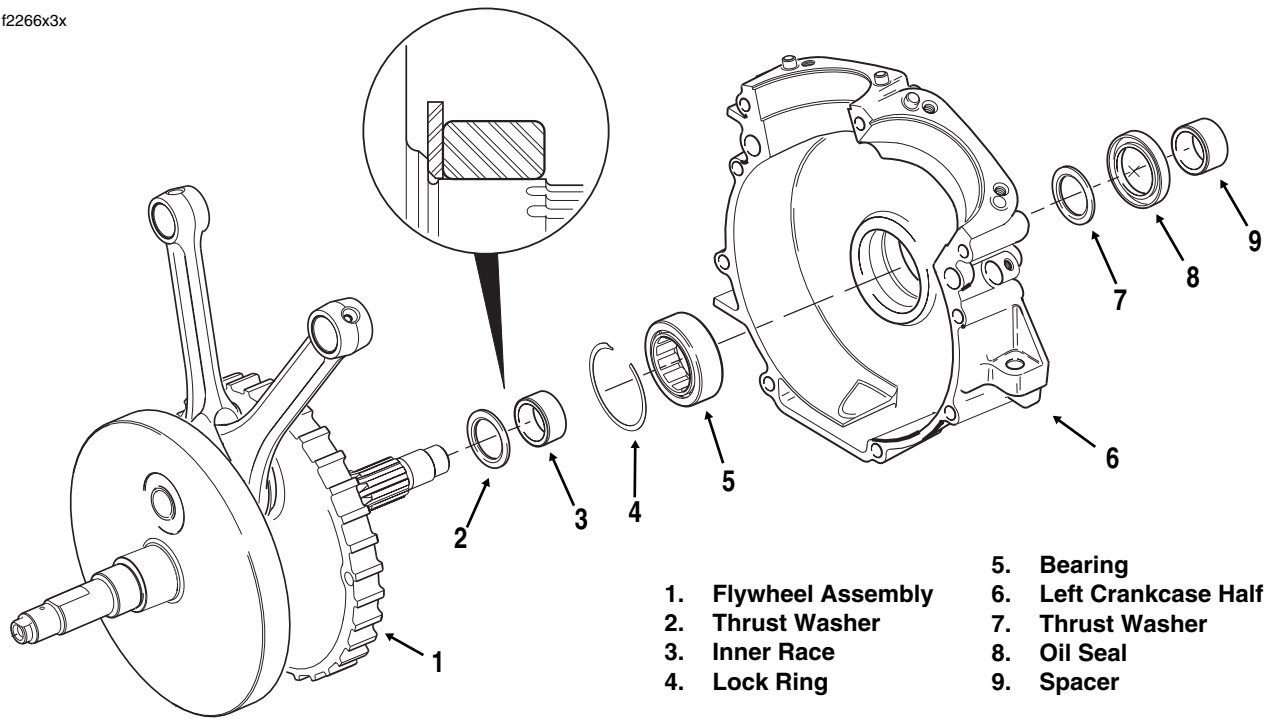


Figure 3-131. Sprocket Shaft Bearing Assembly

- m. Verify that the tool assembly is square, so that the bearing inner race is not cocked during removal. See [Figure 3-128](#).
- n. Using the Robinair Heat Gun (HD-25070), uniformly heat the bearing inner race for about 30 seconds using a circular motion.

**NOTE**

*To facilitate removal without heat, apply a light penetrating oil to shaft and leading edge of bearing inner race.*

- o. Turn forcing screw until bearing inner race is pulled free of sprocket shaft.
- p. Remove thrust washer from sprocket shaft.

- 2. Discard thrust washer and bearing inner race.

**Installation**

- 1. Place **new** thrust washer over sprocket shaft with the ink stamp facing outside (and the chamfer on the ID inboard).
- 2. Place **new** bearing inner race on bench top. Using the Robinair Heat Gun (HD-25070), uniformly heat bearing inner race for about 60 seconds using a circular motion.
- 3. Wearing suitable gloves to protect hands from burns, place heated bearing inner race over sprocket shaft.

**NOTE**

*To facilitate installation without heat, apply a light penetrating oil to shaft and leading edge of bearing inner race.*

**WARNING**

**Never use both heat and penetrating oil. Use only one or the other. Excessive heat can cause the penetrating oil to ignite resulting in flames or fire. Inadequate safety precautions can result in death or serious injury.**

- 4. Obtain the SPROCKET SHAFT TIMKEN BEARING CONE INSTALLER (HD-97225-55B). See [Figure 3-129](#). Assemble tool as described below.
  - a. Thread pilot onto sprocket shaft until contact is made with shoulder.
  - b. Sparingly apply graphite lubricant to threads of pilot shaft to prolong service life and ensure smooth operation.
  - c. Slide sleeve over pilot until it contacts bearing inner race.
  - d. Slide Nice bearing and large flat washer over pilot until contact is made with sleeve.
  - e. Thread handle onto pilot shaft. See upper frame of [Figure 3-130](#).

5. Rotate handle of tool in a clockwise direction until bearing inner race bottoms against thrust washer. See lower frame of [Figure 3-130](#).
6. Remove handle, flat washer, Nice bearing, sleeve and pilot from sprocket shaft.

## Cylinder Studs

### Removal

1. Thread a 3/8"-16 nut onto cylinder stud.
2. Thread a second nut onto stud until it contacts the first.
3. Placing wrench on first nut installed, remove stud from cylinder deck.

### Installation

1. Hand start stud in cylinder deck with the collar side down.
2. Install steel ball bearing into unused cylinder head bolt. Position head bolt on end of stud.
3. Using an air gun, tighten stud until collar almost contacts cylinder deck.
4. Leaving cylinder head bolt installed, hand tighten stud to 10-20 ft-lbs (14-27 Nm).

## Pipe Plug and Oil Fittings

### Removal

1. Turn hex on oil fittings in a counterclockwise direction until free.
2. Turn pipe plug in a counterclockwise direction until free.

### Installation

1. Apply Loctite Pipe Sealant with Teflon 565 to threads.
2. Turn hex on oil fittings in a clockwise direction until snug. Tighten fittings to 120-168 **in-lbs** (13.6-18.9 Nm).
3. Install pipe plug. Tighten pipe plug to 120-168 **in-lbs** (13.6-18.9 Nm).

## Cleaning and Inspection

1. Scrape old gasket material from the crankcase flanges. Old gasket material left on mating surfaces will cause leaks.
2. Clean all parts in a non-volatile cleaning solution or solvent.
3. Thoroughly dry all parts with low pressure compressed air.
4. Verify that all oil holes and passageways are clean and open.

5. Check ring dowels for looseness, wear or damage. Replace as necessary.
6. Use a file to carefully remove any nicks or burrs from machined surfaces.
7. Clean out tapped holes and clean up damaged threads.
8. Check the top of the crankcase for flatness with a straightedge and feeler gauge. Replace if warped.

### Installation

1. See Section [3.10 BOTTOM END OVERHAUL, ASSEMBLY](#), steps 1-29.
2. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 1-39.



## FLYWHEEL/CONNECTING ROD ASSEMBLY

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-29.
2. See Section 3.10 BOTTOM END OVERHAUL, DISASSEMBLY, steps 1-18.
3. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, CRANKCASE, LEFT CRANKCASE HALF, SPROCKET SHAFT BEARING, REMOVAL.

### Inspection

1. Replace the flywheel/connecting rod assembly if any of the following conditions are noted:

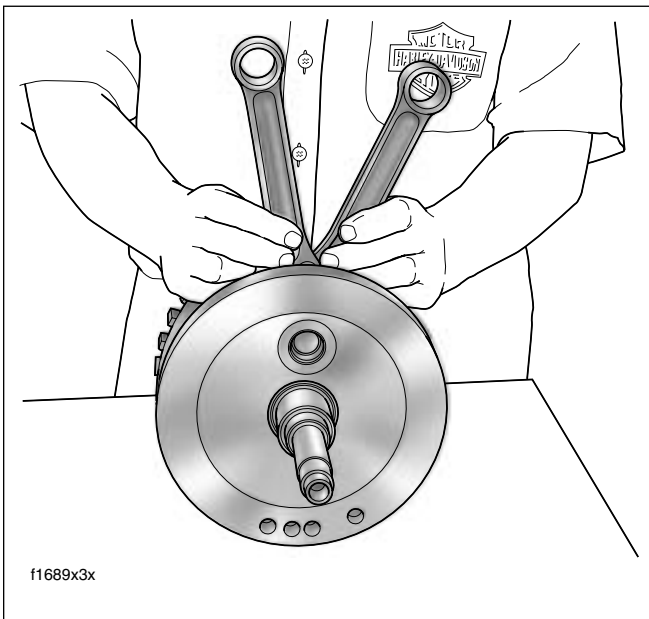
#### CAUTION

**Do not attempt to straighten connecting rods. Straightening rods will damage both the upper bushing and lower bearing.**

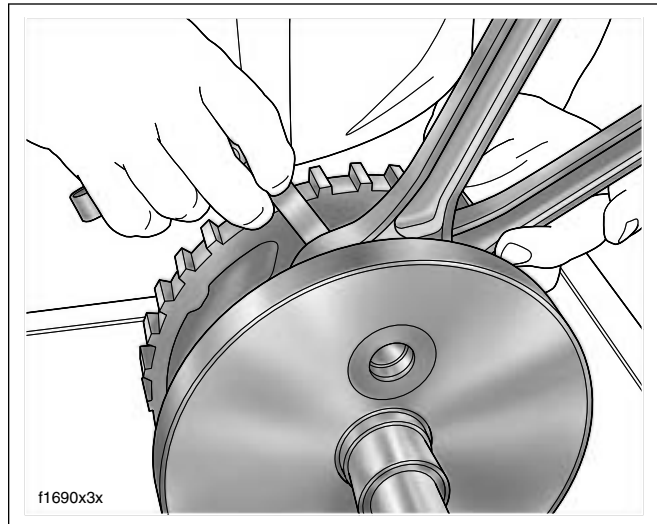
- Connecting rods are bent or twisted.
- Connecting rods do not fall under their own weight or are in a bind.

#### NOTE

*Bluing on connecting rods is from induction hardening and is considered a normal condition.*



**Figure 3-132. Check Connecting Rod Bearing Clearance**



**Figure 3-133. Check Connecting Rod Side Play**

- The crankshaft/sprocket shaft bearing inner races are brinelled, burnt, scored, blued or damaged.
2. Orient the assembly as shown in Figure 3-132. Holding the shank of each rod just above the bearing bore, pull up and down on the connecting rods. Any discernable up and down movement indicates excessive lower bearing clearance. Replace the flywheel/connecting rod assembly.
  3. Insert a feeler gauge between the thrust washer and the outboard side of the connecting rod. See Figure 3-133. Replace the assembly if rod side play exceeds 0.020 inch (0.51 mm).

#### NOTE

*If the flywheel, connecting rods or right side bearing inner race need to be replaced, then replace the entire flywheel assembly.*

### Installation

1. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, CRANKCASE, LEFT CRANKCASE HALF, SPROCKET SHAFT BEARING, INSTALLATION.
2. See Section 3.10 BOTTOM END OVERHAUL, ASSEMBLY, steps 1-29.
3. See Section 3.9 TOP END OVERHAUL, ASSEMBLY, steps 1-39.