

## CHECKING AND ADDING OIL

Check engine oil level in oil tank at least once every 500 miles (800 km). Check level more frequently if engine uses more oil than normal or if vehicle is operated under harsh conditions.

## CHANGING OIL AND FILTER

After a new engine has run its first 500 miles (800 km) and at 5000 mile (8000 km) intervals or annually thereafter, completely drain oil tank of used oil. Refill with fresh oil. If vehicle is driven extremely hard, used in competition or driven on dusty roads, change engine oil at shorter intervals. Always change oil filter when changing engine oil.

### NOTE

See [1.6 ENGINE LUBRICATION SYSTEM](#) for more information on checking oil level and changing oil and filter.

## WINTER LUBRICATION

Normal fuel combustion in a gasoline engine produces water vapor and carbon dioxide along with other gases and particulates. When first starting and warming an engine, some of the water vapor that gets into the engine crankcase condenses to form liquid water. If the engine is driven long enough to thoroughly warm the crankcase, most of this liquid water is again vaporized and exhausted through the crankcase breather system.

A moderately driven vehicle making short runs may not be able to vacate water vapors allowing liquid water to accumulate in the oil tank. This is especially true if the vehicle is operated in cold weather. In freezing weather, an accumulation of water in the engine oil may become slush or ice, which can block oil lines and lead to severe engine damage. Water remaining in the engine oil for long periods of time can form an acidic sludge that is corrosive to metal engine parts and causes accelerated wear of moving components.

In winter the oil change interval should be shorter than normal. The colder the weather, the shorter the recommended oil change interval. A vehicle used only for short runs in cold weather must have the engine oil drained frequently.

## GENERAL

See [Figure 3-45](#). The oil tank has four hoses. The drain hose (2) attaches to a fitting on the left side. From the top of the tank, the vent hose (3) runs along the right side to below the battery tray. The return hose (4) runs along the left side and joins the bottom feed hose (1) under the battery tray.

See [Figure 3-46](#). The feed (1) and return hoses (3) run together between the swingarm mount block and crankcase, beneath the engine and forward to the oil pump. The feed hose attaches to the rear most oil pump fitting; the return hose connects forward and above. To prevent unnecessary wear, the hoses have a fitted cover.

After diverging from the feed and return hoses, the vent hose is routed beneath the starter. It continues on to the right side of the motorcycle. See [Figure 3-47](#). Here the vent hose (1) connects to an elbow fitting (3) on the gearcase cover (4).

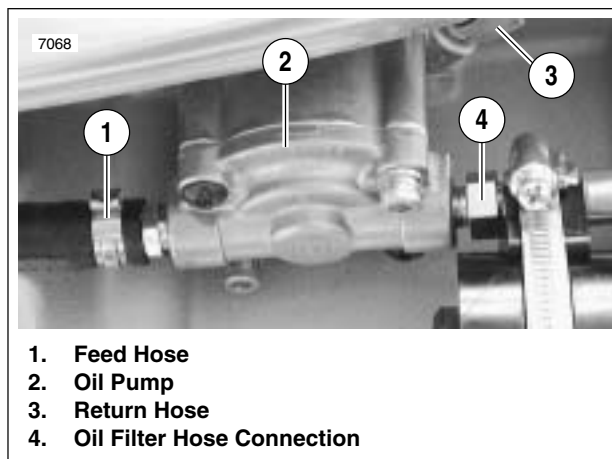


Figure 3-46. Oil Pump Connections

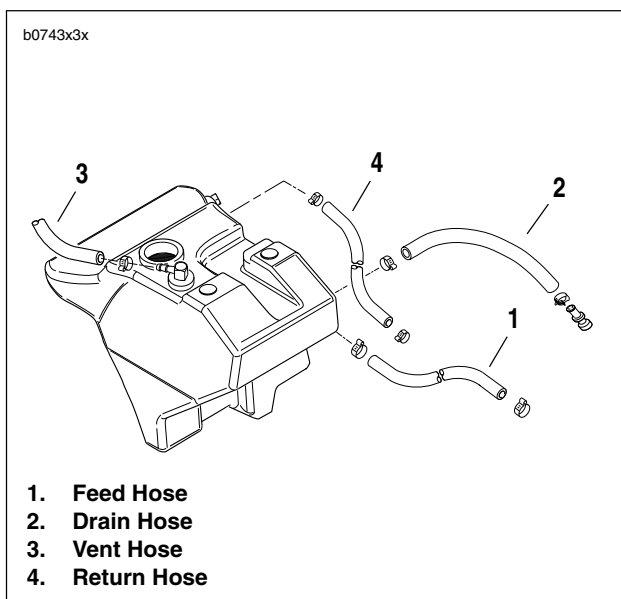


Figure 3-45. Oil Tank Hoses

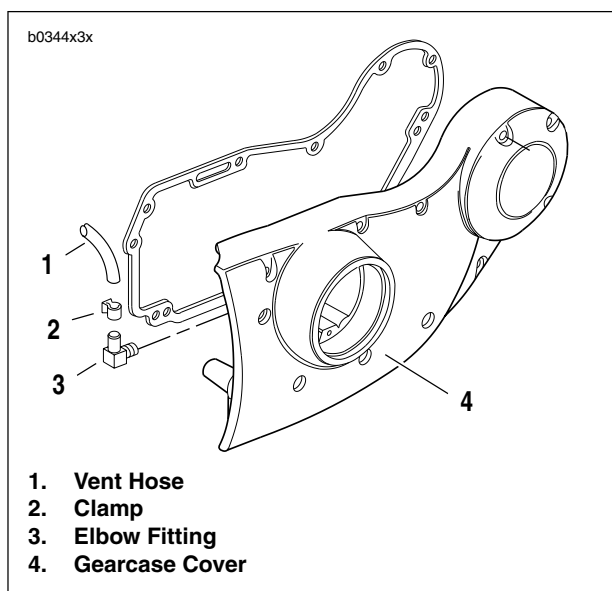
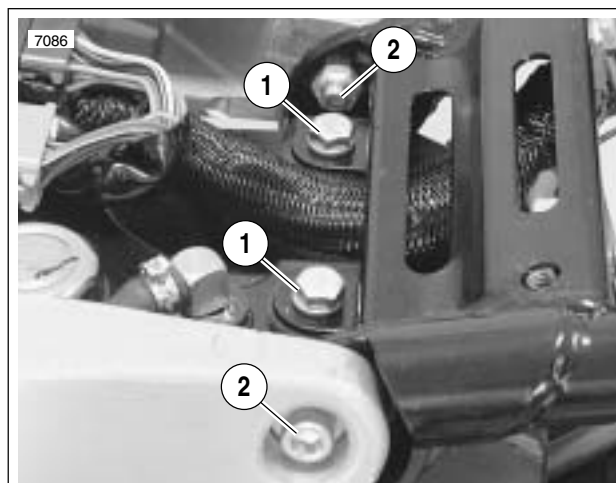


Figure 3-47. Vent Hose Connection (Typical)

## REMOVAL/DISASSEMBLY

1. Remove seat. See [2.40 SEAT](#).
2. Remove lower bolts on tail section and disconnect tail section wiring. See [2.38 TAIL SECTION](#).
3. Drain oil tank. See [1.6 ENGINE LUBRICATION SYSTEM](#). The oil filter need not be removed unless it is due to be replaced.
4. See [Figure 3-48](#). Remove bolts and lockwashers (1) from wellnuts.
5. Loosen top bolts (2) on tail section. Rotate tail section upward. Secure with straps.
6. See [Figure 3-49](#). Remove clamps to detach hoses from oil tank. Label each hose upon removal.
  - a. Remove clamp from feed hose (3).
  - b. Remove clamp from drain hose (4).
  - c. Remove clamp from vent hose (6).
  - d. Remove clamp from return hose (5).
7. Lift tank upward to remove. Both tabs on bottom of tank must clear frame before detaching oil tank.



1. Bolt and Lockwasher (2)
2. Top Bolts on Tail Section (2)

Figure 3-48. Oil Tank Mounts

## ASSEMBLY/INSTALLATION

1. See [Figure 3-49](#). Place oil tank on frame and align mounts. Loosely install bolts and lockwashers (1).
2. Connect the four oil tank hoses. Tighten **new** clamps using HOSE CLAMP PLIERS (Part No. HD-41137).

### NOTE

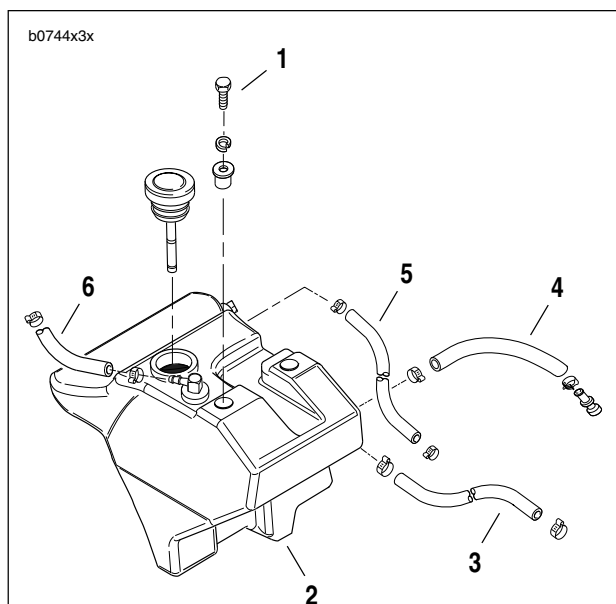
*Clamp may be reused on feed hose (3) at oil tank connection.*

3. Fill oil tank. See [1.6 ENGINE LUBRICATION SYSTEM](#).
4. Attach tail section. See [2.38 TAIL SECTION](#).

### WARNING

After installing seat, pull upward on front of seat to be sure it is locked in position. If seat is loose, it could shift during vehicle operation and startle the rider, causing loss of control. These events could result in death or serious injury.

5. Install seat. See [2.40 SEAT](#).



1. Bolt, Lockwasher and Wellnut (4)
2. Oil Tank
3. Feed Hose with 3/8 in. Clamps
4. Drain Hose with Plug Assembly and 3/8 in. Clamp
5. Return Hose with 3/8 in. Clamps
6. Vent Hose with 1/4 in. Clamps

Figure 3-49. Oil Tank

## GENERAL

The oil pressure indicator switch is a pressure-actuated diaphragm-type switch. When oil is not circulating through the system or when oil pressure is abnormally low, spring tension holds the switch contacts closed, thereby completing the signal light circuit and causing the indicator lamp to illuminate.

## OIL PRESSURE SIGNAL LIGHT

The oil pressure signal light turns ON when:

- Ignition switch is turned on prior to starting engine.
- Oil is not circulating through the running engine.
- Oil pressure is abnormally low on the running engine.
- Engine is idling far below 1000 RPM.

The oil pressure signal light turns OFF when:

- Oil is circulating with adequate pressure through the engine running at 1000 RPM or greater.

Troubleshooting information is listed in [Table 3-9](#).

### NOTE

*If the ignition is turned back on immediately after the engine is stopped, the oil light may not turn on right away because of oil pressure retained in the filter housing.*

## OIL PRESSURE

See [Figure 3-50](#). The oil pump is nonregulatory and delivers its entire volume of oil under pressure to the oil filter mount. When an engine is cold, the engine oil will be more viscous (i.e., thicker). During start-up of a cold engine, oil pressure will be higher than normal and oil circulation will be somewhat restricted within the oiling system. As the engine warms to normal operating temperature, the engine oil will warm up and become less viscous — oil pressure decreases.

When an engine is operated at high speeds, the volume of oil circulated through the oiling system increases, resulting in higher oil pressure. As engine speed is reduced, the volume of oil pumped is also reduced, resulting in lower oil pressure.

To check oil pressure, use OIL PRESSURE GAUGE (Part No. HD-96921-52A) and OIL PRESSURE GAUGE ADAPTER (Part No. HD-96940-52A). Remove oil pressure indicator switch and insert pressure gauge fitting. See [Figure 3-51](#).

Ride motorcycle at least 20 miles (32 km) at or above 50 MPH (80 KM/H) until engine oil reaches normal operating temperature. At 2500 RPM, oil pressure will vary from 10-17 psi (69-117 kN/m<sup>2</sup>). At idle speed (950-1050 RPM), oil pressure will vary from 7-12 psi (48-83 kN/m<sup>2</sup>).

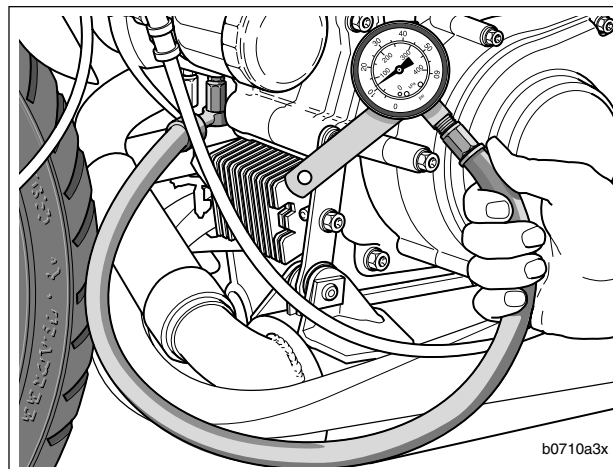


Figure 3-50. Checking Oil Pressure

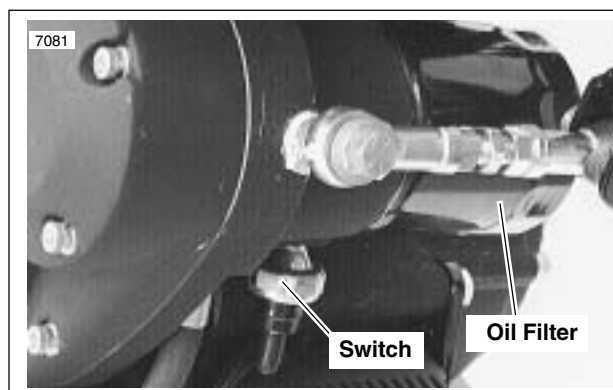


Figure 3-51. Oil Pressure Indicator Switch

Table 3-9. Troubleshooting Oil Pressure Signal Light

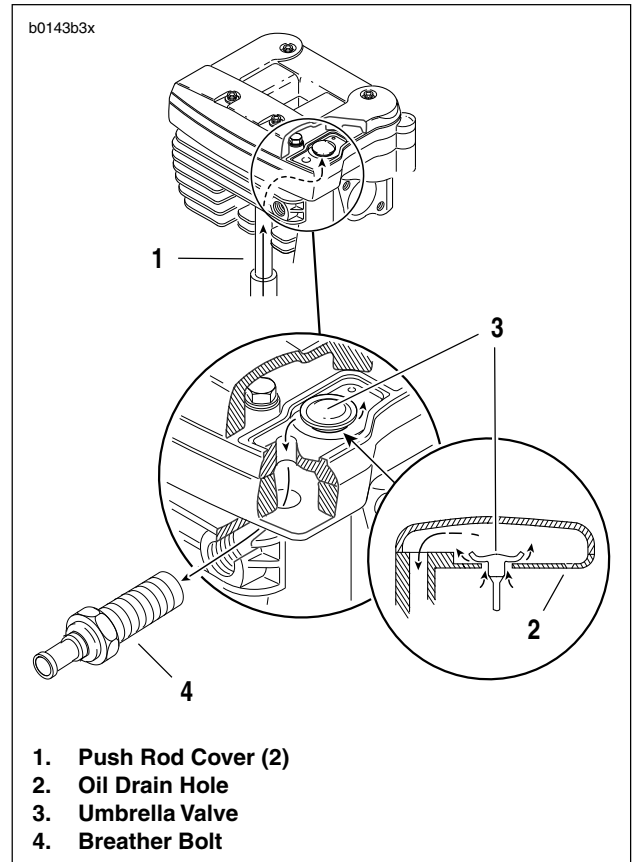
OIL PRESSURE SIGNAL LIGHT	PROBABLE CAUSES
Stays on at speeds above idle.	<ul style="list-style-type: none"> <li>● Empty oil tank.</li> <li>● Clogged feed line (ice and sludge, freezing temperatures).</li> <li>● Air-bound oil line.</li> <li>● Grounded oil switch wire.</li> <li>● Malfunctioning signal switch.</li> <li>● Diluted oil.</li> <li>● Malfunctioning check valve (see <a href="#">3.14 OIL FILTER MOUNT</a>).</li> </ul>
Flickers at idle.	<ul style="list-style-type: none"> <li>● Incorrect idle speed. Malfunctioning or improperly installed check valve (see <a href="#">3.14 OIL FILTER MOUNT</a>).</li> </ul>
Does not glow when ignition is turned on (prior to operating engine).	<ul style="list-style-type: none"> <li>● Malfunctioning signal switch.</li> <li>● Malfunction in wiring.</li> <li>● Burned-out signal bulb.</li> <li>● Dead battery (see NOTE above).</li> </ul>

## GENERAL

See [Figure 3-52](#). On piston downstroke, a mixture of crankcase air and oil mist is vented up the push rod covers (1) through an umbrella valve (3) in each middle rocker box section.

The oil mist separates from the crankcase air, collects and passes through a small drain hole (2) where it eventually returns to the crankcase.

The crankcase air is routed through a passage in each cylinder head. The air then travels through each air cleaner breather bolt (4). Hoses leading from the air cleaner bolts deposit the air inside the air cleaner's snorkel.



**Figure 3-52. Crankcase Breathing System, Typical Cylinder**

## GENERAL

## NOTE

The following paragraph numbers correspond with the numbered callouts in the **INTERNAL ENGINE PASSAGES** illustration.

1. Oil is gravity-fed from the oil tank to the gerotor-style oil pump through a **feed hose**. Oil enters the **feed section** and fills a cavity located under the feed pump.

## NOTE

See **3.13 OIL PUMP** for a complete explanation of the gerotor pump sets.

2. The feed pump transfers oil from the inlet cavity through the **feed hose** to the oil filter mount.
3. Oil flows through the **filter mount cavity** to the oil filter.
4. Oil enters the peripheral cavity of the **oil filter**, passes through the filtering medium into the central cavity of the oil filter, and flows into the filter adapter (fitting which connects filter to filter mount).
5. Adequate oil pressure in the filter mount cavity activates the **oil pressure signal light switch** and shuts off the oil pressure signal light.
6. Oil flowing from the filter adapter opens the **check ball**. The check ball opens at 4-6 psi (28-41 kN/m<sup>2</sup>) oil pressure.
7. With the check ball open, oil flows into the **crankcase feed galley**.
8. Oil flows through the feed galley in the crankcase to the lifter blocks and hydraulic lifters. **Cross-drilled passages** intersect the main feed galley and carry oil to each hydraulic lifter.
9. Oil also enters an **intersecting passage** in the gearcase cover. Oil flow is then routed to the crankshaft area.
10. Oil enters a hole in the end of the **pinion gear shaft** and travels to the right flywheel where it is routed through the flywheel to the **crankpin**. Oil is forced through the crankpin to properly lubricate the rod bearing assembly.
11. Oil flows up passages in the **push rods** to the rocker arm shafts and bushings.
12. The valve stems are lubricated by oil supplied through drilled oil holes in the **rocker arms**.
13. Oil collected in the push rod areas of the cylinder heads flows down the **push rod covers**, through drain holes in the **lifter blocks** and into the gearcase. After providing lubrication to the gearcase components, the oil flows to the left side of the oil pump.
14. Feed oil to the rocker area is returned to the crankcase through a **passage** in the head and cylinder.
15. Oil collected in the **sump** is splash-fed to the pistons, cylinder walls and flywheel components.
16. Oil collected in the sump area returns to the scavenge section of the oil pump through a **passage** located in the rear section of the sump. Oil flow to the pump is accomplished by the scavenging effect of the pump and by the pressure created by the downward stroke of the pistons.
17. Return oil fills a **cavity** above the pump's return gears. The return gears pump oil back to the oil tank.
18. A small amount of oil flows from the feed galley in the right crankcase half through a **restricted orifice**, which sprays the oil onto the rear intake cam gear in the gearcase. Oil is transferred to the teeth of all the cam gears through the gear meshing action.

## GENERAL

See [Figure 3-53](#). The oil pump consists of two gerotor gear sets, feed and scavenge (return), housed in one pump body. The feed set distributes oil to the engine, the scavenge set returns oil to the tank.

A gerotor-type gear set has two parts — an inner and an outer gerotor. The inner gerotor has one less tooth than the outer gerotor. Both gerotors have fixed centers which are off-set to each other.

In a gerotor gear set, oil is transferred from inlet to outlet as it is trapped between the rotating inner and outer gerotors. The illustration below shows the principle of gerotor operation:

1. During the first 180° of rotation, the cavity between inner and outer gerotors gradually increases in size until it reaches its maximum size, equivalent to the full volume of the “missing tooth.” The gradually enlarging cavity creates a vacuum into which oil flows from the inlet.
2. During the next 180° of rotation, the size of the cavity decreases forcing oil into the outlet.

See [Figure 3-55](#). Gravity-fed oil from the oil tank enters the pump through the feed hose connector (5). It is forced by the gerotor feed set (7) through a hose to the oil filter. Return oil from the flywheel compartment is drawn back into the pump and is forced by the gerotor scavenge set (9) back to the oil tank.

See [INTERNAL ENGINE PASSAGES](#) for oil passages within the engine.

The oil pump seldom needs servicing. Before you disassemble an oil pump suspected of not producing adequate oil pressure, be absolutely certain that all possible related malfunctions have been eliminated:

1. Make sure all oil hose clamps are tight and that hoses are not pinched or damaged.
2. Check oil level and condition of oil in tank. Pressure will be affected if oil is diluted. In freezing weather, proper circulation of oil can be affected if the oil feed hose becomes clogged with ice and sludge.
3. Check for a grounded oil pressure switch wire or faulty switch if oil indicator light fails to go out with engine running.

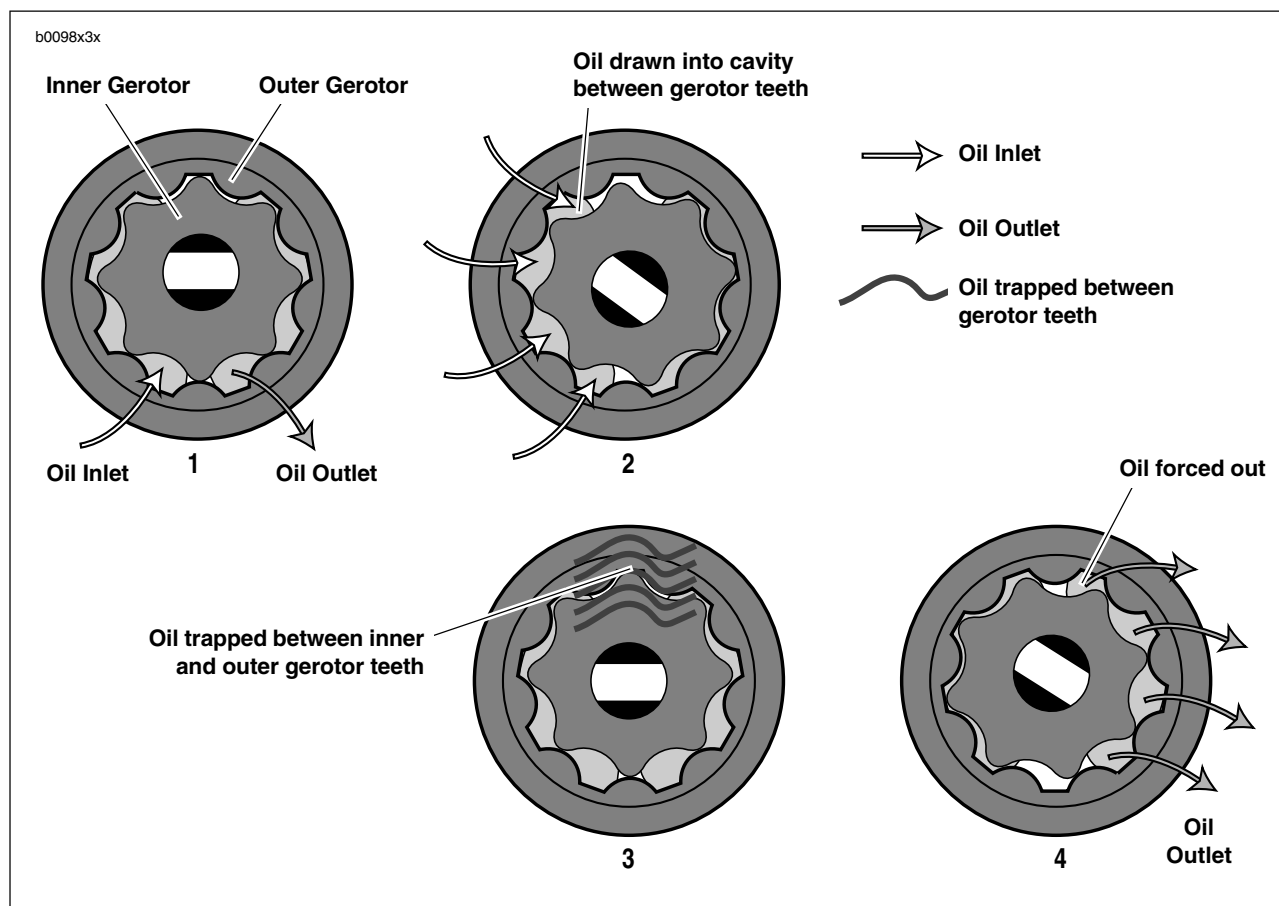


Figure 3-53. Principle of Gerotor Operation



## REMOVAL/DISASSEMBLY

### NOTE

Oil pump can be removed with engine in frame and without removing gearcase cover.

1. Drain oil tank. See 1.6 ENGINE LUBRICATION SYSTEM.
2. See Figure 3-54. Disconnect feed hose (3).
3. Remove clamp (6) from filter hose. Detach oil filter hose connection (5).

### NOTE

Loosen nut on oil filter hose connection (5) and then remove pressurized hose.

4. Carefully remove mounting screws and washers (1). Pump will drop with screws removed. Discard mounting gasket.
5. Remove clamp and detach return hose connection (4).

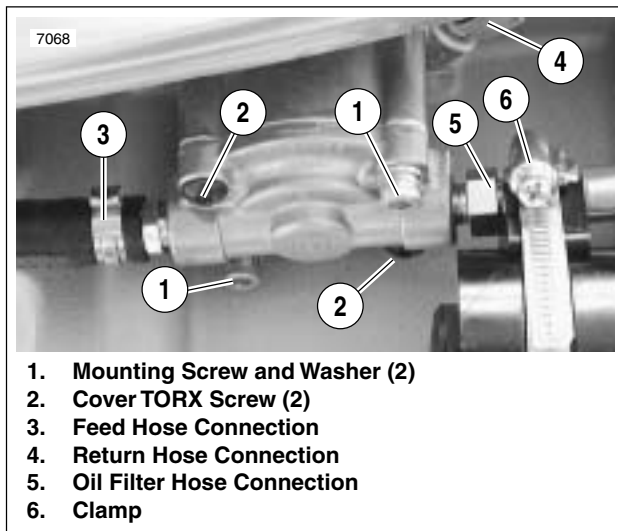
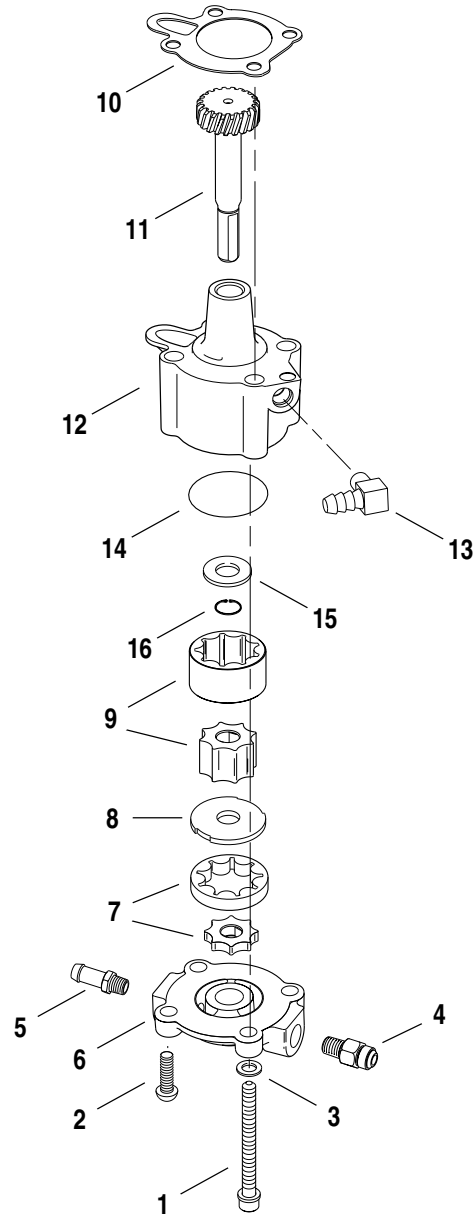


Figure 3-54. Oil Pump Hardware

6. See Figure 3-55. Remove cover TORX screws (2). Lift cover (6) off body (12). Remove and discard O-ring (14).
7. Slide both pieces of gerotor feed set (7), separator plate (8) and both pieces of gerotor scavenge set (9) off gear shaft (11).
8. Remove and discard retaining ring (16). Remove thrust washer (15) and gear shaft (11).

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1. Mounting Screw (2)
2. Cover TORX Screw (2)
3. Washer (2)
4. Oil Filter Mount Connector
5. Feed Hose Connector
6. Cover
7. Gerotor Feed Set
8. Gerotor Separator Plate
9. Gerotor Scavenge Set
10. Mounting Gasket
11. Gear Shaft
12. Body
13. Return Hose Elbow Connector
14. O-Ring
15. Thrust Washer
16. Retaining Ring

Figure 3-55. Oil Pump



## CLEANING AND INSPECTION

1. Clean all parts in cleaning solvent. Blow out holes and oil passages with compressed air.
2. See [Figure 3-56](#). Inspect both gerotor sets for wear.
  - a. Mesh pieces of each set together as shown.
  - b. Use a feeler gauge to determine clearance.
  - c. The **SERVICE WEAR LIMIT** between gerotors is 0.004 in. (0.102 mm). Replace gerotors as a set if clearance exceeds this dimension.
  - d. Measure thickness of feed gerotors with a micrometer. Replace gerotors as a set if they are not the same thickness.
3. See [Figure 3-55](#). Check gear shaft (11) teeth for damage or wear. Replace if necessary.

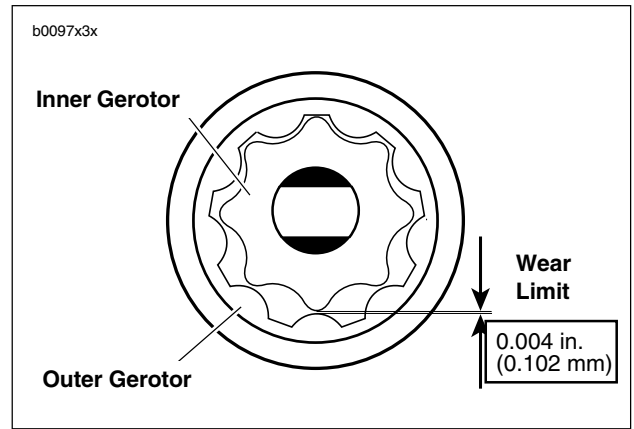


Figure 3-56. Gerotor Wear Limits

## ASSEMBLY/INSTALLATION

### NOTE

*Liberally coat all moving parts with clean engine oil to ensure easy assembly and smooth operation at start-up.*

1. See [Figure 3-55](#). Install gear shaft (11) through body (12). Position thrust washer (15) over end of shaft. Install **new** retaining ring (16) into groove in shaft.
2. Insert inner gerotor of the gerotor scavenge set (9) over gear shaft.
3. Place outer gerotor over inner gerotor to complete scavenge set (9).
4. See [Figure 3-57](#). Install gerotor separator plate (1) by lining up slots (2) on perimeter with tabs (3) inside oil pump body.
5. Install a **new** O-ring (4) into groove in pump body.
6. See [Figure 3-55](#). Place gerotor feed set (7) over gear shaft (11).
7. Place cover onto pump body. Install cover TORX screws (2). Tighten screws to 70-80 **in-lbs** (8-9 Nm).
8. Place **new** mounting gasket (10) in position.

### NOTE

*Use **new** hose clamps. If fittings were removed, use **TEFLON® PIPE SEALANT** or **HYLOMAR®** on fitting threads.*

9. See [Figure 3-54](#). Attach return hose connection (4).
10. Secure pump to crankcase with mounting screws (1) and washers. Tighten screws to 125-150 **in-lbs** (14-17 Nm).
11. Attach feed hose (3) and oil filter hose connection (5).
12. Attach clamp (6) and canister to hose.
13. Check engine oil level. Add oil to correct level if needed. See [1.6 ENGINE LUBRICATION SYSTEM](#).

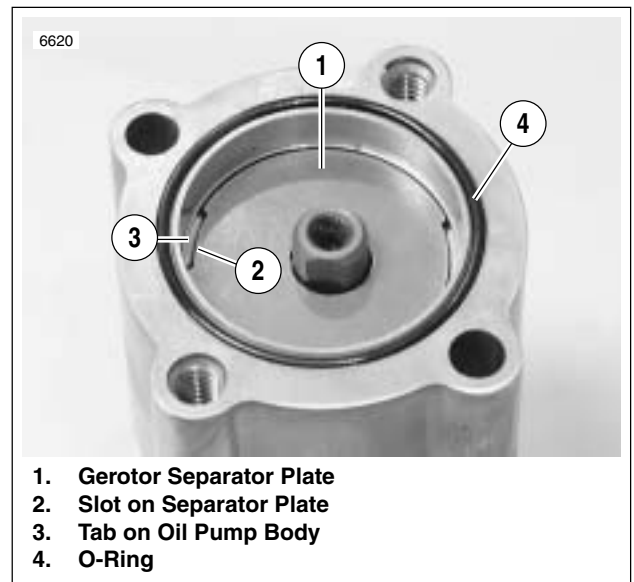


Figure 3-57. Separator Plate Slots

## GENERAL

See [Figure 3-58](#). Oil is pressure-fed from the oil pump to the filter mount (4) via a hose (5). Oil travels through the filter mount into the filter via outer filter holes.

Adequate oil pressure activates the oil pressure indicator switch (6) in the filter mount, which turns off the oil pressure indicator lamp.

The check ball (2) in the filter adapter (1) “opens” at 4-6 psi (28-41 kN/m<sup>2</sup>) oil pressure. Filtered oil leaves the filter, flowing past the check ball.

## DISASSEMBLY

1. Drain oil tank and remove filter. See [1.6 ENGINE LUBRICATION SYSTEM](#).
2. Remove filter adapter (1) from filter mount (4). Remove check ball (2) and spring (3).
3. Detach indicator lamp wire (7) from oil pressure indicator switch (6). Remove switch using OIL PRESSURE SENDING UNIT WRENCH (Part No. HD-41675).

## CLEANING AND INSPECTION

Thoroughly clean all parts in cleaning solvent. Blow out holes and passages using compressed air.

## ASSEMBLY

### NOTE

Use *TEFLON PIPE SEALANT* or *HYLOMAR* on all fittings installed to oil filter mount.

1. Install oil pressure indicator switch (6) using OIL PRESSURE SENDING UNIT WRENCH (Part No. HD-41675). Tighten to 4-6 ft-lbs (5-8 Nm).

### NOTE

The filter adapter (1) has identical ends; either end may be installed into the filter mount (4).

2. Apply LOCTITE THREADLOCKER 243 (blue) to the threads on that end of the filter adapter (1) which is installed into filter mount (4). Do not apply LOCTITE to adapter threads on filter element side.

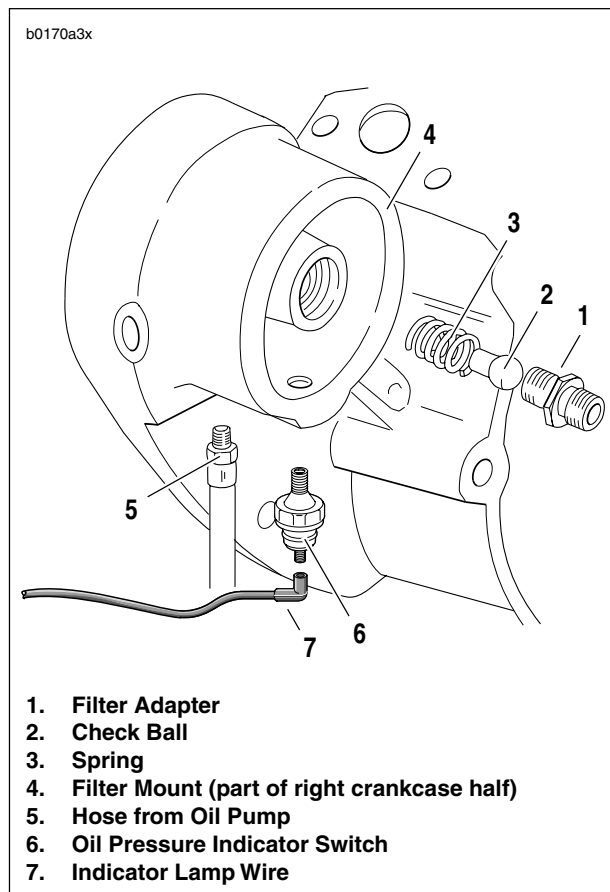


Figure 3-58. Oil Filter Mount

3. Install filter mount components.
  - a. Place spring (3) and check ball (2) into threaded hole at center of mount (4).
  - b. Push threaded end of filter adapter (with LOCTITE) (1) against check ball to compress spring.
  - c. Screw adapter into threaded hole. Tighten to 8-12 ft-lbs (11-16 Nm).
4. Attach indicator lamp wire (7).
5. Install a **new** filter and fill oil tank with proper oil. See [1.6 ENGINE LUBRICATION SYSTEM](#).

## GENERAL

See [Figure 3-59](#). The hydraulic lifter assembly consists of a lifter and roller. The lifter and roller, under compression force from valve spring, follow the surface of the revolving cam. The up-and-down motion produced is transmitted to the valve by the push rod and rocker arm. The lifter contains a piston (or plunger) and cylinder; it also contains a check valve, which allows the unit to fill with engine oil, thereby reducing clearance in the valve train.

When a lifter is functioning properly, the assembly operates with minimal clearance. The unit automatically compensates for heat expansion to maintain a no-clearance condition.

It is normal for lifters to click when engine is started after standing for some time. Lifters have a definite leakdown rate which permits the oil in the lifters to escape. This is necessary to allow units to compensate for various expansion conditions of parts and still maintain correct clearance operation. Lifters are functioning properly if they become quiet after a few minutes of engine operation.

## REMOVAL

1. Clean all dirt from around crankcase. Blow loose particles from area with compressed air.
2. Remove the upper, middle, and lower rocker covers. See [3.5 CYLINDER HEAD](#). Pull each push rod upward through top of cylinder head.
3. See [Figure 3-61](#). Remove both push rod covers (4).
  - a. Remove screw (8) and washer (10).
  - b. Lift retainer (6) and seal (7) upward a few inches on push rod cover (4).
  - c. Push upward on push rod cover while pulling bottom of cover clear of crankcase. Remove cover.
4. Remove both hydraulic lifters (3).
  - a. Remove two anti-rotation screws with washers (2).
  - b. Remove lifters (3) from crankcase bore using a thin-bladed screwdriver. Mark the location and orientation (front/back) of each lifter.

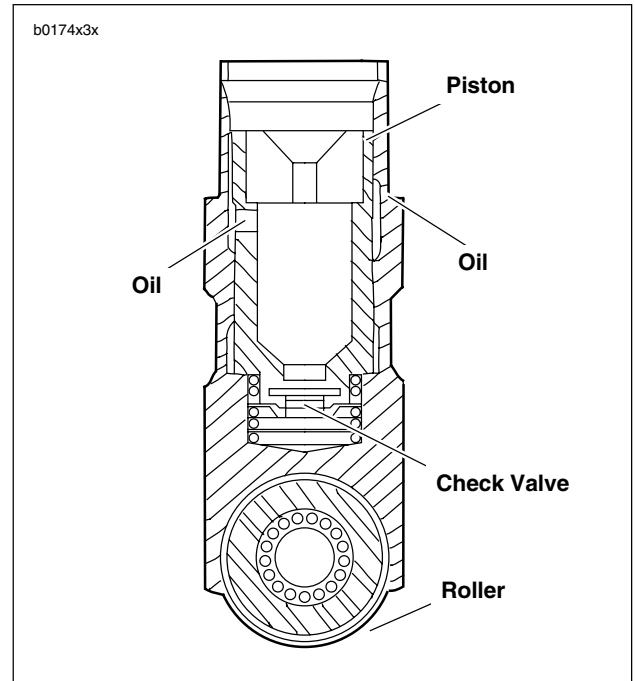
## CLEANING AND INSPECTION

1. Clean all parts, except roller/lifter assembly, thoroughly in solvent. Blow dry with compressed air.

### NOTE

*Inside and outside micrometers used for measuring lifters and lifter guides must be calibrated to ensure accurate readings.*

2. Inspect hydraulic lifters for excessive clearance in guide. Accurately measure lifter bore inner diameter with a gauge.
  - a. Clearance should be within 0.0008-0.0020 in. (0.0203-0.0508 mm).
  - b. Fit a **new** lifter and/or replace crankcases if clearance exceeds SERVICE WEAR LIMIT of 0.0030 in. (0.076 mm).

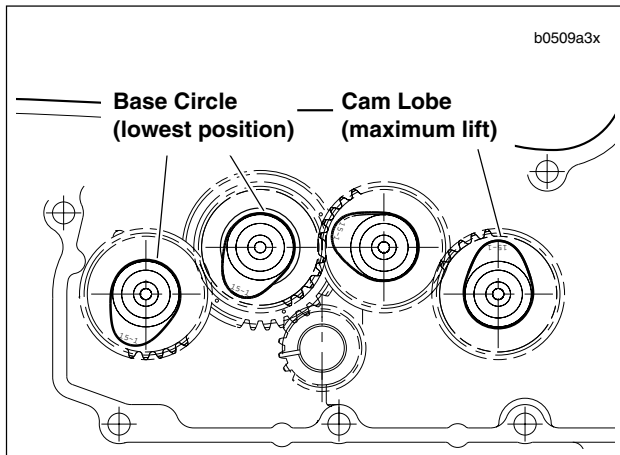


**Figure 3-59. Lifter Assembly (Typical)**

3. Check lifter roller freeplay.
  - a. Roller clearance on pin should be within 0.0006-0.0010 in. (0.0152-0.0254 mm).
  - b. Replace lifters if clearance exceeds SERVICE WEAR LIMIT of 0.0015 in. (0.0381 mm).
4. Check lifter roller end clearance.
  - a. End clearance should be within 0.008-0.022 in. (0.203-0.559 mm).
  - b. Replace lifters if clearance exceeds SERVICE WEAR LIMIT of 0.026 in. (0.660 mm).
5. Soak lifters in clean engine oil. Keep covered until assembly.

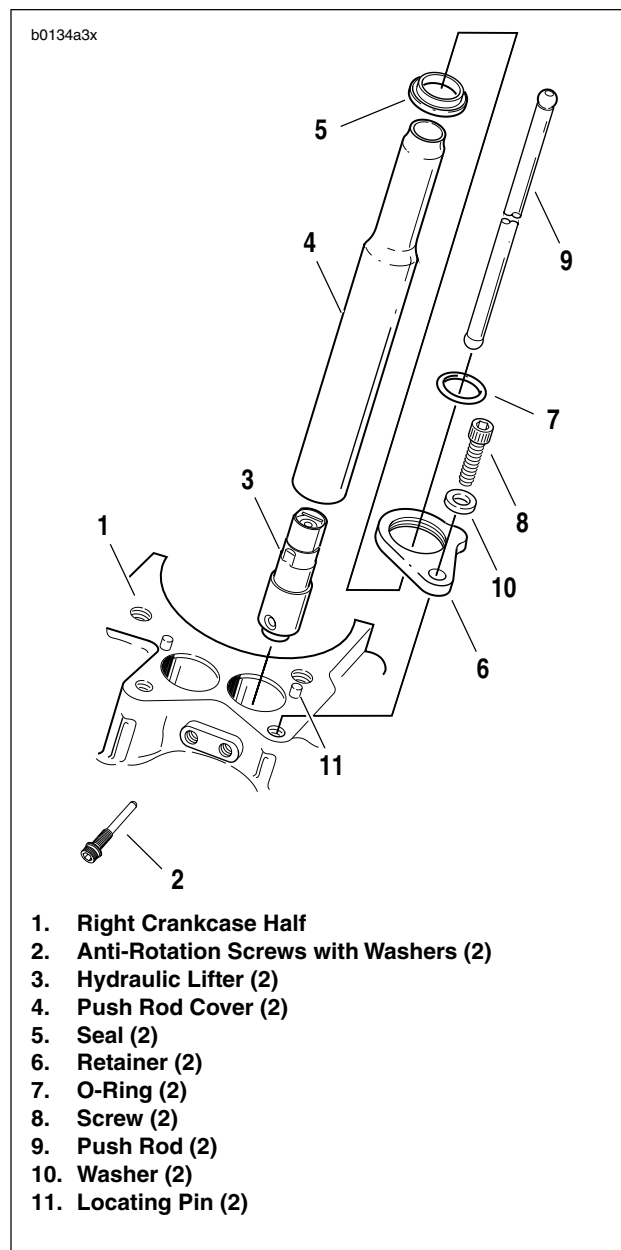
## INSTALLATION

1. See [Figure 3-60](#). Rotate engine so that both lifters, from the cylinder being serviced, will be installed on the base circle (1) of the cam.



**Figure 3-60. Base Circle**

2. Apply a liberal amount of engine oil to each lifter assembly (especially the roller needles) for smooth initial operation.
3. See [Figure 3-61](#). Insert lifter (3) into bore in crankcase (1) with lifter oil hole facing towards the oil trough. Rotate lifter so that flats at upper end of lifter faces the front and rear of the engine. If the lifter is installed incorrectly, anti-rotation screws (2) cannot be inserted.
4. Secure lifters in place.
  - a. Insert anti-rotation screws with washers (2) in the threaded holes in crankcase.
  - b. Tighten anti-rotation screws to 55-65 **in-lbs** (6-7 Nm)
5. Install push rod covers.
  - a. Slide **new** seal (5) and retainer (6) over top of push rod cover (4).
  - b. Position **new** O-ring (7) at top of push rod cover.
  - c. Hold cover at an angle and insert top through hole in cylinder head. Push up on cover while aligning bottom of cover with lifter bore in crankcase.
  - d. Lower retainer (6) with seal (5) onto crankcase, aligning locating pin (11) with hole in retainer.
  - e. Insert screw (8) with washer (10) through hole in retainer (6). Thread screw (8) into tapped hole in crankcase. Tighten screw to 15-18 **ft-lbs** (20-24 Nm).
6. Install push rods and rocker covers. See [3.5 CYLINDER HEAD](#).



**Figure 3-61. Hydraulic Lifter Service**

## GENERAL

Read the complete gearcase section carefully before you begin any service work.

For the gearcase components to operate at their optimum, all components must be properly fitted and matched. Changing one component can affect many others. It is important to know and understand all inspection procedures and how components interact.

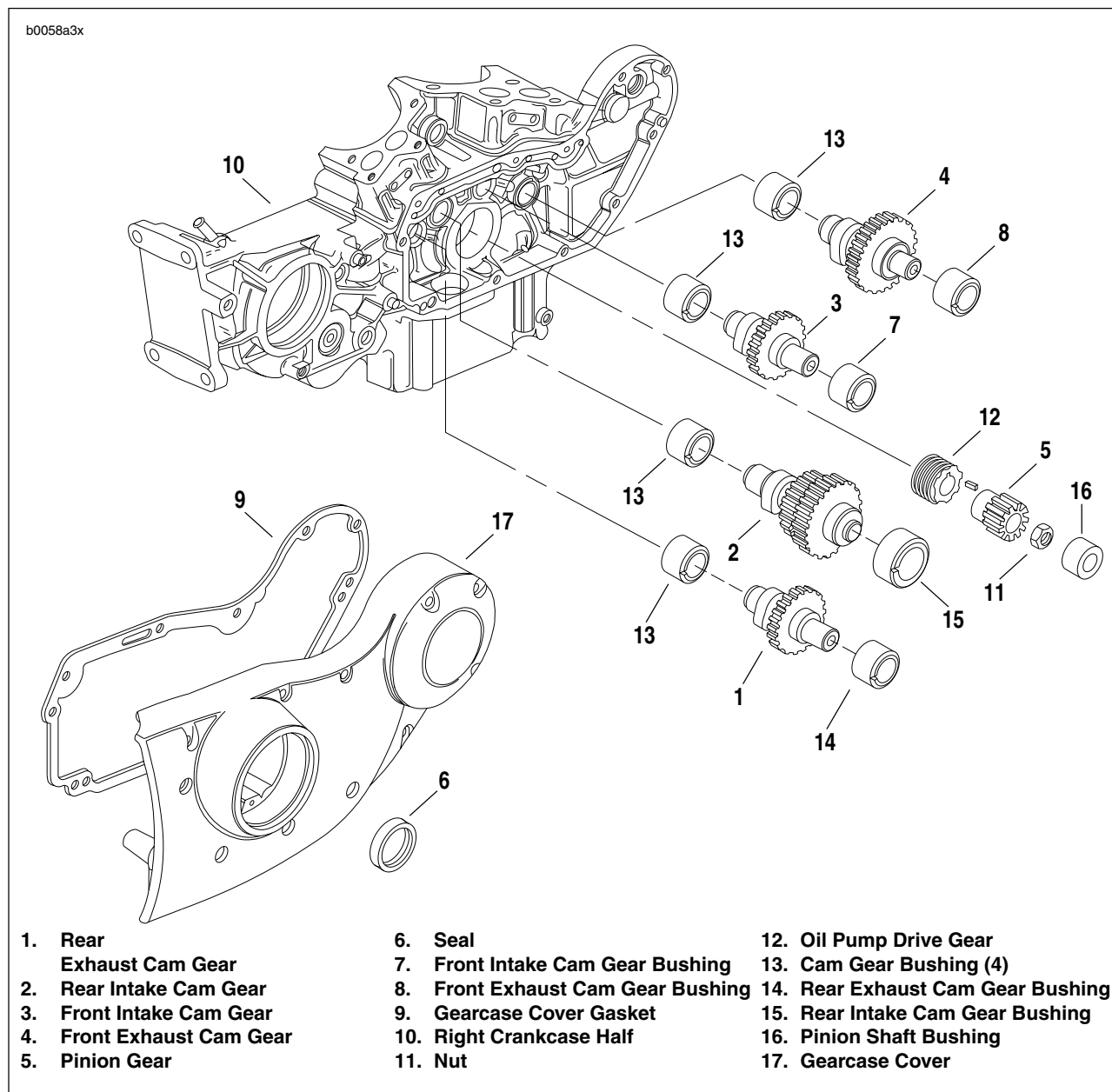


Figure 3-62. Gearcase and Valve Train Components

## REMOVAL/DISASSEMBLY

1. See [Figure 3-62](#). Thoroughly clean area around gearcase cover (17) and lifters. Blow loose dirt from crankcase with compressed air.
2. Remove any parts that will interfere with gearcase disassembly (i.e., exhaust header, air cleaner, etc.).
3. Remove push rods. See [3.5 CYLINDER HEAD](#).
4. Remove hydraulic lifters. See [3.15 HYDRAULIC LIFTERS](#).
5. Check for minimum cam gear end play. Record readings.
6. Remove cam position sensor and rotor from gearcase cover. See [4.30 CAM POSITION SENSOR AND ROTOR](#).
7. Place a pan under gearcase to collect oil. Remove cover screws. Carefully remove gearcase cover. Discard old gasket (9).

### NOTE

If cover does not come loose on removal of screws, tap lightly with a plastic hammer. Never pry cover off.

8. Remove cam gears (1, 2, 3 and 4). Carefully mark each component to ensure correct installation.

### NOTE

Nut (11) is secured by **LOCTITE THREADLOCKER 262 (red)** on the nut threads.

9. Remove nut (11). Slide pinion gear (5) and oil pump drive gear (12) off pinion shaft.

## CLEANING AND INSPECTION

1. Thoroughly clean gearcase compartment, gearcase cover and gears in solvent to remove oil and carbon deposits.
2. Blow out all cover oil passages and bushings with compressed air.
3. Clean old gasket material from gearcase and cover faces with cleaning solvent.

### Cam and Pinion Gear Identification

See [Figure 3-63](#). Cam lobes are stamped with the number "15" followed by a number (1, 2, 3 or 4). The number "15" indicates model year application; the number identifies the cam location/function.

### NOTE

Prior to changing any cam gears, check gear shaft fit within corresponding bushings. Worn bushings can cause excessive backlash.

### Cam Bushing Inspection and Removal

1. See [Figure 3-62](#). Bushings (7, 8, 13, 14, 15 and 16) are press fit in gearcase cover (17) and crankcase. Inspect each bushing against its corresponding cam gear shaft or pinion gear shaft. See [Table 3-10](#).
2. See [Figure 3-65](#). Use a BUSHING AND BEARING PULLER (Part No. HD-95760-69A) to remove bushings from gearcase cover and crankcase.

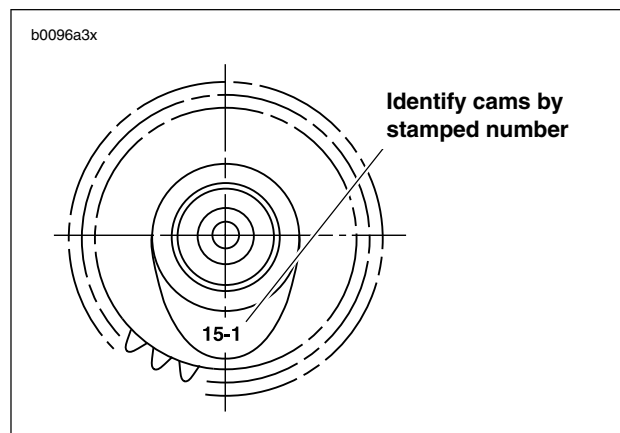


Figure 3-63. Cam Identification

Table 3-10. Gear Shaft Specifications

GEAR SHAFT	CORRECT CLEARANCE	SERVICE WEAR LIMIT
Cam	0.0007-0.0022 in. (0.0178-0.0559 mm)	0.003 in. (0.076 mm)
Pinion	0.0023-0.0043 in. (0.0584-0.1092 mm)	0.0050 in. (0.1270 mm)

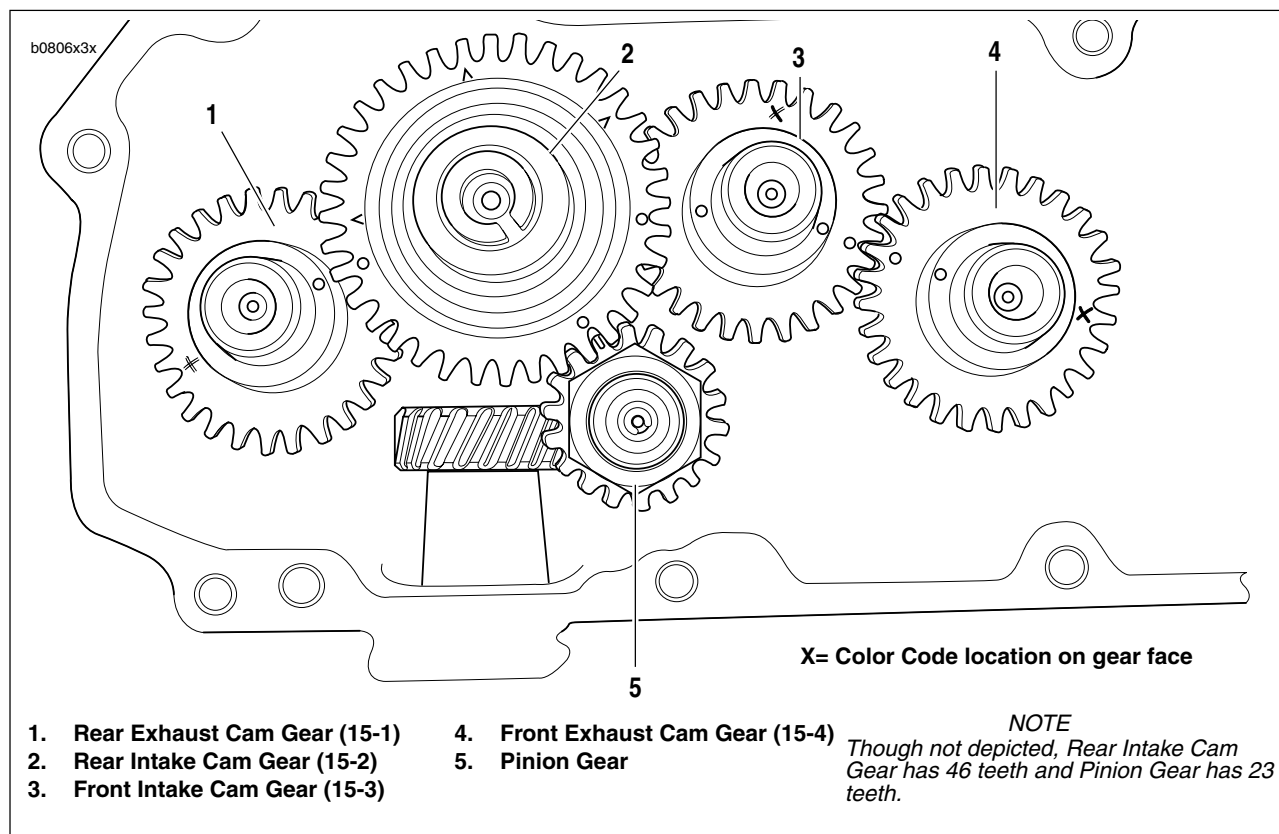


Figure 3-64. Cam and Pinion Gear Timing Mark Indexing

## Cam Bushing Installation (to Crankcase)

### NOTE

Installing and reaming crankcase and gearcase cover bushings may alter the center distances between mating gears and may result in an increase in gear noise. For quiet-running gears, the gears should be matched to the center distances.

1. See Figure 3-67. Each cam gear bushing (1), to be installed in right crankcase half (2), must be positioned in crankcase bore with its oiling slot at exact top of bore (12 o'clock position).
2. Using an arbor press, install each bushing in its crankcase bore so that bushing shoulder contacts crankcase boss.
3. After you install a **new** bushing in right crankcase half, ream the bushing to correct size. See [CAM BUSHING REAMING \(CRANKCASE\)](#).

## Cam Bushing Installation (to Gearcase Cover)

### NOTE

For all cam bushings except rear intake, see steps 1 and 2. For rear intake cam bushing, see steps 3 through 6.

1. See Figure 3-62. Using an arbor press, install each bushing (7, 8 and 14) in its gearcase cover (17) bore so that bushing shoulder contacts cover boss. Orient each

bushing so the oiling slot is at the 9 o'clock position within the gearcase cover bore.

2. After you install a **new** bushing in gearcase cover, line-ream the bushing to correct size. See [CAM BUSHING REAMING \(GEARCASE COVER\)](#).
3. See Figure 3-62. Rear intake cam gear bushing (15) must be installed in its gearcase cover (17) bore using an arbor press. You will need to orient the bushing in a specific position of rotation within the cover bore, and will need to drill a lubrication hole in the bushing, according to the following procedures.
4. See Figure 3-66. Position bushing (1) over bore of gearcase cover (2) with chamfered edge downward and slot upward. Align slot in bushing with slot in gearcase cover boss. Press bushing into cover bore until bushing is flush with cover boss.
5. Drill a 5/32 in. (3.97 mm) diameter hole through bushing using existing hole in gearcase cover as a guide.
6. After you install a **new** bushing in gearcase cover, line-ream the bushing to the correct size. See [CAM BUSHING REAMING \(GEARCASE COVER\)](#).



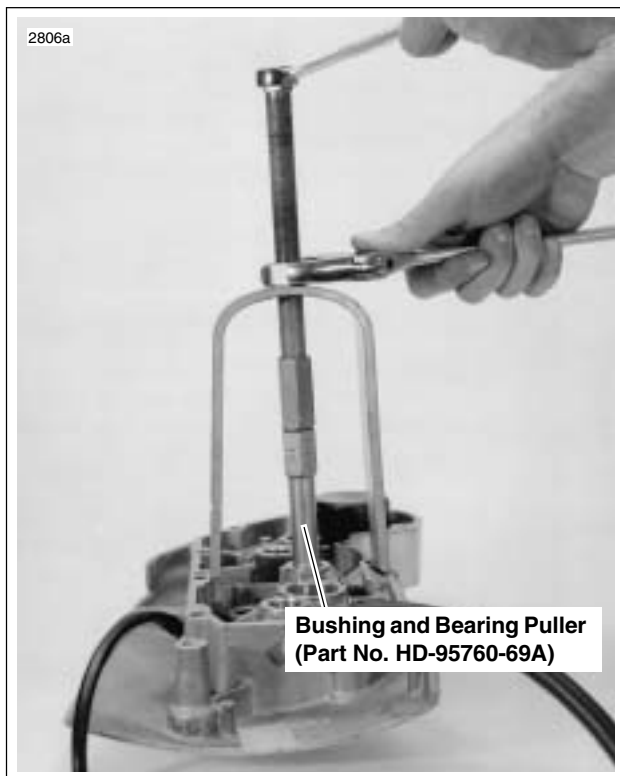


Figure 3-65. Removing Bushing

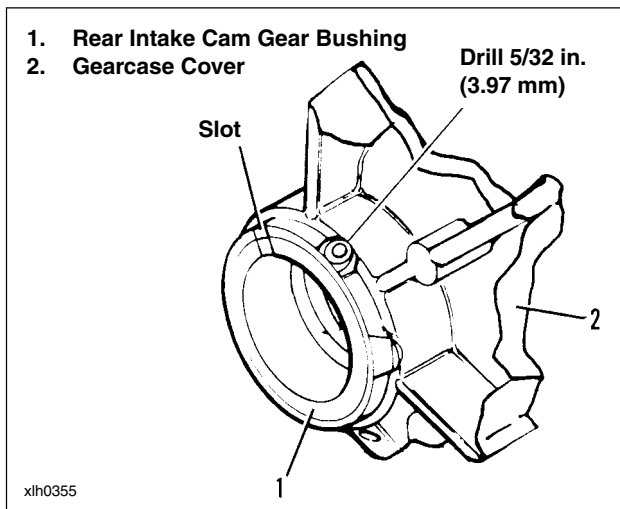


Figure 3-66. Rear Intake Cam Gear Bushing Installed in Gearcase Cover

### Pinion Shaft Bushing Installation (to Gearcase Cover)

1. See Figure 3-62. Using an arbor press, install pinion shaft bushing (16) in its gearcase cover (17) so that bushing is flush with cover boss. There is no need to orient this particular bushing in any specific position of rotation within the gearcase cover bore.
2. Although the original pinion shaft bushing is not "pinned," the replacement bushing must be secured, from possible rotation within the cover bore, by installation of a dowel

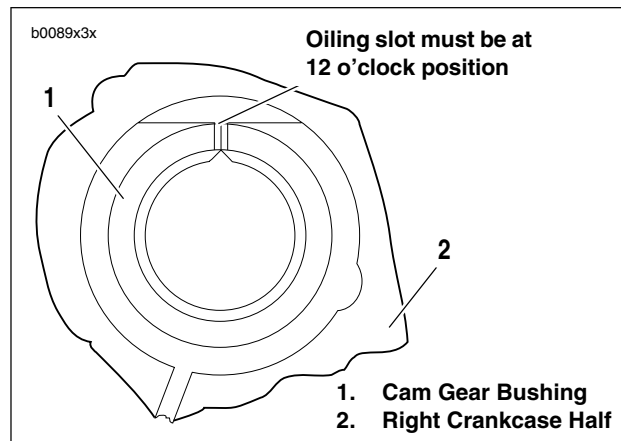


Figure 3-67. Cam Gear Bushing Installed in Crankcase

pin. See Figure 3-68. Drill a No. 31 hole, 0.281 in. (7.137 mm) deep, at top side of boss (side toward top of gearcase cover), centering the drill bit on the cover bore circle (hole is drilled half in bushing OD and half in cover bore ID).

3. Drive a **new** dowel pin no more than 0.20 in. (5.08 mm) below the bushing face. Carefully peen edges of hole to lock the pin in place.
4. After you install a **new** bushing in gearcase cover, line-ream the bushing to the correct size. See [PINION SHAFT BUSHING REAMING \(GEARCASE COVER\)](#).

### Bushing Reaming

#### NOTE

- Installing and reaming crankcase and gearcase cover bushings may alter the center distances between mating gears and may result in an increase in gear noise. For quiet-running gears, the gears should be matched to the center distances.
- Bushings in right crankcase half serve as pilots for reaming gearcase cover bushings and must, therefore, be reamed to size first.
- After reaming any bushing, check shaft fit in the bushing. It may be necessary to make a second pass with reamer to attain proper fit.

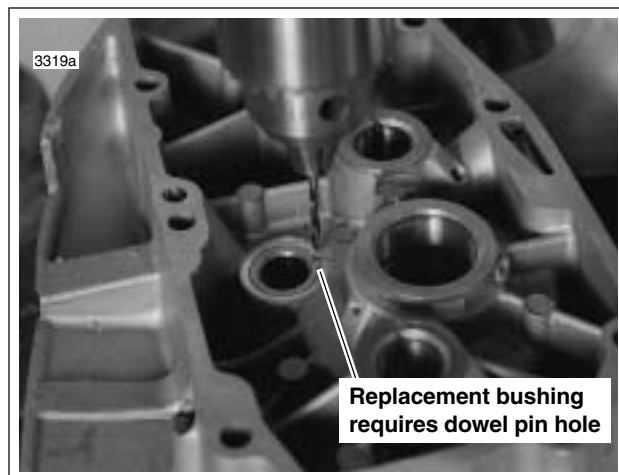


Figure 3-68. Drilling Dowel Pin Hole

## Cam Bushing Reaming (Crankcase)

1. Separate two halves of crankcase, if not already accomplished. Place right crankcase half on flat surface with gearcase side upward. Bushing to be reamed must be oriented as shown in [Figure 3-67](#).
2. See [Figure 3-69](#). Position CAMSHAFT BUSHING REAMER PILOT (Part No. HD-38871) onto gearcase side of crankcase half; upper right and lower left indexing holes in pilot must be placed over dowels in crankcase half. Insert two bolts (supplied with pilot) through two remaining holes in pilot, and into threaded holes of crankcase half. Tighten bolts securely.
3. Insert the 11/16 in. diameter reamer through pilot hole and into bushing while turning reamer clockwise. Continue turning reamer clockwise through bushing until smooth shank of reamer passes through hole in pilot.
4. Detach reamer from handle. Pull reamer out opposite side of crankcase half.
5. Thoroughly clean right crankcase half, removing all metal chips/shavings. Blow out all oil passages using compressed air.

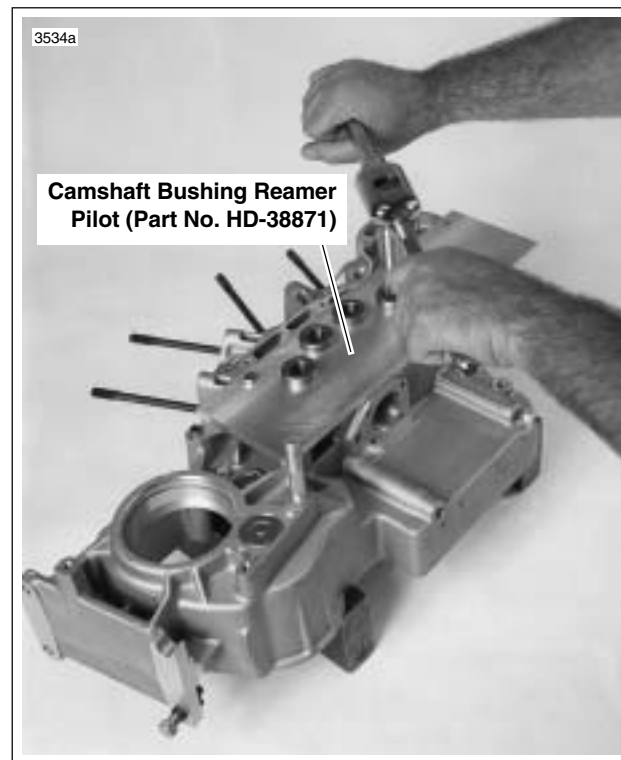
## Cam Bushing Reaming (Gearcase Cover)

### NOTE

For all cam bushings except rear intake, see steps 1 through 6. For rear intake cam bushing, see steps 7 through 12.

Newly installed cam gear bushings in the gearcase cover must be line reamed, using the right crankcase half as a pilot for the reamer, to establish correct clearance and to ensure perfect alignment. If crankcase halves are not separated on your motorcycle, use a spare right crankcase half to perform the following line reaming procedures.

1. See [Figure 3-62](#). Bushings (7, 8 and 14) to be reamed must be installed in gearcase cover (17) as described in [CAM BUSHING INSTALLATION \(TO GEARCASE COVER\)](#). Attach gearcase cover to right crankcase half (10), which has been disassembled from left crankcase half, securing with a minimum of three mounting screws.
2. Insert a standard 11/16 in. diameter reamer through the previously reamed cam gear bushing (13) in right crankcase half, which is in line with one of the bushings to be reamed in gearcase cover.
3. Turn reamer clockwise through bushing in cover until reamer bottoms. Then give reamer one complete clockwise turn to size the bushing. Continue turning reamer clockwise while extracting reamer from bushing.
4. Repeat Steps 2 and 3 for remaining two cam gear bushings (except rear intake bushing) in gearcase cover, if required.
5. Separate gearcase cover from right crankcase half. Inspect bushings for proper cam gear shaft fit. Repeat line reaming operation if necessary.
6. Thoroughly clean gearcase cover, removing all metal chips/shavings. Blow out all oil passages using compressed air.



**Figure 3-69. Reaming Cam Gear Bushing in Right Crankcase Half**

### NOTE

A **newly** installed rear intake cam gear bushing in the gearcase cover must be line reamed, using the right crankcase half as a pilot for the reamer, to establish correct clearance and to ensure perfect alignment. If crankcase halves are not separated on your motorcycle, use a spare right crankcase half to perform the following line reaming procedures.

7. See [Figure 3-62](#). Rear intake cam gear bushing (15) must be installed in gearcase cover (17) as described in [CAM BUSHING INSTALLATION \(TO GEARCASE COVER\)](#).
8. Identify the previously reamed rear intake cam gear bushing (13) in right crankcase half (10), which has been disassembled from left crankcase half. Insert the shank end of REAR INTAKE CAMSHAFT BUSHING REAMER (Part No. HD-94803-67) through gearcase side of this bushing.
9. With reamer inserted into bushing in right crankcase half, attach gearcase cover to right crankcase half, securing with a minimum of three mounting screws.
10. Turn reamer clockwise through bushing in gearcase cover until reamer bottoms. Then give reamer one complete clockwise turn to size the bushing. Continue turning reamer clockwise while extracting reamer from bushing.
11. Separate gearcase cover from right crankcase half. Inspect bushing for proper cam gear shaft fit. Repeat line reaming operation if necessary.
12. Thoroughly clean gearcase cover, removing all metal chips/shavings. Blow out all oil passages using compressed air.

## Pinion Shaft Bushing Reaming (Gearcase Cover)

### NOTE

A **newly** installed pinion shaft bushing in the gearcase cover must be line reamed, using both the right crankcase half and Pilot (Part No. HD-94812-87) as pilots for the reamer, to establish correct clearance and to ensure proper alignment. If crankcase halves are not separated on your motorcycle, use a spare right crankcase half to perform the following line reaming procedures.

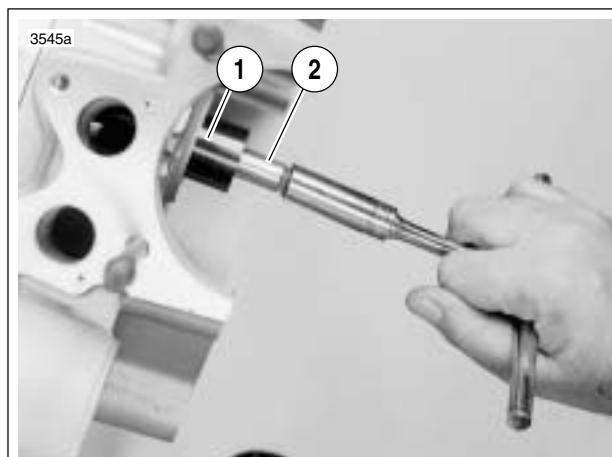
1. See Figure 3-62. Pinion shaft bushing (16) must be installed in gearcase cover (17) as described in **CAM BUSHING INSTALLATION (TO CRANKCASE)**. Attach gearcase cover to right crankcase half (10), which has been disassembled from left crankcase half, securing with a minimum of three mounting screws.
2. See Figure 3-70. Install PINION SHAFT BUSHING REAMER PILOT (Part No. HD-94812-87) into right crankcase roller race. Insert PINION SHAFT BUSHING REAMER (Part No. HD-94812-1) through the pilot.
3. Turn reamer clockwise through bushing in gearcase cover until reamer bottoms. Then give reamer one complete clockwise turn to size the bushing. Continue turning reamer clockwise while extracting reamer from bushing.
4. Separate gearcase cover from right crankcase half. Inspect bushing for proper pinion shaft fit. Repeat line reaming operation if necessary.
5. Remove pilot from right crankcase roller race. Thoroughly clean gearcase cover, removing all metal chips/shavings. Blow out all oil passages using compressed air.

## ASSEMBLY/INSTALLATION

1. See Figure 3-71. Install oil pump drive gear (5) and pinion gear on pinion shaft.
  - a. Slide oil pump gear drive gear (5) over pinion shaft (1). Drive gear must align with shaft key (4).
  - b. Align keyway (3) in ID of pinion gear with shaft key (4).
  - c. Slide pinion gear over shaft key (4) and against oil pump drive gear (5).
2. See Figure 3-62. Install nut (11).
  - a. Clean threads on pinion shaft and nut.
  - b. See Figure 3-72. Install CRANKSHAFT LOCKING TOOL (Part No. HD-43984) to gearcase with "Side A" facing out, over pinion shaft, with two screws.
  - c. Apply several drops of LOCTITE THREADLOCKER 262 (red) to threads of nut.
  - d. Install nut to pinion shaft. Tighten nut to 35-45 ft-lbs (48-61 Nm).
3. Liberally apply engine oil to bushings, shafts, and gears. Install all cam gears into bushings of right crankcase half, properly aligning timing marks of cam gears and pinion gear. See Figure 3-64.

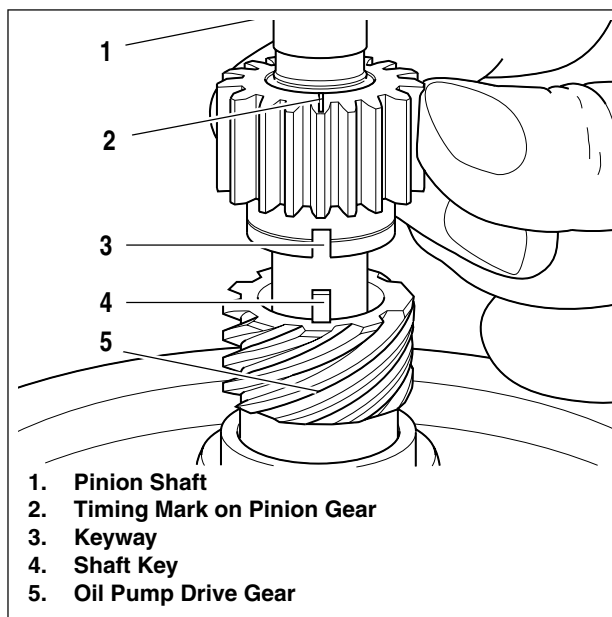
### NOTE

Because of the larger diameter additional gear (which meshes with the pinion gear) on the outboard end of the rear intake (15-2) cam gear, the rear exhaust (15-1) and front intake (15-3) cam gears must both be installed before the rear intake (15-2) cam gear is installed.



1. Pilot (Part No. HD-94812-87)
2. Reamer (Part No. HD-94812-1)

Figure 3-70. Line Reaming Pinion Shaft Bushing



1. Pinion Shaft
2. Timing Mark on Pinion Gear
3. Keyway
4. Shaft Key
5. Oil Pump Drive Gear

Figure 3-71. Aligning Pinion Gear

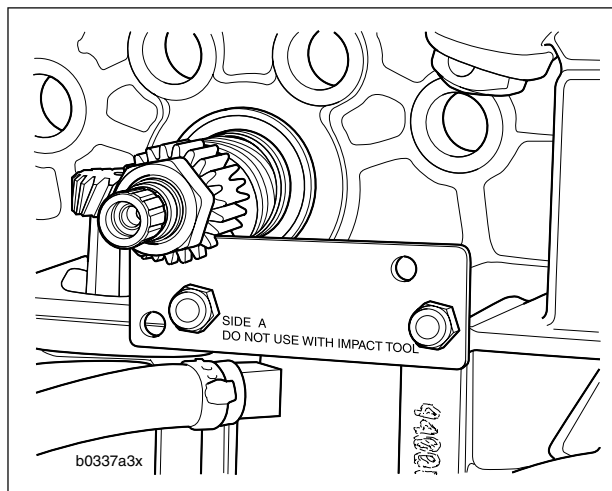
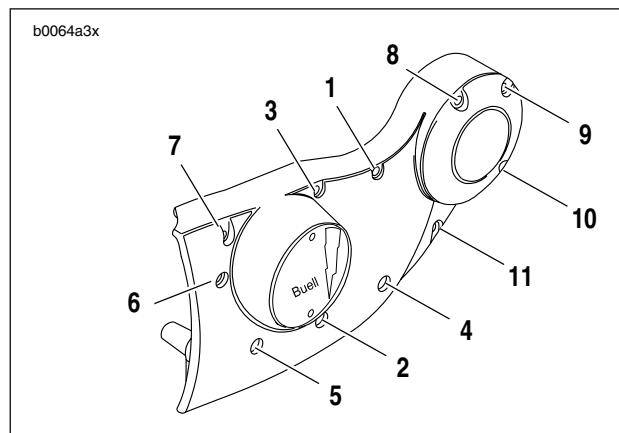


Figure 3-72. Crankshaft Locking Tool (HD-43984)

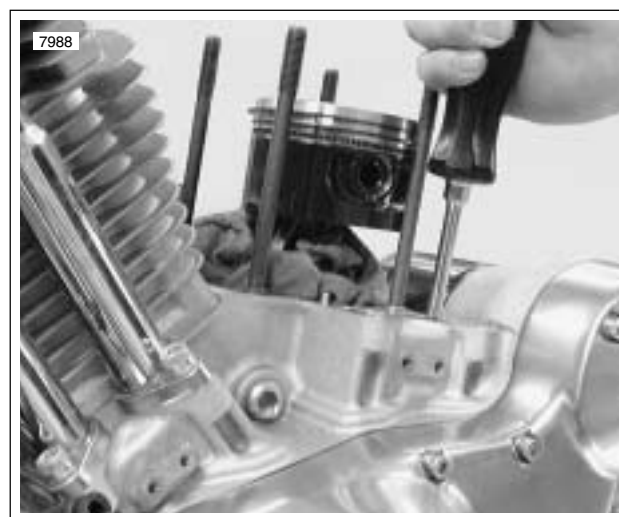
**CAUTION**

**Use only the correct gearcase cover gasket (see parts catalog for Part No.). Using pre-2000 model year gasket will obstruct oil galley and result in engine damage.**

4. See [Figure 3-62](#). Install a **new** seal (6) and **new** dry gearcover gasket (9) on gearcase cover (17).
5. Install gearcase cover over all gears and onto right crankcase half (10). Secure cover to crankcase half with 11 socket head screws. Tighten screws evenly to 80-110 **in-lbs** (9-12 Nm). Use torque sequence shown in [Figure 3-73](#).
6. See [Figure 3-74](#). Check cam gear end play for each cam gear as follows:
  - a. Turn engine over until lobe of cam gear being checked is pointing toward its respective lifter guide hole.
  - b. Gently pry the cam gear toward the gearcase cover using a flat blade screwdriver.
  - c. Measure gap between bushing (in crankcase half) and cam gear shaft thrust face (shoulder) using a feeler gauge. This is cam gear end play.
  - d. Compare cam gear end play measurements with the **SERVICE WEAR LIMITS**. Make repairs as required if end play does not meet specifications.
7. Install hydraulic lifters and push rods. See [3.15 HYDRAULIC LIFTERS](#).
8. Install cam position sensor in gearcase cover. See [4.30 CAM POSITION SENSOR AND ROTOR](#).
9. Install any components removed to gain access to gearcase (i.e. exhaust system components, air cleaner, etc.).



**Figure 3-73. Gearcase Cover Mounting Screw Torque Sequence**



**Figure 3-74. Checking Cam Gear End Play**

## GENERAL

## CAUTION

If engine is removed from chassis, do not lay engine on primary side. Placing engine on primary side will damage clutch cable end fitting. If fitting is damaged, clutch cable must be replaced.

Remove engine from chassis to repair rod bearings, pinion shaft bearing or sprocket shaft bearing. See [3.3 STRIPPING MOTORCYCLE FOR ENGINE REPAIR](#).

It is recommended procedure to overhaul engine if removed. This includes inspecting and repairing cylinder heads, cylinders, gearcase and transmission.

## ADJUSTMENT/TESTING

## Flywheel End Play

Before completely disassembling crankcases, check flywheel end play.

1. After engine has been removed from chassis, securely fasten it to a stand or workbench.
2. Remove gearcase cover. See [3.16 GEARCASE COVER AND CAM GEARS](#).
3. See [Figure 3-75](#). Attach a dial indicator to gear side crankcase with indicator stem on end of gearshaft.
4. To obtain an accurate flywheel end play reading, preload sprocket shaft bearings. Create a suitable tool by welding two handles to an old engine sprocket nut. Install the nut and sprocket. Tighten to 190-210 ft-lbs (258-285 Nm).
5. Check flywheel end play.
  - a. Rotate and **push** on sprocket shaft while reading dial indicator.
  - b. Then rotate and **pull** on sprocket shaft while reading dial indicator.
  - c. Replace bearing inner shim (See [Figure 3-78](#).) if difference (end play) in indicator readings is not 0.001-0.005 in. (0.025-0.127 mm). Choose shim from [Table 3-11](#).

## NOTE

Use a thinner shim for less end play; use a thicker shim for more end play.

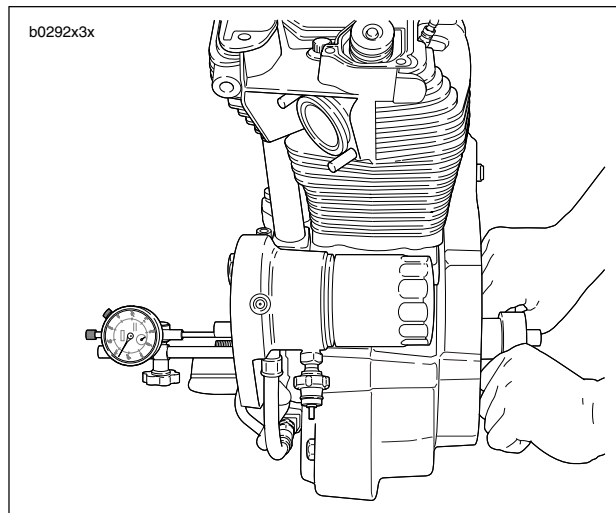


Figure 3-75. Checking Flywheel End Play

Table 3-11. Flywheel End Play Shims

PART NUMBER	THICKNESS	
	IN.	MM
9155	0.0975-0.0985	2.4765-2.5019
9142	0.0995 - 0.1005	2.5273-2.5527
9143	0.1015-0.1025	2.5781-2.6035
9144	0.1035 - 0.1045	2.6289-2.6543
9145	0.1055 - 0.1065	2.6797-2.7051
9146	0.1075 - 0.1085	2.7305-2.7559
9147	0.1095 - 0.1105	2.7813-2.8067
9148	0.1115 - 0.1125	2.8321-2.8575
9149	0.1135 - 0.1145	2.8829-2.9083

Table 3-12. Gearshaft Bearings

PART NUMBER	COLOR
24647-87	Blue
24650-87	Red
24659-87	White/Grey
24660-87	Green



## DISASSEMBLY

### Crankcase Halves

1. Remove cylinder heads. See [3.5 CYLINDER HEAD](#).

#### CAUTION

After removing cylinders, install plastic or rubber hose over cylinder studs. Lifting or moving crankcase by grasping studs will cause cylinder stud damage.

2. Remove cylinders and pistons. See [3.6 CYLINDER AND PISTON](#).
3. Remove oil pump. See [3.13 OIL PUMP](#).

4. Remove gearcase components. See [3.16 GEARCASE COVER AND CAM GEARS](#).
5. Remove primary cover and primary drive/clutch components. See [PRIMARY CHAIN/DRIVE](#) under [6.5 PRIMARY DRIVE/CLUTCH](#).
6. Remove starter motor. See [5.7 STARTER](#).
7. Remove transmission. See [6.7 TRANSMISSION CASE](#).
8. See [Figure 3-76](#). Remove screws and rear engine mount bolt securing crankcase halves together.
9. Position crankcase on work bench, gearcase side up. Tap crankcase with plastic mallet to loosen top half and separate the halves.

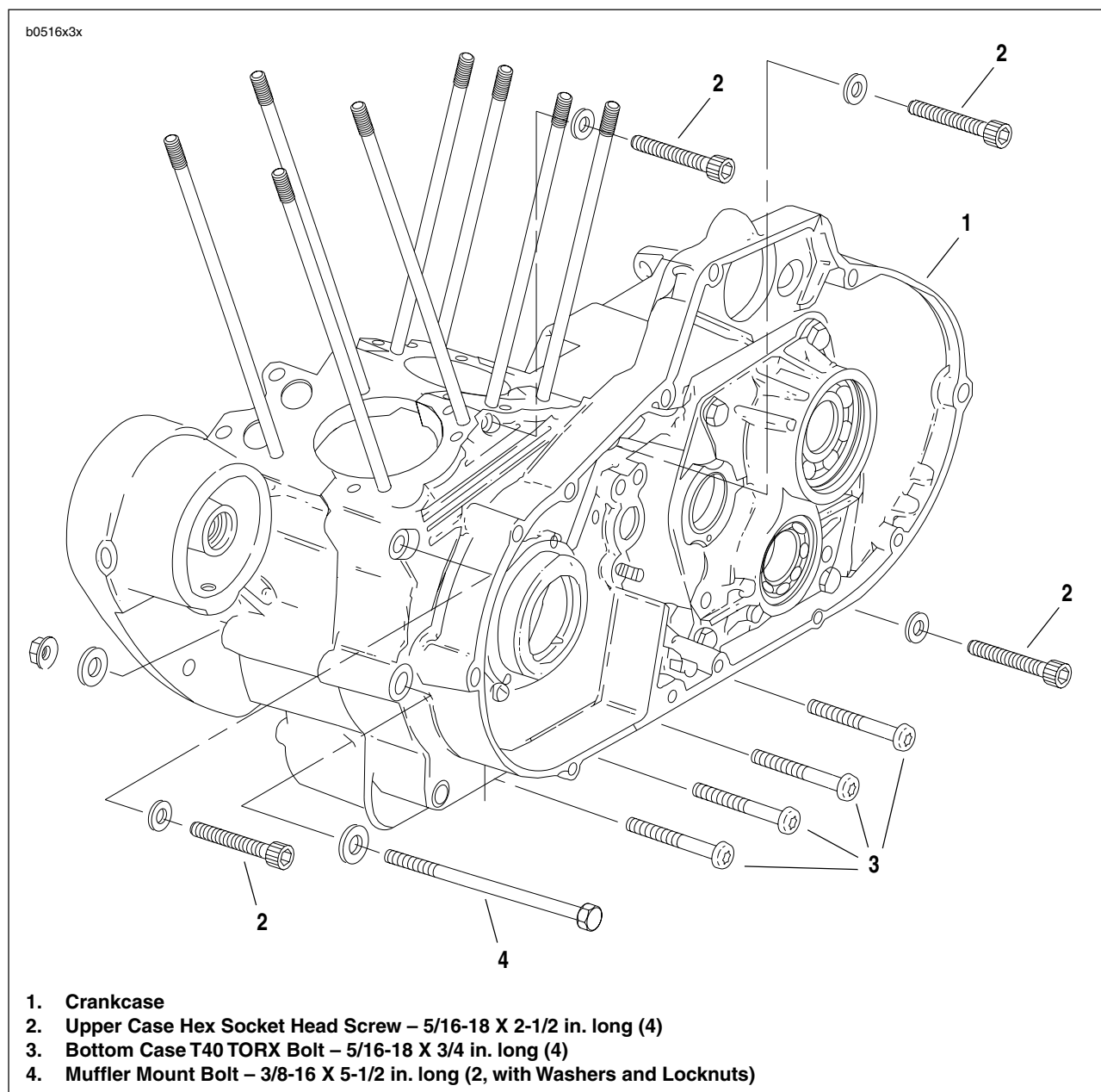


Figure 3-76. Crankcase Hardware (Typical)

# **WARNING**

The next step requires using a press. Wear eye protection and make certain set-up is stable. The pressure involved could cause parts to “fly out” with considerable force. Inadequate safety precautions could result in death or serious injury.

10. See Figure 3-77. Mount the left crankcase half and flywheel assembly on a press table, supporting crankcase on parallel bars. Press on end of sprocket shaft with arbor press until flywheel assembly is free from crankcase half. Do not drive flywheel assembly from crankcase half as flywheels may be knocked out of alignment.

## NOTE

See Figure 3-77. If it is necessary to remove either the pinion shaft bearing (11) or sprocket shaft bearing (4 and 9), proceed as follows:

11. Gearshaft bearing will remain on flywheel pinion shaft. Remove retaining ring, and bearing may be slipped off pinion shaft.
12. See Figure 3-79. Place flywheel assembly in FLYWHEEL FIXTURE (Part No. HD-44385). Pull sprocket shaft bearing with SPROCKET SHAFT INNER TIMKIN BEARING REMOVER (Part No. HD-44404) and ALL PURPOSE CLAW PULLER (Part No. HD-95635-46) using bolts in place of jaws. Insert a penny (or suitable coin) between shaft and claw puller to avoid damaging shaft.
13. See Figure 3-80. Use CRANKSHAFT BEARING TOOL (Part No. HD-94547-101) to remove sprocket shaft outer races.

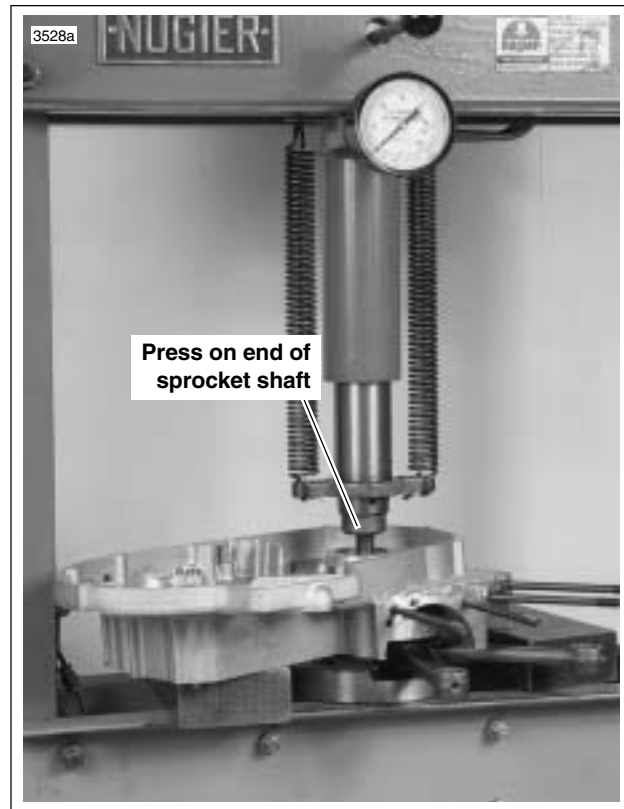


Figure 3-77. Pressing Flywheel from Crankcase

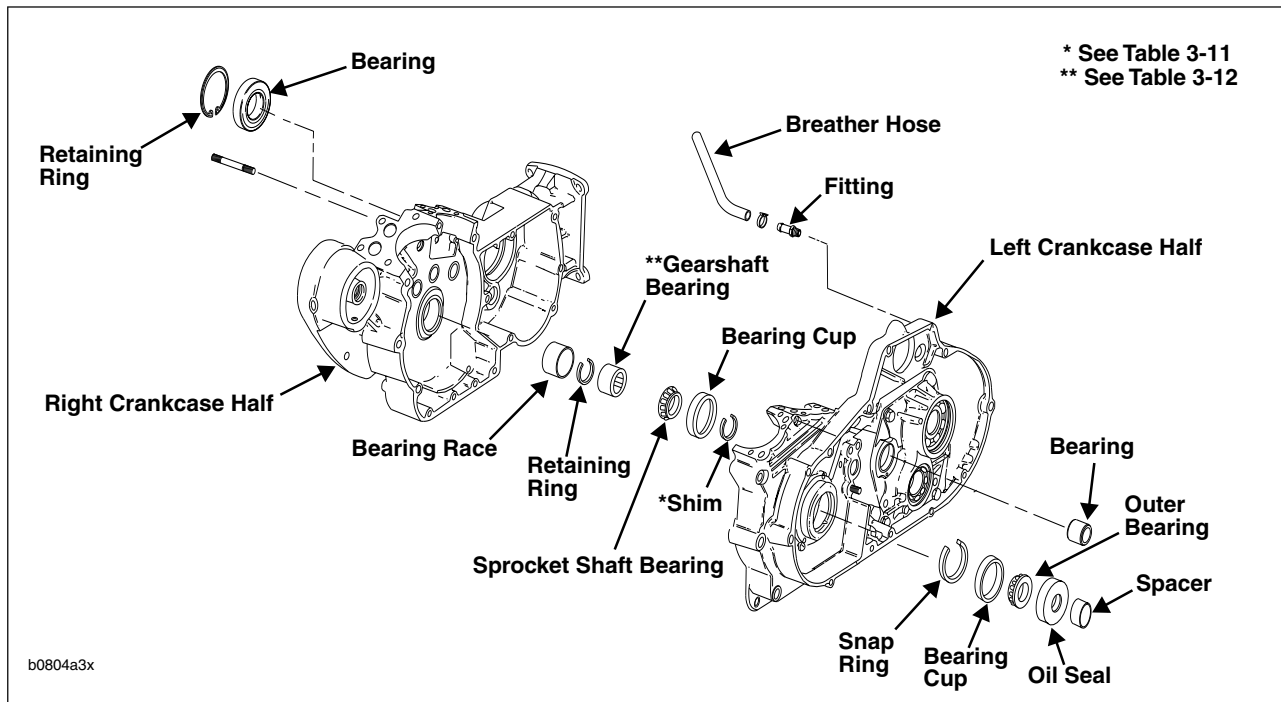
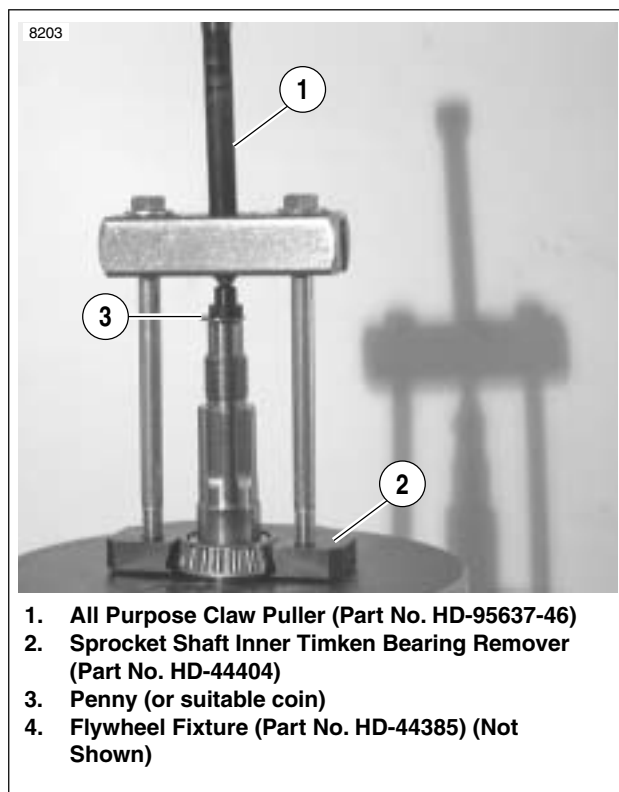
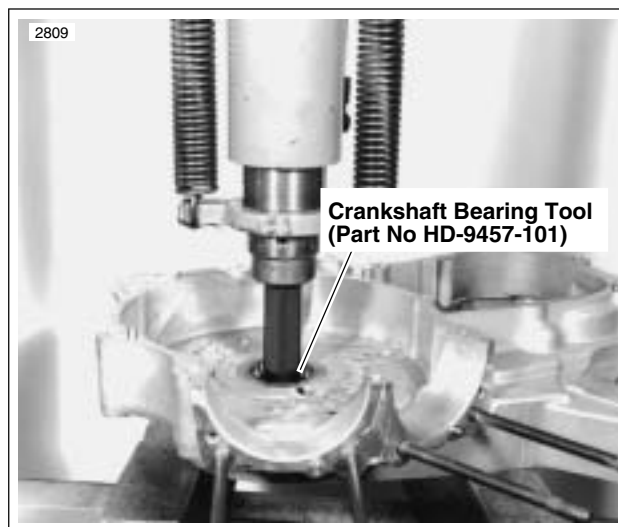


Figure 3-78. Crankcase Assembly



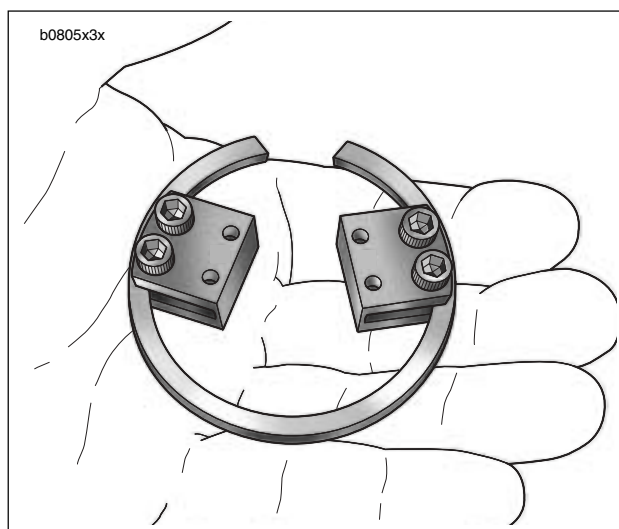


**Figure 3-79. Removing Sprocket Shaft Inner Timken Bearing (Typical)**

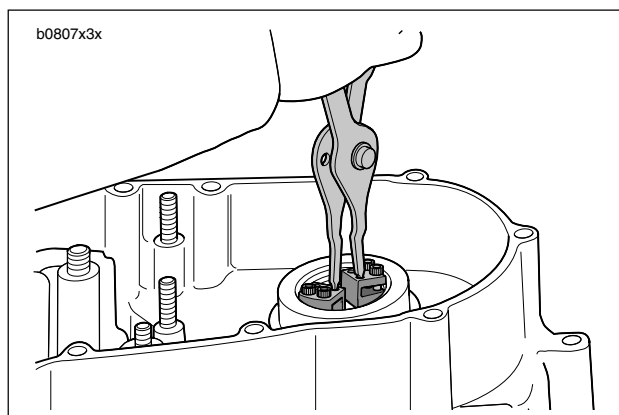


**Figure 3-80. Sprocket Shaft Outer Race Removal**

14. Remove crankcase retaining ring from crankcase bore.
  - a. Place the crankcase half on a flat surface with the outboard side facing up.
  - b. Obtain the two-piece TIMKEN SNAP RING REMOVER/INSTALLER (HD-44069).
  - c. See [Figure 3-81](#). With the gap in the retaining ring being the 12 o'clock position, place the two claws so that the slotted sides engage the inside edge of the retaining ring at the 10 and 2 o'clock positions.
  - d. Using a 9/64 inch allen head bit, tighten the screws to fix the position of the claws on the retaining ring.
  - e. See [Figure 3-82](#). Inserting the tips of a large retaining ring pliers (Snap-On PR-56A) into one hole in each claw, compress the retaining ring and remove it from the crankcase bore.
  - f. Loosen allen head screws and remove claws from retaining ring.



**Figure 3-81. Install Claws on Snap Ring**



**Figure 3-82. Remove Snap-Ring From Crankcase Bore**

## CLEANING AND INSPECTION

Wash all parts in solvent and blow dry with compressed air.

### Flywheel/Connecting Rod Assembly

#### NOTE

*If the flywheel or connecting rods need to be replaced, then they must be replaced together as one assembly. Return the flywheel/connecting rod assembly to the factory for service or replacement.*

1. Replace the flywheel/connecting rod assembly if any of the following conditions are noted:
  - Connecting rods are bent or twisted.
  - Connecting rods do not fall under their own weight or are in a bind.
  - The crankshaft (roller) bearing inner race is bur-nelled, burnt, scored, blued or damaged.
2. Inspect connecting rods for correct free play.
  - a. Holding the shank of each rod just above the bearing bore, pull up and down on the connecting rods. Any discernible up and down movement indicates excessive lower bearing clearance. Replace the flywheel/connecting rod assembly.
3. See [Figure 3-83](#). Check connecting rod side play.
  - a. Insert a feeler gauge between the thrust washer and the outboard side of the connecting rod.
  - a. Replace the assembly if the rod side play exceeds 0.030 inch (0.762 mm).

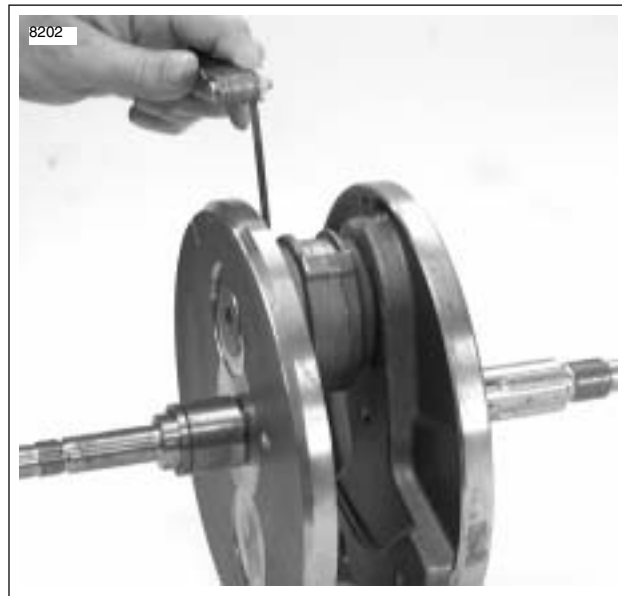
### Fitting Sprocket Bearings

If flywheel end play is within tolerance, and if tapered roller bearings and races pass visual check and have no apparent wear, the same set may be reinstalled. Make certain all parts of bearing are installed in exactly the same order in which they were removed. If any part of bearing assembly is worn, entire assembly should be replaced.

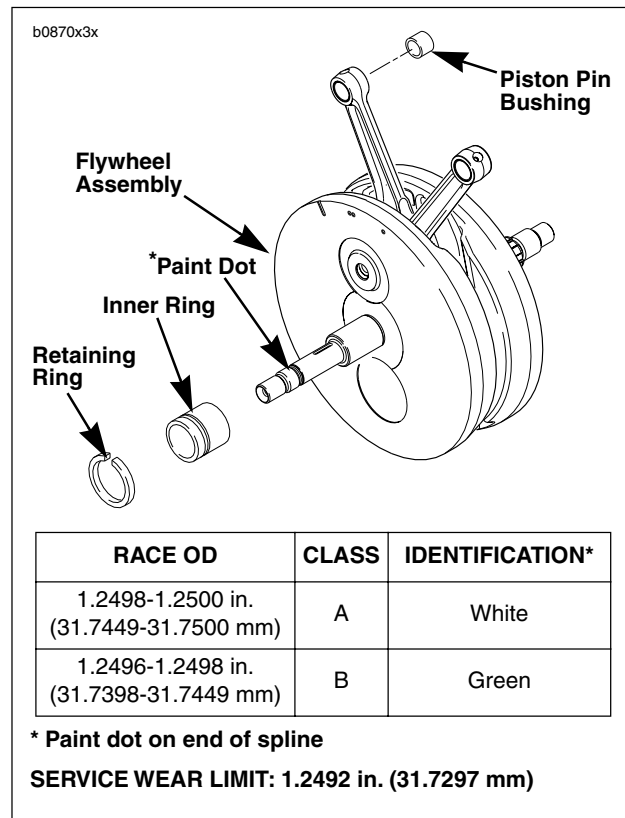
### Fitting Pinion Bearings

See [Figure 3-78](#). A pressed-in bushing in the right crankcase half is the outer race. The inner race is pressed on the pinion shaft.

See [Figure 3-86](#). To remove pinion shaft inner race, use TWO CLAW PULLER (Part No. HD-97292-61), CENTER CAP (Part HD-95652-43A), and BEARING SEPARATOR (SNAP-ON TOOLS Stock No. CJ950). Apply heat to race to aid removal. Four sizes of pinion bearings are available. Pinion bearing selection at the factory, during engine rebuild, or replacement of crankcase set or flywheel assembly is based on the largest measured outside diameter (OD) of the inner race and the smallest measured inside diameter (ID) of the outer race (crankcase bushing). A running clearance of 0.0002-0.0008 in. (0.0051-0.0203 mm) is established during crankcase set or flywheel assembly replacement and engine rebuild.



**Figure 3-83. Checking Connecting Rod Side Play**



**Figure 3-84. Low Inertia Flywheel and Connecting Rod Assembly/Factory Inner Race Sizes**

See [Figure 3-84](#). Installed inner races are identified at the factory as shown.

See [Figure 3-85](#). Outer races are identified at the factory as shown.

See [Figure 3-86](#). To remove pinion shaft inner race, use TWO CLAW PULLER (Part No. HD-97292-61), CENTER CAP (Part HD-95652-43A), and BEARING SEPARATOR (SNAP-ON TOOLS Stock No. CJ950). Apply heat to race to aid removal. Four sizes of pinion bearings are available. Pinion bearing selection at the factory, during engine rebuild, or replacement of crankcase set or flywheel assembly is based on the largest measured outside diameter (OD) of the inner race and the smallest measured inside diameter (ID) of the outer race (crankcase bushing). A running clearance of 0.0002-0.0008 in. (0.0051-0.0203 mm) is established during crankcase set or flywheel assembly replacement and engine rebuild.

See [Figure 3-84](#). Installed inner races are identified at the factory as shown.

See [Figure 3-85](#). Outer races are identified at the factory as shown.

#### NOTE

*The different sizes of crankcase sets and flywheel assemblies will not have separate part numbers. That is, a replacement crankcase set may have a class 1, 2 or 3 pinion outer race. Replacement flywheel assemblies will have either a class A or B inner race.*

See [Figure 3-88](#). Pinion bearings are identified as shown.

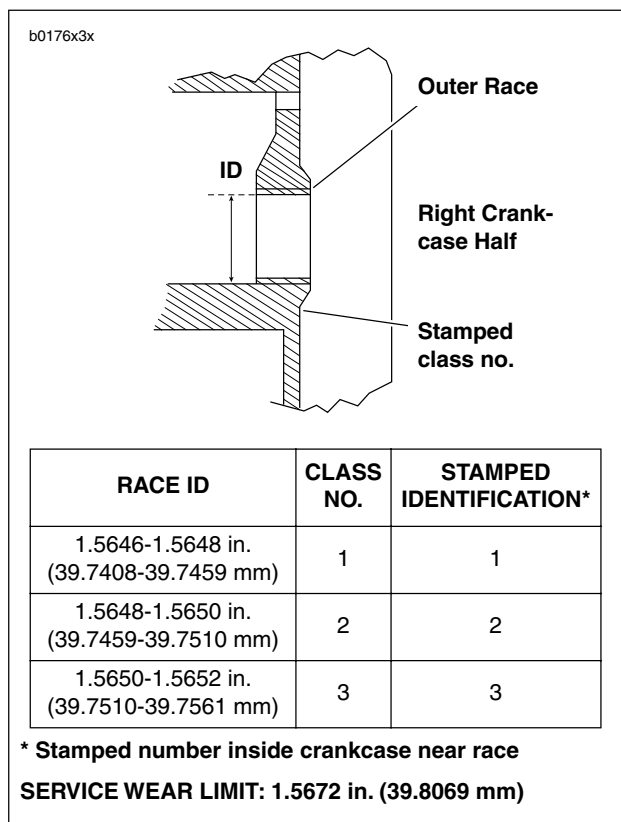


Figure 3-85. Factory Outer Race Sizes

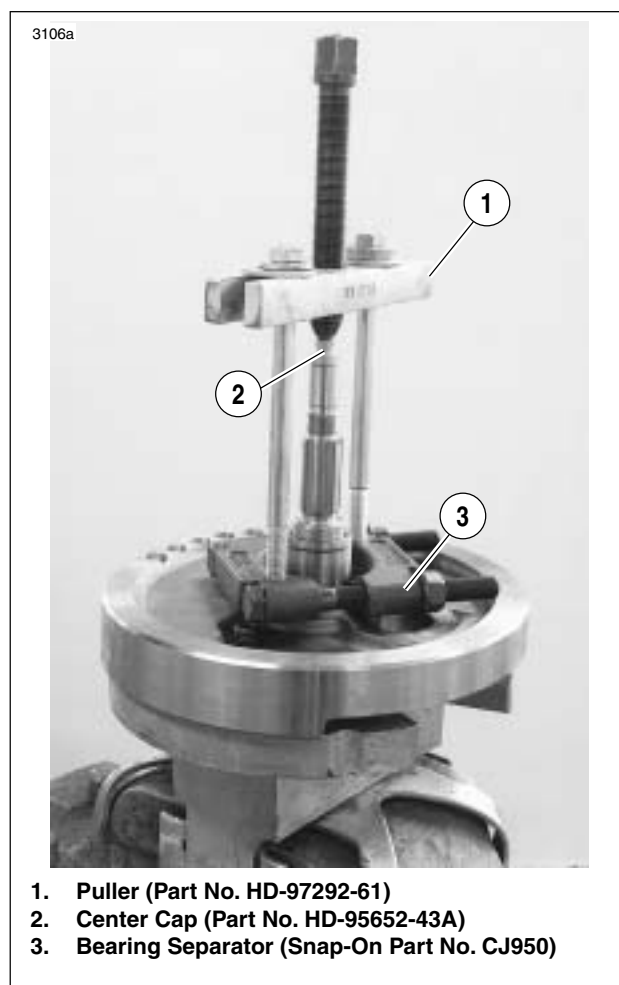


Figure 3-86. Pulling Pinion Shaft Inner Race (Typical)

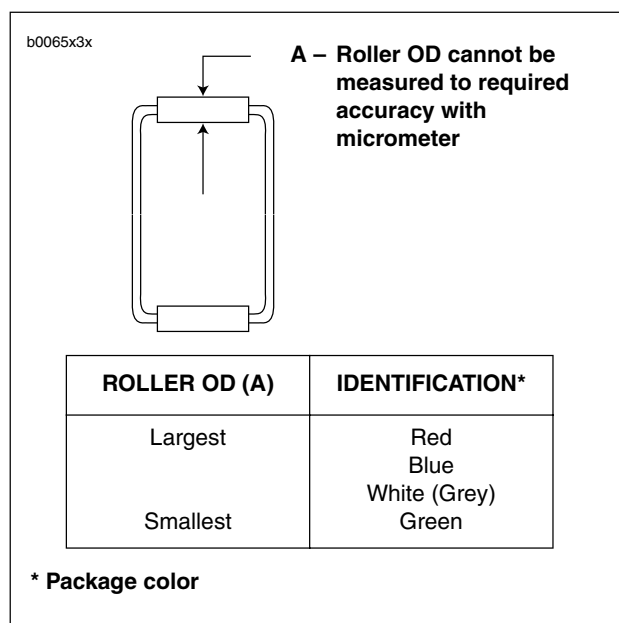


Figure 3-87. Bearing Identification

## Pinion Bearing Selection

Select bearings using the identification information given for inner and outer races and bearings. See [Table 3-12.](#) and [Table 3-13.](#)

### NOTE

If either inner or outer race show wear, measure both races to confirm correct bearing fit.

1. Use a dial bore gauge to measure and record ID of outer race. Take four measurements on ID where bearing rollers ride.
  - a. If the largest measurement is larger than 1.5672 in. (39.8069 mm) or the required lapping to remove wear marks would enlarge bore beyond 1.5672 in., continue at Step 5.
  - b. If largest measurement is 1.5672 in. (39.8069 mm) or less, cover the cam bearings with masking tape to prevent debris from entering bearings. Assemble crankcase halves.

### NOTE

The next step requires lapping the outer race. To keep sprocket shaft and pinion shaft bearings aligned the lap must be supported by an adaptor or pilot in the left crankcase half.

2. See [LAPPING ENGINE MAIN BEARING RACES.](#) Lap race until all wear marks are removed.
3. Measure and record ID of race at four places.
4. Check measurements against these specifications:

**Largest ID measured:** 1.5672 in. (39.8069 mm) or less

**Roundness of ID:** within 0.0002 in. (0.0051 mm)

**Taper:** within 0.0002 in. (0.0051)

- a. If lapping increased bore ID to larger than 1.5672 in. (39.8069 mm), go to Step 5.
  - b. If roundness or taper do not meet specifications, continue lapping until specifications are met.
  - c. If all specifications are met, continue at Step 7 to remove and size inner race.
5. Press the outer race from the right crankcase. Press **new** outer race into crankcase flush with inside edge of cast-in insert.

See [Figure 3-89.](#) Dimensions are shown for fabrication of tools used in pressing the outer race into or out of crankcase.

6. The **new** outer race must be lapped slightly to true and align with left case bearing and to meet the following specifications. See [LAPPING ENGINE MAIN BEARING RACES.](#)

**ID:** 1.5646 - 1.5652 in. (39.7408 - 39.7561 mm)

**Roundness:** within 0.0002 in. (0.0051 mm)

**Taper:** within 0.0002 in. (0.0051 mm)

**Surface finish:** 16 RMS

7. See [Figure 3-86.](#) Pull inner race from pinion shaft using TWO CLAW PULLER (Part No. HD-97292-61), CENTER CAP (Part No. HD-95652-43A), and BEARING SEPARATOR (SNAP-ON TOOLS Stock No. CJ950). Apply heat to race to aid removal.

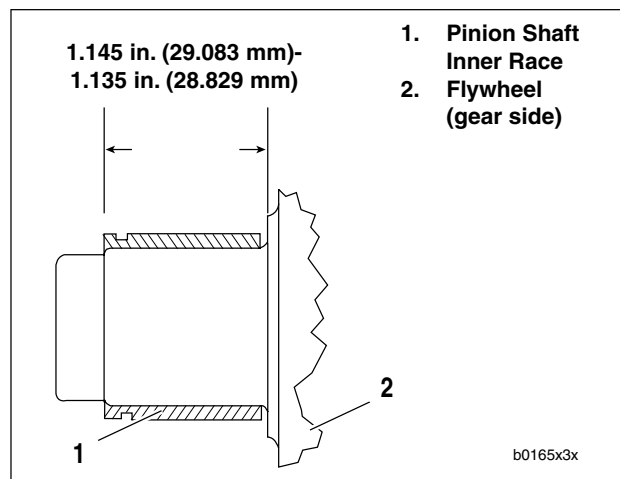


Figure 3-88. Inner Race Location

8. See [Figure 3-88.](#) Press **new** inner race on pinion shaft as shown. The **new** inner race must be ground by a competent machinist to OD dimension range for the finished lapped ID of the outer race. See [Table 3-13.](#) The finished inner race must meet these specifications. For necessary dimensions for constructing a press-on tool see [Figure 3-89.](#) When the tool bottoms against the flywheel, correct inner race location is automatically established.

**Roundness:** within 0.0002 in. (0.0051 mm)

**Taper:** within 0.0002 in. (0.0051 mm)

**Surface finish:** 16 RMS

### NOTE

Always use the smallest outer race ID measurement and the largest OD inner race measurement when selecting bearings.

9. The following example illustrates how to determine the required inner race OD.
  - a. See [Table 3-13.](#) For example purposes, suppose the smallest outer race ID measurement is 1.5651 in. (39.754 mm). This requires an inner race OD range of 1.2496-1.2504 in. (31.740 - 31.760 mm).

### NOTE

Have machinist grind outer race to center or middle of required OD range. This will prevent grinding outer race undersize and gives a more easily achieved tolerance range.

- b. Grind inner race. Measure OD at four places. Check that specifications in Step 8 are met.
  - c. For example purposes, suppose the largest inner race OD measurement after grinding is 1.2499 in. (31.747 mm) OD.
  - d. With a 1.5651 in. (39.754 mm) ID outer race and a 1.2499 in. (31.747 mm) OD inner race, a blue bearing is required.

## Lapping Engine Main Bearing Races

1. Secure right and left crankcase halves with three crankcase stud bolts (top center and bottom left and right). The sprocket shaft bearing outer races and large spacer must be installed in left crankcase.
2. See [Figure 3-90](#). Obtain CRANKCASE MAIN BEARING LAPPING TOOL (Part No. HD-96710-40B). Assemble CRANKCASE MAIN BEARING LAP (Part No. HD-96718-87) to lapping handle. Assemble guide sleeve to sprocket shaft bearing bushing. Sleeves, for use with tapered bearing, are assembled to case with bearings and small spacer collar. Finger-tighten the sleeve parts.
3. Insert lap shaft with arbor assembled through pinion bearing bushing and into guide sleeve. Tighten arbor expansion collars using a length of 0.156 in. (3.962 mm) rod as spanner until arbor begins to drag. Do not adjust arbor snug in bushing or bushing will "bell," a condition where hole is larger at ends than it is in the center.
4. Withdraw arbor far enough to coat lightly with 220 grit lapping compound. Do not apply a heavy coat. Reposition lap in bushing and turn handle at moderate hand speed. Work lap back and forth in bushing, as it is revolved, to avoid grooving and tapering.

At frequent intervals, remove lap from crankcase, wash and inspect bushing. Lapping is completed when entire bushing surface has a dull, satin finish rather than a glossy, smooth appearance. If necessary, flush off lap in cleaning solvent, air dry and apply fresh, light coat of fine lapping compound.

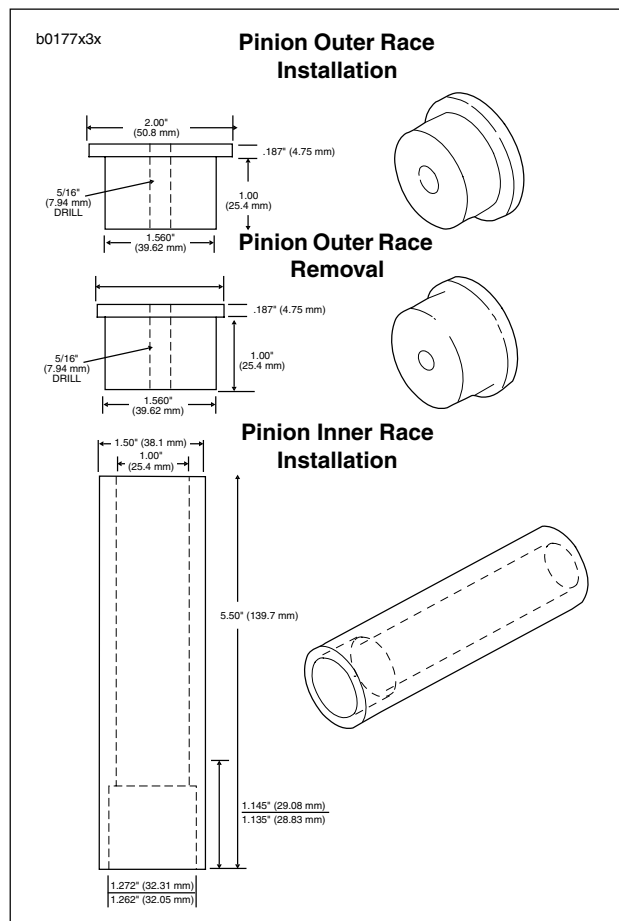


Figure 3-89. Pinion Shaft Bearing Tools

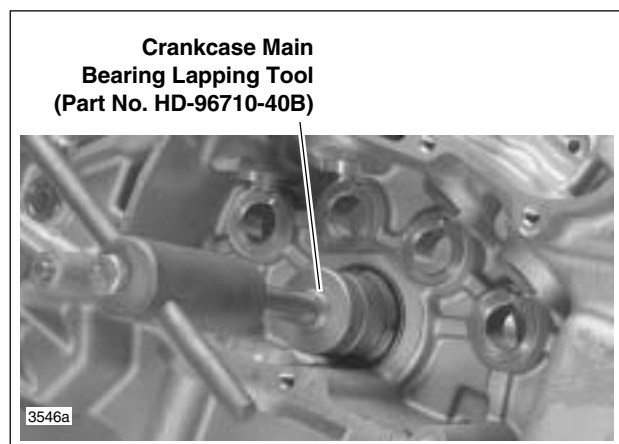


Figure 3-90. Lapping Pinion Shaft Main Bearing

**Table 3-13. Pinion Shaft Bearing Selection**

FACTORY STAMPED NUMBER	OUTER RACE ID	BEARING SIZE AS IDENTIFIED BY COLOR CODING										
	over 1.5672 in. 39.807 mm	Service Wear Limit Exceeded – Replace Outer Race and Resize										
	1.5670-1.5672 in. 39.802-39.807 mm											Red
	1.5668-1.5670 in. 39.797-39.802 mm										Red	Blue
	1.5666-1.5668 in. 39.792-39.797 mm									Red	Blue	White-Gray
	1.5664-1.5666 in. 39.787-39.792 mm								Red	Blue	White-Gray	Green
	1.5662-1.5664 in. 39.781-39.787 mm							Red	Blue	White-Gray	Green	
	1.5660-1.5662 in. 39.776-39.781 mm						Red	Blue	White-Gray	Green		
	1.5658-1.5660 in. 39.771-39.776 mm					Red	Blue	White-Gray	Green			
	1.5656-1.5658 in. 39.766-39.771 mm				Red	Blue	White-Gray	Green				
	1.5654-1.5656 in. 39.761-39.766 mm			Red	Blue	White-Gray	Green					
	1.5652-1.5654 in. 39.756-39.761 mm		Red	Blue	White-Gray	Green						
3	1.5650-1.5652 in. 39.751-39.756 mm	Red	Blue	White-Gray	Green							
2	1.5648-1.5650 in. 39.746-39.751 mm	Blue	White-Gray	Green								
1	1.5646-1.5648 in. 39.741-39.746 mm	White-Gray	Green									
INNER RACE OD (in)		1.2496-1.2498 in.	1.2498-1.2500 in.	1.2500-1.2502 in.	1.2502-1.2504 in.	1.2504-1.2506 in.	1.2506-1.2508 in.	1.2508-1.2510 in.	1.2510-1.2512 in.	1.2512-1.2514 in.	1.2514-1.2516 in.	1.2516-1.2518 in.
		31.740 31.745 mm	31.745 31.750 mm	31.750- 31.755 mm	31.755- 31.760 mm	31.760- 31.765 mm	31.765- 31.770 mm	31.770- 31.775 mm	31.775- 31.780 mm	31.780- 31.786 mm	31.786- 31.791 mm	3.791- 31.796 mm
FACTORY COLOR CODE		Green	White									



## ASSEMBLY

### Crankcase Halves

Lubricate all parts with Harley-Davidson 20W50 engine oil, and proceed as follows:

1. Install **new** snap ring to crankcase bore (if bearings were replaced).
  - a. Place the crankcase half on a flat surface with the outboard side facing up.
  - b. Obtain the two TIMKEN SNAP RING REMOVER/INSTALLER (HD-44069).
  - c. See [Figure 3-81](#). With the gap in the snap ring being the 12 o'clock position, place the two claws so that the slotted sides engage the inside edge of the snap ring at the 10 and 2 o'clock positions.
  - d. Using a 9/64 inch allen head bit, tighten the screws to fix the position of the claws on the snap ring.
  - e. See [Figure 3-82](#). Inserting the tips of a large retaining ring pliers (Snap-On PR-56A) into one hole in each claw, compress the snap ring and install in groove of crankcase bore.
  - f. See [Figure 3-91](#). Verify that the gap in the snap ring is centered below the oil hole at the top of the ring groove. Move snap ring if not properly centered.
  - g. Loosen allen head screws and remove claws from snap ring.

#### NOTE

See [Figure 3-92](#). Use *SPROCKET SHAFT BEARING OUTER RACE INSTALLATION TOOL* (1, 2) (Part No. HD-39458) to install left and right outer races (4, 5) of sprocket shaft tapered roller bearings into left crankcase half (6). Always install left outer race (4) prior to installing right outer race (5) because the installer base (1) is usable only when you follow this sequence of race installation.

2. Insert "SPORTSTER" end of installer base (1) into inboard side of left crankcase half (6) bearing bore until base contacts installed retaining ring (3).
3. Position left outer race (4) over bearing bore on outboard side of left crankcase half (6).
4. Insert shaft of installer plug (2) through left outer race (4) and into installer base (1). Press race into bore until firmly seated against retaining ring (3).
5. Insert "SPORTSTER" end of installer base (1) into outboard side of left crankcase half (6) bearing bore until base contacts outboard surface of installed left outer race (4).
6. Position right outer race (5) over bearing bore on inboard side of left crankcase half (6).
7. Insert shaft of installer plug (2) through right outer race (5) and into installer base (1). Press race into bore until firmly seated against retaining ring (3).

#### NOTE

See [Figure 3-93](#). Use *SPROCKET SHAFT BEARING/SEAL INSTALLATION TOOL* (Part No. HD-42579) to install sprocket shaft tapered roller bearings and seal.

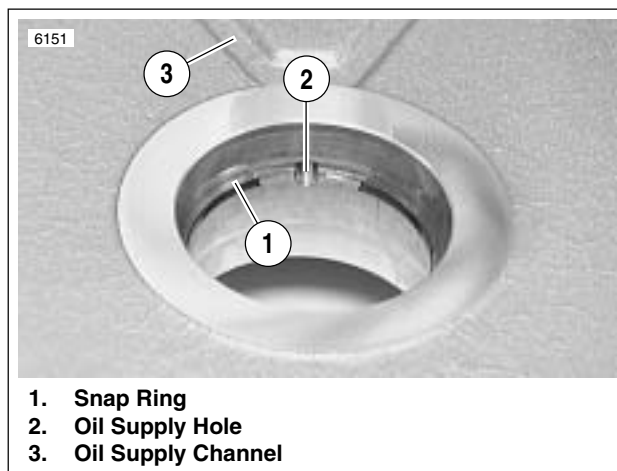


Figure 3-91. Snap Ring

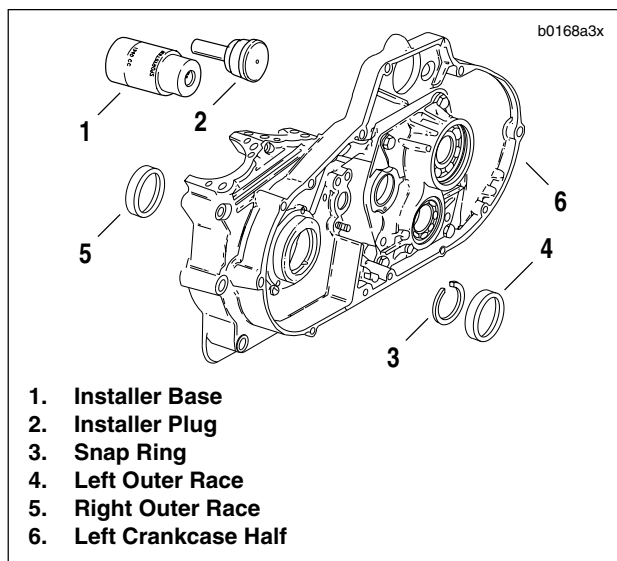


Figure 3-92. Installing Sprocket Shaft Bear Outer Races

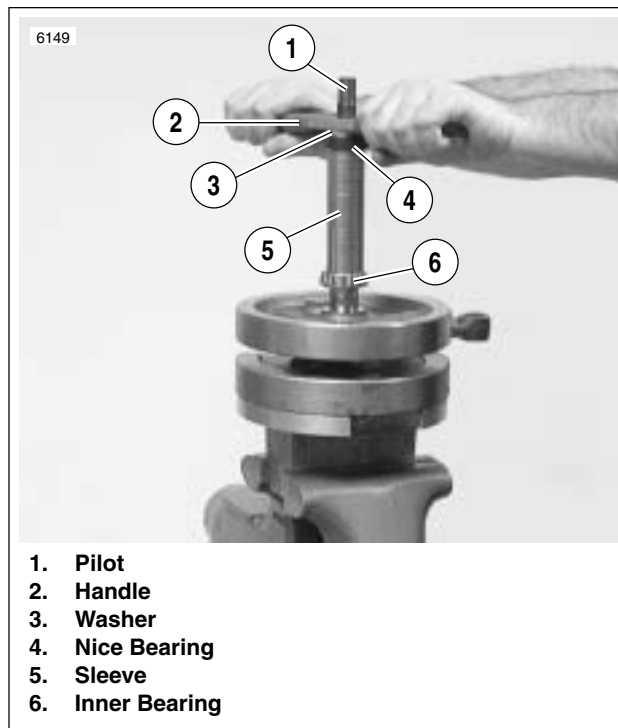


8. Install inner bearing (6).
  - a. Place **new** bearing, small end upward, over end of sprocket shaft.
  - b. Thread pilot (1) onto sprocket shaft until pilot bottoms on sprocket shaft shoulder.
  - c. Sparingly apply graphite lubricant to threads of pilot shaft to ensure smooth operation.
  - d. Slide sleeve (5) over pilot (1) until sleeve contacts inner bearing race. Install Nice bearing (4), washer (3) and handle (2) on top of sleeve.
  - e. Rotate handle clockwise until bearing (6) contacts flywheel shoulder. Remove tool from sprocket shaft.
9. See [Figure 3-78](#). Install shim and outer bearing.
  - a. See [Figure 3-94](#). Carefully place crankcase half over sprocket shaft so that it rests flat on inner bearing.
  - b. Slide **new** inner spacer over sprocket shaft until it contacts inner bearing race.
  - c. Place **new** outer bearing, small end downward, over sprocket shaft.
  - d. Assemble SPROCKET SHAFT BEARING/SEAL INSTALLATION TOOL (Part No. HD-42579) onto sprocket shaft. Follow procedure in Step 8.
  - e. Rotate handle clockwise until bearing firmly contacts inner spacer. Inner and outer bearings must be tight against inner spacer for correct bearing clearance. Remove tool from sprocket shaft.
  - f. Spin crankcase half to verify that flywheel assembly is free.
10. See [Figure 3-95](#). Install **new** spacer in seal ID. With the open (lipped) side facing outward, center seal/spacer assembly over bearing bore.

### CAUTION

**Do not remove the spacer after installation or the new seal will have to be discarded and the procedure repeated.**

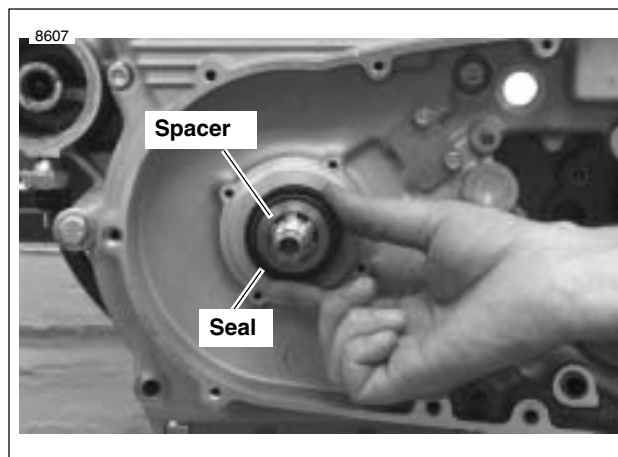
11. See [Figure 3-96](#). Install bearing seal and spacer.
  - a. Center seal/spacer driver (2) over seal, so that the sleeve (smaller OD) seats between seal wall and garter spring.
  - b. Assemble SPROCKET SHAFT BEARING/SEAL INSTALLATION TOOL (1) (Part No. HD-42579) and SPROCKET SHAFT SEAL/SPACER INSTALLER (Part No. HD-45206) onto sprocket shaft. Follow procedure in Step 8.
  - c. Rotate handle clockwise until the spacer makes contact with the bearing. Remove tool from sprocket shaft.



**Figure 3-93. Inner Bearing Installation (Typical)**



**Figure 3-94. Installing Flywheel Spacer and Outer Bearing**



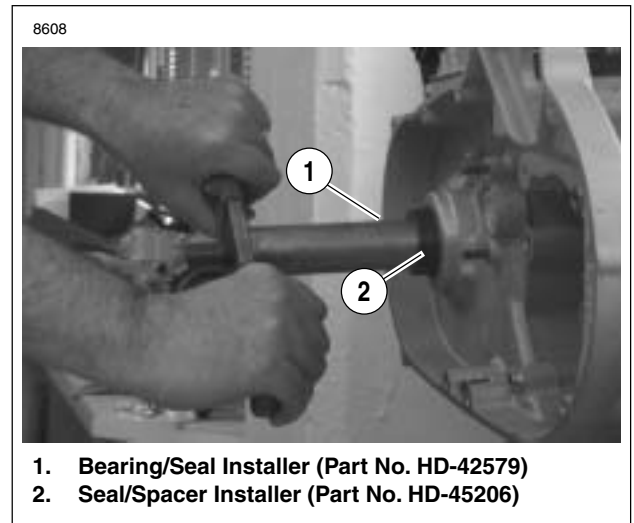
**Figure 3-95. Install Spacer in Seal**

12. See [Figure 3-97](#). Install pinion shaft bearing.
  - a. Lubricate pinion shaft bearing with engine oil.
  - b. Slip bearing on pinion shaft.
  - c. Install **new** retaining ring in groove of pinion shaft bearing inner race.
13. Assemble crankcase halves together.
  - a. Apply a thin coat of DOW CORNING SILASTIC or 3-M 800 sealant to crankcase joint faces.
  - b. Slide pinion shaft through outer race in right crankcase.
  - c. Attach crankcase halves using hardware shown in [Figure 3-76](#).
  - d. Tighten the 3/8-in. fasteners to 22-27 ft-lbs (30-37 Nm)
  - e. Tighten the 5/16-in. fasteners to 15-19 ft-lbs (20-26 Nm).
14. See [Figure 3-98](#). Install cylinder studs.
  - a. Pack clean towels into crankcase opening.
  - b. Place a steel ball into a head screw (1).
  - c. The cylinder studs (2) have a shoulder (3) at the lower end. Place the end of the stud without the shoulder into the head screw.
  - d. Install the stud in the crankcase with the shoulder end down. Use an air gun (4) to drive the stud until the shoulder reaches the crankcase.
  - e. Remove air gun. Use a torque wrench to tighten stud to 10-20 ft-lbs (14-27 Nm).
15. Install pistons and cylinders. See [3.6 CYLINDER AND PISTON](#).
16. Install oil pump. See [3.13 OIL PUMP](#).
17. Install cam gears, gearcase cover, lifter guides and lifters. See [3.16 GEARCASE COVER AND CAM GEARS](#).
18. Install cylinder heads. See [3.5 CYLINDER HEAD](#).
19. Install starter. See [5.7 STARTER](#).
20. Install transmission. See [6.13 TRANSMISSION INSTALLATION AND SHIFTER PAWL ADJUSTMENT](#).
21. Install all primary drive components. This includes engine sprocket, primary chain, complete clutch assembly, engine sprocket nut and mainshaft nut. See [6.5 PRIMARY DRIVE/CLUTCH](#).
22. Install primary cover. See [PRIMARY COVER](#) under [6.2 PRIMARY CHAIN](#).

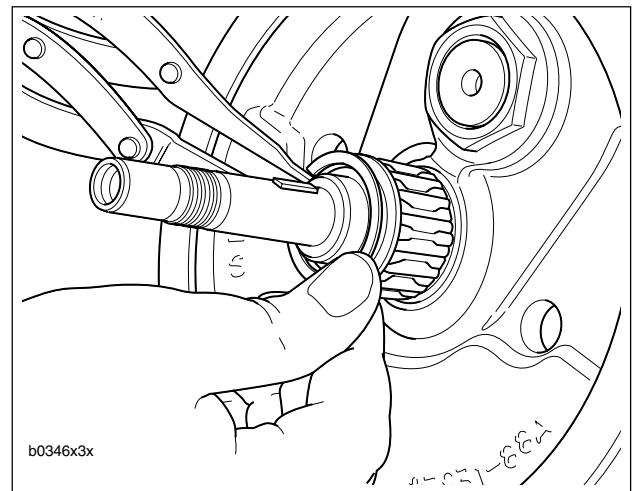
**NOTE**

*Be sure to refill transmission to proper level with fresh lubricant. See [1.10 CLUTCH](#).*

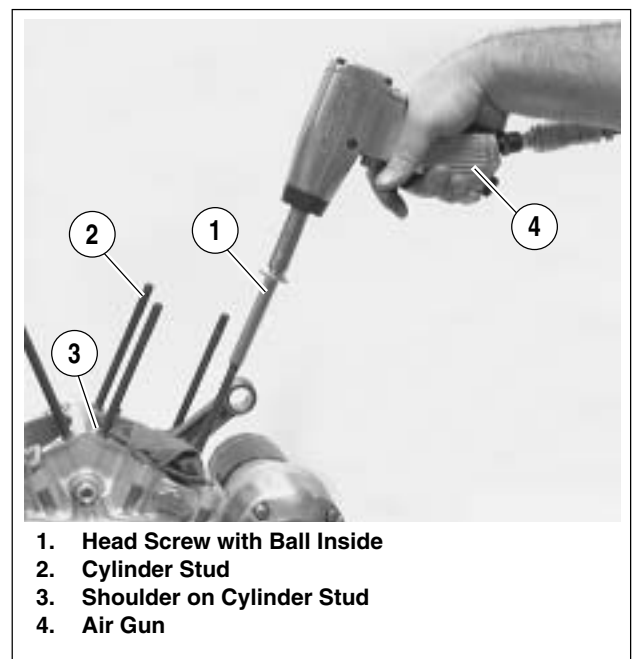
23. See [3.4 INSTALLING THE ENGINE](#) and perform the applicable steps.



**Figure 3-96. Install Bearing Seal/Spacer**



**Figure 3-97. Pinion Shaft Bearing**



**Figure 3-98. Cylinder Studs**

# NOTES

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