

CHECKING AND ADDING OIL

Check engine oil level in oil reservoir 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. Check oil when engine is warmed up to operating temperature (see Hot Check).

CHANGING OIL AND FILTER

After a new engine has run its first 1000 miles (1600 km) and at 5000 miles (8000 km) intervals or annually thereafter, completely drain oil reservoir of used oil. If riding habits include severe dust conditions, operation at temperature above 80° F (26.7° C), extensive idling, speeds in excess of 65 mph (105 kph) and/or extensive two up riding or similar loads the oil should be changed at 2500 mile (4000 km) intervals. Refill with fresh oil. Always change oil filter when changing engine oil.

NOTE

See [1.7 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 reservoir. 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 3-110](#). Engine oil runs through the swingarm which serves as the oil reservoir. From the front of the reservoir, the vent hose, the return hose and the feed hose run downward below the crankcases. Two rubberized clamps secure the hoses in place.

The feed line exits the front of the oil pump and routes across

the front of the engine to the oil cooler on the left front side of the crankcases. The feed line then exits the oil cooler and connects to the oil filter housing on the right front side of the crankcases.

The vent hose continues upward from under the vehicle to connect to an elbow fitting at the rear of the gearcase cover.

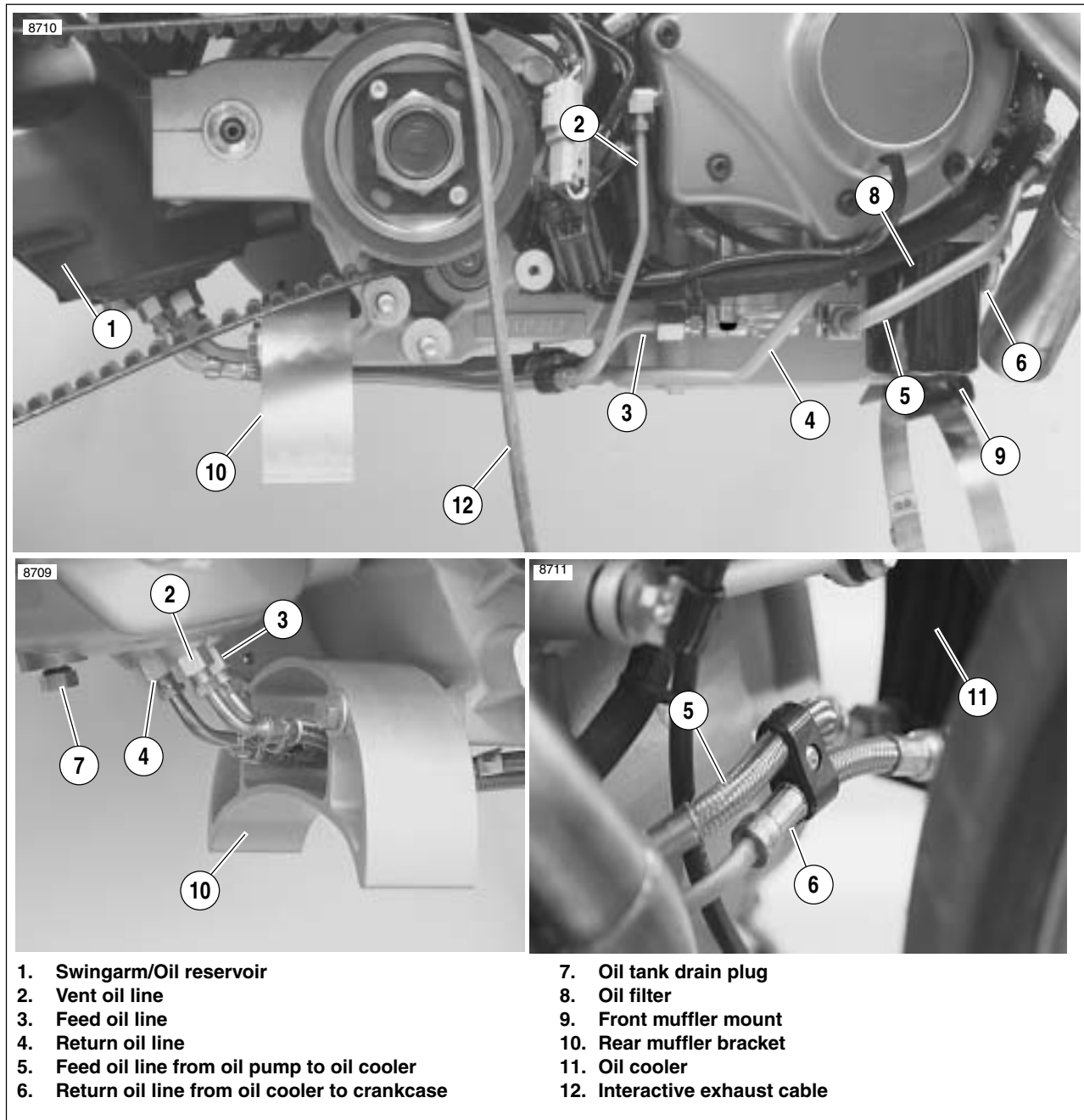


Figure 3-110. Oil Lines and Connections

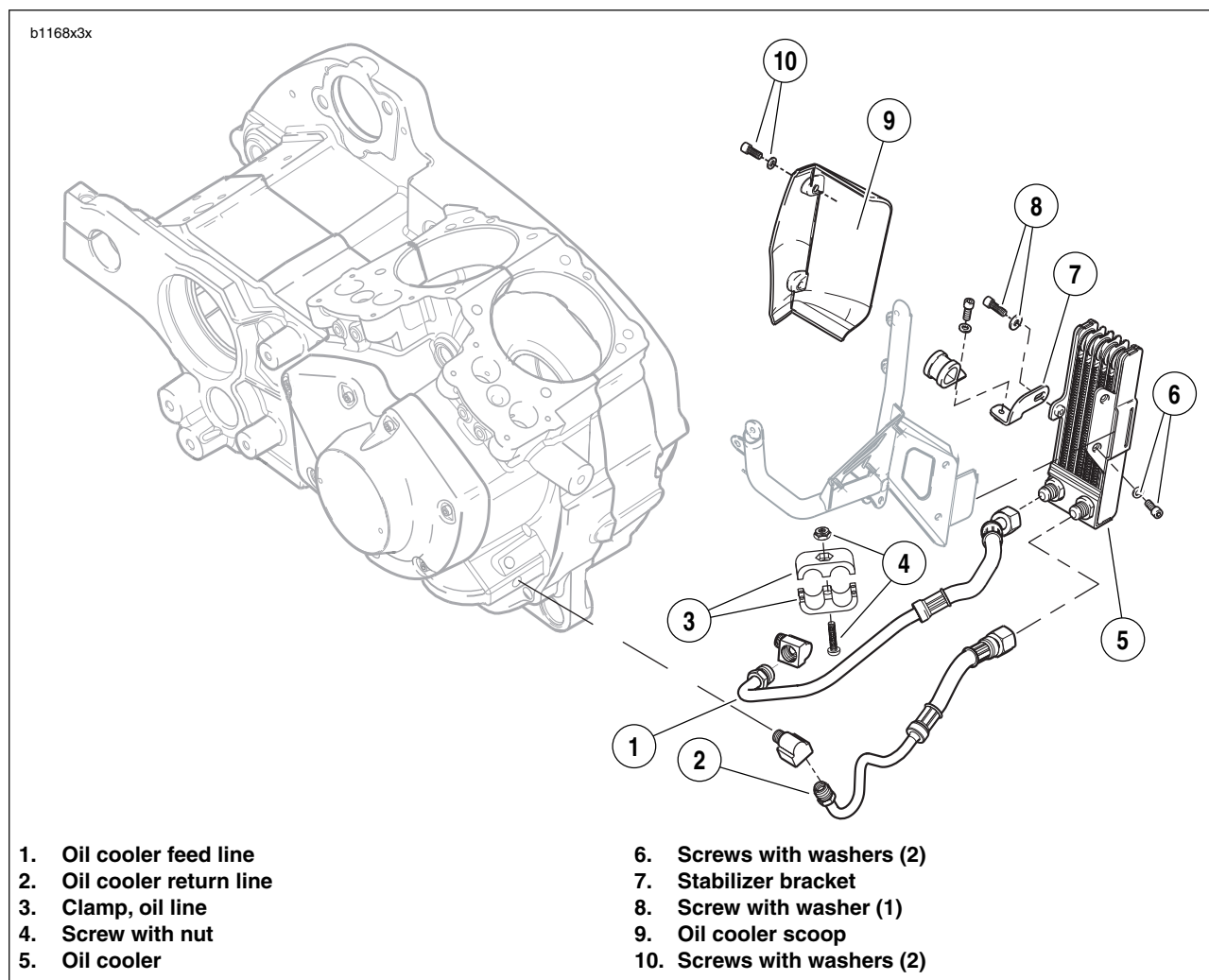


Figure 3-111. Oil Cooler

GENERAL

For engine oil flow through the engine, See [3.13 OILING SYSTEM](#).

See [Figure 3-111](#). The XB9/12 models are equipped with a factory installed oil cooler.

Engine oil flows from the oil pump to the oil cooler through a supply hose. The oil circulates through the finned tubes of the cooler to dissipate heat and returns to the oil filter mount through a return hose.

REMOVAL

1. Cover the front chin fairing to protect finish.

IMPORTANT NOTE

Dispose of oil in accordance with local regulations.

2. Place a container under the motorcycle to catch excess oil.
3. Remove clamp (3) from oil cooler oil lines.
4. Loosen oil cooler return line (2) at oil cooler. Do not disconnect.
5. Loosen oil cooler feed line (1) at oil cooler. Do not disconnect.
6. Remove two fasteners (10) securing the oil cooler scoop (9) and remove scoop.

NOTE

Place protective covering over primary cover to prevent cosmetic damage when removing and installing fastener for stabilizer bracket.

7. Remove fastener (8) securing oil cooler to stabilizer bracket.
8. Remove the fasteners (6) holding the oil cooler (5) to mounting bracket.
9. Slightly move oil cooler towards you and disconnect both oil lines from oil cooler before removing from bracket.

NOTE

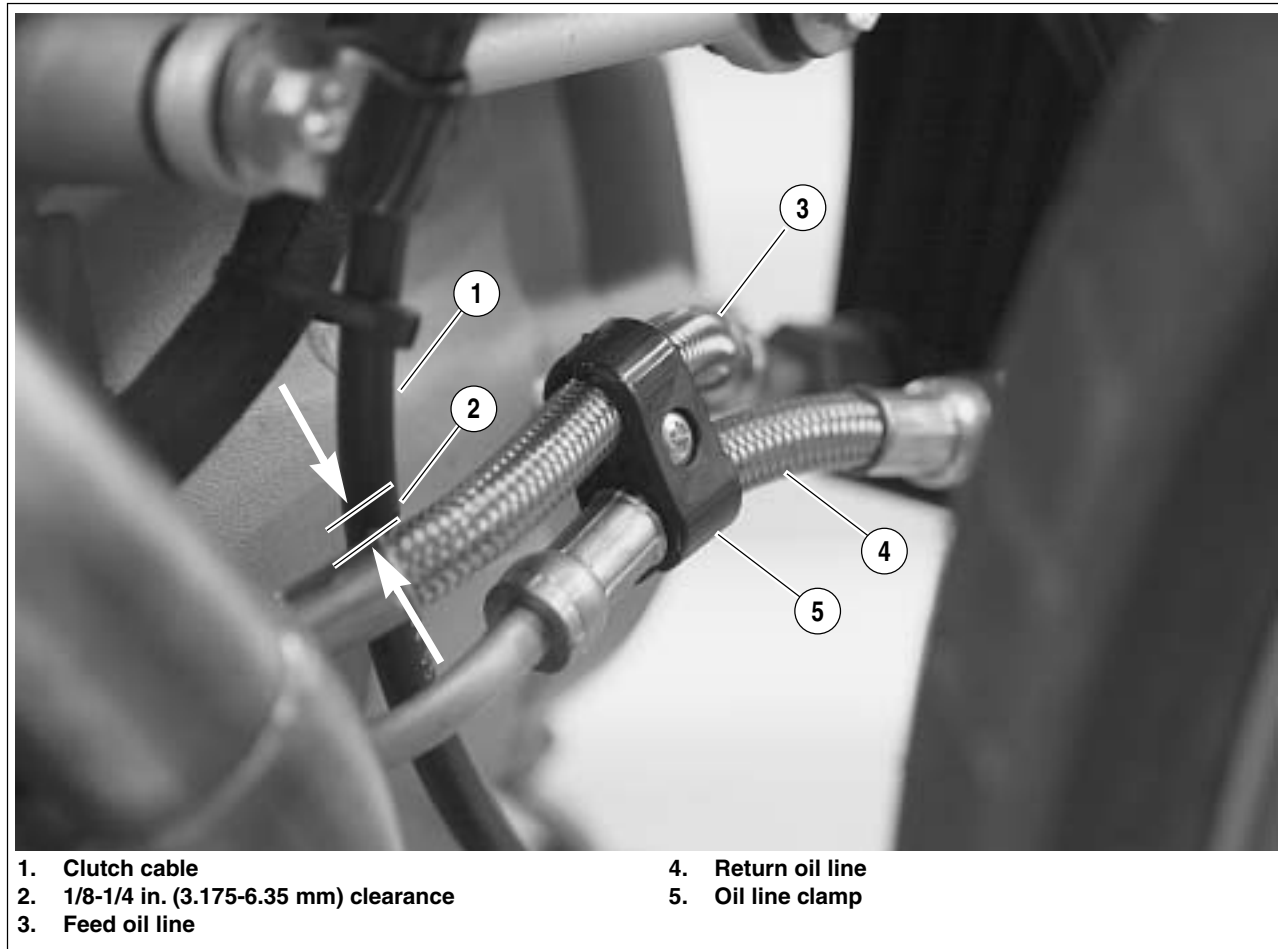
The oil cooler should be checked for dirt and debris.

INSTALLATION

1. See [Figure 3-111](#). Lightly coat the threads of the oil cooler fittings with clean H-D 20W50 engine oil. Wipe off any excess oil.
2. While sliding the oil cooler back onto the bracket, loosely install the feed oil line to the rear fitting on the oil cooler

and return oil line to the front fitting on the oil cooler. Do not tighten.

3. After the oil cooler is in place, apply Loctite 272 to the two fasteners (6) and tighten to 120-144 **in-lbs** (13.6-16.3 Nm).
4. Apply Loctite 272 to the stabilizer bracket fastener (8) and tighten to 66-78 **in-lbs** (7.5-8.8 Nm).
5. Install oil cooler scoop and apply Loctite 272 to the two fasteners (10) and tighten to 120-144 **in-lbs** (13.6-16.3 Nm).
6. Tighten feed oil line to 19-21 ft-lbs (25.8-28.5 Nm) at oil cooler.
7. Tighten return oil line to 19-21 ft-lbs (25.8-28.5 Nm) at oil cooler.
8. See [Figure 3-112](#). Verify that the clutch cable and feed line have a clearance of 1/8-1/4 in. (3.175-6.35 mm) between them.
9. Install oil line clamp and tighten.



1. Clutch cable
2. 1/8-1/4 in. (3.175-6.35 mm) clearance
3. Feed oil line

4. Return oil line
5. Oil line clamp

Figure 3-112. Oil Cooler Oil Lines and Clamp

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 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 in the running engine.
- Engine is idling 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 3-24](#).

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 3-113](#). The oil pump is non regulatory 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).

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-96921-52B) and OIL PRESSURE GAUGE ADAPTER (Part No. HD-96940-58). Remove oil pressure indicator switch and insert pressure gauge fitting.

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 10-12 psi (69-83 kPa). At idle speed (1050-1150 RPM), oil pressure will vary from 6-8 psi (42-55 kPa).

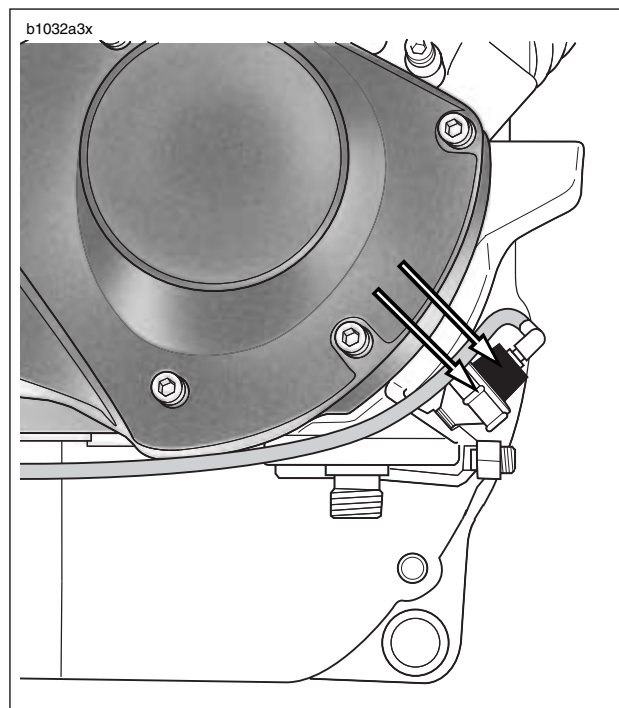


Figure 3-113. Oil Pressure Indicator Switch

Table 3-24. Troubleshooting Oil Pressure Signal Light

OIL PRESSURE SIGNAL LIGHT	PROBABLE CAUSES
Stays on at speeds above idle.	<ul style="list-style-type: none"> ● Empty oil reservoir. ● Clogged feed line (ice and sludge, freezing temperatures). ● Air-bound oil line. ● Grounded oil switch wire. ● Malfunctioning signal switch. ● Diluted oil. ● Malfunctioning check valve (see 3.15 OIL FILTER MOUNT).
Flickers at idle.	<ul style="list-style-type: none"> ● Incorrect idle speed. Malfunctioning or improperly installed check valve (see 3.15 OIL FILTER MOUNT).
Does not glow when ignition is turned on (prior to operating engine).	<ul style="list-style-type: none"> ● Malfunctioning signal switch. ● Malfunction in wiring. ● Burned-out signal bulb. ● Dead battery (see NOTE).

GENERAL

See Figure 3-114. Pressure created in the flywheel area on piston downstroke is released through the **reed valve** into the gearcase. From there a mixture of crankcase air and oil mist is vented up the push rod covers to the upper rocker box.

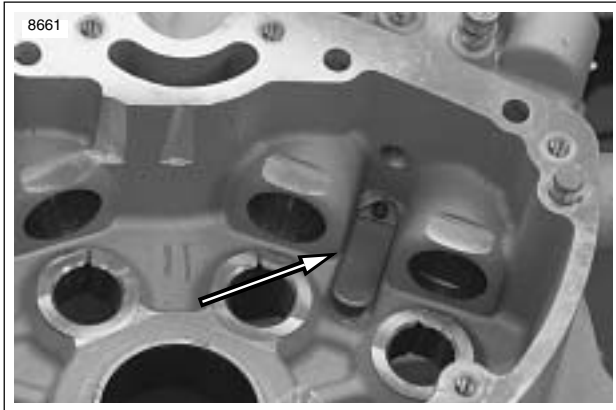


Figure 3-114. Reed Valve Assembly in Gearcase

See Figure 3-115. Air is allowed to escape the rocker boxes by exiting the positive crankcase vent (PCV) valves (4) located on top of the rocker boxes. From the PCV valves the air enters the crankcase breather hoses (2 & 3). The crankcase breather hoses route through the air cleaner base plate (1) to the air box where it is directed inside the air filter element and back into the engine.

The oil mist collects and eventually returns to the crankcase through oil passageways in the cylinder head.

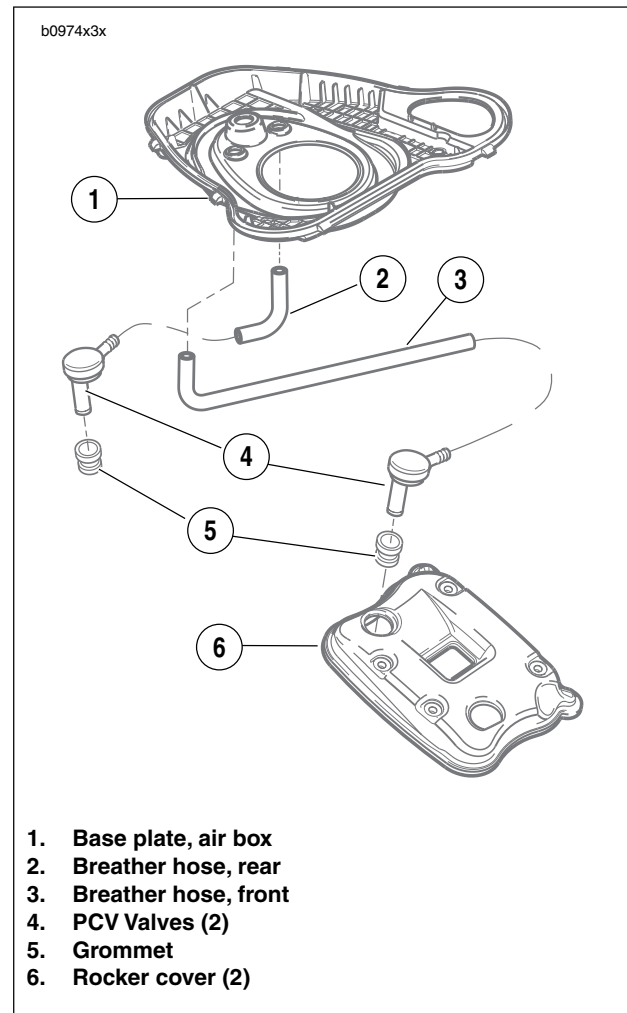


Figure 3-115. Crankcase Breathing System

Reed Valve Replacement

NOTES

- See [Figure 3-117](#). The reed valve (2) is what moves out with the downstroke and in with the upstroke of the pistons. The reed valve stop (1) limits the movement the reed valve (2). See [3.12 CRANKCASE BREATHING SYSTEM](#).
- Whenever the gearcase cover is removed, the reed valve should always be inspected for cracks, chips and breakage.
- Fasteners should be tightened to 30-40 **in-lbs** (3.4-4.5 Nm).

CAUTION

See [Figure 3-117](#). When replacing the reed valve it is extremely important to ensure that both edges of the reed valve stop (1) and the reed valve (2) are properly aligned to prevent premature failure of the reed valve. When replacing the reed valve it is not necessary to replace the reed block. See [Figure 3-116](#).

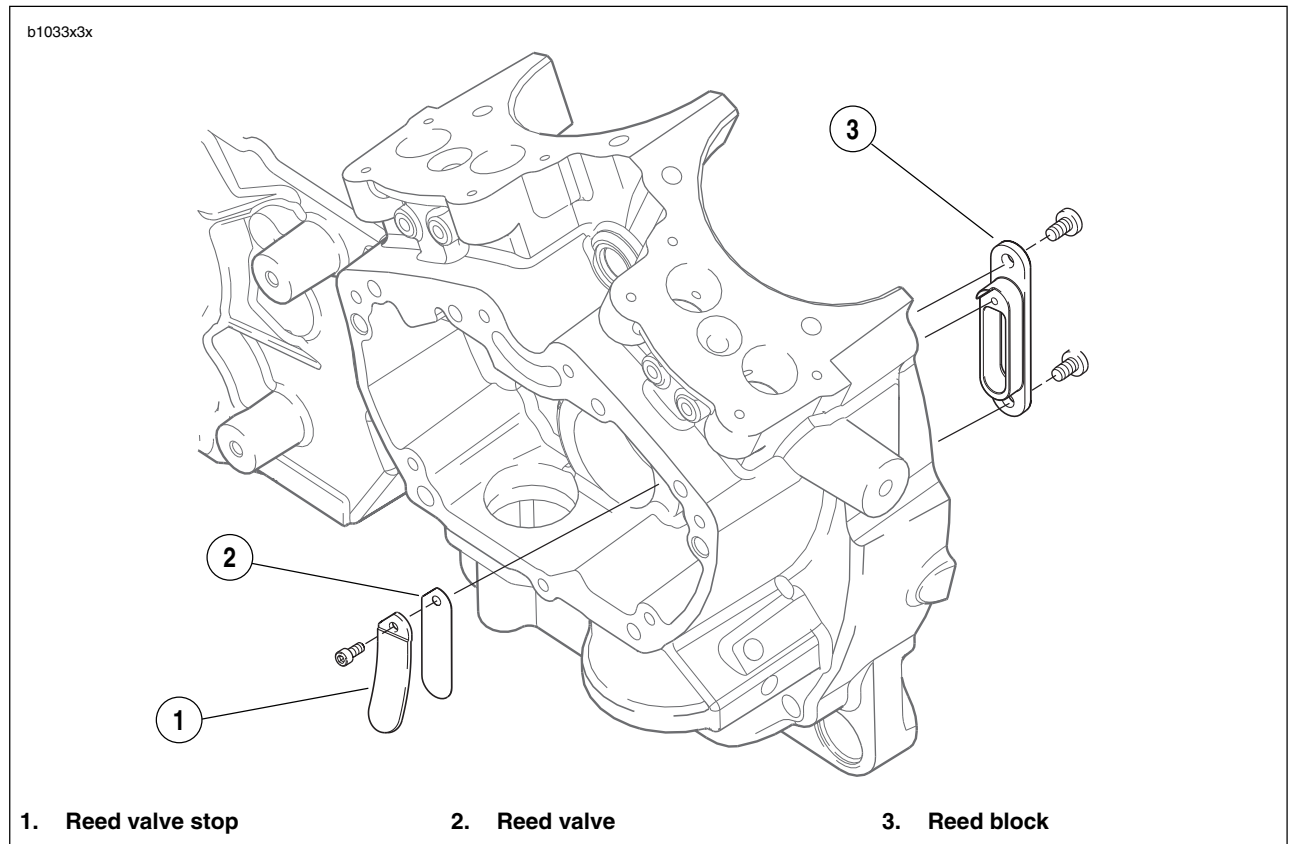


Figure 3-116. Reed Valve Assembly

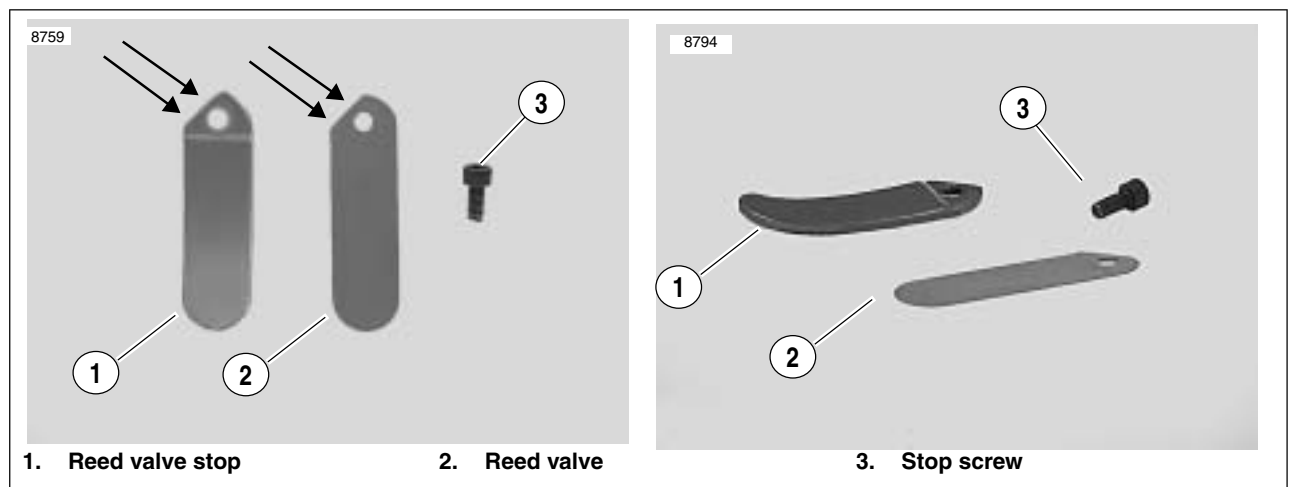


Figure 3-117. Reed Valve Stop and Reed Valve

GENERAL

1. Oil is gravity-fed from the oil reservoir 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 3.14 OIL PUMP for a complete explanation of the gerotor pump sets.

2. The feed pump transfers oil from the inlet cavity through the external steel line to the oil cooler.
3. From the oil cooler oil flows to the oil filter mount.
4. Through the filter mount cavity oil flows to the oil filter.
5. 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).
6. Adequate oil pressure in the filter mount cavity activates the oil pressure signal light switch and shuts off the oil pressure signal light.
7. Oil flowing from the filter adapter opens the check ball. The check ball opens at 4-6 psi (28-41 kPa) oil pressure.
8. With the check ball open, oil flows into the crankcase feed galley.
9. Oil enters an intersecting passage in the gearcase cover and flow is then routed to the pinion bushing.
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 flow then continues through the gearcase cover to the main feed galley at the top of the gearcase cover. Drilled passages in the crankcase intersect the main feed galley and carry oil to all hydraulic lifters and piston jets.
12. Oil flows up passages in the push rods to the rocker arm shafts and bushings.
13. The valve stems are lubricated by oil supplied through drilled oil holes in the rocker arms.
14. Oil collected in the push rod areas of the cylinder heads flows down the push rod cover, through drain holes in the tappet blocks and into the gearcase. After providing lubrication to the gearcase components oil returns to the scavenge section of the oil pump through a passage located in the top of the pump. Oil is then returned to the oil tank.
15. Feed oil to the rocker area is returned to the crankcase through a passage in the head and cylinder.
16. Oil collected in the sump is splash-fed to the pistons, cylinder walls and flywheel components.
17. A pair of piston oil jets cools the bottom of the piston with a spray of oil.
18. 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.
19. Return oil fills a cavity above the pump's return gears. The return gears pump oil back to the oil reservoir.

GENERAL

See [Figure 3-118](#). The oil pump consists of two gerotor gear sets, feed and return, housed in one pump body. The feed set distributes oil to the engine, the scavenge set returns oil to the tank/frame reservoir.

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.

Gravity-fed oil from the oil reservoir enters the pump through the feed line connector. It is forced by the gerotor feed set through a line to the oil filter. Return oil from the flywheel compartment is drawn back into the pump and is forced by the gerotor scavenge set back to the oil reservoir.

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

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

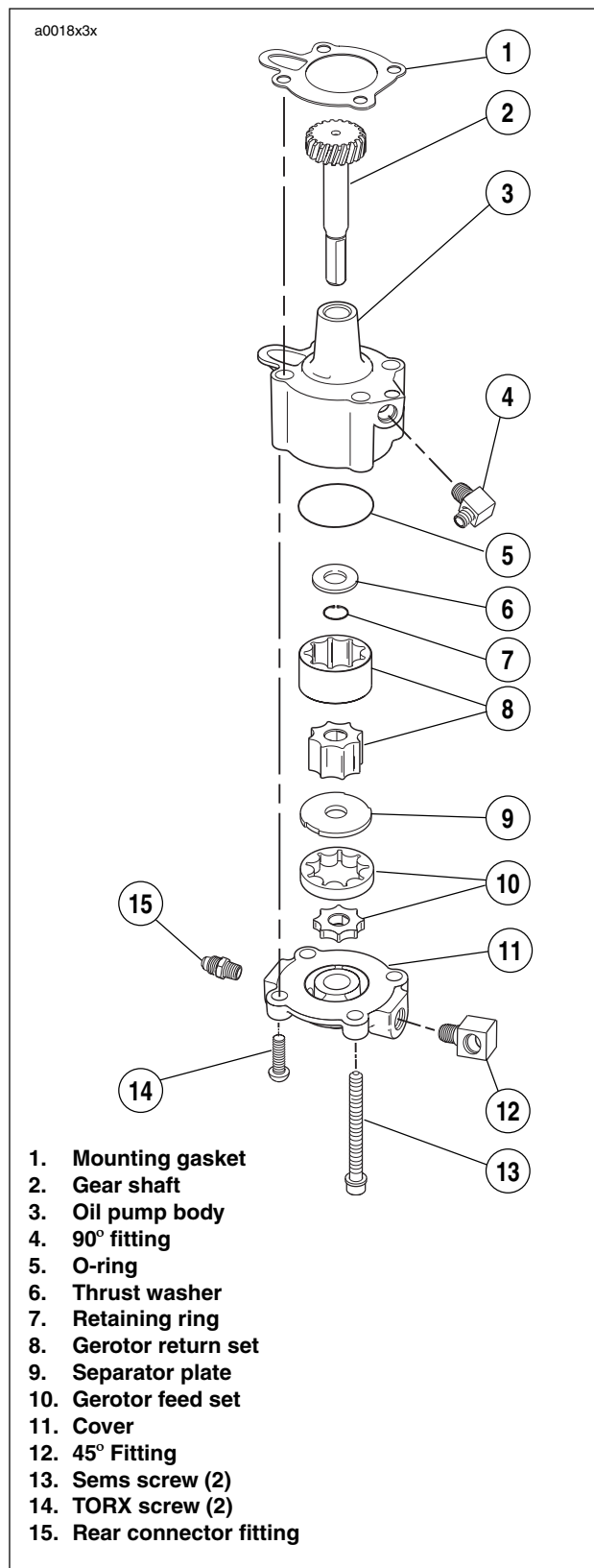


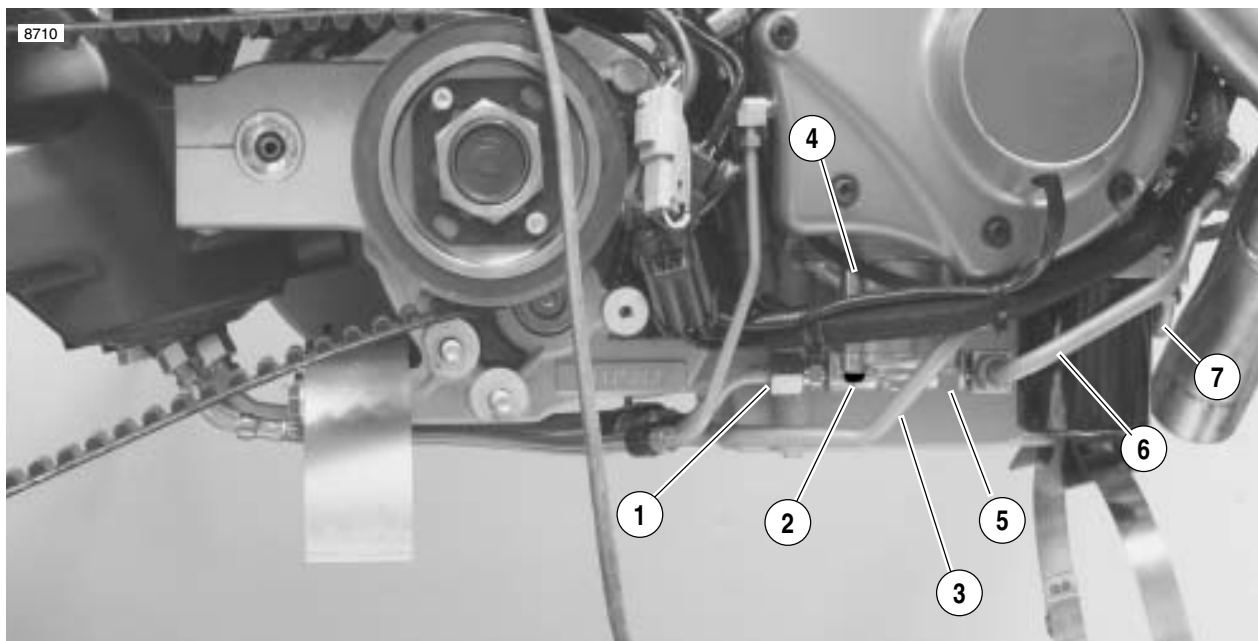
Figure 3-118. Oil Pump

REMOVAL/DISASSEMBLY

NOTE

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

1. Drain oil reservoir. See [1.7 ENGINE LUBRICATION SYSTEM](#).
2. Remove and discard oil filter.
3. See [Figure 3-119](#). Disconnect feed line connections (1, 6) on both sides of the oil pump.
4. Detach return line connection (3).
5. Carefully remove mounting screws (5) and washers only. Pump will drop with screws removed. Discard mounting gasket.
6. Remove cover TORX screws (2). Lift cover off body.
7. Remove and discard O-ring.
8. Slide both pieces of gerotor feed set, separator plate and both pieces of gerotor scavenge set off gear shaft.
9. Remove and discard retaining ring. Remove thrust washer and gear shaft.



1. Feed line connection
2. Cover TORX screw (2)
3. Return line
4. Oil pump
5. Mounting screw and washer (2)
6. Steel line connection to oil cooler
7. Connection from oil cooler to oil filter housing

Figure 3-119. Oil Pump Hardware

CLEANING AND INSPECTION

1. Clean all parts in cleaning solvent. Blow out holes and oil passages with compressed air.

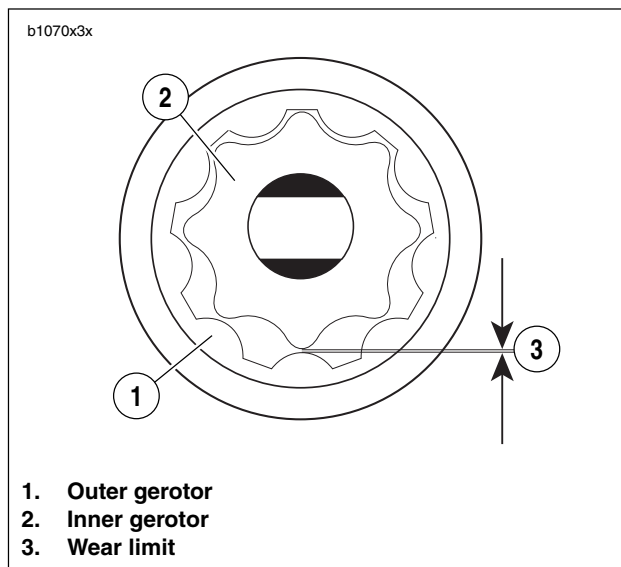


Figure 3-120. Gerotor Wear Limits

2. See Figure 3-120. 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 3-118. Check gear shaft teeth for damage or wear. Replace if necessary.

ASSEMBLY/INSTALLATION

NOTE

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

1. See Figure 3-118. Install gear shaft through body. Position thrust washer over end of shaft. Install **new** retaining ring into groove in shaft.
2. Insert inner gerotor of the gerotor scavenge set over gear shaft.
3. Place outer gerotor over inner gerotor to complete scavenge set.

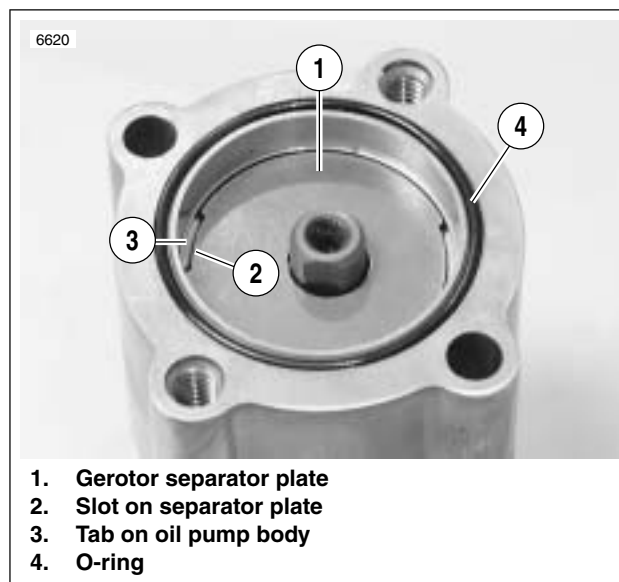


Figure 3-121. Separator Plate Slots

4. See Figure 3-121. Install gerotor separator plate by lining up slots on perimeter with tabs inside oil pump body.
5. Install a **new** O-ring into groove in pump body.
6. See Figure 3-118. Place gerotor feed set over gear shaft.
7. Place cover onto pump body. Install cover TORX screws. Tighten to 70-80 **in-lbs** (8-9 Nm).
8. Place **new** mounting gasket in position.

NOTE

If fittings were removed, use TEFLON® PIPE SEALANT or HYLOMAR® on fitting threads.

9. Secure pump to crankcase with mounting screws. Tighten to 125-150 **in-lbs** (14-17 Nm).
10. See Figure 3-119. Attach return line connection.
11. Attach feed line connections to both sides of the oil pump.
12. Install **new** oil filter and fill oil reservoir with proper oil. See 1.7 ENGINE LUBRICATION SYSTEM.

GENERAL

See [Figure 3-122](#). Oil is pressure-fed from the oil pump to the oil cooler via an external steel line. From the oil cooler, oil flows to the oil filter mount. Oil travels through the filter mount into the filter through the outer filter holes.

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

The check ball in the filter adapter opens at 4-6 psi (28-41 kPa) oil pressure. Filtered oil leaves the filter, flowing past the check ball.

DISASSEMBLY

1. Remove chin fairing. See [2.36 CHIN FAIRING](#).
2. Drain oil reservoir and remove filter. See [1.7 ENGINE LUBRICATION SYSTEM](#).
3. See [Figure 3-122](#). Remove filter adapter (6) from filter mount (3). Remove check ball (5) and spring (4).
4. Detach indicator lamp wire (2) from oil pressure indicator switch (1). Remove switch using OIL PRESSURE SENDING UNIT WRENCH (Part No. HD-41675).

CLEANING AND INSPECTION

WARNING

Compressed air can pierce the skin and flying debris from compressed air could cause serious eye injury. Wear safety glasses when working with compressed air. Never use your hand to check for air leaks or to determine air flow rates. (00061a)

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. See [Figure 3-122](#). Install oil pressure indicator switch (1) using OIL PRESSURE SENDING UNIT WRENCH (Part No. HD-41675). Tighten to 50-70 **in-lbs** (6-8 Nm).
2. Attach indicator lamp wire (2).

NOTE

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

3. Apply several drops of *LOCTITE 243* (blue) to last few threads on that end of the filter adapter which is installed into filter mount. Do not apply *LOCTITE* to adapter threads on filter element side.

4. Install filter mount components.
 - a. Place spring (4) and check ball (5) into threaded hole at center of mount.
 - b. Push threaded end of filter adapter (6) (with *LOCTITE*) against check ball to compress spring.
 - c. Screw adapter into threaded hole. Tighten to 96-144 **in-lbs** (11-16 Nm).
5. Install a **new** filter and fill oil reservoir with proper oil. See [1.7 ENGINE LUBRICATION SYSTEM](#).
6. Install chin fairing. See [2.36 CHIN FAIRING](#).

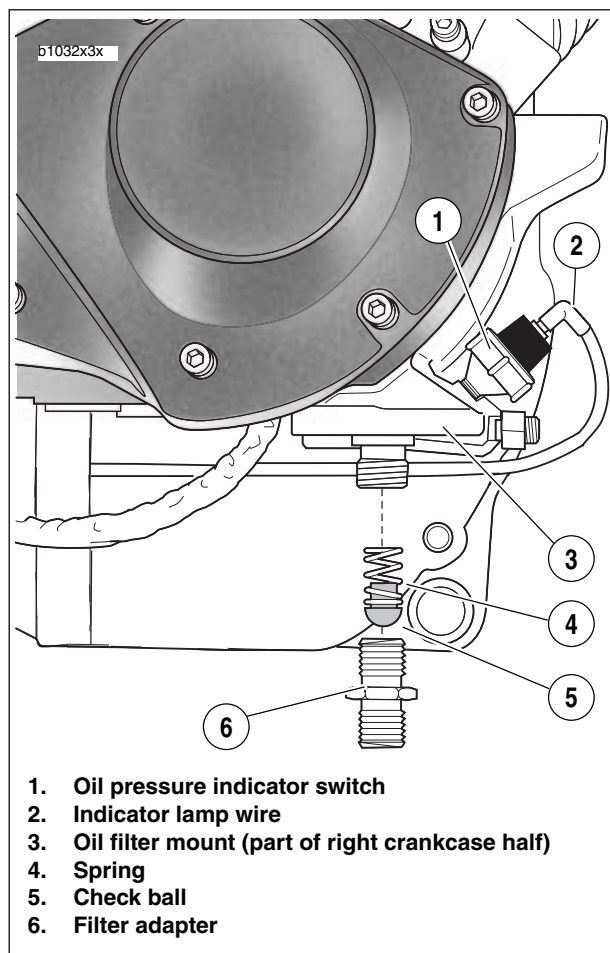


Figure 3-122. Oil Filter Mount Assembly

GENERAL

See [Figure 3-123](#). The lifter assembly consists of a hydraulic 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 lifter 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. Hydraulic lifters have a definite leak-down 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.

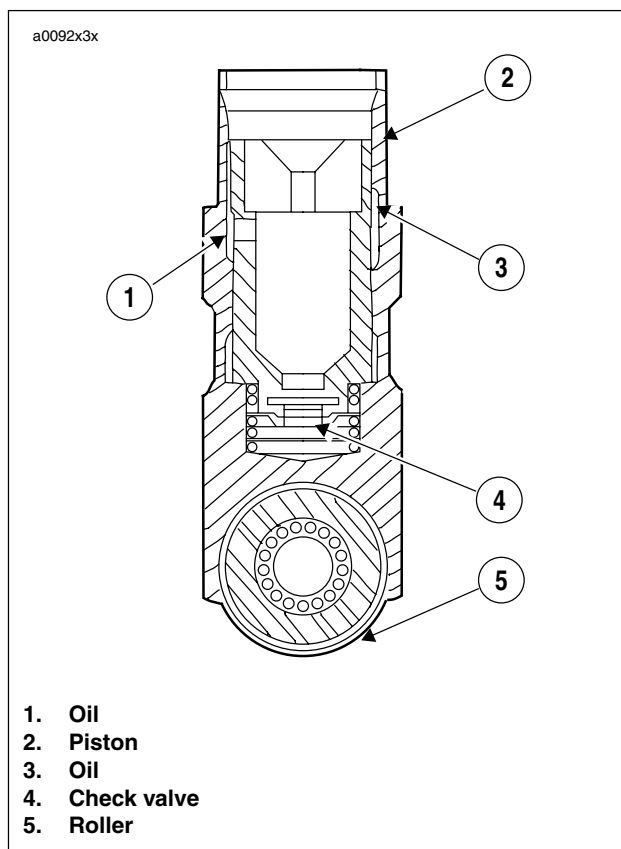


Figure 3-123. Lifter Assembly (Typical)

REMOVAL

1. Clean all dirt from around crankcase. Blow loose particles from area with compressed air.
2. Pull each push rod upward through top of cylinder head. See [3.6 CYLINDER HEAD](#).
3. Remove cylinder head assemblies. See [3.6 CYLINDER HEAD](#).
4. See [Figure 3-125](#). Remove push rod covers.
 - a. Remove screws.
 - b. Remove push rod covers.
 - c. Remove gaskets and o-rings. Discard parts.
5. Remove valve hydraulic lifters.
 - a. Remove anti-rotation screws.
 - b. Remove lifters from crankcase bore using a thin-bladed screwdriver. Mark the location and orientation (front/back) of each lifter.

CLEANING AND INSPECTION

WARNING

Compressed air can pierce the skin and flying debris from compressed air could cause serious eye injury. Wear safety glasses when working with compressed air. Never use your hand to check for air leaks or to determine air flow rates. (00061a)

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

NOTE

Inside and outside micrometers used for measuring tappets and tappet guides must be calibrated to ensure accurate readings.

2. Inspect valve 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).
3. Check lifter roller free play.
 - 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 3-124](#). Rotate engine so that both lifters from the cylinder will be installed on the base circle of the cam.

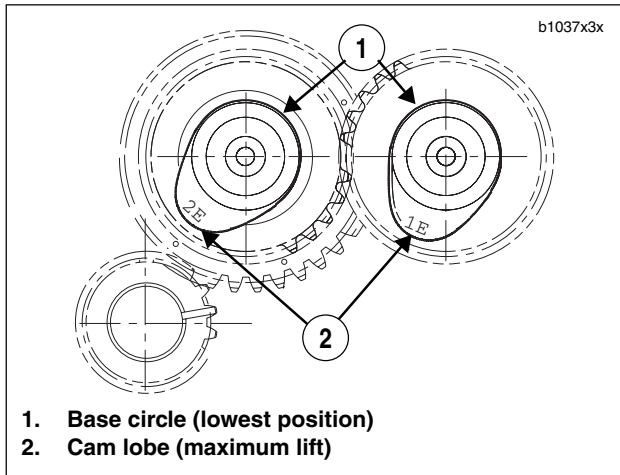


Figure 3-124. Base Circle

2. Apply a liberal amount of engine oil to each lifter assembly (especially the roller needles) for smooth initial operation.
3. See [Figure 3-125](#). Insert lifter into bore in crankcase. Rotate lifter so that flats at upper end of lifter face the front and rear of the engine. If the lifter is installed incorrectly, anti-rotation screws cannot be inserted.
4. Secure lifters in place.
 - a. Install anti-rotation screws with washers in the holes in lifter block.
 - b. Tighten anti-rotation screws to 55-65 **in-lbs** (6-7 Nm).
5. See [Figure 3-125](#). Install push rod cover.
 - a. Place **new** push rod cover gasket over bottom of push rod cover.
 - b. Position push rod cover onto crankcase.
 - c. Install screws through holes in push rod cover into tapped holes in crankcase. Tighten screws evenly to 30-40 **in-lbs** (3-5 Nm).
 - d. Place **new** o-rings on top of push rod cover.
6. Install push rods, cylinder head, lower and upper rocker covers. See [3.6 CYLINDER HEAD](#).
7. Repeat process for remaining cylinder head.

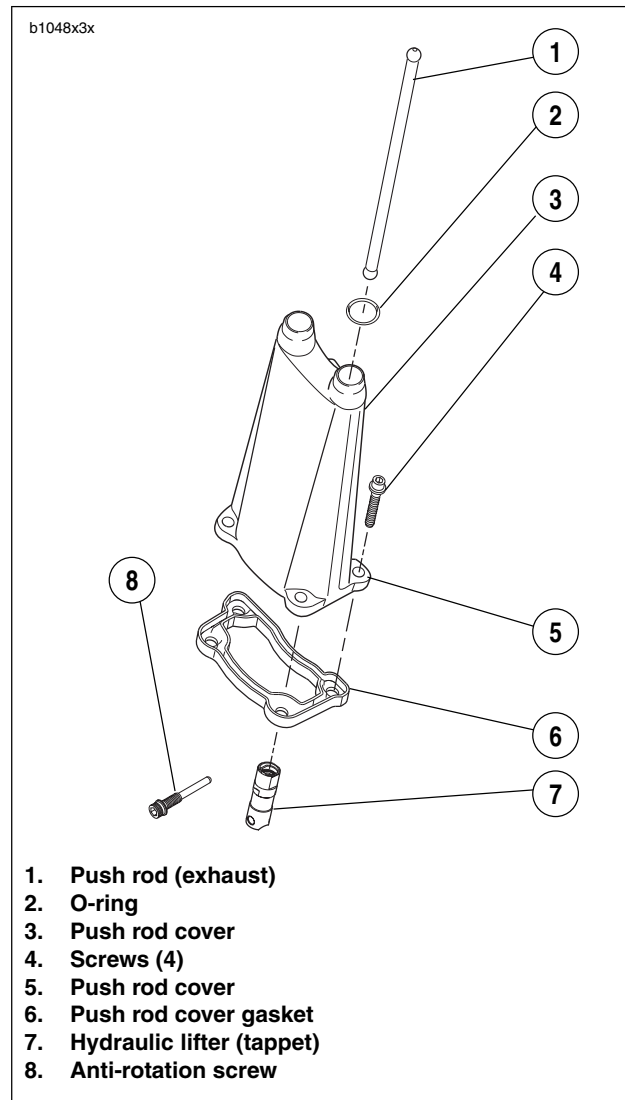


Figure 3-125. Valve Lifter Service

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.

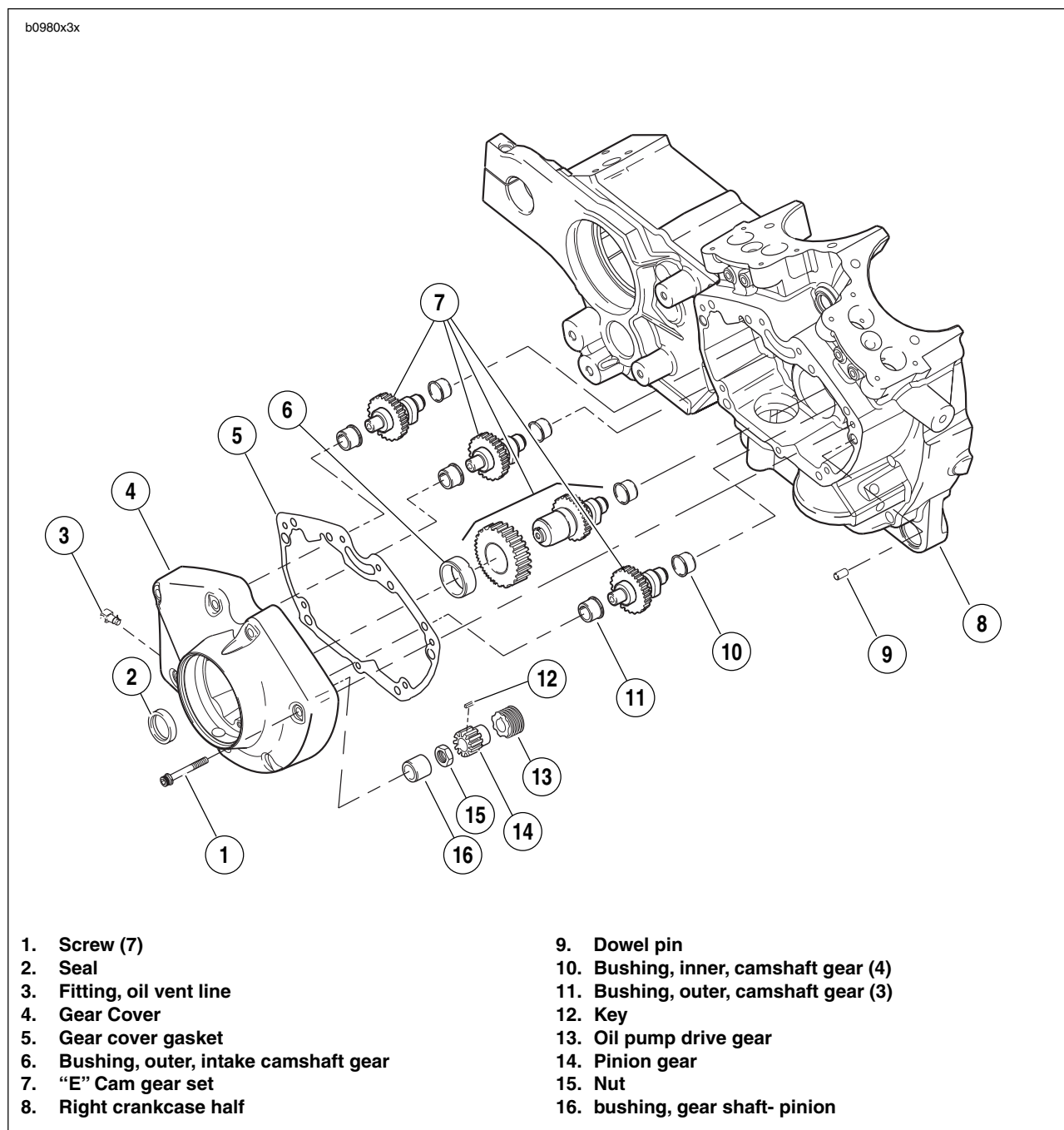


Figure 3-126. Gearcase Cover & Cam Assembly

REMOVAL/DISASSEMBLY

⚠ WARNING

Compressed air can pierce the skin and flying debris from compressed air could cause serious eye injury. Wear safety glasses when working with compressed air. Never use your hand to check for air leaks or to determine air flow rates. (00061a)

1. See [Figure 3-126](#). Thoroughly clean area around gearcase cover and tappets. Blow loose dirt from crankcase with compressed air.
2. Remove any parts that will interfere with gearcase disassembly.
3. Remove push rods. See [3.6 CYLINDER HEAD](#).
4. Remove hydraulic lifters. See [3.16 HYDRAULIC LIFTERS](#).
5. Check for minimum cam gear end play. Record readings.

6. Remove cam position sensor and rotor from gearcase cover. See [4.31 CAM POSITION SENSOR AND ROTOR](#).
7. Place a pan under gearcase to collect oil. Remove cover screws. Carefully remove gearcase cover. Discard old gasket.

NOTE

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

8. See [Figure 3-127](#). Remove cam gears (1, 2, 3 & 4).

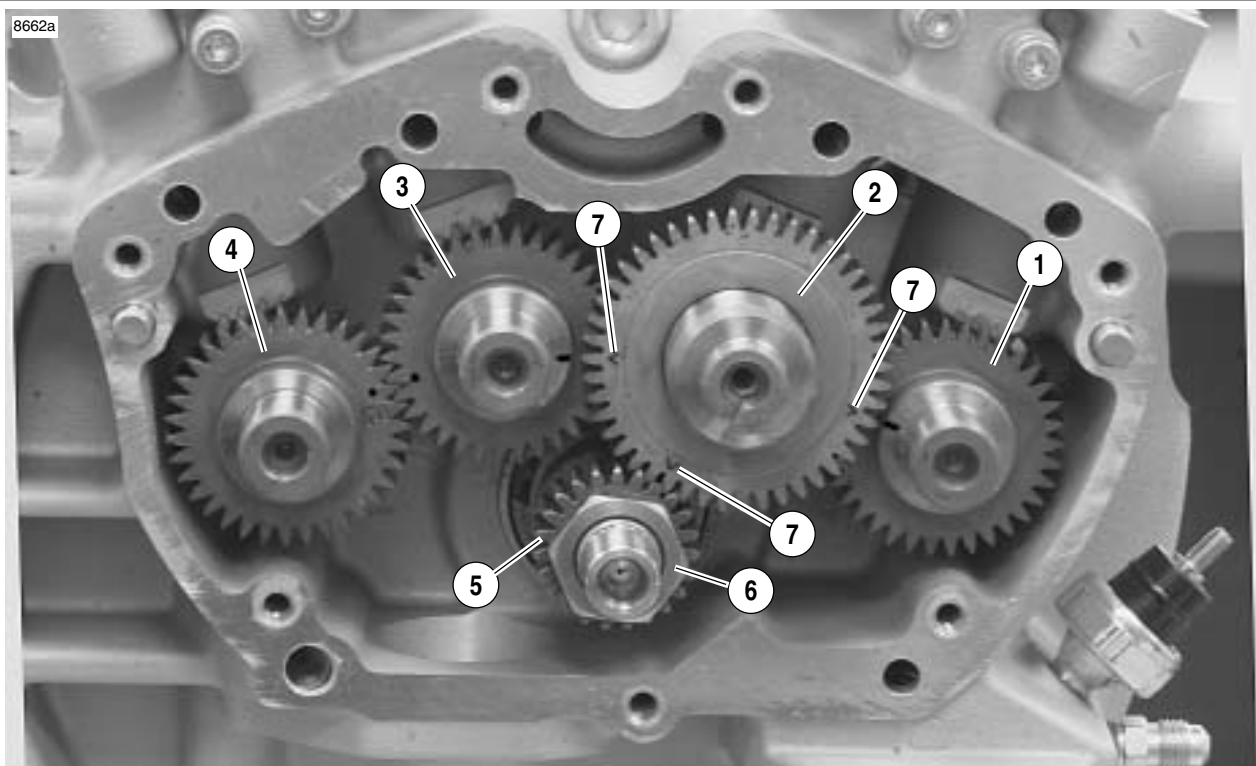
NOTE

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

9. Remove pinion nut (6). Slide pinion gear (5) and oil pump drive gear (6) off pinion shaft.

NOTE

See [Figure 3-127](#). The **XB9SX** timing marks are located on the front intake cam assembly (2). Note the "V" marks.



1. Front exhaust cam gear
2. Front intake cam gear
3. Rear intake cam gear
4. Rear exhaust cam gear
5. Pinion gear
6. Pinion nut
7. Timing V mark

Figure 3-127. Cam and Pinion Gear Location and Timing Mark Indexing

CLEANING AND INSPECTION

1. Thoroughly clean gearcase compartment, gearcase cover and gears in solvent to remove oil and carbon deposits.

⚠ WARNING

Compressed air can pierce the skin and flying debris from compressed air could cause serious eye injury. Wear safety glasses when working with compressed air. Never use your hand to check for air leaks or to determine air flow rates. (00061a)

2. Blow out all cover oil passages and bushings with compressed air.
3. Clean old gasket material from gearcase and crankcase.

Cam and Pinion Gear Identification, Inspection and Selection

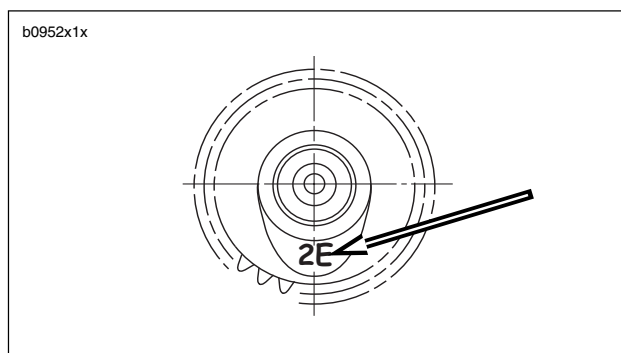


Figure 3-128. Cam Identification Stamp

See [Figure 3-128](#). Cam lobes are stamped with a number (1, 2, 3 or 4) followed by a letter ("E"). The numbers identify the cam location/function and the letter ("E") indicates model year application:

Table 3-25. Cam Identification

Stamp	Location/Function
1E	Front Exhaust
2E	Front Intake
3E	Rear Intake
4E	Rear Exhaust

NOTE

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

Bushing Inspection

1. Bushings are press fit in gearcase cover and crankcase. Inspect each bushing against its corresponding cam gear shaft or pinion gear shaft. Refer to [Table 3-26](#).

NOTE

If Service Wear Limits are exceeded, replace crankcase set and/or gearcase cover as required.

Table 3-26. 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)

ASSEMBLY/INSTALLATION

1. See [Figure 3-129](#). Install oil pump drive gear and pinion gear on pinion shaft.
 - a. Install shaft key into pinion shaft slot.
 - b. Slide oil pump drive gear over pinion shaft. Drive gear must align with shaft key.
 - c. Align keyway in ID of pinion gear with shaft key.
 - d. Slide pinion gear over shaft key and against oil pump drive gear.
2. See [Figure 3-126](#). Install pinion nut.
 - a. Clean threads on pinion shaft and nut.
 - b. See [Figure 3-130](#). Install CRANKSHAFT LOCKING TOOL (Part No. HD-43984) to gearcase with "Side B" facing out, over pinion shaft, with two screws.
 - c. Apply several drops of LOCTITE 262 (red) to last few threads of nut.
 - d. Install nut to pinion shaft. Tighten nut to 19-21 ft-lbs (26-29 Nm) plus an additional 15° to 19° rotation.
3. See [Figure 3-126](#). 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.

NOTES

- The XB9SX uses new style timing marks on the front intake cam assembly. Please note the "V" design.
 - Because of the larger diameter additional gear (which meshes with the pinion gear) on the outboard end of the cam, the front exhaust cam gear and the rear intake cam gear must be installed before the front intake cam gear is installed.
4. See [Figure 3-126](#). Install a **new** seal and **new** dry gear cover gasket on crankcase.

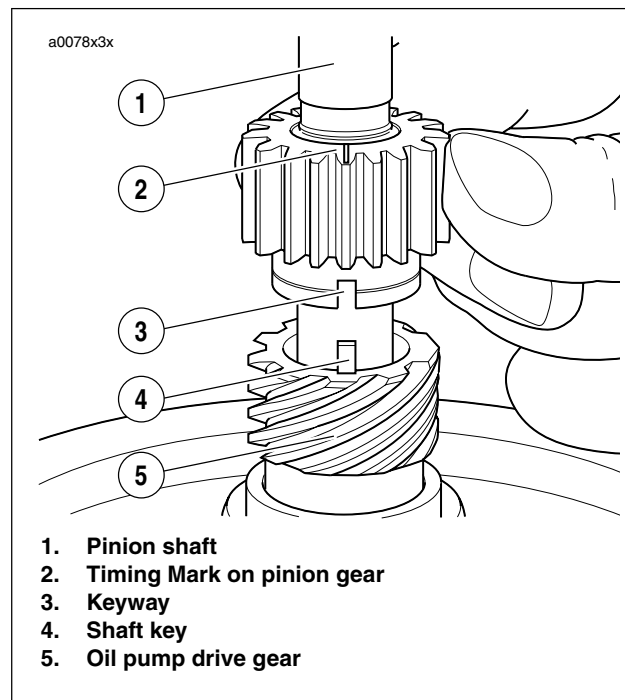


Figure 3-129. Aligning Pinion Gear



Figure 3-130. Crankshaft Locking Tool
(Part No. HD-43984)

5. See [Figure 3-131](#). Install gearcase cover over all gears and onto right crankcase half. Secure cover to crankcase half with 7 socket head screws. Tighten screws evenly to 80-110 **in-lbs** (9-12 Nm). Use torque sequence as shown in [Figure 3-131](#).
6. See [Figure 3-132](#). 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 tappet 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 [3.16 HYDRAULIC LIFTERS](#).
8. Install cam position sensor and rotor in gearcase cover. See [CAM POSITION SENSOR AND ROTOR](#) section.
9. Install any components removed to gain access to gearcase (i.e. exhaust system components, air cleaner, etc.).

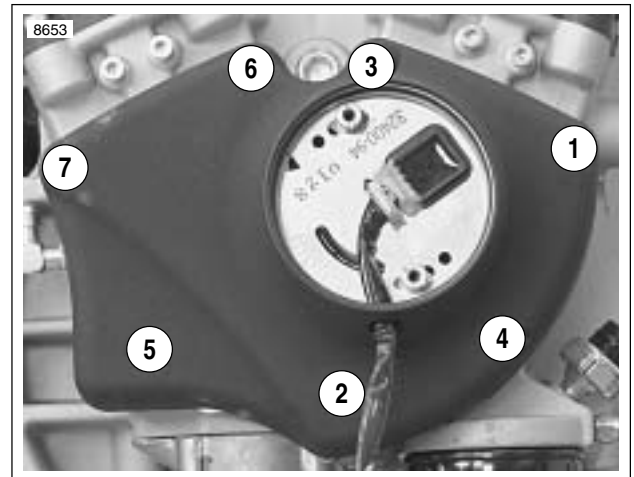


Figure 3-131. Gearcase Cover Mounting Screw Torque Sequence



Figure 3-132. Checking Cam Gear End Play

GENERAL

When rod bearings, pinion shaft bearing, or sprocket shaft bearing are in need of repair, the engine must be removed from the chassis; see [3.4 STRIPPING MOTORCYCLE FOR ENGINE SERVICE](#) in this section. It is recommended procedure to check and make repairs to cylinder heads, cylinders, gear case and transmission at the same time (perform entire engine overhaul).

CAUTION

Laying engine on primary side will damage clutch cable end fitting. If fitting is damaged, clutch cable must be replaced.

DISASSEMBLY

Crankcase Halves

1. Remove cylinder heads. See [3.6 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 HEAD](#).
3. Remove oil pump. See [3.14 OIL PUMP](#).
4. Remove gearcase components. See [3.17 GEARCASE COVER AND CAM GEARS](#).
5. Remove primary cover and primary drive/clutch components. See [6.2 PRIMARY COVER](#).
6. Remove starter motor. See [5.7 STARTER](#).

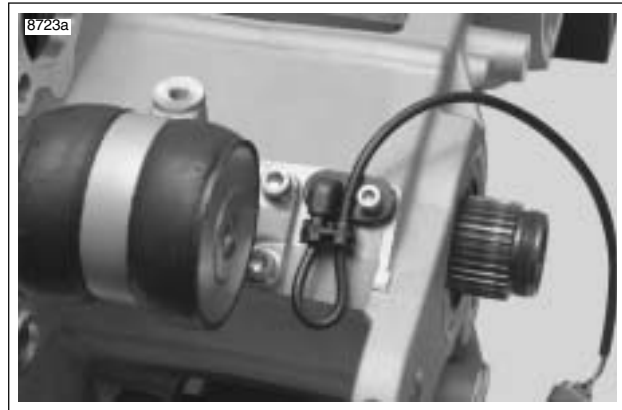


Figure 3-133. Rear Isolator Assembly

7. See [Figure 3-133](#). Remove rear isolator assembly by removing the forward two fasteners first and then the two rear fasteners (re-install with new fasteners).
8. See [Figure 3-134](#). Remove screws securing crankcase halves together.
9. Tap crankcase with plastic mallet to loosen and separate the halves.

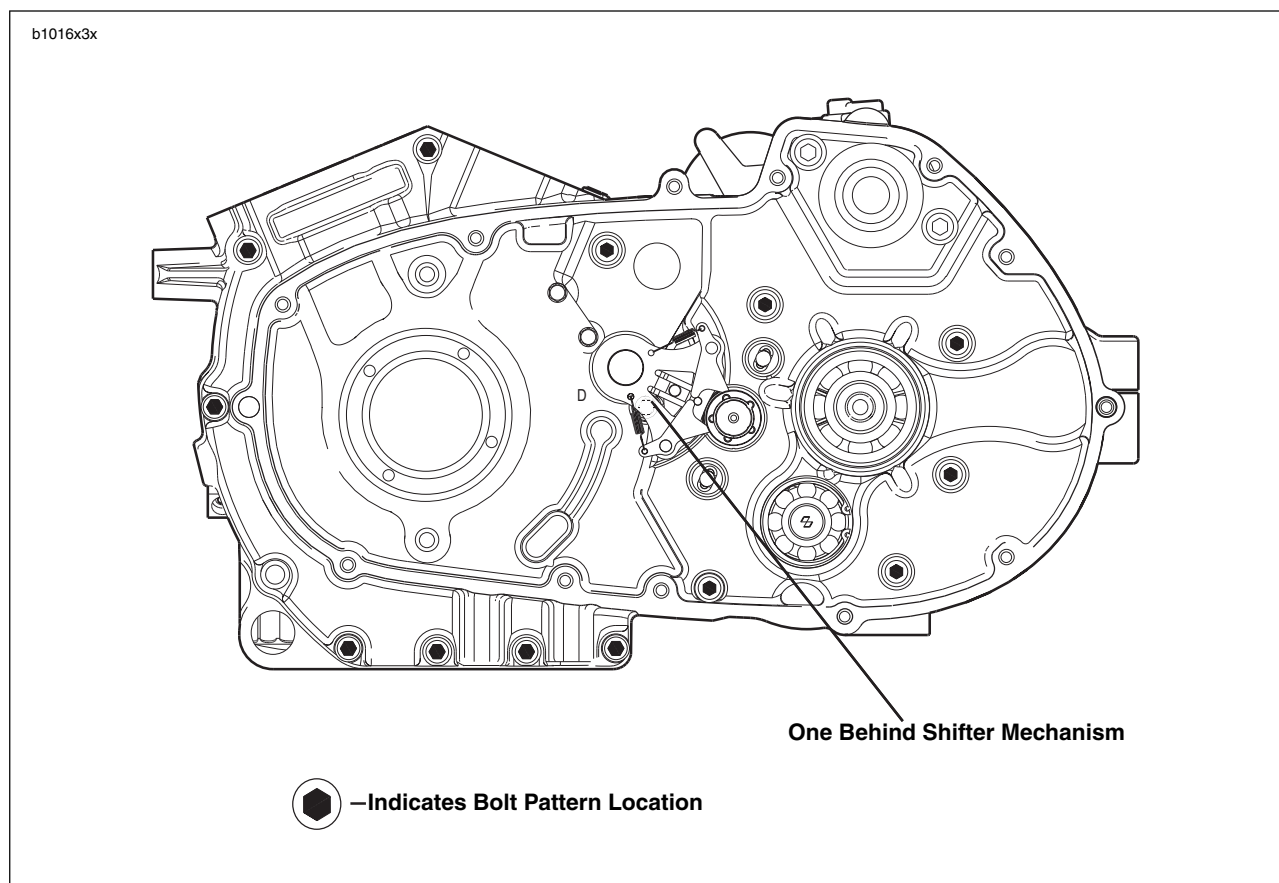


Figure 3-134. Crankcase Fasteners

PISTON JETS

Removal

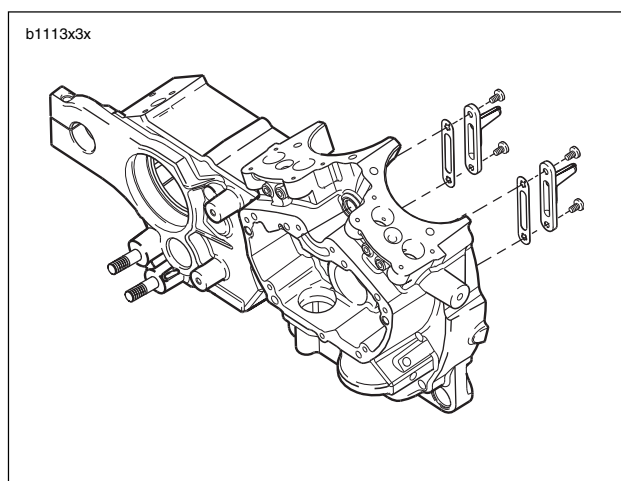


Figure 3-135. Piston Oil Jet Assemblies

1. See [Figure 3-135](#). Remove two TORX screws from each piston jet assembly to free piston jets from right crankcase.
2. Remove piston jet gaskets from right crankcase.

Installation

CAUTION

Gaskets that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure.

NOTE

Gasket is part of the piston jet assembly. Gasket not sold separately.

1. Install **new** piston oil jet assemblies in right crankcase.
2. Apply LOCTITE Low Strength Threadlocker 222 (purple) to threads of 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).

Flywheel Assembly

1. See [Figure 3-136](#). Remove the flywheel assembly from left crankcase half.

NOTE

Flywheel assembly slides out of the sprocket shaft bearing by hand. No tools are required for this operation.

NOTE

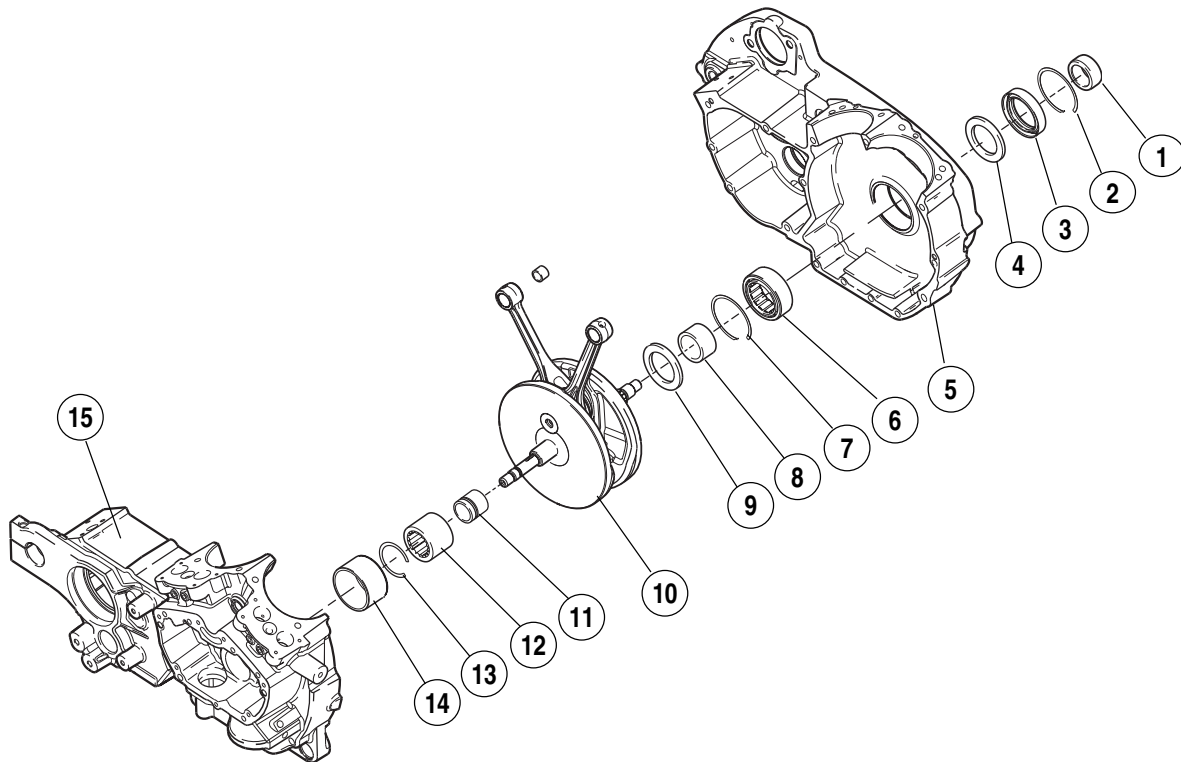
See [Figure 3-137](#). If it is necessary to remove either the pinion shaft bearing or sprocket shaft bearing, proceed as follows:

2. See [Figure 3-137](#). Pinion shaft bearing (12) will remain on flywheel pinion shaft. Remove retaining ring (13) and bearing can be slipped off pinion shaft.



Figure 3-136. Removing Flywheels from Left Crankcase

b0975a3x



1. Spacer, sprocket shaft
2. Retaining ring, oil seal
3. Oil seal
4. Thrust washer
5. Crankcase half
6. Bearing
7. Bearing retaining ring
8. Inner race, sprocket shaft bearing

9. Thrust washer
10. Connecting rod and flywheel assembly
11. Inner race
12. Gear shaft bearing
13. Retaining ring
14. Outer bearing race
15. Crankshaft case

Figure 3-137. Crankcase and Flywheel Assembly



Figure 3-138. Removing Sprocket Shaft Inner Bearing Race

3. See [Figure 3-138](#). Place flywheel assembly in FLY-WHEEL SUPPORT FIXTURE (Part No. HD-44385). Pull sprocket shaft bearing inner race with WEDGE ATTACHMENT for CLAW PULLER (Part No. HD-95637-46A) with BEARING RACE REMOVER/INSTALLER (Part No. HD-34902B) and END CAP (Part No. HD-34902-7).

NOTE

Sprocket shaft bearing inner race does not need to be ground once it is installed on the sprocket shaft.



Figure 3-139. Sprocket Shaft Seal Retaining Ring

4. See [Figure 3-139](#). Remove sprocket shaft oil seal retaining ring.
5. See [Figure 3-137](#). Remove sprocket shaft oil seal (3) from crankcase using Snap-On Tool (Part No. CJ 114, Body Dent Puller)
6. Remove outer thrust washer (4) next to sprocket shaft bearing (6).



Figure 3-140. Removing Sprocket Shaft Bearing Retaining Ring

7. See [Figure 3-140](#). Remove sprocket shaft bearing retaining ring from the inside of the left crankcase half.

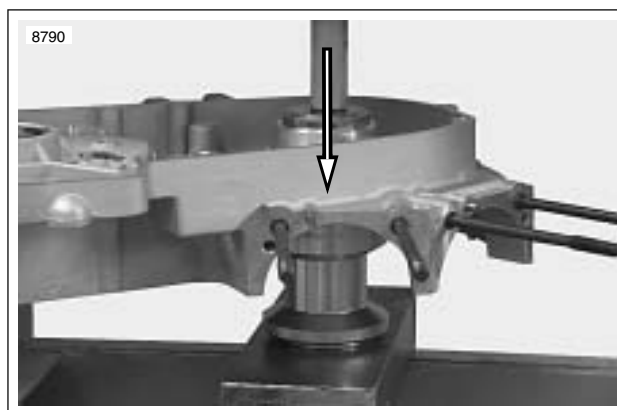


Figure 3-141. Direction of Bearing Removal From Left Crankcase

8. See [Figure 3-141](#). Using CRANKCASE BEARING REMOVER/INSTALLER with ADAPTER (Part No. B-45655, HD-42720-2 and HD-46663) press sprocket shaft bearing out of the left crankcase half.

NOTE

The bearing presses to the inside. There is a shoulder incorporated into the left crankcase half which allows the bearing to be removed in one direction only.

PINION SHAFT BEARING

General

See [Figure 3-137](#). The right side pinion shaft bearing consists of an inner and outer race with rollers.

The inner race (11) is pressed onto the pinion shaft. The outer race is a pressed into the right crankcase half (14).

NOTE

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

Table 3-27. Pinion Shaft Bearing Service Wear Limits

	in.	mm
Inner race OD	1.2492	31.7297
Outer race ID	1.5672	39.8069

NOTE

Pinion shaft bearing selection at the factory, during engine build, 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.

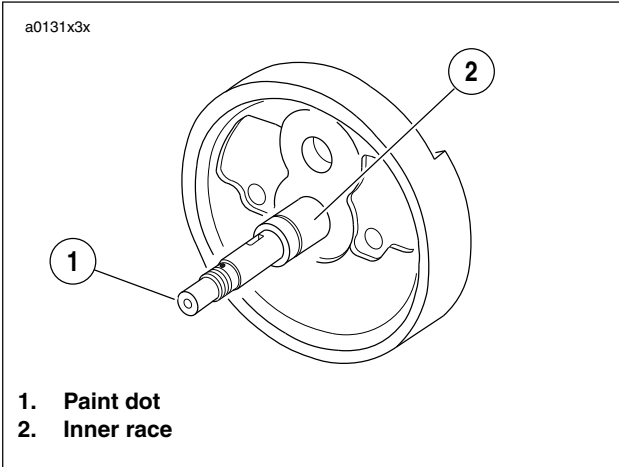


Figure 3-142. Pinion Shaft Inner Race

Table 3-28. Pinion Shaft Inner Race Paint Dot Specifications

PAINT DOT COLOR	CLASS	INNER RACE OD
White	A	1.2498-1.2500 in. (31.7449-31.7500 mm)
Green	B	1.2496-1.2498 in. (31.7398-31.7449 mm)

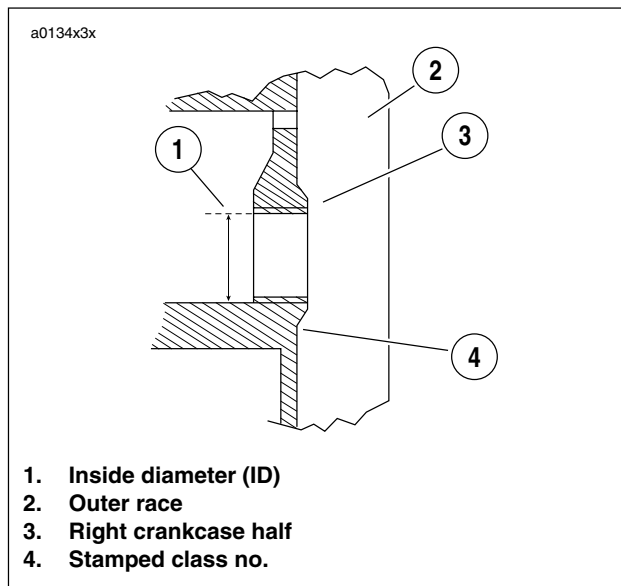


Figure 3-143. Pinion Shaft Outer Race

Table 3-29. Pinion Shaft Outer Race Stamp Specifications

OUTER RACE ID	CLASS NO.	STAMPED NO.
1.5646-1.5648 in. (39.7408-39.7459 mm)	1	1
1.5648-1.5650 in. (39.7459-39.7510 mm)	2	2
1.5650-1.5652 in. (39.7510-39.7561 mm)	3	3

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 bearing outer race. Replacement flywheel assemblies will have either a class A or B inner race.

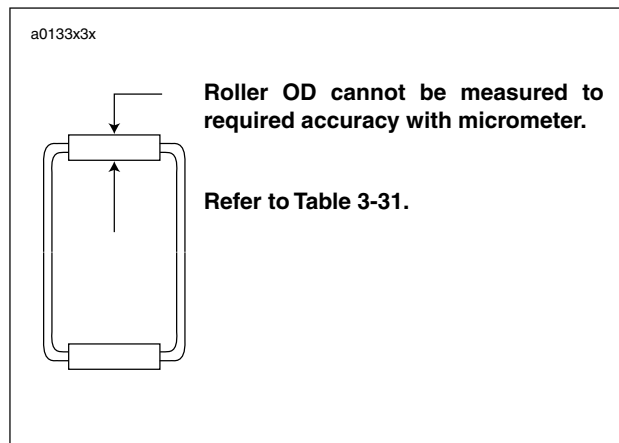


Figure 3-144. Bearing Roller OD

Table 3-30. Pinion Bearing Roller Specifications

ROLLER OD	COLOR*
Largest	Red
	Blue
	White (grey)
Smallest	Green

Selection

See [Table 3-31](#). Select bearings using the identification information given for inner and outer races.

Table 3-31. Pinion Shaft Bearing Selection

FAC- TORY STAMP ED NUM- BER	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									

Replacement

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 PINION SHAFT BEARING OUTER RACE](#). Lap race until all wear marks are removed.
3. Measure and record ID of race at four places.
4. Check measurements against the specifications listed in [Table 3-32](#).

Table 3-32. Outer Pinion Race Service Wear Limits

Largest ID measured	1.5672 in. (39.8069 mm)
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.
6. Press **new** outer race into crankcase flush with inside edge of cast-in insert.

NOTE

See [Figure 3-145](#). Dimensions are shown for fabrication of tools used in pressing the outer race into or out of crankcase.

7. The **new** outer race must be lapped slightly to true and align with left case bearing and to meet the following specifications in [Table 3-33](#). See [LAPPING PINION SHAFT BEARING OUTER RACE](#).

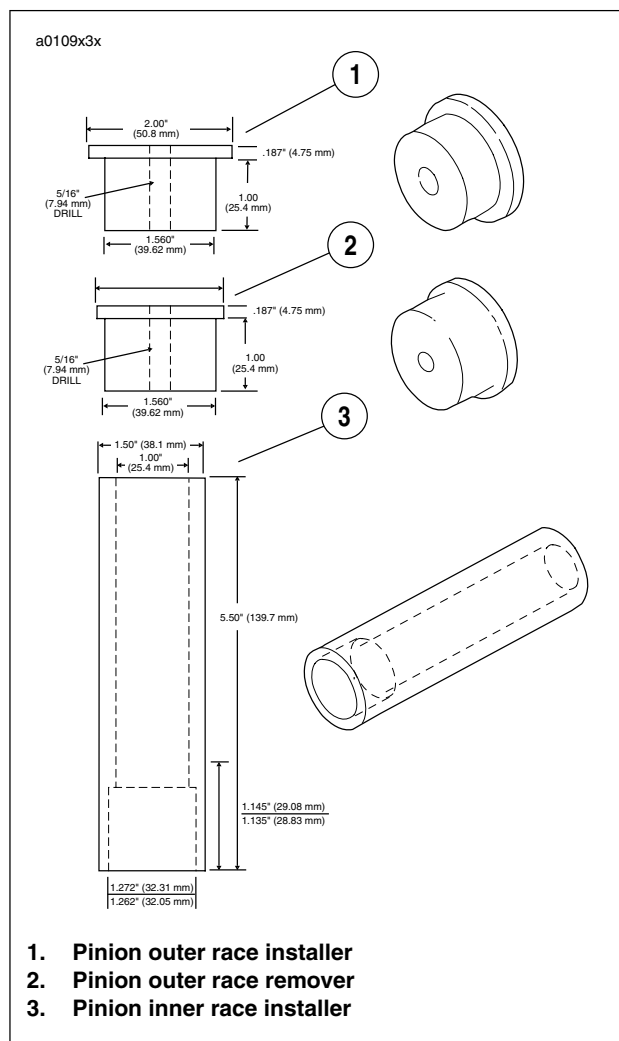


Figure 3-145. Pinion Shaft Bearing Tools

Table 3-33. New Component Specifications

Outer Race 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

8. See [Figure 3-146](#). Pull inner race from pinion shaft using WEDGE ATTACHMENT for CLAW PULLER (Part No. HD-95637-46A) with BEARING RACE REMOVER/INSTALLER (Part No. HD-34902B) and END CAP (Part No. HD-34902-7). Apply heat to race to aid removal.

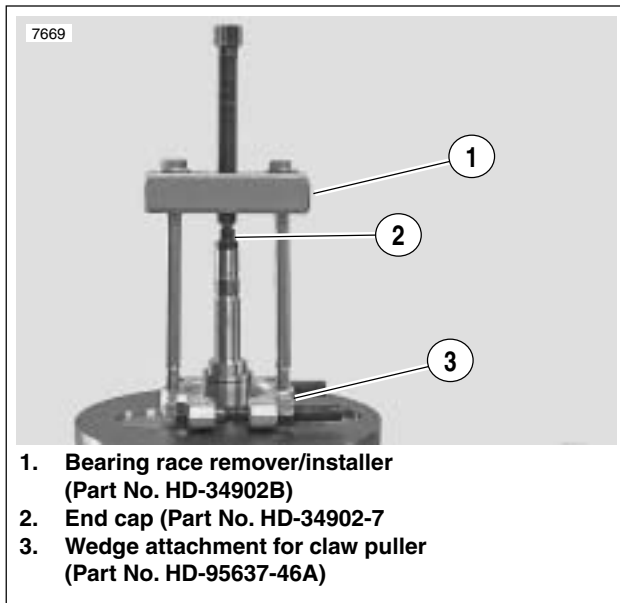


Figure 3-146. Removing Pinion Bearing Inner Race

NOTES

- For necessary dimensions for constructing a press-on tool for the pinion bearing inner race see [Figure 3-145](#).
 - 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 3-31](#).
9. See [Figure 3-147](#). Press **new** inner race on pinion shaft as shown. When the tool bottoms against the flywheel, correct inner race location is automatically established. The finished inner race must meet the specifications in [Table 3-34](#).

Table 3-34. Pinion Inner Race Specifications

Roundness	within 0.0002 in. (0.0051 mm)
Taper	within 0.0002 in. (0.0051 mm)
Surface finish	16 RMS

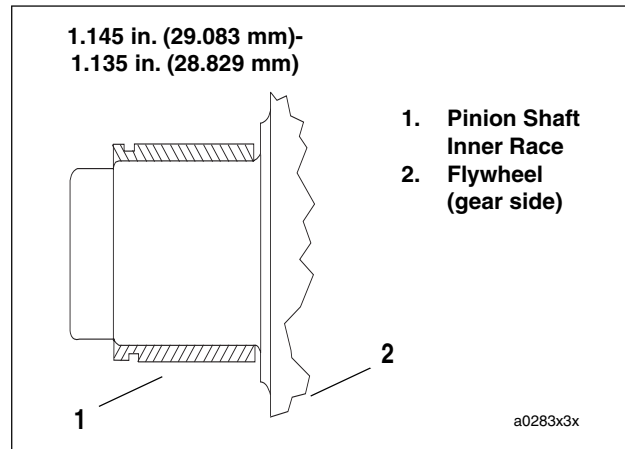


Figure 3-147. Inner Race Location

NOTES

- Have machinist grind inner race to center or middle of required OD range in [Table 3-31](#). This will prevent grinding outer race undersize and gives a more easily achieved tolerance range.
 - If you are unable to perform this operation, Harley-Davidson Motor Company provides a flywheel refurbishing program as outlined in Tech Tip #38.
 - Always use the smallest outer race ID measurement and the largest OD inner race measurement when selecting bearings.
10. The following example illustrates how to determine the required inner race OD.
- See [Table 3-31](#). 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).
 - Grind inner race. Measure OD at four places. Check that specifications in Step 8 are met.
 - For example purposes, suppose the largest inner race OD measurement after grinding is 1.2499 in. (31.747 mm) OD.
 - 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 Pinion Shaft Bearing Outer Race

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 3-148](#). 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 develop 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.
5. 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.
6. 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.

CHECKING CONNECTION ROD SIDE PLAY

1. See [Figure 3-149](#). Check connecting rod side play with a thickness gauge as shown.
2. If side play measurement is greater than service wear limit listed below, replace flywheel/connecting rod assembly. Service wear limit, 0.036 in. (0.8 mm)

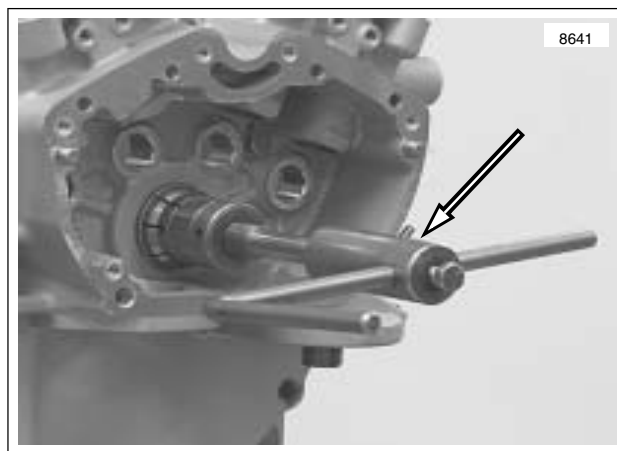


Figure 3-148. Lapping Pinion Shaft Bearing Outer Race with Crankcase Main Bearing Lapping Tool (Part No. HD-96710-40B)

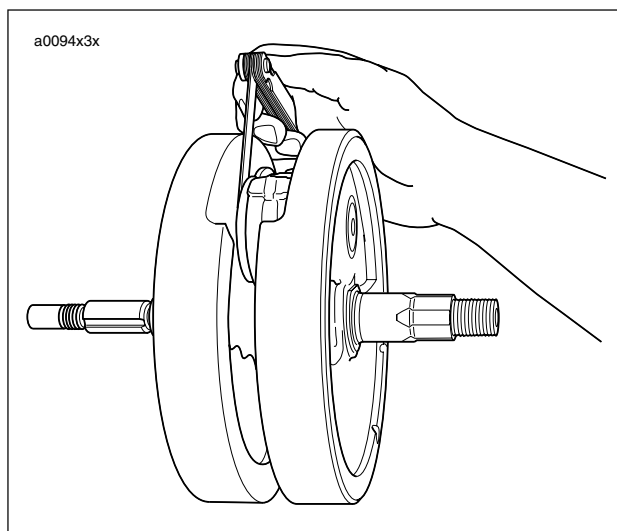


Figure 3-149. Checking Connecting Rod Side Play

ASSEMBLY

Crankcase Halves

NOTE

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

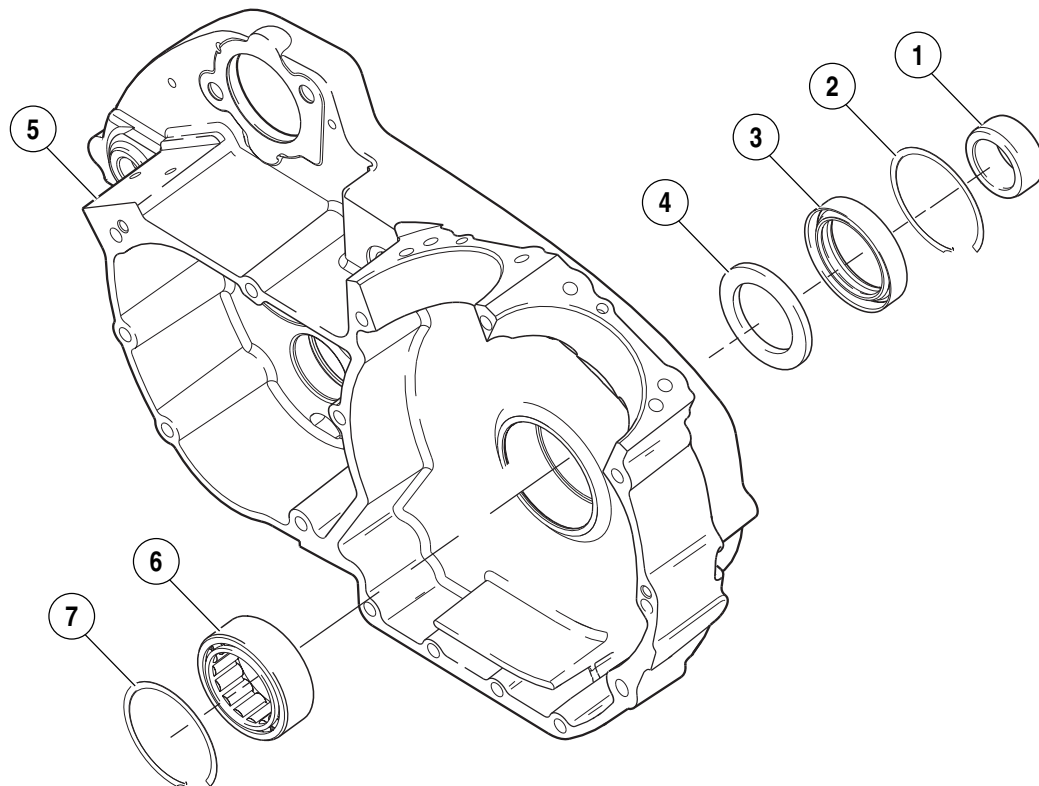
1. See [Figure 3-151](#). Using CRANKCASE BEARING REMOVER/INSTALLER (Part No. B-45655, HD-42720-2 and HD-46663), install sprocket shaft bearing into left crankcase half from the inside.

NOTE

Make sure that the bearing assembly bottoms against the machined shoulder in the left crankcase half.

2. Install **new** bearing retaining ring in left crankcase half.
3. Install transmission. See [6.14 TRANSMISSION INSTALLATION](#).

b1046a3x



1. Spacer, sprocket shaft
2. Retaining ring, oil seal
3. Oil seal
4. Thrust washer
5. Crankcase half
6. Bearing
7. Bearing retaining ring

Figure 3-150. Sprocket Shaft Bearing Assembly

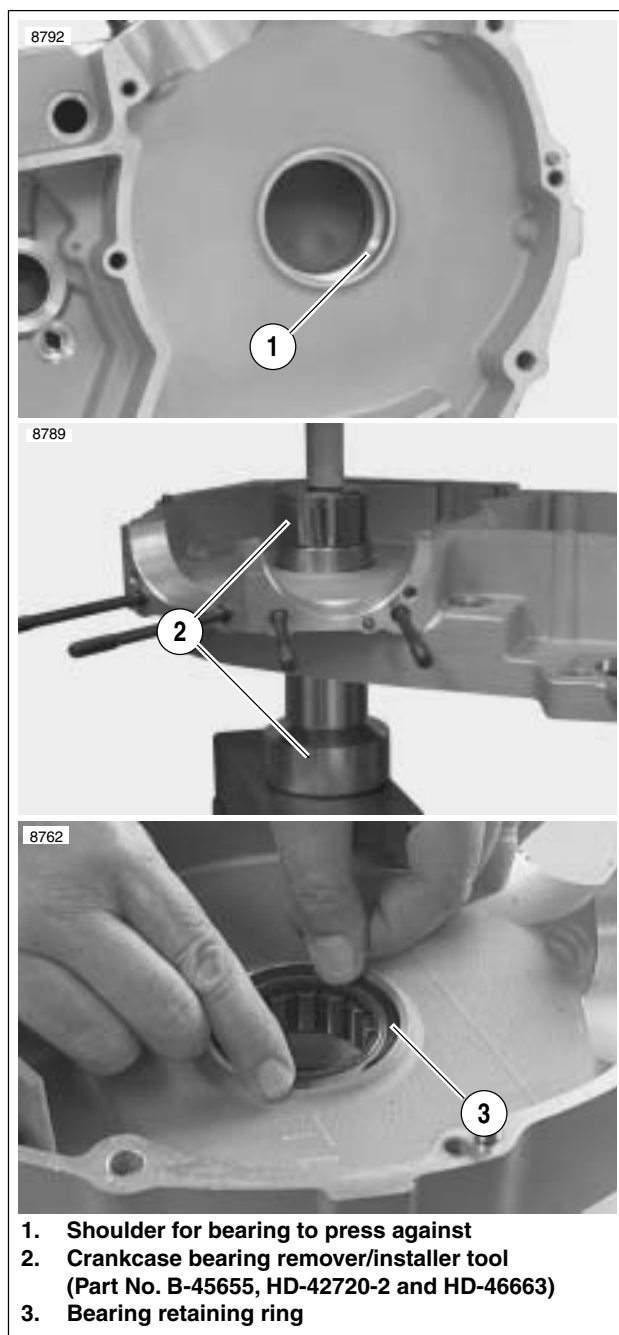


Figure 3-151. Sprocket Shaft Bearing Installation

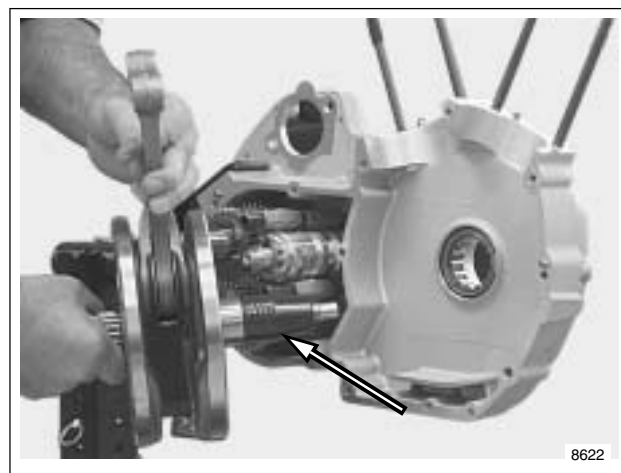


Figure 3-152. Installing Flywheel Assembly with CRANKSHAFT GUIDE (Part No. HD-42326)

4. See [Figure 3-152](#). Attach left crankcase half to engine stand.
5. Install flywheel assembly using CRANKSHAFT GUIDE (Part No. HD-42326).

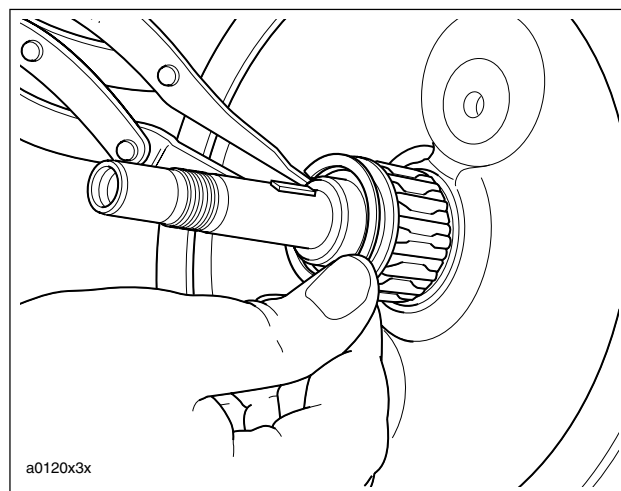
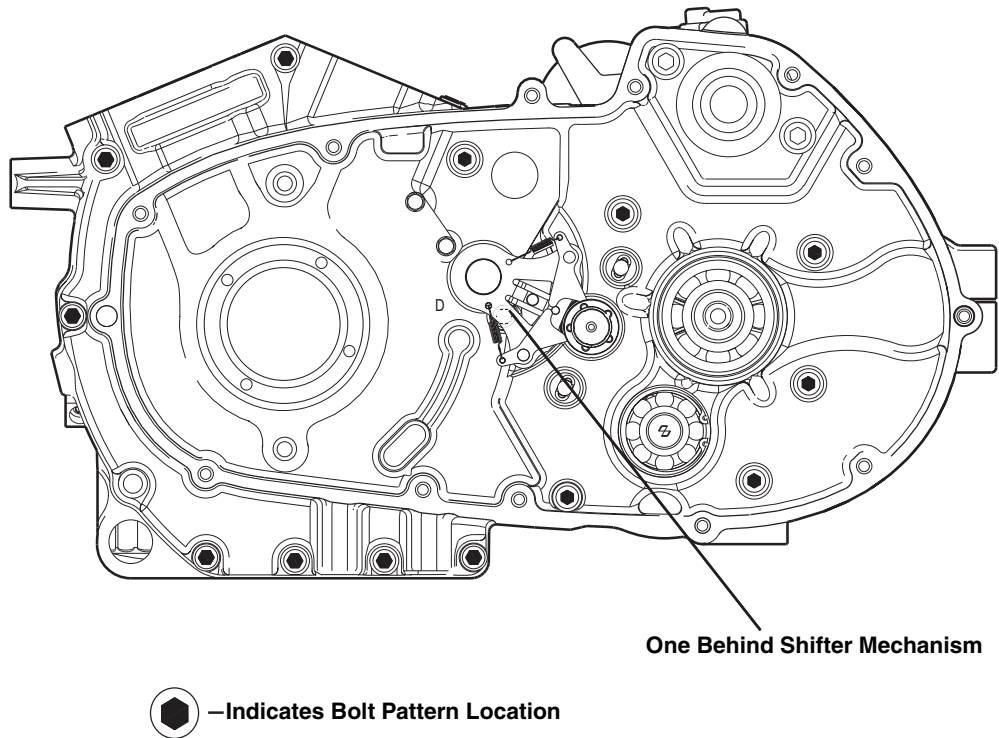


Figure 3-153. Pinion Shaft Bearing

6. See [Figure 3-153](#). 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.

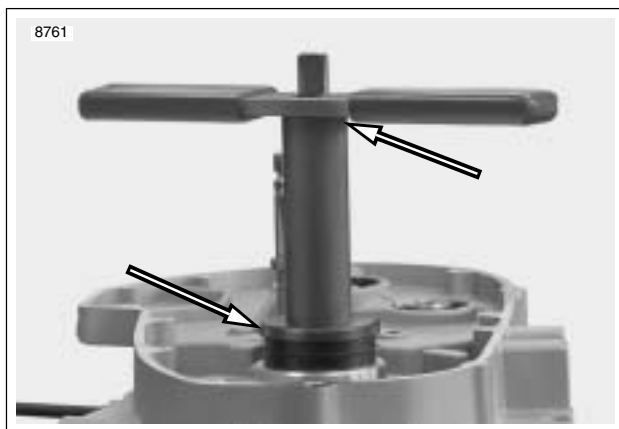
b1016x3x

**Figure 3-154. Crankcase Fasteners**

7. See [Figure 3-154](#). Assemble crankcase halves together.
 - a. Apply a thin coat of DOW CORNING SILASTIC #732 CLEAR sealant to crankcase joint faces.
 - b. Slide outer race in right crankcase over pinion shaft and bearing assembly.
 - c. Tighten fasteners to 15-19 ft-lbs (20-26 Nm).

NOTE

According to manufacturing, there is no torque sequence to follow when tightening crankcase fasteners.

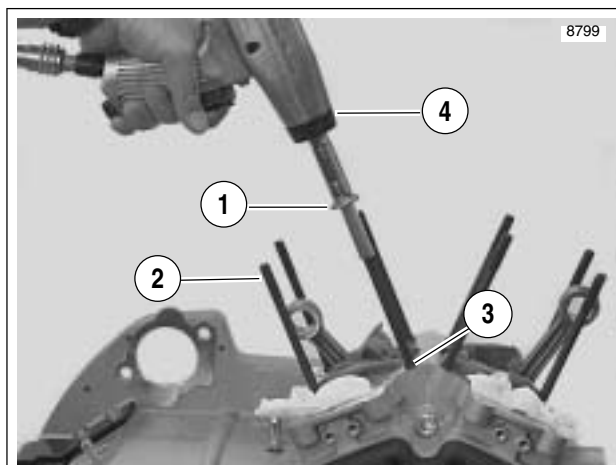


**Figure 3-155. Sprocket Shaft Seal/Spacer Installer
(Part No. HD-42579 and B-45676)**

8. See [Figure 3-155](#). Use SPROCKET SHAFT SEAL INSTALLER (Part No. B-45676) to install sprocket shaft seal.
 - a. Center seal/spacer driver over seal, so that the sleeve (smaller OD) seats between seal wall and garter spring.
 - b. Sparingly apply graphite lubricant to threads of pilot shaft to ensure smooth operation.
 - c. Slide sleeve over pilot until sleeve contacts the oil seal. Install handle on top of sleeve.
 - d. Rotate handle clockwise until tool bottoms on crankcase lip. Remove tool from sprocket shaft.
 - e. Install **new** retaining ring in groove in left crankcase next to oil seal.
9. See [Figure 3-150](#). Install thrust washer (4) from the outside against the sprocket shaft bearing.
10. Install **new** spacer (1) in seal ID. With the thin (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.



1. Head Screw with ball inside
2. Cylinder stud
3. Shoulder on cylinder stud
4. Air gun

Figure 3-156. Cylinder Studs

11. See [Figure 3-156](#). Install cylinder studs.
 - a. Pack clean towels into crankcase opening.
 - b. Place a steel ball into a head screw.
 - c. The cylinder studs have a shoulder 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 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).
12. Install piston and cylinder. See [3.7 CYLINDER AND PISTON](#).
13. Install oil pump. See [3.14 OIL PUMP](#).
14. Install cam gears, gearcase cover, lifter guides and lifters. See [3.17 GEARCASE COVER AND CAM GEARS](#).
15. Install cylinder head. See [3.6 CYLINDER HEAD](#).
16. Install starter. See [5.7 STARTER](#).
17. Install shift linkage.
18. Install all primary drive components. This includes engine sprocket, primary chain, complete clutch assembly, engine sprocket nut and mainshaft nut. See [6.4 CLUTCH](#).
19. Install primary cover. See [6.2 PRIMARY COVER](#).

NOTE

Be sure to refill transmission to proper level with fresh lubricant. See [1.12 PRIMARY CHAIN](#).

20. See [3.6 CYLINDER HEAD](#) and perform the applicable steps.
21. To reinstall engine in frame see [3.5 ENGINE INSTALLATION](#).

NOTES
