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Crankshaft, Bearings, Flywheel, and Related Components

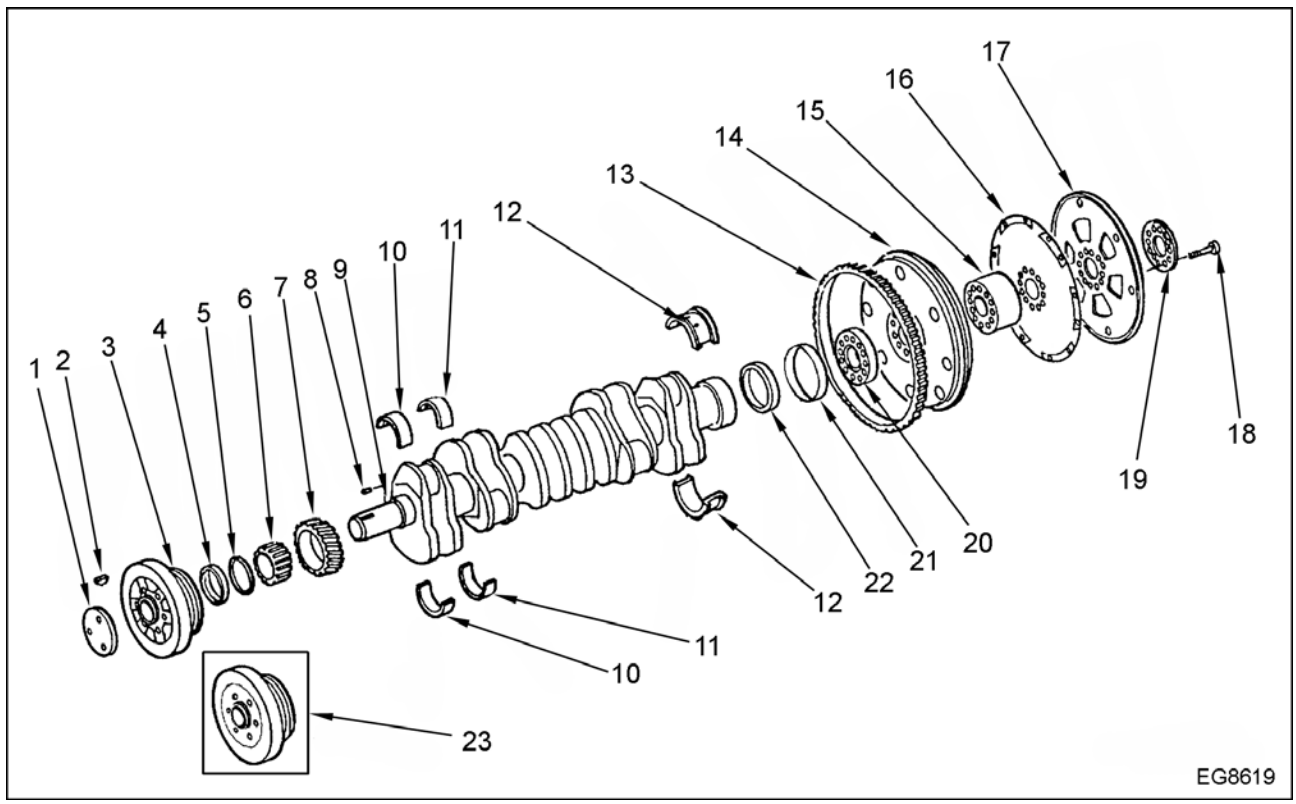

Figure 254 Crankshaft, bearings, flywheel and related components

1. Damper Retaining Plate
2. Woodruff Key
3. Vibration Damper
4. Front Wear Sleeve
5. Seal Washer
6. Oil Pump Drive Spline
7. Crankshaft Gear
8. Roll Pin
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23. Viscous Damper

Crankcase and Related Parts

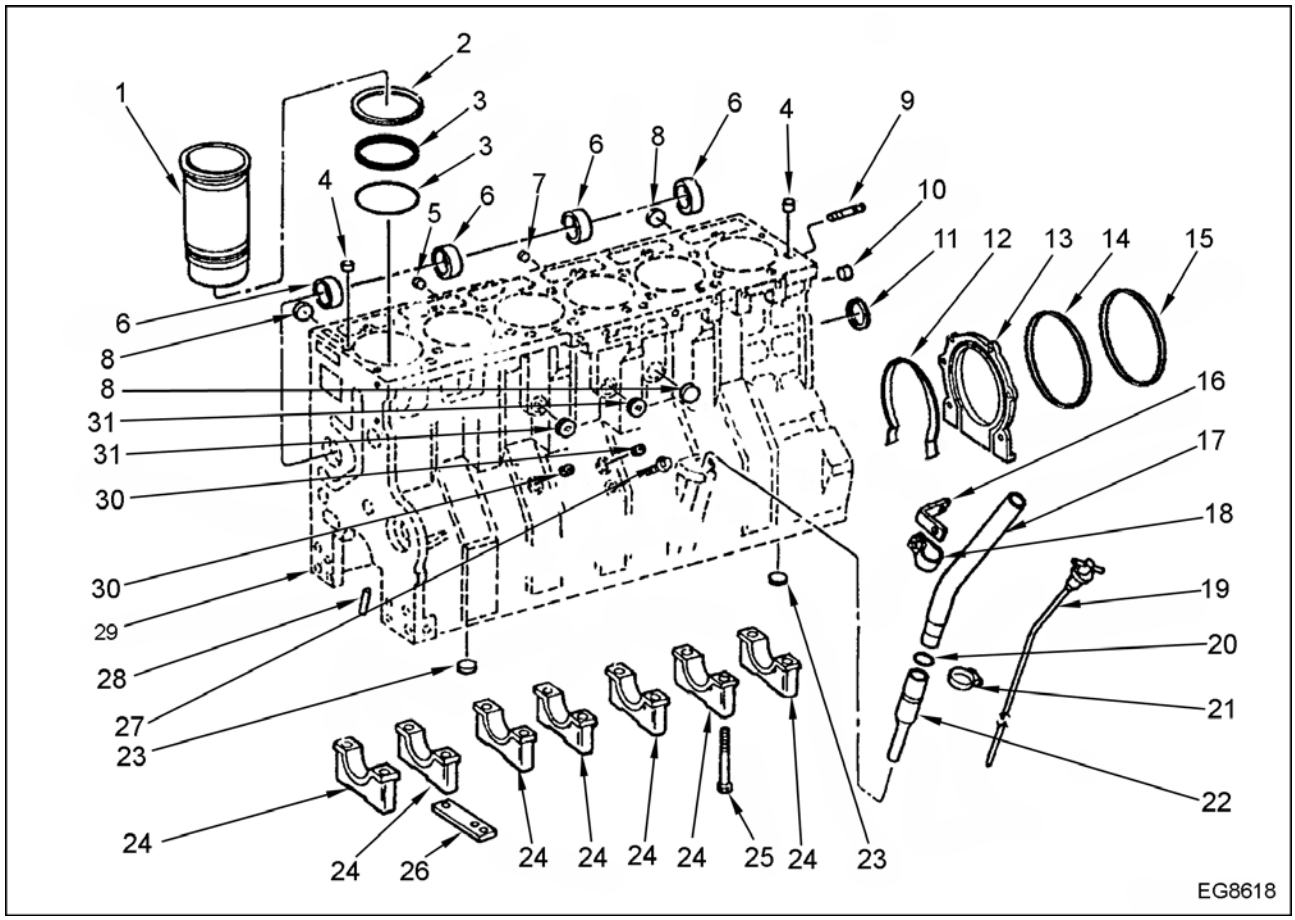

Figure 255 Crankcase and related parts

1. Cylinder Sleeve
2. Cylinder Sleeve Shim (For Service Only)
3. Cylinder Sleeve Seal Rings
4. Cylinder Head Alignment Dowel
5. Plug, Pipe Hex Head 1/4 in NPT
6. Camshaft Bearing Set
7. Plug, Pipe Hex Socket 1/8 in NPT
8. Cup Plug, 32 mm (1.26 in)
9. Power Take Off (PTO) mounting stud (if installed)
10. Cup Plug, 20.6 mm (0.811 in)
11. Camshaft Seal Ring
12. Rear Oil Seal Carrier Gasket
13. Rear Oil Seal Carrier
14. Rear Oil Seal
15. Pose Seal
16. Oil Filler Tube Bracket
17. Oil Filler Tube
18. Oil Filler Tube Clamp
19. Oil Level Gauge
20. Oil Level Gauge Tube Seal
21. Oil Filler Tube Clamp
22. Oil Level Gauge Lower Tube
23. Cup Plug, 15.8 mm (0.622 in)
24. Main, Front, and Intermediate Bearing Caps
25. Main Cap Bolt
26. Oil Inlet Tube Support Bracket (If Applicable)
27. Bolt
28. Oil Jet Cooling Tube
29. Crankcase
30. Plug, Pipe Hex Socket 1/8 in NPT
31. Plug, Pipe Sq. Socket 1/2 in NPT

Engine Mounting, Flywheel Housing, and Rear Power Take-Off (PTO)

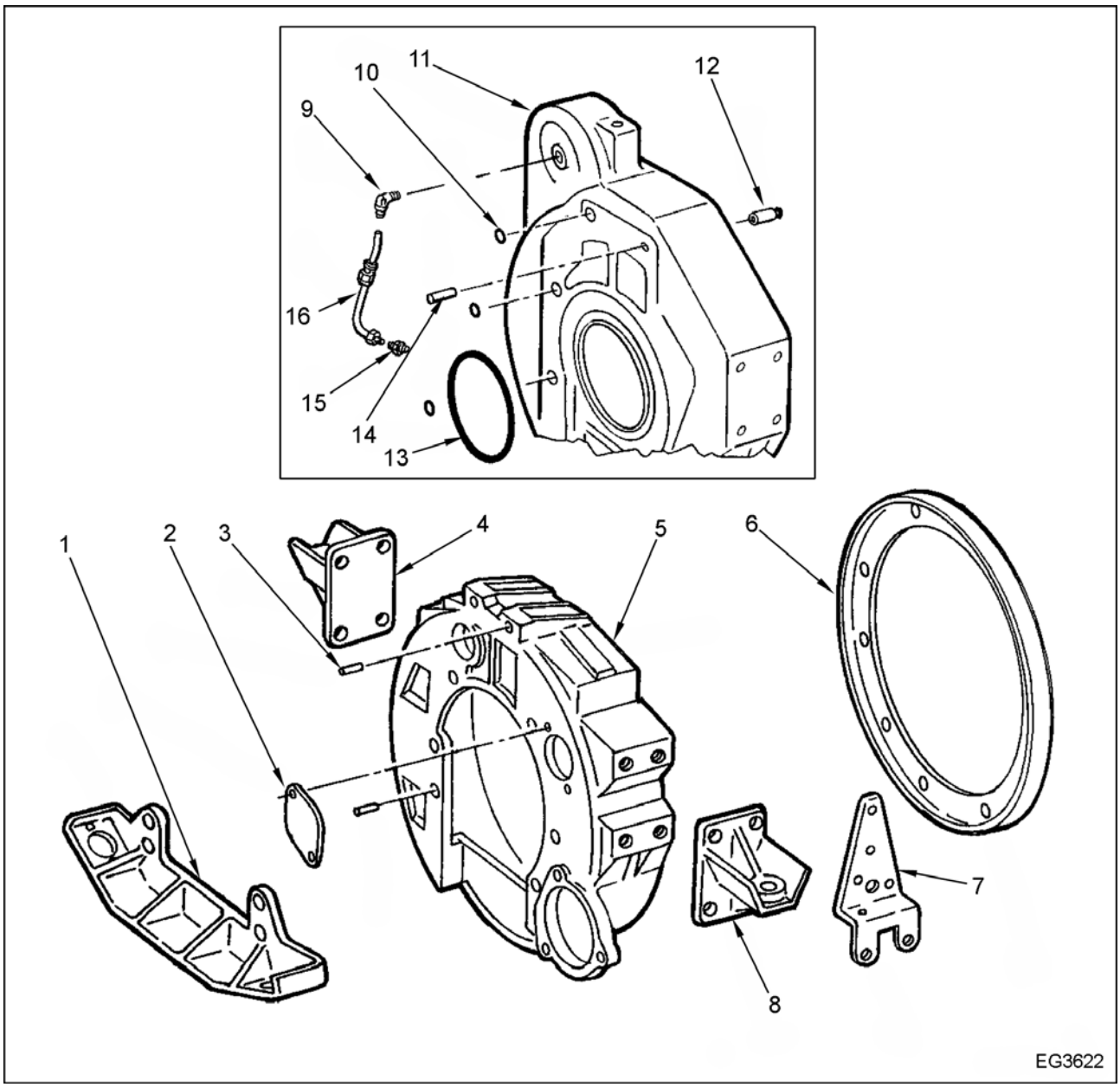

Figure 256 Engine mounting, flywheel housing, and rear PTO

1. Front engine mounting bracket
2. Housing cover plate
3. Hollow dowel
4. Rear right engine mounting bracket
5. Flywheel housing
6. Flywheel housing adapter (for AT and MT transmission)
7. Transmission Fill Tube and Pipe Support Bracket
8. Rear Left Engine Mounting Bracket
9. Rear PTO lube oil elbow
10. PTO O-ring (small)
11. Flywheel housing with rear PTO
12. Rear PTO nut
13. PTO O-ring (large)
14. Hollow dowel
15. Tube connector
16. Rear PTO lube oil tube

Oil Pan Assembly

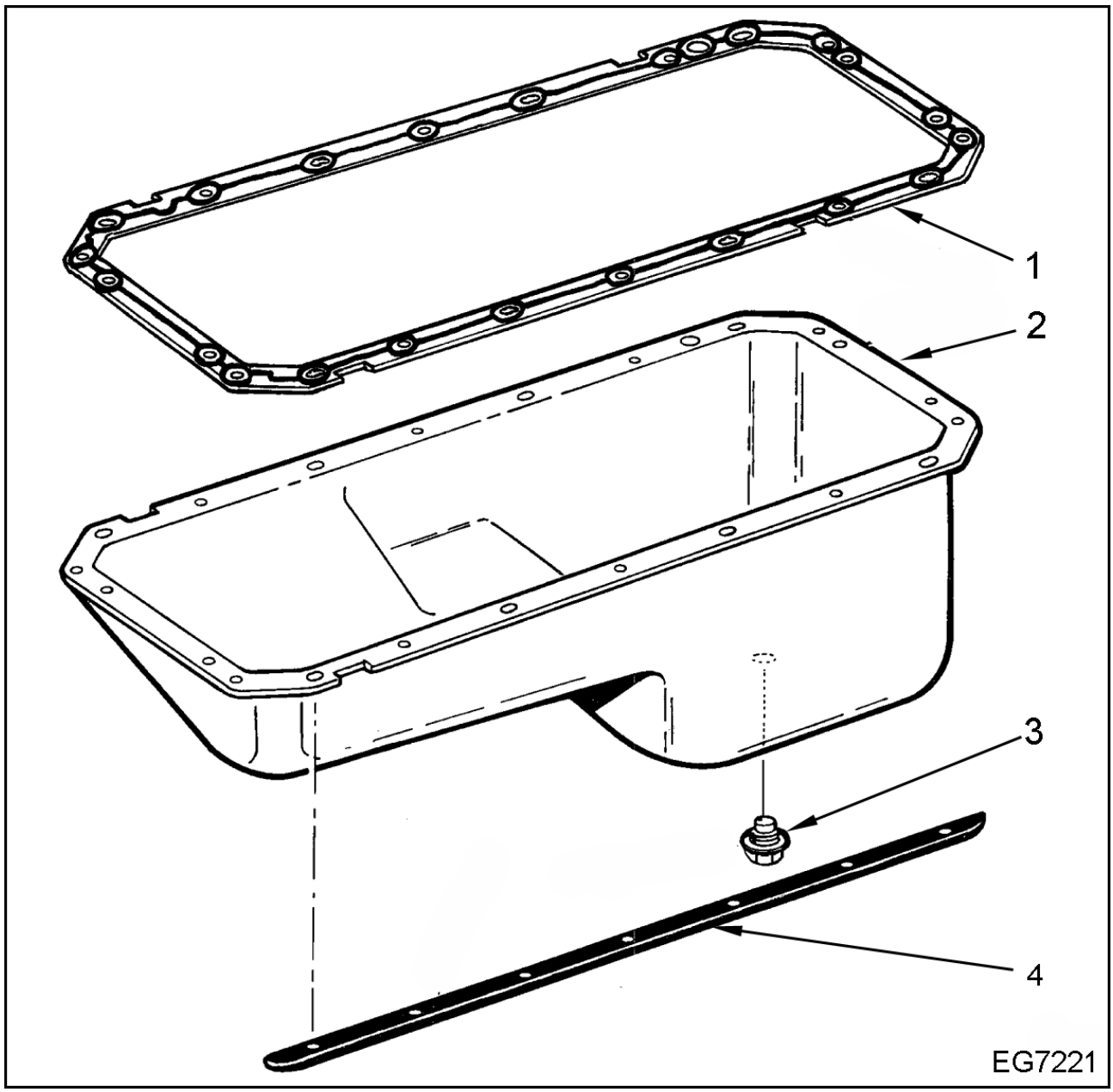

Figure 257 Rear sump oil pan and related parts

1. Oil Pan Gasket
2. Oil Pan Assembly
3. Drain Plug and Seal
4. Mounting Bar

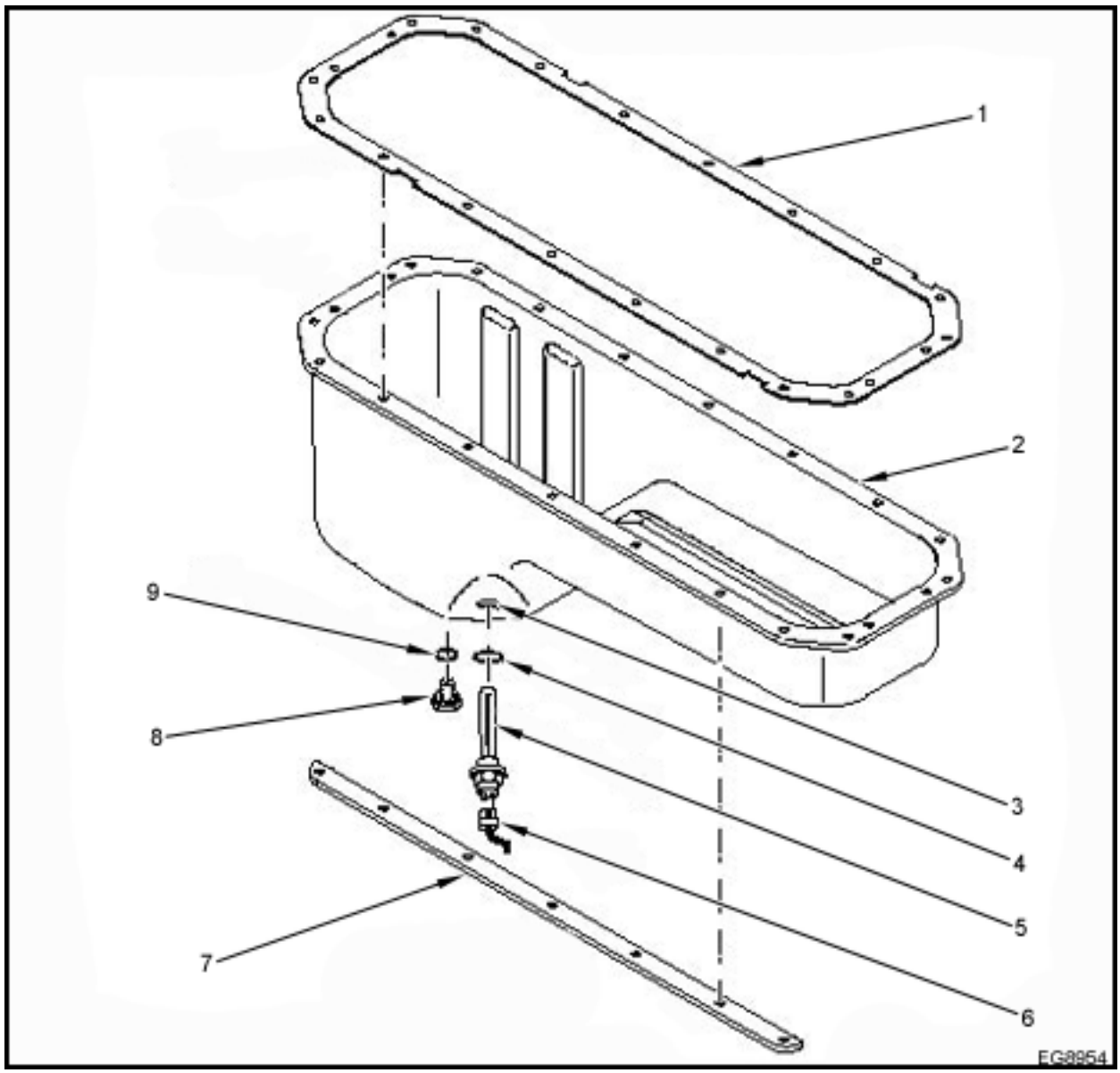

Figure 258 NGV rear sump oil pan (with heater installation) and related parts

1. Oil pan gasket
2. Oil pan assembly
3. Oil pan heater port (optional)
4. Oil pan heater seal (optional)
5. Oil pan heater (optional)
6. Oil pan heater cord (optional)
7. Mounting bar (1 each side)
8. Drain plug
9. Drain plug seal

Flexplate/Flywheel Assemblies

Allison 2000 Series Transmissions

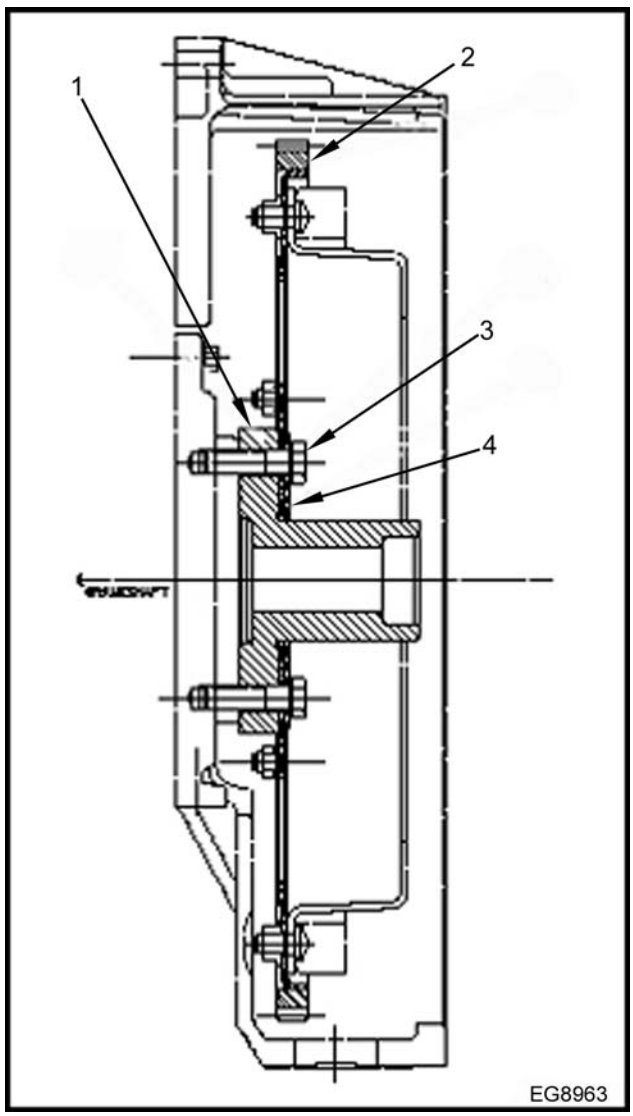

Figure 259 Allison 2000 Series transmission flywheel assembly

1. Adapter Hub
2. Flywheel Assembly
3. Mounting Bolt
4. Reinforcement Ring

MD-3000 Series Transmissions

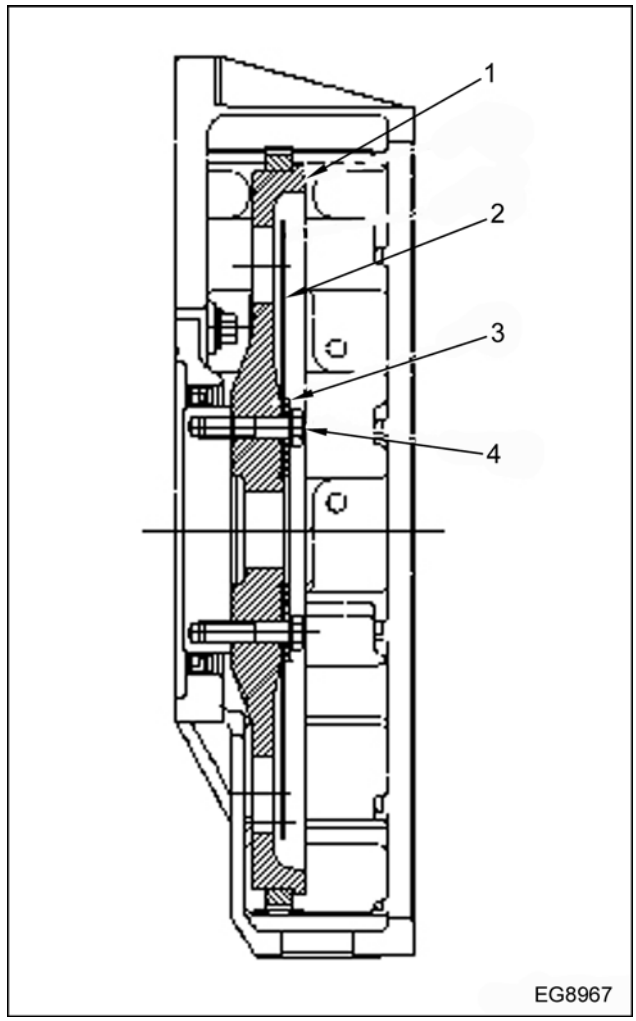

Figure 260 MD-3000 series transmission flywheel assembly

1. Flywheel Assembly
2. Flexplate
3. Reinforcement Ring
4. Mounting Bolts

Remove

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure transmission is in neutral or park, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

NOTE: Rear oil seal can be serviced in chassis. Procedure is performed as part of an engine overhaul or separately, when required.

NOTE: If an optional rear PTO assembly is installed, see rear PTO service procedures in appropriate *Chassis Service Manual*.

NOTE: If removing 148 tooth ring gear flywheel (approximate 18.70 inch outside diameter), first loosen two bolts in engine mounts on side of flywheel housing to provide clearance for flywheel ring gear. These bolts are lowest and rear most bolts on engine mounts.

NOTE: Flywheel housing supports rear engine mounts. Do not remove any mounting hardware or flywheel housing bolts until engine is properly supported.

Miscellaneous

See appropriate sections of this publication, remove miscellaneous components as required:

- Oil, fuel, and coolant filters
- Auto tensioner
- Belt
- ECM and mounting bracket (if equipped)
- Valve cover and intake manifold
- Road draft tube
- Cylinder head
- Fuel injectors
- Wiring harness
- Thermostat
- Oil level gauge and tube assembly
- Exhaust manifold
- Turbocharger
- Turbocharger supply and drain lines
- Coolant filter head
- Fuel filter header and fuel lines

Flywheel or Flexplate

Remove Flywheel

NOTE: For applications using automatic transmissions, take note of the position and orientation of flexplate(s), spacers, and reinforcing ring.

1. Remove two flywheel mounting bolts at 3 and 9 o'clock positions. Install two guide studs from Guide Stud Set (ZTSE4375) (page 219) in place of mounting bolts.
2. Remove remaining ten flywheel mounting bolts.
3. Slide flywheel out of flywheel housing and off guide studs.

NOTE: With flywheel removed, guide studs can be removed from crankshaft flange.

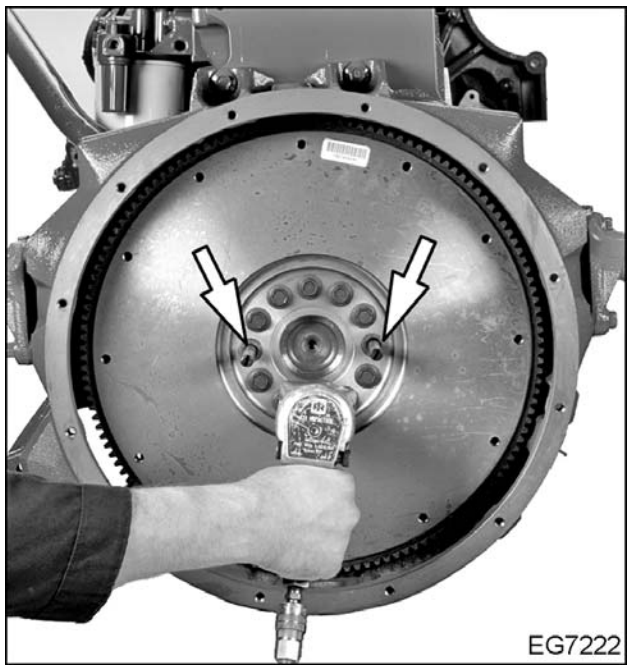

Figure 261 Remove flywheel

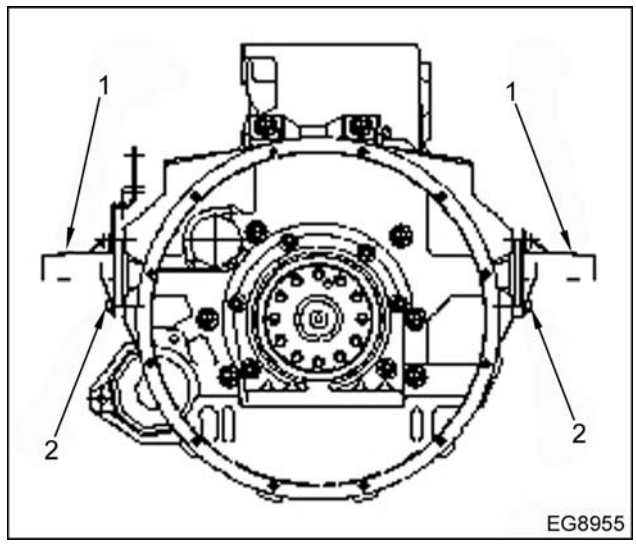

Figure 262 Engine mounting bolts

1. Rear engine mounts
2. Mounting bolts

Remove Flywheel - (148 Tooth Ring Gear) Manual Transmissions

NOTE: With 148 Tooth Ring Gears (approximately 18.70" OD) Manual Transmissions

WARNING: To avoid personal injury, or possible death, do not remove any engine mount hardware until the engine is properly supported.

Follow same procedure as Automatic Transmission flywheels, EXCEPT lower rear engine mount bolts on side of flywheel housing must be loosened. Must be done to provide clearance for removal and installation of flywheel ring gear.

CAUTION: When installing 148 tooth ring gear (ring gear approximately 18.70" OD) flywheel, be sure to torque engine mount bolts to special torque after flywheel replacement.

Remove Flexplate - (Allison 2000 Series) Automatic Transmissions

NOTE: Vehicles Equipped with Allison 2000 Series Automatic Transmissions

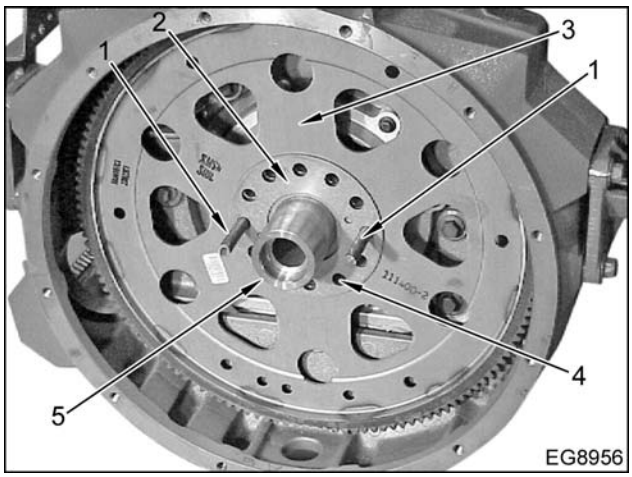

Figure 263 Remove flexplate (vehicles equipped with Allison 2000 series transmissions)

1. Guide pins
2. Reinforcement ring
3. Flexplate assembly with ring gear
4. Mounting bolt holes
5. Adapter hub

NOTE: Note position and orientation of flexplate, spacers and reinforcing ring.

1. Use paint marker to identify exposed face of reinforcing ring.
2. Remove two flexplate mounting bolts at 3 and 9 o'clock positions. Install guide studs from Guide Stud Set (ZTSE4375) (page 219) in place of mounting bolts.
3. Remove remaining ten bolts from flexplate.
4. Slide reinforcing ring, flexplate and adapter hub, off guide studs. Guide studs may be removed after flexplate is removed.

Remove Flexplate - (MD-3000 Series) Automatic Transmissions

NOTE: Vehicles Equipped with MD-3000 Series Automatic Transmissions

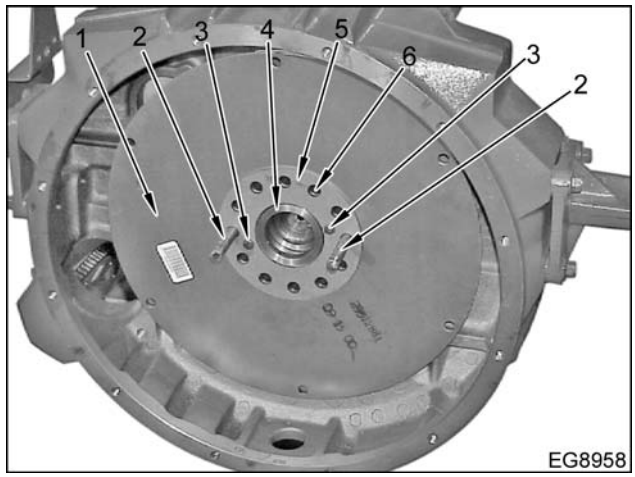

Figure 264 Remove flexplate (vehicles equipped with MD-3000 series transmissions

1. Flexplate assembly
2. Guide studs
3. Flexplate assembly bolts (DO NOT REMOVE)
4. Adapter flexplate
5. Ring reinforcement
6. Mounting bolt holes

CAUTION: To avoid possible engine or vehicle damage, do not remove two small flexplate assembly bolts near the twelve flexplate mounting bolts. Alignment of flexplate assembly will be affected and will cause engine vibration and possible engine and transmission failure.

1. Remove two flexplate mounting bolts at 3 and 9 o'clock positions. Install guide studs from Guide

Stud Set (ZTSE4375) (page 219) in place of mounting bolts.

2. Remove remaining ten bolts from flexplate.
3. DO NOT REMOVE flexplate assembly bolts.

   NOTE: Flexplate assembly is available as a complete service part. There is no need to disassemble flexplate assembly.
4. Slide flexplate assembly off guide studs. Guide studs may be removed after flexplate assembly removal.

Remove Flywheel Housing

WARNING: To prevent personal injury or possible death, due to heavy weight and limited access, get assistance to remove or install the flywheel housing, especially when working in chassis.

CAUTION: To avoid engine damage, for vehicles equipped with MT-654CR transmission, a transmission adapter ring is bolted to transmission side of flywheel housing. It is not necessary to remove adapter ring from flywheel housing. This is a special flywheel housing with adapter ring bolted in place to match with flywheel housing as it was machined.

NOTE: Only remove flywheel housing if required.

1. Remove eight flywheel housing mounting bolts from crankcase.
2. Remove flywheel housing from crankcase.

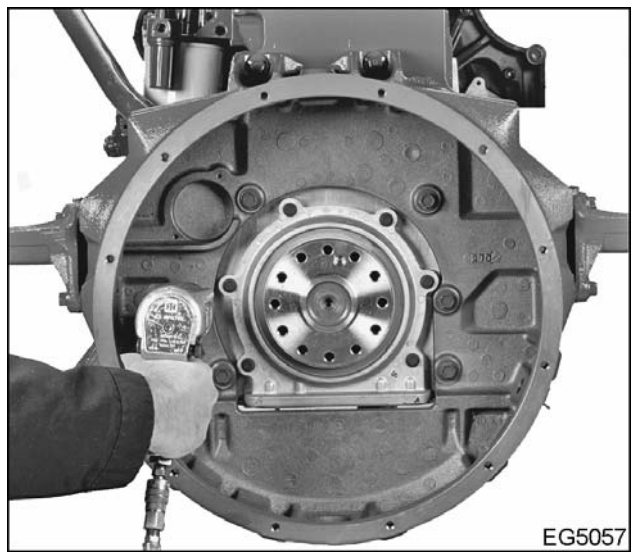

Figure 265 Remove flywheel housing

Remove Rear Oil Seal

NOTE: It is not necessary to remove the flywheel housing if the rear oil seal carrier, oil seal, and wear sleeve are being replaced. It is not necessary to remove the rear oil seal carrier if there is no leakage and the crankshaft is not being removed. The applicable steps should be followed.

1. Remove pose seal by sliding or prying it off rear oil seal.

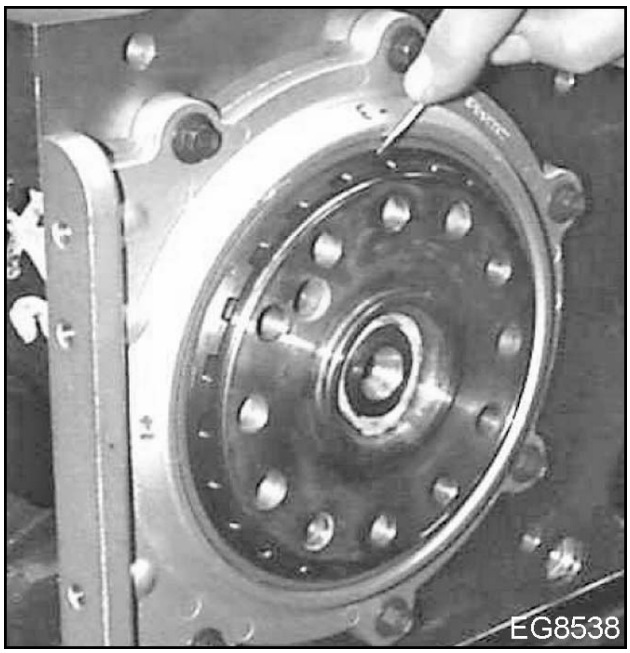

Figure 266 Remove pose seal

2. Punch two holes in rear oil seal at 3 and 9 o'clock positions. Insert two sheet metal screws (from Slide Hammer Puller Set) in holes.

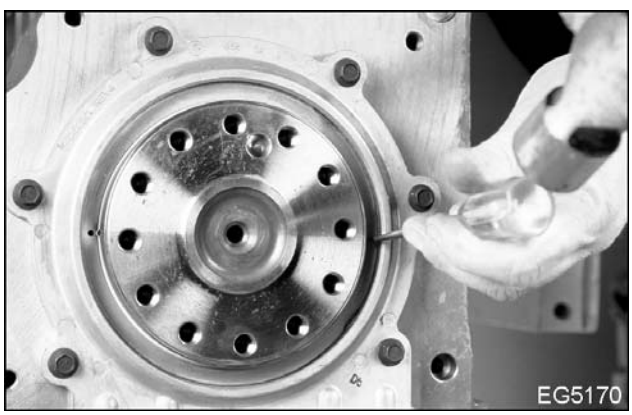

Figure 267 Punch holes in rear oil seal

3. Remove rear oil seal from carrier, discard oil seal. Use slide hammer with appropriate adapter end from Slide Hammer Puller Set (ZTSE1879) (page 219).

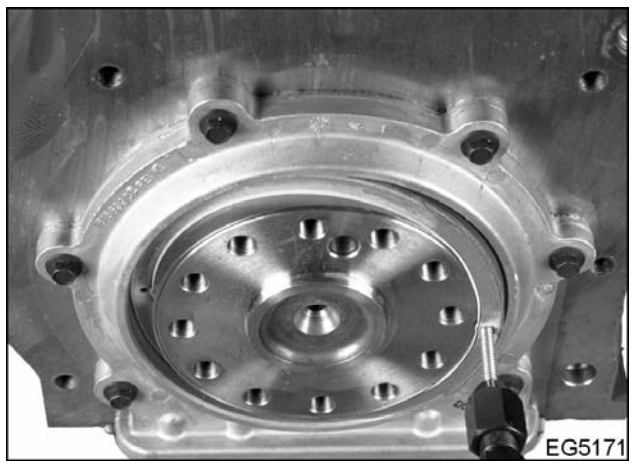

Figure 268 Remove rear oil seal

4. If the rear oil seal carrier must be removed and replaced, continue with "Remove Rear Oil Seal Carrier" in this section. If there is no leakage at the rear oil seal carrier and the crankshaft is not being replaced, remove the rear wear sleeve with the rear oil seal carrier installed. See "Remove Rear Wear Sleeve" with "Rear Oil Seal Carrier Installed" in this section.

Remove Rear Oil Seal Carrier

NOTE: The rear oil seal carrier should not be removed unless repairing a carrier leak or removing the crankshaft.

1. Remove six rear oil seal carrier bolts from crankcase.
2. Remove rear oil seal carrier. Remove rear oil seal from carrier. Hammer may be used to remove seal from carrier. Discard oil seal.

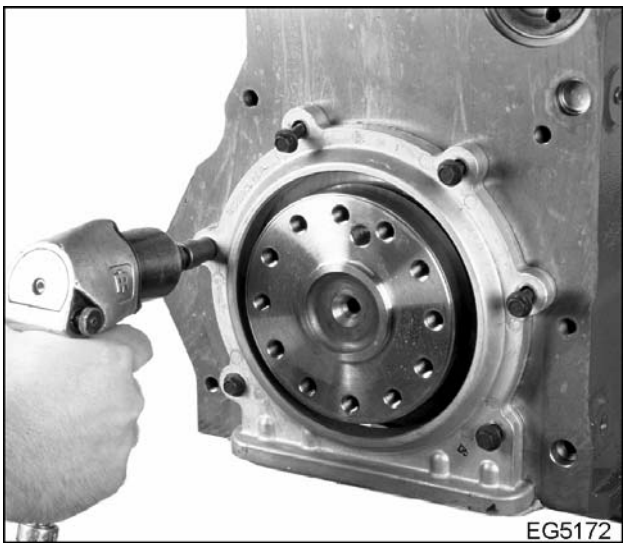

Figure 269 Remove rear oil seal carrier

3. Remove and discard rear oil seal carrier gasket.

Remove Rear Wear Sleeve

Rear Oil Seal Carrier Removed

1. With rear oil seal carrier removed, tap outside diameter of wear sleeve.

   NOTE: This will cause wear sleeve to expand and slide off easily.

2. Remove and discard wear sleeve.

Rear Oil Seal Carrier Installed

CAUTION: To avoid possible damage to engine, do not nick crankshaft flange.

NOTE: This method may be used when repair is to be done in chassis with flywheel housing in place.

NOTE: The rear oil seal carrier should not be removed and replaced if there is no leakage or the crankshaft is not being removed.

1. Mount Rear Wear Sleeve Remover (ZTSE4404) guide plate against crankshaft (page 219). Assemble three collets around wear sleeve, guide plate and crankshaft flange.

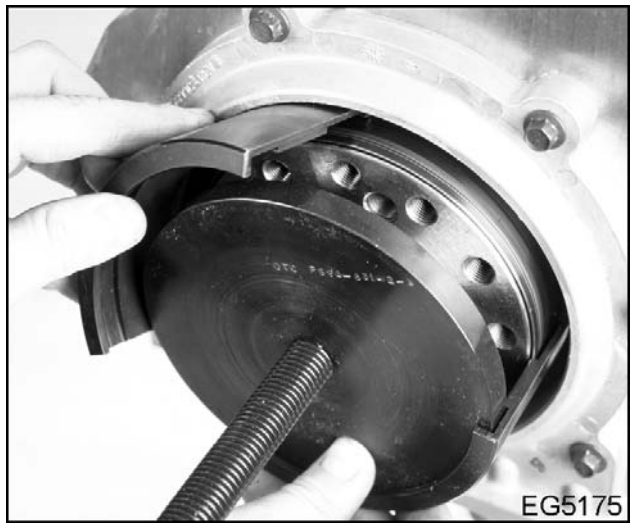

Figure 270 Assemble Wear Sleeve Removal Tool

2. Assemble sleeve over three collets on crankshaft flange.

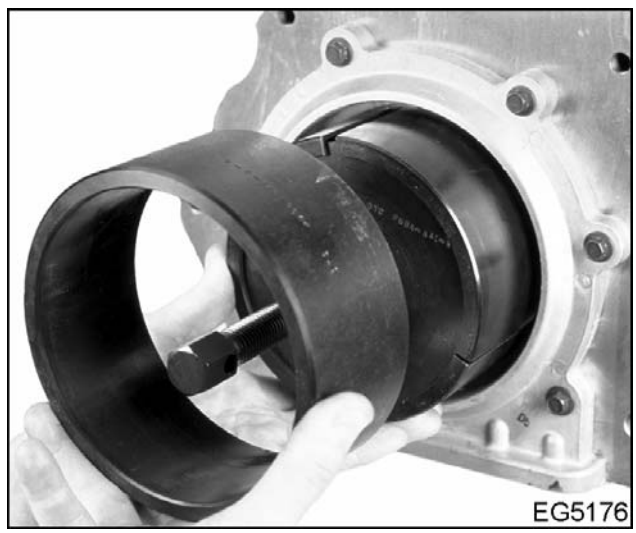

Figure 271 Assemble sleeve

3. Hold guide plate while turning forcing screw to remove wear sleeve. Remove wear sleeve from sleeve remover. Discard wear sleeve.

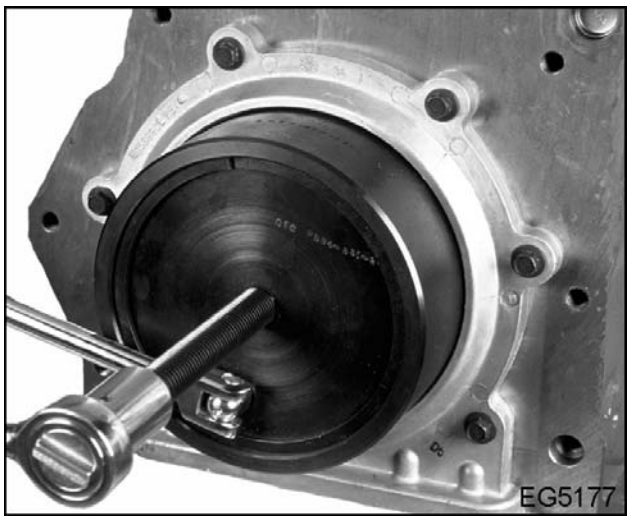

Figure 272 Remove wear sleeve

4. Inspect crankshaft flange for damage.

Remove Rear PTO Housing Assembly (If Equipped)

CAUTION: To avoid engine damage, support back end of engine when servicing rear PTO assembly.

NOTE: Rear oil seal can be serviced in chassis. This procedure can be performed as part of engine overhaul or separately, when required.

NOTE: Rear oil seal is in rear PTO housing assembly. This rear seal is different than engine rear oil seal.

Remove Flywheel or Flexplate

See “Remove Flywheel” in this section. Removal of flexplate is similar.

NOTE: For applications using automatic transmissions, take note of position and orientation of the flexplate, spacers, and reinforcing ring.

Remove Rear PTO Housing Assembly

1. Install 5/8 in course thread lifting eye in tapped hole located on top of rear PTO housing. Use an appropriate lifting device to support rear PTO housing.
2. Loosen lubrication supply tube nuts from crankcase to rear PTO housing. Remove supply tube.
3. Loosen and remove lubrication supply tube elbow on rear PTO housing.

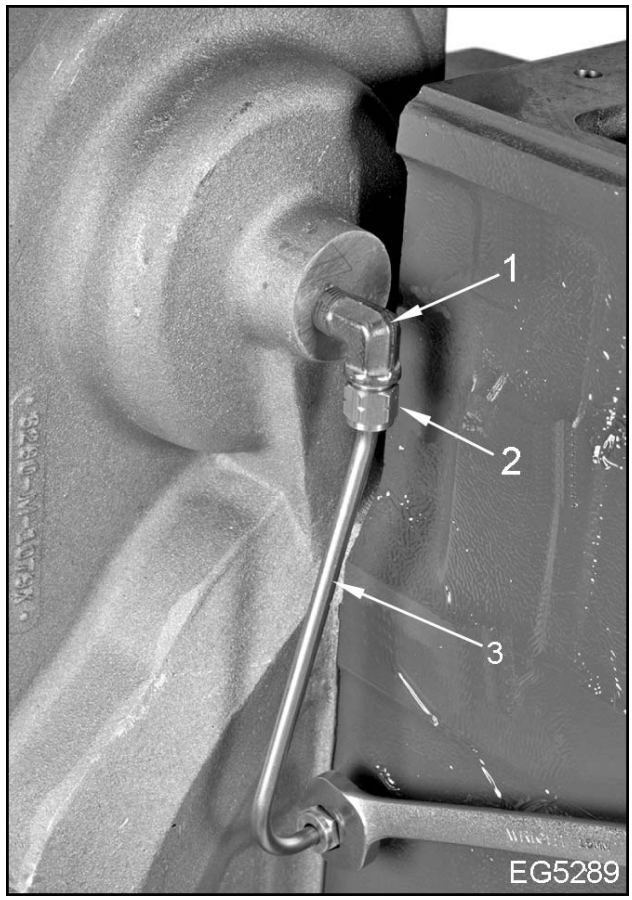

Figure 273 Oil lubrication supply tube connections

1. Lubrication supply tube elbow
2. Lubrication supply tube nut
3. Lubrication supply tube

4. Remove four pipe plugs from rear PTO housing. Save pipe plugs for installation.

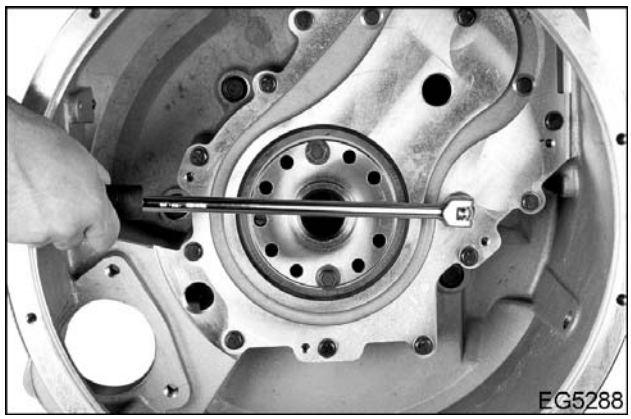

Figure 274 Remove pipe plugs

5. Remove special hex nut inside rear PTO housing (under PTO unit drive center line upper pipe plug). Do not let special nut fall inside housing.

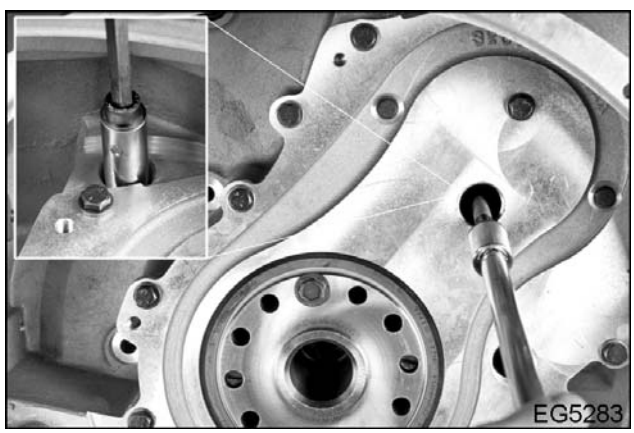

Figure 275 Remove special nut

6. Remove three PTO housing mounting bolts after pipe plugs have been removed.

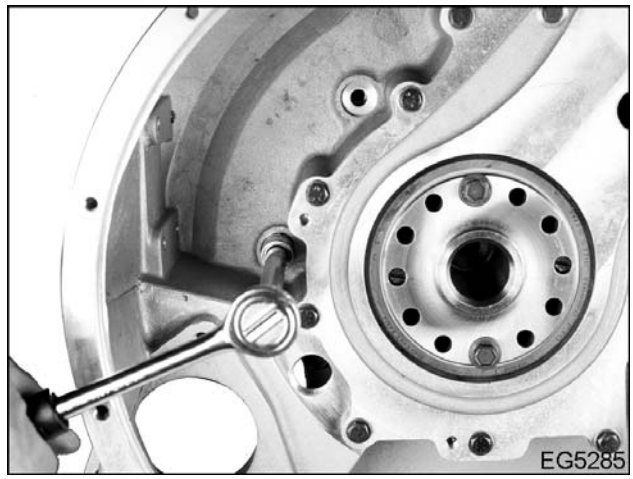

Figure 276 Remove PTO mounting bolts

7. Install four pipe plugs back in rear PTO housing.
8. Remove remaining four PTO housing mounting bolts.
9. Place rags or suitable container under rear PTO housing assembly. Dispose of rags, containers, and oil according to local regulations.

NOTE: Approximately one quart of oil remains in housing sump area.

NOTE: Be sure to support crank gear when removing PTO housing. If crank gear is not supported, it may fall in PTO housing.

10. Pull rear PTO housing assembly straight back, away from crankcase.
11. Remove one hollow dowel pin and four O-rings from PTO housing.
12. Lay rear PTO housing assembly face down on engine mounting surface side. Remove dowel guide pins.

NOTE: Some additional oil may drain from PTO housing as it is laid flat.

Remove PTO Housing Rear Oil Sleeve

Remove the pose seal and rear oil seal. See “Remove Rear Oil Seal (page 178)” in this section.

Remove PTO Housing Rear Oil Seal Carrier

NOTE: The rear oil seal is in the rear PTO housing assembly. See appropriate *Chassis Service Manual* for service procedures.

NOTE: The rear oil seal carrier can not be removed until four bolts mounted through oil pan and in bottom of rear oil seal carrier are removed. See “Remove Oil Pan” in this section.

1. Remove six bolts securing rear carrier to crankcase. Remove carrier.

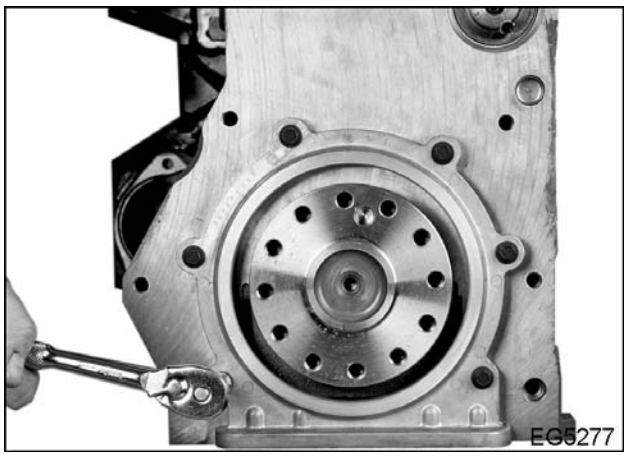

Figure 277 Remove rear carrier mounting bolts

2. Remove rear oil seal carrier. Remove rear oil seal from carrier. Hammer may be used to remove seal from carrier. Discard oil seal.
3. Remove and discard rear oil seal carrier gasket.

Remove PTO Housing Rear Wear Sleeve

Remove rear wear sleeve. See “Remove Rear Wear Sleeve” in this section.

Oil Pan

Remove Oil Pan

1. Remove 22 oil pan mounting bolts.

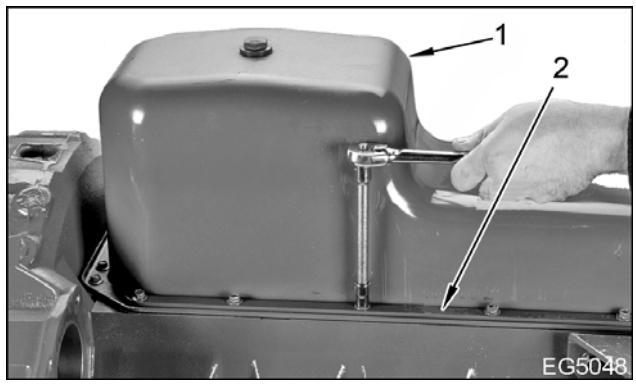

Figure 278 Remove oil pan mounting bolts

1. Oil pan
2. Mounting bar (2)

2. Remove mounting bars.
3. Remove oil pan and gasket from crankcase. Discard gasket.

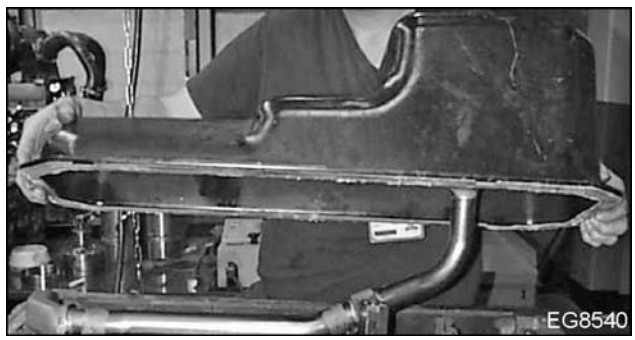

Figure 279 Remove oil pan

Remove Oil Level Gauge Tube Assembly

1. Loosen and remove oil filler tube clamp screw from crankcase.
2. Remove oil level gauge, oil filler tube, and oil filler tube clamp from crankcase as an assembly.
3. Discard O-ring.
4. If necessary lightly tap, with a brass drift and hammer, oil level gauge lower tube to remove from crankcase.

   NOTE: Removal of oil level gauge lower tube from crankcase requires removal of oil pan.

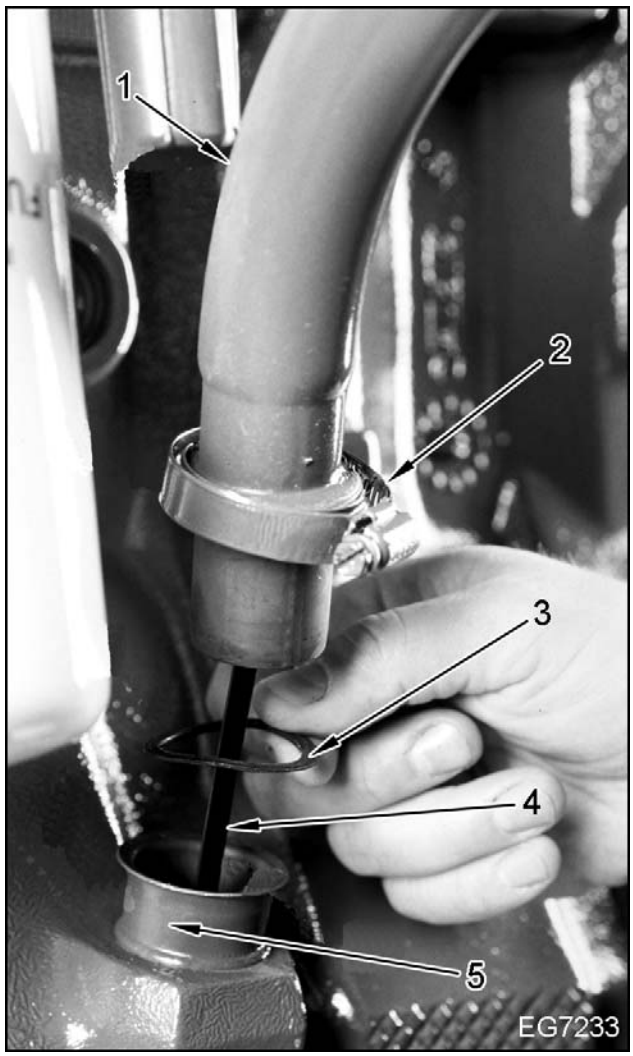

Figure 280 Remove oil level gauge and oil filler tube

1. Oil filler tube
2. Tube clamp
3. O-ring gasket
4. Oil level gauge
5. Oil level gauge lower tube

Remove Vibration Damper Assembly

1. Remove paint from face of vibration damper at four points, 90° apart.
2. Pry crankshaft forward to remove end play.

   NOTE: All crankshaft end play should be removed prior to measuring vibration damper runout.
3. Mount Dial Indicator (page 219) on front cover. Position indicator point on an unpainted surface and “zero” Dial Indicator.
4. Pry crankshaft forward and measure runout, read Dial Indicator.
5. Repeat steps at each unpainted surface. If runout exceeds “Specification (page 215),” replace vibration damper.

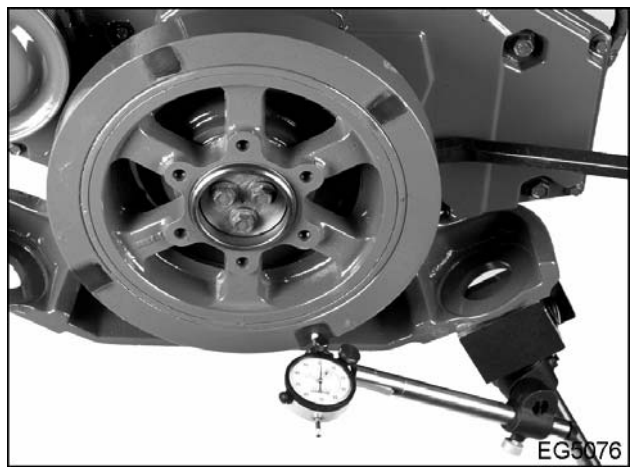

Figure 281 Measure vibration damper runout

6. Remove three vibration damper pulley bolts and vibration damper retainer.

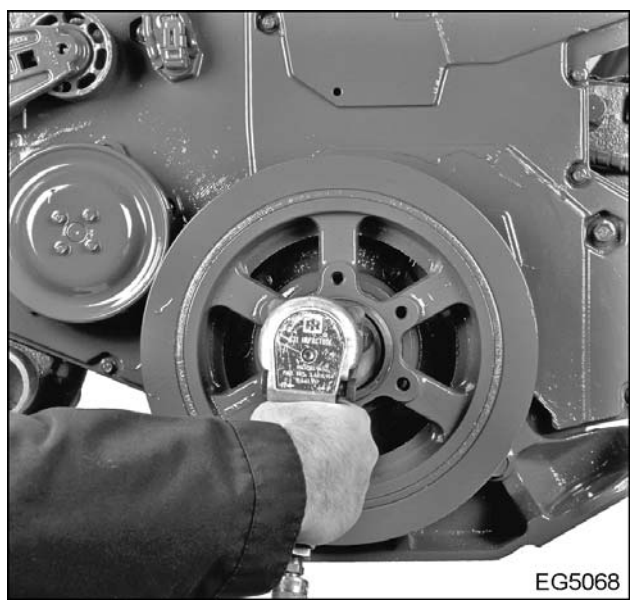

Figure 282 Remove vibration damper retainer

7. Inspect the damper bolts and damper retaining plate. If the damper bolts are not grade 12.9 or one or more are damaged, discard the three vibration damper bolts and the vibration damper retaining plate. The damper retainer kit will be used to replace the vibration damper components. If the damper retaining plate is not 2.54 mm (0.10 inch) thick or is damaged, discard the three vibration damper bolts and the vibration damper retaining plate. The damper retainer kit will be used to replace the vibration damper components.
8. Mount Gear and Pulley Puller (Large) (OEM4245) (page 219) on vibration damper pulley, use bolts long enough to hold puller in place. Turn forcing screw, remove vibration damper pulley.

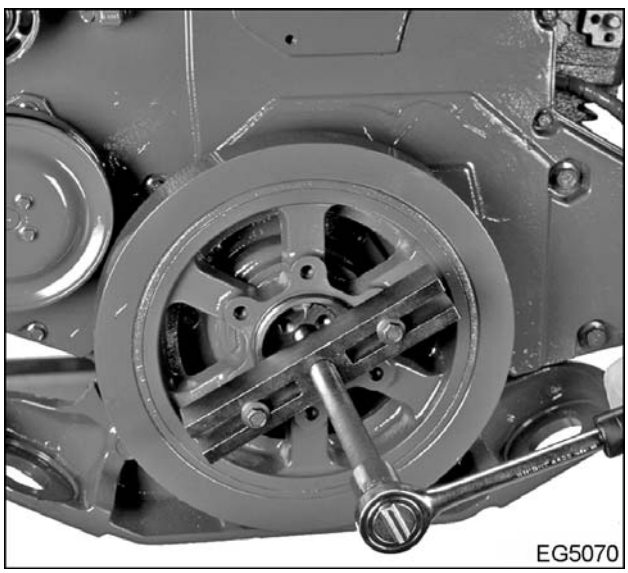

Figure 283 Remove vibration damper pulley

CAUTION: To avoid possible engine or vehicle damage, support front of engine before removing front engine mounting bracket bolts.

9. Remove front engine mounting bracket bolts.

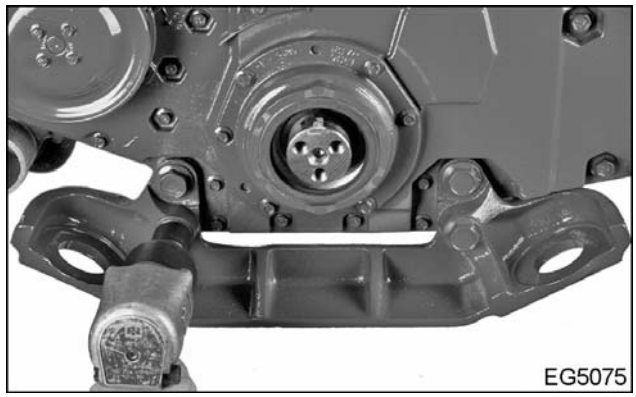

Figure 284 Remove front engine mounting bracket

Remove Oil Pickup Tube

NOTE: To remove oil pickup tube, remove vibration damper pulley first.

1. Remove two oil pickup tube retaining bolts in front cover.

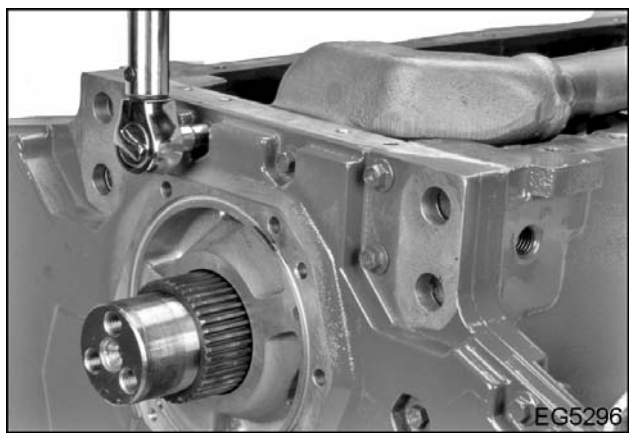

Figure 285 Remove oil pickup tube retaining bolts

2. Support oil pickup tube, remove support bracket retaining bolt.

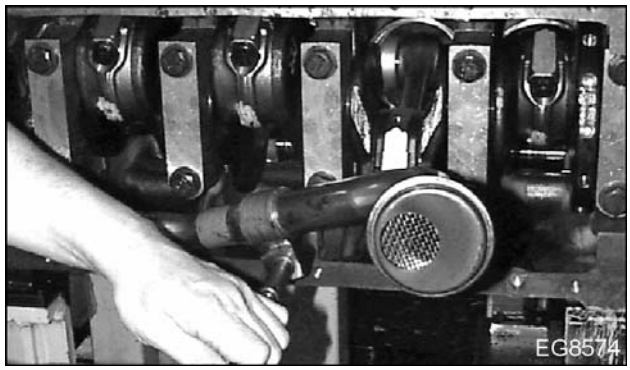

Figure 286 Remove oil pickup tube support bracket bolt

3. Remove oil pickup tube and gasket. Discard gasket.
4. Remove piston and connecting rod assemblies. See “Remove - Piston and Rod Assembly (page 136)” in the Power Cylinders” section in this manual, for procedure.

Remove Crankshaft and Main Bearings

1. Rotate engine stand so crankshaft is on top and horizontal.
2. Verify bearing caps and crankcase are stamped to identify location. Stamp crankcase oil pan rail and main bearing caps on camshaft side. Stamp in numerical order; number caps from 1 through 7, starting with 1 at front of engine.

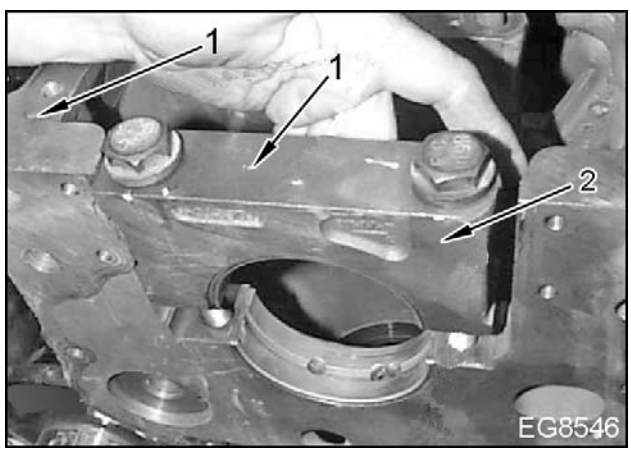

Figure 287 Main bearing cap numbers

1. Number stamp location
2. Bearing cap

3. Loosen and remove main bearing cap bolts.

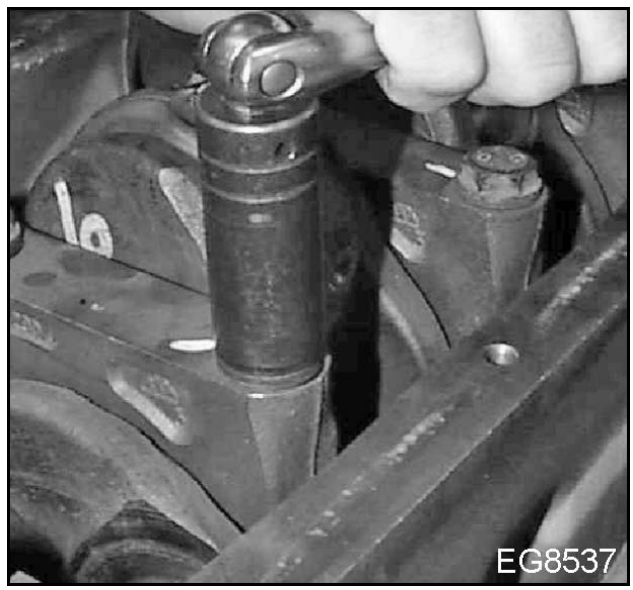

Figure 288 Remove main bearing cap bolts

4. Grasp main bearing cap and rock back and forth to loosen, remove cap. Bearing cap bolts may be used to rock cap as necessary.

   NOTE: Use only hand pressure when rocking caps during removal.
5. Remove lower bearing shell from main bearing cap and keep in order with bearing cap for inspection.
6. Loosen and remove the two rear thrust bearing, bearing 7, mounting bolts.
7. Grasp bearing cap 7 and rock back and forth to loosen, remove cap. Bearing cap bolts may be used to rock cap as necessary.

   NOTE: Use only hand pressure when rocking caps during removal.

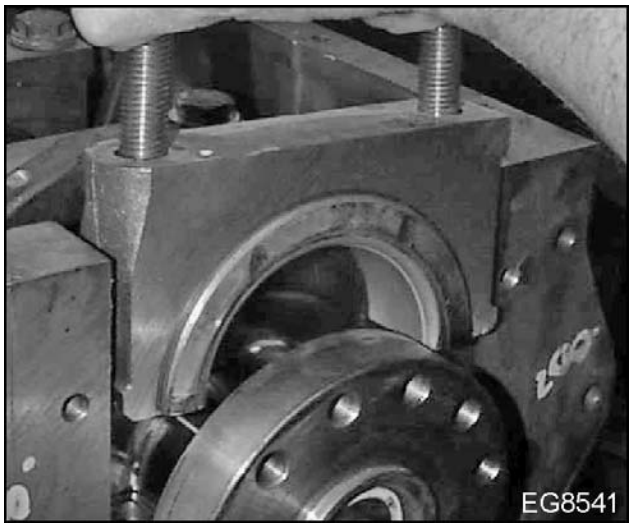

Figure 289 Remove rear thrust bearing (bearing 7)

CAUTION: To avoid possible engine or vehicle damage, do not bind, bend, drop, or gouge crankshaft.

8. Remove crankshaft from crankcase using an appropriate lifting sling. Keep crankshaft level to prevent binding. Do not drop or gouge crankshaft during removal. Set crankshaft on a protected surface and prevent it from falling or rolling.

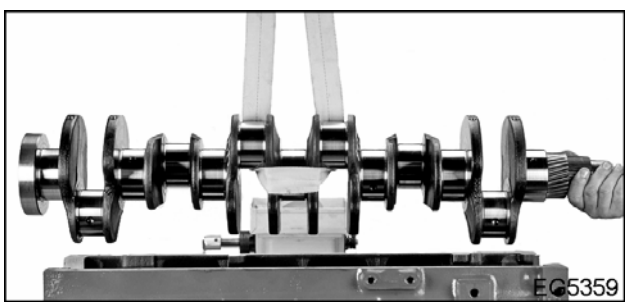

Figure 290 Lift crankshaft

9. Remove upper main bearing shells. Push bearing shells out of main bearing saddle. Mark upper shells and put with lower shells.

Figure 291 Remove upper main bearing shells

Crankshaft Gear

CAUTION: To avoid possible engine damage, strike chisel carefully to prevent damaging the crankshaft during gear removal.

1. Remove oil pump drive spline. Place chisel between teeth of oil pump drive spline. Strike chisel with hammer to break spline off crankshaft.

Figure 292 Remove oil pump drive spline

2. Remove crankshaft gear. Place chisel between teeth of crankshaft gear. Strike chisel with hammer to break gear off crankshaft.

Remove Engine Block Heater (if equipped)

WARNING: To avoid personal injury from hot coolant, allow engine time to cool down before draining coolant.

1. Drain cooling system.
2. Flush system, if necessary.
3. Disconnect power cord to socket.
4. Loosen cap screw at center of engine block heater.

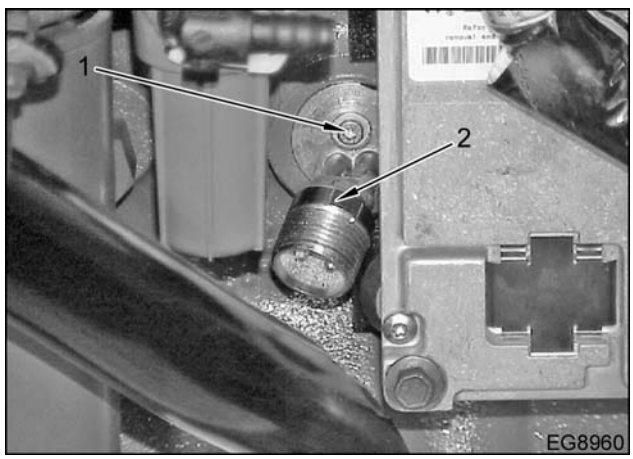

Figure 293 Engine block heater

1. Cap Screw
2. Engine block heater

5. Carefully slide heater out of engine.

Clean, Inspect, and Test

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi).

NOTE: Do not use a caustic solution on engine or related components.

Flywheel or Flexplate Housing

Clean Rear PTO Housing (If Equipped)

Clean O-rings grooves (one large and three small) free of all old sealant material.

Measure Flywheel Housing Bore Concentricity and Face Runout

CAUTION: To avoid engine damage, bore concentricity and face runout are checked to ensure proper engine-to-transmission alignment. Failure to ensure proper bore concentricity and face runout may result in reduced transmission or engine life.

1. Attach Dial Indicator (page 219) to crankshaft. Place indicator tip against flywheel housing bore.
2. Zero Dial Indicator.
3. Rotate crankshaft slowly. Measure flywheel housing bore concentricity. See “Specifications (page 215)” for tolerances.

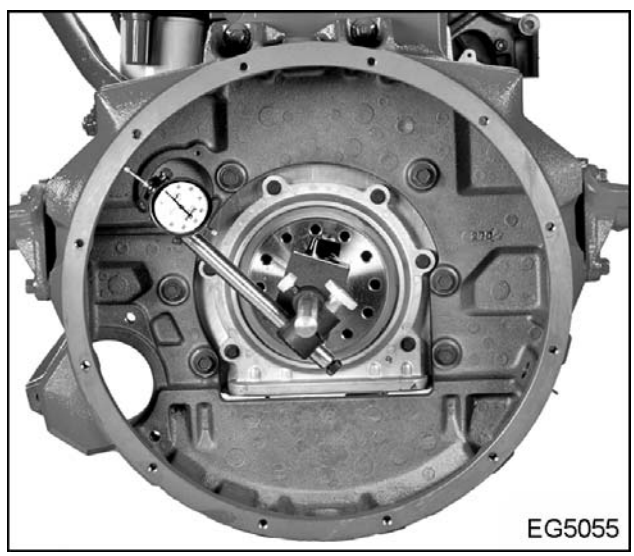

Figure 294 Measure flywheel bore concentricity

Measure Flywheel Housing Face Runout

1. Attach Dial Indicator (page 219) to crankshaft. Place Dial Indicator tip against housing face.
2. Zero Dial Indicator.
3. Keep crankshaft end play at zero in same direction for all measurements.

4. Measure flywheel housing face runout at four points 90 degrees apart for total face runout variation. See “Specifications (page 215)” for housing face runout tolerance.

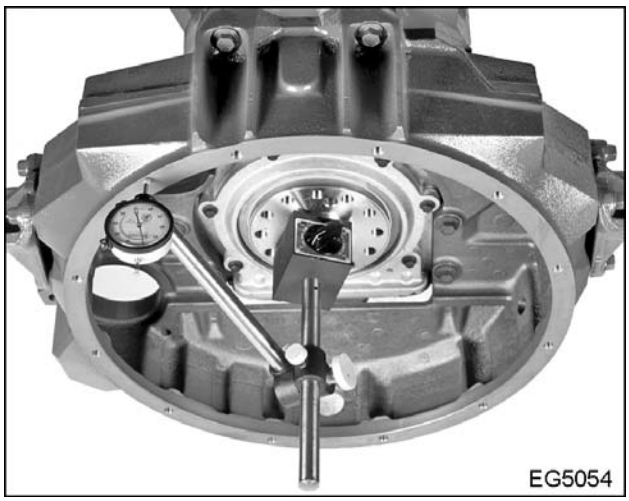

Figure 295 Measure flywheel housing face runout

Measure Crankshaft Pilot Concentricity

1. Attach Dial Indicator (page 219) to flywheel housing, place Dial Indicator tip against flywheel pilot.
2. Zero Dial Indicator.
3. Rotate crankshaft slowly, measure flywheel crankshaft pilot concentricity. See “Specifications (page 215)” for crankshaft pilot concentricity tolerance.

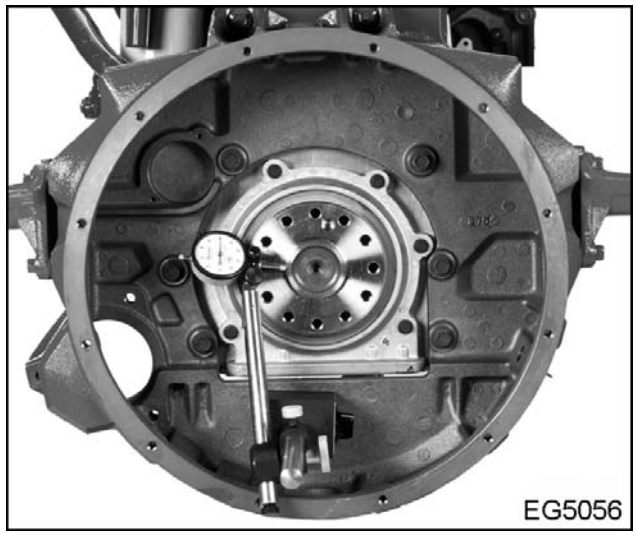

Figure 296 Measure crankshaft pilot concentricity

Flywheel

Clean Flywheel

Clean flywheel with a non-caustic solvent and dry with compressed air.

Inspect Flywheel

1. Inspect flywheel for cracks, heat checks, and extensive scoring that would make it unfit for further service. Replace or resurface as required.
2. Inspect ring gear for worn, chipped, or cracked teeth. If teeth are damaged, replace ring gear.

Measure Flywheel for Reconditioning

WARNING: To avoid serious personal injury or possible death, possible engine or vehicle damage, flywheel resurfacing information is provided for guidance only. International Truck and Engine Corporation assumes no responsibility either for the results of any work performed in accordance with this information or for the ability of service personnel to detect heat cracks. Any crack or heat check in the flywheel could cause it to separate, creating the possibility of injury to the operator or bystanders. Carefully examine the flywheel, after resurfacing, for any cracks or heat checks. If there is any question, do not use the flywheel.

NOTE: Flywheels used with manual transmissions may be reconditioned to correct minor wear and scoring. Flywheels used with automatic transmissions cannot be reconditioned. If damaged replace flywheel.

1. Measure from Clutch Disc and Cover Plate Mounting Face to Crankcase Flange Mounting Face. Determine if flywheel has been previously reconditioned. Determine if there is adequate stock to recondition flywheel.
2. If dimensions are 0.380 to 0.405 mm (1.50 to 1.51 in), flywheel has not been reconditioned.
3. Minimum dimension after reconditioning is 0.36 mm (1.430 in) at lowest point on flywheel. Surface should be flat and even. If dimensions cannot be maintained, flywheel must be replaced.

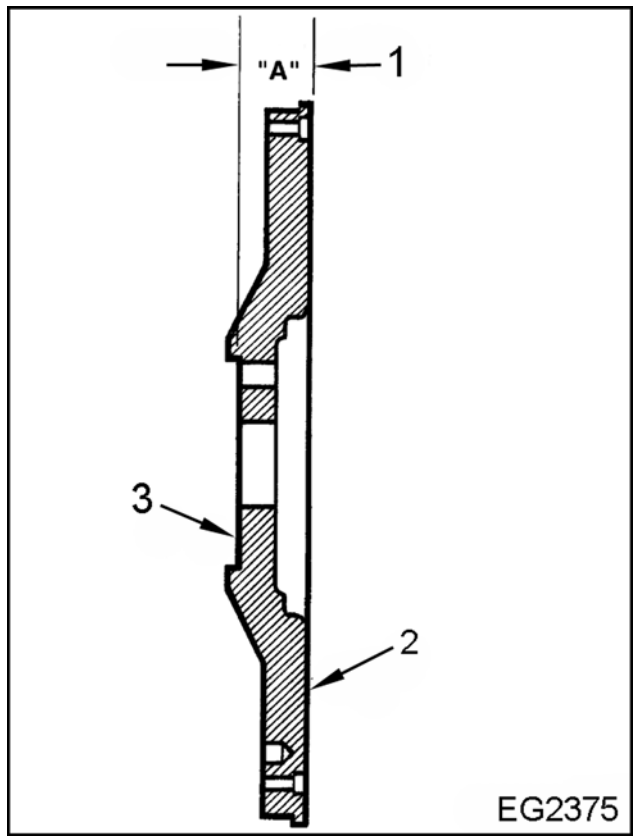

Figure 297 Flywheel reconditioning

1. Dimension “A”
   a. New Flywheel 0.380 to 0.405 mm (1.50 to 1.51 in)
   b. Minimum Permissible After Resurfacing 0.36 mm (1.430 in)
2. Clutch Disc and Cover Plate Mounting Face
3. Crankcase Flange Mounting Face

Replace Ring Gear

Remove Damaged Ring Gear

1. Heat ring gear evenly with torch until ring gear expands enough to be removed.

CAUTION: To avoid possible damage to engine or transmission, do not hit flywheel when removing ring gear.

2. Once expanded, knock ring gear off flywheel.

Install Ring Gear

1. Heat new ring gear evenly until gear expands enough to slip on flywheel.

CAUTION: To avoid possible damage to engine or transmission, do not heat ring gear to temperature above 278 °C (500 °F). Heating beyond this temperature will adversely affect ring gear hardness.

2. Seat ring gear firmly and properly against flywheel shoulder.

Oil Level Gauge Tube Assembly

Clean Oil Level Gauge Tube Assembly

1. Thoroughly clean both tubes and clear any obstructions.
2. Remove all old Loctite® from oil level gauge and crankcase casting area, where oil level gauge mates with tubes.

Inspect Oil Level Gauge Tube Assembly

1. Inspect components for kinks, bends, or restrictions.
2. Replace components as required.

Vibration Damper

Clean Vibration Damper

1. Clean vibration damper using suitable solvent.
2. Dry with filtered compressed air.

Inspect Vibration Damper

CAUTION: To avoid possible engine damage, the vibration damper cannot be repaired. Dents, leakage, or housing distortion can result in improper damper functioning leading to extensive engine damage.

1. Inspect vibration damper pulley.
2. Inspect vibration damper for dents and leaks.
3. Inspect rubber insert for swelling, separation, or cracking.

Main Bearing Cap Bolts

Replace all main bearing bolts.

Crankshaft and Main Bearings

Clean Crankshaft and Main Bearings

1. Clean bearing inserts and caps thoroughly in solvent and dry with filtered compressed air.

   NOTE: Do not scrape gum or varnish deposits off bearing shells.

2. Clean all internal oil passages in crankshaft. Use Crankshaft Oil Hole Brush (ZTSE4392) (page 219). Loosen all dirt, sludge, and deposits that may have accumulated. Flush oil passages with suitable non-caustic solvent.
3. Blow passages dry with filtered compressed air.

Inspect Crankshaft and Main Bearings

1. Inspect crankshaft journals (main and rod) for scratches, grooves, and scoring.
2. Inspect crankshaft journals and main bearing journals for cracks. See “Inspect Cylinder Head for Cracks (page 81)” in “Cylinder Head and Valve” section of this manual for inspection criteria.
3. Inspect all bearing inserts. Replace all bearings that are scored, chipped, or worn.

Measure Main Bearings

1. Measure diameter of each journal with Outside Micrometer (page 219). Measure each journal at two points right angles to each other. Move micrometer over entire width of journal.
2. If journals exceed maximum out-of-round “Specification (page 215),” crankshaft must be reground.

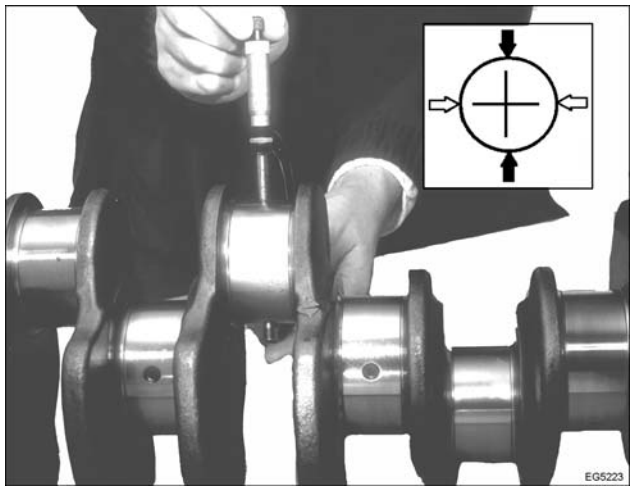

Figure 298 Measure crankshaft

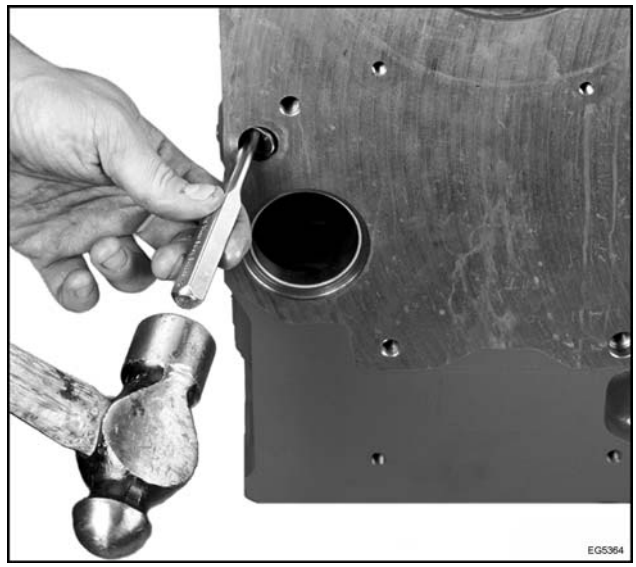

Figure 299 Remove main gallery cup plug

Crankcase

Clean Crankcase

NOTE: Use a chemical bath or “hot tank” to clean crankcase during engine overhaul. Chemical bath removes all carbon material and mineral deposits that collect in cooling passages. If chemical bath is not available, use following cleaning procedure.

1. Clean all old gasket material off surfaces of crankcase. Use scraper and sanding block.
2. Clean cylinder sleeve bores. Use nylon brush with soap and water.
3. Remove main oil gallery cup plug from rear of crankcase with hammer and chisel.
4. With cup plug removed, clean oil galleries and cross drilling. Use Main Oil Gallery Brush (ZTSE4389) (page 219) with soap and water.

Figure 300 Clean crankcase galleries

5. Blow out oil galleries and cross drilling with filtered compressed air.
6. Clean all threaded holes with an appropriate sized Critical Metric Taps (ZTSE4386) (page 219).

7. Clean mating surfaces of crankcase main oil gallery and cup plug.
8. Apply Loctite® to outside edge of main oil gallery cup plug.
9. Drive main oil gallery cup plug in crankcase with arbor, approximately 6 mm (.0236 in). Recess cup plug 3.2 mm (0.126 in).
10. Clean excess Loctite® off crankcase around cup plug before it hardens.

Inspect Crankcase

NOTE: Threaded holes with damaged threads may be salvaged with use of a thread insert.

NOTE: Do not resurface crankcase. Surface defects beyond those listed are not correctable. Replace crankcase.

1. Measure the crankcase deck for flatness. Use Bevelled Edge Straightedge (OEM1293) and Feeler Gauge (page 219). Use flatness pattern. If 0.076 mm (0.003 in) feeler gauge can pass through, crankcase must be replaced.

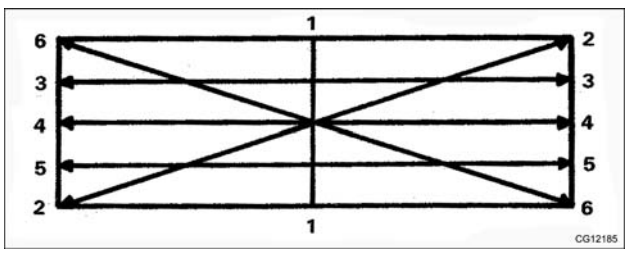

Figure 301 Flatness pattern

Inspect Piston Cooling Jet Tubes

1. Inspect both ends of cooling jet tubes while installed in crankcase. Verify flanged end under bearing saddle is intact and orifice end protruding from crankcase is not broken. Replace any damaged cooling jet tubes.
2. Shine light source under small orifice in tube end protruding in crankcase from insertion point in bearing saddle.
3. Look in large orifice of piston cooling jet. If light source is visible, tube is clear. If light source is not visible, tube is blocked. Clean tube to remove blockage.

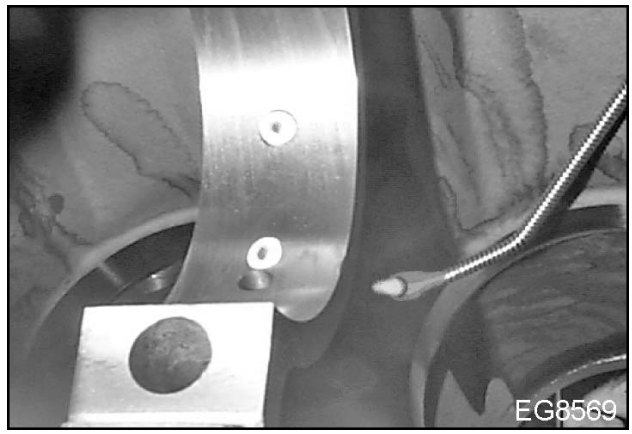

Figure 302 Inspect piston cooling jet tubes

CAUTION: To avoid possible engine damage, do not use any metal wire or torch tip cleaner to force debris out of the jet. Internal orifice size is critical for correct power cylinder lubrication. Any distortion or increased orifice size caused by cleaning may damage engine.

NOTE: Do not remove piston cooling jet tubes unless they are damaged or cannot pass visual inspection after cleaning.

Clean Piston Cooling Jet Tubes

1. Blow debris out of piston cooling jet tube with filtered compressed air.
2. Shine light source under small orifice in tube end protruding in crankcase from insertion point in bearing saddle.
3. If compressed air alone will not dislodge blockage, replace piston cooling jet tube.

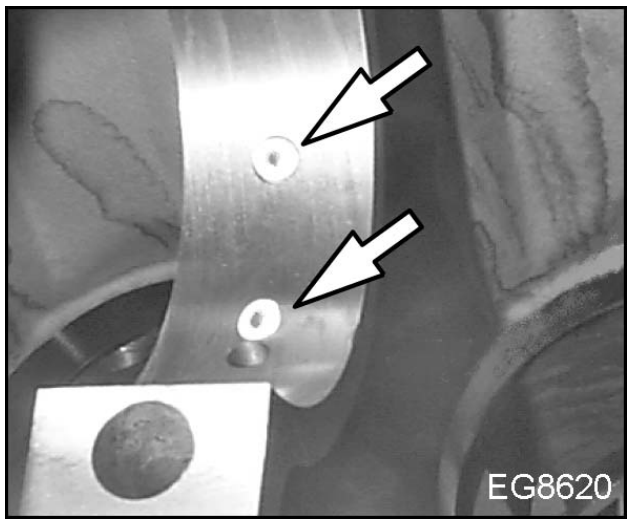

Figure 303 Clean piston cooling jet tube

Oil Pan

1. Clean RTV from oil pan lip using wire wheel.

NOTE: Clean all RTV from oil pan lip, crankcase rails, front cover, and rear oil seal carrier.

Install

Install Engine Block Heater (if equipped)

1. Remove any corrosion from engine block heater bore.
2. Apply a coating of grease to O-ring and mounting hole in engine block.

   NOTE: Be sure tee bar is positioned in channel groove before installing.

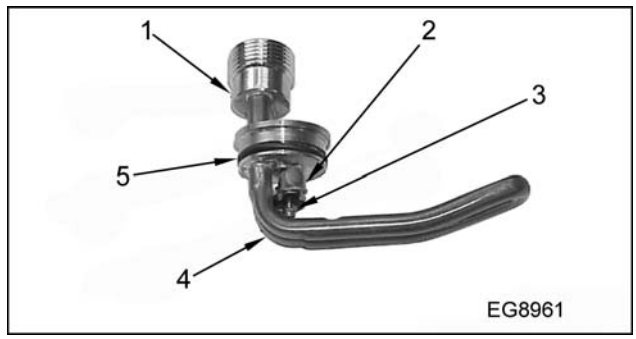

Figure 304 Engine block heater

1. Socket
2. Channels
3. Tee bar
4. Heating element
5. O-ring

3. Install engine block heater in crankcase with element pointing up.

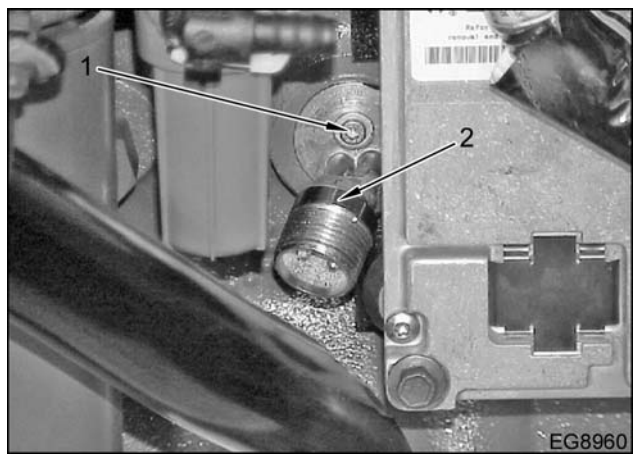

Figure 305 Mount engine block heater in engine block

1. Cap screw
2. Engine block heater

4. Torque cap screw to “Special Torque (page 218)” to lock channels against inside block wall.
5. Connect power cord to socket, taking care to align pins with sockets of connector cord. Press plug in firmly and tighten strain relief nut securely by hand. Connector cord wire should point upwards.

6. Route cord outside, securing where necessary to insure that cord does not touch engine, hot pipes, or moving parts.
7. Refill cooling system.

   CAUTION: Before applying power to heater, remove all trapped air by running engine for 5 to 10 minutes after thermostat opens (normal operating temperature).
8. Connect to 120 Volt AC grounded outlet. If an extension cord is used, it must be three-wire grounded type.

Install Crankshaft Gear

1. With gears removed, heat crankshaft gear and oil pump drive spline to 188 to 202 °C (370 to 395 °F).
2. Install crankshaft gear first. Make sure locating pin on crankshaft gear aligns with crankshaft properly. Press gear in place.
3. Install (heated) oil pump drive spline on crankshaft until flush with crankshaft gear.

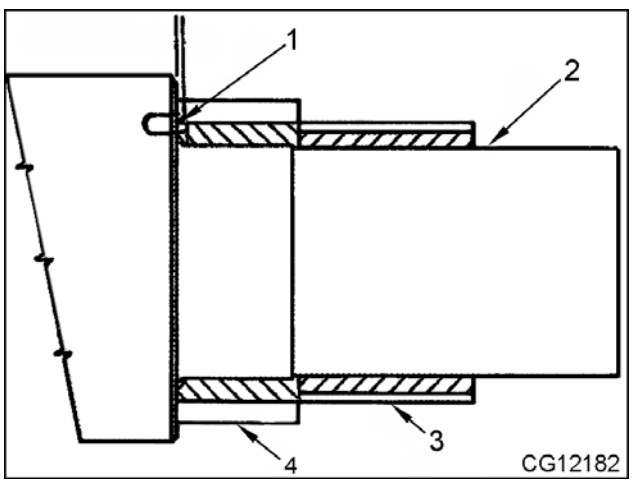

Figure 306 Install crankshaft gear

1. Locating pin
2. Crankshaft
3. Oil pump drive spline
4. Crankshaft gear

Install Crankshaft and Main Bearings

1. Rotate engine so main bearing saddles are facing up. Clean bearing saddles with lint-free cloth. Supports must be free of oil.

NOTE: Do not lubricate back side of bearing inserts.

2. Install upper bearing inserts in bearing saddle. Make sure locking tangs on bearings are snapped in crankcase.

Figure 307 Install upper bearing inserts

3. Apply marker die paste (Prussian Blue™ or equivalent) to crankshaft main bearing journals. Carefully lower crankshaft on main bearing inserts in crankcase.

NOTE: Do not install main bearing caps and lower bearing inserts at this time.

4. Rotate crankshaft 180 degrees (1/2 turn).
5. Carefully remove crankshaft and inspect upper bearing inserts for an even transfer of bluing from journals to bearings.

NOTE: If voids appeared in bluing transfer, crankcase integrity is questionable.

6. If crankcase is not damaged and is free of distortion and burrs around upper bearing insert seats, clean all marker die paste from bearings and crankshaft journals.
7. Lubricate upper main bearing inserts with clean engine oil.

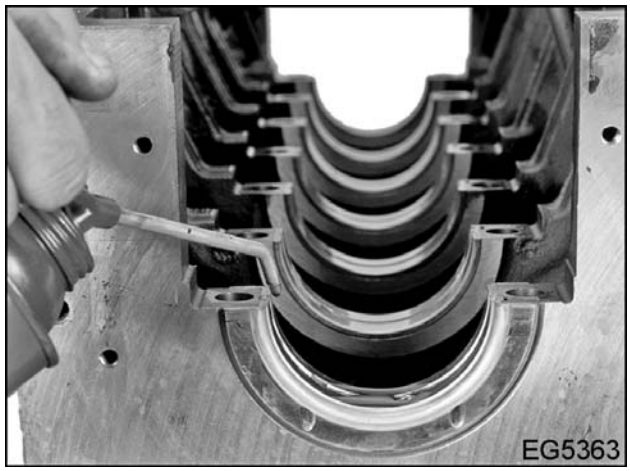

Figure 308 Lubricate upper main bearing insert

8. Carefully install crankshaft in main bearing saddles. Use an appropriate lifting sling to lower crankshaft.

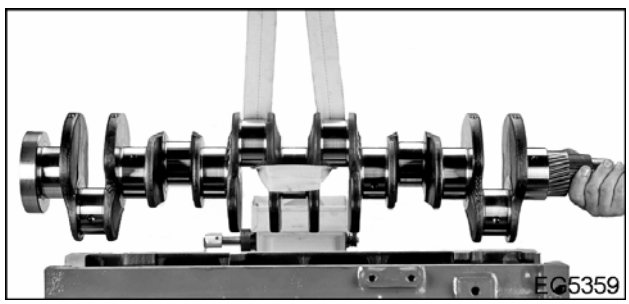

Figure 309 Install crankshaft

Fit Bearings

1. Install new bearing(s) in bearing cap(s), as required. Make sure locking tangs on bearing inserts are snapped in bearing cap notch.
2. Clean bearing surface and exposed half of crankshaft journal. Make sure these surfaces are free of oil.

NOTE: Do not follow torque to yield procedure until final assembly. Install bearing caps and lower inserts. Torque bolts to 136 N·m (100 lbf·ft) and then 177 N·m (130 lbf·ft).

3. Remove one bearing cap and insert at a time. Leave remaining caps tight while checking bearing clearance fit with cap removed.
4. Wipe oil from all contact surfaces of exposed journal, bearing insert and cap that is removed.
5. Place a piece of Plastigage® across full width of bearing surface on crankshaft journal (or bearing insert) approximately 6 mm (1/4 in) off center. Install bearing cap and tighten cap bolt to 136 N·m (100 lbf·ft) and then 177 N·m (130 lbf·ft).

NOTE: Do not turn crankshaft.

NOTE: For in chassis service only - When bearing clearance is checked, crankshaft will have to be supported and held against upper main bearing halves to get a correct Plastigage® reading. Use a jack at counter weight next to each main bearing being checked to support crankshaft. Failure to support crankshaft will result in inaccurate readings.

6. Remove bearing cap with insert.
7. Do not disturb Plastigage®. Use scale on Plastigage® envelope to measure widest point of Plastigage®. This reading indicates bearing clearance in thousandths of an inch or millimeters.

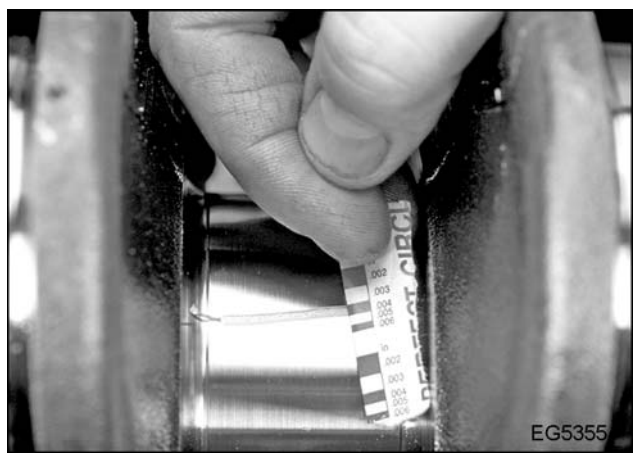

Figure 310 Measure Plastigage®

8. If bearing clearance is not within “Specifications (page 215),” crankshaft must be replaced or reground and under size bearings installed (as described earlier in this section).

Install Main Bearing and Cap

NOTE: Use new main bearing cap bolts whenever bearing caps are serviced.

1. Clean Plastigage® from main bearing or crankshaft journal surface.

2. Coat all bearing surface journals and new main bearing cap bolts with clean engine oil.
3. Install main bearing cap 1 through 6, complete with lower bearing inserts.

NOTE: Make sure main bearings are installed with arrow pointing to cam side and numbered from front of engine to rear.

4. Install new main bearing cap bolts and torque cap bolts to “Special Torque (page 218)” follow “Main Bearing Cap Bolt Tensioning” procedure following the “Special Torque” table in this section (page 218).

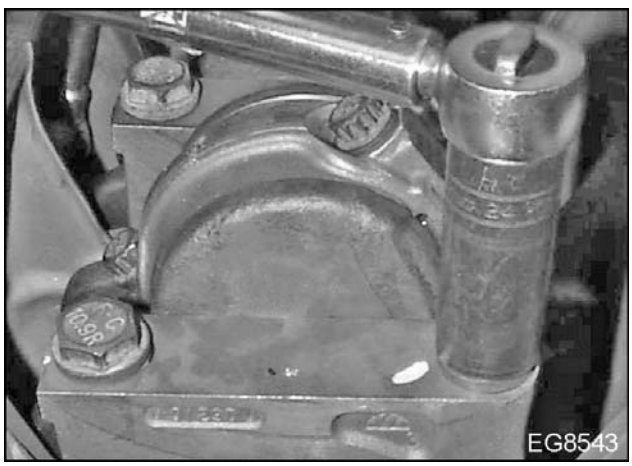

Figure 311 Install main bearing cap

5. Insert main bearing cap with rear thrust bearing in position. Center rear thrust bearing by moving crankshaft rearward, then forward.
6. Torque two rear thrust bearing bolts to 136 N·m (100 lbf·ft) and then 177 N·m (130 lbf·ft).
7. Check crankshaft end play, mount the dial indicator on crankcase with indicator tip on crankcase flange face.
8. Lightly pry the crankshaft forward and zero indicator.
9. Lightly pry crankshaft rearward and monitor dial indicator reading. Repeat to assure an accurate reading.
10. If end play exceeds “Specifications (page 215),” replace thrust bearing and recheck crankshaft end play.
11. If end play does not meet “Specifications (page 215),” loosen main bearing caps, reposition, torque and check end play again.

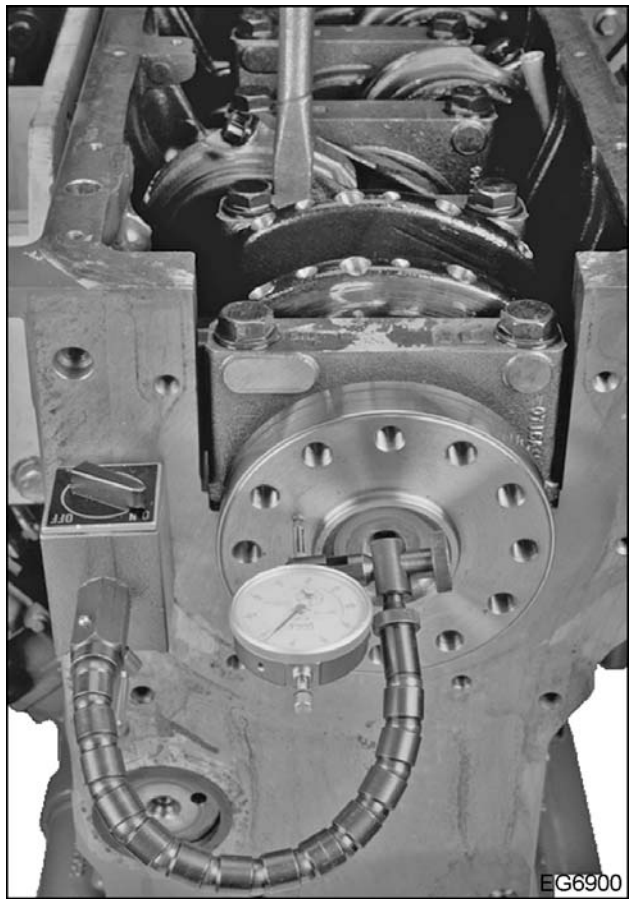

Figure 312 Measure crankshaft end play

12. Install piston and connecting rod assemblies. See “Install Piston and Connecting Rod Assembly (page 158)” in the Power Cylinders” section of this manual.
13. Install front cover. See “Install Front Cover (Front Half) Assembly (page 236)” in the “Timing Gear Train and Front Cover” section of this manual.
14. Install oil pump assembly. See “Install Lubricating Oil Pump (page 254)” in the “Lubricating Oil Pump, Oil filter, and Cooler” section of this manual.

Install Rear Oil Seal And Wear Sleeve

Install Rear Oil Seal Carrier

NOTE: It is not necessary to remove the flywheel housing if the rear oil seal carrier, oil seal, and wear sleeve are being replaced.

1. Attach Rear Oil Seal and Wear Sleeve Installer (ZTSE2535C) (page 219) with two mounting bolts to crankshaft flange.

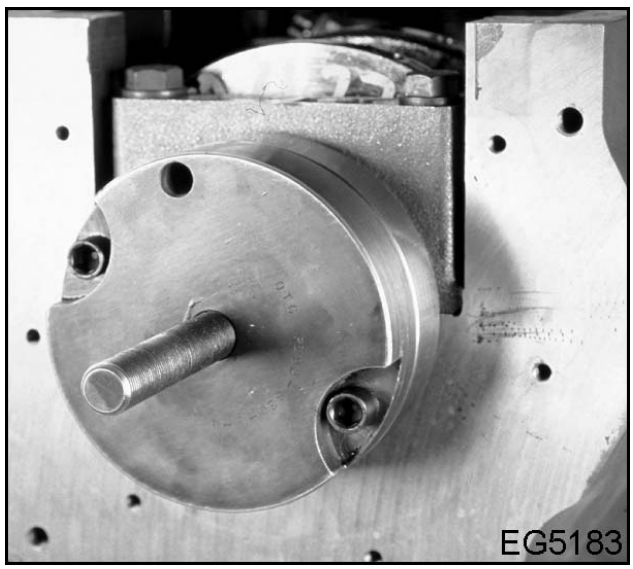

Figure 313 Install Rear Oil Seal and Wear Sleeve Installer

2. Place new gasket in rear oil seal carrier. Install rear oil seal carrier on crankcase loosely with mounting bolts.

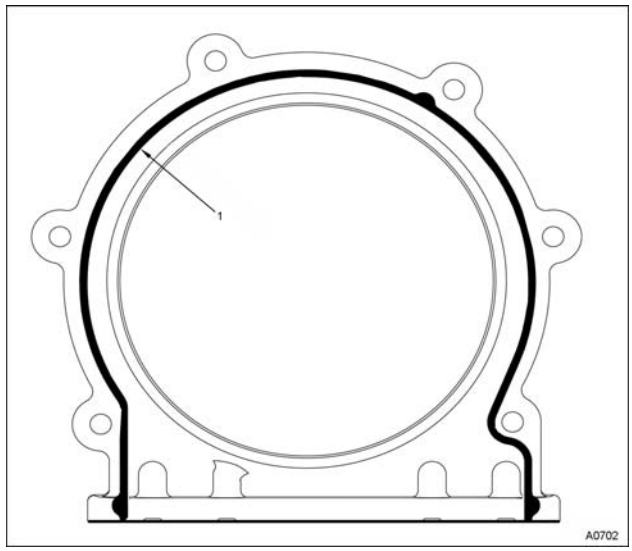

Figure 314 Install gasket on carrier

1. Oil seal carrier gasket

NOTE: If the carrier gasket does not seat on the crankcase, it will leak.

3. Rotate carrier, as necessary, to align carrier with crankcase rails. Verify proper alignment. Use Bevelled Edge Straightedge (OEM1293) (page 219).
4. When rear oil seal carrier is level, tighten mounting bolts to “Special Torque (page 218).”
5. Assemble Rear Oil Seal and Wear Sleeve Installer on crankshaft.

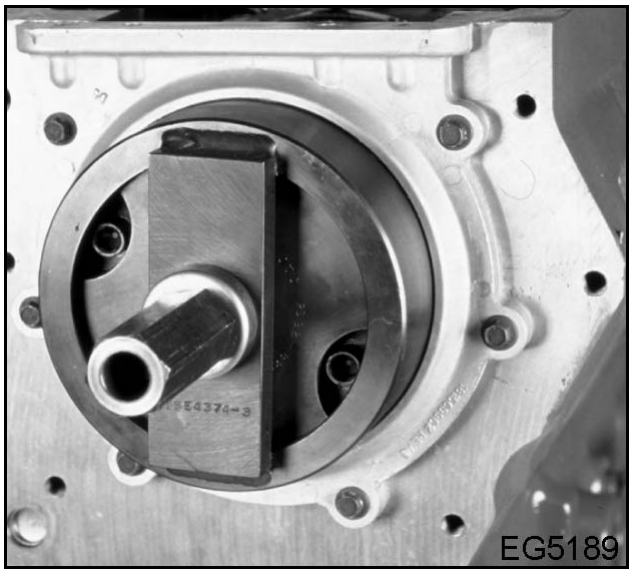

Figure 315 Assemble Rear Oil Seal and Wear Sleeve Installer

6. Turn forcing nut, with appropriate sized wrench, on Rear Oil Seal and Wear Sleeve Installer until seal and sleeve are seated in bore.

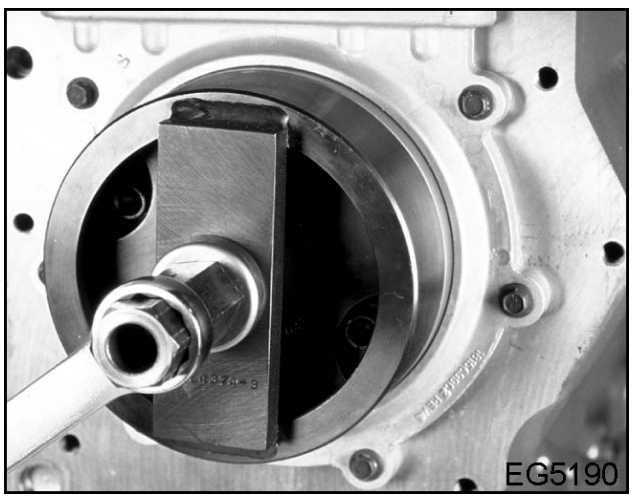

Figure 316 Install oil seal carrier

Install Rear Oil Seal and Wear Sleeve

1. Install main oil gallery cup plug, if not already installed. See “Clean Crankcase” in this section.

NOTE: Install rear oil seal and wear sleeve as a unit. Do not remove seal from wear sleeve prior to installation.

2. Clean crankshaft flange and seal carrier bore thoroughly. Remove any debris.
3. Attach Rear Oil Seal and Wear Sleeve Installer (ZTSE2535C) (page 219) with two mounting screws to crankshaft flange.

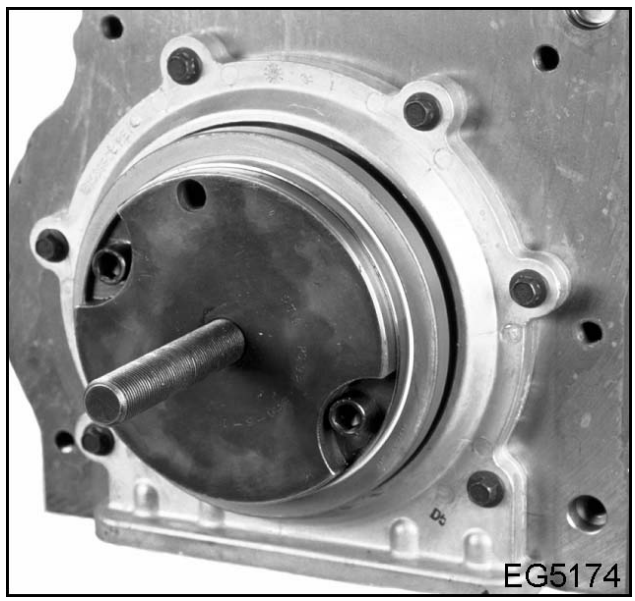

Figure 317 Attach Rear Oil Seal and Wear Sleeve Installer

4. Coat inside diameter of wear sleeve and outside diameter of oil seal with Permatex®.

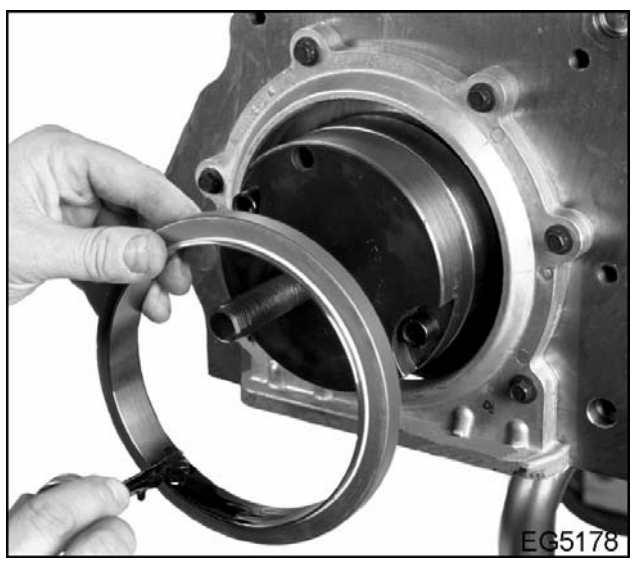

Figure 318 Prepare rear wear sleeve

5. Position oil seal and wear sleeve over crankshaft.

   NOTE: Proper use of installer tool will ensure oil seal and wear sleeve are pressed on crankshaft flange to proper depth.

6. Assemble Rear Oil Seal and Wear Sleeve Installer on crankshaft. Turn forcing nut, with appropriate sized wrench, on Rear Oil Seal and Wear Sleeve Installer until seal and sleeve are seated in bore.

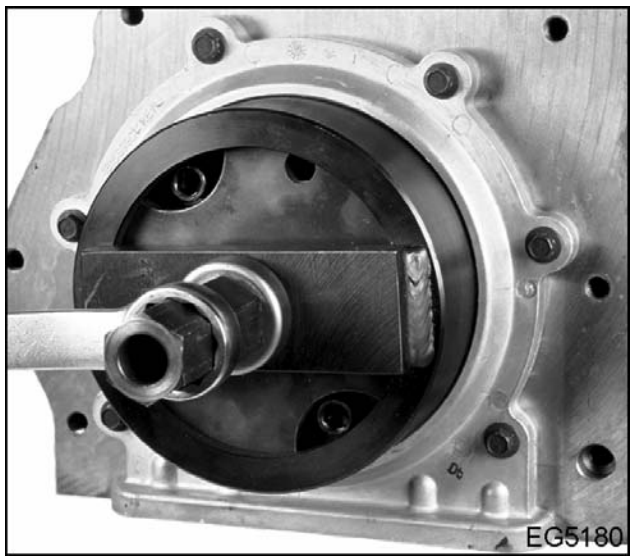

Figure 319 Install rear oil seal and wear sleeve

7. Remove Rear Oil Seal and Wear Sleeve Installer.

8. Place new pose seal on end of crankshaft. Work pose seal on by moving pose seal in circular direction until pose seal is on completely.

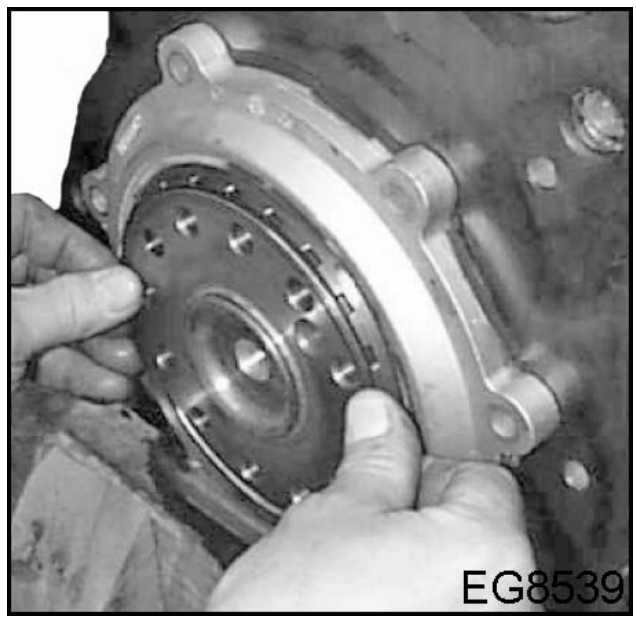

Figure 320 Install pose seal

Install Flywheel Housing

1. Install new camshaft O-ring over camshaft end opening at rear of crankcase.

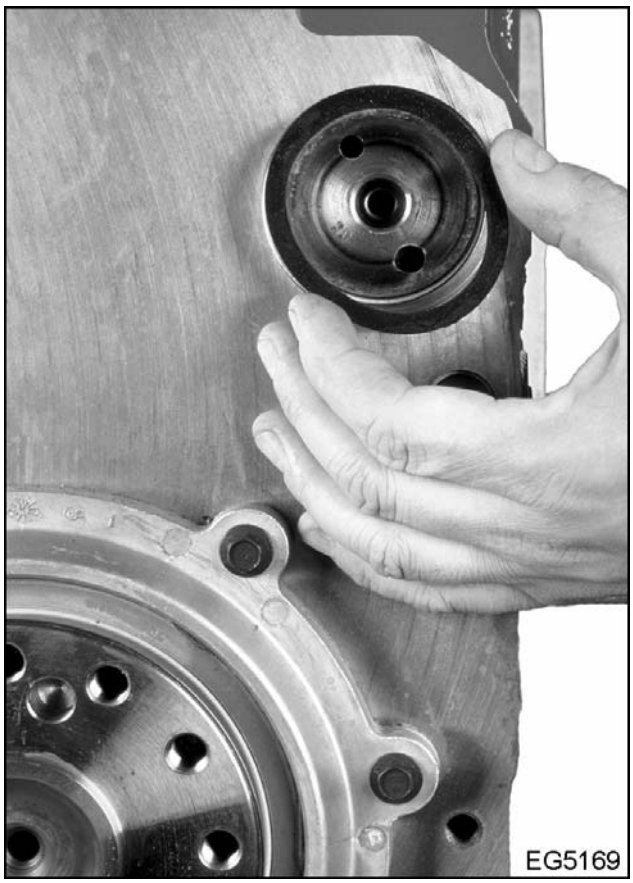

Figure 321 Install camshaft O-ring

WARNING: To avoid serious injury, possible death, and damage to vehicle or engine, when installing the flywheel housing, make sure the automatic transmission access cover on the front of the flywheel housing does not get caught between the flywheel housing and the crankcase.

WARNING: To prevent personal injury or possible death, due to heavy weight and limited access, get assistance to remove or install the flywheel housing, especially when working in chassis.

2. Install flywheel housing by guiding housing and hollow dowels against crankcase. Install eight flywheel housing eight mounting bolts. Tighten mounting bolts to “Special Torque (page 218).”

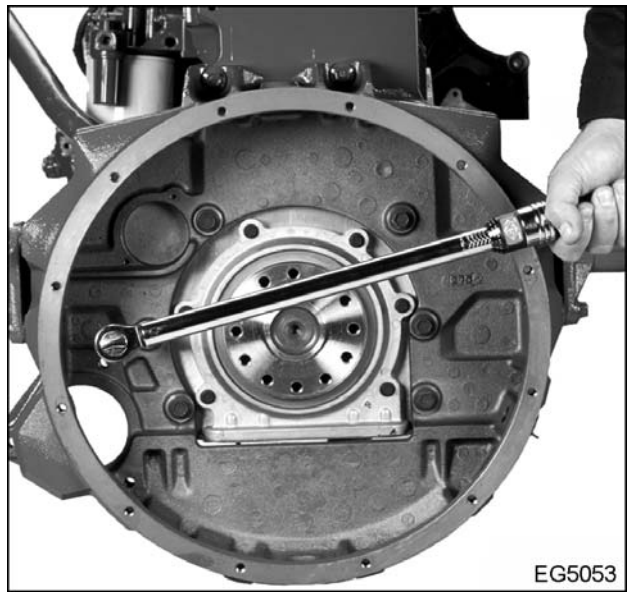

Figure 322 Install and torque flywheel housing

Flywheel

Install Flywheel

NOTE: When installing 148 tooth ring gear flywheel (approximate 18.70 inch outside diameter), make sure two bolts in engine mounts on side of flywheel housing are loosened enough to allow installation of flywheel with ring gear. These bolts are lowest and rear most bolts on the engine mounts. After installation, torque engine mount bolts to “Special Torque (page 218).”

1. Install two flywheel guide studs from Guide Stud Set (ZTSE4375) (page 219) in 3 and 9 o’clock positions of crankshaft.
2. Install flywheel over guide studs, fasten flywheel to crankshaft with ten flywheel mounting bolts.

NOTE: For applications using automatic transmissions, install spacer, flexplate(s) and reinforcing ring, and then install ten flywheel mounting bolts.

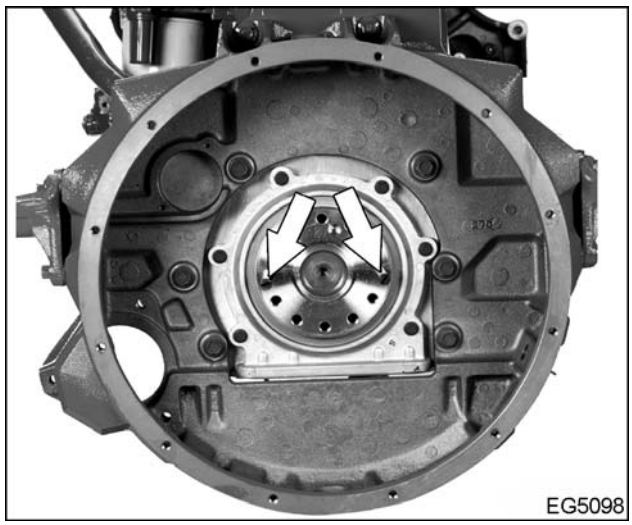

Figure 323 Install flywheel guide studs

3. Remove two guide studs and install remaining two mounting bolts. Tighten all twelve flywheel mounting bolts to “Special Torque (page 218).”

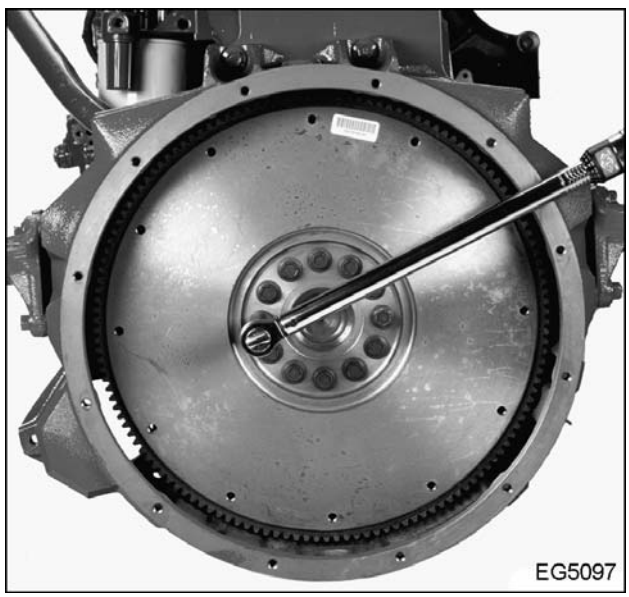

Figure 324 Install and torque flywheel

Vehicles Equipped with Allison 2000 Series Transmissions

CAUTION: For vehicles equipped with Allison 2000 series transmission only. If this is a vehicle re-configuration (not previously equipped with Allison 2000 series). Correct part number flywheel housing must be used. Failure to do so will cause interference between the flexplate studs and the flywheel housing. This will be evident only after the transmission has been installed.

1. Install two guide pins from Guide Stud Set (ZTSE4375) (page 219) at 3 and 9 o’clock positions.
2. Slide Adapter hub over guide pins.

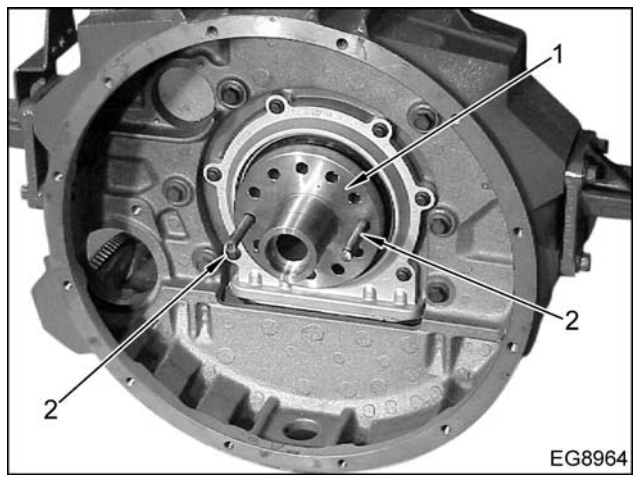

Figure 325 Install adapter hub

1. Adapter hub
2. Guide pins

3. Slide flywheel assembly over guide pins and over adapter hub.

Figure 326 Install flywheel assembly

CAUTION: To avoid possible engine or transmission damage, install reinforcing ring, with stamped 4 digit number on ring facing outward (toward the transmission). If part number is not visible, install with previous paint mark facing toward transmission. Failure to install this part correctly may result in premature flexplate failure.

NOTE: Ring gear is offset (not centered) on flywheel. Flywheel must be installed so ring gear is offset away from engine, toward transmission.

4. Slide reinforcing ring over guide pins.

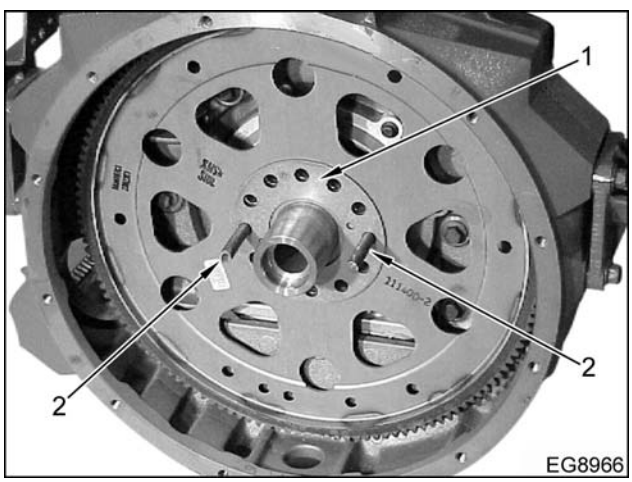

Figure 327 Install reinforcement ring

1. Reinforcement ring
2. Guide pins

5. Install ten flywheel mounting bolts.
6. Remove two guide pins and install two remaining mounting bolts.
7. Torque twelve flywheel mounting bolts to “Special Torque (page 218).”

Vehicles Equipped with MT-640/650 Transmissions

1. Install two guide pins from Guide Stud Set (ZTSE4375) (page 219) at 3 and 9 o’clock positions.
2. Install flywheel over guide pins.

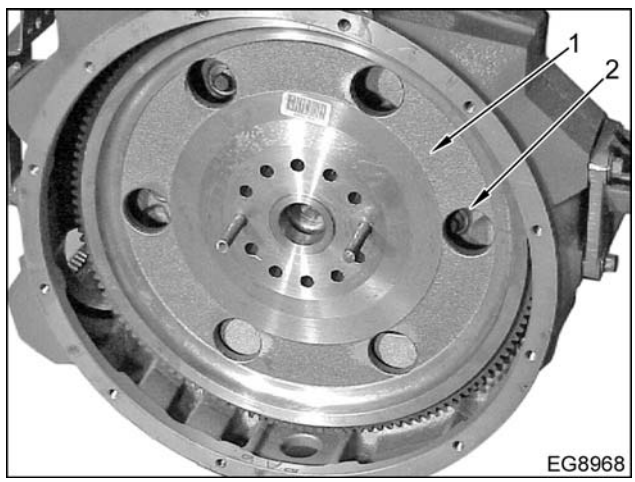

Figure 328 Install flywheel

1. Flywheel
2. Large hole in flywheel

CAUTION: To avoid possible engine or transmission damage, small bolt holes in flexplate for torque converter must line up with large holes in flywheel.

3. Install flexplate over guide pins with logo and part number toward transmission. If part number and logo are not visible, face previous paint mark toward transmission.

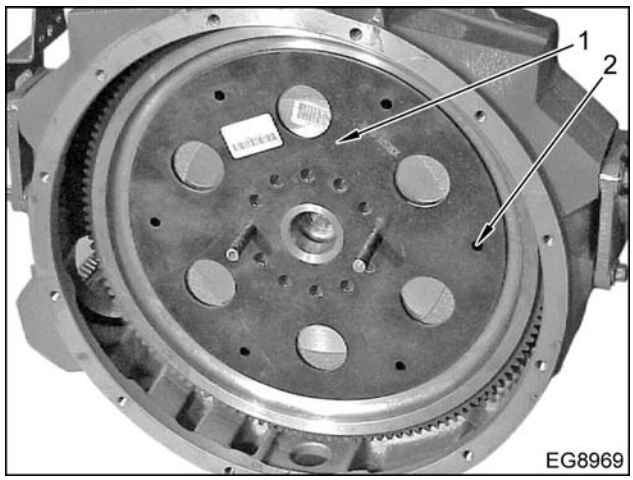

Figure 329 Install flexplate

1. Flexplate
2. Small holes in flexplate

CAUTION: To avoid possible engine or transmission damage, install reinforcing ring, with stamped 4 digit number on ring facing outward (toward the transmission). If part number is not visible, install with previous paint mark facing toward transmission. Failure to install this part correctly may result in premature flexplate failure.

4. Slide reinforcement ring over guide pins.

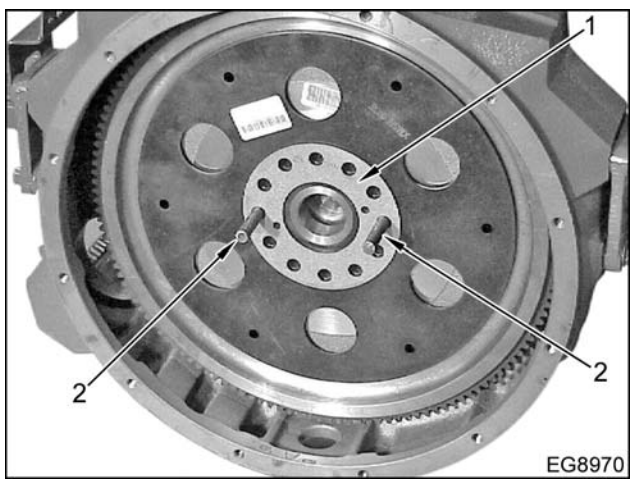

Figure 330 Install reinforcement ring

1. Reinforcement ring
2. Guide pins

5. Install ten flywheel mounting bolts.
6. Remove two guide pins and install two remaining mounting bolts.
7. Torque twelve flywheel mounting bolts to “Special Torque (page 218).”

Vehicles Equipped with MD-3060 and 3570 or D-4000 Transmissions

1. Install two guide pins from Guide Stud Set (ZTSE4375) (page 219) at 3 and 9 o’clock positions.

   NOTE: Flexplate assembly is available as a service part completely assembled.

2. Slide flexplate assembly over guide pins with adapter hub toward engine.

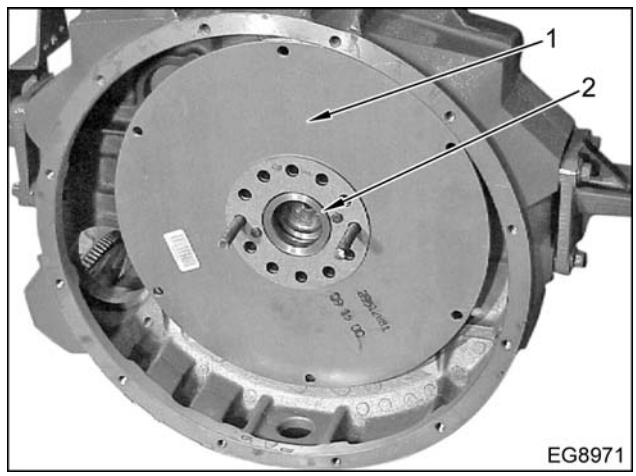

Figure 331 Install flywheel assembly

1. Flywheel assembly
2. Adapter hub

3. Install ten flywheel mounting bolts.
4. Remove two guide pins and install two remaining mounting bolts.
5. Torque twelve flywheel mounting bolts to “Special Torque (page 218).”

Rear PTO Housing Assembly (If Equipped)

Install Rear Oil Seal Carrier

1. Place new gasket in rear oil seal cover.

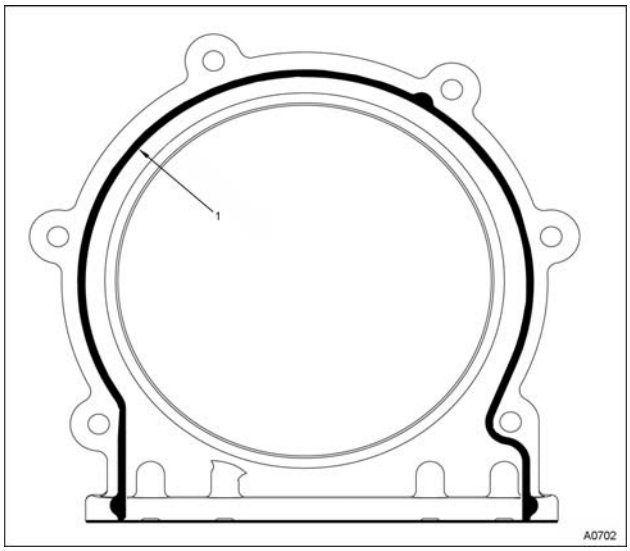

Figure 332 Install rear oil seal carrier gasket

1. Gasket

2. Install rear oil seal carrier with mounting bolts in crankcase. Finger tighten mounting bolts.
3. Rotate carrier, as necessary, to align carrier with crankcase rails. Verify proper alignment. Use Bevelled Edge Straightedge (OEM1293) (page 219).

NOTE: If the carrier gasket does not seat on the crankcase, it will leak.

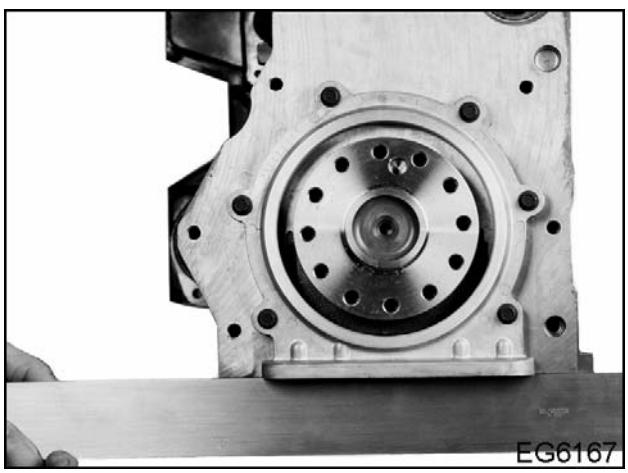

Figure 333 Aligning rear oil seal carrier

4. When rear oil seal carrier is level, tighten mounting bolts to “Special Torque (page 218).”

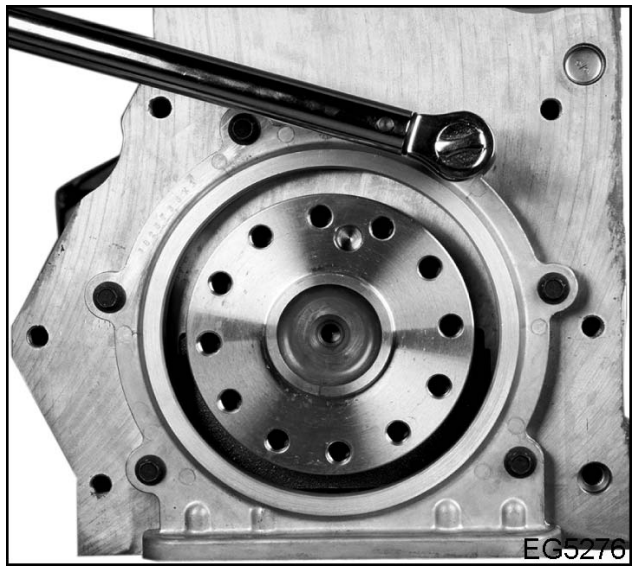

Figure 334 Torque rear oil seal carrier

Install Rear PTO Housing

1. Lay rear PTO housing assembly with transmission side face down.
2. Install one large O-ring and three small O-rings in O-ring grooves using Aviation Permatex #3.
3. Install two hollow dowel pins in rear PTO housing assembly.

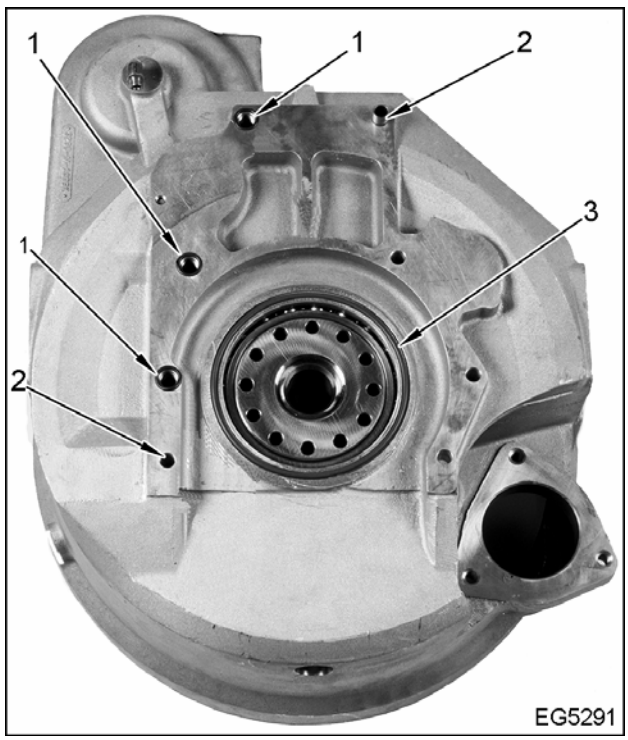

Figure 335 Rear PTO housing O-rings and dowel pins

1. Large O-ring
2. Small O-ring
3. Hollow dowel pins

4. Inspect PTO mounting stud threads, replace stud as required. Install PTO mounting stud in crankcase.

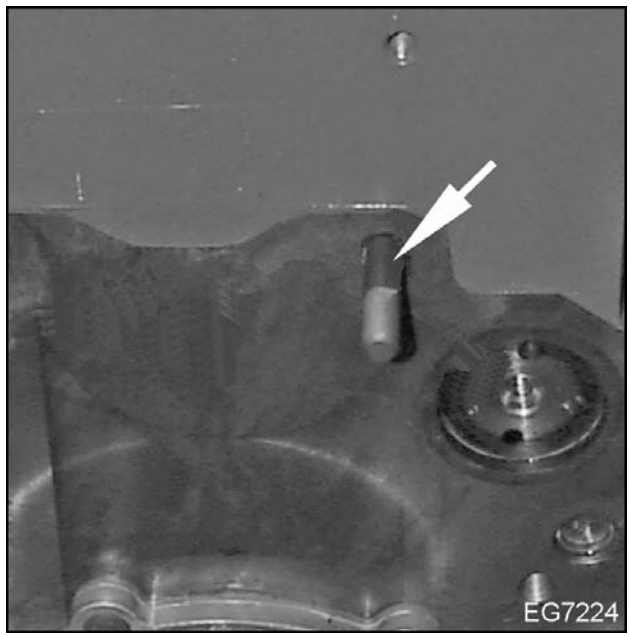

Figure 336 PTO mounting stud

5. Install new camshaft O-ring over camshaft end opening at rear of crankcase.

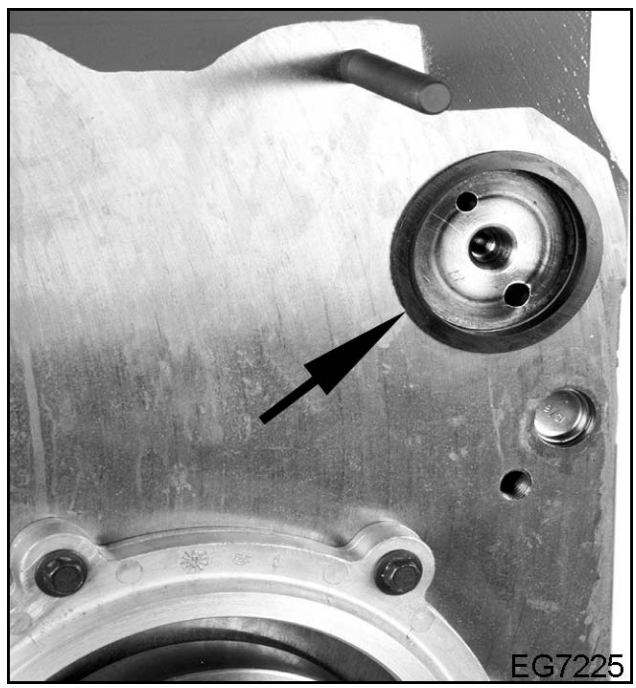

Figure 337 Install camshaft O-ring

6. Install two guide pins from Guide Stud Set (ZTSE4375) (page 219) at 3 and 9 o'clock positions.

Figure 338 Install guide pins

7. If not already done, remove four pipe plugs from rear PTO housing assembly.
8. Assemble Rear Oil Seal and Wear Sleeve Installer on crankshaft.
9. Lift rear PTO housing assembly and align with crankcase.
10. Slowly guide rear PTO housing assembly over guide pins and PTO mounting stud. Attach to crankcase with seven mounting bolts. Tighten mounting bolts to "Special Torque (page 218)."

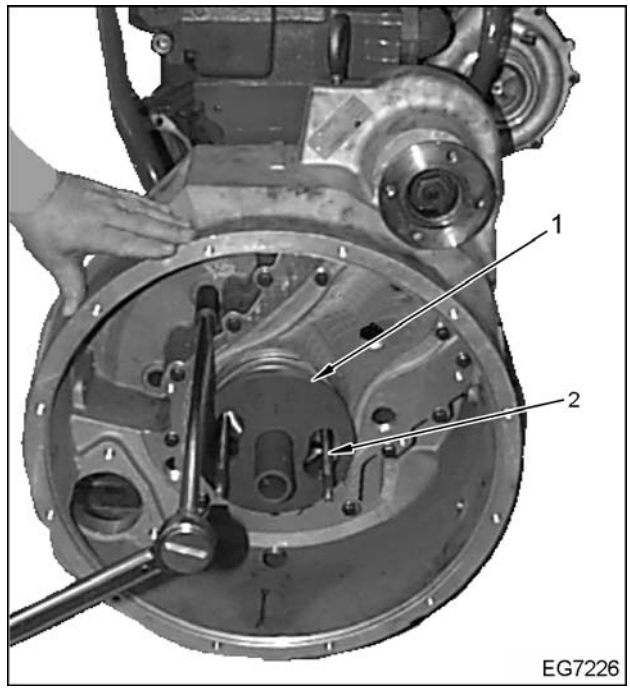

Figure 339 Install PTO housing

1. Rear Oil Seal and Wear Sleeve Installer
2. Guide pins

11. Install and hand tighten special mounting nut on crankcase stud at upper hollow dowel.

Figure 340 Special mounting nut

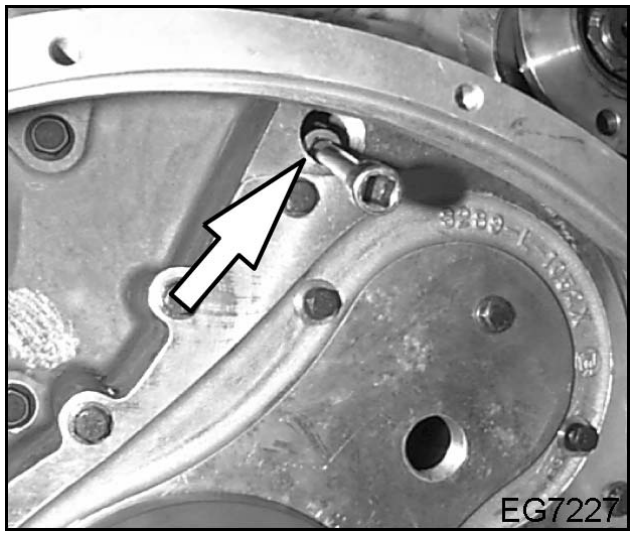

Figure 341 Install special mounting nut

12. Tighten special mounting nut to “Special Torque (page 218).”

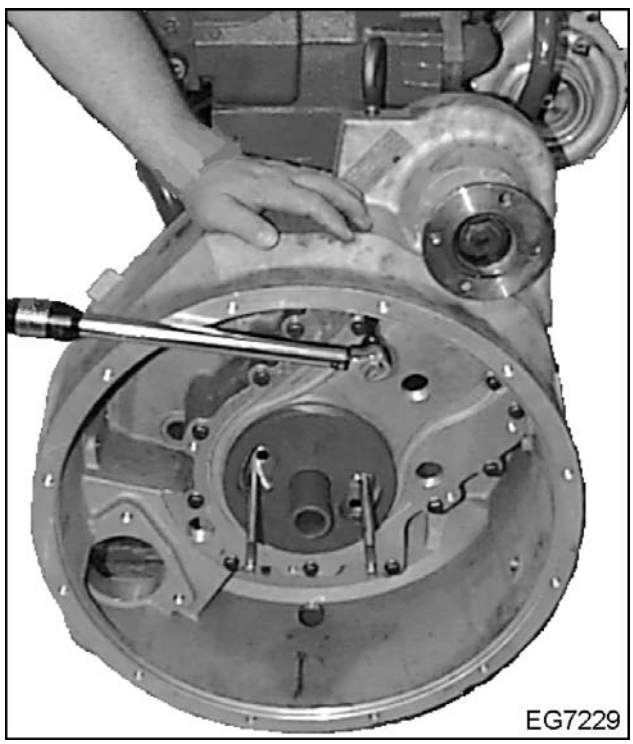

Figure 342 Torque special mounting nut

13. Install four pipe plugs and tighten.

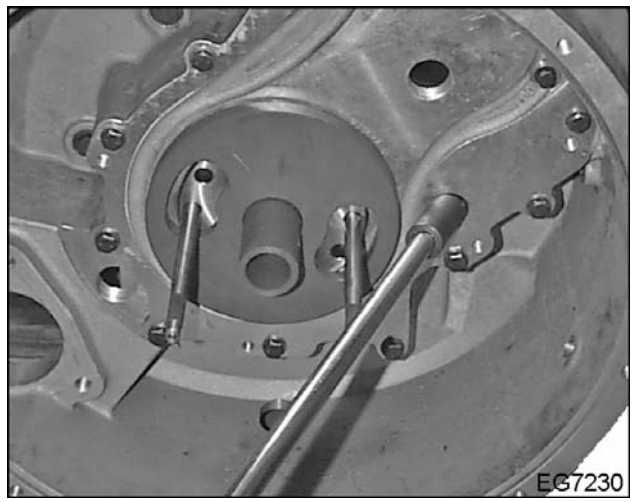

Figure 343 Install pipe plugs

14. Remove lifting eye from rear PTO housing assembly.
15. Install lubrication supply elbow and connect lubrication supply tube to crankcase and rear PTO housing assembly. Tighten tubing fitting nuts.

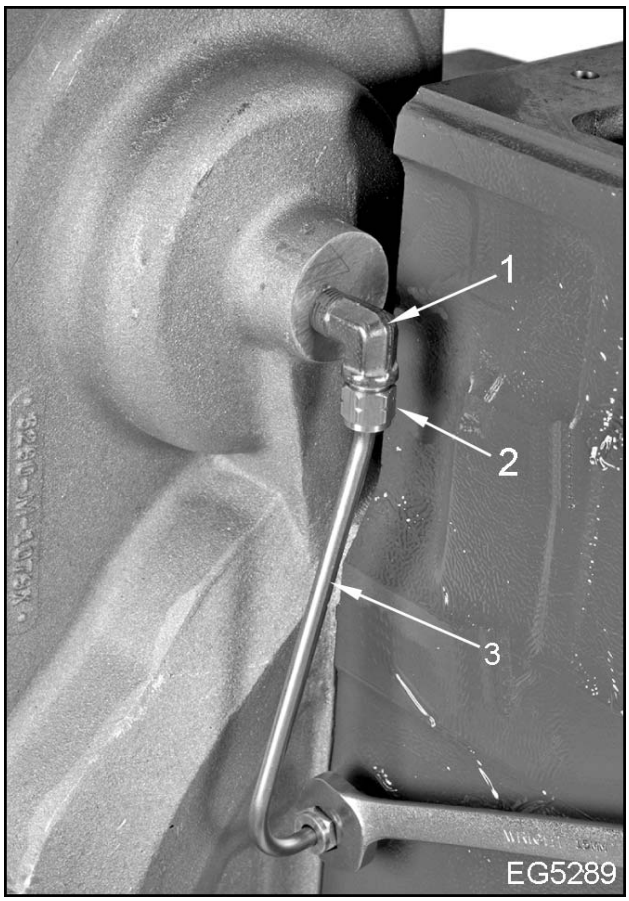

Figure 344 PTO lubrication tube

1. Elbow
2. Nut
3. Lubrication tube

16. Insert steel rod of installation tool through hole of the tube assembly of Rear Oil seal installation tool.

NOTE: Do not pull tube assembly out.

17. Pull out on steel rod until tube assembly comes out together with cover assembly of installation tool.

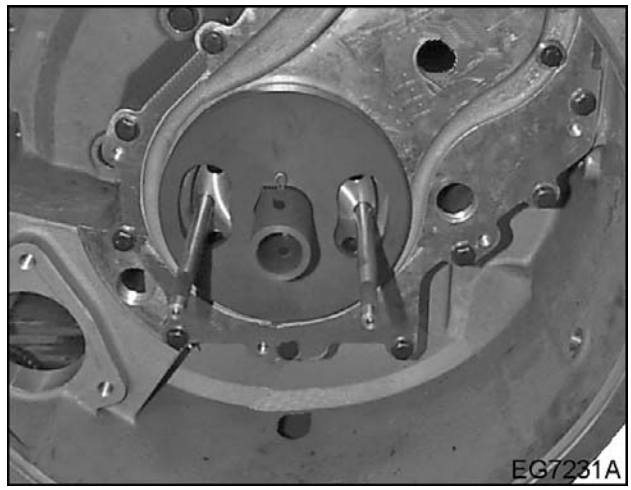

Figure 345 Rear Oil Seal Installation tool

18. Push input gear towards engine until input gear reaches mating surface of crankshaft.
19. Apply grease to inner surface of wear sleeve and rear oil seal before pressing it on input gear.
20. Press seal in cover using oil seal driver and hammer.

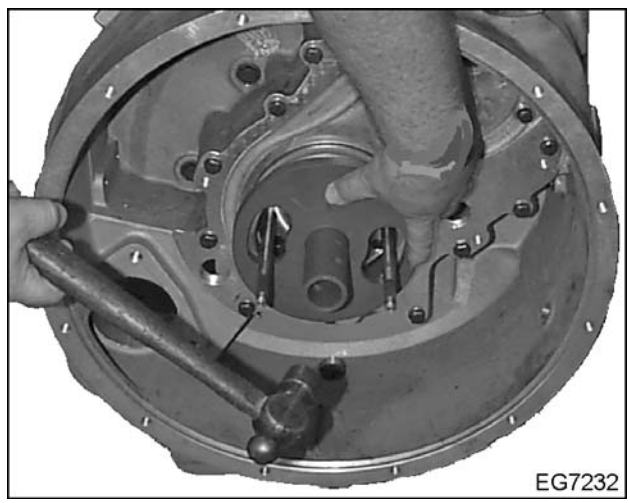

Figure 346 Install PTO rear oil seal

21. Remove installation tool, do not remove guide pins.
22. Place new pose seal on end of crankshaft. Work pose seal on by moving pose seal in circular direction until pose seal is on completely.

Install Flywheel

1. Install flywheel over guide pins and secure to crankshaft with (10) flywheel mounting bolts.

NOTE: For automatic transmissions, install spacer, flexplate(s) and reinforcing ring, and then install ten flywheel mounting bolts.

2. Remove two guide pins and install remaining two mounting bolts. Tighten all 12 flywheel mounting bolts to “Special Torque (page 218).”

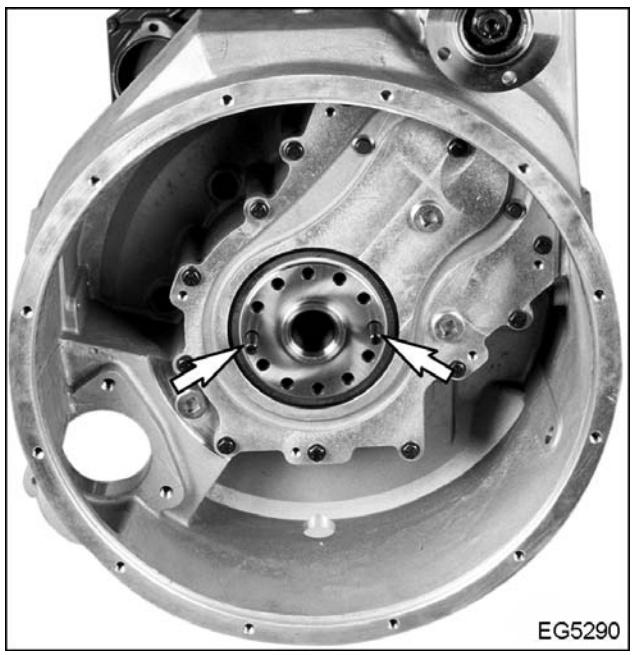

Figure 347 Install flywheel over guide pins

Install Oil Level Gauge Tube Assembly

1. Apply Loctite® around entire circumference of lower oil level gauge tube and casting.
2. Press lower oil level gauge tube in until bead is seated in chamber of crankcase.

NOTE: Slots in oil level gauge tube need not be oriented in any special manner.

3. Install new O-ring gasket on oil level filler tube.
4. Insert oil level filler tube in oil level gauge tube and orient oil filler tube to the rear and as far inboard as possible.
5. Tighten oil filler tube clamp screw to “Special Torque (page 218).”

Oil Pickup Tube

1. Install two oil pickup tube mounting bolts and place a new gasket in position.

Figure 348 Install oil pickup tube gasket

2. Align holes of oil pickup tube with two holes in the front cover. Install and tighten oil pickup tube bolts through front cover. Torque oil pickup tube bolts to “Special Torque (page 218).”

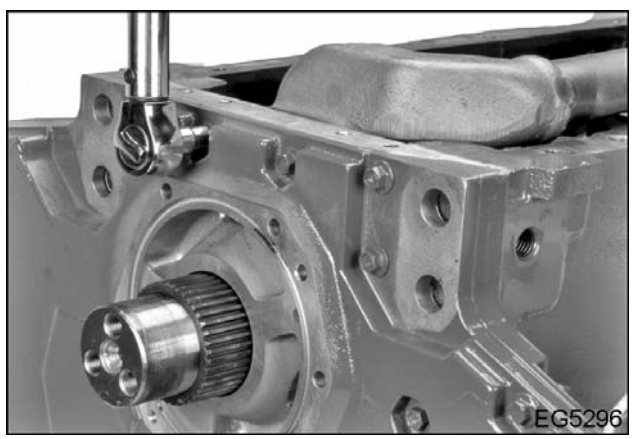

Figure 349 Tighten oil pickup tube bolts

3. Install front cover bolts and gasket. Align oil pickup tube with bolts. Torque bolts to “Special Torque (page 218).”
4. Inspect oil pickup tube support bracket. It should be flush with crankcase. Install and torque oil pickup tube support bolt to “Special Torque (page 218).”

   NOTE: If stress occurs when tightening oil pickup tube mounting bolt after front bolts are tightened, replace oil pickup tube. If no stress occurs, torque bracket bolt.

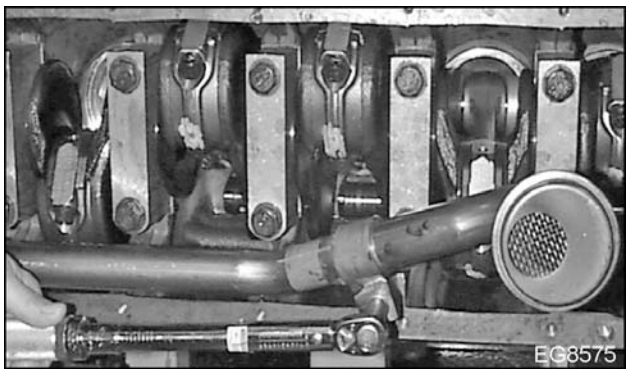

Figure 350 Install oil pickup tube support bracket

Oil Pan

NOTE: Do not apply RTV sealant more than five minutes before installing oil pan.

1. Apply 6 mm (1/4 in) bead of RTV sealant where crankcase, rear half of front cover, crankcase, and rear oil seal carrier contact each other.
2. Apply circle of RTV around cup plug crankcase orientation holes on oil pan rails of crankcase.

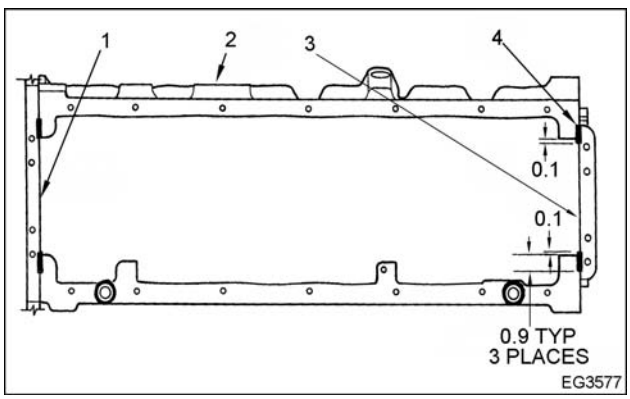

Figure 351 Apply RTV to crankcase (bottom view)

1. Front cover (rear half) assembly
2. Crankcase
3. Seal carrier
4. To edge of seal carrier

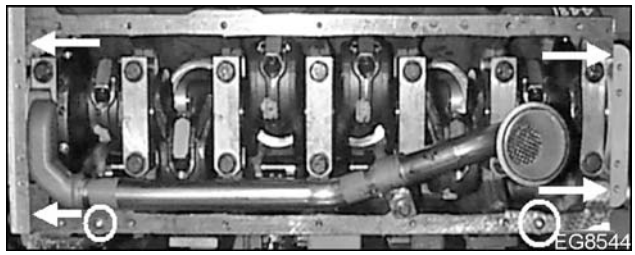

Figure 352 Apply RTV to crankcase rails

3. Place oil pan gasket on oil pan so seal bead of gasket is toward crankcase and edge marked FRONT is facing front cover.
4. Install oil pan with gasket on crankcase. Install two oil pan mounting bars on pan oil rail with 14 long mounting bolts. Fasten oil pan to front cover and rear oil seal carrier with eight shorter bolts. Tighten all bolts to “Special Torque (page 218).”

Figure 353 Install oil pan mounting bars

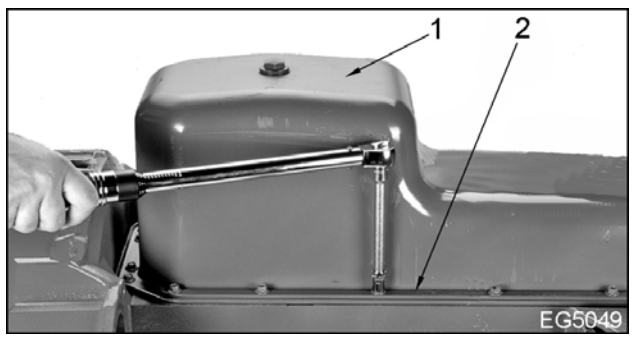

Figure 354 Torque oil pan

1. Oil pan
2. Mounting bar (2)

Front Mounting Bracket

Install front mounting bracket on engine with four mounting bolts. Tighten mounting bolts to “Special Torque (page 218).”

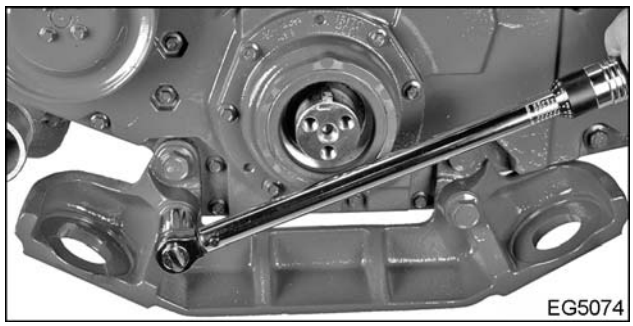

Figure 355 Install front mounting bracket

Wear Sleeve

NOTE: Whenever rubber vibration damper or viscous damper pulley is removed, replace wear sleeve and oil seals.

1. Split wear sleeve with Muffler Chisel (page 219) to remove it from damper. Be careful to not damage vibration damper flange.

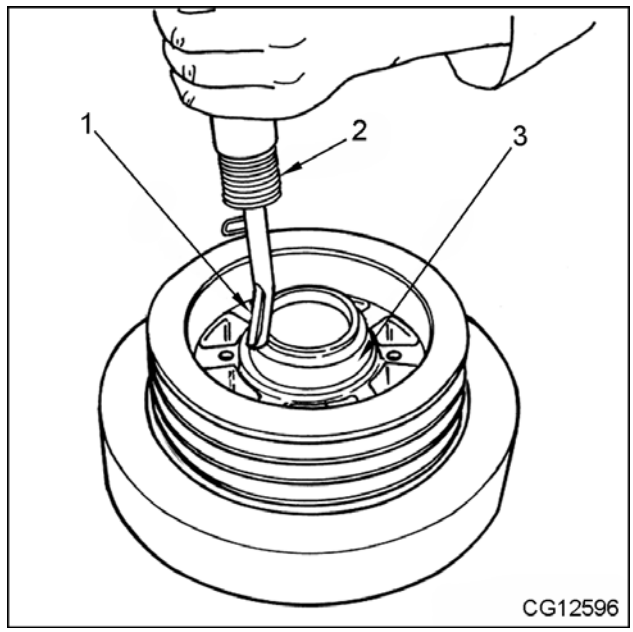

Figure 356 Remove vibration damper wear sleeve

1. Muffler chisel
2. Air hammer
3. Wear sleeve

NOTE: If service kit contains more than one wear sleeve, use one that is same width as wear sleeve that is currently on vibration damper or crankshaft pulley.

NOTE: Chamfer on wear sleeve outside diameter must be facing out when viewing rear (pulley end) of damper.

2. Apply hydraulic sealant to the inside diameter of new wear sleeve. Press wear sleeve on vibration damper with Crankshaft, Front Oil Seal / Wear Sleeve Installer (ZTSE3004B) (page 219). Wipe any excess sealant from outside diameter of wear sleeve.

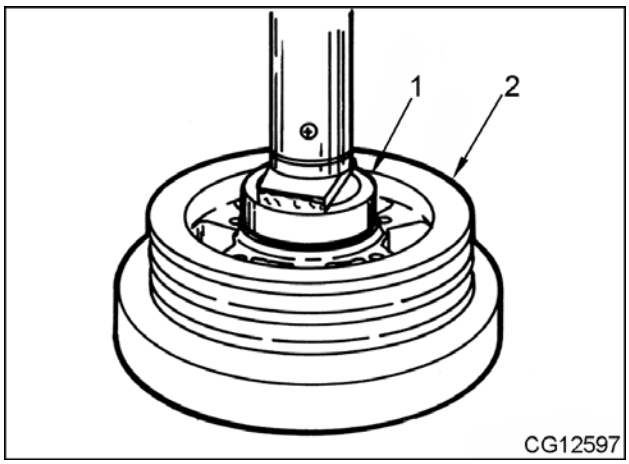

Figure 357 Install vibration damper wear sleeve

1. Crankshaft, Front Oil Seal / Wear Sleeve Installer (ZTSE3004B)
2. Damper

3. Use same procedure for wear sleeve and dust lip (POSE) assemblies where applicable.

NOTE: Do not remove POSE from wear sleeve. Front POSE seal is not used on International® DT466 engines.

Vibration Damper

Rubber Vibration Damper

NOTE: Make sure front mounting bracket is mounted to engine before installing vibration damper.

1. Mark rubber vibration damper with 100 °C (212 °F) Thermo-melt Crayon (page 219).
2. Apply heat, attach Damper Heater (ZTSE4384) (page 219) to vibration damper or place damper directly on hot plate.

WARNING: To avoid serious personal injury or possible death, use heat protecting gloves to install heated vibration damper.

CAUTION: To avoid possible engine damage, do not install rubber vibration damper when it is cold (room temperature).

3. When crayon mark melts, install rubber vibration damper on crankshaft nose with welding or heavy insulated gloves. Make sure keyway on damper aligns with key on crankshaft.

Figure 358 Heat vibration damper with Damper Heater

Figure 359 Heat vibration damper on hot plate

Figure 360 Install vibration damper

Viscous Vibration Damper

CAUTION: To avoid possible engine damage, install the viscous vibration damper pulley and the viscous vibration damper separately. Mechanical persuasion will damage the viscous vibration damper.

NOTE: Make sure front mounting bracket is mounted to engine before installing vibration damper.

1. Mark viscous vibration damper pulley with 100 °C (212 °F) Thermo-melt Crayon (page 219).
2. Apply heat, attach Damper Heater (ZTSE4384) (page 219) to viscous vibration damper pulley.

WARNING: To avoid serious personal injury or possible death, use heat protecting gloves to install heated viscous vibration damper pulley.

CAUTION: To avoid possible engine damage, do not install viscous vibration damper pulley when it is cold (room temperature).

3. When crayon mark melts, install damper pulley on crankshaft nose with welding or heavy insulated gloves. Make sure keyway on pulley aligns with key on crankshaft.
4. Install viscous vibration damper to damper pulley. Install six mounting bolts to “Special Torque (page 218).”

Retain Vibration Damper

NOTE: A damper retainer kit is available with grade 12.9 damper bolts and thicker damper retaining plate.

1. Install 2.54 mm (0.10 inch) thick damper retaining plate.
2. Install three grade 12.9 damper bolts.
3. Prevent crankshaft from turning, tighten damper bolts in sequence, continue until “Special Torque (page 218)” is reached with no movement of any of the bolts.

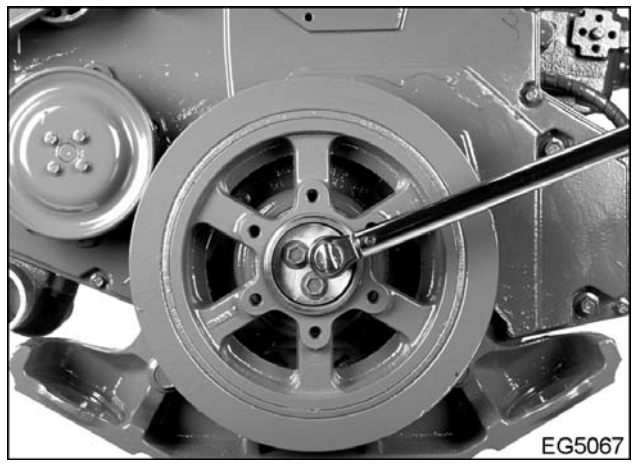

Figure 361 Torque vibration damper retainer

Miscellaneous

See appropriate sections of this manual for proper installation procedures:

Oil, fuel, and coolant filters

Belt and Auto tensioner

ECM and mounting bracket, if equipped

Valve cover and intake manifold

Road draft tube

Cylinder head

Fuel injectors

Wiring harness

Thermostat

Oil level gauge and tube assembly

Exhaust manifold

Turbocharger and turbocharger supply and drain lines

Coolant filter header

Fuel filter header and fuel lines

1. Adjust valve lash, see “Valve Lash Adjustment (page 99)” in the “Cylinder Head and Valves” section in this manual.
2. Prime lubricating system, see “Prime Lubricating System - Pressure Priming (page 256)” in the “Lubricating Oil Pump, Oil Filter, and Cooler” section in this manual.

Special Information

Specifications

Crankshaft	
Type	**Steel forging, induction hardened, grindable**
Main bearing journal diameter:	
Standard size	89.8 ± 0.0152 mm (3.535 ± 0.0006 in)
0.254 mm (0.010 in) undersize	89.5 ± 0.0152 mm (3.525 ± 0.0006 in)
0.508 mm (0.020 in) undersize	89.3 ± 0.0152 mm (3.515 ± 0.0006 in)
0.762 mm (0.030 in) undersize	89.0 ± 0.0152 mm (3.505 ± 0.0006 in)
Main bearing width (except rear thrust)	33.0 ± 0.254 mm (1.286 ± 0.010 in)
Main bearing journal maximum out-of-round	0.05 mm (0.002 in)
Main bearing thrust face runout (TIR maximum)	0.025 mm (0.001 in)
Main bearing journal taper (maximum per inch)	0.0711 mm (0.0028 in)
Main bearing journal fillet radius	5.72/1.27 mm (0.225/0.050 in)
Rod journal fillet radius	5.72/1.27 mm (0.225/0.050 in)
Rear oil seal journal runout (maximum)	0.076 mm (0.003 in)
Damper mounting area runout (maximum)	0.013 mm (0.0005 in)
Flywheel mounting surface runout (maximum)	0.05 mm (0.002 in)
Number of main bearings	7
Thrust taken by	Rear main bearing
Thrust Bearing Journal Length:	
Standard size to 0.508 mm (0.020 in) undersize	34.4 ± 0.0254 mm (1.3545 ± 0.010 in)
0.762 mm (0.030 in) undersize	34.4043 ± 0.0254 mm (1.3545 ± 0.0010 in)
Main bearing to crankshaft running clearance	0.046 to 0.127 mm (0.0018 to 0.0050 in)
Connecting rod journal diameter standard size	80.0 ± 0.0152 mm (3.1500 ± 0.0006 in)
0.0254 mm (0.010 in) undersize	79.7 ± 0.0152 mm (3.1400 ± 0.0006 in)
0.508 mm (0.020 in) undersize	79.5 ± 0.0152 mm (3.1300 ± 0.0006 in)
0.762 mm (0.030 in) undersize	79.2 ± 0.0152 mm (3.1200 ± 0.0006 in)

Connecting rod bearing width	35.2 mm (1.385 in)
Connecting rod journal maximum out-of-round	0.0064 mm (0.00025 in)
Connecting rod journal taper (maximum per inch)	0.0069 mm (0.00027 in)
Connecting rod bearing to crankshaft running clearance	0.127 to 0.046 mm (0.0050 to 0.0018 in)
Crankshaft flange outside diameter	141 mm (5.550 in)
Crankshaft end play	0.152-0.305 mm (0.006-0.012 in)
Crankshaft end play maximum wear limit	0.508 mm (.020 in)
Rod to crankshaft side clearance	0.30 to 0.42 mm (0.012 to 0.017 in)
Crankshaft gear backlash	0.076 to 0.406 mm (0.003 to 0.016 in)
Face runout - measured at 177.8 mm (7.0 in) radius	0.18 mm (0.007 in)
Pot flywheel for clutch applications:	
Face runout-measured at 165.1 mm (6.5 in) radius	0.165 mm (0.0065 in)
Face runout (mounting surface for clutch cover plate) - measured at 190.5 mm (7.5 in) radius	0.19 mm (0.0075 in)
Flywheel concentricity (radial runout)	
Flat flywheel for clutch applications:	
Radial runout measured at clutch mounting holes	0.20 mm (0.008 in)
Pot flywheel for clutch applications:	
Radial runout of clutch pilot bore (inside diameter of pot flywheel)	0.13 mm (.005 in)

Flywheel resurfacing (for clutch applications):

Requires measurement from crankshaft mounting surface of flywheel to clutch surface of flywheel.

NOTE: DO NOT machine beyond minimum dimension shown.

Flat flywheel	36.3 mm (1.430 in)
Pot flywheel	39.4 mm (1.550 in)
Flywheel housing bore concentricity	SAE 1 = 0.30 mm (0.012 in) SAE 2 = 0.28 mm (0.011 in)
Flywheel housing face runout	SAE 1 = 0.30 mm (0.012 in) SAE 2 = 0.28 mm (0.011 in)

NOTE: Must be measured per SAE specification J1033.

Vibration damper maximum allowable member misalignment	1.5 mm (0.060 in)
Vibration damper wobble (maximum)	1.5 mm (0.060 in)

Crankcase deck flatness	0.076 mm (0.003 in)
Crankcase deck finish (micro inches)	125AA
Centerline of main bearing bore to head deck	368.3 ± 0.0381 mm (14.5 ± 0.0015 in)
Crankcase main bearing bore diameter	97.8 ± 0.0127 mm (3.8491 ± 0.0005 in)

Crankcase	
Tappet bore diameter	28.511 to 28.549 mm (1.1225 to 1.1240 in)
Valve and Roller tappet outside diameter	28.435 to 28.448 mm (1.1195 to 1.1200 in)
Oil jet tube bore (spray hole) diameter	1.22 to 1.24 mm (0.048 to 0.049 in)
Counterbore dimension in crankcase	8.860 ± 0.025 at 132 mm (0.349 ± 0.001at 5.1885 in)
Maximum allowable variation of counterbore depth (between four points)	0.025 mm (0.001 in)
Cylinder sleeve counterbore maximum allowable depth	9.25 to 10.49 mm (0.364 to 0.413 in)
Sleeve protrusion above crankcase	0.050 to 0.127 mm (0.002 to 0.005 in)
Main bearing type	Precision replaceable
Material	Steel-backed copper/lead
Thrust taken by	No. 7 rear
Cap attachment	2 bolts per cap
Camshaft Bushing Bore Diameter in Crankcase	
Front	65.513 to 63.550 mm (2.5005 to 2.5020 in)
Intermediate front	63.005 to 63.043 mm (2.4805 to 2.4820 in)
Intermediate rear	62.496 to 62.535 mm (2.4605 to 2.4620 in)
Rear	61.988 to 62.026 mm (2.4405 to 2.4420 in)

Special Torque

Connecting rod bolt	163 N·m (120 lbf·ft)
Crankshaft main bearing cap bolts	(page 218)
Vibration damper bolts (grade 12.9)	163 N·m (120 lbf·ft)
Pulley retainer bolts	136 N·m (100 lbf·ft)
Viscous damper mounting bolts	54 N·m (40 lbf·ft)
Flywheel bolts	136 N·m (100 lbf·ft)
Flywheel housing mounting bolts	108 N·m (80 lbf·ft)
Oil pan mounting bolts	32 N·m (24 lbf·ft)
Oil pan drain plug	68 N·m (50 lbf·ft)
Oil pickup tube bolts	20 N·m (15 lbf·ft)
Oil pickup tube bracket bolt (Rear Sump)	32 N·m (24 lbf·ft)
Oil pickup tube support bracket bolt (Front Sump)	20 N·m (15 lbf·ft)
Oil filler tube clamp	3.5 N·m (30 lbf·in)
Front engine mounting bracket mounting bolts	386 N·m (284 lbf·ft)
Rear engine mounting bracket mounting bolts	108 N·m (80 lbf·ft)
Special mounting nut (PTO application only)	108 N·m (80 lbf·ft)
Engine Block Heater Cap Screw	2.8 Nm (25 lb-in.)

Main Bearing Cap Bolt Tensioning

NOTE: This is required for final assembly and after the bearing fitting procedure and measurement of crankshaft end play.

NOTE: New main bearing cap mounting bolts and tapped bolt holes must be clean and dry before installation.

1. Apply a thin coat of clean engine oil to the threads of the mounting bolts prior to installation.
2. Align and seat each bearing cap.
3. Torque each main cap bolt to 136 N·m (100 lbf·ft).
4. Torque each main cap bolt to 177 N·m (130 lbf·ft).
5. Place a paint mark on each socket and bolt head and another mark 90 degrees clockwise on the main surface.

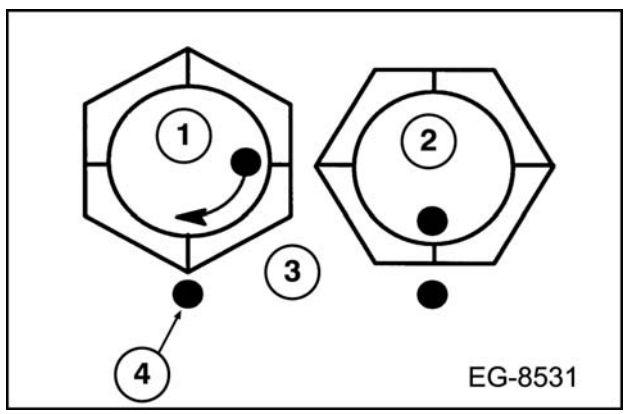

Figure 362 Place paint marks

1. Head of main bolt
2. Head of main bolt
3. Main cap surface
4. Paint mark

6. Rotate each bolt 90 degrees (1/4 turn).

Special Service Tools

Air Hammer	Obtain locally
Bevelled Edge Straightedge	OEM1293
Crankshaft, Front Oil Seal / Wear Sleeve Installer	ZTSE3004B
Crankshaft Oil Hole Brush	ZTSE4392
Critical Metric Taps	ZTSE4386
Damper Heater	ZTSE4384
Dial Indicator with Magnetic Base	Obtain locally
Gear and Pulley Puller (Large)	OEM4245
Guide Stud Set	ZTSE4375
Feeler Gauge	Obtain locally
Main Oil Gallery Brush	ZTSE4389
Muffler Chisel	Obtain locally
Rear Oil Seal and Wear Sleeve Installer	ZTSE2535C
Rear Wear Sleeve Remover	ZTSE4404
Slide Hammer Puller Set	ZTSE1879
Front Seal / Injector Remover	ZTSE4300
Telescopic gauge set	OEM1032
Thermo-melt Crayon 100 °C (212 °F)	Obtain locally
Flex Hone	ZTSE4349

Table of Contents

Exploded Views and Identification

Exploded Views

Crankcase Front Cover and Related Parts

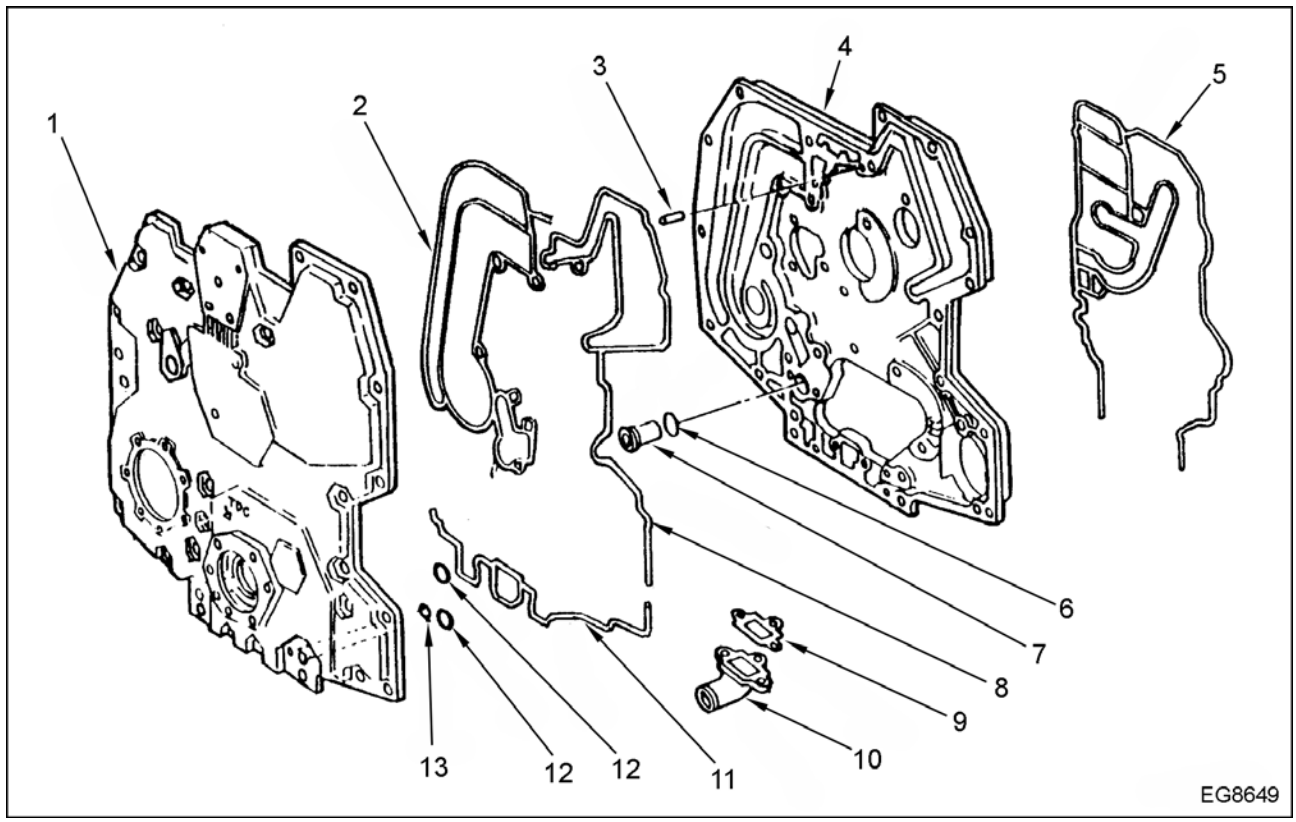

Figure 363 Crankcase front cover and related parts

1. Front crankcase cover (front half)
2. Front cover oil pressure gasket
3. Front cover dowel (rear half)
4. Front crankcase cover (rear half)
5. Front cover-to-crankcase gasket
6. Relief valve O-ring
7. Relief valve assembly
8. Front cover reservoir gasket
9. Water inlet elbow gasket
10. Water inlet elbow
11. Front cover oil suction gasket
12. O-ring, 27 mm (1.068 in)
13. O-ring, 16 mm (0.638 in)

Fan Drive, Thermostat and Water Pump

Timing Gear Identification

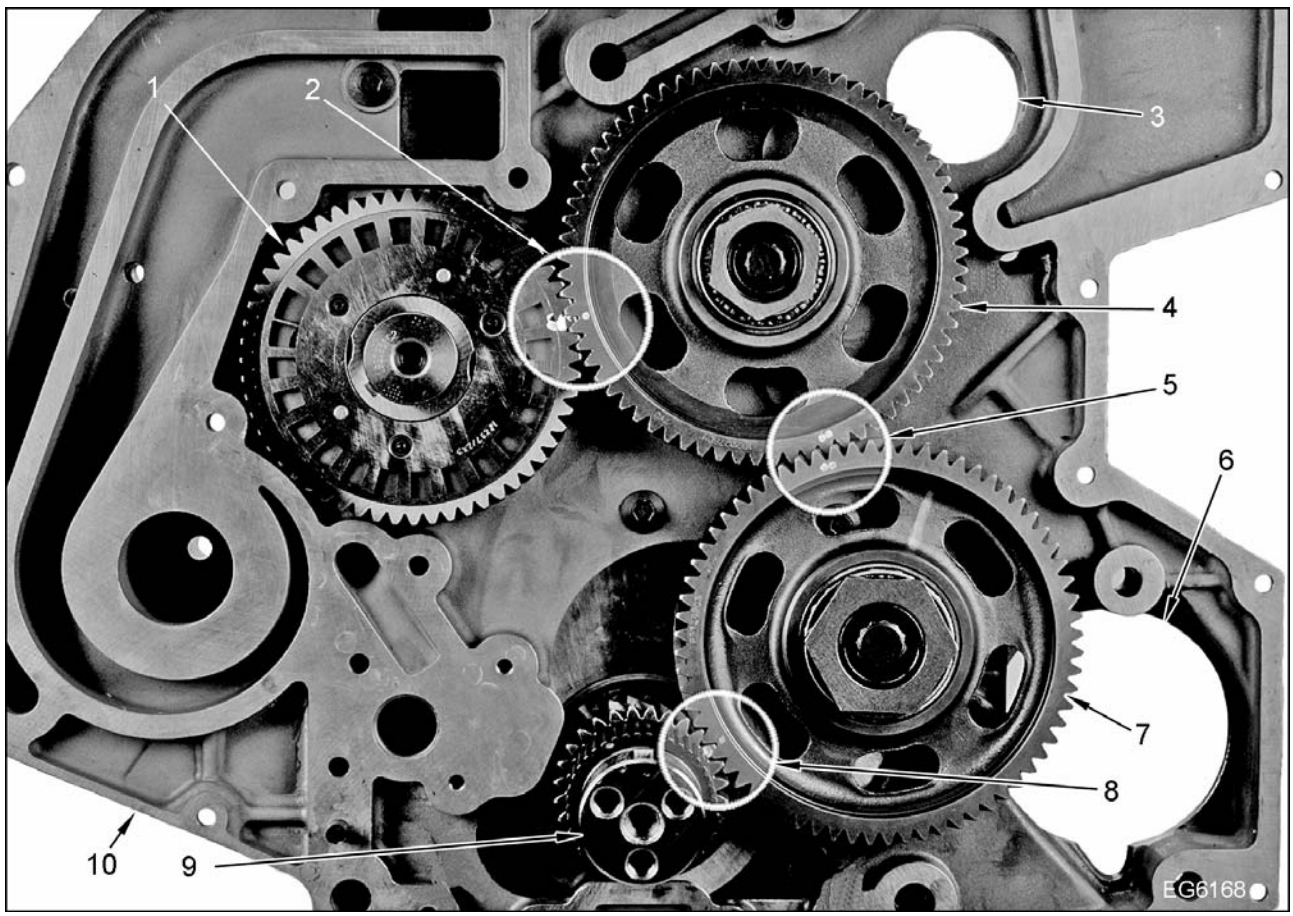

Figure 364 Timing gear indicators

1. Camshaft gear with timing disk plate
2. Camshaft gear and upper idler gear timing marks
3. High-pressure pump gear location
4. Upper idler gear
5. Upper idler gear and lower idler gear timing marks
6. Air compressor gear location
7. Lower idler gear
8. Lower idler gear and crankshaft timing marks
9. Crankshaft
10. Rear half front cover

Engine Gear Train Timing

CAUTION: To avoid possible engine damage, properly set the valve lash and time the gear train. Valve train failures from broken or bent push rods, valves, rocker arms, worn valve keepers, or rotators in many instances could be caused by improper timing of the gear train. Depending on valve lash setting, if the camshaft gear is improperly timed by one tooth early, engine pistons will strike intake valve heads or if timing is set one tooth late, piston may contact exhaust valve.

Measure Engine Gear Train Timing without Front Cover Removed or Engine Tear Down

Feeler Gauge Method

1. Rotate engine to approximately Top Dead Center (TDC) compression on cylinder 1 (no valves open). Set lash on intake valve 1 to nominal lash setting of 0.635 mm (0.025 in).
2. Place mark on damper pulley at radial distance of 82.5 mm (3.25 in) or straight line distance of 81 mm (3.188 in) clockwise from timing notch.

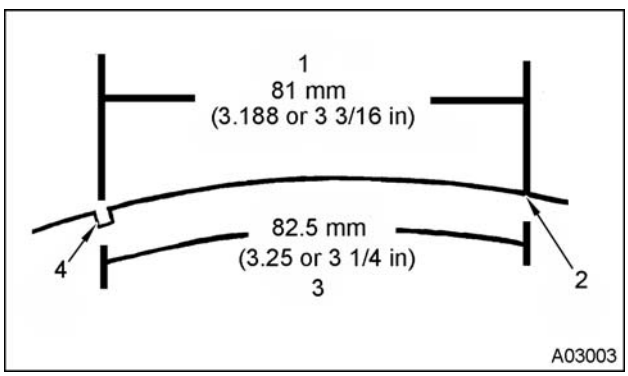

Figure 365 Measure engine gear train timing

1. Straight line
2. Scribe mark
3. Radial distance
4. Timing notch

3. Place 0.25 mm (0.010 in) Feeler Gauge (page 241) between valve lever and valve stem of intake valve 1. Slowly rotate engine forward (clockwise) until intake valve starts to lift and feeler gauge becomes tight. Mark should line up with TDC arrow on front cover or be within 3.5 crank degrees of TDC. A radial (or straight) line distance of 6.8 mm (0.27 in) at damper pulley is equivalent to 3.5 degrees of TDC.

NOTE: One tooth “out of time” on gear train equals approximately 11 degrees of movement or 21.4 mm (0.84 in) of radial distance of damper pulley.

4. If timing on valve 1 is within specifications, other valves, barring extreme camshaft lobe wear or poor adjustment, will also be in time. If timing is found to be incorrect, engine’s front cover removal is required to inspect punch marks on gear train.

Dial Indicator Method

1. Adjust intake valve 1 for piston set 1 at TDC compression stroke to 0.64 mm (0.025 in).
2. Position magnetic base Dial Indicator (page 241) on valve cover fence of cylinder head rail with indicator tip on intake valve rotator 1.
3. Zero Dial Indicator.
4. Rotate engine approximately one full revolution either direction to a position of 360 degrees from starting point.
5. Dial Indicator should read 0.28 to 0.84 mm (0.011 to 0.033 in) from starting position for proper gear train timing.
6. If Dial Indicator readings are outside specified range, engine’s front cover must be removed and punch mark and gear tooth position adjusted.

Remove

Miscellaneous

Before removing front cover, fuel, oil, and coolant must be drained and interference components removed. See appropriate sections for removal:

Water inlet elbow, if equipped

Oil pan

Thermostat and thermostat housing (if installed)

Water pump and pulley

High-pressure pump

Coolant filter header, if equipped

Camshaft Position (CMP) sensor

Wiring harness

Front Cover (Front Half) Assembly

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral or park, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

1. Install breaker bar in belt tensioner and remove tension on belt.
2. Remove serpentine belt.
3. Slowly release breaker bar and return belt tensioner to original position. Remove breaker bar.
4. Loosen mounting bolt and remove belt tensioner.

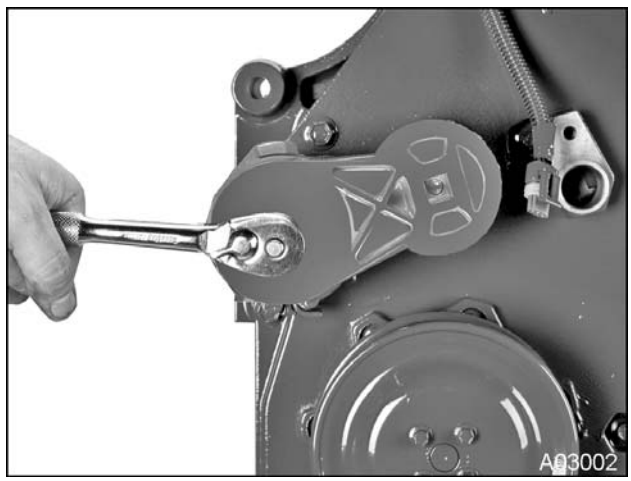

Figure 366 Remove belt tensioner

5. Remove alternator.
6. Loosen and remove alternator mounting bracket bolts.
7. Remove bracket.

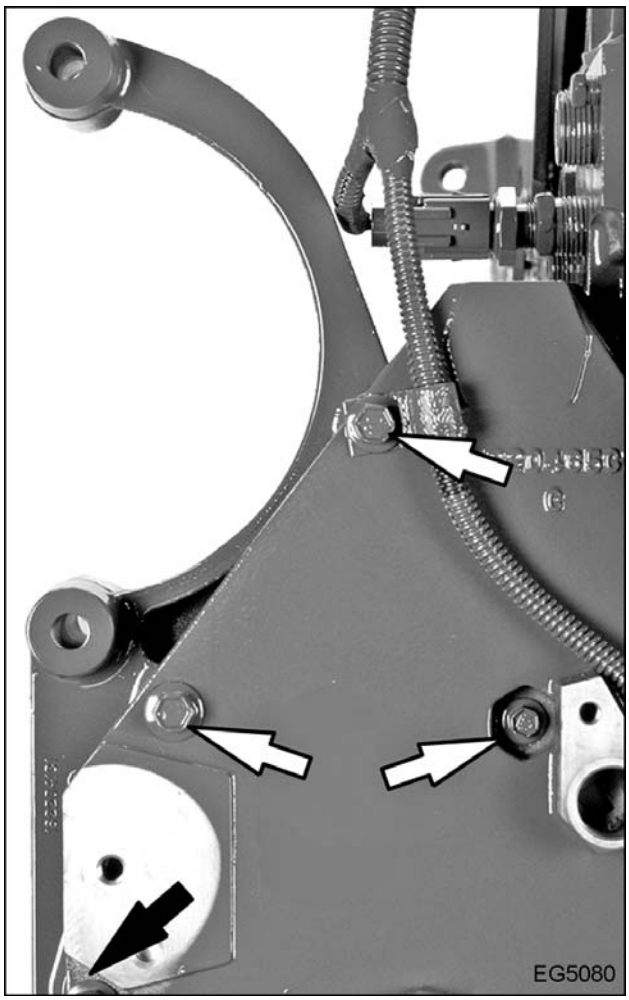

Figure 367 Remove alternator mounting bracket

8. Remove fan pulley bolts. Remove pulley. Use Special Pulley “C” Wrench (page 241) to hold pulley during fastener removal.

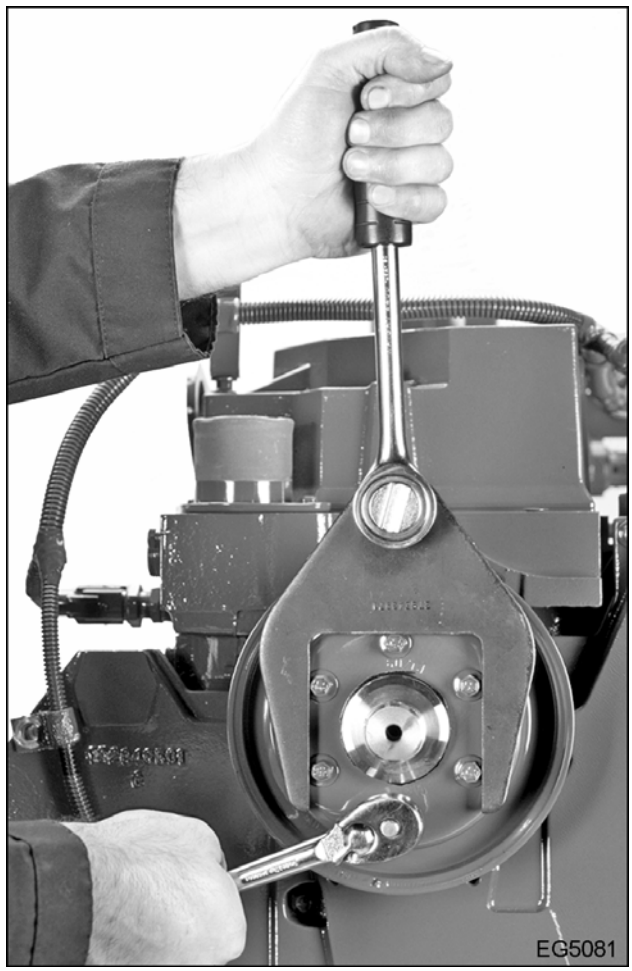

Figure 368 Remove fan drive hub pulley

9. Remove fan hub drive cap screws and hub.

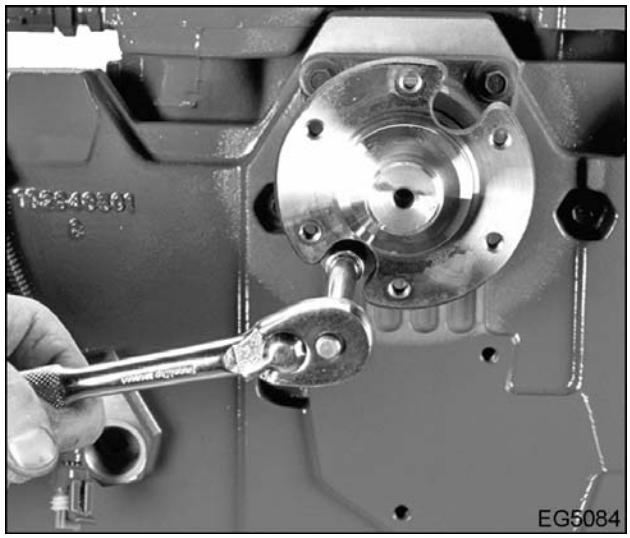

Figure 369 Remove fan drive hub

NOTE: Engines may be equipped with either an optional air compressor or power steering pump or both.

10. Loosen and remove two steering pump bolts from air compressor.
11. Loosen two coolant hose clamps connecting coolant hoses to air compressor and crankcase and remove coolant hoses.

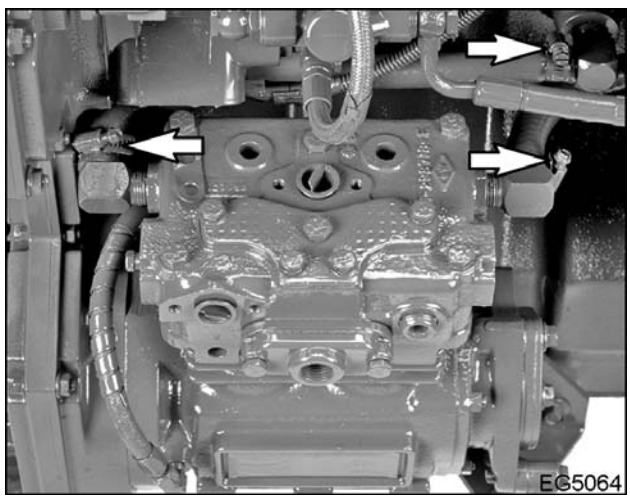

Figure 370 Loosen coolant hose clamps

12. Loosen and remove two oil lubrication line nuts from air compressor. Remove oil line.

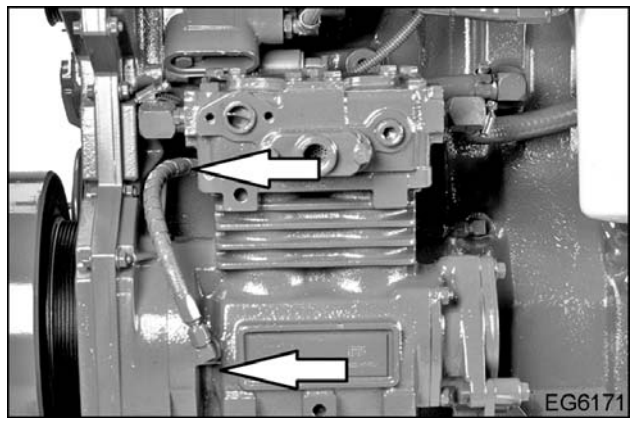

Figure 371 Remove oil lubrication line

13. Remove two air compressor bracket mounting bolts from air compressor.

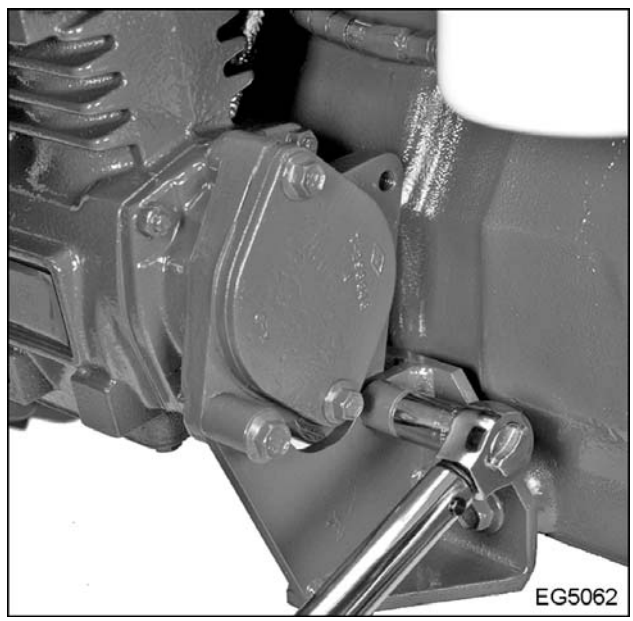

Figure 372 Remove air compressor bracket mounting bolts

14. Remove two air compressor bracket mounting bolts from crankcase. Remove bracket.

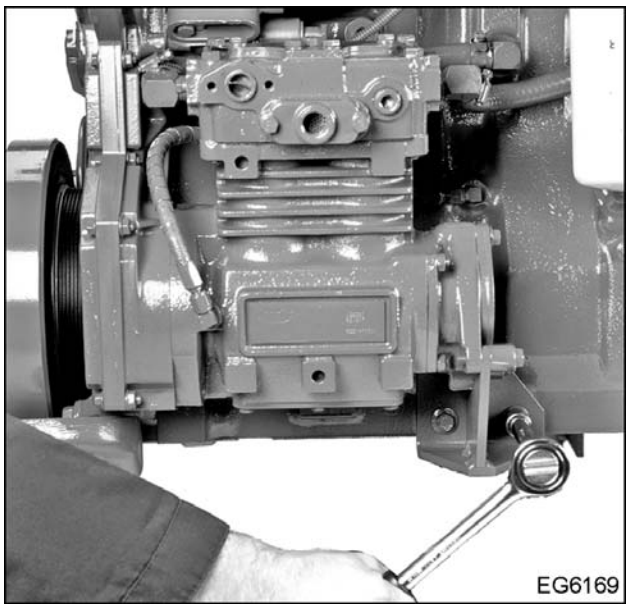

Figure 373 Remove air compressor mounting bolts

15. Remove two air compressor mounting bolts from front cover. Remove air compressor.
16. Remove engine front mounting bracket and vibration damper. See “Vibration Damper Assembly (page 184)” in the “Vibration Damper, Crankshaft, Main Bearings, Flywheel, and Crankcase” section in this manual.
17. Remove lubricating oil pump. See “Remove Lubricating Oil Pump (page 248)” in the “Lubricating Oil Pump, Oil Filter, and Cooler” section of this manual.
18. Loosen and remove front cover mounting bolts from rear half of front cover and crankcase.

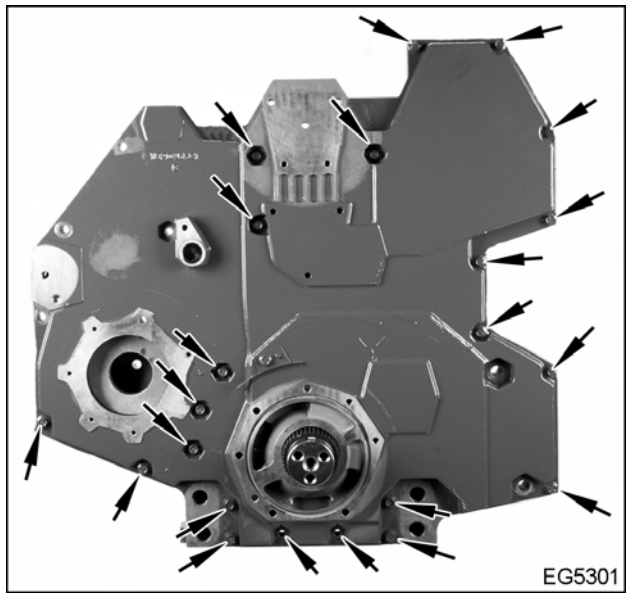

Figure 374 Front cover mounting bolts

19. Remove front half of front cover (with hardware) from rear half of front cover and set aside.
20. Remove and discard gaskets, seals, and O-rings from front cover.

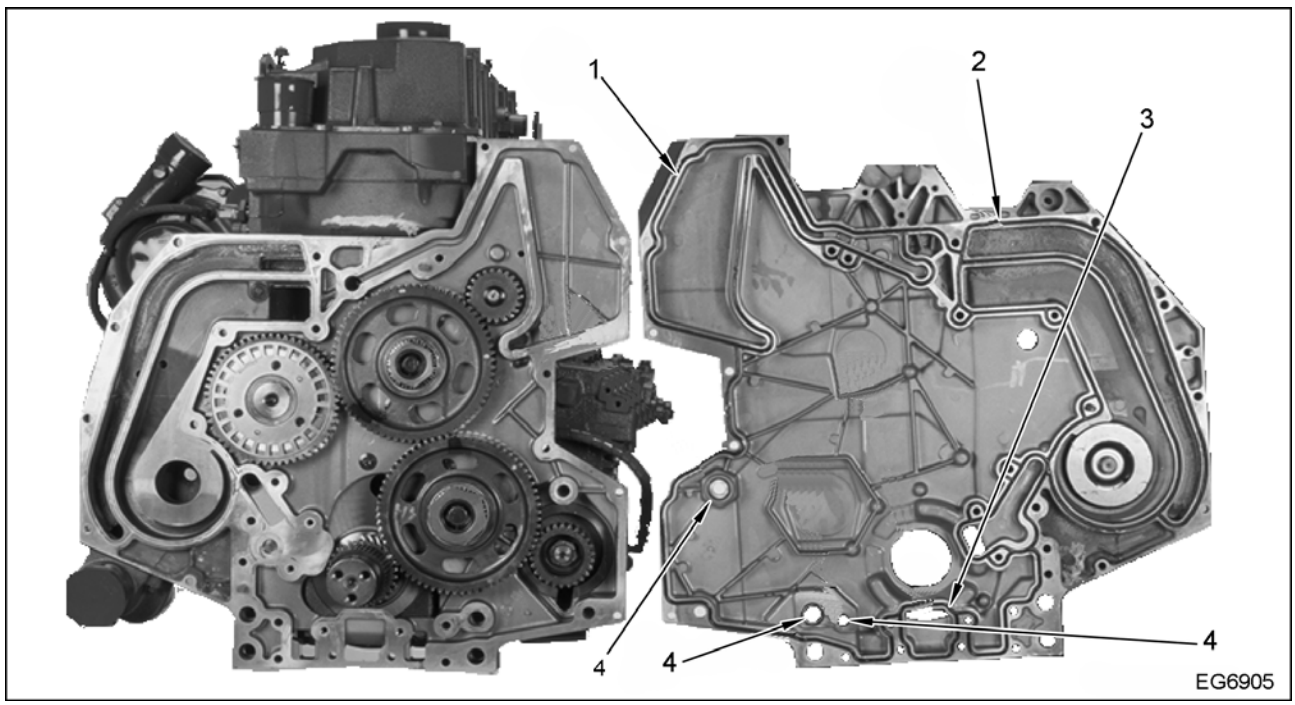

Figure 375 Front cover O-rings, seals, and gaskets

1. Crankcase front cover reservoir seal
2. Front cover oil pressure gasket
3. Front cover oil suction gasket
4. O-rings

NOTE: Oil pressure relief valve (stamped with “fc”) should be tagged when removed to ensure identification. Do not mix oil pressure relief valve with oil pressure regulator valve (found inside crankcase).

21. Depress oil pressure relief valve plunger, trap a length of copper wire under plunger seat, release plunger. Pull the copper wire and oil pressure relief valve from front cover (rear half).

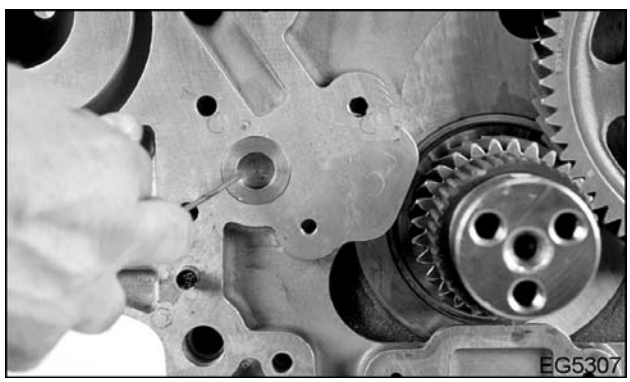

Figure 376 Remove oil pressure relief valve

Idler Gear Assembly

Measure Gear Train Backlash

NOTE: Prior to removing any gear, mount Dial Indicator on engine and measure for gear backlash.

1. Inspect gear train gears for nicks, chips, or wear. See “Inspect Idler Gear Assembly” in this section.
2. Rotate engine so timing marks on lower idler gear, upper idler gear, crankshaft gear, and camshaft gear are aligned.

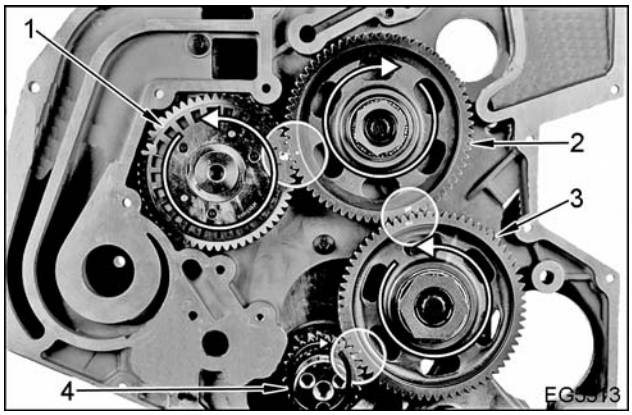

Figure 377 Align timing marks

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

NOTE: Once aligned at “marks aligned” position, engine will require 34 crankshaft revolutions to return to “marks aligned” position again.

NOTE: The following backlash measurements are more difficult to perform if cylinder head and valve train are assembled on engine. Additional force will be required to rotate camshaft back and forth to overcome valve spring force exerted on camshaft lobes.

3. Mount magnetic base of Dial Indicator (page 241) on top of crankcase.
4. Position Dial Indicator tip on upper idler gear tooth and zero Dial Indicator.
5. Place screwdriver between crankshaft and lower idler gear to prevent gear movement.
6. Rotate upper idler gear back and forth.
7. If backlash exceeds “Specification (page 241),” replace upper idler gear.

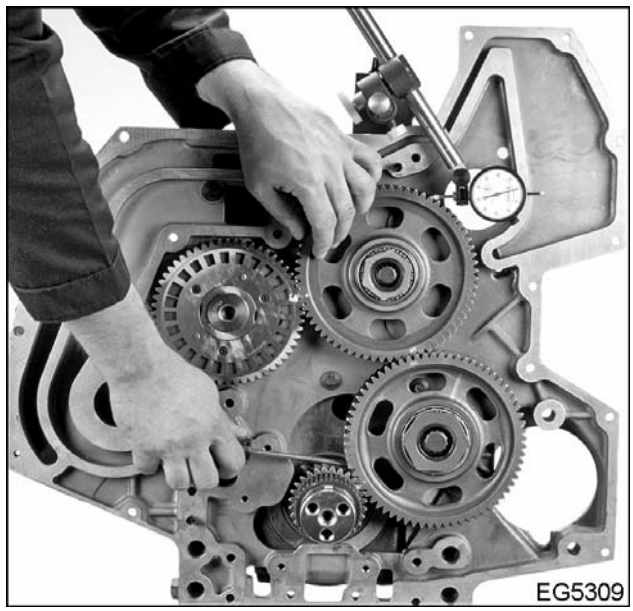

Figure 378 Measure upper idler gear backlash

8. Position Dial Indicator tip on upper idler gear face and zero Dial Indicator. Measure upper idler gear end play.
9. Position Dial Indicator tip on lower idler gear tooth and zero Dial Indicator.
10. Place screwdriver between crankshaft and upper idler gear to prevent gear movement.
11. Move lower idler gear back and forth.
12. If backlash exceeds “Specification (page 241),” replace lower idler gear.

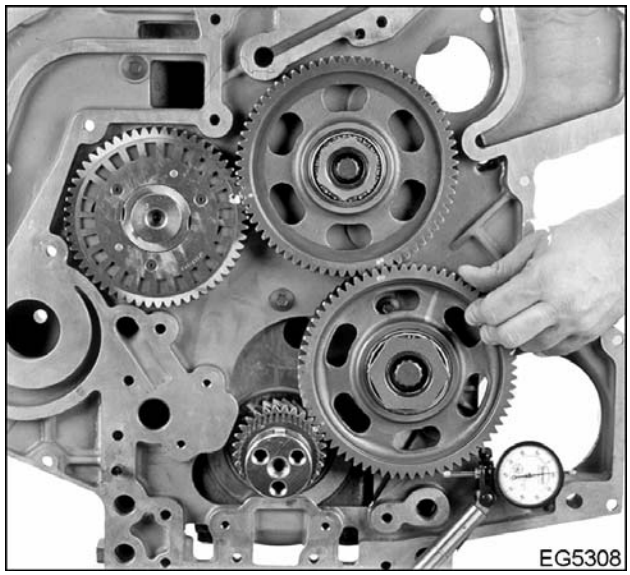

Figure 379 Measure lower idler gear backlash

13. Position Dial Indicator tip on lower idler gear face and zero Dial Indicator. Measure lower idler gear end play.
14. Position Dial Indicator tip on camshaft gear tooth and zero Dial Indicator.
15. Place screwdriver between upper and lower idler gear to prevent gear movement.
16. Rotate camshaft gear back and forth.
17. If backlash exceeds “Specification (page 241),” replace camshaft gear.

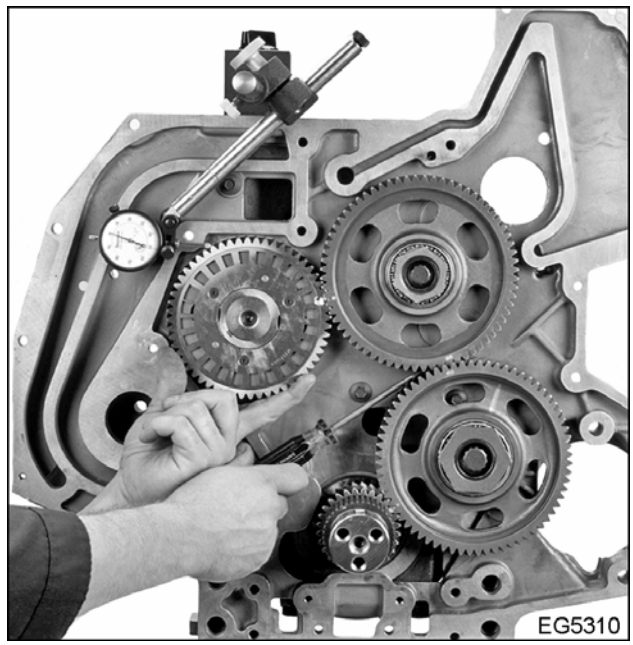

Figure 380 Measure camshaft gear backlash

18. Position Dial Indicator tip on camshaft gear face and zero Dial Indicator. Measure camshaft gear end play.

Remove Idler Gear Assembly

NOTE: Before idler gear assembly removal, measure idler gear assembly backlash and end play.

1. Loosen and remove lower idler gear retaining bolt. Remove idler gear assembly from front cover. Use Lower Idle Gear Socket (ZTSE4383) (page 241) or equivalent.

Figure 381 Remove lower idler gear

2. Remove and discard upper idler gear retaining bolt. Remove upper idler gear.

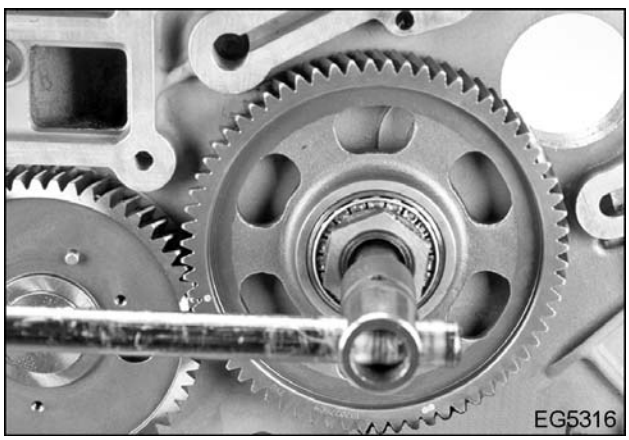

Figure 382 Remove upper idler gear

NOTE: New upper idler gear bolt must be used with each installation of upper idler gear. There is pre-applied sealant on new mounting bolt.

NOTE: Each idler gear (upper and lower) is supported on tapered roller bearings and shafts. Bearings are not serviced separately. If bearing is worn or loose, replace complete gear assembly.

Remove Camshaft Gear

Remove cam gear or camshaft and gear as an assembly. See “Camshaft Gear and Camshaft (page 116)” in the “Rocker Arm Assembly, Camshaft, Tappets, and Push Rods” section in this manual.

Remove Crankshaft Gear

Remove crankshaft and gears. See “Crankshaft and Main Bearings (page 186)” in the “Vibration Damper, Crankshaft, Main Bearings, Flywheel, and Crankcase” section of this manual.

Remove Front Cover (Rear Half) Assembly

1. With cam and idler gears removed, remove nine front cover (rear half) assembly retaining bolts from crankcase.

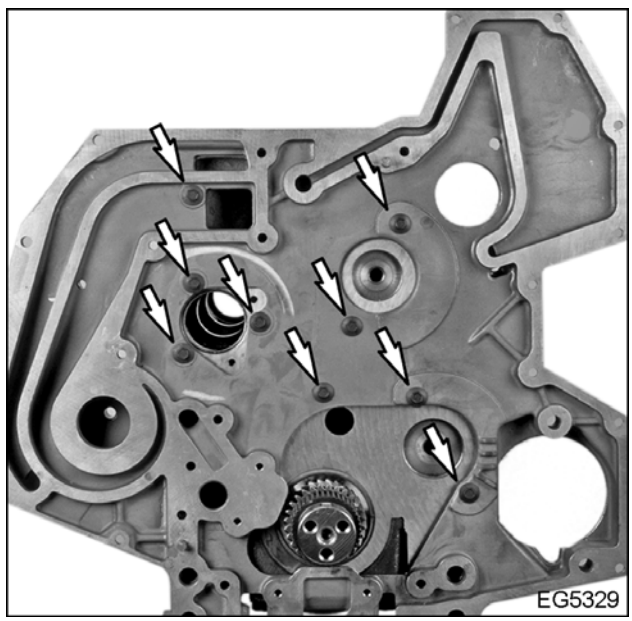

Figure 383 Front cover (rear half) assembly mounting bolts

2. Remove front cover (with dowels) from crankcase.
3. Remove and discard O-ring, clean any sealing material from front cover and crankcase.

Clean and Inspect

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi).

NOTE: Do not use a caustic solution on engine or related components.

Front Cover (Front Half) Assembly

Clean Front Cover (Front Half) Assembly

1. Use a scraper or wire brush to remove all gasket material and sealant from front cover (front half) assembly.
2. Clean all bolt threads before assembly.

Inspect Front Cover (Front Half) Assembly

NOTE: The following steps are especially important if oil and coolant contamination has been found and no other cause is discovered.

1. Inspect front cover (front half) assembly for cracks or porosity.
2. Replace any front cover (front half) assembly that fails visual inspection.

Front Cover (Rear Half) Assembly

Clean Front Cover (Rear Half) Assembly

1. Use scraper or wire brush to remove sealing material from front cover (rear half) assembly.
2. Clean all bolt threads before assembly.

Inspect Front Cover (Rear Half) Assembly

NOTE: The following steps are especially important if oil and coolant contamination has been found and no other cause is discovered.

1. Inspect front cover (rear half) assembly for cracks or porosity.
2. Replace any front cover (rear half) assembly that fails visual inspection.

Idler Gear Assembly

Clean Idler Gear Assembly

1. Clean all components in a suitable solvent.
2. Dry with filtered compressed air.

Inspect Idler Gear Assembly

1. Inspect bearings for looseness without disassembling. Replace gear and bearing assembly as required.

   NOTE: Camshaft, crankshaft, oil pump spline gears, high-pressure pump bearing and high-pressure pump gears are serviced as an assembly. See appropriate section for inspection criteria and replacement.
2. Inspect each gear in idler gear assembly for nicks, chips, or wear. Replace as necessary.

Install

Install Front Cover (Rear Half) Assembly

1. Install new crankshaft gear and oil spline gear, if required. Install crankshaft. See “Install Crankshaft Gear (page 195)” in the “Vibration Damper, Crankshaft, Main Bearings, Flywheel, and Crankcase” section of this manual.
2. Install new front cover O-rings, seals, and gaskets in grooves in front cover. Apply RTV to the gasket “T” joints.

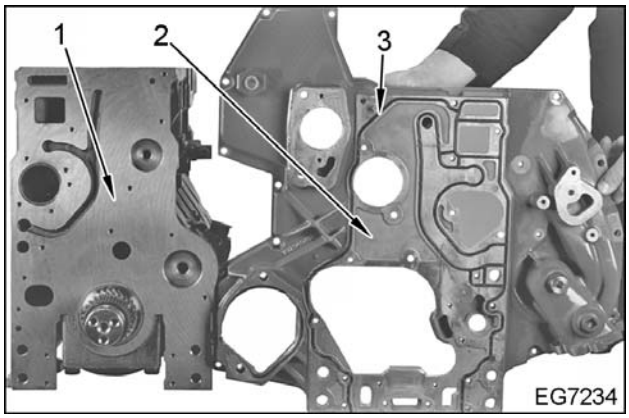

Figure 384 Rear half front cover O-rings, seals, and gaskets

1. Crankcase
2. Front cover
3. Gasket

3. Install rear half of front cover on crankcase with nine bolts. Tighten bolts to “Special Torque (page 241).”

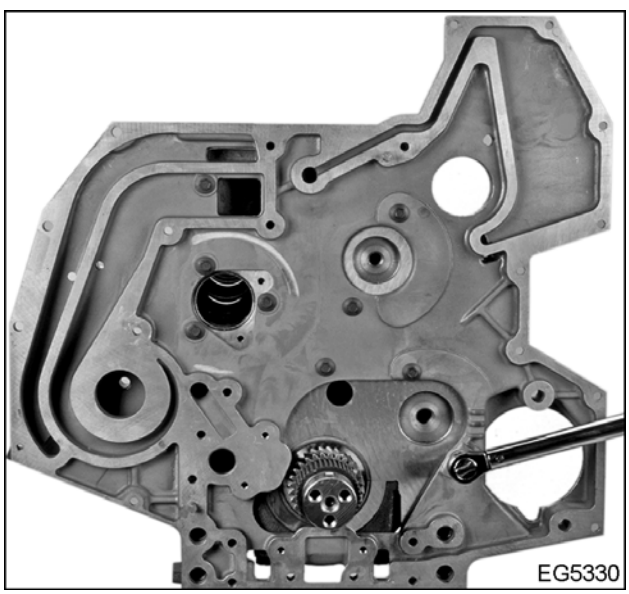

Figure 385 Install front cover (rear half) assembly

4. Install cam gear or cam gear and camshaft assembly. See “Camshaft (page 128)” in the “Rocker Arm Assembly, Camshaft Assembly, Tappets, and Push Rods” section in this manual.

Install Idler Gear Assembly

NOTE: When an engine has been disassembled and camshaft, crankshaft or idler gear removed, gears must be assembled with timing marks properly aligned.

NOTE: Single punch marks on crankshaft and lower idler gear and camshaft and upper idler gear must align, while two punch marks on both idler gears must align.

NOTE: Once assembled at “marks aligned” position, engine will require 34 crankshaft revolutions to return to “marks aligned” position again.

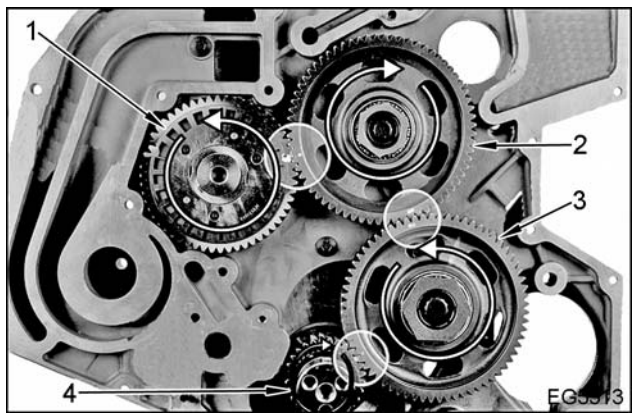

Figure 386 Align timing marks

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

1. Install lower idler gear with timing marks facing out.
2. Align crankshaft gear and lower idler gear timing marks.
3. Tighten retaining bolt to “Special Torque (page 241).”
4. Verify measurement of crankshaft gear and lower idler gear backlash to confirm proper assembly. See “Measure Gear Train Backlash Prior to Removal” in this section.

Figure 387 Install lower idler gear

5. Install upper idler gear with timing marks facing out.
6. Align camshaft gear, upper idler gear and lower idler gear timing marks.
7. Install new upper idler gear retaining bolt in upper idler gear. Tighten retaining bolt to “Special Torque (page 241).”
8. Verify measurement of camshaft gear, lower idler gear, and upper idler gear backlash to confirm proper assembly. See “Measure Gear Train Backlash Prior to Removal” in this section.

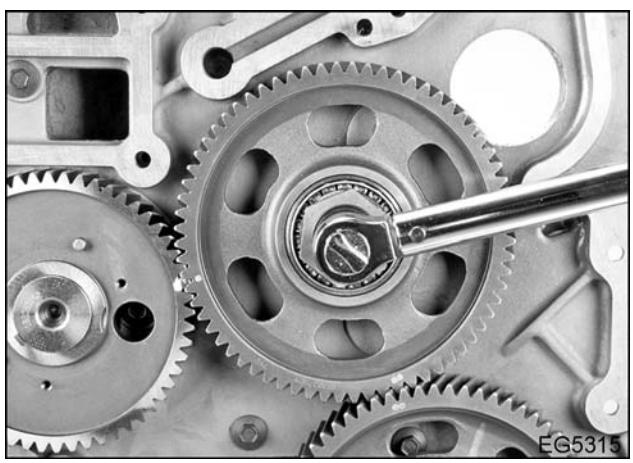

Figure 388 Install upper idler gear

9. Install high-pressure pump in rear cover. Use new gasket. See “High-pressure Oil Pump (page 305)” in the “High-pressure Lube Oil System” section in this manual.
10. Place new O-ring on oil pressure relief valve and install oil pressure relief valve in crankcase.

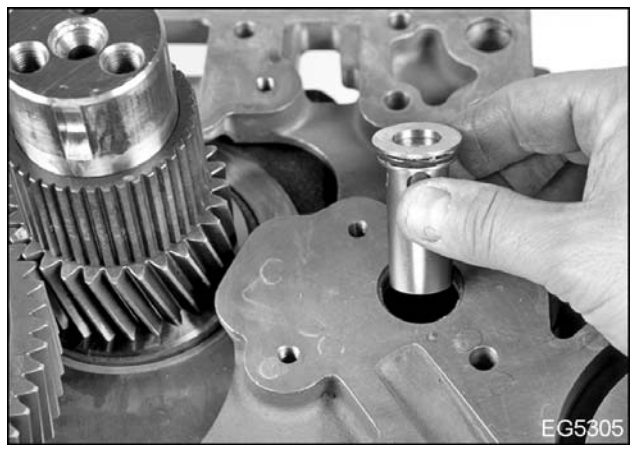

Figure 389 Install oil pressure relief valve

Install Front Cover (Front Half) Assembly

1. Apply assembly grease to three O-rings and install in front cover.
2. Install new gasket (3 segments) in front half of front cover. Gasket segments are molded pieces. Once gasket segments are in place, apply RTV to joints.

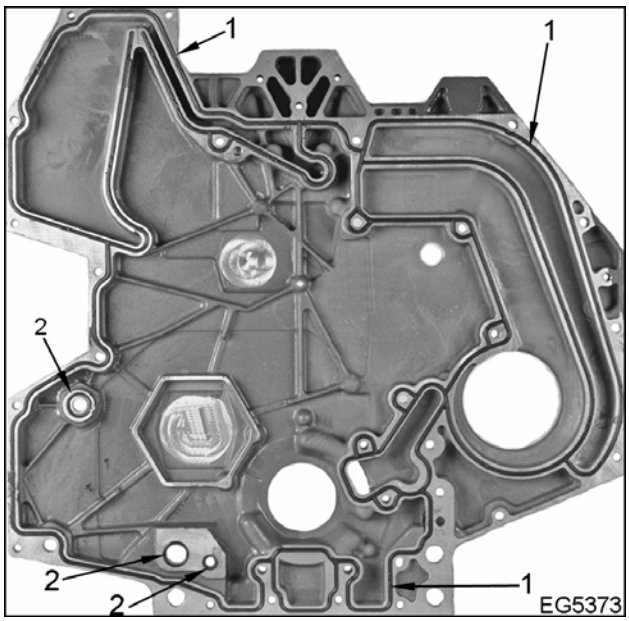

Figure 390 Front cover O-rings and gaskets

1. Gasket (three segments)
2. O-rings

3. Install front cover over locating dowel pins and install mounting bolts.
4. Tighten front cover mounting bolts to “Special Torque (page 241).”

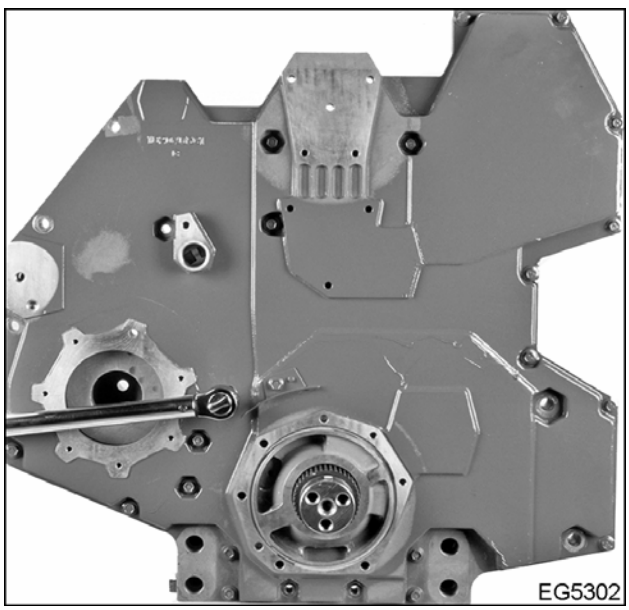

Figure 391 Install front cover (front half) assembly

Install Air Compressor and Power Steering Pump (If Equipped)

NOTE: When installing air compressor, it is critical that all bolts are tightened in same sequence as described in Steps 2 through 5 to avoid warping front cover.

1. Apply a small amount of assembly grease to O-ring and install in groove on front cover.
2. Mount air compressor on front cover with mounting bolts. Tighten mounting bolts to “Special Torque (page 241).”

   CAUTION: To avoid engine damage, do not overtighten air compressor mounting bolts or front cover may warp or fracture.

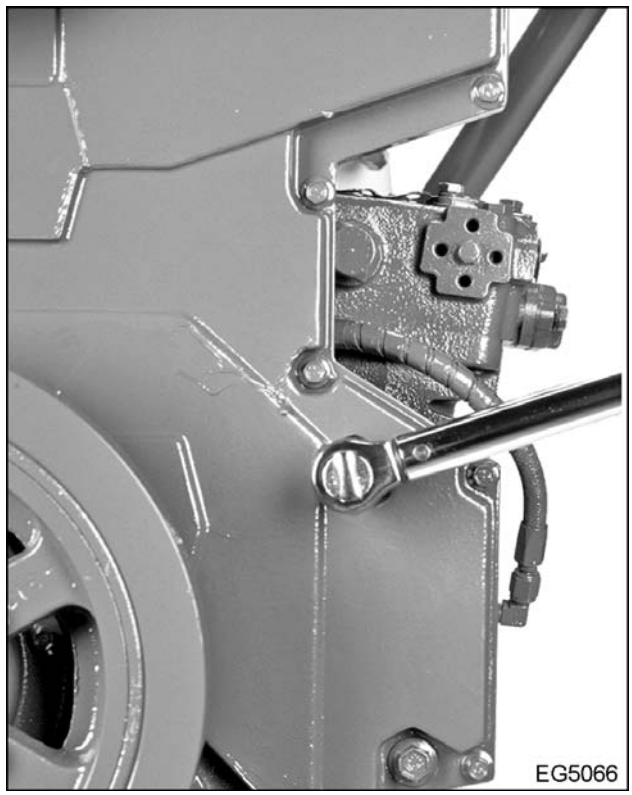

Figure 392 Install air compressor

3. Place air compressor bracket against crankcase. Slide bracket forward to air compressor mounting face. Install two bolts finger tight to hold bracket to crankcase.

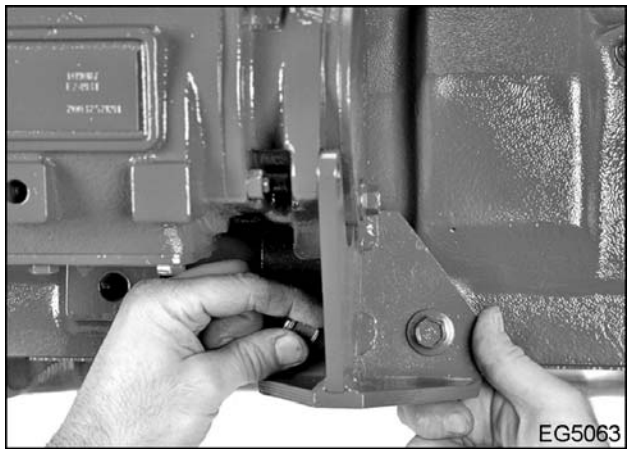

Figure 393 Install air compressor rear bracket

4. Fasten air compressor bracket to air compressor with two bolts and two washers. Tighten bolts to “Special Torque (page 241).”

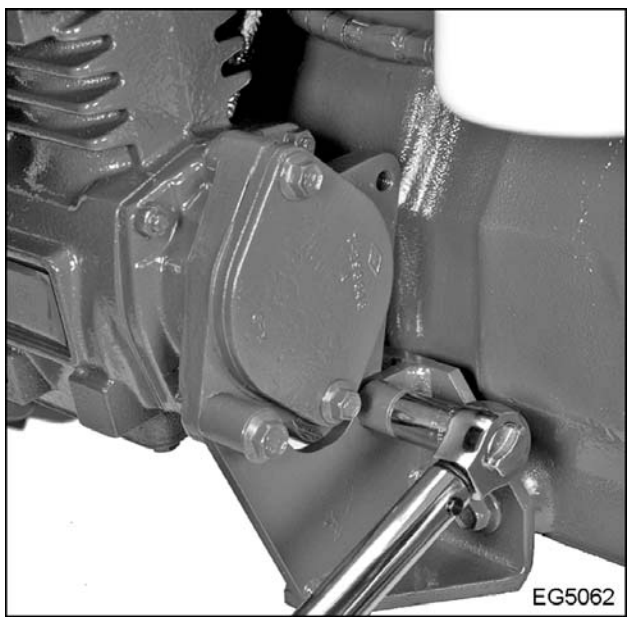

Figure 394 Air compressor rear bracket mounting bolts

5. Tighten two air compressor bracket mounting bolts to crankcase to “Special Torque (page 241).”

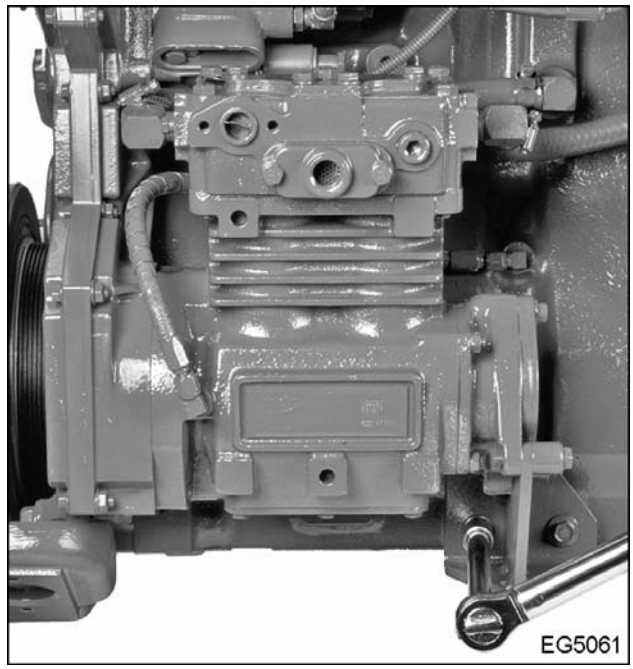

Figure 395 Rear air compressor bracket mounting bolts

6. Install two coolant hoses on air compressor and crankcase.

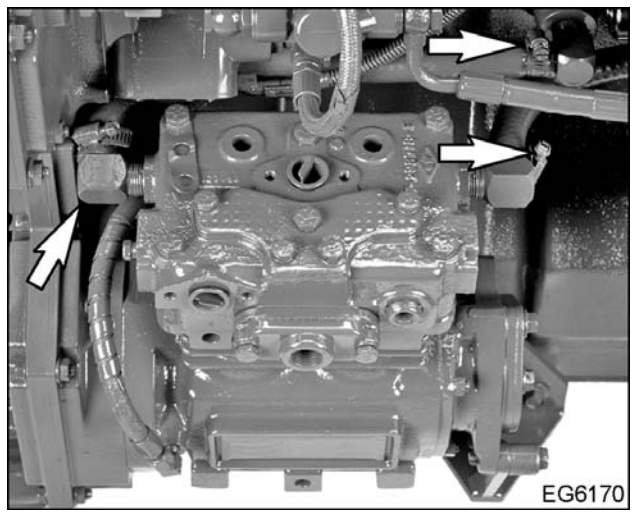

Figure 396 Install coolant hoses

7. Install oil lubrication line on air compressor and tighten nuts on both ends of lubrication line.

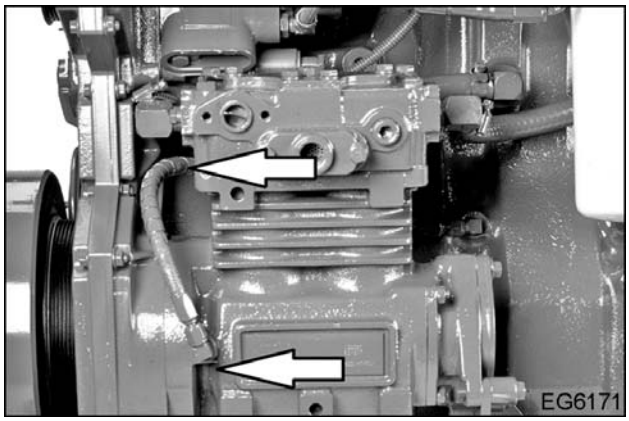

Figure 397 Install oil lubrication line

8. Mount steering pump to air compressor and tighten both bolts.

Install Fan Hub and Pulley

1. Mount fan drive hub on front cover with four mounting bolts.

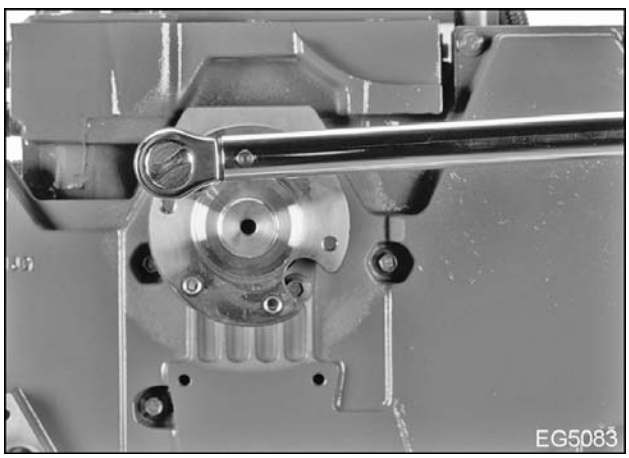

Figure 398 Install fan drive hub

2. Mount fan drive pulley on fan hub and tighten to “Special Torque (page 241).” Use Special Pulley “C” Wrench to hold pulley during fastener installation.

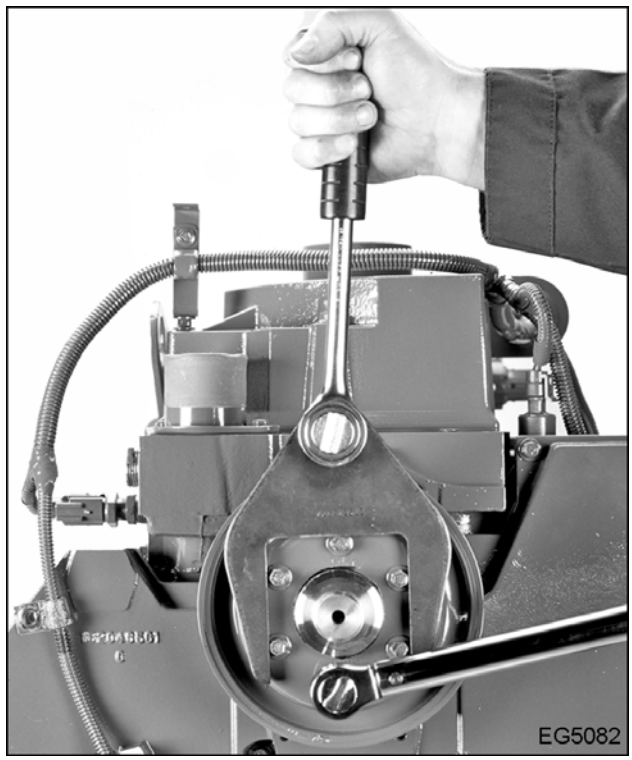

Figure 399 Install fan drive pulley

Install Alternator Bracket

1. Coat alternator support bracket mounting bolts with Loctite® 262.
2. Install alternator support bracket on front cover with mounting bolts.

Install Auto Belt Tensioner

1. Install auto belt tensioner on front cover. Align locating pin on tensioner with the recess in front cover.

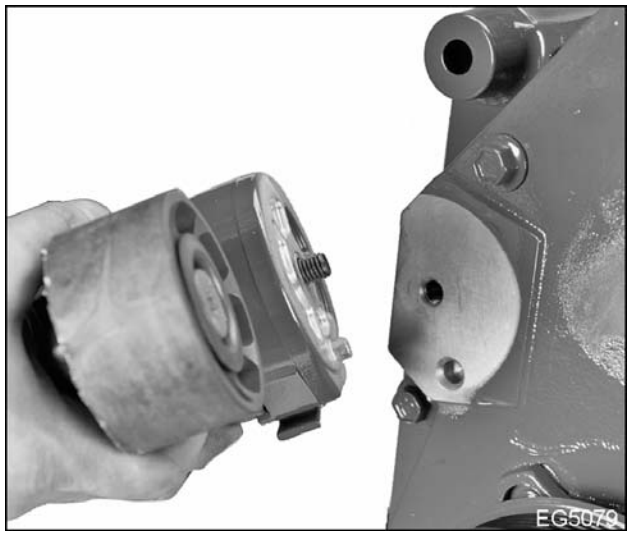

Figure 400 Install auto belt tensioner

2. Install 80 mm (3-1/8 in) mounting bolt through belt tensioner in front cover. Tighten mounting bolt to “Special Torque (page 241).”

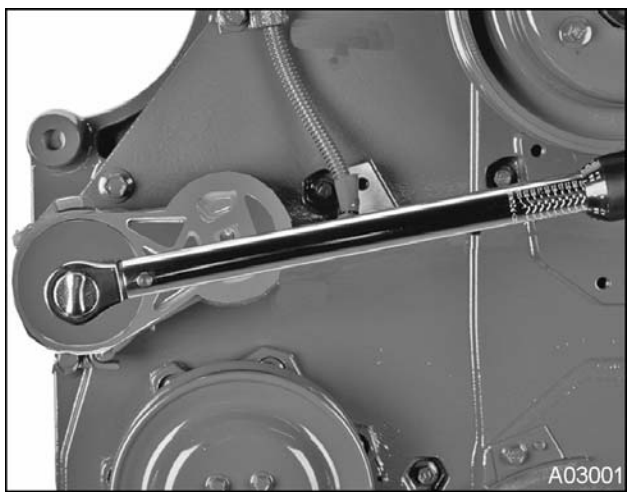

Figure 401 Torque auto belt tensioner

Miscellaneous

After installing front cover, install components removed to complete maintenance. See appropriate sections for installation information:

Water inlet elbow, if equipped

Oil pan

Oil pump assembly

Thermostat and thermostat housing (if applicable)

Water pump and pulley

High-pressure pump

Coolant filter header, if equipped

Front engine mounting bracket

Vibration damper

CMP sensor

Wiring harness

Belt

1. After previous work in complete refill the fuel, oil, and coolant systems.
2. Prime the lubricating system prior to returning engine to service. See “Prime Lubricating System - Pressure Priming (page 256)” in the “Lubricating Oil Pump, Oil Filter, and Cooler” section in this manual.

Special Information

Specifications

Crankshaft to idler backlash (maximum)	0.356 mm (0.014 in)
Idler to camshaft backlash	0.457 mm (0.018 in)
Idler to idler backlash	0.482 mm (0.019 in)
Idler to air compressor or power steering pump backlash	0.508 mm (0.020 in)
Idler to high-pressure pump backlash	0.482 mm (0.019 in)

Special Torque

Crankcase front cover bolts (front and rear halves)	22 N·m (16 lbf·ft)
Crankcase front cover (rear half to crankcase)	26 N·m (19 lbf·ft)
Front Cover Bracket to Head Bolts (no air conditioning)	62 N·m (46 lbf·ft)
Idler gear retaining bolt (upper)	326 N·m (240 lbf·ft)
Idler gear retaining bolt (lower)	639 N·m (470 lbf·ft)
Camshaft thrust plate bolt	26 N·m (19 lbf·ft)
Cam gear timing disk plate screws	6.8 N·m (60 lbf·in)
Air compressor hose clamps	5 N·m (42 lbf·in)
Air compressor tail bracket mounting bolts (crankcase)	115 N·m (85 lbf·ft)
Air compressor tail bracket mounting bolt (compressor)	66 N·m (49 lbf·ft)
Air compressor drive gear nut	149 N·m (110 lbf·ft)
Air compressor mounting bolts	62 N·m (46 lbf·ft)
Belt tensioner (front cover)	50 N·m (37 lbf·ft)
Belt tensioner (Freon compressor)	50 N·m (37 lbf·ft)
Water pump pulley (6 mm)	6.8 N·m (60 lbf·in)
Water pump (6 mm)	6.8 N·m (60 lbf·in)
Water pump mounting bolts (8 mm)	18 N·m (13 lbf·ft)
Fan drive	18 N·m (13 lbf·ft)
Thermostat Housing Bolt (M12)	90 N·m (66 lbf·ft.)

Special Service Tools

Dial Indicator with Magnetic Base	Obtain locally
Feeler Gauge	Obtain locally
Lower Idle Gear Socket	ZTSE4383
Special Pulley “C” Wrench	Obtain locally