

SPECIFICATIONS

DIMENSION	VALUES
CRANKSHAFT:	
Connecting Rod Journal Taper (Max./In.) . . .	0.00027 in. (0.068 mm)
Connecting Rod Bearing to Crankshaft	
Running Clearance	0.0050 – 0.0018 in. (0.127 – 0.046 mm)
Crankshaft Flange O.D.	5.550 in. (141 mm)
Crankshaft End Play	0.006 – .012 in. (0.15 – 0.30 mm)
Crankshaft End Play Max. Wear Limit	0.020 in. (0.51 mm)
Rod to Crankshaft Side Clearance	0.012 \pm .0045 in. (0.30 \pm .0114)
Crankshaft Gear Backlash	0.003 – .016 in. (0.08 – 0.41 mm)
Flywheel Runout	7.0 in. (178 mm)
Flywheel Concentricity	0.008 in. (0.203 mm)
Flywheel Housing Bore Concentricity*	SAE#1 = 0.12 in. (3.048 mm), SAE #2 = 0.011 in. (.028 mm)
Flywheel Housing Face Runout*	SAE#1 = 0.12 in. (3.048 mm), SAE #2 = 0.011 in. (.028 mm)
Vibration Damper Max. Allowable	
Member Misalignment	0.060 in. (1.5 mm)
Vibration Damper Wobble (Max.)	0.060 in. (1.5 mm)
CRANKCASE:	
Crankcase Deck Flatness	0.003 in. (0.08 mm)
Crankcase Deck Finish (Micro inches)	125 AA
Centerline of Main Bearing Bore	
to Head Deck	14.5 \pm 0.0015 in. (368.35 \pm 0.381 mm)
Crankcase Main Bearing Bore Diameter	3.8491 \pm 0.0005 in. (97.8 \pm 0.0127 mm)
Tappet Bore Diameter	1.1225/1.1240 in. (28.511/28.550 mm)
Valve/Roller Tappet O.D.	1.1195/1.1200 in. (28.435/28.448 mm)
Oil Jet Tube Bore Diameter	
(Spray Hole Dia.)	0.048/0.049 in. (1.22/1.24 mm)
Counter Dimension in Crankcase	0.349 \pm 0.001/ at 5.1885 gage diameter (8.86 \pm 0.03/ at 131.8 mm)
Maximum Allowable Variation of Counterbore	
Depth (Between Four Points)	0.001 (0.02 mm)

SPECIFICATIONS

DIMENSION	VALUES
CRANKCASE:	
Maximum Cylinder Liner Counterbore Allowable Depth364 in. (9.2 mm)
Flange Thickness	TBD
Protrusion Above Crankcase002 to .005 in. (0.05 to 0.127 mm)
Main Bearings	
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	2.5005/2.5020 in. (63.512/63.550 mm)
Intermediate Front	2.4805/2.4820 in. (63.005/63.043 mm)
Intermediate Rear	2.4605/2.4620 in. (62.496/62.535 mm)
Rear	2.4405/2.4420 in. (61.988/62.026 mm)

* = Must be measured per SAE specification J1033

10.2.1 Special Torque Values

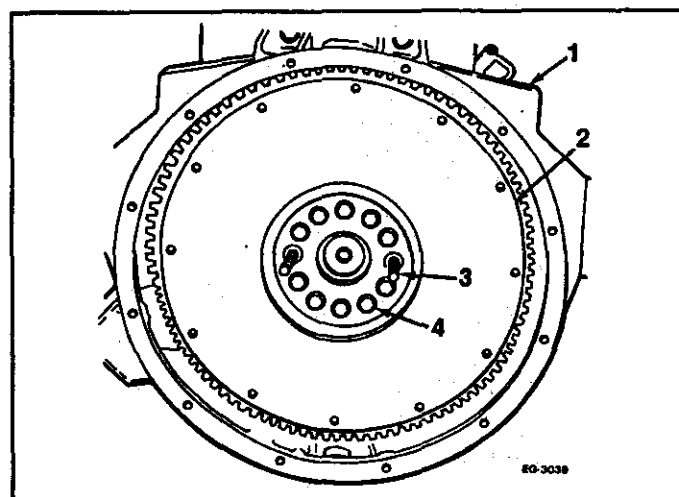
Connecting Rod Bolt	115 lb-ft (156 N·m)
Crankshaft Main Bearing Cap Bolts	115 lb-ft (156 N·m)
Crankshaft Pulley Retainer Bolts	100 lb-ft (136 N·m)
Flywheel Bolts	100 lb-ft (136 N·m)
Flywheel Housing Mounting Bolts	80 lb-ft (108 N·m)
Oil Pan Bolts	13 lb-ft or 156 lb-in. (18 N·m)
Oil Pan Drain Plug 7/8 inch	50 lb-ft (68 N·m)
Oil Pick-up Tube Bolts	13 lb-ft or 156 lb-in. (18 N·m)
Oil Pick-up Tube Bracket Bolt	13 lb-ft or 156 lb-in. (18 N·m)
Oil Level Gauge Tube Clamp	30 lb-ft (4.07 N·m)

SPECIFICATIONS

10.2.2 Special Service Tools

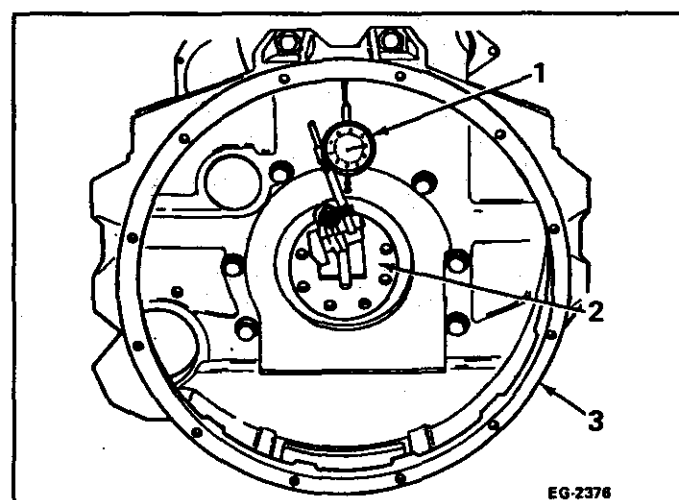
Tool No.	Description
PT2200-55	Counterbore Tool
PT2250-A	Cutter Head
J41163	Crankshaft – Rear Oil Seal Installer
J39266	Crankshaft – Front Oil Seal Wear liner Installer

10.3 REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY



1. Flywheel Housing
2. Flywheel
3. Dowel Pins
4. Flywheel Mounting Bolts (12)

FIGURE 10-4



1. Dial Indicator
2. Crankshaft Flange
3. Flywheel Housing

FIGURE 10-5

Refer to FIGURE 10-4.

NOTE:

The rear oil seal can be serviced in chassis. The procedure is performed as part of engine overhaul and separately, when required.

10.3.1 In-Chassis Procedure

1. Remove two (2) flywheel mounting bolts located at the 3 and 9 o'clock positions. Install two (2) guide dowel pins at these locations.
2. Remove remaining ten (10) flywheel mounting bolts.
3. Slide flywheel out of the flywheel housing and off guide dowel pins.

NOTE:

With flywheel removed, guide dowel pins can be removed from crankshaft flange.

10.3.2 Checking Flywheel Housing Bore Concentricity And Face Runout

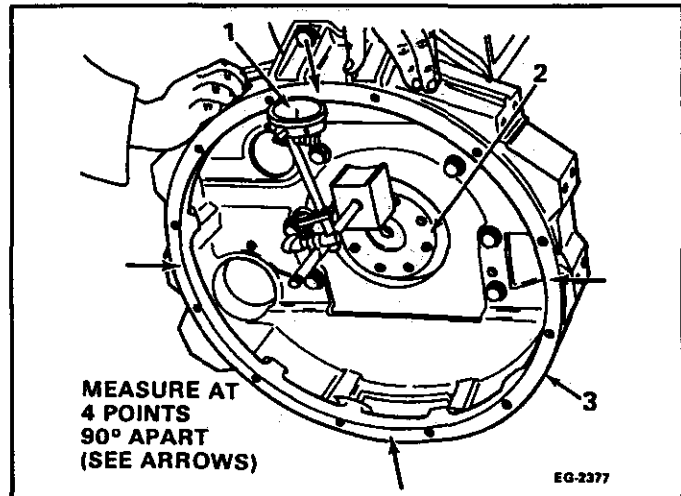
NOTE:

Flywheel housing bore concentricity and flywheel housing face runout is checked to ensure proper engine to transmission alignment.

1. Check flywheel housing bore concentricity as follows:
 - a. Attach a dial indicator to the crankshaft and place the indicator tip against the flywheel housing bore. Refer to FIGURE 10-5.

REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

- b. Zero the dial indicator.
 - c. Rotate the crankshaft slowly and record the total indicator variation. Refer to "Specifications" for housing bore to concentricity tolerance.
2. Check flywheel housing face runout as follows:
 - a. Attach a dial indicator to crankshaft and place indicator tip against flywheel housing bore. Refer to **FIGURE 10-6**.
 - b. Measure at four points, 90° apart for total face variation.



1. Dial Indicator
2. Crankshaft Flange
3. Flywheel Housing

FIGURE 10-6

NOTE:

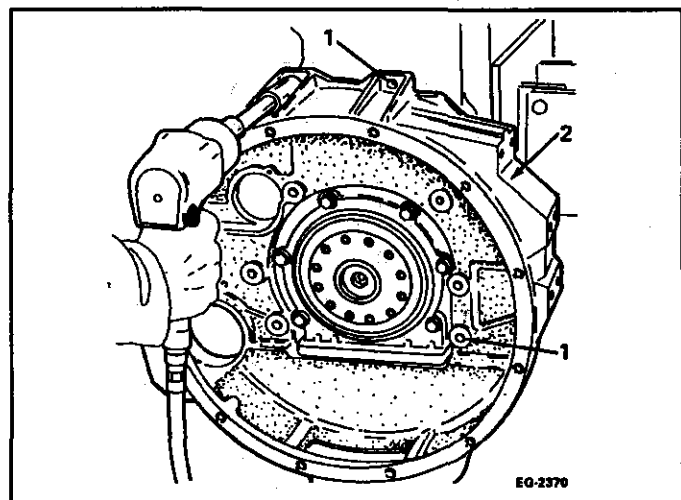
Keep the crankshaft end play at zero in the same direction for all measurements.

- c. Refer to "Specifications" for flywheel housing face runout tolerance.

10.3.3 Flywheel Housing Removal

Refer to (**FIGURE 10-7**)

1. Remove the flywheel housing mounting bolts securing the flywheel housing to crankcase.
2. Remove flywheel housing from crankcase.

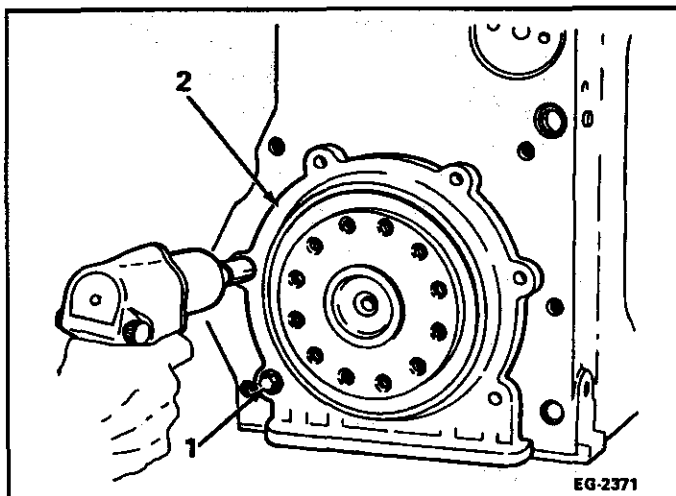


1. Flywheel Housing
2. Flywheel Housing Mounting Bolt

FIGURE 10-7

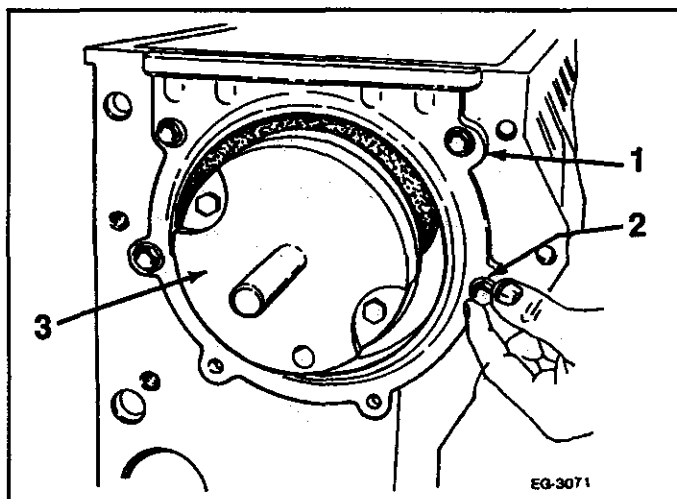
REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

10.3.4 Rear Oil Seal Carrier Removal



1. Rear Oil Seal Carrier Bolt
2. Rear Oil Seal Carrier

FIGURE 10-8



1. Rear Oil Seal Carrier
2. Rear Oil Seal Carrier Mounting Bolts (6)
3. Guide

FIGURE 10-9

NOTE:

The rear seal carrier does not have to be removed to replace the rear oil seal. The rear oil seal carrier can not be removed until the four (4) bolts mounted thru the oil pan and into the bottom of rear oil seal carrier are removed. Refer to oil pan removal in this section for further information.

1. Remove six (6) bolts securing rear oil seal carrier to crankcase (FIGURE 10-8).
2. Remove rear oil seal carrier.

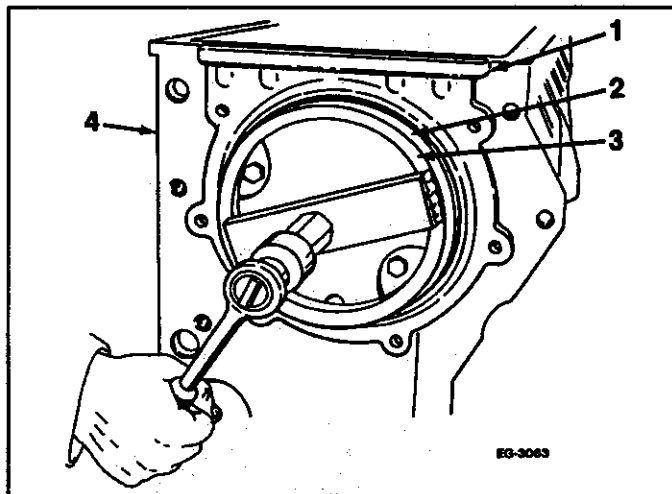
10.3.5 Installing Rear Oil Seal Carrier

Install rear oil seal carrier as follows:

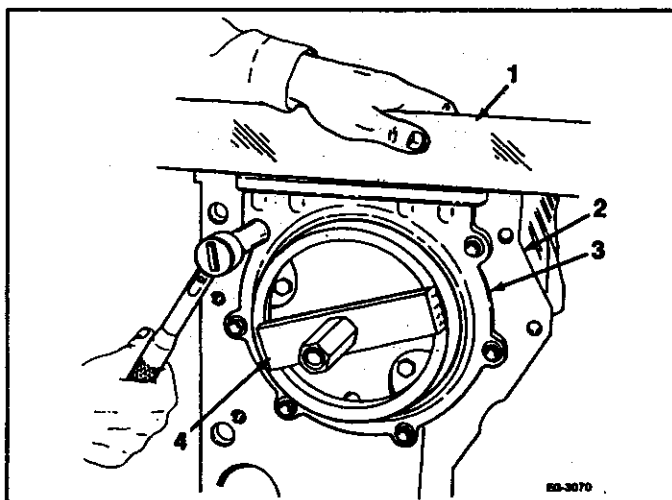
1. Place a new gasket into rear oil seal carrier.
2. Attach guide to crankshaft flange and tighten.
3. Install rear oil seal carrier and secure to crankcase by finger-tightening the mounting bolts (FIGURE 10-9).

REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

4. Install driver and tighten driver nut to center carrier (**FIGURE 10-10**).
5. Rotate/twist carrier to even carrier with cylinder block oil pan rail. Use straight edge to verify.
6. When the rear oil seal carrier is level, tighten the mounting bolts to special torque value (**FIGURE 10-11**).
7. Remove rear oil seal installation tool.



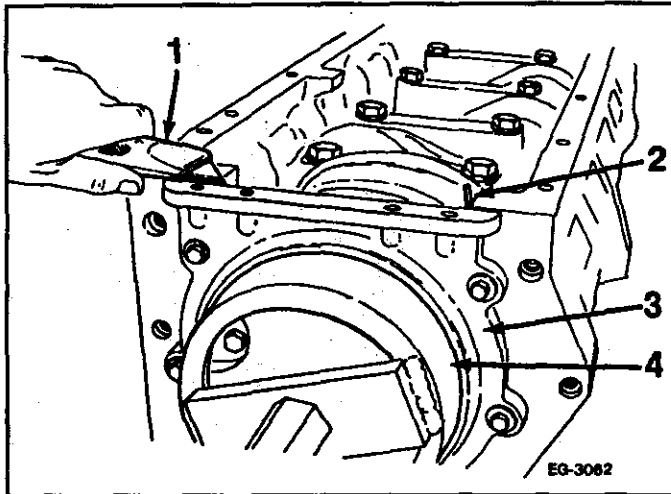
1. Oil Seal Carrier
2. Rear Oil Seal
3. Driver
4. Crankcase

FIGURE 10-10

1. Straightedge
2. Crankcase
3. Oil Seal Carrier
4. Driver

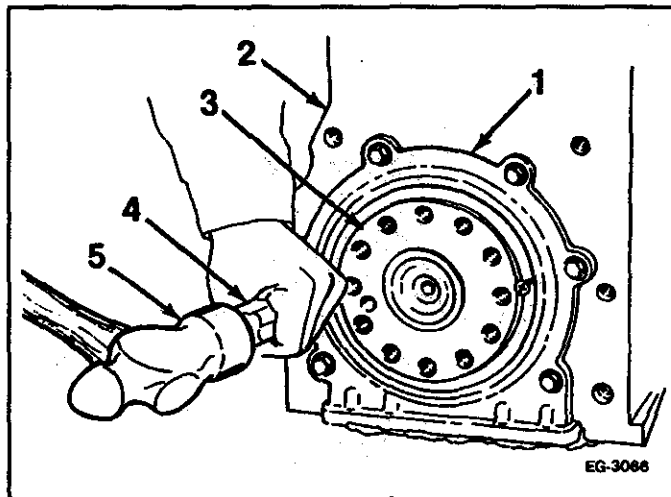
FIGURE 10-11

REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY



1. Knife
2. Rear Oil Seal Gasket
3. Rear Oil Seal Carrier
4. Driver

FIGURE 10-12



1. Oil Seal Carrier
2. Crankcase
3. Crankshaft
4. Punch
5. Hammer

FIGURE 10-13

8. Cut any access O-ring material off from rear oil seal carrier (FIGURE 10-12).

10.3.6 Oil Seal Removal

NOTE:

Use this method if the rear oil seal removal tool is not available.

1. Punch two holes into the rear oil seal and insert two sheet metal screws (FIGURE 10-13).

REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

2. Using a small pry bar, alternately pry on each screw to remove rear oil seal from the carrier (**FIGURE 10-14**).

3. Discard old oil seal.

NOTE:

It is not necessary to remove the flywheel housing if all that is required is to replace the crankshaft rear oil seal or wear liner.

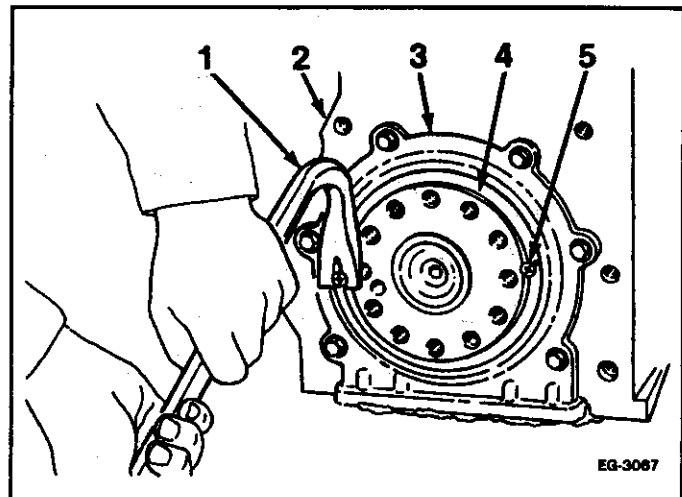
10.3.7 Wear Liner Removal – In-chassis

1. With the rear oil seal removed, the wear liner can be removed using a muffler chisel and air hammer (**FIGURE 10-15**).

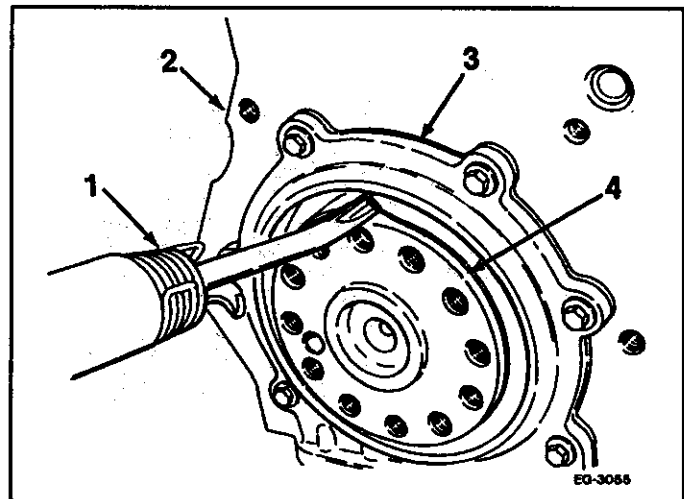
NOTE:

Be careful not to nick the crankshaft flange during this procedure. Use this method only when the repair is to be done in-chassis with the flywheel housing and rear oil seal carrier in place.

2. Discard wear liner.



1. Pry Bar
2. Crankcase
3. Oil Seal Carrier
4. Rear Oil Seal
5. Screw (2)

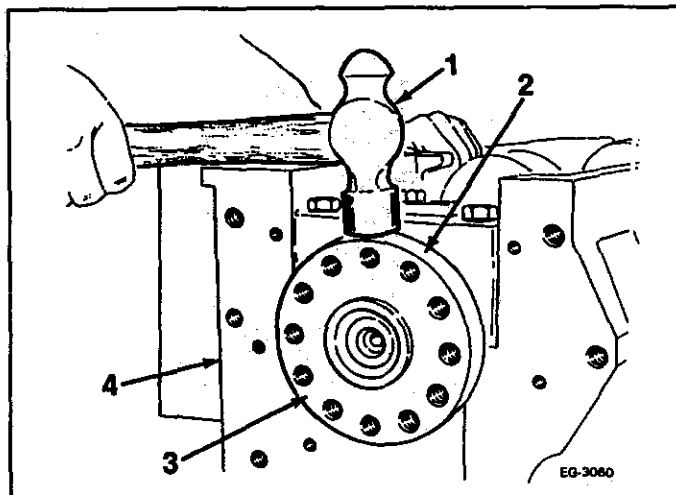
FIGURE 10-14

1. Muffler Chisel
2. Crankcase
3. Oil Seal Carrier
4. Rear Oil Seal

FIGURE 10-15

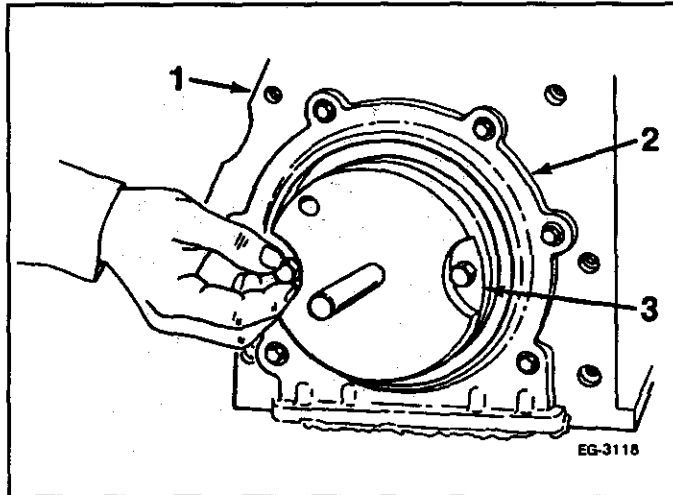
REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

10.3.8 Wear Liner Removal – Out-of-Chassis



1. Hammer
2. Wear Liner
3. Crankshaft
4. Crankcase

FIGURE 10-16



1. Crankcase
2. Rear Oil Seal Carrier
3. Guide

FIGURE 10-17

1. With the flywheel, flywheel housing and rear oil seal carrier removed, use a hammer and tap the O.D. of the wear liner (FIGURE 10-16).

NOTE:

This causes the wear liner to expand and slide off easily.

2. Discard wear liner.

NOTE:

Install the rear oil seal and wear liner as a unit. Do not remove the seal from the wear liner prior to installation.

NOTICE: Install a new rear oil seal and crankshaft wear liner assembly using the installer tool J41163 as follows:

1. Clean crankshaft flange and flywheel housing bore thoroughly. Remove any debris.
2. Attach guide and secure with two (2) mounting screws (FIGURE 10-17).

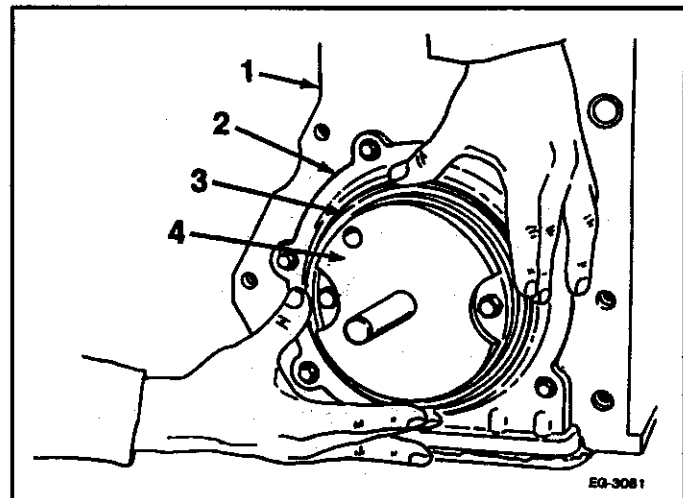
REAR OIL SEAL AND WEAR LINER REMOVAL AND REASSEMBLY

10.3.9 Rear Oil Seal and Wear Liner Installation

3. Coat inner I.D. of wear liner and O.D. of oil seal with Aviation Permatex.
4. Position oil seal and wear liner over crankshaft (FIGURE 10-18).
5. Assemble wear liner/oil seal installer tool onto crankshaft. Turn forcing nut on installer tool until seal and liner are seated in the bore (FIGURE 10-19).

NOTE:

Proper use of the installer tool will assure that the seal and wear liner are pressed onto the crankshaft flange to the proper depth.



1. Crankcase
2. Oil Seal Carrier
3. Wear Liner
4. Guide

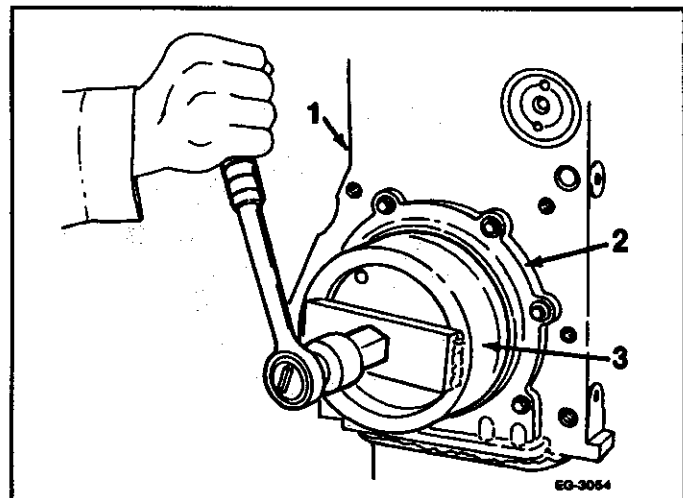
FIGURE 10-18

10.4 FLYWHEEL RECONDITIONING AND REASSEMBLY

The first step in flywheel reconditioning is to clean and inspect the flywheel.

10.4.1 Cleaning and Inspection

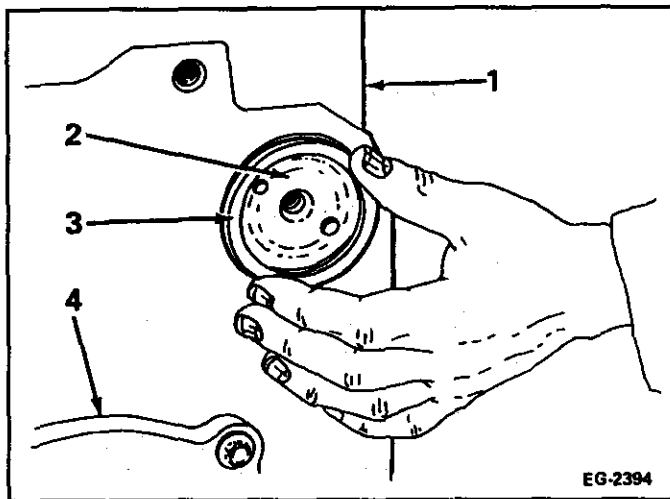
1. Clean the flywheel with a non-caustic solvent and dry with compressed air.
2. Visually inspect the flywheel for cracks, heat checks and extensive scoring which would make it unfit for further service. Replace or resurface as required.
3. Inspect the ring gear for worn, chipped or cracked teeth. If teeth are damaged, replace the ring gear.



1. Crankcase
2. Oil Seal Carrier
3. Wear Liner

FIGURE 10-19

FLYWHEEL RECONDITIONING AND REASSEMBLY



1. Crankcase
2. Camshaft
3. Camshaft O-ring
4. Rear Oil Seal Carrier

FIGURE 10-20

10.4.2 Ring Gear Replacement

1. Remove any damaged ring gear from the flywheel as follows:
 - a. Heat the ring gear with a torch to expand the gear.
 - b. Once heated, knock the gear off the flywheel. **Do not hit the flywheel when removing the ring gear.**
2. Install a new ring gear as follows:
 - a. Heat the new ring gear evenly until the gear expands enough to slip onto the flywheel.
 - b. Make sure the ring gear is seated properly against the flywheel shoulder.

NOTICE: Do not heat the ring gear to a temperature higher than 500°F (278°C). Heating beyond this temperature will adversely affect ring gear hardness.

10.4.3 Flywheel Housing Installation

Install flywheel housing to crankcase as follows:

NOTICE: Be sure to check flywheel housing bore concentricity and flywheel housing face runout as described earlier in this section.

1. Install new camshaft O-ring over camshaft end opening at rear of crankcase (FIGURE 10-20).

NOTICE: Be sure a new camshaft O-ring is installed before preceding.

FLYWHEEL RECONDITIONING AND REASSEMBLY

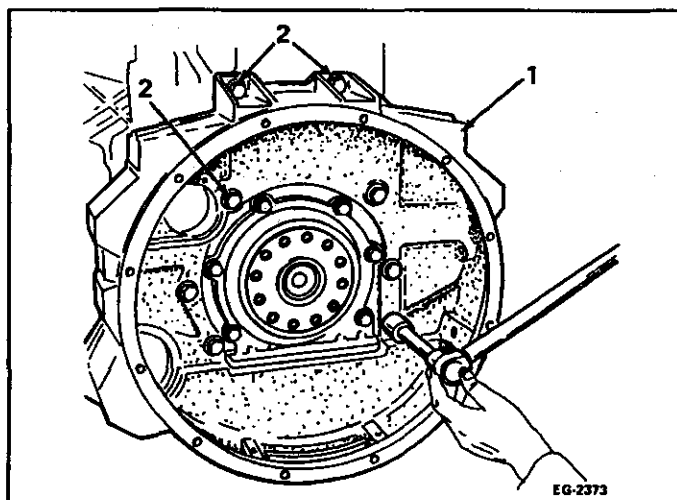
2. Install flywheel housing by guiding housing over dowel guide pins and secure to crankcase using flywheel housing mounting bolts. Tighten the eight (8) bolts to the specified torque. Refer to **FIGURE 10-21**.

NOTICE: When installing the flywheel housing, be sure the automatic transmission access cover, located on the front of the flywheel housing, does not get caught between the flywheel housing and the crankcase.

10.4.4 Flywheel Installation

Install the flywheel as follows:
(**FIGURE 10-22**).

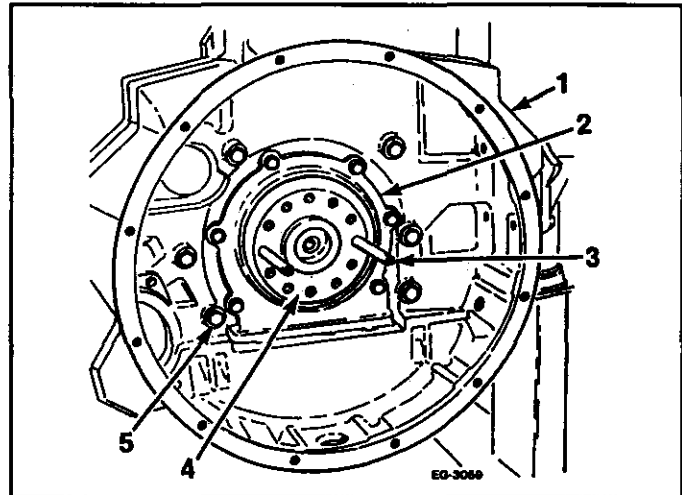
1. Install two (2) dowel pin guides into the three and nine o'clock positions of the crankshaft.
2. Install flywheel over dowel guide pins and secure with ten (10) flywheel mounting bolts.
3. Remove two (2) dowel guide pins and install remaining two (2) mounting bolts. Tighten all twelve (12) flywheel mounting bolts to specified torque.



1. Flywheel Housing

2. Flywheel Housing Mounting Bolt

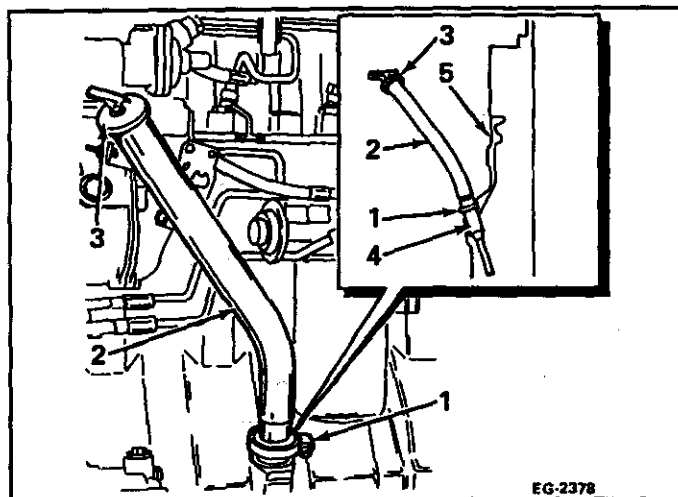
FIGURE 10-21



1. Flywheel Housing
2. Oil Seal Carrier
3. Dowel Guide Pins
4. Crankshaft
5. Flywheel Housing
6. Mounting Bolts (6)

FIGURE 10-22

10.5 OIL LEVEL GAUGE TUBE REMOVAL AND REASSEMBLY



1. Tube Clamp
2. Oil Filler Tube
3. Oil Level Gauge
4. Oil Level Gauge Lower Tube
5. Crankcase

FIGURE 10-23

(Refer to **FIGURE 10-23**)

1. Loosen screw securing oil filler tube clamp to crankcase.
2. Lift oil level gauge, oil filler tube and oil filler tube clamp from crankcase as an assembly.
3. Discard O-ring gasket.
4. If necessary, remove oil level gauge tube from crankcase using a brass drift and hammer.

NOTICE: Removal of oil level gauge tube from crankcase requires removal of oil pan. Refer to oil pan removal in this section.

10.5.1 Cleaning And Inspection

1. Thoroughly clean both tubes and clear any obstructions.
2. Remove all old Loctite® from oil level gauge and crankcase casting area which mates with the tube.
3. Visually inspect the components for kinks, bends or restrictions.
4. Replace components as required.

10.5.2 Reassembly

(Refer to **FIGURE 10-23**)

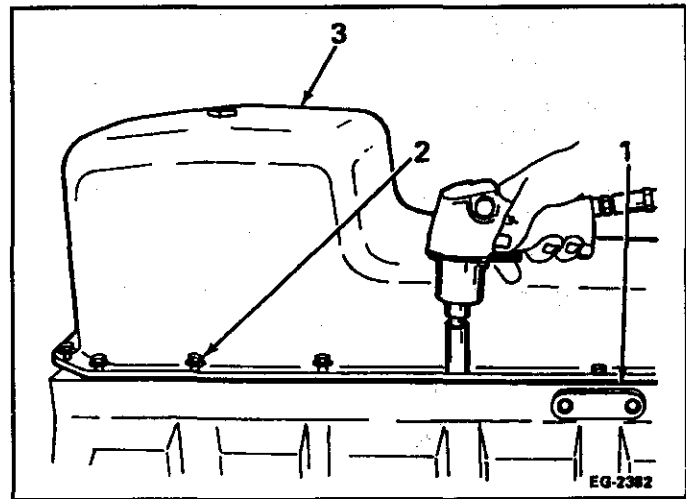
1. Install the lower oil level gauge tube into the crankcase orifice as follows:
 - a. Apply Loctite® #609 around entire circumference of tube and casting.
 - b. Press tube in until the bead is seated in chamber of the crankcase.

OIL LEVEL GAUGE TUBE REMOVAL AND REASSEMBLY

NOTE:

The slots in oil level gauge tube need not be oriented in any special manner.

2. Install new O-ring gasket onto the oil level filler tube.
3. Insert oil level filler tube into oil level gauge tube and orient oil filler tube to the rear and as far inboard as possible.
4. Tighten oil filler tube clamp screw to specified torque.

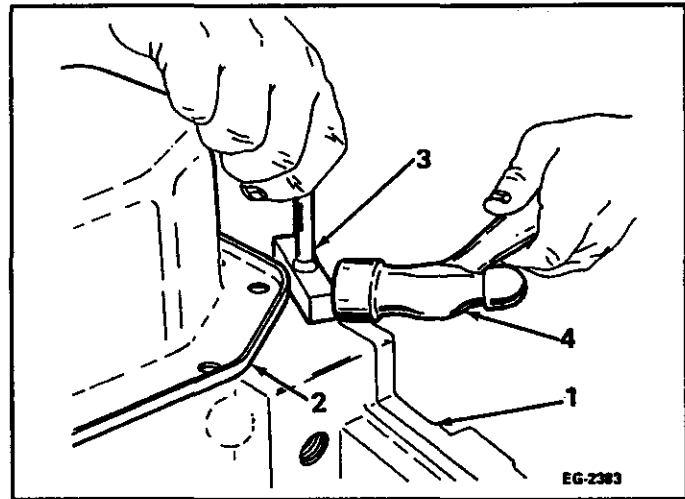


1. Crankcase
2. Oil Pan Mounting Bolts (22)
3. Oil Pan

FIGURE 10-24

10.5.3 Oil Pan Removal

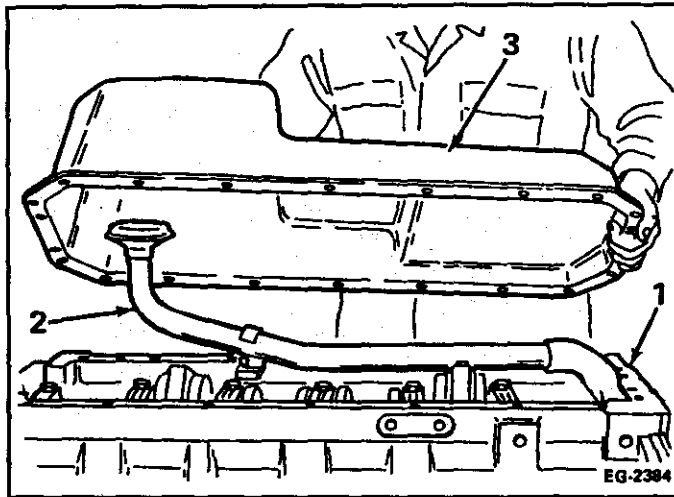
1. Remove twenty-two (22) oil pan mounting bolts (FIGURE 10-24).
2. Using tool a wedge tool between oil pan and crankcase. Tapping tool with a hammer, cut RTV all along the outside edge of the oil pan. (FIGURE 10-25).



1. Front Cover
2. Oil Pan
3. Cutting Tool
4. Hammer

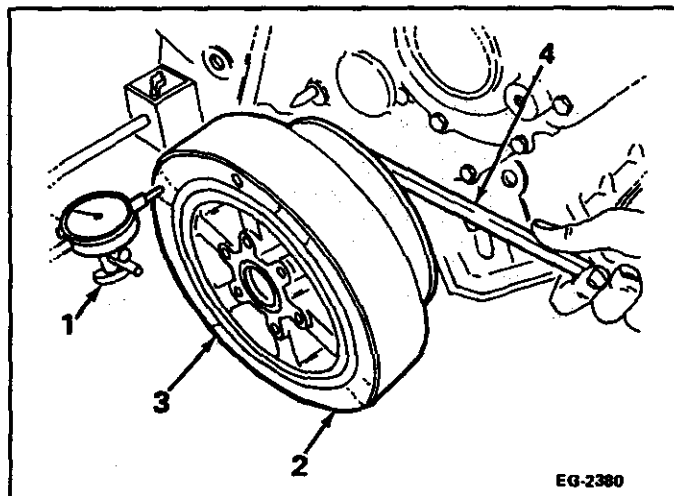
FIGURE 10-25

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING



1. Crankcase
2. Oil Pick-Up Tube
3. Oil Pan

FIGURE 10-26



1. Dial Indicator
2. Pulley Damper
3. Removed Paint Area
4. Pry Bar

FIGURE 10-27

3. Remove oil pan from crankcase (FIGURE 10-26).

10.6 DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

The first step in reconditioning the damper, crankshaft and main bearing is the removal of the pulley damper assembly

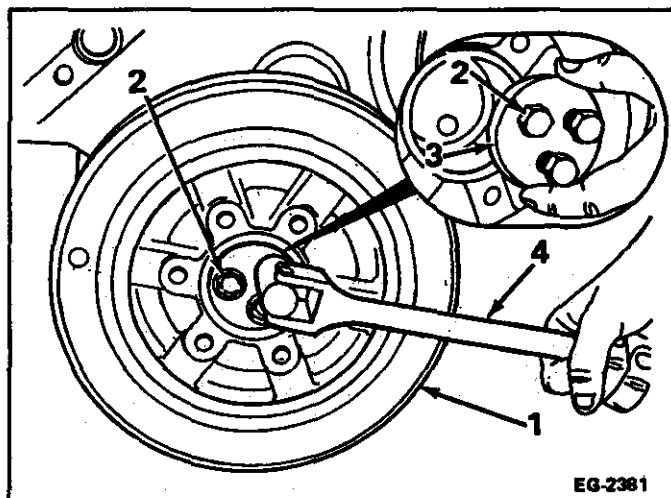
10.6.1 Pulley Damper Assembly Removal

1. Prior to pulley damper removal, inspect the damper for wobble as follows: (Refer to FIGURE 10-27).
 - a. Remove paint from the face of the damper at 4 points 90° apart.
 - b. Clamp/attach a dial indicator to the front cover. Position the indicator point on an unpainted surface and "zero" the indicator.
 - c. Pry the crankshaft pulley forward and read the indicator.
 - d. Record readings and repeat at each unpainted surface. If wobble exceeds specification, replace the damper.

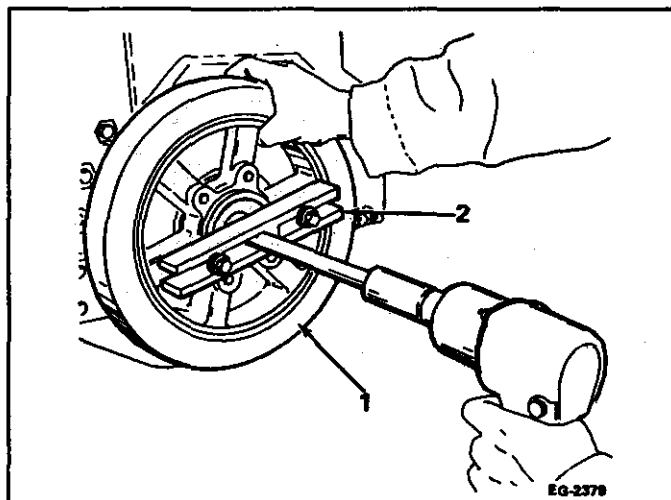
NOTICE: Do not pry the crankshaft pulley back and forth. Pry only in one direction, to eliminate the possibility of replacing a damper for excessive wobble when the crankshaft end play was really excessive.

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

2. Remove the pulley damper assembly as follows:
 - a. Remove three (3) bolts and retainer. Refer to **FIGURE 10-28**.
3. Install a universal puller using bolts long enough to hold the puller in place. Turn the forcing screw and remove the pulley damper assembly. Refer to **FIGURE 10-29**.



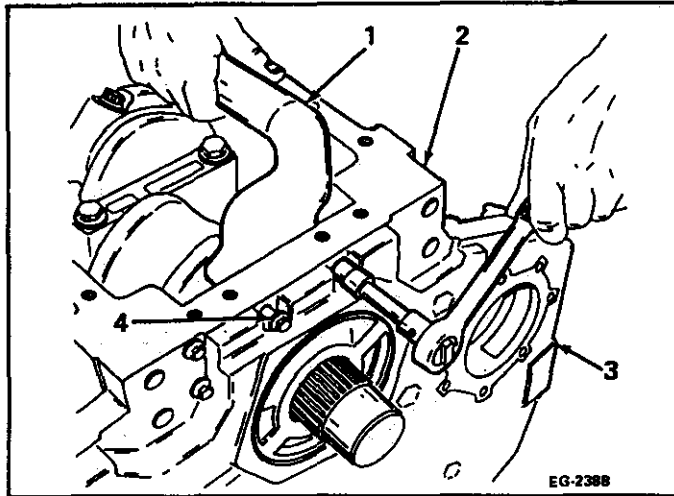
1. Pulley Damper
2. Retainer Bolt
3. Retainer
4. Wrench

FIGURE 10-28

1. Pulley Damper
2. Universal Puller

FIGURE 10-29

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

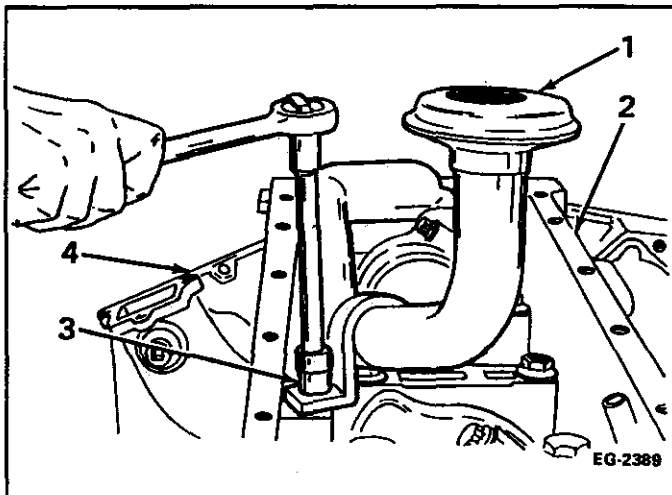


1. Oil Pick-Up Tube
2. Crankcase
3. Front Cover
4. Oil Pick-Up Tube Mounting Bolt

FIGURE 10-30

10.6.2 Oil Pick-up Tube Removal

1. With pulley damper removed, remove the oil pick-up tube as follows: (Refer to **FIGURE 10-30**) (Rear sump tube shown).
2. Remove the two (2) retaining bolts at the front cover.
3. Support oil pick-up tube and remove retaining bolt at support bracket (**FIGURE 10-31**).
4. Remove the pick-up tube and gasket. Discard gasket.



1. Oil Pick-Up Tube
2. Crankcase
3. Support Bracket

FIGURE 10-31

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

10.6.3 Removal Of Miscellaneous Components

1. Remove the oil pump assembly as outlined in Section 12.
2. Remove the water pump pulley and water pump as directed in Section 13.
3. Remove the engine front cover. Refer to Section 11.
4. Remove the piston and connecting rod assemblies as described in Section 9.

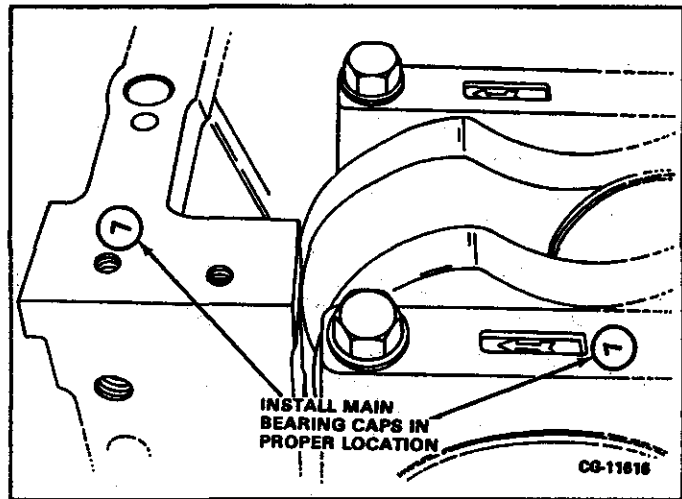


FIGURE 10-32

10.6.4 Removal of Crankshaft and Main Bearings

1. Rotate the engine stand so the crankshaft is facing up.
2. Remove the six (6) main bearing caps as follows:

NOTE:

Prior to bearing cap removal, check to see that caps and crankcase are stamped to identify location. If they are not marked, stamp in numerical order 1-7, starting with No.1 at the front of the engine. Stamp the crankcase oil pan rail and main bearing caps on the camshaft side. Refer to FIGURE 10-32.

- a. Loosen main bearing cap bolts. Grasp bolts and rock main bearing cap back and forth to loosen and remove cap. (FIGURE 10-33)

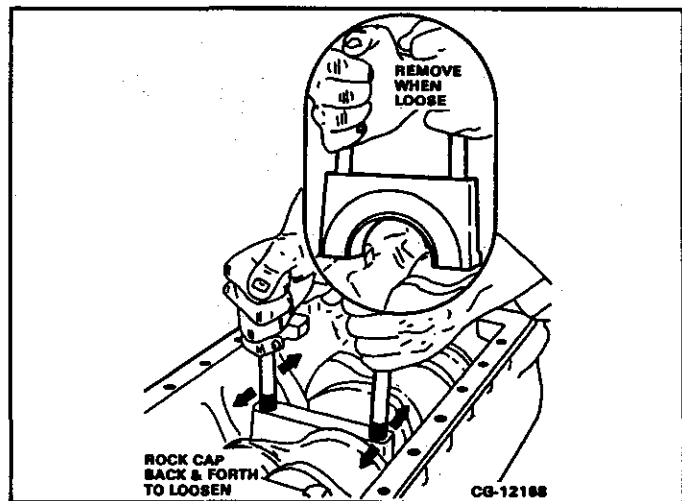
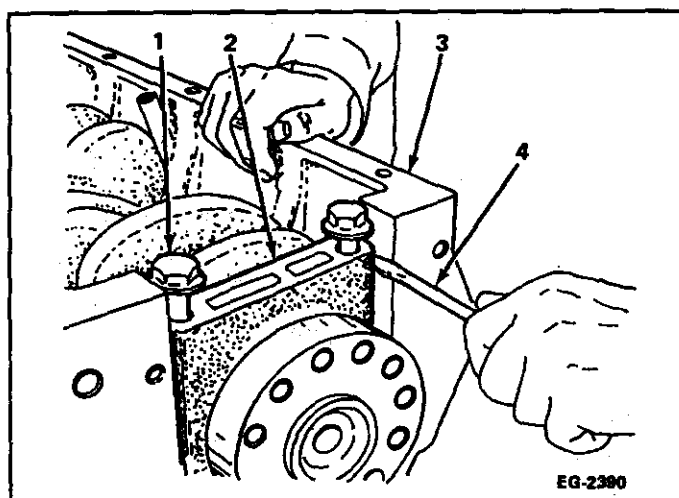


FIGURE 10-33

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING



1. Mounting Bolt
2. Main (Thrust) Bearing Cap
3. Crankcase
4. Screwdriver

FIGURE 10-34

the screwdriver and walk bearing cap up. Alternate from side to side of the bearing cap with each twist of the screwdriver.

NOTICE: Only use hand pressure when twisting the screwdriver.

c. Remove bearing cap.

3. Remove crankshaft from the crankcase using an appropriate lifting sling, as shown in FIGURE 10-35.

NOTICE: Be careful not to damage the crankshaft when removed.

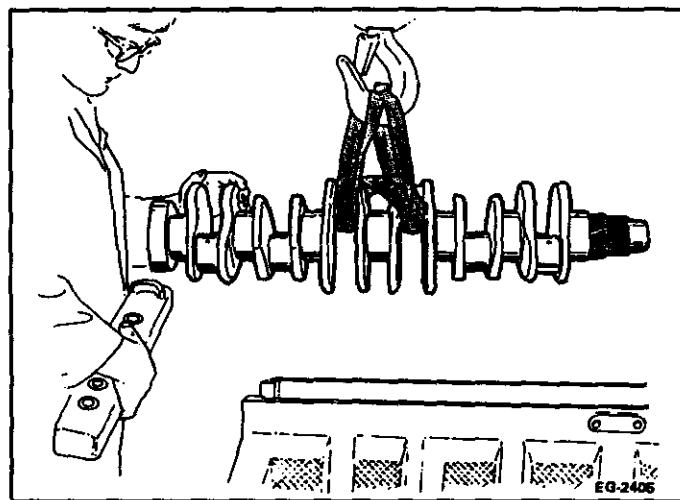


FIGURE 10-35

- a. Loosen two (2) rear thrust bearing mounting bolts.
- b. Insert a flat blade screwdriver between bearing cap and crankcase wall. Twist

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

4. Remove upper main bearing shells by pushing them out of main bearing saddle with your thumbs as shown in **FIGURE 10-36**. Mark the upper shells and put with lower shells until a proper inspection can be done.

10.6.5 Cleaning the Vibration Damper

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

10.6.6 Cleaning the Crankshaft and Main Bearings

1. Clean the bearing inserts and caps thoroughly in solvent and dry with filtered compressed air. **Do not scrape gum or varnish deposits from bearing shells.**
2. Clean all the internal oil passages of the crankshaft using a stiff nylon brush. Loosen all dirt, sludge and deposits which may have accumulated. Flush the oil passages with a suitable non-caustic solvent.
3. Blow the passages dry with filtered compressed air.
4. Remove No. 7 (rear) thrust bearing as follows: (**FIGURE 10-34**)

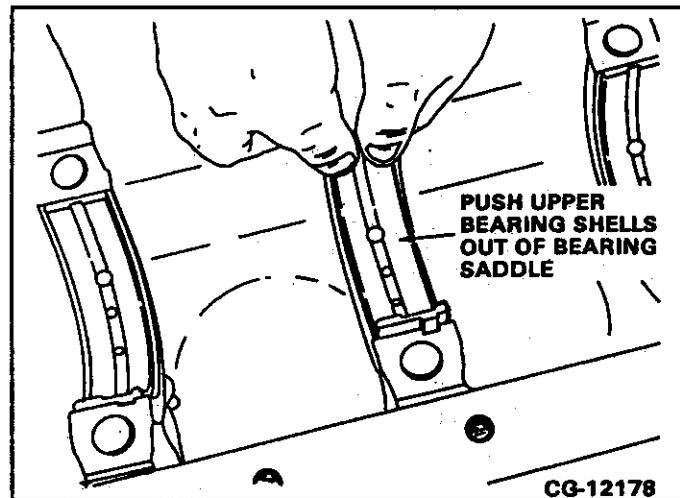


FIGURE 10-36

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

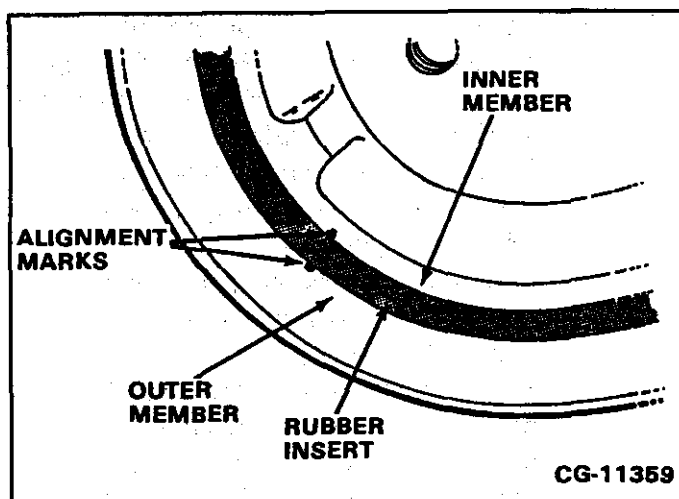


FIGURE 10-37

10.6.7 Pulley Damper Assembly Inspection and Repair

1. Visually inspect the pulley damper alignment marks (if applied).

NOTE:

Inspect the rubber insert for swelling, separation, or cracking which may indicate possible failure.

2. If the marks (FIGURE 10-37) are misaligned by more than the specified maximum, replace the damper. Refer to "Specifications."

10.6.8 Crankshaft and Main Bearings

1. Visually inspect the crankshaft journals (main and rod) for scratches, grooves and scoring. Use dye penetrate methods to check for cracks.
2. Visually inspect all bearing inserts. Replace bearings that are scored, chipped or worn.
3. Measure the diameter of each journal using a micrometer. (See "Specifications"). Measure each journal at two points, at right angles to each other. Move the micrometer over the entire width of the journal. Refer to FIGURE 10-38.

NOTE:

If the journals exceed the maximum out-of-round specification, the crankshaft must be reground or replaced.

4. The crankshaft can be ground 0.010 in., 0.020 in. or 0.030 in. (0.25 mm, 0.51 mm or 0.76 mm) undersize as follows:

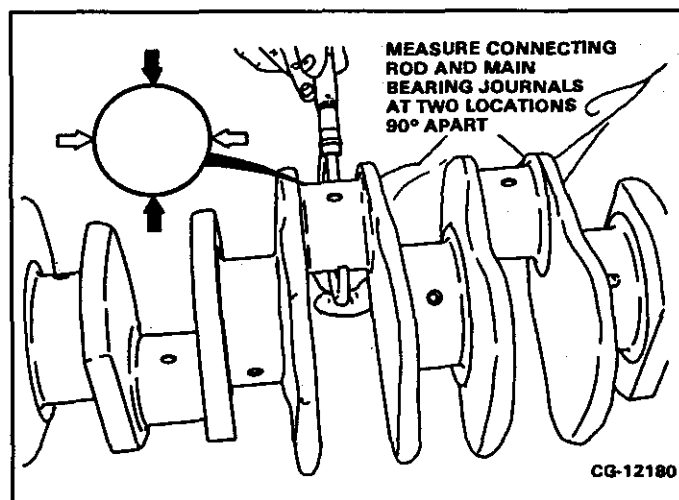


FIGURE 10-38

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

NOTE:

An induction hardened fillet and journal crankshaft can be re-ground similar to any precision crankshaft. However, these shafts require special treatment when grinding. Before grinding all crankshafts must be checked for hardness.

- a. Check crankshaft hardness before re-grinding and on every journal which incurred a bearing failure or shows evidence of overheating.

NOTE:

Bearing failures can cause overheating of crankshaft journals and reduction of hardness. When this occurs, the crankshaft strength may be unacceptably reduced.

- b. Check crankshaft journal hardness using a Rockwell Hardness Tester as follows:

NOTICE: The hardness test is destructive and is only made prior to grinding the crankshaft. The grinding process will correct the damage made by the Rockwell Hardness Tester. **DO NOT TEST FOR HARDNESS UNLESS THE CRANKSHAFT IS TO BE RE-GROUND.**

- c. Check crankshaft rod and main journals at three locations: the top, bottom and one other location.

NOTE:

The top and bottom is determined with the crankshaft journal at TDC.

- d. Check as close to the fillet as possible. If any reading is below 50 RC hardness, **REPLACE** the crankshaft. If hardness is acceptable, grind the crankshaft.

NOTICE: Superior strength of the fillet-hardened shaft is due to the special process by which the bearing surfaces and fillets are hardened. This localized hardening greatly increases the bending strength of the crankshaft; in order to maintain this strength, special precautions must be taken when regrinding the shaft. If special precautions are not taken, the crankshaft can be severely weakened. The metallurgical characteristics of the shaft demand exacting standards and control when regrinding journals. However, it can be reground locally where equipment and experience can produce quality standards outlined in the following instructions.

Grind the crankshafts similar to any precision crankshaft with the following guidelines and precautions:

1. A mechanical or an automatic wheel dresser is mandatory to prevent chatter, burning and poor surface finish. A hand stone should **NEVER** be used to rough or fine dress the face or radii of the wheel. The radii should blend evenly into the journal.
2. The selection of the grinding wheel is important because too hard a wheel will increase the possibility of burning. An aluminum-oxide wheel with a grit size of approximately 50 and a maximum hardness of M will produce satisfactory results, with other conditions being suitable.

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

3. The coolant must be such that it minimizes burning. This requires a fluid with high lubricity properties. The straight-cutting oils appear to be the best for grinding crankshafts and are strongly recommended.

NOTICE: Use every precaution to avoid burns on the shaft during the grinding operation.

4. A grinding wheel speed of 6500 surface feet per minute with a work spindle speed of approximately 40 to 45 revolutions per minute is usually satisfactory.
5. Grind all journals with crankshaft rotating in a counterclockwise direction (viewed from front of crankshaft), lap all journals with crankshaft rotating in clockwise direction. **Do not refinish rear seal flange.**
6. Feed rates should be slower than normal to prevent any burning.
7. Maximum allowable taper on crankpins (rod journals) and main journals 0.015 per inch of length (.38 mm per 25.4 mm) of length. Crankpins and journals must be polished to 20 Micro-inch maximum – to 5 Micro-inch minimum, and must not be over 0.005 inch (0.12 mm) out of round.

NOTE:
Do not grind the crankshaft flange.

CAUTION

As a normal precaution, it is recommended that a CO₂ fire extinguisher be near the grinding machine, just in case any excessive heat should ignite the oil. If a fire should start, it can be rapidly extinguished without causing any damage to the machine or surrounding area by following the normal fire-extinguishing procedure.

8. Inspection of the crankshaft for dimensional tolerances is the same as for conventionally hardened crankshafts, except that extra care must be taken to be sure the shaft is cool before inspecting. Scrap only those crankshafts which do not meet the specified tolerances.
9. In addition to inspecting the dimensional tolerances, the crankshaft must also be carefully checked for surface defects, particularly for grinding cracks and burns. It is advisable to spray check the crankshaft (using dye penetrant methods) after grinding and lapping to insure that there is no surface cracking.
10. **TARASOV ETCH:** In order to establish the acceptability of a regrind procedure, crankshaft should be etched before lapping to determine whether the crankshaft was burned during the regrinding procedure. The best etch to use is the Tarasov etch, which will show both the rehardened and the overtempered areas. The etching procedure is as follows:

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

NOTICE: Due to the sharp odor and flammability of the TARASOV ETCH, the etching should be done in a well-ventilated area, away from any open flame.

1. Clean surface with a scouring powder and water or a good solvent.
2. Wash thoroughly and rinse with alcohol.
3. Apply etchant No. 1 (4 parts nitric acid in 96 parts water) for approximately 16 seconds with a cotton swab.
4. Rinse with water and dry with filtered compressed air.
5. Apply etchant No. 2 (2 parts hydrochloric acid in 98 parts acetone) for approximately 15 seconds with a cotton swab.

CAUTION

Acetone is highly flammable.

6. Rinse with alcohol and dry thoroughly with compressed air.

NOTICE: If the crankshaft has been burned, it will show up as a change of color after the etch. Areas rehardened by excessive heat appear nearly white, while softened areas turn dark gray or black. Areas unaffected by the heat of grinding etch a light gray. If any burns show up after the etch is used, the physical properties of the crankshaft will have been seriously reduced, and the crankshaft should not be used.

NOTE:

If burning becomes a serious problem, it can usually be eliminated by reducing the infeed rate, using a softer grade of wheel, or increasing the work spindle speed. Sometimes, a combination of these factors, along with the recommendations mentioned above, will be necessary to overcome the problem.

7. After the crankshaft passes the Tarasov etch test, it may be lapped.

NOTICE: Thoroughly clean crankshaft oil passages with nylon bristle brush, soap and water to remove all debris which may have accumulated during regrinding procedure. Any debris left in crankshaft oil passages cannot be removed by oil filters and will damage bearings immediately upon engine start-up. Once cleaned, wrap crankshaft, to protect it from contamination, until it is installed.

8. Visually inspect the crankshaft gears for chipping or wear. If replacement is required, the gears can be replaced.

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

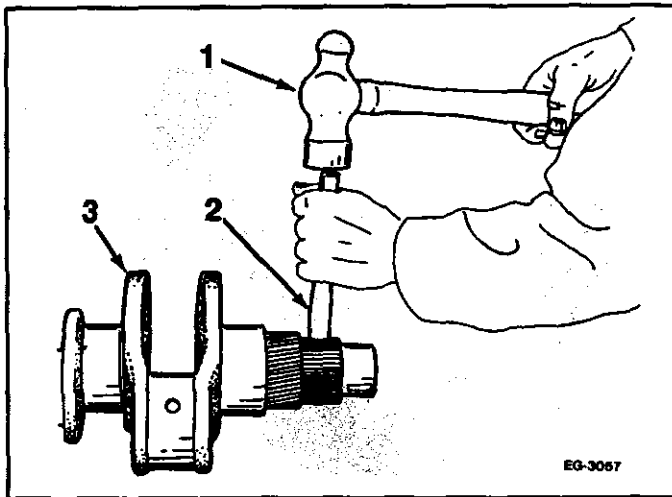


FIGURE 10-39

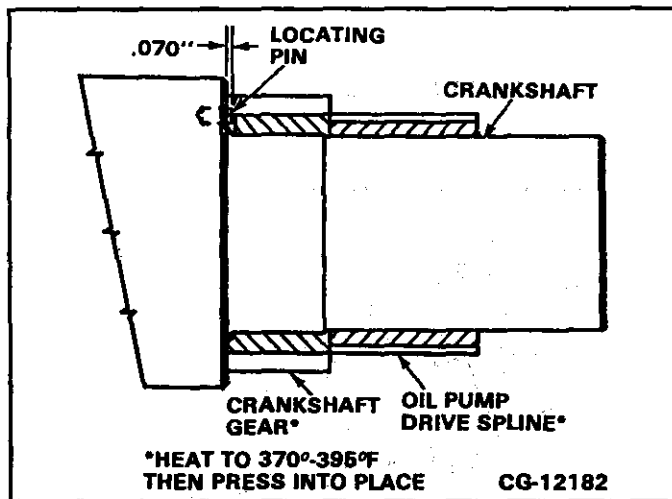


FIGURE 10-40

10.6.9 GEAR REPLACEMENT

1. Place a chisel between the gear teeth and strike the chisel with a hammer to split the gear.
2. Remove the oil pump drive spline first to access the crankshaft gear. Refer to **FIGURE 10-39**.
3. Be careful not to damage the crankshaft during gear removal.
4. With gears removed, heat the crankshaft gear and oil pump drive spline to 370–395°F (188–202°C).
5. Install the crankshaft gear first. Be sure the locating pin on the crankshaft gear aligns with the crankshaft properly. Refer to **FIGURE 10-40**. Press the gear into place.
6. Install the hot oil pump drive spline onto the crankshaft until flush with the crankshaft gear. See **FIGURE 10-40**.

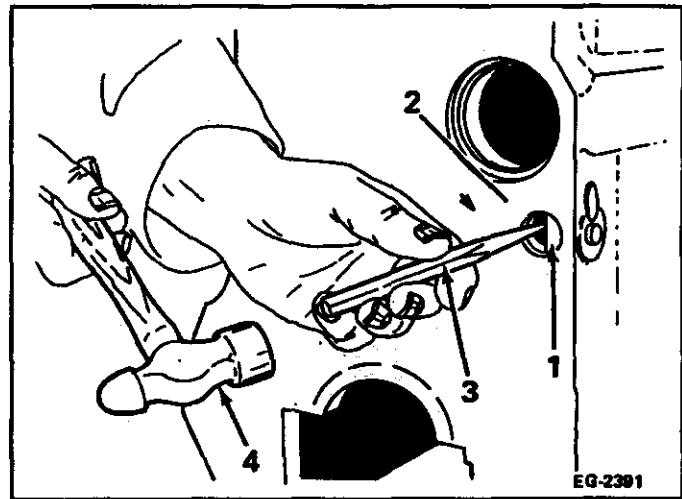
NOTE:

The best way to clean the crankcase during engine overhaul is in a chemical bath or "HOT TANK". This removes all carbonous material and mineral deposits which collect in the cooling passages. If the "HOT TANK" is not available, use the following cleaning procedure.

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

10.6.10 CLEANING

1. Clean all old gasket material from the machined surfaces of the crankcase using a scraper and a sanding block.
2. Clean the cylinder liner bores using soap, water and a nylon brush.
3. Remove main oil gallery cup plug, located at rear of crankcase by using a hammer and chisel, knockout the main oil galley plug (**FIGURE 10-41**)
4. With the plugs removed from the crankcase, clean the crankcase as follows:
 - a. Use a nylon brush with soap and water to clean the oil galleries.
 - b. Clean the cross drillings using a nylon brush with soap and water. (**FIGURE 10-42**)
 - c. Blow out all oil galleries and cross drillings using filtered compressed air.
 - d. Clean all threaded holes using a tap of appropriate size.
5. Install new main oil gallery cup plug as follows:
 - a. Clean mating surfaces on plug and crankcase.
 - b. Apply Loctite® 262 to the outside edge of the cup plug.
 - c. Drive the cup plug in using an arbor approximately 1/4 in. (6mm) smaller in diameter than the plug being installed.
 - d. Recess the plug 1/8 inch (3.2mm).
6. Install new pipe plug into rear of crankcase.



1. Oil Galley Plug
2. Crankcase
3. Chisel
4. Hammer

FIGURE 10-41

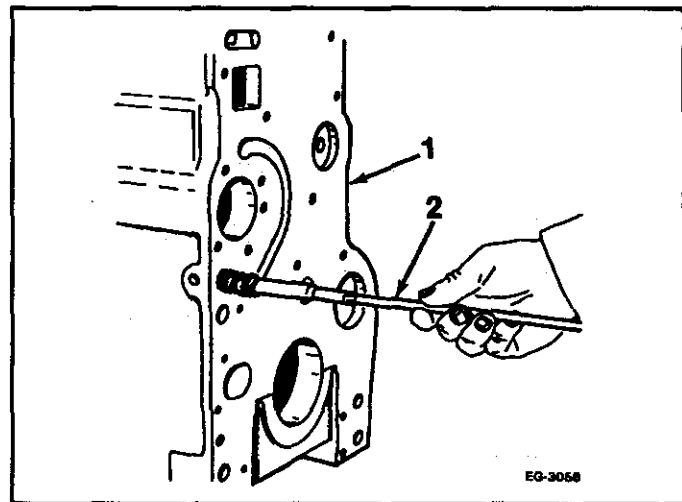


FIGURE 10-42

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

10.6.11 Inspection And Repair

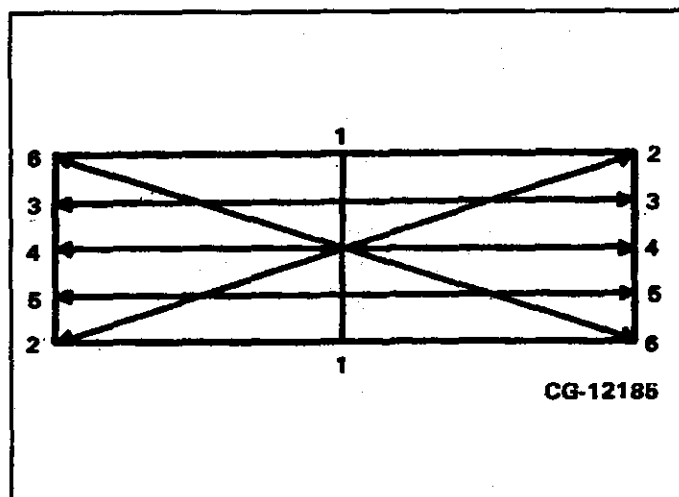


FIGURE 10-43

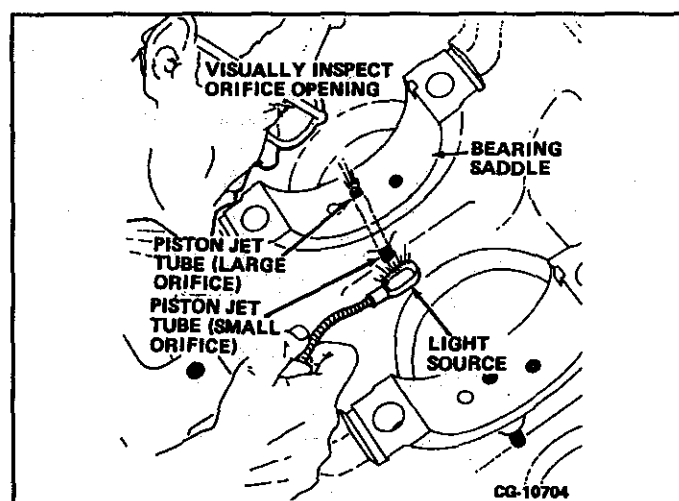


FIGURE 10-44

NOTE:

Threaded holes with damaged threads may be salvaged with the use of a "Hell-Coll repair".

1. Inspect the crankcase deck for flatness using a straightedge and feeler gauge. Use the checking pattern shown in **FIGURE 10-43**. If a 0.003 in. (0.076mm) feeler gauge can pass, the crankcase must be replaced.
2. Visually inspect the piston oil jet tubes for blockage as follows: (Refer to **FIGURE 10-44**).

NOTICE: Do not resurface the crankcase. Surface defects beyond those listed in step one, above, are not correctable. Replace the crankcase.

- a. Shine a light source under the small orifice in the tube end which protrudes into the crankcase from its insertion point in the bearing saddle.
- b. Position your eye to align with the large orifice of the piston cooling jet. If the light source is visible, the jet tube is clear and requires no further service.

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

3. Clean any piston oil jet tube blockage as follows: (Refer to **FIGURE 10-45**)
 - a. Run an appropriately sized wire or torch tip cleaner through the tube orifice to remove blockage.
 - b. Using filtered compressed air, blow loosened debris out from the jet tube orifice.
 - c. Reinspect piston cooling jet tube using a light source as previously described.

NOTE:

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

- d. If the light source is not visible, the piston cooling jet tube is blocked. Clean the tube to remove any blockage.

10.6.11.1 Check Crankcase Integrity

1. Rotate engine so the main bearing saddles are facing upward.
2. Wipe main bearing saddle using a lint-free cloth. The supports must be free of oil. **Do not lubricate the back side of the bearing inserts.**
3. Install upper bearing inserts into bearing saddle. Be sure the locking tangs on the bearings are snapped into the crankcase. Refer to **FIGURE 10-46**.

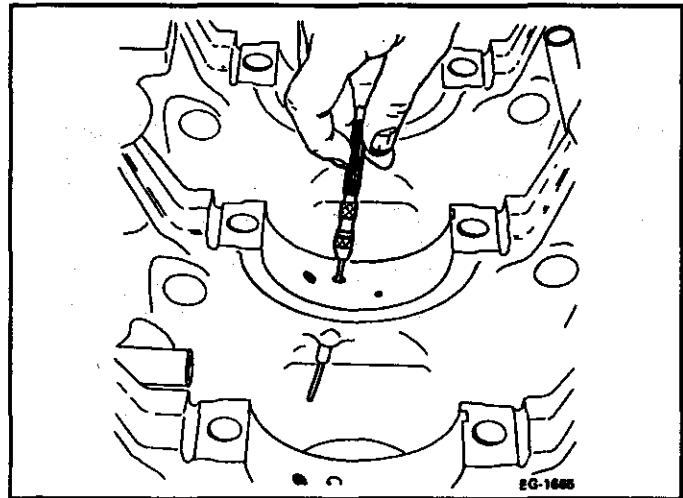


FIGURE 10-45

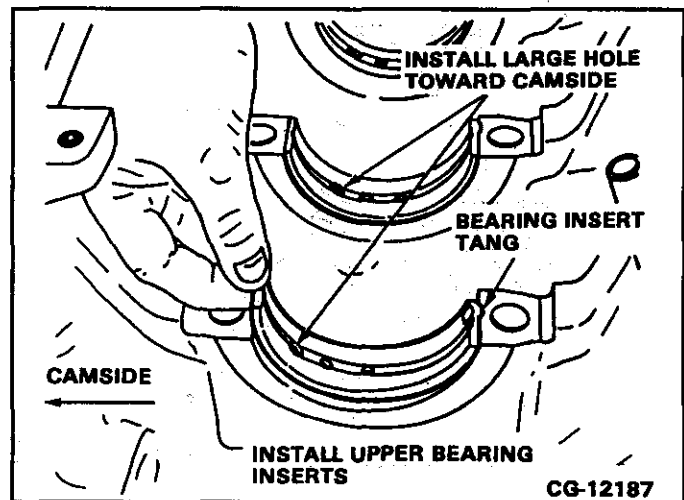


FIGURE 10-46

DAMPER, CRANKSHAFT AND MAIN BEARINGS RECONDITIONING

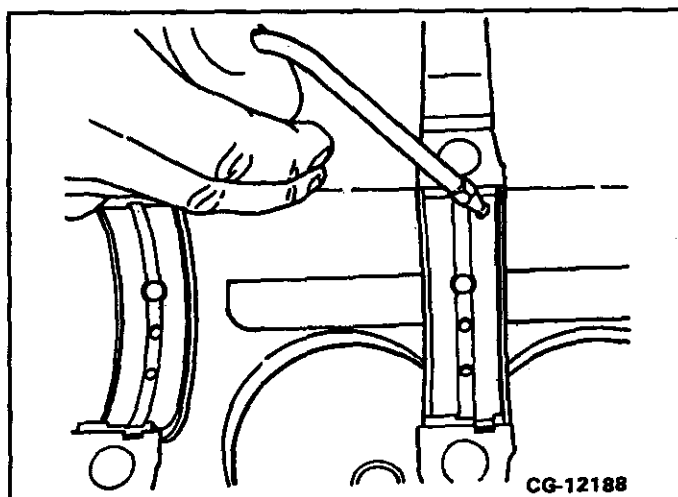


FIGURE 10-47

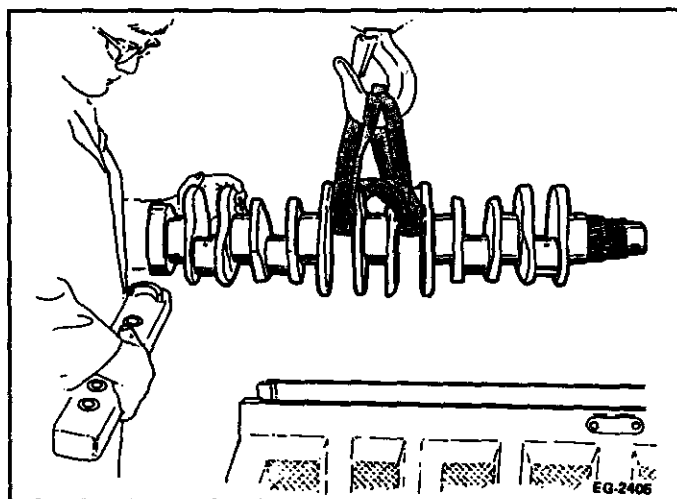


FIGURE 10-48

4. Apply Prussian Blue® to the crankshaft main bearing journals. Carefully lower the crankshaft onto the main bearing inserts in the crankcase.

NOTE:

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

5. Rotate the crankshaft 1/2 turn.
6. Carefully remove the crankshaft and inspect the upper bearing inserts for an even transfer of bluing from the journals to the bearings.

NOTICE: If voids appeared in the bluing transfer, the crankcase integrity is questionable and the crankcase must be repaired or replaced.

7. If satisfied that the crankcase is in good order and free of distortion and burrs around the upper bearing insert seats, clean all Prussian Blue® from the bearings and crankshaft journals.
8. Lubricate the upper main bearing inserts with clean engine oil. Refer to **FIGURE 10-47**.
9. Carefully install the crankshaft into the main bearing saddle. Use an appropriate lifting sling to lower the crankshaft. Refer to **FIGURE 10-48**.

10.7 INSTALLATION

10.7.1 Bearing Fitting Procedure

1. Install a new bearing in a new bearing cap or in the original bearing cap, as required. Be sure the locking tangs on the bearing inserts are snapped into the bearing cap notch.
2. Check bearing clearance as follows:
 - a. Clean the bearing surface and the exposed half of the crankshaft journal. Be sure these surfaces are free of oil.
 - b. Install the bearing caps and lower inserts and tighten to the specified torque.
 - c. Remove one bearing cap with insert one at a time. Remaining caps are left tight while checking the fit of the bearing with the cap removed.
 - d. Wipe the oil from all contact surfaces of the exposed journal and bearing insert and cap removed.
 - e. Place a piece of Plastigage® across the full width of the bearing surface on the crankshaft journal (or bearing cap insert) approximately 1/4 in. (6 mm) off center. Install bearing cap and tighten cap bolt to specified torque.

NOTE:

Do not turn crankshaft while making check with Plastigage®.

INSTALLATION

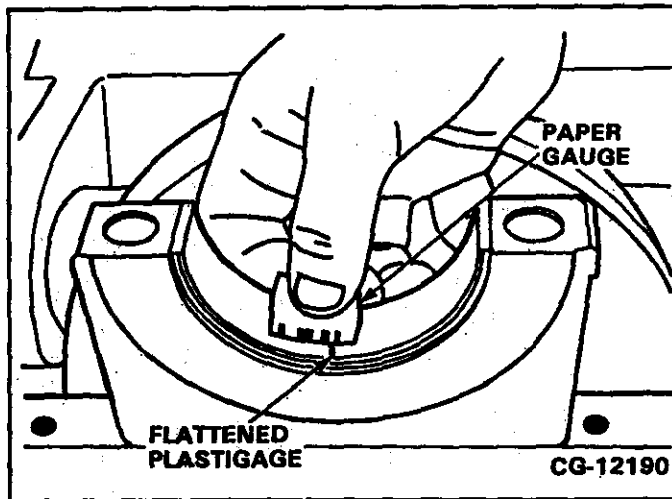


FIGURE 10-49

NOTE:

IN CHASSIS SERVICE ONLY –

When bearing clearance is checked, the crankshaft will have to be supported and held against the 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 the crankshaft. Failure to support the crankshaft will result in inaccurate readings.

- f. Remove bearing cap with insert.
- g. Do not disturb Plastigage®. Using the Plastigage® envelope, measure the widest point of the Plastigage®, FIGURE 10-49. This reading indicates the bearing clearance in thousandths of an inch or millimeters.
- h. If the bearing clearance is not within specifications, the crankshaft must be replaced or reground and undersize bearings installed (as described earlier in this section).

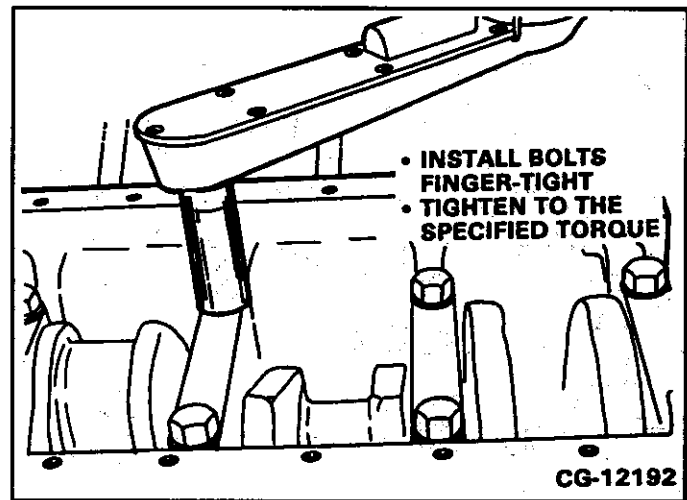
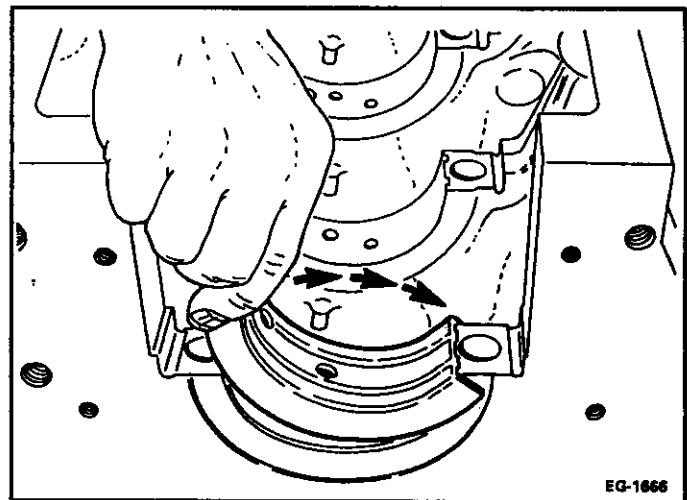
10.7.2 Main Bearing and Cap

With acceptable bearing clearance, proceed as follows:

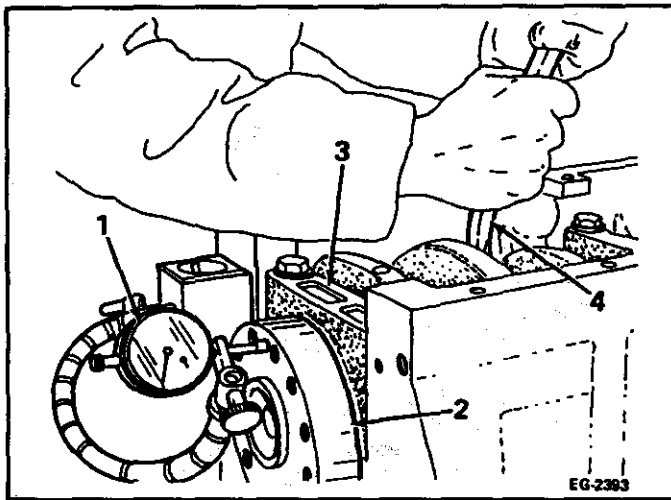
1. Clean Plastigage® from main bearing or crankshaft journal surface.
2. Coat all bearing surface journals and bolts with clean engine oil.
3. Place No. 1 and No. 6 main bearing caps with lower bearing inserts over crankshaft in the proper location.

INSTALLATION

4. Tighten No.1 through No. 6 main bearing cap bolts to specified torque. Refer to **FIGURE 10-50**.
5. Install rear thrust bearing as follows:
6. Insert main bearing cap with rear thrust bearing in position as shown in **FIGURE 10-51**.
7. Center rear thrust bearing by moving crankshaft rearward, then forward.
8. Tighten two (2) rear thrust bearing bolts finger-tight, then tighten to specified torque.

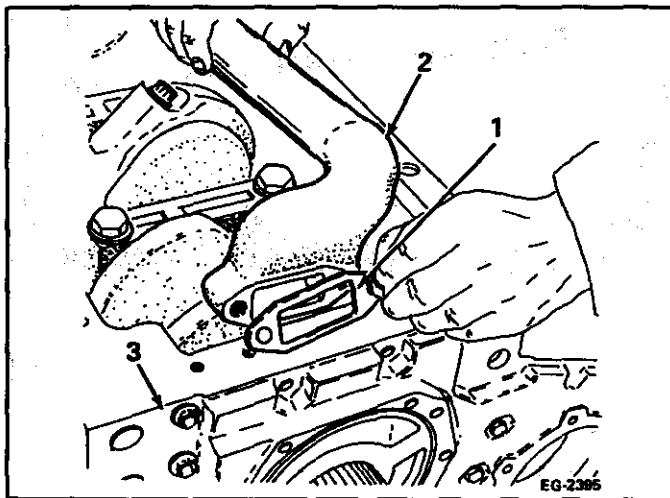
**FIGURE 10-50****FIGURE 10-51**

INSTALLATION



1. Dial Indicator
2. Crankshaft
3. Rear Thrust Bearing Cap
4. Pry Bar

FIGURE 10-52



1. Gasket
2. Oil Pick-Up Tube
3. Crankcase

FIGURE 10-53

9. Check crankshaft end play using a dial indicator as follows: Refer to **FIGURE 10-52**.
10. Mount the dial indicator on crankcase with indicator tip on crankcase flange face.
11. Lightly pry the crankshaft forward and zero indicator.
12. Then pry crankshaft rearward and record dial indicator reading. Repeat to assure an accurate reading.

NOTE:

If end play exceeds specifications, replace thrust bearing and recheck crankshaft end play. If end play is less than specified, loosen main bearing caps, reposition, retorque and recheck end play.

13. Install piston and connecting rod assemblies. Refer to Section 9.
14. Install front cover. Refer to Section 11.
15. Install oil pump assembly. Refer to Section 12.

10.7.3 Oil Pickup Tube Reassembly

Install oil pick-up tube as follows:

1. Using a new gasket, place gasket onto oil pick-up tube (**FIGURE 10-53**).

INSTALLATION

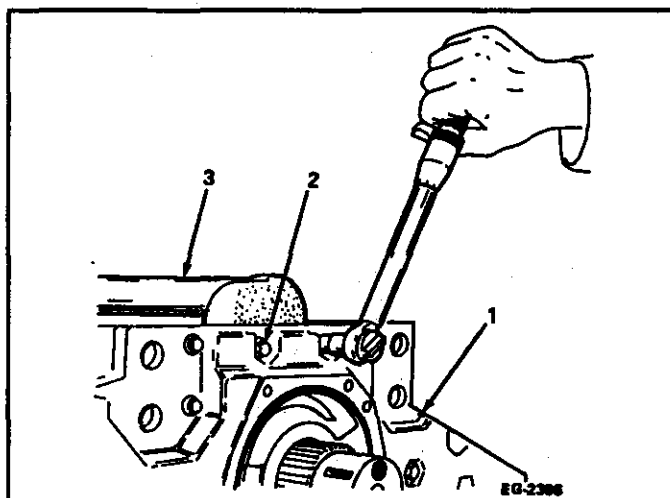
2. Align holes of oil pick-up tube with two (2) holes in front cover. Secure oil pick-up tube to front cover.
3. Align oil pick-up tube with support bracket and secure using one (1) bolt. Tighten to specified torque.
4. Tighten two (2) front bolts to specified torque. (Refer to **FIGURE 10-54**)

10.7.4 Oil Pan

Prepare oil pan for installation by using a wire wheel to clean RTV from the oil pan lip (**FIGURE 10-55**)

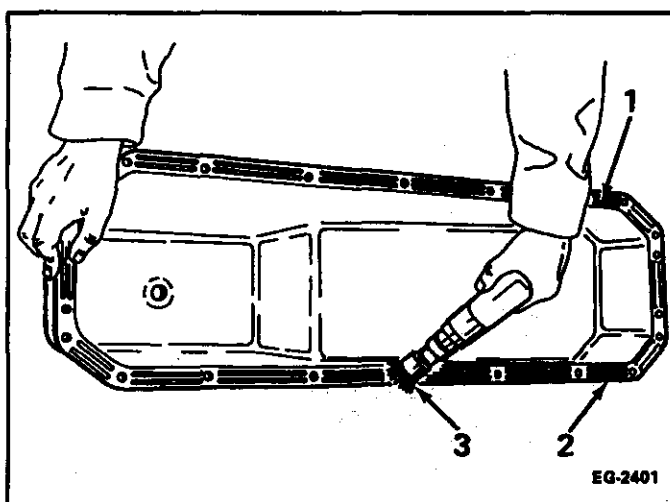
NOTICE: Be sure to clean all RTV from oil pan lip to ensure a proper application of new RTV.

NOTICE: Be sure all RTV or other debris has been cleaned from crankcase rails, front cover and rear oil seal carrier.



1. Front Cover
2. Oil Pick-Up Tube Mounting Bolt
3. Oil Pick-Up Tube

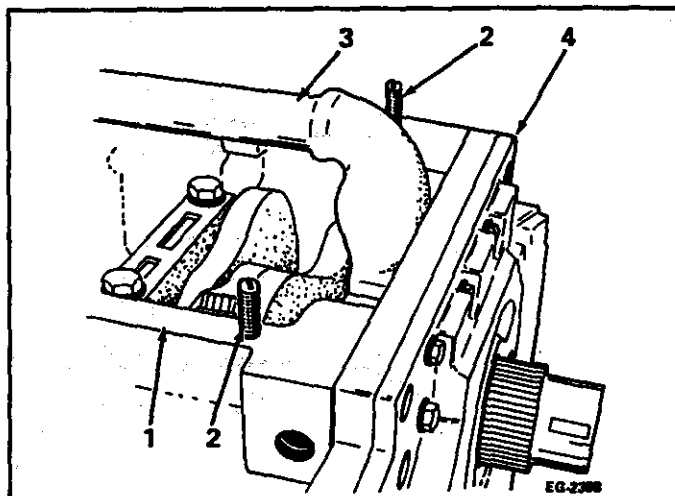
FIGURE 10-54



1. Oil Pan Lip
2. Oil Pan
3. Wire Wheel

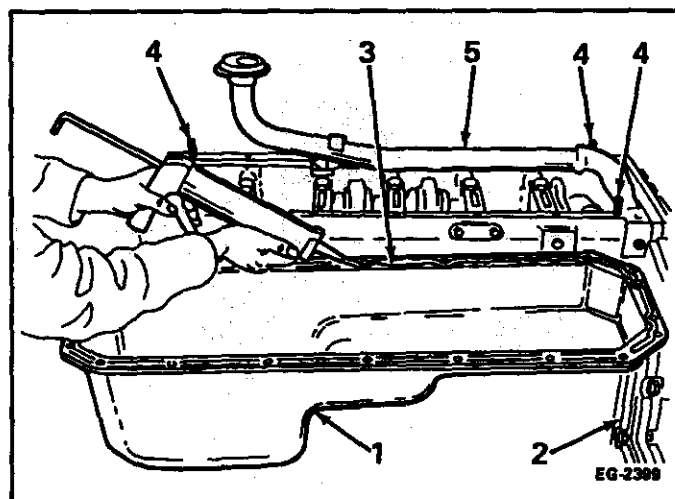
FIGURE 10-55

INSTALLATION



1. Crankcase 3.
2. Guide Pins 4.
3. Oil Pick-Up Tube
4. Front Cover

FIGURE 10-56



1. Oil Pan
2. Front Cover
3. RTV Bead
4. Guide Pins
5. Oil Pick-Up Tube

FIGURE 10-57

1. Install four (4) guide pins/dowels (make locally) into the four corners of the crankcase (FIGURE 10-56).
2. Apply 1/4 in. (6mm) bead of Wacker T-95 RTV to top ledge of oil pan (FIGURE 10-57).
3. Continue applying a 1/4 in. (6mm) bead of Wacker T-95 RTV to grooves located between the rear oil seal carrier and crankcase and between crankcase and rear half of front cover. Also apply a circle of Wacker T-95 RTV around the cupped plug crankcase orientation holes located on the oil pan rails of the crankcase.
4. Place oil pan onto crankcase. Secure oil pan using eighteen (18) bolts.

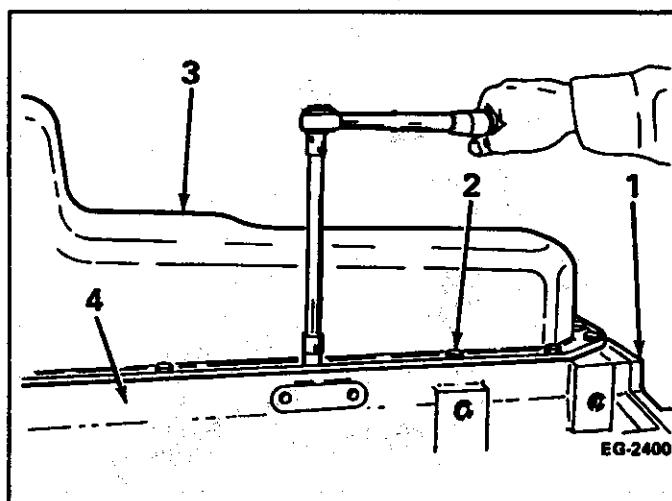
INSTALLATION

5. Remove four (4) guide dowel pins and replace with four (4) bolts. Tighten all bolts to specified torque. (Refer to **FIGURE 10-58**)

10.7.5 Vibration Damper and Pulley Assembly

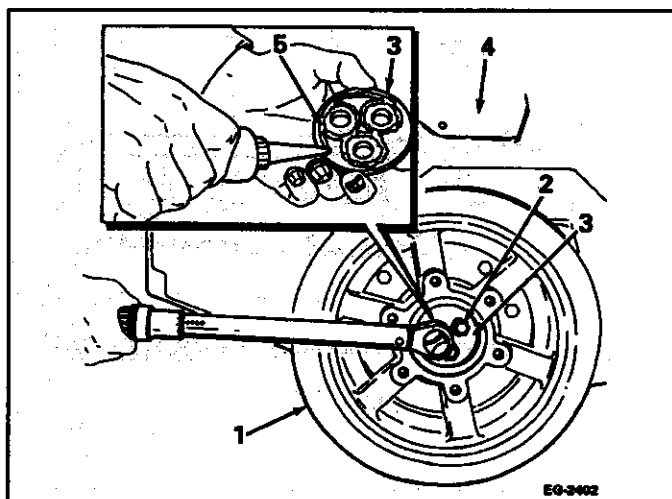
Install the vibration damper as follows:

1. Place damper directly on a hot plate. Mark damper with a thermomelt crayon (388°F / 198°C) and heat. When crayon melts, use **welding gloves** and install damper on crankshaft nose. Be sure that keyway on damper aligns with key on crankshaft. **DO NOT** install damper when cold (room temperature).
2. Install damper retainer using correct bolts. Refer to **FIGURE 10-59**.
3. Prevent crankshaft from turning and tighten bolts to special torque. Refer to **FIGURE 10-59**.



1. Front Cover
2. Oil Pan Mounting Bolt
3. Oil Pan
4. Crankcase

FIGURE 10-58



1. Vibration Damper
2. Retainer Mounting Bolt
3. Retainer
4. Front Cover
5. RTV Bead

FIGURE 10-59

INSTALLATION

10.7.6 Miscellaneous Installation

1. Refer to the appropriate manual sections and install the following:

- ☐ Fuel injection pump
- ☐ Oil cooler
- ☐ Water pump and pulley
- ☐ Cylinder head assembly
(with valve cover/intake manifold, exhaust manifold, and turbocharger attached)
- ☐ Rocker arm assembly

IMPORTANT

Adjust valve lash as specified in Section 7.

- ☐ Crankcase breather assembly
- ☐ Oil level gauge tube assembly
- ☐ Turbocharger oil inlet and oil drain tubes
- ☐ Thermostat
- ☐ Aneroid tube
- ☐ Fuel leak-off lines (low pressure)
- ☐ Fuel injection lines (high pressure)
- ☐ Fuel injection nozzles

NOTE:

Install new lube oil filter and fuel filter.

2. Prime the lubricating system as specified in Section 9.