REPAIR INSTRUCTIONS

CAMSHAFT POSITION (CMP) ACTUATOR REMOVAL - RIGHT EXHAUST

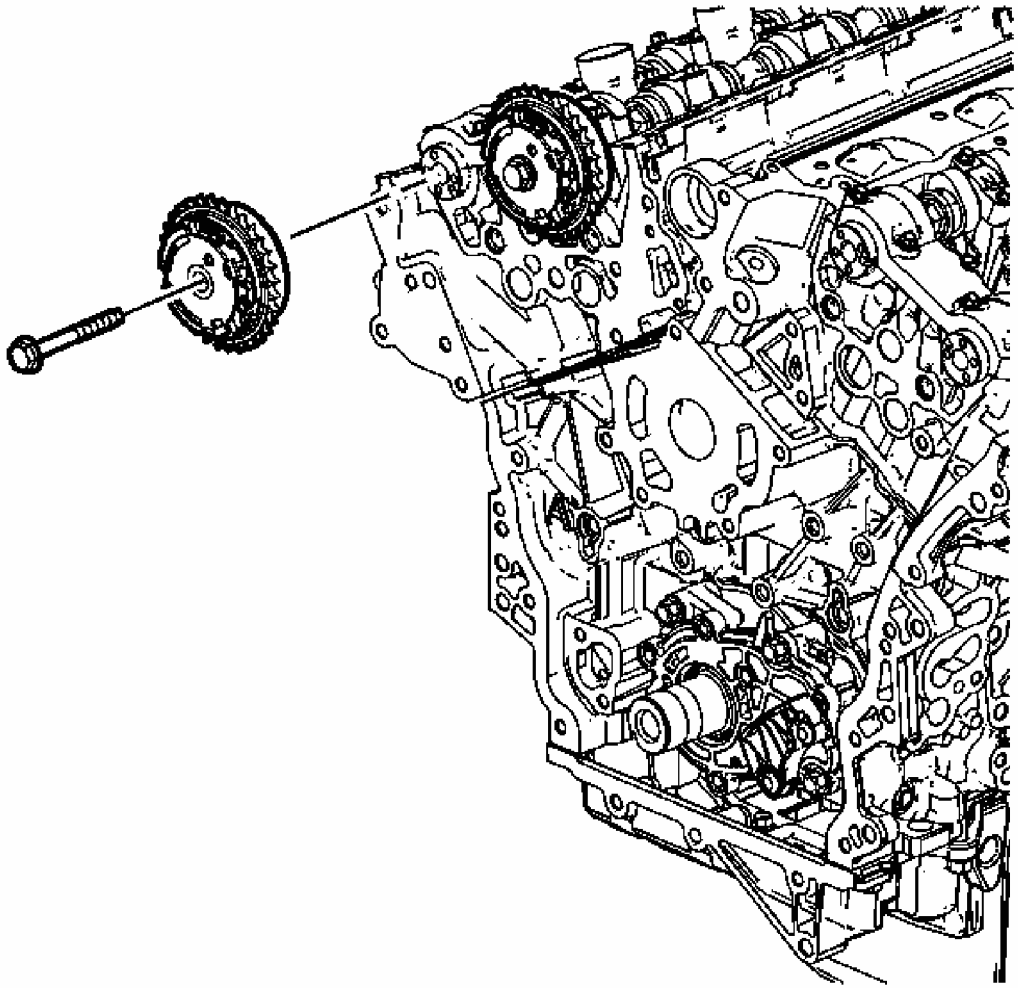

Fig. 1: View Of Right Exhaust Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Torque Reaction Against Timing Drive Chain Notice in Cautions and Notices.**

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the right exhaust camshaft position actuator bolt.
3. Remove the right exhaust camshaft position actuator.

CAMSHAFT POSITION (CMP) ACTUATOR REMOVAL - RIGHT INTAKE

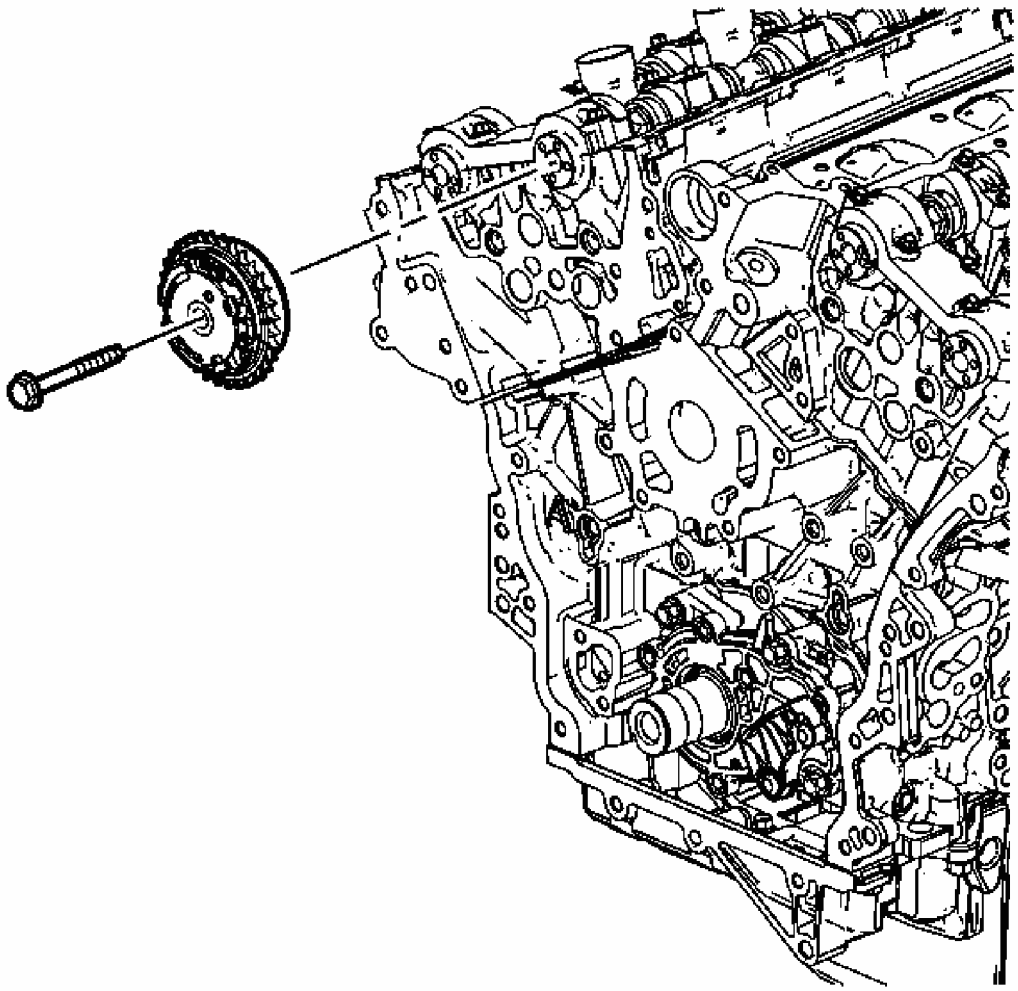

Fig. 2: View Of Camshaft Position (CMP) Actuator - Bank1 Intake
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Torque Reaction Against Timing Drive Chain Notice in Cautions and Notices.

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the right intake camshaft position actuator bolt.
3. Remove the right intake camshaft position actuator.

CAMSHAFT REMOVAL - LEFT

Tools Required

EN 46105 Camshaft Locking Tool

Removal Procedure

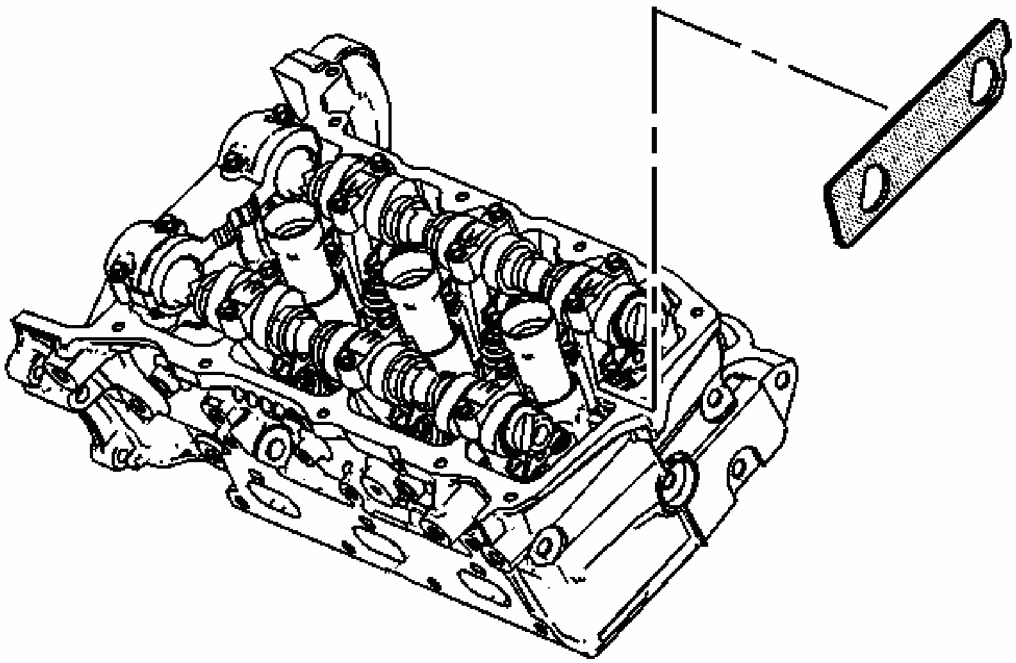

Fig. 3: Identifying EN 46105-2
Courtesy of GENERAL MOTORS CORP.

1. Remove the EN 46105-2 from the left camshafts.
2. Position the camshaft lobes in a neutral position.

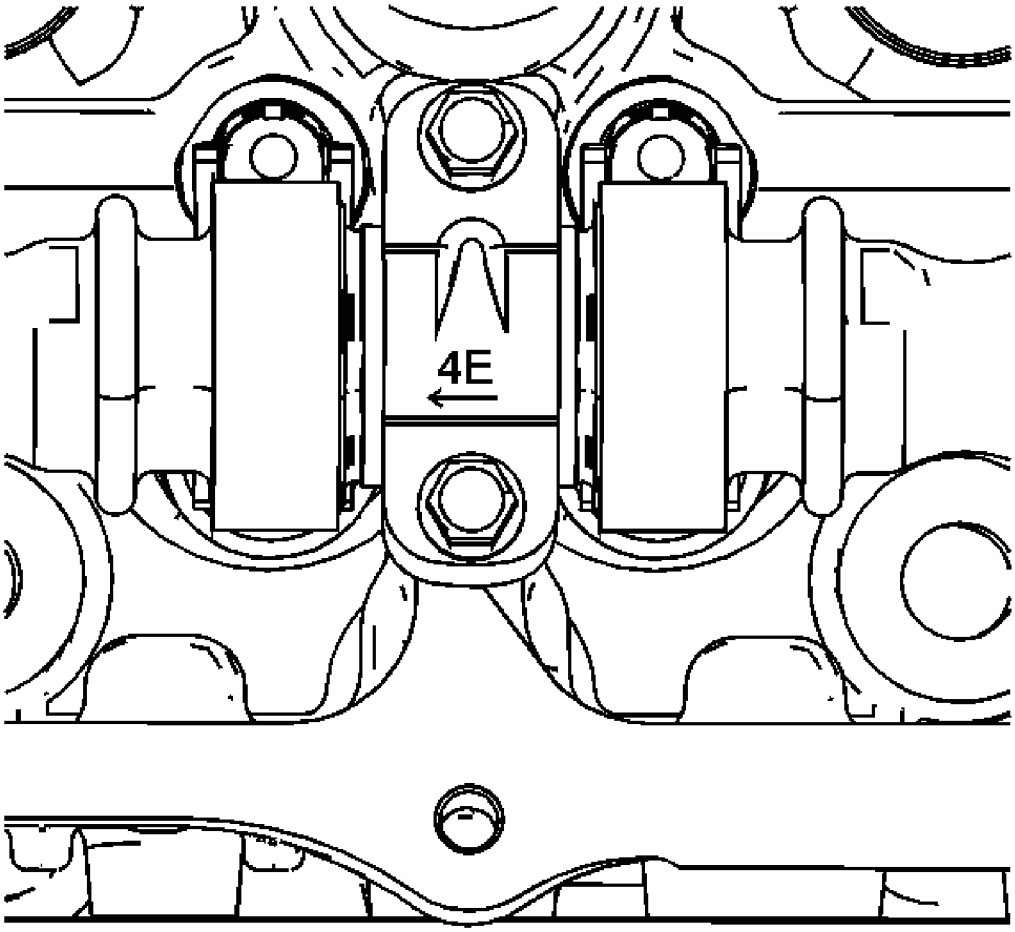

Fig. 4: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

3. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
    - The raised feature must always be oriented toward the center of the cylinder head.
    - The I indicates the intake camshaft.
    - The E indicates the exhaust camshaft.
    - The number indicates the journal position from the front of the engine.

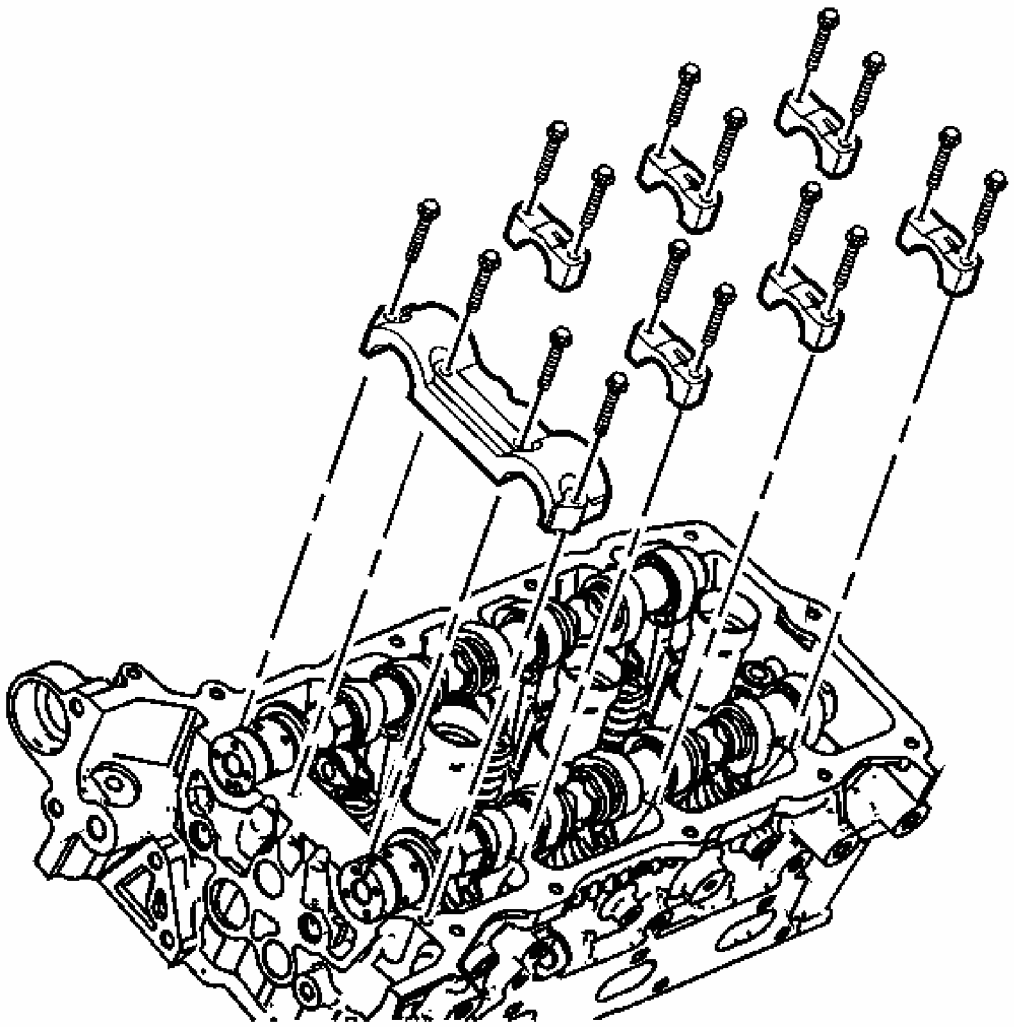

Fig. 5: Locating Camshaft Bearing Cap & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft bearing cap bolts.
5. Remove the camshaft bearing caps.

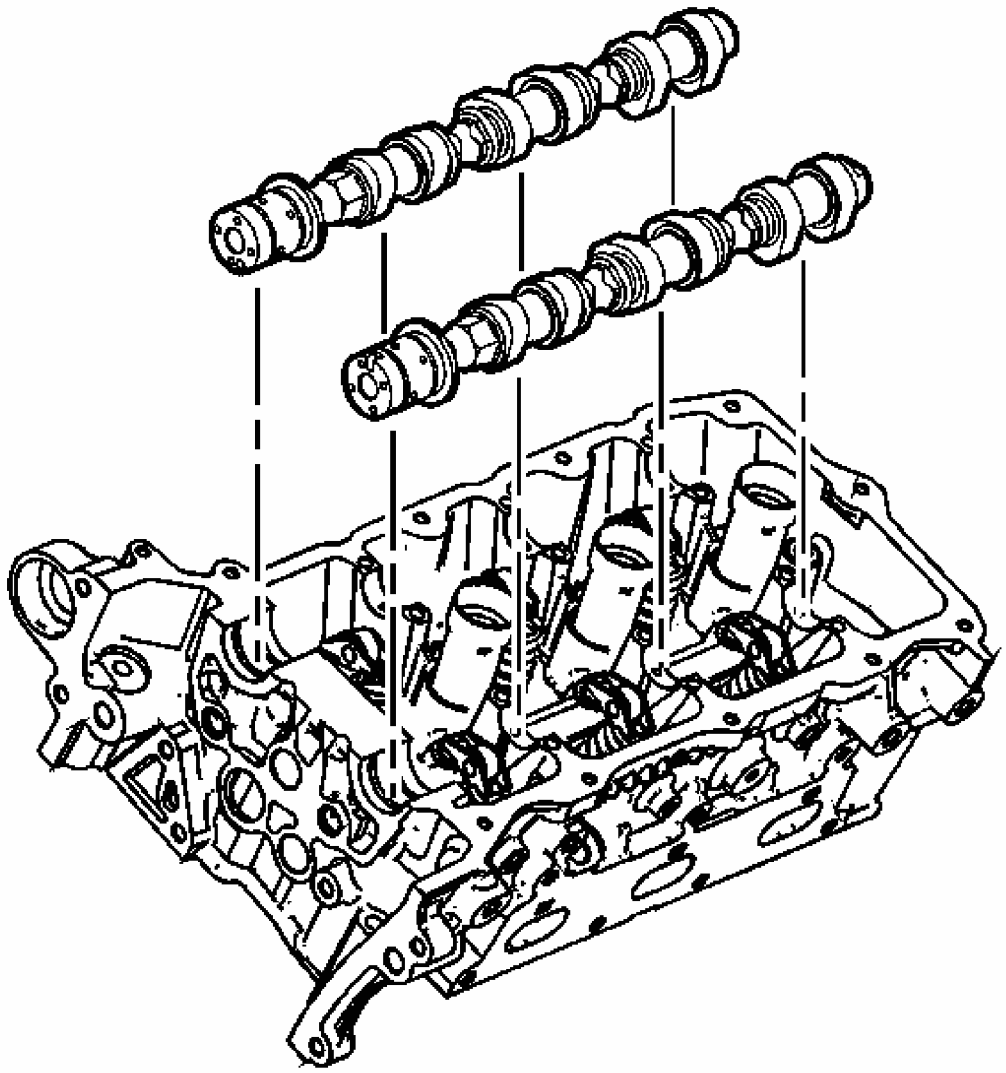

Fig. 6: View Of Camshafts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshafts.
7. Replace the camshaft bearing caps and bolts.

VALVE ROCKER ARM REMOVAL - LEFT

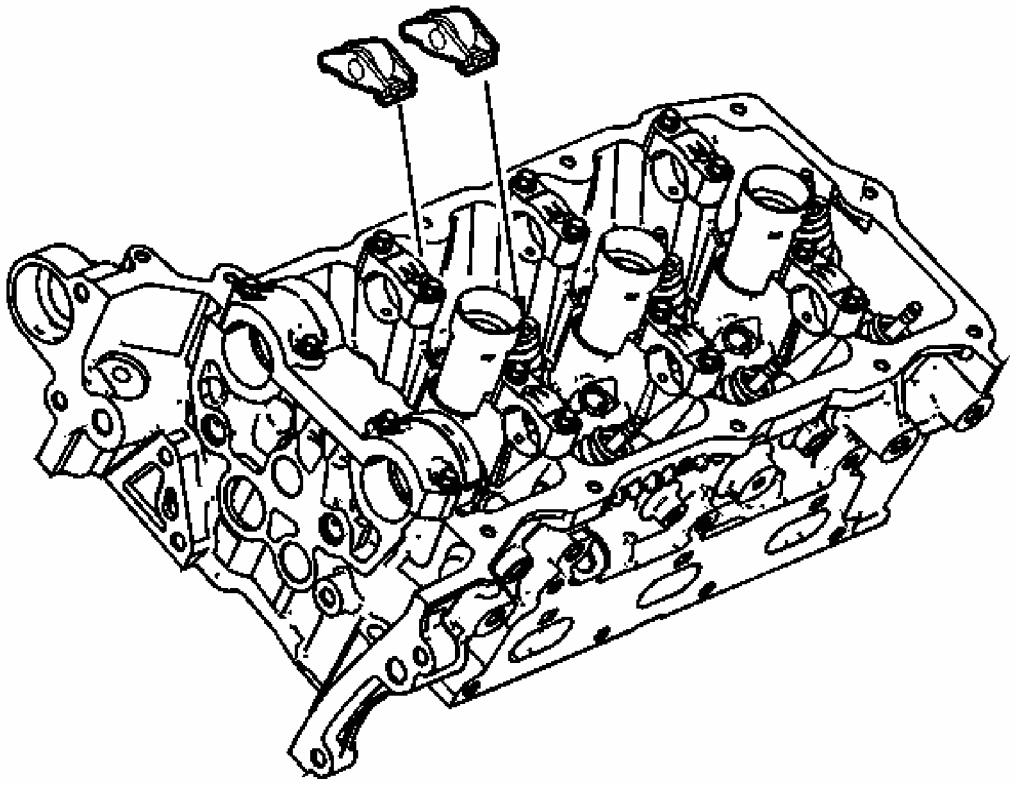

Fig. 7: View Of Valve Rocker Arm
Courtesy of GENERAL MOTORS CORP.

Remove the valve rocker arms, camshaft followers, from the left cylinder head.

VALVE LIFTER REMOVAL - LEFT

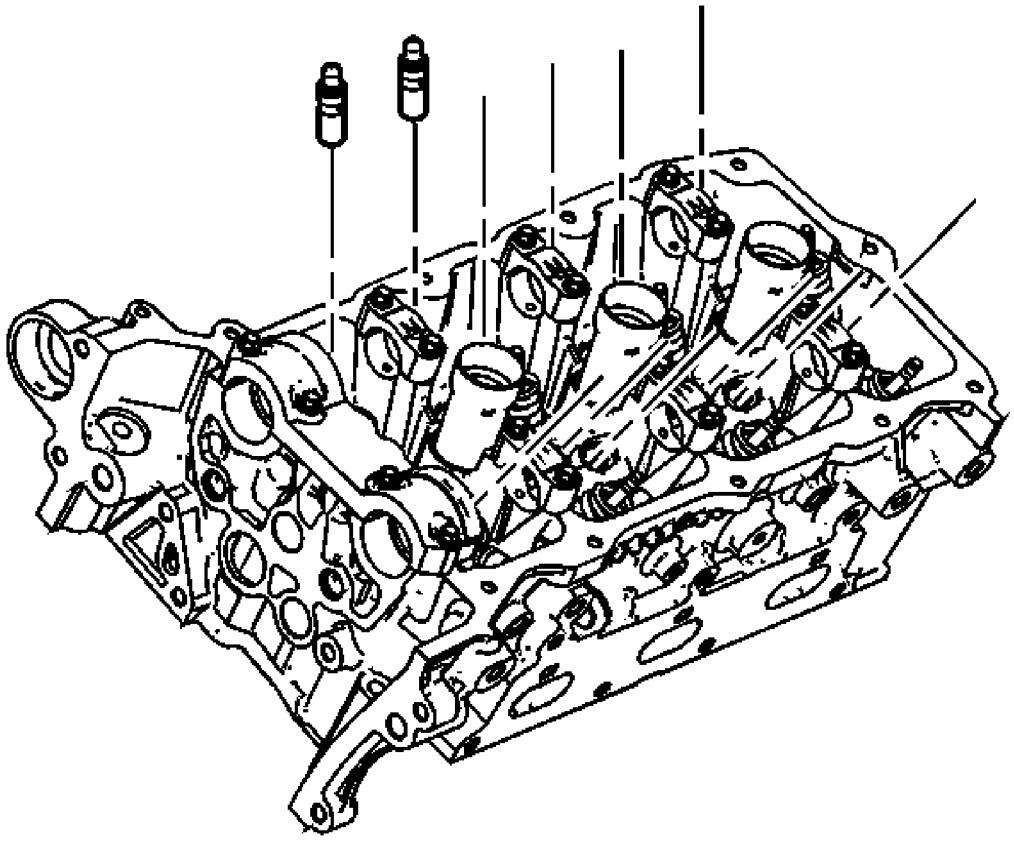

Fig. 8: View Of SHLAs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.**
- **Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.**

Remove the valve lifters, stationary hydraulic lash adjuster, (SHLAs) from the left cylinder head.

CYLINDER HEAD REMOVAL - LEFT

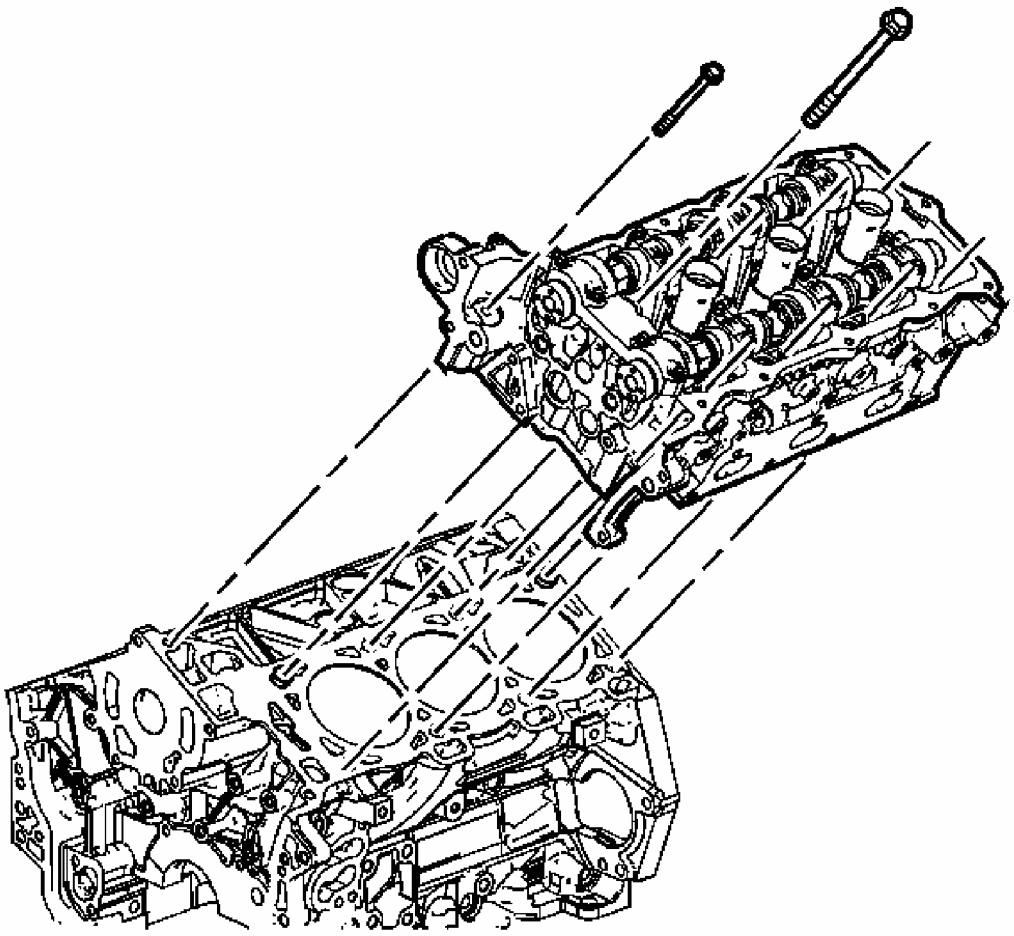

Fig. 9: View Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the two front M8 left cylinder head bolts.
2. Remove the left cylinder head bolts.
3. Remove the left cylinder head.

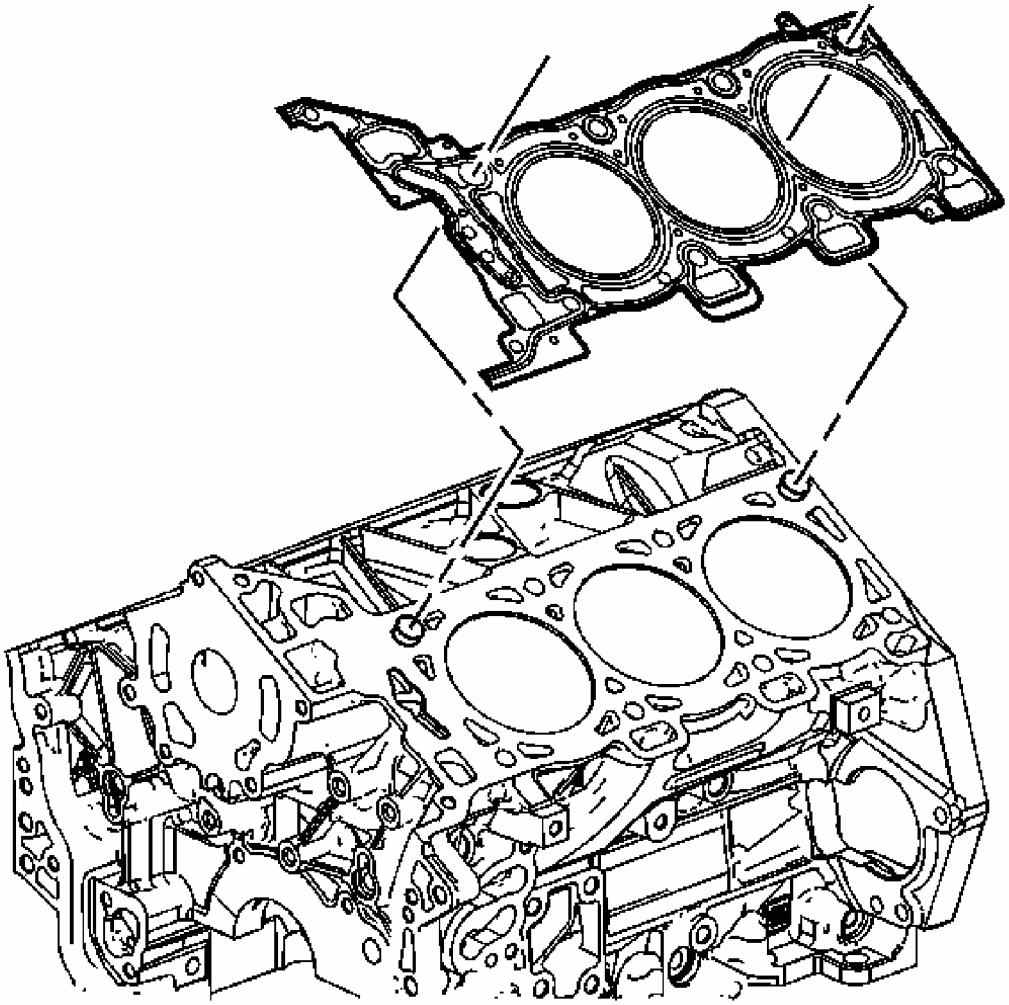

Fig. 10: View Of Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the left cylinder head gasket.

CAMSHAFT REMOVAL - RIGHT

Tools Required

EN 46105 Camshaft Locking Tool

Removal Procedure

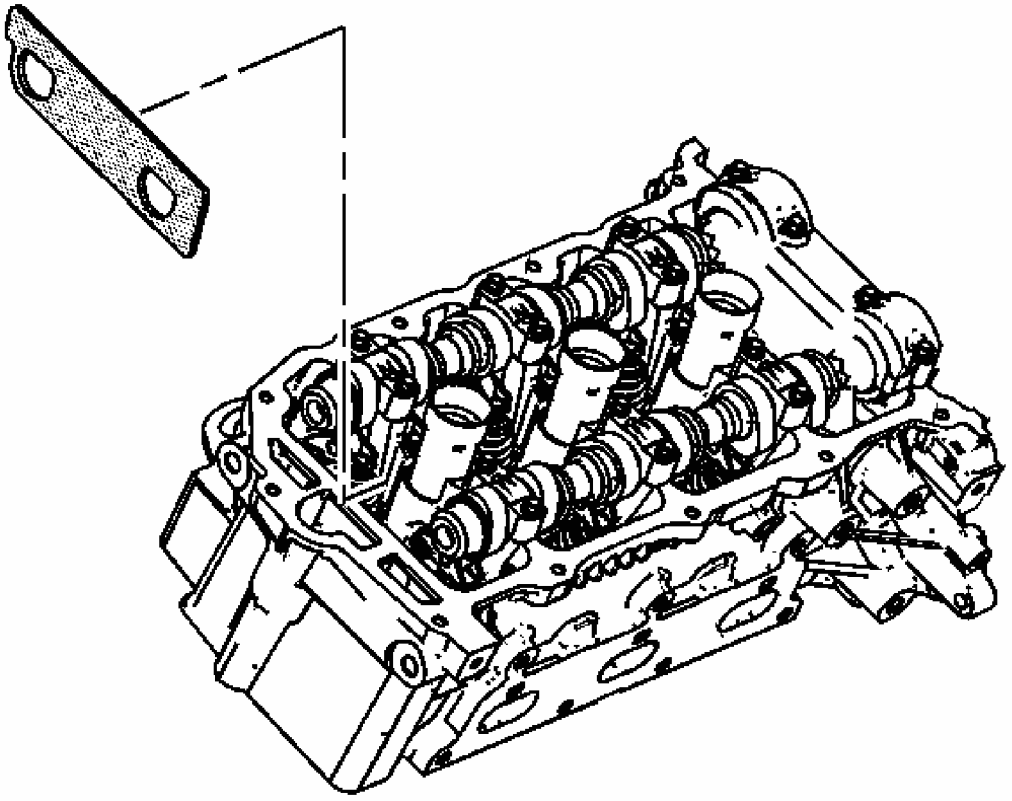

Fig. 11: Identifying EN 46105-1
Courtesy of GENERAL MOTORS CORP.

1. Remove the EN 46105-1 from the right camshafts.
2. Position the camshaft lobes in a neutral position.

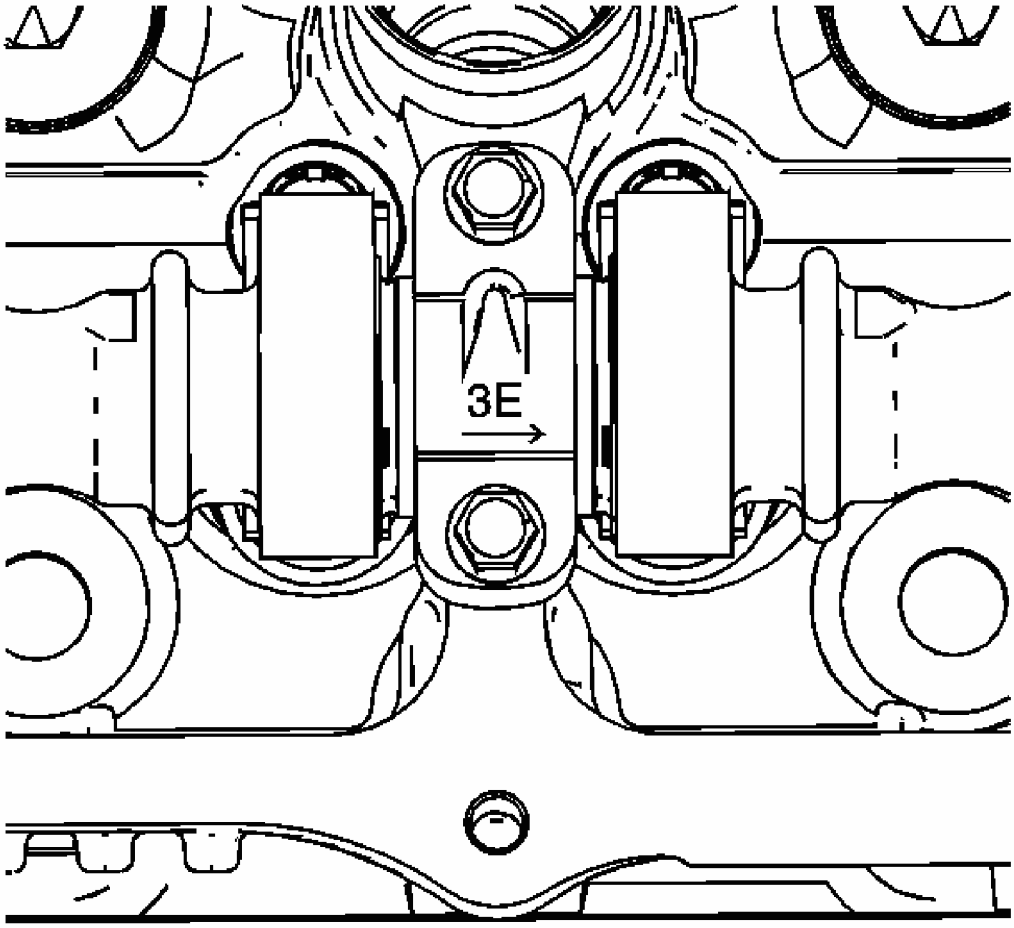

Fig. 12: Identifying Markings On Bearing Caps
Courtesy of GENERAL MOTORS CORP.

3. Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
    - The raised feature must always be oriented toward the center of the cylinder head.
    - The I indicates the intake camshaft.
    - The E indicates the exhaust camshaft.
    - The number indicates the journal position from the front of the engine.

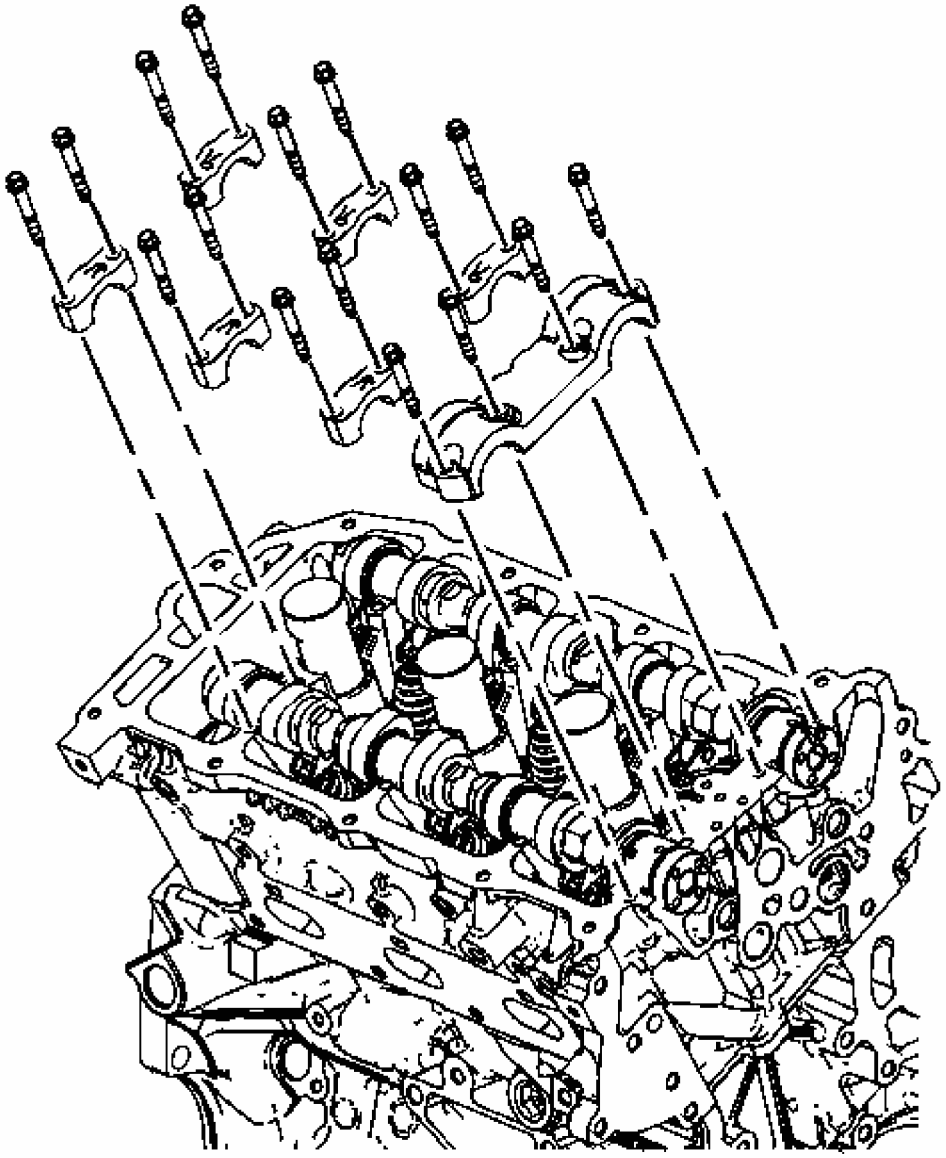

Fig. 13: View Of Camshaft Bearing Caps & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft bearing cap bolts.
5. Remove the camshaft bearing caps.

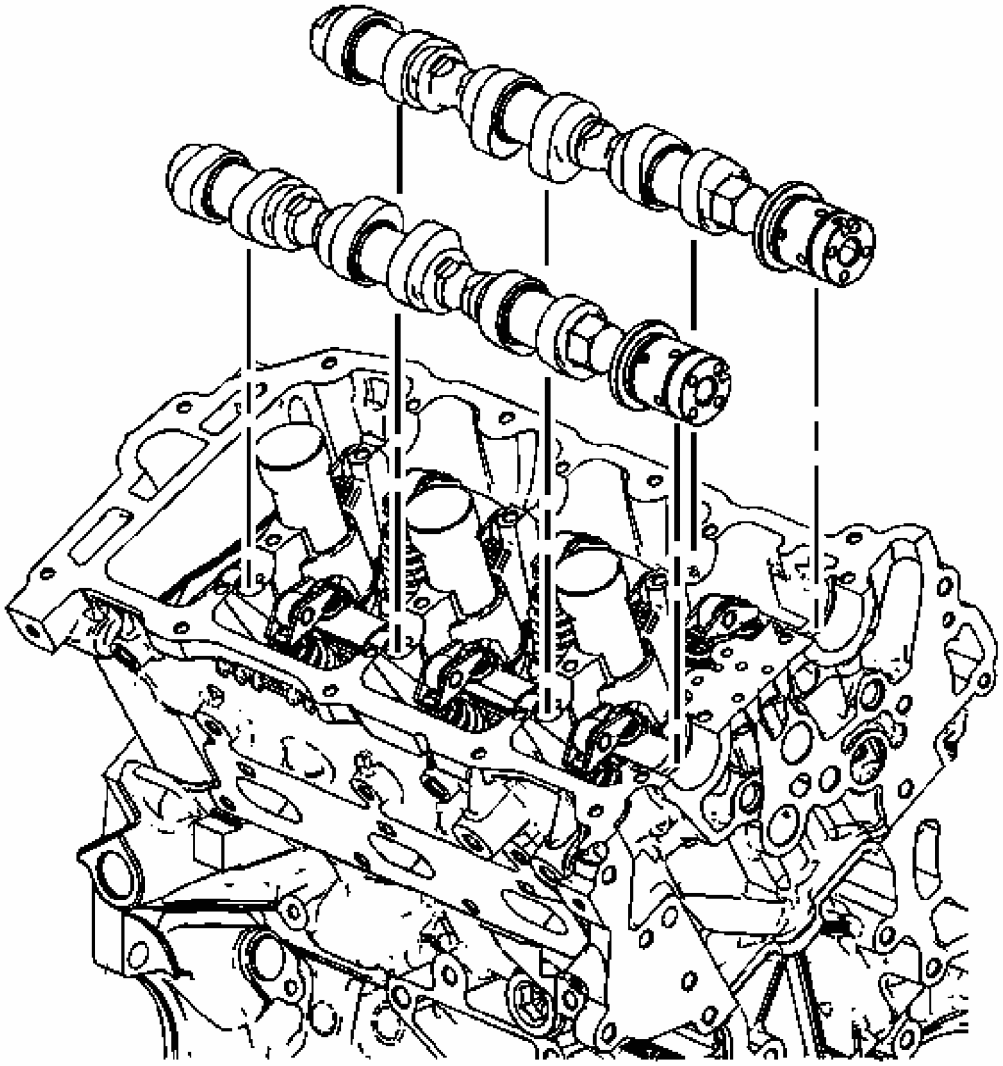

Fig. 14: Locating Camshafts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshafts.
7. Replace the camshaft bearing caps and bolts.

VALVE ROCKER ARM REMOVAL - RIGHT

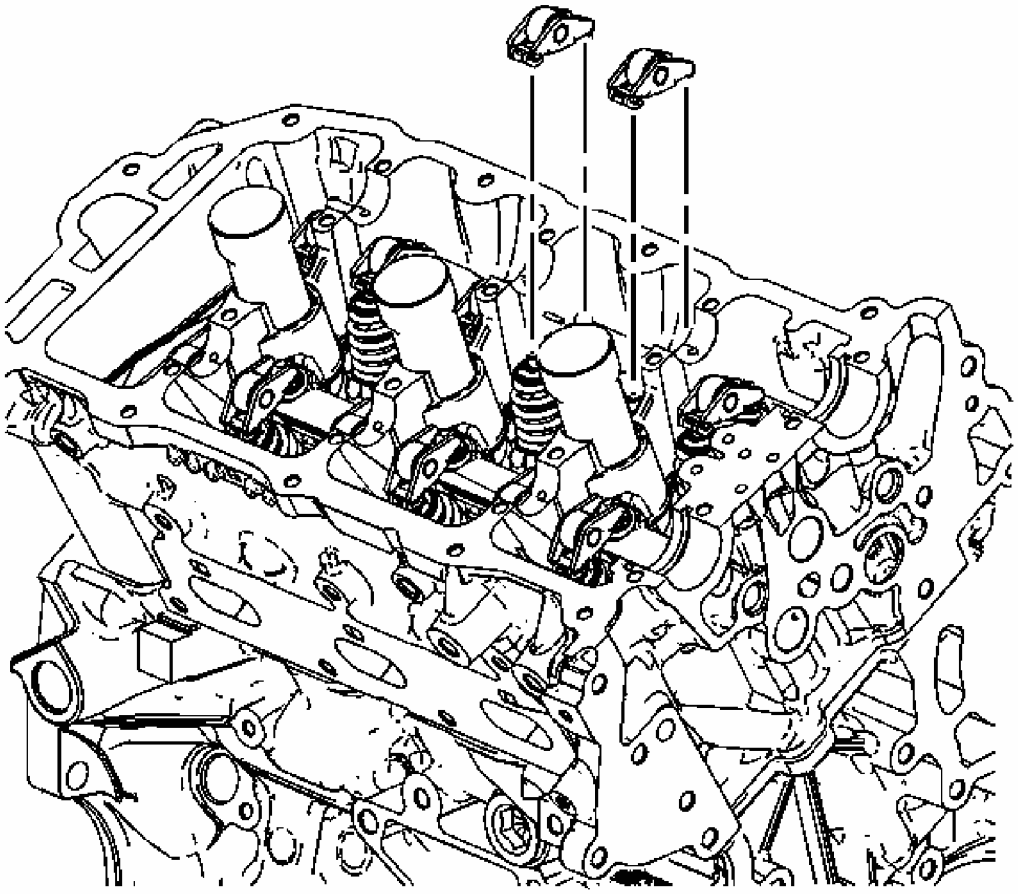

Fig. 15: Identifying Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

Remove the valve rocker arms, camshaft followers, from the right cylinder head.

VALVE LIFTER REMOVAL - RIGHT

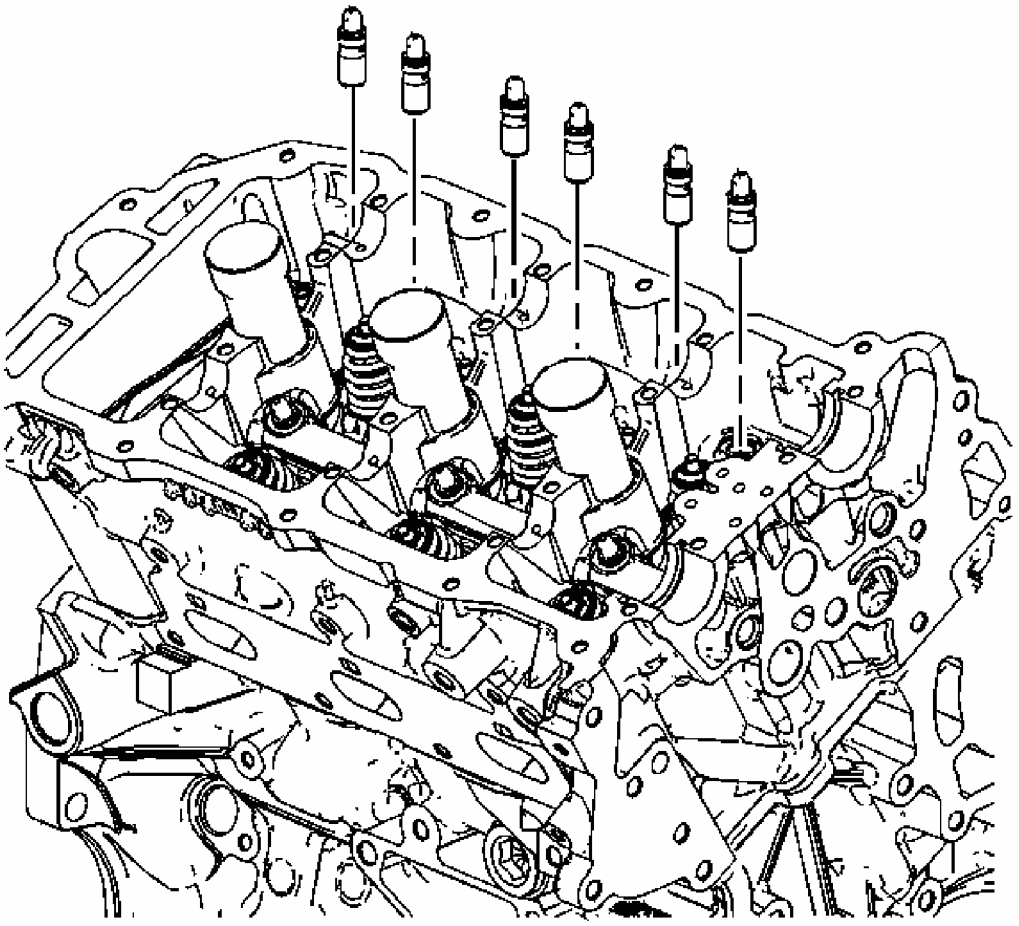

Fig. 16: Identifying Stationary Hydraulic Lash Adjuster (SHLA)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.**
- **Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.**

Remove the valve lifters, stationary hydraulic lash adjuster, (SHLAs) from the right cylinder head.

CYLINDER HEAD REMOVAL - RIGHT

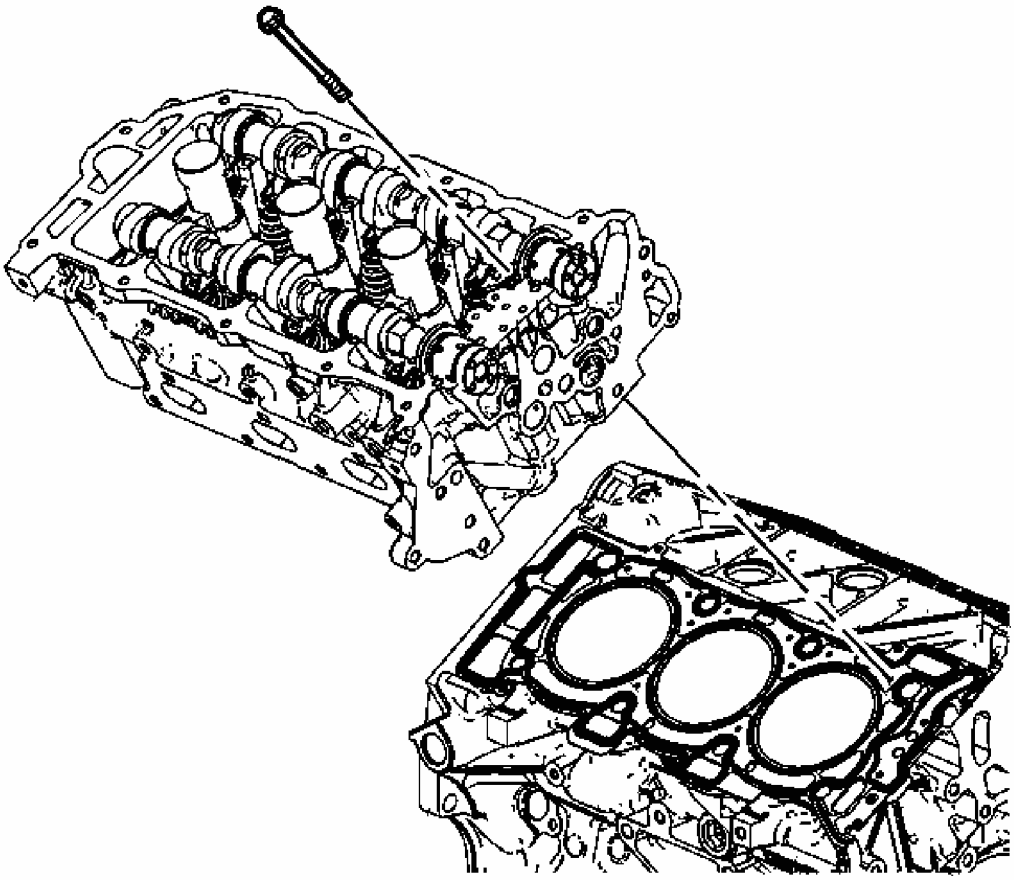

Fig. 17: View Of Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Remove the right cylinder head bolts.
2. Remove the right cylinder head.

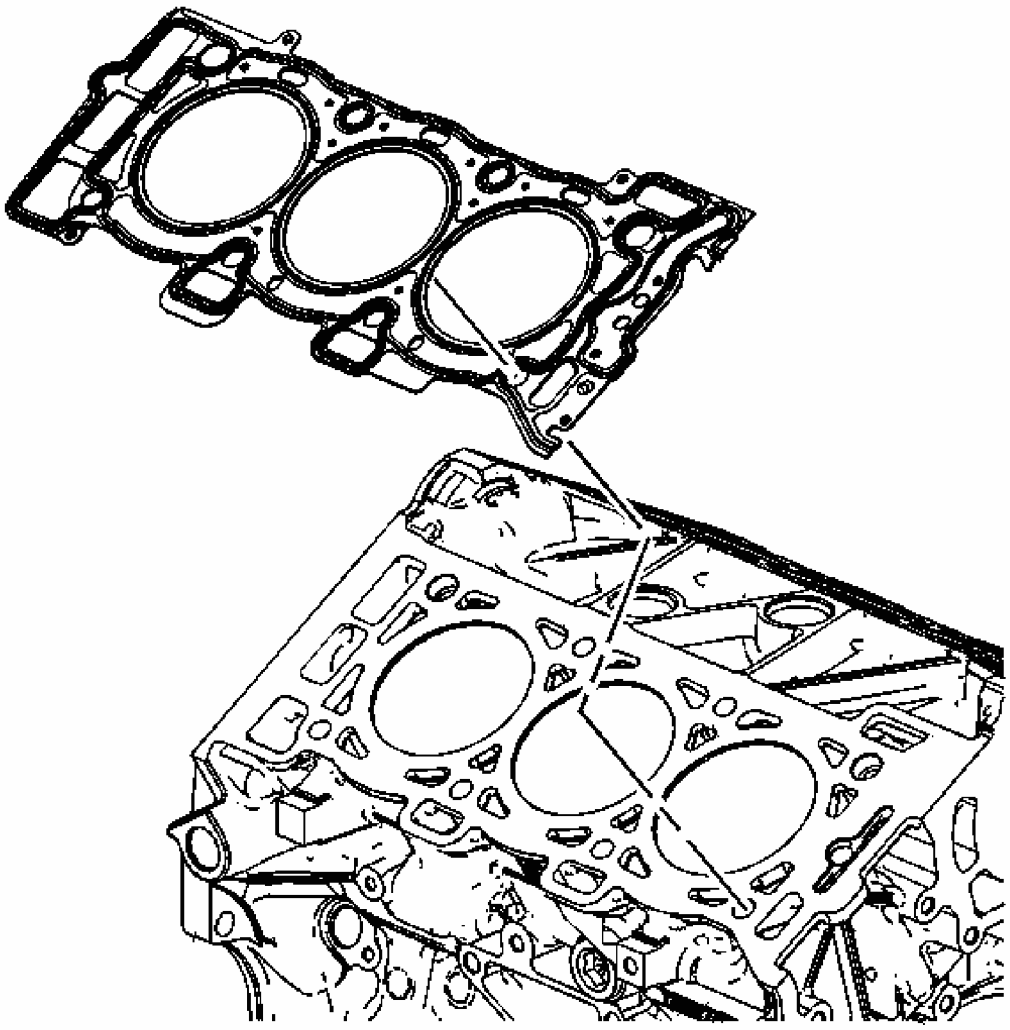

Fig. 18: View Of Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the right cylinder head gasket.

OIL PAN REMOVAL

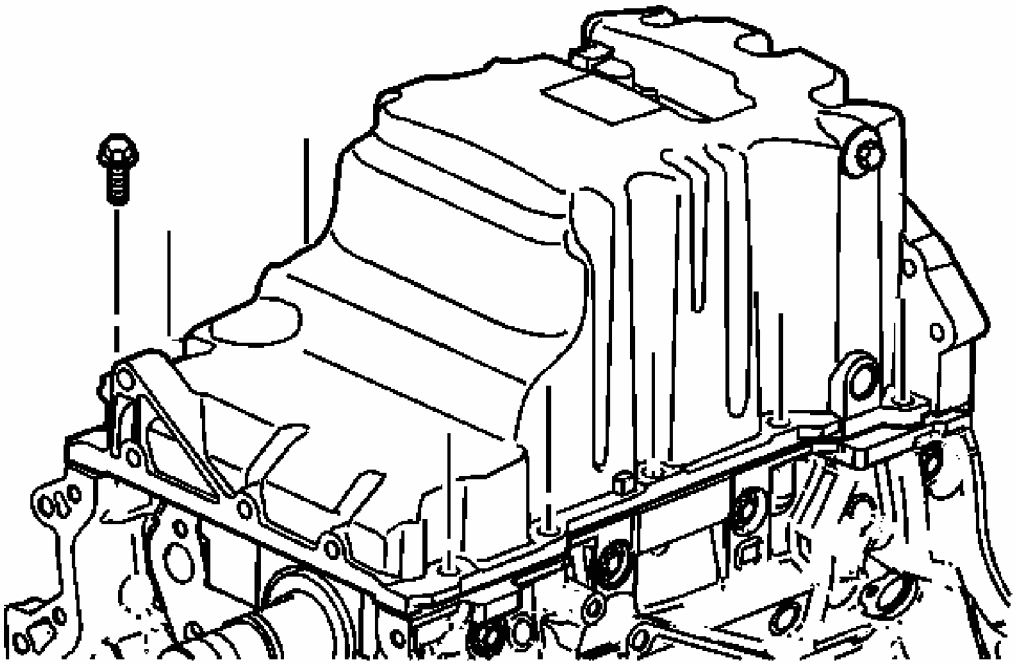

Fig. 19: Removing & Installing Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts.
2. Using the pry points located at the edge of the oil pan shear the RTV sealant.

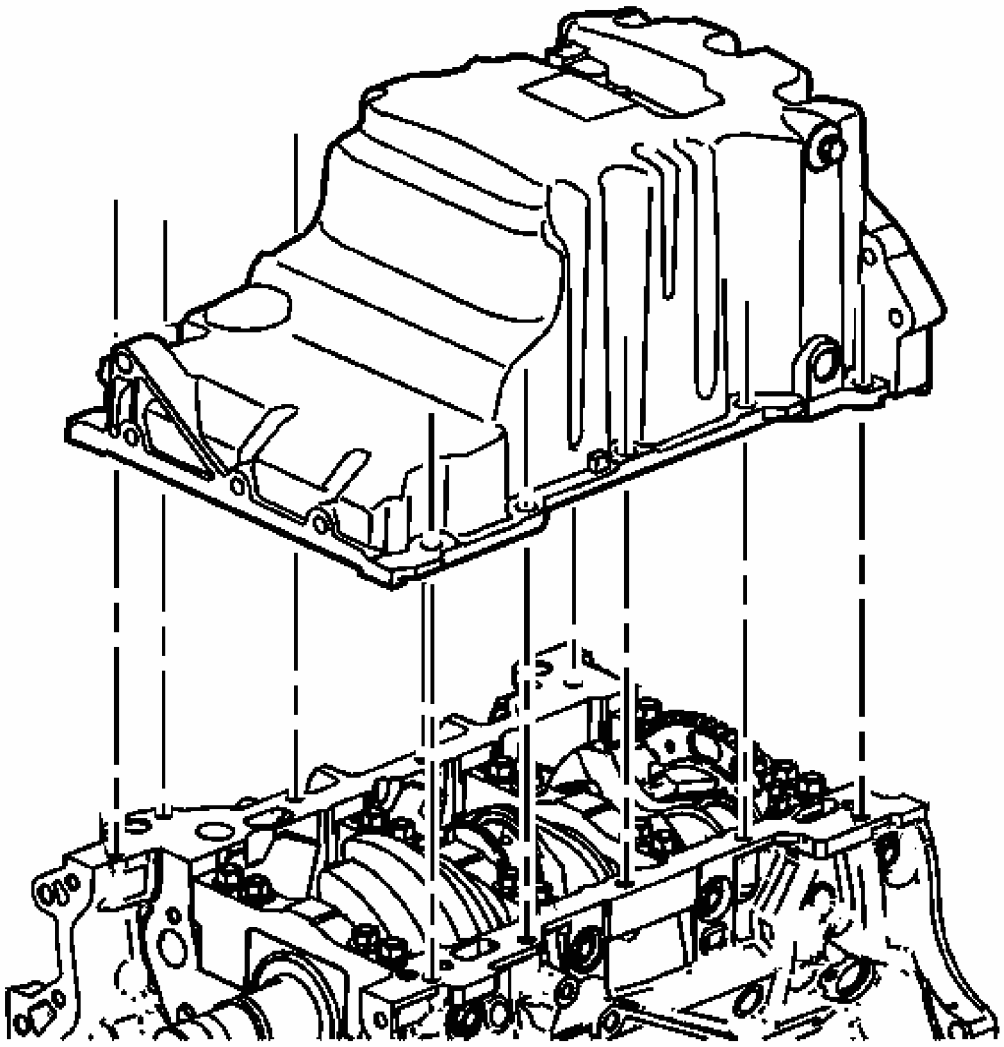

Fig. 20: Removing & Installing Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan from the block.

OIL PUMP REMOVAL

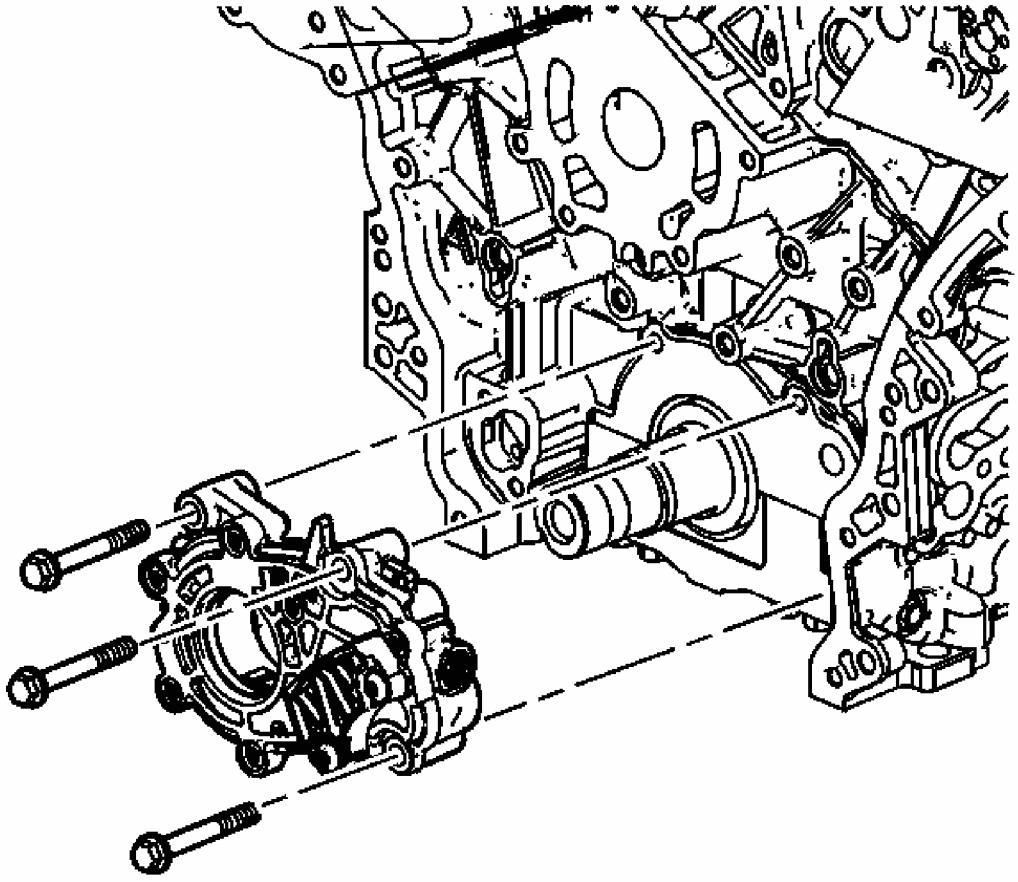

Fig. 21: View Of Oil Pump & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump bolts.
2. Remove the oil pump.

CRANKSHAFT REAR OIL SEAL AND HOUSING REMOVAL

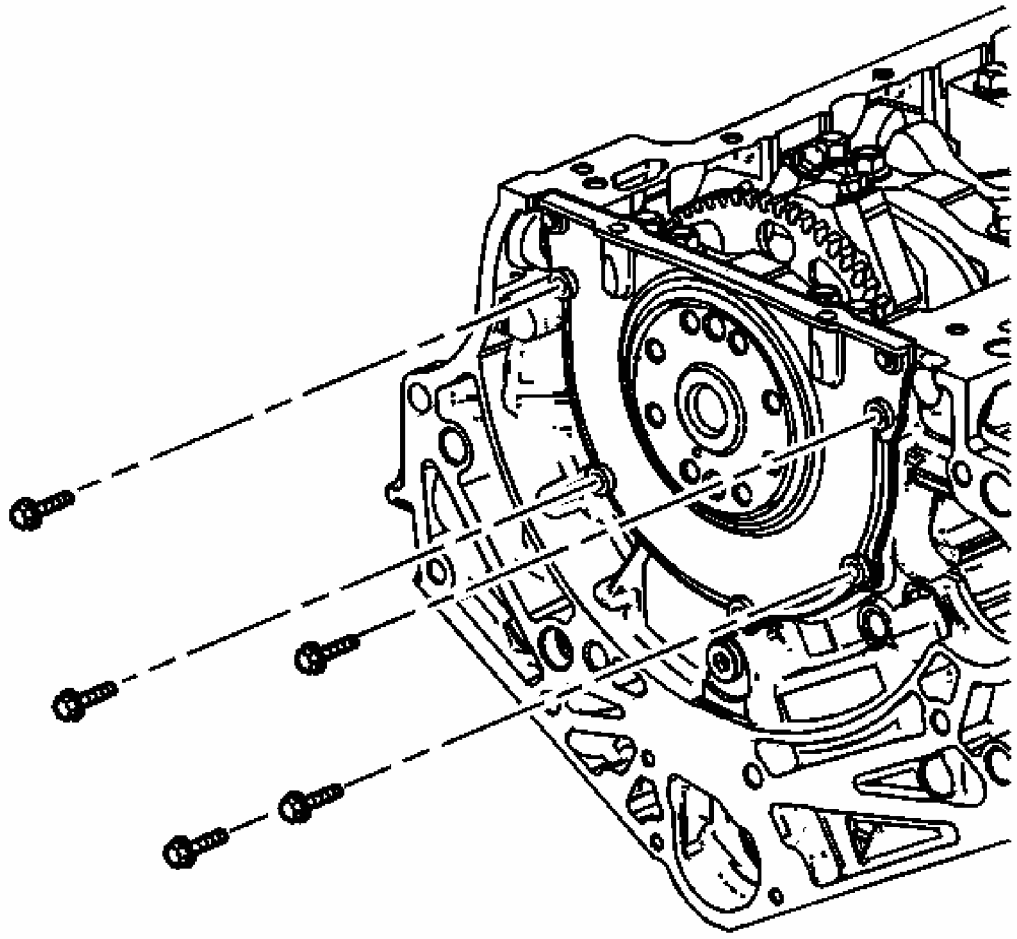

Fig. 22: Locating Crankshaft Rear Oil Seal Housing Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft rear oil seal housing bolts.

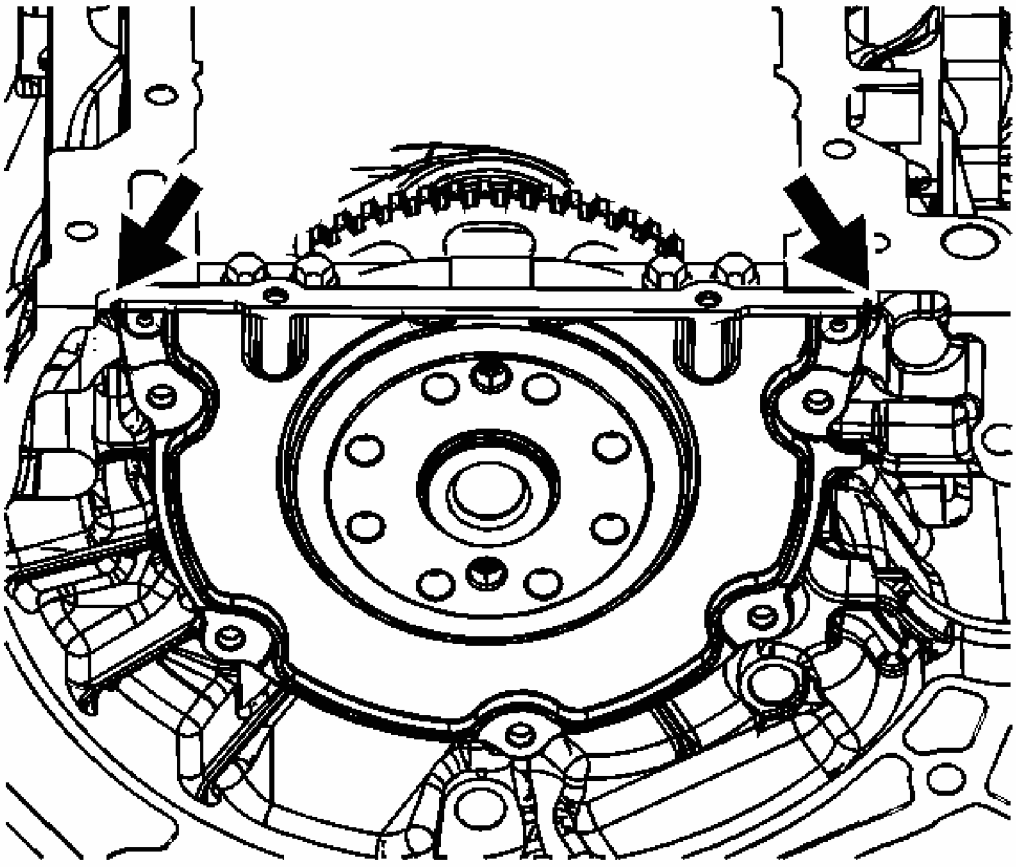

Fig. 23: Identifying Pry Points On Edge Of The Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

2. Using the pry points located at the edge of the crankshaft rear oil seal housing shear the RTV sealant.

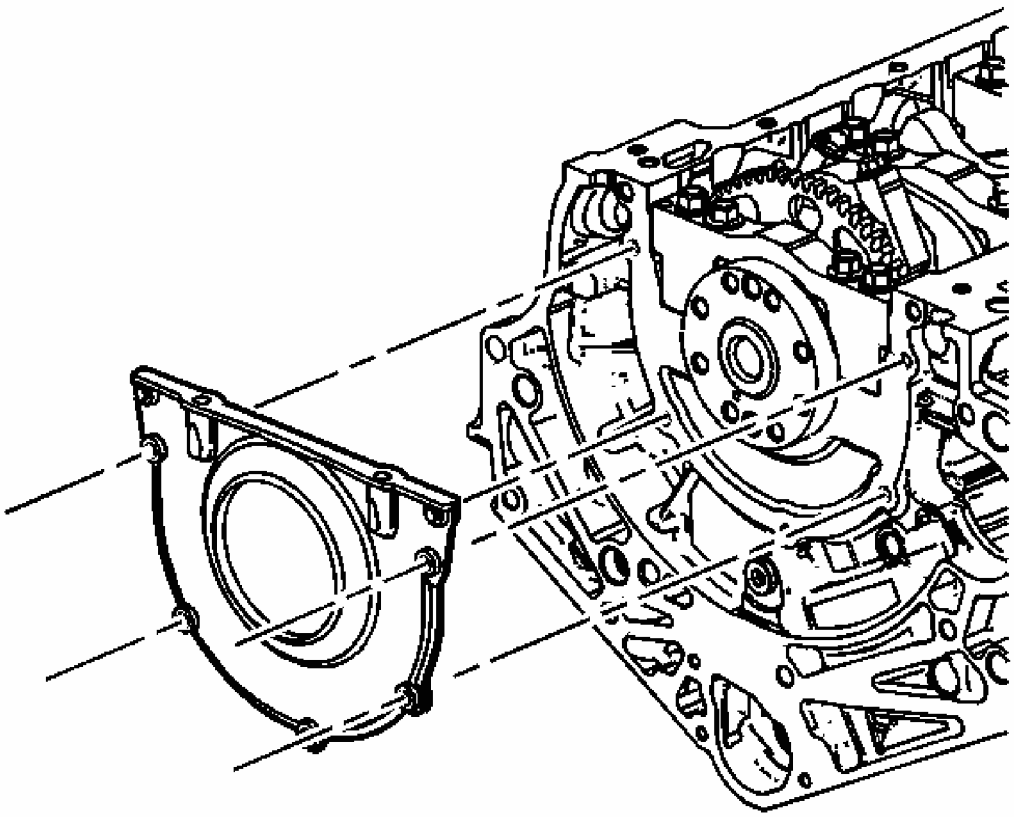

Fig. 24: View Of Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS CORP.

3. Remove and discard the crankshaft rear oil seal housing.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

EN 46121 Connecting Rod Guide Pin Set

Removal Procedure

IMPORTANT:

- **An arrow/dot showing proper piston orientation is located on the top of the piston.**
- **If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.**

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
    1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
    2. Using feeler gages, measure the clearance between the crankshaft counterweight and the connecting rod.
    3. The connecting rod side clearance should not exceed specifications. Refer to **Engine Mechanical Specifications** .
    4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection** .
    5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
    6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

NOTE: **Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.**

3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.

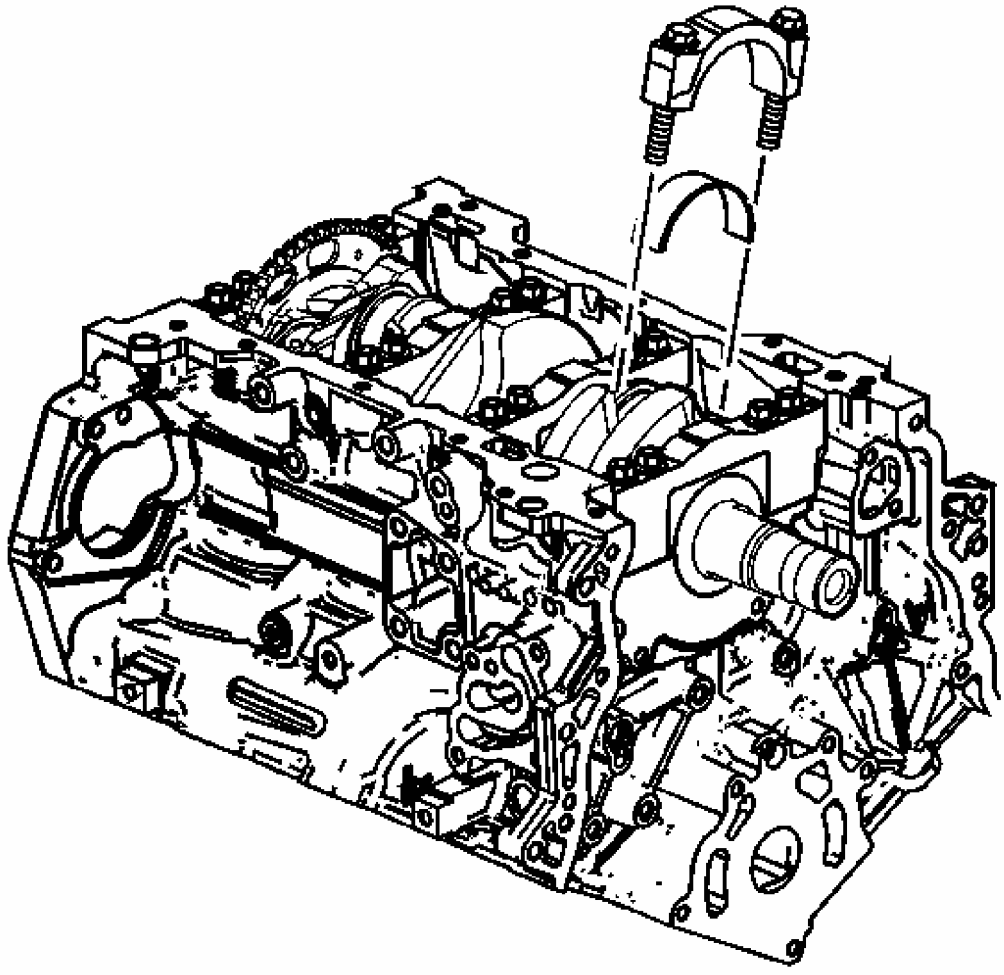

Fig. 25: View Of Connecting Rod Bearing And Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not replaced will not torque to the correct clamp load and can lead to serious engine damage.

4. Remove the connecting rod bolts.

IMPORTANT: The connecting rod caps must remain with the original connecting rod.

5. Remove the connecting rod cap.

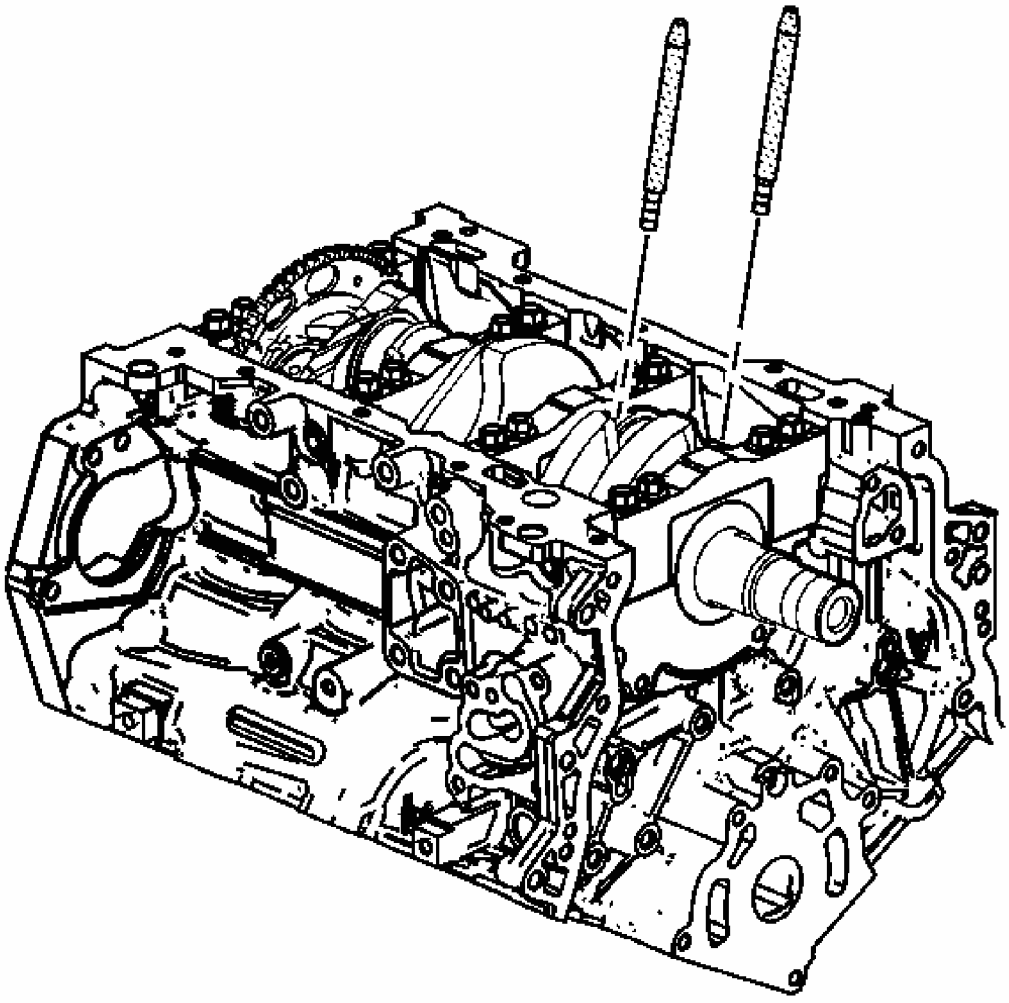

Fig. 26: Identifying EN 46121
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46121** into the connecting rod bolt holes.

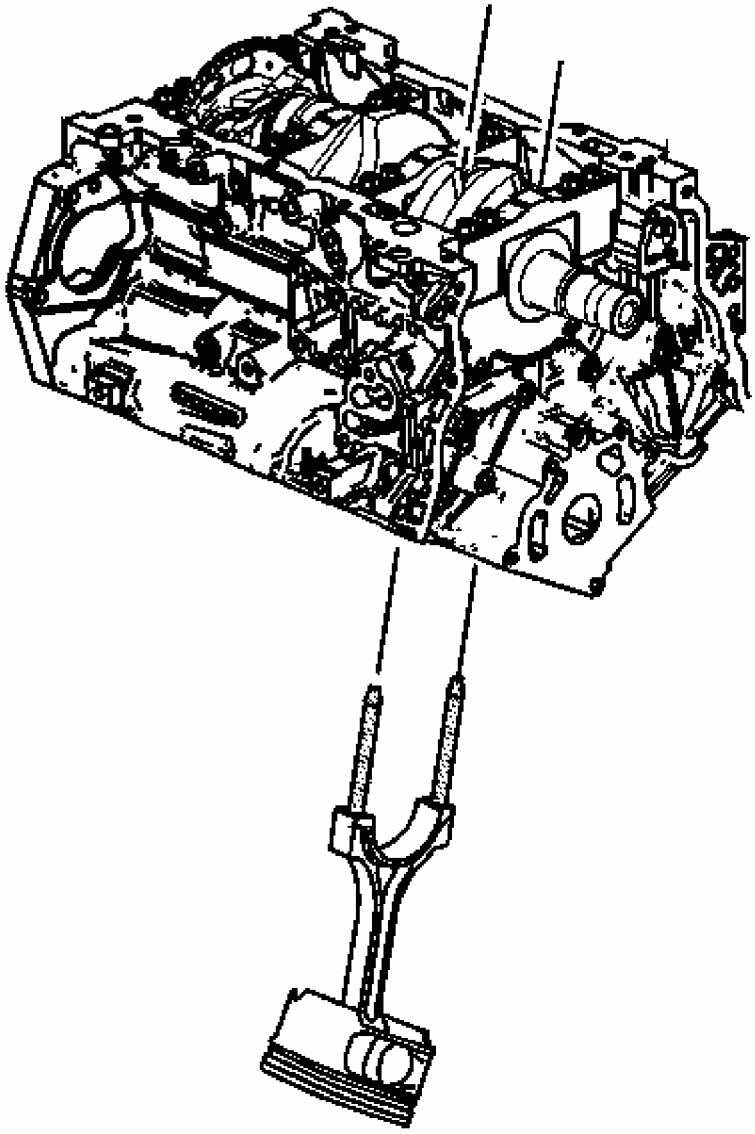

Fig. 27: View Of Connecting Rod And Piston Assembly
Courtesy of GENERAL MOTORS CORP.

7. Using the **EN 46121** , push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.

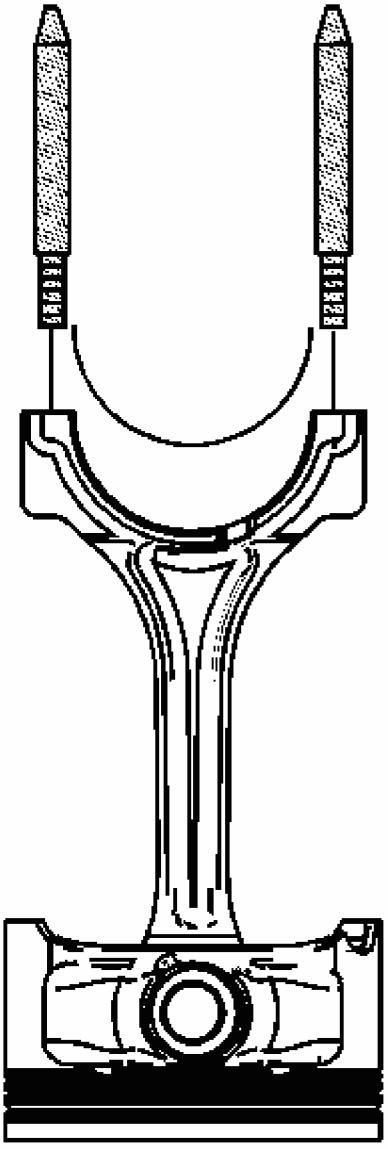

Fig. 28: View Of Piston/Connecting Rod Installation Tool
Courtesy of GENERAL MOTORS CORP.

8. Remove the **EN 46121** from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.

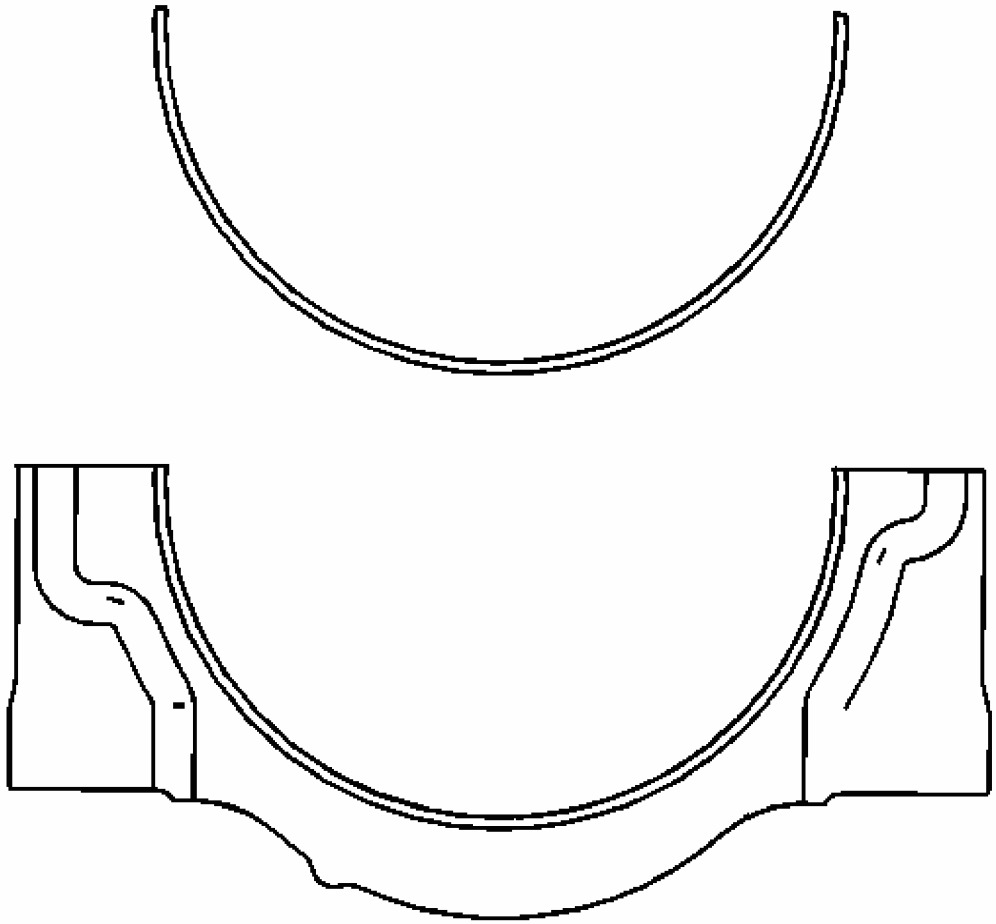

Fig. 29: View Of Lower Connecting Rod Cap And Bearing
Courtesy of GENERAL MOTORS CORP.

10. Remove the lower connecting rod bearing from the connecting rod cap.

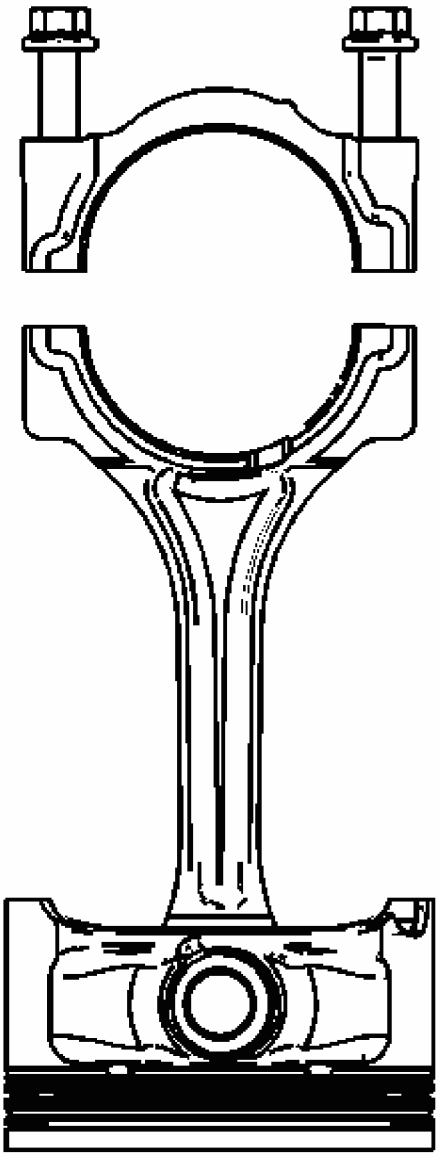

Fig. 30: View Of Connecting Rod Cap, Connecting Rod & Piston Assembly
Courtesy of GENERAL MOTORS CORP.

11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

CRANKSHAFT AND BEARINGS REMOVAL

Tools Required

- **J 6125-1B** Slide Hammer Adapter
- **J 41818** Crankshaft Bearing Cap Remover

Crankshaft End Play Measurement

1. Place a dial indicator at the crankshaft nose.
2. Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
3. The crankshaft end play should not exceed specifications. Refer to **Engine Mechanical Specifications** .
4. If the specifications are exceeded inspect the thrust bearing thrust OD and the crankshaft thrust wall for wear and/or excessive runout. Refer to **Engine Mechanical Specifications** .
5. Replace the thrust bearing or crankshaft as necessary.

Crankshaft Removal

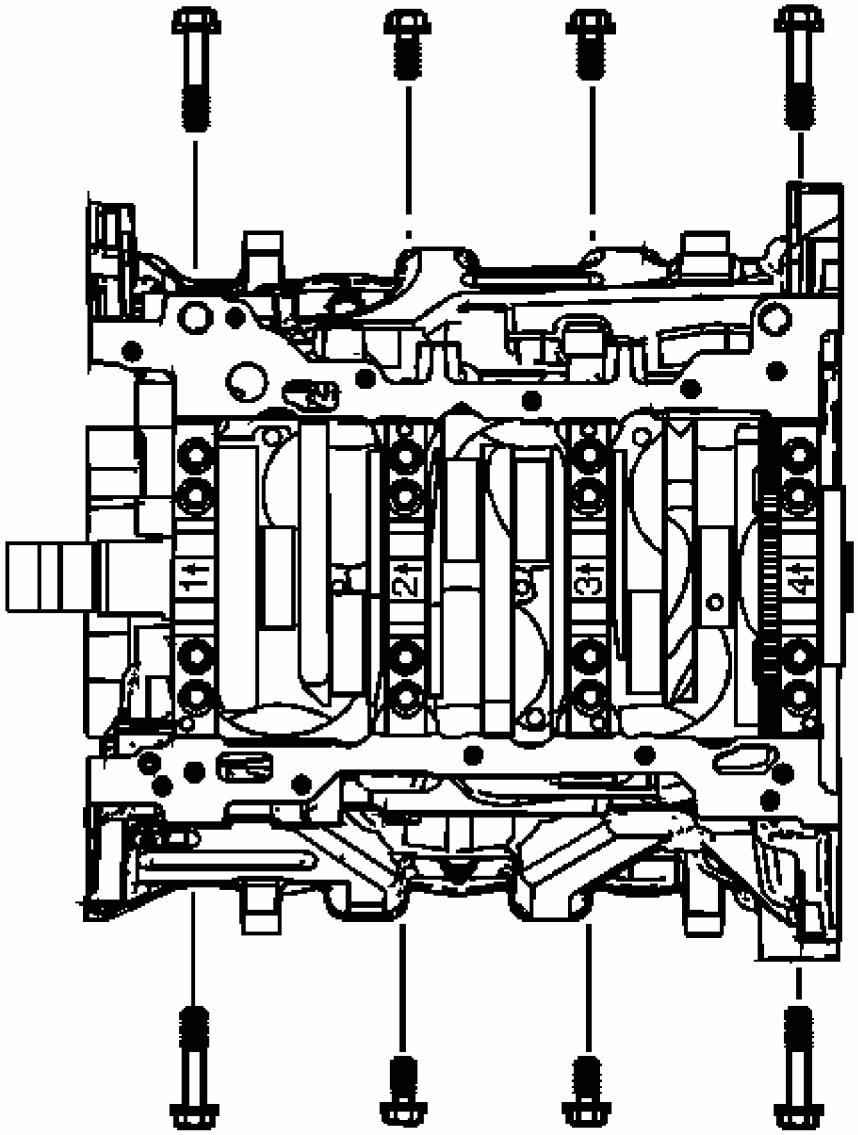

Fig. 31: Identifying Crankshaft Main Bearing Cap Side Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft bearing cap side bolts.
2. Remove the crankshaft bearing cap outer bolts.
3. Remove the crankshaft bearing cap inner bolts.

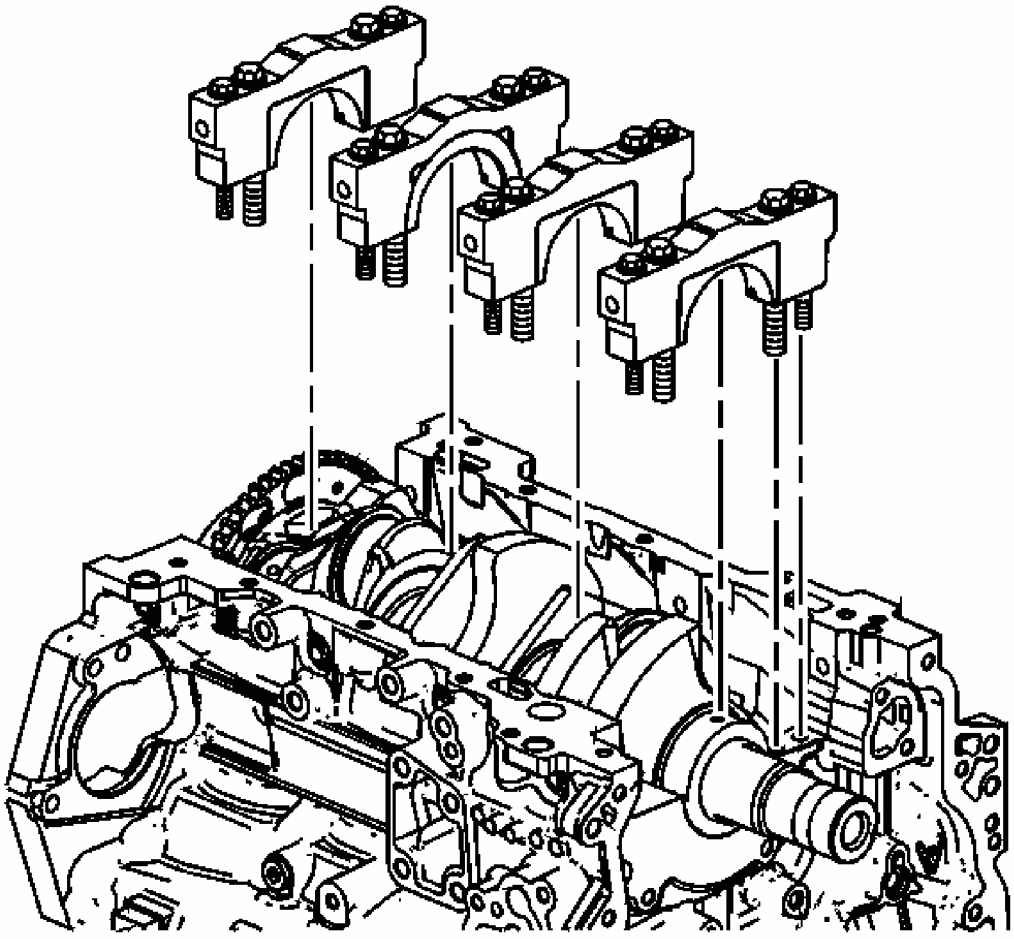

Fig. 32: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft bearing caps using the **J 6125-1B** and **J 41818** .

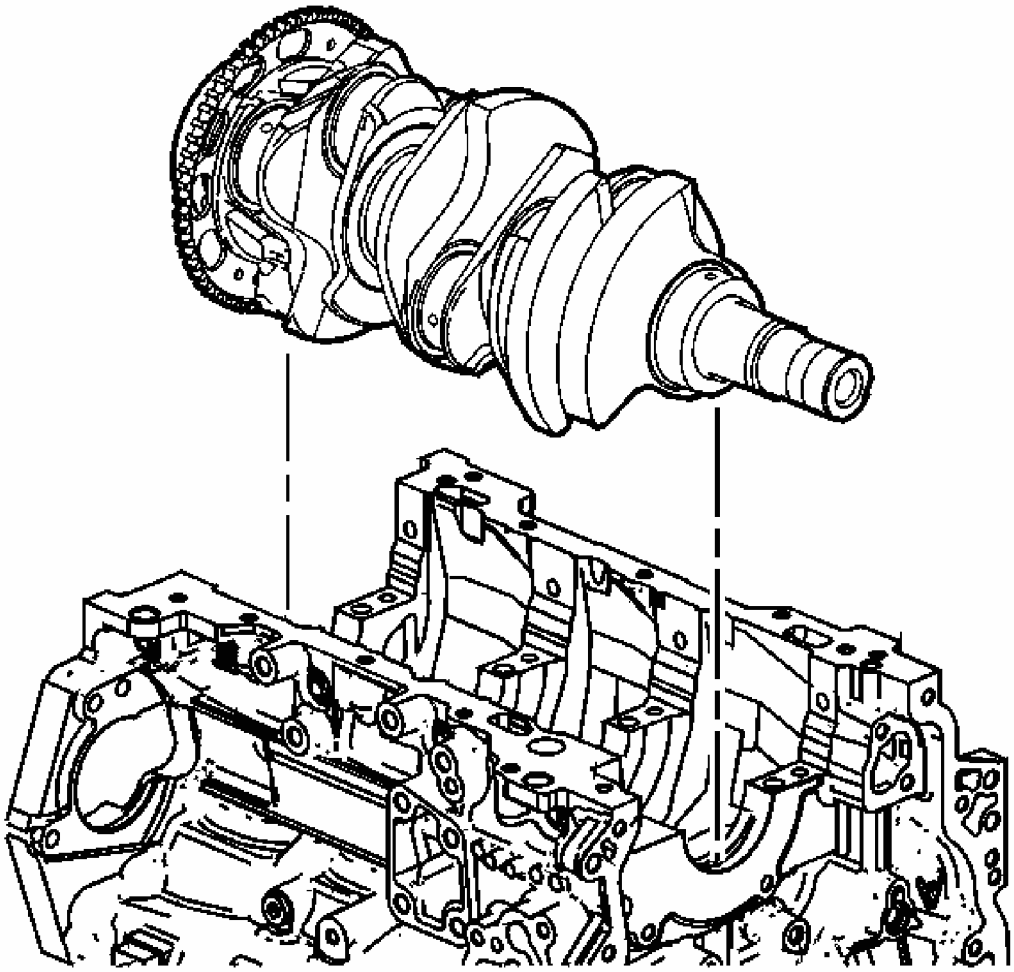

Fig. 33: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

5. Using two hands, lift the crankshaft straight up from the engine block.
6. Place the crankshaft in a secure place.

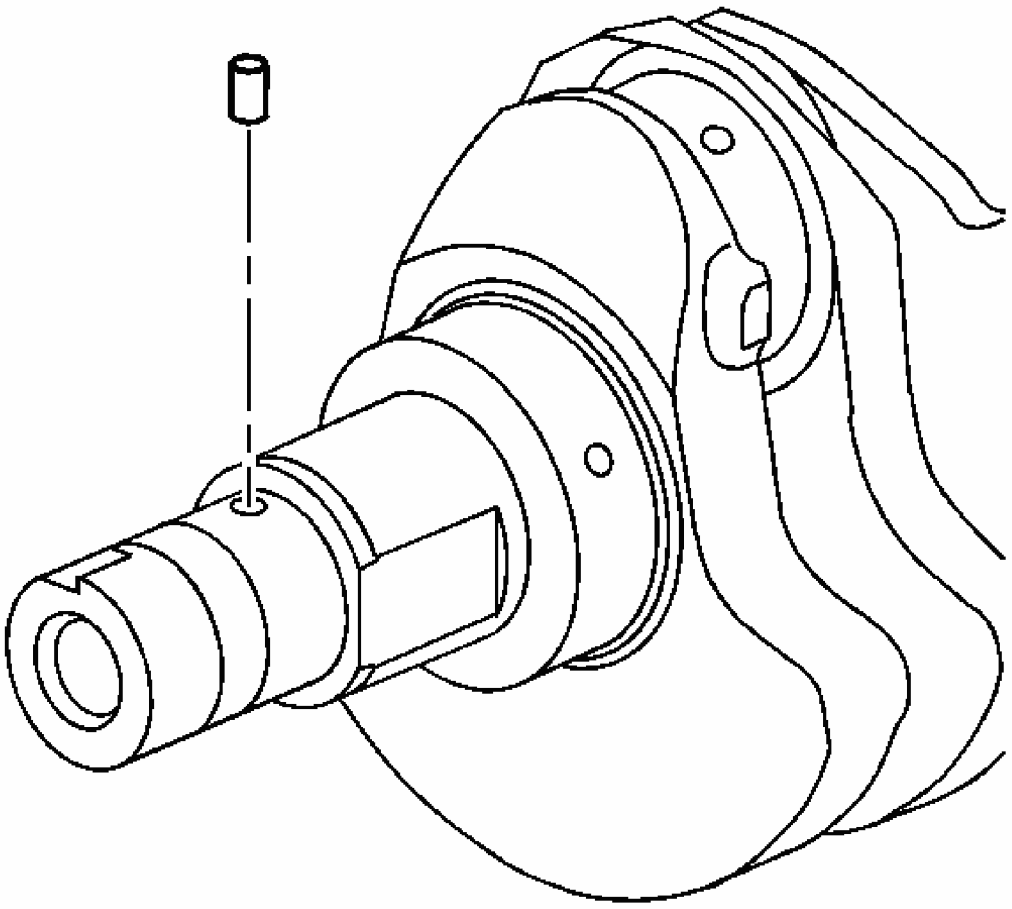

Fig. 34: Locating Crankshaft Sprocket Drive Pin
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket drive pin from the nose of the crankshaft, if damaged.

Crankshaft Bearing Removal

1. Prepare a piece of cardboard or equivalent, numbered 1-4 for bearing identification. Main bearing journals are numbered from the front of the engine.

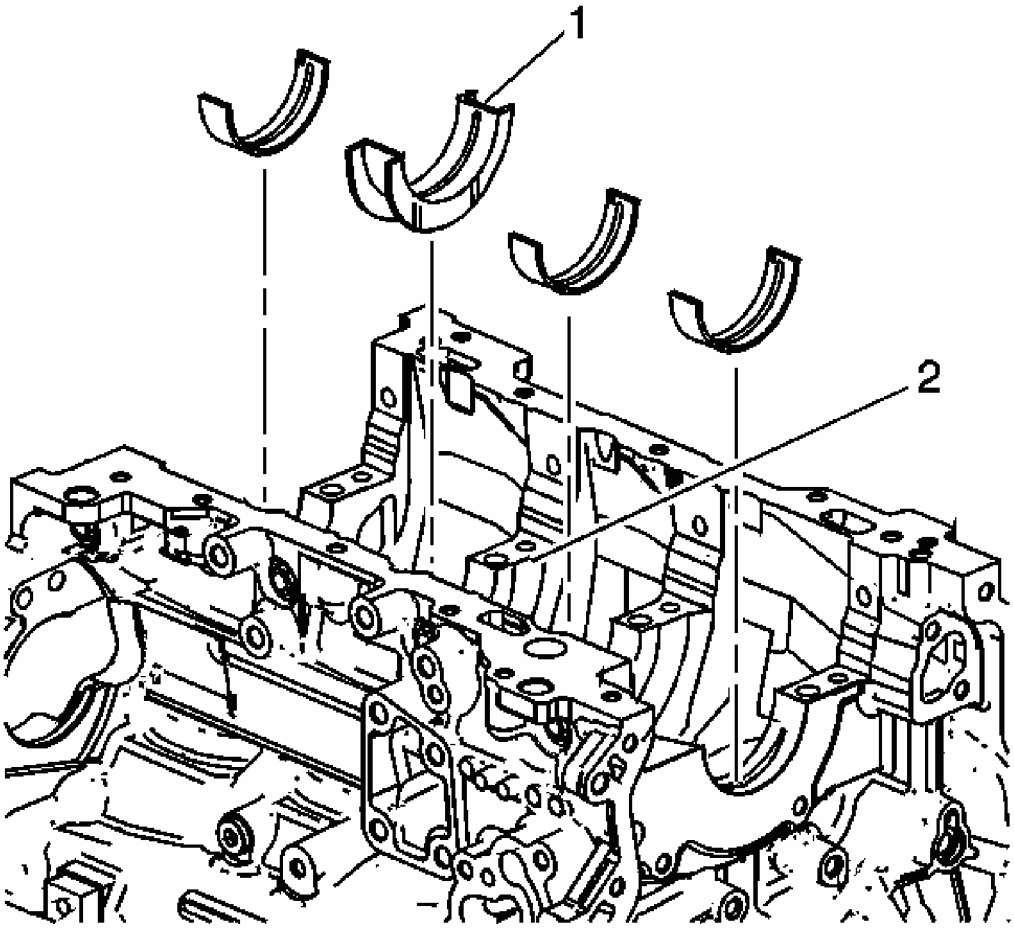

Fig. 35: Locating Thrust Bearing In Number 3 Journal
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).
3. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.

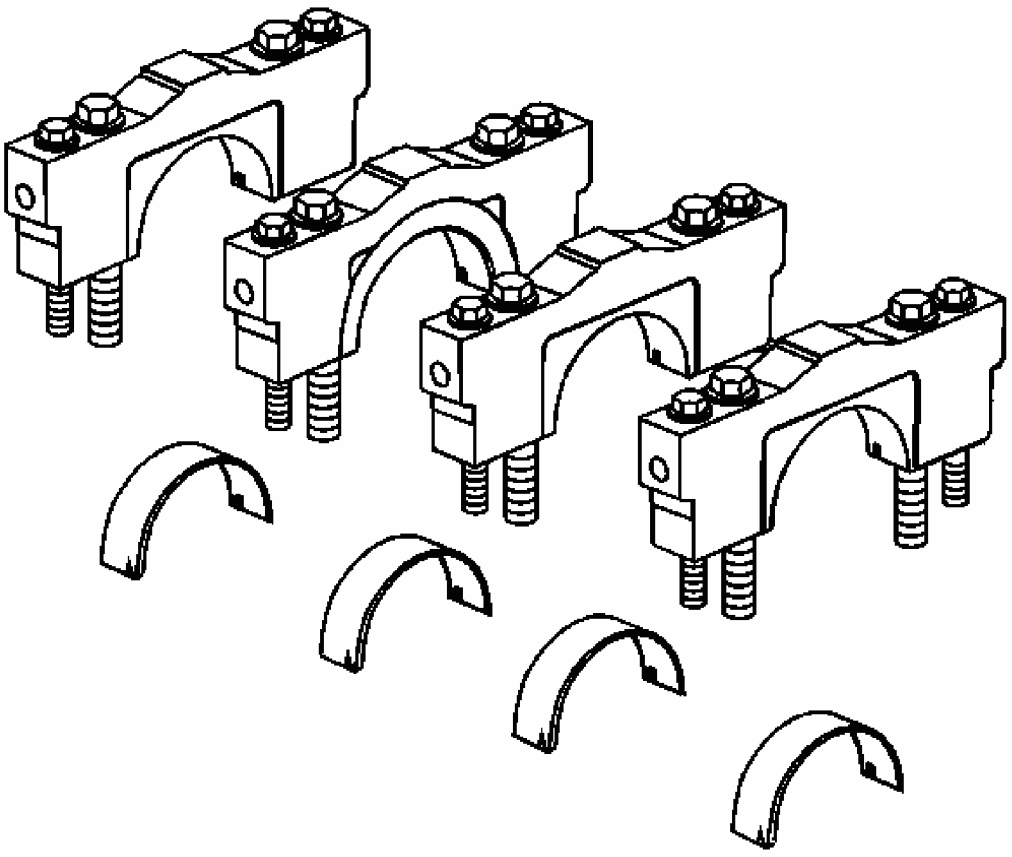

Fig. 36: Identifying Crankshaft Lower Bearing Halves & Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft lower bearing halves from the crankshaft bearing caps.
5. Place the crankshaft lower bearing halves in the correct positions on the cardboard.

ENGINE BLOCK DISASSEMBLE

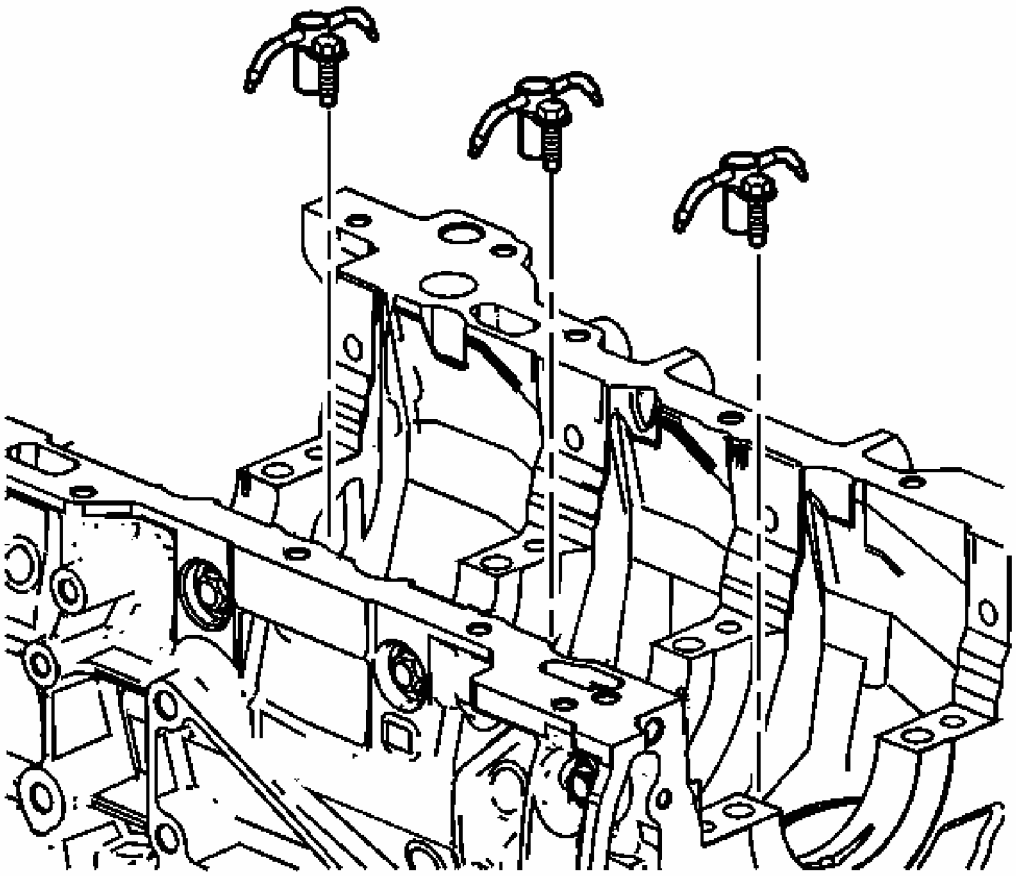

Fig. 37: View Of Oil Jets & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove oil jet bolts.
2. Remove oil jets.

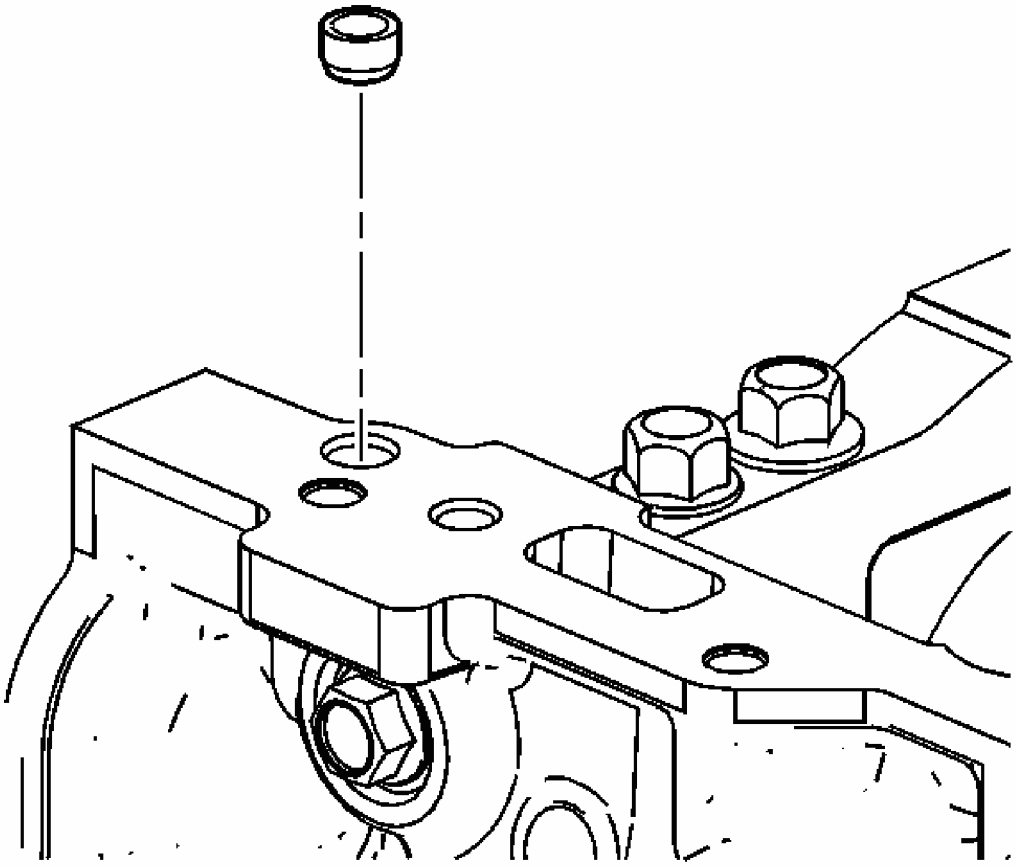

Fig. 38: Locating Right Front Oil Pan Rail Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the right front oil pan rail oil gallery expansion plug.

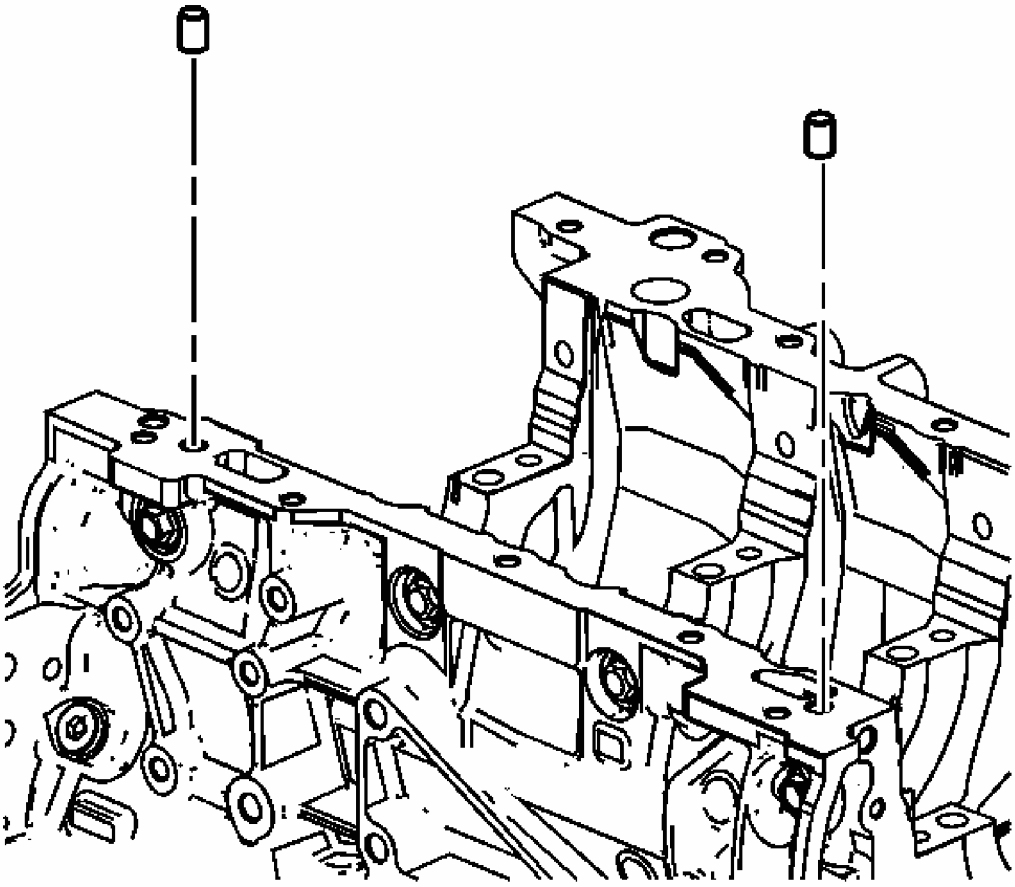

Fig. 39: Cylinder Block-To-Oil Pan Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

4. Remove the cylinder block-to-oil pan alignment dowels.

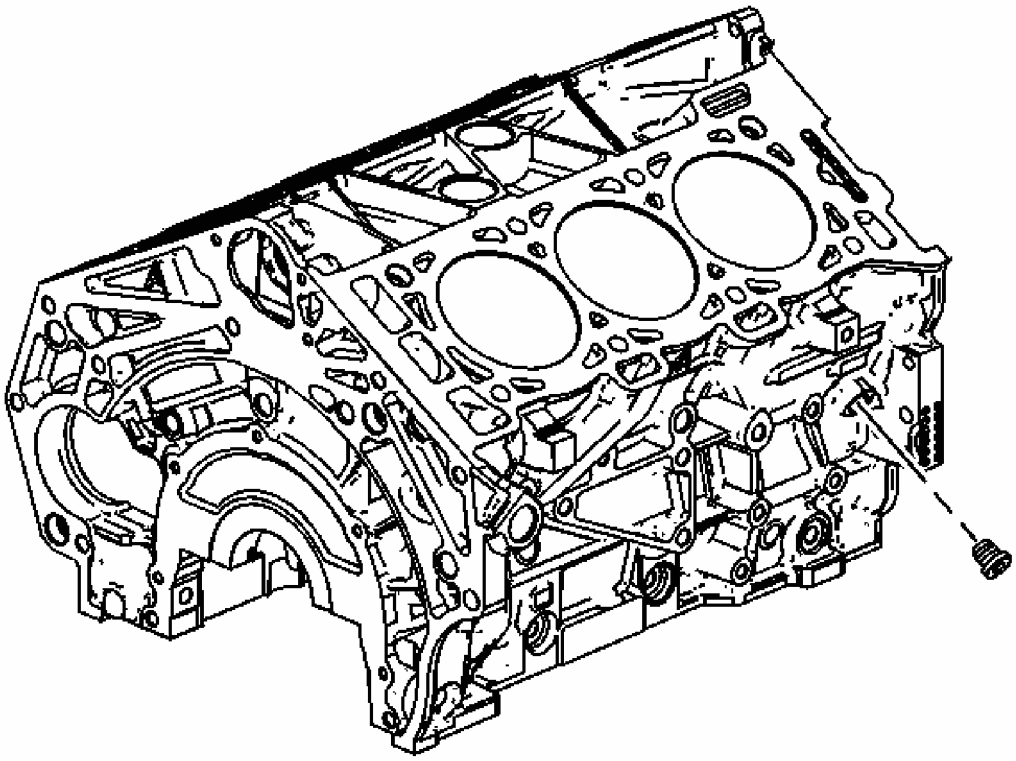

Fig. 40: Identifying M14 Right Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

5. Remove the M14 right side oil gallery threaded plug.

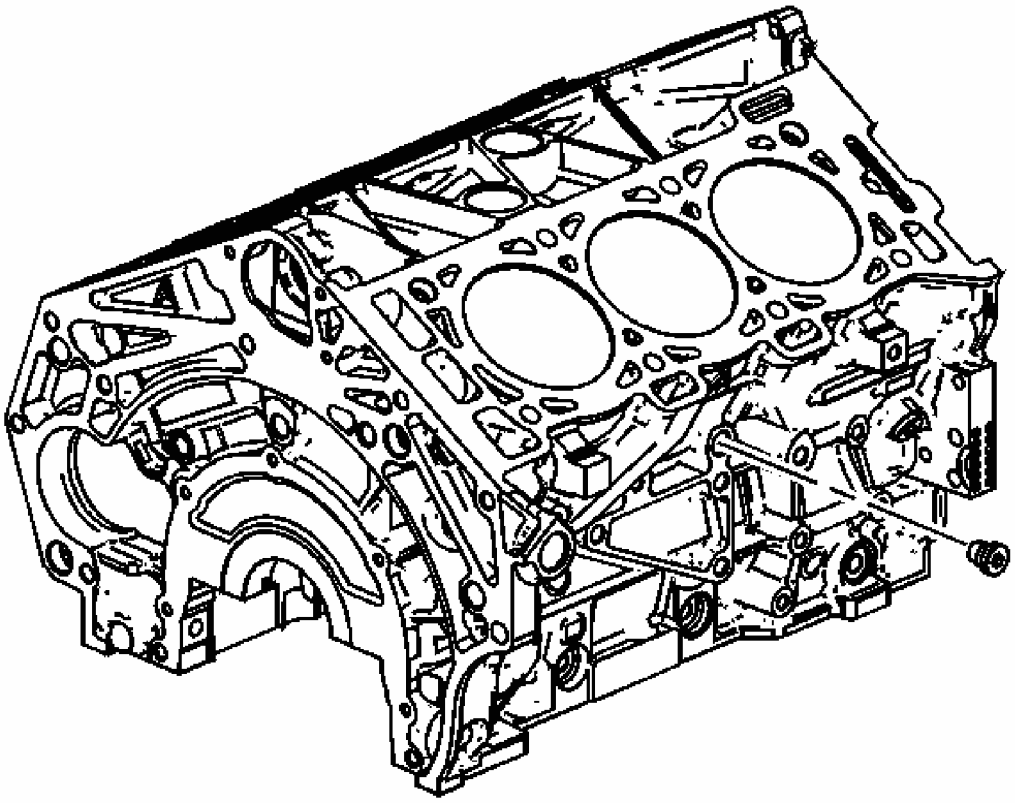

Fig. 41: Locating M14 Right Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

6. Remove the M14 right side coolant drain threaded plug.

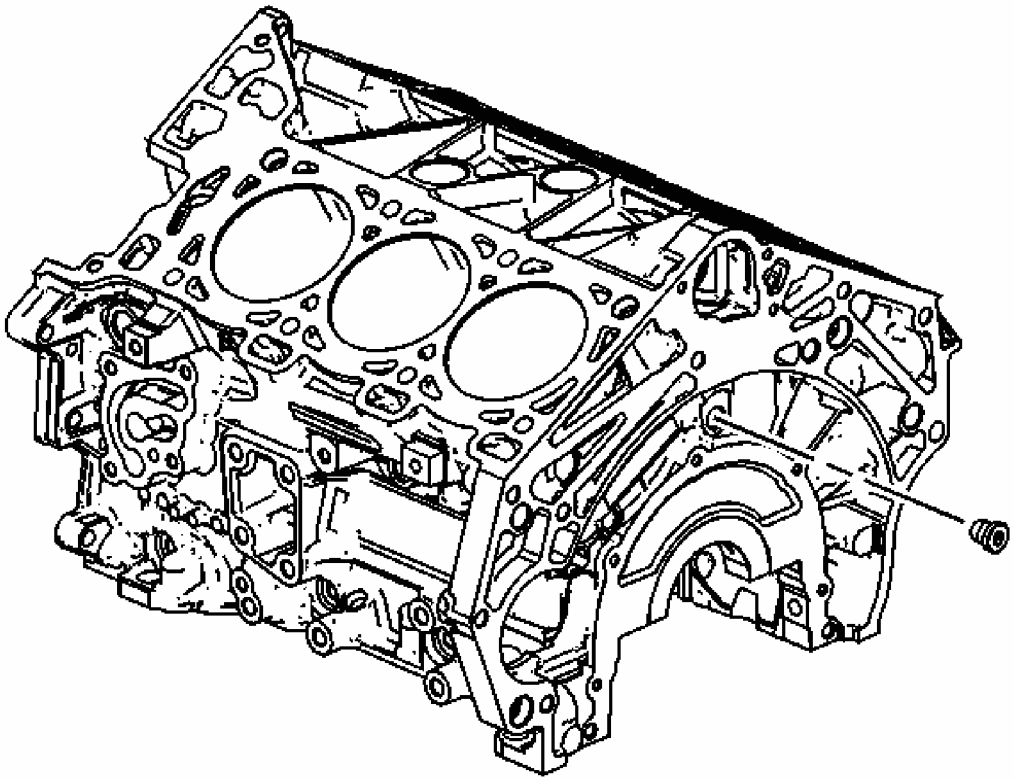

Fig. 42: M14 Rear Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

7. Remove the M14 rear oil gallery threaded plug.

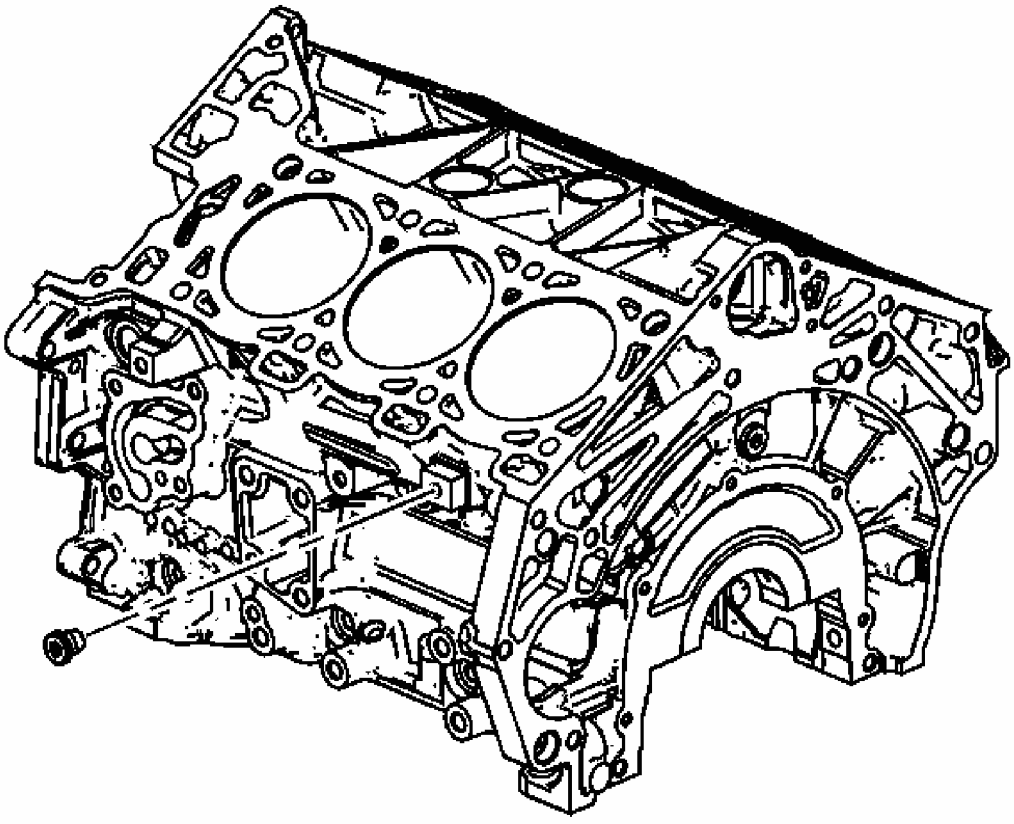

Fig. 43: View Of M14 Left Side Coolant Drain Threaded Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the M14 left side coolant drain threaded plug.

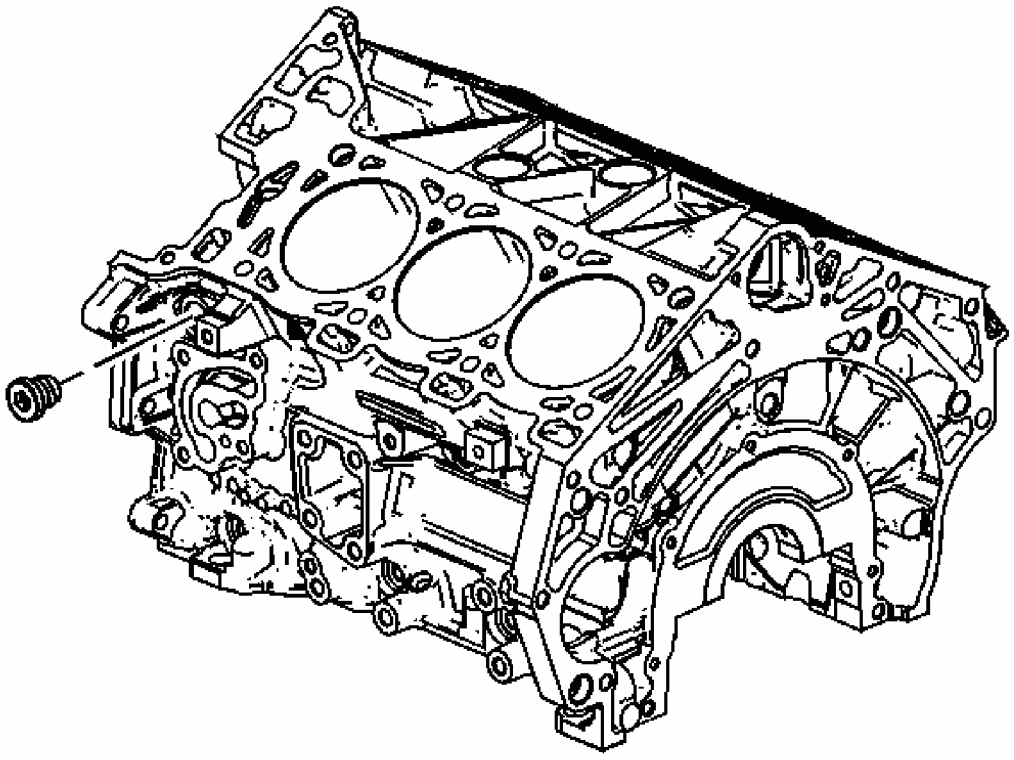

Fig. 44: Removing/Installing M20 Left Side Oil Gallery Threaded Plug
Courtesy of GENERAL MOTORS CORP.

9. Remove the M20 left side oil gallery threaded plug.

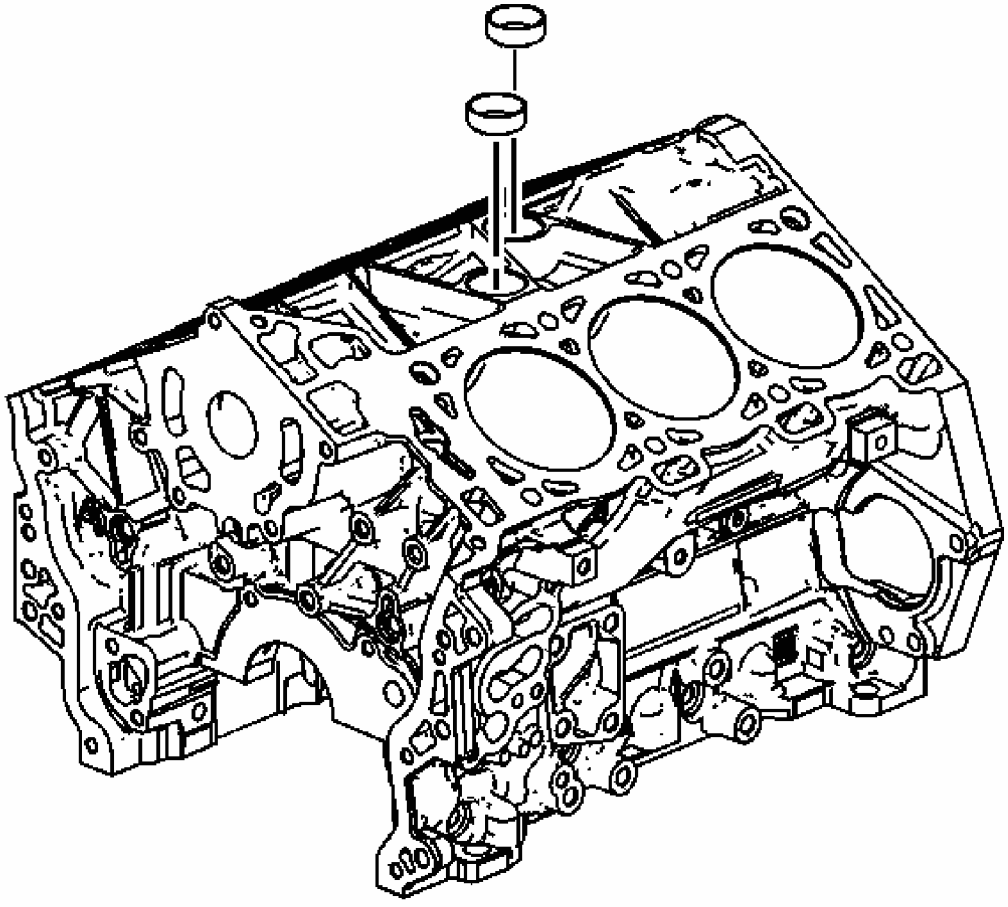

Fig. 45: Identifying Coolant Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant expansion plugs.

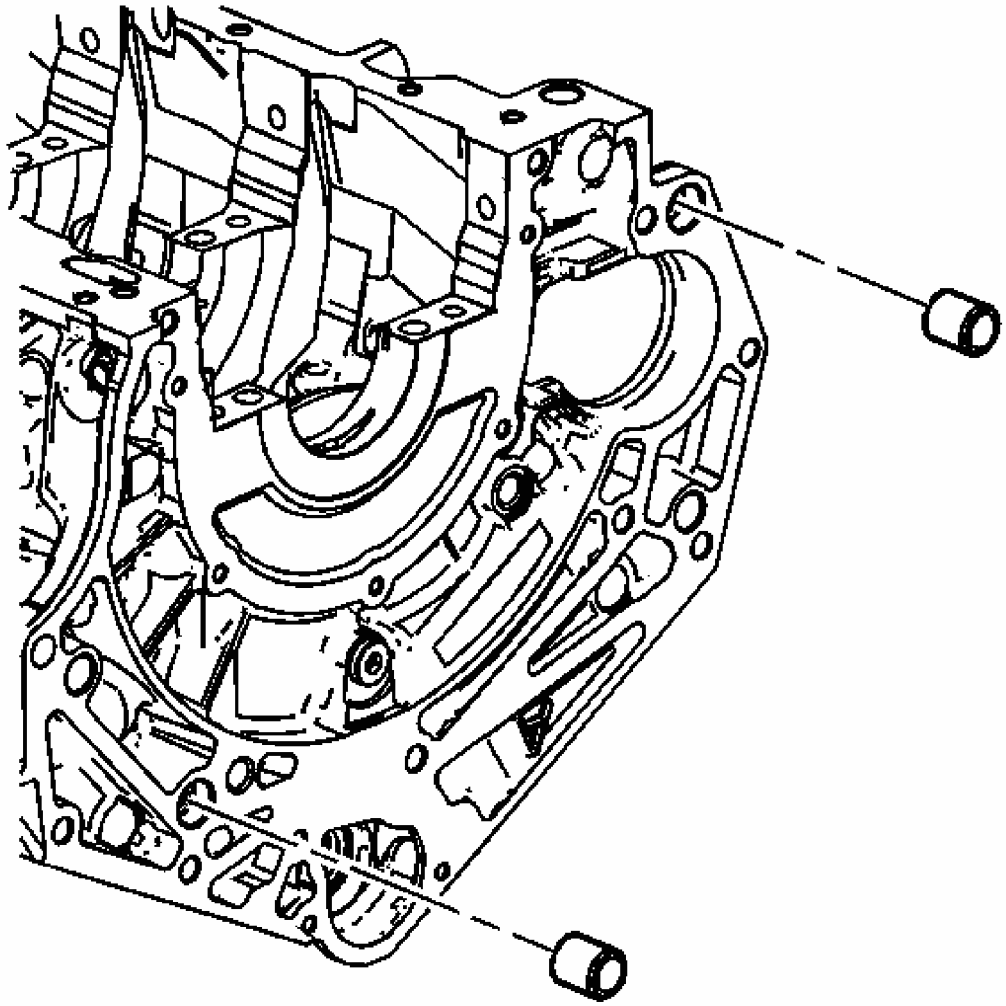

Fig. 46: Cylinder Block-To-Transmission Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

11. Remove the cylinder block-to-transmission alignment dowels.

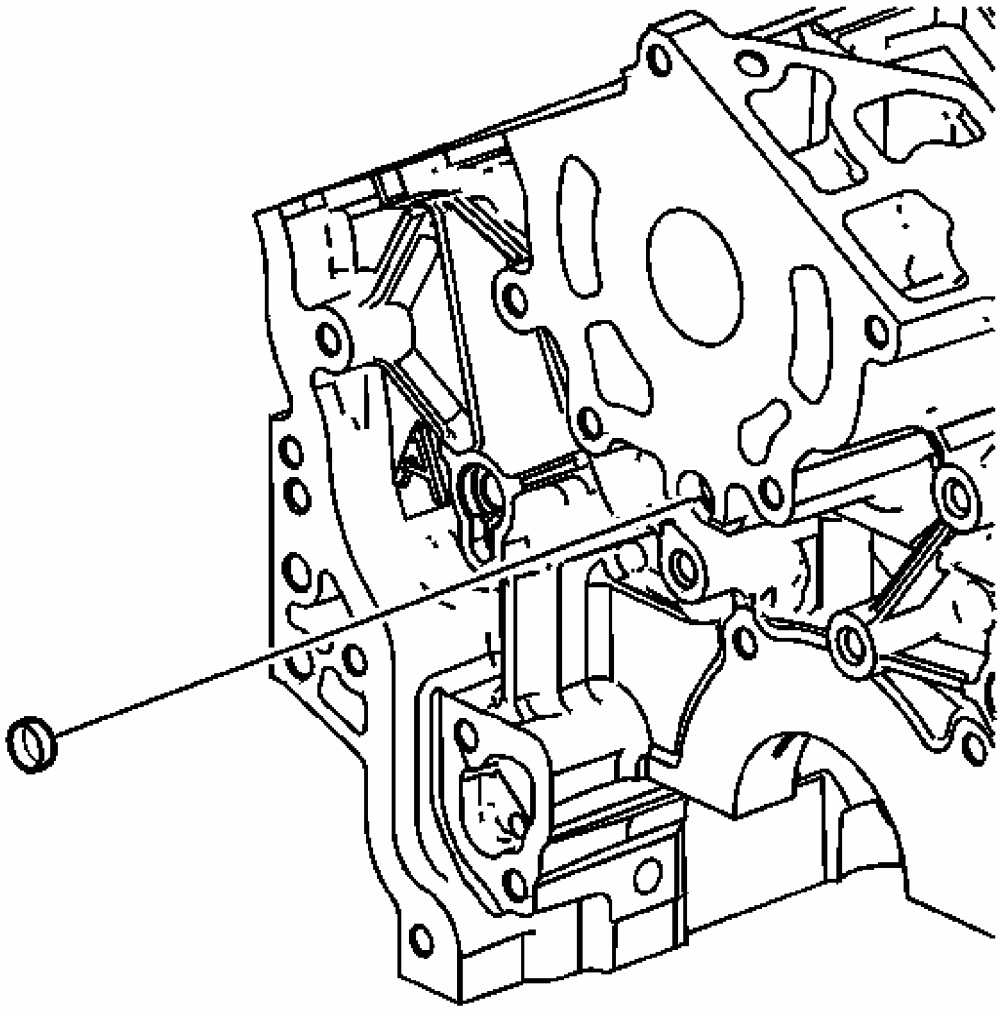

Fig. 47: Locating Front Oil Gallery Expansion Plug
Courtesy of GENERAL MOTORS CORP.

12. Remove the front oil gallery expansion plug.

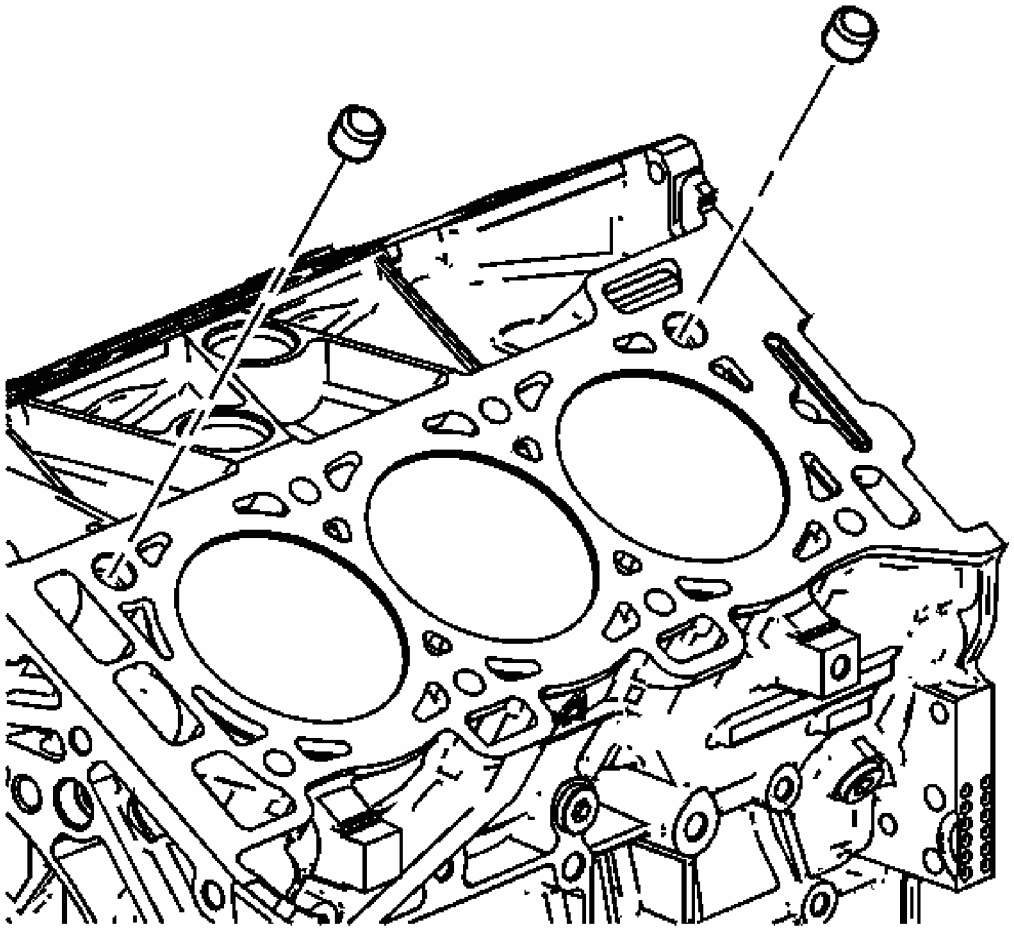

Fig. 48: Cylinder Block-To-Cylinder Head Alignment Dowels
Courtesy of GENERAL MOTORS CORP.

13. Remove the cylinder block-to-cylinder head alignment dowels.

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

- **J 8087** Cylinder Bore Gage
- **J 28410** Gasket Remover

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using **J 28410** .
2. Clean all the following areas with solvent:

- Sealing surfaces
- Cooling passages
- Oil passages
- Bearing journals

3. Clean all threaded and through holes with solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

4. Dry the engine block with compressed air.

Visual Inspection

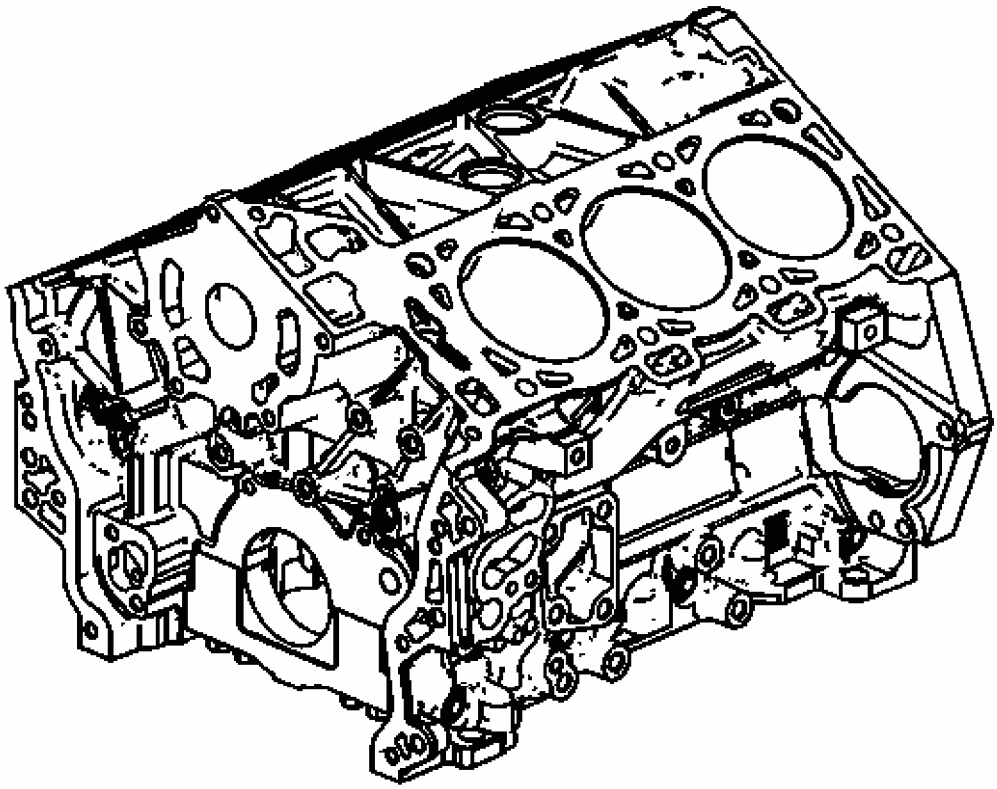

Fig. 49: View Of Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft

bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.

2. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or excessive debris.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to **Thread Repair Specifications** and **Thread Repair** .

Measuring Cylinder Bore Diameter

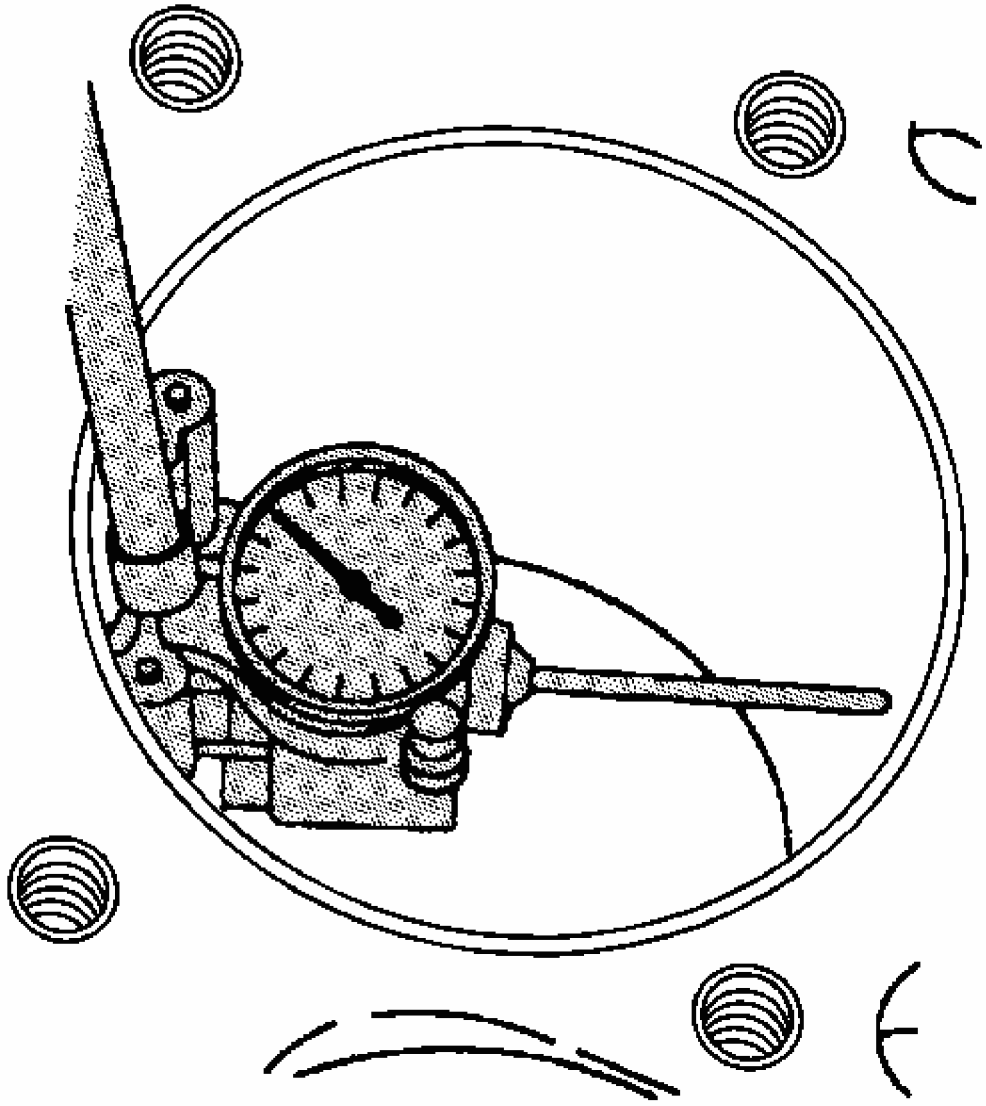

Fig. 50: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the **J 8087** .

Compare your results with the **Engine Mechanical Specifications** . If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Taper

1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the **Engine Mechanical Specifications** . If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Out-of-Round

1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the **Engine Mechanical Specifications** . If the cylinders exceed these specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Deck Flatness Inspection

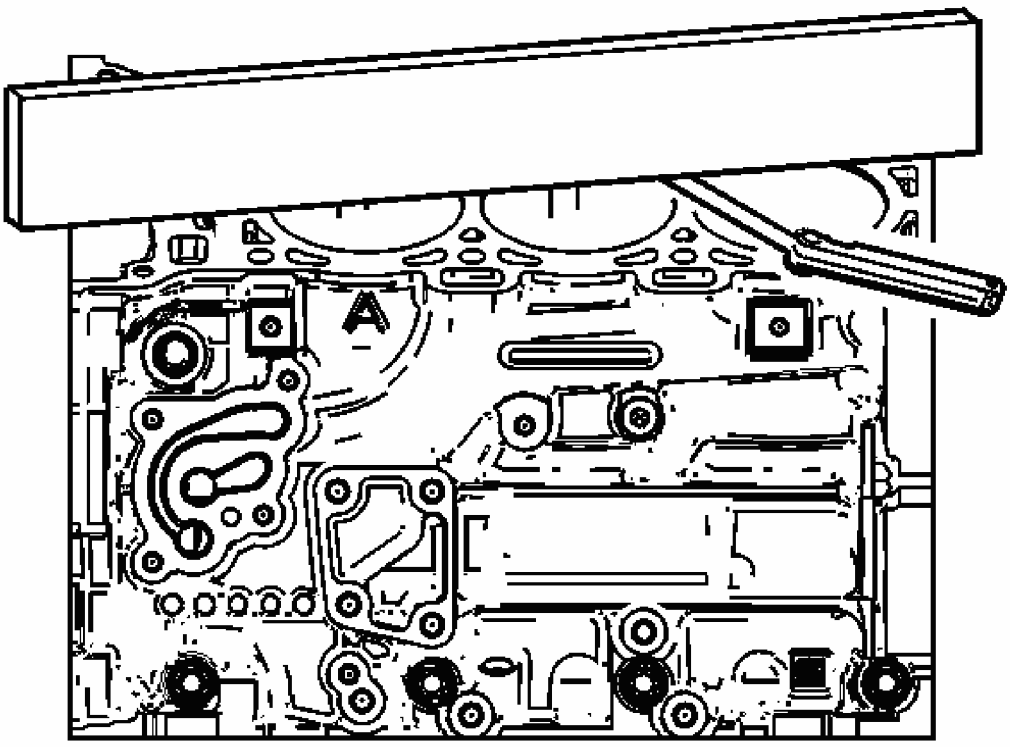

Fig. 51: Measuring Deck Flatness
Courtesy of GENERAL MOTORS CORP.

1. Ensure the engine block decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gage at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the following components in solvent:
    - Crankshaft bearings
    - Connecting rod bearings
    - Crankshaft journals
    - Crankpin journals
    - Crankshaft oil passages
    - Crankshaft threaded holes

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the following components with compressed air:
    - Crankshaft bearings
    - Connecting rod bearings
    - Crankshaft journals
    - Crankpin journals
    - Crankshaft oil passages
    - Crankshaft threaded holes

Visual Inspection

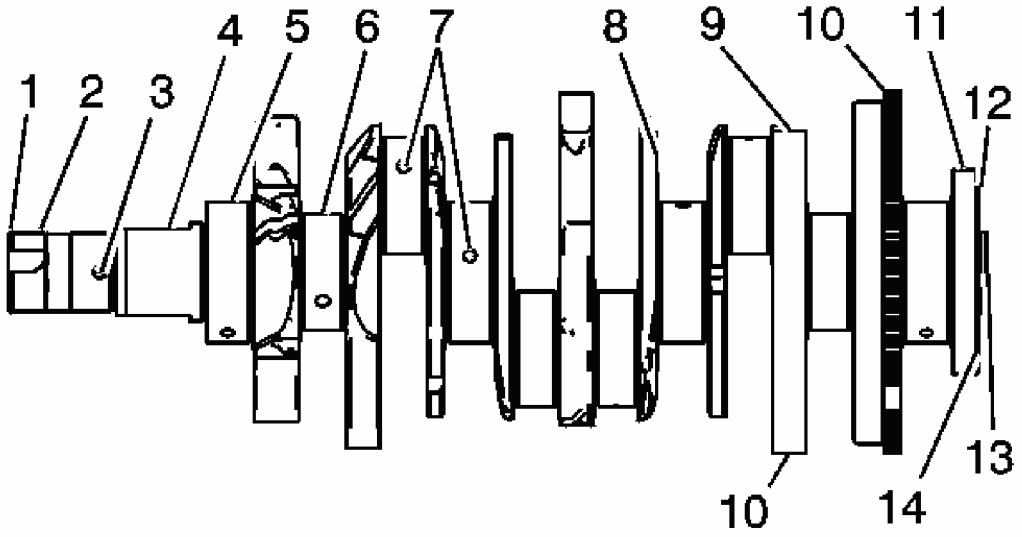

Fig. 52: Inspecting Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Perform the following visual inspections:
    - Inspect the crankshaft balancer bolt hole (1) for thread damage.
    - Inspect the crankshaft balancer mounting area (2) for damage.
    - Inspect the crankshaft sprocket pin hole (3) for damage.
    - Inspect the oil pump drive flats (4) for damage.
    - Inspect the crankshaft main journals (5) for damage.
    - Inspect the crankshaft connecting rod journals (6) for damage.
    - Inspect the crankshaft oil passages (7) for obstructions.
    - Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
    - Inspect the crankshaft counterweights (9) for damage.
    - Inspect the crankshaft reluctor ring teeth (10) for damage.
    - Inspect the crankshaft rear main oil seal surface (11) for damage.
    - Inspect the crankshaft engine flywheel mounting surface (12) for damage.
    - Inspect the crankshaft pilot hole (13) for damage.
    - Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.
2. Repair or replace the crankshaft as necessary.

Crankshaft Bearing Inspection

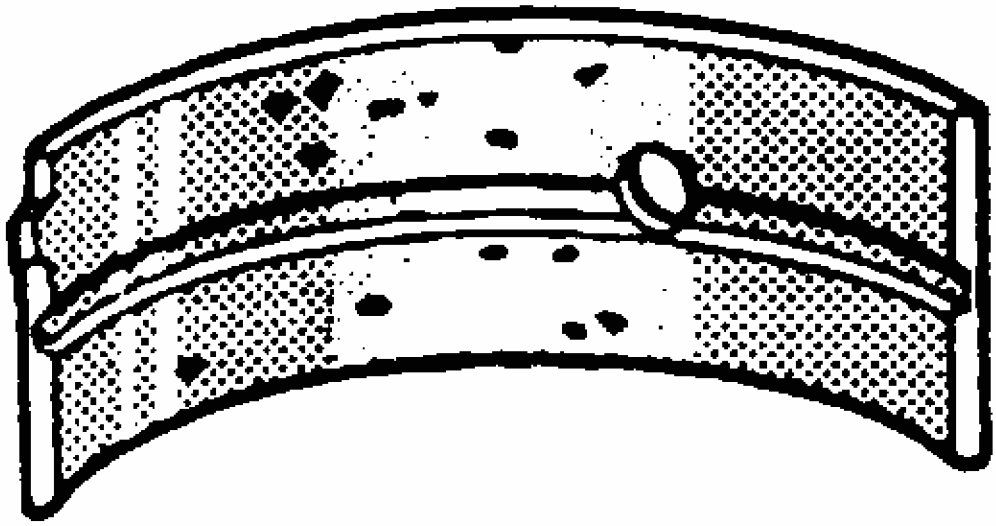

Fig. 53: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.**
- **The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.**

1. Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

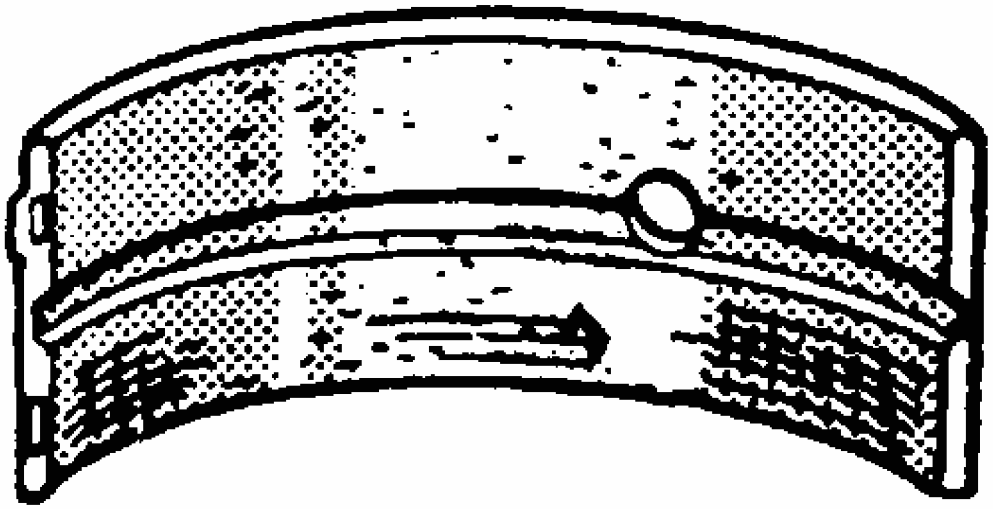

Fig. 54: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

2. Inspect for excessive scoring or discoloration on both front and back of the bearing halves.
3. Inspect the main bearings for dirt embedded into the bearing material.

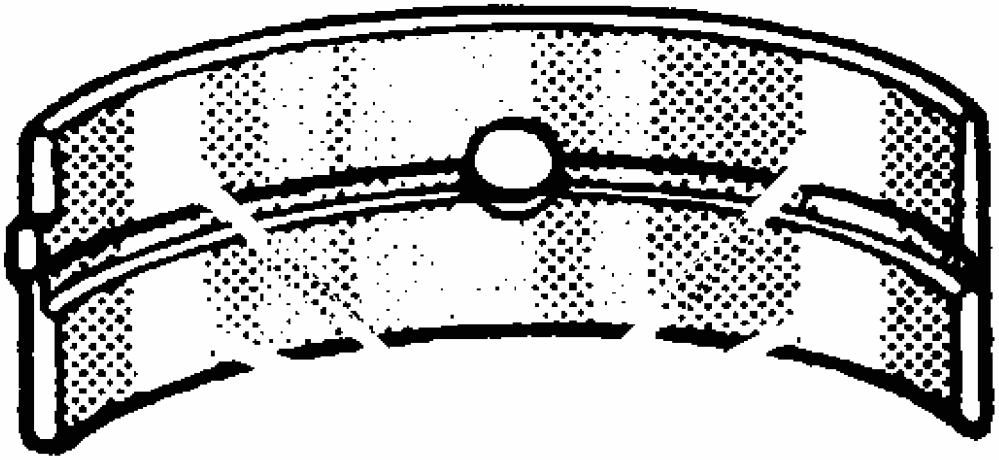

Fig. 55: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

4. Inspect for improper seating indicated by bright, polished sections.

Crankshaft Measurement

Tools Required

J 7872 Magnetic Base Dial Indicator

Measurement Procedure

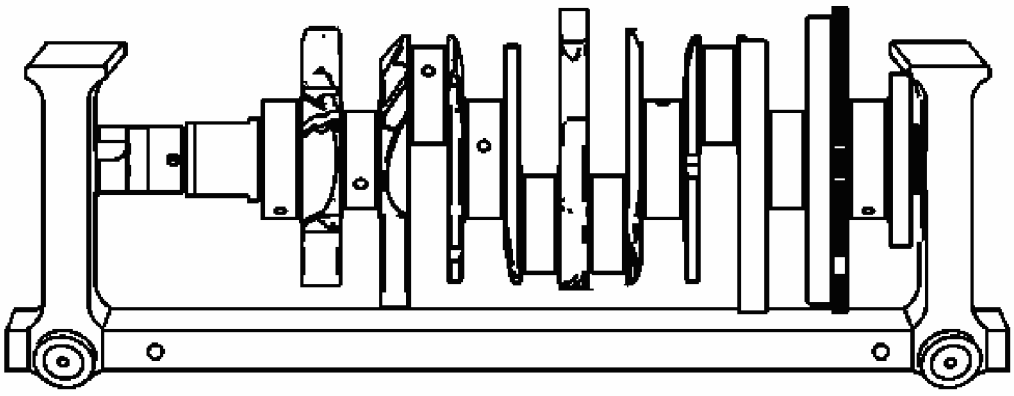

Fig. 56: View Of Crankshaft In Fixture
Courtesy of GENERAL MOTORS CORP.

1. Using a suitable fixture, support the crankshaft.

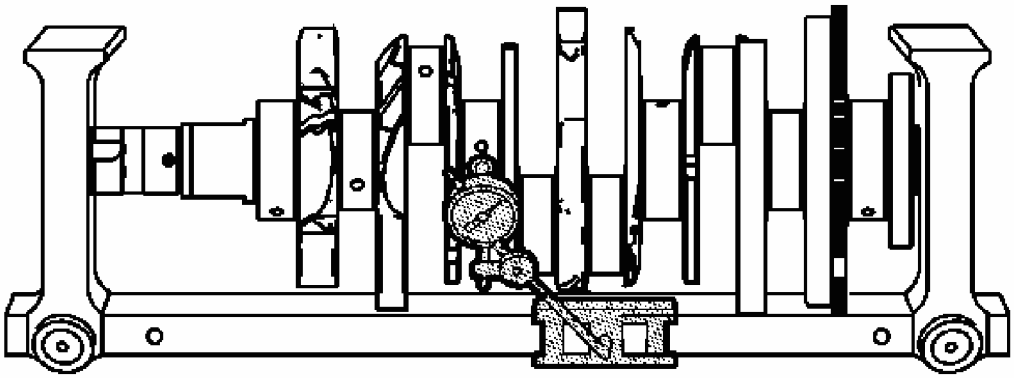

Fig. 57: Identifying J 7872
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 7872** .
3. Measure the crankshaft runout using the **J 7872** . Refer to **Engine Mechanical Specifications** .

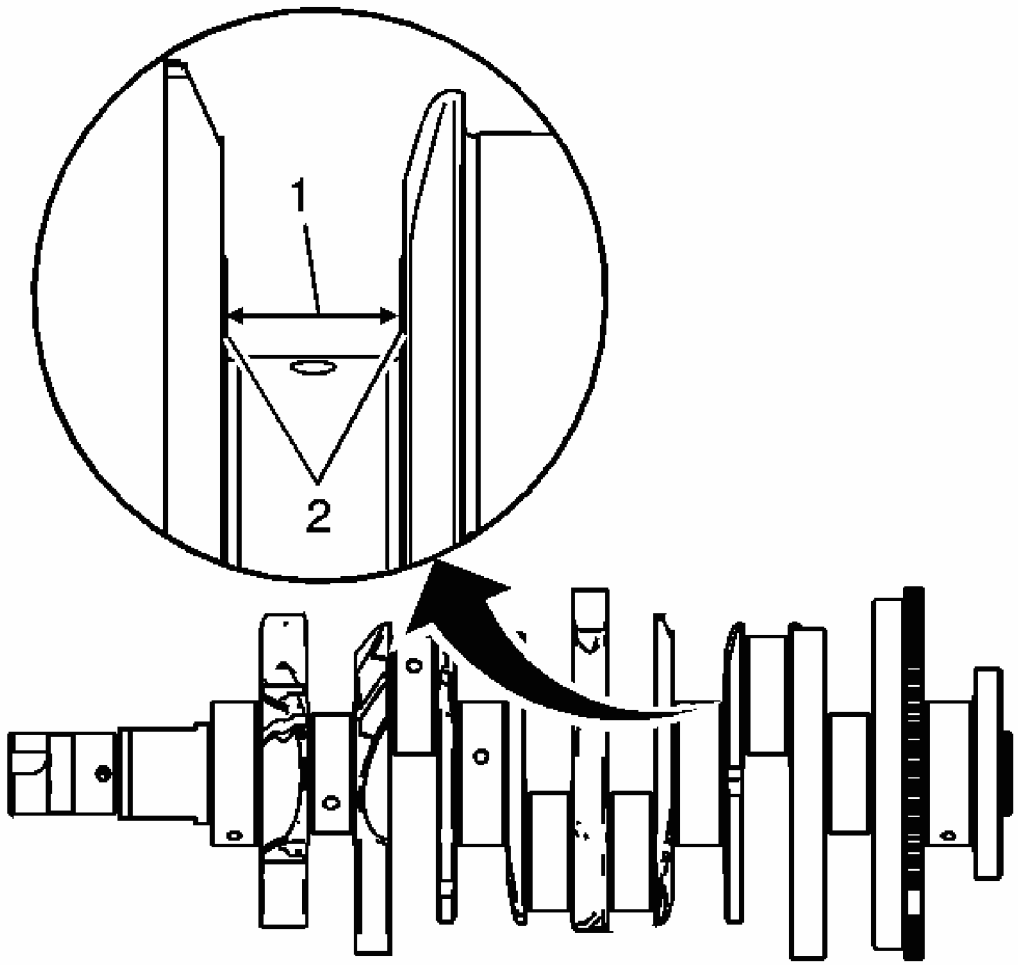

Fig. 58: Measuring Crankshaft Thrust Wall Width For Wear
Courtesy of GENERAL MOTORS CORP.

4. Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to **Engine Mechanical Specifications** .
5. Measure the crankshaft thrust wall surface (2) for runout using the **J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.

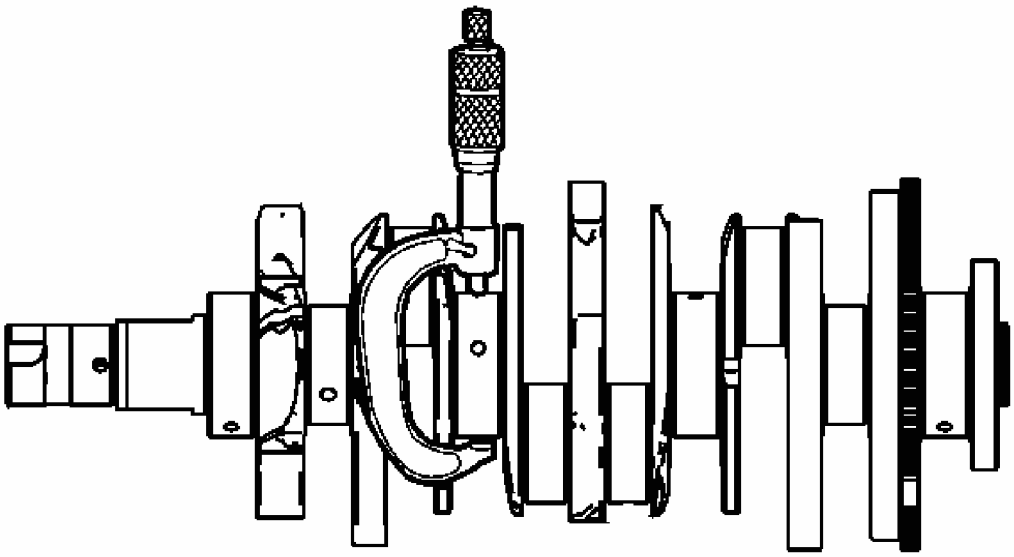

Fig. 59: Inspecting Crankshaft Main Journals For Undersize
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft main journals for undersize, using an outside micrometer.

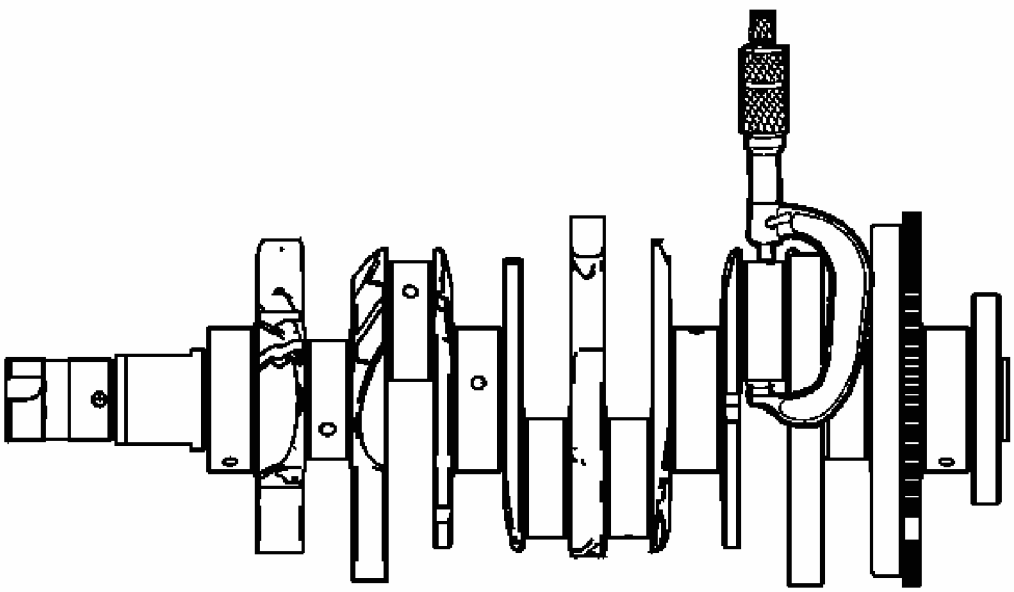

Fig. 60: Using An Outside Micrometer To Inspect Crankpins For Undersize
Courtesy of GENERAL MOTORS CORP.

8. Inspect the crankpins for undersize using an outside micrometer.
9. Compare your measurements with those listed in the **Engine Mechanical Specifications** . If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.

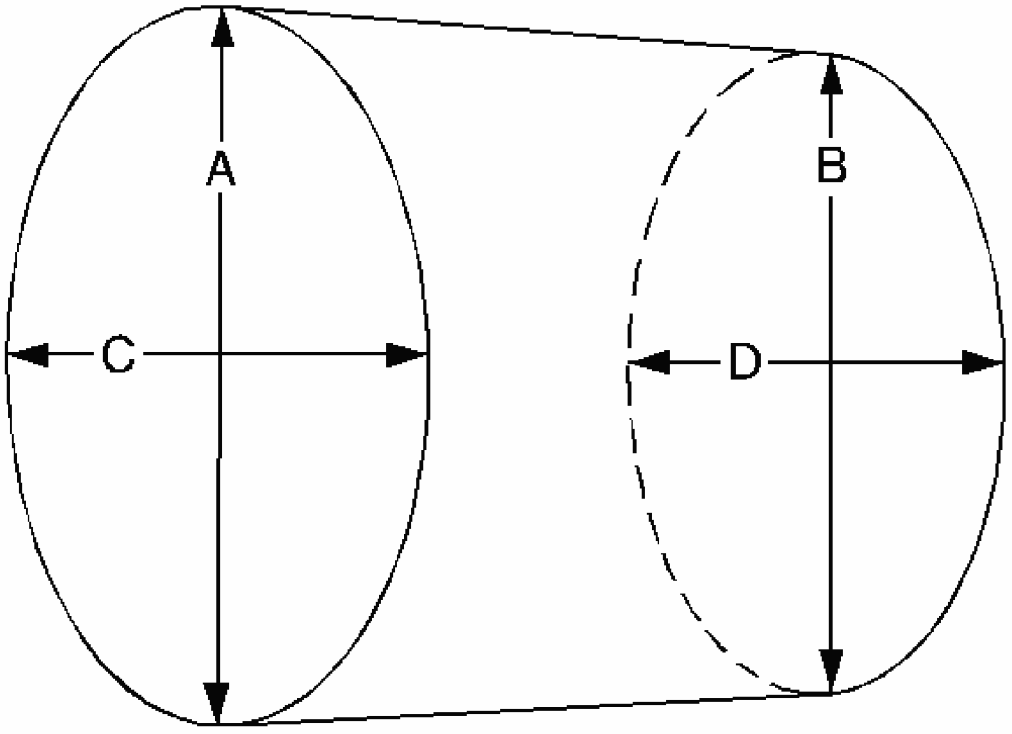

Fig. 61: Identifying Out-Of-Round Measurements
Courtesy of GENERAL MOTORS CORP.

10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
    2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
    3. Subtract A from C and B from D. The differences will indicate journal out-of-

round.

4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

11. Measure the main bearing and crankpin journals for taper using the following procedure:
    1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
    2. Subtract the smallest from the largest measurement. The result will be the journal taper.
    3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.
    4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the crankshaft balancer in solvent that is compatible with the rubber.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the crankshaft balancer with compressed air.

Inspection Procedure

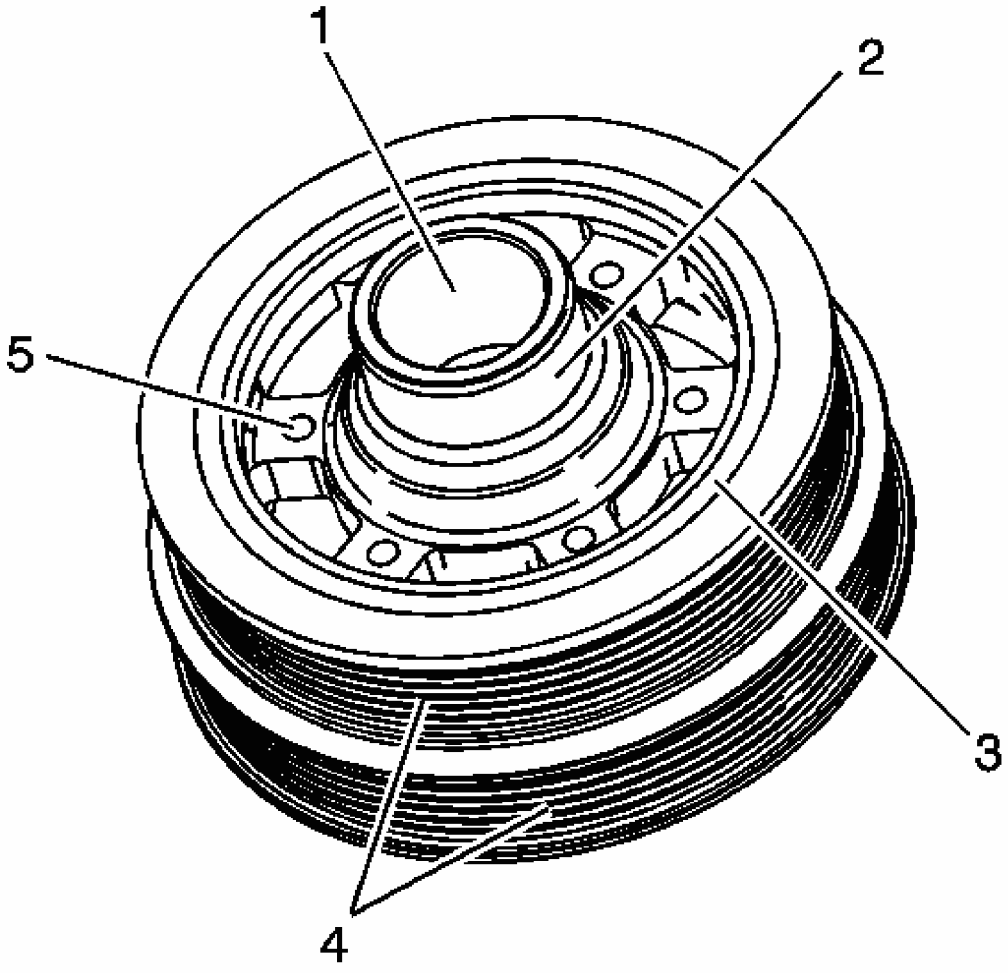

Fig. 62: Inspecting Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft balancer for the following:
    - Worn or damaged hub-to-crankshaft surface (1)
    - Worn, grooved or damaged hub seal surface (2) - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
    - Worn, chunking or deteriorated rubber between the hub and pulley (3)
    - Damaged drive belt ribs (4)
    - Damaged threaded holes (5)
2. Repair or replace the crankshaft balancer as necessary.

ENGINE FLYWHEEL CLEANING AND INSPECTION (AUTOMATIC TRANSMISSION)

Cleaning Procedure

1. Clean the engine flywheel in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the engine flywheel with compressed air.

Inspection Procedure

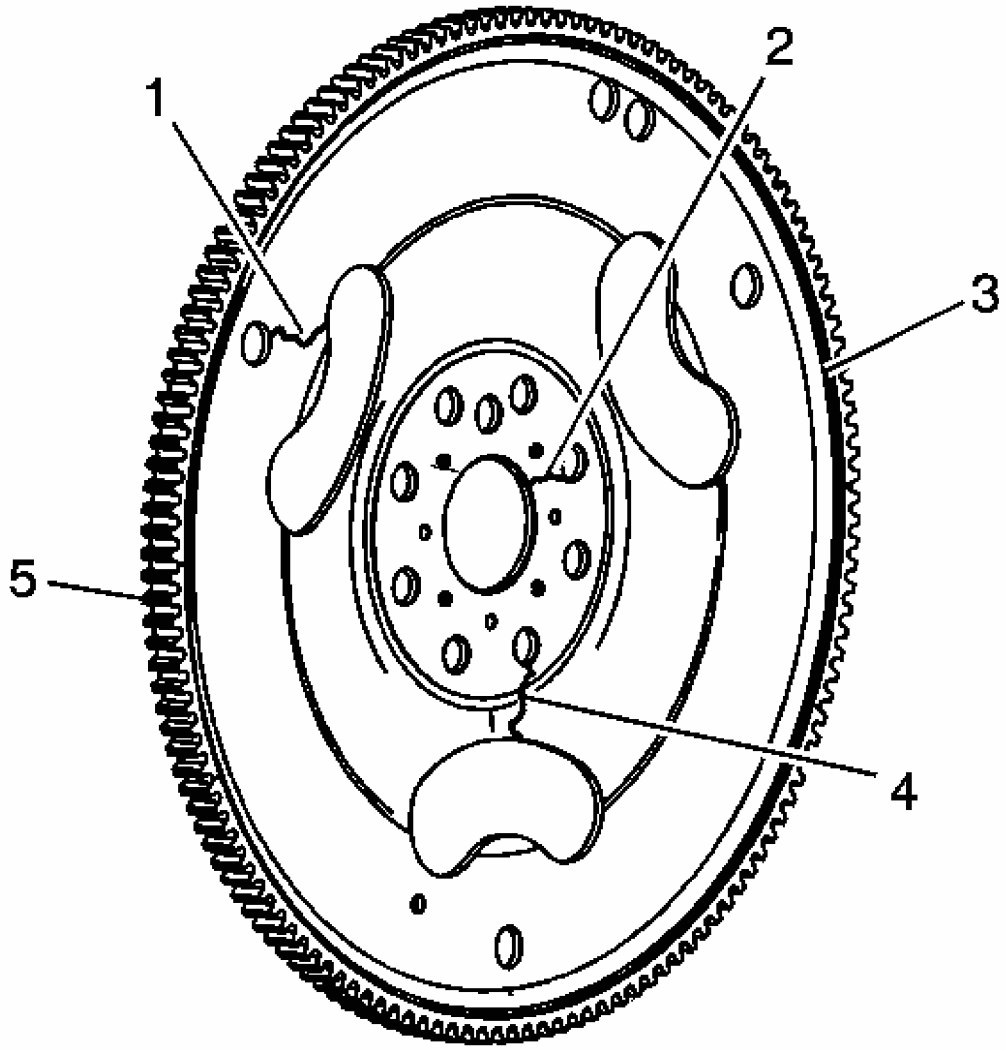

Fig. 63: Inspecting Automatic Transmission Engine Flywheel For Damage

Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 4)

     IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.

   - Cracks at welded areas that retain the ring gear onto the engine flywheel (3)
   - Damaged or missing ring gear teeth (5)
2. Replace the engine flywheel as necessary.

ENGINE FLYWHEEL CLEANING AND INSPECTION (MANUAL TRANSMISSION)

1. Clean the engine flywheel in solvent.

   CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the engine flywheel with compressed air.

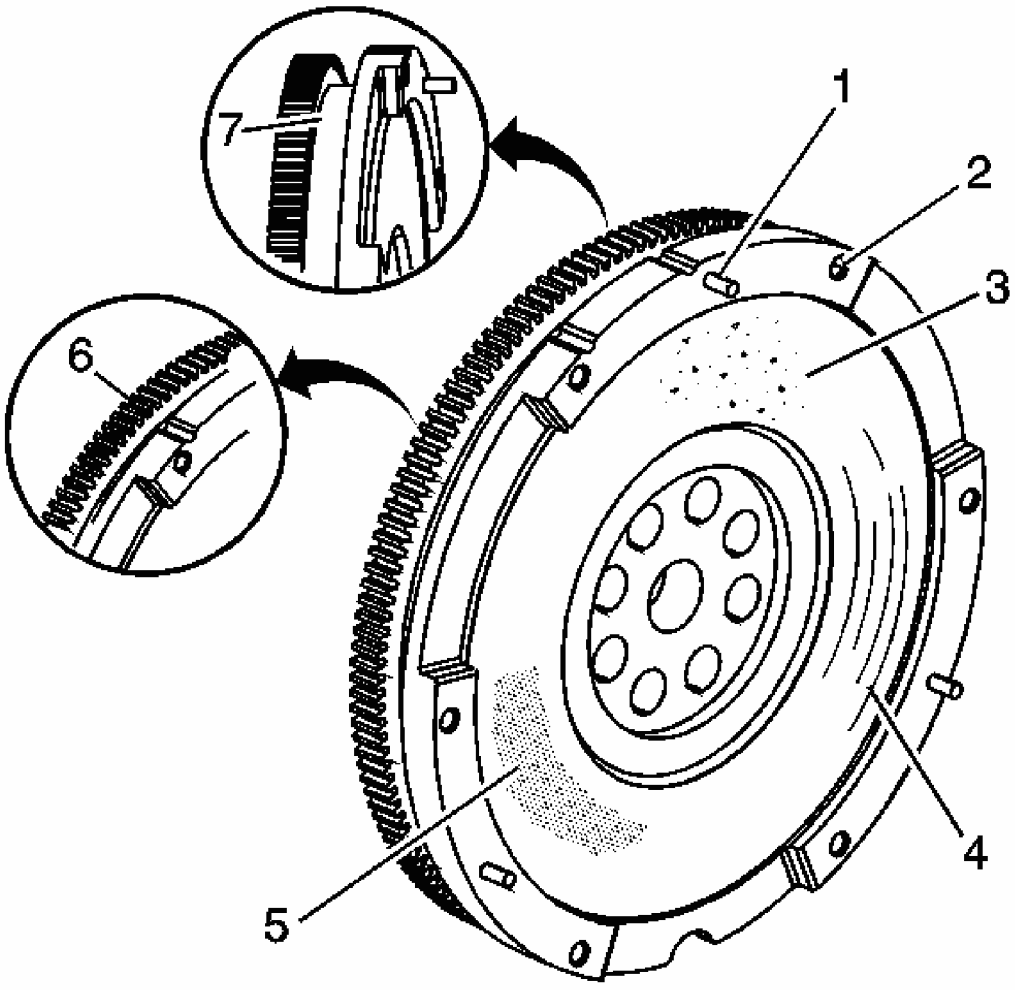

Fig. 64: Inspecting Manual Transmission Engine Flywheel For Damage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the manual transmission engine flywheel for the following conditions:
    - Missing and/or damaged alignment pins (1)
    - Damaged threaded holes (2)
    - Pitted surface (3)
    - Scoring or grooves (4)
    - Rust or other surface damaged (5)
    - Damaged ring gear teeth (6)
    - Loose or improperly positioned ring gear

The ring gear has an interference fit onto the engine flywheel and should be positioned completely against the flange of the engine flywheel (7).

PISTON AND CONNECTING ROD DISASSEMBLE

Tools Required

J 43654 Piston Pin Clip Remover and Installer

Disassemble Procedure

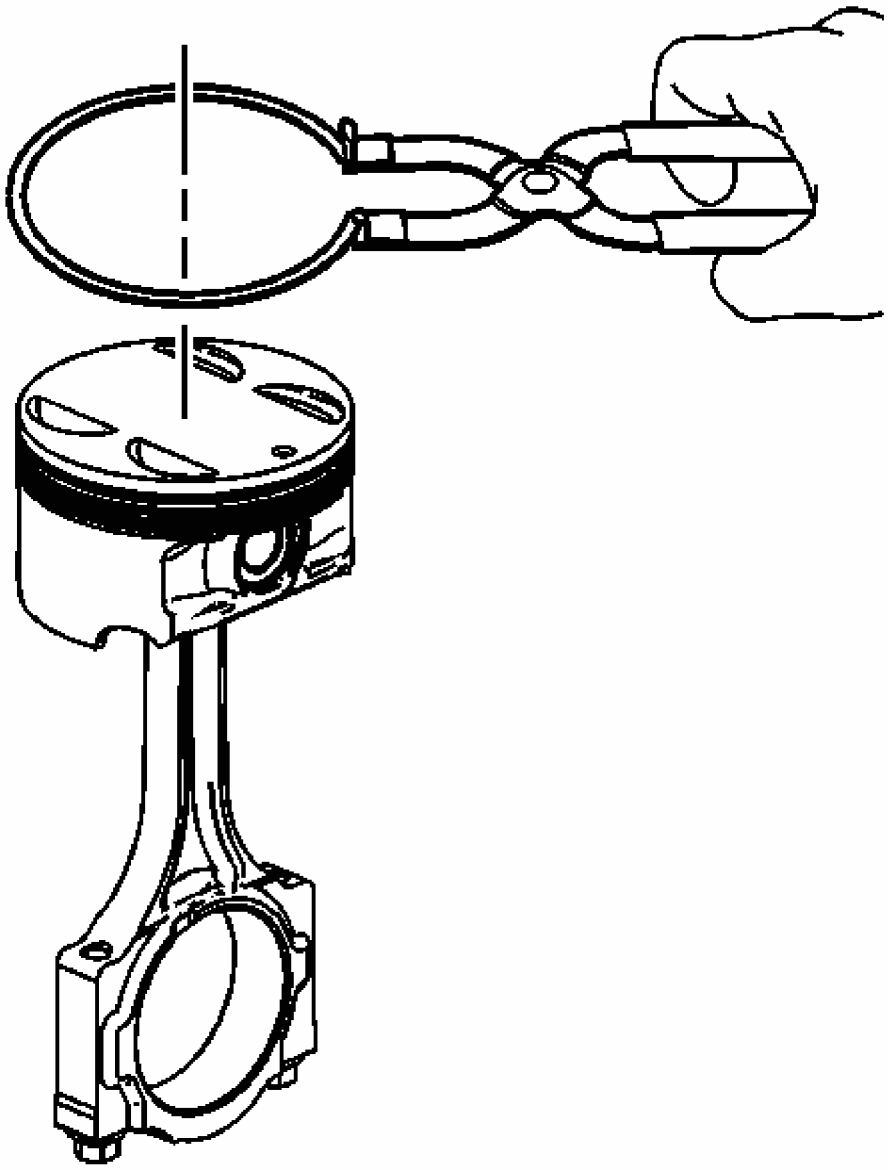

Fig. 65: View Of Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

NOTE: **You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.**

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.

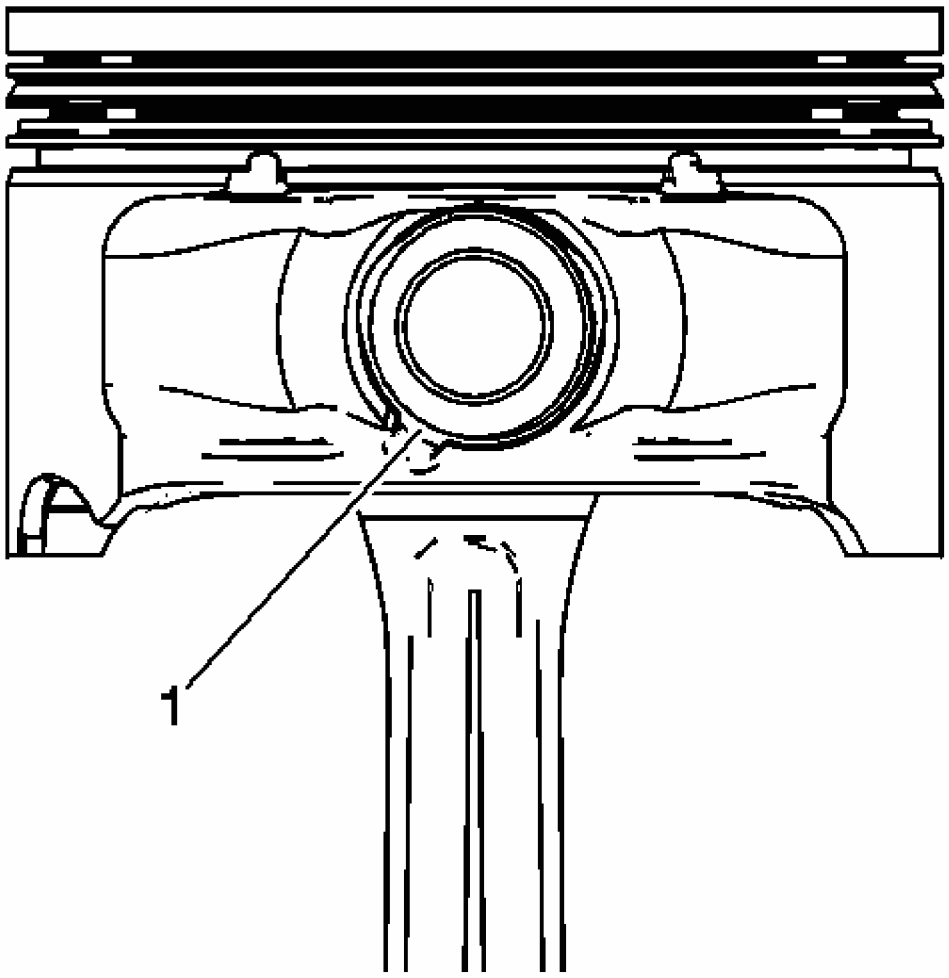

Fig. 66: Identifying Piston Pin Retainers Removal Access Notch
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.**
- **DO NOT reuse the piston pin retainers.**

2. Using the **J 43654** , remove the piston pin retainers by using the removal access notch (1)

in the side of the piston. Discard the piston pin retainers.

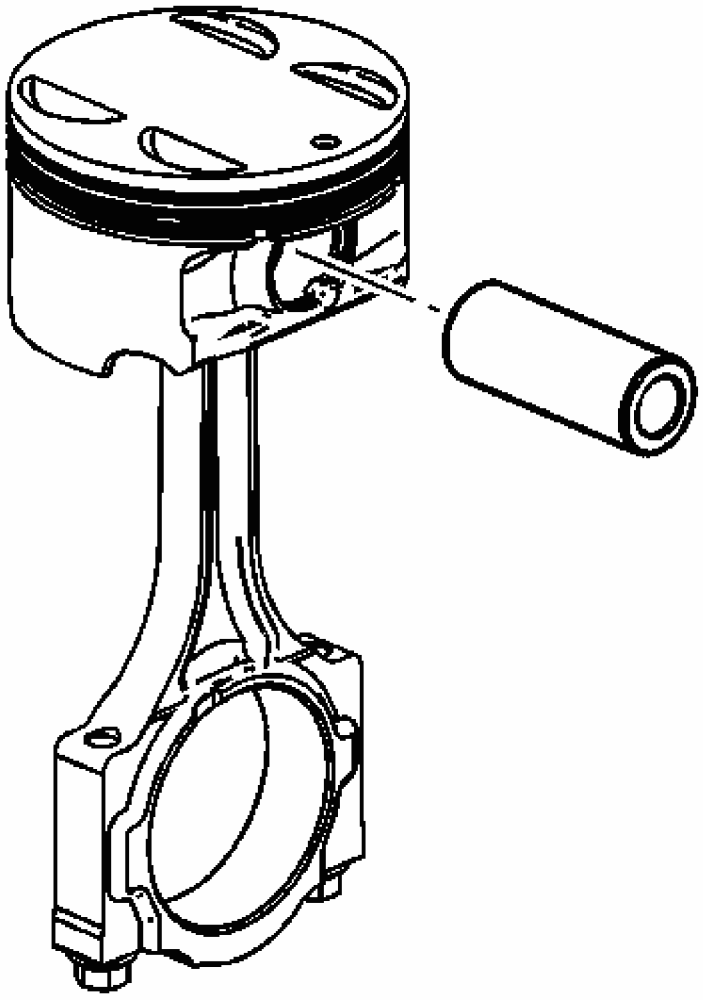

Fig. 67: View Of Piston Pin
Courtesy of GENERAL MOTORS CORP.

3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION

Cleaning Procedure

IMPORTANT: DO NOT wire brush any part of the piston.

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the piston with compressed air.

Piston Inspection Procedure

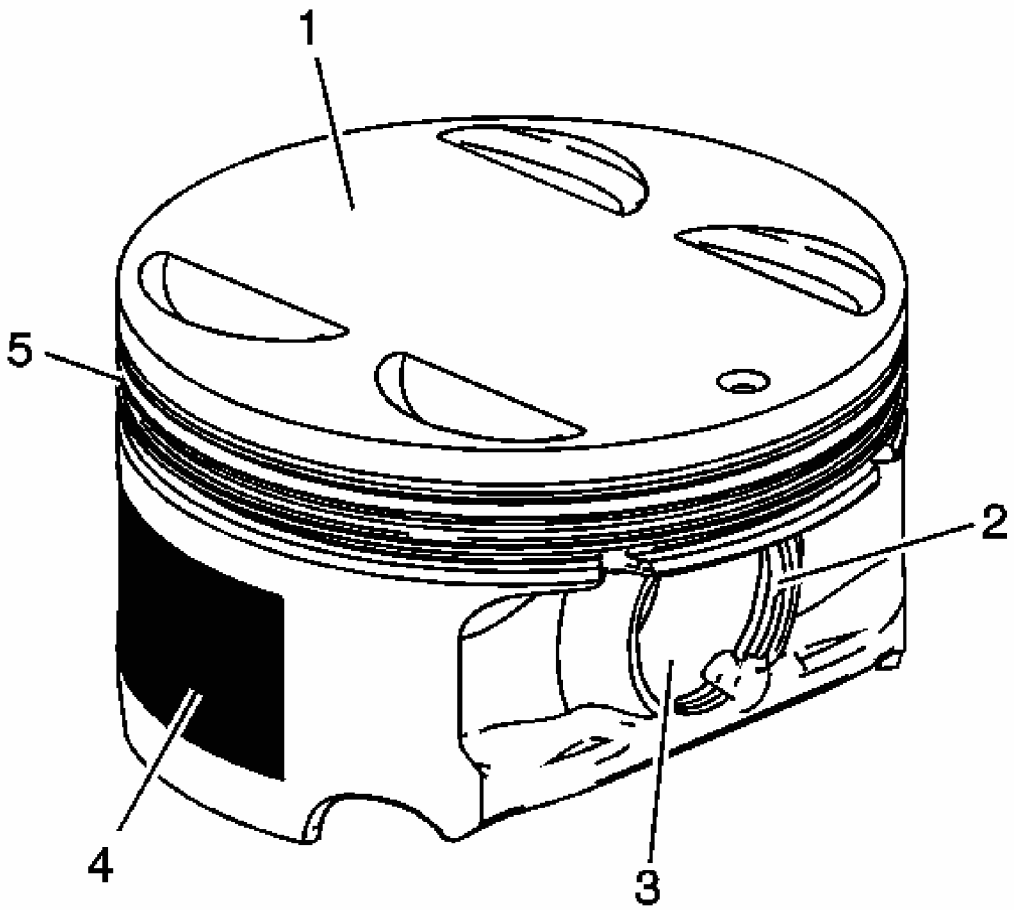

Fig. 68: Piston Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the pistons for the following conditions:

- Cracked ring lands, skirts or pin bosses
- Ring grooves for nicks, burrs that may cause binding (5)
- Warped or worn ring lands (5)
- Piston pin retainer grooves for burrs (2)
- Eroded areas at the top of the piston (1)
- Scuffed or damaged skirt coating (4)
- Worn piston pin bores or worn piston pins (3)

2. Replace pistons that show any signs of damage or excessive wear.

Piston Measurement Procedure

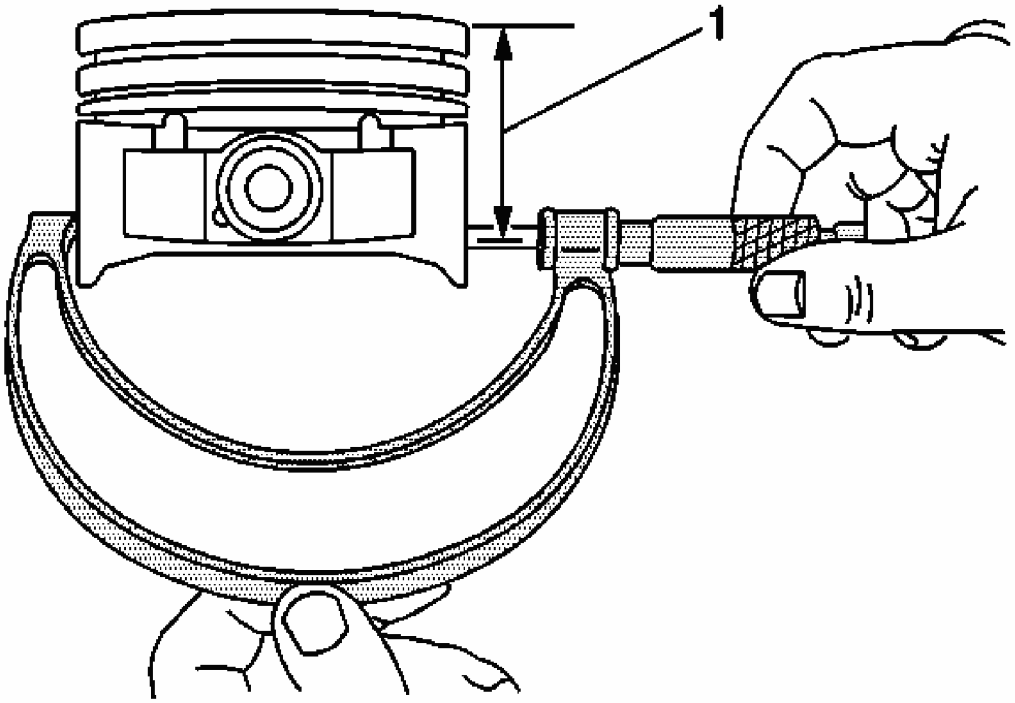

Fig. 69: Measuring Piston Width
Courtesy of GENERAL MOTORS CORP.

1. Measure piston width using the following procedure:
    1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top (1), at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
    2. Compare the measurement of the piston to its original cylinder by subtracting the

piston width from the cylinder diameter.

3. Check your measurements with the **Engine Mechanical Specifications** .
4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.

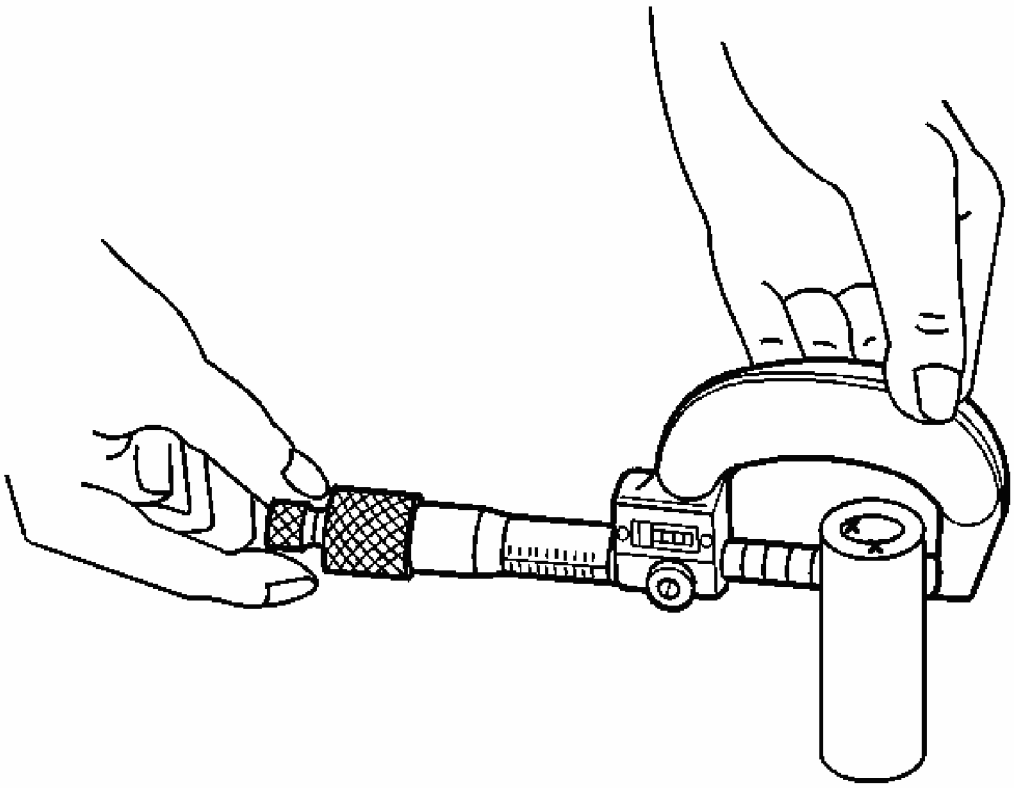

Fig. 70: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

2. Measure the piston pin bore to piston pin clearances using the following procedure:
    1. Piston pin bores and pins must be free of varnish or scuffing.
    2. Use an outside micrometer to measure the piston pin in the piston contact areas.

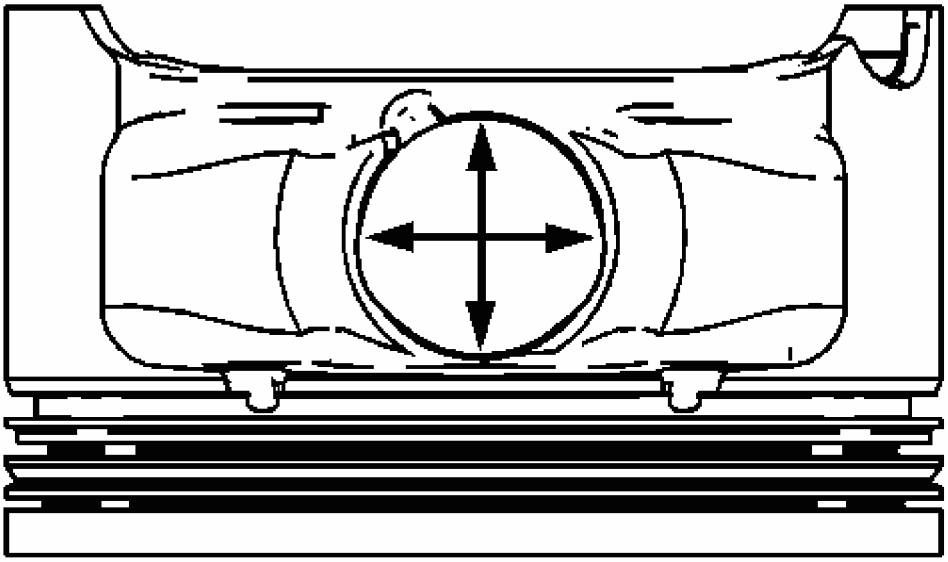

Fig. 71: Checking Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS CORP.

3. Using an inside micrometer, measure the piston pin bore. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the **Engine Mechanical Specifications** .
4. If the clearance is excessive, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Piston Ring Measurement Procedure

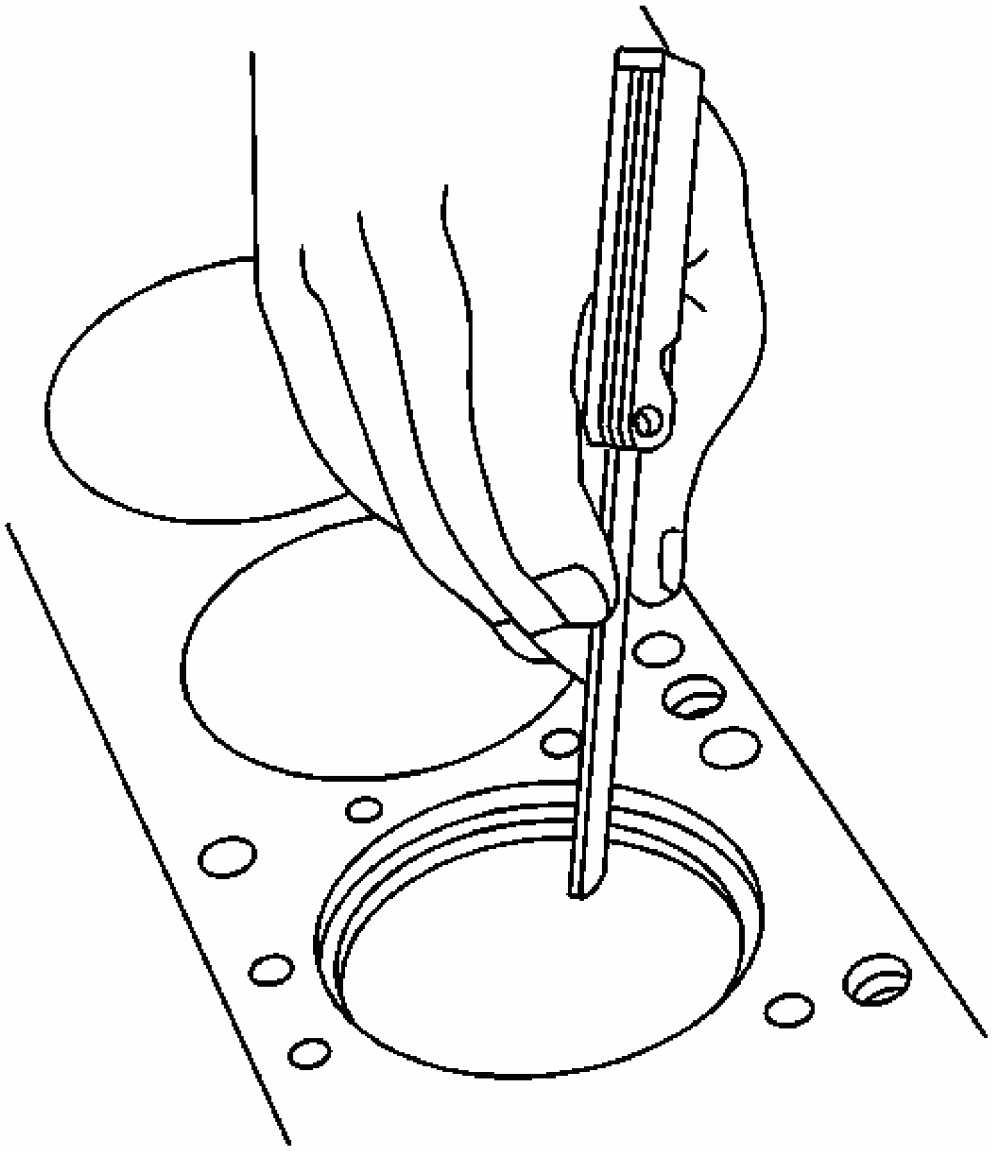

Fig. 72: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

1. Measure the piston ring end gap using the following procedure:
    1. Place the piston ring in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
    2. Measure the end gap of the piston ring with feeler gages. Refer to **Engine**

Mechanical Specifications .

3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

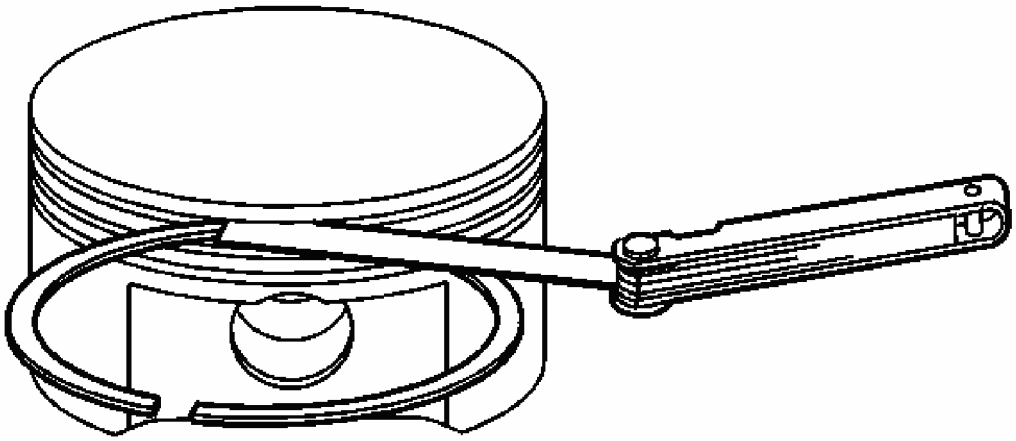

Fig. 73: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

2. Measure the piston ring side clearance using the following procedure:
    1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.
    2. With the piston ring on the piston, use feeler gages to check clearance at multiple locations.
    3. Compare the measurements with piston ring side clearance listed in the **Engine Mechanical Specifications** .
    4. If the clearance is greater than specifications, replace the piston rings.

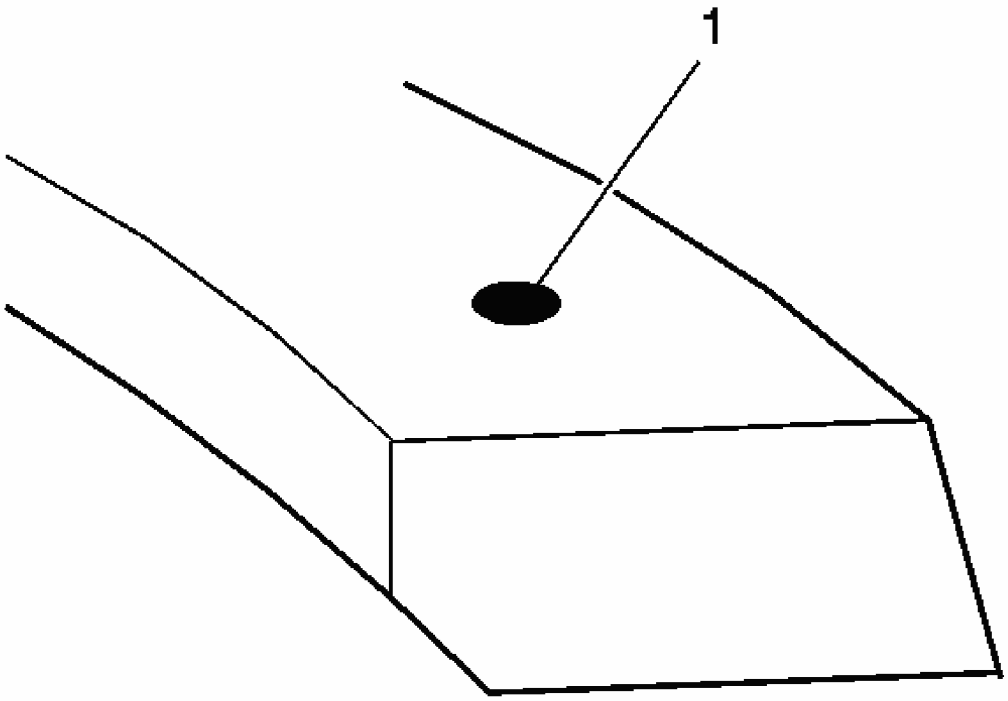

Fig. 74: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the proper specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Connecting Rod Cleaning Procedure

1. Clean the connecting rods in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.

4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure

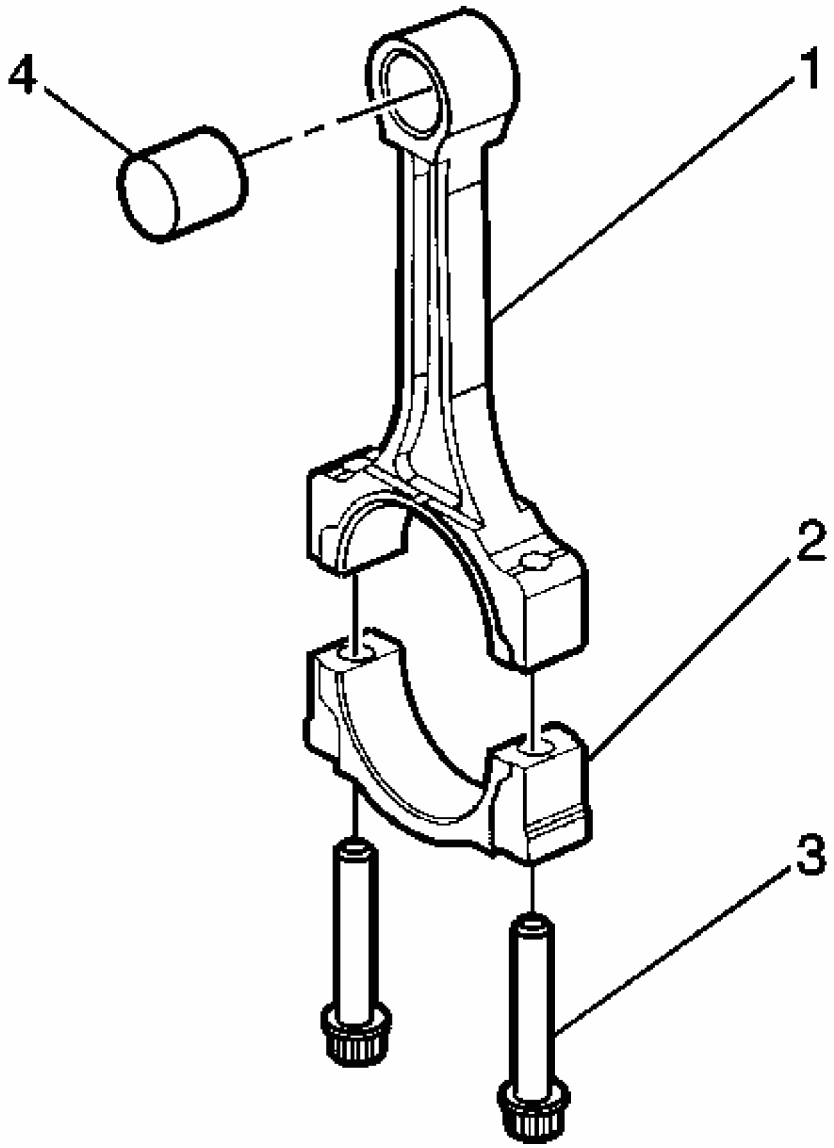

Fig. 75: Inspecting Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Inspect the piston pin bushing (4) for scoring or damage.

2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

IMPORTANT: DO NOT scrape the rod or rod cap.

5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

Connecting Rod Measurement Procedure

Piston Pin End

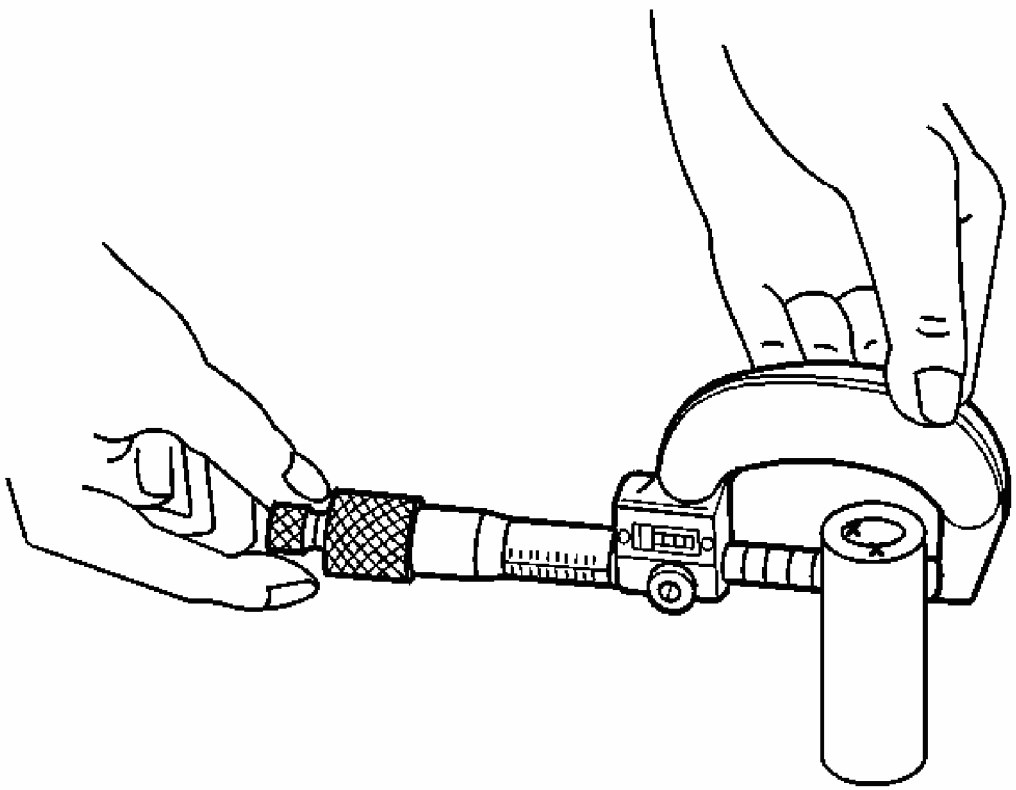

Fig. 76: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.

1. Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact.

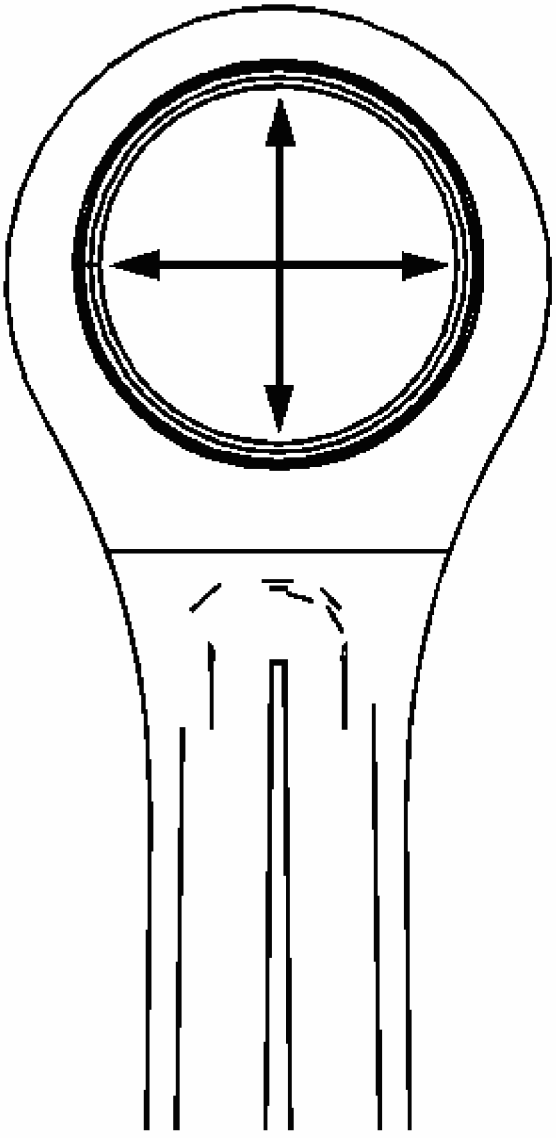

Fig. 77: Checking Connecting Rod Piston Pin Bore Dimensions
Courtesy of GENERAL MOTORS CORP.

2. Using an inside micrometer, measure the connecting rod piston pin bore.
3. Subtract the piston pin diameter from the piston pin bore.
4. Compare the clearance measurements with the **Engine Mechanical Specifications** .

5. If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

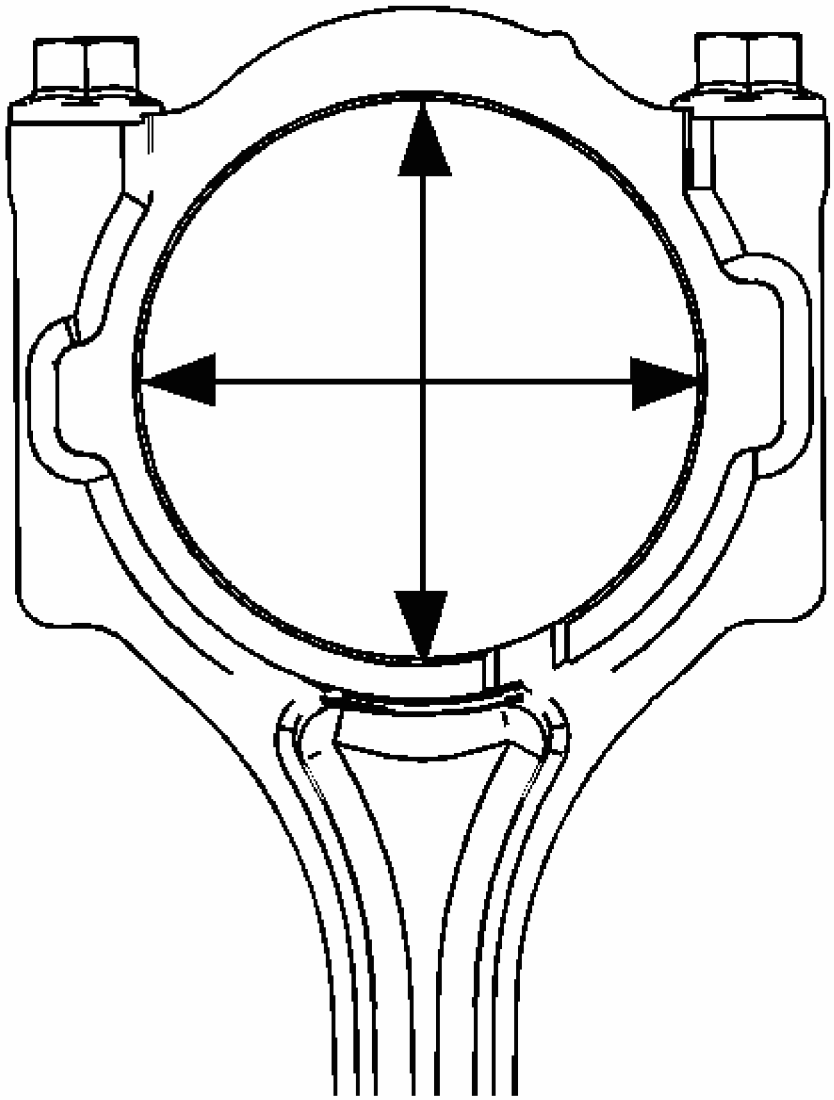

Fig. 78: Measuring Connecting Rod Crankshaft Bearing Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore.
2. Compare the bore measurements with the **Engine Mechanical Specifications** .
3. Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

PISTON AND CONNECTING ROD ASSEMBLE

Tools Required

- **EN 46121** Connecting Rod Guide Pin Set
- **J 43654** Piston Pin Clip Remover and Installer

Piston and Piston Pin Installation Procedure

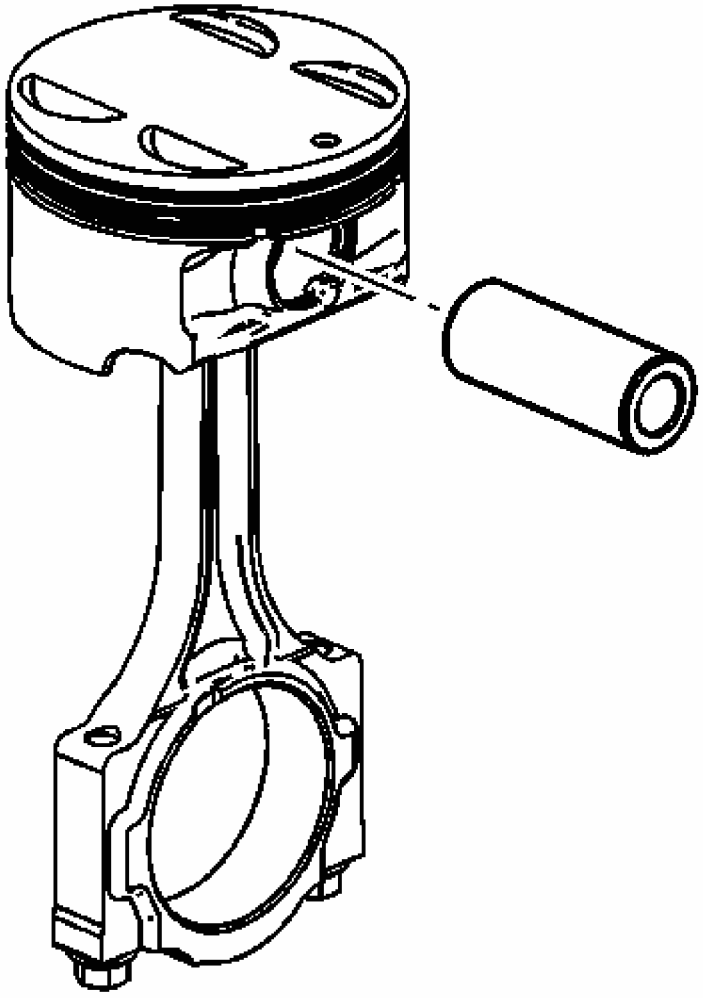

Fig. 79: View Of Piston Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The arrow located on top of the piston must point toward the front of the engine.**
- **The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.**

1. Lubricate the piston pin bores in the piston and the connecting rod with GM prelube lubricant GM P/N 1052367 (Canadian P/N 992869) or equivalent.
2. Assemble the piston and piston pin to the connecting rod. Properly orient the piston

when reusing a marked connecting rod.

3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin into the piston and the connecting rod.

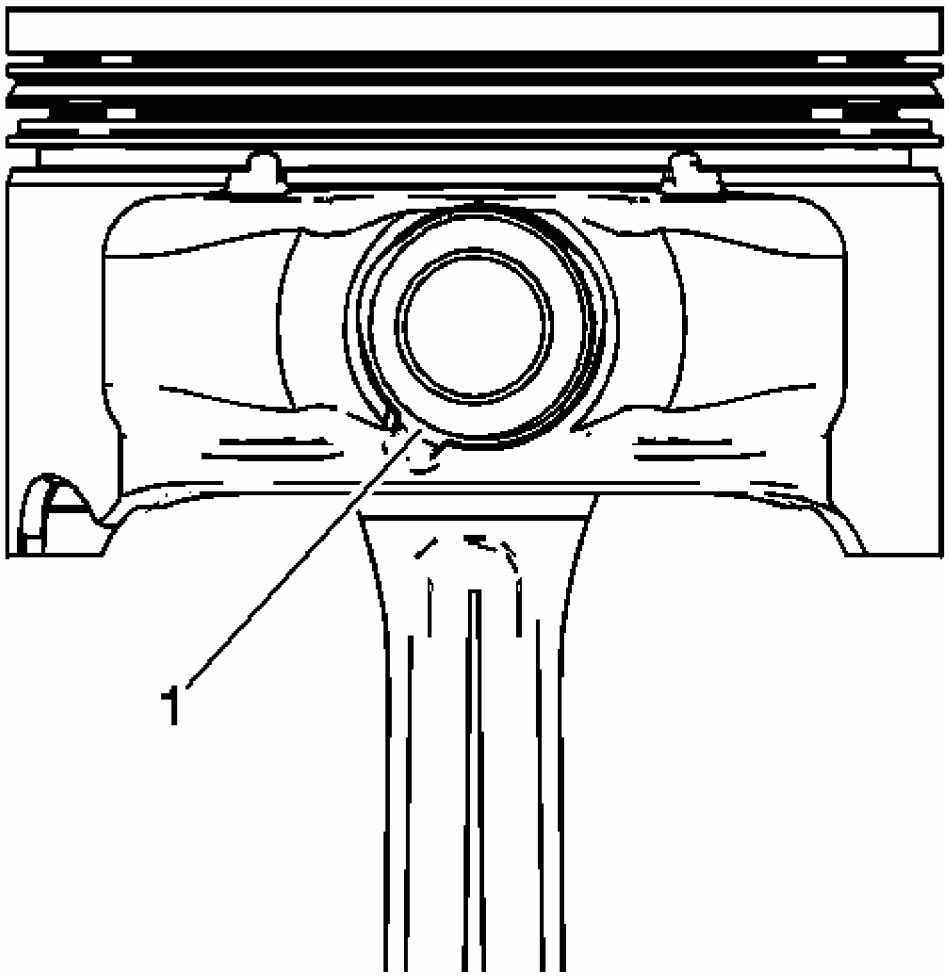

Fig. 80: Identifying Piston Pin Retainers Removal Access Notch
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: New piston pin retainers must be used. Never reuse the piston pin retainers.

5. Install NEW piston pin retainers using the **J 43654** . Align the **J 43654** to the notch (1) in the piston.

6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure

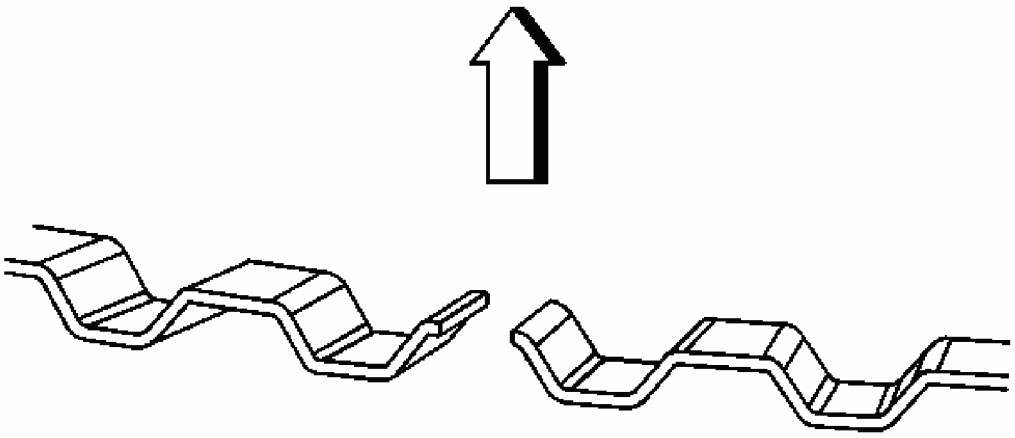

Fig. 81: Aligning Oil Control Ring Expander
Courtesy of GENERAL MOTORS CORP.

1. Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.

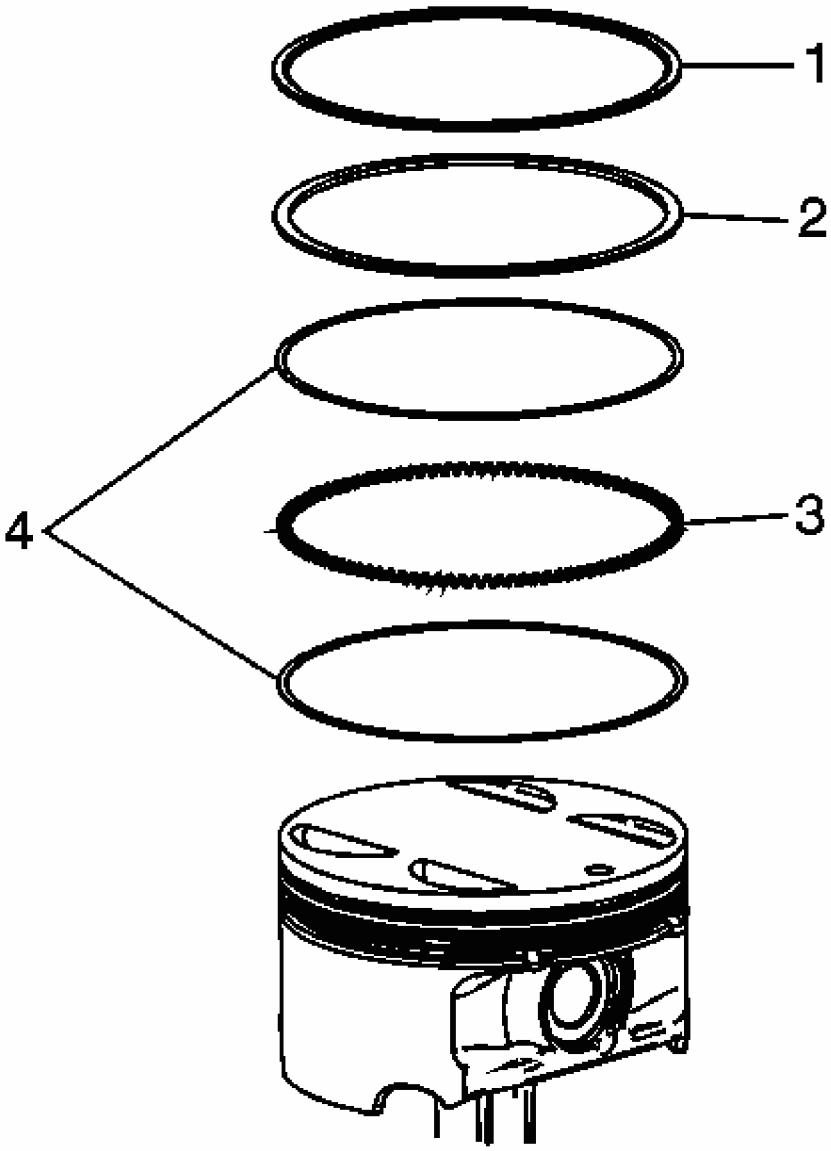

Fig. 82: Identifying Piston Rings
Courtesy of GENERAL MOTORS CORP.

2. Using a piston ring expander, install the oil control ring assembly using the following procedure:
    1. Install the expander ring (3).
    2. Install the 2 oil scraper rings (4). Expand the rings only enough to clear the piston diameter. Overexpanding the piston rings will distort or crack the rings.

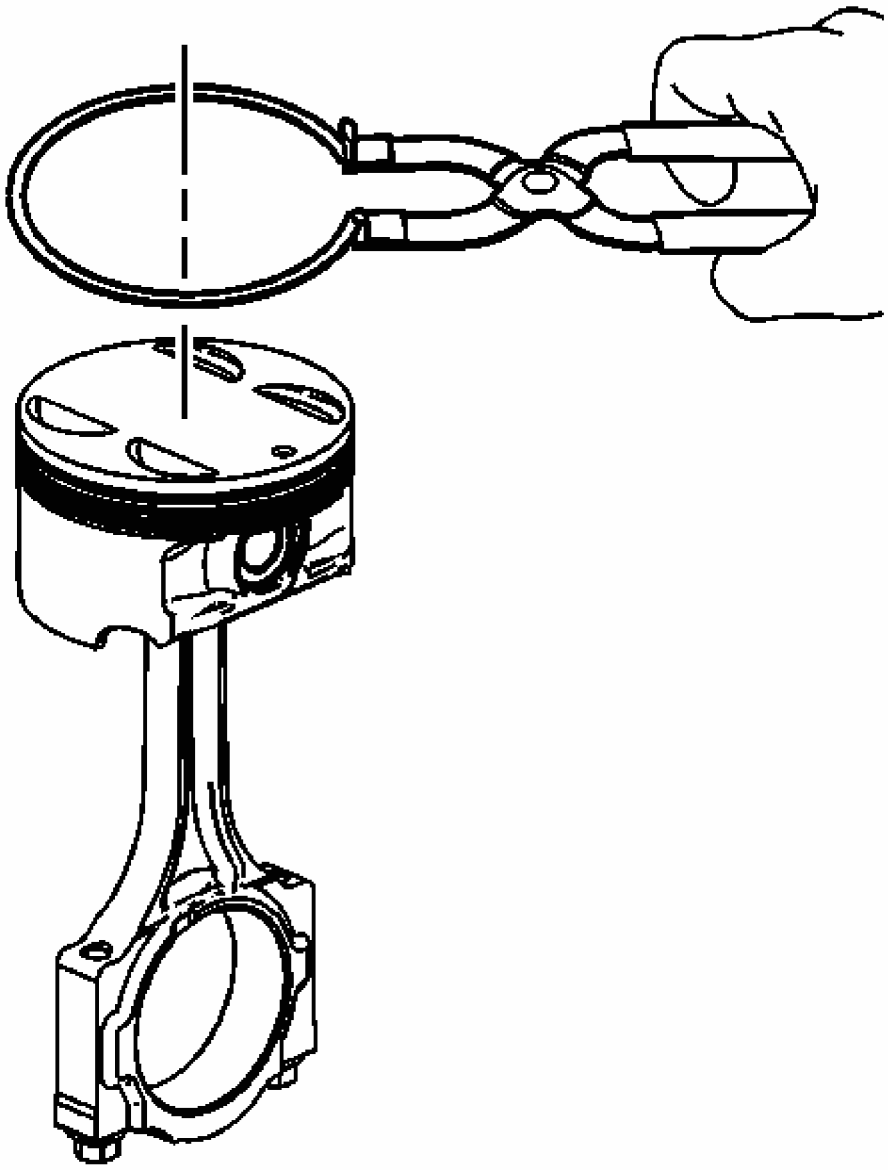

Fig. 83: View Of Piston Ring Expander
Courtesy of GENERAL MOTORS CORP.

3. Install the second and top piston rings using the ring expander. Ensure that you do not overexpand the rings.

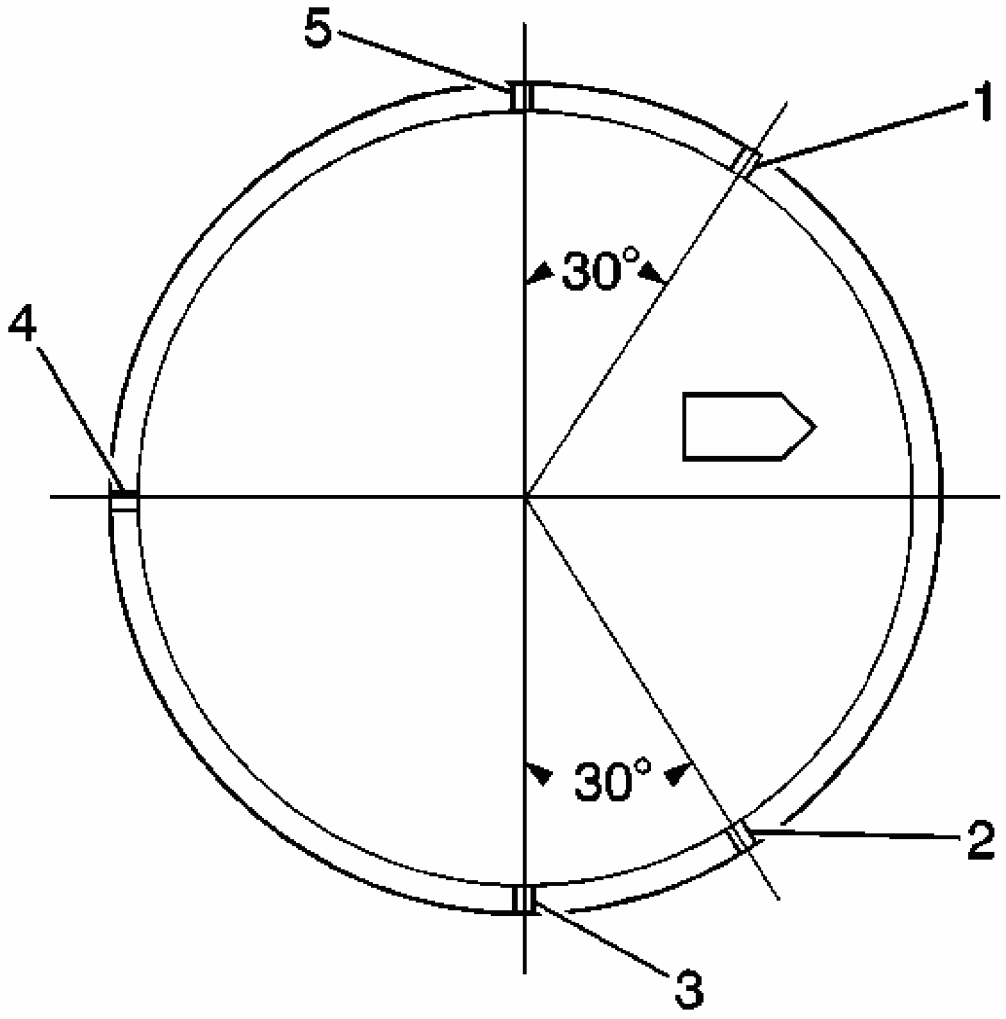

Fig. 84: Illustrating Ring Gap Positions
Courtesy of GENERAL MOTORS CORP.

4. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.
    1. Lower oil control ring - position 1
    2. Upper oil control ring - position 2
    3. Top Ring - position 3
    4. Oil control ring expander - position 4
    5. Second ring - position 5

Connecting Rod Bearing Installation Procedure

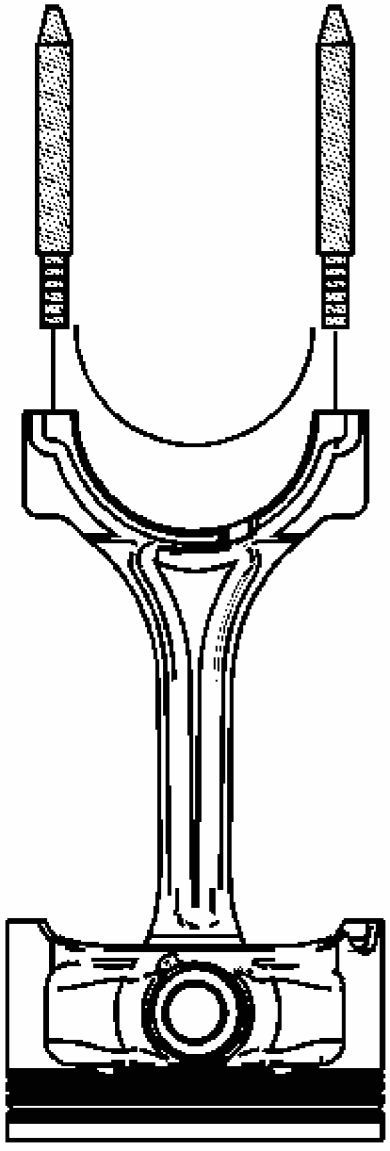

Fig. 85: View Of Piston/Connecting Rod Installation Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.
2. Clean all the oil from behind the connecting rod bearing halves.

3. Install new upper connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
4. Install the **EN 46121** into the connecting rod bolt holes.

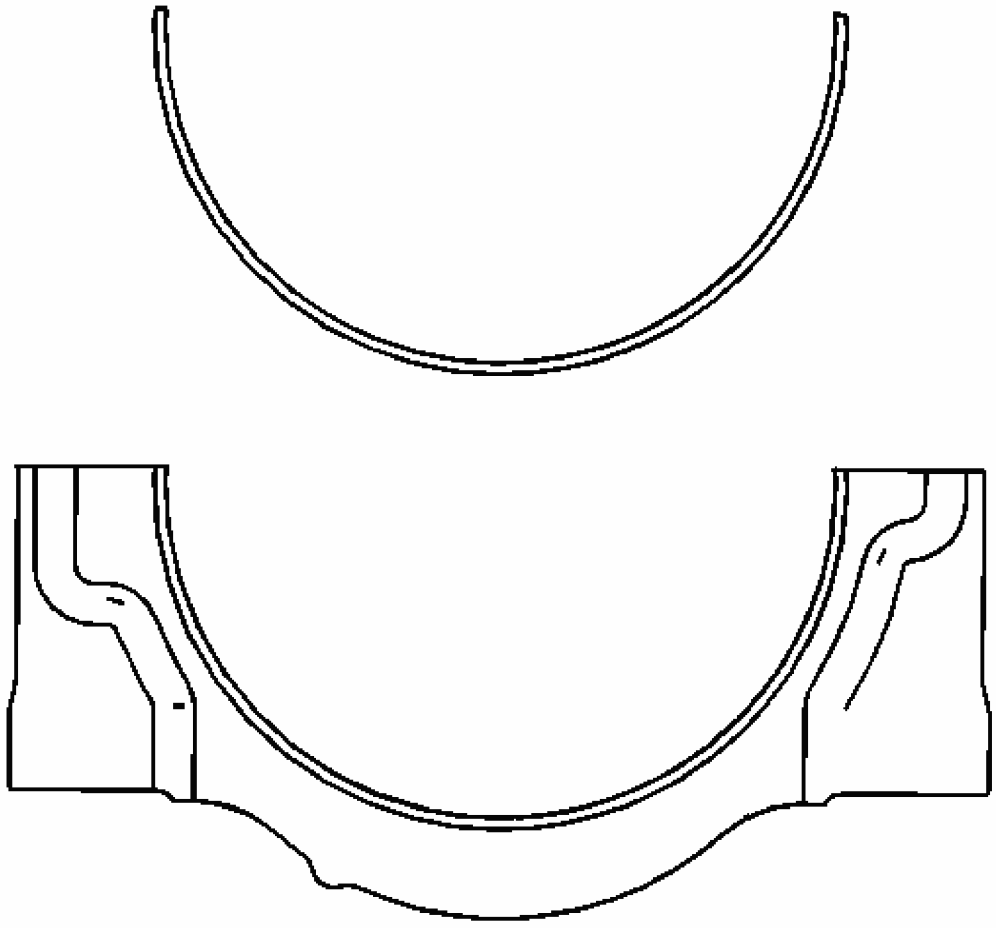

Fig. 86: View Of Lower Connecting Rod Cap And Bearing
Courtesy of GENERAL MOTORS CORP.

5. Install new lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

CYLINDER HEAD DISASSEMBLE

Tools Required

- **EN 46116** Valve Stem Seal Remover/Installer
- **EN 46117** Valve Stem Key Remover/Installer
- **EN 46119** Off-Vehicle Valve Spring Compressor Adapter
- **J 8062** Valve Spring Compressor - Head Off

Disassemble Procedure

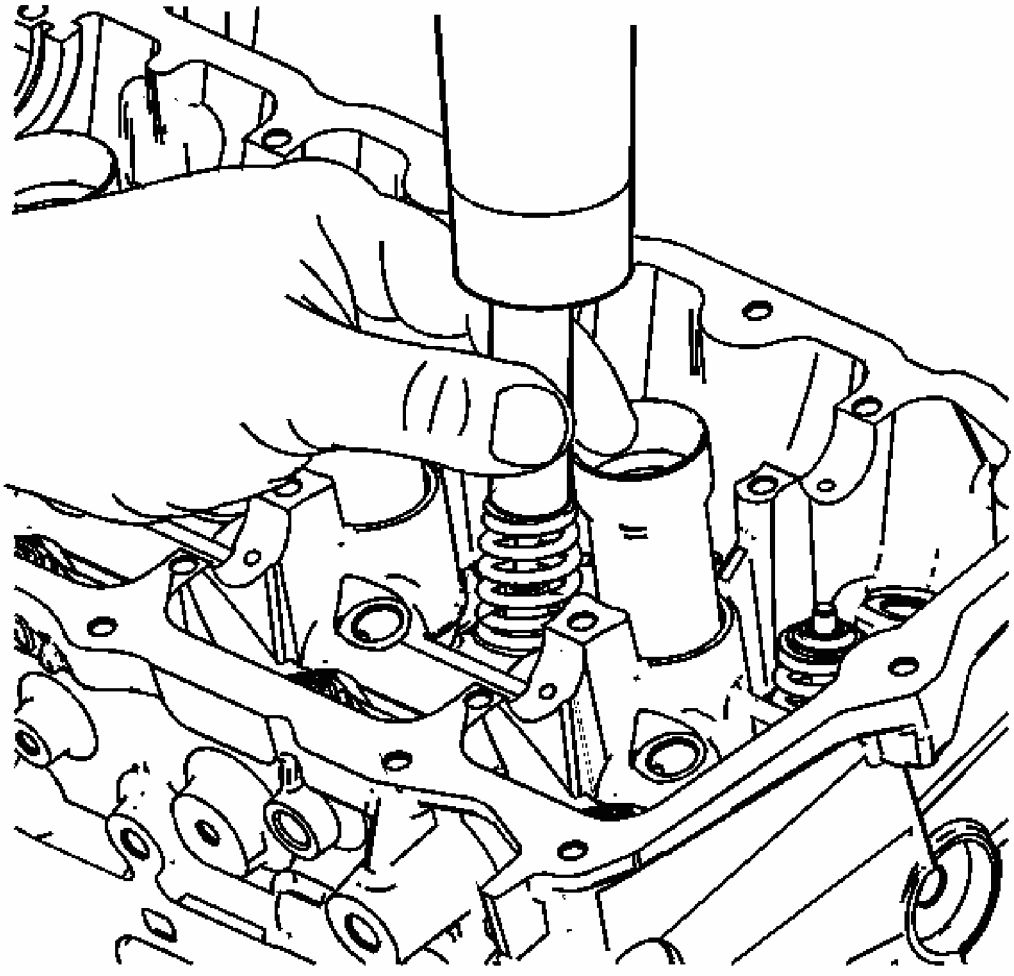

Fig. 87: Loosening Valve Keepers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

1. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve

spring retainer to loosen the valve keepers.

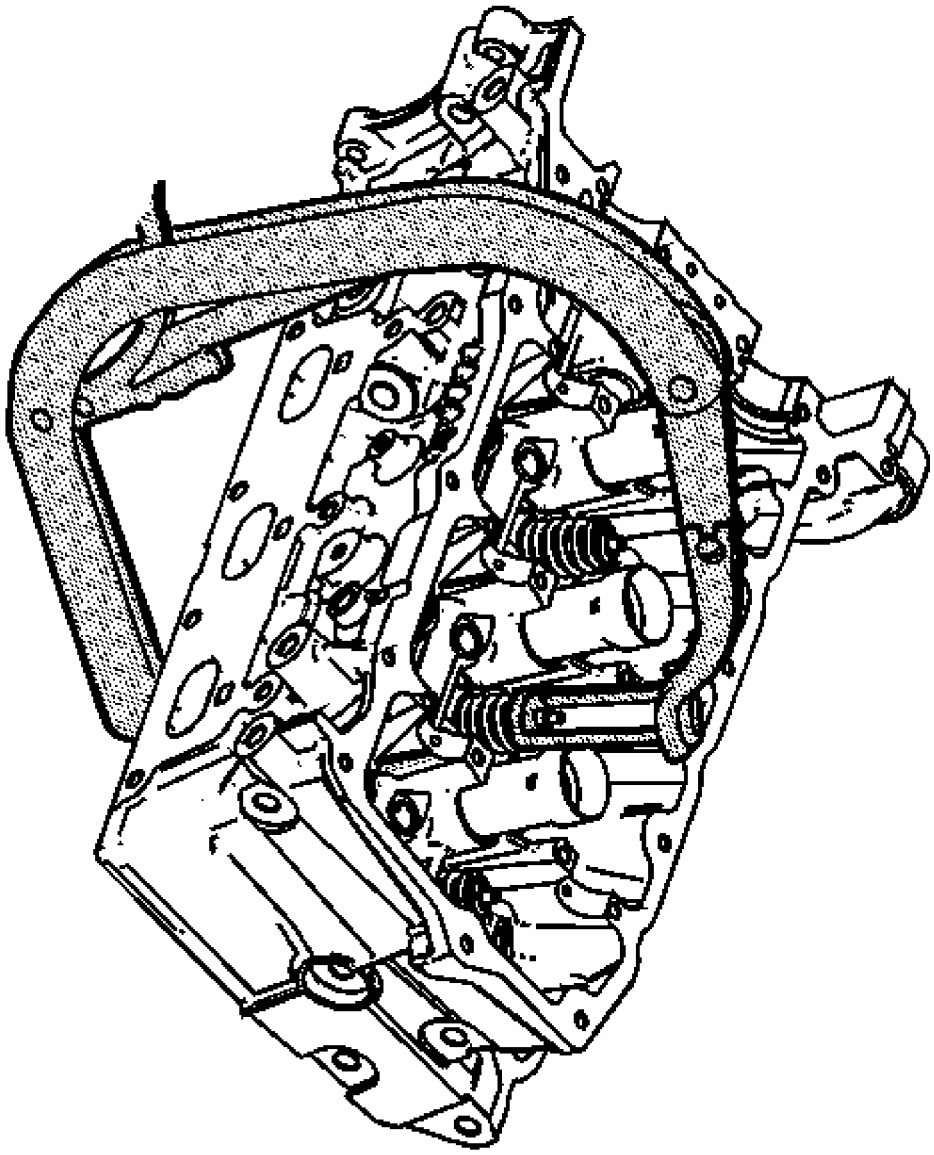

Fig. 88: Identifying J 8062 & EN 46119
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve

spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

NOTE: **Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.**

2. Compress the valve spring using the **J 8062** and the **EN 46119** .

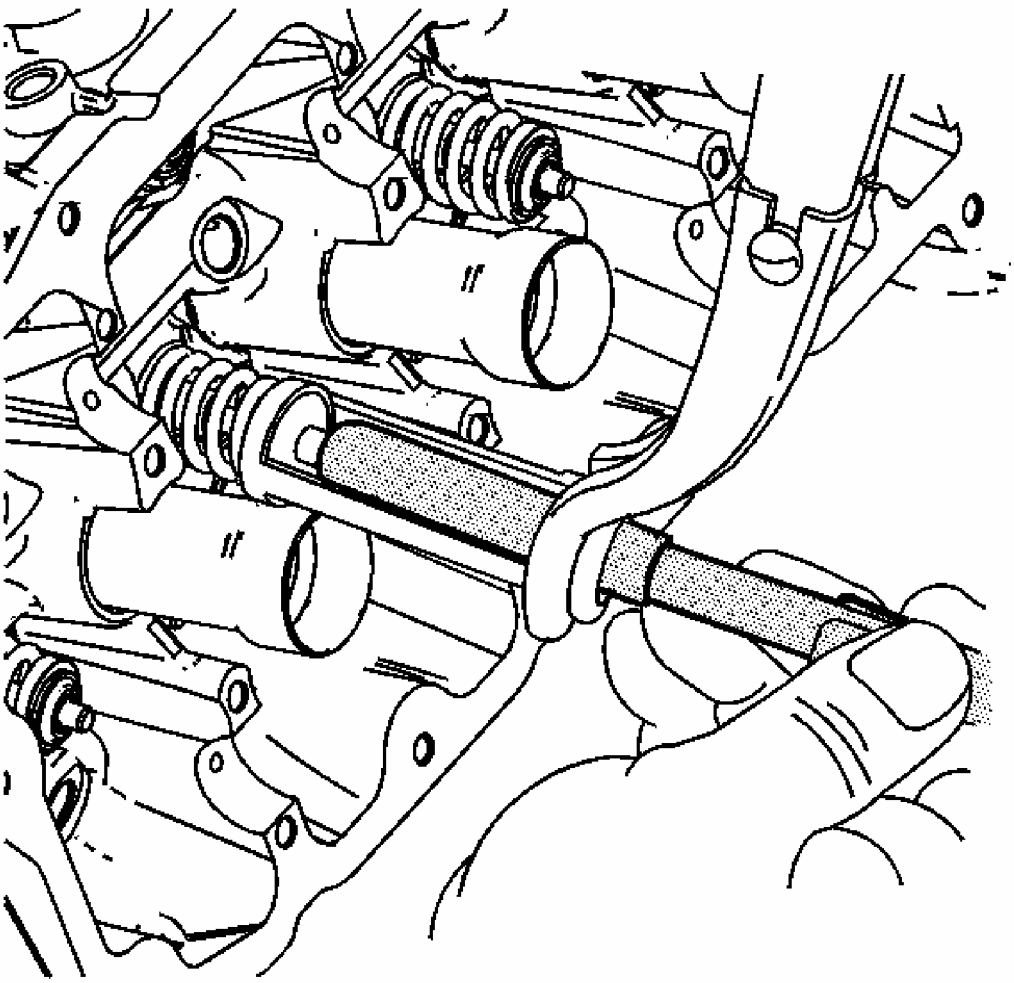

Fig. 89: View Of EN 46117

Courtesy of GENERAL MOTORS CORP.

3. Use the magnet of the **EN 46117** in order to remove the valve keepers.
4. Remove the valve spring compressor and the adapter.

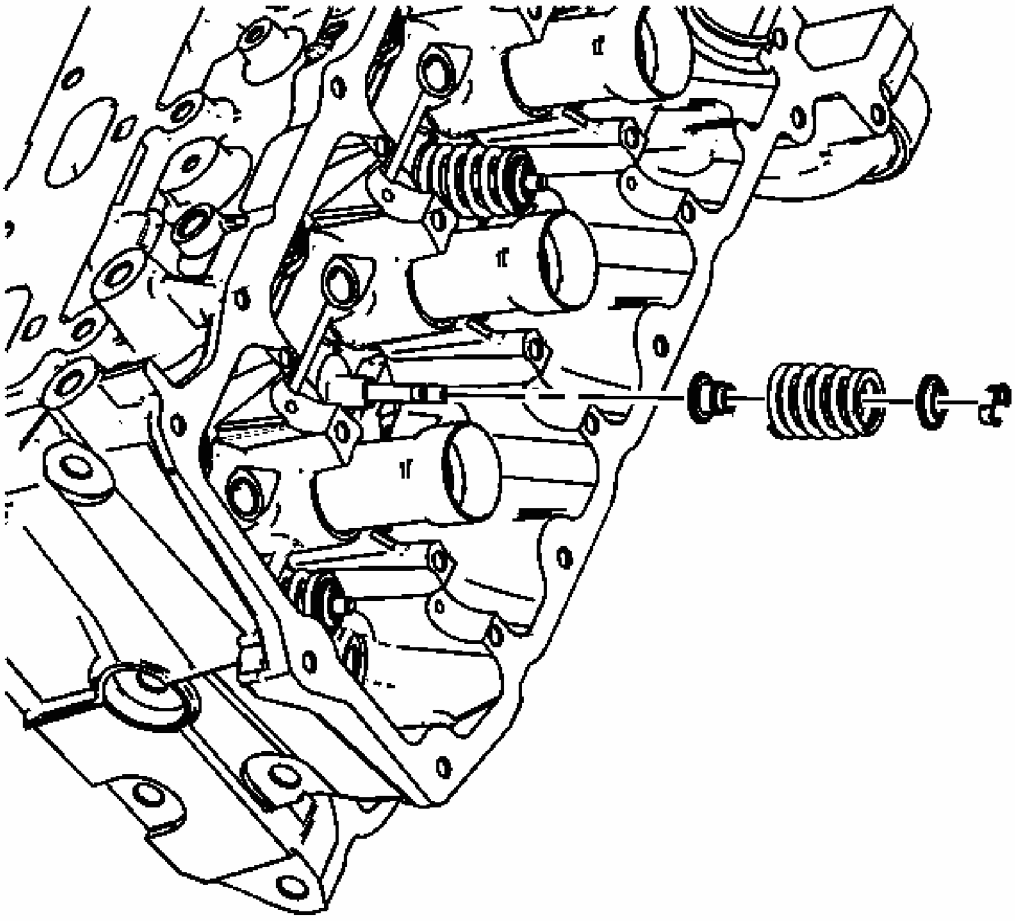

Fig. 90: Identifying Valve Spring & Retainer
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve spring retainer.
6. Remove the valve spring.

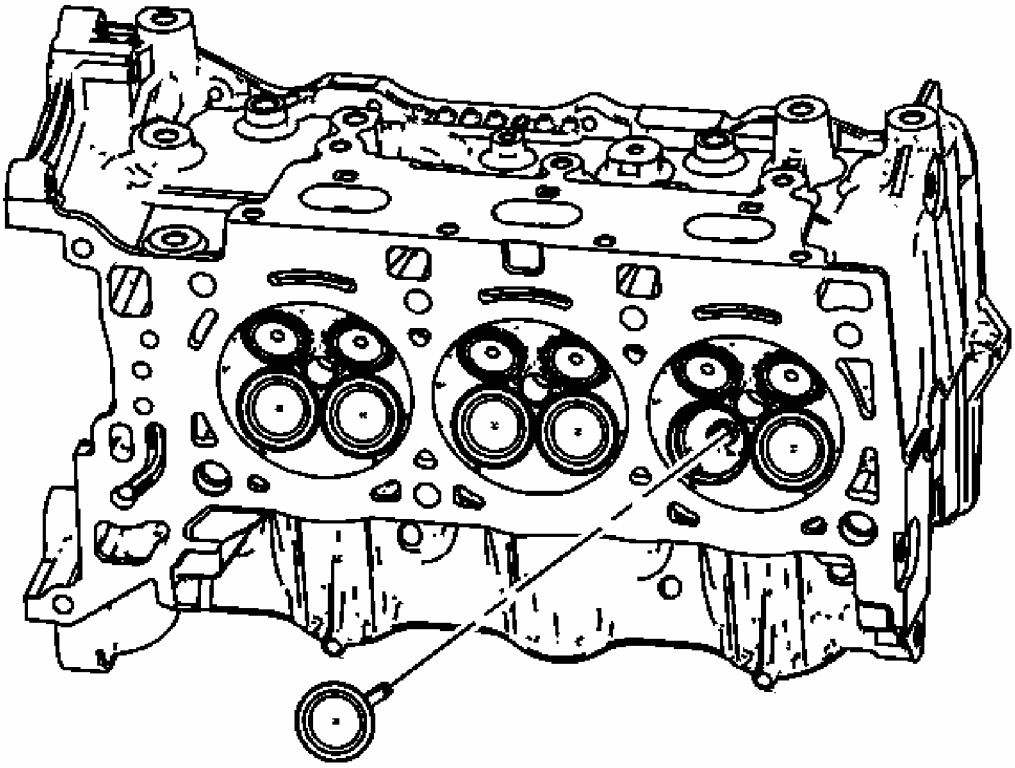

Fig. 91: View Of Valve
Courtesy of GENERAL MOTORS CORP.

7. Remove the valve.

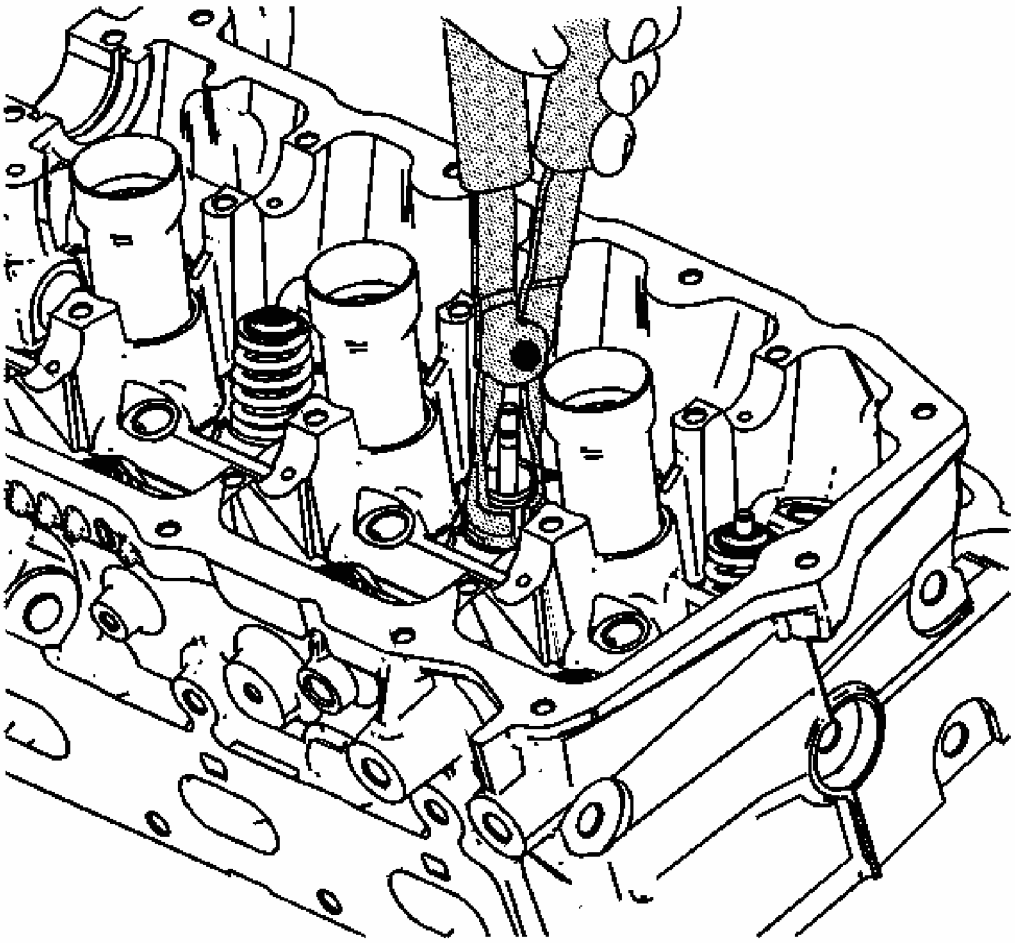

Fig. 92: Removing/Installing Valve Stem Oil Seals With EN 46116
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: NEVER reuse a valve stem oil seal.

8. Remove the valve stem oil seal using the **EN 46116** and discard.
9. Repeat these procedures for the remaining valves.

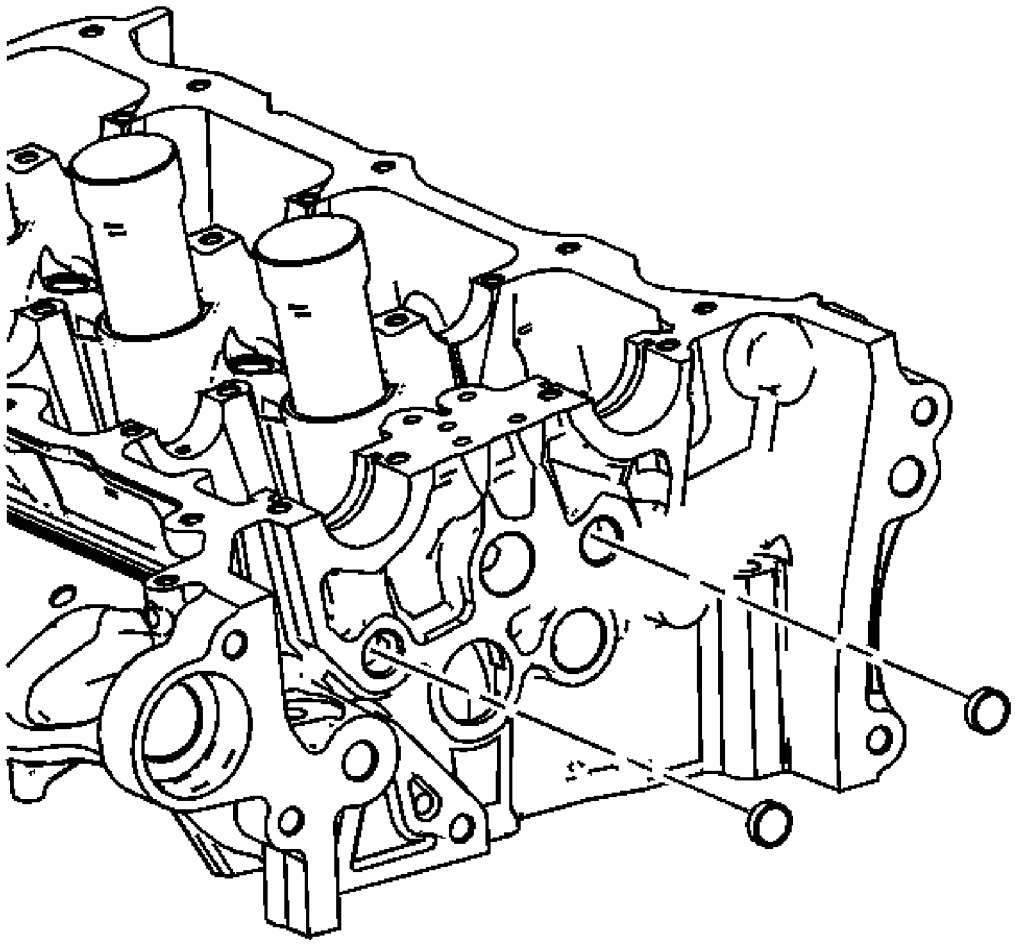

Fig. 93: Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head oil gallery expansion plugs.

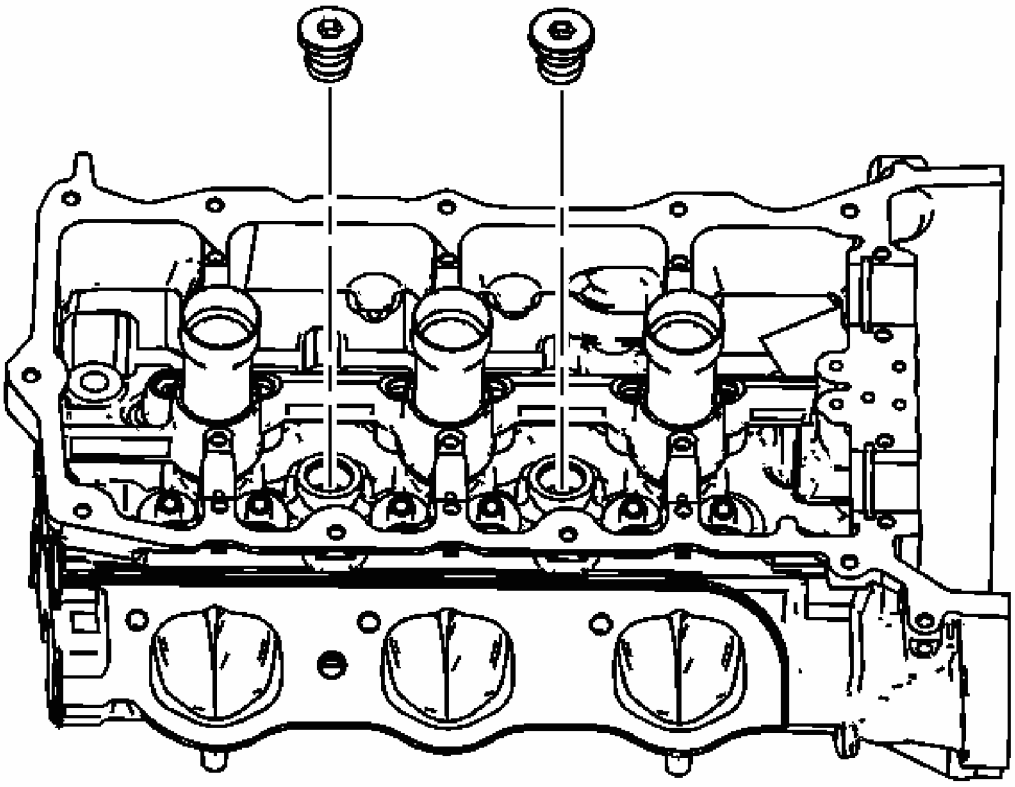

Fig. 94: Locating Cylinder Head Coolant Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

11. Remove the cylinder head coolant threaded plugs.

CYLINDER HEAD CLEANING AND INSPECTION

Tools Required

- **EN 46122** Camshaft Position Actuator Check-Ball Valve Remover/Installer
- **J 8001** Dial Indicator Set
- **J 8358** Carbon Removal Brush
- **J 28410** Gasket Remover
- **J 42096** Valve Guide Reamer

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using **J 28410** .
2. Clean all cylinder head surfaces with non-corrosive solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chambers using the **J 8358** .
5. Clean any debris or build-up from the lifter pockets.

Visual Inspection

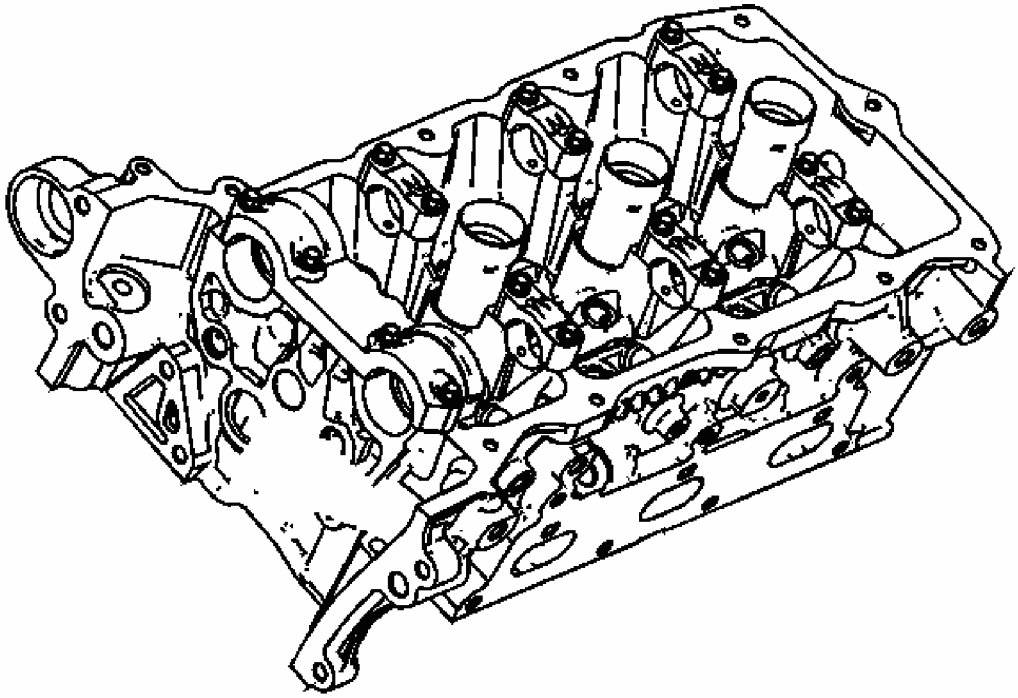

Fig. 95: View Of Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:
   - Excessive scoring or pitting
   - Discoloration from overheating
   - Deformation from excessive wear
   - If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.
2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.

3. Inspect the cylinder head for the following:
    - Cracks, damage or pitting in the combustion chambers
    - Debris in the oil galleries - Continue to clean the galleries until all debris is removed.
    - Coolant leaks or damage to the deck face sealing surface - If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement - Deck Flatness Inspection.
    - Burrs or any defects that would degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
    - Damage to any gasket surfaces
    - Damage to any threaded bolt holes
    - Burnt or eroded areas in the combustion chamber
    - Cracks in the exhaust ports and combustion chambers
    - External cracks in the water passages
    - Restrictions in the intake or exhaust passages
    - Restrictions in the cooling system passages
    - Rusted, damaged or leaking core plugs
4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.

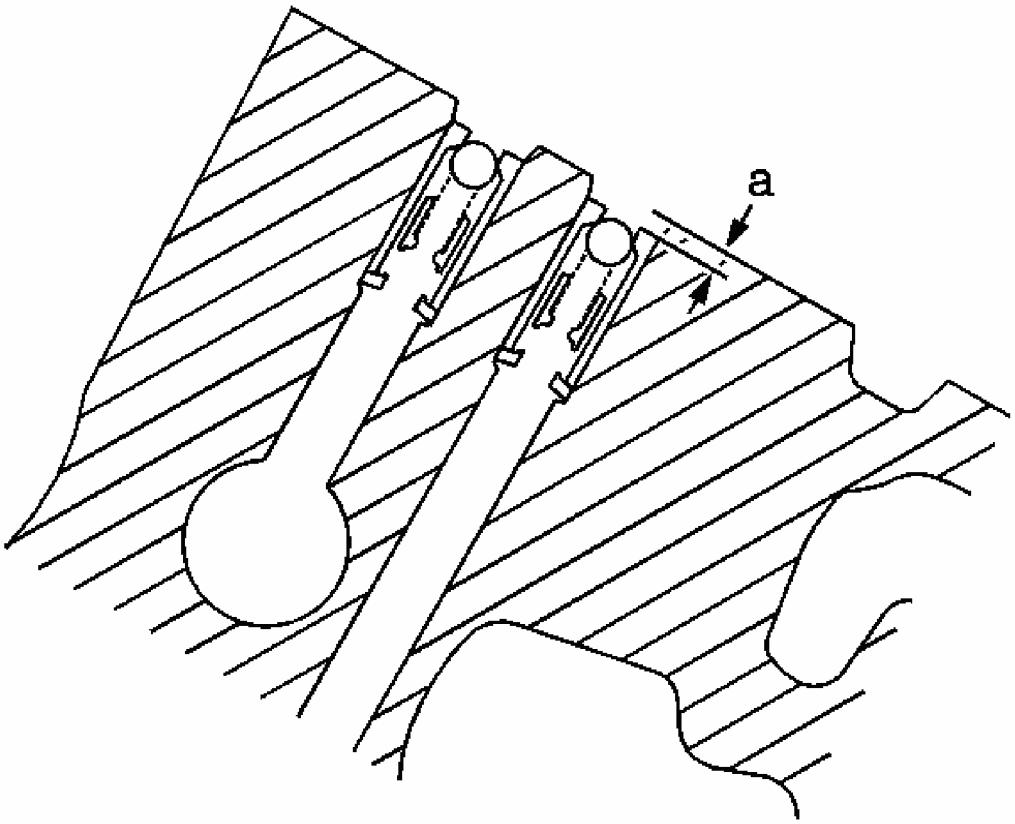

Fig. 96: Inspecting Camshaft Position Actuator Oil Feed Check Valve
Courtesy of GENERAL MOTORS CORP.

5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly positioned in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).

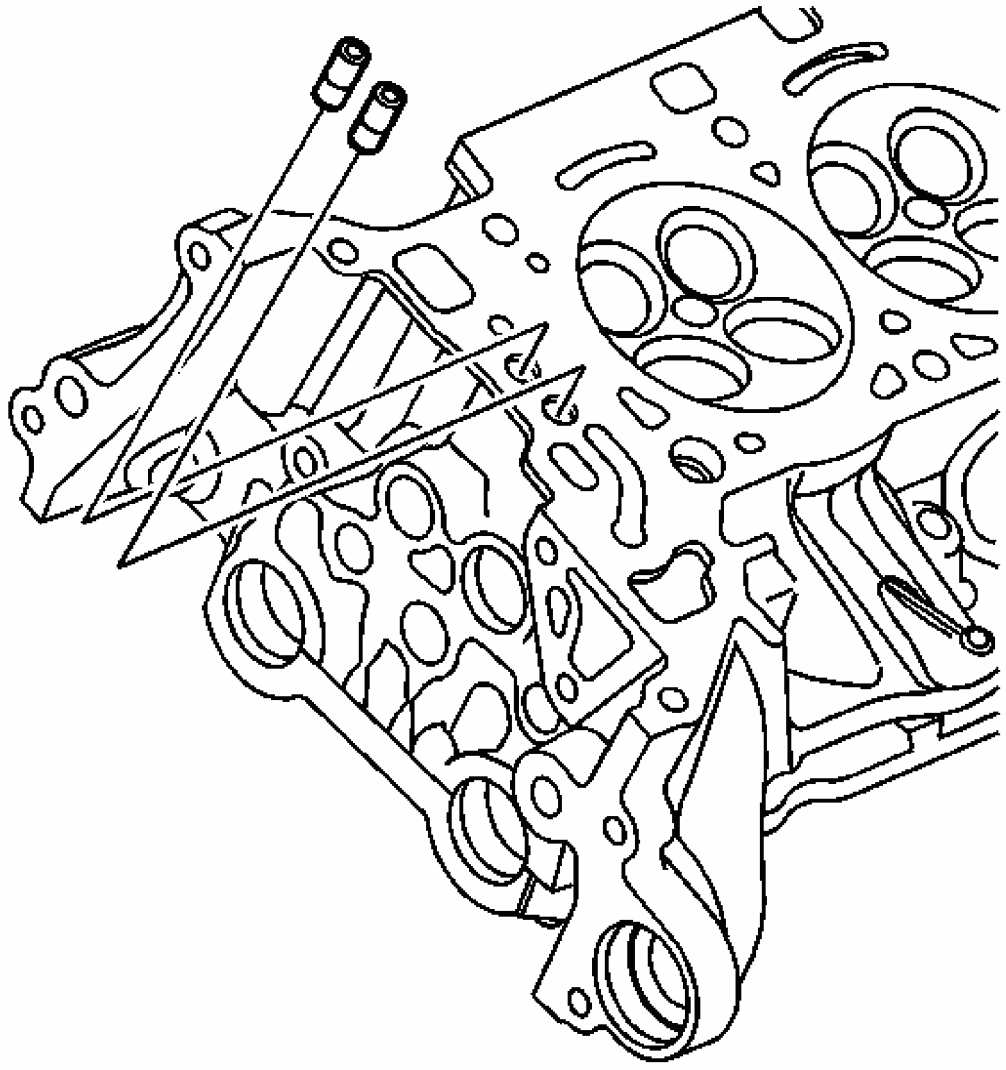

Fig. 97: View Of Camshaft Position Actuator Oil Feed Check Valve
Courtesy of GENERAL MOTORS CORP.

6. Damaged, restricted or clogged check valves can be replaced using the **EN 46122** .

Cylinder Head Measurement

Camshaft Journal Clearance

1. Install the camshaft bearing cap in the cylinder head without the camshaft.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft cap bolts.

   Tighten: Tighten the camshaft cap bolts to 10 N.m (89 lb in).

3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts.

   Tighten: Tighten the camshaft cap bolts to 10 N.m (89 lb in).

6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

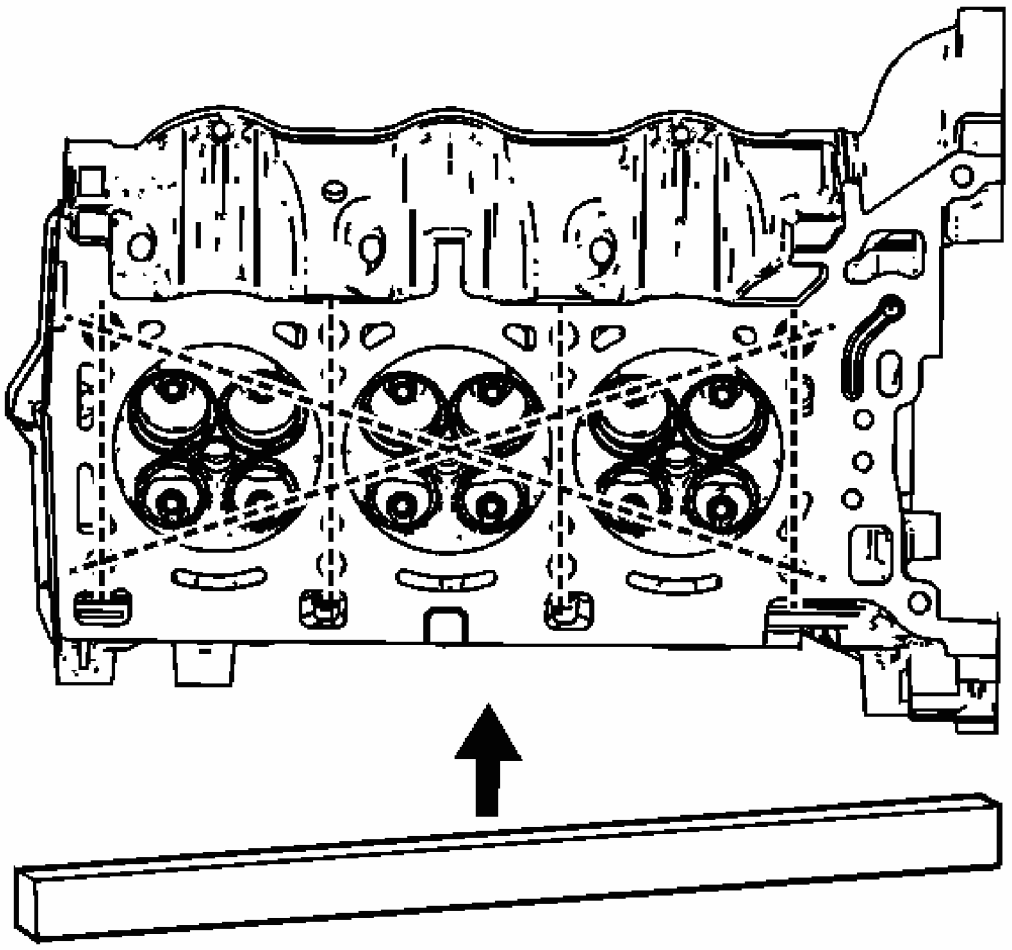

Fig. 98: Measuring Deck Flatness
Courtesy of GENERAL MOTORS CORP.

1. Ensure the cylinder head decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder head deck face surface.
4. Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gage at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head deck surface does not require resurfacing.
6. If the warpage is between 0.05-0.20 mm (0.002-0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder

head deck surface requires resurfacing.

7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the head must be replaced.

Valve Guide Measurement

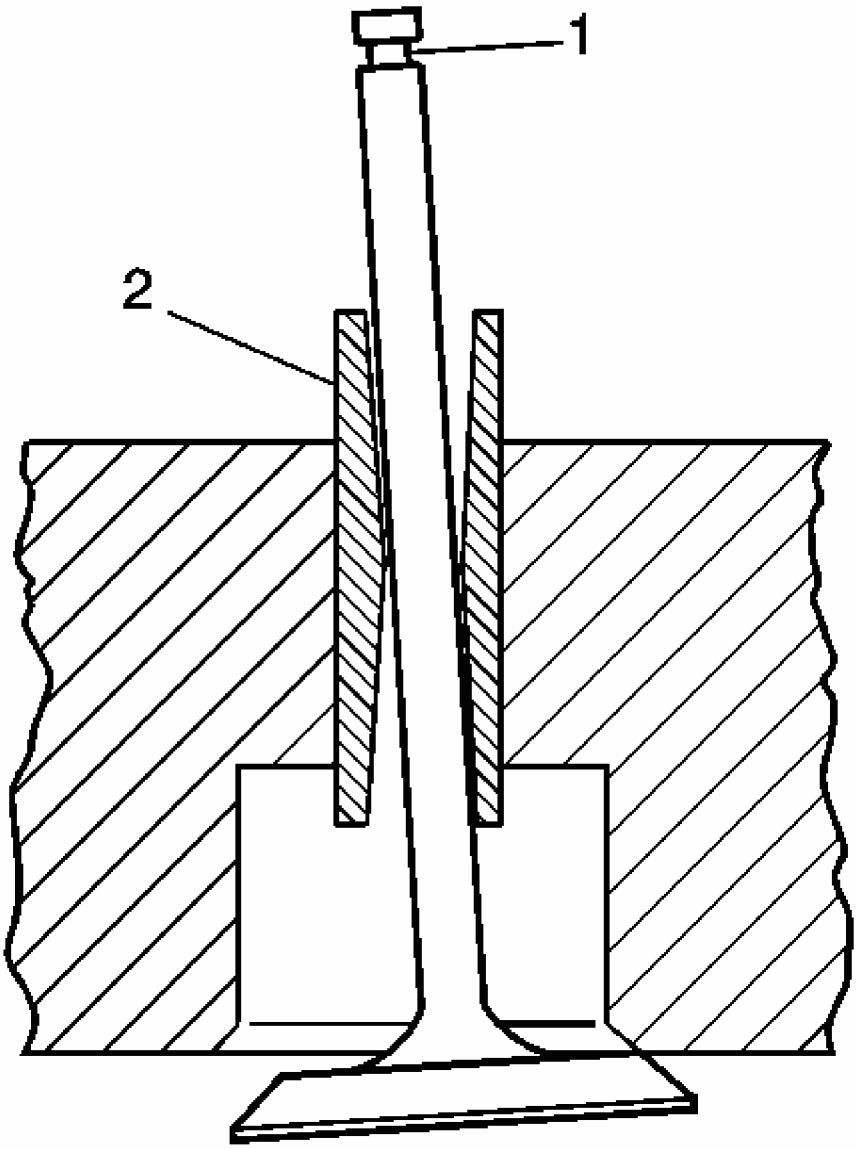

Fig. 99: Inspecting For Excessive Valve Stem To Guide Clearance

Courtesy of GENERAL MOTORS CORP.

1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **J 8001** to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications** for proper clearance.
    - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the **J 42096** . There is 1 size of oversized valve stem available for service.
    - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
    - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

VALVE SPRING INSPECTION AND MEASUREMENT

Tools Required

J 22738-B Valve Spring Tester

Inspection Procedure

1. Clean the valve springs in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

Measurement Procedure

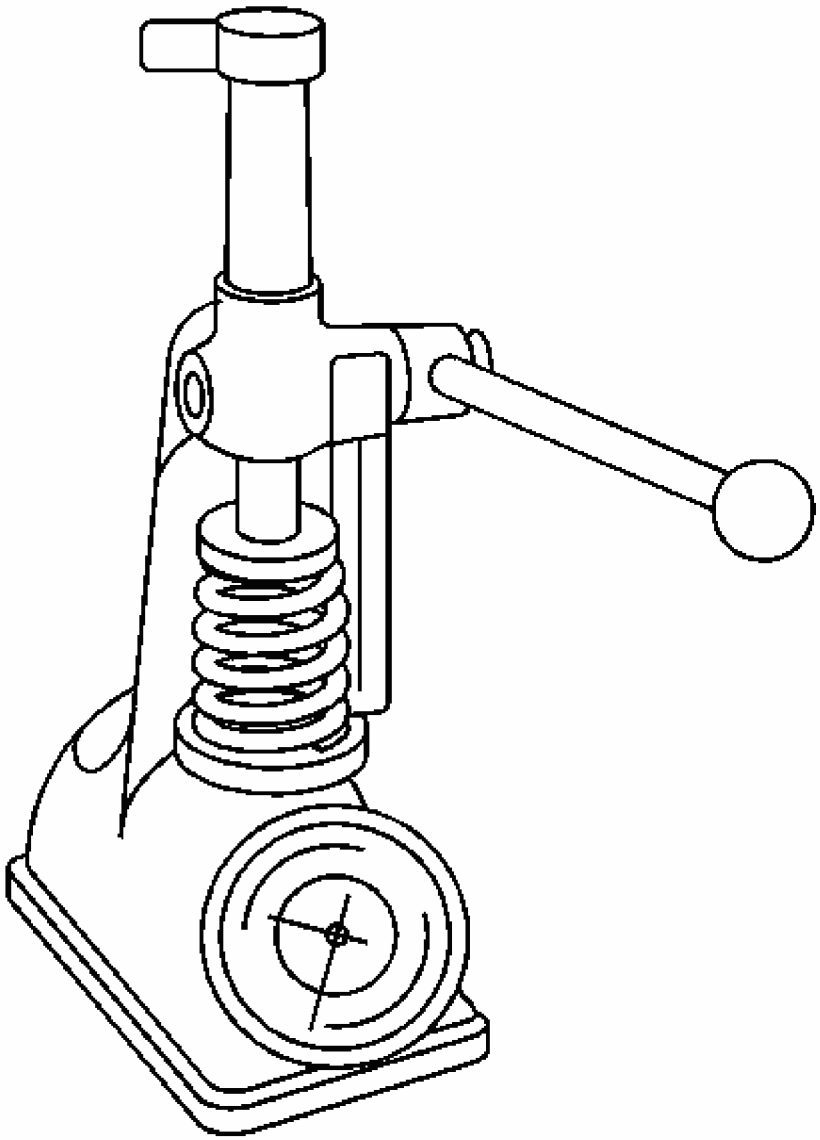

Fig. 100: View Of J 22738-B
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve spring tension using the **J 22738-B** . Refer to **Engine Mechanical Specifications** .
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

VALVE AND SEAT GRINDING

Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure

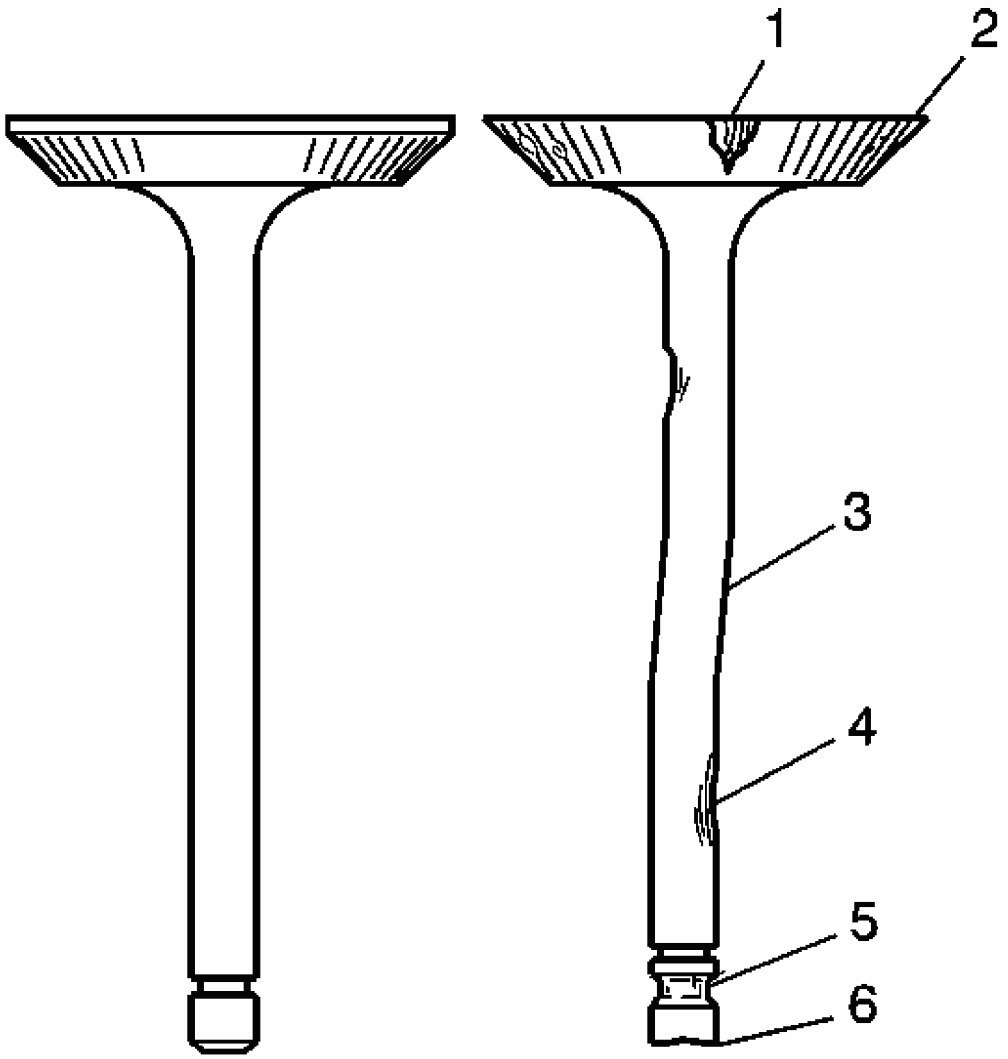

Fig. 101: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve for damage from the head to tip for the following conditions:
   - Pitting in the valve seat area (1)
   - Lack of valve margin (2)
   - Bending in the valve stem (3)
   - Pitting or excessive wear in the stem (4)
   - Worn valve key grooves (5)
   - Worn valve tip (6)
2. Replace the valve if any of these conditions exist.

Valve Measurement and Reconditioning Overview

IMPORTANT:

- **Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.**
- **If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.**

Valve Seat Width Measurement Procedure

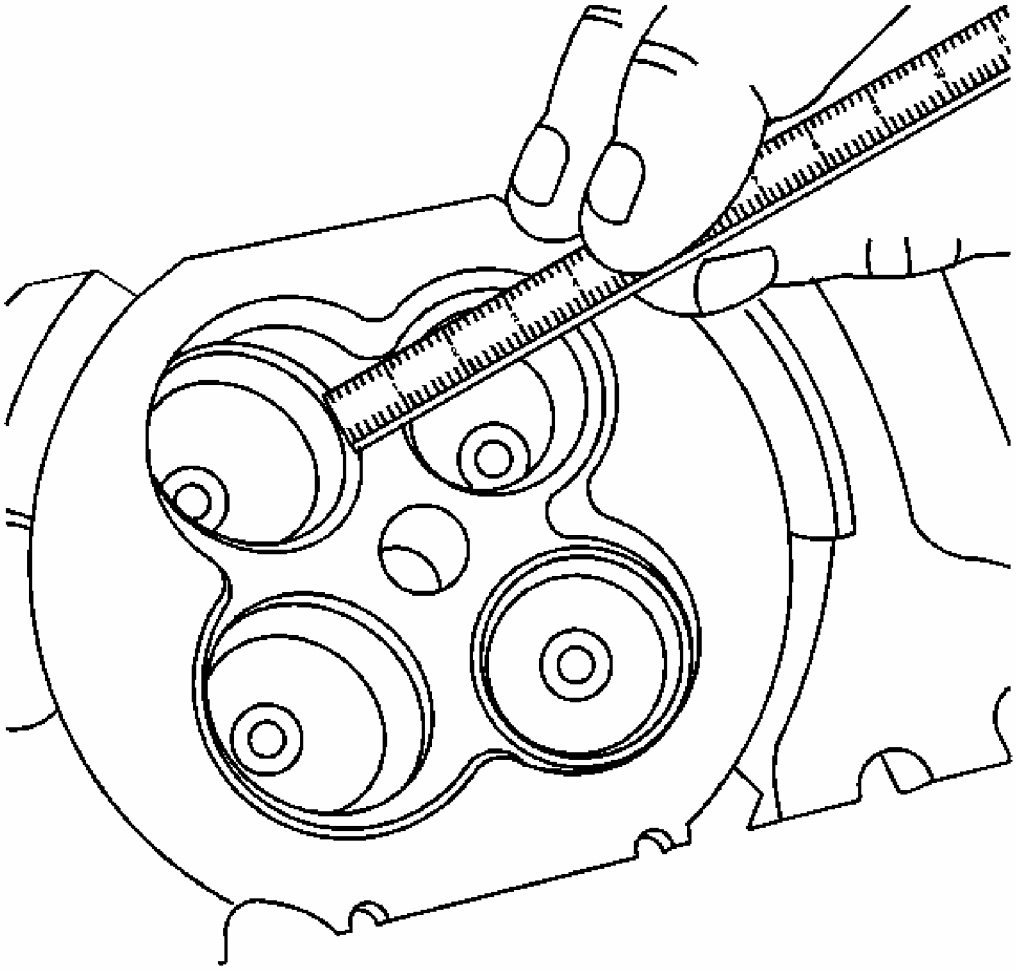

Fig. 102: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve seat width in the cylinder head using a proper scale.

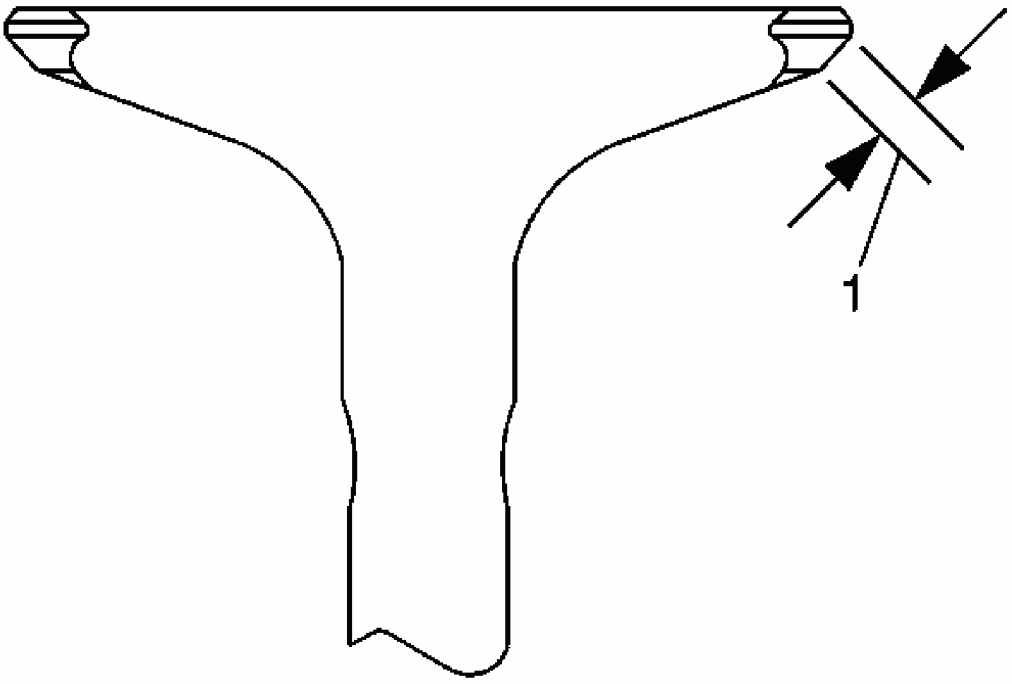

Fig. 103: Measuring Seat Width On Valve Face
Courtesy of GENERAL MOTORS CORP.

2. Measure the seat width on the valve face (1) using a proper scale.

IMPORTANT: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in **Engine Mechanical Specifications** .
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

NOTE: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications** .
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Margin Measurement Procedure

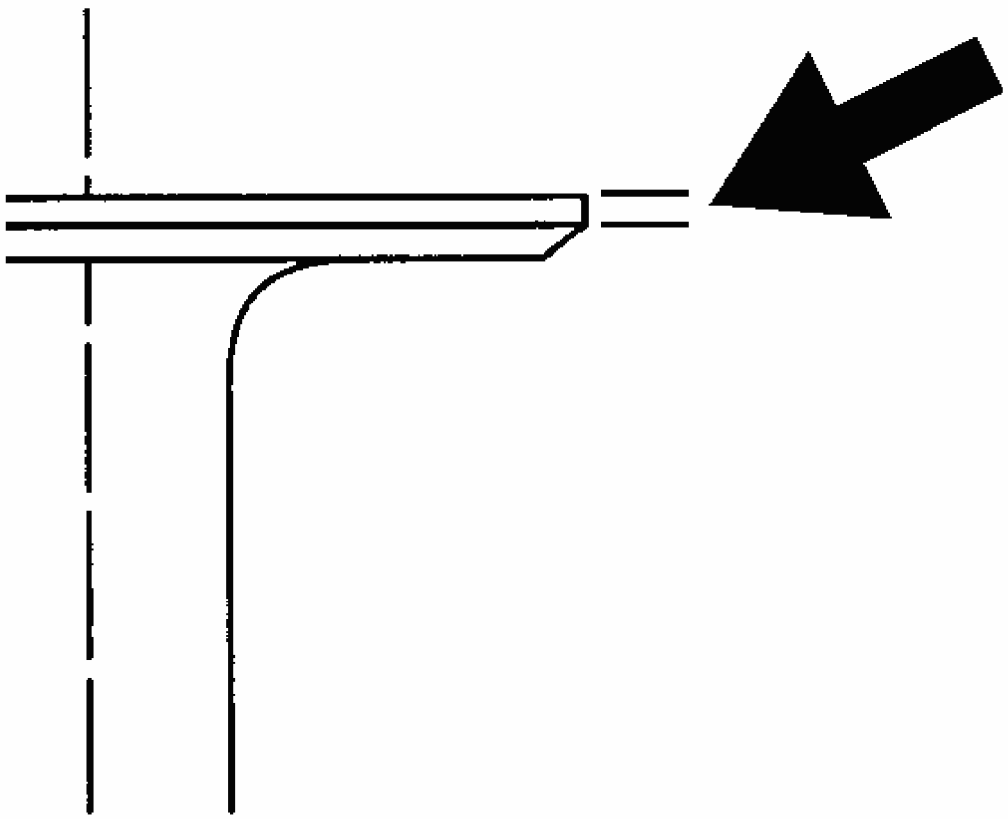

Fig. 104: View Of Valve Margin Measurement

Courtesy of GENERAL MOTORS CORP.

1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification and do not require refacing, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve-to-Seat Concentricity Measurement Procedure

IMPORTANT:

- **Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.**
- **You must measure the valve face and the valve seat to ensure proper valve sealing.**

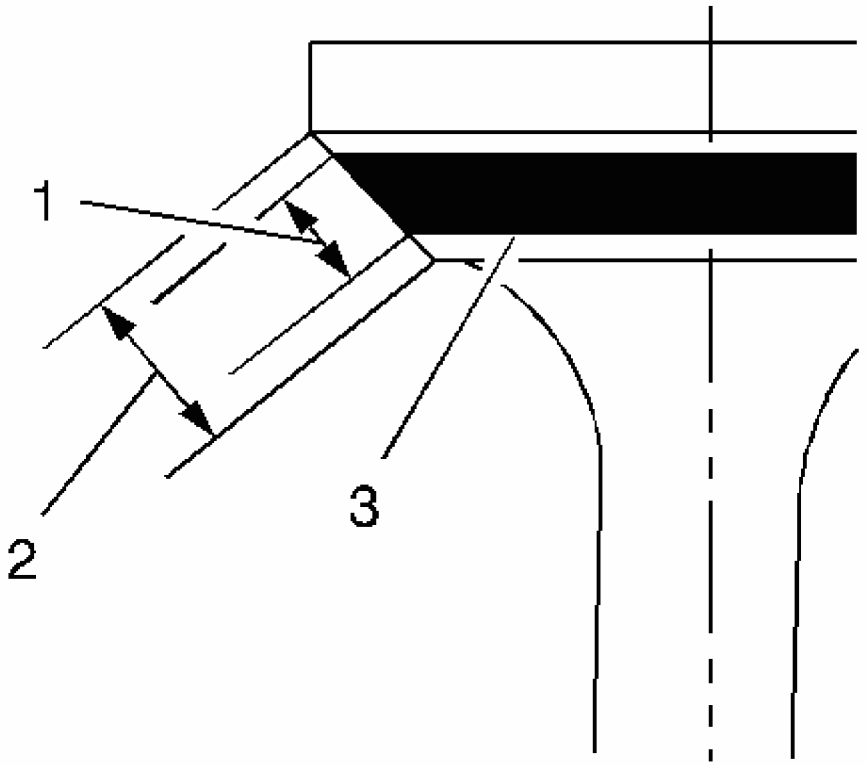

Fig. 105: View Of Valve Contact Face Measurements

Courtesy of GENERAL MOTORS CORP.

1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
    - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark will be made around the entire face (1).

      IMPORTANT: The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

    - If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

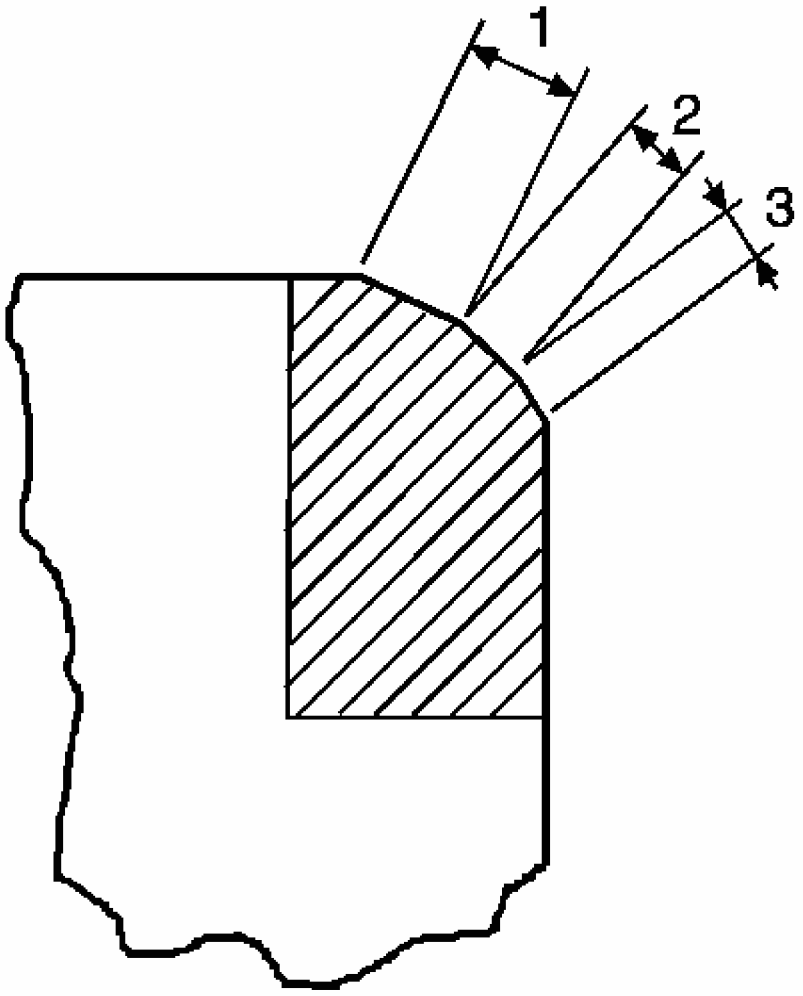

Fig. 106: Illustrating Valve Seat Proper Angles
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.**
- **It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.**

1. Grind the valve seats (2) to the proper angle specification listed in **Engine Mechanical Specifications** .

2. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in **Engine Mechanical Specifications** , grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in **Engine Mechanical Specifications** .
4. If the original valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications** . Measure the valve margin again after grinding using the Valve Margin Measurement Procedure. Replace the valve if the margin is out of specification. New valves do not require grinding.
5. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
6. Install the valve in the cylinder head.
    - If you are using refaced valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.

      IMPORTANT: Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.

    - If you are using new valves, do not lap the valves under any condition.
7. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
8. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

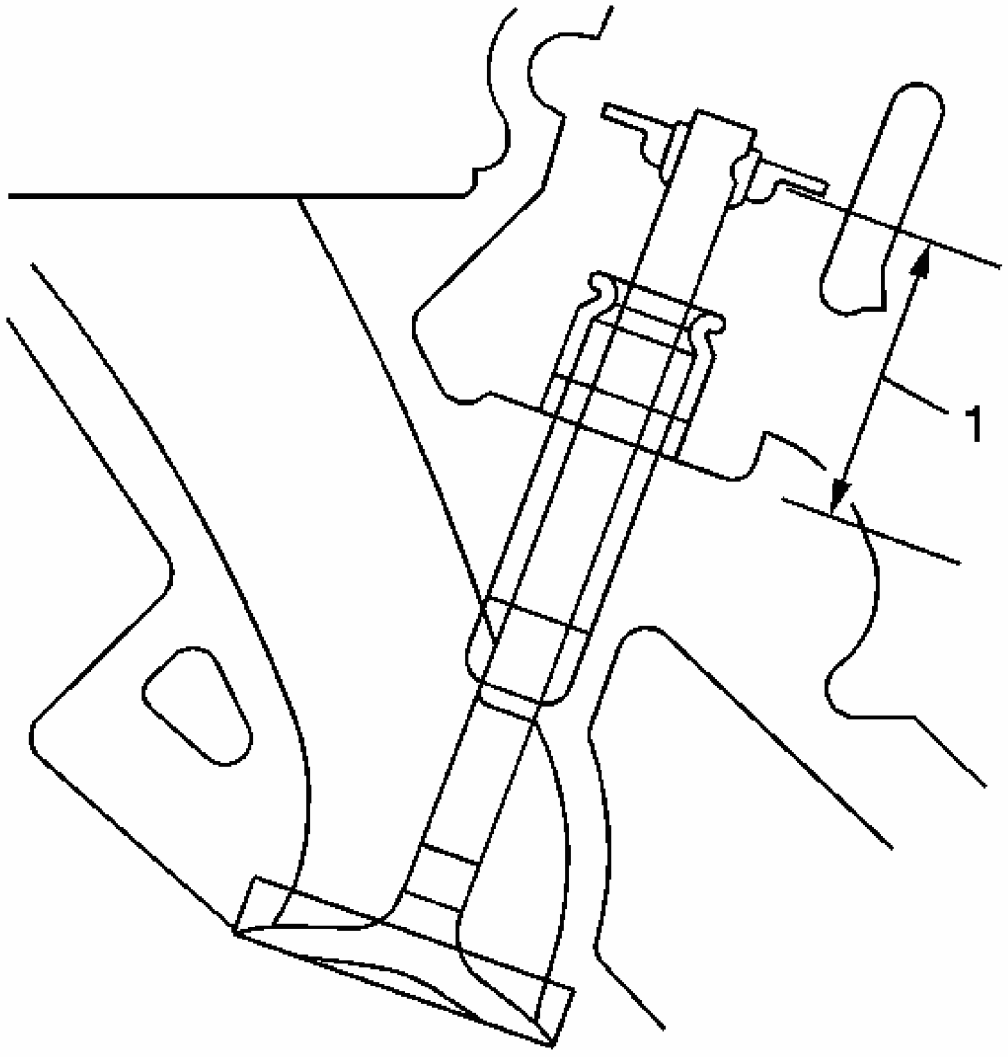

Fig. 107: Measuring Valve Stem Height
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.

5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to **Engine Mechanical Specifications** .
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

NOTE: **DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.**

NOTE: **DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.**

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

Tools Required

- **J 8062** Valve Spring Compressor - Head Off
- **EN 46116** Valve Stem Seal Remover/Installer
- **EN 46117** Valve Stem Key Remover/Installer
- **EN 46119** Valve Spring Compressor Adapter Off-Vehicle

Assemble Procedure

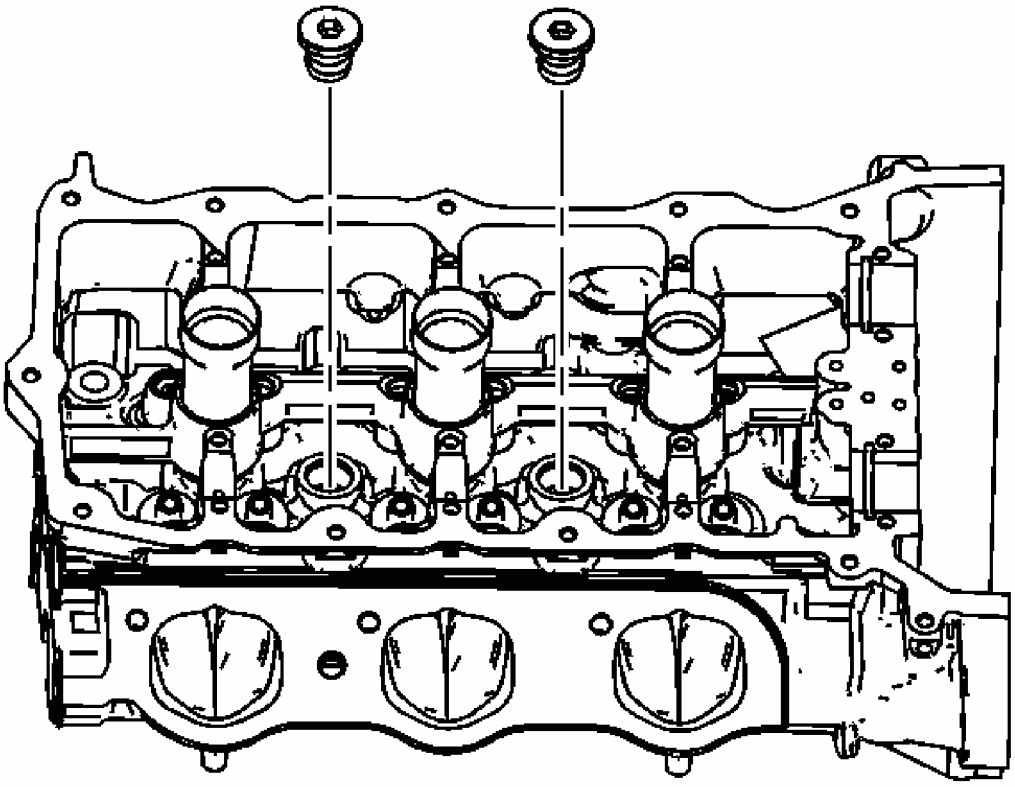

Fig. 108: Locating Cylinder Head Coolant Threaded Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the cylinder head coolant threaded plugs.

   Tighten: Tighten the cylinder head coolant threaded plug to 31 N.m (23 lb ft).

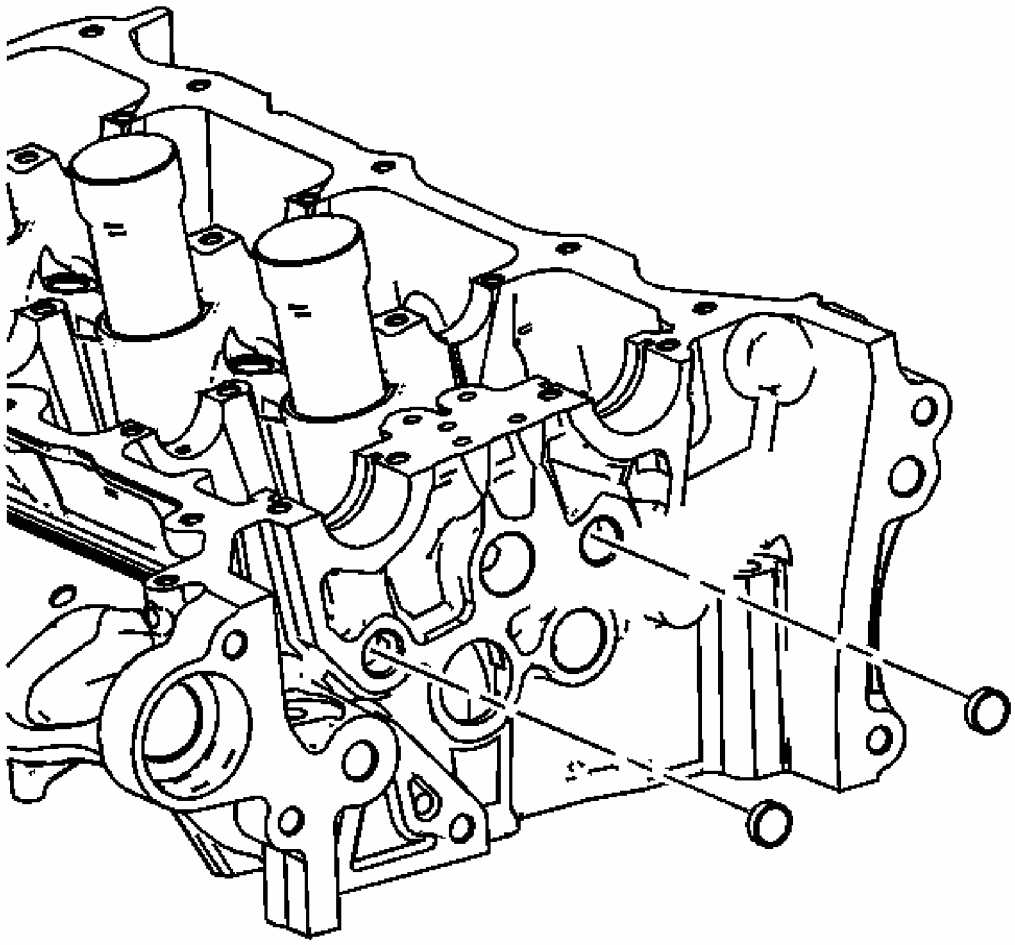

Fig. 109: Cylinder Head Oil Gallery Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

2. Install the cylinder head oil gallery expansion plugs.

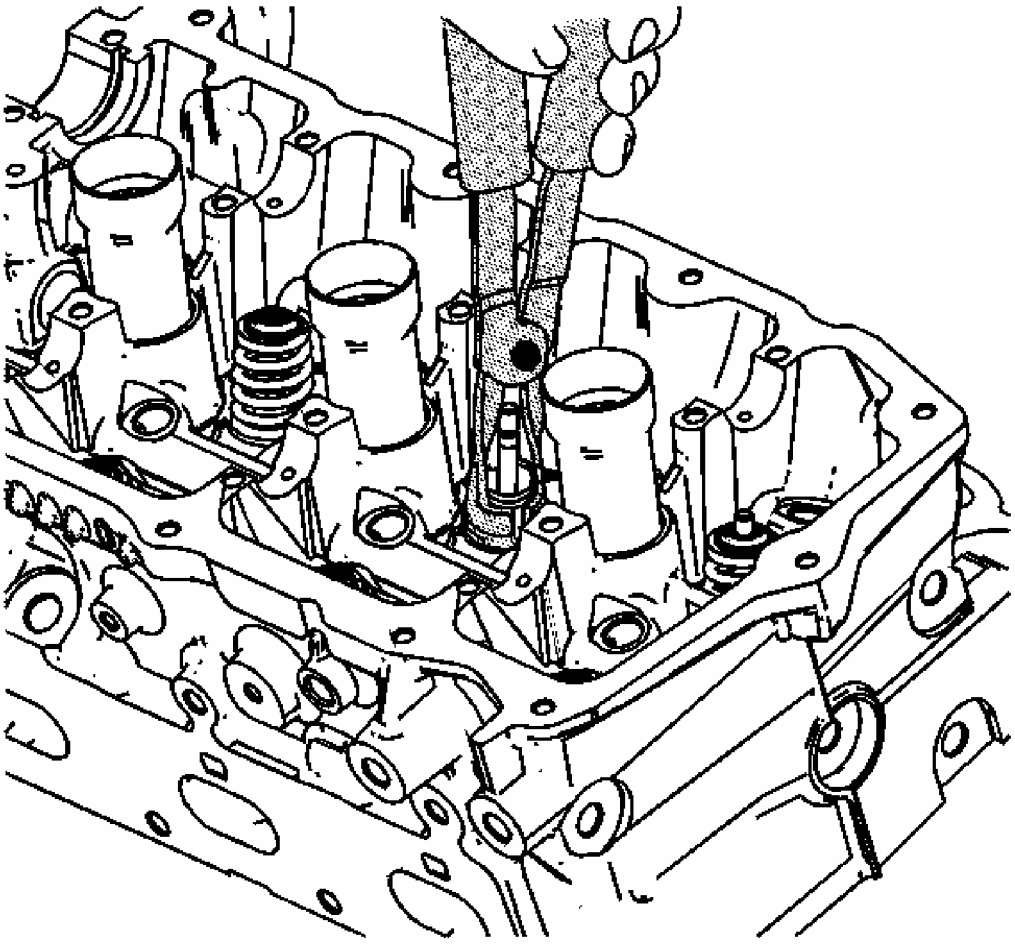

Fig. 110: Removing/Installing Valve Stem Oil Seals With EN 46116
Courtesy of GENERAL MOTORS CORP.

3. Place the valve stem oil seals onto the guides.

IMPORTANT: NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.

4. Mount a new valve stem oil seal using the **EN 46116** .

IMPORTANT: Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.

5. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the **EN 46116** .

6. Lubricate the valve stem and valve guide ID with clean engine oil GM P/N 12345501 (Canadian P/N 992704) or equivalent.

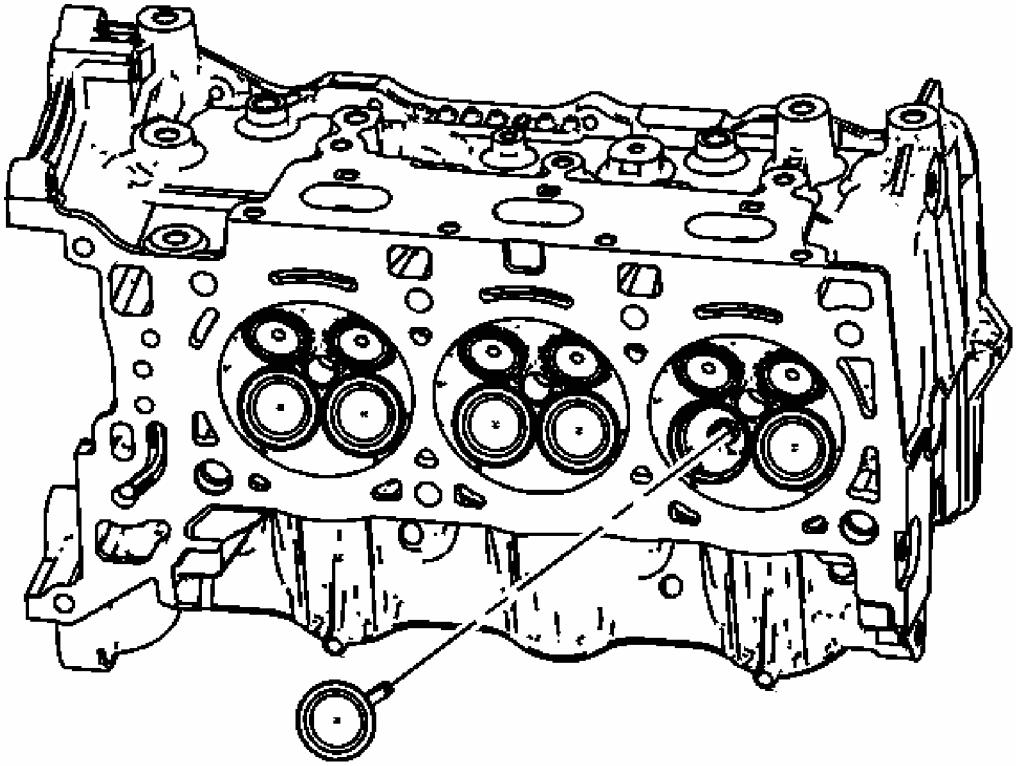

Fig. 111: View Of Valve
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The valve stem oil seal must not come loose from the valve guide when the valve is installed.

7. Insert the valve into the valve guide until it bottoms on the valve seat.

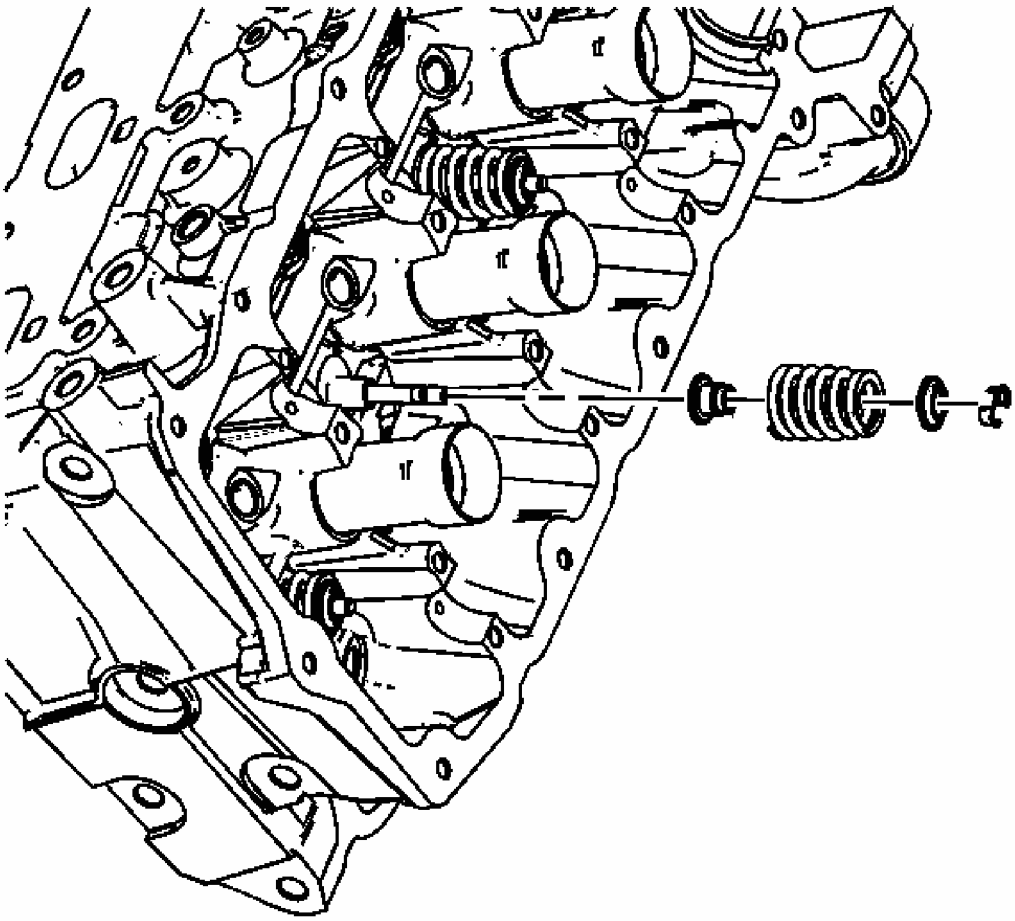

Fig. 112: Identifying Valve Spring & Retainer
Courtesy of GENERAL MOTORS CORP.

8. Position the valve spring on the spring seat.
9. Place the valve spring retainer onto the valve spring.

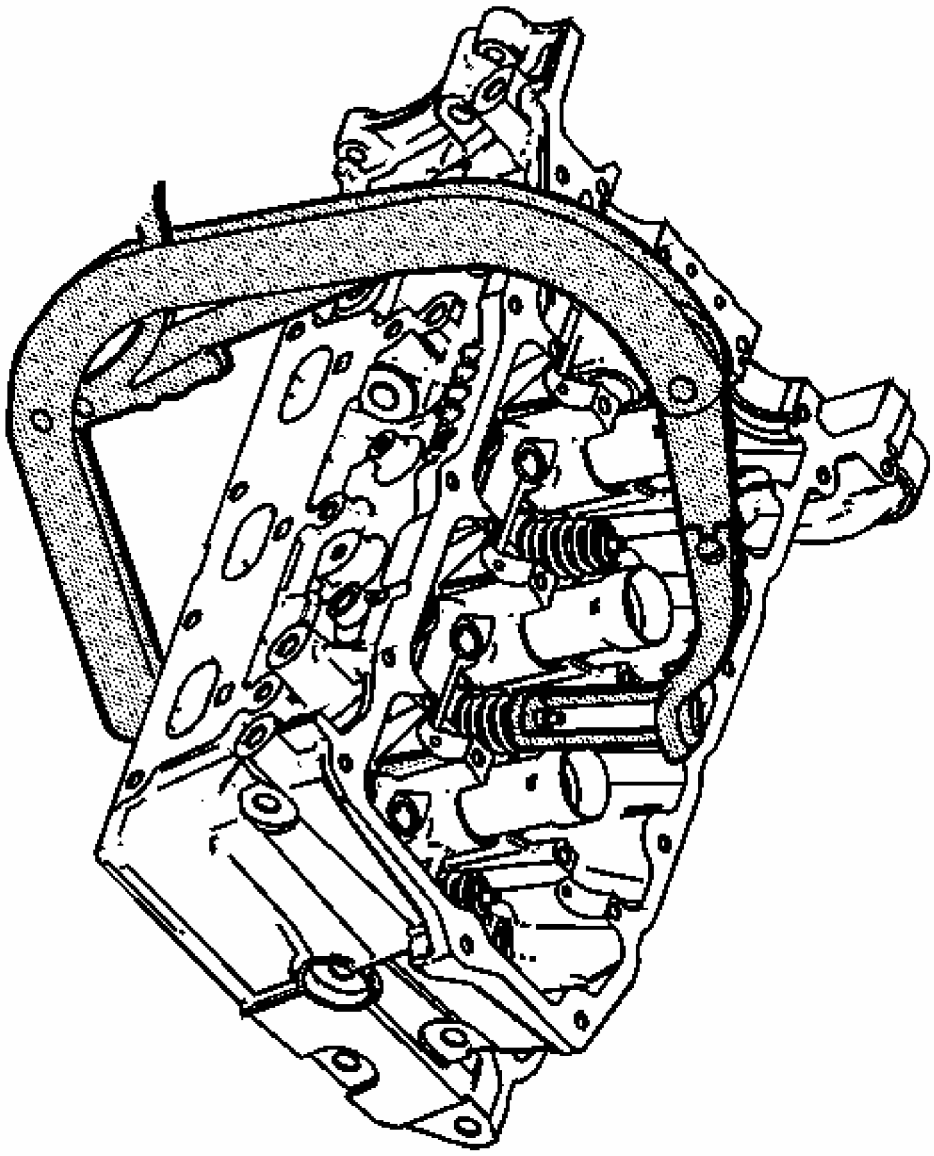

Fig. 113: Identifying J 8062 & EN 46119
Courtesy of GENERAL MOTORS CORP.

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when

compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

NOTE: **Do not compress the valve springs less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.**

10. Compress the valve spring using the **J 8062** and the **EN 46119** .

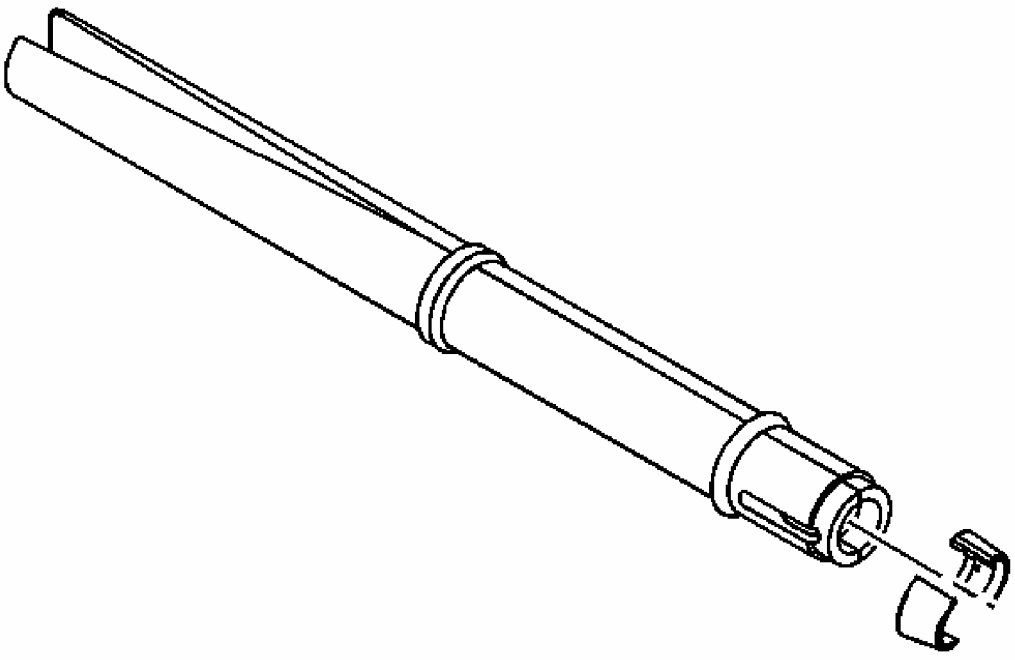

Fig. 114: Installing Valve Keepers With EN 46117
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure proper directional placement of valve keepers in the EN 46117 . The valve keepers must be installed with the tapered end towards the valve stem seal.

11. With the spring compressed, install the valve keepers into the **EN 46117** .

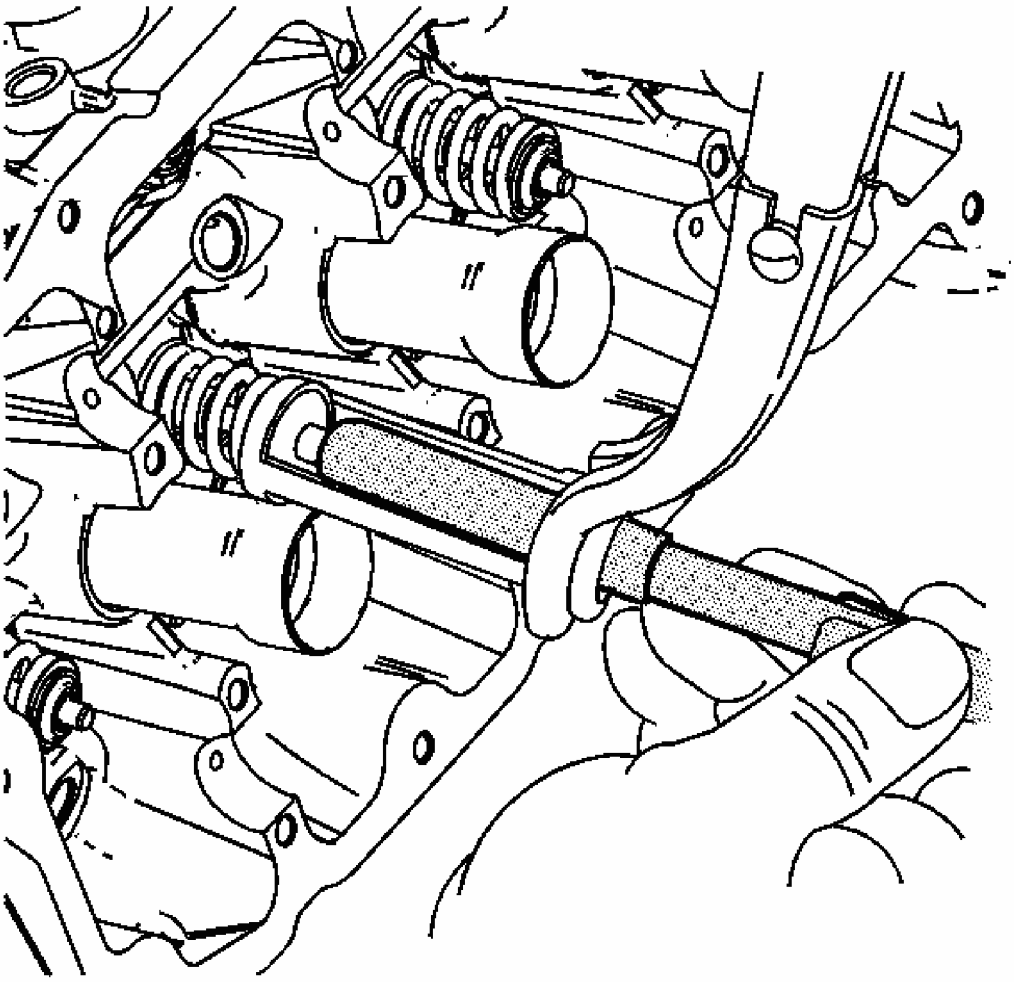

Fig. 115: View Of EN 46117
Courtesy of GENERAL MOTORS CORP.

12. Place the keepers into position by pushing the tool downward and releasing tension on the **EN 46119** and the **J 8062** .
13. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.

CAMSHAFT CLEANING AND INSPECTION

Tools Required

J 7872 Magnetic Base Dial Indicator

Cleaning Procedure

1. Clean the camshaft in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the camshaft with compressed air.

Visual Inspection

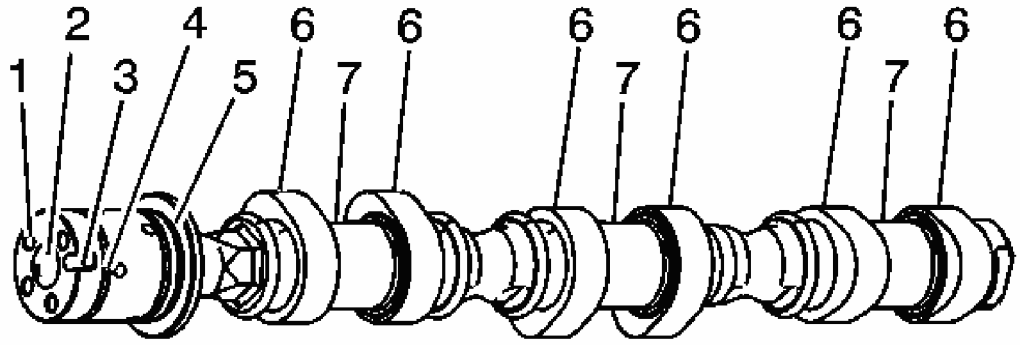

Fig. 116: Identifying Camshaft Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
   - Excessive scoring or pitting
   - Discoloration from overheating
   - Deformation from excessive wear, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement

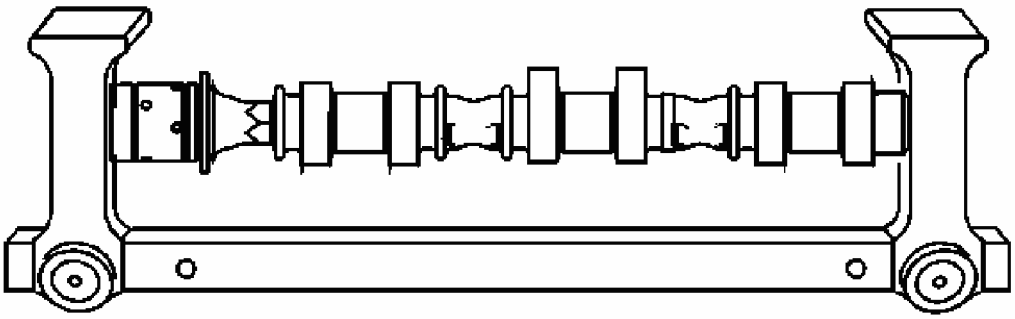

Fig. 117: Supporting Camshaft In Fixture
Courtesy of GENERAL MOTORS CORP.

1. With the camshaft in a suitable fixture, measure the camshaft for wear.

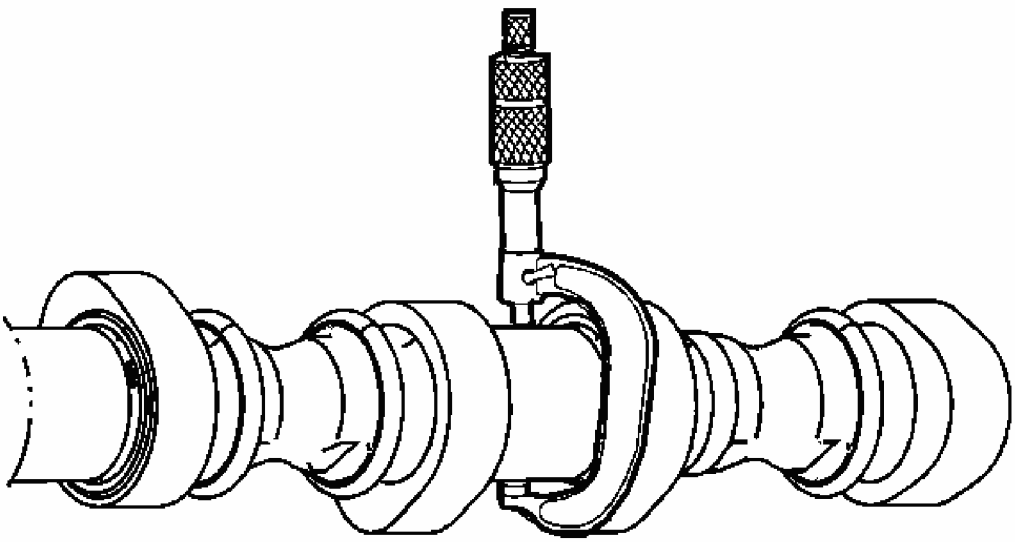

Fig. 118: Measuring Camshaft Journals
Courtesy of GENERAL MOTORS CORP.

2. Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Refer to **Engine Mechanical Specifications** .
    - If the diameter is smaller than specifications, replace the camshaft.

- If the out-of-round exceeds specifications, replace the camshaft.

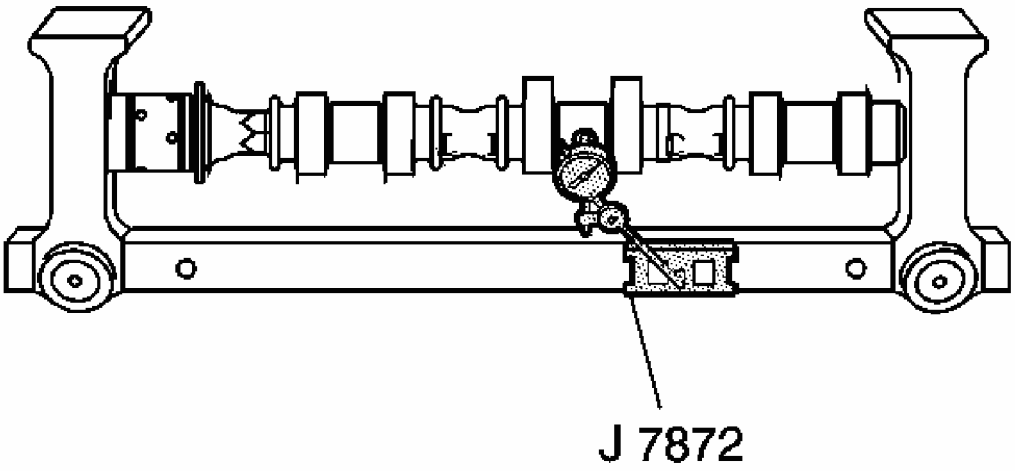

Fig. 119: Checking Camshaft Runout With J 7872
Courtesy of GENERAL MOTORS CORP.

3. Measure the camshaft runout using the **J 7872** . Refer to **Engine Mechanical Specifications** .

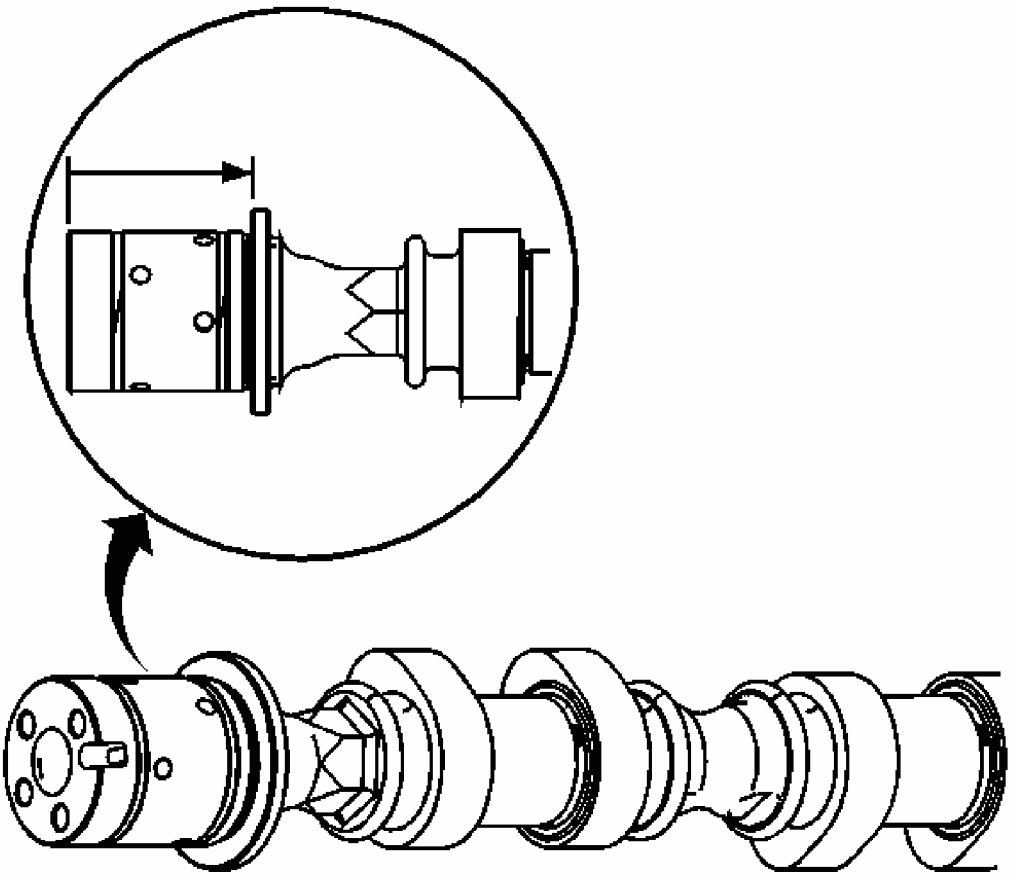

Fig. 120: Measuring Camshaft Thrust
Courtesy of GENERAL MOTORS CORP.

4. Measure the camshaft thrust width for wear using a depth micrometer. Refer to **Engine Mechanical Specifications** .

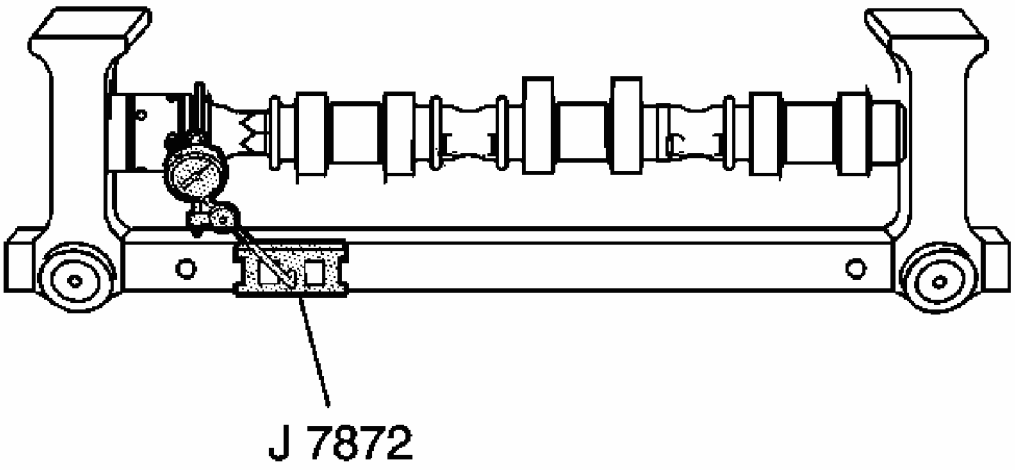

Fig. 121: Identifying J 7872
Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft thrust wall surface for runout using **J 7872** . Refer to **Engine Mechanical Specifications** .
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

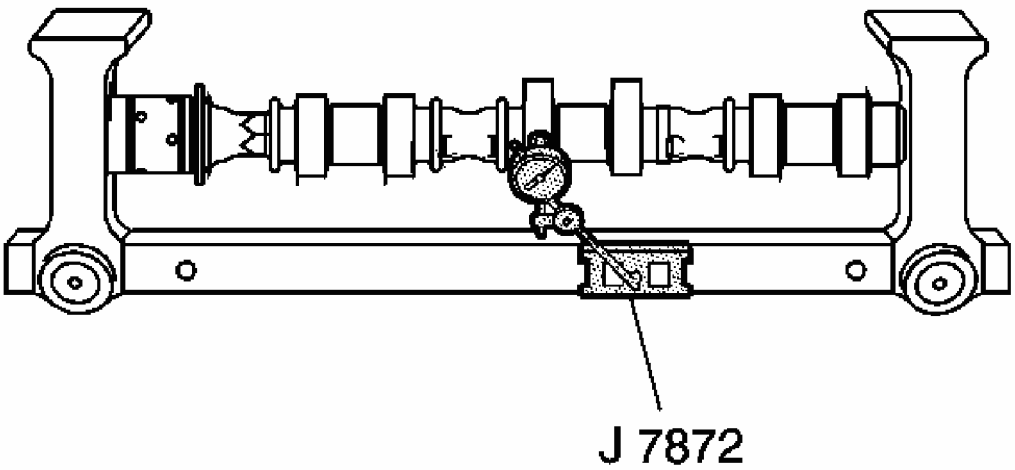

Fig. 122: Measuring Camshaft Lobes For Wear

Courtesy of GENERAL MOTORS CORP.

7. Measure the camshaft lobes for wear using the **J 7872** .

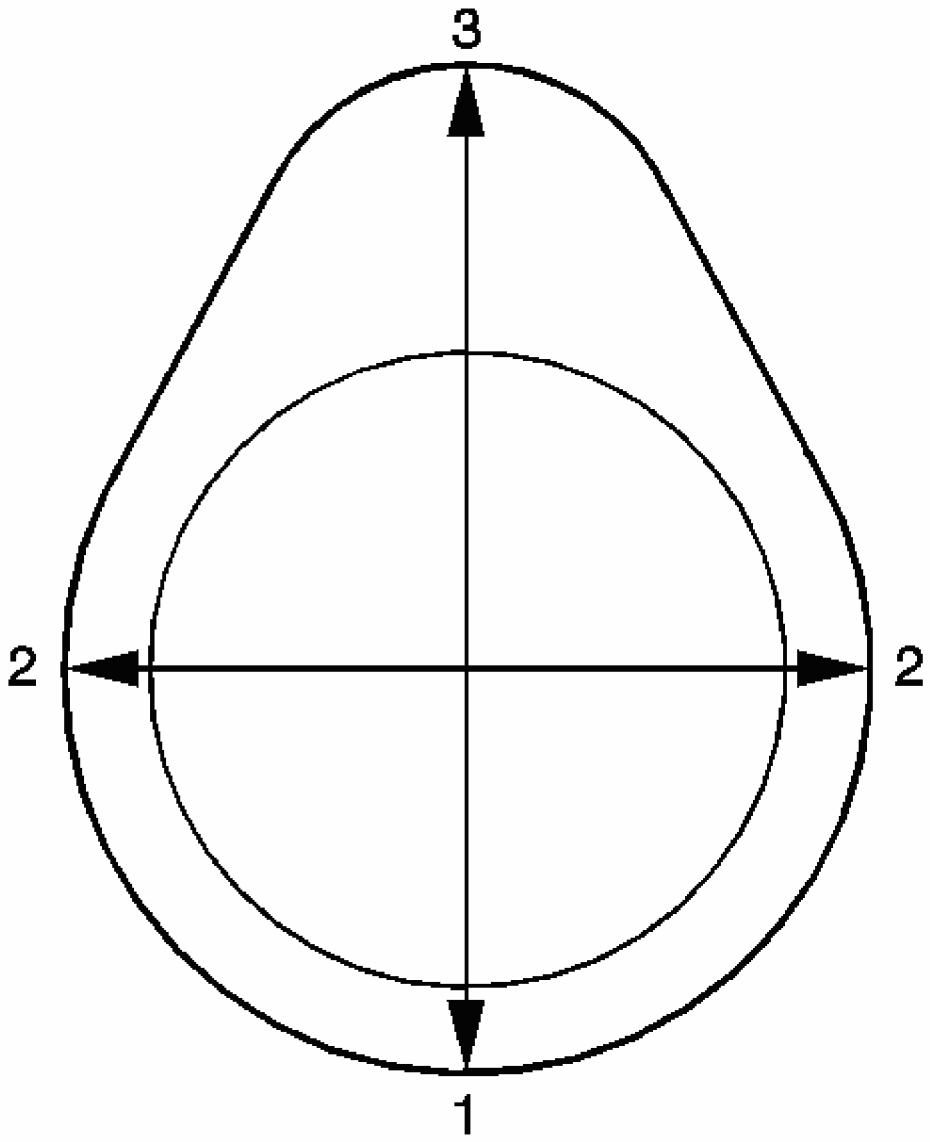

Fig. 123: Identifying Camshaft Lobe Dimensions
Courtesy of GENERAL MOTORS CORP.

8. Place the **J 7872** with the indicator tip on the base circle (1) of the camshaft lobe.
    1. Place the **J 7872** at zero.

2. Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. Refer to **Engine Mechanical Specifications** .
3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

VALVE LIFTERS CLEANING AND INSPECTION

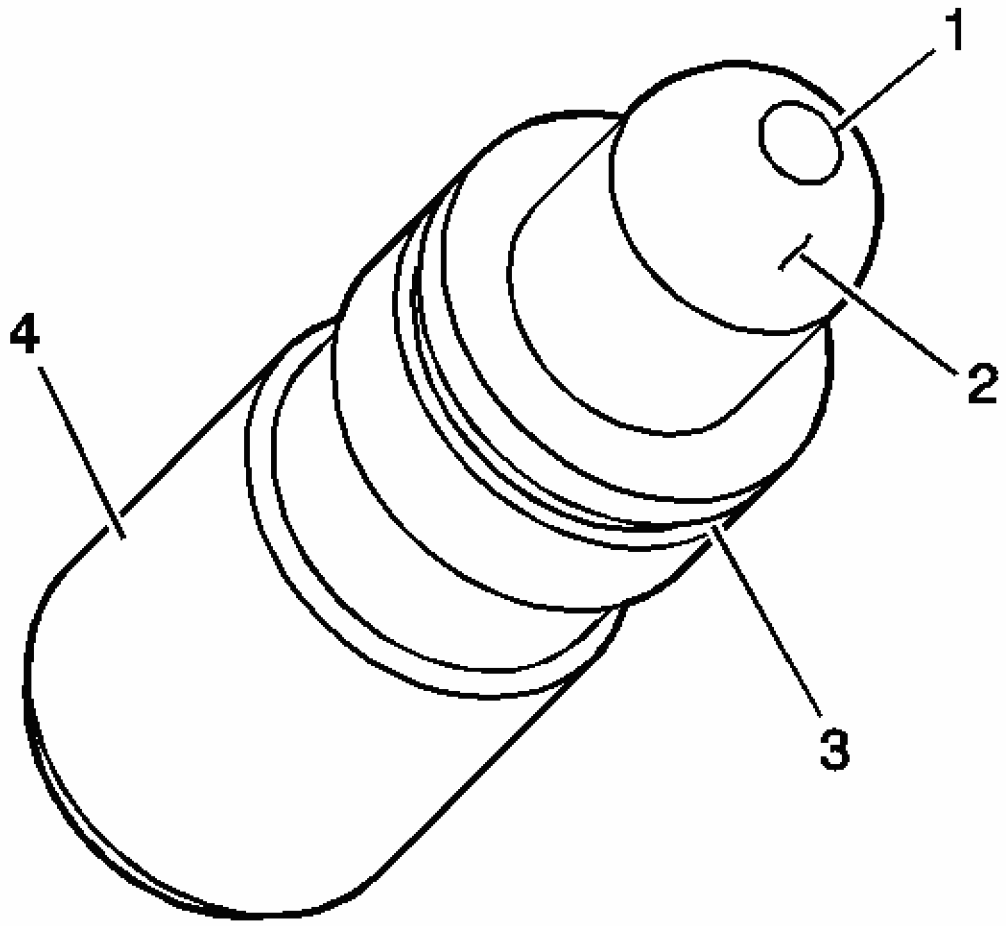

Fig. 124: Inspecting Valve Lifter
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to VALVE LIFTER PRIMING NOTICE in Cautions and Notices.**

1. Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:
    - A plugged oil passage (1)
    - A scored or worn camshaft follower pivot area (2)
    - A damaged or broken retainer (3)
    - A severely scuffed or worn SHLA body (4)
2. Replace the SHLA or SHLAs as necessary.

VALVE ROCKER ARMS CLEANING AND INSPECTION

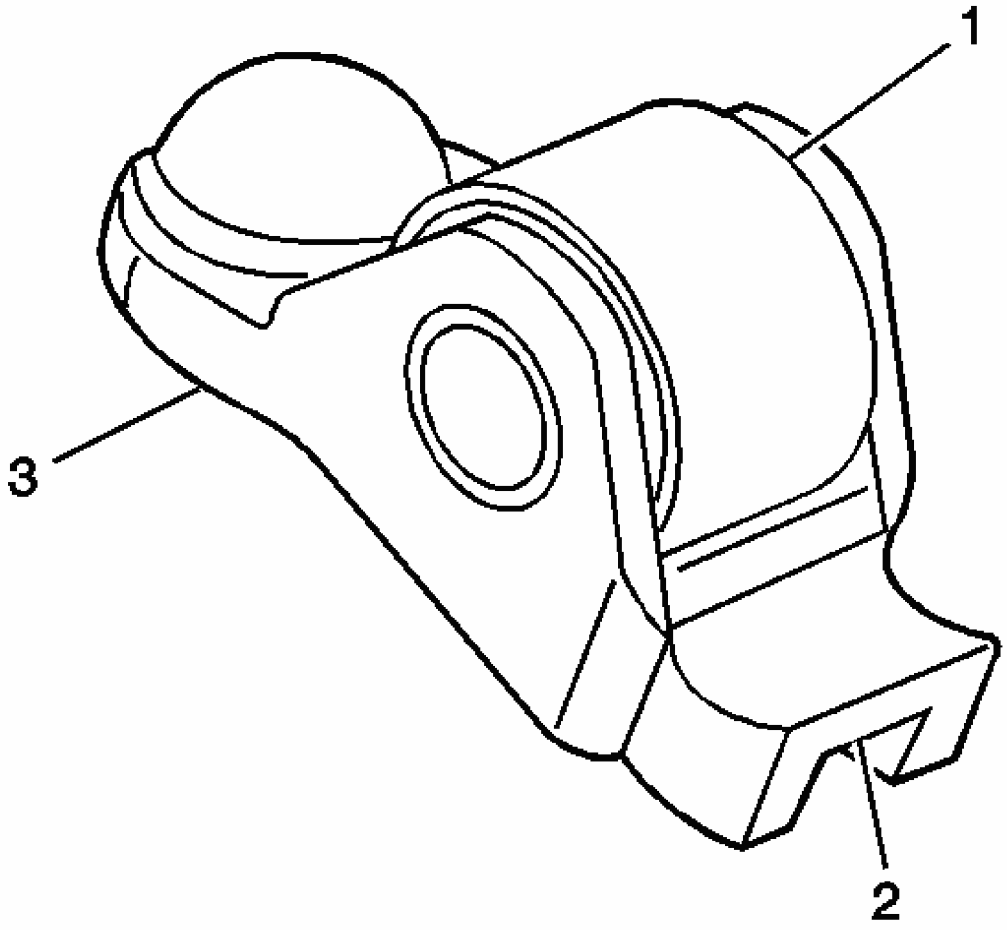

Fig. 125: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft follower roller (1) for the following:
    - Flat spots

- Excessive scoring and pitting
- Ensure the roller spins freely

2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

CAMSHAFT TIMING DRIVE COMPONENTS CLEANING AND INSPECTION

Cleaning Procedure

1. Clean all the following components with solvent:
   - Crankshaft sprocket
   - Primary timing drive chain
   - Primary timing drive chain shoe
   - Primary timing drive chain guides
   - Primary timing drive chain tensioner
   - Secondary timing drive chains
   - Secondary timing drive chain shoes
   - Secondary timing drive chain guides
   - Secondary timing drive chain tensioners
   - Timing component fastening bolts
2. Clean each camshaft position actuator's exterior with solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

3. Dry the timing components with compressed air.

Visual Inspection

Camshaft Position Actuators

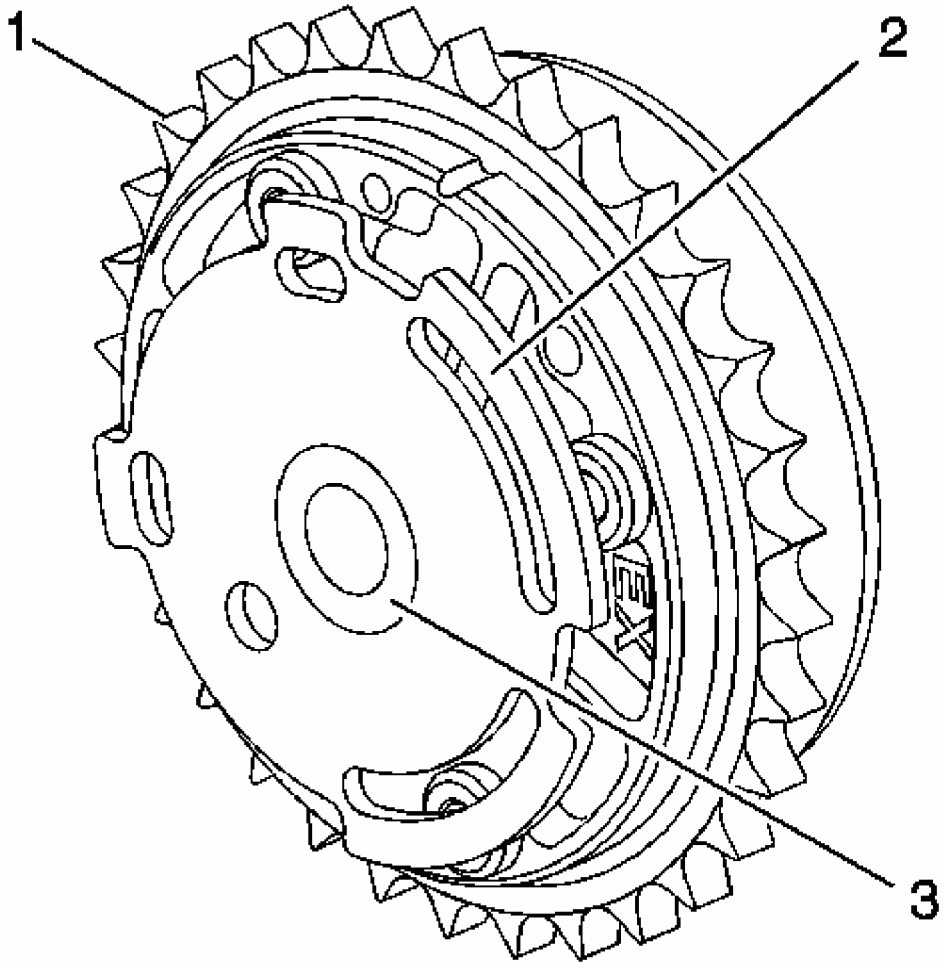

Fig. 126: Inspecting Front Of Exhaust Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the exhaust camshaft position actuators for the following:
    - Sprocket damage (1)
    - Reluctor/sensor wheel damage (2)
    - Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

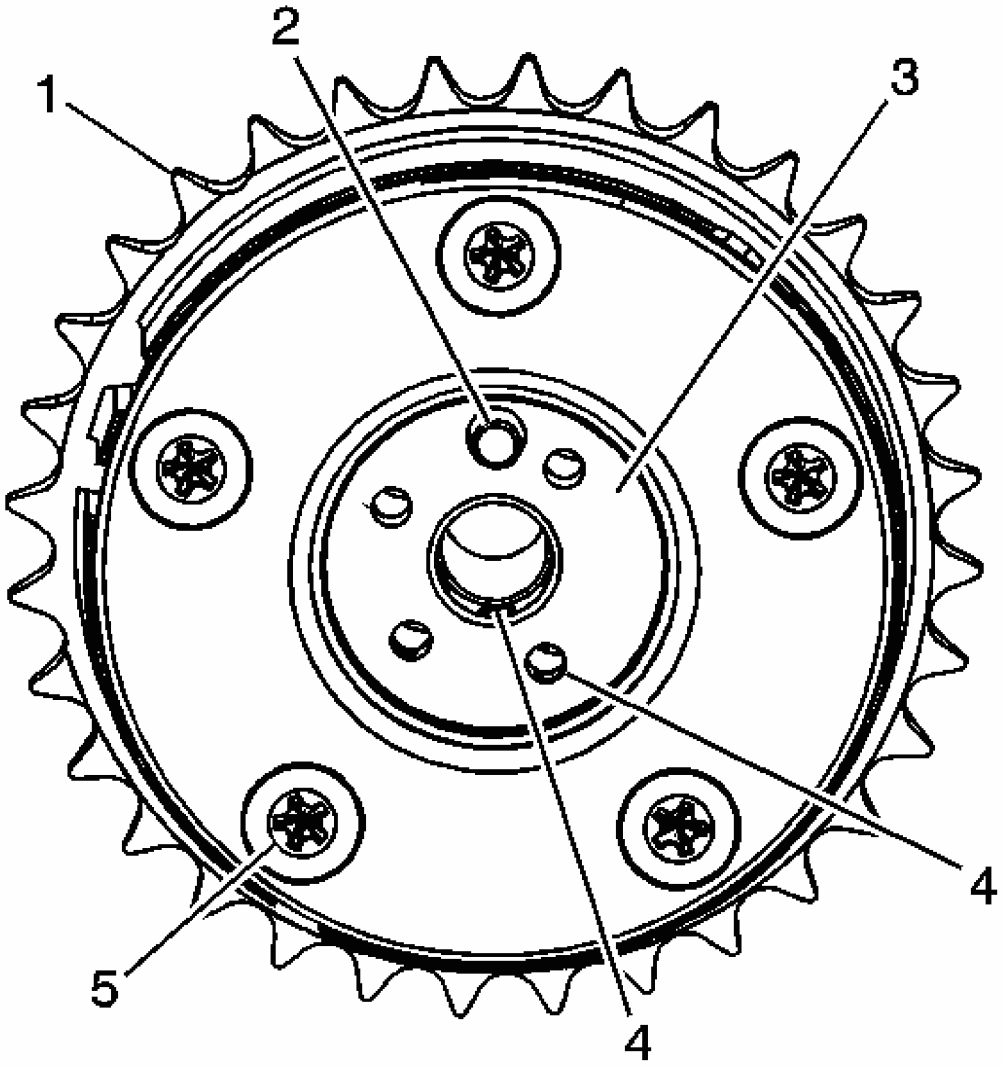

Fig. 127: Identifying Exhaust Camshaft Position Actuators Inspection Areas
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the exhaust camshaft position actuators for the following:
    - Sprocket damage (1)
    - Camshaft locating pin damage (2)
    - Camshaft seating/sealing inner hub flange damage (3)
    - Blockage to the oil passages (4)
    - Loose or missing housing bolts (5)

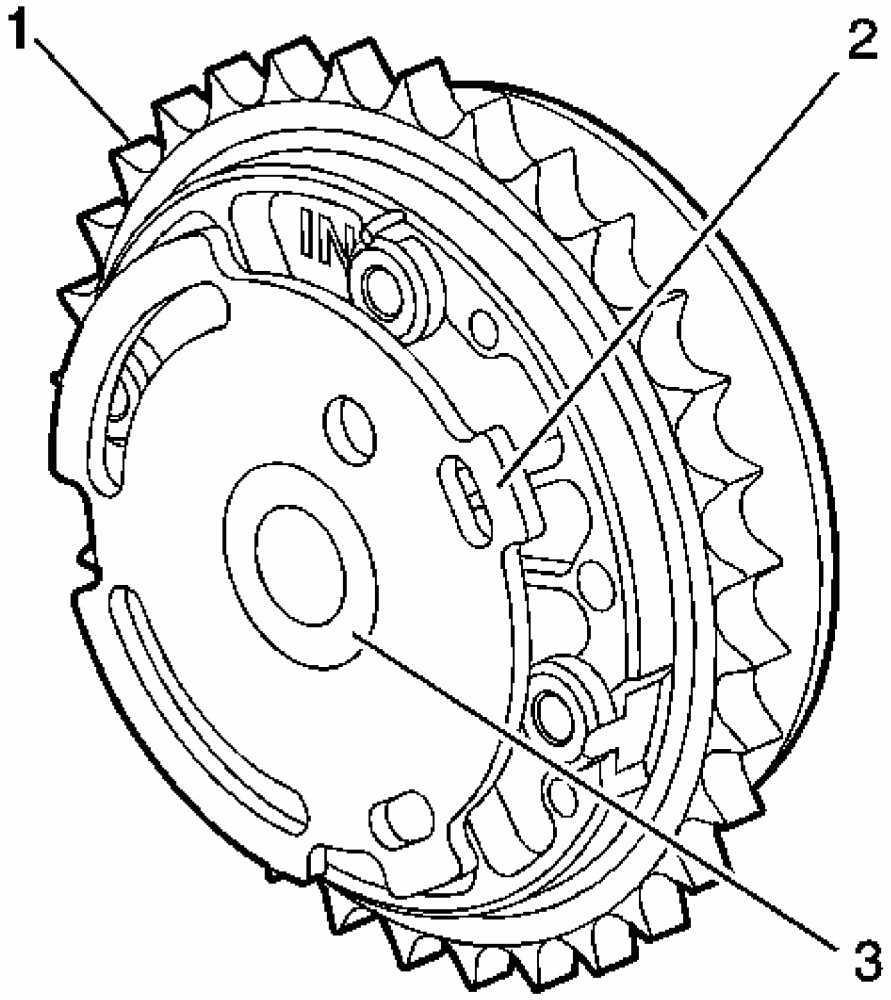

Fig. 128: Inspecting Front Intake Camshaft Position Actuators
Courtesy of GENERAL MOTORS CORP.

3. Inspect the front of the intake camshaft position actuators for the following:
   - Sprocket damage (1)
   - Reluctor/sensor wheel damage (2)
   - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3)

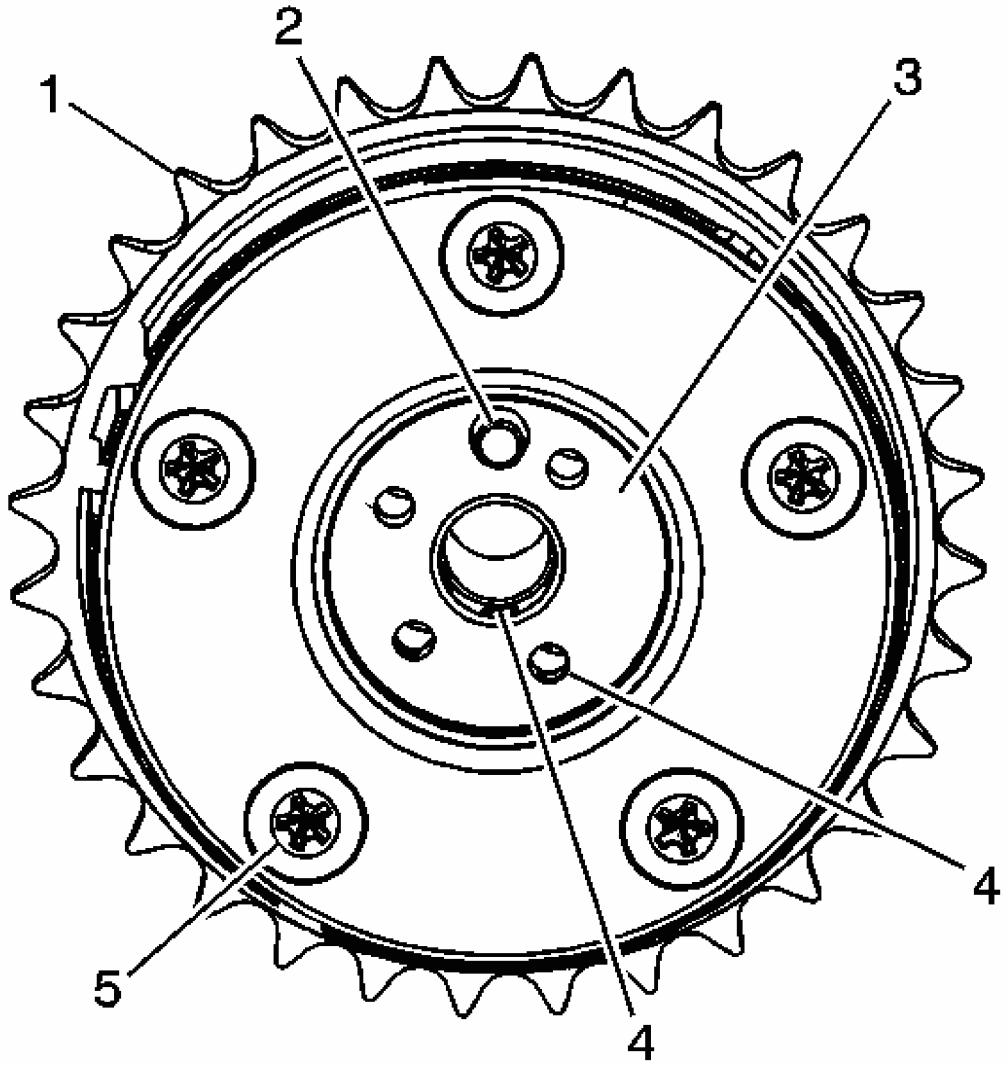

Fig. 129: Identifying Exhaust Camshaft Position Actuators Inspection Areas
Courtesy of GENERAL MOTORS CORP.

4. Inspect the back of the intake camshaft position actuators for the following:
    - Sprocket damage (1)
    - Camshaft locating pin damage (2)
    - Camshaft seating/sealing inner hub flange damage (3)
    - Blockage to the oil passages (4)
    - Loose or missing housing bolts (5)
5. Replace a damaged camshaft position actuator.

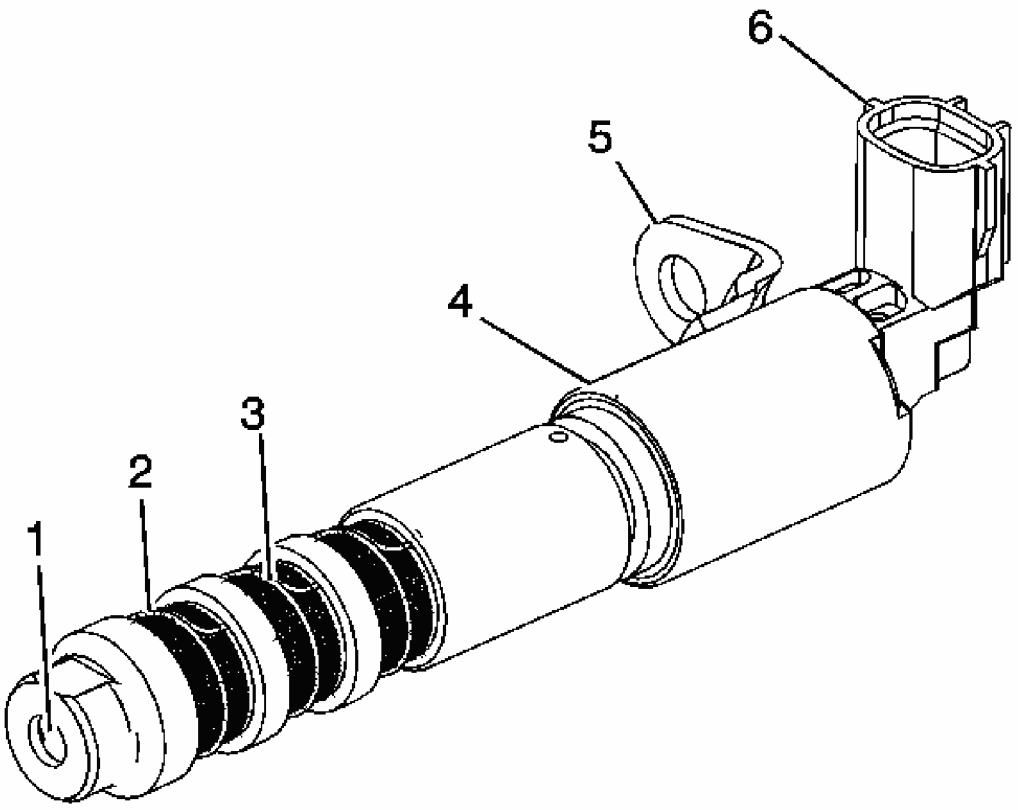

Fig. 130: Identifying Camshaft Position Actuator Oil Control Valves Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft position actuator oil control valves for the following:
   - Blockage to the oil passage (1)
   - Missing or damaged oil screen clip (2)
   - Blockage or damage to the oil screen (3)
   - Damage to the sealing surface for the camshaft position actuator oil control valve solenoid oil seal (4)
   - Damage to the bracket (5)
   - Damage to the wiring harness connection and/or terminals (6)
2. Replace a damaged camshaft position actuator oil control valve.

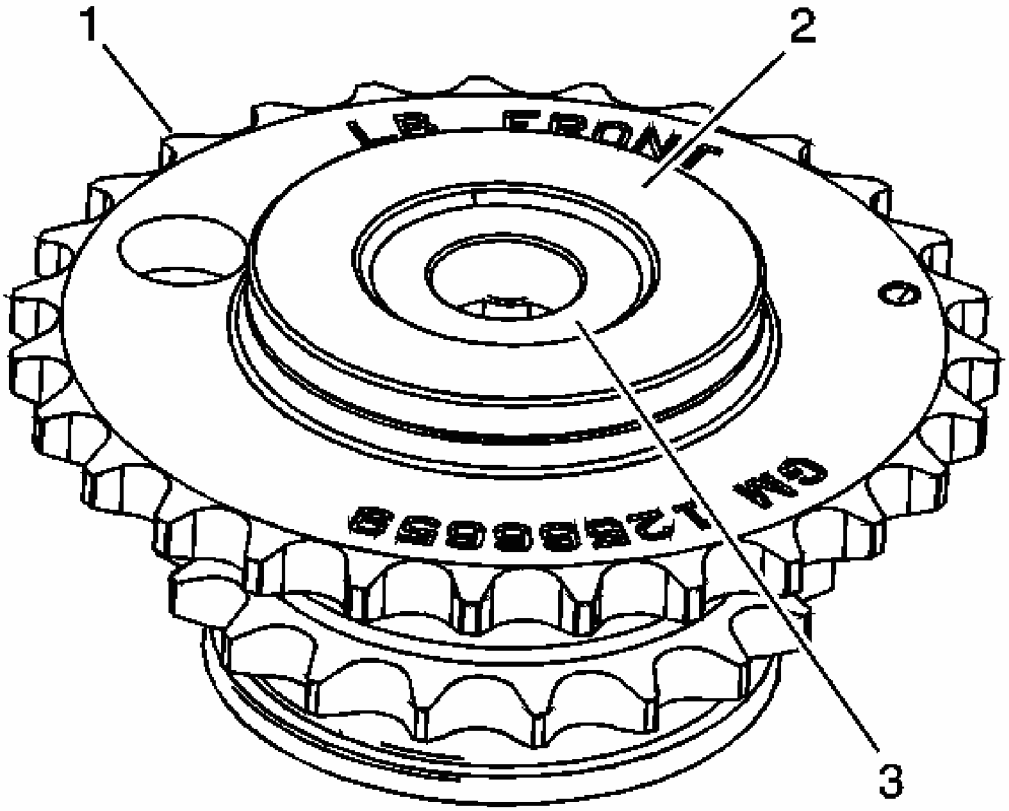

Fig. 131: Inspecting Front Of Left Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the left intermediate sprocket for the following:
   - Damage to the primary camshaft drive chain sprocket (1)
   - Damage to the hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
   - Damage to the bolt flange seating/sealing surface (3)

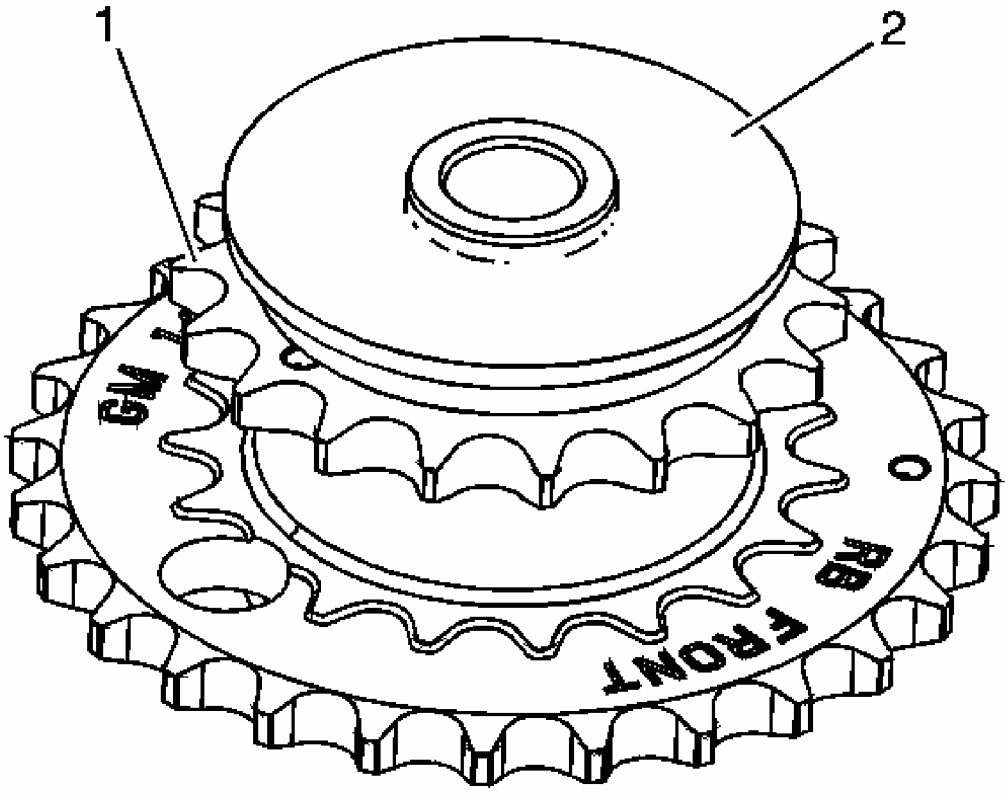

Fig. 132: Checking Back Of The Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the intermediate sprocket for the following:
    - Damage to the left secondary camshaft drive chain sprocket (1)
    - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged left intermediate sprocket.

Left Intermediate Sprocket with Primary (IT) Inverted Tooth Chain

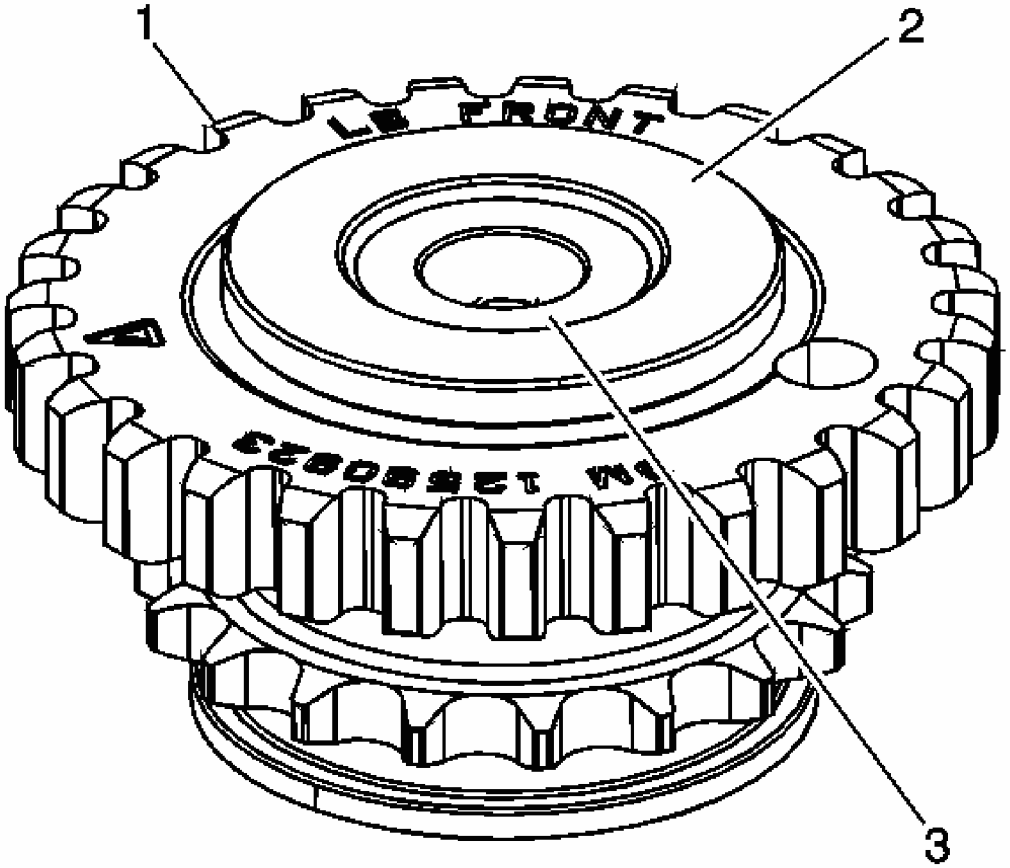

Fig. 133: Checking Front Of Left Intermediate Sprocket Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the left intermediate sprocket for the following:
    - Damage to the primary camshaft drive chain sprocket (1)
    - Damage to the hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
    - Damage to the bolt flange seating/sealing surface (3)

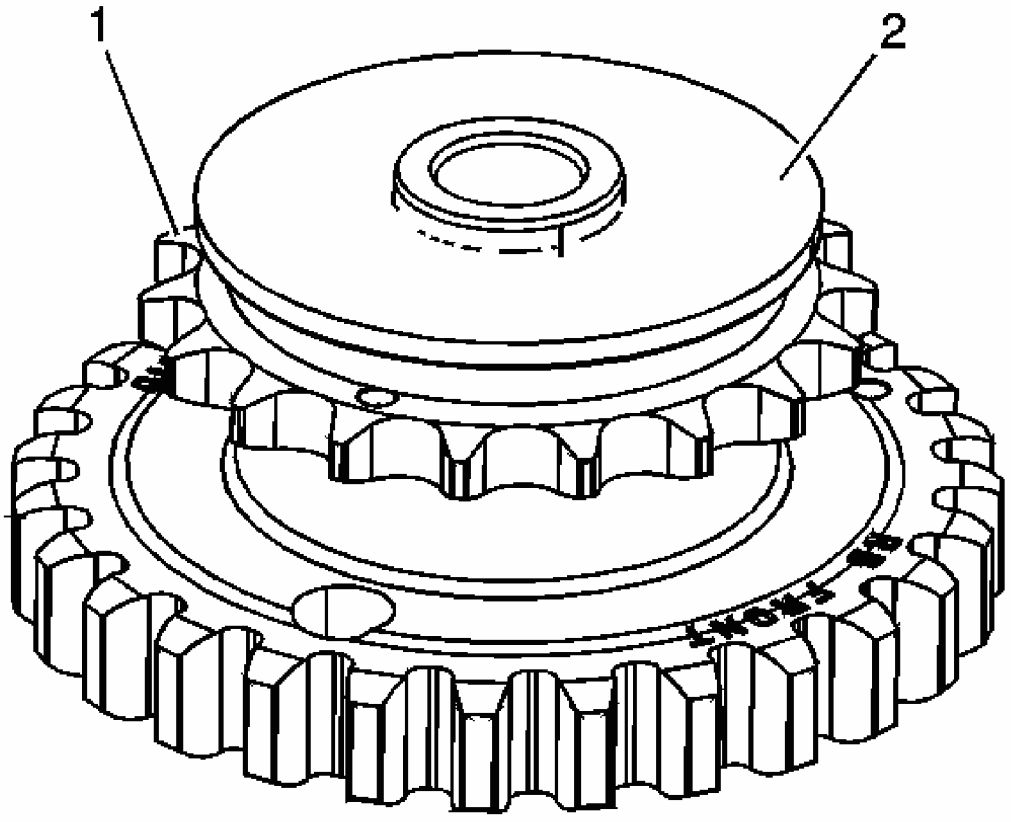

Fig. 134: Inspecting Back Of Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the intermediate sprocket for the following:
    - Damage to the left secondary camshaft drive chain sprocket (1)
    - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged left intermediate sprocket.

Right Intermediate Sprocket with Primary Roller Chain

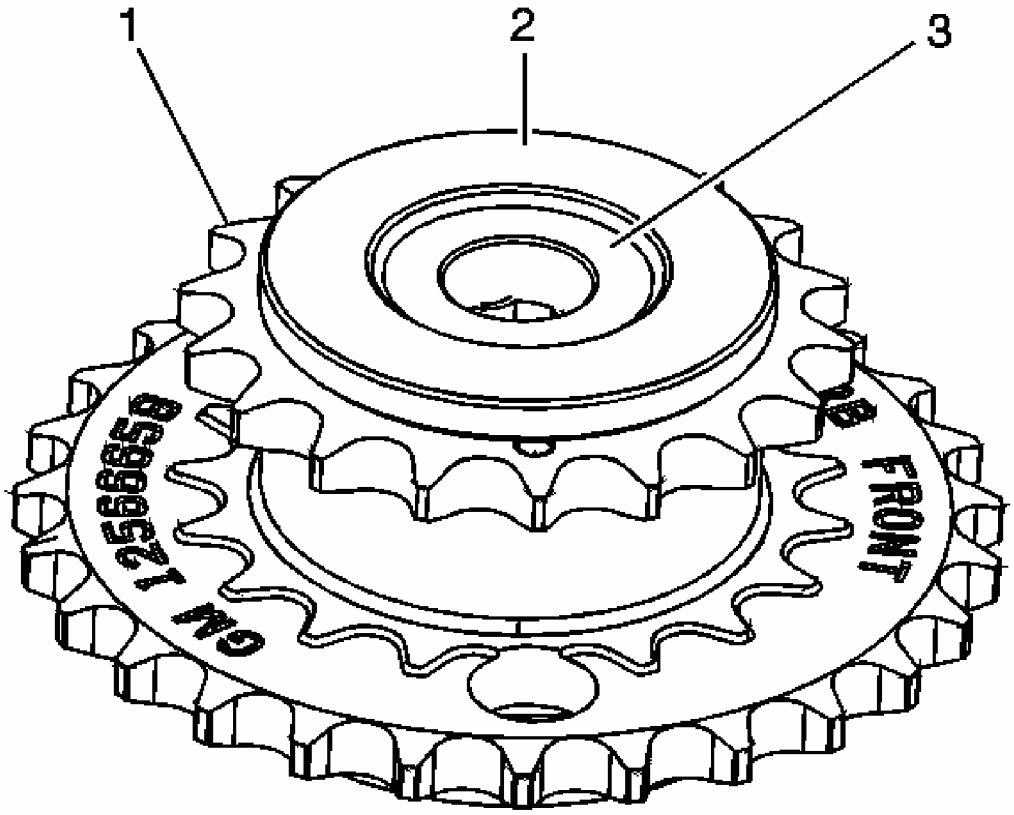

Fig. 135: Identifying Front Of Right Intermediate Sprocket Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the right intermediate sprocket for the following:
   - Damage to the right secondary camshaft drive chain sprocket (1)
   - Damage to the bearing hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
   - Damage to the bolt flange seating/sealing surface (3)

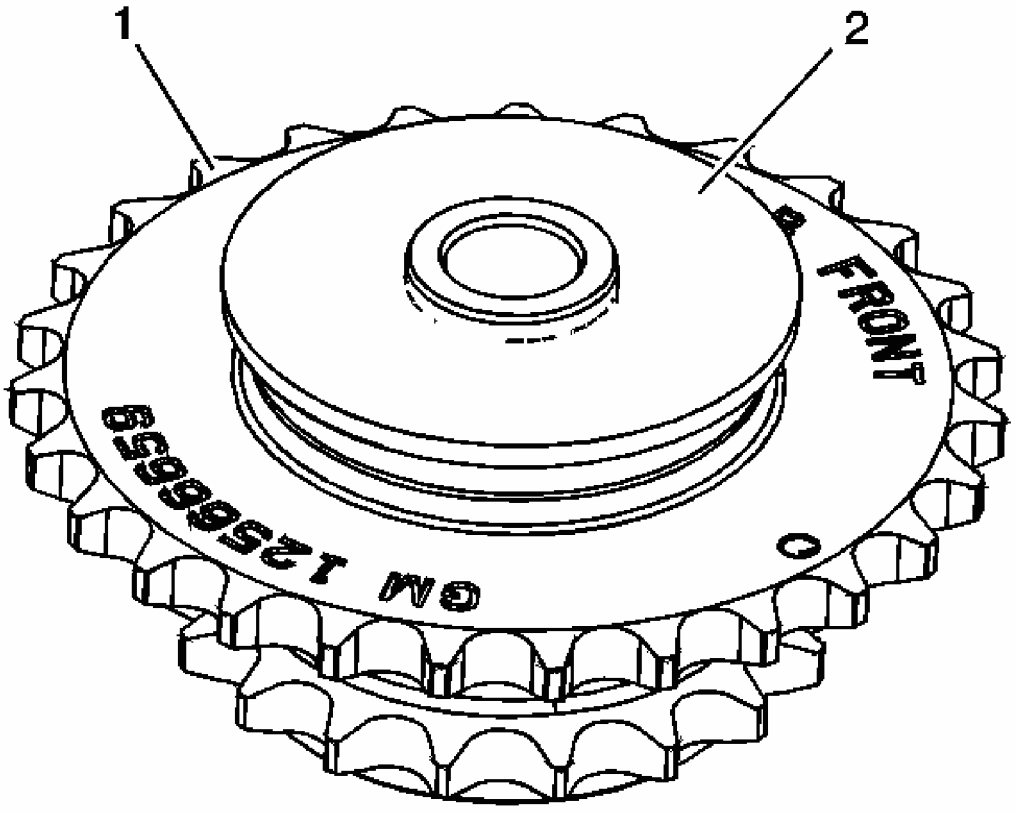

Fig. 136: Inspecting Back Of Right Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the right intermediate sprocket for the following:
    - Damage to the primary camshaft drive chain sprocket (1)
    - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged right intermediate sprocket.

Right Intermediate Sprocket with Primary (IT) Inverted Tooth Chain

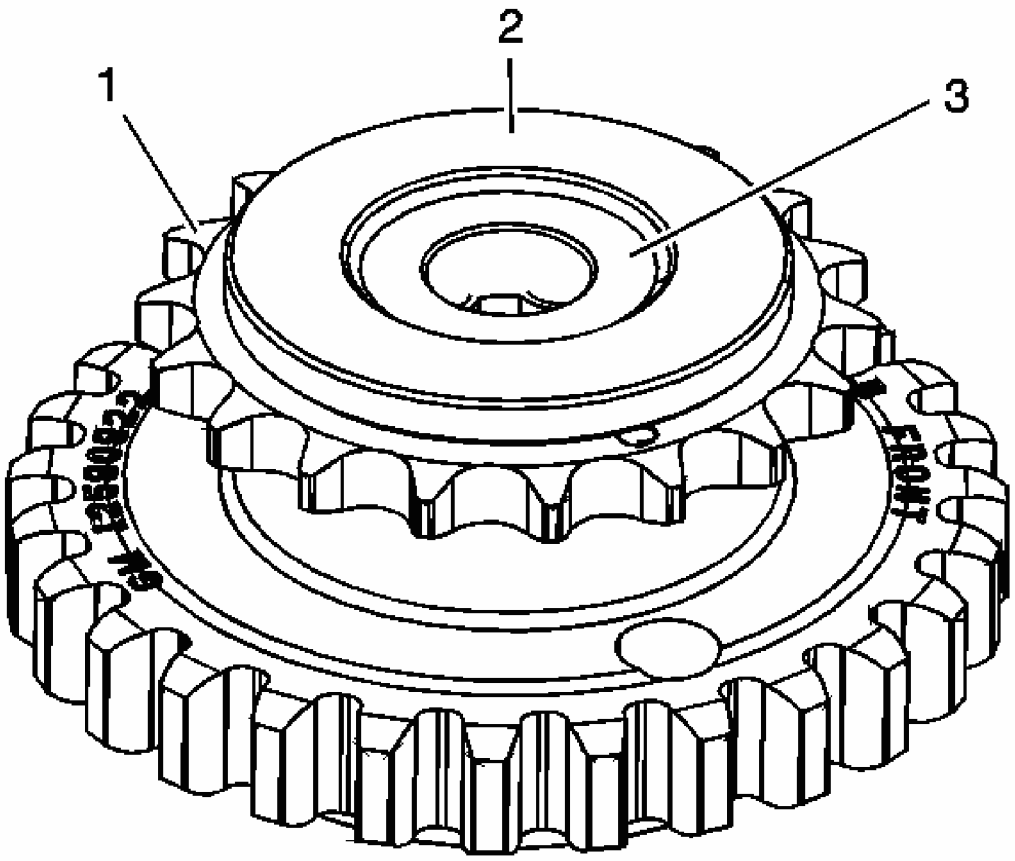

Fig. 137: Identifying Front Of Right Intermediate Sprocket Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the right intermediate sprocket for the following:
    - Damage to the right secondary camshaft drive chain sprocket (1)
    - Damage to the bearing hub bearing (2) - Ensure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
    - Damage to the bolt flange seating/sealing surface (3)

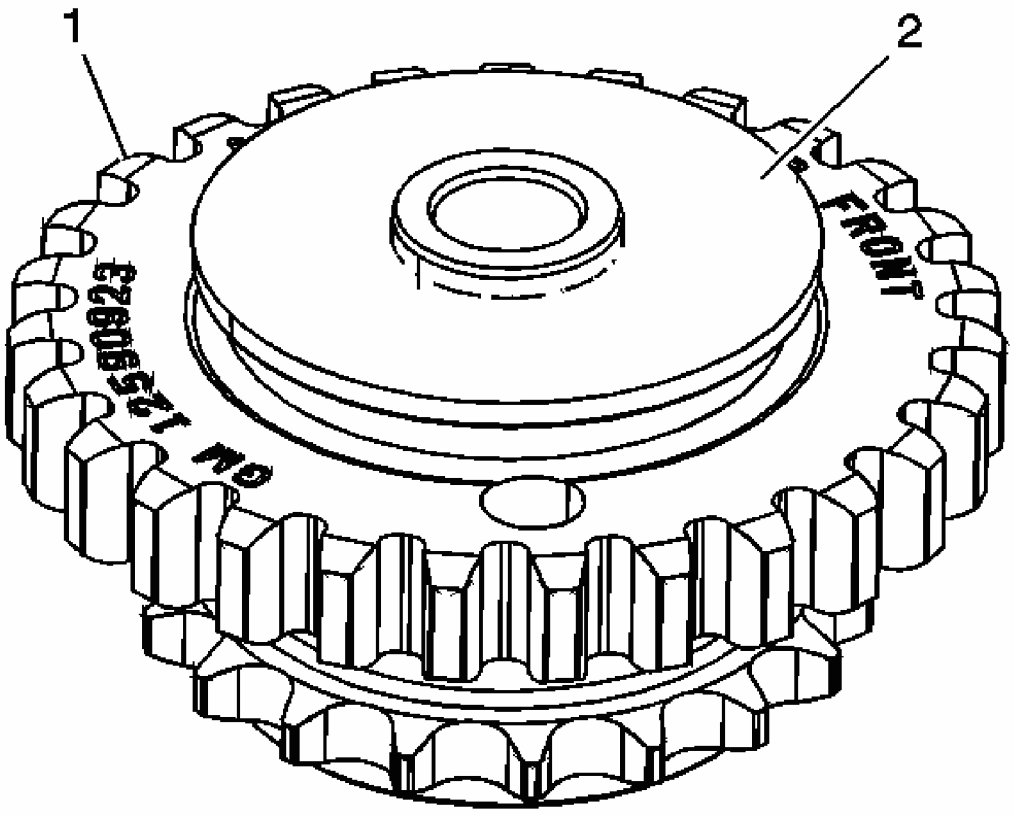

Fig. 138: Inspecting Back Of Right Intermediate Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the right intermediate sprocket for the following:
    - Damage to the primary camshaft drive chain sprocket (1)
    - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged right intermediate sprocket.

Crankshaft Sprocket with Primary Roller Chain

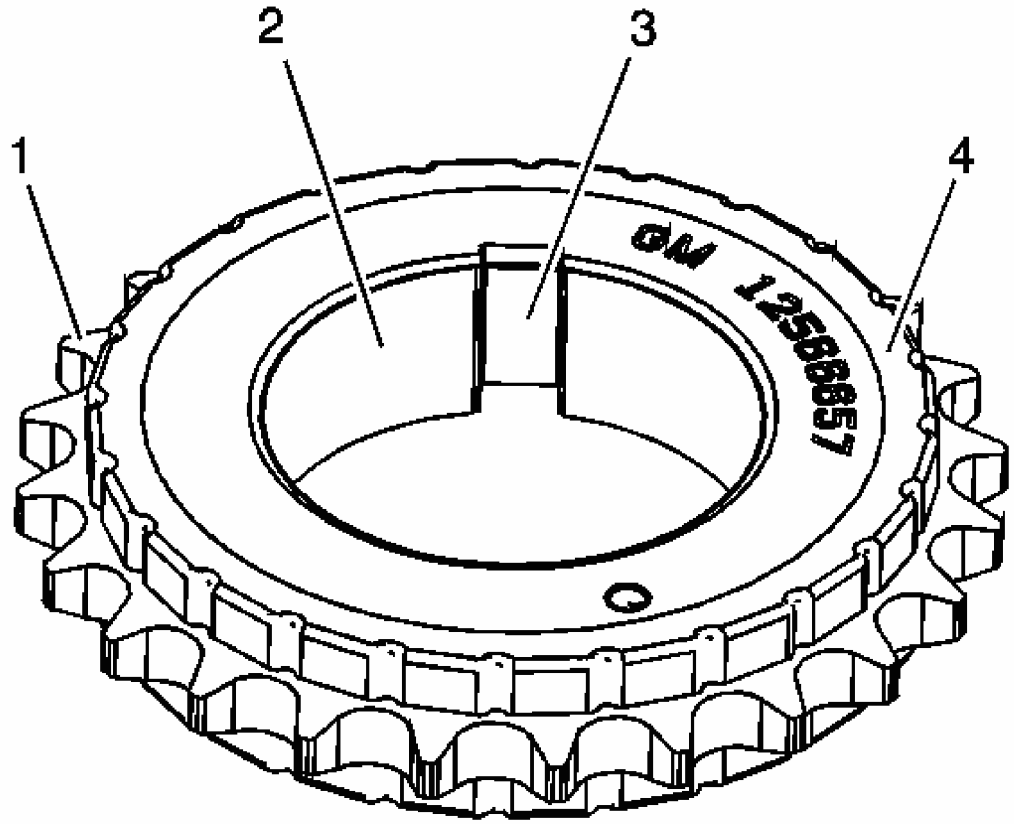

Fig. 139: Inspecting Crankshaft Sprocket With Primary Roller Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft sprocket for the following:
    - Sprocket damage (1)
    - Bore damage (2)
    - Keyway damage (3)
    - Damage to the cushion material (4)
2. Replace a damaged crankshaft sprocket.

Crankshaft Sprocket with Primary (IT) Inverted Tooth Chain

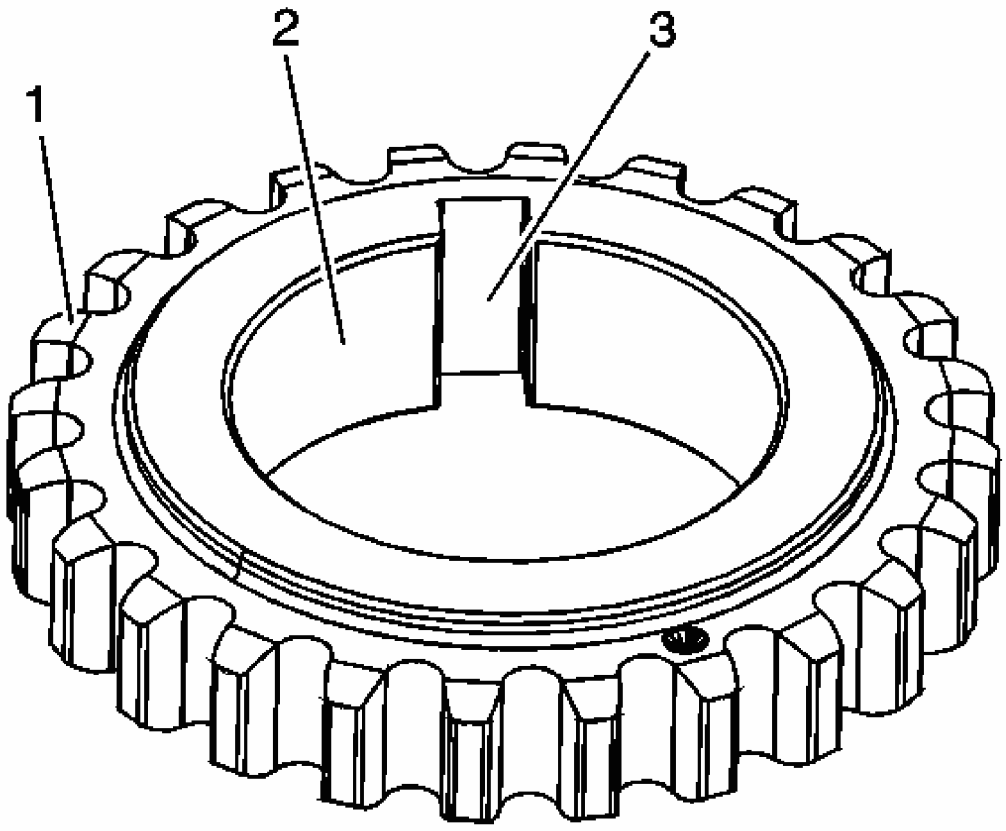

Fig. 140: Checking Crankshaft Sprocket With Primary (IT) Inverted Tooth Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the crankshaft sprocket for the following:
    - Sprocket damage (1)
    - Bore damage (2)
    - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

Primary and Secondary Timing Chains with Roller Chain

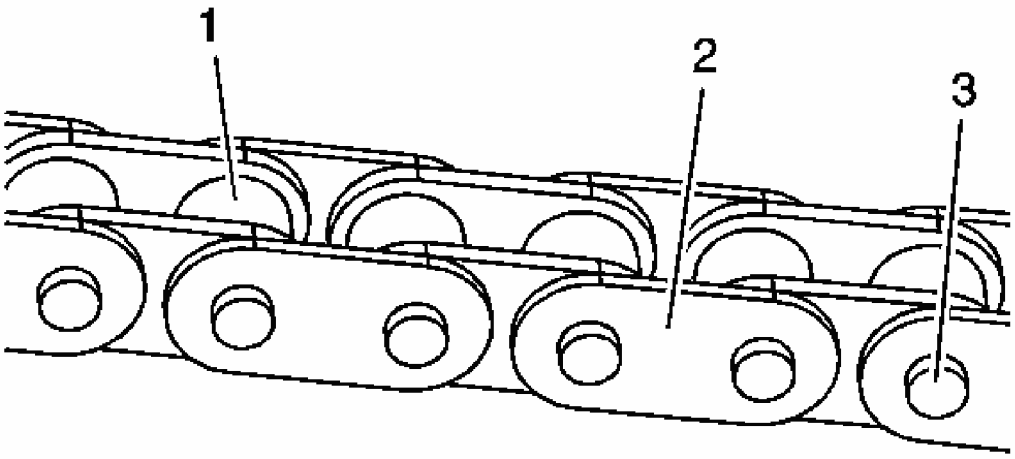

Fig. 141: Inspecting Primary And Secondary Timing Chains With Roller Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary and/or secondary timing chain for the following:
   - Binding or worn rollers (1)
   - Loose links (2)
   - Loose pins (3)
2. Replace a damaged primary and/or secondary timing chain.

Primary Timing Chain with (IT) Inverted Tooth Chain

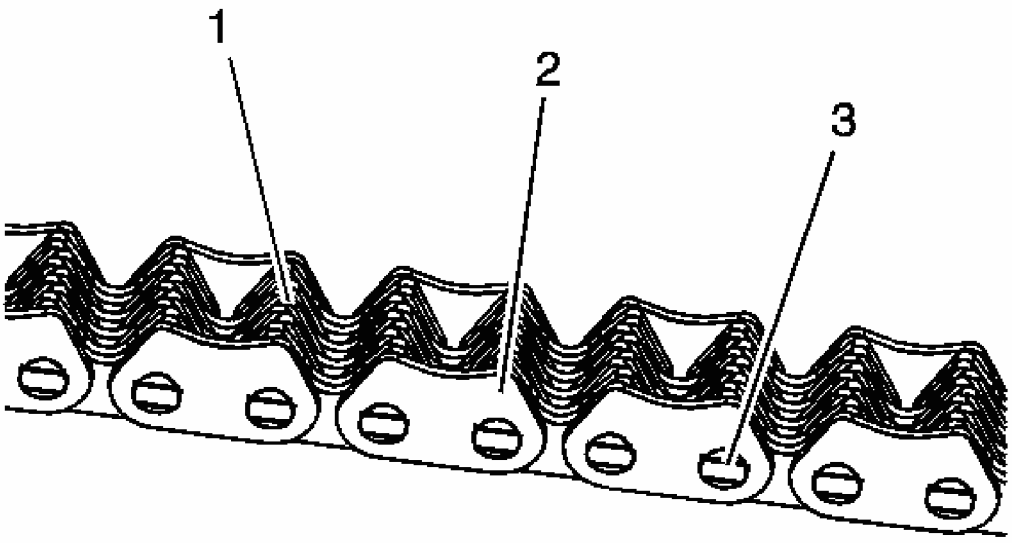

Fig. 142: Identifying Primary Timing Chain With (IT) Inverted Tooth Chain
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain for the following:
   - Binding or worn links (1)
   - Loose links (2)
   - Loose pins (3)
2. Replace a damaged primary timing chain.

Primary Timing Chain Upper Guide

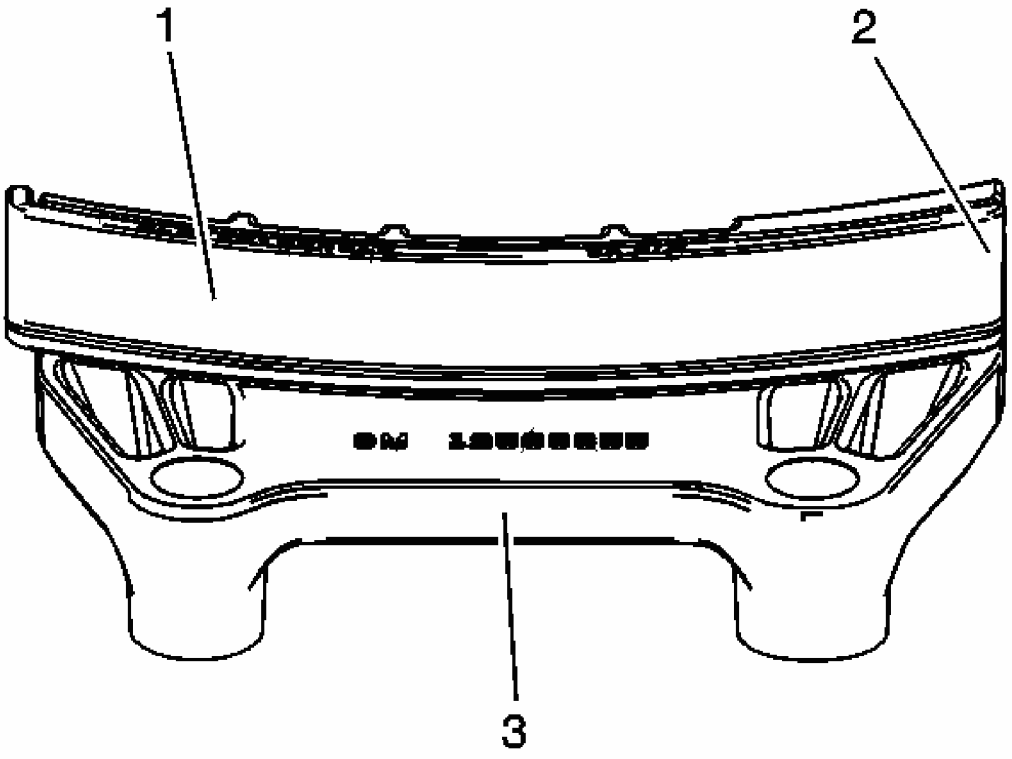

Fig. 143: Checking Primary Timing Chain Upper Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain upper guide for the following:
    - Worn guide surface (1)
    - Cracked or broken guide surface (2)
    - Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Primary Timing Chain Lower Guide

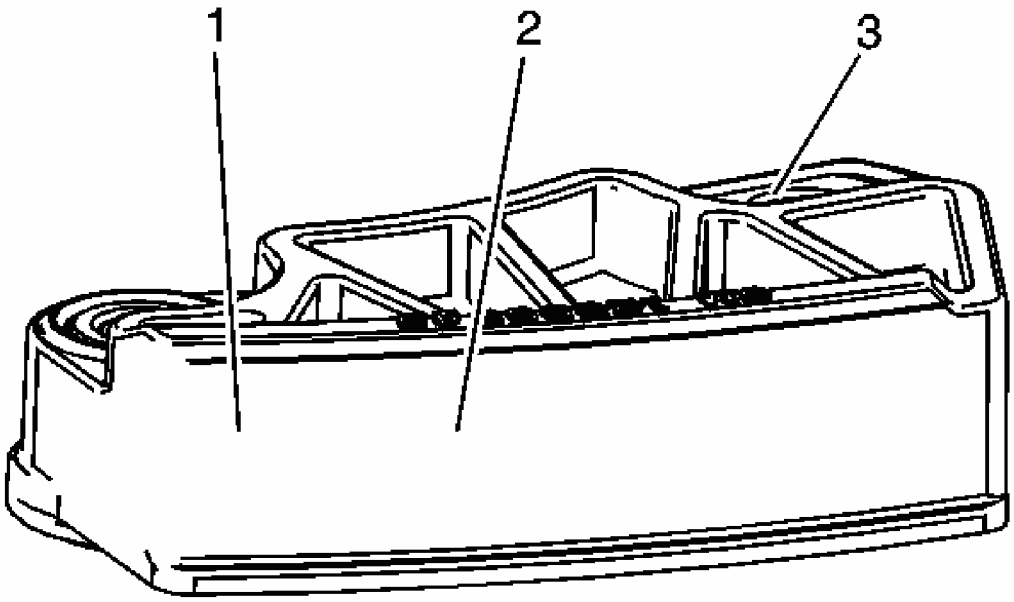

Fig. 144: Inspecting Primary Timing Chain Lower Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain lower guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)

IMPORTANT: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

2. Replace a damaged primary timing chain lower guide by replacing the oil pump.

Left Secondary Timing Chain Guide

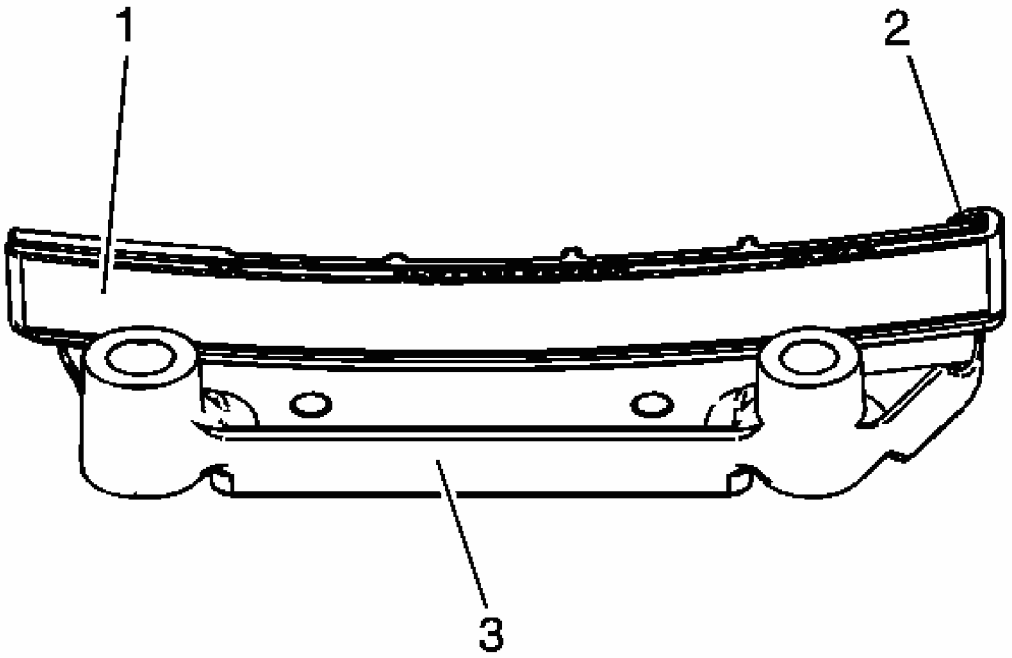

Fig. 145: Checking Left Secondary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the left secondary timing chain guides for the following:
    - Worn guide surface (1)
    - Cracked or broken guide surface (2)
    - Cracked or damaged guide base (3)
2. Replace a damaged left secondary timing chain guide.

Right Secondary Timing Chain Guide

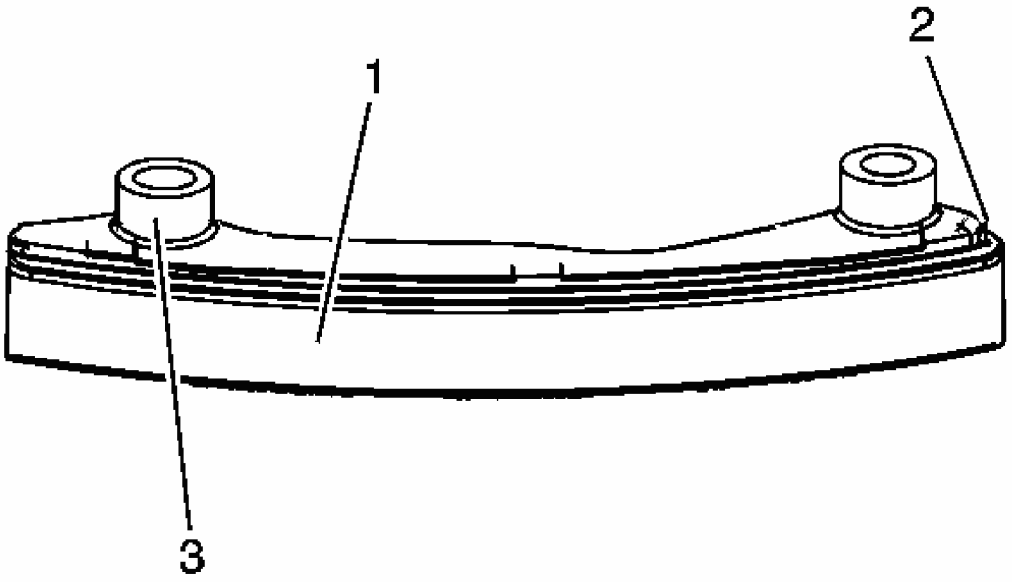

Fig. 146: Identifying Right Secondary Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Inspect the right secondary timing chain guides for the following:
    - Worn guide surface (1)
    - Cracked or broken guide surface (2)
    - Cracked or damaged guide base (3)
2. Replace a damaged right secondary timing chain guide.

Left Secondary Timing Chain Shoe

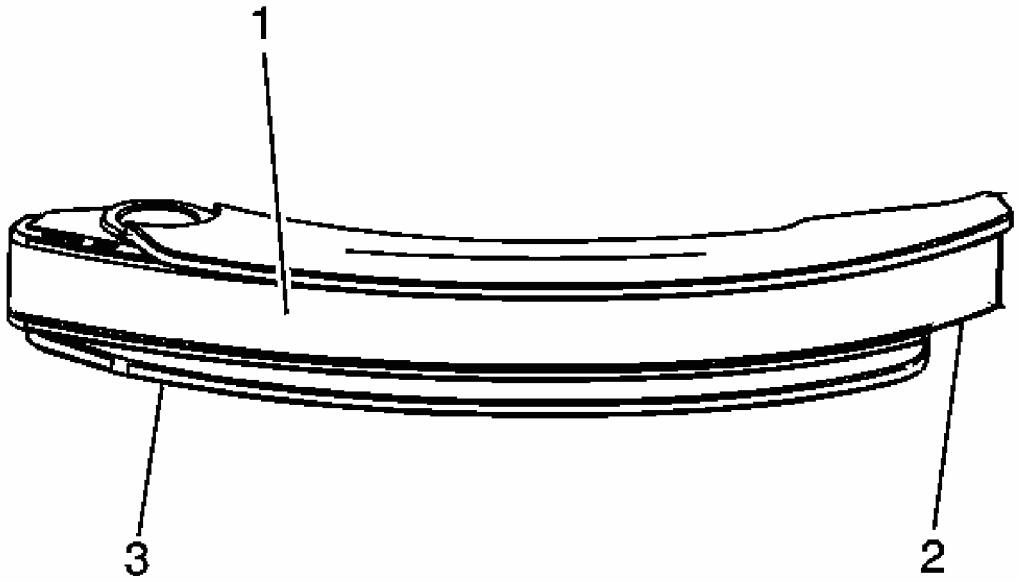

Fig. 147: Checking Left Secondary Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the left secondary timing chain shoe for the following:
    - Worn shoe surface (1)
    - Cracked or broken shoe surface (2)
    - Cracked or damaged shoe (3)

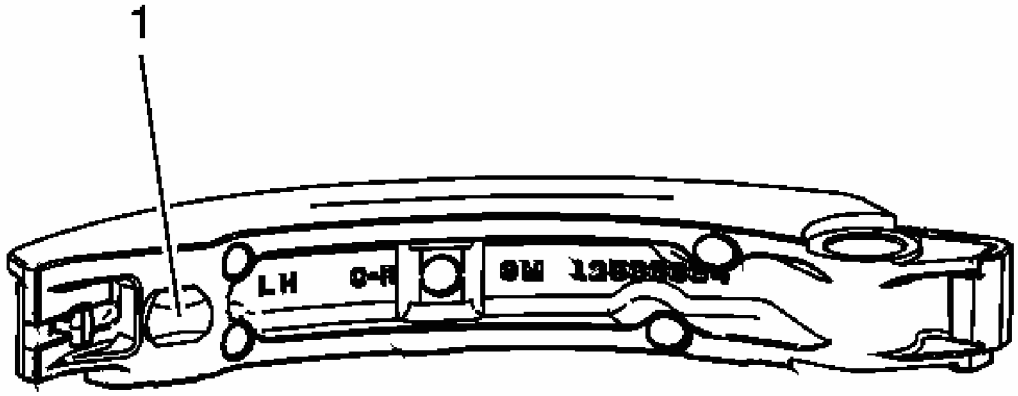

Fig. 148: Inspecting Left Secondary Timing Chain Tensioner Contact Pad
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the left secondary timing chain shoe for a damaged, worn or missing left secondary timing chain tensioner contact pad (1).
3. Replace a damaged left secondary timing chain shoe.

Right Secondary Timing Chain Shoe

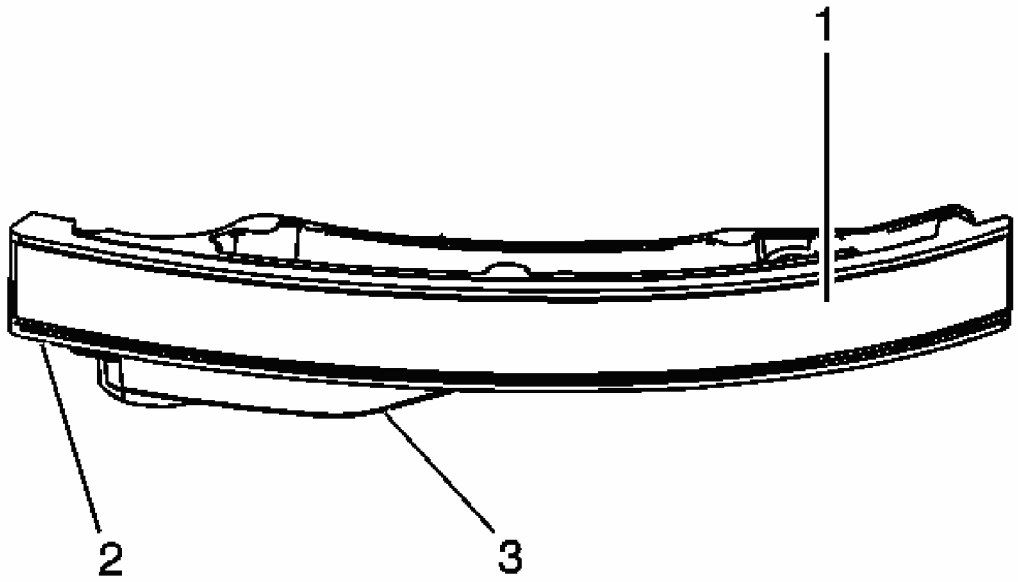

Fig. 149: Identifying Right Secondary Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Inspect the front of the right secondary timing chain shoe for the following:
   - Worn shoe surface (1)
   - Cracked or broken shoe surface (2)
   - Cracked or damaged shoe (3)

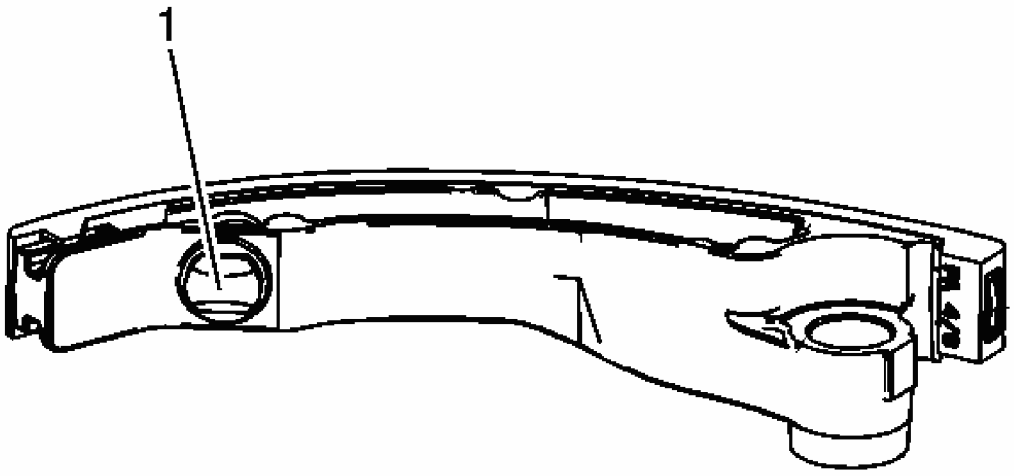

Fig. 150: Inspecting Right Secondary Timing Chain Tensioner Contact Pad
Courtesy of GENERAL MOTORS CORP.

2. Inspect the back of the right secondary timing chain shoe for a damaged, worn or missing right secondary timing chain tensioner contact pad (1).
3. Replace a damaged right secondary timing chain shoe.

Primary Timing Chain Tensioner

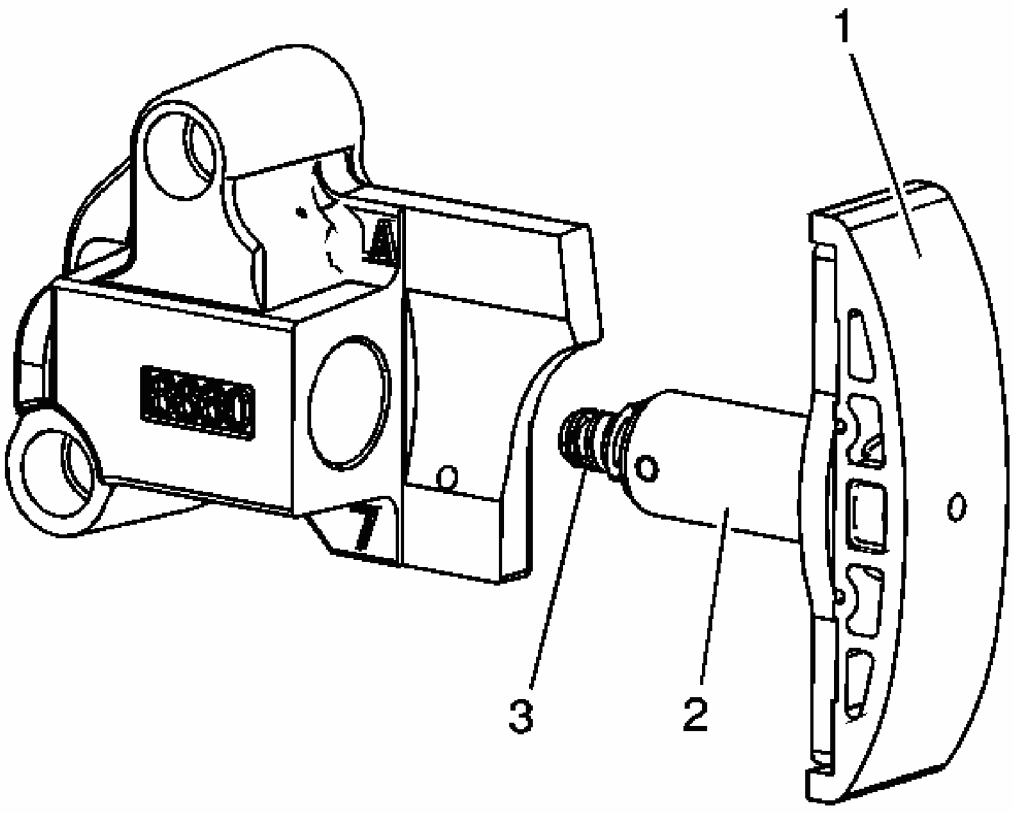

Fig. 151: Checking Primary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **PRIMARY CAMSHAFT DRIVE CHAIN TENSIONER INSTALLATION** .
3. Replace a damaged primary timing chain tensioner.

Left Secondary Timing Chain Tensioner

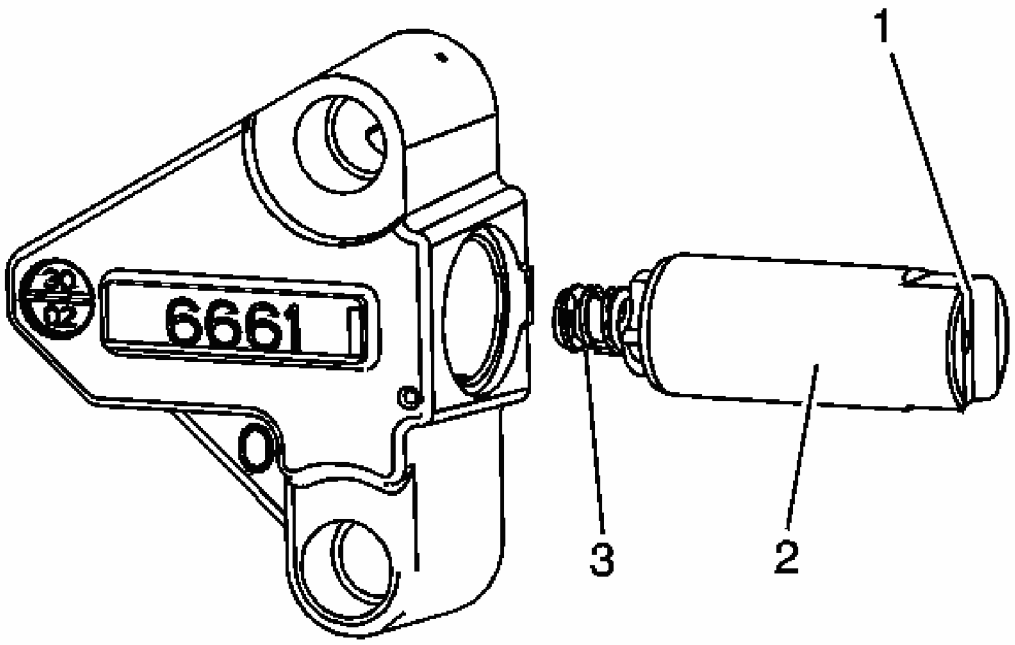

Fig. 152: Checking Left Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Left** .
3. Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner

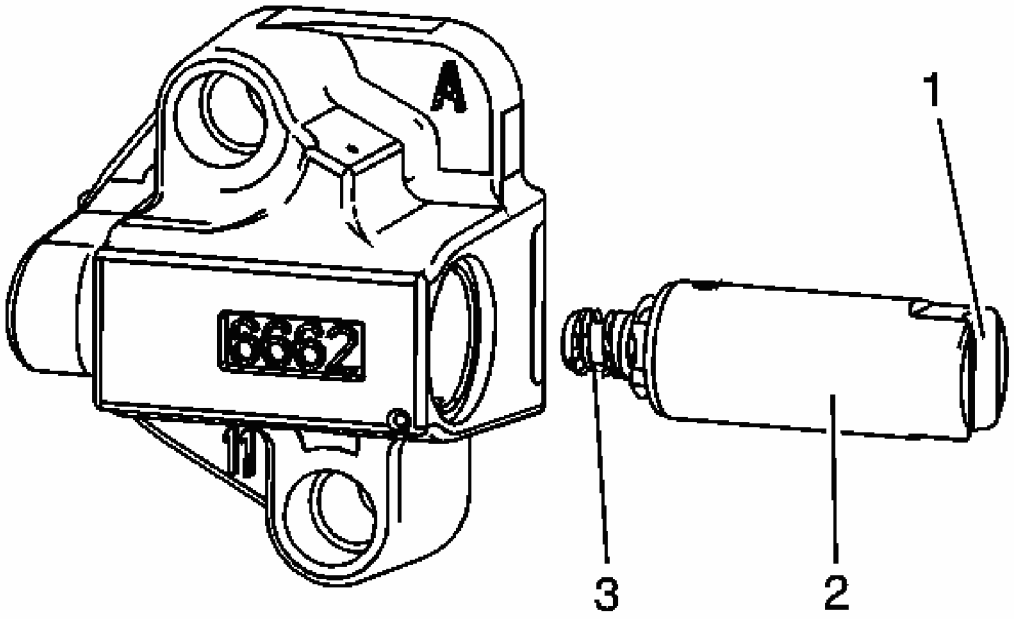

Fig. 153: Inspecting Right Secondary Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the right secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Installation - Right** .
3. Replace a damaged right secondary timing chain tensioner.

OIL PUMP DISASSEMBLE

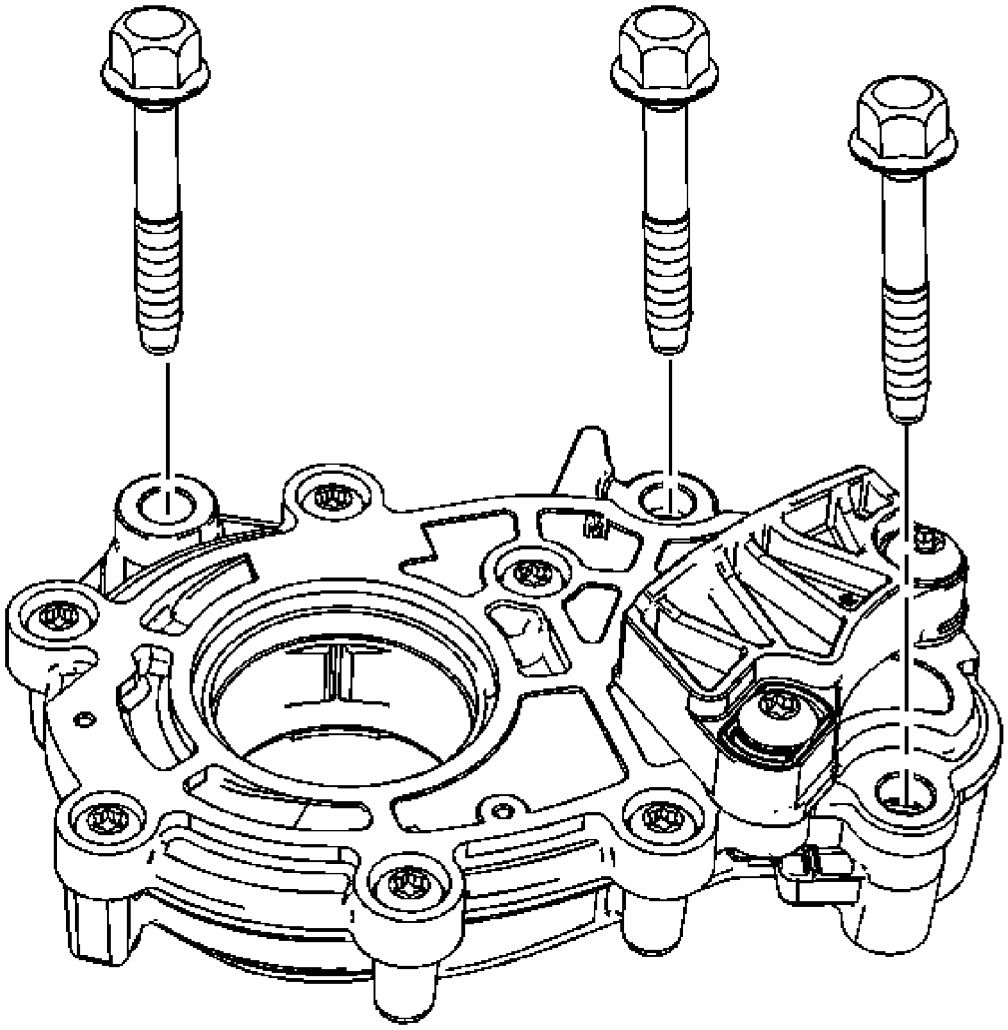

Fig. 154: View Of Oil Pump Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

1. Remove the oil pump mounting bolts.

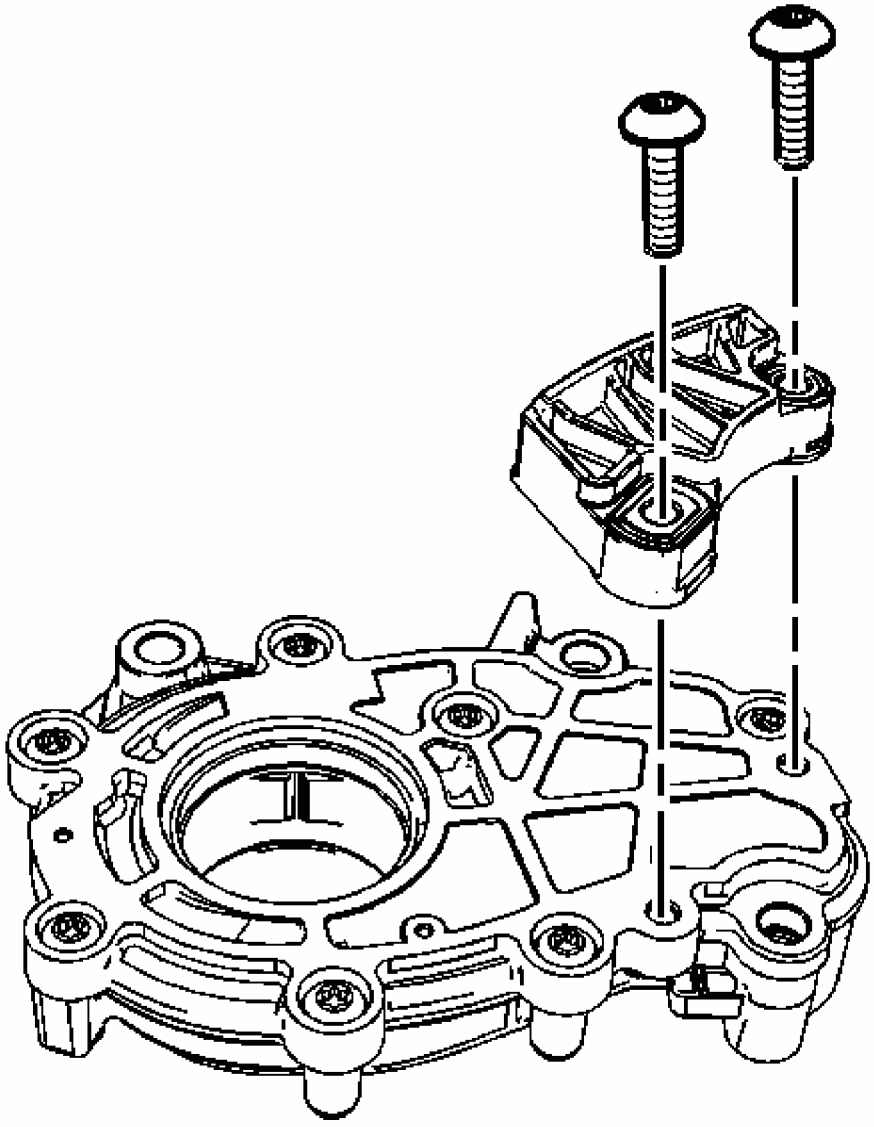

Fig. 155: Locating Primary Camshaft Drive Chain Lower Guide Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

2. Remove the primary camshaft drive chain lower guide bolts.
3. Remove the primary camshaft drive chain lower guide.

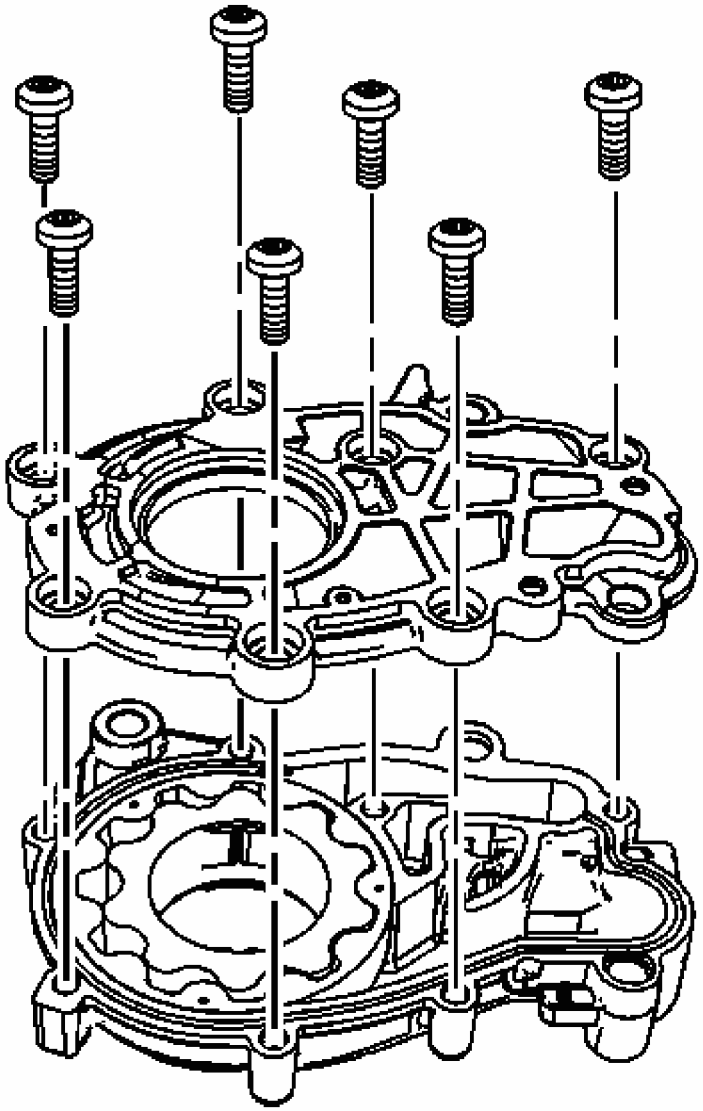

Fig. 156: Identifying Bolts Holding Oil Pump Cover To Oil Pump Housing
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolts holding the oil pump cover to the oil pump housing.
5. Remove the oil pump cover from the oil pump housing.

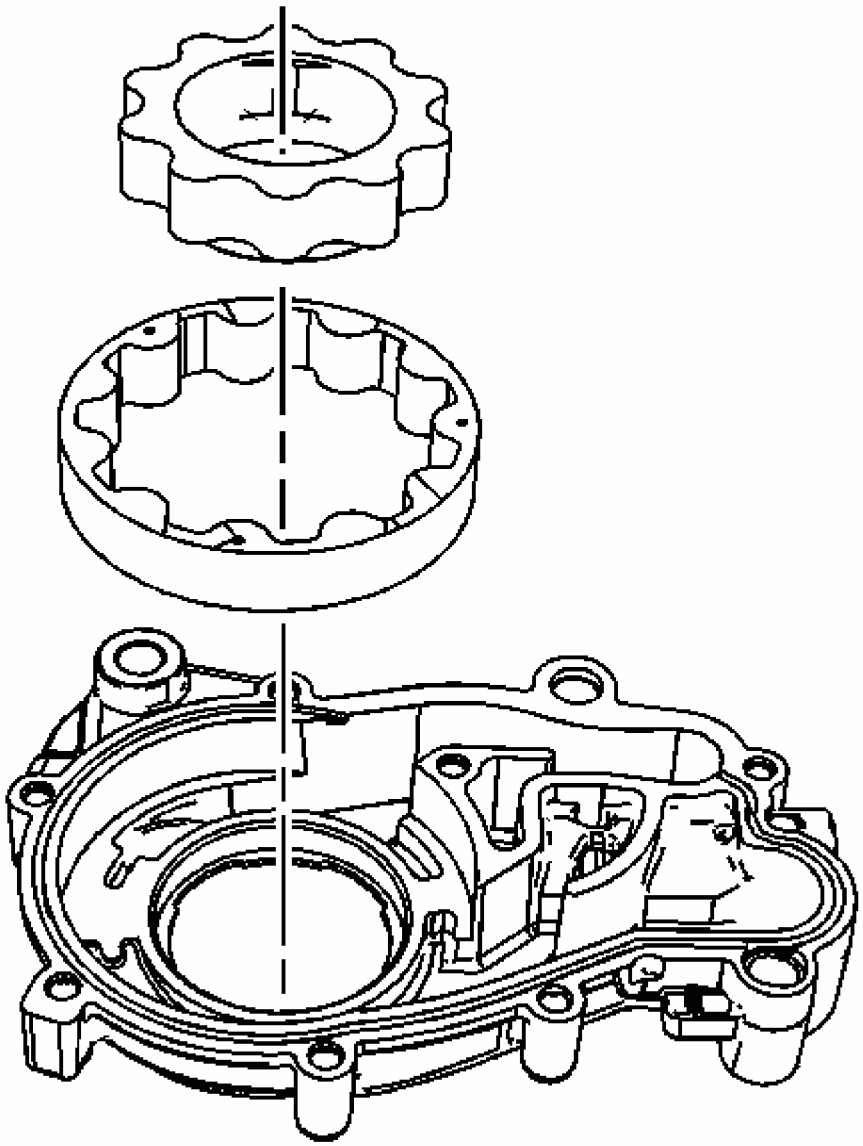

Fig. 157: View Of Outer/Inner Oil Pump Drive/Driven Gear
Courtesy of GENERAL MOTORS CORP.

6. Remove the inner oil pump drive gear.
7. Remove the outer oil pump driven gear.

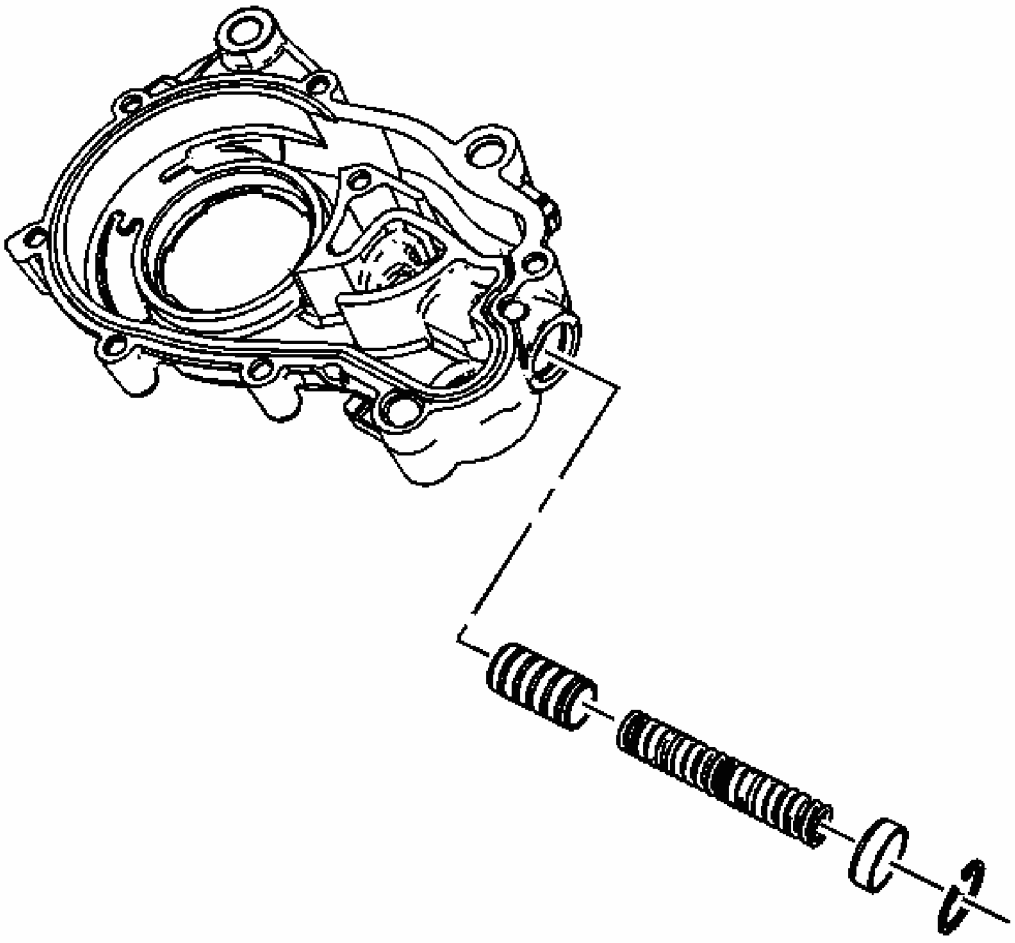

Fig. 158: Identifying Oil Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

8. Remove the clip, holding the cap, for the oil relief valve components.
9. Remove the cap, spring and plunger from the oil pump housing.

OIL PUMP CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the oil pump components with non-corrosive solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil pump components with compressed air.

Inspection Procedure

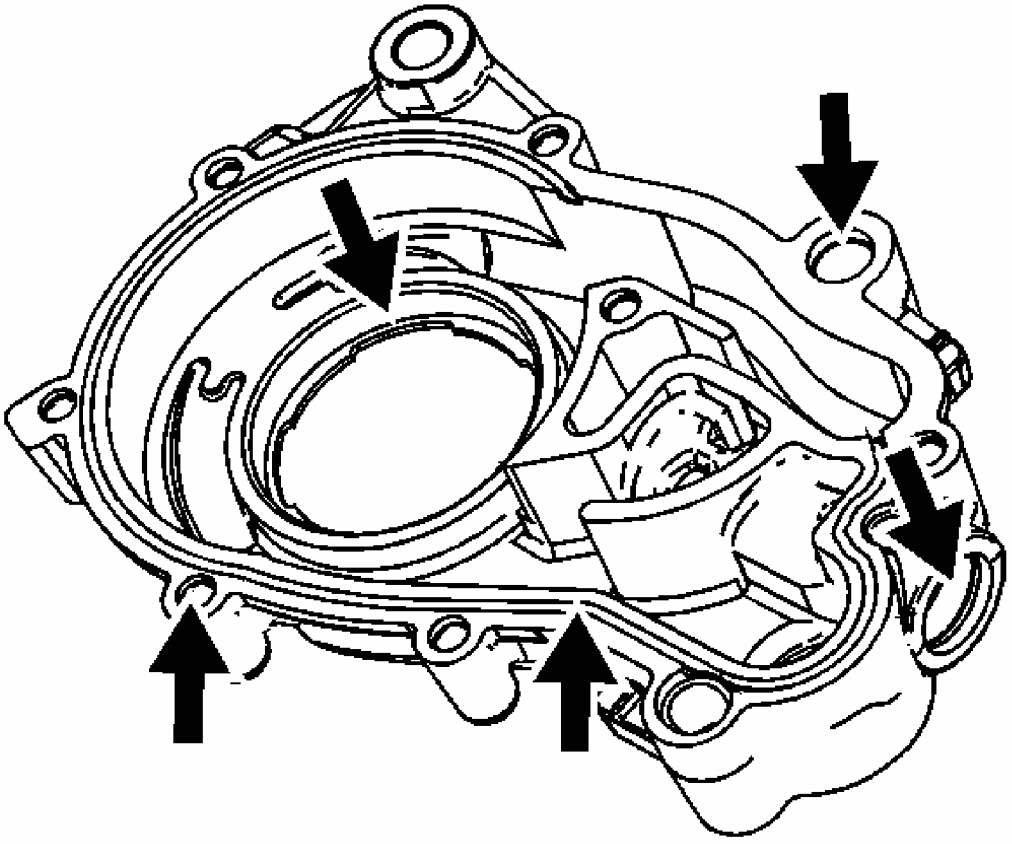

Fig. 159: Identifying Oil Pump Housing Inspection Areas
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

1. Inspect the oil pump housing for damage.

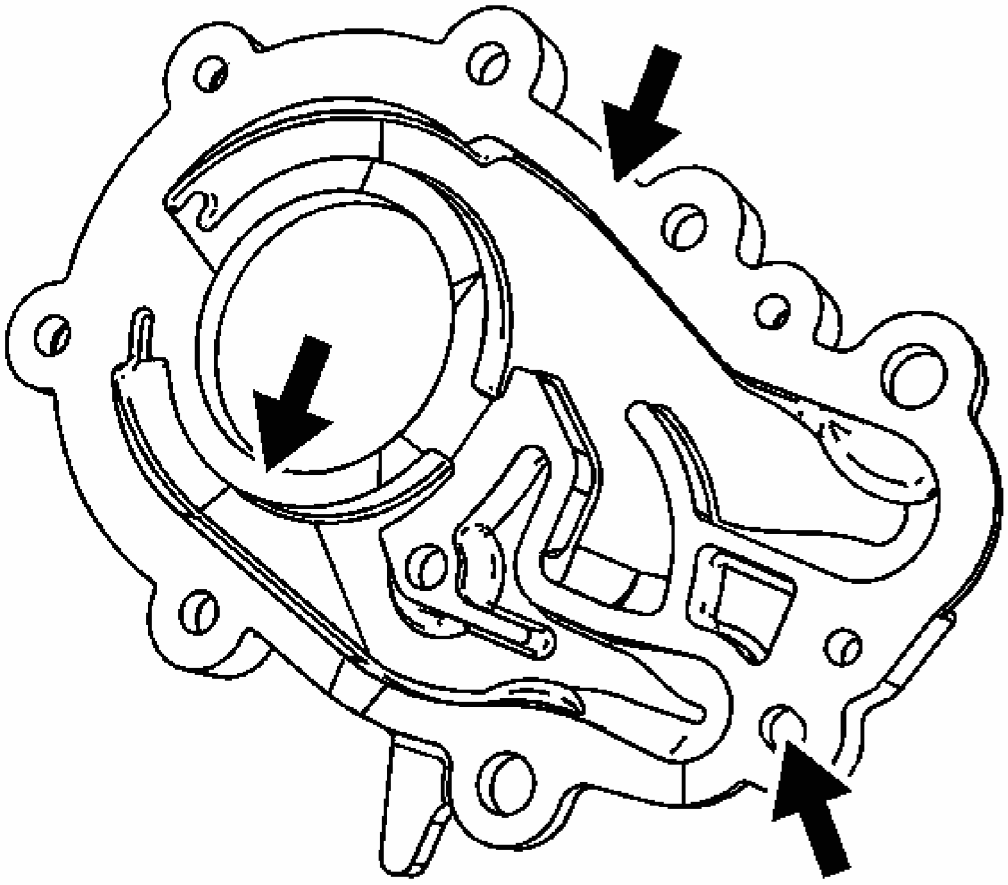

Fig. 160: Inspecting Oil Pump Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil pump cover for damage.

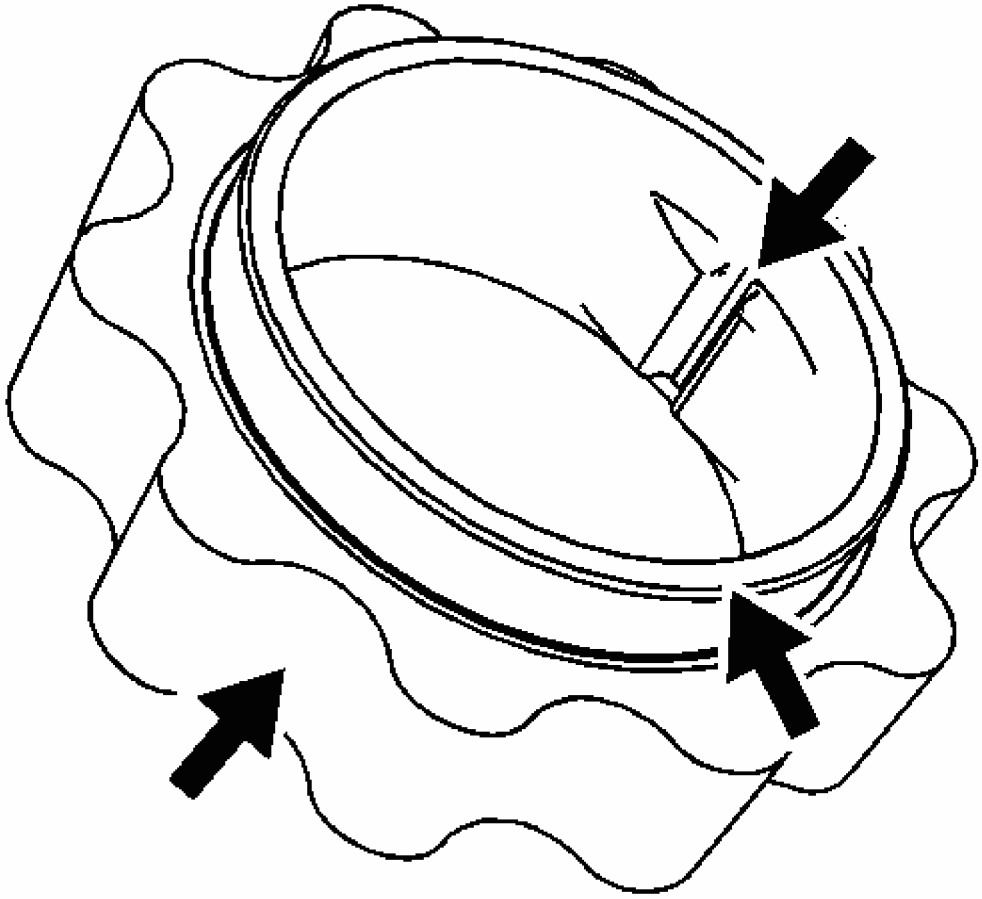

Fig. 161: Locating Inspection Areas On Inner Drive Gear
Courtesy of GENERAL MOTORS CORP.

3. Inspect the inner drive gear for damage. If inner diameter damage is found, ensure the crankshaft is also inspected.

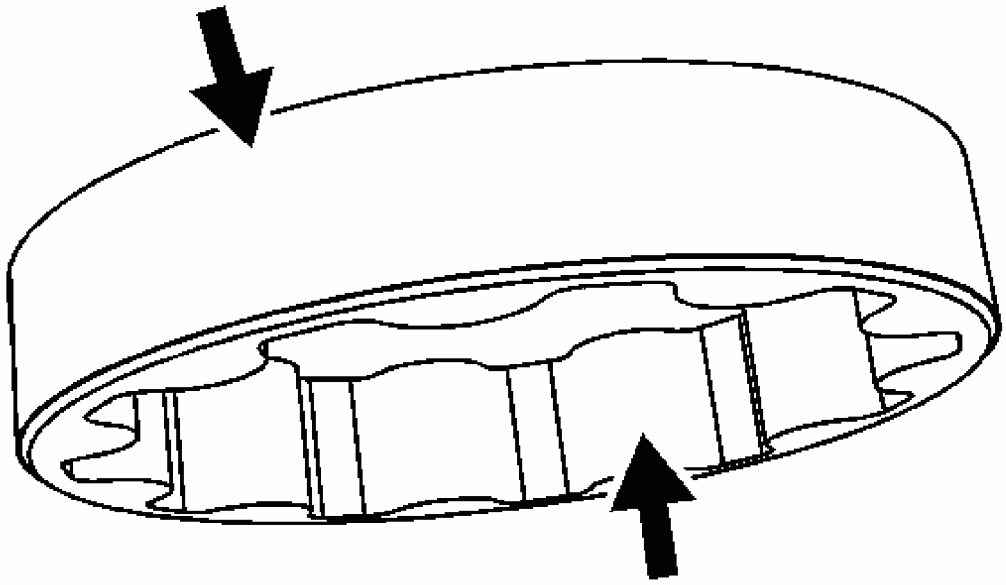

Fig. 162: Checking Outer Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Inspect the outer driven gear for damage.

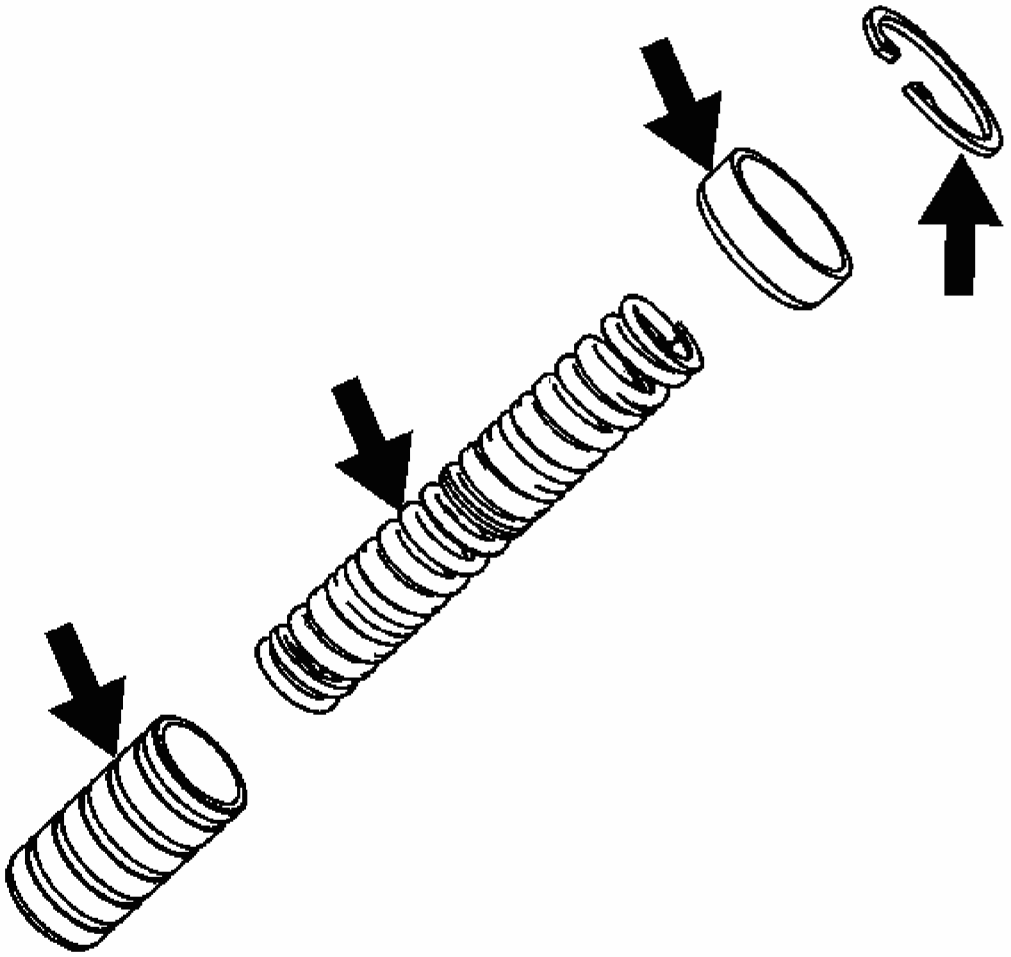

Fig. 163: Inspecting Oil Pump Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

5. Inspect the oil pump relief valve components for debris or damage.

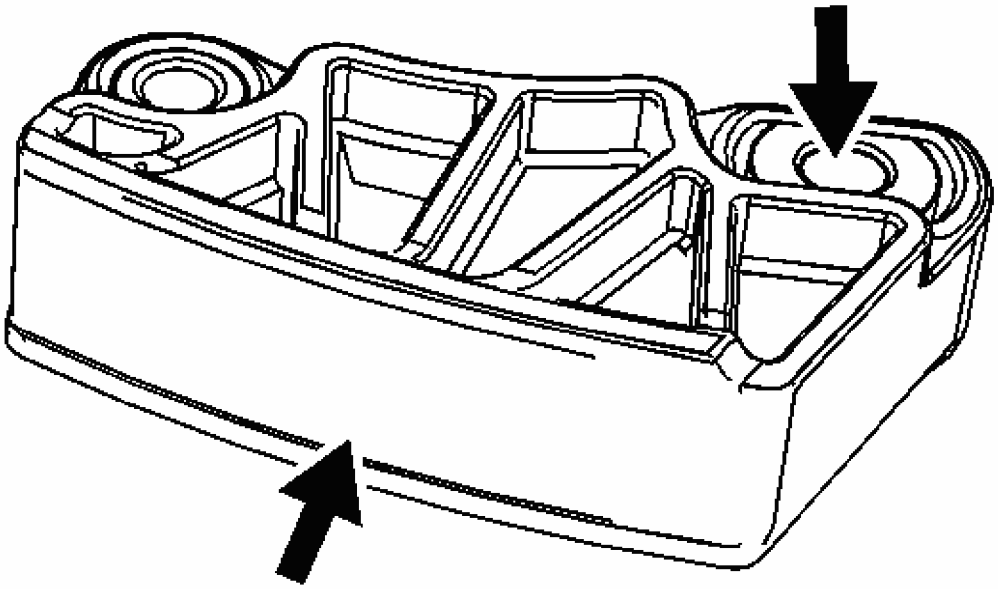

Fig. 164: Identifying Primary Camshaft Drive Chain Lower Guide Inspection Areas
Courtesy of GENERAL MOTORS CORP.

6. Inspect the primary camshaft drive chain lower guide for damage. If replacement of the primary camshaft drive chain lower guide is necessary, replace the entire oil pump assembly. The primary camshaft drive chain lower guide is not serviceable separately.
7. If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

OIL PUMP ASSEMBLE

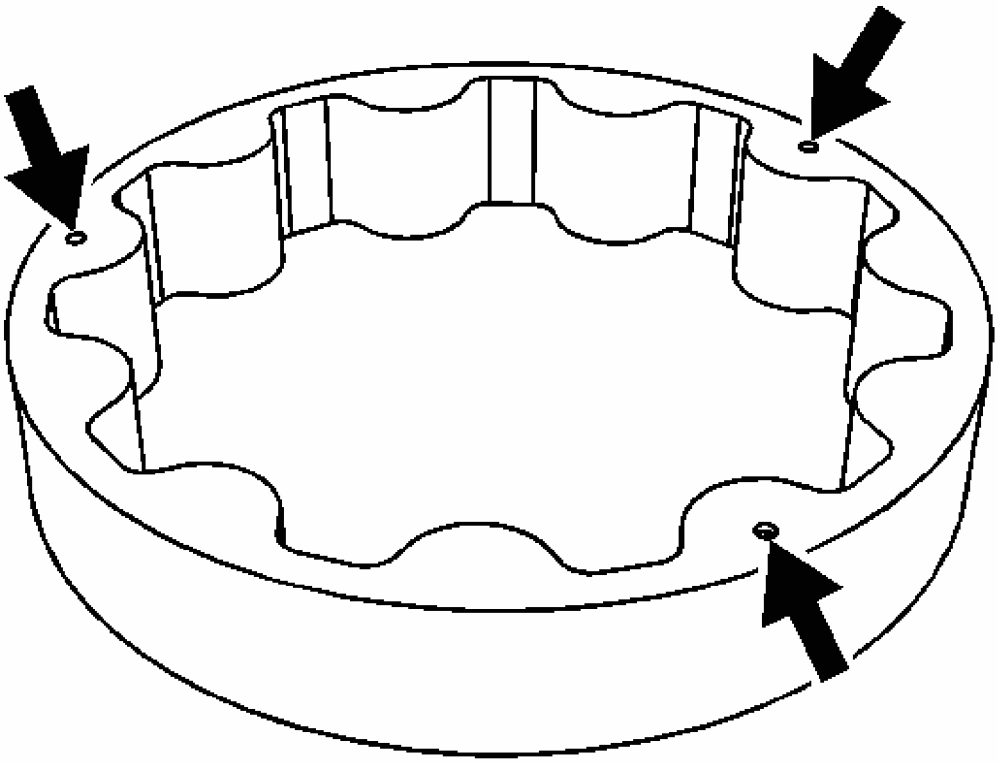

Fig. 165: Aligning Dimpled Surface
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must be replaced. DO NOT reuse a disassembled oil pump or a serviceable oil pump with a primary camshaft drive chain lower guide that needs to be replaced.**
- **The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.**

1. The dimpled surface must be face-up in the pump body.

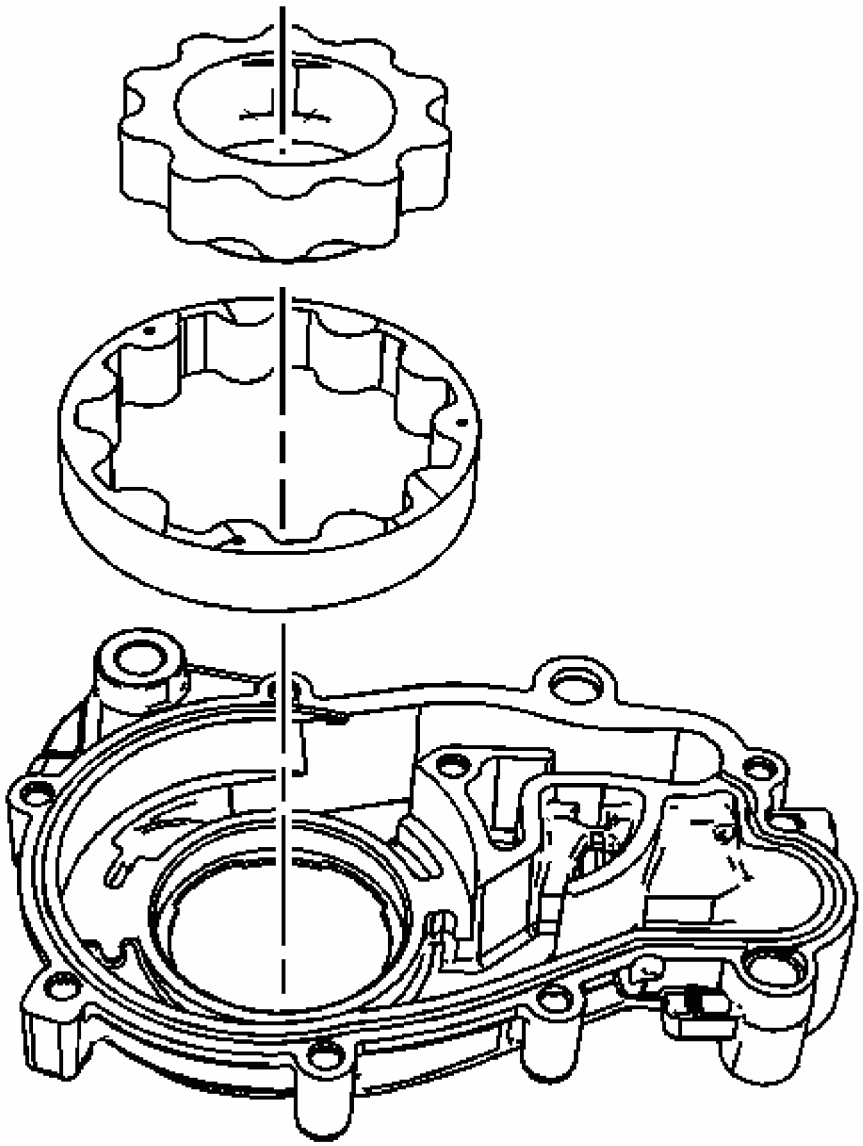

Fig. 166: View Of Outer/Inner Oil Pump Drive/Driven Gear
Courtesy of GENERAL MOTORS CORP.

2. Install the inner and the outer rotors in the pump cover in the same orientation as removed.
3. The outer rotor has a dimple to indicate the outer surface.

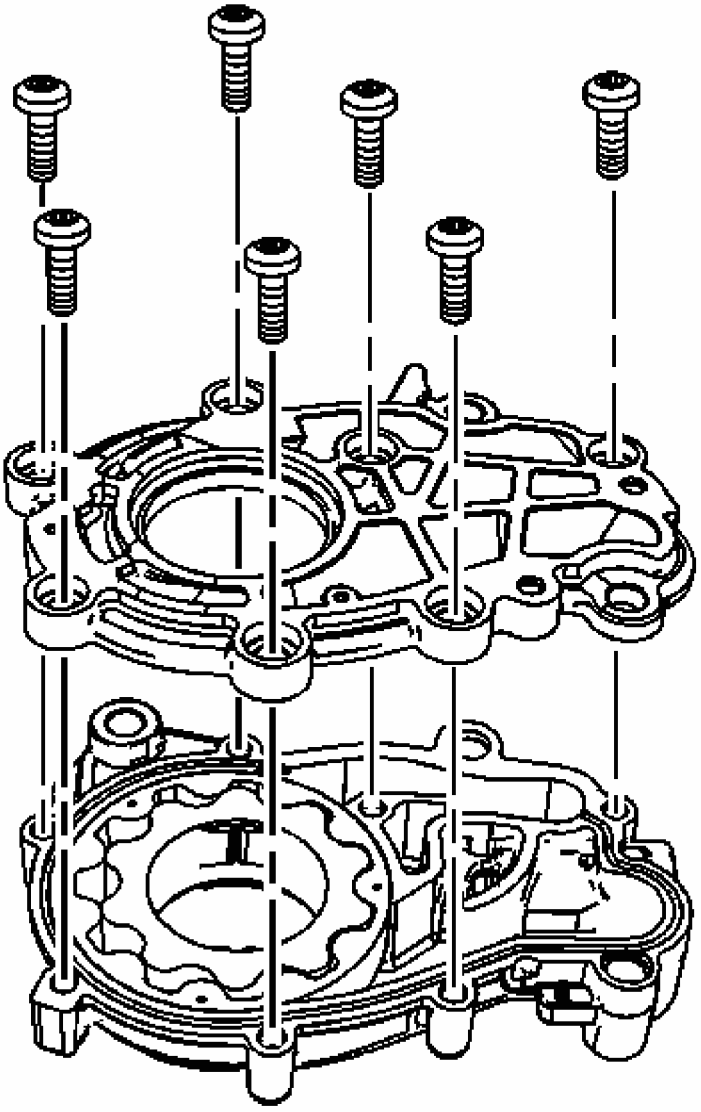

Fig. 167: Identifying Bolts Holding Oil Pump Cover To Oil Pump Housing
Courtesy of GENERAL MOTORS CORP.

4. Assemble the housing and cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the bolts.

Tighten: Tighten the bolts to 10 N.m (89 lb in).

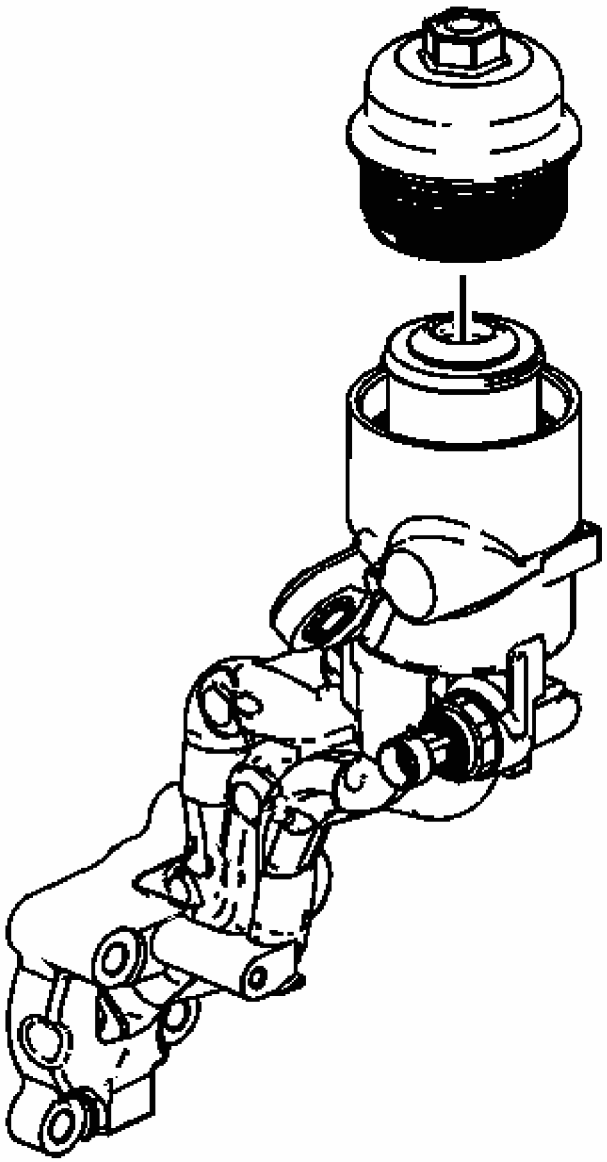

Fig. 168: View Of Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter cap.

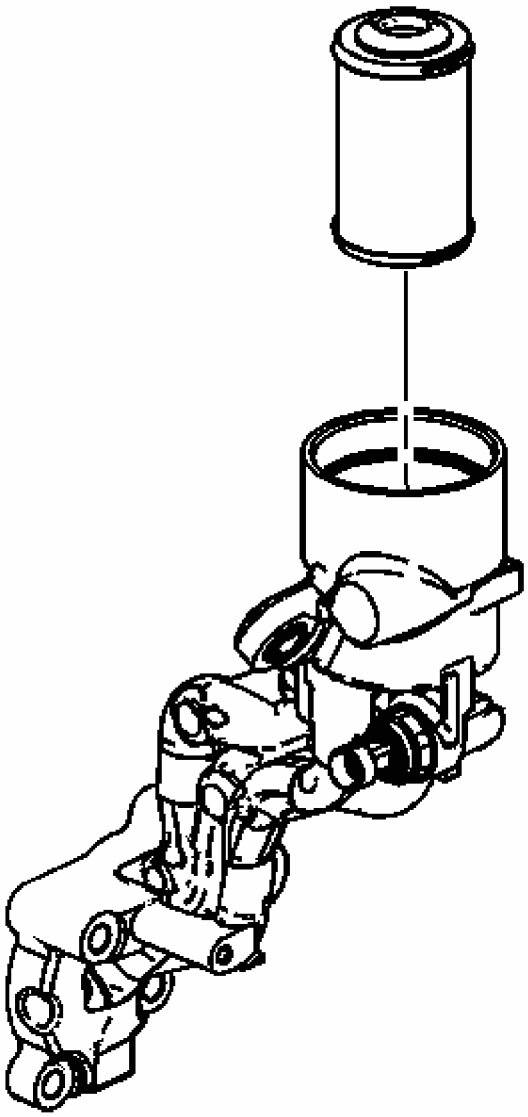

Fig. 169: View Of Oil Filter Cartridge
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter cartridge and discard.

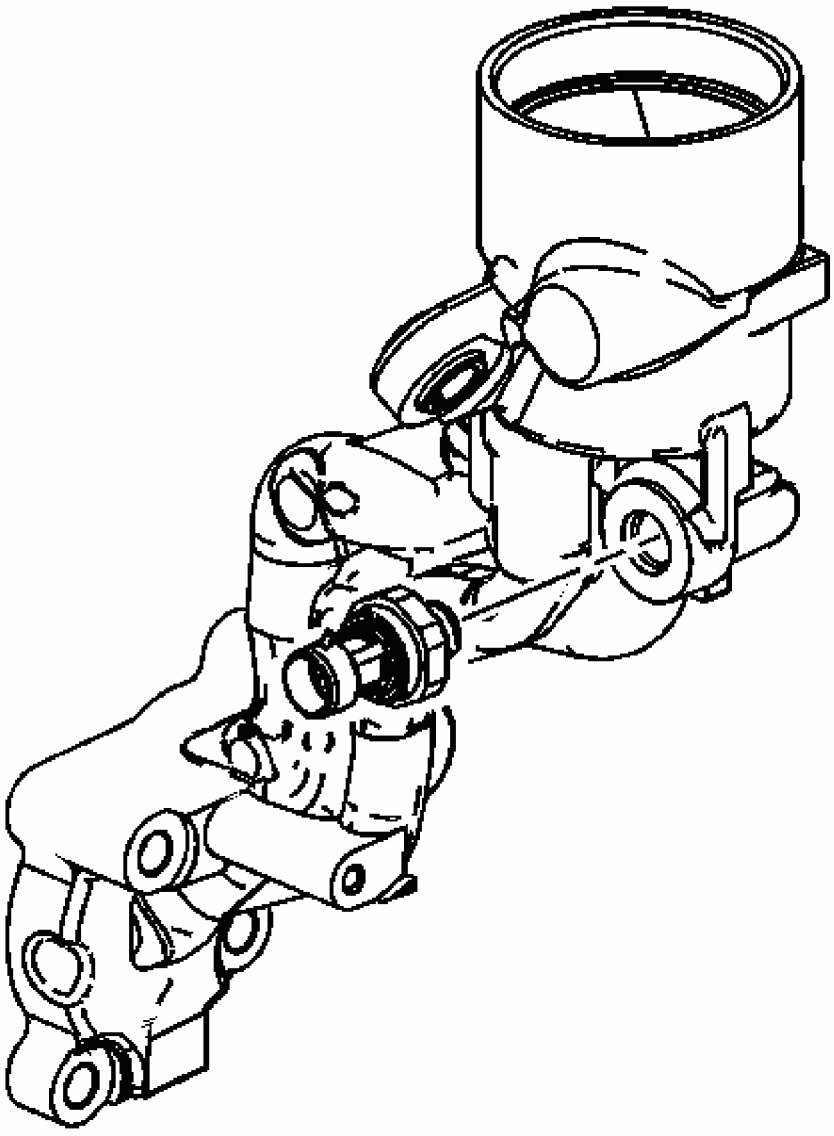

Fig. 170: View Of Oil Pressure Sender
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pressure sender.

OIL FILTER ADAPTER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the oil filter adapter components with non-corrosive solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil filter adapter components with compressed air.

Inspection Procedure

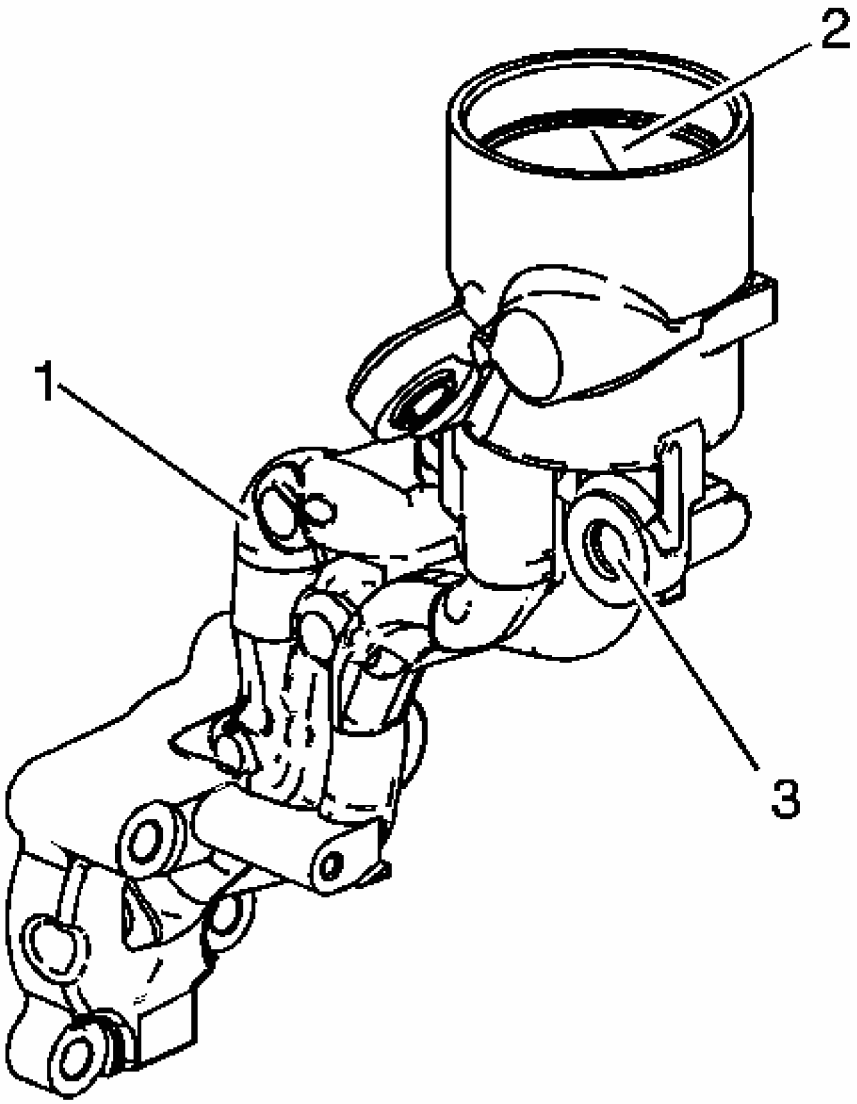

Fig. 171: Inspecting Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil filter adapter are not serviced separately. If wear or damage is noted, replace the entire oil filter adapter assembly.

1. Inspect the oil filter housing for cracks, scoring, casting imperfections (1) and damaged threads (3).
2. Inspect the drain back valve (2) for damage or blockage.

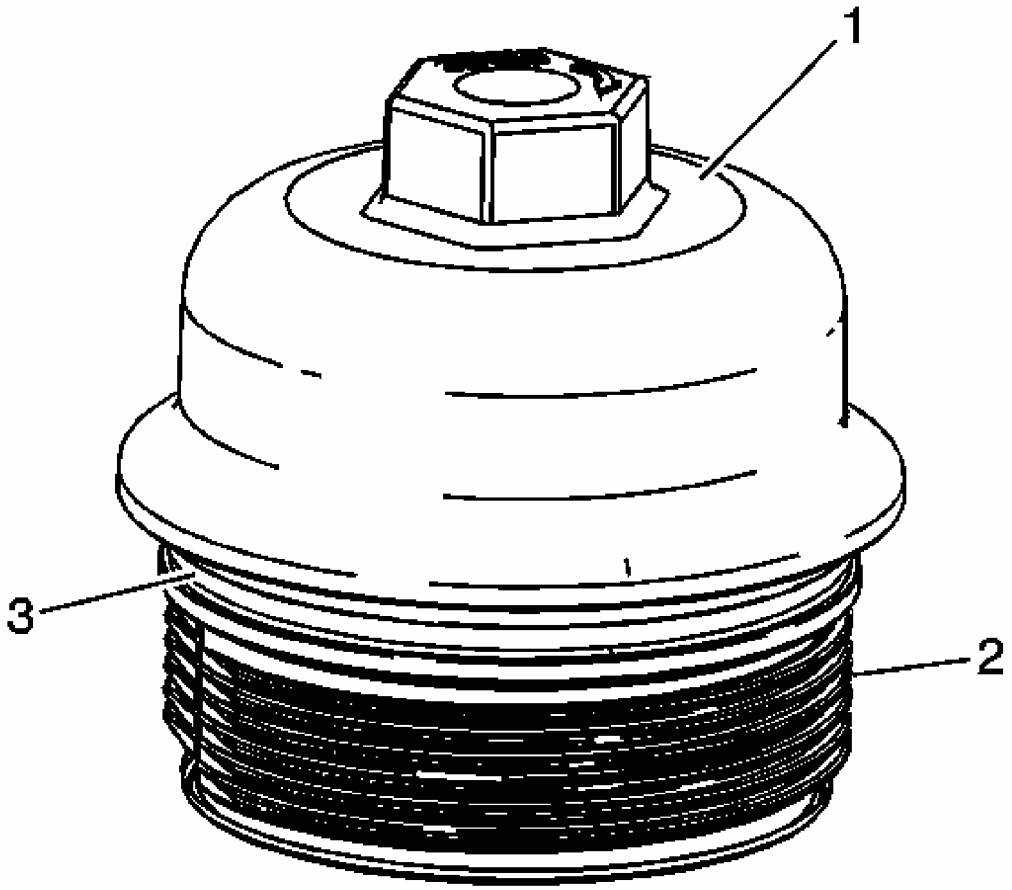

Fig. 172: Inspecting Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil filter cap for cracks, scoring, casting imperfections (1) and damaged threads (2). Replace as necessary.
4. Inspect the oil filter cap O-ring (3) for damage. Replace as necessary.

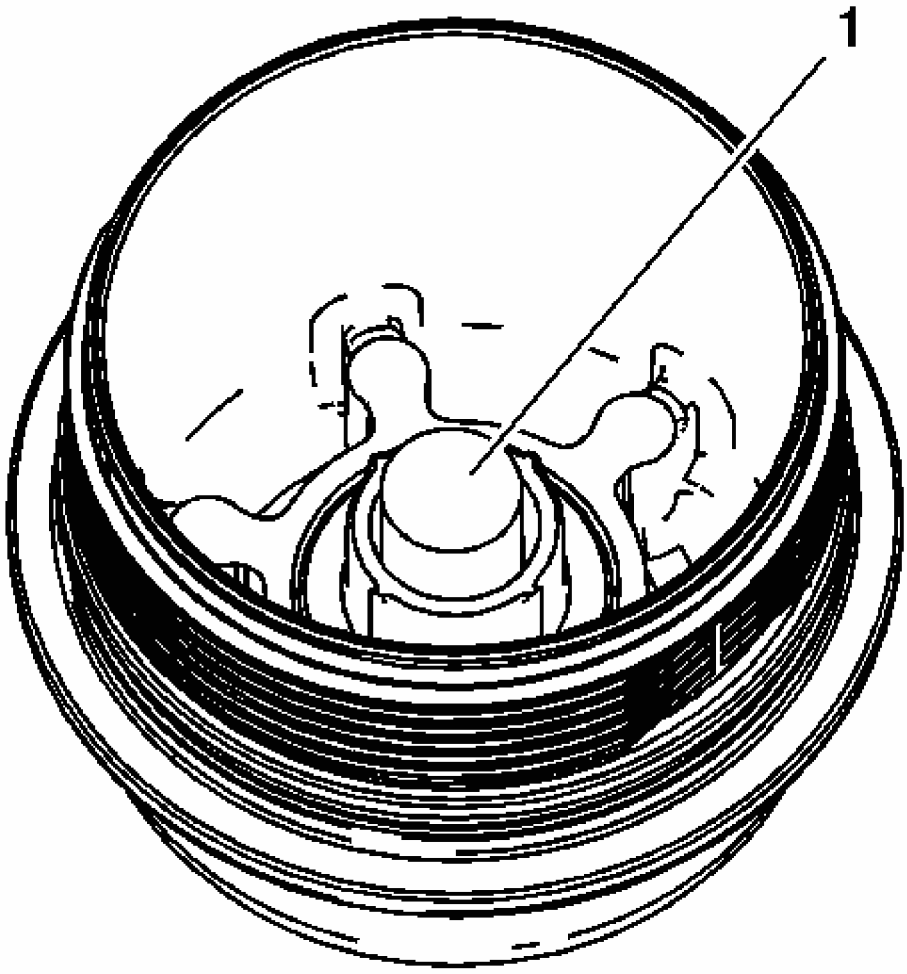

Fig. 173: Inspecting Bypass Valve
Courtesy of GENERAL MOTORS CORP.

5. Inspect the bypass valve (1) for damage or blockage.

OIL FILTER ADAPTER ASSEMBLE

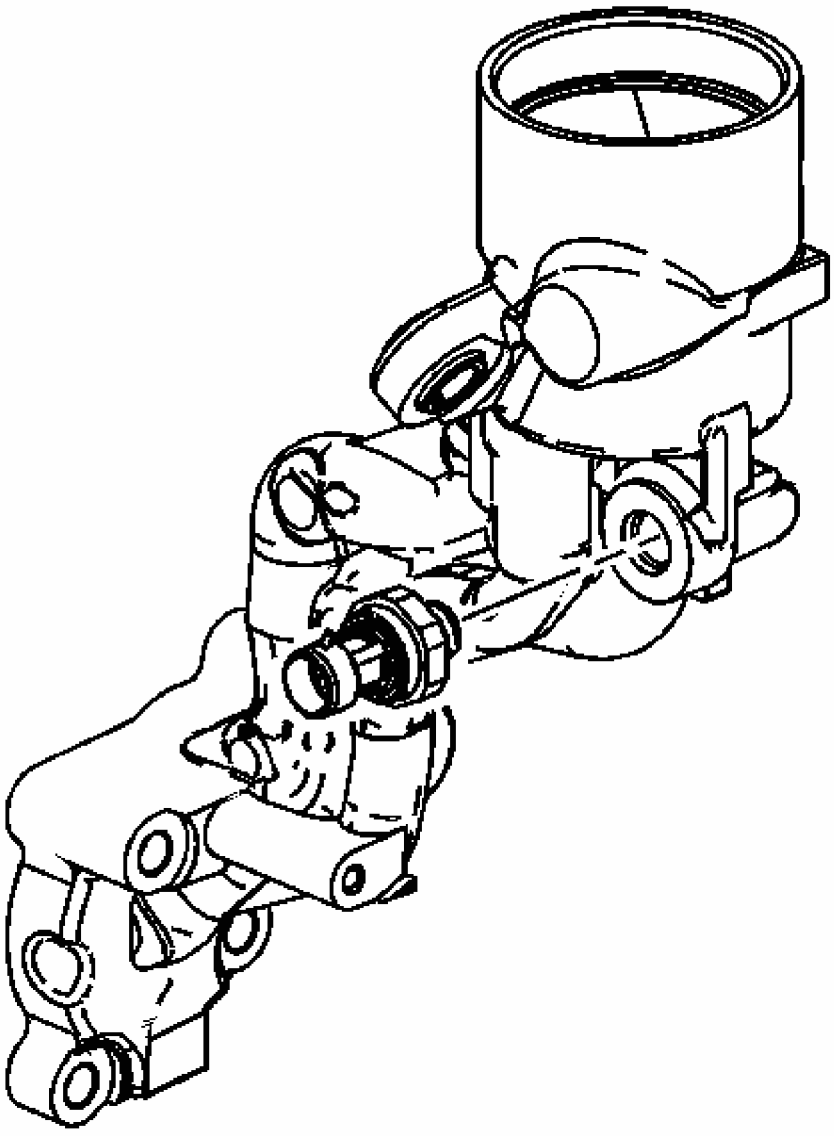

Fig. 174: View Of Oil Pressure Sender
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil pressure sender.

   Tighten: Tighten the oil pressure sender to 20 N.m (15 lb in).

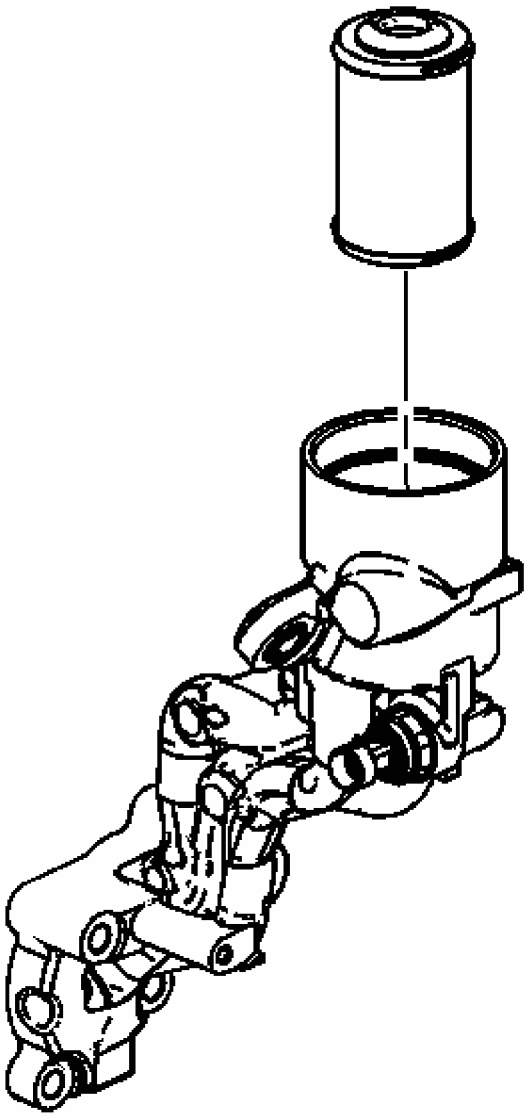

Fig. 175: View Of Oil Filter Cartridge
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW oil filter cartridge.

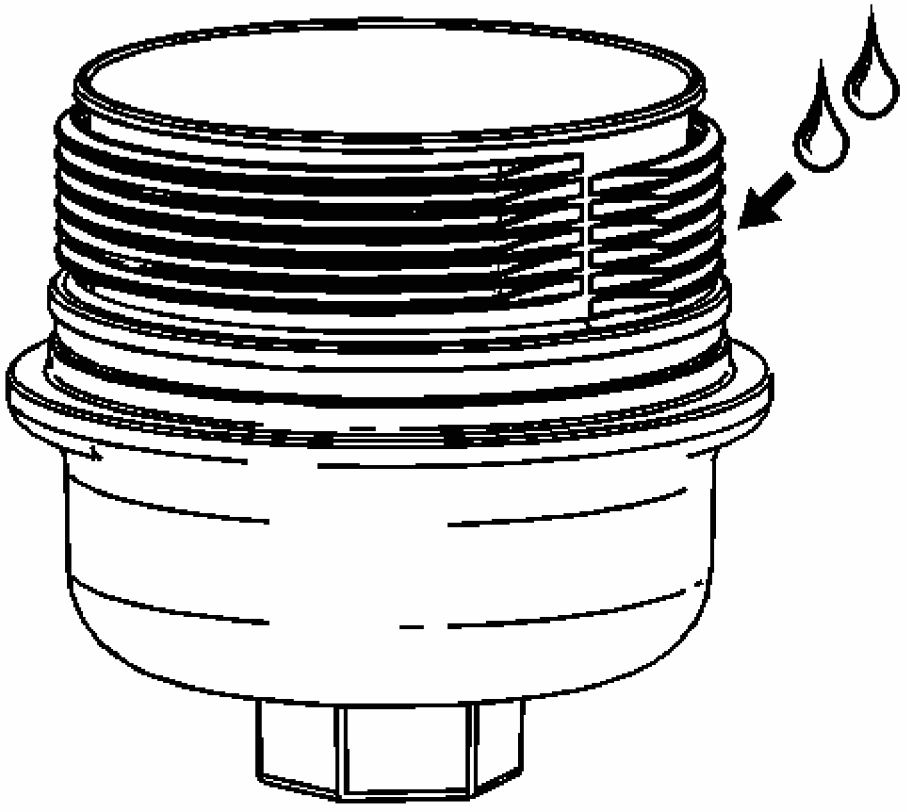

Fig. 176: Lubricating Threads Of Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

3. Lubricate the oil filter cap threads with clean engine oil.

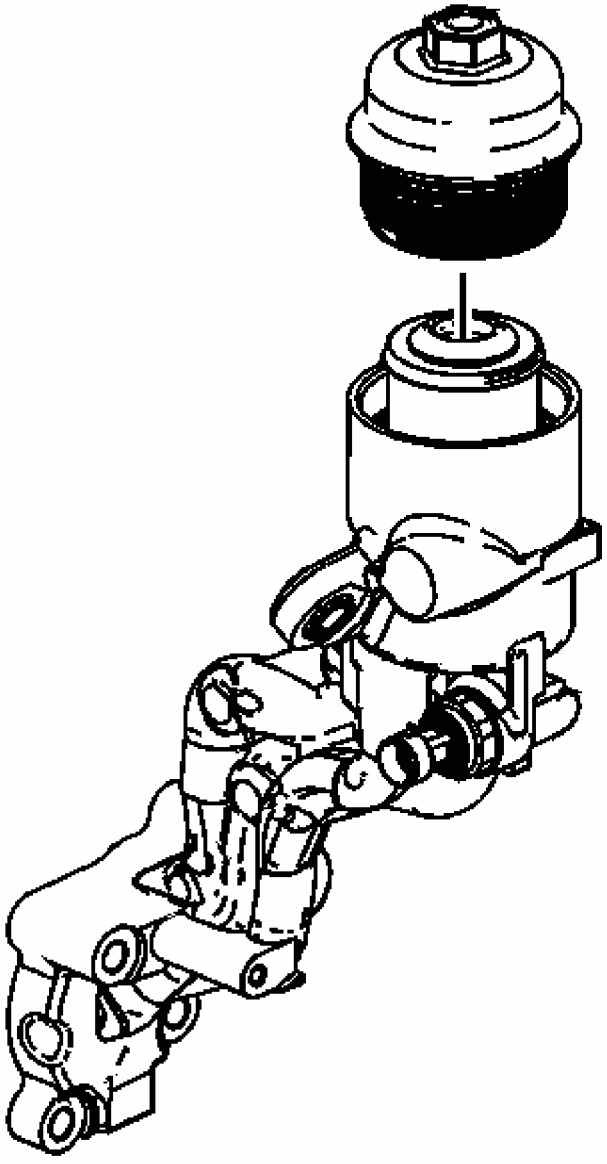

Fig. 177: View Of Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

4. Install the oil filter cap.

   Tighten: Tighten the oil filter cap to 25 N.m (18 lb in).

OIL PAN DISASSEMBLE

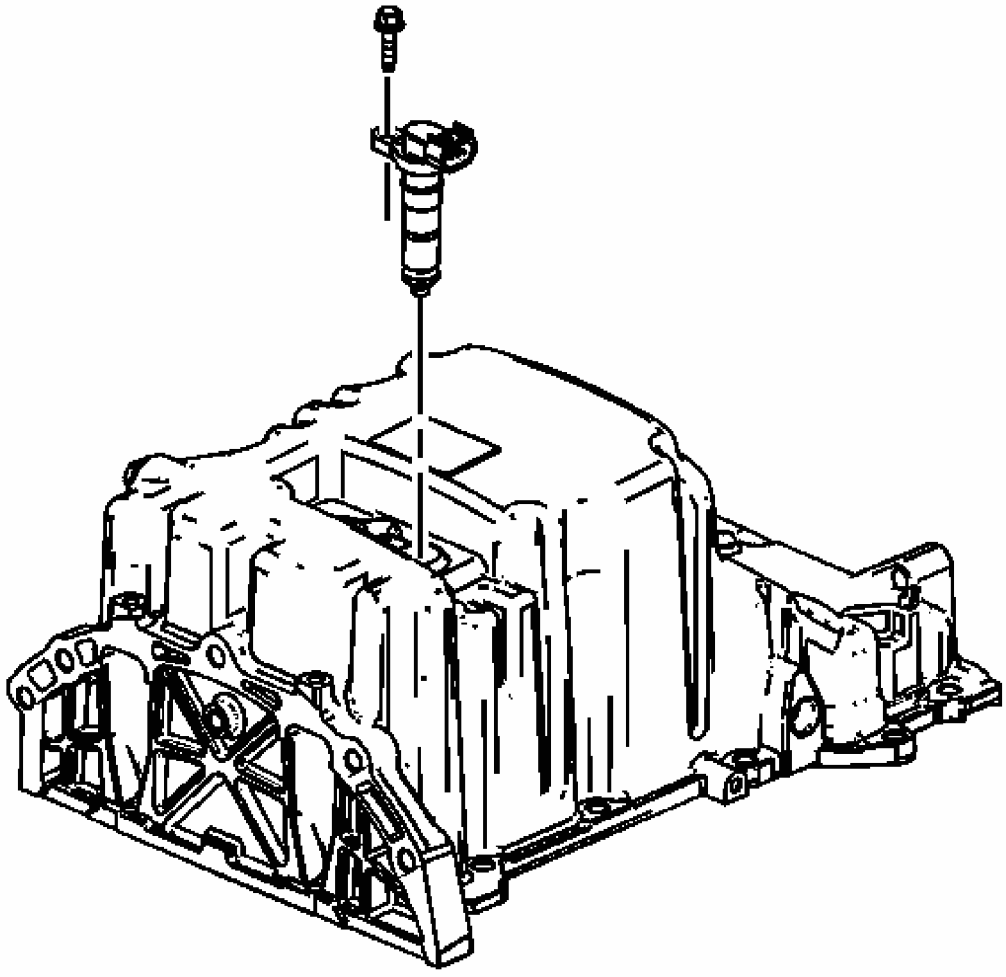

Fig. 178: Removing & Installing Oil Level/Condition Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level/condition sensor bolt.
2. Remove the oil level/condition sensor.

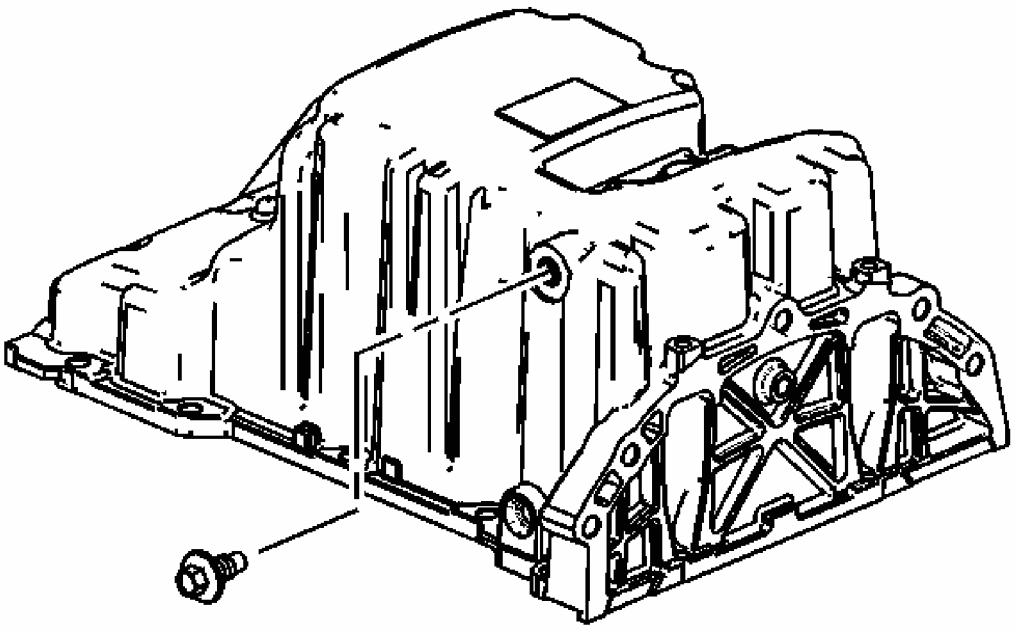

Fig. 179: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan drain plug.

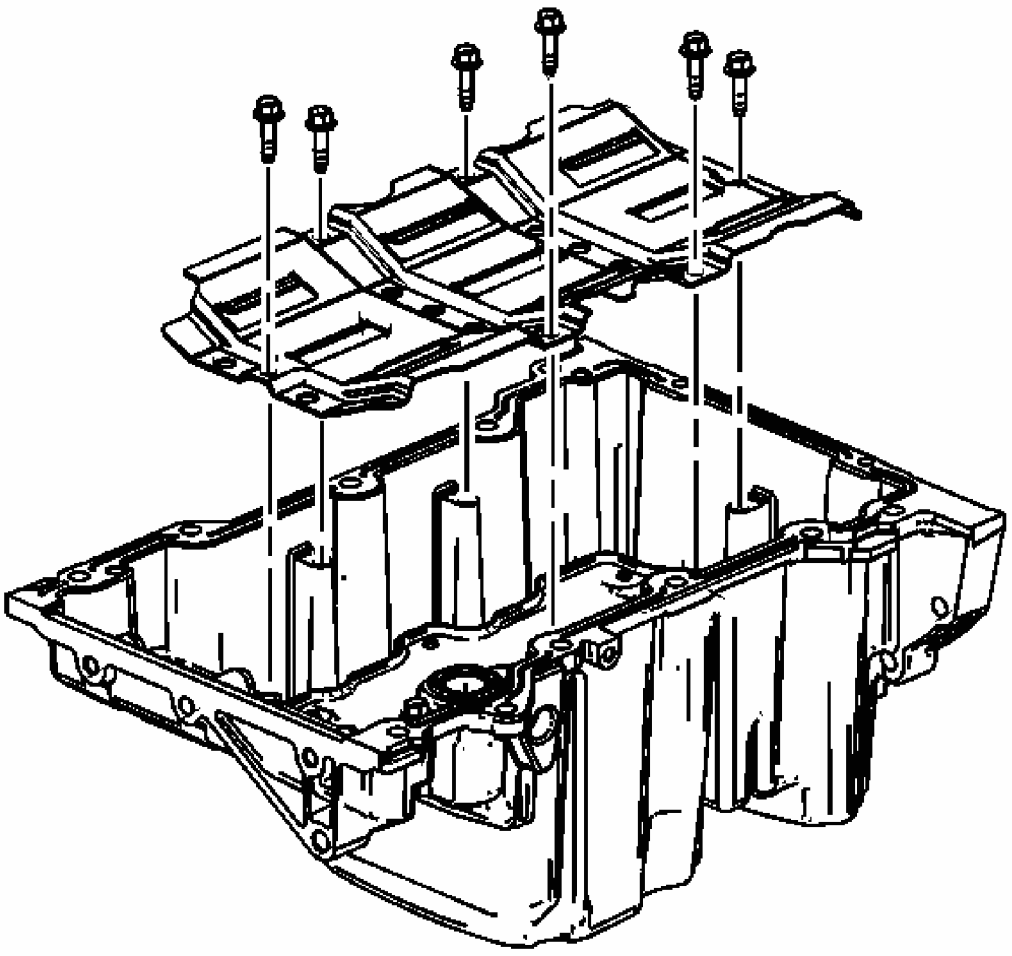

Fig. 180: View Of Oil Pan Scraper And Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan scraper bolts.
5. Remove the oil pan scraper.

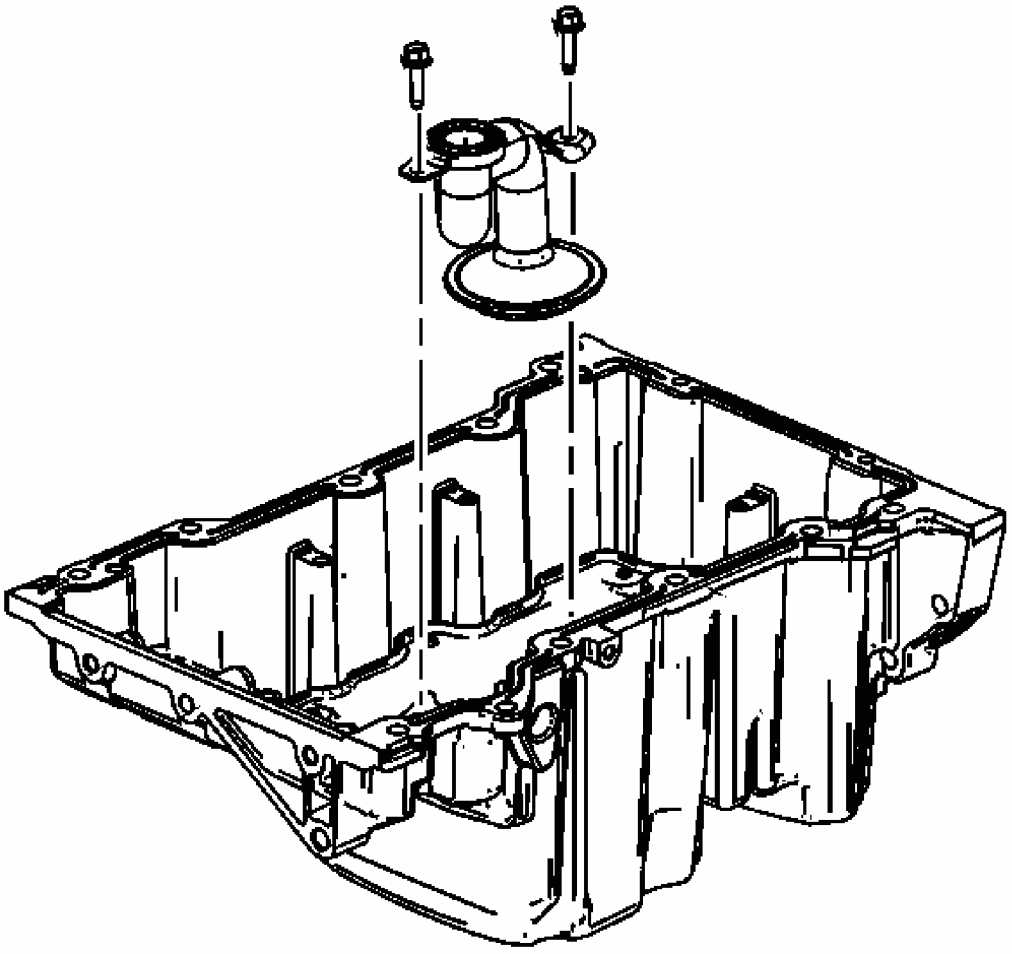

Fig. 181: View Of Oil Suction Pipe
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil suction pipe bolts.
7. Remove the oil suction pipe.

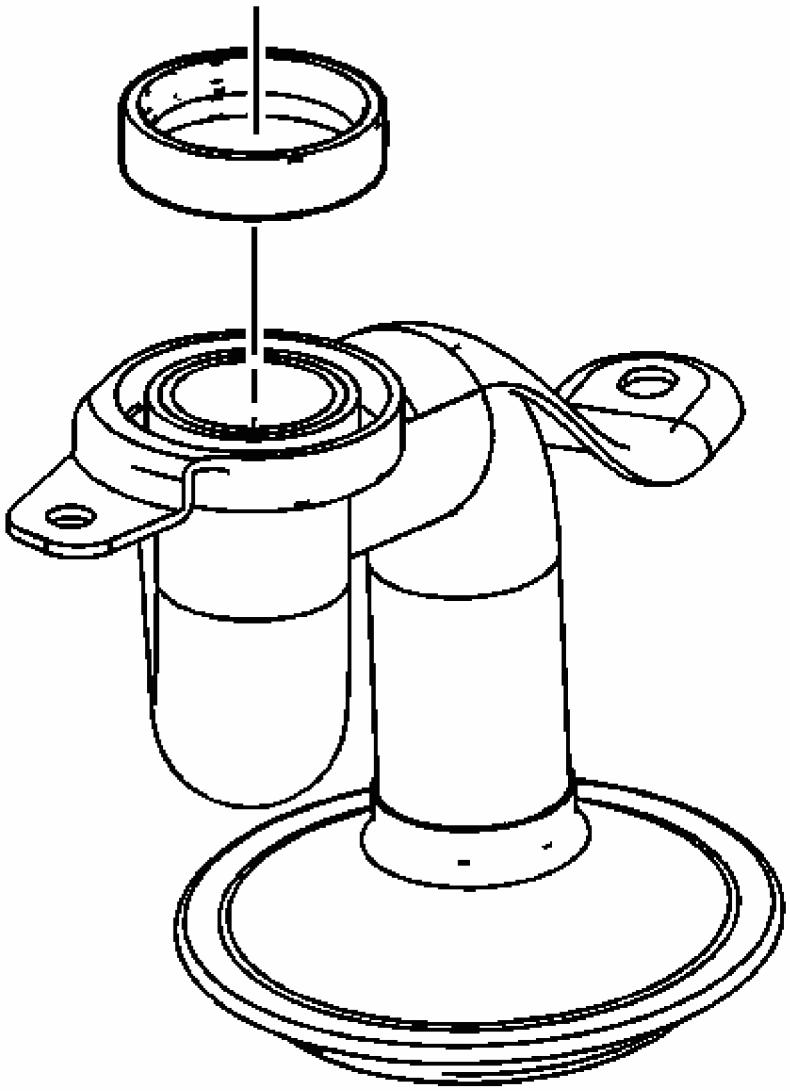

Fig. 182: View Of Oil Suction Tube Seal & Oil Suction Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil suction tube seal from the oil suction tube. Discard the oil suction tube seal.

OIL PAN CLEANING AND INSPECTION

Tools Required

J 28410 Gasket Remover

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using **J 28410** .
2. Clean the oil pan and oil pan components in solvent.
3. Clean out debris from the bolt holes.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

4. Dry the oil pan and oil pan components with compressed air.

Inspection Procedure

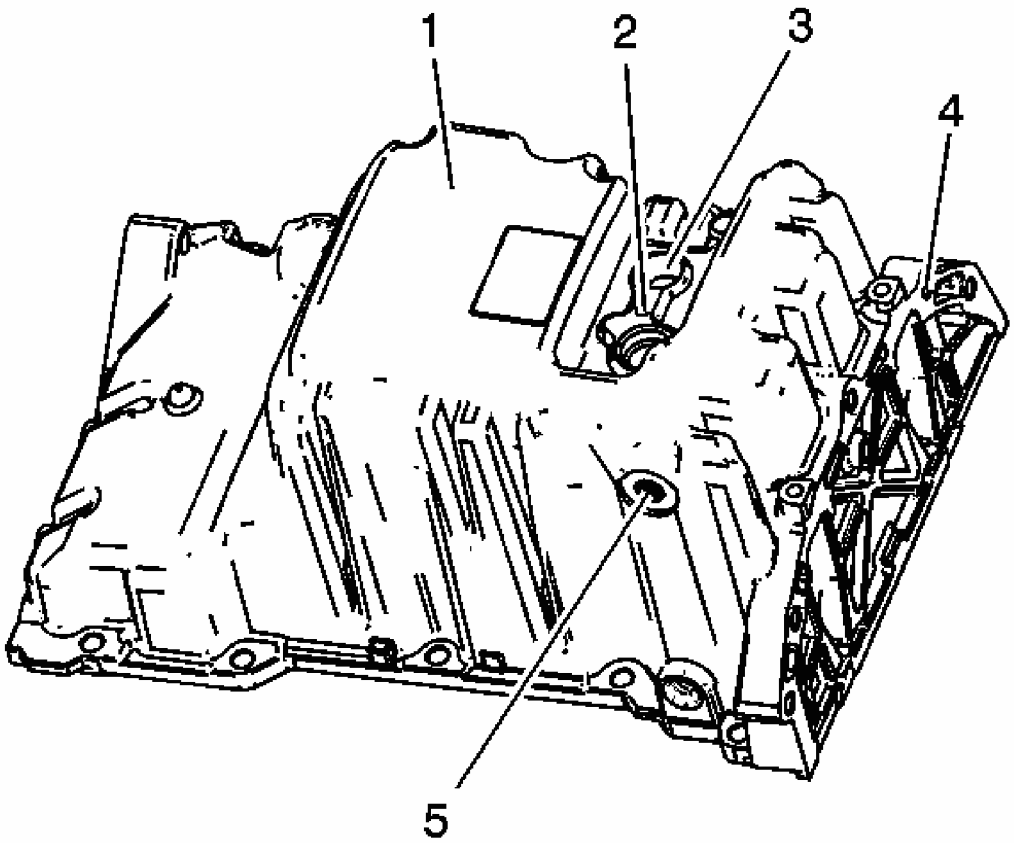

Fig. 183: Identifying Oil Pan Exterior
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the oil pan for the following conditions:

- Damage to the drain plug or drain plug hole (5)
- Damage to the transmission mounting bosses (4)
- Damage to the oil level/condition sensor bolt hole threads (2)
- Damage to the oil level/condition sensor hole (3)
- Dents or damage to the exterior (1)

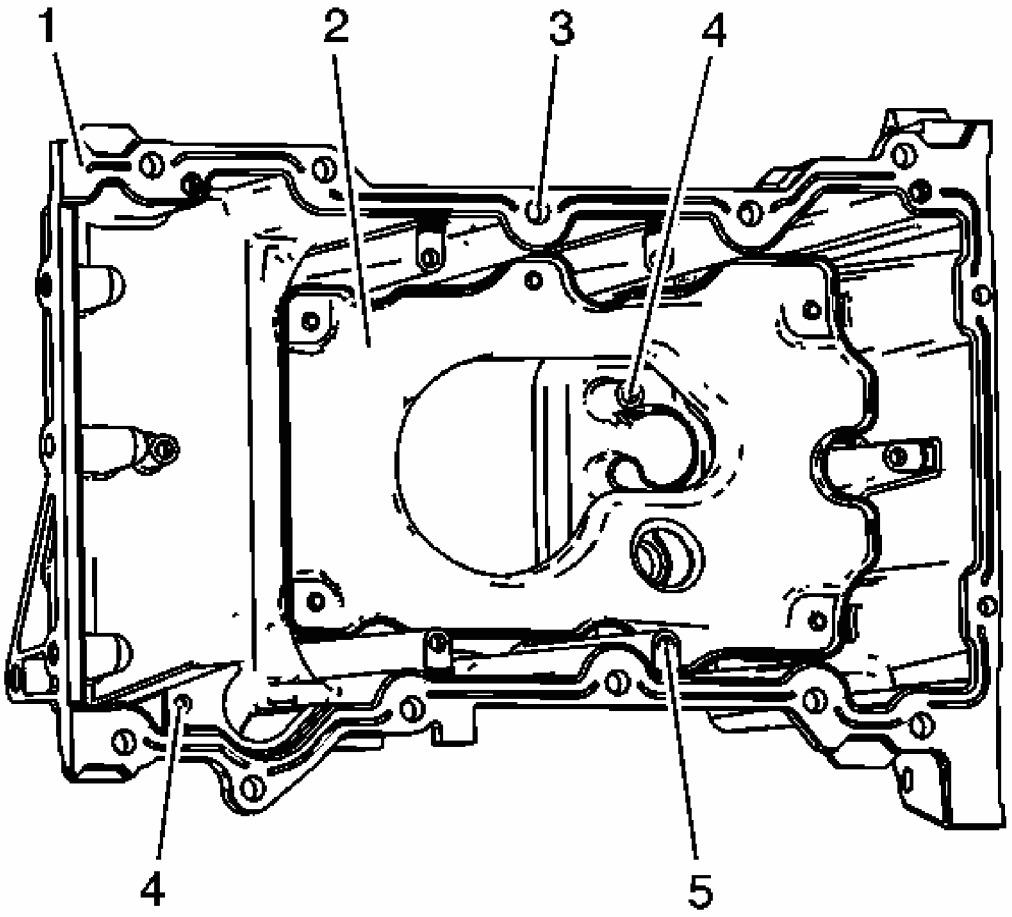

Fig. 184: Identifying Oil Pan Interior
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the oil pan for the following conditions:
   - Gouges or damage to the oil pan sealing surfaces (1)
   - Damage to the oil pan baffle (2)
   - Damage to the bolt holes (3)
   - Damage to the oil suction tube mounting bosses (4)

- Damage to the oil pan scraper mounting bosses (5)

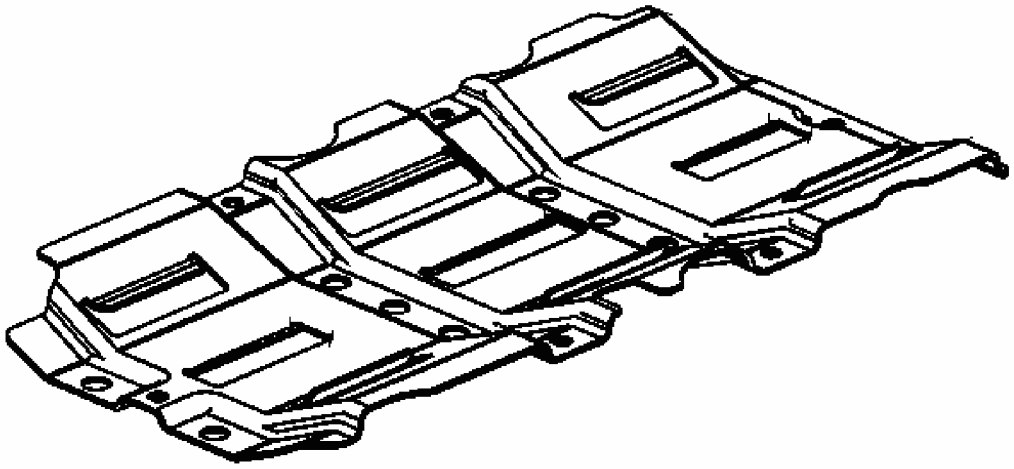

Fig. 185: Inspecting Oil Pan Baffle Scraper For Damage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the oil pan scraper for damage.
4. Repair or replace the oil pan and/or oil pan components as necessary.

OIL PUMP PIPE AND SCREEN CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the oil pump pipe and screen with solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the oil pump pipe and screen with compressed air.

Inspection Procedure

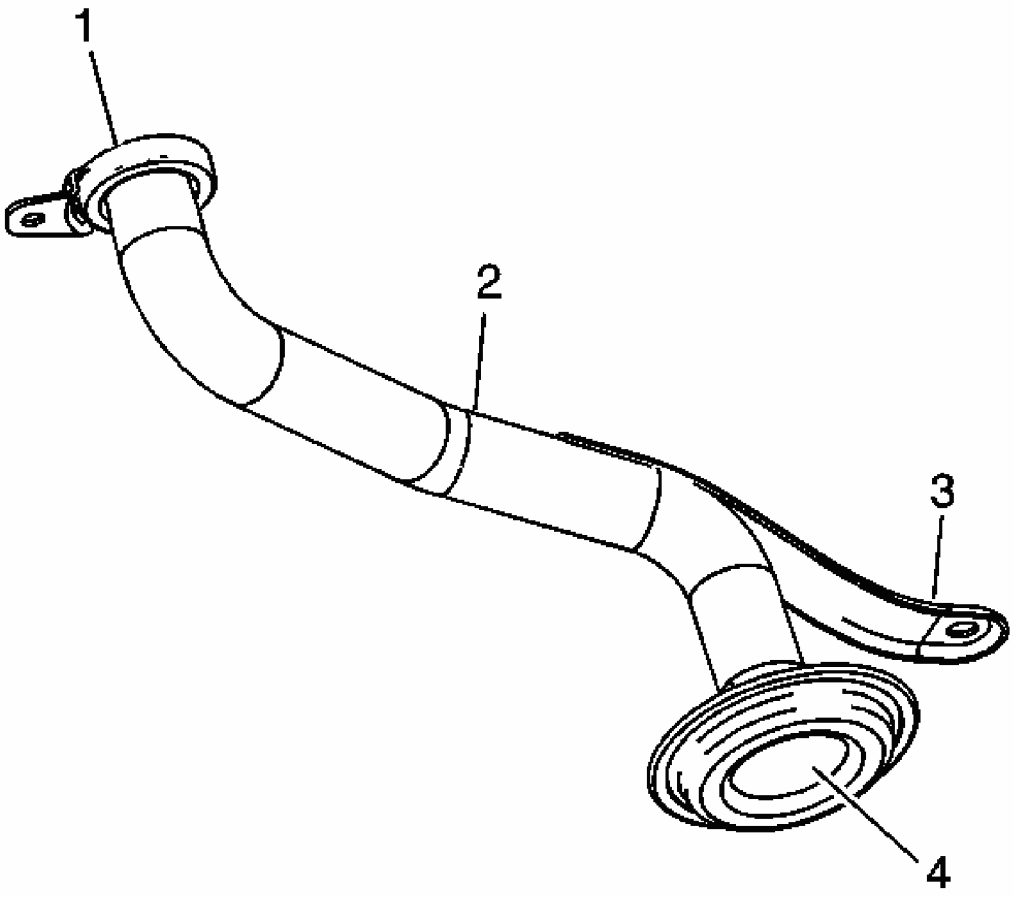

Fig. 186: Inspecting Mounting Surface For Leaks
Courtesy of GENERAL MOTORS CORP.

1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

OIL PAN ASSEMBLE

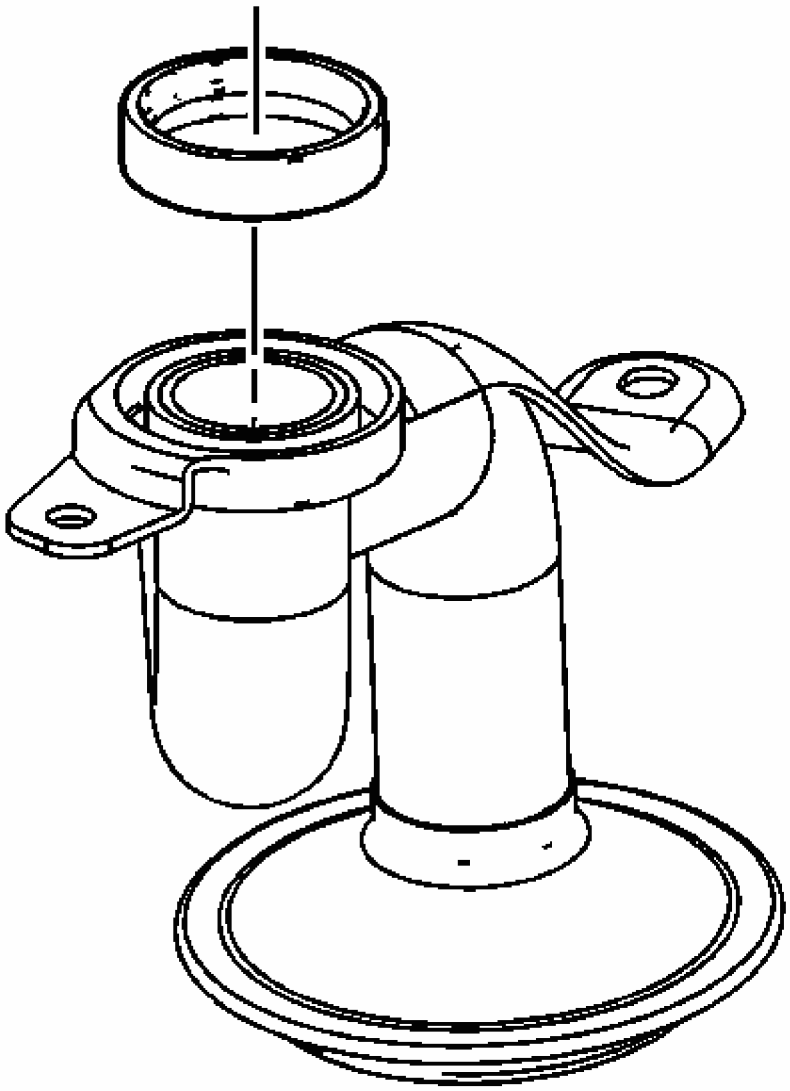

Fig. 187: View Of Oil Suction Tube Seal & Oil Suction Tube
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW oil suction tube seal onto the oil suction tube. DO NOT reuse the old oil suction tube seal.

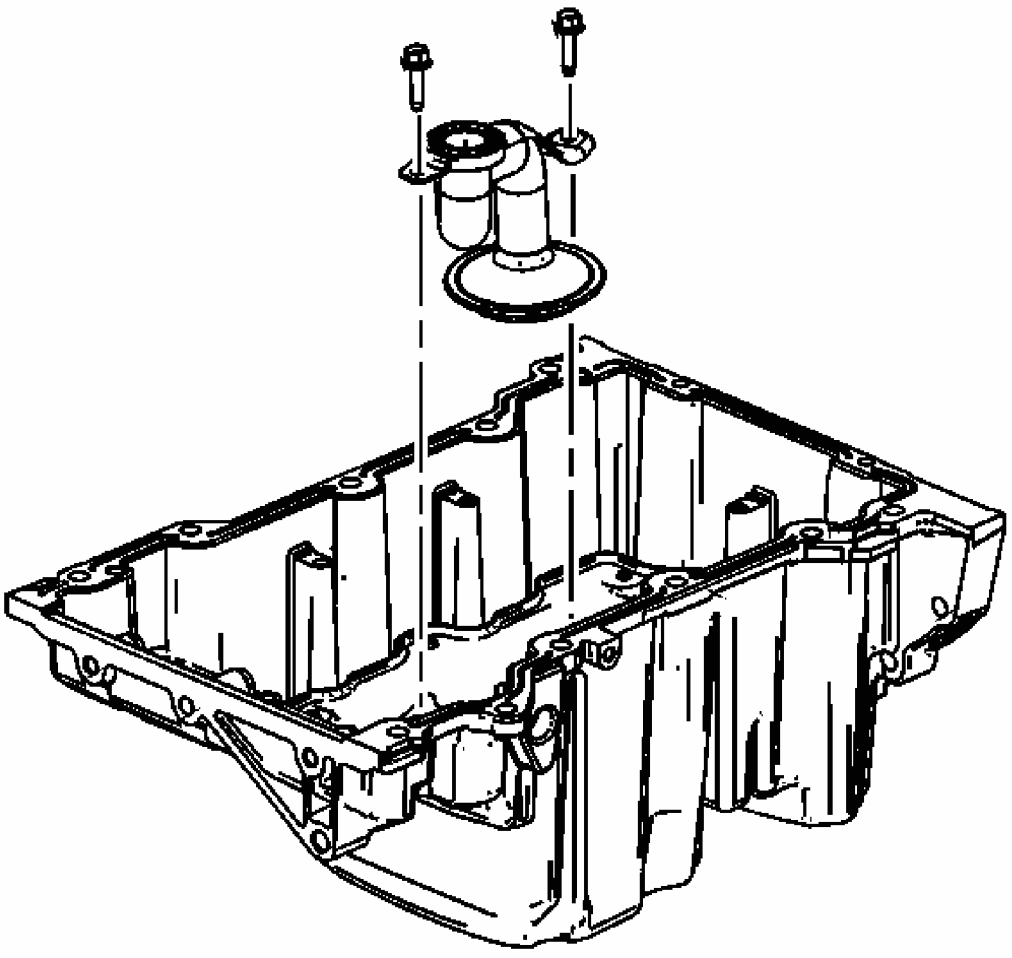

Fig. 188: View Of Oil Suction Pipe
Courtesy of GENERAL MOTORS CORP.

2. Install the oil suction pipe.

NOTE: **Refer to Fastener Notice in Cautions and Notices.**

3. Install the oil suction pipe bolts.

Tighten: Tighten the oil suction pipe bolts to 10 N.m (89 lb in).

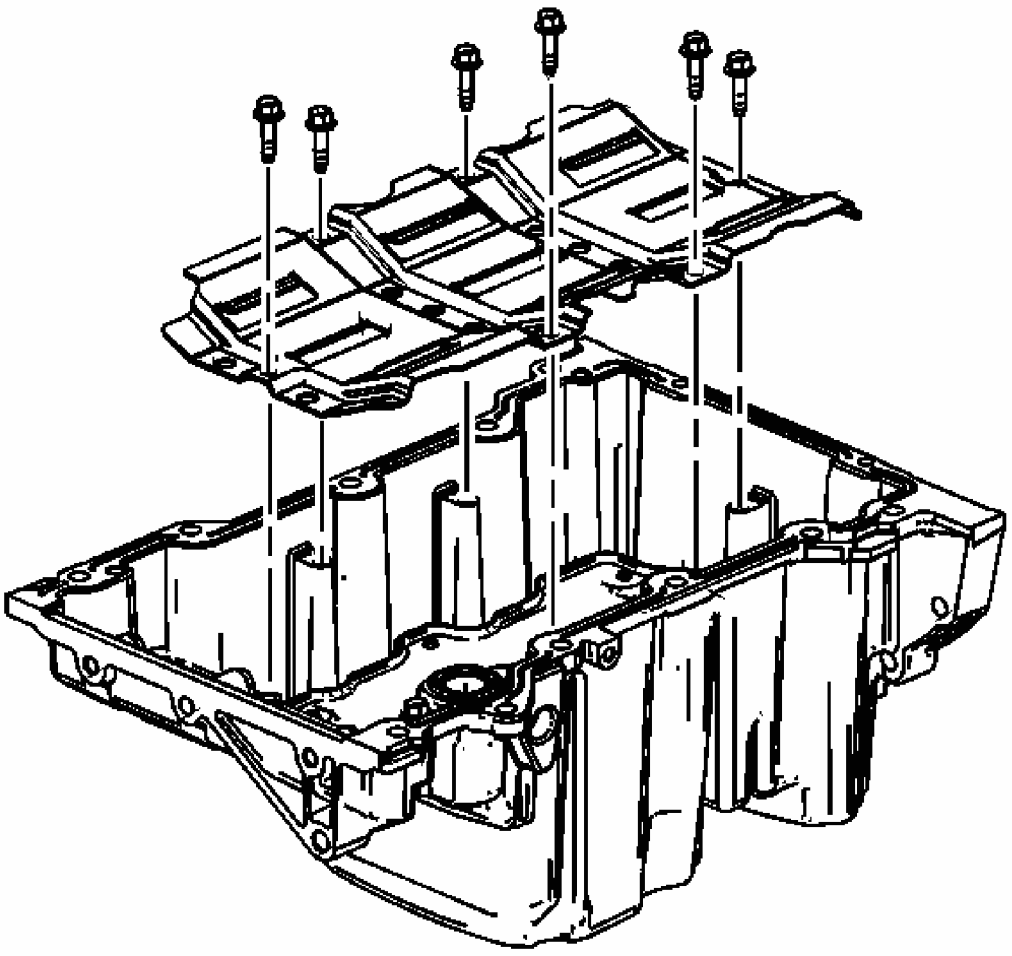

Fig. 189: View Of Oil Pan Scraper And Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan scraper.
5. Install the oil pan scraper bolts.

Tighten: Tighten the oil pan scraper bolts to 10 N.m (89 lb in).

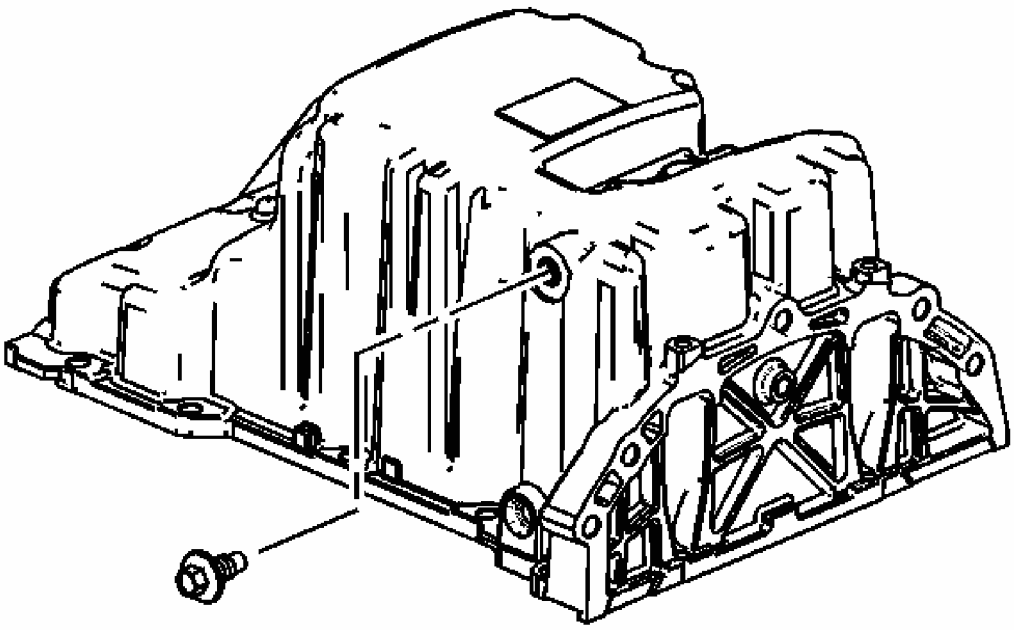

Fig. 190: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug and NEW O-ring seal.

   Tighten: Tighten the oil pan drain plug to 20 N.m (15 lb ft).

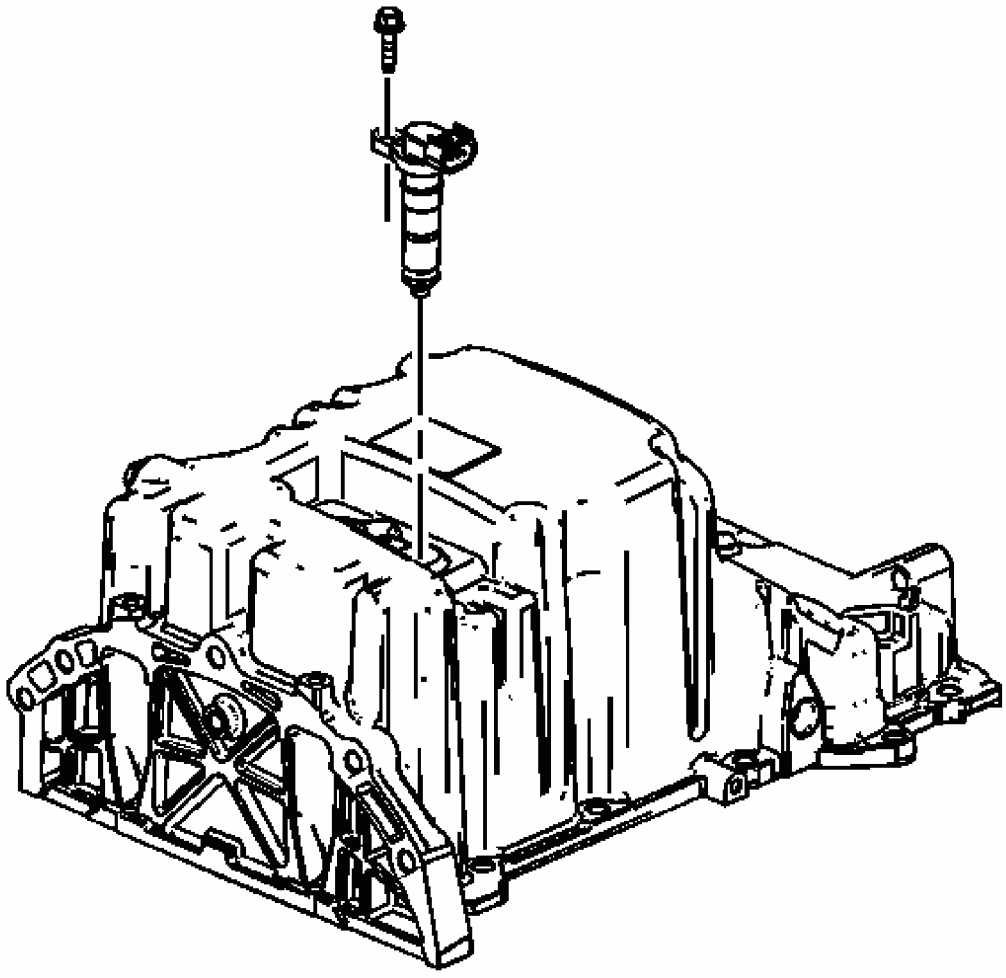

Fig. 191: Removing & Installing Oil Level/Condition Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the oil level/condition sensor.
8. Install the oil level/condition sensor bolt.

Tighten: Tighten the oil level/condition bolt to 10 N.m (89 lb in).

ENGINE FRONT COVER DISASSEMBLE

Tools Required

J 45000 Seal Remover

Disassemble Procedure

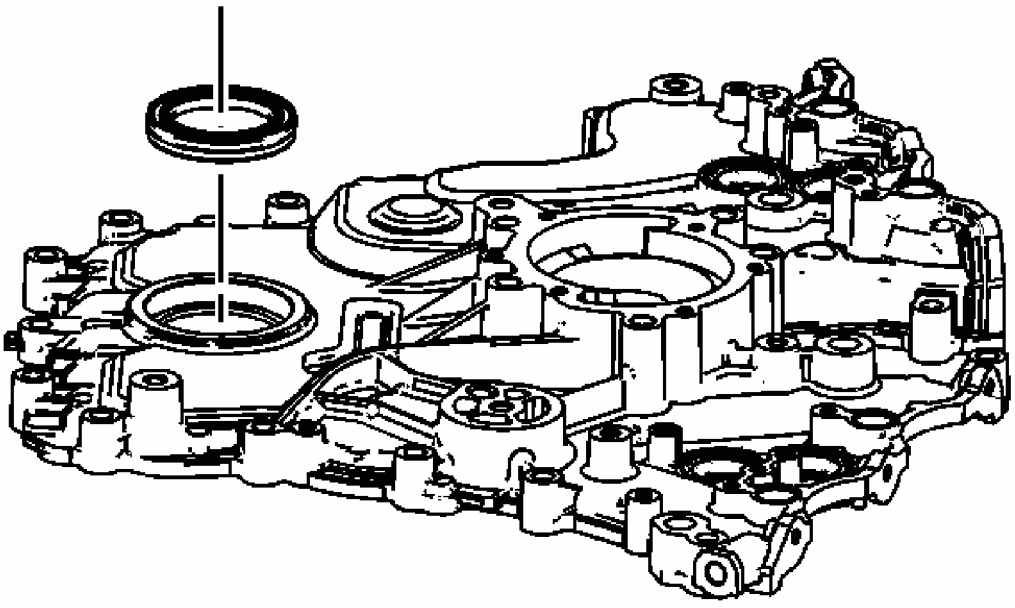

Fig. 192: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft front oil seal from the engine front cover using the **J 45000** .

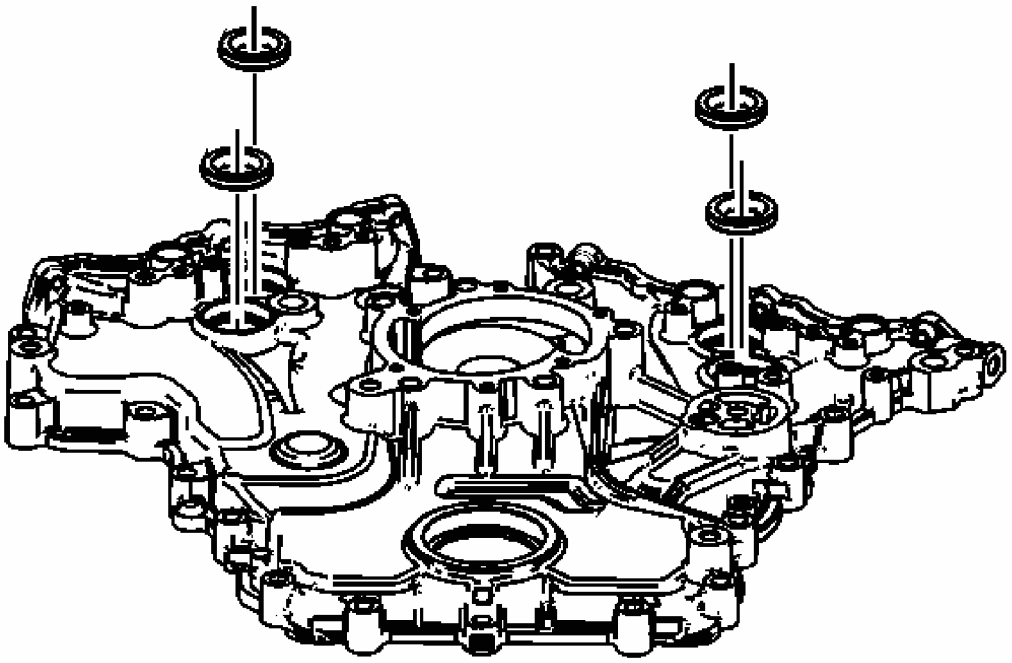

Fig. 193: View Of Camshaft Position Actuator Valve Oil Seals
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft position actuator valve oil seals from the engine front cover.

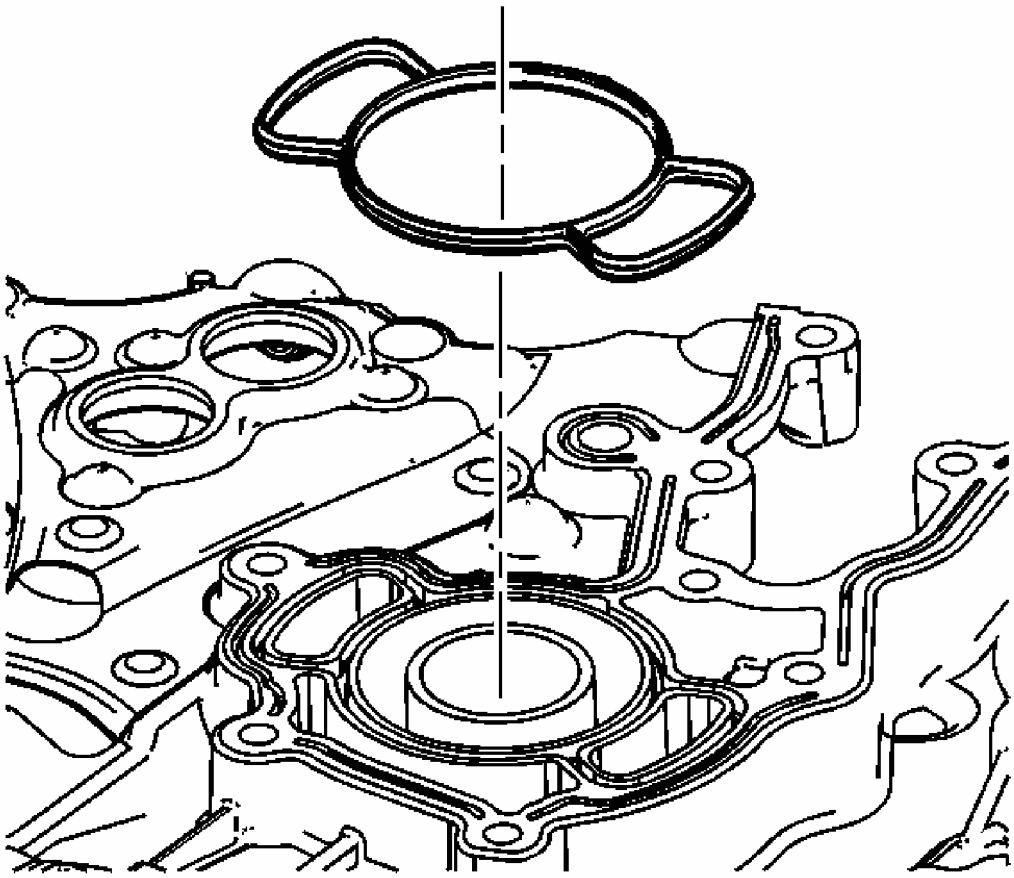

Fig. 194: Identifying Water Pump Seal
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump seal from the engine front cover.
4. Discard the water pump seal.

ENGINE FRONT COVER CLEANING AND INSPECTION

Tools Required

J 28410 Gasket Remover

Cleaning Procedure

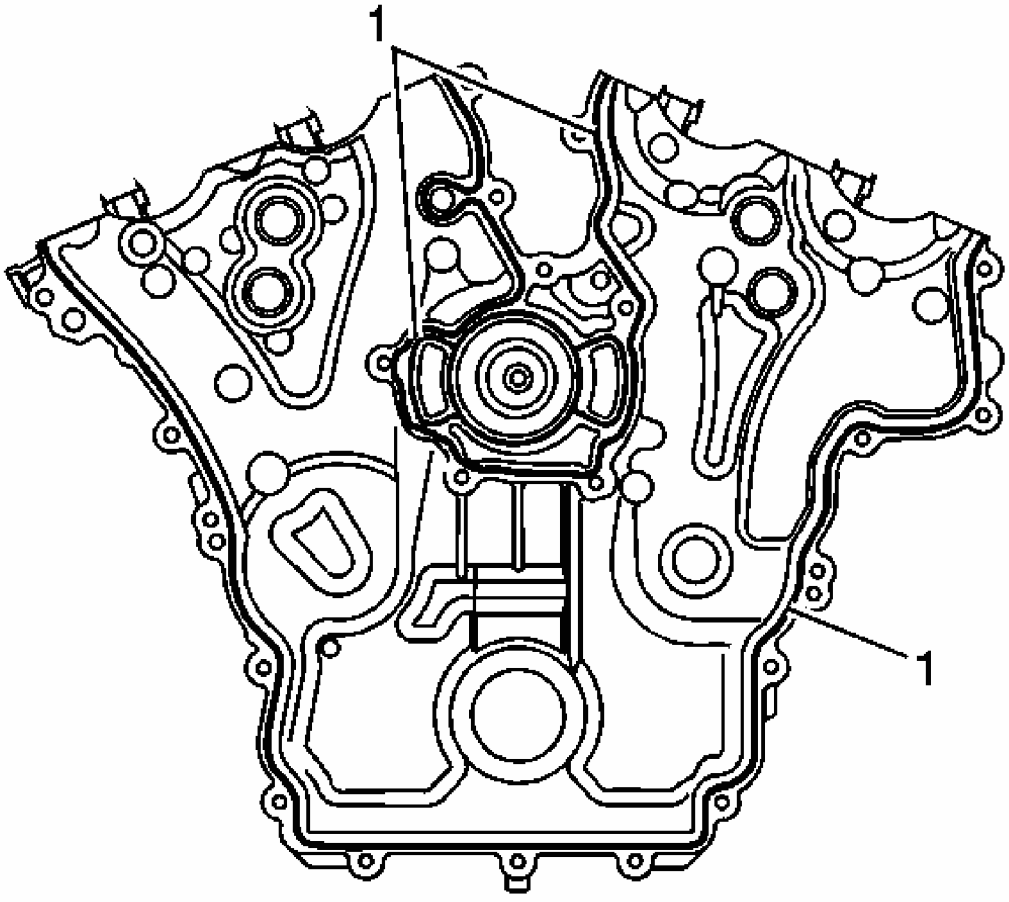

Fig. 195: Locating RTV Sealant
Courtesy of GENERAL MOTORS CORP.

1. Remove any RTV sealant (1) from the engine front cover using **J 28410** .
2. Clean out debris from the bolt holes.
3. Clean the engine front cover in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

4. Dry the engine front cover with compressed air.

Inspection Procedure

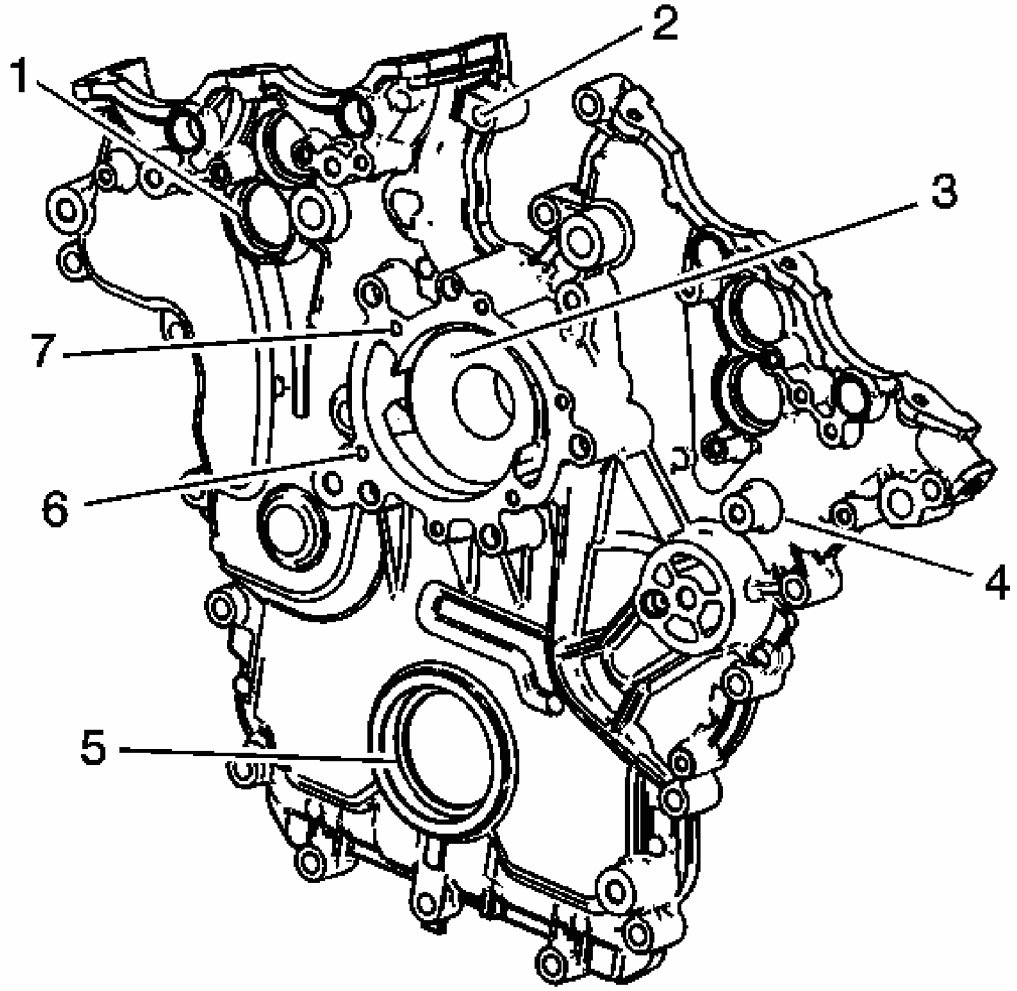

Fig. 196: Inspecting Exterior Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Inspect the exterior of the engine front cover for the following conditions:
    - Damage to the water pump bolt hole threads (7)
    - Gouges or damage to the water pump sealing surfaces (6)
    - Damage to the crankshaft front oil seal bore (5)
    - Damage to the camshaft position actuator valve oil seal bores (1)
    - Damage to the engine front cover bolt holes (2)
    - Damage and/or corrosion to the engine coolant passage (3)
    - Dents or damage to the exterior (4)

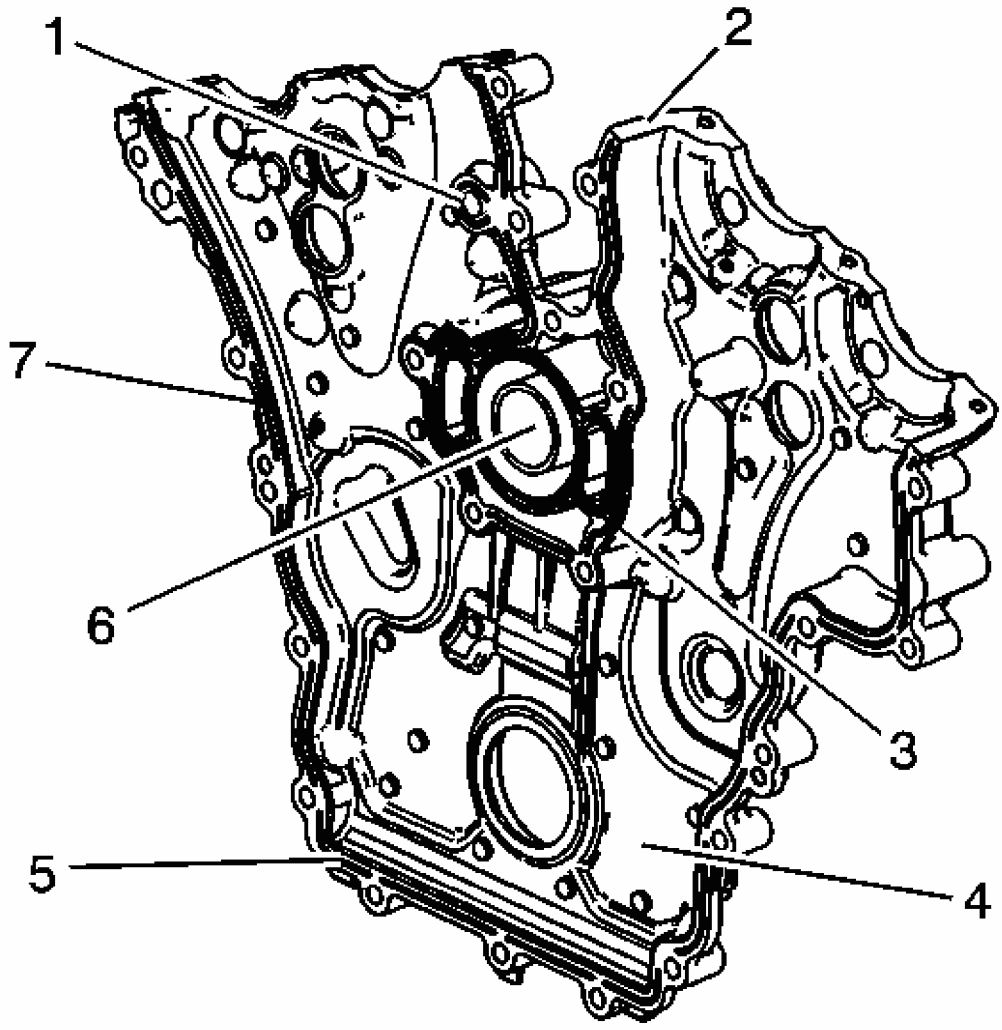

Fig. 197: Inspecting Interior Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the interior of the engine front cover for the following conditions:
    - Gouges or damage to the engine front cover sealing surfaces to the engine block (7), oil pan (5), and/or camshaft covers (2)
    - Damage and/or corrosion to the engine coolant passage (6)
    - Damage to the crankshaft front oil seal bore
    - Gouges or damage to the O-ring sealing areas
    - Gouges or damage to the water pump seal area (3)
    - Loose or damaged deadener plates (4)

- Damage to the engine front cover bolt holes (1)

3. Repair or replace the engine front cover as necessary.

ENGINE FRONT COVER ASSEMBLE

Tools Required

- **EN 46103** Camshaft Actuator Valve Seal Remover/Installer
- **J 29184** Oil Seal Installer

Assemble Procedure

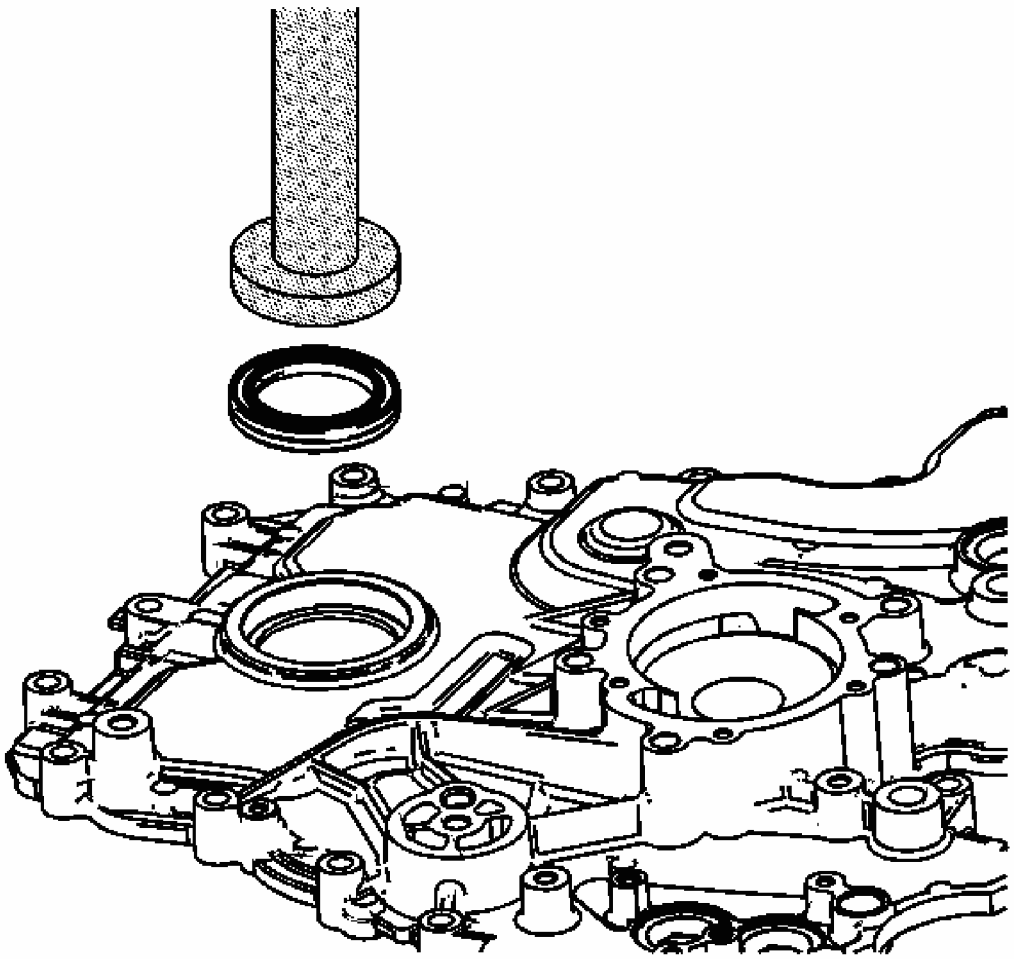

Fig. 198: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

1. Install the NEW crankshaft front oil seal into the engine front cover using the **J 29184** .

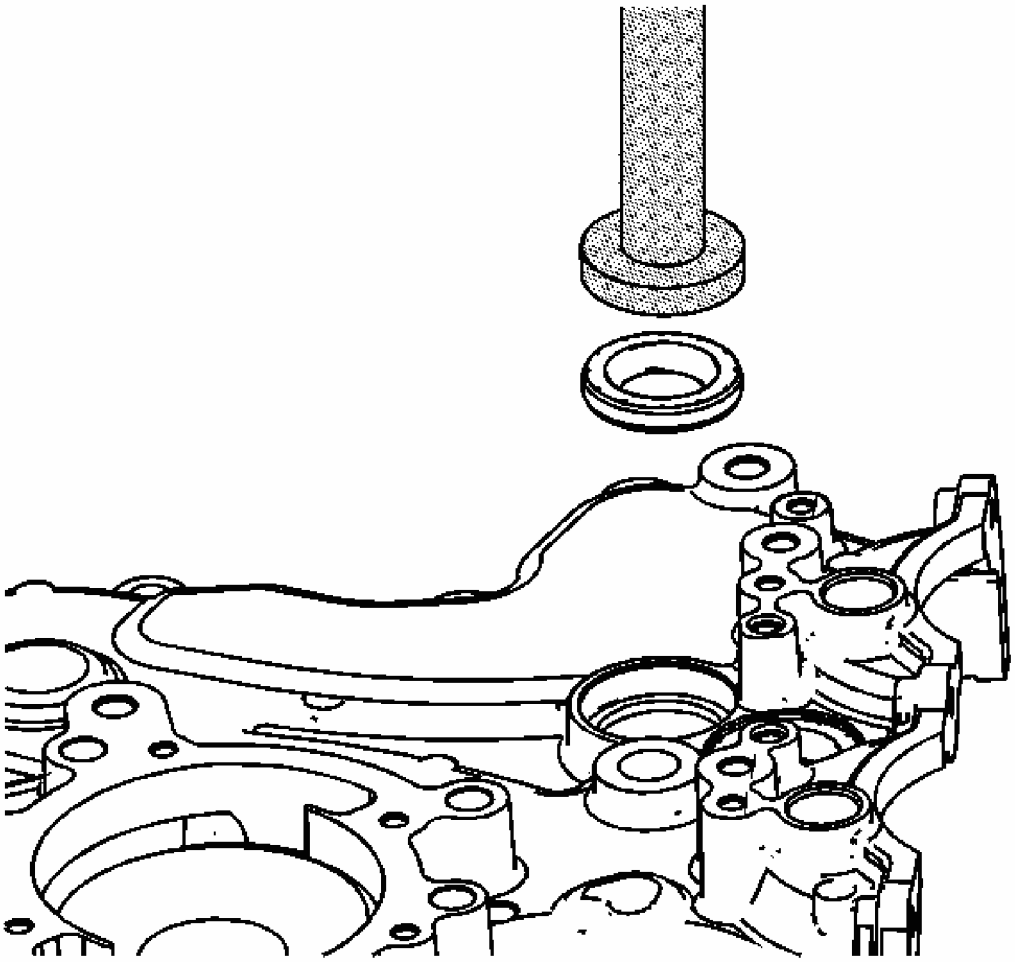

Fig. 199: Installing Camshaft Position Actuator Valve Oil Seals
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW camshaft position actuator valve oil seals into the engine front cover using the **EN 46103** .

CAMSHAFT COVER DISASSEMBLE

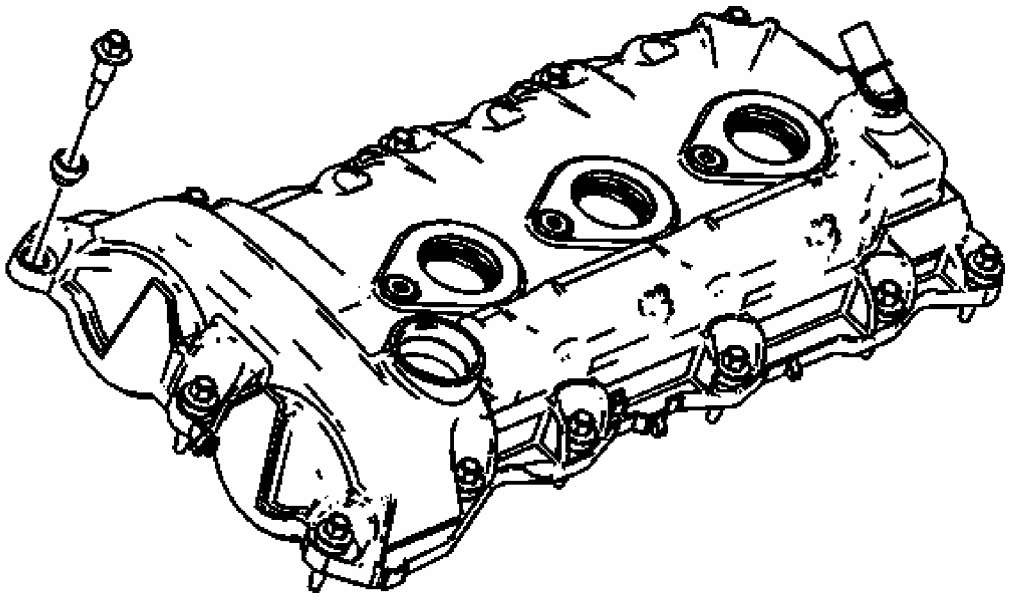

Fig. 200: Locating Camshaft Cover Bolts & Grommets
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover bolts.
2. Remove and discard the camshaft cover bolt grommets.

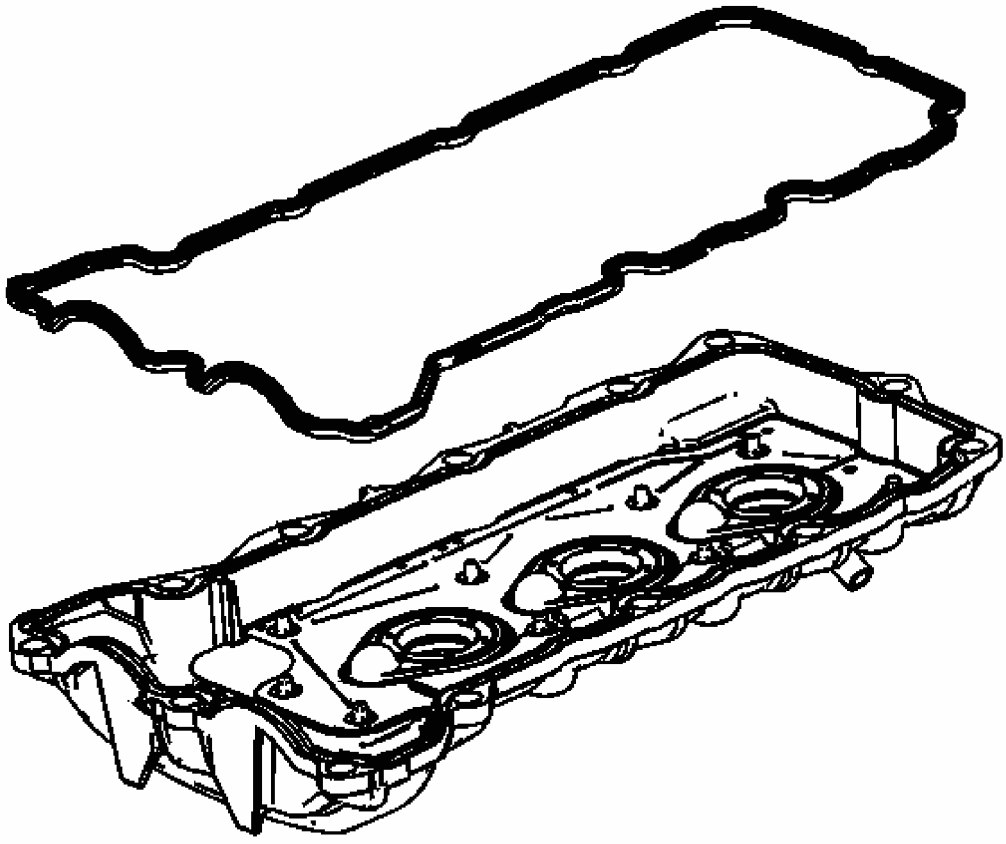

Fig. 201: Identifying Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the camshaft cover gasket and ignition coil seals.

3. Remove and discard the camshaft cover gasket.

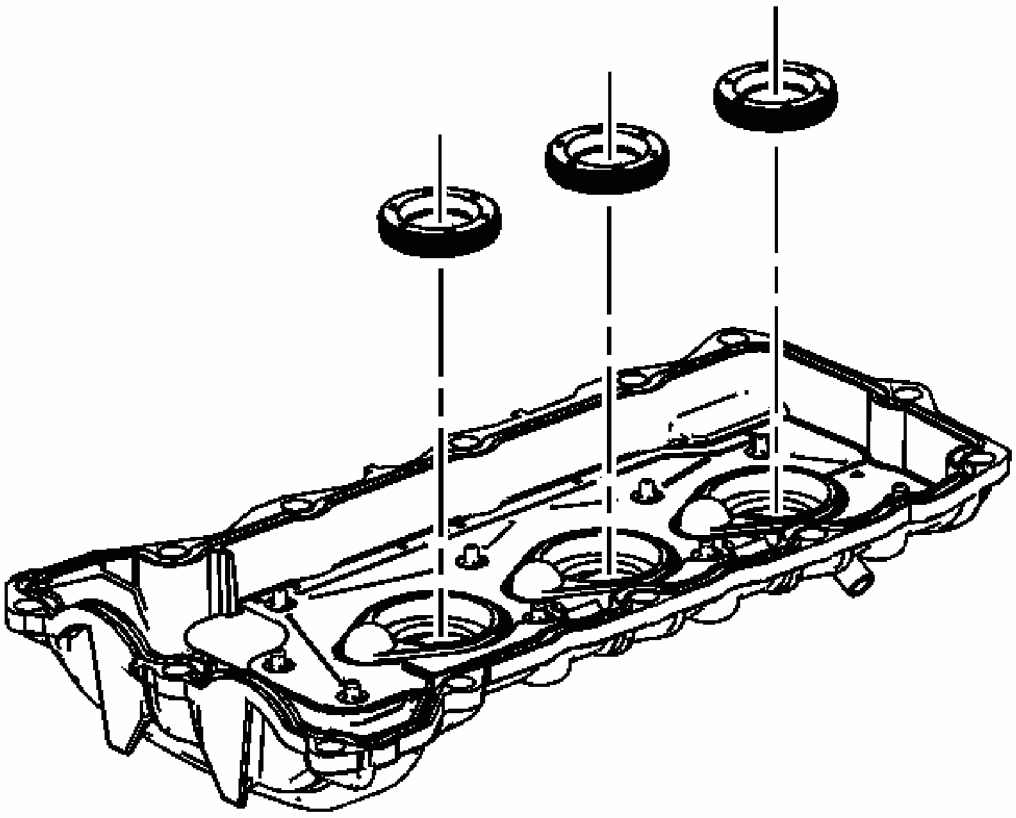

Fig. 202: Locating Ignition Coil Seals
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the ignition coil seals.

CAMSHAFT COVER CLEANING AND INSPECTION

Cleaning Procedure

1. Clean the camshaft covers in solvent.

CAUTION: Refer to Safety Glasses Caution in Cautions and Notices.

2. Dry the camshaft covers with compressed air.

Inspection Procedure

1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or

damaged camshaft cover may:

- Leak engine oil
- Effect crankcase ventilation
- Interfere with the camshafts
- Interfere with the ignition coil sealing
- Allow water or condensation to enter the engine

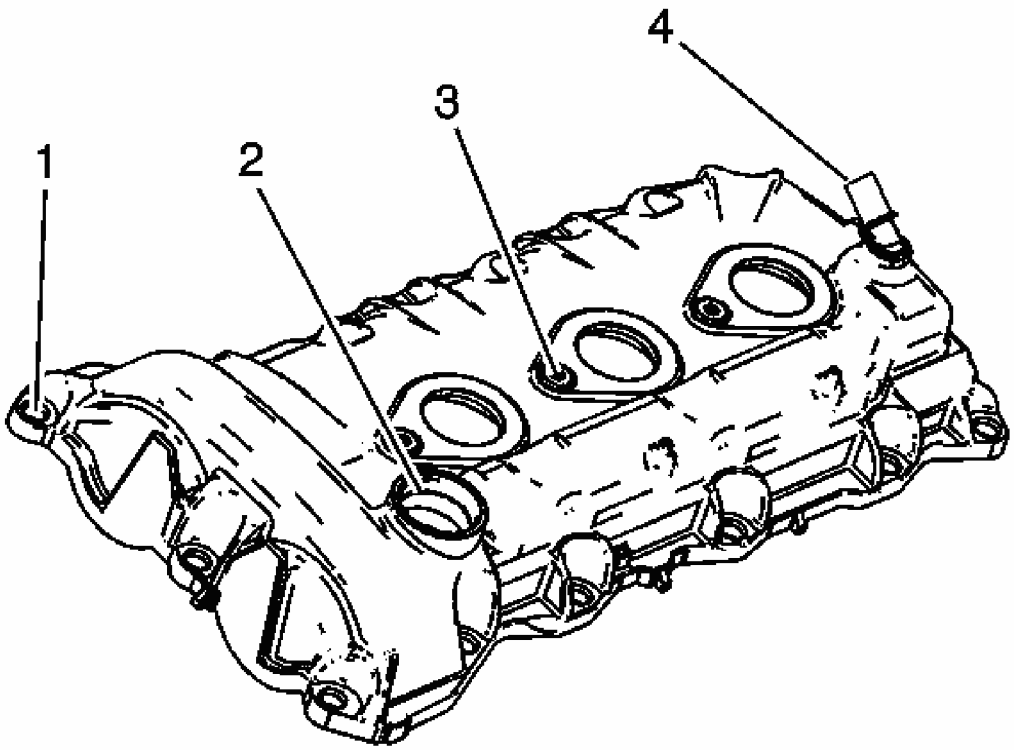

Fig. 203: Inspecting Exterior Of The Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the exterior of the left camshaft cover for the following conditions:
   - Damage to the camshaft cover bolt holes (1)
   - Damage to the oil fill hole (2)
   - Damage to the mounting holes (3) for the ignition coil assembly
   - Damage to the positive crankcase ventilation (PCV) hose connector (4) - A damaged PCV hose connector is replaceable.

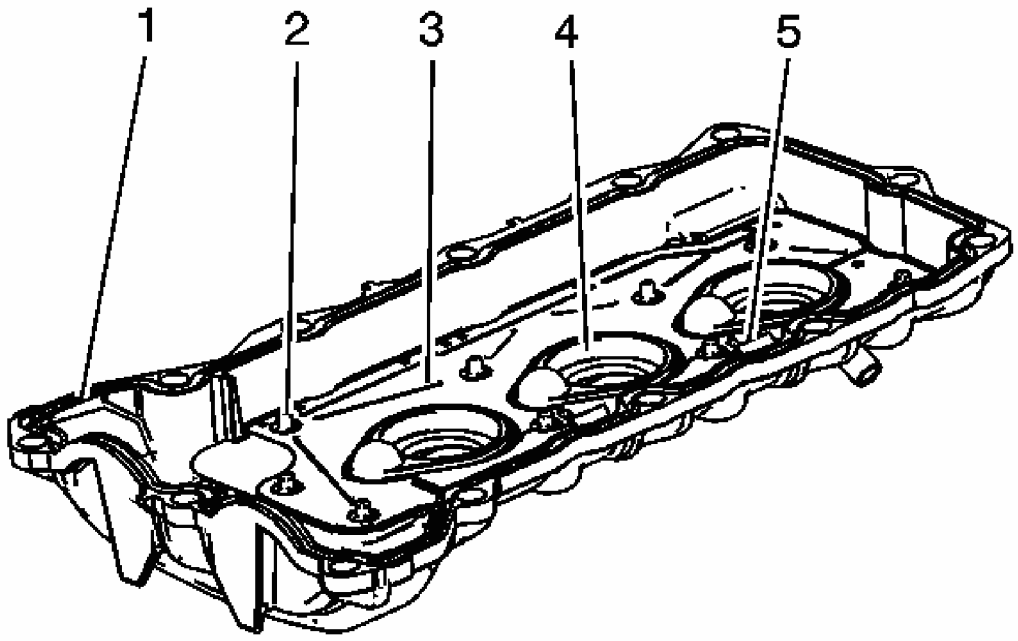

Fig. 204: Checking Interior Of Left Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

3. Inspect the interior of the left camshaft cover for the following conditions:
    - Gouges or damage to the camshaft cover sealing groove (1)
    - Damaged, loose or missing baffle fasteners (2)
    - Damaged, loose or missing baffle (3)
    - Gouges or damage to the ignition coil seal bore (4)
    - Restrictions to the ventilation system (5)

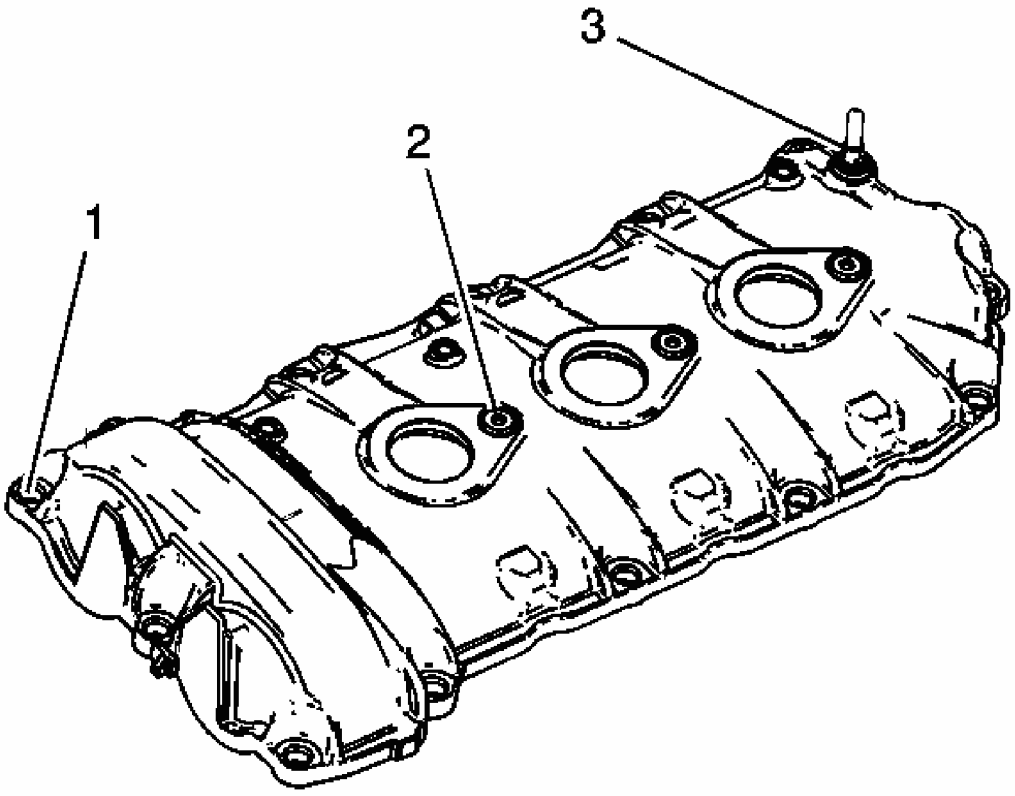

Fig. 205: Checking Exterior Of Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

4. Inspect the exterior of the right camshaft cover for the following conditions:
   - Damage to the camshaft cover bolt holes (1)
   - Damage to the mounting holes (2) for the ignition coil assembly
   - Damage to the PCV orifice (3) - A damaged PCV orifice can be replaced. Refer to **PCV Orifice Replacement**.

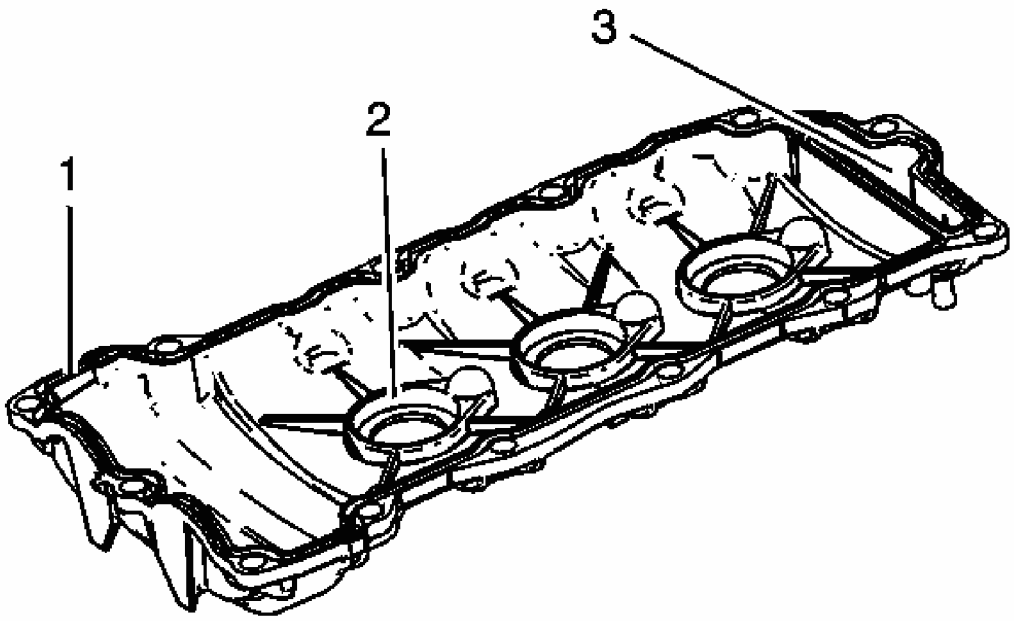

Fig. 206: Inspecting Interior Of The Right Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

5. Inspect the interior of the right camshaft cover for the following conditions:
   - Gouges or damage to the camshaft cover sealing groove (1)
   - Gouges or damage to the ignition coil seal bore (2)
   - Restrictions to the ventilation system (3)
6. Repair or replace the camshaft cover or covers as necessary.

PCV Orifice Replacement

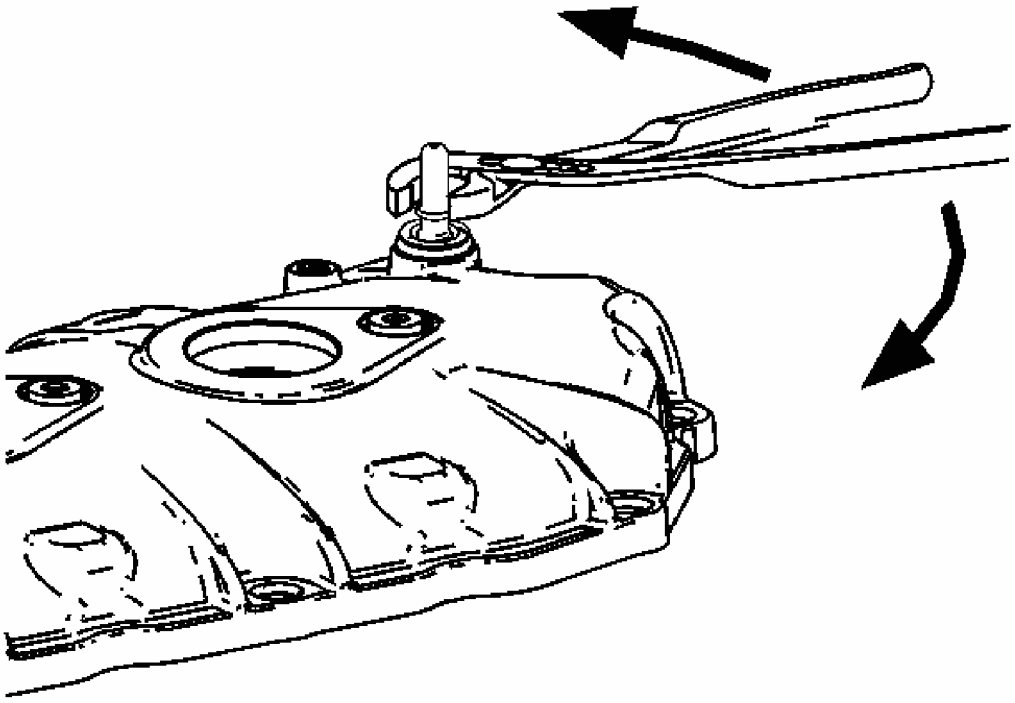

Fig. 207: PCV Orifice Removal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the PCV orifice is damaged or plugged and cannot be cleaned out, the PCV orifice can be replaced.

1. Remove the old PCV orifice by griping the neck of the orifice with pliers and twisting and pulling out of the right camshaft cover.

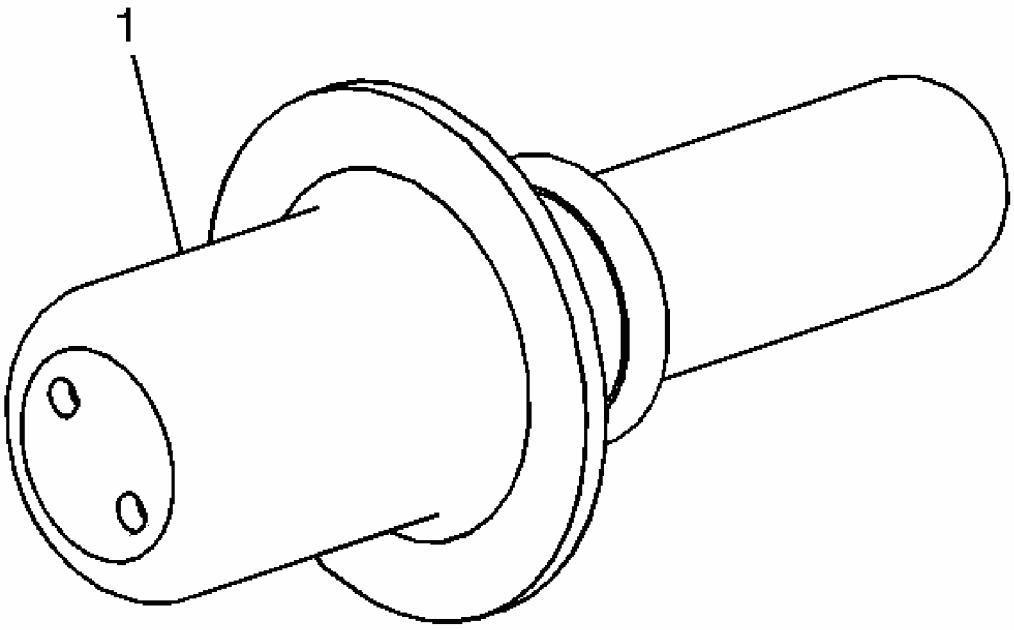

Fig. 208: Identifying Sealant Area On PCV Orifice
Courtesy of GENERAL MOTORS CORP.

2. Apply sealant GM P/N 12378521 (Canadian P/N 88901148) or equivalent to the NEW PCV orifice (1).

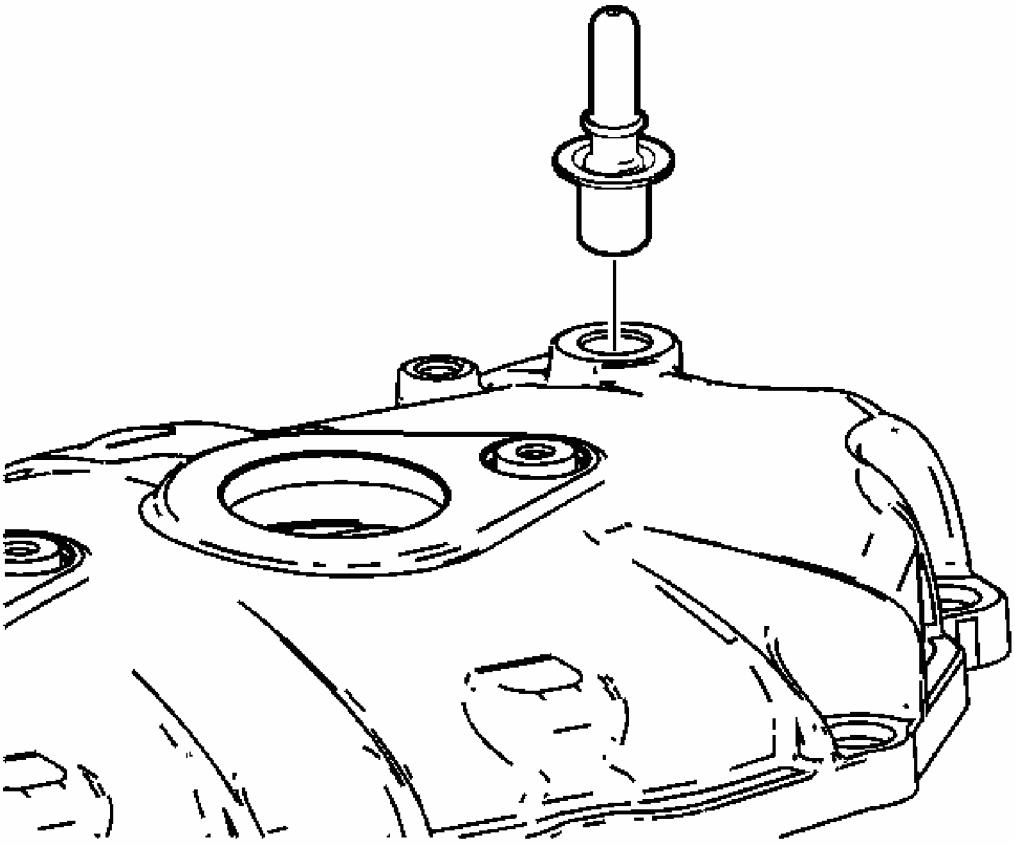

Fig. 209: Installing PCV Orifice
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW PCV orifice into the right camshaft cover. After insertion, twist the PCV orifice in order to eliminate any vertical leak paths in the sealant.

PCV Fitting Replacement

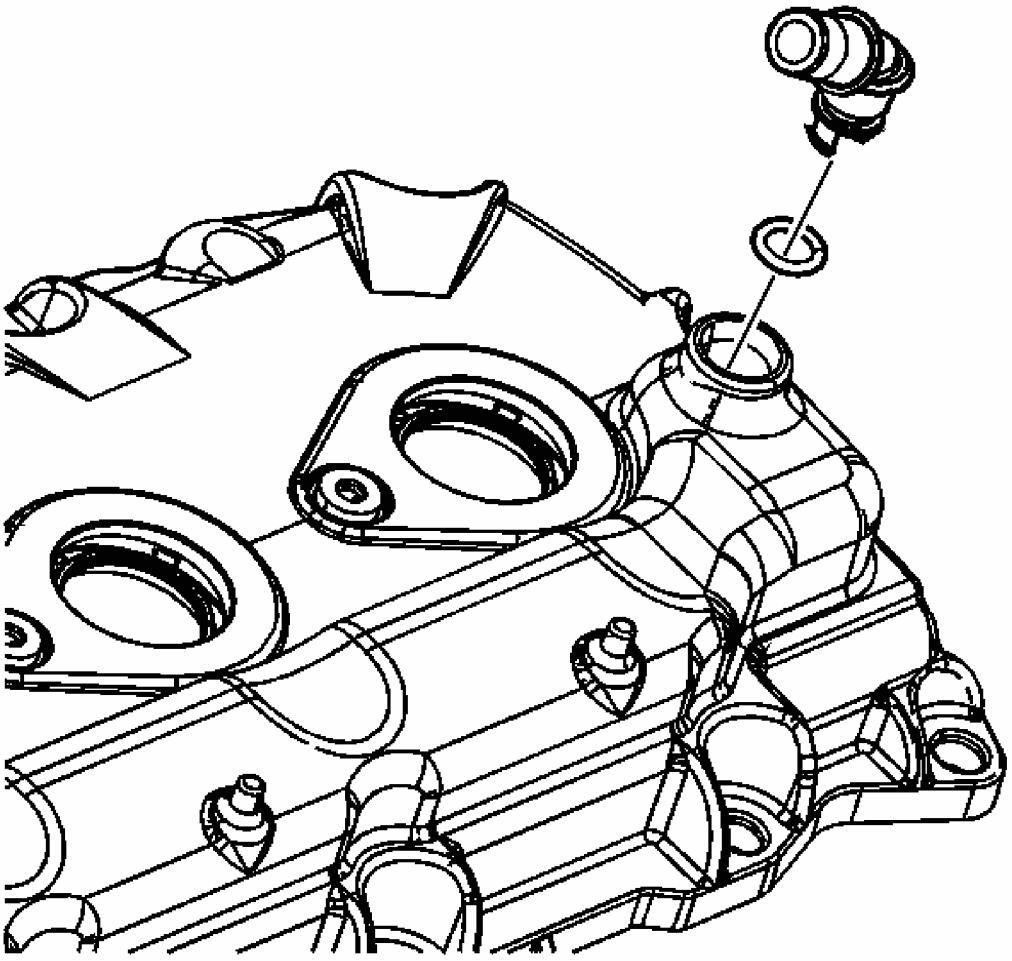

Fig. 210: PCV Fitting
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the PCV fitting is damaged or plugged and cannot be cleaned out, the PCV fitting can be replaced.

1. Remove the old PCV fitting.
2. Install the new PCV fitting with a NEW O-ring.

CAMSHAFT COVER ASSEMBLE

Tools Required

J 24254 Oil Seal Installer

Assemble Procedure

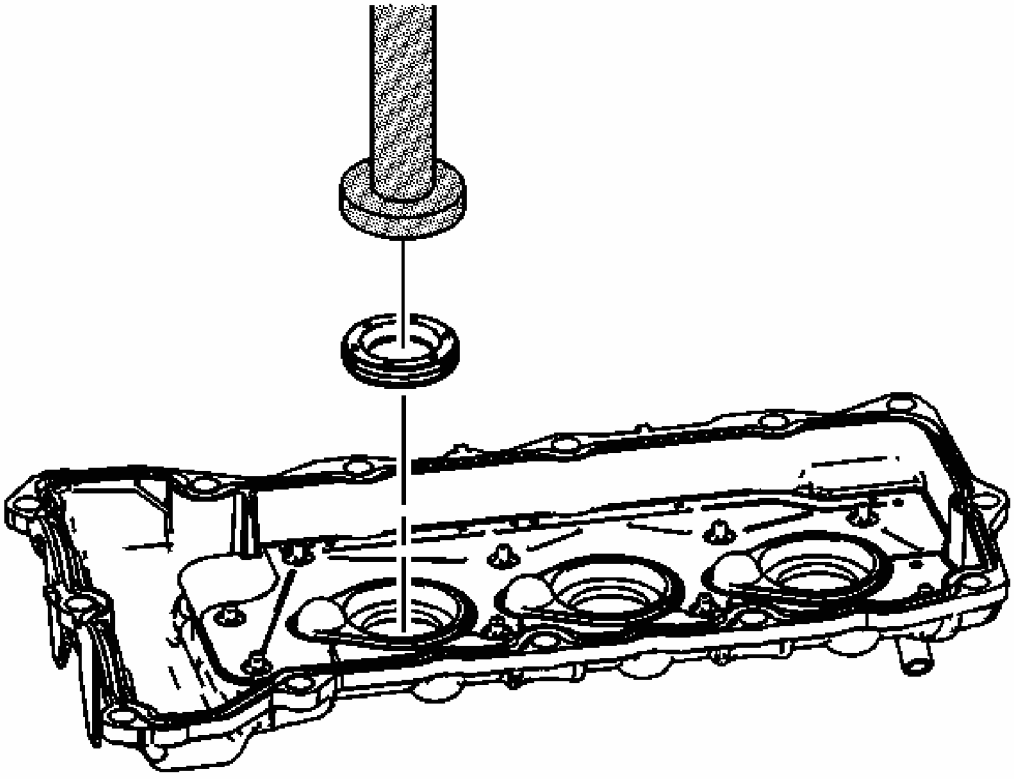

Fig. 211: Installing Ignition Coil Seals With J 24254
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW ignition coil seals using the **J 24254** .

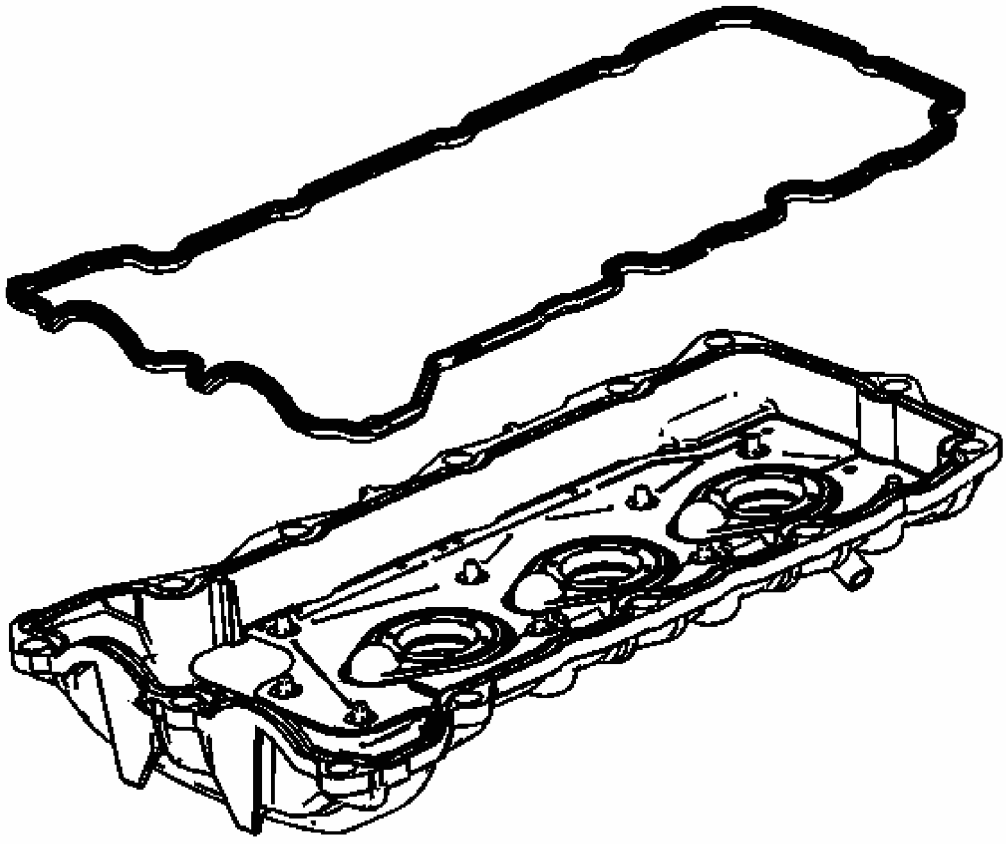

Fig. 212: Identifying Camshaft Cover Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW camshaft cover gasket.

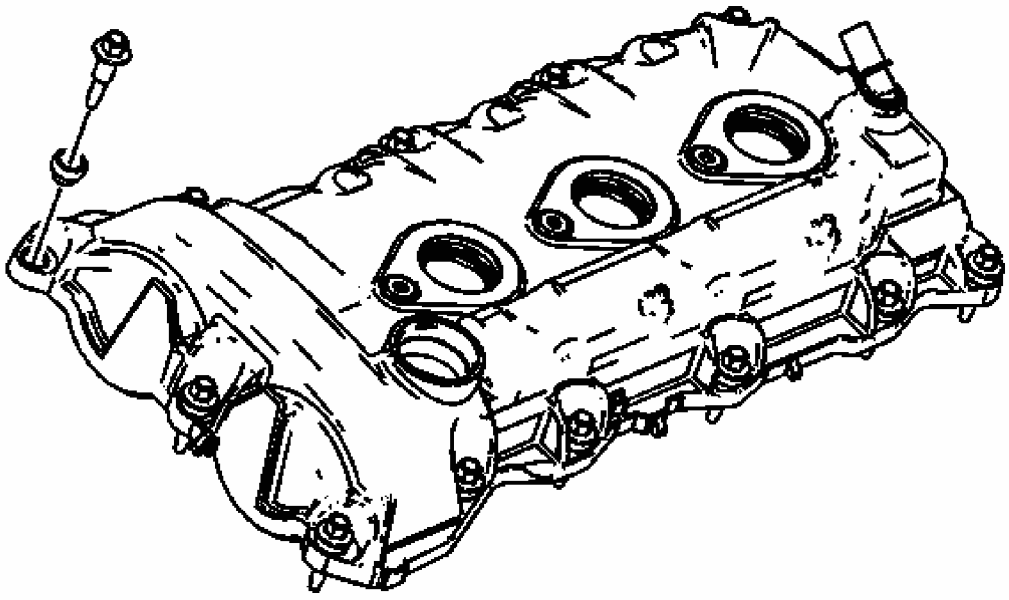

Fig. 213: Locating Camshaft Cover Bolts & Grommets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft cover bolt grommet must be installed into the camshaft cover bolt hole before installing the camshaft cover bolt.

3. Install the NEW camshaft cover bolt grommets.
4. Install the camshaft cover bolts.

INTAKE MANIFOLD DISASSEMBLE

Upper to Lower Intake Manifold Disassemble Procedure

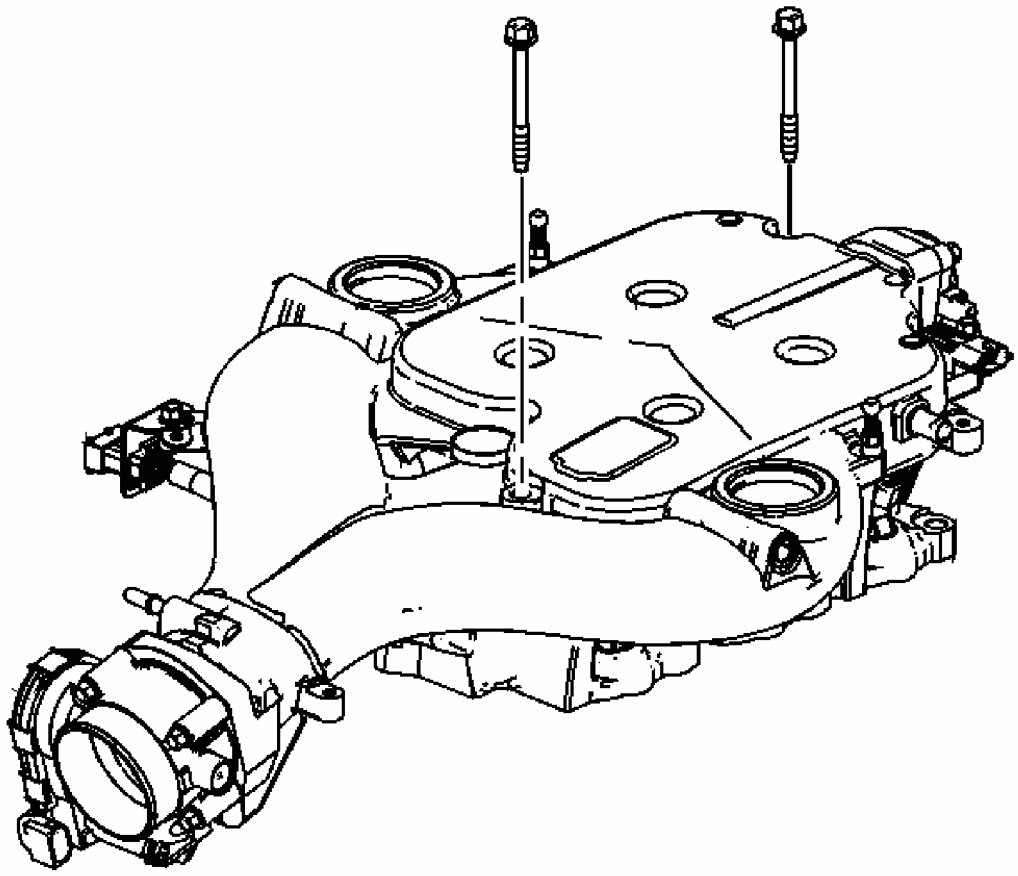

Fig. 214: View Of Upper-To-Lower Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

1. Remove the upper-to-lower intake manifold bolts.

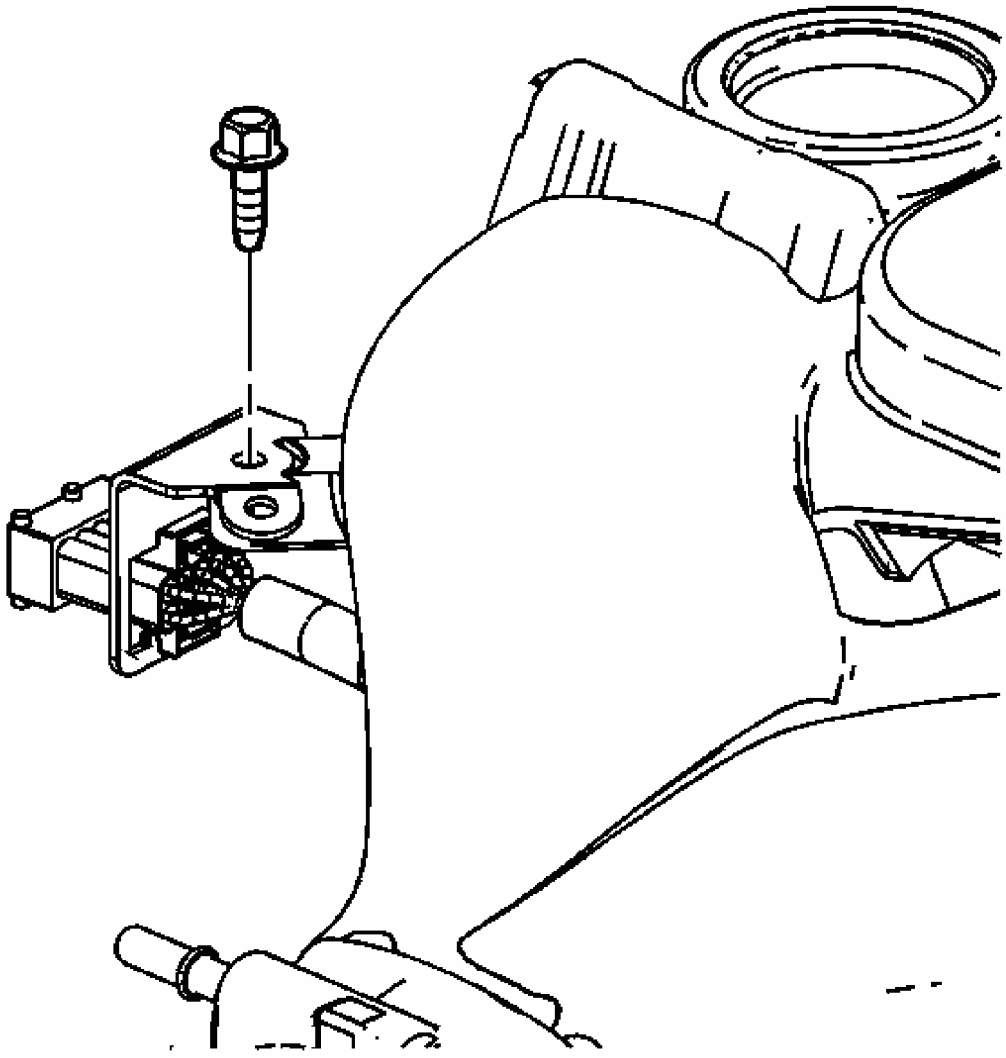

Fig. 215: View Of Injector Harness Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector wiring harness bracket bolt from the upper intake manifold.

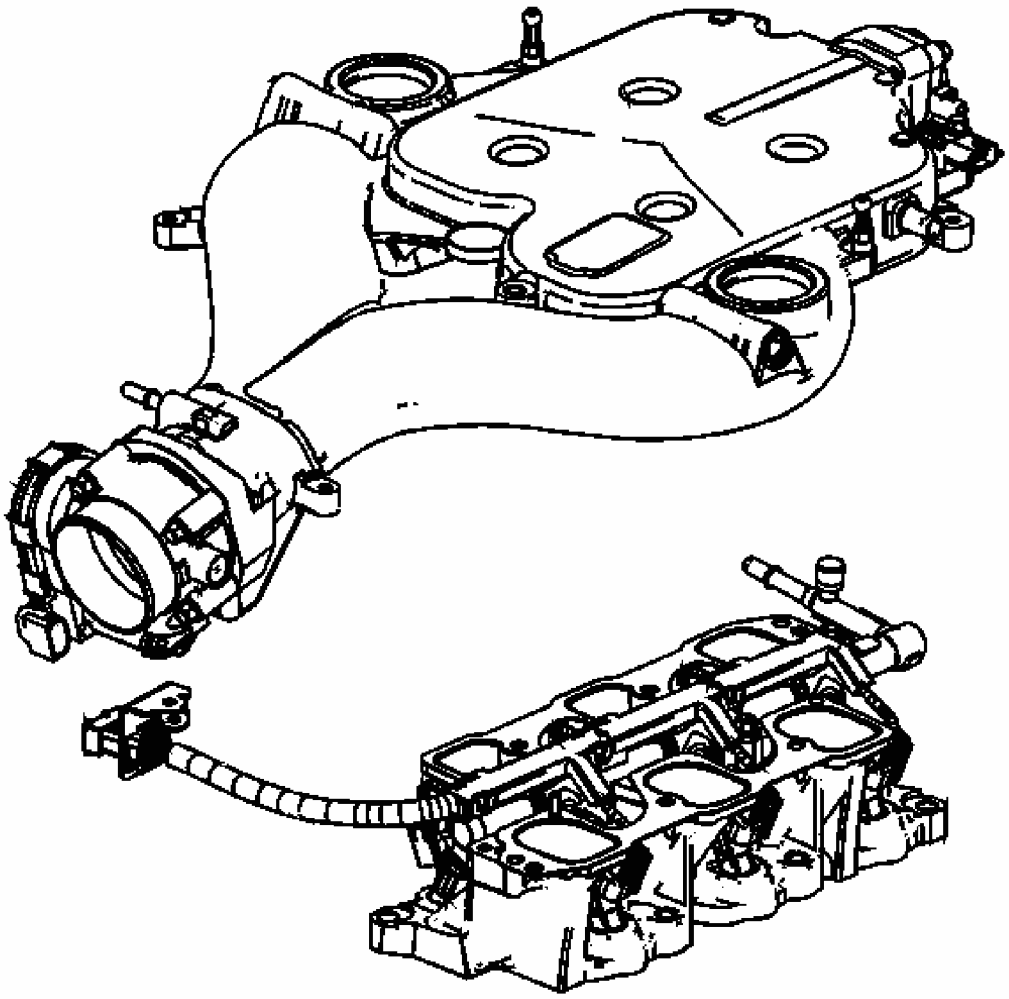

Fig. 216: View Of Upper & Lower Intake Manifolds
Courtesy of GENERAL MOTORS CORP.

3. Remove the upper intake manifold from the lower intake manifold.

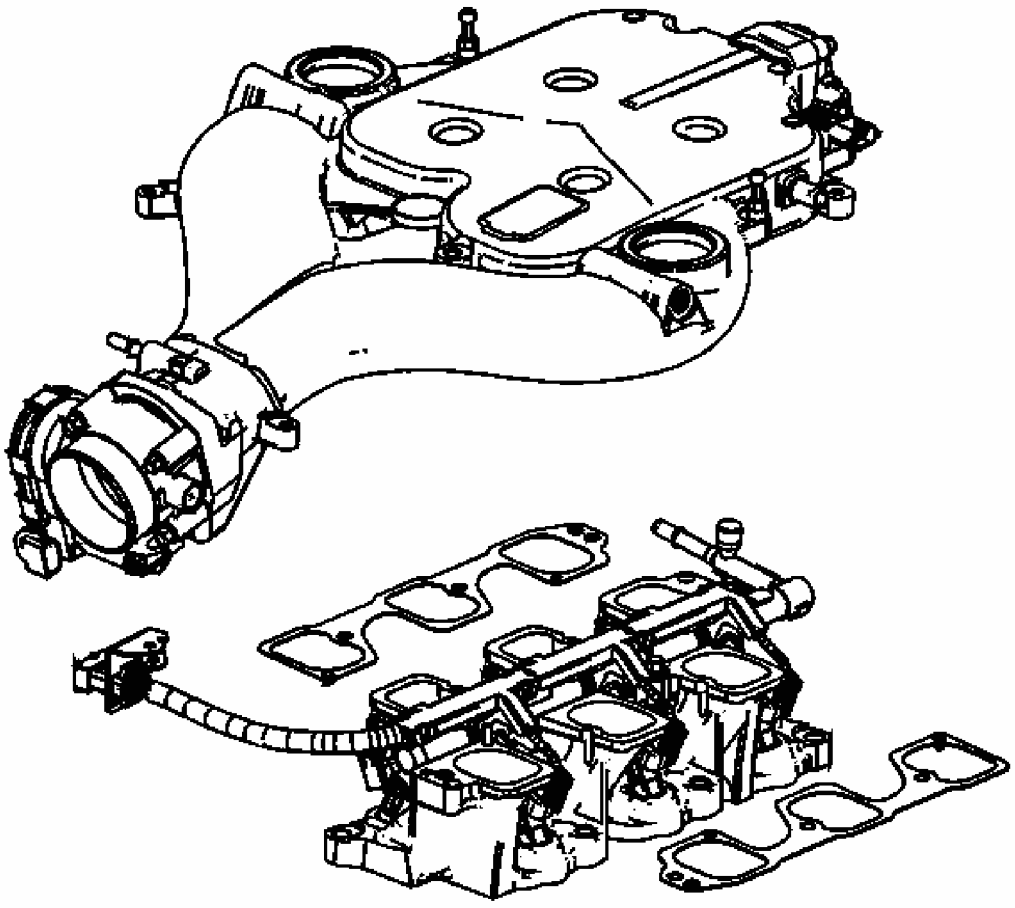

Fig. 217: View Of Upper-To-Lower Intake Manifold Gaskets
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the upper-to-lower intake manifold gaskets.

Upper Intake Manifold Disassemble Procedure

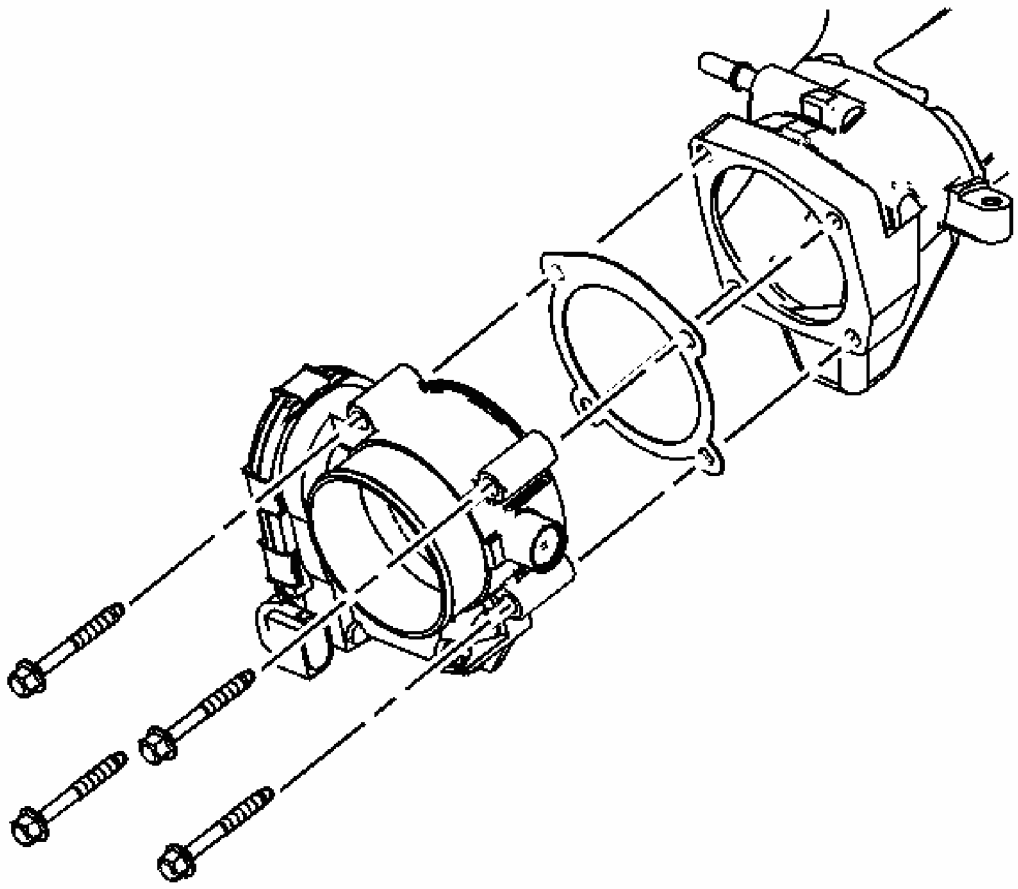

Fig. 218: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body bolts.
2. Remove the throttle body.
3. Remove and discard the throttle body gasket.

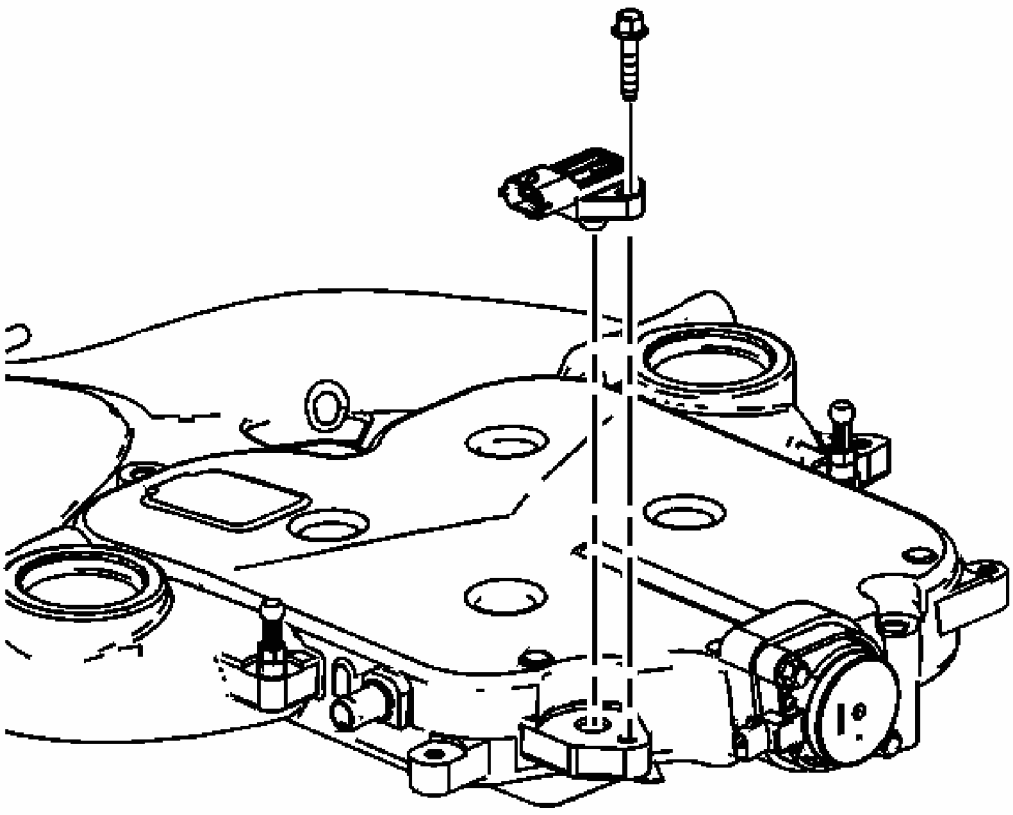

Fig. 219: View Of BARO Sensor
Courtesy of GENERAL MOTORS CORP.

4. Remove the barometric pressure (BARO) sensor bolt.
5. Remove the BARO sensor.

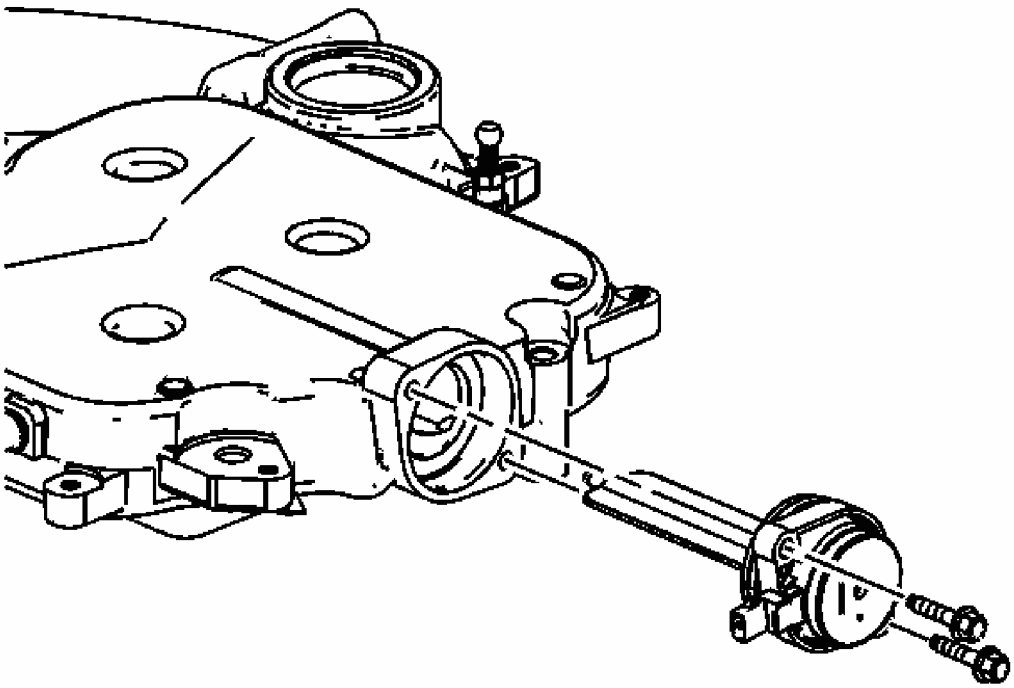

Fig. 220: View Of Communicator Valve
Courtesy of GENERAL MOTORS CORP.

6. Remove the communicator valve bolts.
7. Remove the communicator valve.

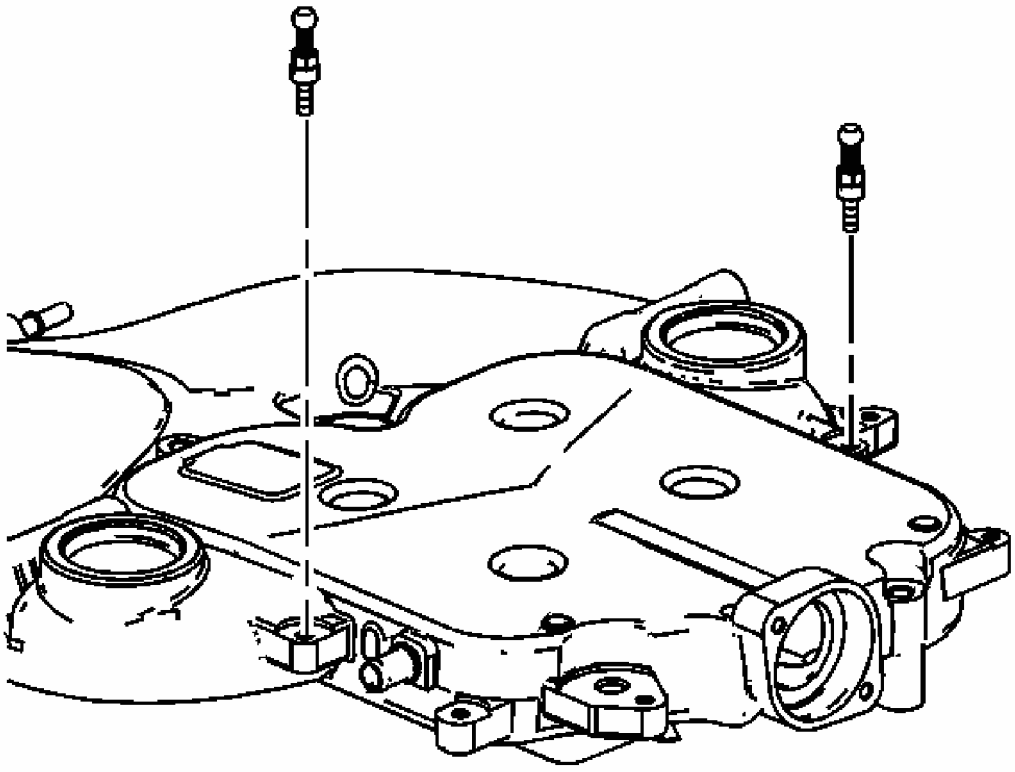

Fig. 221: View Of Sight Shield Ball Studs
Courtesy of GENERAL MOTORS CORP.

8. Remove the sight shield ball studs.

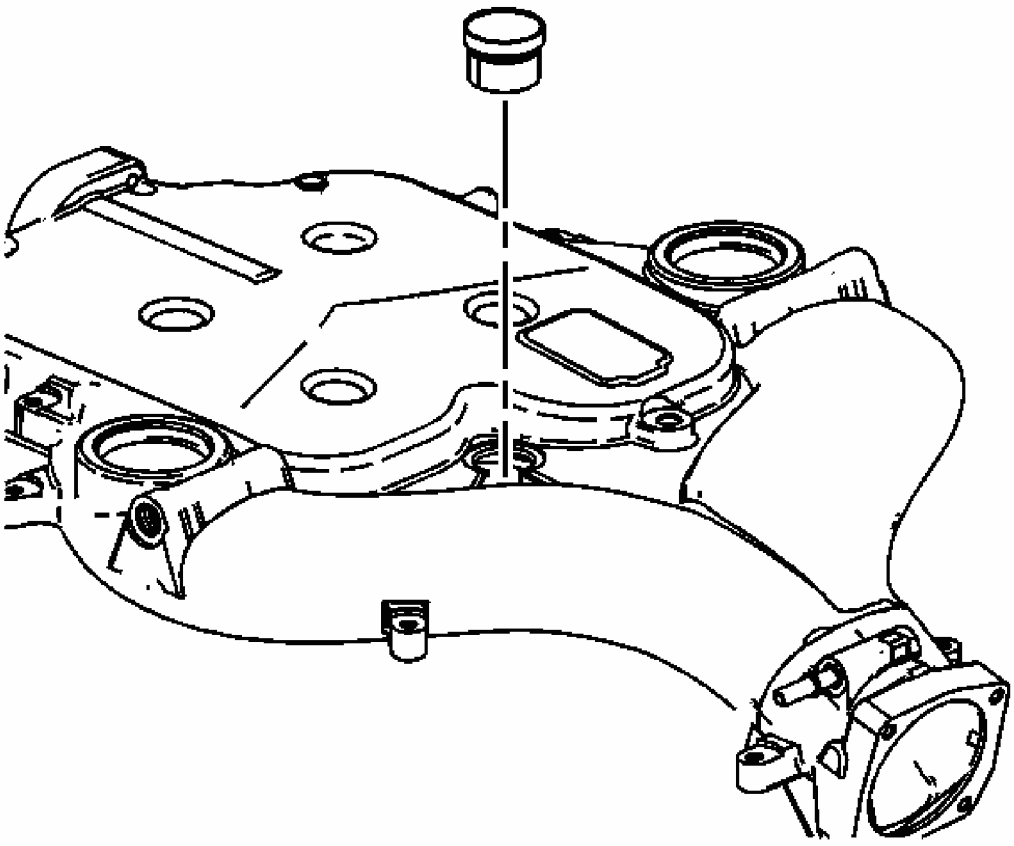

Fig. 222: View Of Sight Shield Grommet
Courtesy of GENERAL MOTORS CORP.

9. Remove the sight shield grommet.

Lower Intake Manifold Disassemble Procedure

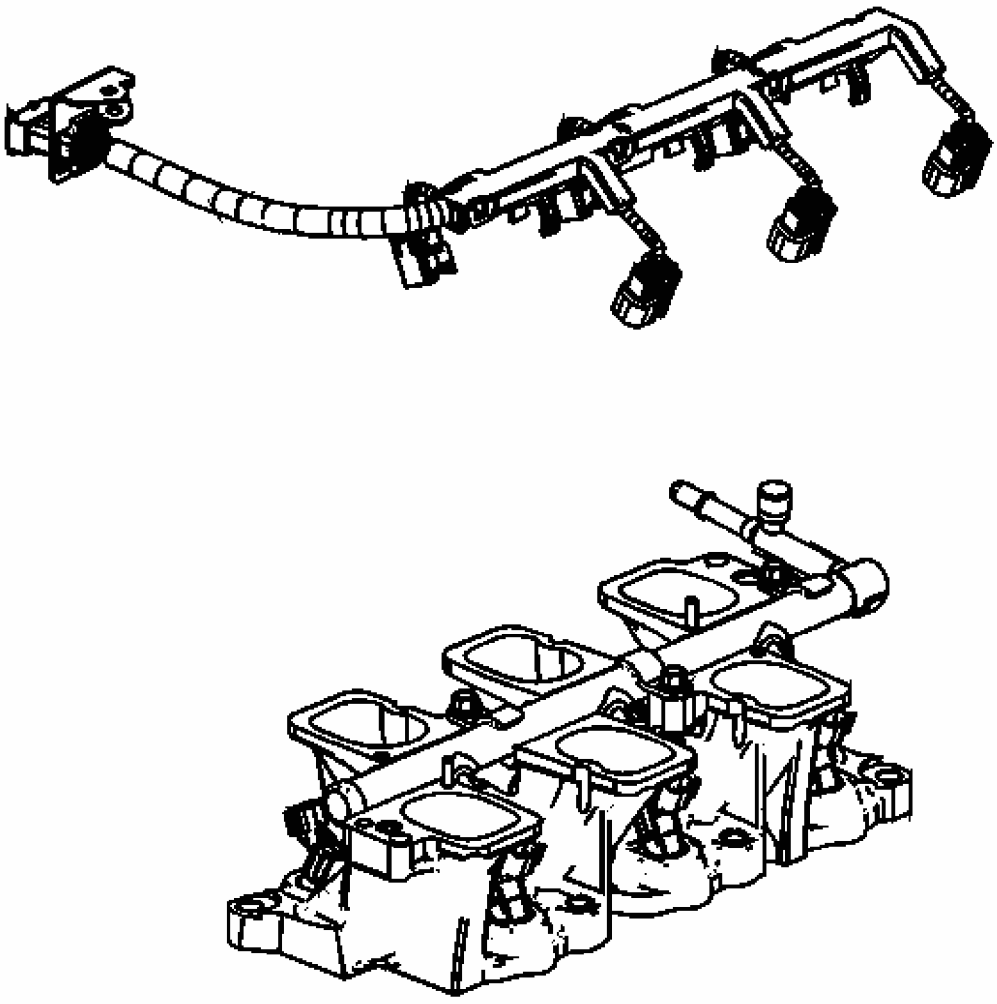

Fig. 223: View Of Fuel Injector Wiring Harness
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector wiring harness.

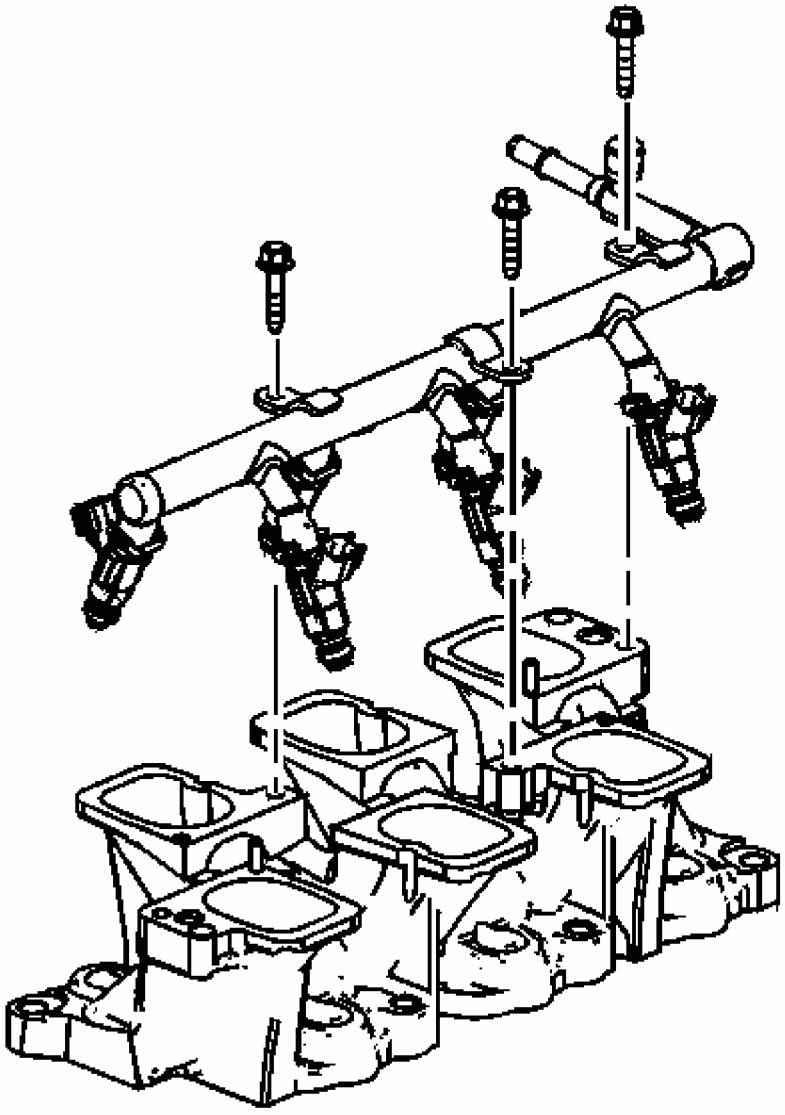

Fig. 224: View Of Fuel Injector Rail
Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector rail bolts.
3. Remove the fuel injector rail.