2011 ENGINE

Engine Mechanical - 2.4L - Repair Instructions - On Vehicle - Malibu

DRIVE BELT REPLACEMENT (LE5)

SPECIAL TOOLS

J 44811 Accessory Belt Tensioner Unloader. See **Special Tools** .

REMOVAL PROCEDURE

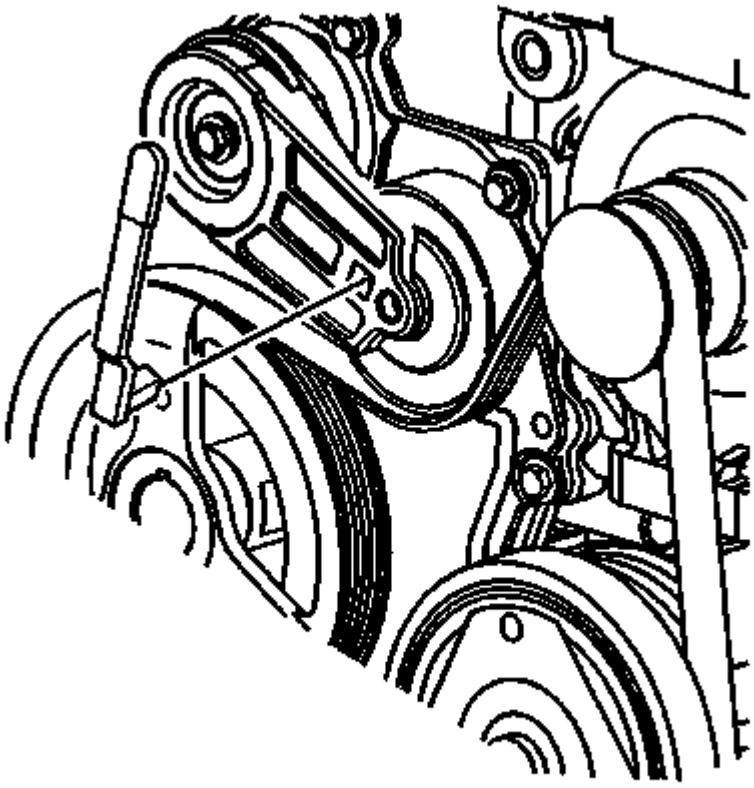

Fig. 1: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
3. Install the **J 44811** to the drive belt tensioner. See **Special Tools** .
4. Using the **J 44811** , rotate the tensioner counterclockwise in order to release the tensioner from the drive belt. See **Special Tools** .

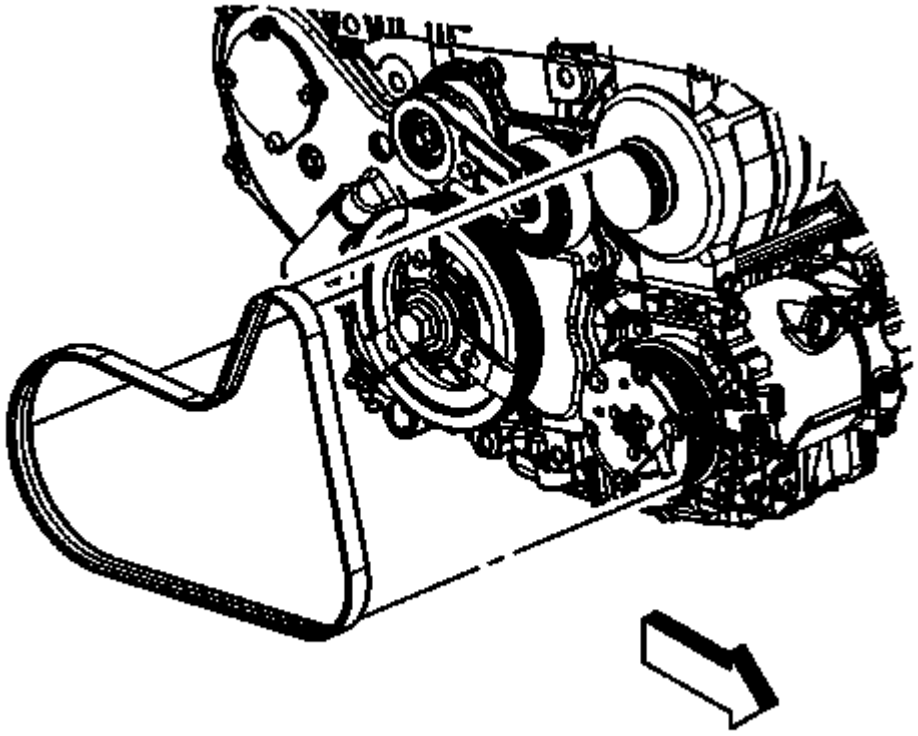

Fig. 2: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

5. Remove the drive belt.
6. Slowly rotate the **J 44811** and the tensioner clockwise in order to allow the tensioner to rest. See **Special Tools** .
7. Remove the **J 44811** from the drive belt tensioner. See **Special Tools** .

INSTALLATION PROCEDURE

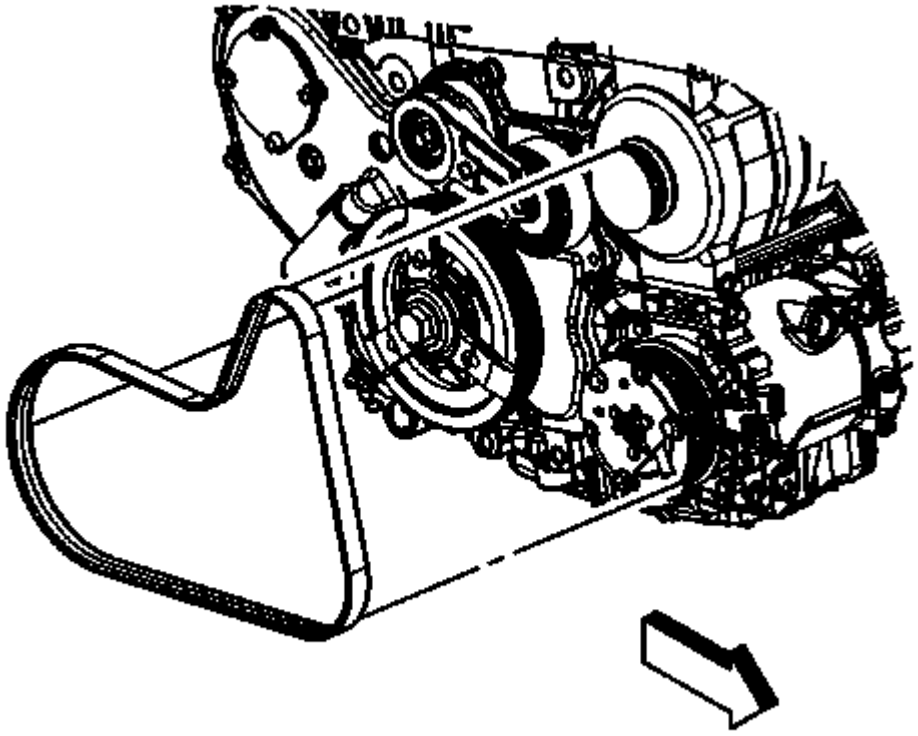

Fig. 3: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Install and position the drive belt around all of the pulleys except for the drive belt tensioner.
2. Install the **J 44811** to the drive belt tensioner. See **Special Tools** .
3. Using the **J 44811** , rotate the tensioner counterclockwise. See **Special Tools** .
4. Position the drive belt under the tensioner pulley.

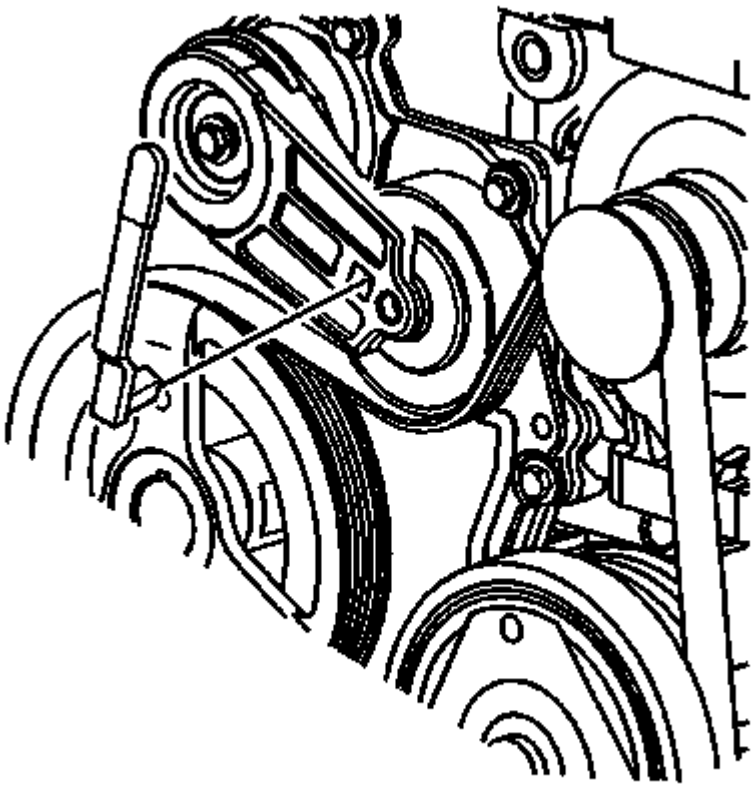

Fig. 4: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 44811** , rotate the tensioner clockwise in order to seat the tensioner pulley onto the drive belt. See **Special Tools** .
6. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
7. Install the engine splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .

DRIVE BELT TENSIONER REPLACEMENT (LE5)

REMOVAL PROCEDURE

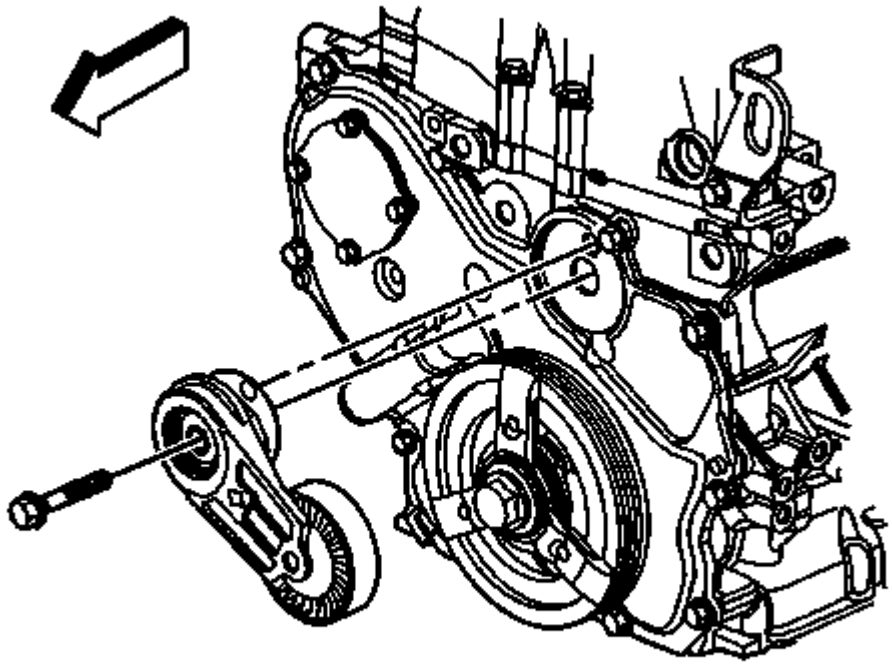

Fig. 5: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement (LE5)**.
2. Remove the right engine mount. Refer to **Engine Mount Replacement**.
3. Remove the drive belt tensioner bolt.
4. Remove the drive belt tensioner.

INSTALLATION PROCEDURE

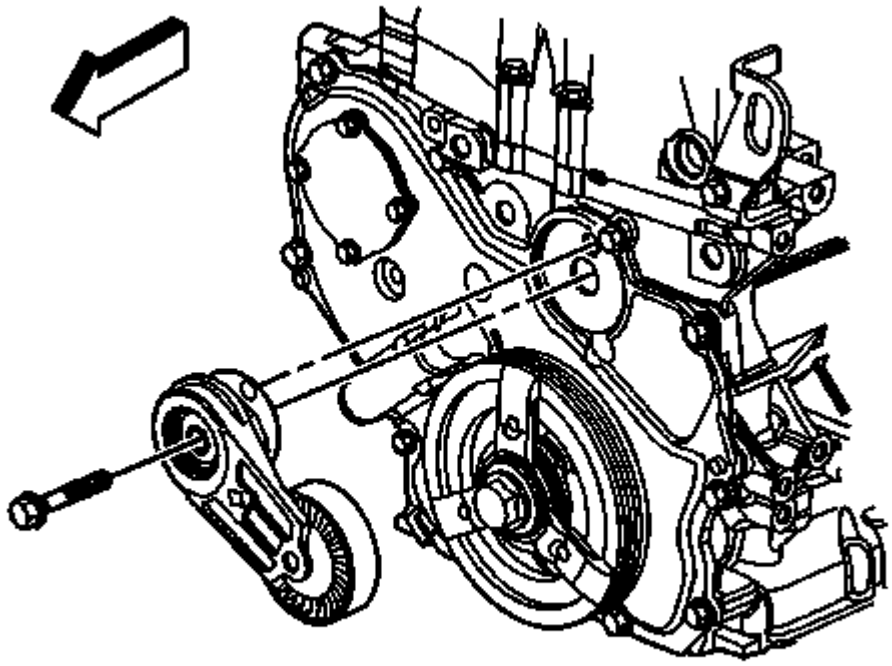

Fig. 6: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner. Ensure that the tensioner is flush with the front cover.

CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).
3. Install the right engine mount. Refer to **Engine Mount Replacement**.
4. Install the drive belt. Refer to **Drive Belt Replacement (LE5)**.

ENGINE OIL PRESSURE SWITCH REPLACEMENT

REMOVAL PROCEDURE

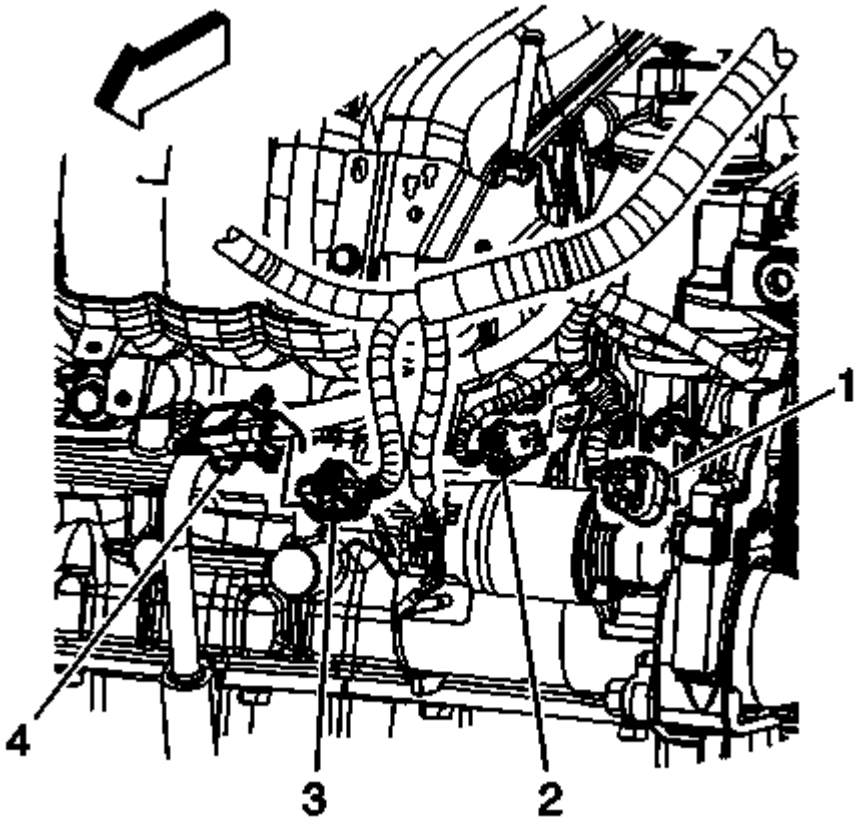

Fig. 7: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the starter. Refer to **Starter Replacement (LE5/LE9)** .
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch.

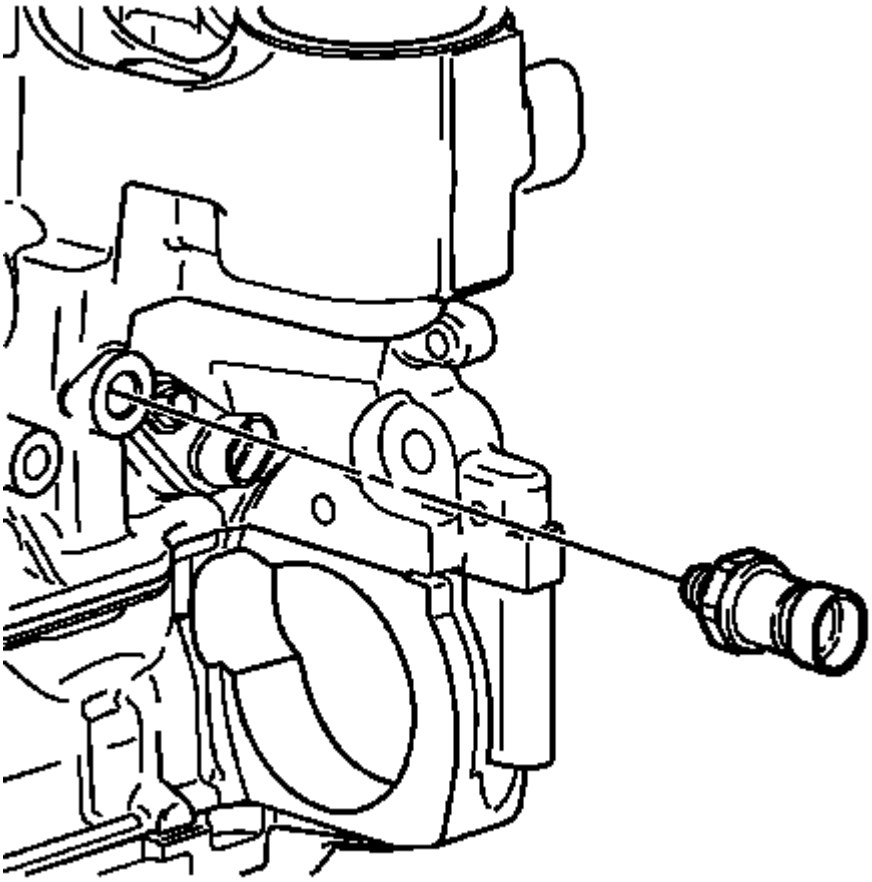

Fig. 8: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch.

INSTALLATION PROCEDURE

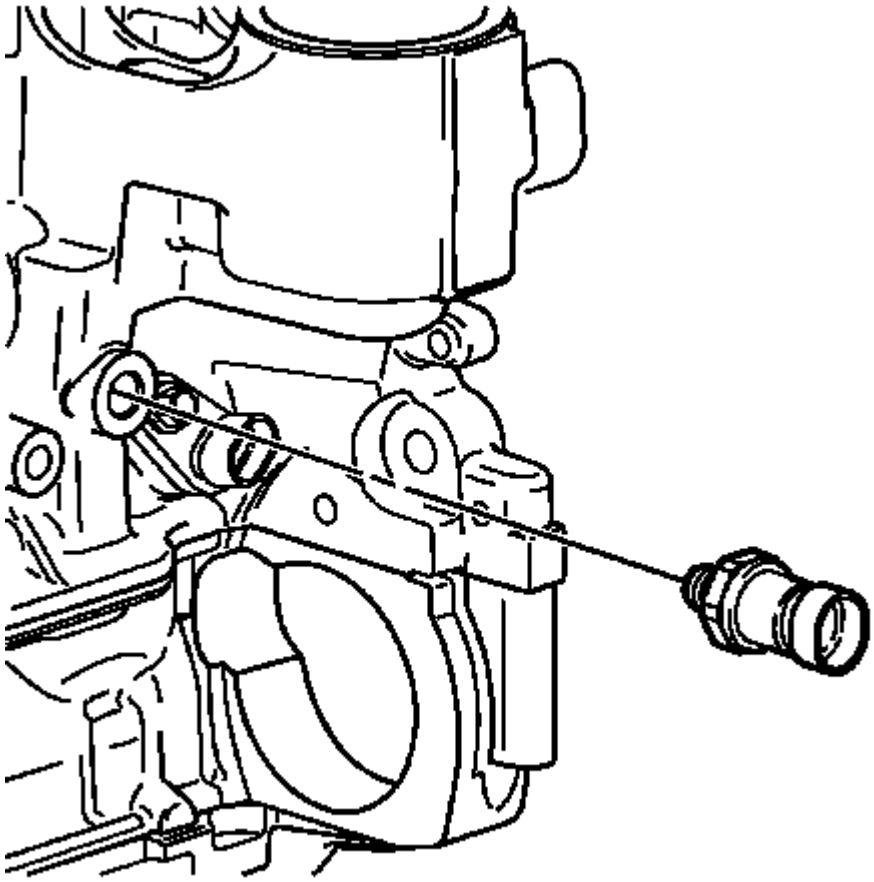

Fig. 9: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil pressure switch. Tighten the switch to 22 N.m (16 lb ft).

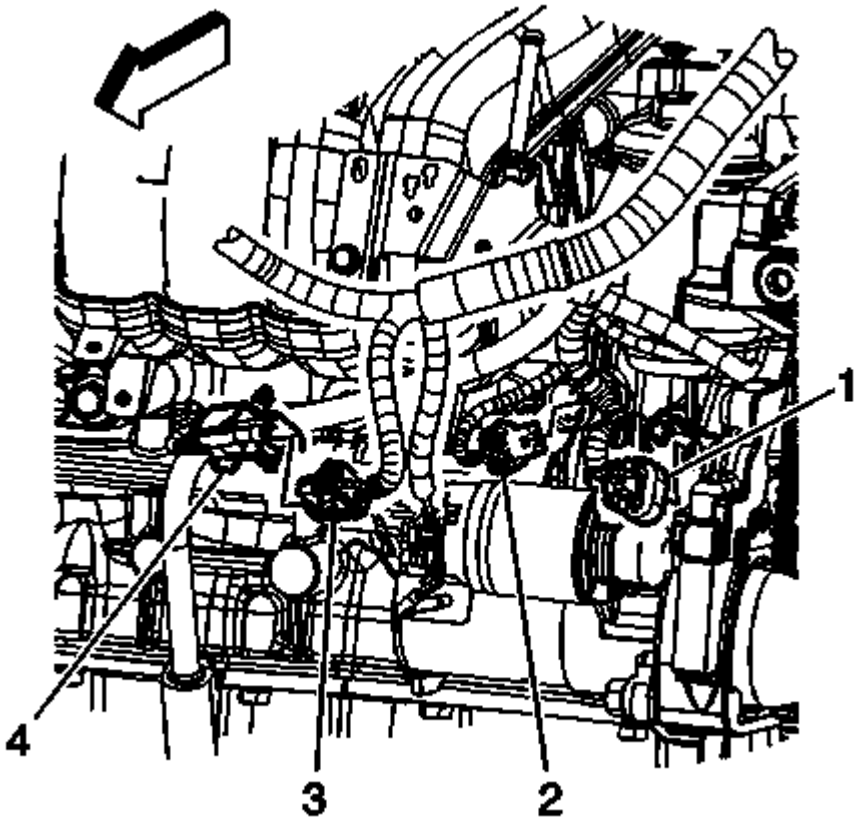

Fig. 10: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness electrical connector (2) to the oil pressure switch.
3. Install the starter. Refer to **Starter Replacement (LE5/LE9)** .

ENGINE MOUNT INSPECTION

IMPORTANT: Before replacing any engine mount due to suspected fluid loss, verify that the source of the fluid is the engine mount, not the engine or accessories.

1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Raise the engine slightly and observe the engine mount. Raising the engine removes the weight from the engine mount and creates a slight tension on the rubber portion.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The engine mount itself is leaking fluid.

4. For engine mount replacement. Refer to **Engine Mount Replacement**.

ENGINE MOUNT BRACKET REPLACEMENT

REMOVAL PROCEDURE

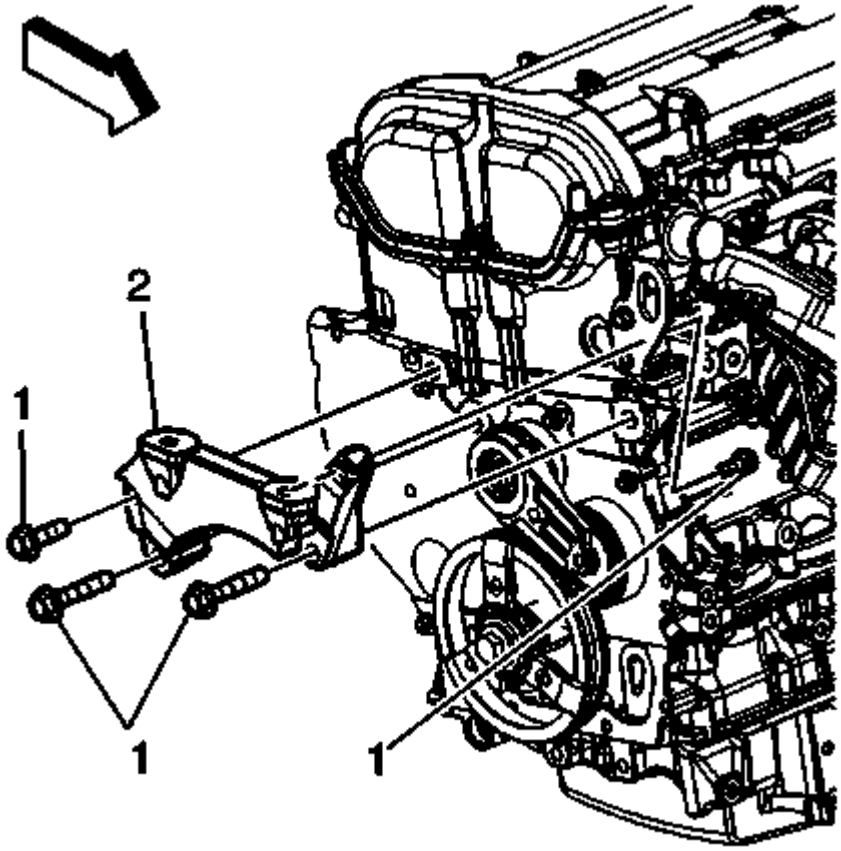

Fig. 11: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to **Engine Mount Replacement**.
2. Remove the engine mount bracket to engine bolts (1).
3. Remove the engine mount bracket (2).

INSTALLATION PROCEDURE

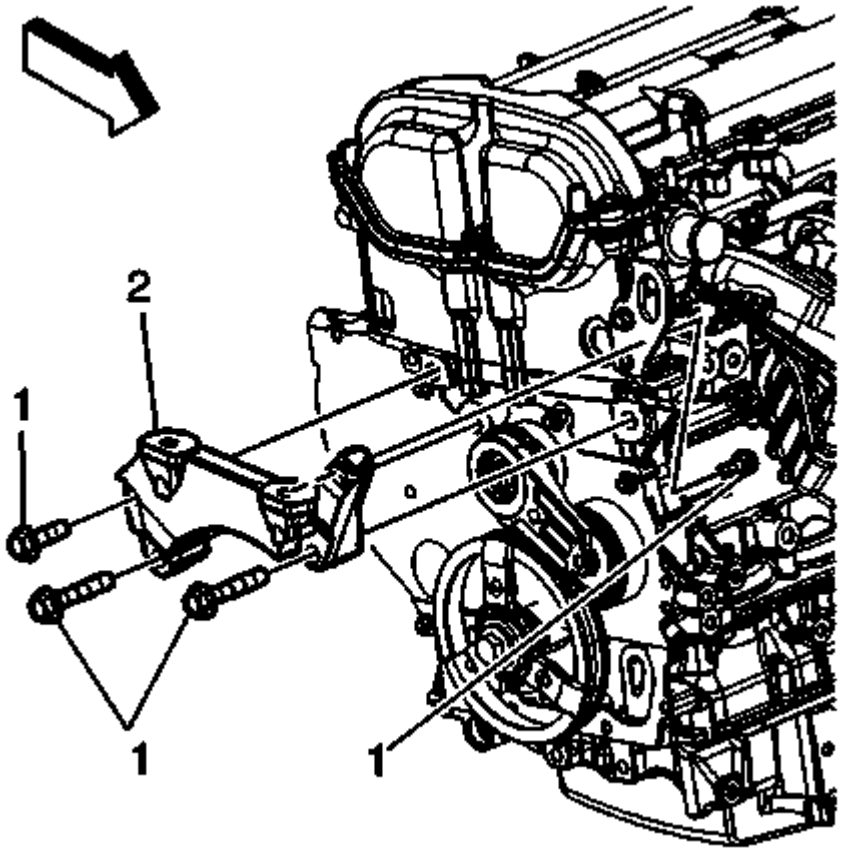

Fig. 12: Identifying Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket (2) to the engine.
2. Install the engine mount bracket bolts (1) in the following locations:
   - The long bolts through the engine mount bracket to the engine block
   - The short bolt through the engine lift bracket to the engine mount bracket

CAUTION: Refer to Fastener Caution .

3. Tighten the engine mount bracket bolts in the following sequence:
   1. Tighten the engine mount bracket to engine block bolts to 90 N.m (66 lb ft).
   2. Tighten the engine lift bracket to engine mount bracket bolts to 33 N.m (24 lb ft).
4. Install the engine mount. Refer to **Engine Mount Replacement**.

POWERTRAIN MOUNT BALANCING

NOTE: Follow the balance procedure steps listed below when no starting point has

been established such as in a collision repair.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

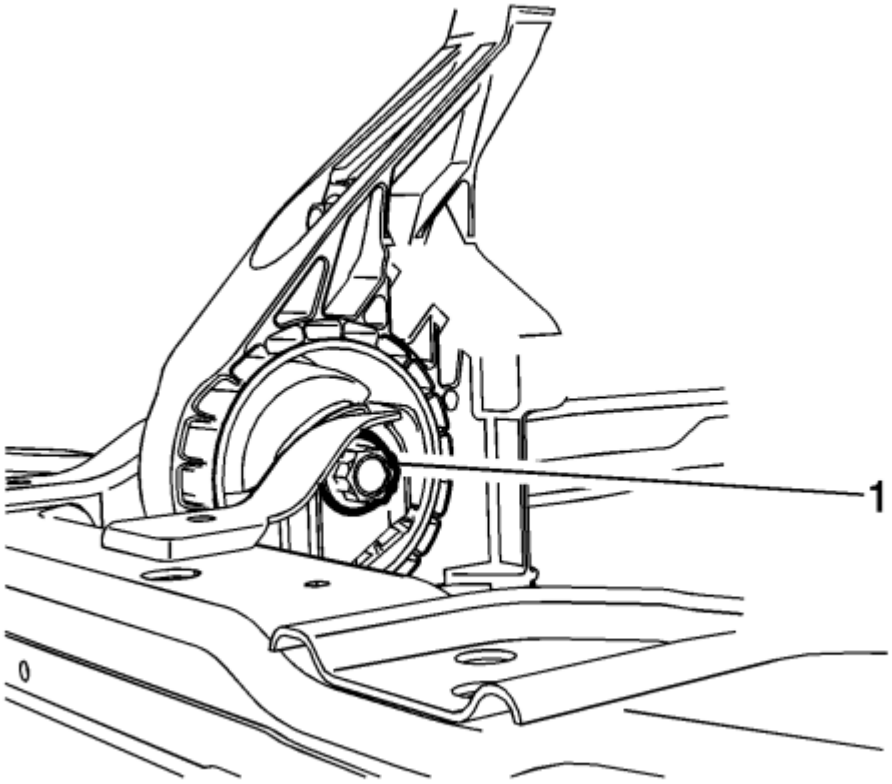

Fig. 13: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosen the front transaxle mount through bolt (1) until it is finger tight.

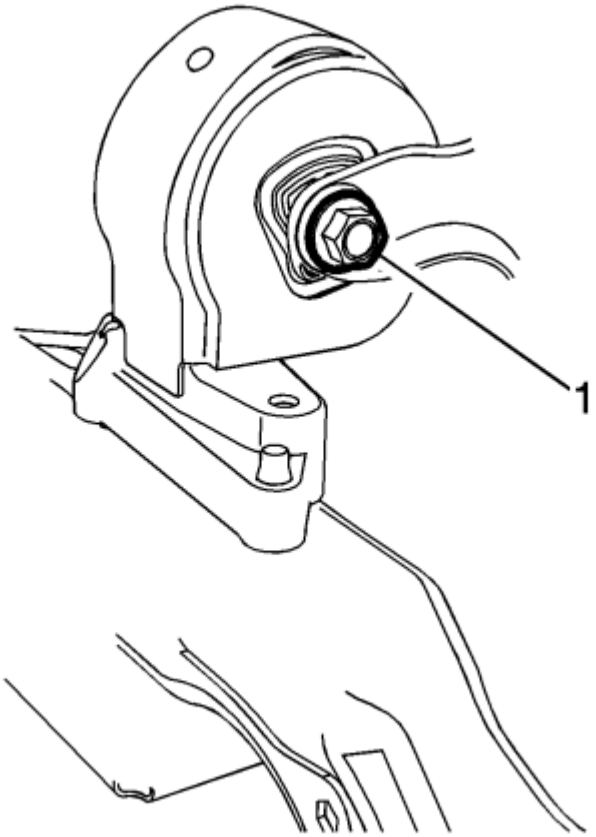

Fig. 14: Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear transaxle mount (1) through bolt until it is finger tight.
4. Lower the vehicle.

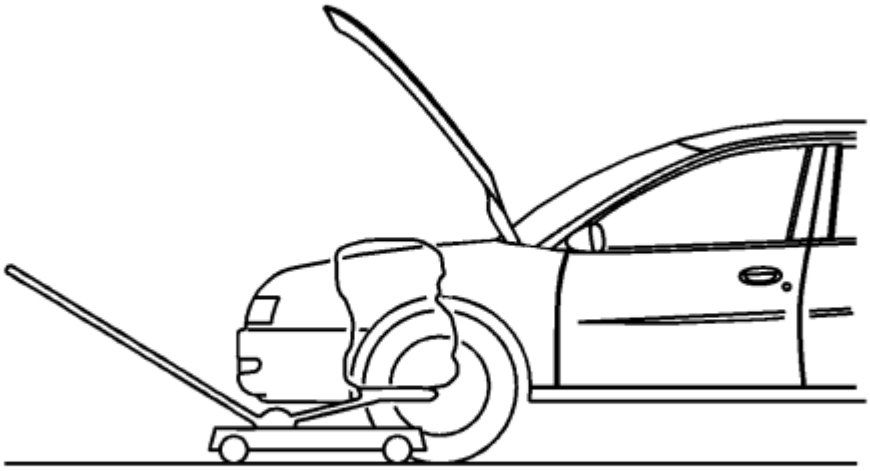

Fig. 15: Supporting Engine/Transmission With Hydraulic Floor Jack
Courtesy of GENERAL MOTORS CORP.

5. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.

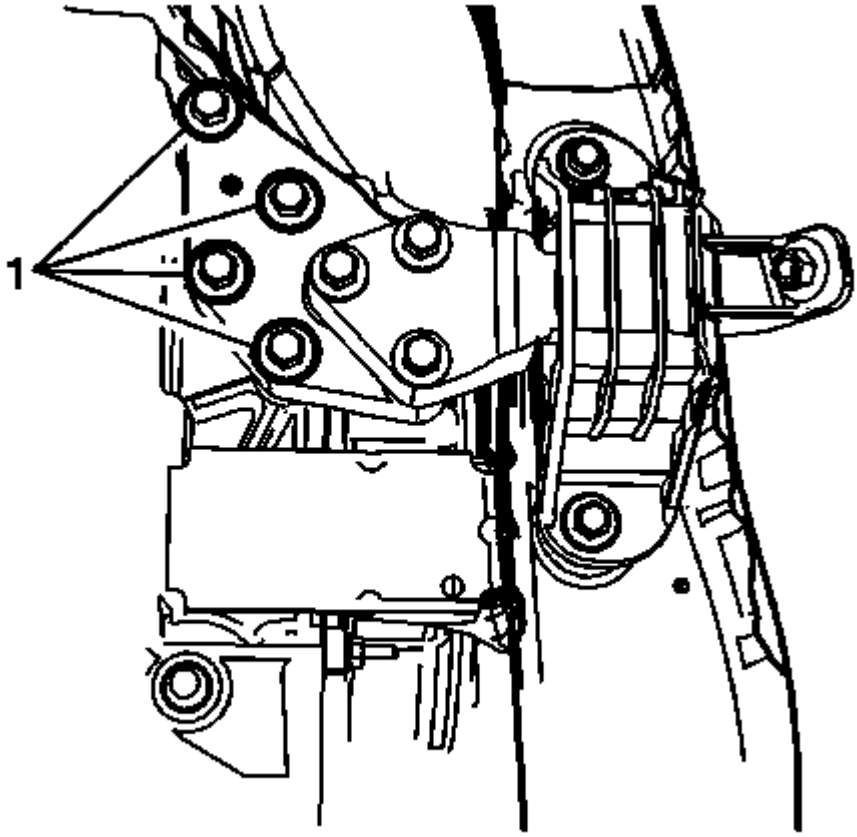

Fig. 16: Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosen the transaxle adapter to transaxle bolts (1).

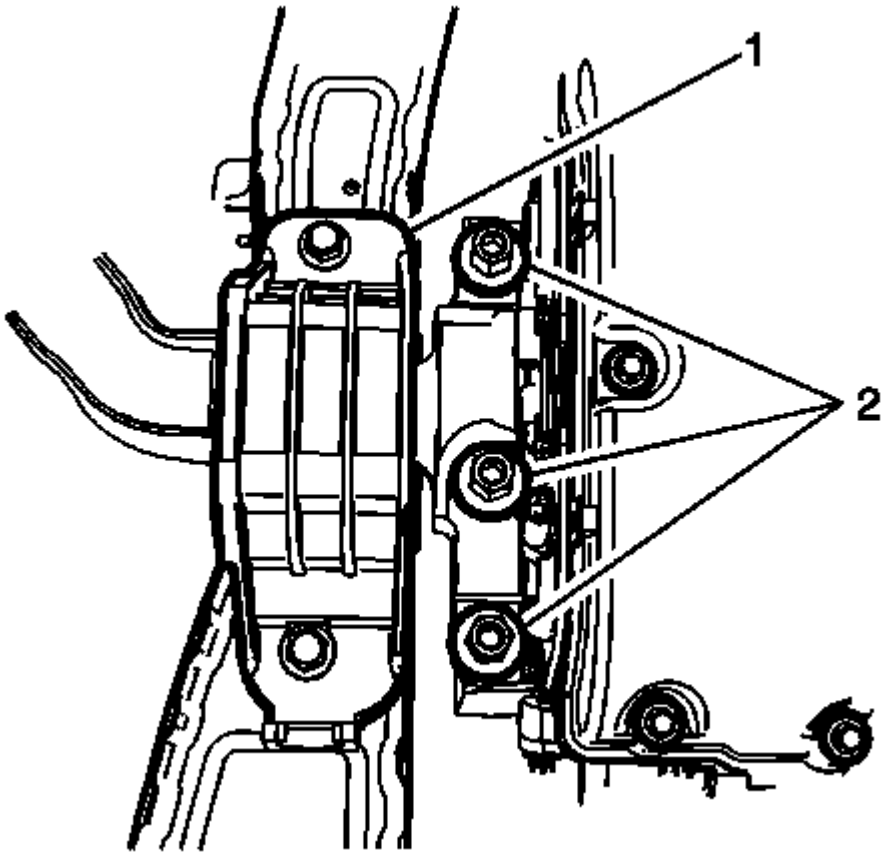

Fig. 17: Engine Mount And Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the engine mount (1) to bracket bolts (2).
8. Lower the floor jacks in order to allow a 1/4 inch (6 mm) gap between the upper engine mount and engine mount bracket, and also between the transmission and left transmission mount.

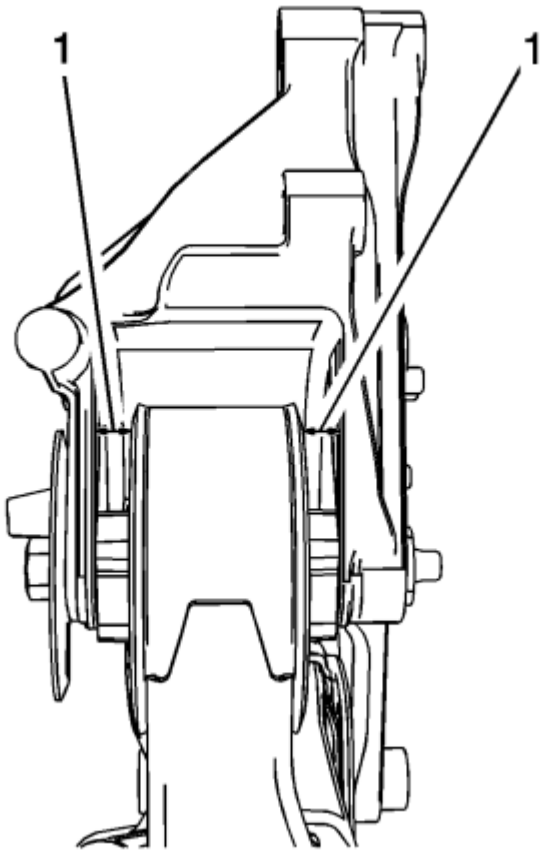

Fig. 18: Front And Rear Mounts
Courtesy of GENERAL MOTORS CORP.

9. Check that the front and rear mounts are centered (1) in the mount brackets, adjust if necessary.
10. Tighten the left hand (transaxle side) mount bolts, starting with the bolt nearest to the center of the mount. See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

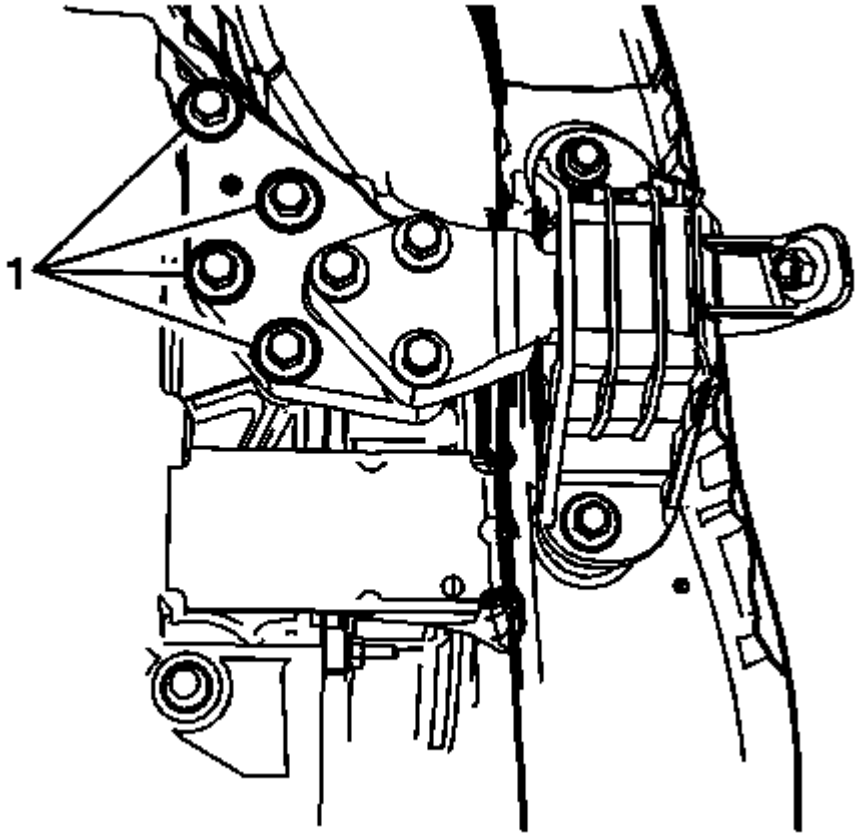

Fig. 19: Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

11. Tighten the right hand (engine side) mount bolts (1), starting with the bolt nearest to the center of the mount. See the appropriate engine mount replacement procedure for the fastener tightening specifications.
12. Remove the floor jacks from under the oil pan and transmission.
13. Raise the vehicle.
14. Shake the powertrain from front to rear and allow the powertrain to settle.

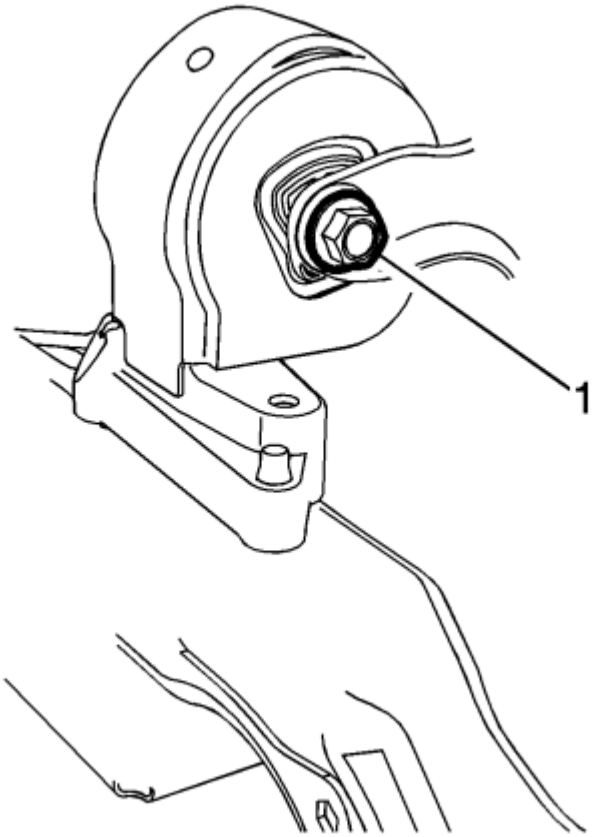

Fig. 20: Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: It is essential that the lower mount through bolts should be as close to centered as possible in the oversized mount insert holes before tightening to specification.

15. Tighten the rear transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.

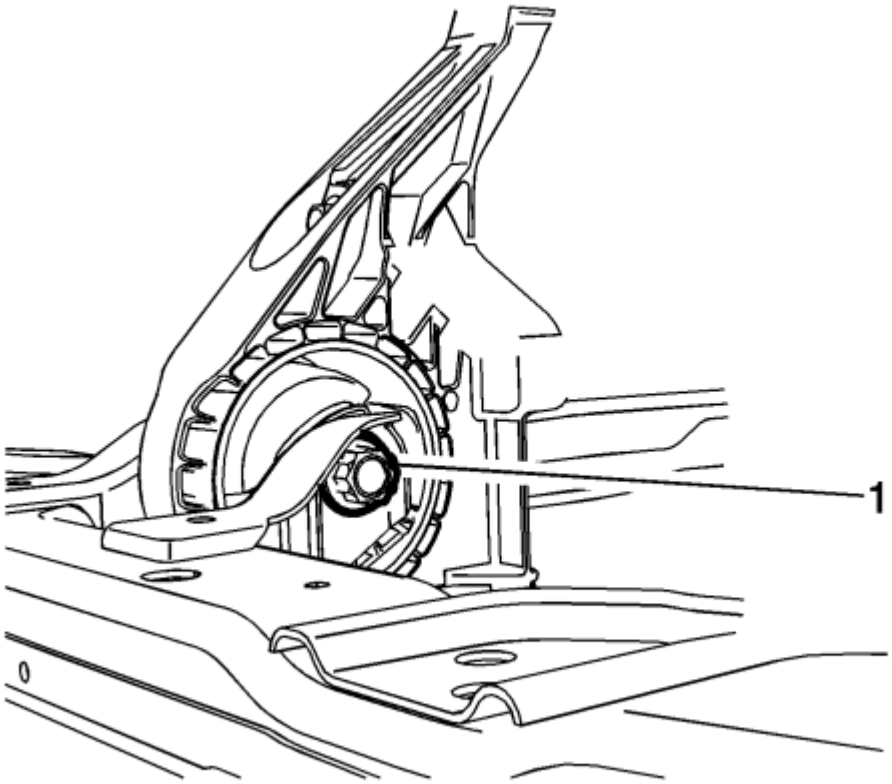

Fig. 21: Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

16. Tighten the front transaxle mount through bolt (1). See the appropriate transmission mount replacement procedure for the fastener tightening specifications.
17. Lower the vehicle.

ENGINE MOUNT REPLACEMENT

REMOVAL PROCEDURE

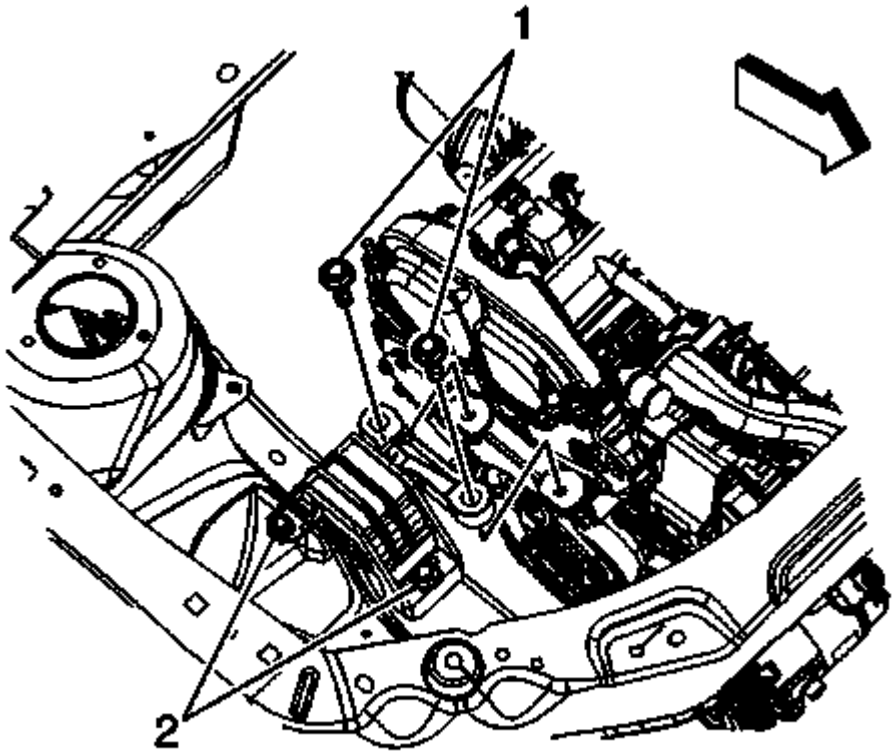

Fig. 22: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Support the engine with a hydraulic floor jack. Use a piece of wood between the floor jack and the oil pan.
3. Remove the engine mount to bracket bolts (1).
4. Remove the engine mount to side rail bolts (2).
5. Remove the engine mount from the engine compartment.

INSTALLATION PROCEDURE

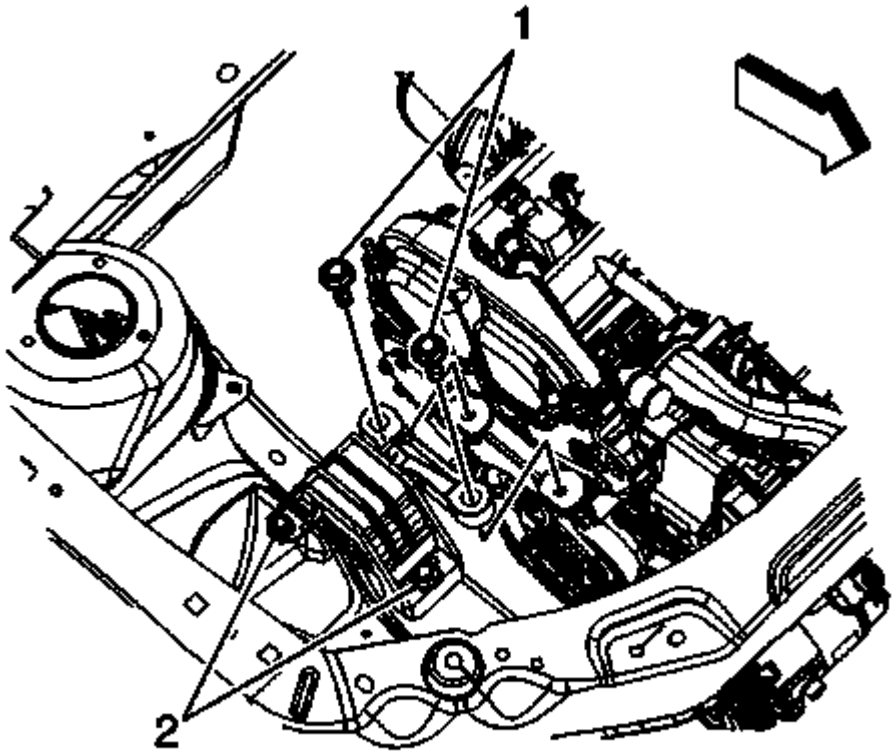

Fig. 23: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Place the engine mount onto the side rail studs.

CAUTION: Refer to Fastener Caution .

2. Install the engine mount to side rail bolts (2) and tighten to 50 N.m (37 lb ft).

NOTE: The engine mount to bracket bolts must be hand started. Do not pry the engine mount to align the holes.

3. Install the engine mount to bracket bolts (1) and tighten to 90 N.m (66 lb ft).
4. Remove the hydraulic floor jack from under the oil pan.
5. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

ENGINE SUPPORT FIXTURE

Special Tools

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools** .
- **J 28467-7A** Bolt Hook
- **J-28467-13** Engine Support Fixture Adapters
- **J 28467-34** Lift Hook Wing Nut and Washer
- **J 36462-A** Engine Support Adapter Leg Set

1. Remove the front compartment sight shield. Refer to **Front Compartment Sight Shields Replacement** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

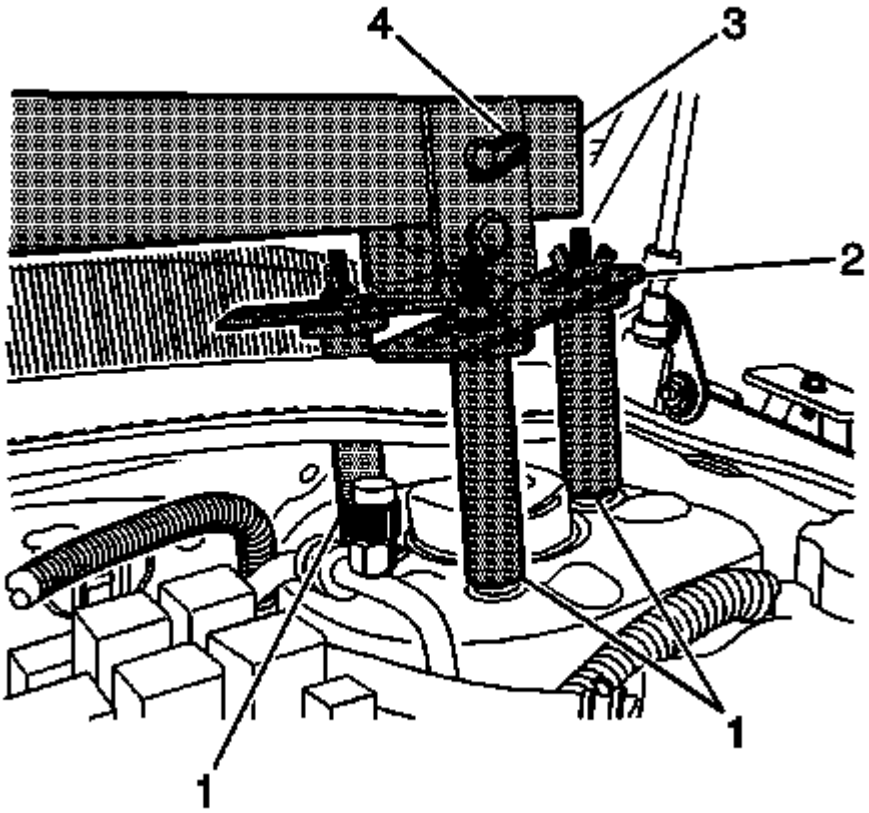

Fig. 24: View Of Engine Support Fixture Adapter (J-28467-13)
Courtesy of GENERAL MOTORS CORP.

3. Install three **J-28467-13** (1) and two J-28467-5 strut tower adapters (2) to the top of the left and right strut tower.
4. Install a 127 cm (50 in) engine support fixture cross bar **J 28467-B** (3) transversely across the vehicle between both J-28467-5 strut tower adapters (2). See **Special Tools** .
5. Insert safety pins J-28467-10 (4) through the J-28467-5 strut tower adapters (2) and the cross bar (3) to prevent movement.

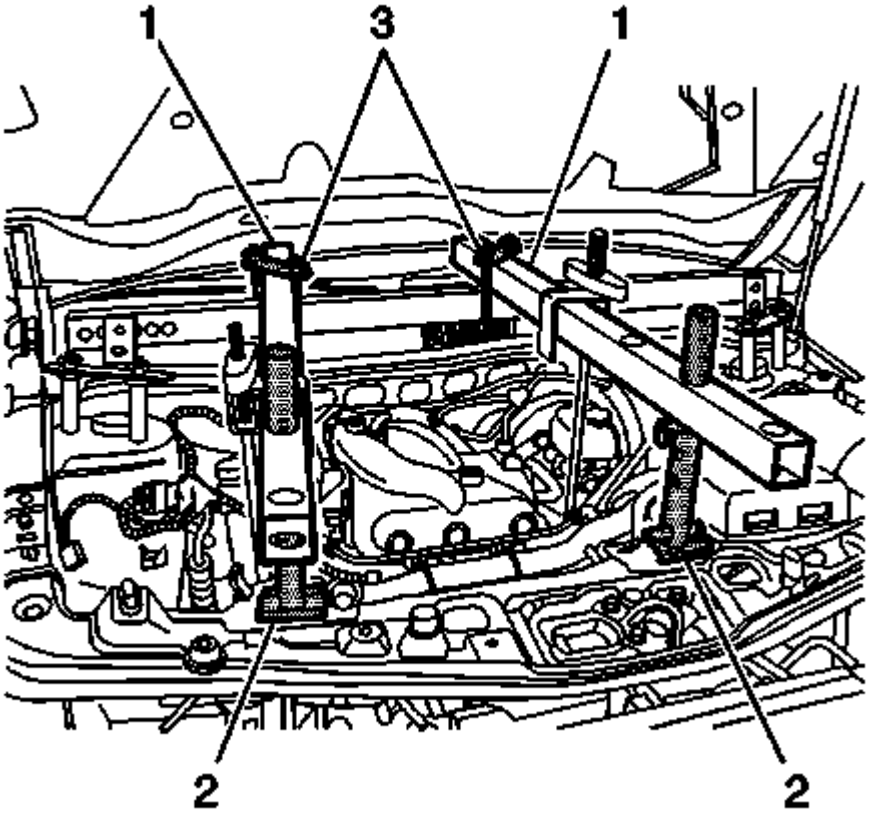

Fig. 25: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

6. Position two 58 cm (23 in) engine support fixture cross bars (1) longitudinally with two **J 36462-A** leg assembly (2).
7. Install two J-28467-1A clamp (3) to secure the longitudinal mounted cross bar to the transverse mounted cross bar.

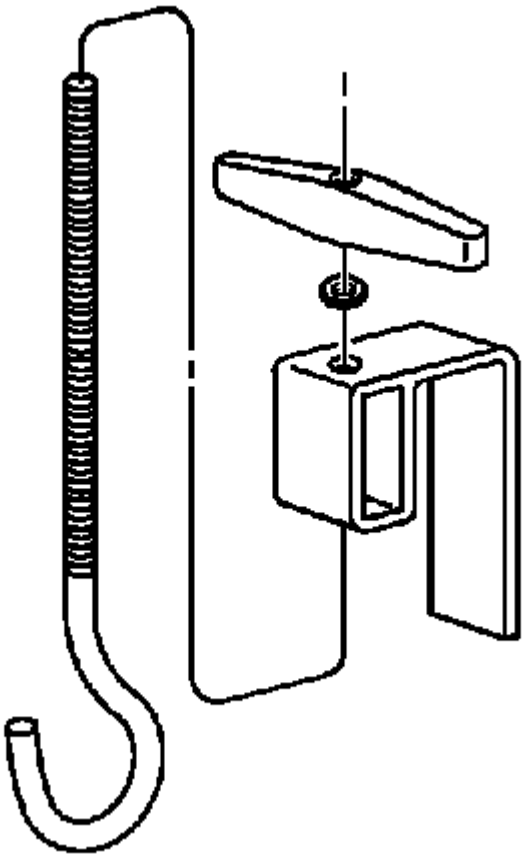

Fig. 26: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

8. Assemble the lift hook wing nut **J 28467-34** , lift hook bracket J-28467-6A and lift hook **J 28467-7A** to the engine lift bracket on the engine.

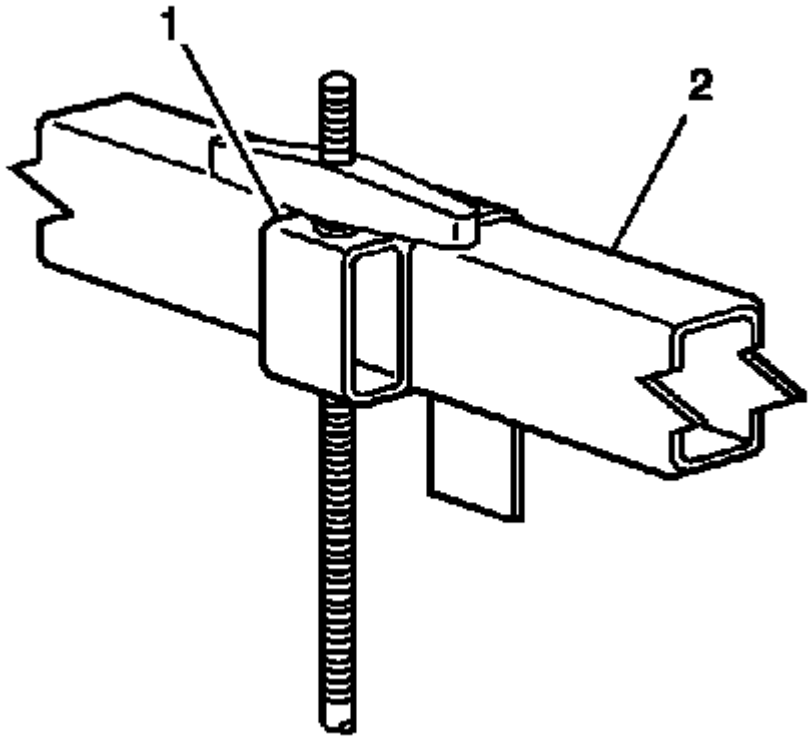

Fig. 27: View Of Lift Hook & radiator shelf tube Assembly
Courtesy of GENERAL MOTORS CORP.

9. Install the lift hook and bracket assembly (1) to the longitudinal mounted cross bar (2).
10. Position the **J 28467-7A** lift hook to the rear engine lift bracket.

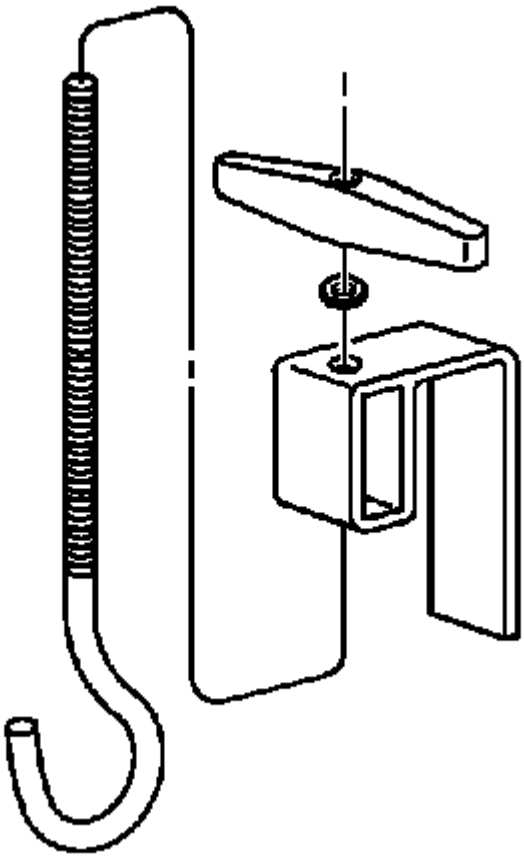

Fig. 28: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

11. Assemble the lift hook wing nut **J 28467-34** and the lift hook bracket J-28467-6A to the lift hook **J 28467-7A** .

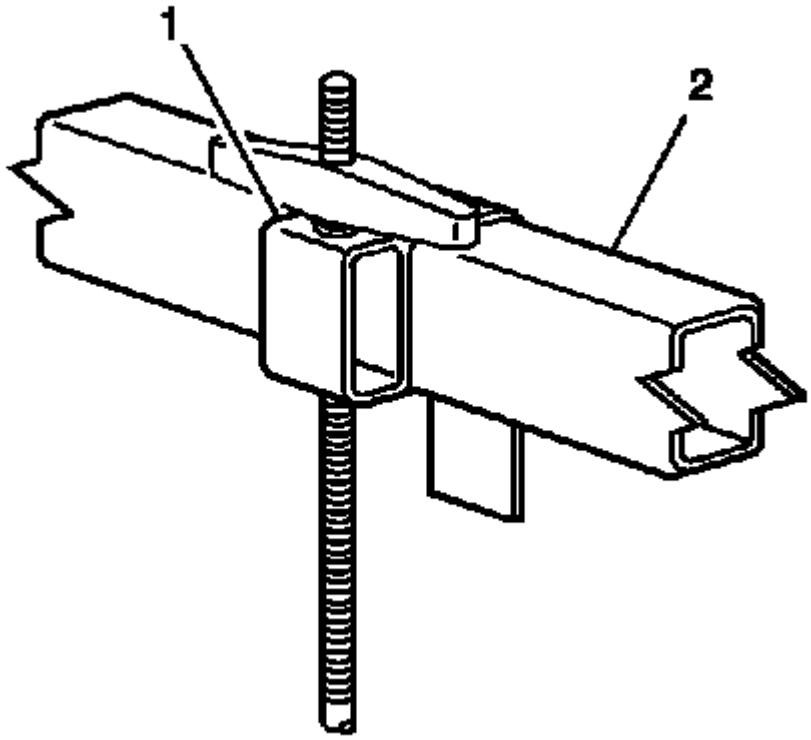

Fig. 29: View Of Lift Hook & radiator shelf tube Assembly
Courtesy of GENERAL MOTORS CORP.

12. Install the lift hook and bracket assembly (1) to the longitudinal mounted cross bar (2).
13. Position the **J 28467-7A** bolt hook (1) to the front engine lift bracket.

Fig. 30: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

14. Evenly tighten both wing nuts **J 28467-34** (1) until the engine weight is supported by the engine support fixture and no longer carried by the engine mounts.

OIL LEVEL INDICATOR TUBE REPLACEMENT (LE5)

REMOVAL PROCEDURE

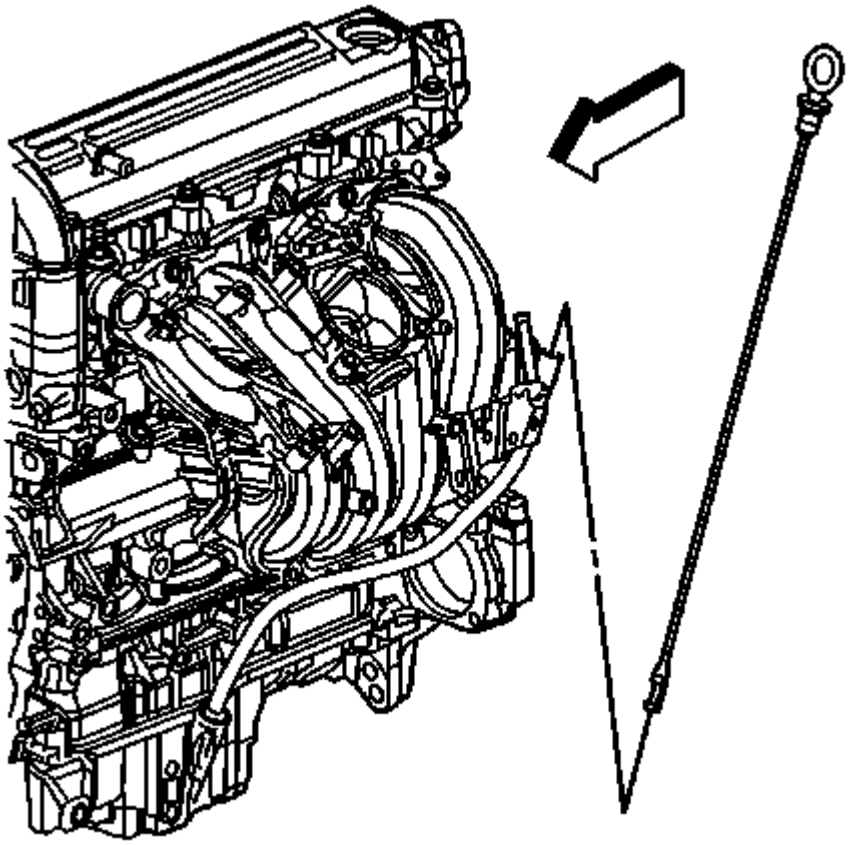

Fig. 31: Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.

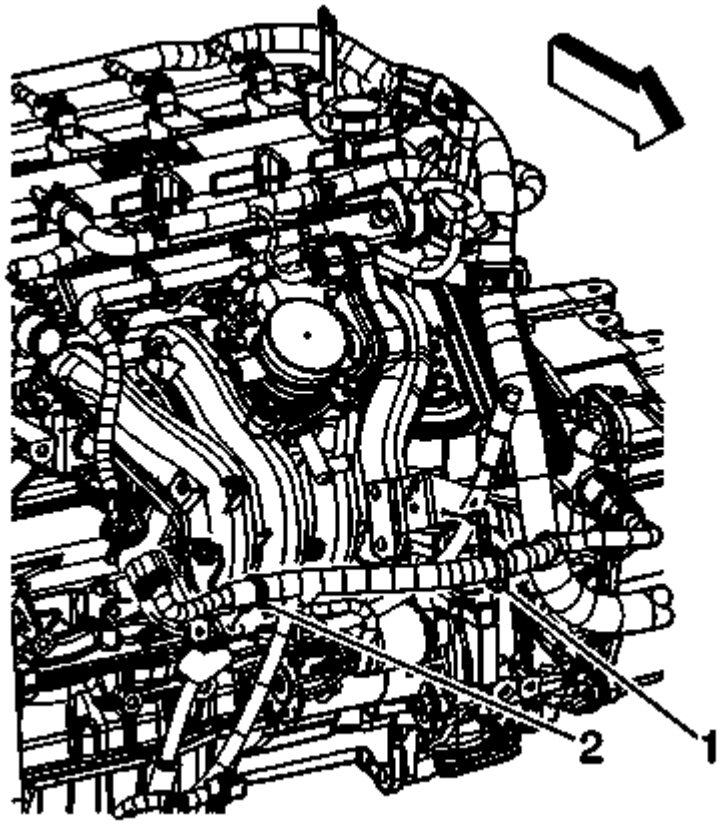

Fig. 32: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine harness clip (1) from the oil level indicator tube.

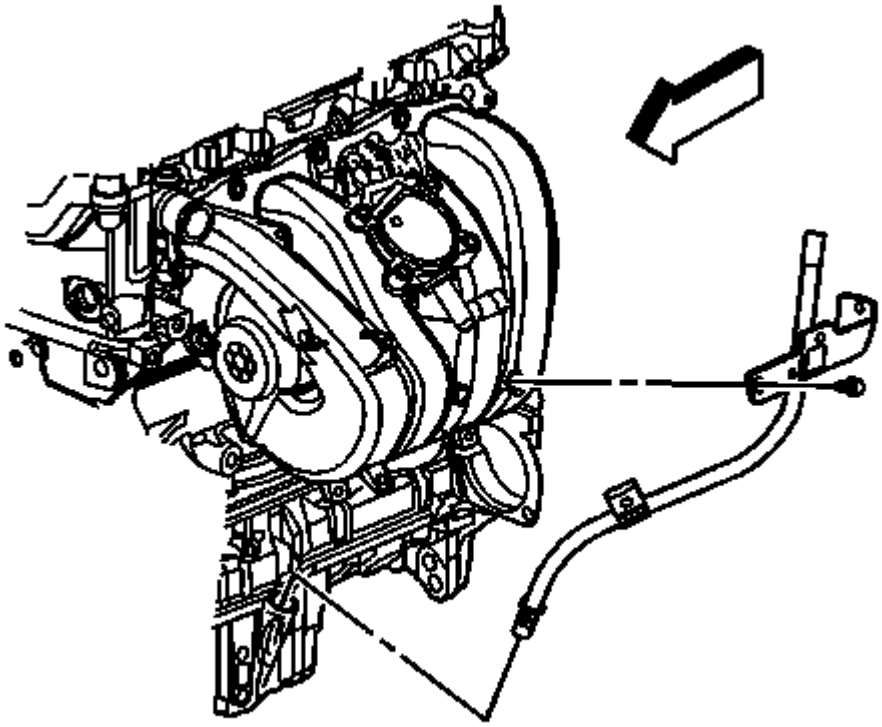

Fig. 33: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube.

INSTALLATION PROCEDURE

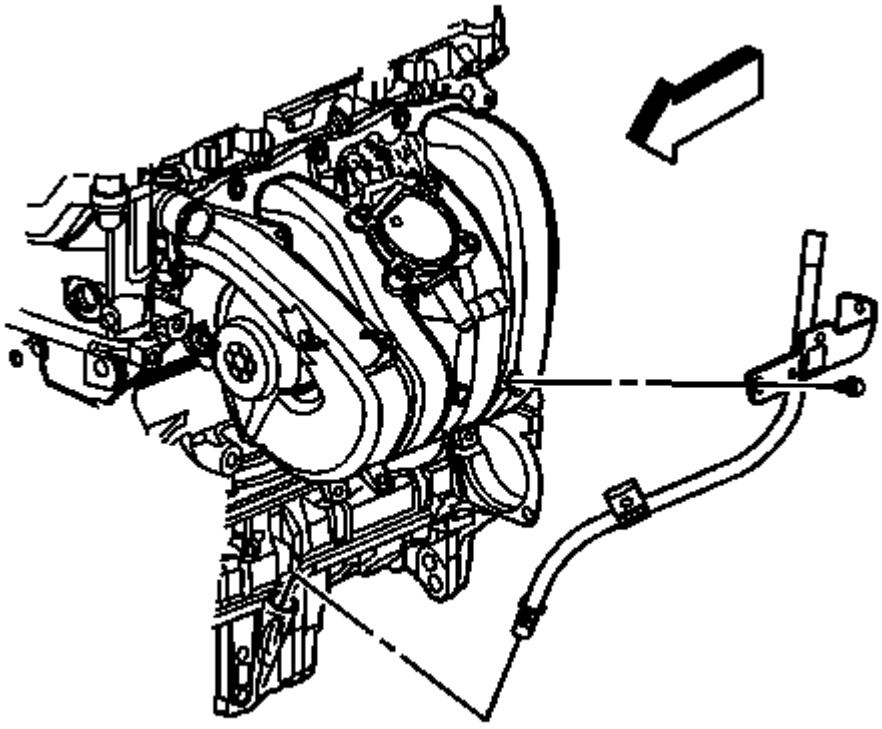

Fig. 34: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring seal with engine oil lubricant.
2. Install the oil level indicator tube.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bolt and tighten to 10 N.m (89 lb in).

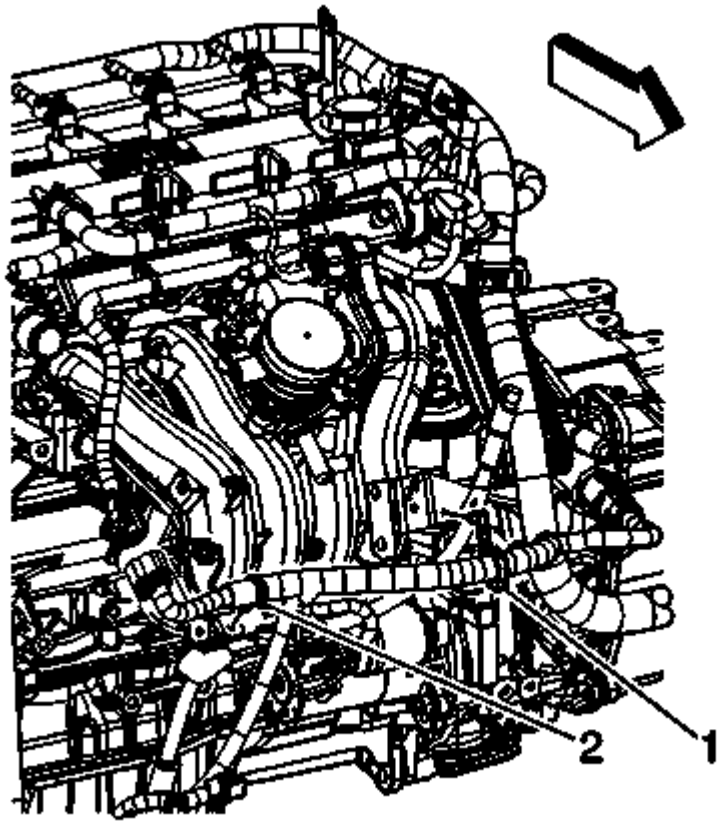

Fig. 35: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

4. Install the engine harness clip (1) to the oil level indicator tube.

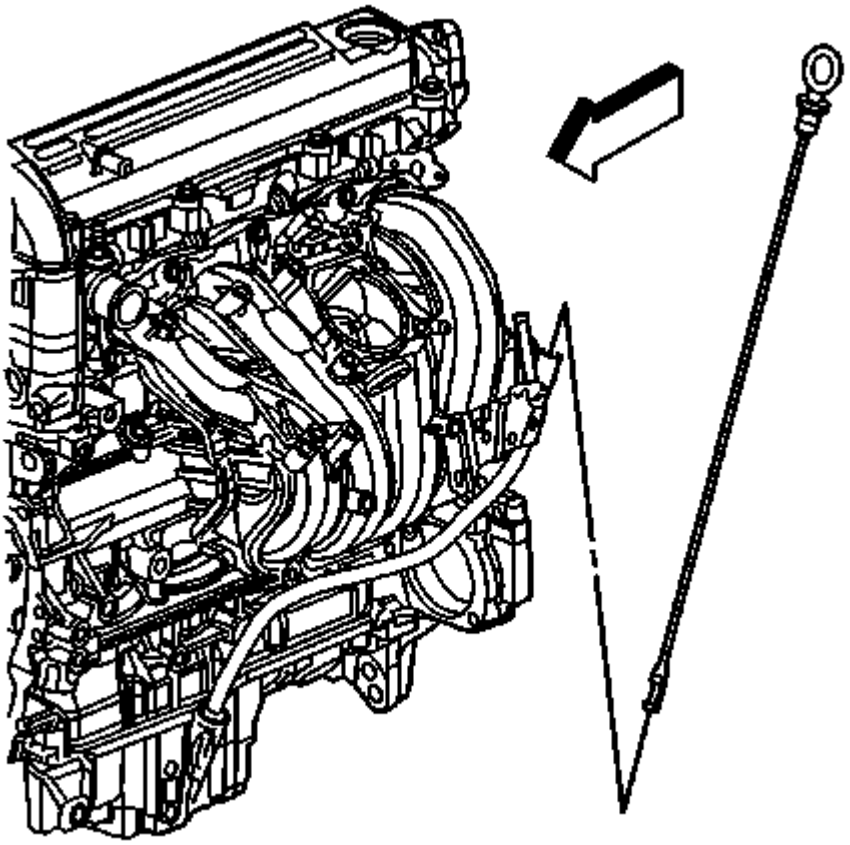

Fig. 36: Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

5. Install the oil level indicator.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (LE5)

REMOVAL PROCEDURE

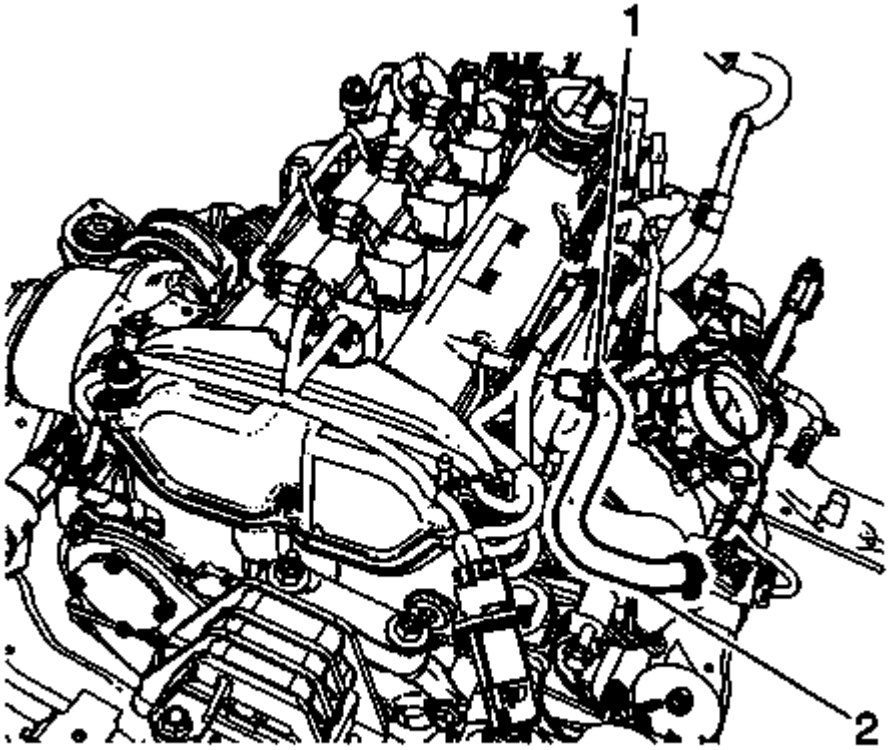

Fig. 37: Locating PCV Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Reposition the positive crankcase ventilation (PCV) hose clamp (1) at the camshaft cover.
3. Remove the PCV hose (2) from the camshaft cover.

INSTALLATION PROCEDURE

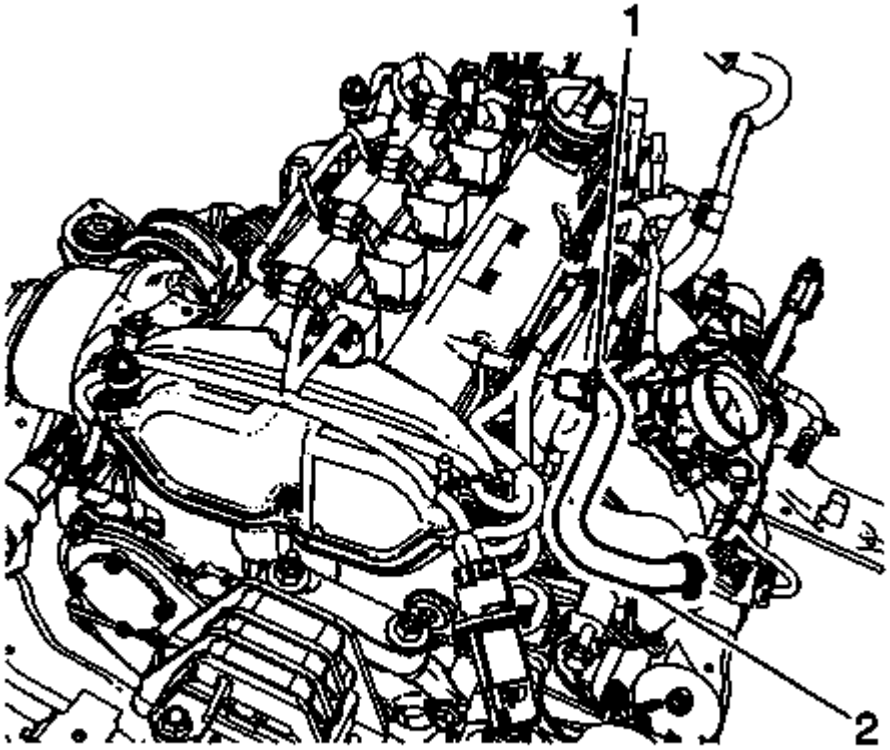

Fig. 38: Locating PCV Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV hose (2) to the camshaft cover.
2. Position the PCV hose clamp (1) at the camshaft cover.
3. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

INTAKE MANIFOLD REPLACEMENT (LE5)

REMOVAL PROCEDURE

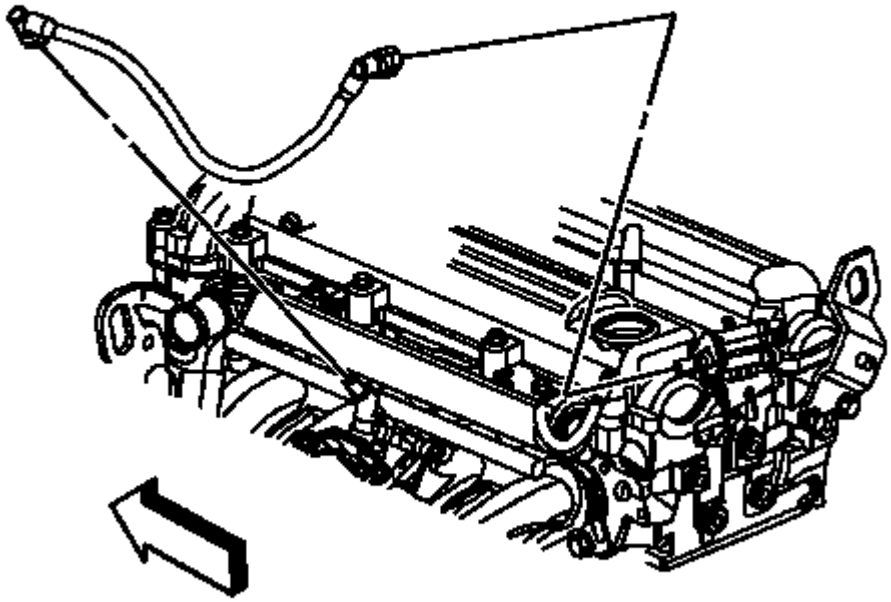

Fig. 39: EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
2. Remove the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
3. Remove the evaporative emission (EVAP) canister purge solenoid valve tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

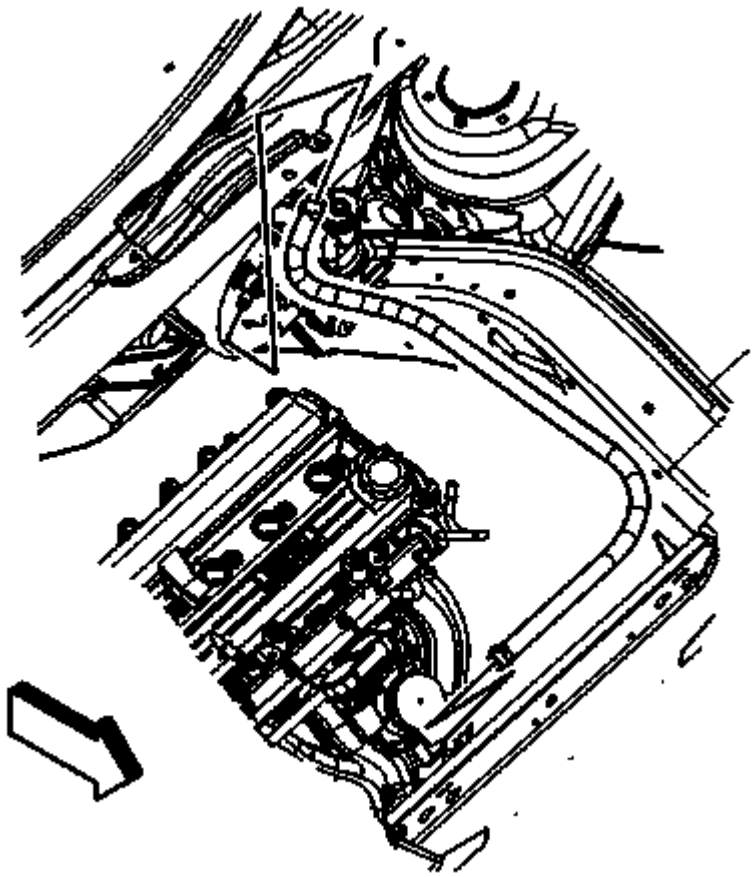

Fig. 40: Identifying Brake Booster Vacuum Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

4. Reposition the brake booster vacuum hose clamp at the intake manifold.
5. Remove the brake booster hose from the intake manifold.
6. Remove the oil level indicator tube bolt.

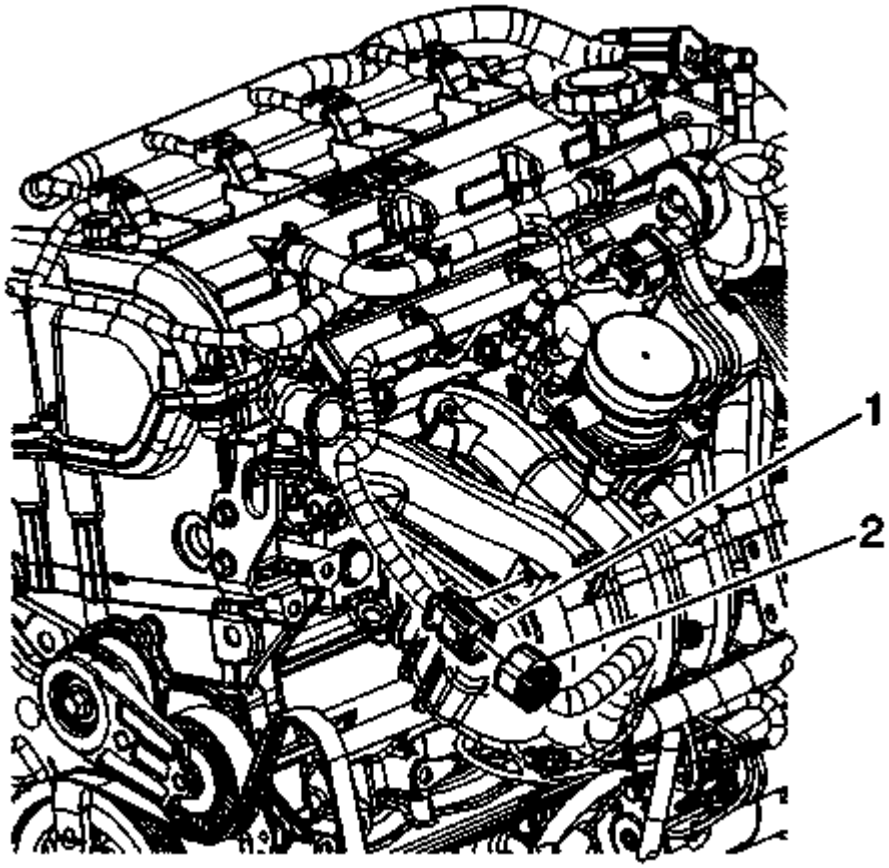

Fig. 41: Locating Fuel Injector Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the engine harness electrical connector (1) from the fuel injector inline electrical connector (2).
8. Remove the fuel injector inline connector clip from the intake manifold.

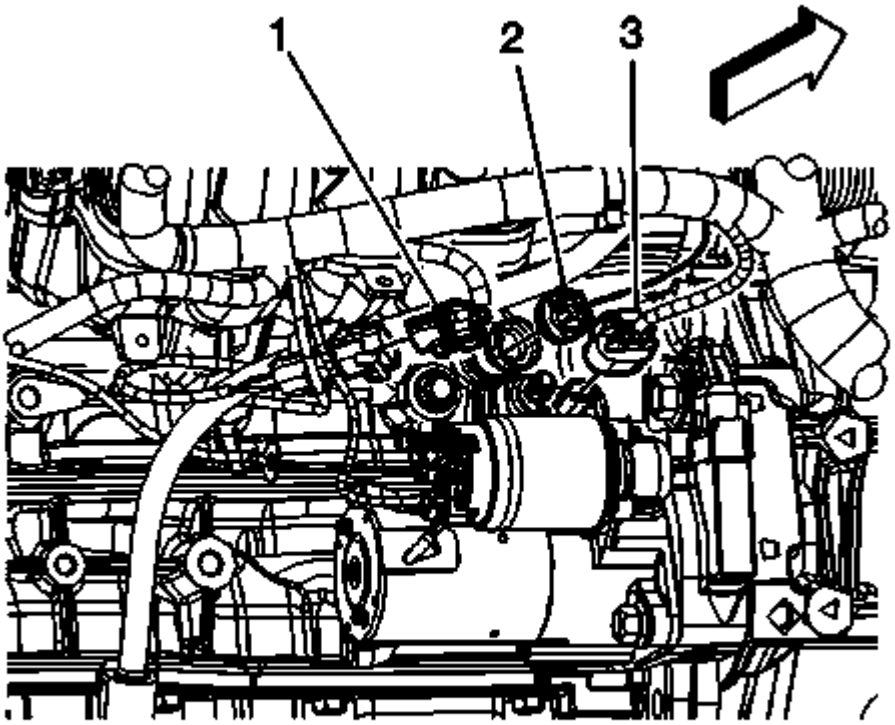

Fig. 42: Identifying Engine Oil Pressure Sensor, Knock Sensor, & CKP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine harness electrical connector (1) from the knock sensor harness.
10. Remove the knock sensor connector clip from the oil level indicator tube.

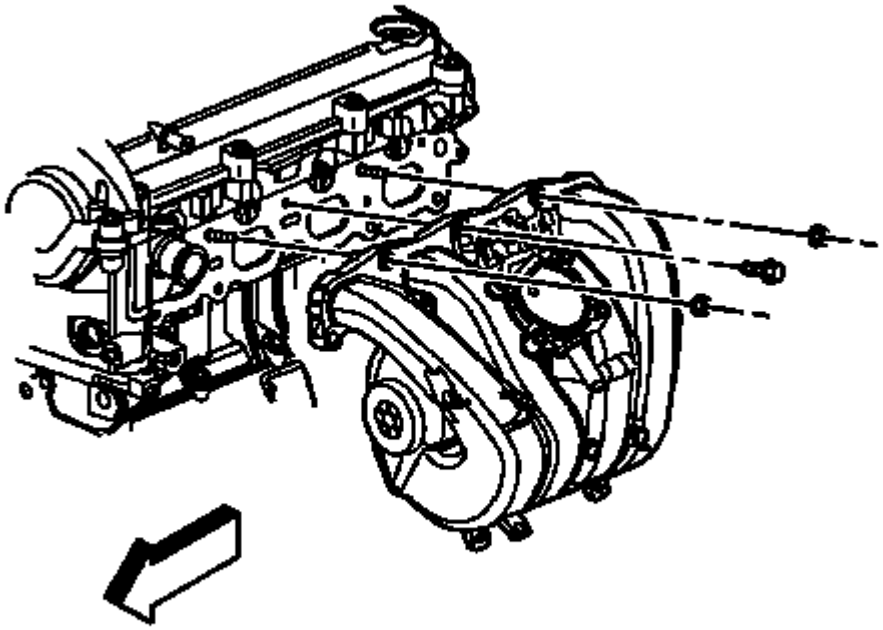

Fig. 43: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold bolts and nuts.
12. Remove the intake manifold.

NOTE: The intake manifold gasket is reusable. Only replace the gasket if damage has occurred.

13. Remove the intake manifold gasket, if necessary.

INSTALLATION PROCEDURE

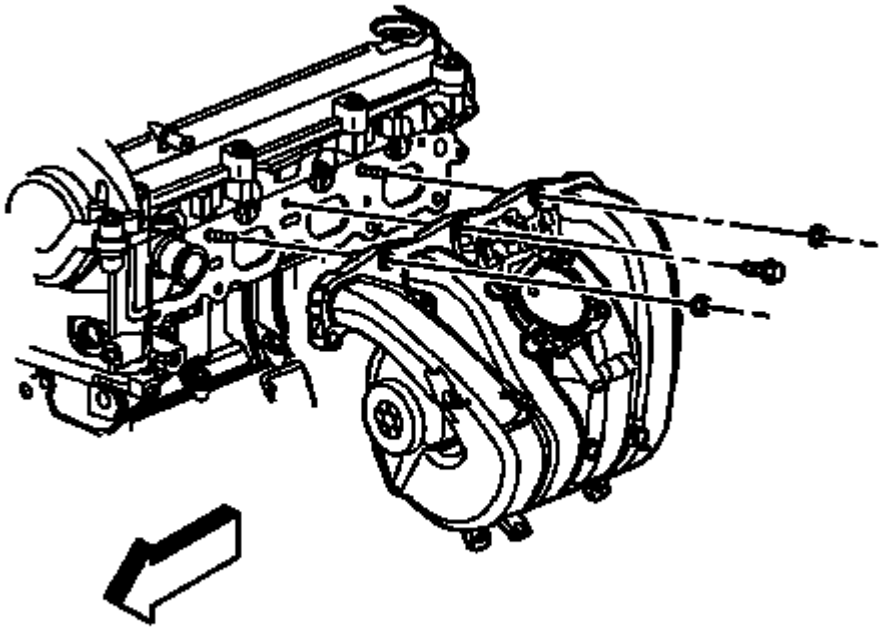

Fig. 44: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold gasket, if necessary.
2. Install the intake manifold.

CAUTION: Refer to Fastener Caution .

3. Install the intake manifold bolts and nuts and tighten to 10 N.m (89 lb in).

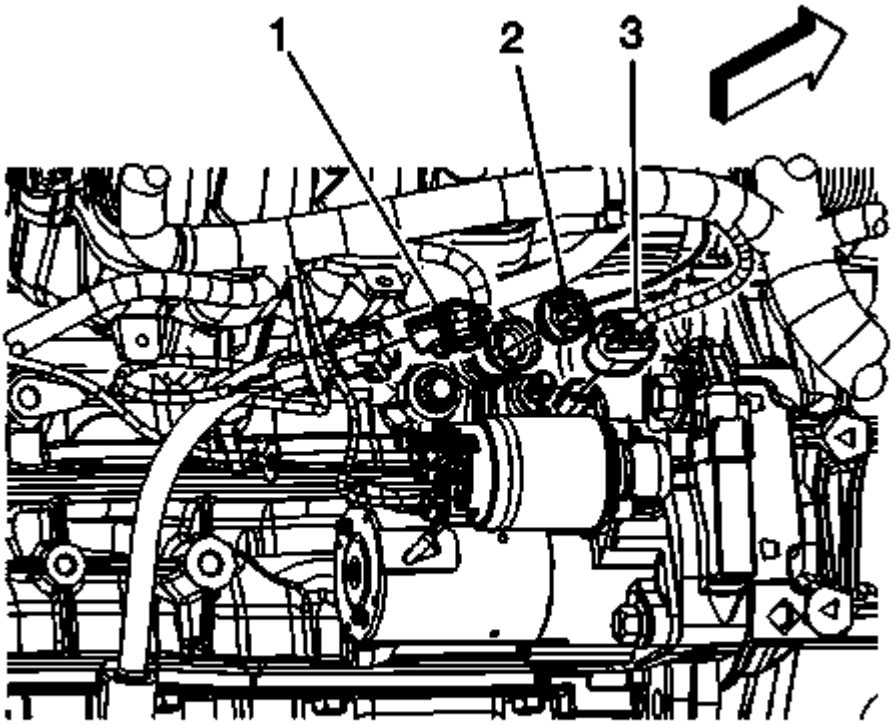

Fig. 45: Identifying Engine Oil Pressure Sensor, Knock Sensor, & CKP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

4. Connect the engine harness electrical connector (1) to the knock sensor harness.
5. Install the knock sensor connector clip to the oil level indicator tube.

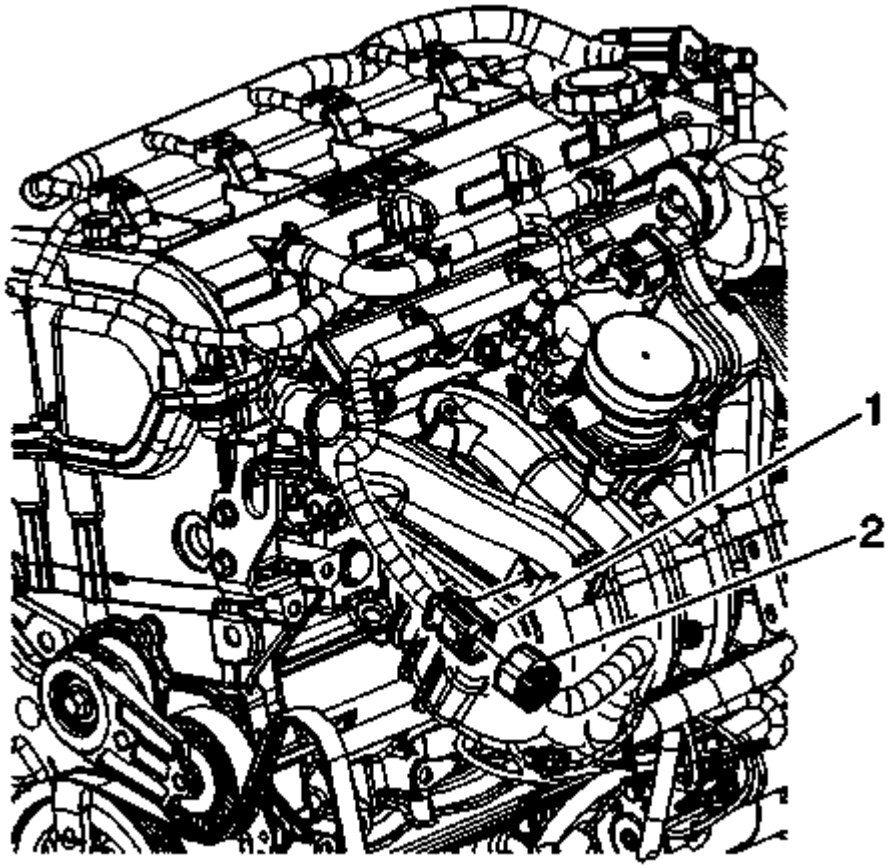

Fig. 46: Locating Fuel Injector Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

6. Connect the engine harness electrical connector (1) to the fuel injector inline electrical connector (2).
7. Install the fuel injector inline connector clip to the intake manifold.
8. Install the oil level indicator tube bolt and tighten to 10 N.m (89 lb in).

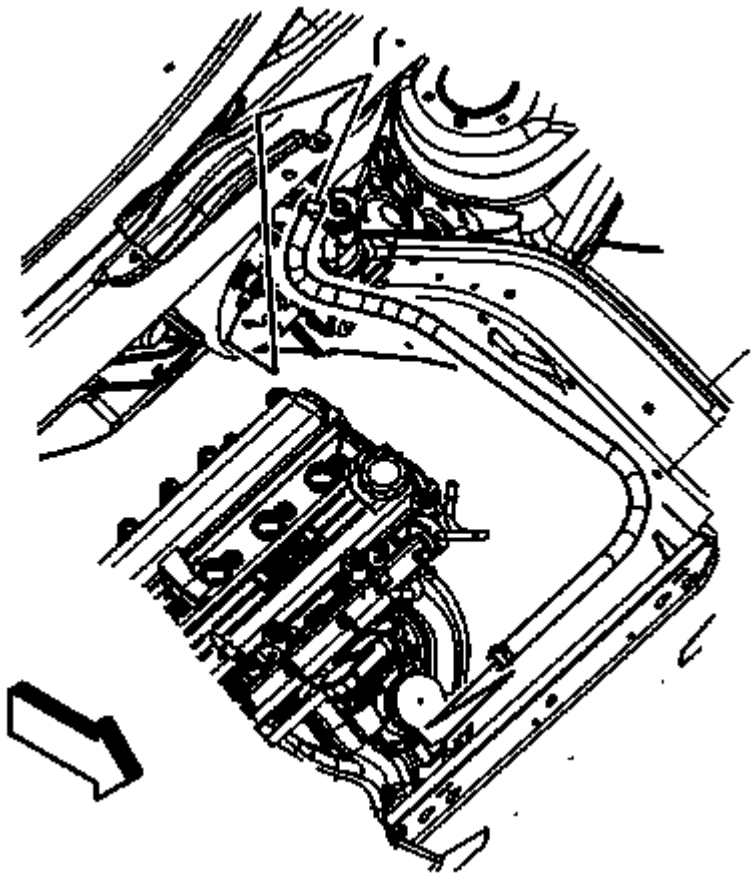

Fig. 47: Identifying Brake Booster Vacuum Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

9. Install the brake booster hose to the intake manifold.
10. Position the brake booster vacuum hose clamp at the intake manifold.

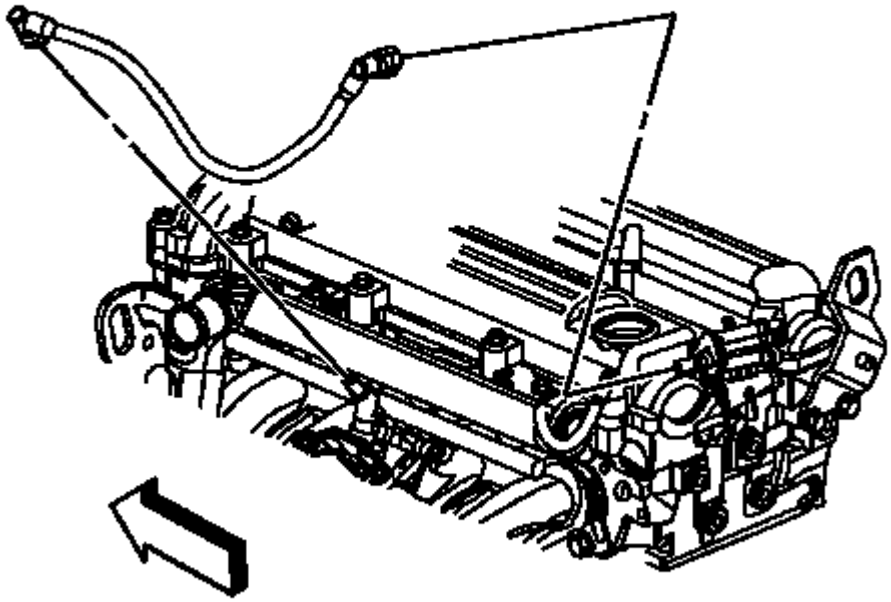

Fig. 48: EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

11. Install the EVAP canister purge solenoid valve tube. Refer to **Plastic Collar Quick Connect Fitting Service** .
12. Install the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
13. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .

CRANKSHAFT BALANCER REPLACEMENT (LE5)

SPECIAL TOOLS

- **J 38122-A** Harmonic Balancer Holder. See **Special Tools** .
- **J 45059** Angle Meter

REMOVAL PROCEDURE

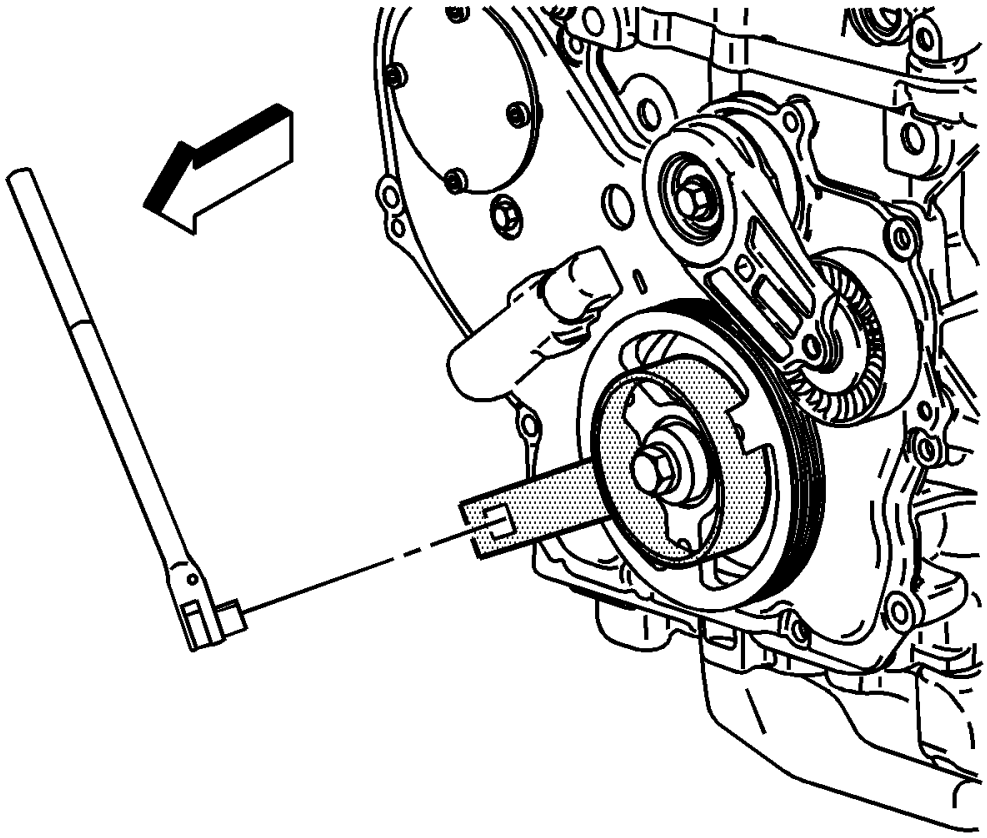

Fig. 49: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement (LE5)**.
2. Use **J 38122-A** to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt. See **Special Tools** .
3. Remove and discard the crankshaft balancer bolt.

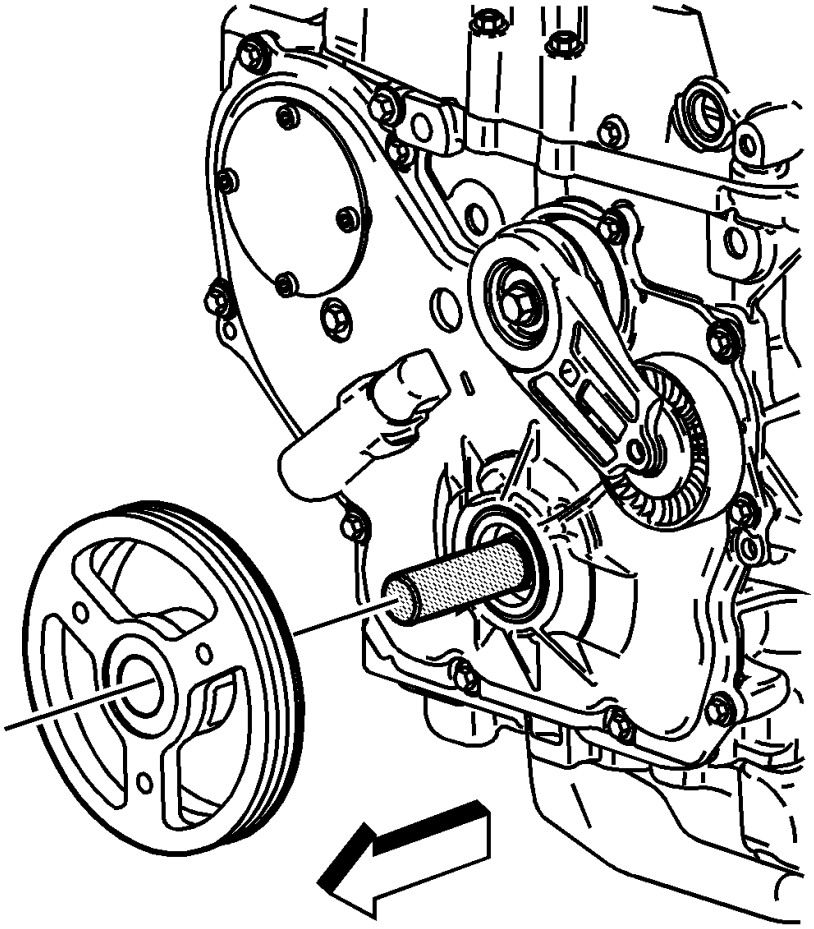

Fig. 50: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

INSTALLATION PROCEDURE

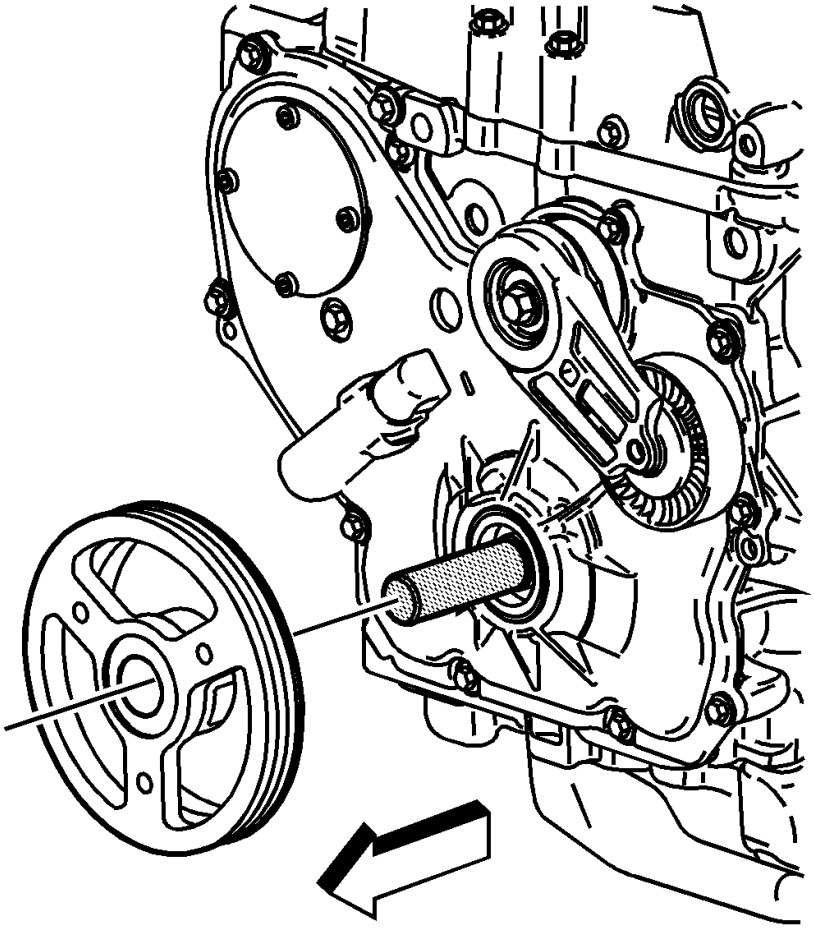

Fig. 51: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer.
2. Install a NEW crankshaft balancer bolt.

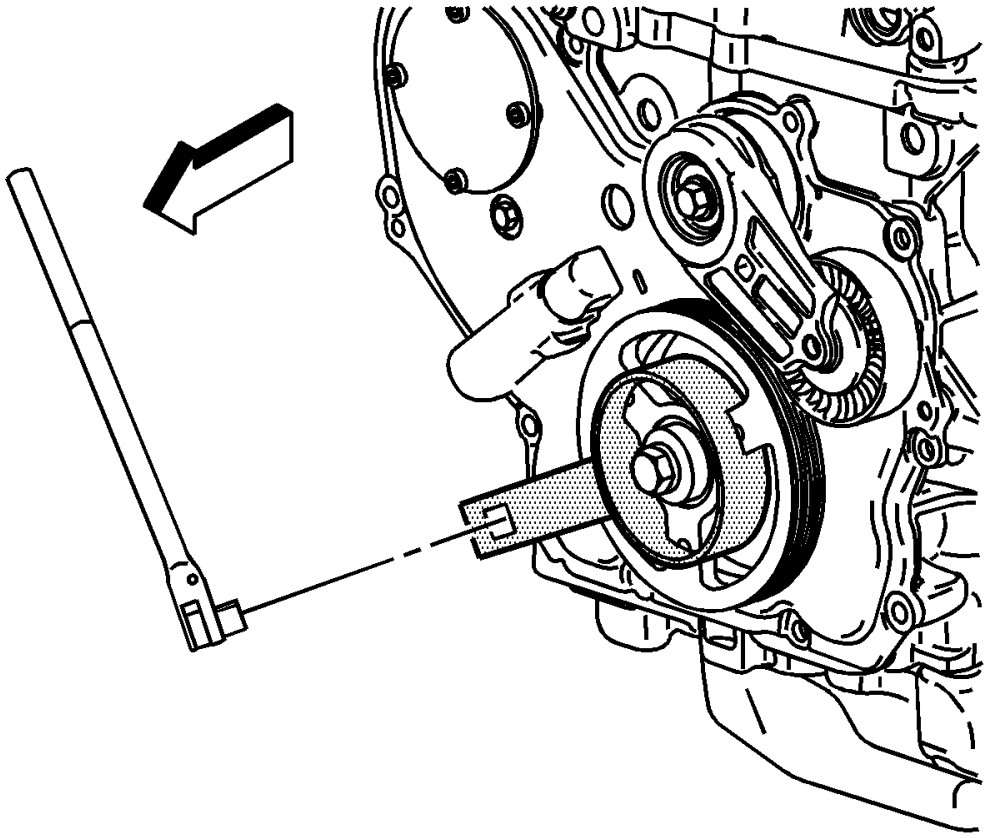

Fig. 52: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 38122-A** to hold the crankshaft balancer in order to prevent the balancer from rotating while tightening the bolt. See **Special Tools** .

CAUTION: Refer to Fastener Caution .

4. Tighten the crankshaft balancer bolt to 100 N.m (74 lb ft) plus an additional 125 degrees using the **J 45059** .
5. Install the drive belt. Refer to **Drive Belt Replacement (LE5)**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

TOOLS REQUIRED

J 35268-A Camshaft/Front Main Seal Installer

REMOVAL PROCEDURE

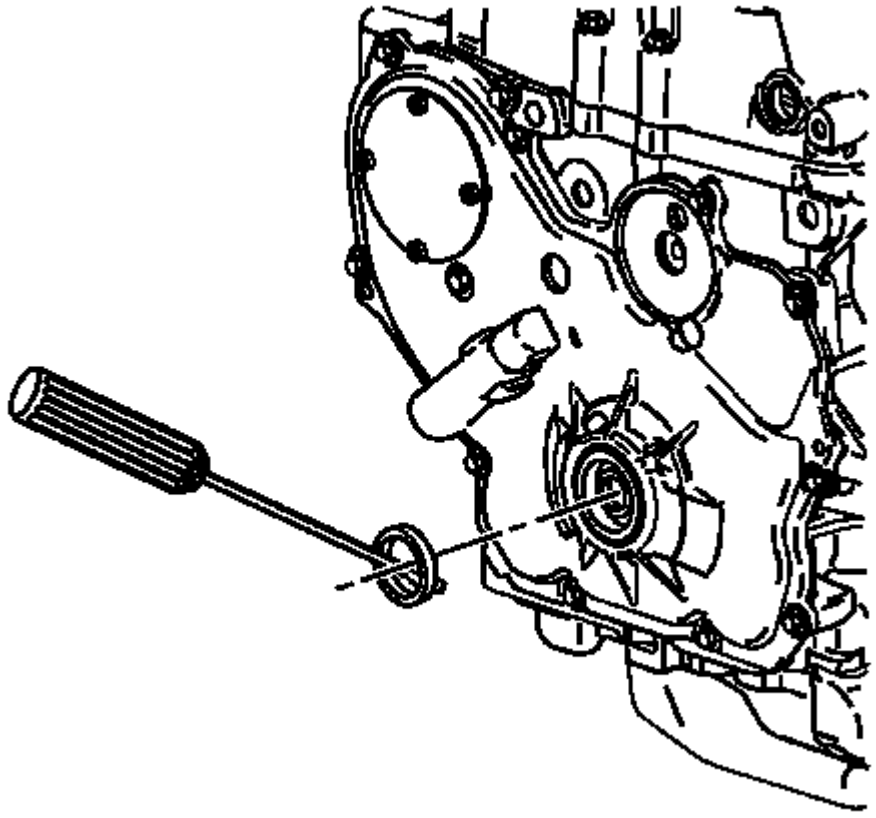

Fig. 53: Front Crankshaft Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement (LE5)**.
2. Use a flat-bladed tool to remove the seal from the front cover.

INSTALLATION PROCEDURE

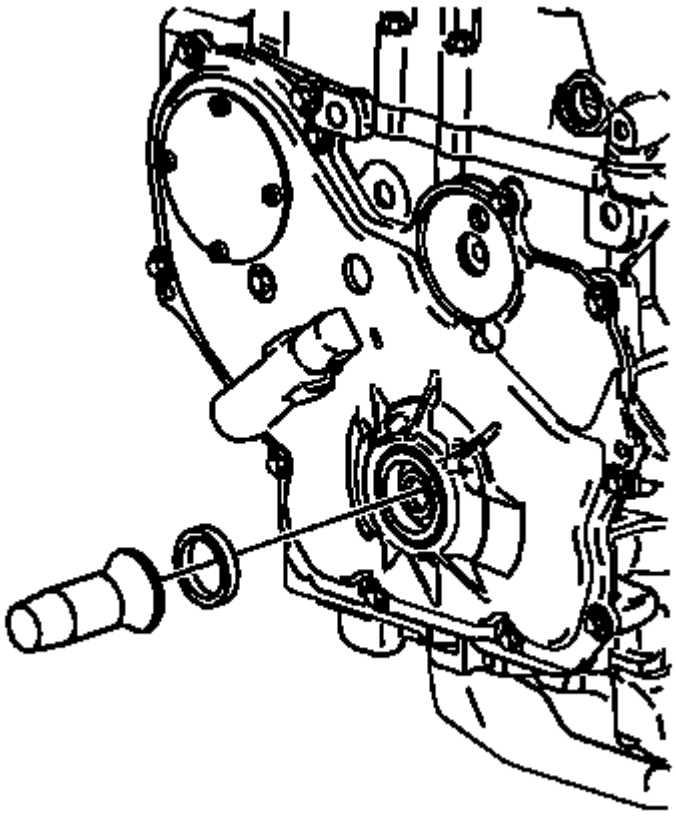

Fig. 54: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 35268-A** in order to install the crankshaft front oil seal to the engine front cover.
2. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement (LE5)**.

ENGINE FRONT COVER REPLACEMENT

REMOVAL PROCEDURE

1. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement (LE5)**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement (LE5)**.

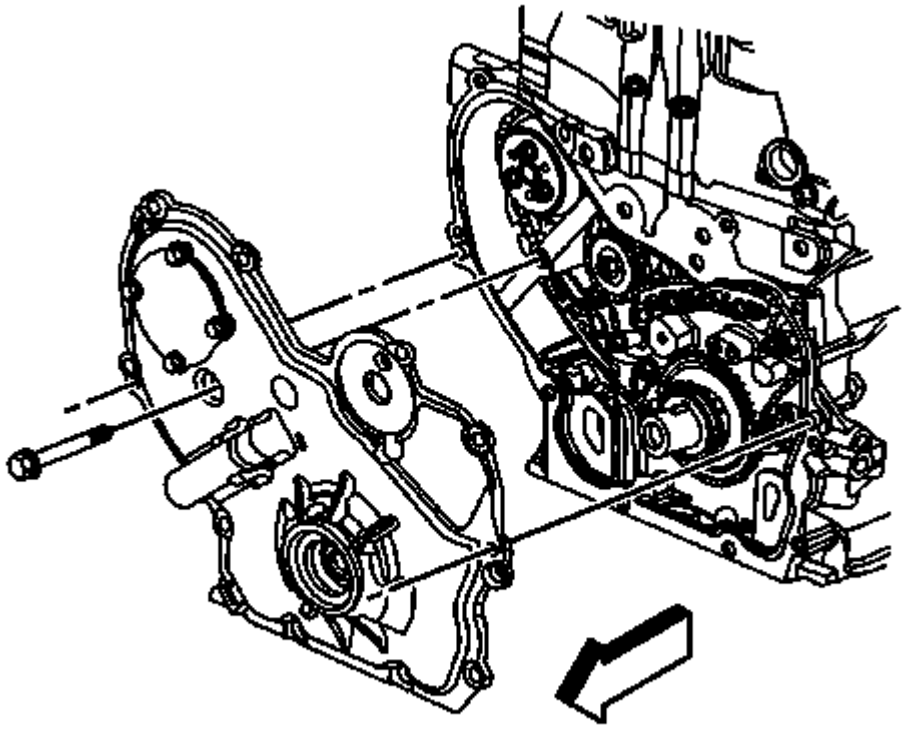

Fig. 55: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover to water pump bolt.

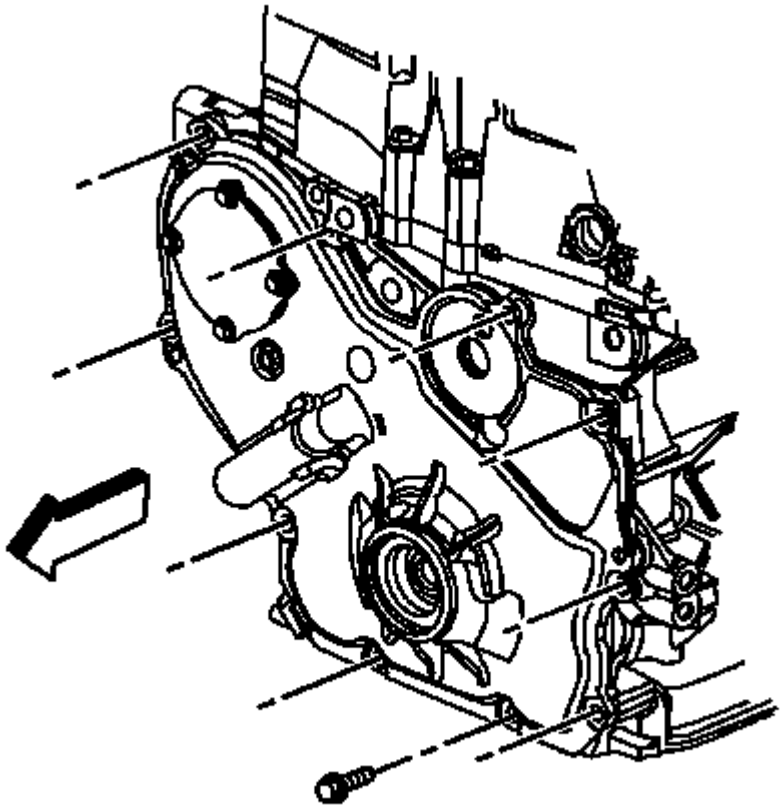

Fig. 56: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
5. Remove the engine front cover bolts.
6. Remove the engine front cover.

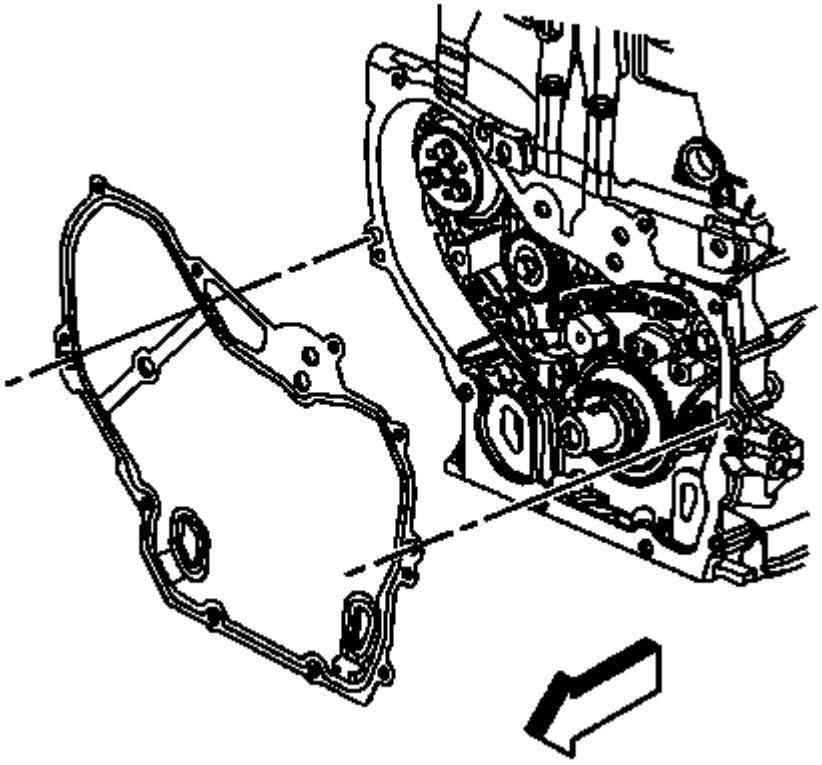

Fig. 57: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove and discard the engine front cover gasket.

INSTALLATION PROCEDURE

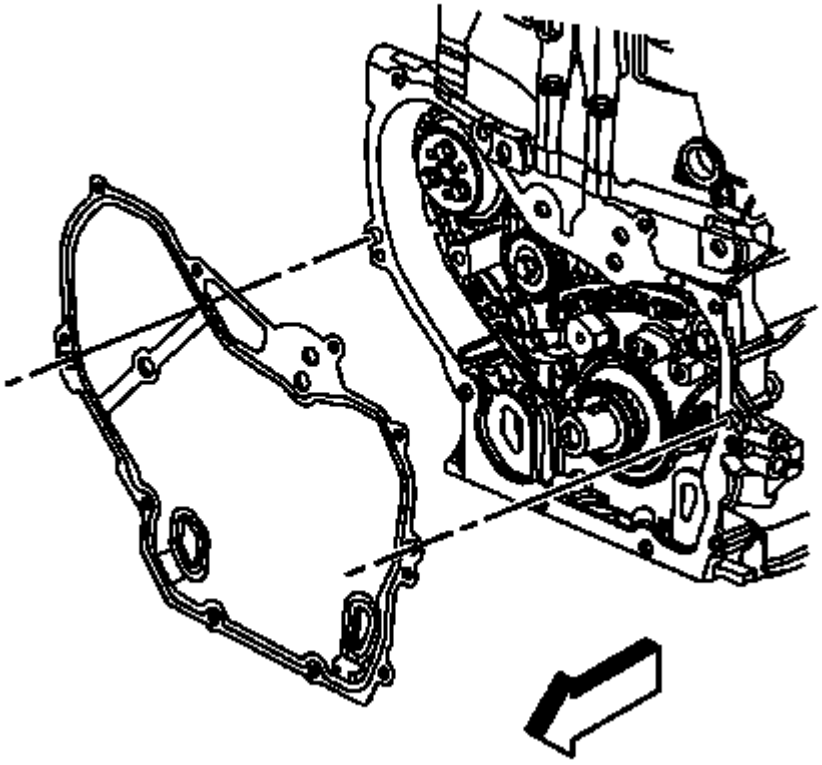

Fig. 58: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW engine front cover gasket to the dowel pins.
2. Install the engine front cover.

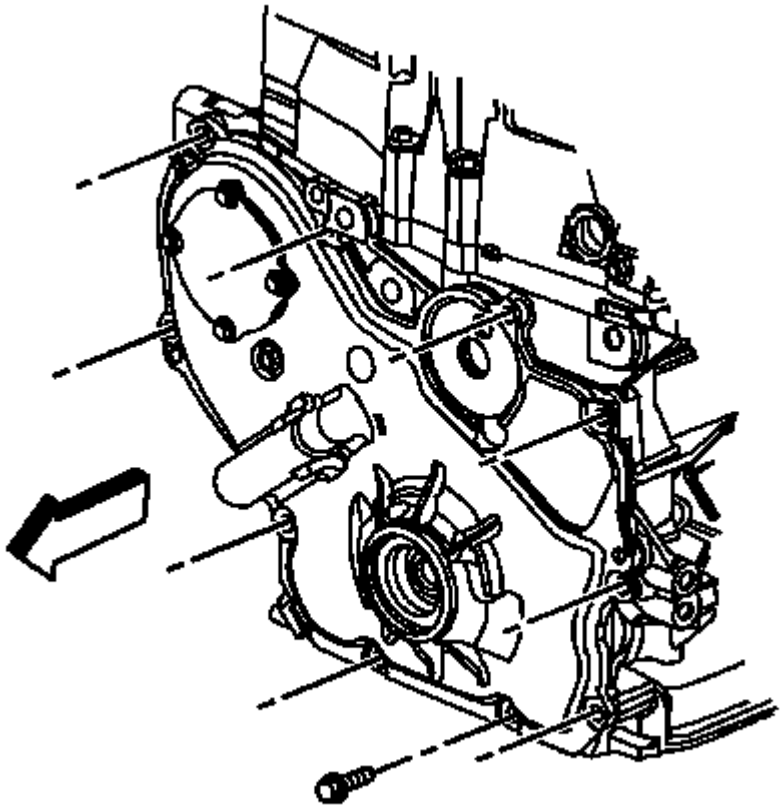

Fig. 59: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
4. Lower the vehicle.

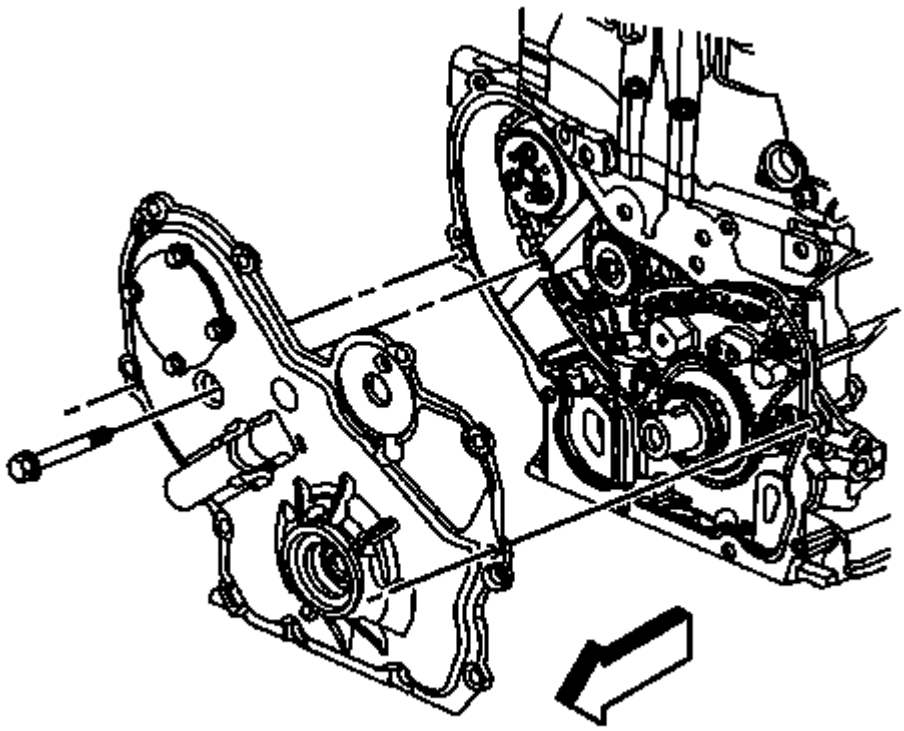

Fig. 60: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover to water pump bolt and tighten to 25 N.m (18 lb ft).

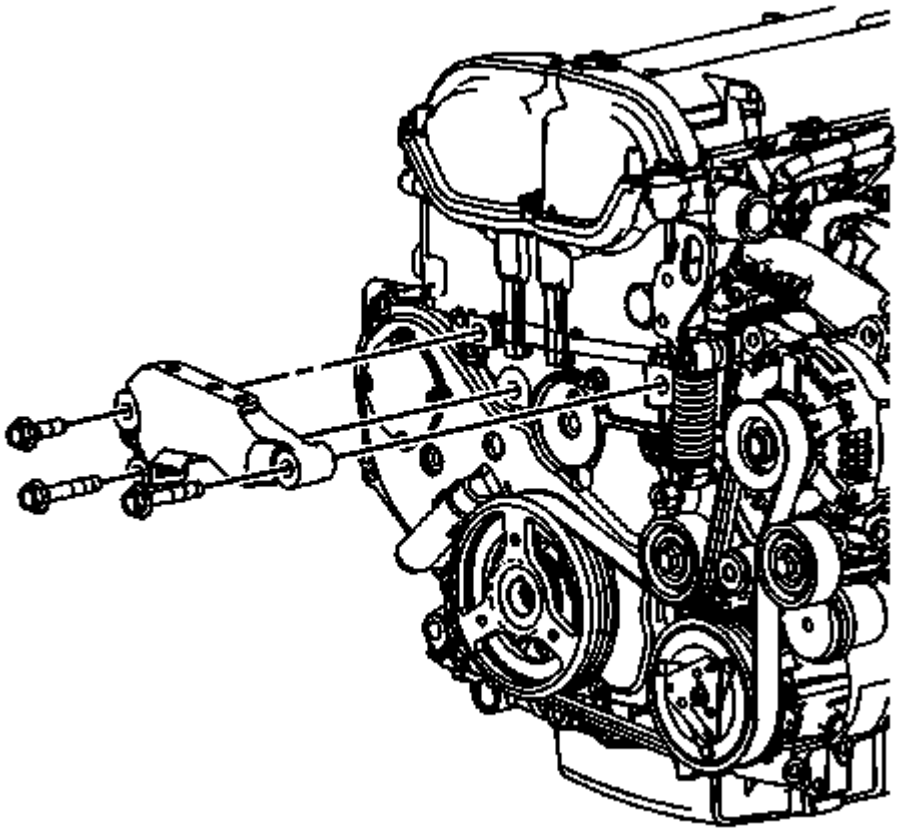

Fig. 61: Engine Mount Bracket And Engine Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement (LE5)**.
7. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement (LE5)**.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

SPECIAL TOOLS

- **EN-45027:** Tensioner Tool
- **EN-45059:** Angle Meter

For equivalent regional tools, refer to **Special Tools** .

REMOVAL PROCEDURE

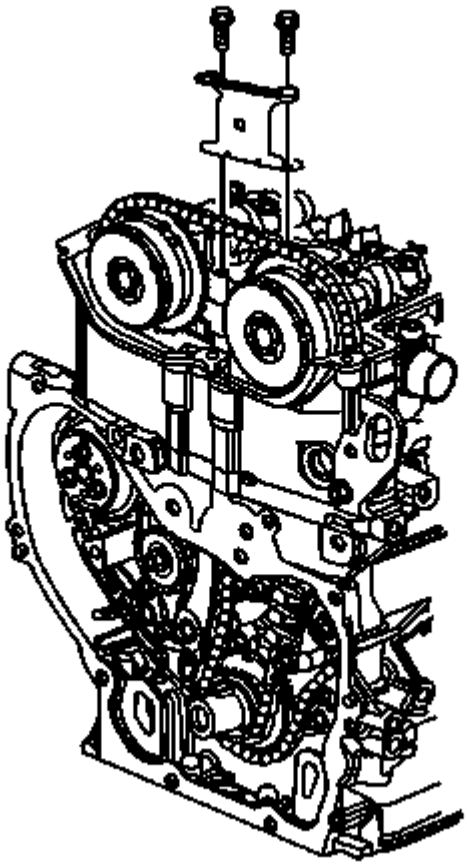

Fig. 62: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the number 1 cylinder spark plug. Refer to **Spark Plug Replacement** .
2. Rotate the crankshaft in the engine rotational direction clockwise, until the number 1 piston is at top dead center (TDC) on the exhaust stroke.
3. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
4. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Remove the upper timing chain guide bolts and guide.

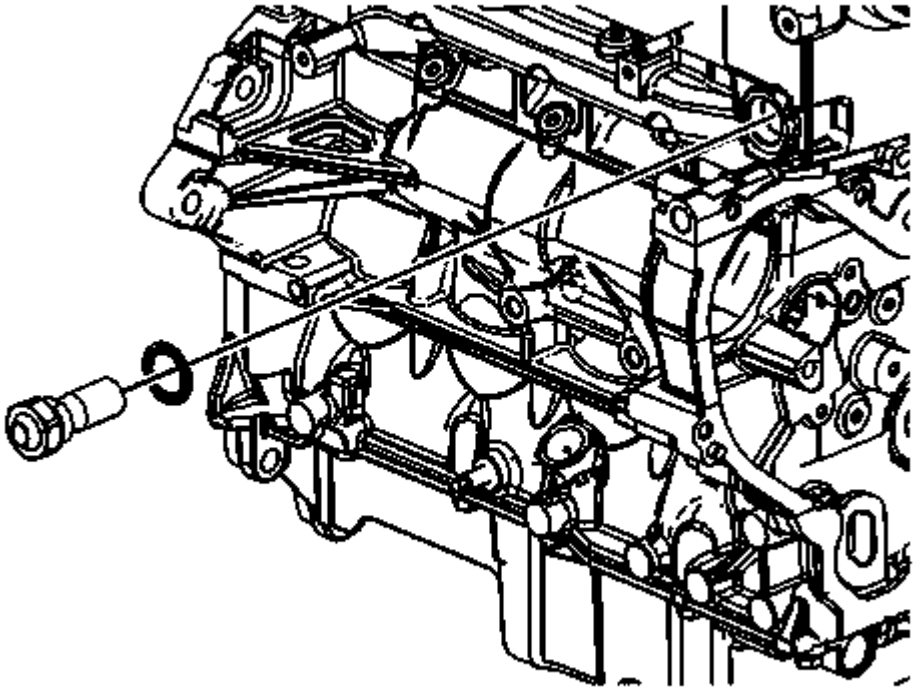

Fig. 63: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

6. Remove the timing chain tensioner.

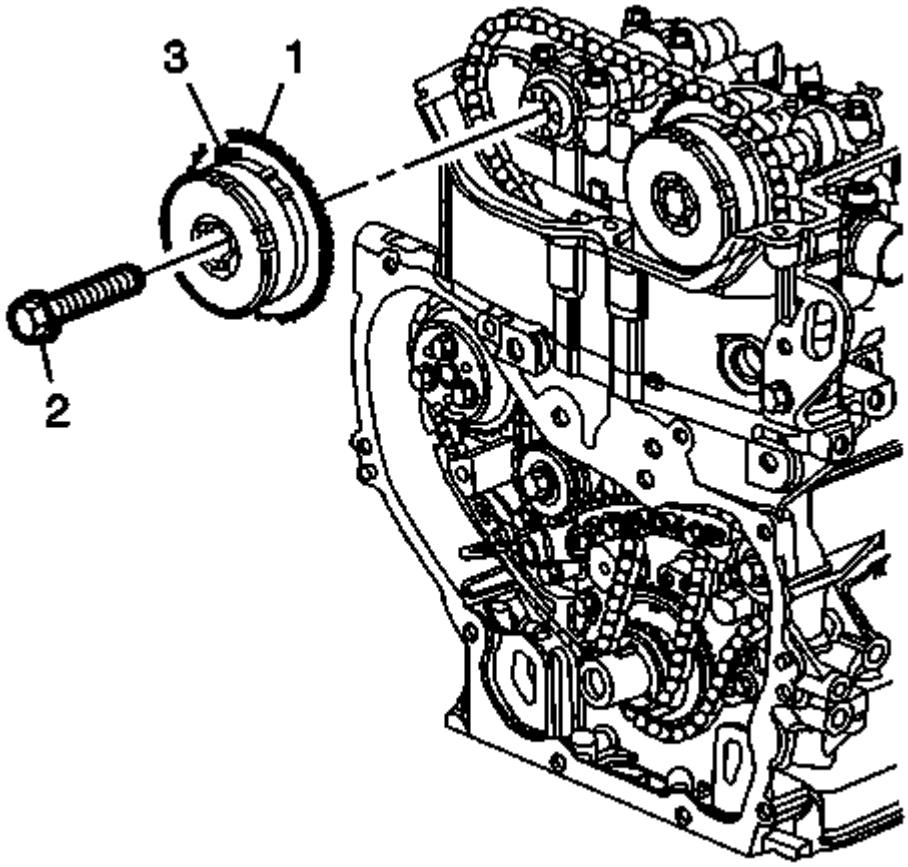

Fig. 64: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

7. Install a 24 mm wrench on the hex on the exhaust camshaft in order to hold the camshaft.
8. Remove and discard the exhaust camshaft actuator bolt (2).
9. Remove the exhaust camshaft actuator (1, 3) from the camshaft and timing chain.

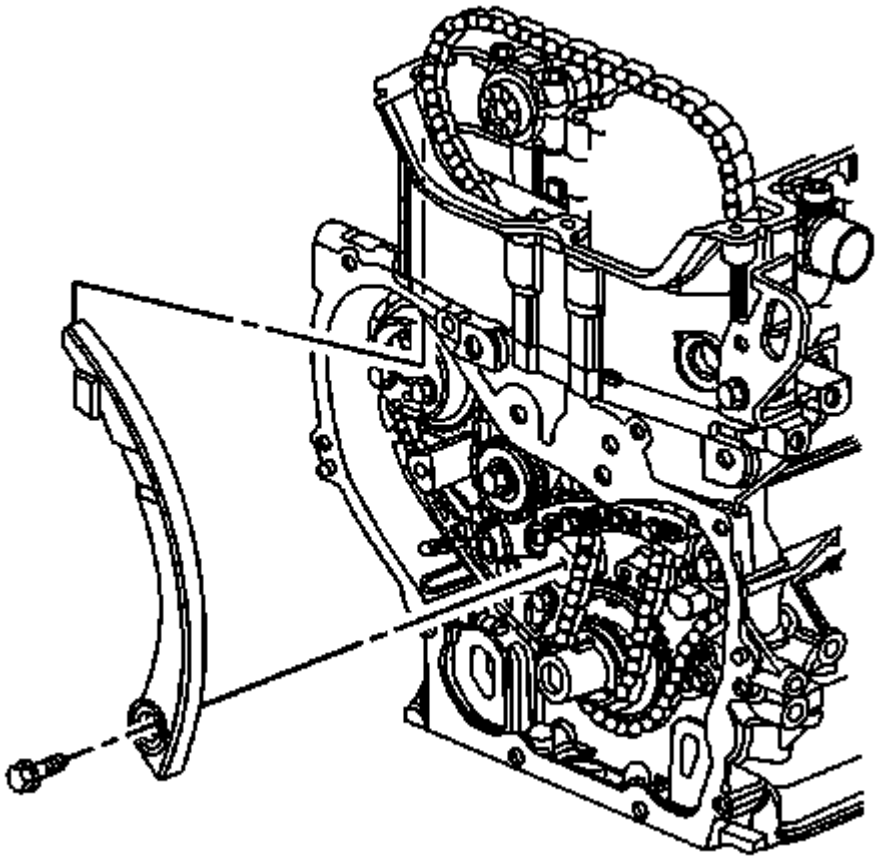

Fig. 65: Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner guide bolt and guide.

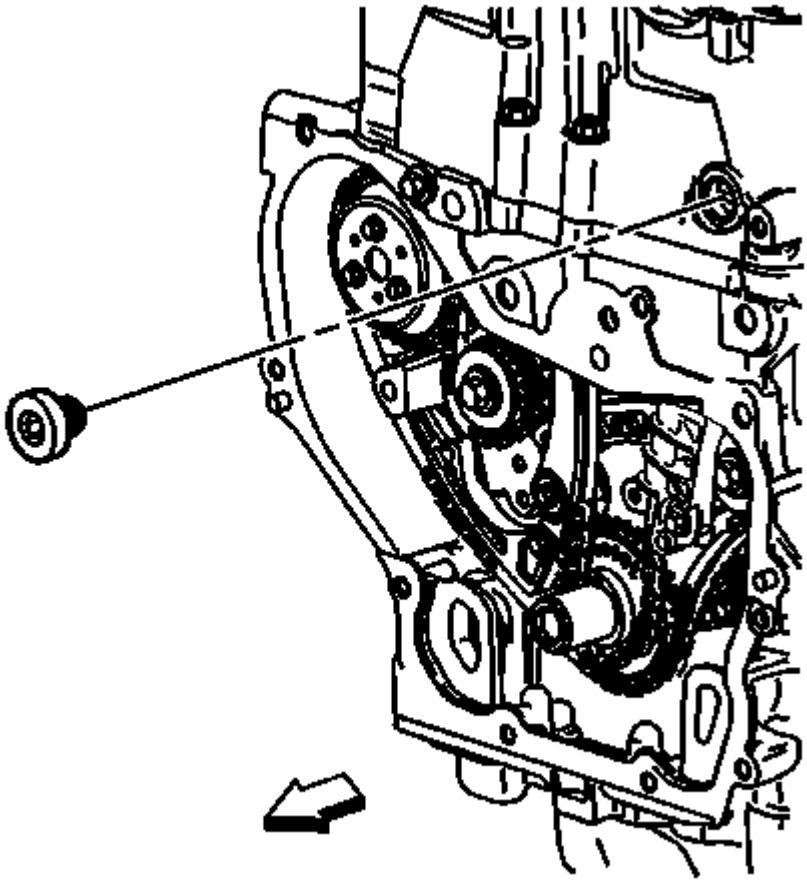

Fig. 66: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

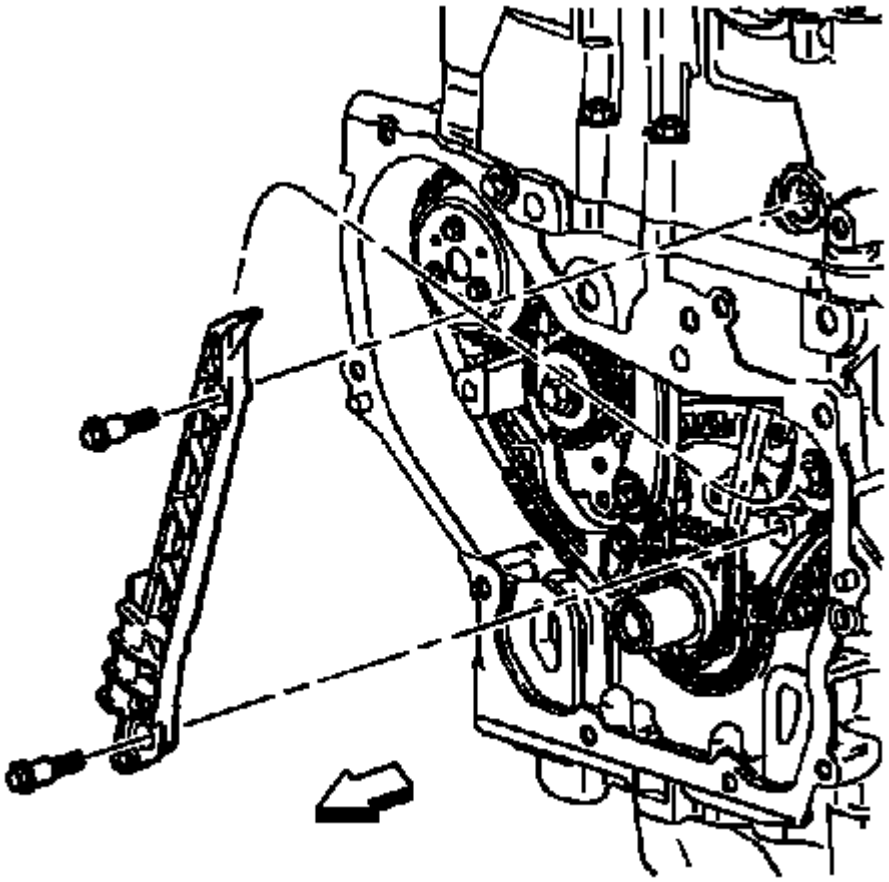

Fig. 67: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Remove the fixed timing chain guide bolts and guide.

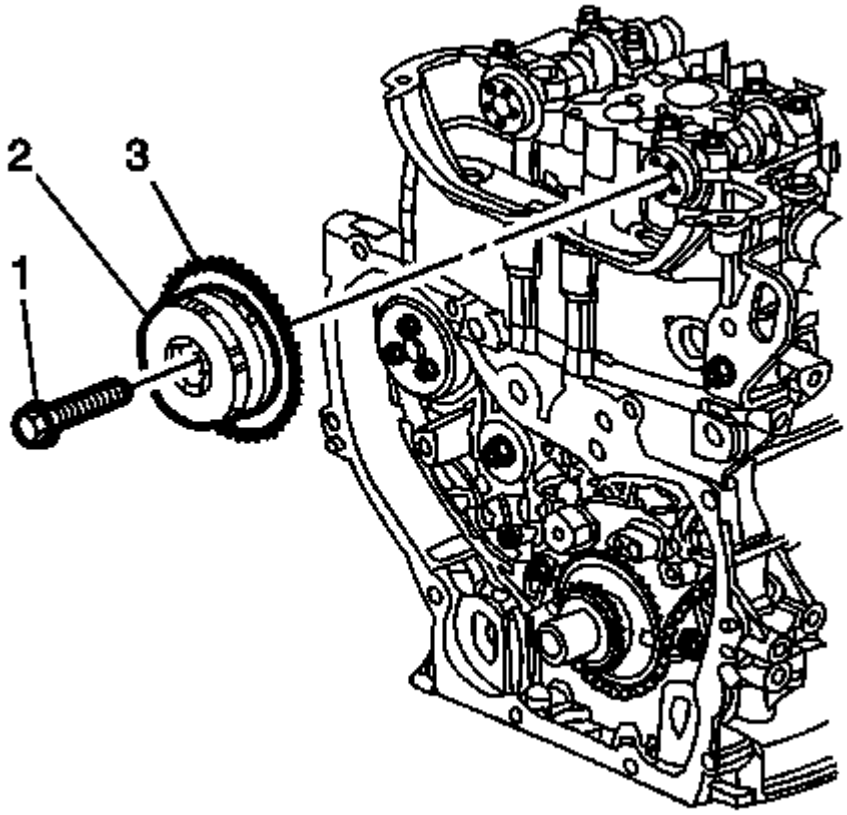

Fig. 68: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Install a 24 mm wrench on the hex on the intake camshaft in order to hold the camshaft.
14. Remove and discard the intake camshaft actuator bolt (2).
15. Remove the intake camshaft actuator (3), and the timing chain through the top of the cylinder head.

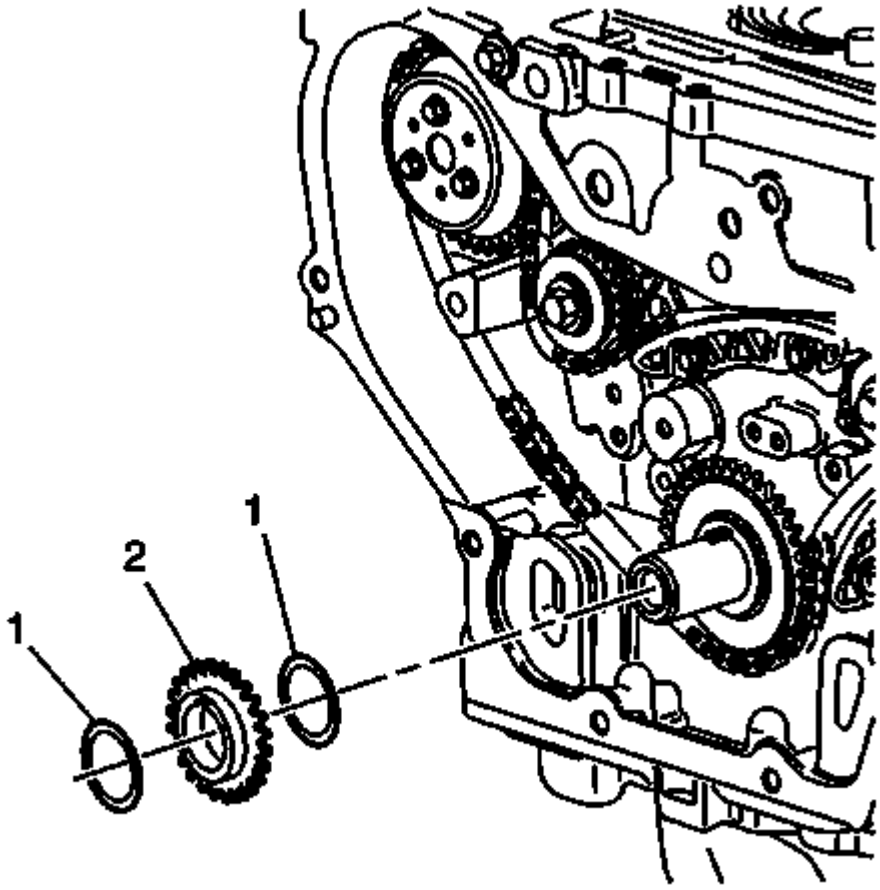

Fig. 69: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Remove the crankshaft sprocket (2) and friction washers (1), if equipped.

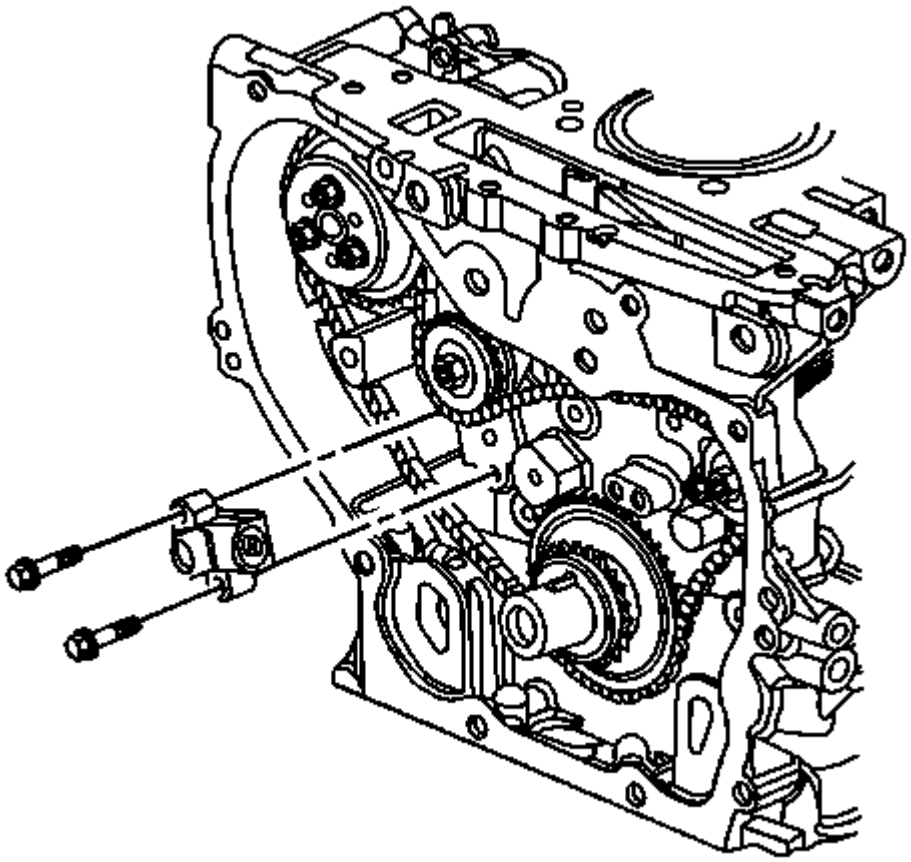

Fig. 70: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

17. If replacing the balance shaft timing chain and sprocket, perform the following steps, if not proceed to step 10 in the installation procedure.
18. Remove the balance shaft drive chain tensioner bolts and tensioner.

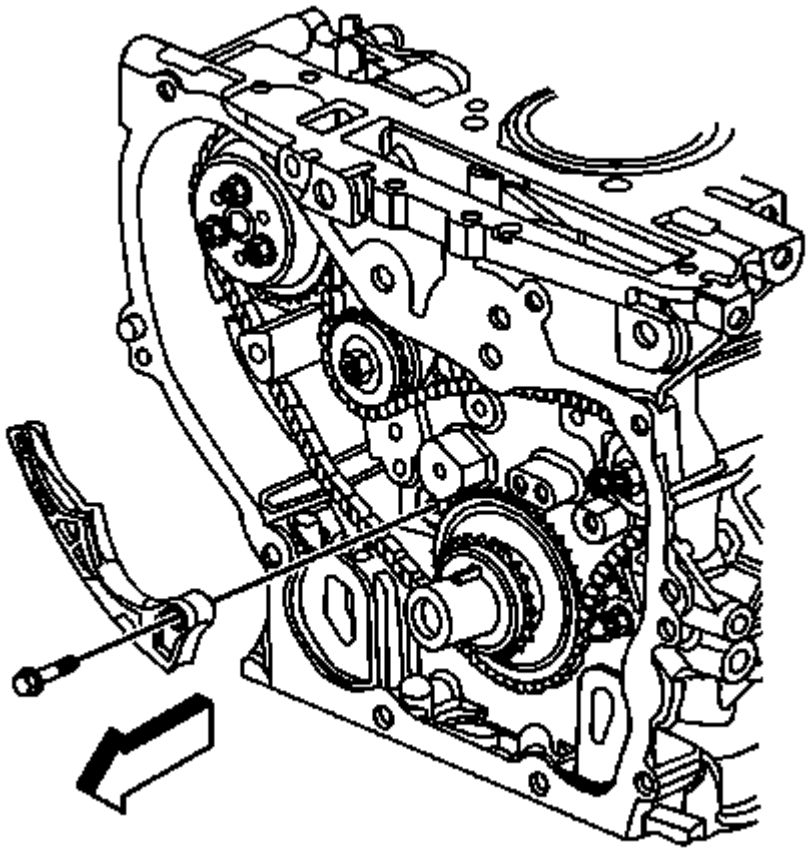

Fig. 71: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

19. Remove the adjustable balance shaft chain guide bolt and guide.

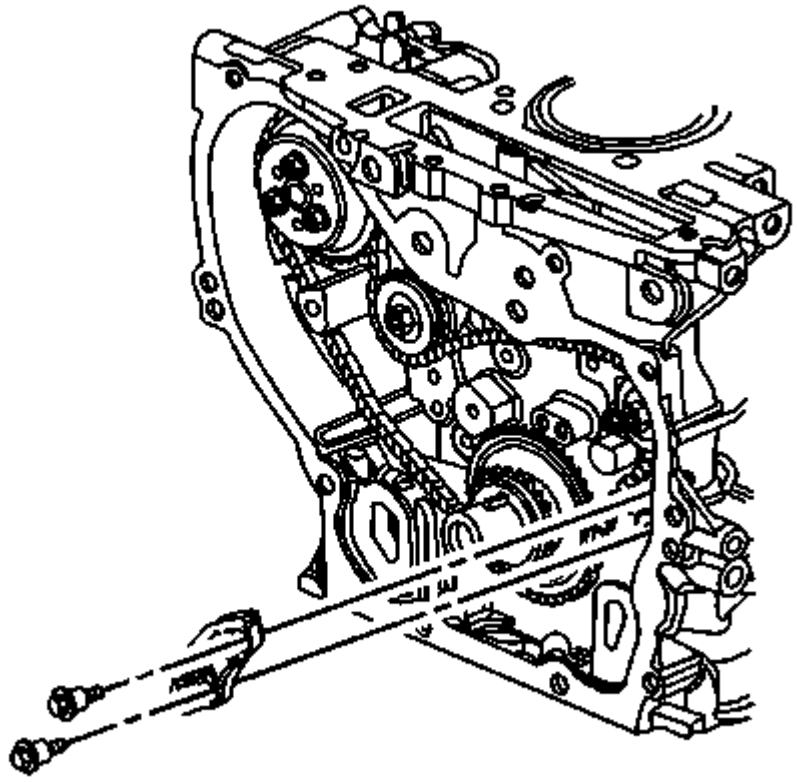

Fig. 72: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Remove the small balance shaft drive chain guide bolts and guide.

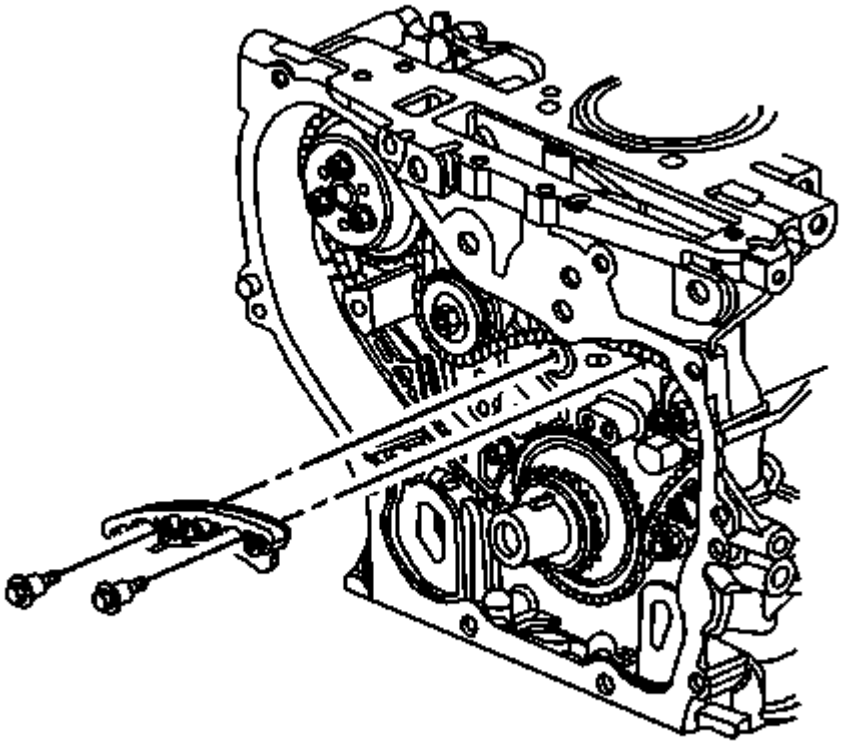

Fig. 73: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

21. Remove the upper balance shaft drive chain guide bolts and guide.

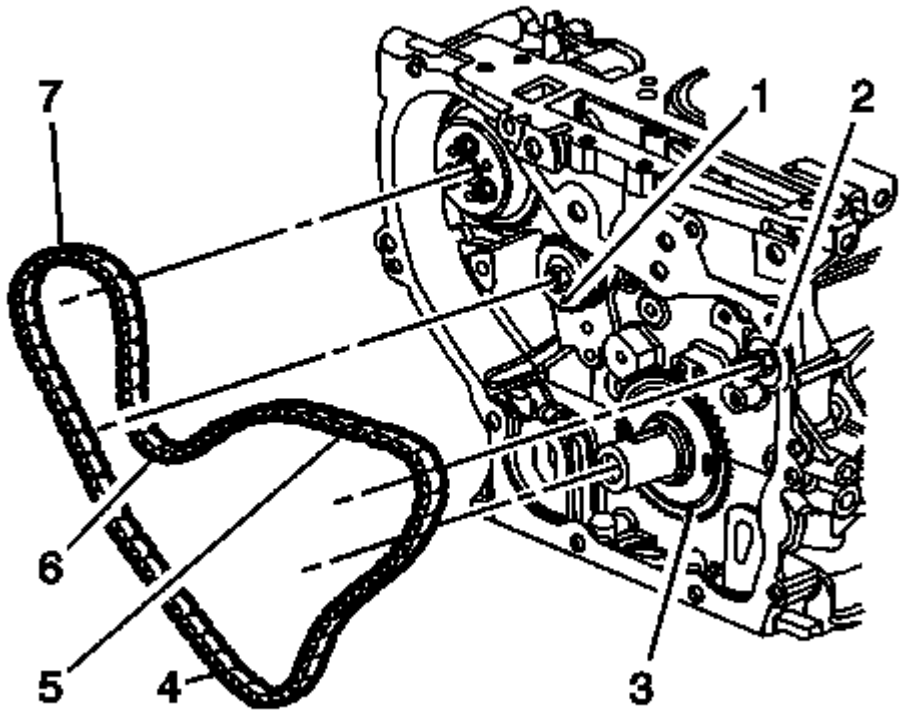

Fig. 74: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: It may ease removal of the balance shaft drive chain to get all the slack in the chain between the crankshaft and water pump sprockets.

22. Remove the balance shaft drive chain (7).
23. Remove the balance shaft drive sprocket.

INSTALLATION PROCEDURE

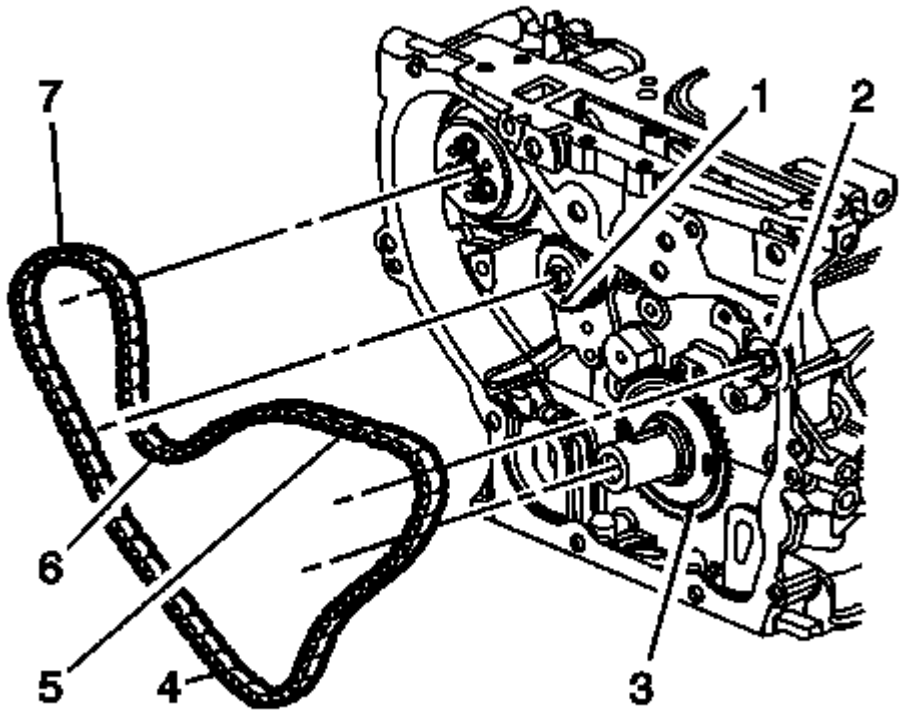

Fig. 75: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. If replacing the balance shaft timing chain, perform the following steps, if not proceed to step 10.
2. Install the balance shaft drive sprocket.

NOTE: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

3. Install the balance shaft drive chain (7) with the colored link lined up with the marks on the balance shaft sprockets and the balance shaft drive sprocket. There are 3 colored links on the chain. Two are chrome and one is copper. Use the following steps in order to line up the links with the sprockets.
    1. Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft sprocket.
    2. Working clockwise around the chain, place the chrome link (4) in line with the timing mark (3) on the balance shaft drive sprocket (approximately 6 o'clock position on the sprocket).
    3. Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
    4. Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

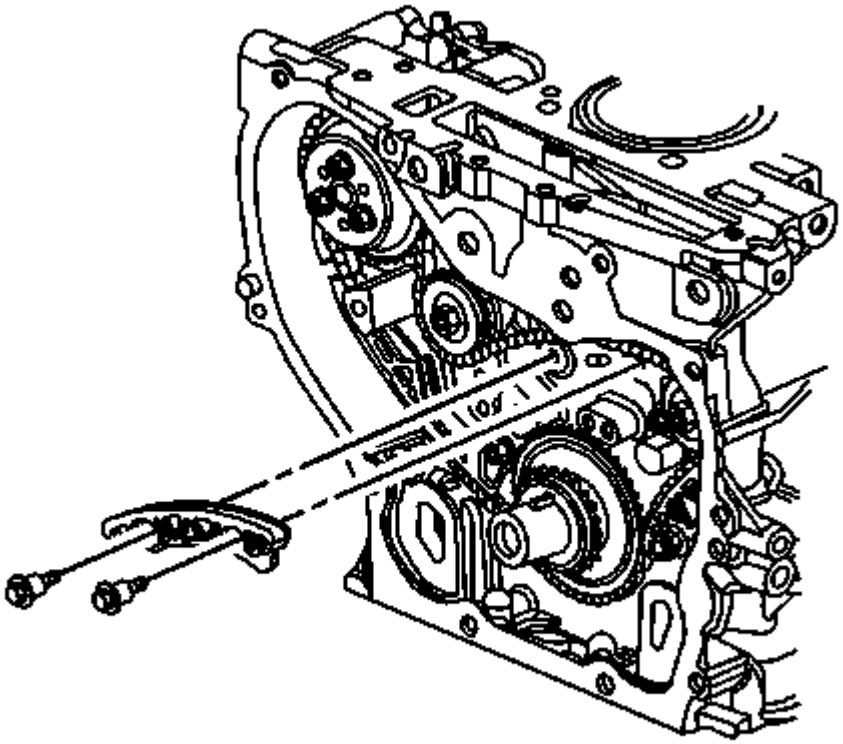

Fig. 76: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the upper balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

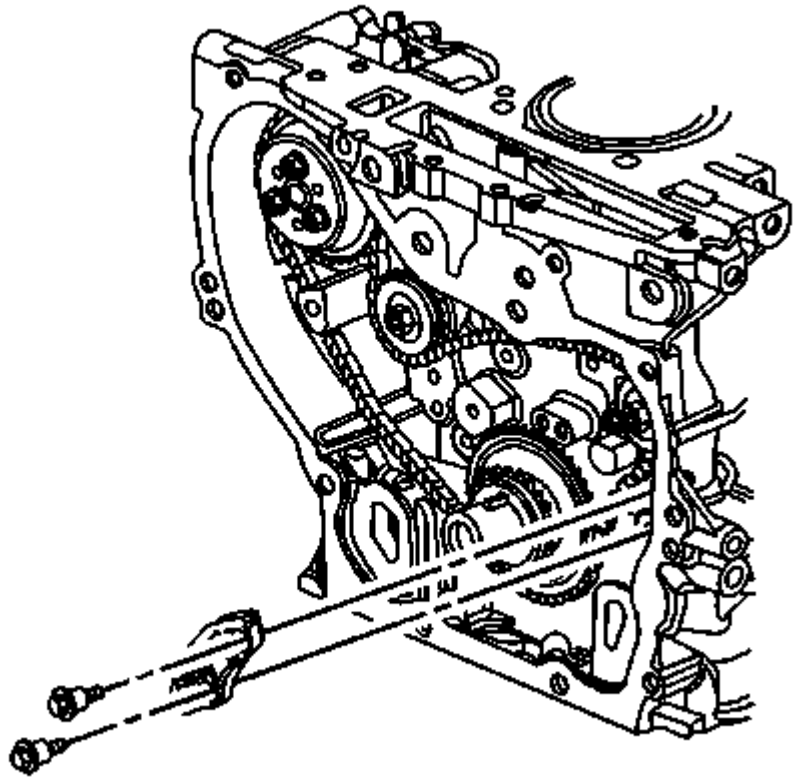

Fig. 77: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

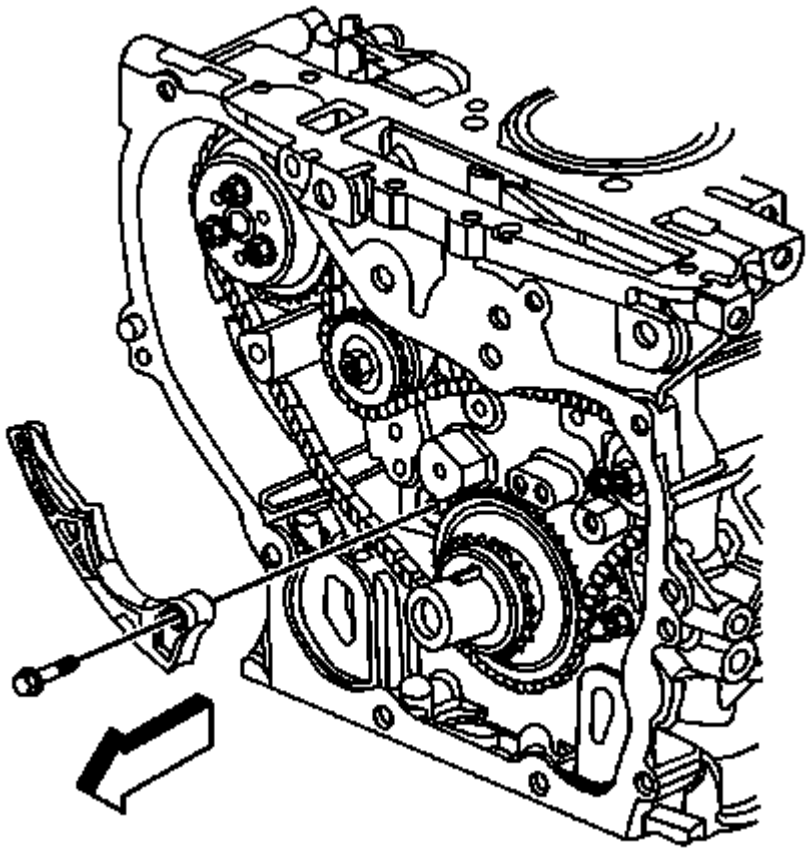

Fig. 78: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt and tighten to 10 N.m (89 lb in).

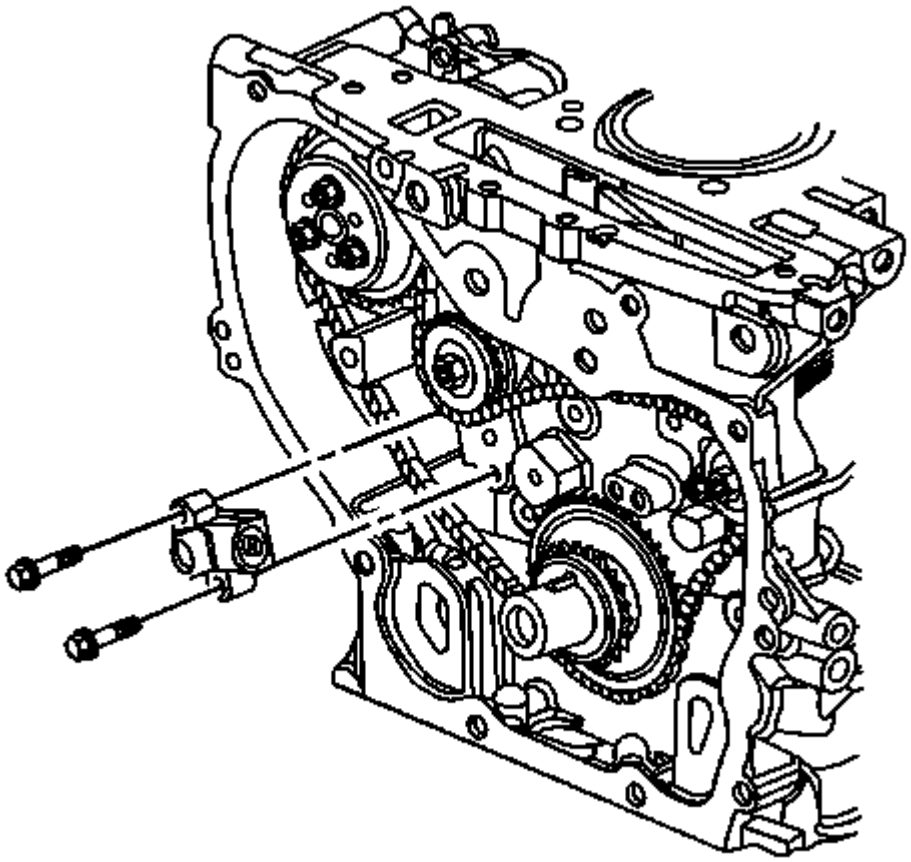

Fig. 79: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Reset the timing chain tensioner by performing the following steps:
    1. Rotate the tensioner plunger 90 degrees in its bore and compress the plunger.
    2. Rotate the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hose in the tensioner plunger.
8. Install the balance shaft drive chain tensioner and bolts and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

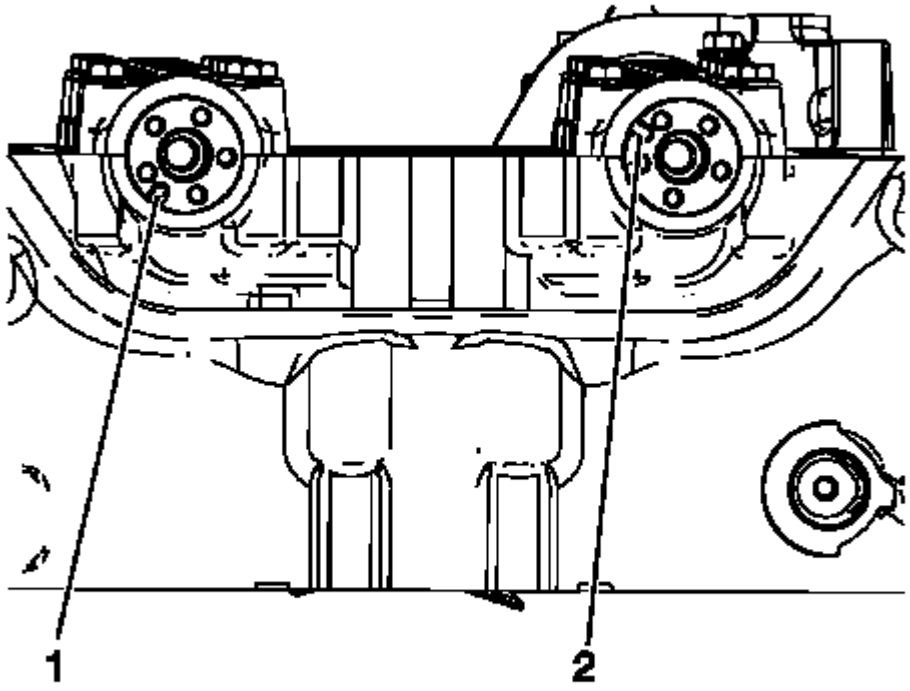

Fig. 80: Camshaft Notches (2.2L)
Courtesy of GENERAL MOTORS CORP.

10. On 2.2L engines, ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

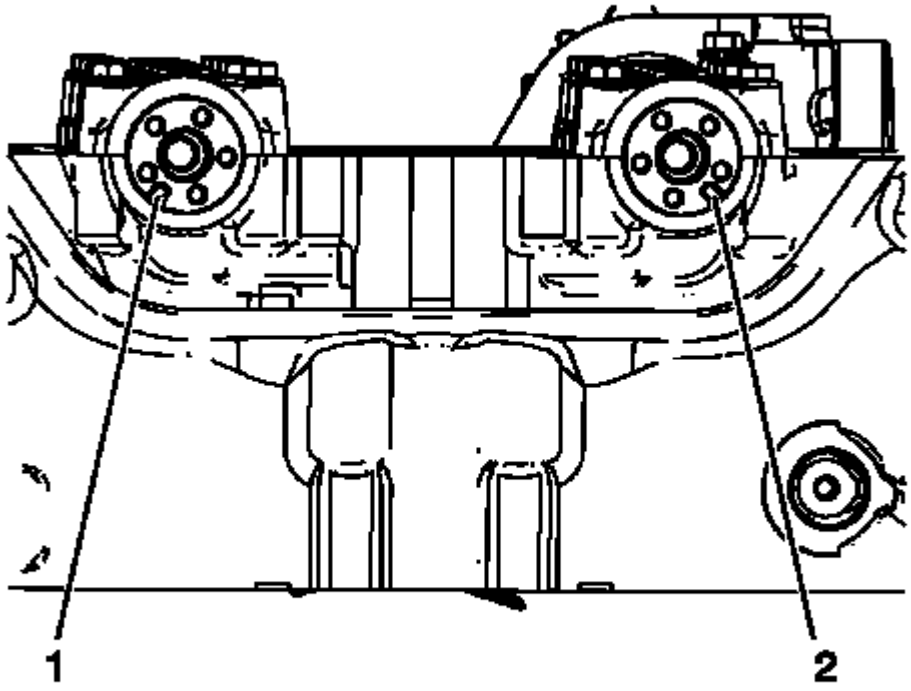

Fig. 81: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

11. On 2.4L engines, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

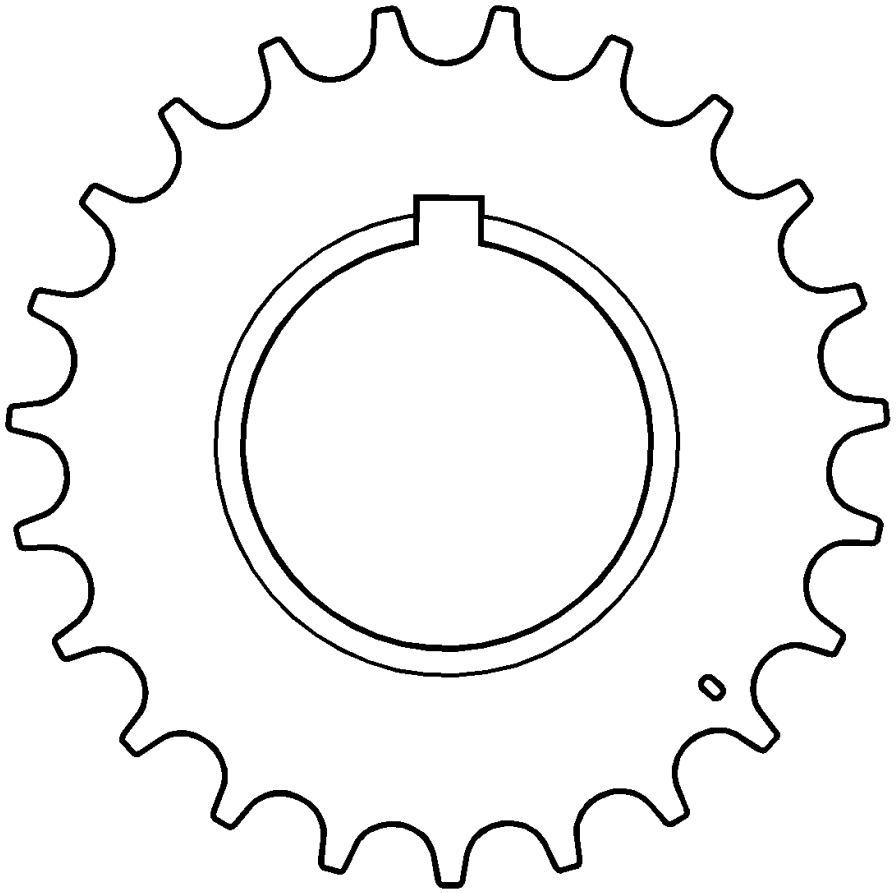

Fig. 82: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Install the friction washer, if applicable.
13. Install the timing chain drive sprocket to the crankshaft with the timing mark in the 5 o'clock position and the front of the sprocket facing.

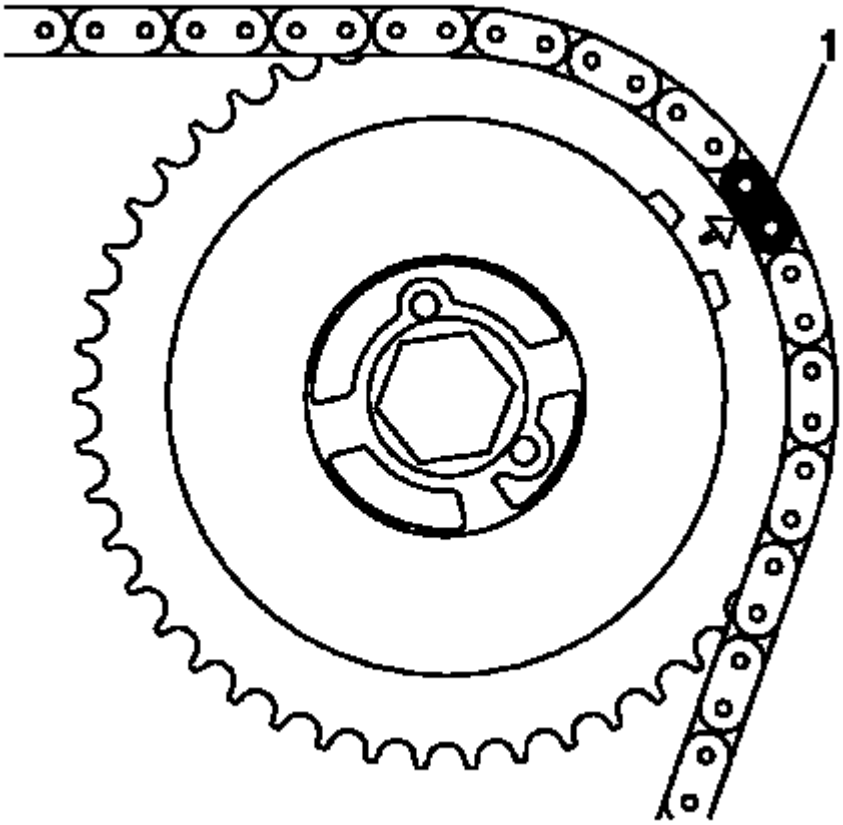

Fig. 83: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **There are 3 colored links on the timing chain. Two links are of matching color, and 1 link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.**
- **Always use new actuator bolts.**

14. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).

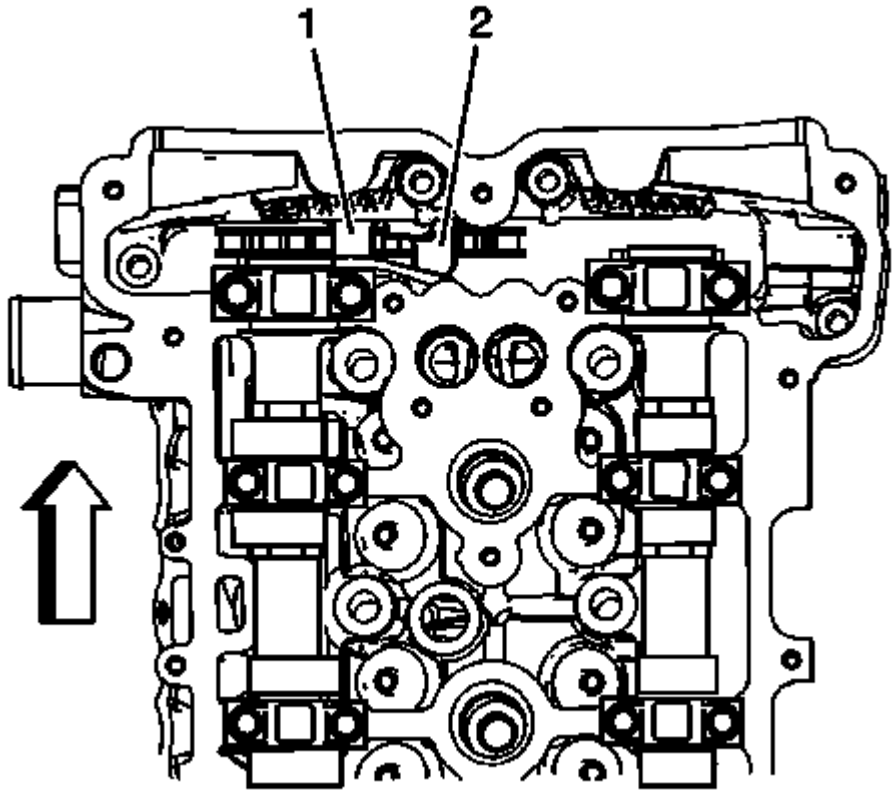

Fig. 84: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

15. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).
16. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
17. Hand tighten the new intake camshaft actuator bolt.

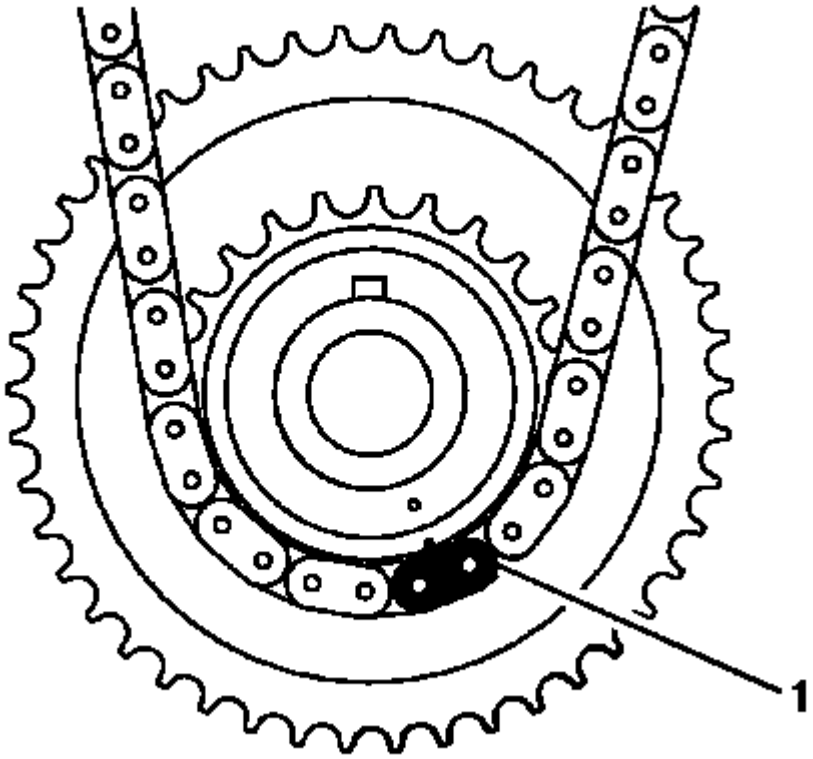

Fig. 85: Identifying Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

18. Route the timing chain around the crankshaft sprocket and line up the first matching colored link with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.
19. Install the friction washer, if applicable.

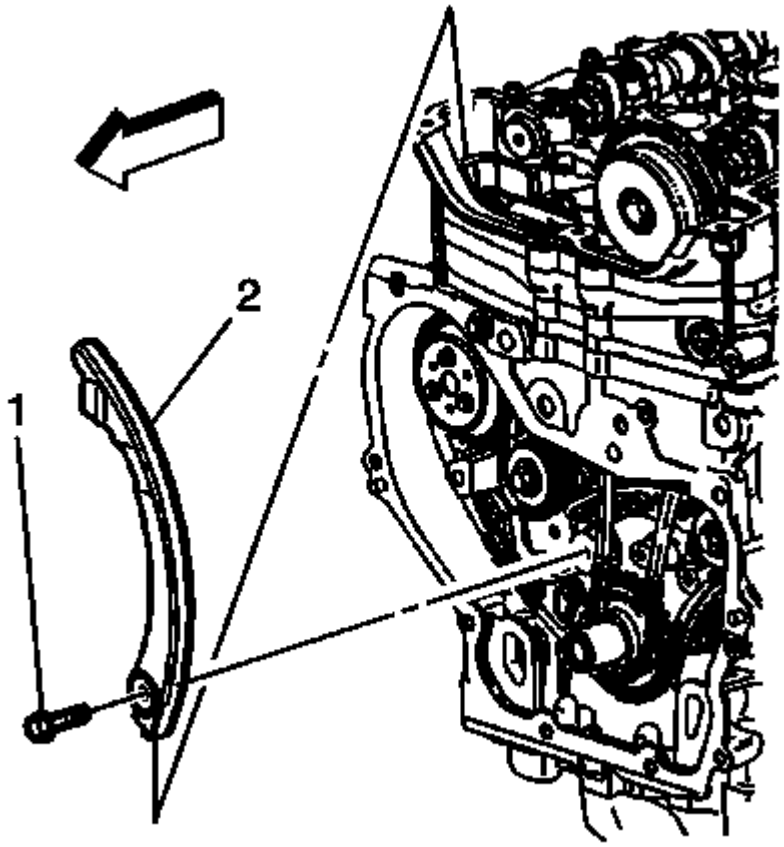

Fig. 86: Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.
21. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt. Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

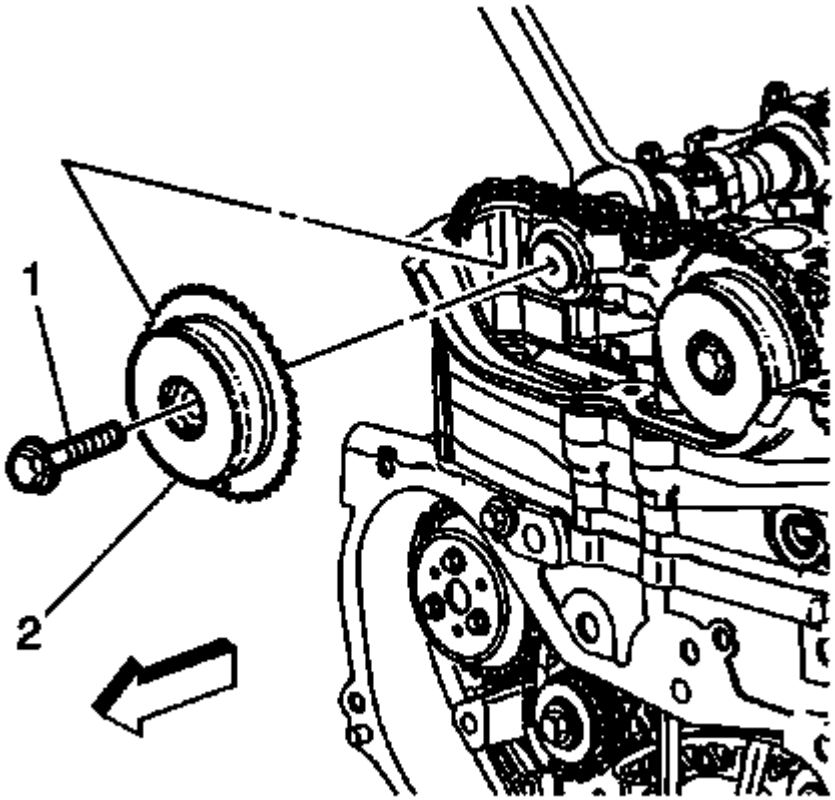

Fig. 87: Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install NEW actuator bolts.

22. Install the exhaust camshaft actuator into the timing chain with the timing mark lined up with the second matching colored link.

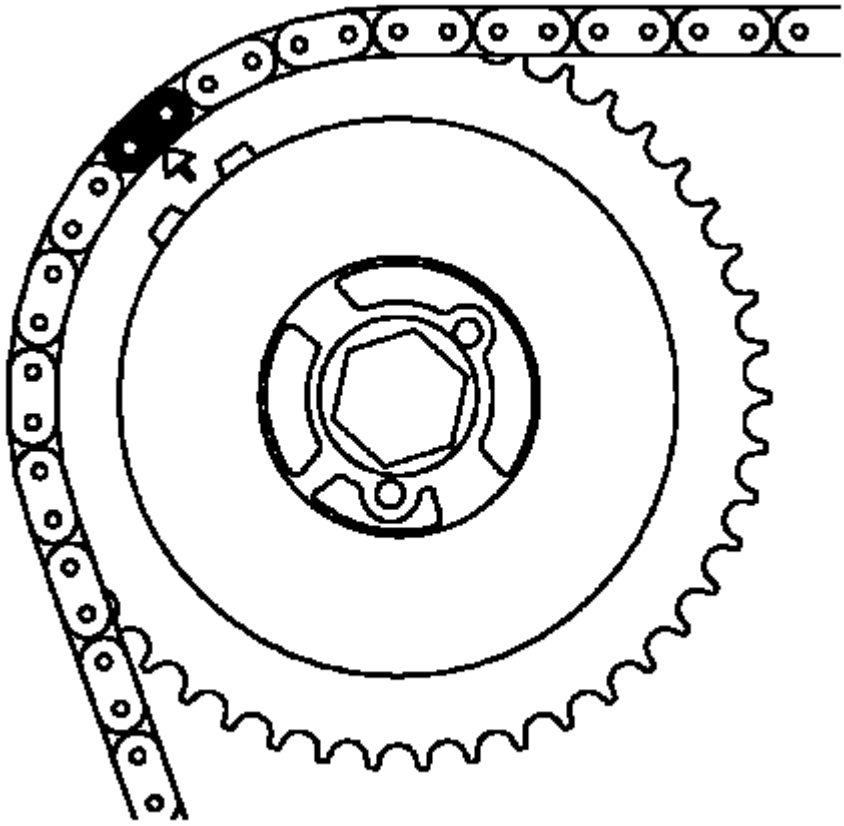

Fig. 88: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

23. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
24. Use 24 mm open ended wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

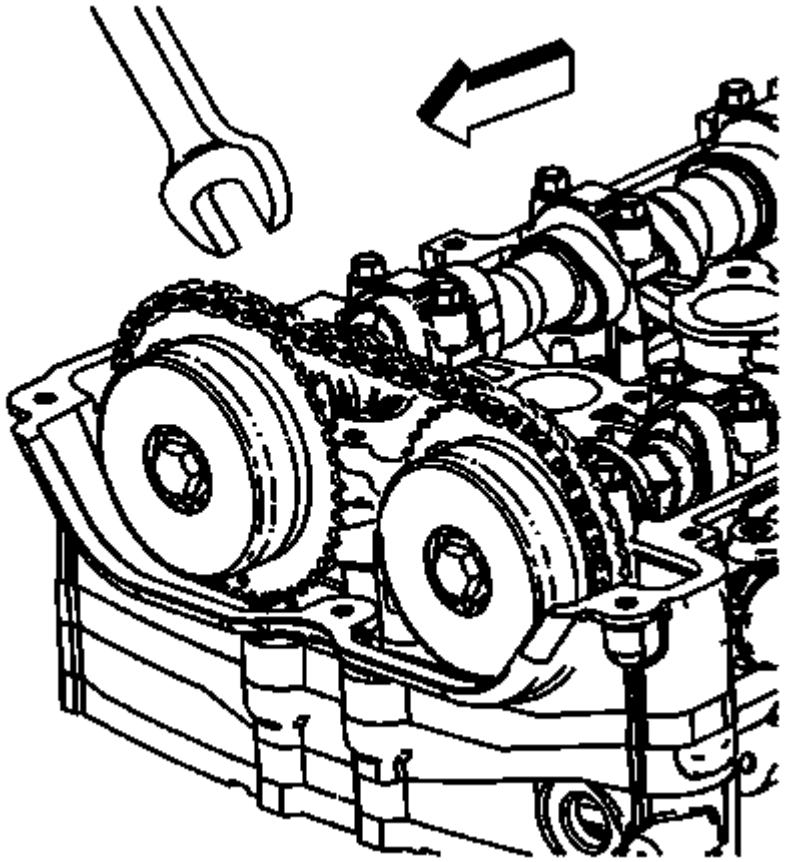

Fig. 89: Identifying Cam Actuator, Camshaft & Chain
Courtesy of GENERAL MOTORS CORP.

25. When the actuator seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.

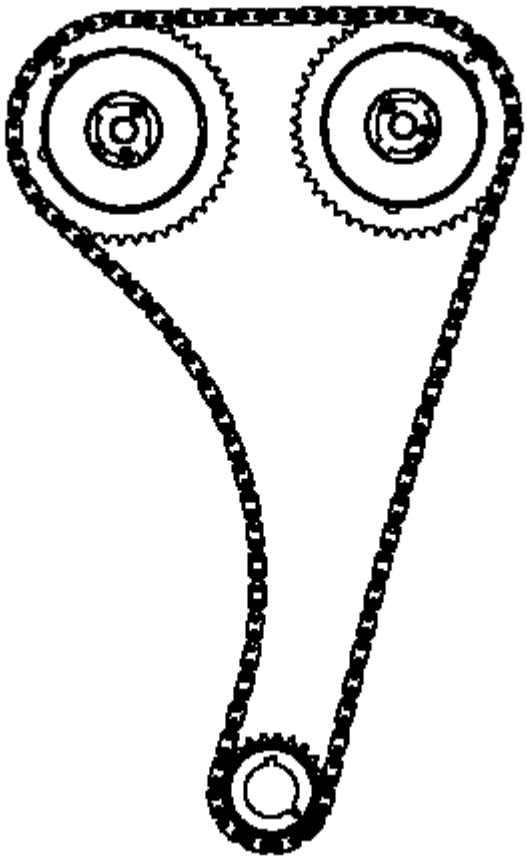

Fig. 90: Identifying Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

26. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not aligned, repeat the portion of the procedure necessary to align the timing marks.

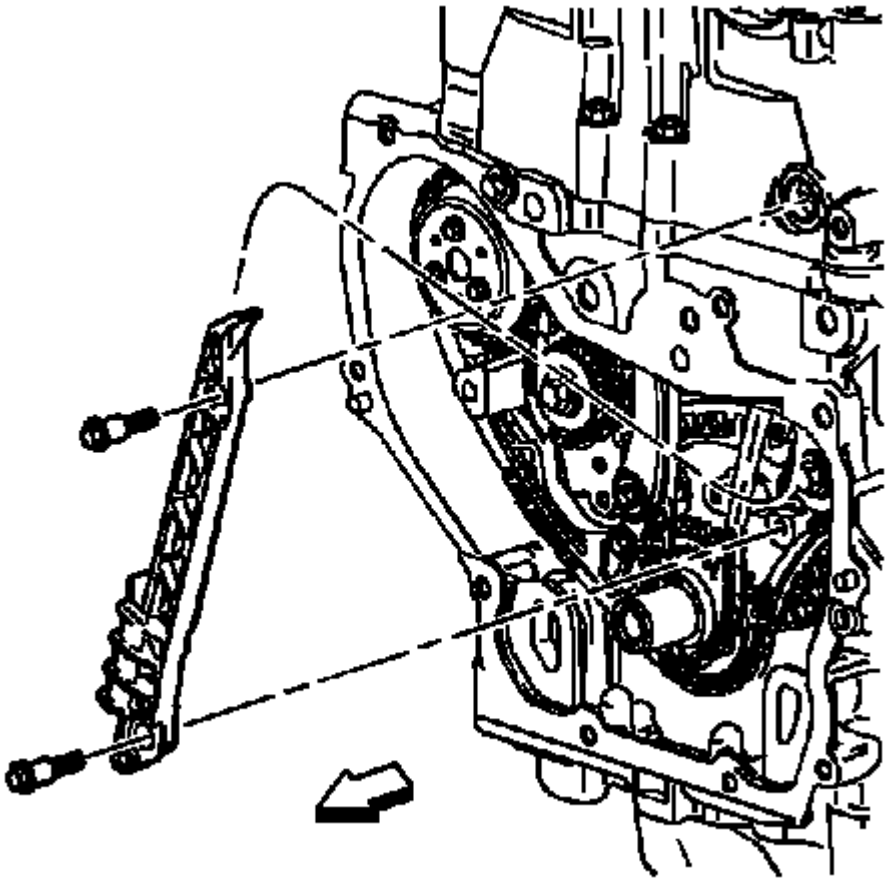

Fig. 91: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

27. Install the fixed timing chain guide and bolts. Tighten the fixed timing chain guide bolts to 12 N.m (106 lb in).

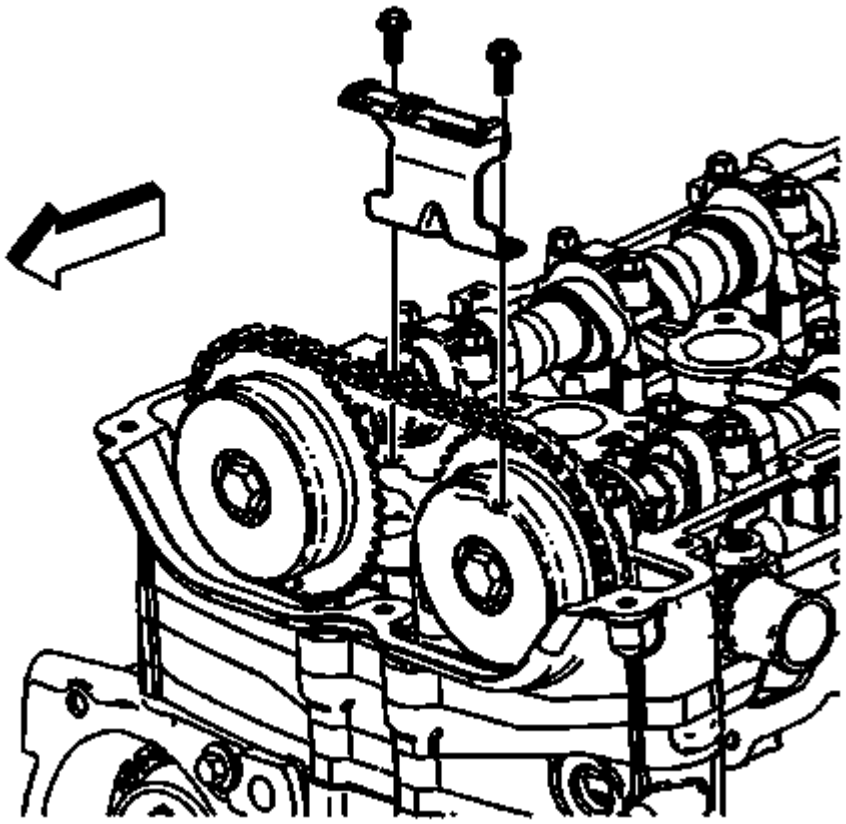

Fig. 92: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

28. Install the upper timing chain guide and bolts. Tighten the upper timing chain guide bolts to 10 N.m (89 lb in).

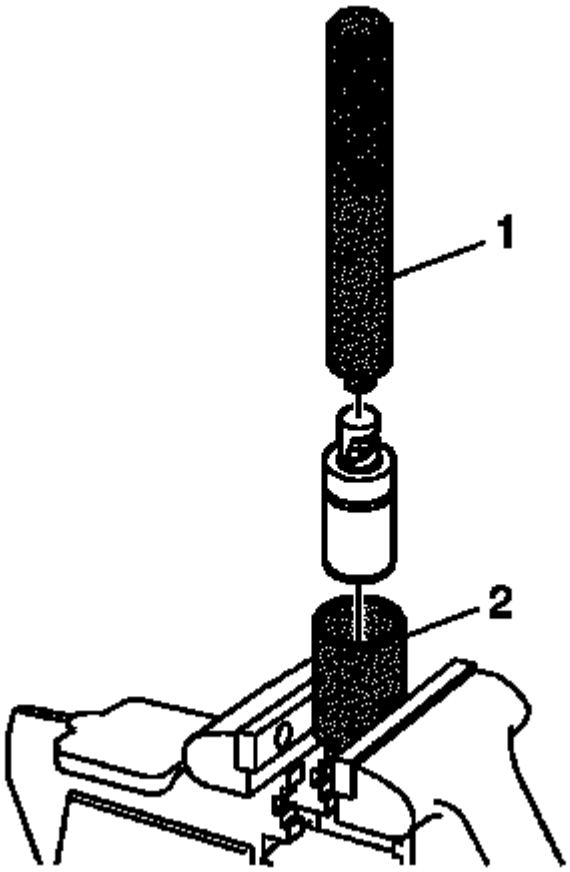

Fig. 93: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

29. Reset the timing chain tensioner by performing the following steps:
    1. Remove the snap ring.
    2. Remove the piston assembly from the body of the timing chain tensioner.
    3. Install the **EN-45027-2:** tool (2) into a vise.
    4. Install the notch end of the piston assembly into the **EN-45027-2:** tool (2).
    5. Using the **EN-45027-1:** tool (1), turn the ratchet cylinder into the piston.
    6. Reinstall the piston assembly into the body of the tensioner.
    7. Install the snap ring.

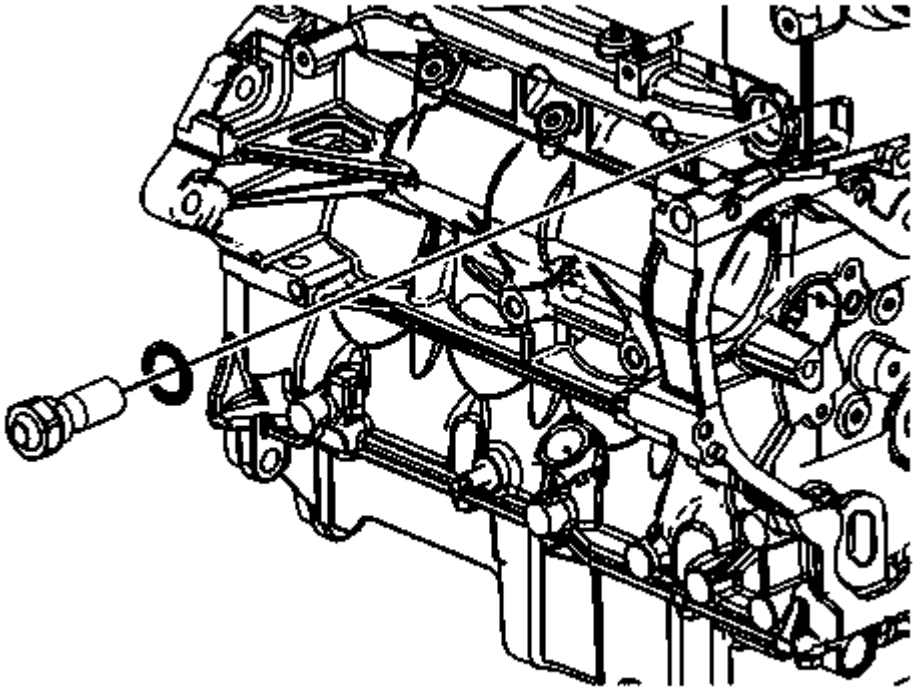

Fig. 94: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

30. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
31. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

NOTE: Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.

32. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
33. The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.

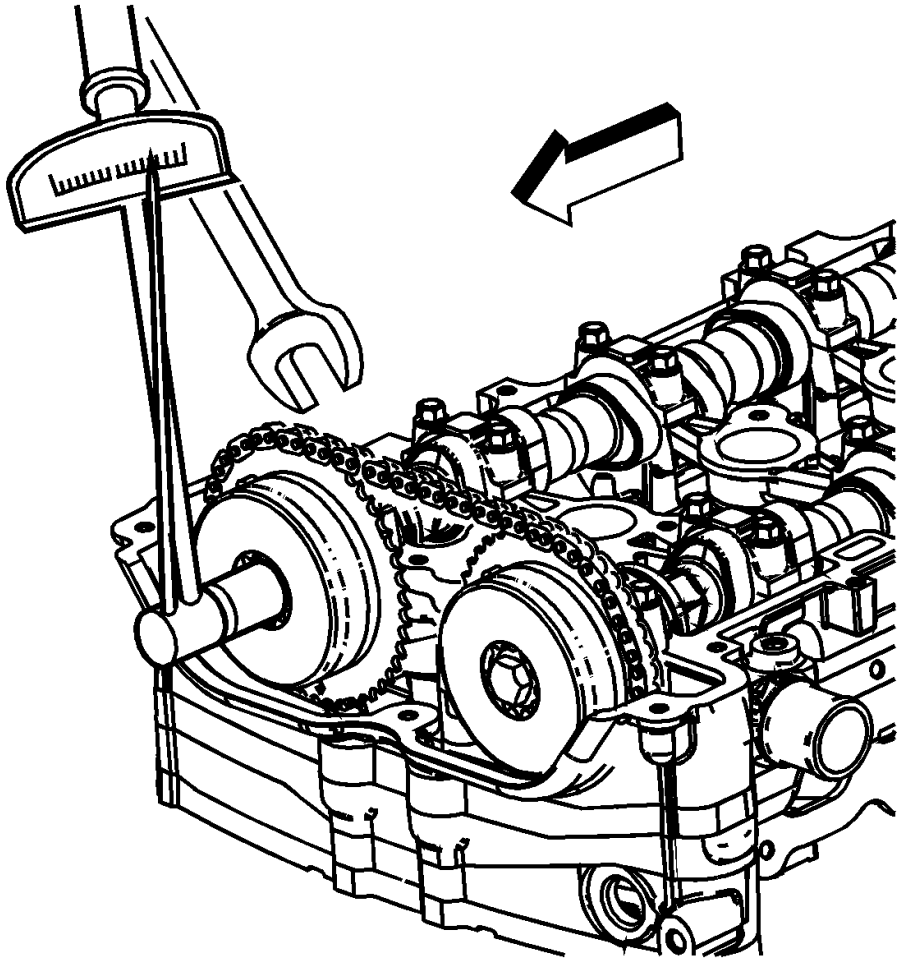

Fig. 95: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

34. Using a 24 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059:** meter.
35. Using a 24 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **EN-45059:** meter.

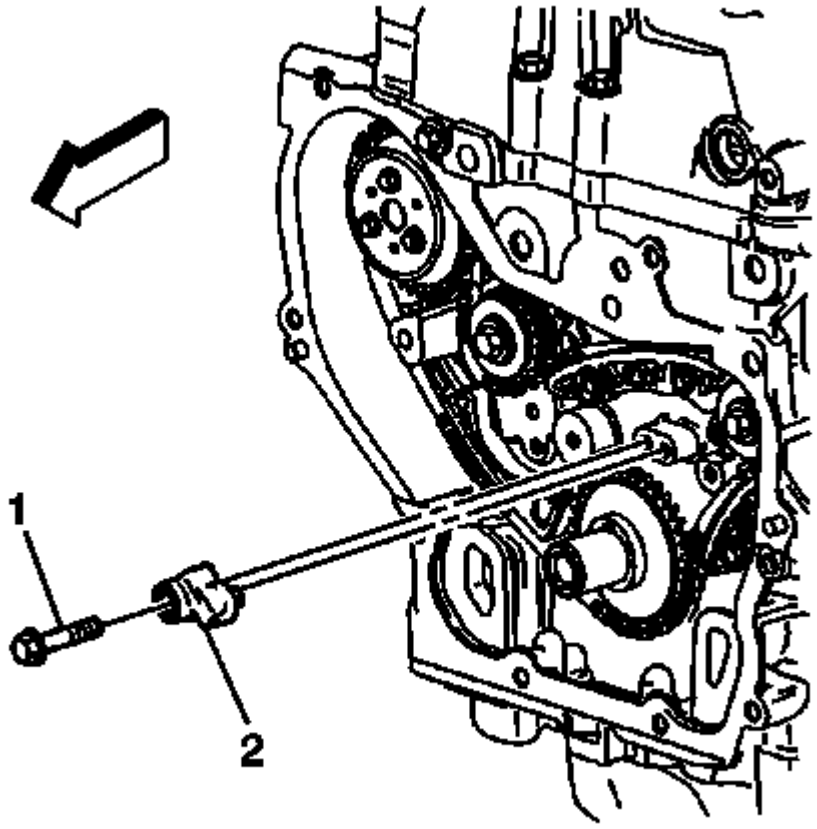

Fig. 96: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

36. Install the timing chain oiling nozzle. Tighten the timing chain oiling nozzle bolt to 10 N.m (89 lb in).

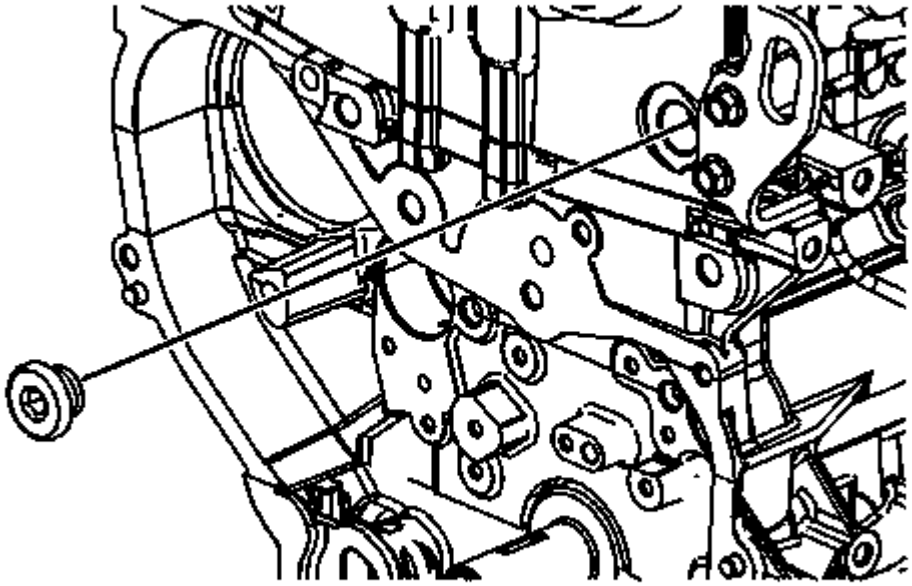

Fig. 97: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

37. Apply sealant compound to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended sealant.
38. Install the timing chain guide bolt access hole plug. Tighten the access hole plug to 90 N.m (66 lb ft).
39. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
40. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
41. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement** .

CAMSHAFT COVER REPLACEMENT

REMOVAL PROCEDURE

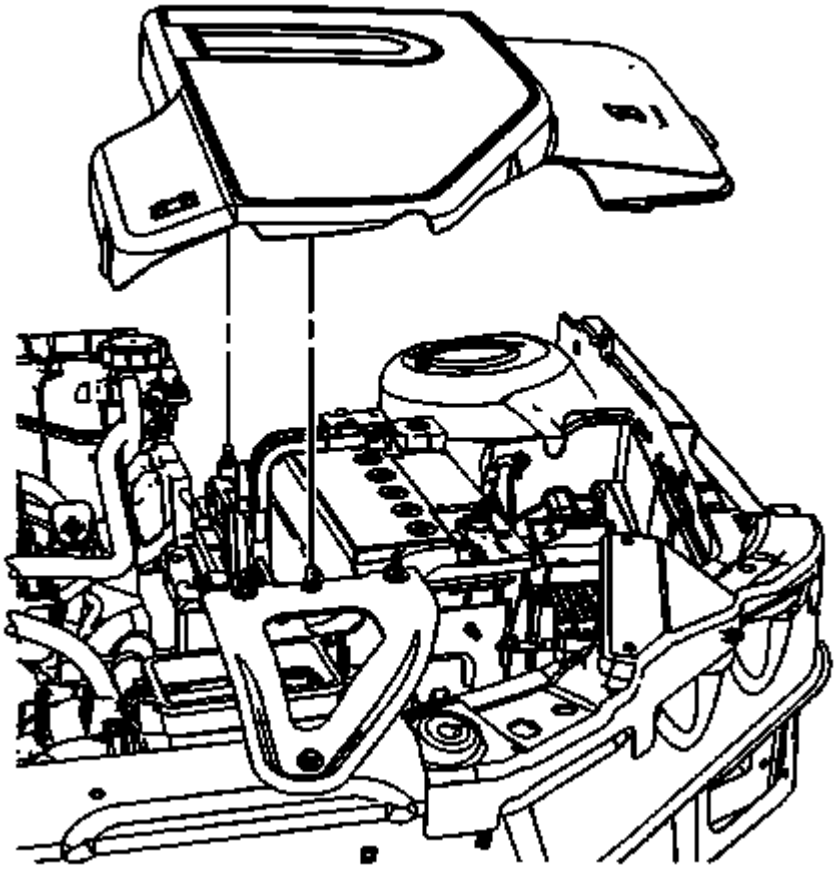

Fig. 98: Battery Box Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
2. Remove the battery box cover, LAT only.

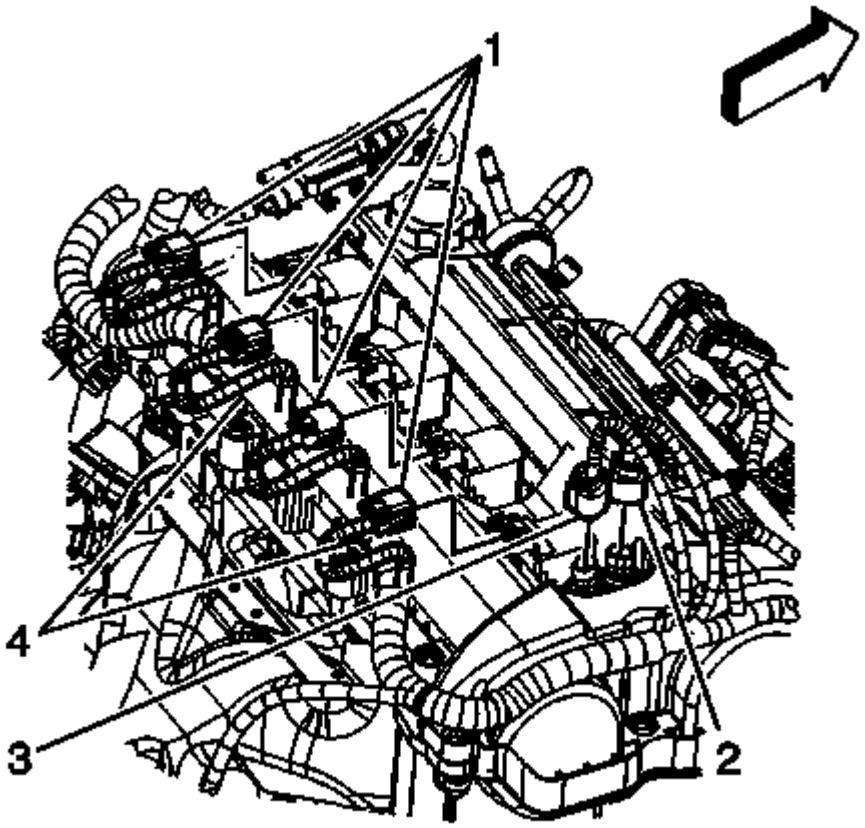

Fig. 99: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the engine wiring harness electrical connectors (2, 3) from the intake and exhaust camshaft position actuator solenoid valves.
4. Remove the ignition coils. Refer to **Ignition Coil Replacement (LE5, LE9, or LAF)** .
5. Remove the engine harness clips (4) from the cover.
6. Reposition the engine wiring harness out of the way.

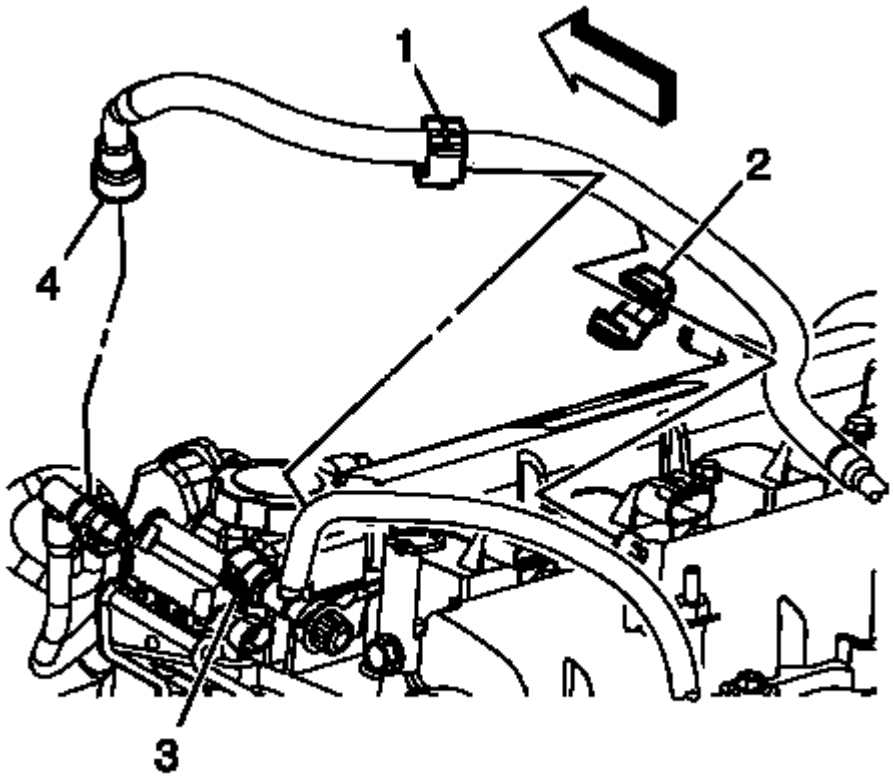

Fig. 100: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

7. Remove the fuel feed line retainers (1, 2) from the engine brackets.

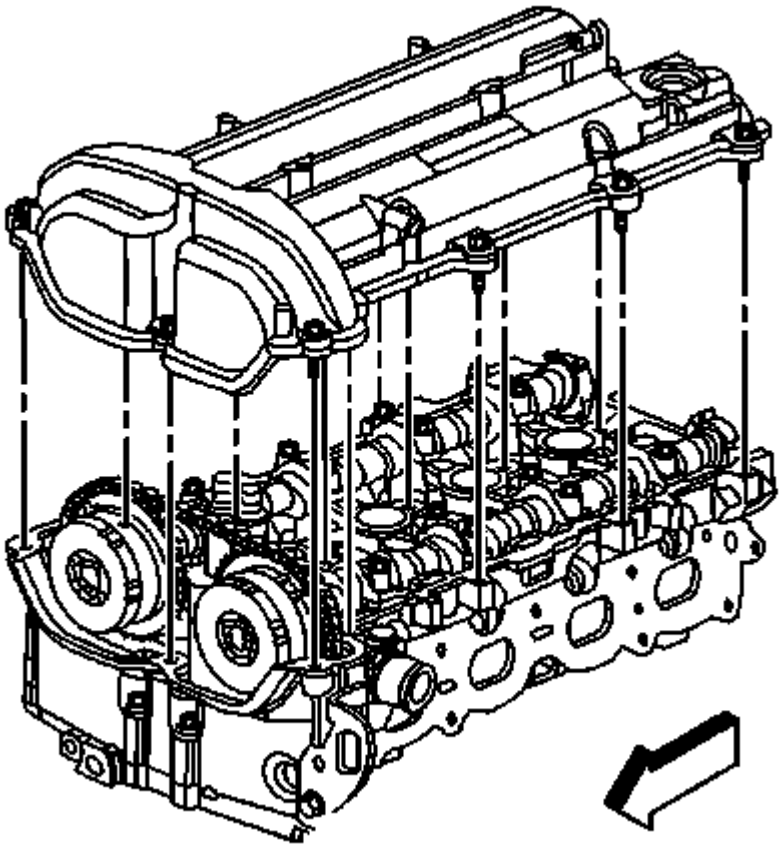

Fig. 101: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

8. Remove the camshaft cover bolts.
9. Remove the camshaft cover.

INSTALLATION PROCEDURE

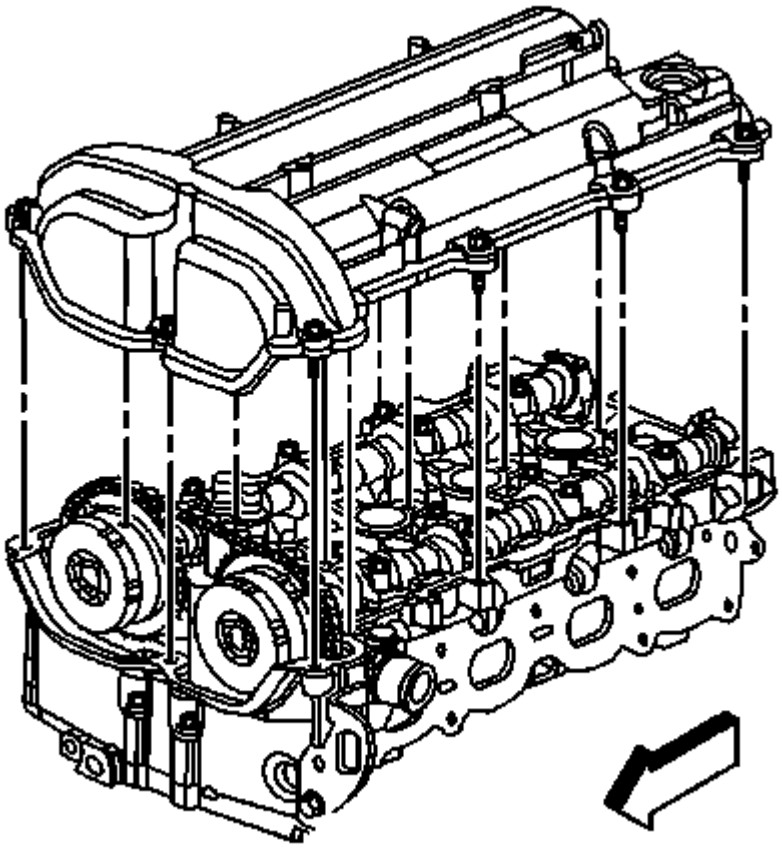

Fig. 102: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the camshaft cover and bolts. Tighten the bolts to 10 N.m (89 lb in).

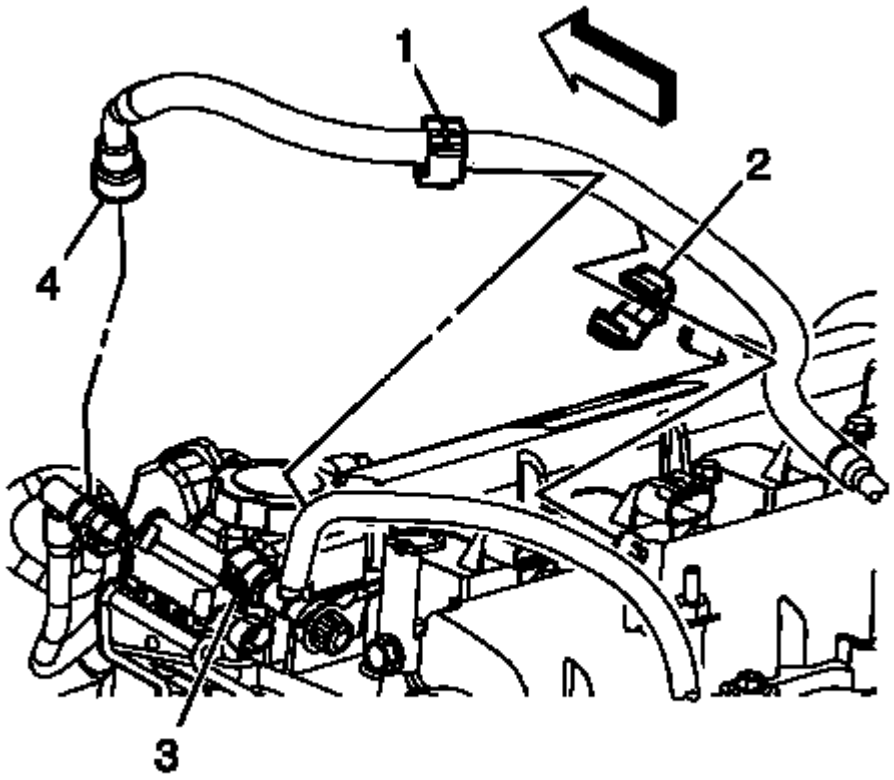

Fig. 103: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

2. Install the feed line retainers (1, 2) to the engine brackets.

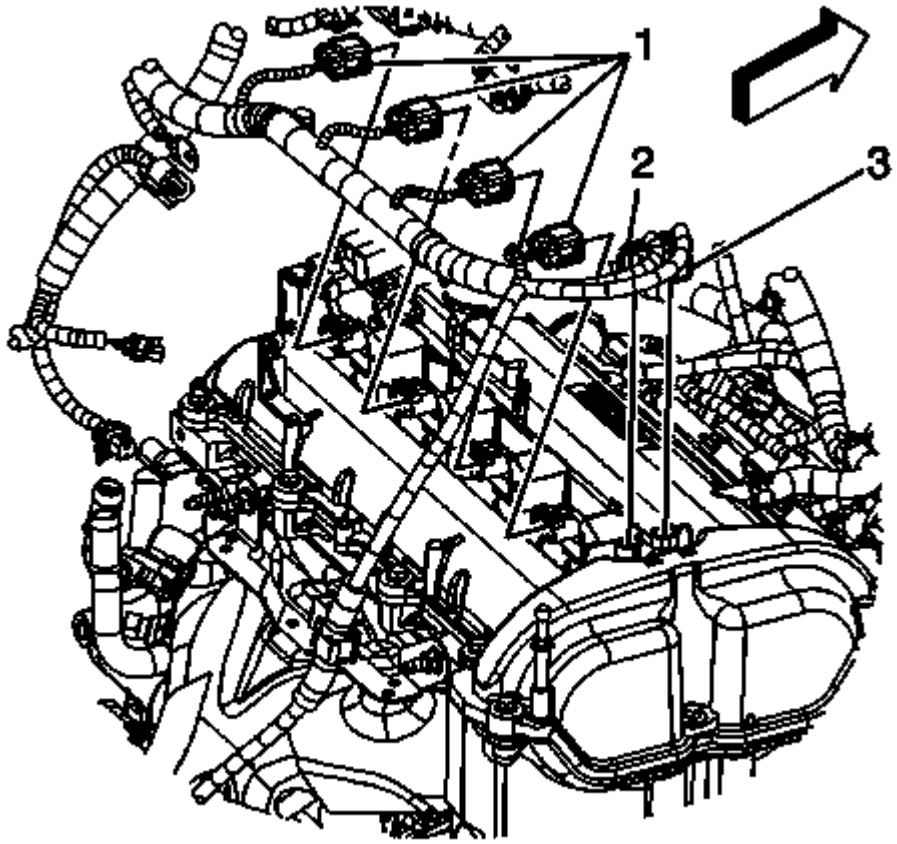

Fig. 104: Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Install the ignition coils. Refer to **Ignition Coil Replacement (LE5, LE9, or LAF)** .
4. Position the engine wiring harness and install the clips (4) to the cover.
5. Connect the engine wiring harness electrical connectors (2, 3) to the intake and exhaust camshaft position actuator solenoid valves.

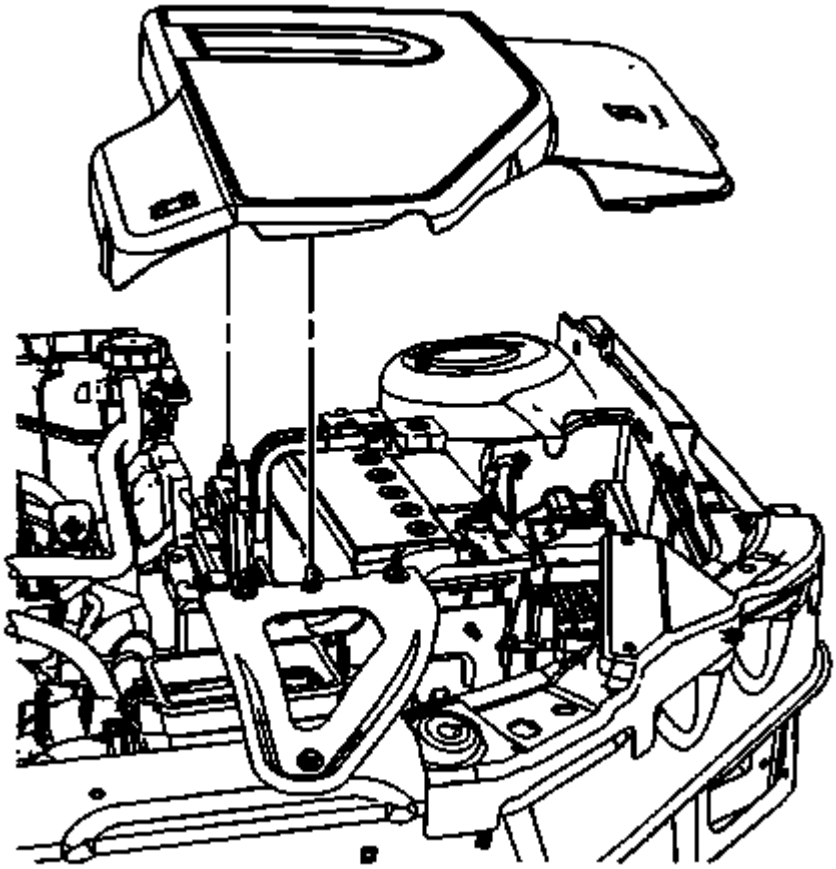

Fig. 105: Battery Box Cover
Courtesy of GENERAL MOTORS CORP.

6. Install the battery box cover, LAT only.
7. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .

TIMING CHAIN TENSIONER REPLACEMENT

SPECIAL TOOLS

J 45027 Tensioner Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (LE5, LE9, LY7)** .
2. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

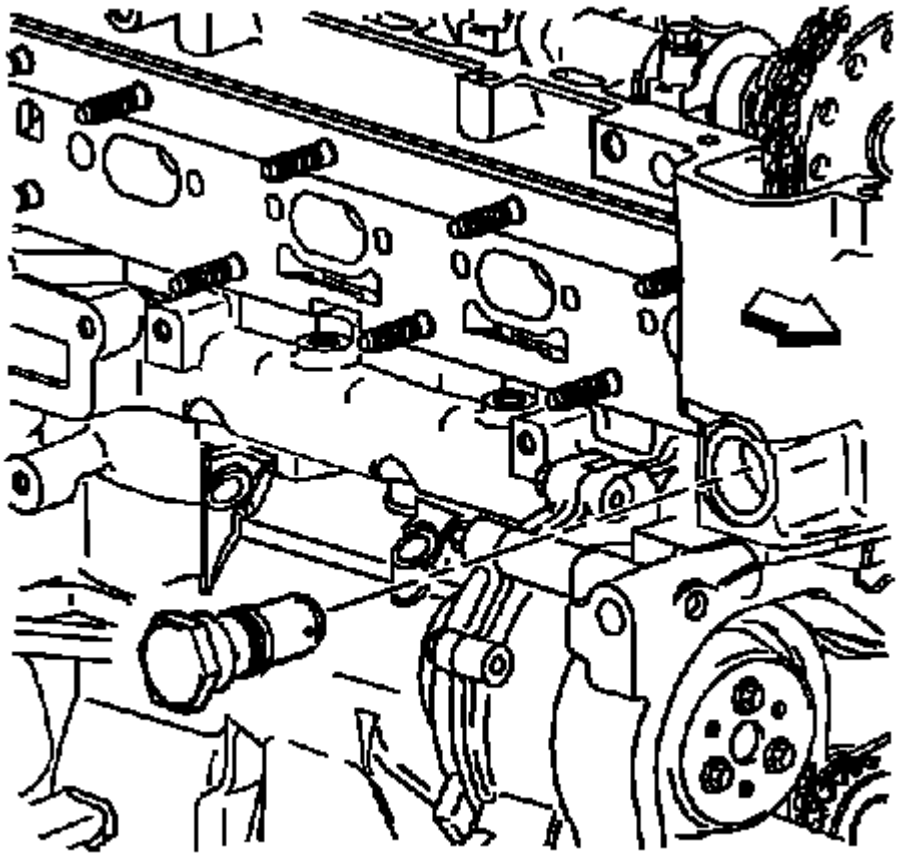

Fig. 106: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain tensioner.
4. Remove the seal from the tensioner.

INSTALLATION PROCEDURE

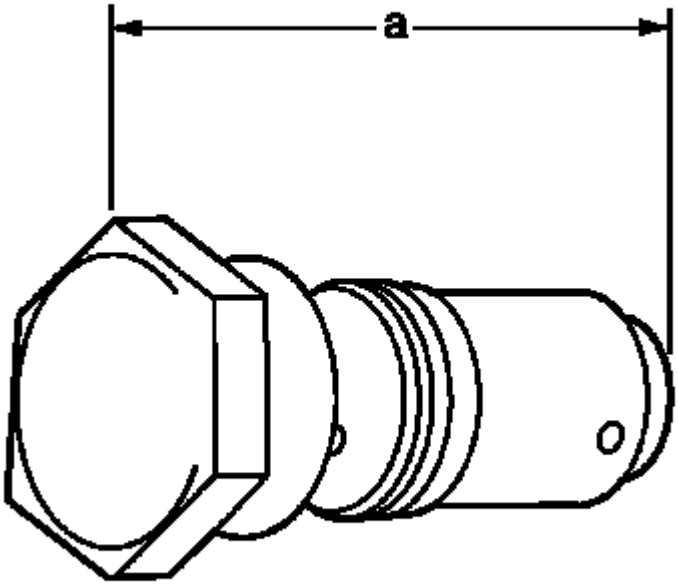

Fig. 107: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner or O-ring seal as applicable.
2. Measure the timing chain tensioner assembly from end to end. If the timing chain tensioner is to be replaced, a new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

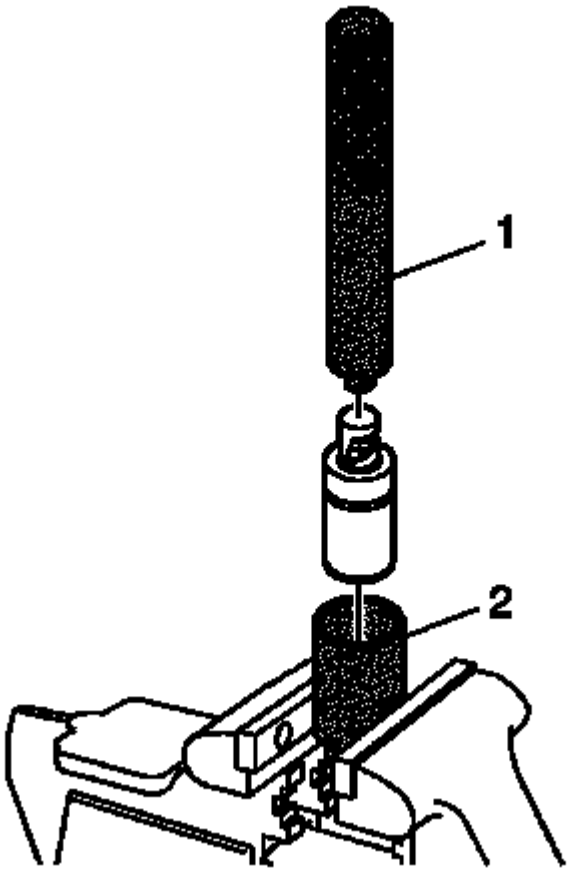

Fig. 108: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. If the timing chain tensioner is not in the compressed state, perform the following steps:
    1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
    2. Install the J 45027-2 (2) into a vise.
    3. Install the notch end of the piston assembly into the J 45027-2 (2).
    4. Using the J 45027-1 (1), turn the ratchet cylinder into the piston.

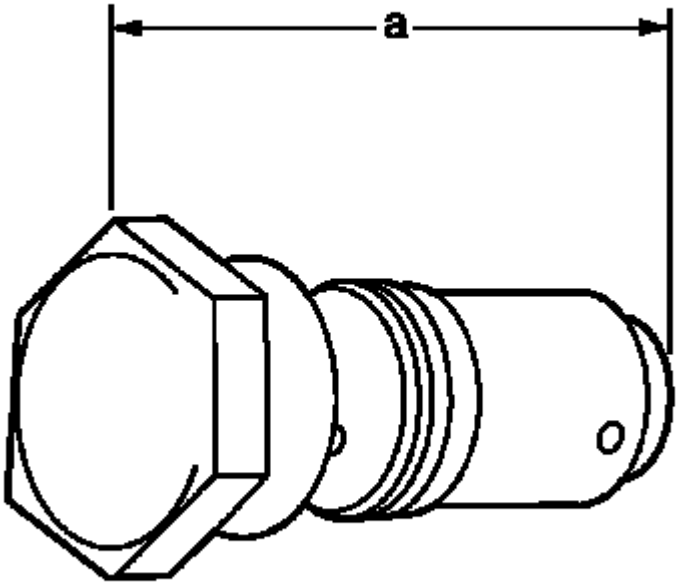

Fig. 109: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

4. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris out with a lint-free cloth.
5. Install the compressed piston assembly back into the timing chain tensioner body until it stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, it will activate the tensioner, which will then need to be reset again.
6. At this point the tensioner should measure approximately 72 mm (2.83 in) (a) from end to end. If the tensioner does not read 72 mm (2.83 in) (a) from end to end, repeat steps 3-5.

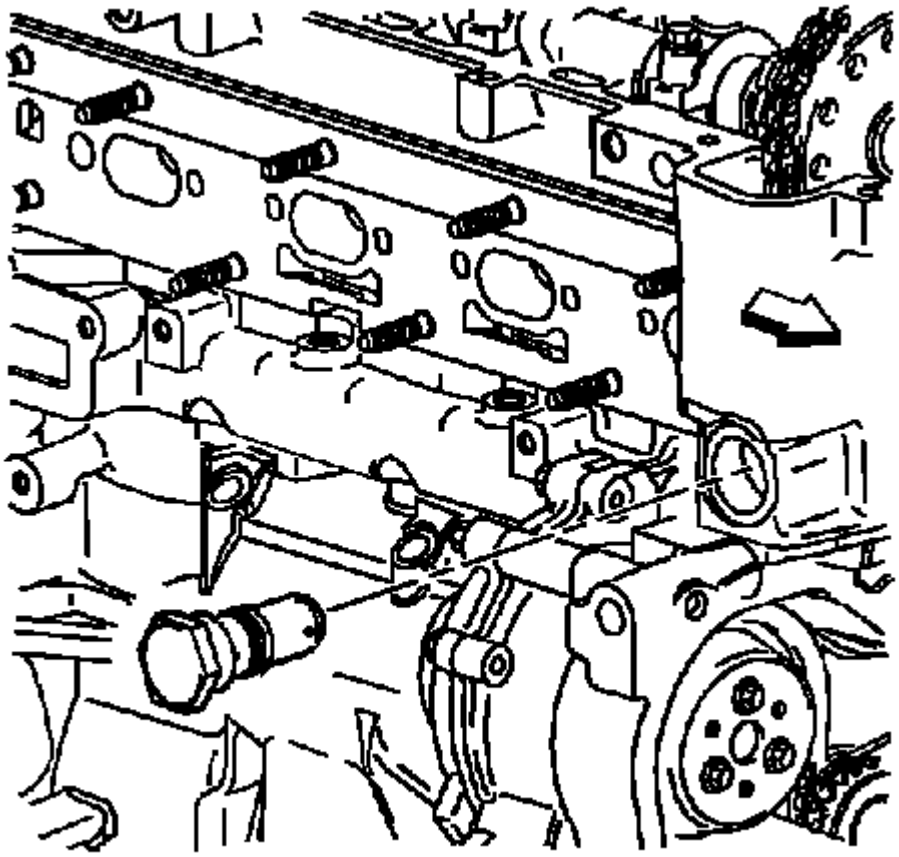

Fig. 110: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

CAUTION: Refer to Fastener Caution .

NOTE: Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.

8. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
9. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.
10. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
11. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (LE5, LE9, LY7)** .

INTAKE CAMSHAFT AND VALVE LIFTER REPLACEMENT

REMOVAL PROCEDURE

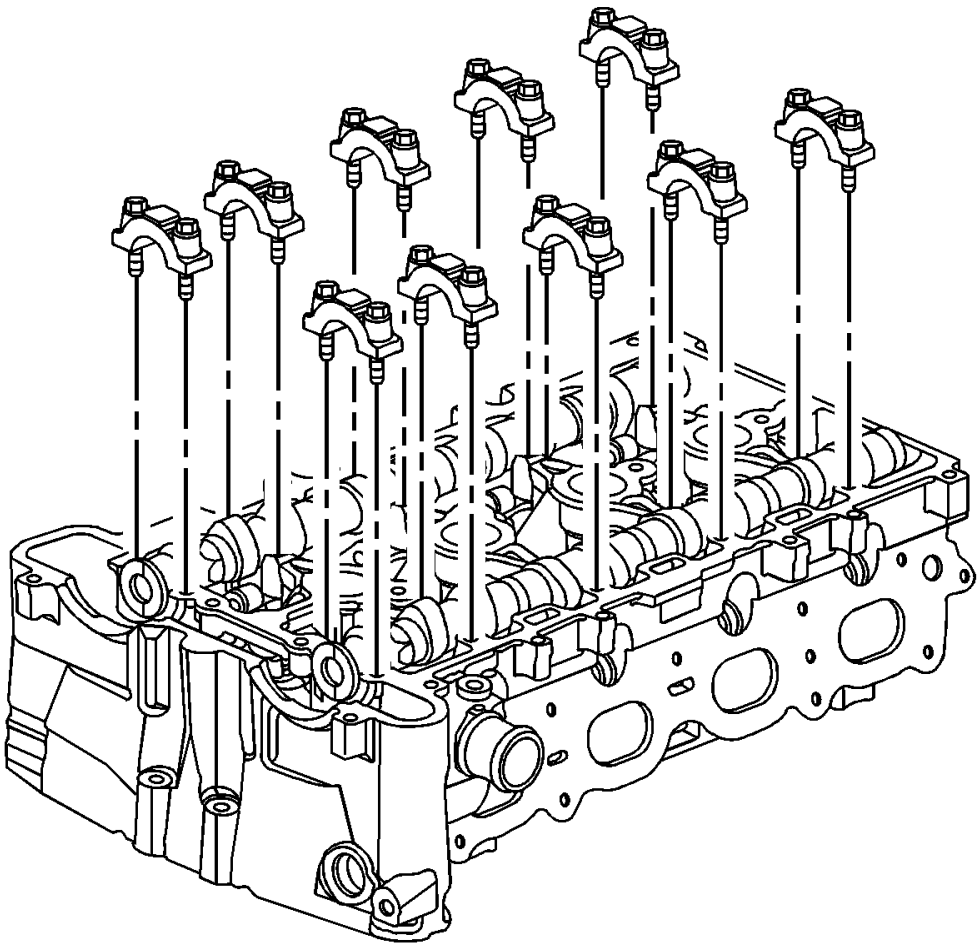

Fig. 111: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

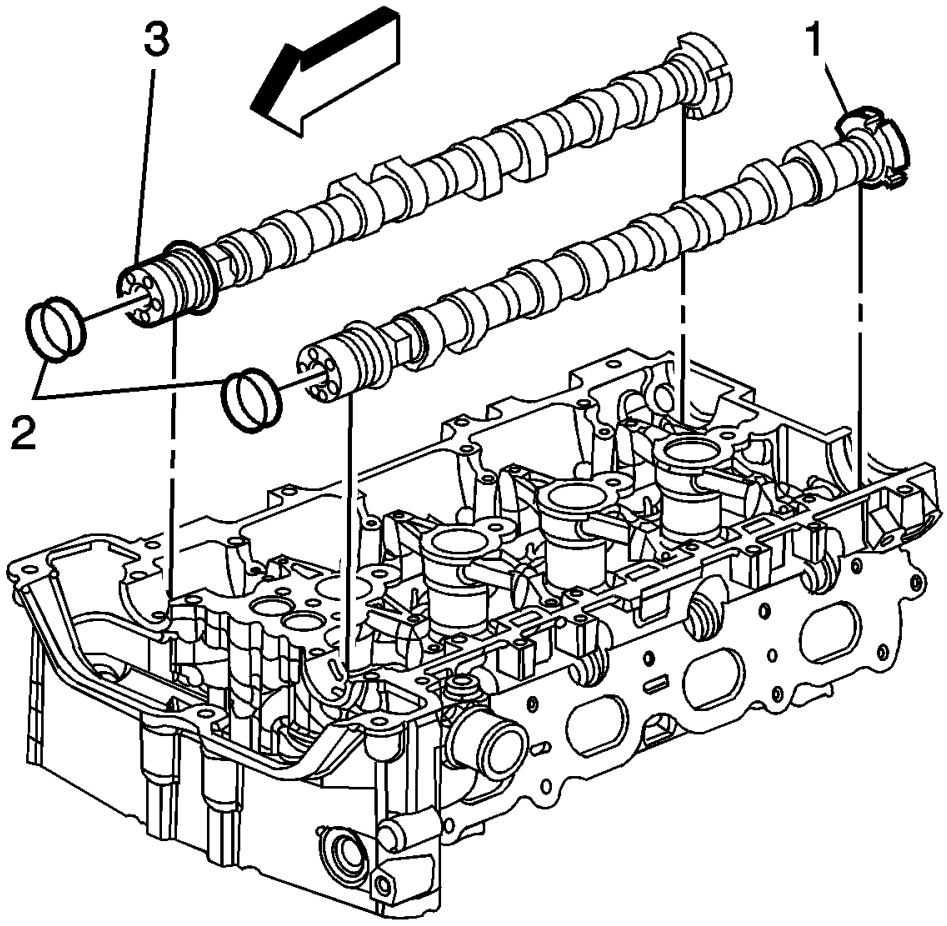

Fig. 112: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake camshaft (1).

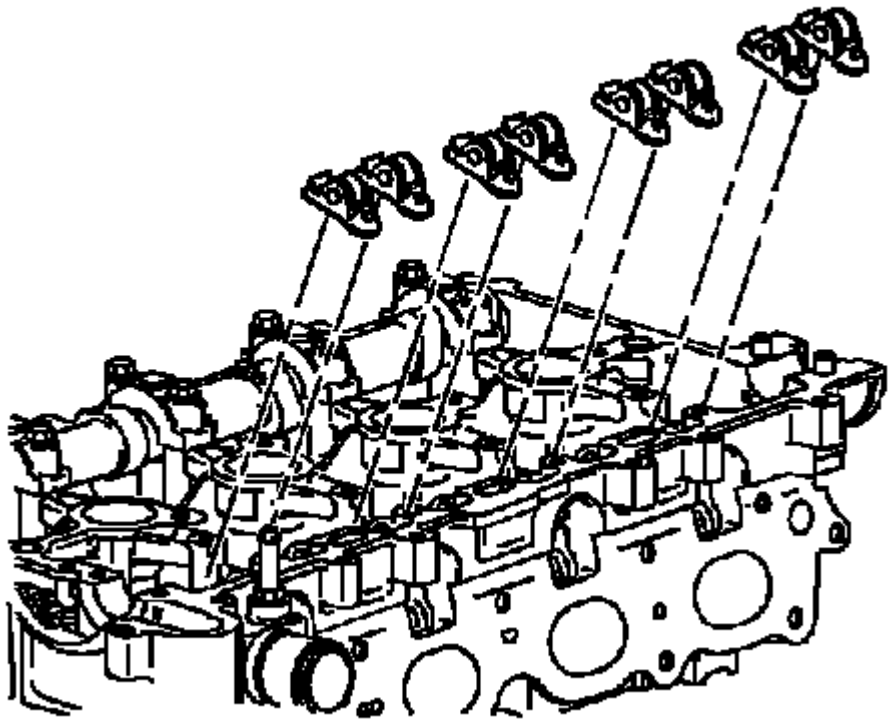

Fig. 113: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

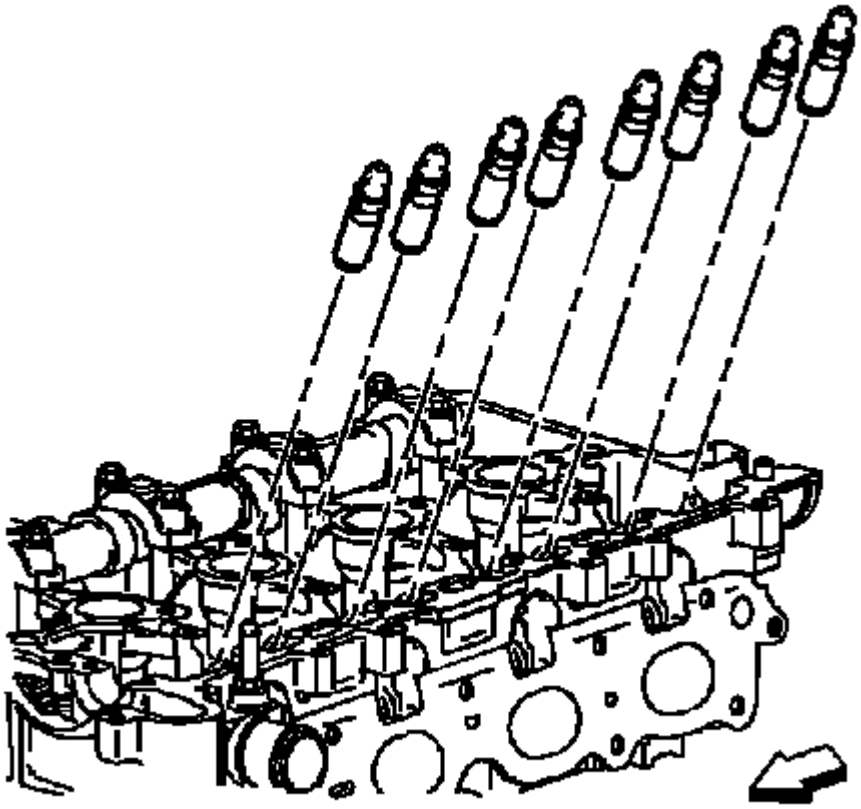

Fig. 114: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

INSTALLATION PROCEDURE

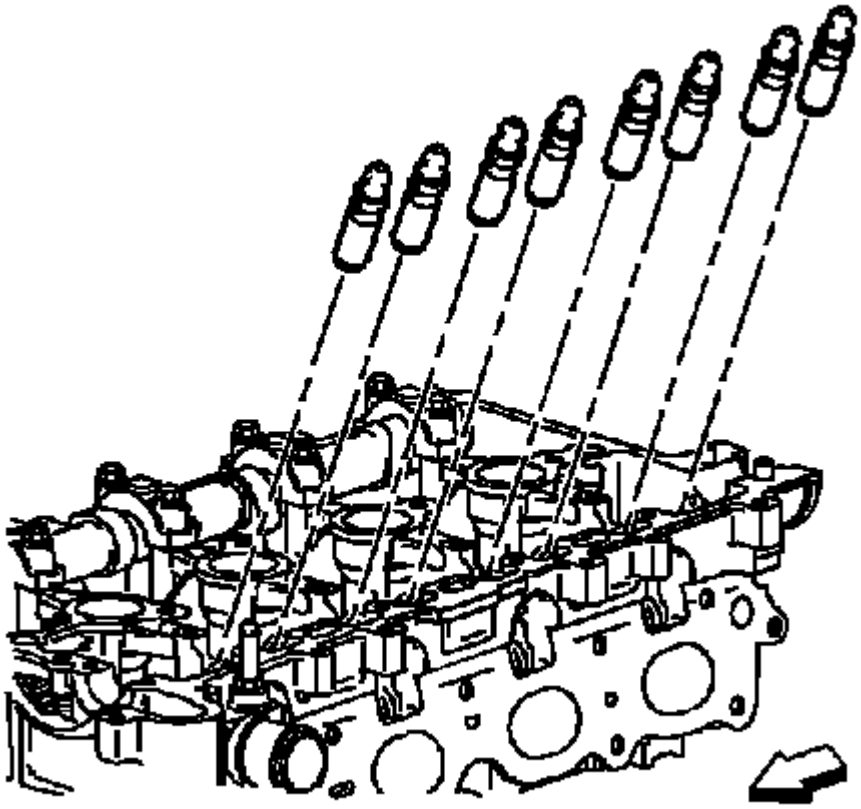

Fig. 115: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

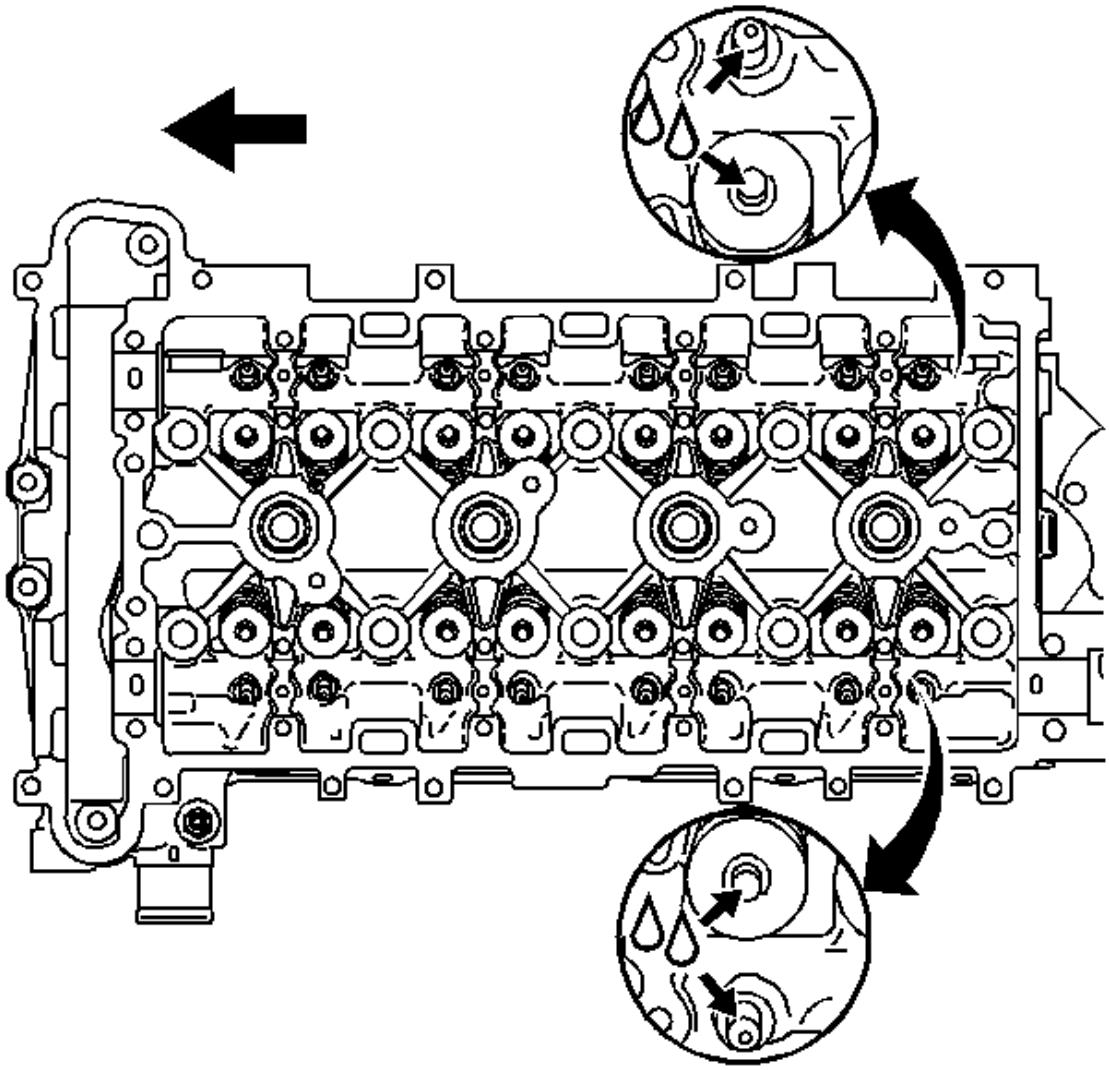

Fig. 116: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

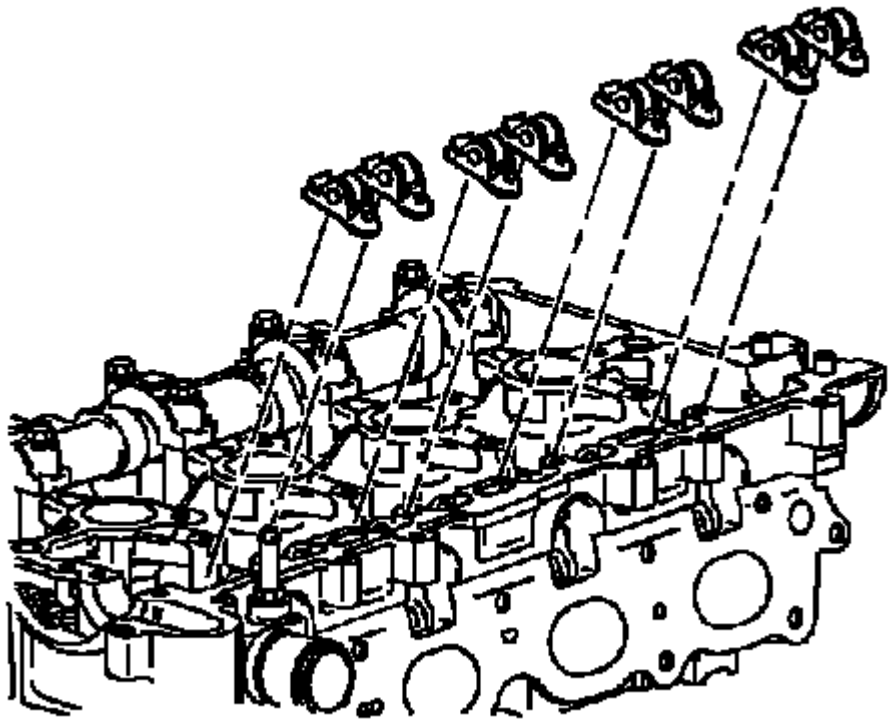

Fig. 117: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers MUST be returned to their original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the camshaft roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

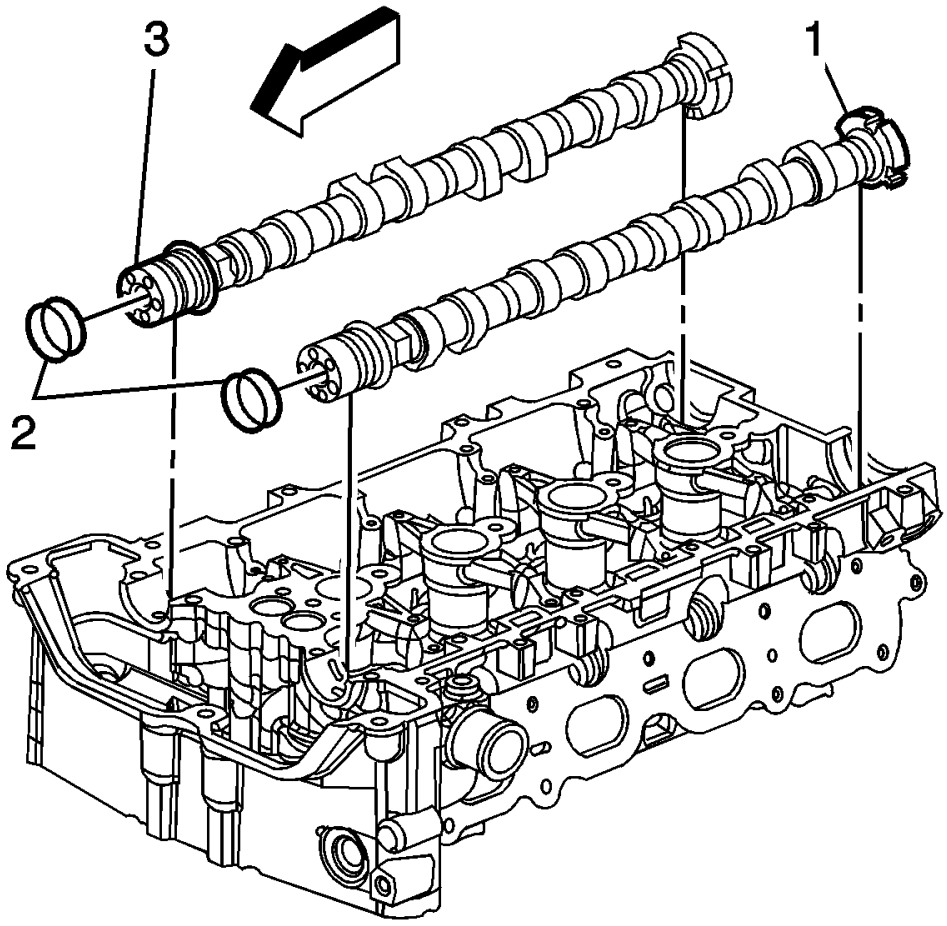

Fig. 118: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft (1) and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

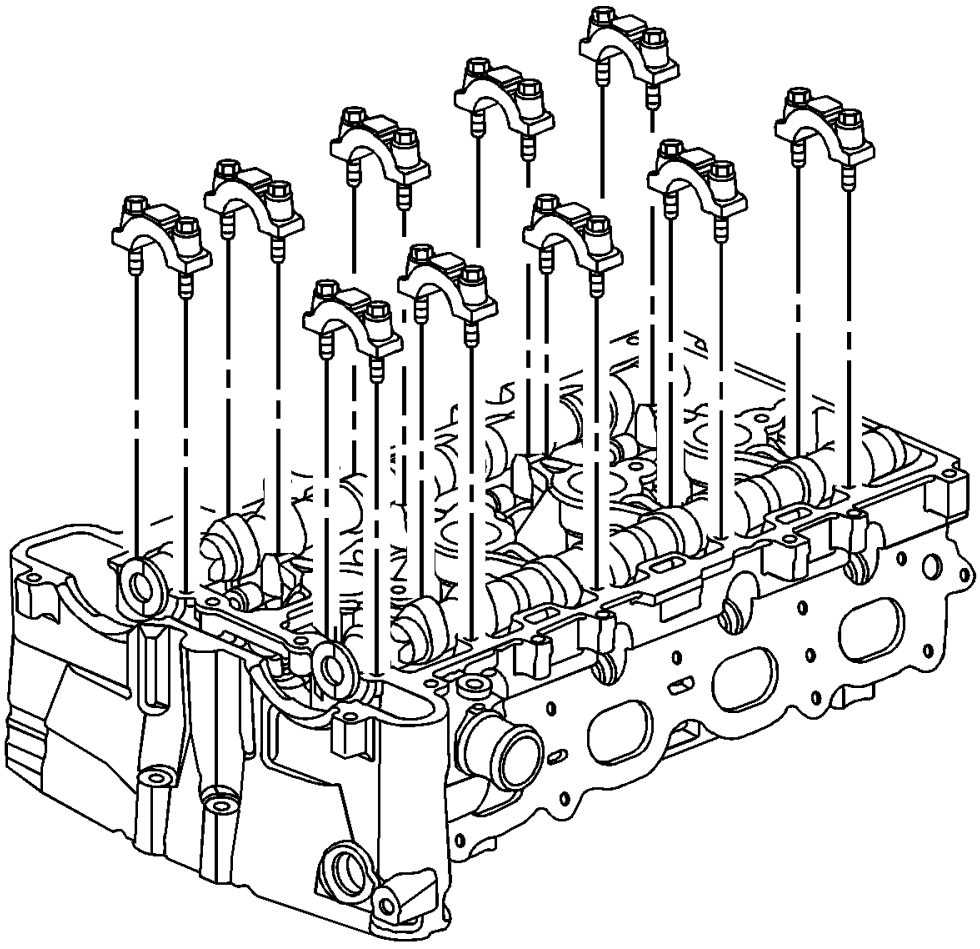

Fig. 119: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

EXHAUST CAMSHAFT AND VALVE LIFTER REPLACEMENT

REMOVAL PROCEDURE

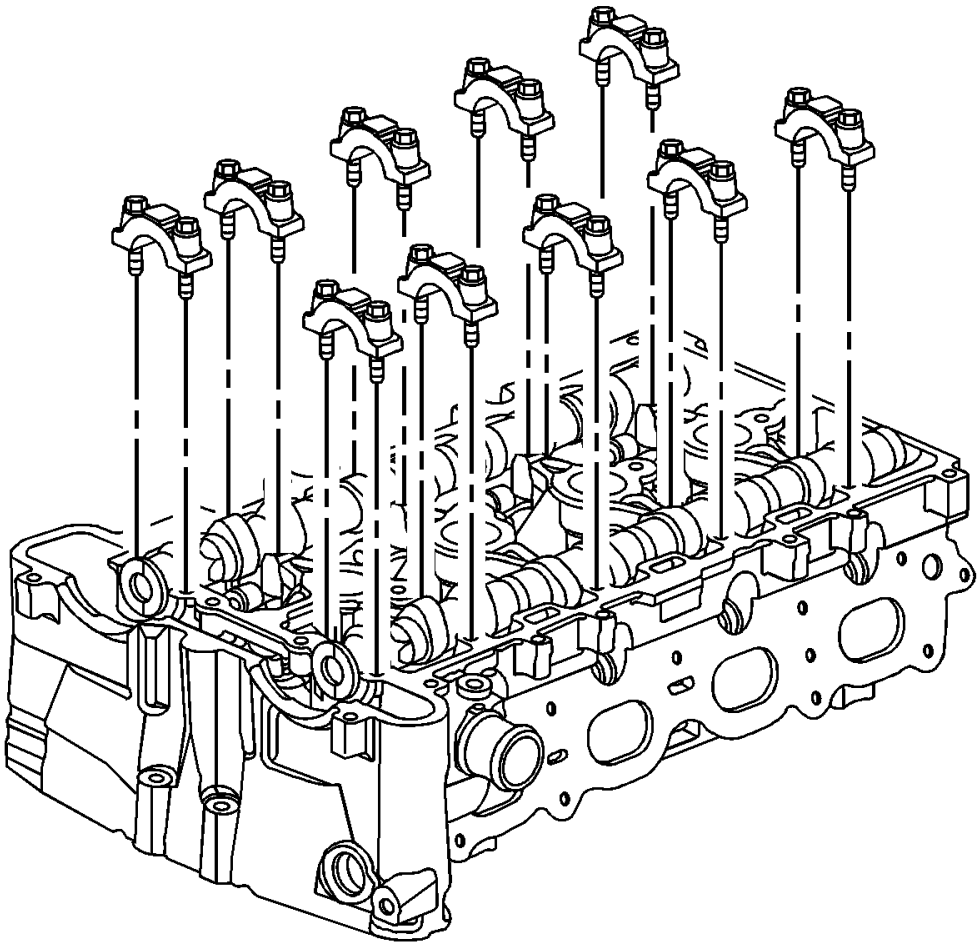

Fig. 120: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

NOTE: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

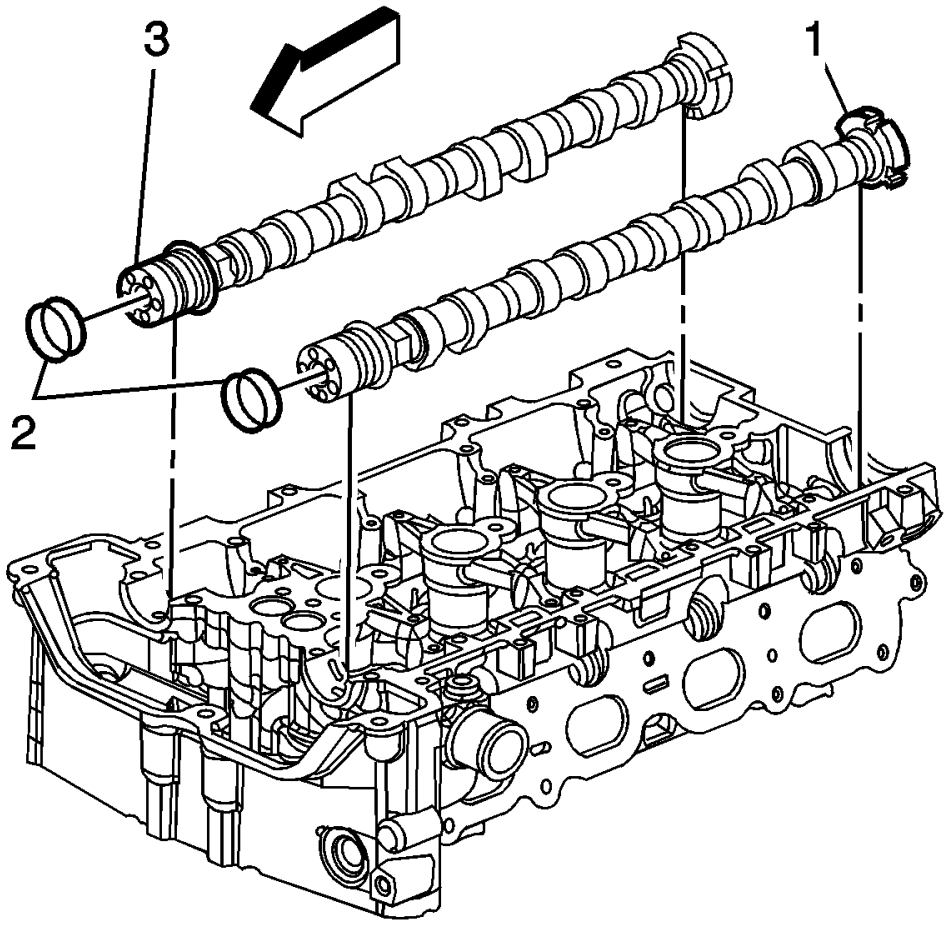

Fig. 121: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft (3).

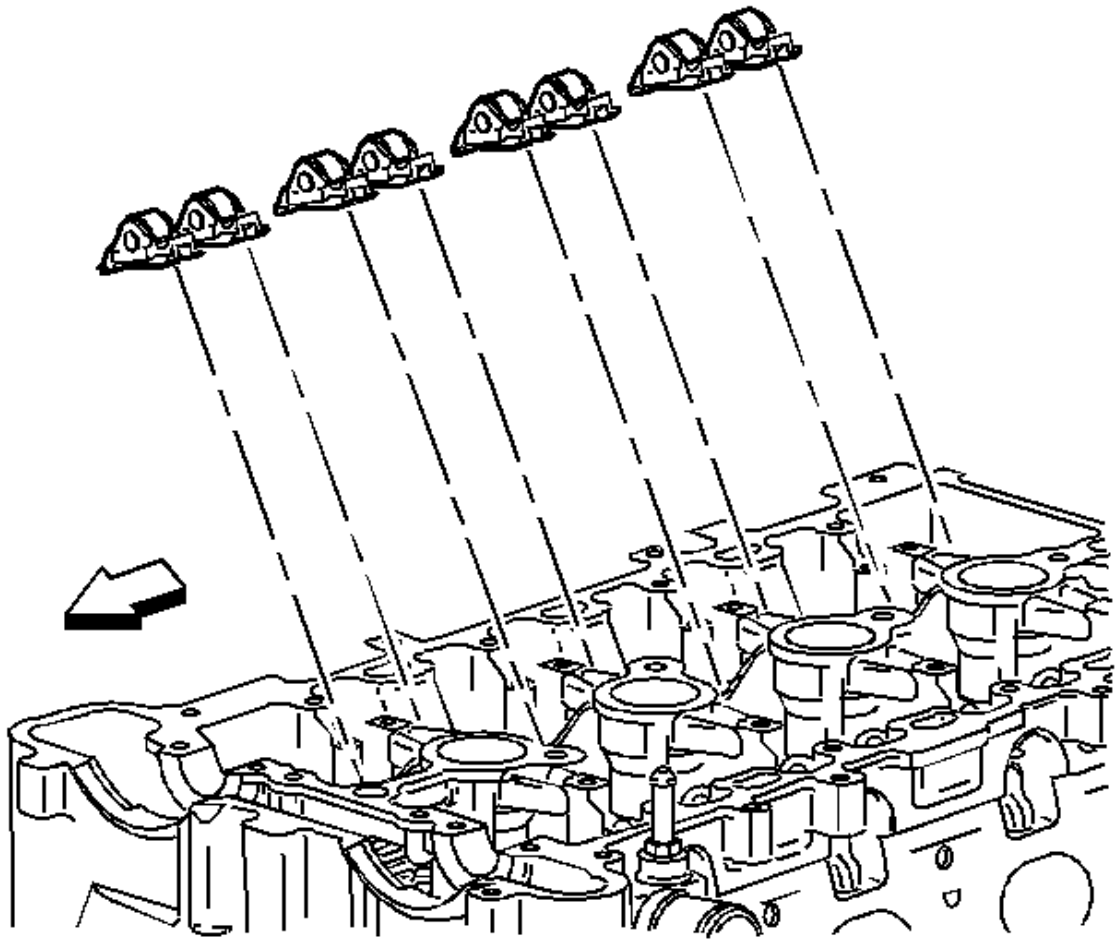

Fig. 122: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

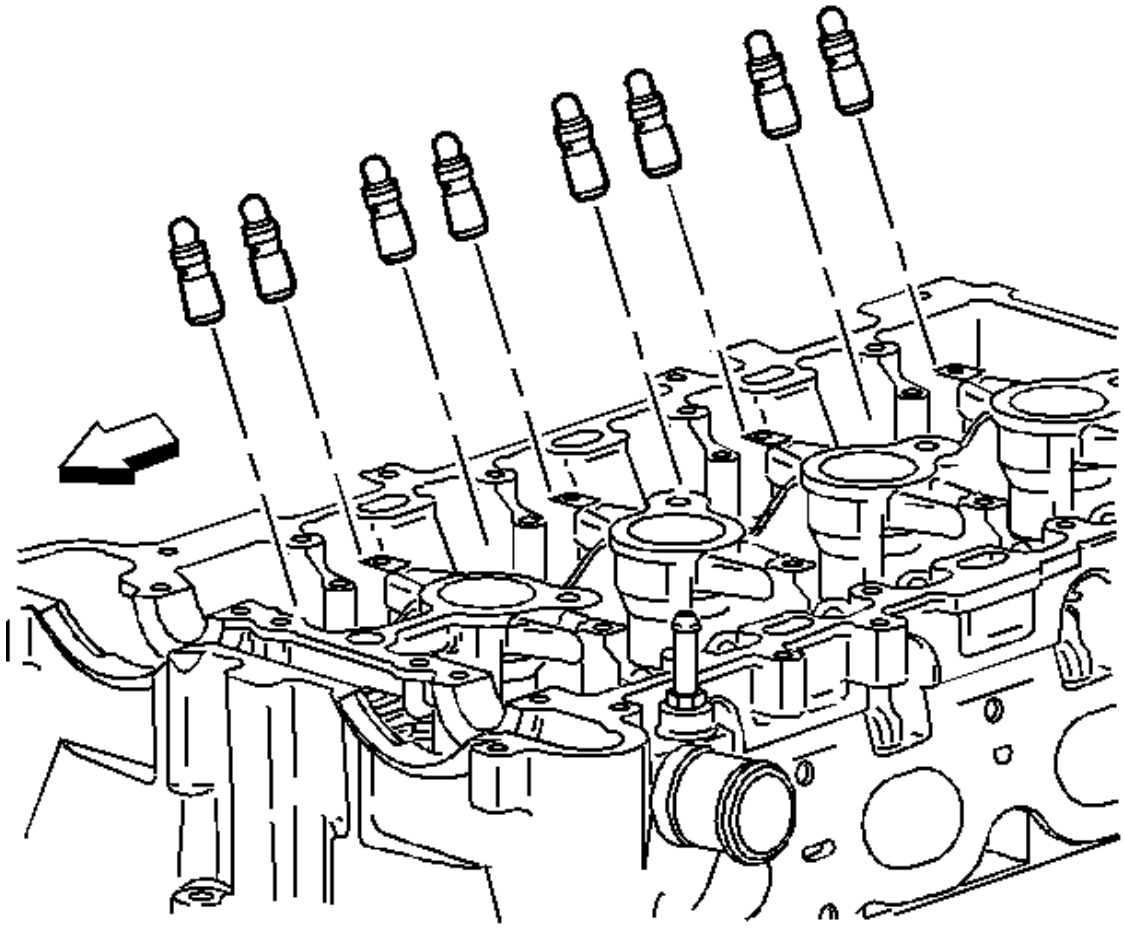

Fig. 123: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

INSTALLATION PROCEDURE

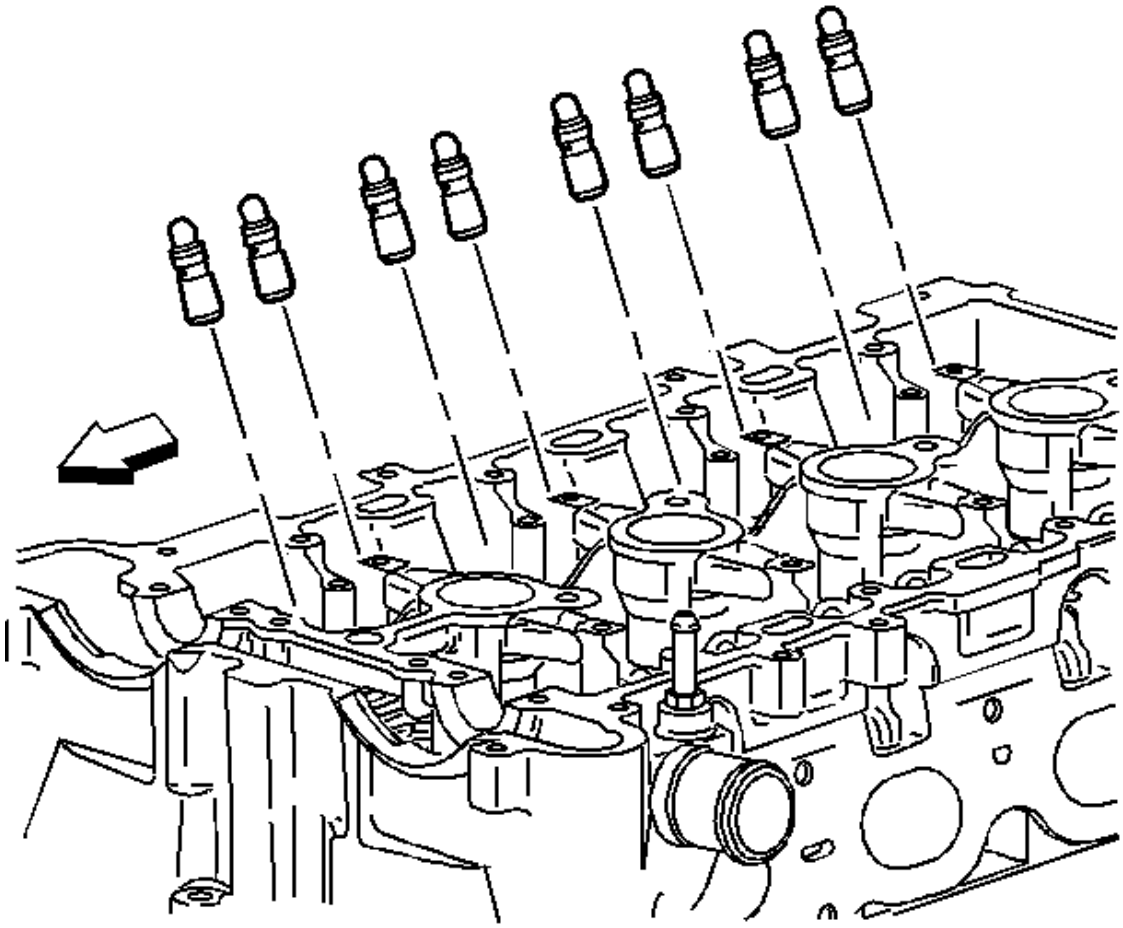

Fig. 124: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

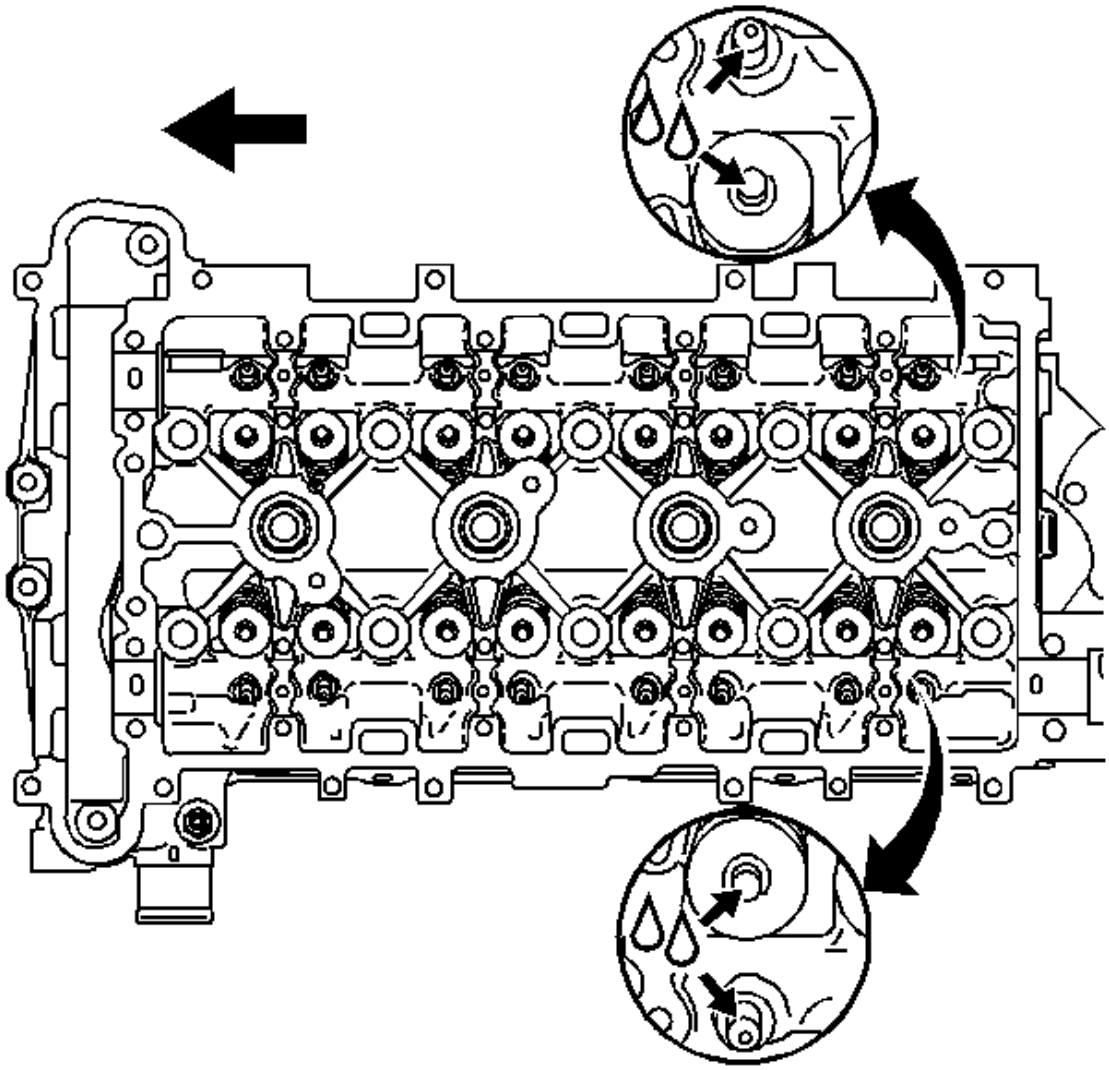

Fig. 125: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with **Adhesives, Fluids, Lubricants, and Sealers** .

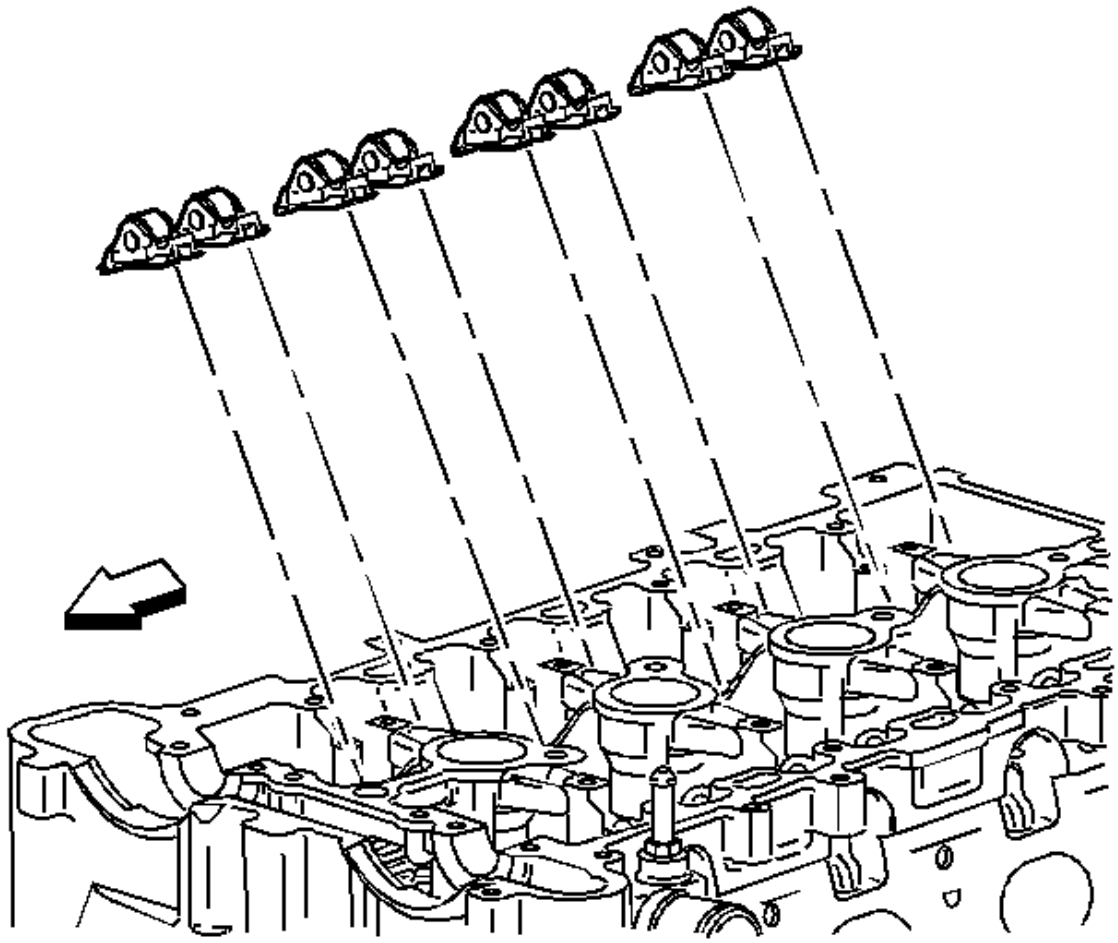

Fig. 126: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: Used roller followers MUST be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

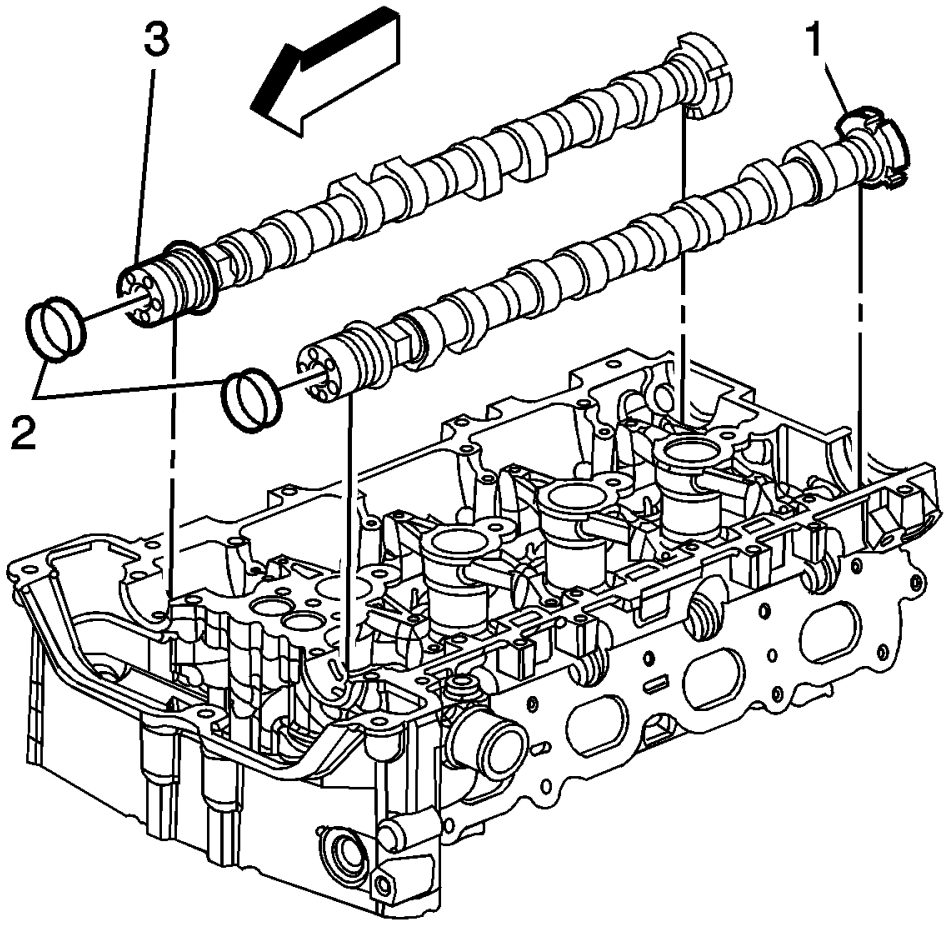

Fig. 127: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft (3). Lubricate with **Adhesives, Fluids, Lubricants, and Sealers** .

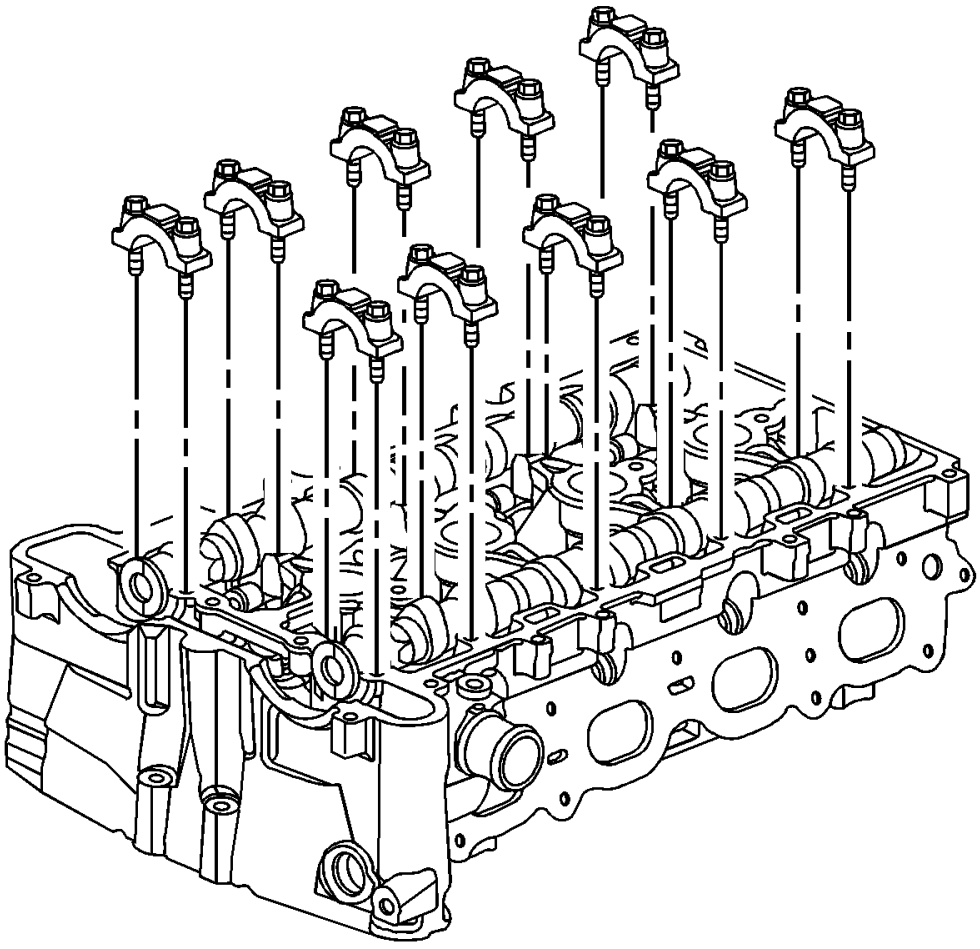

Fig. 128: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated. Tighten the bolts to 10 N.m (89 lb in).
8. Install the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

CAMSHAFT POSITION INTAKE ACTUATOR REPLACEMENT

SPECIAL TOOLS

- **EN-45059:** Angle Meter

- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

For equivalent regional tools, refer to **Special Tools** .

REMOVAL PROCEDURE

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

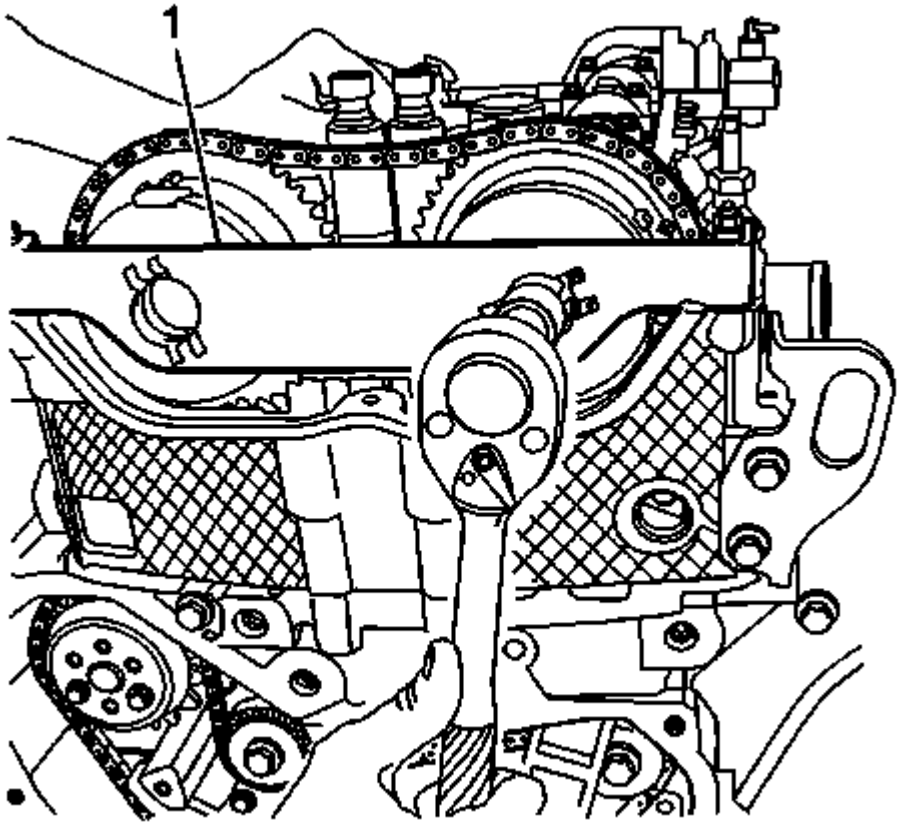

Fig. 129: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953:** retention tool (1).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but DO NOT remove the intake camshaft actuator bolt.

6. Remove the **EN-48953:** locking tool (1).
7. Clean the timing chain and gears with solvent.

NOTE: Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

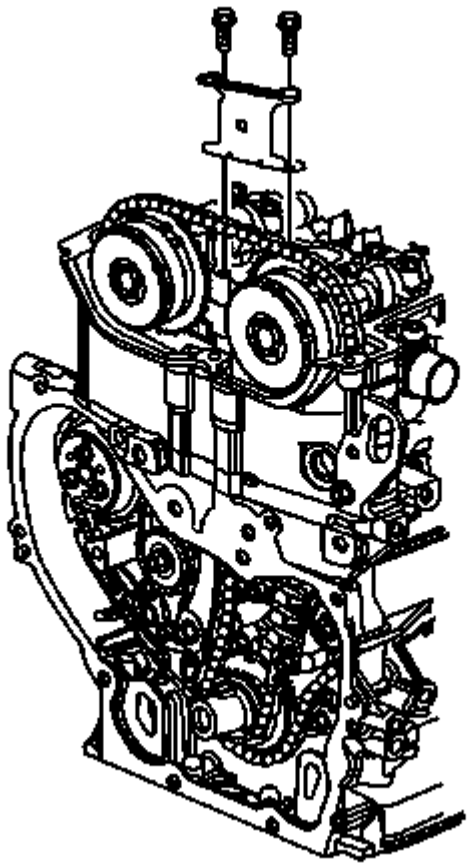

Fig. 130: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

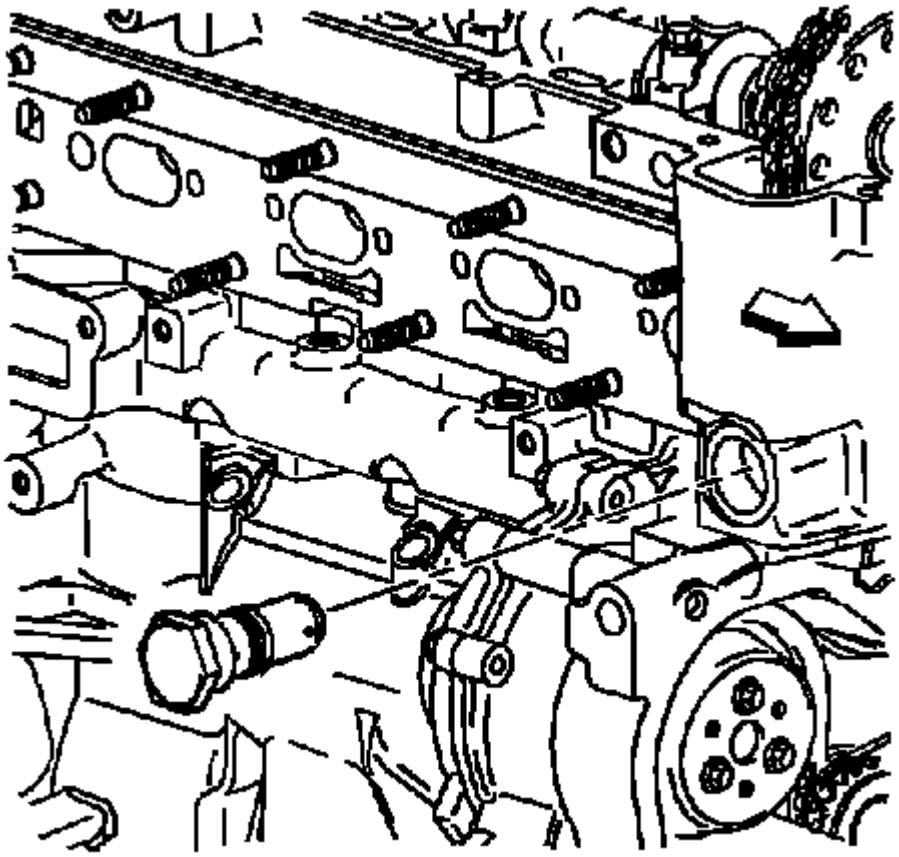

Fig. 131: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

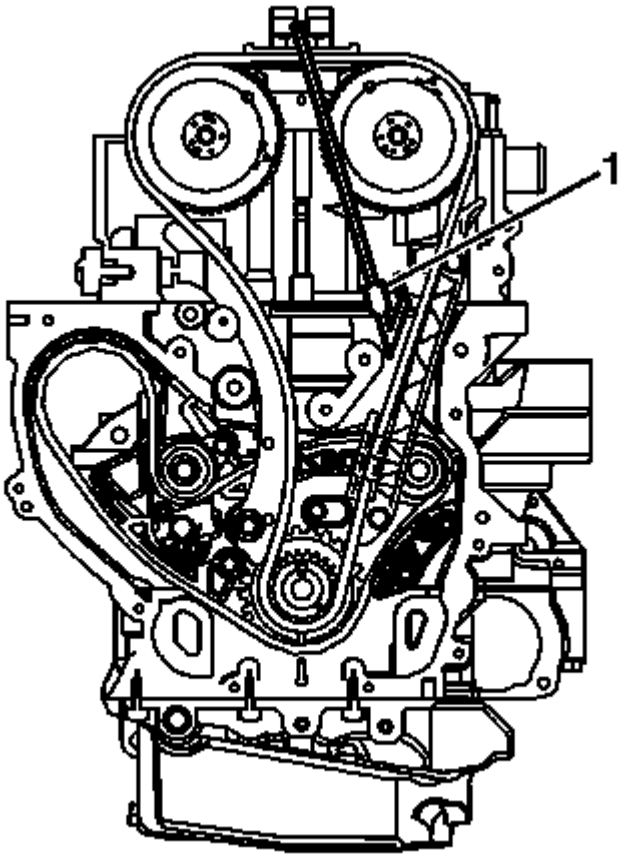

Fig. 132: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The intake camshaft actuator should not rotate during the removal or installation.**
- **Ensure the tips of the tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.**

11. Install the **EN-48749:** retention tool (1) to the intake side of the timing chain.

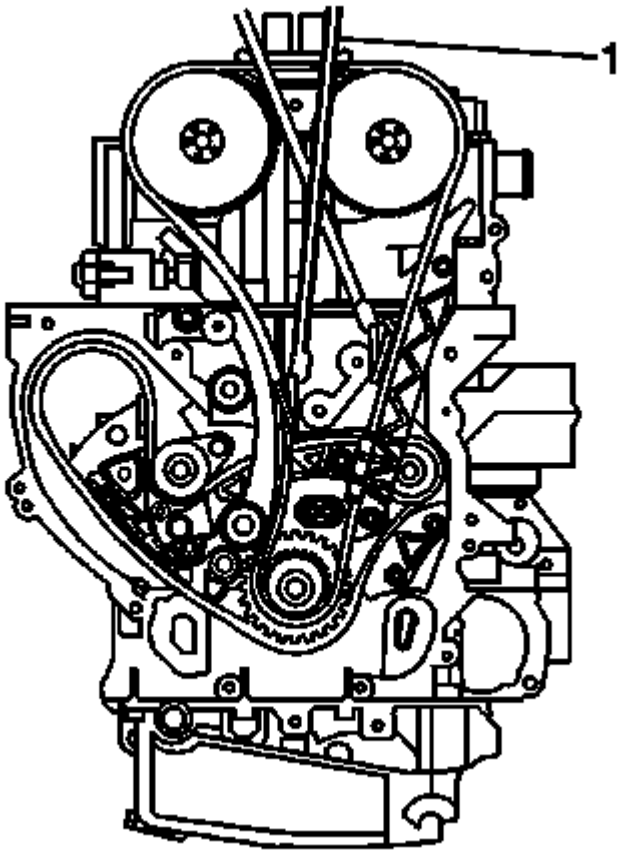

Fig. 133: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN-48749:** retention tool (1) to the exhaust side of the timing chain.

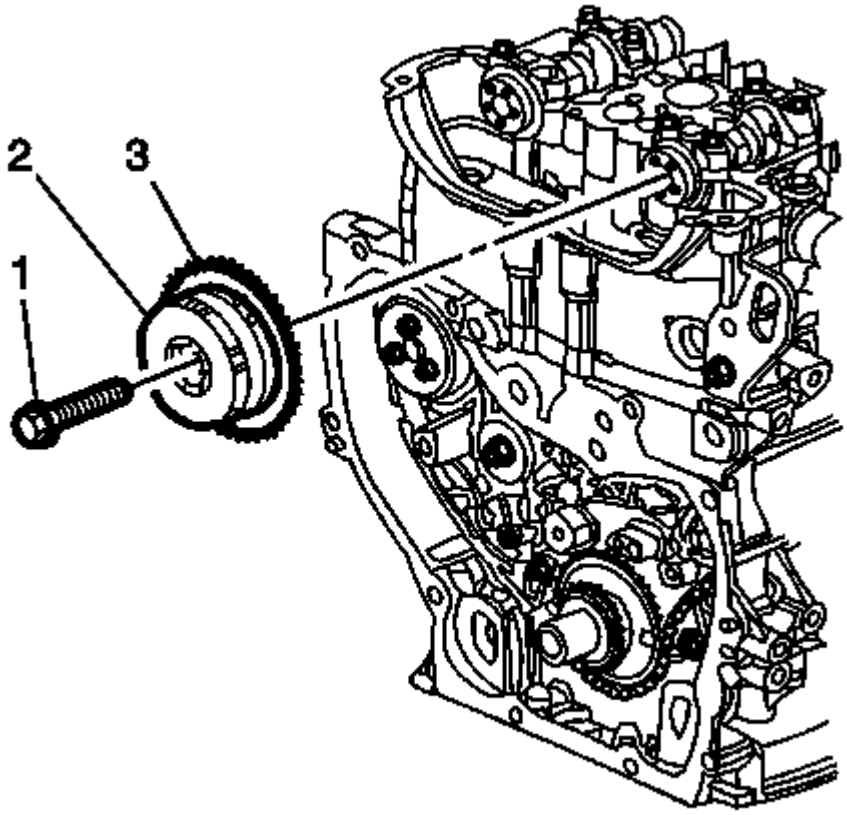

Fig. 134: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the intake camshaft actuator bolt (1).
14. Rotate the exhaust camshaft clockwise slightly to take the tension off of the timing chain on the intake actuator.
15. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

INSTALLATION PROCEDURE

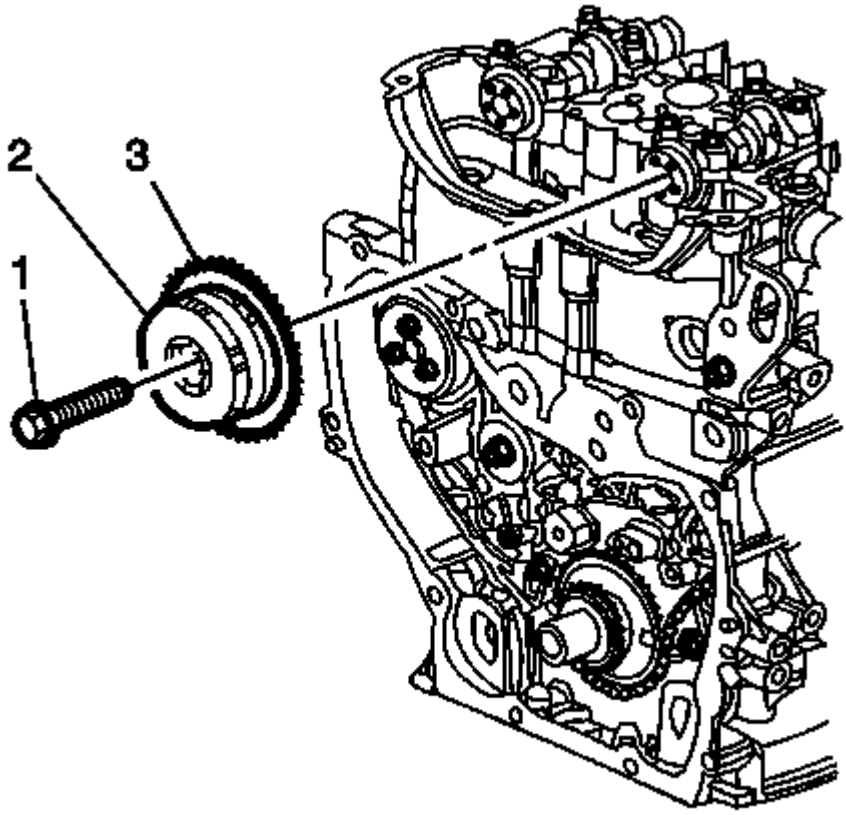

Fig. 135: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

1. Install the timing chain onto the intake camshaft actuator.
2. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft rotating the exhaust camshaft clockwise, if required.
3. Install a NEW intake camshaft actuator bolt (1) until snug.

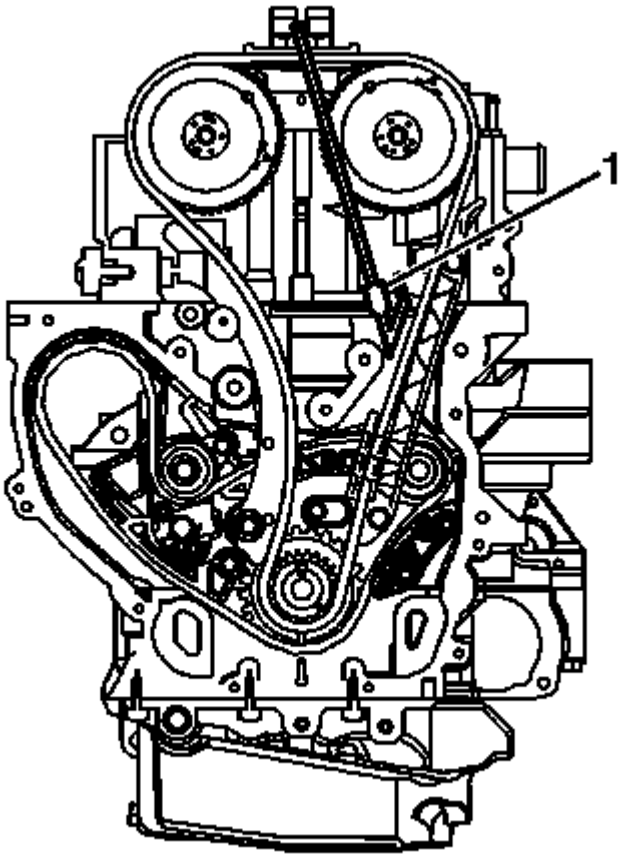

Fig. 136: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the timing chain retention tool (1) from the intake side of the timing chain.

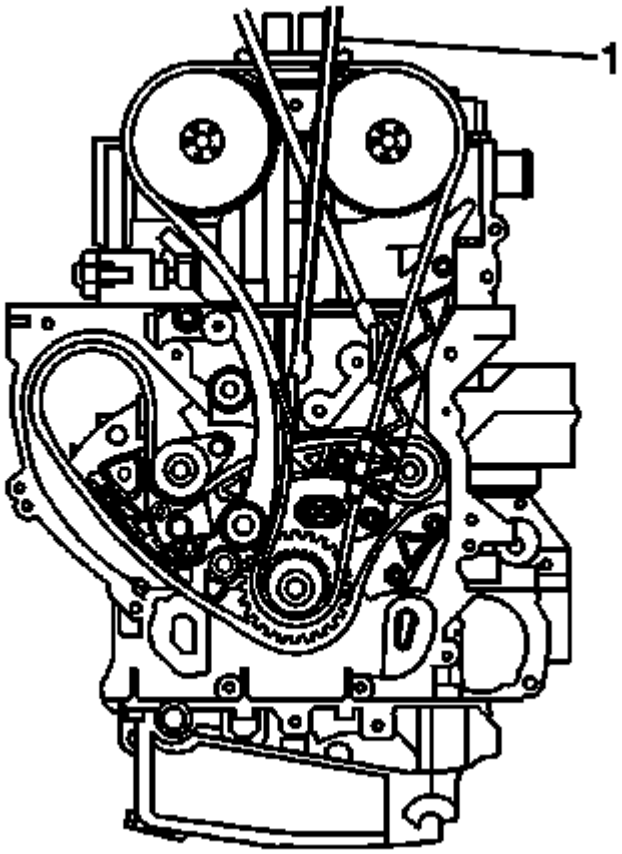

Fig. 137: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the intake camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

5. Remove the timing chain retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend. limiting the timing chain life.

6. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

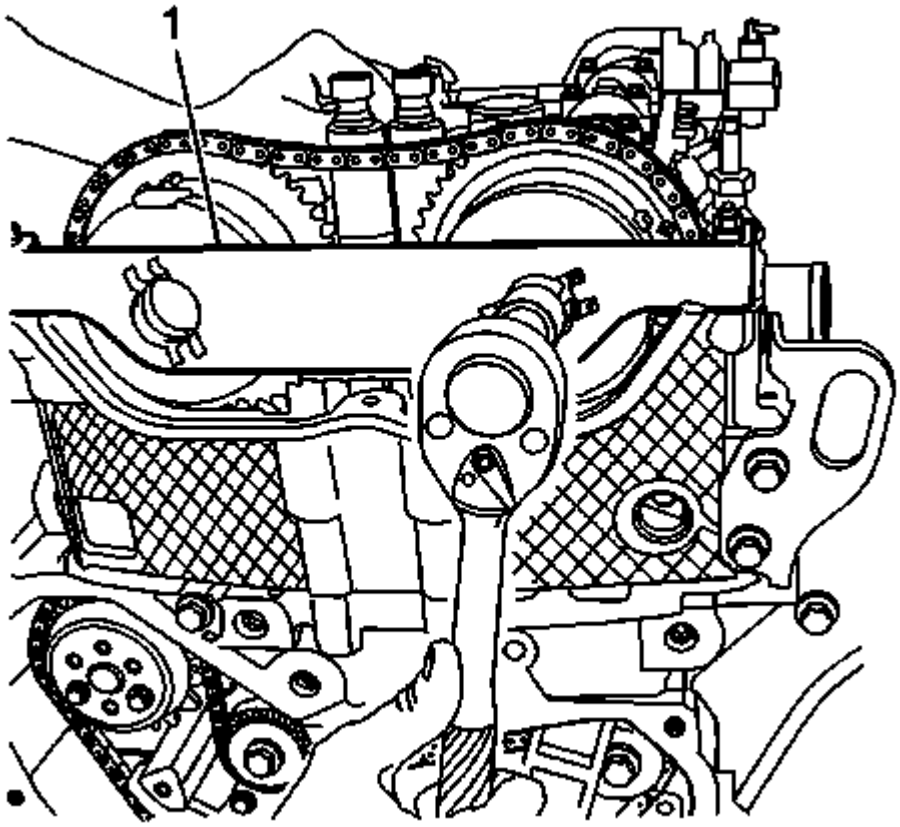

Fig. 138: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

7. Install the **EN-48953:** retention tool (1).
8. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
9. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059:** meter.

NOTE: You must have the EN-48953: retention tool installed to perform this procedure.

10. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).
11. Remove the **EN-48953:** retention tool (1).

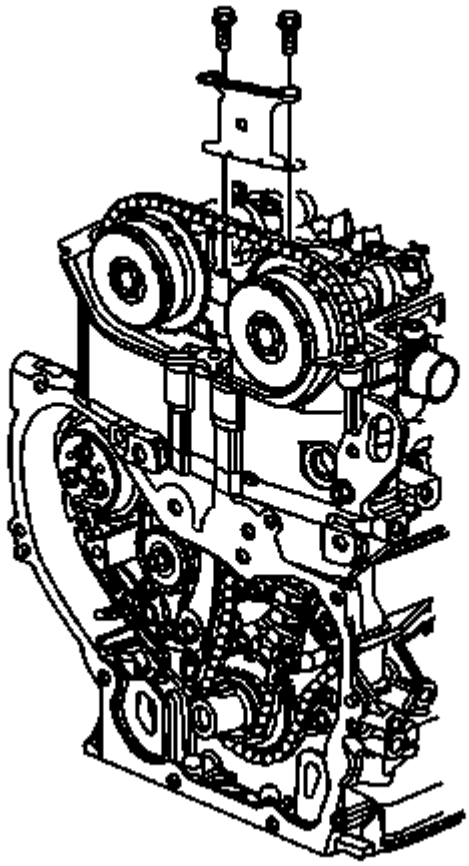

Fig. 139: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

SPECIAL TOOLS

- **EN-45059:** Angle Meter
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** Camshaft Actuator Locking Tool

For equivalent regional tools, refer to **Special Tools** .

REMOVAL PROCEDURE

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

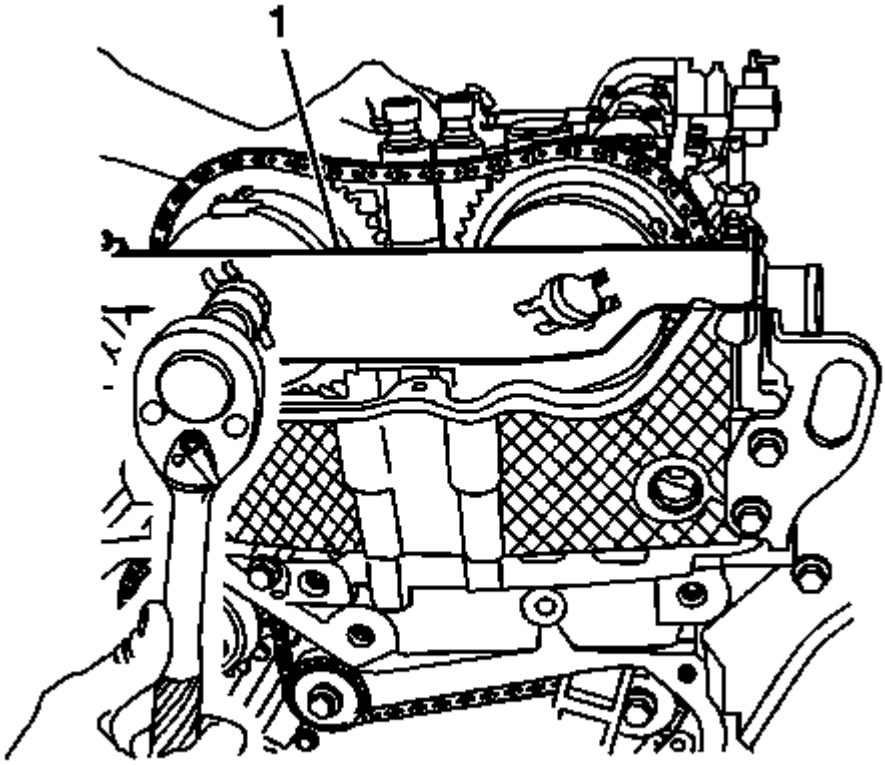

Fig. 140: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the **EN-48953:** locking tool (1).

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but do not remove the exhaust camshaft actuator bolt.
6. Remove the **EN-48953:** locking tool (1).
7. Clean the timing chain and gears with solvent.

NOTE: Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.

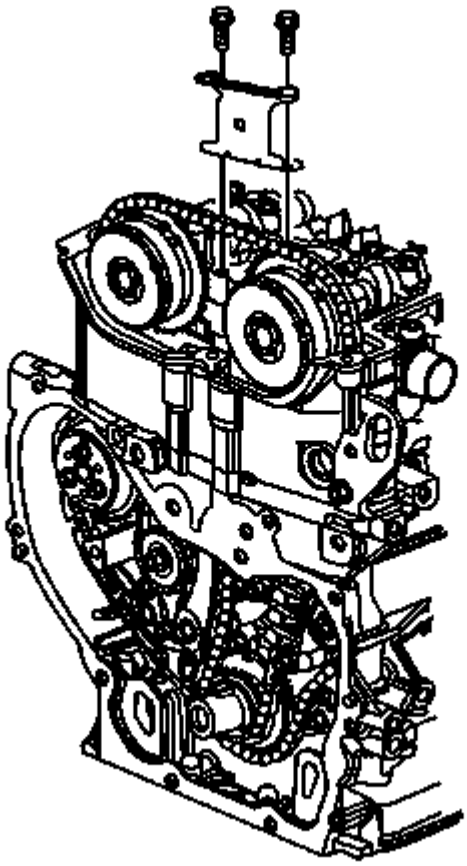

Fig. 141: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

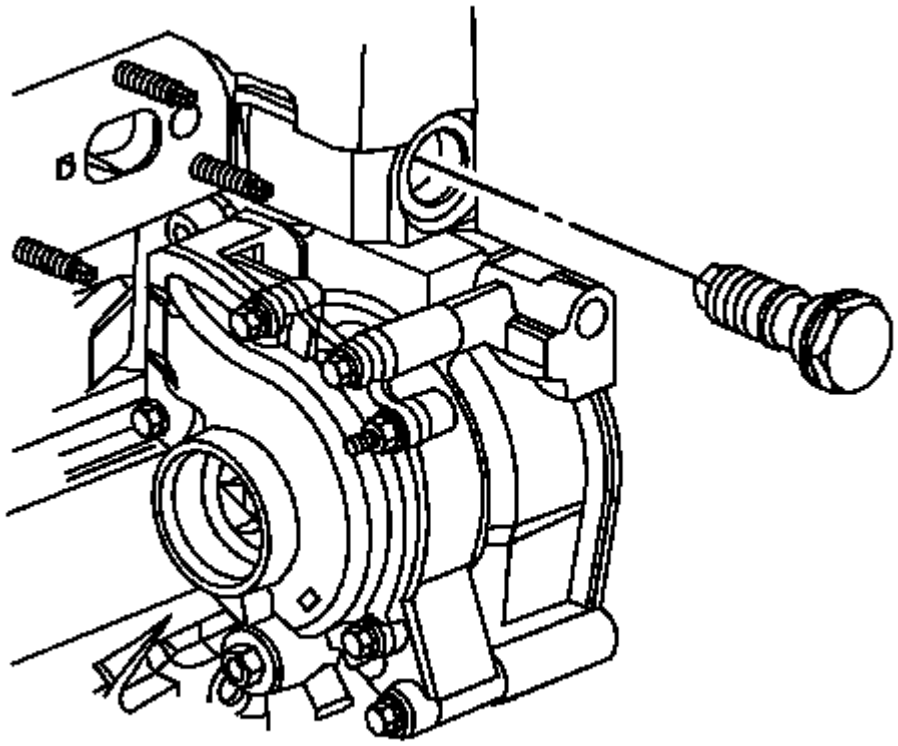

Fig. 142: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

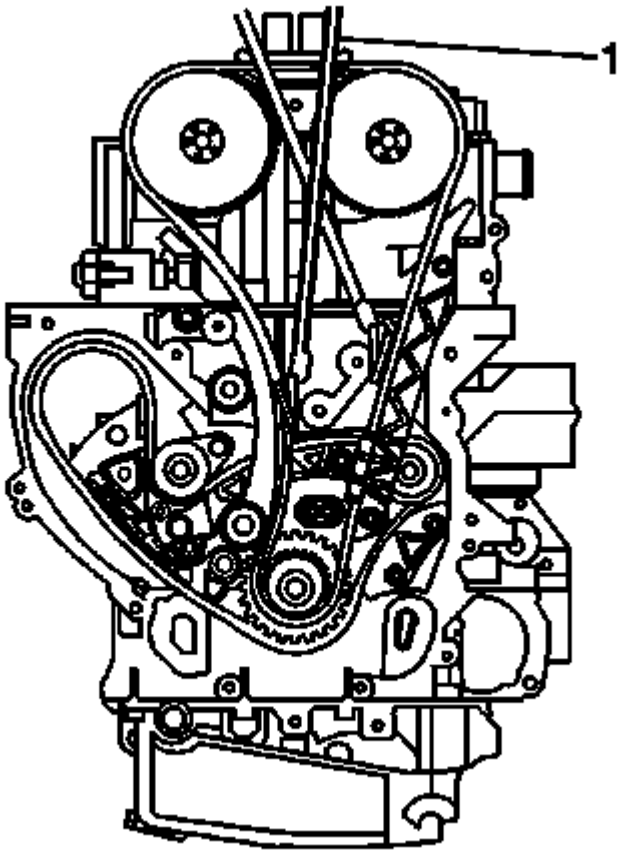

Fig. 143: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The camshaft actuators should not rotate during the removal or installation.**
- **Ensure the tips of the EN-48749: retention tool are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.**

11. Install the **EN-48749:** retention tool (1) to the exhaust side of the timing chain.

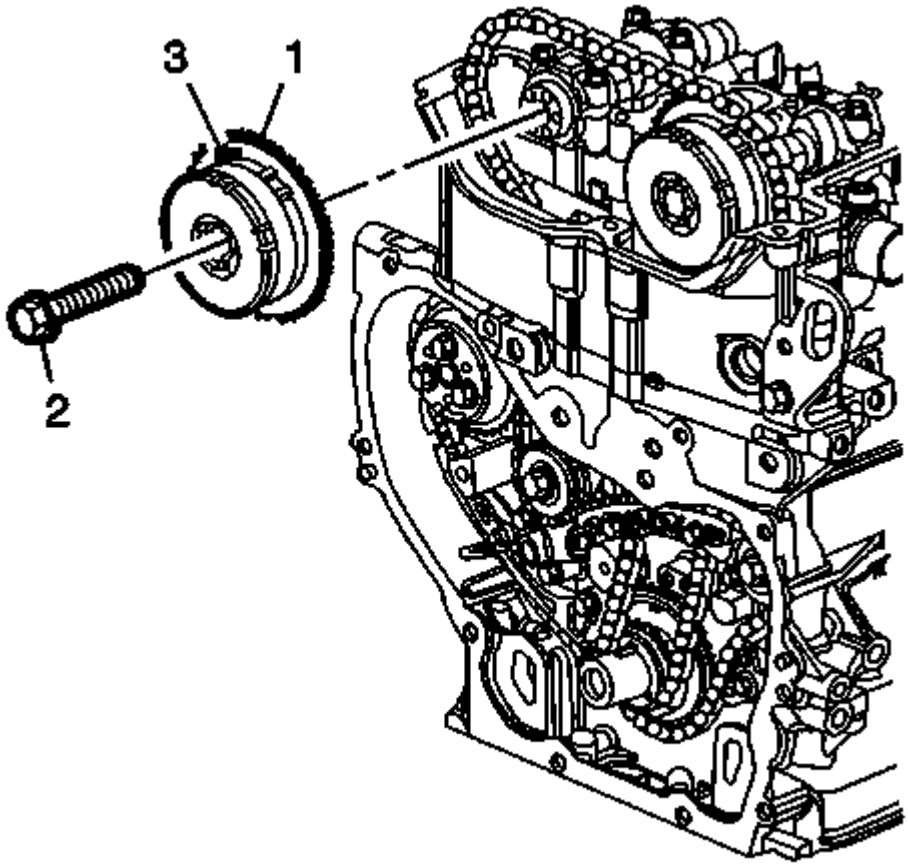

Fig. 144: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

12. Remove and discard the exhaust camshaft actuator bolt (2).
13. Remove the exhaust camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

INSTALLATION PROCEDURE

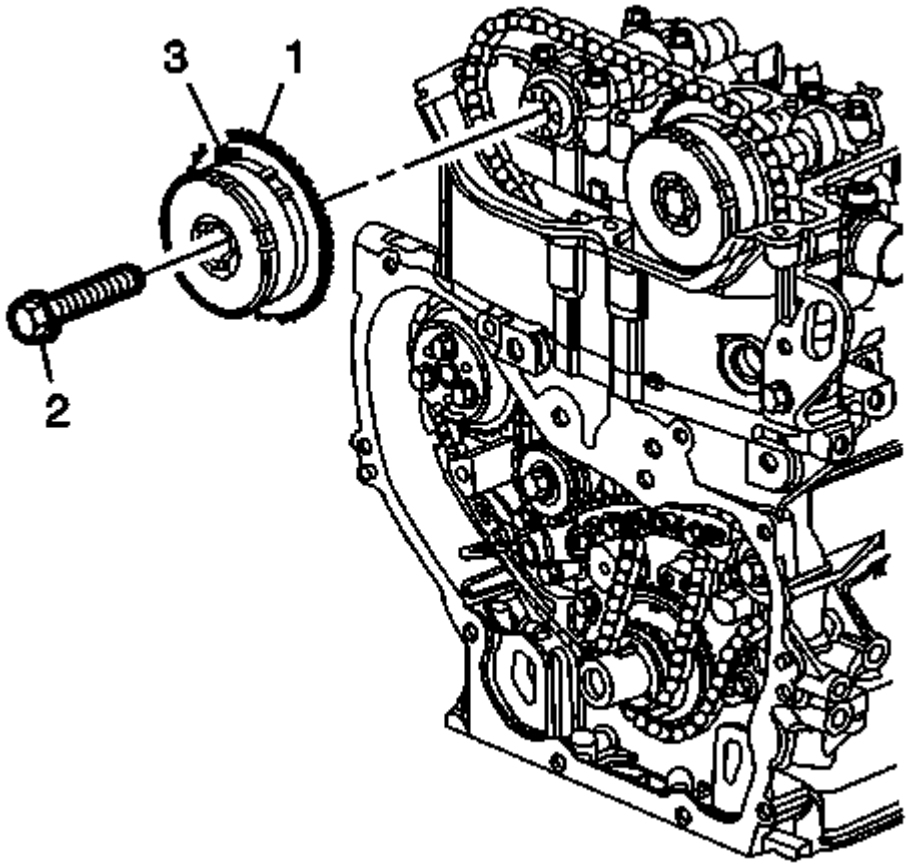

Fig. 145: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.**
- **The exhaust camshaft may need to be rotated clockwise to fully set the camshaft actuator.**

1. Install the timing chain onto the exhaust camshaft actuator.
2. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
3. Install a NEW exhaust camshaft actuator bolt (2) until snug.

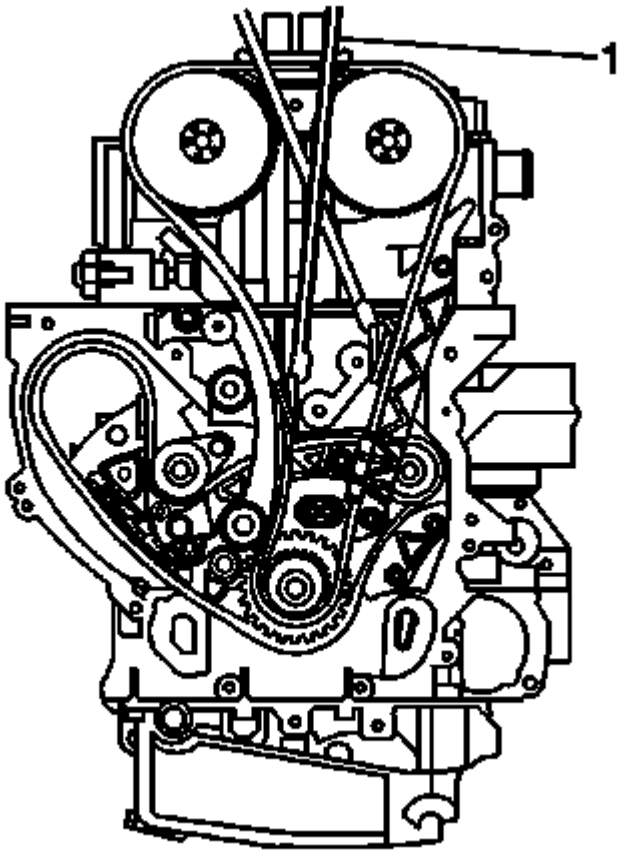

Fig. 146: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the exhaust camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

4. Remove the **EN-48749:** retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend. limiting the timing chain life.

5. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

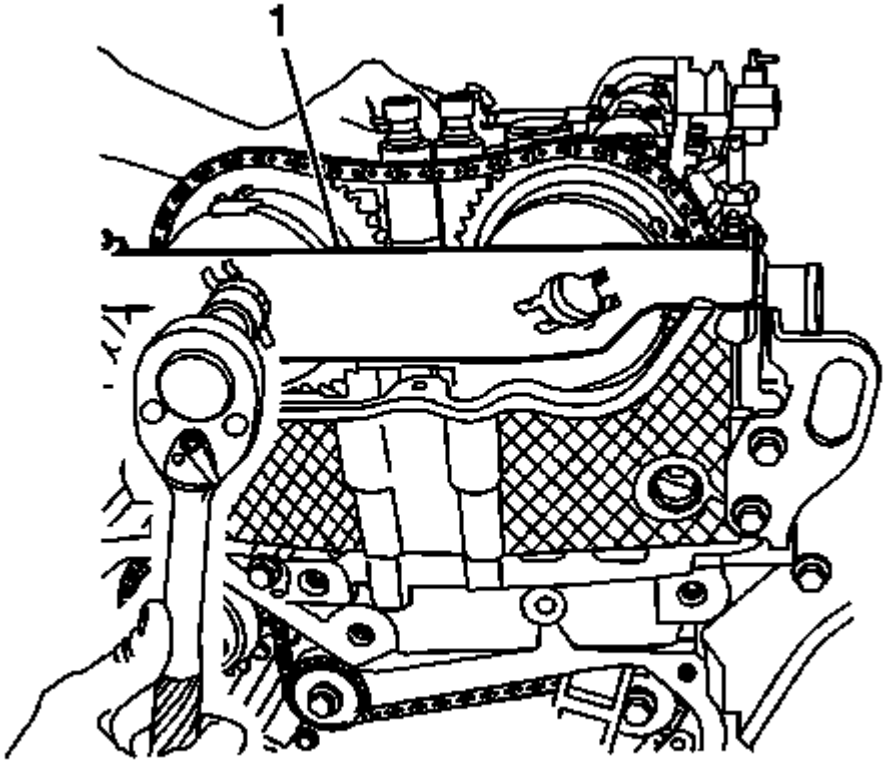

Fig. 147: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-48953:** locking tool (1).
7. Install the camshaft actuator retainer bolts and tighten 10 N.m (89 lb in).
8. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **EN-45059:** meter.

NOTE: You must have the EN-48953: locking tool installed to perform this procedure.

9. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).

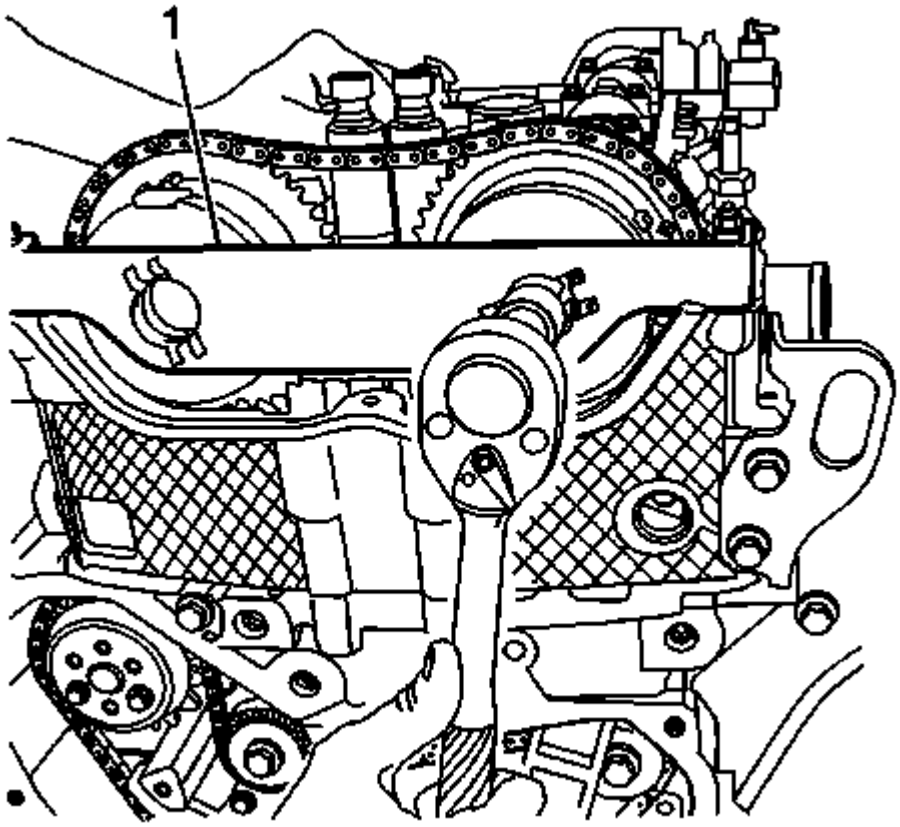

Fig. 148: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft actuator retainer **EN-48953:** locking tool (1).

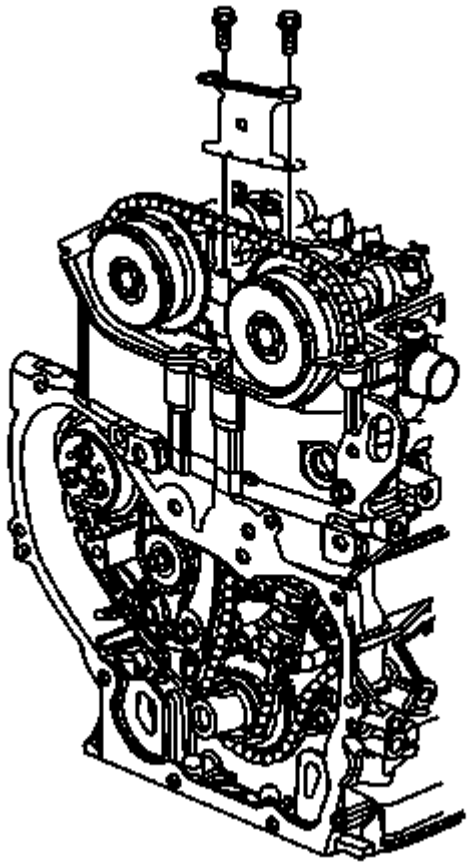

Fig. 149: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
12. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
13. Install the spark plugs. Refer to **Spark Plug Replacement** .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

SPECIAL TOOLS

- **EN-36017:** Valve Guide Seal Remover
- **EN-43649:** Valve Spring Compressor
- **EN-43649-10:** Valve Spring Compressor Adaptor Set
- **EN-43653:** Flywheel Holding Tool

For equivalent regional tools refer to **Special Tools** .

REMOVAL PROCEDURE

NOTE: Prevent the crankshaft from rotating clockwise or counterclockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-43653: holding tool.

1. If equipped, with a manual transmission leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped, with an automatic transmission, remove the starter. Refer to **Starter Replacement (LE5/LE9)** .
3. Install **EN-43653:** holding tool.
4. Remove the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.

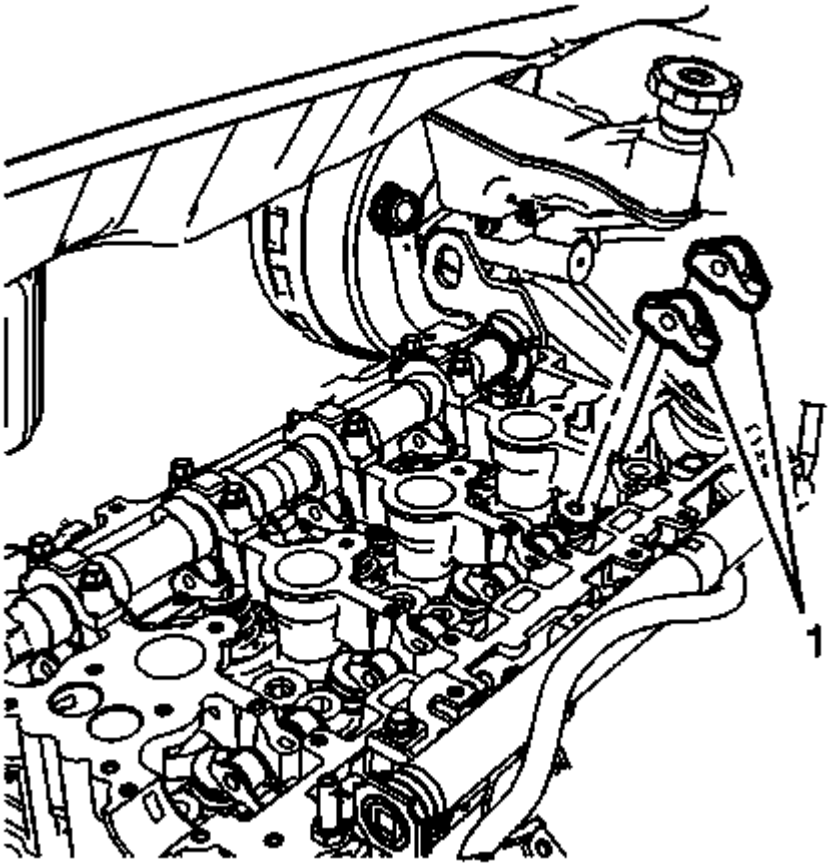

Fig. 150: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft roller followers (1).

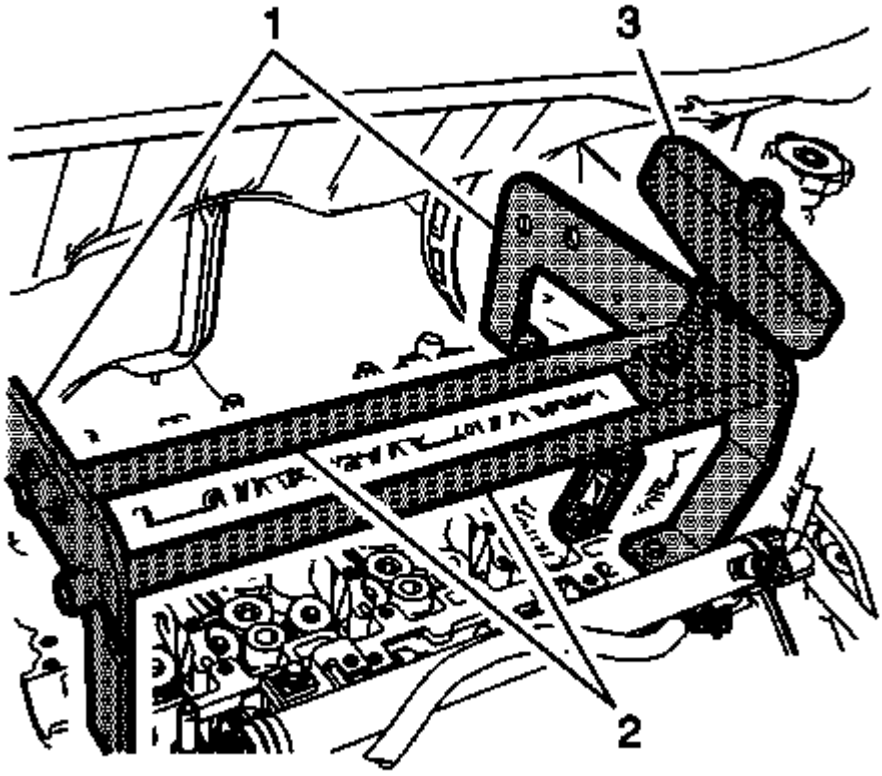

Fig. 151: View Of Valve Spring Compressor Adaptor Set
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-43649-10:** adaptor set (1) to the front and rear of the cylinder head.
7. Install the cross bars and locks (2) of the **EN-43649:** compressor to the valve spring compressor adaptors.
8. Remove the spark plugs. Refer to **Spark Plug Replacement** .
9. Install an air hose adapter into the spark plug hole.
10. Attach an air hose to the adapter and pressurize the cylinder to 690 kPa (100 psi).
11. Compress the valve spring using the valve spring compressor (3).

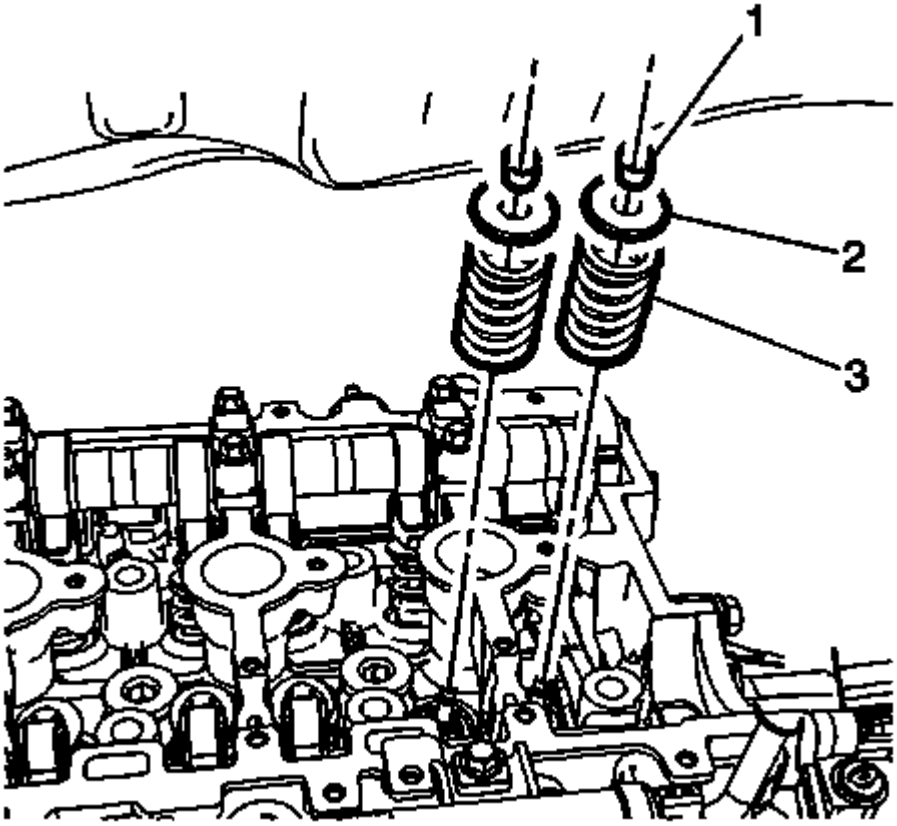

Fig. 152: View Of Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve spring keepers (1).
13. Remove the valve spring (3) and retainer (2).

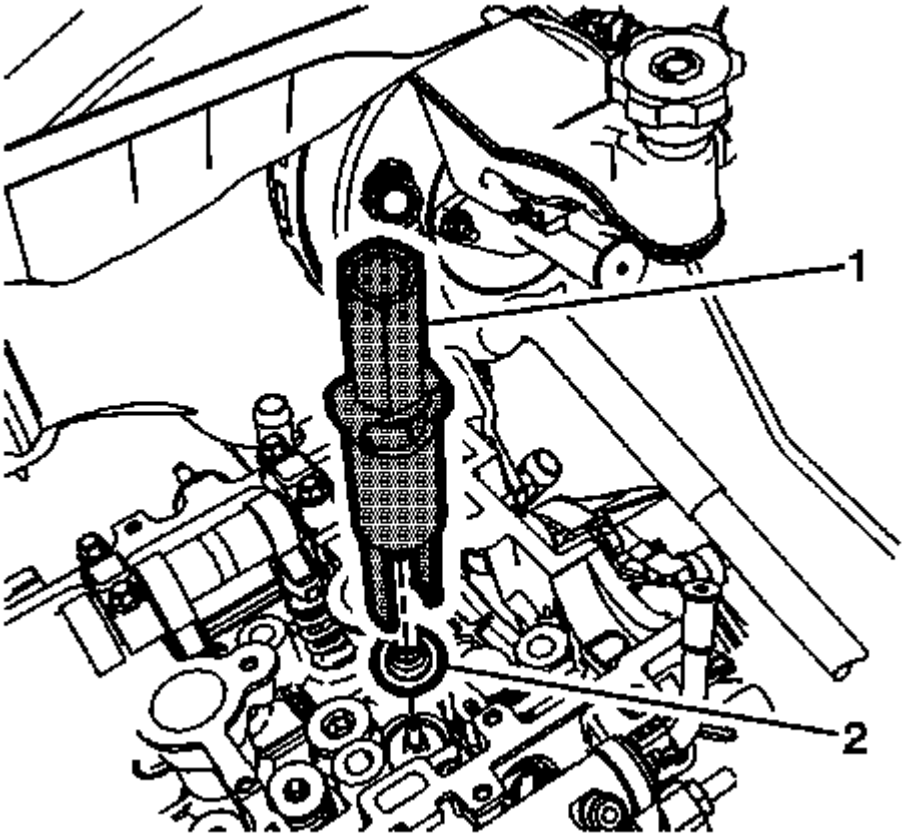

Fig. 153: View Of Valve Guide Seal Remover/Installer
Courtesy of GENERAL MOTORS CORP.

14. Use the **EN-36017:** seal remover (1) to remove the valve seal.

INSTALLATION PROCEDURE

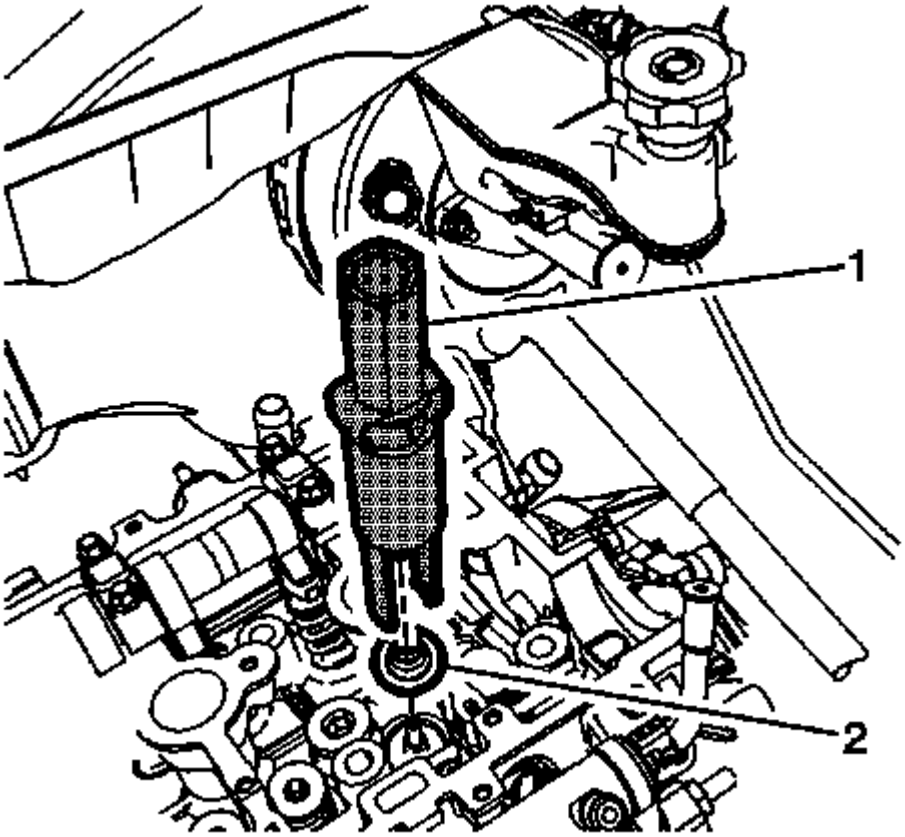

Fig. 154: View Of Valve Guide Seal Remover/Installer
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-36017:** seal remover (1) install the NEW valve seal. Fully seat the seal onto the valve guide.

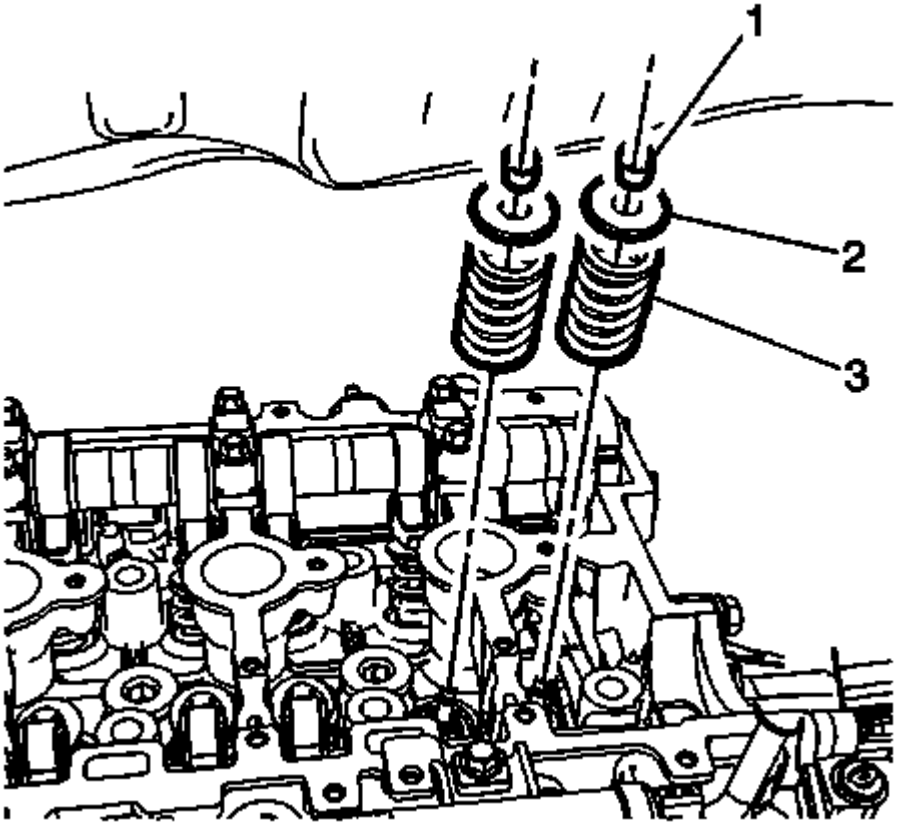

Fig. 155: View Of Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (3) and retainer (2).
3. Compress the valve spring using the valve spring compressor.
4. Install the valve spring keepers (1).
5. Disconnect the air hose and air hose adapter.

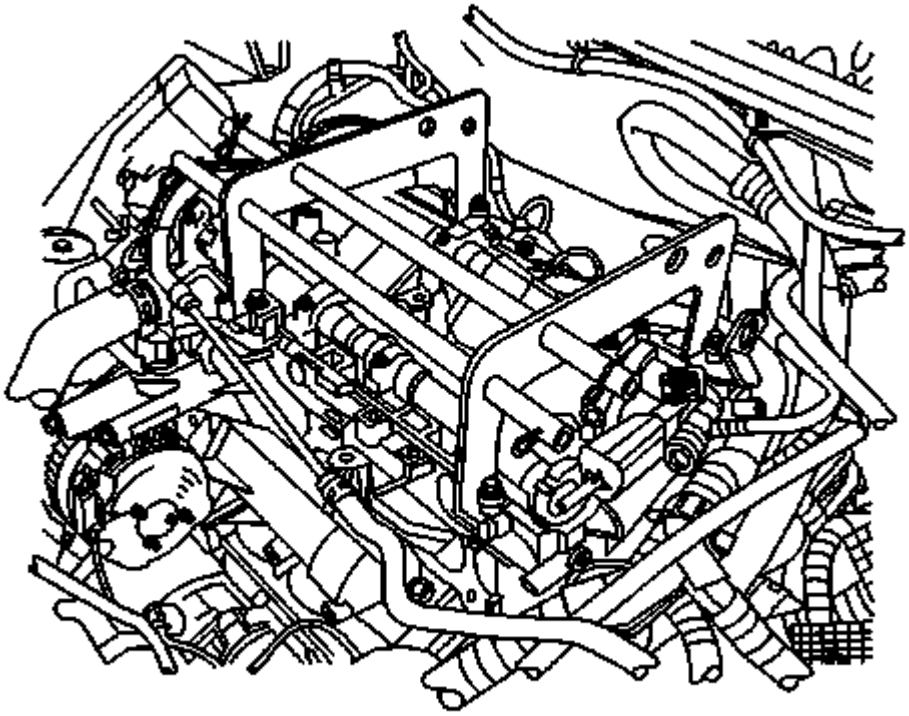

Fig. 156: View Of J 43649 Valve Spring Compressor (Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN-43649:** compressor and **EN-43649-10:** adaptor set from the cylinder head.
7. Install the spark plugs. Refer to **Spark Plug Replacement** .

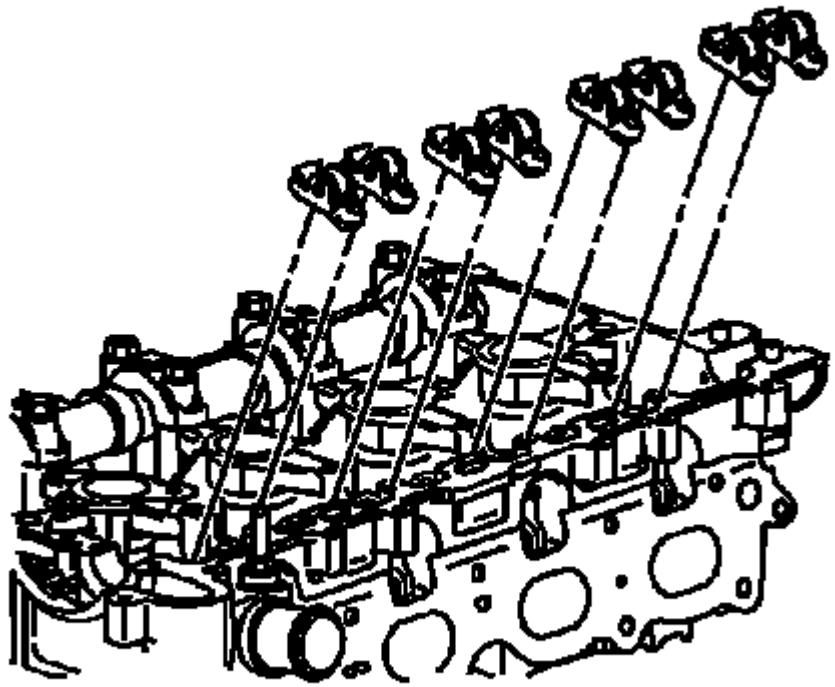

Fig. 157: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers.
9. Install the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.
10. If used, remove the **EN-43653:** holding tool.
11. If removed, install the starter. Refer to **Starter Replacement (LE5/LE9)** .

CYLINDER HEAD REPLACEMENT

SPECIAL TOOLS

- **J 38185** Hose Clamp Pliers
- **J 45059** Angle Meter
- **EN-48749** Timing Chain Retention Tool Kit. See **Special Tools** .
- **EN-48953** Camshaft Actuator Locking Tool. See **Special Tools** .

REMOVAL PROCEDURE

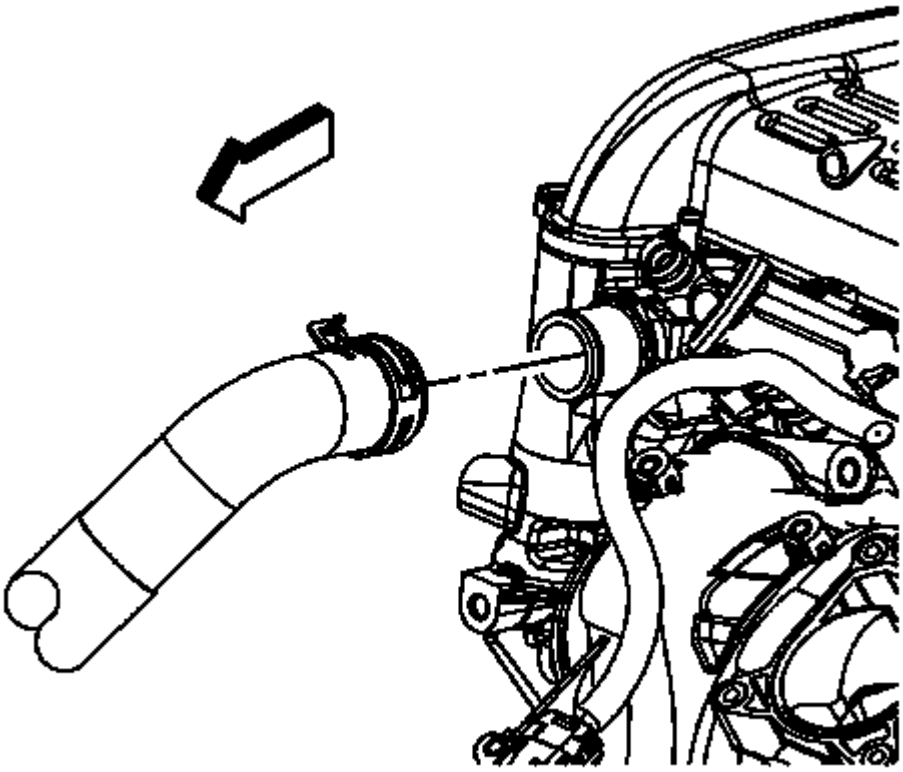

Fig. 158: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (GE 47716)** .
2. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement (LE5 or LE9 With MH8)** or **Exhaust Manifold Replacement (LE5 or LE9)** .
3. Remove the intake manifold. Refer to **Intake Manifold Replacement (LE5)**.
4. Reposition the radiator surge tank air bleed hose clamp.
5. Remove the radiator surge tank air bleed hose from the cylinder head.
6. Reposition the radiator inlet hose clamp using the **J 38185** .
7. Remove the radiator inlet hose from the cylinder head.
8. Disconnect all electrical connectors as necessary.
9. Remove the spark plugs. Refer to **Spark Plug Replacement**
10. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

NOTE: If the intake camshaft actuator is moving independently of the camshaft, this means the camshaft is not locked to the actuator. Rotate the camshaft counter-clockwise while the holding tool is installed and this will lock the

camshaft to the actuator.

11. Rotate the crankshaft clockwise to install the camshaft actuator locking tool **EN-48953:** EGR Cooler Pressure Tester Adapter Set.

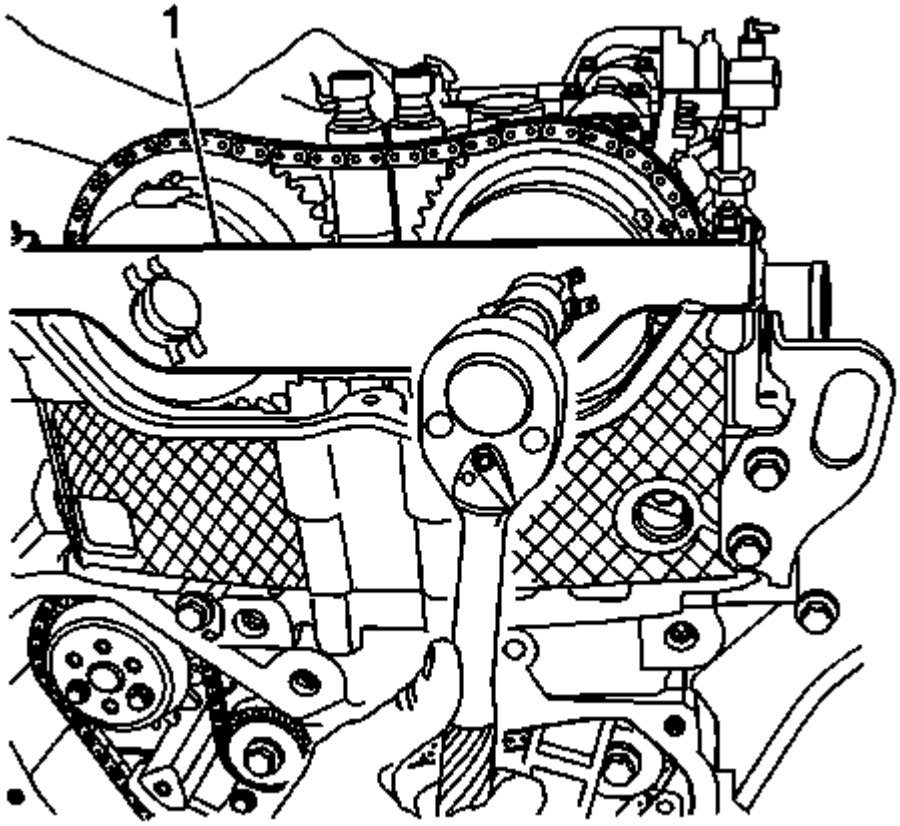

Fig. 159: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN-48953** (1). See **Special Tools** .

CAUTION: Refer to Fastener Caution .

13. Install the camshaft actuator tool and bolts tighten to 10 N.m (89 lb in).

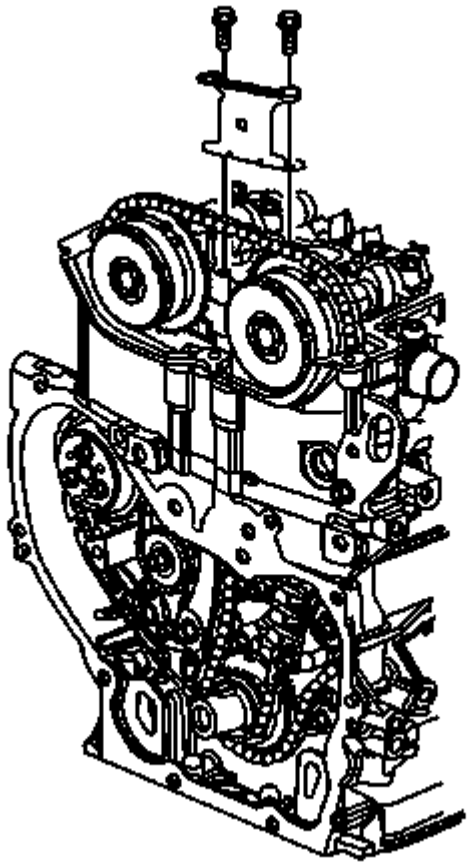

Fig. 160: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

14. Remove the upper timing chain guide bolts and guide.
15. Clean the timing chain and gears with solvent.

NOTE: Ensure the timing chain and the camshaft position actuators are marked for proper assembly.

16. Mark the timing gear sprockets and the timing chain. It is recommended that the paint marks are located in the 12 o'clock position.
17. Loosen, but do not remove the intake and exhaust camshaft actuator bolts.
18. Remove the camshaft actuator locking tool, **EN-48953** . See **Special Tools** .

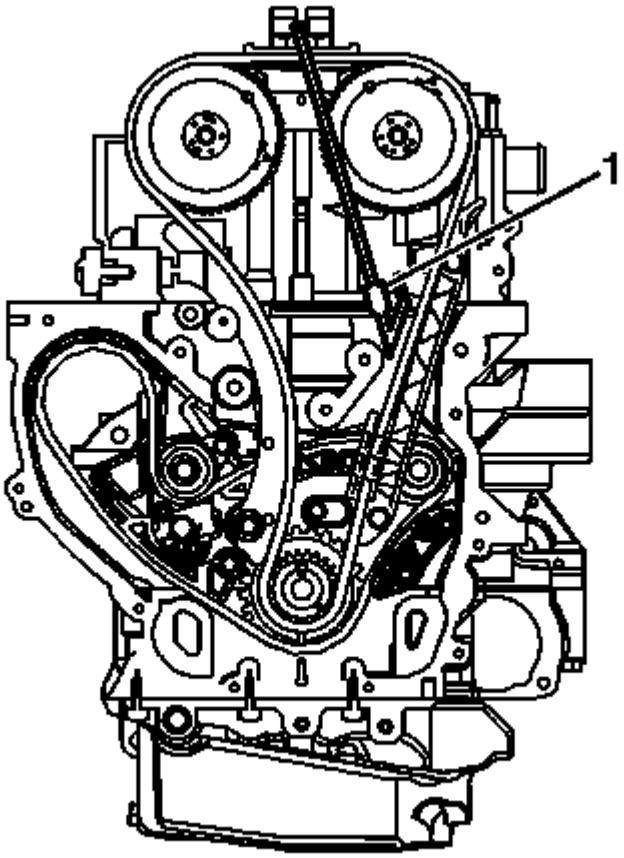

Fig. 161: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the tips of the EN-48749 are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged. See Special Tools .

19. Install the timing chain retention tool **EN-48749** (1) to the intake side of the timing chain. See **Special Tools** .

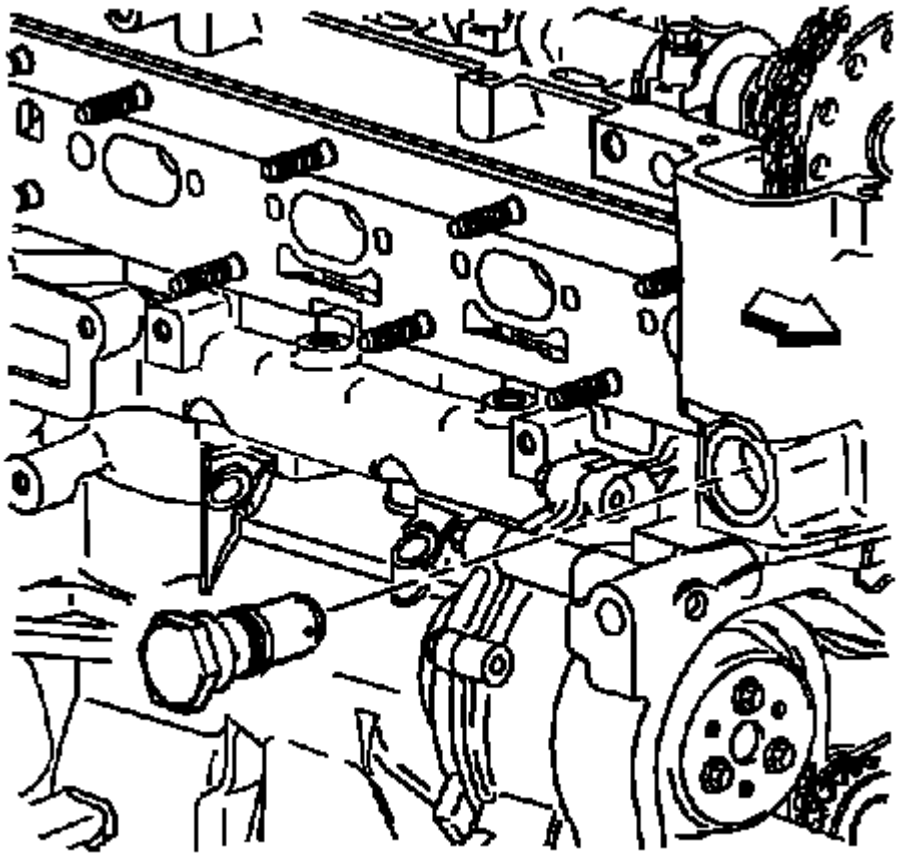

Fig. 162: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

20. Remove the timing chain tensioner.

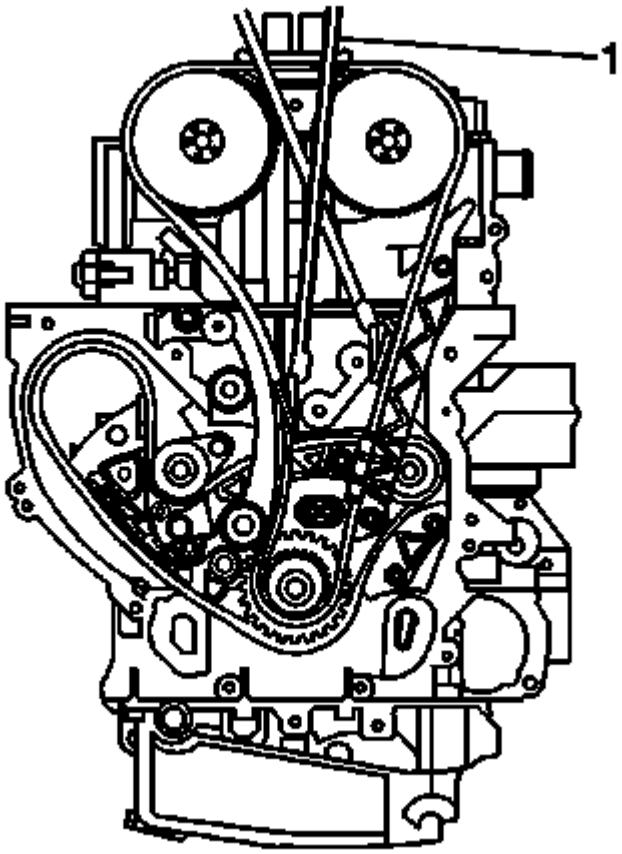

Fig. 163: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: The Intake camshaft and actuator should not rotate during the removal or installation.

21. Install the timing chain retention tool **EN-48749** (1) to the exhaust side of the timing chain. See **Special Tools** .

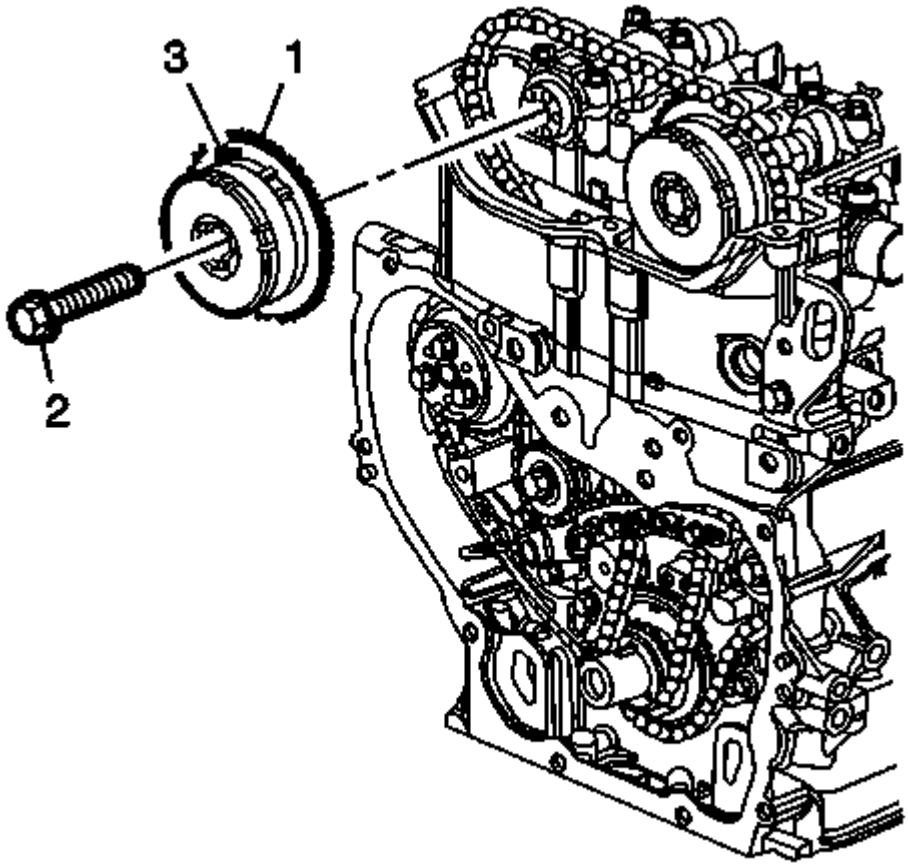

Fig. 164: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

22. Remove and discard the exhaust camshaft actuator bolt (2).
23. Remove the exhaust cam actuator (3) from the exhaust camshaft while also removing the actuator from the chain.

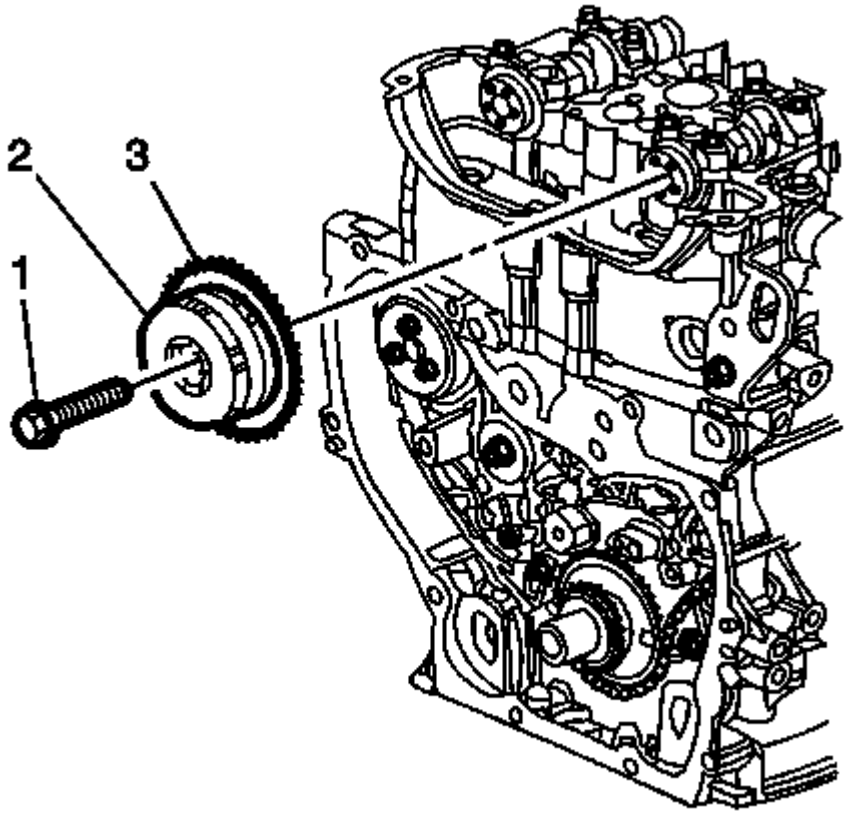

Fig. 165: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

24. Remove and discard the intake camshaft actuator bolt (2).
25. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

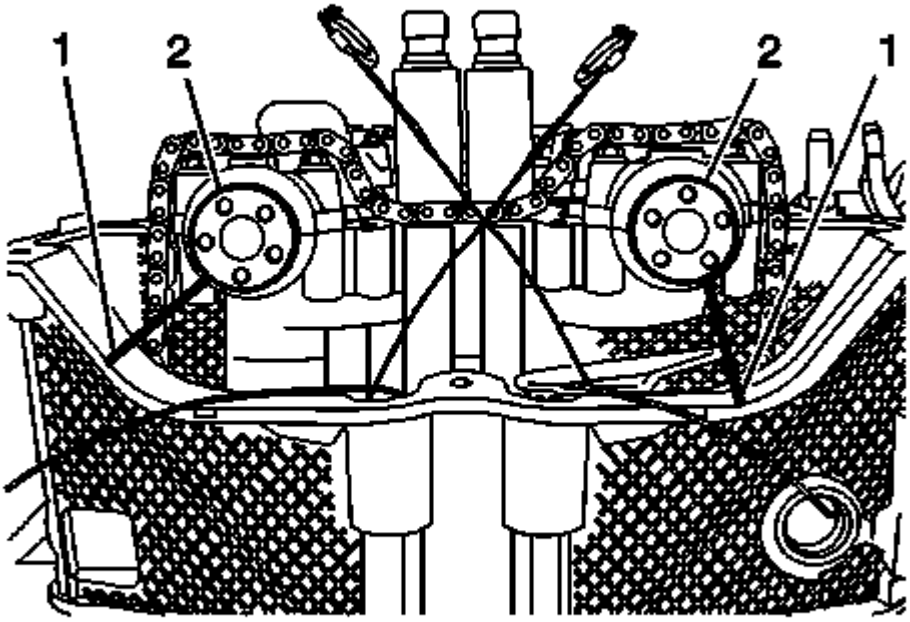

Fig. 166: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

26. Mark the cylinder head (1) in relationship to the camshaft actuator notch is on the camshaft (2).

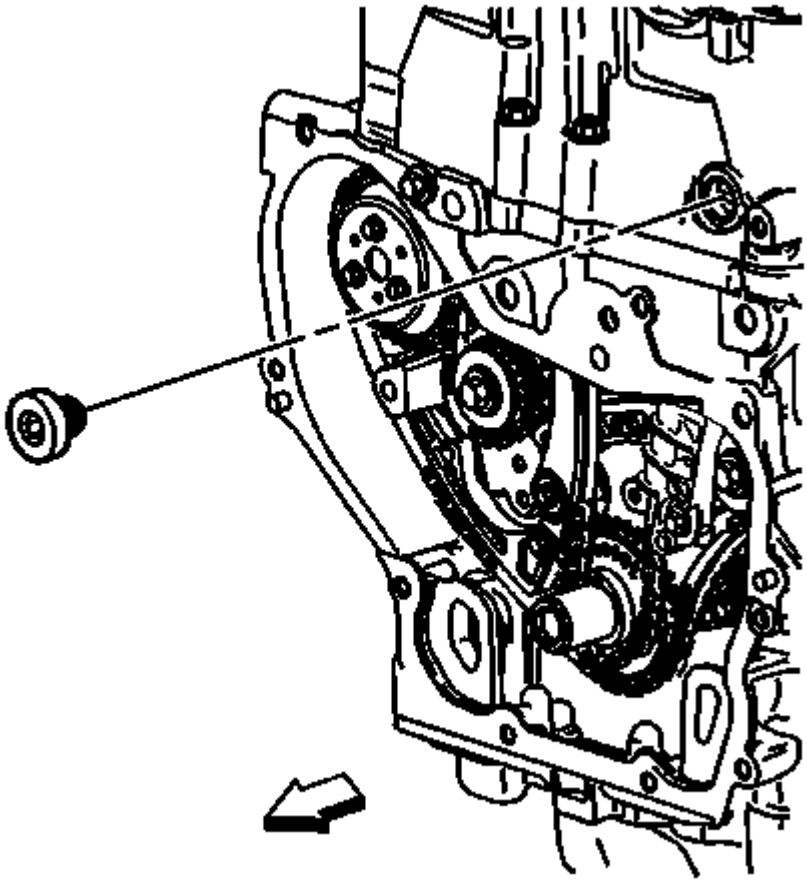

Fig. 167: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

27. Remove the fixed timing chain guide access plug.
28. Remove the upper fixed timing chain guide bolt.

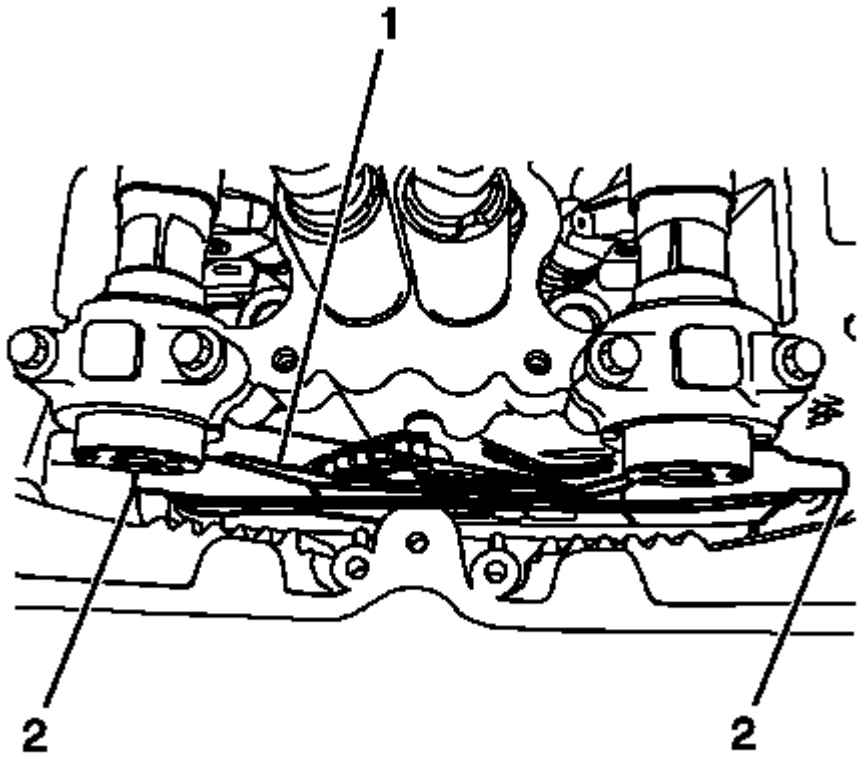

Fig. 168: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

NOTE: The threaded rod from the timing chain retention tool can be used to help feed the rubber band around the chain guides.

29. Install a rubber band (1) around the top of the upper timing chain guides (2) in order to pull the guides together.

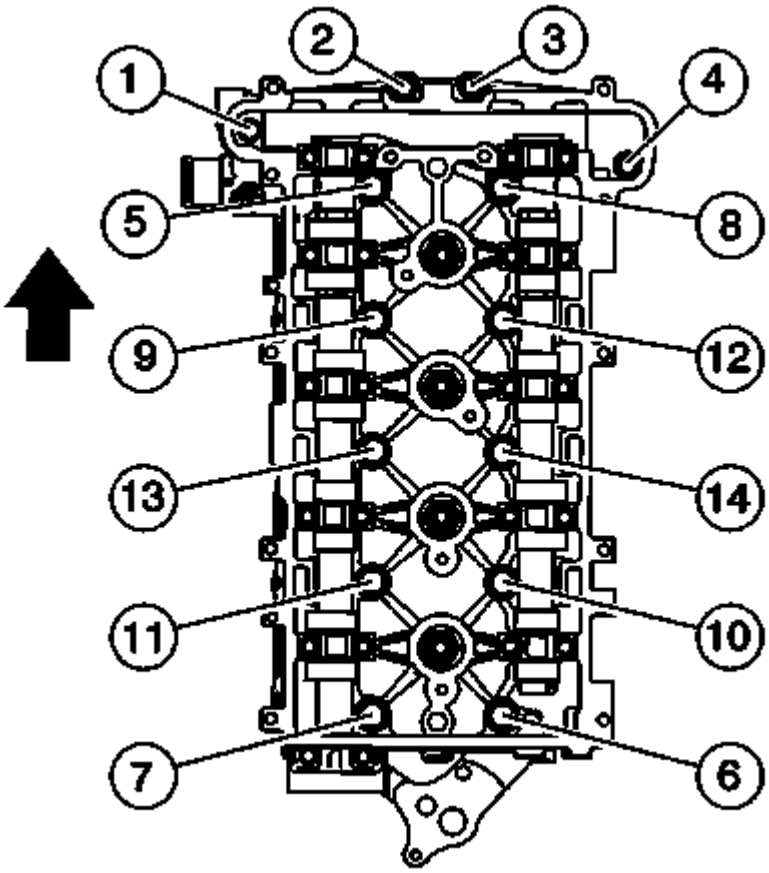

Fig. 169: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

30. Remove the cylinder head bolts in the sequence shown. Discard the bolts.

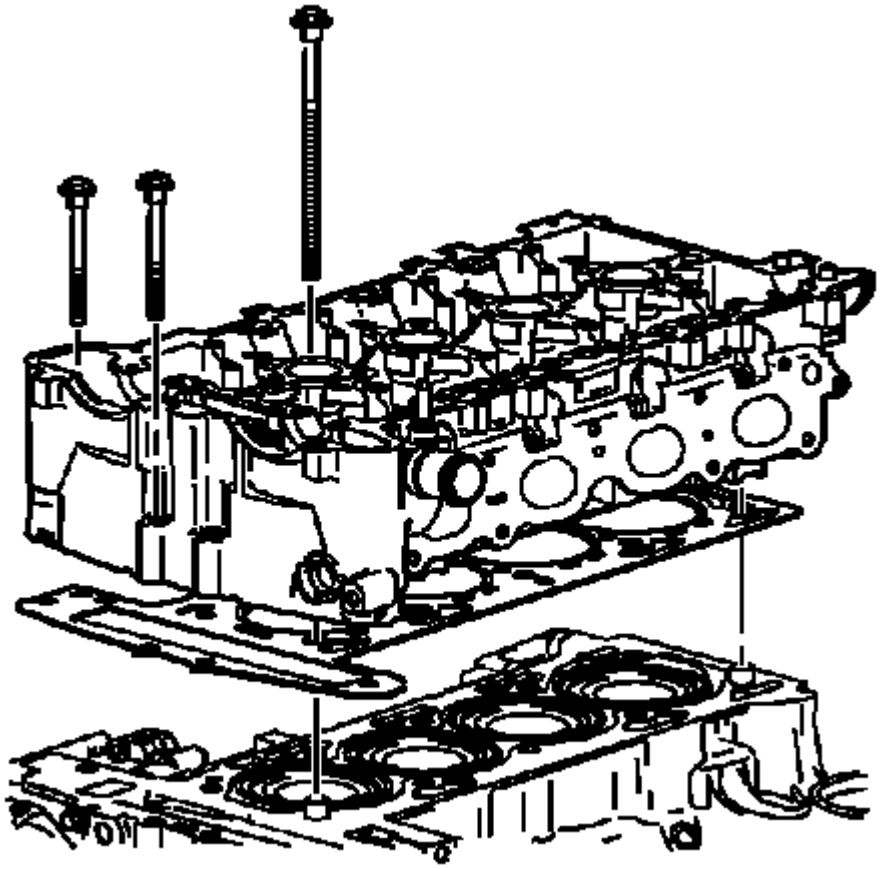

Fig. 170: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

31. Remove the cylinder head.
32. Remove the cylinder head gasket.
33. Clean all of the gasket surfaces.
34. Use the following steps when cleaning the cylinder head and cylinder block surfaces:
    - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge either surface.

      NOTE: DO NOT use any other method or technique to clean these gasket surfaces.

    - Use a NEW razor blade on the cylinder head and a NEW blade on the cylinder block.

      NOTE: Be careful not to gouge or scratch the gasket surfaces. DO NOT gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in

by the NEW gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

35. Clean the old sealer/lube and any dirt from around the bolt holes.

NOTE: DO NOT use a tap to clean the cylinder head bolt holes.

36. Clean the bolts holes with a nylon bristle brush.
37. When cleaning the cylinder head bolt holes use suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun in order to reach the bottom of the holes.
38. If replacing the cylinder head, transfer all parts as necessary.

INSTALLATION PROCEDURE

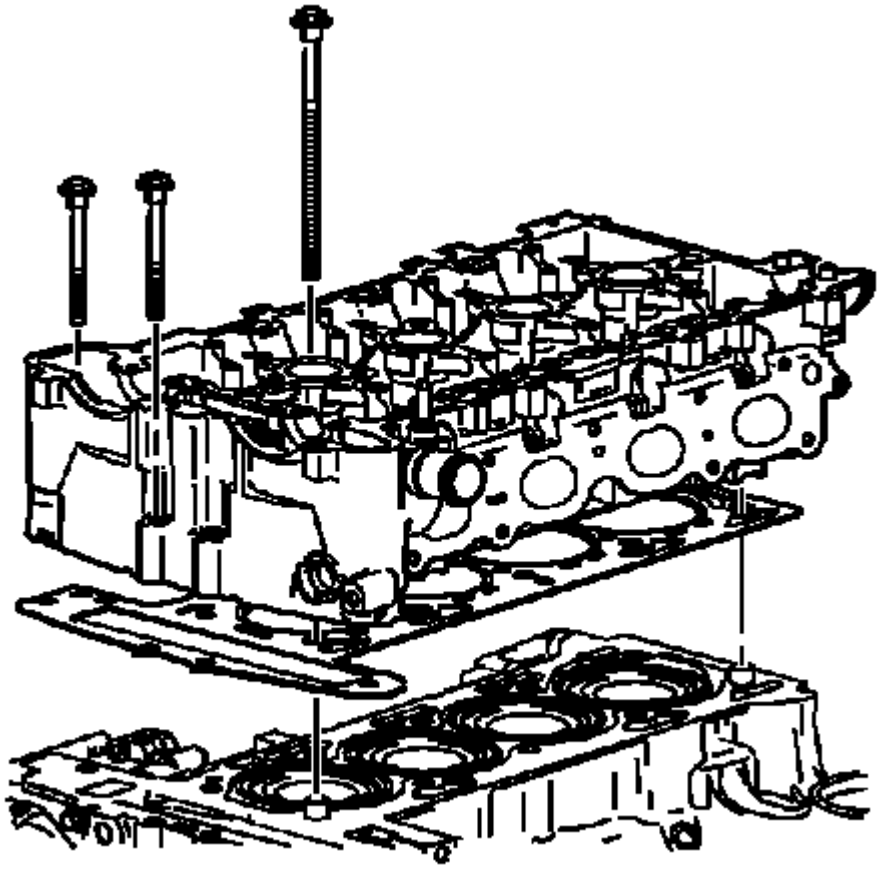

Fig. 171: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use any sealing material.

1. Install the cylinder head gasket.

2. Install the cylinder head.
3. Install NEW cylinder head bolts.

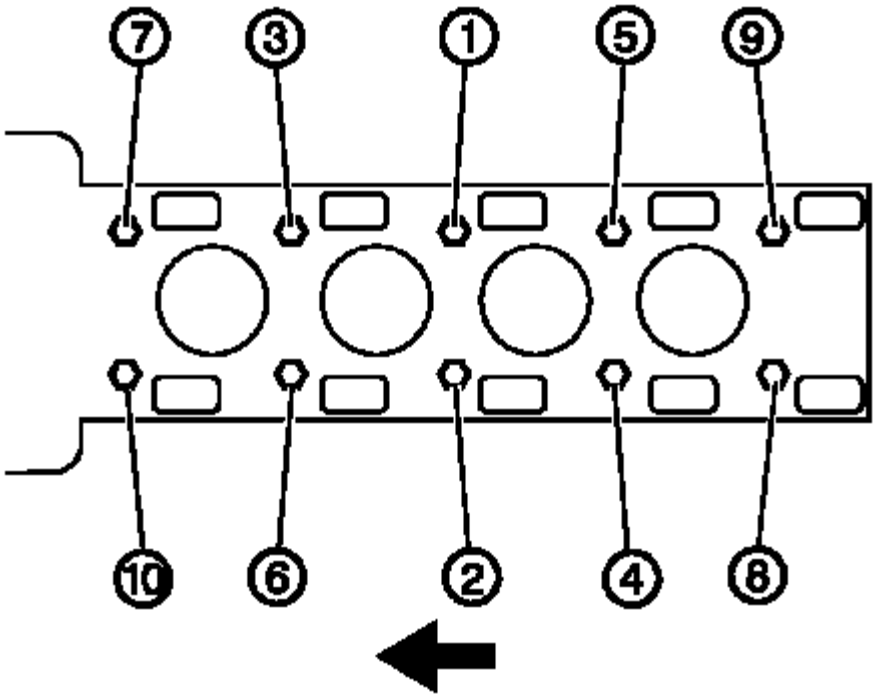

Fig. 172: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown to 30 N.m (22 lb ft) plus an additional 155 degrees using the **J 45059** .

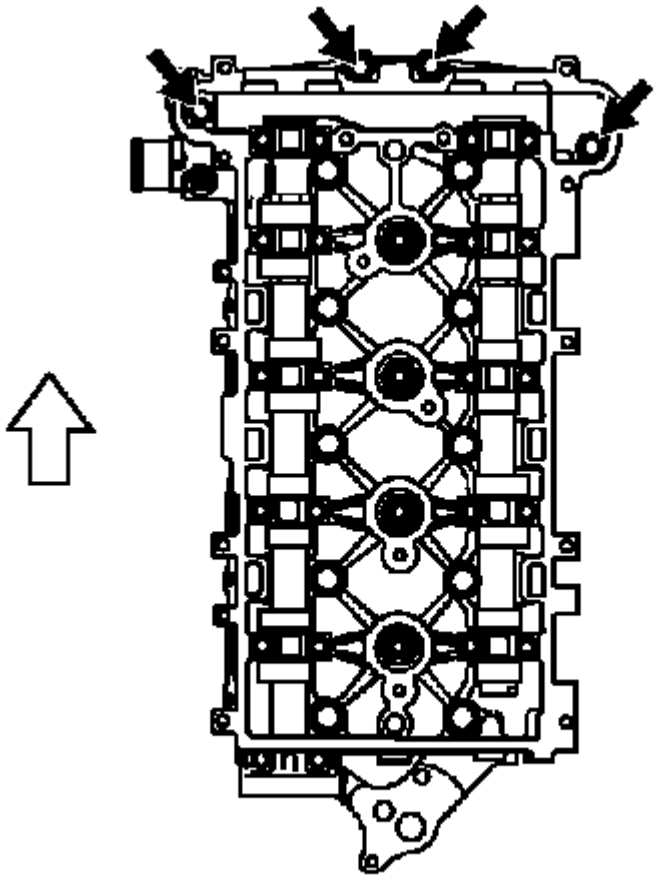

Fig. 173: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts and tighten the bolts to 35 N.m (26 lb ft).

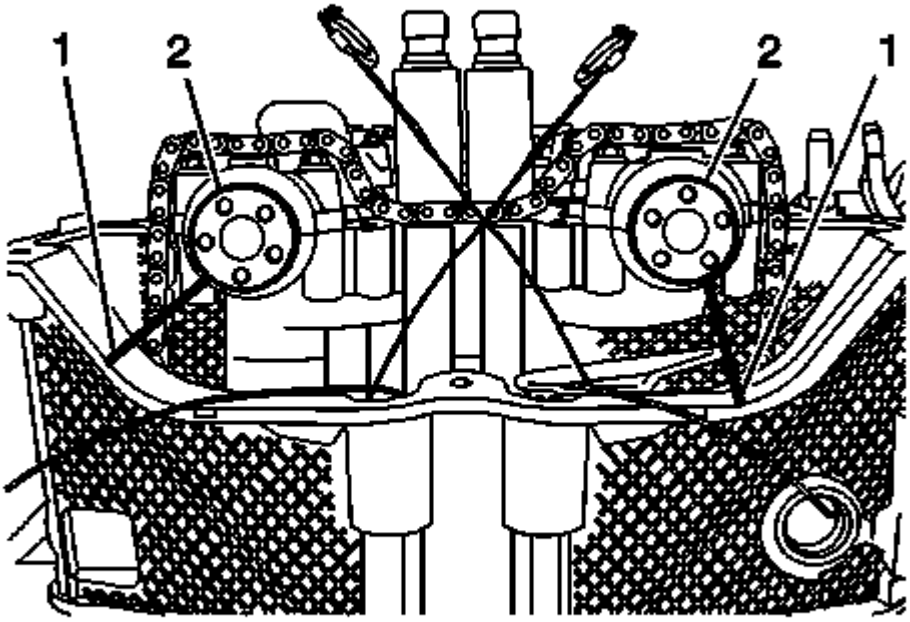

Fig. 174: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

6. Ensure the cylinder head (1) and the camshaft (2) are correctly aligned.

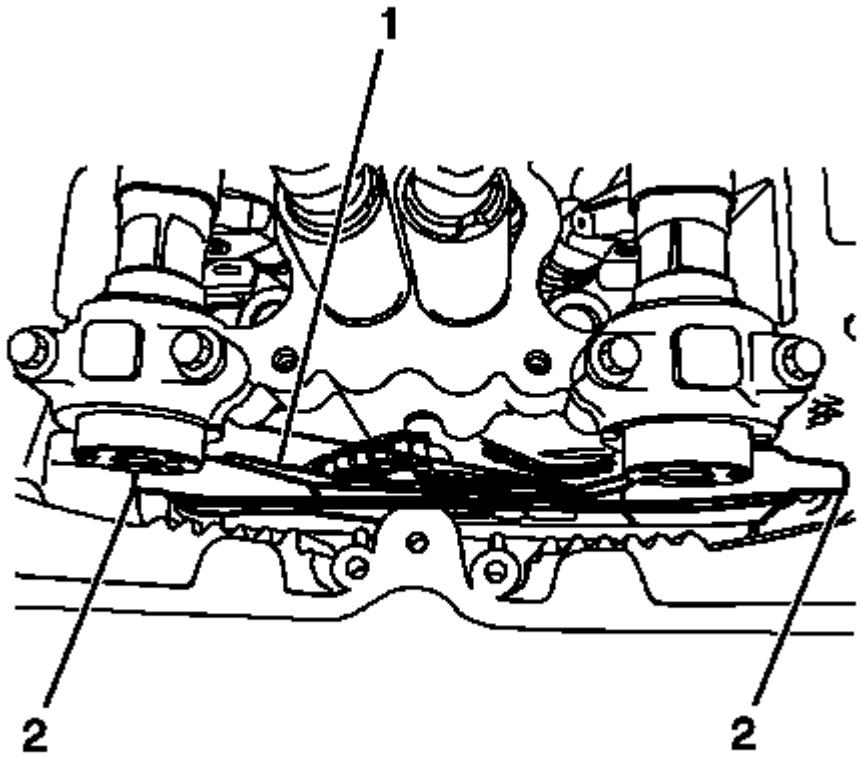

Fig. 175: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

7. Remove the rubber band (1) from around the top of the upper timing chain guides (2).
8. Install the fixed guide bolt into the cylinder head and tighten to 12 N.m (106 lb in).

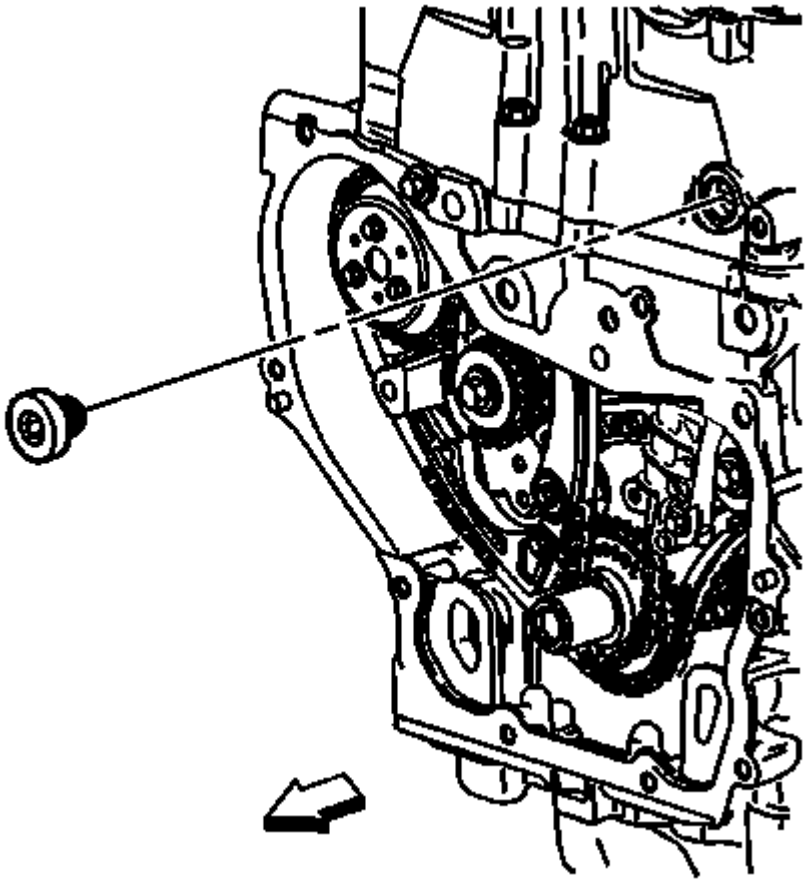

Fig. 176: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant compound to thread and install the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
10. Install the fixed timing chain guide access plug and tighten the plug to 90 N.m (59 lb ft).

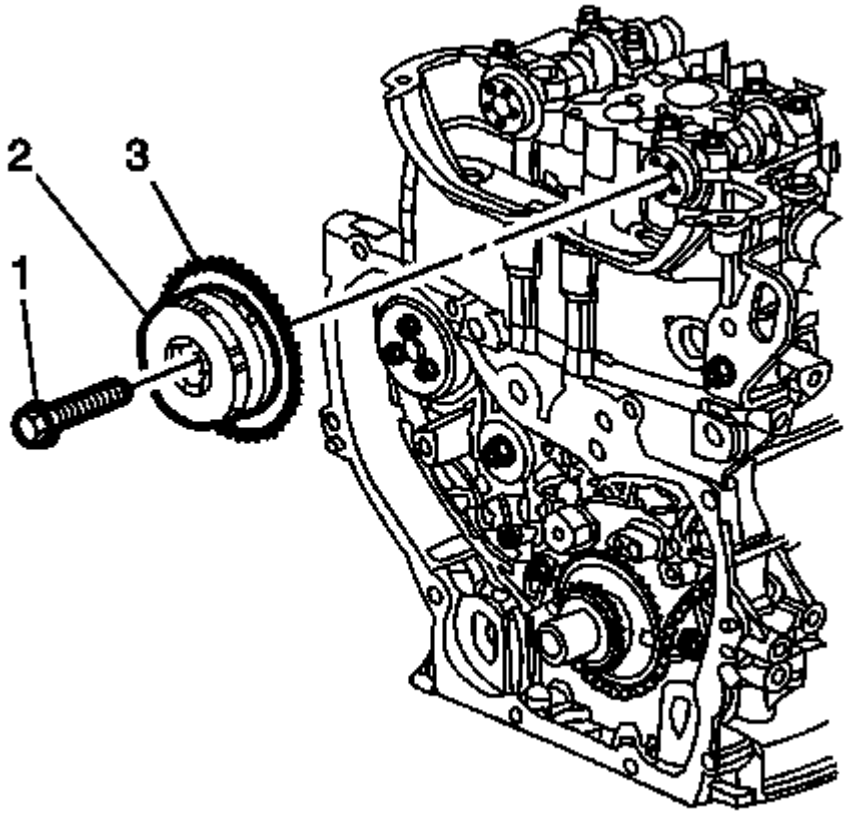

Fig. 177: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intaket camshaft actuator is still aligned properly with the mark on the timing chain. If the mark made previously on the intaket camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

11. Install the timing chain onto the intake camshaft actuator.
12. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
13. Install a NEW intake camshaft actuator bolt (2) until snug.

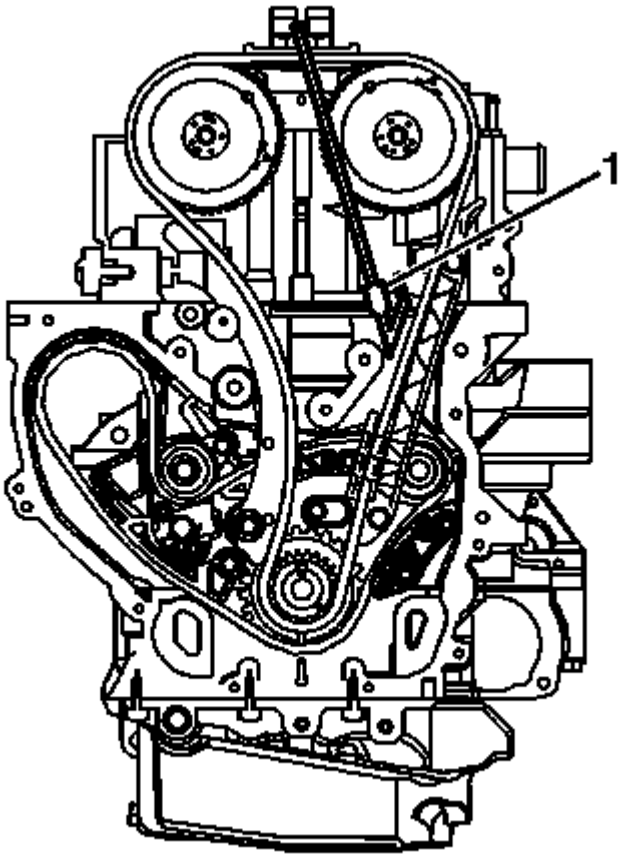

Fig. 178: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

14. Remove the timing chain retention tool **EN-48749** (1) from the intake side of the timing chain. See **Special Tools** .

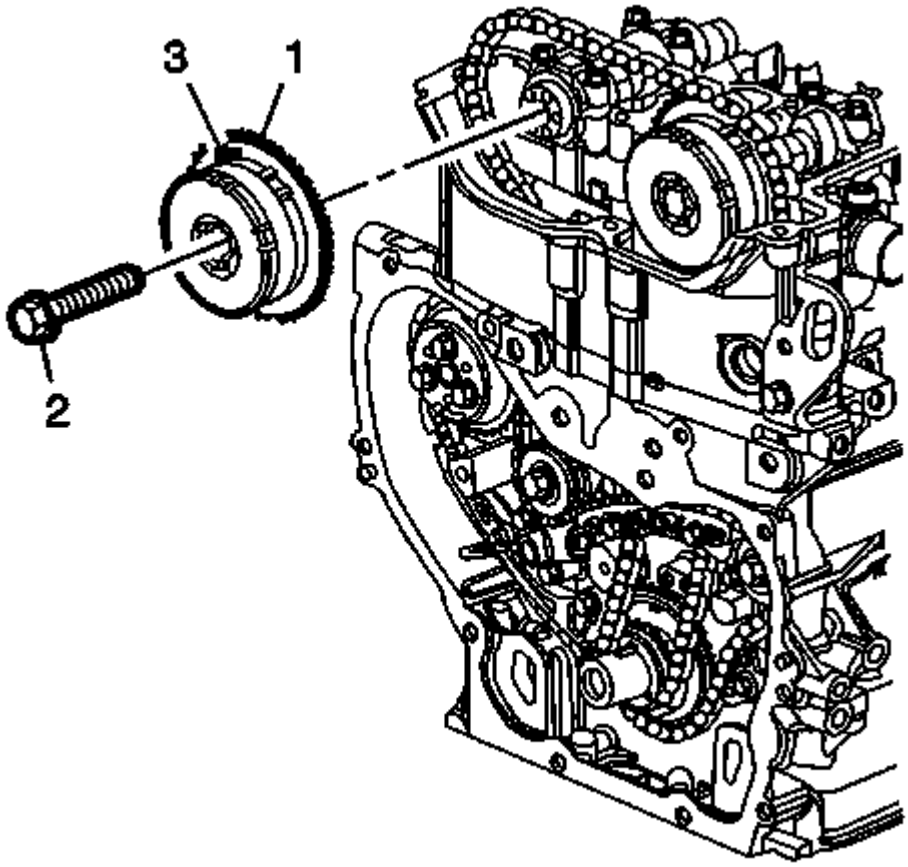

Fig. 179: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the exhaust camshaft actuator is still aligned properly with the mark on the timing chain. The exhaust cam may have to be rotated clockwise to install the eshaust actucator.

15. Install the timing chain onto the exhaust camshaft actuator.
16. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
17. Install a NEW exhaust camshaft actuator bolt (2) until snug.
18. Remove the timing chain retention tool **EN-48749** (1) from the exhaust side of the timing chain. See **Special Tools** .

NOTE: Failure to reset the chain tensioner wil put excess tension on the chain, limiting the chains life.

19. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

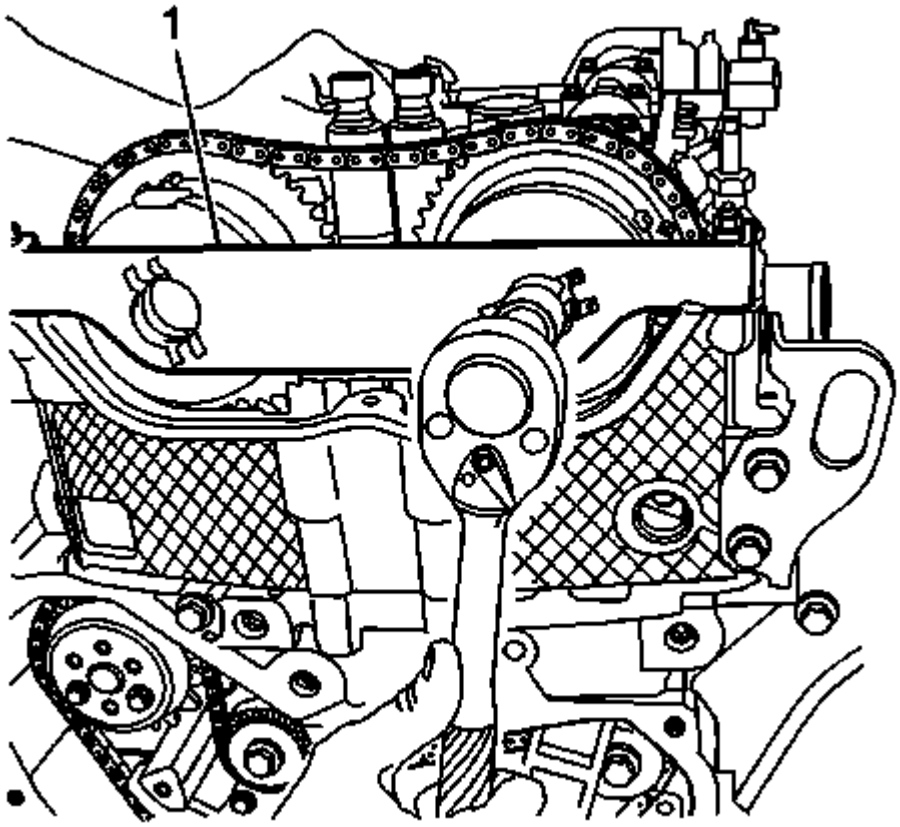

Fig. 180: Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

20. Install the **EN-48953** (1) to the actuators. See **Special Tools** .
21. Install the camshaft actuator locking tool bolts and tighten to 10 N.m (89 lb in).
22. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft), plus an additional 100 degrees using the **J 45059** .
23. Release the tensioner by applying a counterclockwise rotational torque of 45 N.m (33 lb ft) to the harmonic balancer bolt.
24. Remove the camshaft actuator locking tool, **EN-48953** . See **Special Tools** .

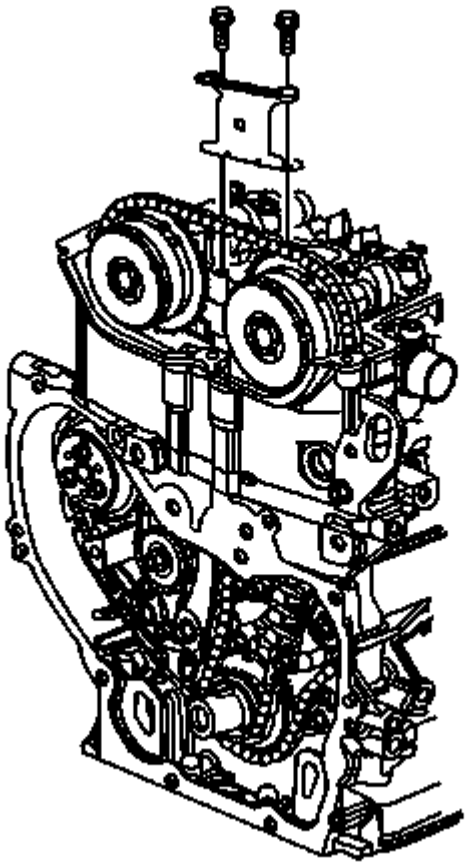

Fig. 181: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

25. Install the upper timing chain guide bolts and guide. Tighten the bolts to 10 N.m (89 lb in).
26. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
27. Install the spark plugs. Refer to **Spark Plug Replacement** .

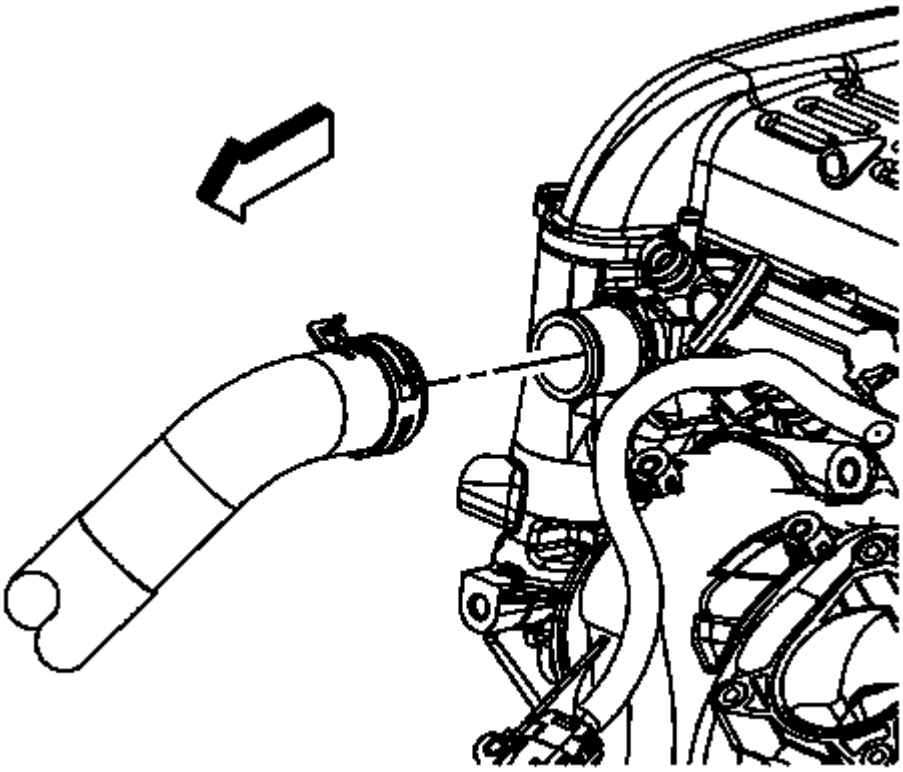

Fig. 182: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

28. Connect all electrical connectors as necessary.
29. Install the radiator inlet hose to the cylinder head.
30. Position the radiator inlet hose clamp using the **J 38185** .
31. Install the radiator surge tank air bleed hose to the cylinder head.
32. Position the radiator surge tank air bleed hose clamp.
33. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (LE5 or LE9 With MH8)** or **Exhaust Manifold Replacement (LE5 or LE9)** .
34. Install the intake manifold. Refer to **Intake Manifold Replacement (LE5)**.
35. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (GE 47716)** .

OIL PAN REPLACEMENT

REMOVAL PROCEDURE

1. Remove the drive belt. Refer to **Drive Belt Replacement (LE5)**.

2. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement (LE5)**.

NOTE: The support fixture bar must be installed to provide enough access to remove and properly tighten the oil pan bolts.

3. Install the engine support fixture. Refer to **Engine Support Fixture**.
4. Remove engine mount. Refer to **Engine Mount Replacement**.
5. Using the engine support fixture, raise the engine approximately 76 mm (3 in).
6. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

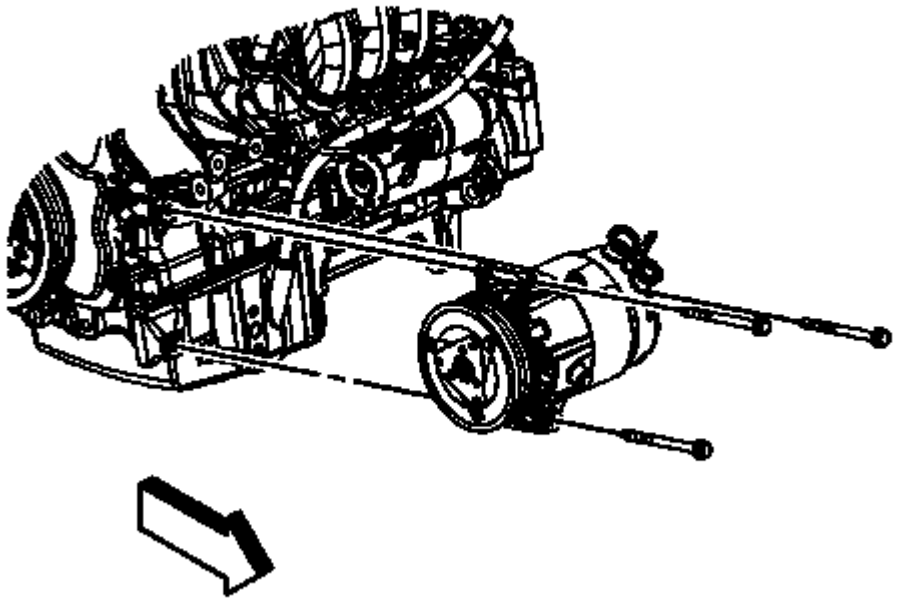

Fig. 183: Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the upper air conditioning (A/C) compressor bolts.
8. Remove the lower A/C compressor bolt.

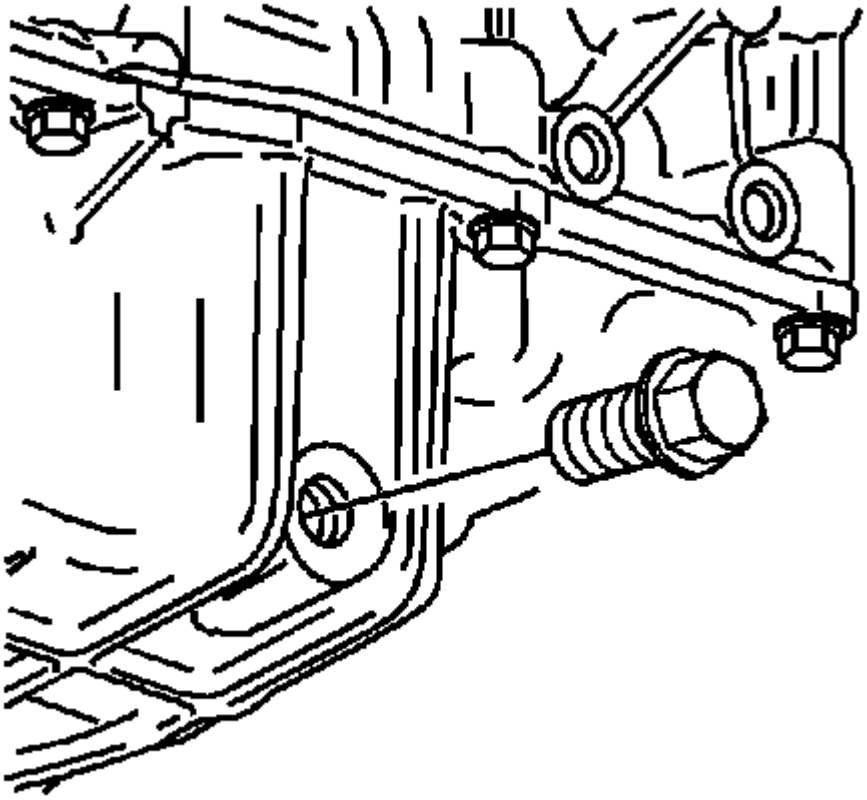

Fig. 184: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

9. Place a suitable drain pan under the oil pan drain plug.
10. Remove the oil pan drain plug.
11. Drain the engine oil.
12. Reinstall the oil pan drain plug until snug.

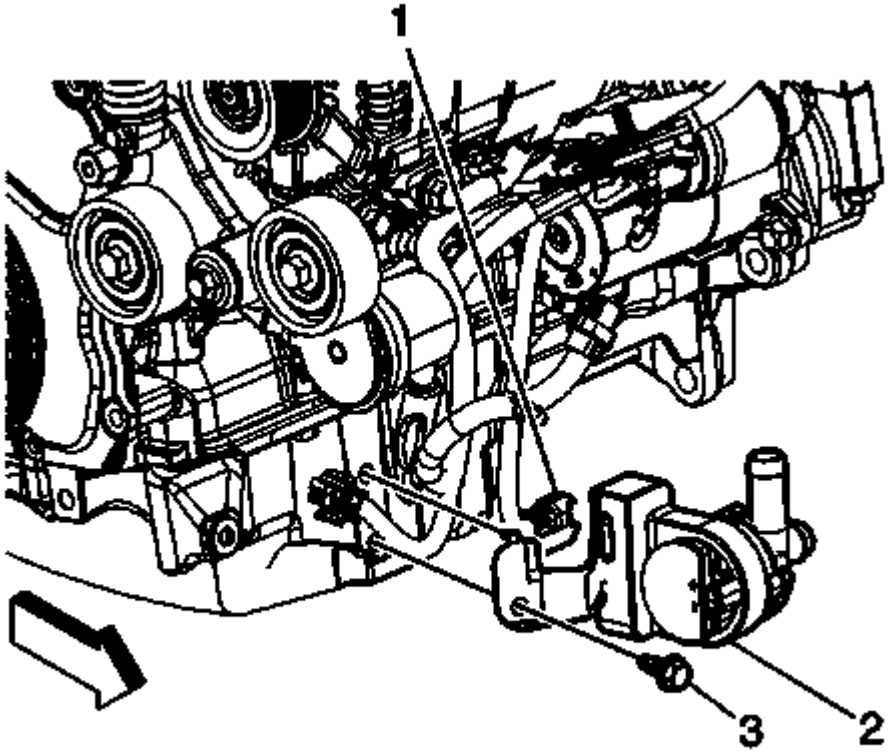

Fig. 185: Generator Control Module Coolant Pump And Bolts
Courtesy of GENERAL MOTORS CORP.

13. LAT only:
    1. Disconnect the engine wiring harness electrical connector (1) from the generator control module coolant pump (2).
    2. Remove the generator control module coolant pump bolt (3).
    3. Remove the generator control module coolant pump from the oil pan.

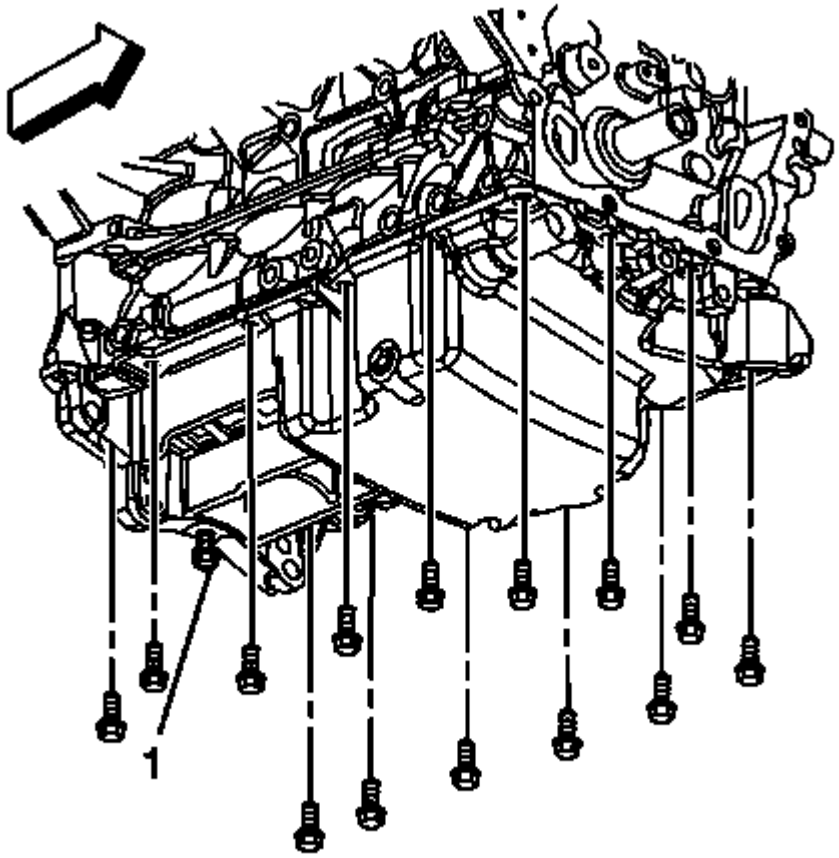

Fig. 186: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 4 oil pan to transaxle bolts.
15. Remove the oil pan bolts.

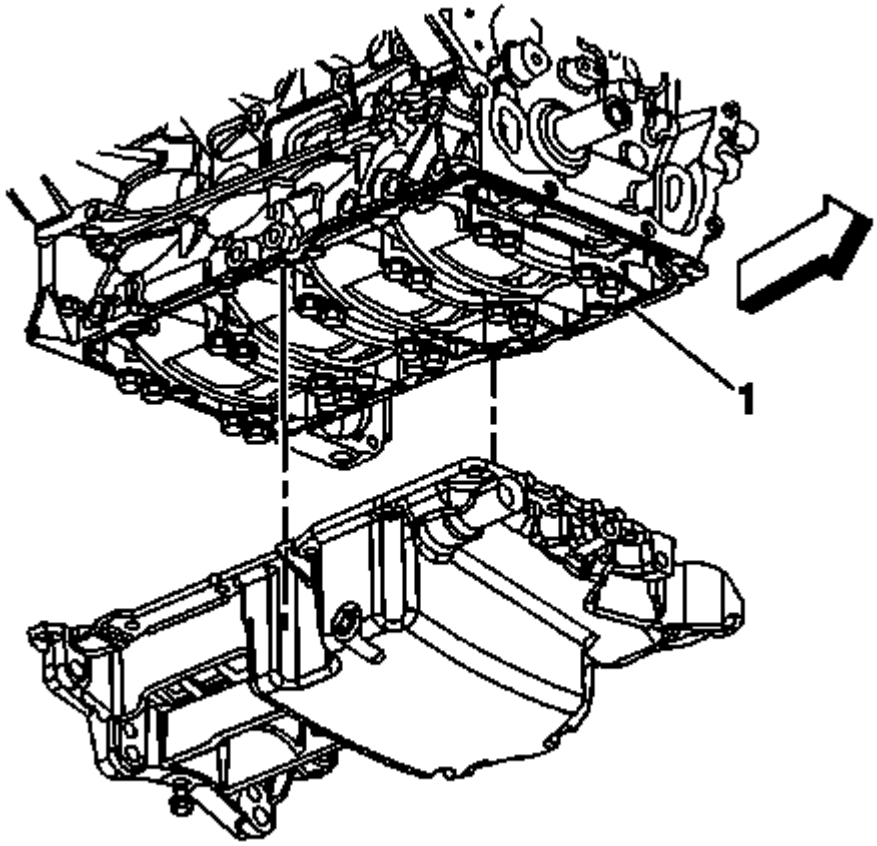

Fig. 187: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil pan
17. Remove any old oil pan sealant (1).

INSTALLATION PROCEDURE

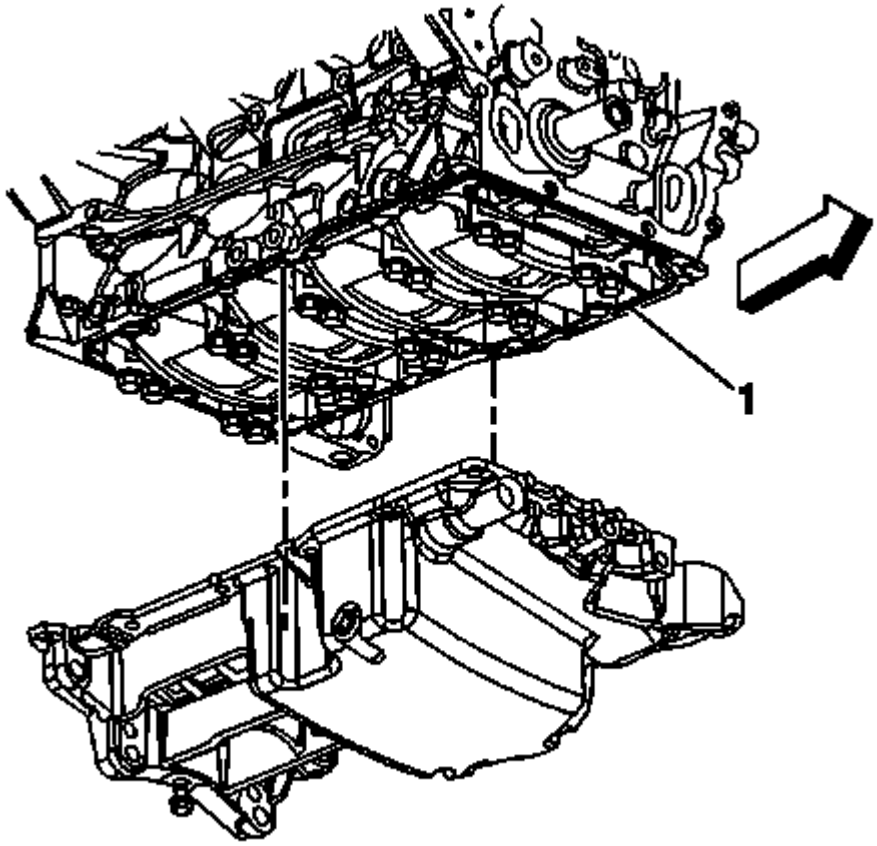

Fig. 188: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the oil pan and the sealing surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of sealant (1) around the perimeter of the oil pan and the oil suction port opening. DO NOT over apply the sealant. More than a 2 mm bead is not required. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
3. Install the oil pan.

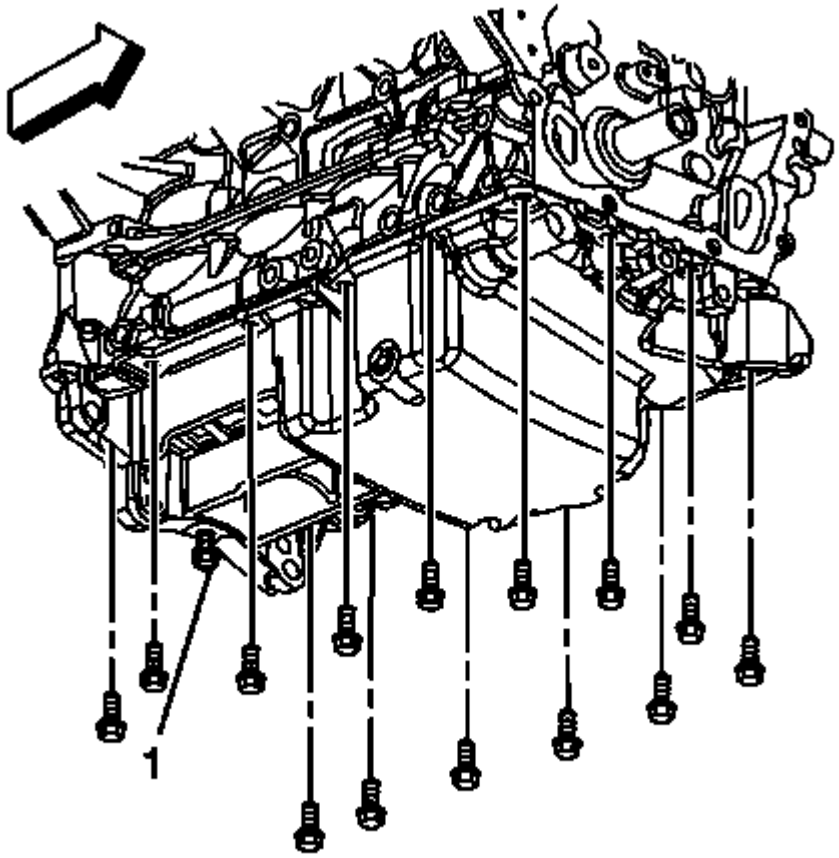

Fig. 189: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

CAUTION: Refer to Fastener Caution .

5. Install the 4 oil pan to transaxle bolts and tighten to 75 N.m (55 lb ft).

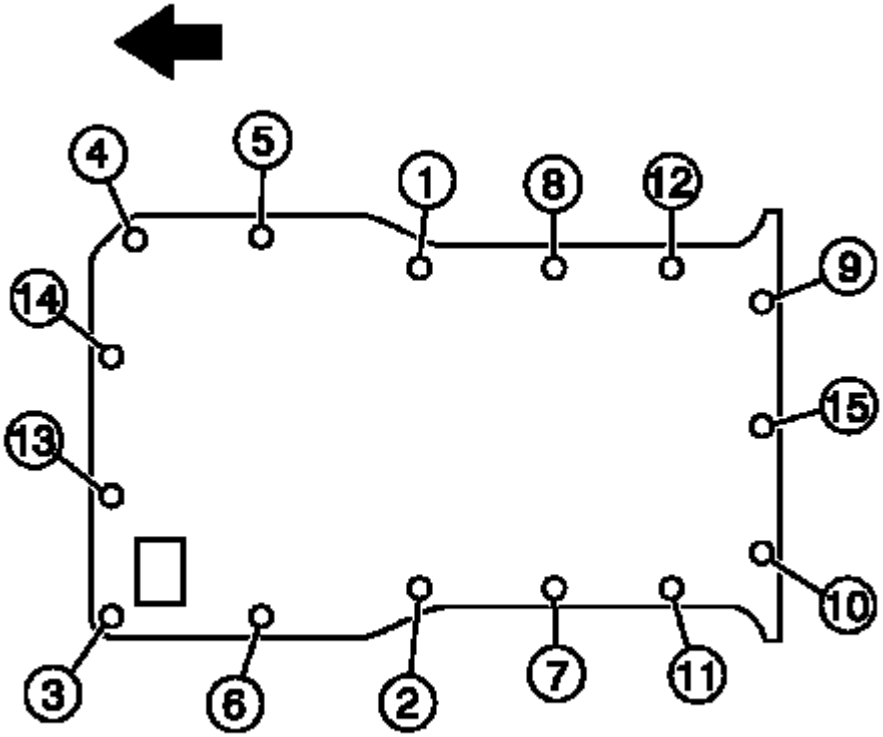

Fig. 190: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

6. Tighten the oil pan bolts in the sequence shown to 25 N.m (18 lb ft).

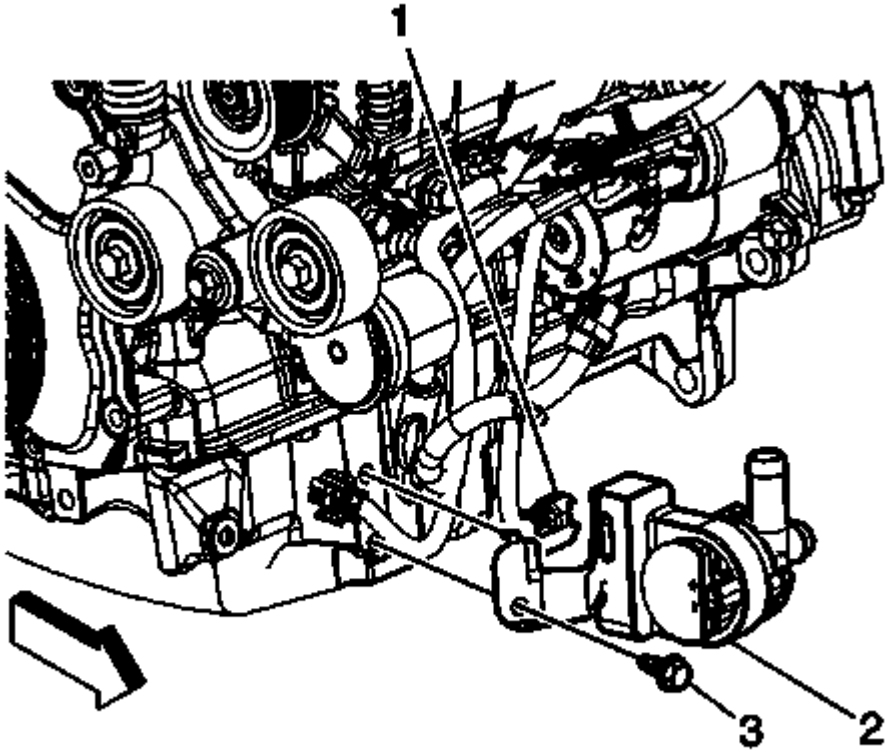

Fig. 191: Generator Control Module Coolant Pump And Bolts
Courtesy of GENERAL MOTORS CORP.

7. LAT only:
    1. Install the generator control module coolant pump to the oil pan. Ensure that the anti-rotation tab is inserted into the hole in the oil pan.
    2. Install the generator control module coolant pump bolt (3) and tighten to 25 N.m (18 lb ft).
    3. Connect the engine wiring harness electrical connector (1) to the generator control module coolant pump (2).
8. Lower the vehicle.
9. Using the engine support fixture, lower the engine.
10. Install the engine mount. Refer to **Engine Mount Replacement**.
11. Remove the engine support fixture.
12. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement (LE5)**.
13. Install the drive belt. Refer to **Drive Belt Replacement (LE5)**.
14. Fill the engine oil to the proper level.

PISTON OIL NOZZLE REPLACEMENT

REMOVAL PROCEDURE

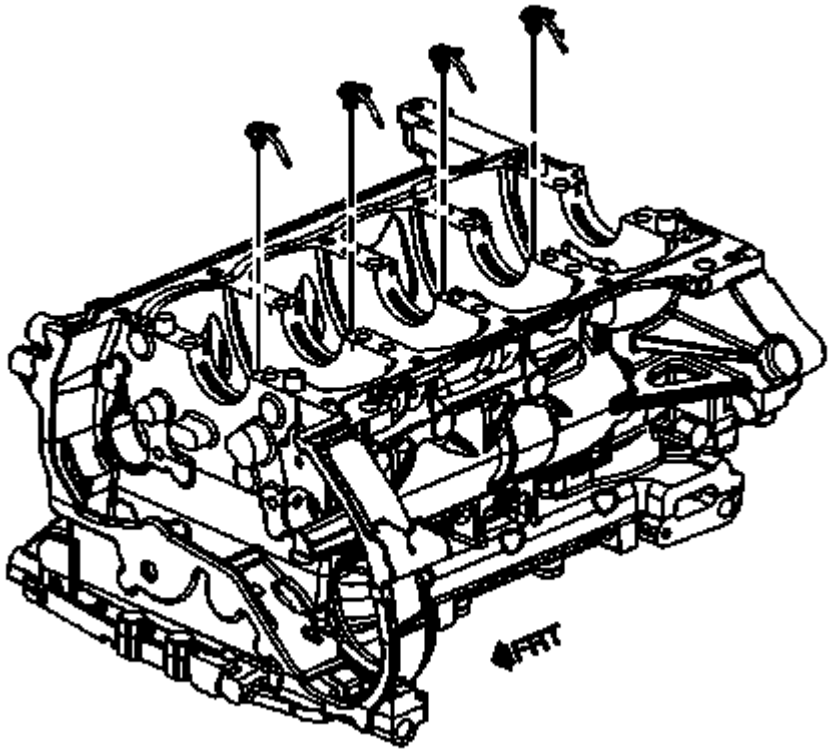

Fig. 192: Piston Oil Squirter
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine oil pan. Refer to **Oil Pan Replacement**.
2. Rotate the crankshaft so that cylinders 1 and 4 are at top dead center (TDC).
3. Remove the piston oil nozzles from cylinders 1 and 4 using a 3/8 inch wobble extension drive with a 6 mm hex drive bit. Remove the piston oil nozzles. (Crankshaft removed for illustrative purposes.)
4. Rotate the crankshaft so that cylinders 2 and 3 are at TDC. Remove the piston oil nozzles.

INSTALLATION PROCEDURE

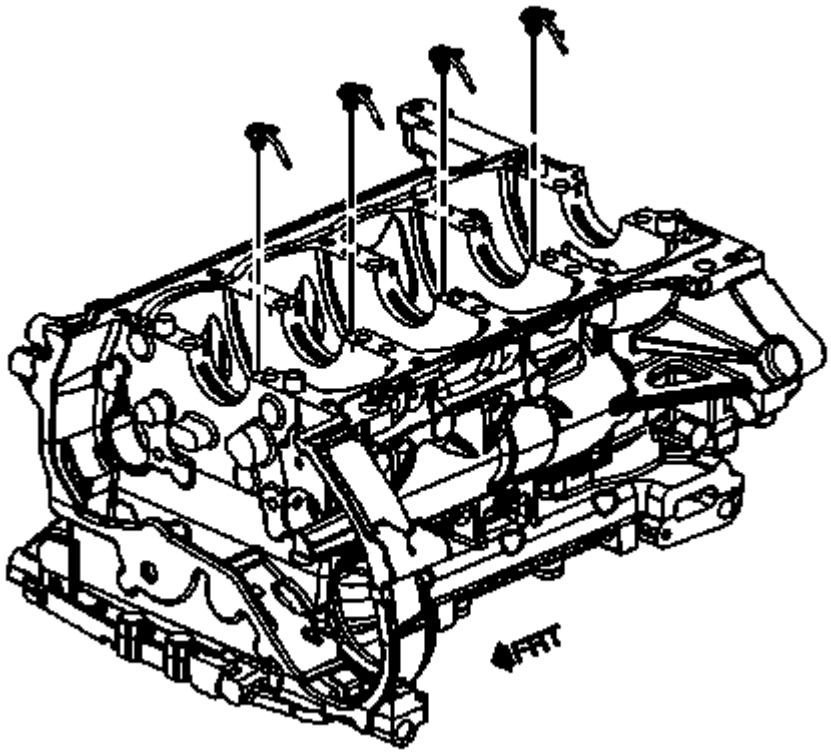

Fig. 193: Piston Oil Squirter
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install new piston oil nozzles. Turn the extension by hand to ensure that the threads are aligned. Use a long screwdriver to ensure that the nozzle does not rotate and make sure that the locating pin is properly indexed in its hole. Tighten the piston oil nozzle bolts to 15 N.m (11 lb ft).
2. Install the engine oil pan. Refer to **Oil Pan Replacement**.
3. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Replace the oil filter and fill the engine with new engine oil. Refer to **Engine Mechanical Specifications (LE5, LE9)** .
5. Reset the engine oil life monitor. Refer to **GM Oil Life System Resetting** .

ENGINE FLYWHEEL REPLACEMENT

SPECIAL TOOLS

- **J-38122-A:** Crankshaft Balancer Holder

- **J-38122:** Angle Meter

For equivalent regional tools, refer to **Special Tools** .

REMOVAL PROCEDURE

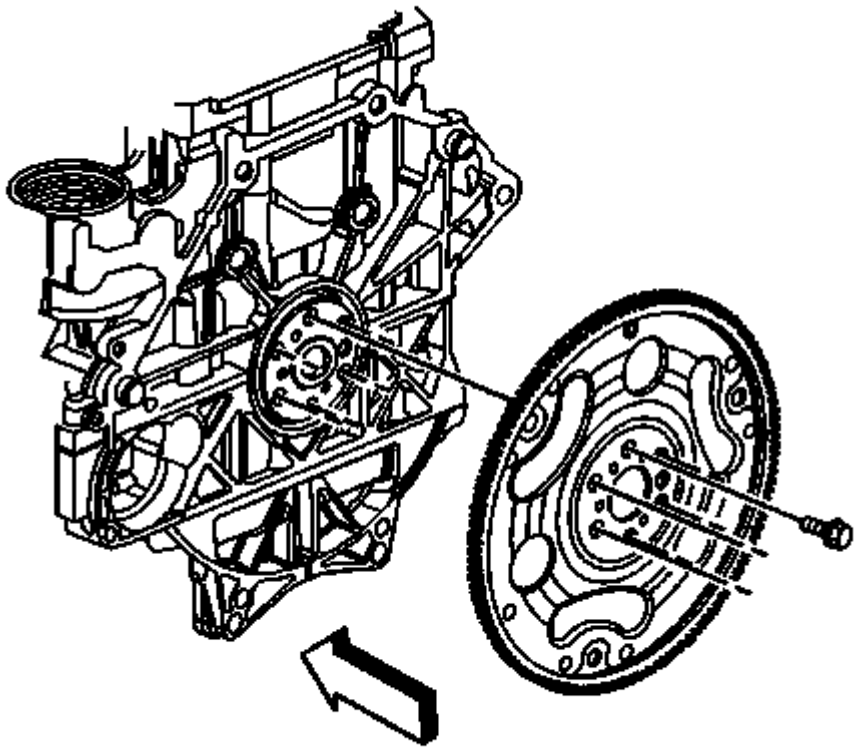

Fig. 194: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Remove the transaxle. Refer to **Transmission Replacement** .
2. Have an assistant install the **J-38122-A:** crankshaft balancer holder, and a breaker bar to the crankshaft balancer in order to prevent the flywheel from rotating when loosening the flywheel bolts.

NOTE: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full engagement on the thin-headed flywheel bolts.

3. Loosen, remove and discard the flywheel bolts.

NOTE: Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

4. Remove the flywheel.
5. Clean the thread adhesive from the flywheel bolt holes. Use a nylon bristle brush to clean the holes in the crankshaft.

INSTALLATION PROCEDURE

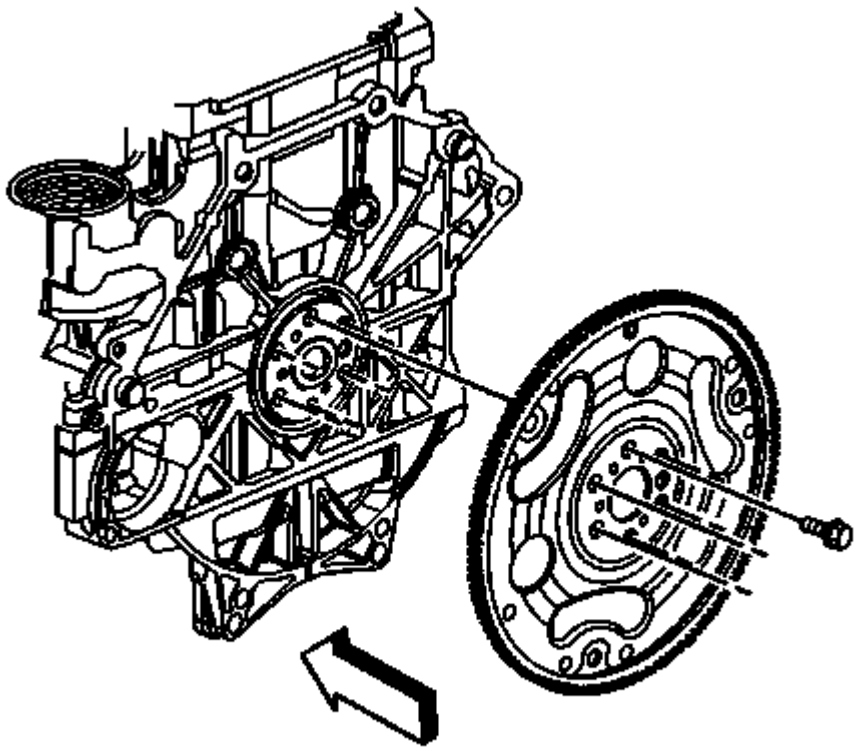

Fig. 195: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Position the flywheel to the crankshaft.
2. Install the NEW flywheel bolts until snug.
3. Have an assistant install the **J 38122-A** , and a breaker bar to the crankshaft balancer in order to prevent the flywheel from rotating when tightening the flywheel bolts. See **Special Tools** .

CAUTION: Refer to Fastener Caution .

4. Tighten the flywheel bolts to 53 N.m (39 lb ft) plus an additional 25 degrees using a **J-38122:** angle meter.
5. Remove the **J 38122-A** and breaker bar. See **Special Tools** .

6. Install the transaxle. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

SPECIAL TOOLS

EN-42067: Rear Main Seal Installer

For equivalent regional tools, refer to **Special Tools** .

REMOVAL PROCEDURE

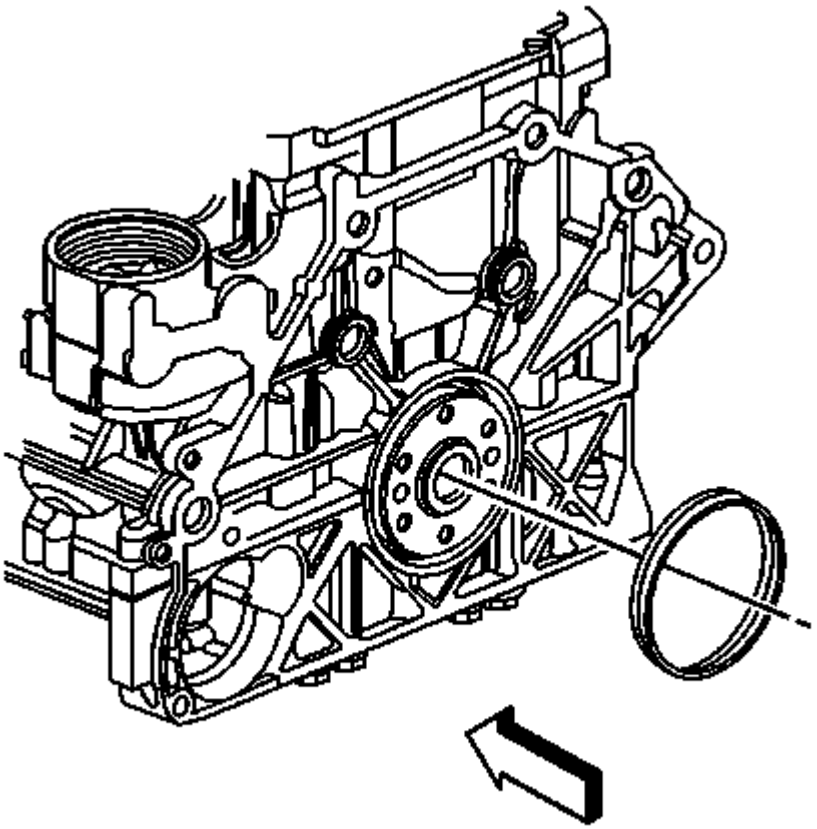

Fig. 196: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

NOTE: Do not damage the outside diameter of the crankshaft or chamber with any tool.

2. Pry out the crankshaft rear oil seal using a flat-bladed tool.

INSTALLATION PROCEDURE

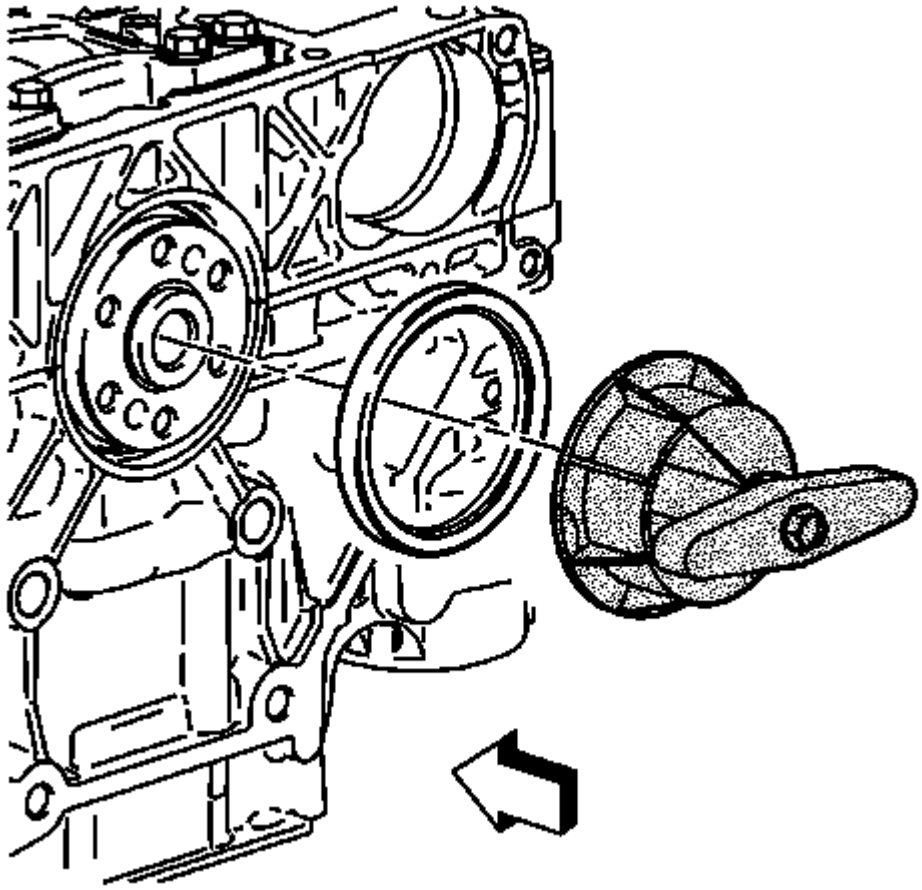

Fig. 197: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-42067:** installer, install a NEW crankshaft real oil seal.
2. Install the flywheel. Refer to **Engine Flywheel Replacement**.

ENGINE REPLACEMENT

SPECIAL TOOLS

J-38185: Hose Clamp Pliers

REMOVAL PROCEDURE

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief (CH 48027-100)** or **Fuel Pressure Relief (Without CH 48027-100)** .
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

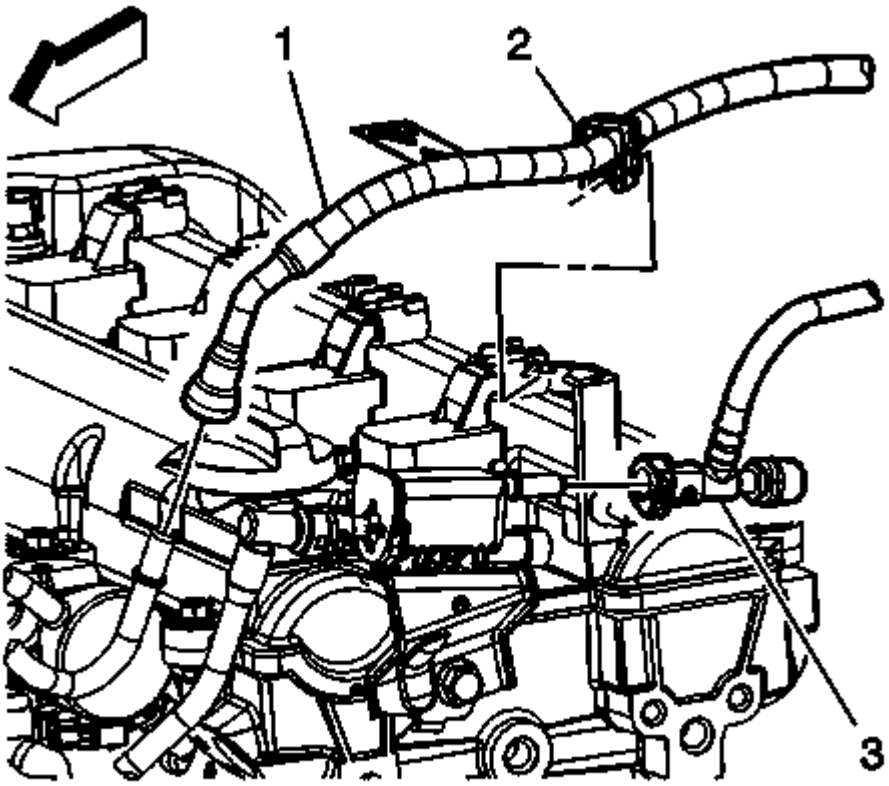

Fig. 198: View Of Fuel Feed Pipe Retainer & Fuel Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the fuel feed pipe (1) quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
4. Disconnect the evaporative emission (EVAP) line (3) quick connect fitting from the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
5. Disconnect the fuel feed pipe clip (2) from the fuel line bracket.

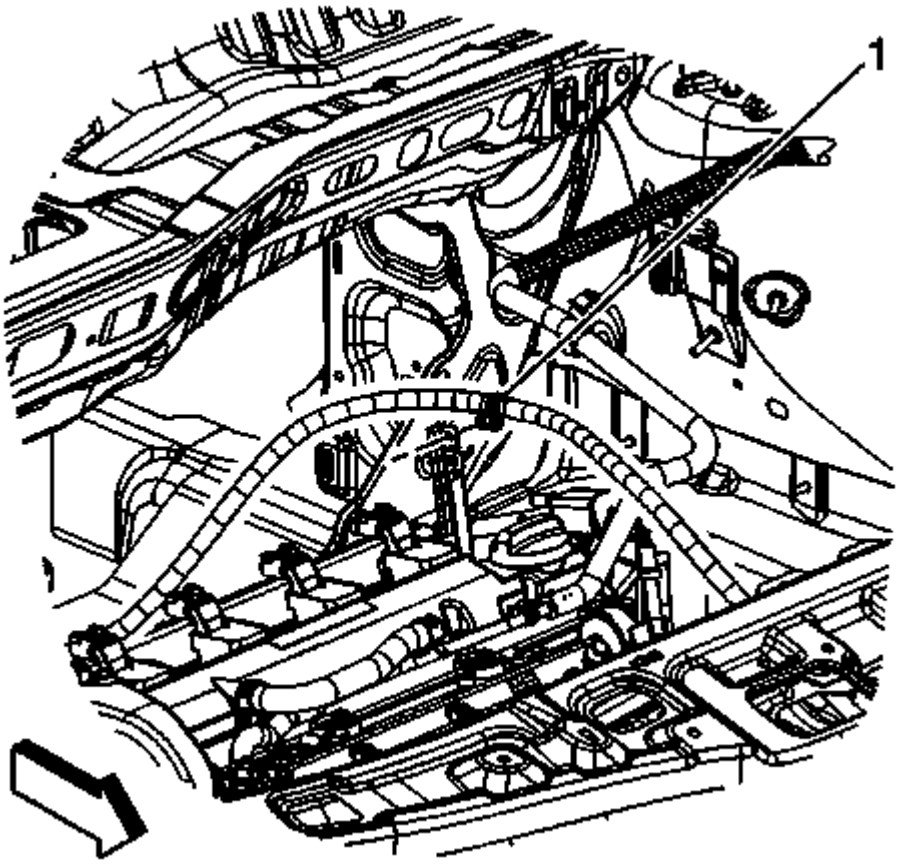

Fig. 199: Transaxle Shift Cable Clip
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the transaxle shift cable clip (1) from the fuel line bracket.
7. Remove the battery tray. Refer to **Battery Tray Replacement (LY7, and LE5)** or **Battery Tray Replacement (LE5, LE9, LY7)** .

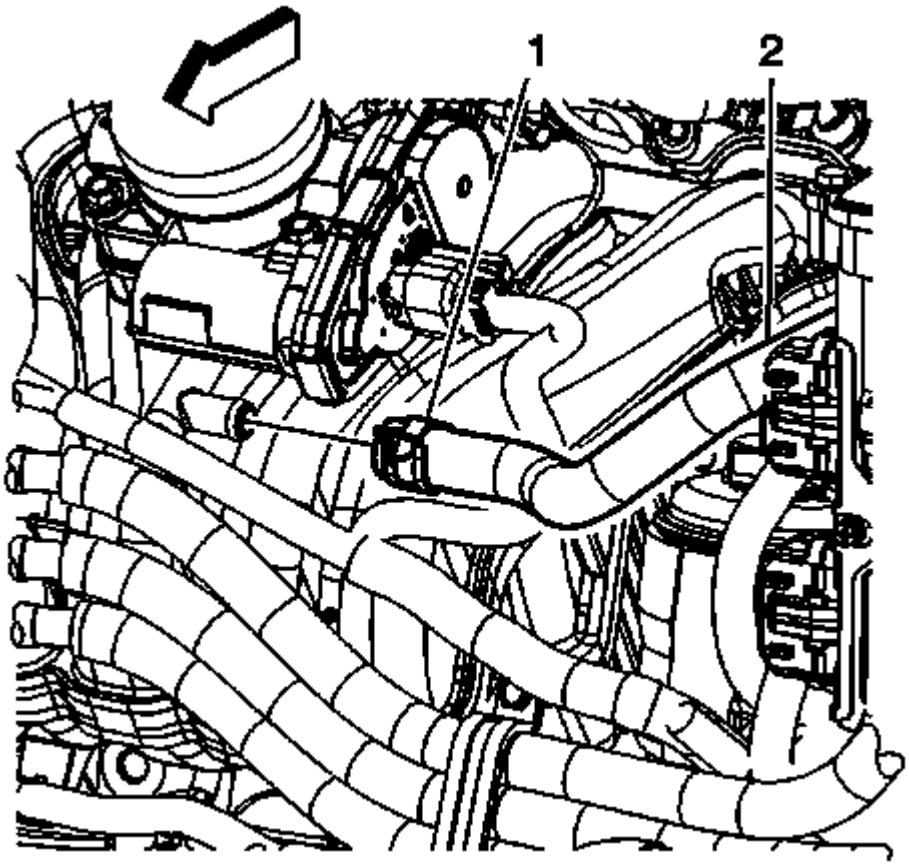

Fig. 200: Identifying Vacuum Brake Booster Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

8. Reposition the vacuum brake booster hose clamp (1) at the intake manifold.
9. Disconnect the vacuum brake booster hose (2) from the intake manifold. Reposition the brake booster hose out of the way.

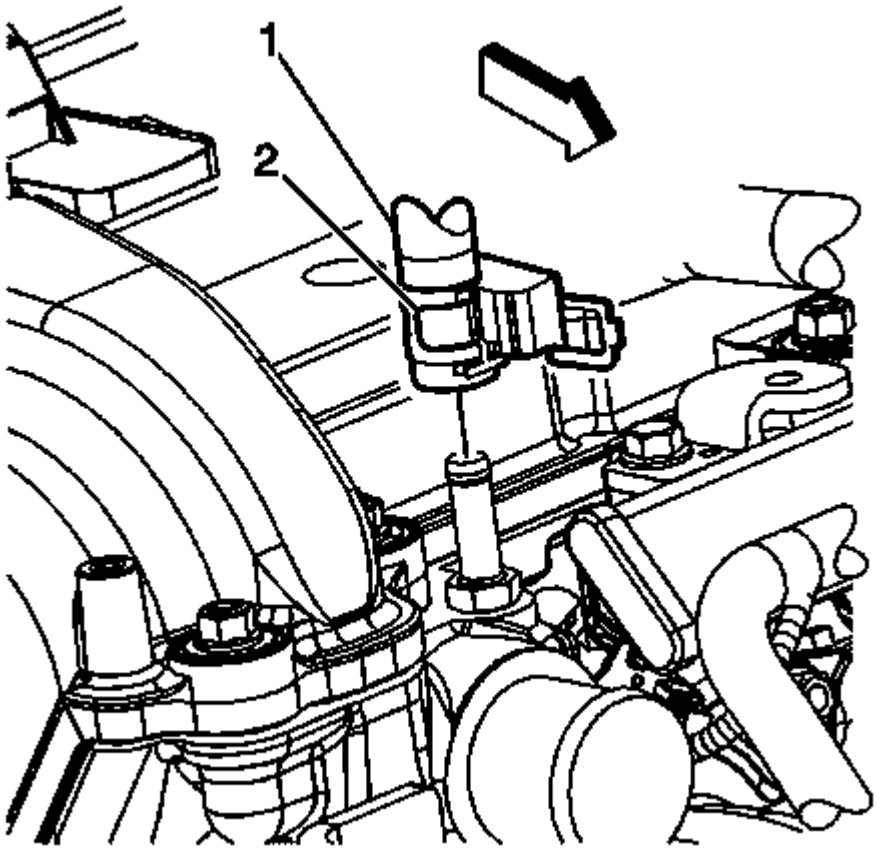

Fig. 201: Coolant Recovery Inlet Hose And Clamp
Courtesy of GENERAL MOTORS CORP.

10. Reposition the coolant recovery inlet hose clamp (2) at the cylinder head.
11. Disconnect the coolant recovery inlet pipe clip from the fuel rail.
12. Disconnect the coolant recovery inlet hose (1) from the cylinder head. Reposition the hose/pipe out of the way.

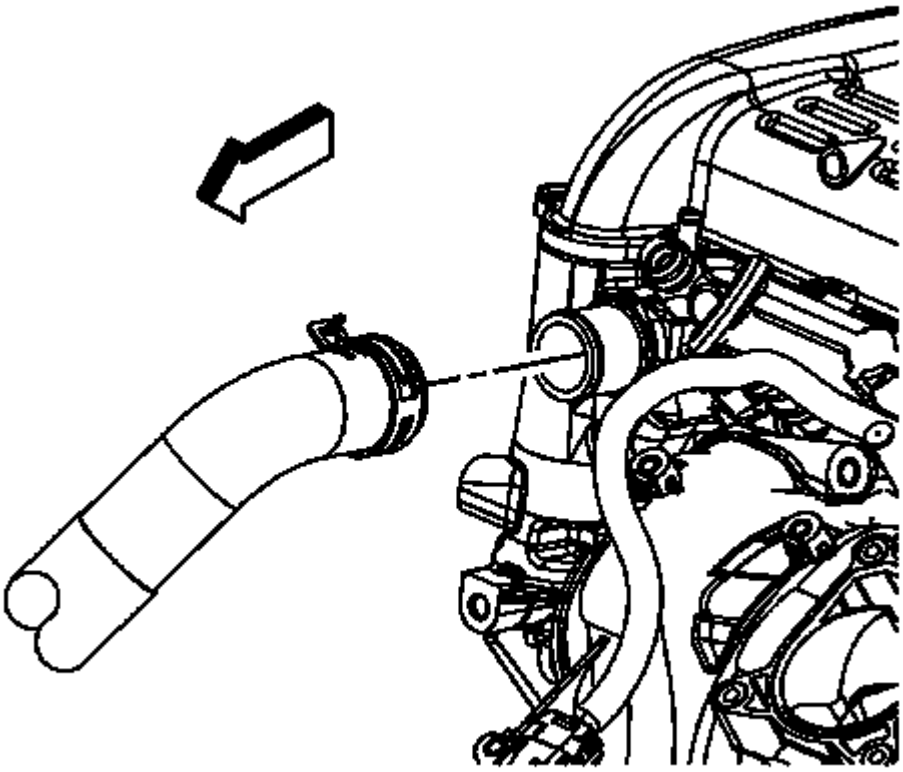

Fig. 202: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

13. Reposition the radiator inlet hose clamp using the **J-38185:** pliers.
14. Disconnect the radiator inlet hose from the cylinder head.
15. Remove the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LY7)** or **Radiator Outlet Hose Replacement (LE5)** .

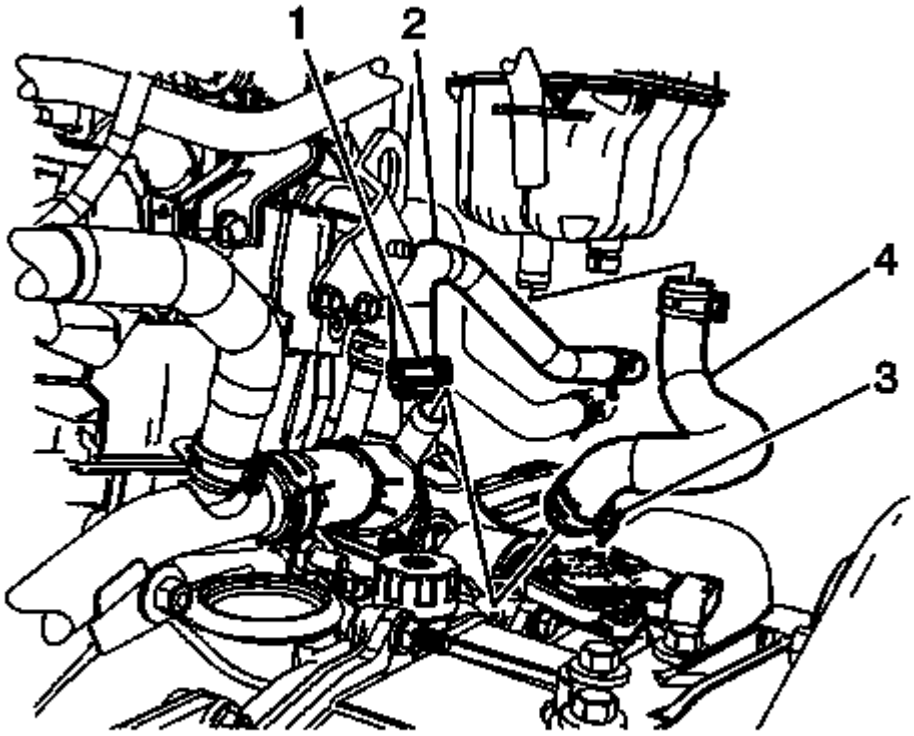

Fig. 203: Inlet Hoses
Courtesy of GENERAL MOTORS CORP.

16. Reposition the heater inlet hose clamp (1) at the thermostat housing.
17. Disconnect the heater inlet hose (2) from the thermostat housing.
18. Reposition the coolant recovery reservoir/heater inlet hose (3) clamp at the thermostat housing.
19. Disconnect the coolant recovery reservoir/heater inlet hose (4) from the thermostat housing.
20. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
21. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

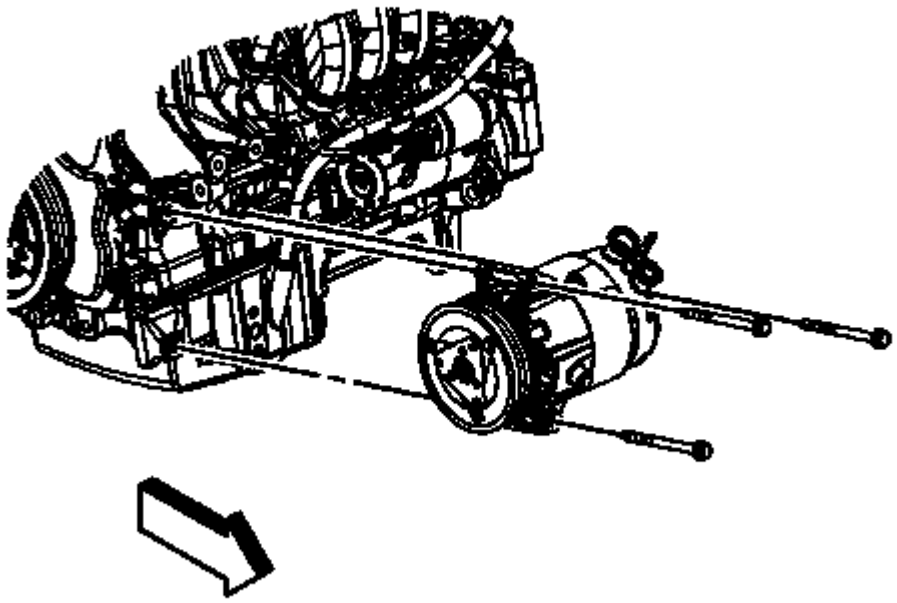

Fig. 204: Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

22. Unbolt the A/C compressor and reposition out of the way.

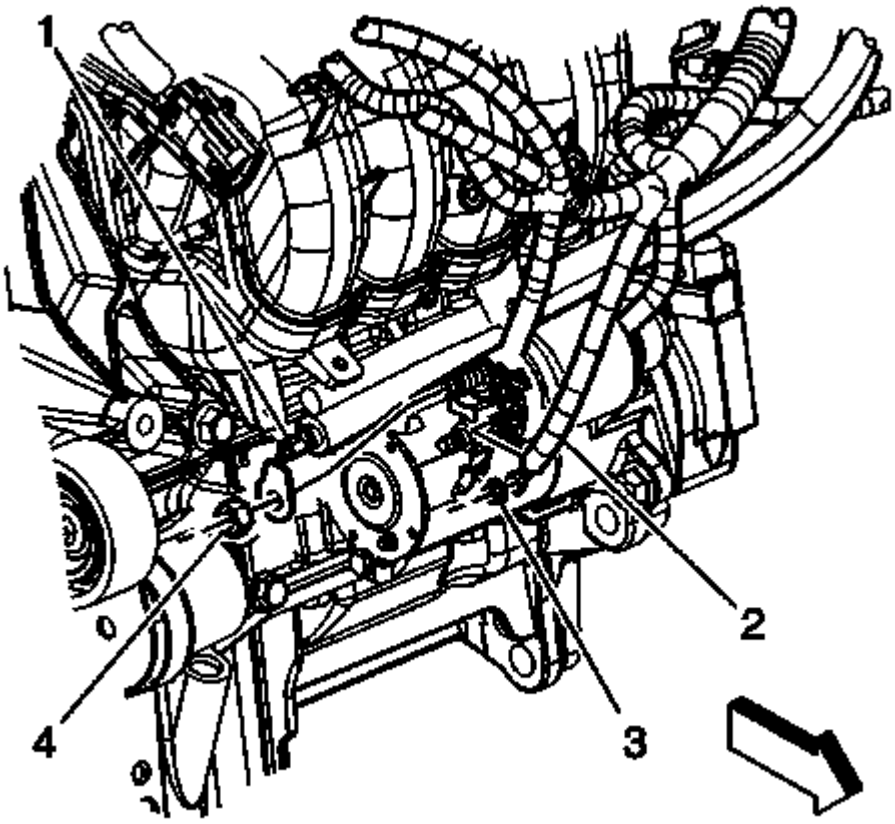

Fig. 205: View Of Starter And Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

23. Remove the positive battery cable to starter motor nut (4).
24. Disconnect the positive battery cable lead (1) from the starter motor.
25. Reposition the positive battery cable from in between the starter and the engine.

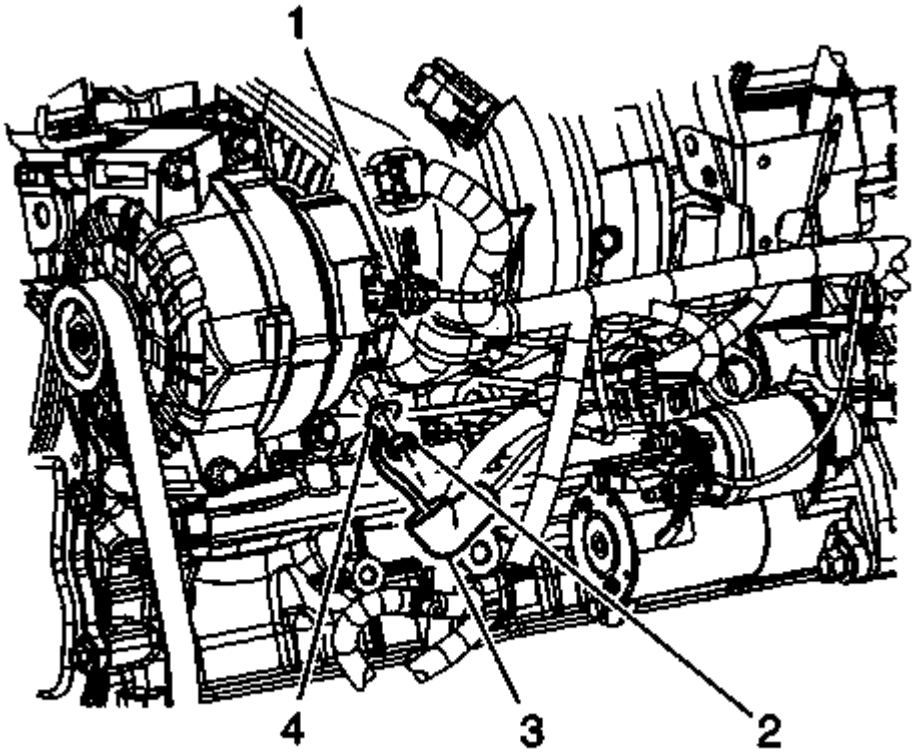

Fig. 206: View Of Generator Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

26. Disconnect the generator electrical connector (1).
27. Reposition the engine harness boot (3).
28. Remove the generator nut (2).
29. Remove the engine harness lead (4) from the generator.
30. Lower the vehicle.

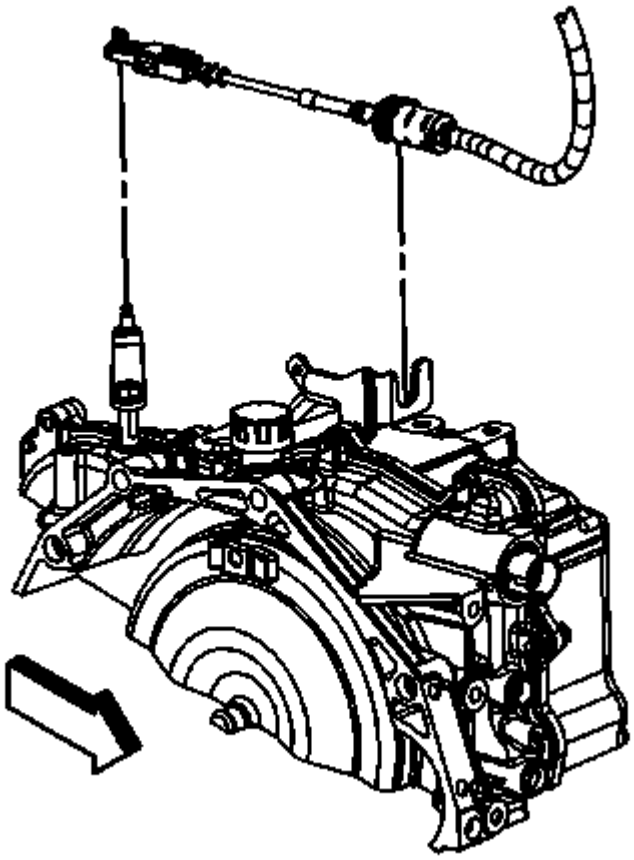

Fig. 207: Transaxle Shift Cable And Range Select Lever
Courtesy of GENERAL MOTORS CORP.

31. Remove the transaxle shift cable from the range select lever.
32. Release the shift control cable retaining clip and remove the cable from the shift control cable bracket.

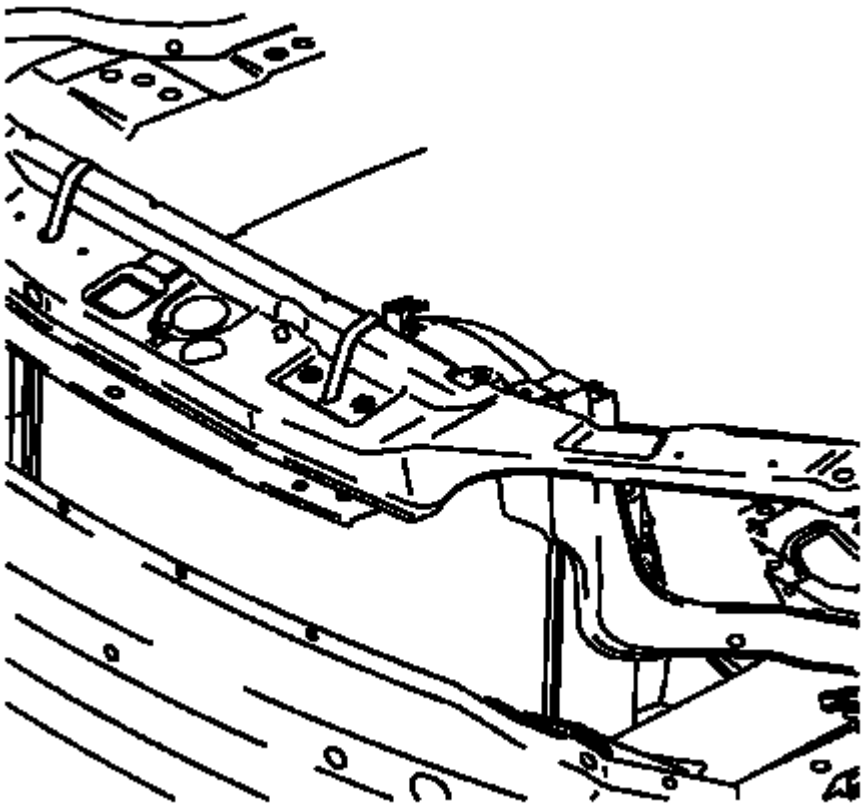

Fig. 208: View Of Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

NOTE: The radiator/condenser/fan assembly will stay in the vehicle during engine removal.

33. Using long tie straps, secure the radiator/condenser/fan assembly to the radiator support.
34. Raise the vehicle and remove the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
35. Remove the front wheelhouse panel. Refer to **Front Wheelhouse Panel Splash Shield Replacement** .

NOTE: A piece of hardwood should be used between the transaxle and the frame. This wood will support the engine when the left side engine mounts bolts are removed.

36. Install a piece of hardwood 1 x 2 x 4 between the transaxle and the frame.

NOTE: A piece of hardwood should be used between the oil pan and the frame. This wood will support the engine when the right side engine mounts are removed.

37. Install a piece of hardwood 1 x 2 x 4 between the oil pan and the frame.

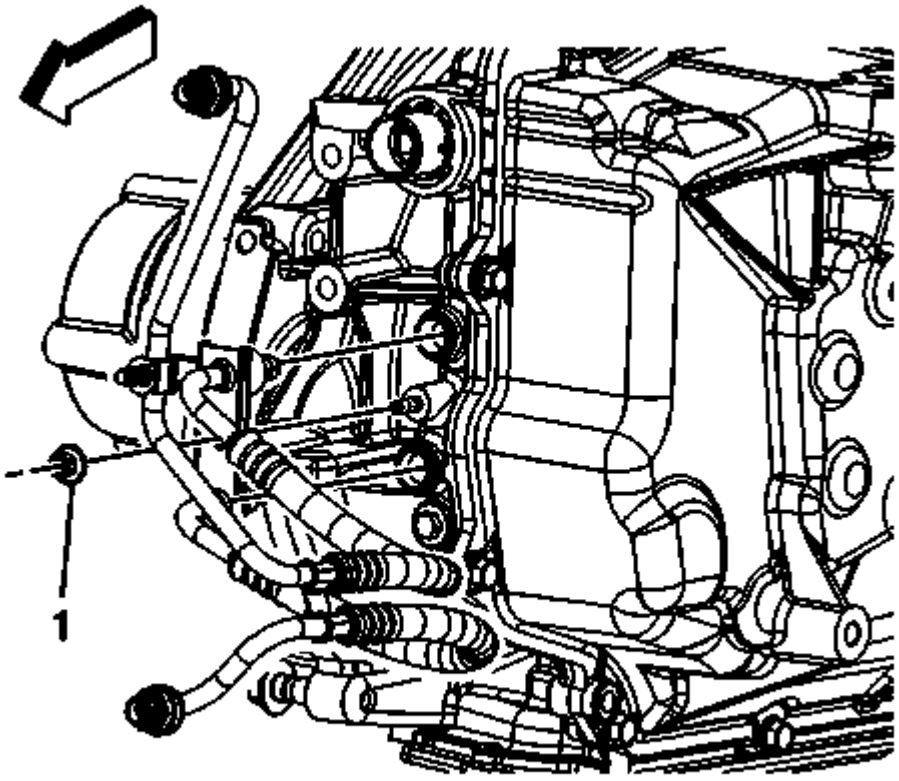

Fig. 209: Transaxle Oil Cooler Line To Transaxle Nut
Courtesy of GENERAL MOTORS CORP.

38. Drain the transaxle fluid.
39. Disconnect the fluid cooler hoses at the transmission. Refer to **Fluid Cooler Inlet Hose Replacement** and **Fluid Cooler Outlet Hose Replacement** .
40. Remove the catalytic converter. Refer to **Exhaust Manifold Pipe Replacement (LE5 or LE9)** .
41. Disconnect the intermediate shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
42. Disconnect the tie rods from the steering knuckles. Refer to **Steering Linkage Outer Tie Rod Replacement** .
43. Disconnect the stabilizer links from the stabilizer shaft. Refer to **Stabilizer Shaft Link Replacement** .
44. Disconnect the lower control arms from the steering knuckles. Refer to **Lower Control Arm Replacement** .
45. Remove the wheel drive shafts. Refer to **Wheel Drive Shaft Replacement** .
46. Lower the vehicle.

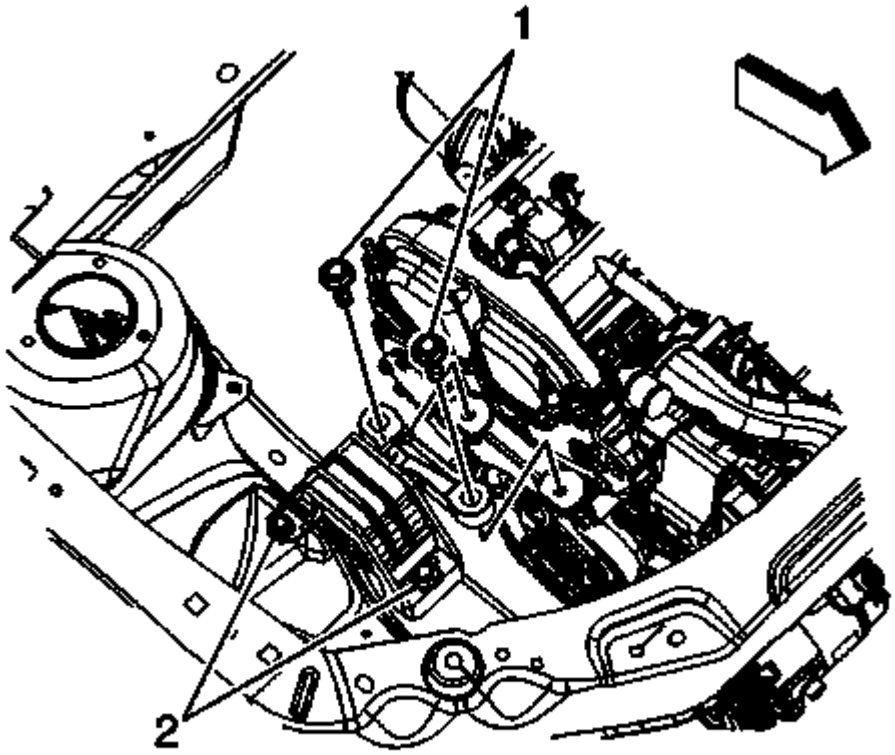

Fig. 210: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

47. Remove the engine mount to bracket bolts (1).

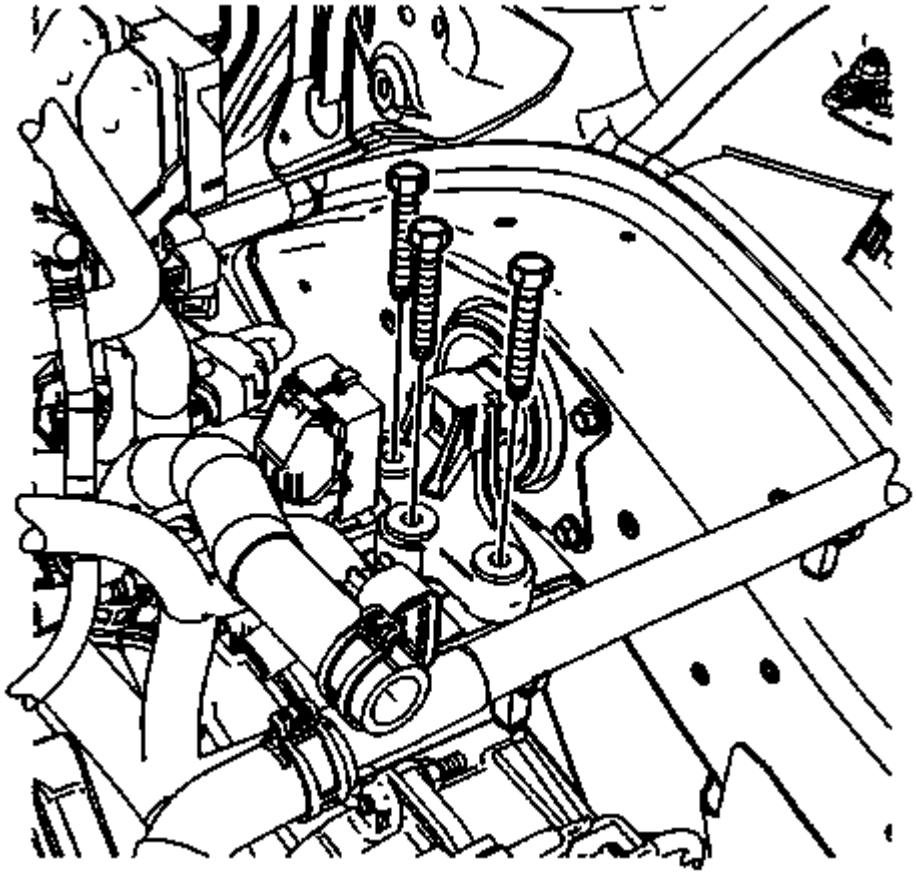

Fig. 211: Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

48. Remove the transaxle mount to transaxle bolts.
49. Raise the vehicle.

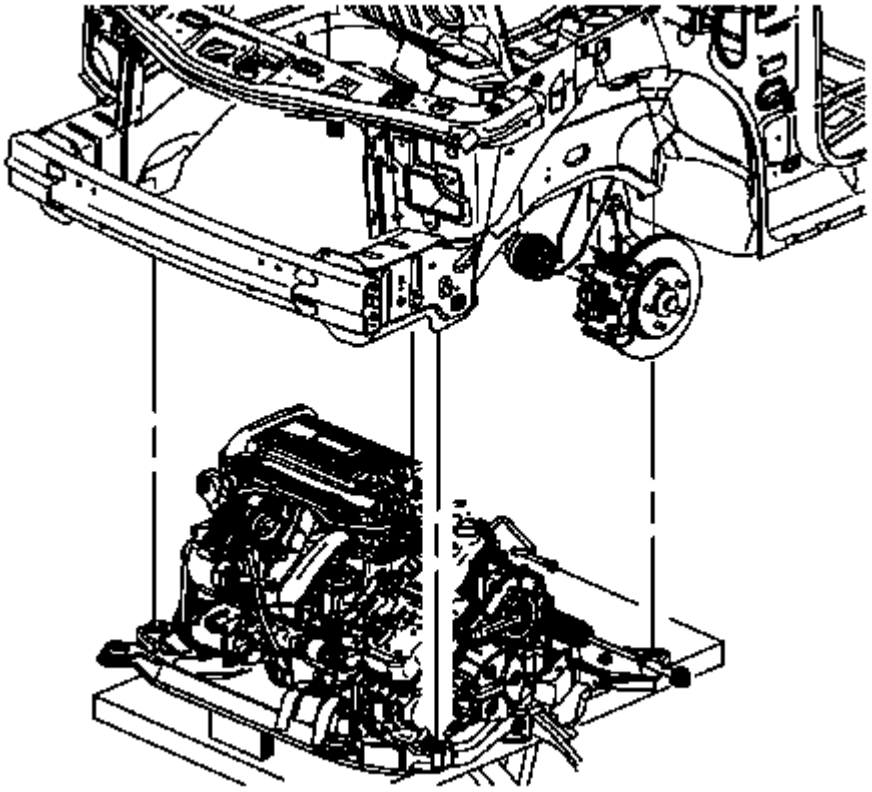

Fig. 212: Positioning Powertrain Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: During the powertrain removal support the vehicle body by placing a jack at the rear of the vehicle.

50. Position an engine support table under the powertrain assembly.

NOTE: Blocks of wood can be used between the front of the frame and the oil pan to table in order to level the powertrain during the removal.

51. With the table positioned, fully raise the table to contact with the powertrain assembly.
52. Remove the frame to body bolts. Discard the bolts.

NOTE: When lowering the engine/transaxle assembly, verify all brake pipes, shifter cables and other components are not interfering with the removal.

53. Lower the engine table and raise the body on the hoist until the engine/transaxle and frame are separated from the vehicle.

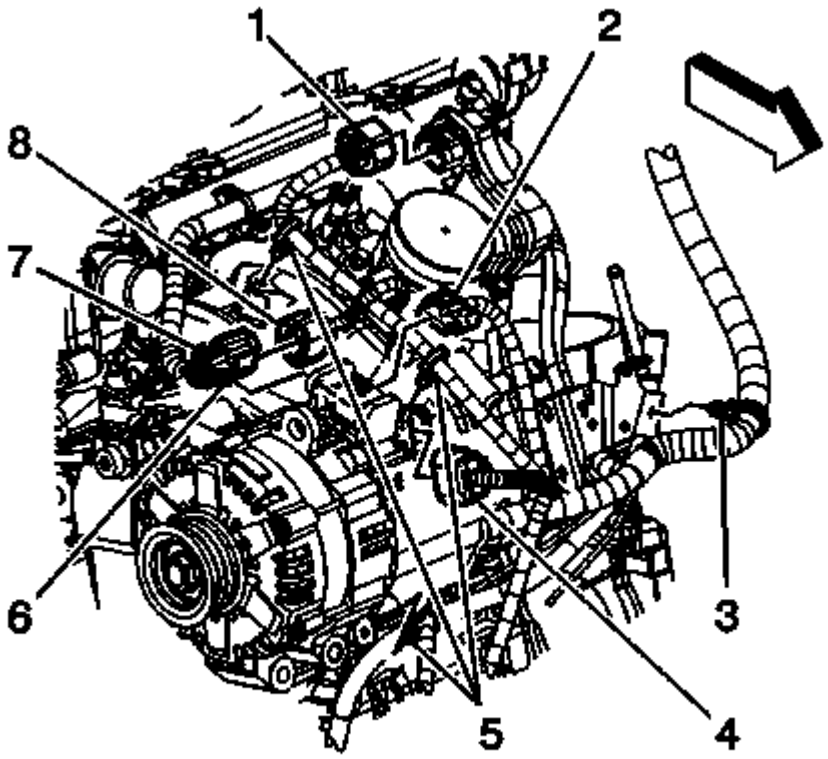

Fig. 213: Identifying Engine Electrical Connectors Left Side
Courtesy of GENERAL MOTORS CORP.

54. Disconnect the engine wiring harness electrical connector (1) from the throttle actuator.
55. Disconnect the engine wiring harness electrical connector (8) from the fuel injector wiring harness electrical connector (7).
56. Disconnect the engine wiring harness clip (3) from the oil level indicator tube bracket.

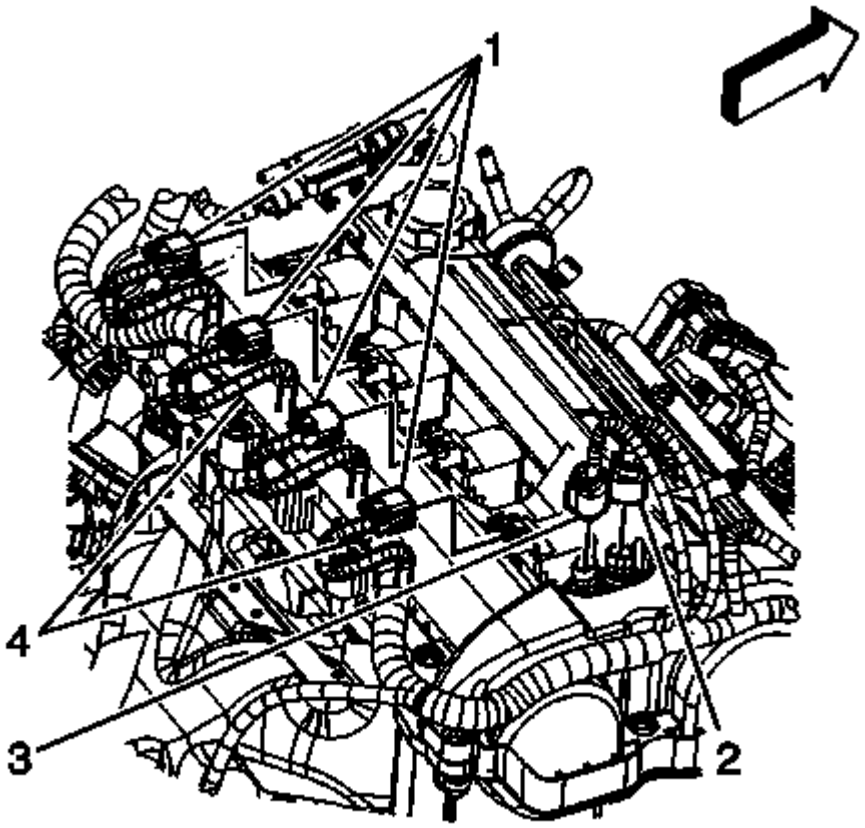

Fig. 214: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

57. Disconnect the engine wiring harness electrical connectors (1) from the ignition coils.
58. Disconnect the engine wiring harness electrical connectors (2, 3) from the camshaft actuators.

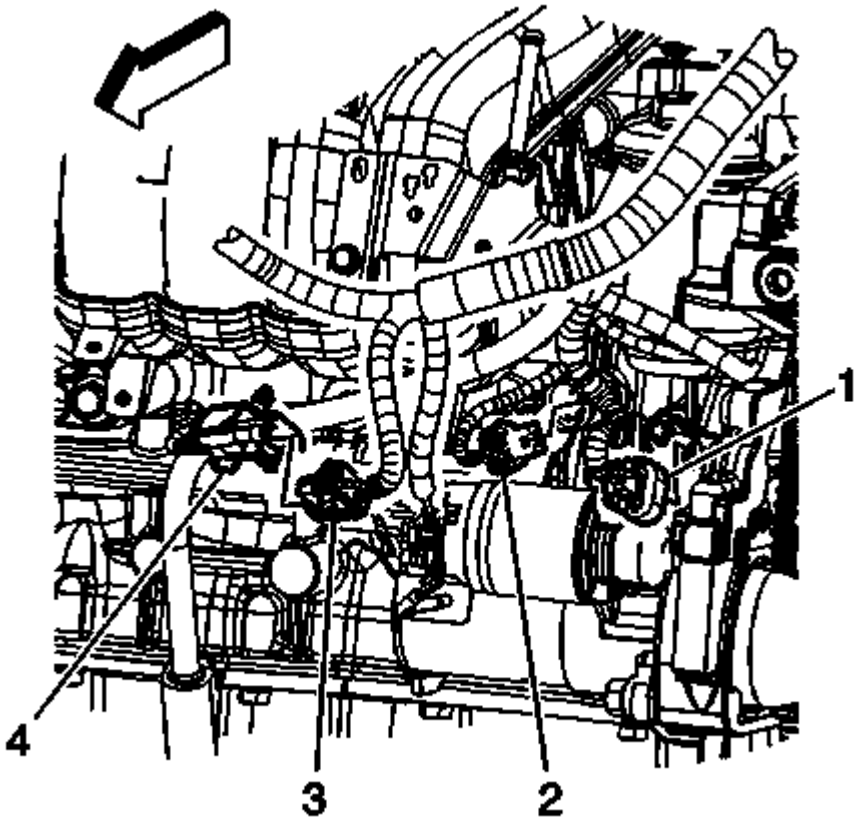

Fig. 215: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

59. Disconnect the engine wiring harness electrical connector (1) from the crankshaft position (CKP) sensor.
60. Disconnect the engine wiring harness electrical connector (2) from the oil pressure sensor.
61. Disconnect the engine wiring harness electrical connector (3) from the knock sensor.

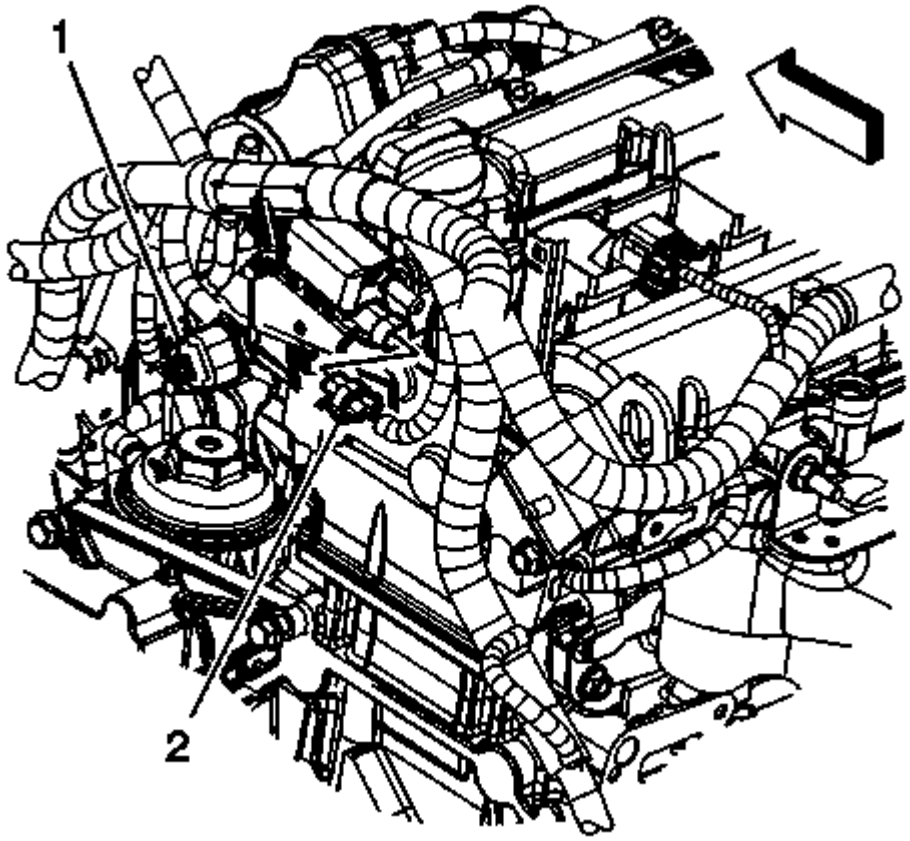

Fig. 216: Locating Intake Camshaft Position (Cmp) Sensor And Intake Camshaft Position (Cmp) Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

62. Disconnect the engine wiring harness electrical connector (1) from the intake camshaft position (CMP) sensor.
63. Disconnect the engine wiring harness electrical connector (2) from the EVAP emission canister purge solenoid valve.

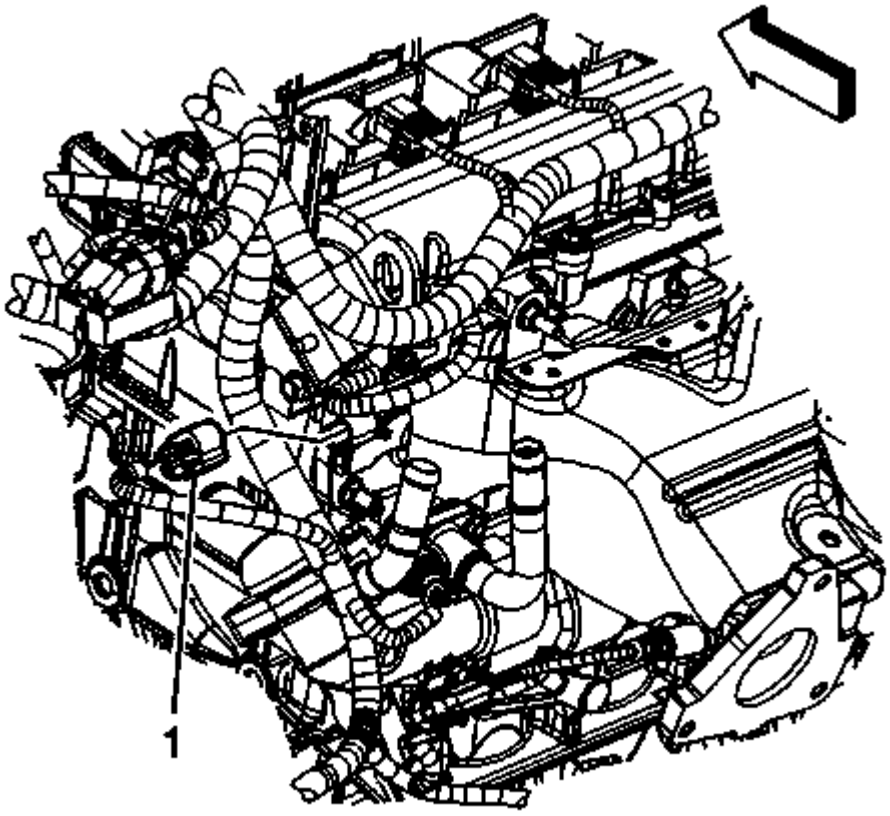

Fig. 217: Locating Exhaust CMP Sensor Connector
Courtesy of GENERAL MOTORS CORP.

64. Disconnect the engine wiring harness electrical connector (1) from the exhaust CMP sensor.

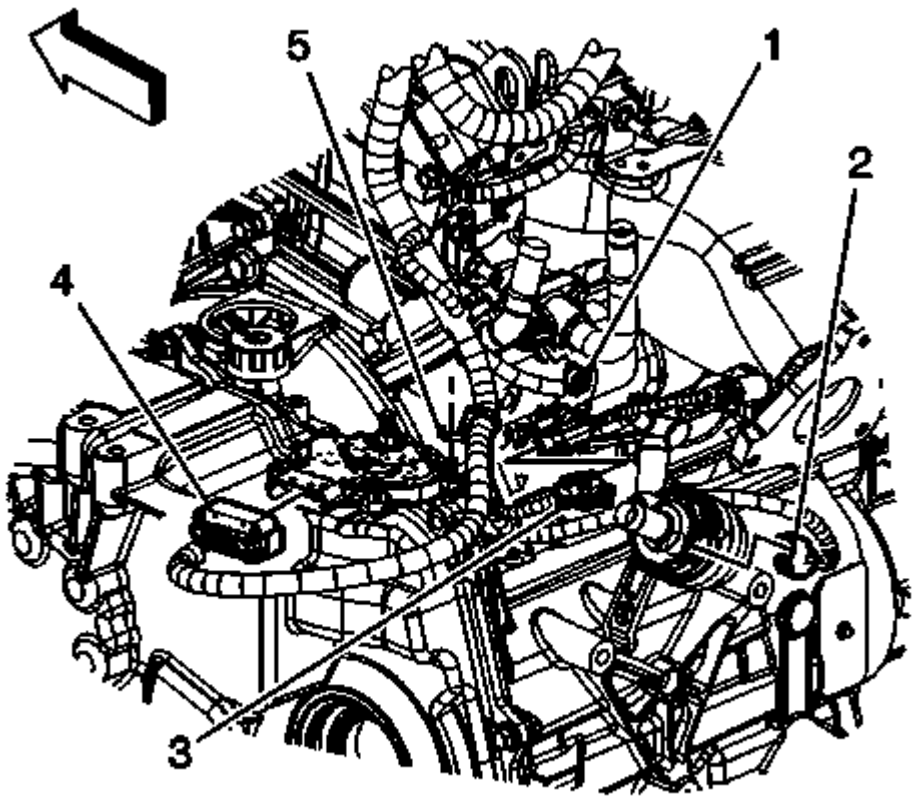

Fig. 218: Identifying Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

65. Disconnect the engine wiring harness electrical connector (1) from the engine coolant temperature (ECT) sensor.
66. Disconnect the engine wiring harness electrical connector (3) from the heated oxygen sensor (HO2S) electrical connector.
67. Remove the engine wiring harness clip (5) from the stud.

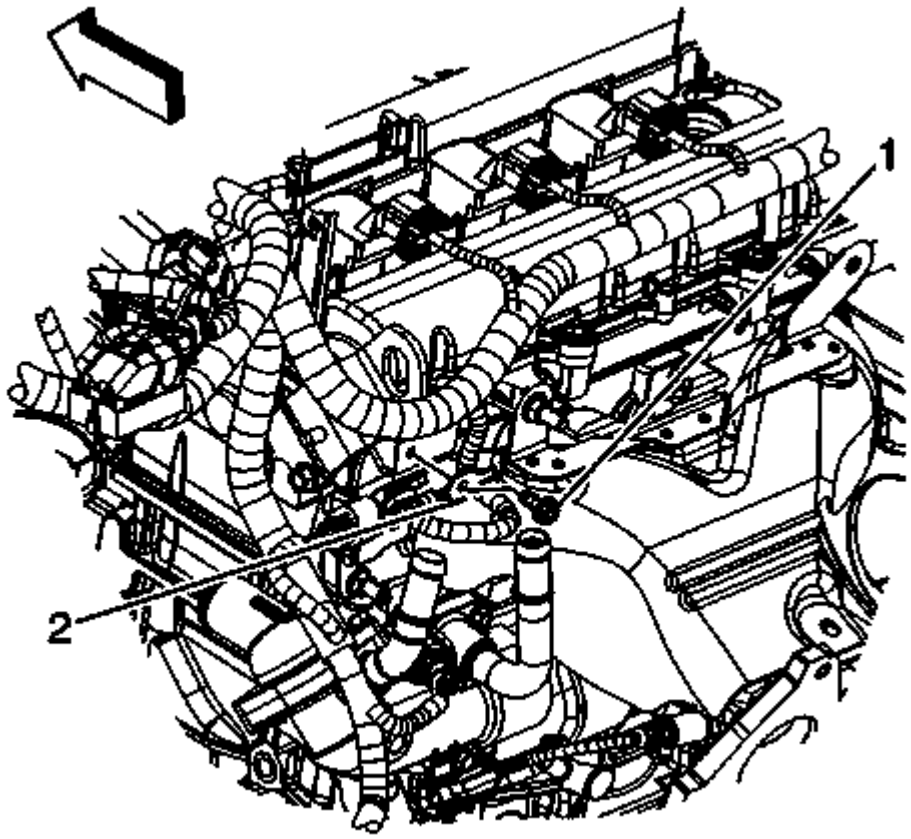

Fig. 219: Engine Wiring Harness Ground Bolt
Courtesy of GENERAL MOTORS CORP.

68. Remove the engine wiring harness ground bolt (1) and reposition the ground terminal from the engine.
69. Gather all branches of the engine wiring harness and reposition the harness out of the way.

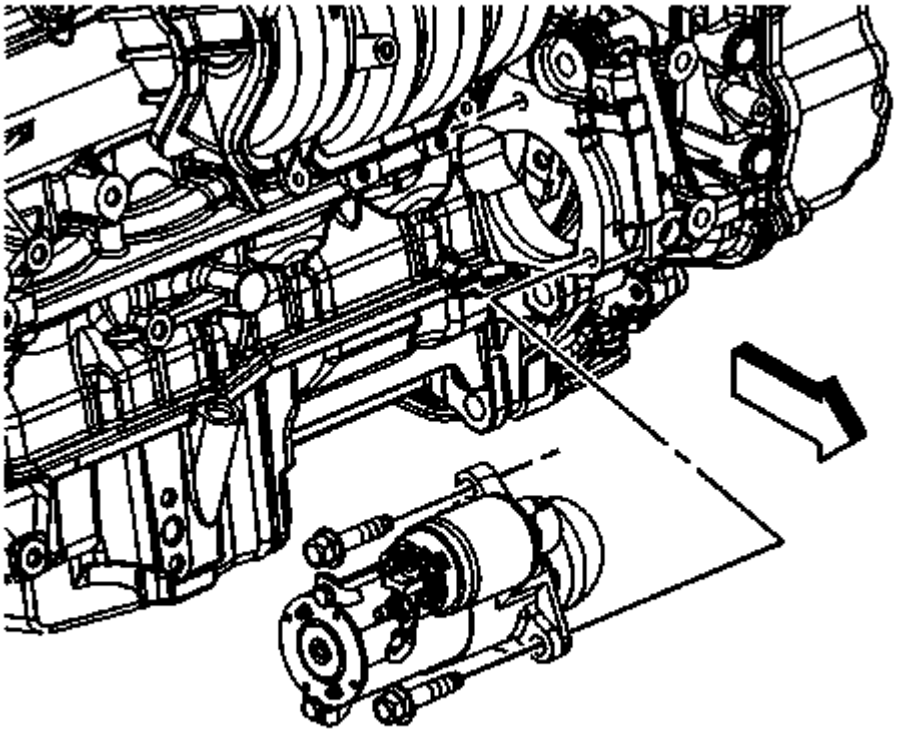

Fig. 220: Identifying Starter Motor Bolts & Starter
Courtesy of GENERAL MOTORS CORP.

70. Remove the starter motor bolts and the starter.

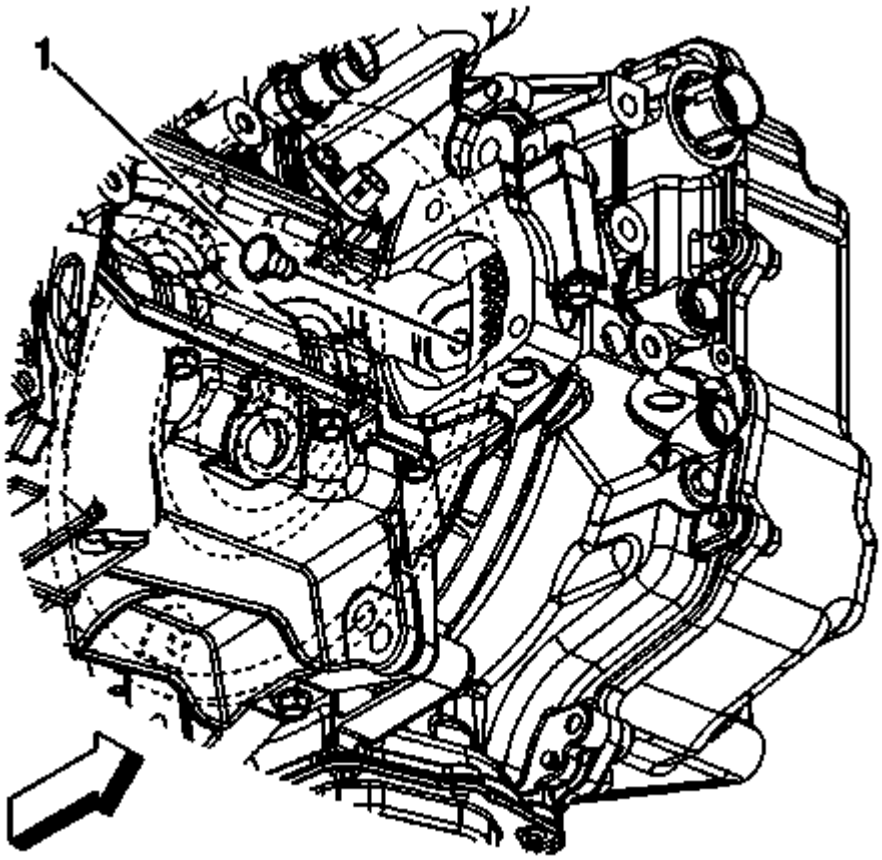

Fig. 221: Torque Converter To Flexplate Bolts
Courtesy of GENERAL MOTORS CORP.

71. Remove the torque converter to flexplate bolts (1).
72. Install a suitable lifting device to the engine.

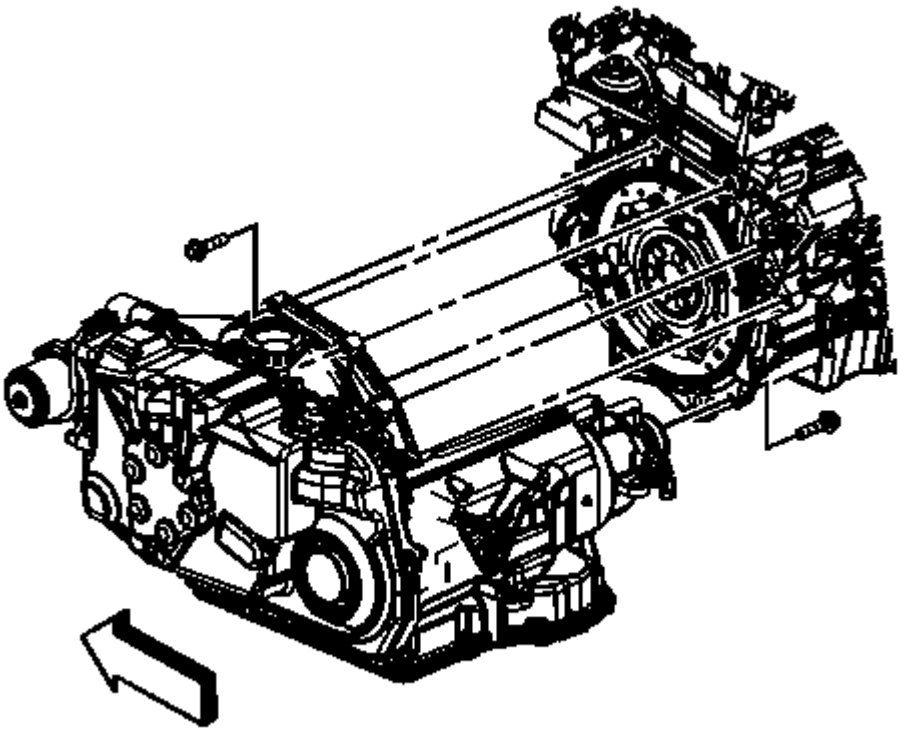

Fig. 222: Transaxle To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

73. If equipped with the 4T45, remove the transaxle bolts from the engine.

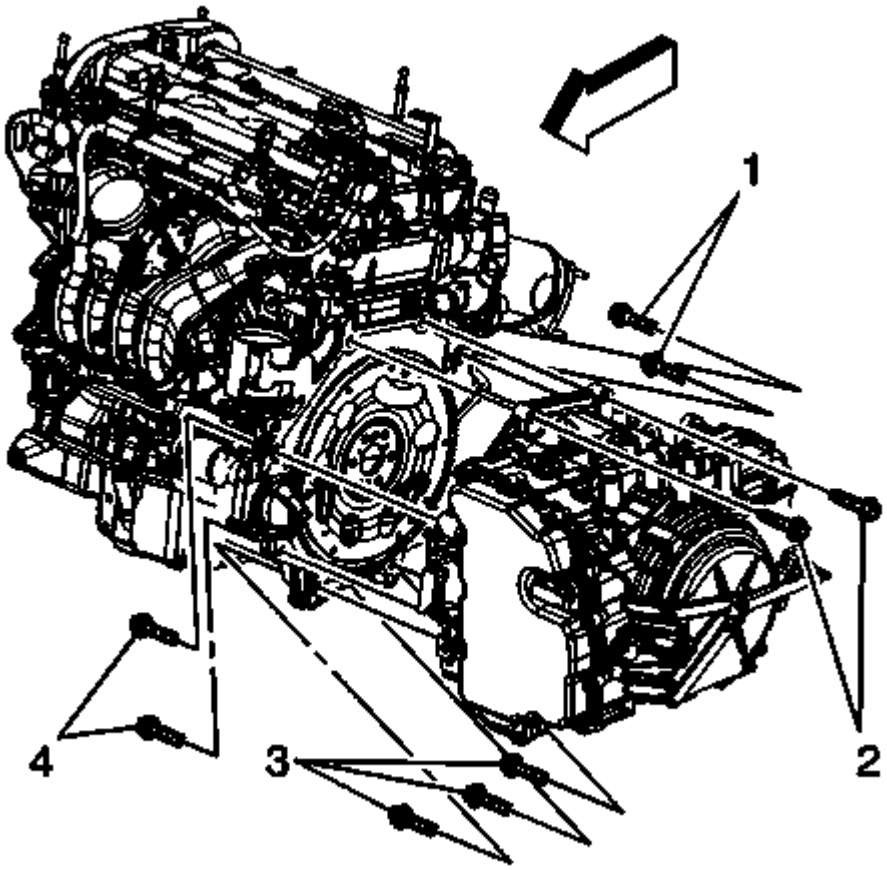

Fig. 223: Identifying Transmission-To-Engine Bolts
Courtesy of GENERAL MOTORS CORP.

74. Remove the transaxle bolts (1, 2, 3, 4) from the engine.
75. Remove the intermediate drive shaft. Refer to **Wheel Drive Shaft Replacement** .
76. Separate the engine from the transaxle.
77. Install the engine to a suitable engine stand.

INSTALLATION PROCEDURE

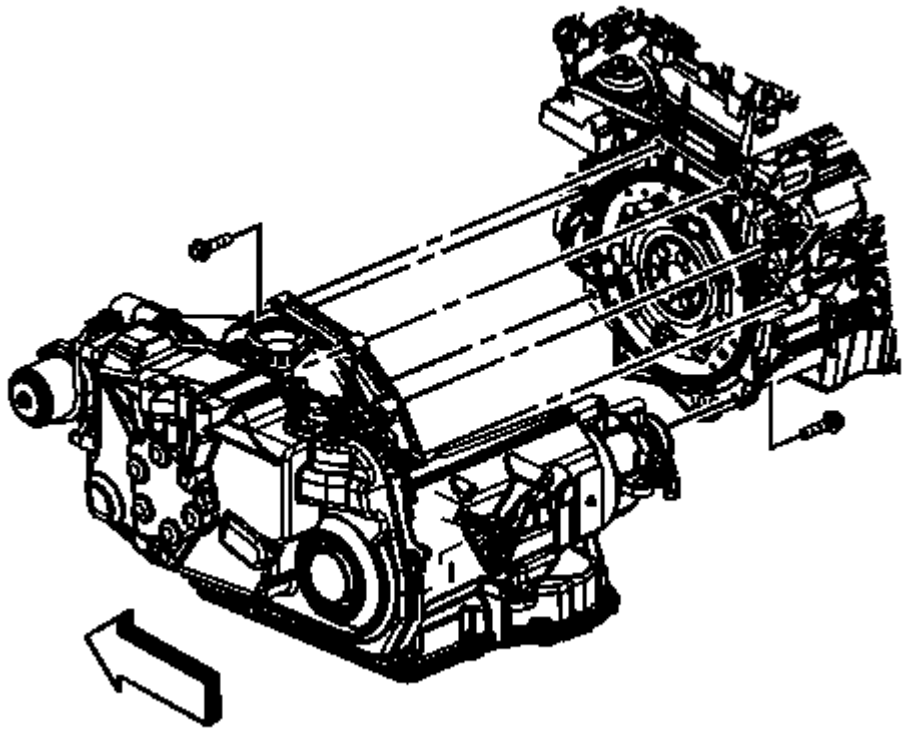

Fig. 224: Transaxle To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install a suitable lifting device to the engine.
2. Using the lifting device, position and install the engine to the transaxle.

CAUTION: Refer to Fastener Caution .

3. Install the transaxle bolts to the engine and tighten to 75 N.m (55 lb ft).

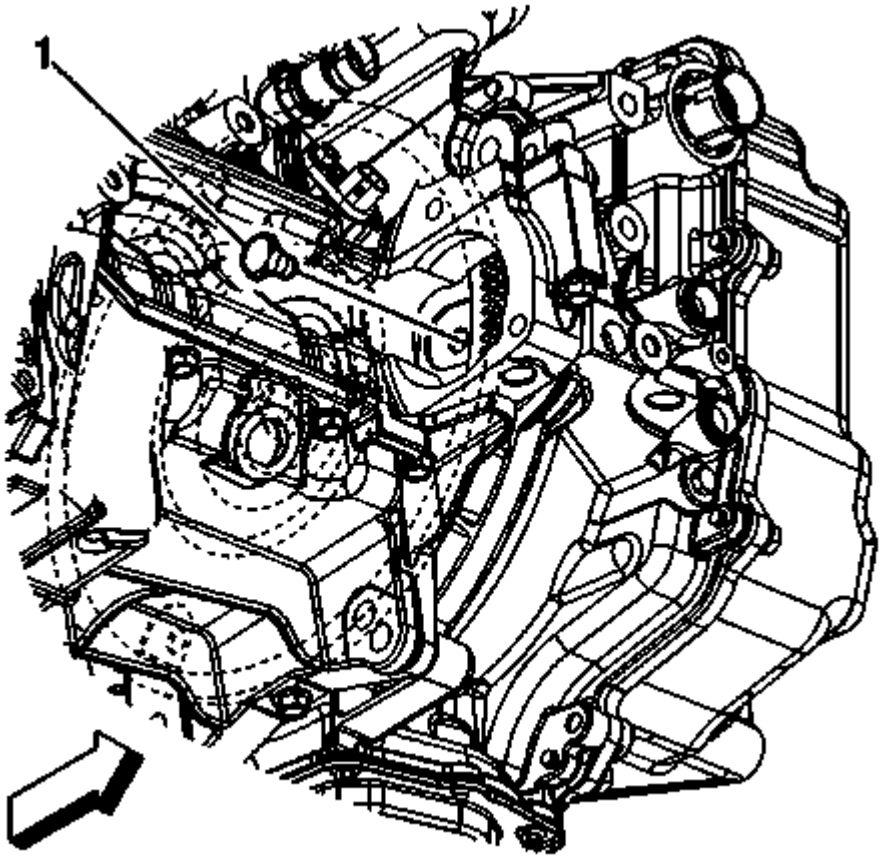

Fig. 225: Torque Converter To Flexplate Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the torque converter to flexplate bolts (1) and tighten to 60 N.m (44 lb ft).
5. Remove the engine lifting device.

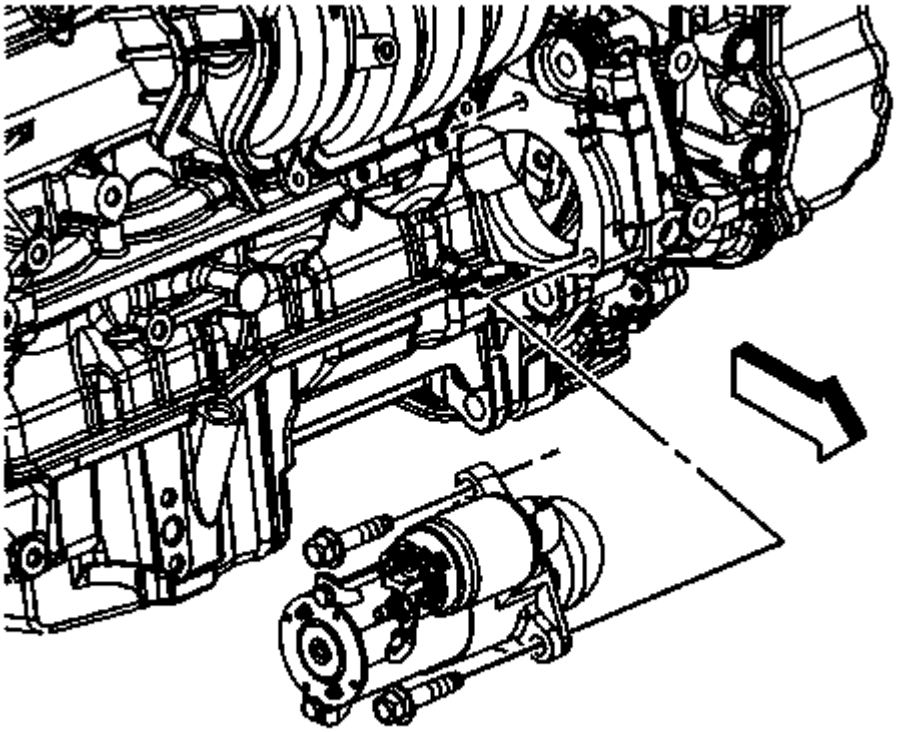

Fig. 226: Identifying Starter Motor Bolts & Starter
Courtesy of GENERAL MOTORS CORP.

6. Install the starter motor and bolts and tighten to 53 N.m (39 lb ft).

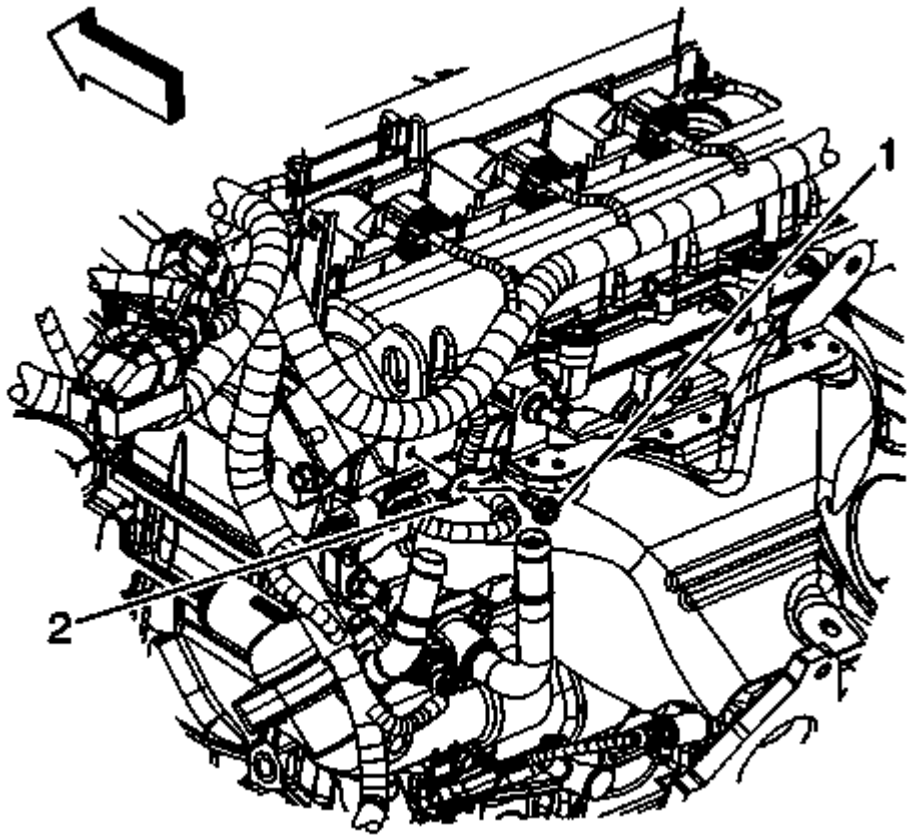

Fig. 227: Engine Wiring Harness Ground Bolt
Courtesy of GENERAL MOTORS CORP.

7. Gather all branches of the engine wiring harness and position the harness to the engine.
8. Position the engine wiring harness ground terminal to the engine and install the engine wiring harness ground bolt (1) and tighten to 20 N.m (15 lb ft).

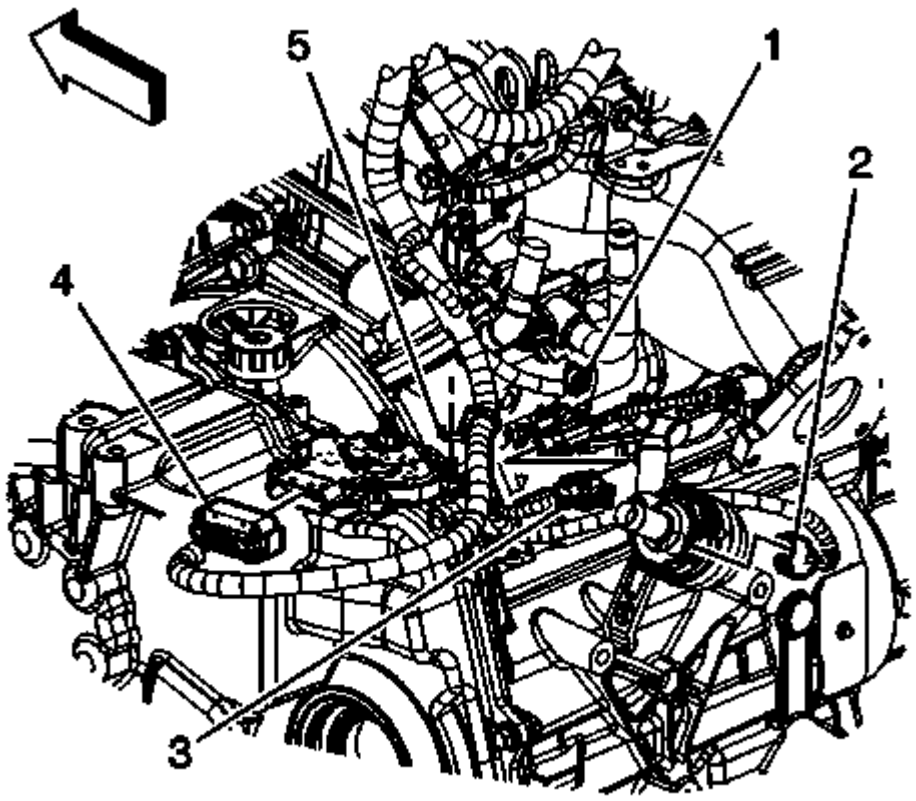

Fig. 228: Identifying Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Connect the engine wiring harness electrical connector (1) to the ECT sensor.
10. Connect the engine wiring harness electrical connector (3) to the HO2S electrical connector.
11. Install the engine wiring harness clip (5) to the stud.

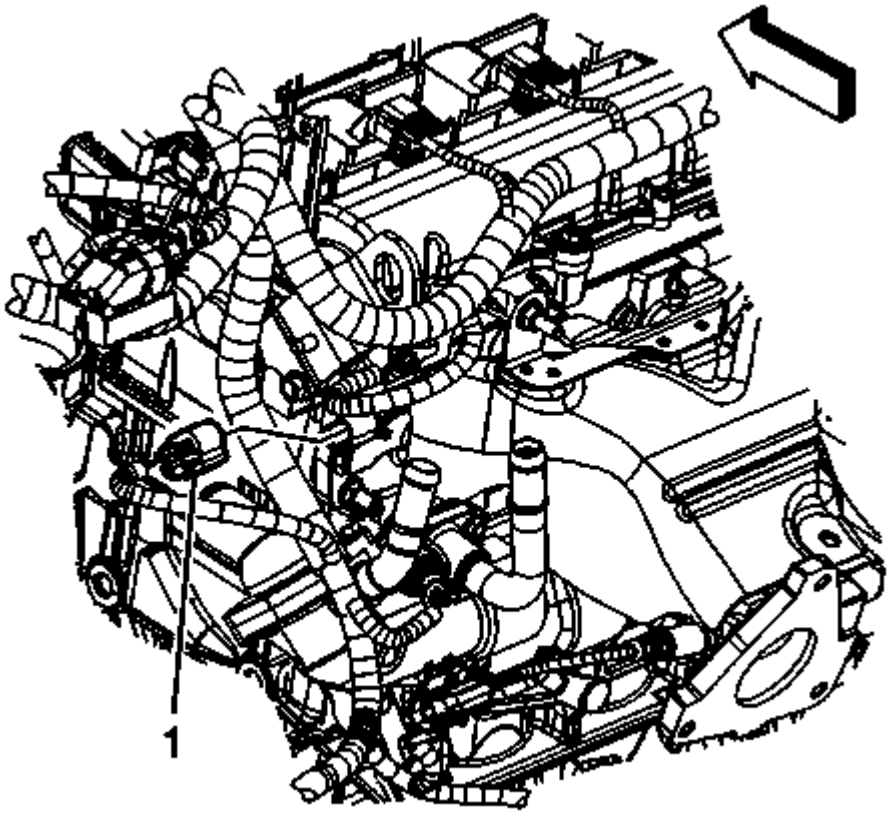

Fig. 229: Locating Exhaust CMP Sensor Connector
Courtesy of GENERAL MOTORS CORP.

12. Connect the engine wiring harness electrical connector (1) to the exhaust CMP sensor.

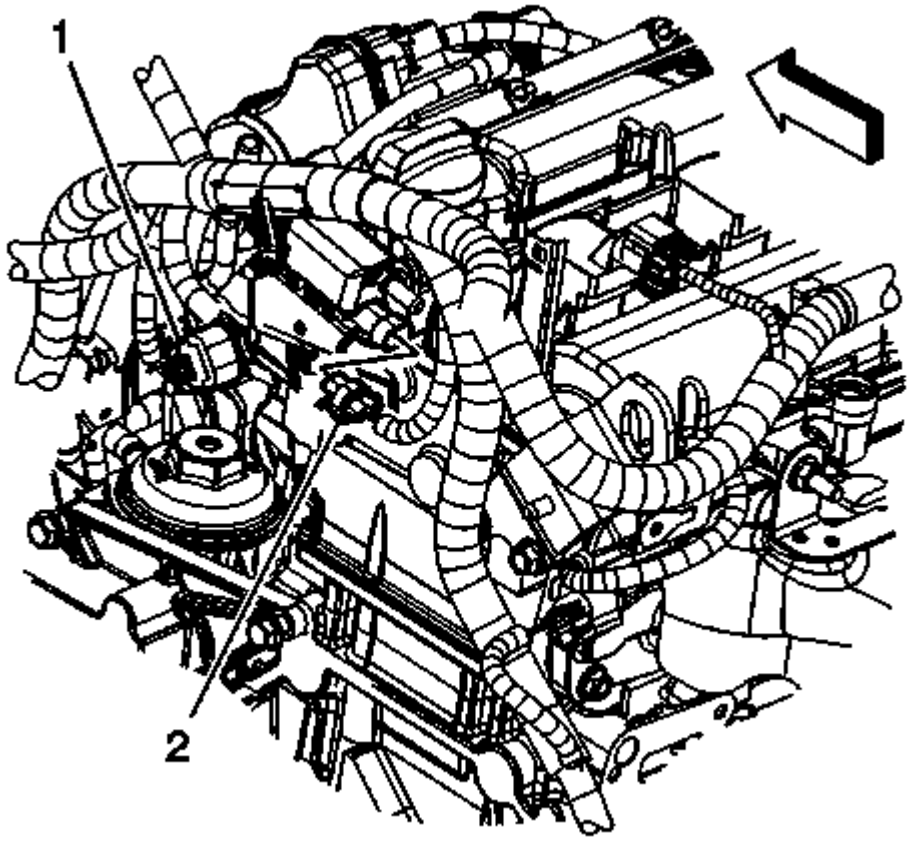

Fig. 230: Locating Intake Camshaft Position (Cmp) Sensor And Intake Camshaft Position (Cmp) Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

13. Connect the engine wiring harness electrical connector (1) to the intake CMP sensor.
14. Connect the engine wiring harness electrical connector (2) to the EVAP emission canister purge solenoid valve.

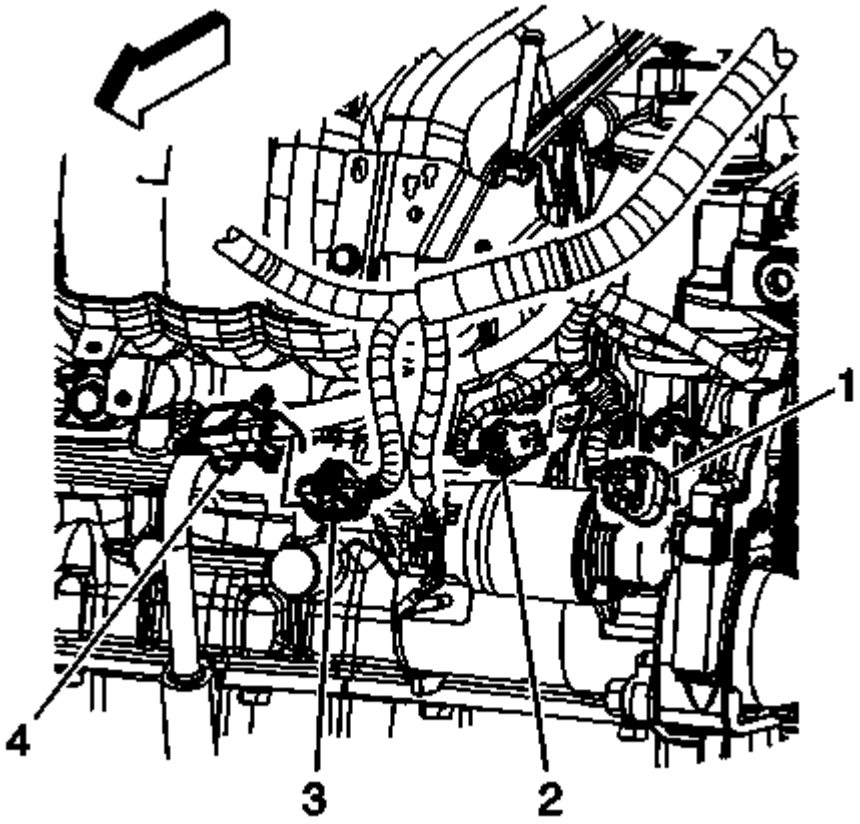

Fig. 231: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

15. Connect the engine wiring harness electrical connector (1) to the CKP sensor.
16. Connect the engine wiring harness electrical connector (2) to the oil pressure sensor.
17. Connect the engine wiring harness electrical connector (3) to the knock sensor.

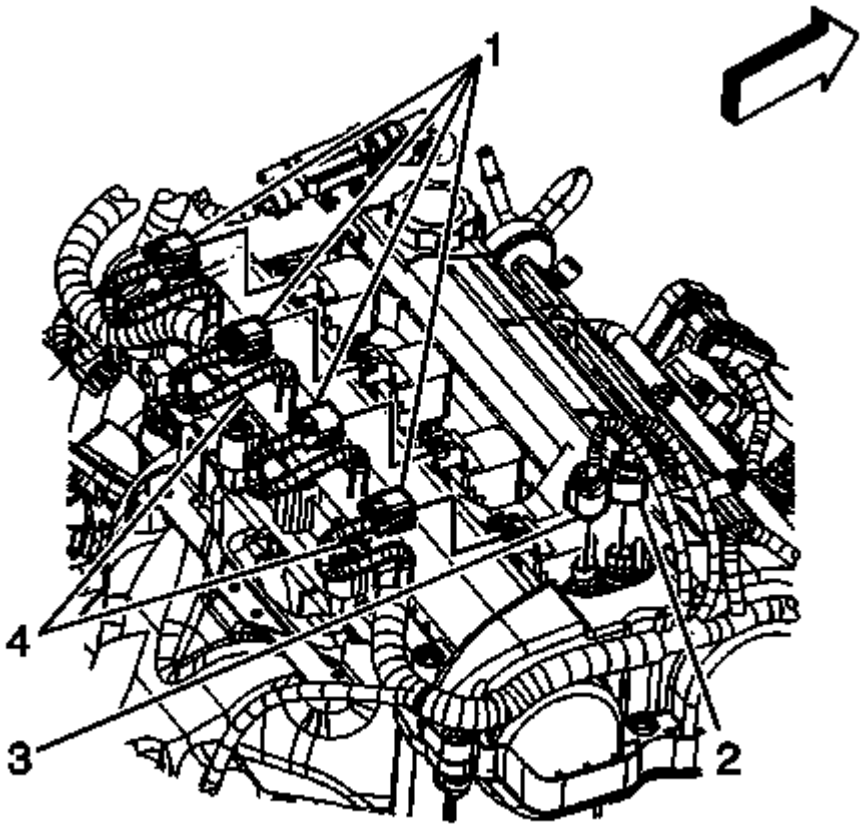

Fig. 232: Identifying Engine Wiring Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Connect the engine wiring harness electrical connectors (1) to the ignition coils.
19. Connect the engine wiring harness electrical connectors (2, 3) to the camshaft actuators.

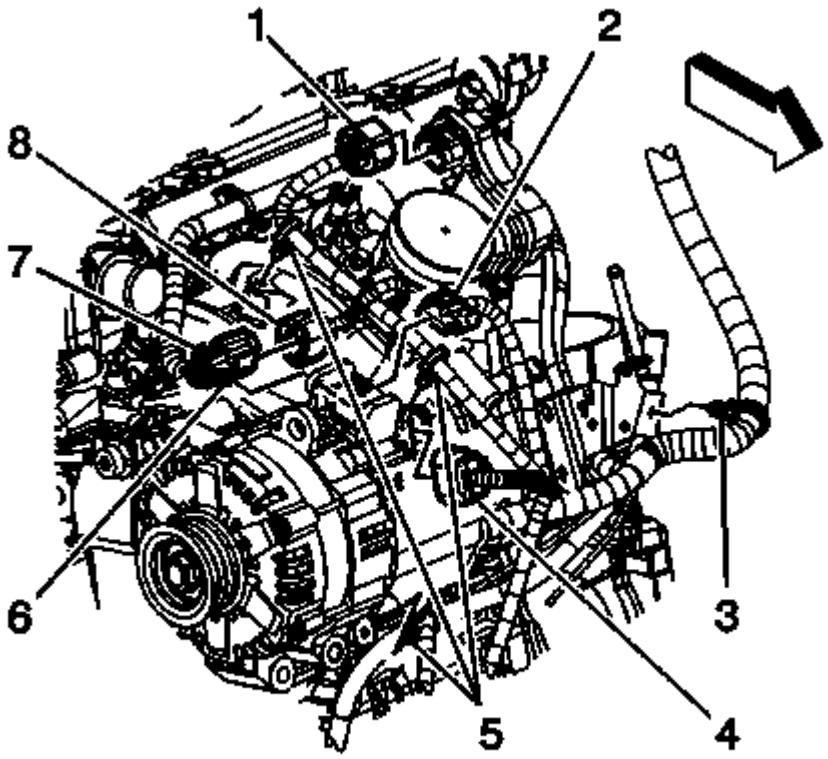

Fig. 233: Identifying Engine Electrical Connectors Left Side
Courtesy of GENERAL MOTORS CORP.

20. Connect the engine wiring harness electrical connector (1) to the throttle actuator.
21. Connect the engine wiring harness electrical connector (8) to the fuel injector wiring harness electrical connector (7).
22. Install the engine wiring harness clip (3) to the oil level indicator tube bracket.

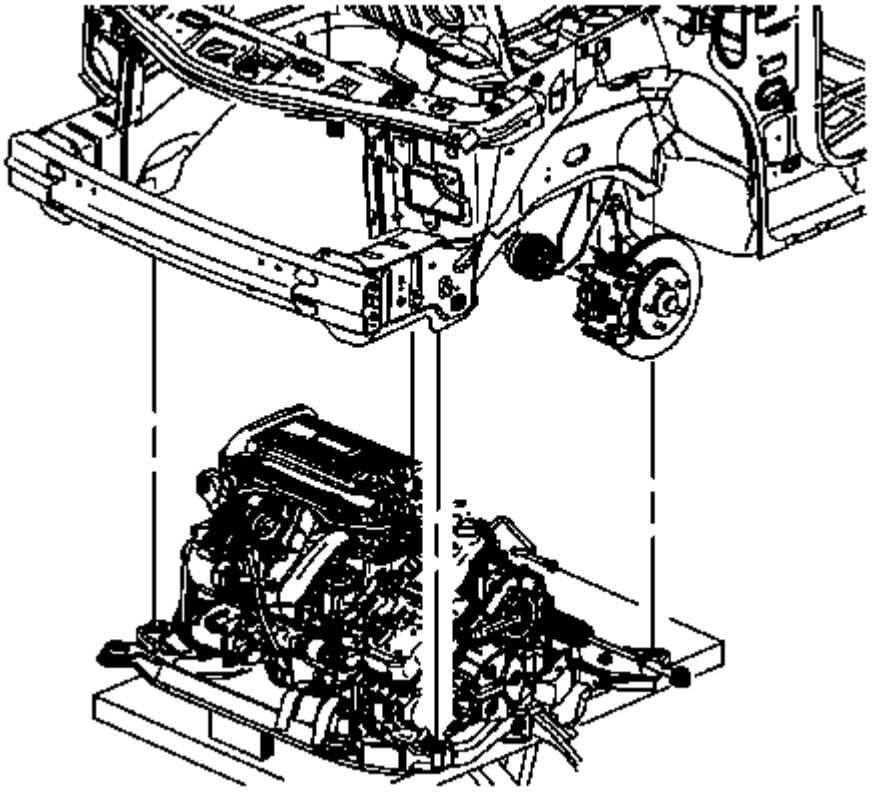

Fig. 234: Positioning Powertrain Assembly
Courtesy of GENERAL MOTORS CORP.

23. Position the powertrain support table under the vehicle.
24. Raise the powertrain into position under the vehicle.
25. With the table positioned, if required, lower the vehicle over the powertrain.
26. Align the lower radiator pins with the frame. Ensure all hoses and electrical harnesses are correctly routed and free from the loading path of the powertrain.
27. Install the NEW frame to body bolts and tighten to 155 N.m (114 lb ft).
28. Lower the vehicle.

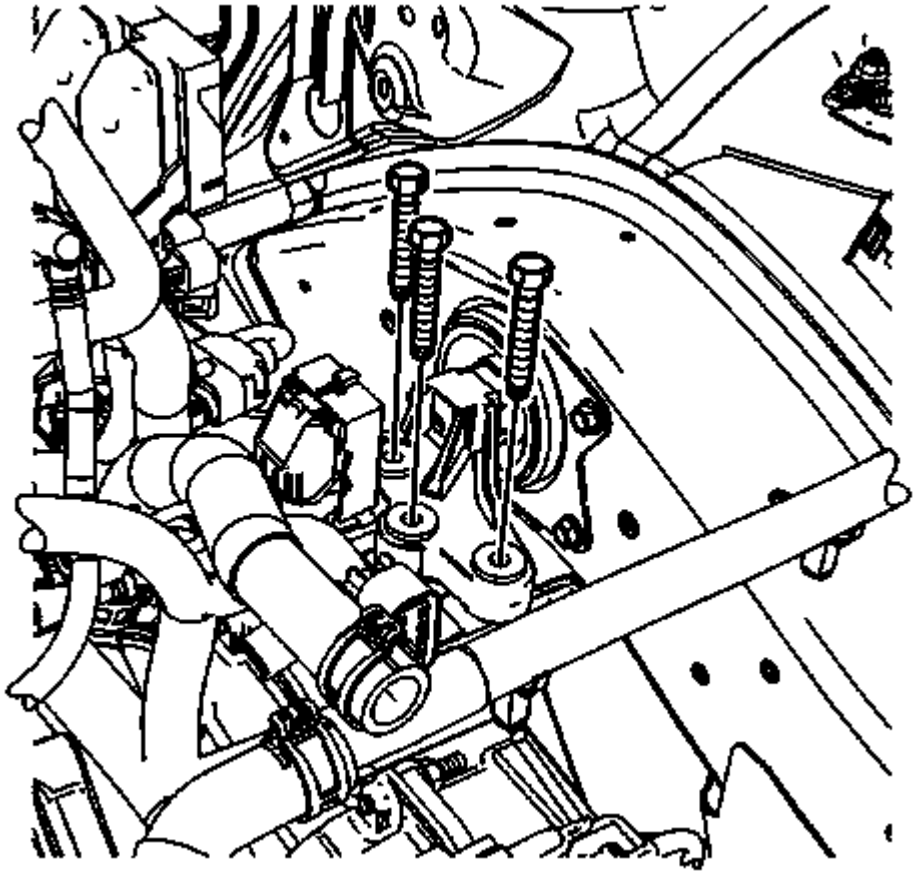

Fig. 235: Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

29. Install the transaxle mount to transaxle bolts and tighten to 55 N.m (41 lb ft).

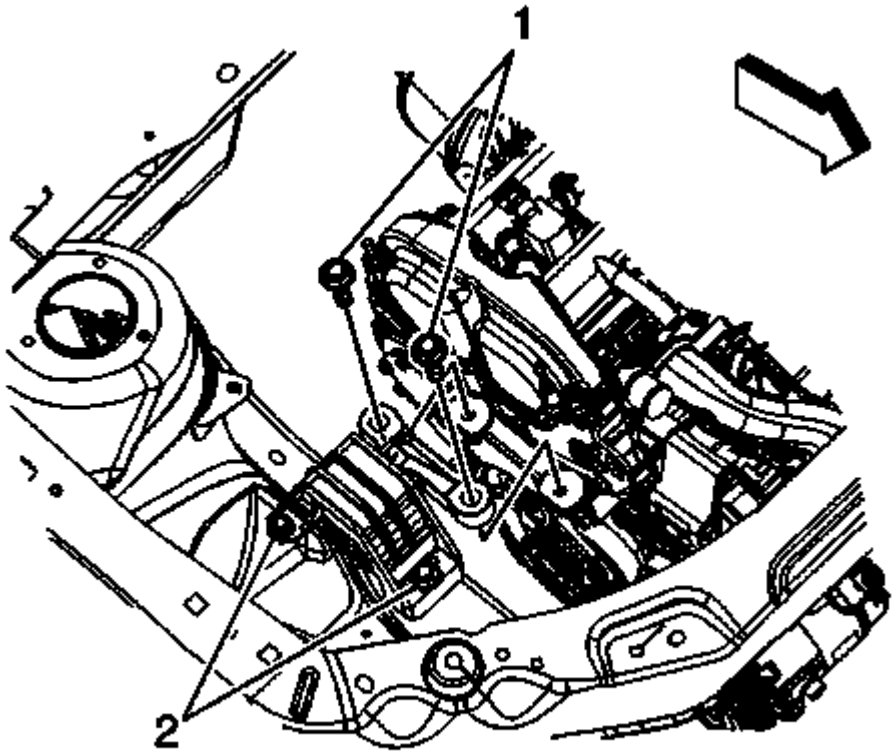

Fig. 236: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine mount to bracket bolts must be hand started. Do not pry the engine mount to align the holes.

30. Install the engine mount to bracket bolts (1) and tighten to 50 N.m (37 lb ft).
31. Raise and support the vehicle.
32. Install the wheel drive shafts. Refer to **Wheel Drive Shaft Replacement** .
33. Connect the control arm to the steering knuckles. Refer to **Lower Control Arm Replacement** .
34. Connect the stabilizer links to the stabilizer. Refer to **Stabilizer Shaft Link Replacement** .
35. Connect the outer tie rods to the steering knuckles. Refer to **Steering Linkage Outer Tie Rod Replacement** .
36. Connect the intermediate shaft to the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
37. Install the catalytic converter. Refer to **Exhaust Manifold Pipe Replacement (LE5 or LE9)** .
38. Connect the fluid cooler hoses to the transaxle. Refer to **Fluid Cooler Inlet Hose Replacement** and **Fluid Cooler Outlet Hose Replacement** .
39. Remove the wood from between the oil pan and the frame.
40. Remove the wood from between the transaxle and the frame.

41. Install the front wheelhouse panel. Refer to **Front Wheelhouse Panel Splash Shield Replacement** .
42. Install the front wheels and tires. Refer to **Tire and Wheel Removal and Installation** .
43. Lower the vehicle.

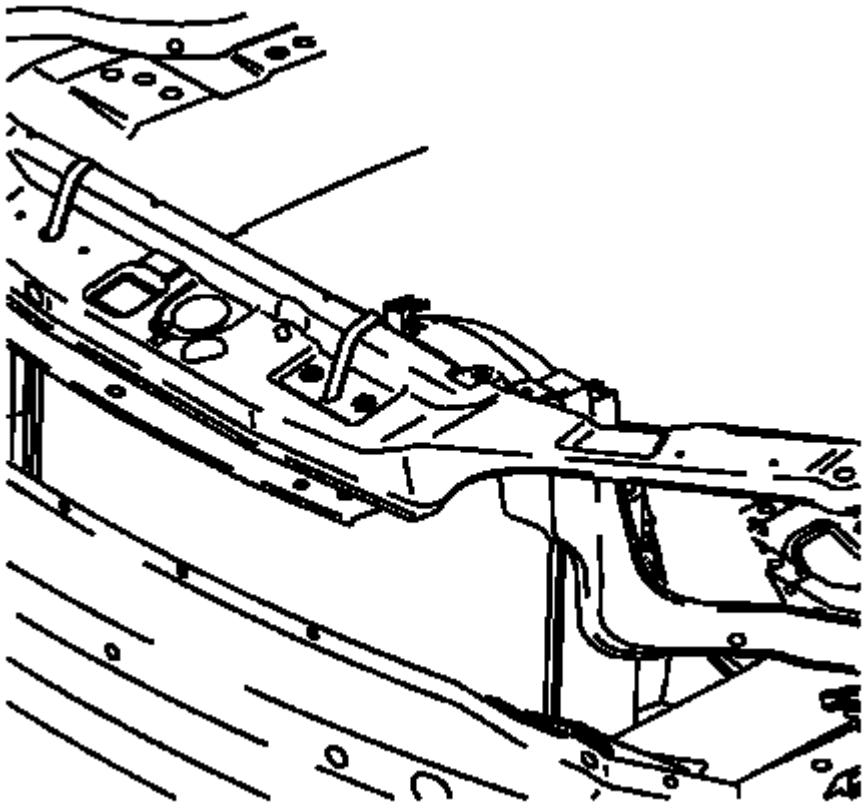

Fig. 237: View Of Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

44. Position the radiator/condenser/fan assembly. Remove the tie straps.

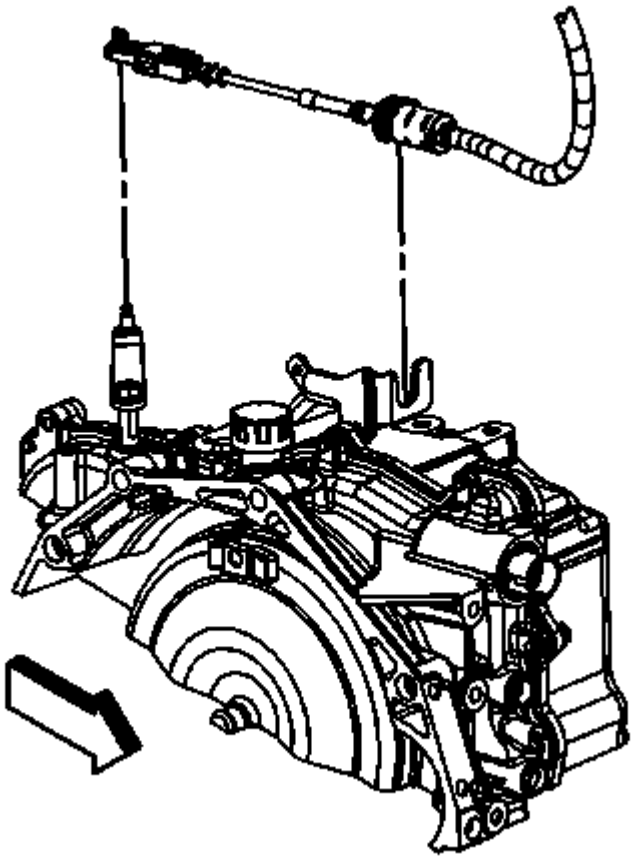

Fig. 238: Transaxle Shift Cable And Range Select Lever
Courtesy of GENERAL MOTORS CORP.

45. Install the shift control cable to the shift control cable bracket and engage the shift control cable retaining clip.
46. Install the transaxle shift cable to the range select lever.
47. Raise and support the vehicle.

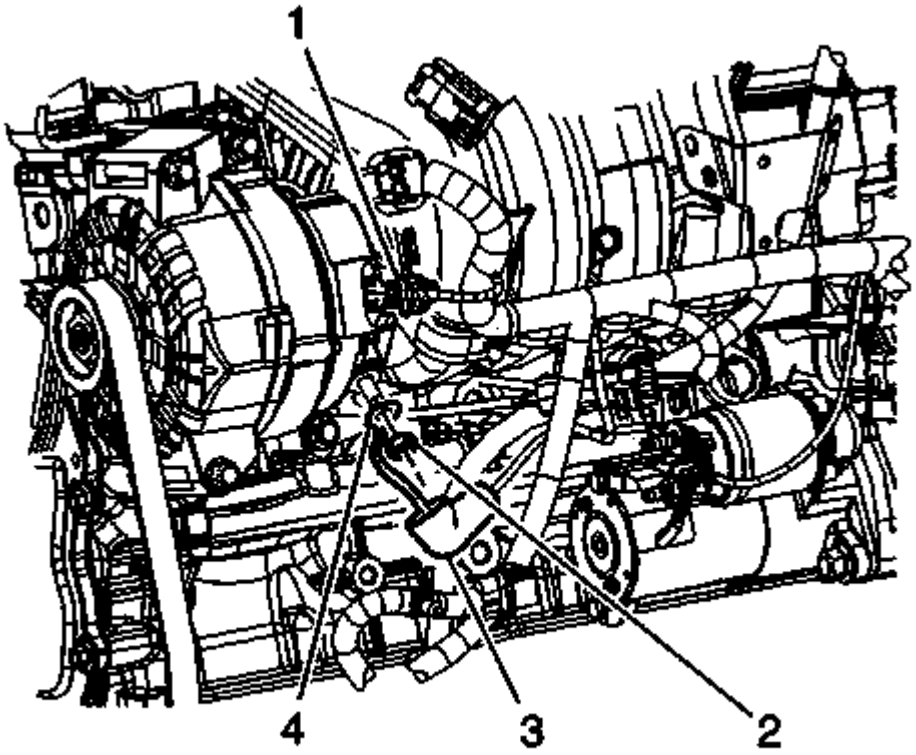

Fig. 239: View Of Generator Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

48. Install the engine harness lead (4) to the generator.
49. Install the generator nut (2) and tighten to 20 N.m (15 lb ft).
50. Seat the engine harness boot (3).
51. Connect the generator electrical connector (1).

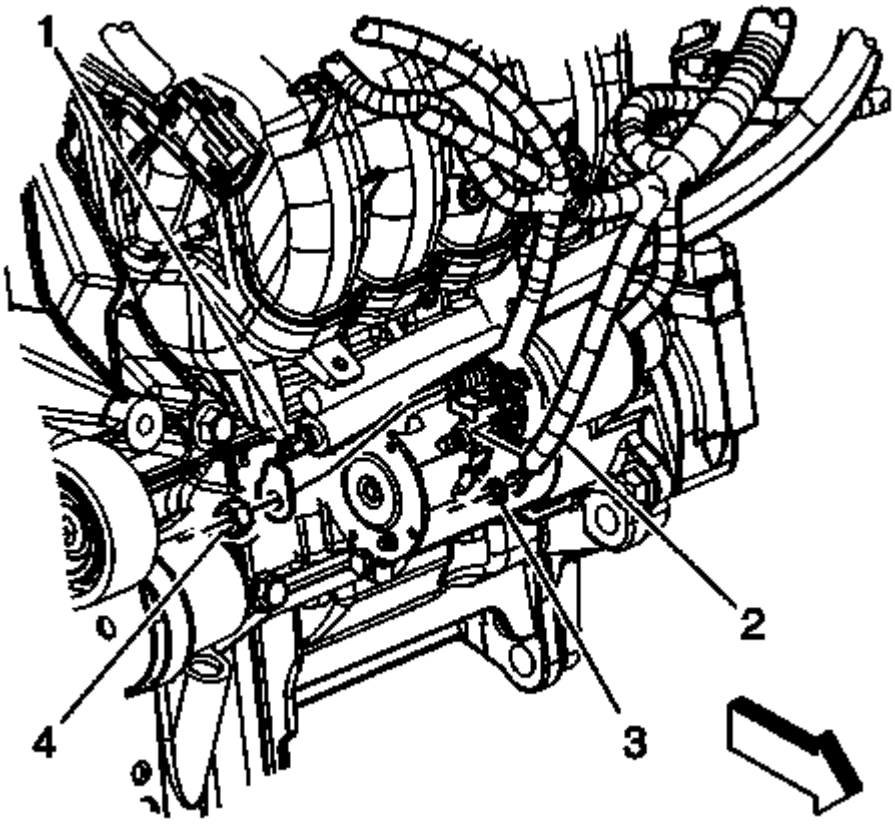

Fig. 240: View Of Starter And Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

52. Position and install the positive battery cable between the starter and the engine.
53. Connect the positive battery cable lead (1) to the starter motor.
54. Install the positive battery cable to starter motor nut (4) and tighten to 9 N.m (80 lb in).

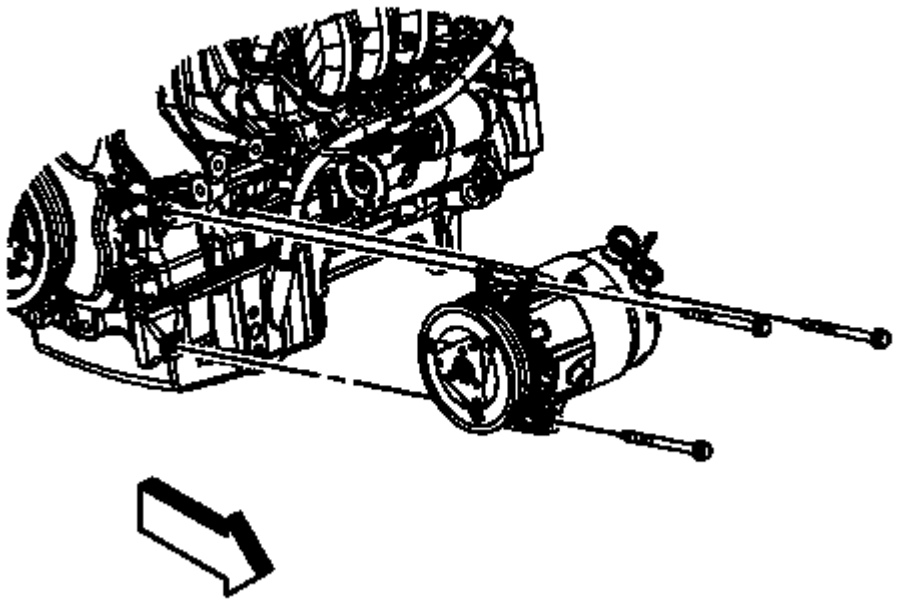

Fig. 241: Compressor Bolts
Courtesy of GENERAL MOTORS CORP.

55. Install the A/C compressor with the bolts and tighten to 50 N.m (37 lb ft).
56. Lower the vehicle.

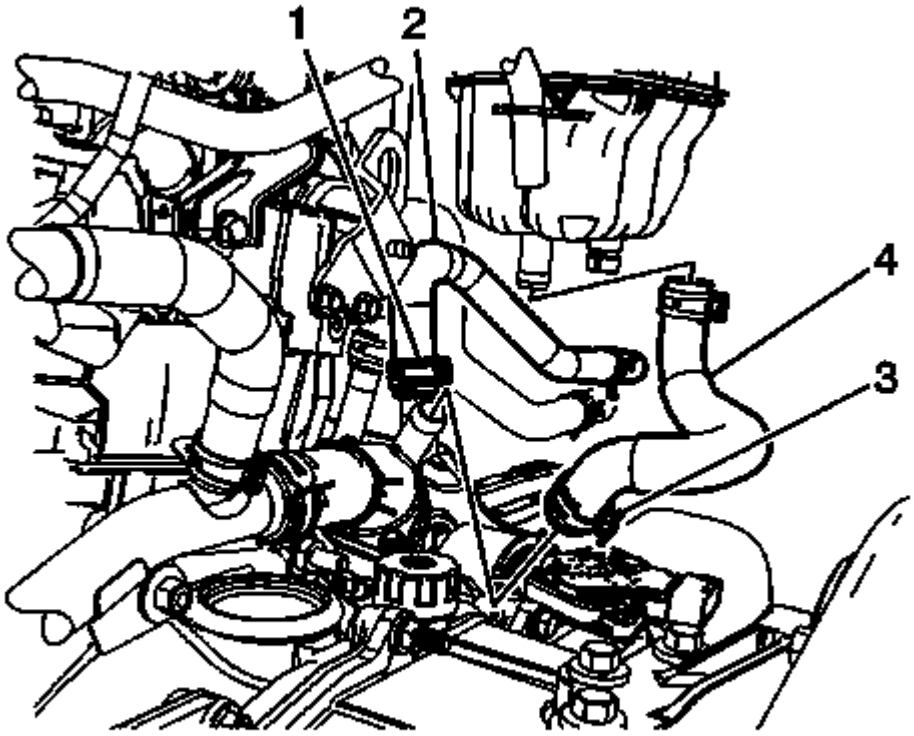

Fig. 242: Inlet Hoses
Courtesy of GENERAL MOTORS CORP.

57. Connect the coolant recovery reservoir/heater inlet hose (4) to the thermostat housing.
58. Position the coolant recovery reservoir/heater inlet hose clamp (3) at the thermostat housing.
59. Connect the heater inlet hose (3) to the thermostat housing.
60. Position the heater inlet hose clamp (1) at the thermostat housing.
61. Position the radiator inlet hose clamp using the **J-38185:** pliers.
62. Connect the radiator inlet hose to the cylinder head.

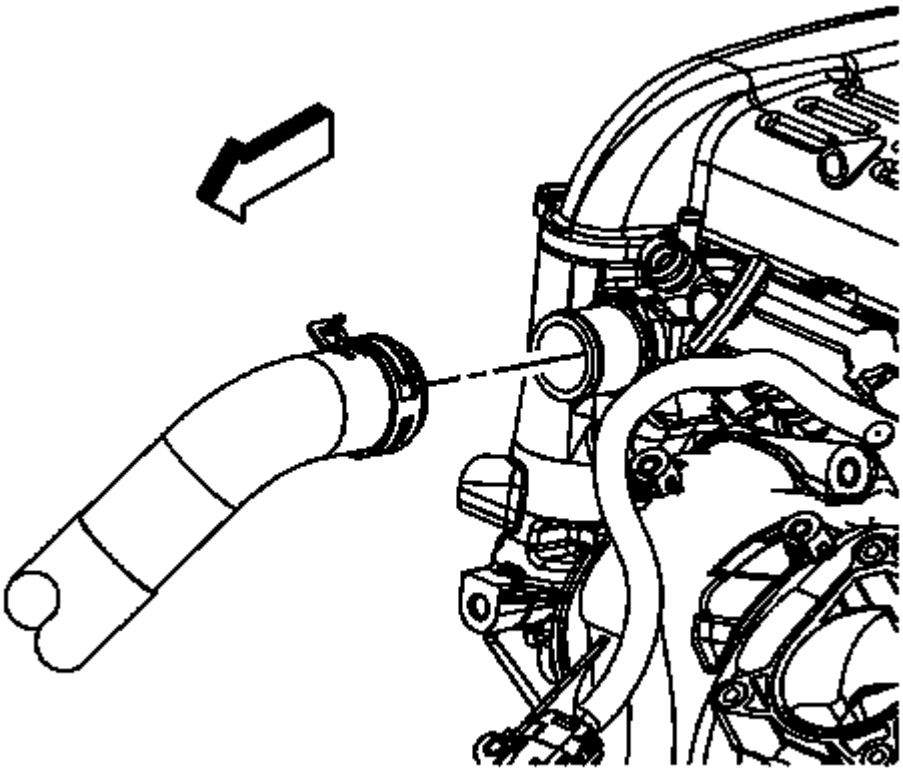

Fig. 243: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

63. Install the radiator outlet hose. Refer to **Radiator Outlet Hose Replacement (LY7)** or **Radiator Outlet Hose Replacement (LE5)** .

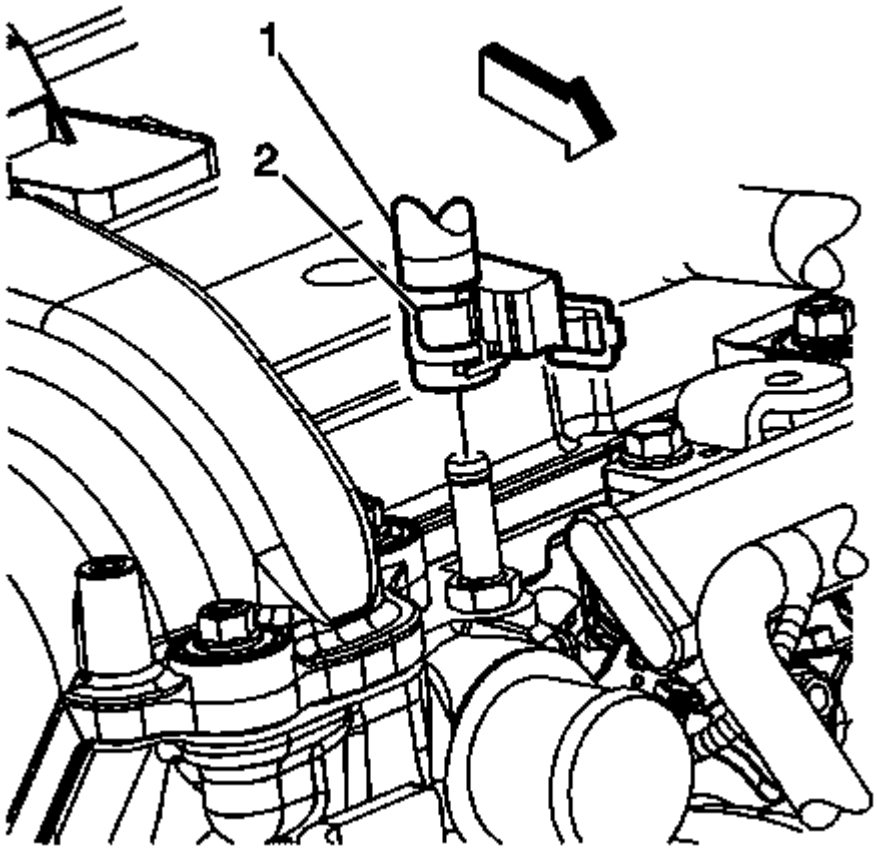

Fig. 244: Coolant Recovery Inlet Hose And Clamp
Courtesy of GENERAL MOTORS CORP.

64. Connect the coolant recovery inlet hose (1) to the cylinder head.
65. Connect the coolant recovery inlet pipe clip to the fuel rail.
66. Position the coolant recovery inlet hose clamp (2) at the cylinder head.

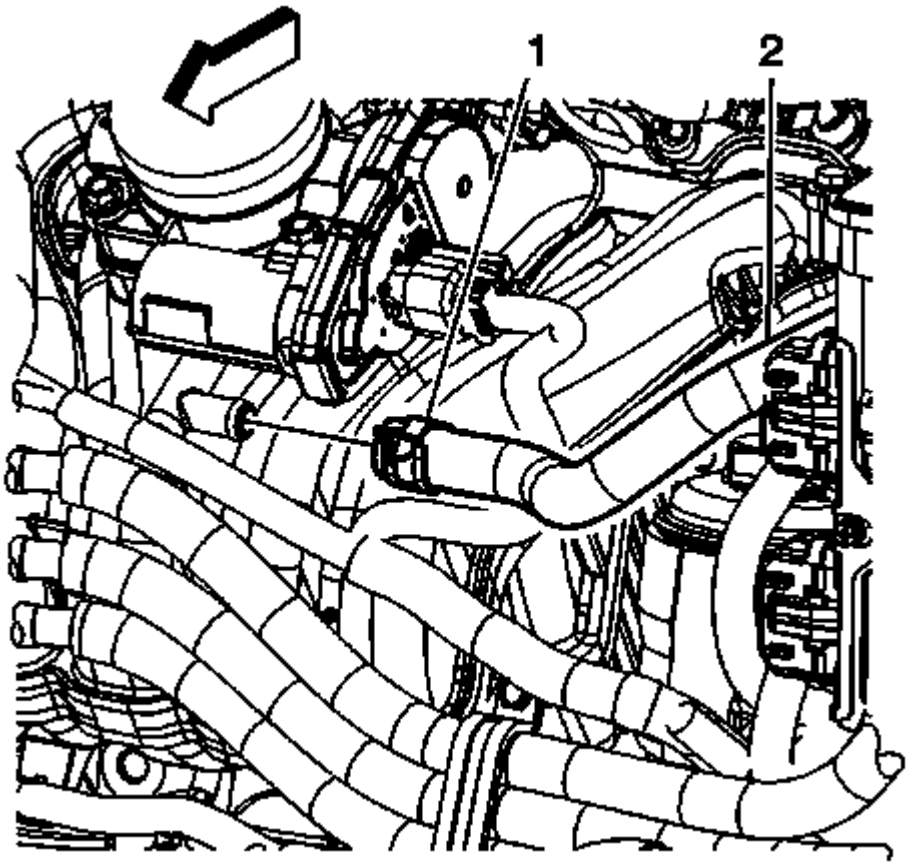

Fig. 245: Identifying Vacuum Brake Booster Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

67. Connect the vacuum brake booster hose (2) to the intake manifold.
68. Position the vacuum brake booster hose clamp (1) at the intake manifold.
69. Install the battery tray. Refer to **Battery Tray Replacement (LY7, and LE5)** or **Battery Tray Replacement (LE5, LE9, LY7)** .

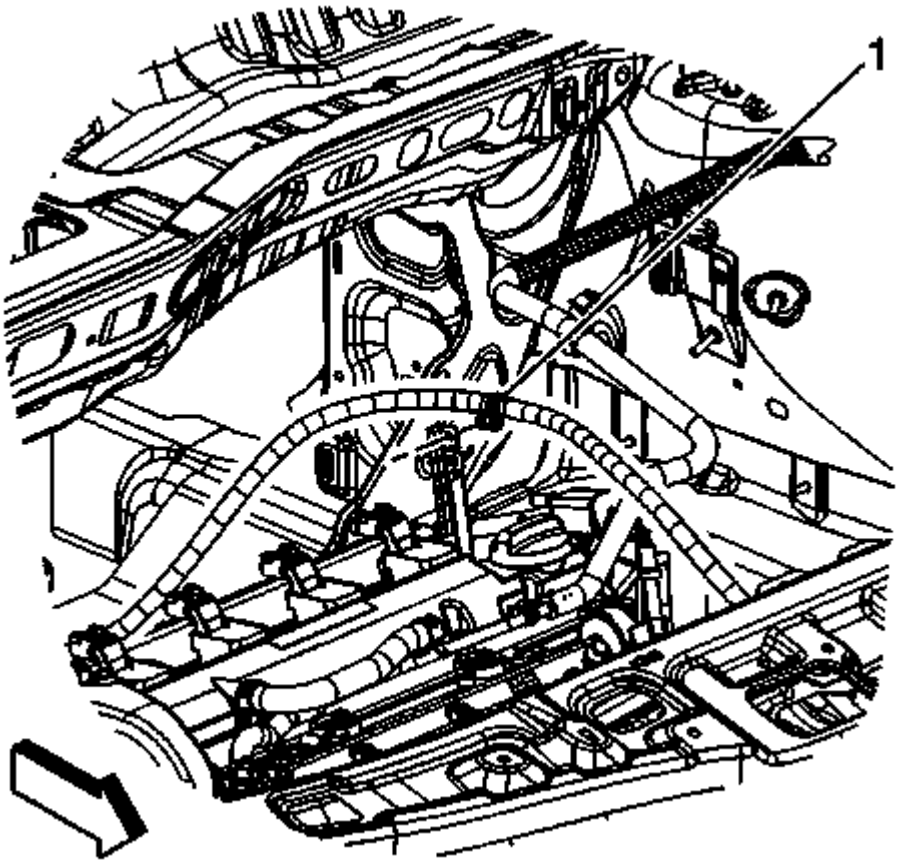

Fig. 246: Transaxle Shift Cable Clip
Courtesy of GENERAL MOTORS CORP.

70. Connect the transaxle shift cable clip (1) to the fuel line bracket.

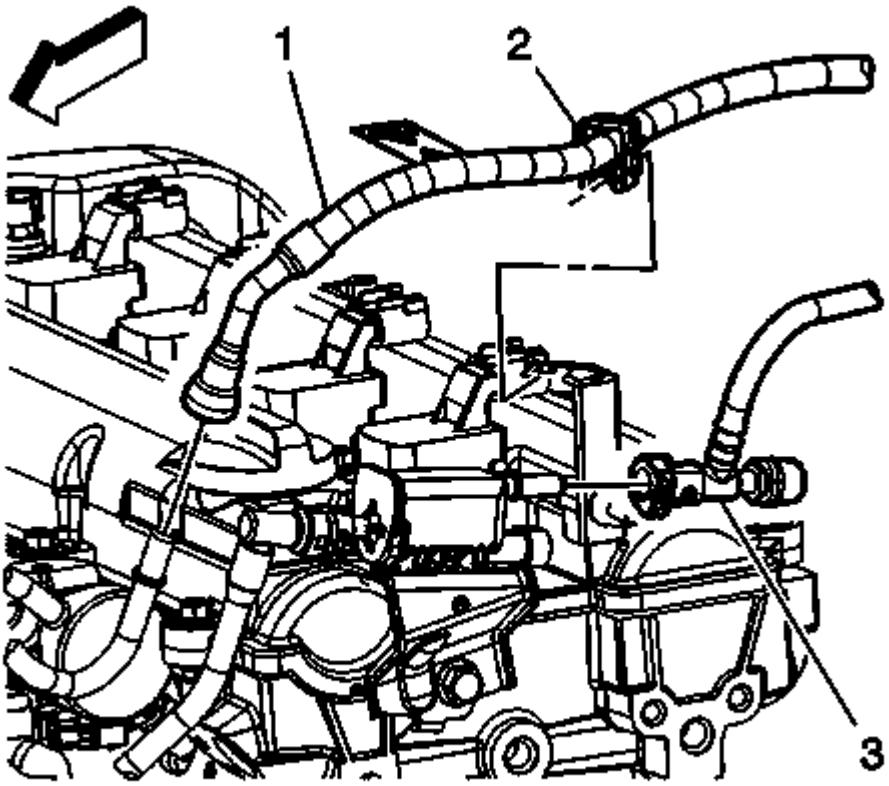

Fig. 247: View Of Fuel Feed Pipe Retainer & Fuel Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

71. Connect the fuel feed pipe clip (2) to the fuel line bracket.
72. Connect the EVAP line (3) quick connect fitting to the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
73. Connect the fuel feed pipe (1) quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
74. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
75. Fill the transaxle with fluid. Refer to **Transmission Fluid Level and Condition Check** .
76. Refill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
77. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .
78. Start the engine and allow the engine to run, inspect for leaks. Correct as necessary.

ENGINE OIL AND OIL FILTER REPLACEMENT

REMOVAL PROCEDURE

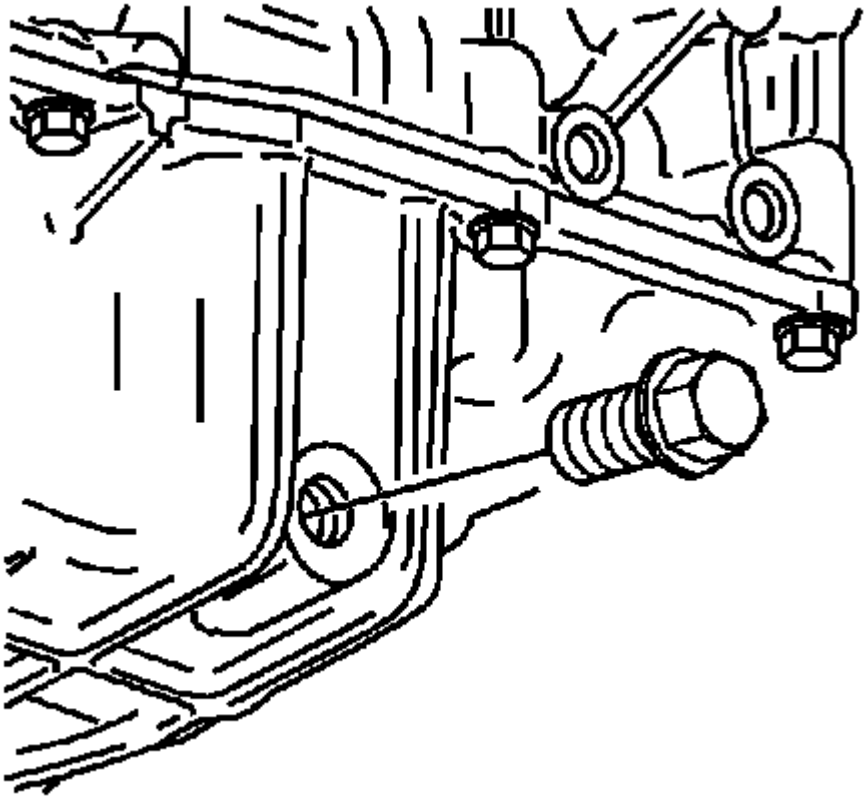

Fig. 248: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil drain plug.
3. Remove the oil pan drain plug.
4. Allow the oil to drain completely.

CAUTION: Refer to Fastener Caution .

5. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
6. Lower the vehicle.

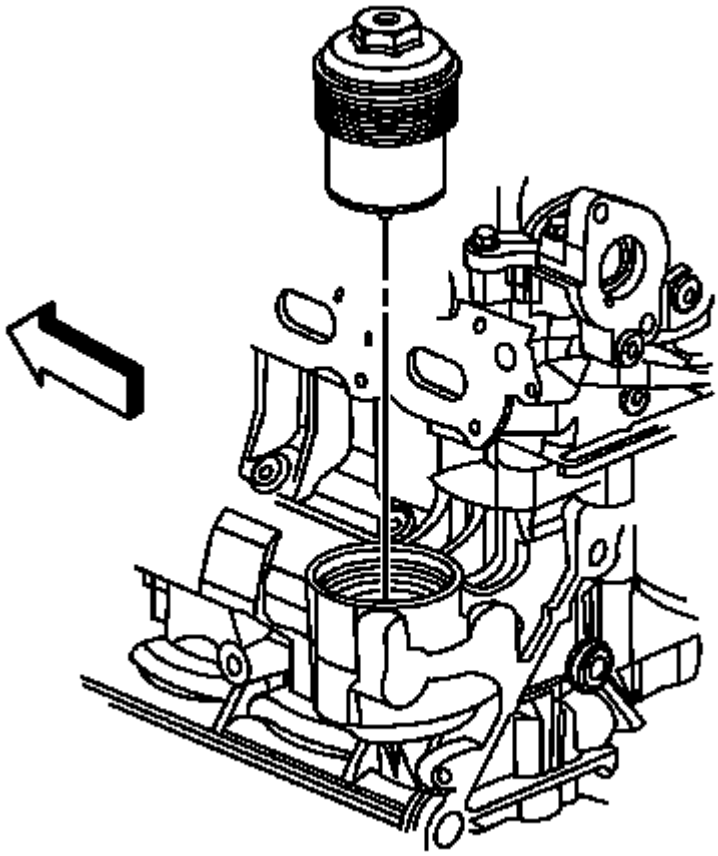

Fig. 249: Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

7. use an oil filter wrench on the outside diameter of the oil filter cap.
8. Remove the oil filter cap and filter.
9. Remove the filter from the cap.

INSTALLATION PROCEDURE

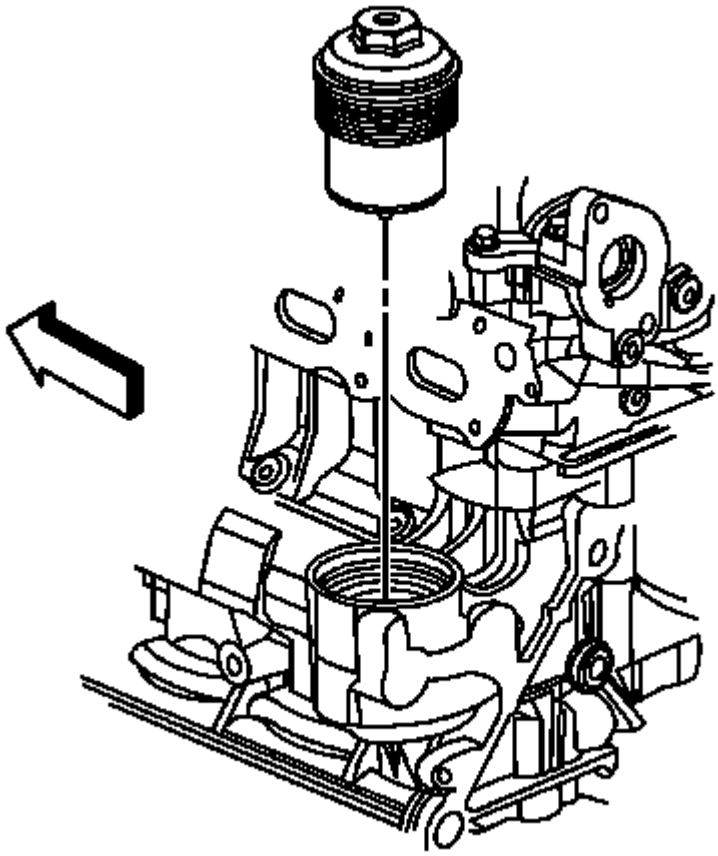

Fig. 250: Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter to the cap.
2. Install the oil filter cap and filter.

CAUTION: Over torquing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

3. use an oil filter wrench on the outside diameter of the oil filter cap. Tighten the oil filter cap until fully seated. DO NOT exceed 25 N.m (18 lb ft).
4. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations (USA and Canada)** .

