2010 ENGINE

Engine Mechanical - 4.6L - Repair Instructions - On Vehicle - Lucerne

DRIVE BELT REPLACEMENT

REMOVAL PROCEDURE

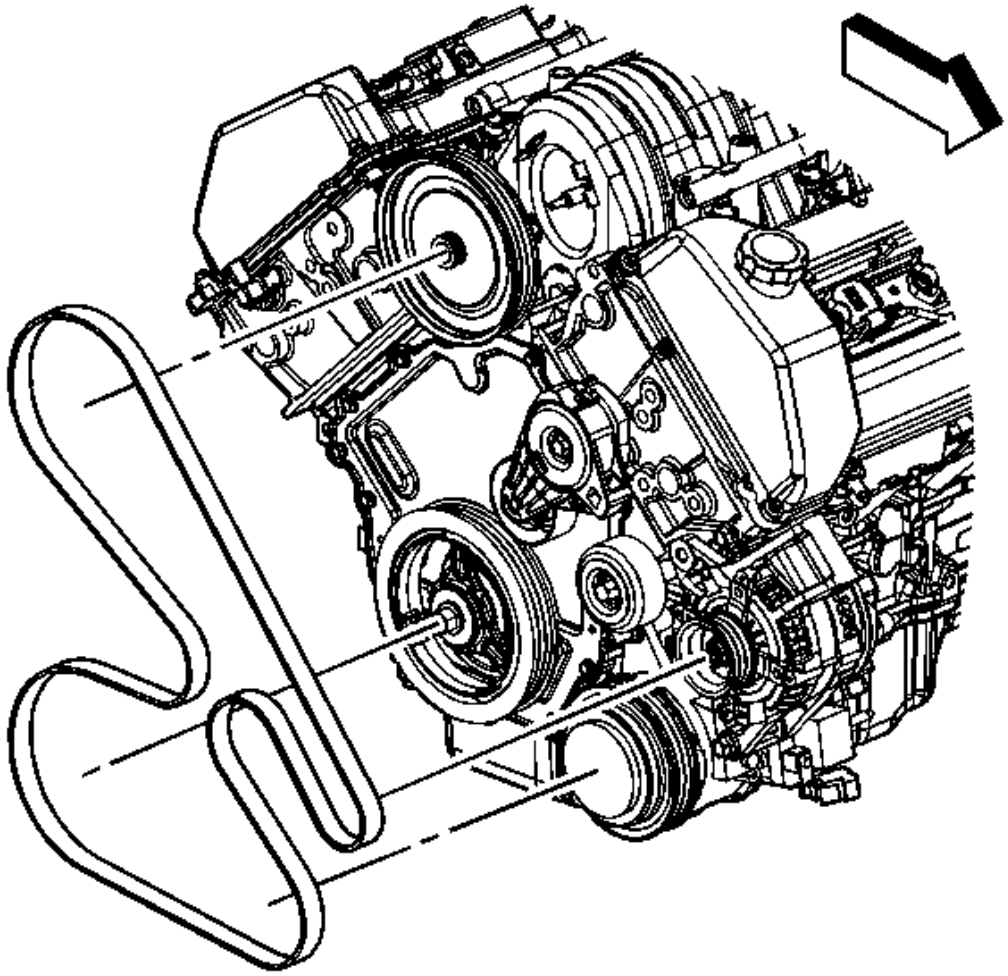

Fig. 1: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .

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2. Install a 1/2 inch drive breaker to the drive belt tensioner.
3. Push down on the breaker bar in order to release the tension.
4. Remove the drive belt from the power steering pump.
5. Slowly return the tensioner to the original position.
6. Remove the belt from the lower pulley and idlers.
7. Partially raise the vehicle. Refer to **Lifting and Jacking the Vehicle** .

INSTALLATION PROCEDURE

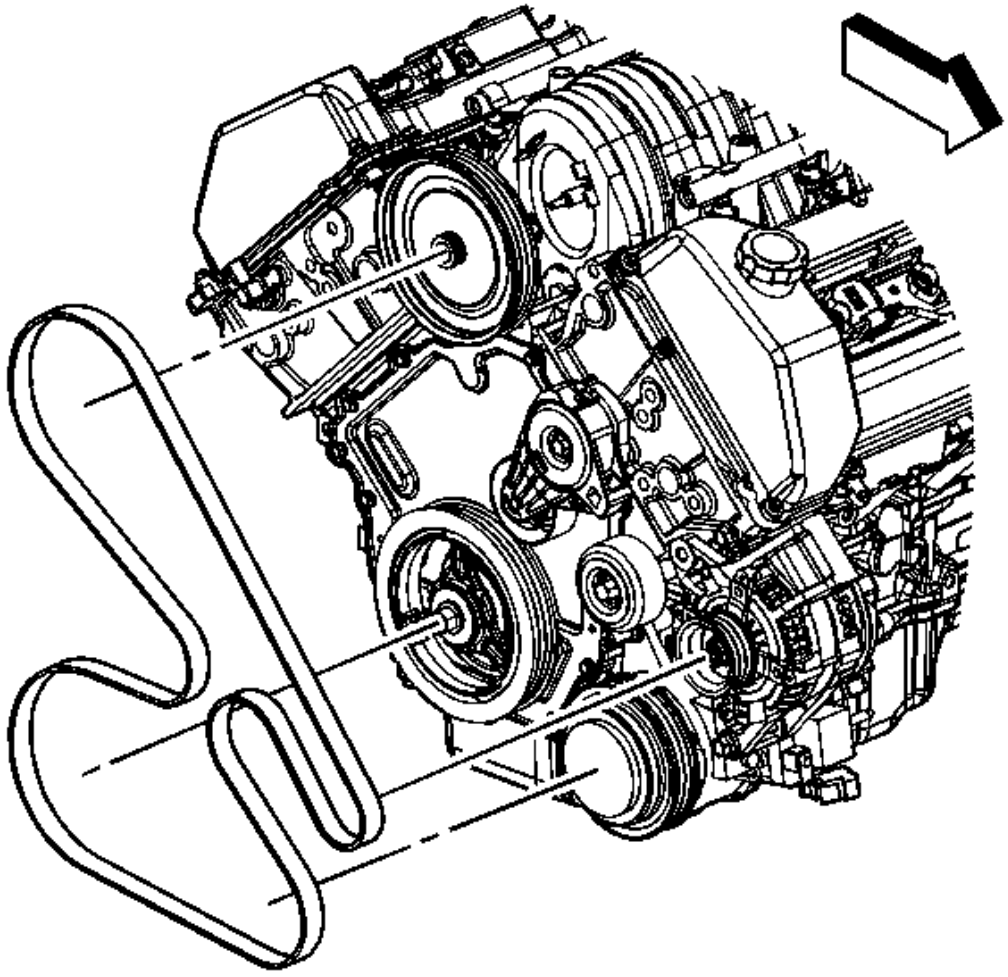

Fig. 2: Identifying Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

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1. Route the drive belt around all the pulleys except for the power steering pump.
2. Lower the vehicle.
3. Install a 1/2 inch drive breaker bar to the drive belt tensioner.
4. Push down on the breaker bar in order to release the tension and route the belt around the power steering pump pulley.

   Ensure the belt is seated on all pulleys.

5. Slowly return the tensioner to its original position.
6. After drive belt installation, inspect the drive belt for the proper routing and correct alignment.
7. Install the right front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement** .
8. Start the engine and check for proper belt and accessory operation.

DRIVE BELT TENSIONER REPLACEMENT

REMOVAL PROCEDURE

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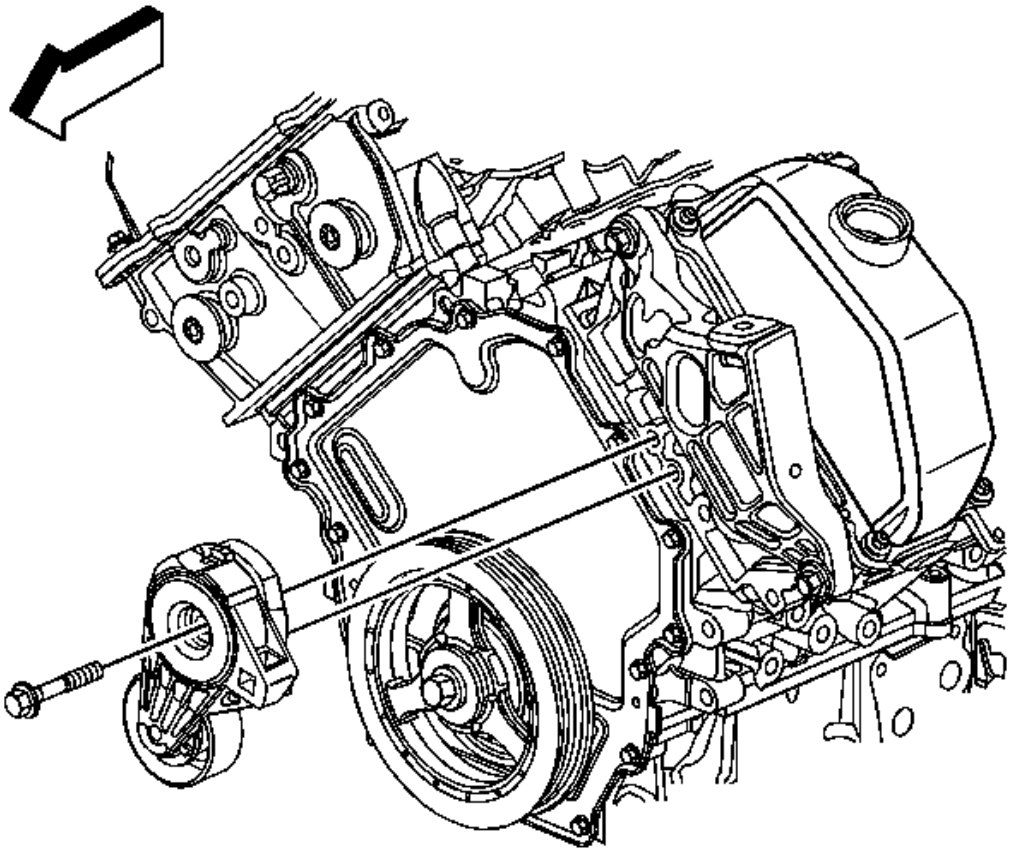

Fig. 3: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the drive belt. Refer to **Drive Belt Replacement**.
3. Remove the right engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.
4. Discharge the air conditioning (A/C) system. Refer to **Refrigerant Recovery and Recharging** .
5. Disconnect the A/C compressor suction hose from the A/C evaporator hose. Discard seal and reposition hose.
6. Remove the drive belt tensioner bolt.
7. Remove the drive belt tensioner.

INSTALLATION PROCEDURE

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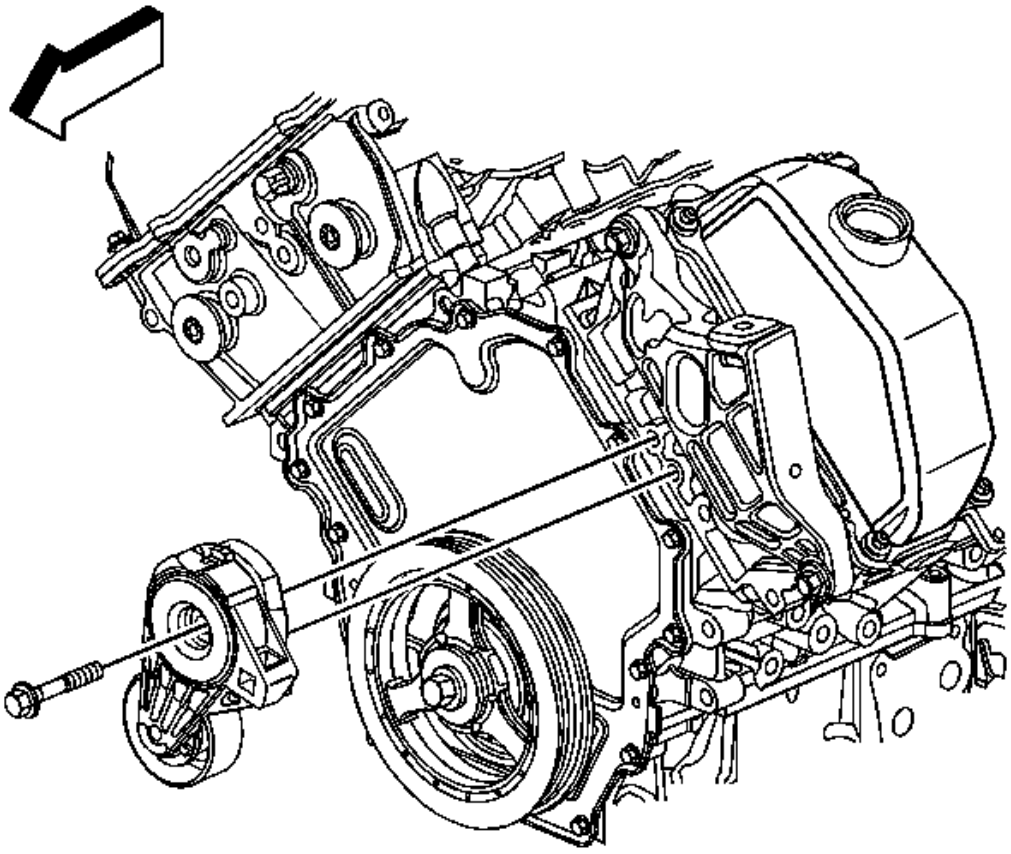

Fig. 4: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner to the left cylinder head. Ensure the anti-rotation pin is in the hole.

   CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt.

   Tighten: Tighten the bolt to 50 N.m (37 lb ft).

3. Install the drive belt. Refer to **Drive Belt Replacement**.
4. Install new seal. Connect the A/C compressor suction hose to the A/C evaporator hose.
5. Recharge the A/C system. Refer to **Refrigerant Recovery and Recharging** .

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6. Install the right engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.
7. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

DRIVE BELT IDLER PULLEY REPLACEMENT

REMOVAL PROCEDURE

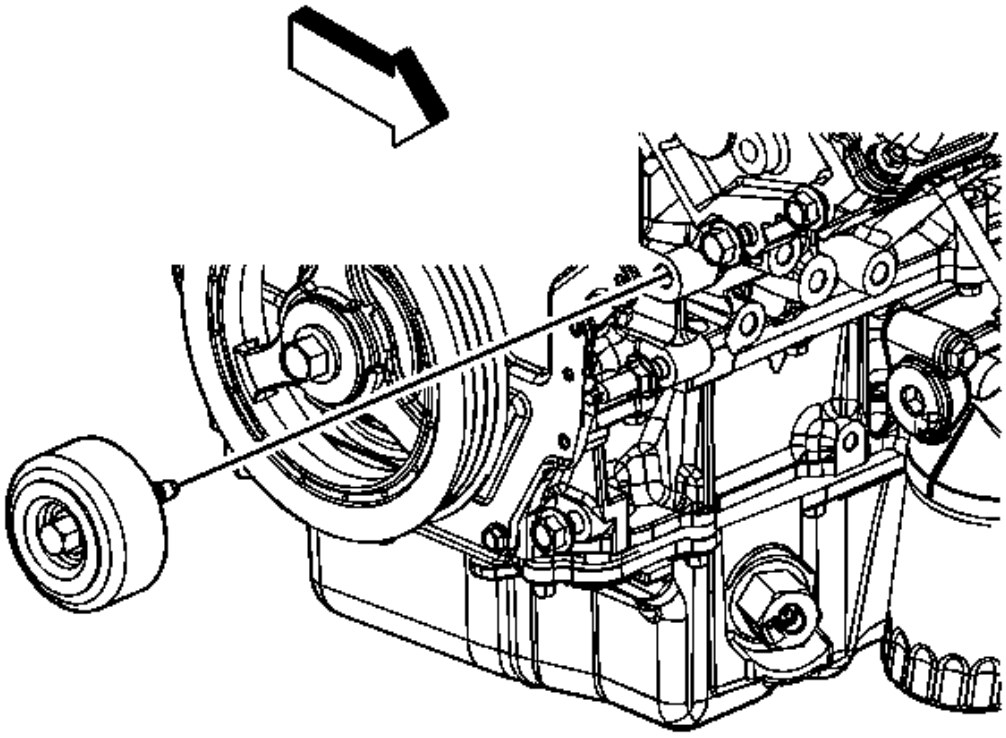

Fig. 5: Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
2. Loosen the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley.

INSTALLATION PROCEDURE

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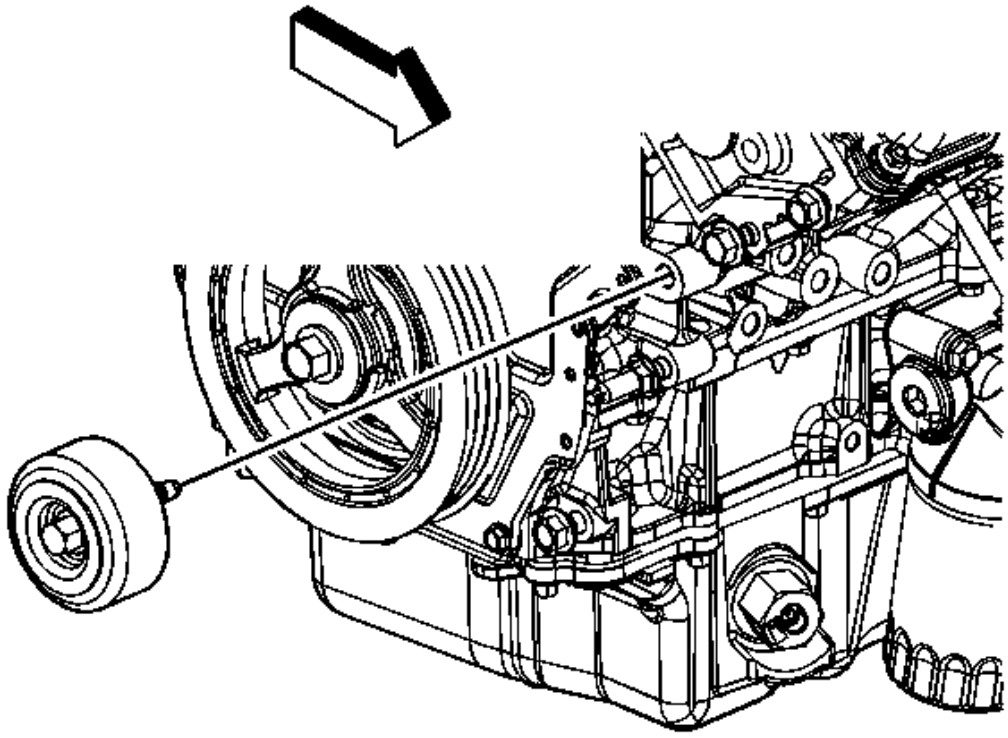

Fig. 6: Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt idler pulley to the engine and finger starter the pulley bolt.

   CAUTION: Refer to Fastener Caution .

2. Tighten the drive belt idler pulley bolt.

   Tighten: Tighten the bolt to 50 N.m (37 lb ft).

3. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.

ENGINE SUPPORT FIXTURE

Special Tools

- **J 28467-B** Universal Engine Support Fixture

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- **J 28467-501** Engine Support Fixture Adapters. See **Special Tools** .

INSTALLATION PROCEDURE

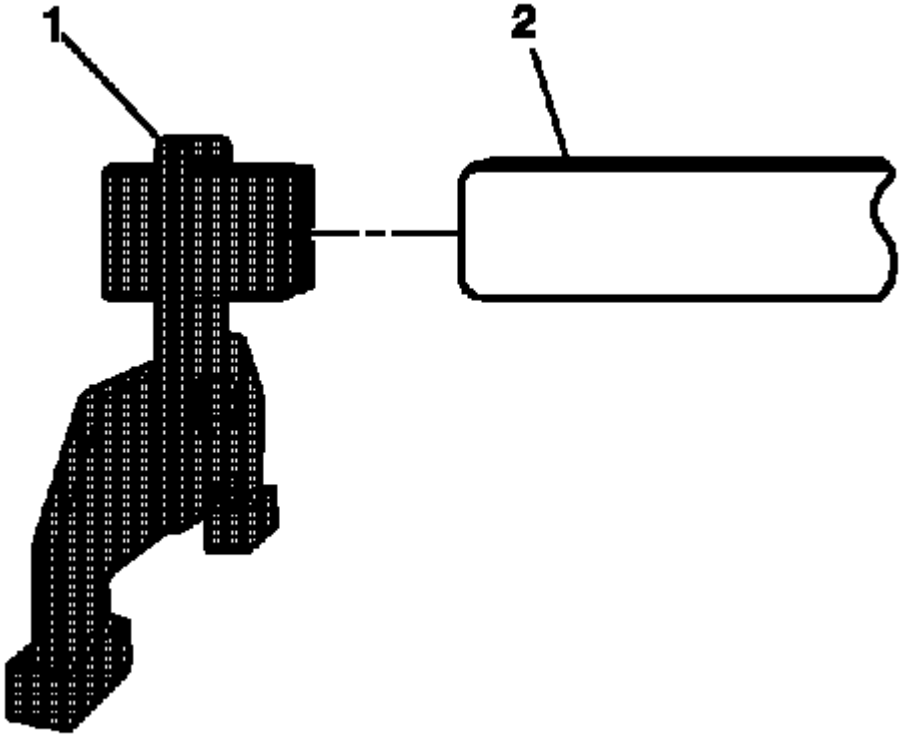

Fig. 7: Support Leg & Main Bar
Courtesy of GENERAL MOTORS CORP.

1. Remove the air inlet grille. Refer to **Air Inlet Grille Panel Replacement** .
2. Install the J 28467-3 strut tower tube (2) into the **J 28467-501** (1). See **Special Tools** .

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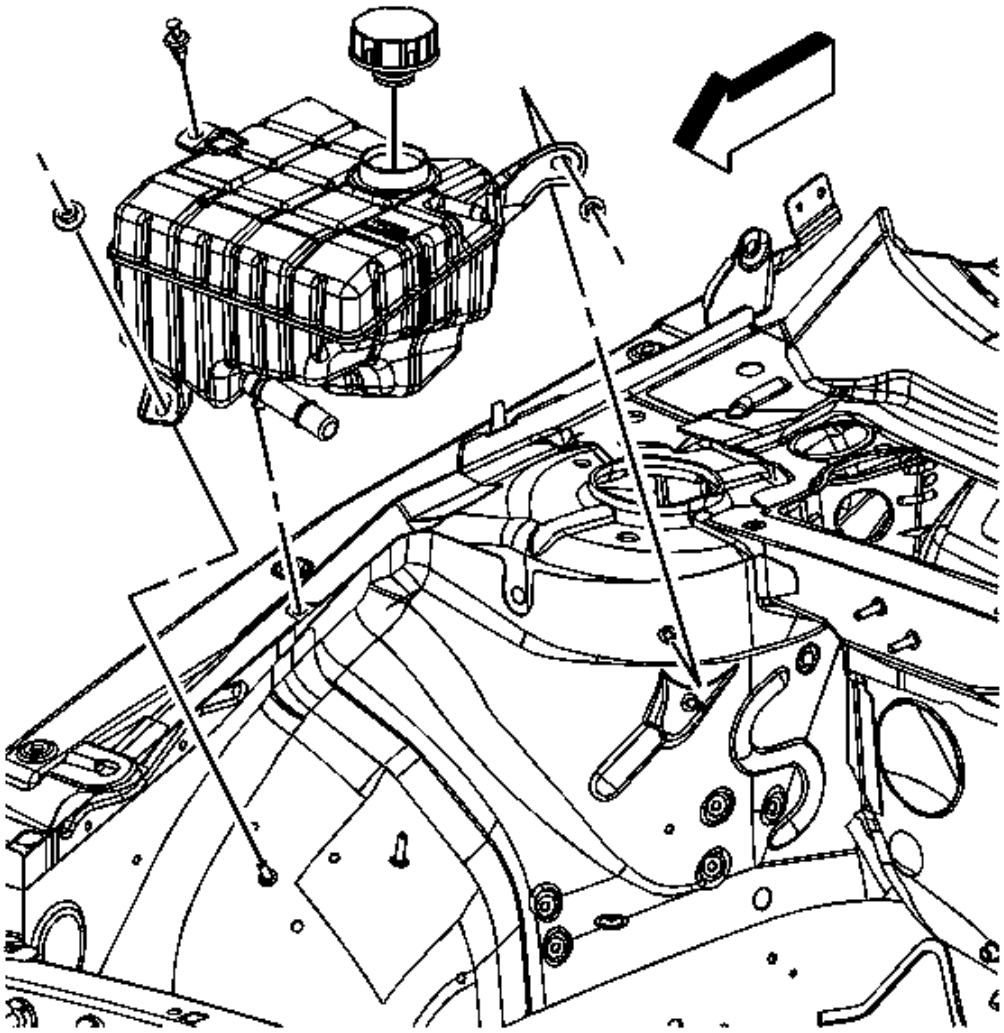

Fig. 8: Surge Tank
Courtesy of GENERAL MOTORS CORP.

3. Remove the surge tank nuts and push pin retainer.
4. Remove the surge tank from the studs and position the tank aside.

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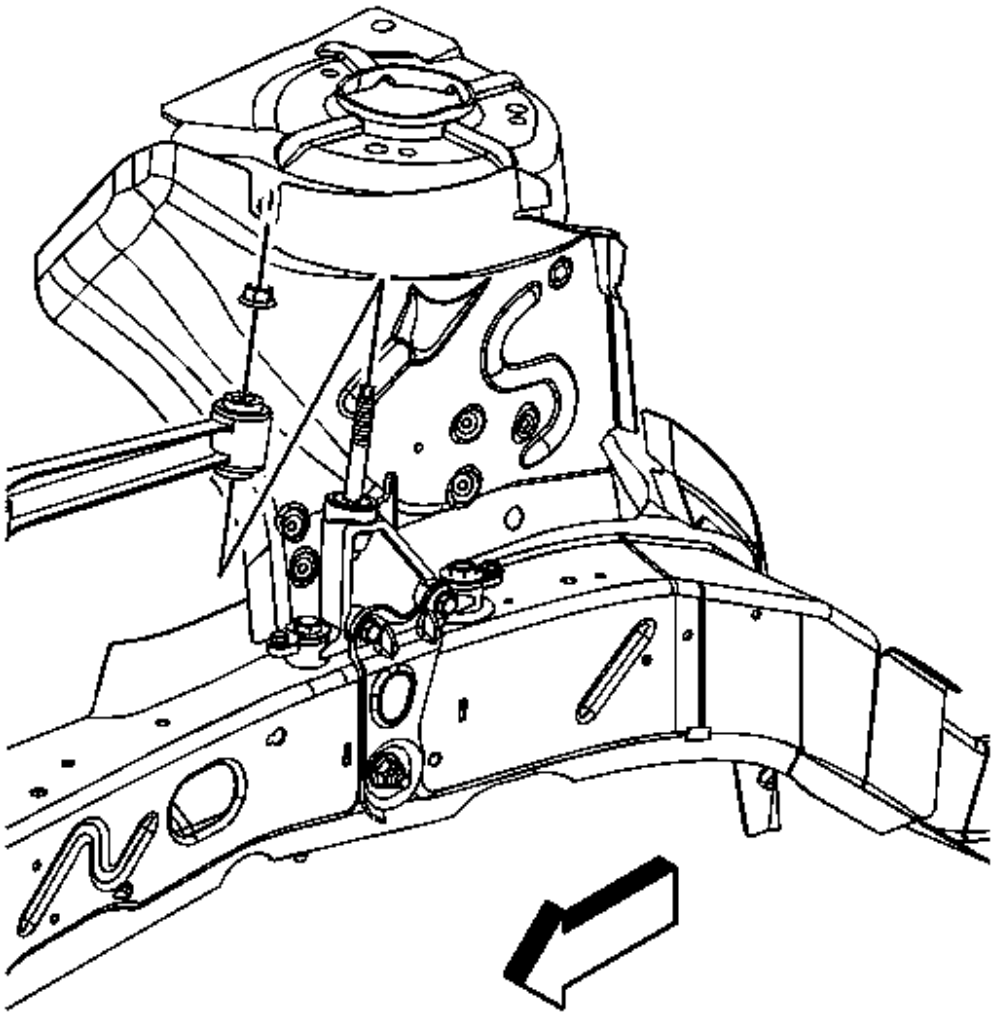

Fig. 9: Engine Mount Strut Brace Nut
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount strut brace nut.

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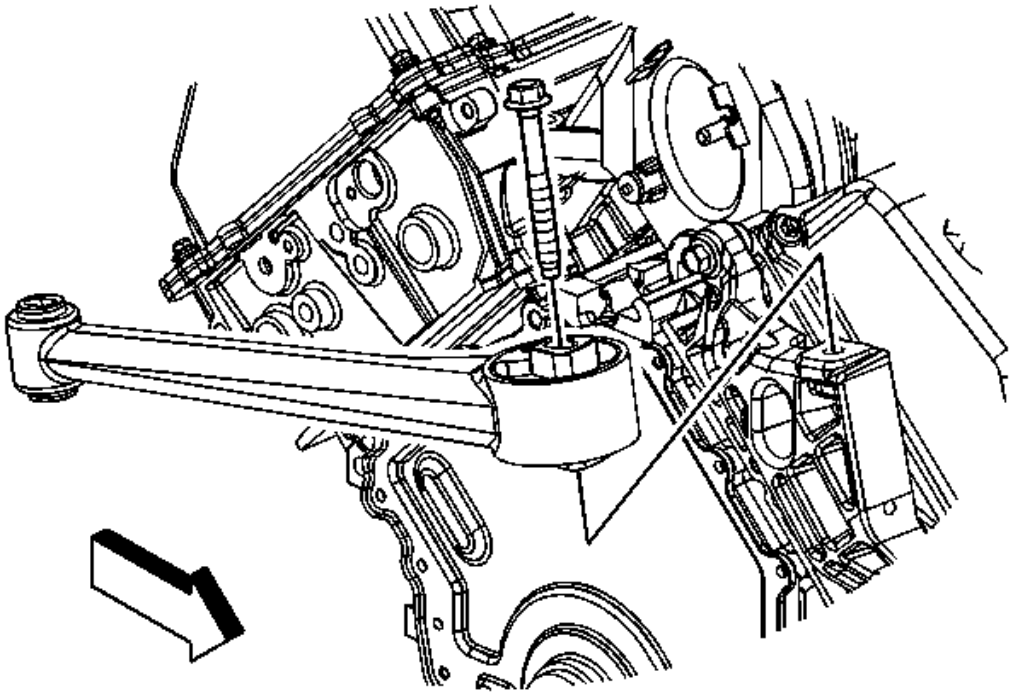

Fig. 10: Engine Mount Strut Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount strut bolt.
7. Remove the engine mount strut.
8. Remove the front compartment sight shield. Refer to **Front Compartment Sight Shields Replacement** .

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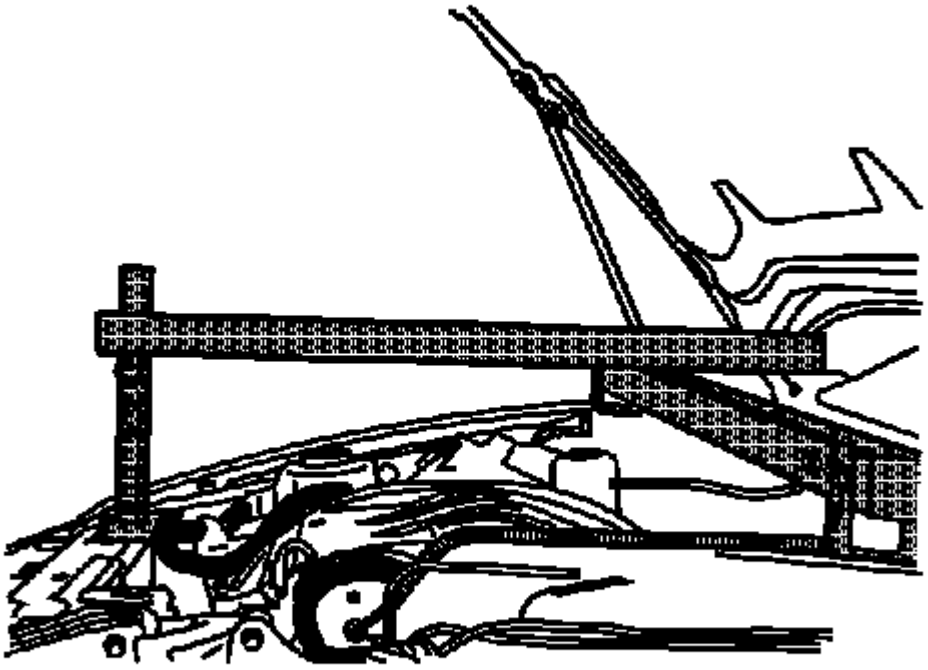

Fig. 11: Radiator Shelf Tube & Strut Tower Tube
Courtesy of GENERAL MOTORS CORP.

9. Install the J 28467-2A radiator shelf tube on top of the J 28467-3 strut tower tube.

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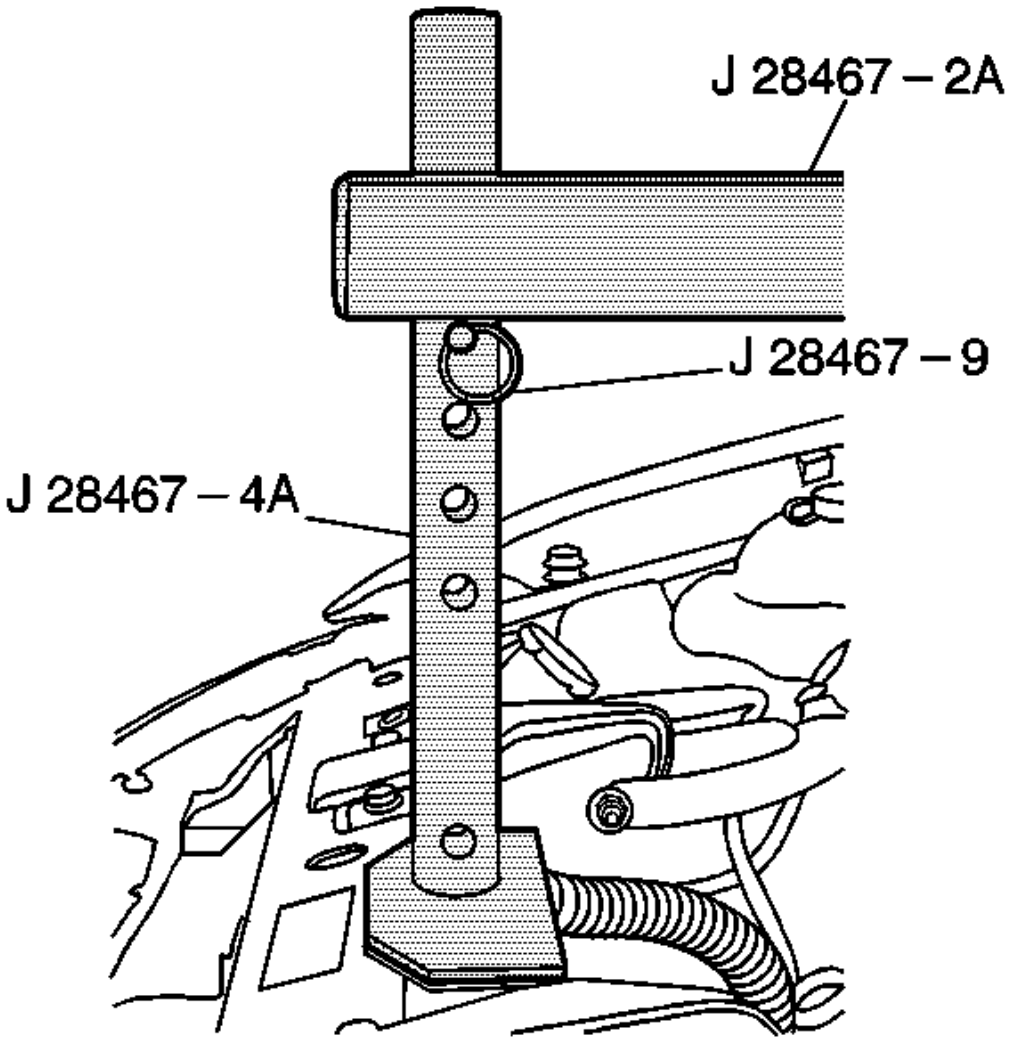

Fig. 12: Special Support Tools
Courtesy of GENERAL MOTORS CORP.

10. Install the round tube of the J 28467-4A front support assembly through the large hole in the J 28467-2A radiator shelf tube. The hole used in the J 28467-2A radiator shelf tube depends on the vehicle application.
11. Place the rubber padded foot of the J 28467-4A front support assembly on the upper tie bar.
12. Install the J 28467-9 7/16 in x 2.0 in quick release pin through the hole in the J 28467-4A front support assembly in order to level the J 28467-2A radiator shelf tube.

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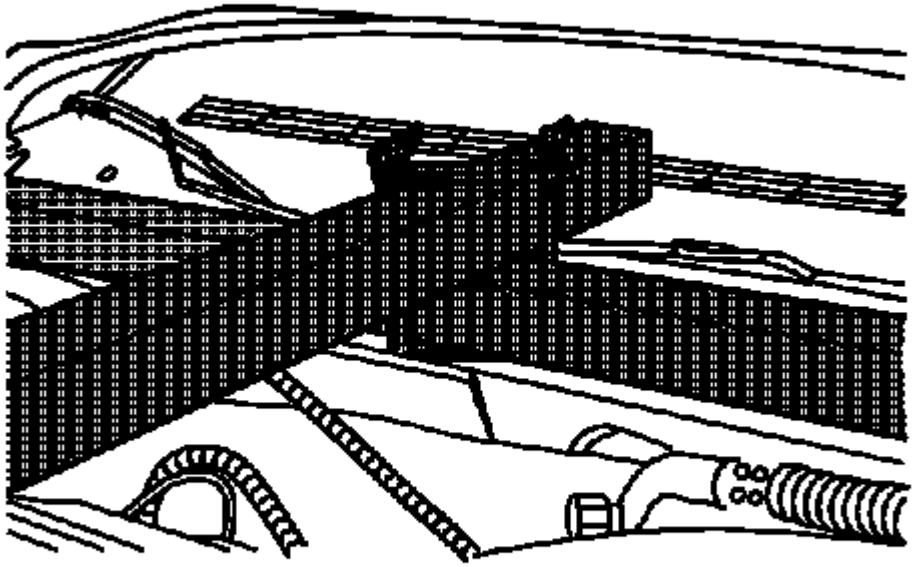

Fig. 13: Cross Bracket Assembly
Courtesy of GENERAL MOTORS CORP.

13. Install the J 28467-1A cross bracket assembly.
14. Hand tighten the J 28467-1A cross bracket assembly wing nuts.

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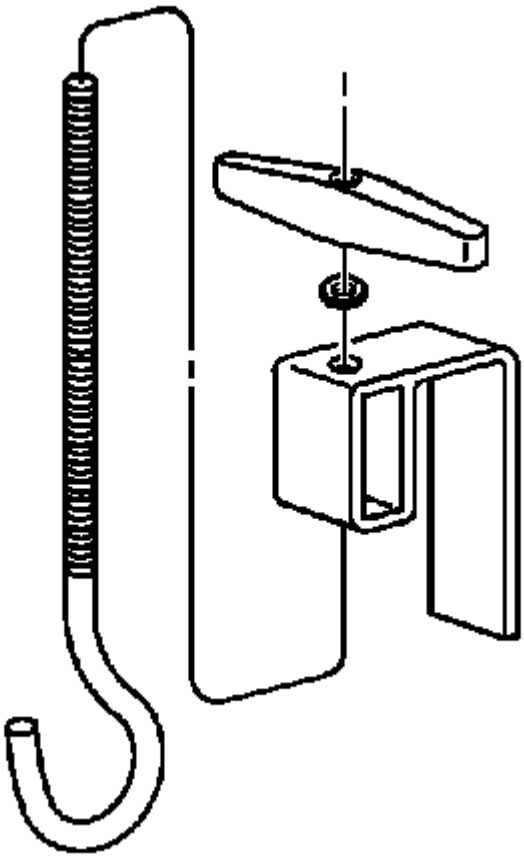

Fig. 14: Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

15. Install the J 28467-7A lift hook through the J 28467-6A lift hook bracket.
16. Install the 1/2 in lift hook washer and J 28467-34 lift hook wing nut onto the J 28467-7A lift hook.

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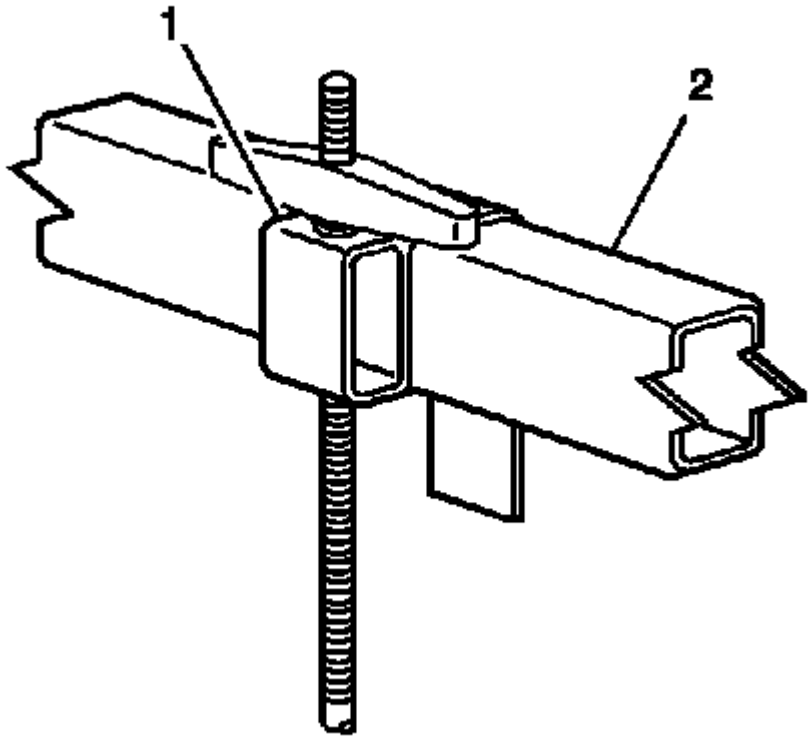

Fig. 15: Lift Hook Bracket & Strut Tower Tube
Courtesy of GENERAL MOTORS CORP.

17. Install the J 28467-6A assembled lift hook bracket (1) over the J 28467-3 strut tower tube (2).
18. Adjust the J 28467-6A assembled lift hook bracket (1) in order to align the hook with the rear engine lift hook bracket.

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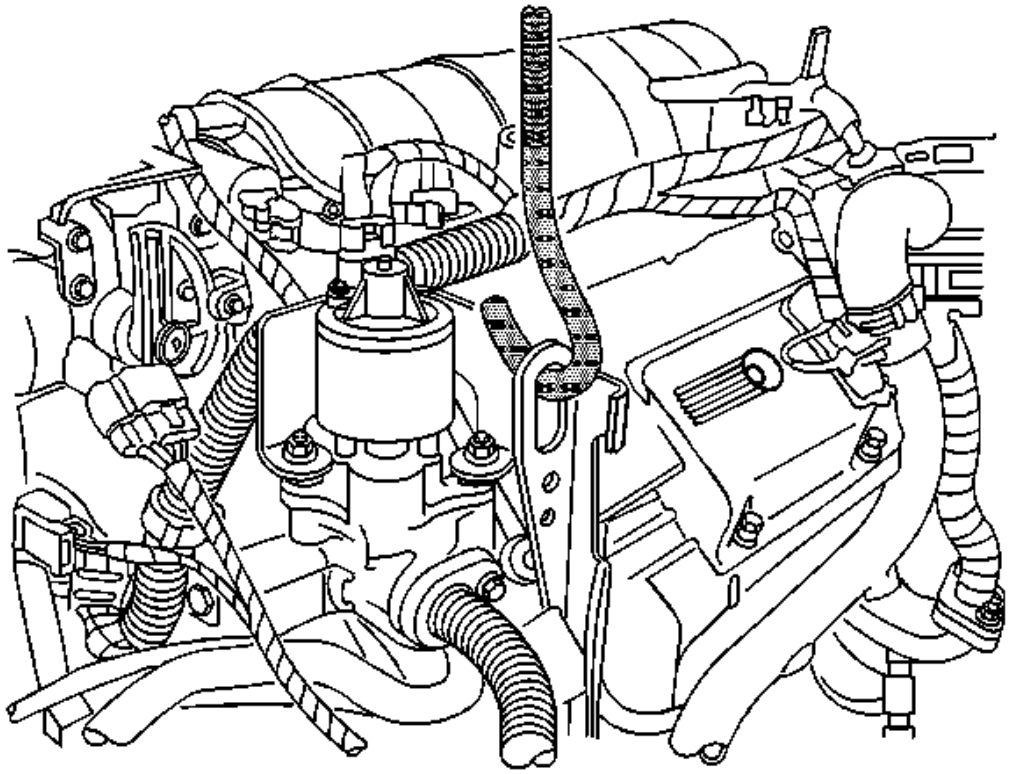

Fig. 16: Lift Hook Through Rear Engine Lift Hook Bracket
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19. Install the J 28467-7A lift hook through the rear engine lift hook bracket. Ensure the hook does not damage the surrounding components.
20. Repeat steps 18 and 19.

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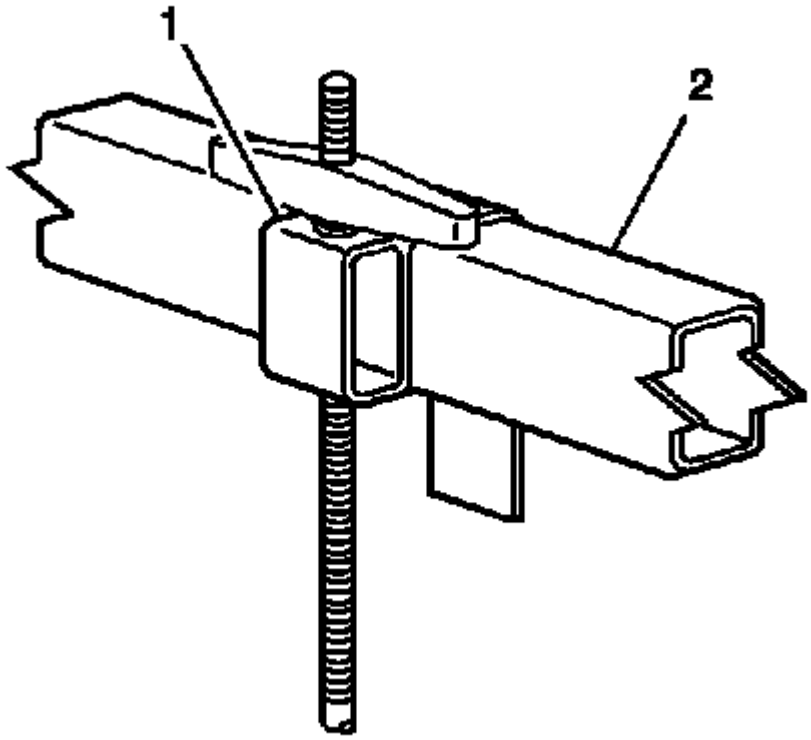

Fig. 17: Lift Hook Bracket & Strut Tower Tube
Courtesy of GENERAL MOTORS CORP.

21. Install the J 28467-6A assembled lift hook bracket (1) over the J 28467-2A radiator shelf tube (2).
22. Adjust the J 28467-6A assembled lift hook bracket (1) in order to align the hook with the torque strut bracket.

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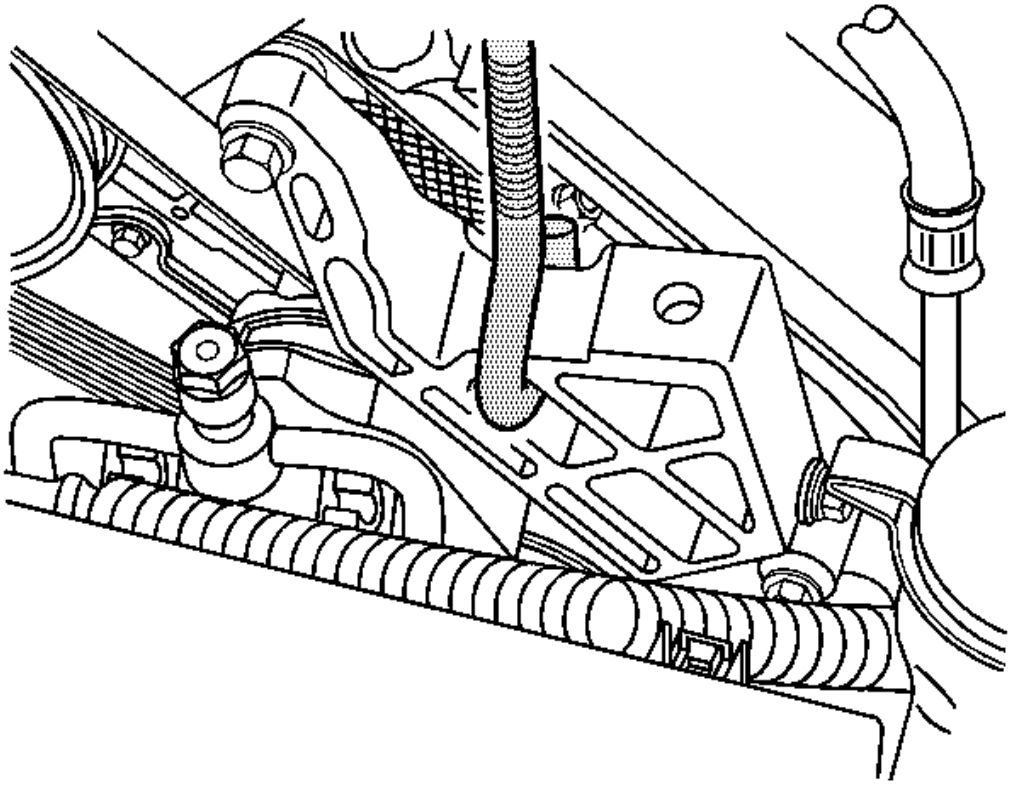

Fig. 18: Lift Hook Through Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

23. Install the J 28467-7A lift hook through the engine mount strut bracket. Ensure the hook does not damage the surrounding components.
24. Hand tighten the J 28467-34 lift hook wing nuts securely to remove all slack from the engine support fixture assembly.

REMOVAL PROCEDURE

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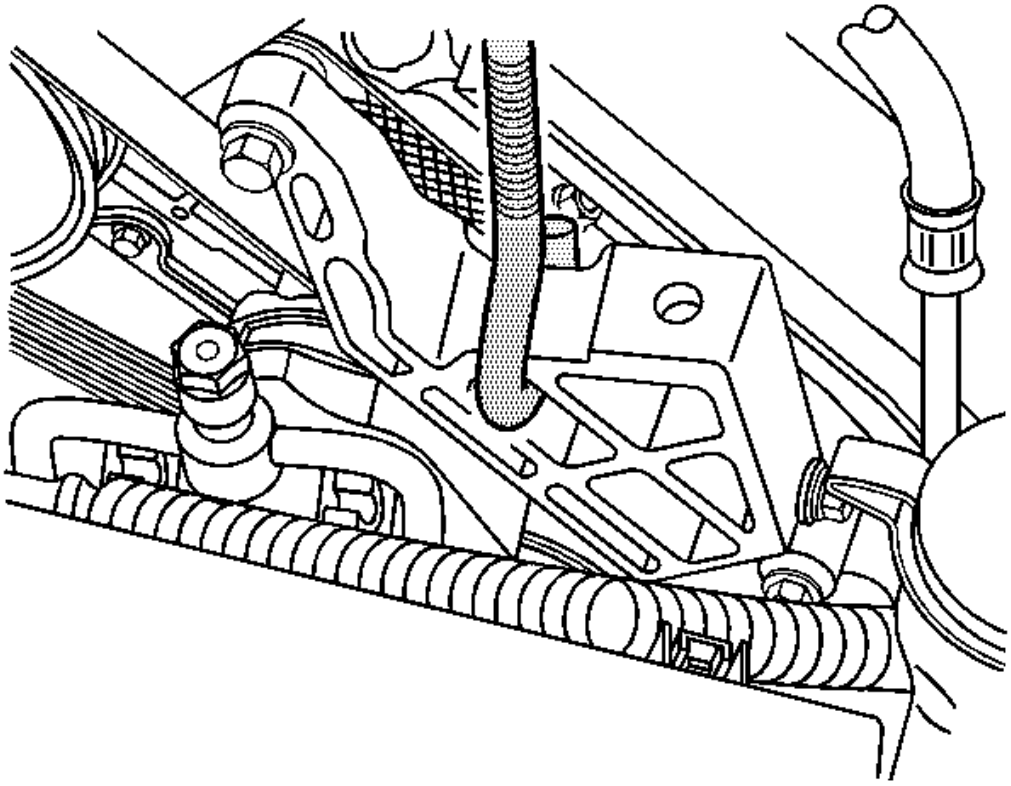

Fig. 19: Lift Hook Through Engine Mount Strut Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the J 28467-7A lift hook from the engine mount strut bracket.
2. Remove the **J 28467-B** .
3. Remove the **J 28467-501** . See **Special Tools** .

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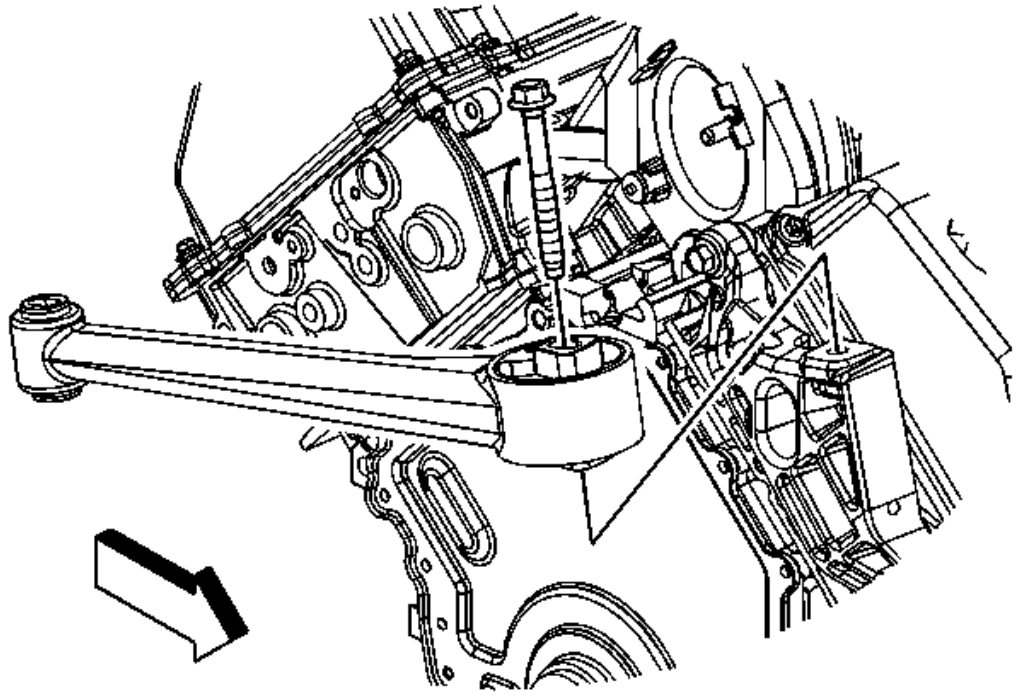

Fig. 20: Engine Mount Strut Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the engine mount strut.

CAUTION: Refer to Fastener Caution .

5. Install the engine mount strut bolt.

Tighten: Tighten the bolt to 70 N.m (52 lb ft).

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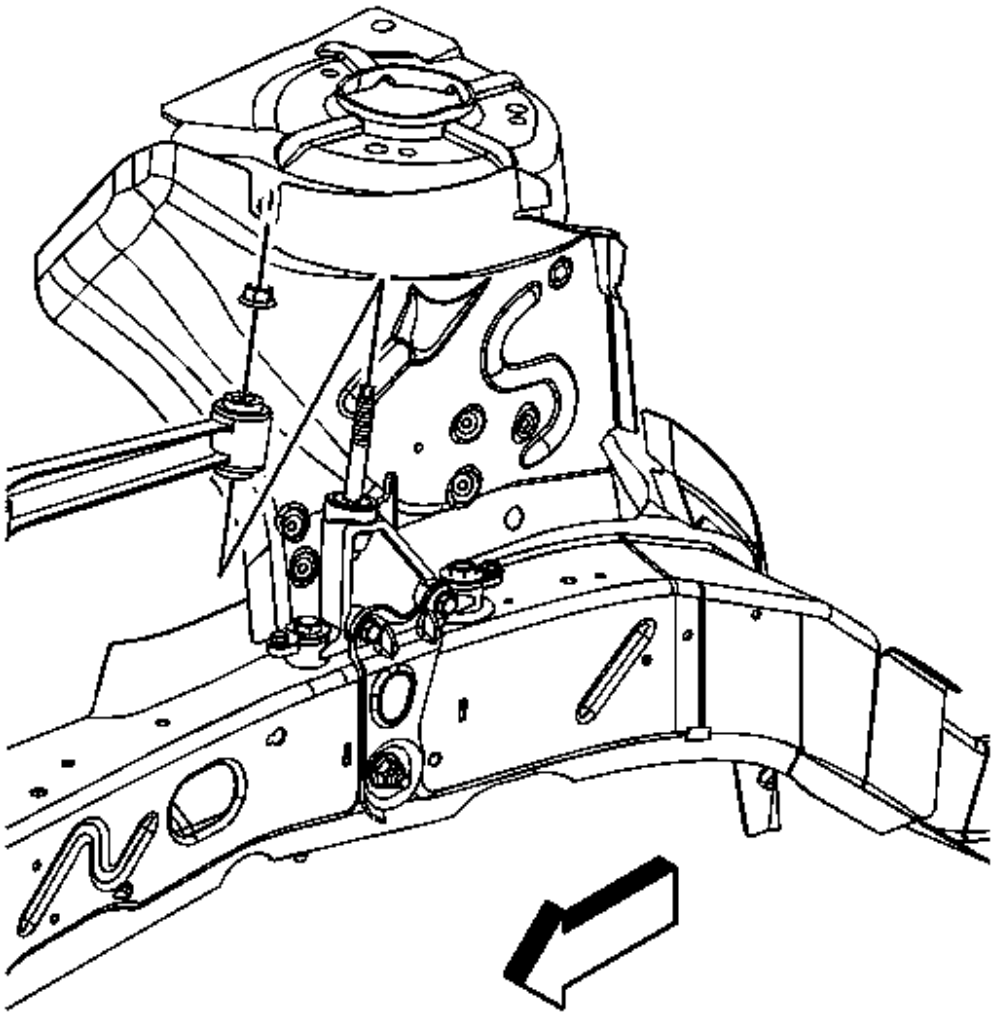

Fig. 21: Engine Mount Strut Brace Nut
Courtesy of GENERAL MOTORS CORP.

6. Install the engine mount strut nut.

   Tighten: Tighten the nut to 70 N.m (52 lb ft).

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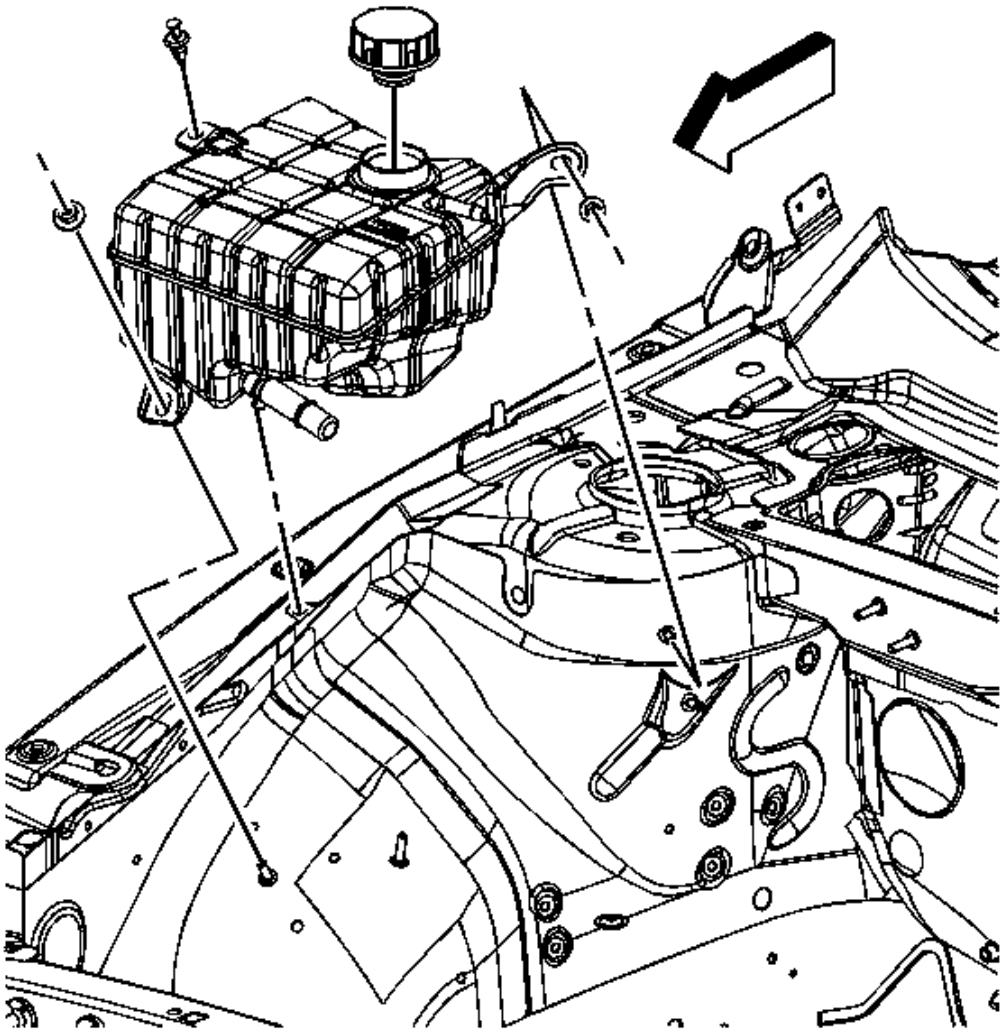

Fig. 22: Surge Tank
Courtesy of GENERAL MOTORS CORP.

7. Position the surge tank to the studs.
8. Install the surge tank nuts and push pin retainer.

   Tighten: Tighten the nuts to 6 N.m (53 lb in).

9. Install the front compartment sight shield. Refer to **Front Compartment Sight Shields Replacement** .
10. Install the air inlet grille. Refer to **Air Inlet Grille Panel Replacement** .

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ENGINE FRONT MOUNT REPLACEMENT

REMOVAL PROCEDURE

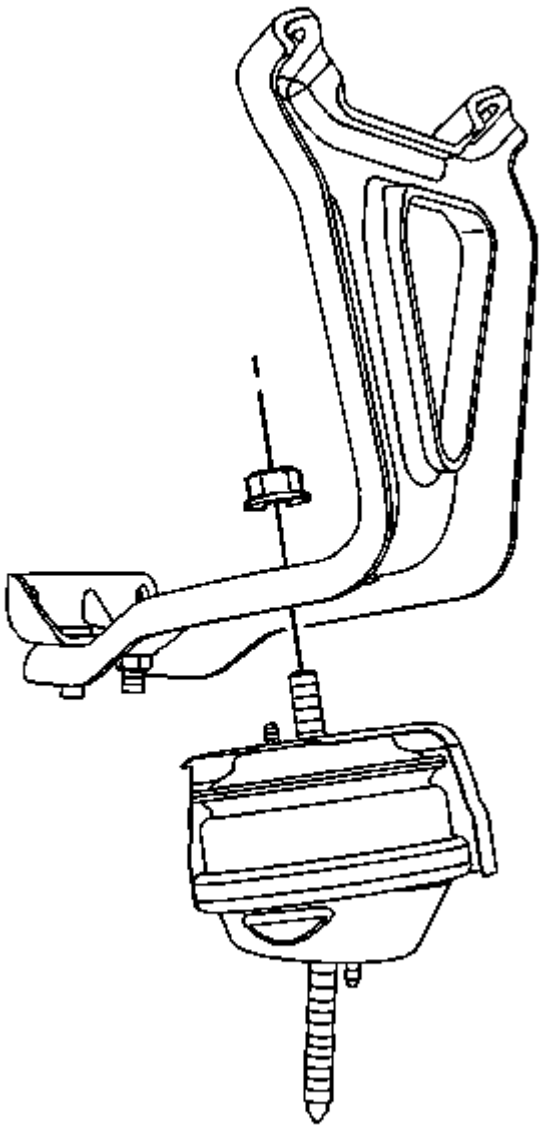

Fig. 23: Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount bracket. Refer to **Engine Front Mount Bracket Replacement**.

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2. Remove the front engine mount to engine mount bracket nut.
3. Remove the front engine mount.

INSTALLATION PROCEDURE

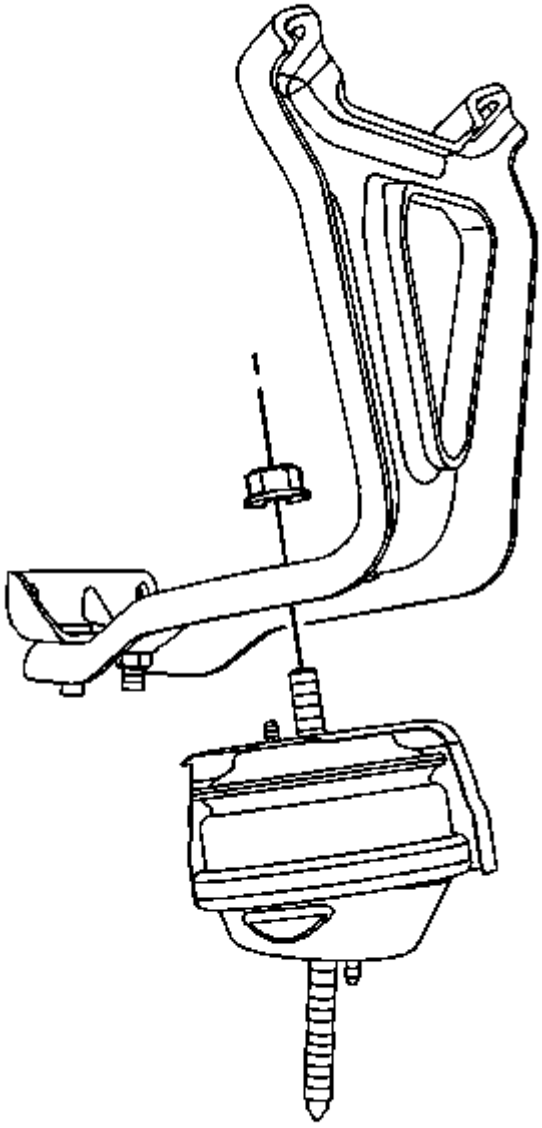

Fig. 24: Front Engine Mount
Courtesy of GENERAL MOTORS CORP.

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1. Install the front engine mount stud through the hole in the front engine mount bracket.
2. Install the front engine mount bracket. Refer to **Engine Front Mount Bracket Replacement**.

CAUTION: Refer to Fastener Caution .

3. Install the front engine mount to engine mount bracket nut.

   Tighten: Tighten the nut to 80 N.m (59 lb ft).

4. Install the frame. Refer to **Drivetrain and Front Suspension Frame Replacement** .

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**. Raising the engine removes the weight from the engine mount and creates slight tension in the rubber.
2. Observe the engine mount while raising the engine. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber surface 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.
3. If there is movement between the metal plate of the engine mount and its attaching points, lower the engine on the engine mount. Tighten the bolts or nuts attaching the engine mount to the frame or engine mount bracket. Refer to **Engine Front Mount Replacement** or **Engine Mount Replacement - Right Side**.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

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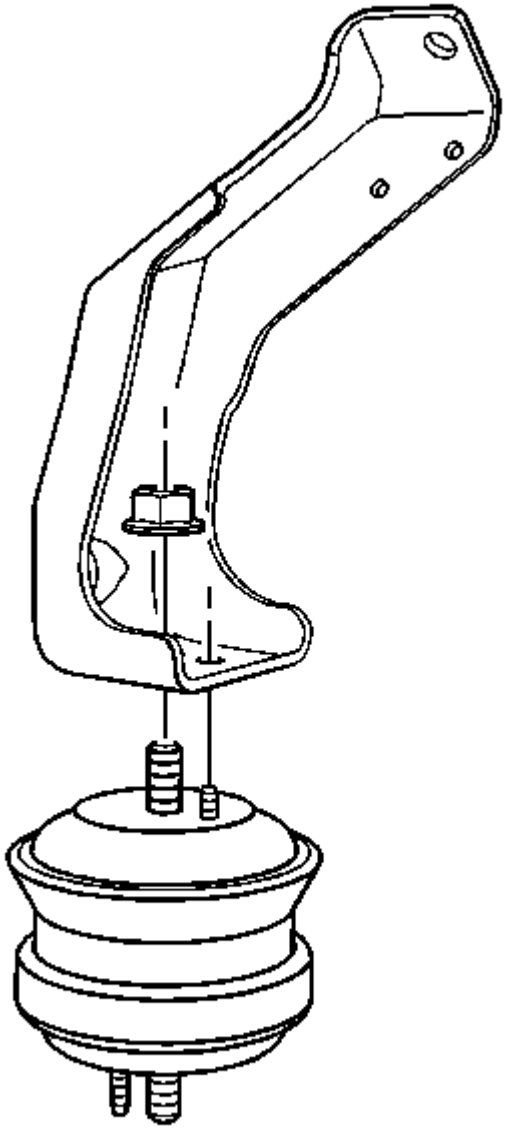

Fig. 25: Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Remove the frame. Refer to **Drivetrain and Front Suspension Frame Replacement (3.9L)** .
2. Remove the right engine mount to engine mount bracket nut.
3. Remove the right engine mount.

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INSTALLATION PROCEDURE

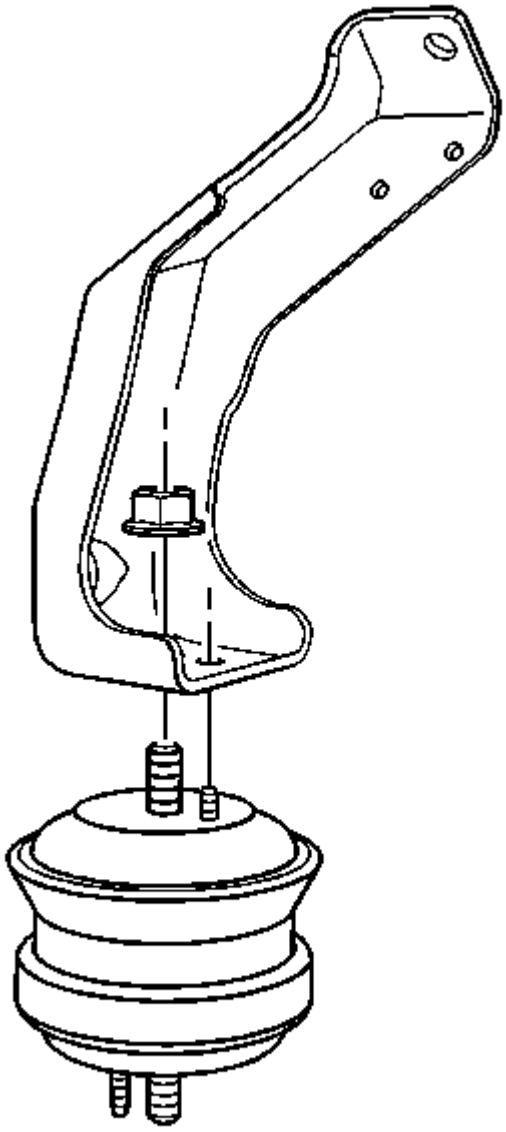

Fig. 26: Right Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Install the right engine mount stud through the hole in the engine mount bracket.

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CAUTION: Refer to Fastener Caution .

2. Install the right engine mount to engine mount bracket nut.

   Tighten: Tighten the nut to 80 N.m (59 lb ft).

3. Install the frame. Refer to **Drivetrain and Front Suspension Frame Replacement (3.9L)** .

ENGINE FRONT MOUNT BRACKET REPLACEMENT

REMOVAL PROCEDURE

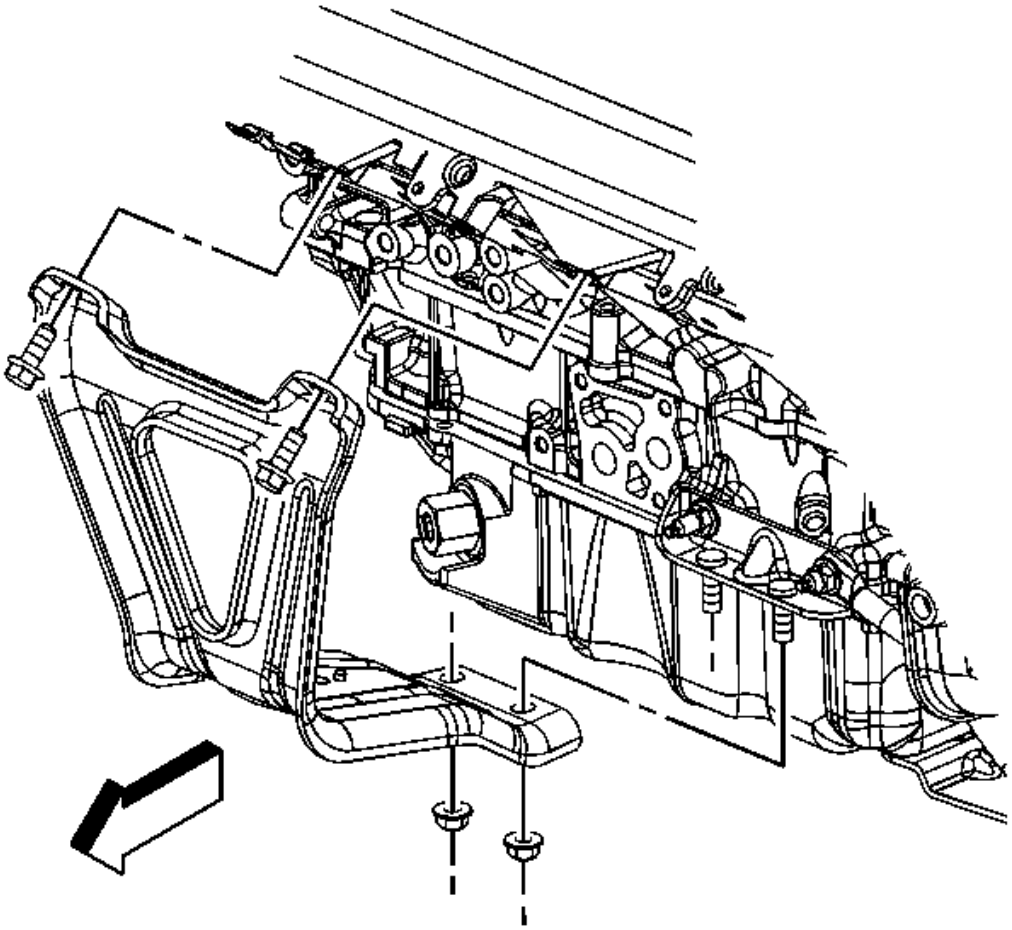

Fig. 27: Upper Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

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1. Remove the front frame. Refer to **Drivetrain and Front Suspension Frame Replacement (3.9L)** .
2. Remove the engine mount bracket to cylinder head bolts.
3. Remove the upper engine mount bracket to lower engine mount bracket nuts.
4. Remove the upper engine mount bracket.

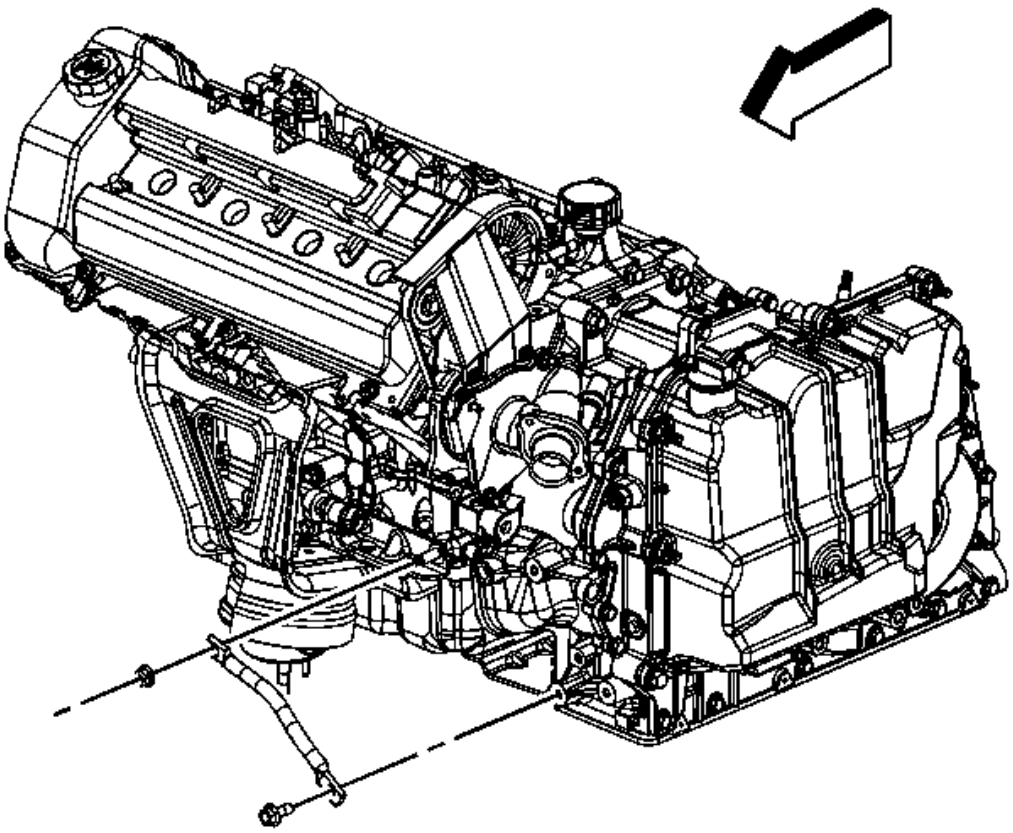

Fig. 28: Transaxle Brace & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the transaxle brace bolt.

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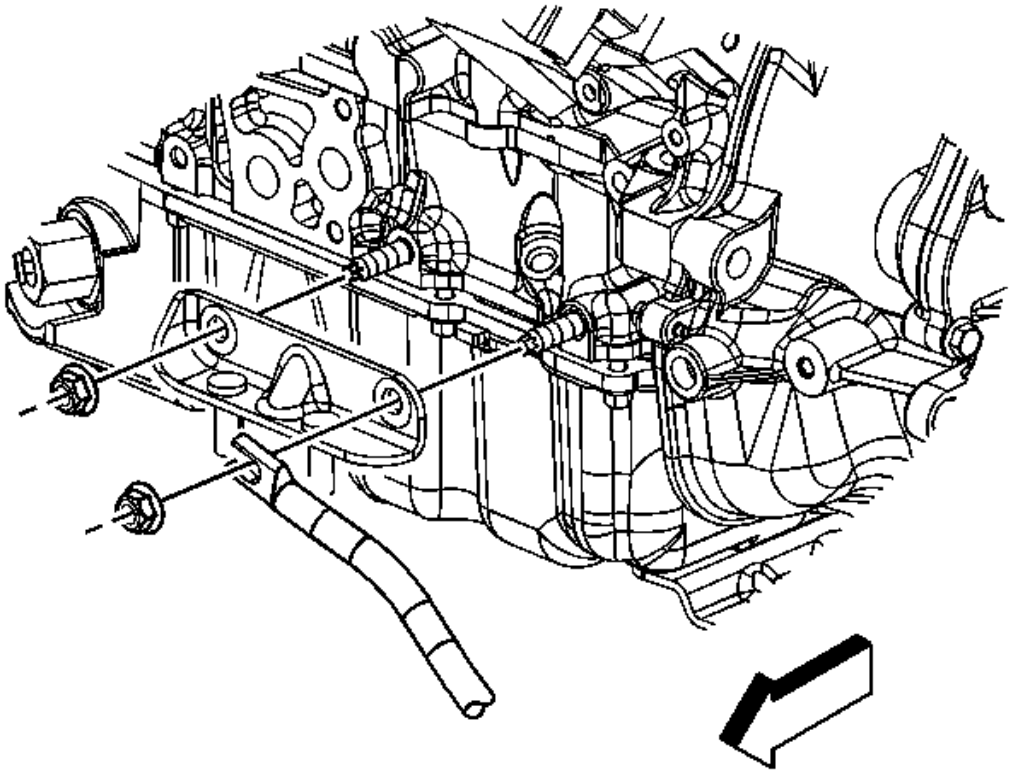

Fig. 29: Lower Engine Mount Bracket & Stud Nuts
Courtesy of GENERAL MOTORS CORP.

6. Remove the lower engine mount bracket to engine stud nuts.
7. Remove the transaxle brace.
8. Remove the lower engine mount bracket.

INSTALLATION PROCEDURE

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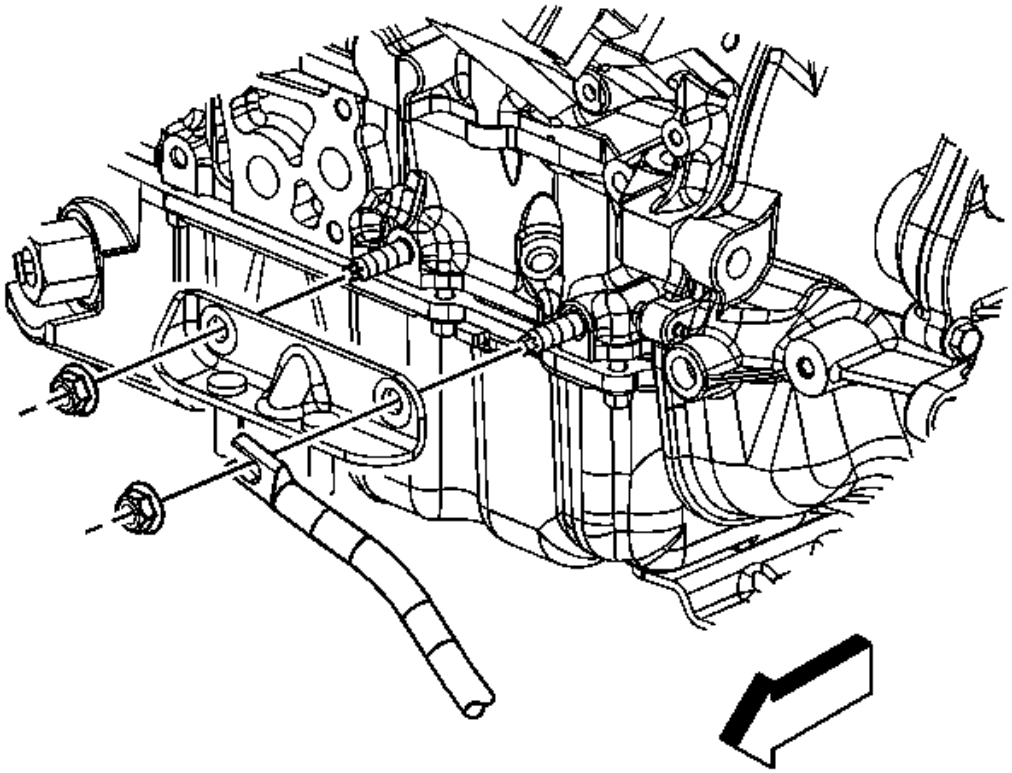

Fig. 30: Lower Engine Mount Bracket & Stud Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the lower engine mount bracket onto the engine studs.
2. Install the transaxle brace.
3. Install the lower engine mount bracket to engine stud nuts finger tight.

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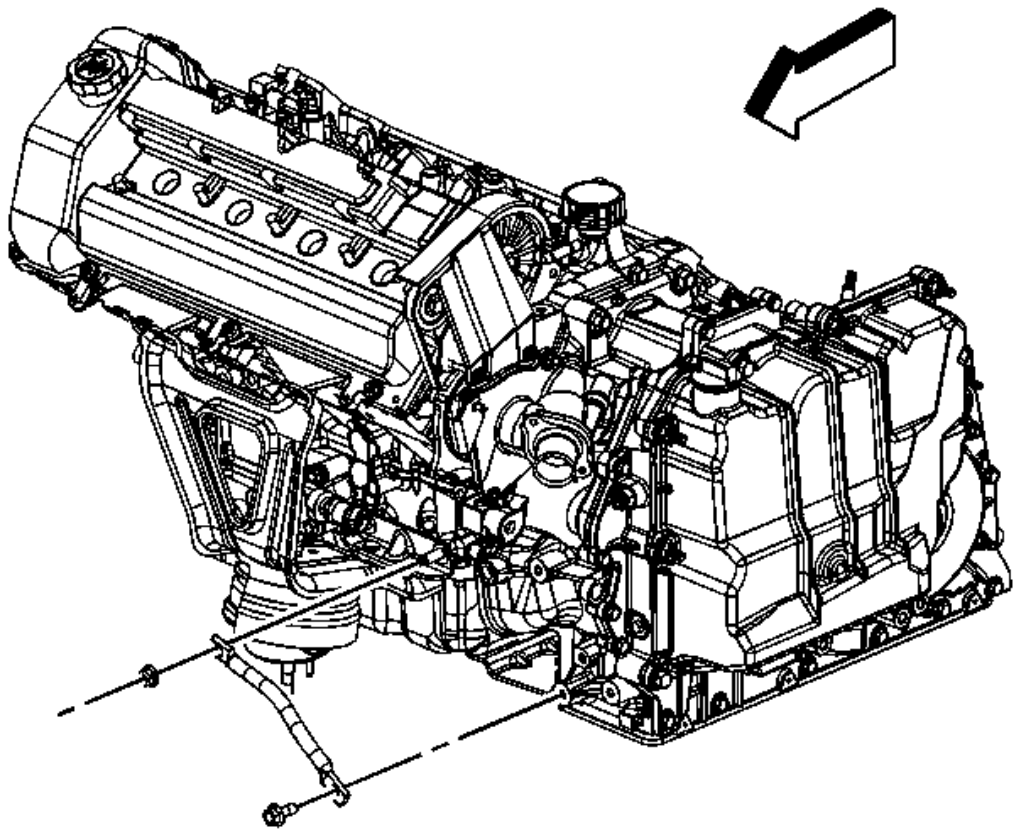

Fig. 31: Transaxle Brace & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the transaxle brace bolt.

Tighten:

- Tighten the transaxle brace bolt to 50 N.m (37 lb ft).
- Tighten the lower engine mount bracket to engine stud nuts to 50 N.m (37 lb ft).

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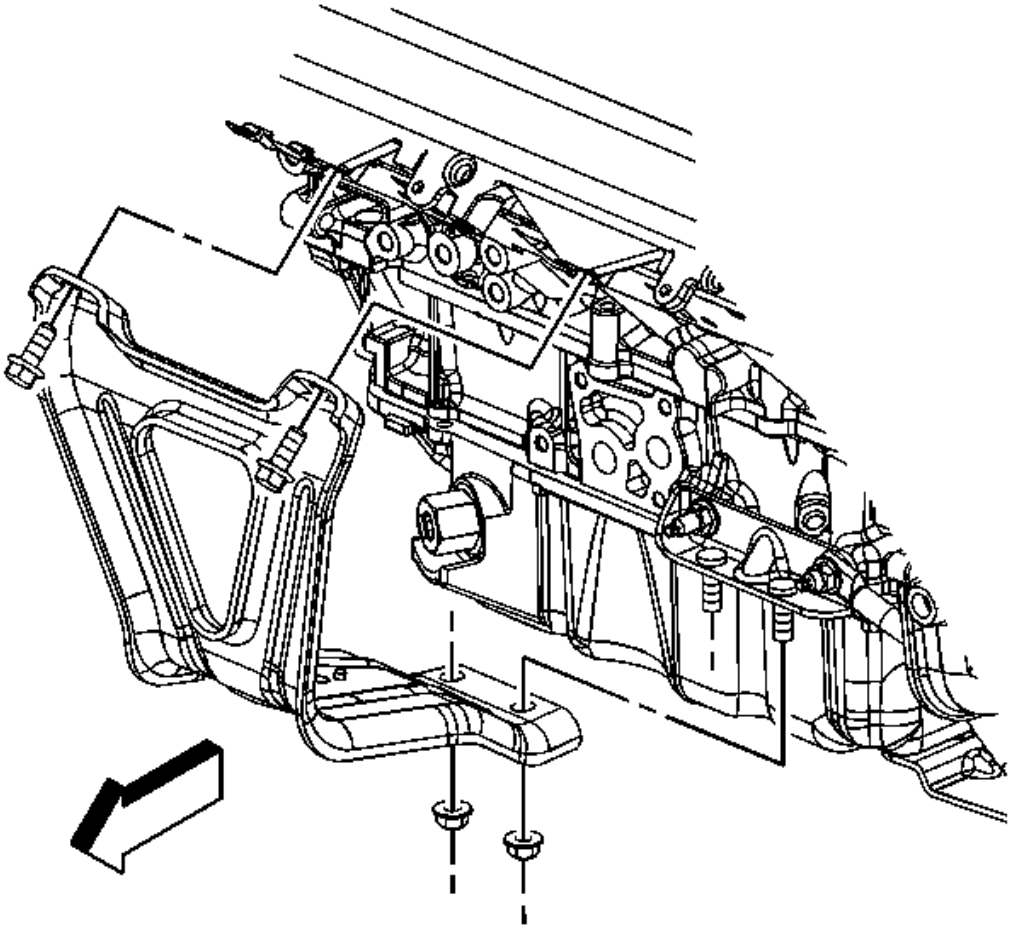

Fig. 32: Upper Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the upper engine mount bracket onto the studs.
6. Install the engine mount bracket to cylinder head bolts.

   Tighten: Tighten the bolts to 50 N.m (37 lb ft).

7. Install the upper engine mount bracket to lower engine mount bracket nuts.

   Tighten: Tighten the nuts to 50 N.m (37 lb ft).

8. Install the front frame. Refer to **Drivetrain and Front Suspension Frame Replacement (3.9L)** .

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ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

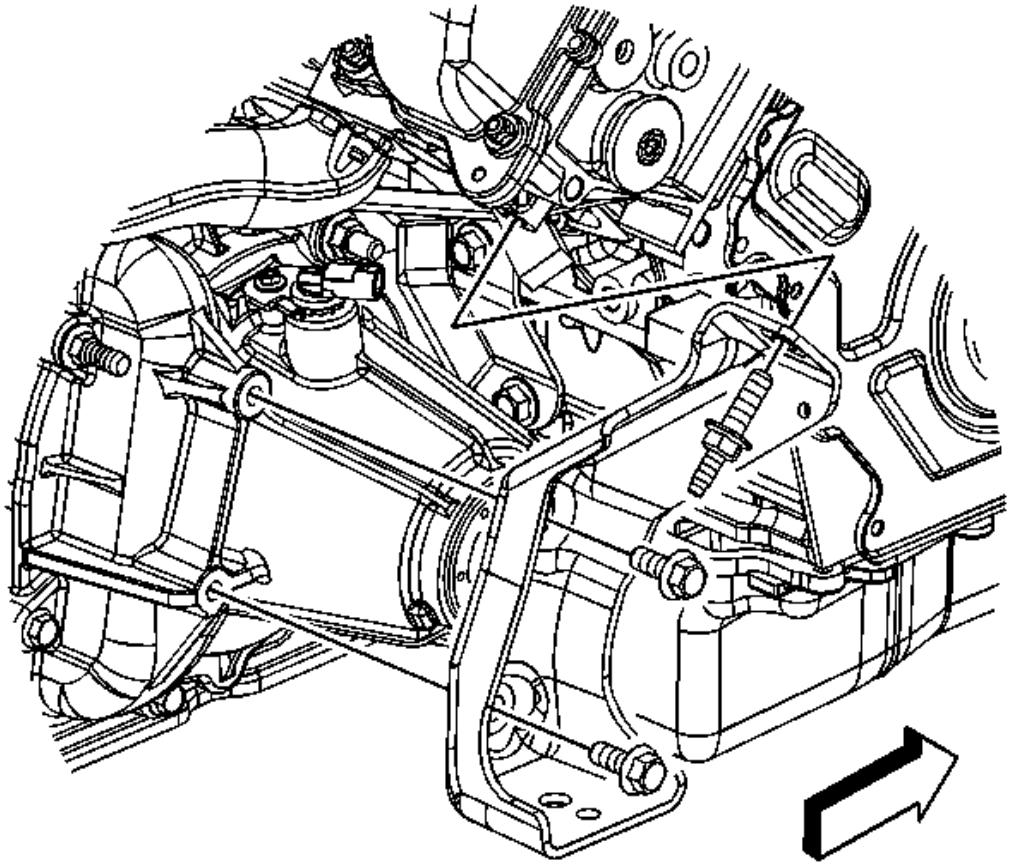

Fig. 33: Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the right engine mount. Refer to **Engine Mount Replacement - Right Side**.
2. Remove the right engine mount bracket to engine stud.
3. Remove the right engine mount bracket to transaxle bolts.
4. Remove the right engine mount bracket.

INSTALLATION PROCEDURE

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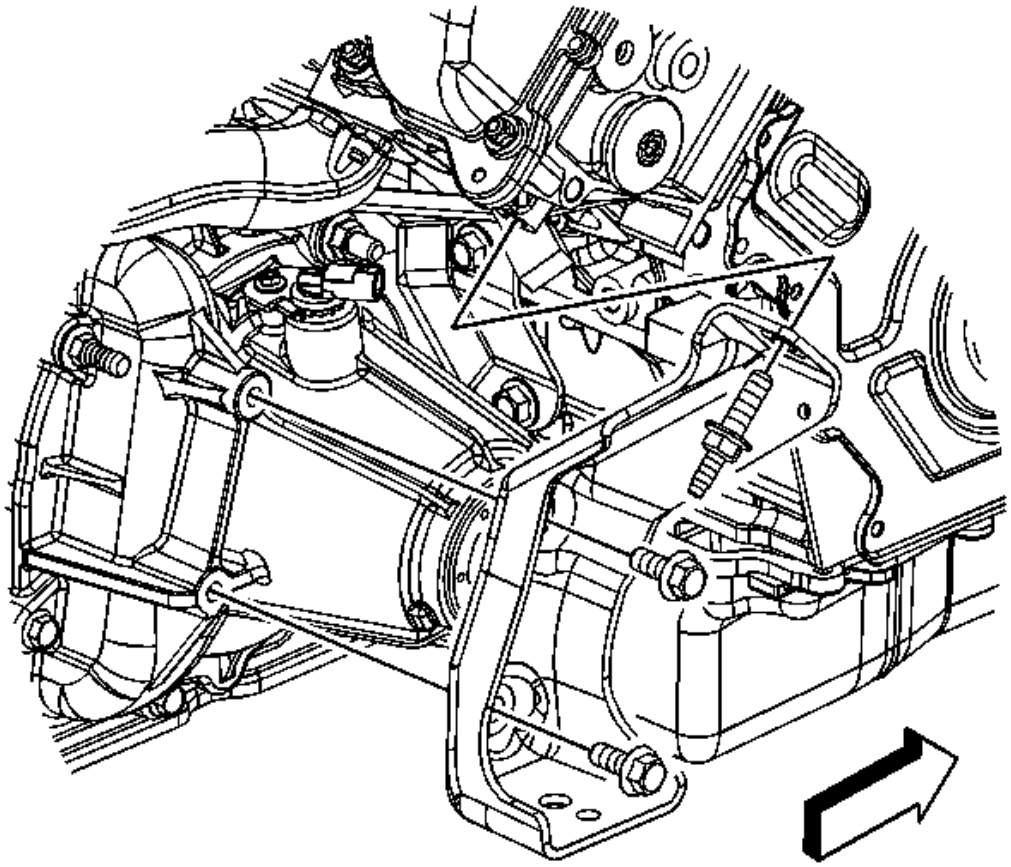

Fig. 34: Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the right engine mount bracket to the correct holes in the engine block and transaxle.
2. Install the right engine mount bracket to transaxle bolts finger tight.

CAUTION: Refer to Fastener Caution .

3. Install the right engine mount bracket to engine stud.

   Tighten: Tighten the bolts/stud to 73 N.m (54 lb ft).

4. Install the right engine mount. Refer to **Engine Mount Replacement - Right Side**.

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ENGINE MOUNT STRUT REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

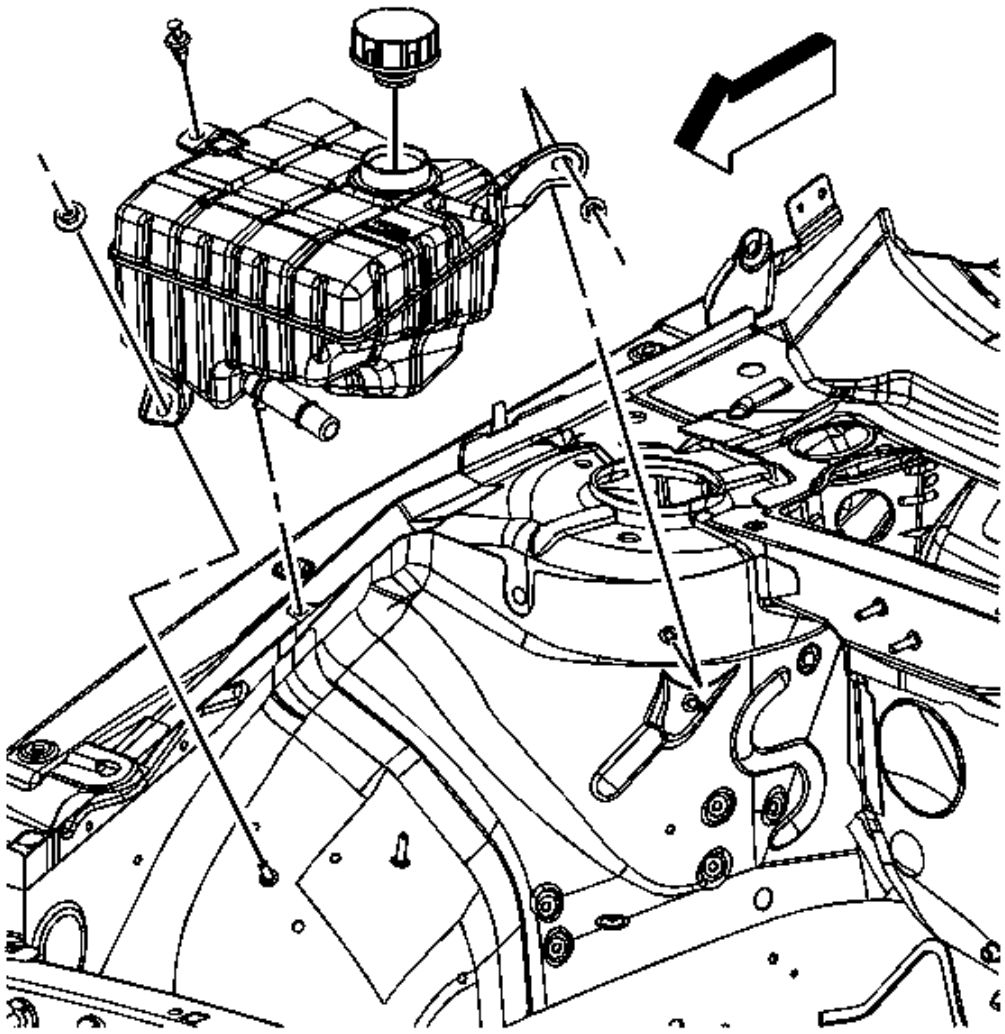

Fig. 35: Surge Tank
Courtesy of GENERAL MOTORS CORP.

1. Remove the surge tank nuts and push pin retainer.
2. Remove the surge tank from the studs and position the tank aside.

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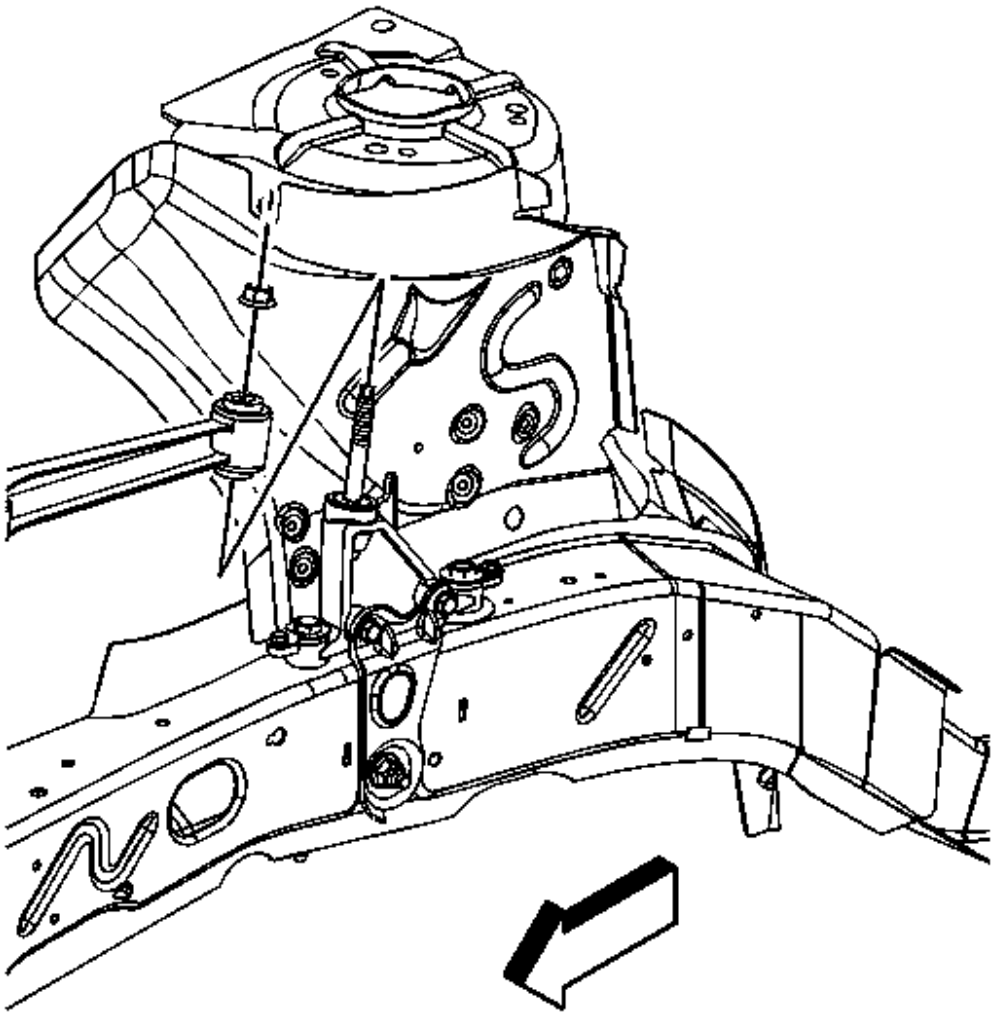

Fig. 36: Engine Mount Strut Brace Nut
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine mount strut brace nut.

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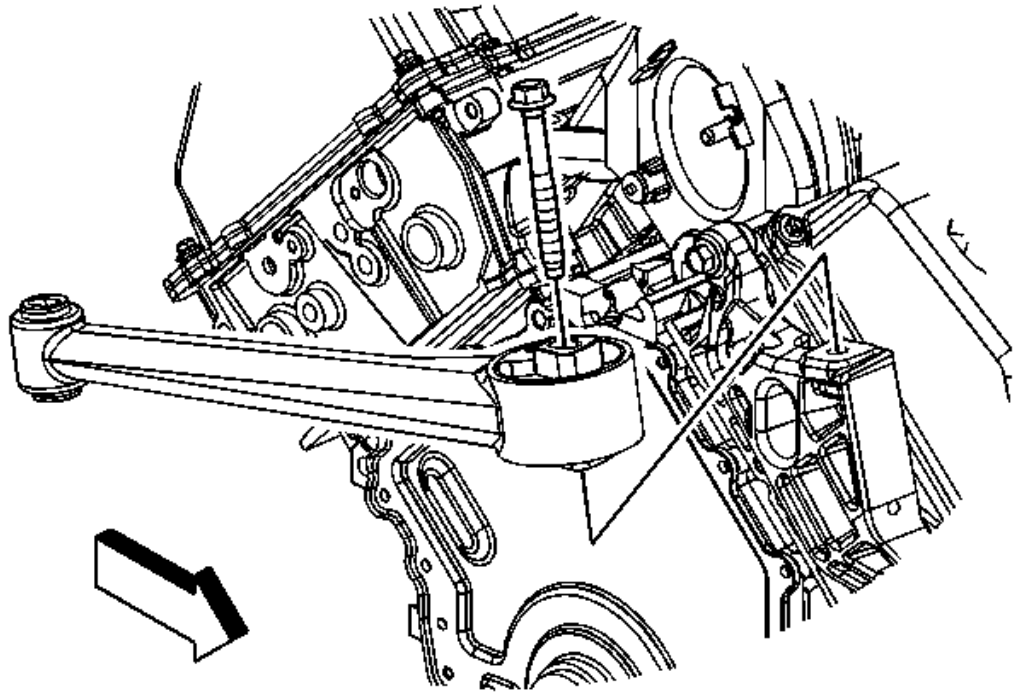

Fig. 37: Engine Mount Strut Bolt
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount strut bolt.
5. Remove the engine mount strut.

INSTALLATION PROCEDURE

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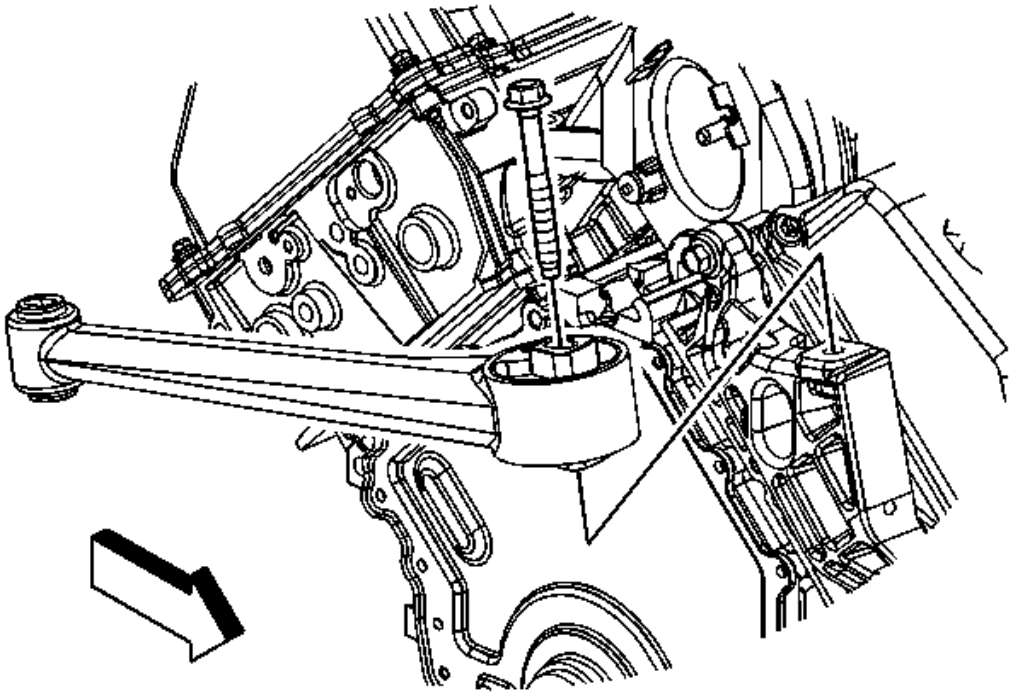

Fig. 38: Engine Mount Strut Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount strut.

   CAUTION: Refer to Fastener Caution .

2. Install the engine mount strut bolt.

   Tighten: Tighten the bolt to 70 N.m (52 lb ft).

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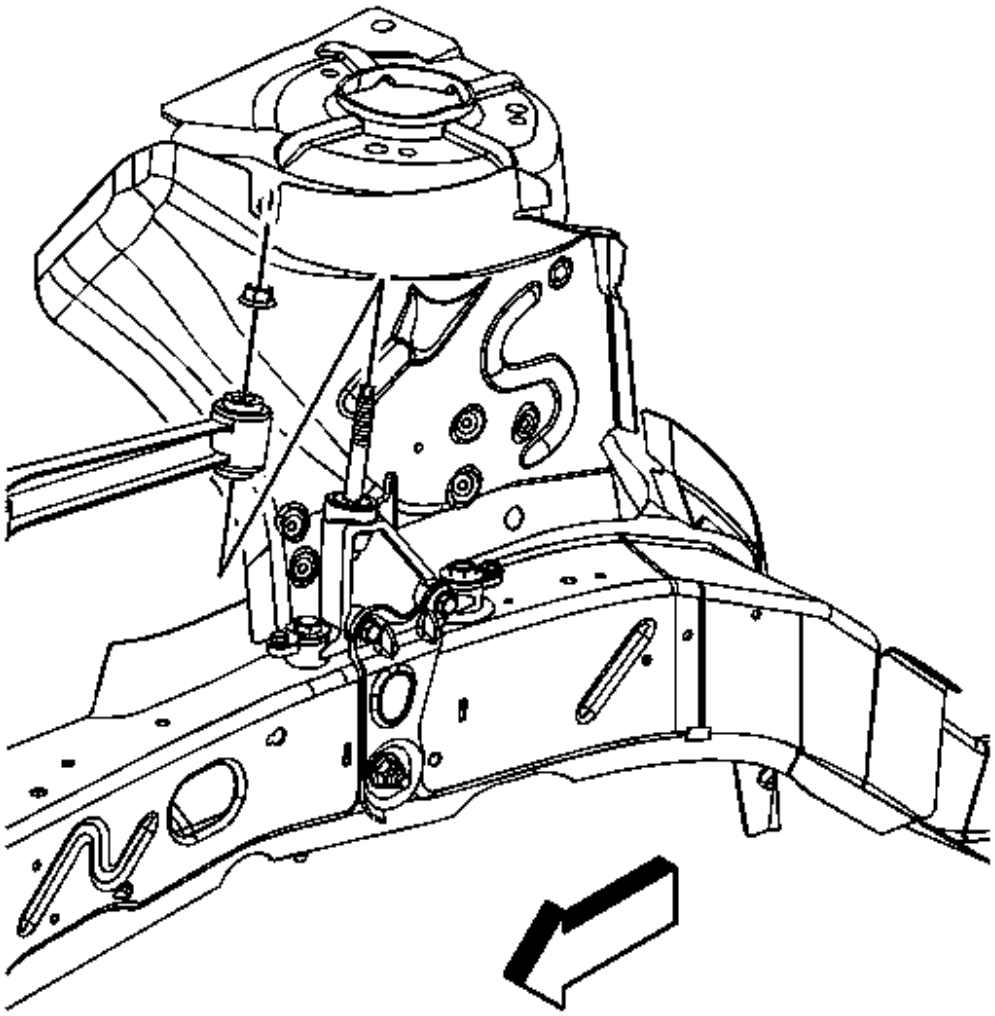

Fig. 39: Engine Mount Strut Brace Nut
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount strut nut.

   Tighten: Tighten the nut to 70 N.m (52 lb ft).

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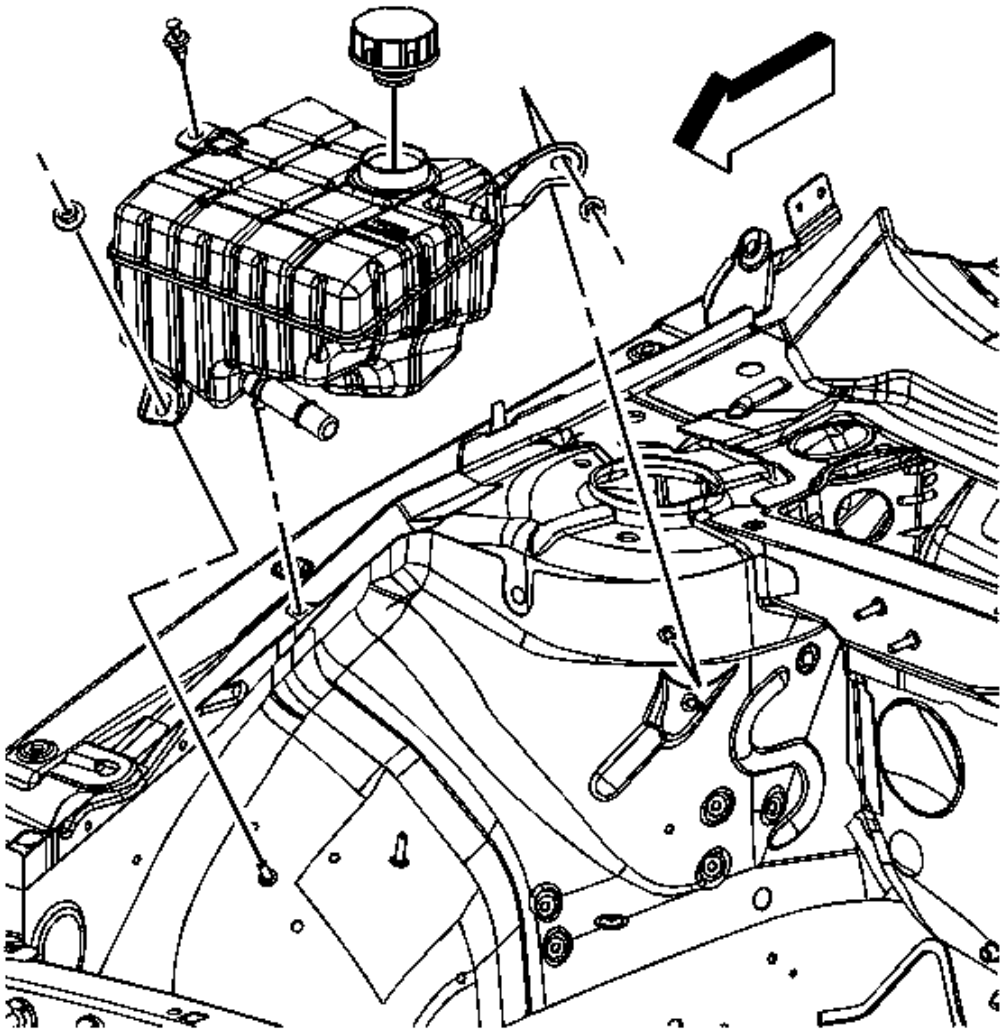

Fig. 40: Surge Tank
Courtesy of GENERAL MOTORS CORP.

4. Position the surge tank to the studs.
5. Install the surge tank nuts and push pin retainer.

Tighten: Tighten the nuts to 6 N.m (53 lb in).

ENGINE MOUNT STRUT BRACKET REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

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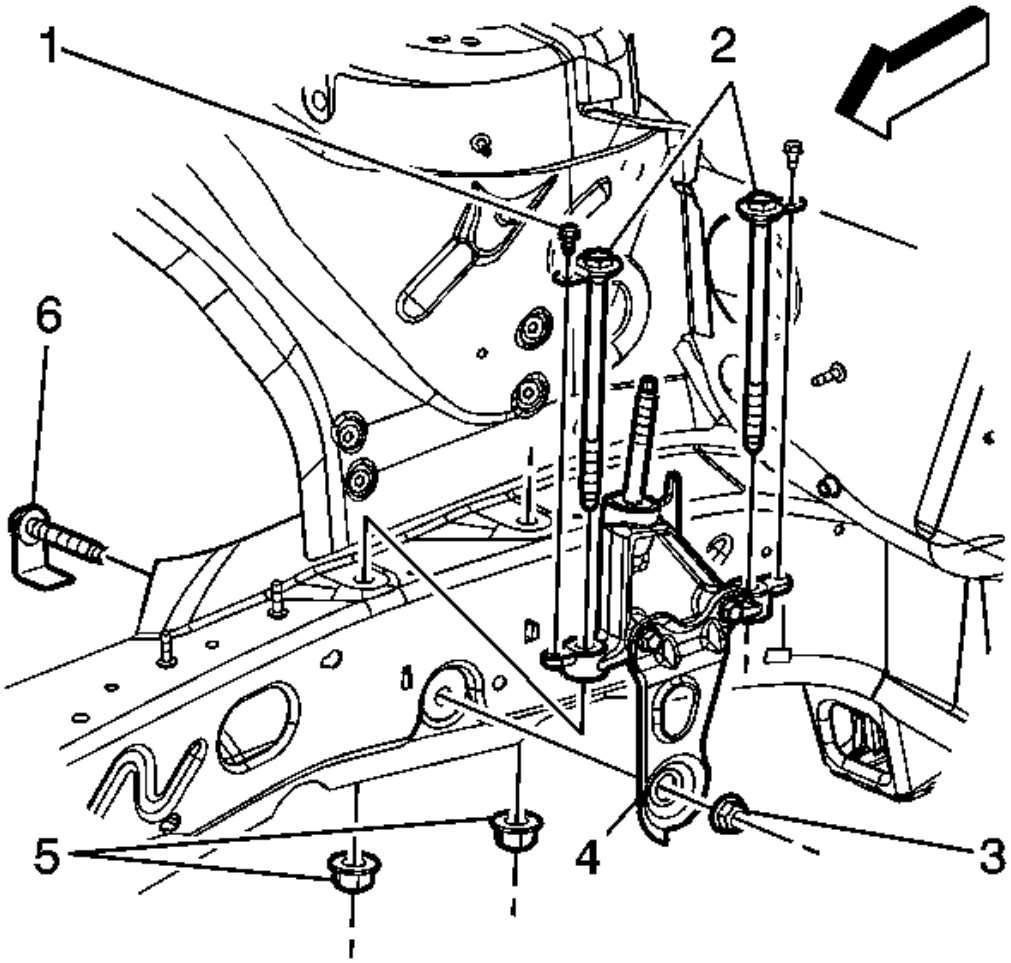

Fig. 41: Engine Mount Strut Bracket Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.
2. Remove the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .
3. Remove the engine mount strut bracket bolts (1).
4. Remove the strut bracket nut (3).
5. Remove the strut bracket bolt (6).
6. Remove the strut bracket nuts (5).
7. Remove the strut bracket bolts (2).
8. Remove the strut bracket (4).

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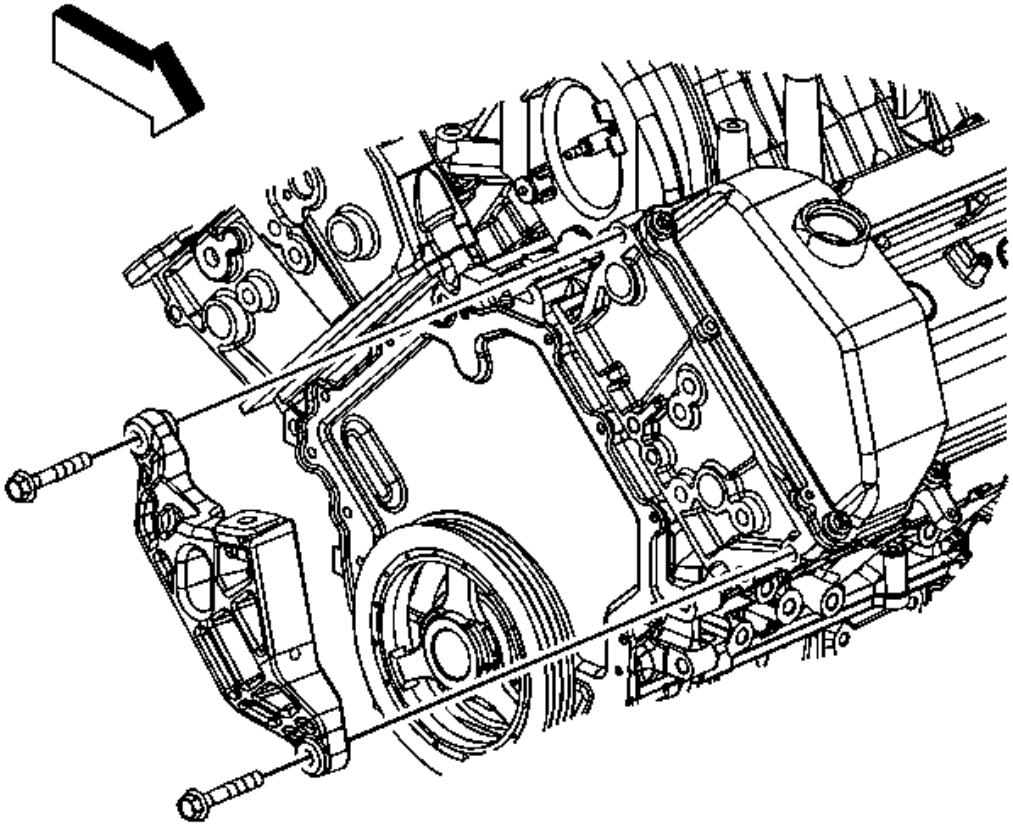

Fig. 42: Engine Mount Strut Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine mount strut bracket to engine bolts.
10. Remove the engine mount strut bracket.

INSTALLATION PROCEDURE

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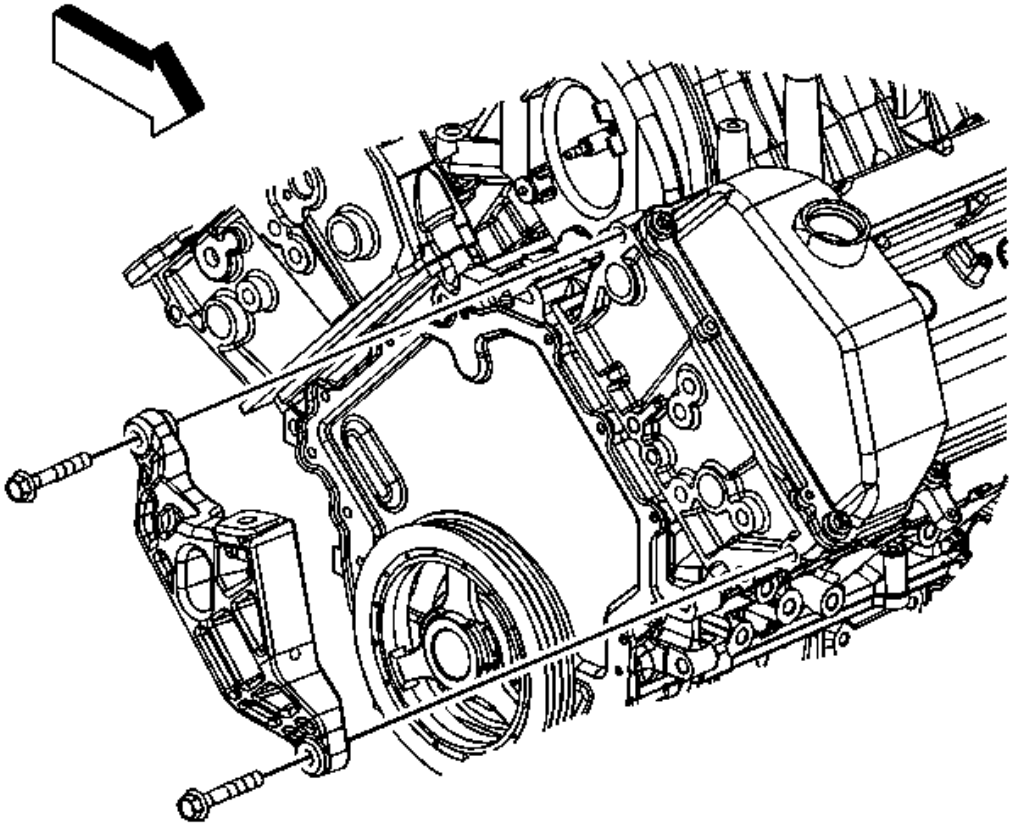

Fig. 43: Engine Mount Strut Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount strut bracket to the cylinder head.

   CAUTION: Refer to Fastener Caution .

2. Install the engine mount strut bracket to engine bolts.

   Tighten: Tighten the bolts to 50 N.m (37 lb ft).

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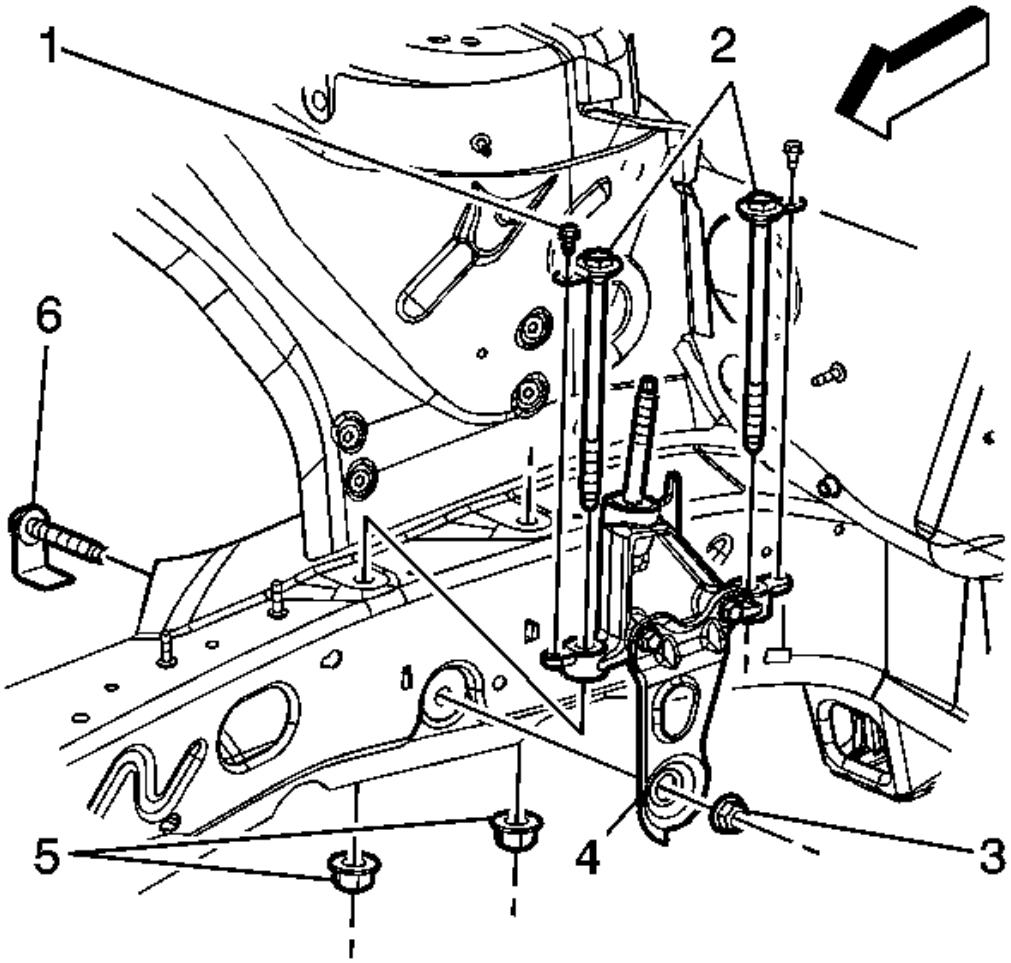

Fig. 44: Engine Mount Strut Bracket Components
Courtesy of GENERAL MOTORS CORP.

3. Position the engine mount strut bracket (4) to the front compartment rail.
4. Install the strut bracket bolts (2).
5. Install the strut bracket bolt (6).
6. Install the strut bracket nut (3).

   Tighten: Tighten the nut to 70 N.m (52 lb ft).

7. Install the strut bracket nuts (5).

   Tighten: Tighten the nuts to 70 N.m (52 lb ft).

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8. Install the strut bracket bolts (1).

   Tighten: Tighten the bolts to 9 N.m (80 lb in).

9. Install the right front wheel and tire. Refer to **Tire and Wheel Removal and Installation** .
10. Install the engine mount strut. Refer to **Engine Mount Strut Replacement - Right Side**.

ENGINE LIFT BRACKET REPLACEMENT

REMOVAL PROCEDURE

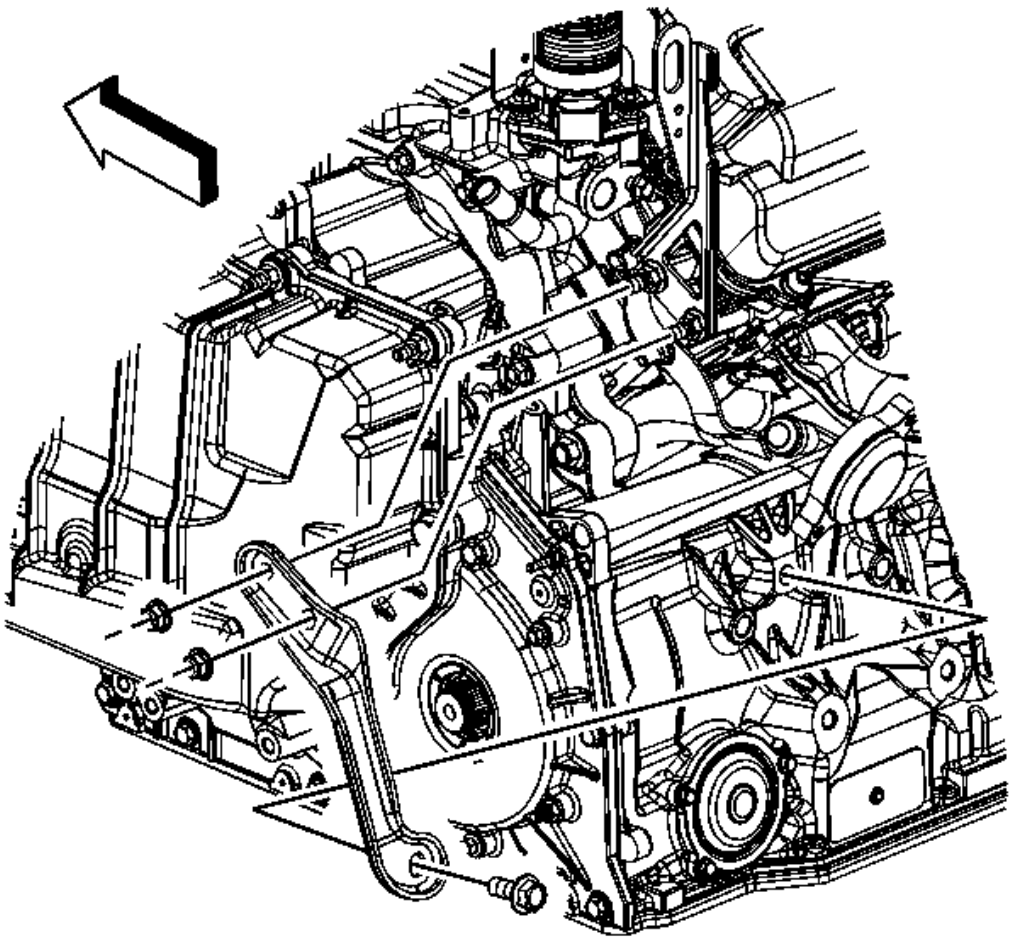

Fig. 45: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

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1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the transaxle brace lower bolt.
3. Lower the vehicle.
4. Remove the transaxle brace nuts.

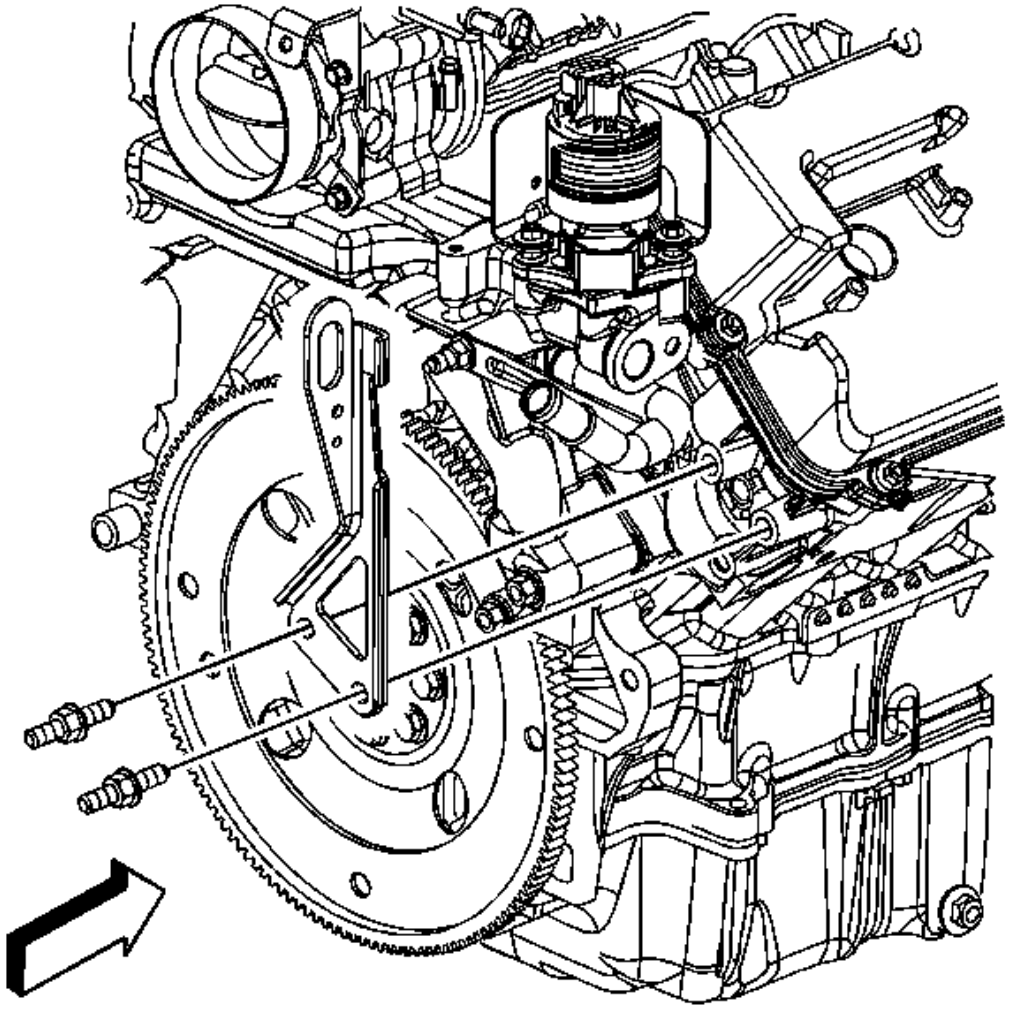

Fig. 46: Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine lift bracket studs.
6. Remove the engine lift bracket.

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INSTALLATION PROCEDURE

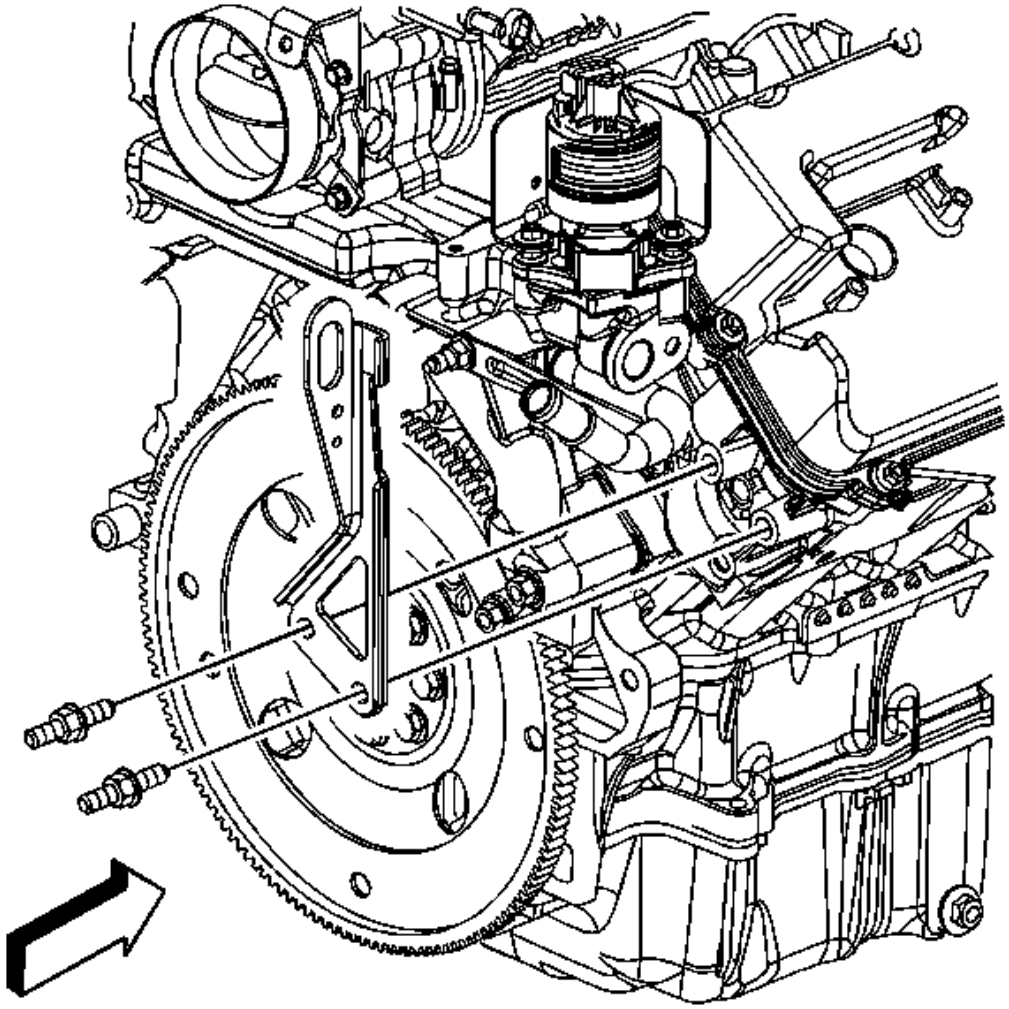

Fig. 47: Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

1. Position the engine lift bracket to the cylinder head.

CAUTION: Refer to Fastener Caution .

2. Install the engine lift bracket studs.

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Tighten: Tighten the studs to 50 N.m (37 lb ft).

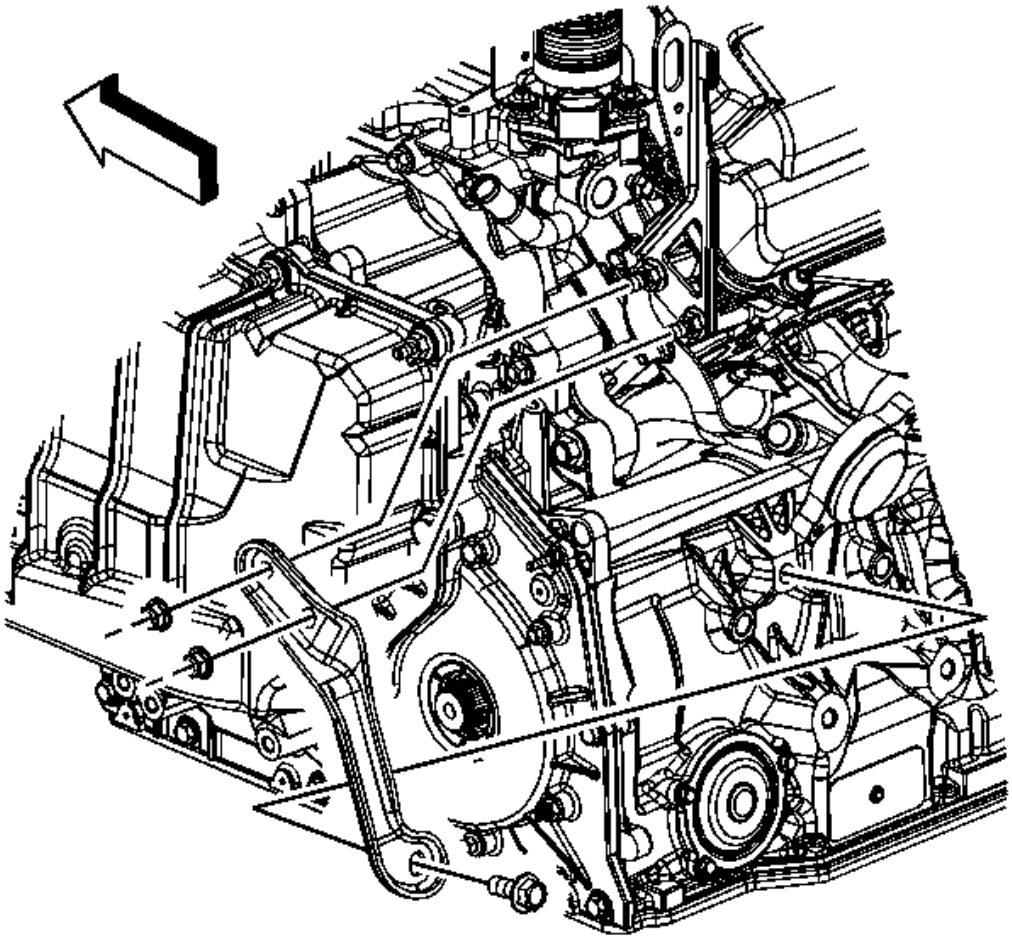

Fig. 48: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

3. Install the transaxle brace onto the lift bracket studs.
4. Install the transaxle brace nuts until sung.
5. Raise the vehicle.
6. Install the transaxle brace bolt.

   Tighten: Tighten the bolt to 50 N.m (37 lb ft).

7. Lower the vehicle.

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8. Tighten the transaxle brace nuts.

   Tighten: Tighten the nuts to 50 N.m (37 lb ft).

FUEL INJECTOR SIGHT SHIELD REPLACEMENT

REMOVAL PROCEDURE

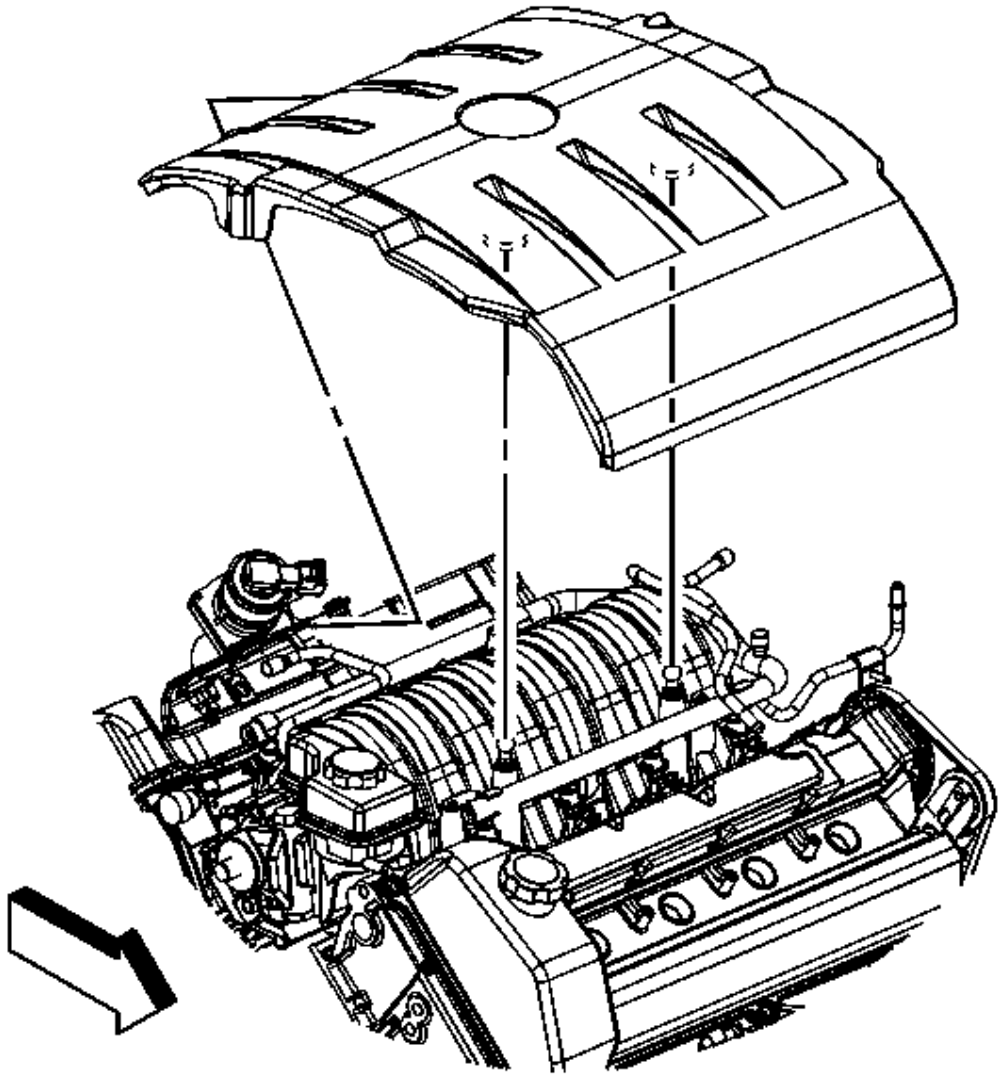

Fig. 49: Intake Manifold Sight Shield Cover

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Courtesy of GENERAL MOTORS CORP.

1. Grasp the intake manifold sight shield cover at the left side, lift up in order to disengage the cover from the ball stud.
2. Grasp the intake manifold sight shield cover at the right side, lift up in order to disengage the cover from the ball stud.
3. Remove the intake manifold sight shield cover from under the tab on the secondary air injection (AIR) check valve bracket.
4. Remove the intake manifold sight shield cover.

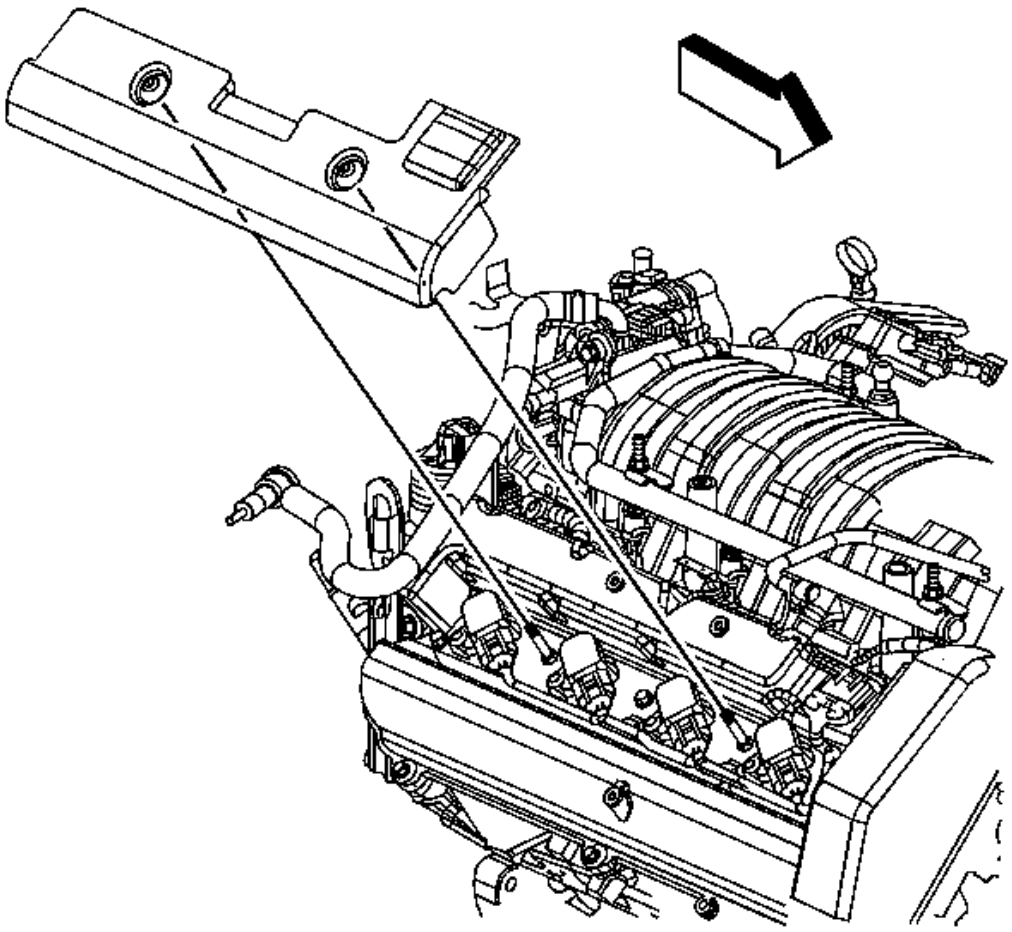

Fig. 50: Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

5. If necessary to remove the fuel injector sight shield perform the following steps, remove the AIR check

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valve. Refer to **Secondary Air Injection Check Valve Replacement** .

6. Grasp the fuel injector sight shield and lift up in order to disengage the cover from the ball studs.
7. Remove the fuel injector sight shield.

INSTALLATION PROCEDURE

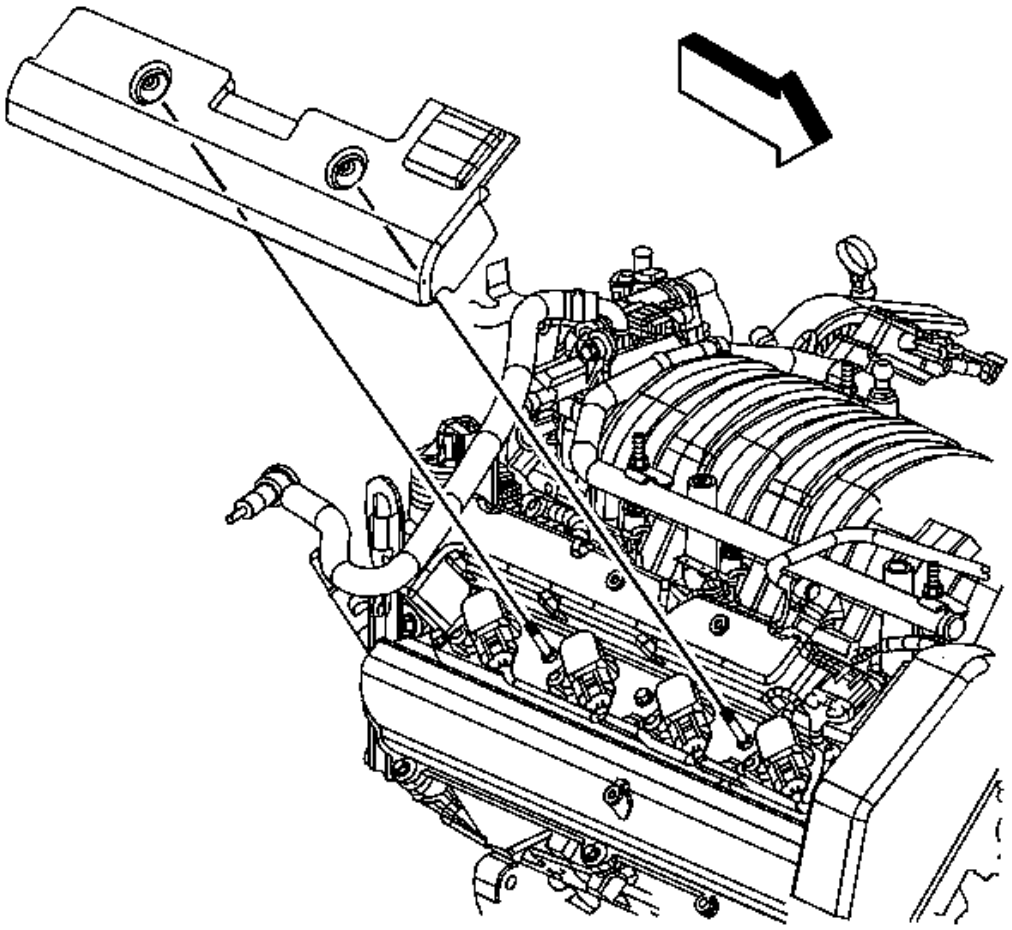

Fig. 51: Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. If necessary to install the fuel injector sight shield perform the following steps, position the fuel injector sight shield over the ball studs.
2. Press down on the fuel injector sight shield over the ball studs in order to engage the cover to the ball studs.
3. Install the AIR check valve. Refer to **Secondary Air Injection Check Valve Replacement** .

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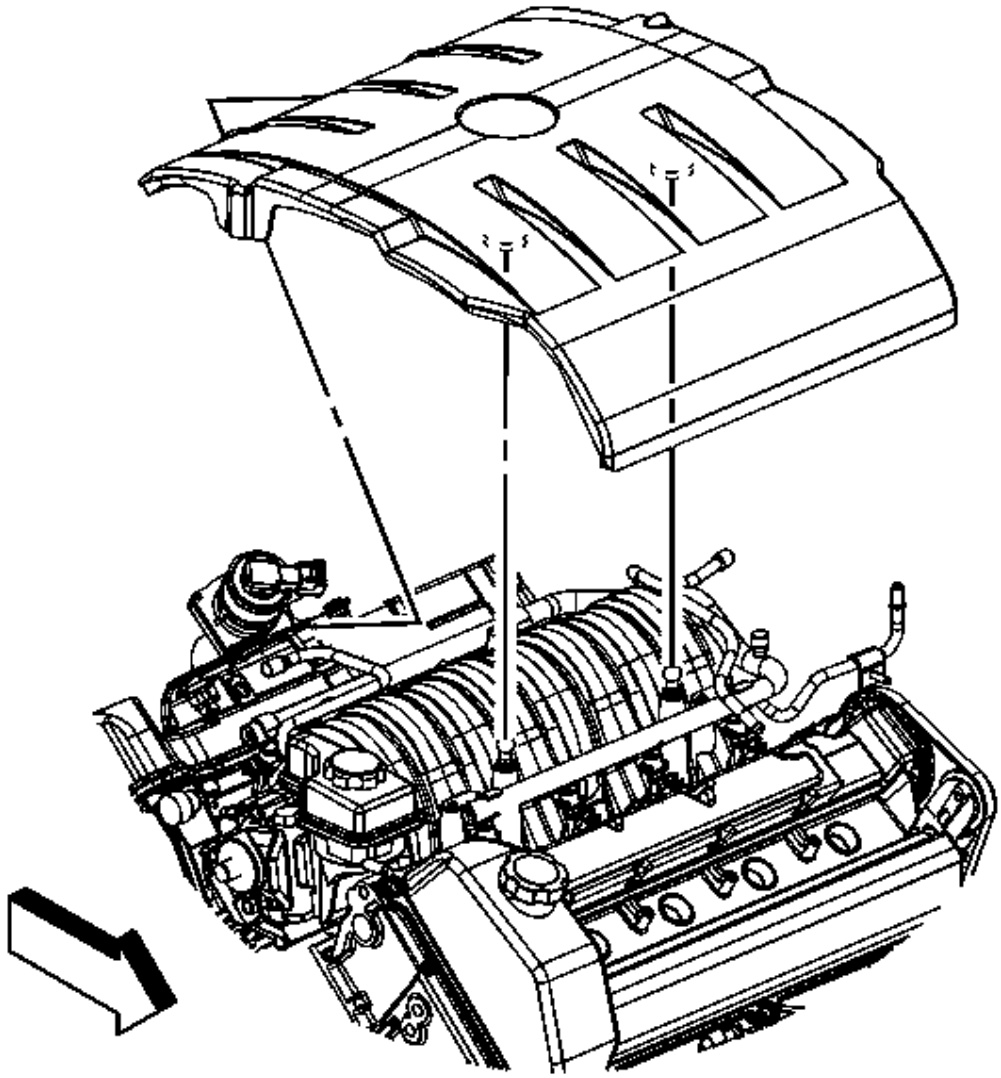

Fig. 52: Intake Manifold Sight Shield Cover
Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold sight shield cover under the tab on the AIR check valve bracket.
5. Position the intake manifold sight shield cover over the ball studs.
6. Press down on the intake manifold sight shield cover over the balls stud in order to engage the cover to the ball studs.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

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REMOVAL PROCEDURE

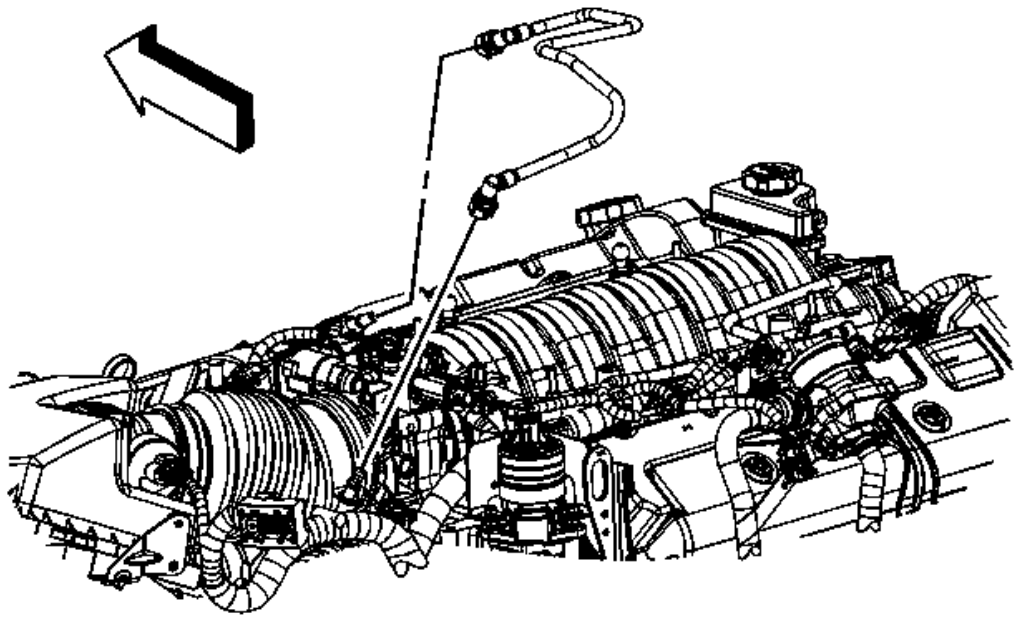

Fig. 53: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. If servicing the positive ventilation crankcase (PCV) fresh air tube, perform the following steps, disconnect the PCV fresh air tube quick connect fitting at the left camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Disconnect the PCV fresh air tube quick connect fitting at the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
4. Remove the PCV fresh air tube from under the brake booster vacuum hose and evaporative emission (EVAP) purge solenoid.

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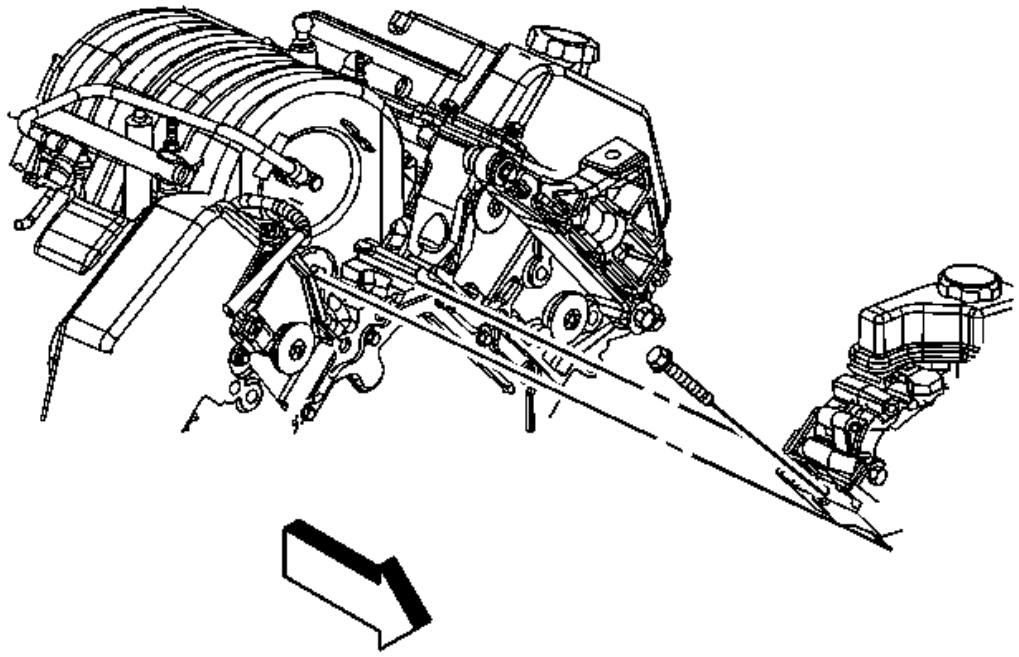

Fig. 54: Power Steering Pump & Bolt
Courtesy of GENERAL MOTORS CORP.

5. If servicing the PCV foul air tube, perform the following steps, remove the drive belt. Refer to **Drive Belt Replacement**.
6. Remove the power steering pump bolt.
7. With the power steering hoses attached, Carefully position the power steering pump aside.

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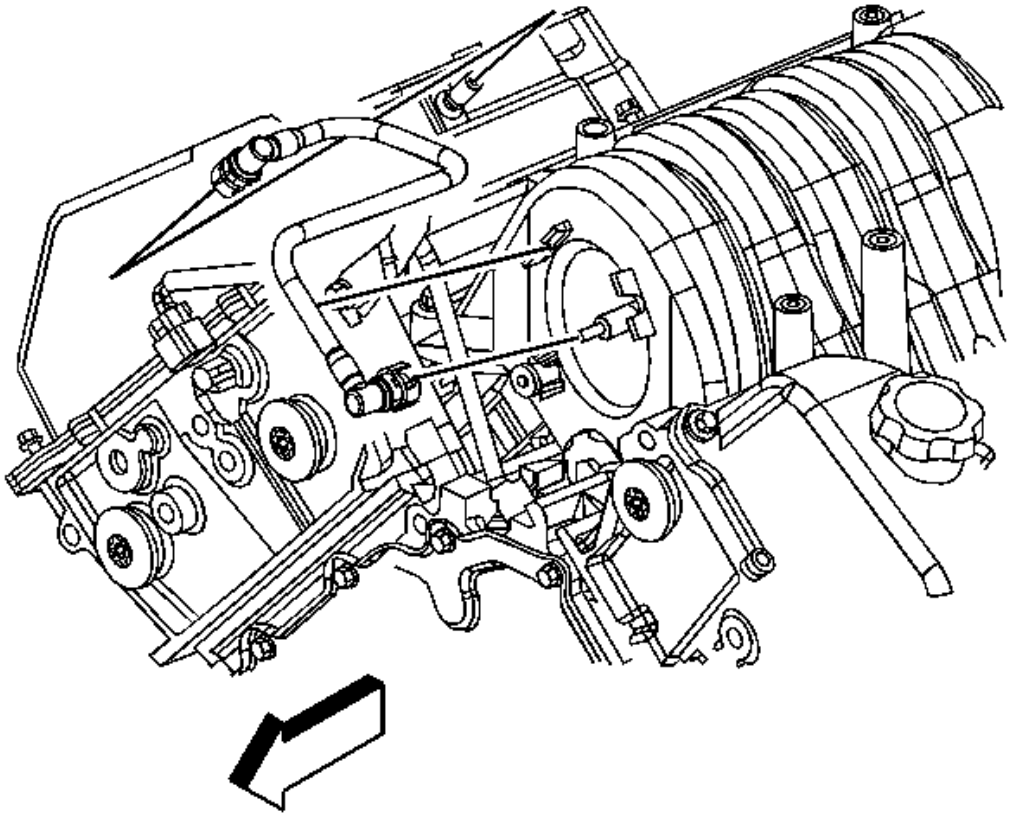

Fig. 55: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the PCV foul air tube quick connect fitting at the right camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
9. Disconnect the PCV foul air tube quick connect fitting at the intake manifold fitting. Refer to **Plastic Collar Quick Connect Fitting Service** .
10. Remove the PCV foul air tube from the retaining features on the intake manifold.

INSTALLATION PROCEDURE

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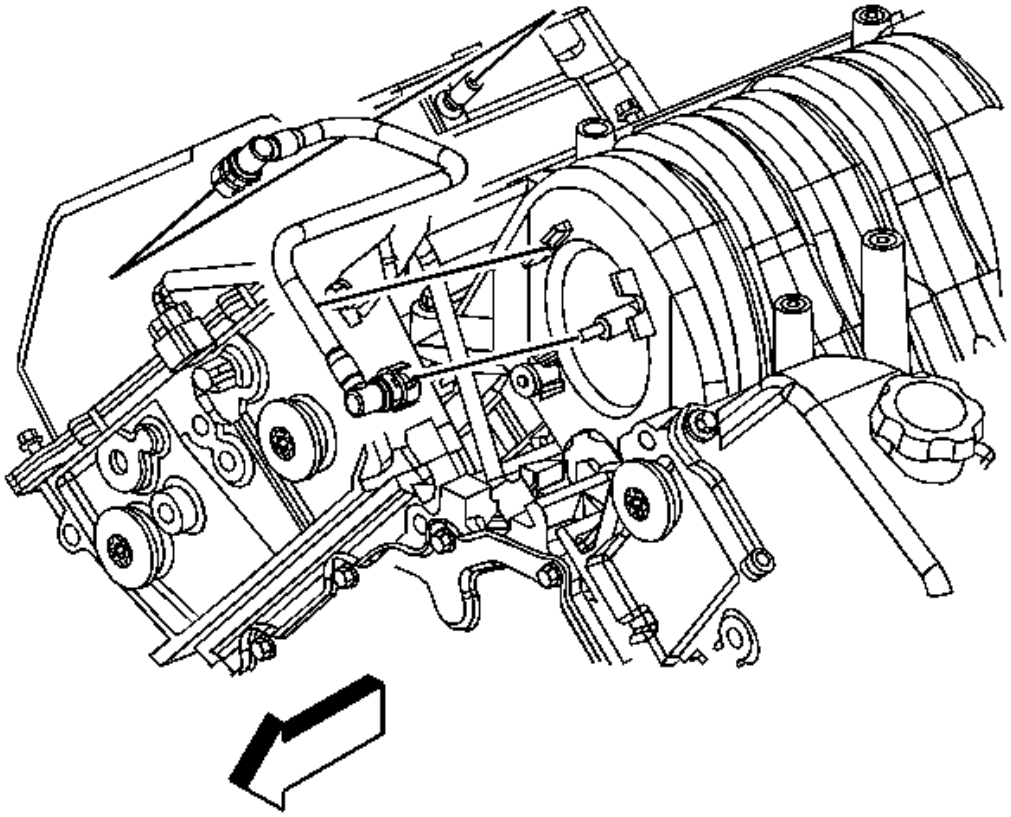

Fig. 56: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

1. If servicing the PCV foul air tube, perform the following steps, connect the PCV foul air tube quick connect fitting to the right camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
2. Connect the PCV foul air tube quick connect fitting at the intake manifold fitting. Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Install the PCV foul air tube to the retaining features on the intake manifold.

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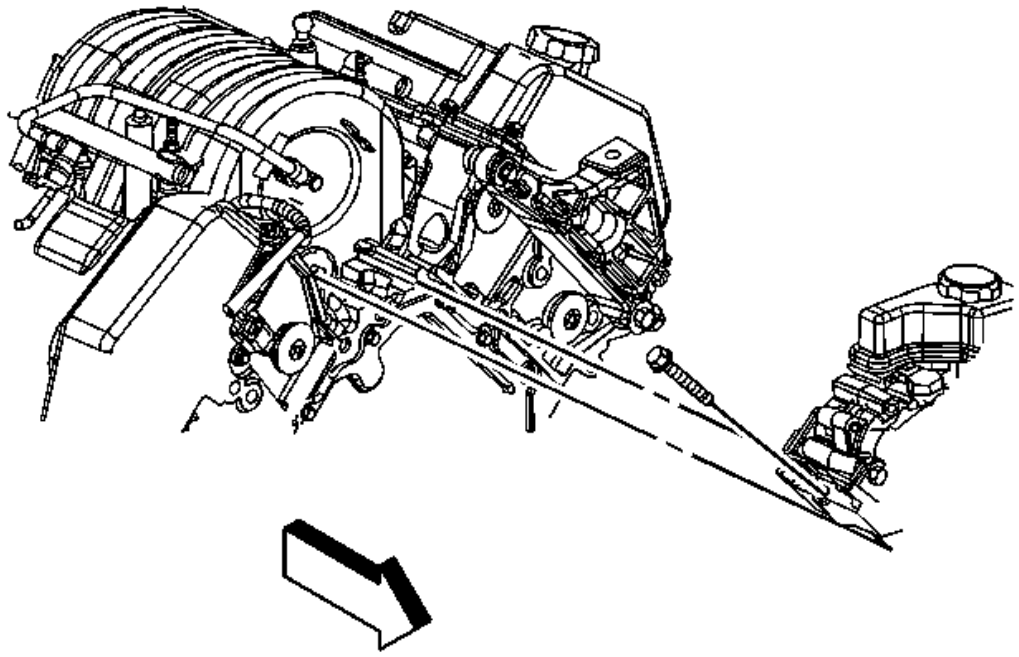

Fig. 57: Power Steering Pump & Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the power steering pump into position.

CAUTION: Refer to Fastener Caution .

5. Install the power steering pump bolt.

   Tighten: Tighten the bolt to 50 N.m (37 lb ft).

6. Install the drive belt. Refer to **Drive Belt Replacement**.

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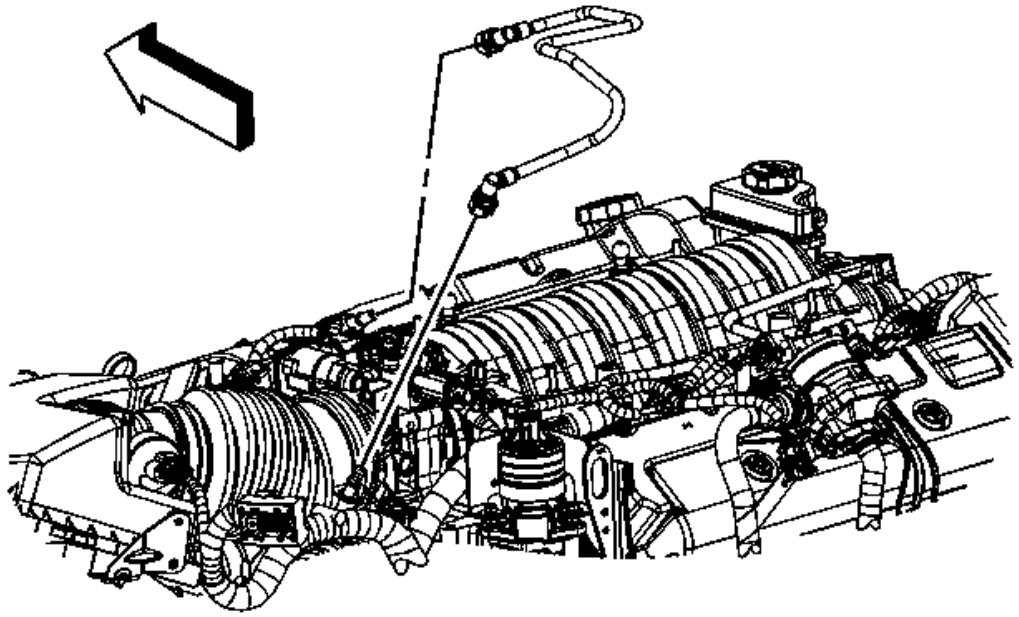

Fig. 58: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

7. If servicing the PCV fresh air tube, perform the following steps, route the PCV fresh air tube under the brake booster vacuum hose and EVAP purge solenoid.
8. Connect the PCV fresh air tube quick connect fitting at the air cleaner outlet duct. Refer to **Plastic Collar Quick Connect Fitting Service** .
9. Connect the PCV fresh air tube quick connect fitting at the left camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
10. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

INTAKE MANIFOLD REPLACEMENT

REMOVAL PROCEDURE

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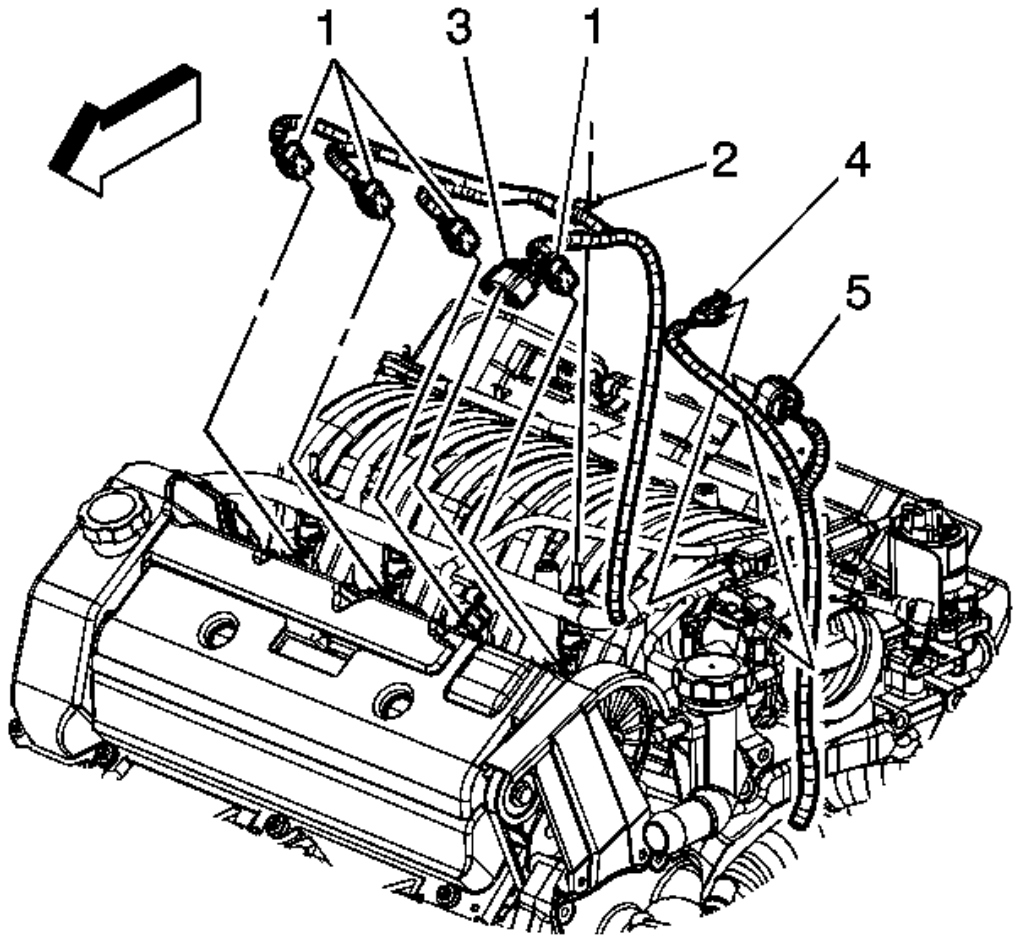

Fig. 59: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield cover. Refer to **Fuel Injector Sight Shield Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. Disconnect the front ignition coil module engine harness electrical connector (3).
4. Disconnect the front fuel injectors engine harness electrical connectors (1).

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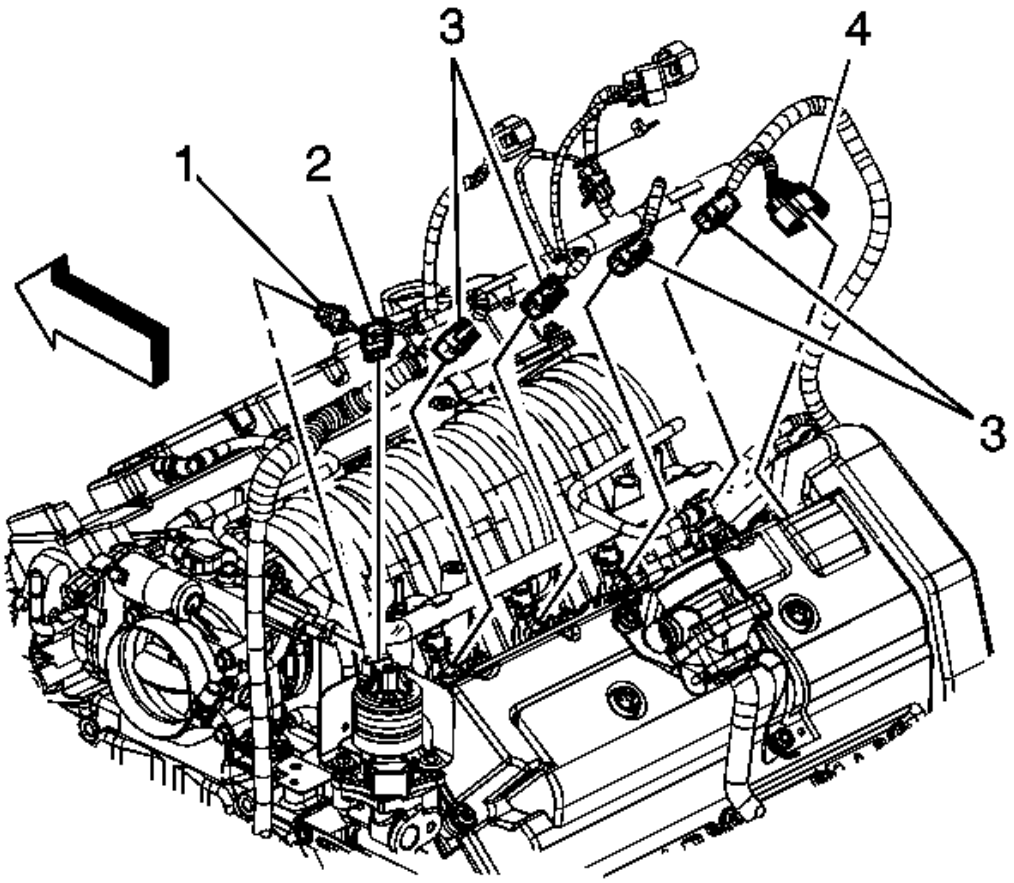

Fig. 60: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the rear ignition coil module engine harness electrical connector (4).
6. Disconnect the rear fuel injectors engine harness electrical connectors (3).

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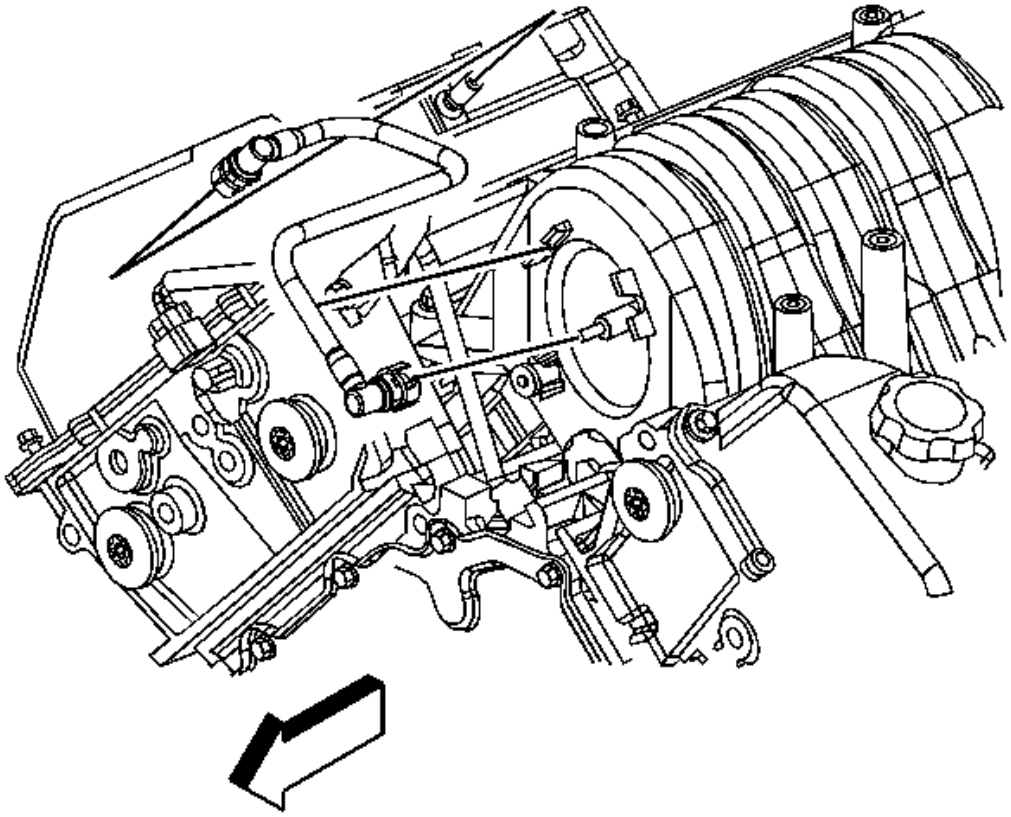

Fig. 61: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the positive crankcase ventilation (PCV) foul air tube quick connect fitting from the right camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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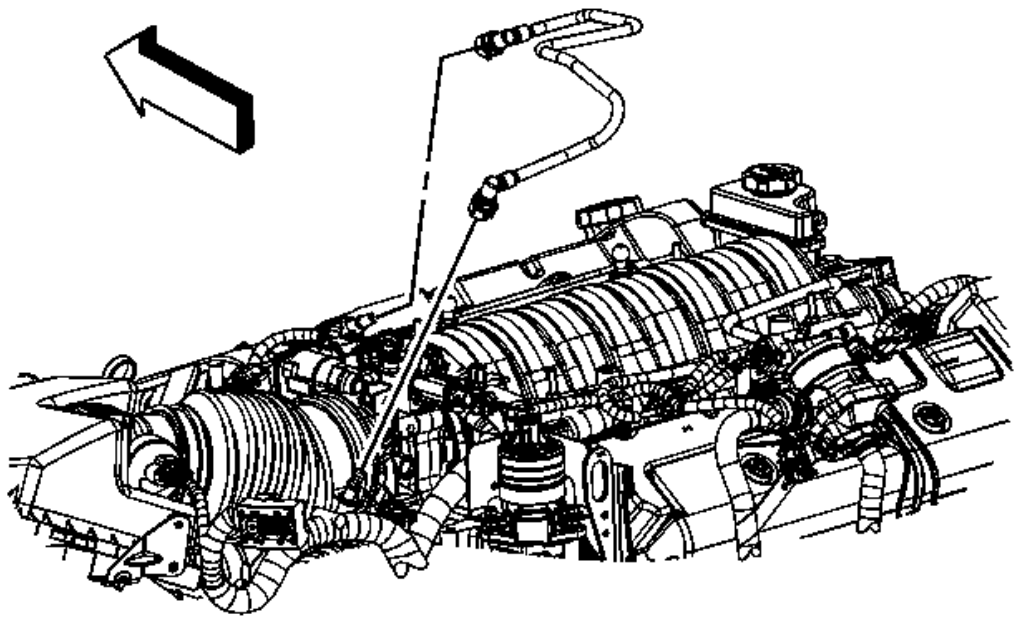

Fig. 62: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the PCV fresh air tube quick connect fitting from the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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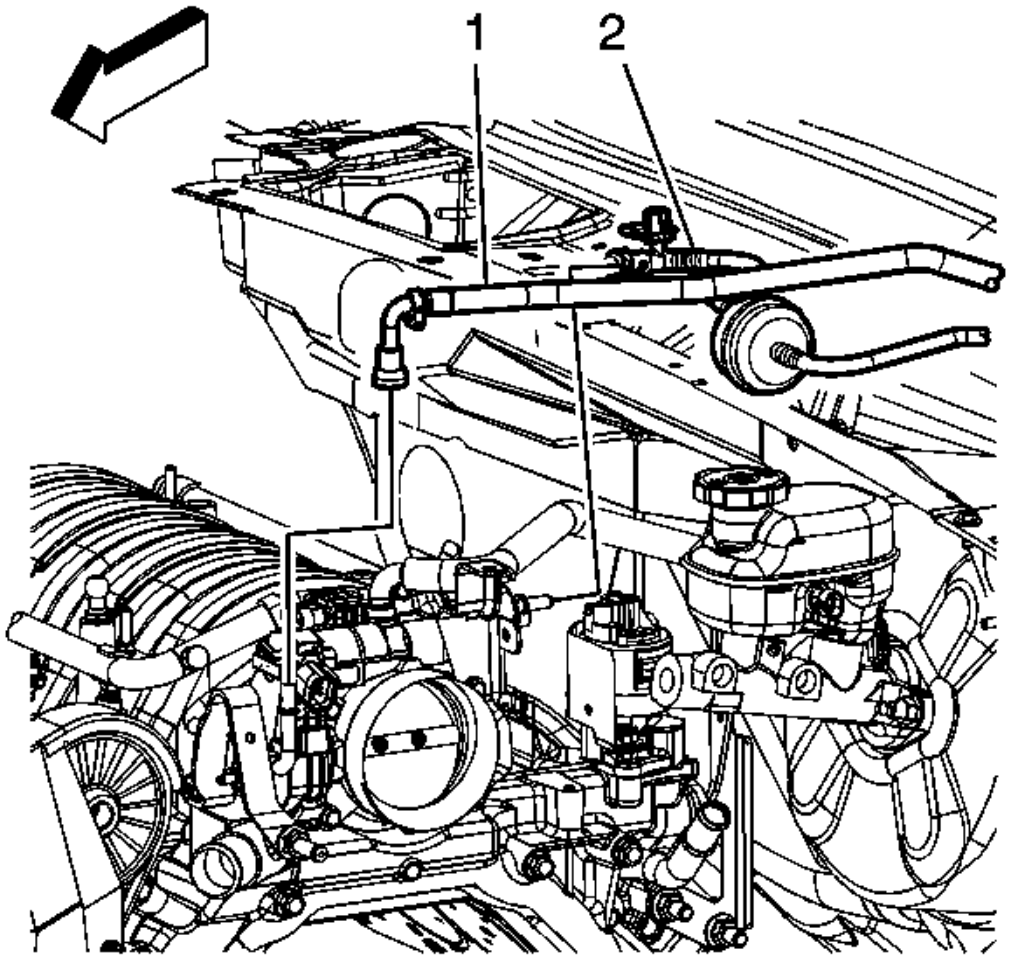

Fig. 63: Fuel Feed & EVAP Line
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the fuel feed line (1) quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .

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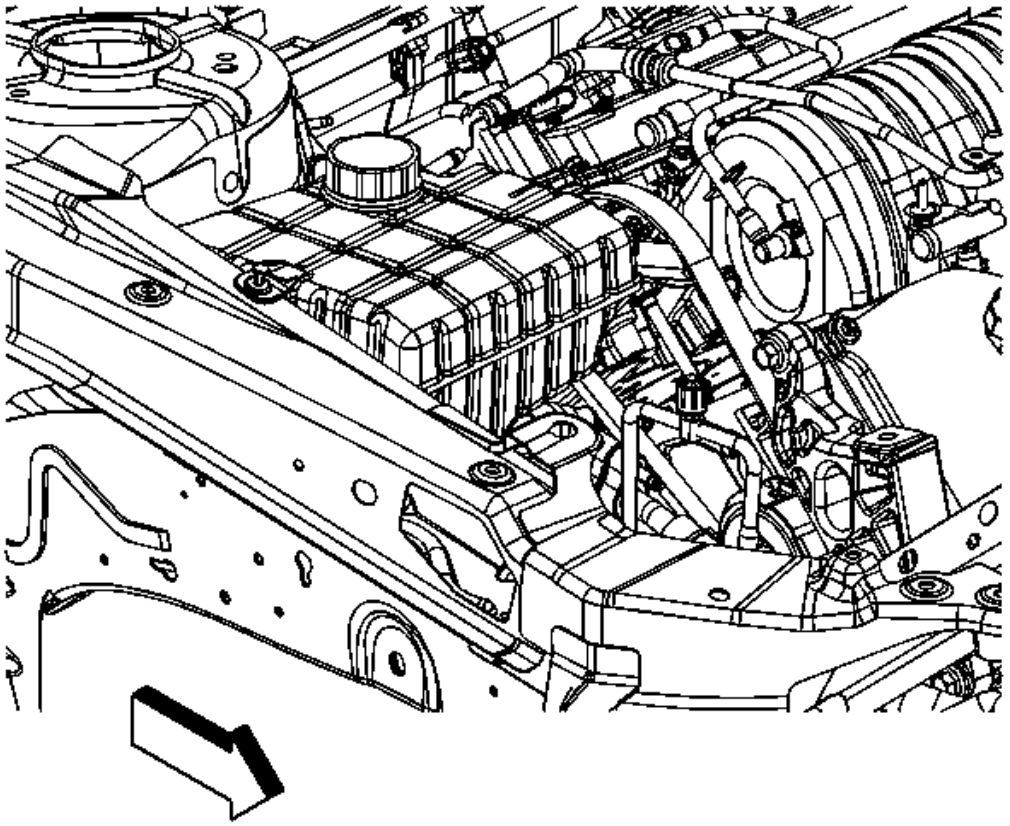

Fig. 64: Surge Tank Inlet Hose/Pipe At Surge Tank
Courtesy of GENERAL MOTORS CORP.

10. Reposition the radiator surge tank inlet hose/pipe clamp at the surge tank.
11. Remove the surge tank inlet hose/pipe from the surge tank.

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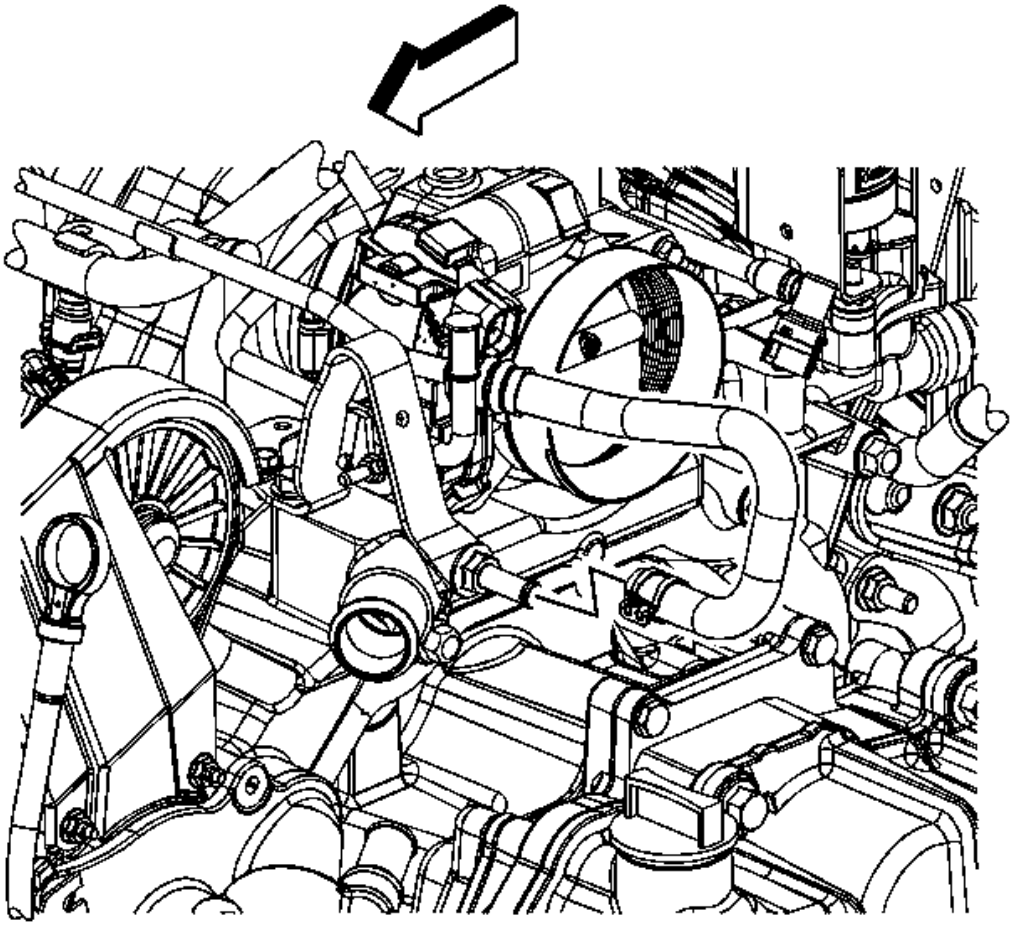

Fig. 65: Surge Tank Inlet Hose/Pipe At Engine Fitting
Courtesy of GENERAL MOTORS CORP.

12. Reposition the radiator surge tank inlet hose/pipe clamp at the engine.
13. Remove the surge tank inlet hose/pipe from the engine fitting.

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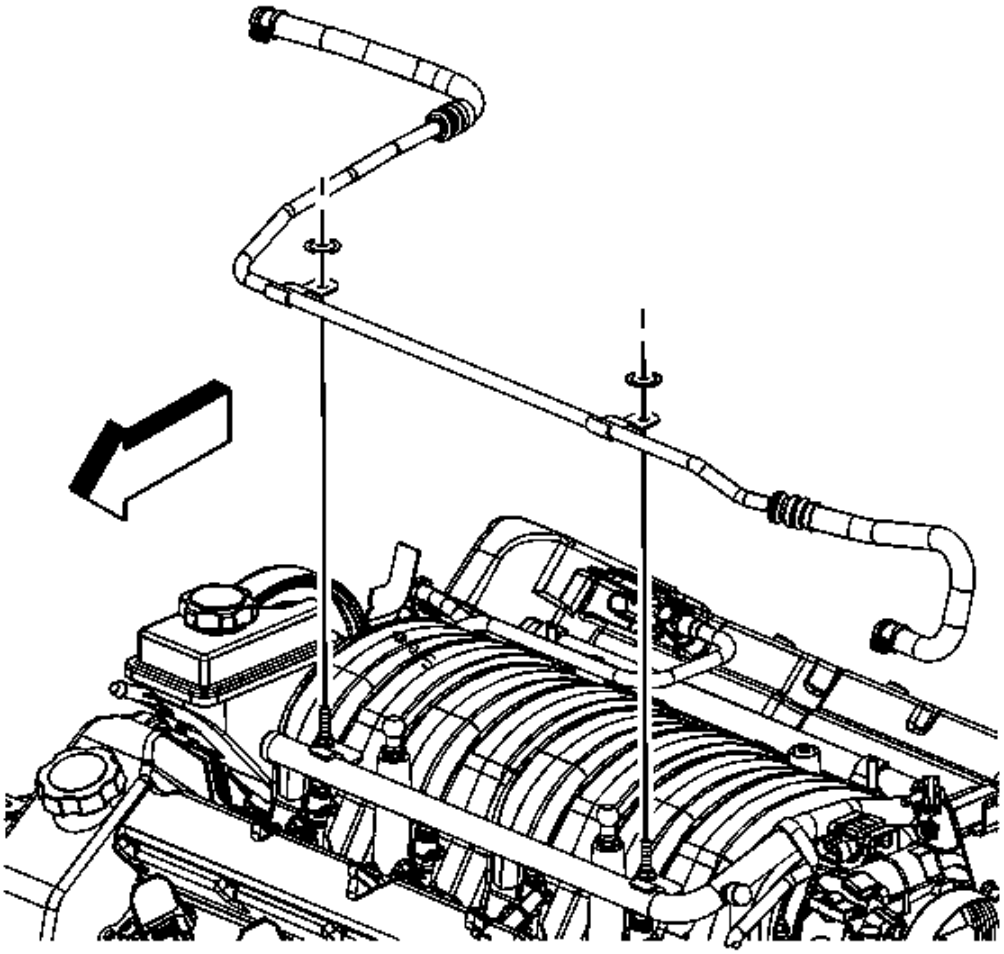

Fig. 66: Surge Tank Inlet Hose/Pipe & Clips
Courtesy of GENERAL MOTORS CORP.

14. Remove the 2 pushnuts securing the surge tank inlet hose/pipe to the fuel rail studs.
15. Remove the surge tank inlet hose/pipe from the fuel rail studs.
16. Remove the engine harness retainer from the fuel rail stud.

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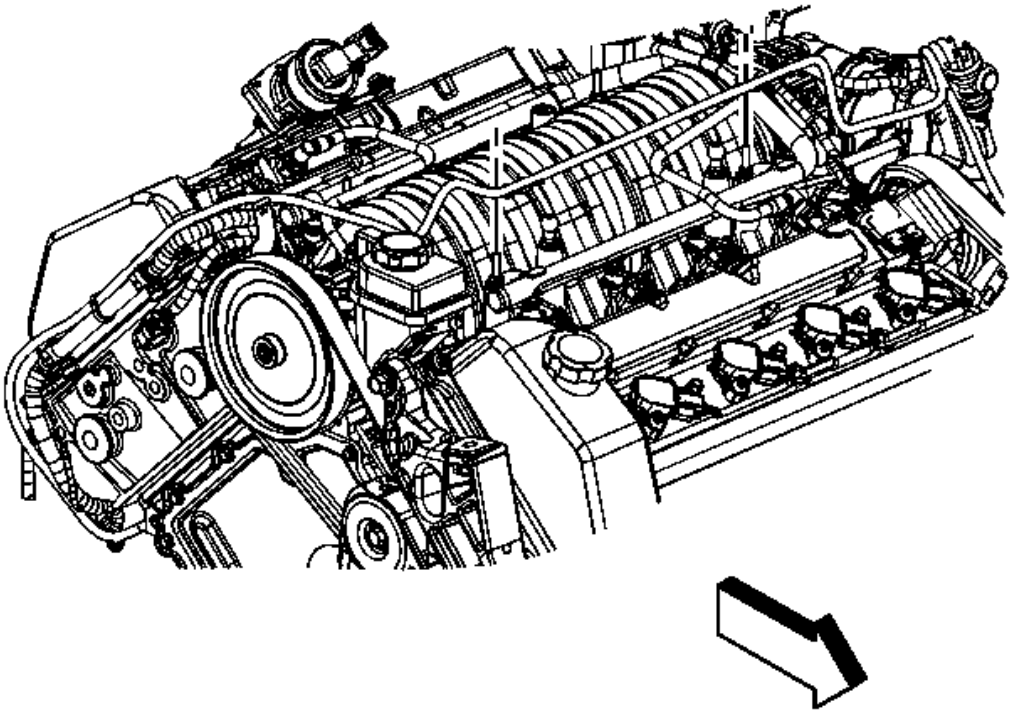

Fig. 67: Coolant Heater Cord Tabs
Courtesy of GENERAL MOTORS CORP.

17. Remove the coolant heater cord tabs from the fuel rail studs, if equipped.

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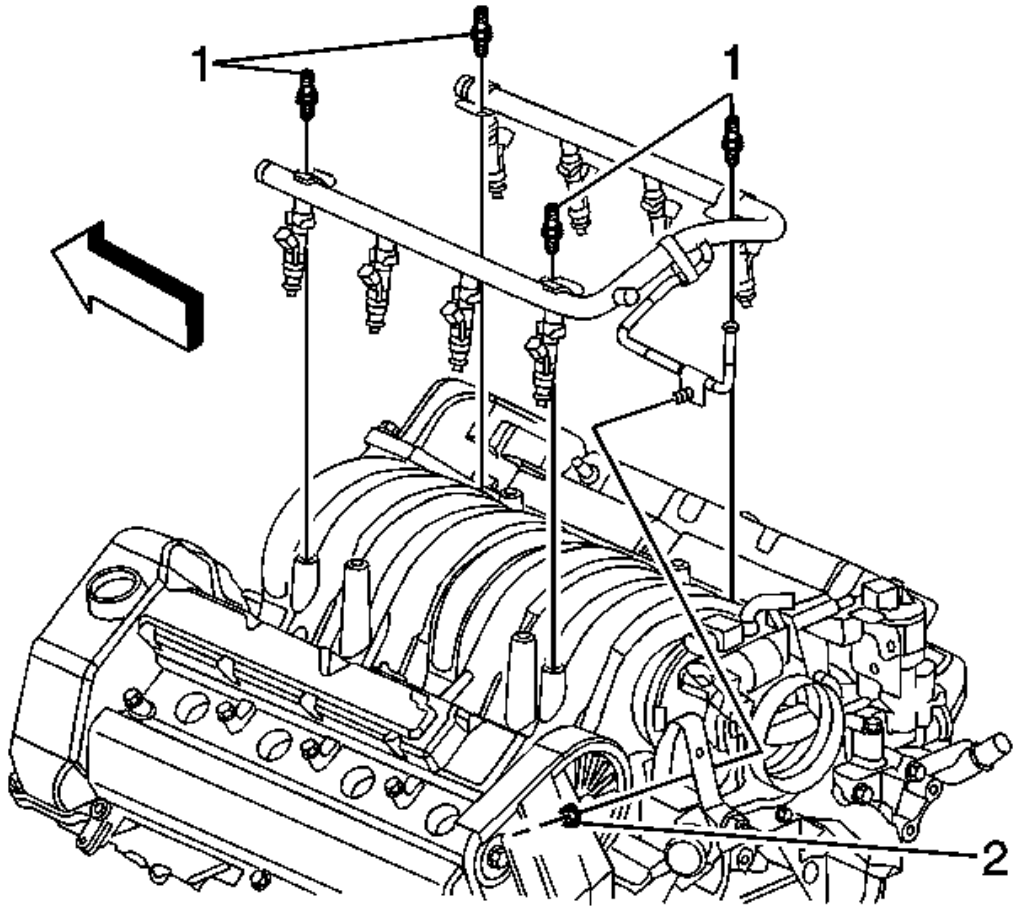

Fig. 68: Fuel Rail, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

18. Remove the fuel rail bracket nut at the rear left lift bracket.
19. Remove the fuel rail studs.
20. Remove the fuel rail.

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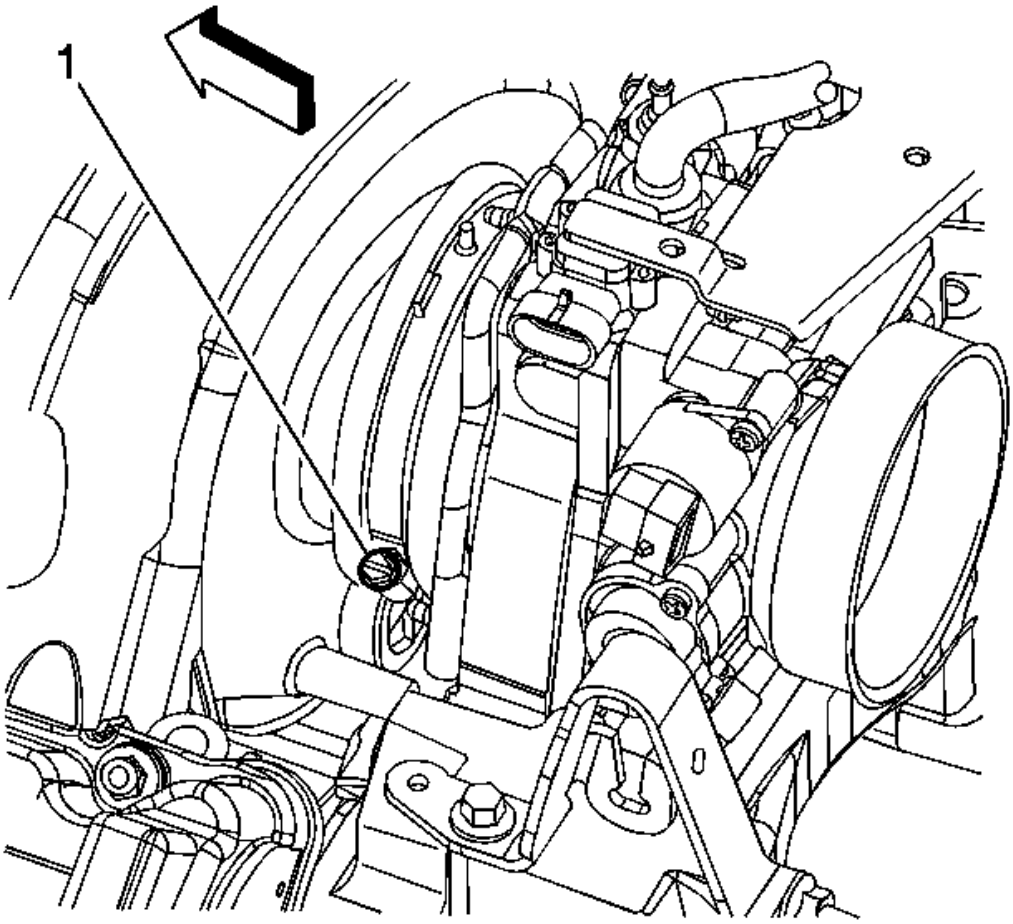

Fig. 69: Plenum Duct Clamp Screw
Courtesy of GENERAL MOTORS CORP.

21. Loosen the plenum duct clamp screw (1) at the water pump housing.

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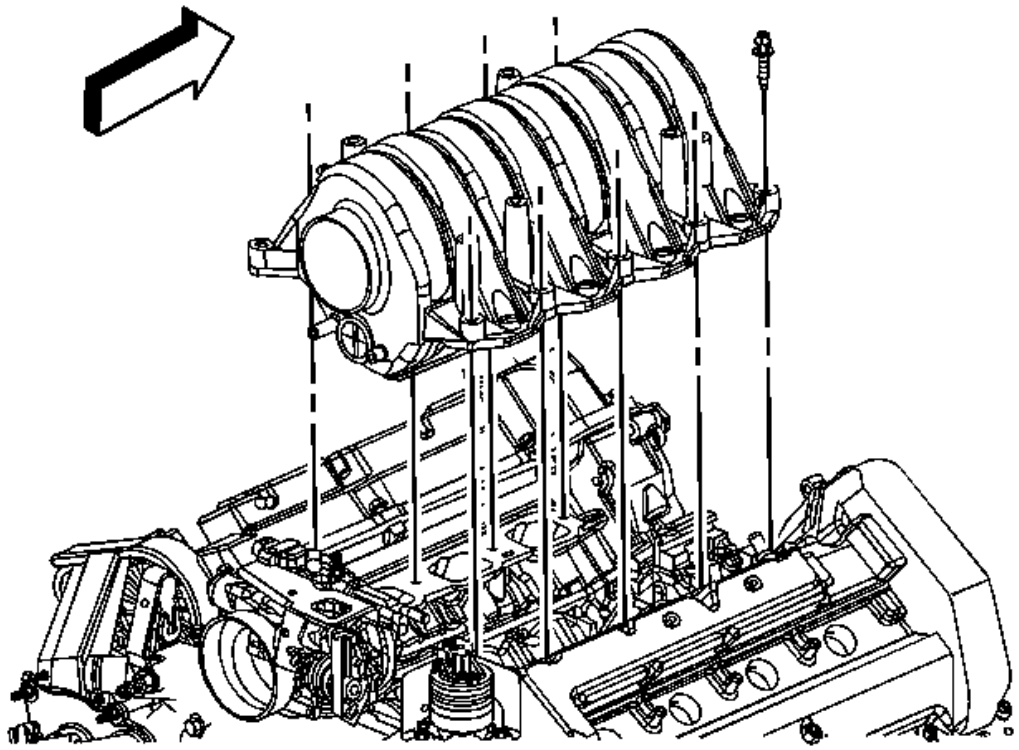

Fig. 70: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

22. Remove intake manifold bolts.
23. Position the power steering aside. Refer to **Power Steering Pump Replacement (L37)** or **Power Steering Pump Replacement (LZ9/LGD)** .
24. Remove the intake manifold.
25. Disconnect the PCV foul air tube quick connect fitting at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .
26. Remove the PCV foul air tube from the retaining features on the intake manifold.
27. Remove and discard the old seals.
28. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection** .

INSTALLATION PROCEDURE

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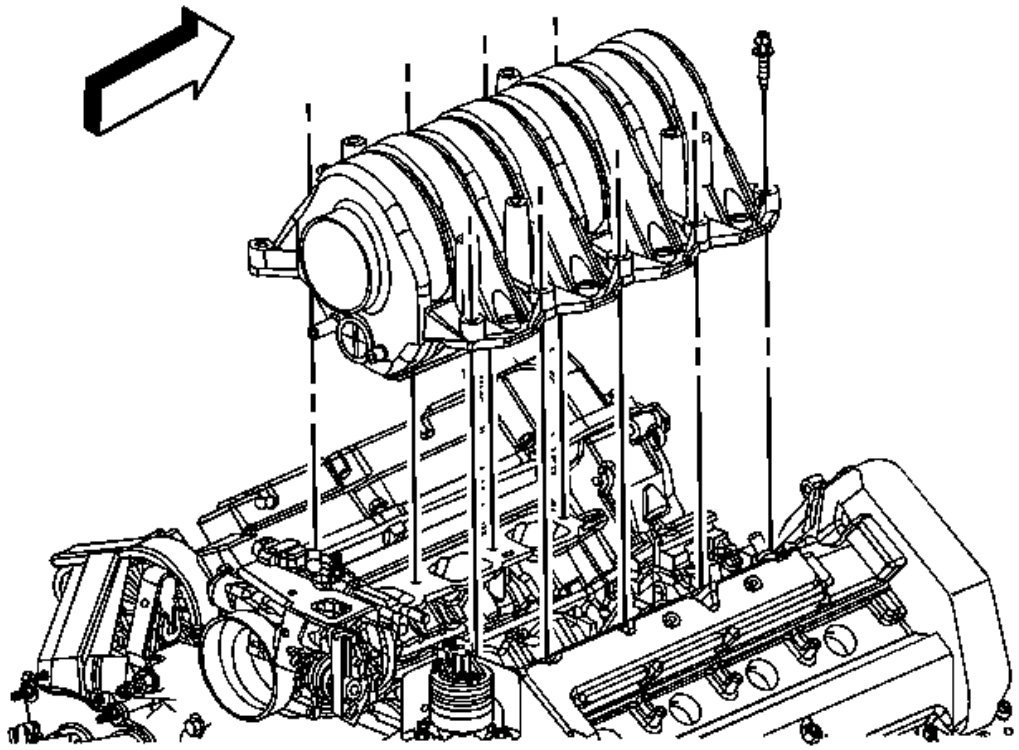

Fig. 71: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Install the new intake manifold seals.
2. Connect the PCV foul air tube quick connect fitting at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .
3. Install the PCV foul air tube to the retaining features on the intake manifold.
4. Lightly grease the inside edge of the rubber plenum duct on the water pump housing.
5. Install the intake manifold.
6. Install intake manifold bolts until snug.

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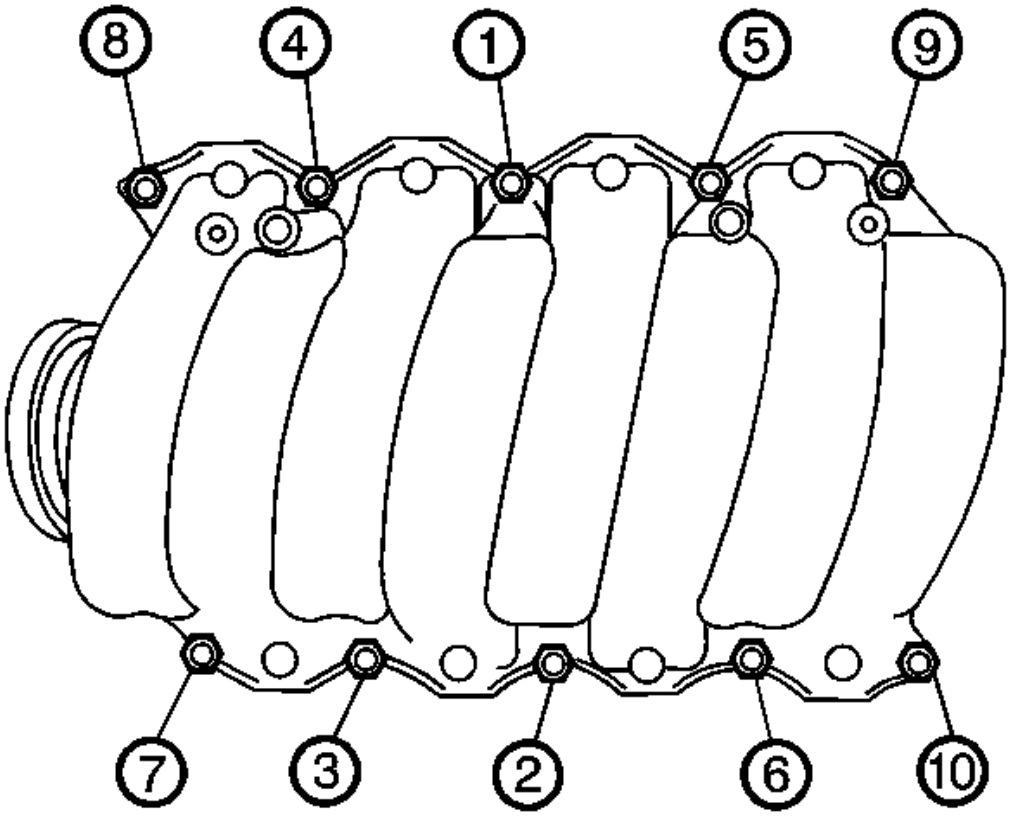

Fig. 72: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

7. Tighten the intake manifold bolts.

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

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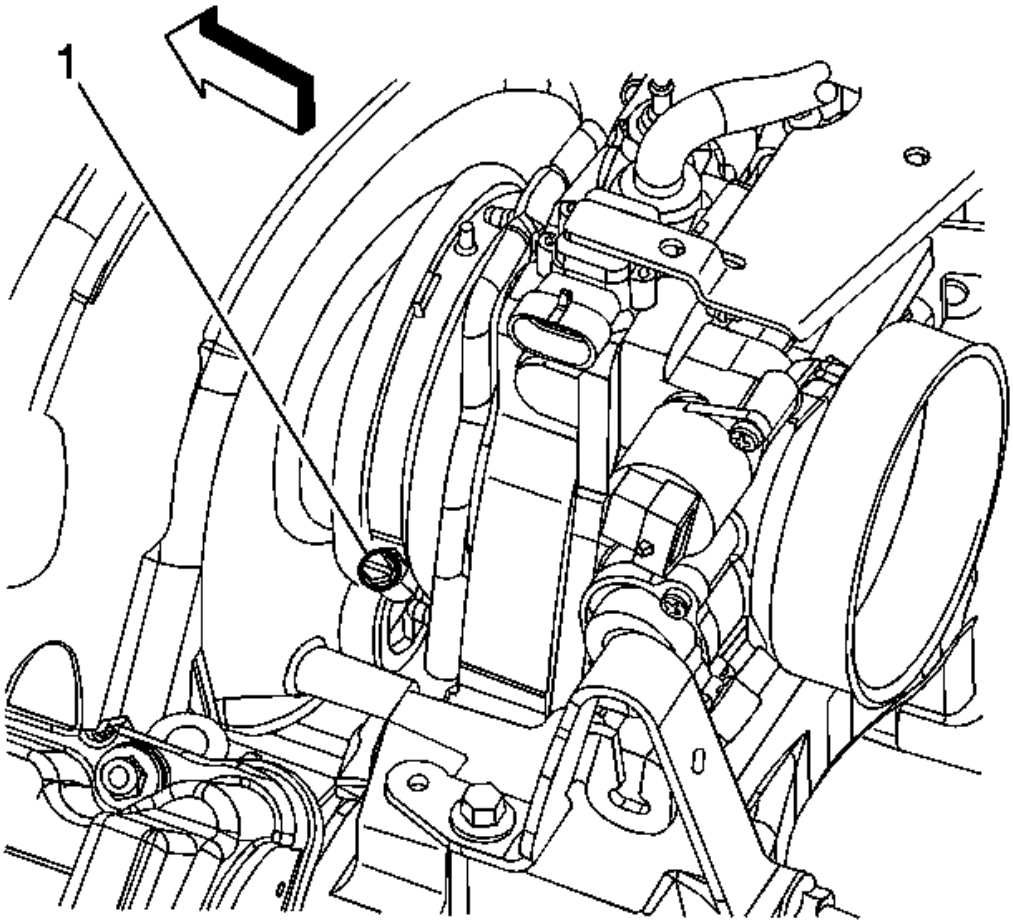

Fig. 73: Plenum Duct Clamp Screw
Courtesy of GENERAL MOTORS CORP.

8. Ensure that the intake manifold is fully installed into the plenum duct on the water pump housing.
9. Install the power steering pump. Refer to **Power Steering Pump Replacement (L37)** or **Power Steering Pump Replacement (LZ9/LGD)** .
10. Tighten the plenum duct clamp screw (1) at the water pump housing.

    Tighten: Tighten the screw to 2.75 N.m (24 lb in).

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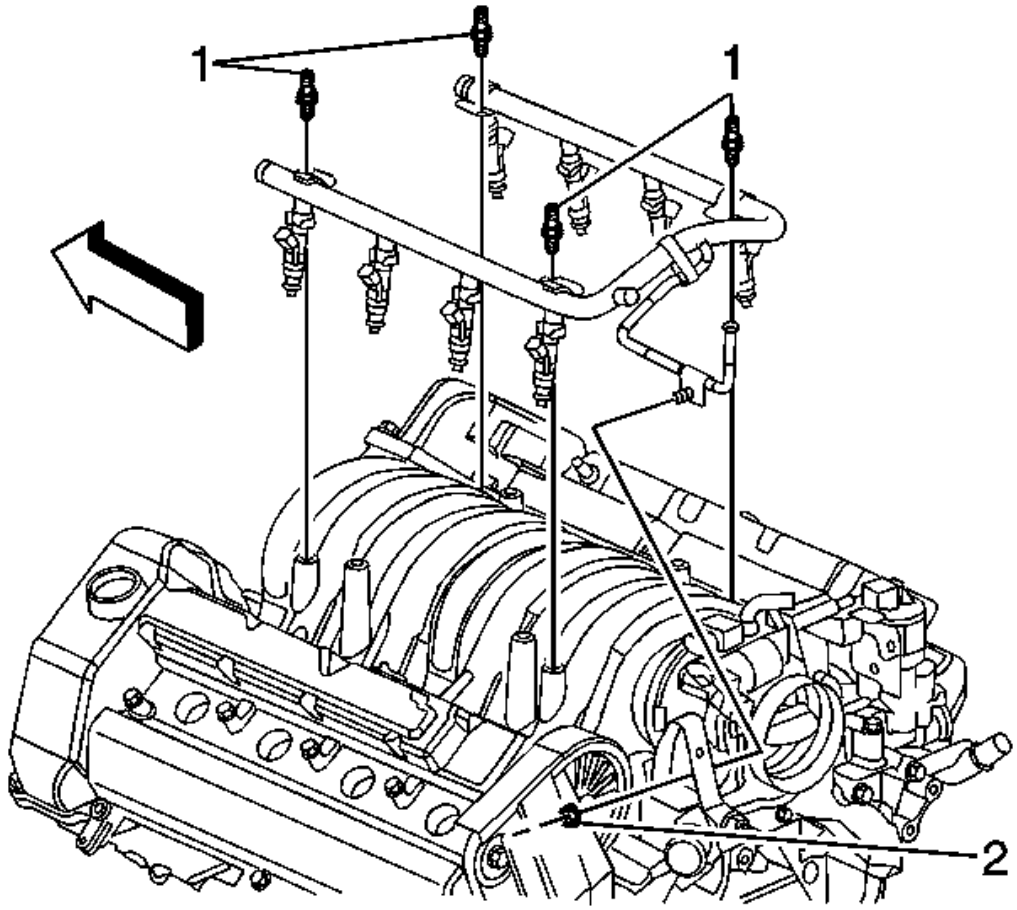

Fig. 74: Fuel Rail, Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Lubricate the fuel injector lower O-ring seals with clean engine oil.
12. Install the fuel rail.
13. Install the fuel rail studs.

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

14. Install the fuel rail bracket nut at the rear left lift bracket.

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

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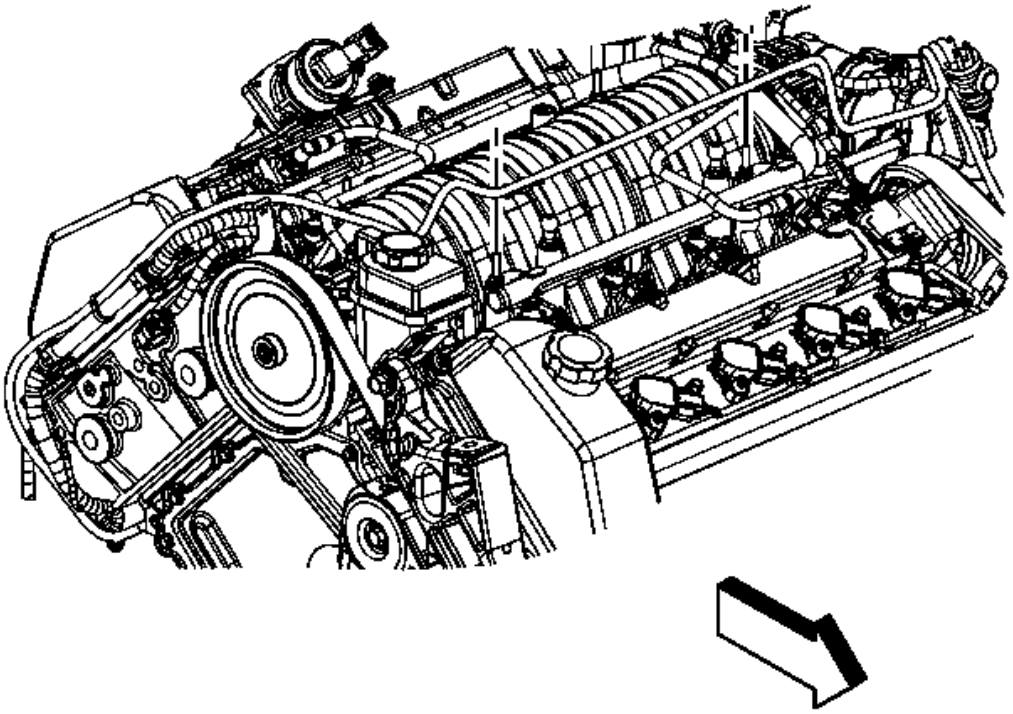

Fig. 75: Coolant Heater Cord Tabs
Courtesy of GENERAL MOTORS CORP.

15. Install the coolant heater cord tabs to the fuel rail studs, if equipped.

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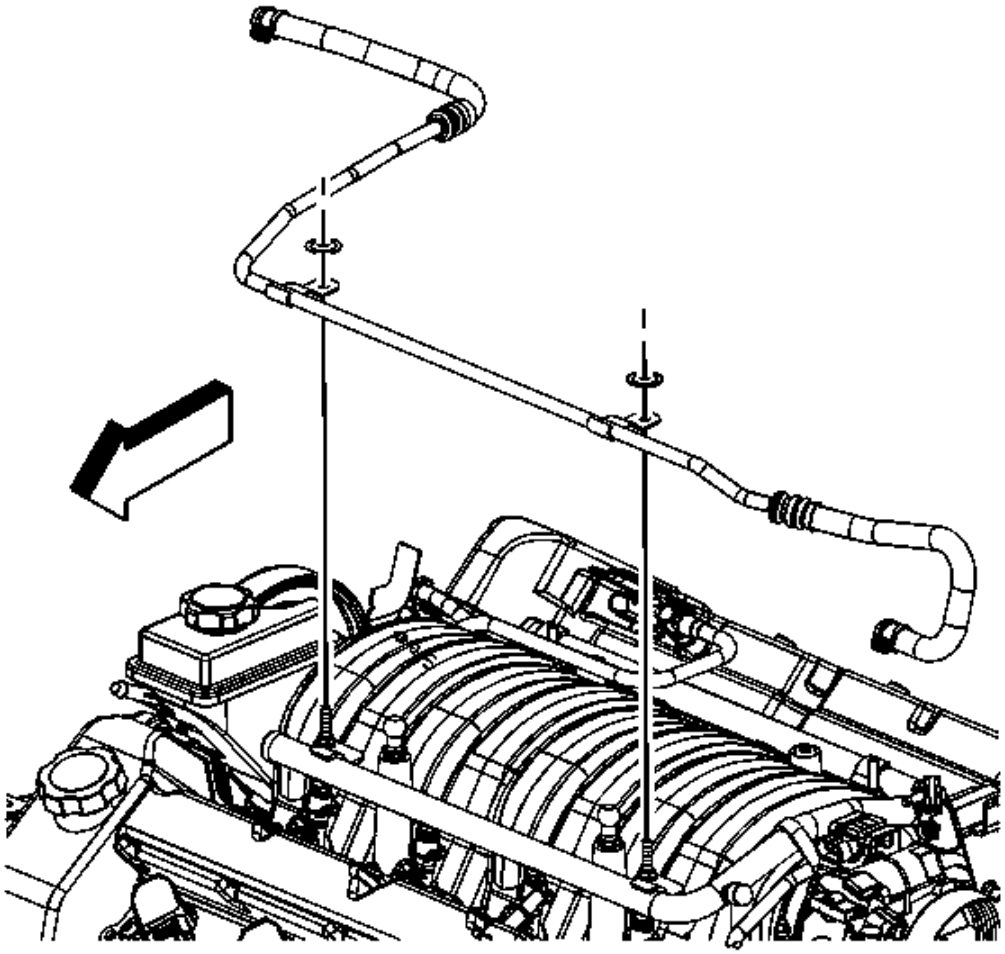

Fig. 76: Surge Tank Inlet Hose/Pipe & Clips
Courtesy of GENERAL MOTORS CORP.

16. Install the engine harness retainer to the fuel rail stud.
17. Install the surge tank inlet hose/pipe to the fuel rail studs.
18. Install the 2 pushnuts securing the surge tank inlet hose/pipe to the fuel rail studs.

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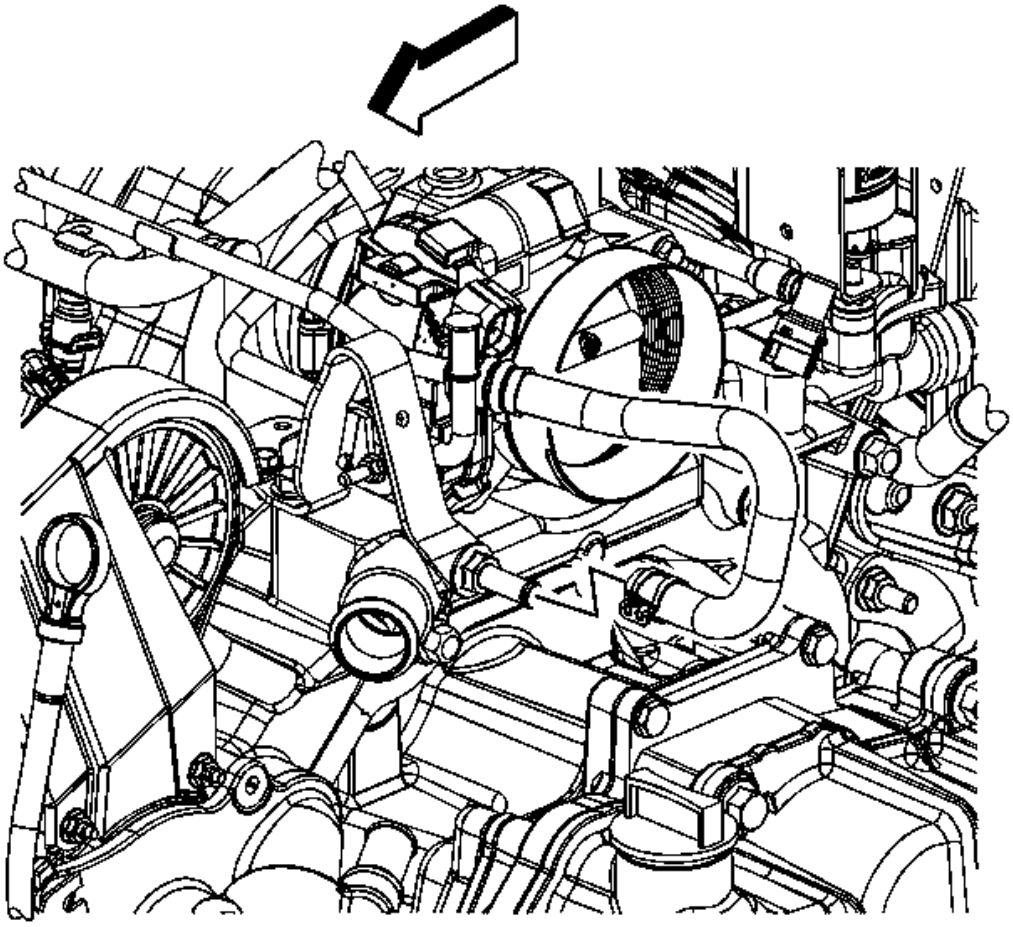

Fig. 77: Surge Tank Inlet Hose/Pipe At Engine Fitting
Courtesy of GENERAL MOTORS CORP.

19. Install the surge tank inlet hose/pipe to the engine fitting.
20. Position the radiator surge tank inlet hose/pipe clamp at the engine.

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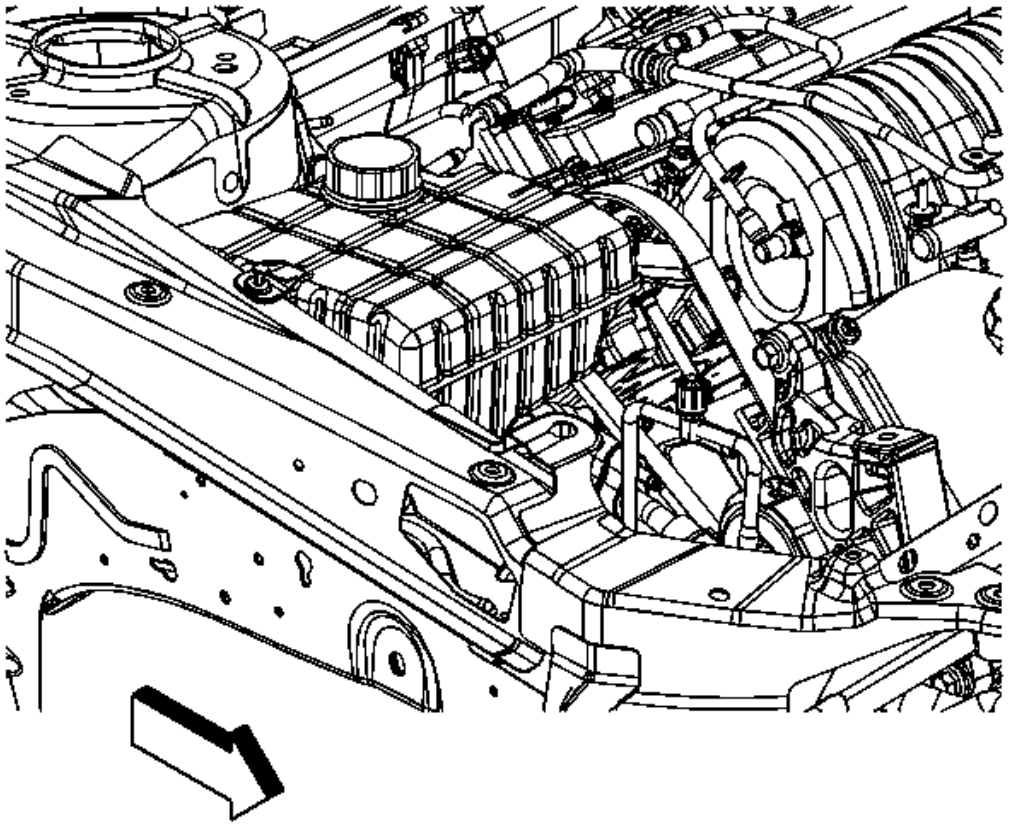

Fig. 78: Surge Tank Inlet Hose/Pipe At Surge Tank
Courtesy of GENERAL MOTORS CORP.

21. Install the surge tank inlet hose/pipe to the surge tank.
22. Position the radiator surge tank inlet hose/pipe clamp at the surge tank.

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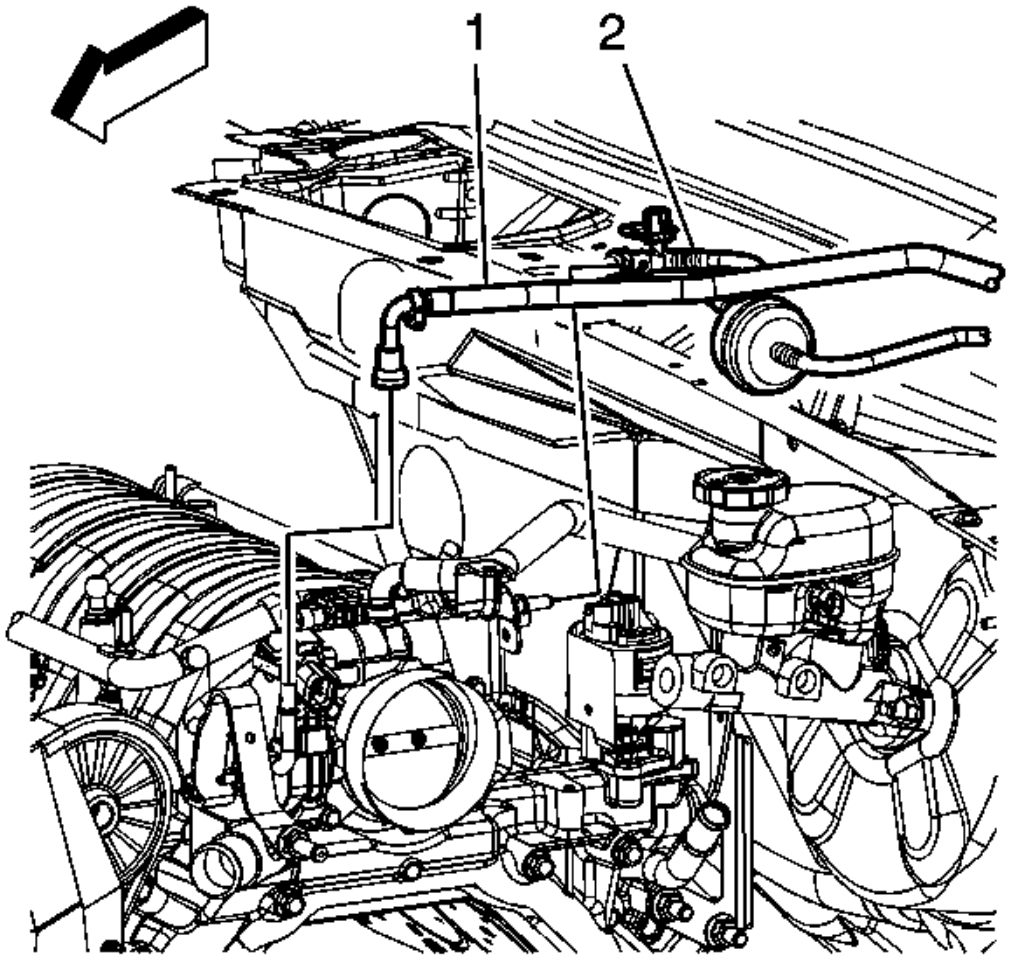

Fig. 79: Fuel Feed & EVAP Line
Courtesy of GENERAL MOTORS CORP.

23. Connect the fuel feed line (1) quick connect fitting at the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .

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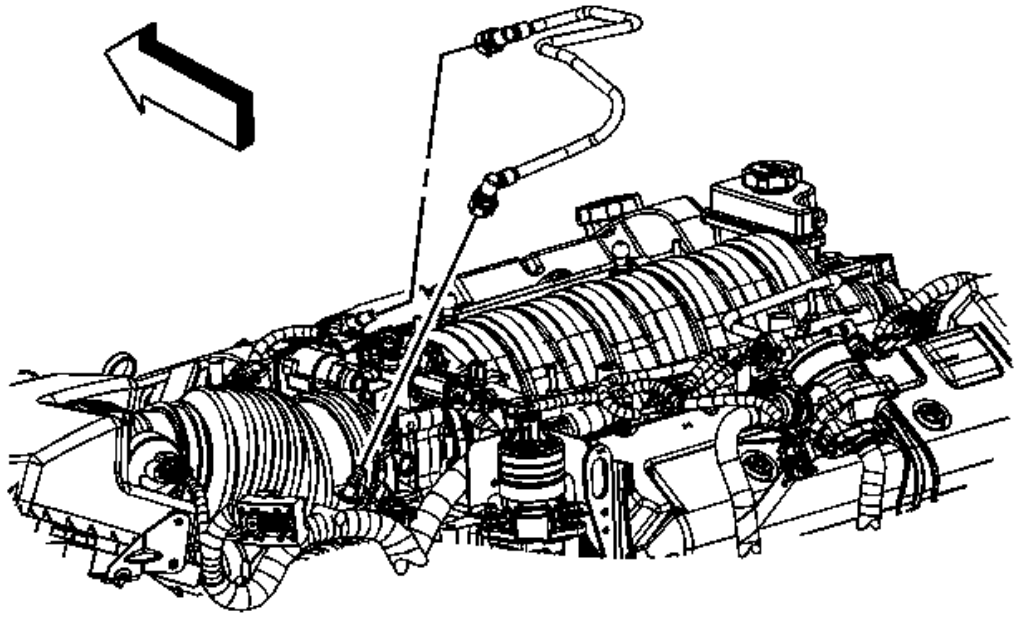

Fig. 80: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

24. Connect the PCV fresh air tube quick connect fitting to the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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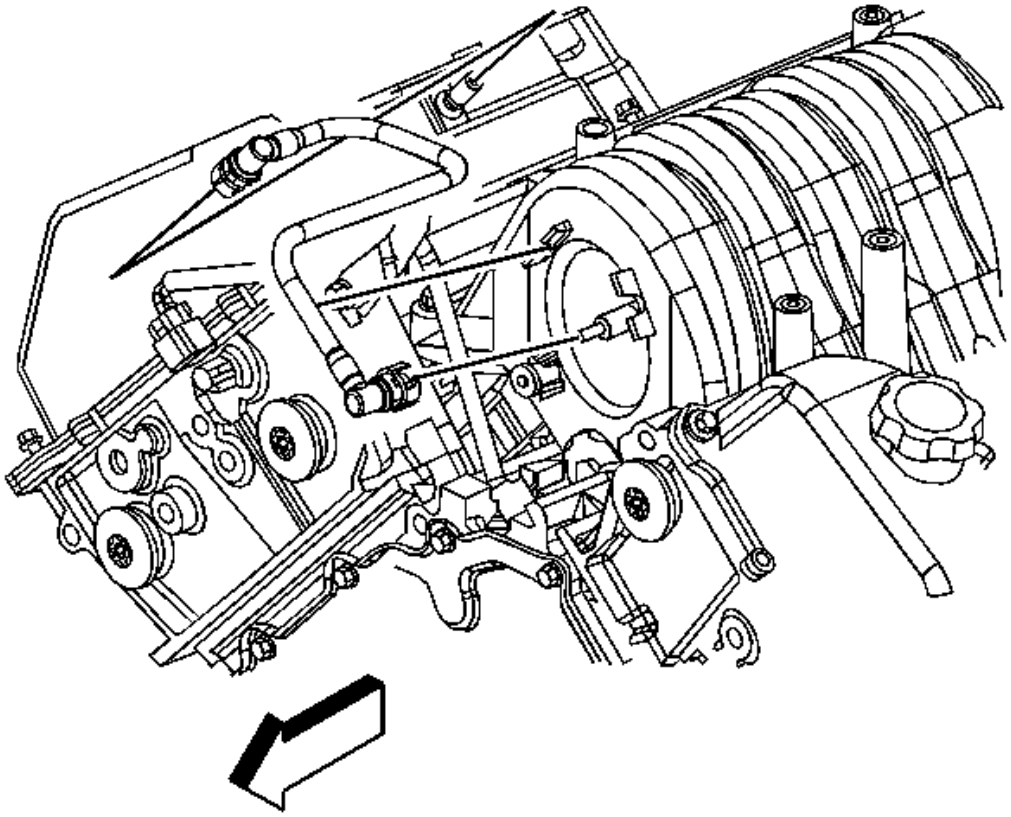

Fig. 81: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

25. Connect the PCV foul air tube quick connect fitting to the right camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .

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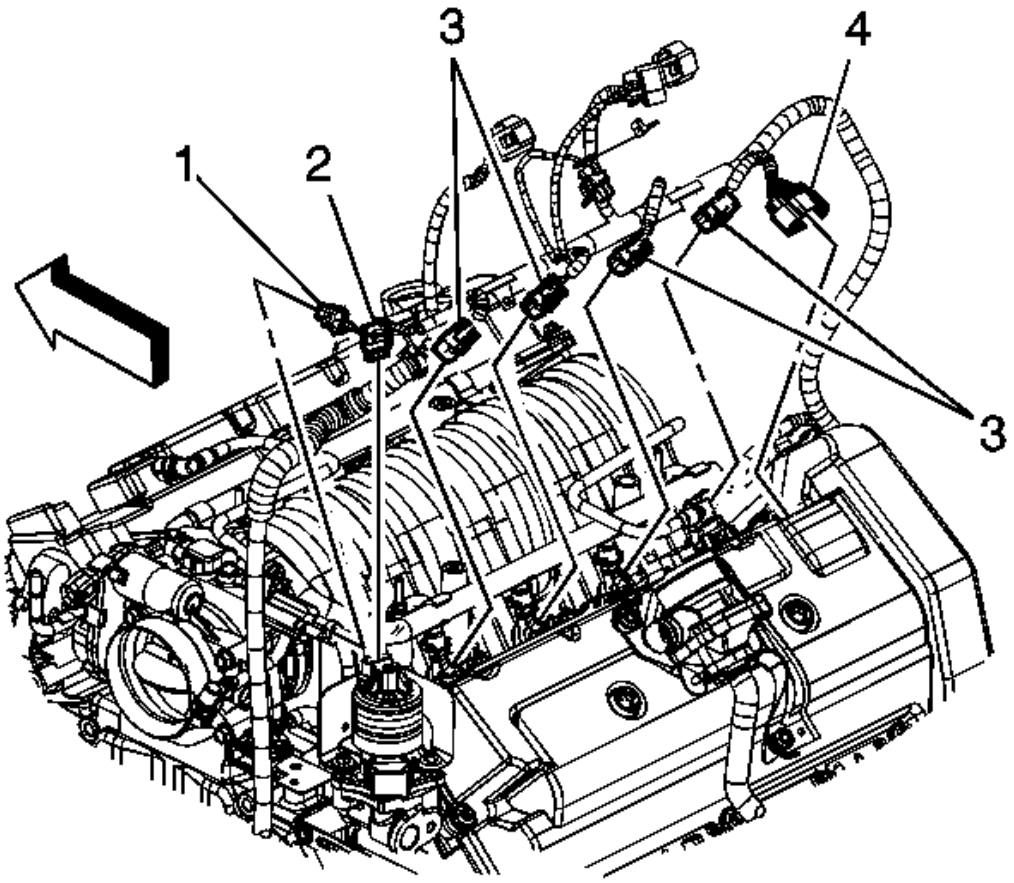

Fig. 82: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

26. Connect the rear fuel injectors engine harness electrical connectors (3).
27. Connect the rear ignition coil module engine harness electrical connector (4).

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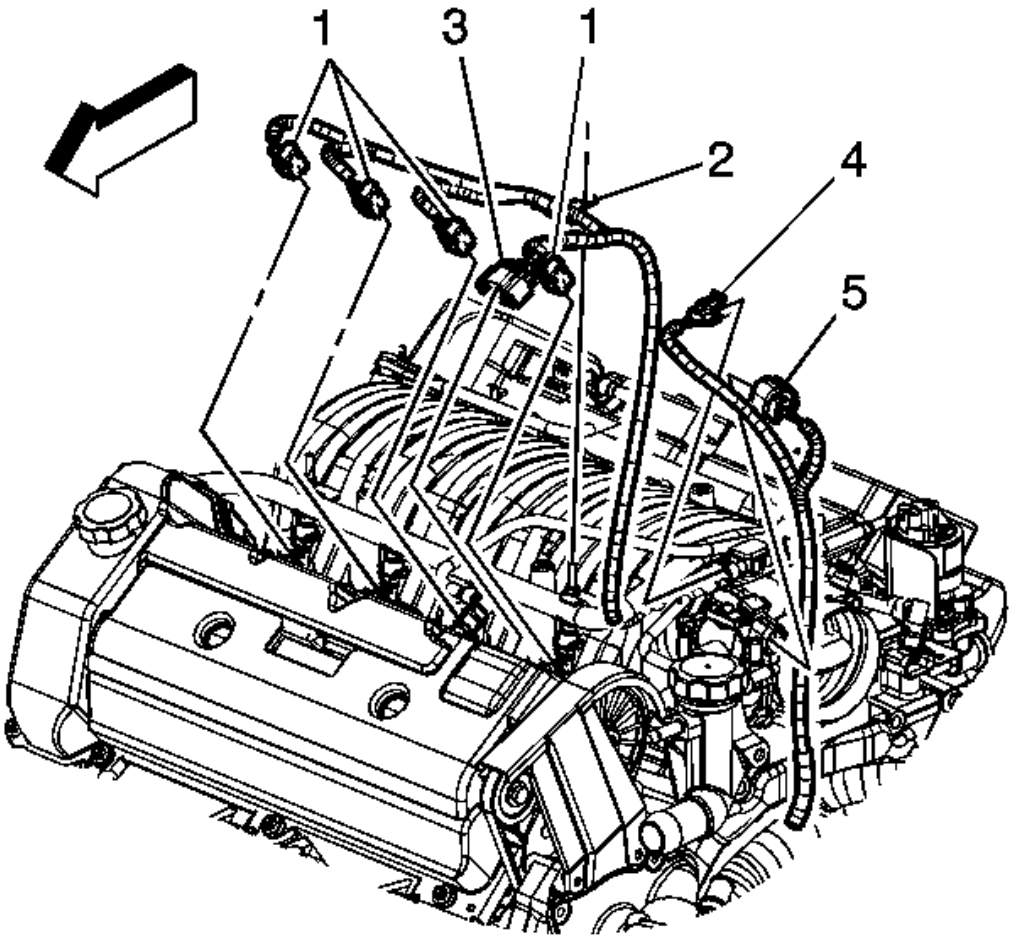

Fig. 83: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

28. Connect the front fuel injectors engine harness electrical connectors (1).
29. Connect the front ignition coil module engine harness electrical connector (3).
30. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
31. Install the fuel injector sight shield cover. Refer to **Fuel Injector Sight Shield Replacement**.

OIL LEVEL INDICATOR TUBE REPLACEMENT

REMOVAL PROCEDURE

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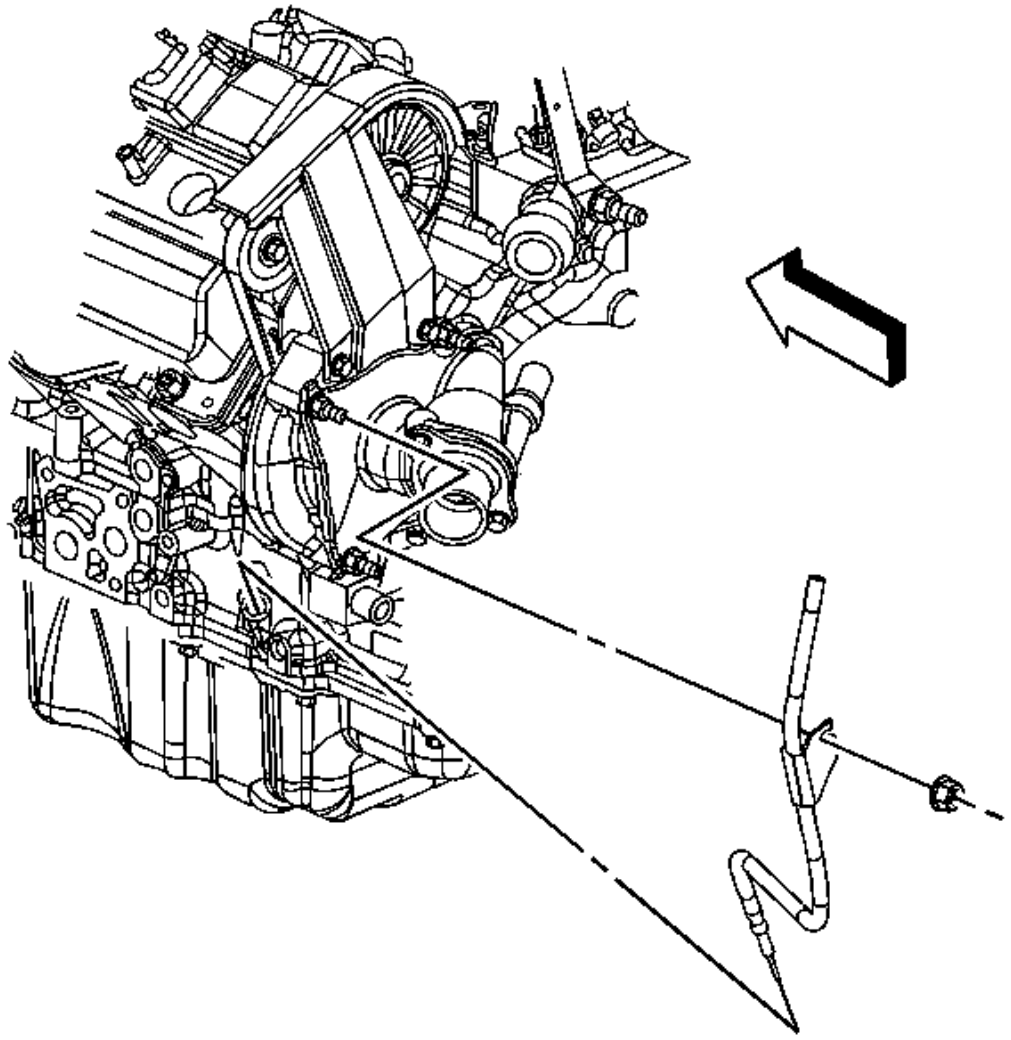

Fig. 84: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the front engine mount bracket. Refer to **Engine Front Mount Bracket Replacement**.
2. Remove the oil level indicator.
3. Loosen the oil level indicator tube nut.
4. Remove the oil level indicator tube.

INSTALLATION PROCEDURE

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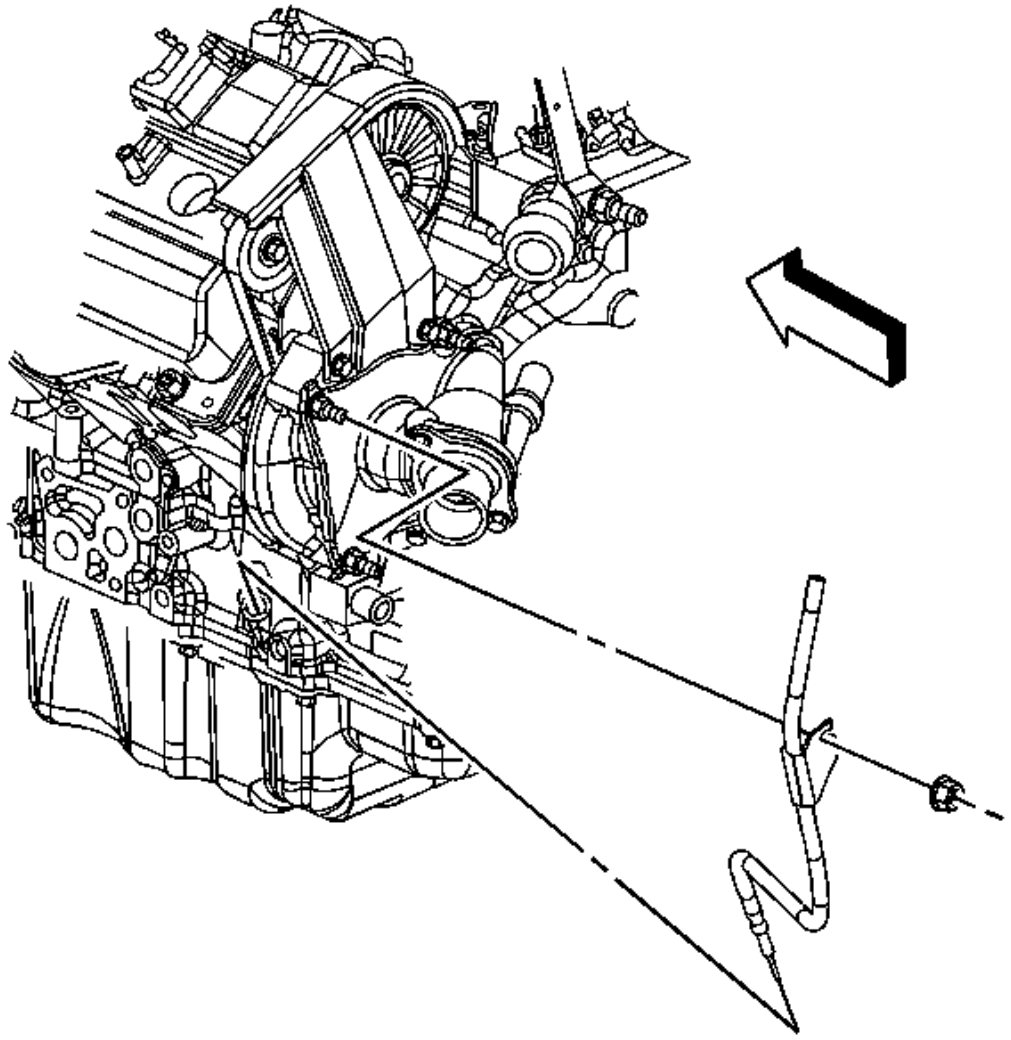

Fig. 85: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring seal with clean engine oil.
2. Install the oil level indictor tube into the lower crankcase opening.

CAUTION: Refer to Fastener Caution .

3. Slide the indicator tube behind the tube nut. Tighten the nut.

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

4. Install the oil level indicator.
5. Install the front engine mount bracket. Refer to **Engine Front Mount Bracket Replacement**.

OIL FILTER ADAPTER REPLACEMENT

REMOVAL PROCEDURE

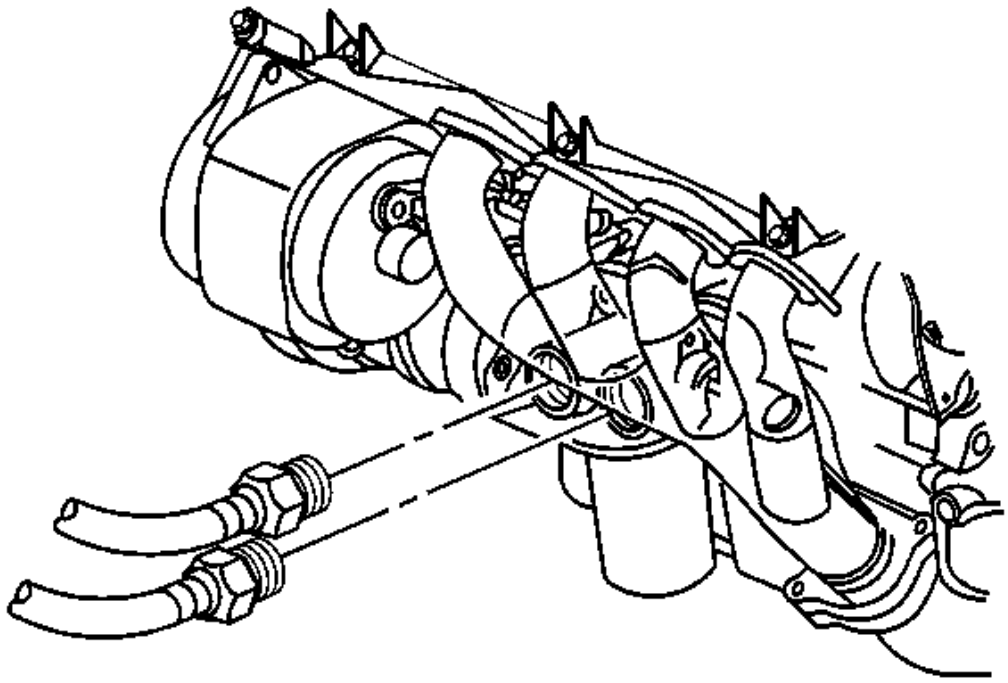

Fig. 86: Engine Oil Cooler Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the air deflector. Refer to **Front Air Deflector Replacement** .

NOTE: Engine oil cooler quick connect fittings must be replaced whenever they are removed from the engine oil filter adapter.

3. If equipped, remove the engine oil cooler quick connect fittings from the engine oil filter adapter, with the oil pipes still attached.

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If not equipped with an engine oil cooler, go to step 7.

4. Remove the dust cover from the quick connect joint.

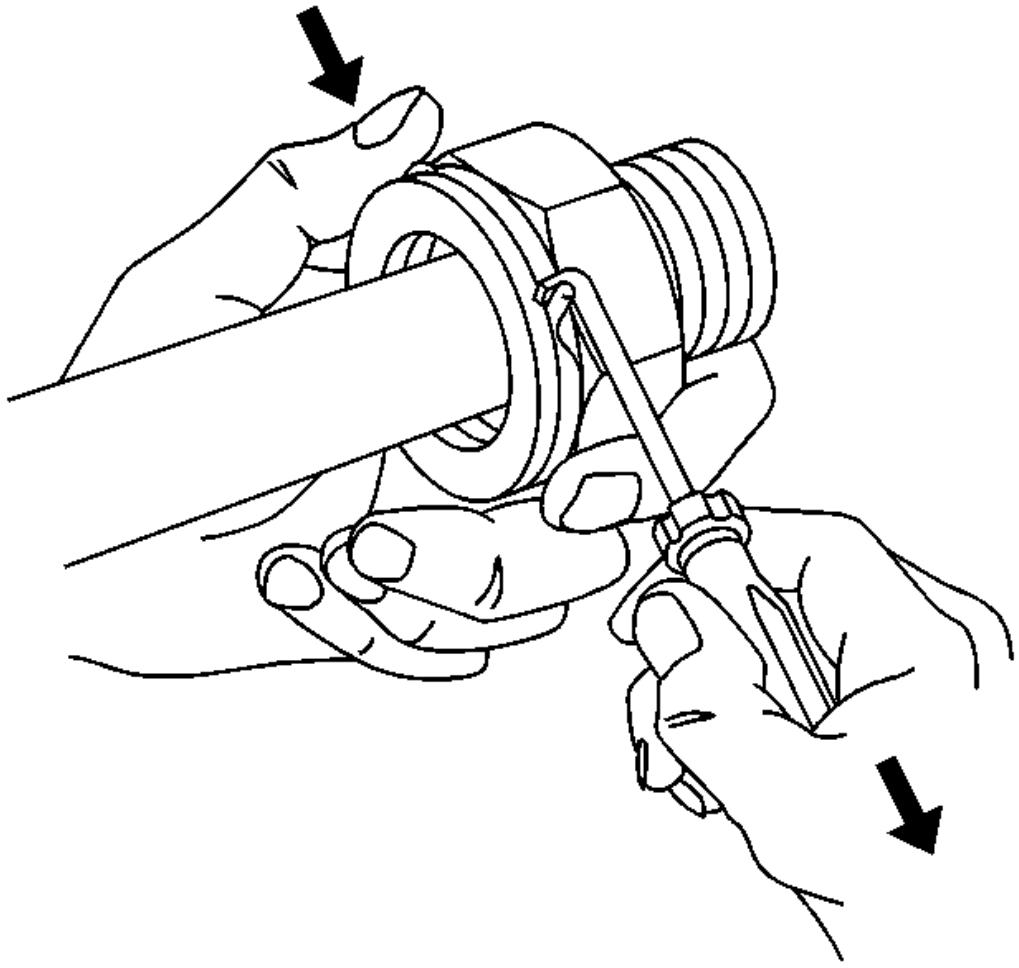

Fig. 87: Removing Internal Spring Clips
Courtesy of GENERAL MOTORS CORP.

5. Remove the internal spring clips from the engine oil cooler fittings.

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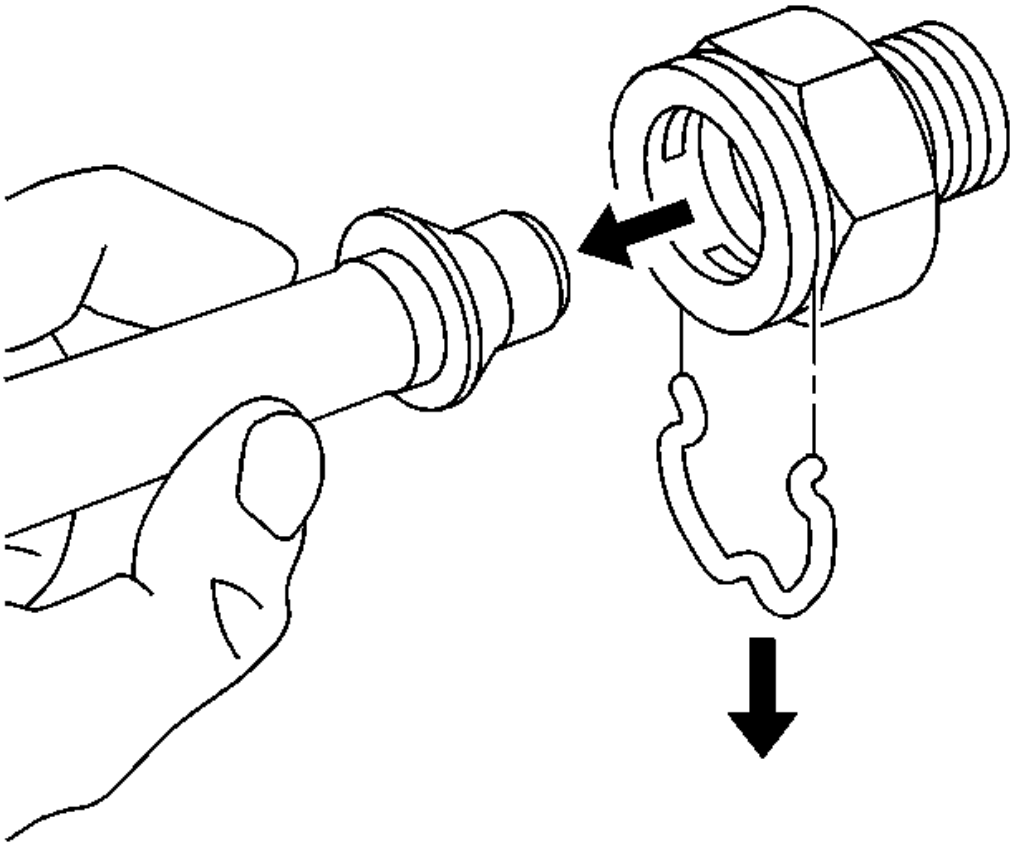

Fig. 88: Removing Engine Oil Cooler Pipes From Cooler Fittings
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine oil cooler pipes from the cooler fittings.

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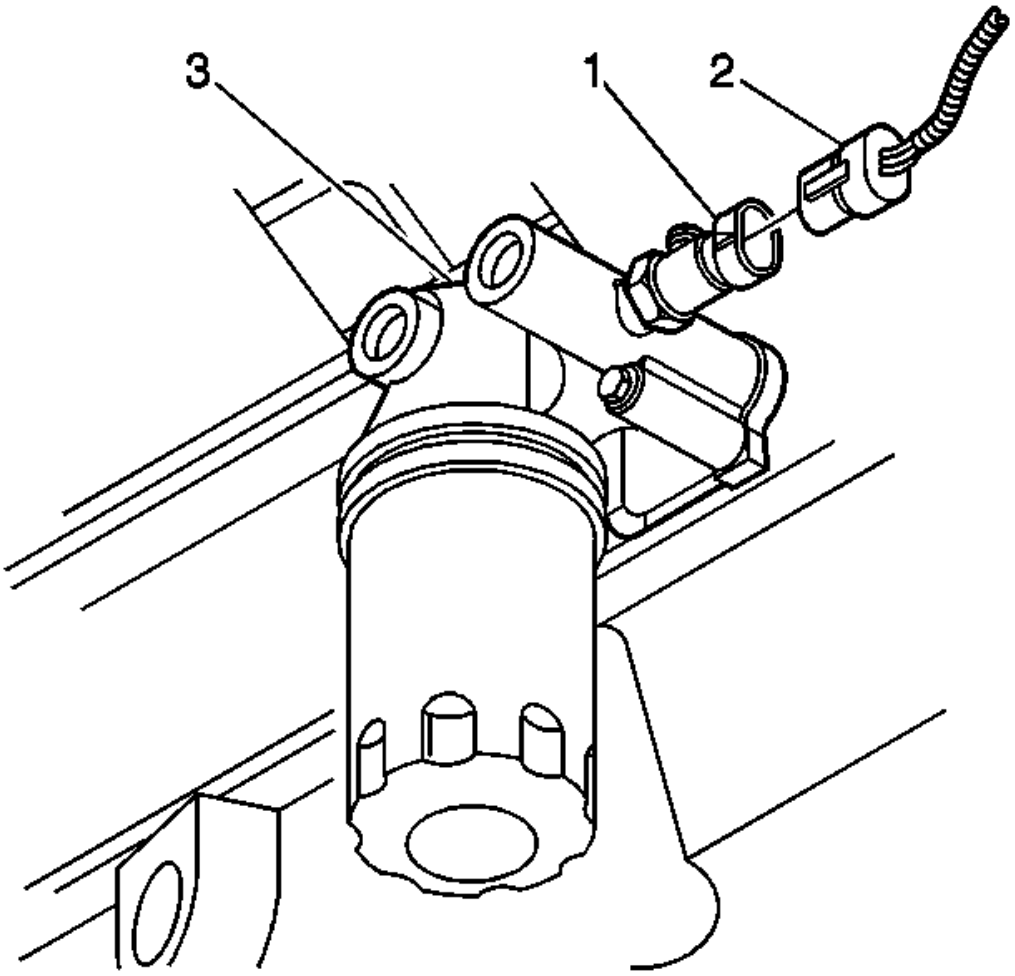

Fig. 89: Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the electrical connector (2) from the engine oil pressure switch (1).

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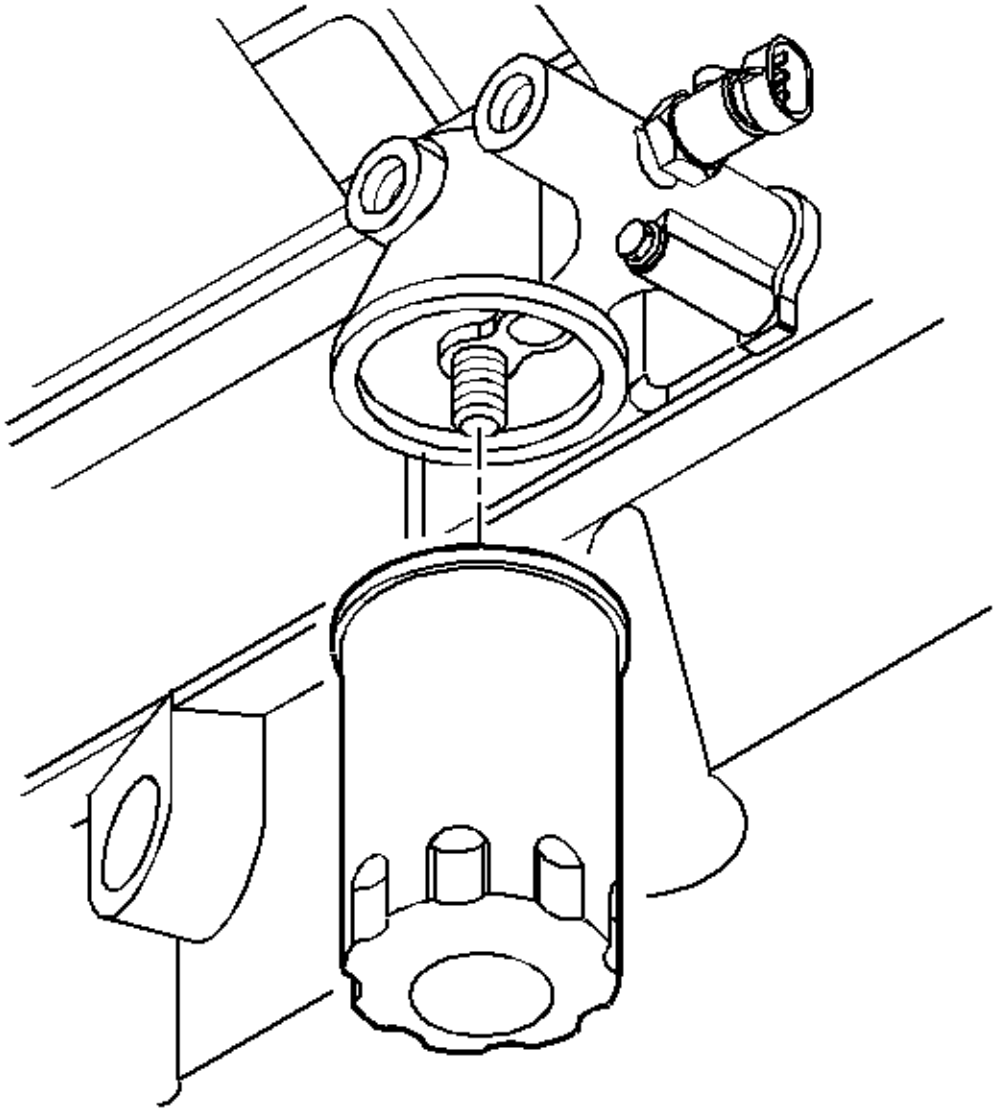

Fig. 90: Oil Filter Adapter & Filter
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil filter.

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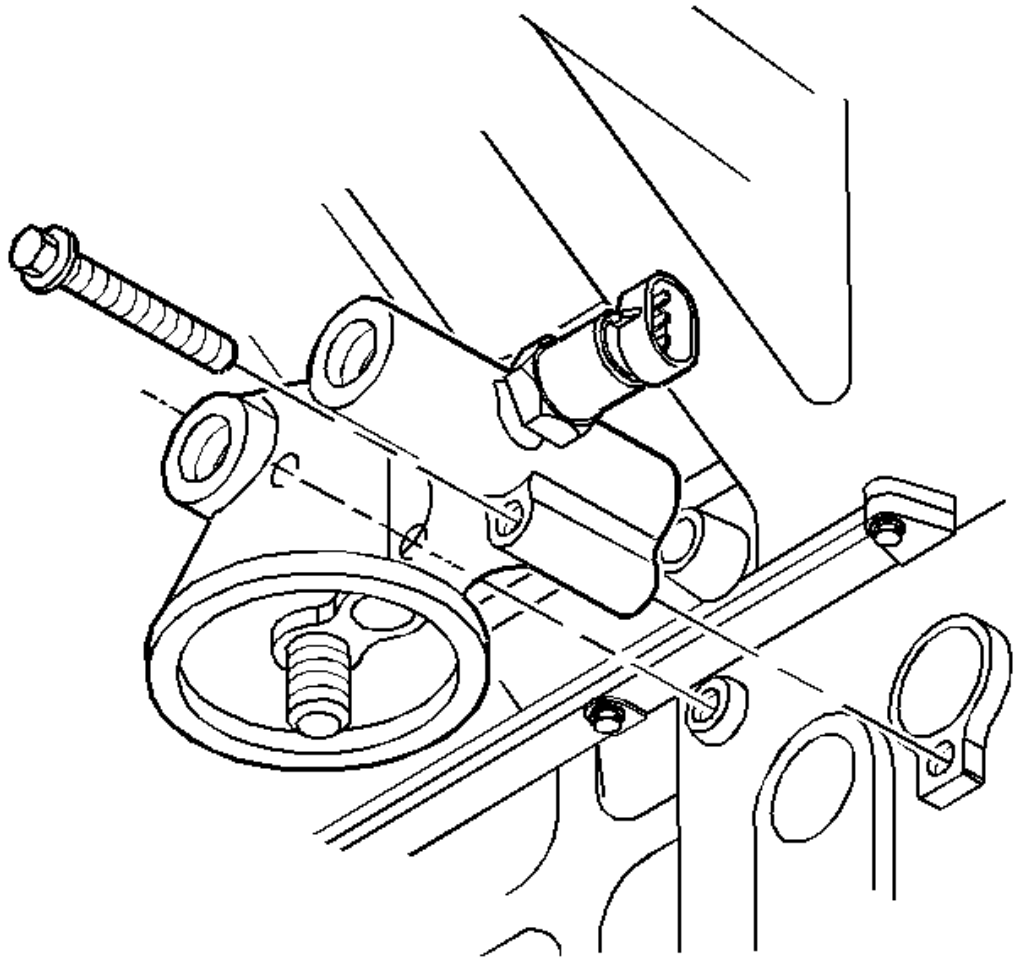

Fig. 91: Oil Filter Adapter Assembly
Courtesy of GENERAL MOTORS CORP.

9. Remove the 2 adapter mounting bolts.
10. Remove the adapter and discard the O-rings.
11. Remove the engine oil pressure switch from the oil filter adapter.
12. Clean and inspect the oil filter adapter. Refer to **Oil Filter Adapter Cleaning and Inspection (without Oil Cooler)** or **Oil Filter Adapter Cleaning and Inspection (with Oil Cooler)** .

INSTALLATION PROCEDURE

CAUTION: Refer to Fastener Caution .

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1. Install the engine oil pressure switch to the oil filter adapter.

   Tighten: Tighten the engine oil pressure switch to 16 N.m (12 lb ft).

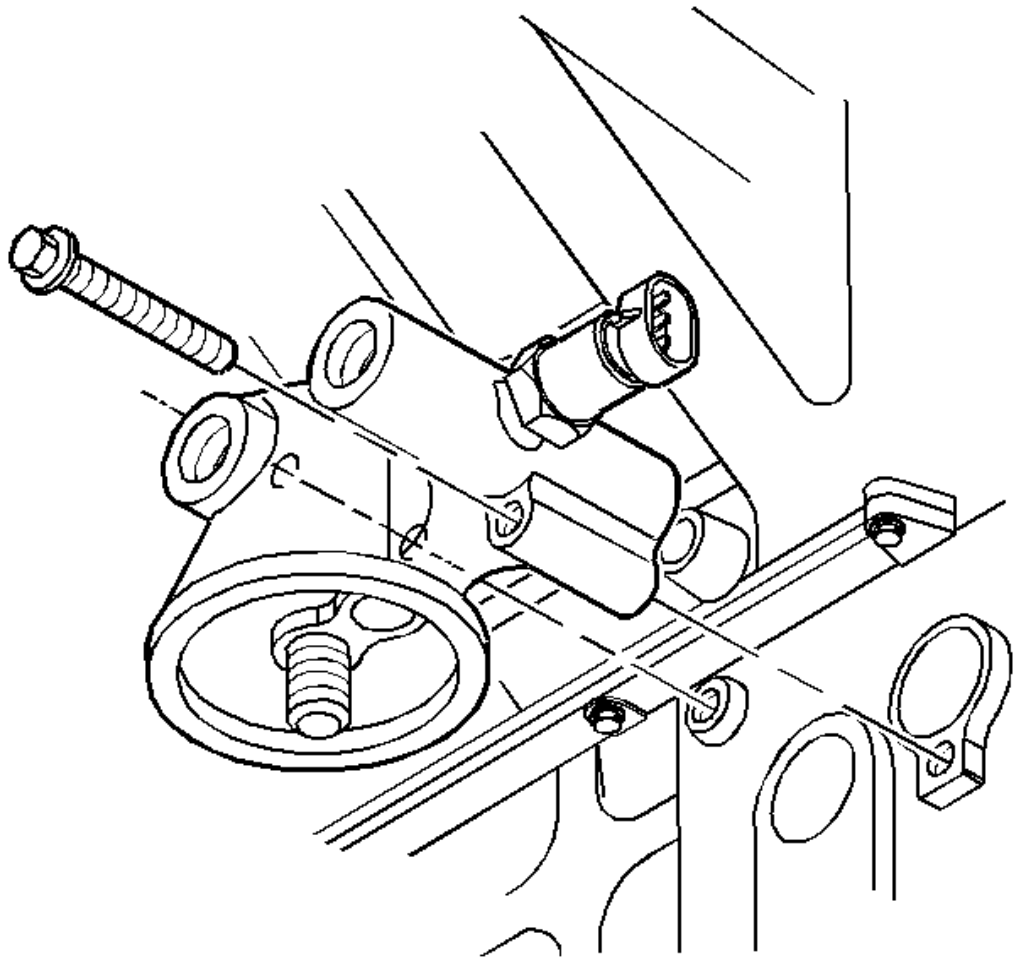

Fig. 92: Oil Filter Adapter Assembly
Courtesy of GENERAL MOTORS CORP.

2. Install the new O-rings. Petrolatum may be used to retain the O-rings in the adapter.
3. Install the 2 bolts attaching the oil filter adapter to the engine block.

   Tighten: Tighten the oil filter adapter bolts to 25 N.m (18 lb ft).

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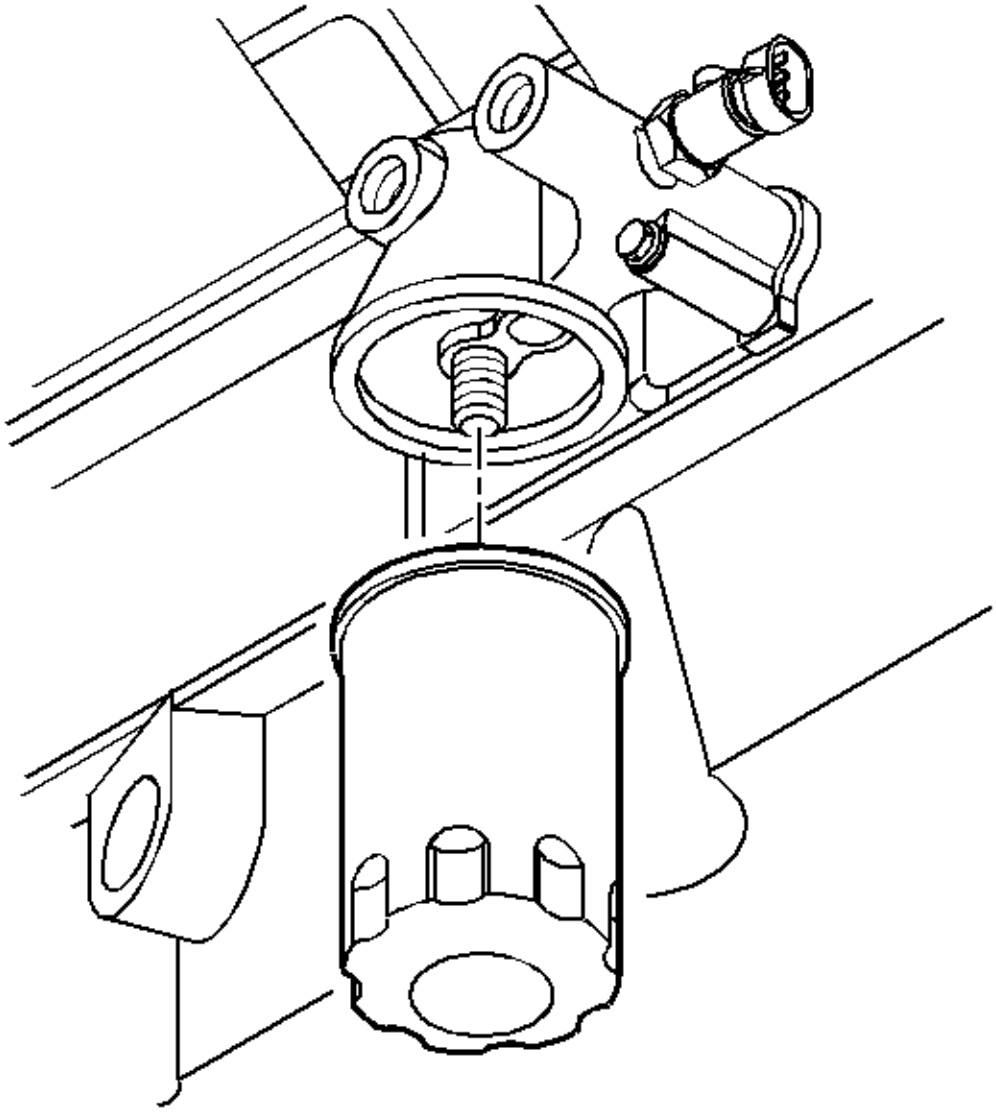

Fig. 93: Oil Filter Adapter & Filter
Courtesy of GENERAL MOTORS CORP.

4. Lightly oil the replacement oil filter gasket with clean oil.

NOTE: Fill the oil filter with the engine oil.

5. Install the oil filter.

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Tighten: Tighten the oil filter to 32 N.m (24 lb ft).

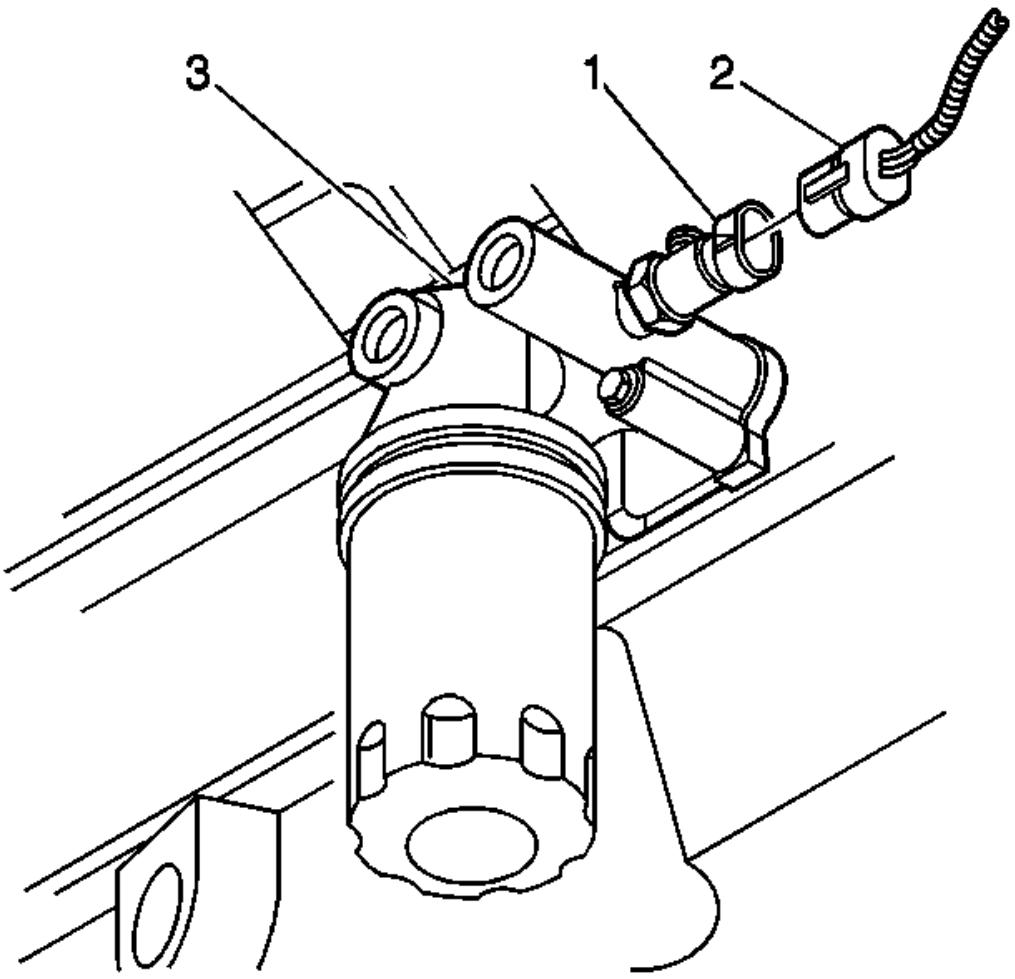

Fig. 94: Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

6. Connect the electrical connector (2) to the engine oil pressure switch (1).

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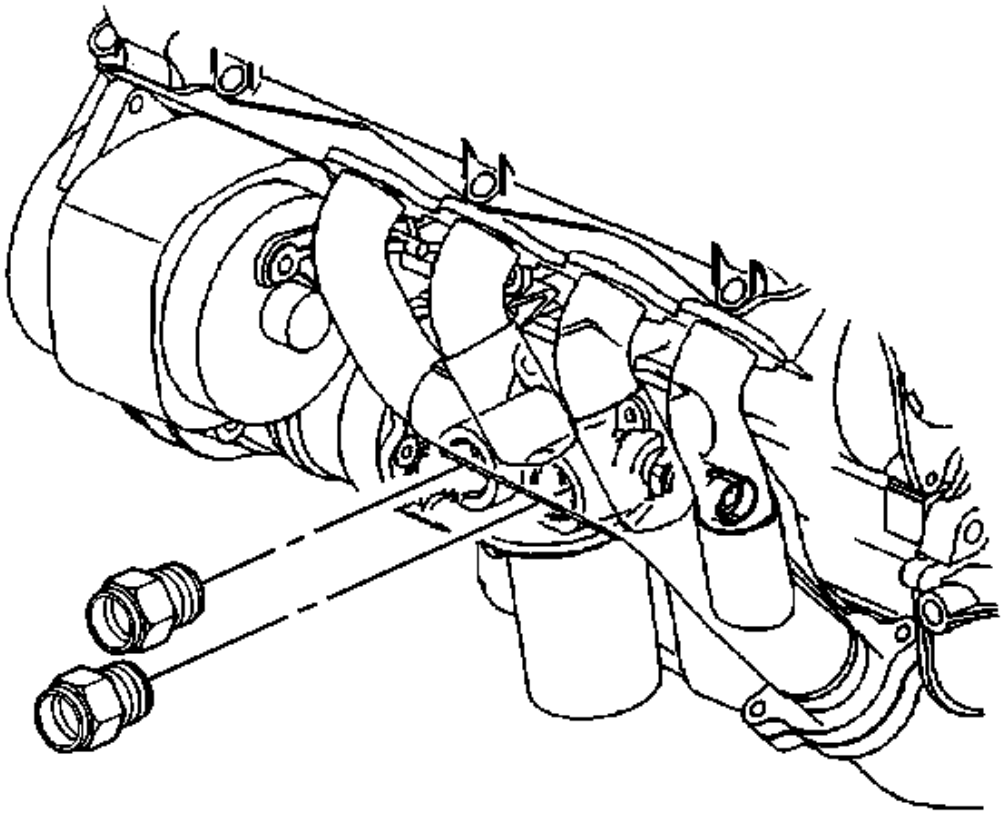

Fig. 95: Engine Oil Cooler Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

NOTE: Engine oil cooler quick connect fittings must be replaced whenever they are removed from the engine oil filter adapter.

7. If equipped, install the engine oil cooler quick connect fittings to the engine oil filter adapter.

   If not equipped with an engine oil cooler, proceed to step 1.

   Tighten: Tighten the engine oil cooler quick connect fittings to 18 N.m (13 lb ft).

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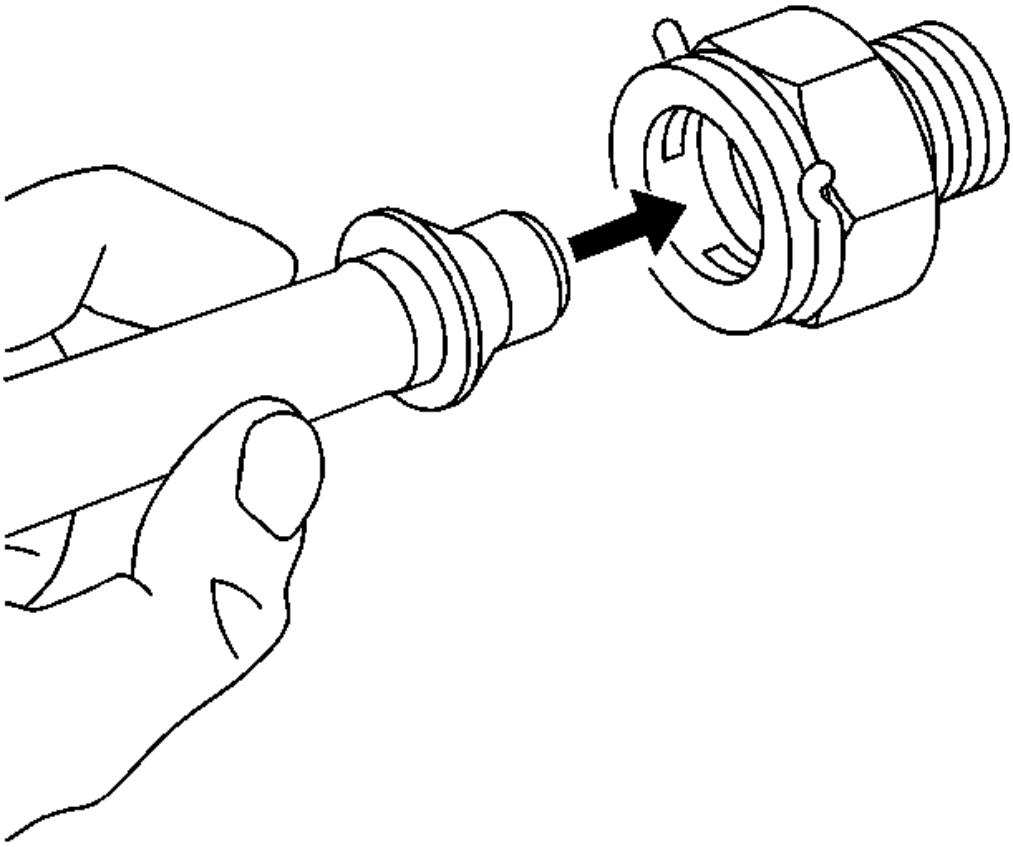

Fig. 96: Installing Engine Oil Cooler Pipes
Courtesy of GENERAL MOTORS CORP.

8. Push the engine oil cooler pipes fully into the oil cooler quick connect fittings, until a "click" is heard.
9. Tug gently on the cooler pipes to ensure proper retention.
10. Slide the dust cover over the quick connect joint.
11. Install the air deflector. Refer to **Front Air Deflector Replacement** .
12. Lower the vehicle.
13. Adjust the engine oil level to the full mark.
14. Inspect for oil leaks after engine start up.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

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- **J 45059** Angle Meter
- **J 41816** Crankshaft Balancer Remover
- **J 41998-B** Crankshaft Balancer Installer. See **Special Tools** .
- **J 44214** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

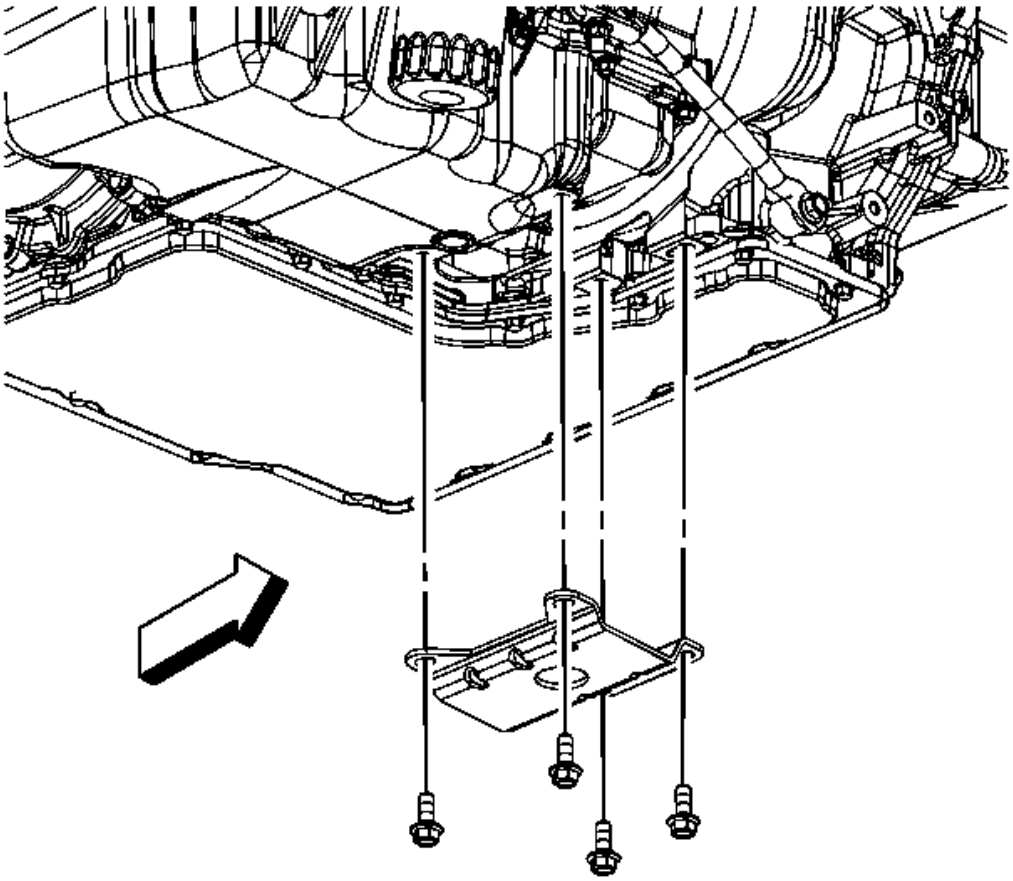

Fig. 97: Transaxle To Engine Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the transaxle to engine brace bolts.
3. Remove the transaxle to engine brace.

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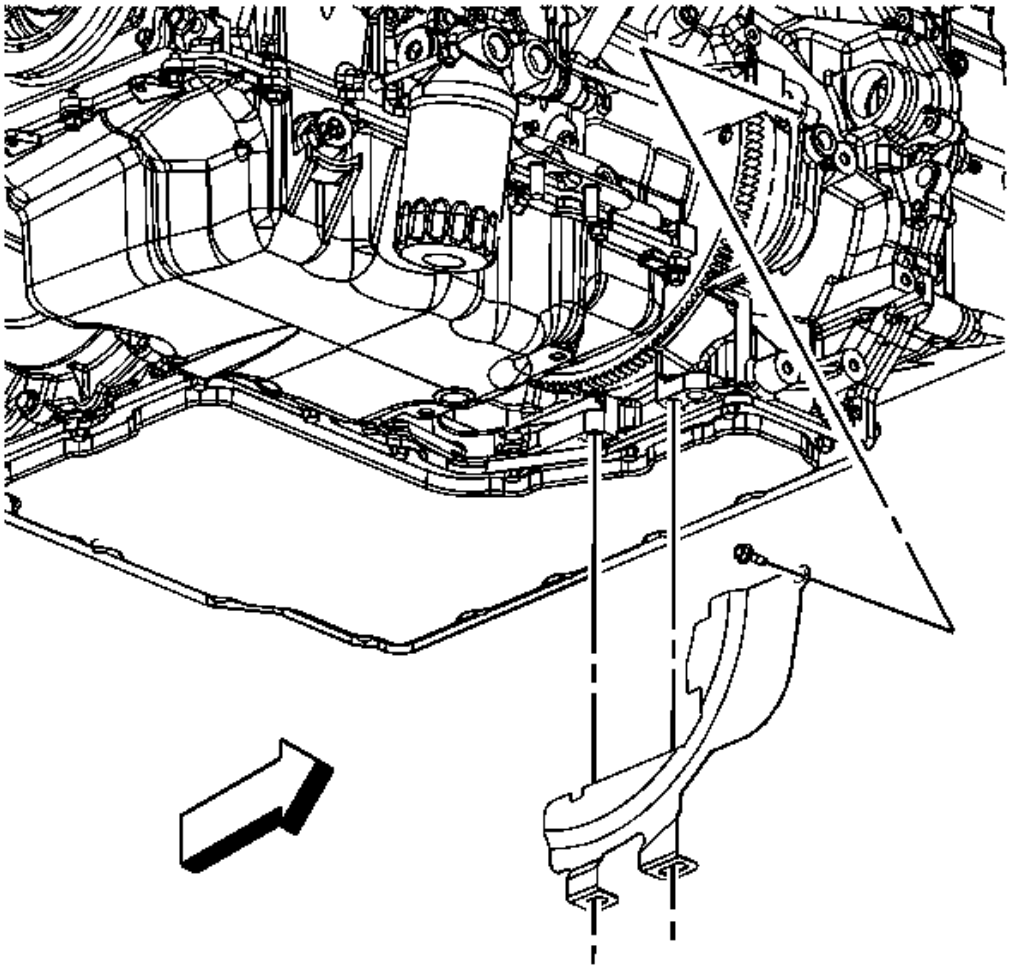

Fig. 98: Torque Converter Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the torque converter cover bolt.
5. Remove the torque converter cover.

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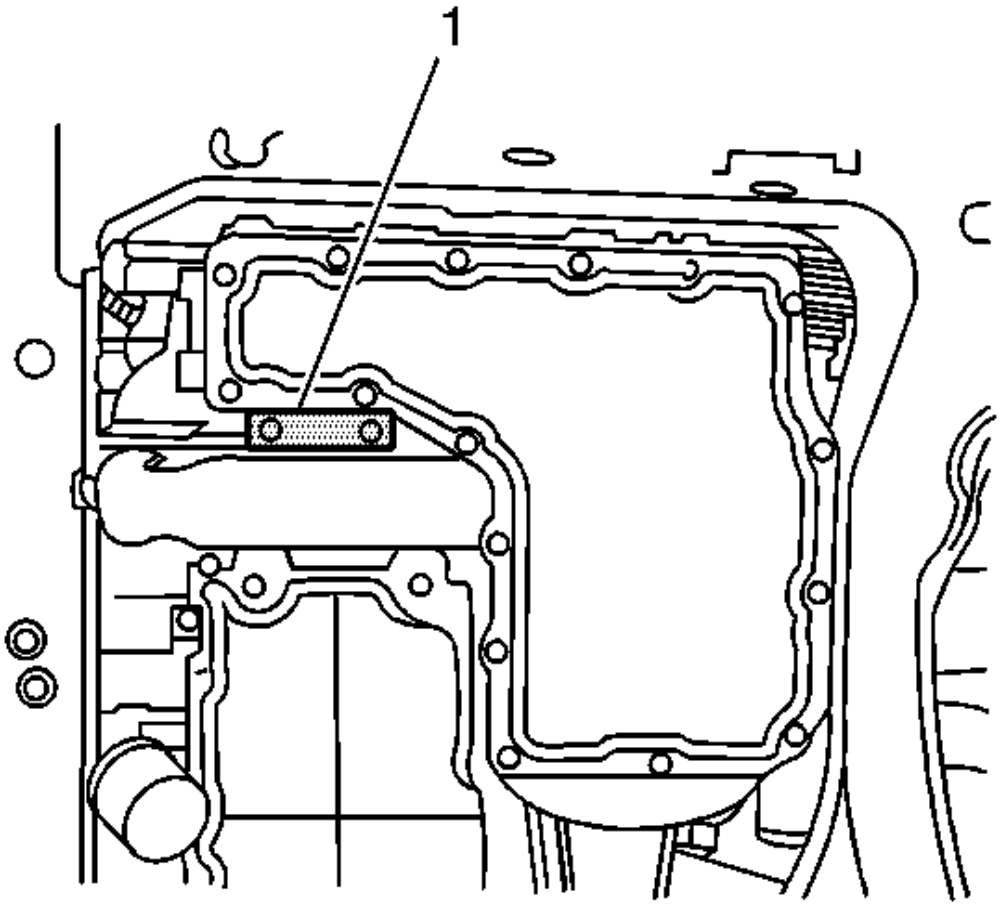

Fig. 99: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 44214** (1). See **Special Tools** .
7. Remove the crankshaft balancer bolt.
8. Remove the front fascia. Refer to **Front Bumper Fascia Replacement** .
9. Support the frame with a suitable adjustable jack.
10. Loosen the right side frame bolts.
11. Lower the frame in order to obtain clearance for the **J 41816** below the body rail.

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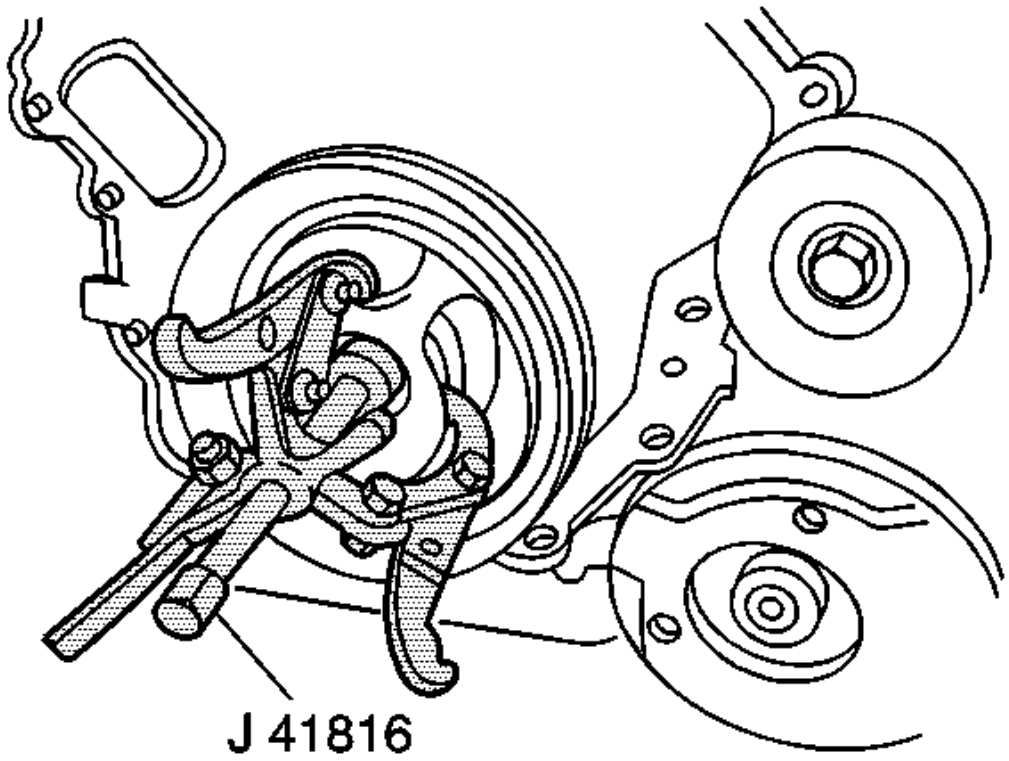

Fig. 100: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

12. Place the remover pilot into the end of the crankshaft.
13. Remove the crankshaft balancer using the **J 41816** .

INSTALLATION PROCEDURE

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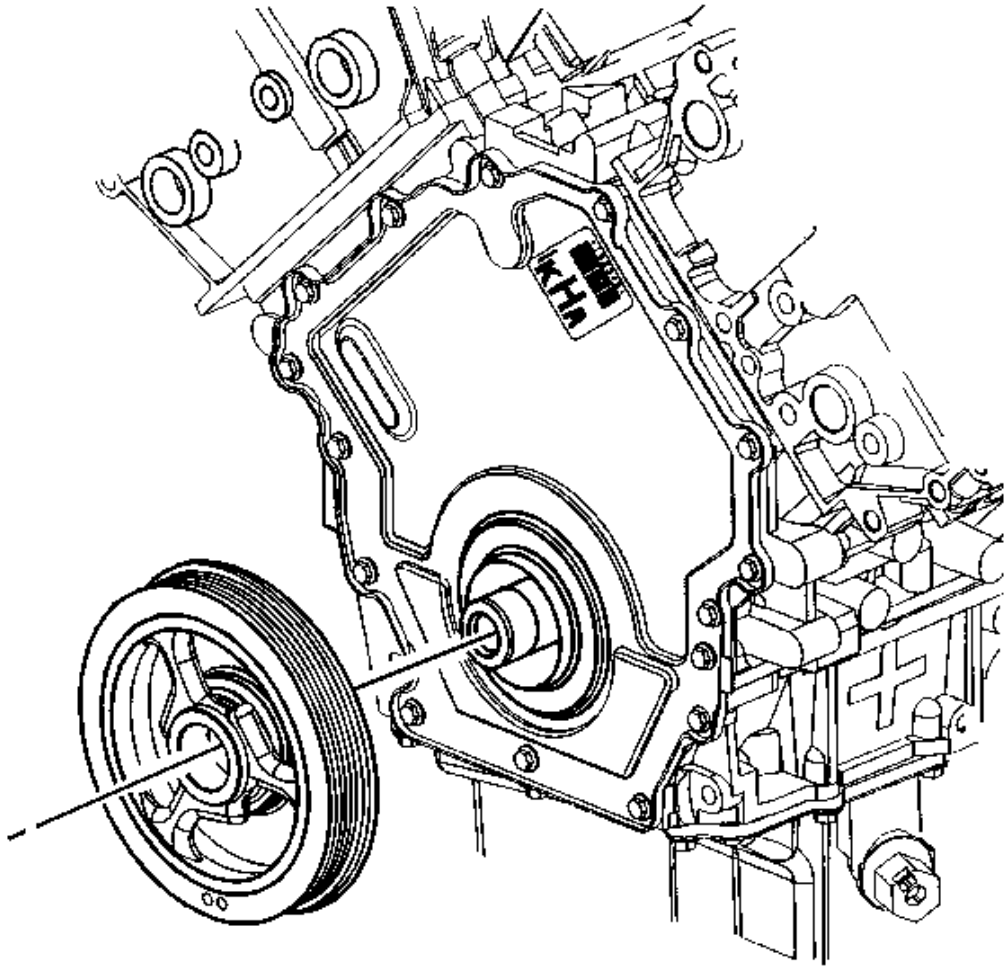

Fig. 101: Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer on the nose of the crankshaft.

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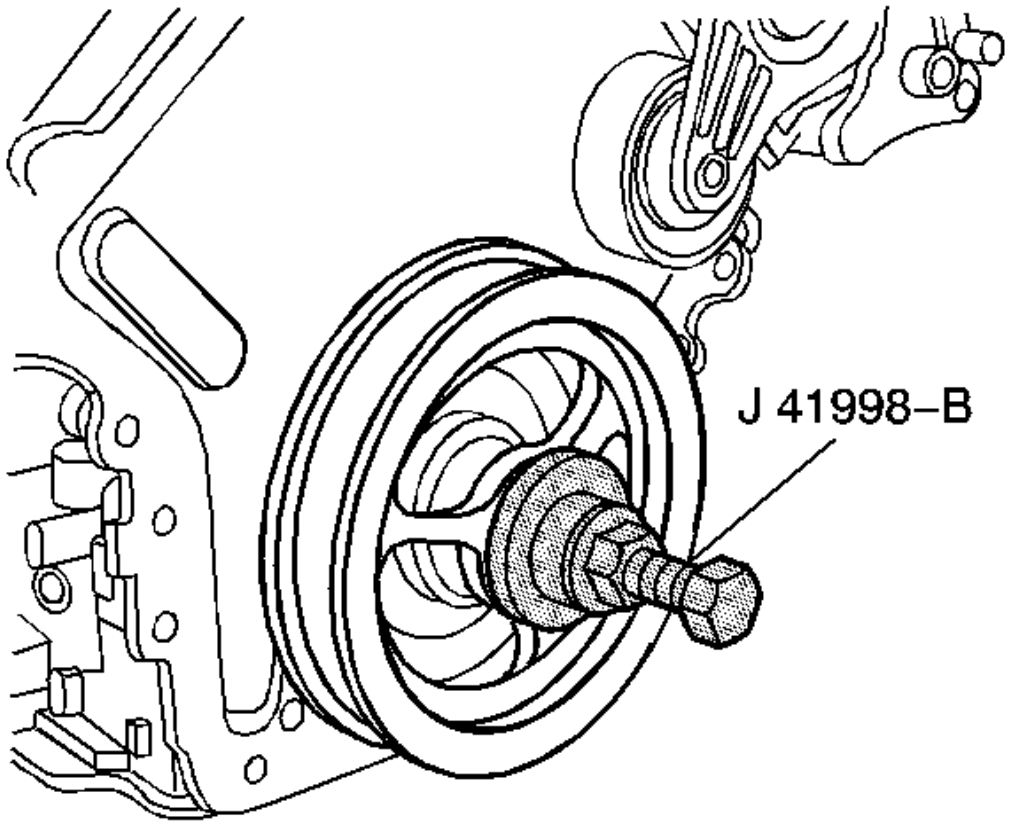

Fig. 102: Pressing Crankshaft Balancer Into Place
Courtesy of GENERAL MOTORS CORP.

2. Press the crankshaft balancer in place using the **J 41998-B** . See **Special Tools** .

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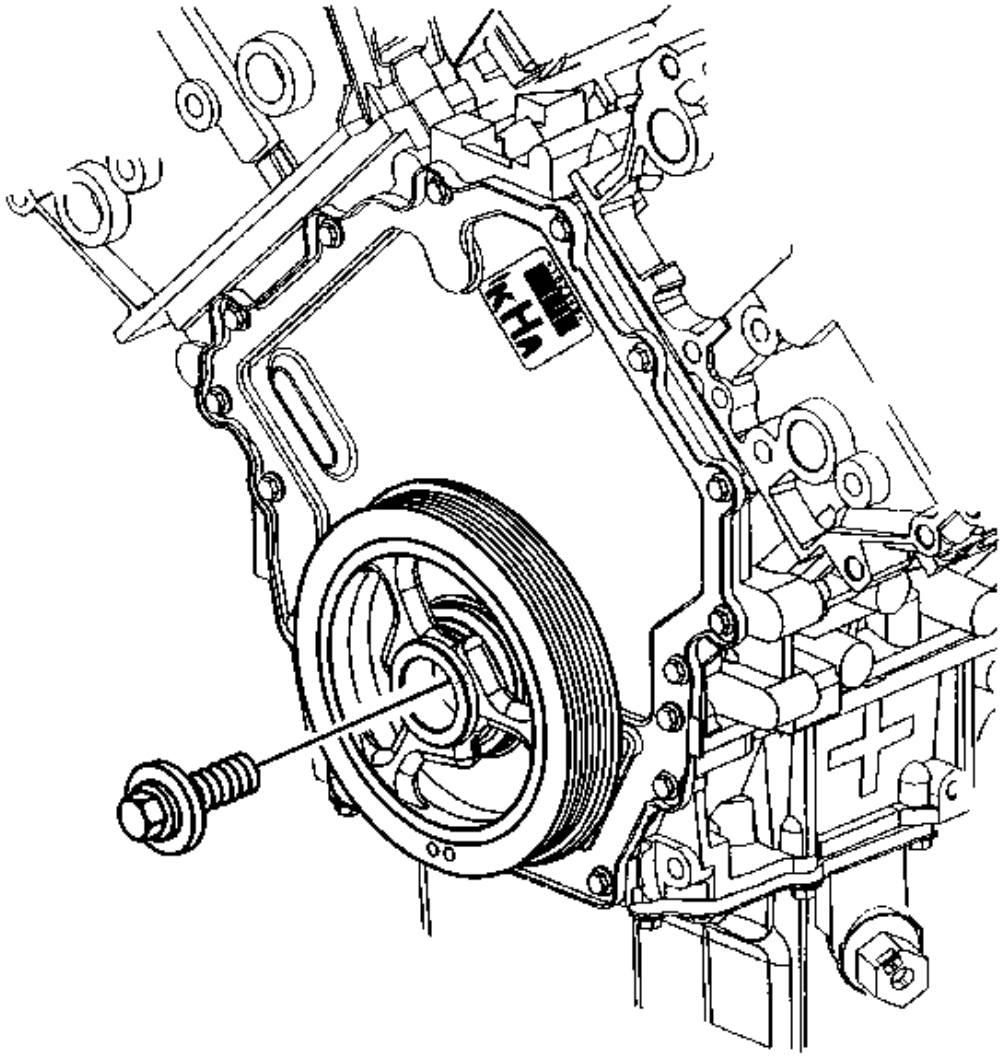

Fig. 103: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

3. Clean the crankshaft balancer bolt threads.
4. Apply engine oil to the crankshaft balancer bolt threads.

CAUTION: Refer to Fastener Caution .

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5. Install the crankshaft balancer bolt.

   Tighten:
   - Tighten the bolt a first pass to 50 N.m (37 lb ft).
   - Tighten the bolt a final pass an additional 120 degrees using the **J 45059** .

6. Raise the frame into position.
7. Install the right side frame bolts.

   Tighten: Tighten the bolts to 181 N.m (133 lb ft).

8. Install the front fascia. Refer to **Front Bumper Fascia Replacement** .
9. Remove the support(s) from the frame.

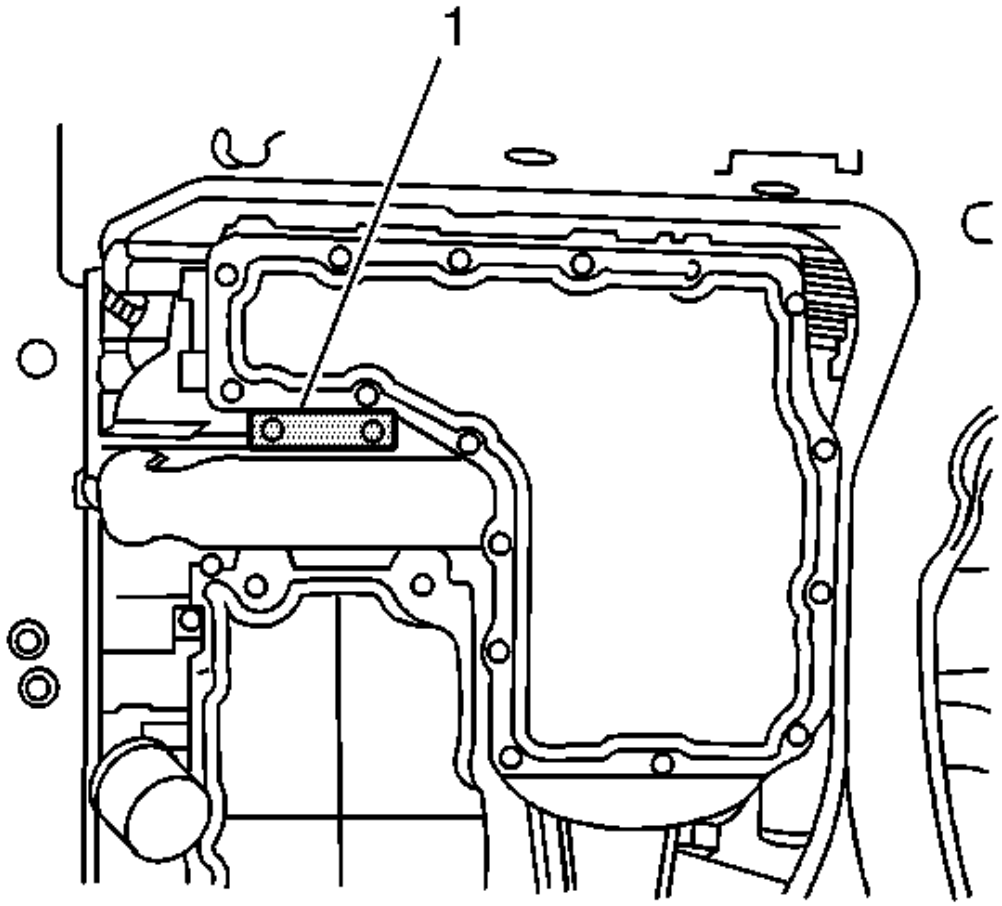

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Fig. 104: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

10. Remove the **J 44214** (1). See **Special Tools** .

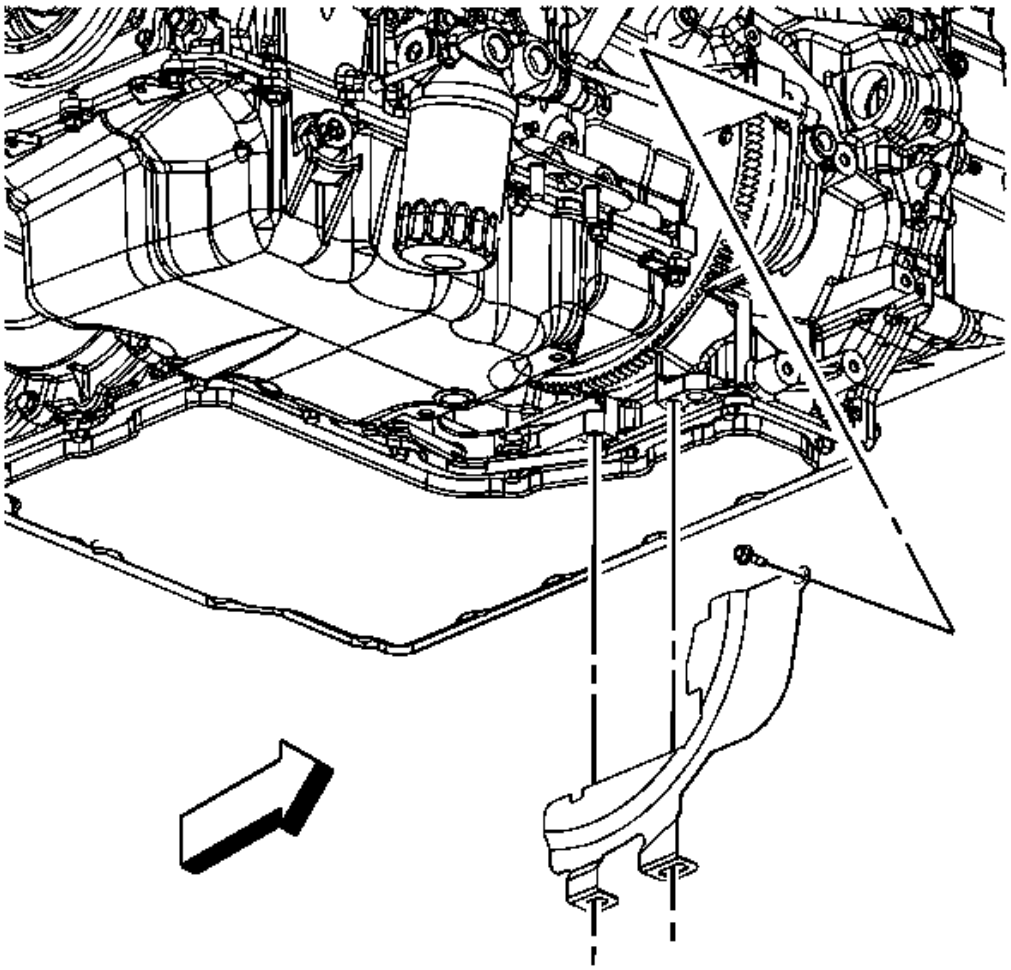

Fig. 105: Torque Converter Cover
Courtesy of GENERAL MOTORS CORP.

11. Position the torque converter cover.
12. Install the torque converter cover bolt.

Tighten: Tighten the bolt to 12 N.m (106 lb in).

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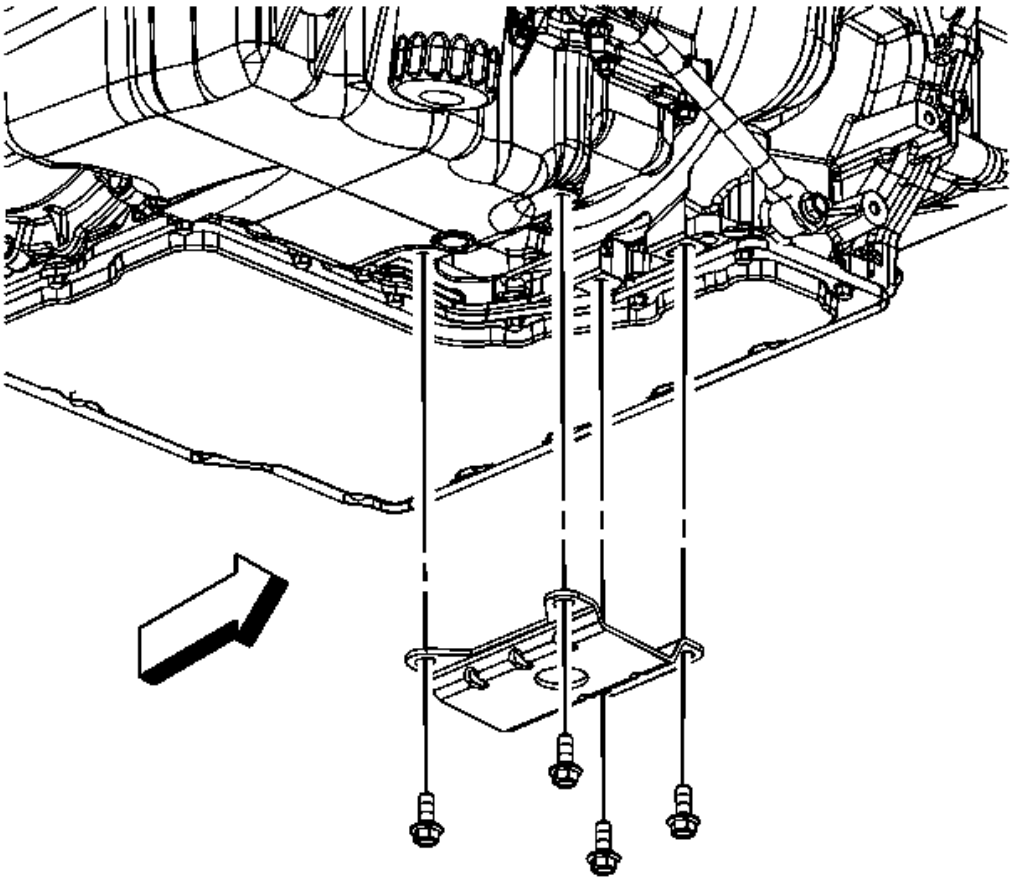

Fig. 106: Transaxle To Engine Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the transaxle to engine brace.
14. Install the transaxle to engine brace bolts.

    Tighten: Tighten the bolts to 47 N.m (35 lb ft).

15. Install the drive belt. Refer to **Drive Belt Replacement**.

ENGINE FRONT COVER REPLACEMENT

REMOVAL PROCEDURE

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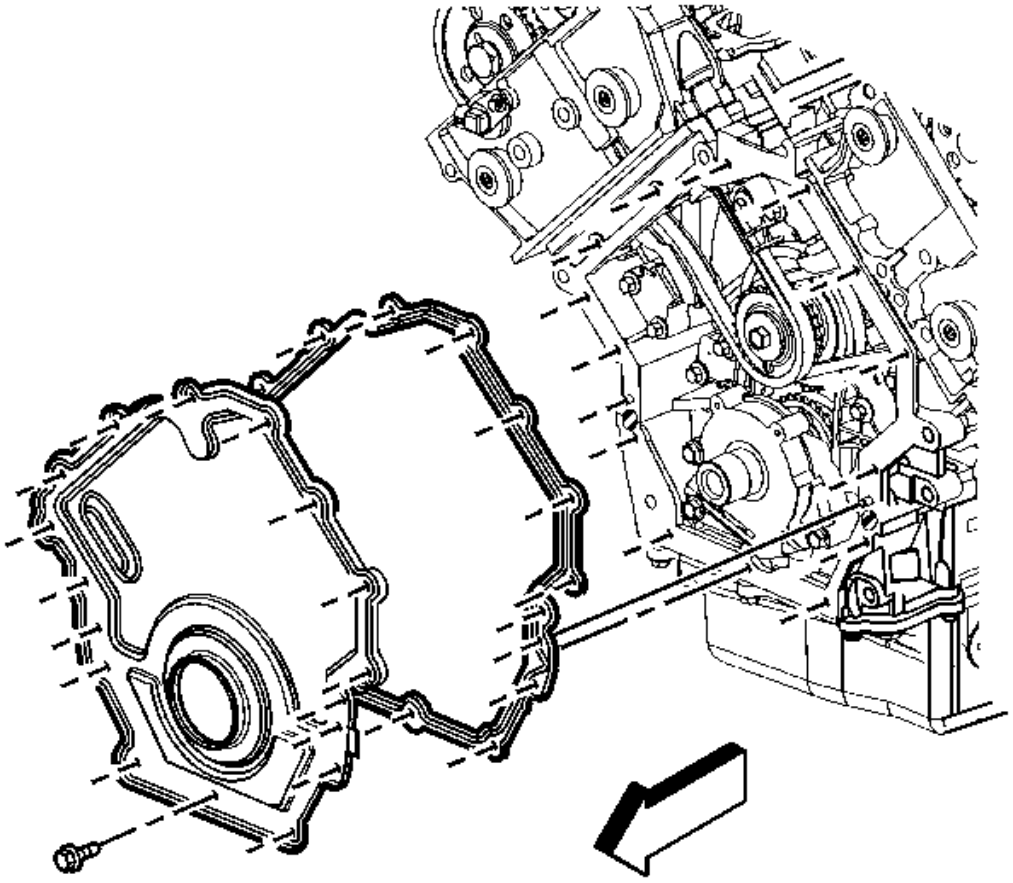

Fig. 107: Engine Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt idler pulley. Refer to **Drive Belt Idler Pulley Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the engine front cover bolts.
4. Remove the engine front cover and gasket. The gasket is reusable. Do not discard unless it is damaged.

INSTALLATION PROCEDURE

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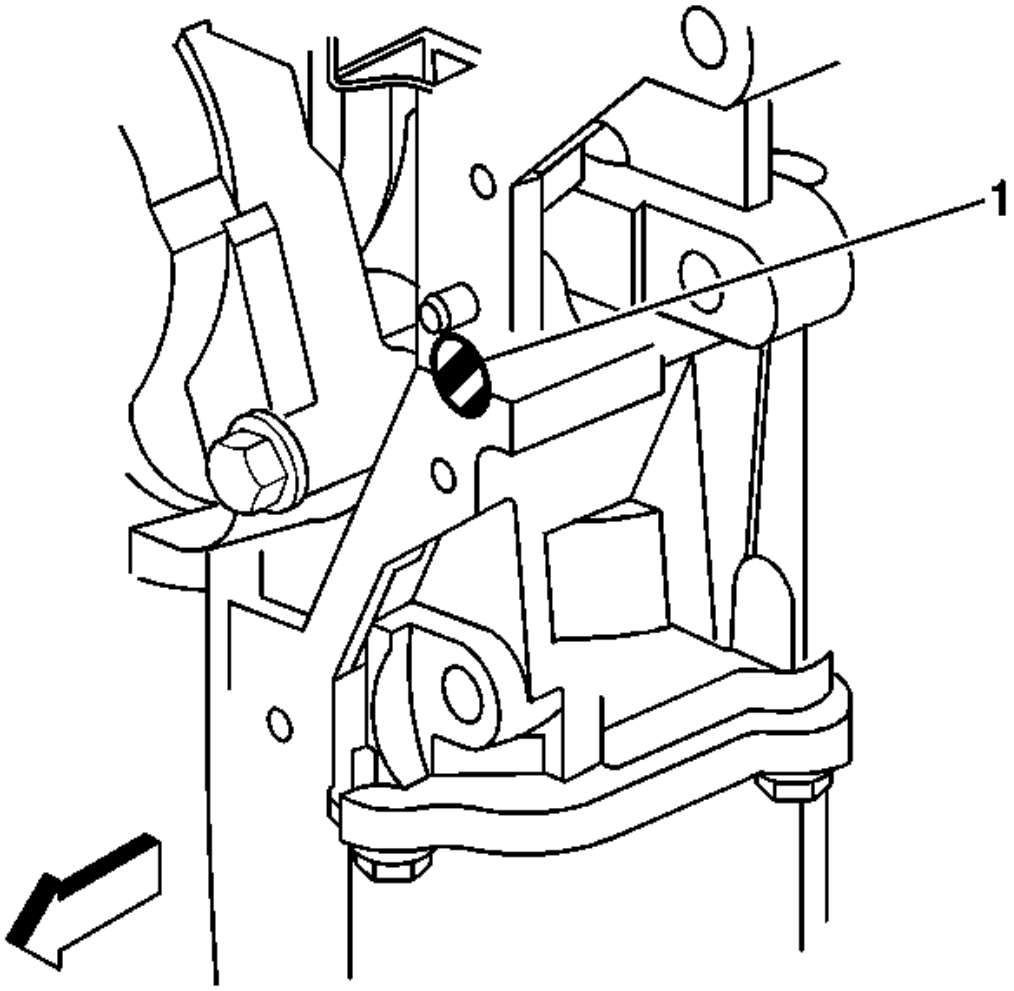

Fig. 108: Split Line Of Upper & Lower Crankcases
Courtesy of GENERAL MOTORS CORP.

1. Place a small amount of sealant at the split line of the upper and lower crankcases (1). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.

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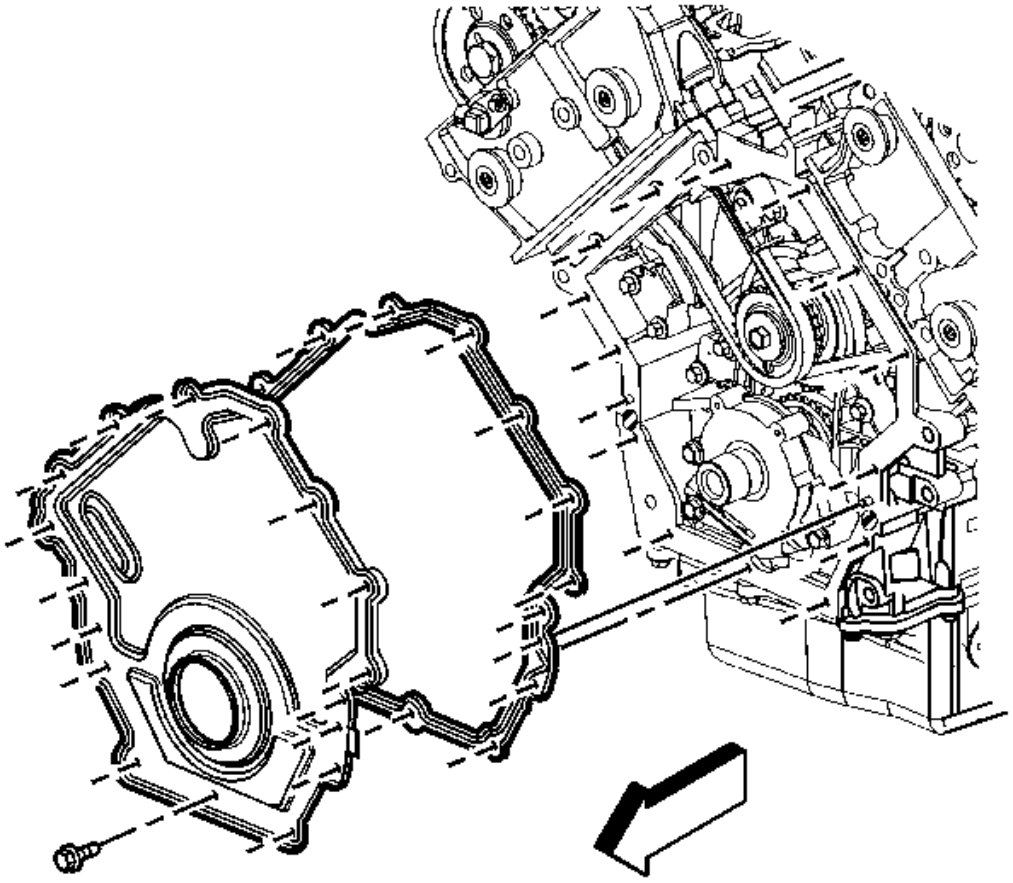

Fig. 109: Engine Front Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Place the engine front cover gasket over the crankcase dowel pins.
3. Place the engine front cover in position on the crankcase.
4. Apply threadlock to the engine front cover bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
5. Install the engine front cover bolts until snug.

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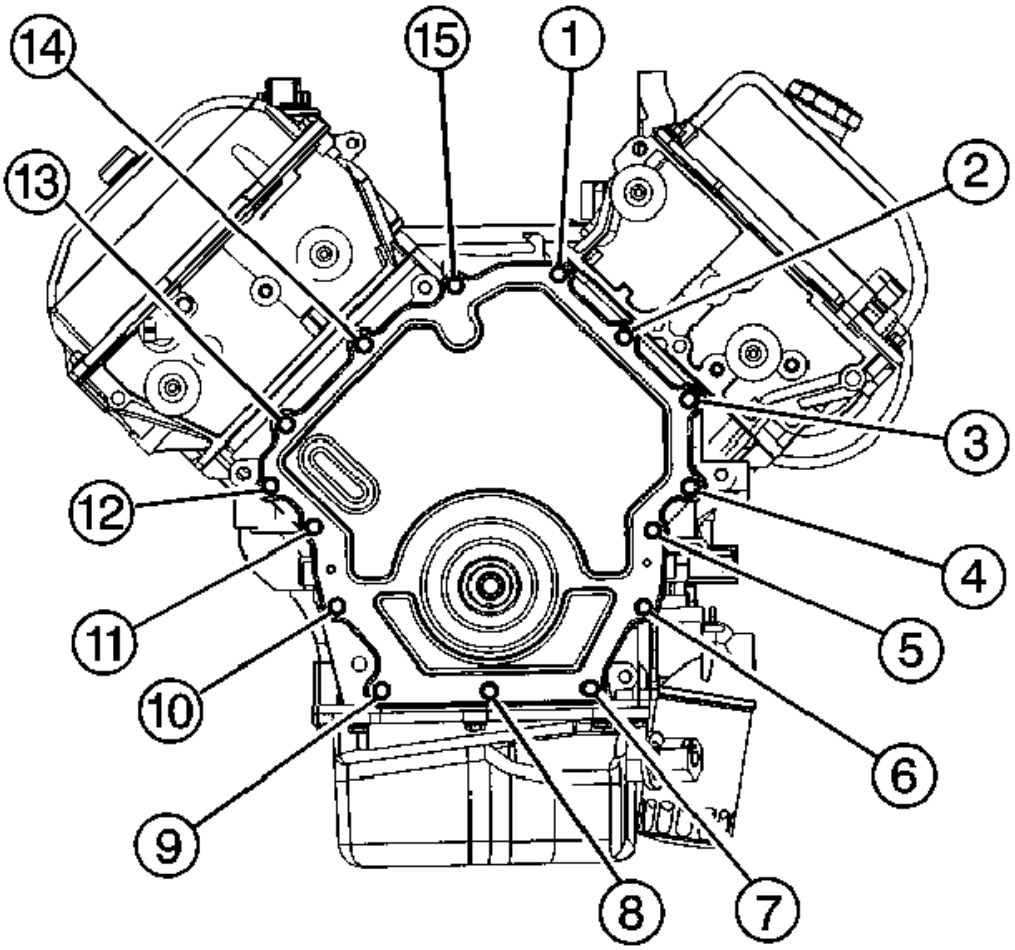

Fig. 110: Identifying Engine Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Tighten the engine front cover bolts.

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

7. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
8. Install the drive belt idler pulley. Refer to **Drive Belt Idler Pulley Replacement**.

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OIL PUMP REPLACEMENT

SPECIAL TOOLS

J 45059 Angle Meter

REMOVAL PROCEDURE

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

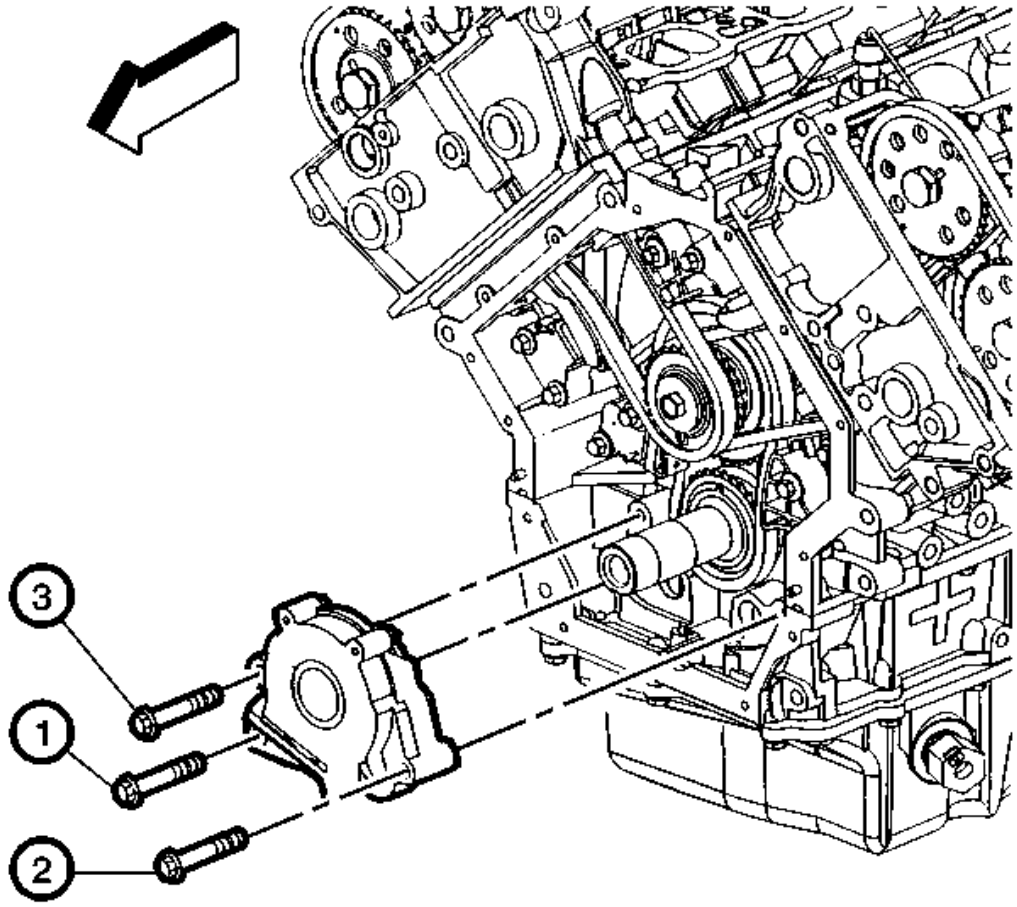

Fig. 111: Identifying Oil Pump Assembly Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the 3 oil pump assembly retaining bolts (1, 2, 3) identified by the larger head size.
3. Slide the oil pump assembly off the nose of the crankshaft with the drive collar in place.

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4. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection** .

INSTALLATION PROCEDURE

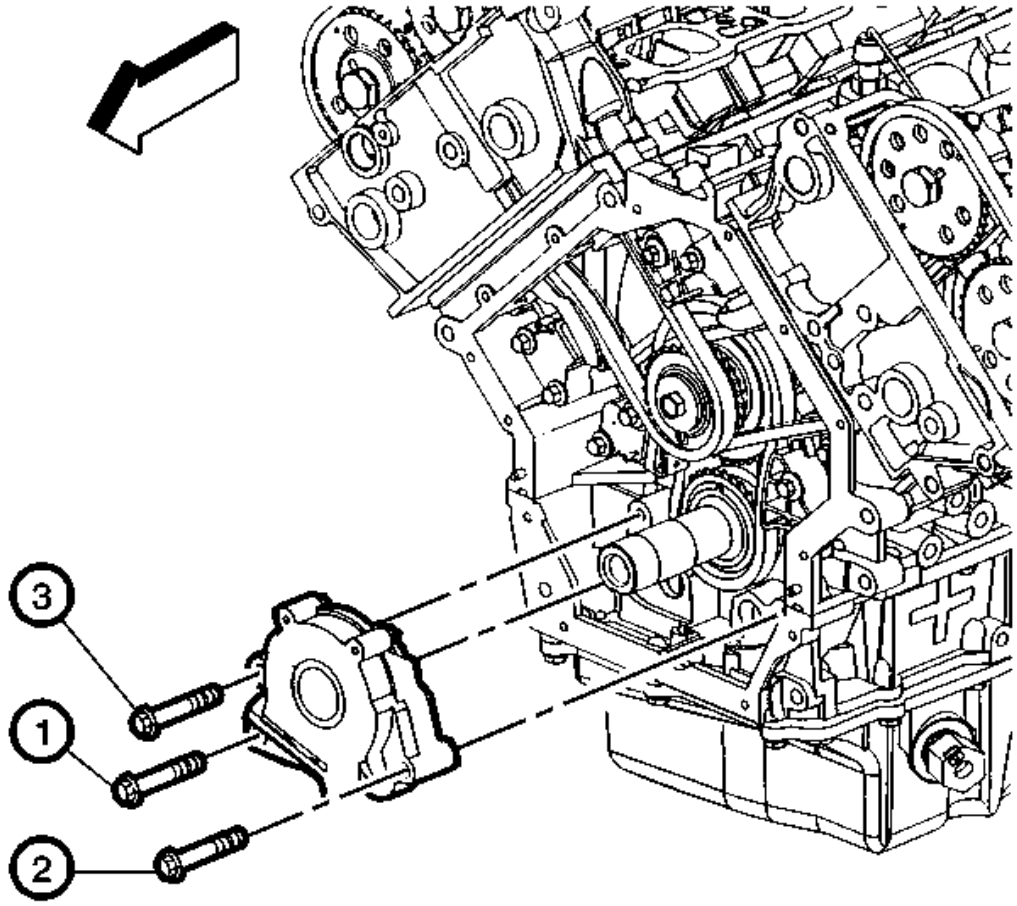

Fig. 112: Identifying Oil Pump Assembly Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the oil pump drive spacer into the oil pump so that the drive flat engages the pump rotor.
2. Position the oil pump on the crankshaft.
3. Install the retaining bolts.

CAUTION: Refer to Fastener Caution .

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4. Apply upward pressure on the pump while tightening the three retaining bolts. Tighten the bolts in the sequence (1, 2, 3) shown.

   Tighten:

   - First Pass

     Tighten the oil pump mounting bolts in sequence to 10 N.m (89 lb in).

   - Final Pass

     Tighten the oil pump mounting bolts in sequence an additional 35 degrees using the **J 45059** .

5. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

REMOVAL PROCEDURE

1. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.

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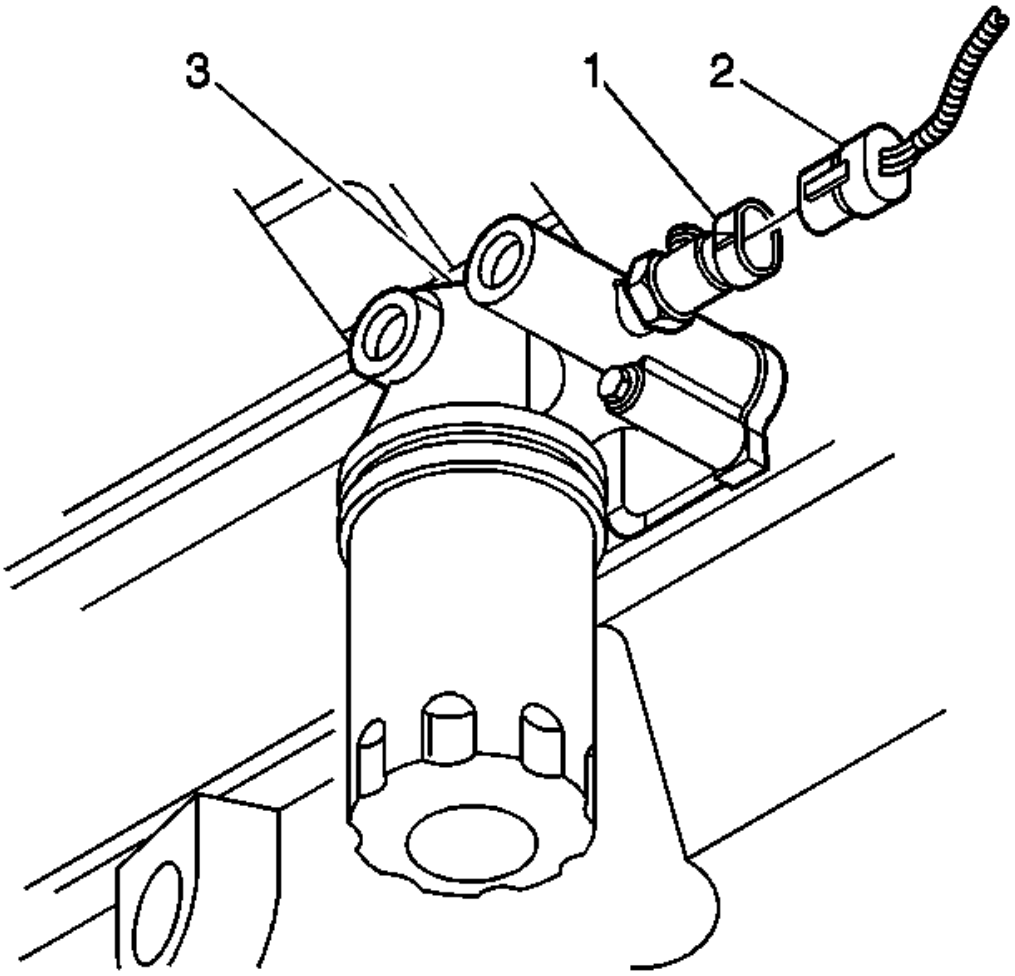

Fig. 113: Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil pressure switch (1) from the oil filter adapter (3).

INSTALLATION PROCEDURE

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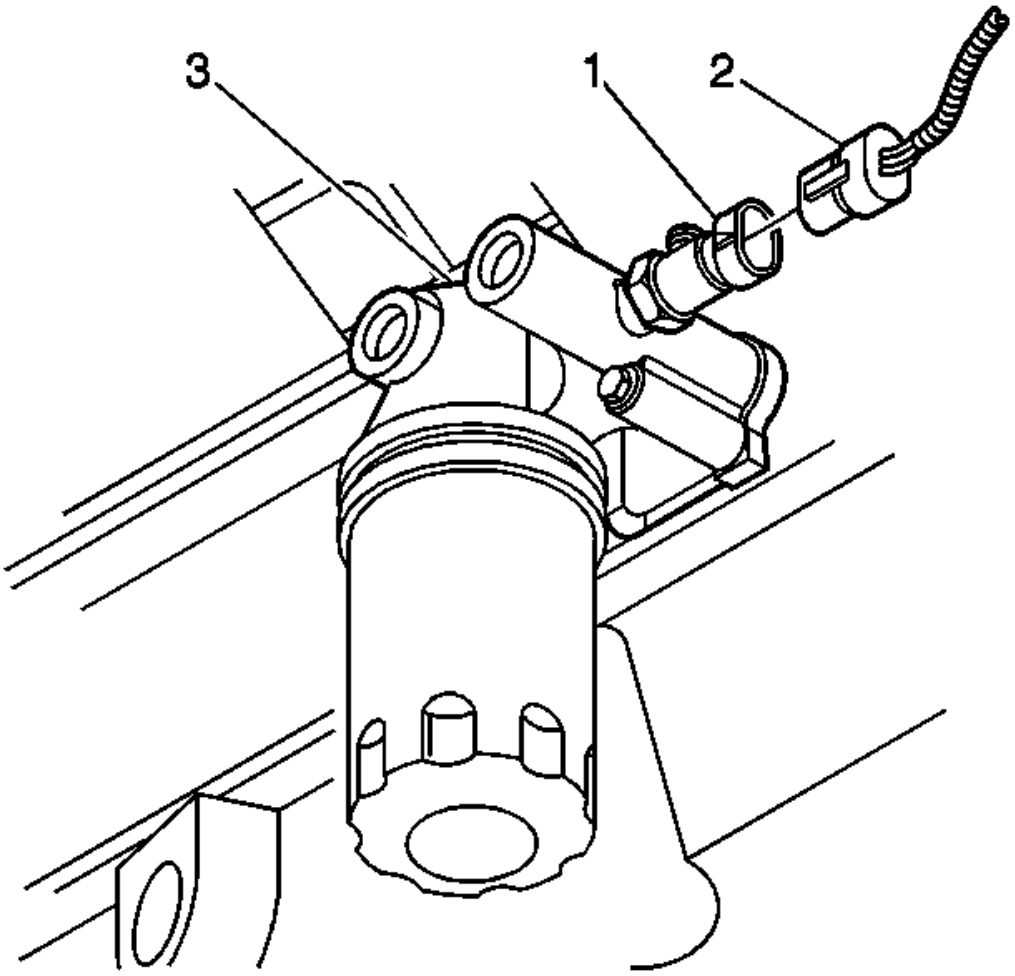

Fig. 114: Engine Oil Pressure Switch Electrical Connector
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil pressure switch (1) to the oil filter adapter (3).

   Tighten: Tighten the engine oil pressure switch to 16 N.m (12 lb ft).

2. Install the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
3. Lower the vehicle.

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4. Adjust the engine oil level to the full mark.
5. Inspect for oil leaks after engine start up.

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

REMOVAL PROCEDURE

1. Remove the air conditioning (A/C) compressor. Refer to **Air Conditioning Compressor Replacement (LGD, LZ9)** or **Air Conditioning Compressor Replacement (L37)** .
2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .

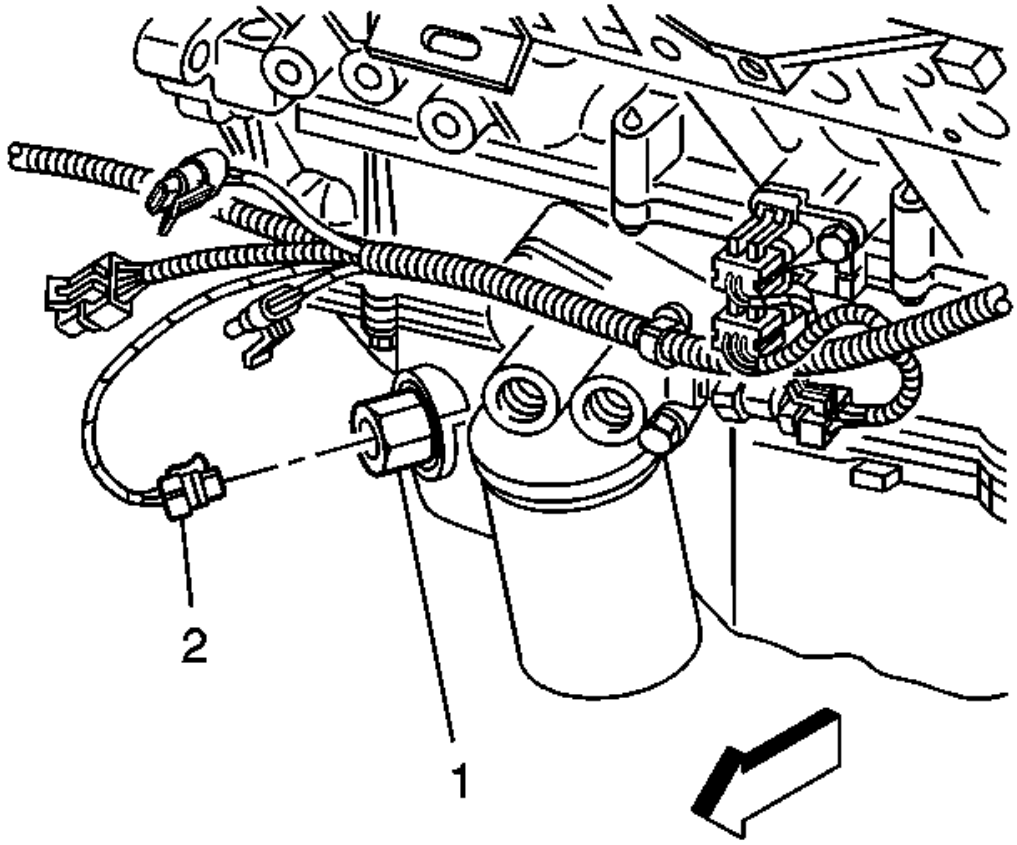

Fig. 115: Engine Oil Level Sensor & Electrical Connector
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the electrical connector (2) from the engine oil level sensor (1).
4. Remove the engine oil level sensor (1) from the oil pan.

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INSTALLATION PROCEDURE

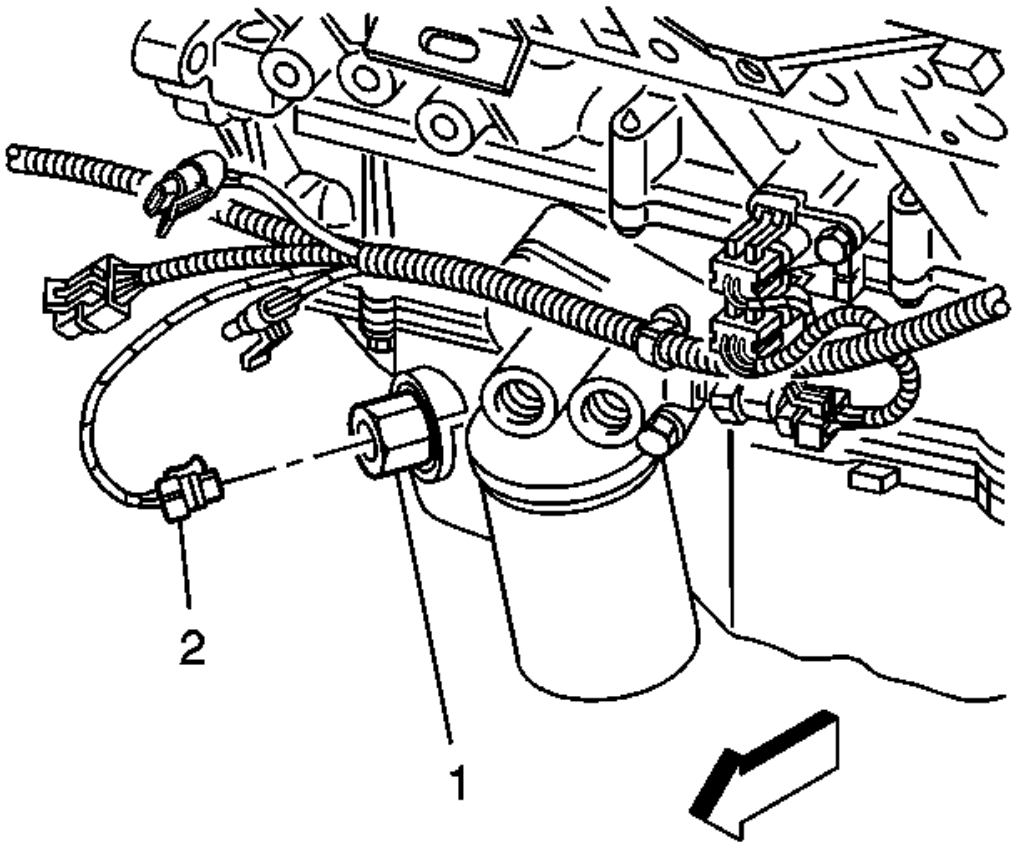

Fig. 116: Engine Oil Level Sensor & Electrical Connector
Courtesy of GENERAL MOTORS CORP.

CAUTION: Replacement components must be the correct part number for the application. Components requiring the use of the thread locking compound, lubricants, corrosion inhibitors, or sealants are identified in the service procedure. Some replacement components may come with these coatings already applied. Do not use these coatings on components unless specified. These coatings can affect the final torque, which may affect the operation of the component. Use the correct torque specification when installing components in order to avoid damage.

CAUTION: Refer to Fastener Caution .

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1. Install the engine oil level sensor (1) into the oil pan.

   Tighten: Tighten the engine oil level sensor to 20 N.m (15 lb ft).

2. Connect the electrical connector (2) to the engine oil level sensor (1).
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
4. Install the A/C compressor. Refer to **Air Conditioning Compressor Replacement (LGD, LZ9)** or **Air Conditioning Compressor Replacement (L37)** .
5. Inspect for oil leaks after engine start up.

OIL PUMP SUCTION PIPE AND SCREEN ASSEMBLY REPLACEMENT

REMOVAL PROCEDURE

1. Remove the engine oil pan. Refer to **Oil Pan Replacement**.

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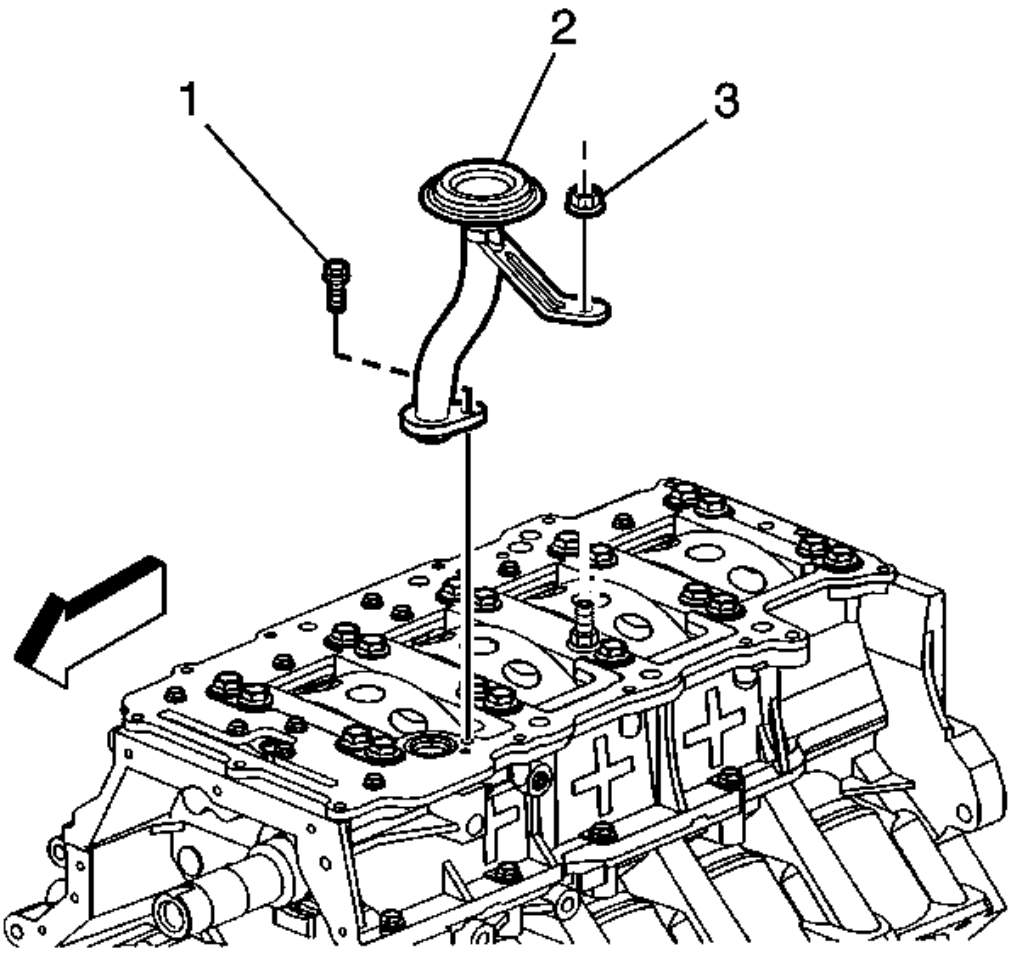

Fig. 117: Oil Pump Pickup Tube Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump pickup tube support nut (3) from the main bearing stud.
3. Remove the mounting bolt (1) from the oil manifold plate.
4. Remove the oil pump pickup tube (2).

INSTALLATION PROCEDURE

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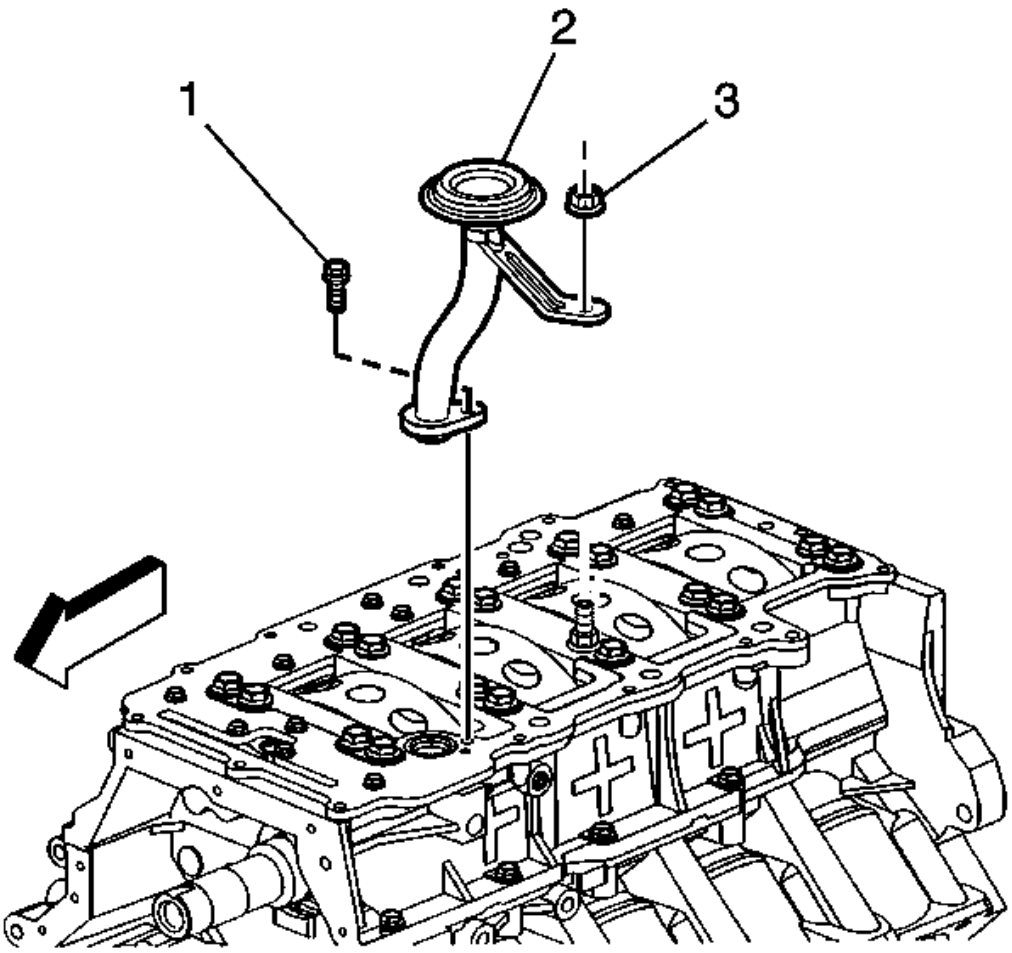

Fig. 118: Oil Pump Pickup Tube Components
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the silicone seal in the oil manifold plate.

   With a twisting motion, install the end of the oil pump pick-up tube (2).

   CAUTION: Refer to Fastener Caution .

2. Install the oil pump pick-up retaining bolt (1) and nut (3).

   Tighten:

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- Tighten the oil pump pick-up tube nut to 24 N.m (18 lb ft).
- Tighten the oil pump pick-up tube bolt to 10 N.m (89 lb in).

3. Install the oil pan. Refer to **Oil Pan Replacement**.

CAMSHAFT COVER REPLACEMENT - LEFT SIDE

Special Tools

- **J 38823** Water Pump Drive Pulley Installer
- **J 38825** Water Pump Drive Pulley Remover

REMOVAL PROCEDURE

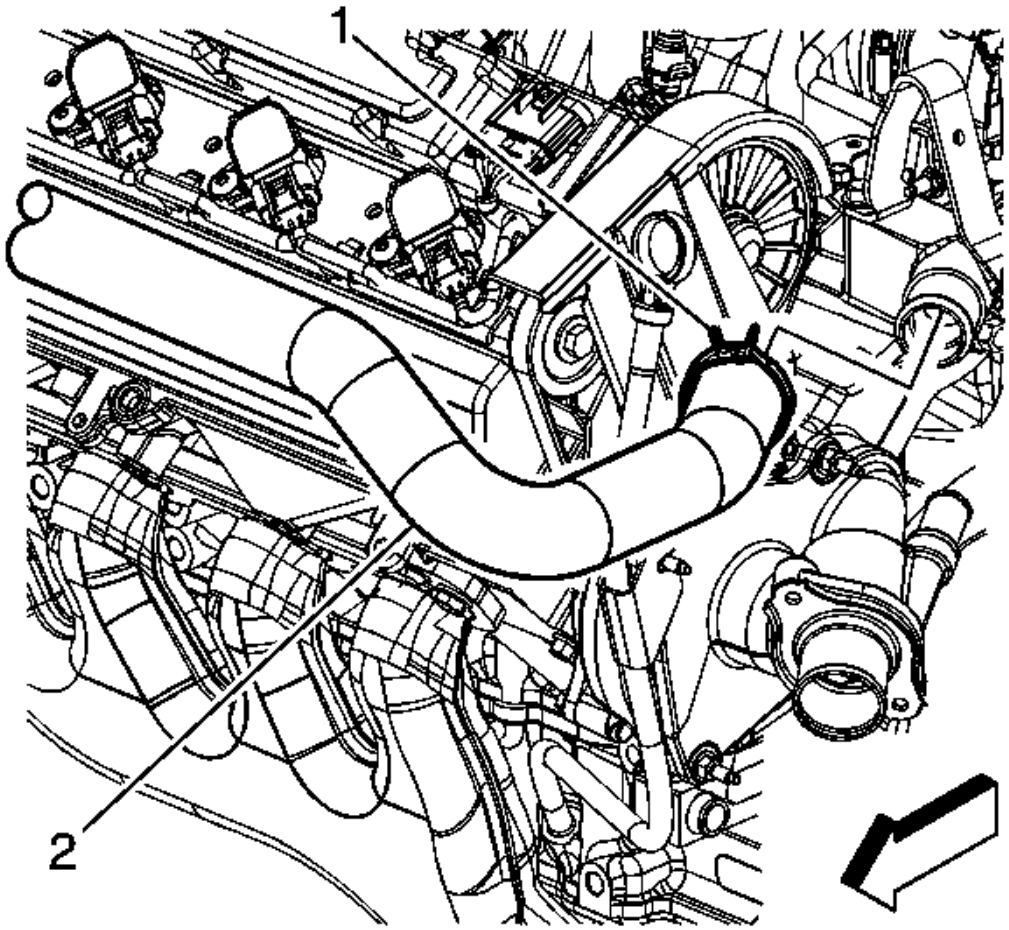

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Fig. 119: Radiator Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Remove the upper tie bar. Refer to **Front End Upper Tie Bar Replacement** .
3. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (Vac-N-Fill)** .
4. Reposition the radiator inlet hose clamp (1).
5. Remove the radiator inlet hose (2) from the water pump housing.

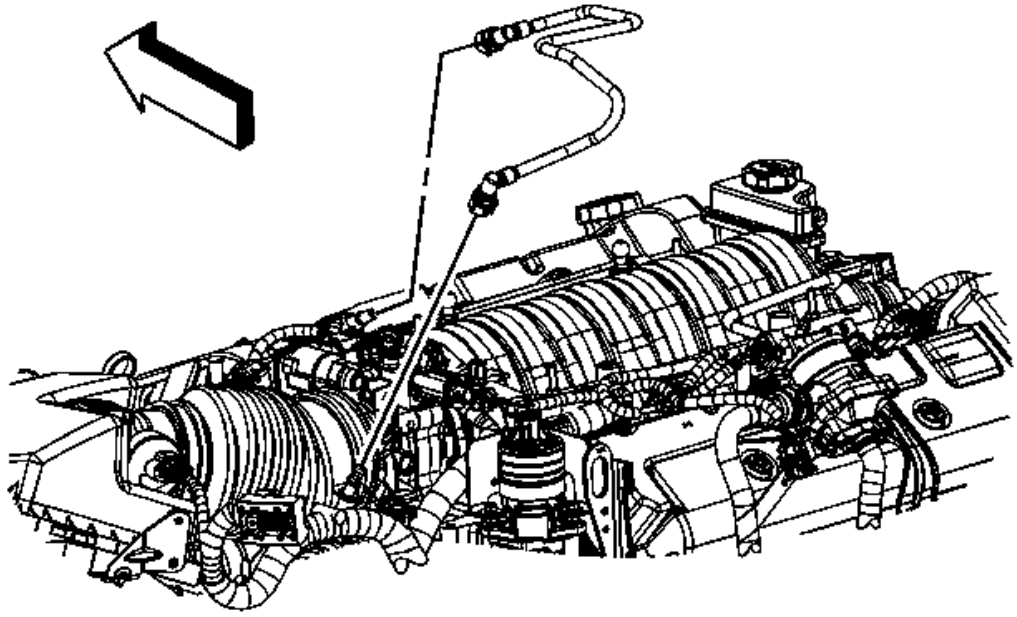

Fig. 120: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the positive crankcase ventilation (PCV) fresh air tube quick connect fitting from the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
7. Remove the ignition coils. Refer to **Ignition Coil Replacement - Bank 2** .

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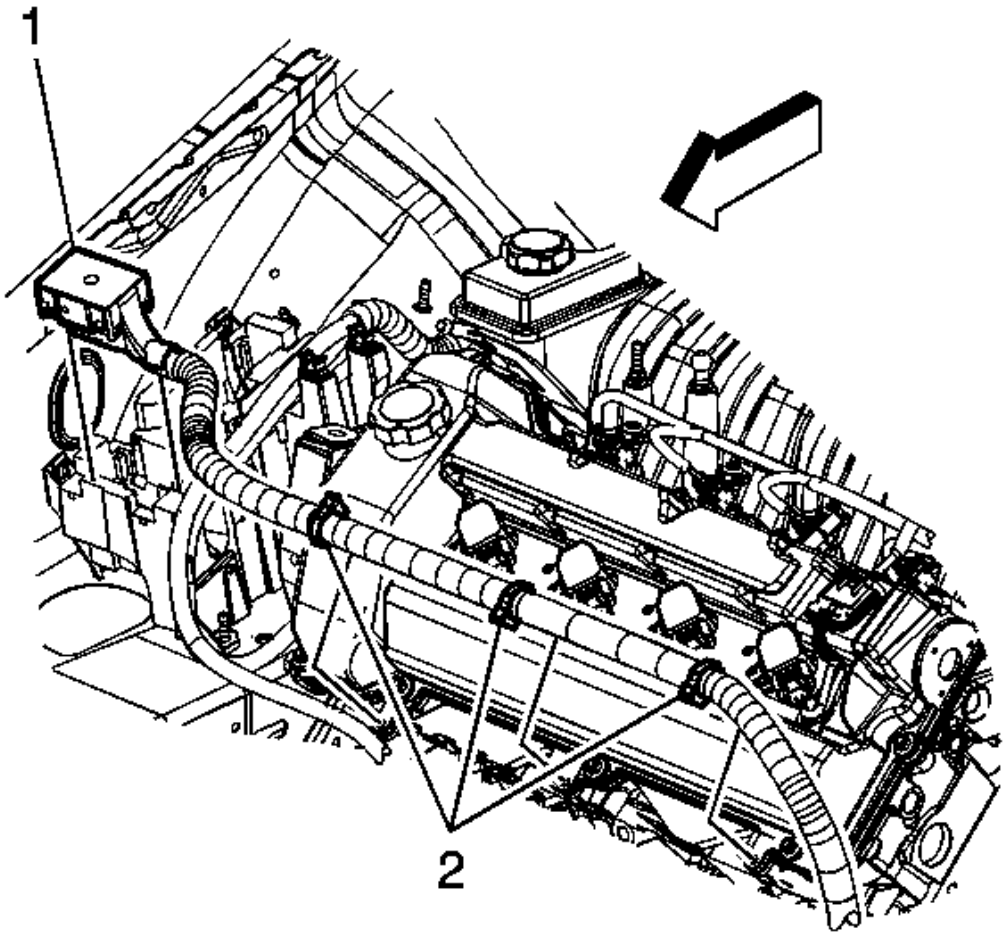

Fig. 121: Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine harness clips (2) from the camshaft cover and position the harness aside.

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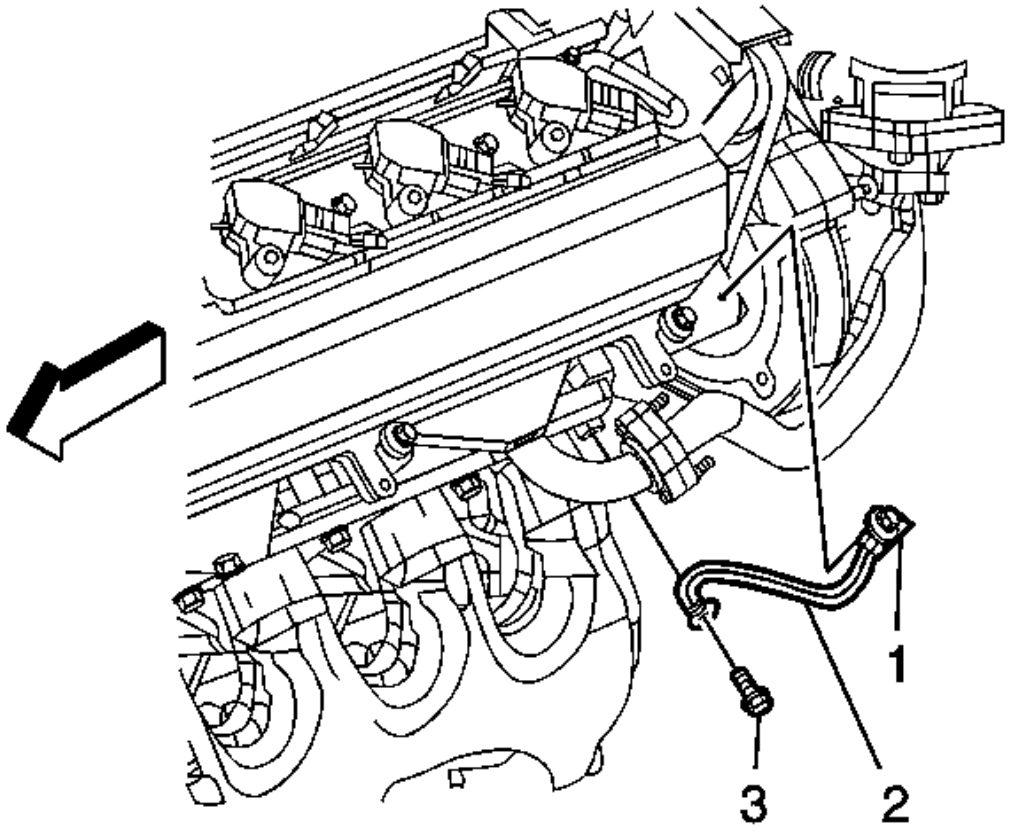

Fig. 122: ICM Wiring Harness Ground
Courtesy of GENERAL MOTORS CORP.

9. Loosen the ignition control module (ICM) wiring harness ground bolt (1) from the camshaft cover.
10. Remove the ground wire terminal/bolt from the camshaft cover.

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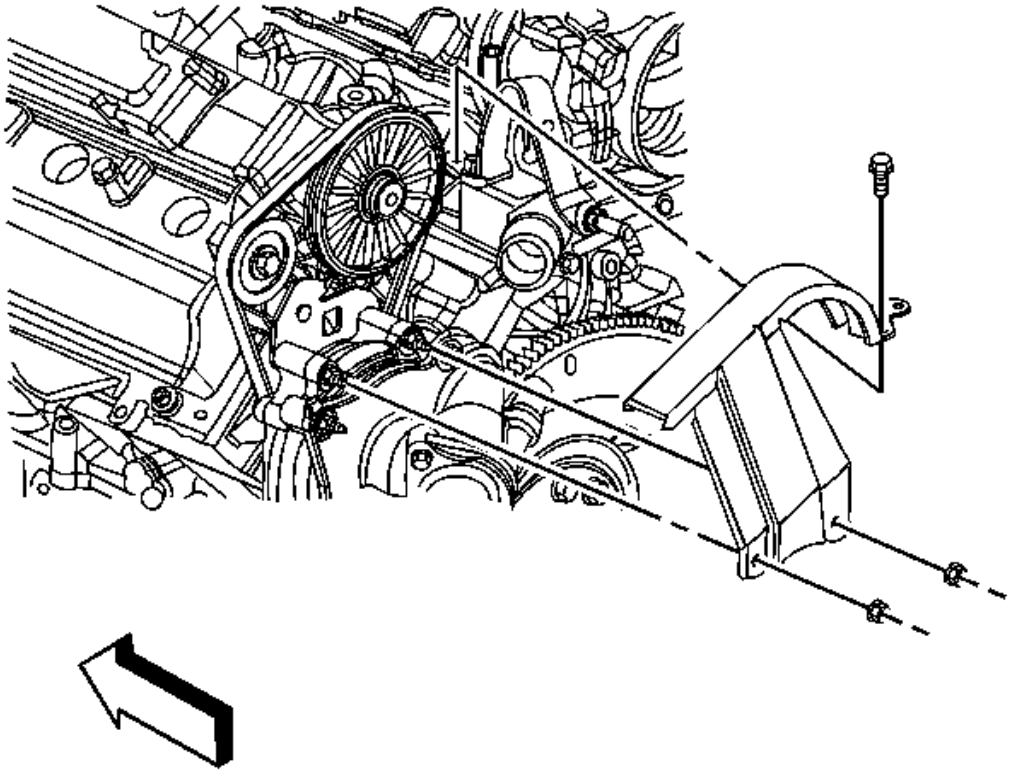

Fig. 123: Water Pump Drive Belt Tensioner Shield
Courtesy of GENERAL MOTORS CORP.

11. Remove the water pump drive belt tensioner shield bolt/nuts.
12. Remove the water pump drive belt shield.
13. Remove the water pump drive belt from the pulleys.

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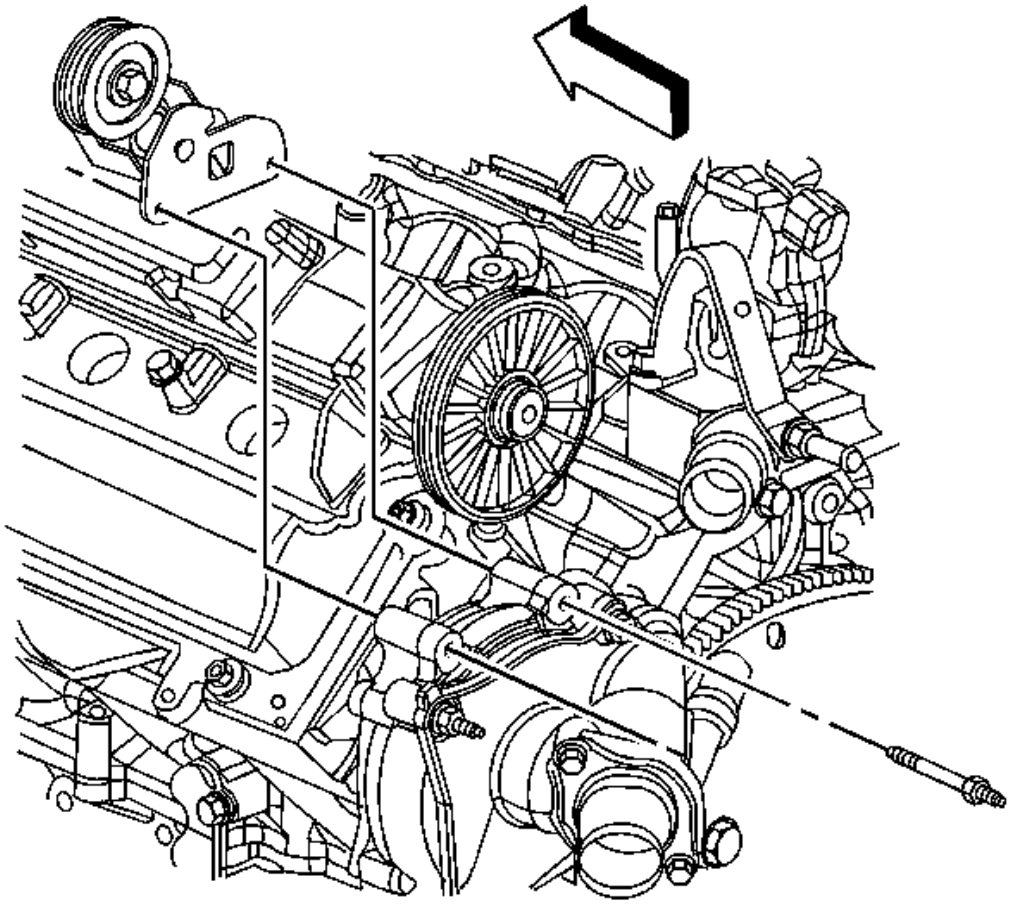

Fig. 124: Water Pump Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

14. Remove the water pump drive belt tensioner studs.
15. Remove the water pump belt tensioner.

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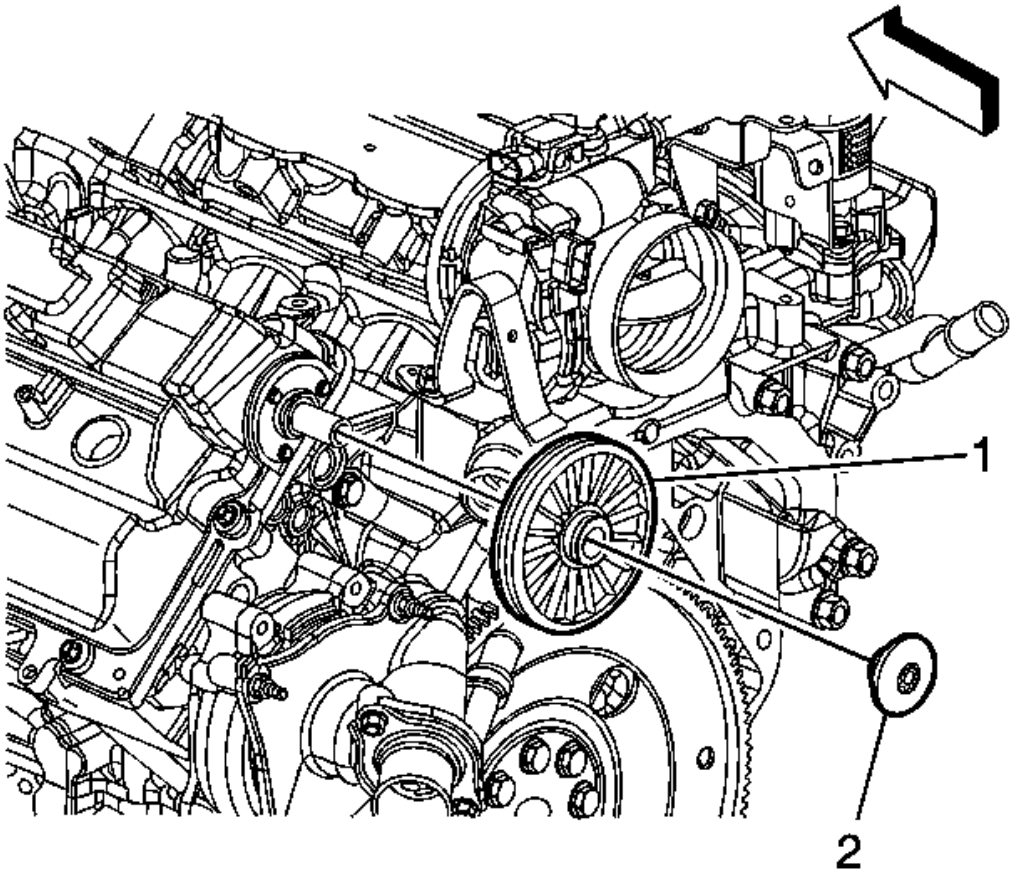

Fig. 125: Plastic Dust Cap
Courtesy of GENERAL MOTORS CORP.

16. Remove the plastic dust cap (2) from the end of the intake camshaft.

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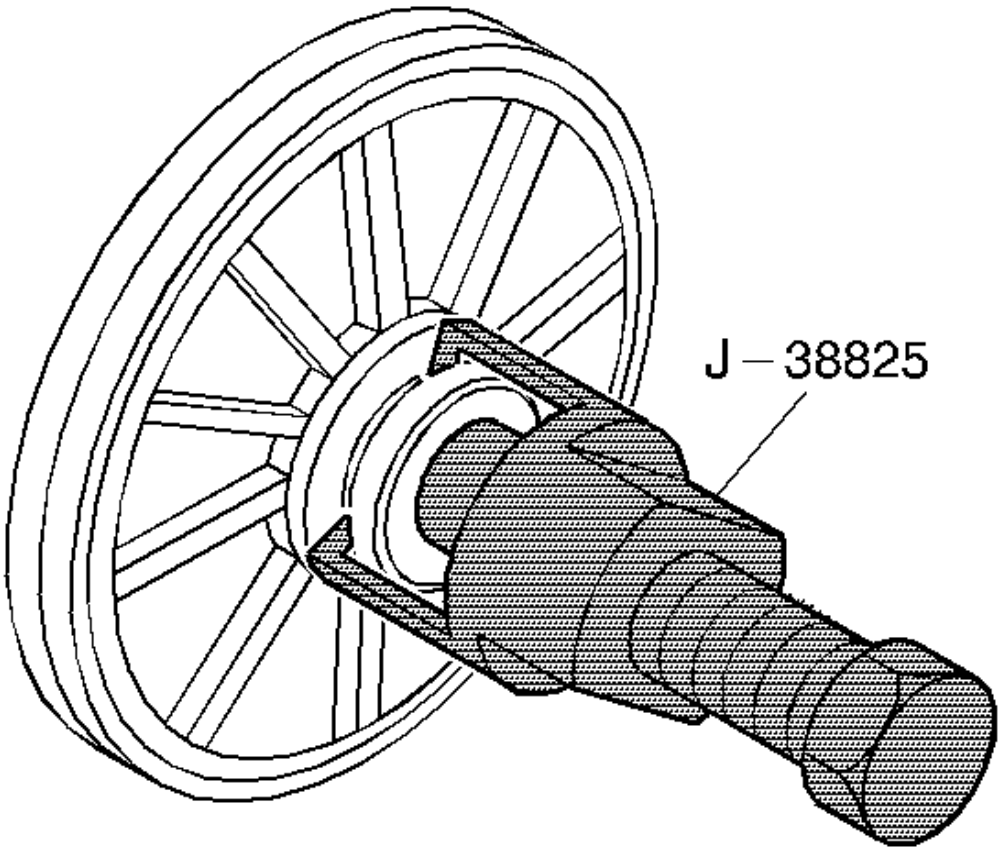

Fig. 126: Removing Water Pump Drive Pulley From Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

17. Remove the water pump pulley from the intake camshaft using the **J 38825** .

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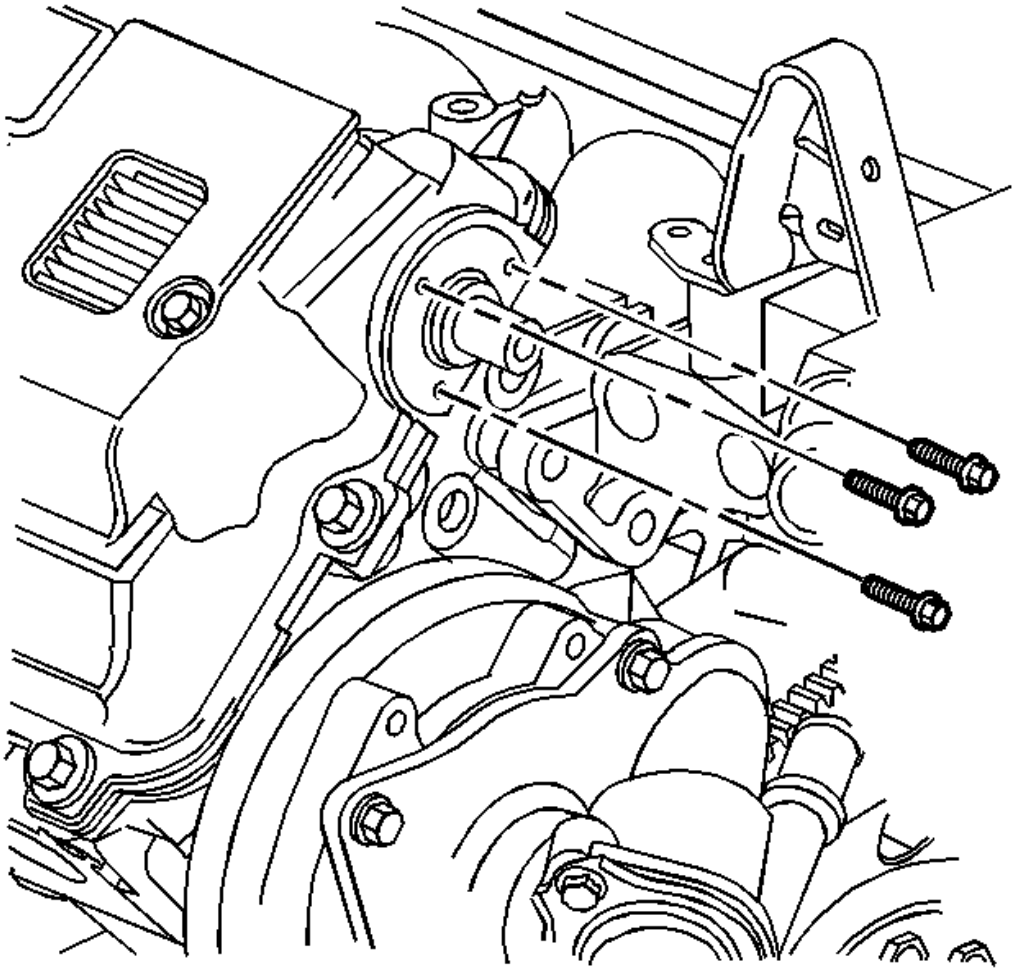

Fig. 127: Camshaft Seal Bolts
Courtesy of GENERAL MOTORS CORP.

18. Remove the camshaft seal bolts.

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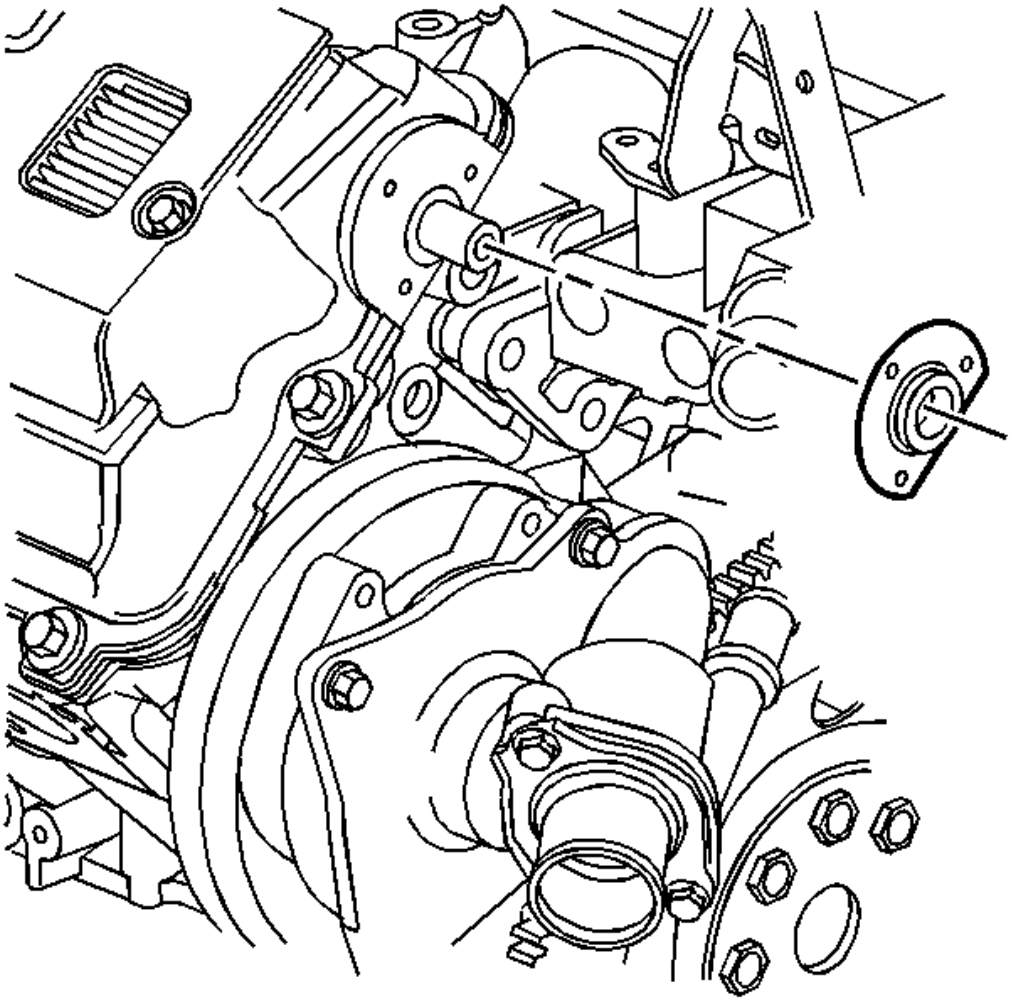

Fig. 128: Camshaft Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT reuse the camshaft seal.

19. Remove and discard the camshaft seal.

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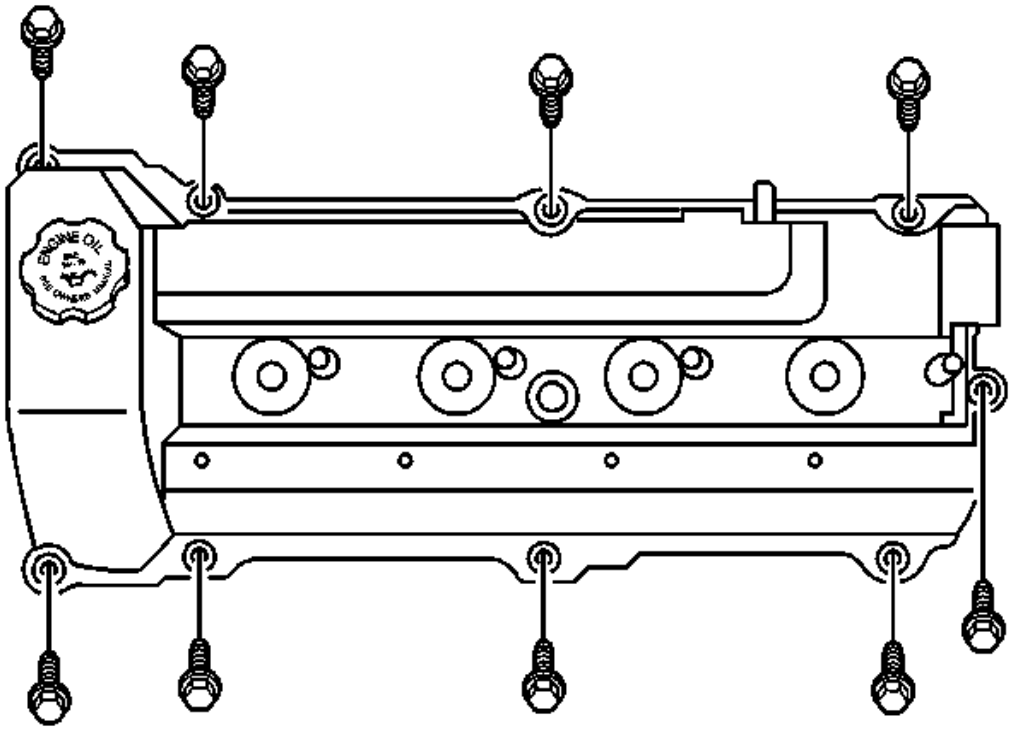

Fig. 129: Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

20. Loosen the camshaft cover bolts.

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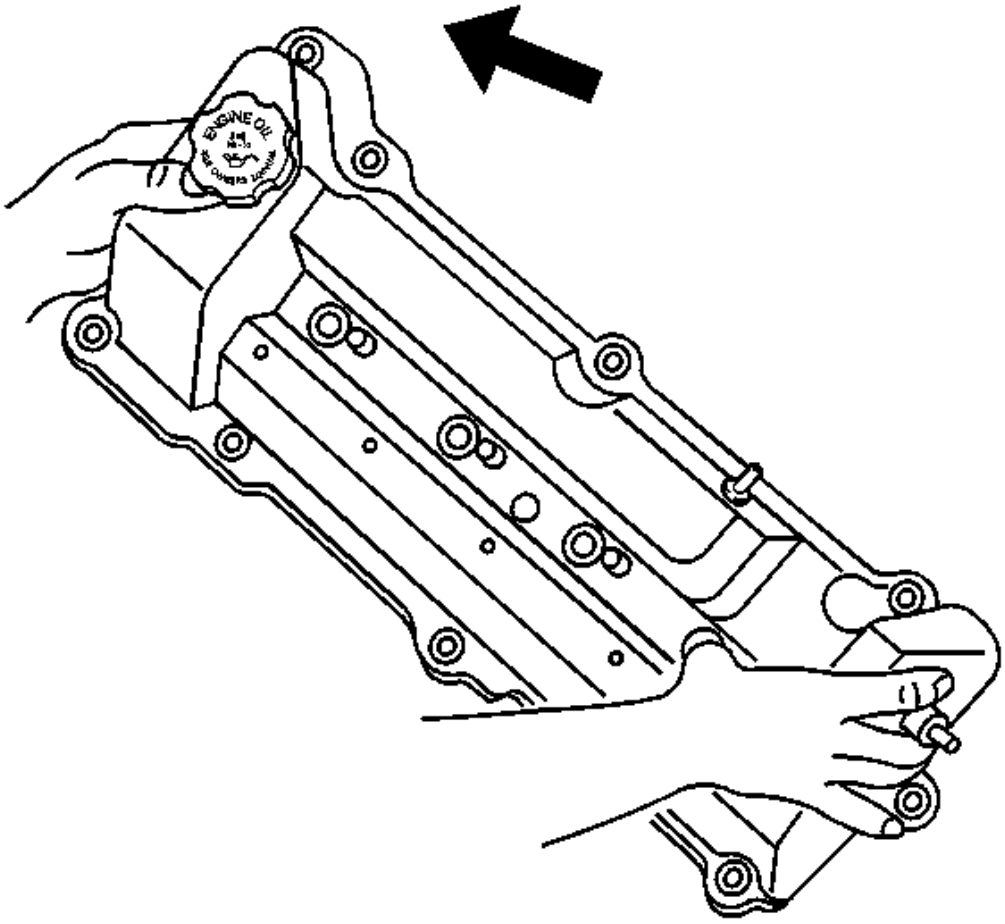

Fig. 130: Lifting Camshaft Drive End Of Cover
Courtesy of GENERAL MOTORS CORP.

21. Lift the camshaft drive end of the cover up.

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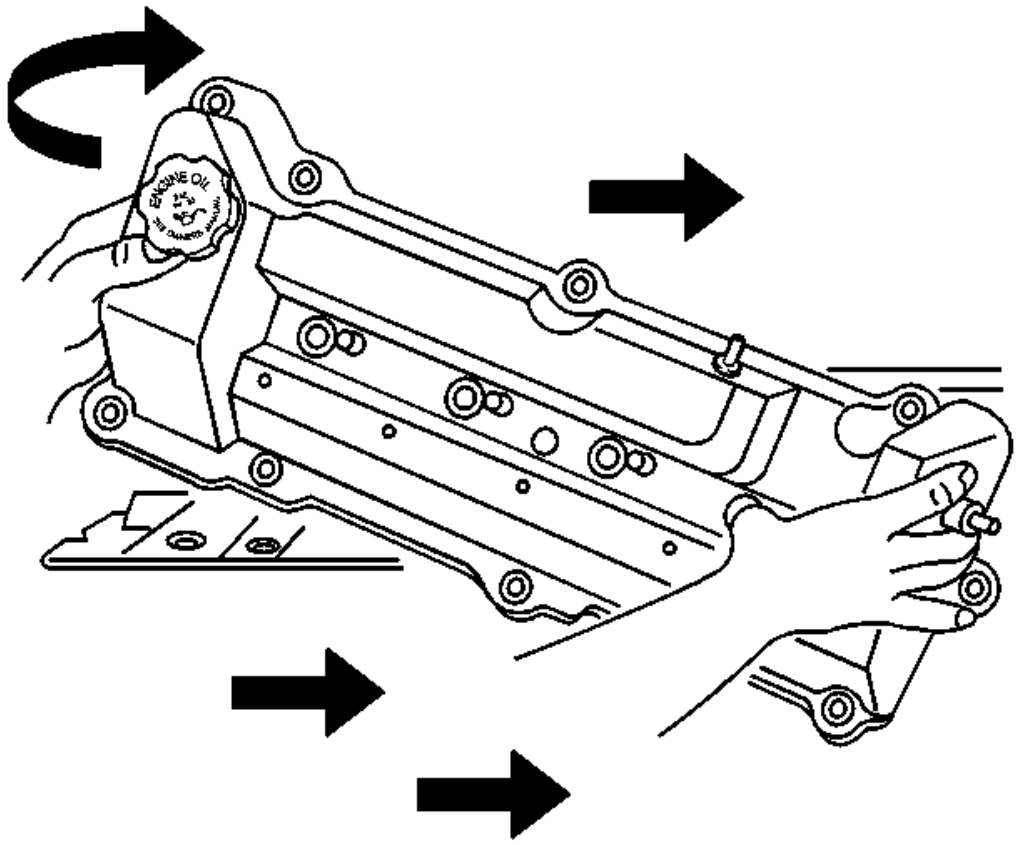

Fig. 131: Removing Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

22. Move the camshaft cover reward in order to clear the water pump drive shaft.
23. Discard the camshaft cover perimeter seals and spark plug seals if there is any evidence of damage or if the seal comes out of the groove in the cover during removal.
24. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection** .

INSTALLATION PROCEDURE

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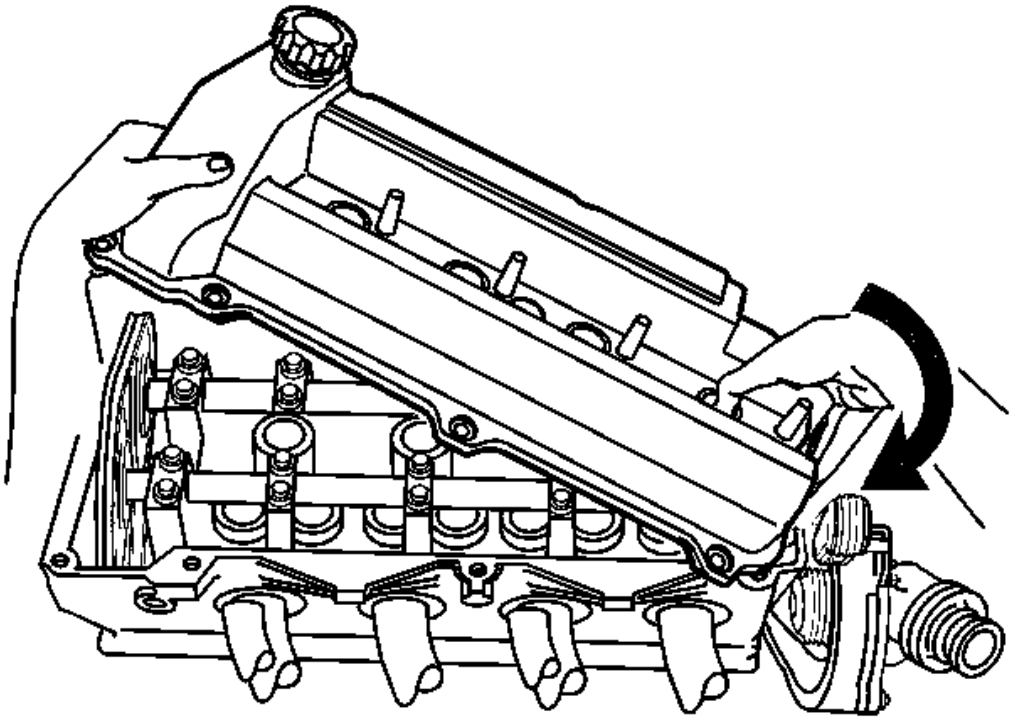

Fig. 132: Installing Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful to prevent the exposed section of the camshaft cover seal from being damaged by the edge of the cylinder head casting.

1. Install the camshaft cover seal as required.
2. Install the camshaft cover end over the intake camshaft end.

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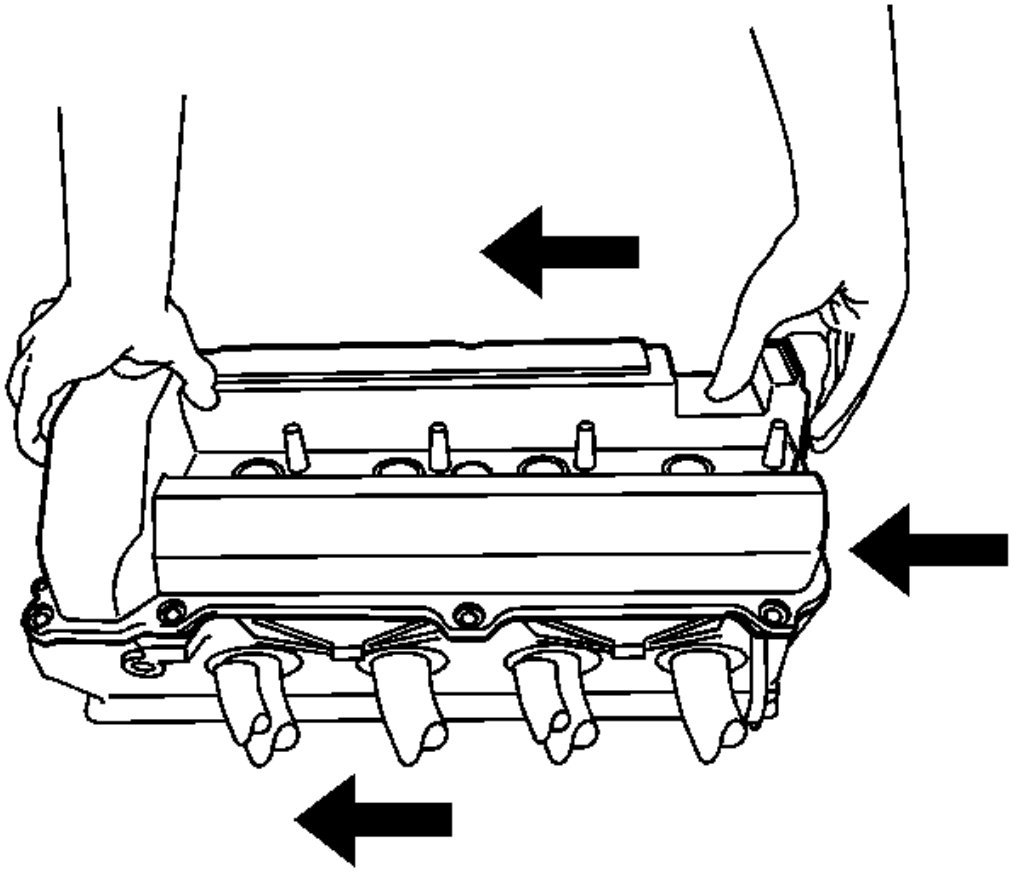

Fig. 133: Pivoting Cover Down & Left
Courtesy of GENERAL MOTORS CORP.

3. Work the camshaft cover into position by pivoting the cover down and to the left allowing the cover to clear the camshaft drive chain and then aligning the bolt holes.

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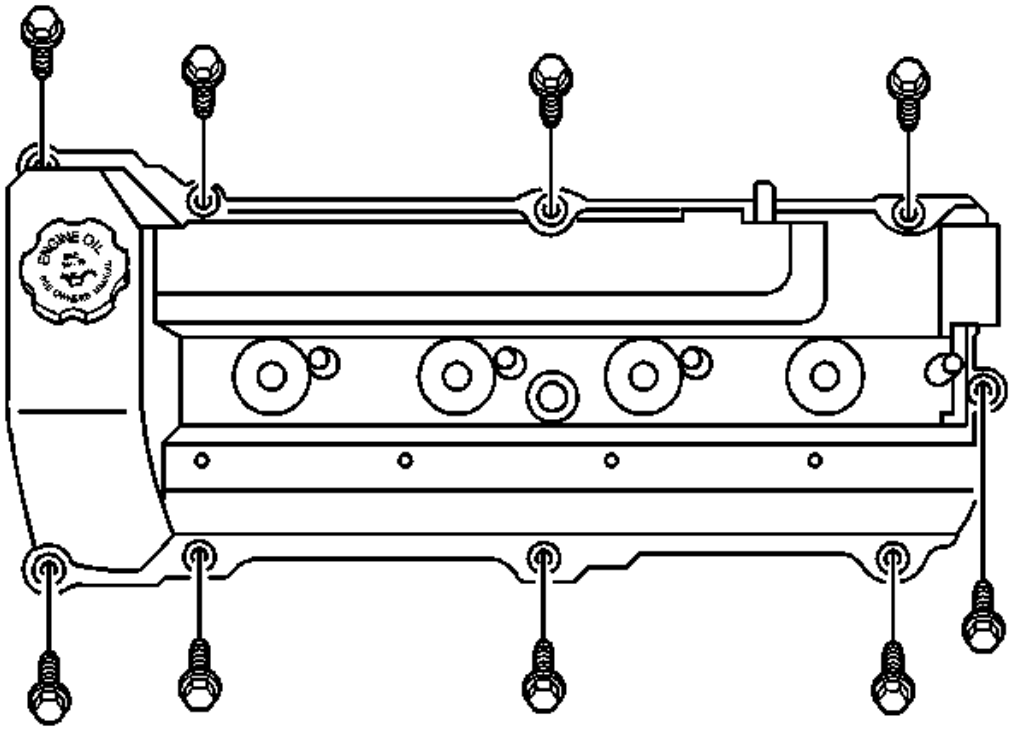

Fig. 134: Camshaft Cover Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Tighten the camshaft cover bolts.

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

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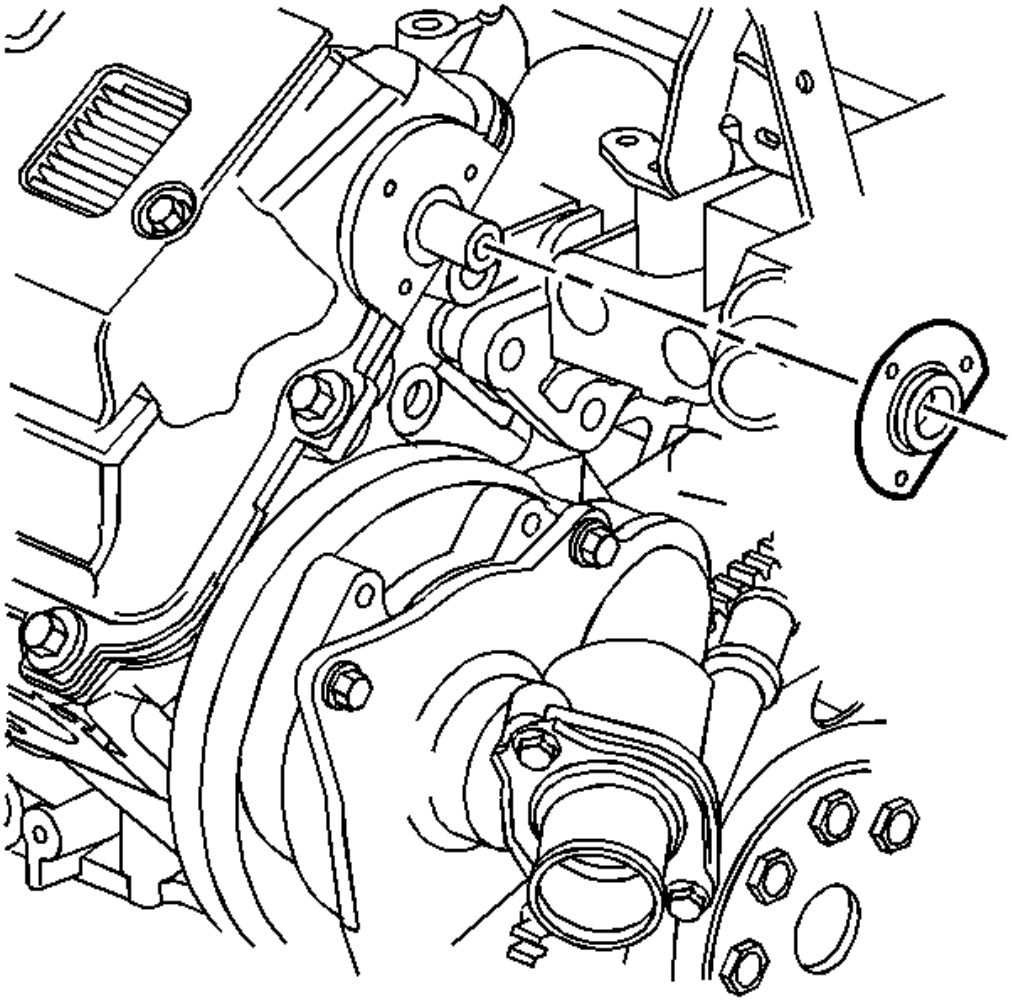

Fig. 135: Camshaft Seal
Courtesy of GENERAL MOTORS CORP.

5. Install a NEW camshaft seal as follows:
    1. Lubricate the camshaft seal lip with engine oil.
    2. Push the camshaft seal into position around the camshaft using the protective sleeve supplied with the seal.

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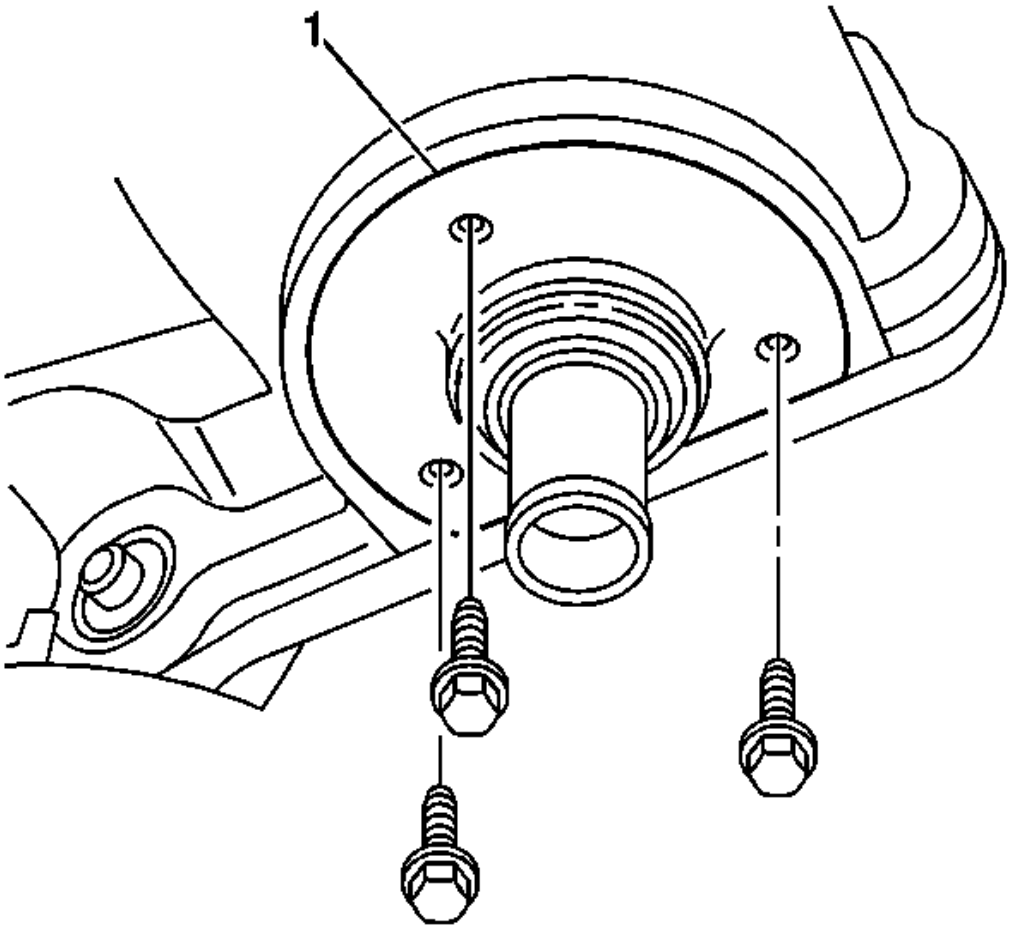

Fig. 136: Camshaft Seal Bolts
Courtesy of GENERAL MOTORS CORP.

6. Coat the threads of the camshaft seal bolts with sealant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
7. Install the camshaft seal (1) bolts.

   Tighten: Tighten the bolts to 3 N.m (27 lb in).

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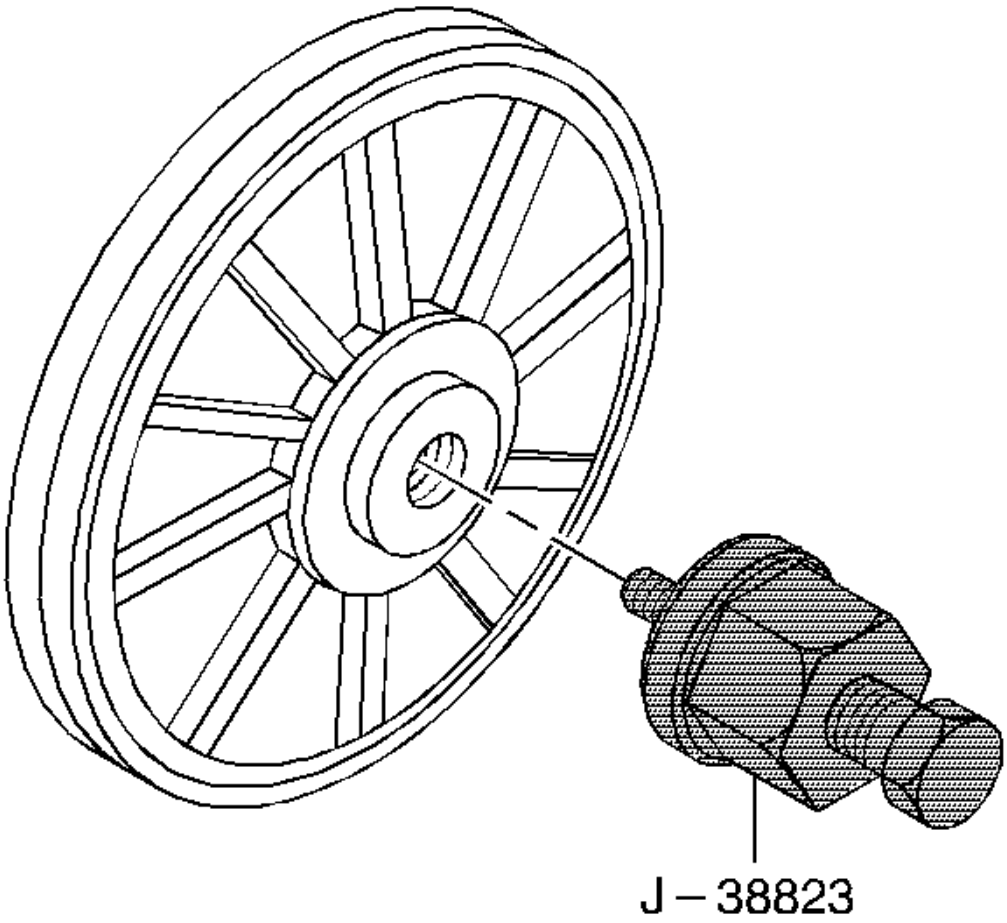

Fig. 137: Installing Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

8. Install the water pump drive pulley onto the intake camshaft.
9. Install the water pump pulley using the **J 38823** . During installation, the tool will bottom out on the camshaft at the proper depth.

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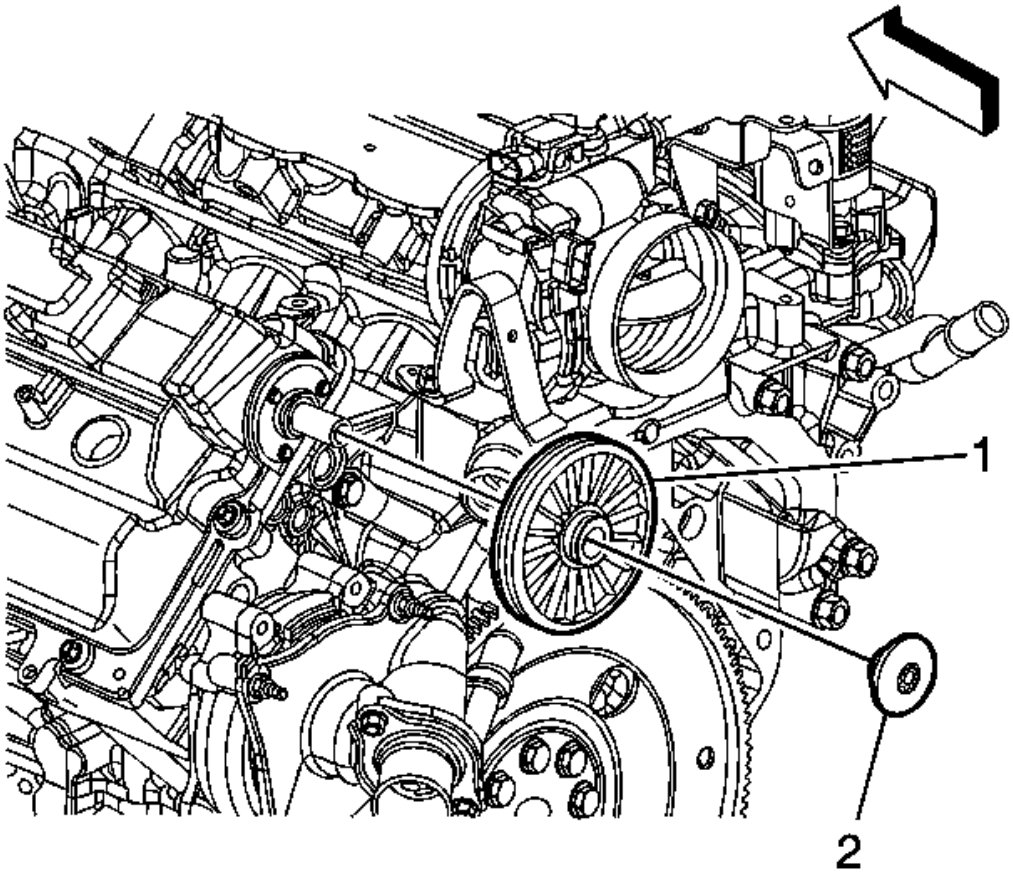

Fig. 138: Plastic Dust Cap
Courtesy of GENERAL MOTORS CORP.

10. Install the plastic dust cap (2) into the end of the camshaft.

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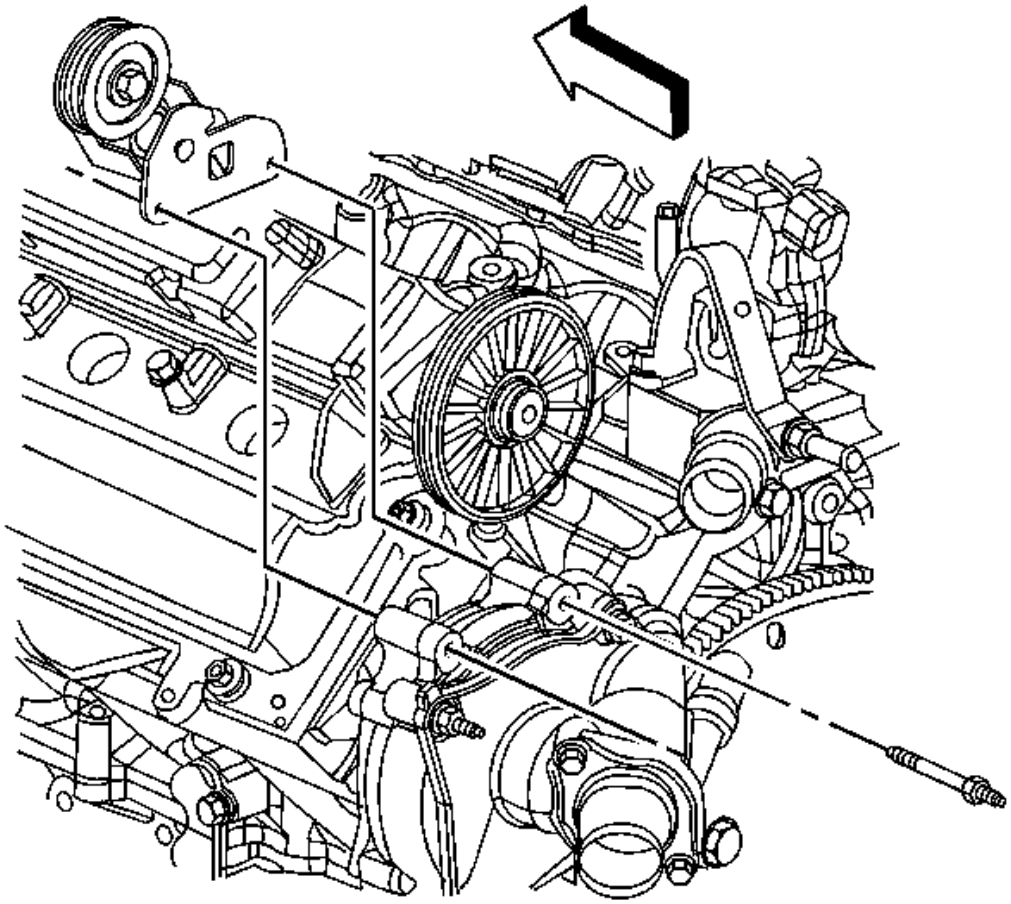

Fig. 139: Water Pump Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

11. Position the water pump drive belt tensioner to the water pump housing.
12. Install the water pump drive belt tensioner studs.

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

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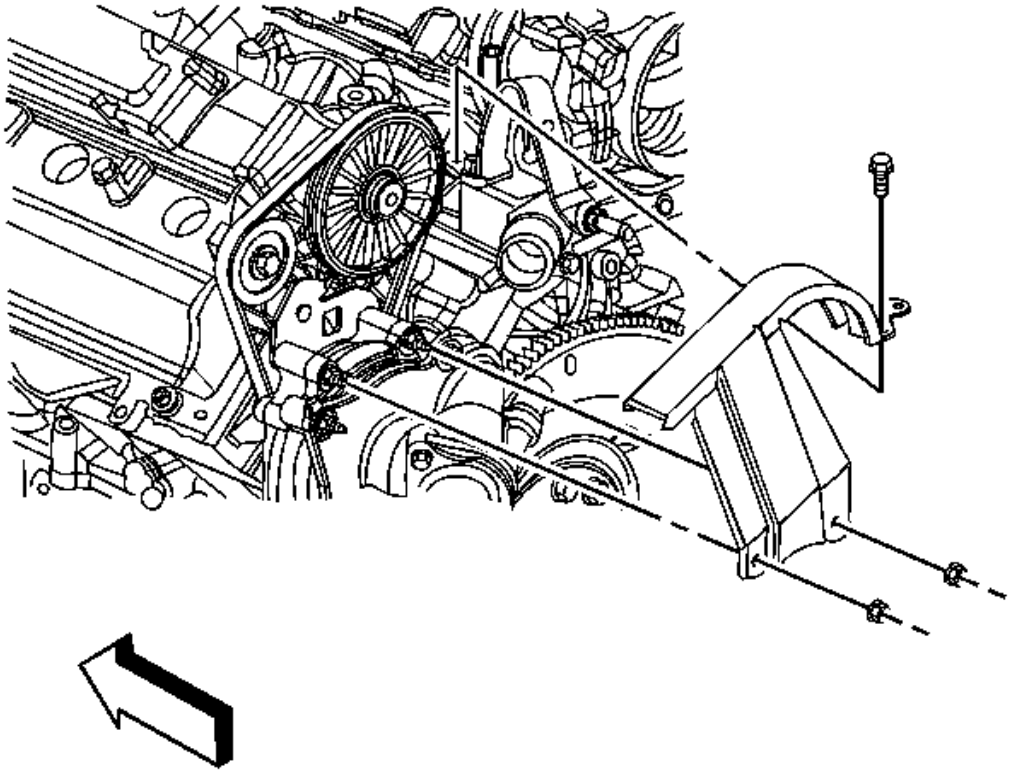

Fig. 140: Water Pump Drive Belt Tensioner Shield
Courtesy of GENERAL MOTORS CORP.

13. Install the water pump drive belt over the pulleys.
14. Install the water pump drive belt shield over the tensioner studs.
15. Install the water pump drive belt shield bolt/nuts.

Tighten: Tighten the bolt/nuts to 10 N.m (89 lb in).

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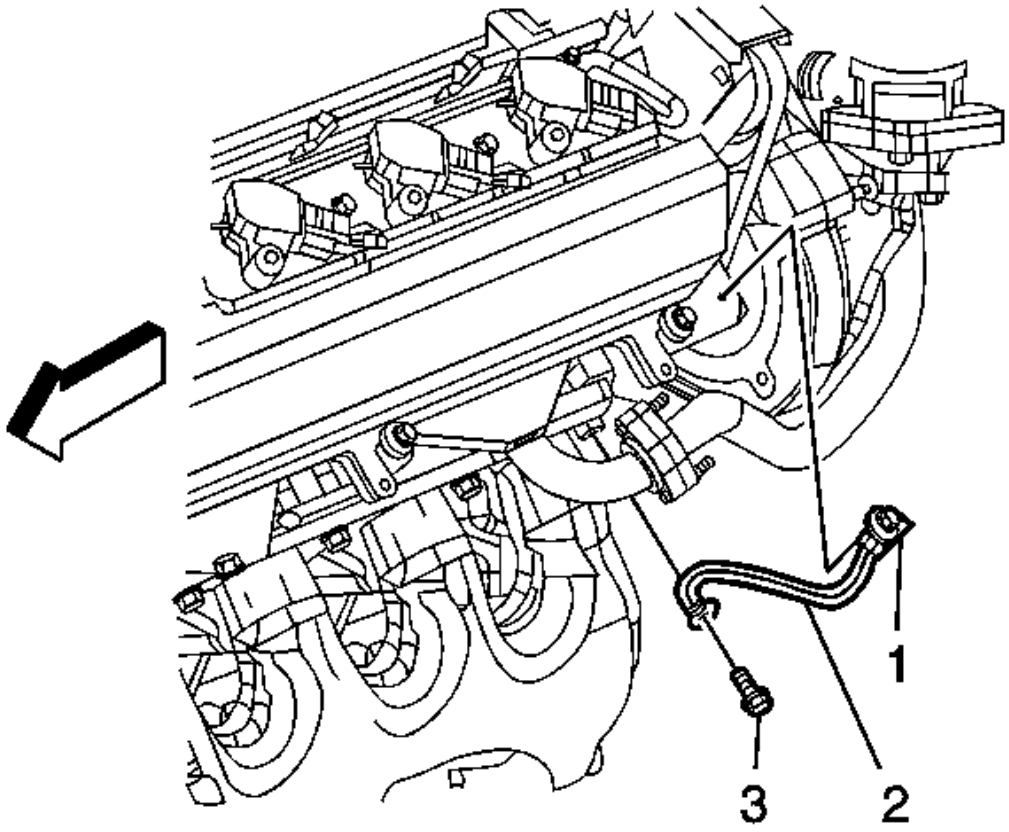

Fig. 141: ICM Wiring Harness Ground
Courtesy of GENERAL MOTORS CORP.

16. Position the ground wire terminal/bolt to the camshaft cover.
17. Tighten the ignition control module (ICM) wiring harness ground bolt (1) to the camshaft cover.

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

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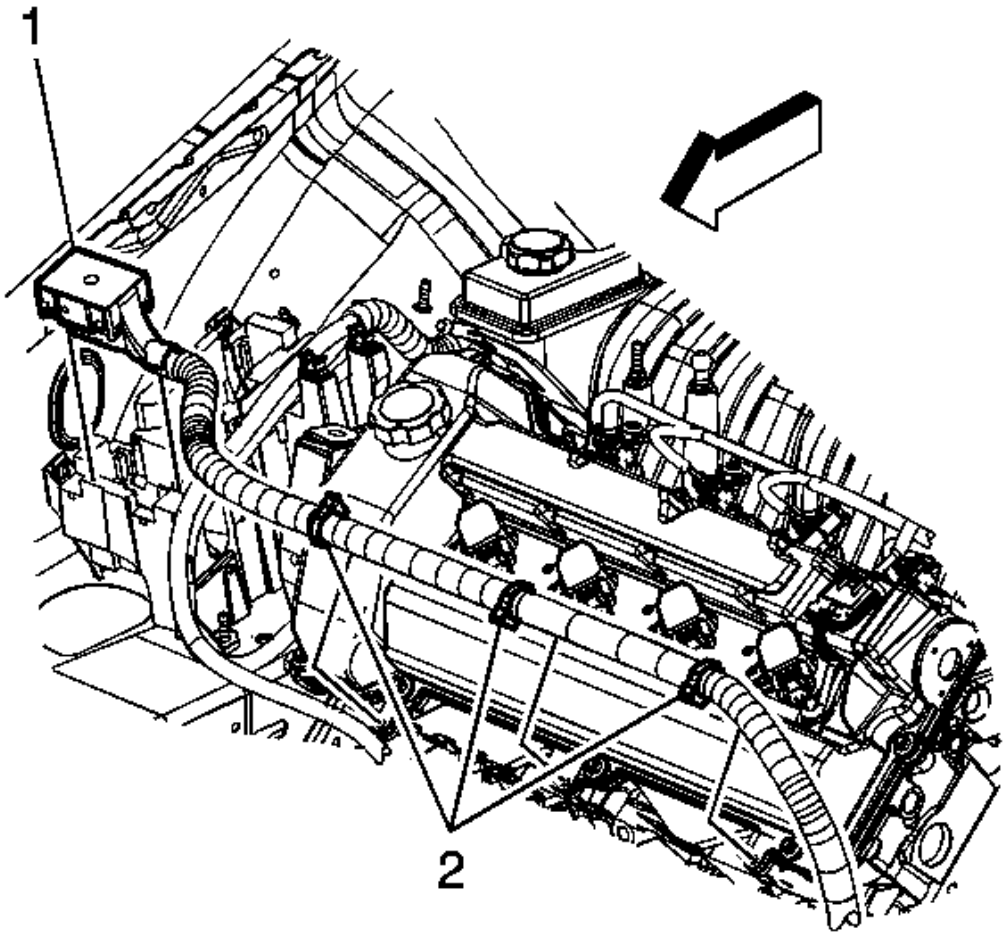

Fig. 142: Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

18. Position the engine harness and install the engine harness clips (2) to the camshaft cover.
19. Install the ignition coils. Refer to **Ignition Coil Replacement - Bank 2** .

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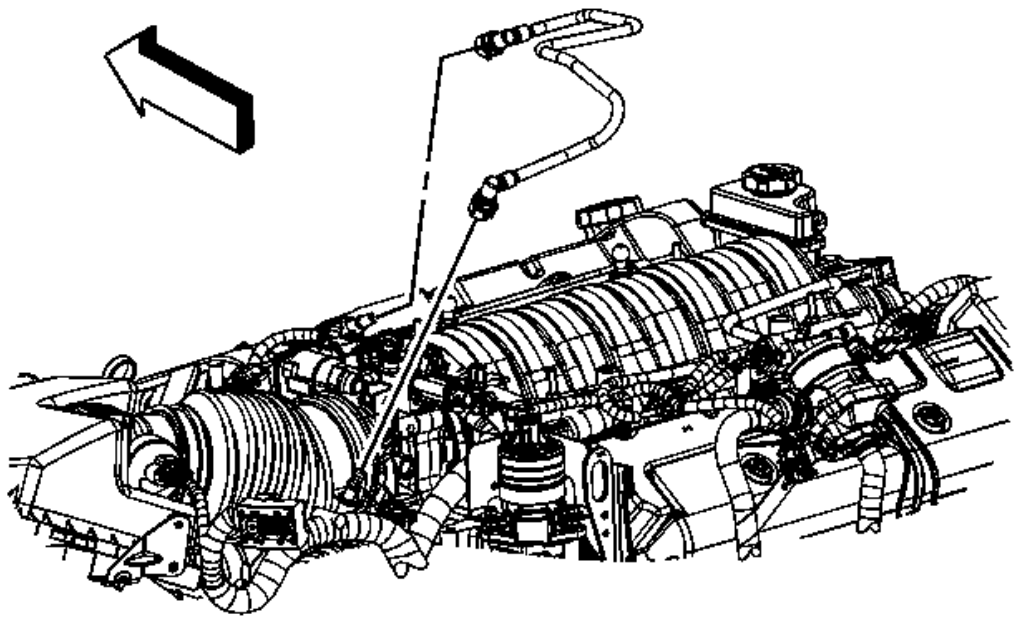

Fig. 143: PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

20. Connect the PCV fresh air tube quick connect fitting to the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service**

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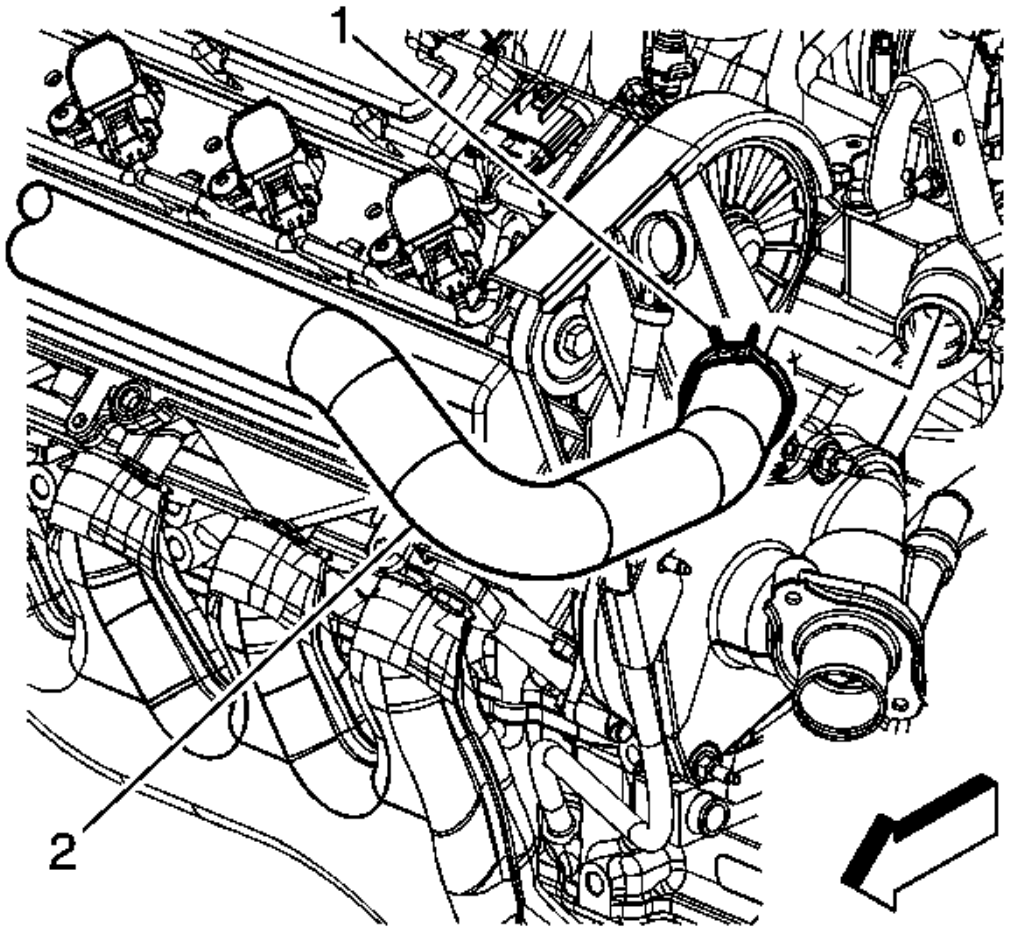

Fig. 144: Radiator Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

21. Install the radiator inlet hose (2) to the water pump housing.
22. Position the radiator inlet hose clamp (1).
23. Install the upper tie bar. Refer to **Front End Upper Tie Bar Replacement** .
24. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (Vac-N-Fill)** .
25. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

CAMSHAFT COVER REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

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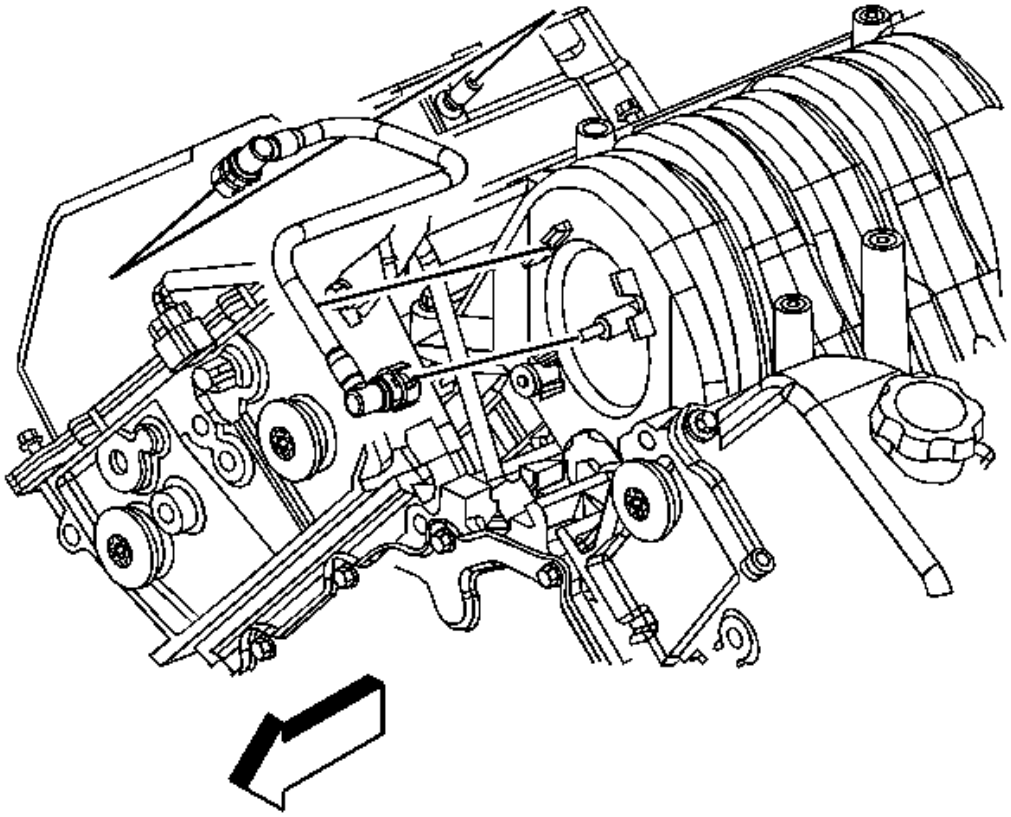

Fig. 145: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Remove the secondary air injection (AIR) check valve. Refer to **Secondary Air Injection Check Valve Replacement** .
3. Disconnect the positive crankcase ventilation (PCV) foul air tube quick connect fitting from the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
4. Remove the ignition coils. Refer to **Ignition Coil Replacement - Bank 1** .

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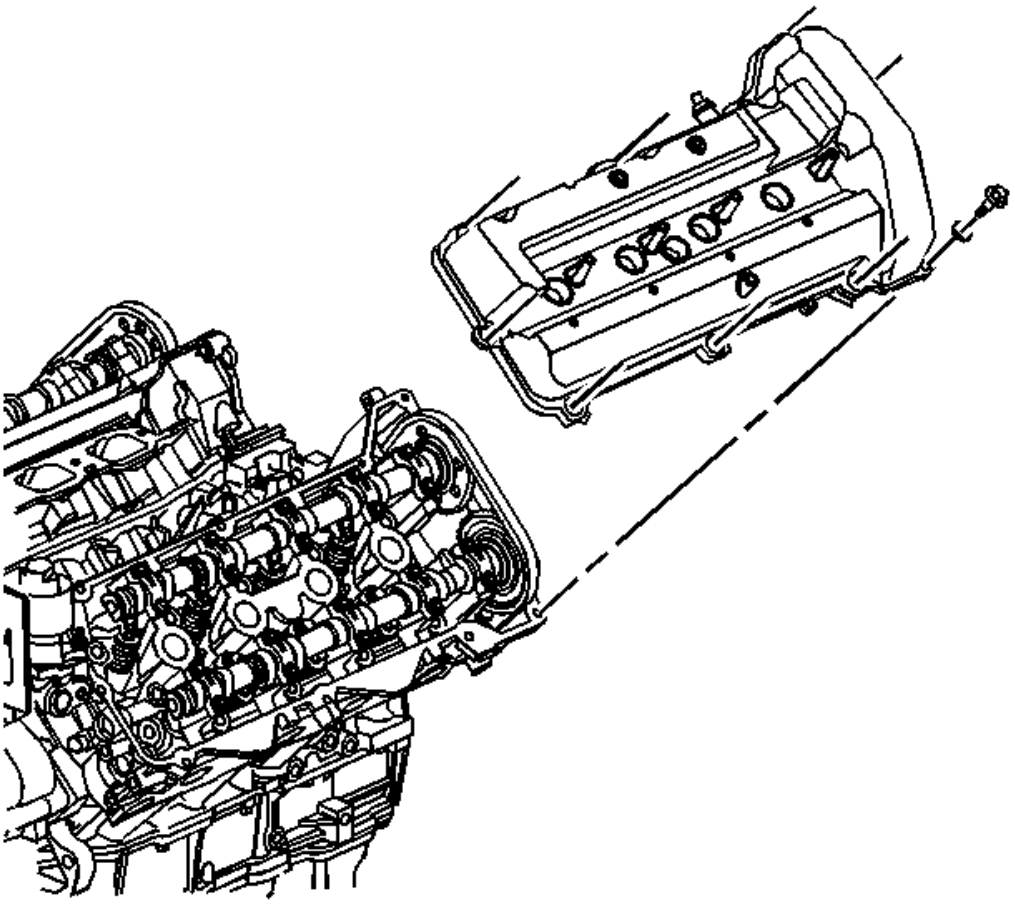

Fig. 146: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

5. Loosen the camshaft cover bolts.
6. Remove the camshaft cover.
7. Discard the camshaft cover perimeter seals and spark plug seals if there is any evidence of damage or if the seal comes out of the groove in the cover during removal.
8. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and Inspection** .

INSTALLATION PROCEDURE

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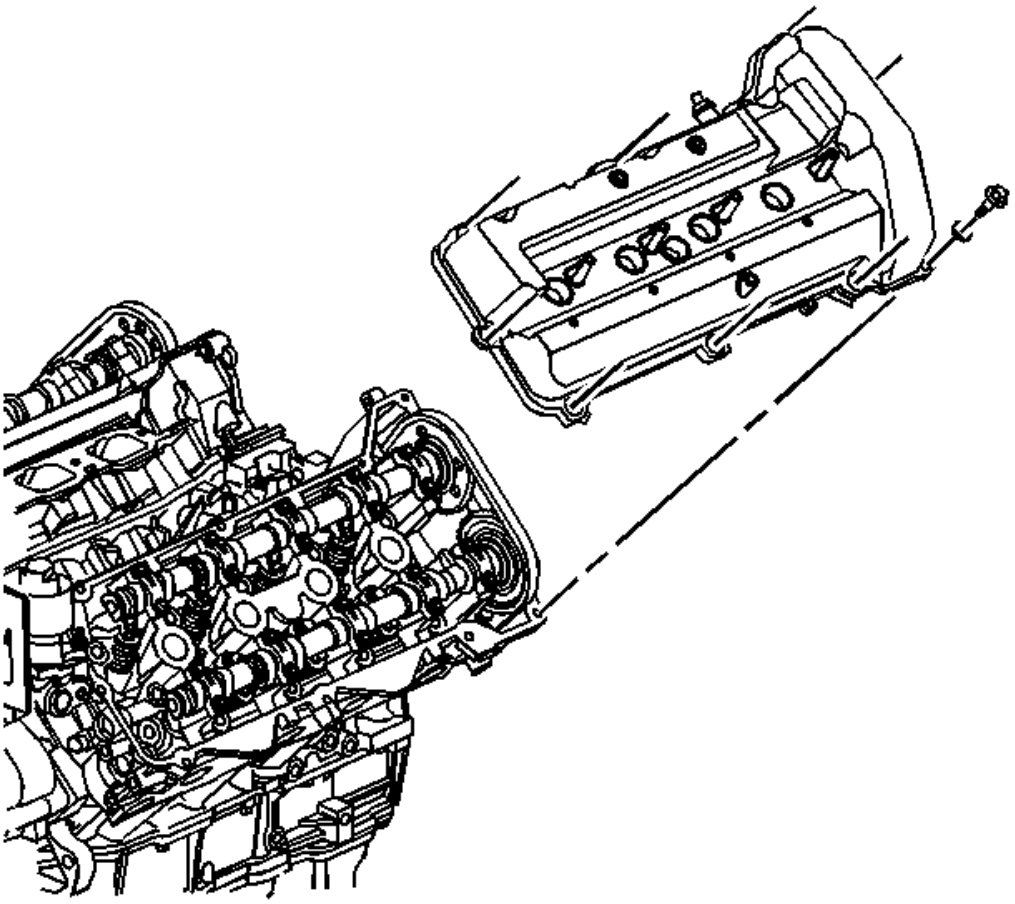

Fig. 147: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: Be careful to prevent the exposed section of the camshaft cover seal from being damaged by the edge of the cylinder head casting.

1. Install the camshaft cover seal as required.
2. Install the camshaft cover.

CAUTION: Refer to Fastener Caution .

3. Tighten the camshaft cover bolts.

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

4. Install the ignition coils. Refer to **Ignition Coil Replacement - Bank 1** .

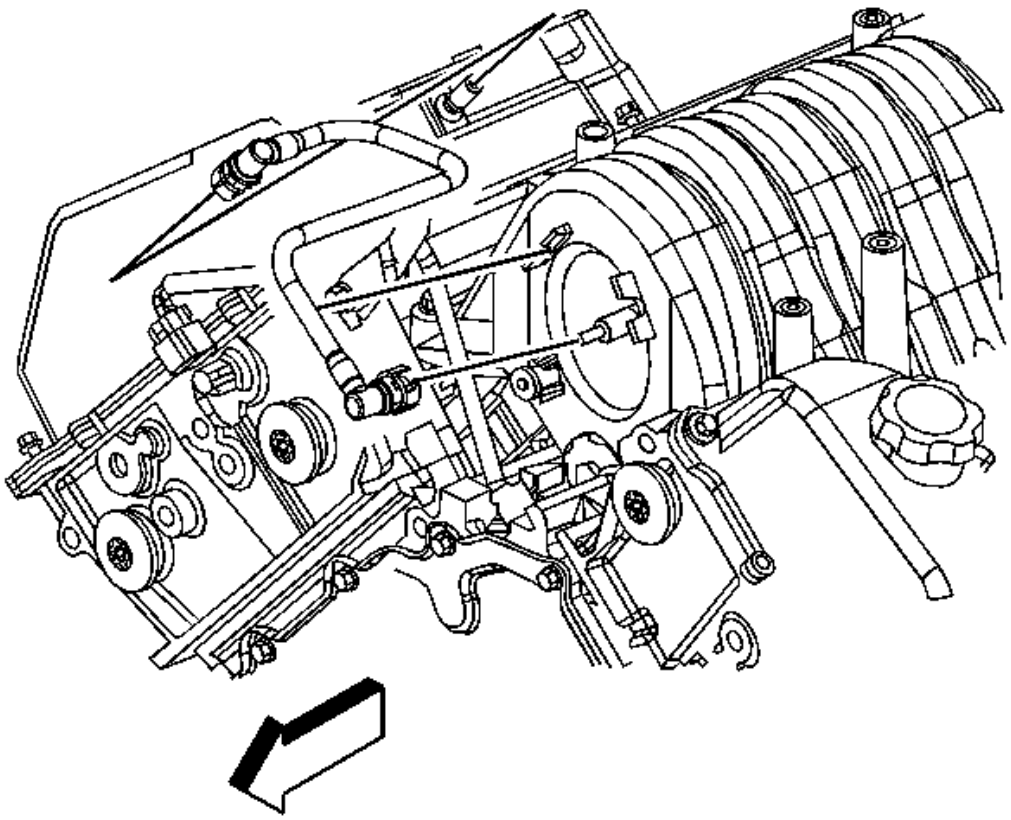

Fig. 148: PCV Foul Air Tube
Courtesy of GENERAL MOTORS CORP.

5. Connect the PCV foul air tube quick connect fitting to the camshaft cover. Refer to **Plastic Collar Quick Connect Fitting Service** .
6. Install the AIR check valve. Refer to **Secondary Air Injection Check Valve Replacement** .
7. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REPLACEMENT - LEFT SIDE

SPECIAL TOOLS

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J 44212 Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the right secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Right Side**.
2. Remove the left secondary drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.
3. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

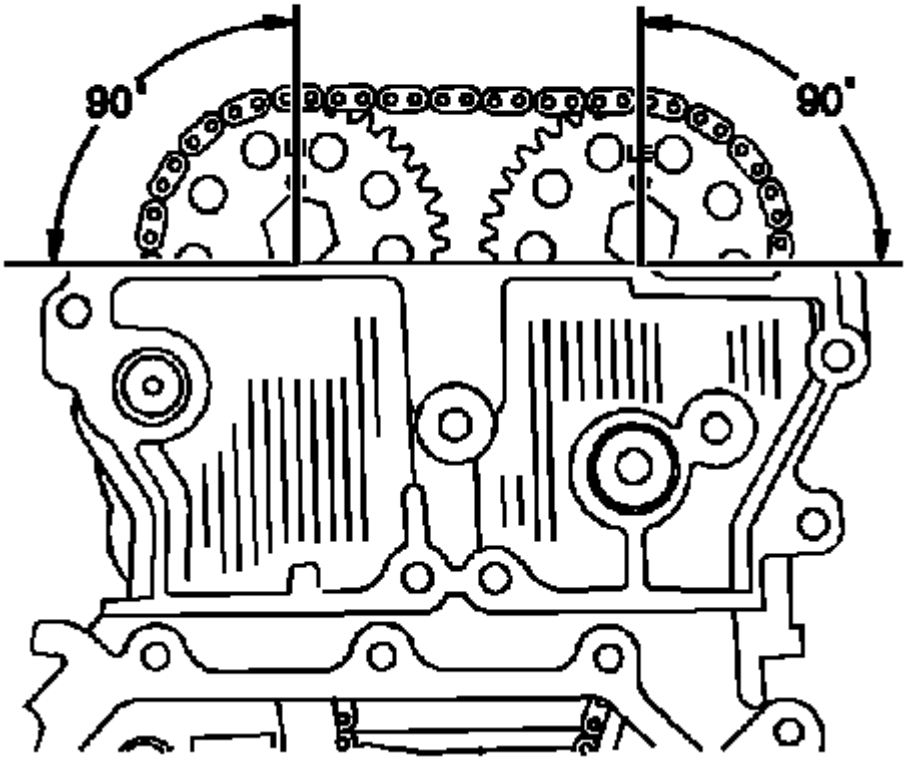

Fig. 149: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

4. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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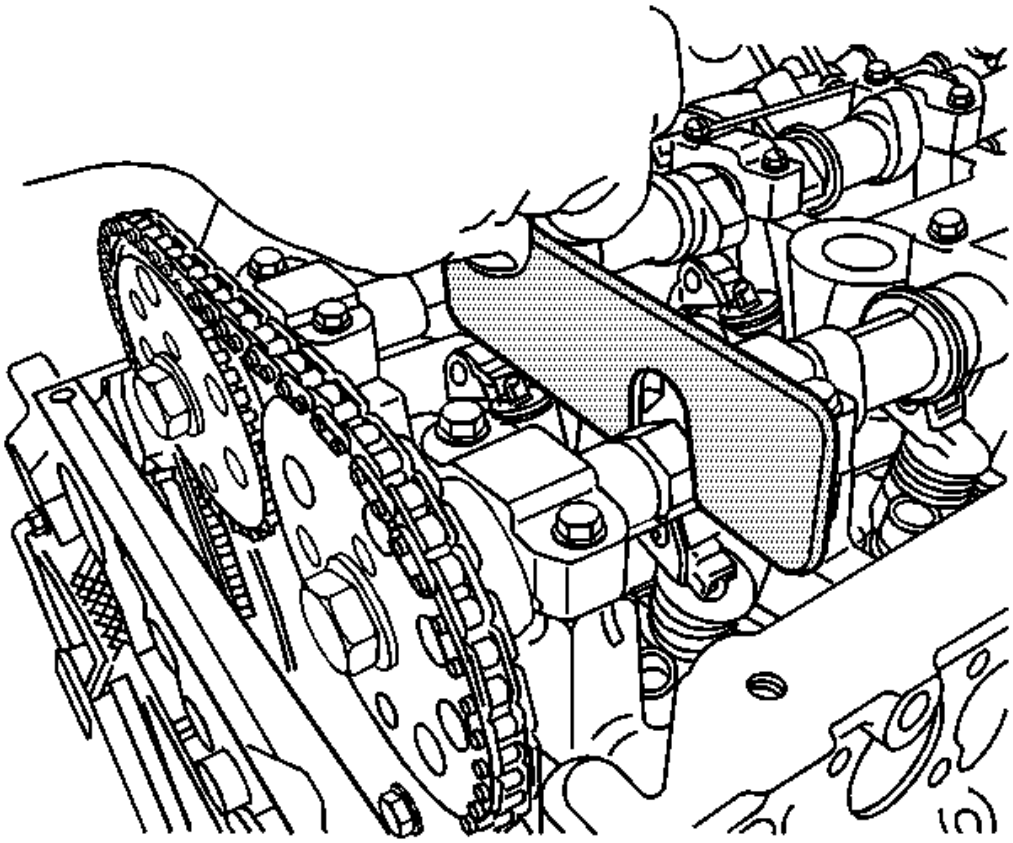

Fig. 150: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

5. Install the **J 44212** over the camshafts. See **Special Tools** .

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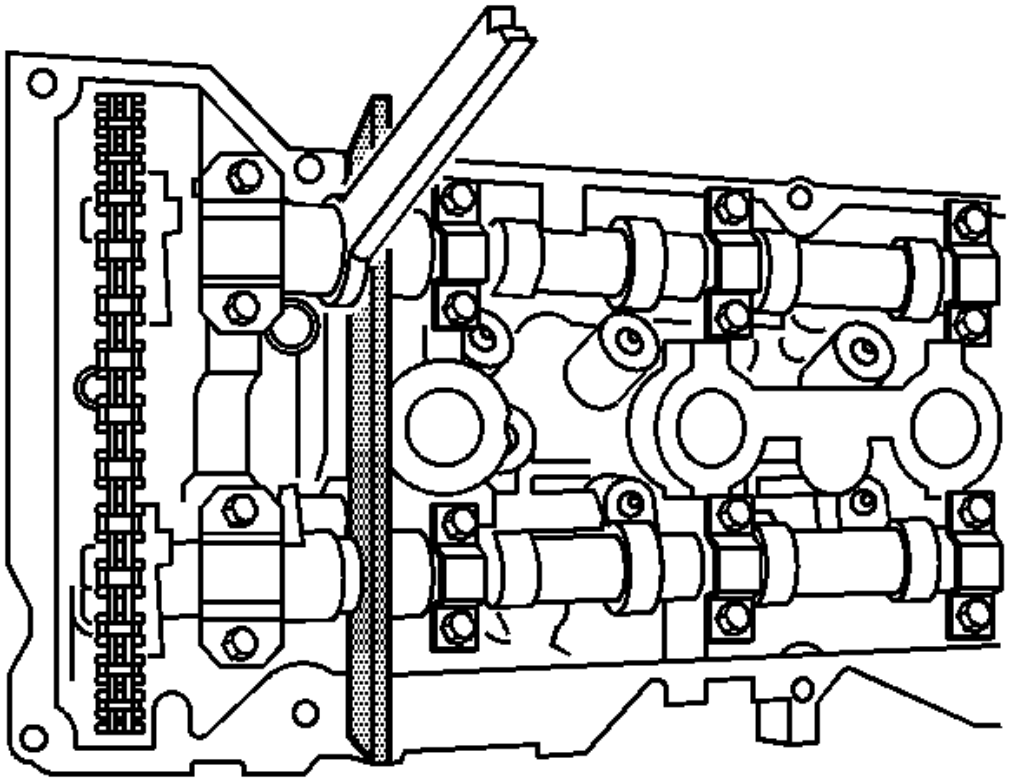

Fig. 151: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

6. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft sprocket bolt.

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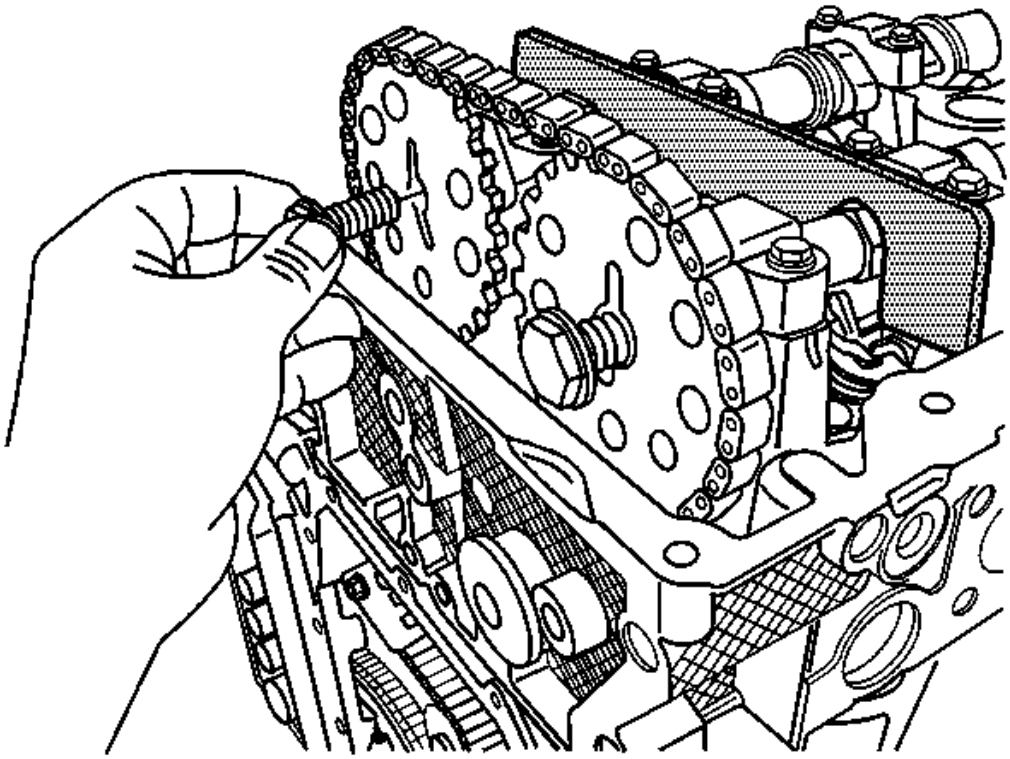

Fig. 152: Left Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the left intake camshaft sprocket bolt.
8. Slide the left intake camshaft sprocket off of the camshaft and remove the left secondary camshaft drive chain from the camshaft sprocket teeth.

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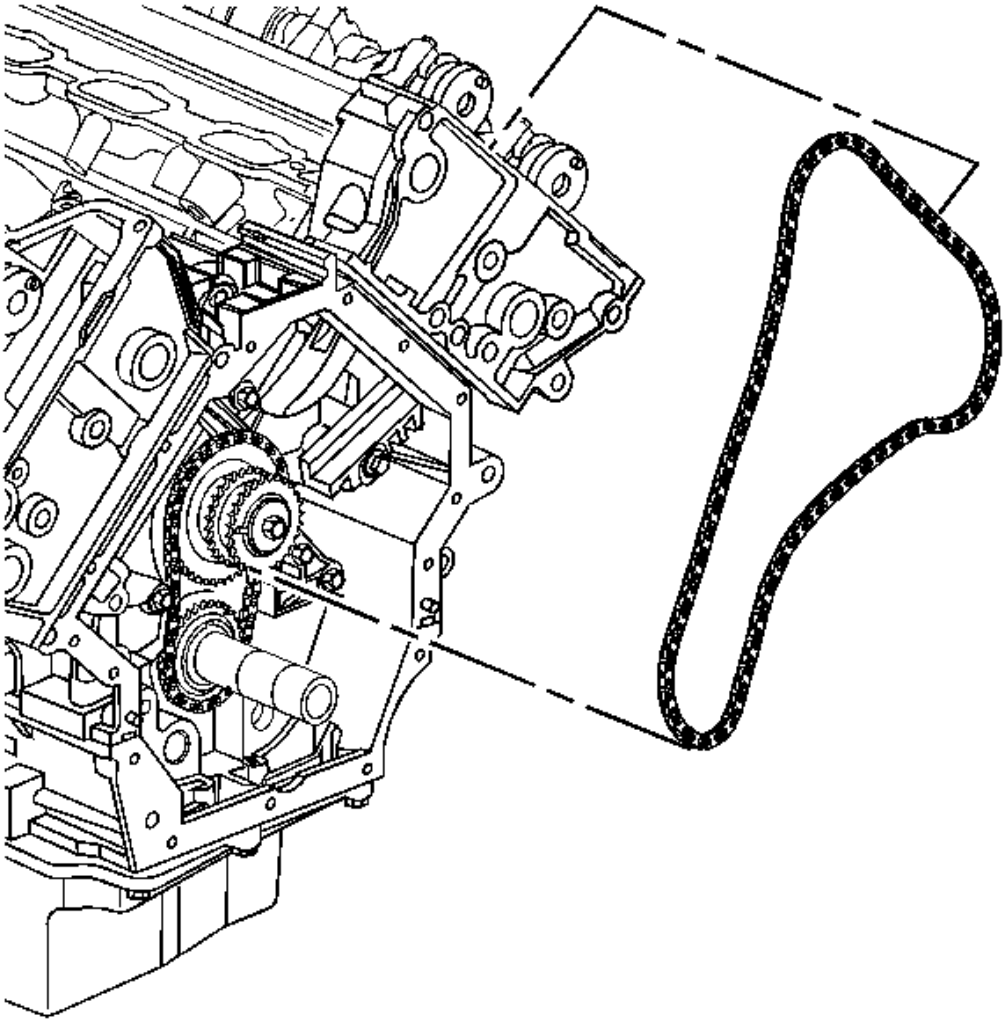

Fig. 153: Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

9. Lift the left secondary camshaft drive chain from the camshaft intermediate drive shaft sprocket teeth.
10. Remove the left secondary camshaft drive chain from the engine.
11. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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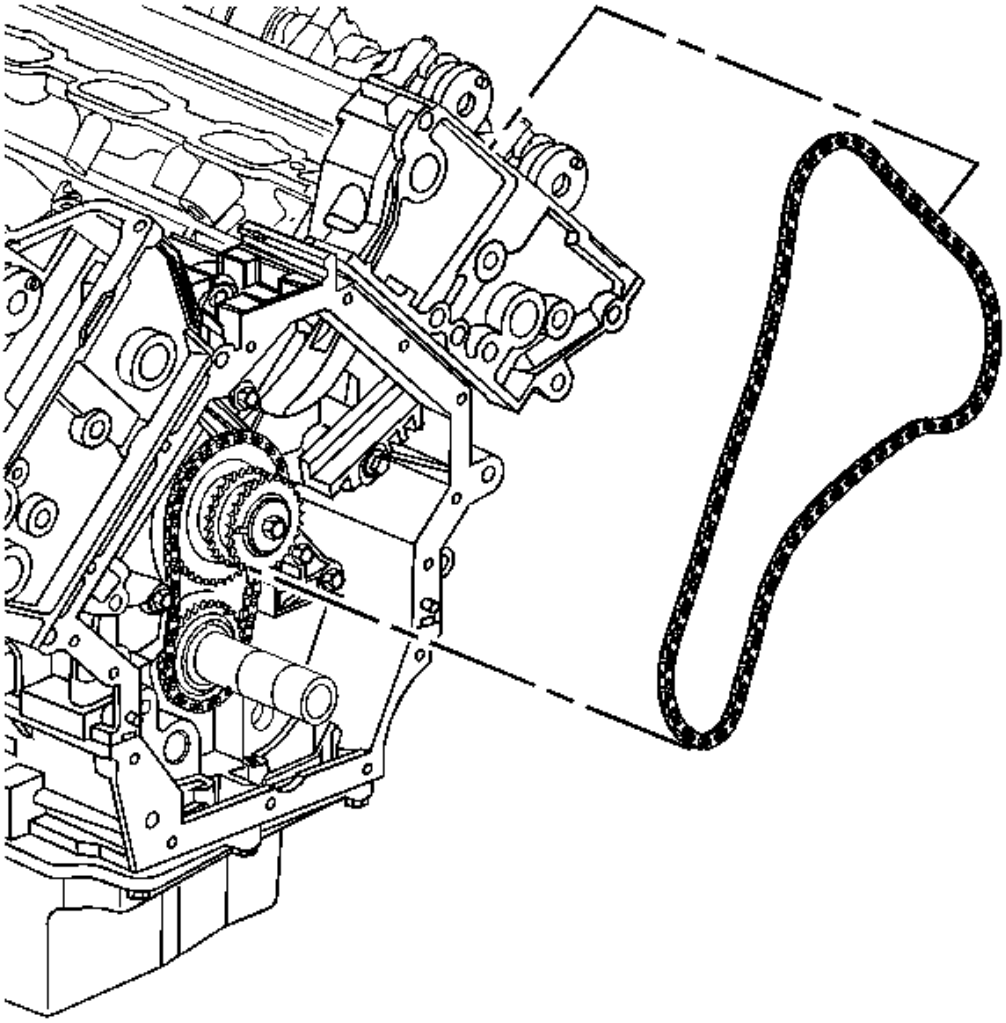

Fig. 154: Left Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the left secondary camshaft drive chain by sliding the chain down through the left cylinder head and placing the chain on the left exhaust camshaft sprocket.
2. Route the left secondary camshaft drive chain around the inner row of the camshaft intermediate drive shaft sprocket teeth.

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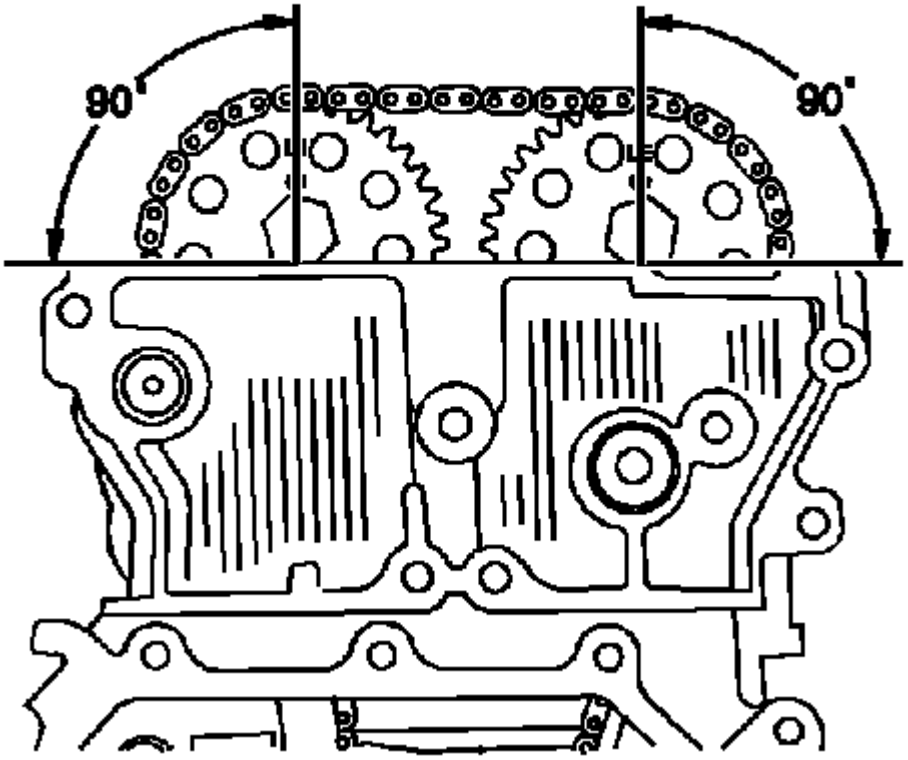

Fig. 155: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Install the left intake camshaft sprocket into the left secondary camshaft drive chain.
4. Install the left intake camshaft sprocket onto the camshaft. The camshaft sprocket notch marked LI (left intake) engages the intake camshaft pin.

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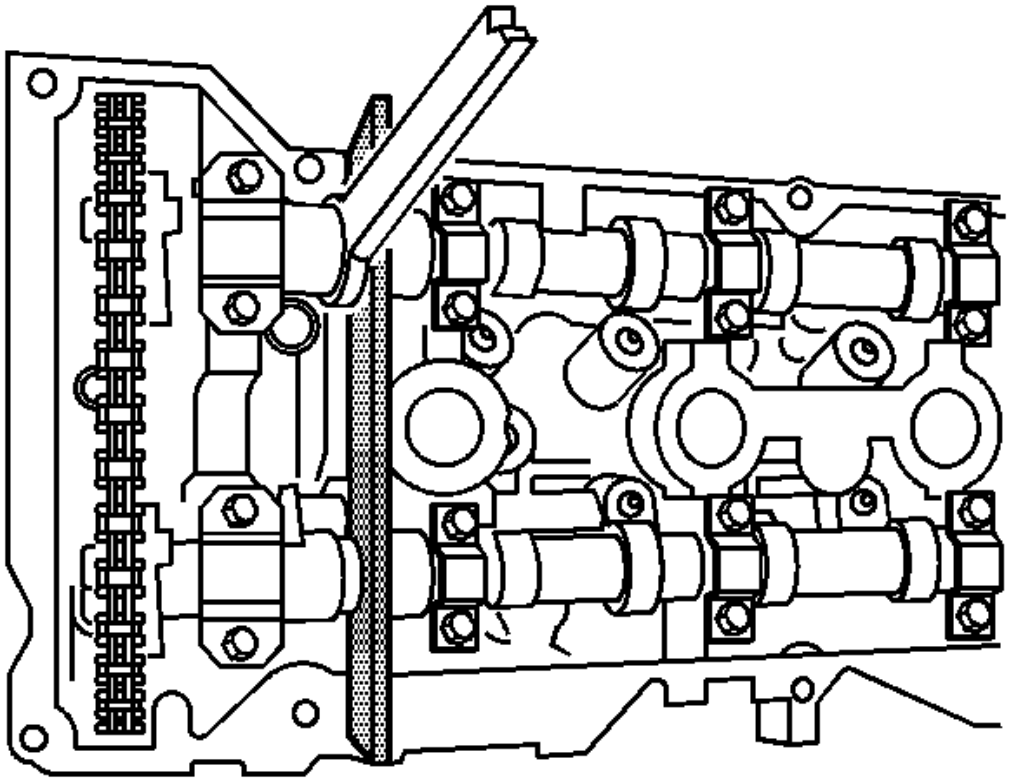

Fig. 156: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

5. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the camshaft sprocket bolt.

   CAUTION: Refer to Fastener Caution .

6. Install the left intake camshaft sprocket bolt.

   Tighten: Tighten the camshaft sprocket bolt to 120 N.m (89 lb ft).

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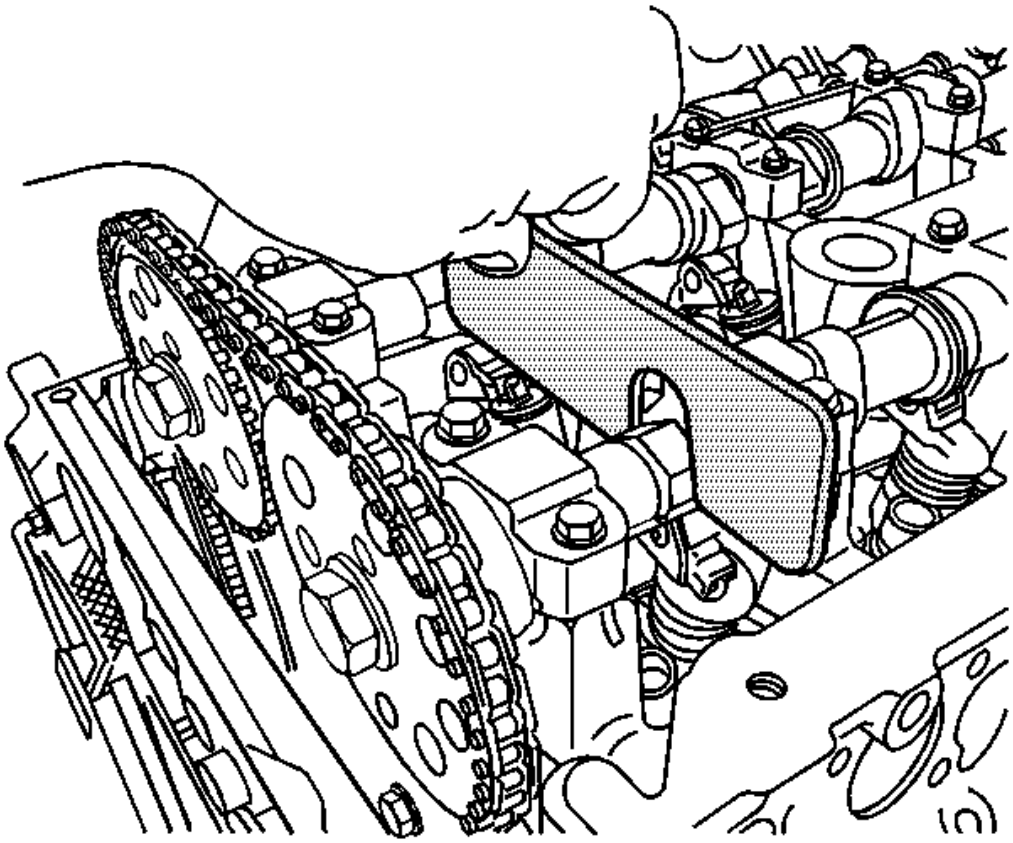

Fig. 157: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

7. Remove the **J 44212** from the camshafts. See **Special Tools** .
8. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
9. Install the left secondary drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.
10. Install the right secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Right Side**.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN REPLACEMENT - RIGHT SIDE

SPECIAL TOOLS

J 44212 Camshaft Holding Tool. See **Special Tools** .

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REMOVAL PROCEDURE

1. Remove the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.
2. Remove the camshaft position (CMP) sensor. Refer to **Camshaft Position Sensor Replacement** .
3. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

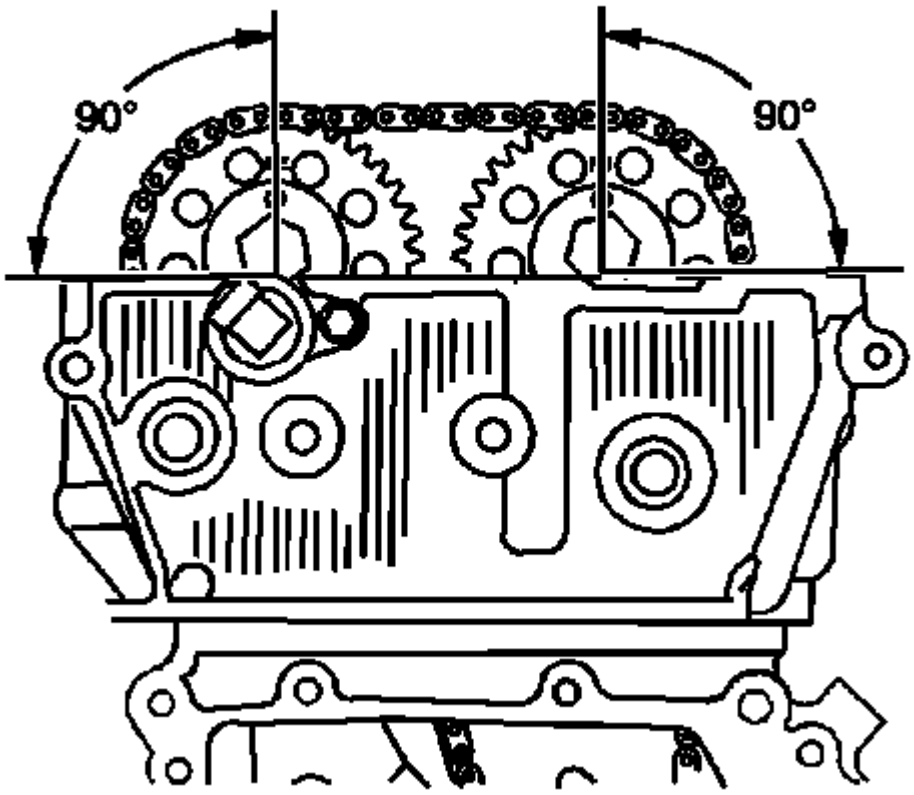

Fig. 158: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

4. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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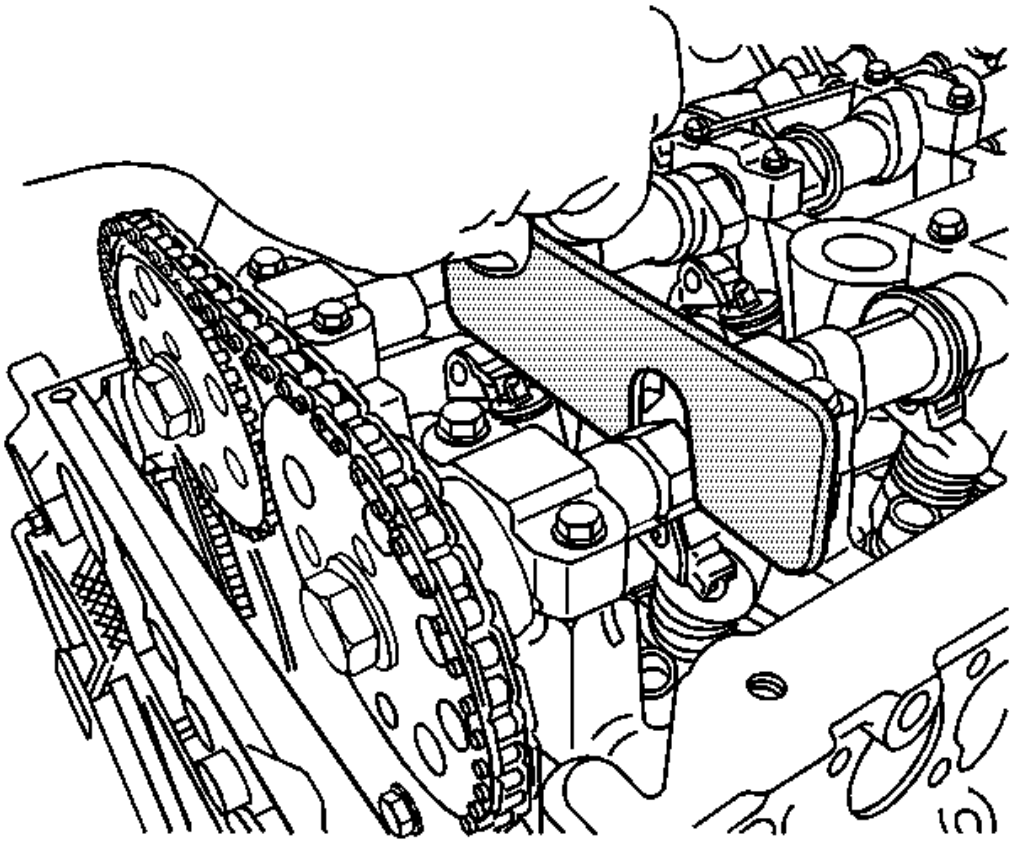

Fig. 159: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

5. Install the **J 44212** over the camshafts. See **Special Tools** .

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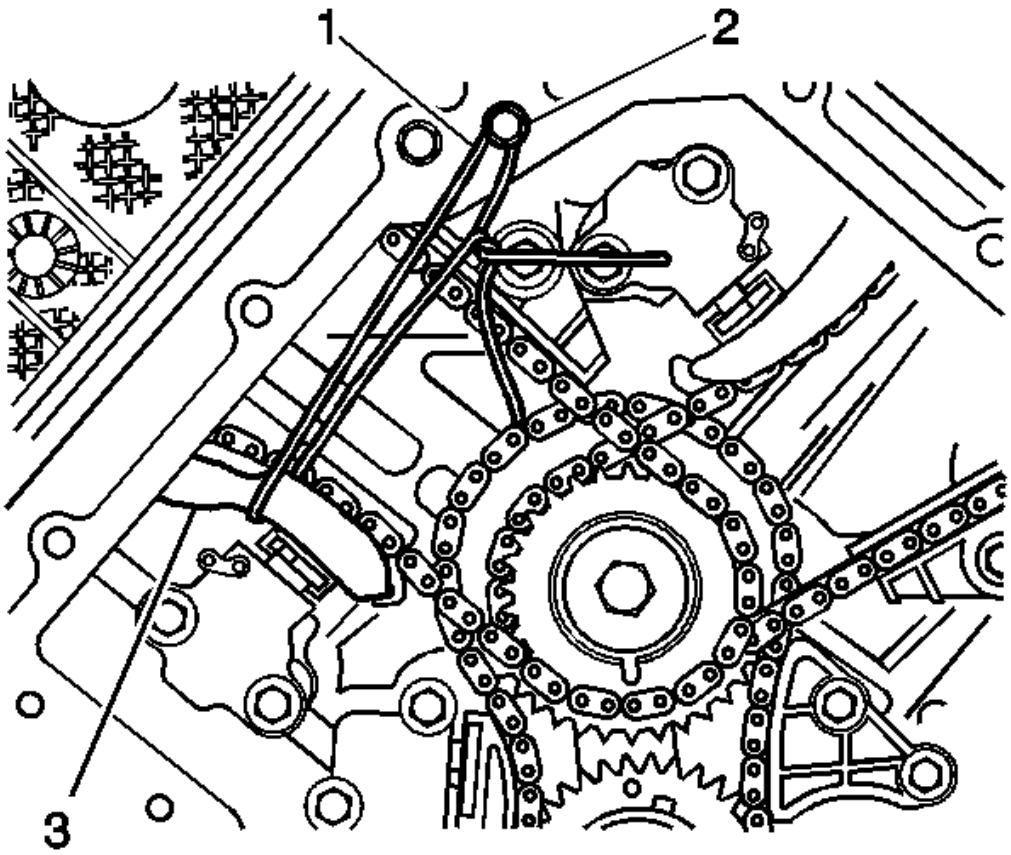

Fig. 160: Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
7. Remove the engine front cover bolt (2) from the front of the engine.

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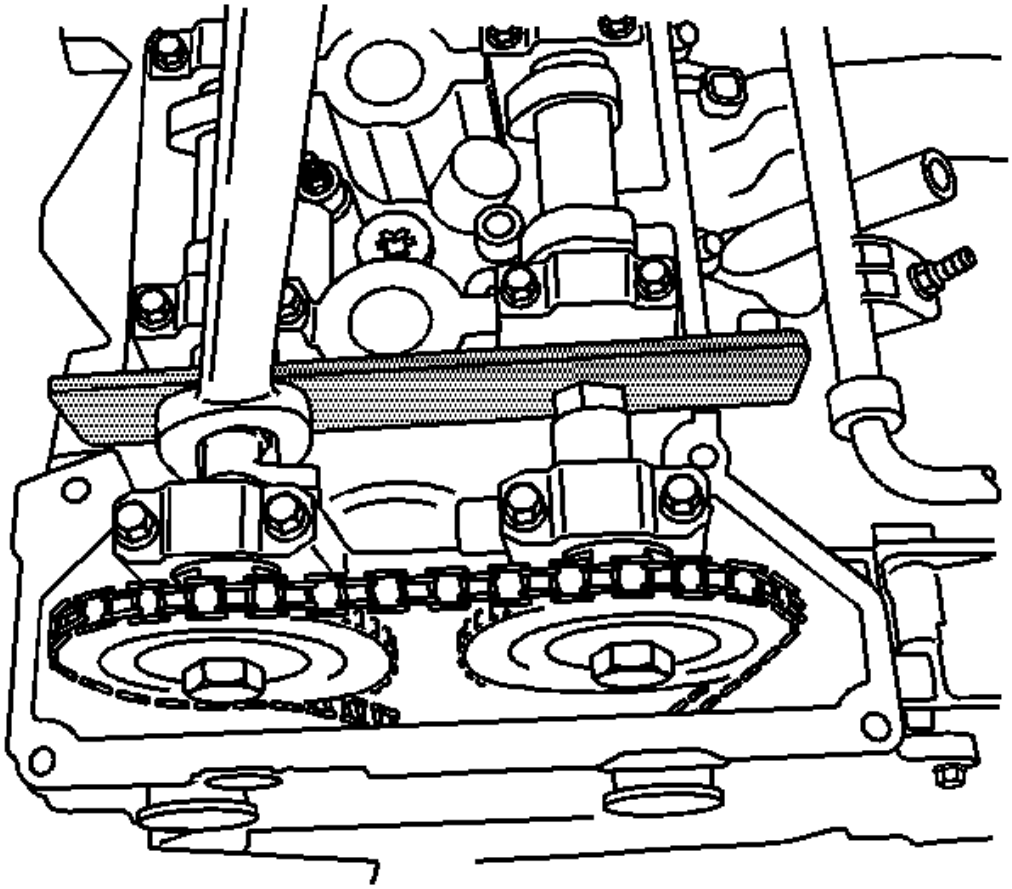

Fig. 161: Preventing Camshaft From Rotating
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

8. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft sprocket bolt.

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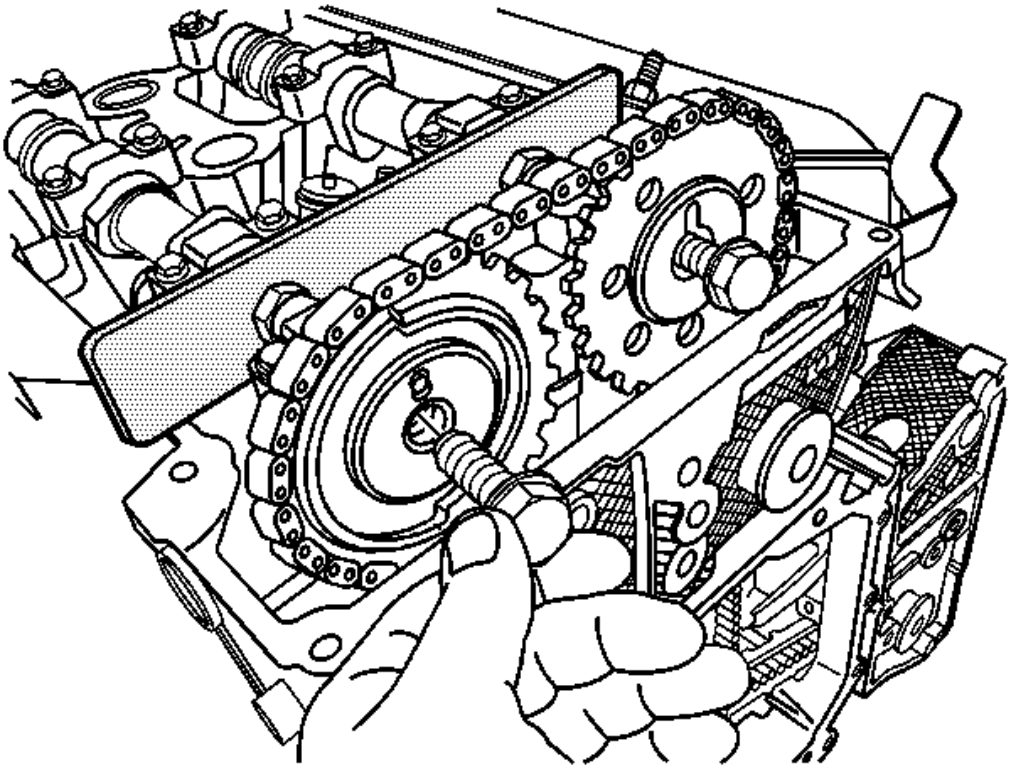

Fig. 162: Right Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the right exhaust camshaft sprocket bolt.
10. Slide the right exhaust camshaft sprocket off of the camshaft and remove the right secondary camshaft drive chain from the camshaft sprocket teeth.

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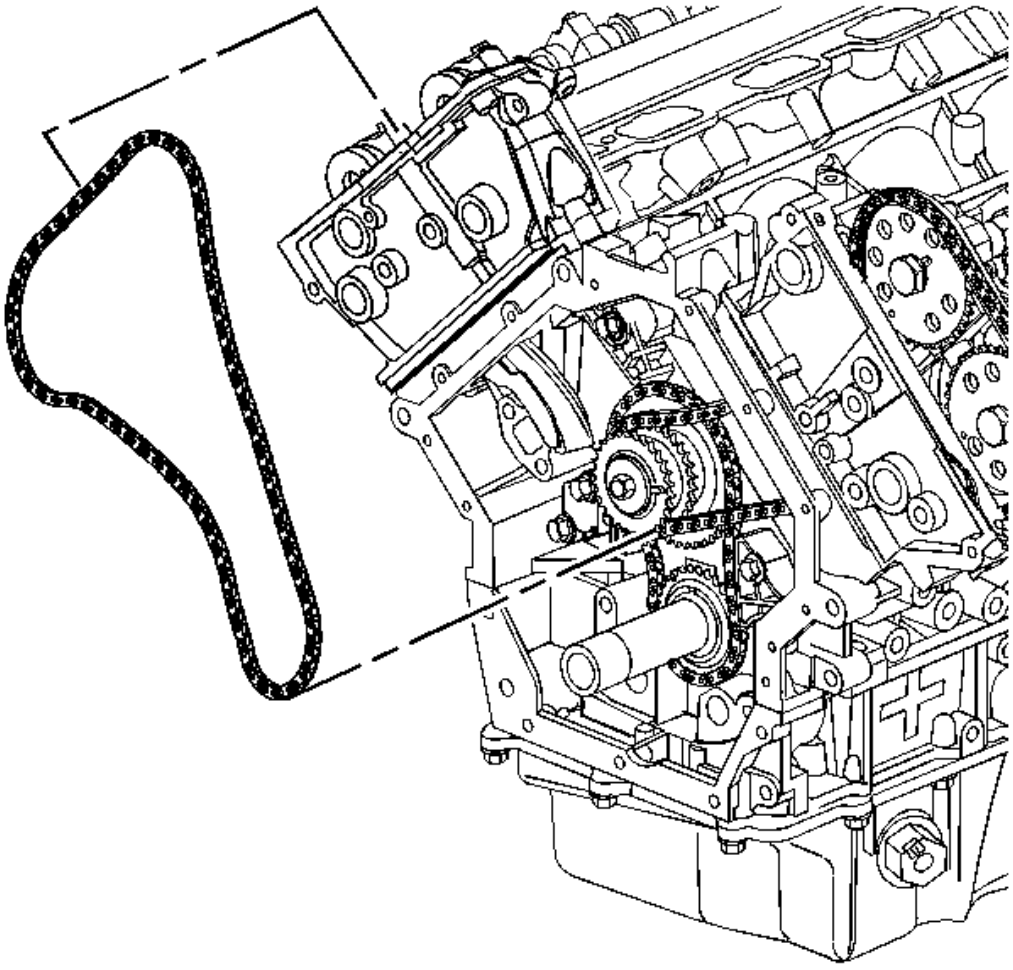

Fig. 163: Right Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

11. Lift the right secondary camshaft drive chain from the camshaft intermediate drive shaft sprocket teeth.
12. Remove the right secondary camshaft drive chain from the engine.
13. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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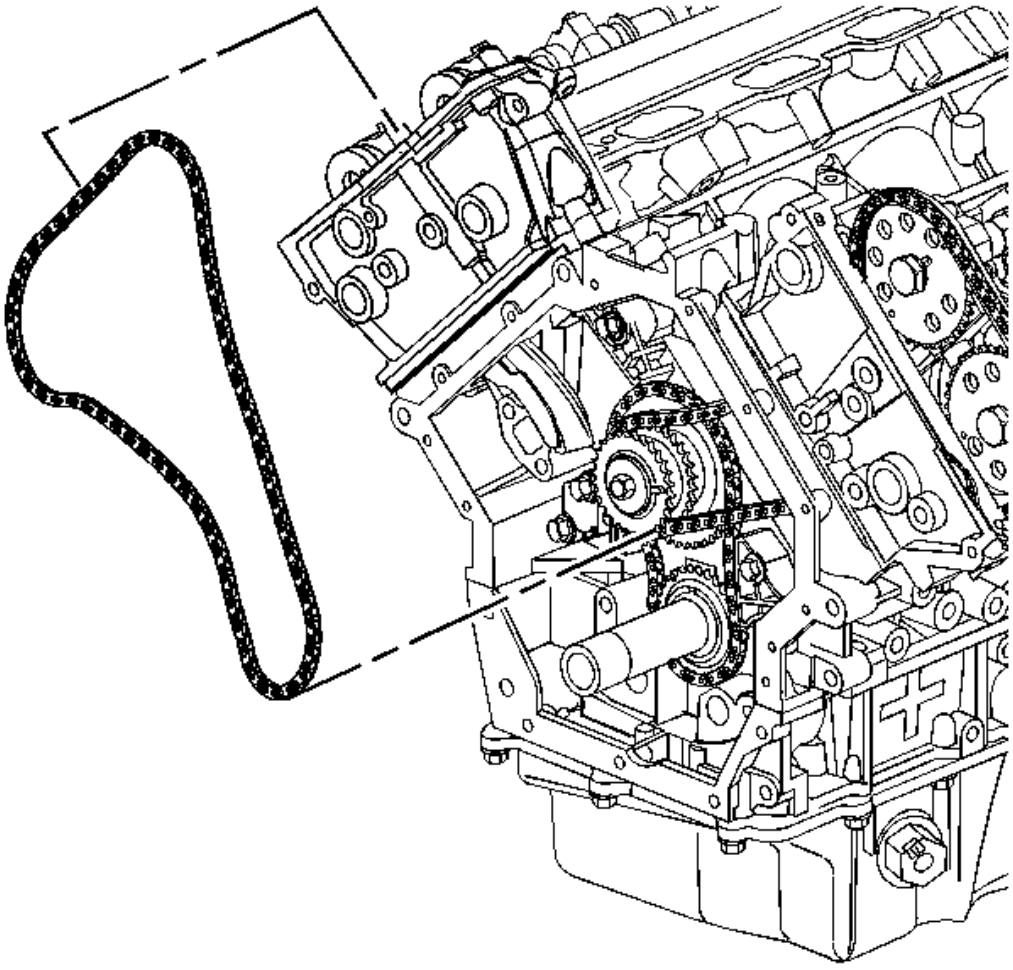

Fig. 164: Right Secondary Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the right secondary camshaft drive chain by sliding the chain down through the right cylinder head and placing the chain on the right intake camshaft sprocket.
2. Route the right secondary camshaft drive chain around the outer row of the camshaft intermediate drive shaft sprocket teeth.

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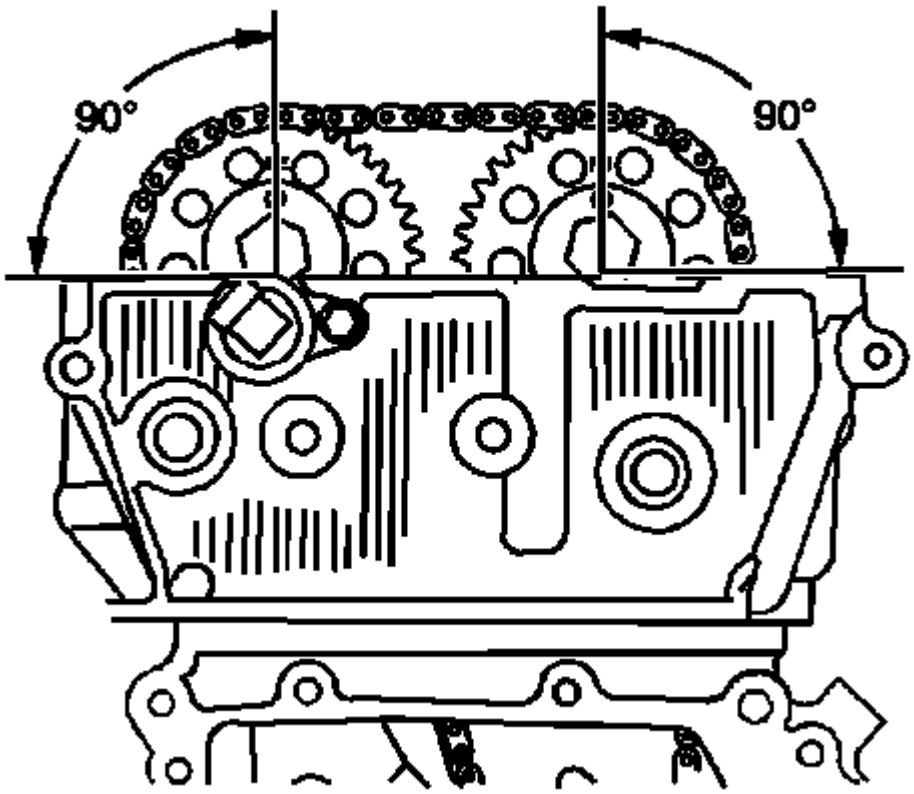

Fig. 165: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Install the right exhaust camshaft sprocket into the right secondary camshaft drive chain.
4. Install the right exhaust camshaft sprocket onto the camshaft. The camshaft sprocket notch marked RE (right exhaust) engages the exhaust camshaft pin.

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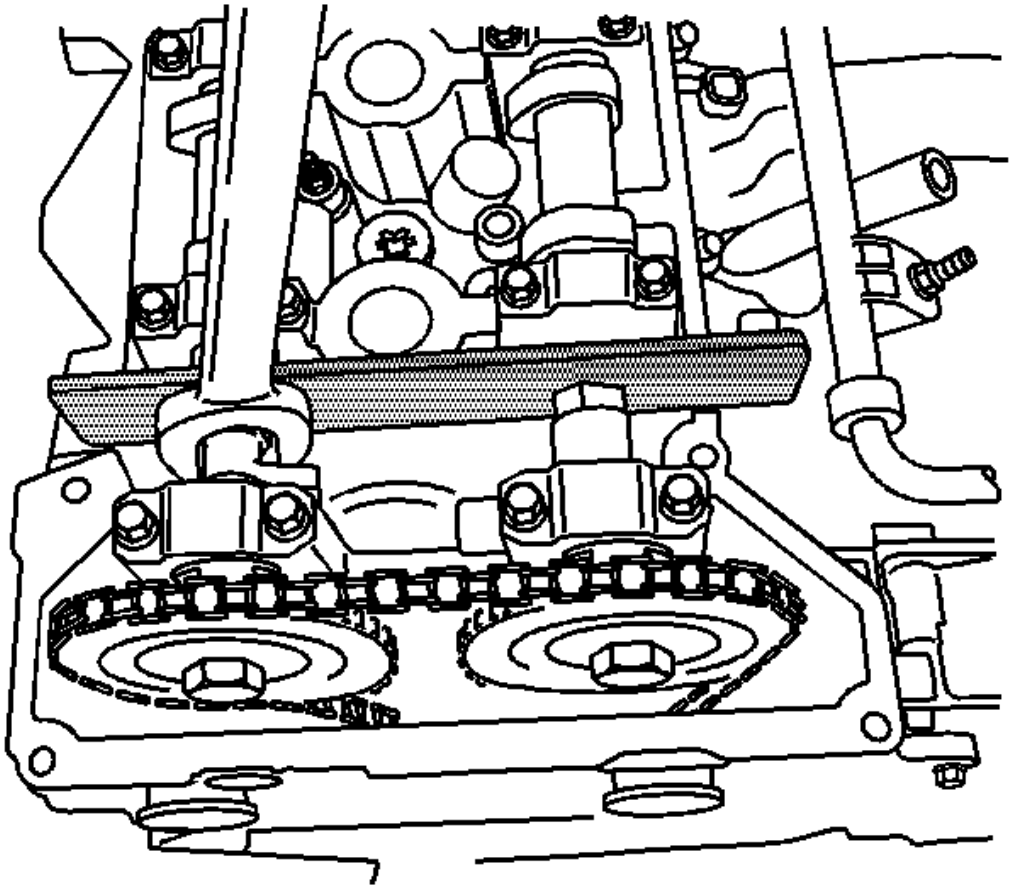

Fig. 166: Preventing Camshaft From Rotating
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

5. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the camshaft sprocket bolt.

CAUTION: Refer to Fastener Caution .

6. Install the right exhaust camshaft sprocket bolt.

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Tighten: Tighten the camshaft sprocket bolt to 120 N.m (89 lb ft).

7. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.

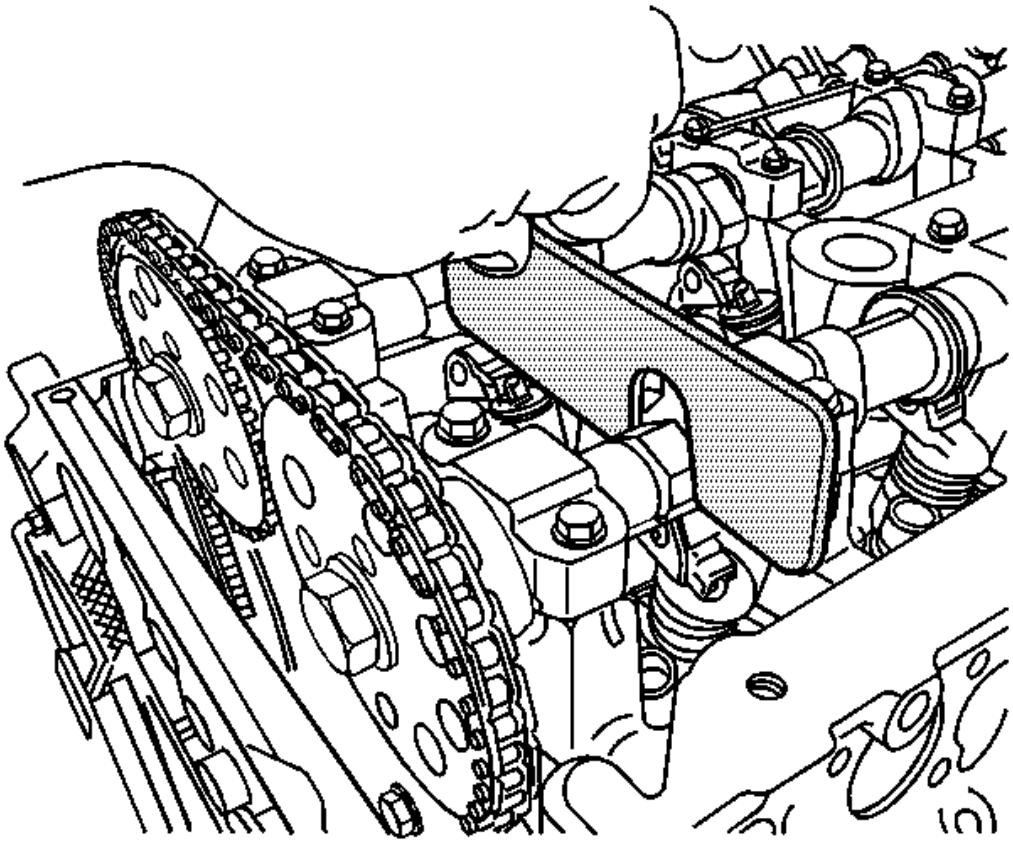

Fig. 167: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

8. Remove the **J 44212** from the camshafts. See **Special Tools** .
9. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
10. Install the CMP sensor. Refer to **Camshaft Position Sensor Replacement** .

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER REPLACEMENT - LEFT SIDE

SPECIAL TOOLS

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J 39946 Crankshaft Socket - 4.0L and 4.6L

REMOVAL PROCEDURE

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

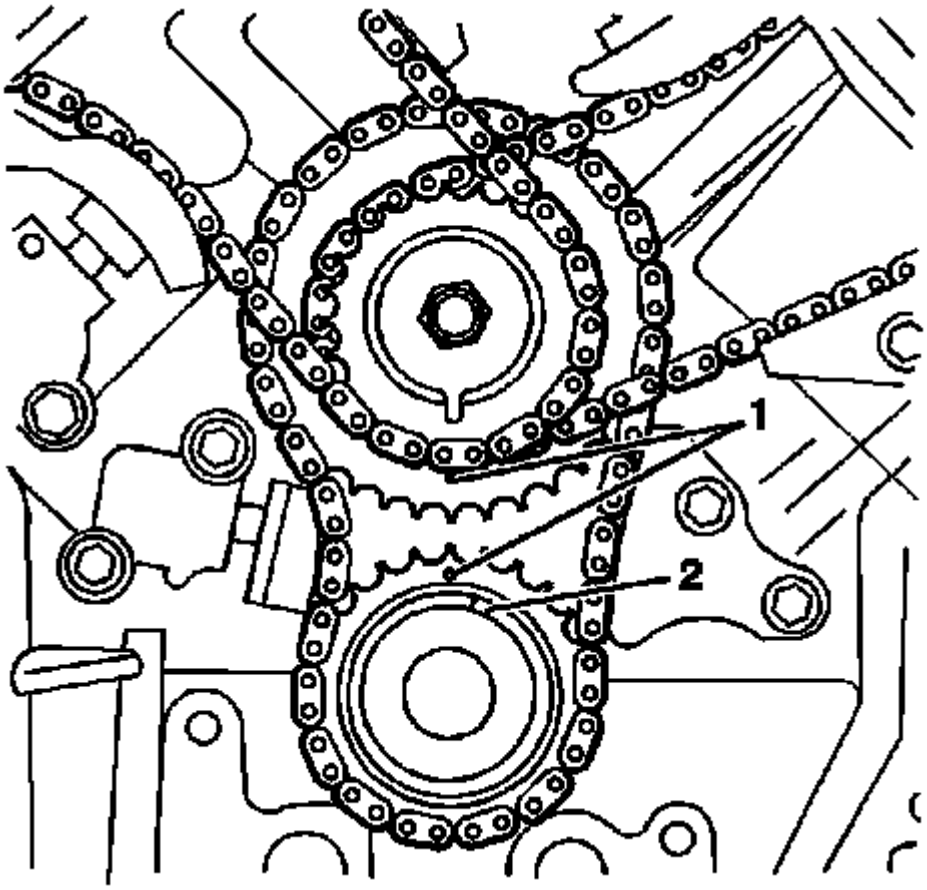

Fig. 168: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

NOTE: Aligning the primary timing marks will locate the left camshafts in a neutral position, preventing them from rotating when the tensioner is removed.

2. Align the primary timing marks (1) using the **J 39946** .

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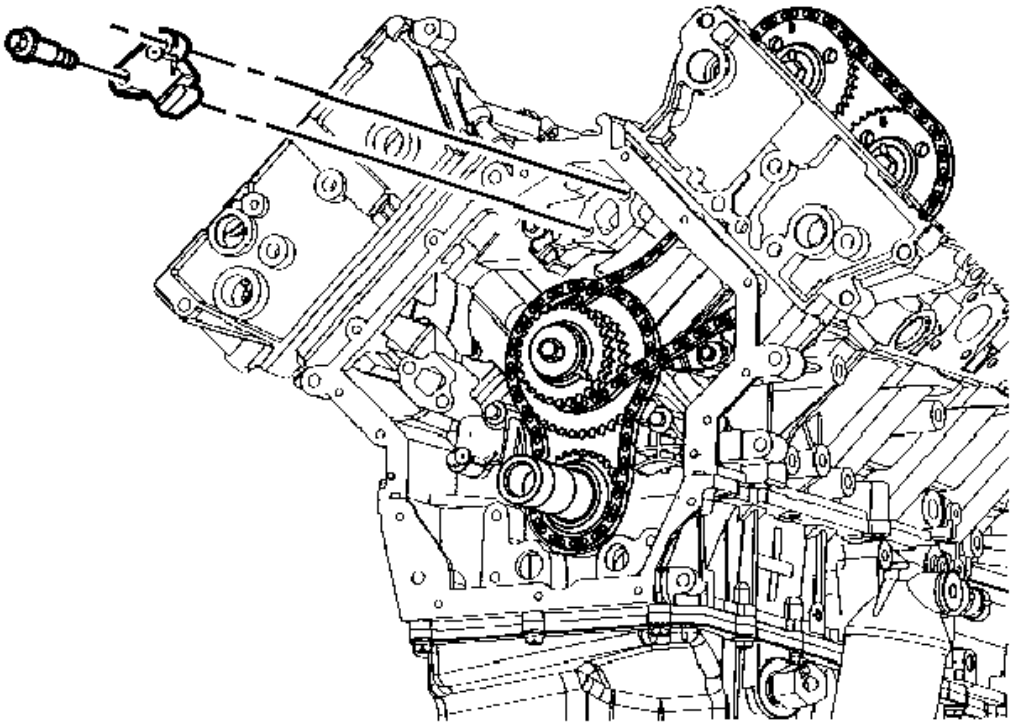

Fig. 169: Left Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the 2 bolts attaching the left secondary camshaft drive chain tensioner to the engine block.
4. Remove the left secondary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
5. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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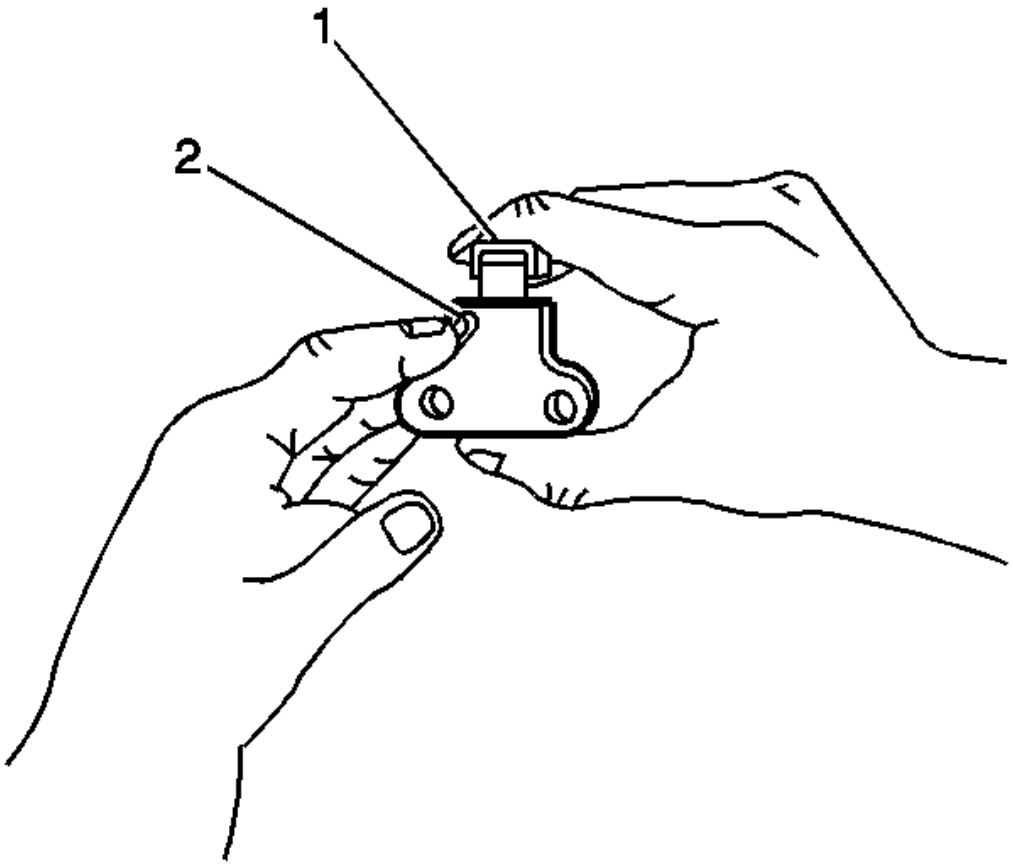

Fig. 170: Collapsing Secondary Camshaft Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Collapse the left secondary camshaft chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) counterclockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a "click" is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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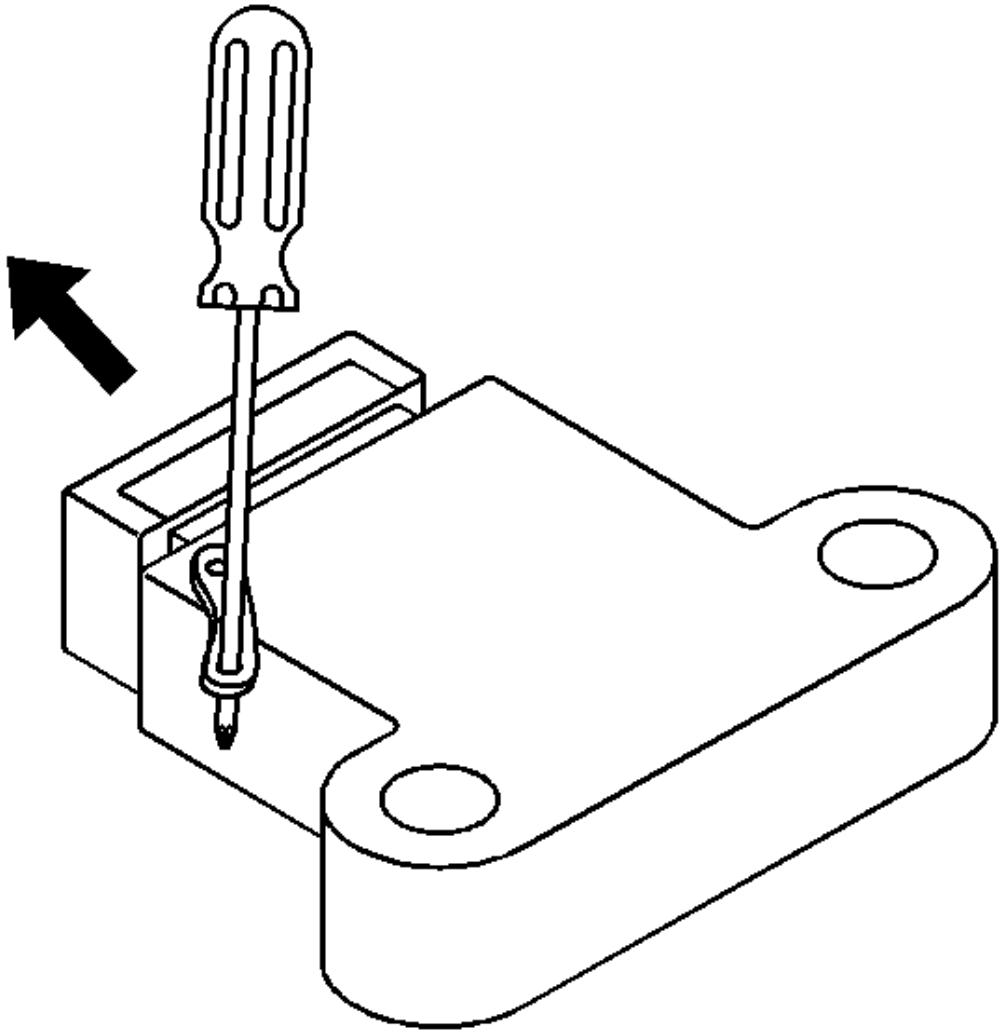

Fig. 171: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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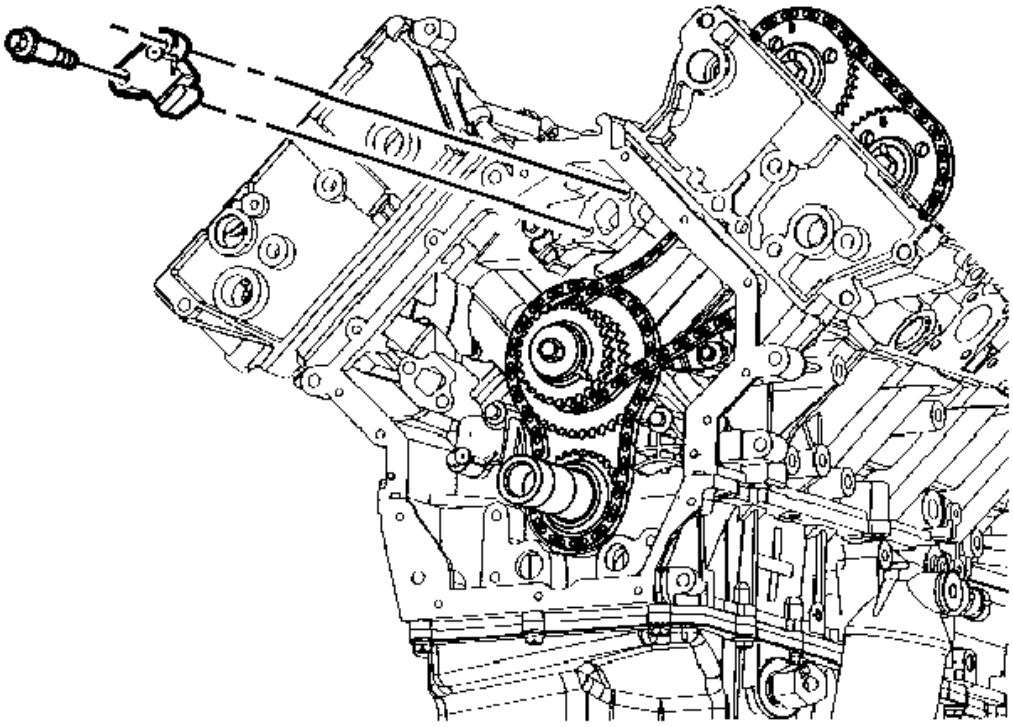

Fig. 172: Left Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Ensure the tensioner release lever is facing outward.

5. Install the left secondary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

6. Remove the pin holding the tensioner to tighten any slack in the timing chain.
7. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

SECONDARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER REPLACEMENT - RIGHT SIDE

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SPECIAL TOOLS

J 39946 Crankshaft Socket - 4.0L and 4.6L

REMOVAL PROCEDURE

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

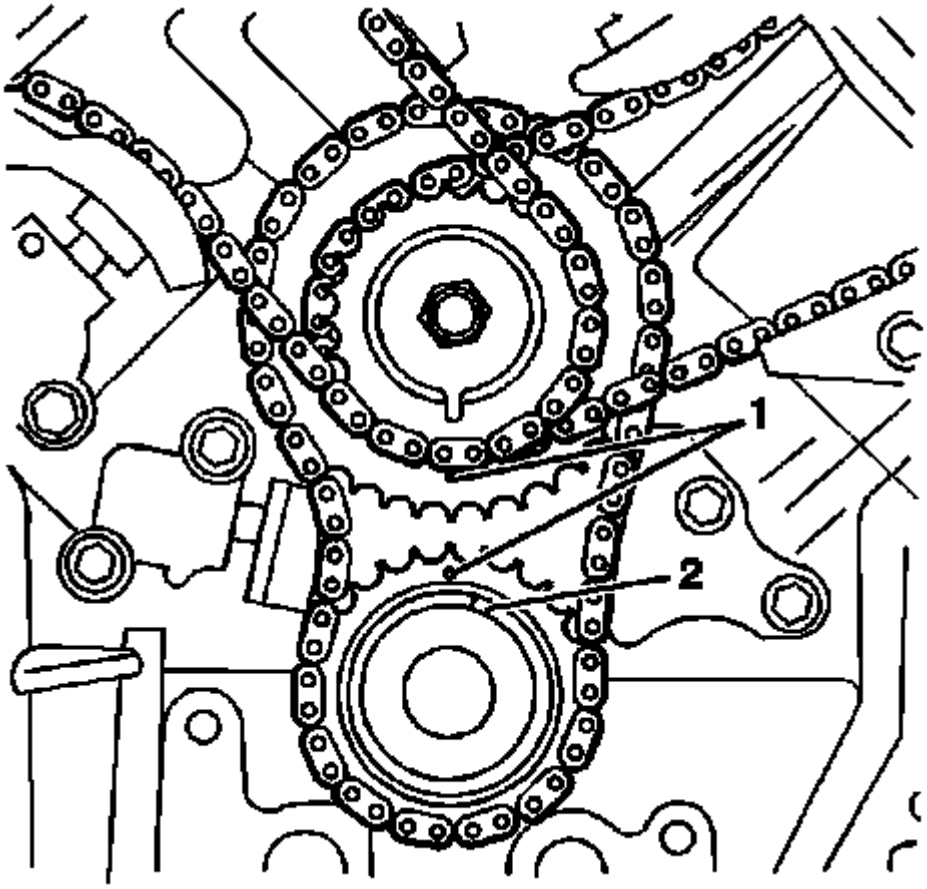

Fig. 173: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the primary timing marks (1) using the **J 39946** .

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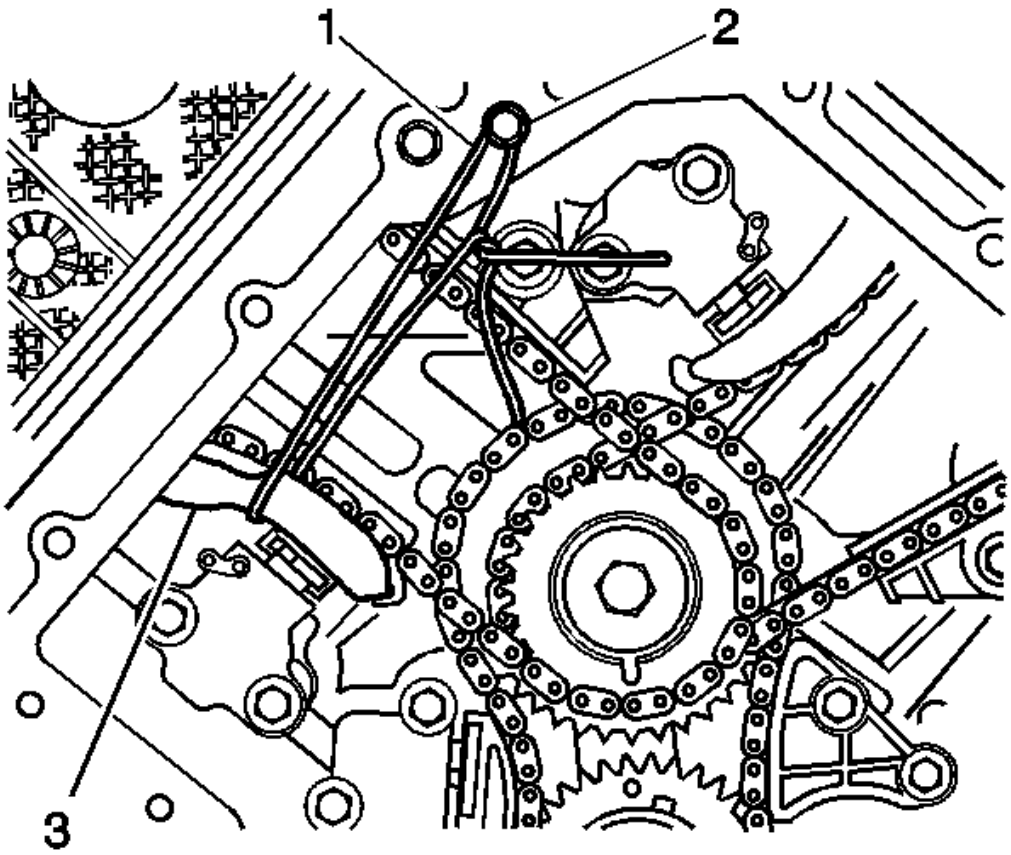

Fig. 174: Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

3. Install an engine front cover bolt (2) into the front of the engine.

NOTE: Securing the right secondary camshaft drive chain shoe will prevent the right camshaft drive sprocket teeth from skipping on the right secondary timing chain.

4. Wrap mechanics wire (1) tightly around both the right secondary camshaft drive chain shoe (3) and the front cover bolt (2).

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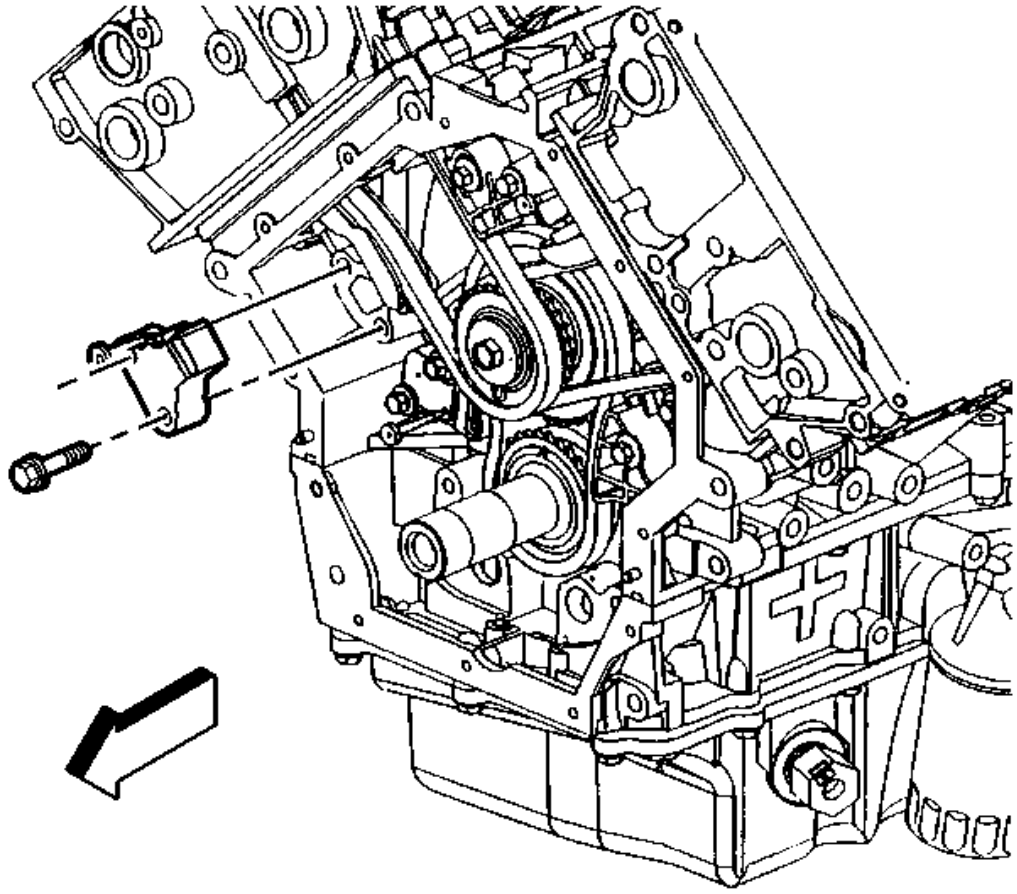

Fig. 175: Right Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the 2 bolts attaching the right secondary camshaft drive chain tensioner to the engine block.
6. Remove the right secondary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
7. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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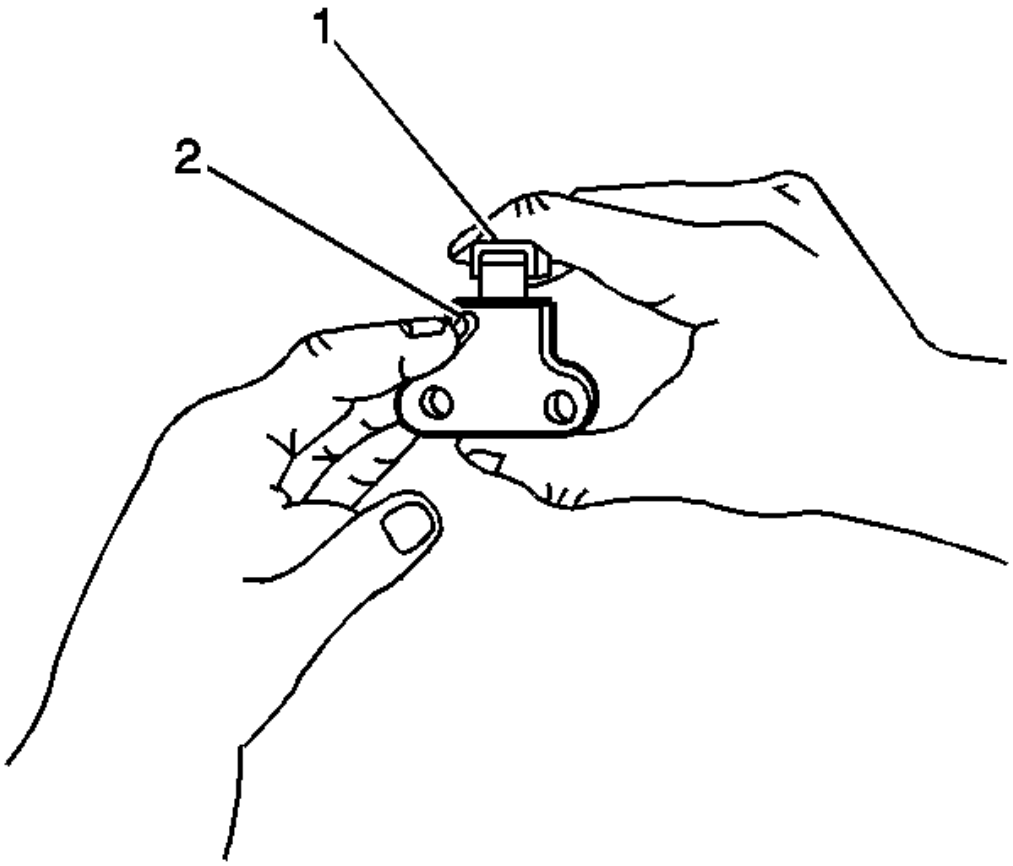

Fig. 176: Collapsing Secondary Camshaft Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Collapse the right secondary camshaft chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) counterclockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a "click" is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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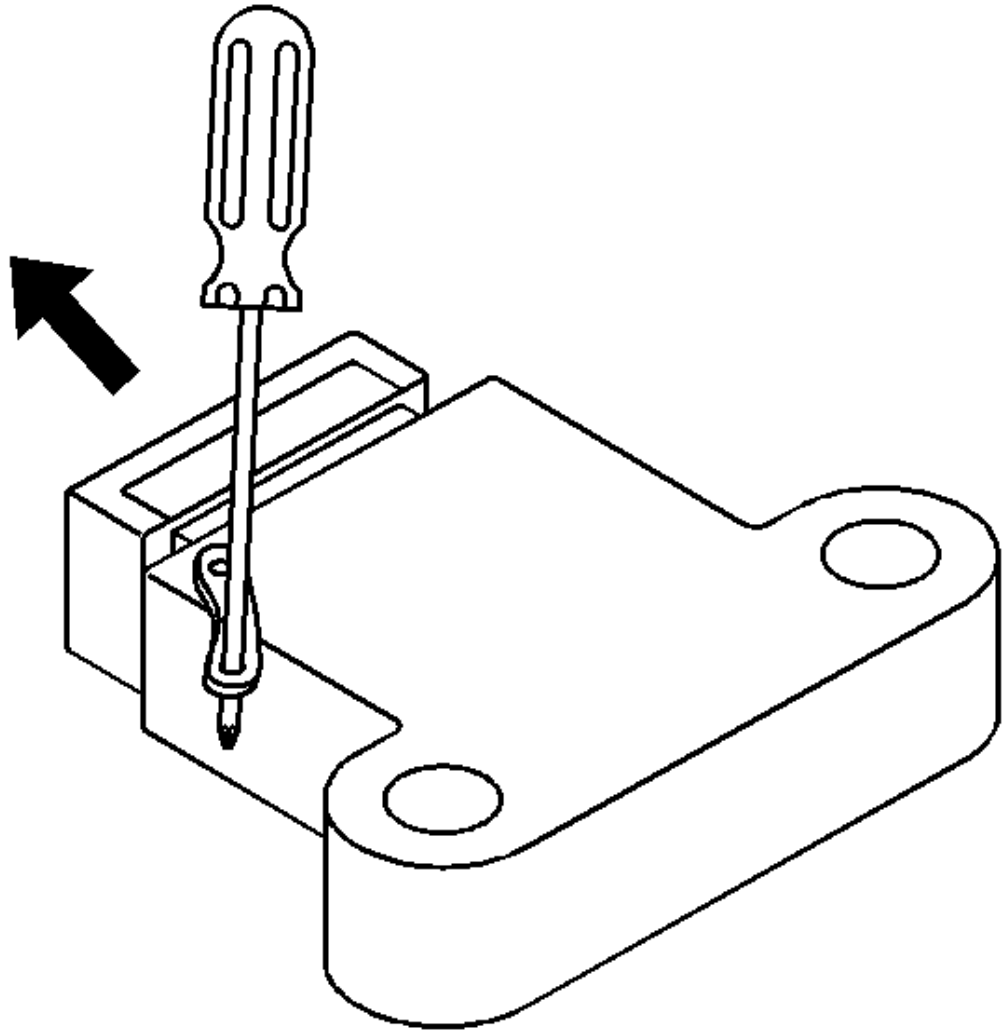

Fig. 177: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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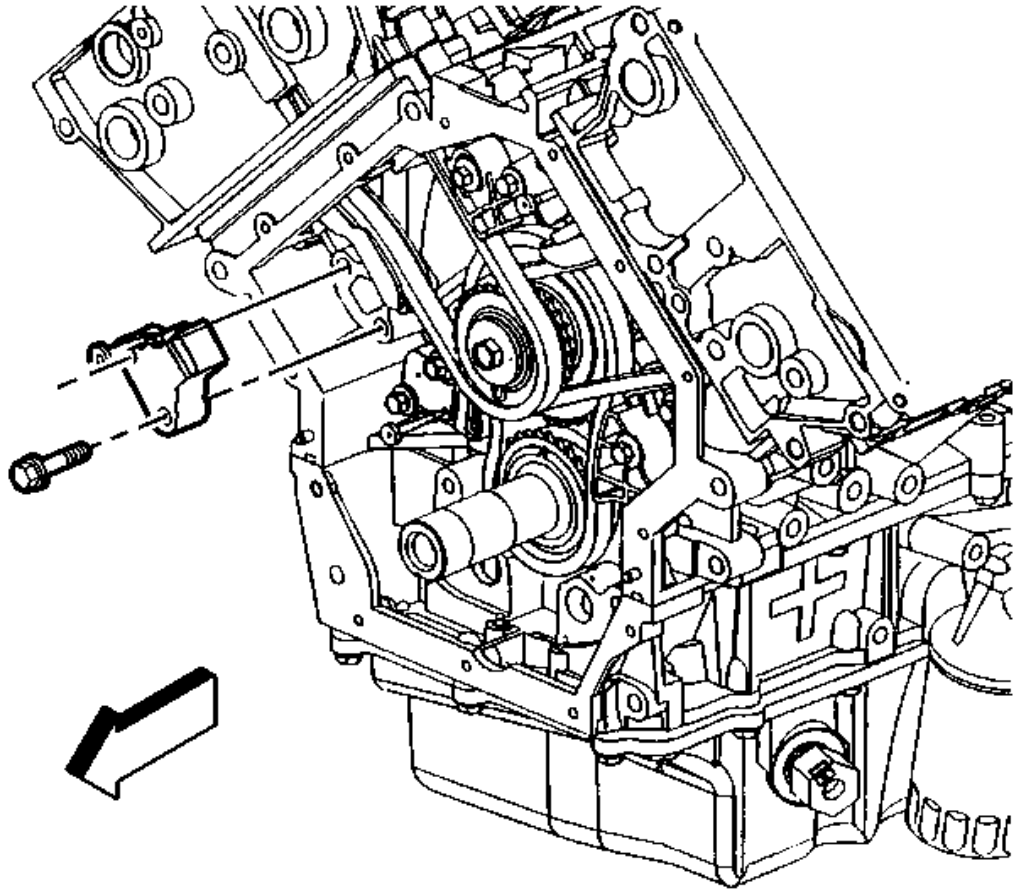

Fig. 178: Right Secondary Camshaft Drive Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Ensure the tensioner release lever is facing outward.

5. Install the right secondary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

6. Remove the pin holding the tensioner to tighten any slack in the timing chain.

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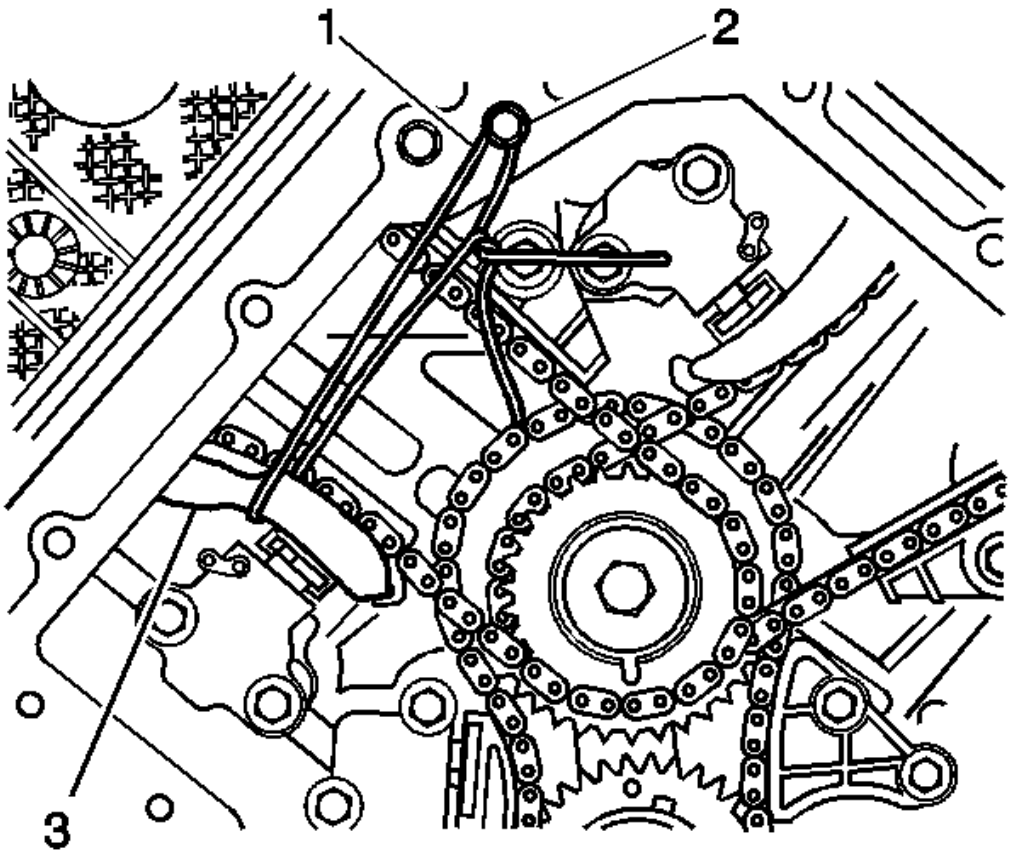

Fig. 179: Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
8. Remove the engine front cover bolt (2) from the front of the engine.
9. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

SECONDARY TIMING CHAIN TENSIONER SHOE REPLACEMENT - LEFT SIDE

SPECIAL TOOLS

J 44212 Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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1. Remove the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.
2. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

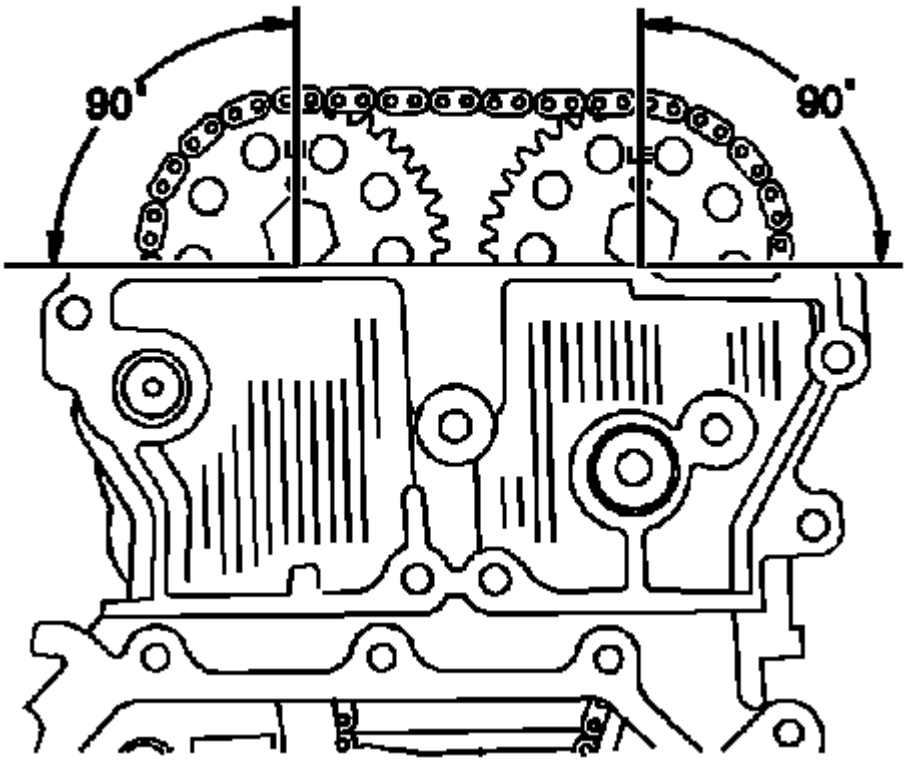

Fig. 180: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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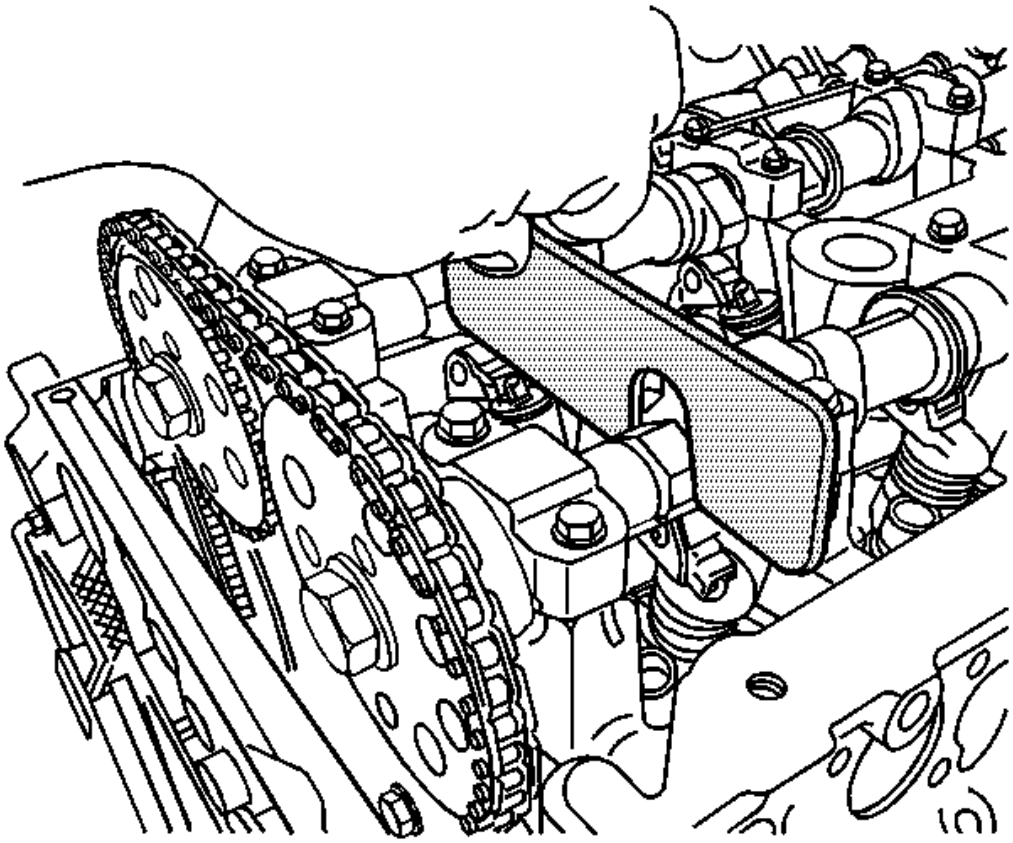

Fig. 181: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

4. Install the **J 44212** over the camshafts. See **Special Tools** .

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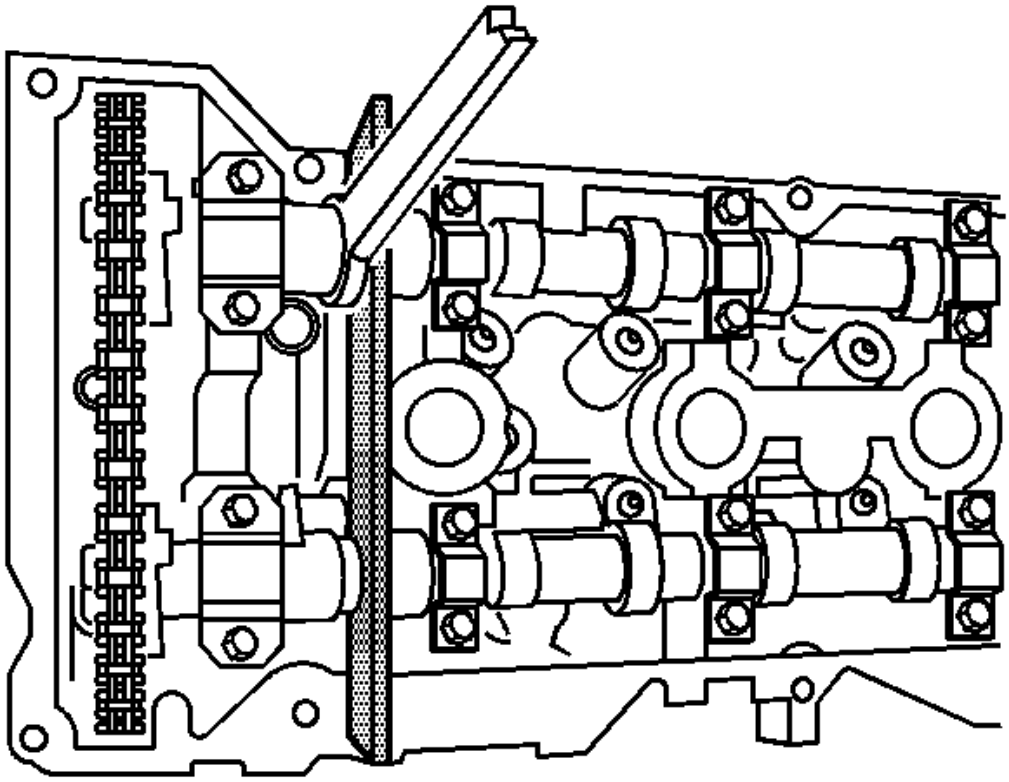

Fig. 182: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

5. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft sprocket bolt.

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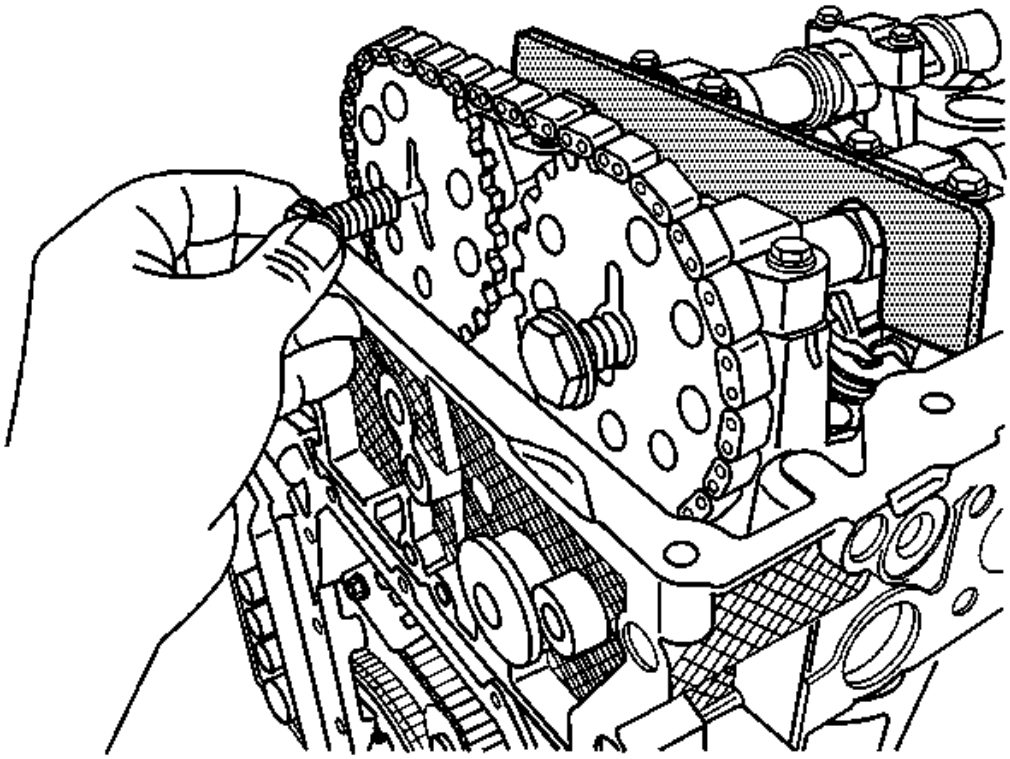

Fig. 183: Left Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the left intake camshaft sprocket bolt.
7. Slide the left intake camshaft sprocket off of the camshaft and remove the left secondary drive chain from the camshaft sprocket teeth.

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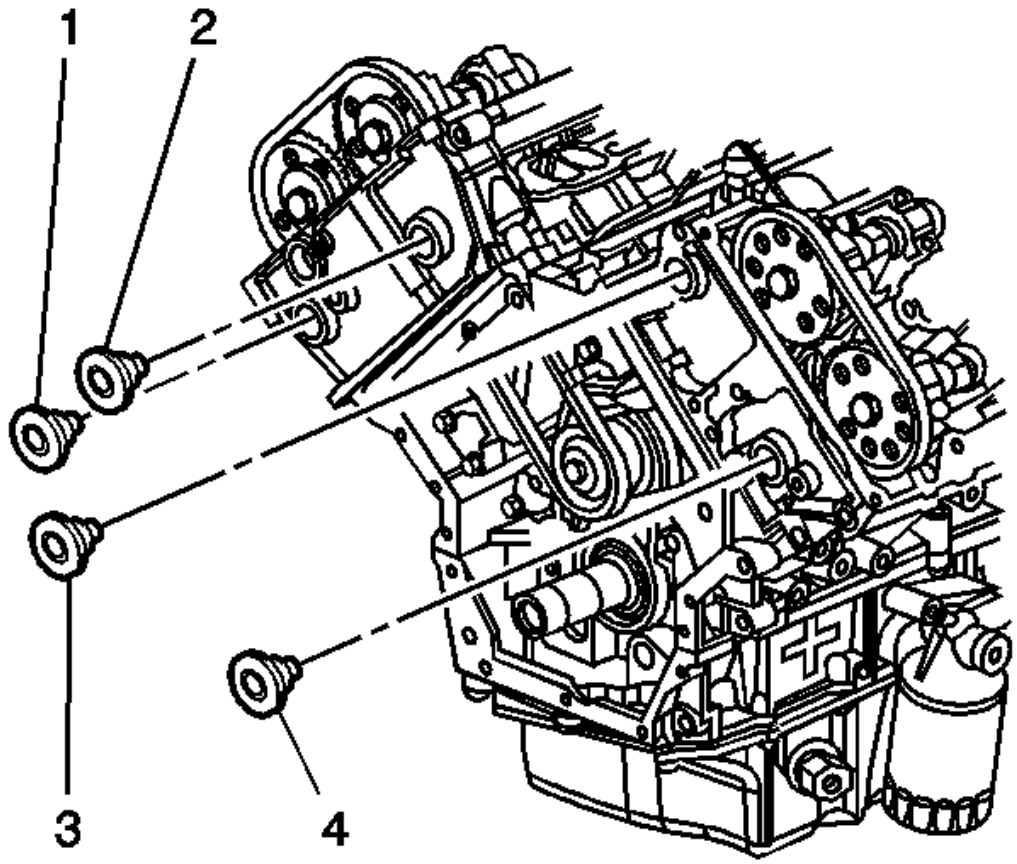

Fig. 184: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

8. Remove the left secondary camshaft drive chain shoe access plug (3) located in the cylinder head. Ensure the O-ring seal remains attached to the access plug.

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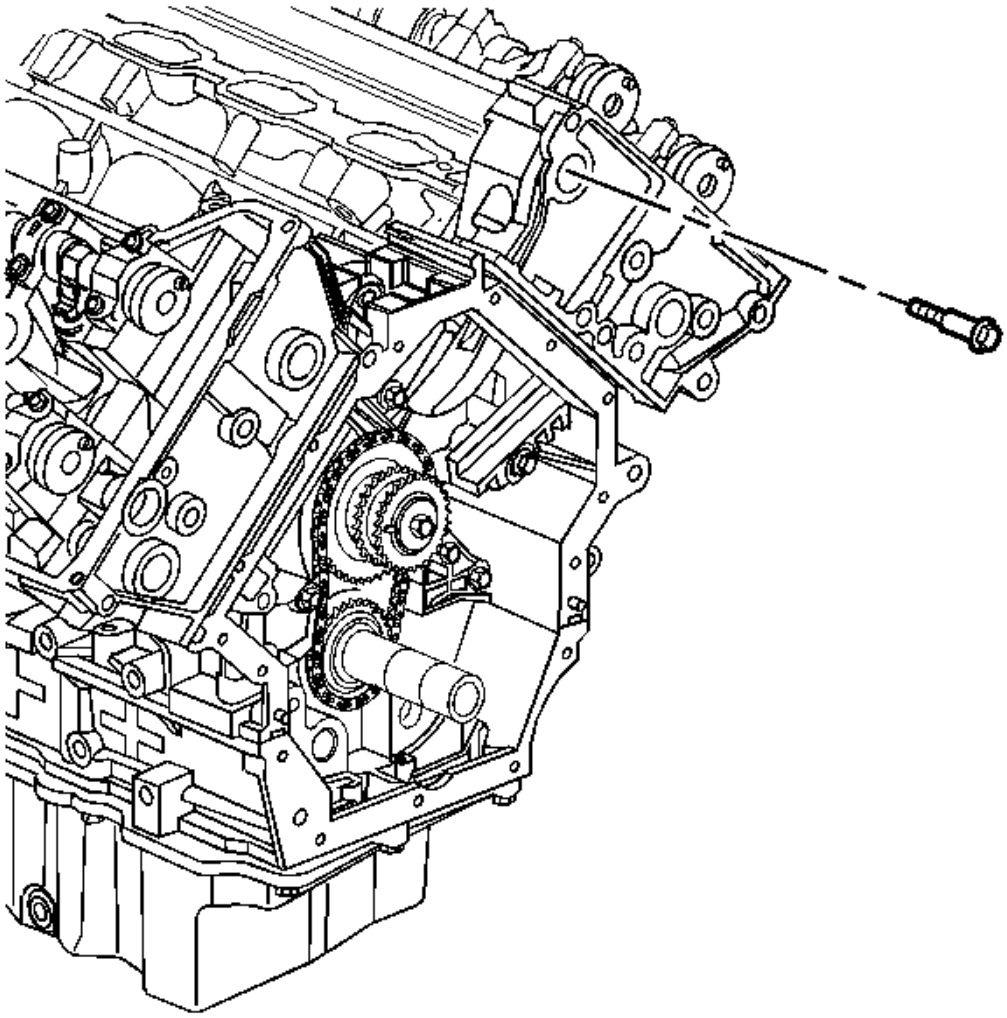

Fig. 185: Left Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the left secondary camshaft drive chain shoe bolt.

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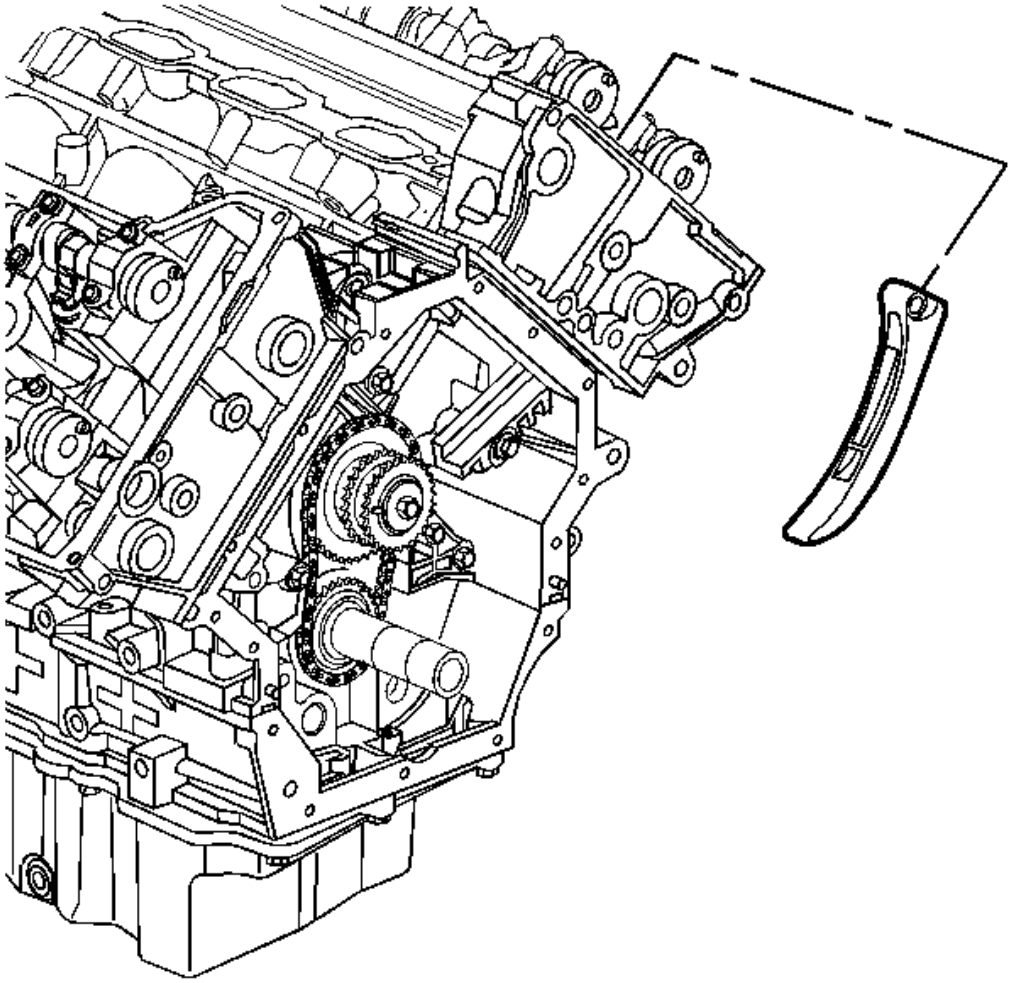

Fig. 186: Left Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

10. Remove the left secondary camshaft drive chain shoe.
11. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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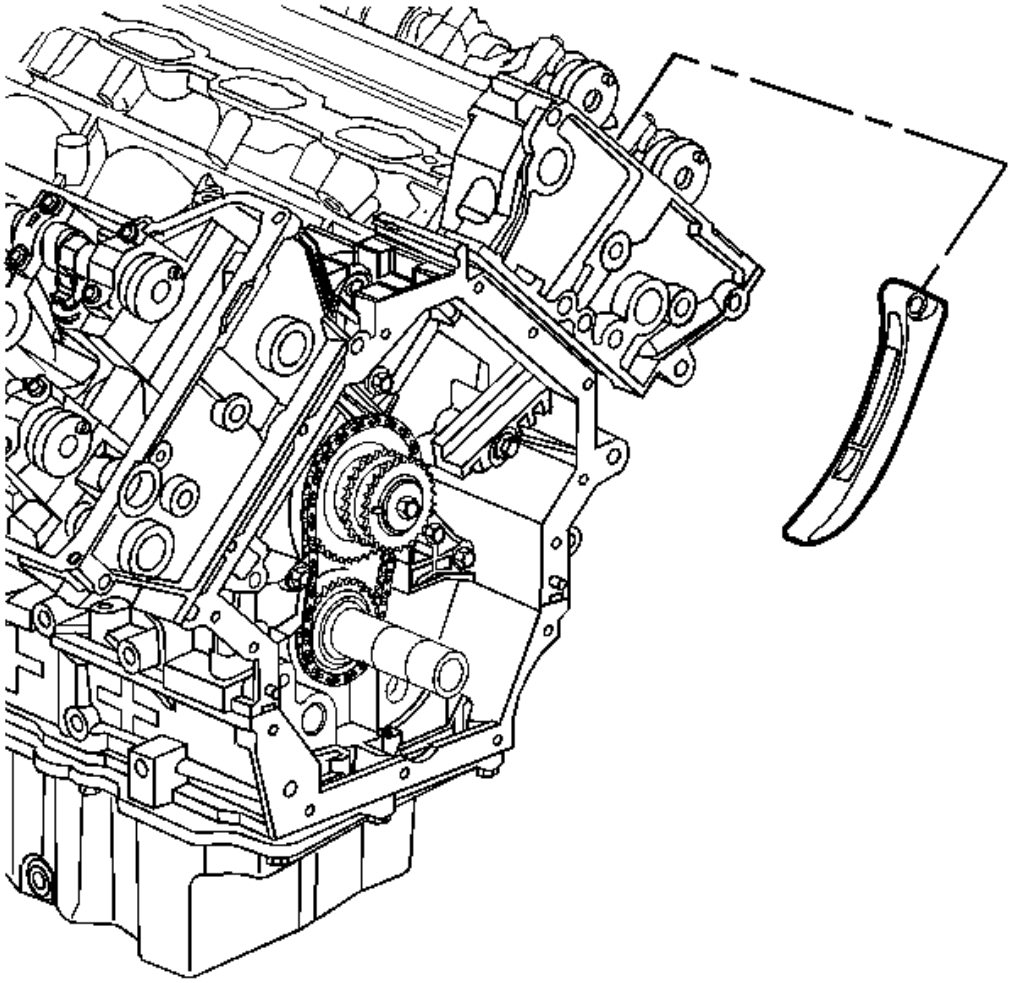

Fig. 187: Left Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain shoe in through the top of the cylinder head.

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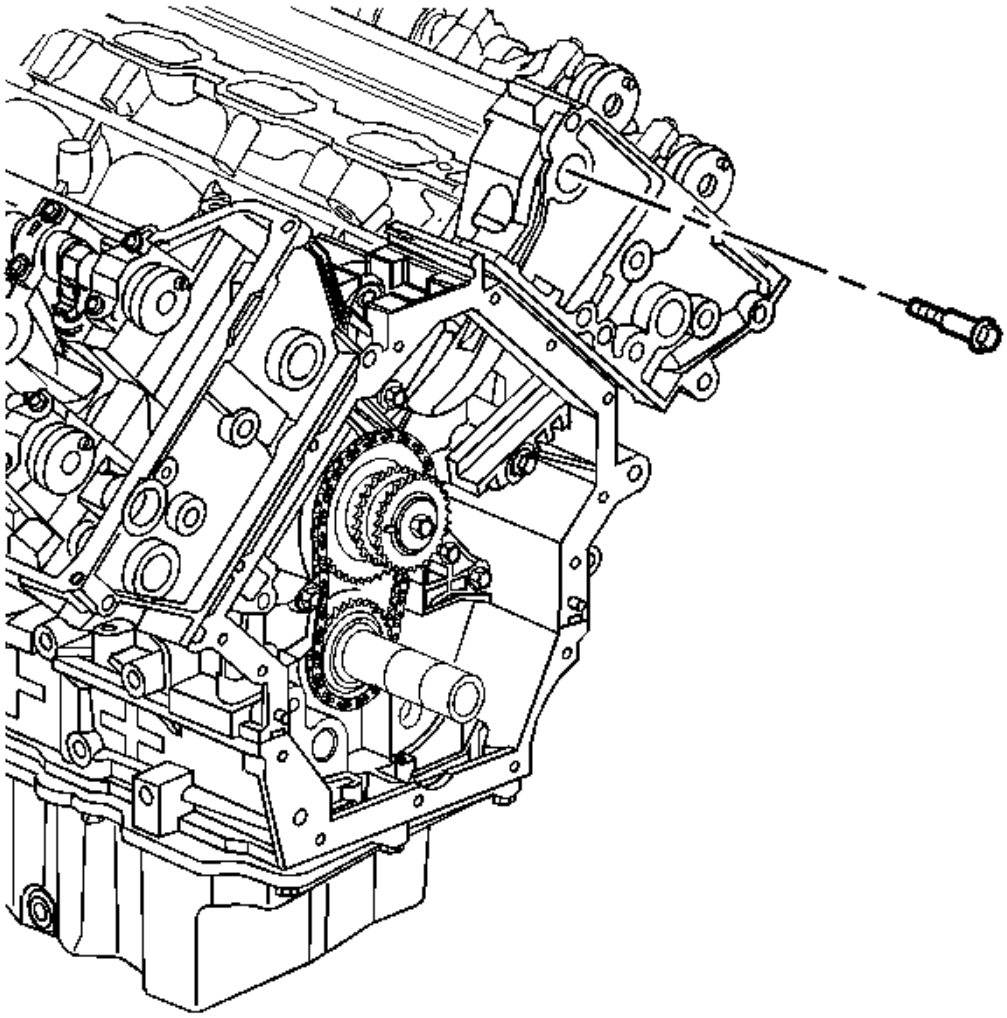

Fig. 188: Left Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install the left secondary camshaft drive chain shoe bolt.

   Tighten: Tighten the secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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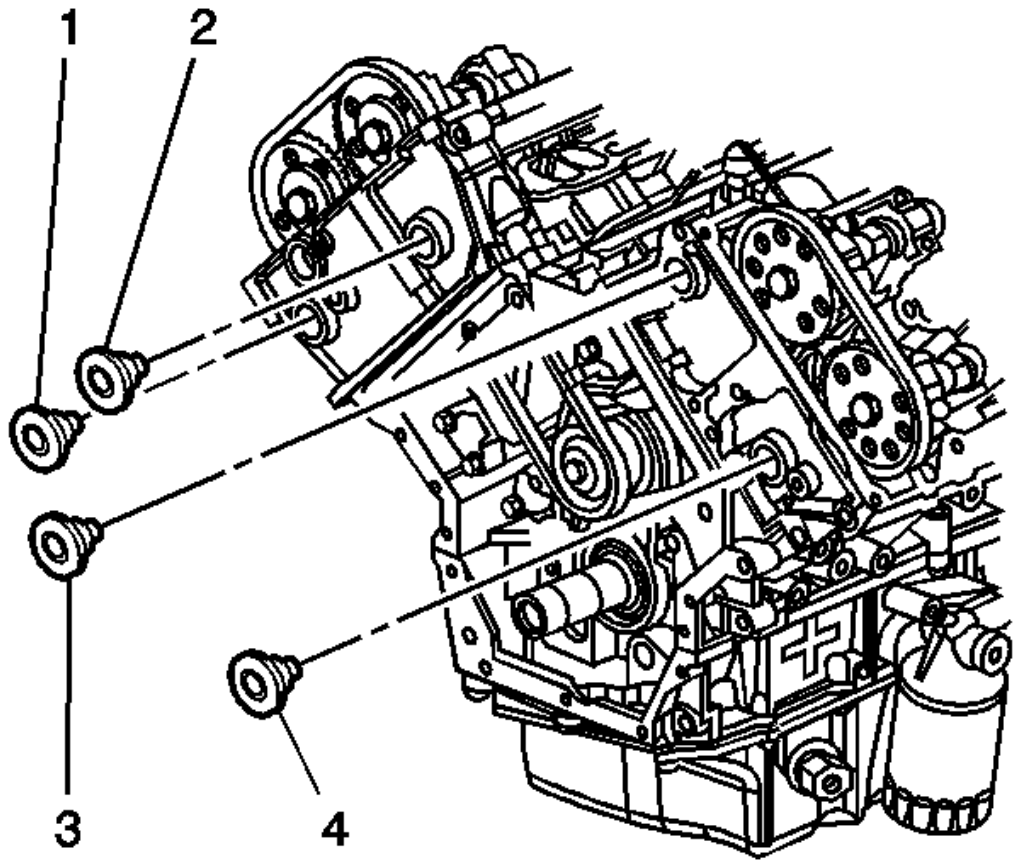

Fig. 189: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

3. Install the left secondary camshaft drive chain shoe access plug (3) located in the cylinder head. Ensure the O-ring seal is attached to the access plug.

   Tighten: Tighten the secondary camshaft drive chain shoe access plug to 4.5 N.m (40 lb in).

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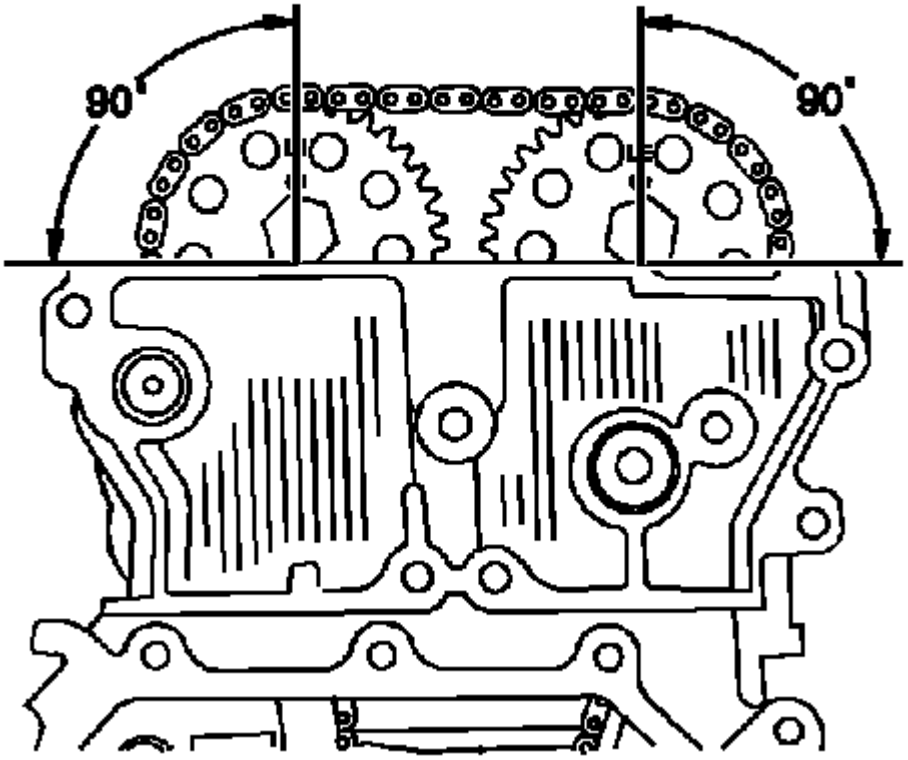

Fig. 190: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

4. Install the left intake camshaft sprocket into the left secondary camshaft drive chain.
5. Install the left intake camshaft sprocket onto the camshaft. The camshaft sprocket notch marked LI (left intake) engages the intake camshaft pin.

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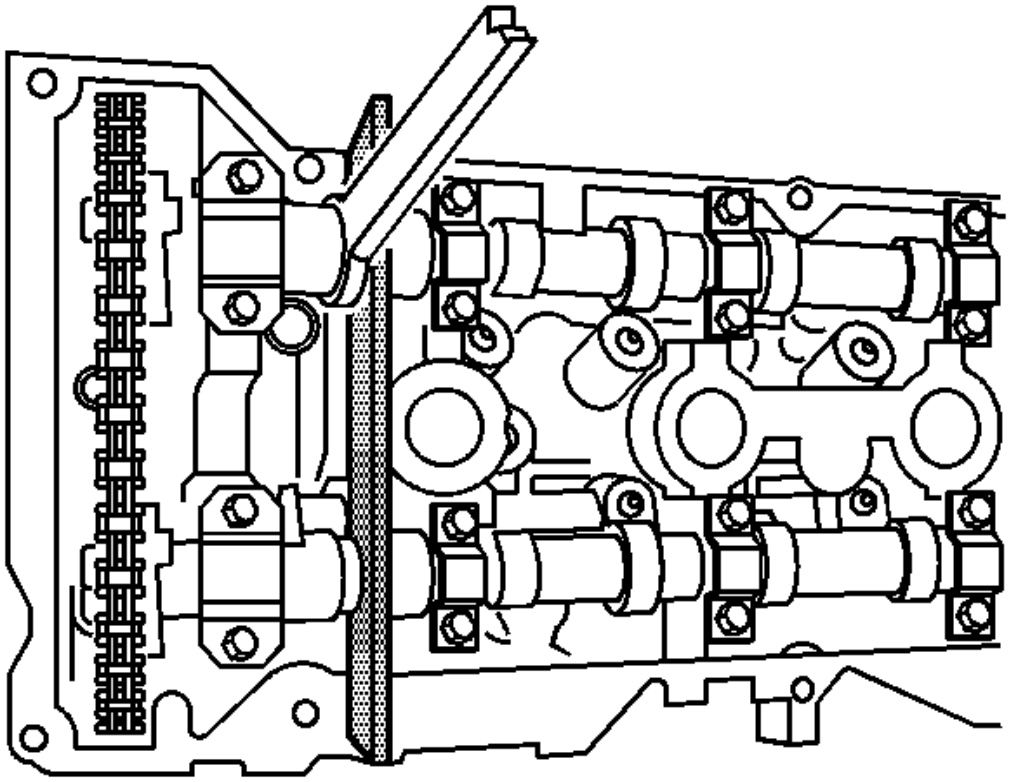

Fig. 191: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

6. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the camshaft sprocket bolt.

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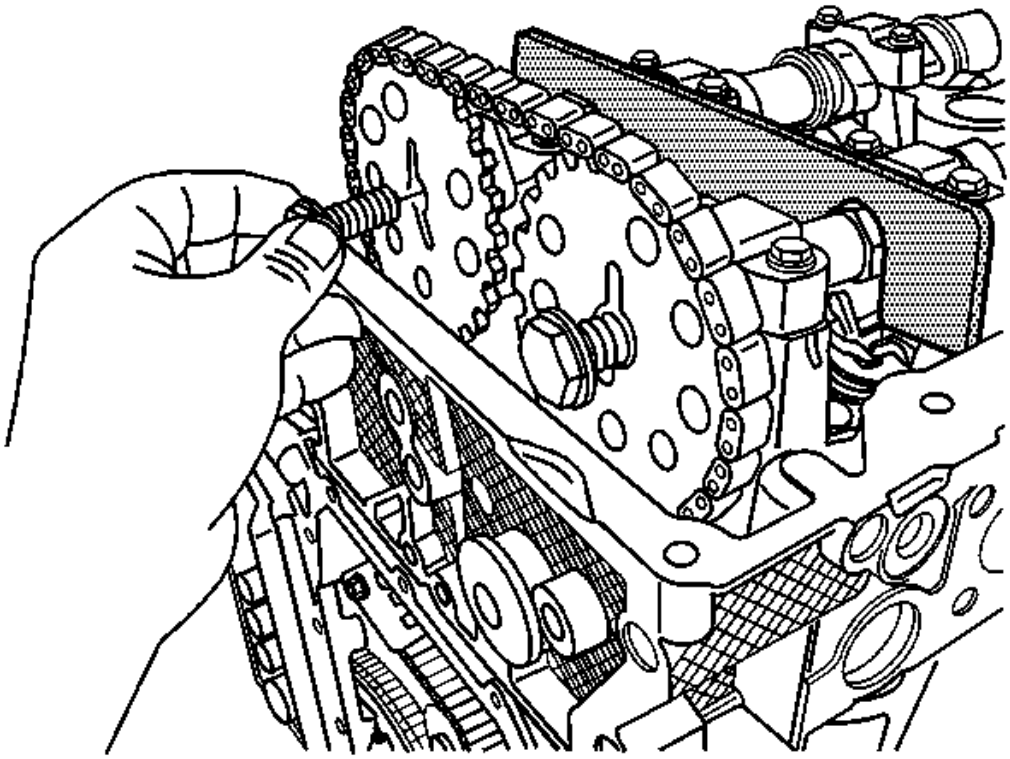

Fig. 192: Left Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the left intake camshaft sprocket bolt.

   Tighten: Tighten the camshaft sprocket bolt to 120 N.m (89 lb ft).

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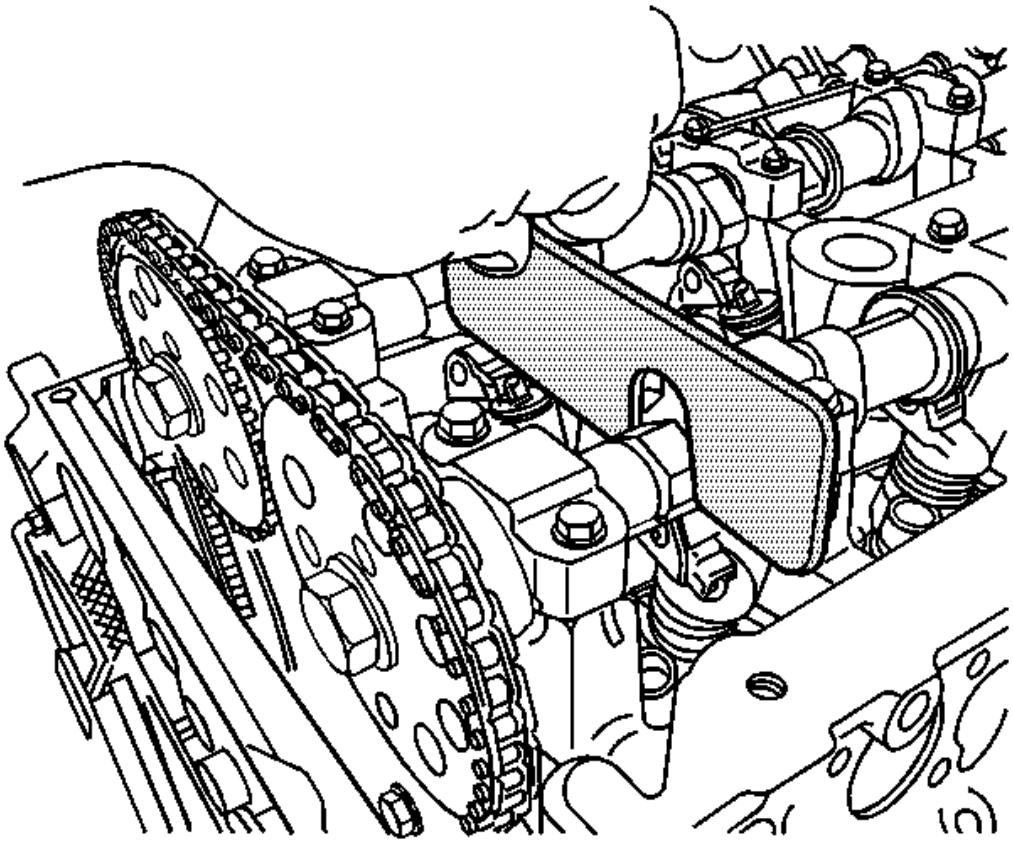

Fig. 193: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

8. Remove the **J 44212** from the camshafts. See **Special Tools** .
9. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
10. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.

SECONDARY TIMING CHAIN TENSIONER SHOE REPLACEMENT - RIGHT SIDE

SPECIAL TOOLS

J 44212 Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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1. Remove the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.
2. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

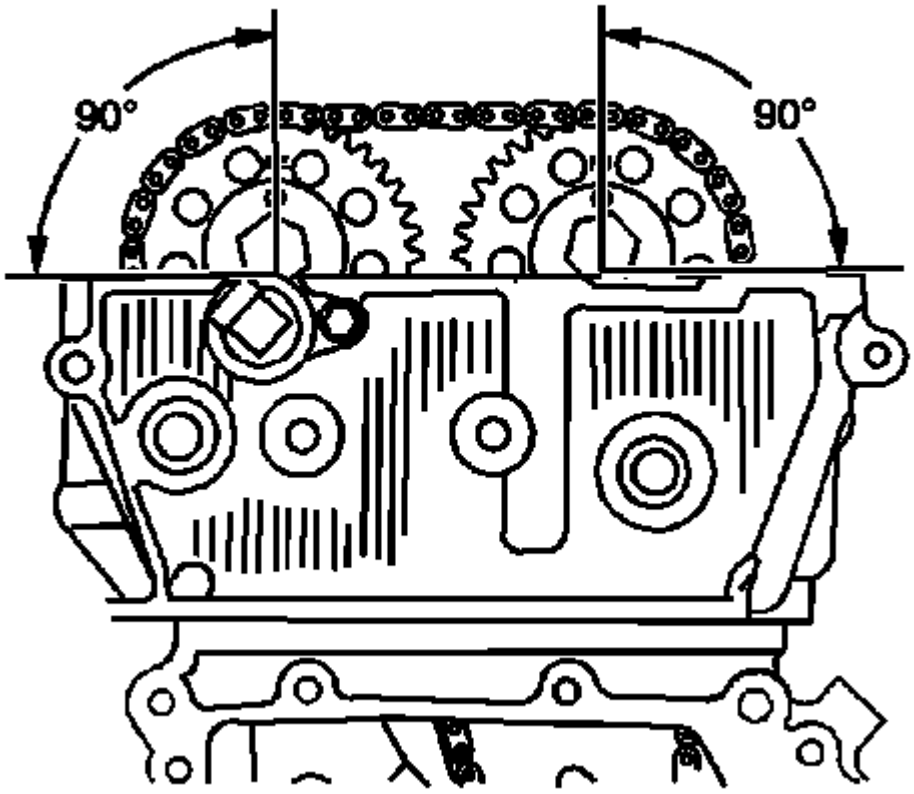

Fig. 194: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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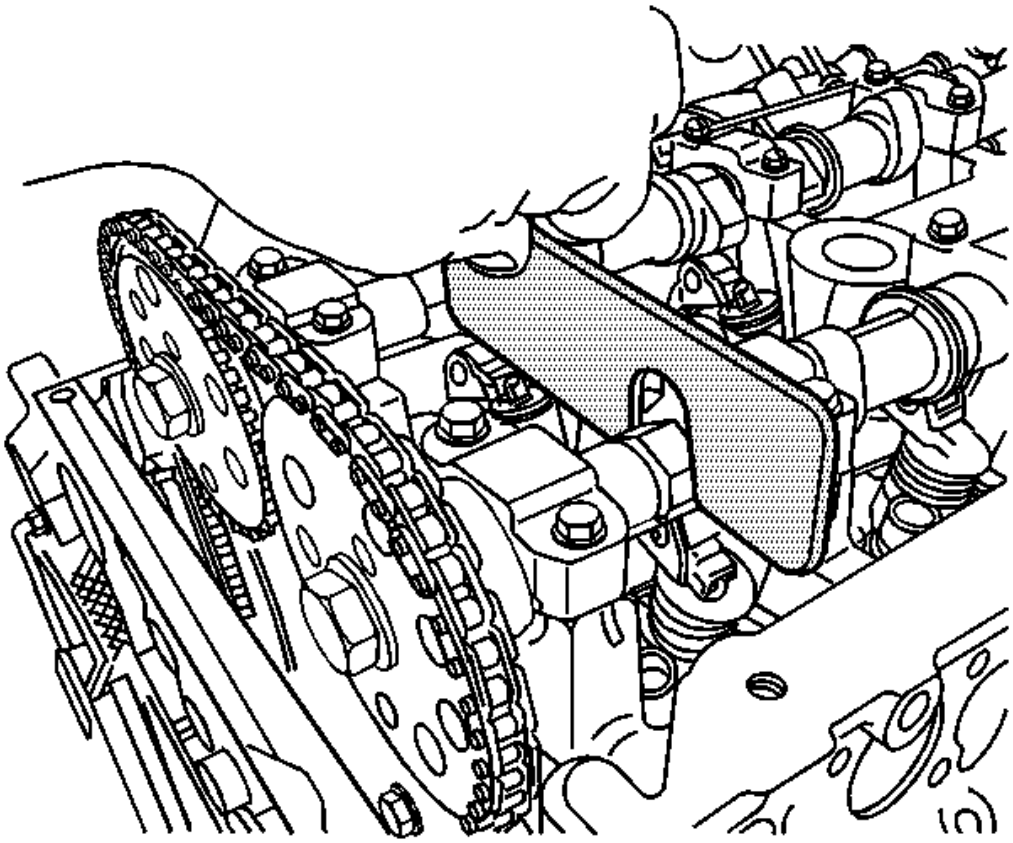

Fig. 195: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

4. Install the **J 44212** over the camshafts. See **Special Tools** .

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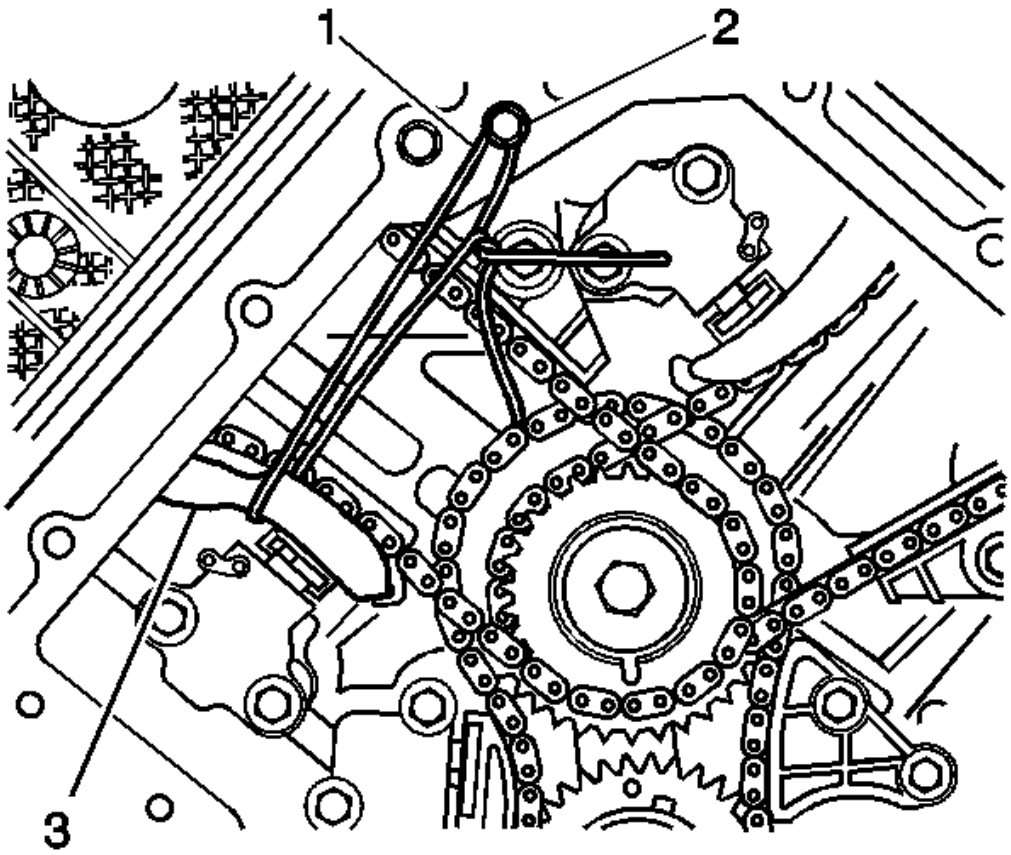

Fig. 196: Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
6. Remove the engine front cover bolt (2) from the front of the engine.

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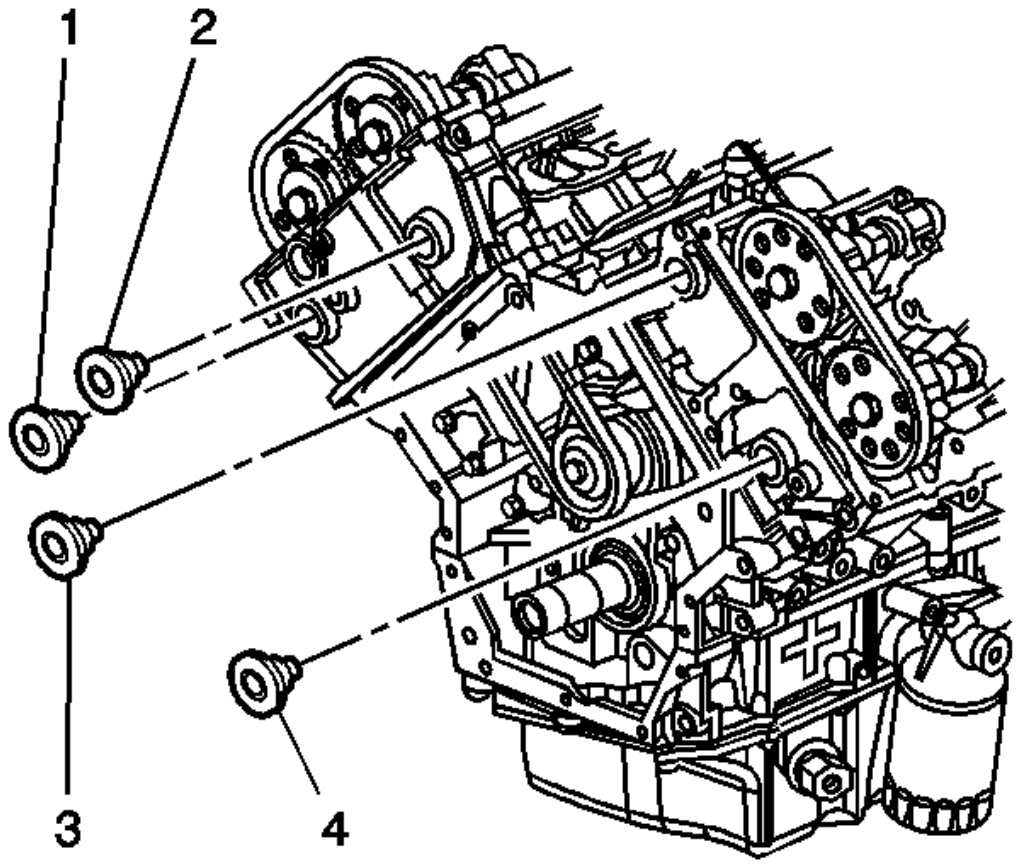

Fig. 197: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the right secondary camshaft drive chain shoe access plug (1) located in the cylinder head. Ensure the O-ring seal remains attached to the access plug.

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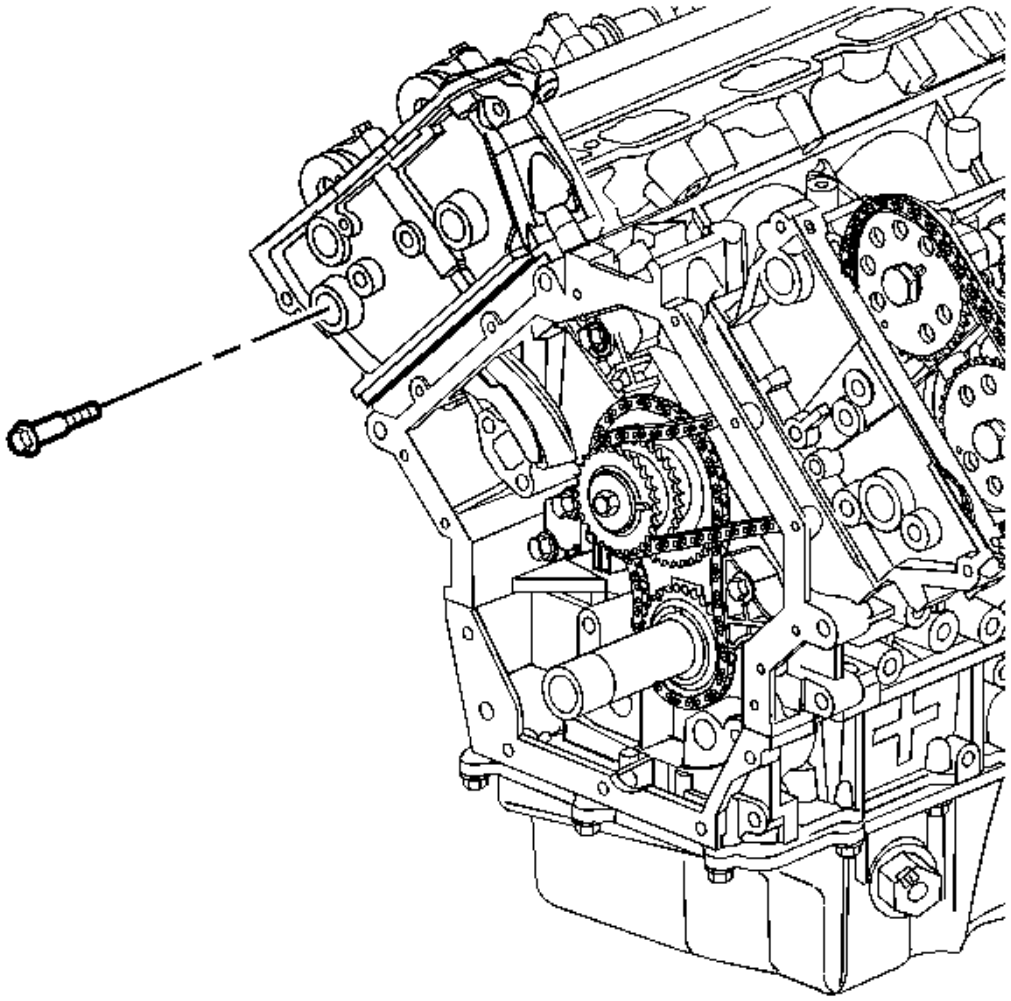

Fig. 198: Right Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the right secondary camshaft drive chain shoe bolt.

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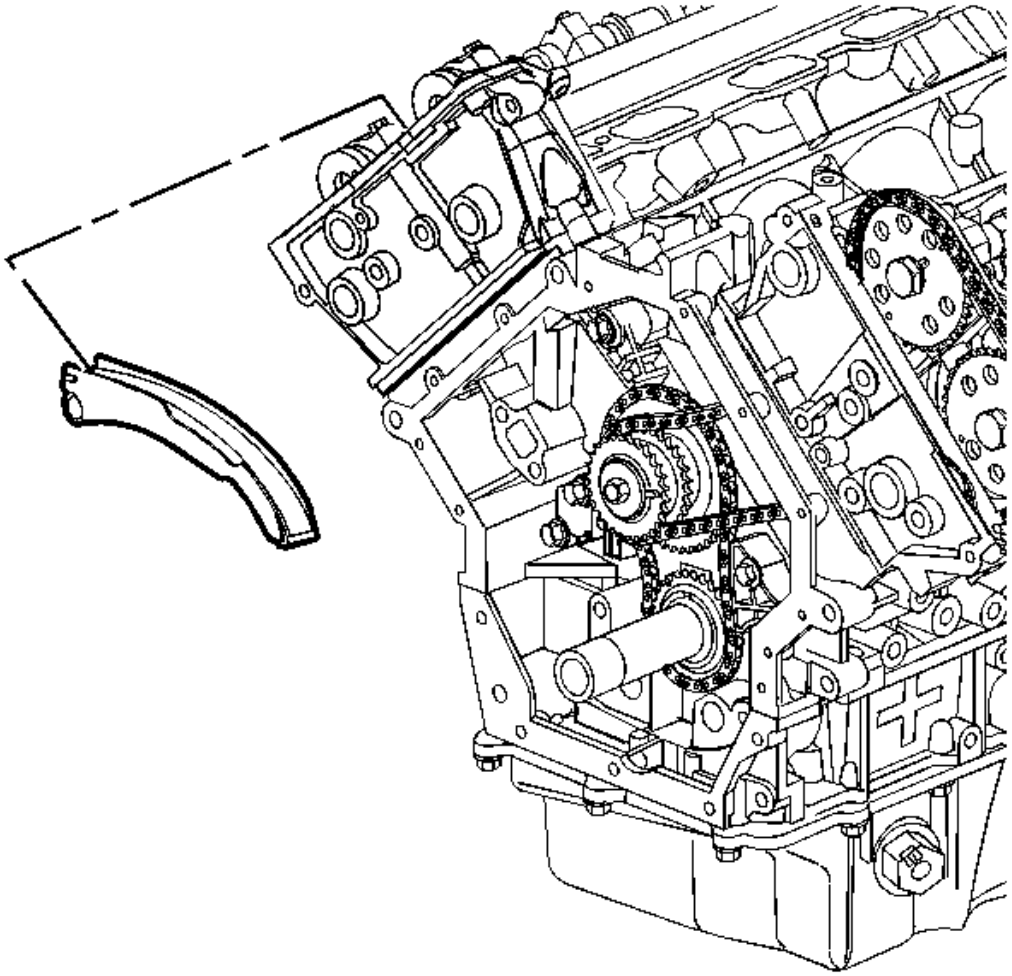

Fig. 199: Right Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

9. Remove the right secondary camshaft drive chain shoe.
10. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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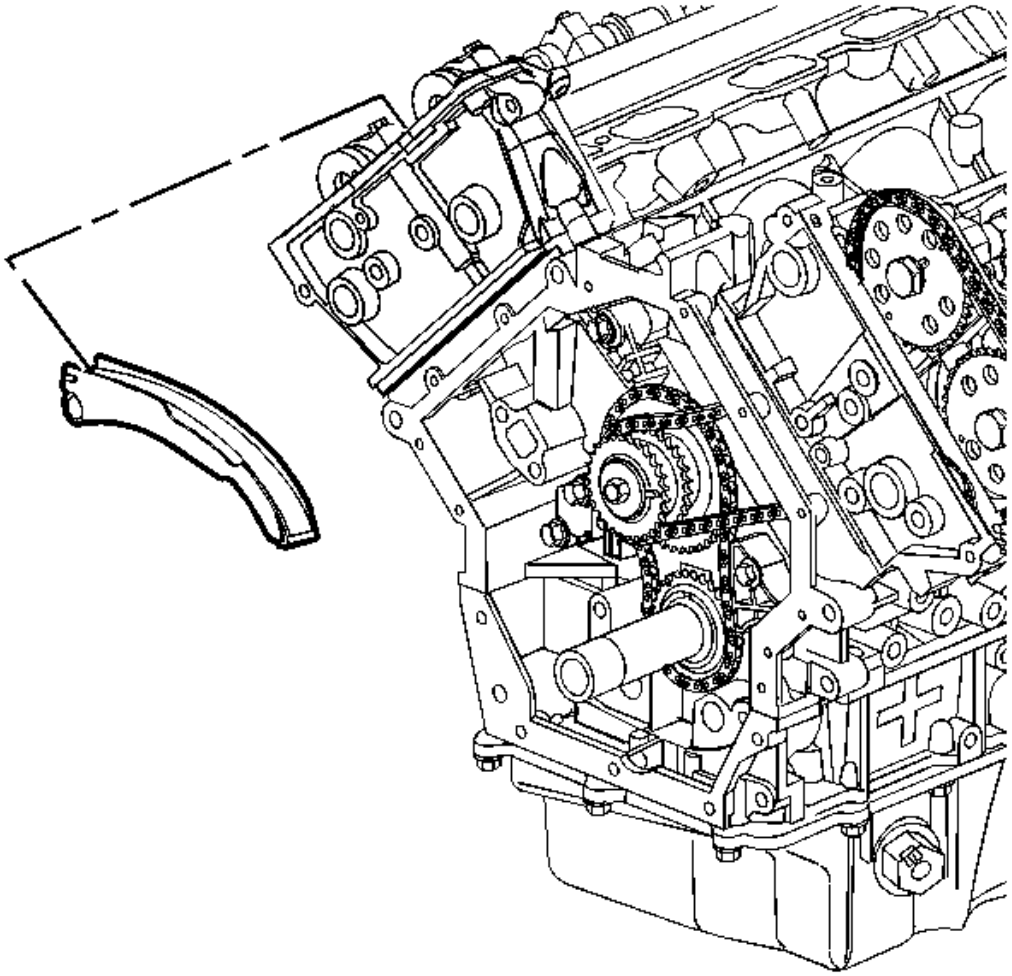

Fig. 200: Right Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain shoe in through the front cover area.

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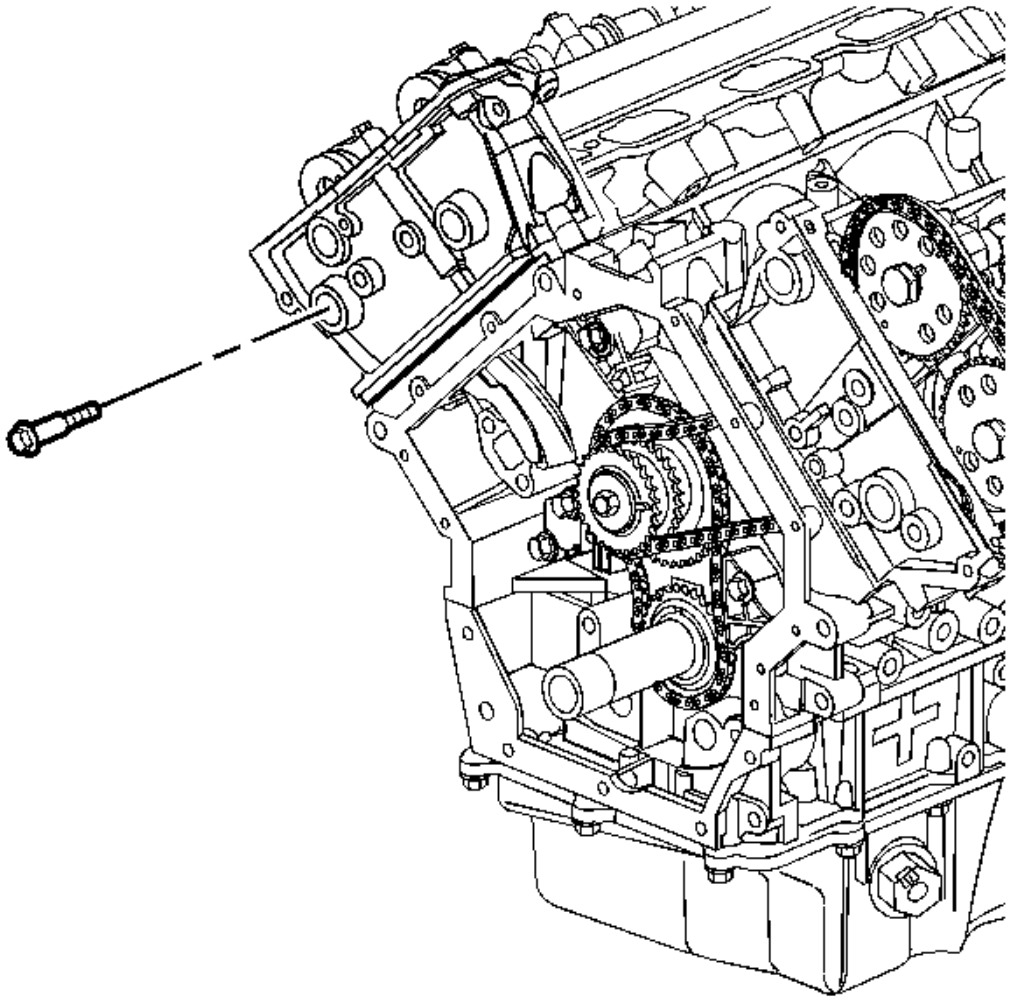

Fig. 201: Right Secondary Camshaft Drive Chain Shoe Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install the right secondary camshaft drive chain shoe bolt.

   Tighten: Tighten the secondary camshaft drive chain shoe bolt to 25 N.m (18 lb ft).

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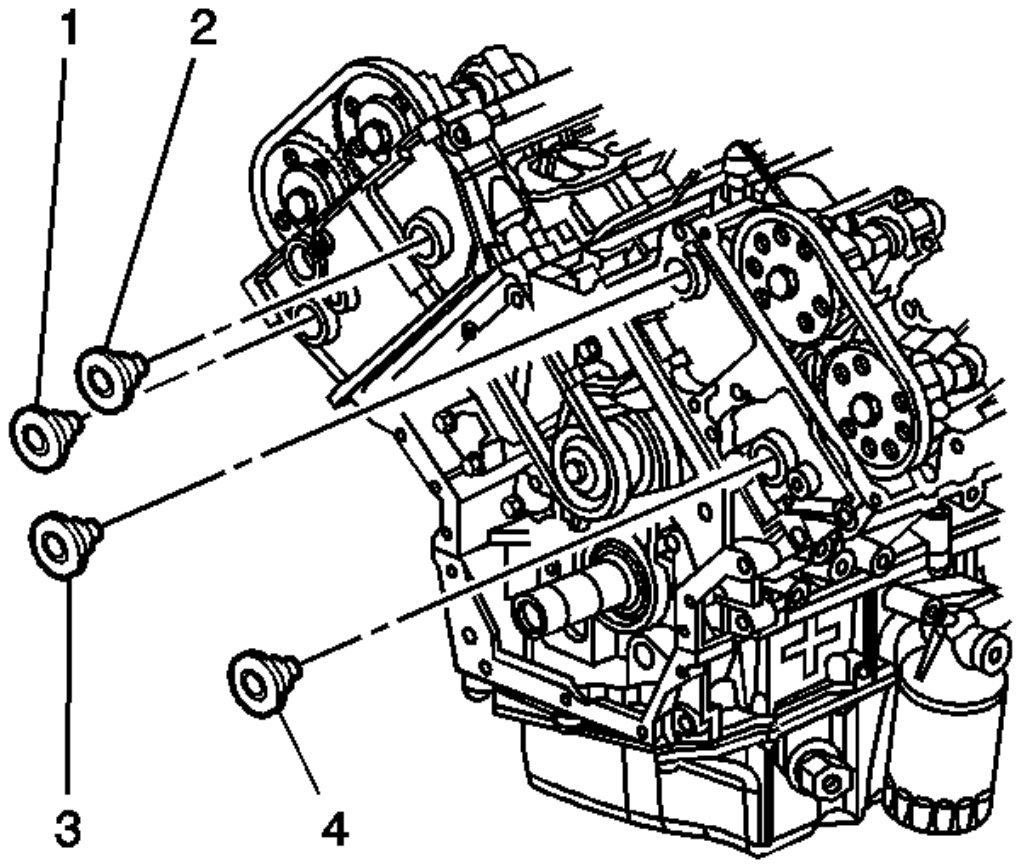

Fig. 202: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

3. Install the right secondary camshaft drive chain shoe access plug (1) located in the cylinder head. Ensure the O-ring seal is attached to the access plug.

   Tighten: Tighten the secondary camshaft drive chain shoe access plug to 4.5 N.m (40 lb in).

4. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.

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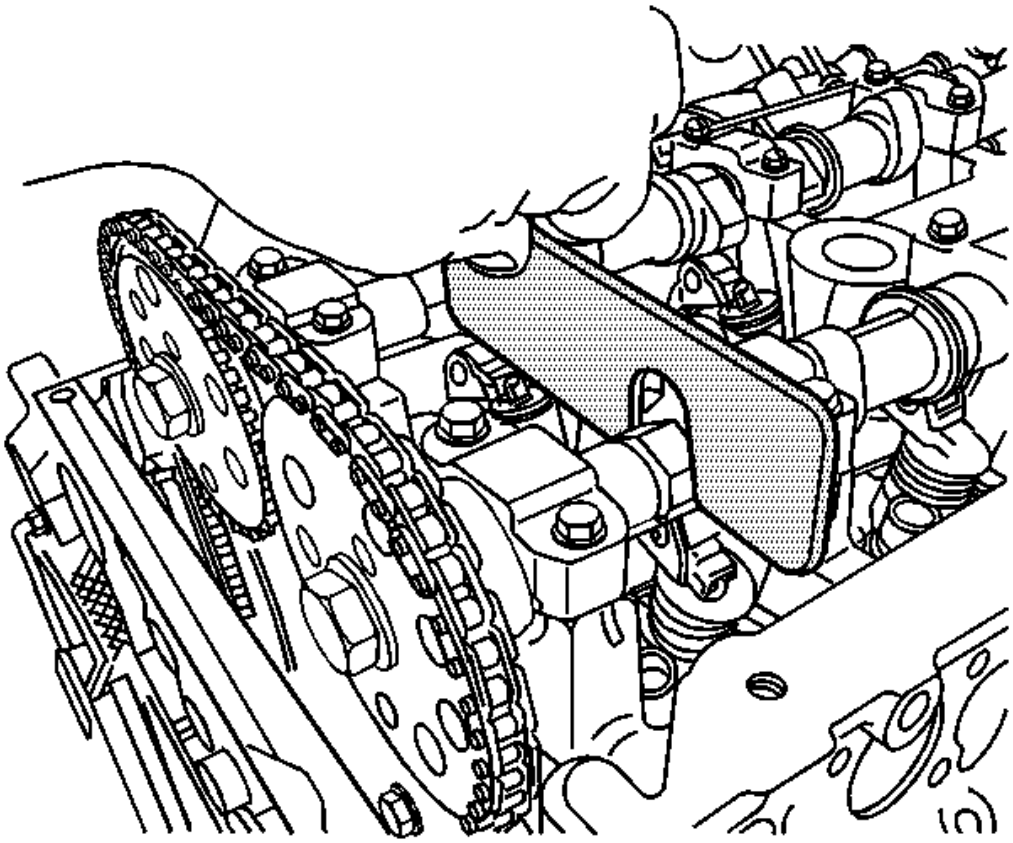

Fig. 203: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 44212** from the camshafts. See **Special Tools** .
6. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

SECONDARY TIMING CHAIN GUIDE REPLACEMENT - LEFT SIDE

SPECIAL TOOLS

J 44212 Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.

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2. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

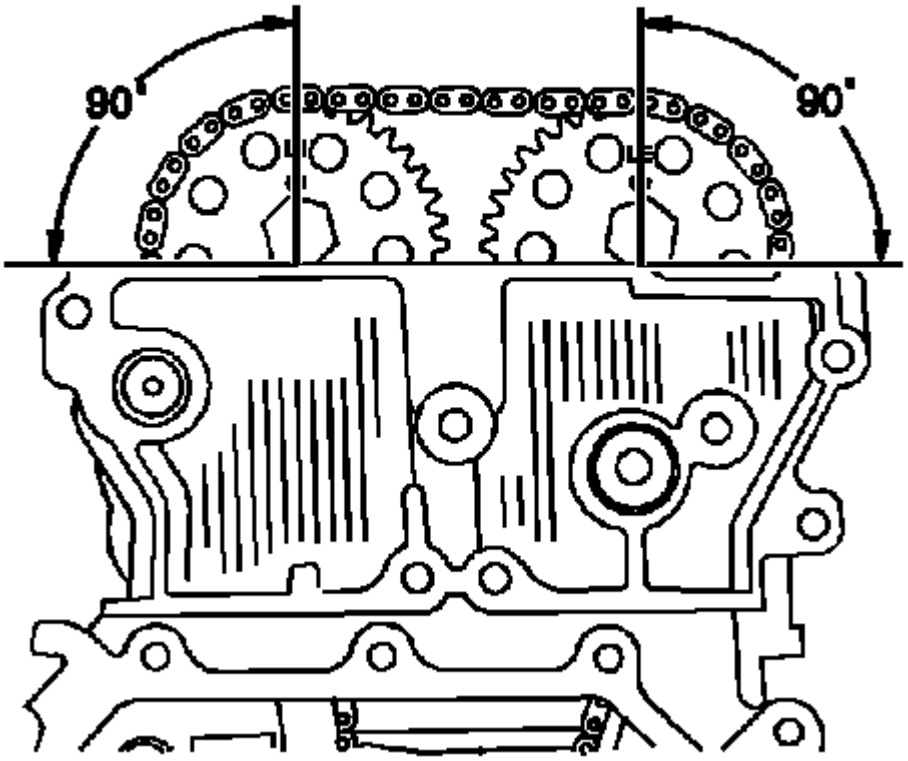

Fig. 204: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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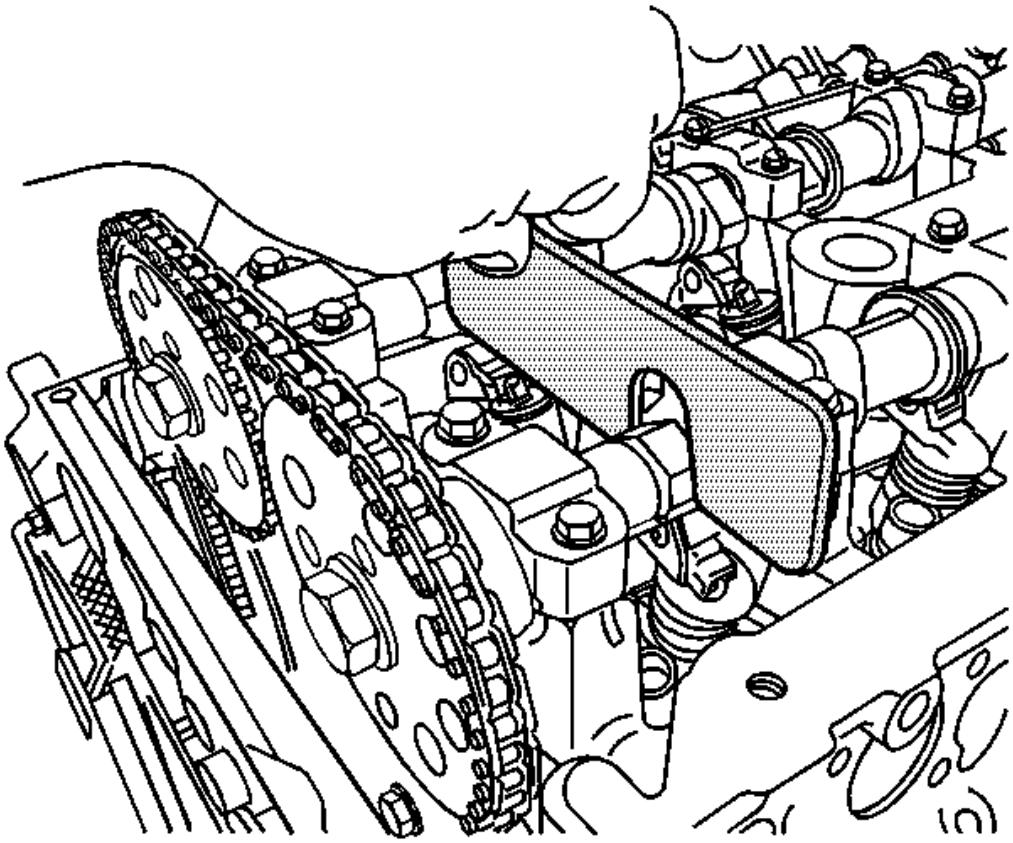

Fig. 205: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: The camshaft holding tools must be installed on the camshafts to prevent camshaft rotation. When performing service to the valve train and/or timing components, valve spring pressure can cause the camshafts to rotate unexpectedly and can cause personal injury.

4. Install the **J 44212** over the camshafts. See **Special Tools** .

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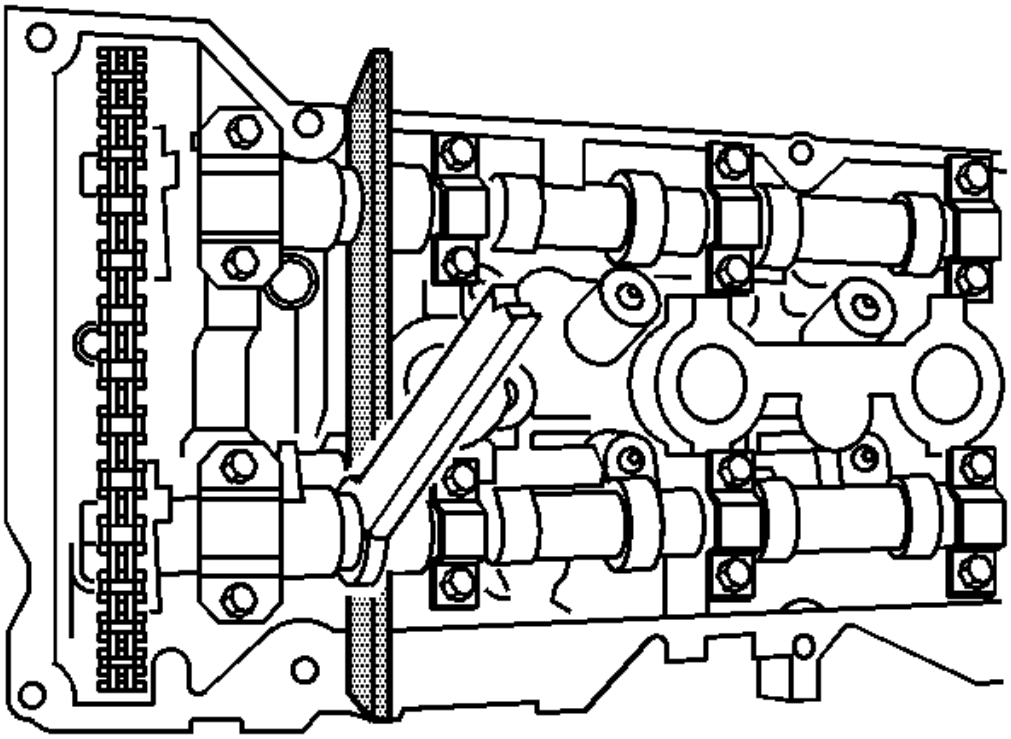

Fig. 206: Securing Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

5. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft sprocket bolt.

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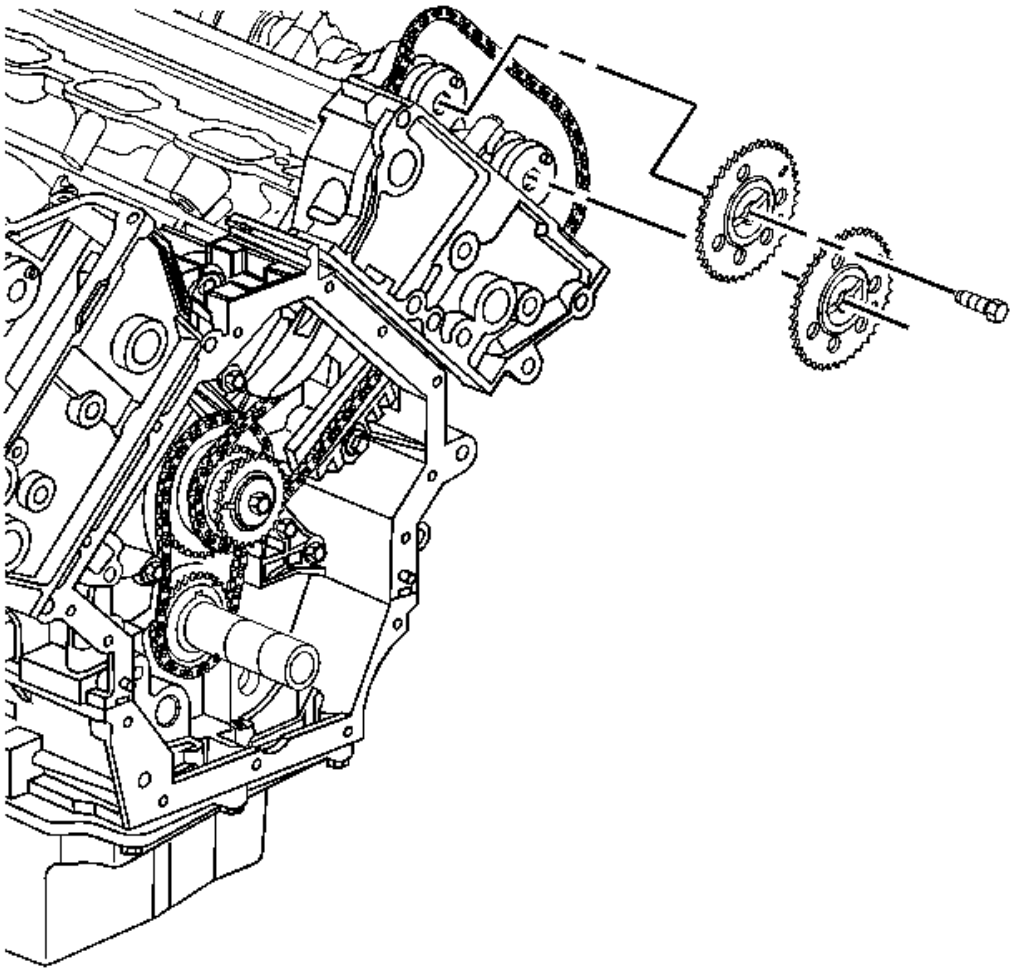

Fig. 207: Left Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the left exhaust camshaft sprocket bolt.
7. Slide the left exhaust camshaft sprocket off of the camshaft and remove the left secondary drive chain from the camshaft sprocket teeth.

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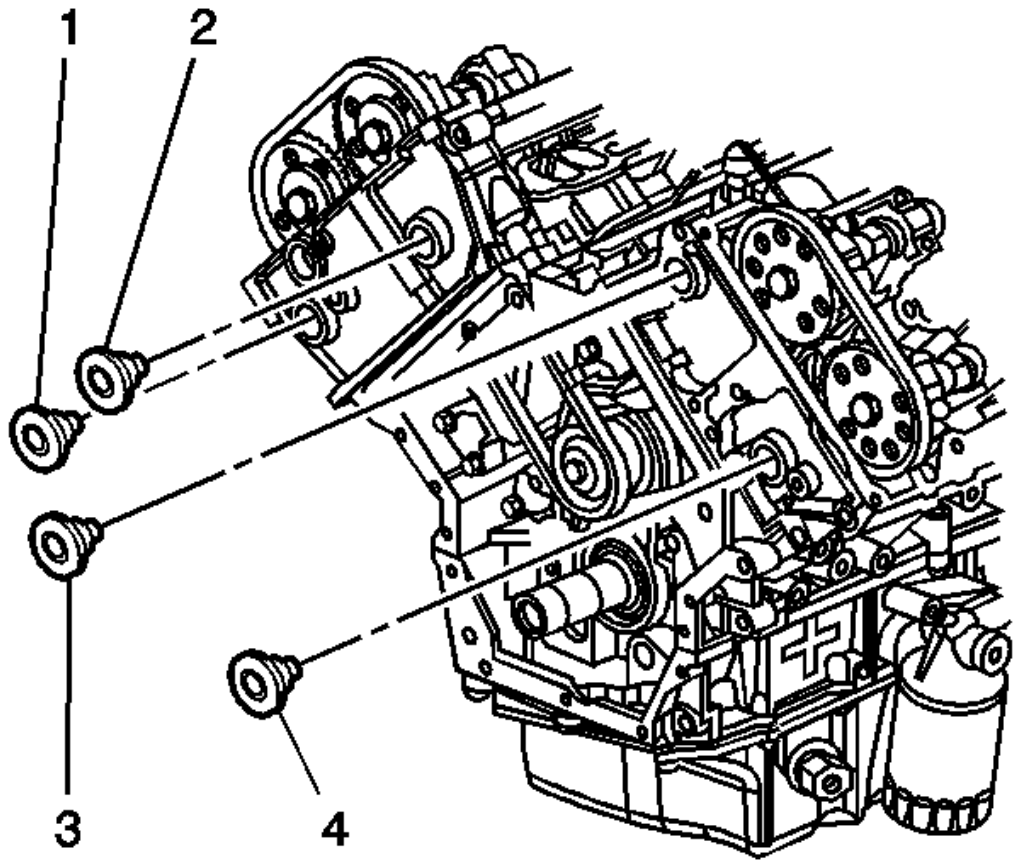

Fig. 208: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

8. Remove the left secondary camshaft drive chain guide access plug (4) located in the cylinder head. Ensure the O-ring seal remains attached to the access plug.

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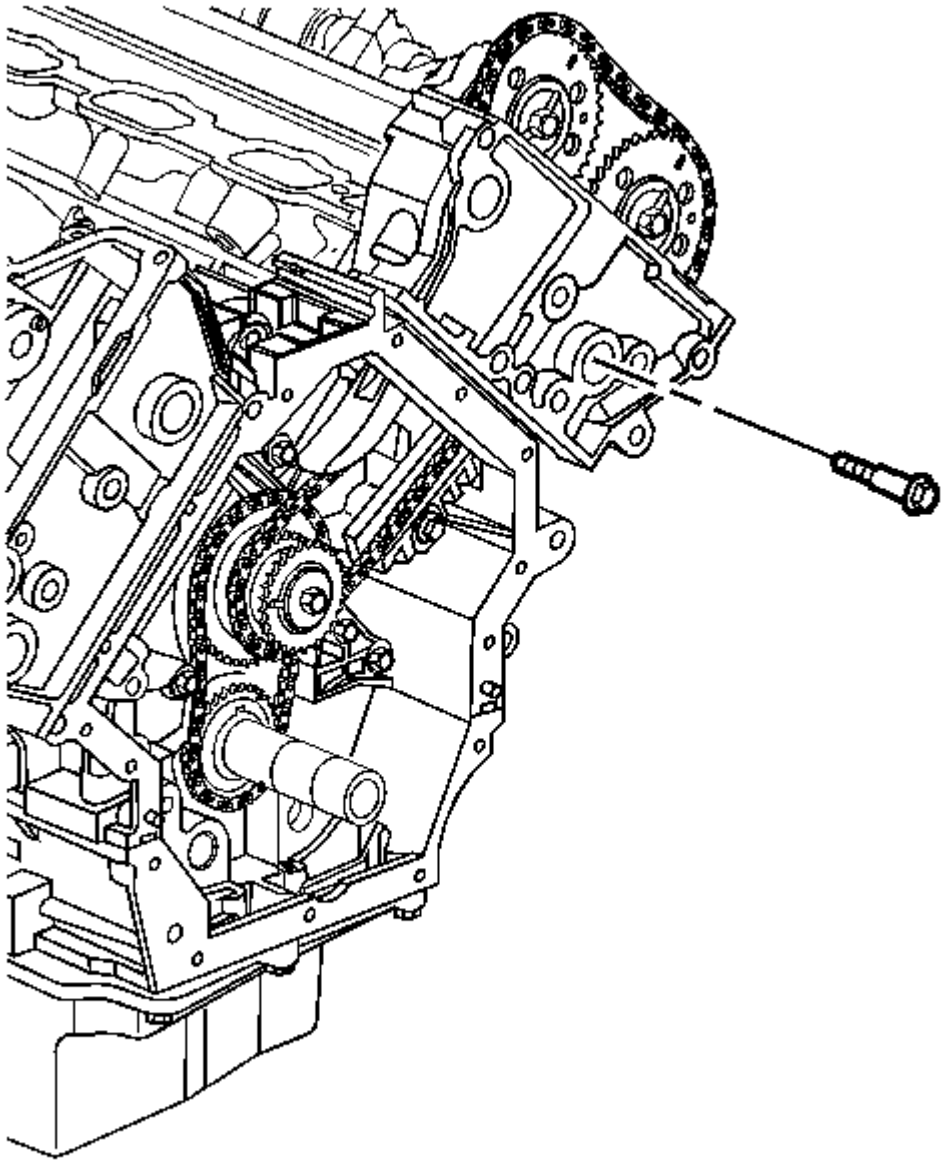

Fig. 209: Upper Left Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper left secondary camshaft drive chain guide bolt.

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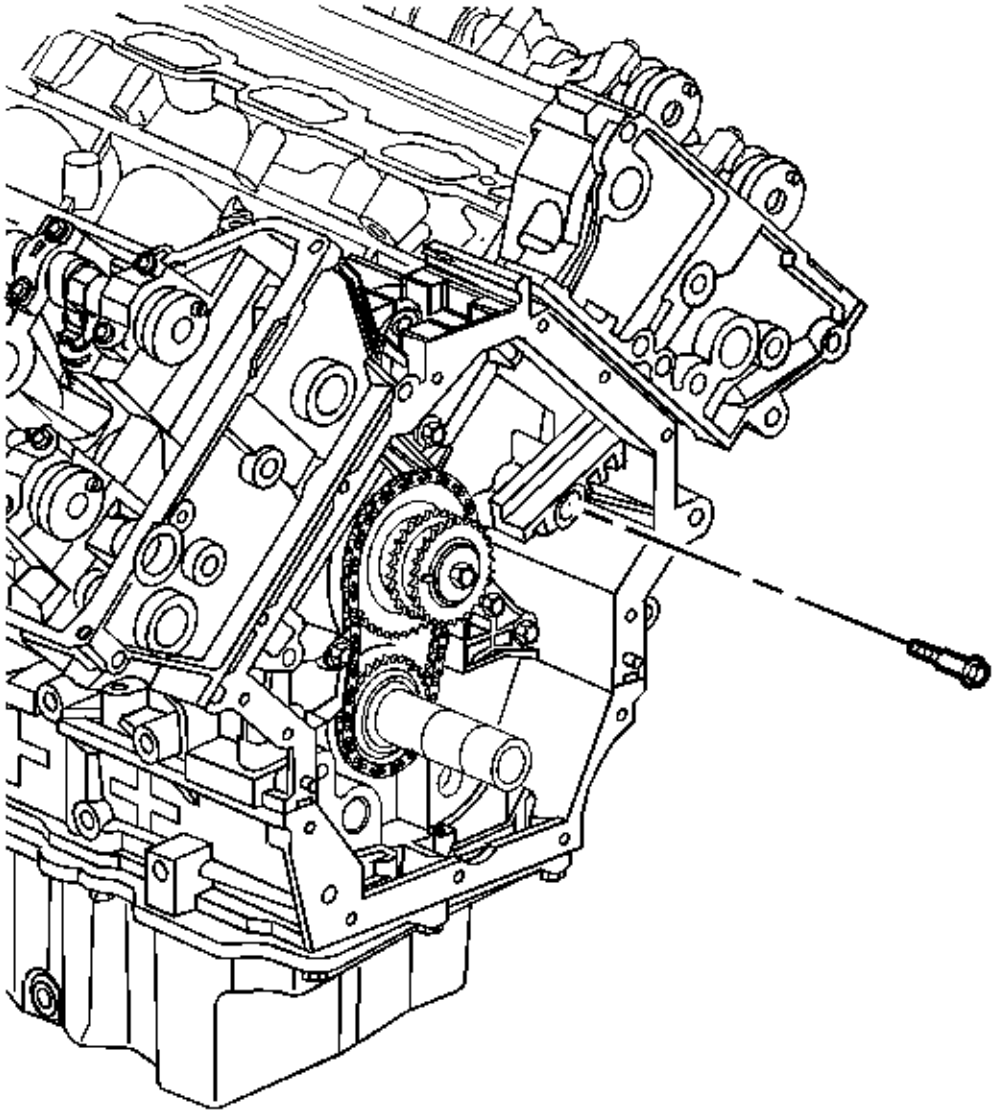

Fig. 210: Lower Left Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove the lower left secondary camshaft drive chain guide bolt.

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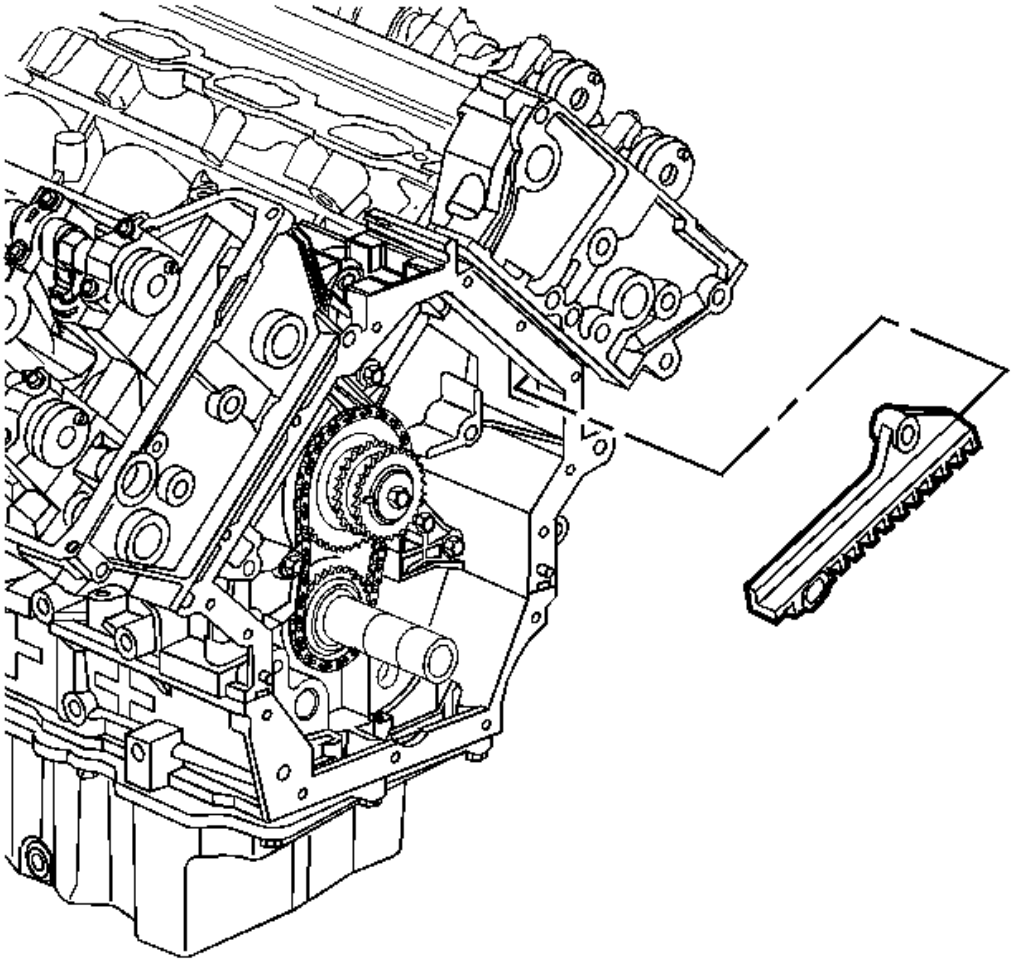

Fig. 211: Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

11. Remove the left secondary camshaft drive chain guide.
12. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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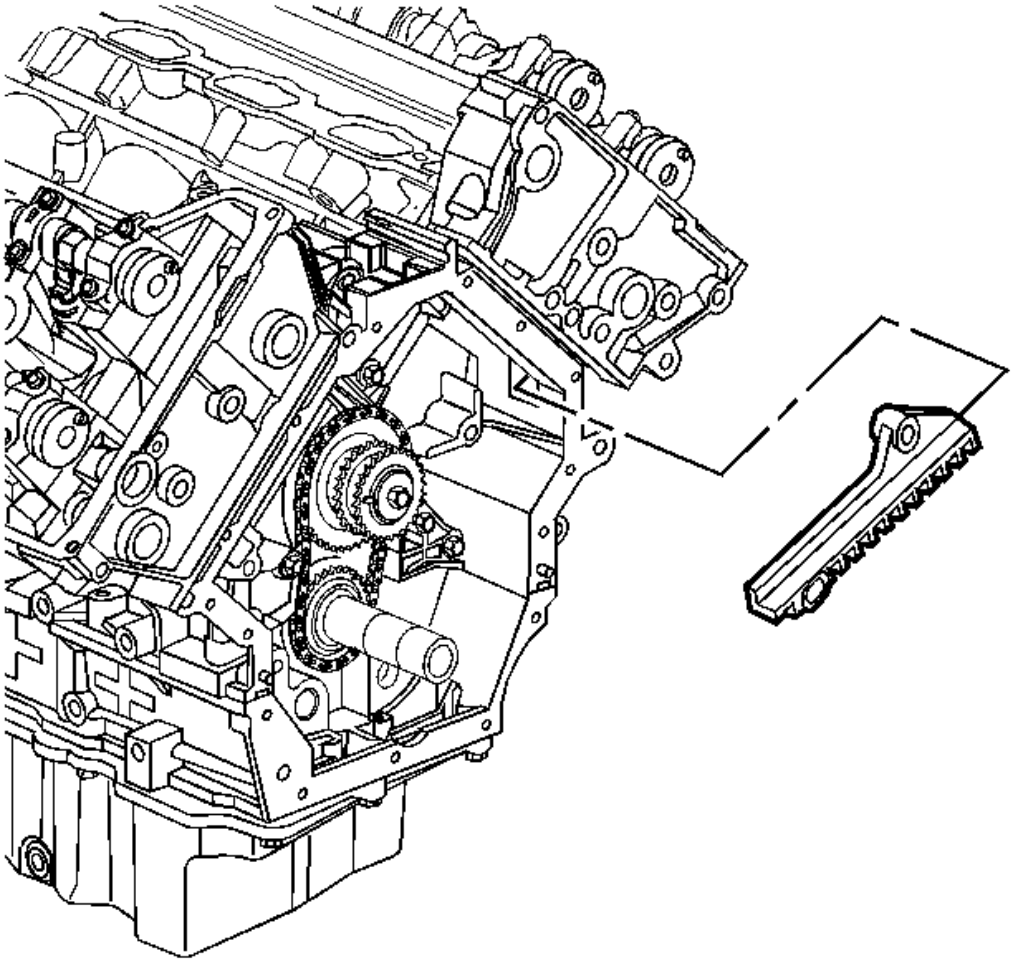

Fig. 212: Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain guide in through the top of the cylinder head.

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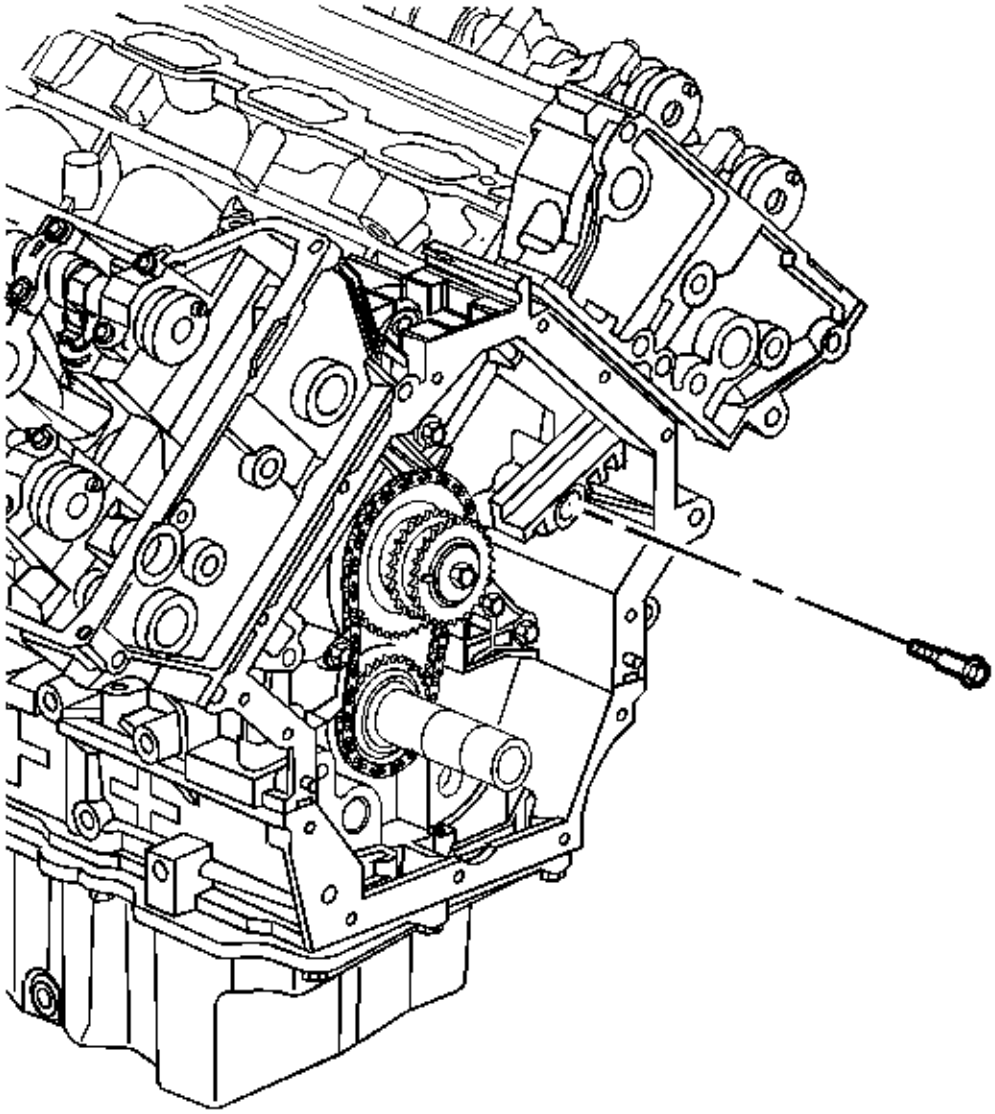

Fig. 213: Lower Left Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosely install the lower left secondary camshaft drive chain guide bolt.

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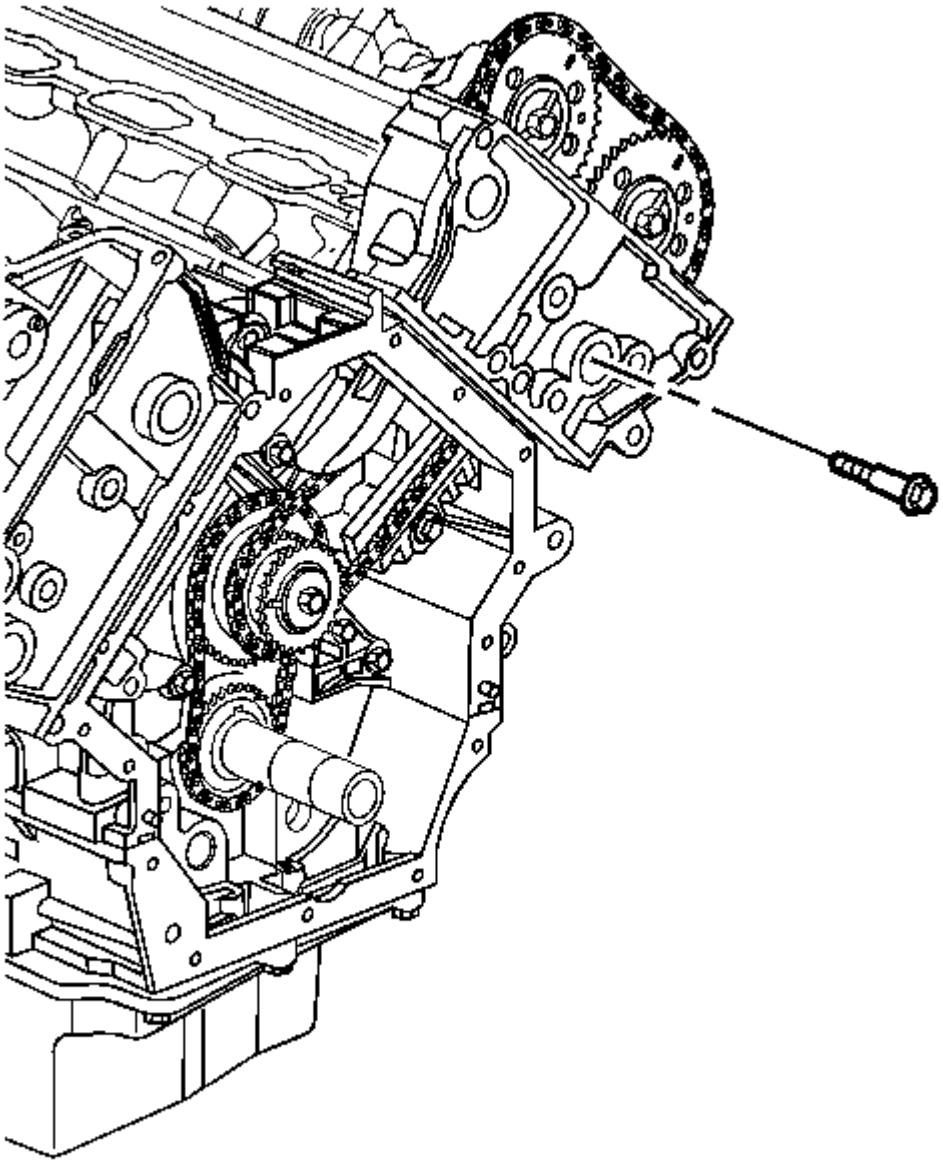

Fig. 214: Upper Left Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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3. Install the upper left secondary camshaft drive chain guide bolt.

   Tighten: Tighten the secondary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

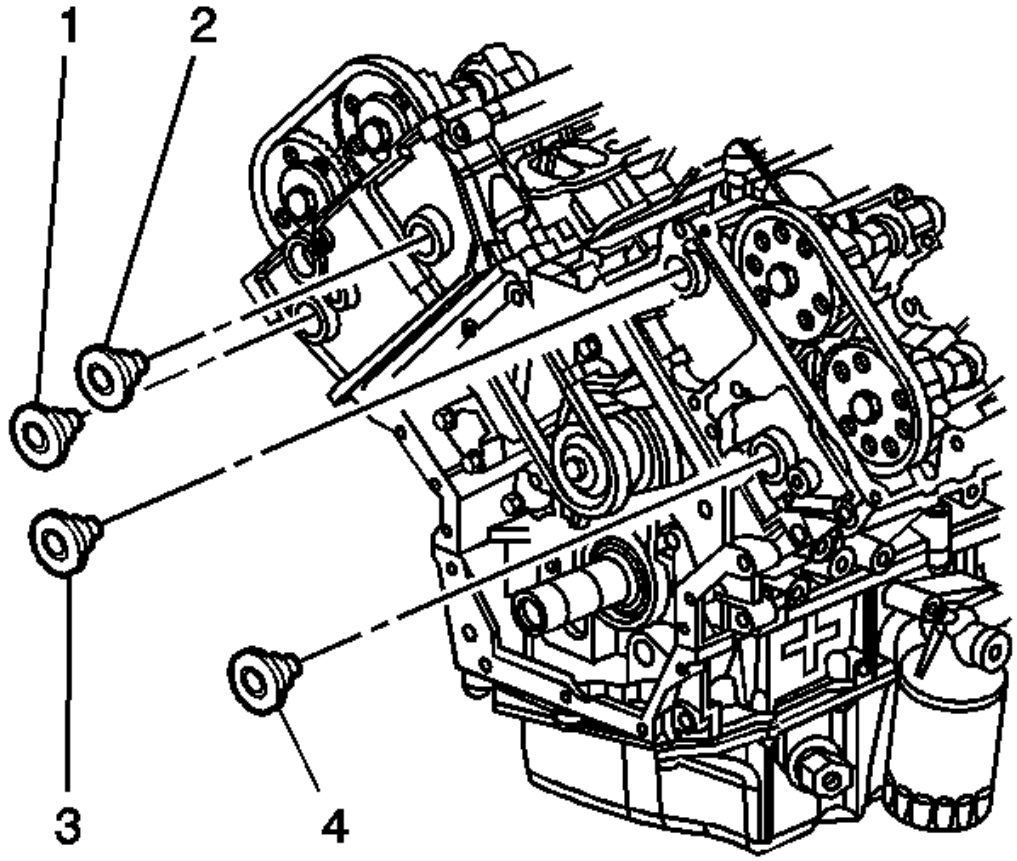

Fig. 215: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

4. Install the left secondary camshaft drive chain guide access plug (4) located in the cylinder head. Ensure the O-ring seal is attached to the access plug.

   Tighten: Tighten the secondary camshaft drive chain guide access plug to 4.5 N.m (40 lb in).

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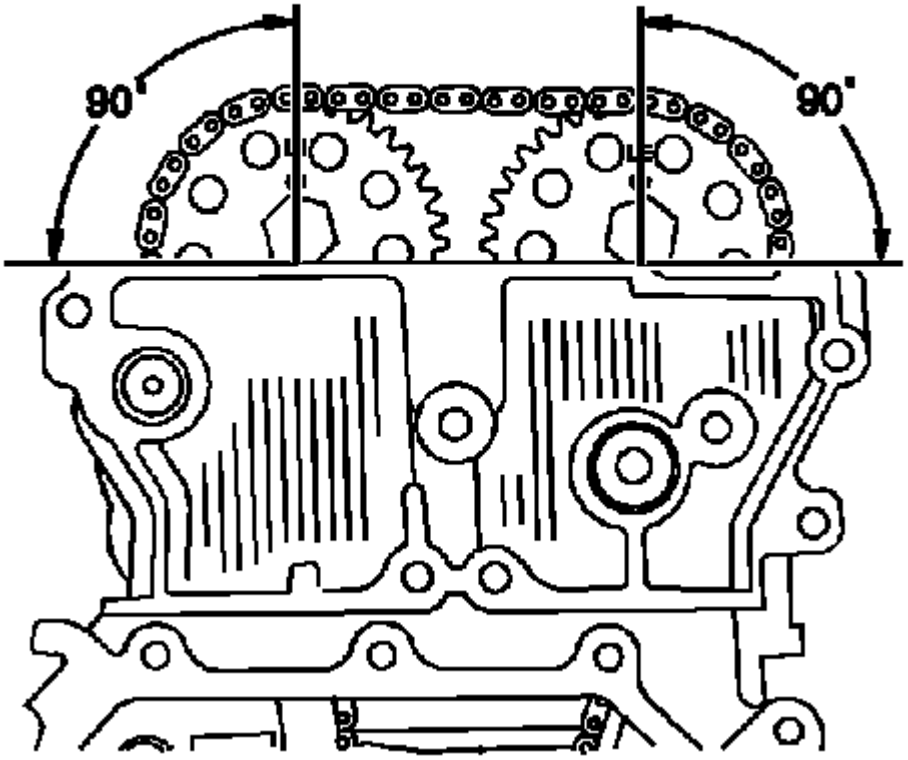

Fig. 216: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

5. Install the left exhaust camshaft sprocket into the left secondary camshaft drive chain.
6. Install the left exhaust camshaft sprocket onto the camshaft. The camshaft sprocket notch marked LE (left exhaust) engages the exhaust camshaft pin.

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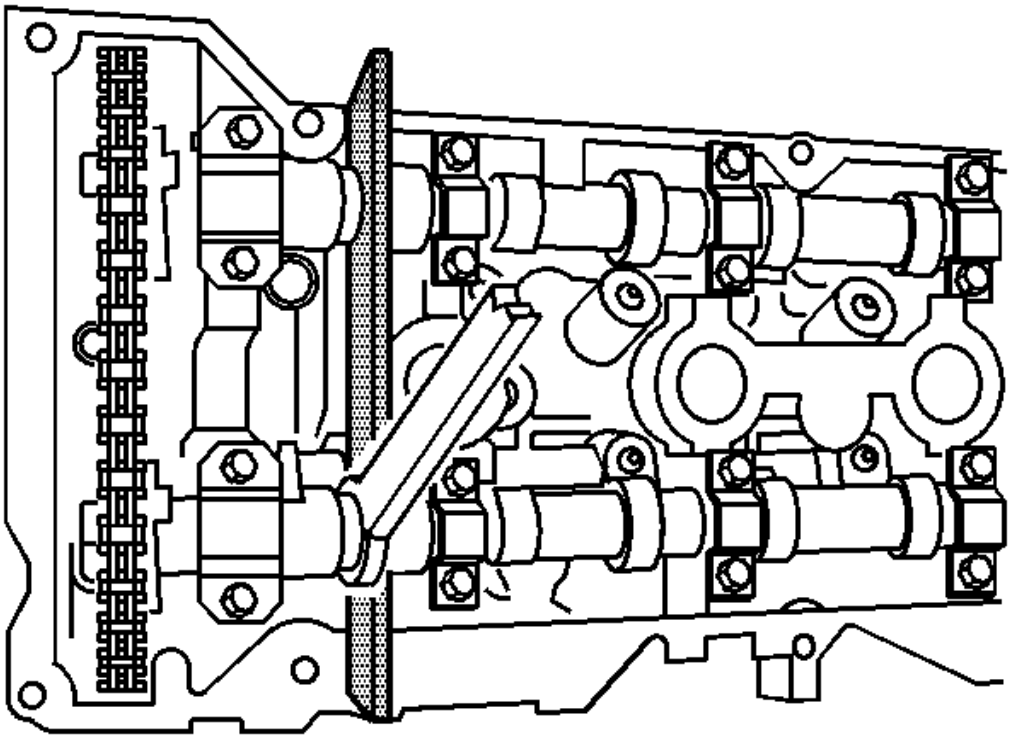

Fig. 217: Securing Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

7. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the camshaft sprocket bolt.

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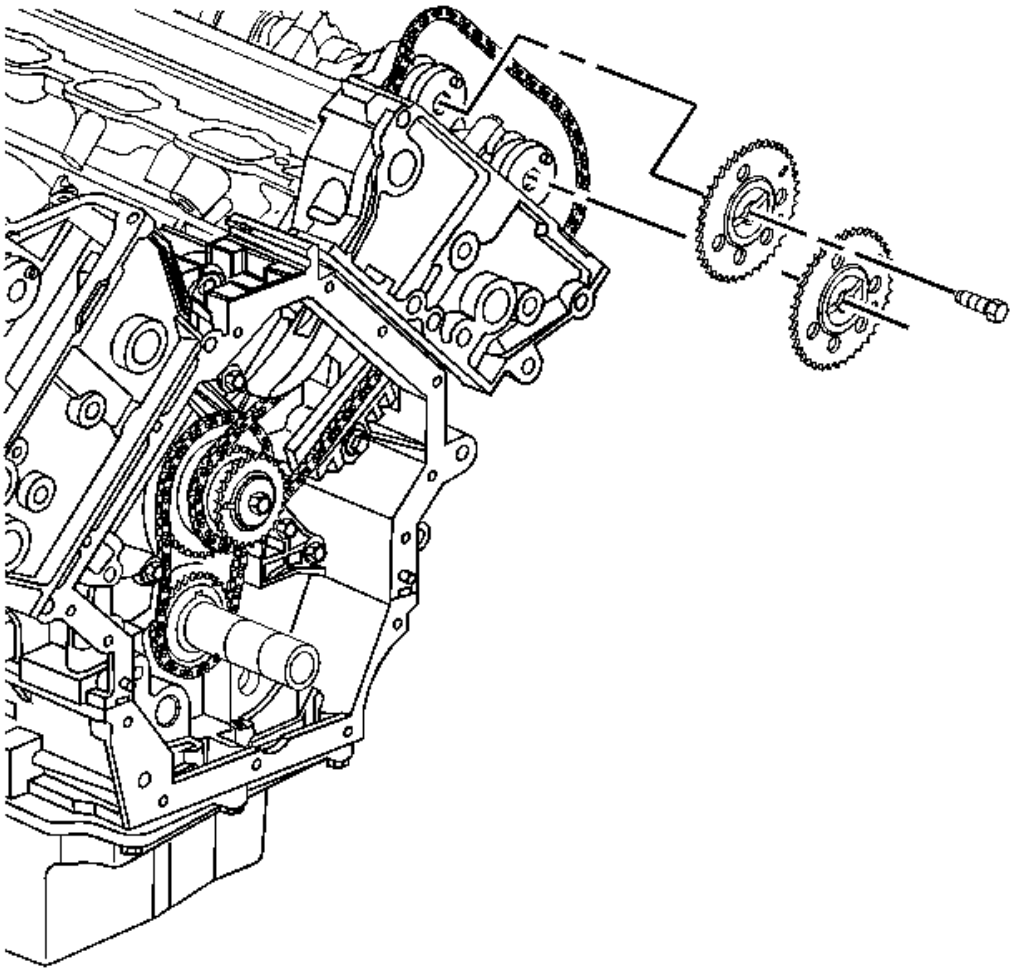

Fig. 218: Left Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the left exhaust camshaft sprocket bolt.

   Tighten: Tighten the camshaft sprocket bolt to 120 N.m (89 lb ft).

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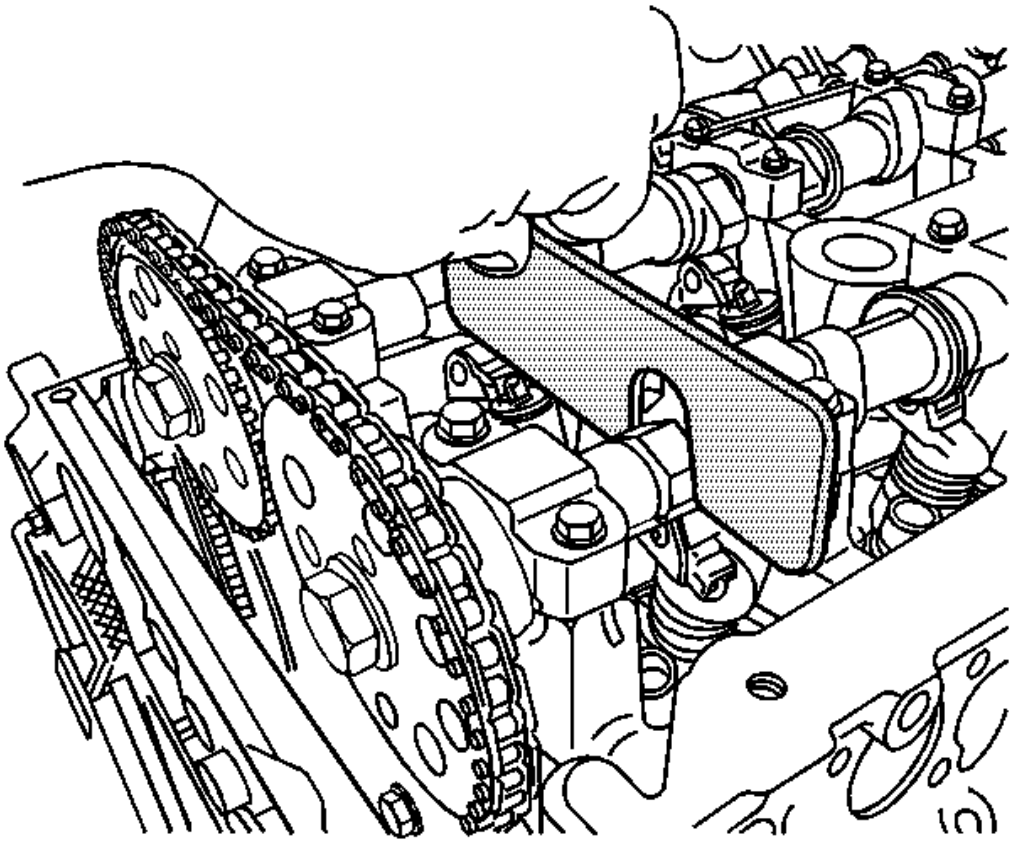

Fig. 219: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

9. Remove the **J 44212** from the camshafts. See **Special Tools** .
10. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
11. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side**.

SECONDARY TIMING CHAIN GUIDE REPLACEMENT - RIGHT SIDE

SPECIAL TOOLS

J 44212 Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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1. Remove the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.
2. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

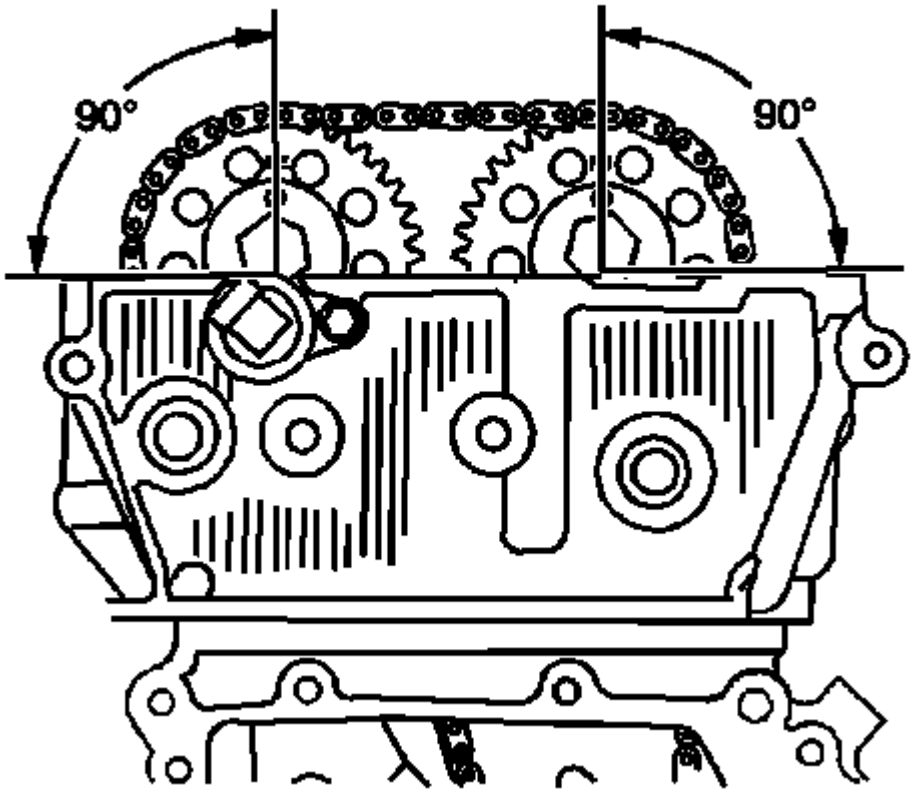

Fig. 220: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Ensure both camshaft sprocket drive pins are at the top of their rotation.

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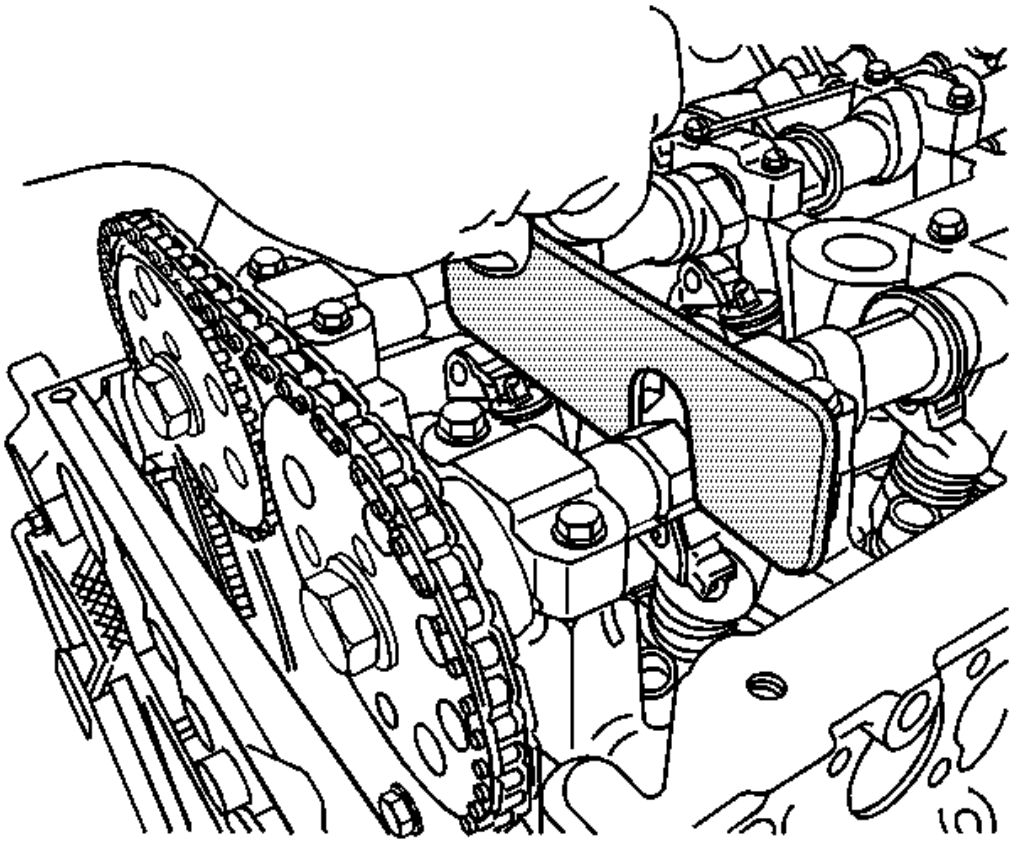

Fig. 221: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

4. Install the **J 44212** over the camshafts. See **Special Tools** .

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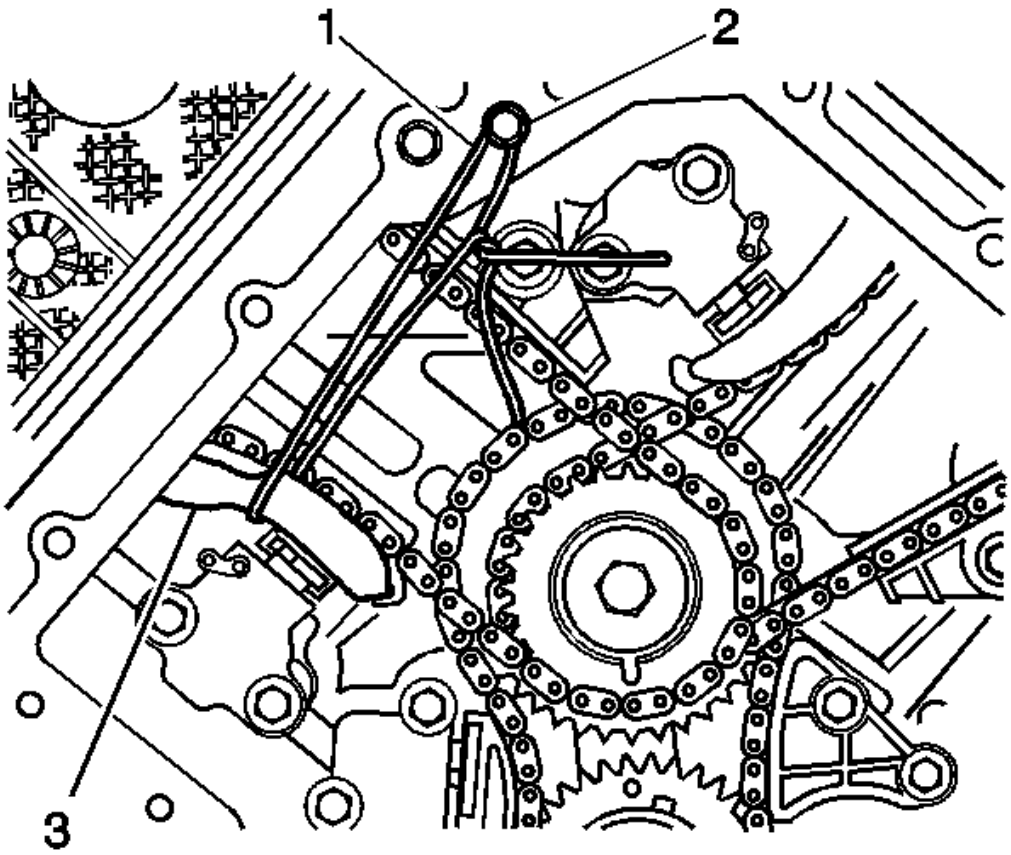

Fig. 222: Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
6. Remove the engine front cover bolt (2) from the front of the engine.

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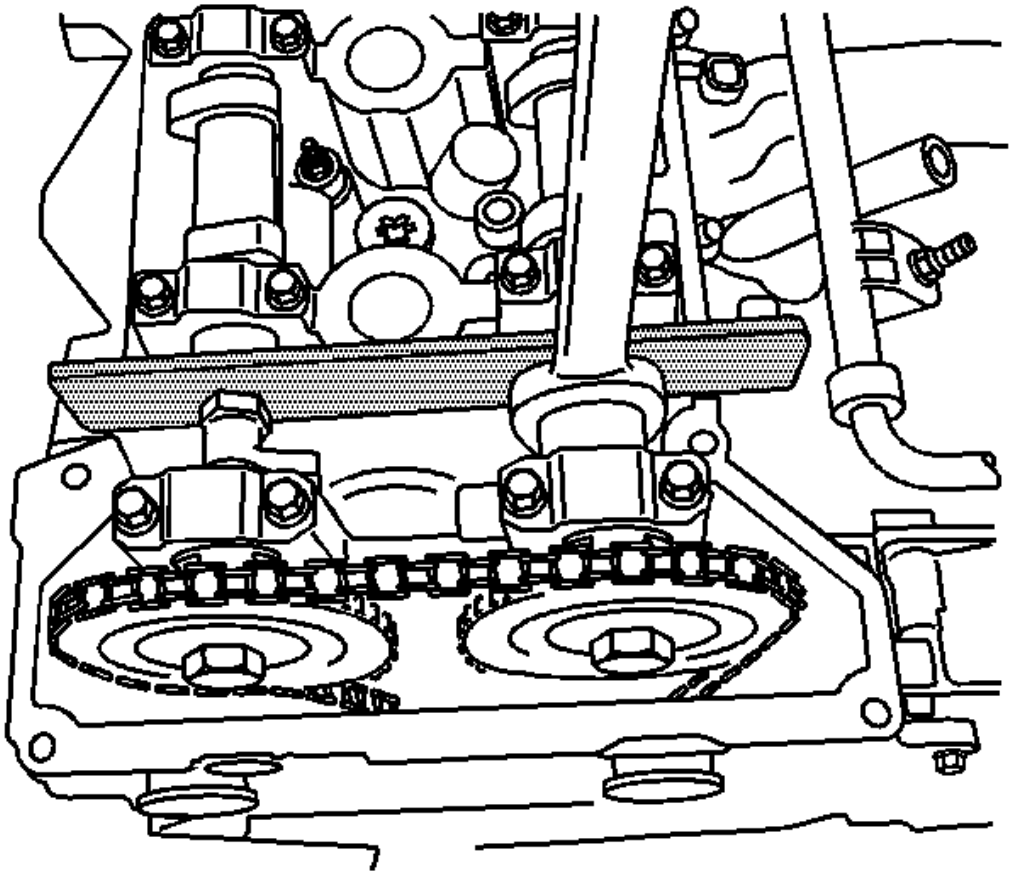

Fig. 223: Securing Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

7. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft sprocket bolt.

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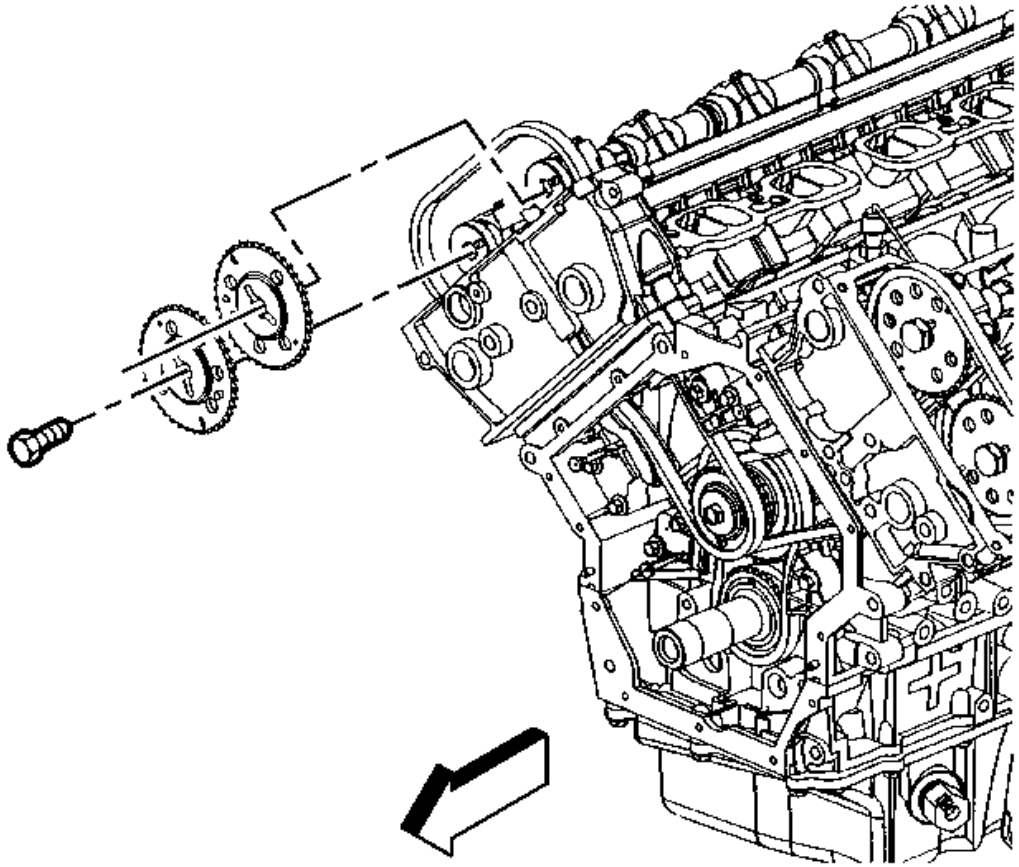

Fig. 224: Right Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the right intake camshaft sprocket bolt.
9. Slide the right intake camshaft sprocket off of the camshaft and remove the right secondary drive chain from the camshaft sprocket teeth.

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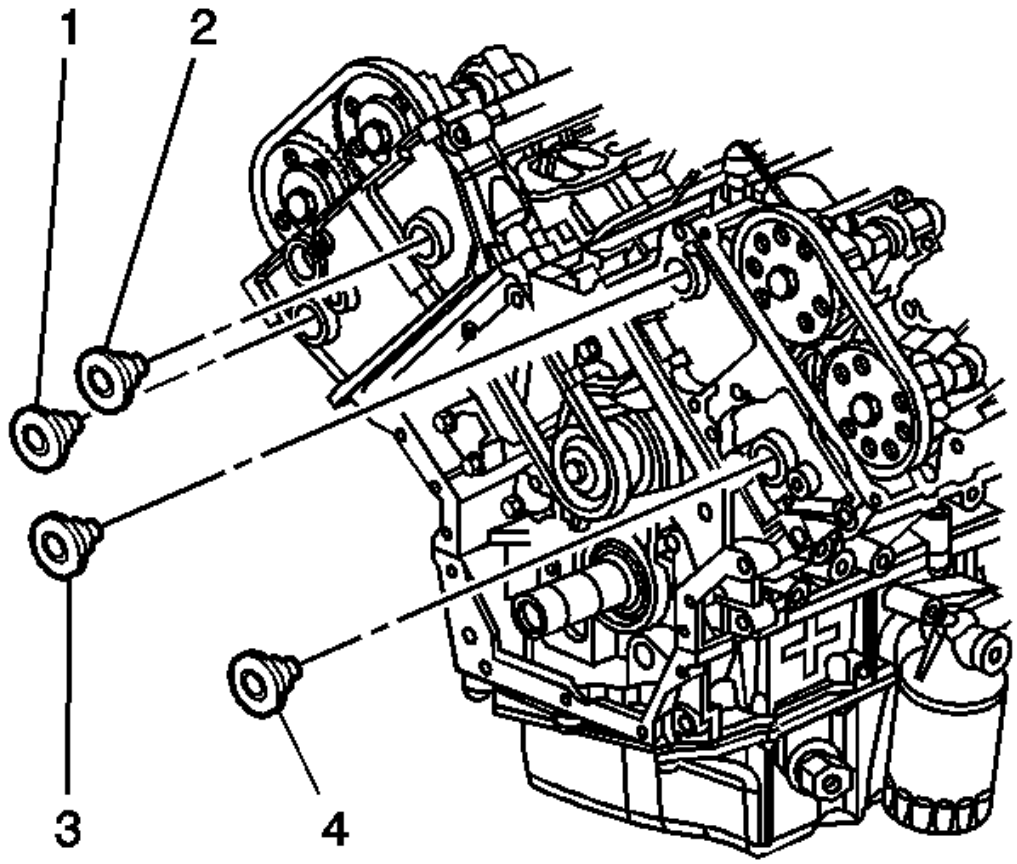

Fig. 225: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the right secondary camshaft drive chain guide access plug (2) located in the cylinder head. Ensure the O-ring seal remains attached to the access plug.

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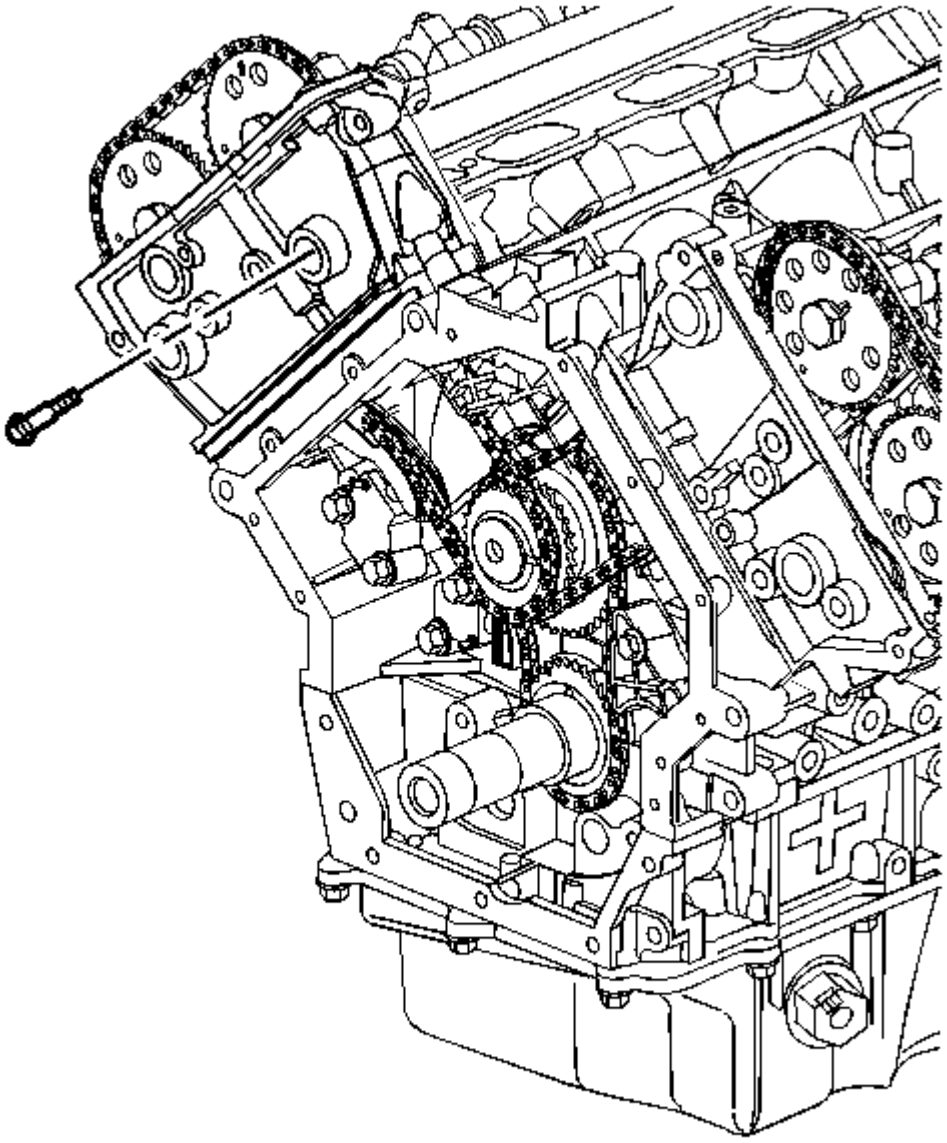

Fig. 226: Upper Right Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the upper right secondary camshaft drive chain guide bolt.

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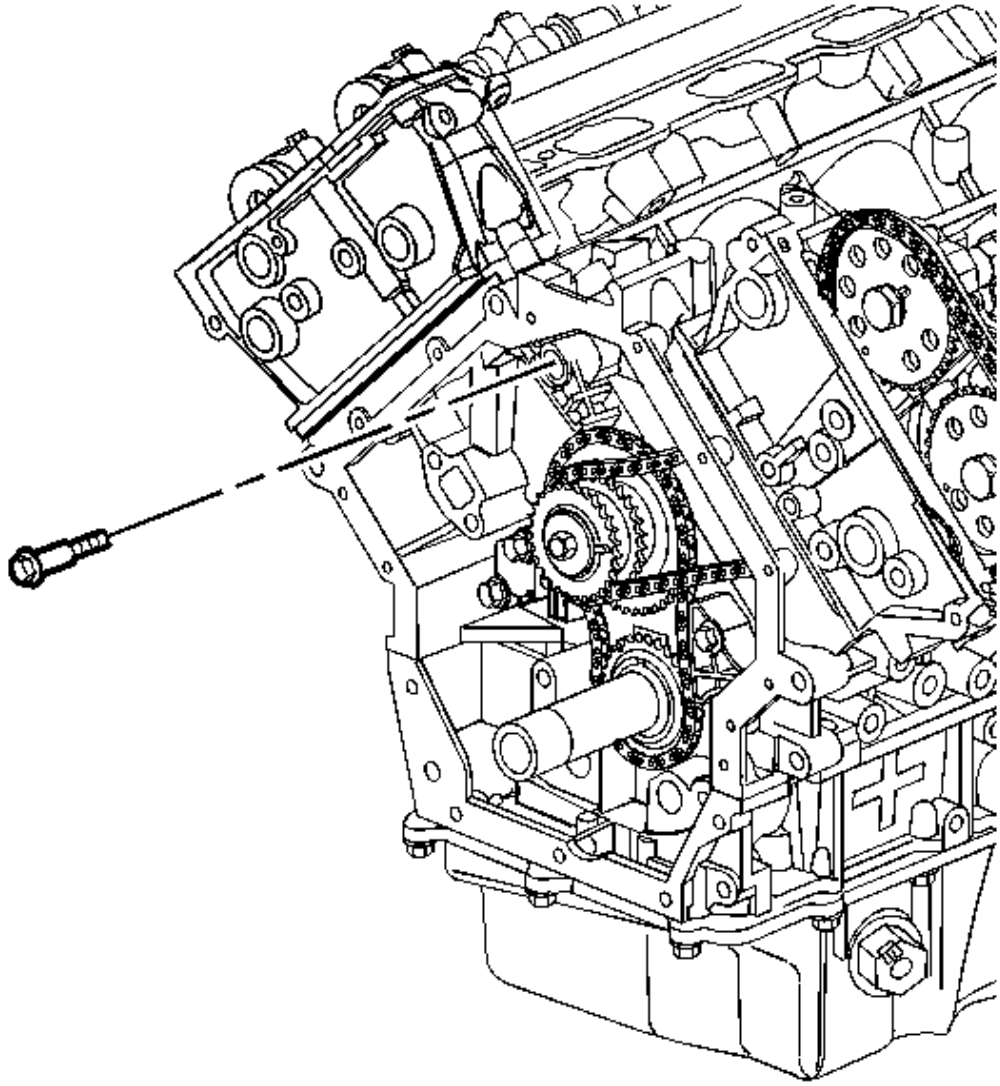

Fig. 227: Lower Right Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

12. Remove the lower right secondary camshaft drive chain guide bolt.

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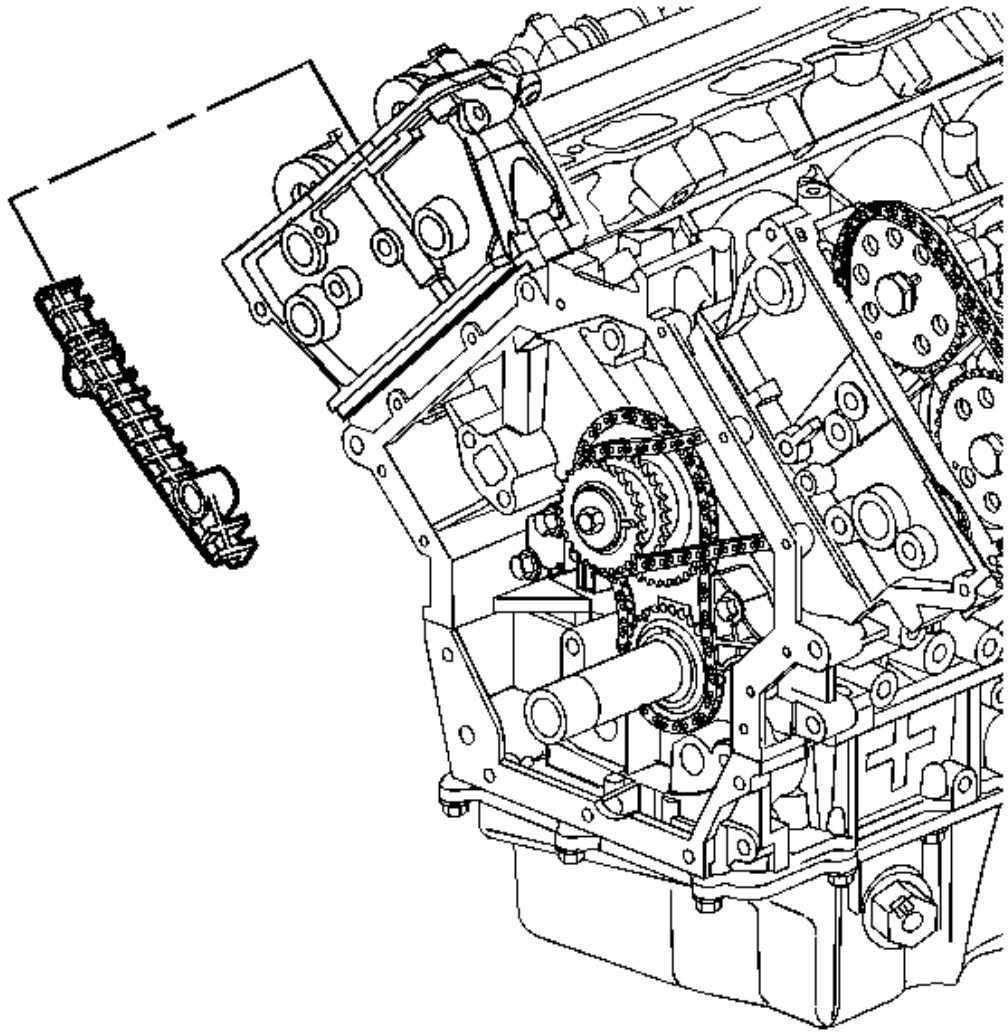

Fig. 228: Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

13. Remove the right secondary camshaft drive chain guide.
14. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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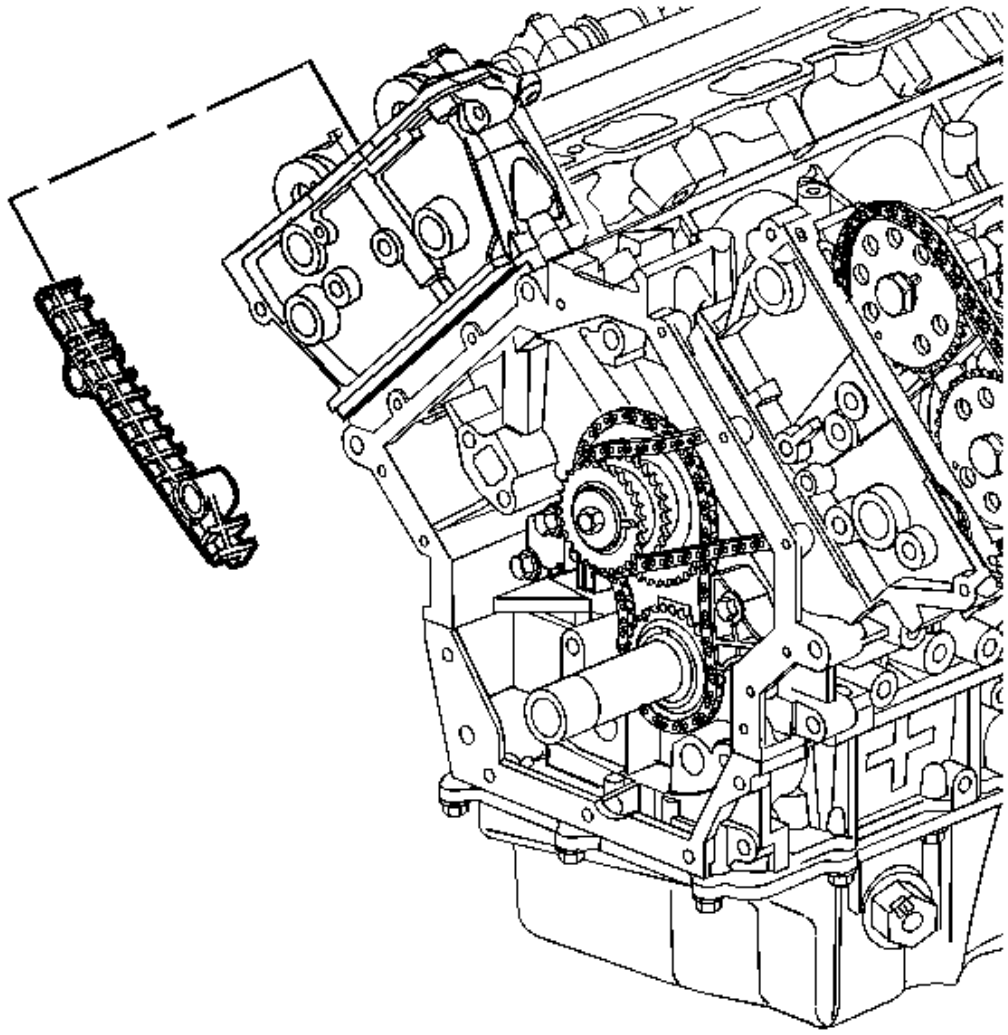

Fig. 229: Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain guide in through the top of the cylinder head.

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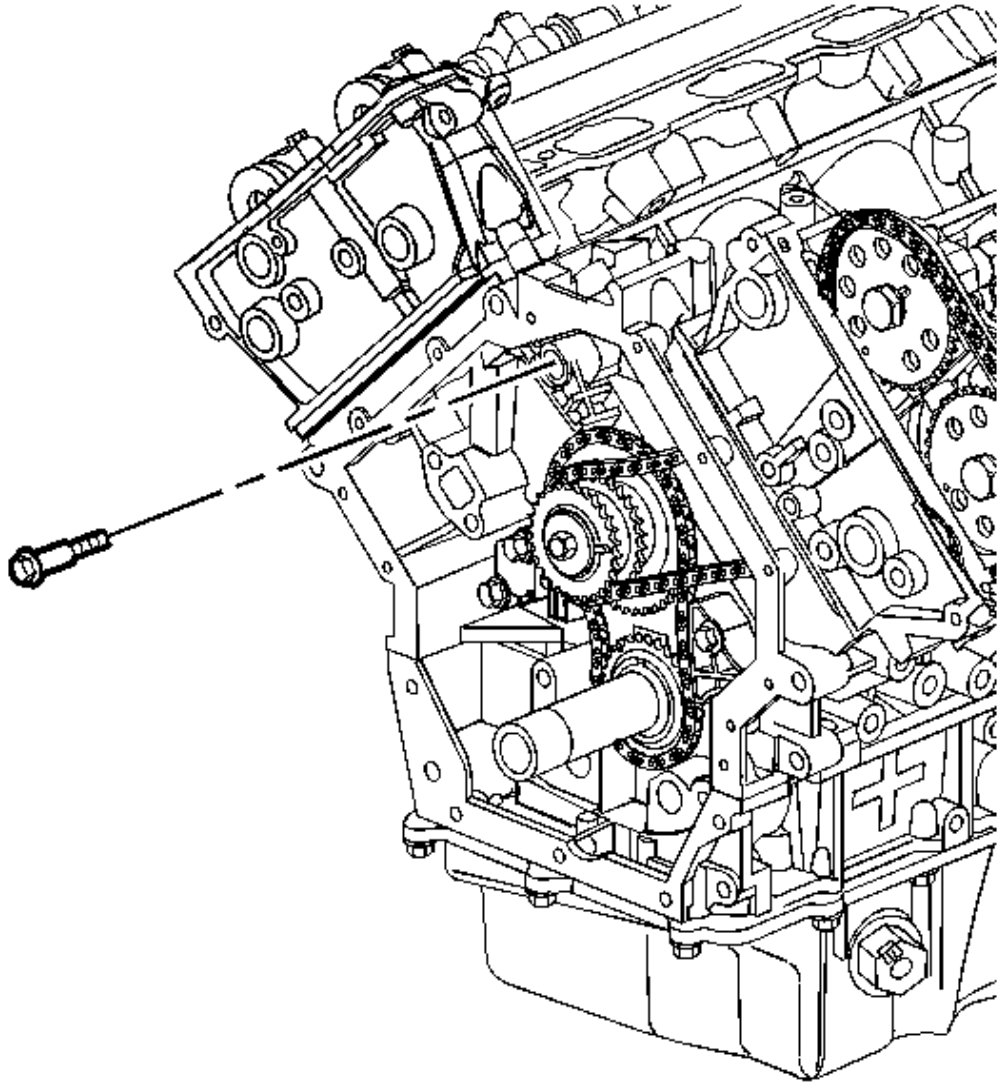

Fig. 230: Lower Right Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

2. Loosely install the lower right secondary camshaft drive chain guide bolt.

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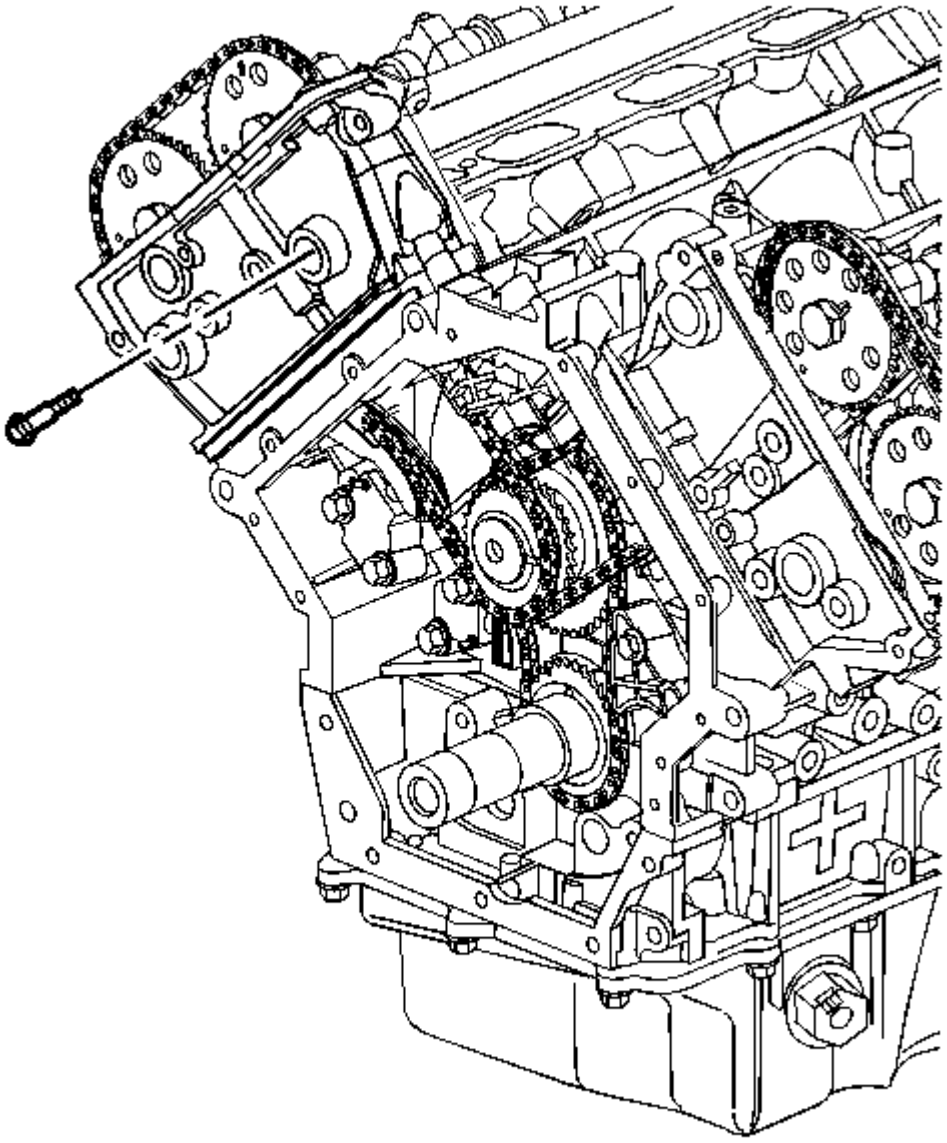

Fig. 231: Upper Right Secondary Camshaft Drive Chain Guide Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the upper right secondary camshaft drive chain guide bolt.

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Tighten: Tighten the secondary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

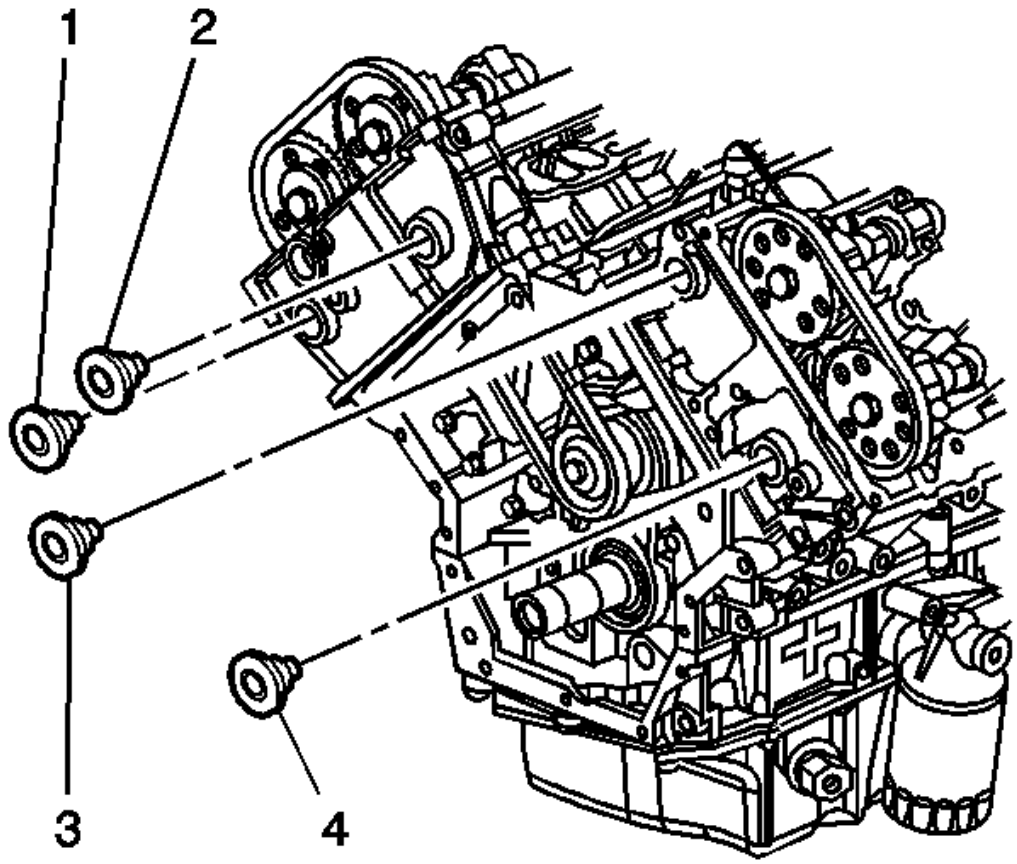

Fig. 232: Locating Camshaft Drive Chain Shoe Access Plugs
Courtesy of GENERAL MOTORS CORP.

4. Install the right secondary camshaft drive chain guide access plug (2) located in the cylinder head. Ensure the O-ring seal is attached to the access plug.

   Tighten: Tighten the secondary camshaft drive chain guide access plug to 4.5 N.m (40 lb in).

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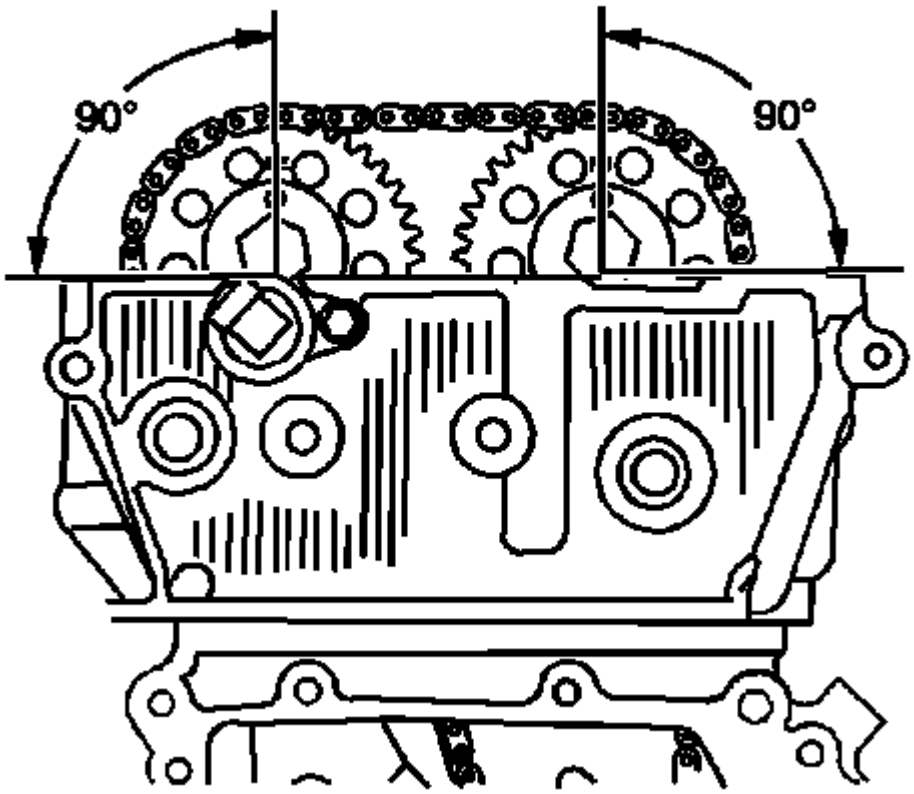

Fig. 233: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

5. Install the right intake camshaft sprocket into the right secondary camshaft drive chain.
6. Install the right intake camshaft sprocket onto the camshaft. The camshaft sprocket notch marked RI (right intake) engages the intake camshaft pin.

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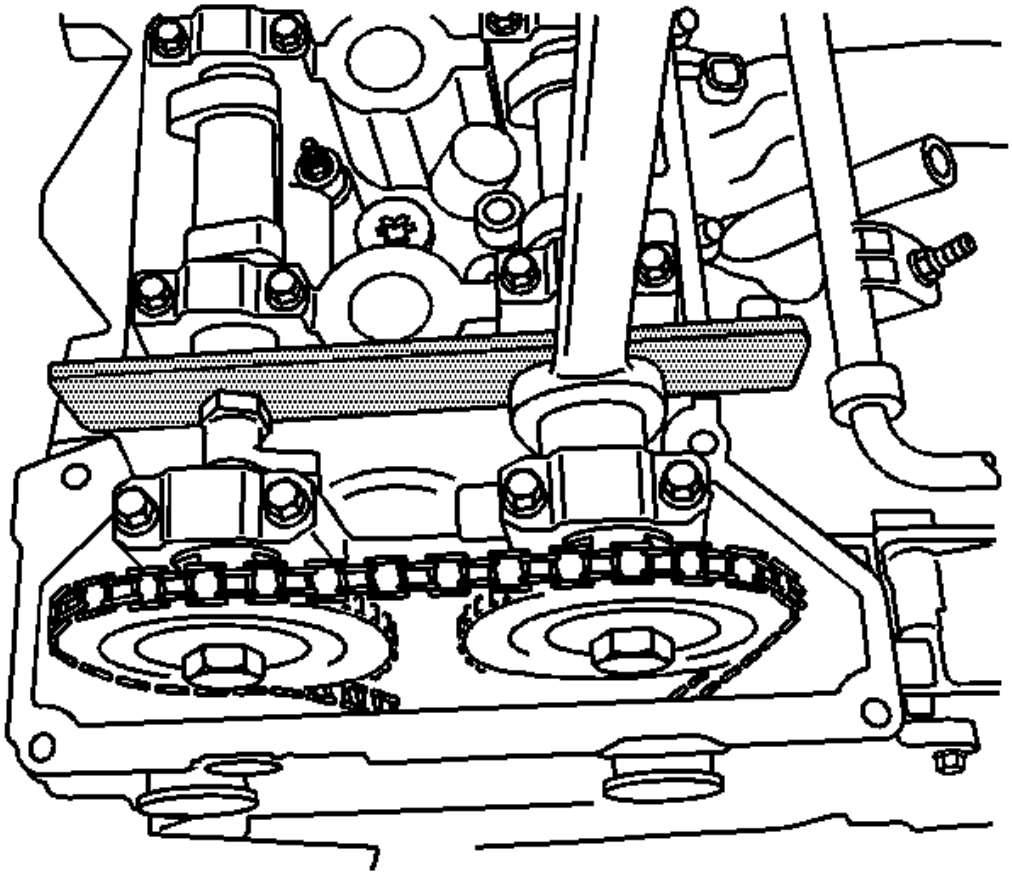

Fig. 234: Securing Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

7. Use an open end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the camshaft sprocket bolt.

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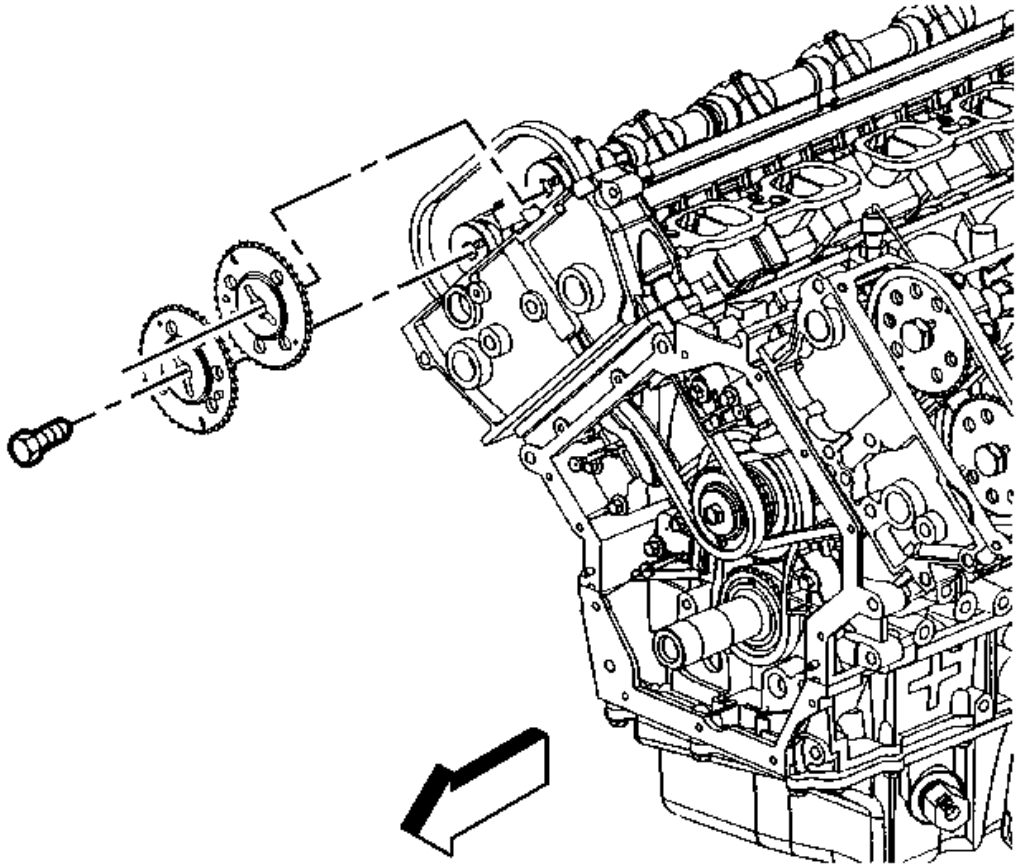

Fig. 235: Right Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the right intake camshaft sprocket bolt.

   Tighten: Tighten the camshaft sprocket bolt to 120 N.m (89 lb ft).

9. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side**.

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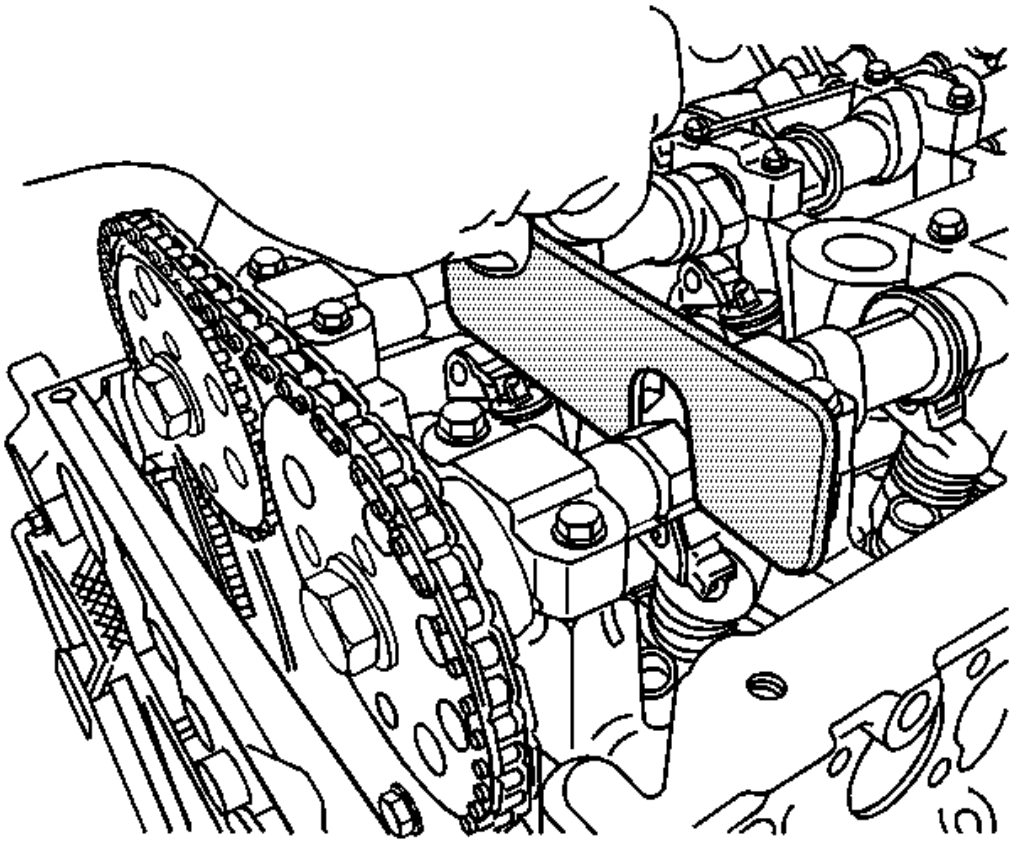

Fig. 236: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

10. Remove the **J 44212** from the camshafts. See **Special Tools** .
11. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

PRIMARY CAMSHAFT INTERMEDIATE DRIVE CHAIN TENSIONER REPLACEMENT

SPECIAL TOOLS

J 39946 Crankshaft Socket - 4.0L and 4.6L

REMOVAL PROCEDURE

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.

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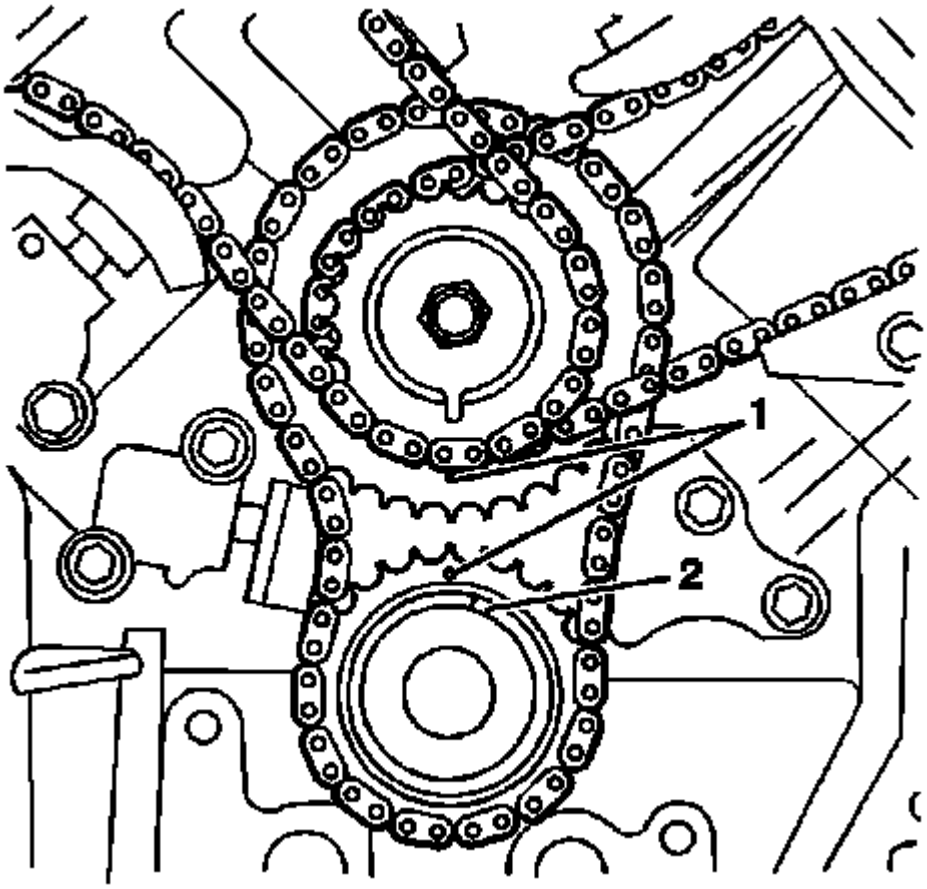

Fig. 237: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the primary timing marks (1) using the **J 39946** .

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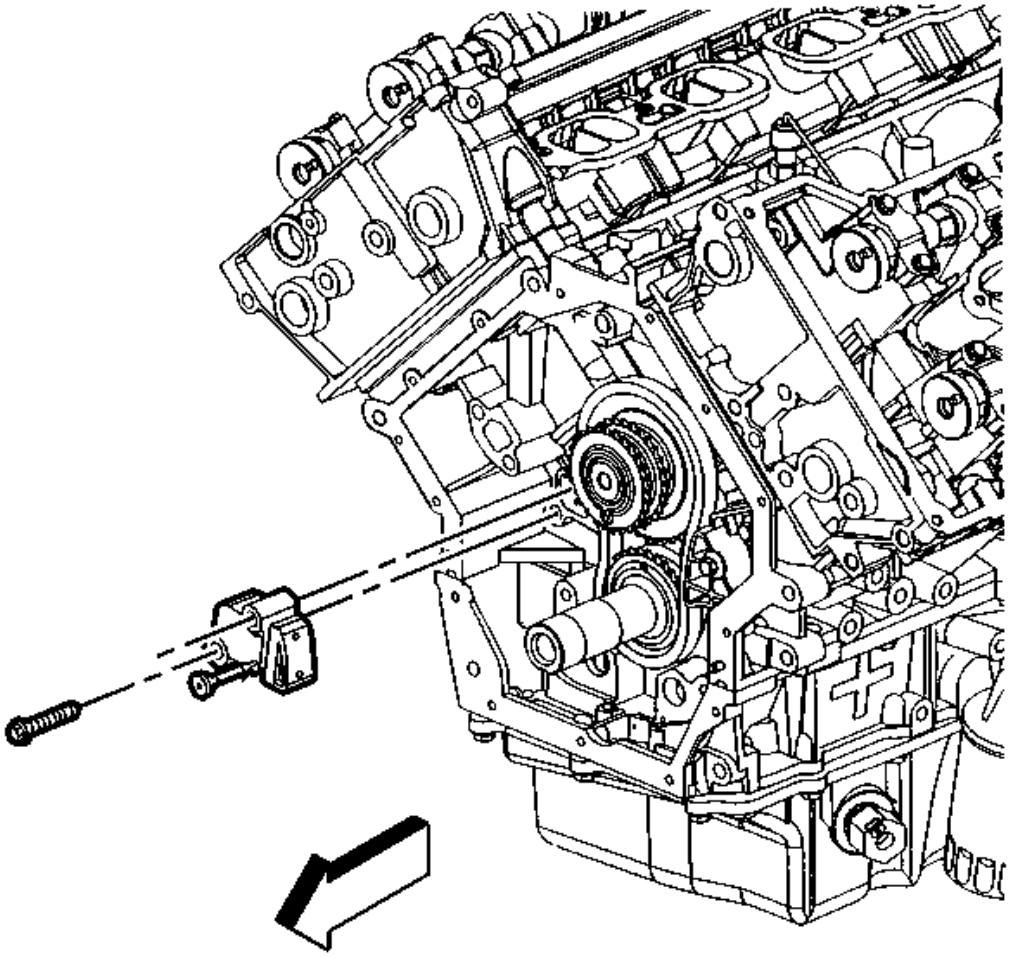

Fig. 238: Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the 2 bolts attaching the primary camshaft drive chain tensioner to the engine block.
4. Remove the primary camshaft drive chain tensioner, allowing the tensioner to expand as you remove it.
5. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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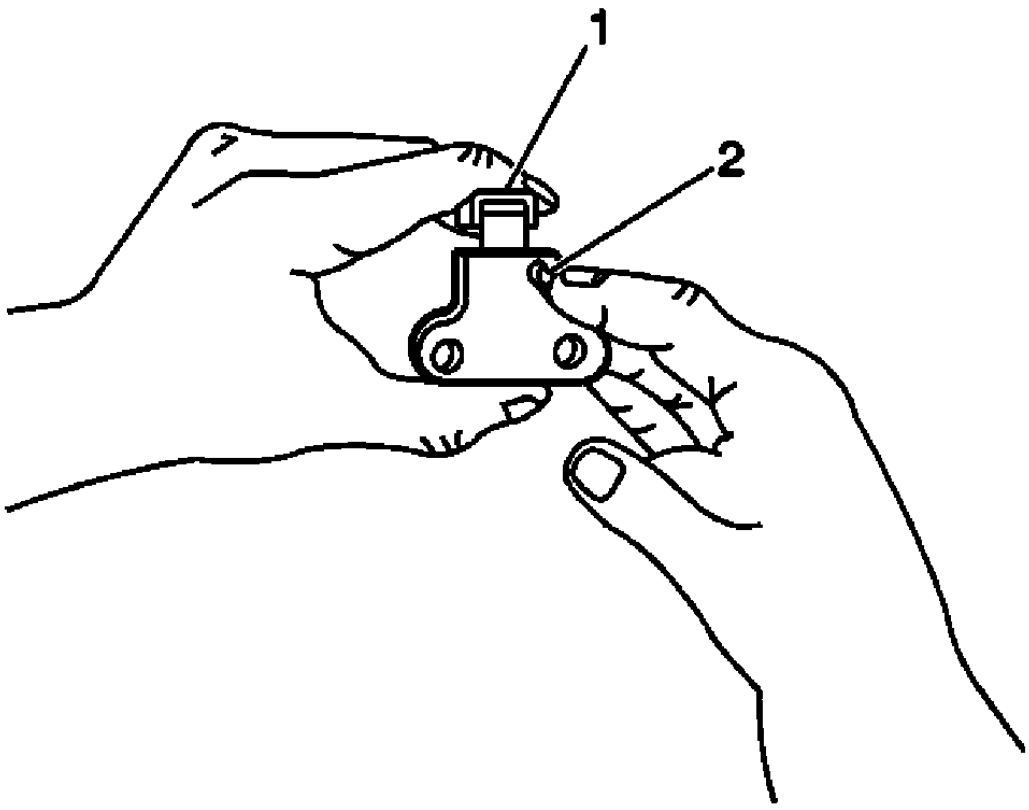

Fig. 239: Collapsing Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Collapse the primary camshaft drive chain tensioner using the following procedure:
    1. Rotate the ratchet release lever (2) clockwise and hold.
    2. Collapse the tensioner shoe (1) and hold.
    3. Release the ratchet lever (2).
2. Slowly release the pressure on the shoe (1), until the ratchet lever (2) moves to the first detent and a "click" is heard and felt.
3. Collapse the tensioner shoe (1) and hold.

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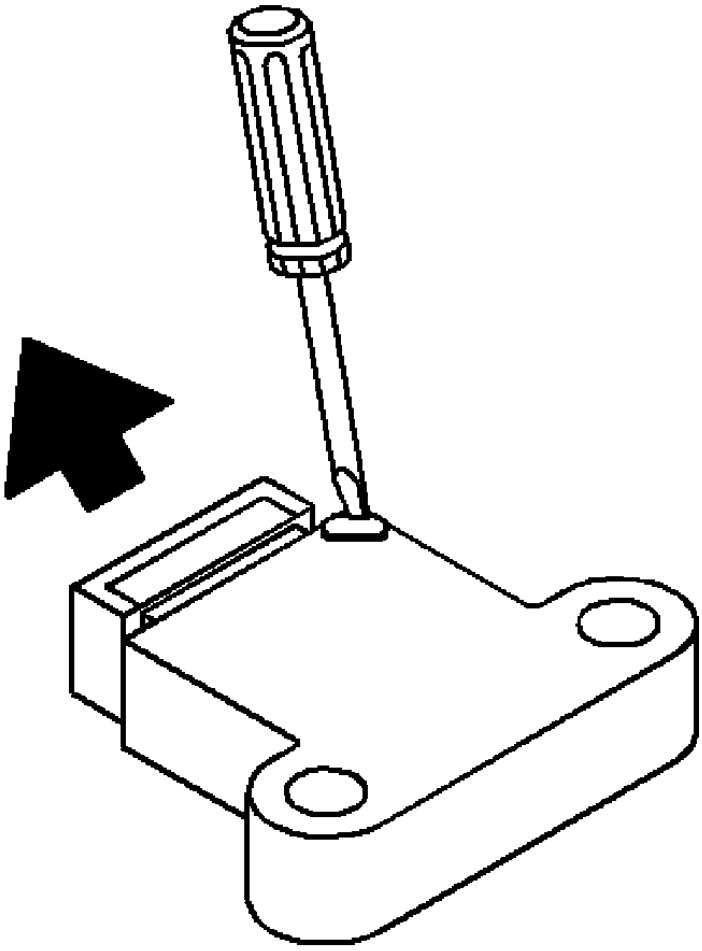

Fig. 240: Locking Primary Camshaft Drive Chain Tensioner Shoe Into Collapsed Position
Courtesy of GENERAL MOTORS CORP.

4. Insert a pin through the hole in the release lever in order to lock the tensioner shoe in the collapsed position.

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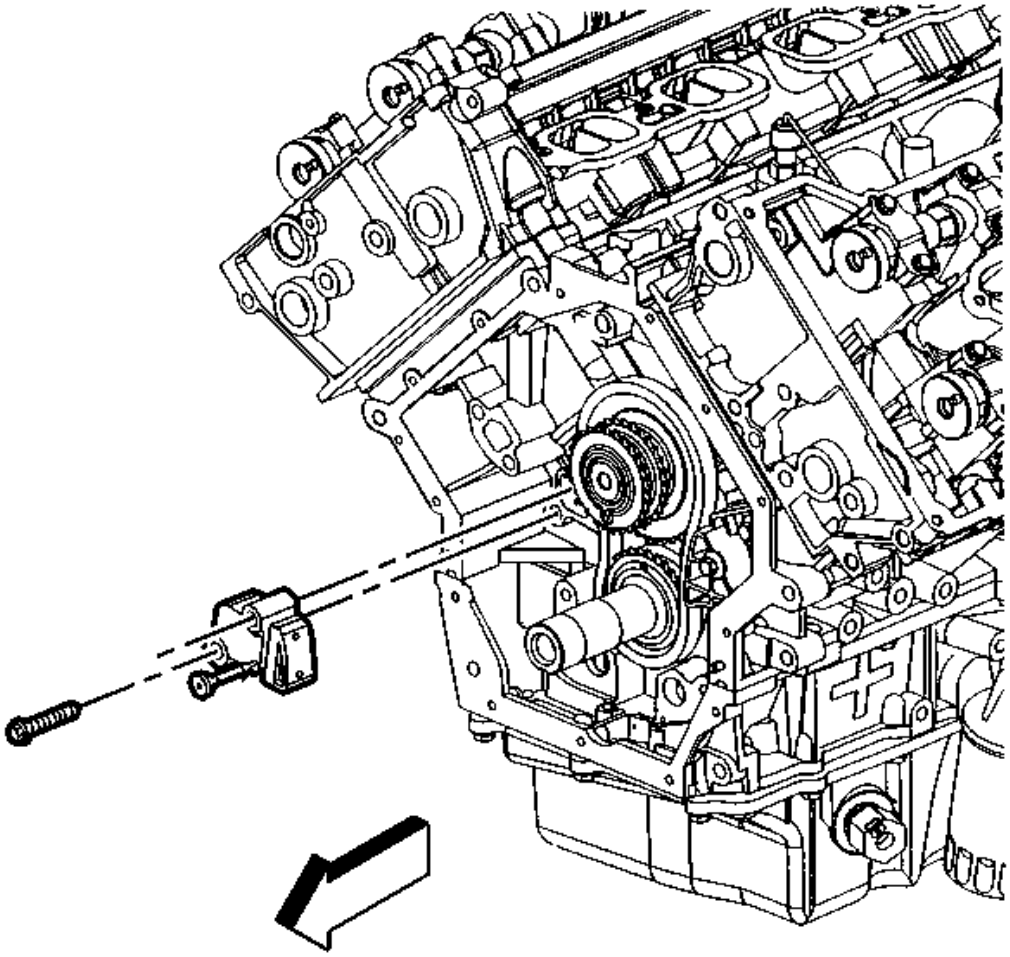

Fig. 241: Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Ensure the tensioner release lever is facing outward.

5. Install the primary camshaft drive chain tensioner and retaining bolts.

   Tighten: Tighten the primary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

6. Remove the pin holding the tensioner to tighten any slack in the timing chain.

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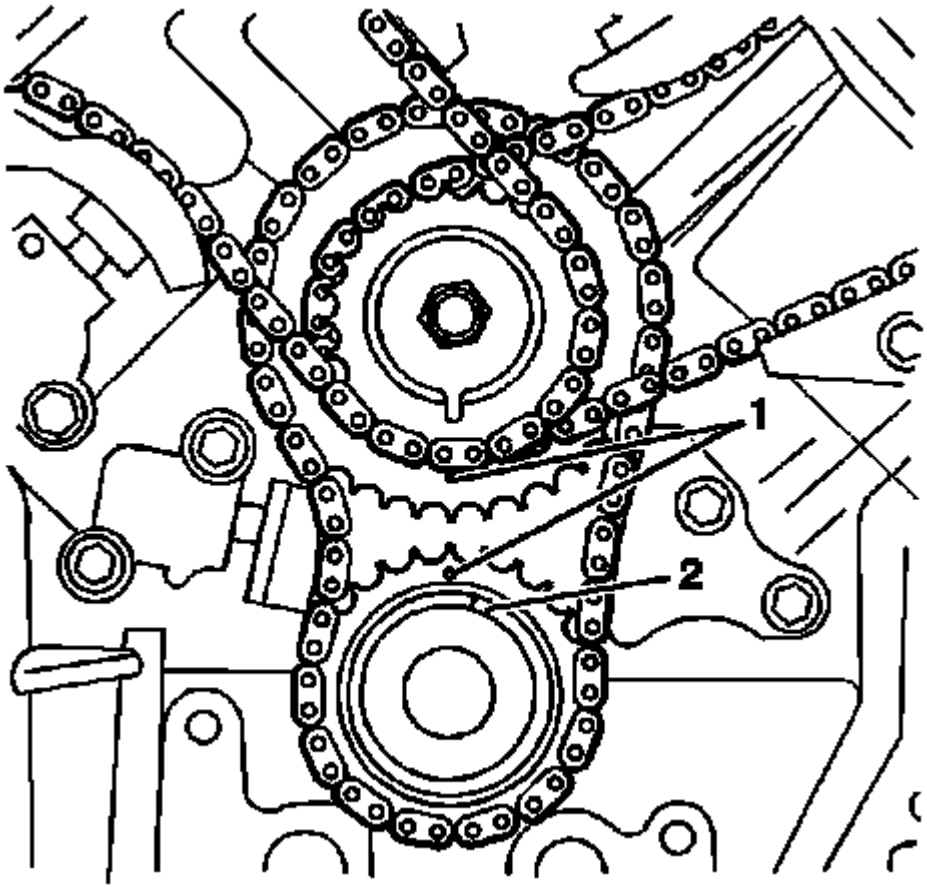

Fig. 242: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure the primary timing marks (1) are aligned vertically.
8. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

PRIMARY TIMING CHAIN GUIDE REPLACEMENT

REMOVAL PROCEDURE

1. Remove the front cover. Refer to **Engine Front Cover Replacement**.

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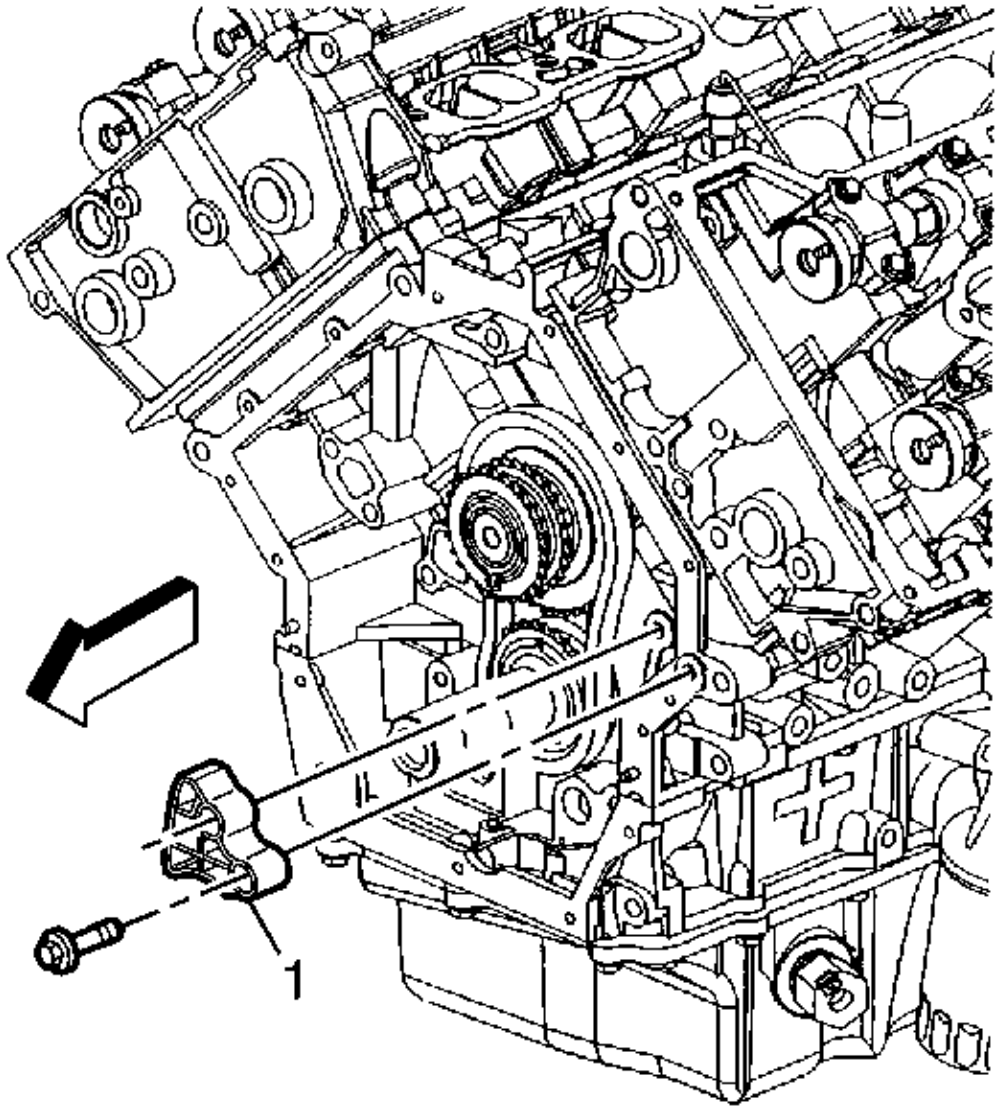

Fig. 243: Primary Camshaft Drive Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the two bolts attaching the primary camshaft drive chain guide (1) to the engine block.
3. Remove the primary camshaft drive chain guide (1).
4. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

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INSTALLATION PROCEDURE

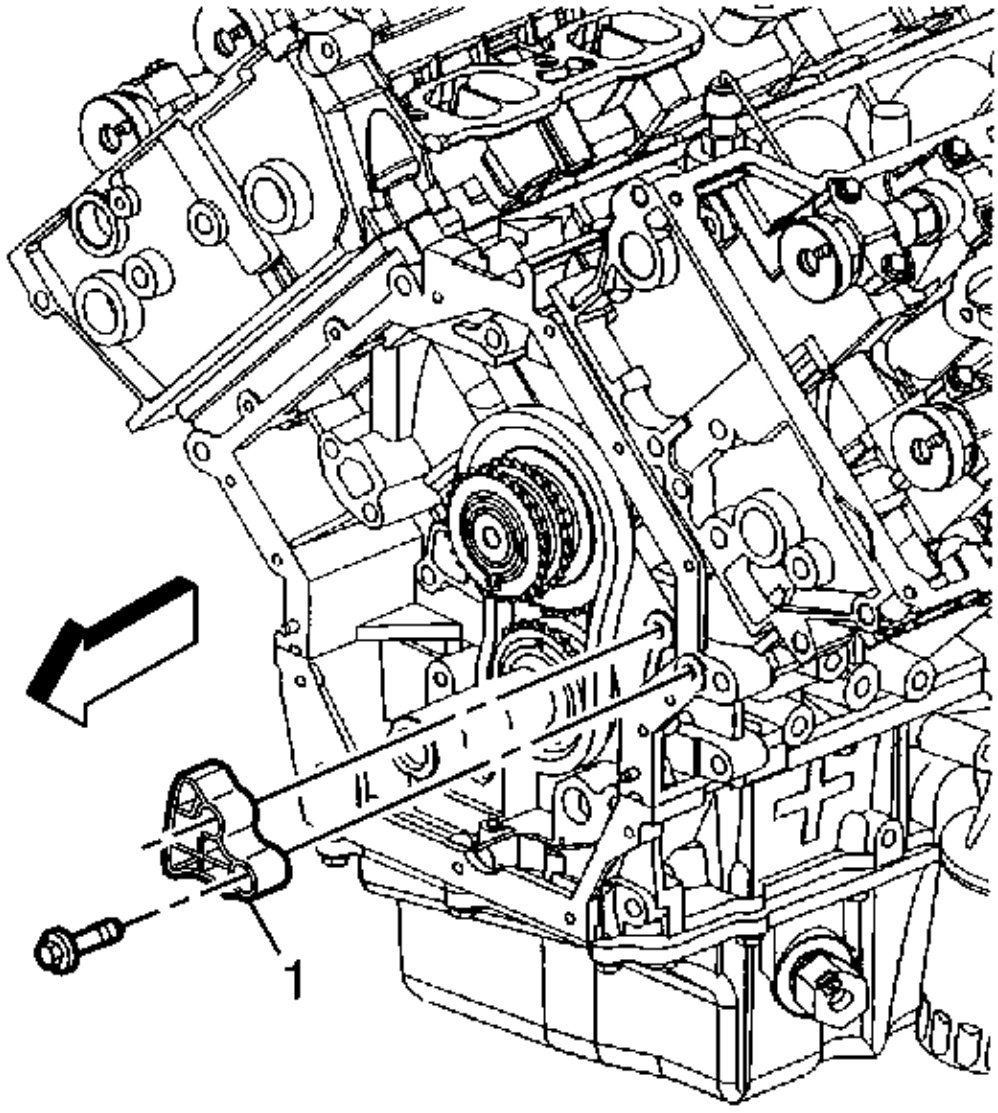

Fig. 244: Primary Camshaft Drive Chain Guide & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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1. Install the primary camshaft drive chain guide (1) and retaining bolts.

   Tighten: Tighten the primary camshaft drive chain guide bolts to 25 N.m (18 lb ft).

2. Install the front cover. Refer to **Engine Front Cover Replacement**.

PRIMARY CAMSHAFT DRIVE CHAIN AND SPROCKETS REPLACEMENT

SPECIAL TOOLS

J 39946 Crankshaft Socket - 4.0L and 4.6L

REMOVAL PROCEDURE

1. Remove the oil pump. Refer to **Oil Pump Replacement**.

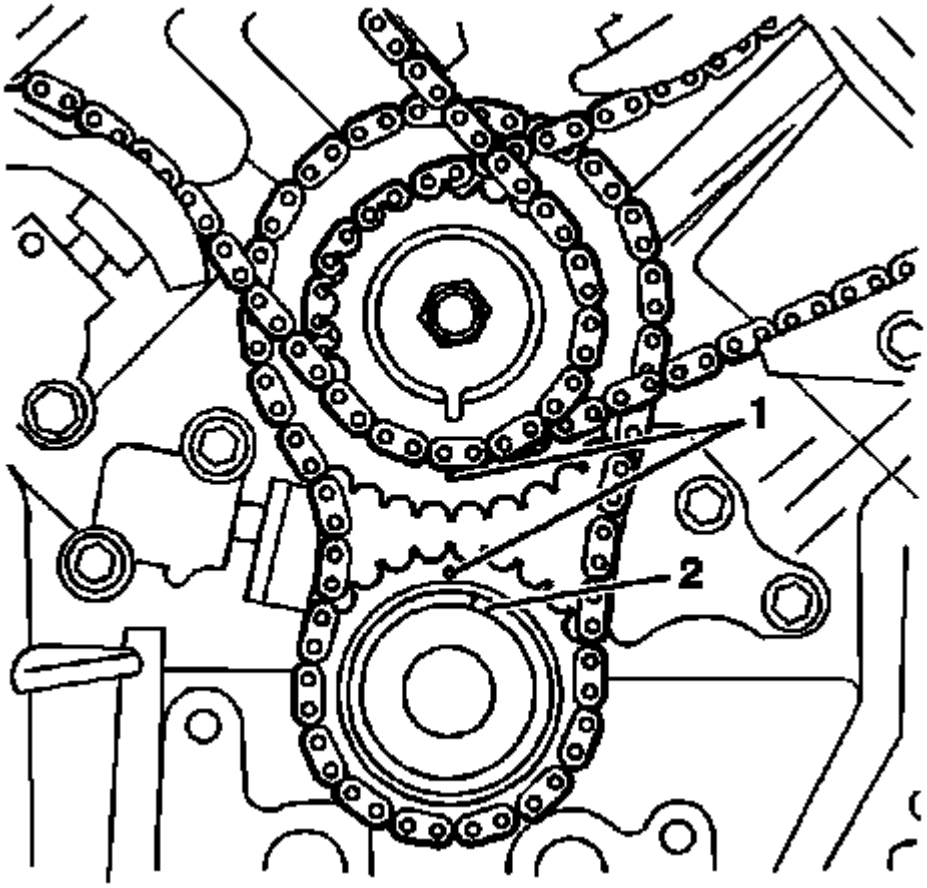

Fig. 245: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the primary timing marks (1) using the **J 39946** .
3. Remove the secondary camshaft drive chains. Refer to **Secondary Camshaft Intermediate Drive Chain**

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Replacement - Right Side and **Secondary Camshaft Intermediate Drive Chain Replacement - Left Side**.

4. Remove the primary drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Replacement**.

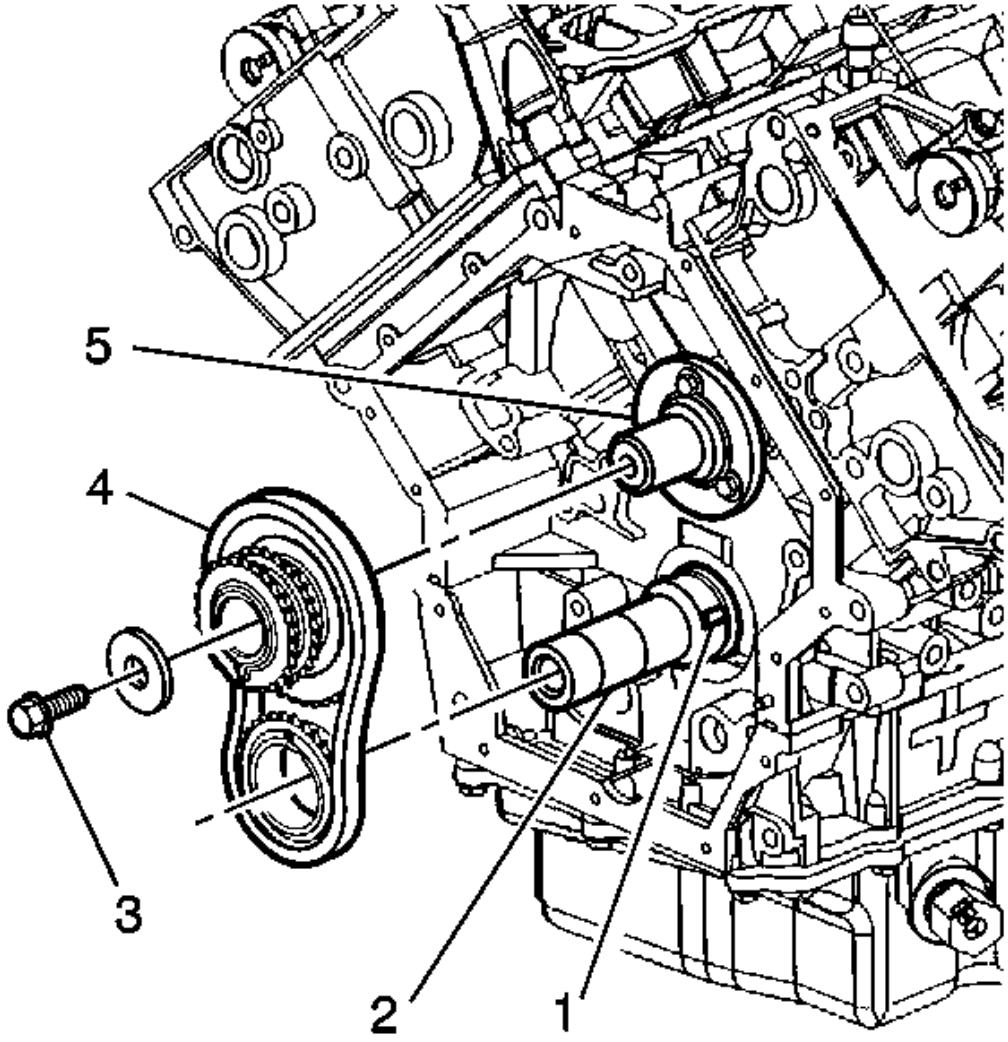

Fig. 246: Camshaft Intermediate Sprocket, Retaining Bolt & Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft intermediate sprocket retaining bolt (3).
6. Remove the following as an assembly:
    - The primary camshaft drive chain (4)

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- The crankshaft sprocket
- The camshaft intermediate sprocket

7. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

INSTALLATION PROCEDURE

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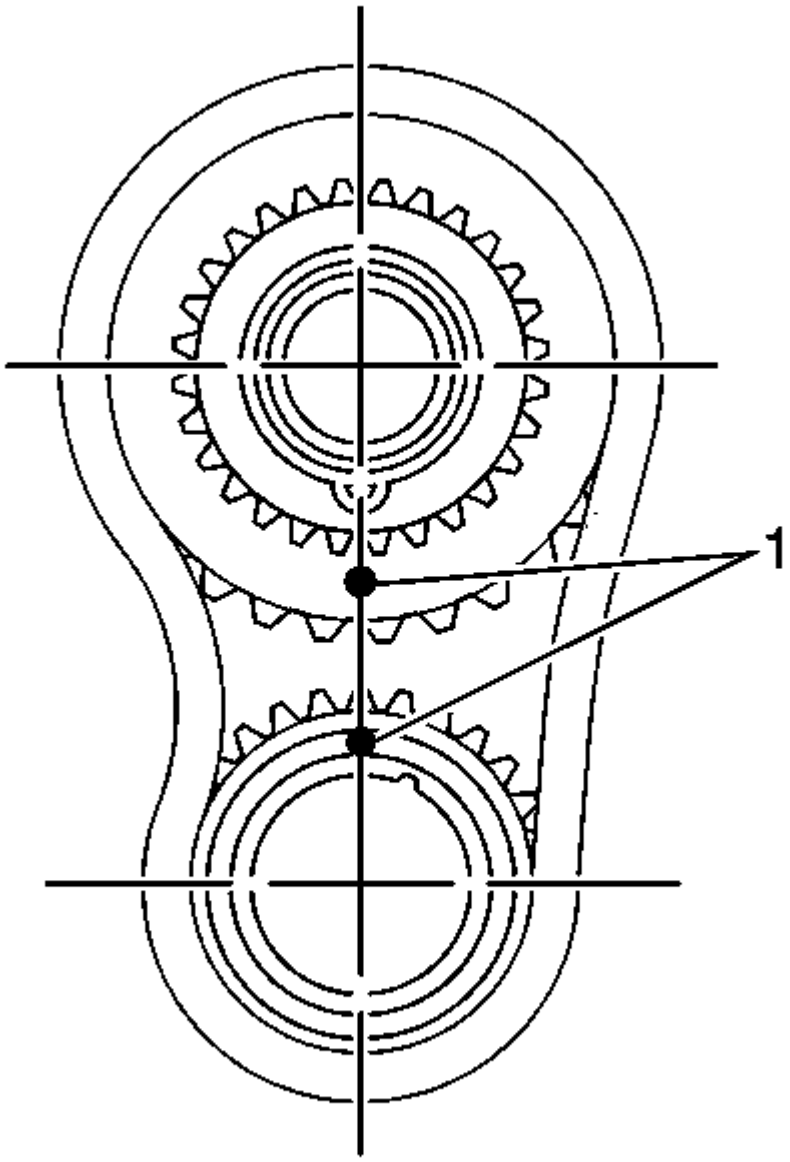

Fig. 247: Aligning Timing Marks Of Camshaft Intermediate & Crankshaft Sprockets
Courtesy of GENERAL MOTORS CORP.

1. Align the timing marks (1) of the camshaft intermediate and crankshaft sprockets. The marks should be aligned vertically in the installed position.
2. Install the primary camshaft drive chain on the drive sprockets.
3. Make sure that the number 1 piston is at top dead center (TDC) and the crankshaft keyway is

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approximately at the 1 o'clock position.

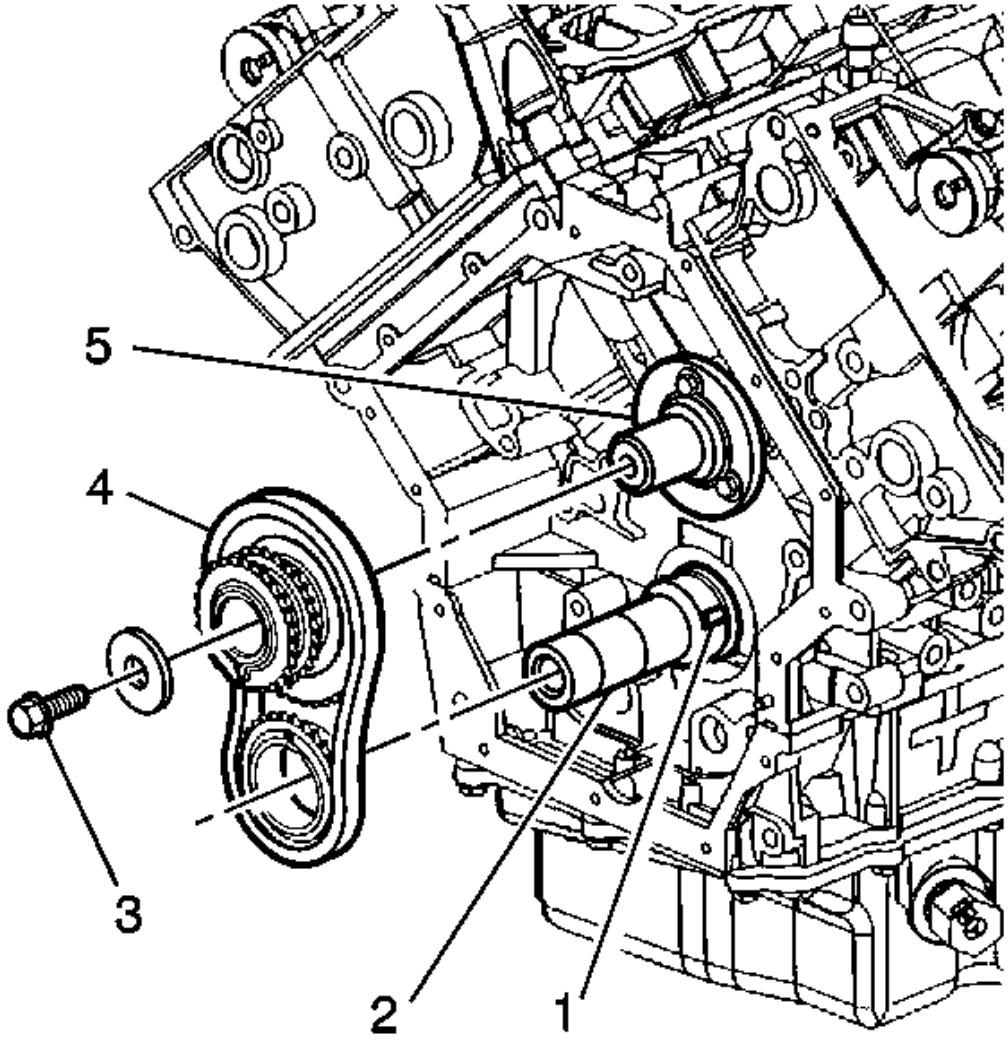

Fig. 248: Camshaft Intermediate Sprocket, Retaining Bolt & Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 39946** to align the crankshaft key (1) with the drive sprocket.
5. Install the following as an assembly:
    - The primary camshaft drive chain (4)
    - The crankshaft sprocket
    - The camshaft intermediate sprocket

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CAUTION: Refer to Fastener Caution .

6. Install the camshaft intermediate sprocket retaining bolt (3).

   Tighten: Tighten the camshaft intermediate sprocket retaining bolt to 60 N.m (44 lb ft).

   NOTE: DO NOT remove the pin holding the tensioner until the secondary timing chains are installed.

7. Install the primary drive chain tensioner. Refer to **Primary Camshaft Intermediate Drive Chain Tensioner Replacement**.
8. Install the secondary camshaft drive chains. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Left Side** and **Secondary Camshaft Intermediate Drive Chain Replacement - Right Side**.
9. Remove the pin from the primary timing chain tensioner release lever.

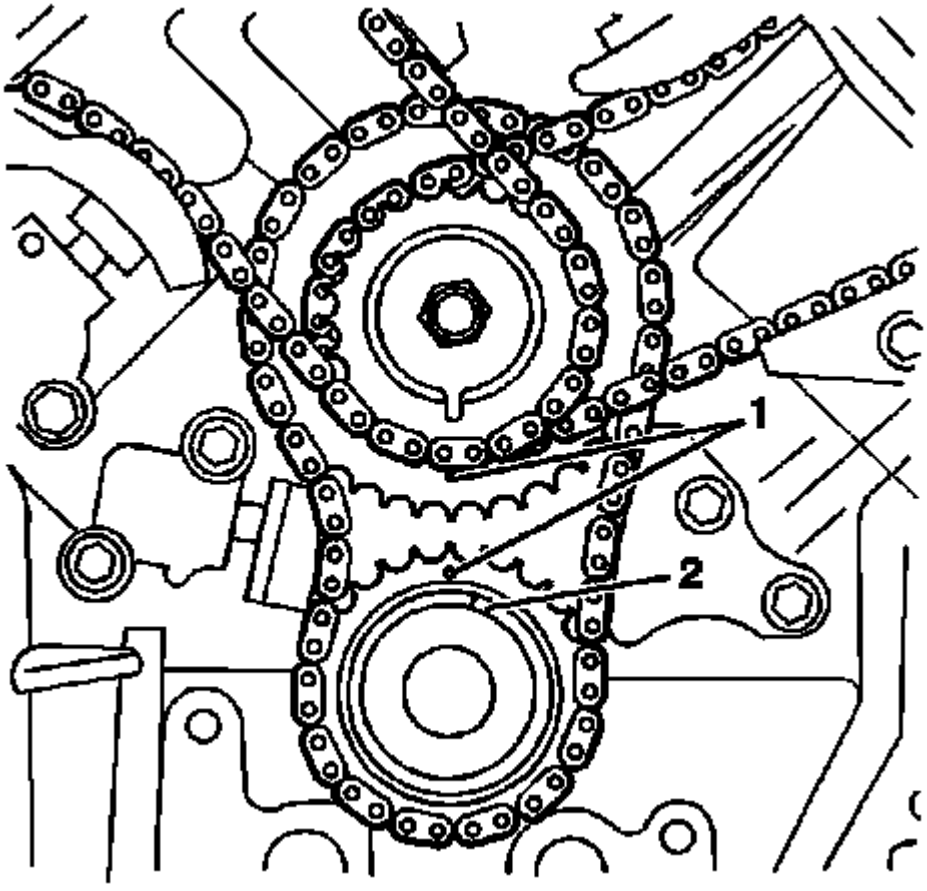

Fig. 249: Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

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10. Ensure the primary timing marks (1) are aligned vertically.
11. Install the oil pump. Refer to **Oil Pump Replacement**.

CAMSHAFT INTERMEDIATE DRIVE SHAFT REPLACEMENT

REMOVAL PROCEDURE

1. Remove the camshaft intermediate drive shaft sprocket. Refer to **Primary Camshaft Drive Chain and Sprockets Replacement**.

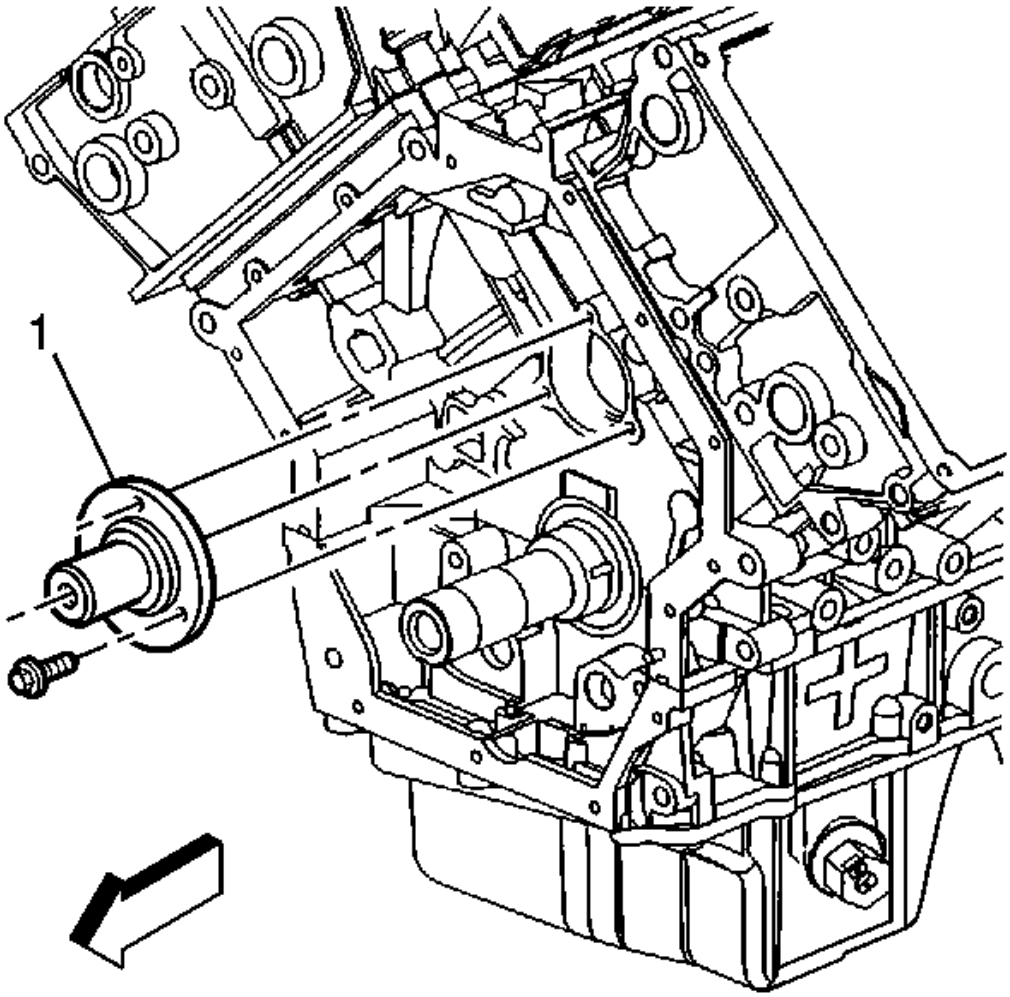

Fig. 250: Camshaft Intermediate Driveshaft
Courtesy of GENERAL MOTORS CORP.

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NOTE: The camshaft intermediate drive shaft should not be removed unless wear is evident.

2. Remove the camshaft intermediate drive shaft retaining bolts.
3. Remove the camshaft intermediate drive shaft (1) from the engine.
4. Clean and inspect the camshaft intermediate driveshaft. Refer to **Camshaft Intermediate Drive Shaft Cleaning and Inspection** .

INSTALLATION PROCEDURE

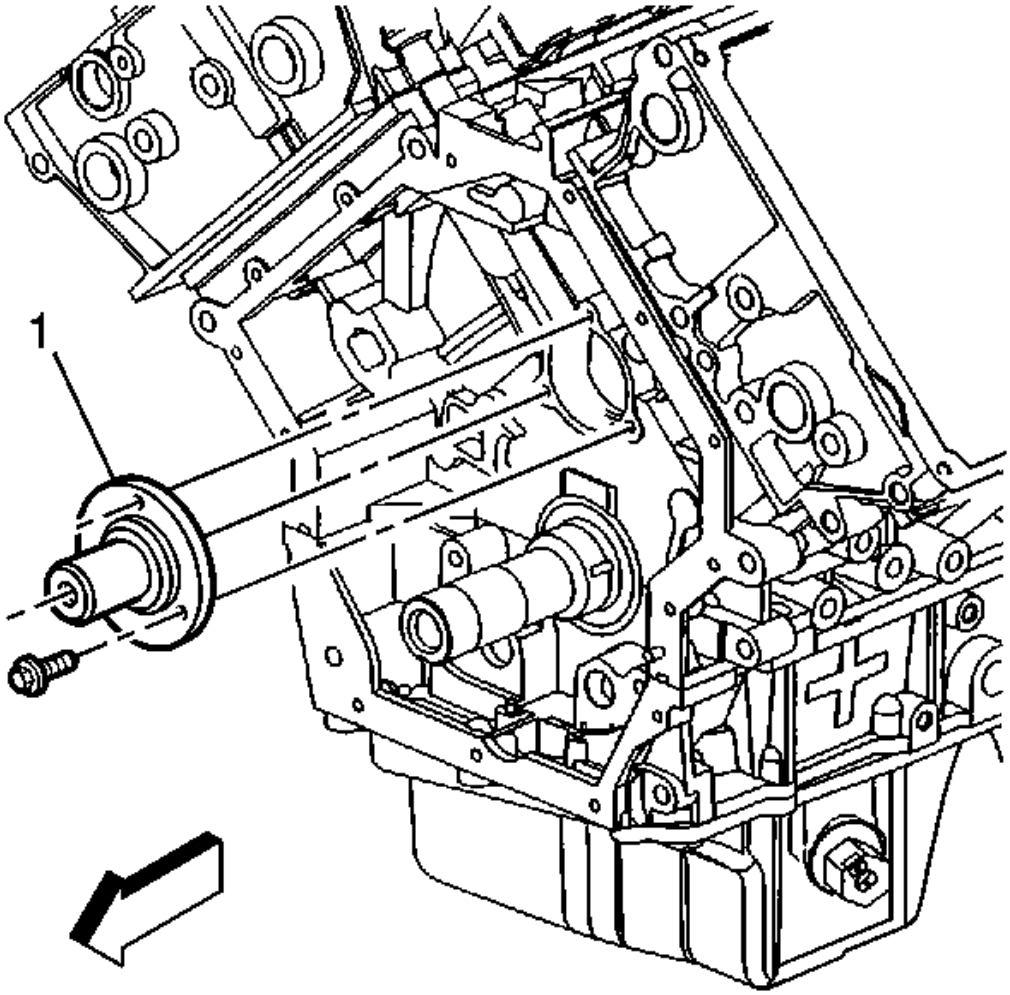

Fig. 251: Camshaft Intermediate Driveshaft
Courtesy of GENERAL MOTORS CORP.

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1. Position the camshaft intermediate drive shaft (1) to the engine, aligning the bolt holes.

   CAUTION: Refer to Fastener Caution .

2. Install the camshaft intermediate drive shaft retaining bolts.

   Tighten: Tighten the camshaft intermediate drive shaft retaining bolts to 15 N.m (11 lb ft).

3. Install the camshaft intermediate drive shaft sprocket. Refer to **Primary Camshaft Drive Chain and Sprockets Replacement**.

SETTING CAMSHAFT TIMING

Special Tools

- **J 39946** Crankshaft Rotation Socket
- **J 44214** Flywheel Holder. See **Special Tools** .

Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the relationship between any chain and sprocket has been lost. Even when only one sprocket is involved the following procedure should be observed since one crankshaft rotation will not provide conditions where correct timing can be confirmed.

The camshafts and crankshaft events are correctly timed when the relationships shown exist. The following procedure explains how to establish this condition. Correct timing exists when the crank sprocket and the intermediate shaft sprocket have their timing marks aligned and all four camshaft drive pins are perpendicular (90 degrees) to the cylinder head surface.

1. Remove the following components for access:
   - The left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side** .
   - The right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side** .
   - The engine front cover. Refer to **Engine Front Cover Replacement** .
   - The three chain tensioners. Refer to **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side** , **Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side** , **Primary Camshaft Intermediate Drive Chain Tensioner Replacement** (the tensioners may be in their installed positions but must be fully retracted).
   - The oil pump. Refer to **Oil Pump Replacement** .

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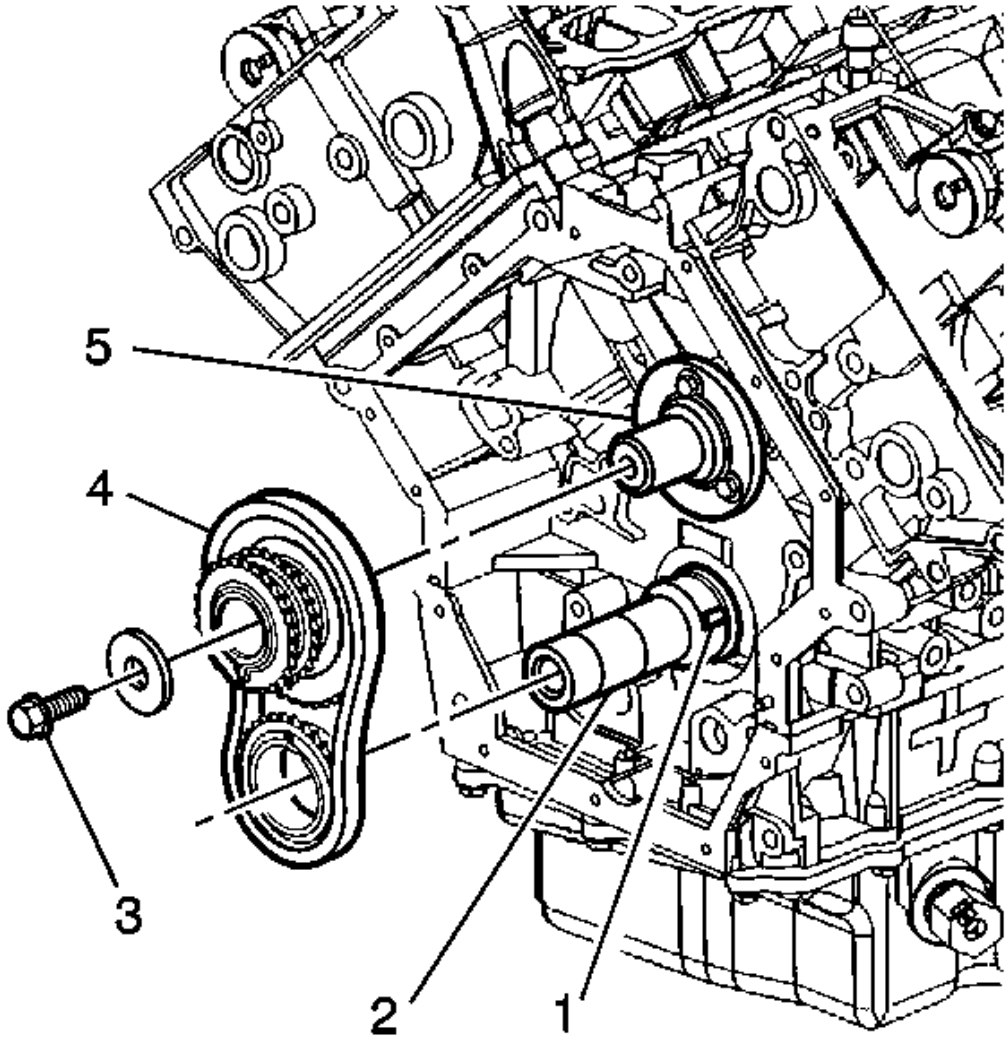

Fig. 252: Camshaft Intermediate Sprocket, Retaining Bolt & Camshaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

2. The primary and secondary chain guides should be reinstalled if previously removed.
3. Rotate the crankshaft (2) until the sprocket drive key (1) is at approximately the 1 o'clock position. Use the **J 39946** to rotate the crankshaft (2).
4. Install the crankshaft and the intermediate shaft sprockets to the primary drive chain with their timing marks adjacent to each other.
5. Install the crank and intermediate sprocket assembly (4) over their respective shafts.
6. Rotate the crankshaft (2) as necessary to engage the crankshaft key (1) in the sprocket without changing

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the relationship of the timing marks to each other. Use the **J 39946** to rotate the crankshaft (2).

CAUTION: Refer to Fastener Caution .

7. Install the camshaft intermediate sprocket bolt (3).

   Tighten: Tighten the camshaft intermediate sprocket bolt to 60 N.m (44 lb ft).

8. Install the primary camshaft drive chain tensioner or release the tensioner shoe.

   Tighten: Tighten the primary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).

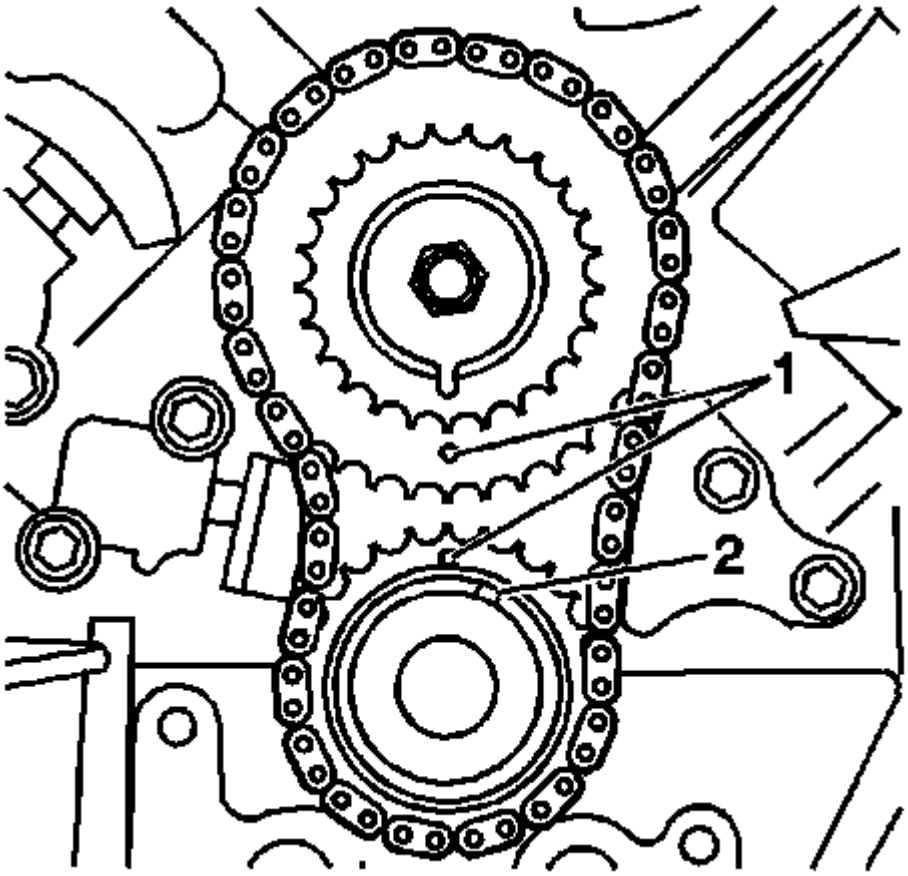

Fig. 253: Ensuring Vertical Timing Mark Alignment
Courtesy of GENERAL MOTORS CORP.

9. Ensure the timing marks (1) are aligned vertically.
10. Install the **J 44214** to lock the crankshaft in this position. See **Special Tools** . If the engine is on a stand, an alternate method should be devised.

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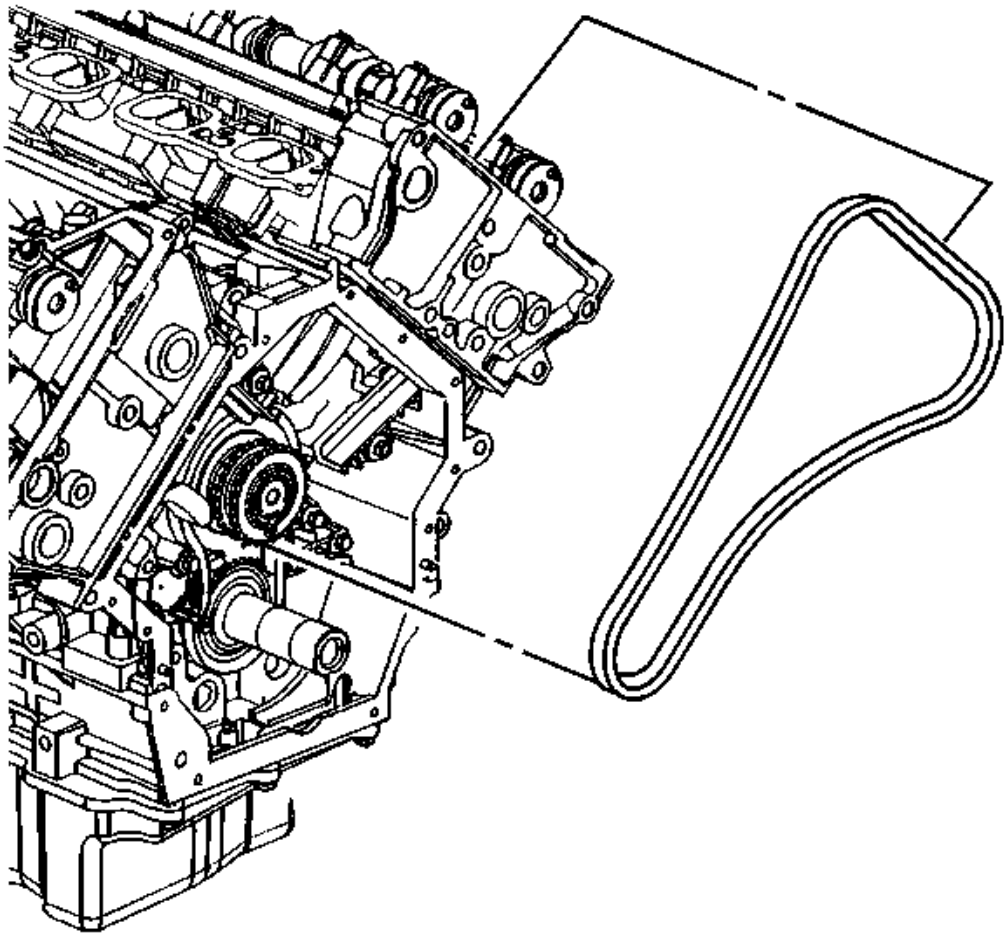

Fig. 254: Left Cylinder Head Secondary Drive Chain
Courtesy of GENERAL MOTORS CORP.

11. Route the secondary drive chain for the LH cylinder head over the inner row of intermediate shaft teeth.

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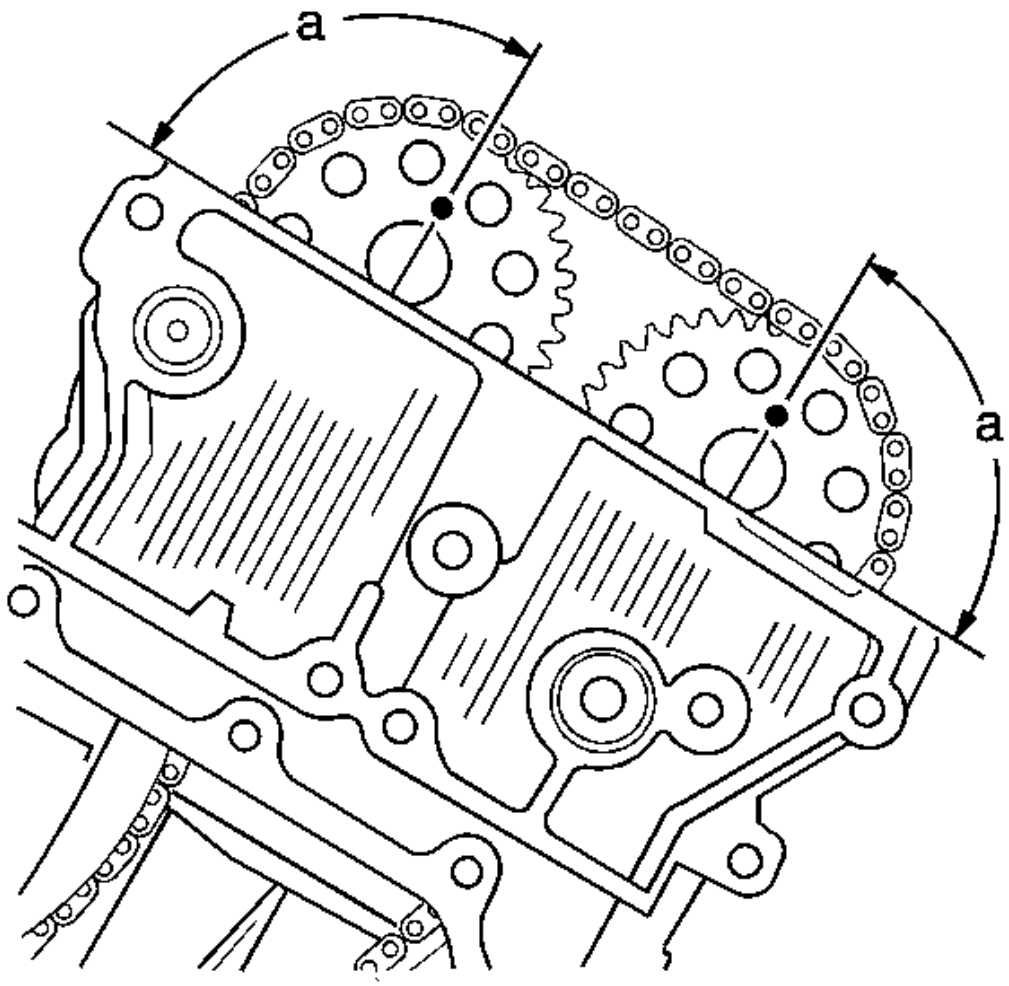

Fig. 255: Routing Secondary Drive Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: The RE camshaft sprocket must contain the camshaft position sensor pick-up.

12. Route the secondary drive chain over the chain guide and install the exhaust camshaft sprocket to the chain such that the camshaft drive pin engages the sprocket notch marked LE (left head exhaust). There should be no slack in the lower section of the chain and the camshaft drive pin must be perpendicular to the cylinder head face.
13. Install the intake camshaft sprocket into the chain so that the sprocket notch marked LI (left head intake) engages the camshaft drive pin while the pin remains perpendicular to the cylinder head face. A hex is

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cast into the camshafts behind the lobes for cylinder -1 (or -2, LH) so that an open end wrench may be used to provide minor repositioning of the camshafts.

14. Loosely install the exhaust camshaft sprocket retainer bolt.
15. Loosely install the intake camshaft sprocket retainer bolt.

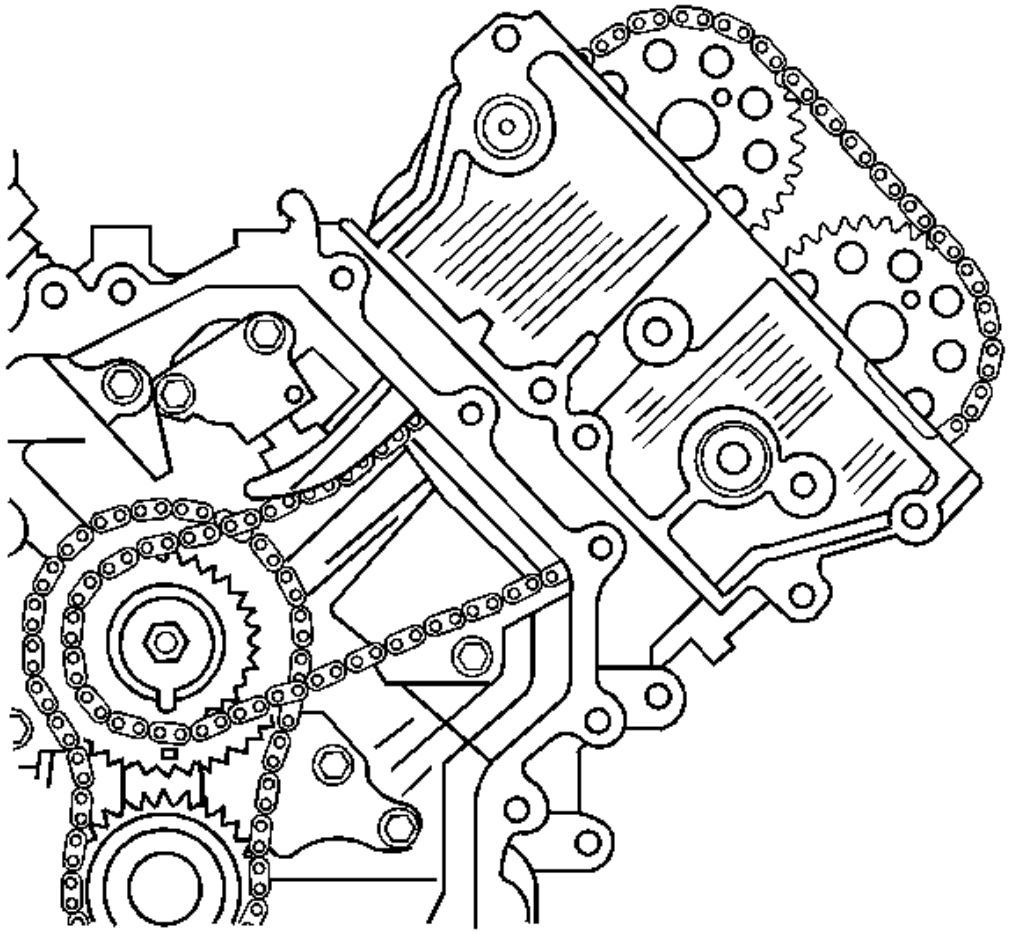

Fig. 256: Secondary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

16. Install the secondary camshaft drive chain tensioner or release the tension on the shoe.

Tighten:

- Tighten the secondary camshaft drive chain tensioner bolts to 25 N.m (18 lb ft).
- Tighten the camshaft sprocket bolts to 120 N.m (89 lb ft).

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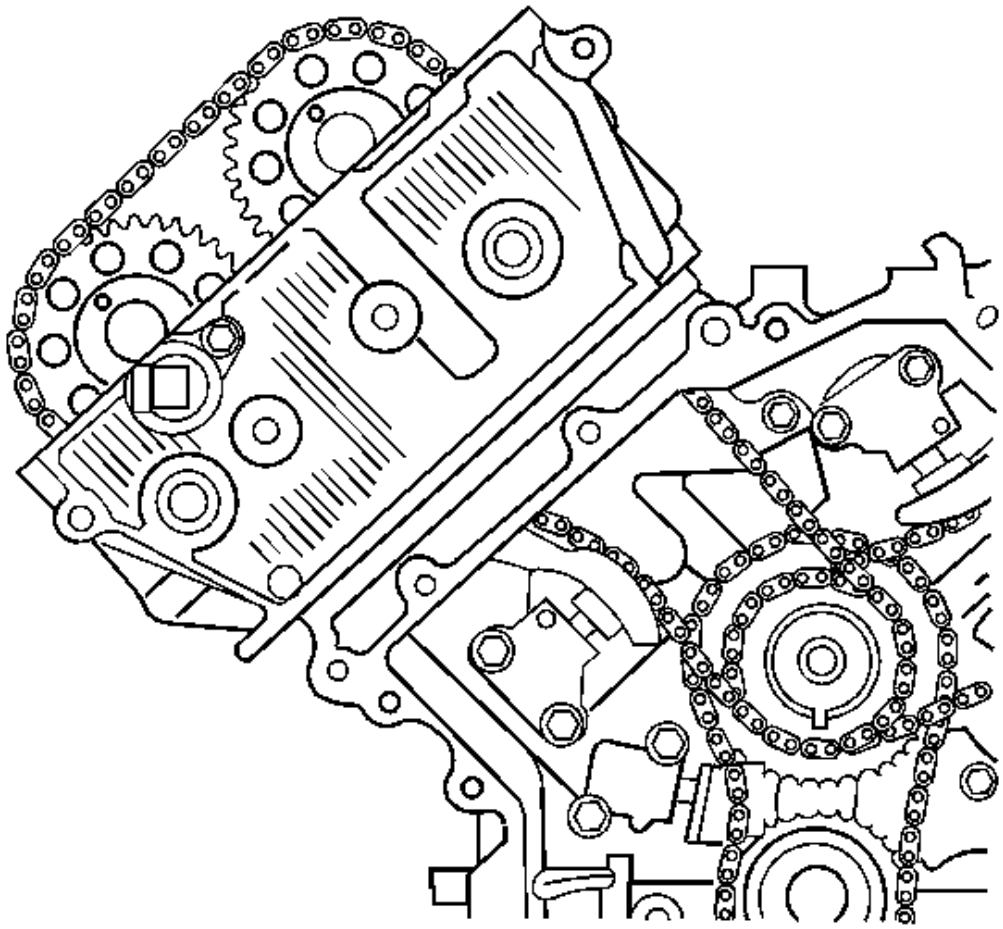

Fig. 257: Routing Right Side Cylinder Head Secondary Drive Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: The RE camshaft sprocket must contain the camshaft position sensor pick-up.

17. Route the secondary drive chain for the right side cylinder head over the outer row of the intermediate shaft teeth and repeat steps 11 through 15 for right side camshafts. Right side camshaft sprockets are identified as RI (right intake) and RE (right exhaust). In addition the RE sprocket must contain the camshaft position sensor pickup.

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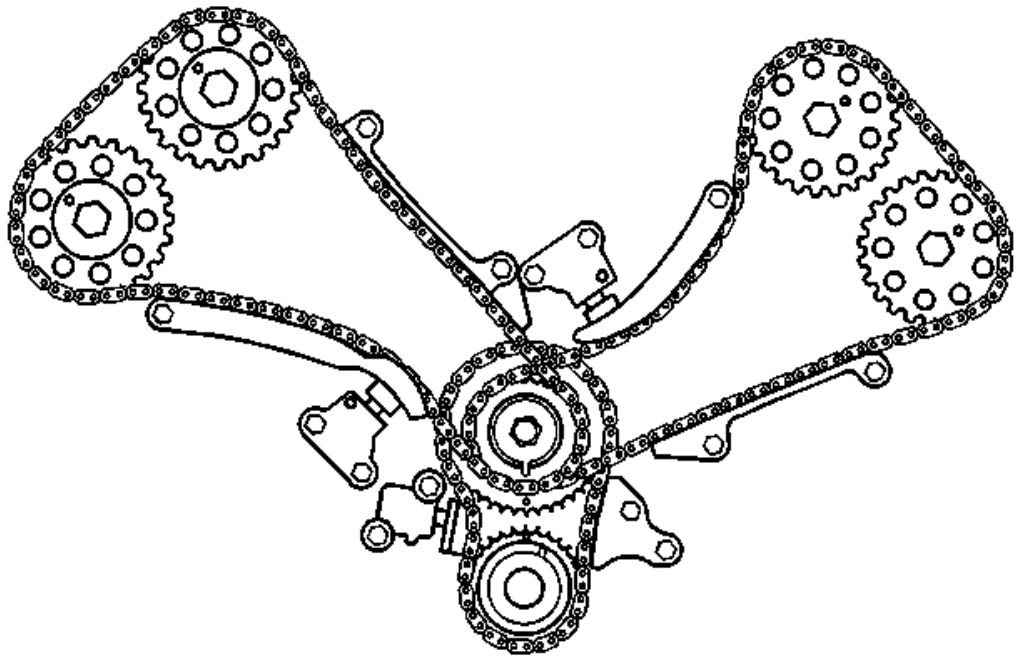

Fig. 258: Aligning Timing Marks
Courtesy of GENERAL MOTORS CORP.

18. Ensure all timing marks are properly aligned.
19. Install the following components:
    - The oil pump. Refer to **Oil Pump Replacement** .
    - The engine front cover. Refer to **Engine Front Cover Replacement** .
    - The right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side** .
    - The left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side** .

CAMSHAFT REPLACEMENT - LEFT SIDE

Special Tools

- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **J 45059** Angle Meter
- **J 44212** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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1. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

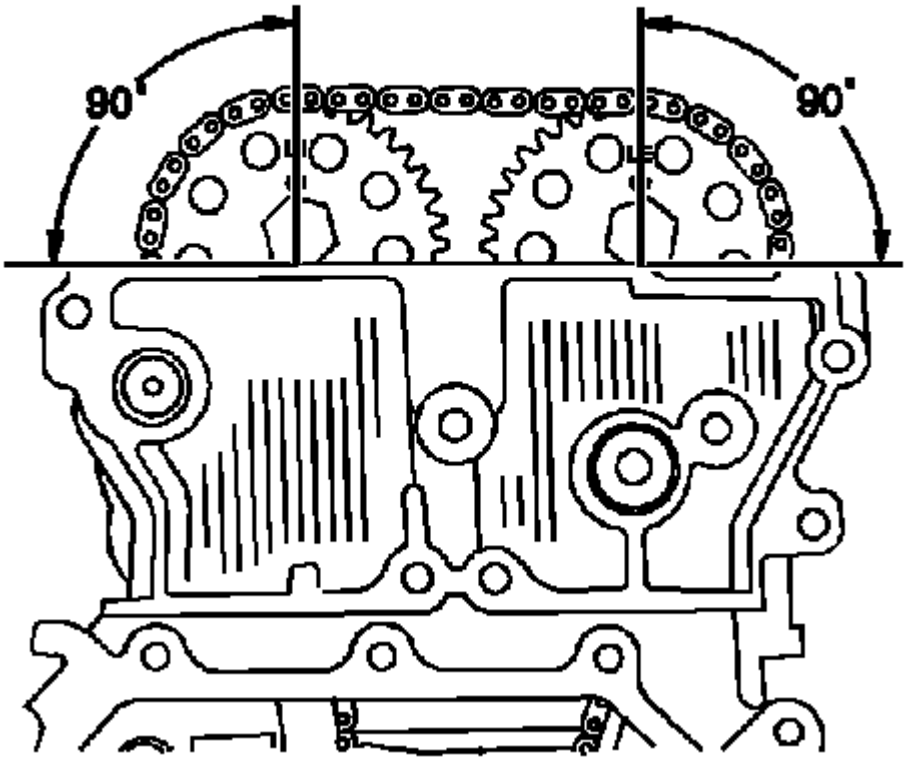

Fig. 259: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

2. Rotate the crankshaft to TDC of the # 1 cylinders compression stroke, both camshaft sprocket drive pins should be at the top of their rotation.

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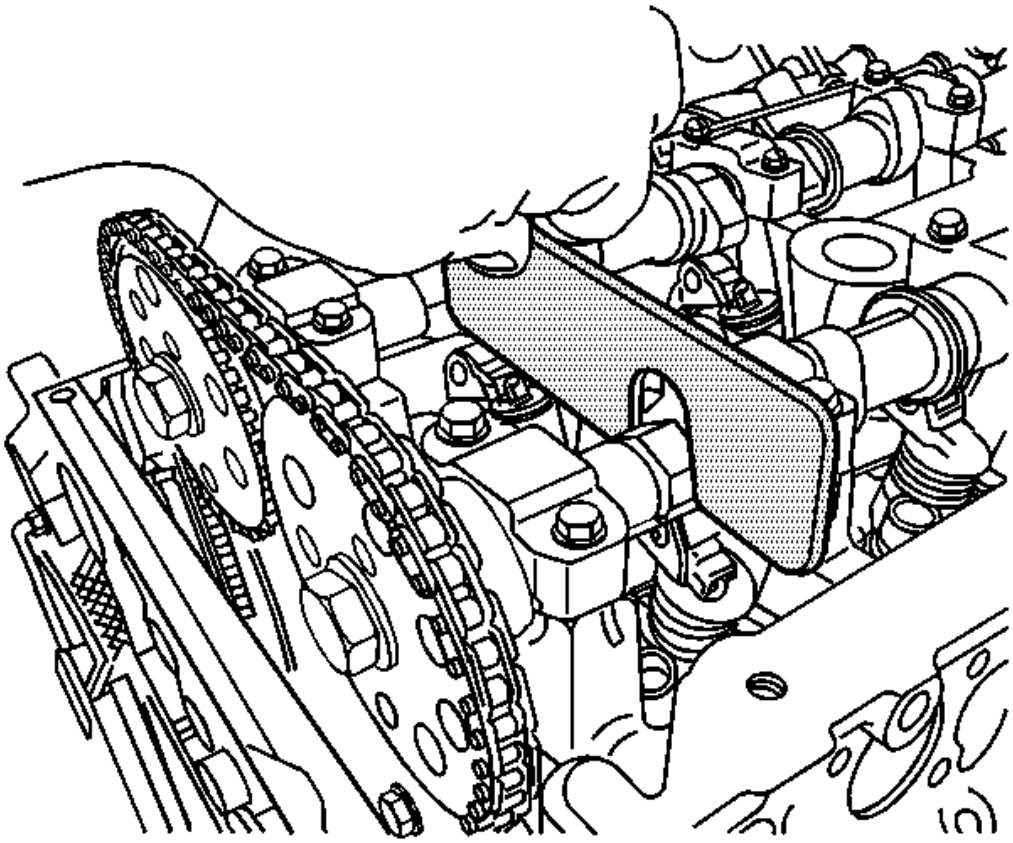

Fig. 260: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

3. Install the **J 44212** over the camshafts. See **Special Tools** .

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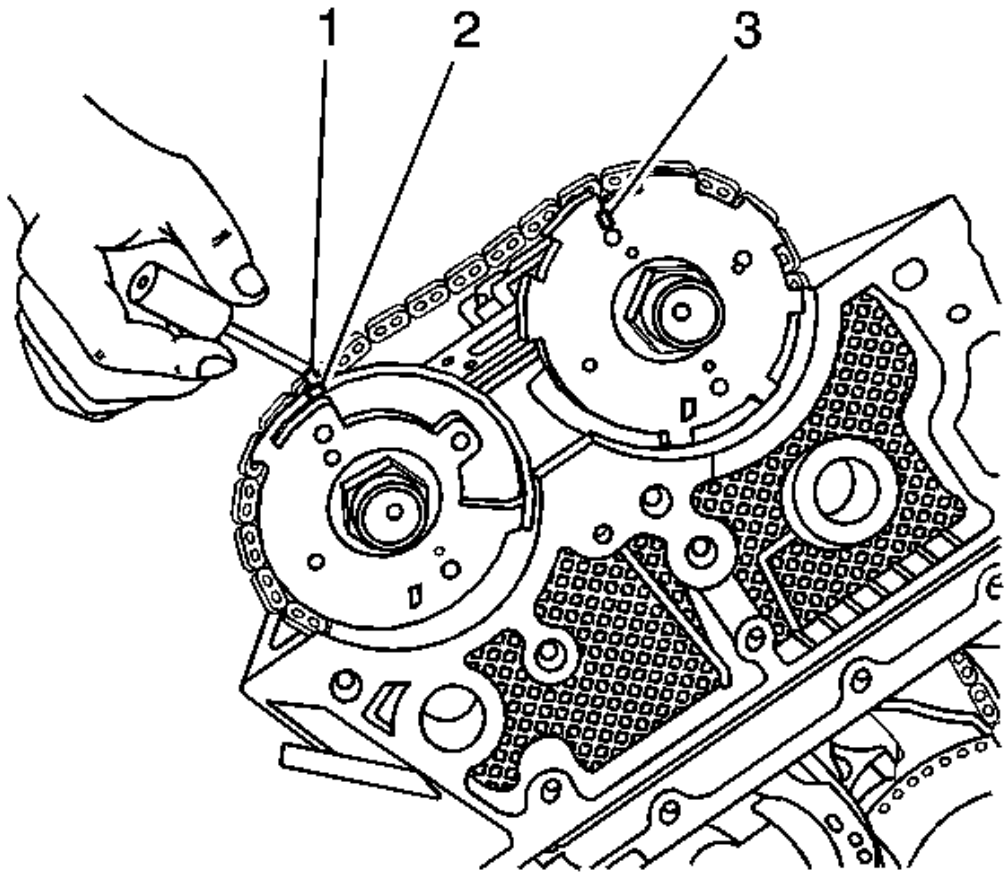

Fig. 261: Marking Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

4. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft sprocket timing mark (2, 3).

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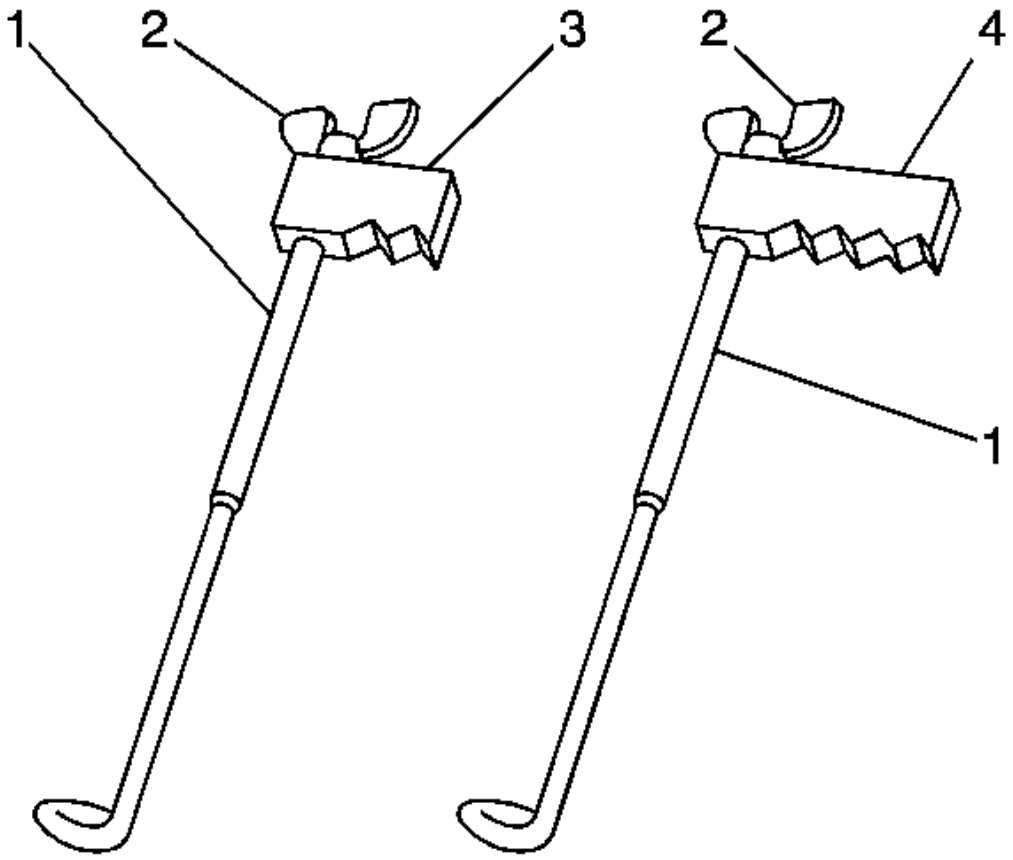

Fig. 262: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Install both **EN 46327** (1) to the engine using the following step: See **Special Tools** .

   Rotate the wing nut (2) of the **EN 46327** (3) to the top of its travel. See **Special Tools** .

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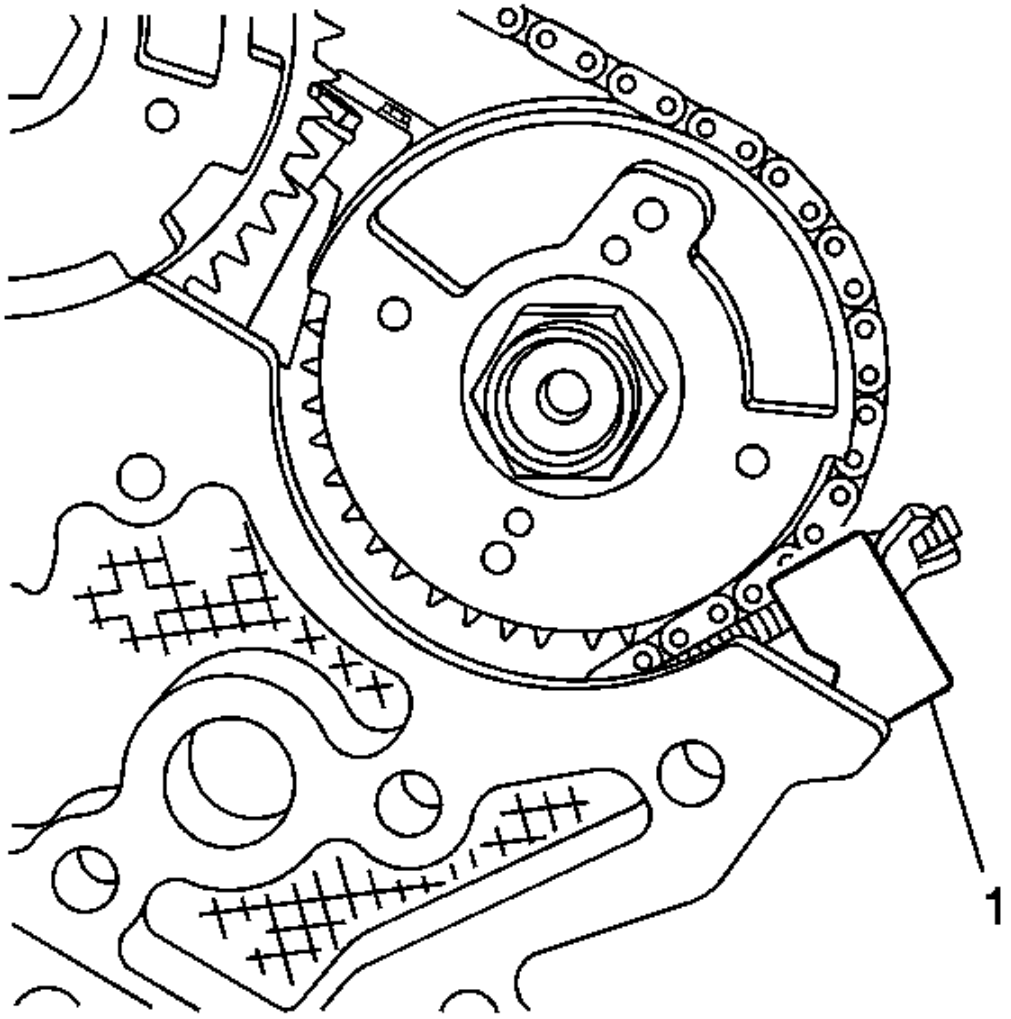

Fig. 263: Positioning Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

6. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left exhaust camshaft sprocket and chain.

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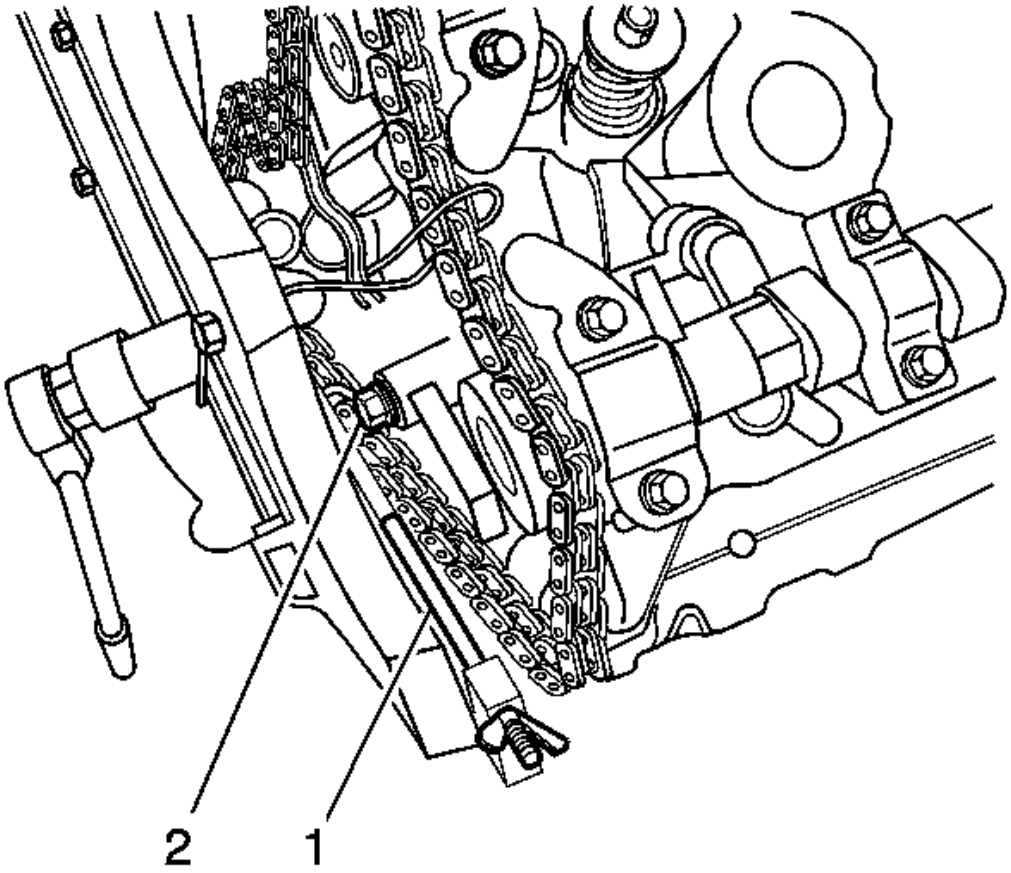

Fig. 264: Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

7. Insert the hook end (2) into a secondary timing chain link as shown.

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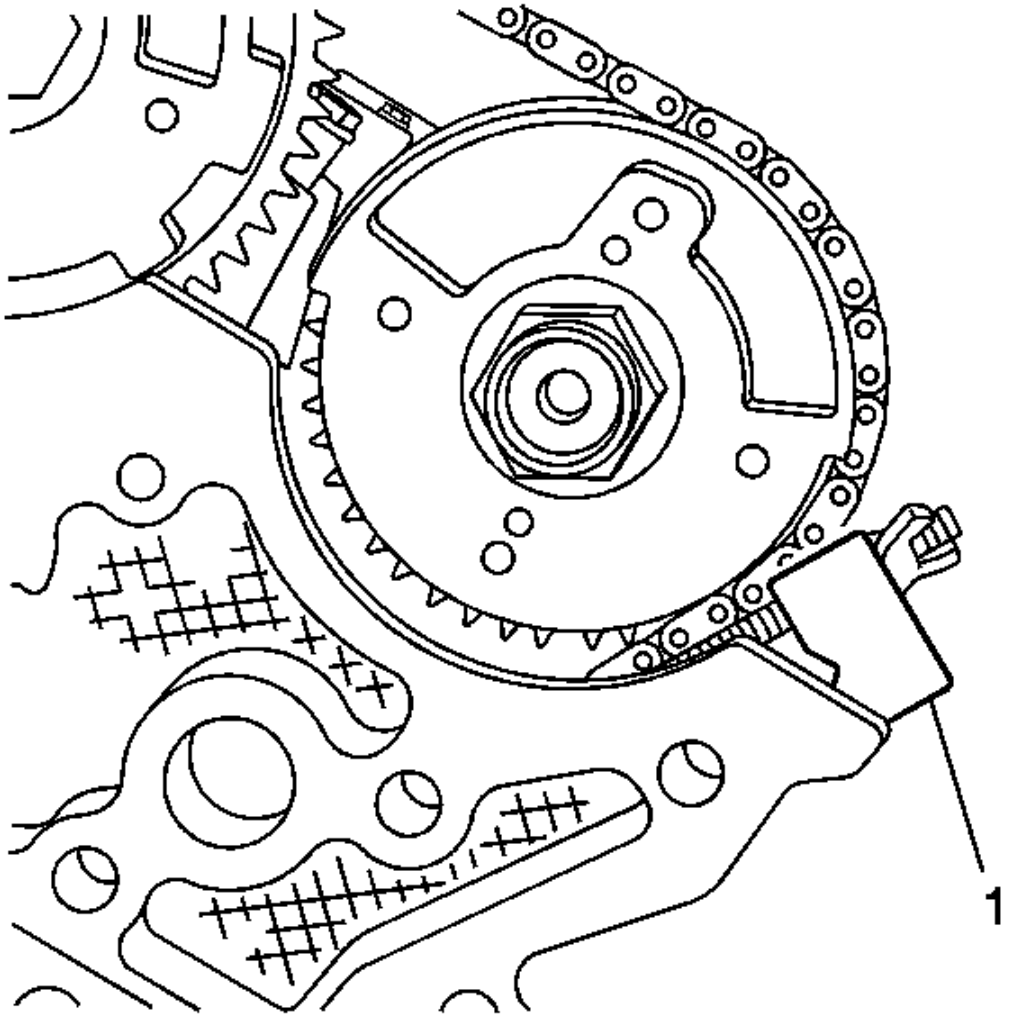

Fig. 265: Positioning Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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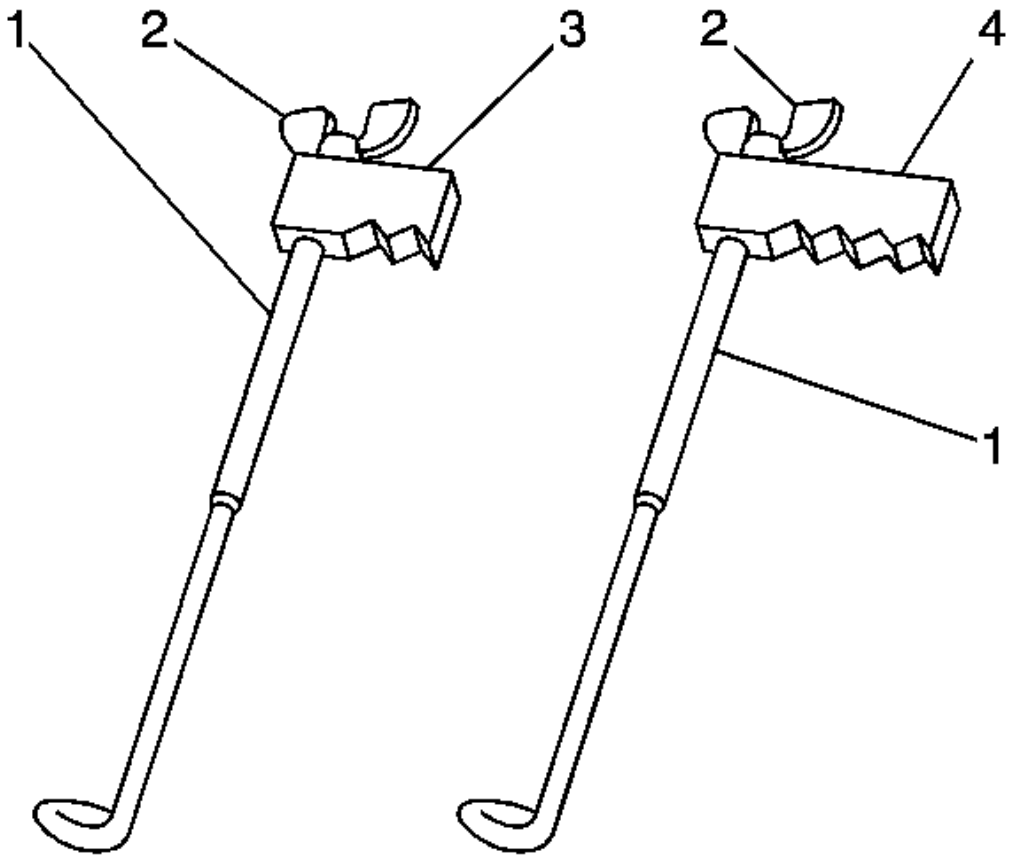

Fig. 266: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

9. Rotate the wing nut (2) of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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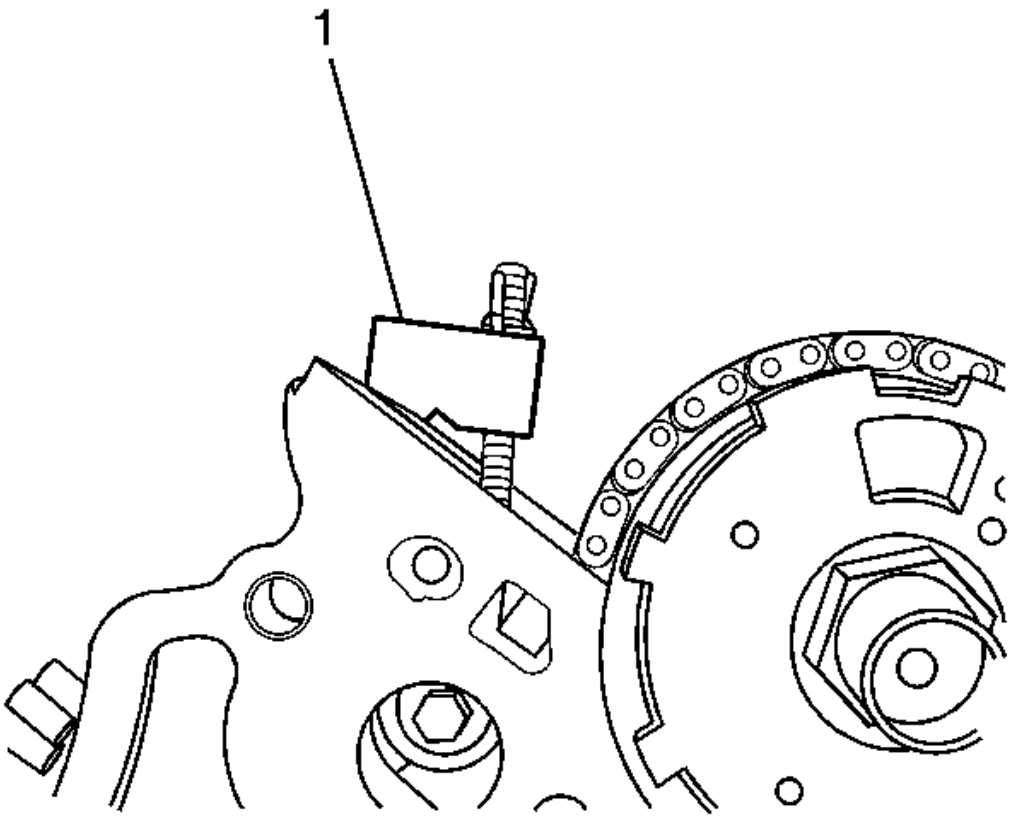

Fig. 267: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

10. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the left intake camshaft sprocket and chain.

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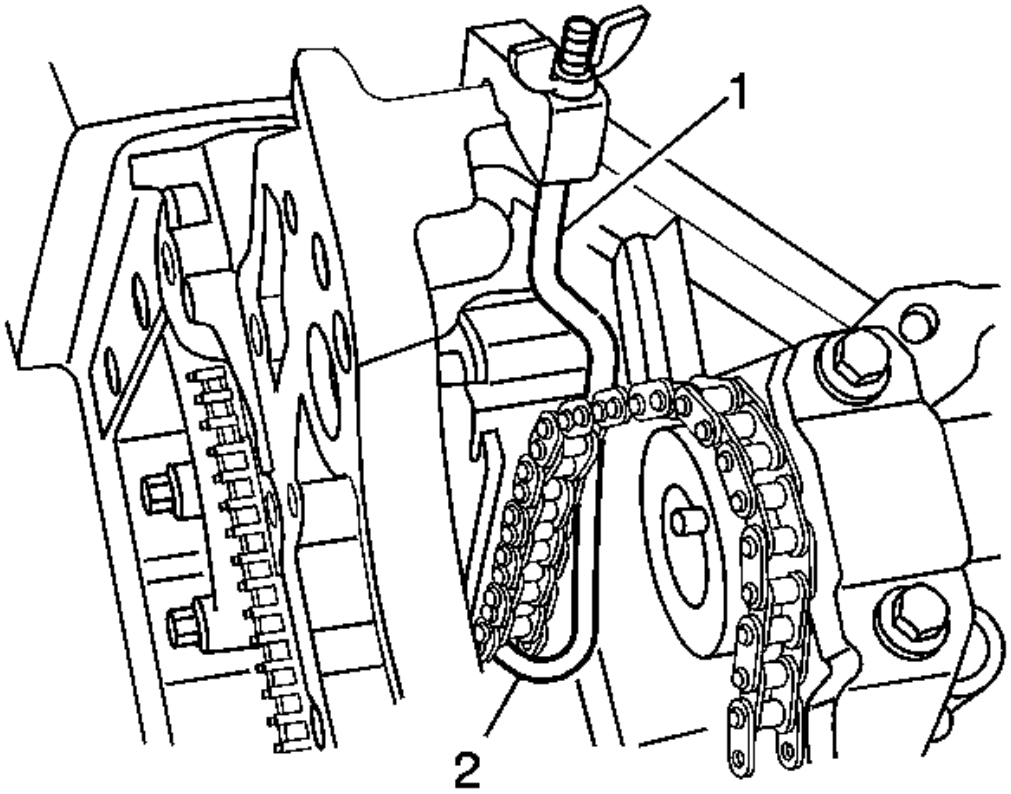

Fig. 268: Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

11. Insert the hook end (2) into a secondary timing chain link as shown.

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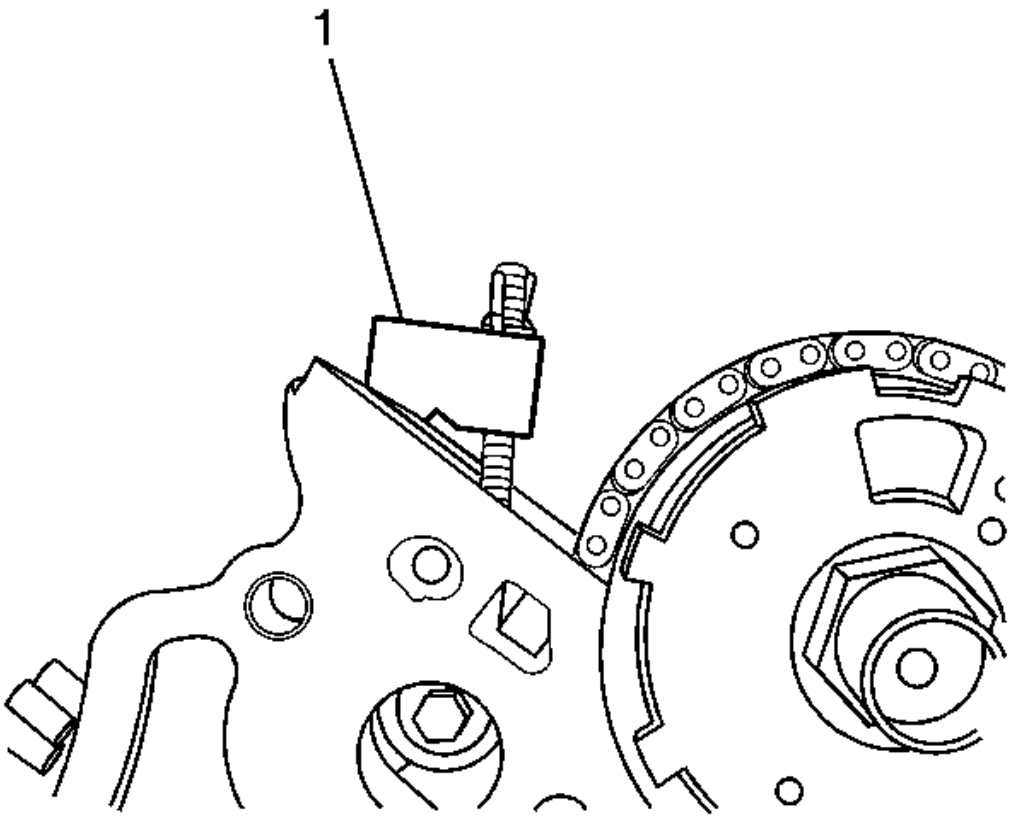

Fig. 269: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

12. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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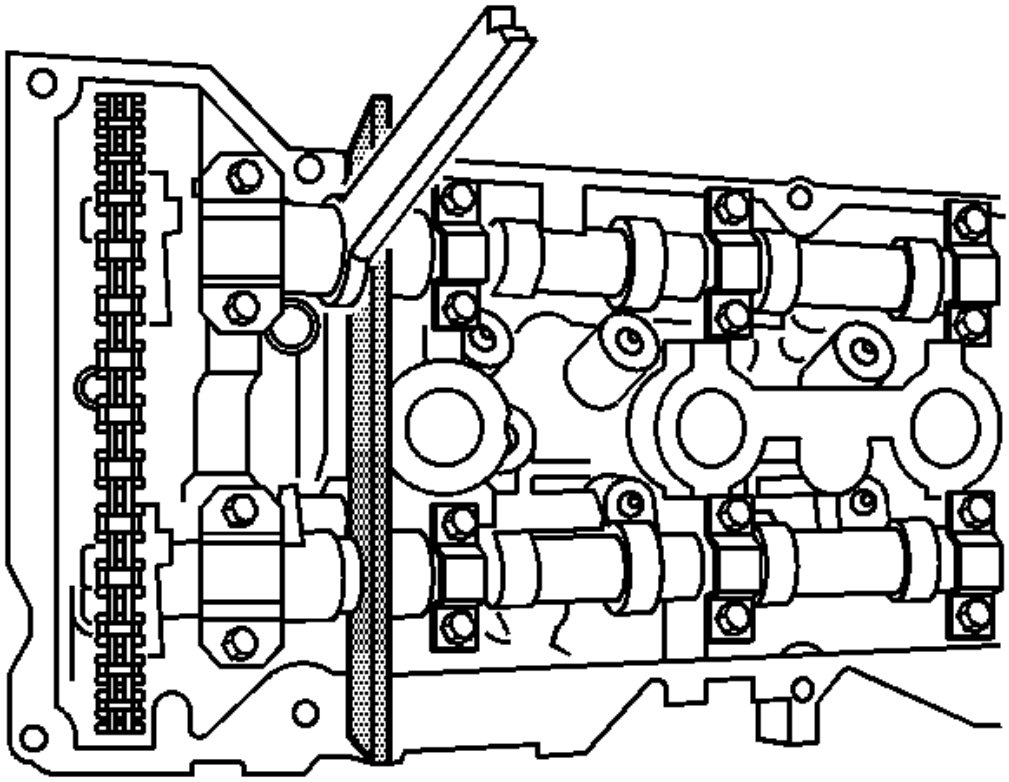

Fig. 270: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

13. Use an open wrench on the hex cast into the camshafts in order to prevent the camshafts from rotating when removing the camshaft sprocket bolts.
14. Remove the camshaft sprocket bolts.
15. Remove the camshaft sprockets.

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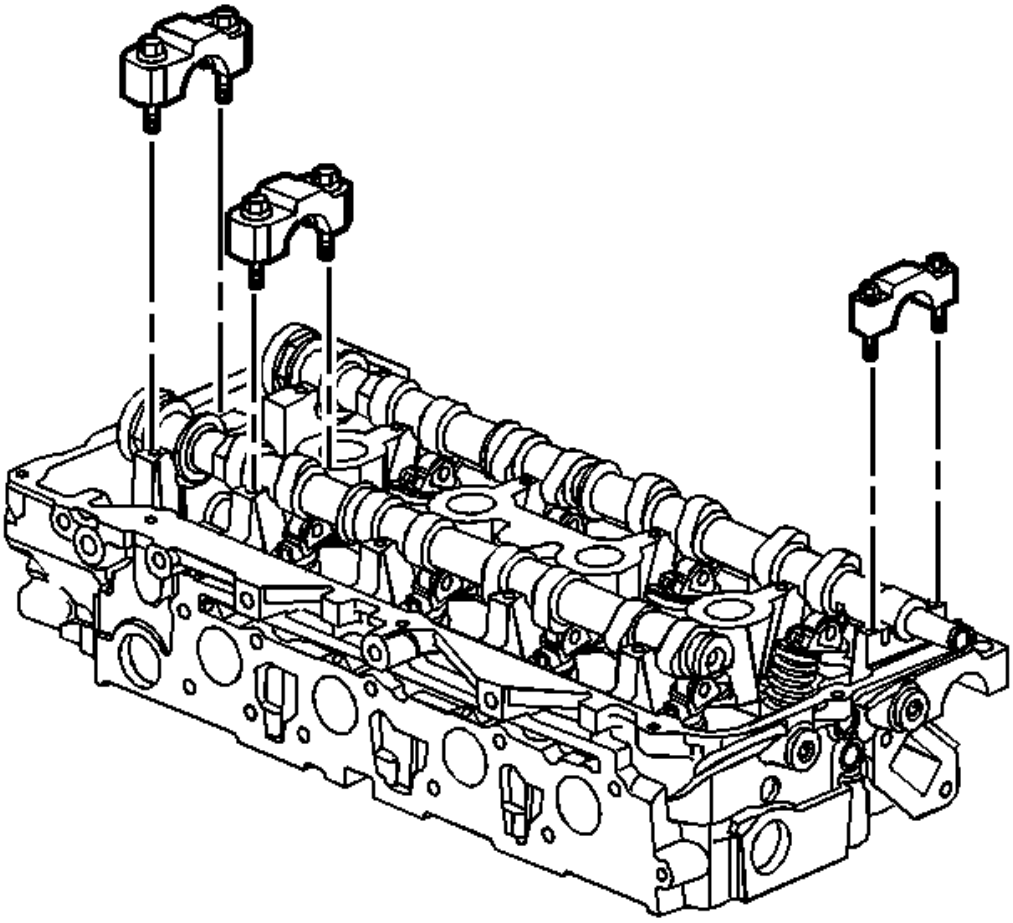

Fig. 271: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

16. Alternately loosen the camshaft bearing cap bolts a few turns at a time until all valve spring pressure has been released.
17. Remove the camshaft bearing caps.
18. Remove the **J 44212** from the camshafts. See **Special Tools** .

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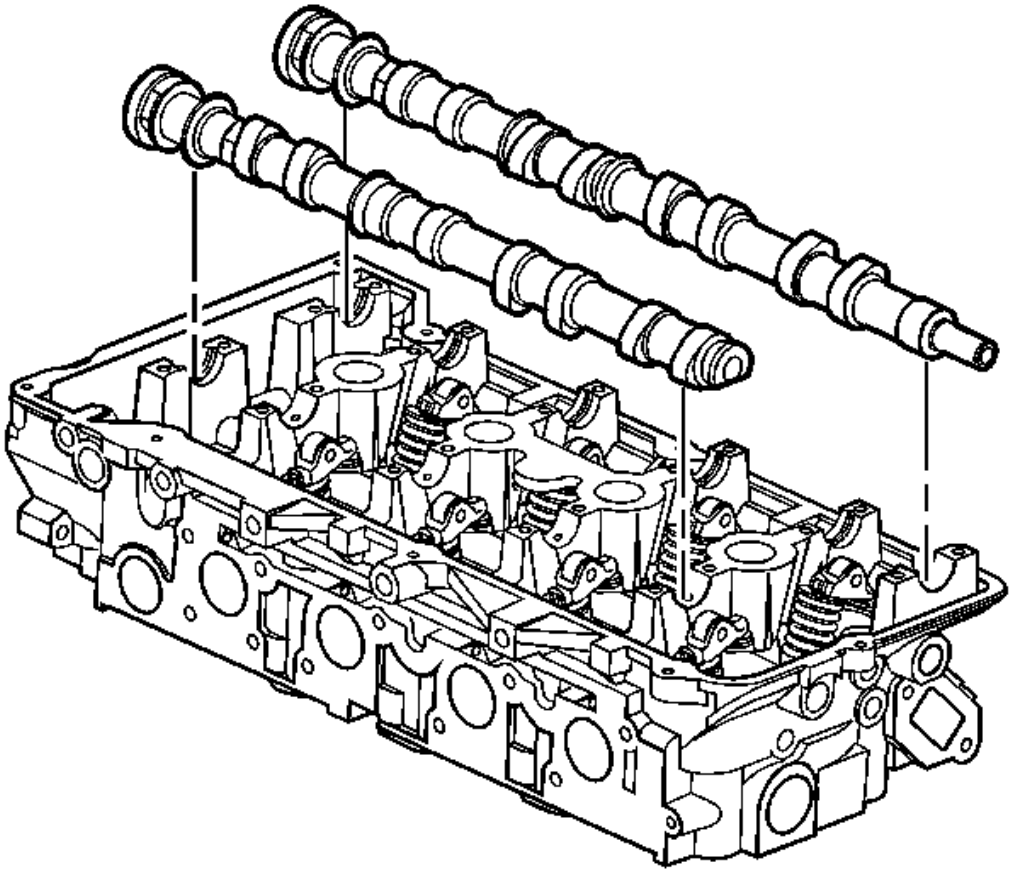

Fig. 272: Camshafts
Courtesy of GENERAL MOTORS CORP.

19. Remove the camshafts.

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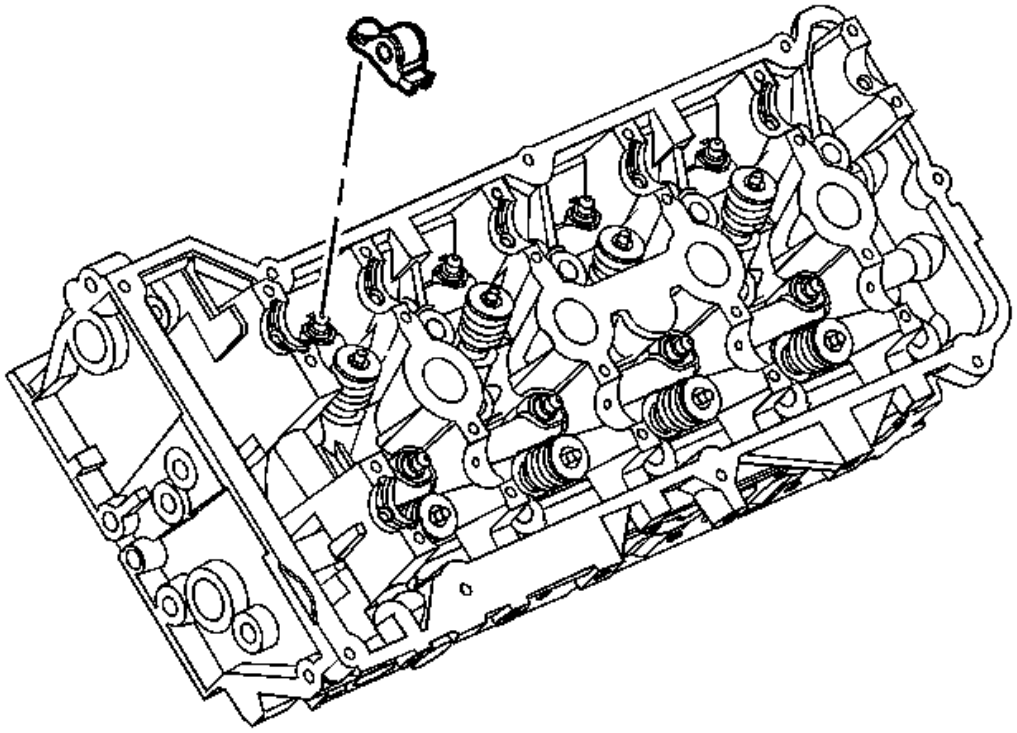

Fig. 273: Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

20. Remove the camshaft followers.
21. Clean and inspect the camshafts. Refer to **Camshaft Cleaning and Inspection** .

INSTALLATION PROCEDURE

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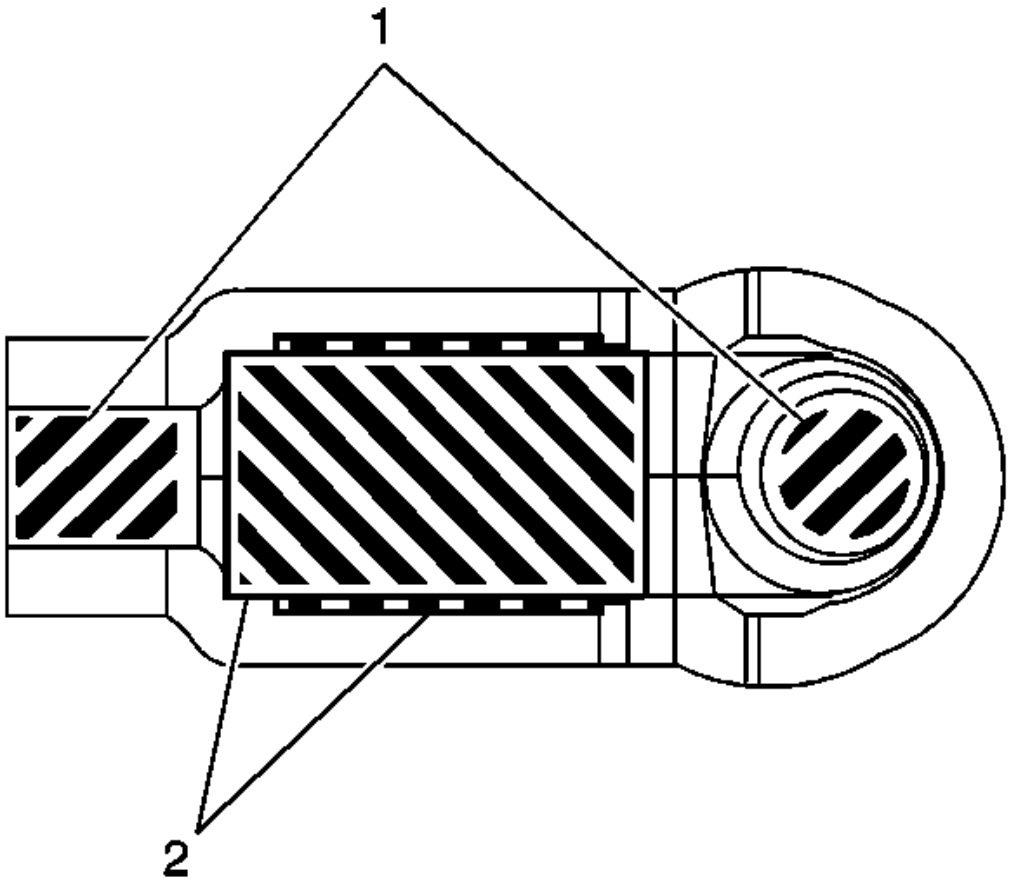

Fig. 274: Roller Pivot Pocket & Valve Slot Areas Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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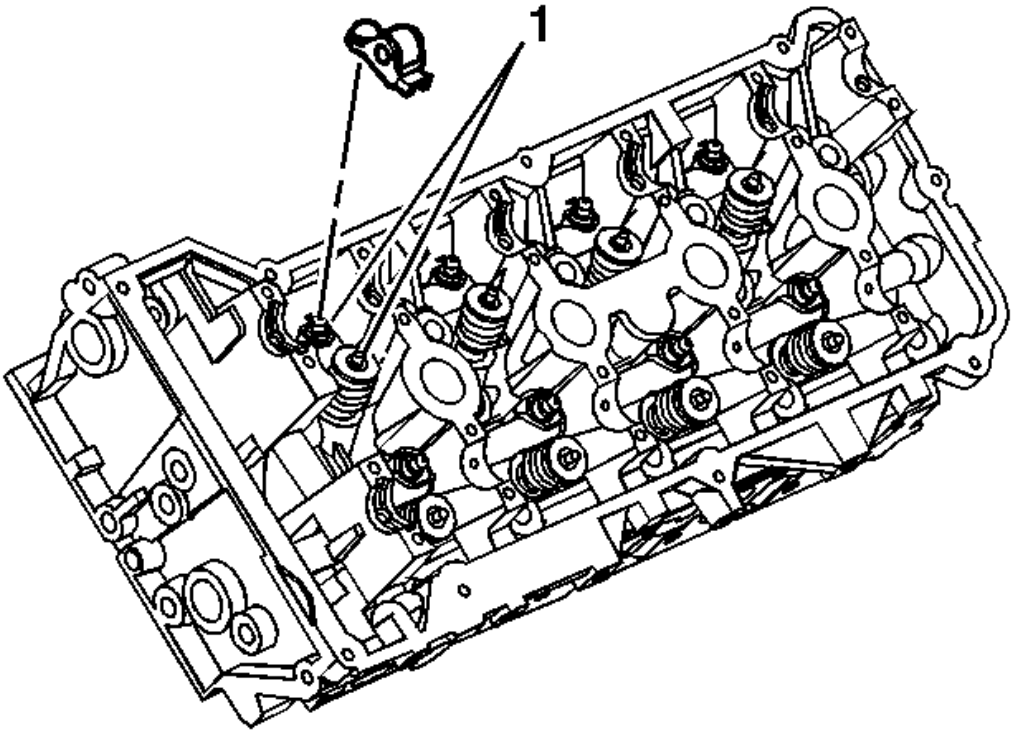

Fig. 275: Positioning Camshaft Follower
Courtesy of GENERAL MOTORS CORP.

NOTE: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and the stationary hydraulic lash adjusters (SHLA) (1). The rounded head of the follower goes on the SHLA, while the flat end goes on the valve tip.
3. Clean the camshaft carriers with a clean, lint-free cloth.

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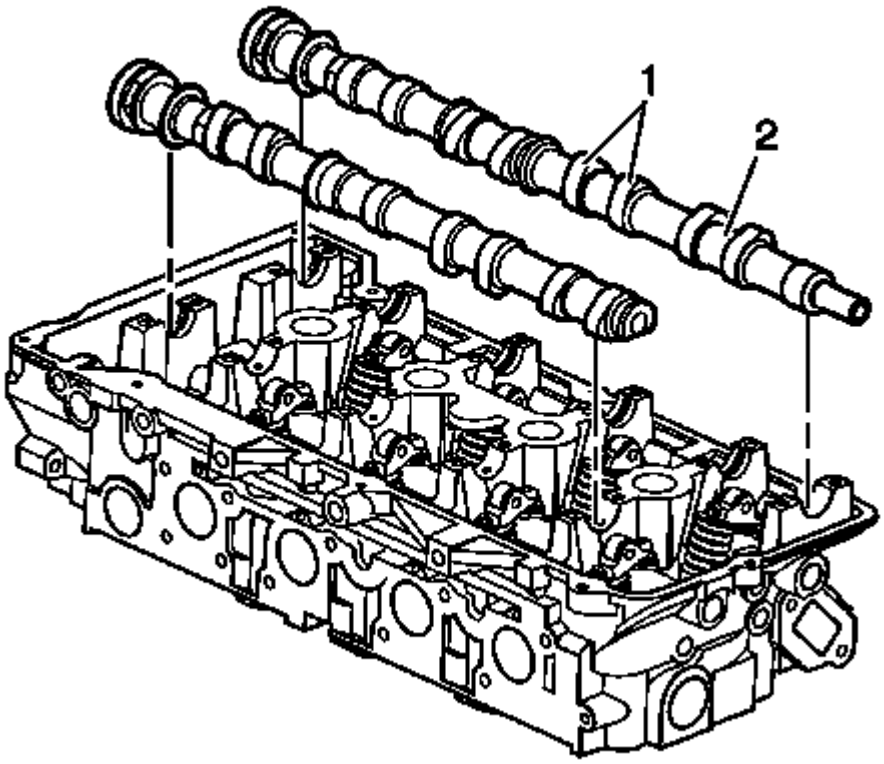

Fig. 276: Camshaft Lobes & Journals
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant to the camshaft carriers, camshaft lobes (1) and the camshaft journals (2). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
5. Place the camshaft in the camshaft carriers with the camshaft sprocket drive pins near the top of their rotation and the camshaft lobes in a neutral position. The camshafts can be identified by a stamping near the rear journal. For example: L-EXH is defined as Left bank Exhaust.

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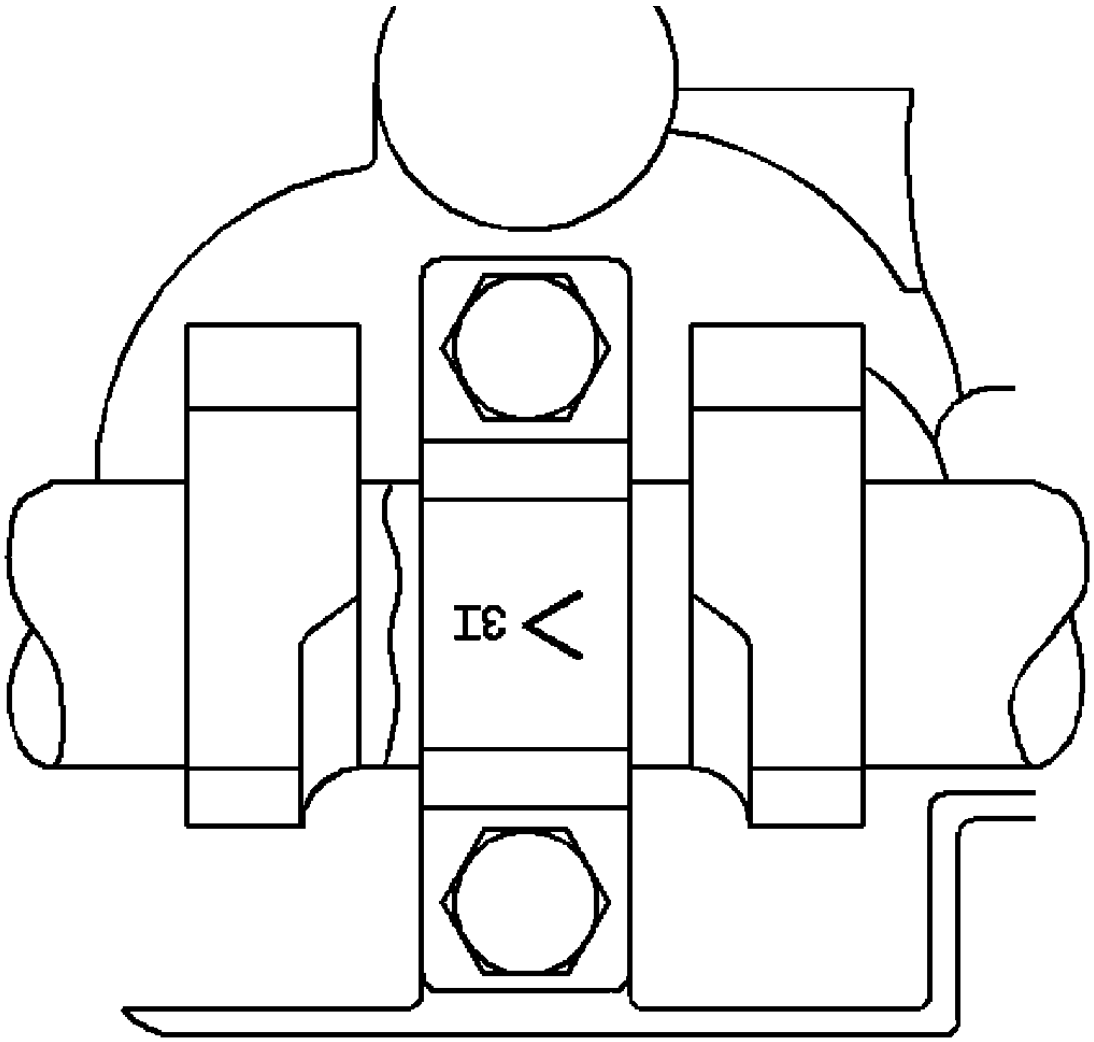

Fig. 277: Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point to the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "E" indicates the exhaust camshaft.
   - The "I" indicates the Intake camshaft.
7. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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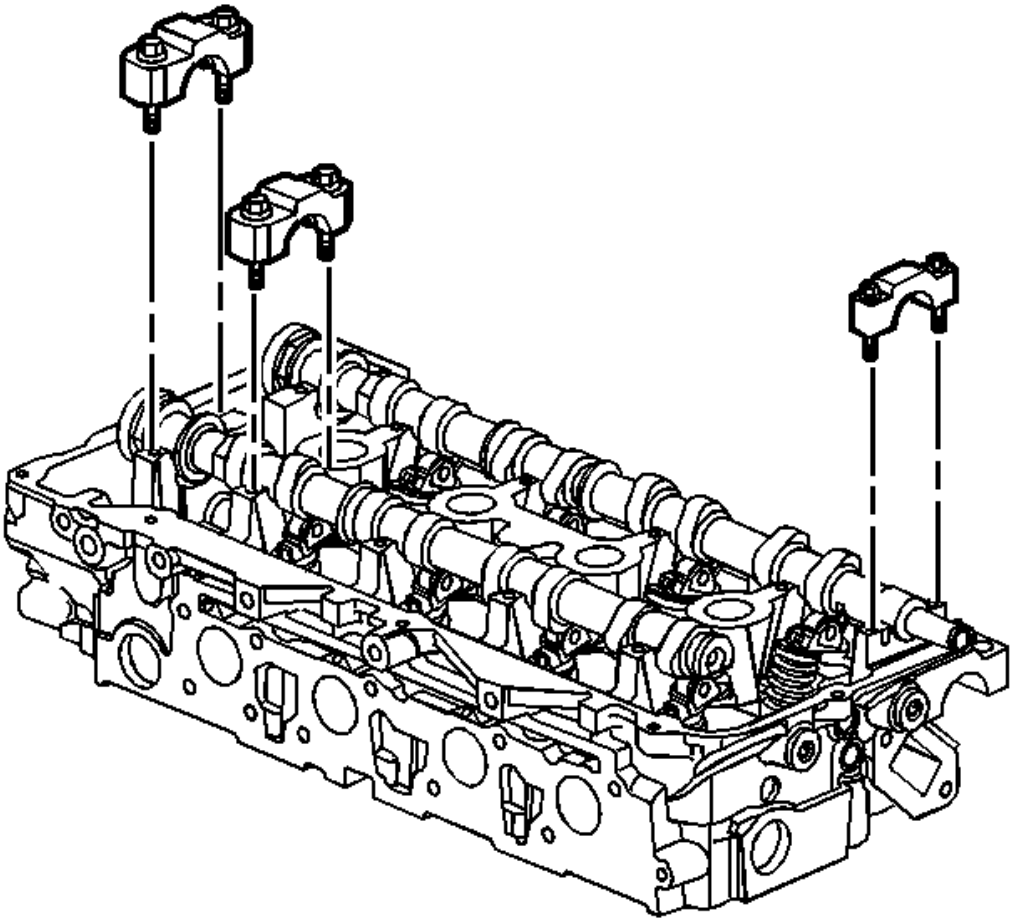

Fig. 278: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft bearing caps according to the identification marks.

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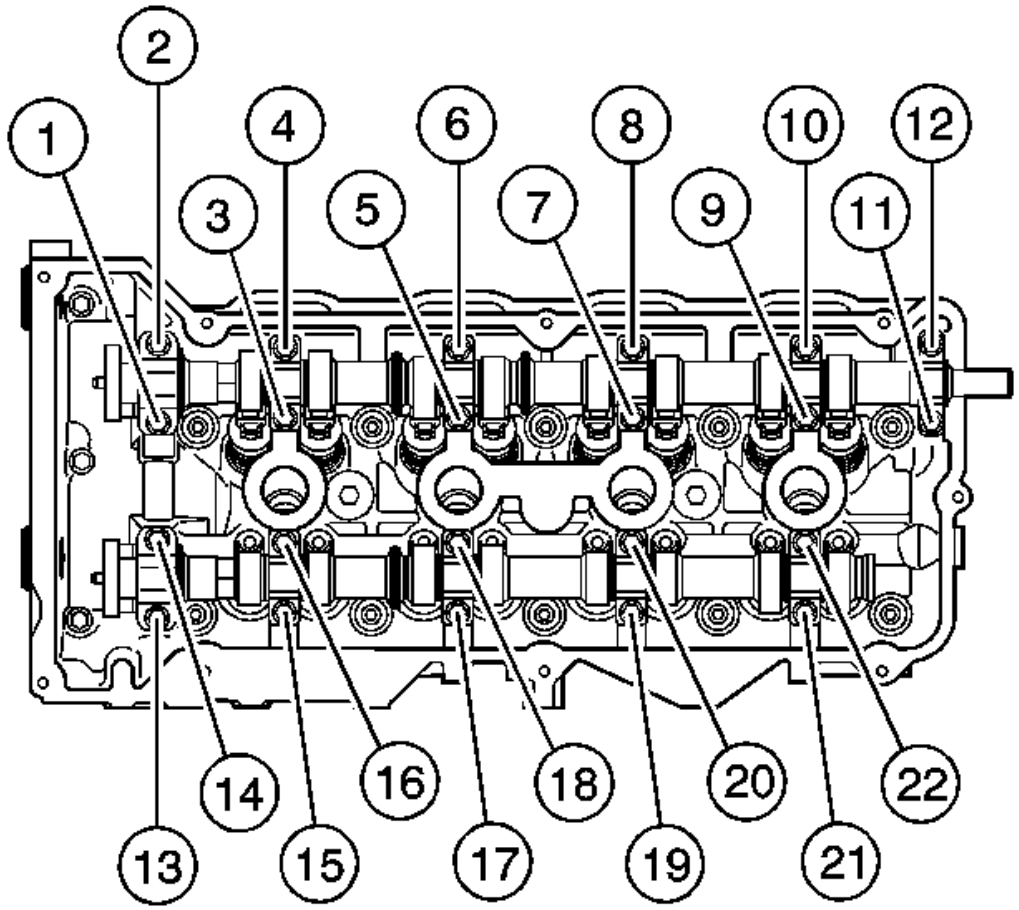

Fig. 279: Camshaft Bearing Cap Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

9. Install the camshaft bearing cap bolts in sequence.

Tighten:

1. Alternately hand tighten the camshaft bearing cap bolts a few turns at a time until all caps are fully seated.
2. Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).
3. Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059**

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CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

10. Align the camshafts.

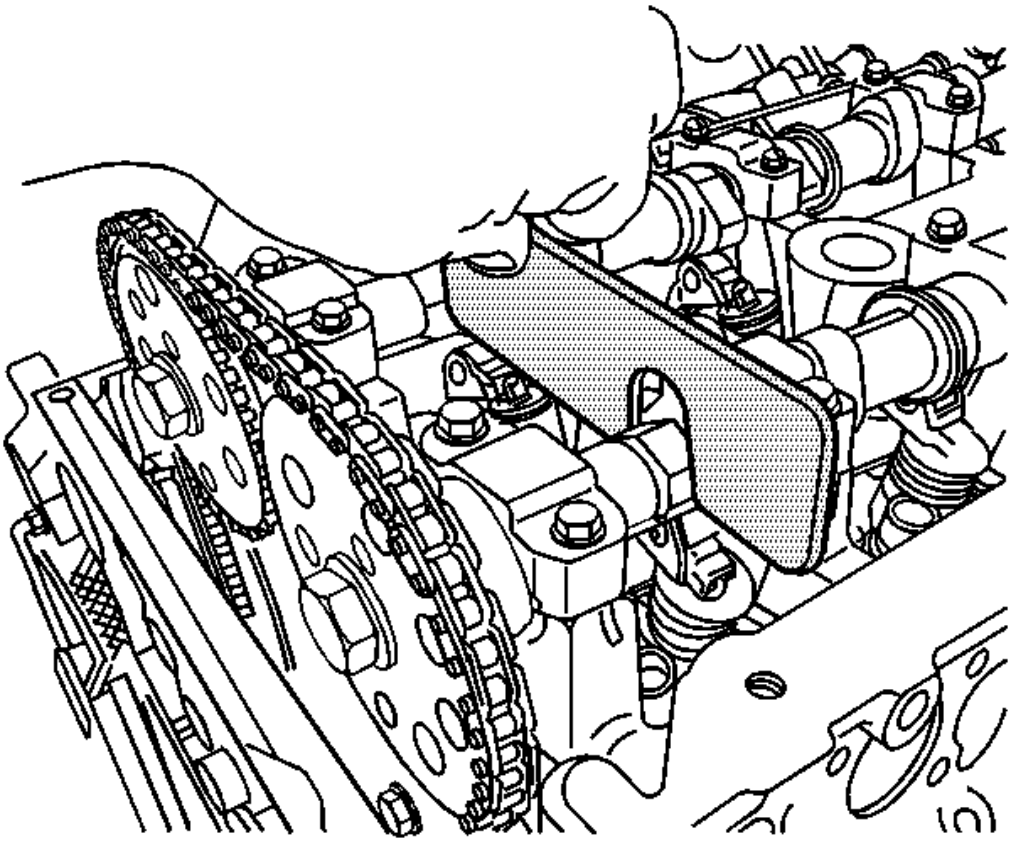

Fig. 280: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning ..

11. Install the **J 44212** over the camshafts. See **Special Tools** .

NOTE: Ensure the camshaft sprockets properly engage the camshaft sprocket drive pins and camshafts.

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12. Install the intake and exhaust camshaft sprockets aligning the paint marks made during disassembly. Ensure that the camshaft sprockets align with the pins of the camshafts.

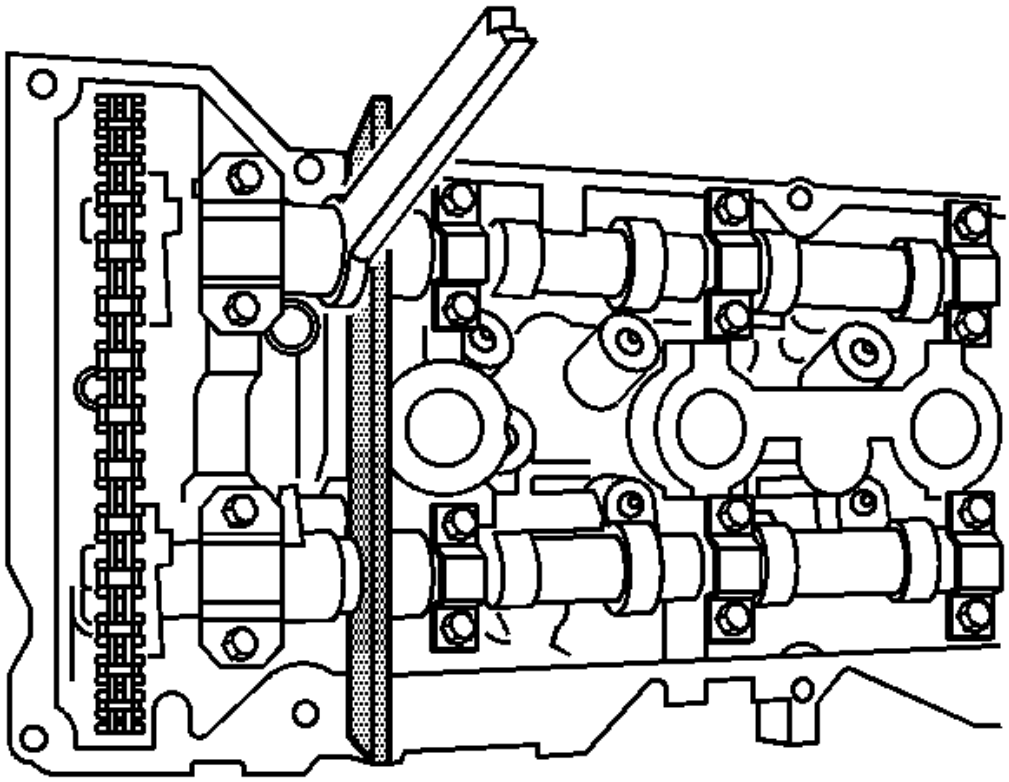

Fig. 281: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

13. Use an open wrench on the hex cast into the camshafts in order to prevent the camshafts from rotating when tightening the camshaft sprocket bolts.

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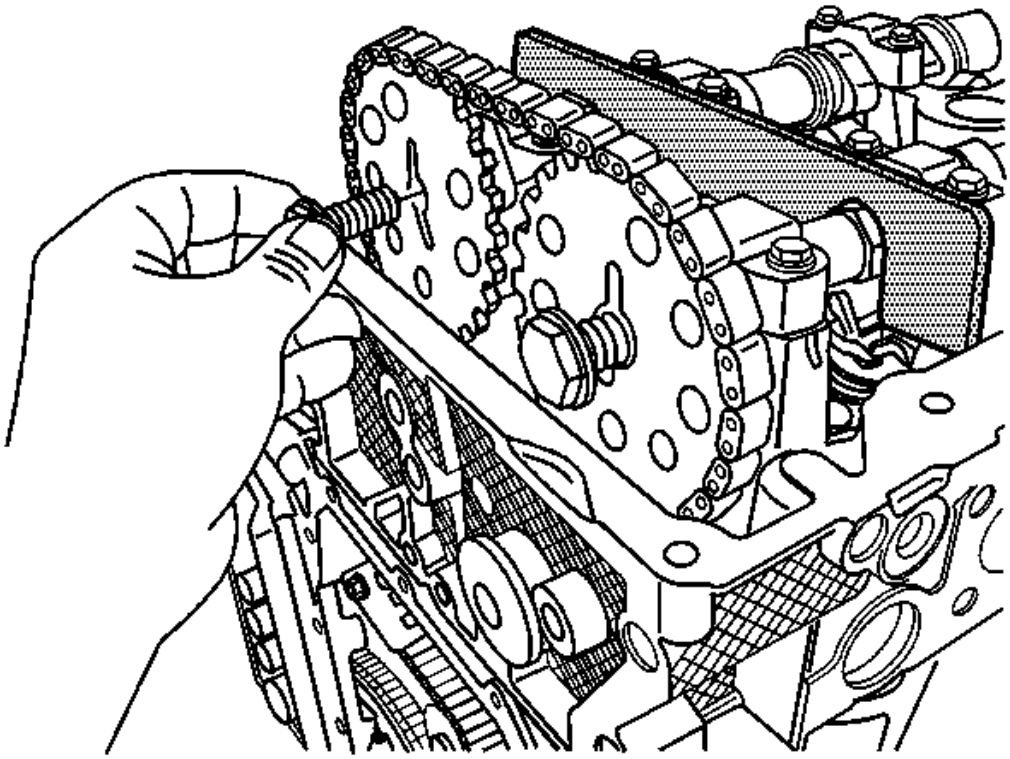

Fig. 282: Left Intake Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the camshaft sprocket bolts.

    Tighten: Tighten the camshaft sprocket bolts to 120 N.m (89 lb ft).

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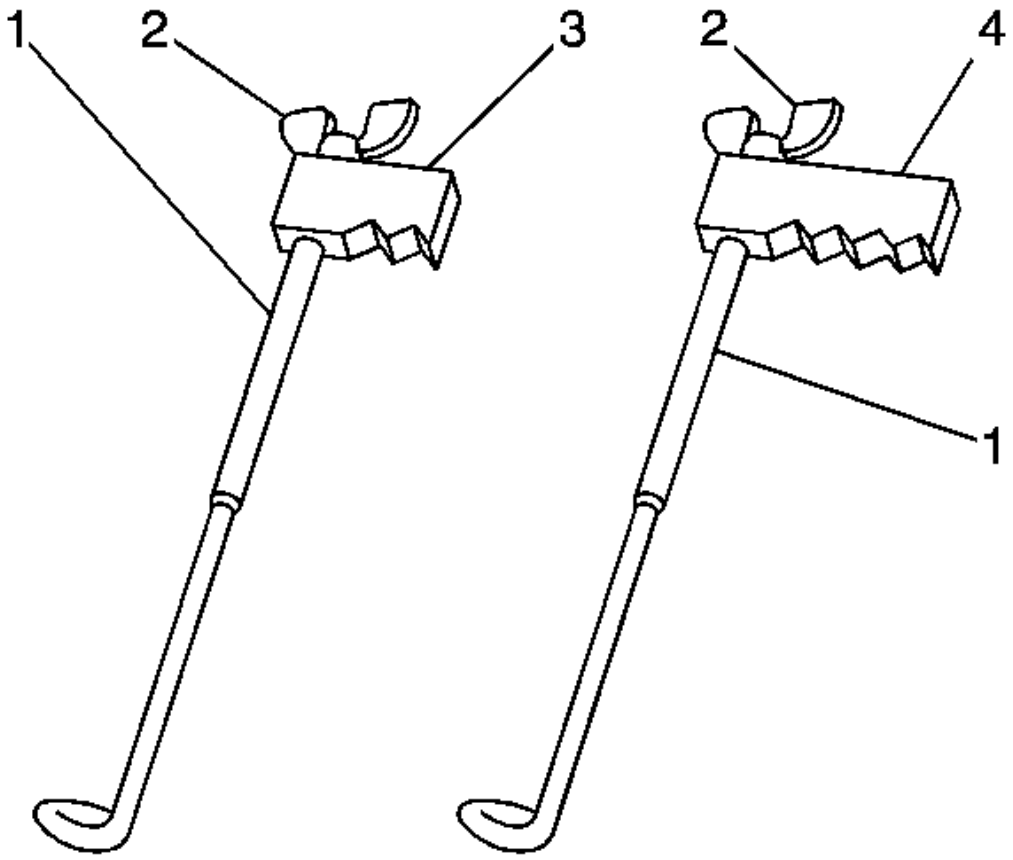

Fig. 283: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

15. Remove the **EN 46327** (1). See **Special Tools** .

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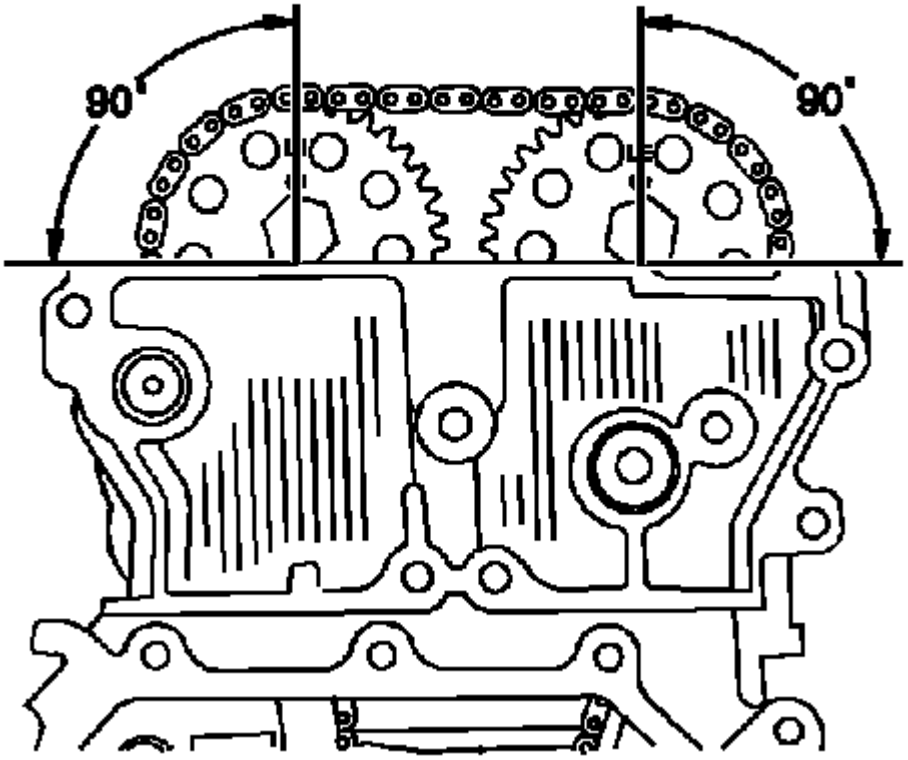

Fig. 284: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

16. Verify the camshaft sprocket alignment.

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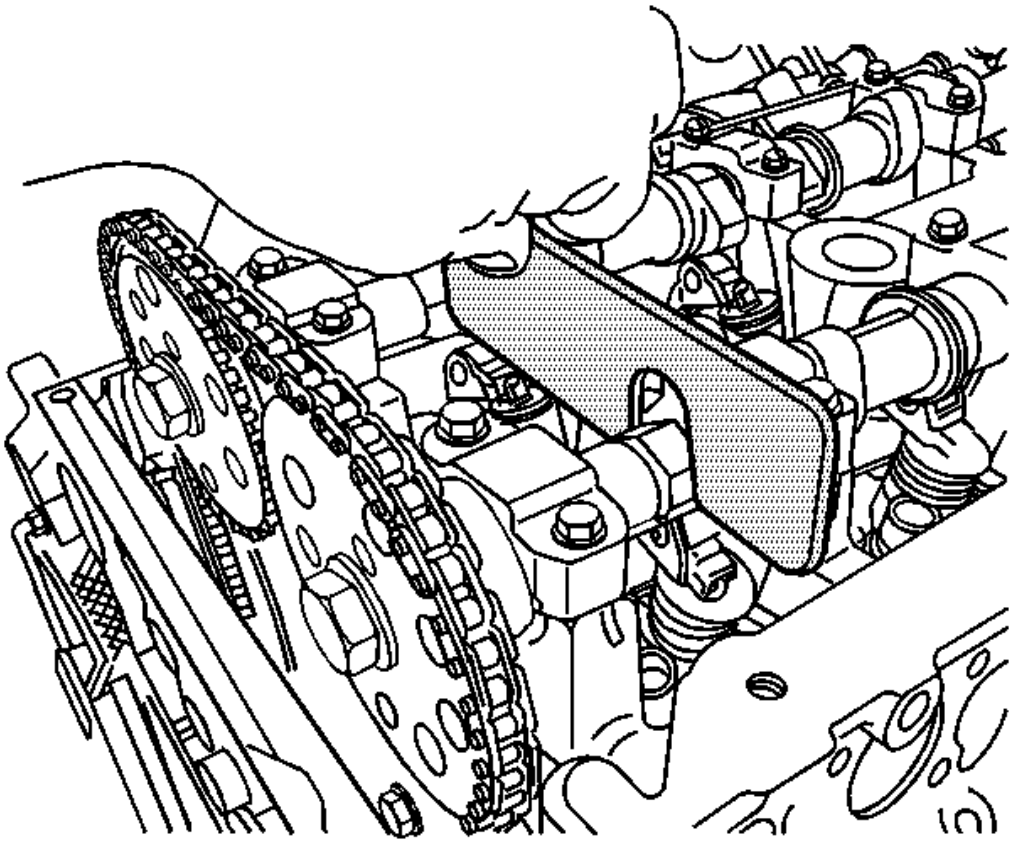

Fig. 285: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

17. Remove the **J 44212** from the camshafts. See **Special Tools** .
18. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.

CAMSHAFT REPLACEMENT - RIGHT SIDE

Special Tools

- **EN 46327** Timing Chain Retention Tool. See **Special Tools** .
- **J 45059** Angle Meter
- **J 44212** Camshaft Holding Tool. See **Special Tools** .

REMOVAL PROCEDURE

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1. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
2. Remove the camshaft position sensor. Refer to **Camshaft Position Sensor Replacement** .

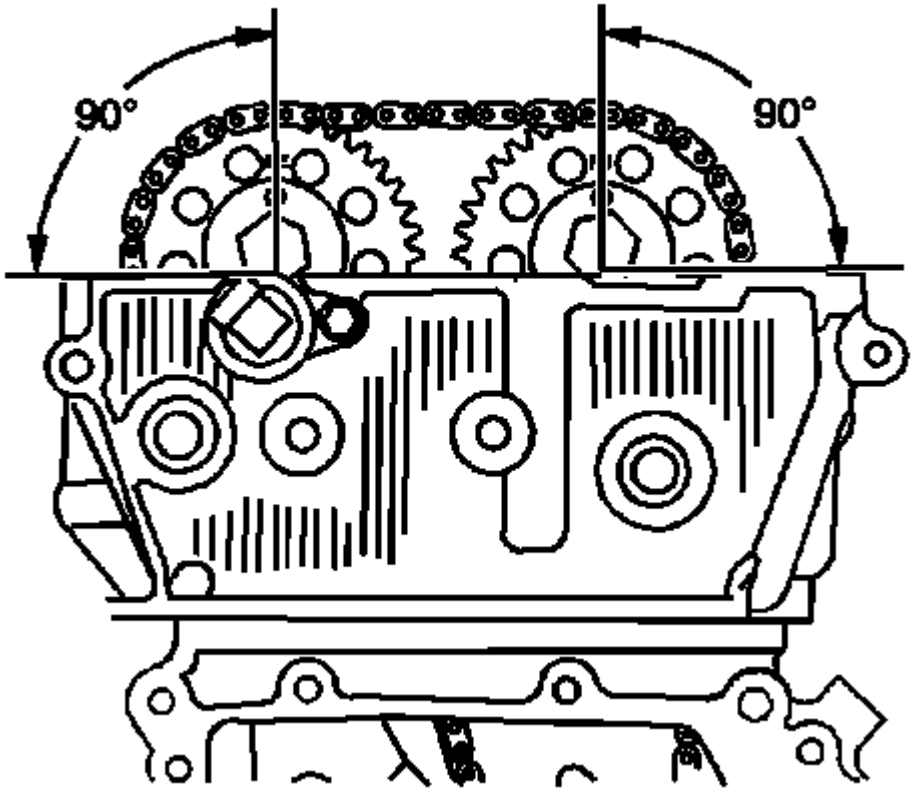

Fig. 286: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft to TDC of the # 1 cylinders compression stroke, both camshaft sprocket drive pins should be at the top of their rotation.

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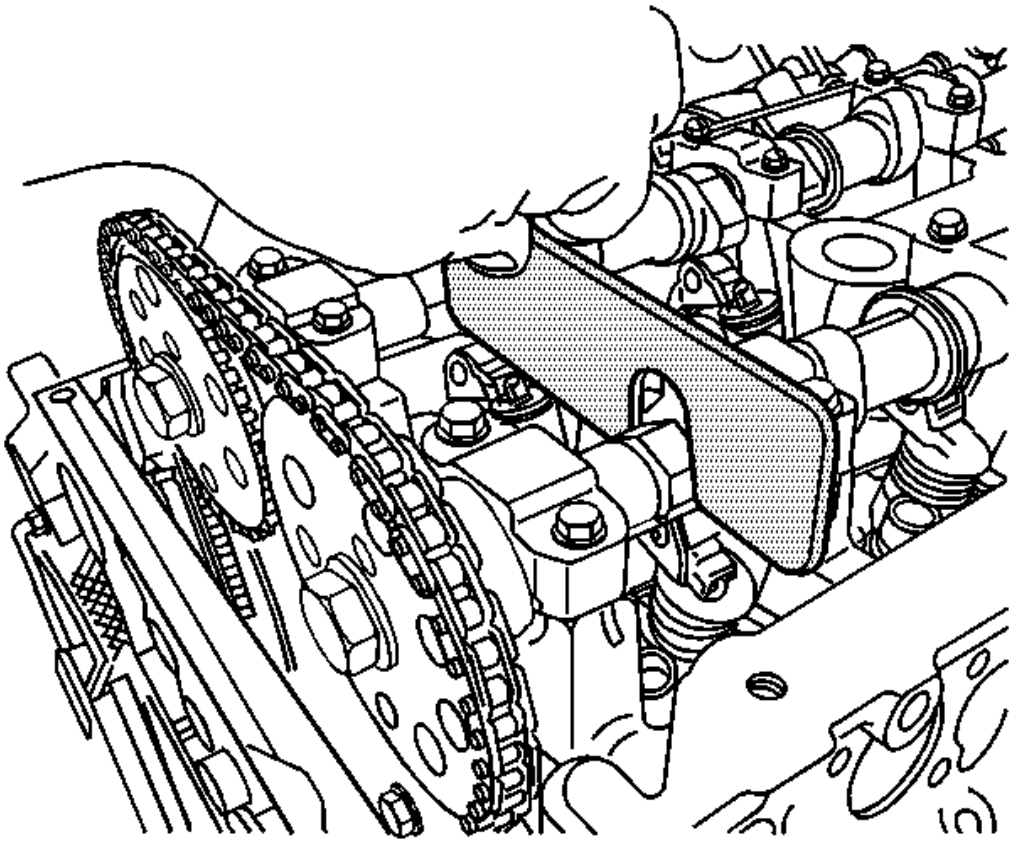

Fig. 287: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

4. Install the **J 44212** over the camshafts. See **Special Tools** .

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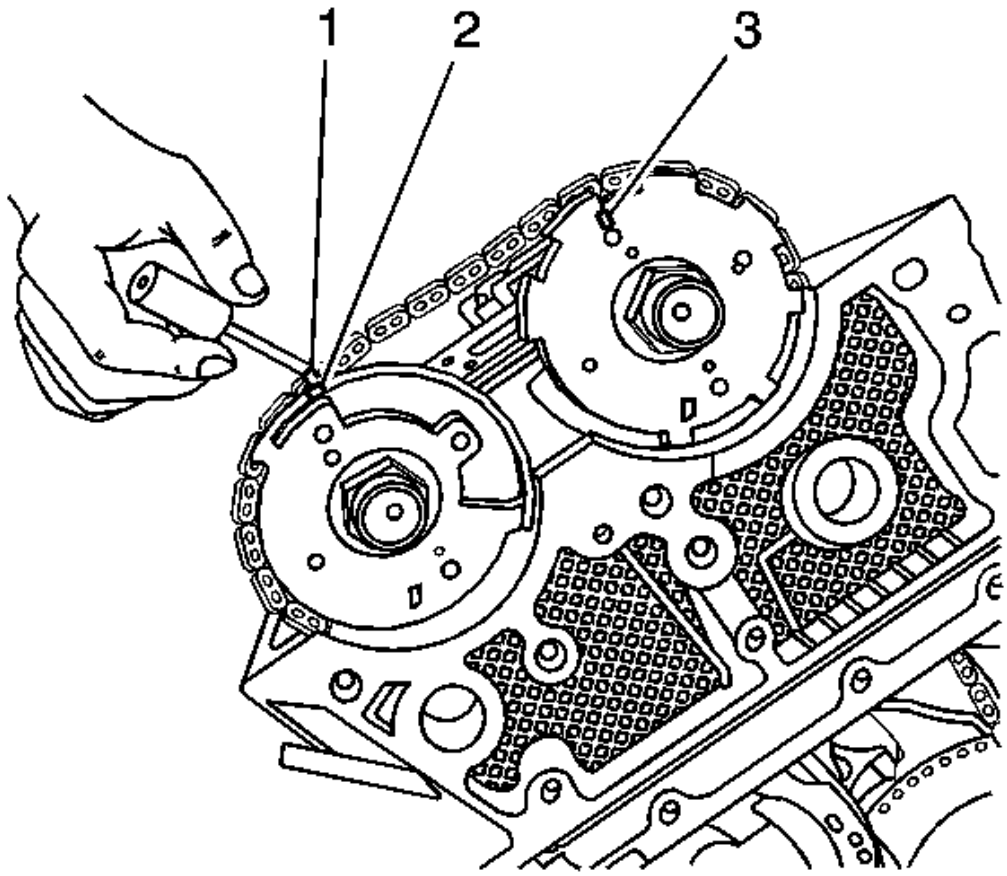

Fig. 288: Marking Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft sprocket timing mark (2, 3).

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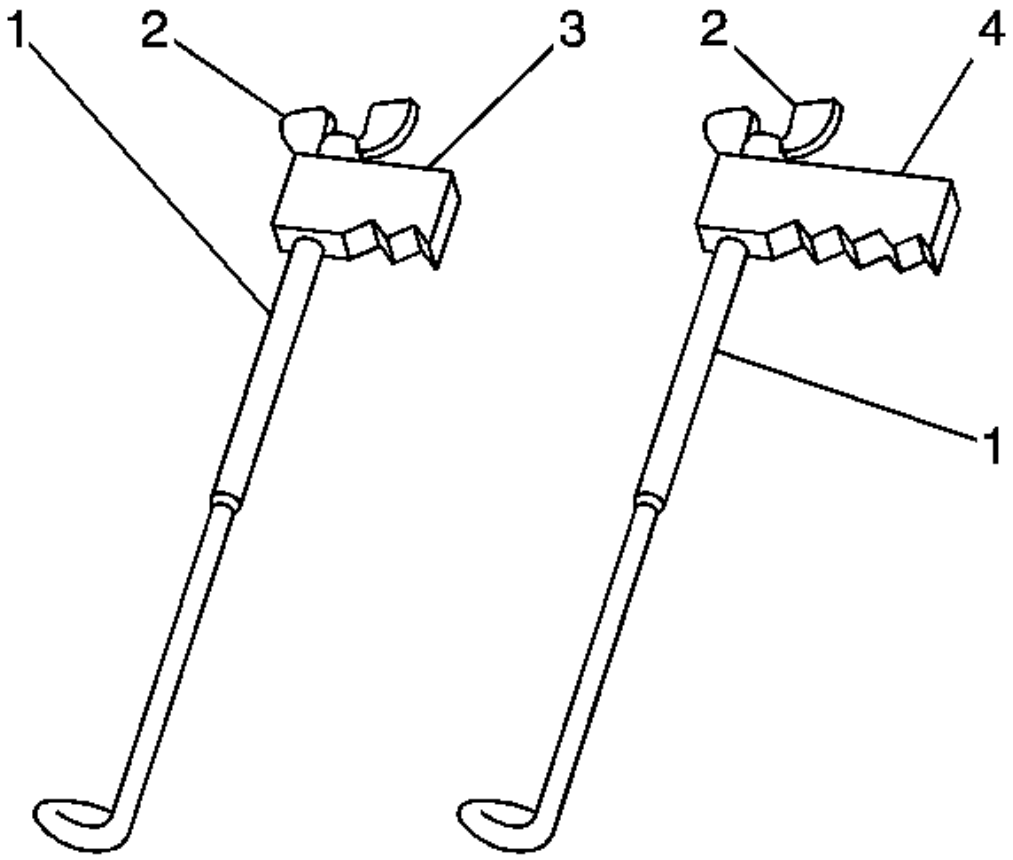

Fig. 289: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install both **EN 46327** (1) to the engine using the following step: See **Special Tools** .

   Rotate the wing nut (2) of the **EN 46327** (3) to the top of its travel. See **Special Tools** .

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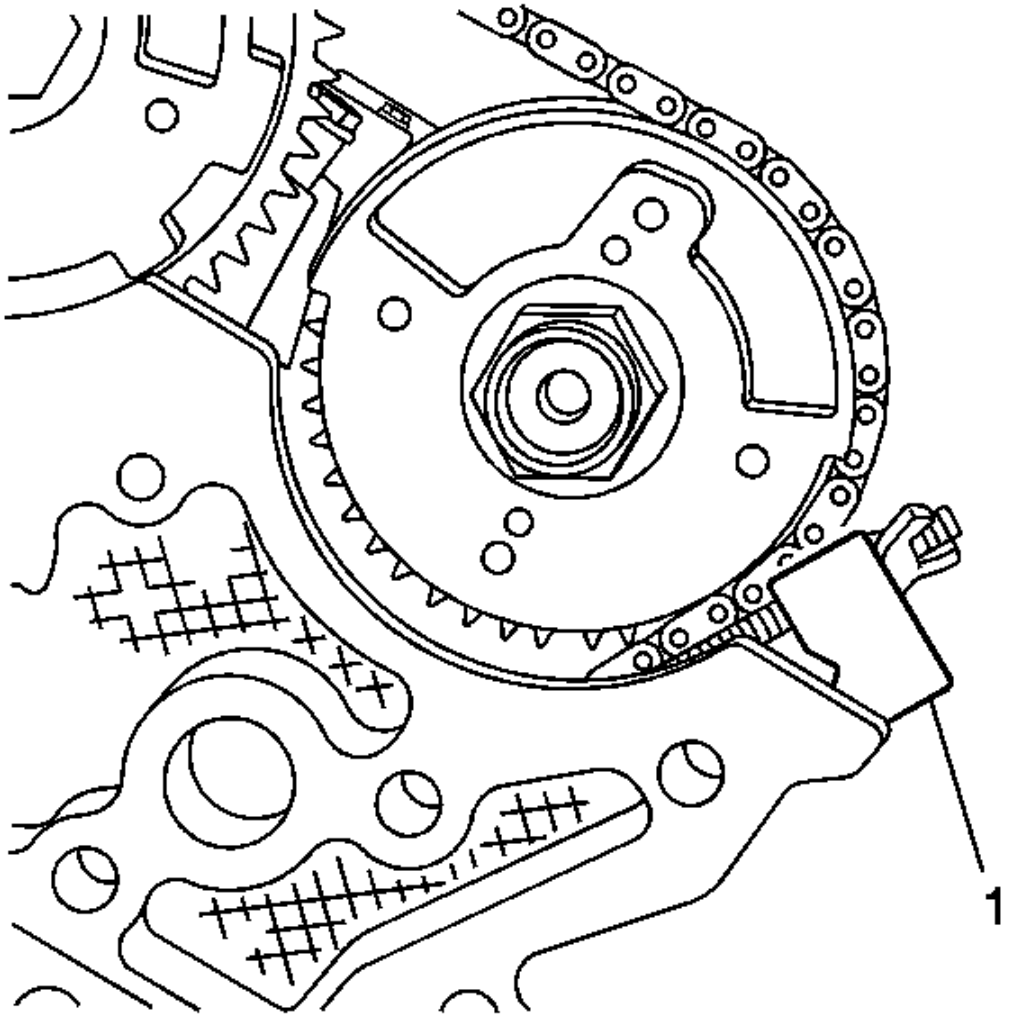

Fig. 290: Positioning Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Position the bottom retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right exhaust camshaft sprocket and chain.

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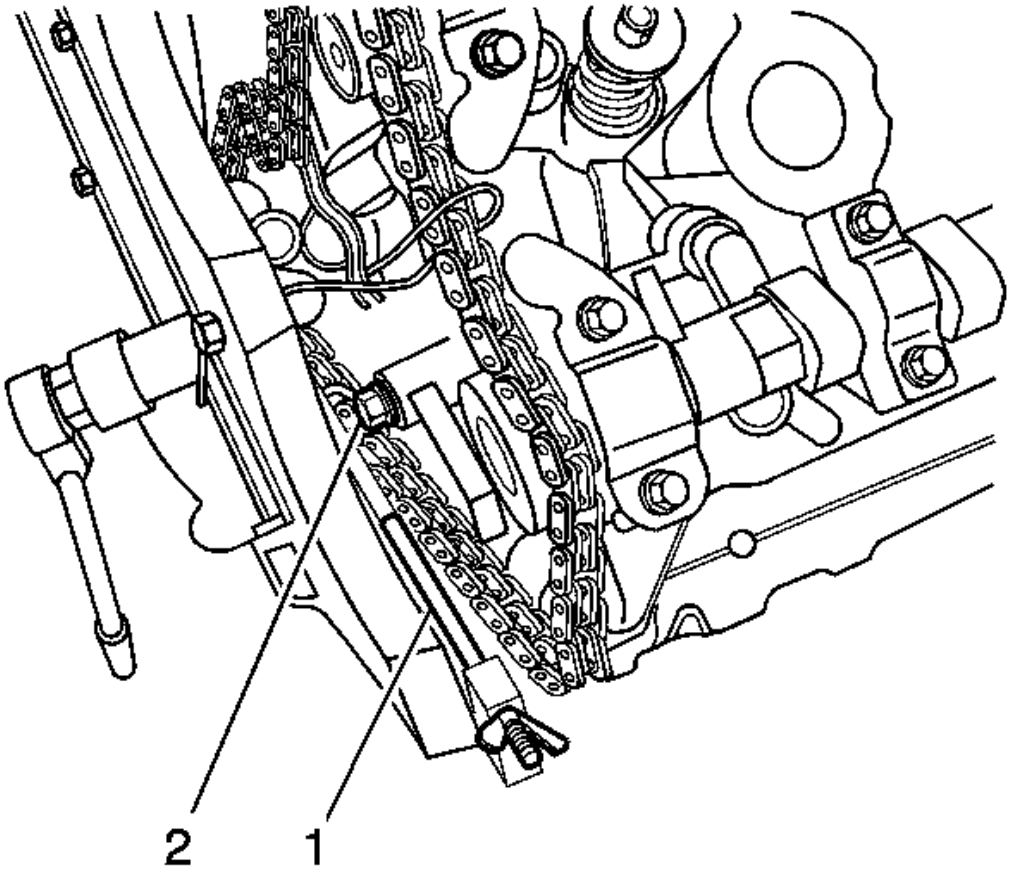

Fig. 291: Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

8. Insert the hook end (2) into a secondary timing chain link as shown.

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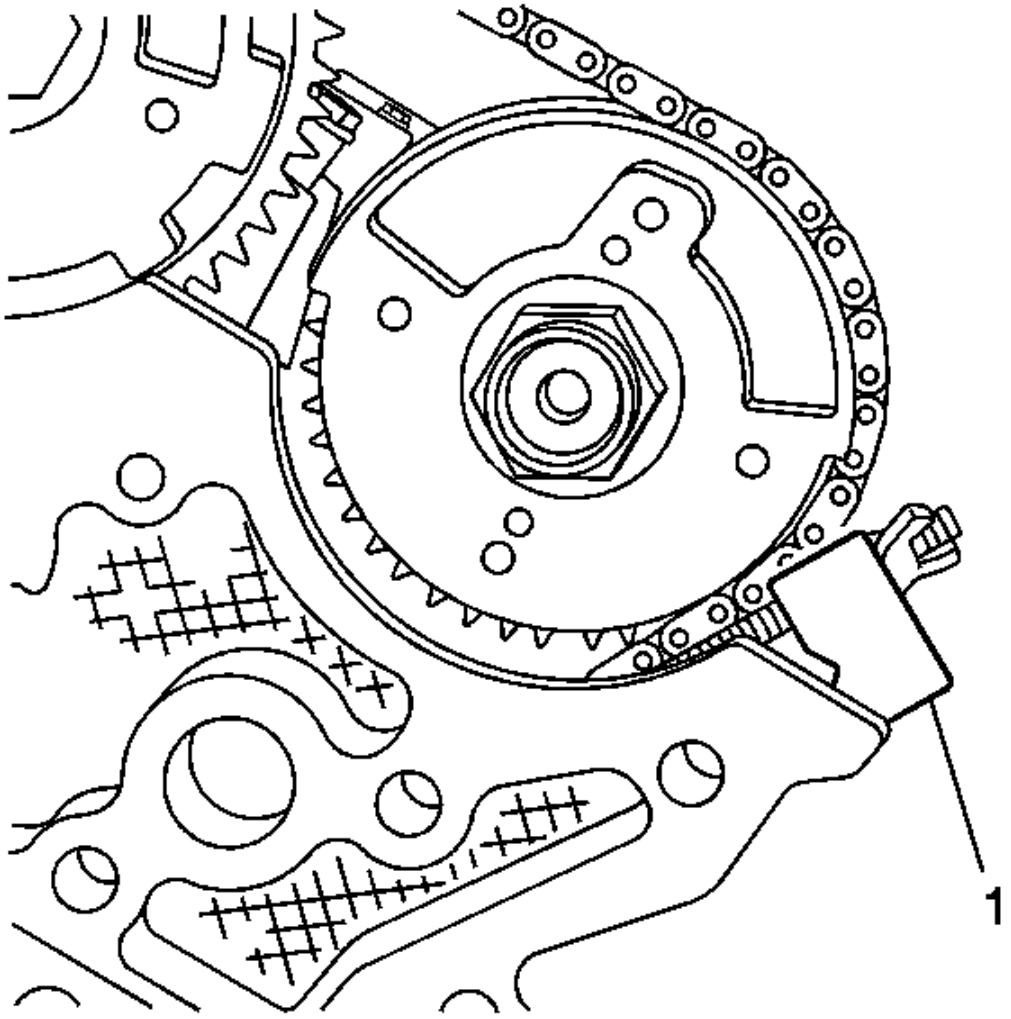

Fig. 292: Positioning Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

9. Rotate the wing nut until it contacts the retention tool block (1). DO NOT tighten the wing nut at this time.

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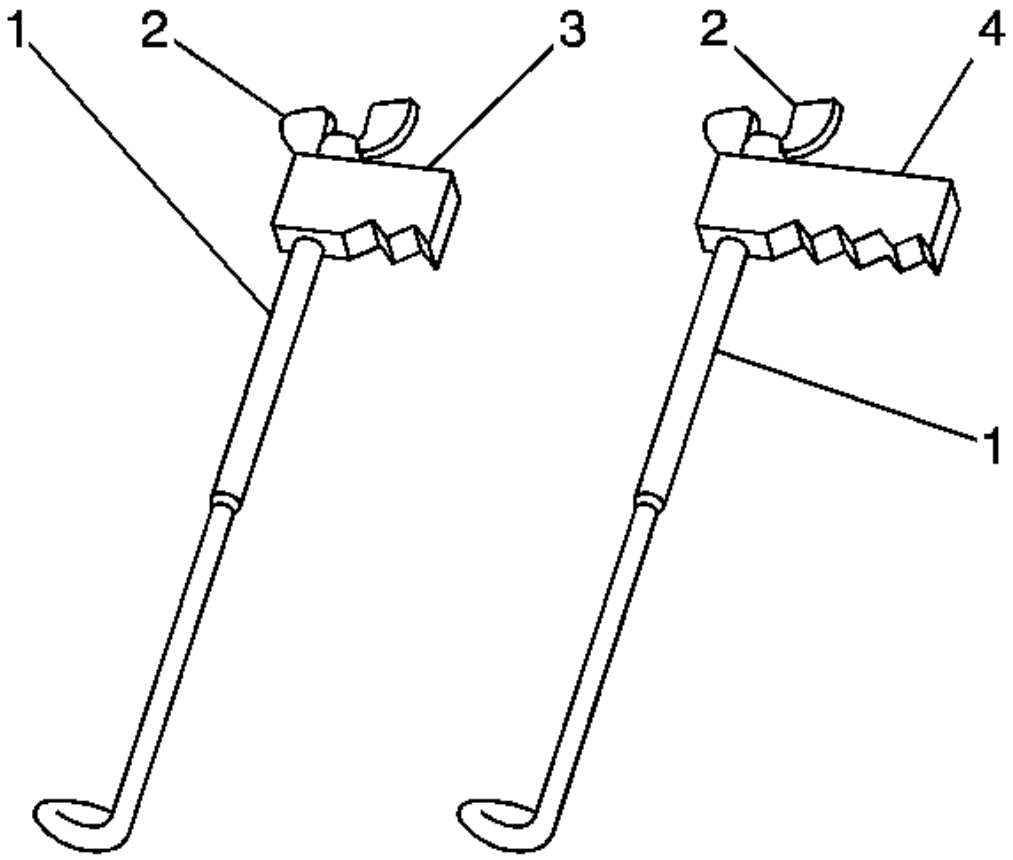

Fig. 293: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

10. Rotate the wing nut (2) of the **EN 46327** (4) to the top of its travel. See **Special Tools** .

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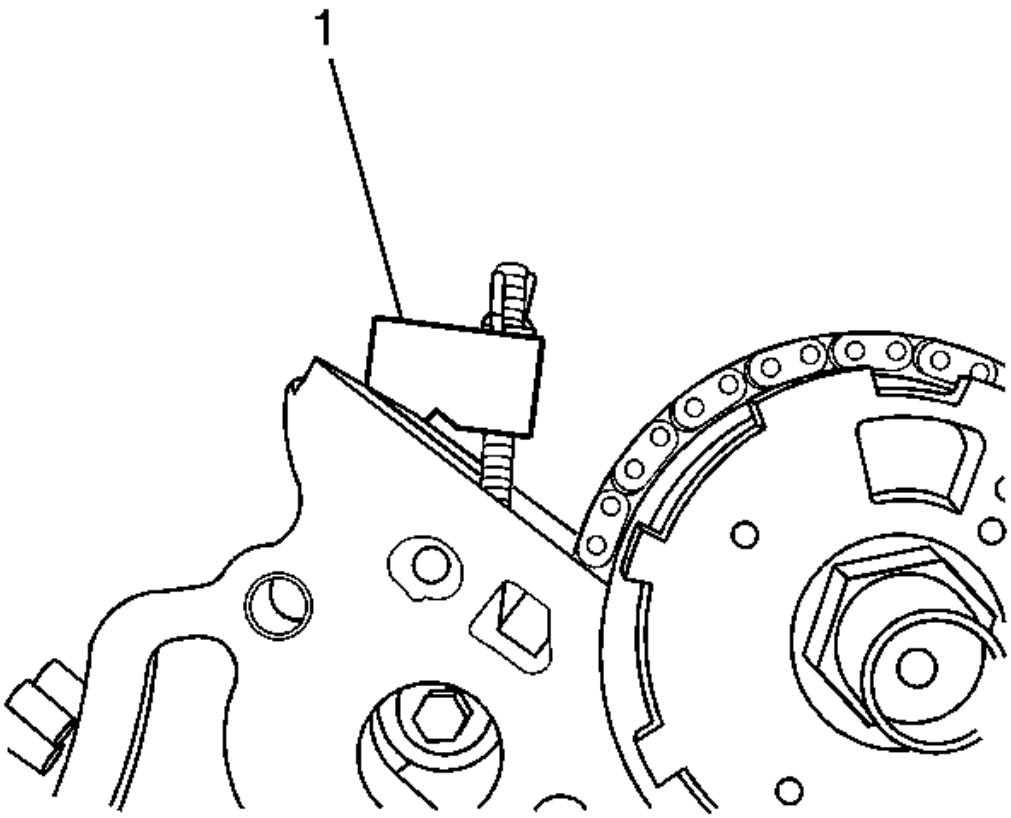

Fig. 294: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

11. Position the top retention tool on the cylinder head with the V-notch of the block (1) adjacent to the right intake camshaft sprocket and chain.

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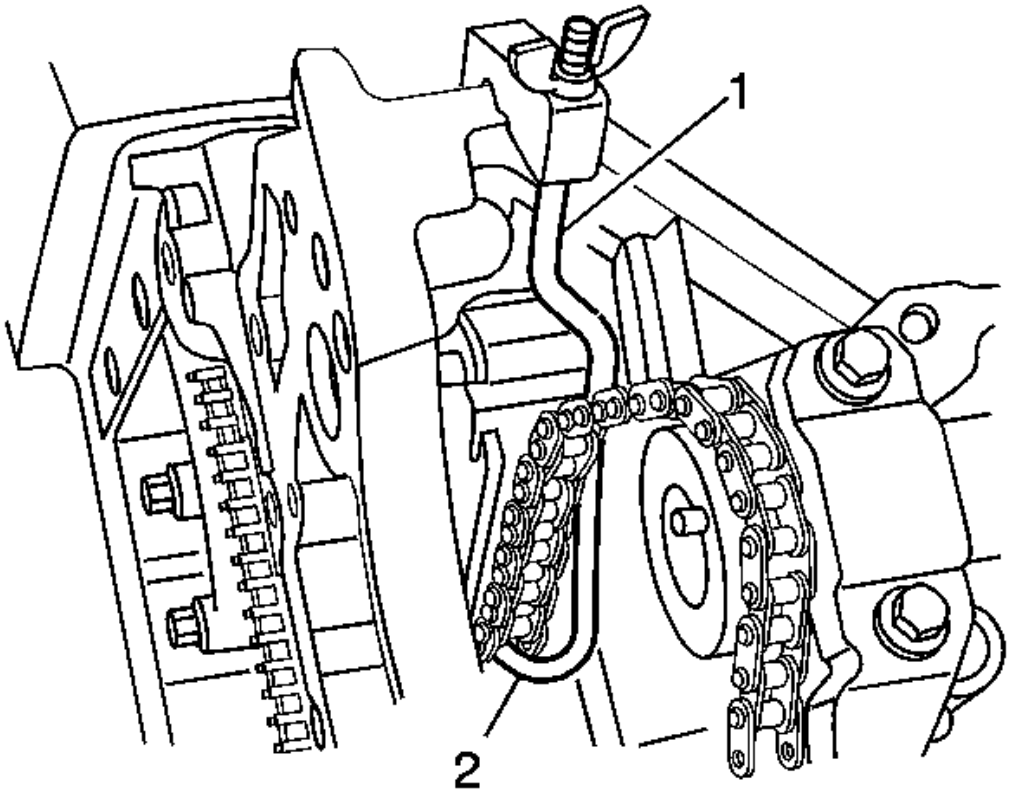

Fig. 295: Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

12. Insert the hook end (2) into a secondary timing chain link as shown.

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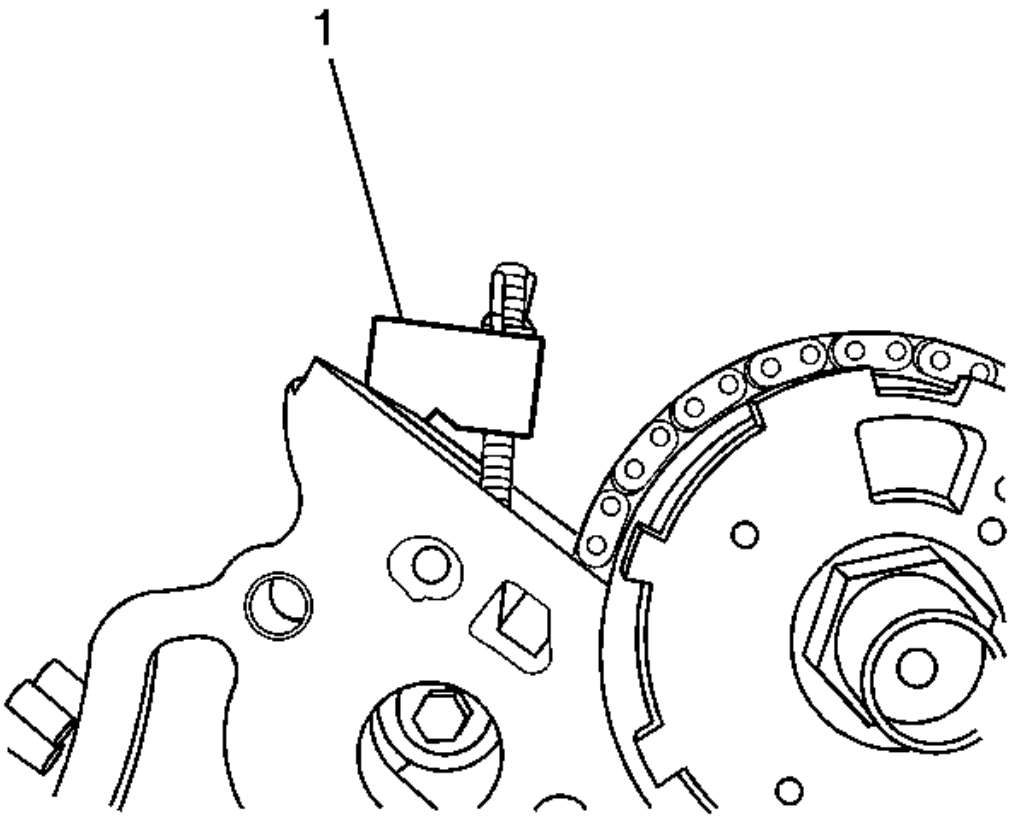

Fig. 296: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

13. Rotate the wing nut until it contacts the retention tool block (1). Alternately tighten both wing nuts to retain the chain.

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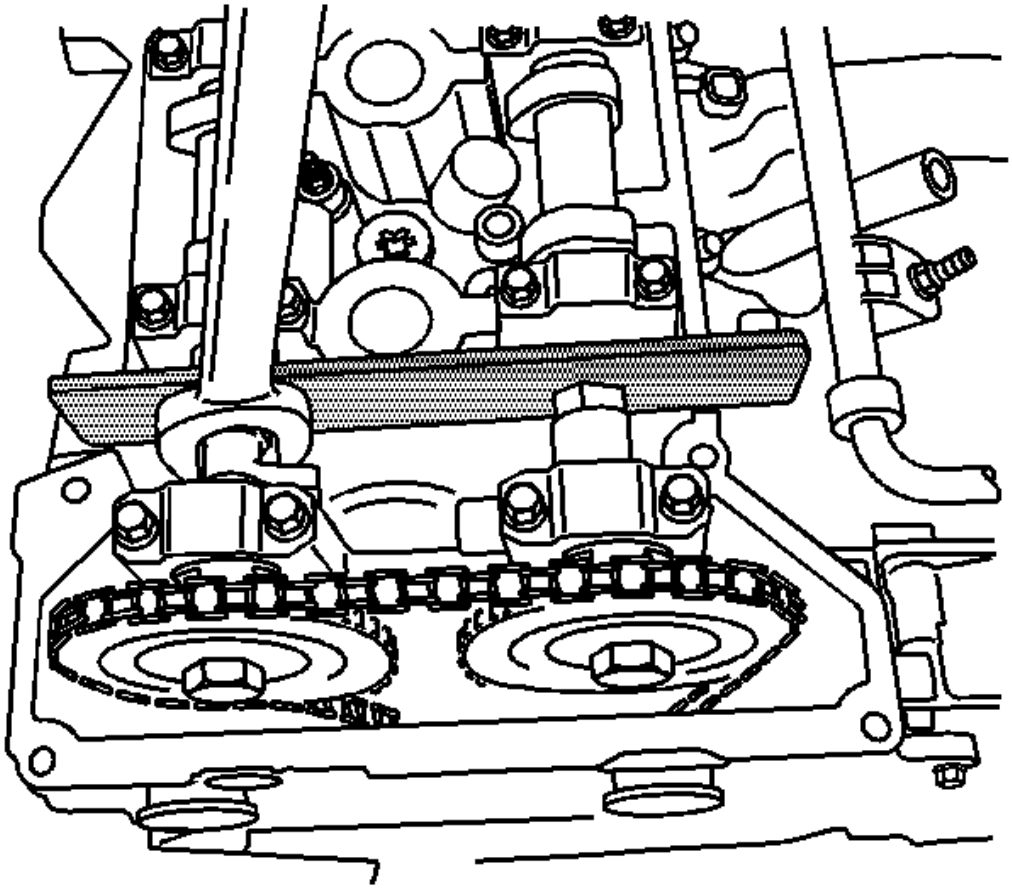

Fig. 297: Preventing Camshaft From Rotating
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

14. Use an open wrench on the hex cast into the camshafts in order to prevent the camshafts from rotating when removing the camshaft sprocket bolts.

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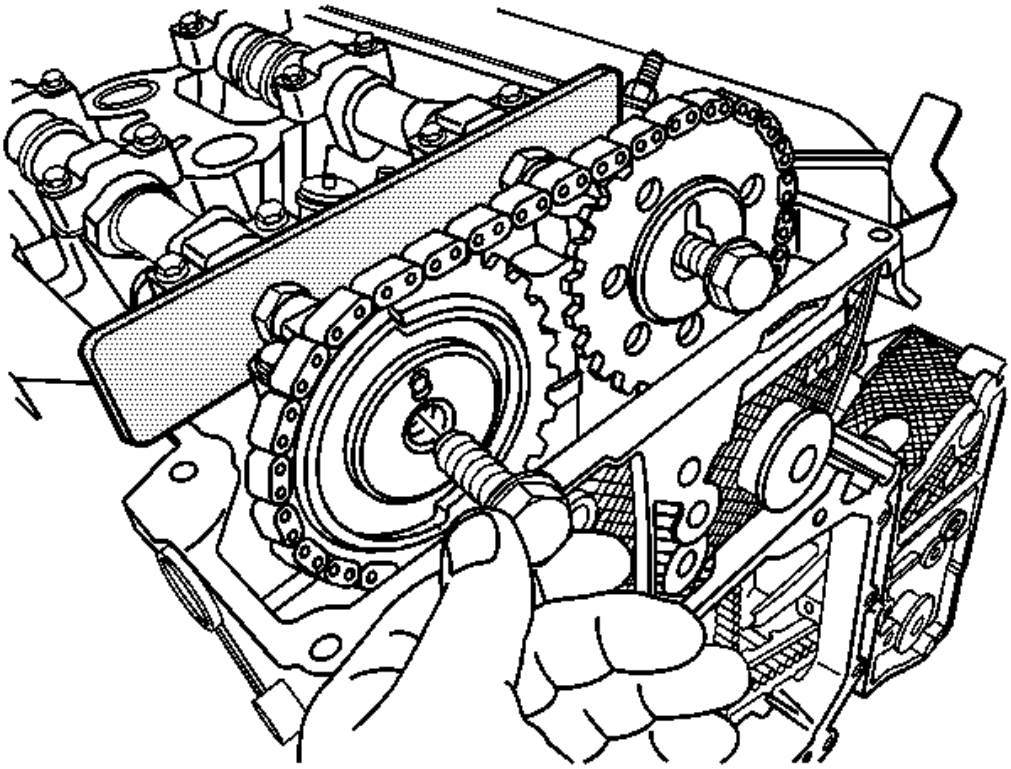

Fig. 298: Right Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

15. Remove the camshaft sprocket bolts.
16. Remove the camshaft sprockets.

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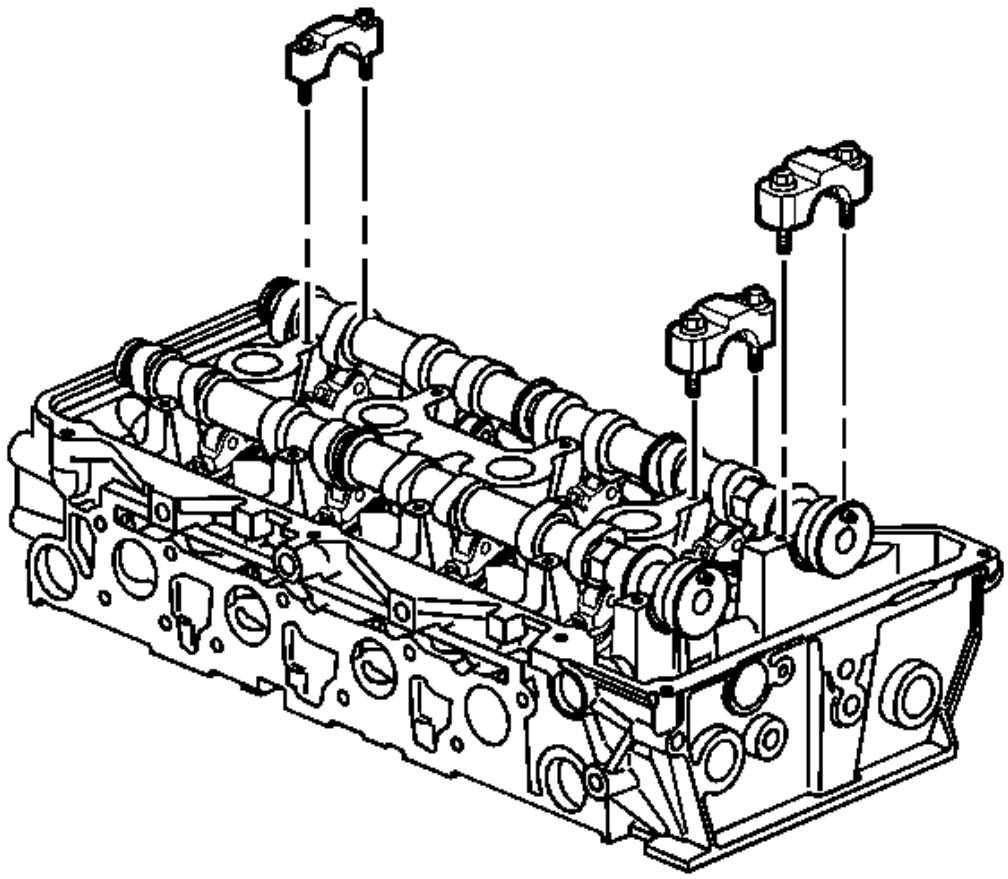

Fig. 299: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

17. Alternately loosen the camshaft bearing cap bolts a few turns at a time until all valve spring pressure has been released.
18. Remove the camshaft bearing caps.
19. Remove the **J 44212** from the camshafts. See **Special Tools** .

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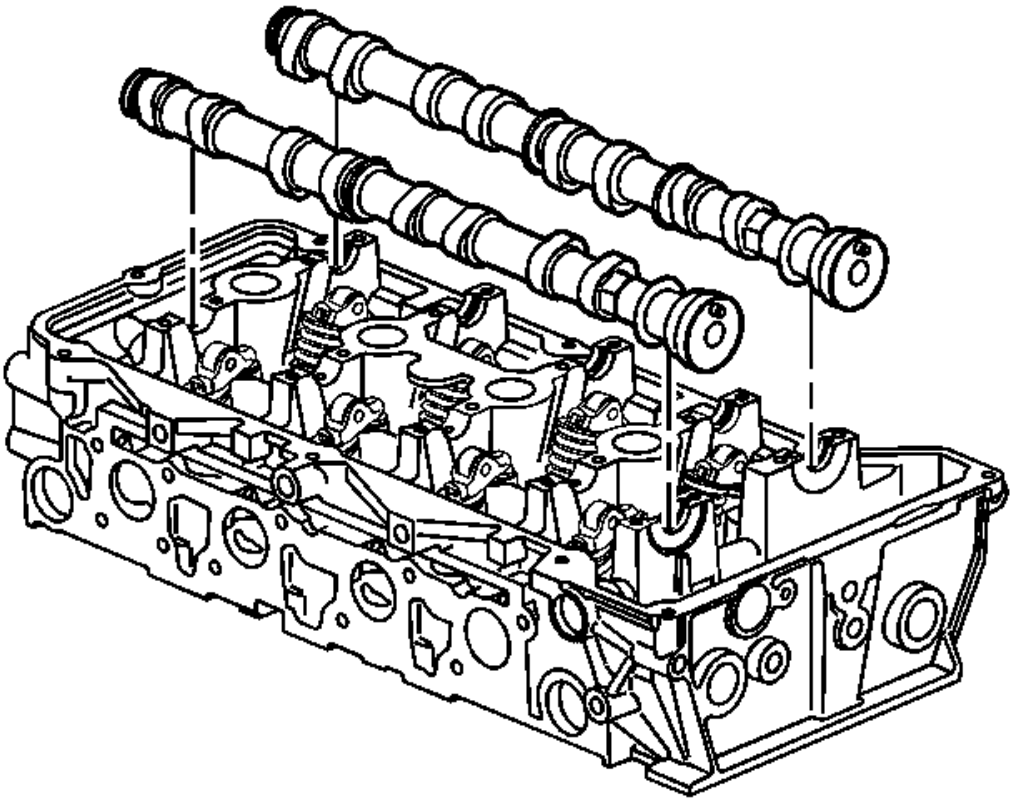

Fig. 300: Camshafts
Courtesy of GENERAL MOTORS CORP.

20. Remove the camshafts.

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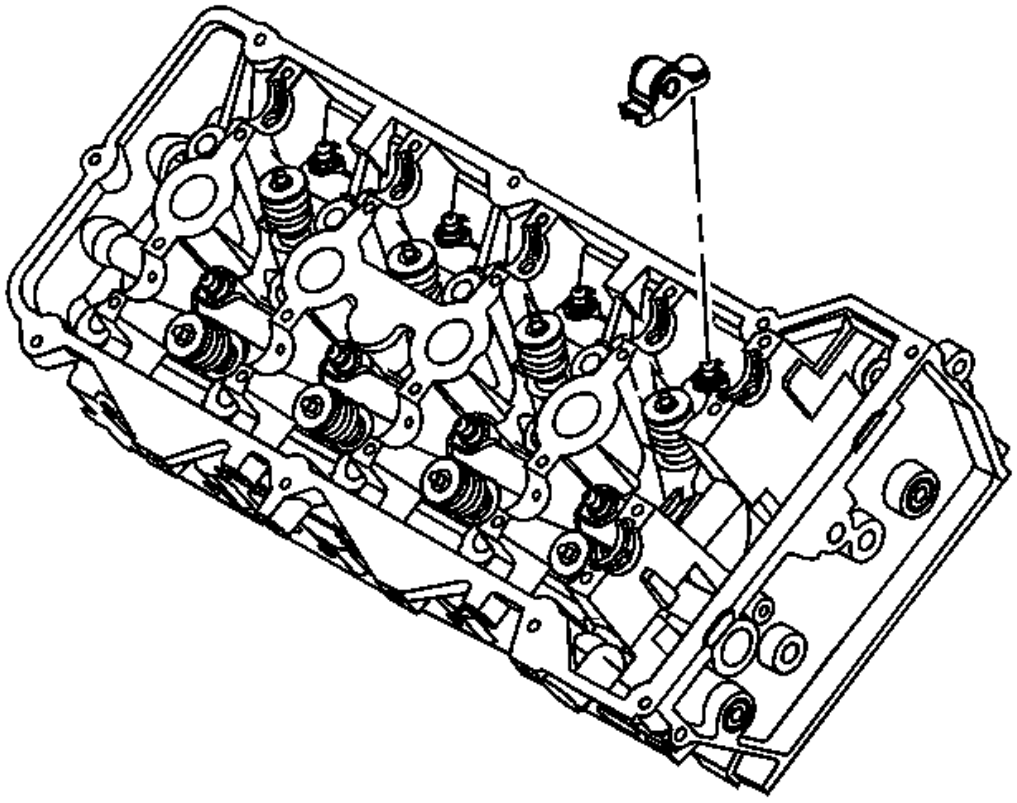

Fig. 301: Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

21. Remove the camshaft followers.
22. Clean and inspect the camshafts. Refer to **Camshaft Cleaning and Inspection** .

INSTALLATION PROCEDURE

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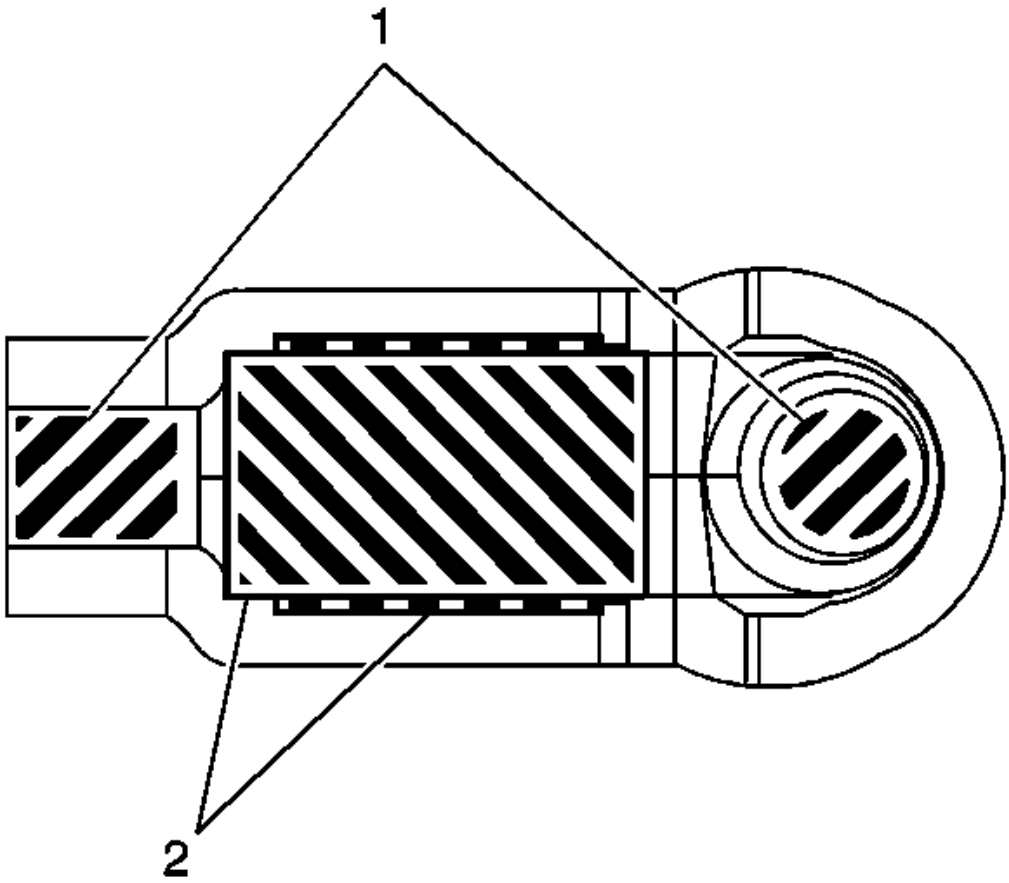

Fig. 302: Roller Pivot Pocket & Valve Slot Areas Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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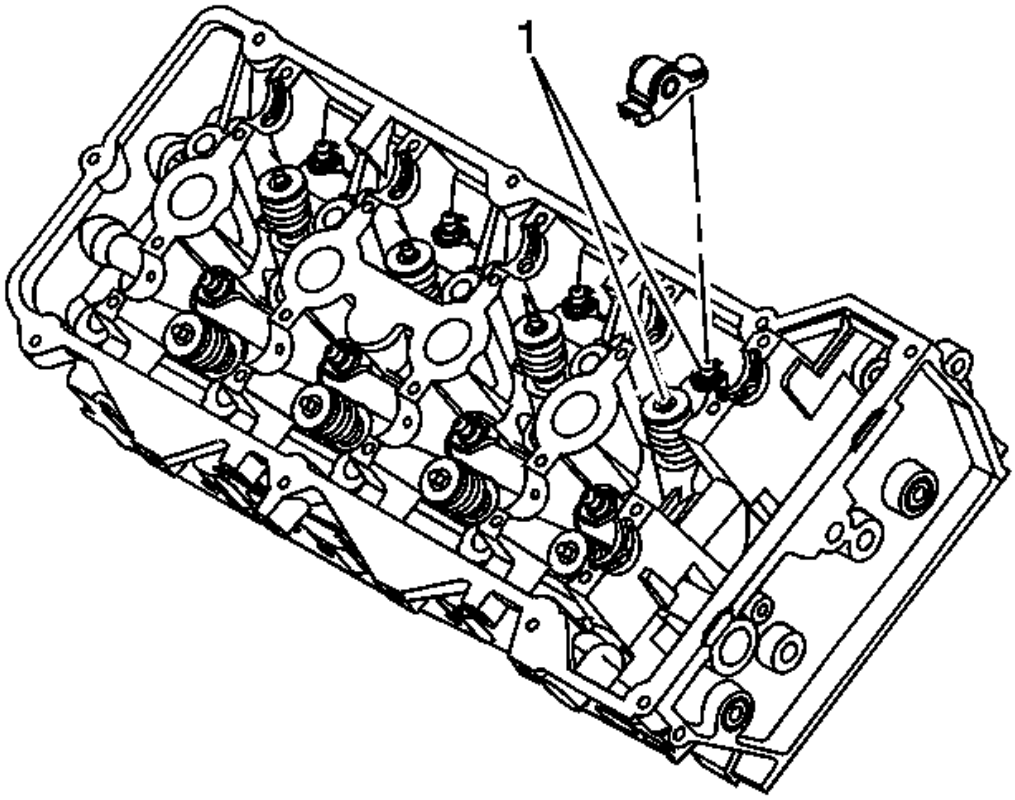

Fig. 303: Positioning Right Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and the stationary hydraulic lash adjusters (SHLA) (1). The rounded head of the follower goes on the SHLA, while the flat end goes on the valve tip.
3. Clean the camshaft carriers with a clean, lint-free cloth.

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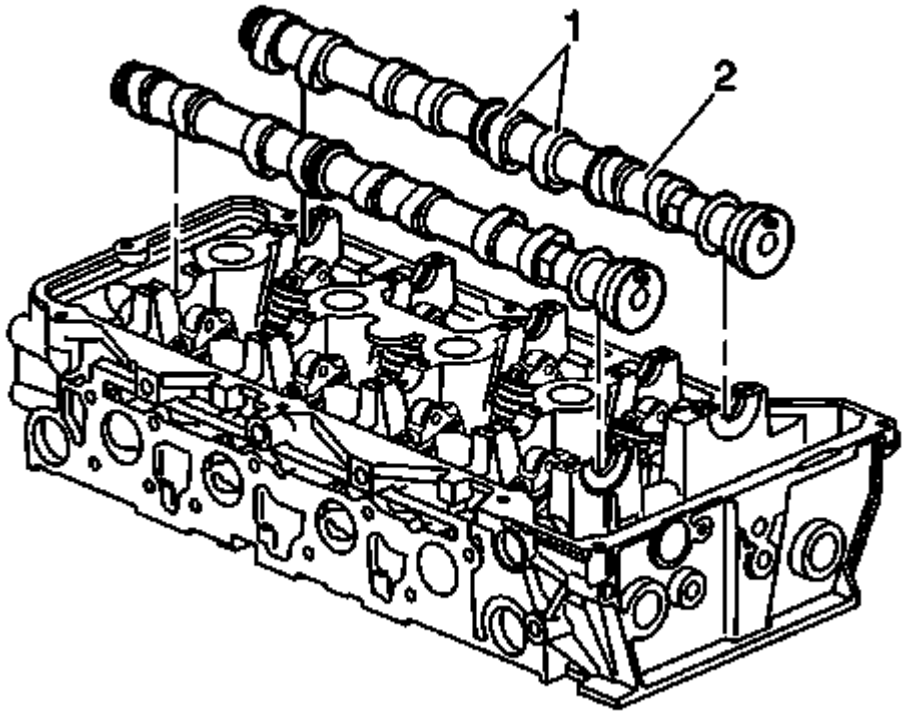

Fig. 304: Camshaft Lobes & Journals
Courtesy of GENERAL MOTORS CORP.

4. Apply a liberal amount of lubricant to the camshaft carriers, camshaft lobes (1) and the camshaft journals (2). Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
5. Place the camshaft in the camshaft carriers with the camshaft sprocket drive pins near the top of their rotation and the camshaft lobes in a neutral position. The camshafts can be identified by a stamping near the rear journal. For example: R-EXH is defined as Right bank Exhaust.

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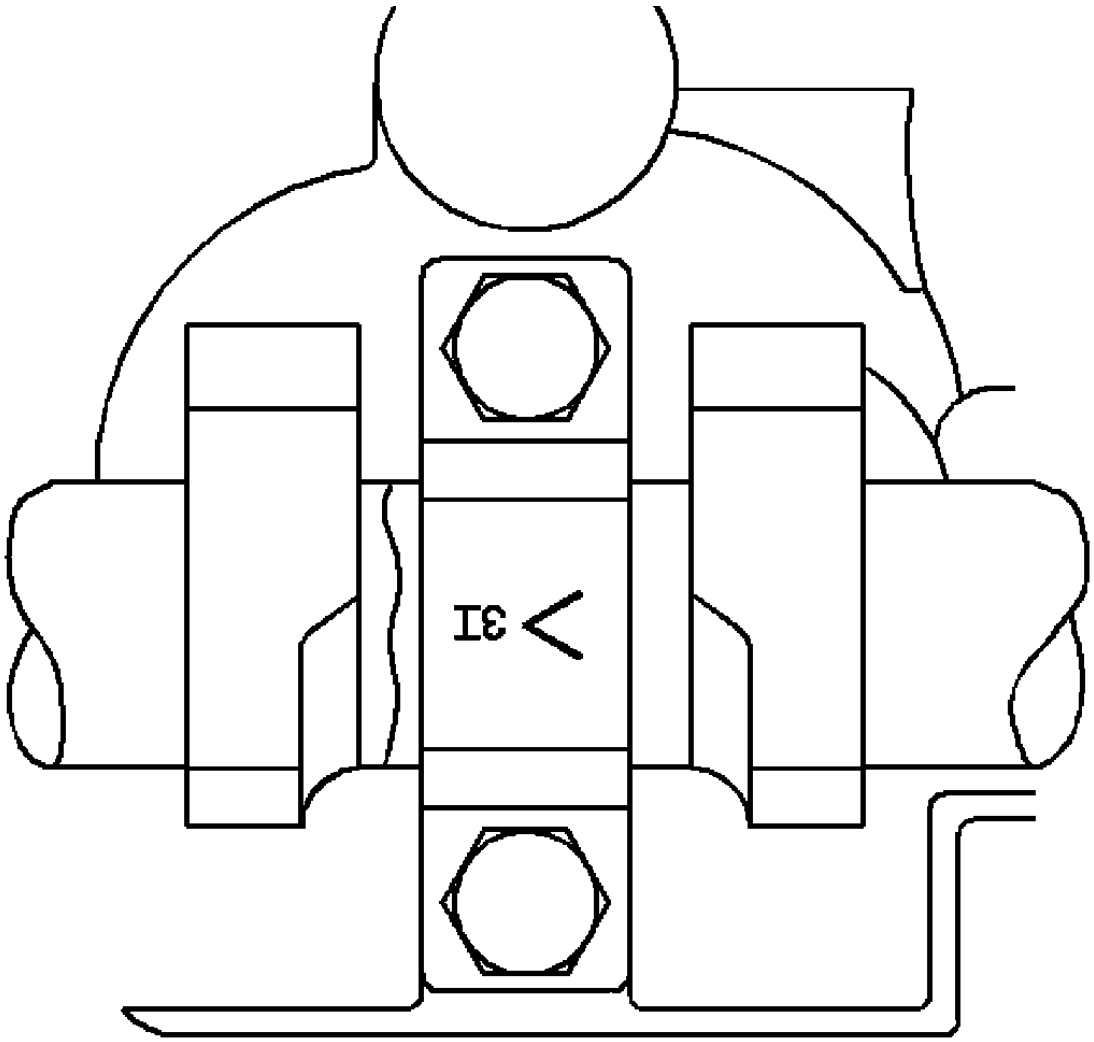

Fig. 305: Camshaft Bearing Cap Markings
Courtesy of GENERAL MOTORS CORP.

6. Observe the markings on the camshaft bearing caps. Each camshaft bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The arrow should point to the front of the engine.
   - The number indicates the position from the front of the engine.
   - The "E" indicates the exhaust camshaft.
   - The "I" indicates the Intake camshaft.
7. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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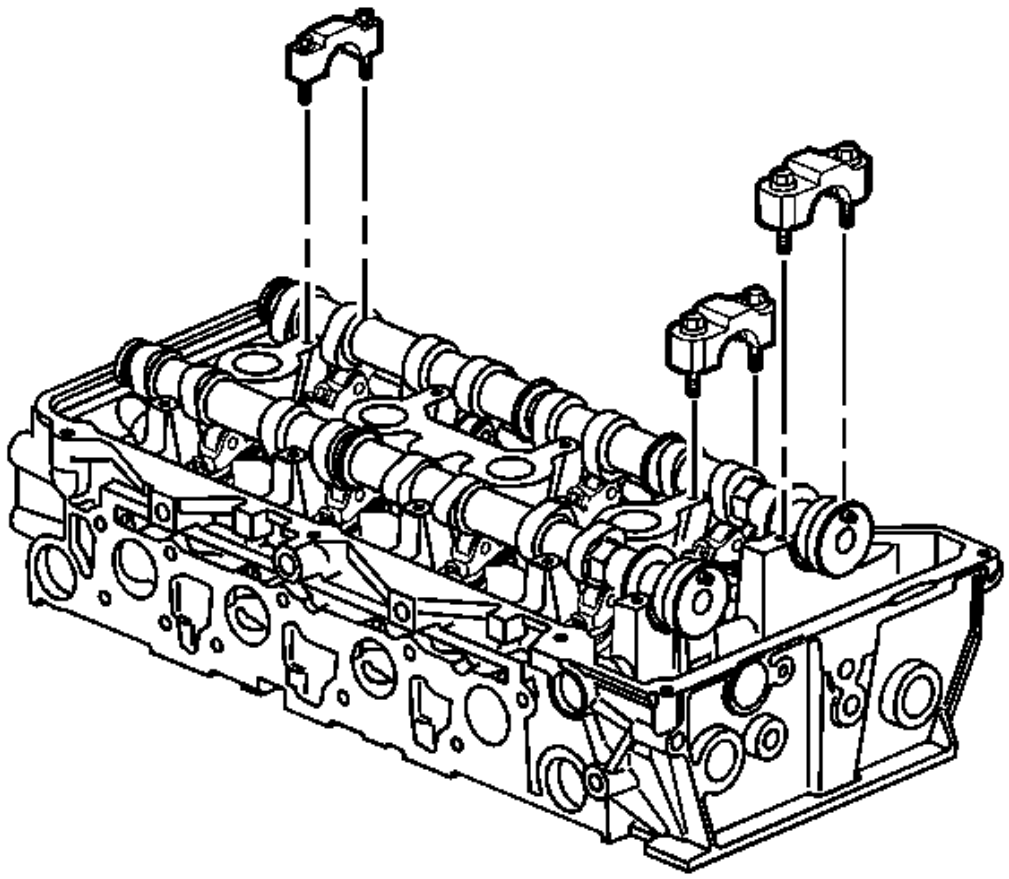

Fig. 306: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft bearing caps according to the identification marks.

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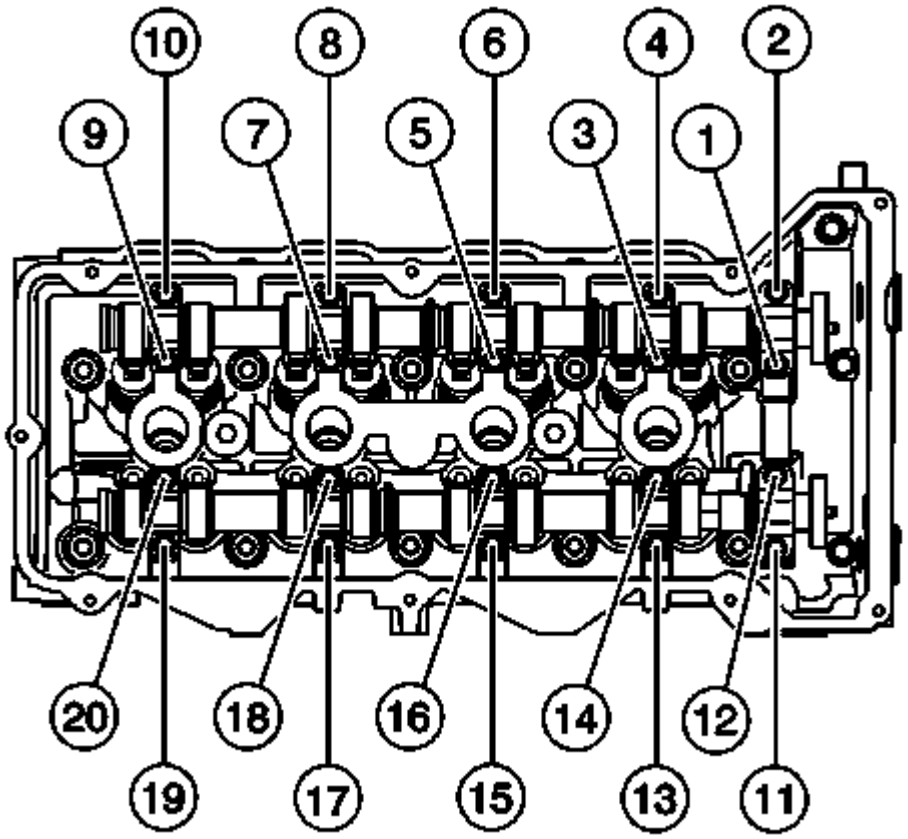

Fig. 307: Identifying Camshaft Bearing Cap Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

9. Install the camshaft bearing cap bolts in sequence.

   Tighten:

   1. Alternately hand tighten the camshaft bearing cap bolts a few turns at a time until all caps are fully seated.
   2. Tighten the camshaft bearing cap bolts to 5 N.m (44 lb in).
   3. Tighten the camshaft bearing cap bolts an additional 30 degrees using the **J 45059** .

CAUTION: Refer to Torque Reaction Against Timing Drive Chain Caution .

10. Align the camshafts.

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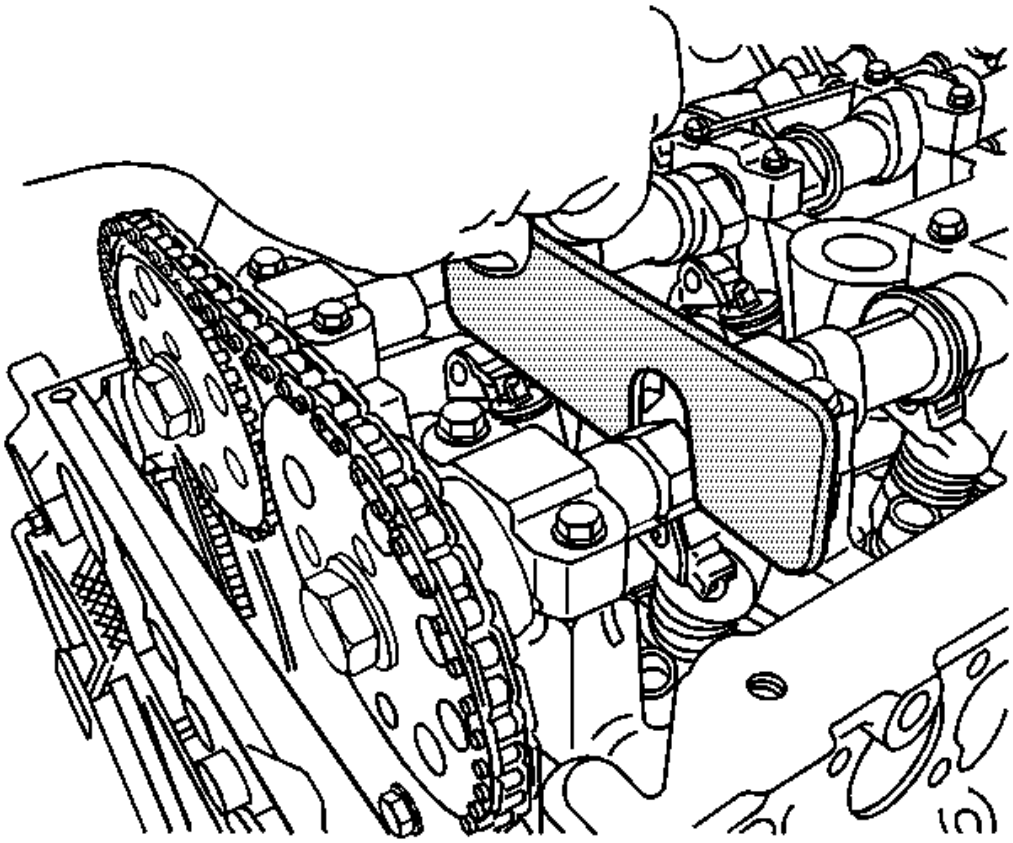

Fig. 308: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Holding Tool Warning .

11. Install the **J 44212** over the camshafts. See **Special Tools** .

NOTE: Ensure the camshaft sprockets properly engage the camshaft sprocket drive pins and camshafts.

12. Install the intake and exhaust camshaft sprockets aligning the paint marks made during disassembly. Ensure that the camshaft sprockets align with the pins of the camshafts.

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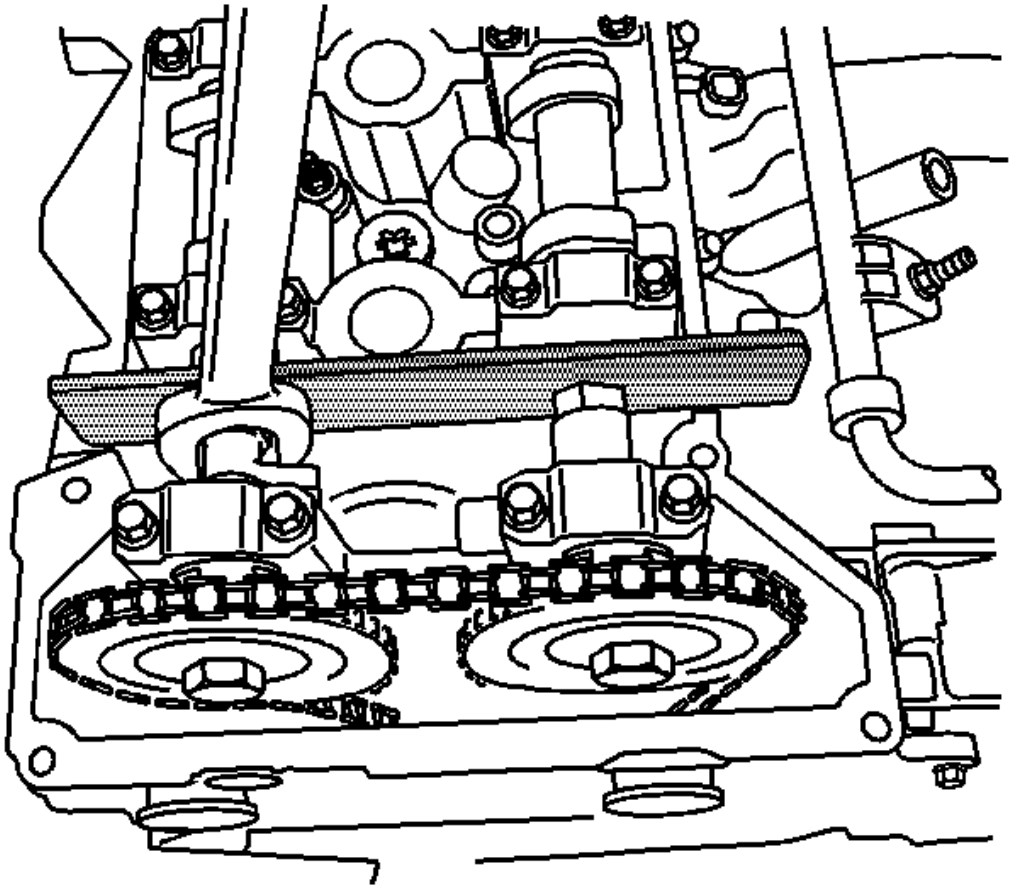

Fig. 309: Preventing Camshaft From Rotating
Courtesy of GENERAL MOTORS CORP.

13. Use an open wrench on the hex cast into the camshafts in order to prevent the camshafts from rotating when tightening the camshaft sprocket bolts.

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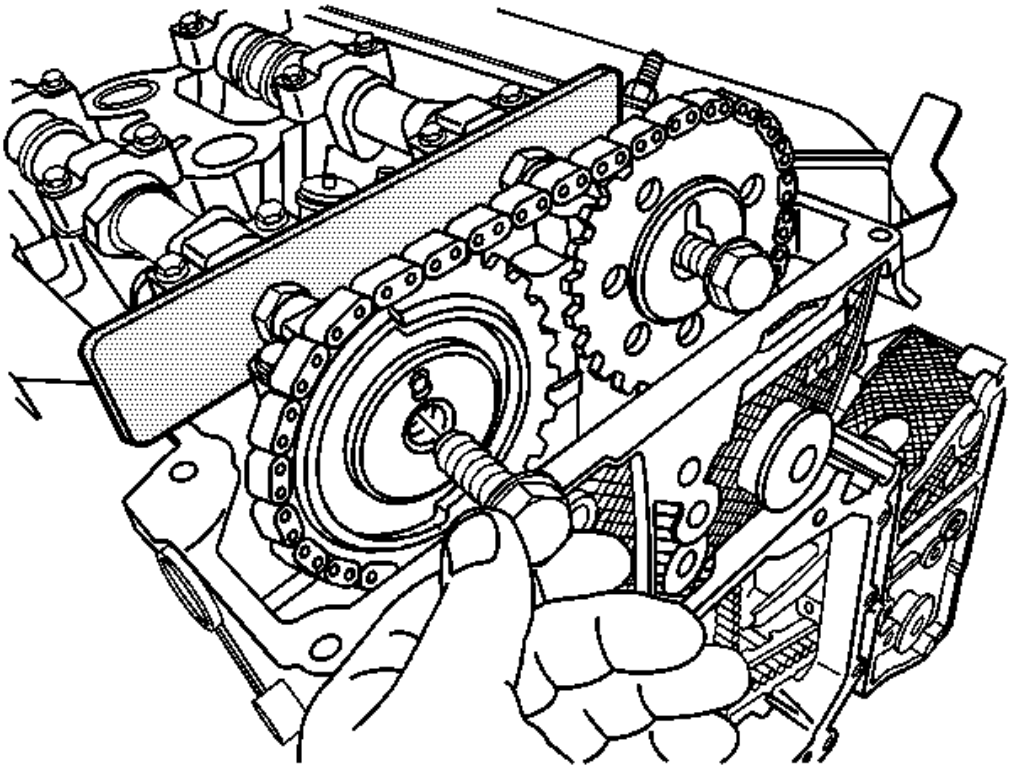

Fig. 310: Right Exhaust Camshaft Sprocket Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the camshaft sprocket bolts.

    Tighten: Tighten the camshaft sprocket bolts to 120 N.m (89 lb ft).

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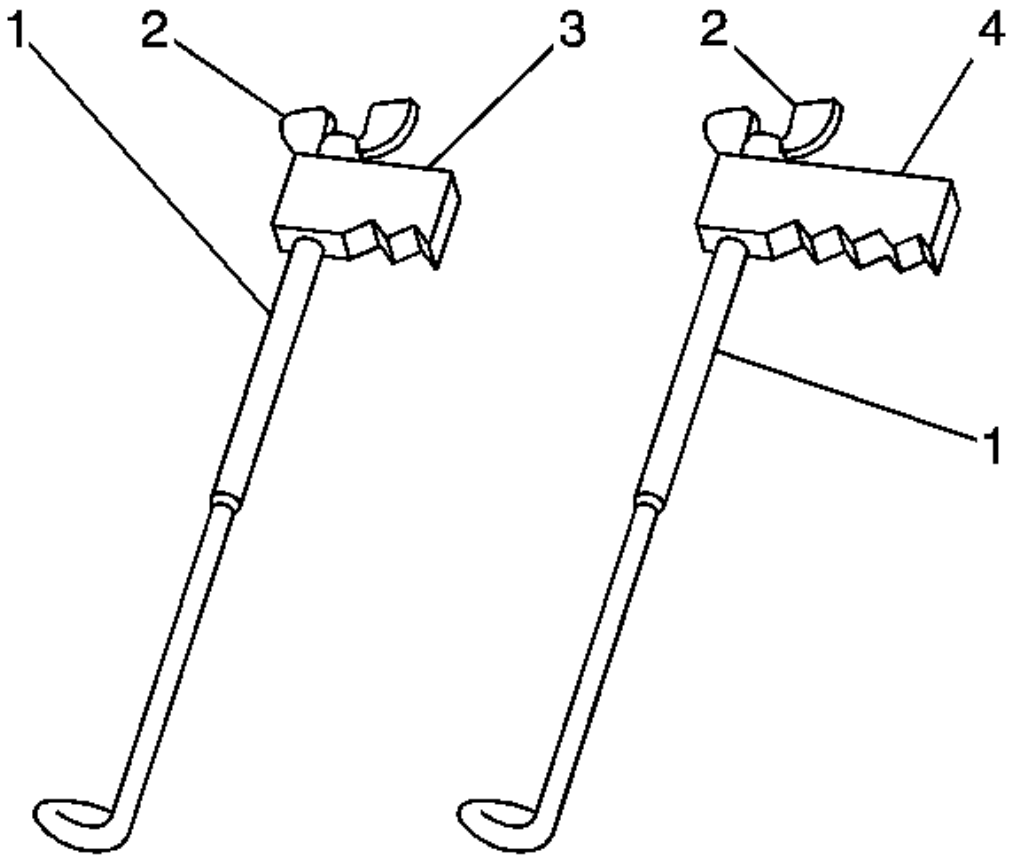

Fig. 311: Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

15. Remove the **EN 46327** (1). See **Special Tools** .

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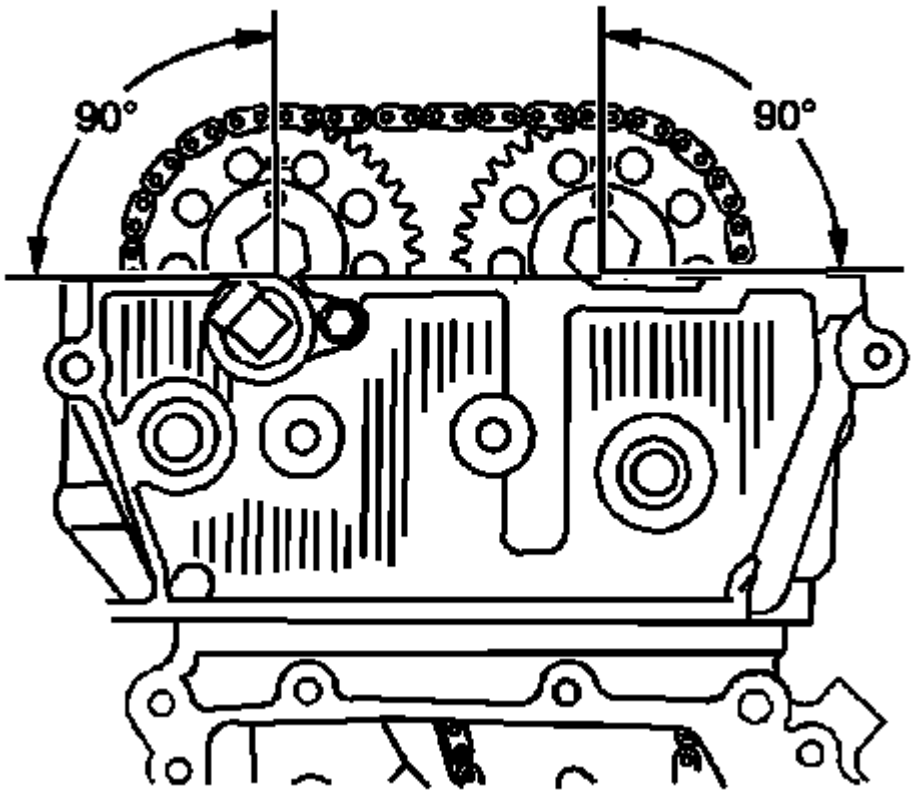

Fig. 312: Ensuring Camshaft Sprocket Drive Pins Are At Top Of Rotation
Courtesy of GENERAL MOTORS CORP.

16. Verify the camshaft sprocket alignment.

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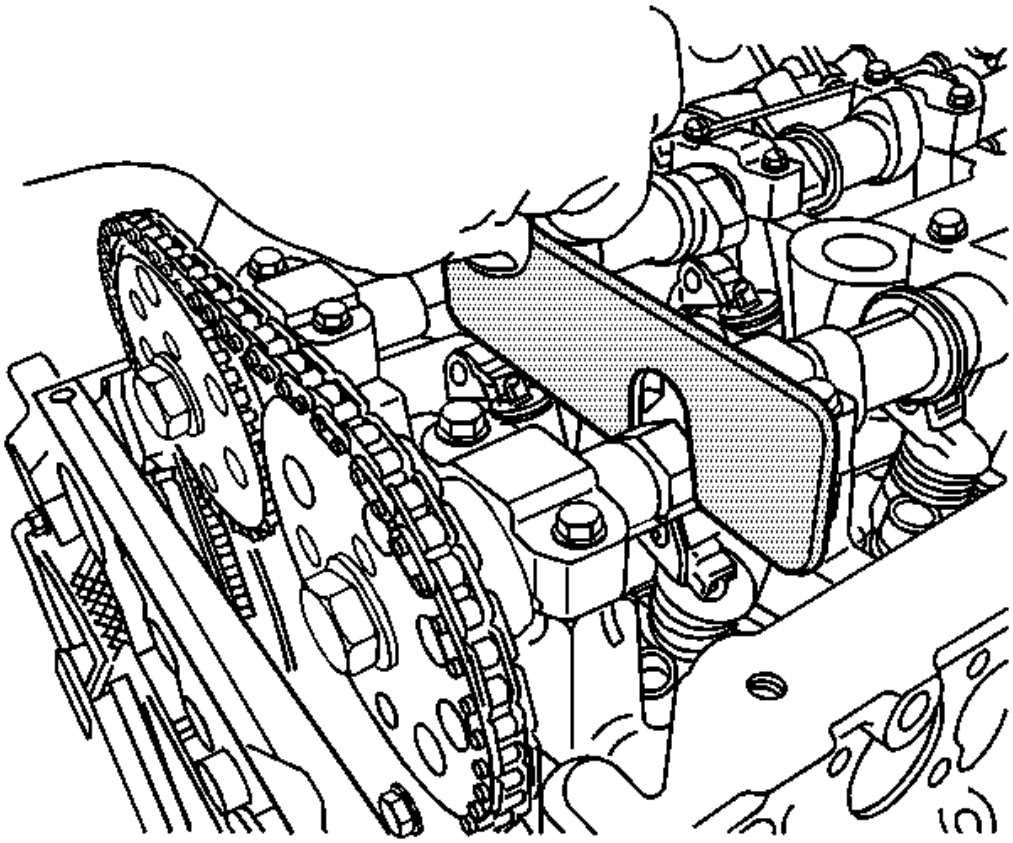

Fig. 313: Using Camshaft Holding Tool
Courtesy of GENERAL MOTORS CORP.

17. Remove the **J 44212** from the camshafts. See **Special Tools** .
18. Install the camshaft position sensor. Refer to **Camshaft Position Sensor Replacement** .
19. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.

VALVE ROCKER ARM REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the left camshafts. Refer to **Camshaft Replacement - Left Side**.

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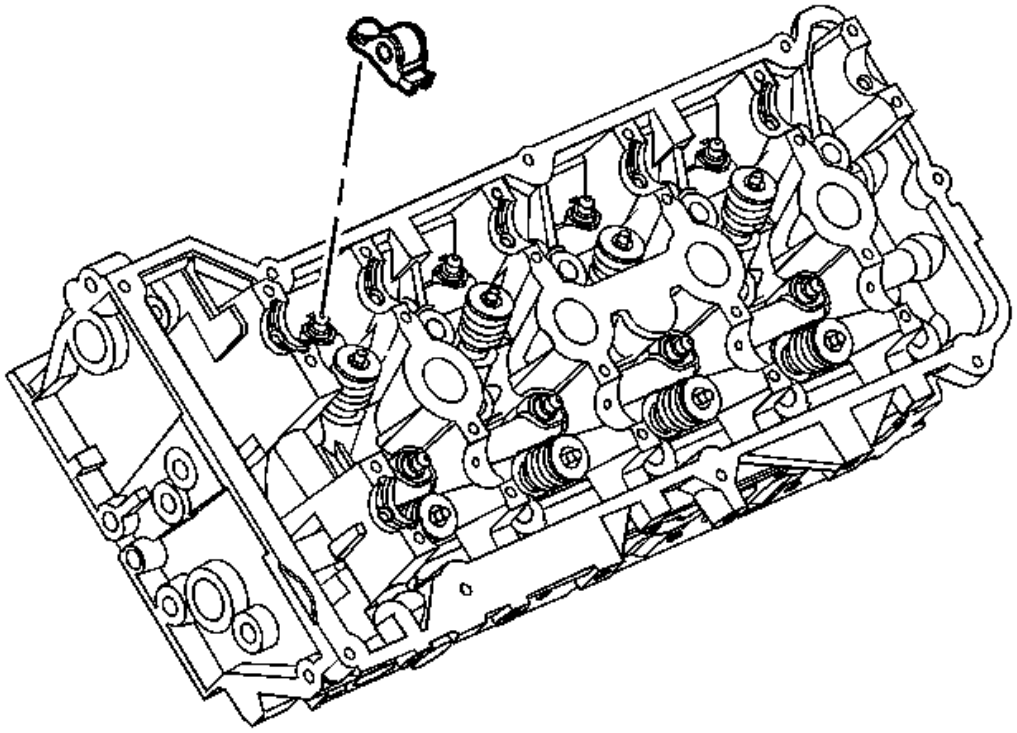

Fig. 314: Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the followers are being reused, arrange them so that they may be put back in their original locations.

2. Remove the camshaft followers.
3. Clean and inspect the rocker arms. Refer to **Valve Rocker Arm Cleaning and Inspection** .

INSTALLATION PROCEDURE

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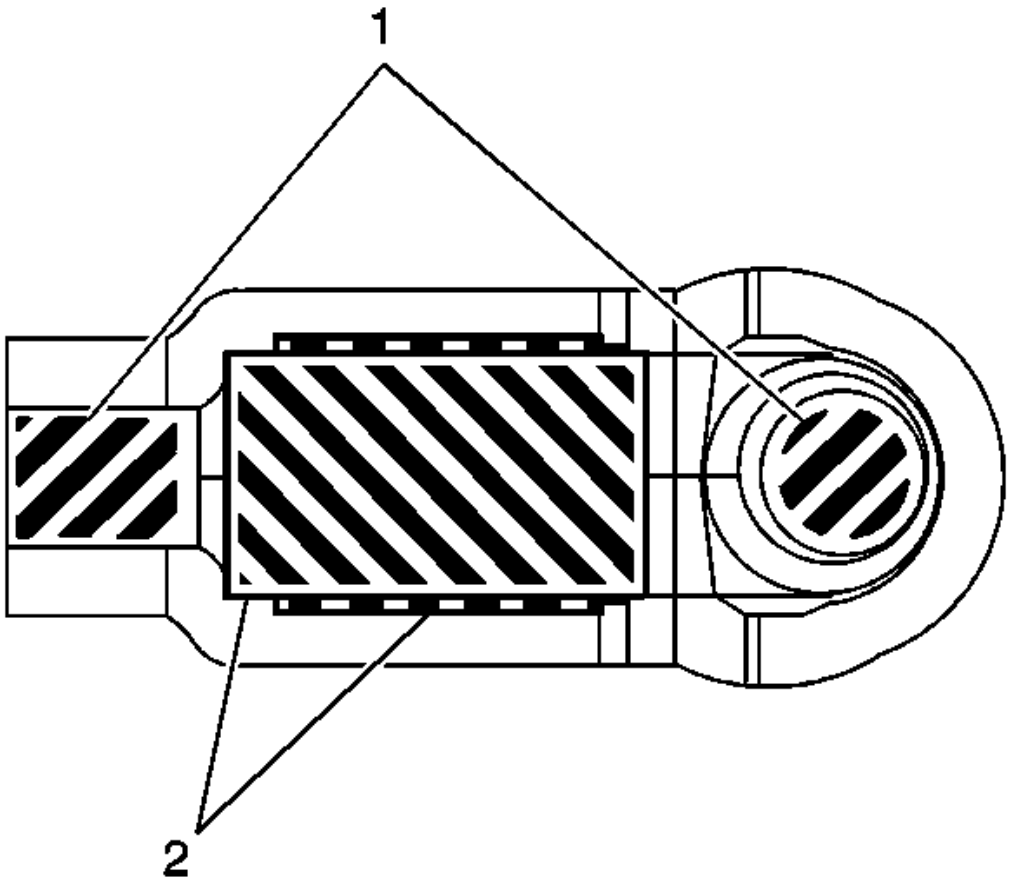

Fig. 315: Roller Pivot Pocket & Valve Slot Areas Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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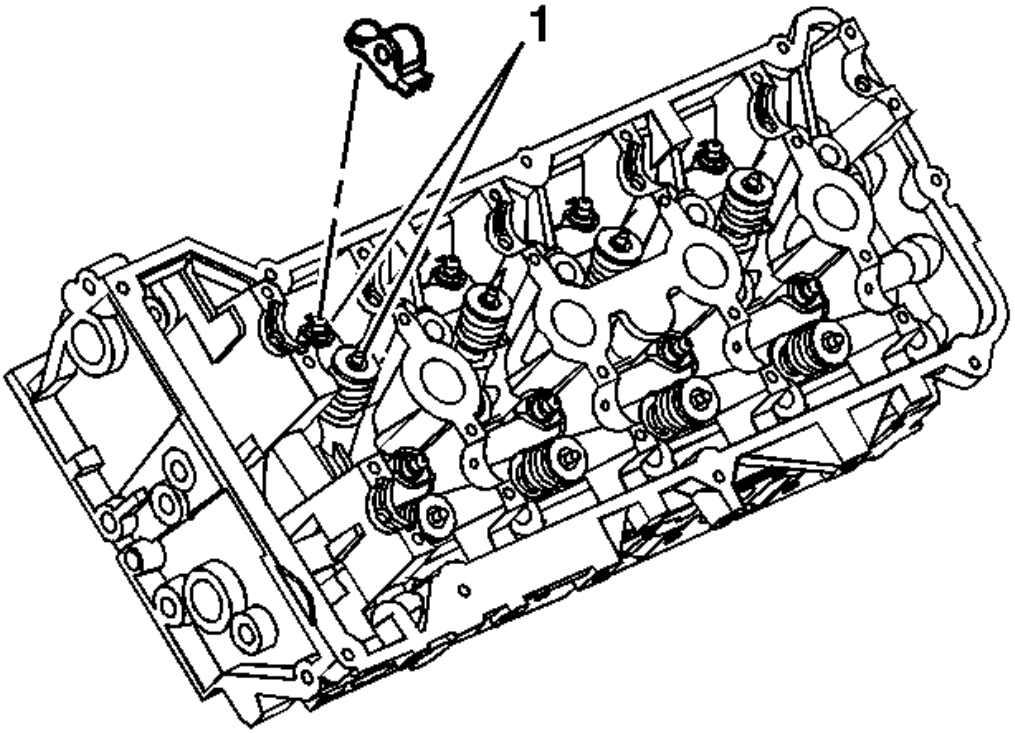

Fig. 316: Positioning Camshaft Follower
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip (1) and the SHLA (1). The rounded head of the follower goes on the SHLA, while the flat end goes on the valve tip.
3. Install the left camshafts. Refer to **Camshaft Replacement - Left Side**.

VALVE ROCKER ARM REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

1. Remove the right camshafts. Refer to **Camshaft Replacement - Right Side**.

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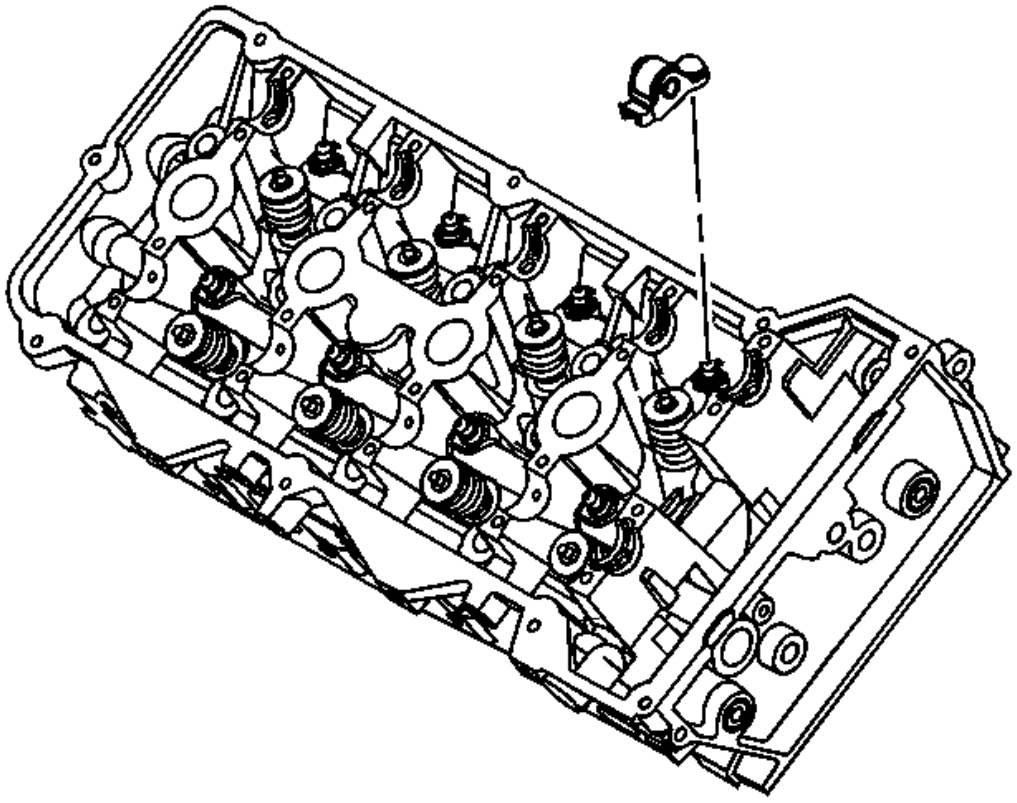

Fig. 317: Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the followers are being reused, arrange them so that they may be put back in their original locations.

2. Remove the camshaft followers.
3. Clean and inspect the rocker arms. Refer to **Valve Rocker Arm Cleaning and Inspection** .

INSTALLATION PROCEDURE

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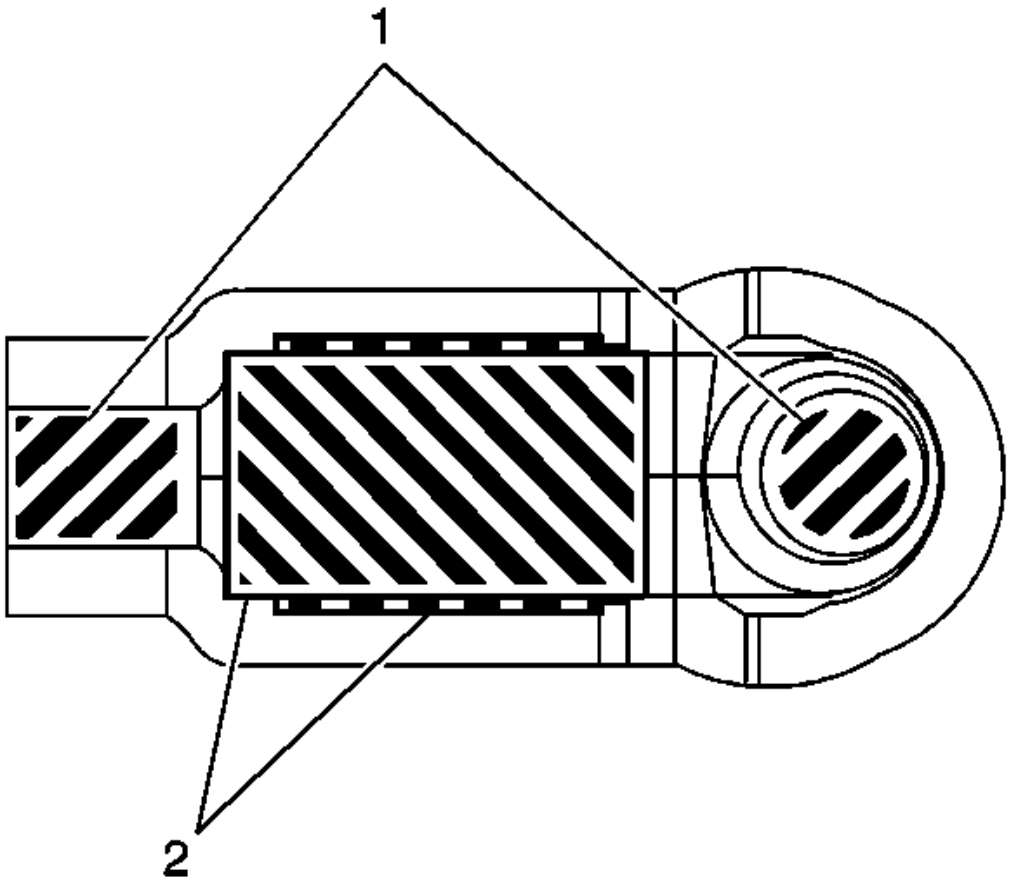

Fig. 318: Roller Pivot Pocket & Valve Slot Areas Of Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

1. Apply a liberal amount of lubricant to the roller pivot pocket (2) and valve slot areas (1) of the camshaft followers. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .

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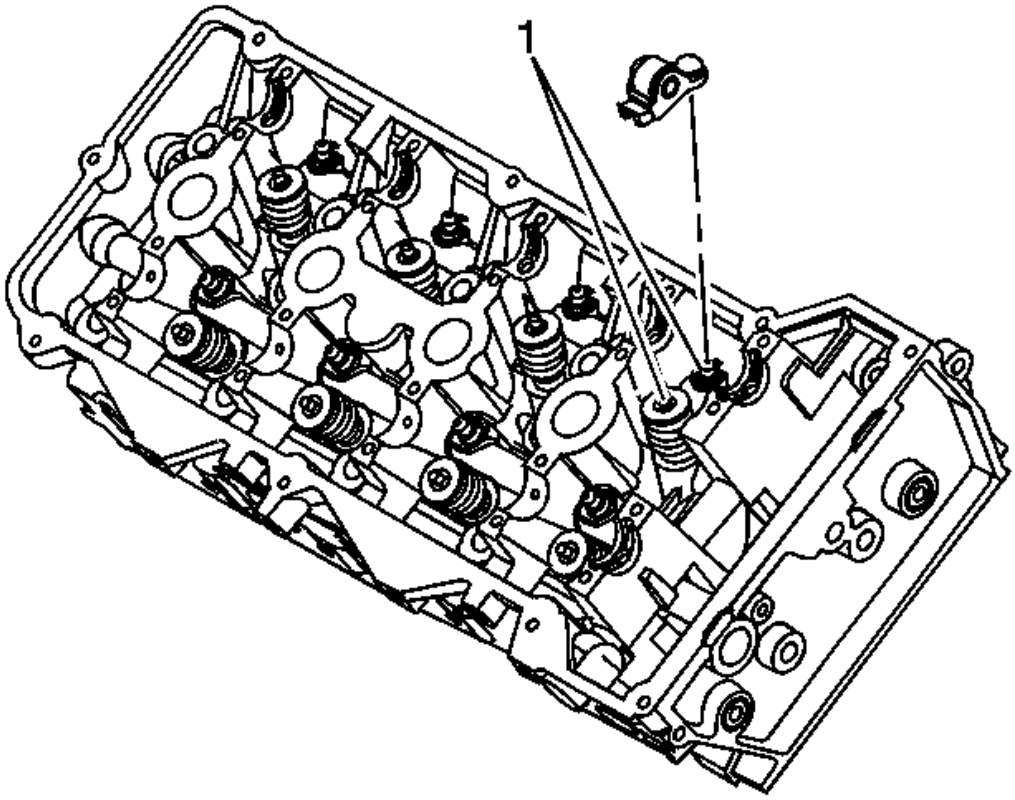

Fig. 319: Positioning Right Camshaft Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip (1) and the SHLA (1). The rounded head of the follower goes on the SHLA, while the flat end goes on the valve tip.
3. Install the right camshafts. Refer to **Camshaft Replacement - Right Side**.

VALVE LIFTER REPLACEMENT - LEFT SIDE

REMOVAL PROCEDURE

1. Remove the left valve rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**.

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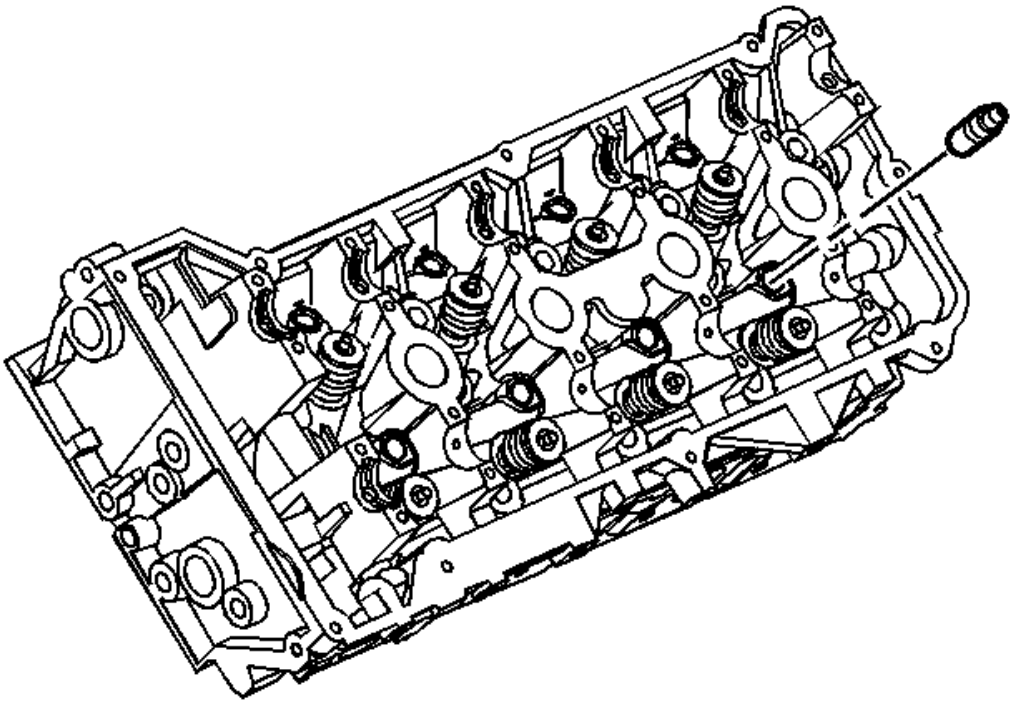

Fig. 320: Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Remove the stationary hydraulic lash adjusters (SHLA) from the bores.
3. Clean and inspect the valve lifters. Refer to **Valve Lifter Cleaning and Inspection** .

INSTALLATION PROCEDURE

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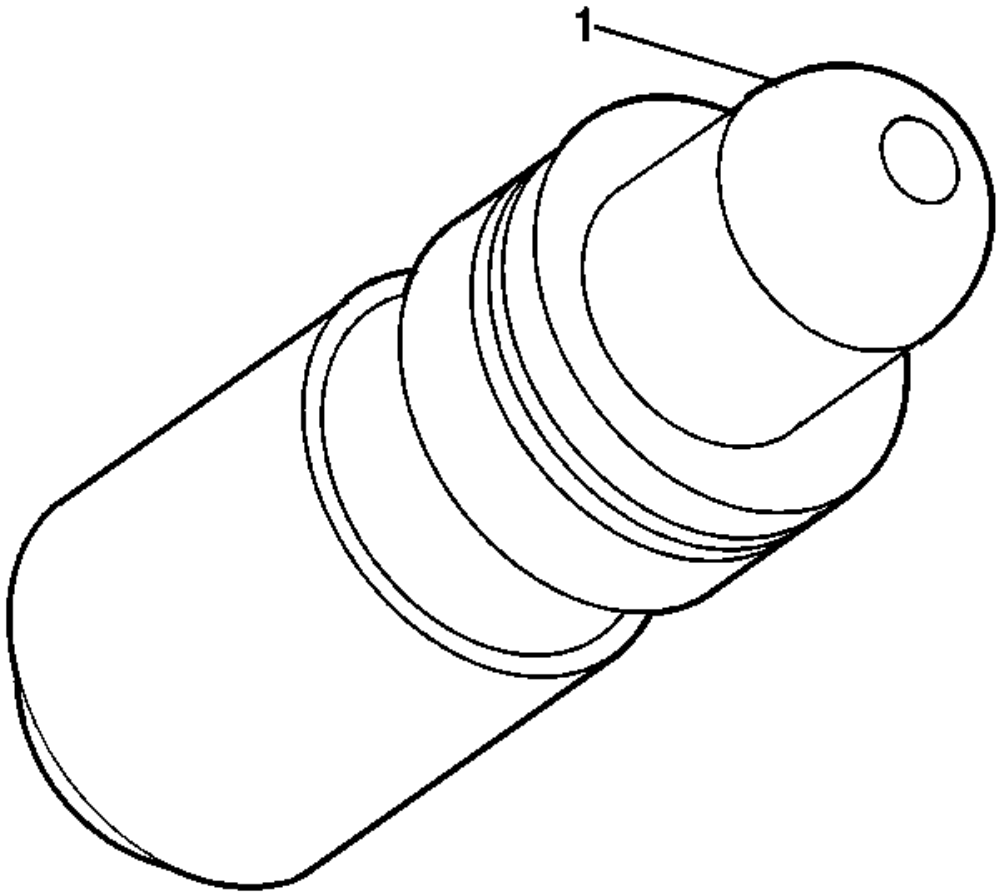

Fig. 321: Pivot Sphere Area Of SHLA
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** . Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.

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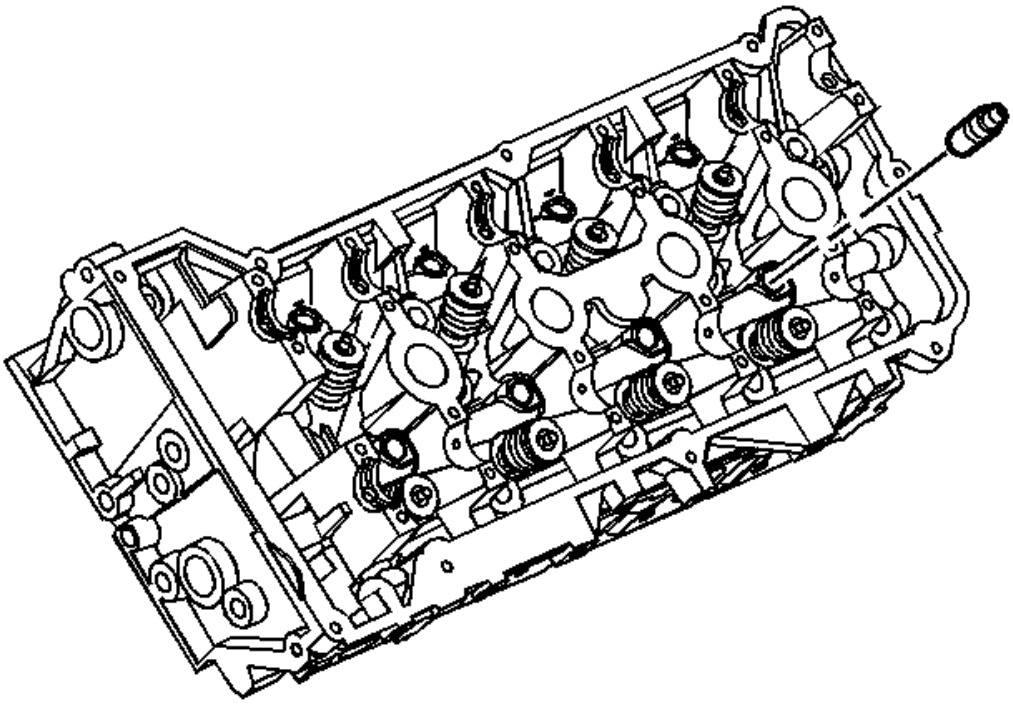

Fig. 322: Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Install the new SHLA's into the bores.
3. Install the left valve rocker arms. Refer to **Valve Rocker Arm Replacement - Left Side**.

VALVE LIFTER REPLACEMENT - RIGHT SIDE

REMOVAL PROCEDURE

1. Remove the right valve rocker arms. Refer to **Valve Rocker Arm Replacement - Right Side**.

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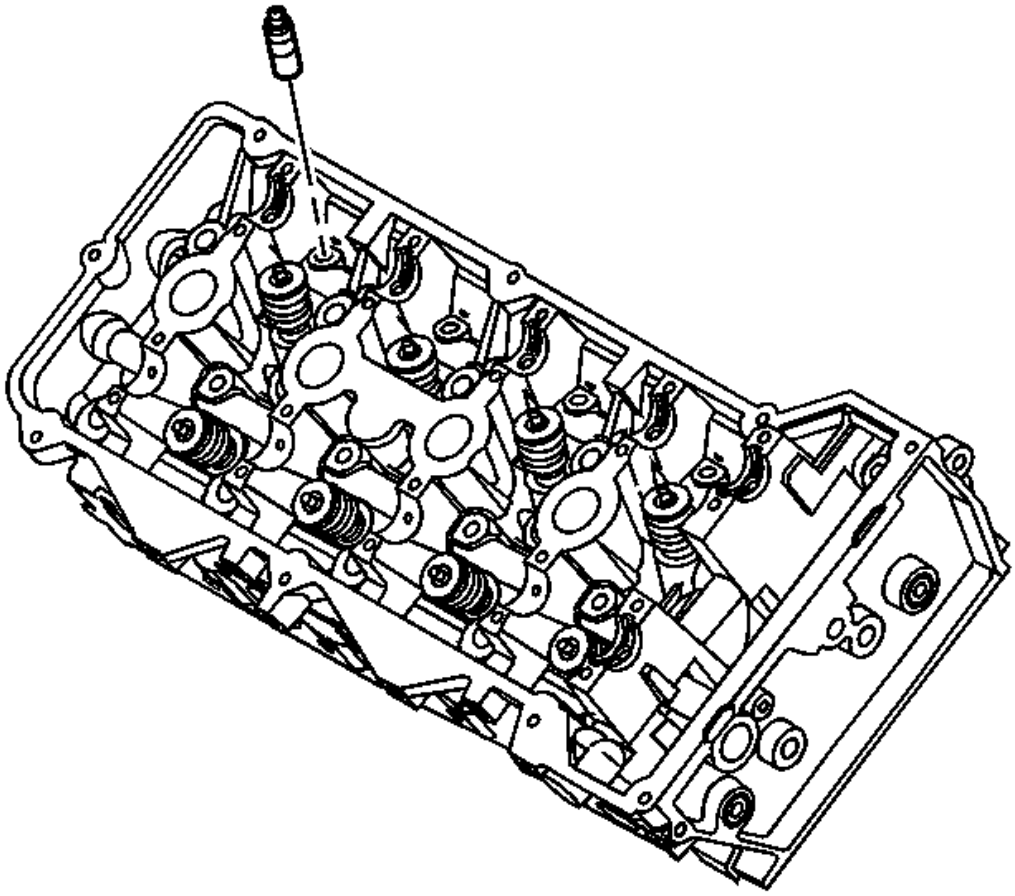

Fig. 323: Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Remove the stationary hydraulic lash adjusters (SHLA) from the bores.
3. Clean and inspect the valve lifters. Refer to **Valve Lifter Cleaning and Inspection** .

INSTALLATION PROCEDURE

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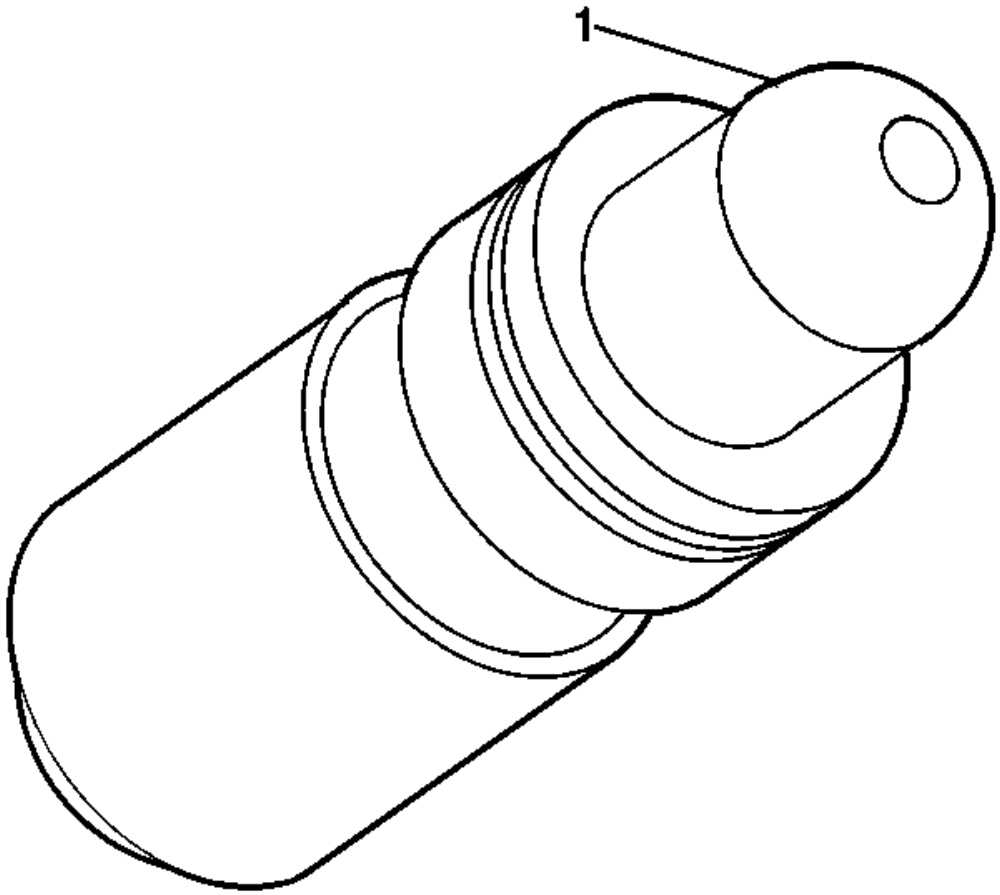

Fig. 324: Pivot Sphere Area Of SHLA
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** . Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.

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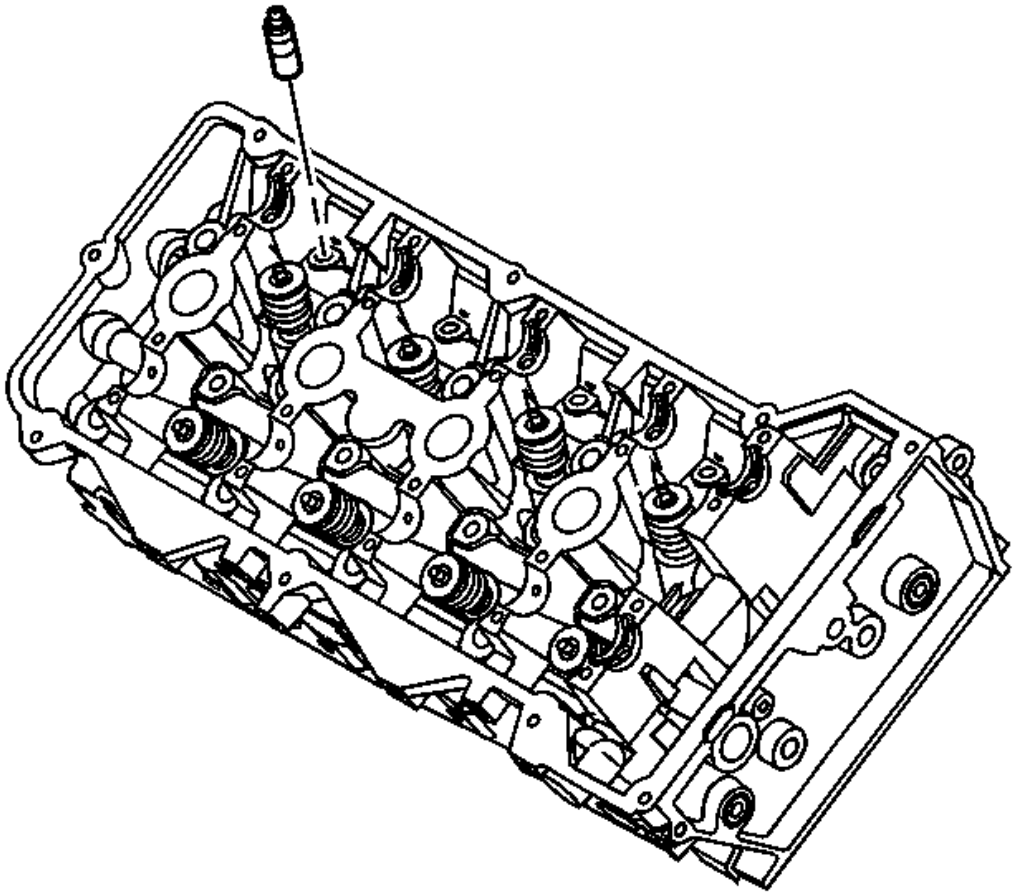

Fig. 325: Stationary Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

2. Install the new SHLA's into the bores.
3. Install the right valve rocker arms. Refer to **Valve Rocker Arm Replacement - Right Side**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - LEFT SIDE

Special Tools

- **J 38820** Valve Stem Seal Remover and Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .
- **J 43059** On-Vehicle Valve Retainer Remover/Installer
- **J 44211** Valve Spring Compressor. See **Special Tools** .

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- **J 44214** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the left camshafts. Refer to **Camshaft Replacement - Left Side**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

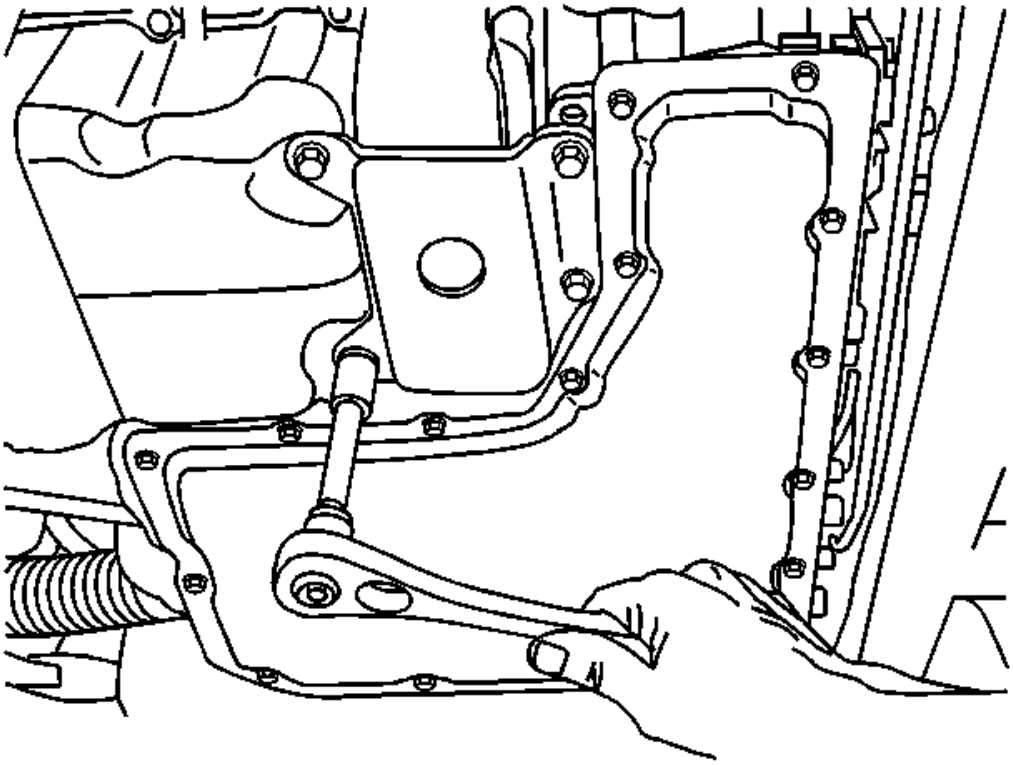

Fig. 326: Brace Between Engine Oil Pan & Transaxle Case
Courtesy of GENERAL MOTORS CORP.

3. Remove the brace between the engine oil pan and the transaxle case.
4. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** .

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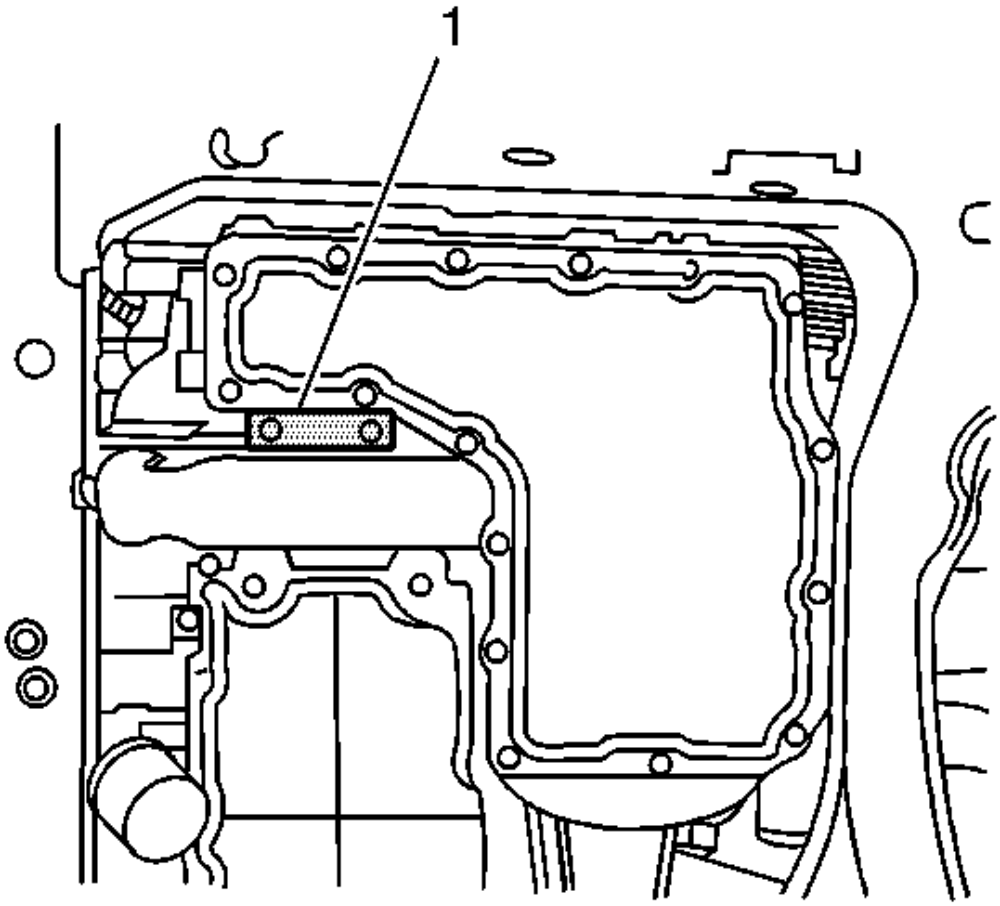

Fig. 327: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 44214** (1). See **Special Tools** .
6. Lower the vehicle.

CAUTION: Clean the spark plug recess area before removing the spark plug. Failure to do so could result in engine damage because of dirt or foreign material entering the cylinder head, or by the contamination of the cylinder head threads. The contaminated threads may prevent the proper seating of the new plug. Use a thread chaser to clean the threads of any contamination.

7. Remove the spark plug from the cylinder being worked on.

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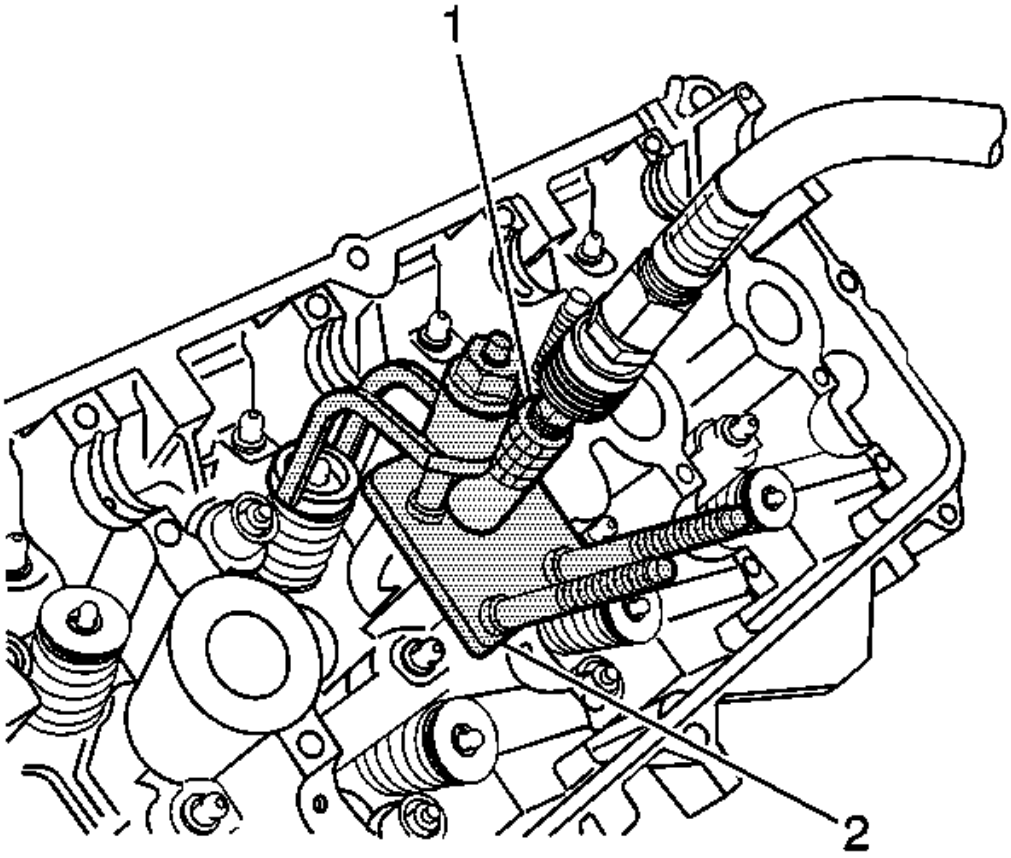

Fig. 328: Base Plate Installed Over Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

8. Install the base plate of the **J 44211** (2) over the spark plug hole of the cylinder to be serviced. See **Special Tools** .
9. Install the **J 39313** (1) in the spark plug hole. See **Special Tools** .
10. Apply constant air pressure to the **J 39313** (1) in order to keep the valve closed. See **Special Tools** .
11. Install the arm and swivel nut of the **J 44211** (2) over the stud corresponding to the valve to be serviced. See **Special Tools** .

WARNING: Refer to Compressed Valve Spring Warning .

12. Tighten the swivel nut of the **J 44211** (2) down only enough to allow access for removal of the valve locks. See **Special Tools** .

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13. Remove the valve locks. A magnet is the most suitable tool for this activity.
14. Loosen the swivel nut of the **J 44211** (2) and swing the arm away from the valve spring retainer. See **Special Tools** .
15. Remove the valve spring retainer and valve spring.

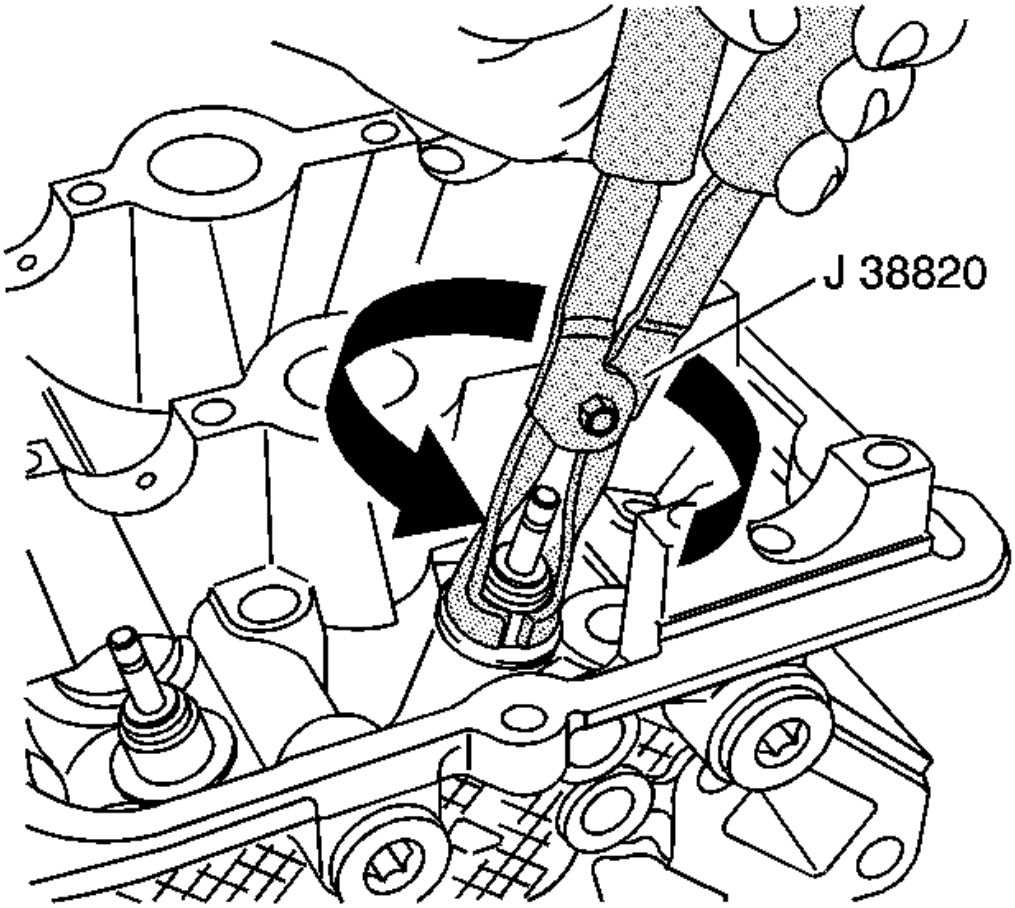

Fig. 329: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: The valve stem seal should not be removed unless replacement is required.

16. Use the **J 38820** in order to grip the seal. See **Special Tools** . Remove the seal by exerting a twisting, pulling motion. Discard the old valve stem seal.
17. Inspect and measure the valve spring. Refer to **Valve Spring Inspection and Measurement** .

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INSTALLATION PROCEDURE

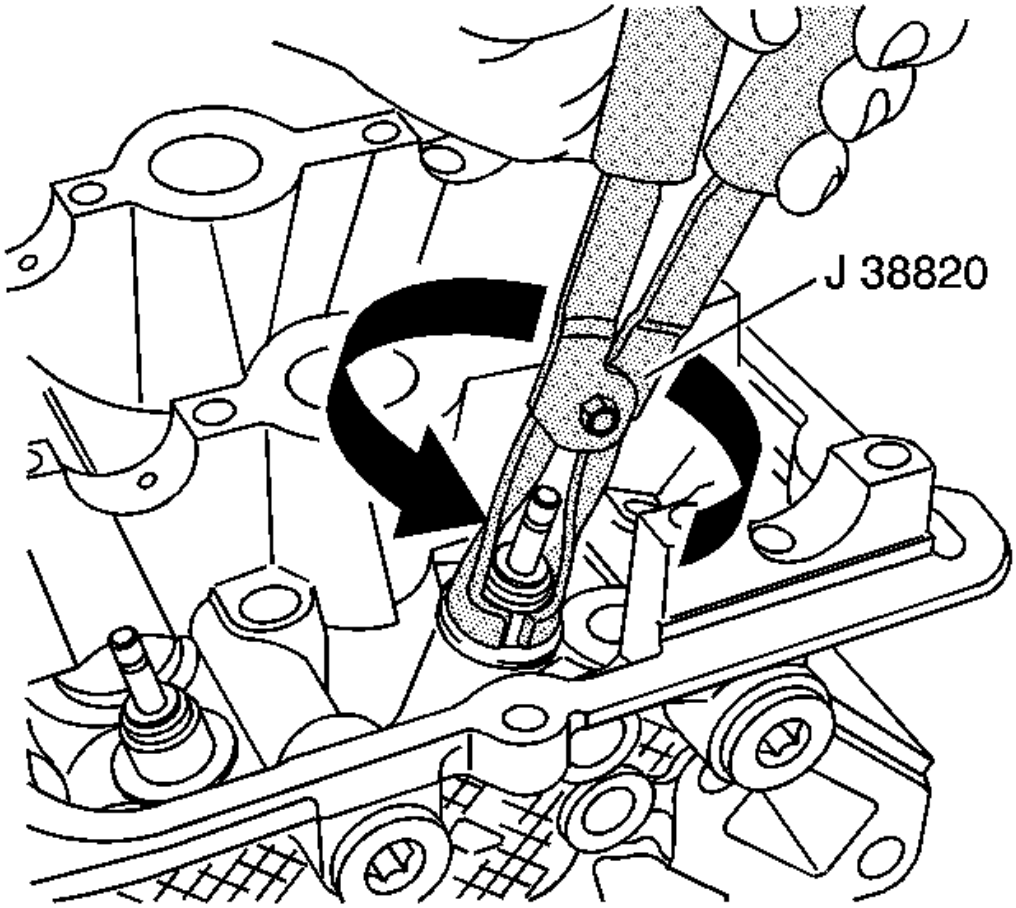

Fig. 330: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem and the inner diameter of the new seal with clean engine oil.

NOTE: Install a seal protector over the valve stem prior to installing the valve stem seal.

2. Using a twisting pushing motion install the NEW valve stem seal using the **J 38820** . See **Special Tools** .
3. Install the valve spring retainer and valve spring.

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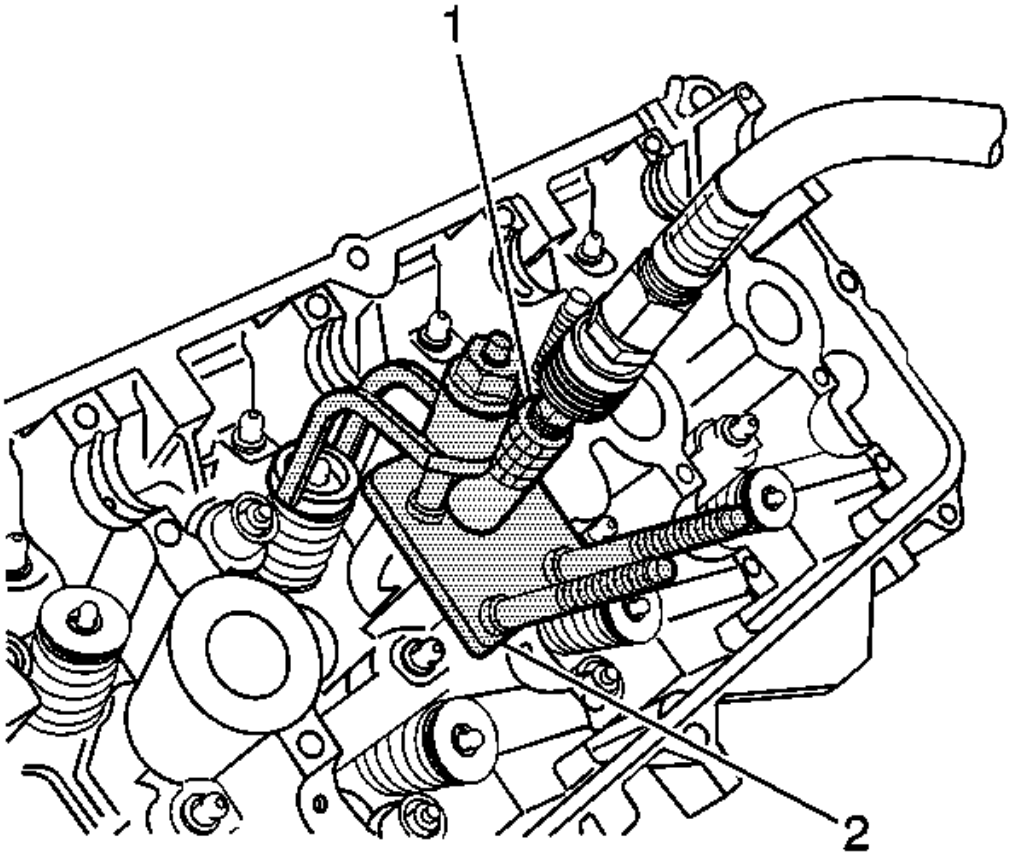

Fig. 331: Base Plate Installed Over Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Compressed Valve Spring Warning .

4. Swing the arm over the valve spring retainer and tighten the swivel nut of the **J 44211** (2) down only enough to allow access for installation of the valve locks. See **Special Tools** .
5. Position the valve locks to the valve stem retainer groove using the **J 43059** .
6. Remove the swivel nut and arm of the **J 44211** (2). See **Special Tools** .
7. Install the arm and swivel nut of the **J 44211** (2) over the stud of any other valves being serviced and repeat removal steps 12 through 17 and installation steps 1 through 7. See **Special Tools** .
8. Relieve the air pressure to the cylinder being serviced.
9. Remove the **J 39313** (1) from the spark plug hole. See **Special Tools** .

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10. Remove the base plate of the **J 44211** (2). See **Special Tools** .
11. Install the spark plug. Refer to **Spark Plug Replacement** .
12. Repeat removal steps 7 through 17 and installation steps 1 through 11 on any other cylinders being serviced.
13. Install the left camshafts. Refer to **Camshaft Replacement - Left Side**.
14. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

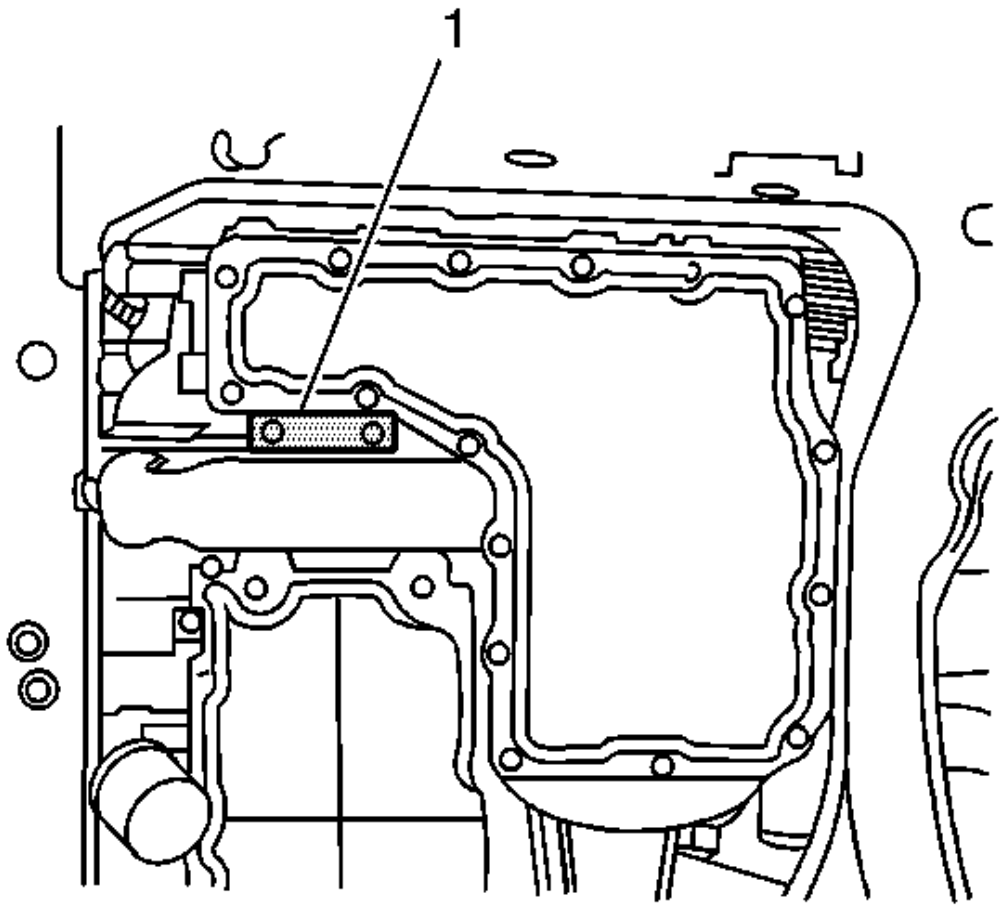

Fig. 332: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

15. Remove the **J 44214** (1). See **Special Tools** .
16. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** .

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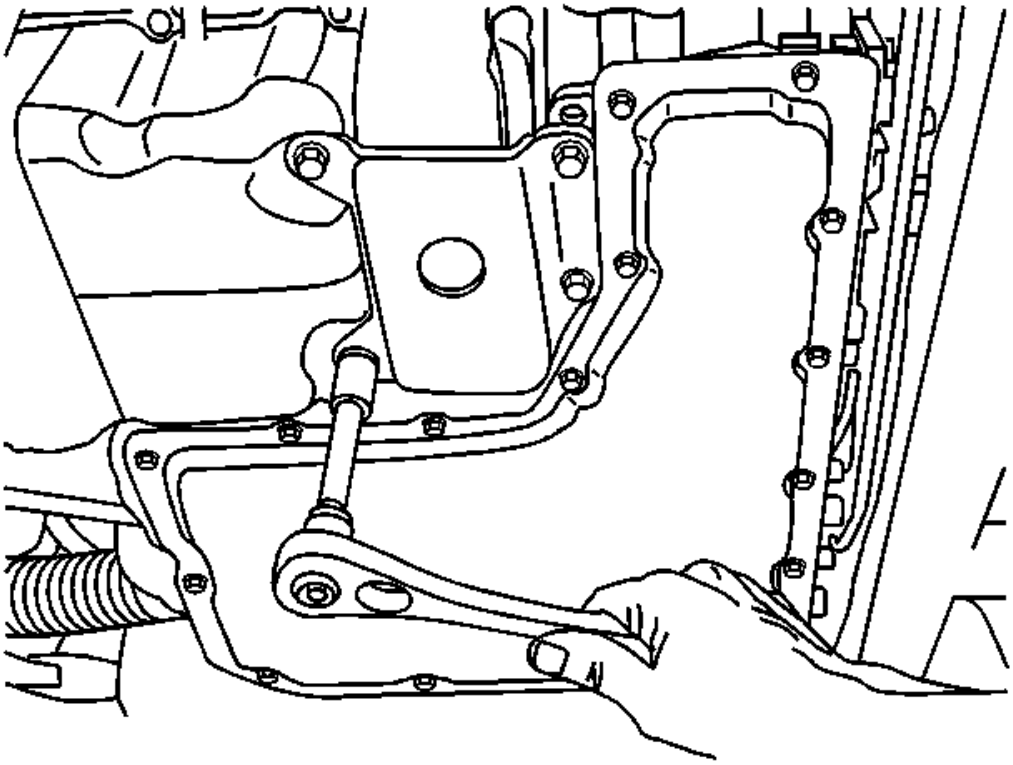

Fig. 333: Brace Between Engine Oil Pan & Transaxle Case
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

17. Install the oil pan to transaxle brace.

    Tighten: Tighten the oil pan to transaxle brace bolts to 50 N.m (37 lb ft).

18. Lower the vehicle.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT - RIGHT SIDE

Special Tools

- **J 38820** Valve Stem Seal Remover and Installer. See **Special Tools** .
- **J 39313** Spark Plug Port Adapter. See **Special Tools** .

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- **J 43059** Valve Retainer Remover/Installer
- **J 44211** On-Vehicle Valve Spring Compressor. See **Special Tools** .
- **J 44214** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the right camshafts. Refer to **Camshaft Replacement - Right Side**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

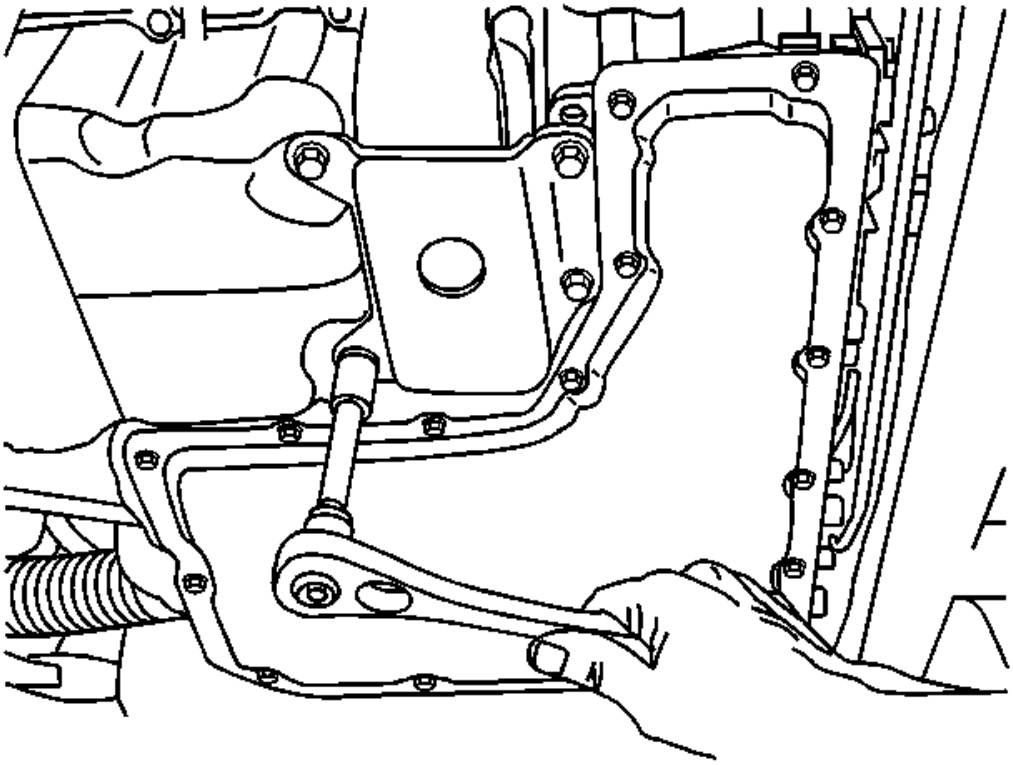

Fig. 334: Brace Between Engine Oil Pan & Transaxle Case
Courtesy of GENERAL MOTORS CORP.

3. Remove the brace between the engine oil pan and the transaxle case.
4. Remove the torque converter cover. Refer to **Torque Converter Cover Replacement** .

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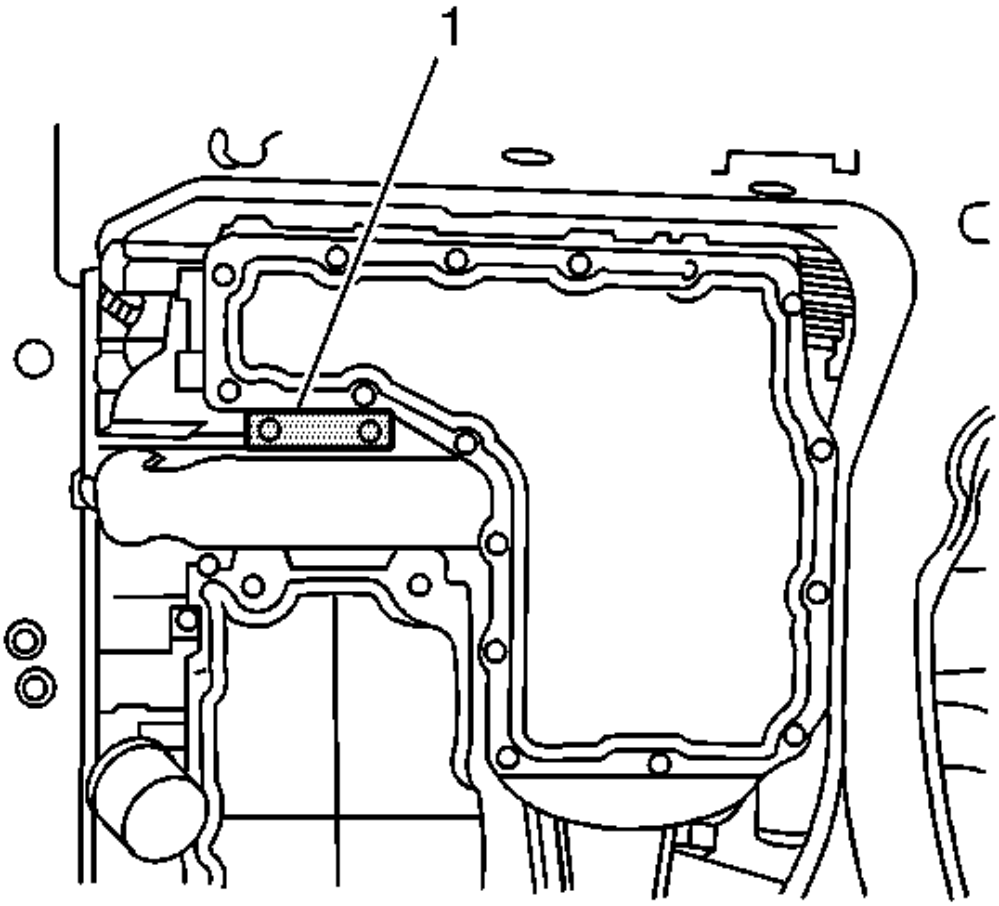

Fig. 335: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 44214** (1). See **Special Tools** .
6. Lower the vehicle.

CAUTION: Clean the spark plug recess area before removing the spark plug. Failure to do so could result in engine damage because of dirt or foreign material entering the cylinder head, or by the contamination of the cylinder head threads. The contaminated threads may prevent the proper seating of the new plug. Use a thread chaser to clean the threads of any contamination.

7. Remove the spark plug from the cylinder being worked on.

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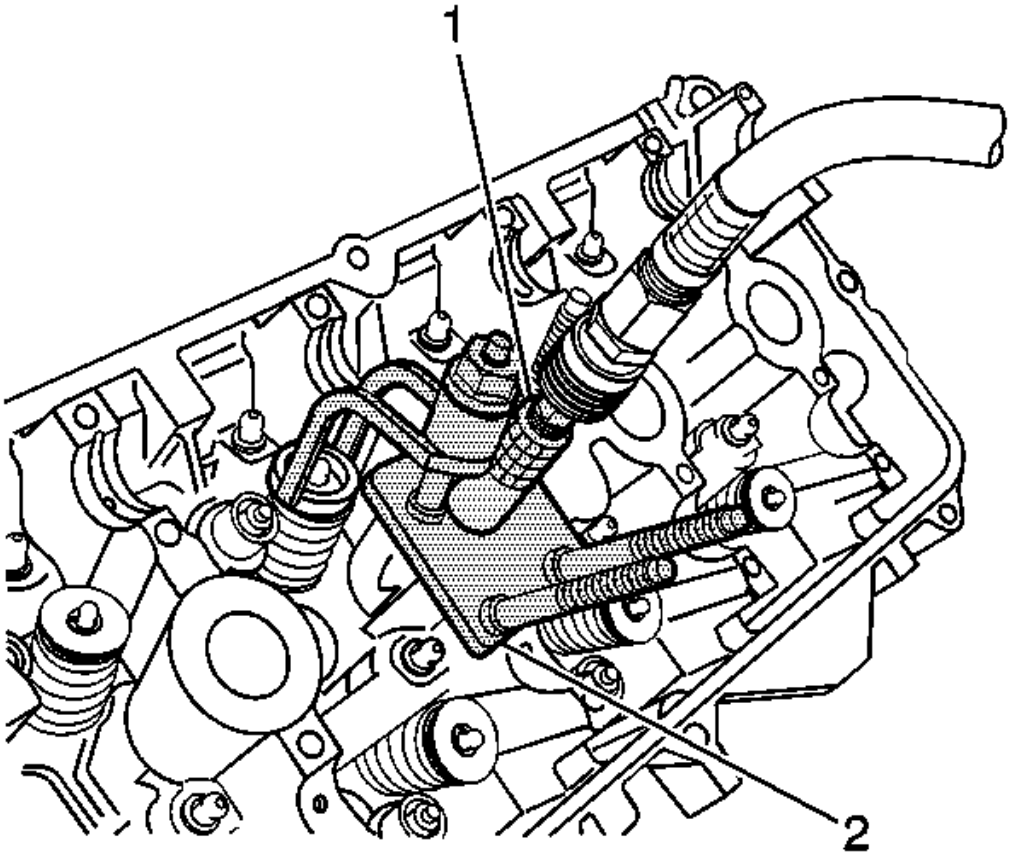

Fig. 336: Base Plate Installed Over Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

8. Install the base plate of the **J 44211** (2) over the spark plug hole of the cylinder to be serviced. See **Special Tools** .
9. Install the **J 39313** (1) in the spark plug hole. See **Special Tools** .
10. Apply constant air pressure to the **J 39313** (1) in order to keep the valve closed. See **Special Tools** .
11. Install the arm and swivel nut of the **J 44211** (2) over the stud corresponding to the valve to be serviced. See **Special Tools** .

WARNING: Refer to Compressed Valve Spring Warning .

12. Tighten the swivel nut of the **J 44211** (2) down only enough to allow access for removal of the valve locks. See **Special Tools** .

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13. Remove the valve locks. A magnet is the most suitable tool for this activity.
14. Loosen the swivel nut of the **J 44211** (2) and swing the arm away from the valve spring retainer. See **Special Tools** .
15. Remove the valve spring retainer and valve spring.

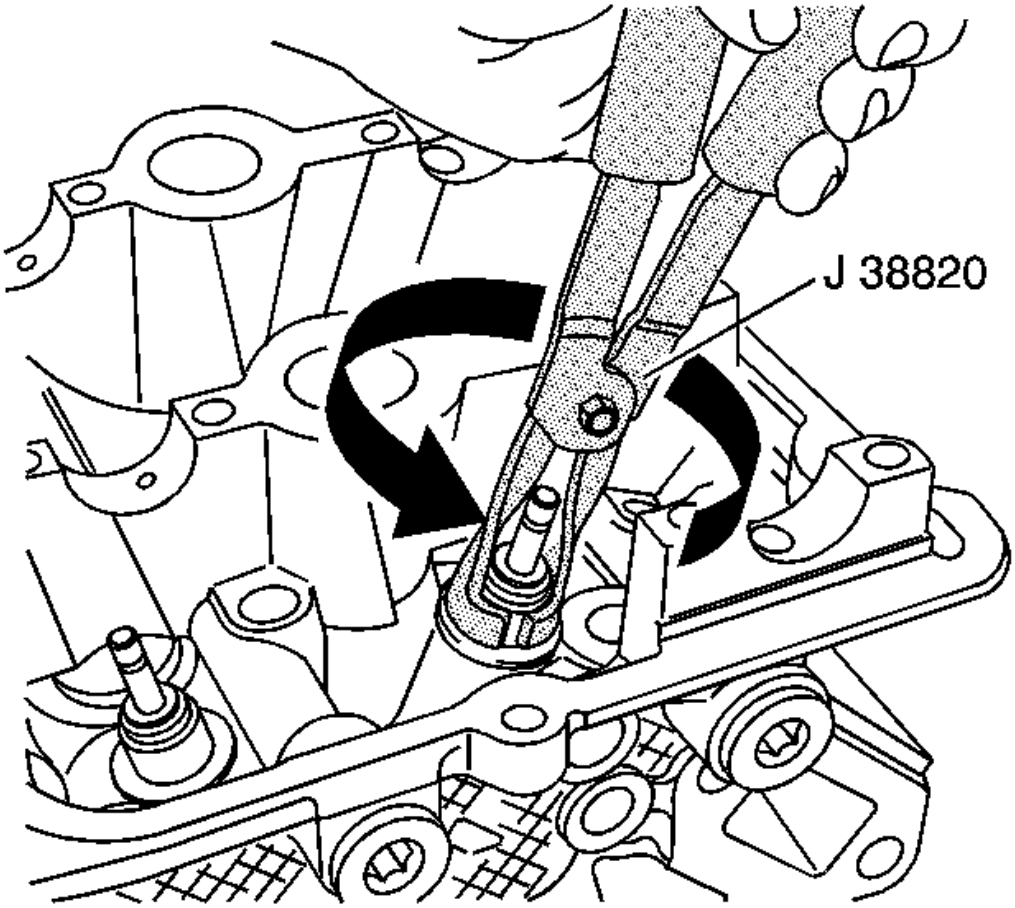

Fig. 337: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: The valve stem seal should not be removed unless replacement is required.

16. Use the **J 38820** in order to grip the seal. See **Special Tools** . Remove the seal by exerting a twisting, pulling motion. Discard the old valve stem seal.
17. Inspect and measure the valve spring. Refer to **Valve Spring Inspection and Measurement** .

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INSTALLATION PROCEDURE

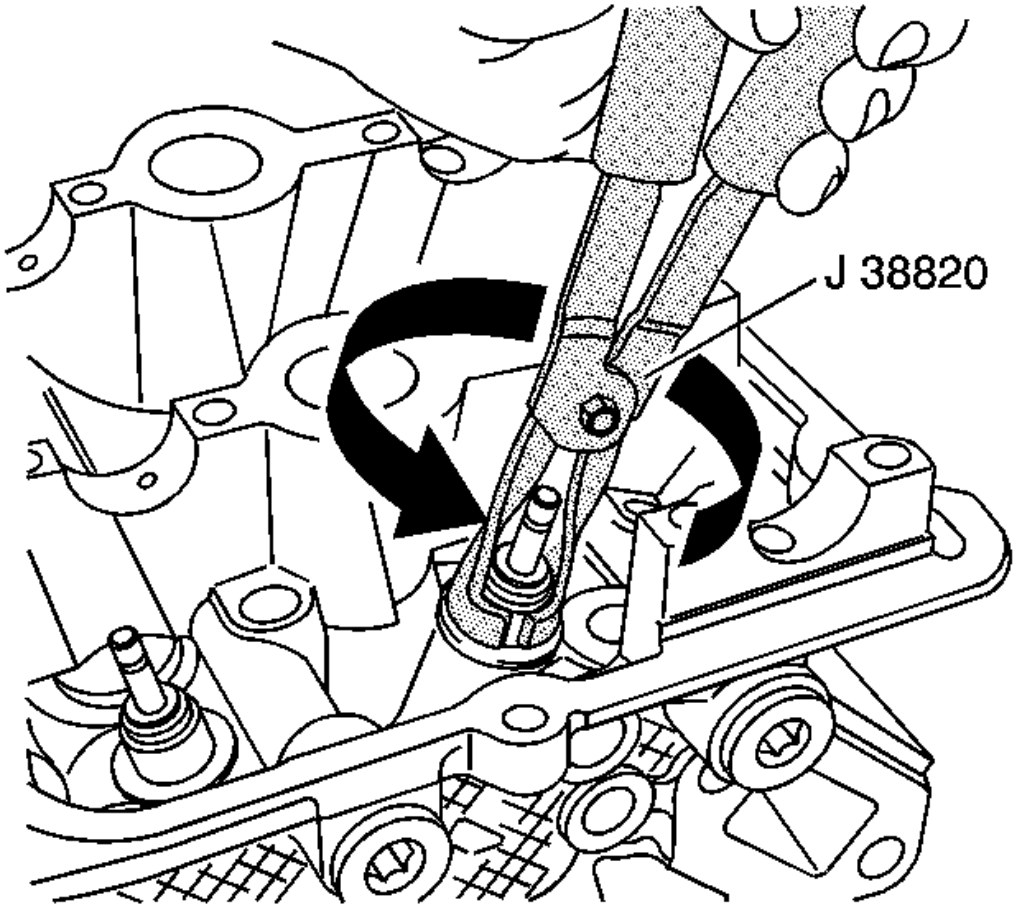

Fig. 338: Removing/Installing Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem and the inner diameter of the new seal with clean engine oil.

NOTE: Install a seal protector over the valve stem prior to installing the valve stem seal.

2. Using a twisting pushing motion install the NEW valve stem seal using the **J 38820** . See **Special Tools** .
3. Install the valve spring retainer and valve spring.

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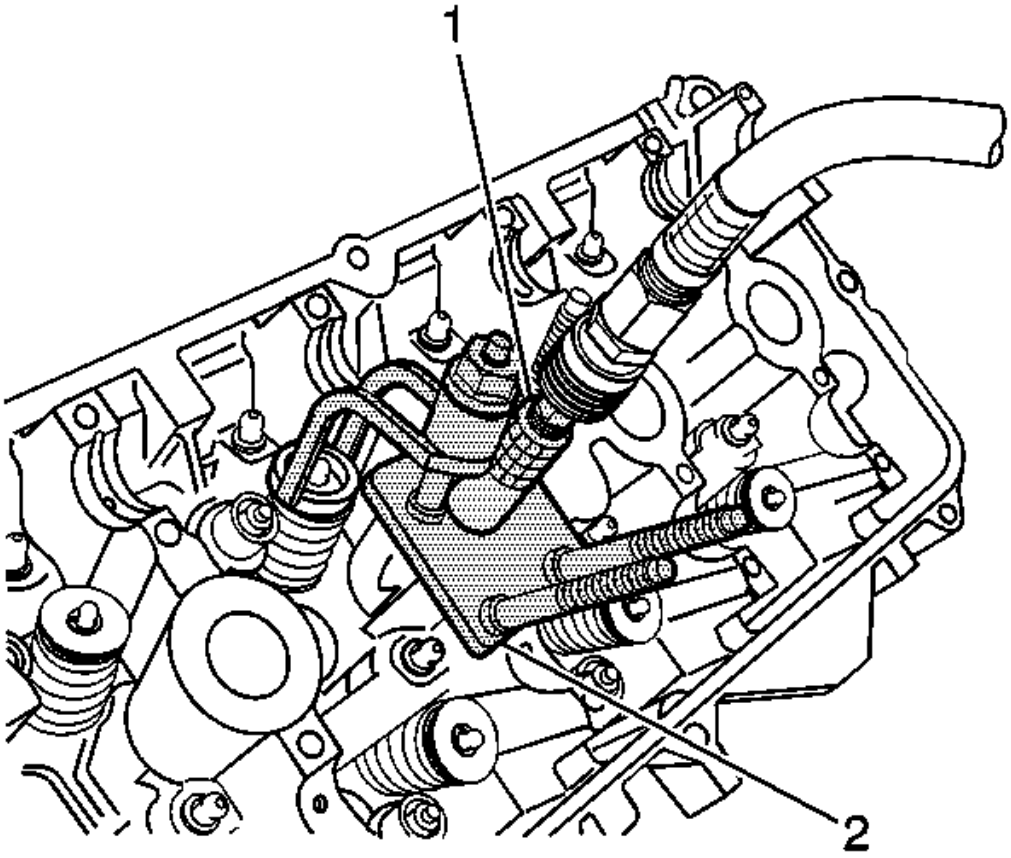

Fig. 339: Base Plate Installed Over Spark Plug Hole
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Compressed Valve Spring Warning .

4. Swing the arm over the valve spring retainer and tighten the swivel nut of the **J 44211** (2) down only enough to allow access for installation of the valve locks. See **Special Tools** .
5. Position the valve locks to the valve stem retainer groove using the **J 43059** .
6. Remove the swivel nut and arm of the **J 44211** (2). See **Special Tools** .
7. Install the arm and swivel nut of the **J 44211** (2) over the stud of any other valves being serviced and repeat removal steps 12 through 17 and installation steps 1 through 7. See **Special Tools** .
8. Relieve the air pressure to the cylinder being serviced.
9. Remove the **J 39313** (1) from the spark plug hole. See **Special Tools** .

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10. Remove the base plate of the **J 44211** (2). See **Special Tools** .
11. Install the spark plug. Refer to **Spark Plug Replacement** .
12. Repeat removal steps 7 through 17 and installation steps 1 through 11 on any other cylinders being serviced.
13. Install the right camshafts. Refer to **Camshaft Replacement - Right Side**.
14. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

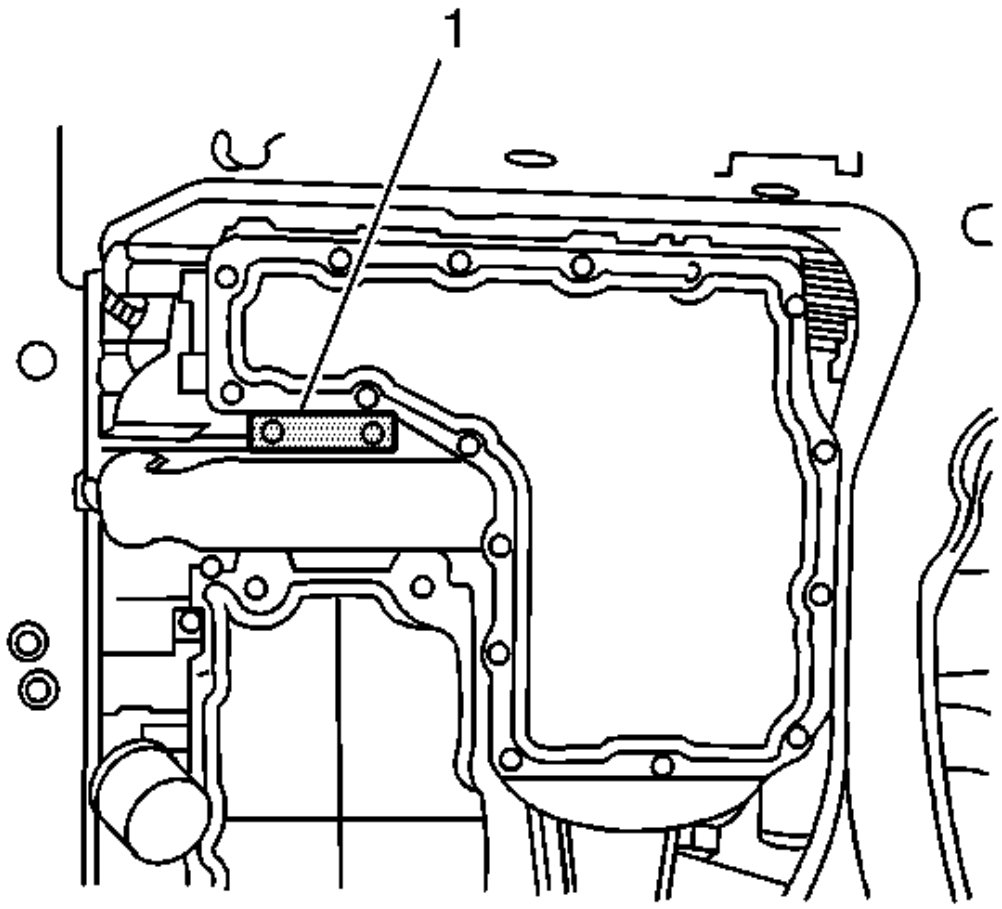

Fig. 340: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

15. Remove the **J 44214** (1). See **Special Tools** .
16. Install the torque converter cover. Refer to **Torque Converter Cover Replacement** .

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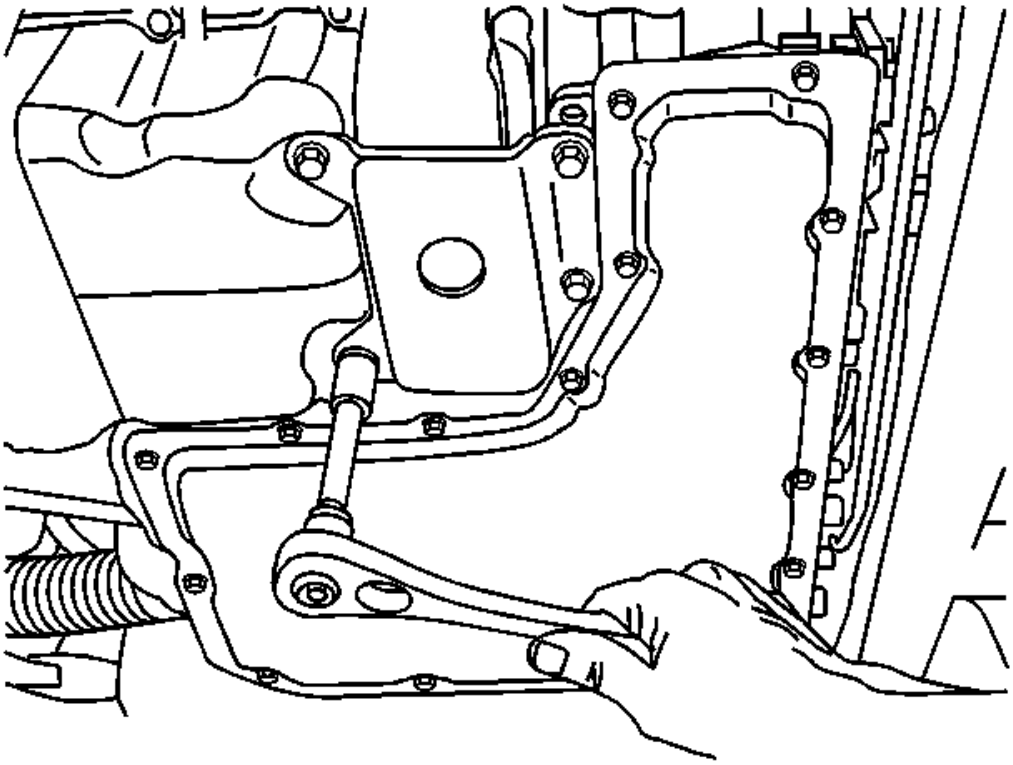

Fig. 341: Brace Between Engine Oil Pan & Transaxle Case
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

17. Install the oil pan to transaxle brace.

    Tighten: Tighten the oil pan to transaxle brace bolts to 50 N.m (37 lb ft).

18. Lower the vehicle.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Special Tools

- **J 28410** Gasket Remover. See **Special Tools** .
- **J 45059** Angle Meter

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REMOVAL PROCEDURE

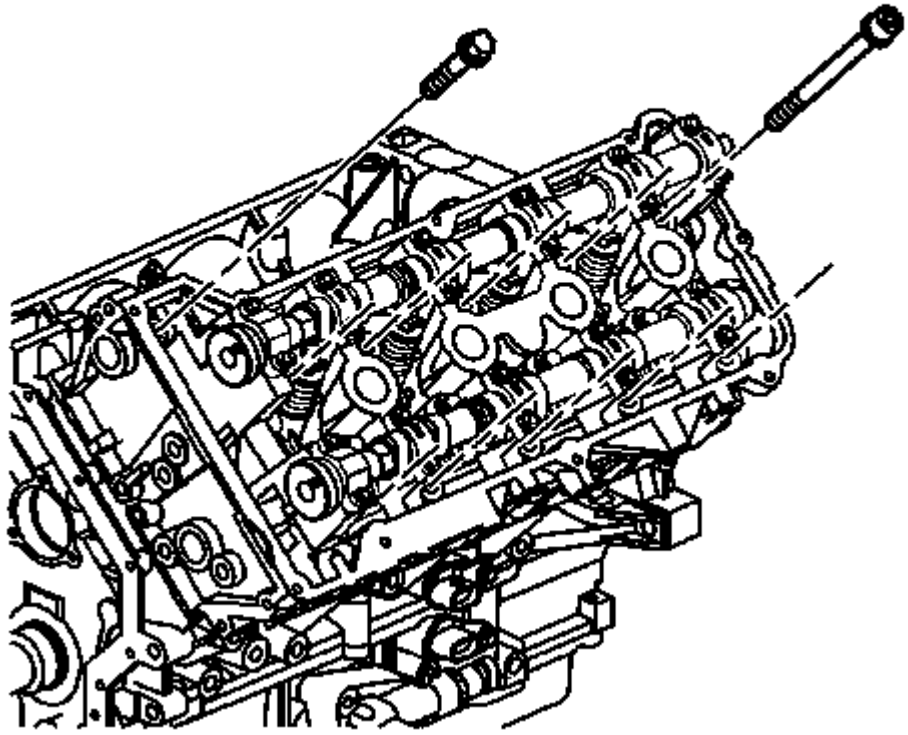

Fig. 342: Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side** .
2. Remove the engine mount strut bracket. Refer to **Engine Mount Strut Bracket Replacement - Right Side**.
3. Remove the generator. Refer to **Generator Replacement (V8)** .
4. Remove the water crossover. Refer to **Engine Coolant Crossover Pipe Replacement** .
5. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
6. Remove the camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
7. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
8. Remove the left secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Left Side**.
9. Remove the 3 M6 cylinder head bolts.

NOTE: DO NOT reuse the M11 cylinder head bolts.

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10. Remove and discard the 10 M11 cylinder head bolts.

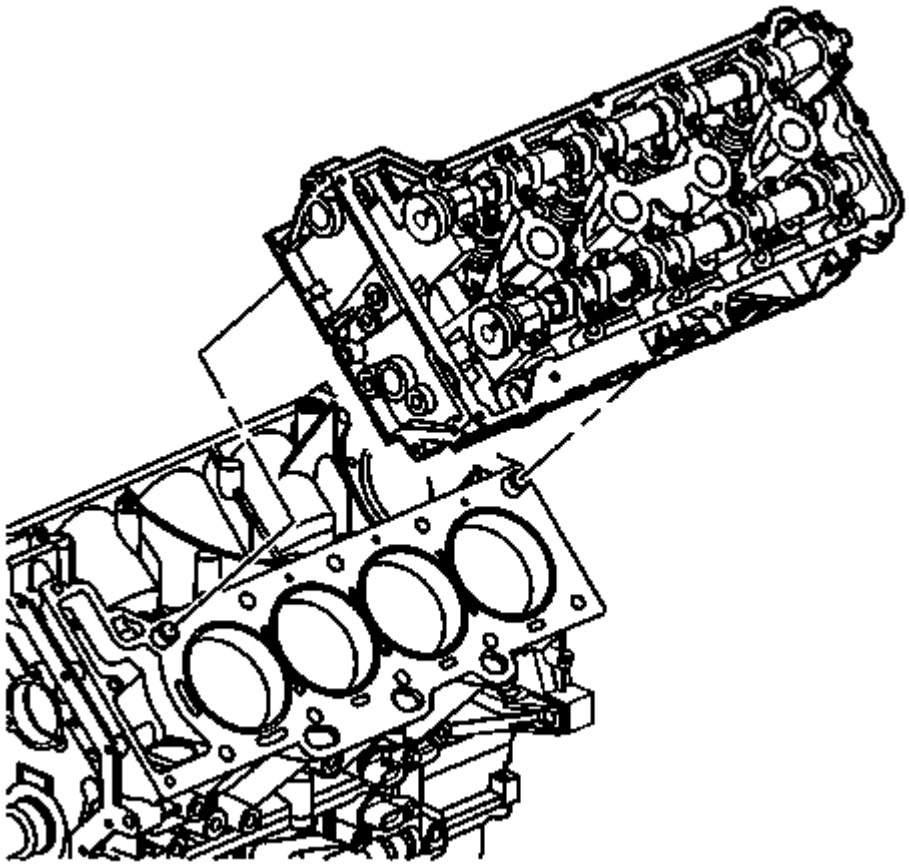

Fig. 343: Cylinder Head With Alignment Dowels - Left
Courtesy of GENERAL MOTORS CORP.

11. Remove the left cylinder head. Make sure that no locating pins are stuck in the cylinder head.

NOTE: You must clean the thread sealant material from the cylinder head bolt holes in the cylinder block. Failure to do so could cause false torque readings during reassembly.

12. After removing the cylinder head, remove any remaining bolt thread sealant material from the threaded cylinder block holes.

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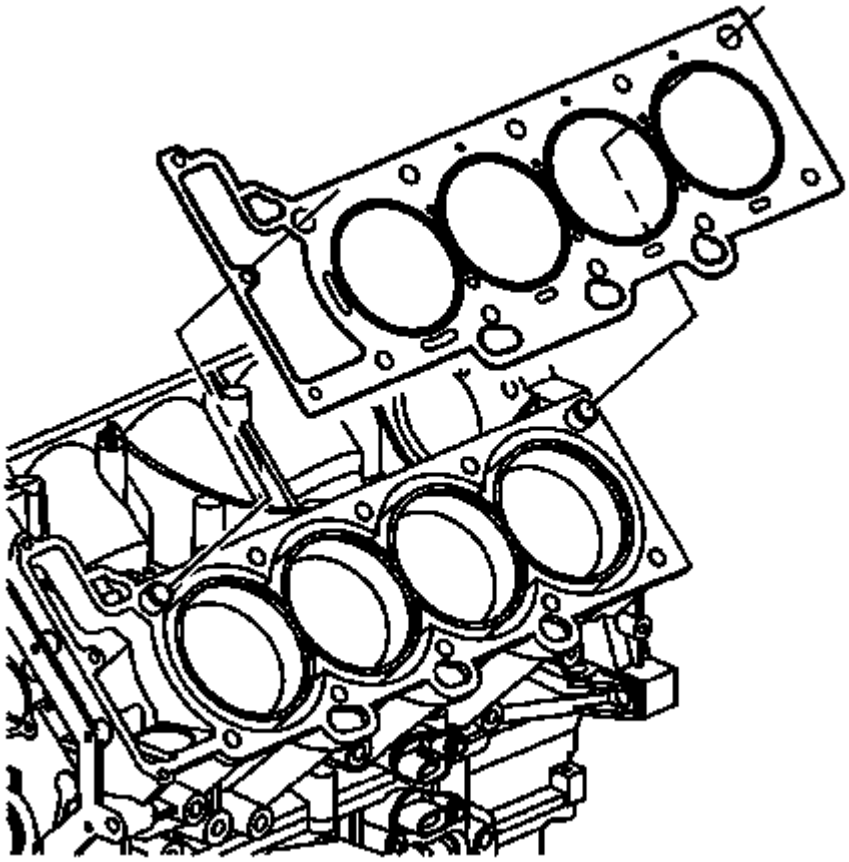

Fig. 344: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT reuse the cylinder head gasket.

13. Remove and discard the left cylinder head gasket.
14. Remove all remaining gasket material from the cylinder head and cylinder block using the **J 28410** . See **Special Tools** .
15. Place the cylinder head on a clean, flat surface with the combustion chambers face-up in order to prevent damage to the deck face.
16. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .

INSTALLATION PROCEDURE

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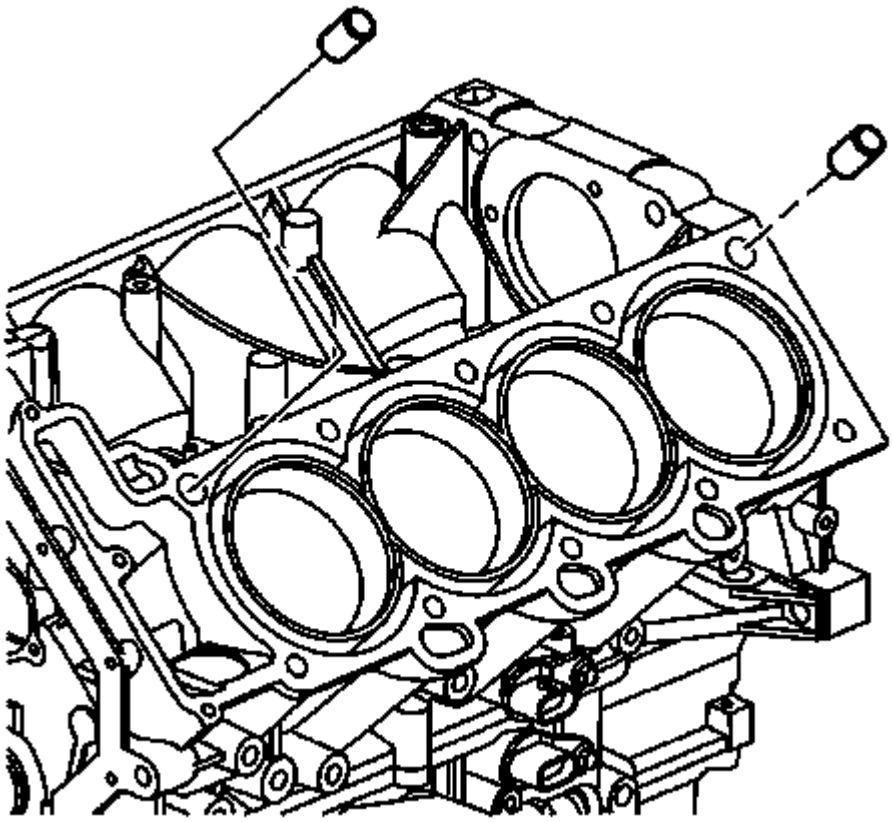

Fig. 345: Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

1. Make sure all the cylinder head locating pins are securely installed in the cylinder block deck face.

NOTE: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

2. Make sure all old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.

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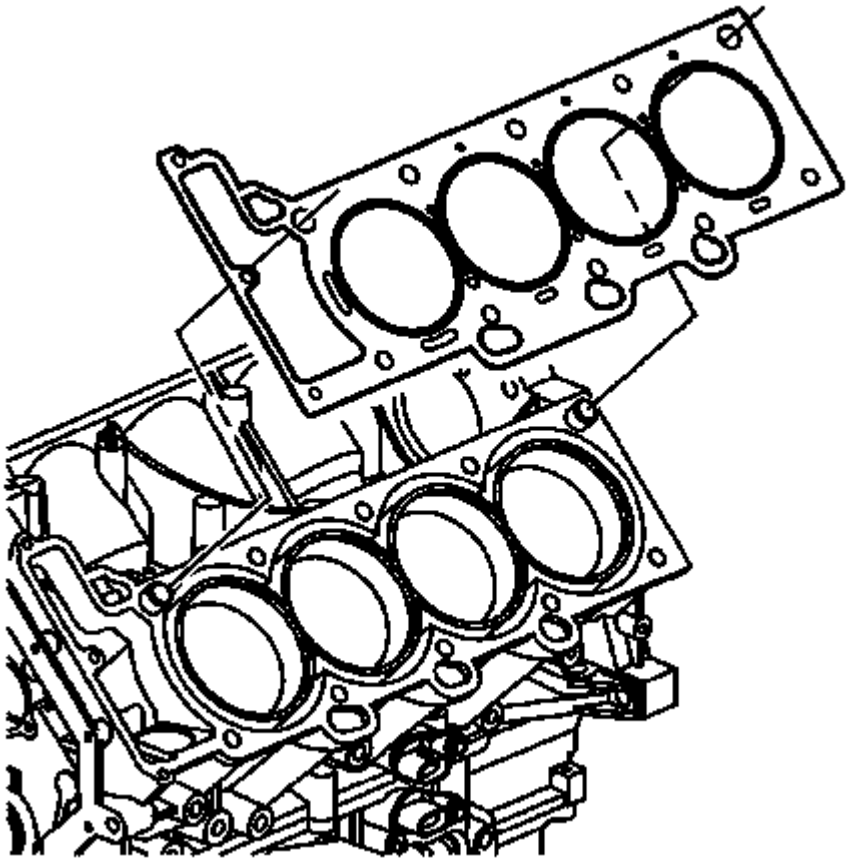

Fig. 346: Left Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW cylinder head gasket using the locating pins for retention.

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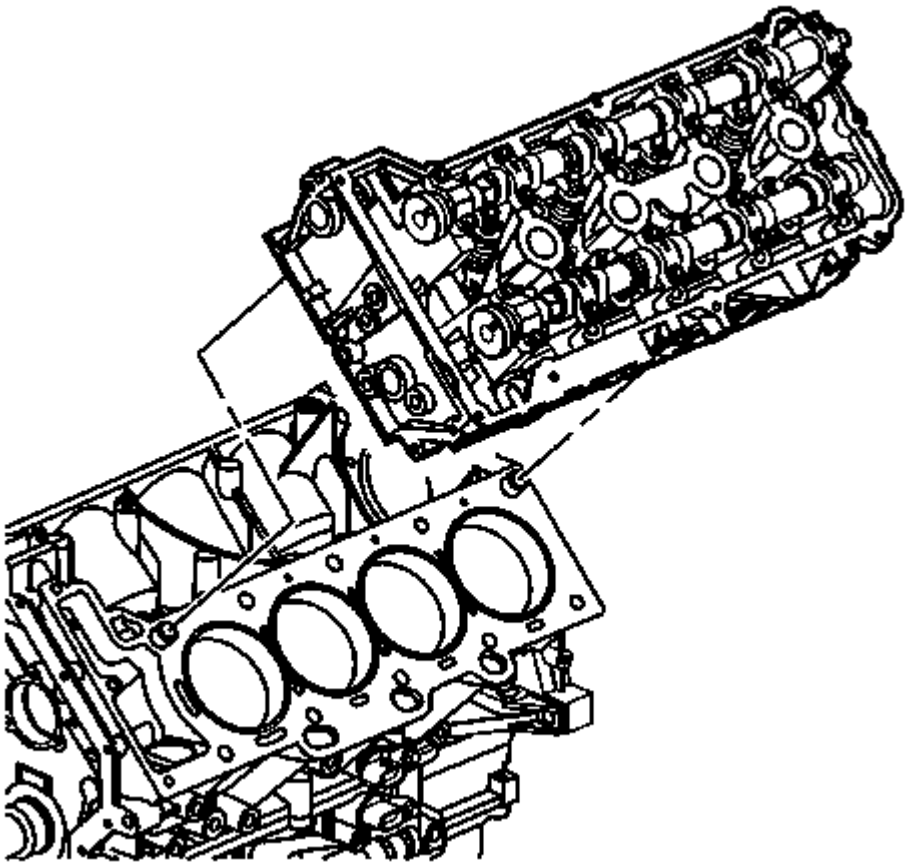

Fig. 347: Cylinder Head With Alignment Dowels - Left
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the locating pins.
5. Place the cylinder head in position on the cylinder block.

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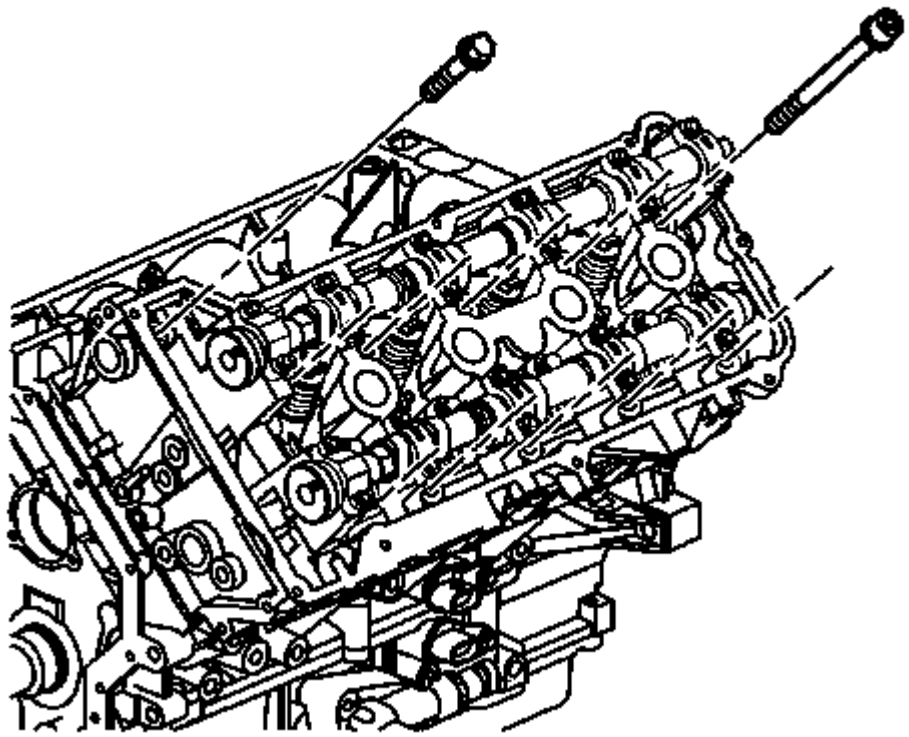

Fig. 348: Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install 10 NEW M11 cylinder head bolts until snug.
7. Install the 3 M6 cylinder head bolts until snug.

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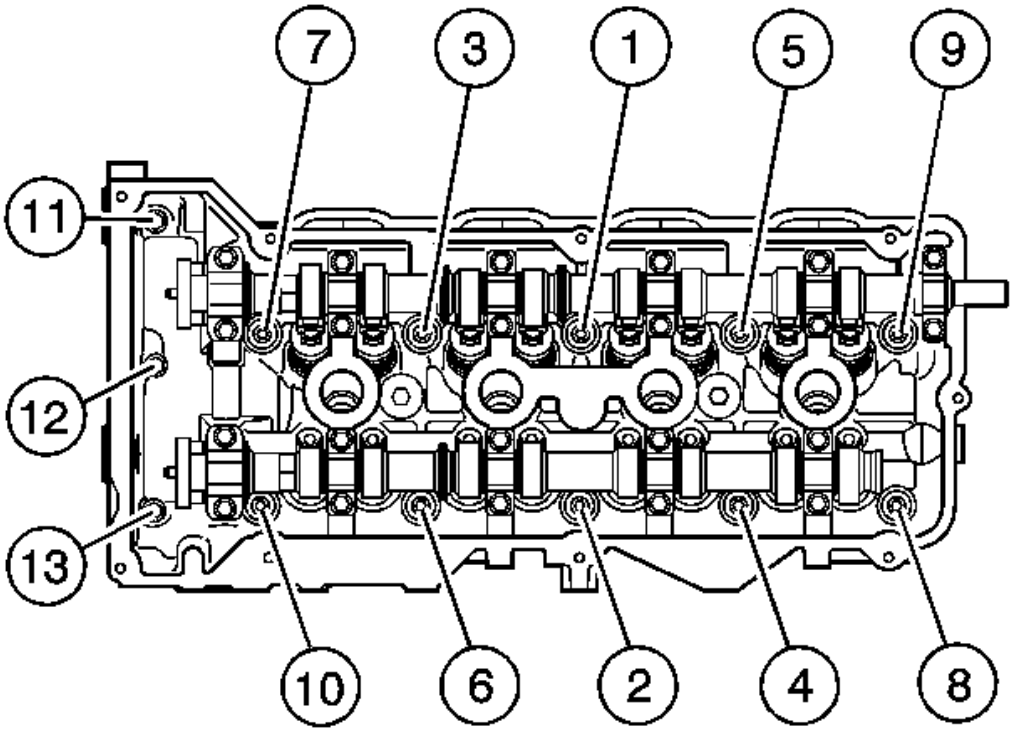

Fig. 349: Identifying Left Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the 10 M11 cylinder head bolts.

   Tighten:
   1. Tighten the bolts (1-10) a first pass in the sequence shown to 30 N.m (22 lb ft).
   2. Tighten the bolts a second pass in the sequence shown an additional 70 degrees using the **J 45059** .
   3. Tighten the bolts a third pass in the sequence shown an additional 60 degrees using the **J 45059** .
   4. Tighten the bolts a final pass in the sequence shown an additional 45 degrees (total 175 degrees) using the **J 45059** .

9. Tighten the 3 M6 bolts cylinder head.

   Tighten: Tighten the bolts to 12 N.m (106 lb in).

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10. Install the left secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Left Side**.
11. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
12. Install the camshaft cover. Refer to **Camshaft Cover Replacement - Left Side**.
13. Install the intake manifold. Refer to **Intake Manifold Replacement**.
14. Install the water crossover. Refer to **Engine Coolant Crossover Pipe Replacement** .
15. Install the generator. Refer to **Generator Replacement (V8)** .
16. Install the engine mount strut bracket. Refer to **Engine Mount Strut Bracket Replacement - Right Side**.
17. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side** .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Special Tools

- **J 28410** Gasket Remover. See **Special Tools** .
- **J 45059** Angle Meter

REMOVAL PROCEDURE

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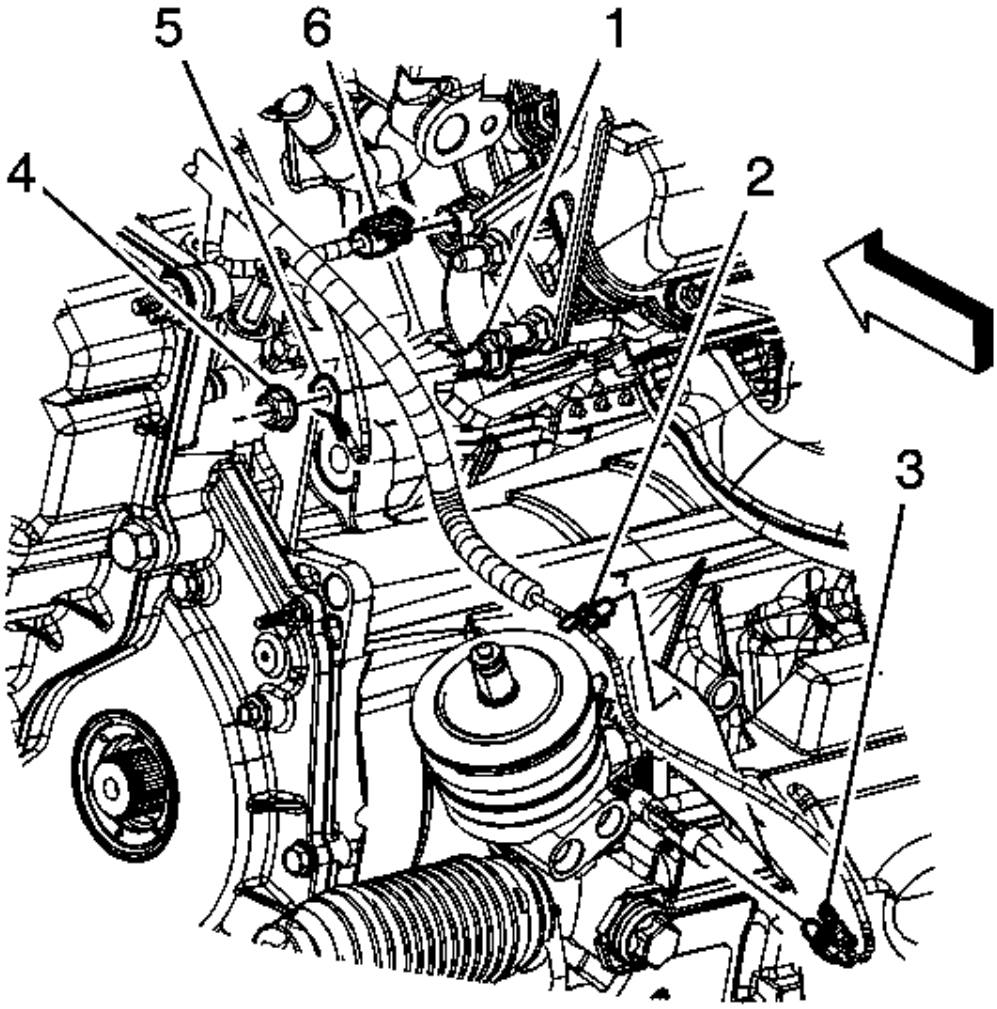

Fig. 350: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .
2. Remove the water crossover. Refer to **Engine Coolant Crossover Pipe Replacement** .
3. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
4. Remove the camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
5. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
6. Remove the right secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Right Side**.

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7. Disconnect the engine harness electrical connector (6) from the engine coolant temperature (ECT) sensor.
8. Remove the engine harness ground terminal nut (4).
9. Remove the engine harness ground terminal (5).

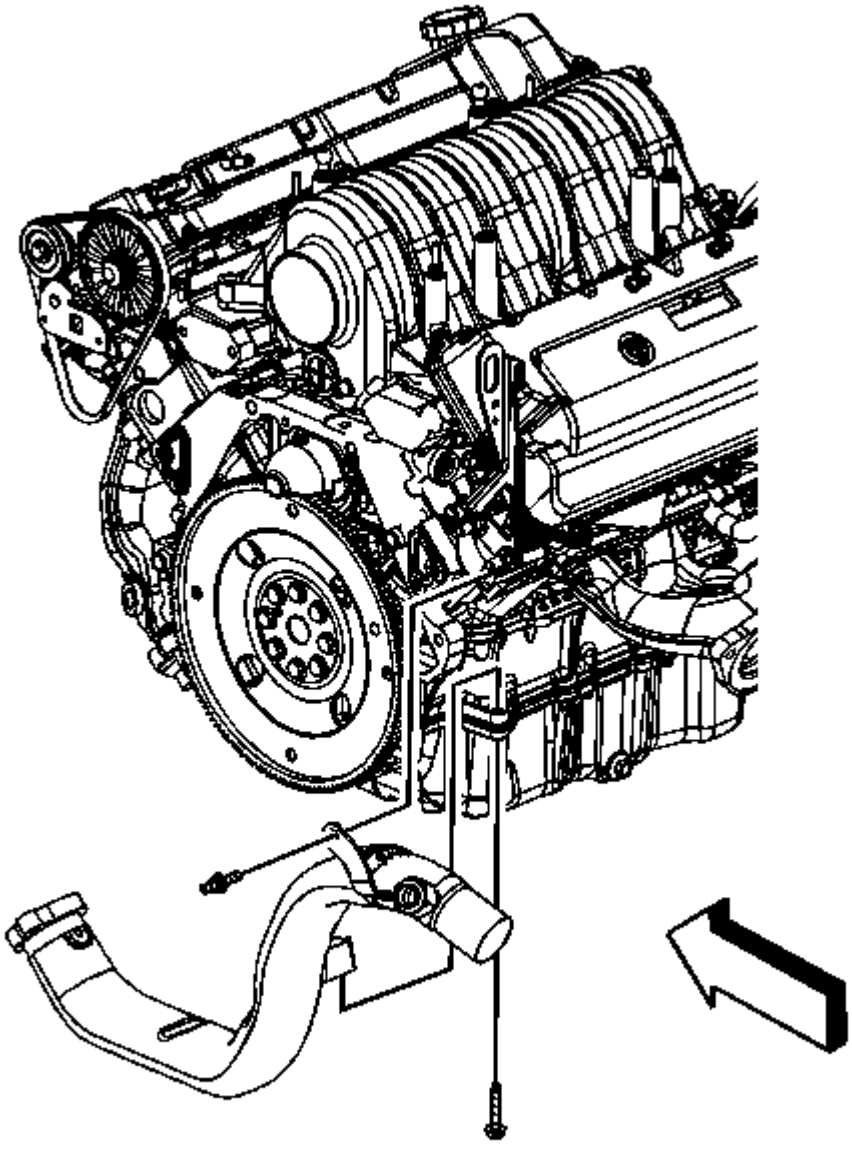

Fig. 351: Exhaust Manifold Front Pipe
Courtesy of GENERAL MOTORS CORP.

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10. Remove the stud attaching the exhaust manifold front pipe to the cylinder head.
11. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

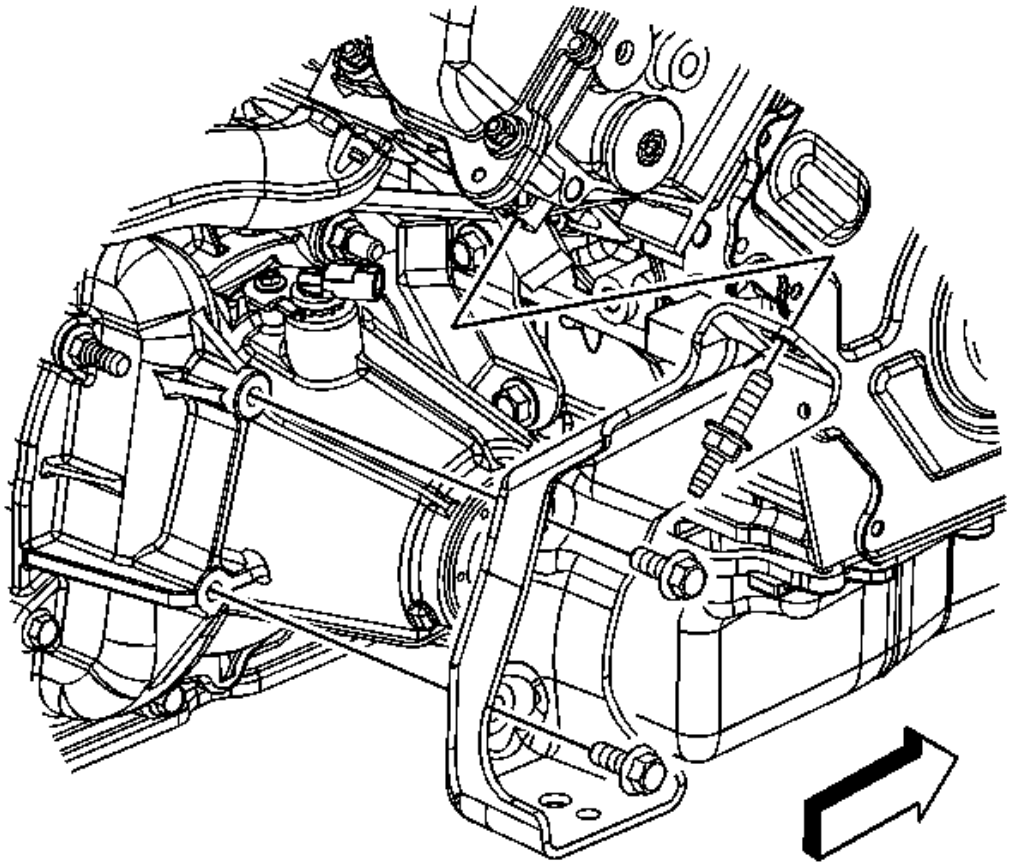

Fig. 352: Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

12. Remove the stud attaching the right engine mount bracket to the cylinder head.
13. Loosen the bolts attaching the engine mount bracket to the transaxle.

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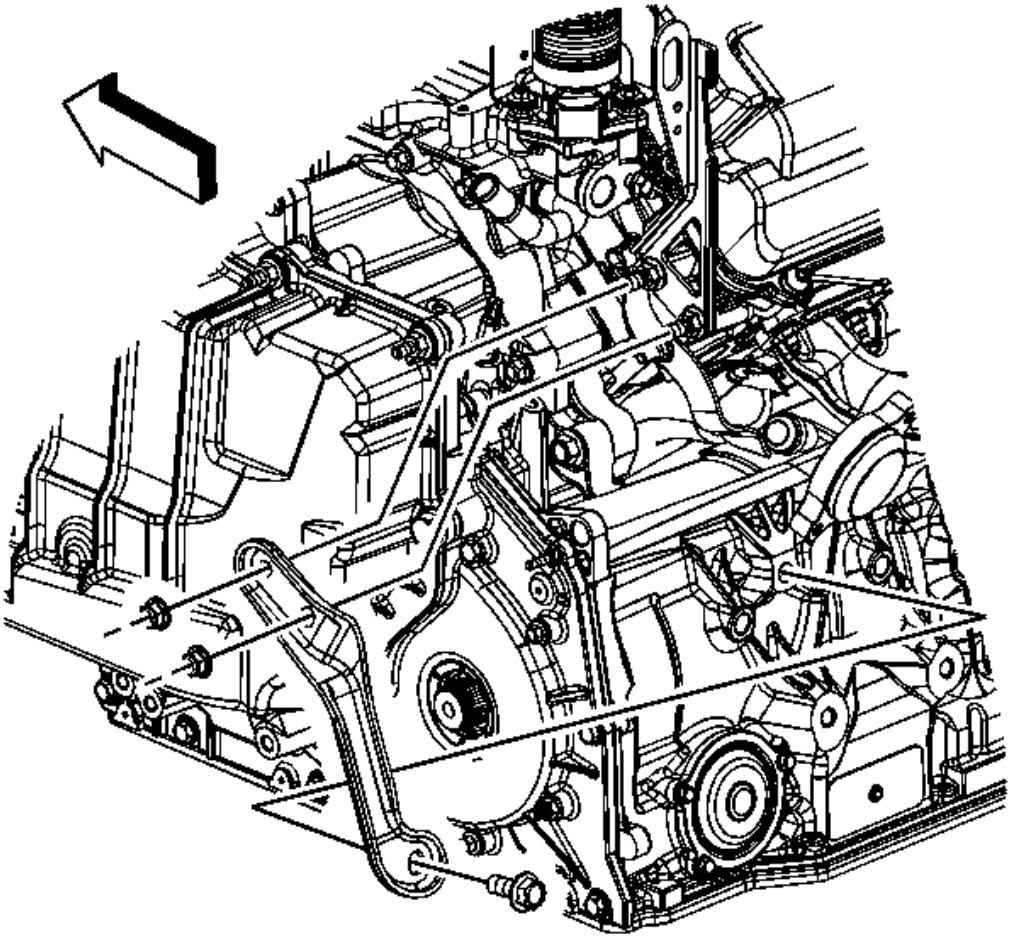

Fig. 353: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

14. Remove the bolt attaching the transaxle brace to the transaxle.
15. Lower the vehicle.
16. Remove the nuts attaching the transaxle brace to the lift bracket studs.
17. Remove the transaxle brace.

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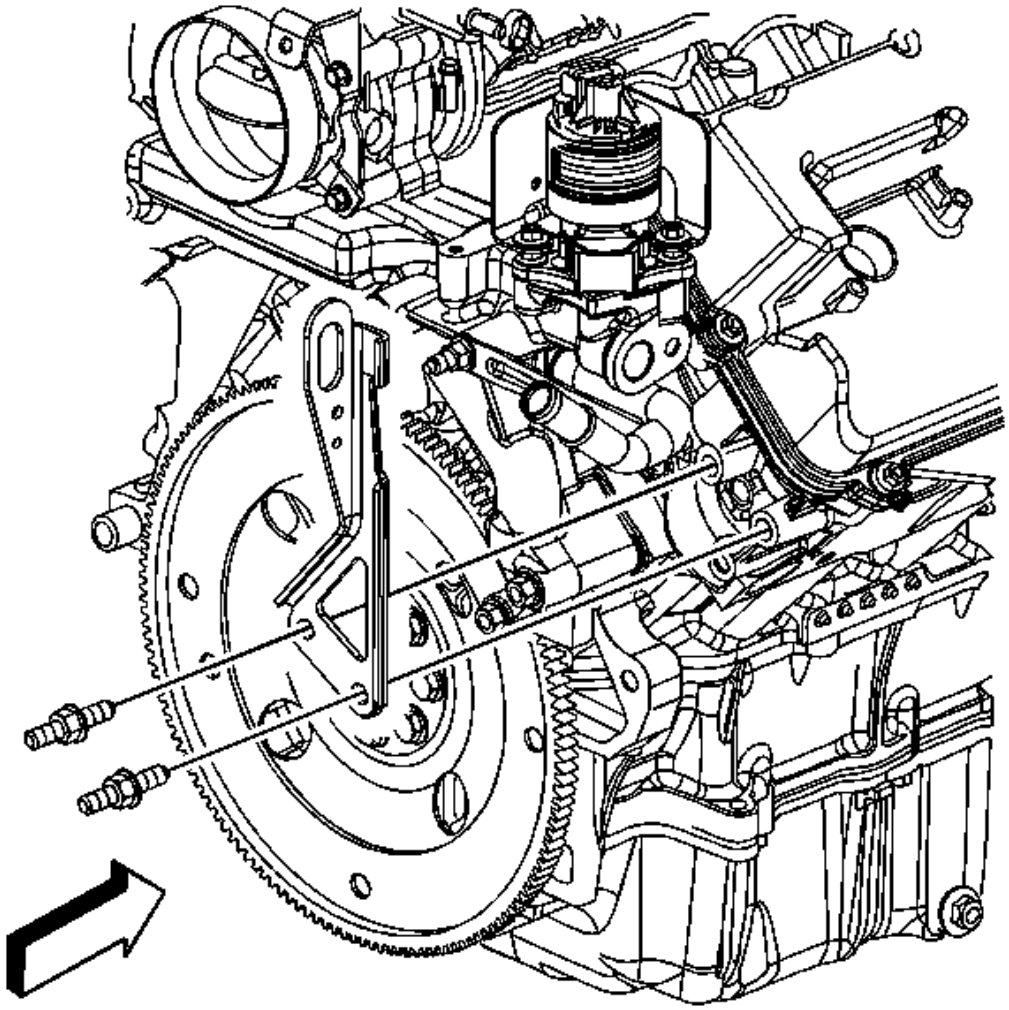

Fig. 354: Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

18. Remove the rear lift bracket studs.
19. Remove the rear lift bracket.

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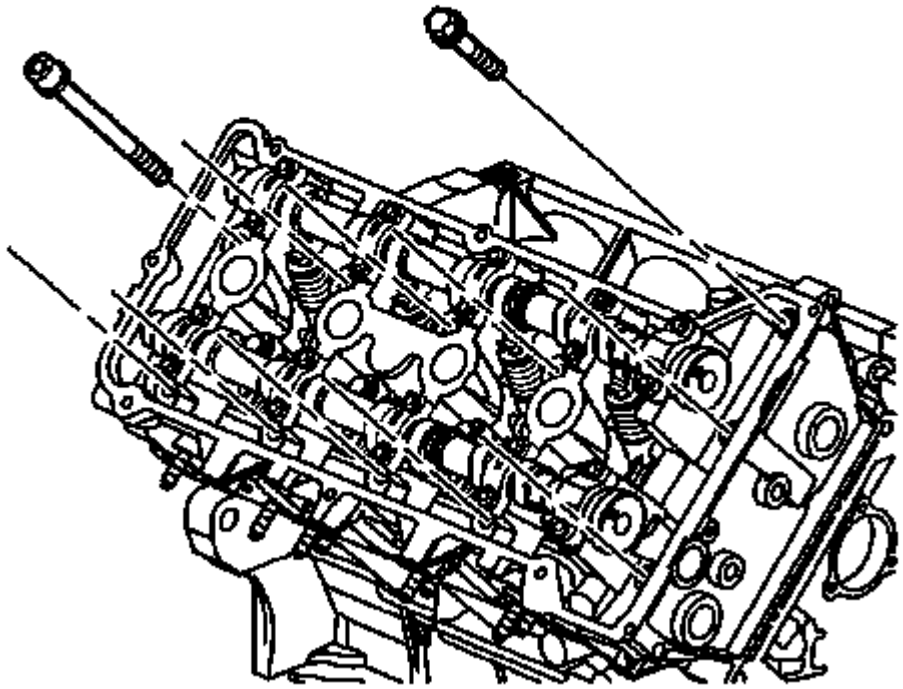

Fig. 355: Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

20. Remove the 3 M6 cylinder head bolts.

NOTE: DO NOT reuse the M11 cylinder head bolts.

21. Remove and discard the 10 M11 cylinder head bolts.

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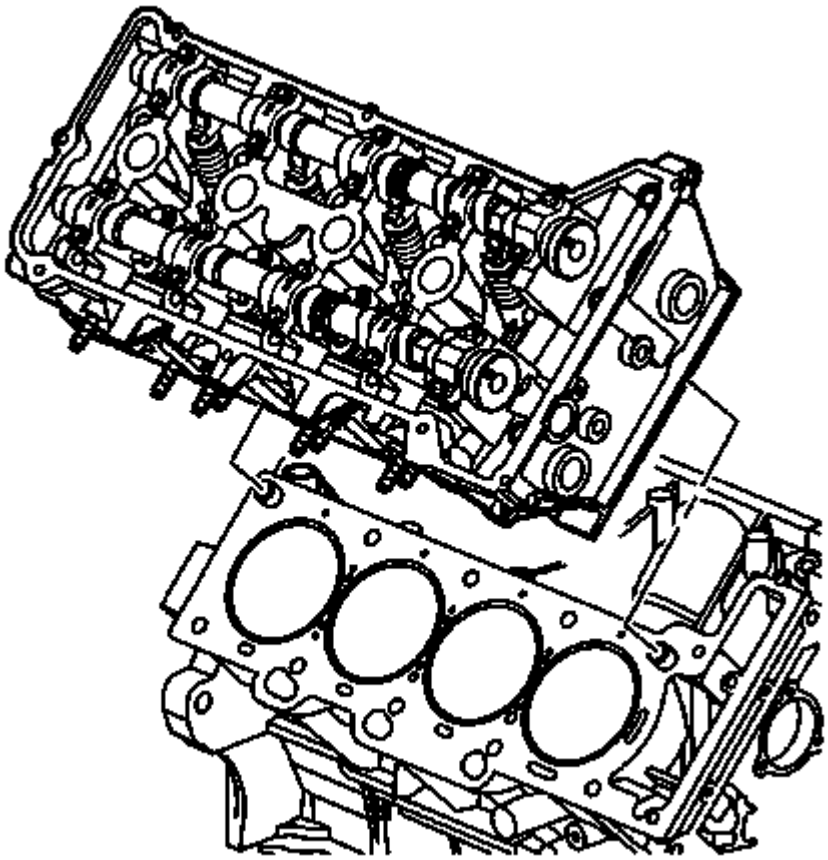

Fig. 356: Cylinder Head With Alignment Dowels - Right
Courtesy of GENERAL MOTORS CORP.

22. Remove the right cylinder head. Make sure that no locating pins are stuck in the cylinder head.

NOTE: You must clean the thread sealant material from the cylinder head bolt holes in the cylinder block. Failure to do so could cause false torque readings during reassembly.

23. After removing the cylinder head, remove any remaining bolt thread sealant material from the threaded cylinder block holes.

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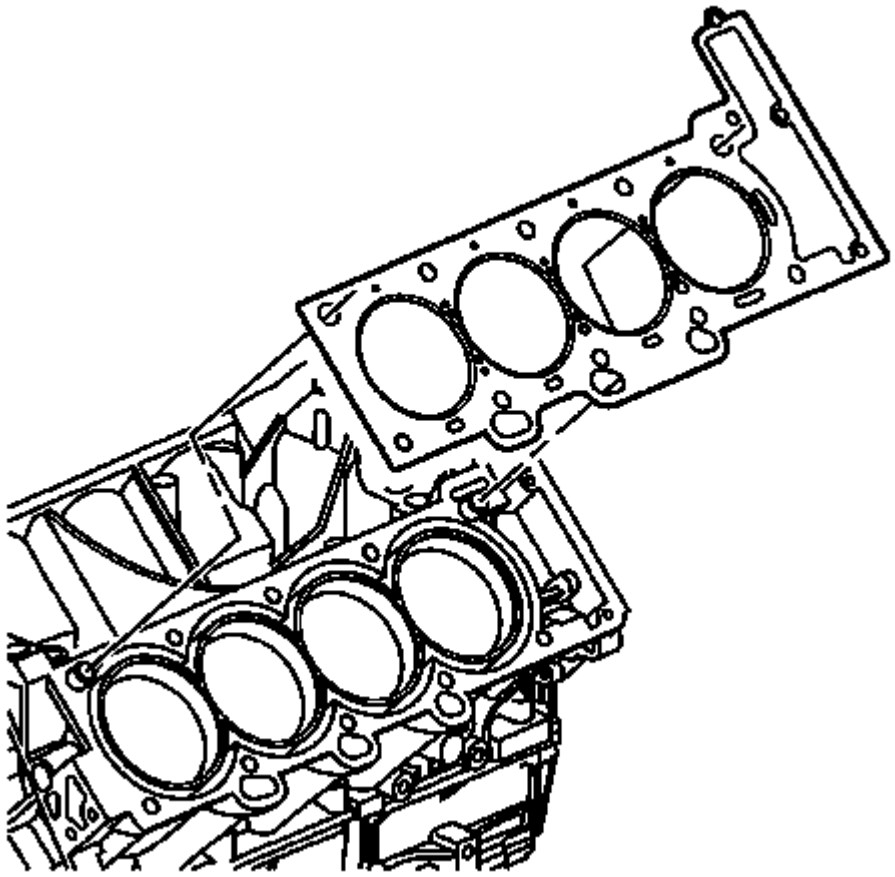

Fig. 357: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT reuse the cylinder head gasket.

24. Remove and discard the right cylinder head gasket.
25. Remove all remaining gasket material from the cylinder head and cylinder block using the **J 28410** . See **Special Tools** .
26. Place the cylinder head on a clean, flat surface with the combustion chambers face-up in order to prevent damage to the deck face.
27. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection** .

INSTALLATION PROCEDURE

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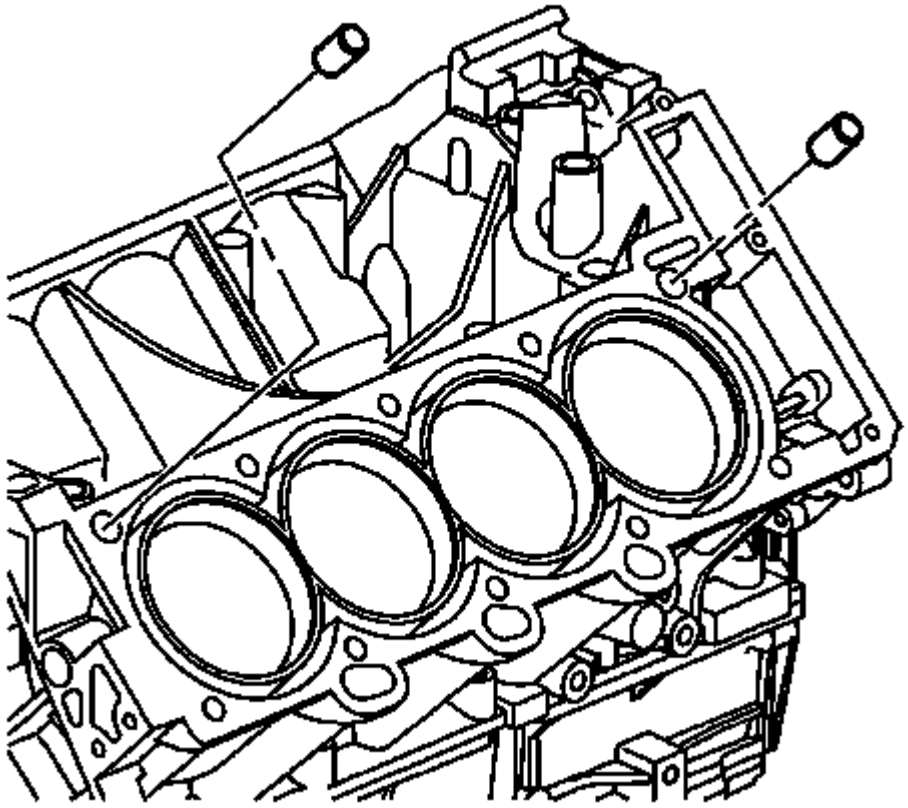

Fig. 358: Cylinder Head Locating Pins
Courtesy of GENERAL MOTORS CORP.

1. Make sure the locating pins are securely mounted in the cylinder block deck face.

NOTE: Failure to remove all the old thread sealant material from the cylinder block could cause false torque readings.

2. Make sure any old thread sealant material is removed from the cylinder head bolt holes in the cylinder block.

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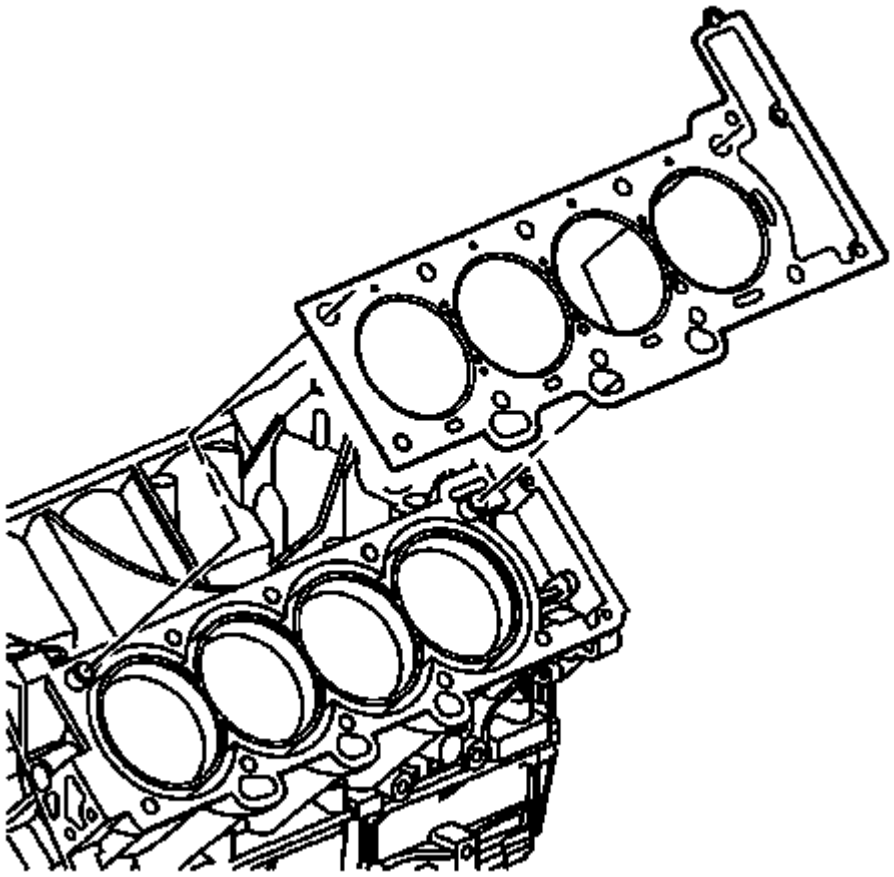

Fig. 359: Right Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW cylinder head gasket using the locating pins for retention.

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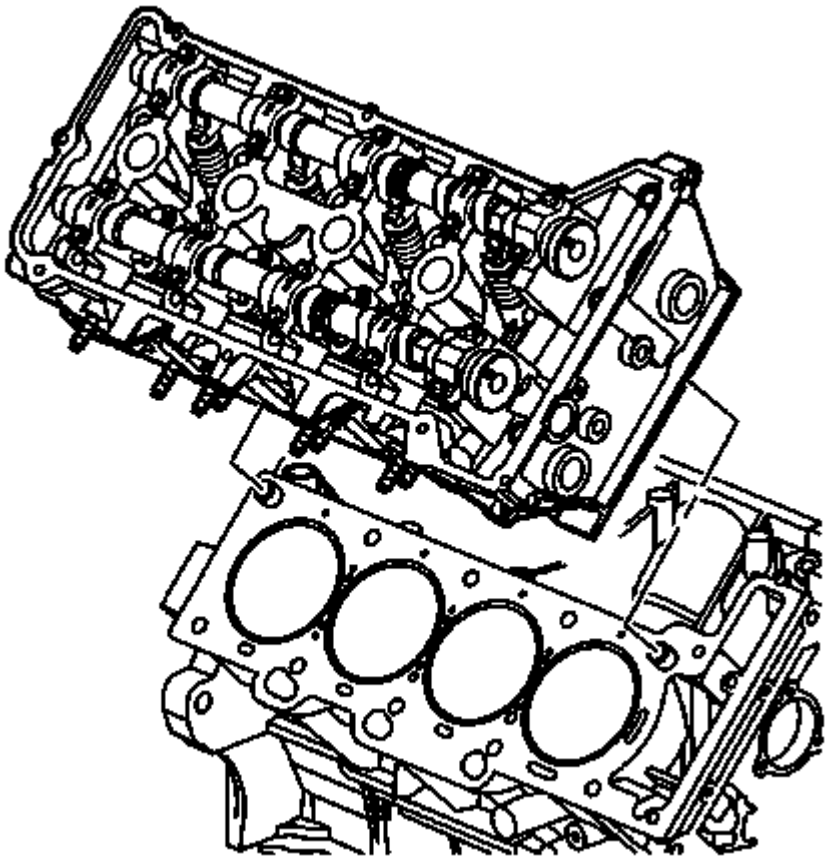

Fig. 360: Cylinder Head With Alignment Dowels - Right
Courtesy of GENERAL MOTORS CORP.

4. Align the cylinder head with the locating pins.
5. Place the cylinder head in position on the cylinder block.

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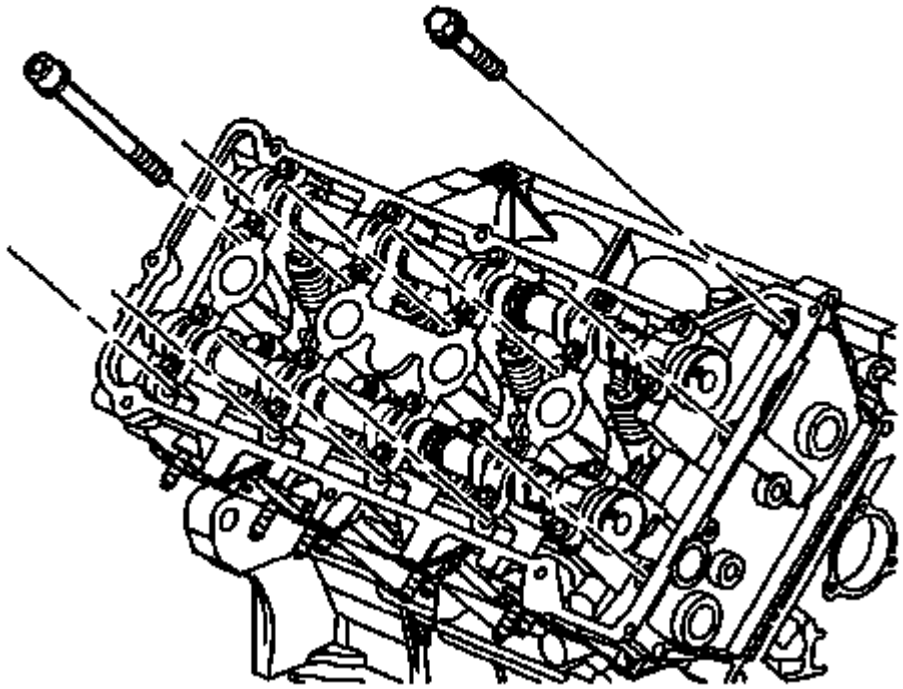

Fig. 361: Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install NEW M11 cylinder head bolts until snug.
7. Install the M6 cylinder head bolts until snug.

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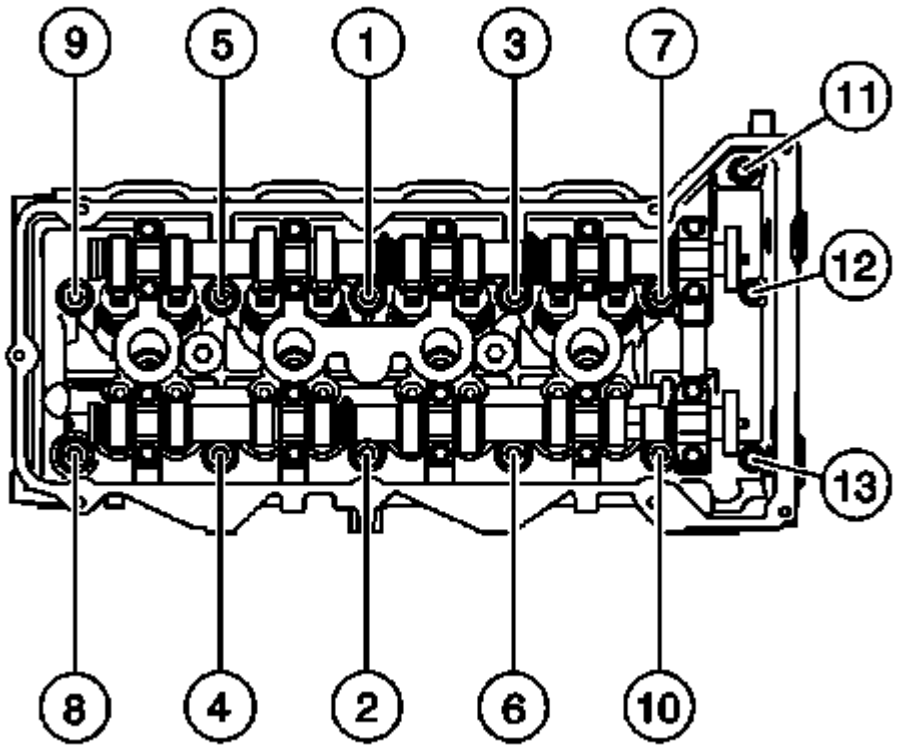

Fig. 362: Identifying Right Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the M11 cylinder head bolts.

   Tighten:
   1. Tighten the bolts (1-10) a first pass in the sequence shown to 30 N.m (22 lb ft).
   2. Tighten the bolts a second pass in the sequence shown an additional 70 degrees using the **J 45059** .
   3. Tighten the bolts a third pass in the sequence shown an additional 60 degrees using the **J 45059** .
   4. Tighten the bolts a final pass in the sequence shown an additional 45 degrees (total 175 degrees) using the **J 45059** .

9. Tighten the M6 cylinder head bolts.

   Tighten: Tighten the bolts to 12 N.m (106 lb in).

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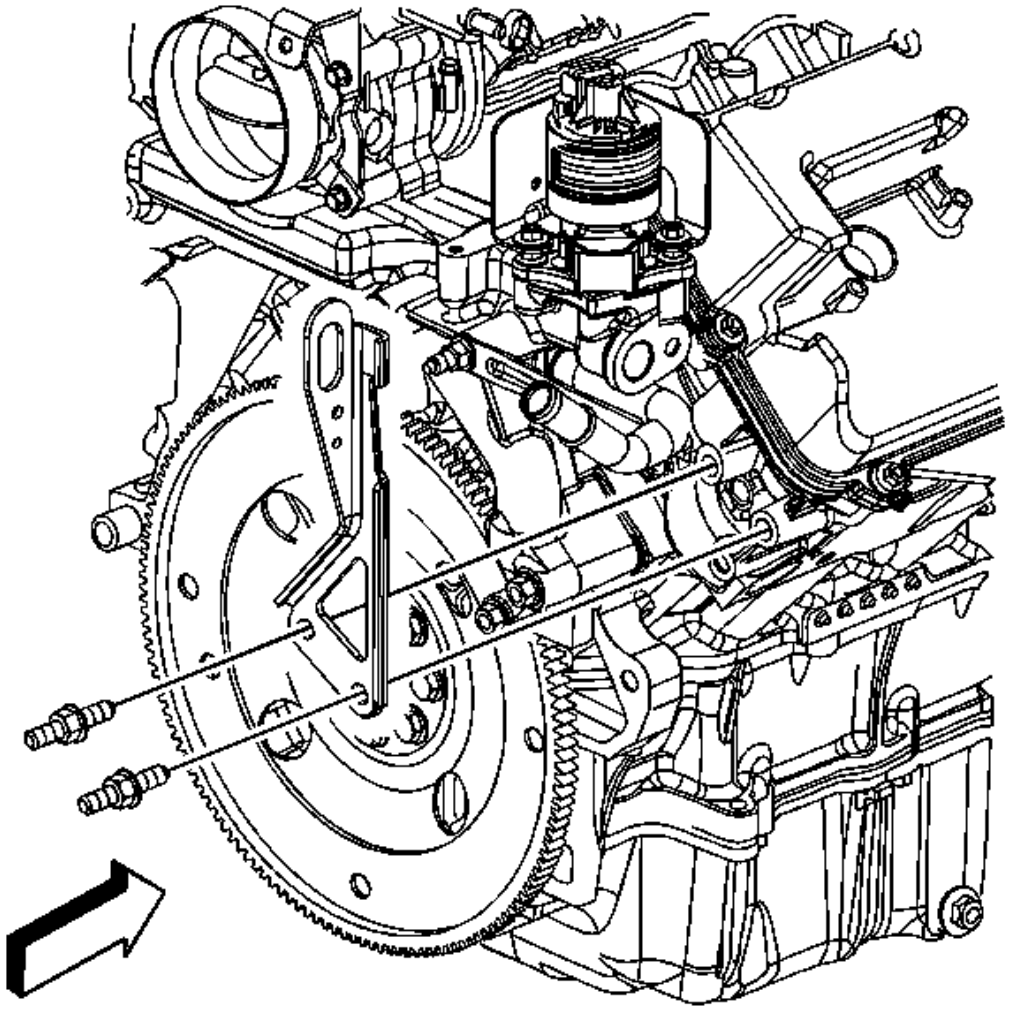

Fig. 363: Engine Lift Bracket
Courtesy of GENERAL MOTORS CORP.

10. Position the rear lift bracket to the cylinder head.
11. Install the rear lift bracket studs.

Tighten: Tighten the studs to 50 N.m (37 lb ft).

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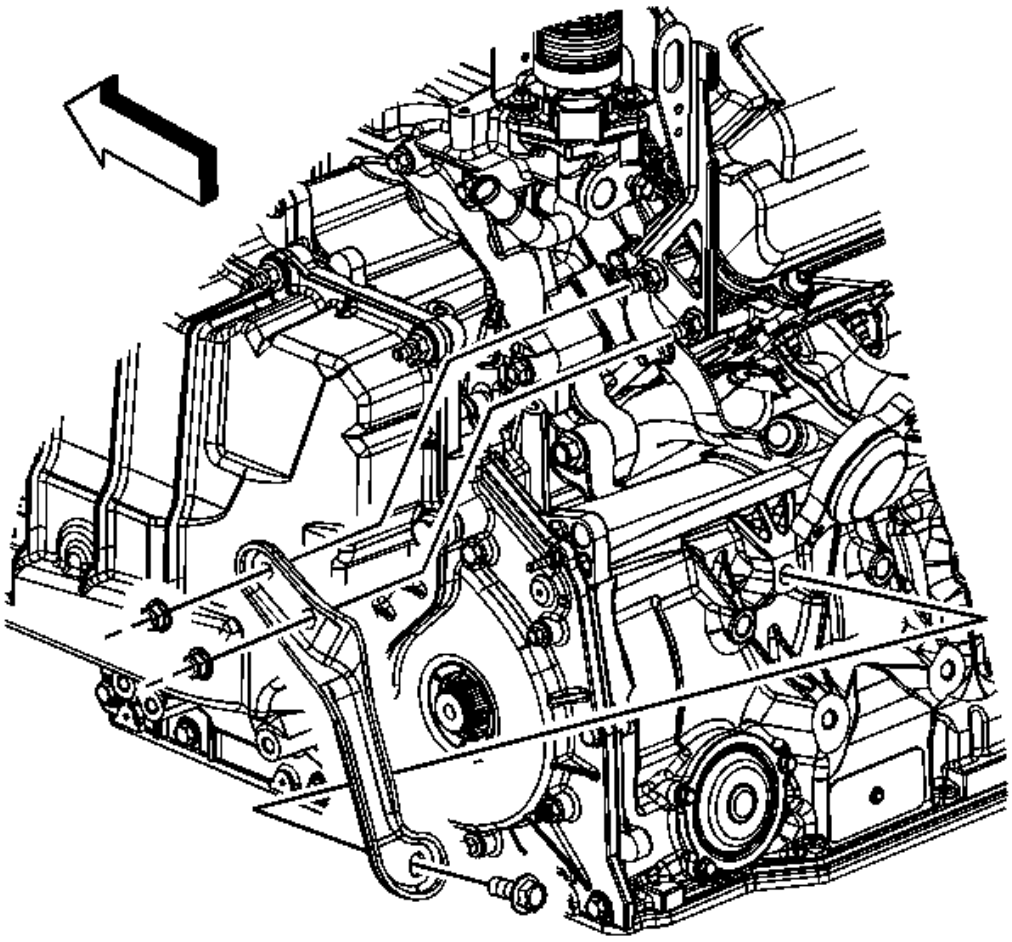

Fig. 364: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

12. Install the transaxle brace to the lift bracket studs.
13. Install the nuts attaching the transaxle brace to the lift bracket studs.

    Tighten: Tighten the nuts to 50 N.m (37 lb ft).

14. Raise the vehicle.
15. Install the bolt attaching the transaxle brace to the transaxle.

    Tighten: Tighten the bolt to 50 N.m (37 lb ft).

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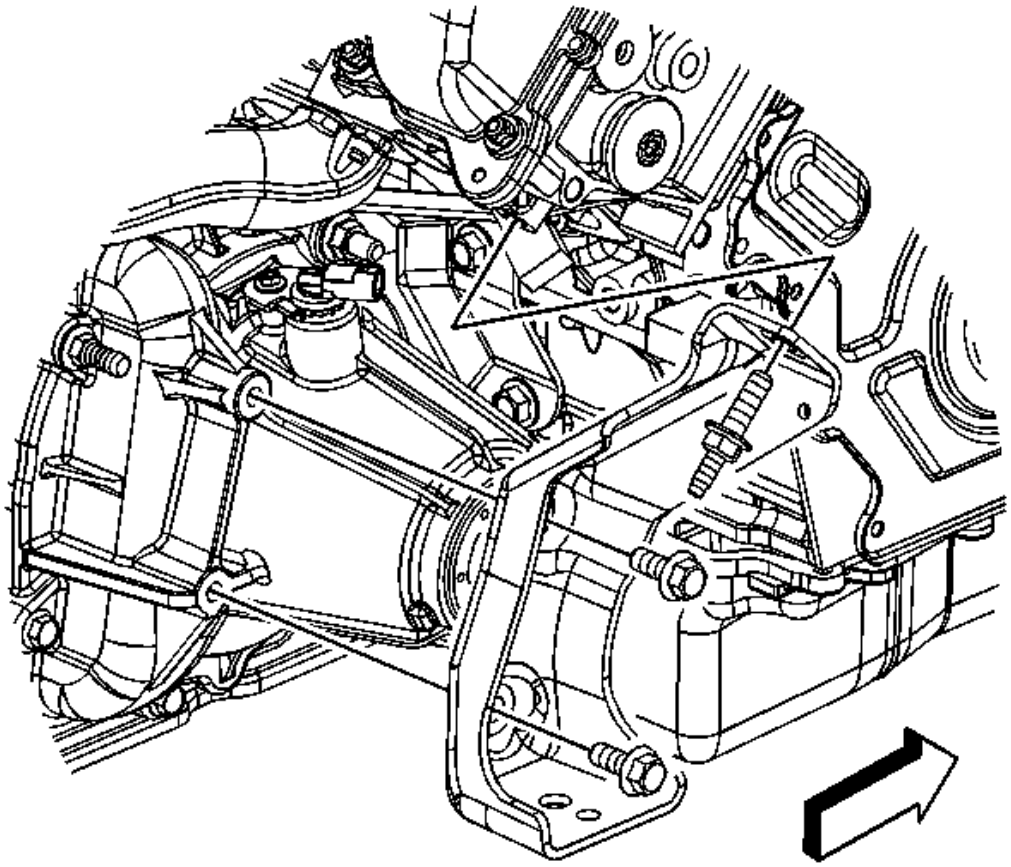

Fig. 365: Right Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

16. Install the stud attaching the right engine mount bracket to the cylinder head.

    Tighten: Tighten the bolt to 73 N.m (54 lb ft).

17. Tighten the bolts attaching the engine mount bracket to the transaxle.

    Tighten: Tighten the bolt to 73 N.m (54 lb ft).

18. Lower the vehicle.

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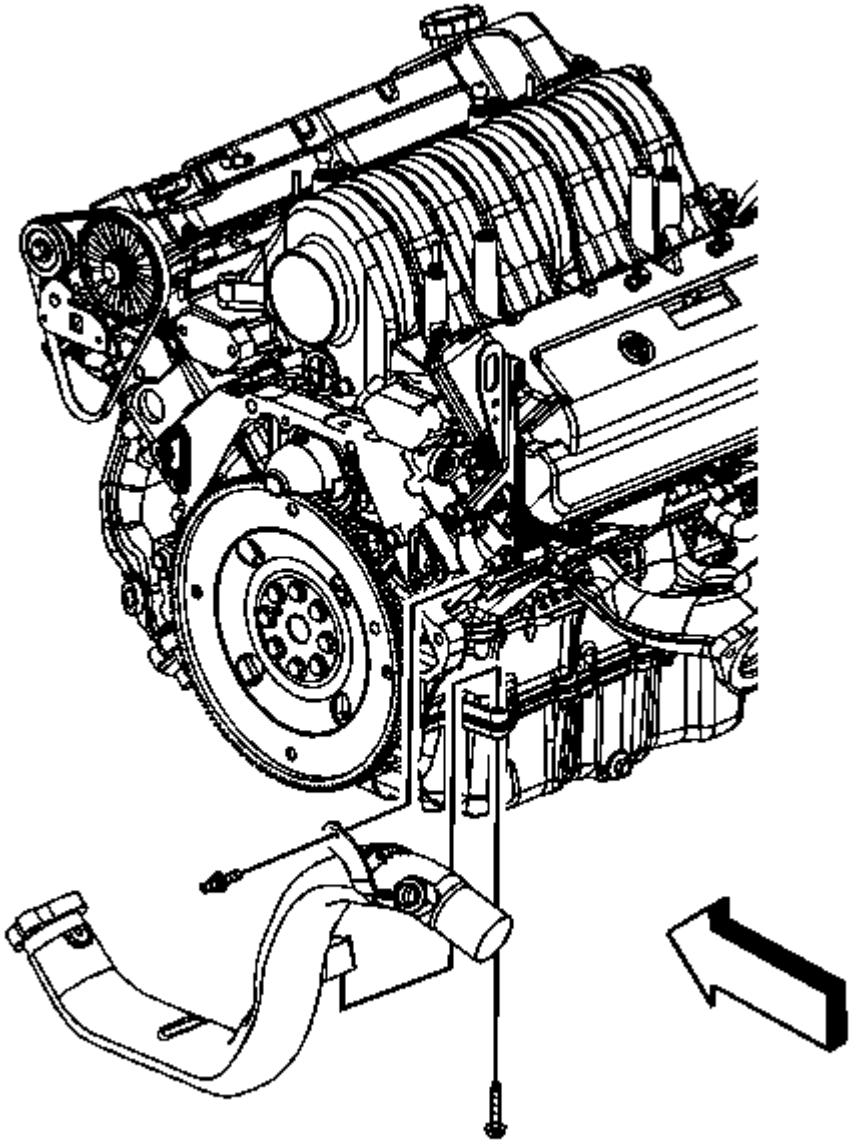

Fig. 366: Exhaust Manifold Front Pipe
Courtesy of GENERAL MOTORS CORP.

19. Install the stud attaching the exhaust manifold front pipe to the cylinder head.

    Tighten: Tighten the stud to 25 N.m (18 lb ft).

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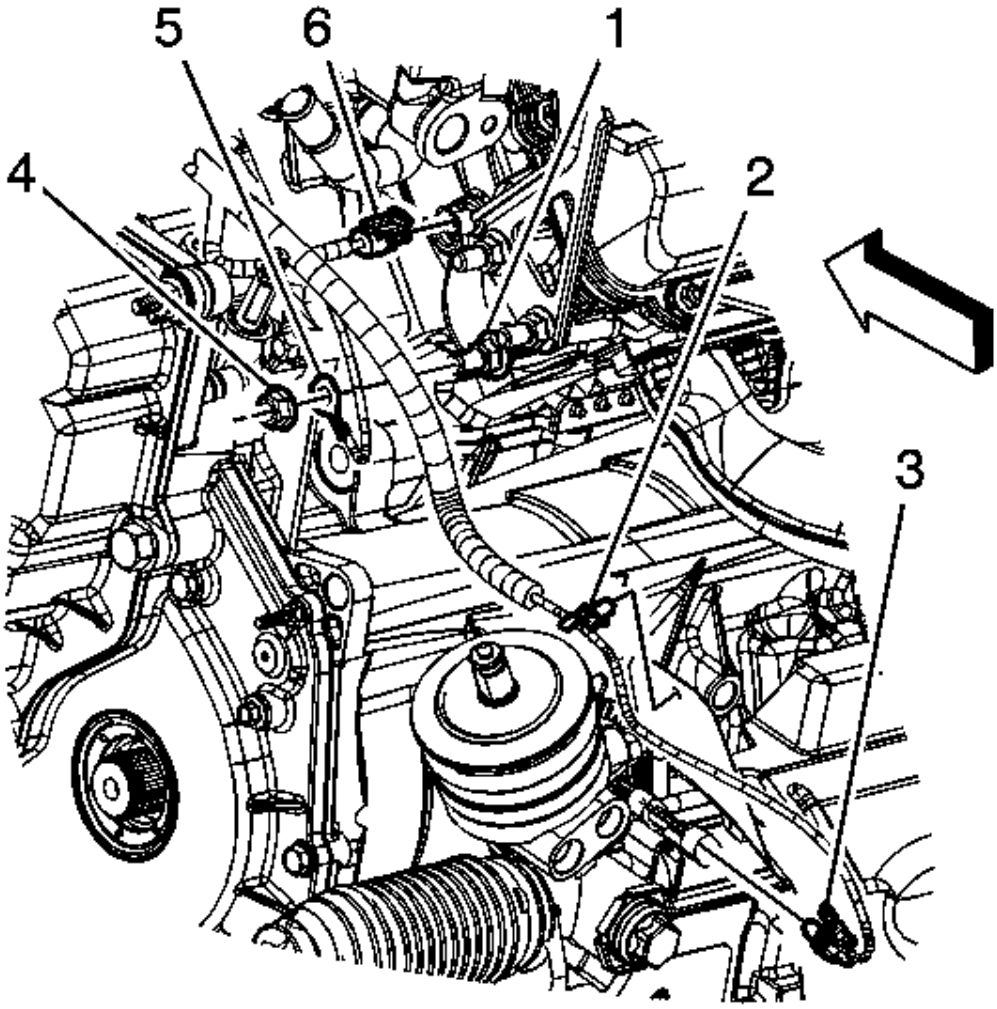

Fig. 367: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

20. Install the engine harness ground terminal (5) onto the stud (1).
21. Install the engine harness ground terminal nut (4).

    Tighten: Tighten the nut to 17 N.m (13 lb ft).

22. Connect the engine harness electrical connector (6) to the ECT sensor.
23. Install the right secondary camshaft drive chain. Refer to **Secondary Camshaft Intermediate Drive Chain Replacement - Right Side**.

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24. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
25. Install the camshaft cover. Refer to **Camshaft Cover Replacement - Right Side**.
26. Install the intake manifold. Refer to **Intake Manifold Replacement**.
27. Install the water crossover. Refer to **Engine Coolant Crossover Pipe Replacement** .
28. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .

ENGINE FLYWHEEL REPLACEMENT

Special Tools

- **J 45059** Angle Meter
- **J 44214** Flywheel Holder. See **Special Tools** .

REMOVAL PROCEDURE

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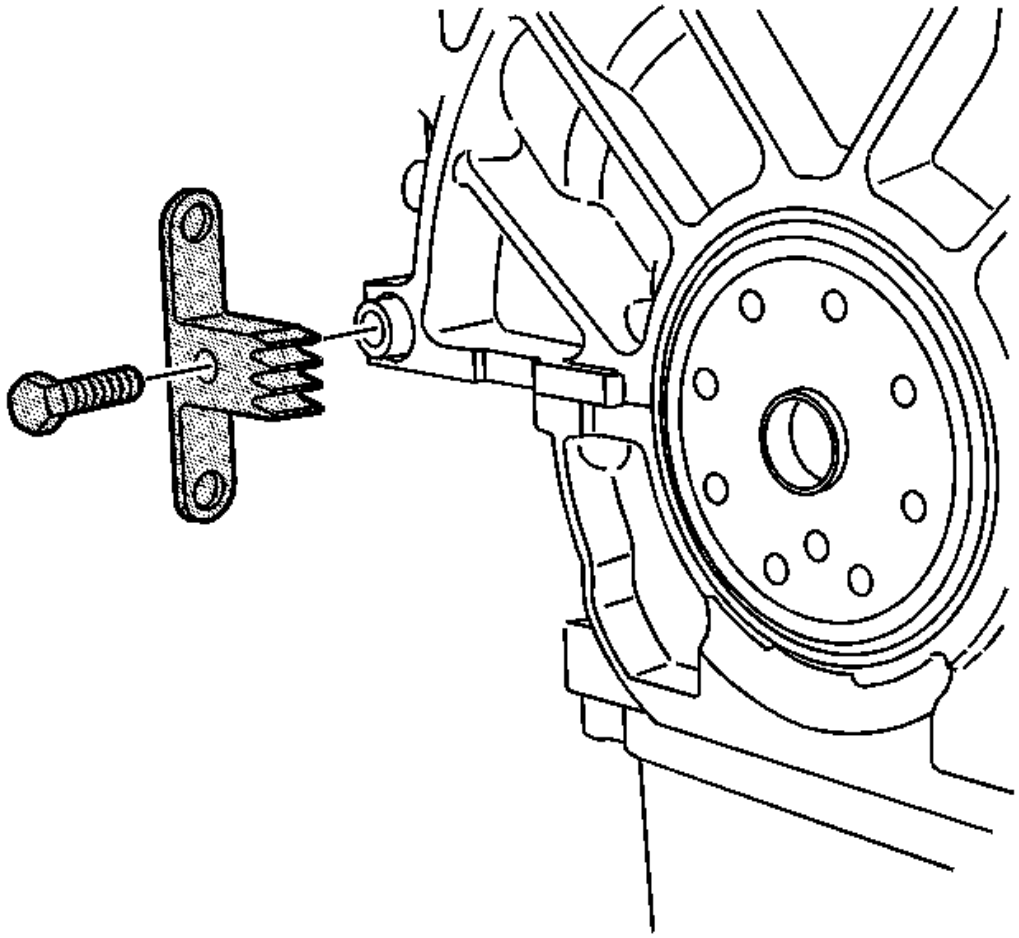

Fig. 368: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

1. Remove the transaxle. Refer to **Transmission Replacement** .
2. Install the **J 44214** to the engine block. See **Special Tools** .

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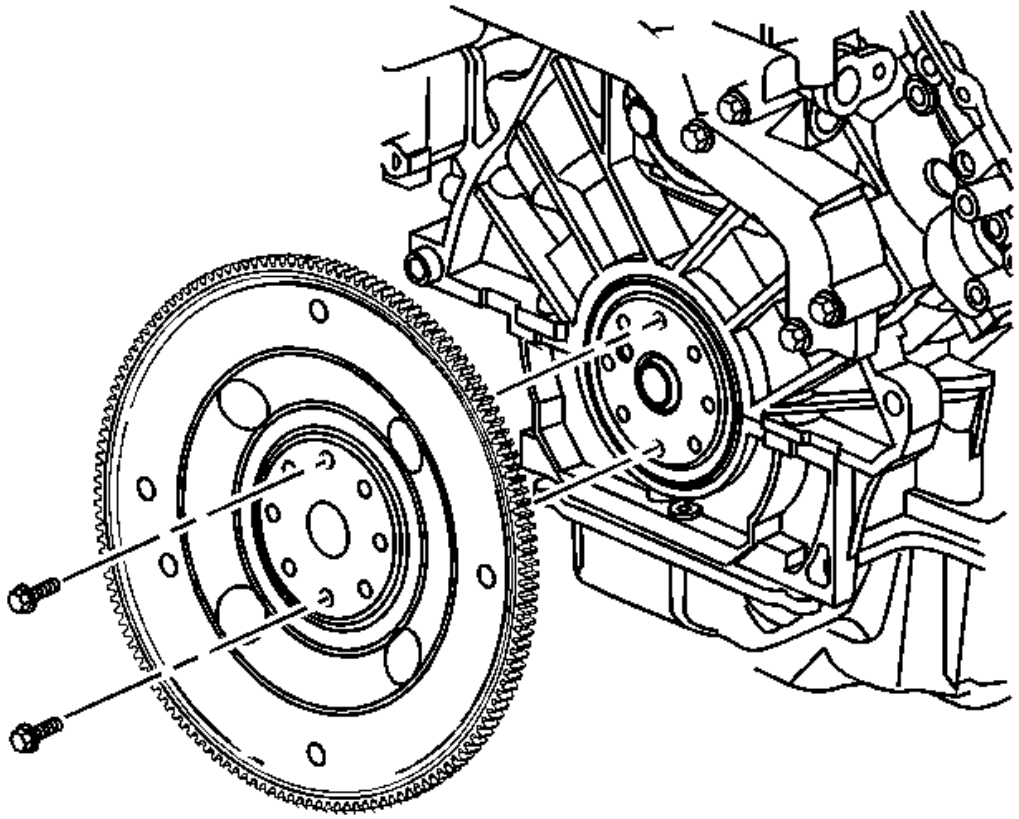

Fig. 369: Engine Flywheel & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

3. Loosen the flywheel bolts.
4. Remove all but one of the flywheel bolts, leaving the one bolt at the top of the crankshaft.
5. Grasp the engine flywheel with one hand and remove the remaining bolt. Do not drop the engine flywheel when removing the final bolt.
6. Clean and inspect the engine flywheel. Refer to **Engine Flywheel Cleaning and Inspection** .

INSTALLATION PROCEDURE

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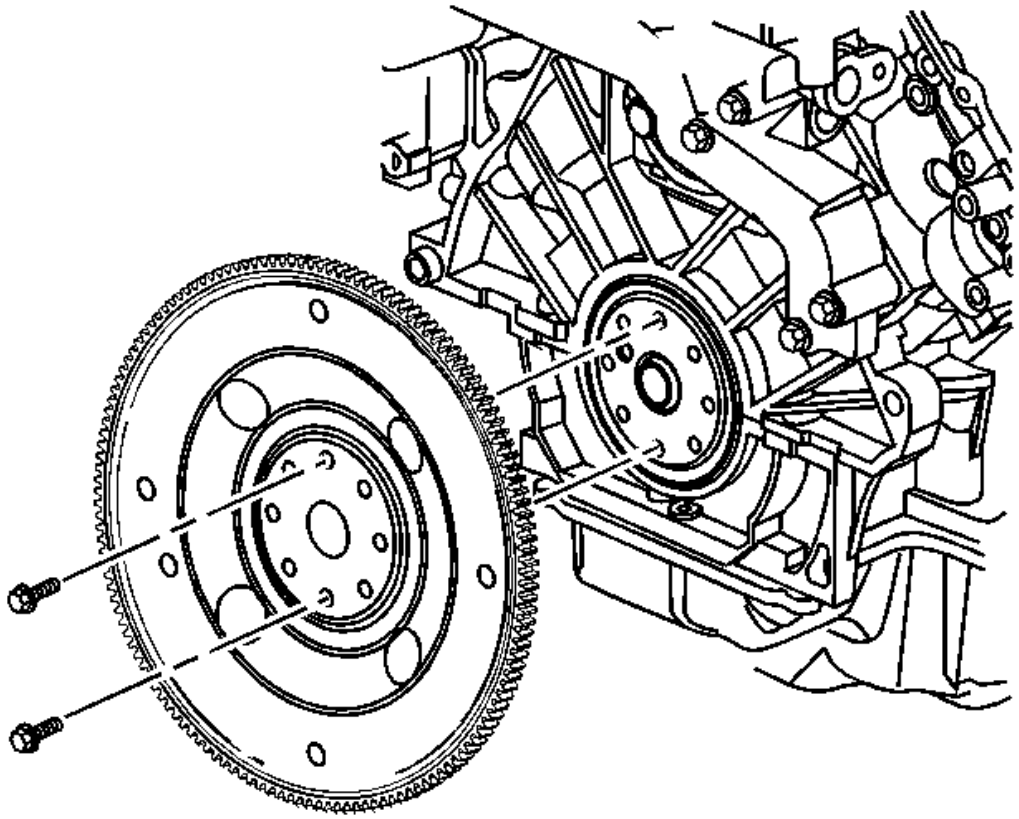

Fig. 370: Engine Flywheel & Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant to the flywheel bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
2. Place the engine flywheel in position against the crankshaft.

CAUTION: Refer to Fastener Caution .

3. Install the flywheel bolts.

Tighten:

- Tighten the bolts a first pass to 30 N.m (22 lb ft).
- Tighten the bolts a final pass an additional 50 degrees using the **J 45059** .

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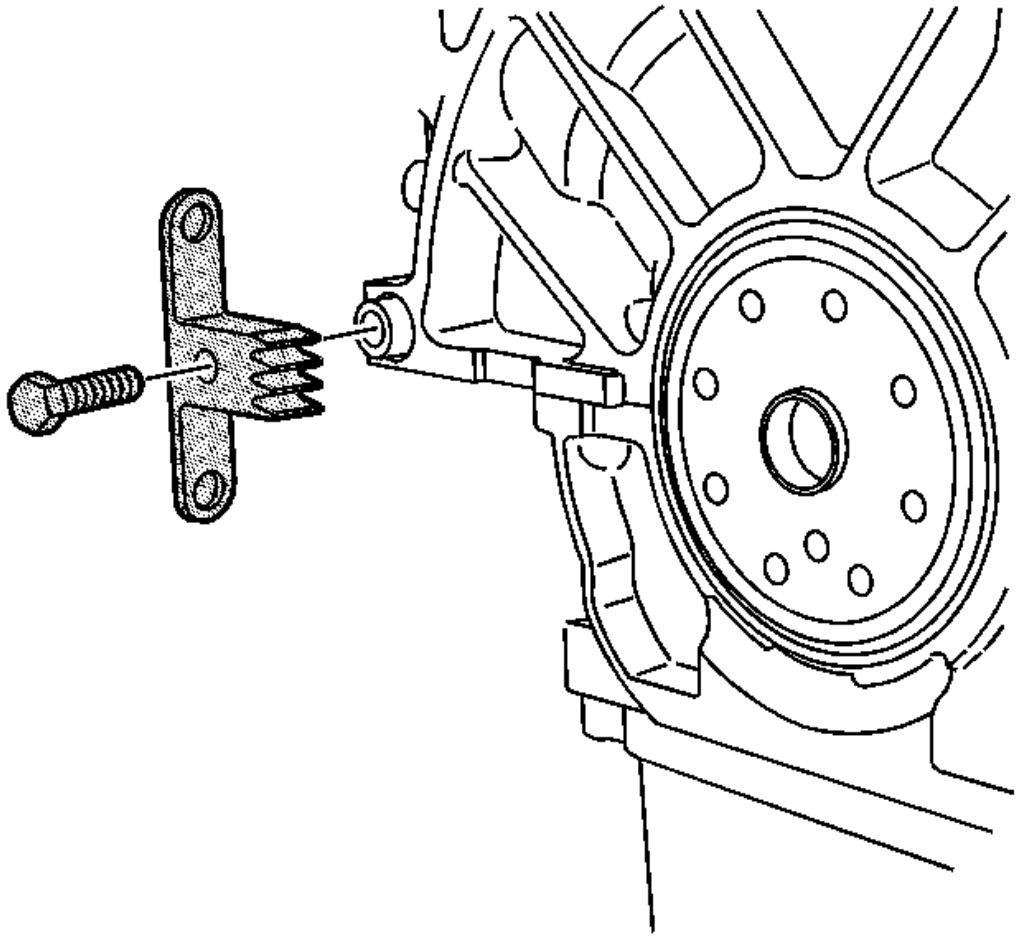

Fig. 371: Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

4. Remove the **J 44214** from the engine block. See **Special Tools** .
5. Install the transaxle. Refer to **Transmission Replacement** .

OIL PAN REPLACEMENT

SPECIAL TOOLS

EN 46109 Engine Front Cover Installation Guide Pins. See **Special Tools** .

REMOVAL PROCEDURE

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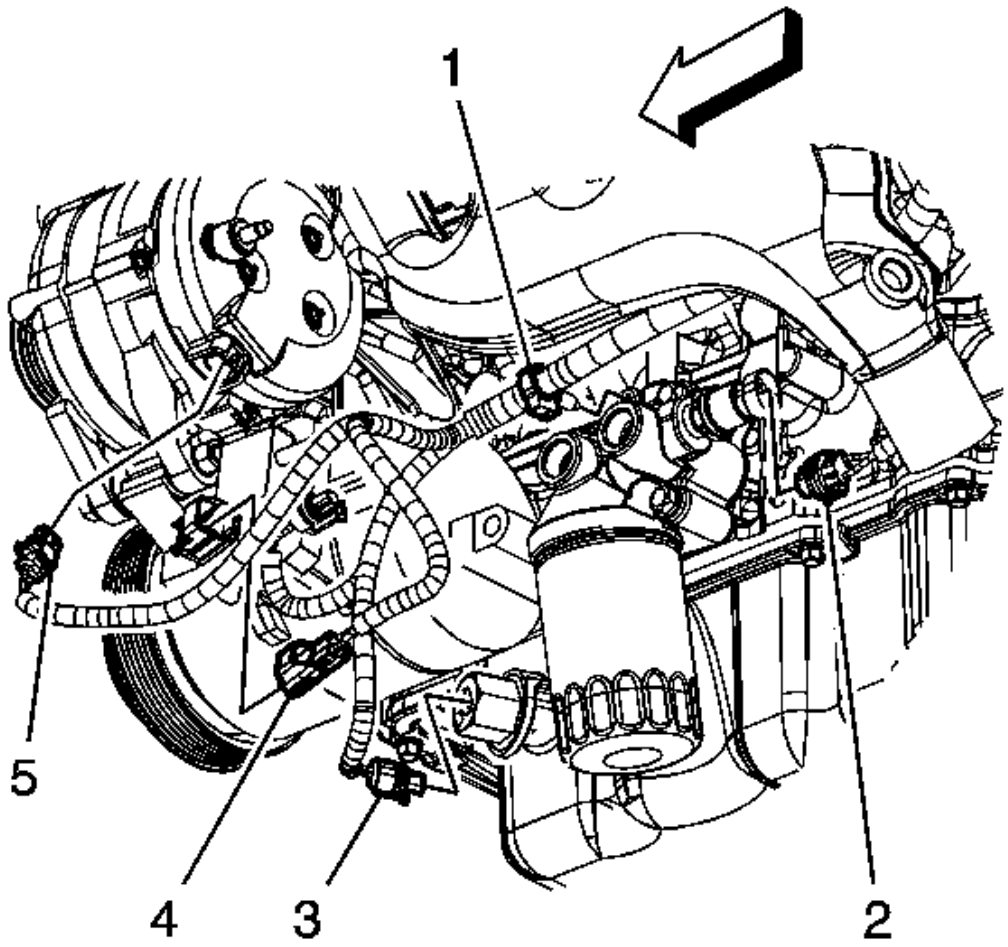

Fig. 372: Disconnecting/Connecting Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement** .
2. Remove the front exhaust manifold pipe. Refer to **Exhaust Manifold Front Pipe Replacement** .
3. Disconnect the engine harness electrical connector (2) from the oil level sensor.

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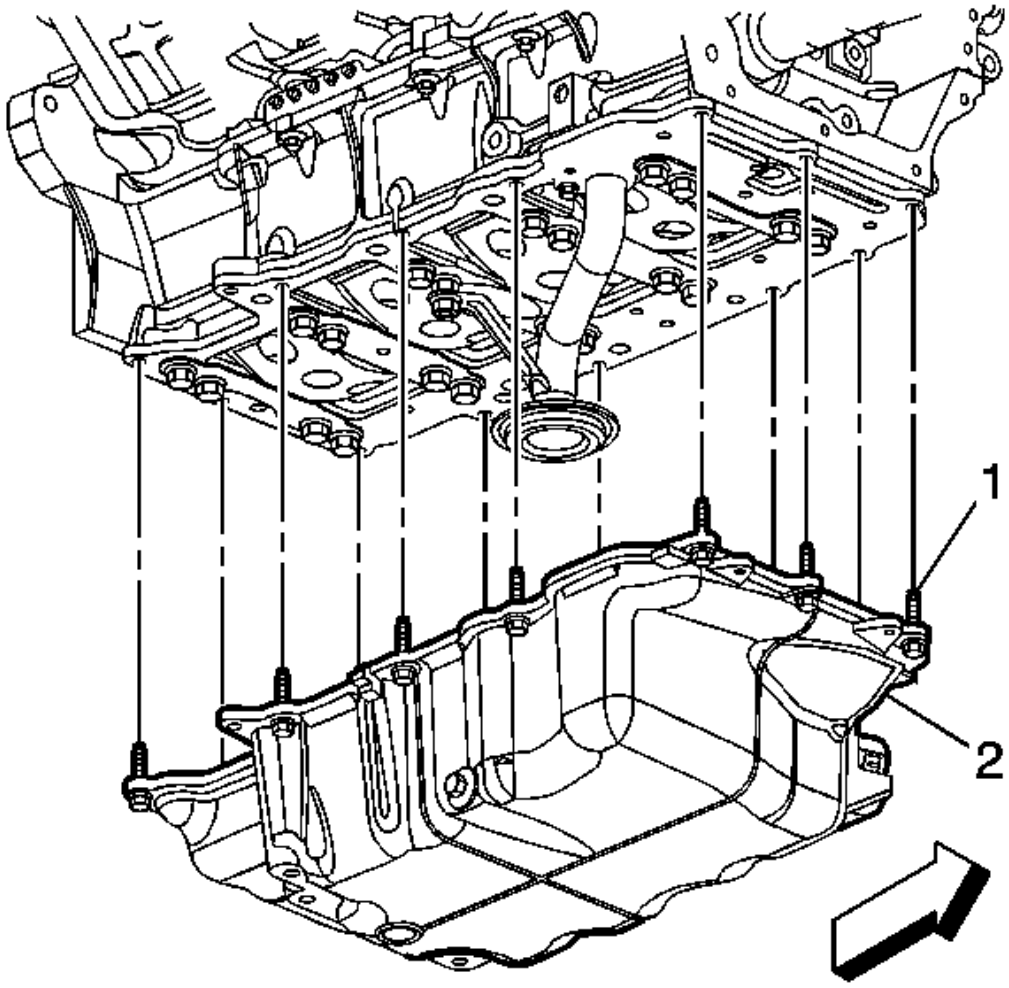

Fig. 373: Oil Pan
Courtesy of GENERAL MOTORS CORP.

4. Loosen the oil pan bolts (1).
5. Remove the oil pan (2) and discard the oil pan gasket.
6. Clean and inspect the oil pan, if necessary. Refer to **Oil Pan Cleaning and Inspection** .

INSTALLATION PROCEDURE

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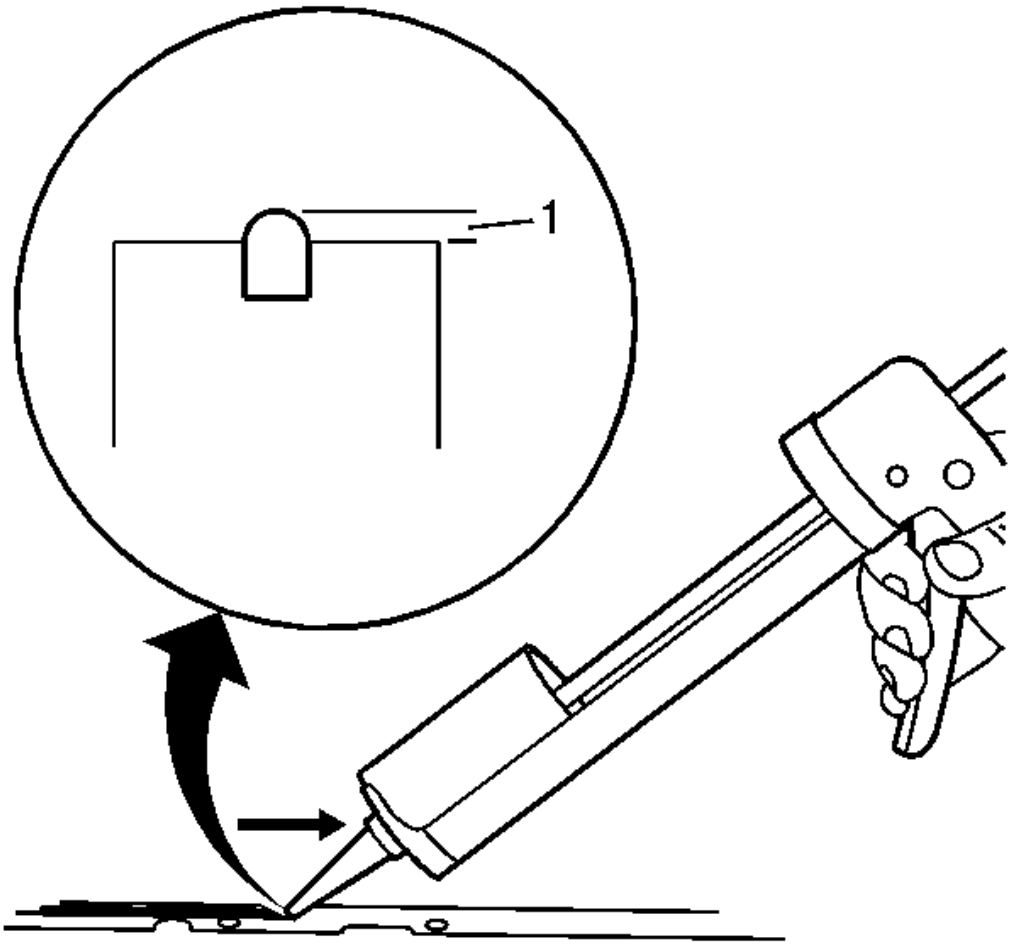

Fig. 374: Applying RTV Sealant
Courtesy of GENERAL MOTORS CORP.

1. Completely fill and slightly overfill the oil pan seal groove with a continuous bead of RTV sealant. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
2. Ensure the RTV sealant is higher than the oil pan sealing surface (1) by 3 mm (0.118 in).

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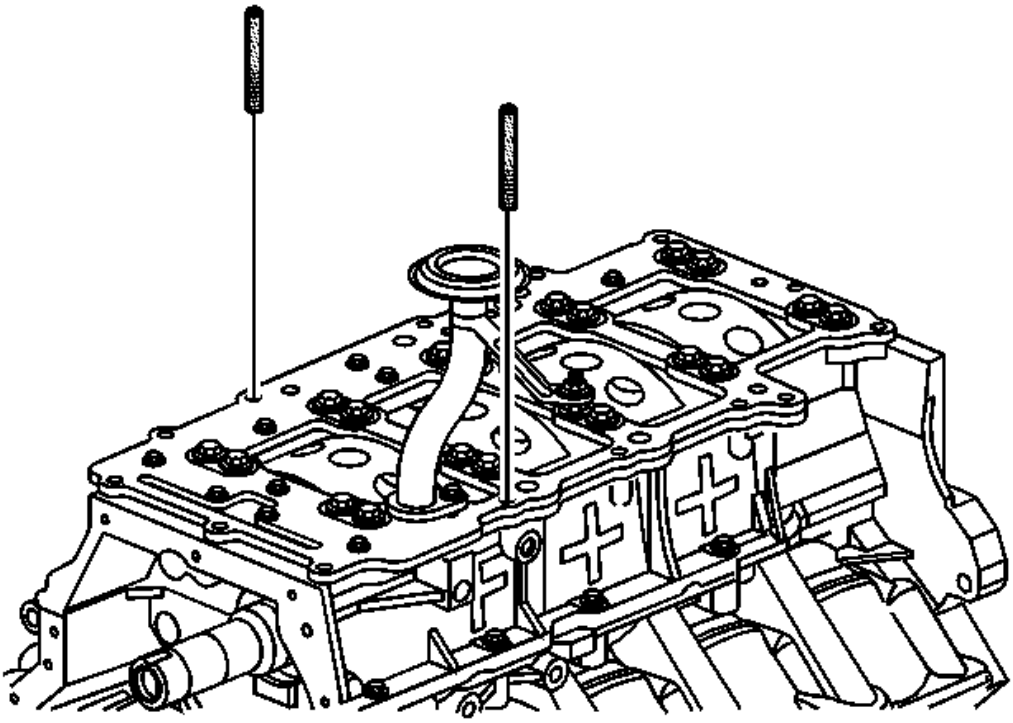

Fig. 375: Guide Pins
Courtesy of GENERAL MOTORS CORP.

3. To prevent shifting of the oil pan, install one **EN 46109** into the bolt hole in each side of the lower crankcase. See **Special Tools** .

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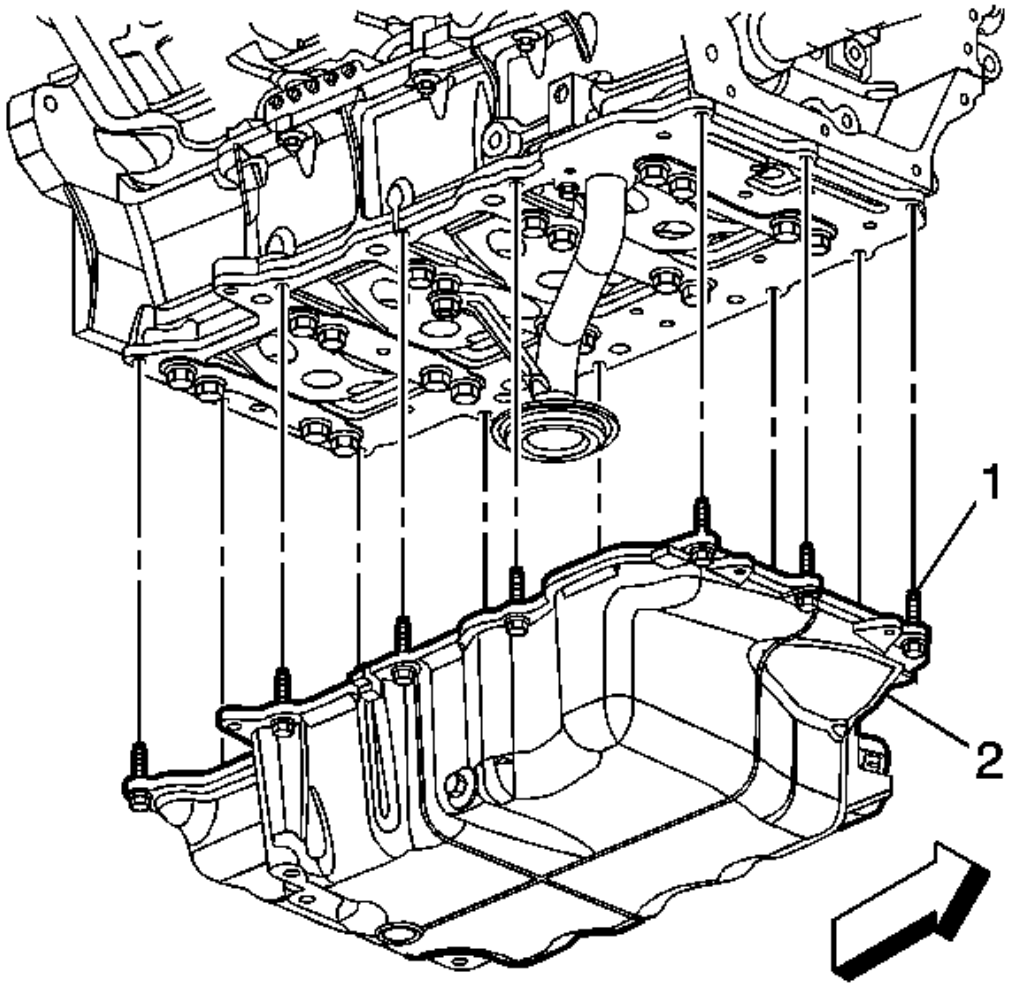

Fig. 376: Oil Pan
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Position the oil pan (2) to the lower crankcase and finger start the oil pan bolts (1).

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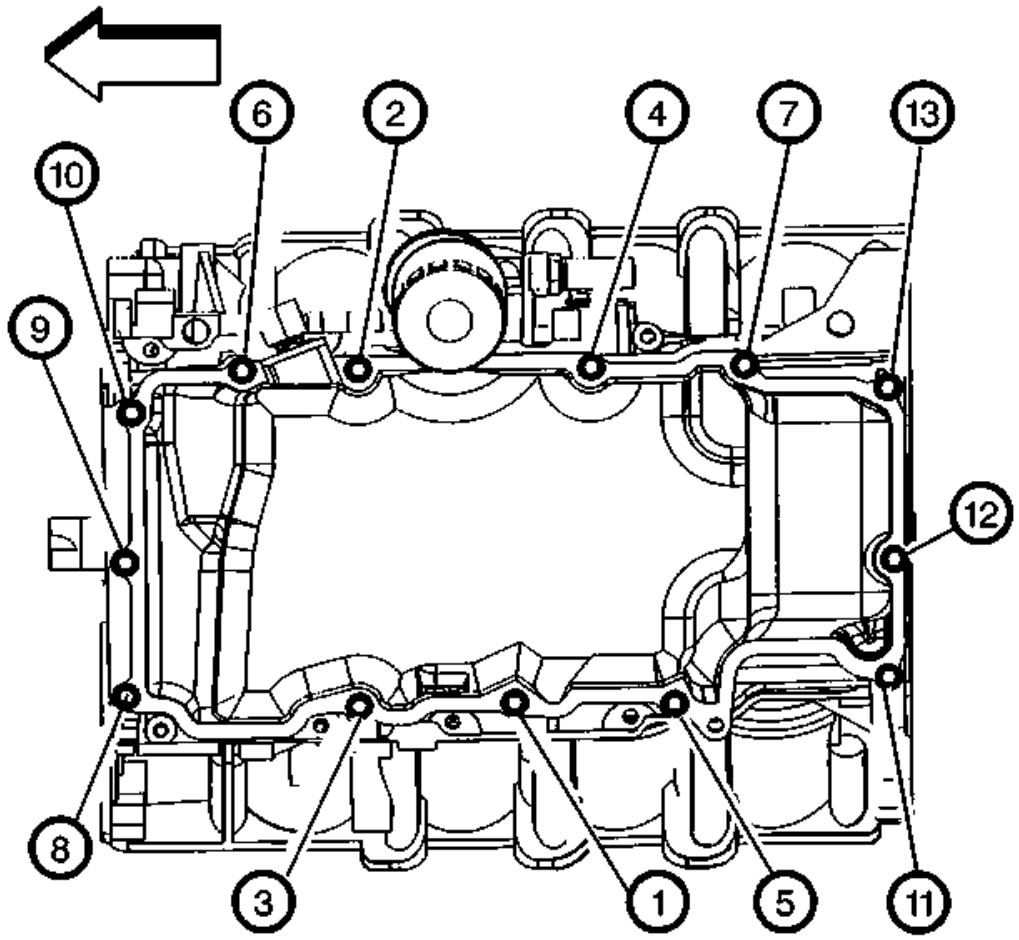

Fig. 377: Identifying Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the oil pan bolts.

Tighten:

1. Tighten the bolts a first pass to 8 N.m (71 lb in).
2. Tighten the bolts a final pass to 12 N.m (106 lb in).

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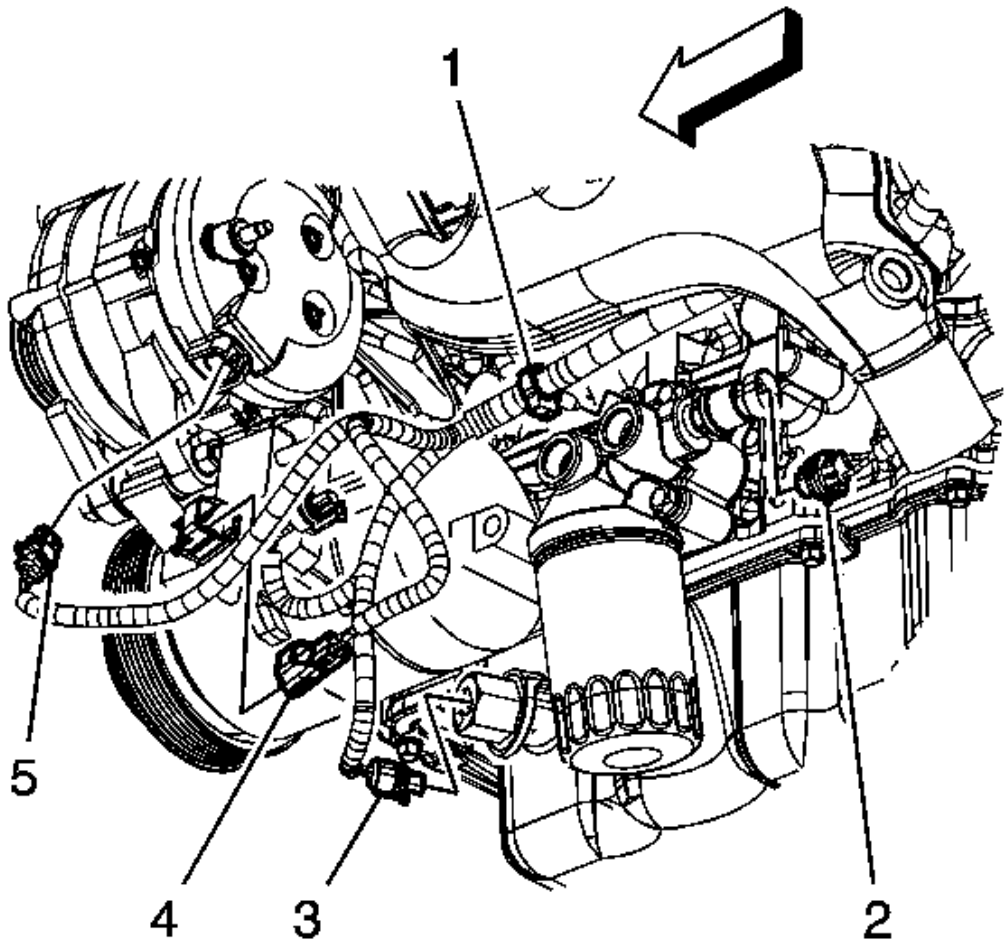

Fig. 378: Disconnecting/Connecting Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

6. Connect the engine harness electrical connector (2) to the oil level sensor.
7. Install the front exhaust manifold pipe. Refer to **Exhaust Manifold Front Pipe Replacement (LD8)**
8. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**

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2010 ENGINE

Engine Mechanical - 4.6L - Repair Instructions - On Vehicle - Lucerne

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

- **EN-48072** Sealant Applicator. See **Special Tools** .
- **J 42841-A** Crankshaft Rear Oil Seal Remover. See **Special Tools** .
- **J 45930-A** Crankshaft Rear Oil Seal Installer. See **Special Tools** .

REMOVAL PROCEDURE

1. Remove the transaxle. Refer to **Transmission Replacement** .
2. Remove the flywheel. Refer to **Engine Flywheel Replacement** .

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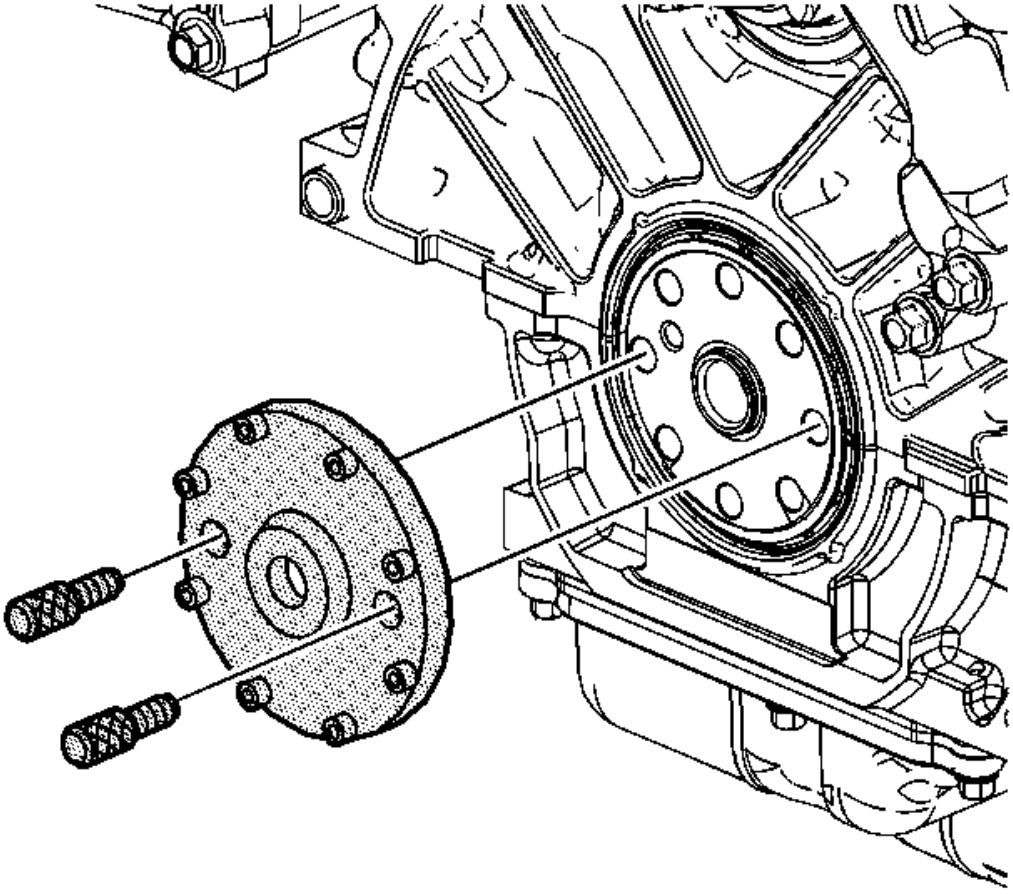

Fig. 1: Placing Rear Crankshaft Oil Seal Remover
Courtesy of GENERAL MOTORS CORP.

3. Place the **J 42841-A** on to the crankshaft. See **Special Tools** .
4. Install the **J 42841-A** retaining bolts. See **Special Tools** .

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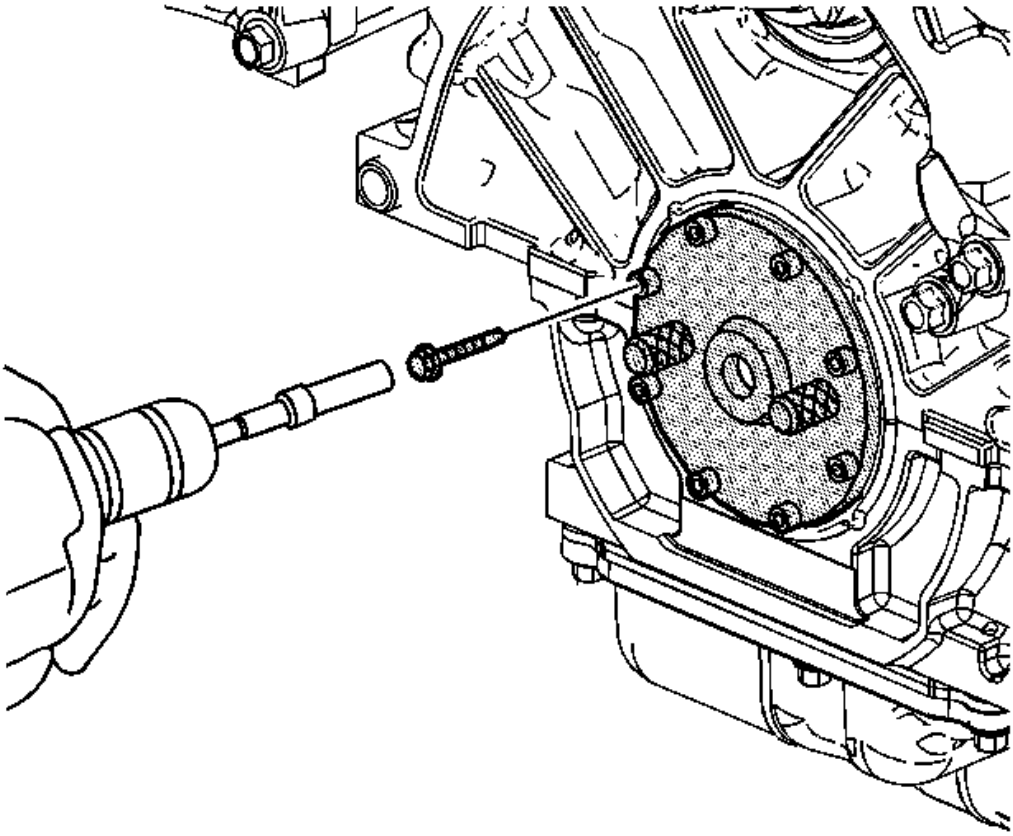

Fig. 2: Drilling Screws Into Seal
Courtesy of GENERAL MOTORS CORP.

5. Using a drill motor, variable speed preferred, with a socket adapter, install eight one-inch self-drilling screws into the seal using the guide holes in the removal tool. When drilling, make sure you reduce the drill speed when the screw begins threading into the seal.

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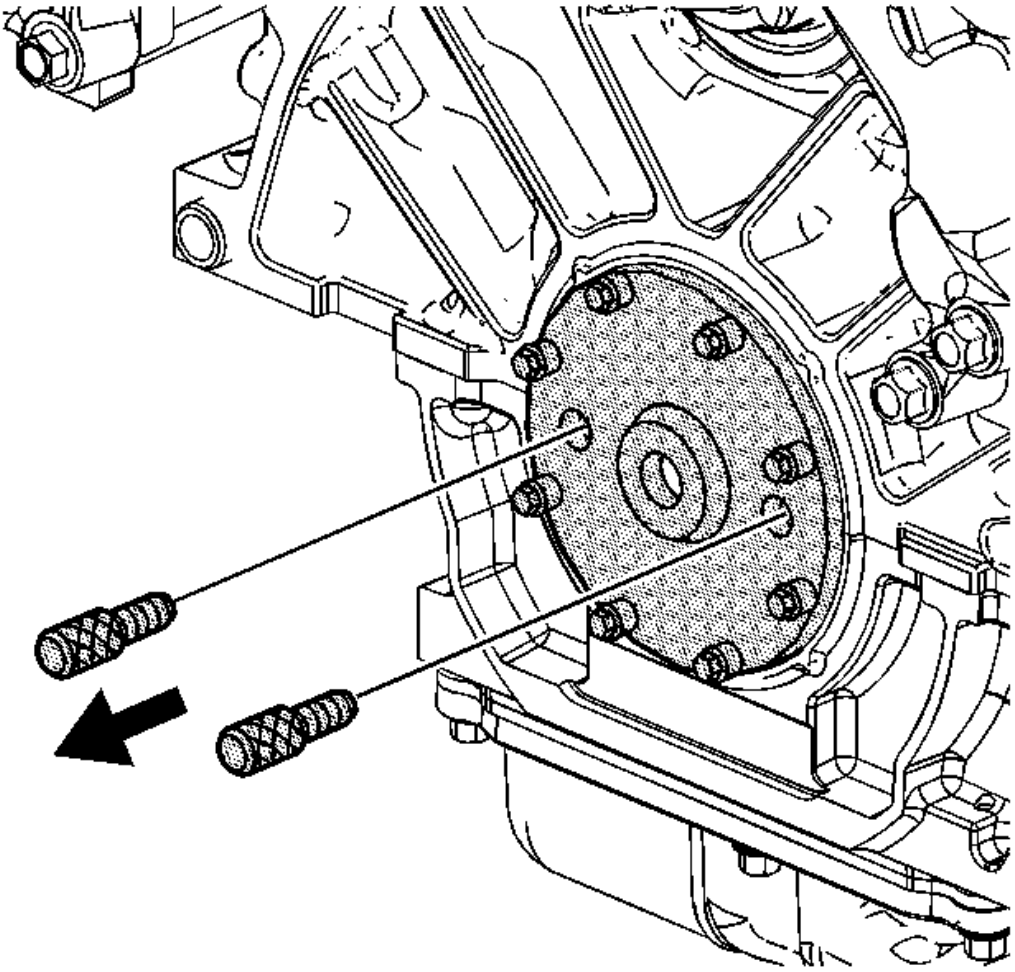

Fig. 3: Removing J 42841 Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

6. With all eight removal screws installed, remove the **J 42841-A** retaining bolts. See **Special Tools** .

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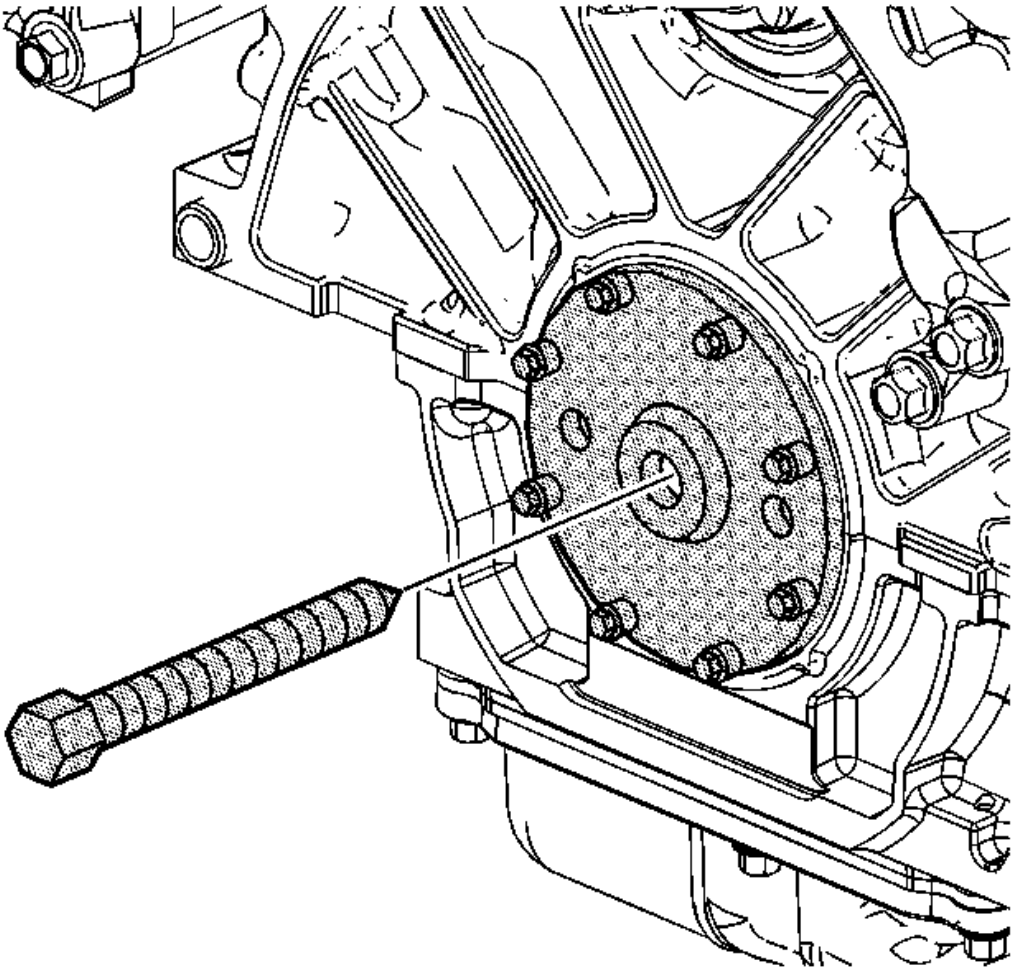

Fig. 4: Installing Center Forcing Screw
Courtesy of GENERAL MOTORS CORP.

7. Install the center screw to the **J 42841-A** . See **Special Tools** .

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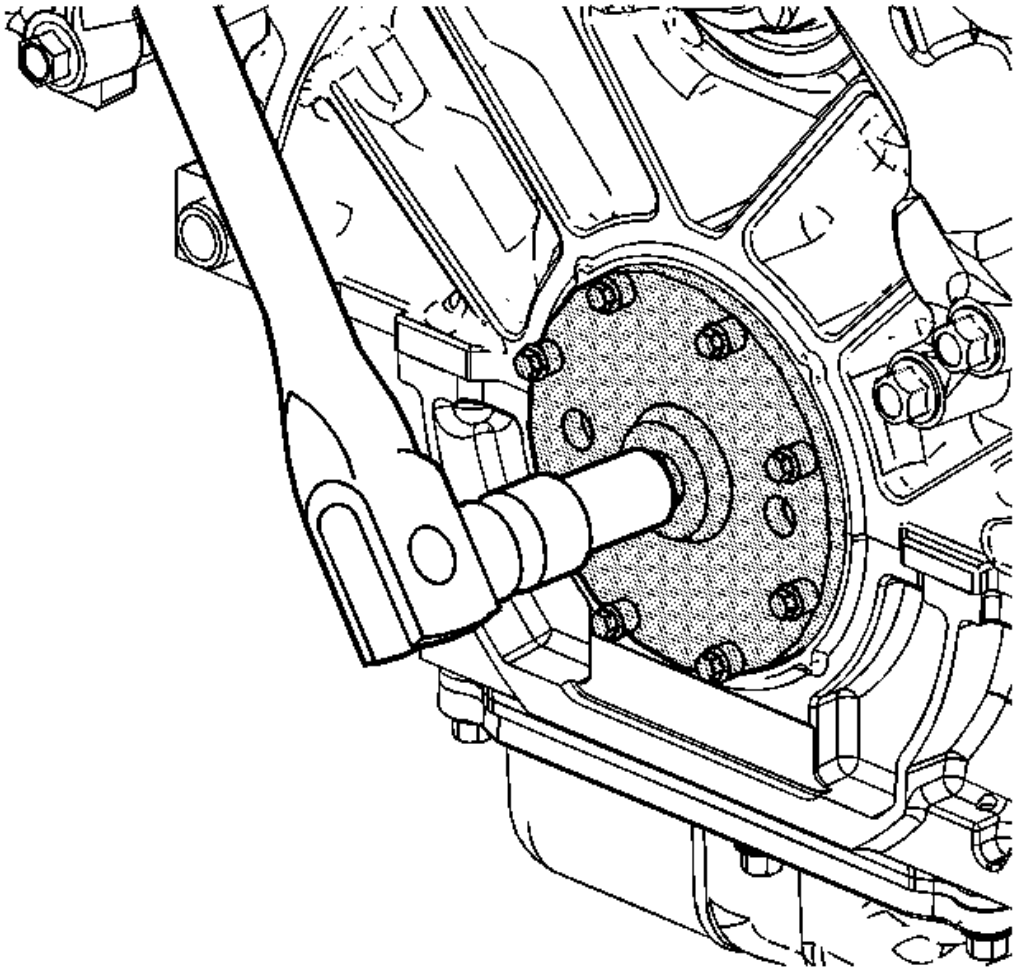

Fig. 5: Removing Seal Assembly From Crankshaft
Courtesy of GENERAL MOTORS CORP.

8. Tighten the center screw on the **J 42841-A** to pull the seal assembly off the end of the crankshaft. See **Special Tools** .

INSTALLATION PROCEDURE

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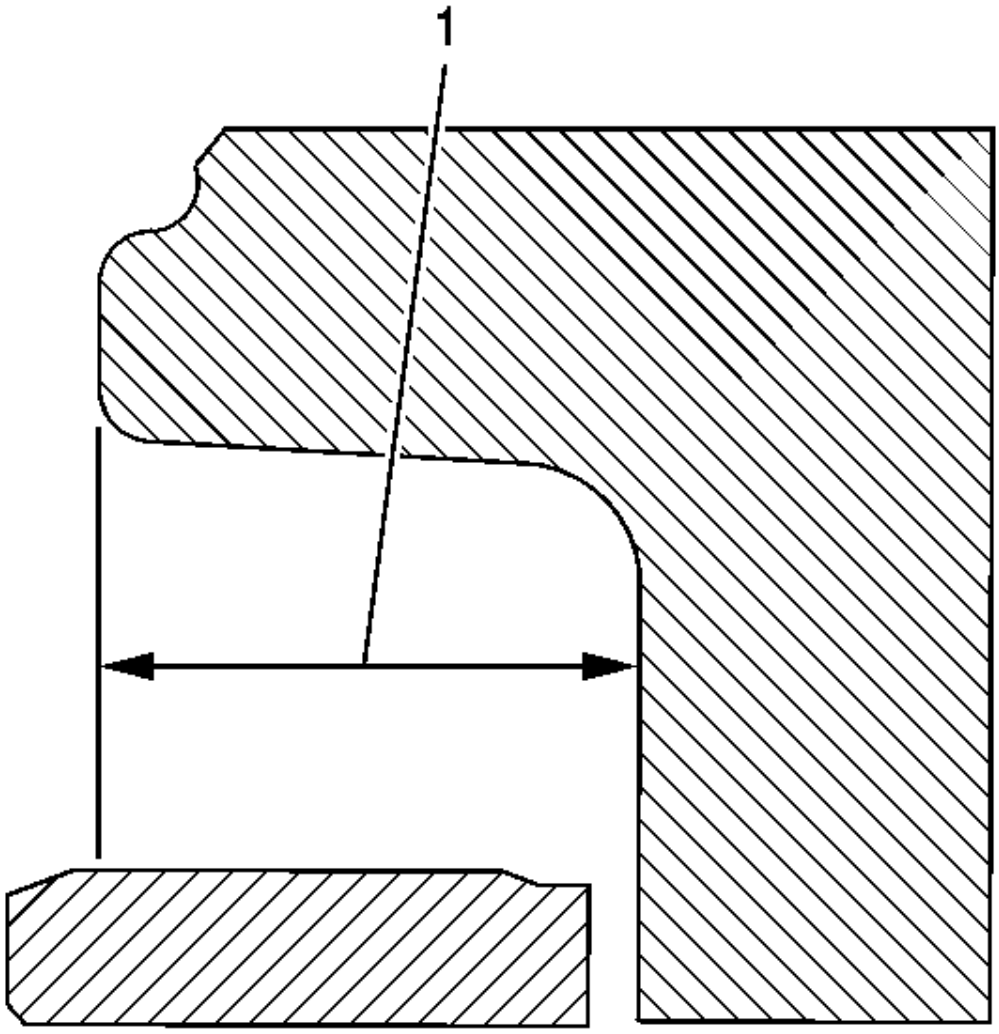

Fig. 6: Checking Oil Seal Bore Depth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The EN-48072 must be used to ensure even application of the sealant in the bore and to prevent blockage of the drain back hole. See Special Tools .**
- **Ensure components that are being sealed with RTV sealant are assembled within 20 minutes. Components assembled after the RTV sealant has skinned-over, approximately 20 minutes, will not bond properly.**

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- **Although originally equipped with a lip-style crankshaft rear oil seal, engines built from March 1, 1996 through 1999 should use the cassette-style crankshaft rear oil seal.**

1. Ensure the engine block where the crankshaft rear oil seal is installed is a deep bore (1).
   - A deep bore of approximately 15 mm (0.5906 in) was used on engines from March 1, 1996 and later.
   - A shallow bore of approximately 8 mm (0.3150 in) was used on engines from 1993 through February 29, 1996. This block would use a lip-style crankshaft rear oil seal and the **J 38817-A** for installation.

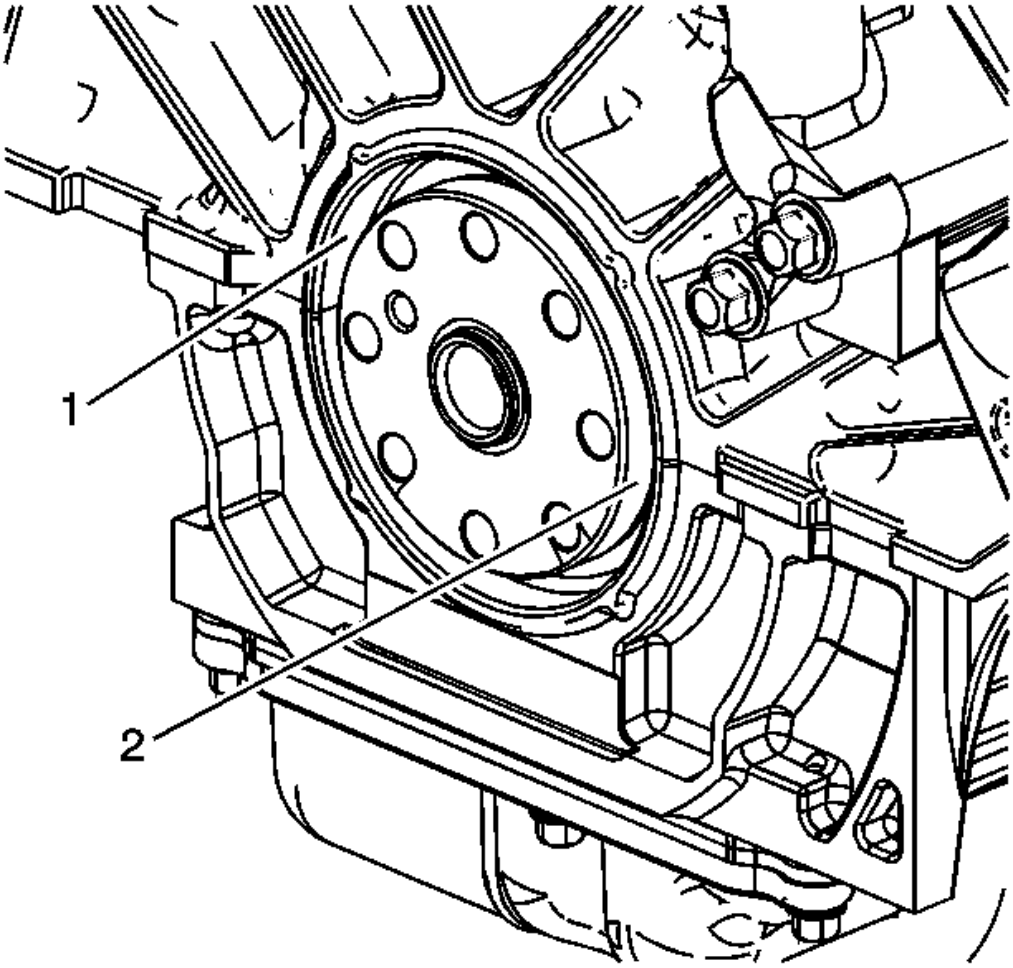

Fig. 7: Engine Block Bore & Crankshaft Flange
Courtesy of GENERAL MOTORS CORP.

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2. Inspect the engine block bore (1) and the crankshaft flange (2) for the damage. Repair or replace any damaged components.

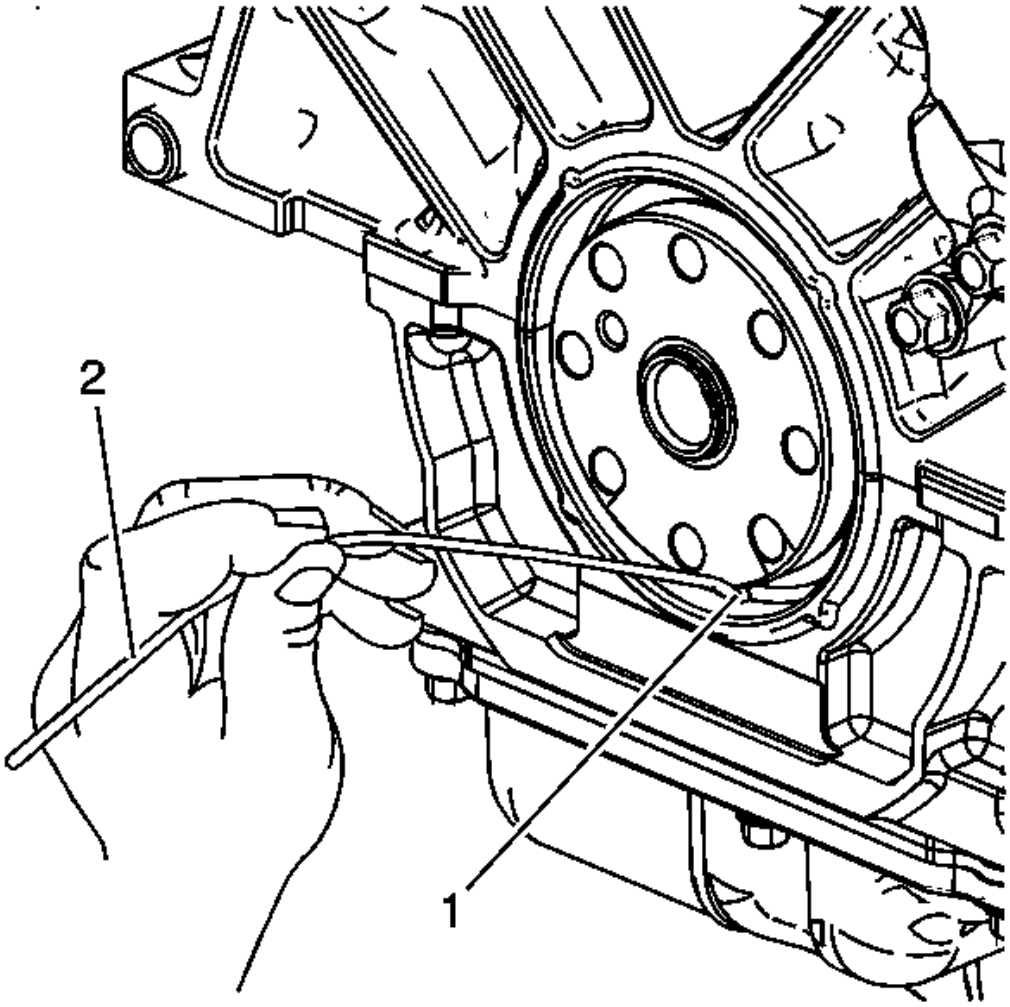

Fig. 8: Cleaning Debris From Oil Drain-Back Hole
Courtesy of GENERAL MOTORS CORP.

3. Ensure the oil drain-back hole (1) is clear of debris using a wire or an unbound plastic tie wrap (2).

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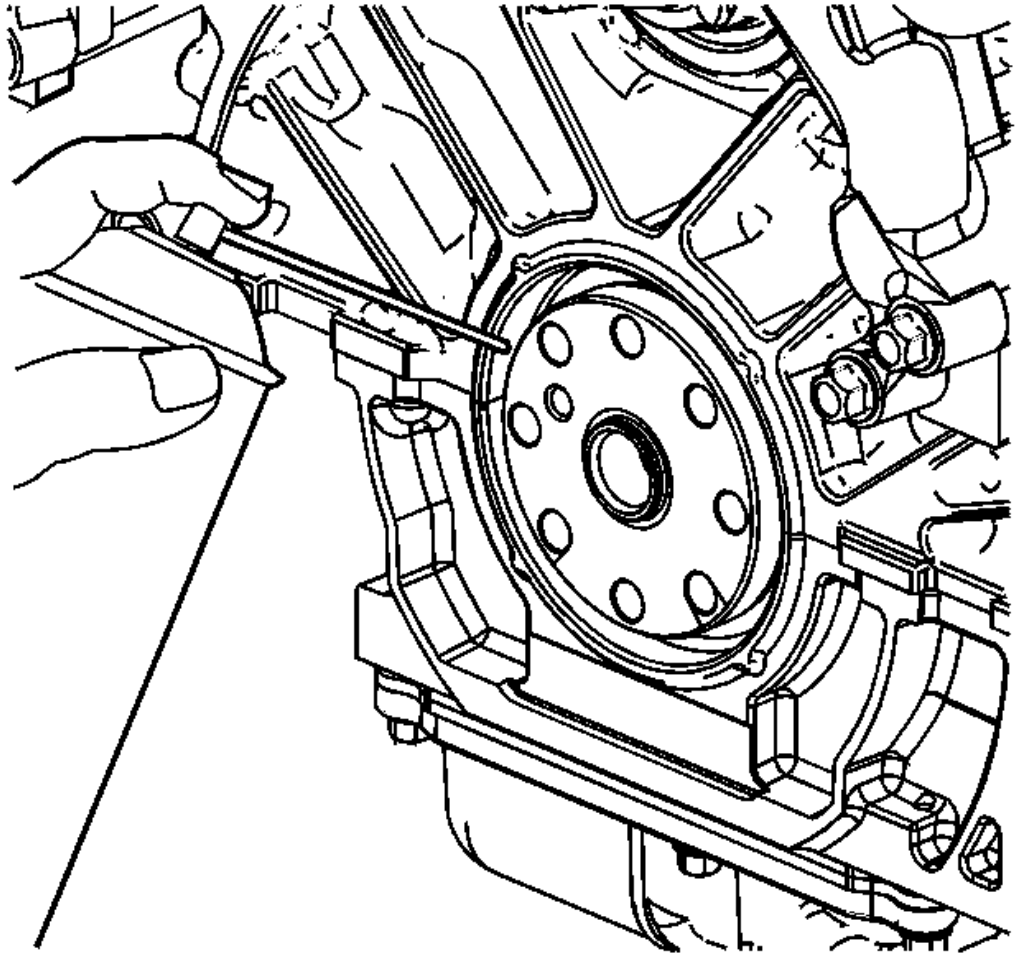

Fig. 9: Cleaning Rear Crankshaft Seal Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to ensure proper bonding of the sealant the bore must be clean and dry.

4. Clean the bore in the block with cleaner solvent GM P/N 12378392 or 12346139 (Canadian P/N 88901247).

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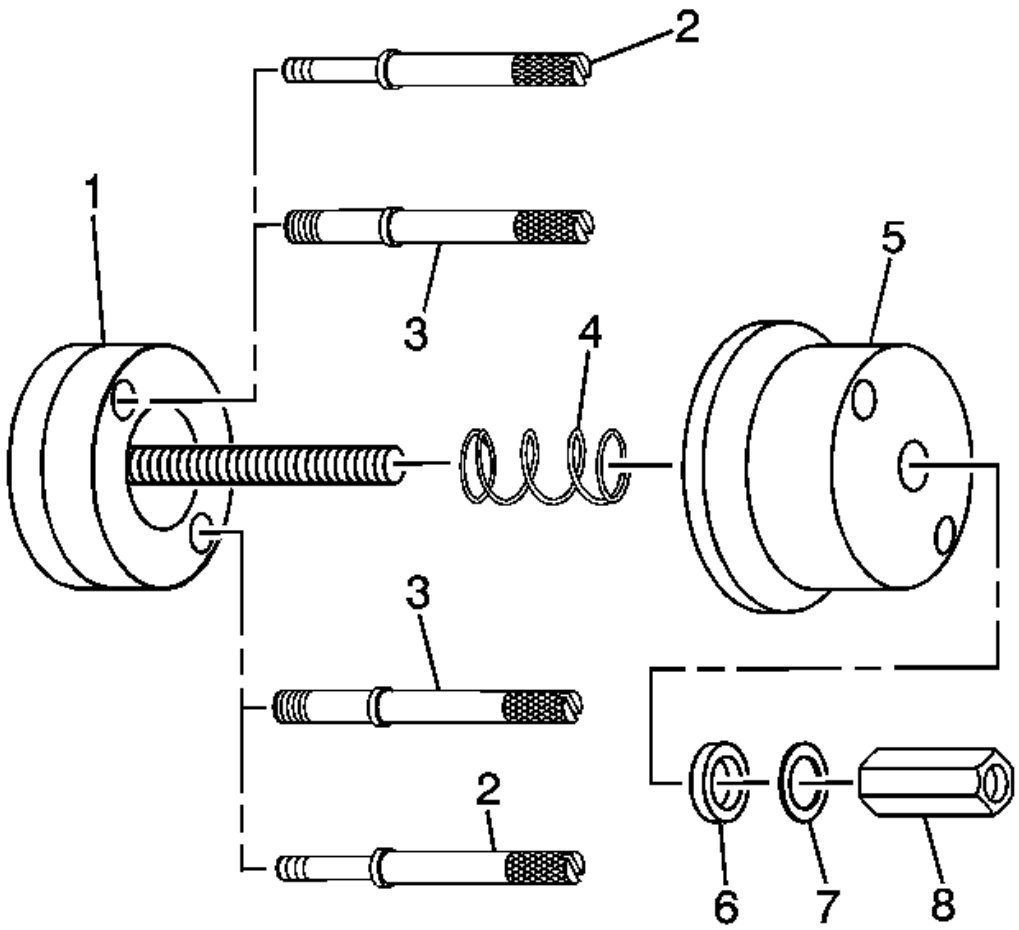

Fig. 10: View Of J 45930-A Tool Set
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

5. Remove the proper sized bolts from the **J 45930-A** . See **Special Tools** . Use the bolts (2) 8 mm or the bolts (3) 11 mm.

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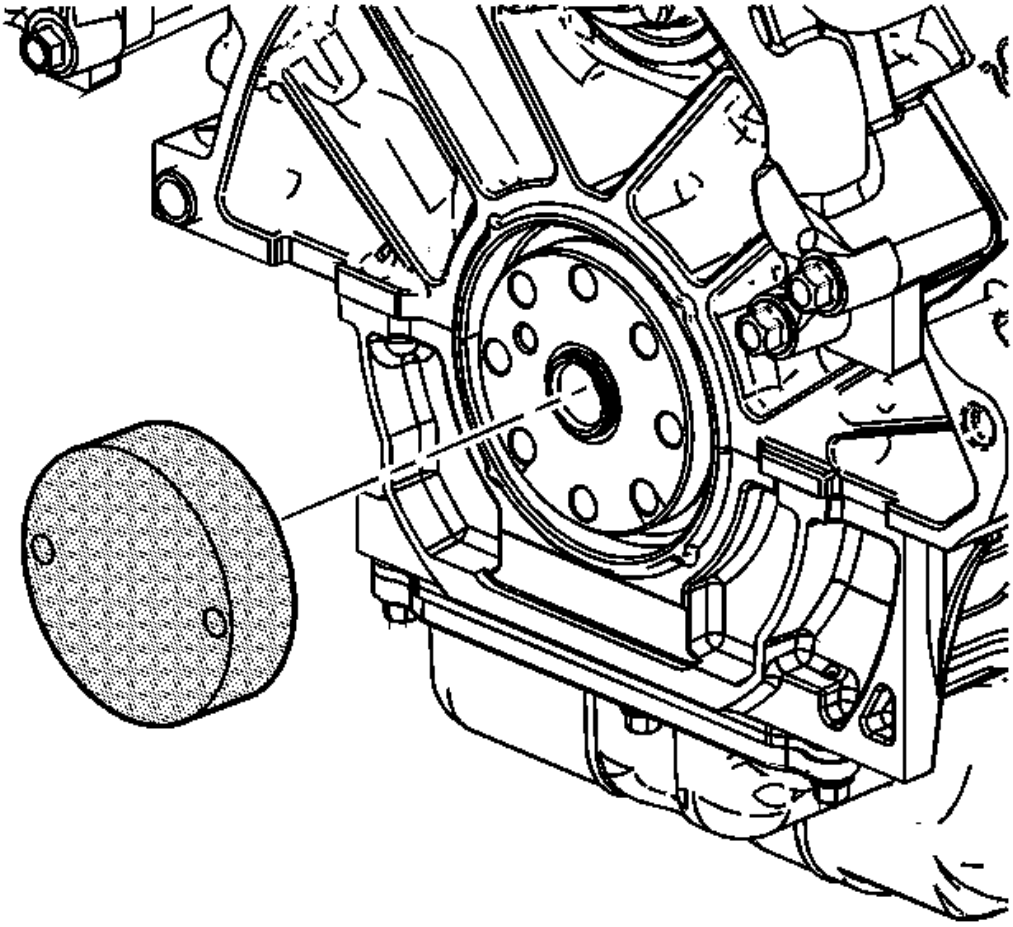

Fig. 11: Applicator Pilot Base
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-48072** pilot base onto the crankshaft. See **Special Tools** . The hub on the crankshaft will fit into the recess on the inboard side of the **EN-48072** pilot base. See **Special Tools** .

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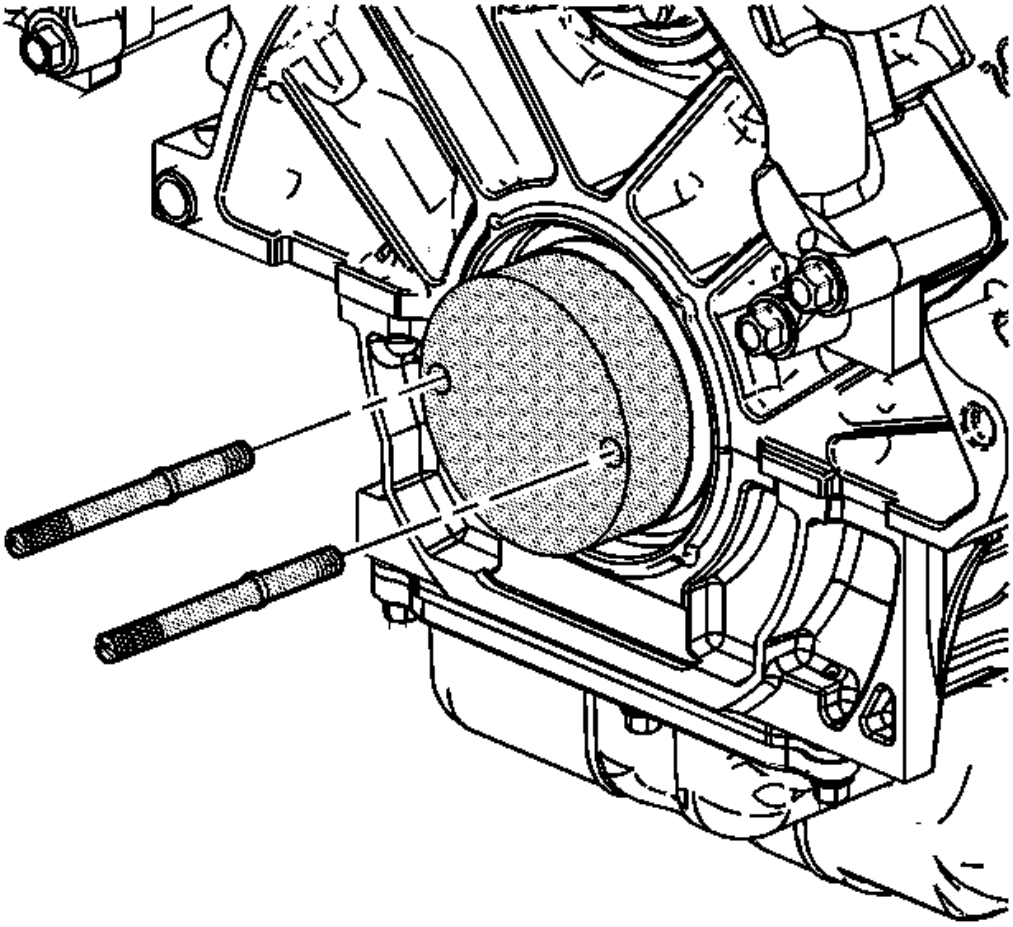

Fig. 12: Pilot Base Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.

7. Use the proper bolts from the **J 45930-A** to retain the **EN-48072** pilot base in place. See **Special Tools** .

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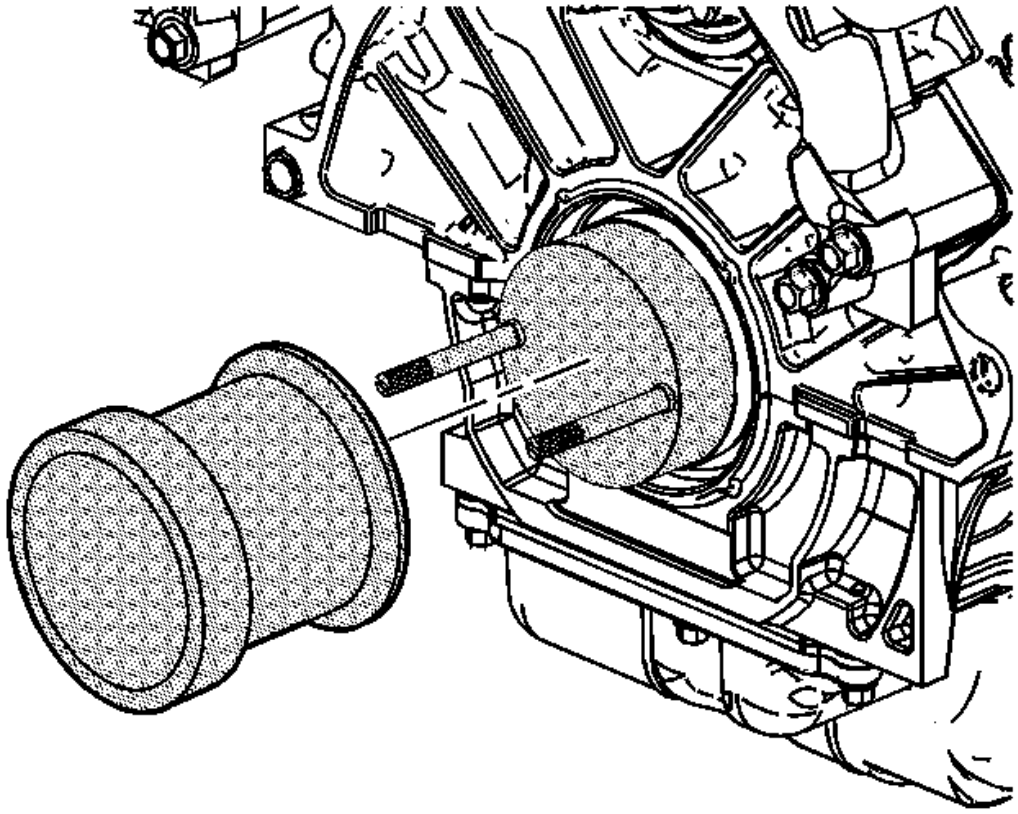

Fig. 13: Rear Seal Applicator Housing
Courtesy of GENERAL MOTORS CORP.

8. Install the **EN-48072** applicator housing over the **EN-48072** pilot base. See **Special Tools** . Ensure the **EN-48072** applicator housing bottoms in the bore of the block. See **Special Tools** .

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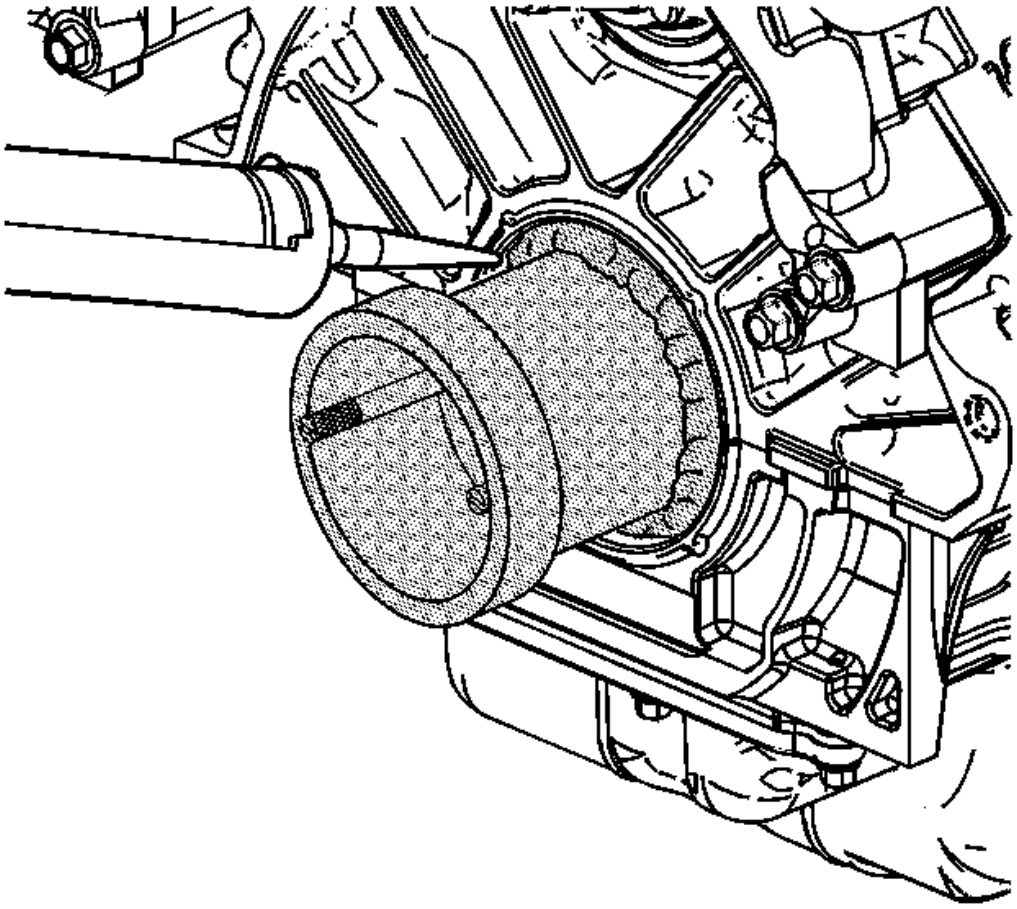

Fig. 14: Applying Sealant To Rear Seal Applicator Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The sealant must not block the drain back hole. Blockage of the drain back hole can lead to oil leakage.

9. Apply the sealant GM P/N 12378521 (Canadian P/N 88901148) to the bore outer diameter in the block. Ensure the sealant does not block the drain hole.

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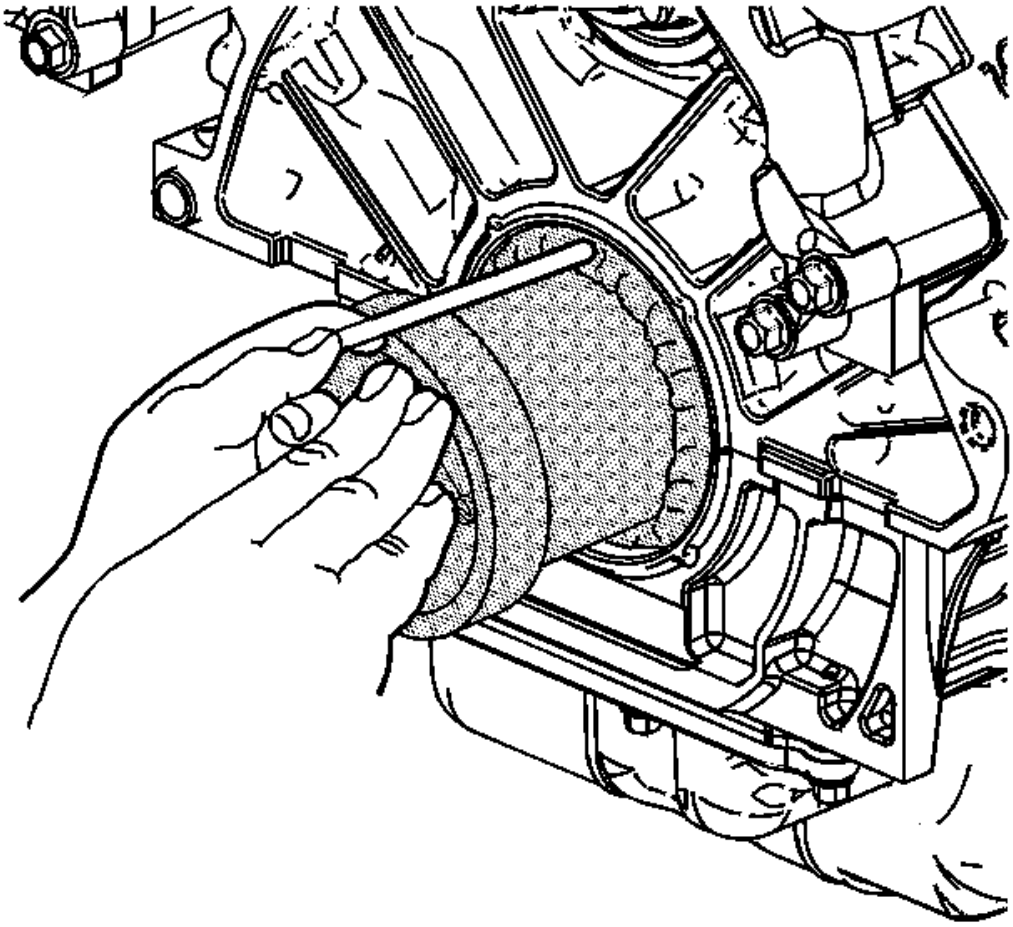

Fig. 15: Spreading Sealant To Rear Seal Applicator Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply steady even pressure to the EN-48072 applicator housing. See Special Tools .

10. Using a suitable tool spread the sealant within the bore to ensure an even coating across the bore.

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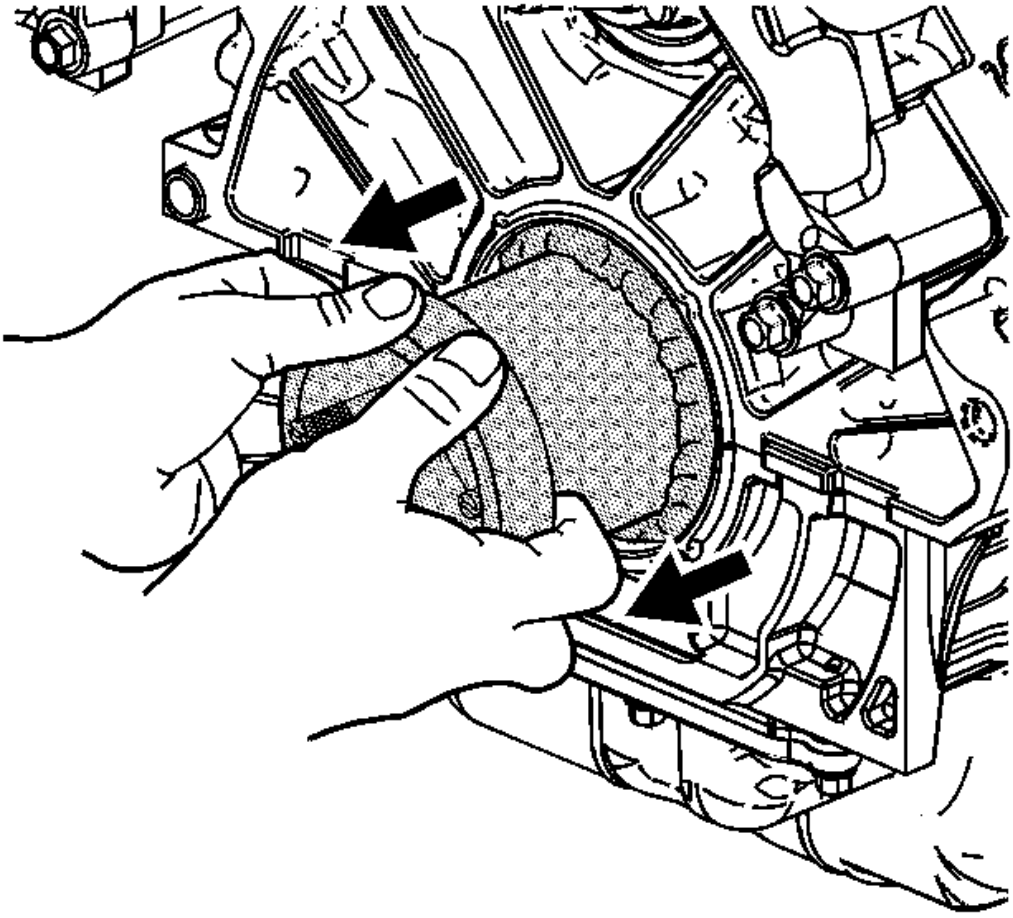

Fig. 16: Removing Rear Seal Applicator Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to apply an even coat of the sealant do not twist or turn the EN-48072 applicator housing as it is pulled away from the bottom of the bore. See Special Tools .

11. Using both hands, slowly and evenly, pull the **EN-48072** applicator housing out of the bore and remove it from the **EN-48072** pilot base. See **Special Tools** .

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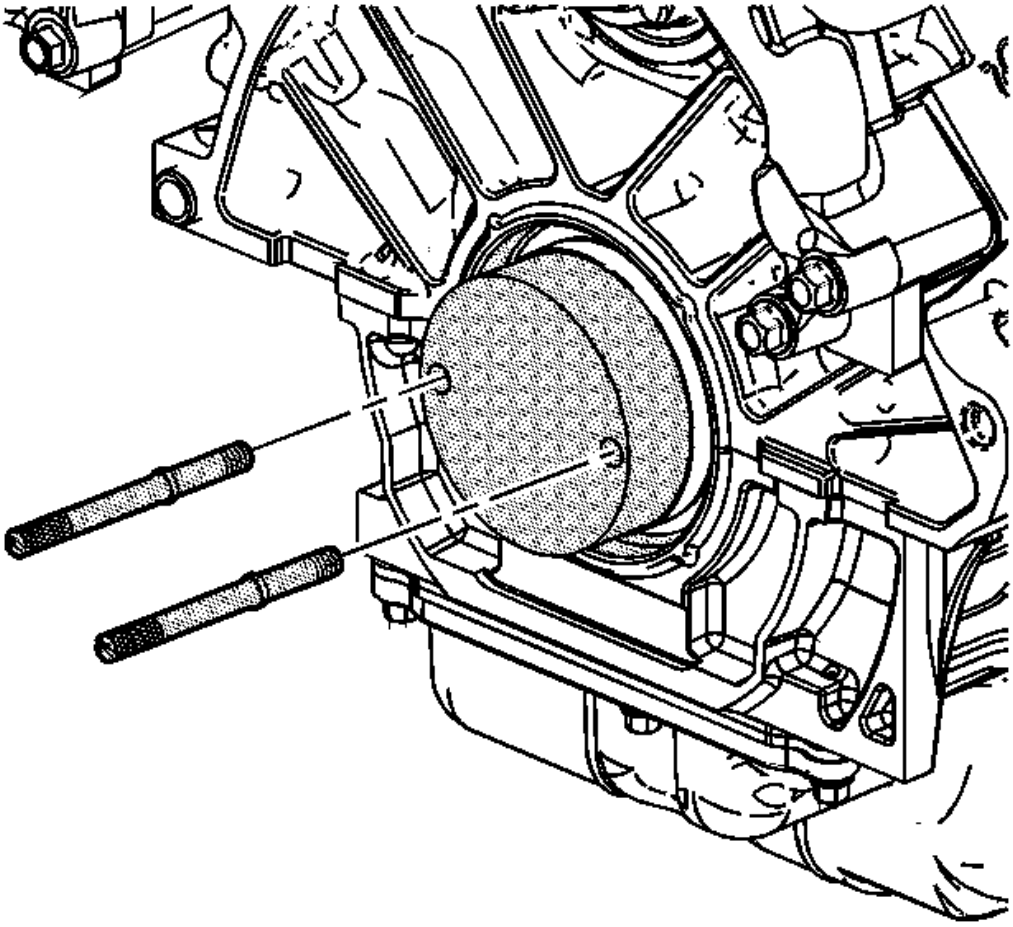

Fig. 17: Pilot Base Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the **J 45930-A** bolts from the **EN-48072** pilot base. See **Special Tools** .

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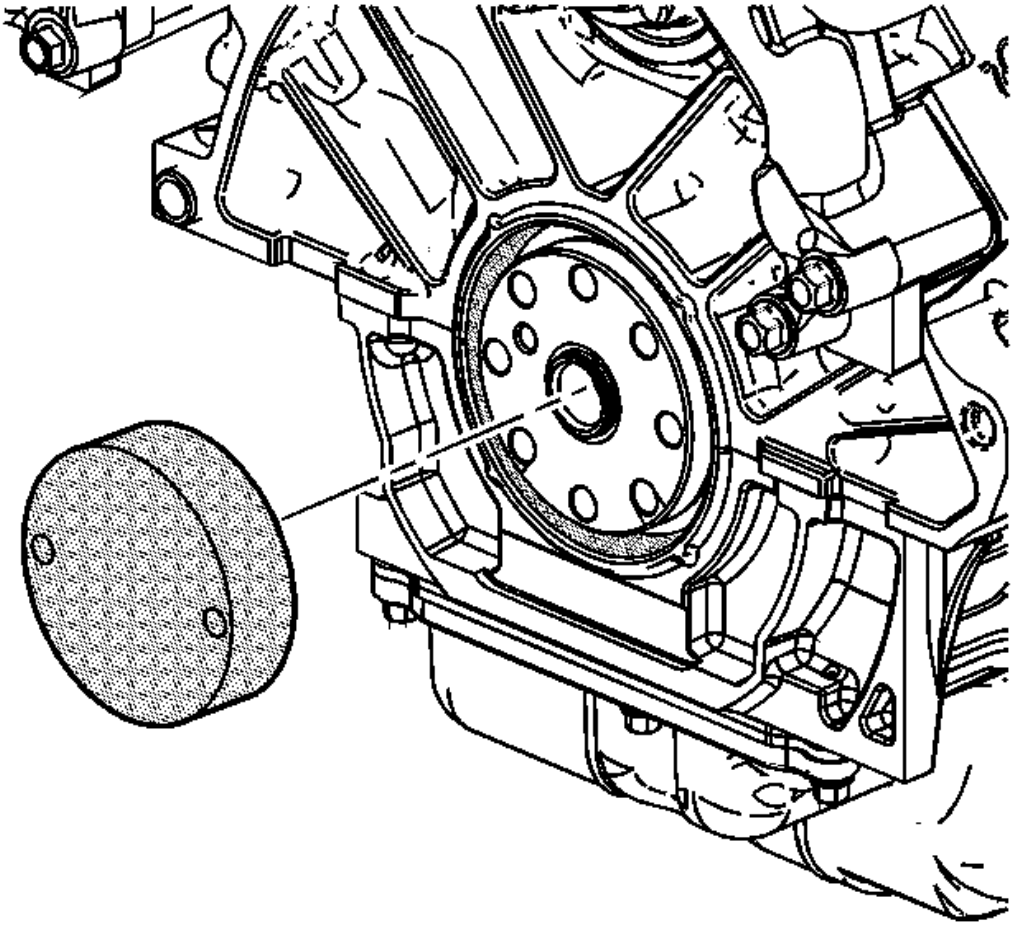

Fig. 18: Rear Seal Pilot Base
Courtesy of GENERAL MOTORS CORP.

13. Remove the **EN-48072** pilot base. See **Special Tools** .

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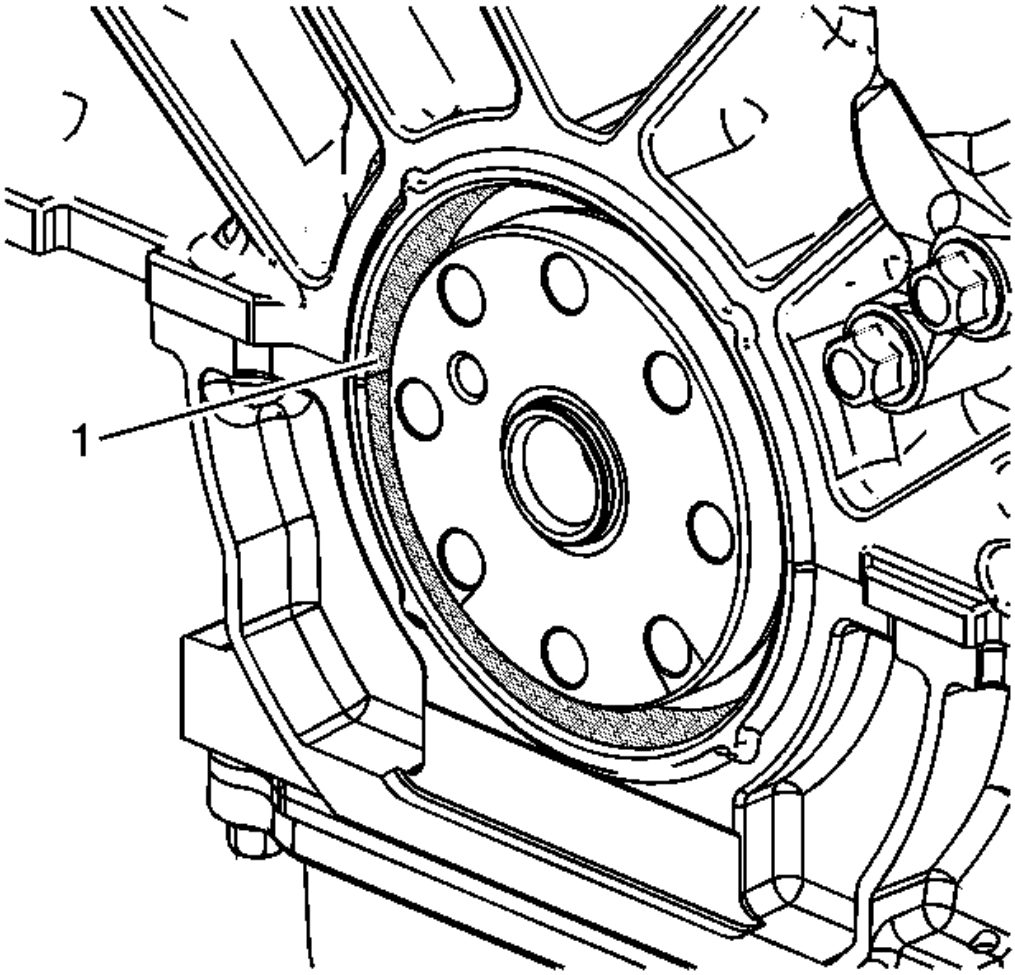

Fig. 19: Spreading Sealant Across Bore Of Block
Courtesy of GENERAL MOTORS CORP.

14. Ensure that the sealant (1) is evenly spread across the bore of the block.

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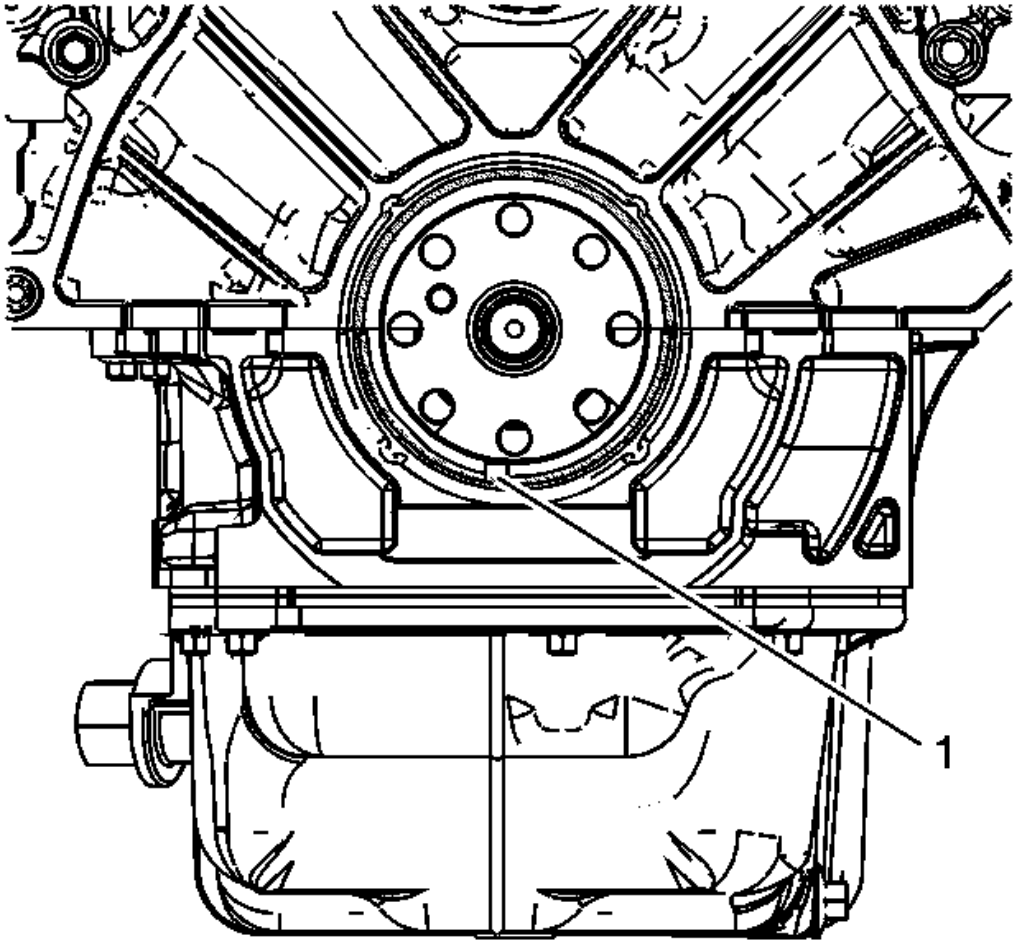

Fig. 20: Checking Seal Bore Drain Back Hole
Courtesy of GENERAL MOTORS CORP.

15. Ensure the drain back hole (1) is clear of the sealant.

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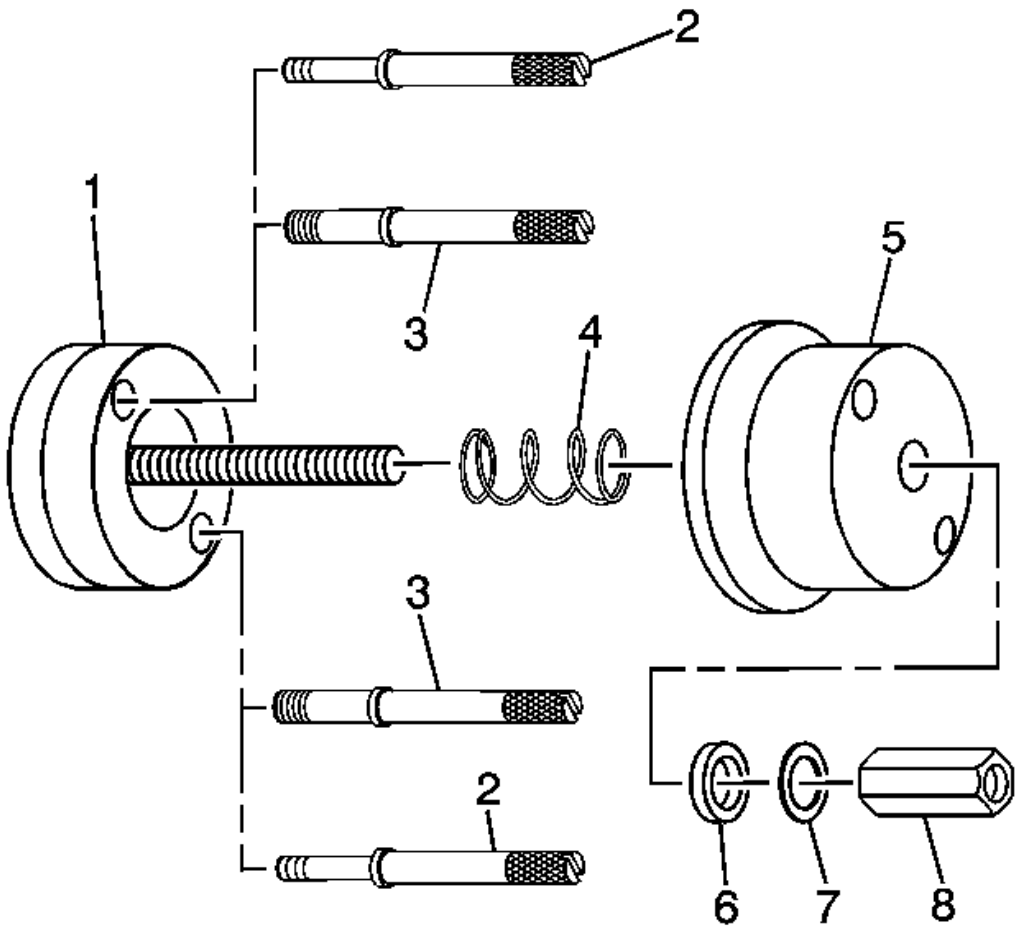

Fig. 21: View Of J 45930-A Tool Set
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Beginning with the model year 2006 the flywheel/flexplate crankshaft bolt hole thread was changed from 8 x 1.25 mm to 11 x 1.5 mm. The J 45930-A will service the cassette seals installed on engines from March 1, 1996 to 2006. See Special Tools . If a J 45930 is to be used on a 2006 or later engine the update kit, J 45930-10, must be used to convert the J 45930 to a J 45930-A . See Special Tools .**
- **Crankshaft rear oil seal and engine flywheel installation requires adequate space for installation. If the engine stand does not allow suitable space to use the J 45930-A install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor or on a bench. See Special Tools .**

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- **Northstar engines 2005 and older have an 8 x 1.25 mm flywheel/flexplate crankshaft bolt hole thread. Northstar engines 2006 and later have an 11 x 1.5 mm flywheel/flexplate crankshaft bolt hole thread.**

16. Ensure the proper size of bolt (2) 8 mm or (3) 11 mm is being installed in the **J 45930-A** . See **Special Tools** .

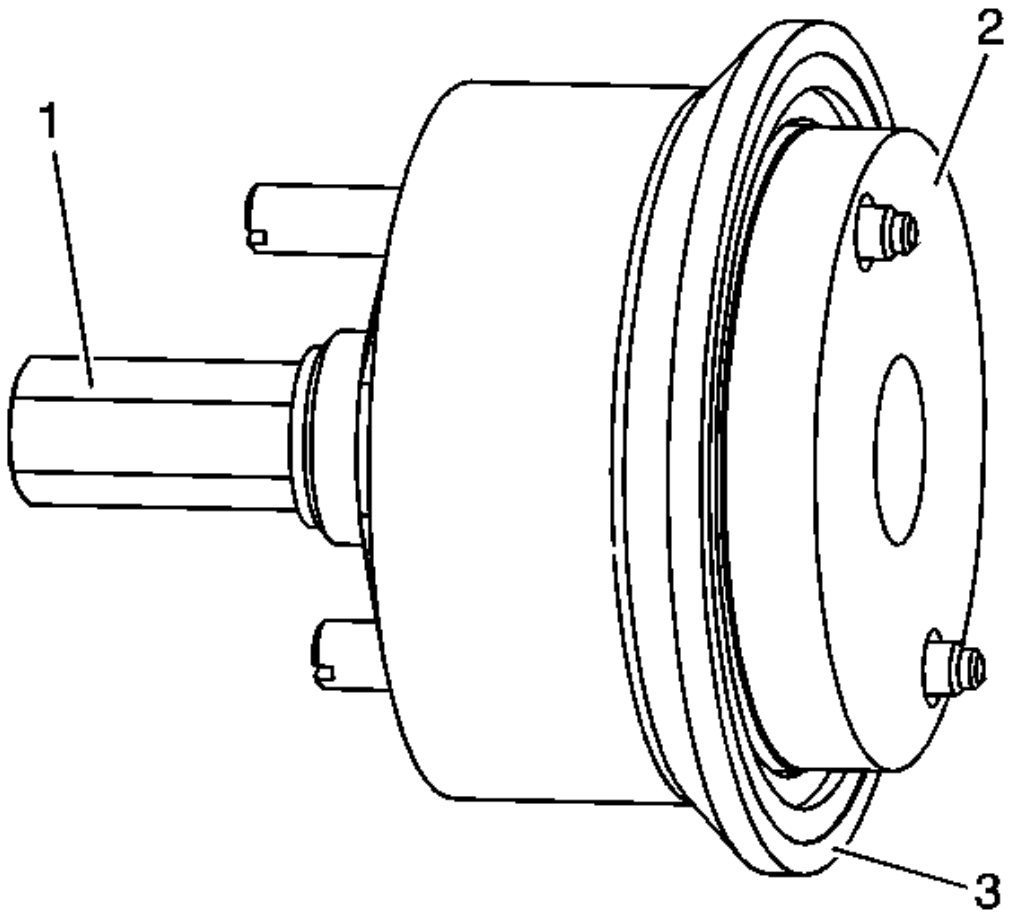

Fig. 22: Crankshaft Rear Oil Seal Installer
Courtesy of GENERAL MOTORS CORP.

17. Turn the center nut (1) of the **J 45930-A** until the center hub (2) protrudes approximately 15 mm (0. See **Special Tools** .591 in) beyond the outer plate (3).

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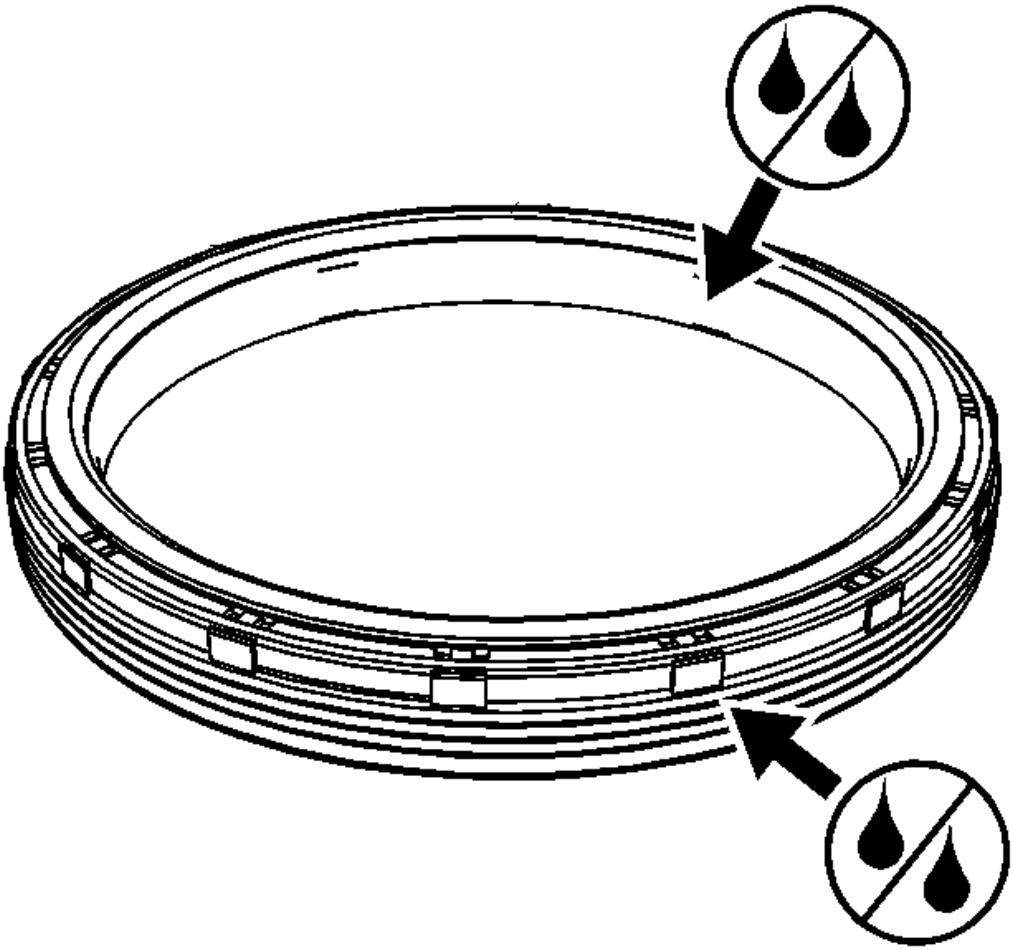

Fig. 23: Identifying Rear Seal Lubrication Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use any lubricant in order to install the crankshaft rear oil seal. Do not use any lubricant on the coating pre-applied to the inner diameter of the crankshaft rear oil seal. The coating is a sealant that must not be contaminated. Do not use any lubricant on the outer diameter of the crankshaft rear oil seal. The sealant applied to the bore of the engine block will not properly bond to a lubricated crankshaft rear oil seal.

18. Do not lubricate any part of the new cassette style crankshaft rear oil seal.

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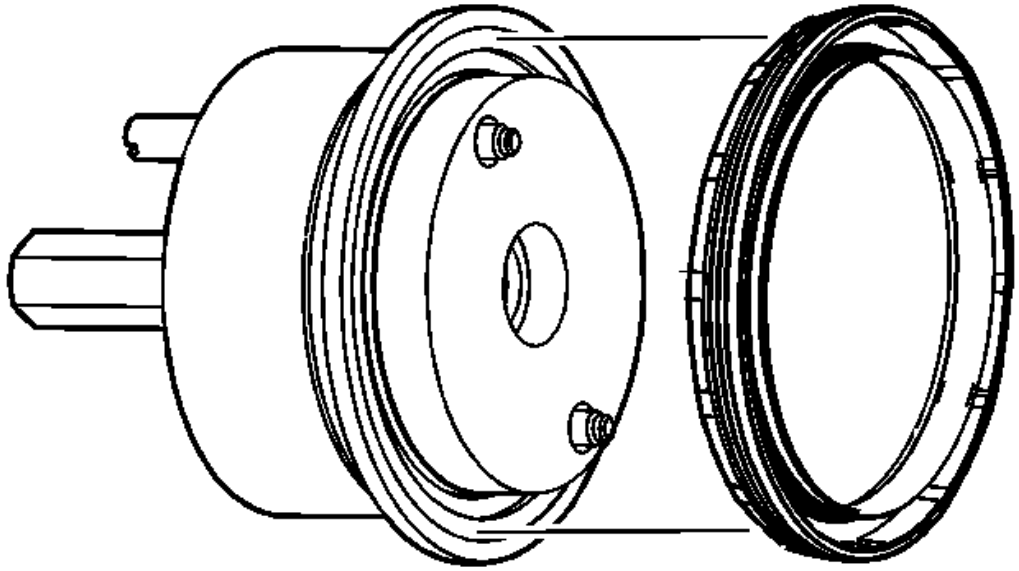

Fig. 24: Cassette Style Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

19. Install the new cassette style crankshaft rear oil seal onto the center hub of the **J 45930-A** . See **Special Tools** .

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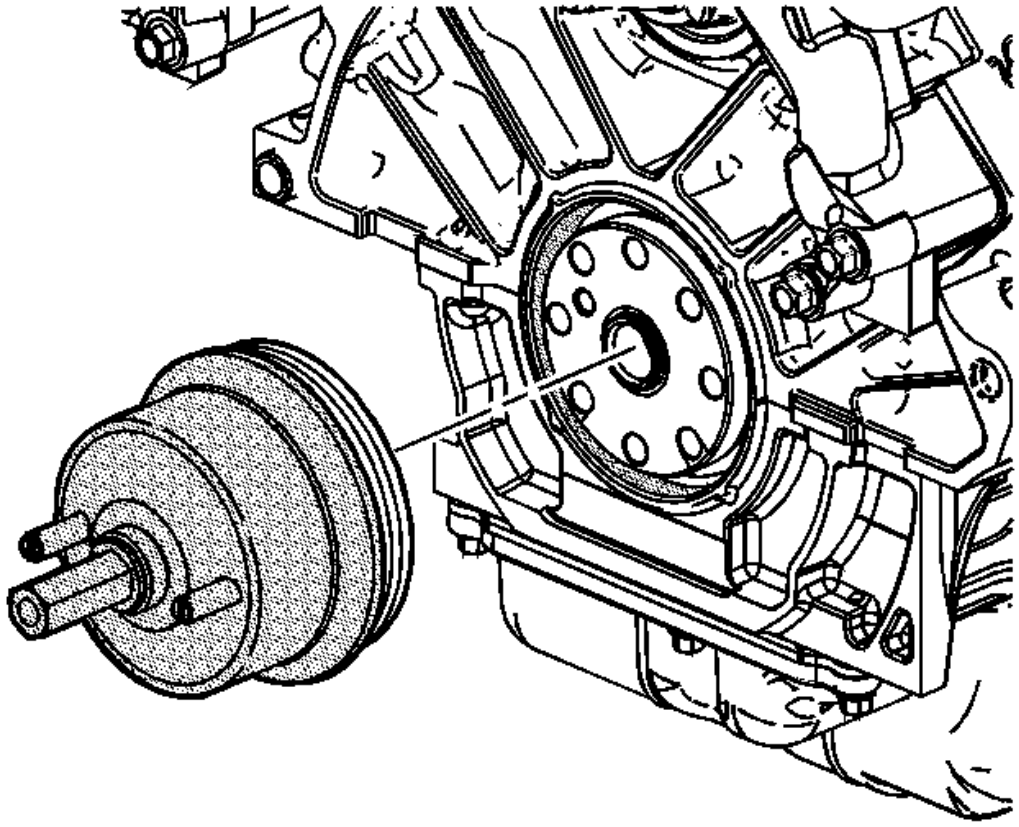

Fig. 25: Threading J 45930-A Mounting Bolts Into Crankshaft Flywheel Bolt Holes
Courtesy of GENERAL MOTORS CORP.

20. Thread the two **J 45930-A** mounting bolts into the crankshaft flywheel bolt holes. See **Special Tools** .

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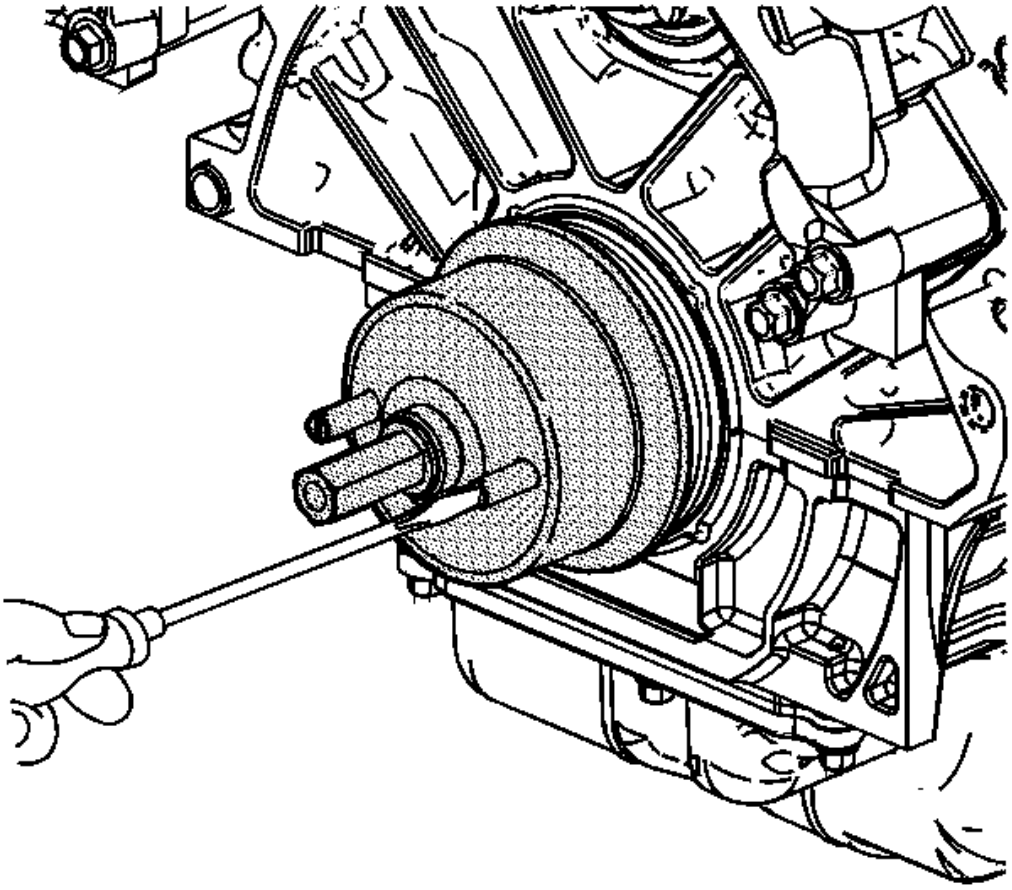

Fig. 26: Tightening Seal Installer
Courtesy of GENERAL MOTORS CORP.

21. Tighten the two mounting bolts until the **J 45930-A** is firmly mounted on the crankshaft. See **Special Tools** .

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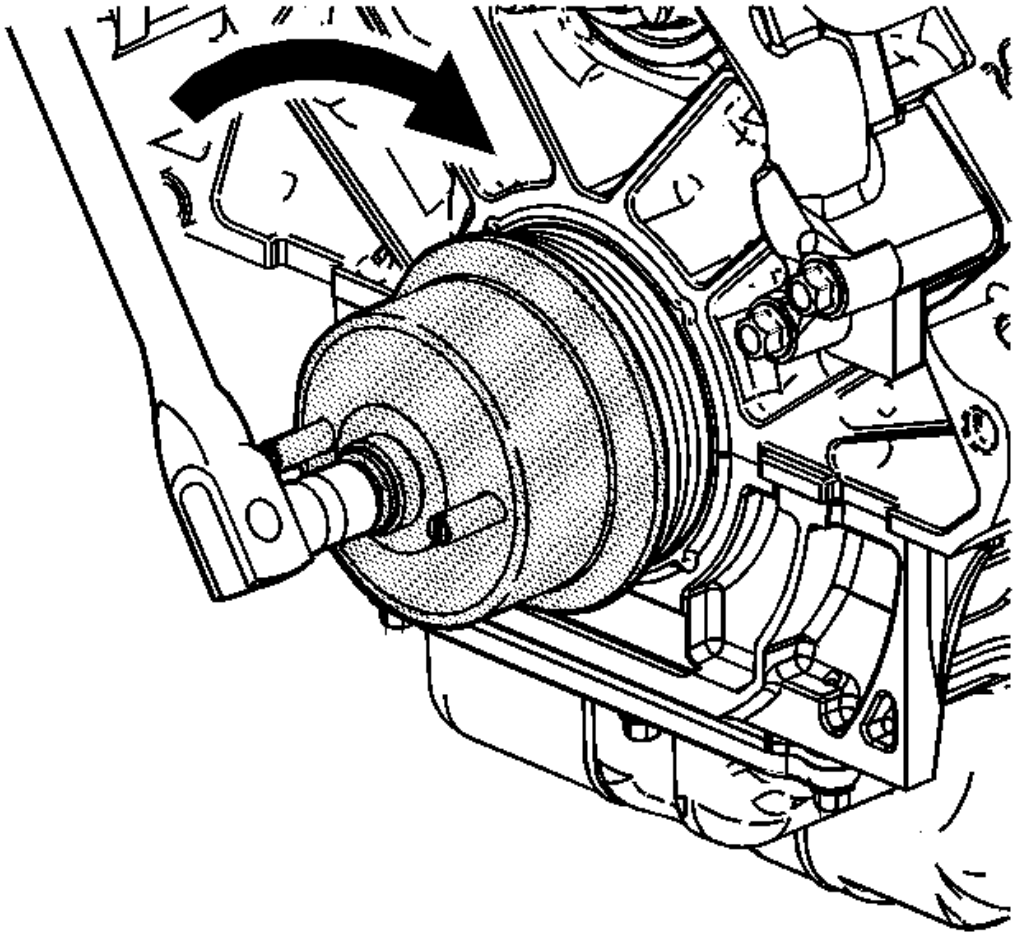

Fig. 27: Installing Crankshaft Rear Seal
Courtesy of GENERAL MOTORS CORP.

22. Install the new cassette style crankshaft rear oil seal by turning the nut of the **J 45930-A** until the drive portion of the **J 45930-A** bottoms against the crankcase. See **Special Tools** .

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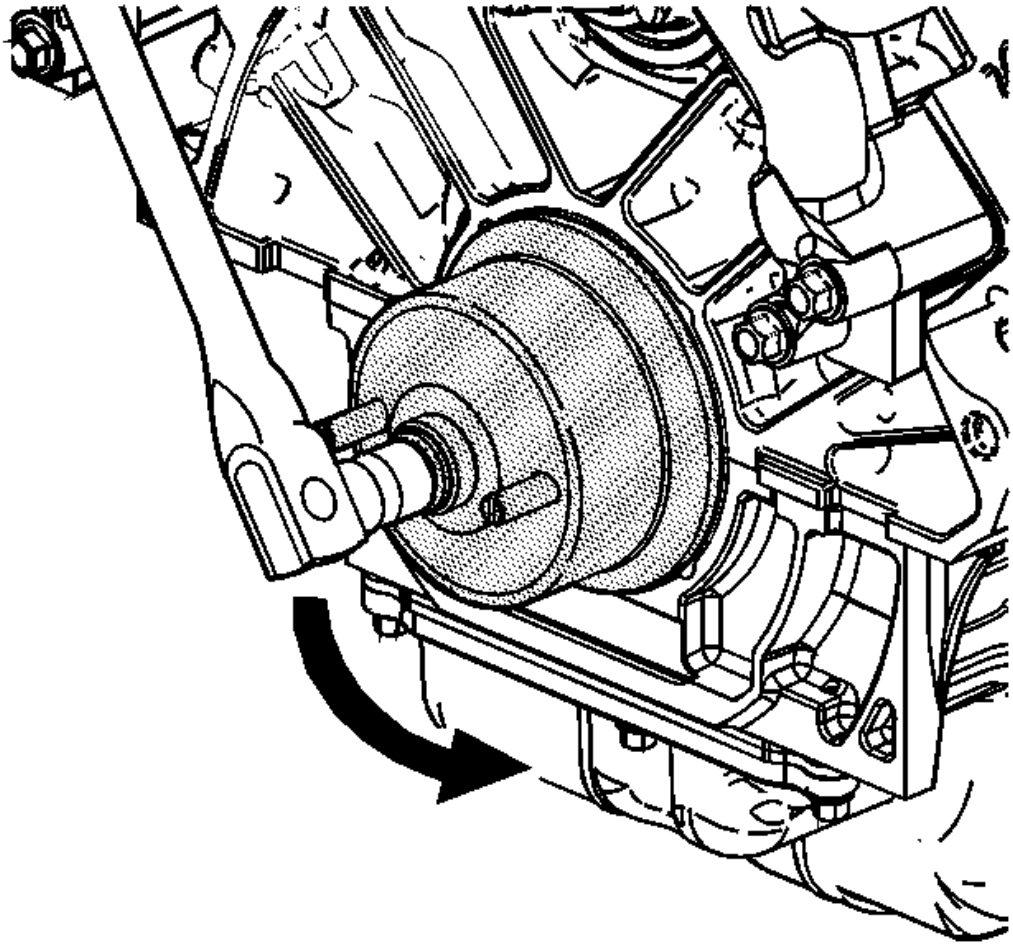

Fig. 28: Loosening Seal Installer Center Nut
Courtesy of GENERAL MOTORS CORP.

23. Loosen the center nut to release pressure on the crankcase.

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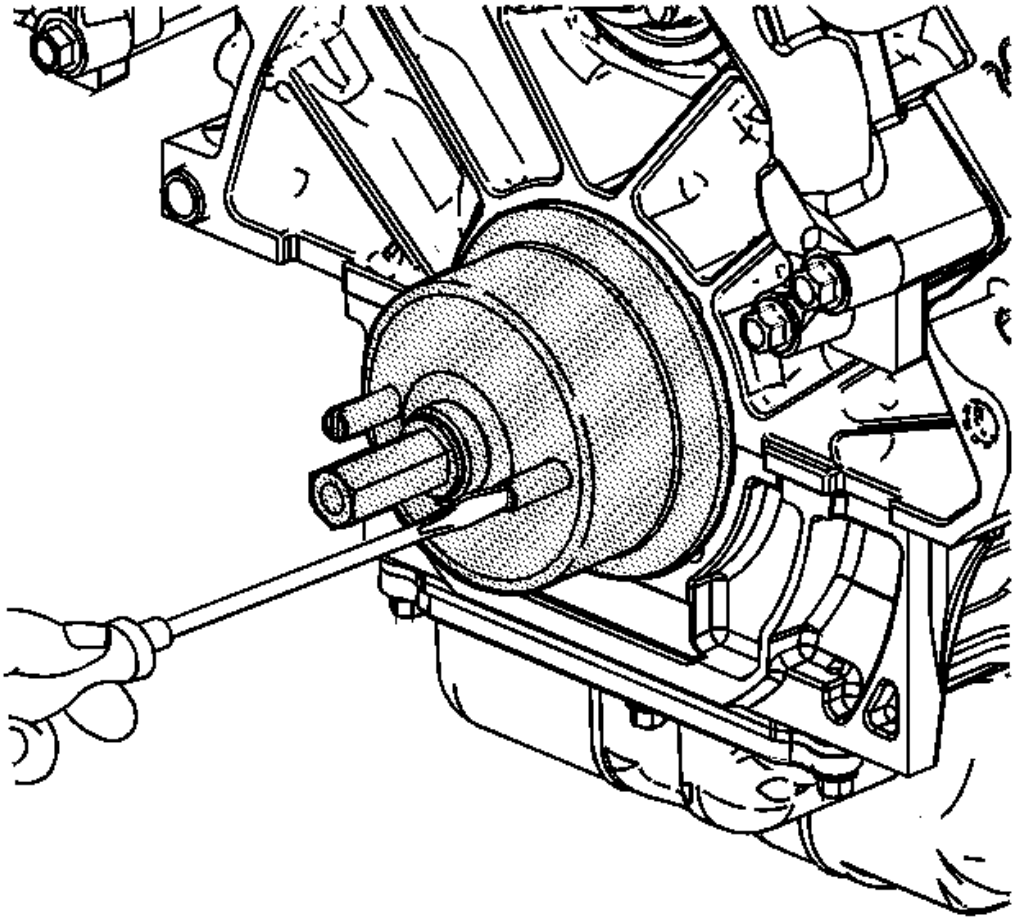

Fig. 29: Loosening Seal Installer Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

24. Loosen the two mounting bolts.

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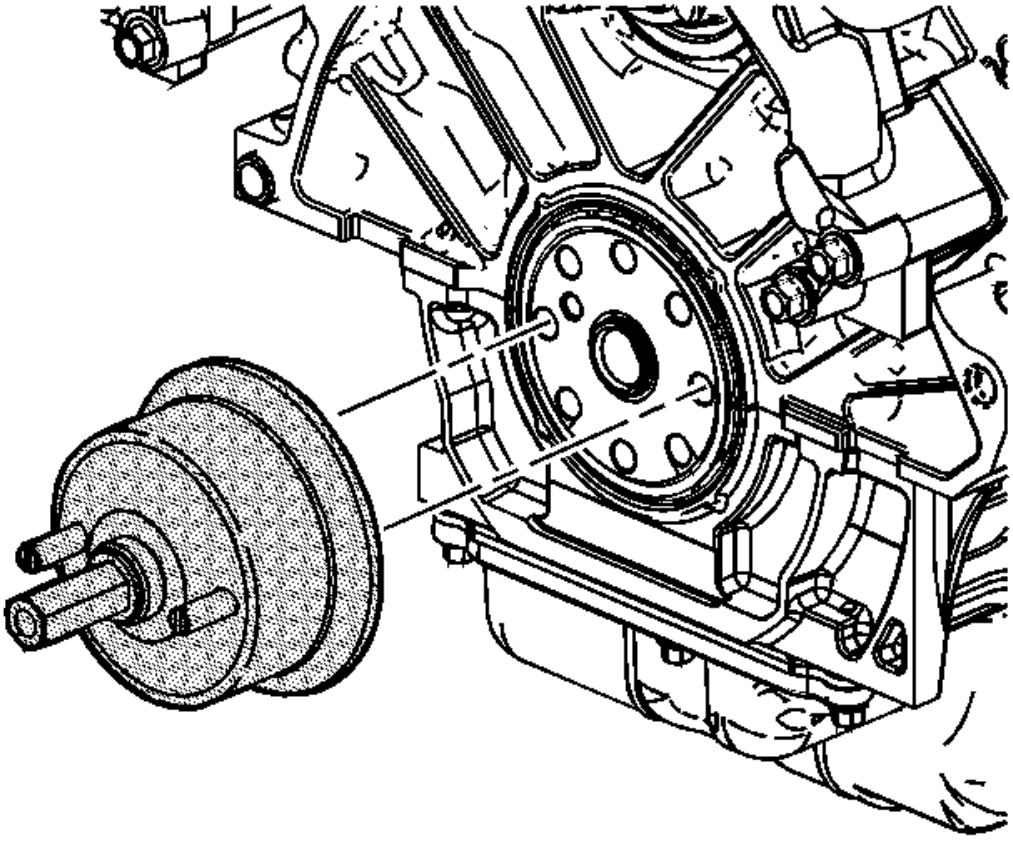

Fig. 30: Removing J 45930-A Seal Installer
Courtesy of GENERAL MOTORS CORP.

25. Remove the **J 45930-A** from the crankshaft. See **Special Tools** .
26. Wipe off any excessive sealant from the block.

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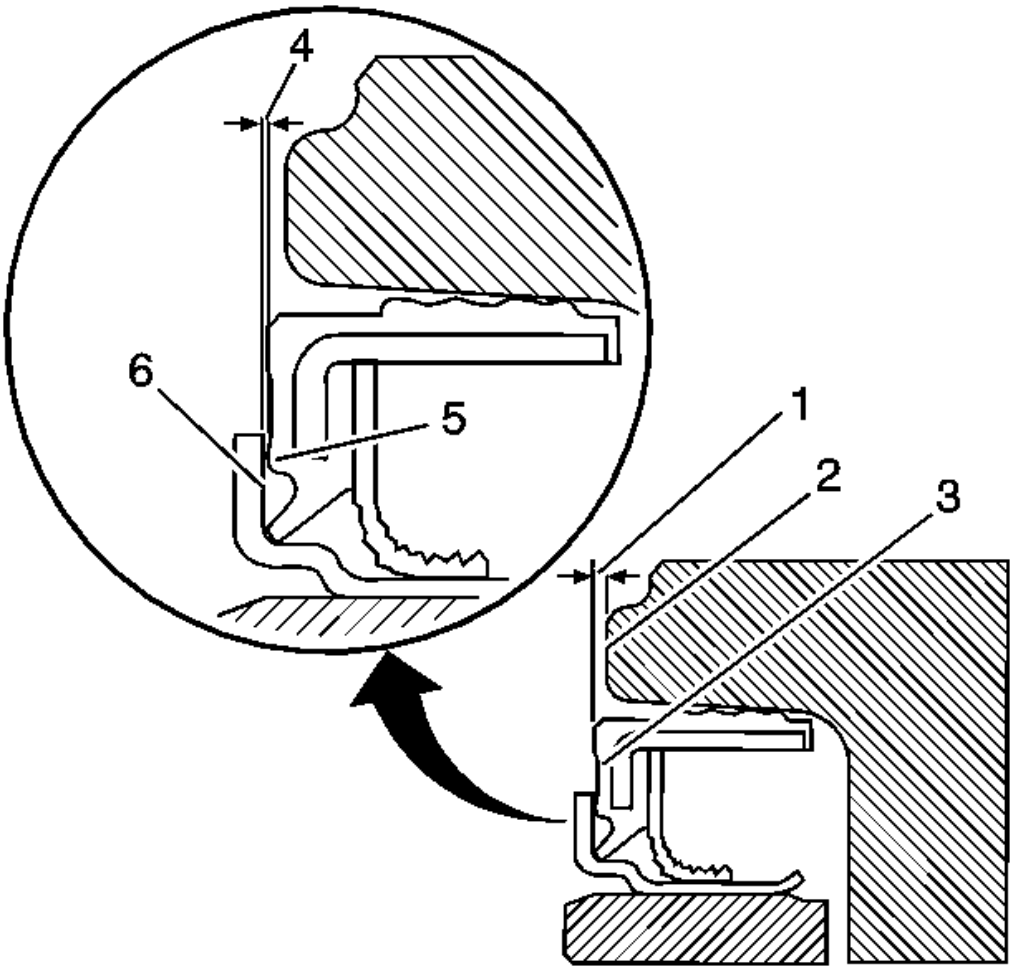

Fig. 31: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

27. Ensure the new cassette style crankshaft rear oil seal is installed properly.
    - The outer surface of the seal (3) should be 0.500-0.800 mm (0.0197-0.0315 in) (1) below the surface of the engine block (2).
    - The inner surface of the sleeve (6) should be 0.400-0.900 mm (0.0158-0.0354 in) (4) below the surface of the outer surface of the seal (5).
    - The installed seal and sleeve need to be parallel to the block by 0.000-0.500 mm (0.000-0.0197 in).
28. Clean all tools to remove any residual sealant.
29. Install the flywheel. Refer to **Engine Flywheel Replacement** .
30. Install the transaxle. Refer to **Transmission Replacement** .

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ENGINE REPLACEMENT

Special Tools

- **J 37097-A** Hose Clamp Remover/Installer. See **Special Tools** .
- **J 38185** Hose Clamp Pliers
- **J 39580** Universal Engine Support Table. See **Special Tools** .
- **J 41623-B** Cooler Quick Connect Tool
- **J 42640** Steering Column Lock Pin

REMOVAL PROCEDURE

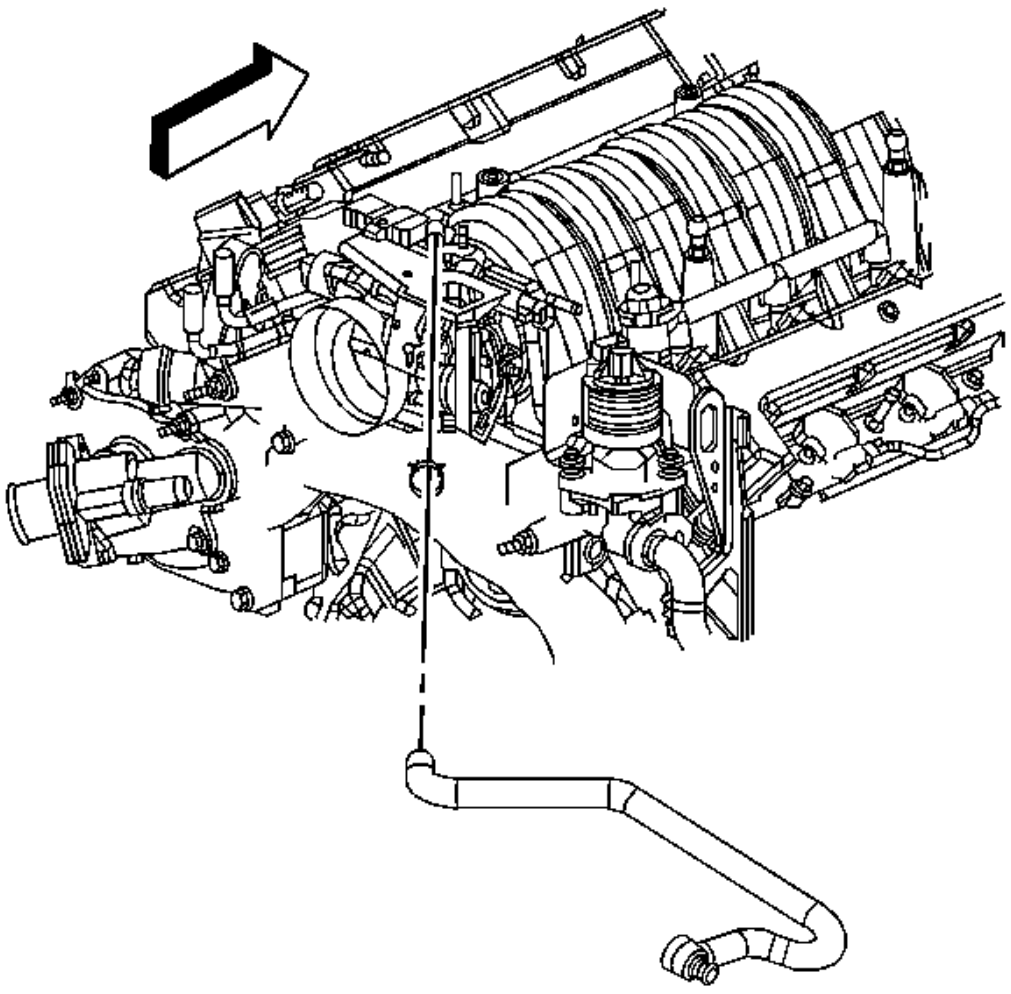

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Fig. 32: Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement** .
3. Recover the air conditioning (A/C) refrigerant system. Refer to **Refrigerant Recovery and Recharging** .
4. Reposition the brake booster vacuum hose clamp at the engine port.
5. Disconnect the brake booster vacuum hose from the vacuum connection and position aside.

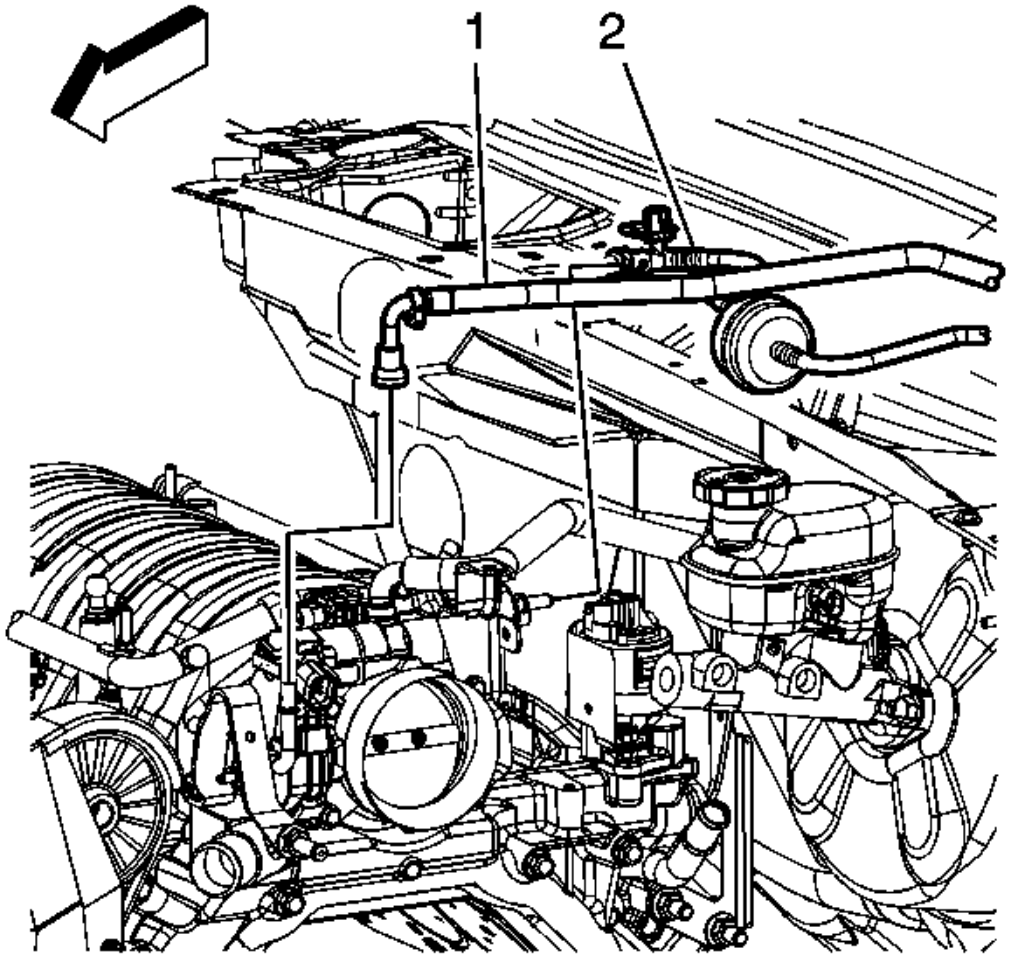

Fig. 33: Fuel Feed Pipe & EVAP Line Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

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6. Disconnect the fuel feed and evaporative emission (EVAP) line quick-connect fittings (1, 2). Refer to **Metal Collar Quick Connect Fitting Service** and **Plastic Collar Quick Connect Fitting Service** .
7. Remove the front compartment sight shield. Refer to **Front Compartment Sight Shields Replacement** .
8. Remove the air cleaner. Refer to **Air Cleaner Assembly Replacement** .

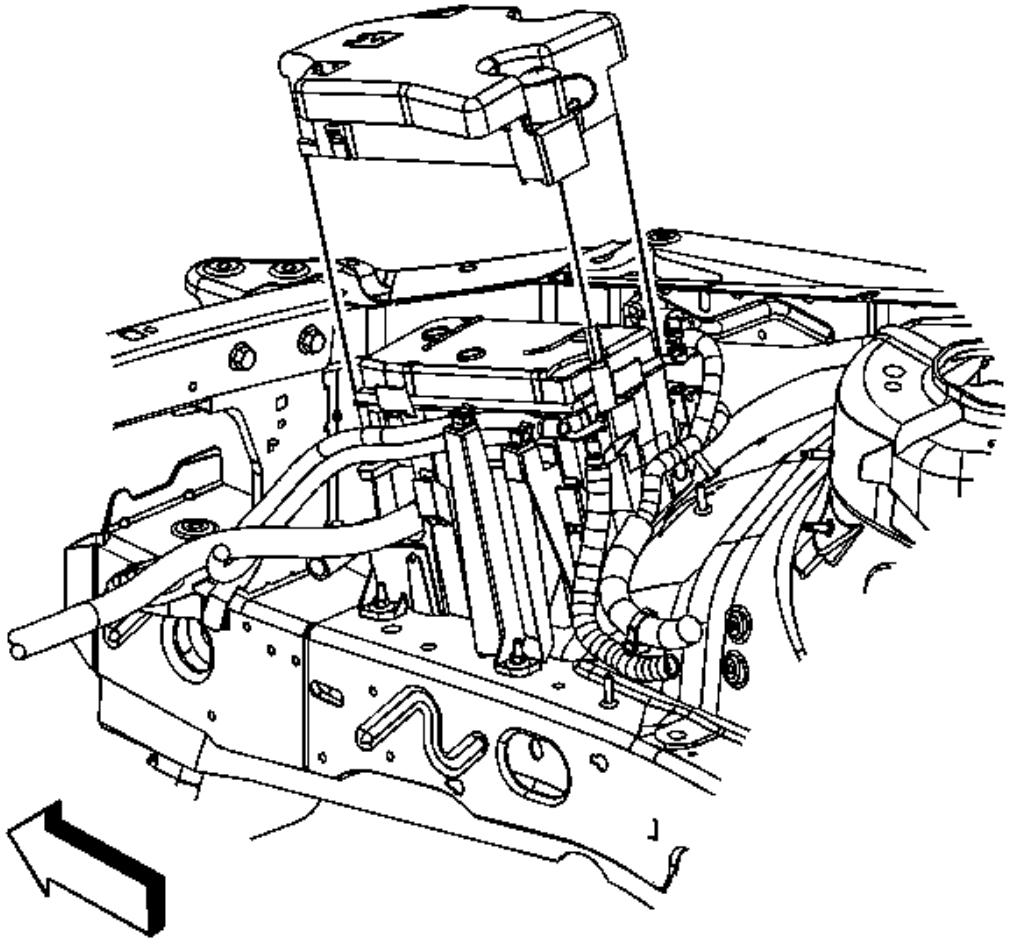

Fig. 34: Junction Block Cover
Courtesy of GENERAL MOTORS CORP.

9. Disengage the junction block cover lock tabs.
10. Remove the junction block cover.

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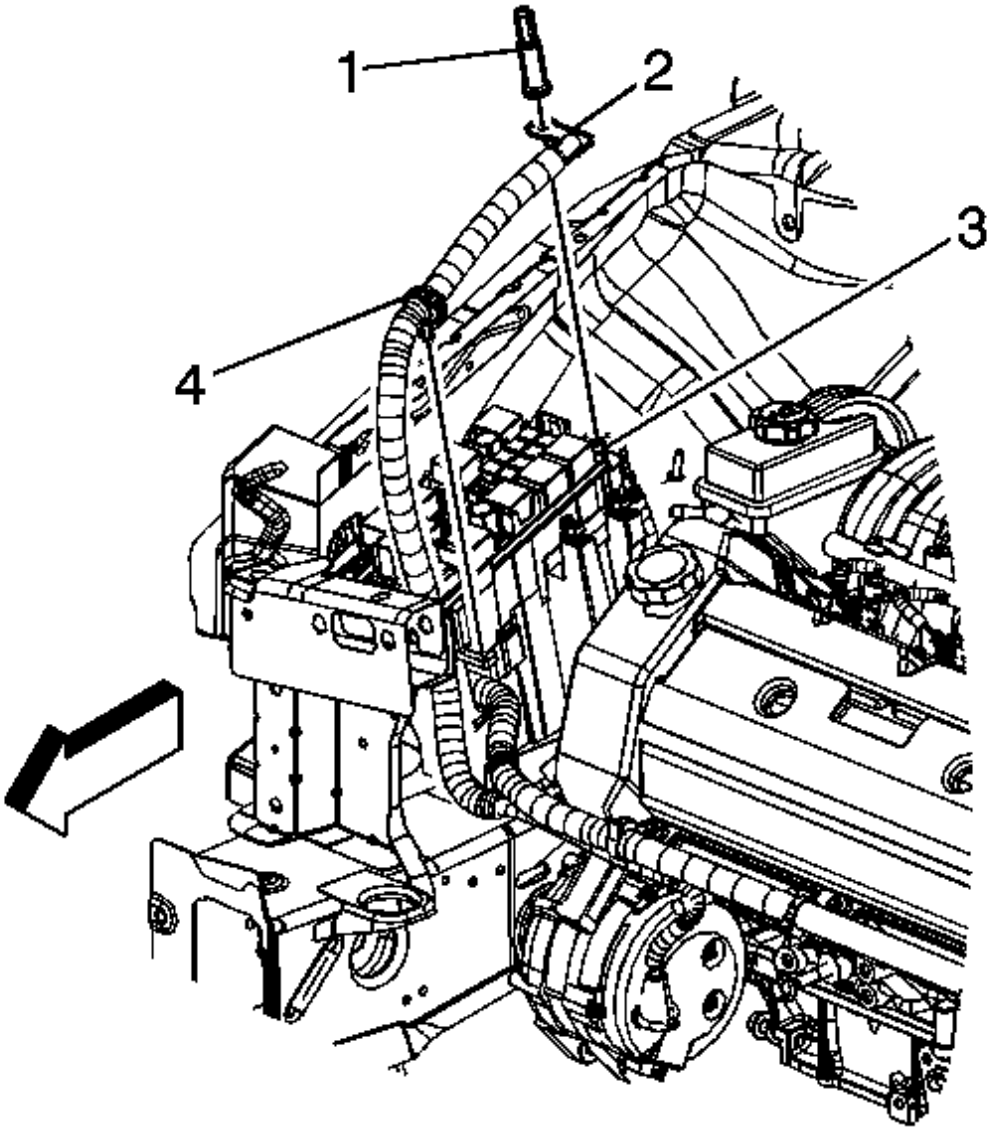

Fig. 35: Starter Solenoid Cable To Bussed Electrical Center
Courtesy of GENERAL MOTORS CORP.

11. Remove the nut (1) securing the starter cable to the bussed electrical center (BEC).
12. Remove the starter cable clip (4) from the BEC.
13. Remove the starter cable from the BEC terminal and secure to the top of the engine.

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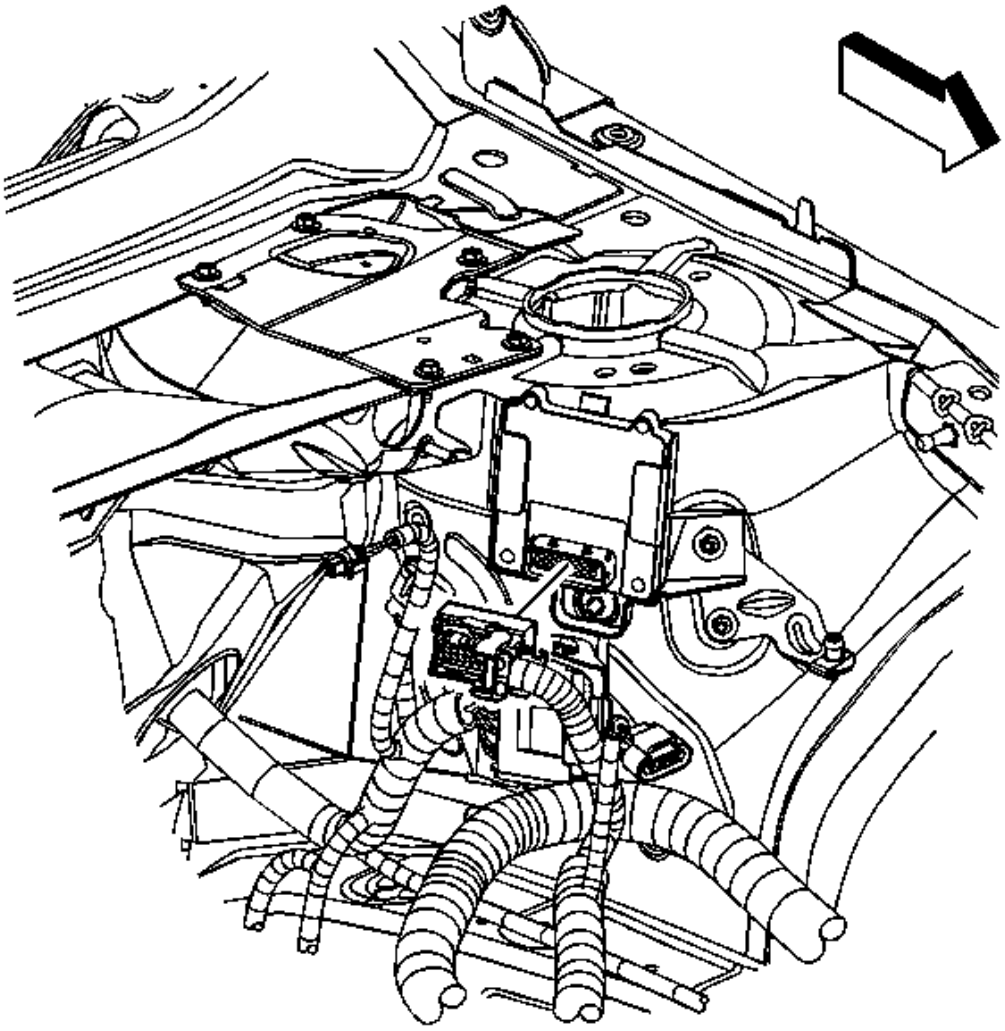

Fig. 36: Engine Harness Electrical Connector At Transaxle Control Module
Courtesy of GENERAL MOTORS CORP.

14. Disengage the lever lock.
15. Disconnect the engine harness electrical connector from the transaxle control module (TCM).

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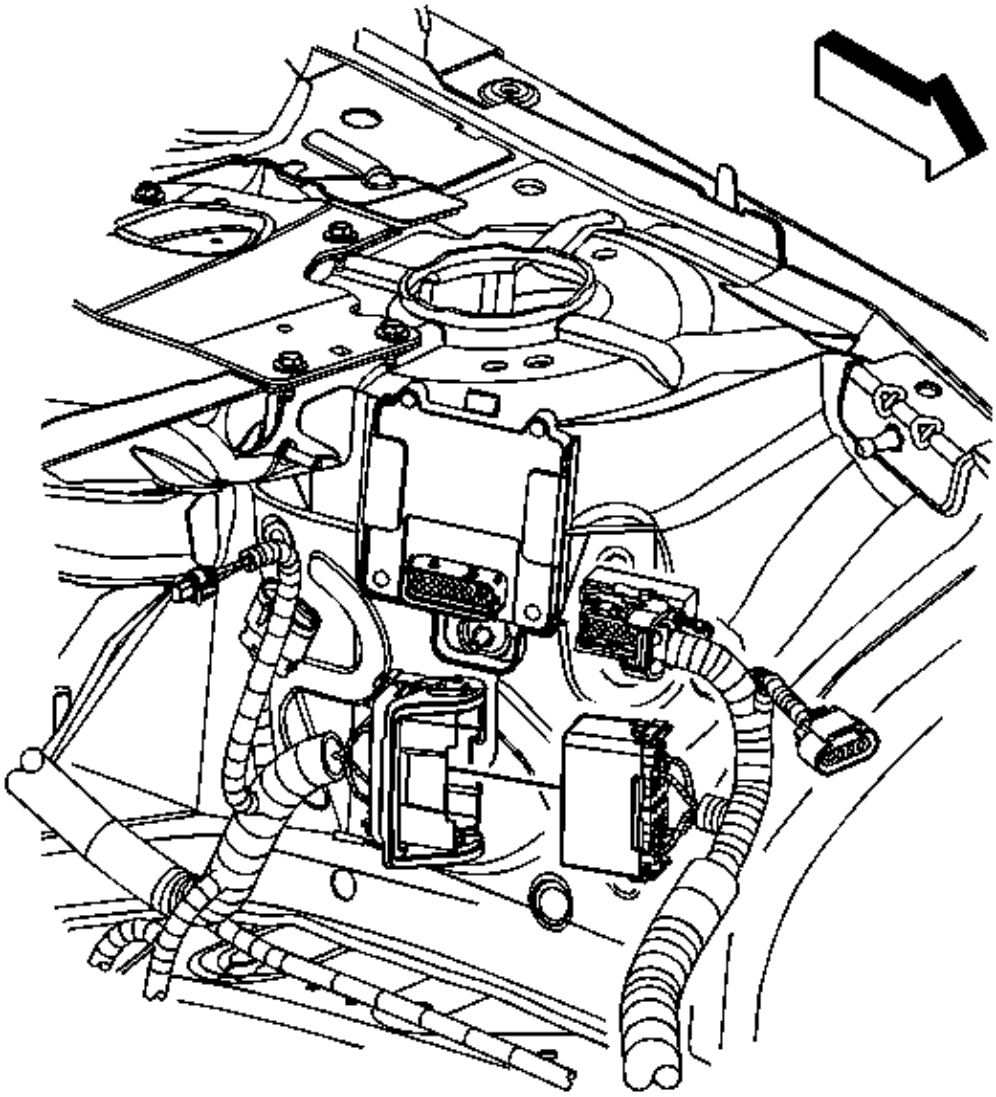

Fig. 37: Engine Harness Electrical Connector At Body Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

16. Disengage the lever lock.
17. Disconnect the engine harness electrical connector from the body harness electrical connector.
18. Secure the TCM and engine harness wiring branches to the engine.

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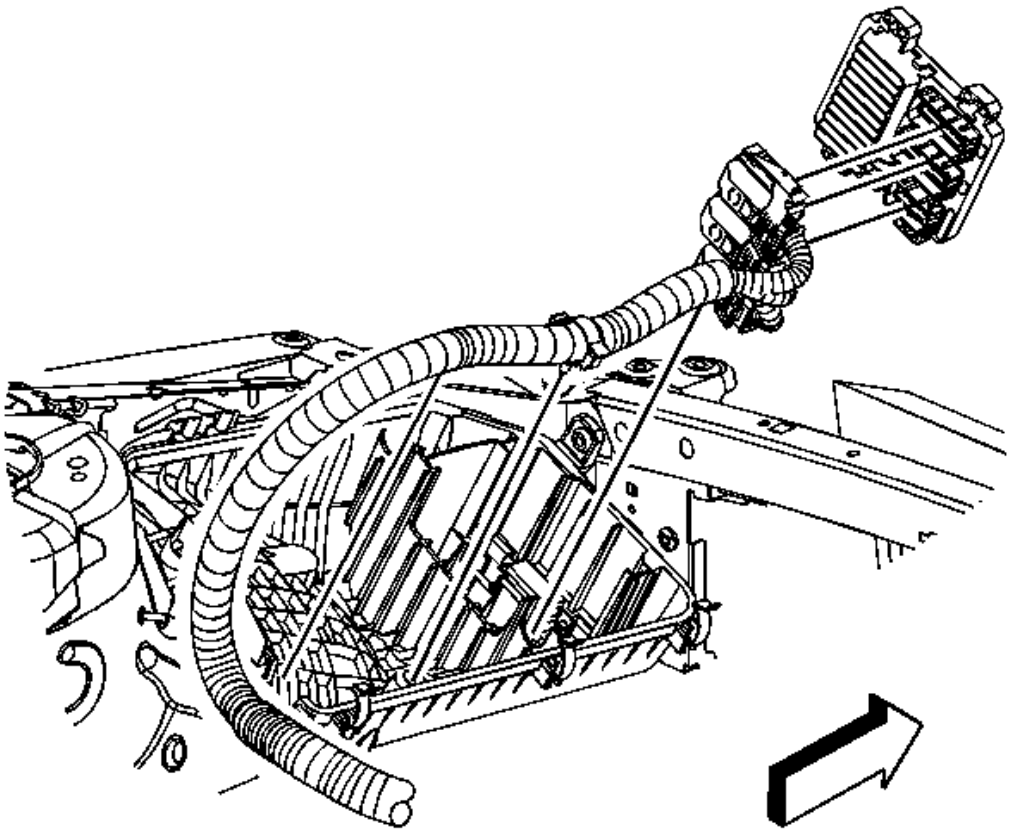

Fig. 38: Engine Harness Electrical Connectors At Engine Control Module
Courtesy of GENERAL MOTORS CORP.

19. Disengage the lever locks.
20. Disconnect the engine harness electrical connectors from the engine control module (ECM).

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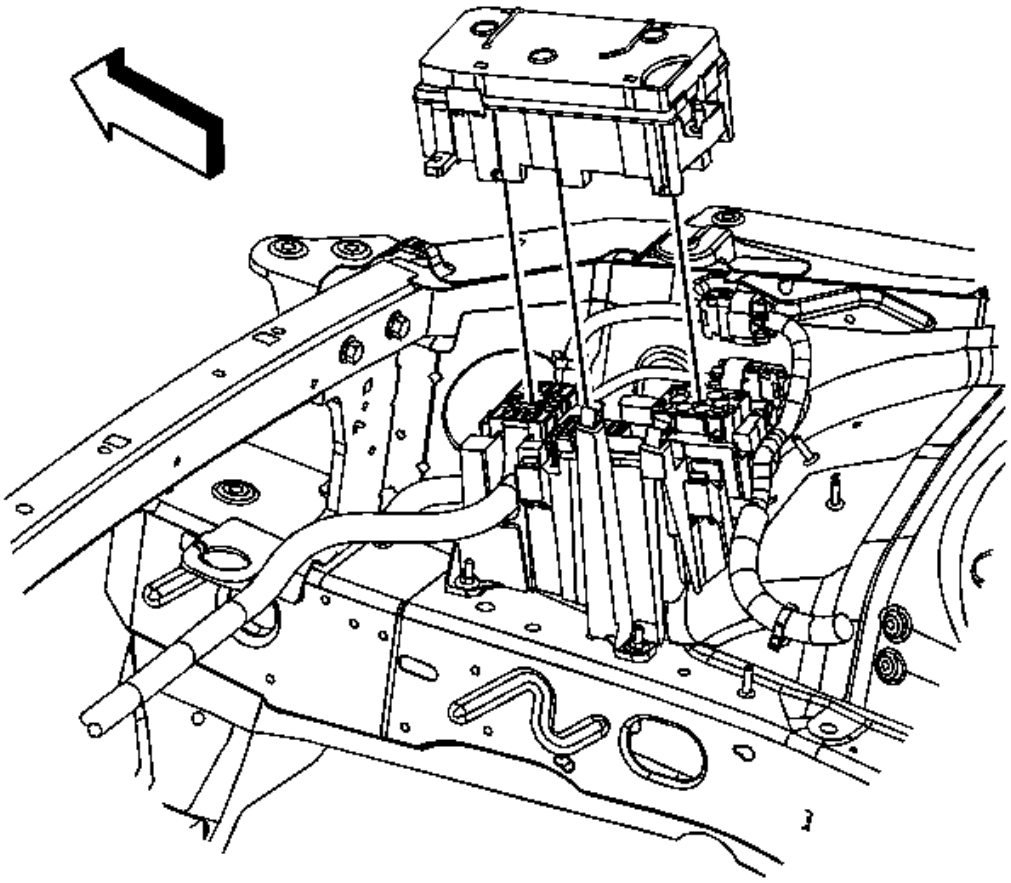

Fig. 39: Junction Block
Courtesy of GENERAL MOTORS CORP.

21. Remove the junction block bolts.
22. Remove the junction block.

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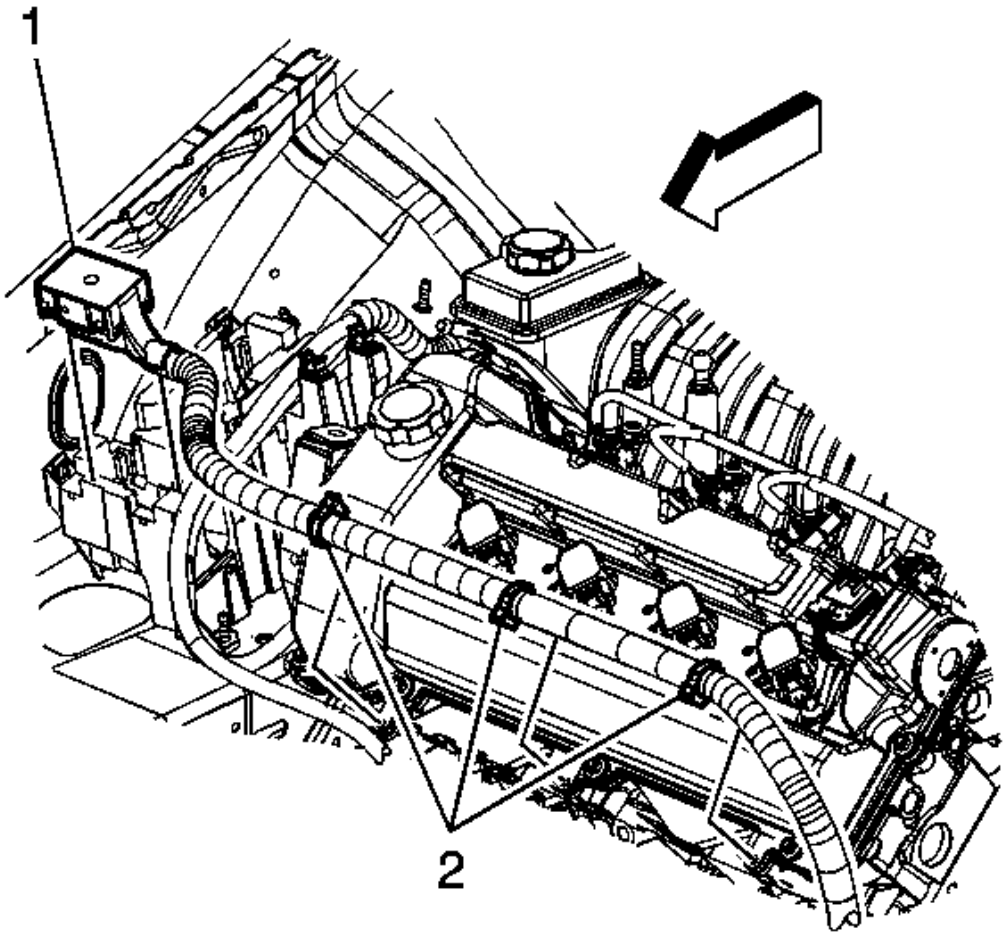

Fig. 40: Engine Harness & BEC
Courtesy of GENERAL MOTORS CORP.

23. Remove the engine harness (1) from the BEC.

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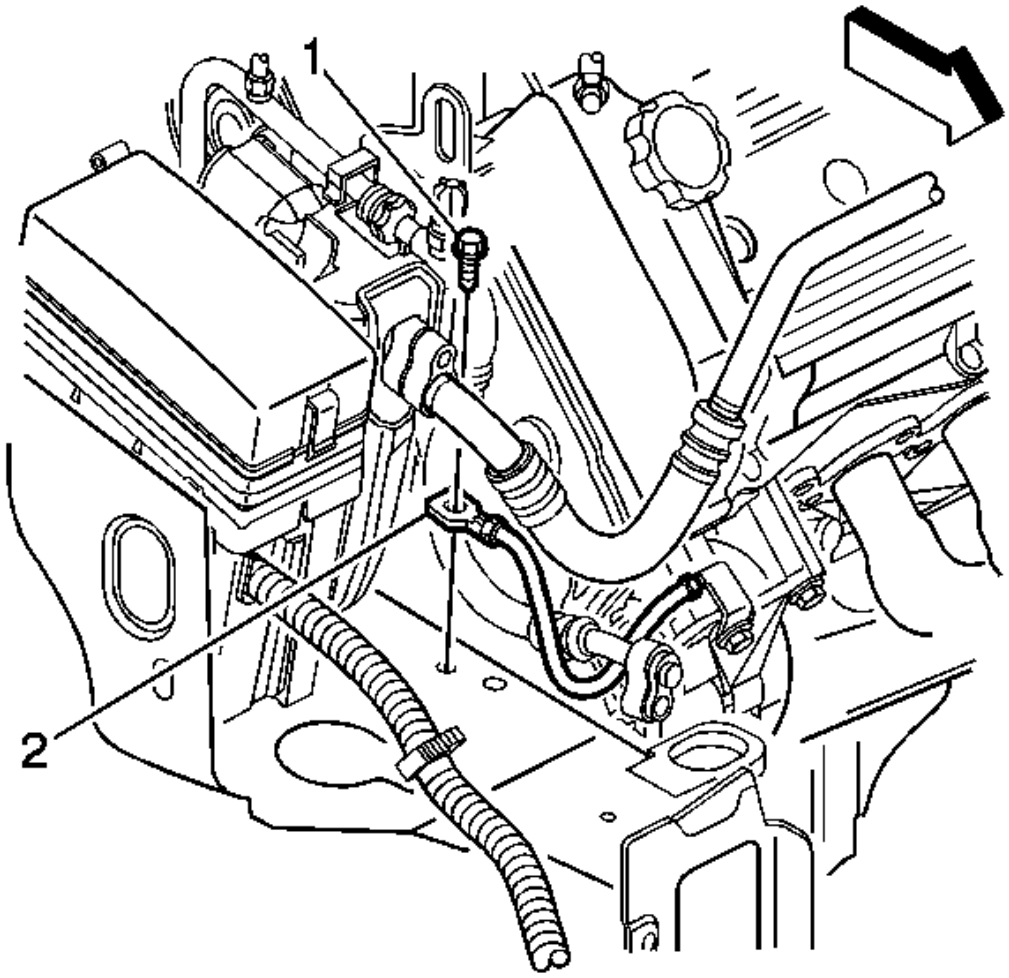

Fig. 41: Engine Ground Strap & Bolt
Courtesy of GENERAL MOTORS CORP.

24. Remove the engine ground strap bolt (1) from the right side frame rail.
25. Secure the ground strap to the engine.

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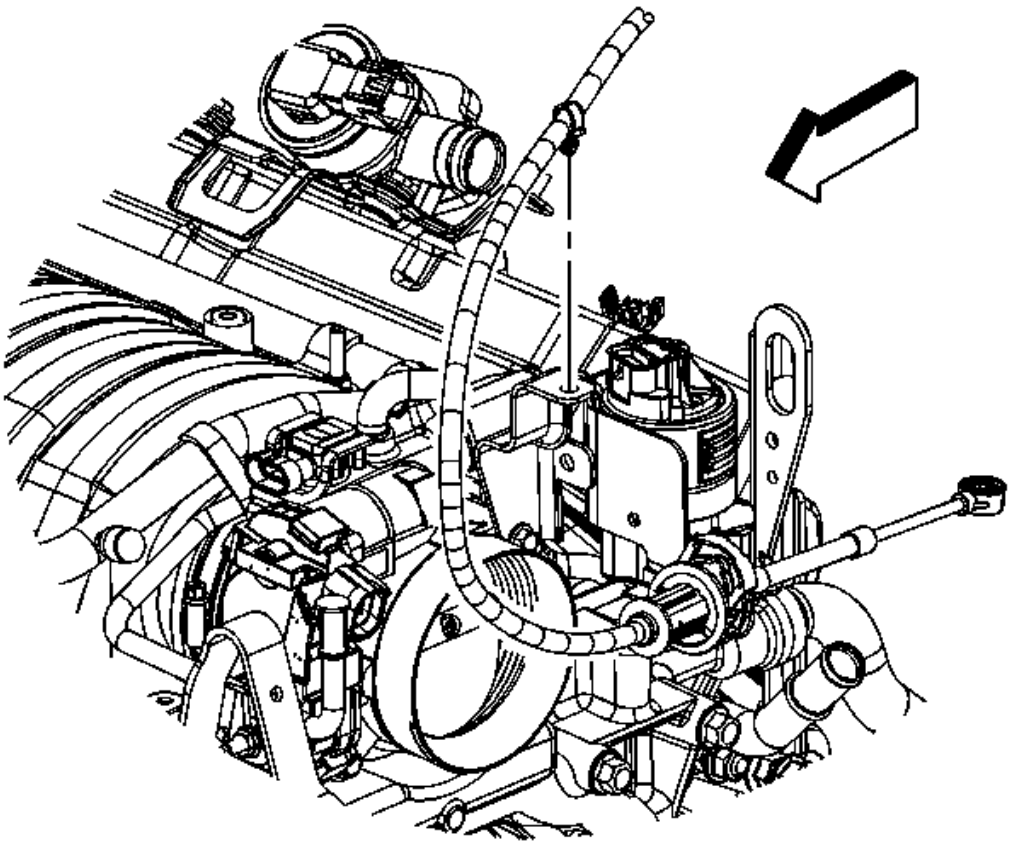

Fig. 42: Transaxle Shift Cable Clip & Bracket
Courtesy of GENERAL MOTORS CORP.

26. Remove the transaxle shift cable clip from the shift cable bracket.

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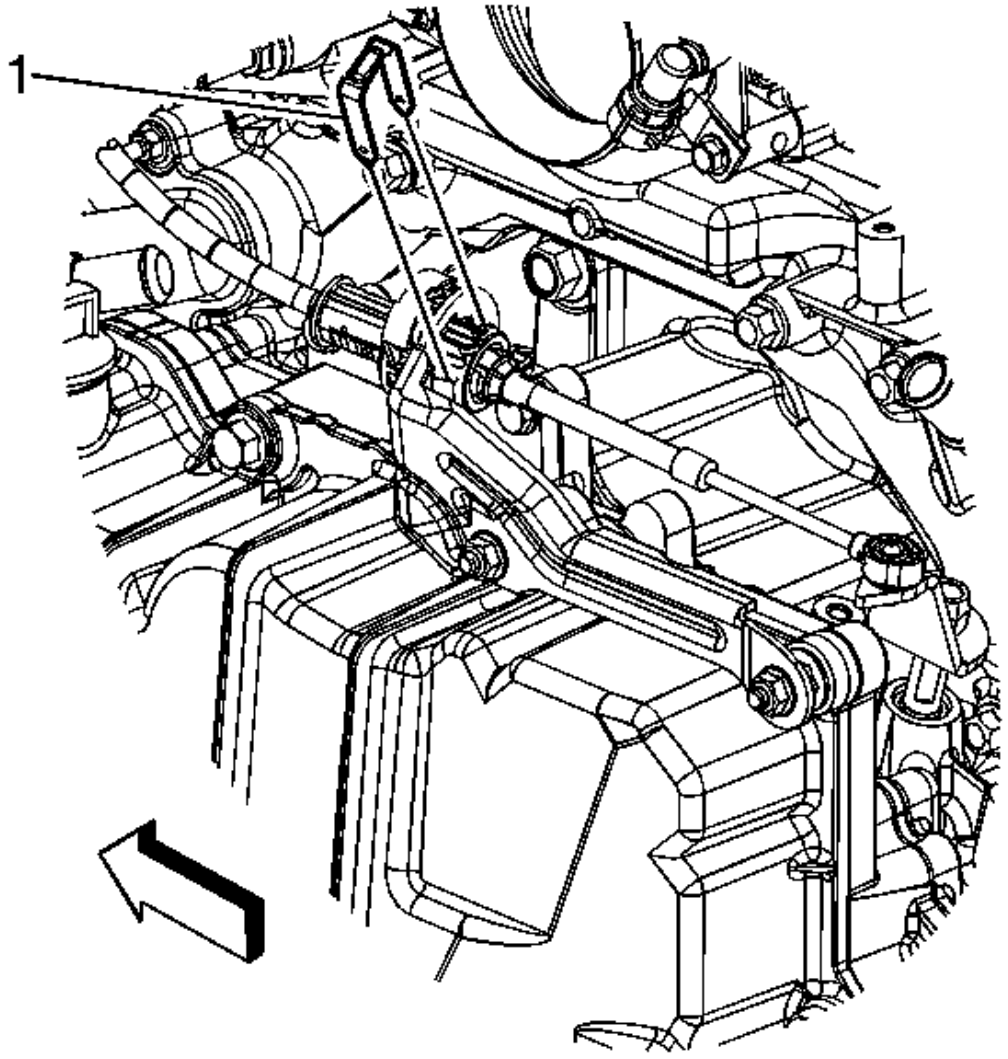

Fig. 43: Transaxle Shift Cable Retainer
Courtesy of GENERAL MOTORS CORP.

27. Remove the transaxle shift cable retainer (1).

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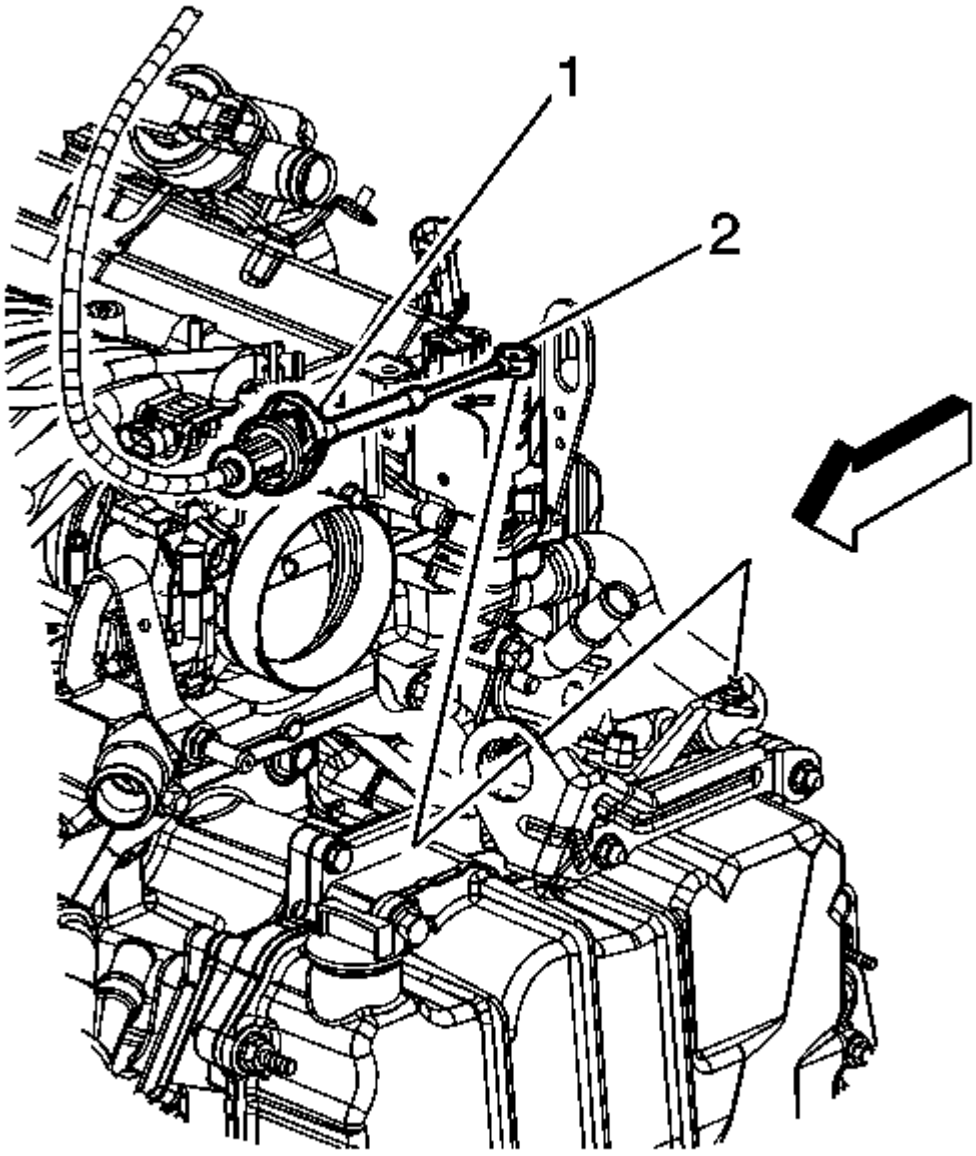

Fig. 44: Transaxle Shift Cable & Range Selector Lever
Courtesy of GENERAL MOTORS CORP.

28. Disconnect the transaxle shift cable end (2) from the range selector lever (1).
29. Remove the transaxle shift cable from the bracket and position the cable aside.
30. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (Vac-N-Fill)** .

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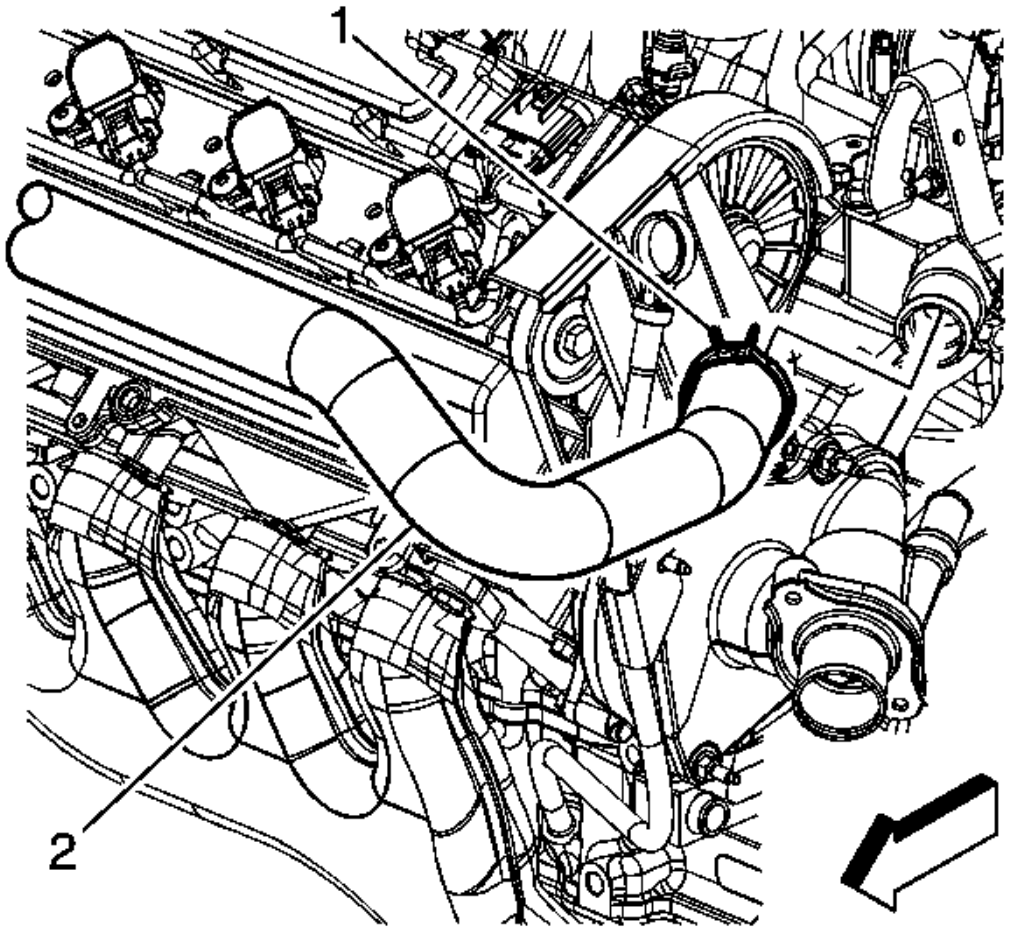

Fig. 45: Radiator Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

31. Using the **J 37097-A** reposition the radiator inlet hose clamp (1). See **Special Tools** .
32. Remove the radiator inlet hose (2) from the water pump housing and position aside.

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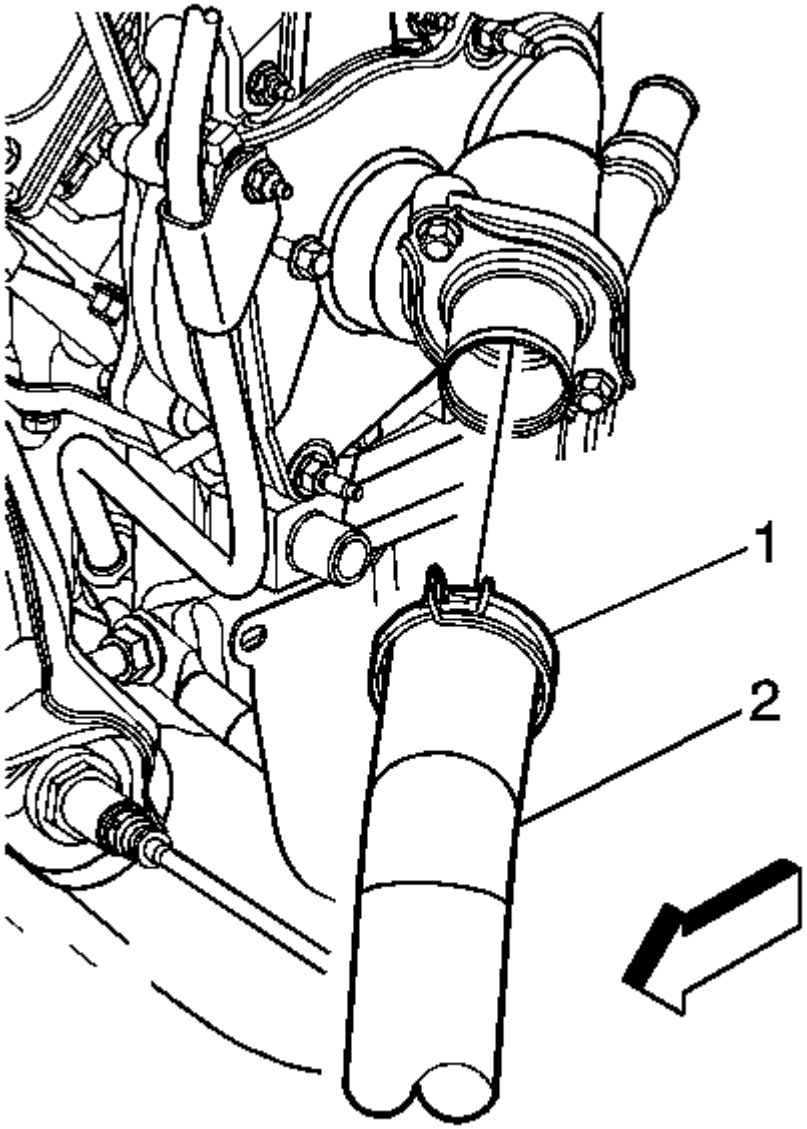

Fig. 46: Radiator Outlet Hose & Clamp At Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

33. Using the **J 38185** reposition the radiator outlet hose clamp (1).
34. Remove the radiator outlet hose (2) from the thermostat housing and position aside.

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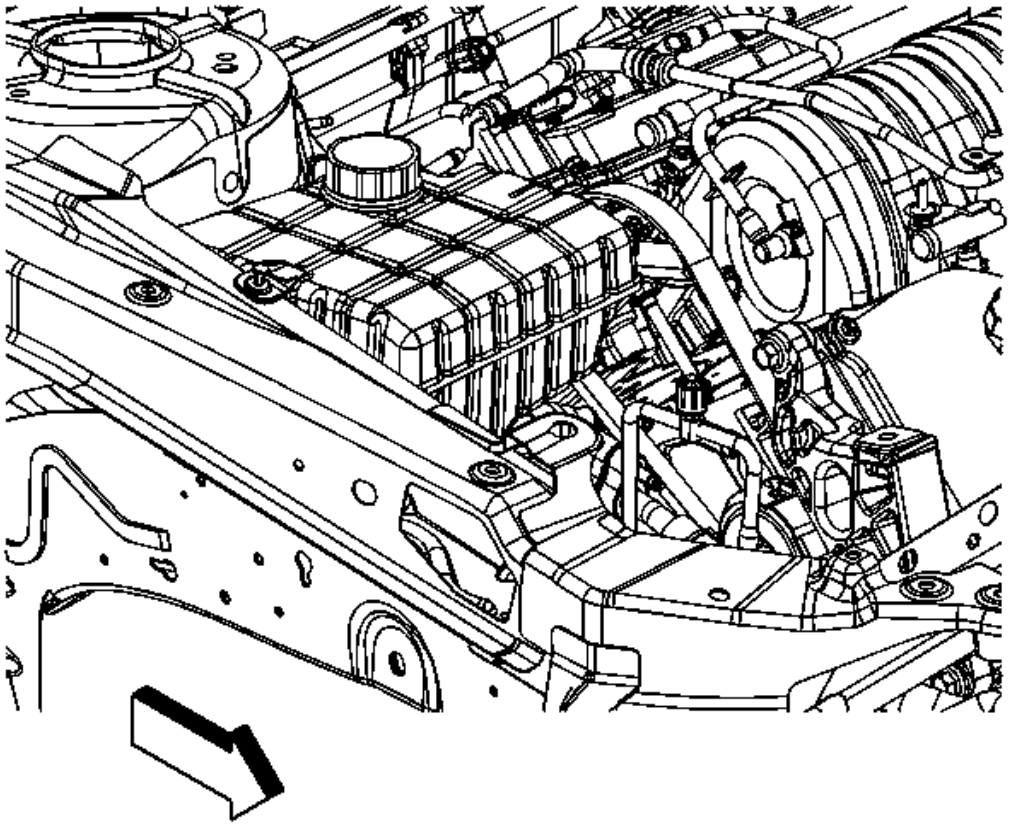

Fig. 47: Surge Tank Inlet Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

35. Reposition the radiator surge tank inlet hose clamp at the surge tank.
36. Remove the surge tank inlet hose from the surge tank.

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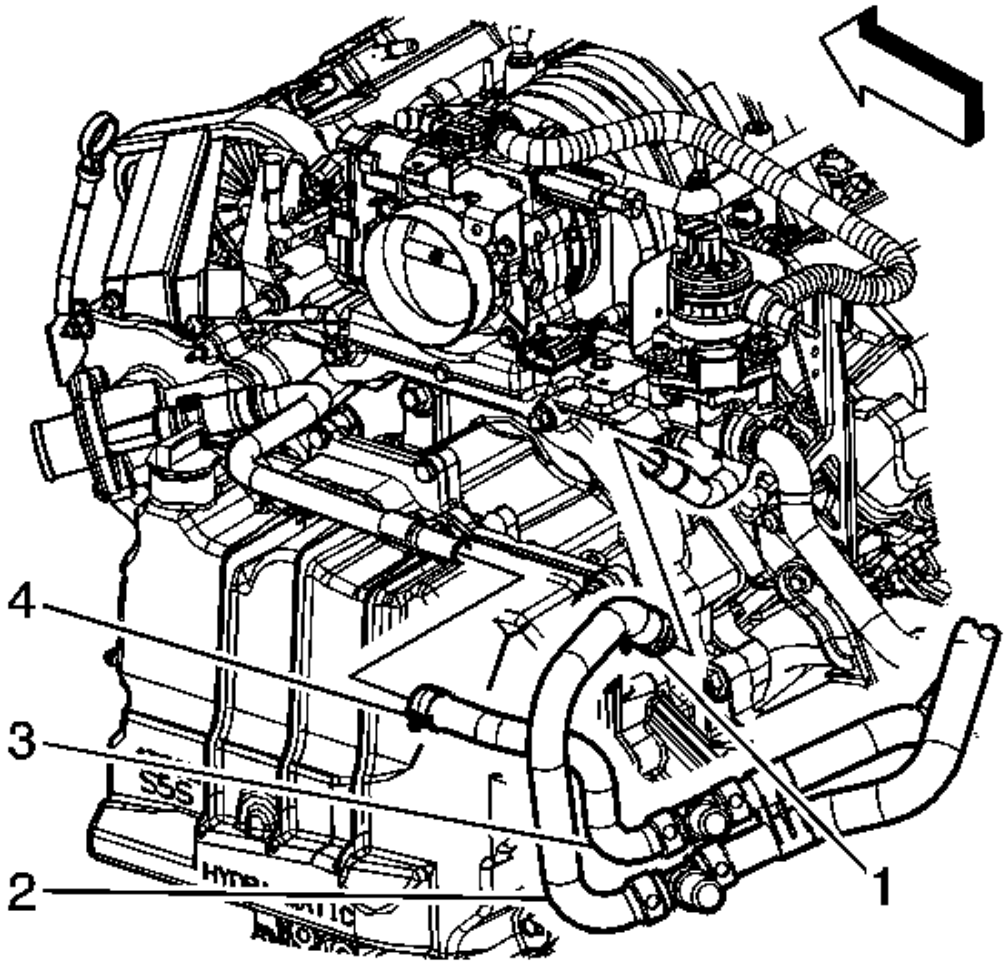

Fig. 48: Heater Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

37. Reposition the heater inlet (1) and outlet (2) hose clamps at the heater pipes.
38. Remove the heater inlet (2) and outlet (3) hoses from the heater pipes.

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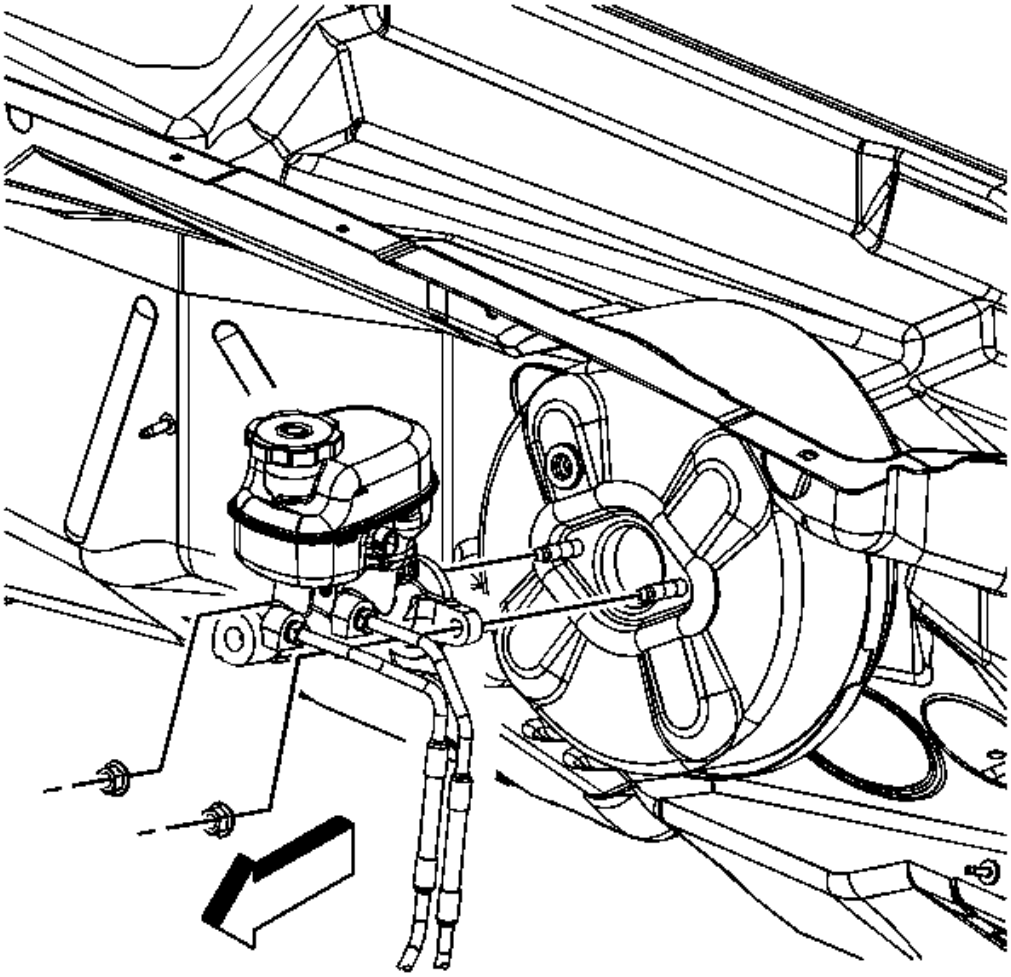

Fig. 49: Master Cylinder & Brake Booster
Courtesy of GENERAL MOTORS CORP.

39. Remove the master cylinder nuts and master cylinder from the brake booster.
40. Reposition the master cylinder and secure the master cylinder to the engine.

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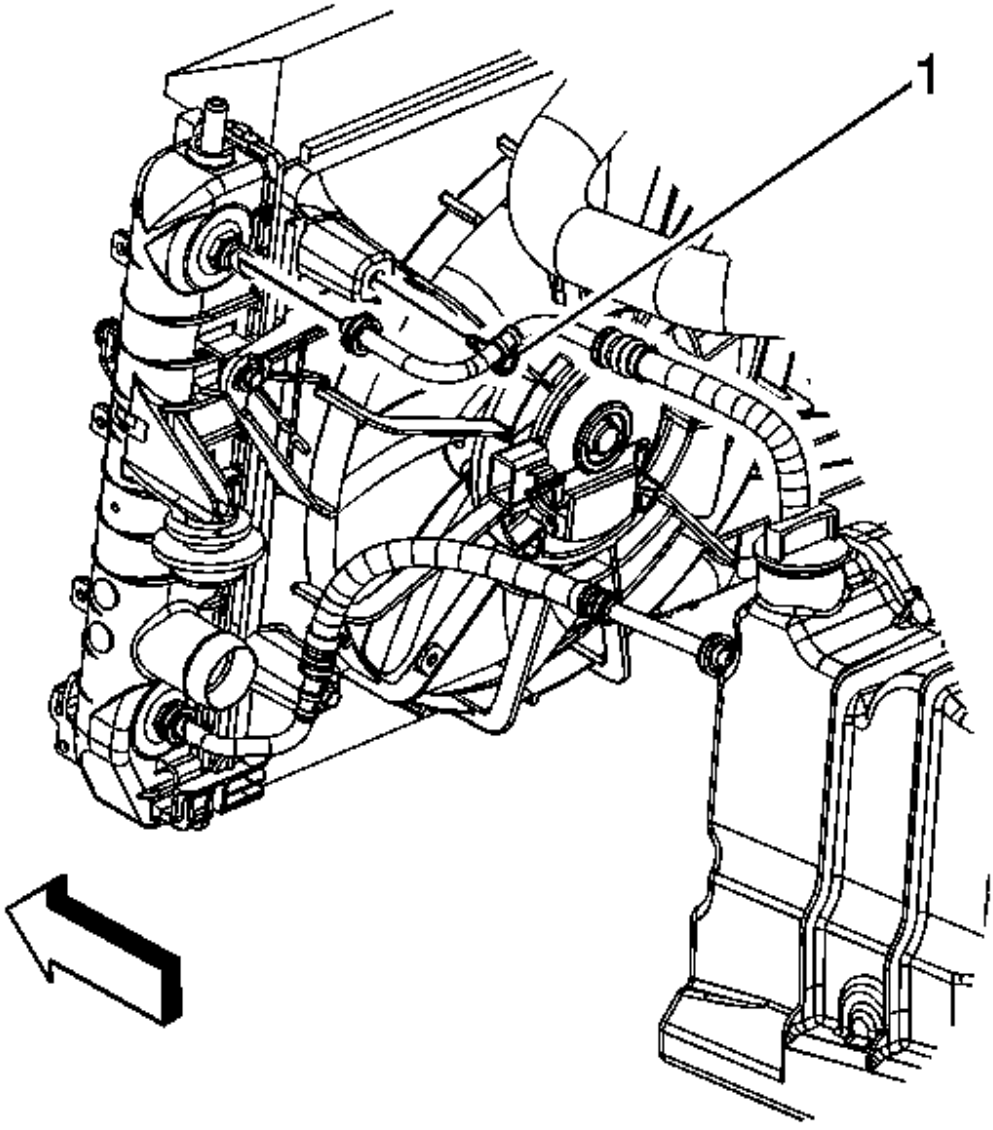

Fig. 50: Upper Transaxle Oil Cooler Pipe Bolt & Bolt
Courtesy of GENERAL MOTORS CORP.

41. Loosen the upper transaxle oil cooler pipe bolt (1) from the fan shroud.
42. Slide the plastic caps off the transaxle oil cooler pipe quick connect fittings.
43. Remove the right front engine mount strut bolt.
44. Disconnect the transaxle oil cooler pipes from the radiator using the **J 41623-B** .

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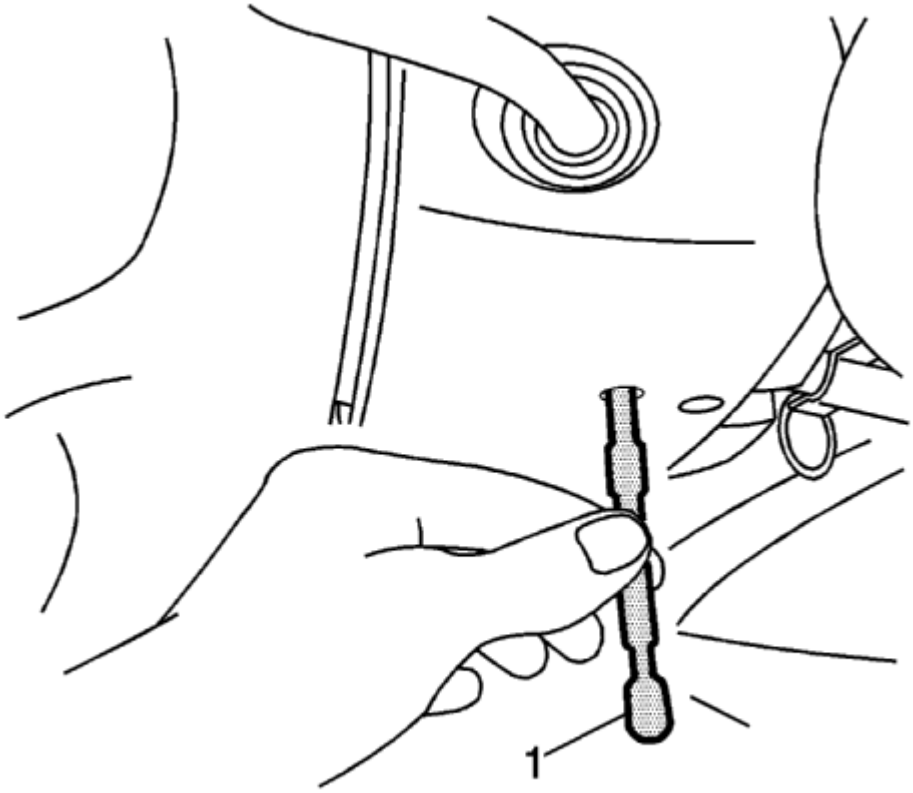

Fig. 51: Locking/Unlocking Steering Column
Courtesy of GENERAL MOTORS CORP.

CAUTION: With wheels of the vehicle facing straight ahead, secure the steering wheel utilizing steering column anti-rotation pin, steering column lock, or a strap to prevent rotation. Locking of the steering column will prevent damage and a possible malfunction of the SIR system. The steering wheel must be secured in position before disconnecting the following components:

- **The steering column**
- **The intermediate shaft(s)**
- **The steering gear**

After disconnecting these components, do not rotate the steering wheel or move the front tires and wheels. Failure to follow this procedure may cause the SIR coil assembly to become un-centered and cause possible damage to the SIR coil. If you think the SIR coil has became un-centered, refer to your specific SIR coil's centering procedure to re-center SIR Coil.

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45. Lock the steering column by installing the **J 42640** into the underside of the steering column.

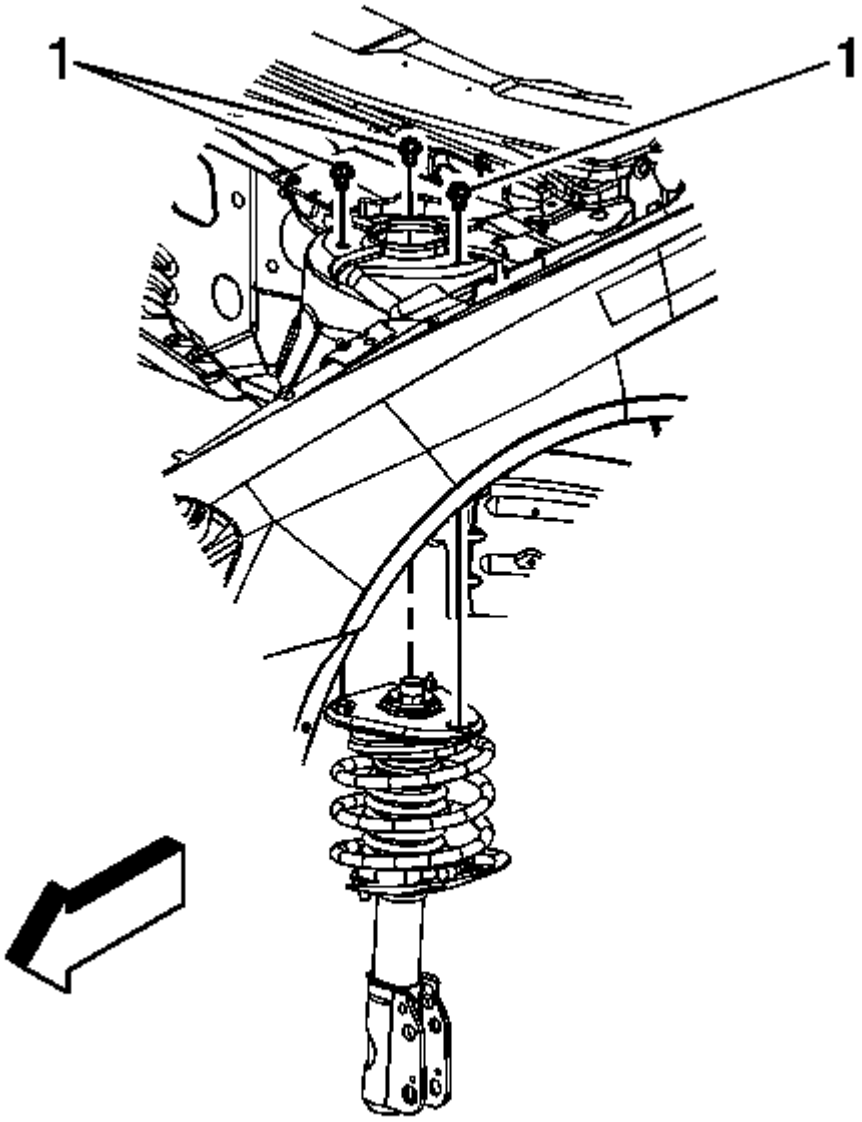

Fig. 52: Strut Tower Bolts
Courtesy of GENERAL MOTORS CORP.

46. Remove the left and right side strut tower bolts (1). (Left side shown, right side similar.)
47. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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48. Remove the rear exhaust manifold pipe. Refer to **Exhaust Manifold Rear Pipe Replacement (LD8)** .
49. Remove the front wheels. Refer to **Tire and Wheel Removal and Installation** .

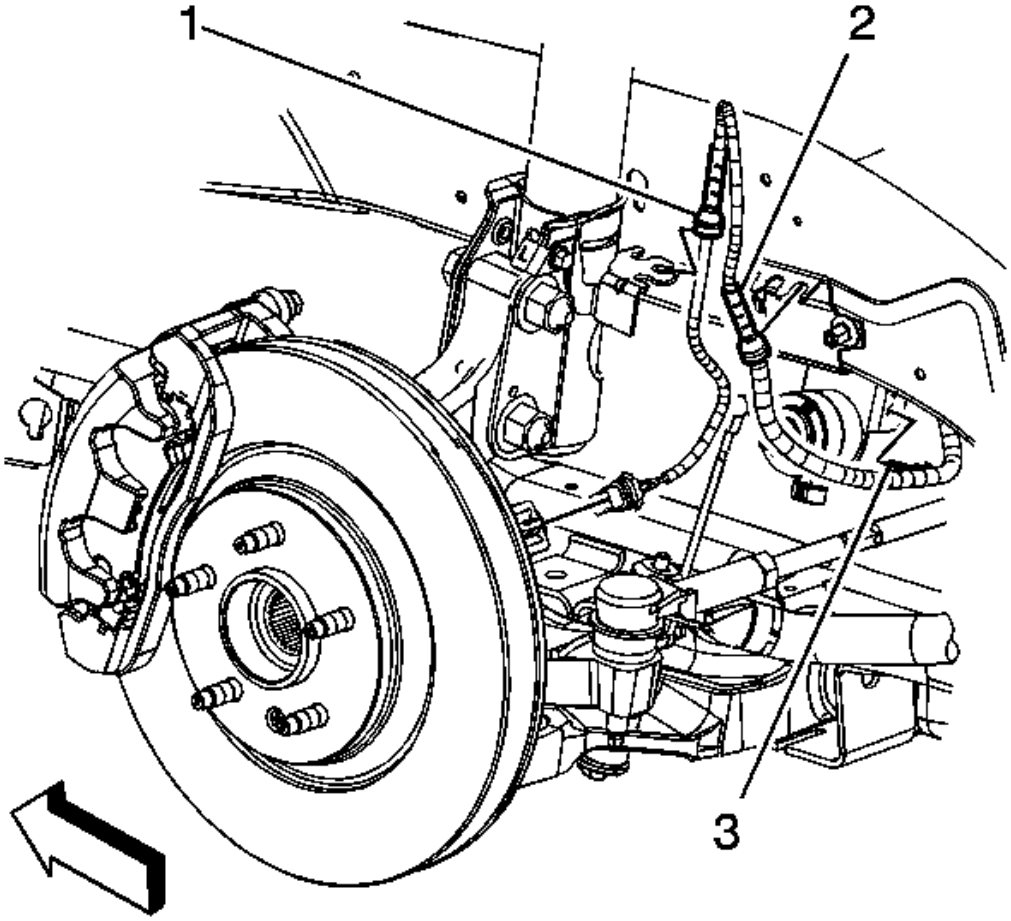

Fig. 53: Engine Harness Grommets & Clips
Courtesy of GENERAL MOTORS CORP.

50. Remove the engine harness grommet (2) from the frame rail bracket.
51. Remove the engine harness clip (3) from the ride lever sensor bracket.

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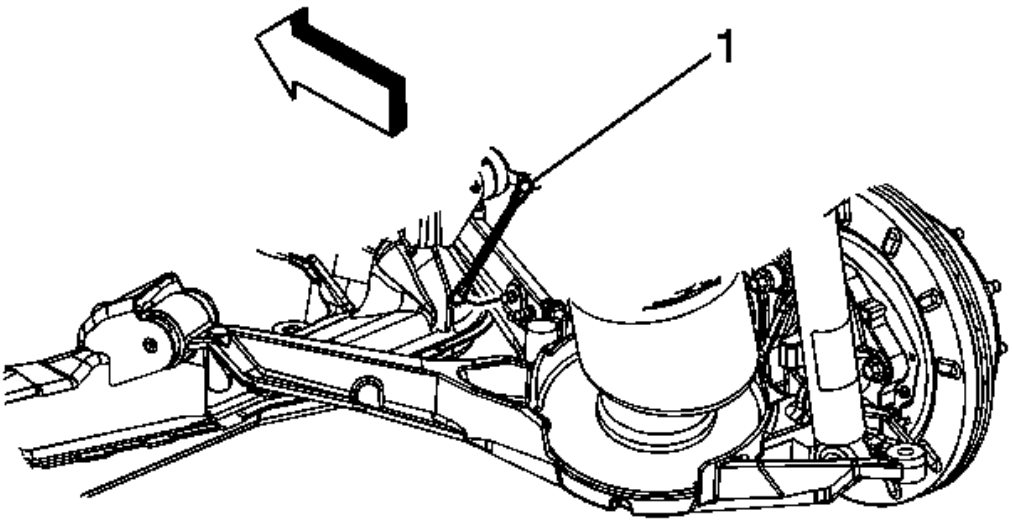

Fig. 54: Electronic Suspension Front Position Sensor Link
Courtesy of GENERAL MOTORS CORP.

52. Disconnect the electronic suspension front position sensor link from the lower control arms ball stud, if equipped.

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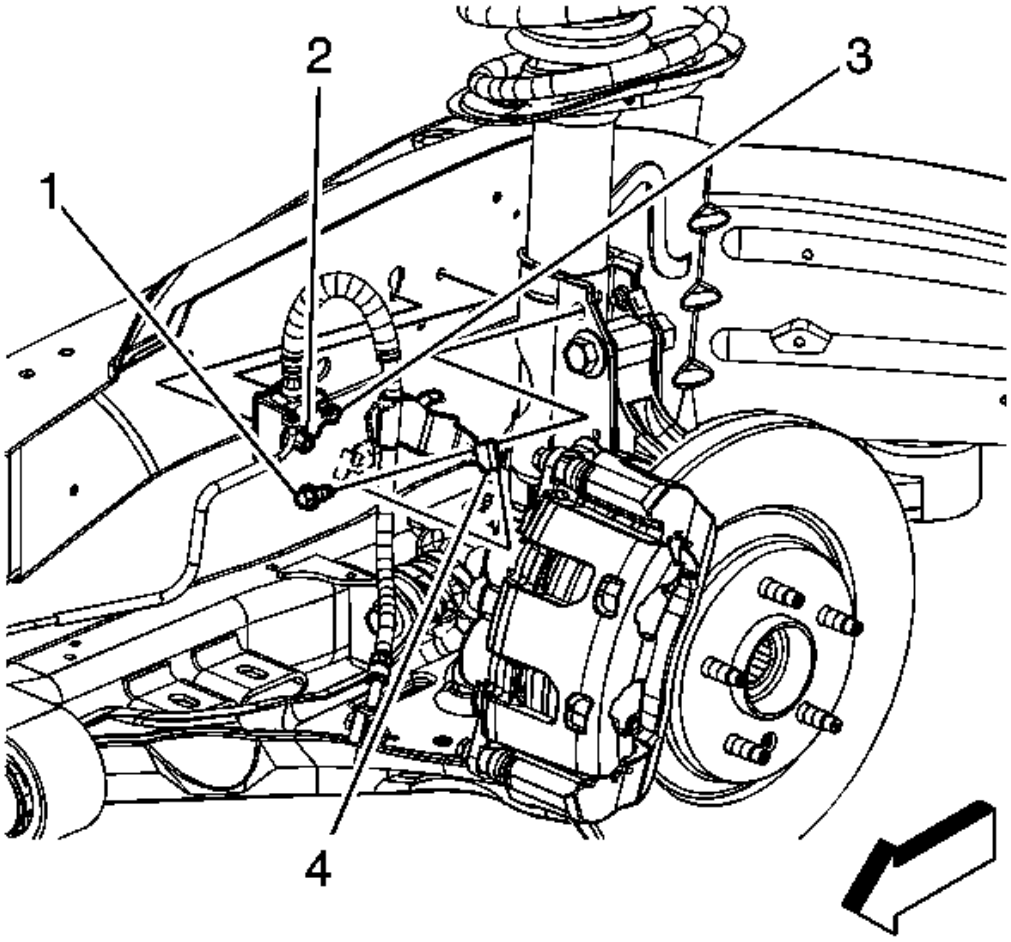

Fig. 55: Left Front Brake Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

53. Loosen the nut (2) securing the left front brake pipe bracket (4) to the body frame rail.
54. Remove the front brake pipe bracket (4) from the body frame rail.

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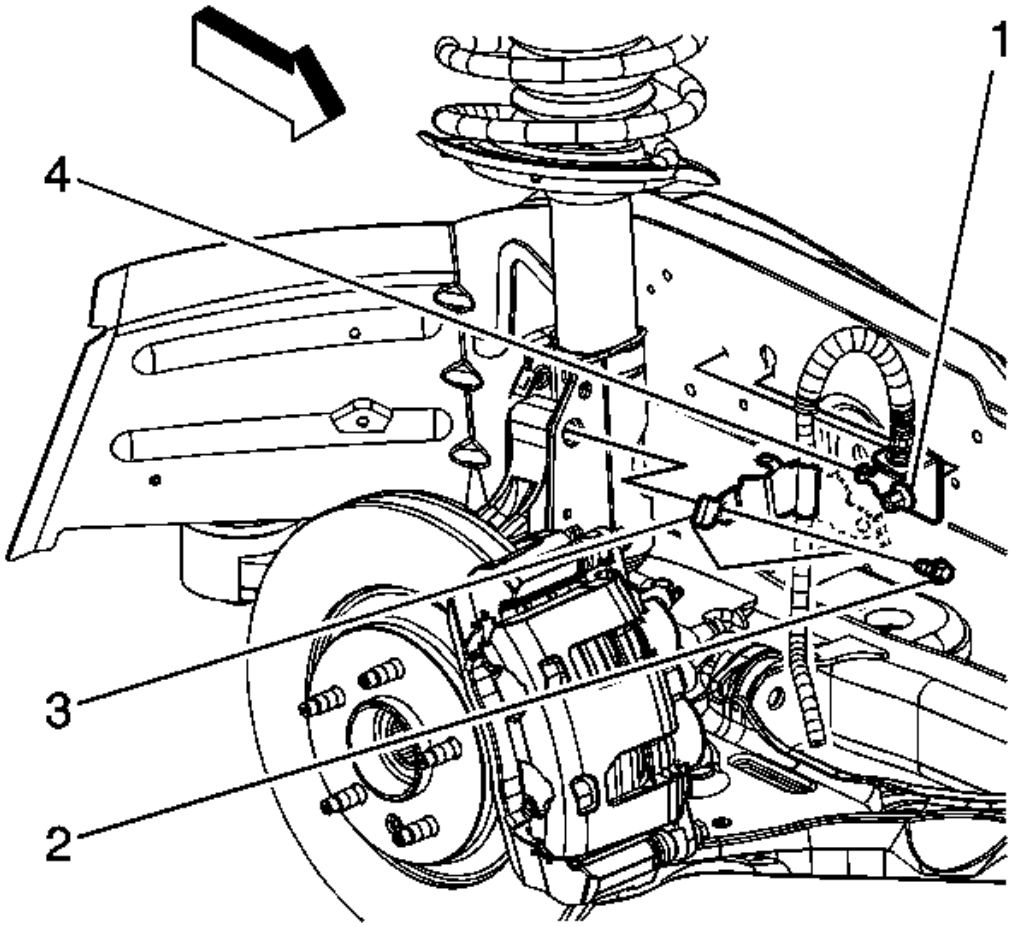

Fig. 56: Right Front Brake Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

55. Loosen the nut (1) securing the right front brake pipe bracket (4) to the body frame rail.
56. Remove the front brake pipe bracket (4) from the body frame rail.

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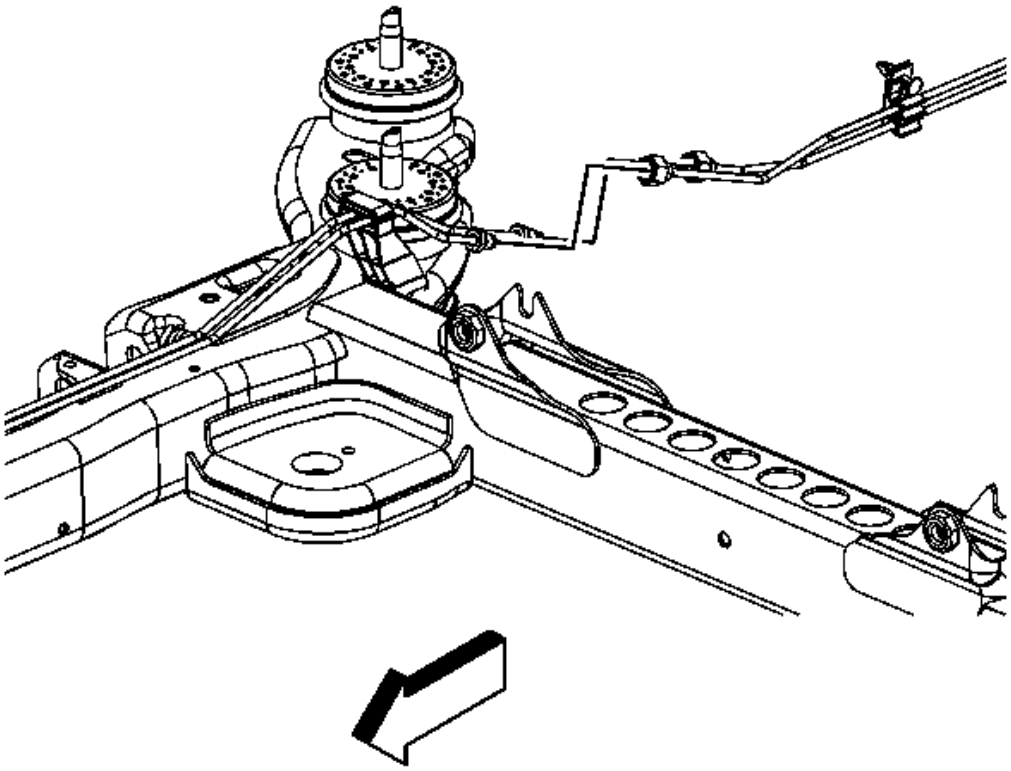

Fig. 57: Front & Rear Brake Pipes
Courtesy of GENERAL MOTORS CORP.

57. Disconnect the rear brake pipes from the front brake pipes.
58. Plug the open brake lines in order to prevent fluid loss and/or system contamination.

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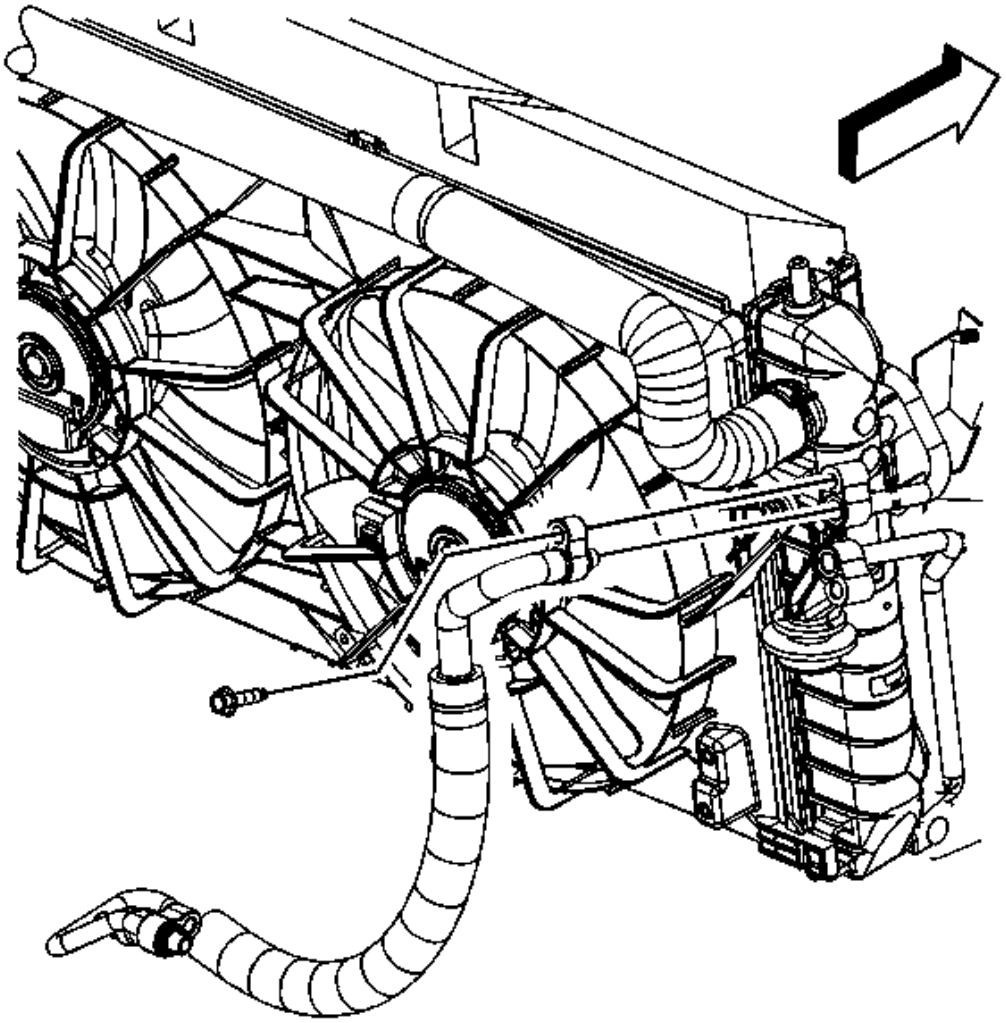

Fig. 58: A/C Discharge Hose & Condenser
Courtesy of GENERAL MOTORS CORP.

59. Remove the A/C compressor discharge hose bolt at the condenser.
60. Remove the A/C compressor discharge hose from the condenser and secure to the engine.
61. Plug the A/C condenser discharge port.

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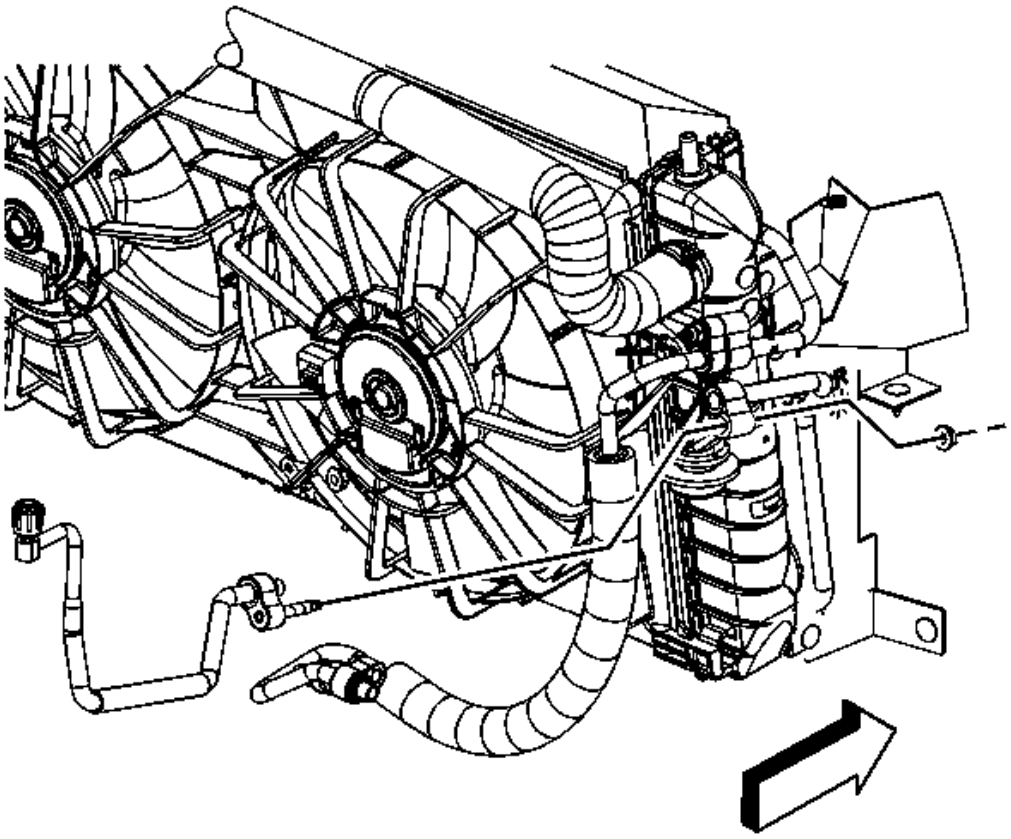

Fig. 59: A/C Suction Hose & Condenser
Courtesy of GENERAL MOTORS CORP.

62. Remove the A/C compressor suction hose nut at the condenser.
63. Remove the A/C compressor suction hose from the condenser and secure to the engine.
64. Plug the A/C condenser suction port.

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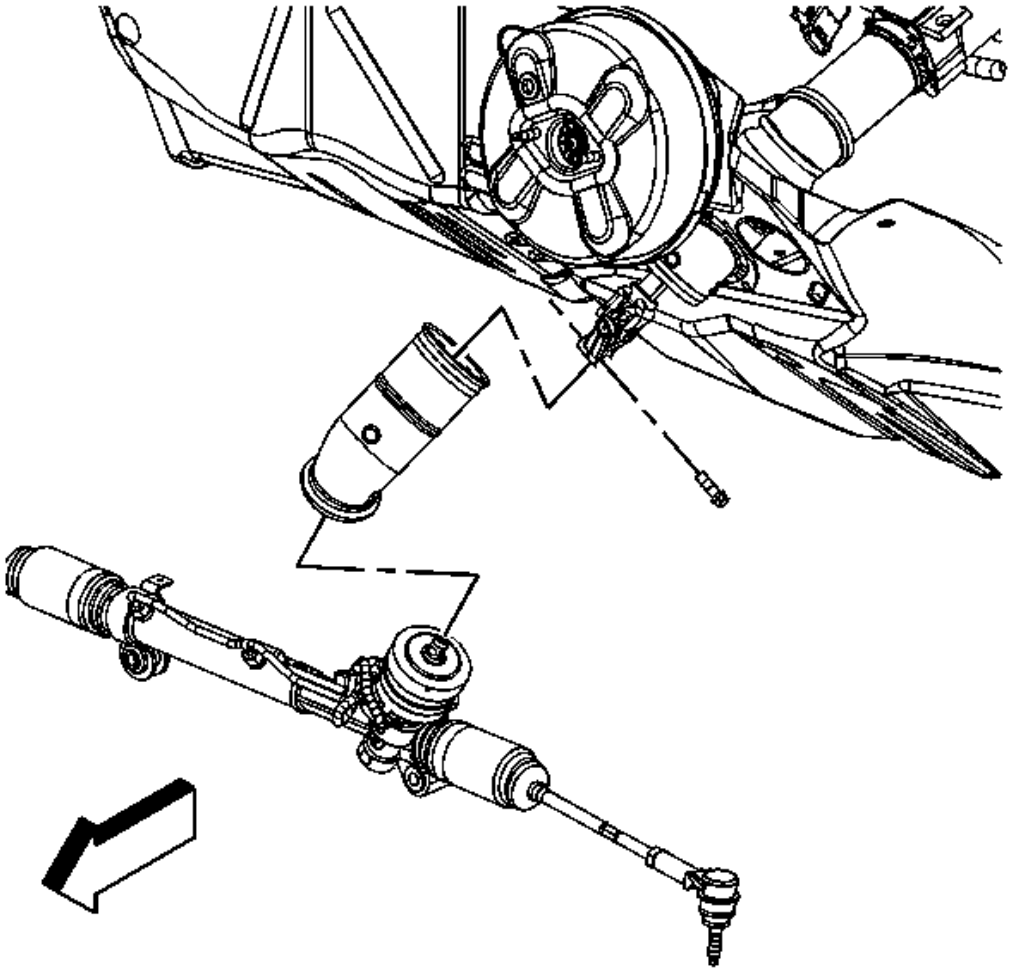

Fig. 60: Intermediate Steering Shaft Components
Courtesy of GENERAL MOTORS CORP.

WARNING: Failure to disconnect intermediate shaft from rack and pinion stub shaft can result in damage to steering gear and/or intermediate shaft. This damage can cause loss of steering control which could result in personal injury.

65. Remove the intermediate steering shaft cover.
66. Remove the intermediate shaft pinch bolt.
67. Remove the intermediate shaft from the steering gear.

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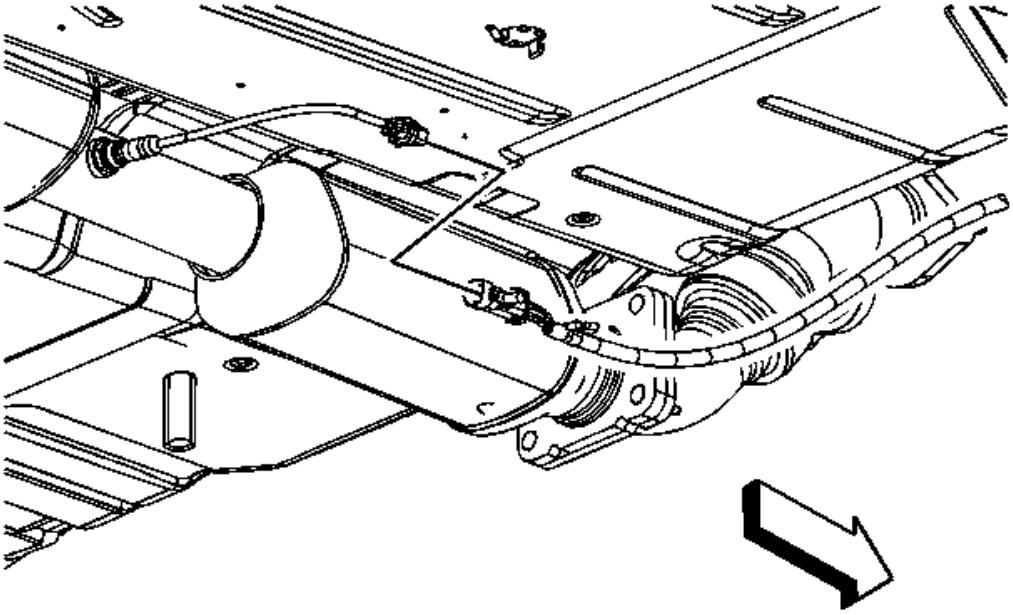

Fig. 61: Oxygen Sensor Wiring Harness & Heat Shield
Courtesy of GENERAL MOTORS CORP.

68. Remove the oxygen sensor wiring harness heat shield. Refer to **Oxygen Sensor Wiring Harness Heat Shield Replacement** .
69. Disconnect the engine harness electrical connector from the heated oxygen sensor (HO2S).

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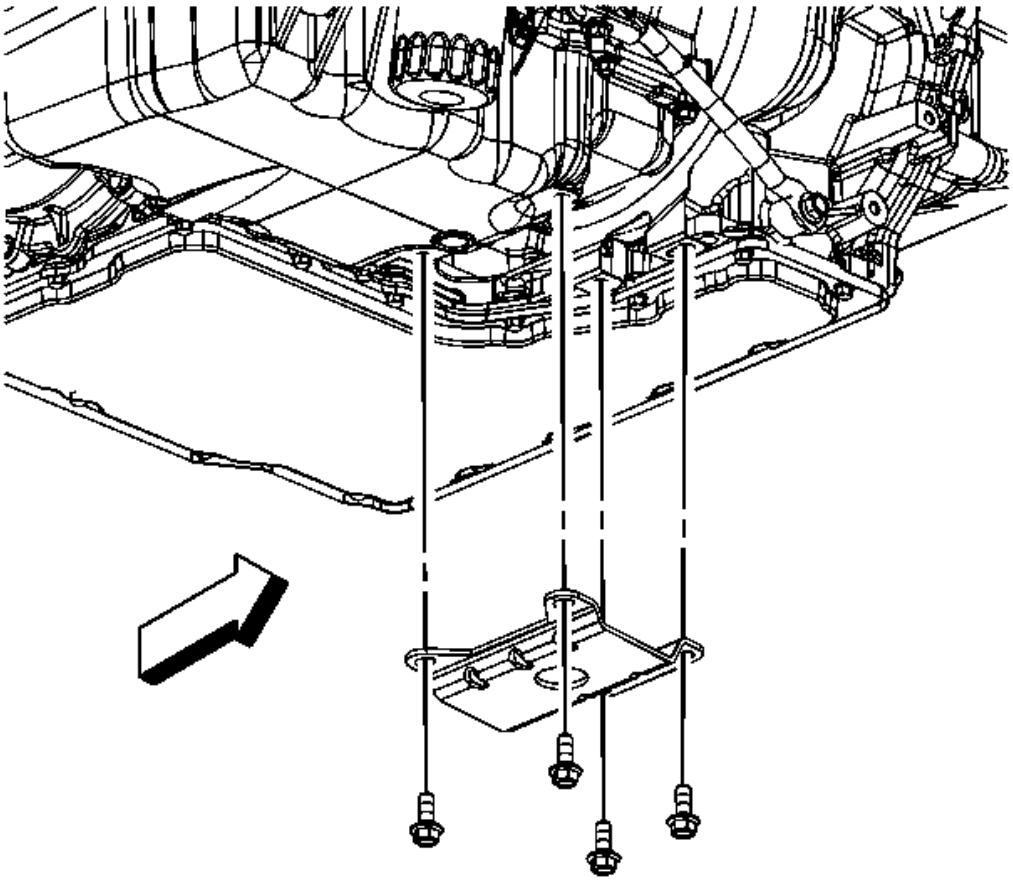

Fig. 62: Transaxle Brace Bolts
Courtesy of GENERAL MOTORS CORP.

70. Remove the transaxle brace bolts.
71. Remove the transaxle brace.

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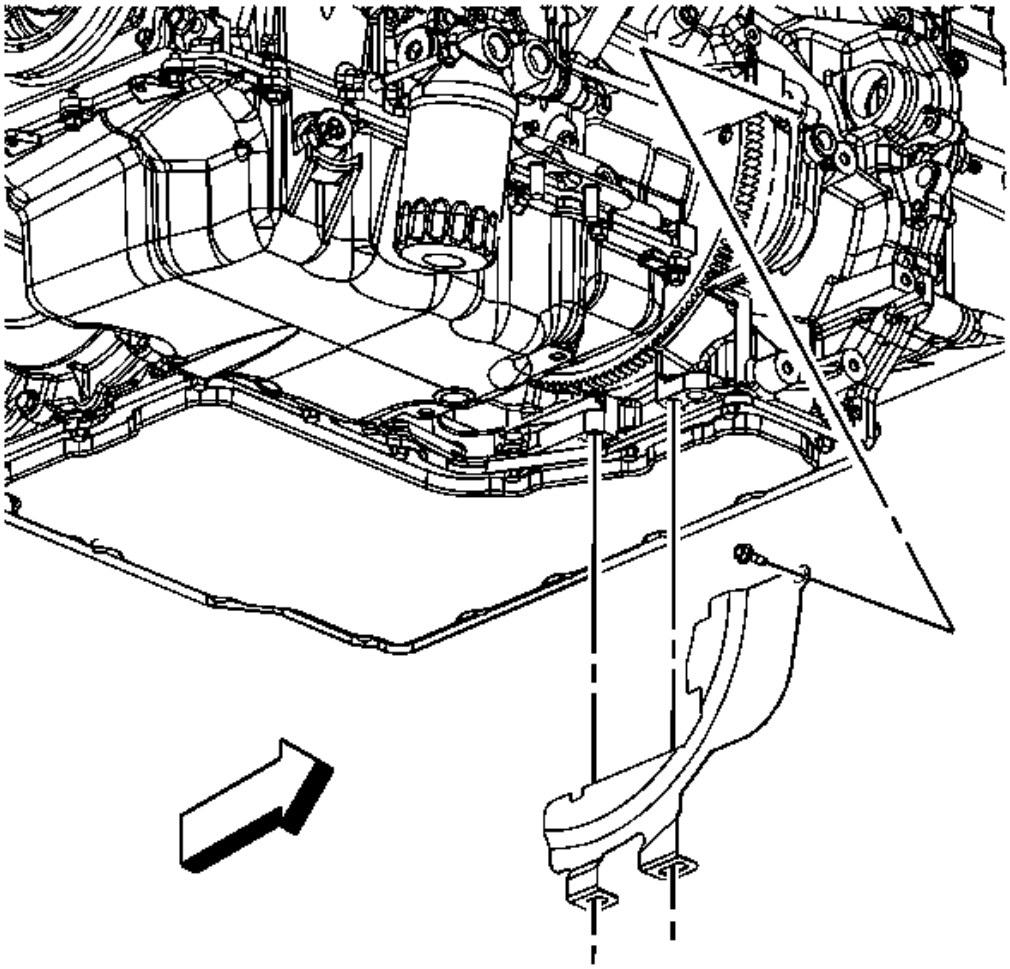

Fig. 63: Torque Converter Cover
Courtesy of GENERAL MOTORS CORP.

72. Remove the torque converter cover bolt.
73. Remove the torque converter cover.

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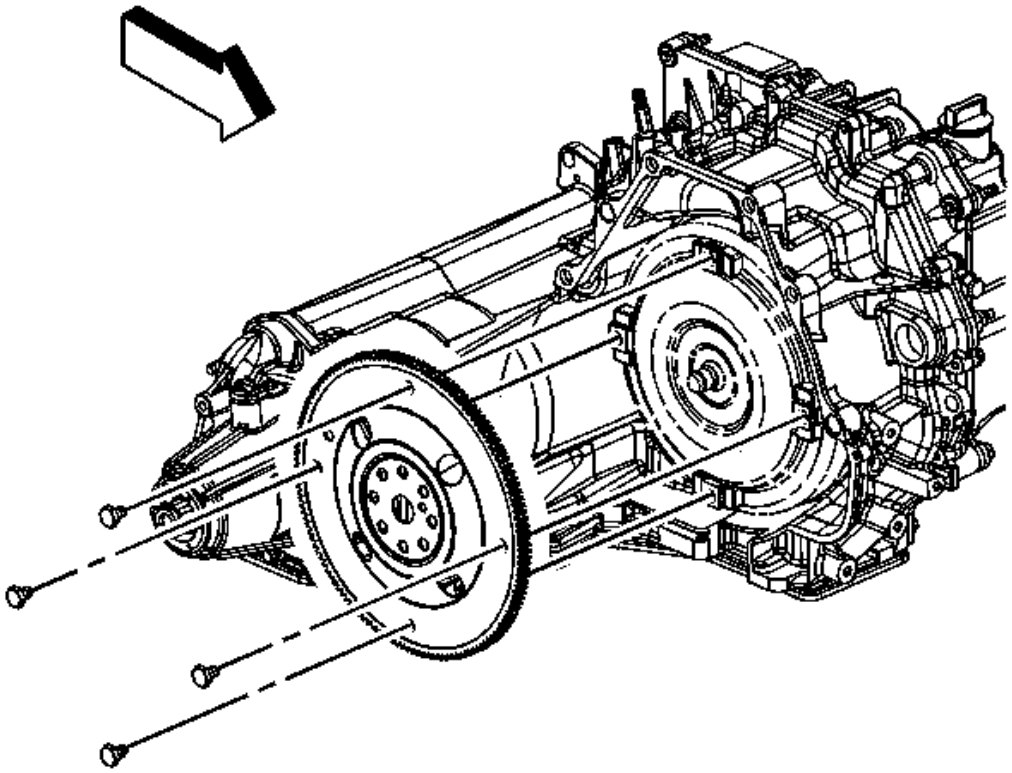

Fig. 64: Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Mark the flywheel to torque converter relationship prior to removal of the bolts.

74. Remove the flywheel to torque converter bolts. (Engine removed for clarity).

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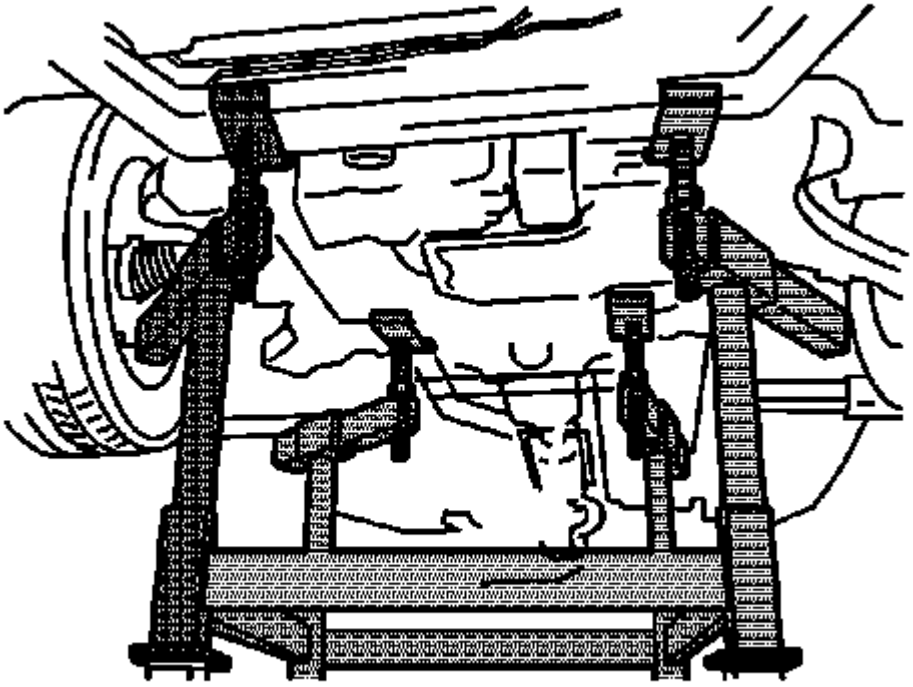

Fig. 65: Utility Stand
Courtesy of GENERAL MOTORS CORP.

75. Position the **J 39580** under the frame. See **Special Tools** .
76. Lower the vehicle onto the **J 39580** . See **Special Tools** .

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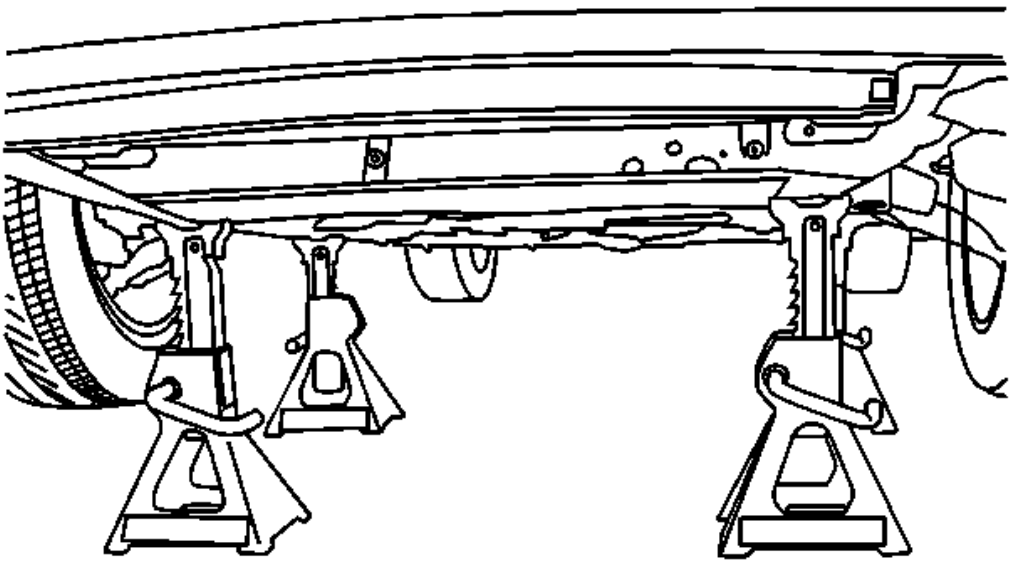

Fig. 66: Jackstands Under Engine Frame
Courtesy of GENERAL MOTORS CORP.

77. If the **J 39580** is not available. See **Special Tools** . Support the powertrain with four suitable jackstands.
78. Place a 2 in x 4 in block of wood between the front of the engine oil pan and the engine frame.

WARNING: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

79. Secure the front hoist pads to the vehicle.
80. Remove the front fascia. Refer to **Front Bumper Fascia Replacement** .

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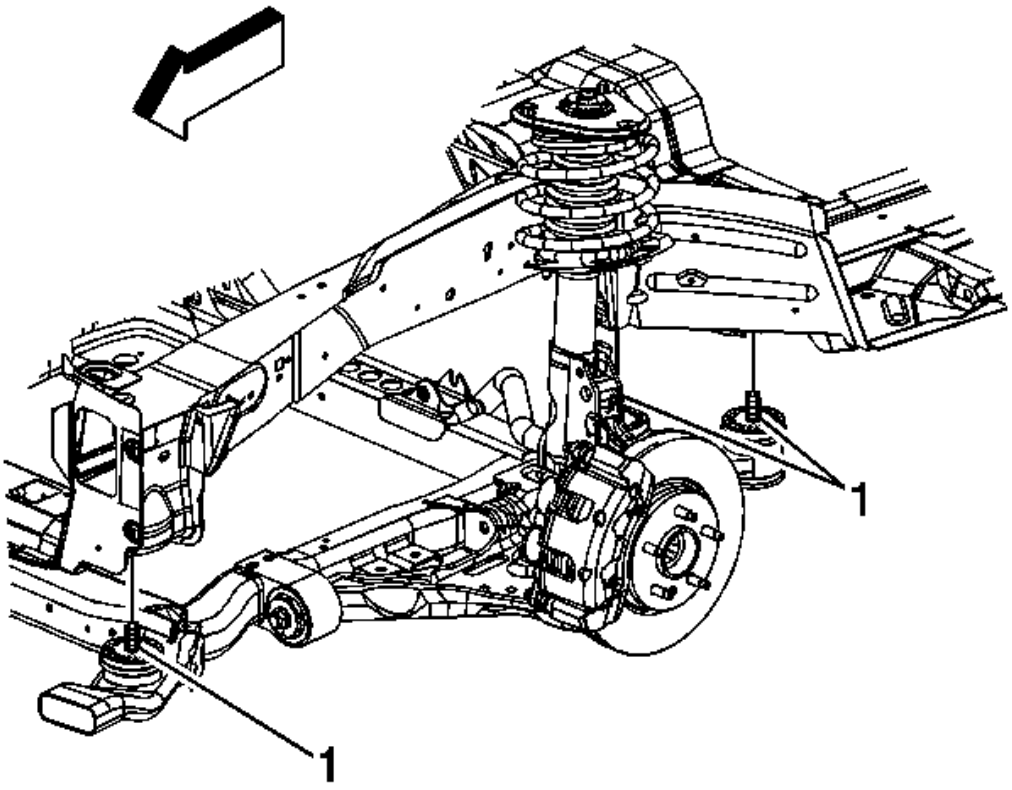

Fig. 67: Frame To Body Bolts
Courtesy of GENERAL MOTORS CORP.

81. Remove the 6 bolts (1) attaching the frame to the body. (Left side shown, right side similar).

NOTE: Ensure clearance is maintained between the engine/transaxle assembly and the following:

- **The A/C compressor components**
- **The brake pipes**
- **The heater hoses**
- **The radiator hoses**
- **The wheel speed sensor leads**
- **The wiring harnesses**

82. Carefully raise the vehicle in order to clear the supported engine/transaxle assembly.
83. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

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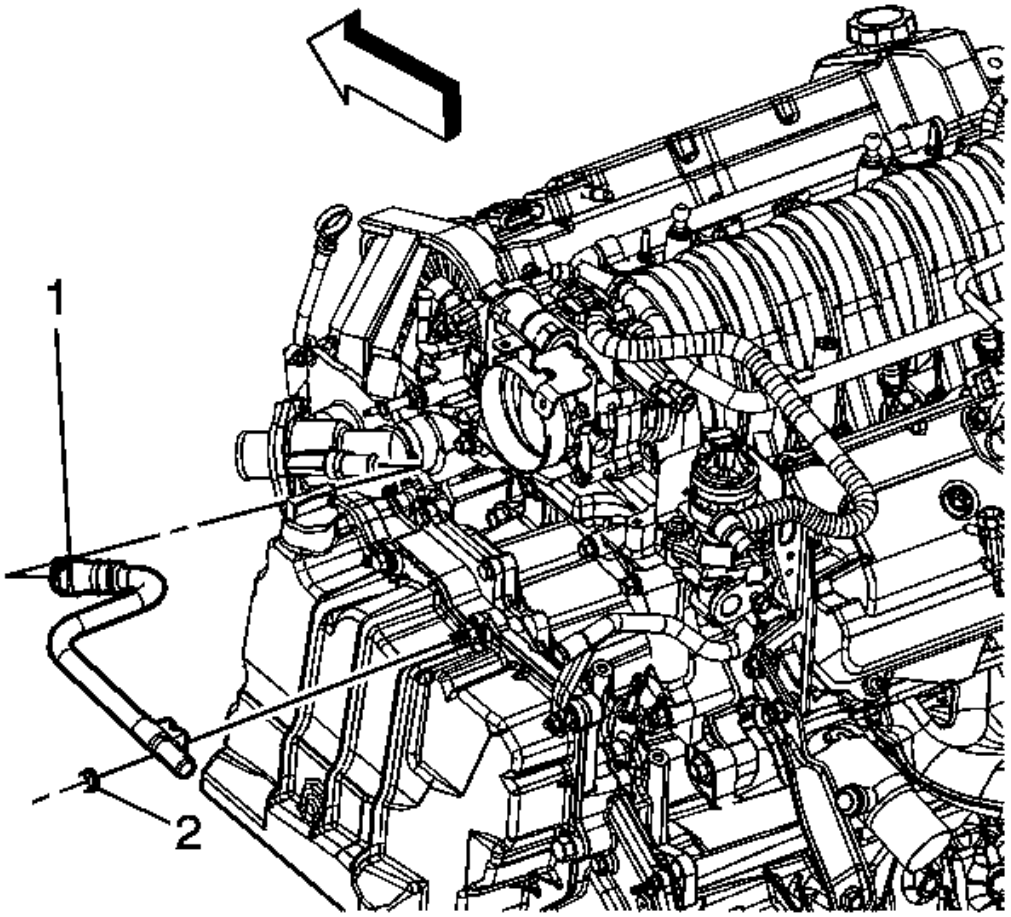

Fig. 68: Heater Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

84. Remove the heater outlet pipe nut (2) from the transaxle stud.
85. Reposition the heater outlet pipe clamp (1) at the water pump housing.
86. Remove the heater outlet pipe.

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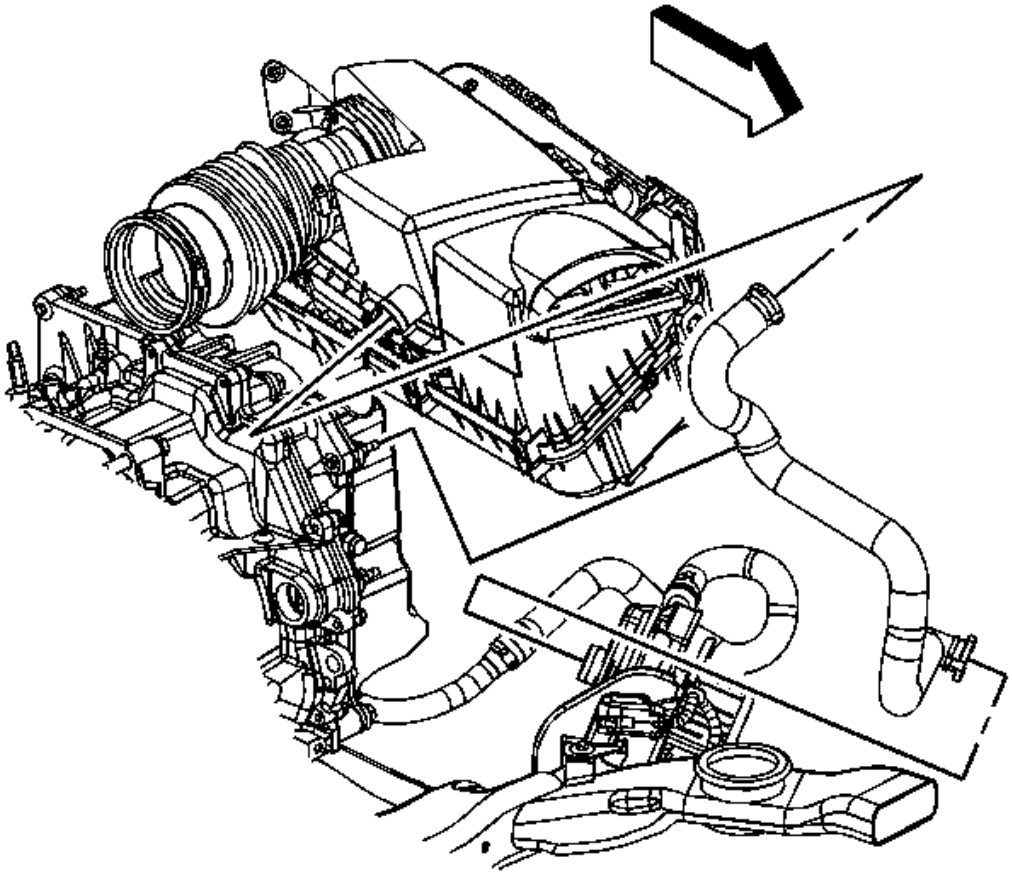

Fig. 69: Secondary AIR Pump Inlet Tube/Hose
Courtesy of GENERAL MOTORS CORP.

87. Remove the secondary air injection (AIR) inlet hose retainer from the transaxle stud.
88. Disconnect the AIR inlet hose quick connect fitting from the AIR pump. Refer to **Plastic Collar Quick Connect Fitting Service** .
89. Remove the AIR inlet hose.

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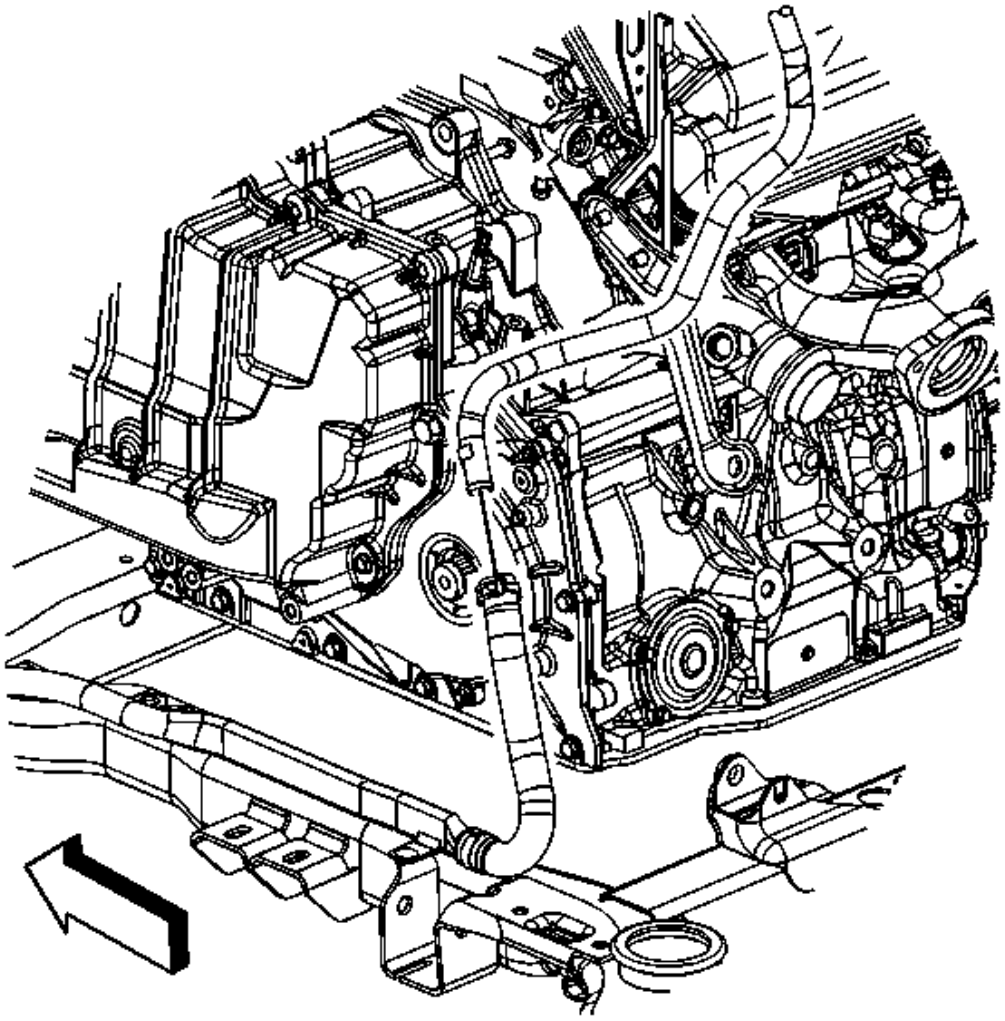

Fig. 70: AIR Outlet Hose
Courtesy of GENERAL MOTORS CORP.

90. Reposition the AIR outlet hose clamp at the AIR outlet pipe.
91. Separate the AIR outlet hose from the outlet pipe.

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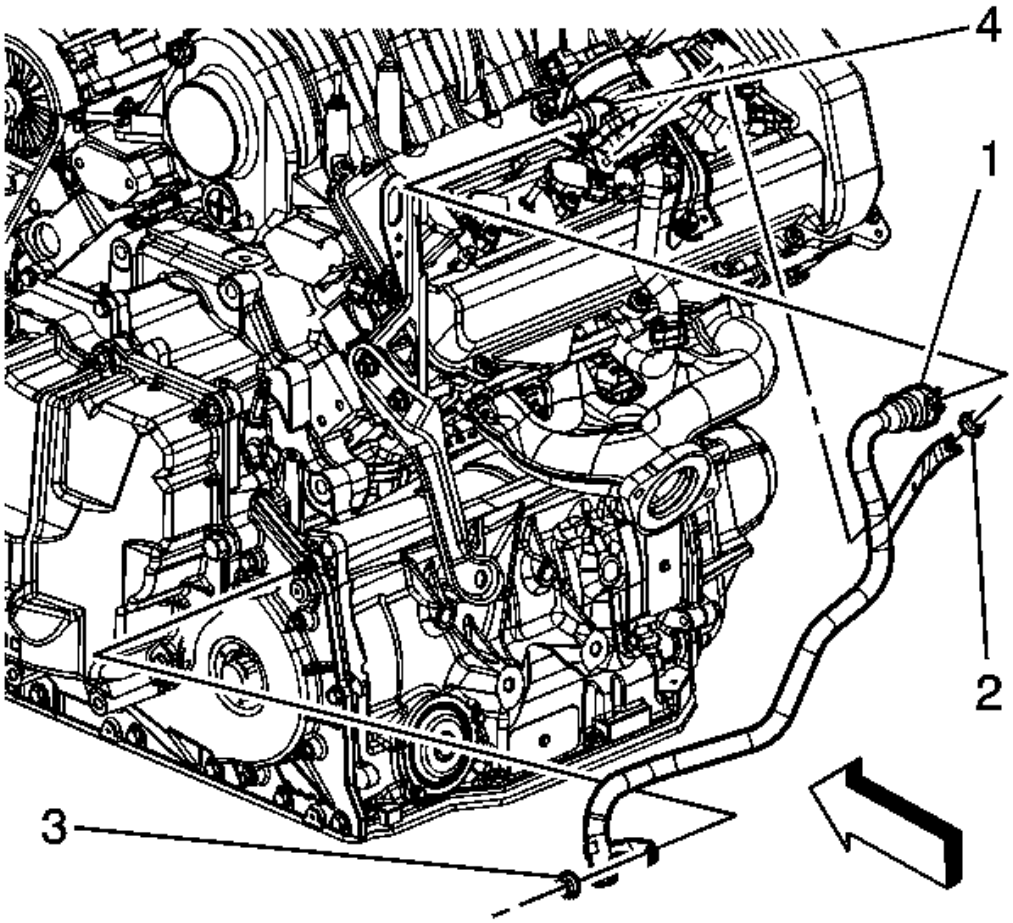

Fig. 71: AIR Pipe Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

92. Remove the AIR pipe outlet pipe nut (3) from the transaxle stud.
93. Remove the AIR pipe outlet pipe nut (2) from the check valve bracket stud.
94. Disconnect the AIR outlet pipe quick connect fitting from the check valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
95. Remove the AIR outlet pipe from the studs.

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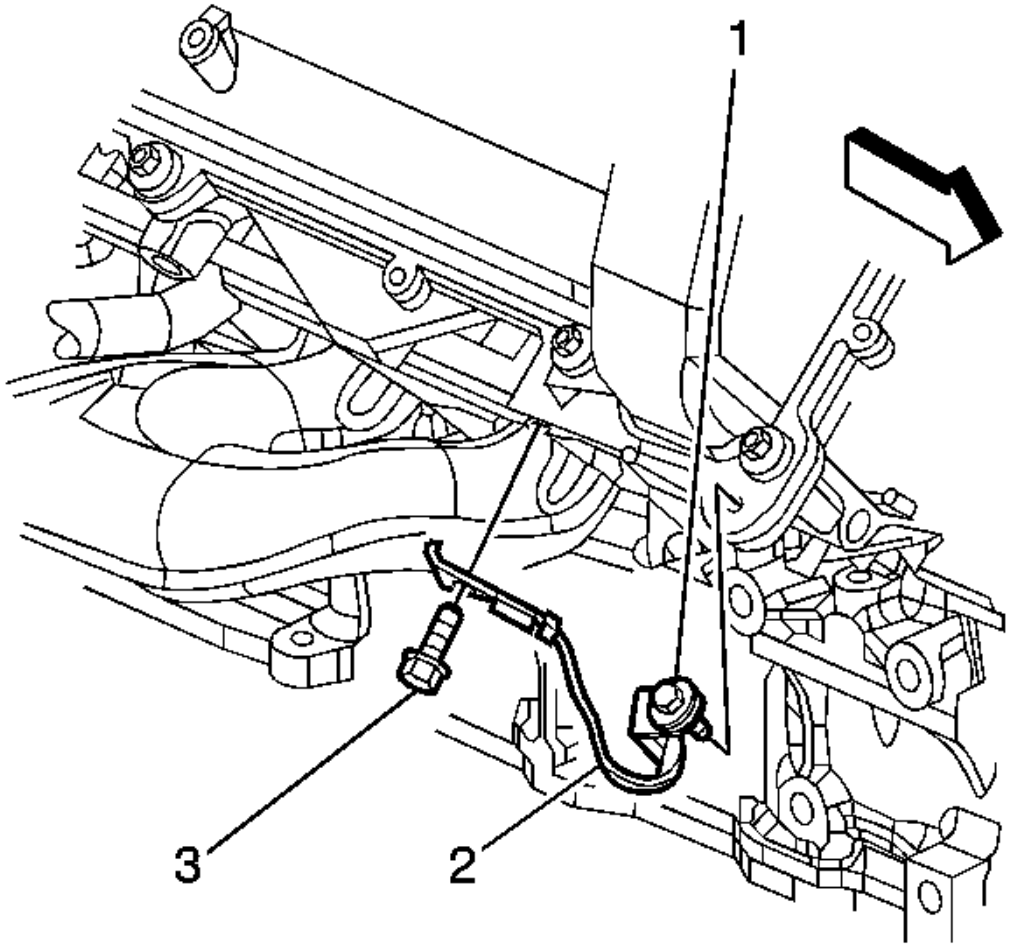

Fig. 72: ICM Ground Strap & Bolt
Courtesy of GENERAL MOTORS CORP.

96. Remove the ignition control module (ICM) ground strap bolt (3) from the right cylinder head.
97. Remove the ICM ground strap (2) from the cylinder head.

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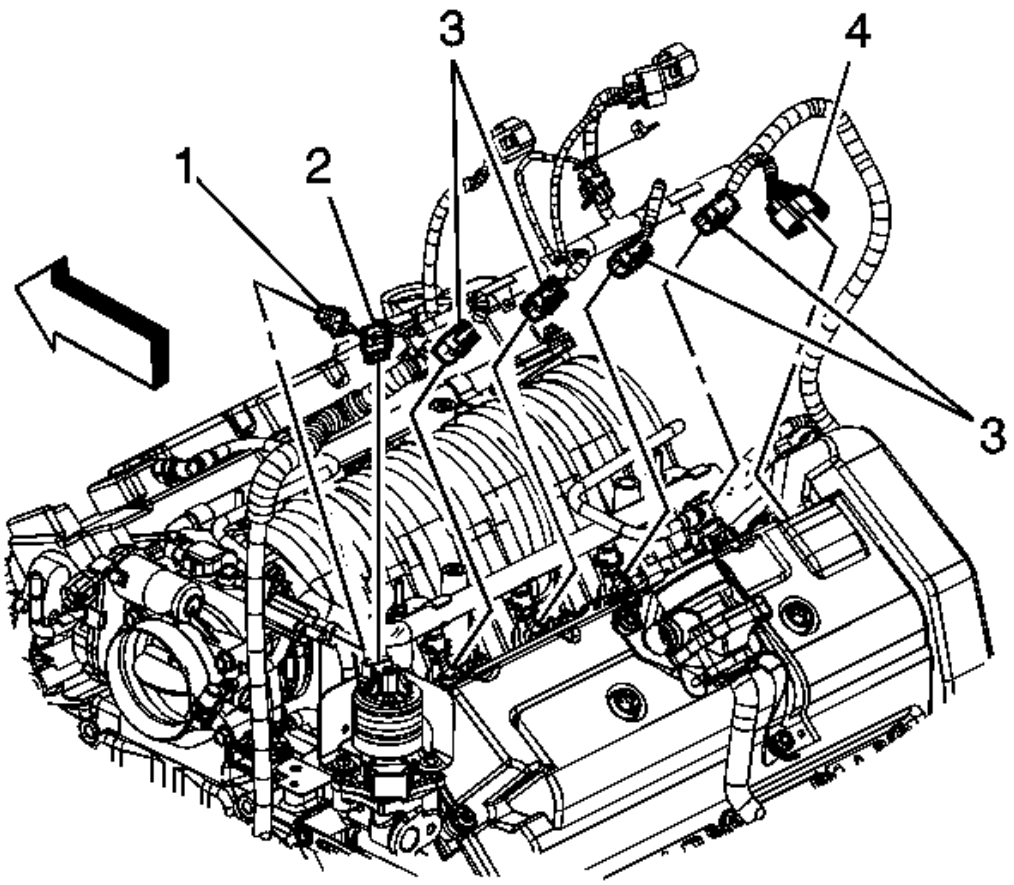

Fig. 73: Rear Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

98. Disconnect the following engine harness electrical connectors from the rear of the engine:
    - The EVAP solenoid (1)
    - The exhaust gas recirculation (EGR) valve (2)
    - The fuel injectors (3)
    - The ICM (4)

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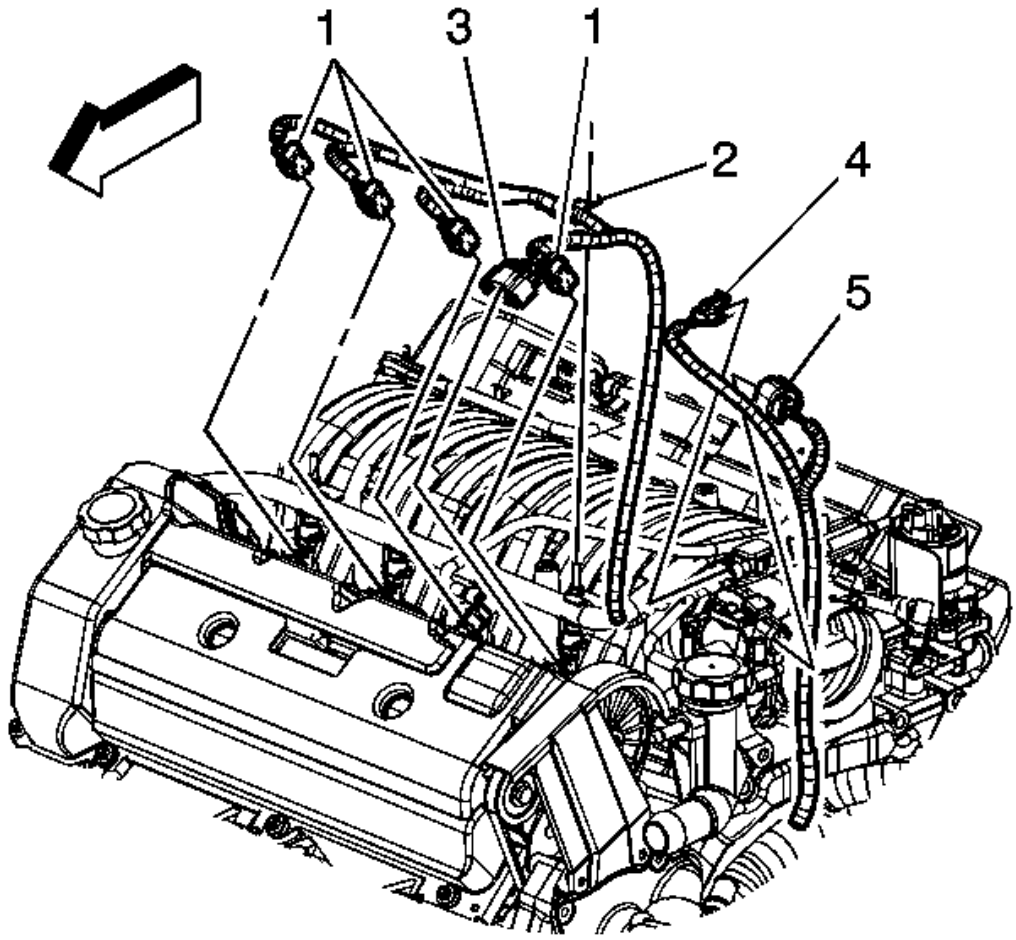

Fig. 74: Front Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

99. Disconnect the following engine harness electrical connectors from the front of the engine:
    - The fuel injectors (1)
    - The ICM (3)
    - The manifold absolute pressure (MAP) sensor (4)
    - the throttle actuator (5)
100. Remove the engine harness clip (2) from the fuel rail stud.

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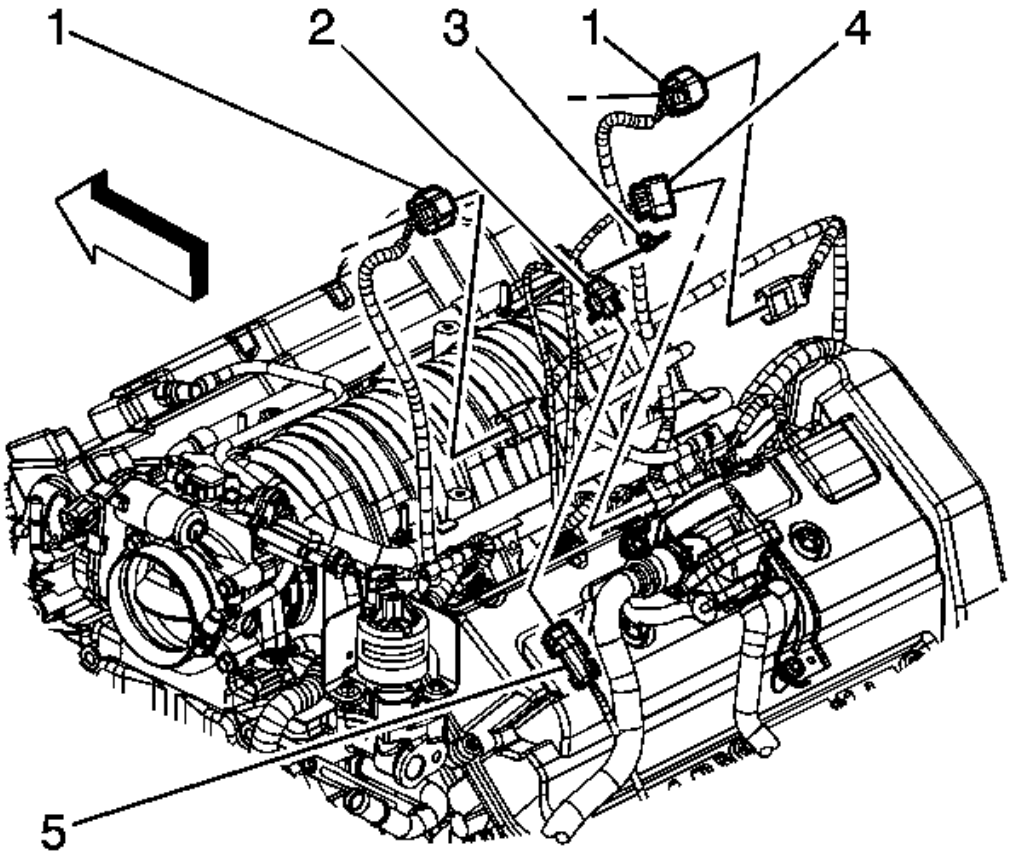

Fig. 75: Top Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

101. Disconnect the following engine harness electrical connectors from the top of the engine:
    - The starter inline (1)
    - The AIR check valve (4)

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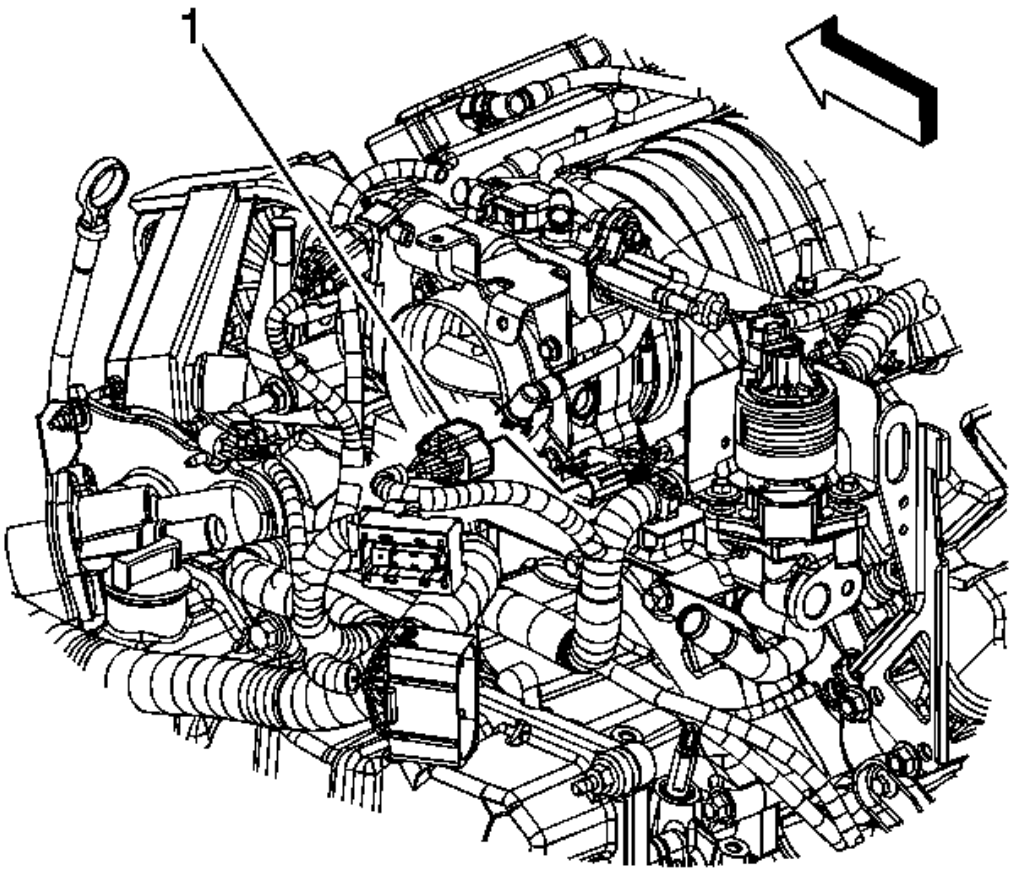

Fig. 76: Engine Valley Jumper Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

102. Disconnect the engine harness electrical connector (1) from the engine valley jumper harness electrical connector.

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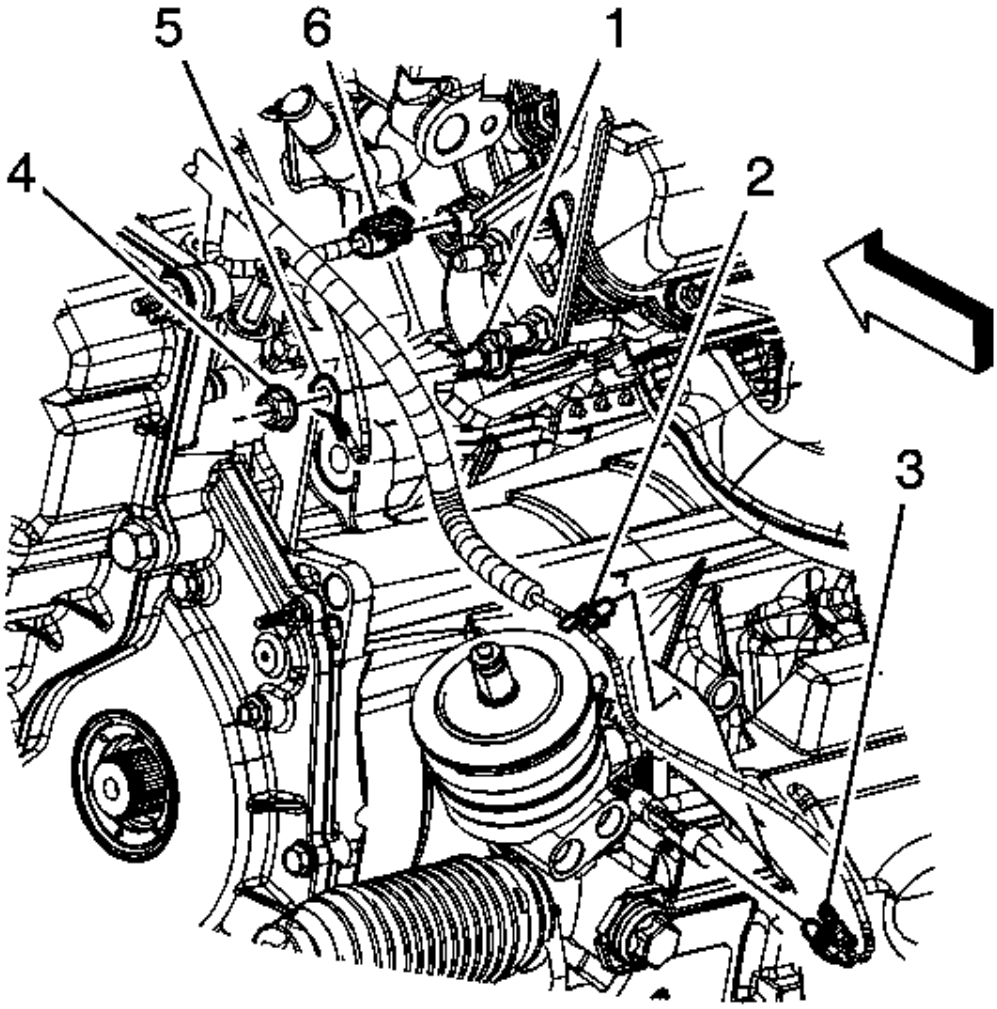

Fig. 77: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

103. Disconnect the engine harness electrical connector (3) from the power steering sensor.
104. Remove the engine harness clip (2) from the steering gear shield.
105. Remove the engine harness ground nut (4).
106. Remove the engine harness ground (5).
107. Disconnect the engine harness electrical connector (6) from the engine coolant temperature (ECT) sensor.

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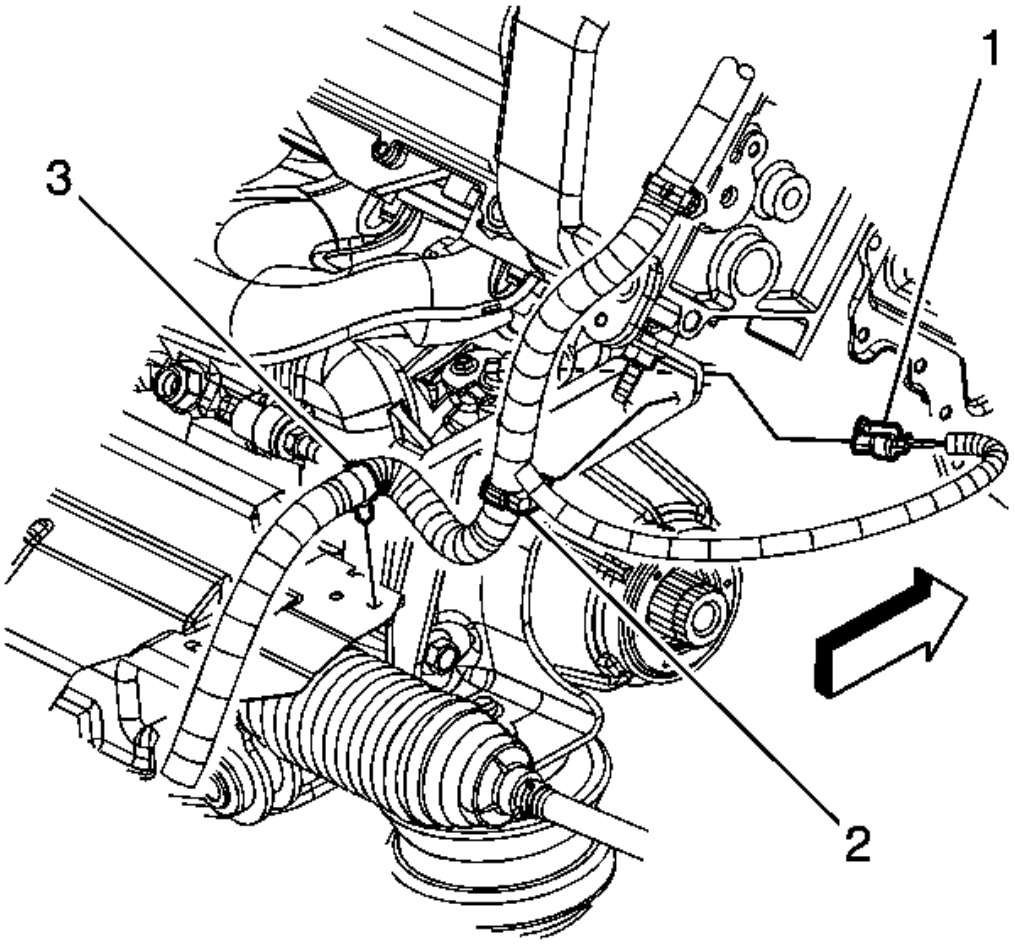

Fig. 78: Disconnecting/Connecting Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

108. Disconnect the engine harness electrical connector (1) from the vehicle speed sensor (VSS).
109. Remove the engine harness clips (2, 3) from the rear engine mount bracket and steering gear shield.

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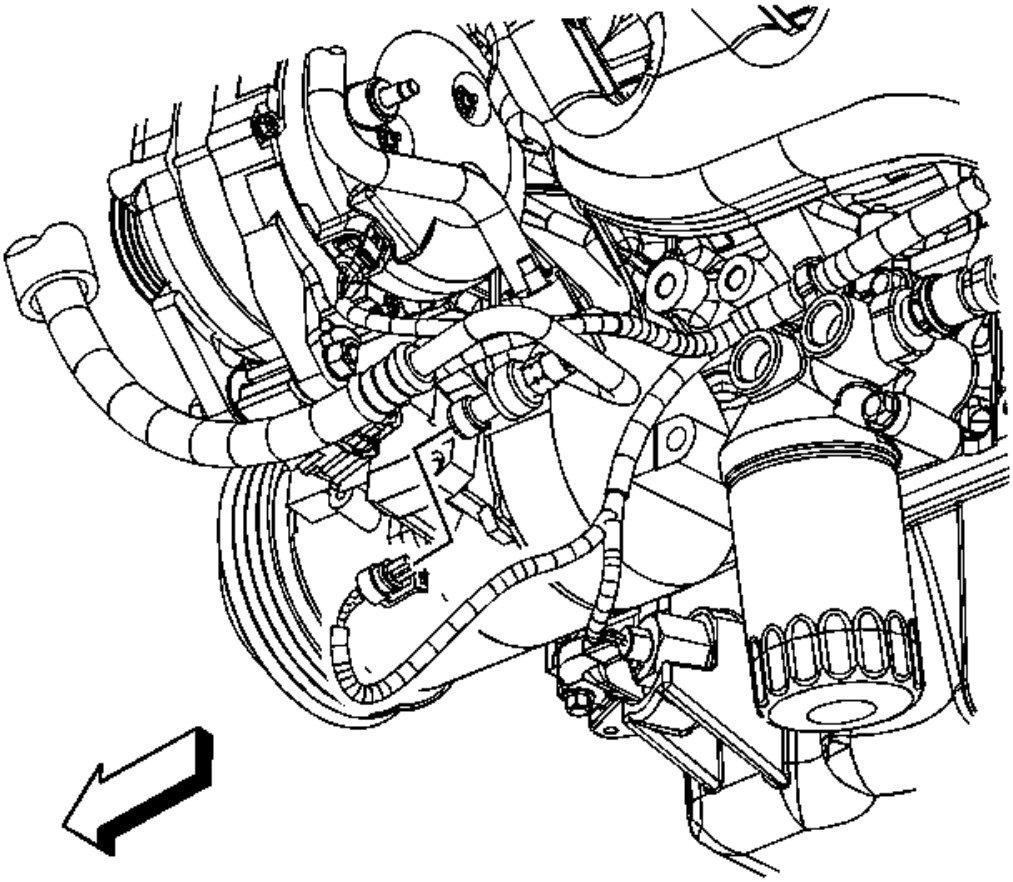

Fig. 79: Engine Harness A/C Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

110. Disconnect the engine harness electrical connector from the A/C pressure sensor.

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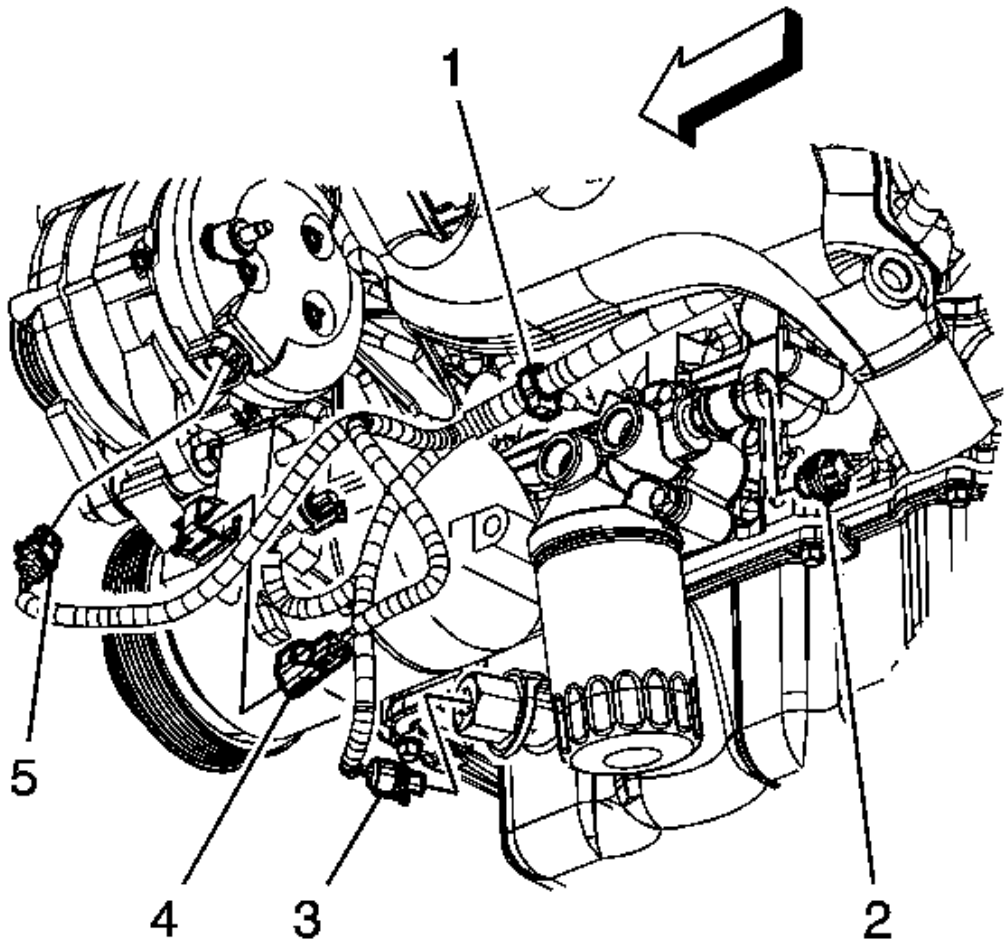

Fig. 80: Disconnecting/Connecting Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

111. Remove the engine harness clip (1) from the boss on the engine block.
112. Disconnect the following engine harness electrical connectors:
    - The oil pressure sensor (2)
    - The oil level sensor (3)
    - The A/C compressor (4)
    - The generator (5)

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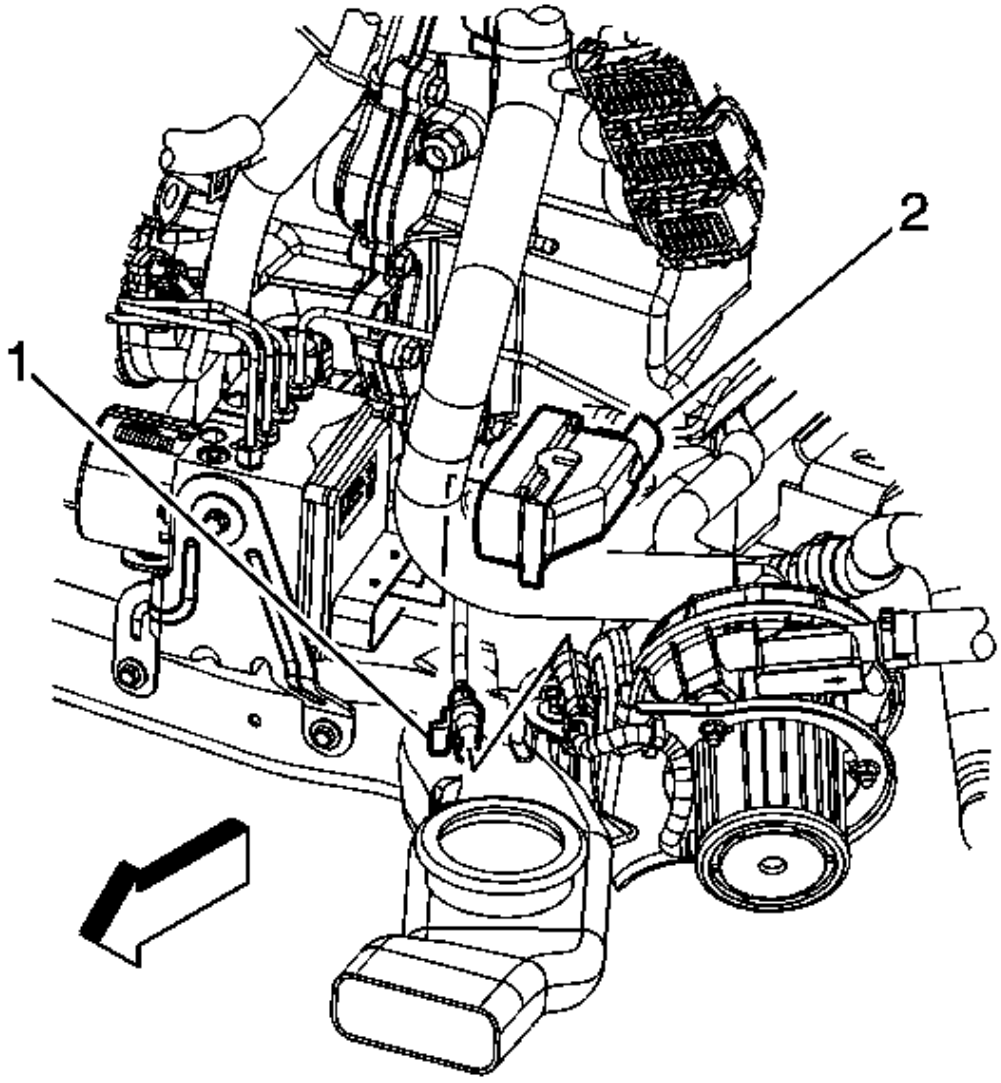

Fig. 81: Engine Harness Electrical Connectors At AIR Pump & Brake Modulator
Courtesy of GENERAL MOTORS CORP.

113. Disconnect the engine harness electrical connectors from the following:
    - The AIR pump (1)
    - The brake modulator (2)

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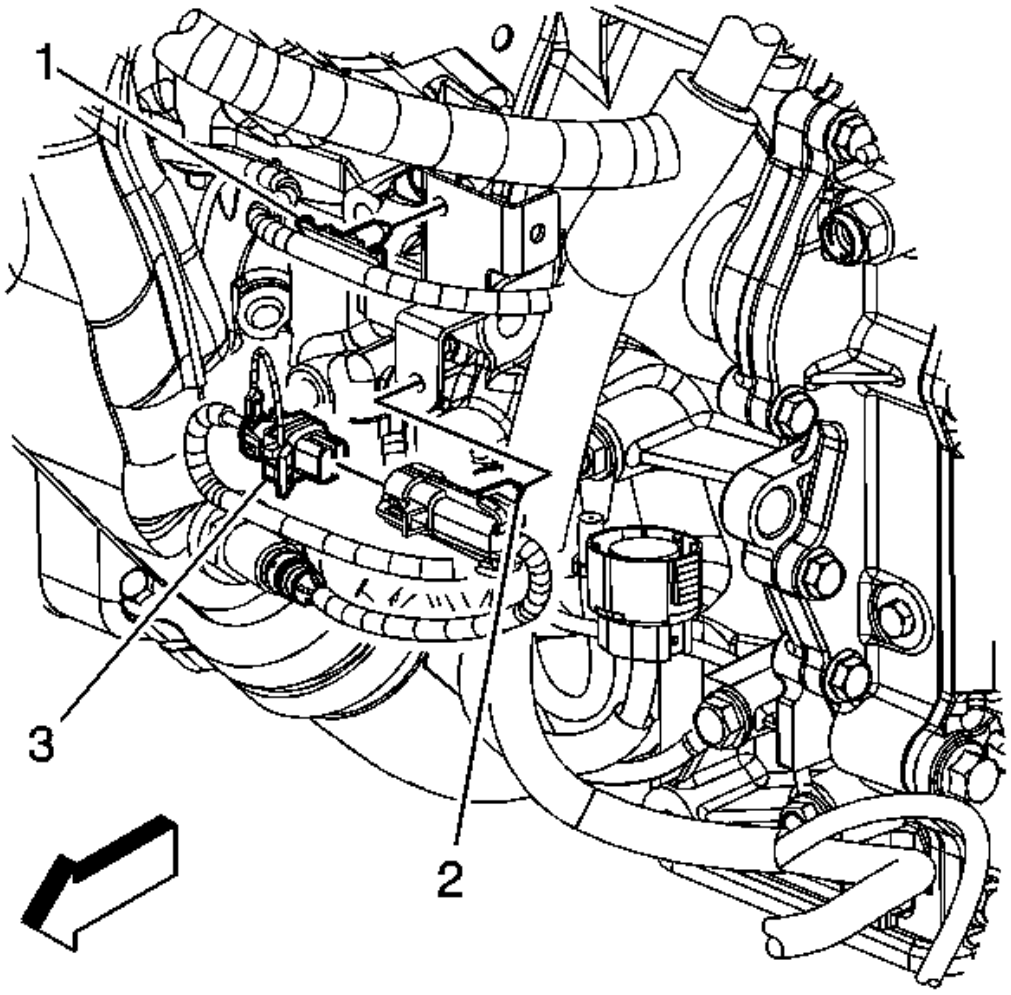

Fig. 82: Engine Harness Electrical Connector & Clips
Courtesy of GENERAL MOTORS CORP.

114. Remove the engine harness clip (1) from the engine bracket.
115. Remove the connector position assurance (CPA) retainer.
116. Disconnect the engine harness electrical connector (3) from the HO2S.

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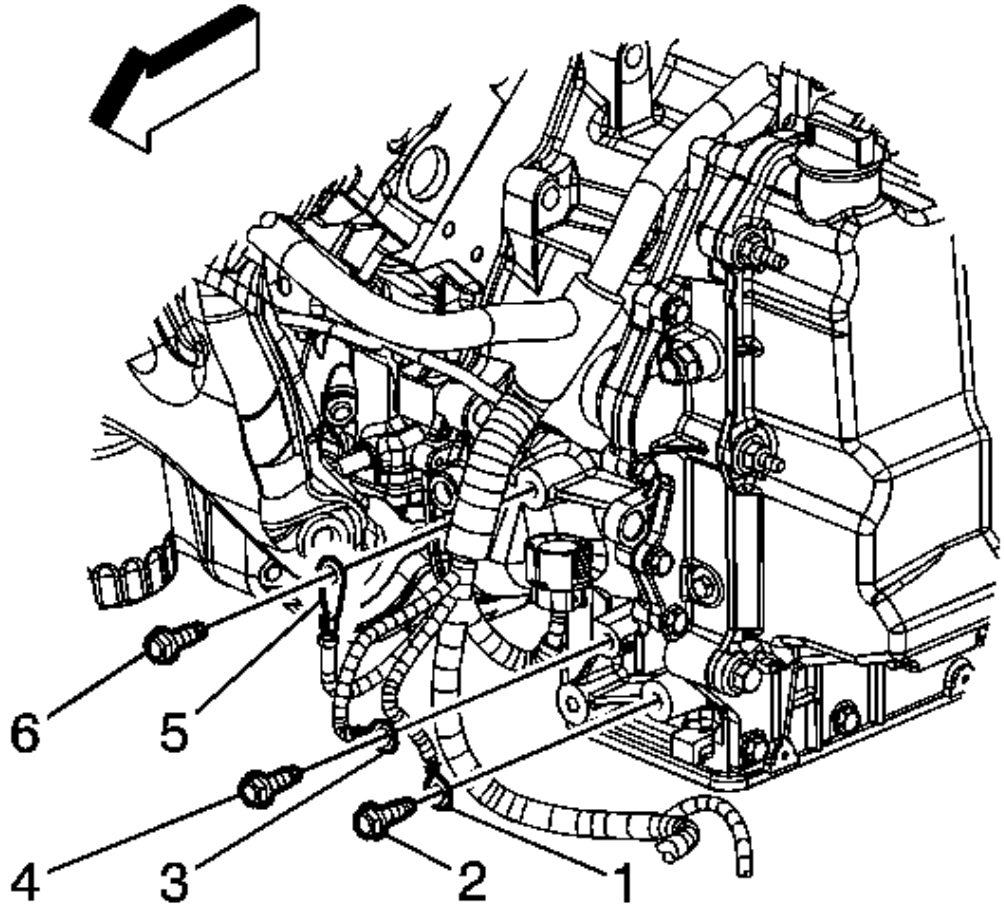

Fig. 83: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

117. Disconnect the engine harness electrical connector from the transaxle.
118. Remove the engine harness ground bolts (2, 4, and 6).
119. Gather all the branches of the engine harness and remove the engine harness from the engine.

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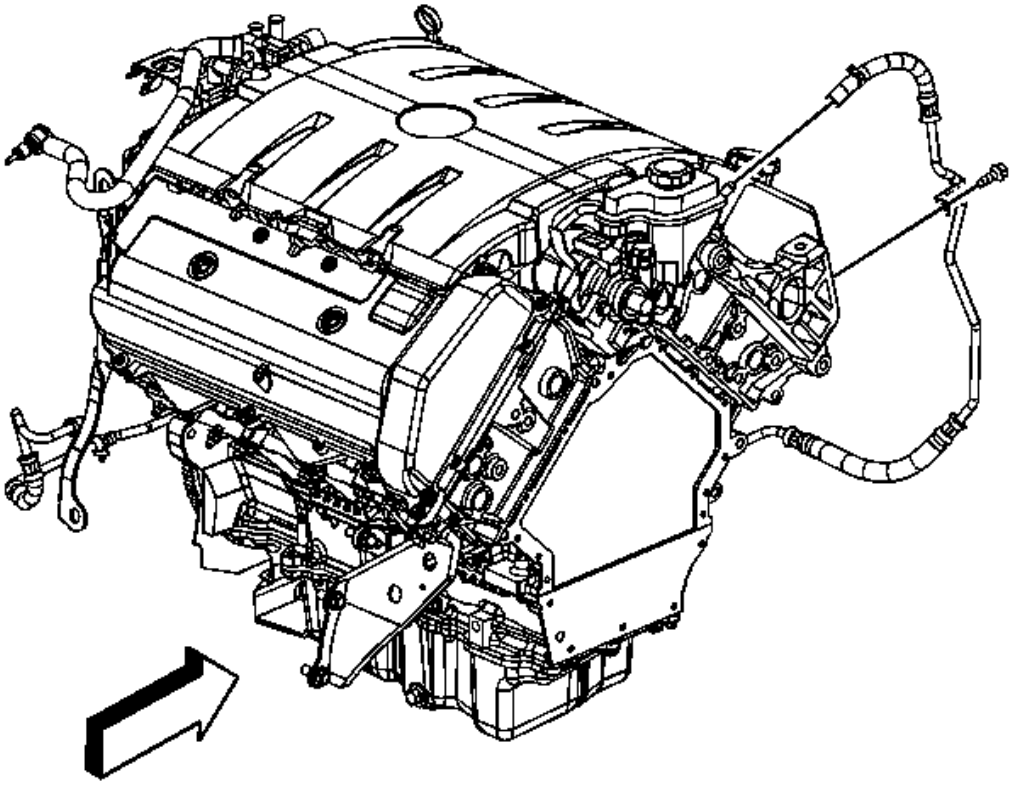

Fig. 84: Power Steering Outlet Hose
Courtesy of GENERAL MOTORS CORP.

120. Reposition the power steering outlet hose clamp at the pump reservoir.
121. Remove the power steering outlet hose from the reservoir.
122. Remove the power steering outlet pipe bolt from the engine mount strut bracket.

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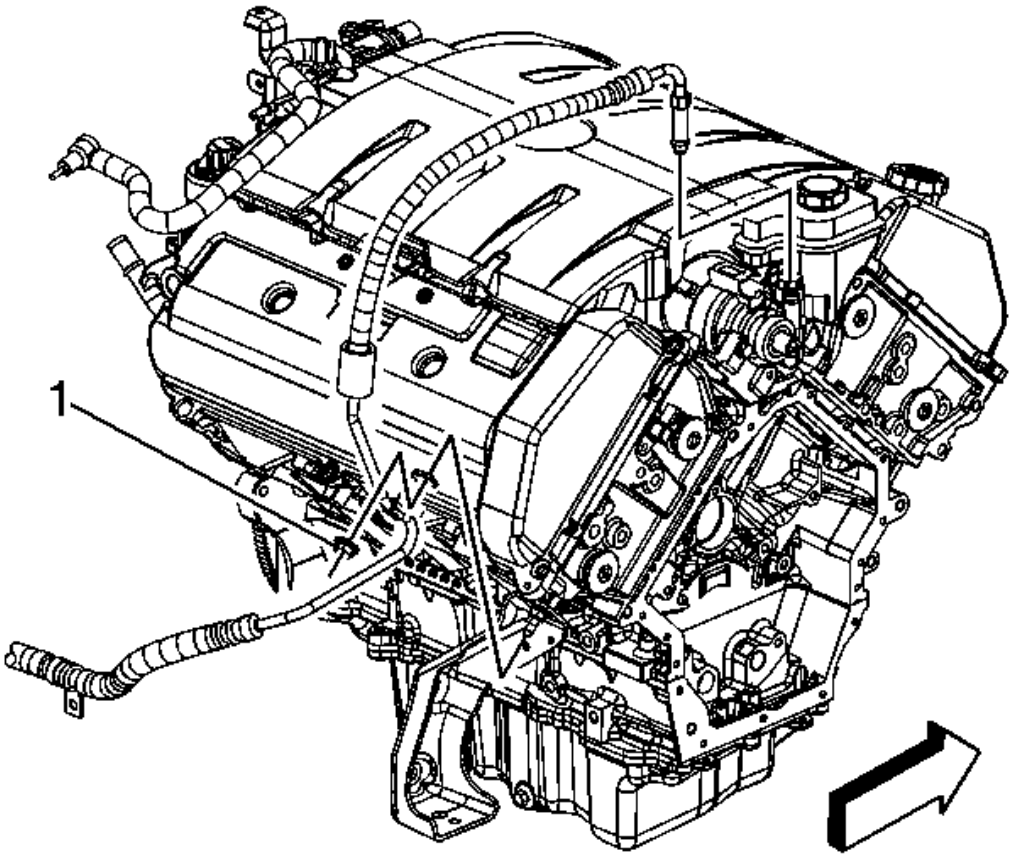

Fig. 85: Power Steering Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

123. Remove the power steering inlet pipe fitting from the power steering pump.
124. Remove the power steering inlet pipe nut (1) from the rear engine mount bracket stud.
125. Remove the power steering inlet pipe bracket from the stud.

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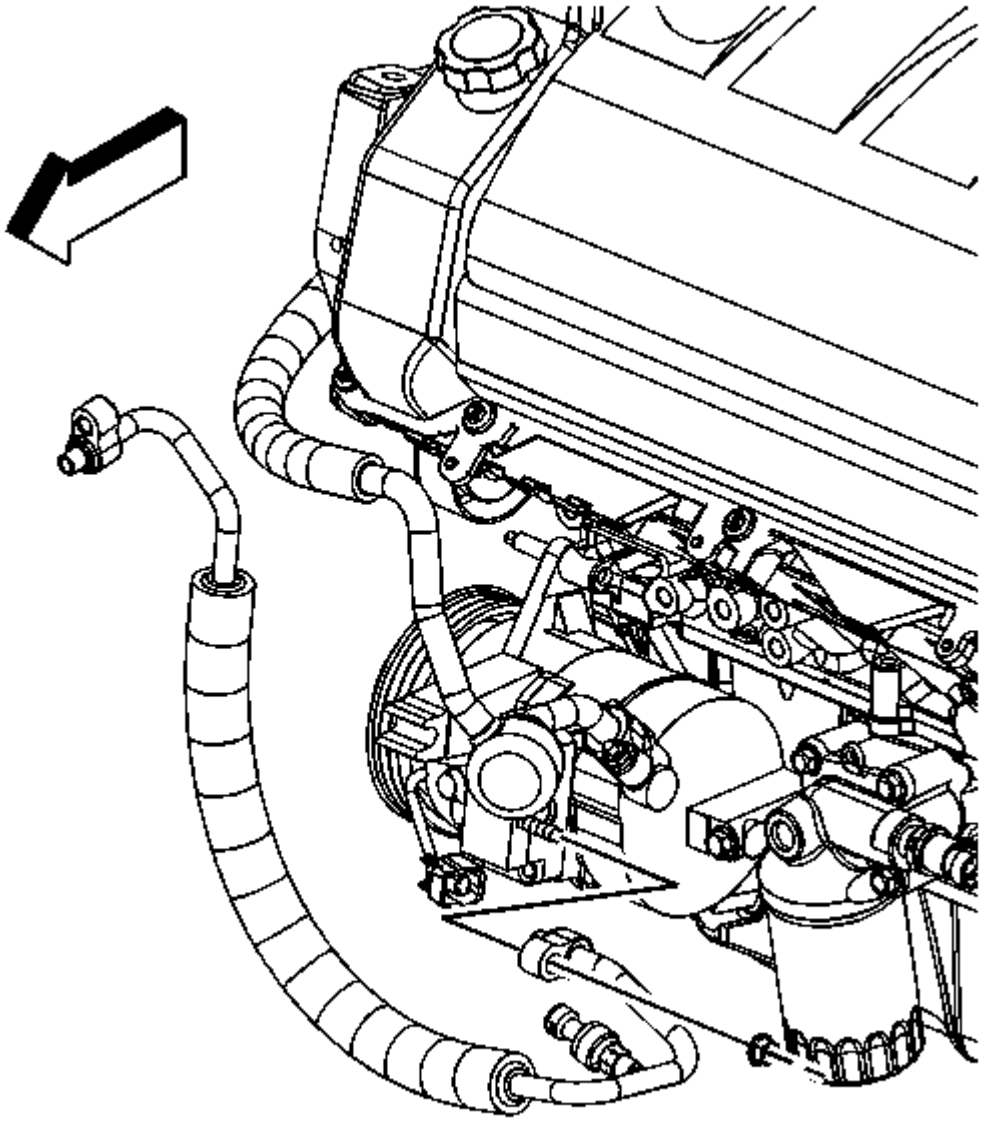

Fig. 86: A/C Compressor Discharge Hose
Courtesy of GENERAL MOTORS CORP.

126. Remove the A/C compressor discharge hose nut at the compressor.
127. Unsecure the hose from the engine and remove the A/C compressor discharge hose.
128. Plug the A/C compressor discharge port.

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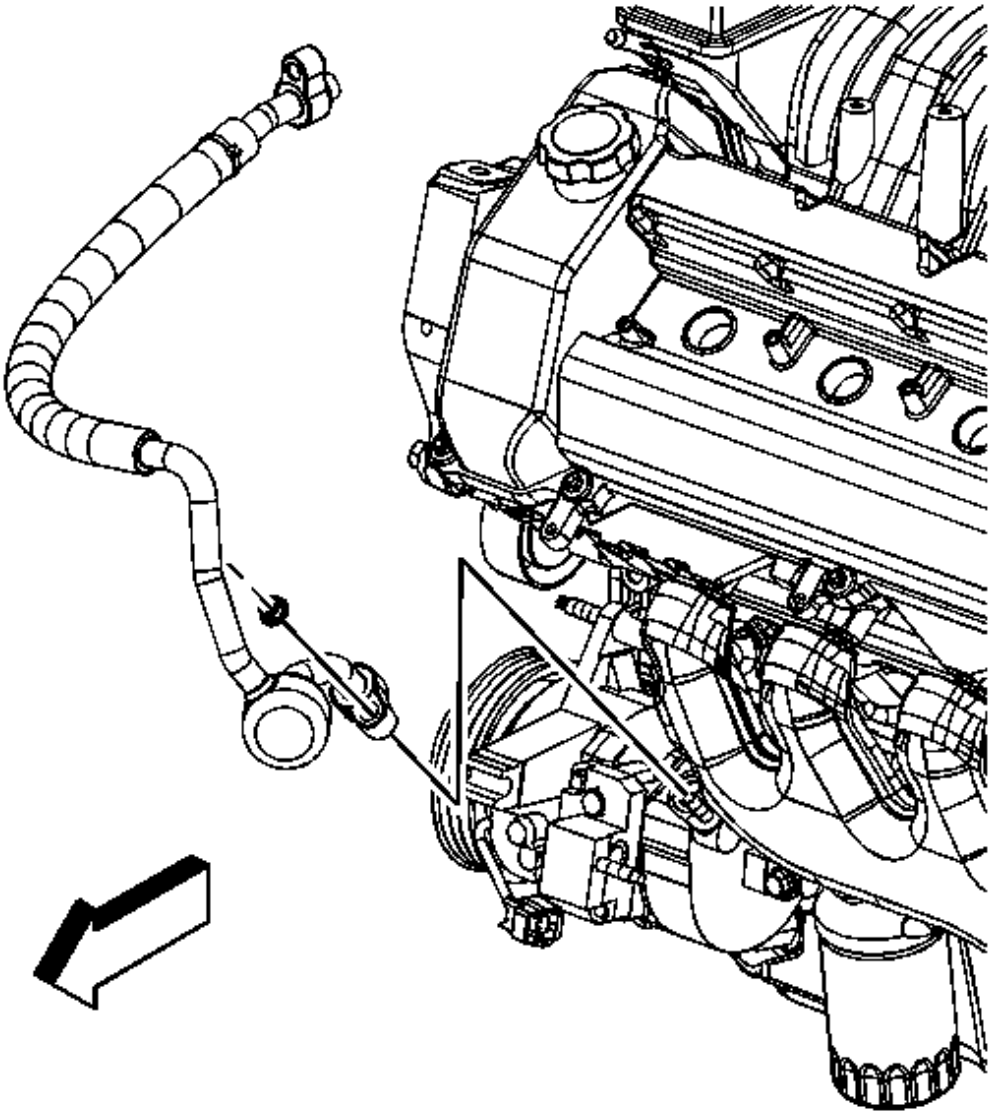

Fig. 87: A/C Compressor Suction Hose
Courtesy of GENERAL MOTORS CORP.

129. Remove the A/C compressor suction hose nut at the compressor.
130. Unsecure the hose from the engine and remove the A/C compressor suction hose.
131. Plug the A/C compressor suction port.

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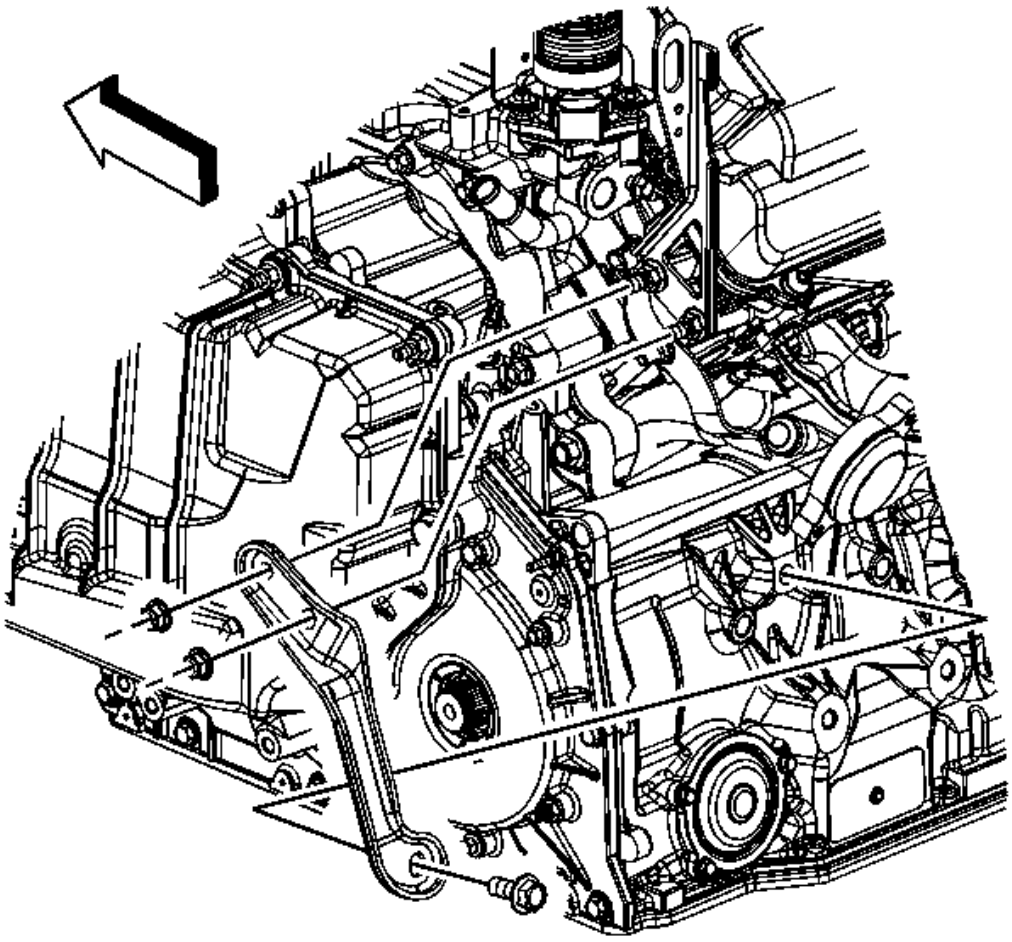

Fig. 88: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

132. Remove the transaxle brace bolt.
133. Remove the transaxle brace nuts.
134. Remove the transaxle brace.

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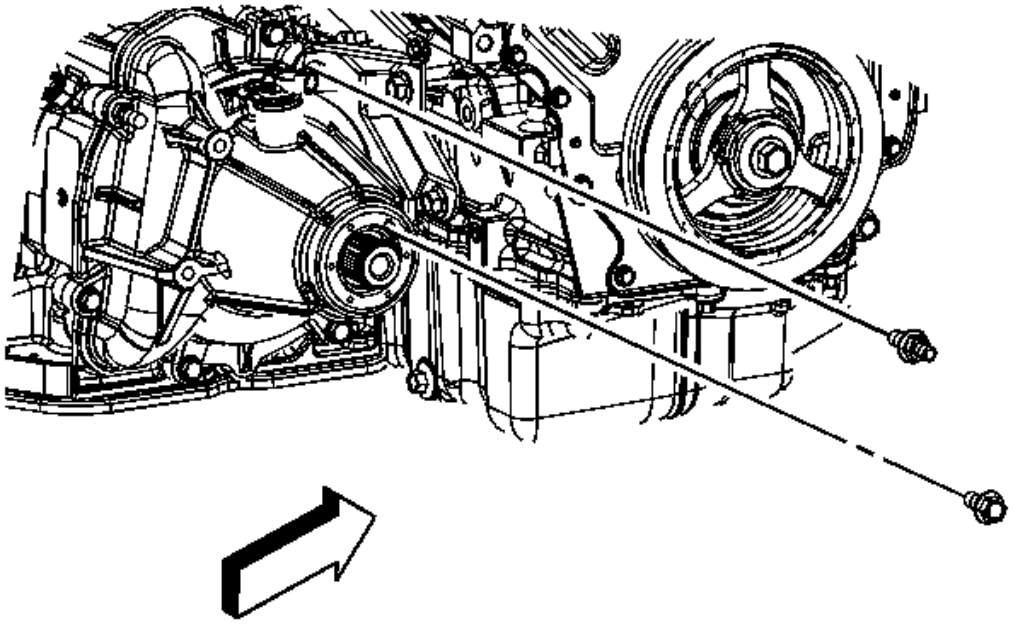

Fig. 89: Transaxle Brace Bolt/Stud To Transaxle
Courtesy of GENERAL MOTORS CORP.

135. Remove the transaxle brace bolt/stud to the transaxle.

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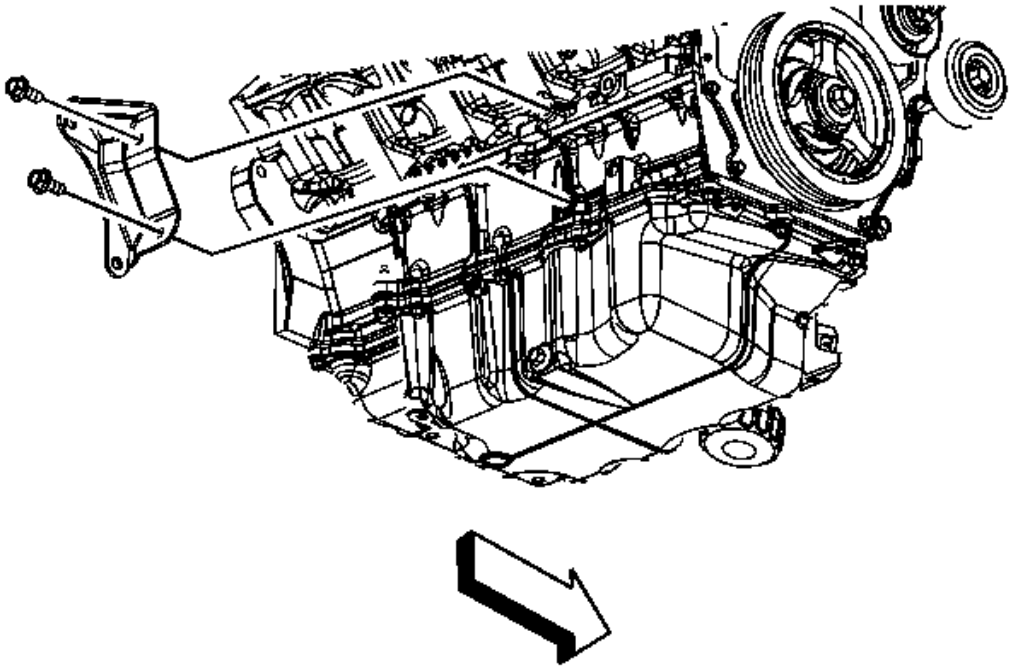

Fig. 90: Transaxle Brace & Bolts To Engine
Courtesy of GENERAL MOTORS CORP.

136. Remove the transaxle brace bolts to the engine.
137. Remove the transaxle brace.

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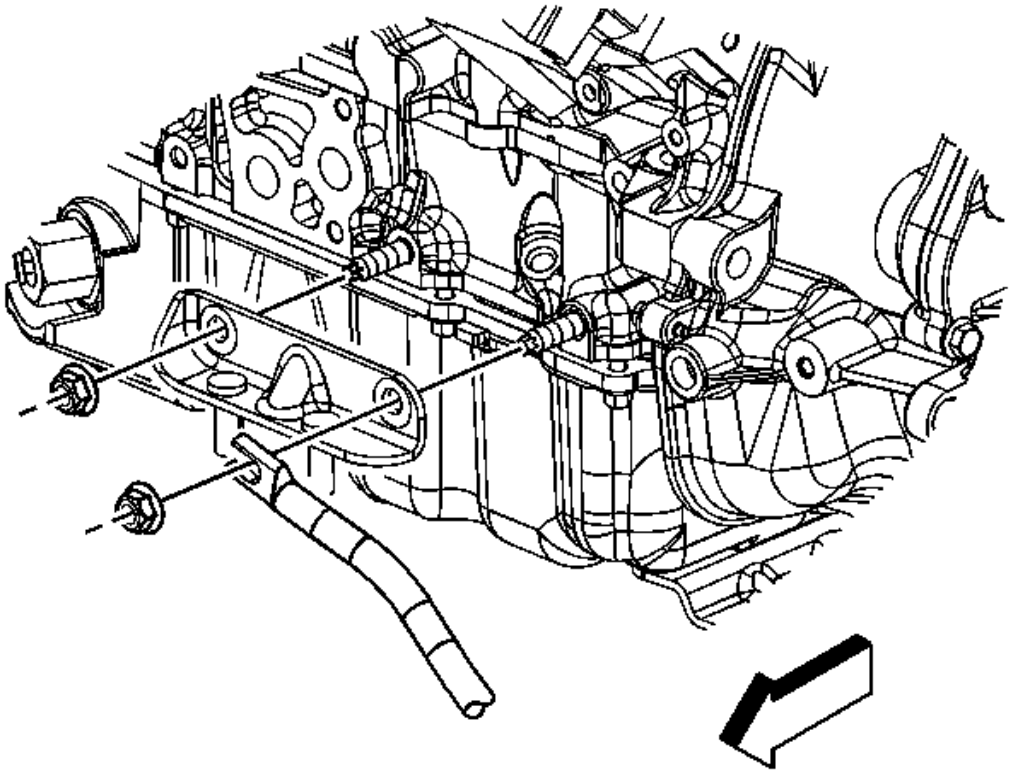

Fig. 91: Front Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

138. Loosen the front engine mount bracket nut with the transaxle brace behind it.

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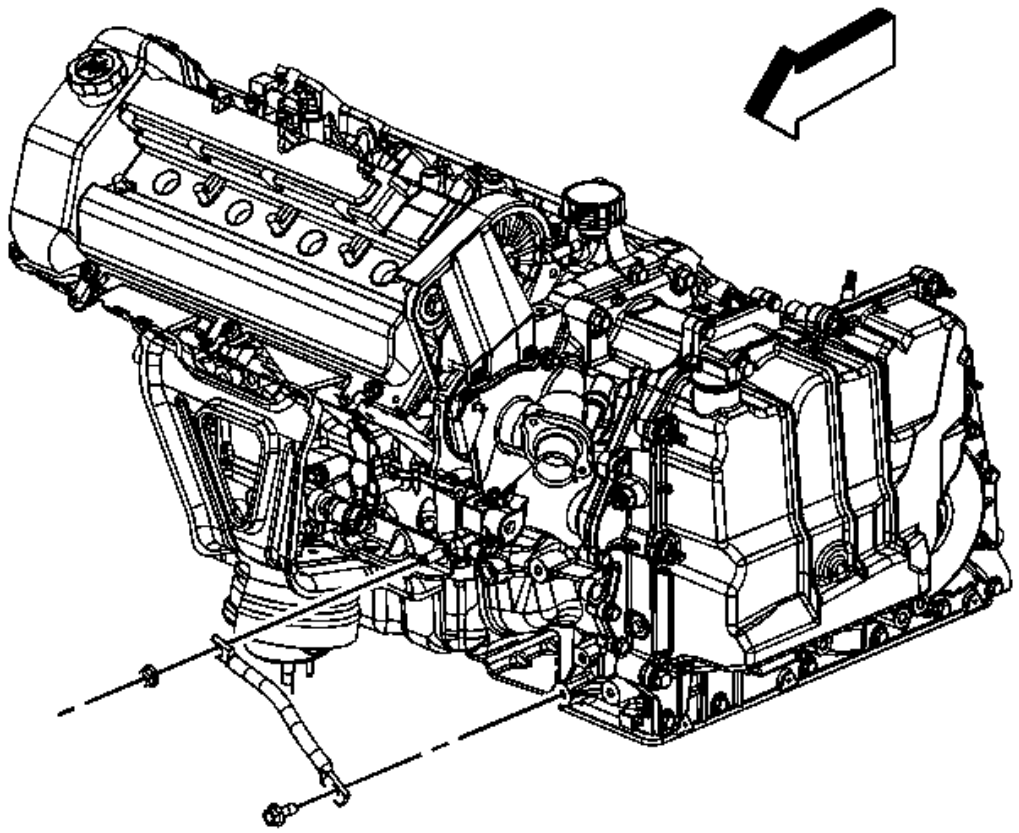

Fig. 92: Transaxle Brace & Bolt
Courtesy of GENERAL MOTORS CORP.

139. Remove the transaxle brace bolt.
140. Remove the transaxle brace.

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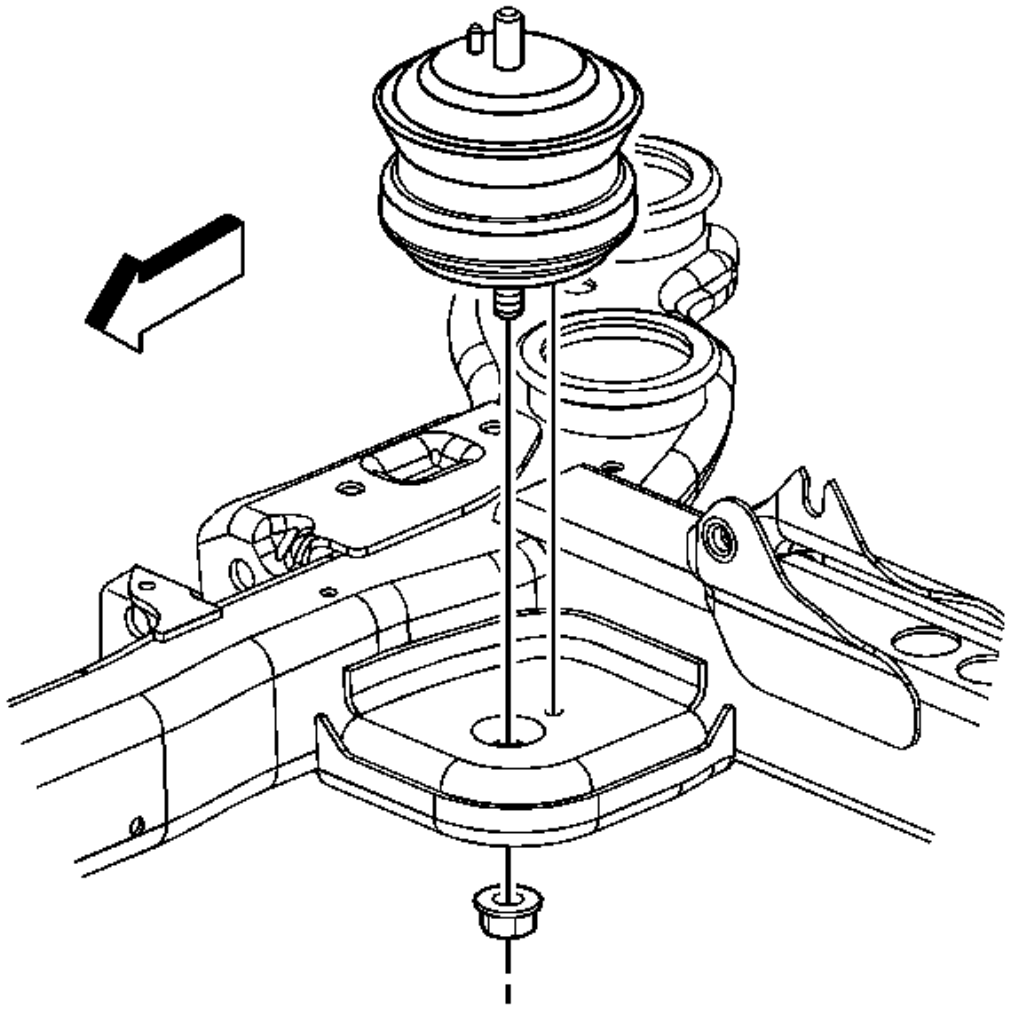

Fig. 93: Rear Engine Mount To Frame Nut
Courtesy of GENERAL MOTORS CORP.

141. Install an engine lift chain to the engine lift brackets and attach an engine lifting device.
142. Remove the rear engine mount to frame nut.

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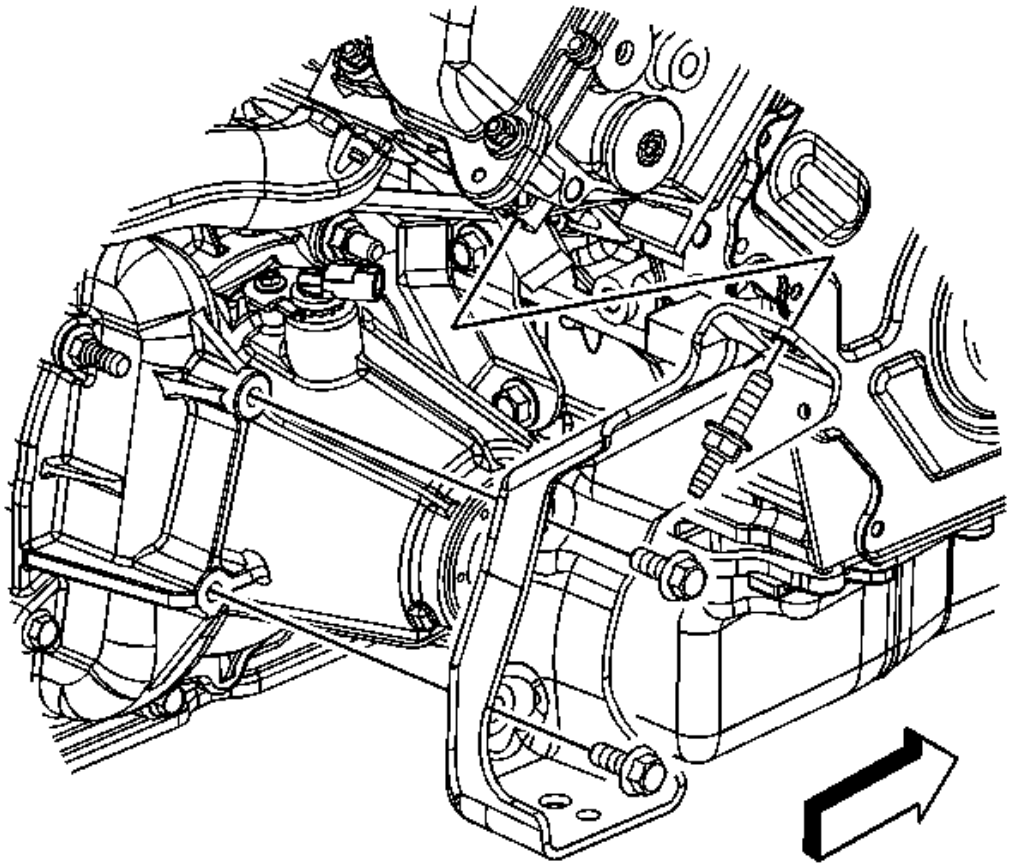

Fig. 94: Rear Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

143. Remove the rear engine mount bracket bolts and stud.
144. Remove the rear engine mount bracket.

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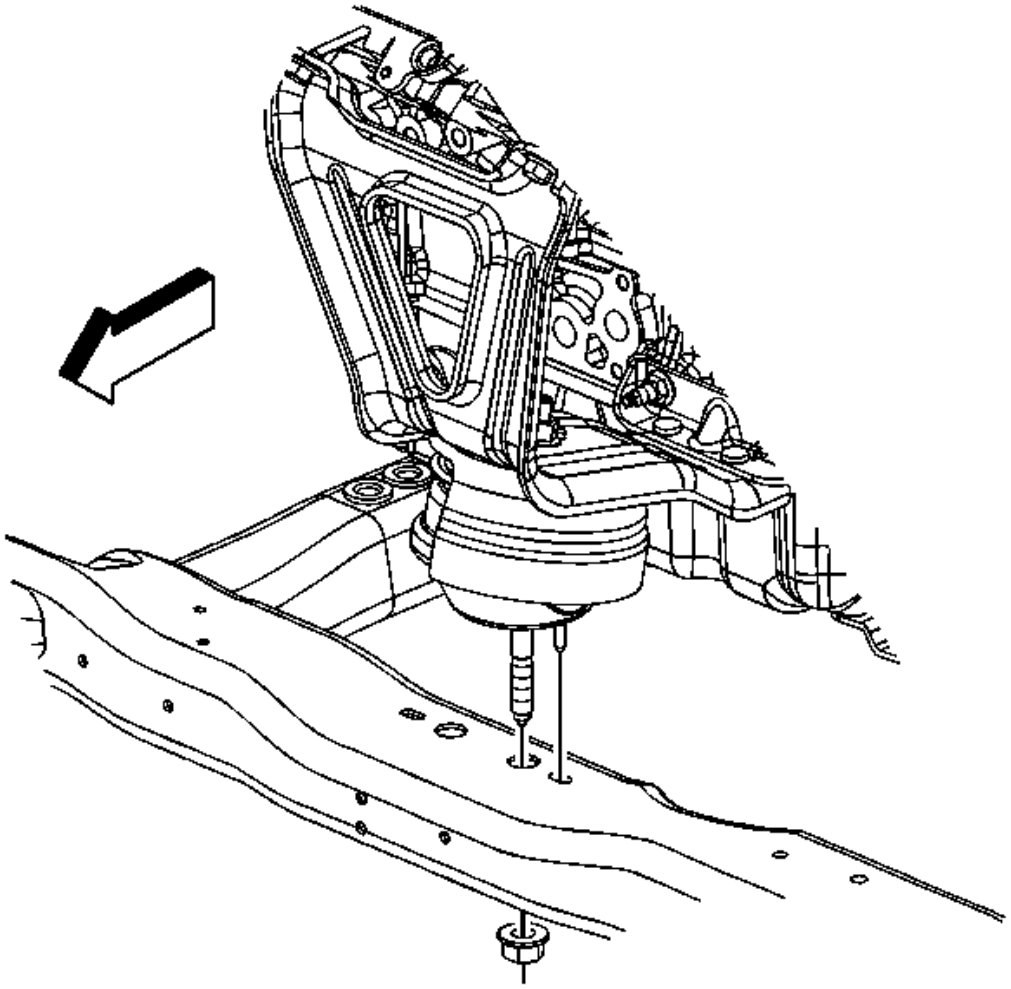

Fig. 95: Front Engine Mount To Frame Nut
Courtesy of GENERAL MOTORS CORP.

145. Remove the front engine mount to frame nut.

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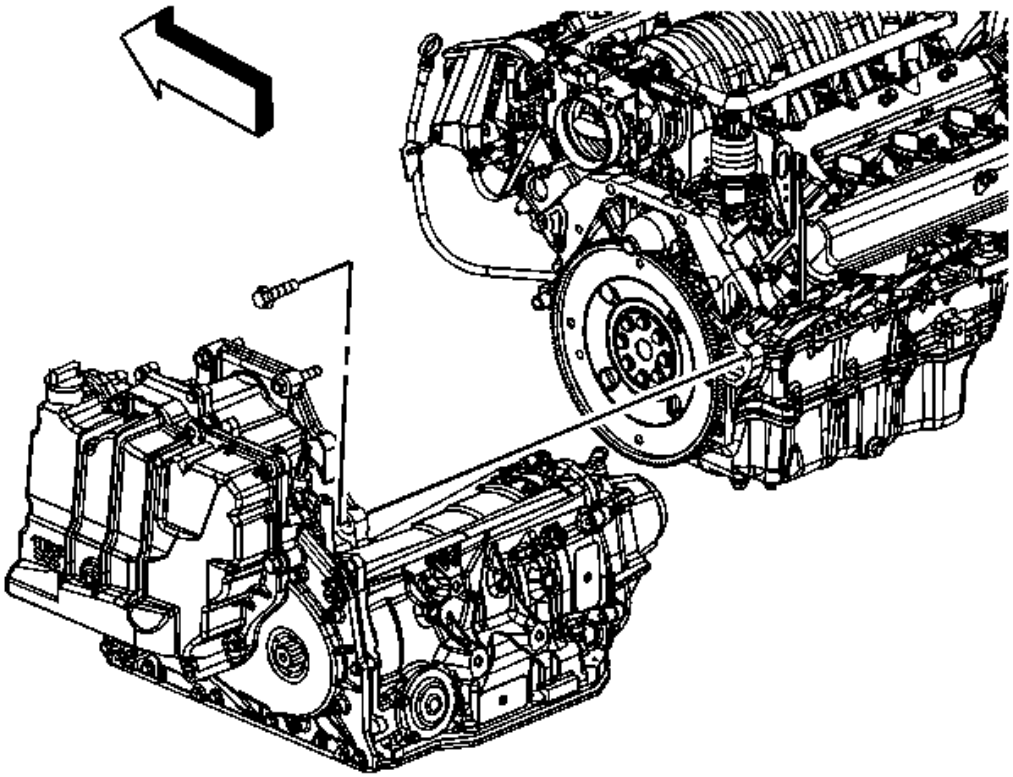

Fig. 96: Rear Transaxle Bolt
Courtesy of GENERAL MOTORS CORP.

146. Remove the rear transaxle bolt.

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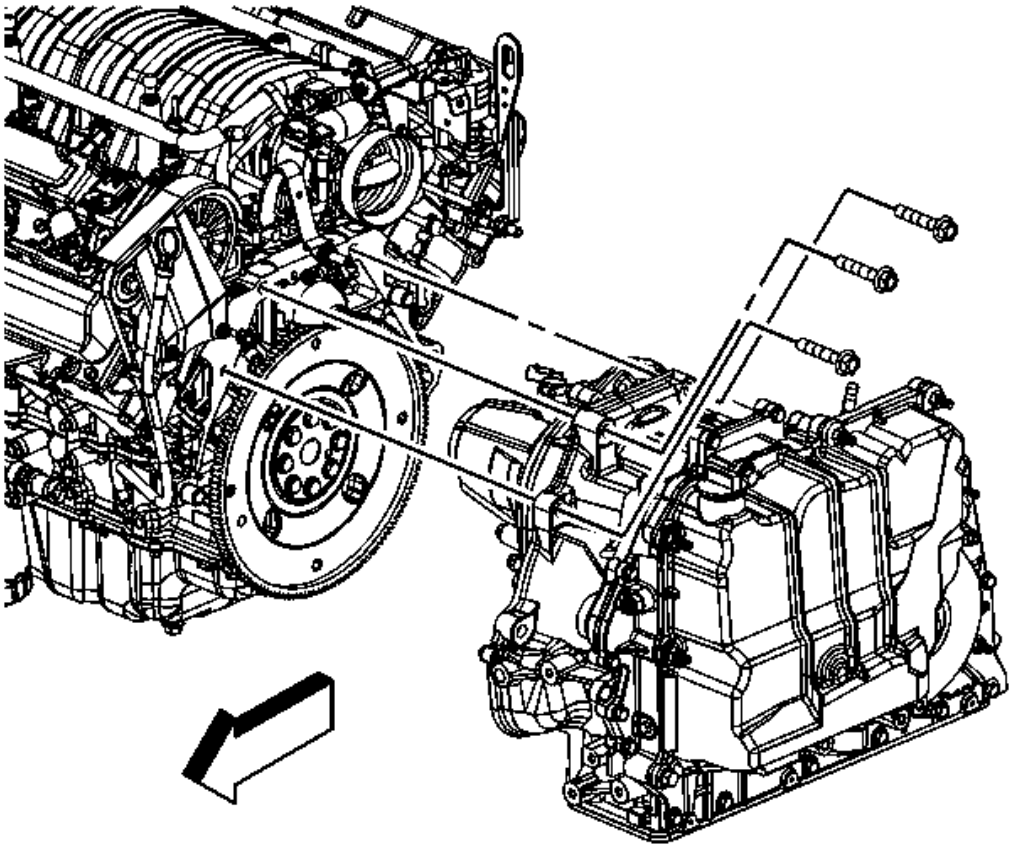

Fig. 97: Upper Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

147. Remove the upper transaxle bolts.
148. Separate the engine from the transaxle.
149. Raise the engine from the supported frame and transaxle assembly.

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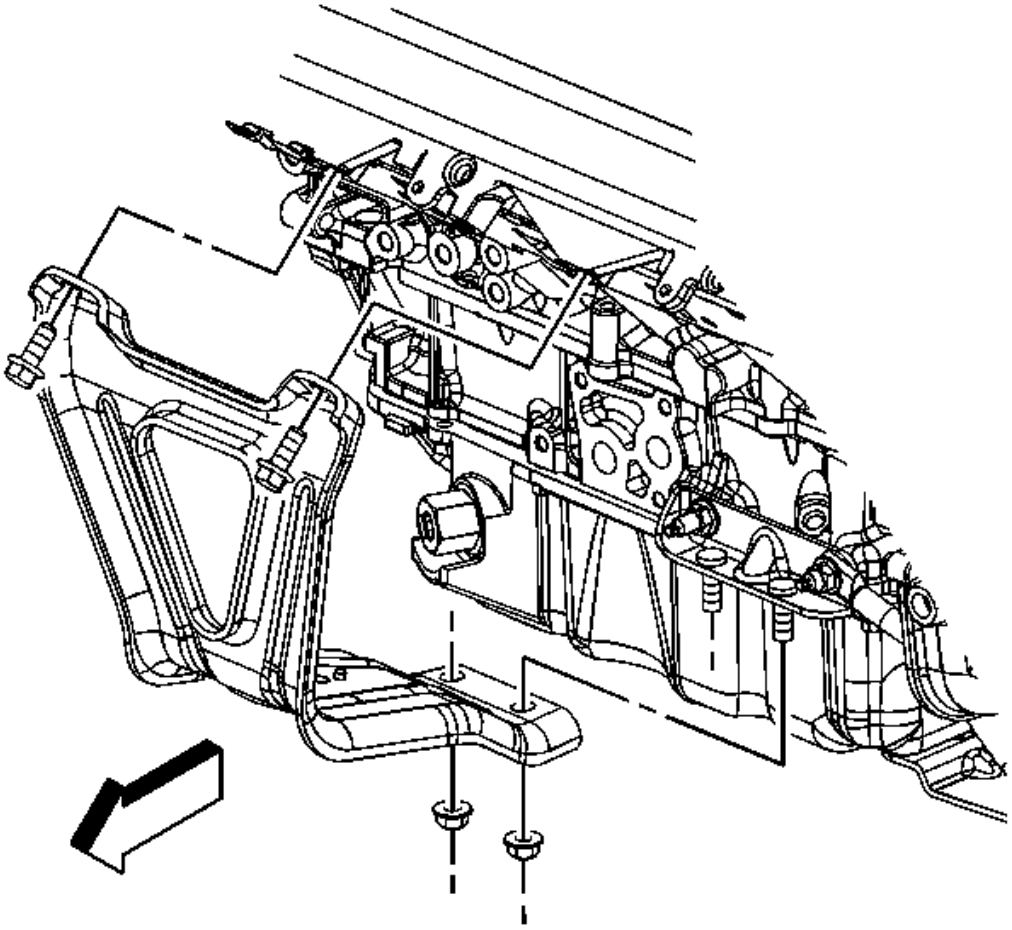

Fig. 98: Front Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

150. Remove the front engine mount bracket bolts/nuts.
151. Remove the front engine mount bracket.
152. Install the engine assembly to a suitable engine stand.

INSTALLATION PROCEDURE

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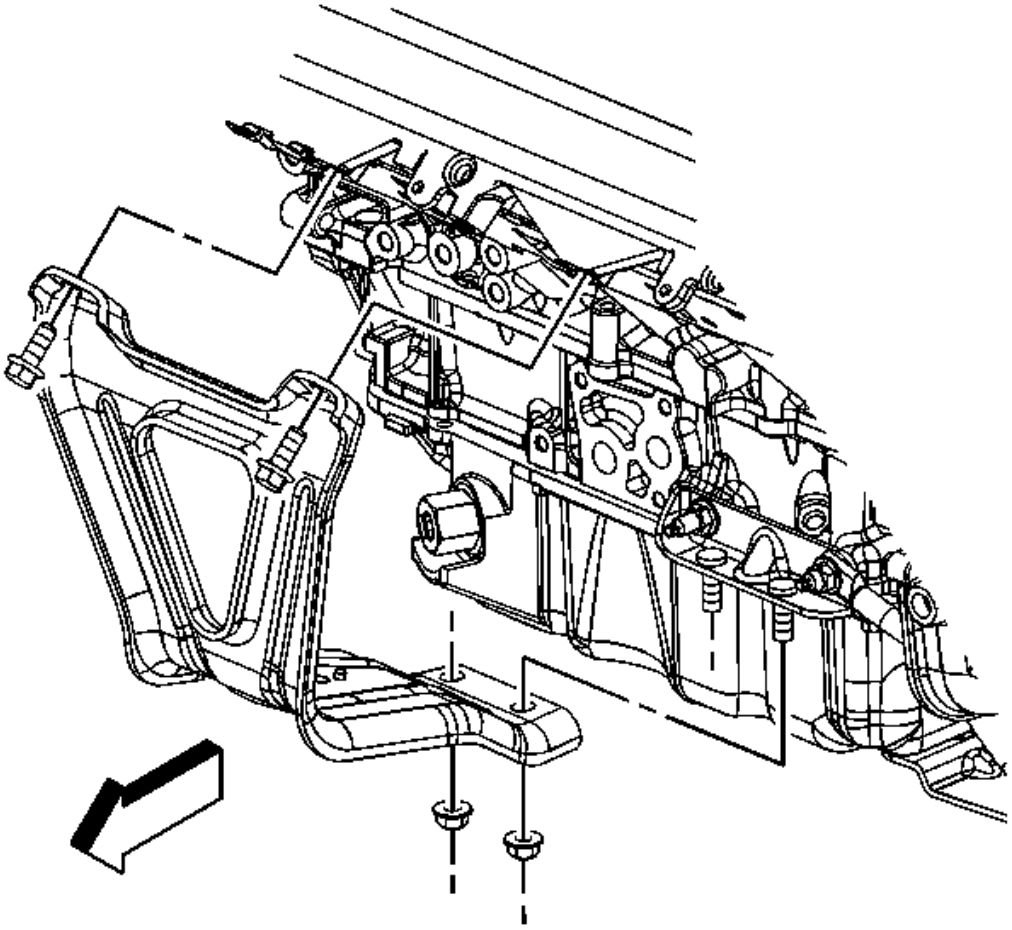

Fig. 99: Front Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the front engine mount bracket.

   CAUTION: Refer to Fastener Caution .

2. Install the front engine mount bracket bolts/nuts.

   Tighten: Tighten the bolts/nuts 50 N.m (37 lb ft).

3. Install an engine lift chain to the engine lift brackets and attach an engine lifting device.
4. Remove the engine assembly from the engine stand.

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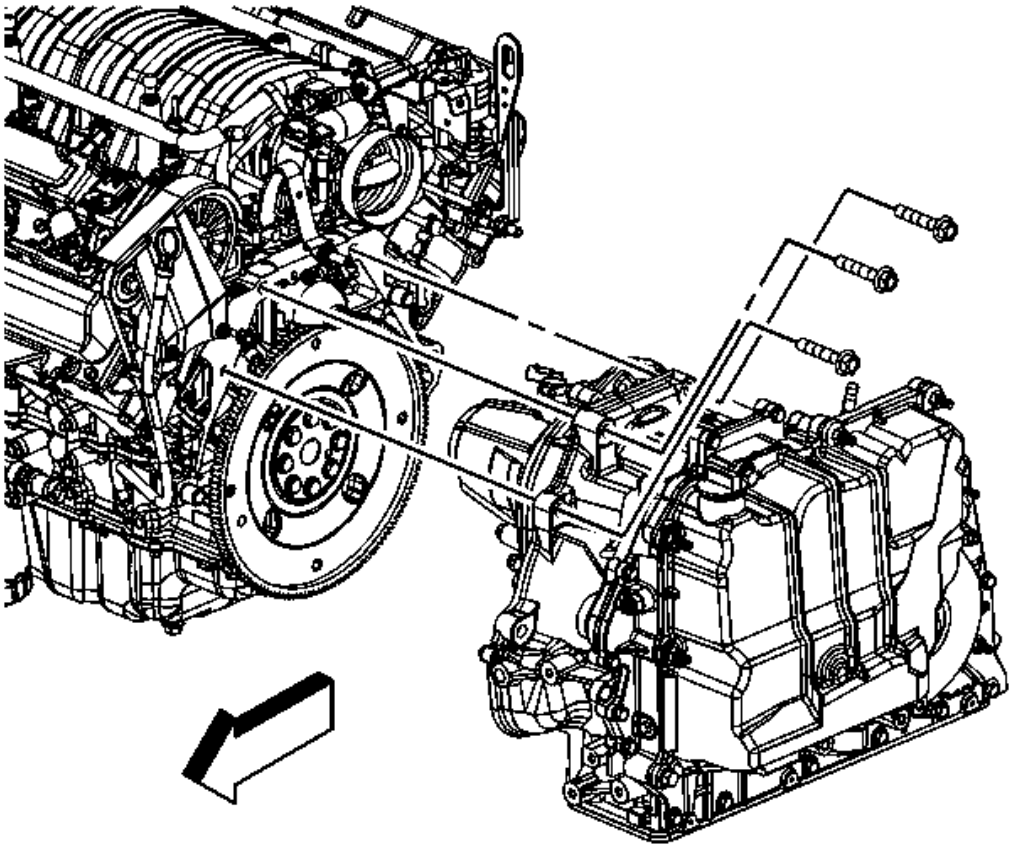

Fig. 100: Upper Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

5. Carefully position and install the engine to the supported frame and transaxle, aligning the engine dowel pins to the transaxle.
6. Install the upper transaxle bolts.

   Tighten: Tighten the bolts to 75 N.m (55 lb ft).

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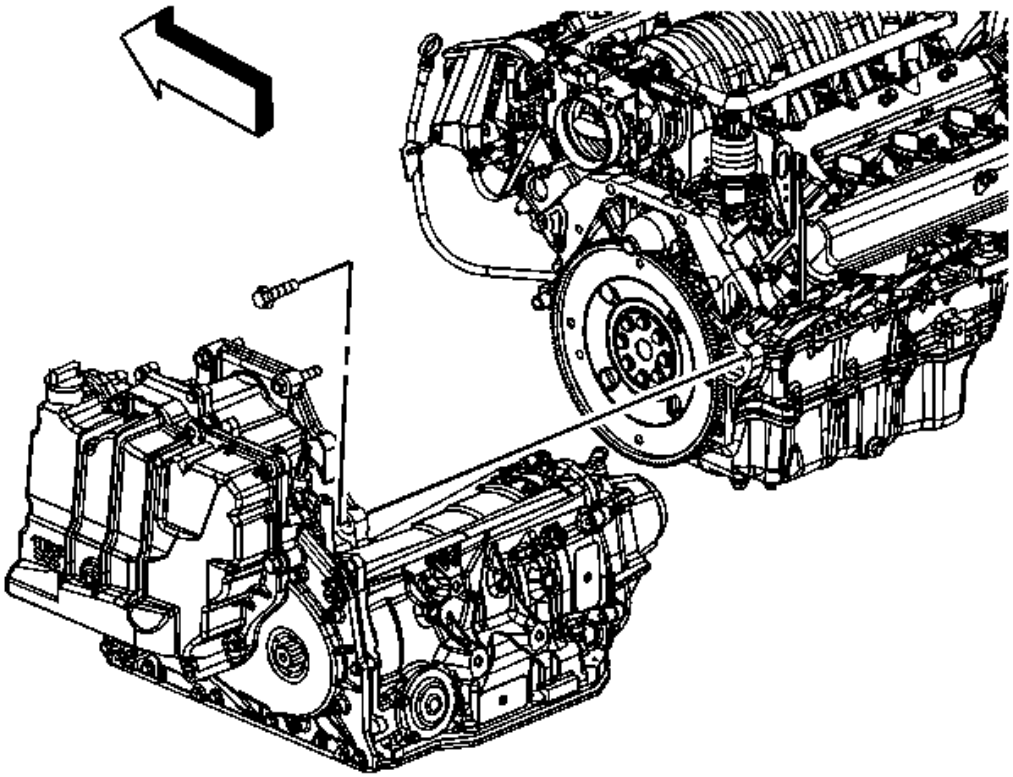

Fig. 101: Rear Transaxle Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the rear transaxle bolt.

   Tighten: Tighten the bolt to 75 N.m (55 lb ft).

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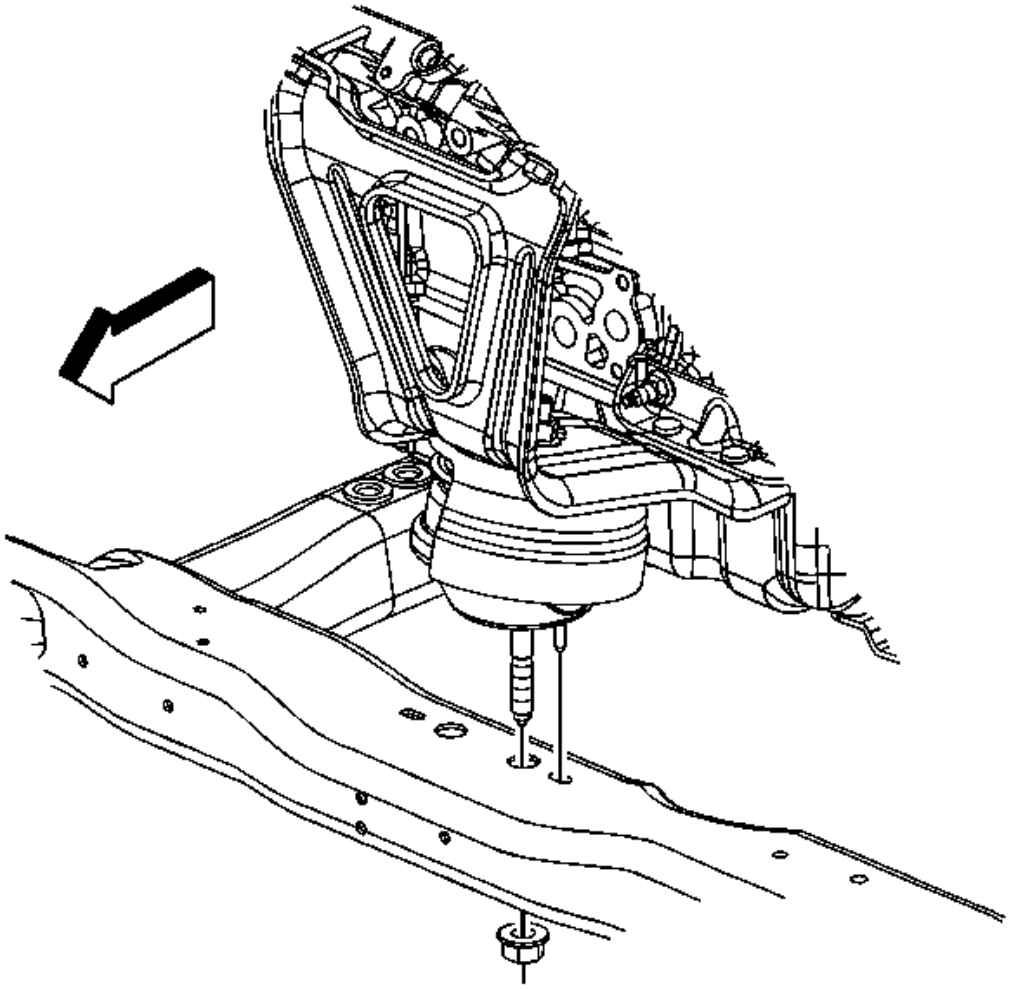

Fig. 102: Front Engine Mount To Frame Nut
Courtesy of GENERAL MOTORS CORP.

8. Install the front engine mount to frame nut.

   Tighten: Tighten the nut to 80 N.m (59 lb ft).

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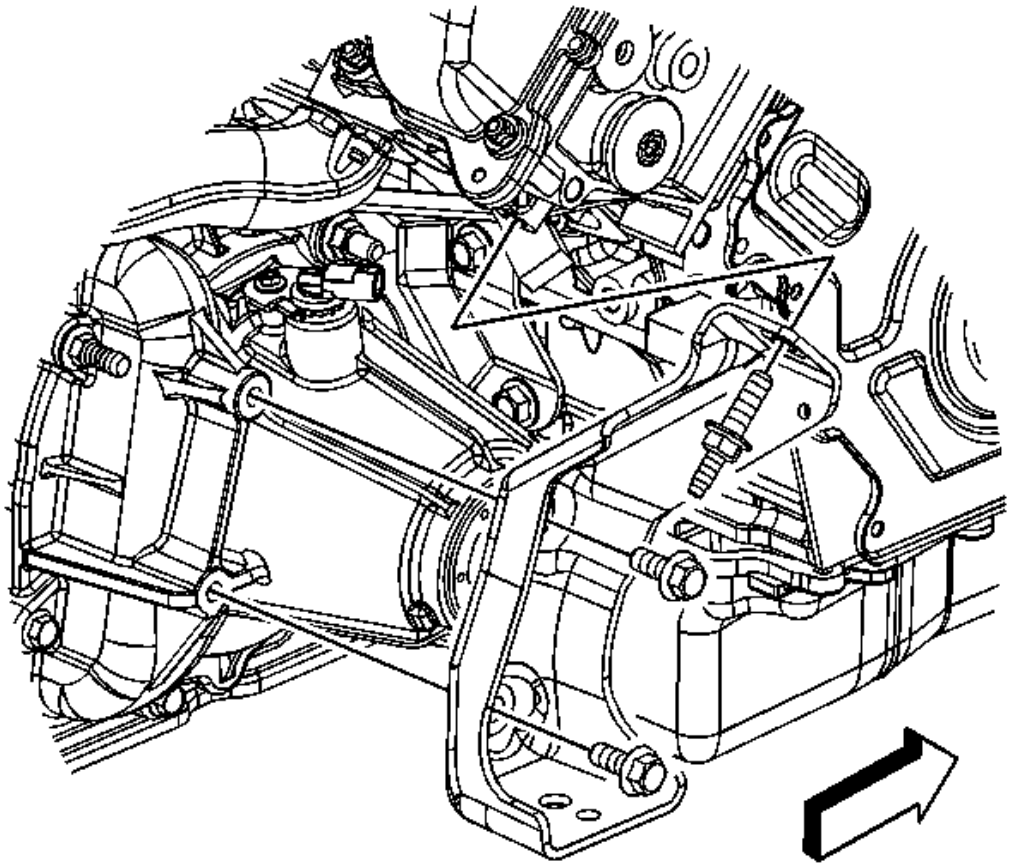

Fig. 103: Rear Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

9. Position the rear engine mount bracket to the engine and transaxle.
10. Install the rear engine mount bracket bolts and stud.

Tighten: Tighten the bolts/stud to 73 N.m (54 lb ft).

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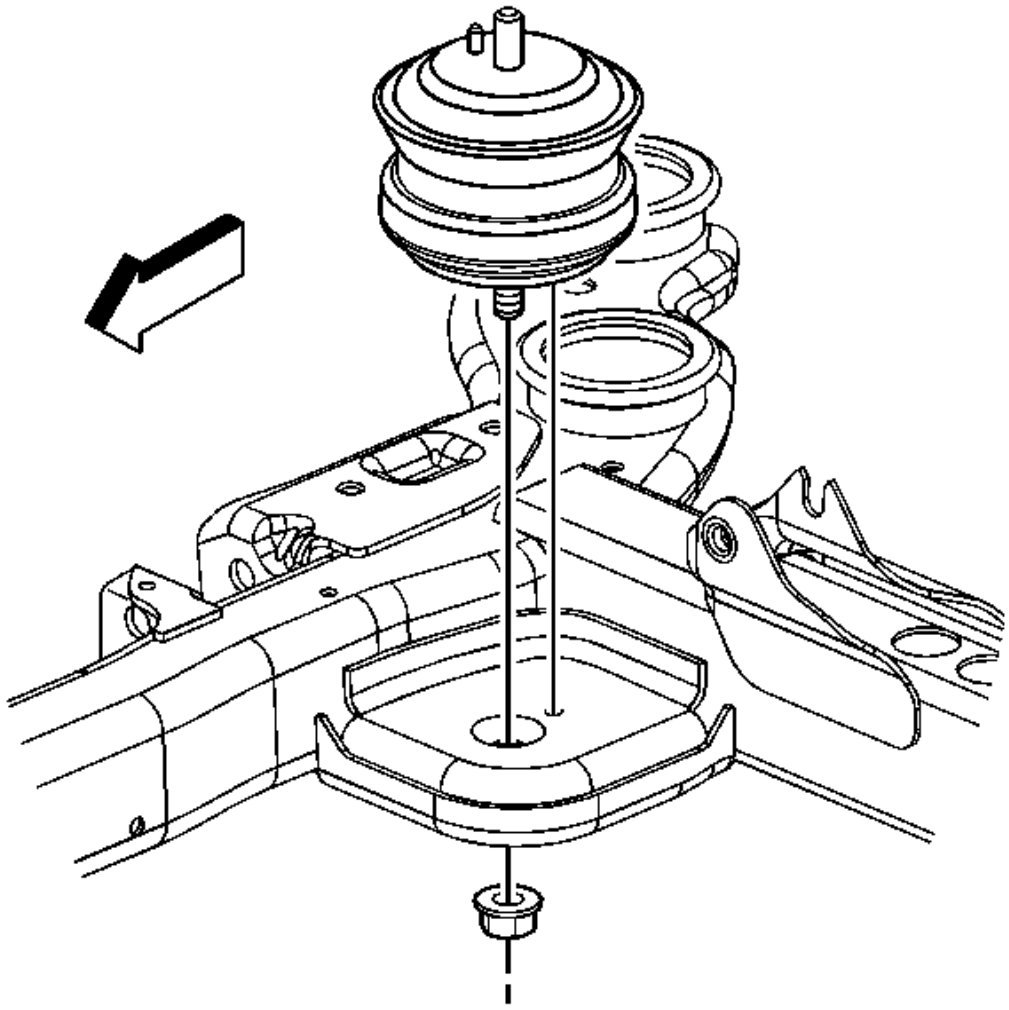

Fig. 104: Rear Engine Mount To Frame Nut
Courtesy of GENERAL MOTORS CORP.

11. Install the rear engine mount to frame nut.

    Tighten: Tighten the nut to 80 N.m (59 lb ft).

12. Remove the engine lifting device and lift chain.

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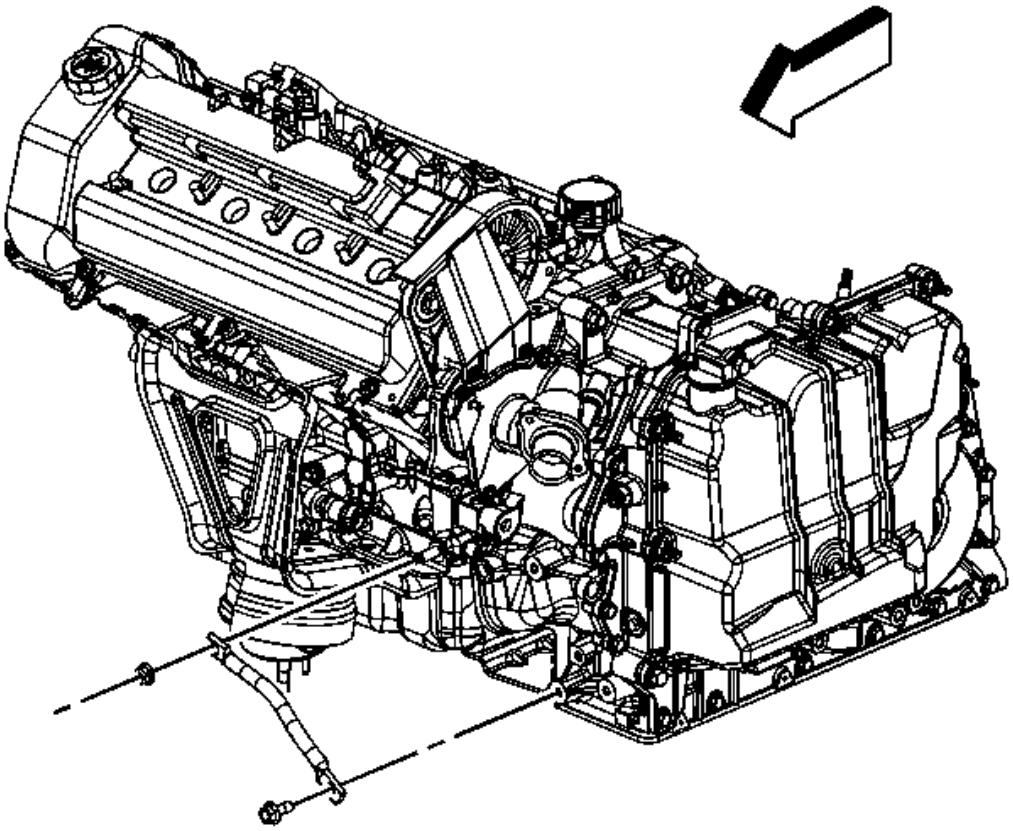

Fig. 105: Transaxle Brace & Bolt
Courtesy of GENERAL MOTORS CORP.

13. Install the transaxle brace.
14. Install the transaxle brace bolt.

Tighten: Tighten the bolt to 50 N.m (37 lb ft).

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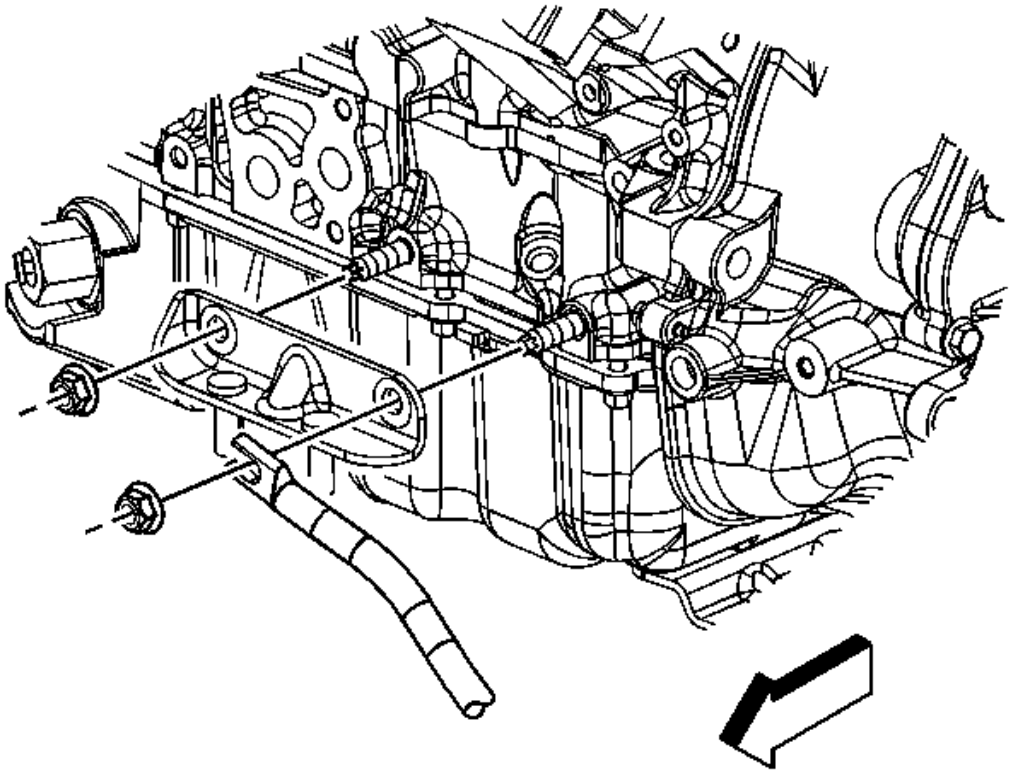

Fig. 106: Front Engine Mount Bracket Nuts
Courtesy of GENERAL MOTORS CORP.

15. Tighten the front engine mount bracket nut with the transaxle brace behind it.

    Tighten: Tighten the nut to 50 N.m (37 lb ft).

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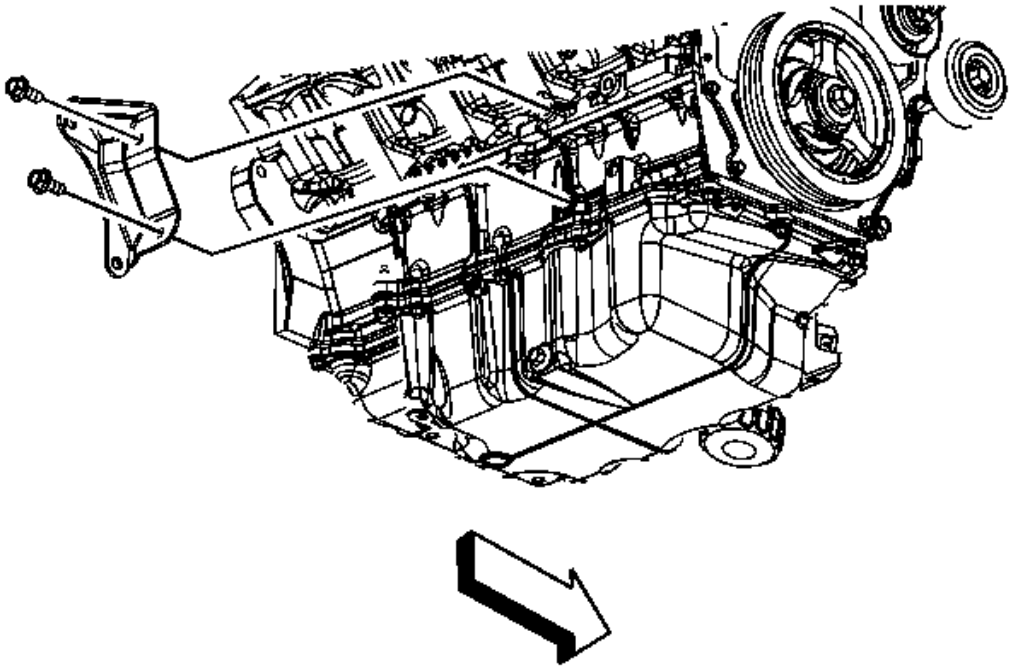

Fig. 107: Transaxle Brace & Bolts To Engine
Courtesy of GENERAL MOTORS CORP.

16. Position the transaxle brace to the engine and transaxle.
17. Install the transaxle brace bolts to the engine.

Tighten: Tighten the bolts to 50 N.m (37 lb ft).

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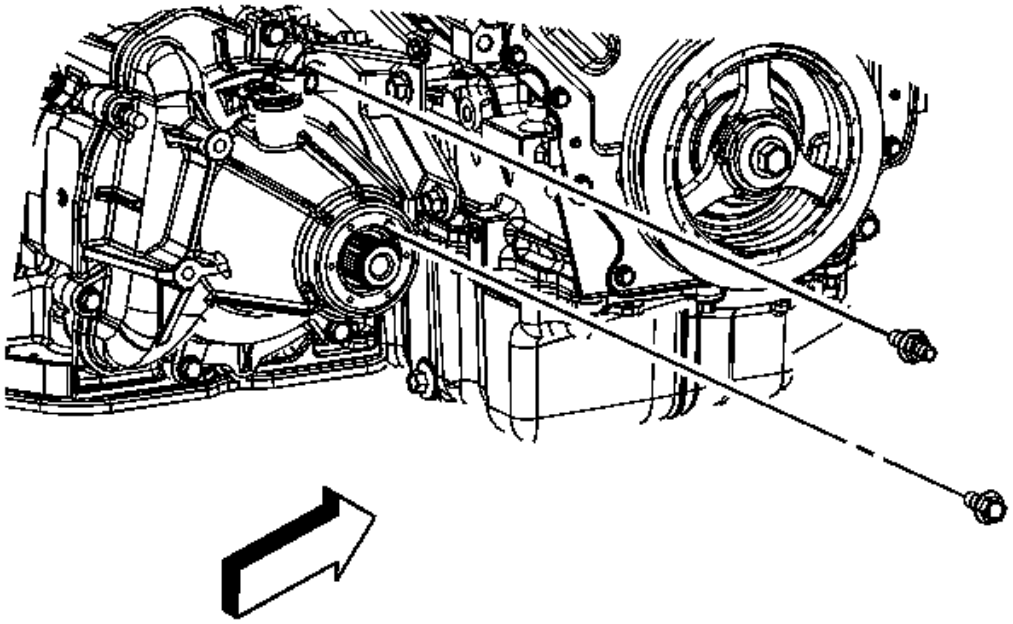

Fig. 108: Transaxle Brace Bolt/Stud To Transaxle
Courtesy of GENERAL MOTORS CORP.

18. Install the transaxle brace bolt/stud to the transaxle.

    Tighten: Tighten the bolt/stud to 50 N.m (37 lb ft).

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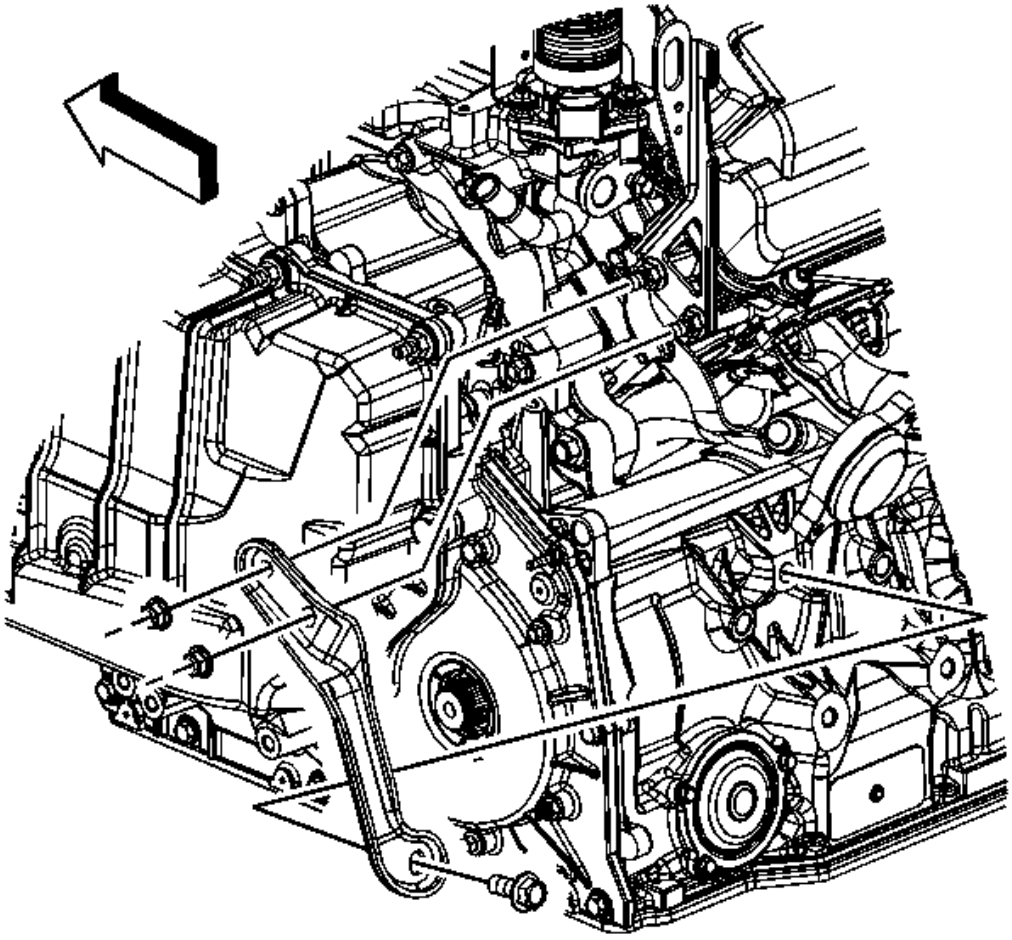

Fig. 109: Transaxle Brace
Courtesy of GENERAL MOTORS CORP.

19. Install the transaxle brace to the lift bracket studs.
20. Install the transaxle brace bolt.

    Tighten: Tighten the bolt to 50 N.m (37 lb ft).

21. Install the transaxle brace nuts.

    Tighten: Tighten the nut to 50 N.m (37 lb ft).

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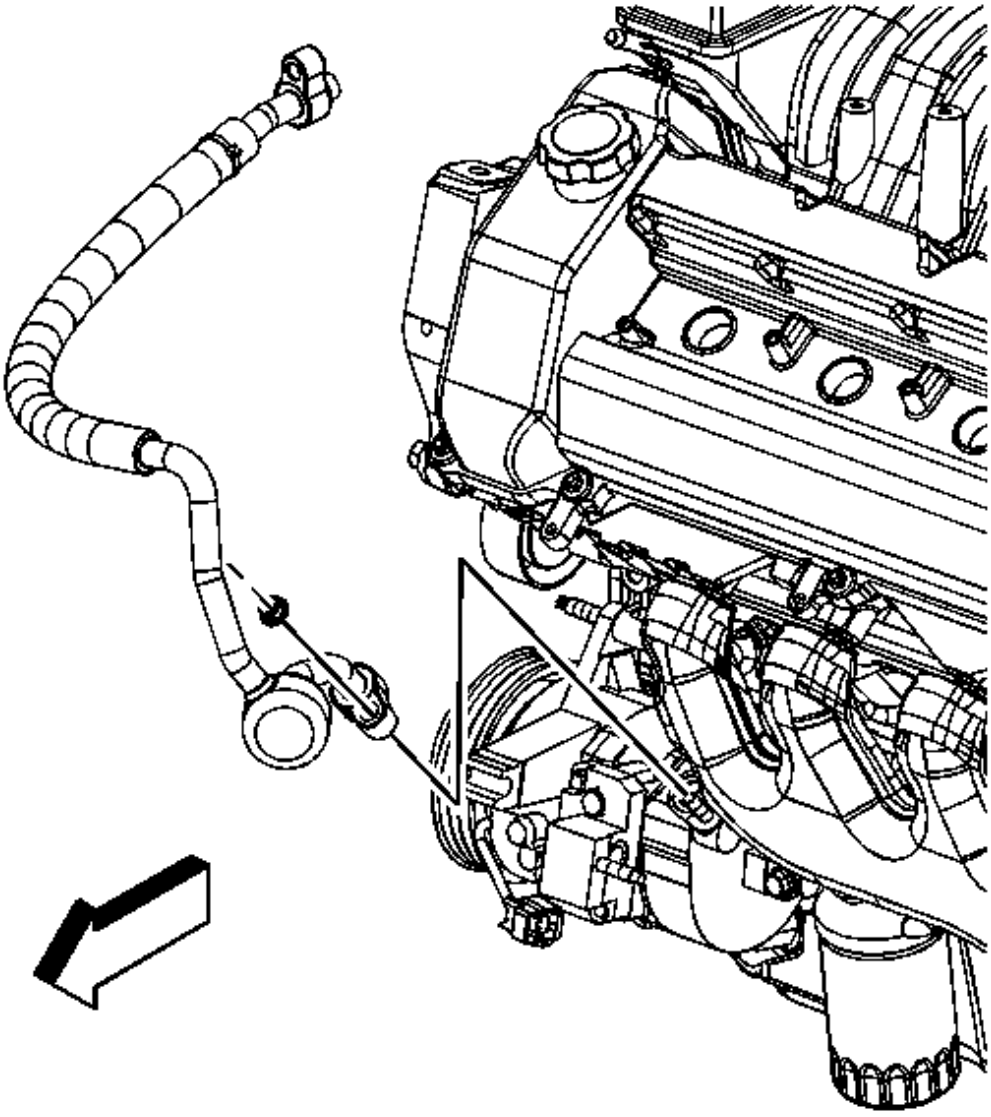

Fig. 110: A/C Compressor Suction Hose
Courtesy of GENERAL MOTORS CORP.

22. Remove the plug from the A/C compressor suction port.
23. Remove and discard the old sealing washer from the compressor end of the suction hose.
24. Install a NEW sealing washer to the compressor end of the suction hose.
25. Install the A/C compressor suction hose the compressor.

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26. Install the A/C compressor suction hose nut at the compressor.

    Tighten: Tighten the nut to 16 N.m (12 lb ft).

27. Secure the suction hose to the engine.

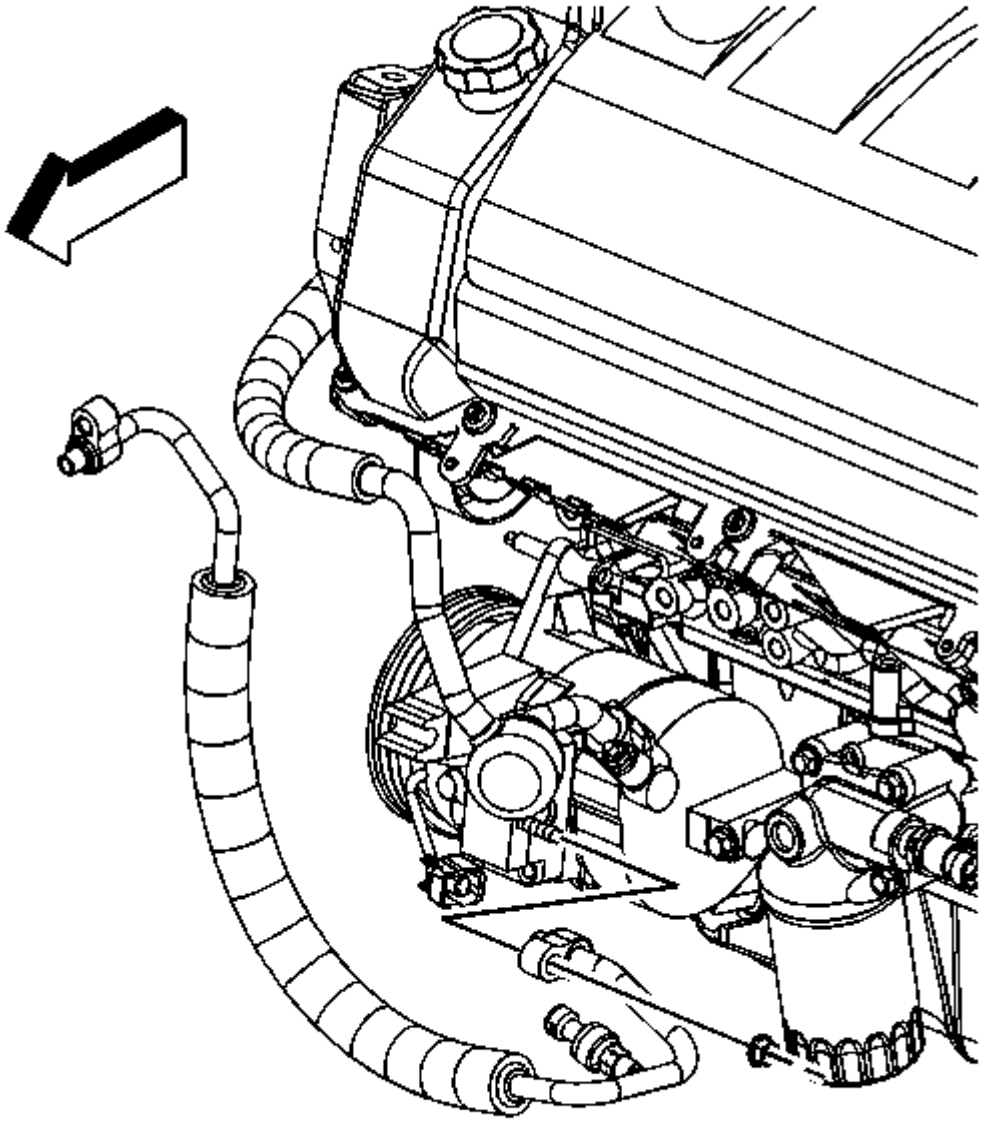

Fig. 111: A/C Compressor Discharge Hose
Courtesy of GENERAL MOTORS CORP.

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28. Remove the plug from the A/C compressor discharge port.
29. Remove and discard the old sealing washer from the compressor end of the discharge hose.
30. Install a NEW sealing washer to the compressor end of the discharge hose.
31. Install the A/C compressor discharge hose the compressor.
32. Install the A/C compressor discharge hose nut at the compressor.

    Tighten: Tighten the nut to 16 N.m (12 lb ft).

33. Secure the discharge hose to the engine.

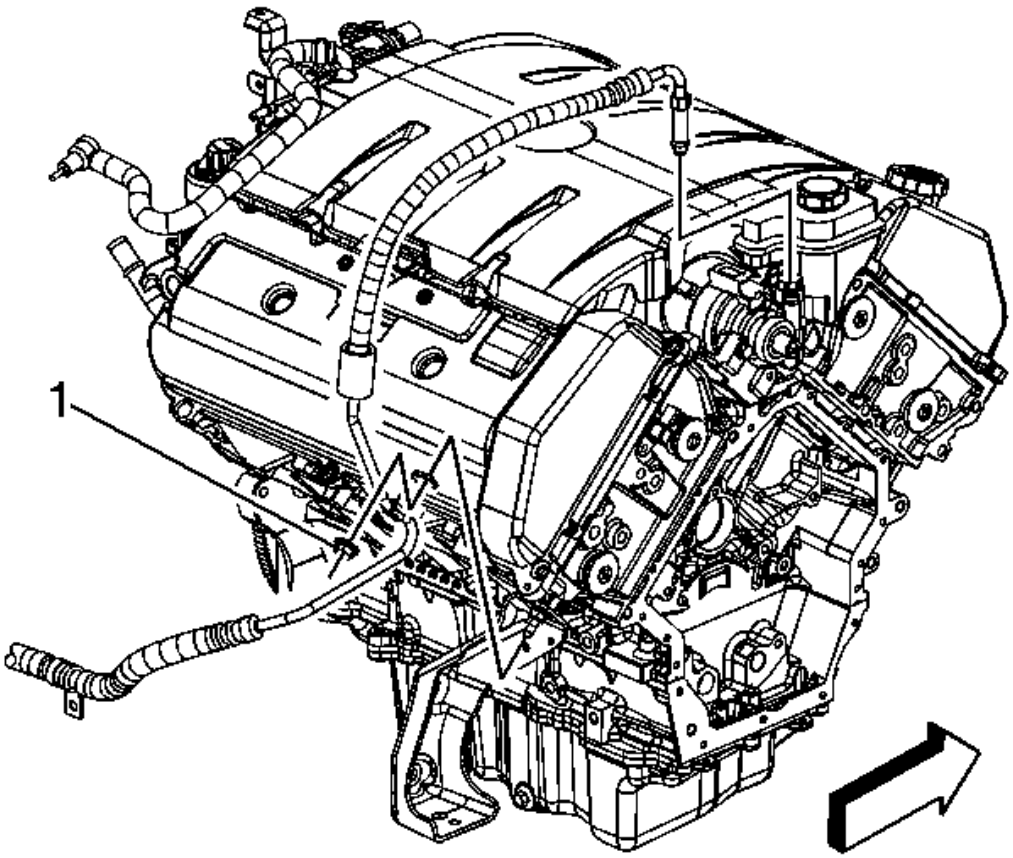

Fig. 112: Power Steering Inlet Pipe
Courtesy of GENERAL MOTORS CORP.

34. Install the power steering inlet pipe fitting to the power steering pump.

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Tighten: Tighten the fitting to 27 N.m (20 lb ft).

35. Install the power steering inlet pipe bracket to the stud.
36. Install the power steering inlet pipe nut (1) to the rear engine mount bracket stud.

    Tighten: Tighten the nut to 9 N.m (80 lb in).

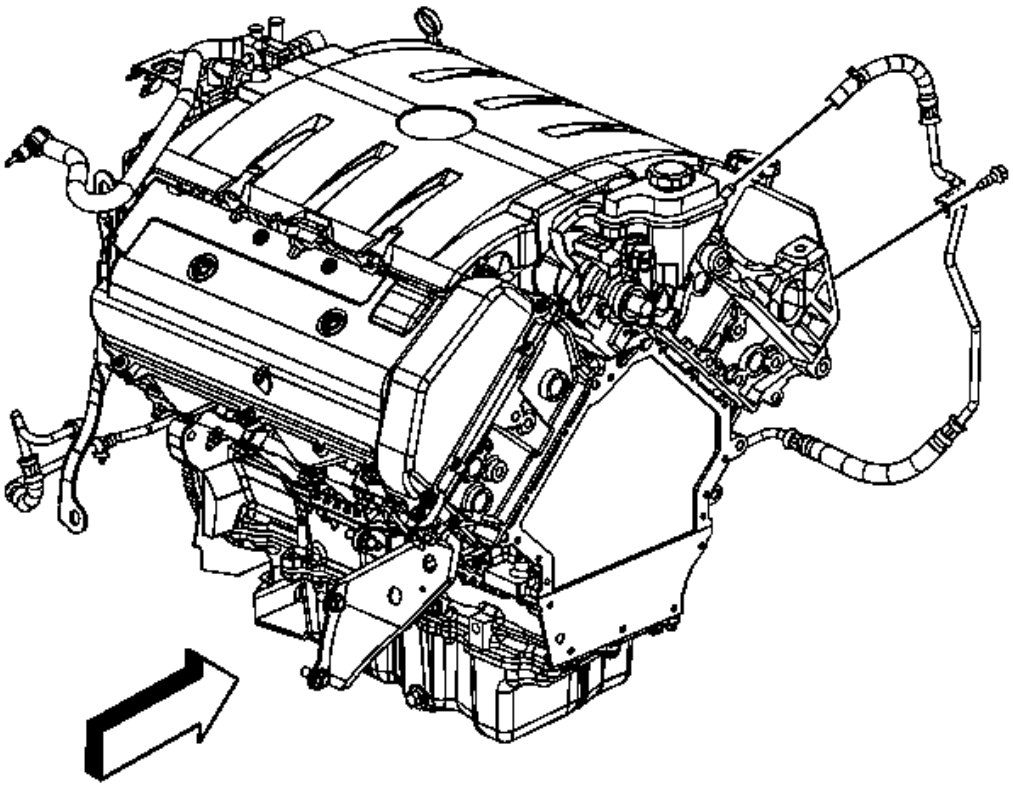

Fig. 113: Power Steering Outlet Hose
Courtesy of GENERAL MOTORS CORP.

37. Install the power steering outlet hose to the reservoir.
38. Position the power steering outlet hose clamp at the pump reservoir.
39. Install the power steering outlet pipe bolt to the engine mount strut bracket.

    Tighten: Tighten the bolt to 9 N.m (80 lb in).

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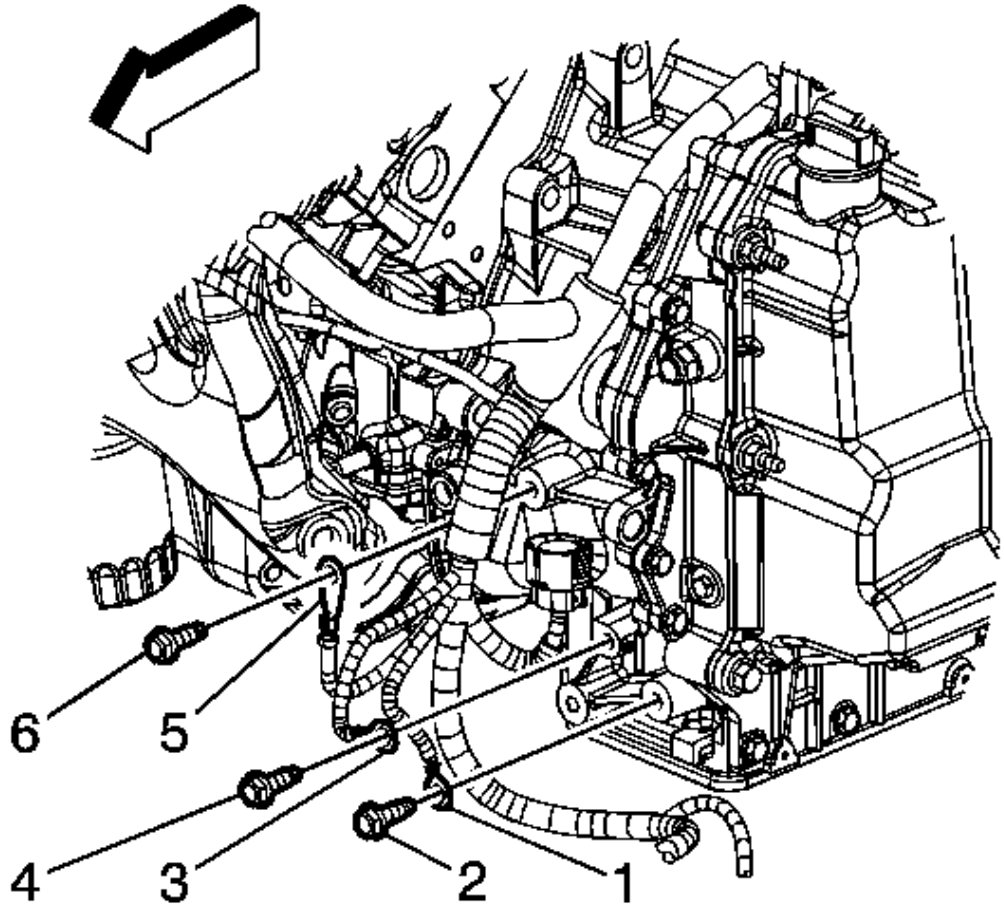

Fig. 114: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

40. Install the engine harness to the engine.
41. Position the engine harness grounds (1, 3, and 5) to the engine block.
42. Install the engine harness ground bolts (2, 4, and 6).

    Tighten: Tighten the bolts to 25 N.m (18 lb ft).

43. Connect the engine harness electrical connector to the transaxle.

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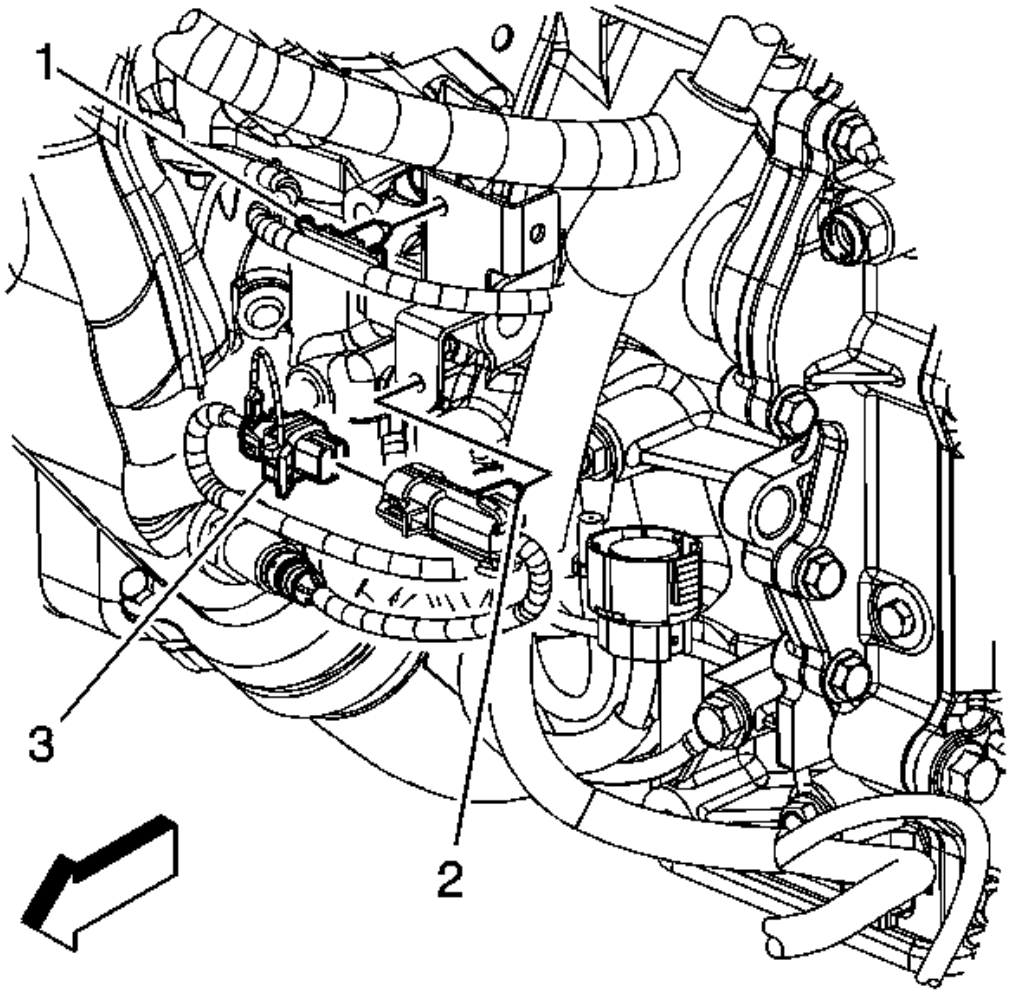

Fig. 115: Engine Harness Electrical Connector & Clips
Courtesy of GENERAL MOTORS CORP.

44. Connect the engine harness electrical connector (3) to the HO2S.
45. Install the CPA retainer.
46. Install the engine harness clip (1) to the engine bracket.

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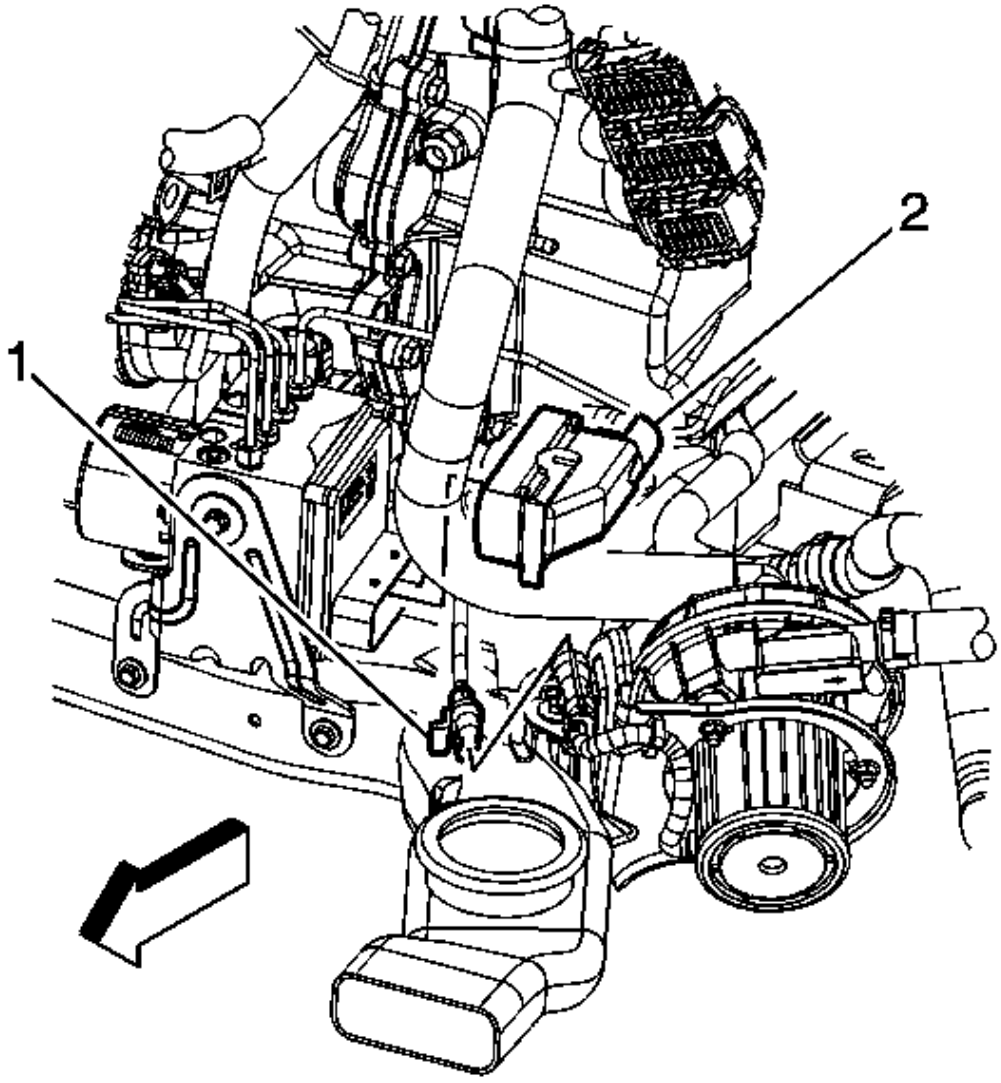

Fig. 116: Engine Harness Electrical Connectors At AIR Pump & Brake Modulator
Courtesy of GENERAL MOTORS CORP.

47. Connect the engine harness electrical connectors to the following:
    - The AIR pump (1)
    - The brake modulator (2)

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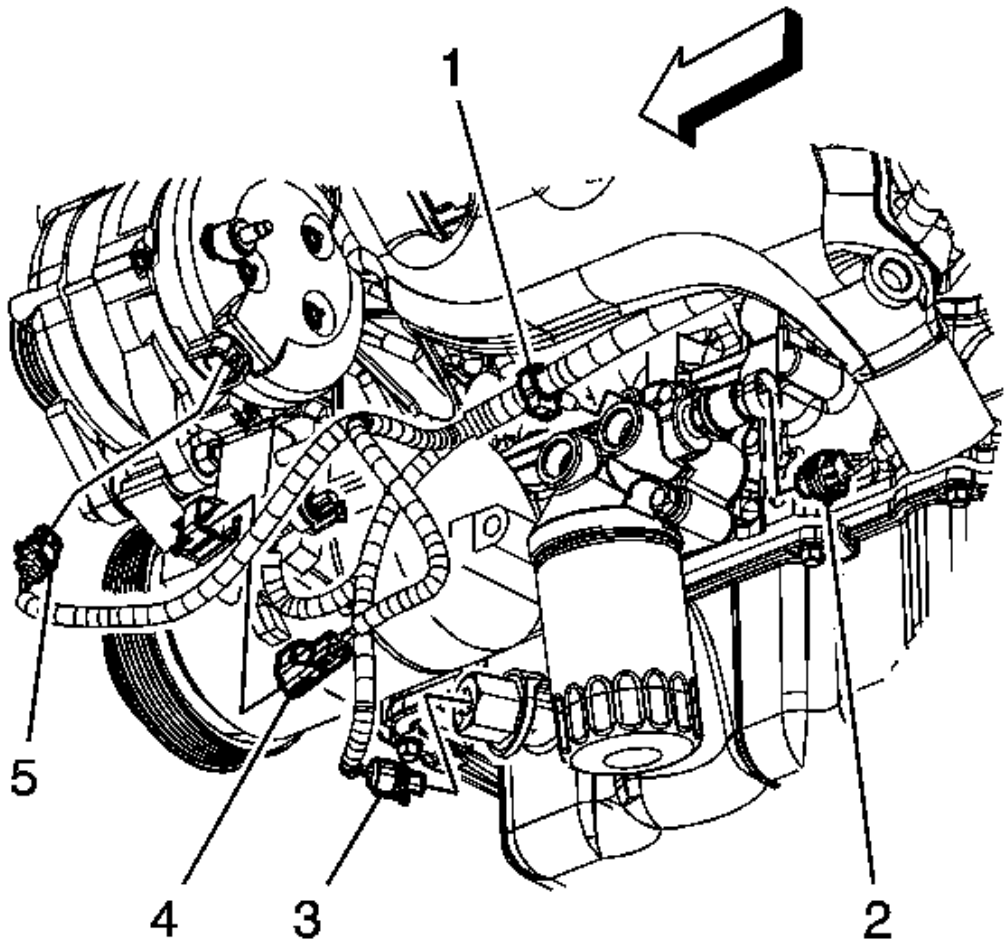

Fig. 117: Disconnecting/Connecting Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

48. Install the engine harness clip (1) to the boss on the engine block.
49. Connect the following engine harness electrical connectors:
    - The oil pressure sensor (2)
    - The oil level sensor (3)
    - The A/C compressor (4)
    - The generator (5)

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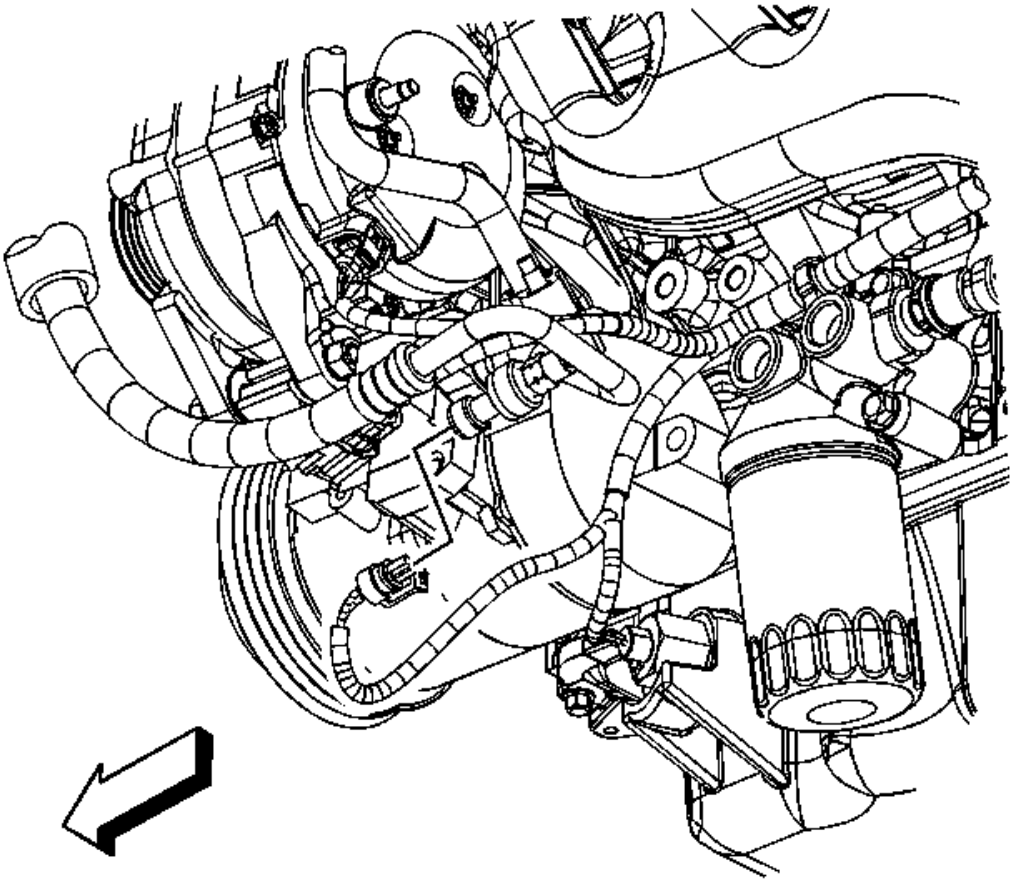

Fig. 118: Engine Harness A/C Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

50. Connect the engine harness electrical connector to the A/C pressure sensor.

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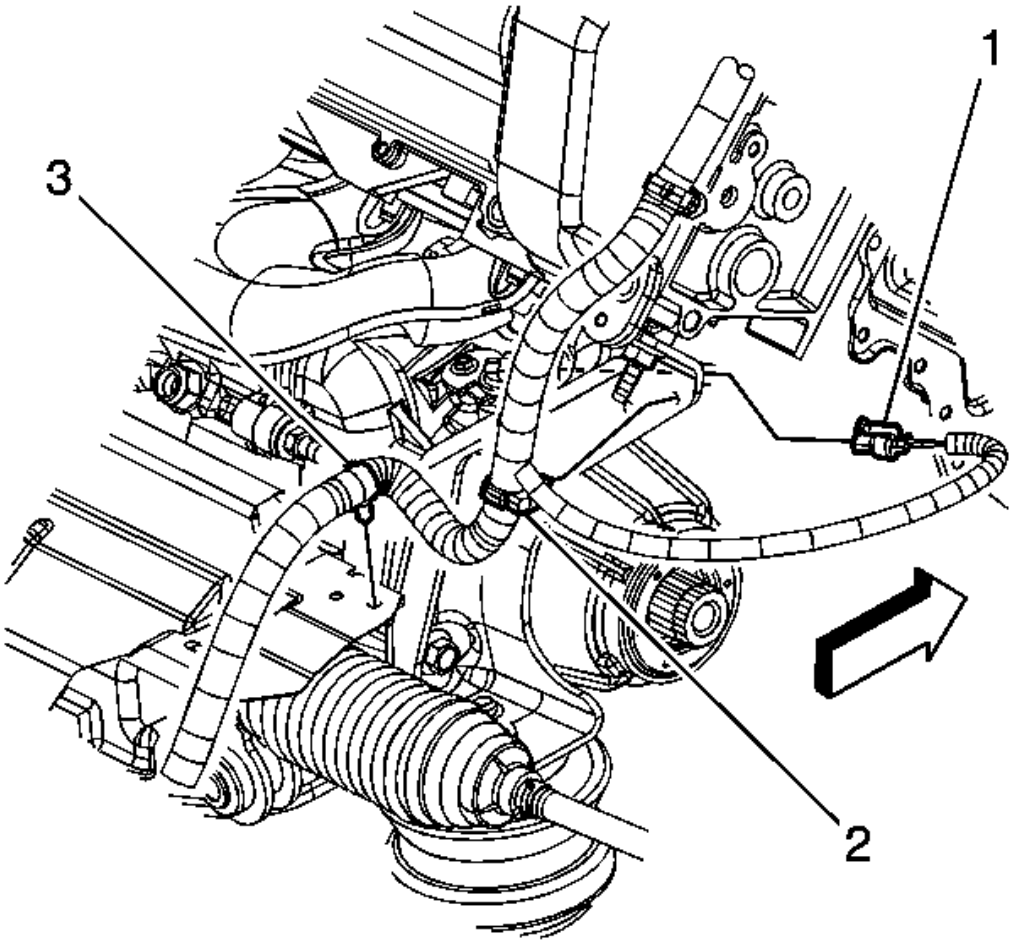

Fig. 119: Disconnecting/Connecting Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

51. Connect the engine harness electrical connector (1) to the VSS.
52. Install the engine harness clips (2, 3) to the rear engine mount bracket and steering gear shield.

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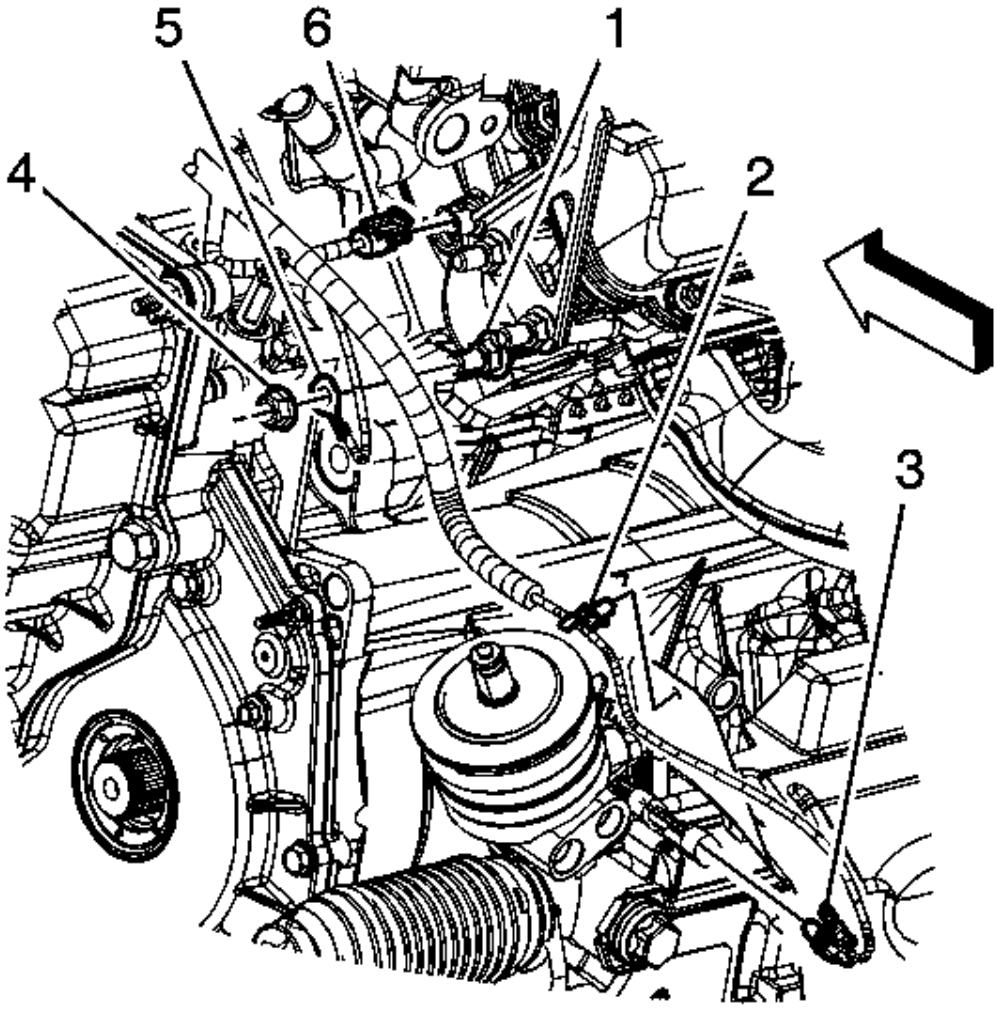

Fig. 120: Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

53. Connect the engine harness electrical connector (6) to the ECT sensor.
54. Install the engine harness ground (5) to the stud.
55. Install the engine harness ground nut (4).

    Tighten: Tighten the bolt to 25 N.m (18 lb ft).

56. Install the engine harness clip (2) to the steering gear shield.
57. Connect the engine harness electrical connector (3) to the power steering sensor.

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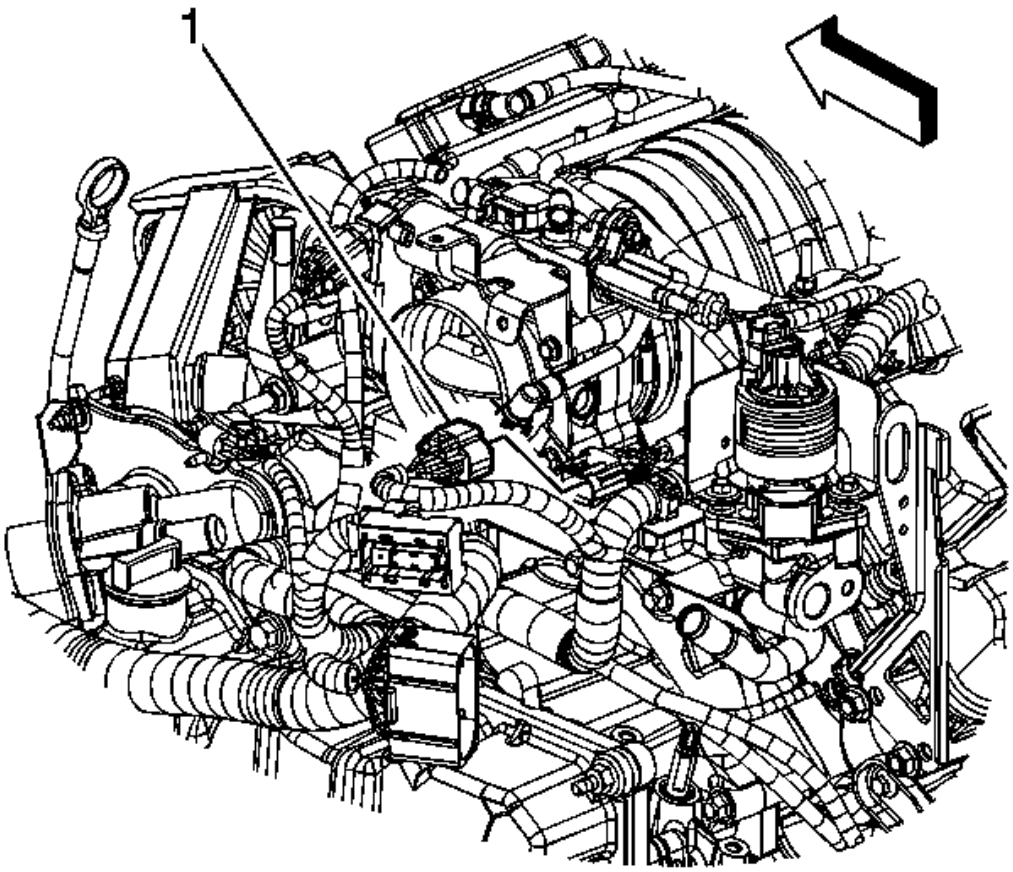

Fig. 121: Engine Valley Jumper Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

58. Connect the engine harness electrical connector (1) to the engine valley jumper harness electrical connector.

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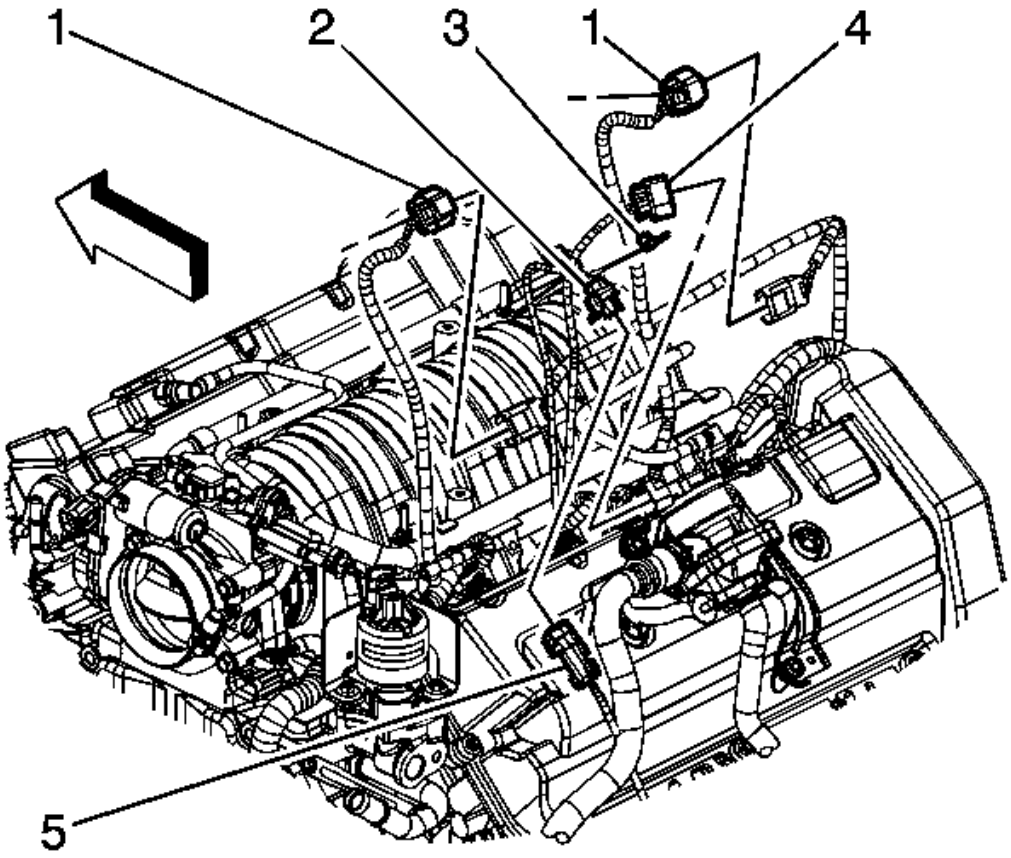

Fig. 122: Top Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

59. Connect the following engine harness electrical connectors to the top of the engine:
    - The starter inline (1)
    - The AIR check valve (4)

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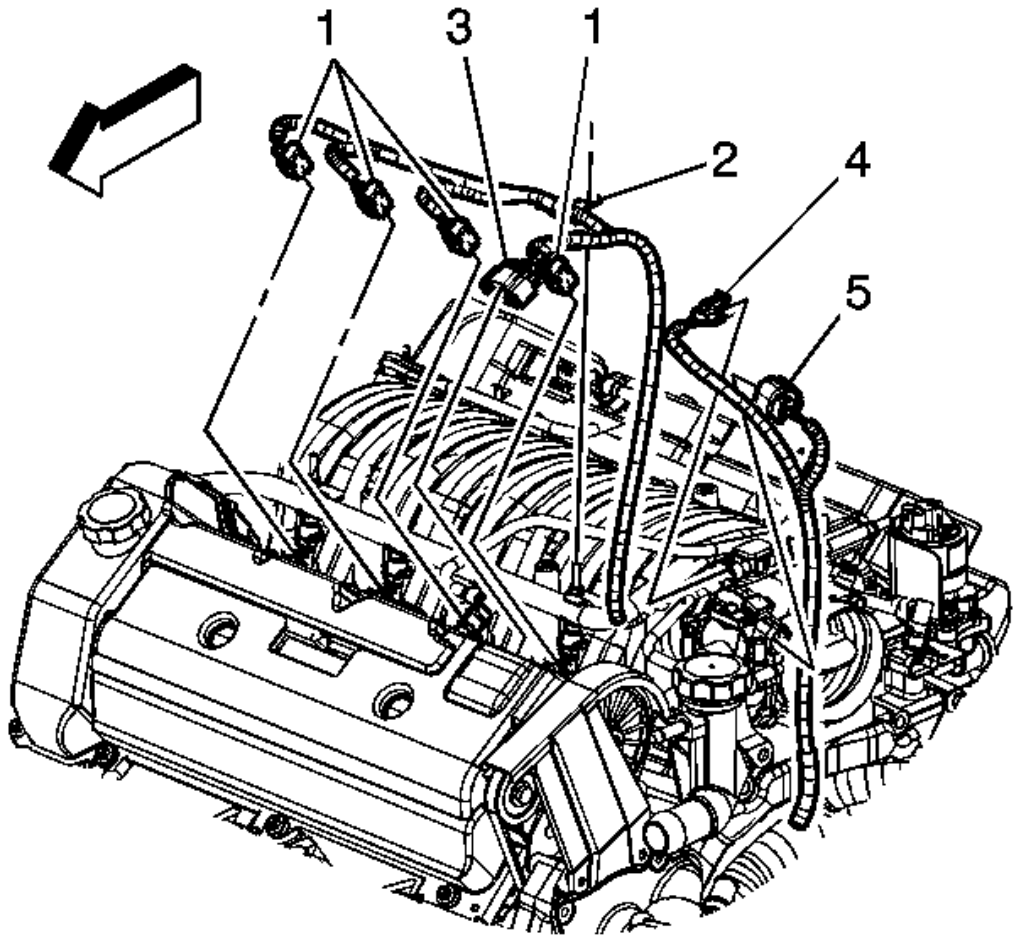

Fig. 123: Front Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

60. Connect the following engine harness electrical connectors to the front of the engine:
    - The fuel injectors (1)
    - The ICM (3)
    - The MAP sensor (4)
    - the throttle actuator (5)
61. Install the engine harness clip (2) to the fuel rail stud.

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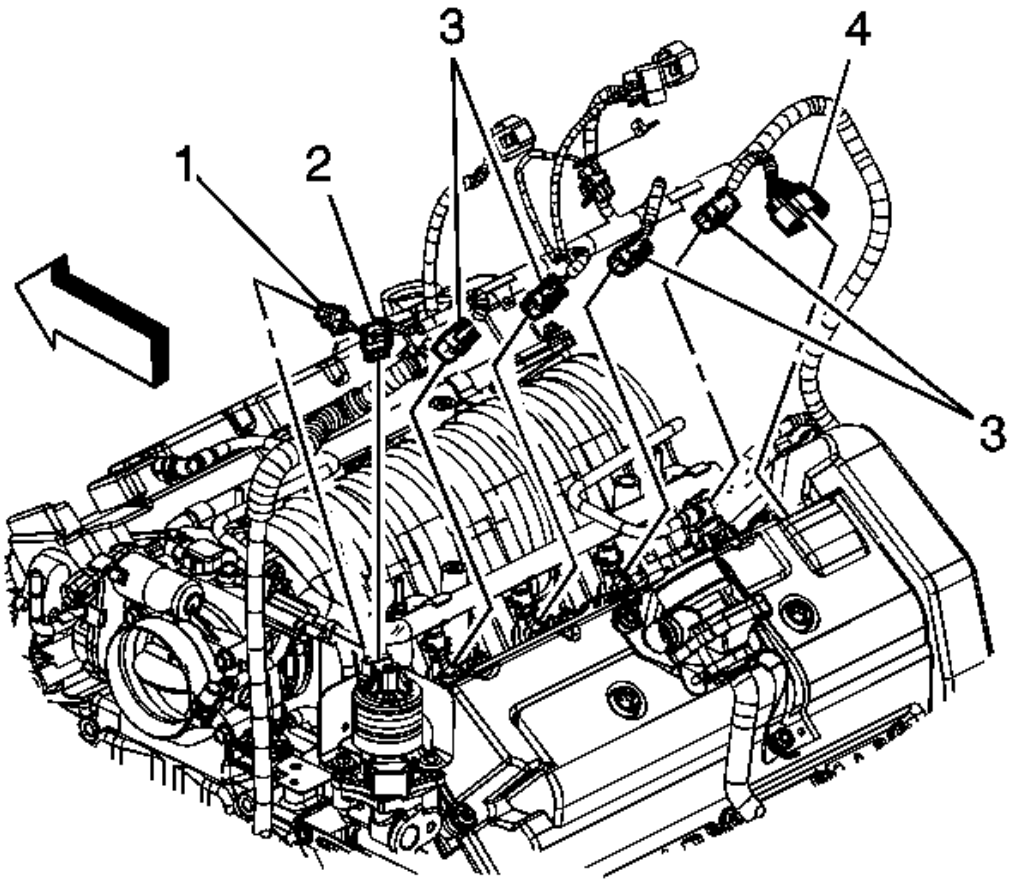

Fig. 124: Rear Of Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

62. Connect the following engine harness electrical connectors to the rear of the engine:
    - The EVAP solenoid (1)
    - The EGR valve (2)
    - The fuel injectors (3)
    - The ICM (4)

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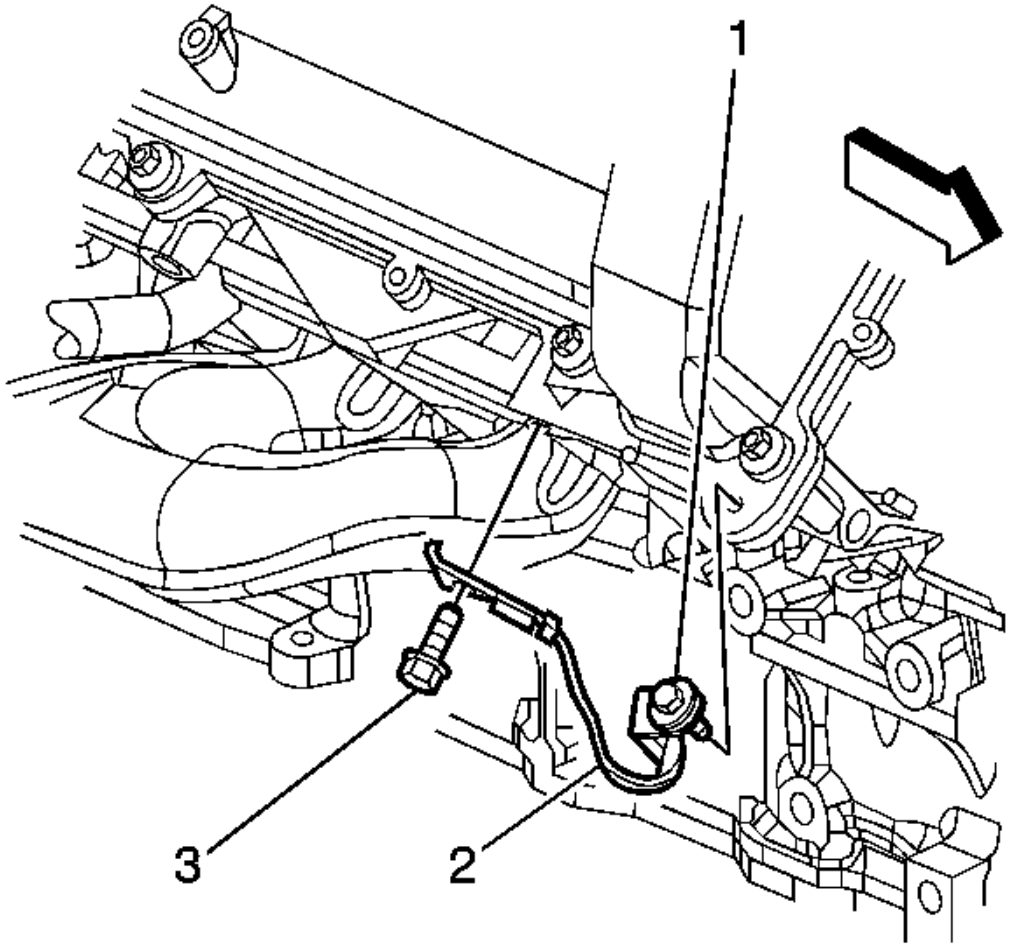

Fig. 125: ICM Ground Strap & Bolt
Courtesy of GENERAL MOTORS CORP.

63. Position the ICM ground strap (2) to the cylinder head.
64. Install the ICM ground strap bolt (3) to the right cylinder head.

Tighten: Tighten the bolt to 25 N.m (18 lb ft).

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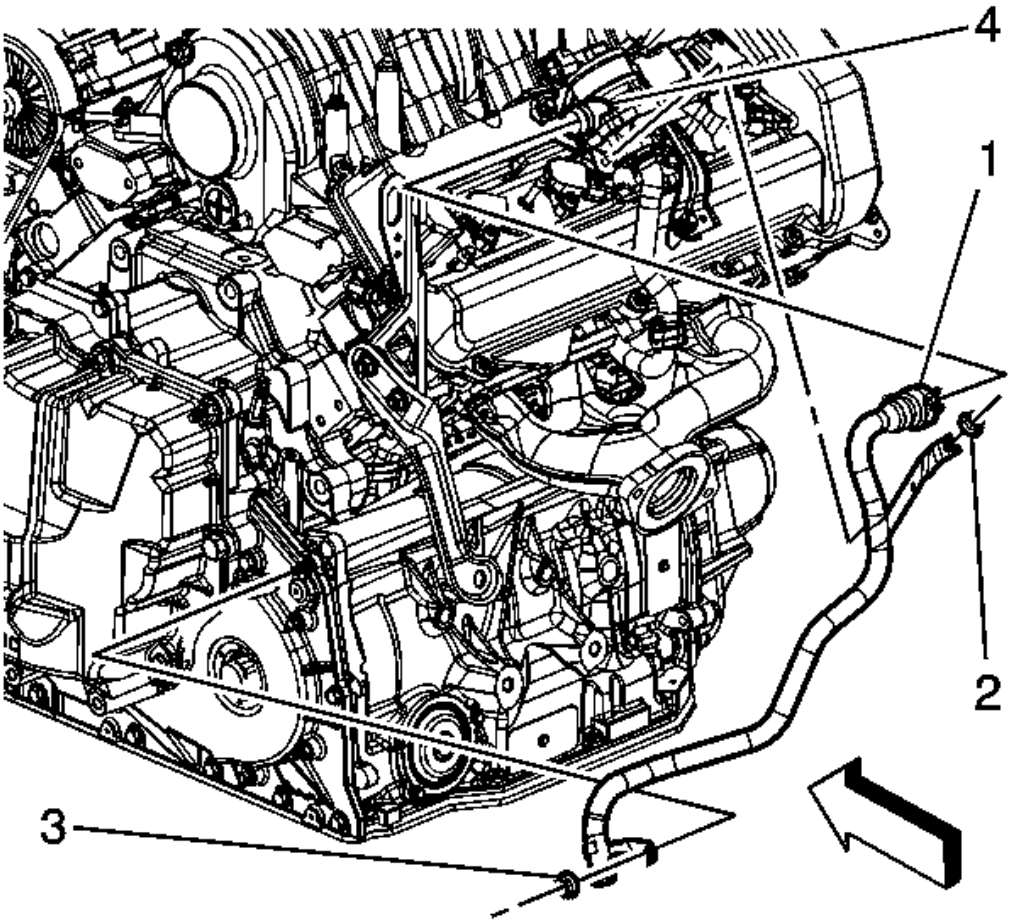

Fig. 126: AIR Pipe Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

65. Install the AIR pipe over the studs.
66. Connect the AIR outlet pipe quick connect fitting to the check valve. Refer to **Plastic Collar Quick Connect Fitting Service** .
67. Install the AIR pipe outlet pipe nut (2) to the check valve bracket stud.

    Tighten: Tighten the nut to 9 N.m (80 lb in).

68. Install the AIR pipe outlet pipe nut (3) to the transaxle stud.

    Tighten: Tighten the nut to 9 N.m (80 lb in).

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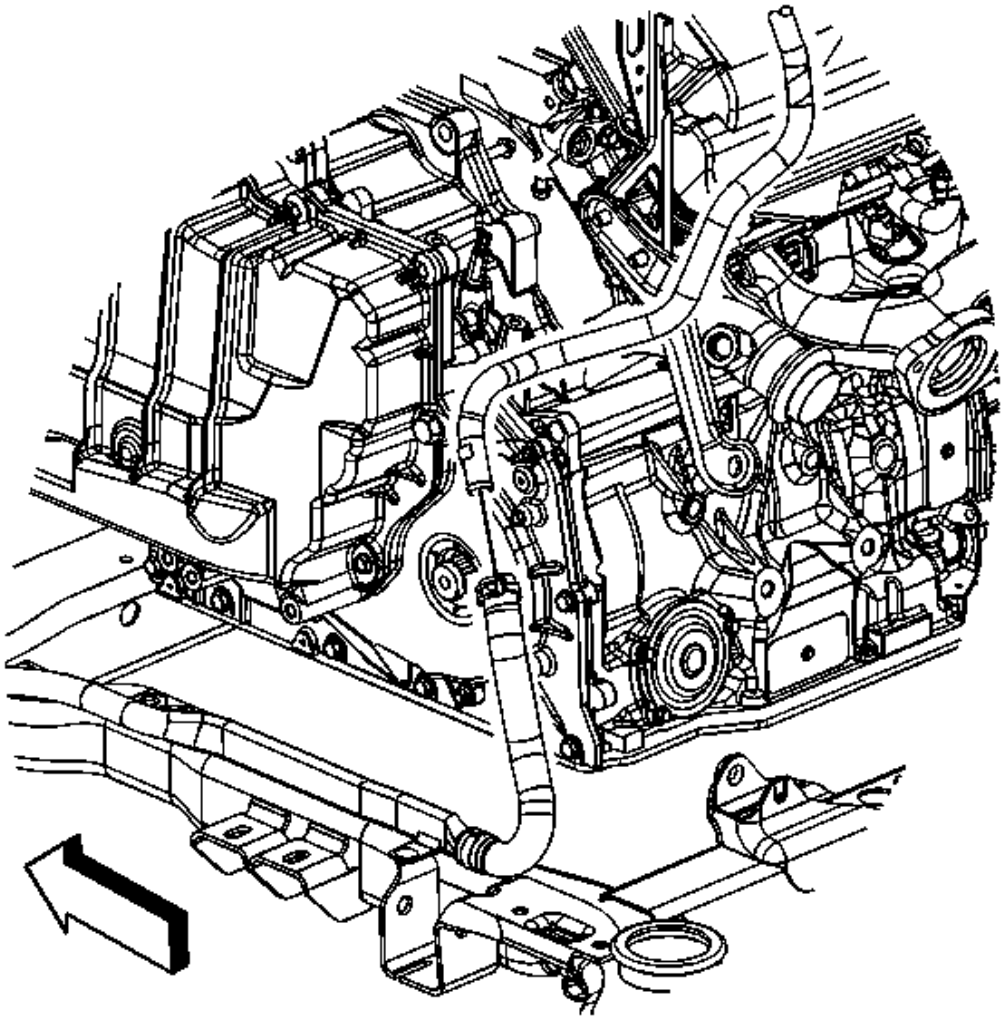

Fig. 127: AIR Outlet Hose
Courtesy of GENERAL MOTORS CORP.

69. Connect the AIR outlet hose to the AIR outlet pipe.
70. Position the AIR outlet hose clamp at the AIR outlet pipe.

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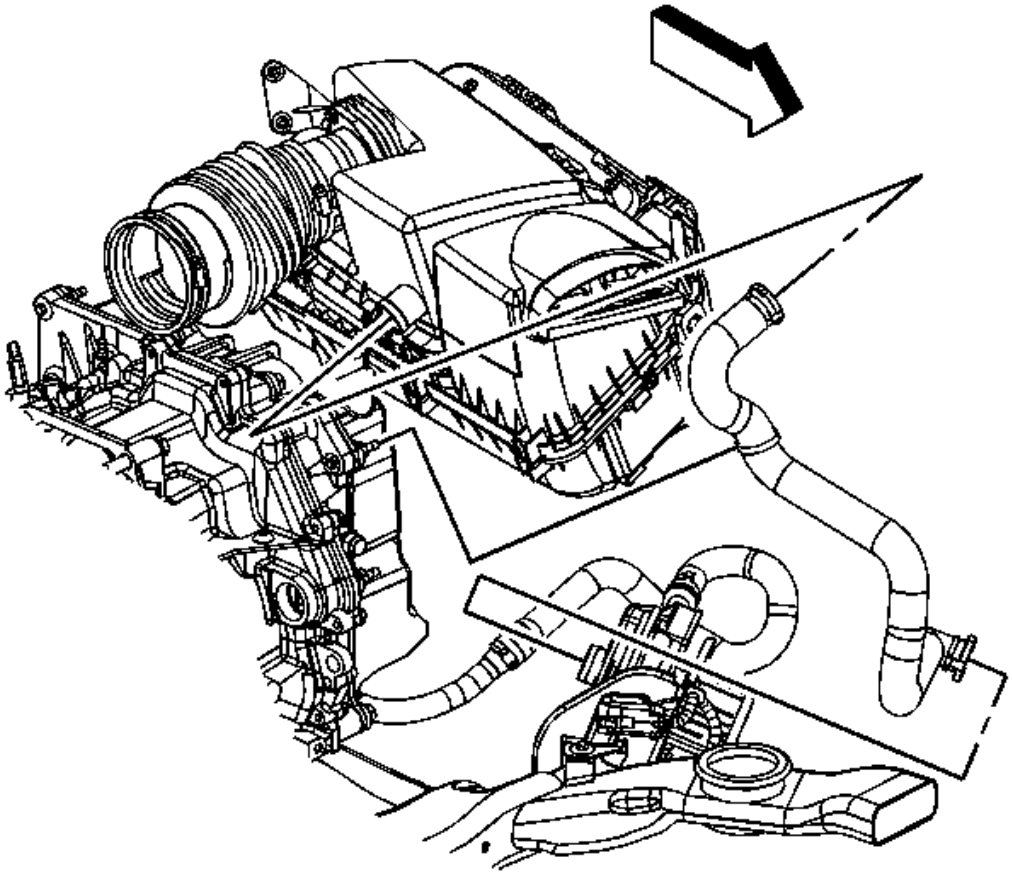

Fig. 128: Secondary AIR Pump Inlet Tube/Hose
Courtesy of GENERAL MOTORS CORP.

71. Install the AIR inlet hose.
72. Connect the AIR inlet hose quick connect fitting to the AIR pump. Refer to **Plastic Collar Quick Connect Fitting Service** .
73. Install the AIR inlet hose retainer to the transaxle stud.

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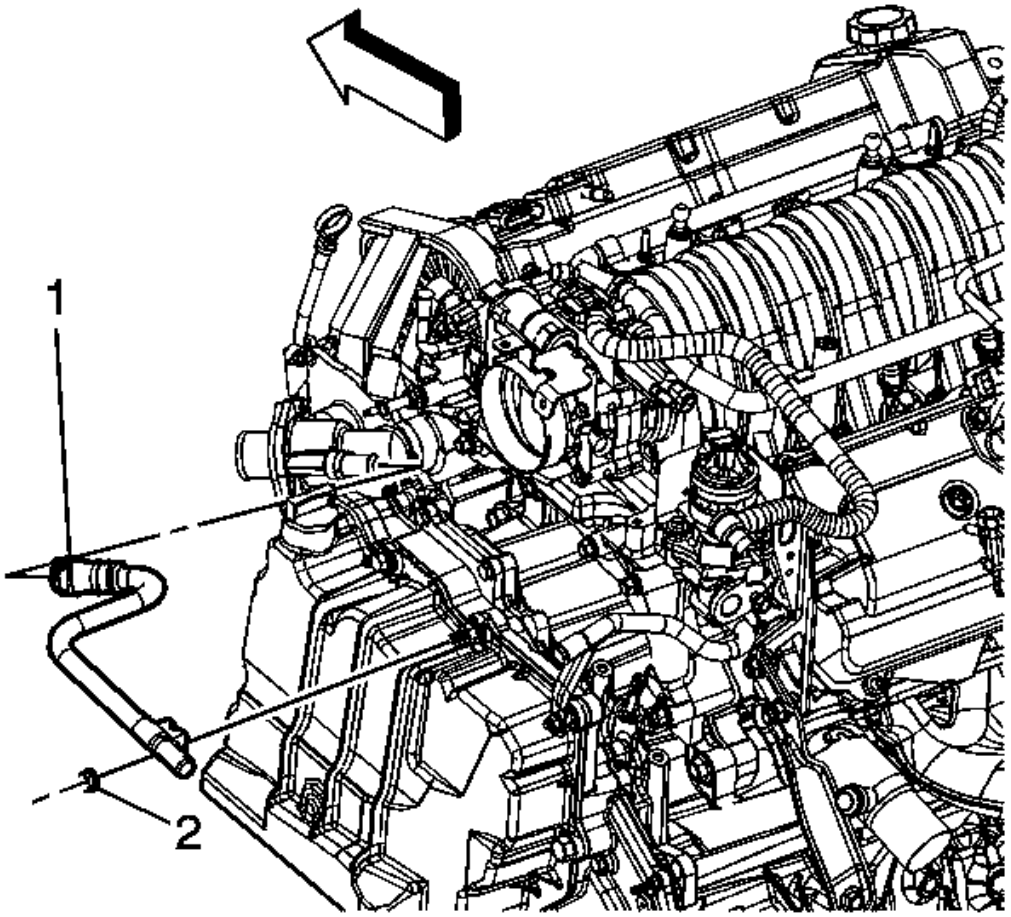

Fig. 129: Heater Outlet Pipe
Courtesy of GENERAL MOTORS CORP.

74. Install the heater outlet pipe to the engine and stud.
75. Install the heater outlet pipe nut (2) to the transaxle stud.

    Tighten: Tighten the nut to 25 N.m (18 lb ft).

76. Position the heater outlet pipe clamp (1) at the water pump housing.

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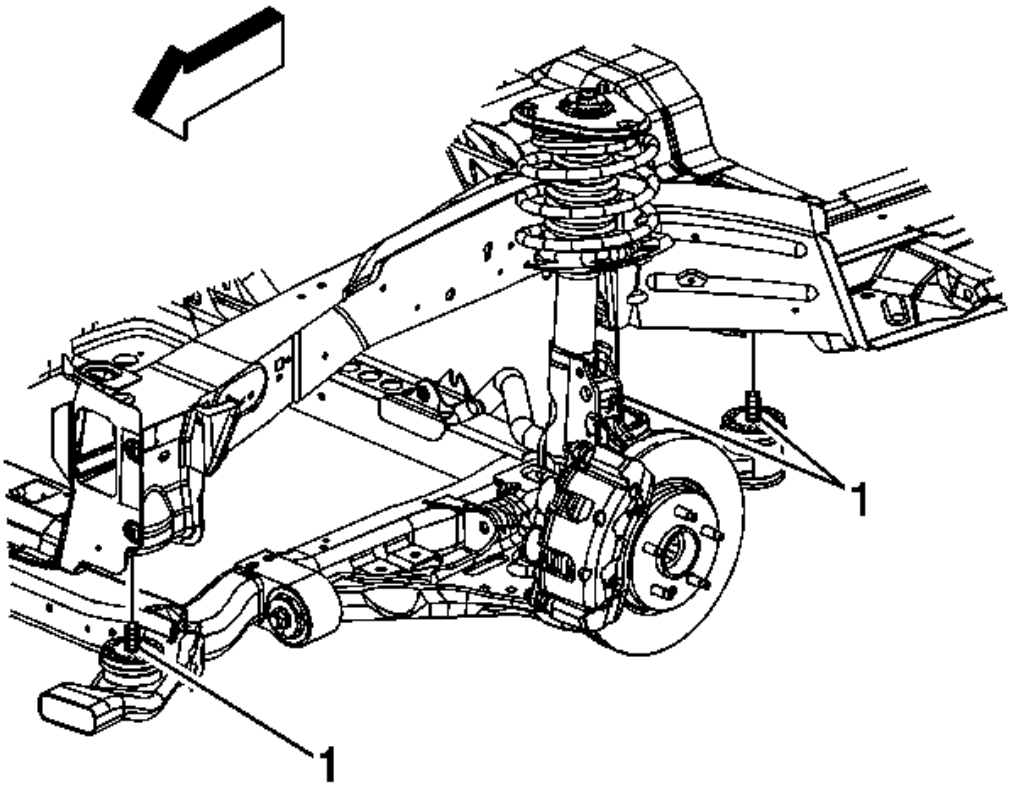

Fig. 130: Frame To Body Bolts
Courtesy of GENERAL MOTORS CORP.

77. Position the engine/transaxle assembly under the vehicle.

NOTE: Ensure clearance is maintained between the engine/transaxle assembly and the following:

- **The A/C compressor components**
- **The brake pipes**
- **The heater hoses**
- **The radiator hoses**
- **The wheel speed sensor leads**
- **The wiring harnesses**

78. Carefully lower the vehicle over the engine/transaxle assembly, aligning the struts to the strut towers.
79. Install the 6 bolts (1) attaching the frame to the body. (Left side shown, right side similar).

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Tighten: Tighten the bolts to 191 N.m (141 lb ft).

80. Install the front fascia. Refer to **Front Bumper Fascia Replacement** .

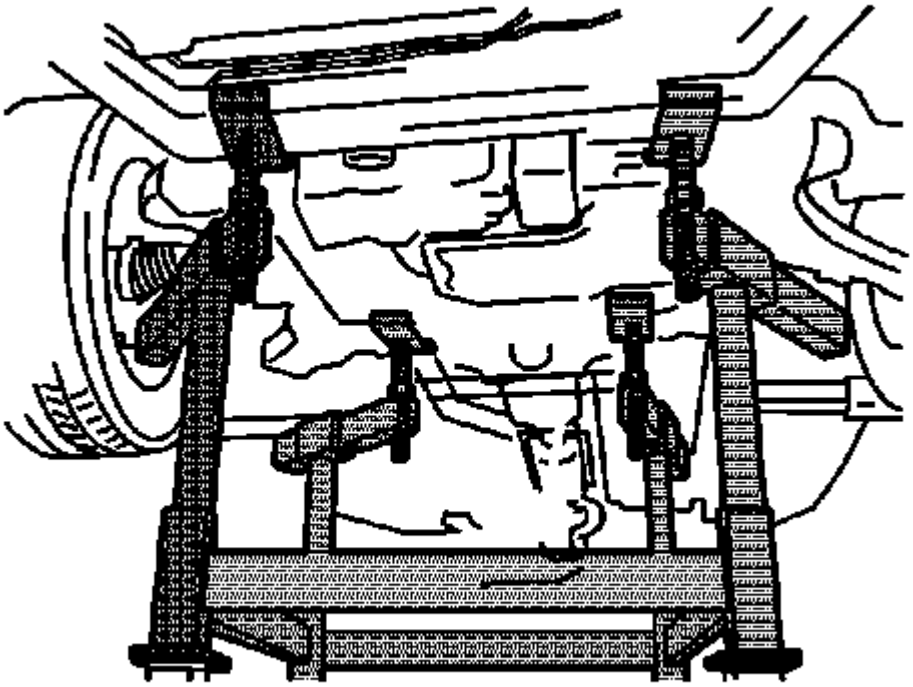

Fig. 131: Utility Stand
Courtesy of GENERAL MOTORS CORP.

81. Raise the vehicle off of the **J 39580** or the jack stands. See **Special Tools** .
82. Remove the **J 39580** or jack stands from under the frame. See **Special Tools** .

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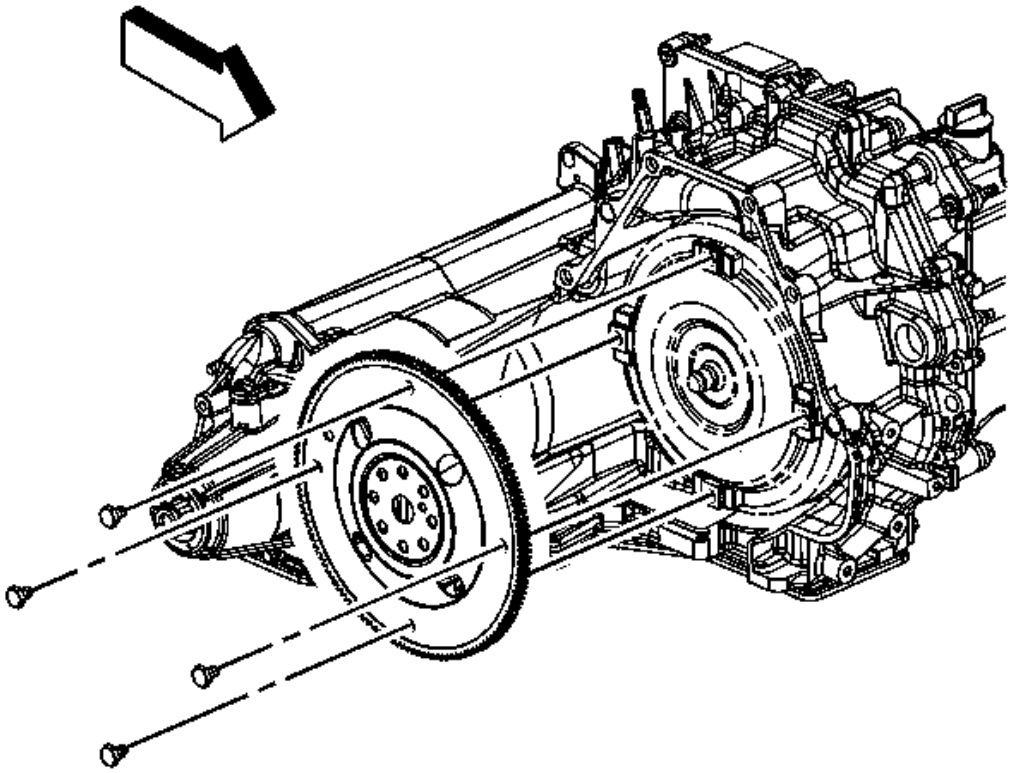

Fig. 132: Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

83. Align the flywheel with the marks made during the removal.
84. Install the flywheel to torque converter bolts. (Engine removed for clarity).

Tighten: Tighten the bolts to 60 N.m (44 lb ft).

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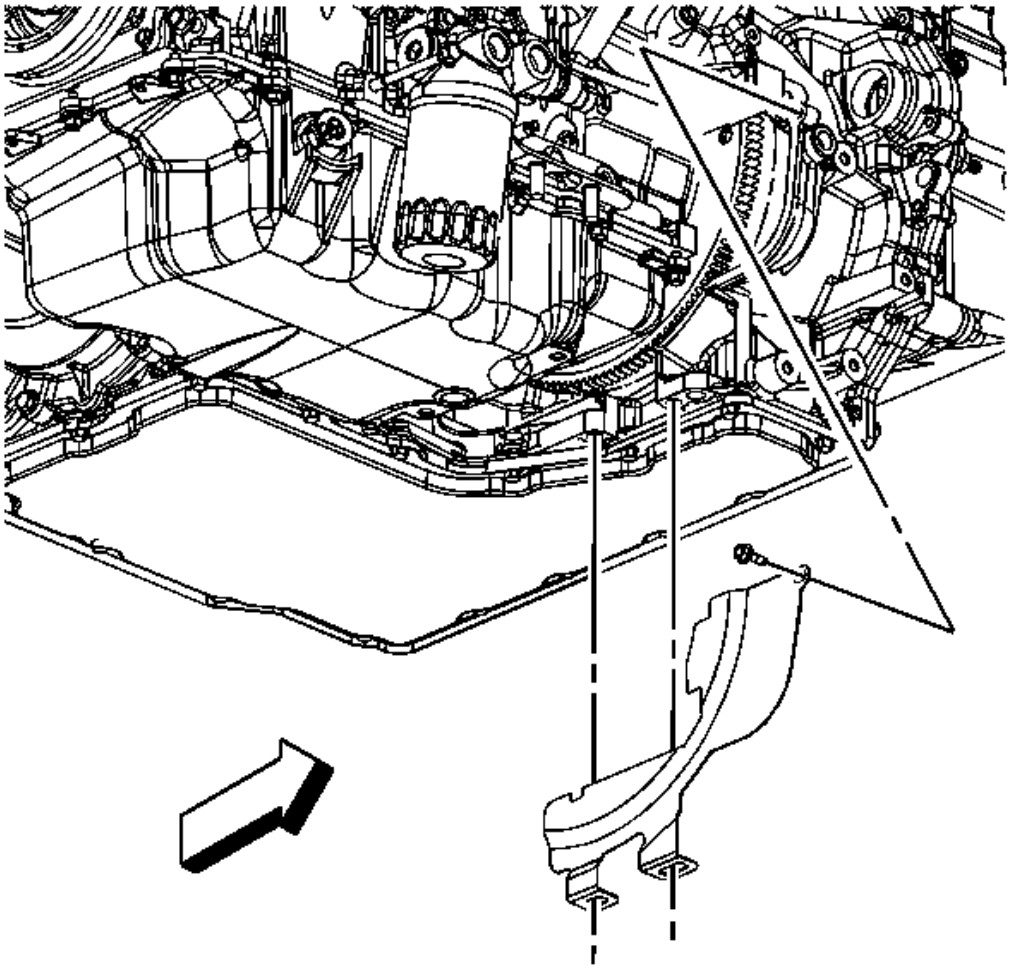

Fig. 133: Torque Converter Cover
Courtesy of GENERAL MOTORS CORP.

85. Position the torque converter cover.
86. Install the torque converter cover bolt.

Tighten: Tighten the bolt to 12 N.m (106 lb in).

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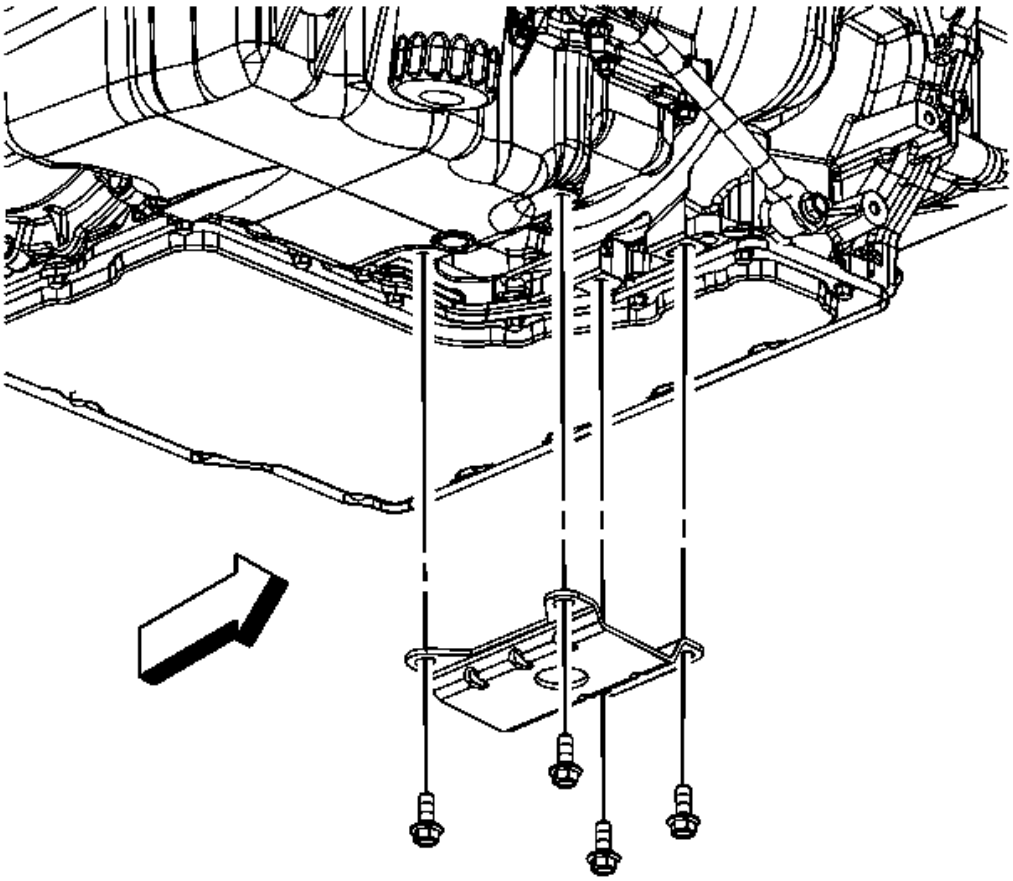

Fig. 134: Transaxle Brace Bolts
Courtesy of GENERAL MOTORS CORP.

87. Install the transaxle brace.
88. Install the transaxle brace bolts.

Tighten: Tighten the bolts to 47 N.m (35 lb ft).

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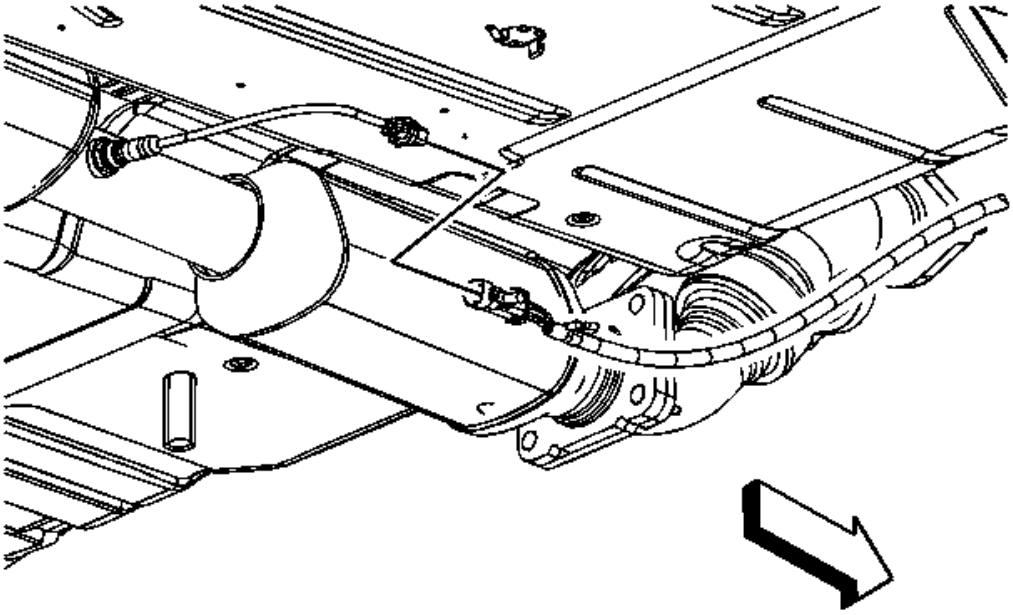

Fig. 135: Oxygen Sensor Wiring Harness & Heat Shield
Courtesy of GENERAL MOTORS CORP.

89. Connect the engine harness electrical connector to the HO2S.
90. Install the oxygen sensor wiring harness heat shield. Refer to **Oxygen Sensor Wiring Harness Heat Shield Replacement** .

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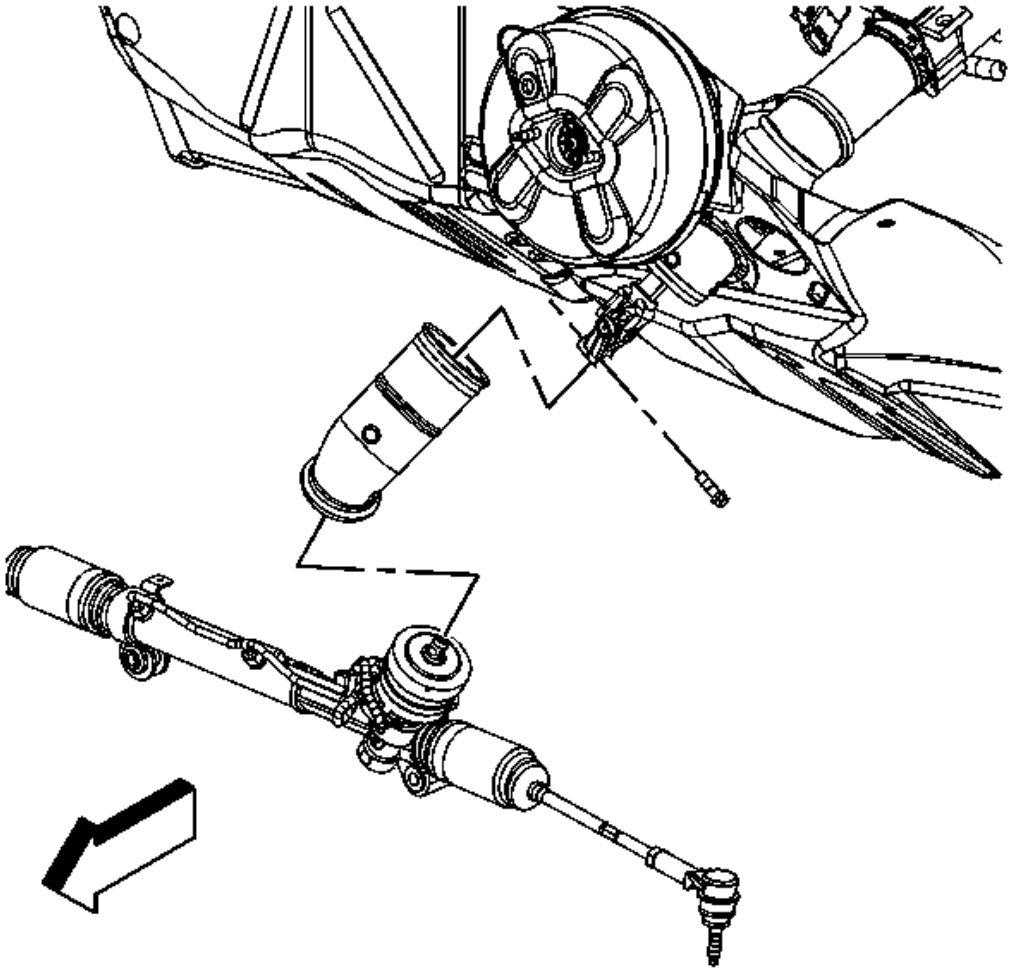

Fig. 136: Intermediate Steering Shaft Components
Courtesy of GENERAL MOTORS CORP.

WARNING: When installing the intermediate shaft make sure that the shaft is seated prior to pinch bolt installation. If the pinch bolt is inserted into the coupling before shaft installation, the two mating shafts may disengage. Disengagement of the two mating shafts will cause loss of steering control which could result in personal injury.

91. Install the intermediate shaft to the steering gear.
92. Install the intermediate shaft pinch bolt.

Tighten: Tighten the bolt to 45 N.m (33 lb ft).

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93. Install the intermediate steering shaft cover.

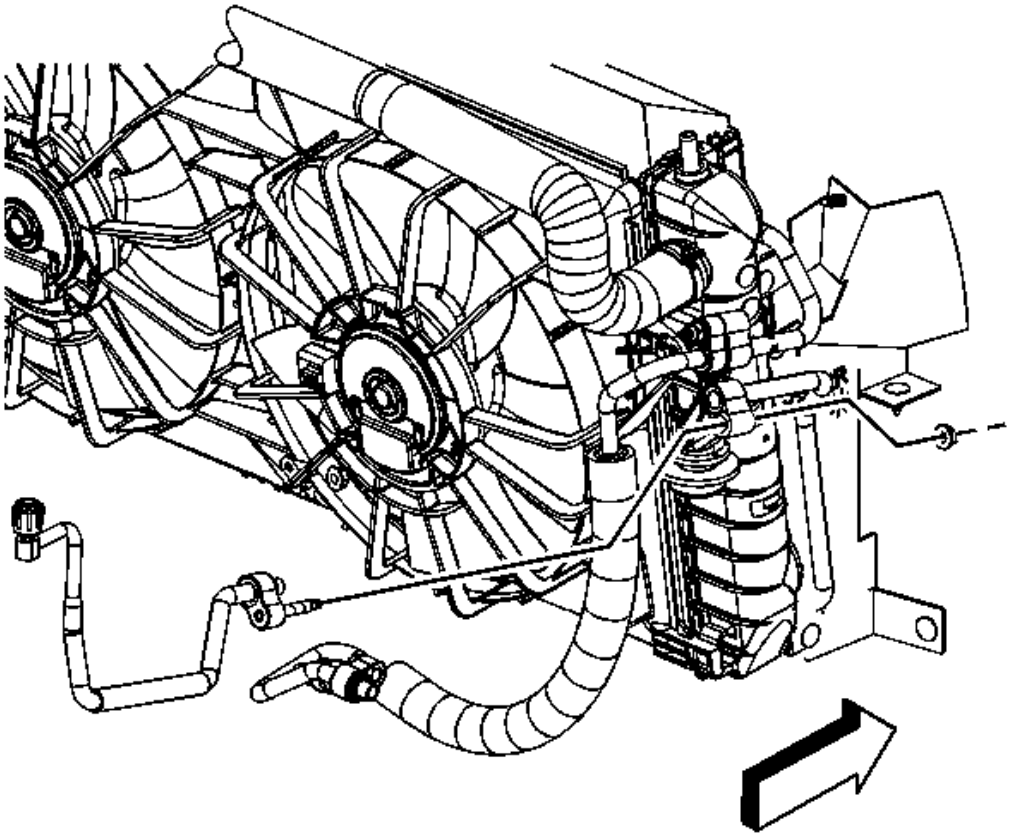

Fig. 137: A/C Suction Hose & Condenser
Courtesy of GENERAL MOTORS CORP.

94. Remove the plug from the A/C condenser suction port.
95. Unsecure the A/C compressor suction hose from the engine.
96. Remove and discard the old sealing washer from the condenser end of the suction hose.
97. Install a NEW sealing washer to the condenser end of the suction hose.
98. Install the A/C compressor suction hose to the condenser.
99. Install the A/C compressor suction hose nut.

Tighten: Tighten the nut to 16 N.m (12 lb ft).

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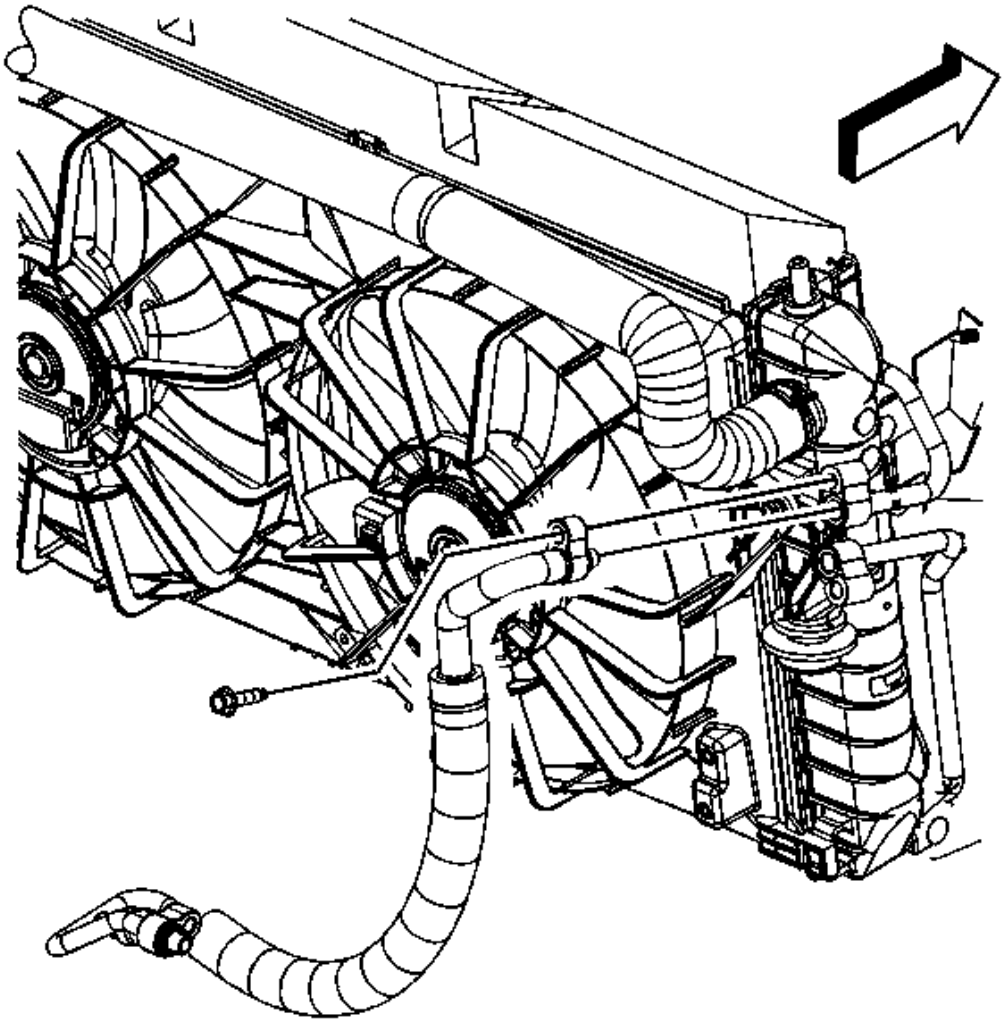

Fig. 138: A/C Discharge Hose & Condenser
Courtesy of GENERAL MOTORS CORP.

100. Remove the plug from the A/C condenser discharge port.
101. Unsecure the A/C compressor discharge hose from the engine.
102. Remove and discard the old sealing washer from the condenser end of the discharge hose.
103. Install a NEW sealing washer to the condenser end of the discharge hose.
104. Install the A/C compressor discharge hose to the condenser.
105. Install the A/C compressor discharge hose nut.

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Tighten: Tighten the nut to 16 N.m (12 lb ft).

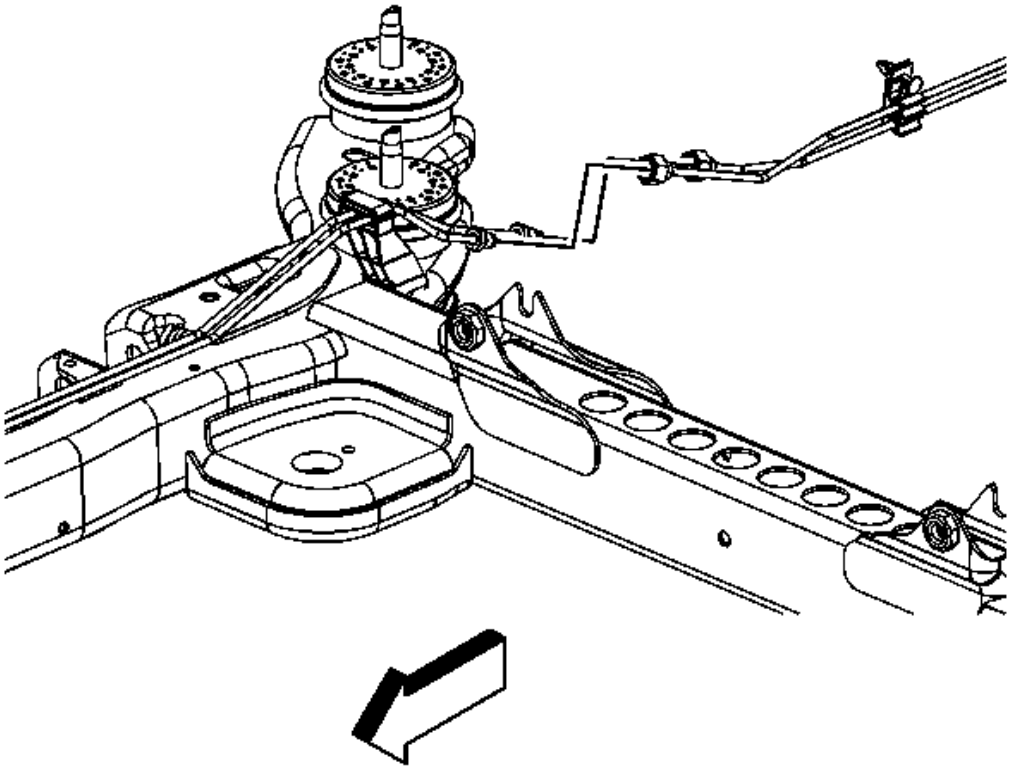

Fig. 139: Front & Rear Brake Pipes
Courtesy of GENERAL MOTORS CORP.

106. Remove the plugs from the open brake lines.
107. Connect the rear brake pipes to the front brake pipes.

Tighten: Tighten the fittings to 20 N.m (15 lb ft).

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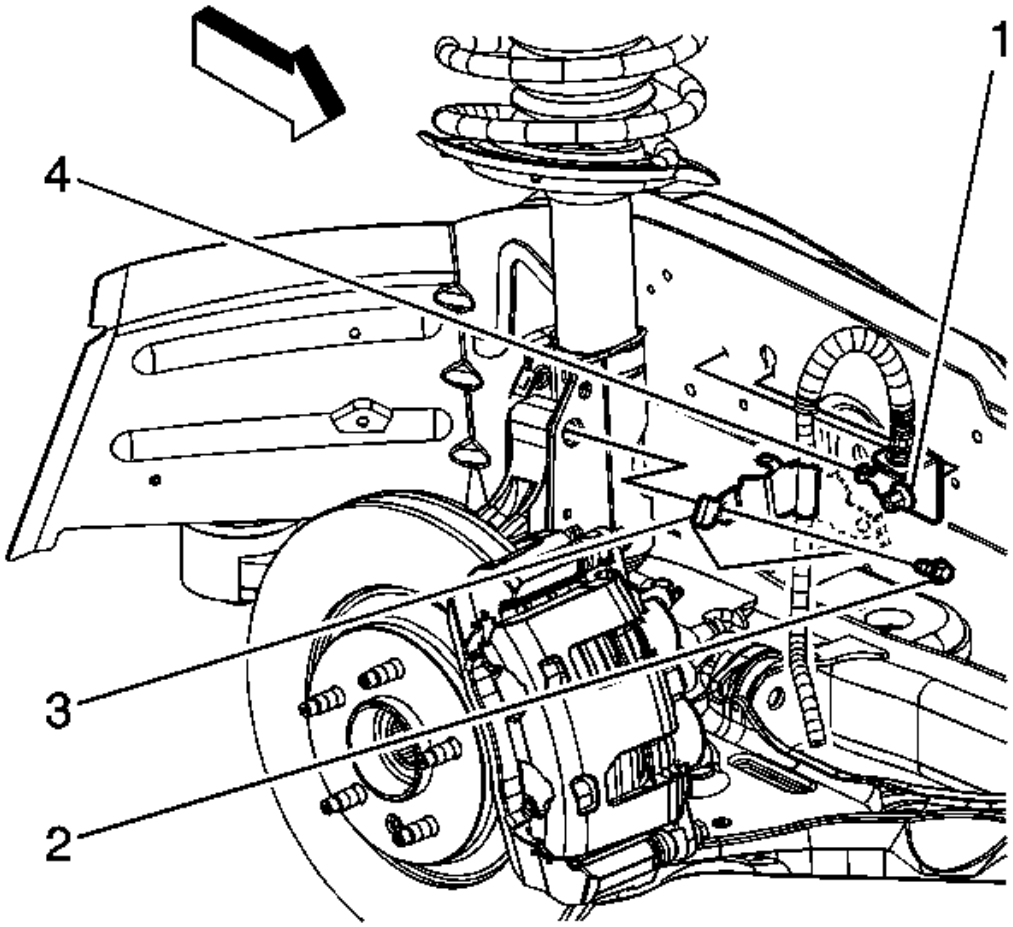

Fig. 140: Right Front Brake Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

108. Install the front brake pipe bracket (4) to the body frame rail.
109. Tighten the nut (1) securing the right front brake pipe bracket (4) to the body frame rail.

Tighten: Tighten the nut to 9 N.m (80 lb in).

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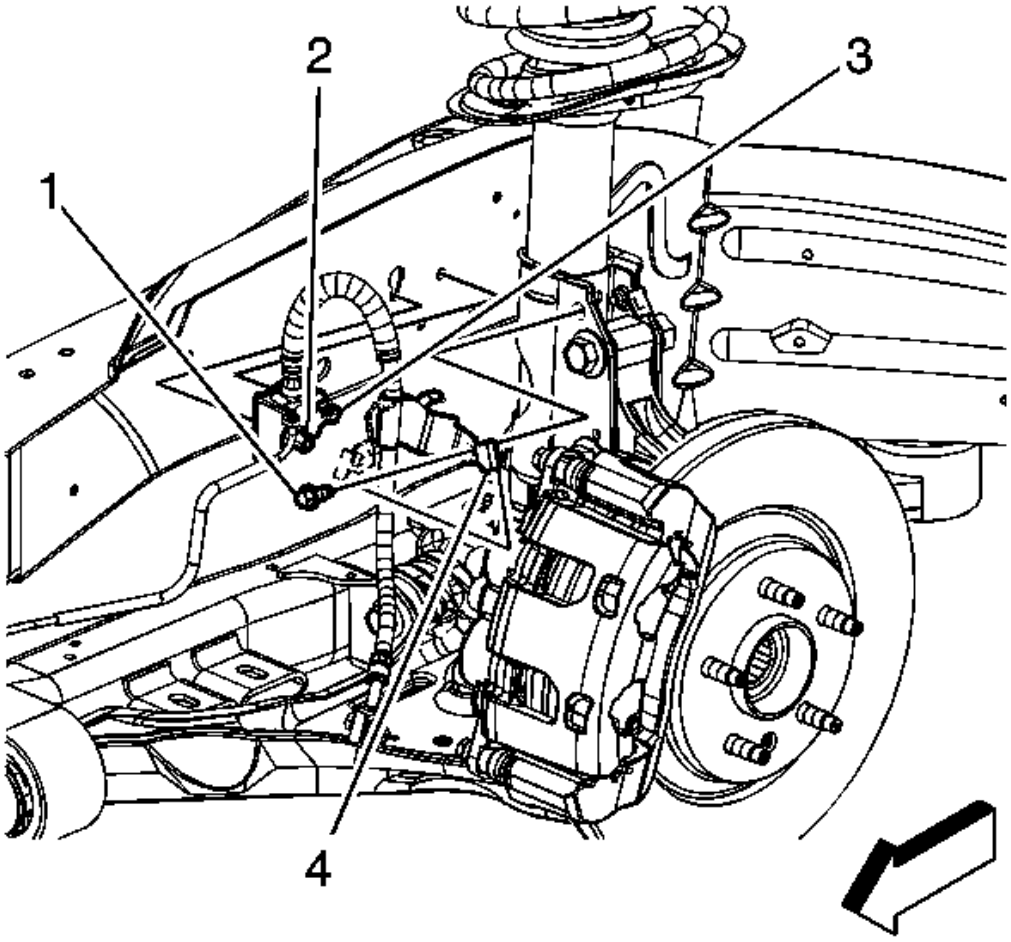

Fig. 141: Left Front Brake Pipe Bracket
Courtesy of GENERAL MOTORS CORP.

110. Install the front brake pipe bracket (4) to the body frame rail.
111. Tighten the nut (2) securing the left front brake pipe bracket (4) to the body frame rail.

Tighten: Tighten the nut to 9 N.m (80 lb in).

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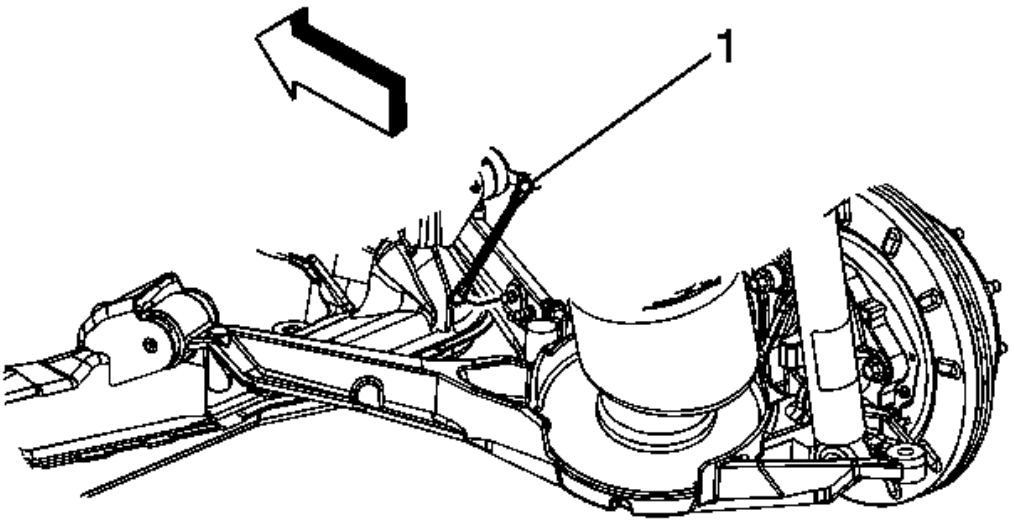

Fig. 142: Electronic Suspension Front Position Sensor Link
Courtesy of GENERAL MOTORS CORP.

112. Install the front air deflector. Refer to **Front Air Deflector Replacement** .
113. Connect the electronic suspension front position sensor link to the lower control arms ball stud, if equipped.

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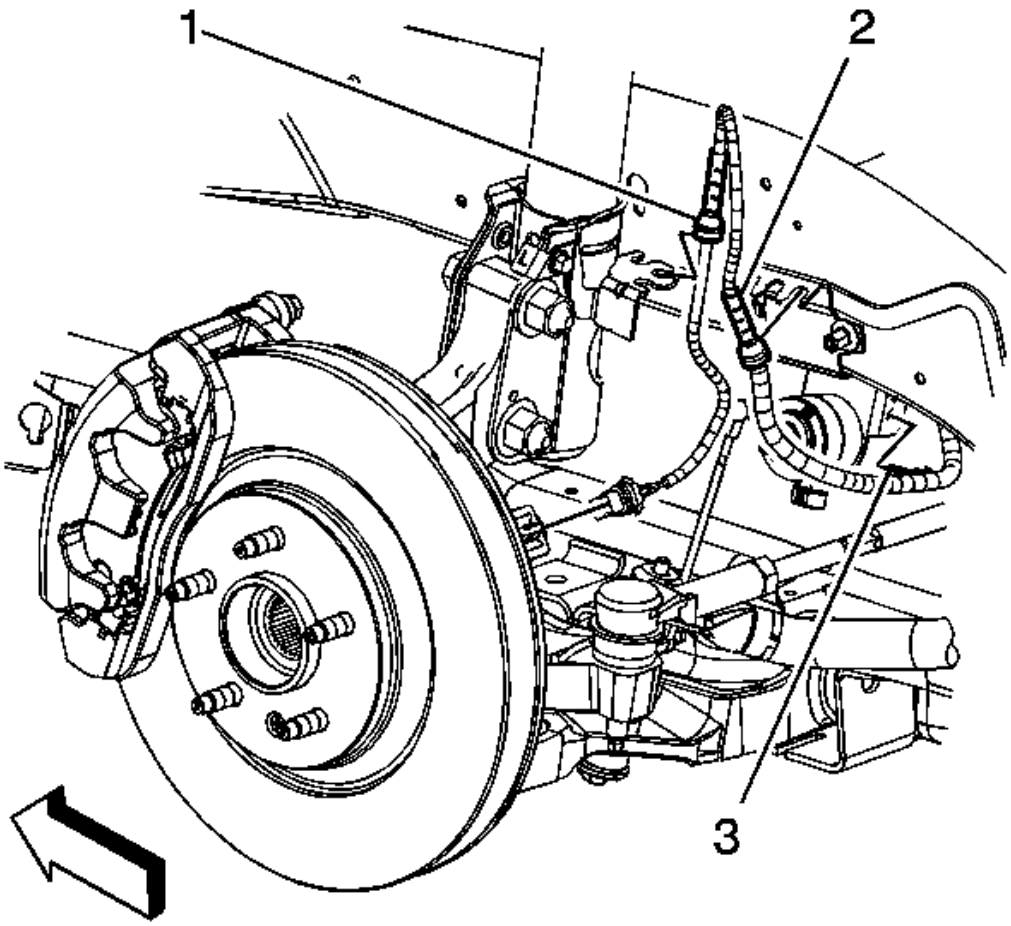

Fig. 143: Engine Harness Grommets & Clips
Courtesy of GENERAL MOTORS CORP.

114. Install the engine harness clip (3) to the ride lever sensor bracket.
115. Install the engine harness grommet (2) to the frame rail bracket.
116. Install the front wheels. Refer to **Tire and Wheel Removal and Installation** .
117. Install the rear exhaust manifold pipe. Refer to **Exhaust Manifold Rear Pipe Replacement (LD8)** .
118. Lower the vehicle.

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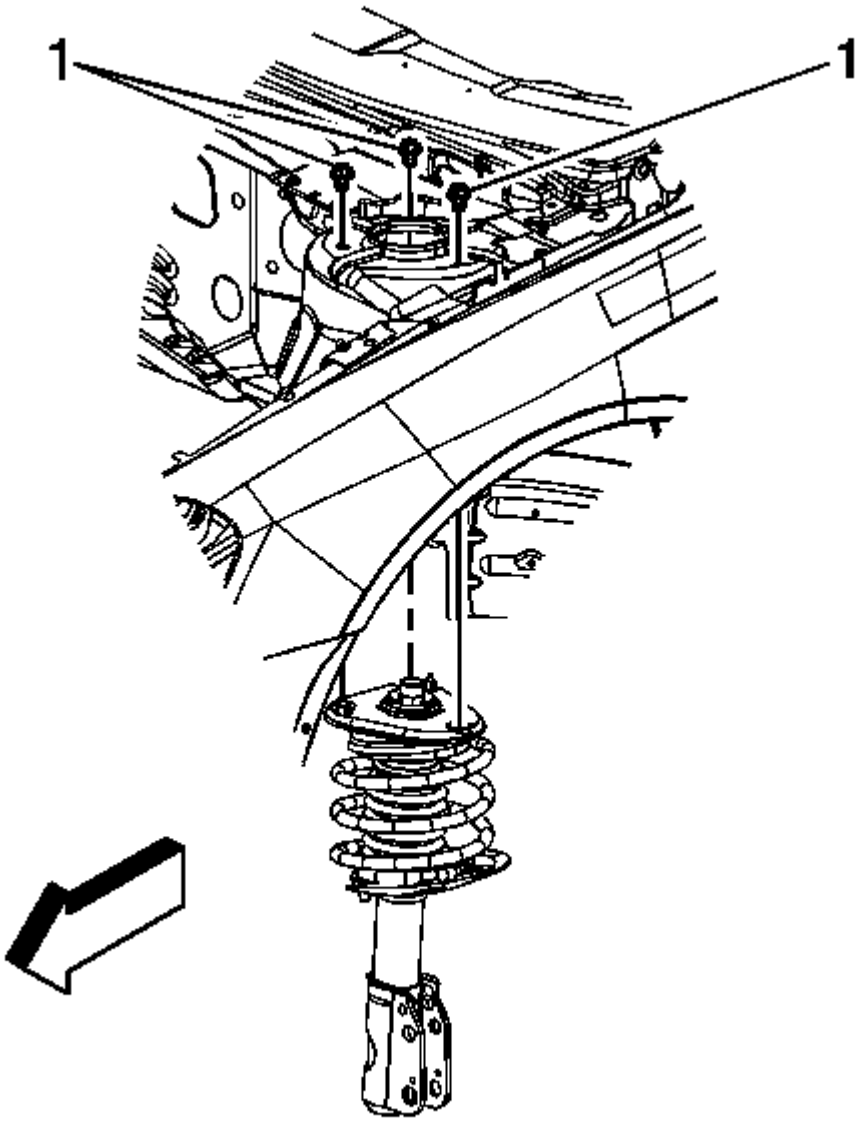

Fig. 144: Strut Tower Bolts
Courtesy of GENERAL MOTORS CORP.

119. Install the left and right side strut tower bolts (1). (Left side shown, right side similar).

Tighten: Tighten the bolts to 40 N.m (30 lb ft).

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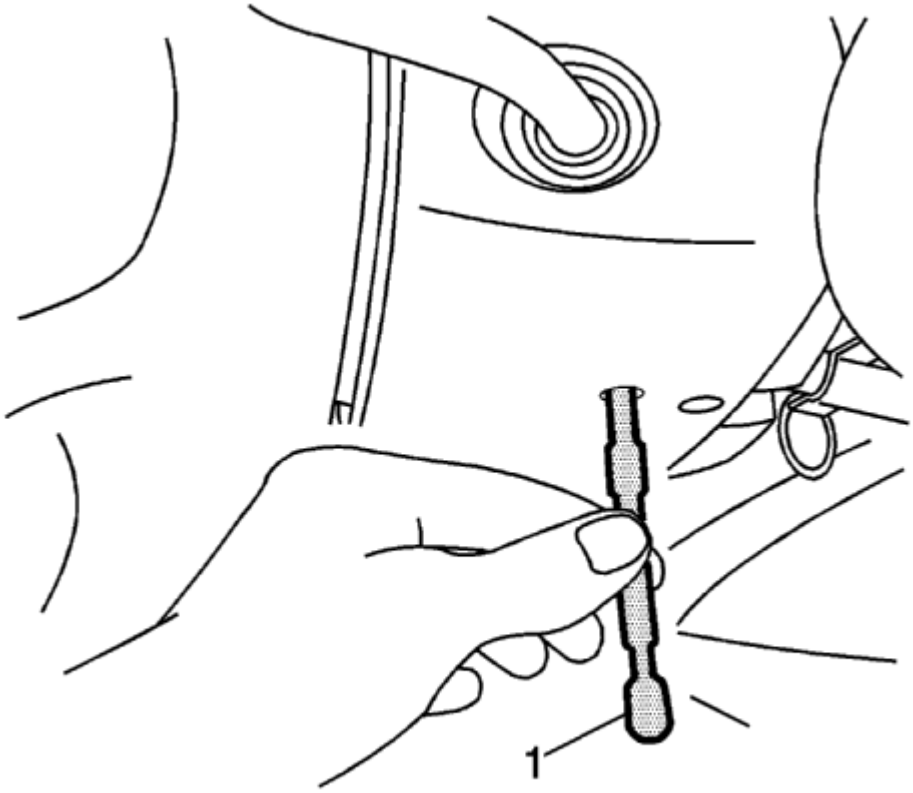

Fig. 145: Locking/Unlocking Steering Column
Courtesy of GENERAL MOTORS CORP.

120. Remove the **J 42640** from the steering column.

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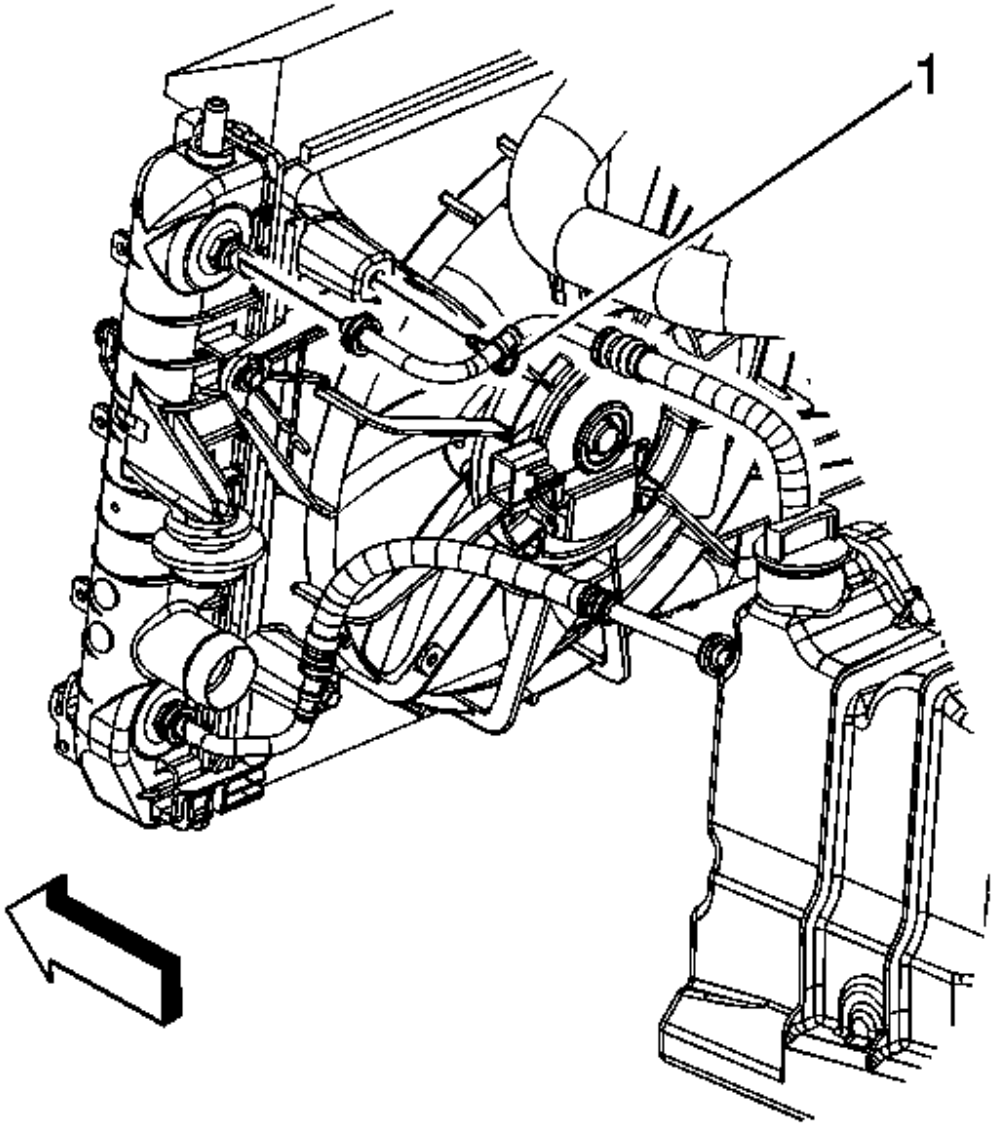

Fig. 146: Upper Transaxle Oil Cooler Pipe Bolt & Bolt
Courtesy of GENERAL MOTORS CORP.

121. Connect the transaxle oil cooler pipes to the radiator.
122. Slide the plastic caps onto the transaxle oil cooler pipe quick connect fittings.
123. Tighten the upper transaxle oil cooler pipe bolt (1) to the fan shroud.

Tighten: Tighten the bolt to 6 N.m (53 lb in).

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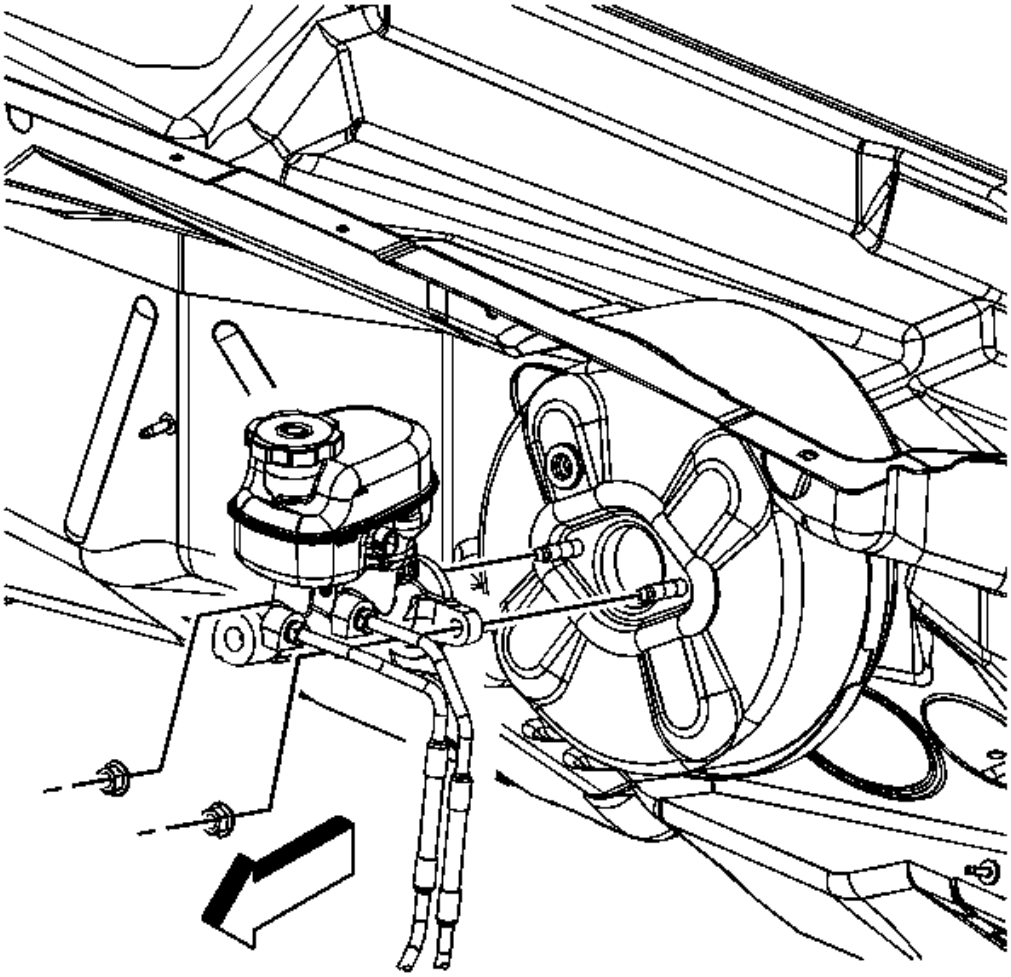

Fig. 147: Master Cylinder & Brake Booster
Courtesy of GENERAL MOTORS CORP.

124. Unsecure the master cylinder from the engine and position the master cylinder the brake booster.
125. Install the master cylinder nuts.

Tighten: Tighten the nuts to 30 N.m (22 lb ft).

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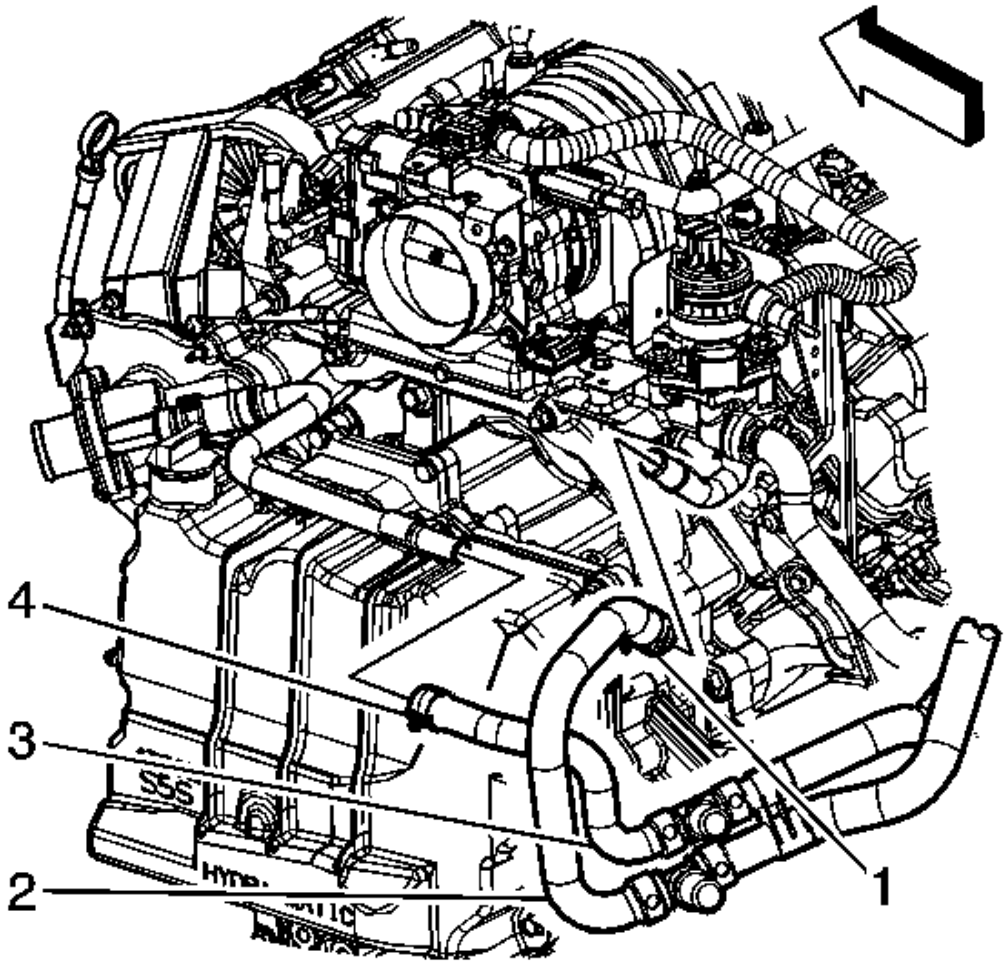

Fig. 148: Heater Inlet & Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

126. Install the heater inlet (2) and outlet (3) hoses to the heater pipes.
127. Position the heater inlet (1) and outlet (2) hose clamps at the heater pipes.

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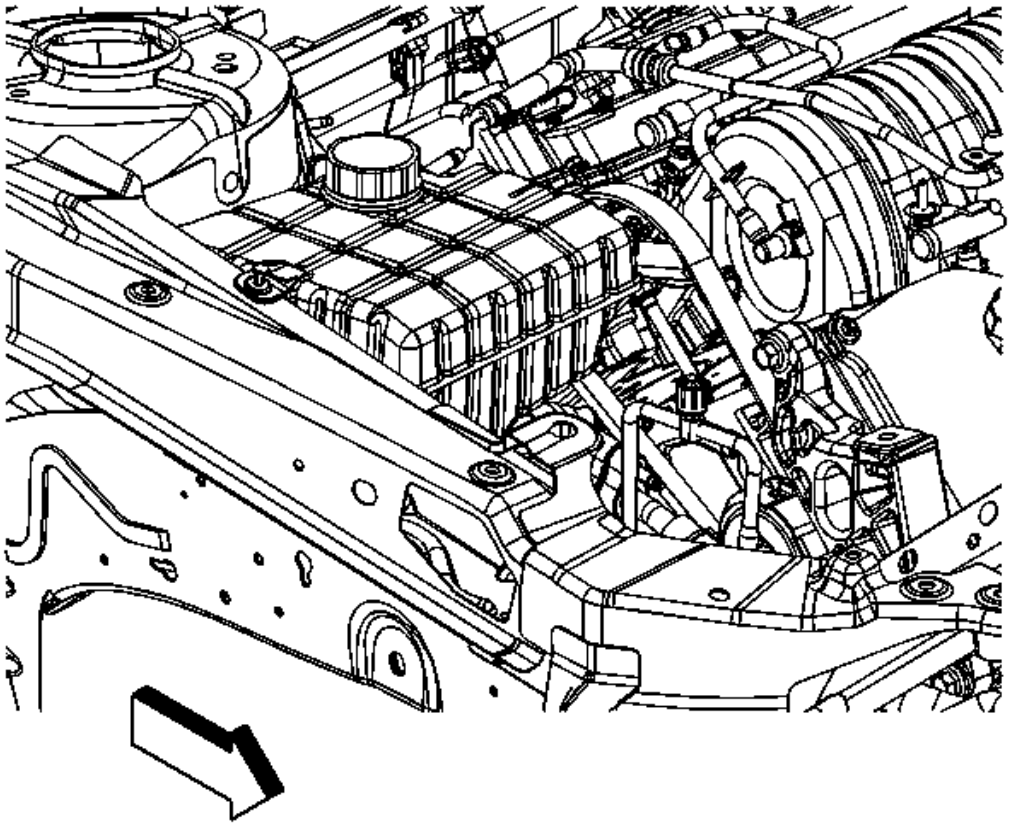

Fig. 149: Surge Tank Inlet Hose/Pipe
Courtesy of GENERAL MOTORS CORP.

128. Install the surge tank inlet hose to the surge tank.
129. Position the radiator surge tank inlet hose clamp at the surge tank.

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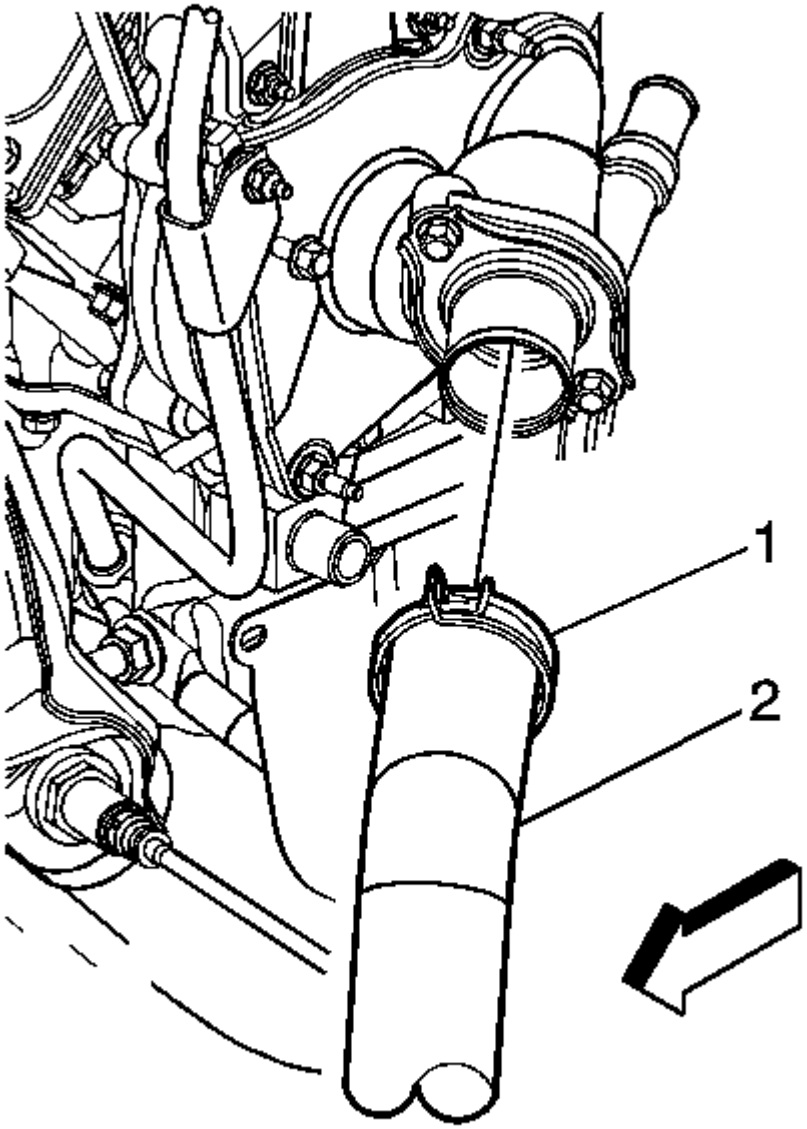

Fig. 150: Radiator Outlet Hose & Clamp At Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

130. Install the radiator outlet hose (2) to the thermostat housing.
131. Using the **J 38185** position the radiator outlet hose clamp (1).

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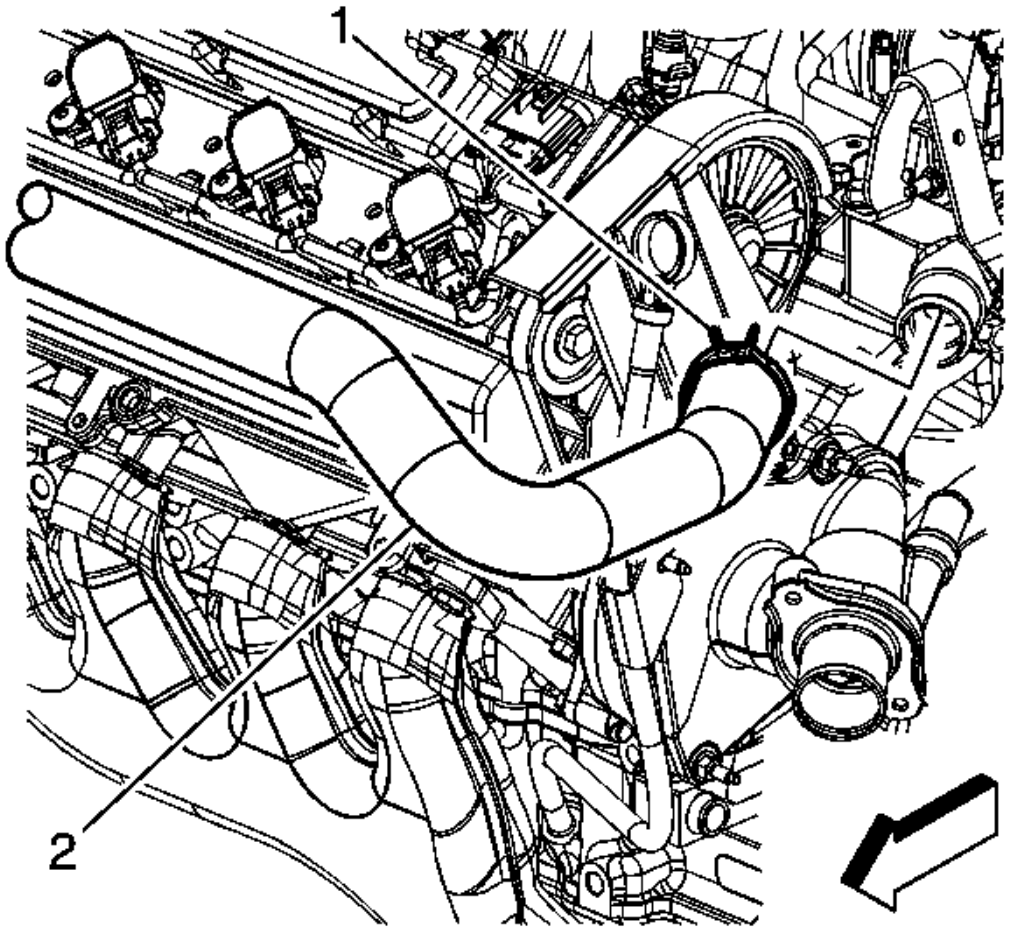

Fig. 151: Radiator Inlet Hose & Clamp
Courtesy of GENERAL MOTORS CORP.

132. Install the radiator inlet hose (2) to the water pump housing.
133. Using the **J 37097-A** position the radiator inlet hose clamp (1). See **Special Tools** .

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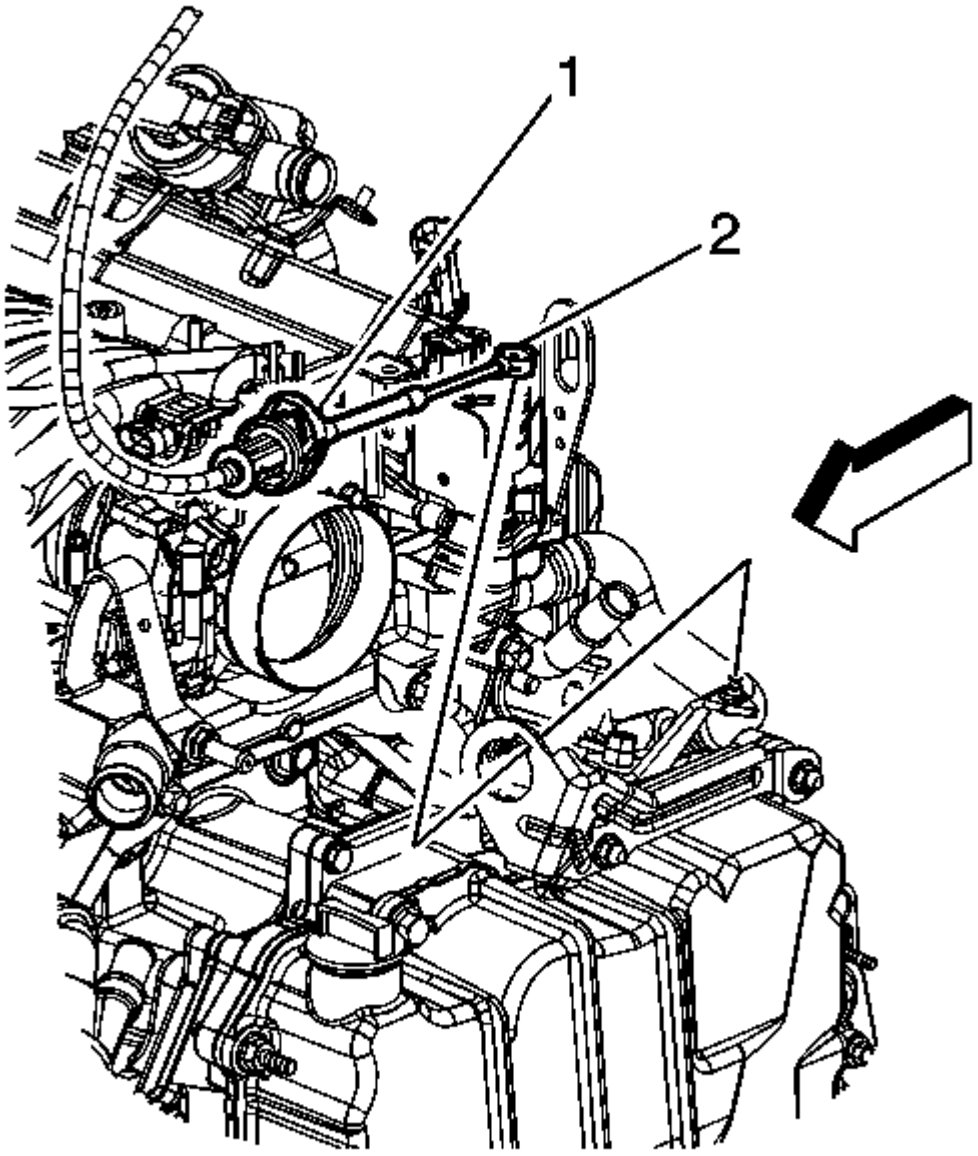

Fig. 152: Transaxle Shift Cable & Range Selector Lever
Courtesy of GENERAL MOTORS CORP.

134. Install the transaxle shift cable to the bracket.
135. Connect the transaxle shift cable end (2) to the range selector lever (1).

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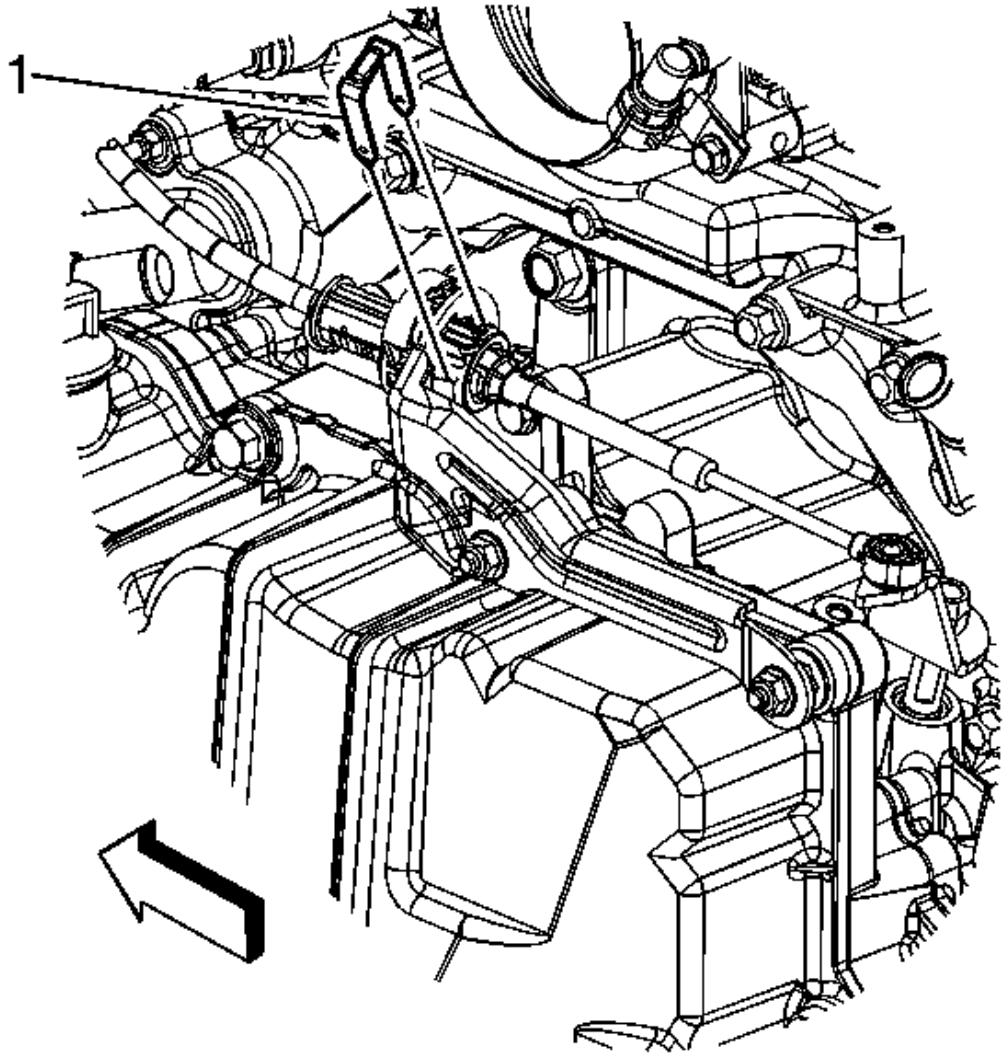

Fig. 153: Transaxle Shift Cable Retainer
Courtesy of GENERAL MOTORS CORP.

136. Install the transaxle shift cable retainer (1).

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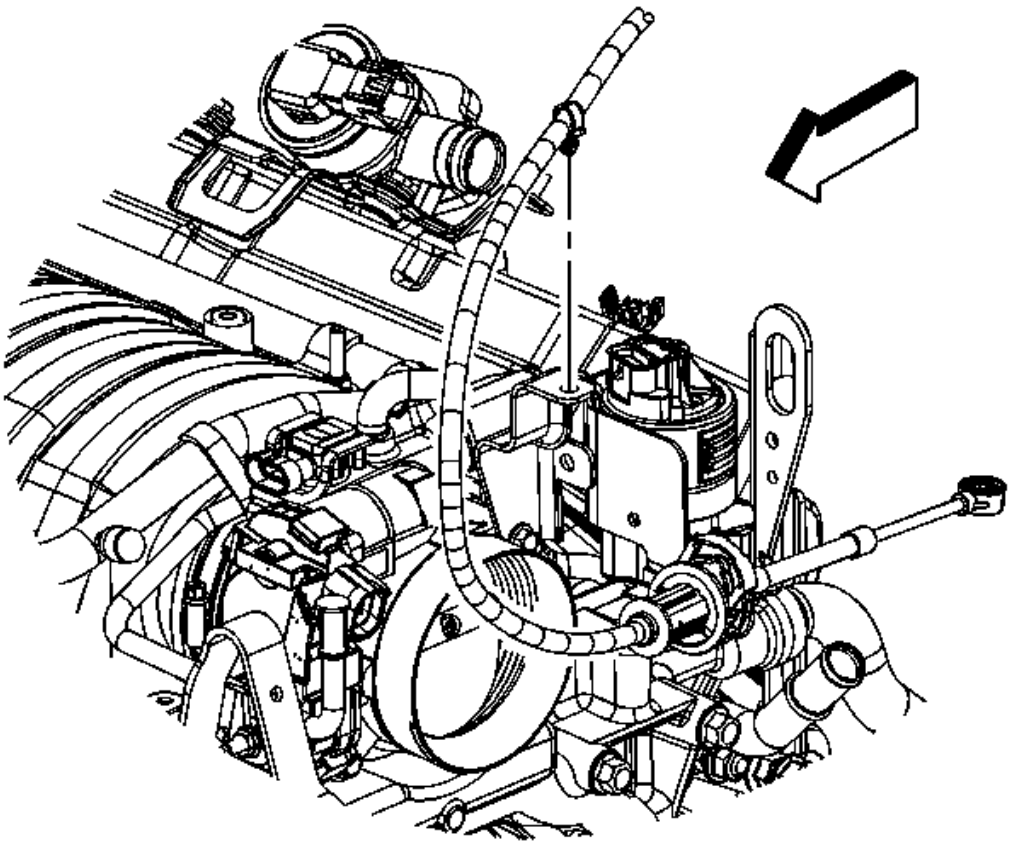

Fig. 154: Transaxle Shift Cable Clip & Bracket
Courtesy of GENERAL MOTORS CORP.

137. Install the transaxle shift cable clip to the shift cable bracket.

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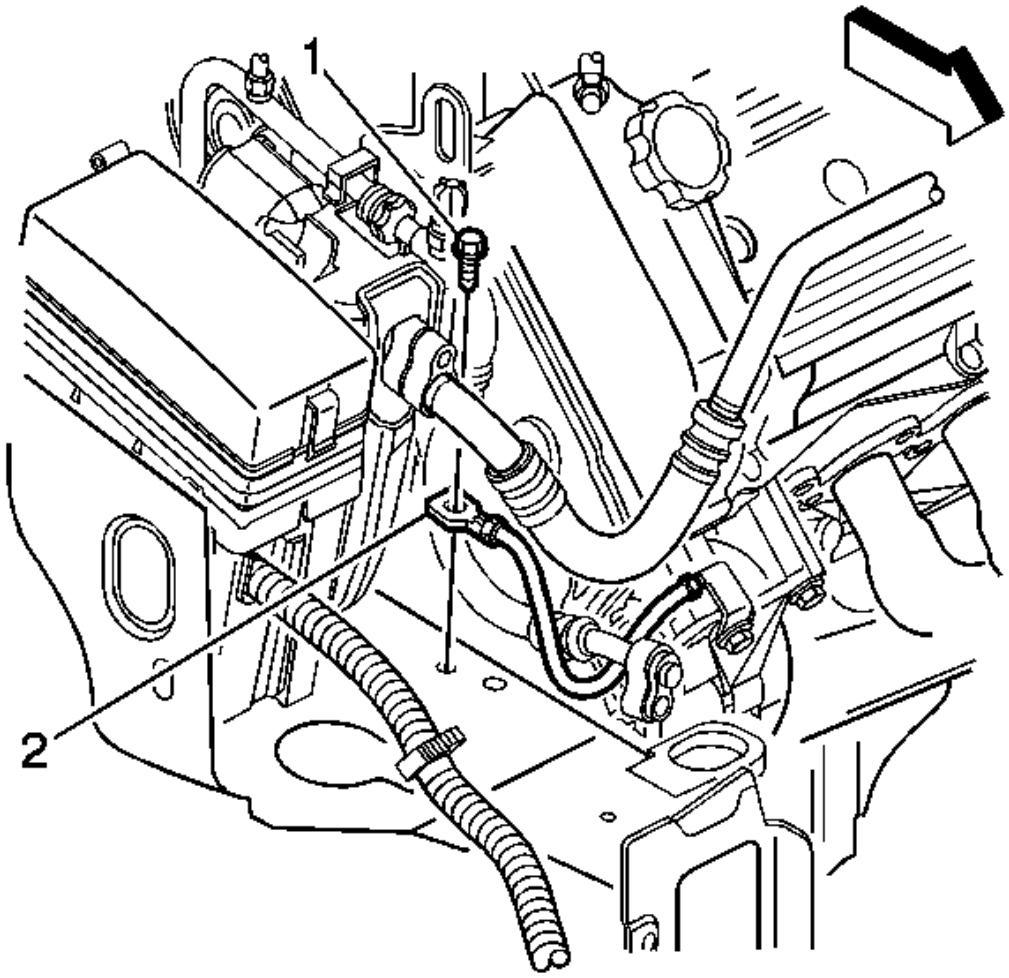

Fig. 155: Engine Ground Strap & Bolt
Courtesy of GENERAL MOTORS CORP.

138. Position the ground strap to the frame rail.
139. Install the engine ground strap bolt (1) to the right side frame rail.

Tighten: Tighten the bolt to 25 N.m (18 lb ft).

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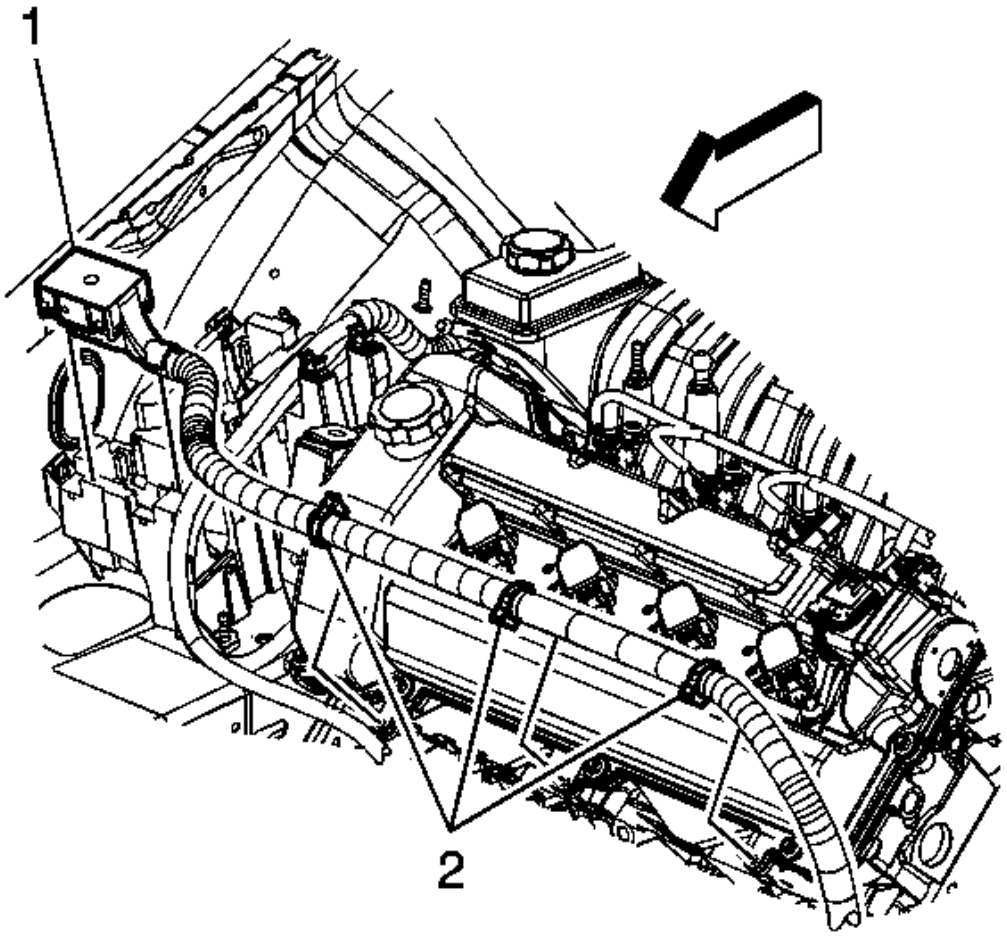

Fig. 156: Engine Harness & BEC
Courtesy of GENERAL MOTORS CORP.

140. Install the engine harness (1) to the BEC.

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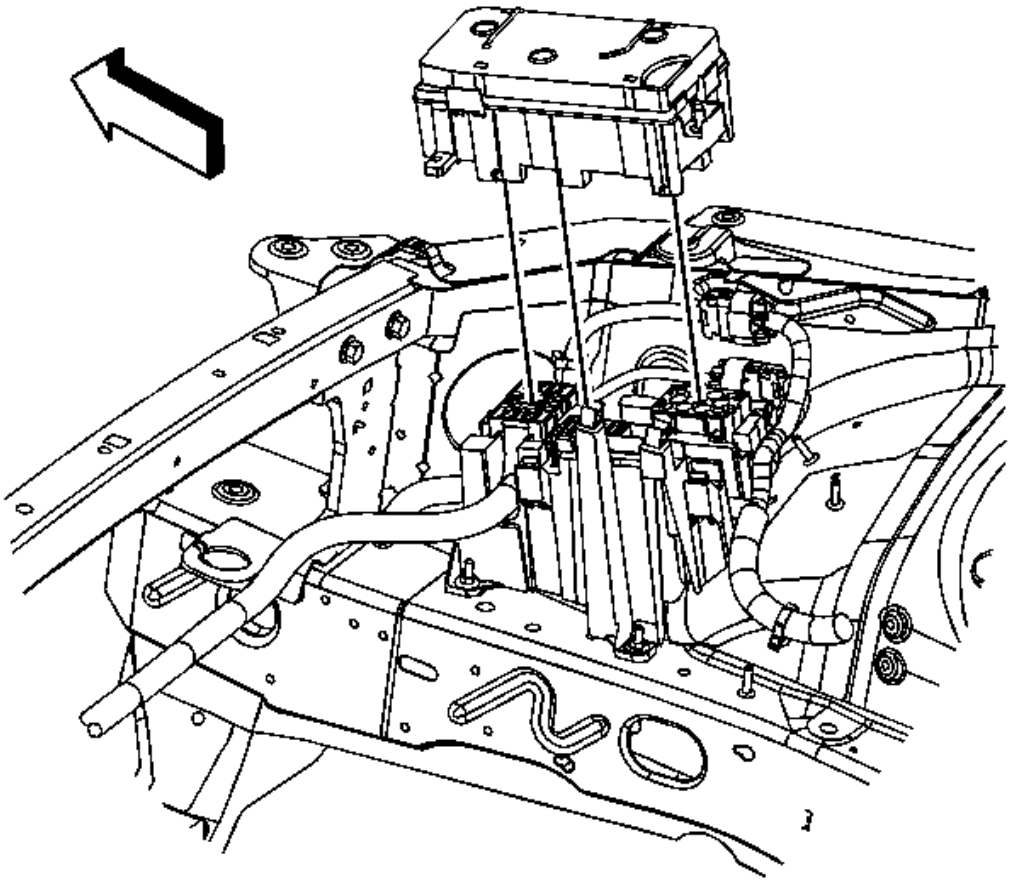

Fig. 157: Junction Block
Courtesy of GENERAL MOTORS CORP.

141. Install the junction block.
142. Install the junction block bolts.

Tighten: Tighten the bolts to 6.5 N.m (58 lb in).

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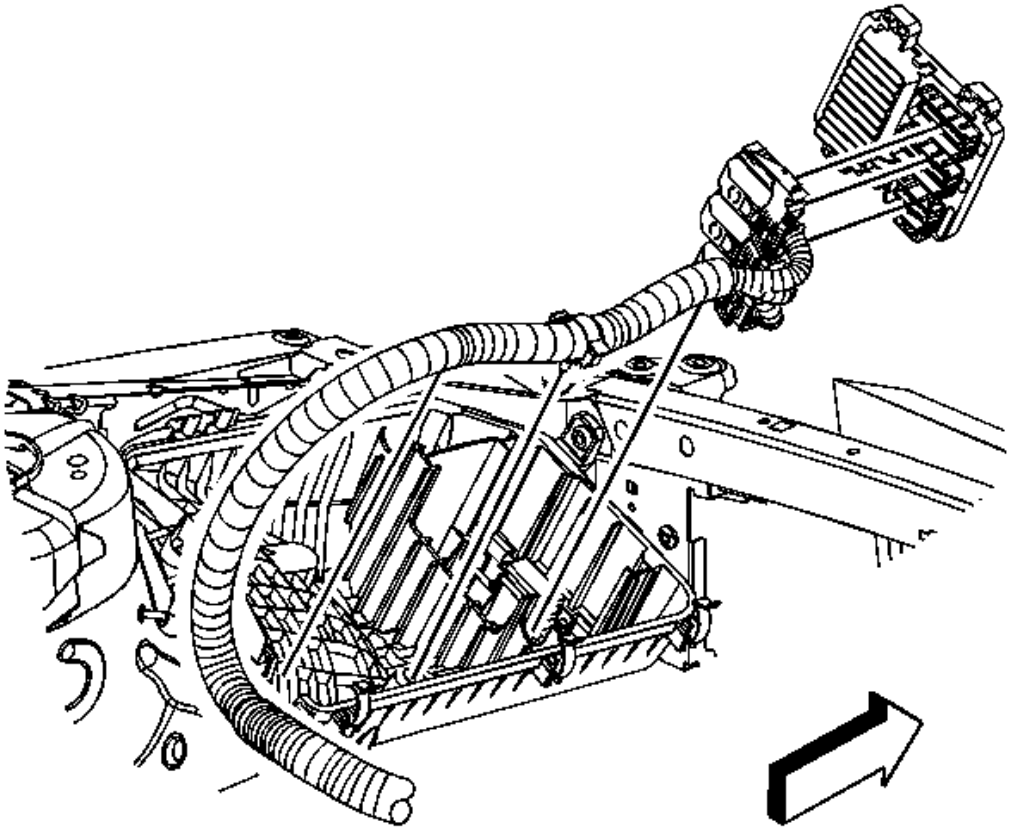

Fig. 158: Engine Harness Electrical Connectors At Engine Control Module
Courtesy of GENERAL MOTORS CORP.

143. Connect the engine harness electrical connectors to the ECM.
144. Engage the lever locks.

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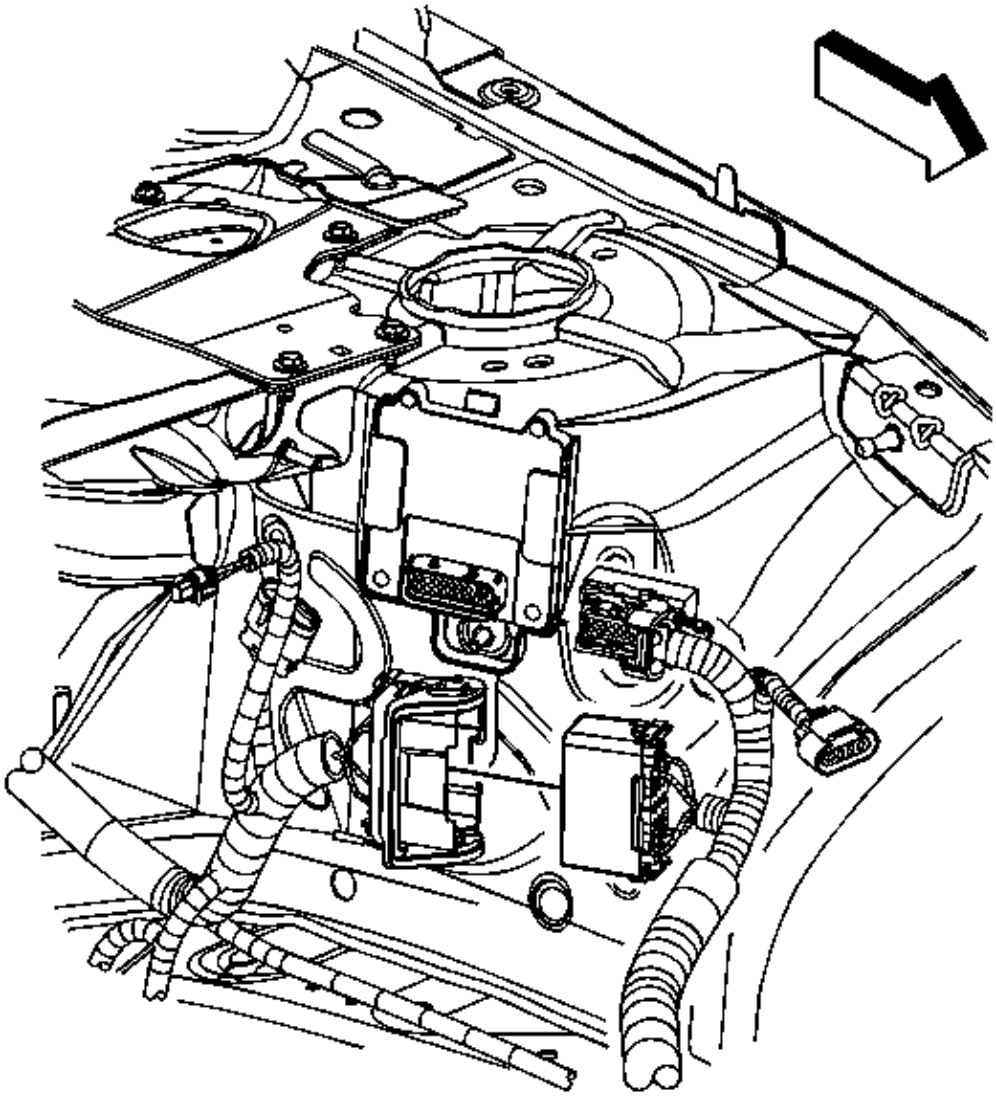

Fig. 159: Engine Harness Electrical Connector At Body Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

145. Connect the engine harness electrical connector to the body harness electrical connector.
146. Engage the lever lock.

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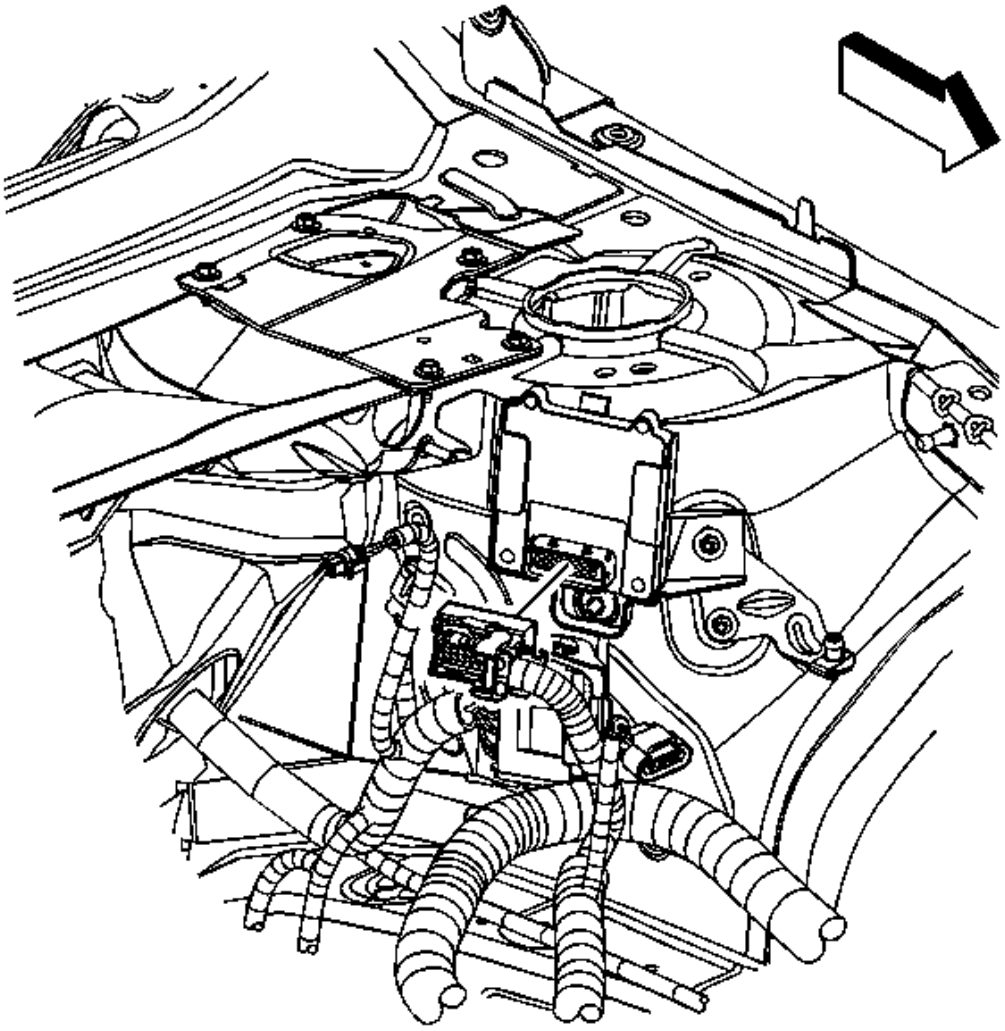

Fig. 160: Engine Harness Electrical Connector At Transaxle Control Module
Courtesy of GENERAL MOTORS CORP.

147. Connect the engine harness electrical connector to the TCM.
148. Engage the lever lock.

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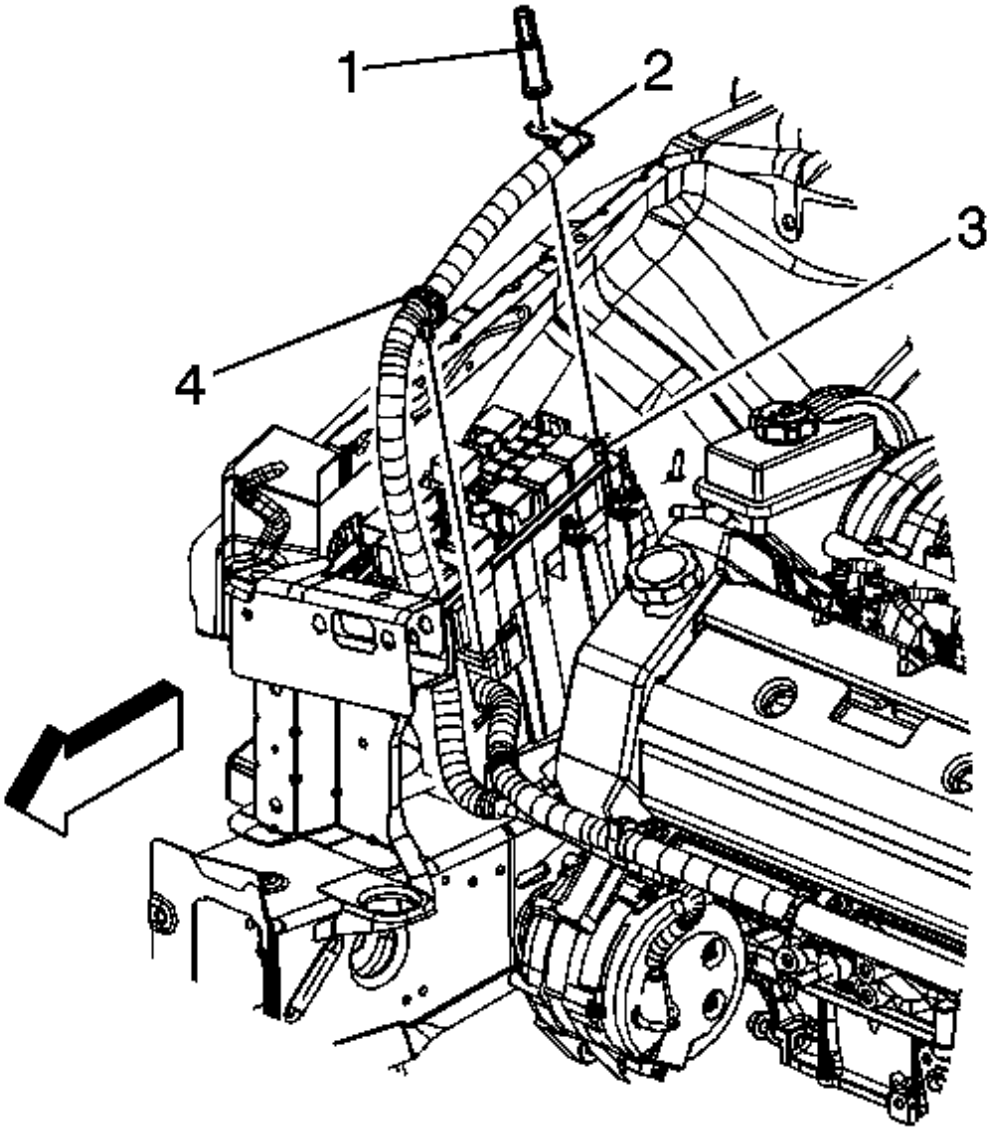

Fig. 161: Starter Solenoid Cable To Bussed Electrical Center
Courtesy of GENERAL MOTORS CORP.

149. Install the starter cable to the BEC terminal.
150. Install the starter cable clip (4) to the BEC.
151. Install the nut (1) securing the starter cable to the BEC.

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Tighten: Tighten the nut to 15 N.m (11 lb ft).

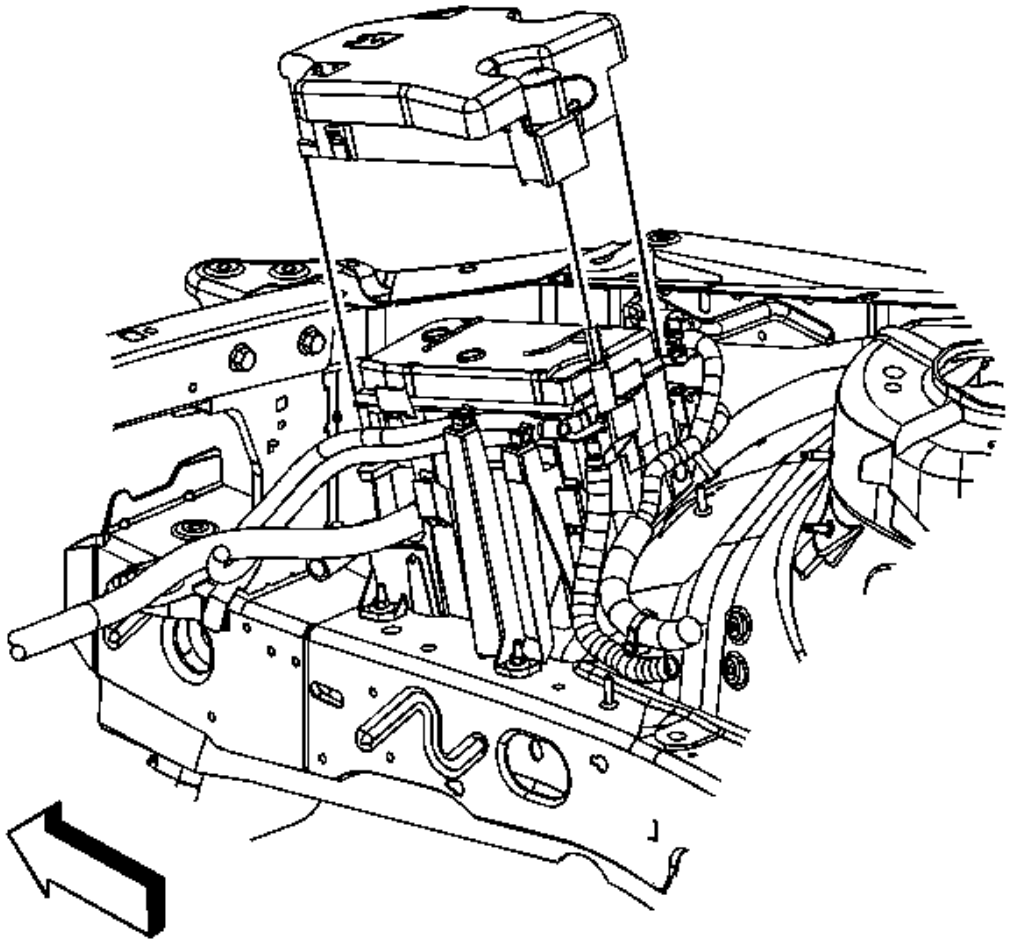

Fig. 162: Junction Block Cover
Courtesy of GENERAL MOTORS CORP.

152. Install the junction block cover.
153. Install the air cleaner. Refer to **Air Cleaner Assembly Replacement** .
154. Install the front compartment sight shield. Refer to **Front Compartment Sight Shields Replacement** .

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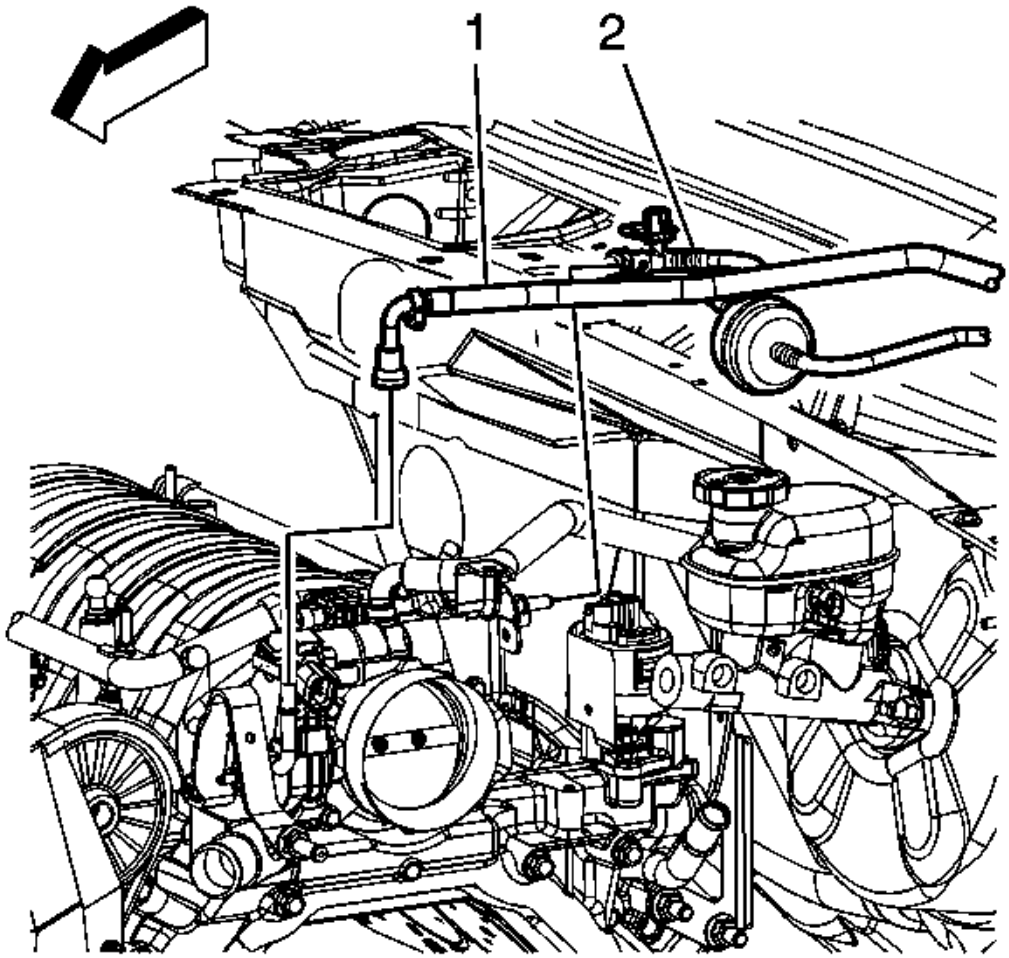

Fig. 163: Fuel Feed Pipe & EVAP Line Quick Connect Fittings
Courtesy of GENERAL MOTORS CORP.

155. Connect the fuel feed and EVAP line quick-connect fittings (1, 2). Refer to **Metal Collar Quick Connect Fitting Service** and **Plastic Collar Quick Connect Fitting Service** .

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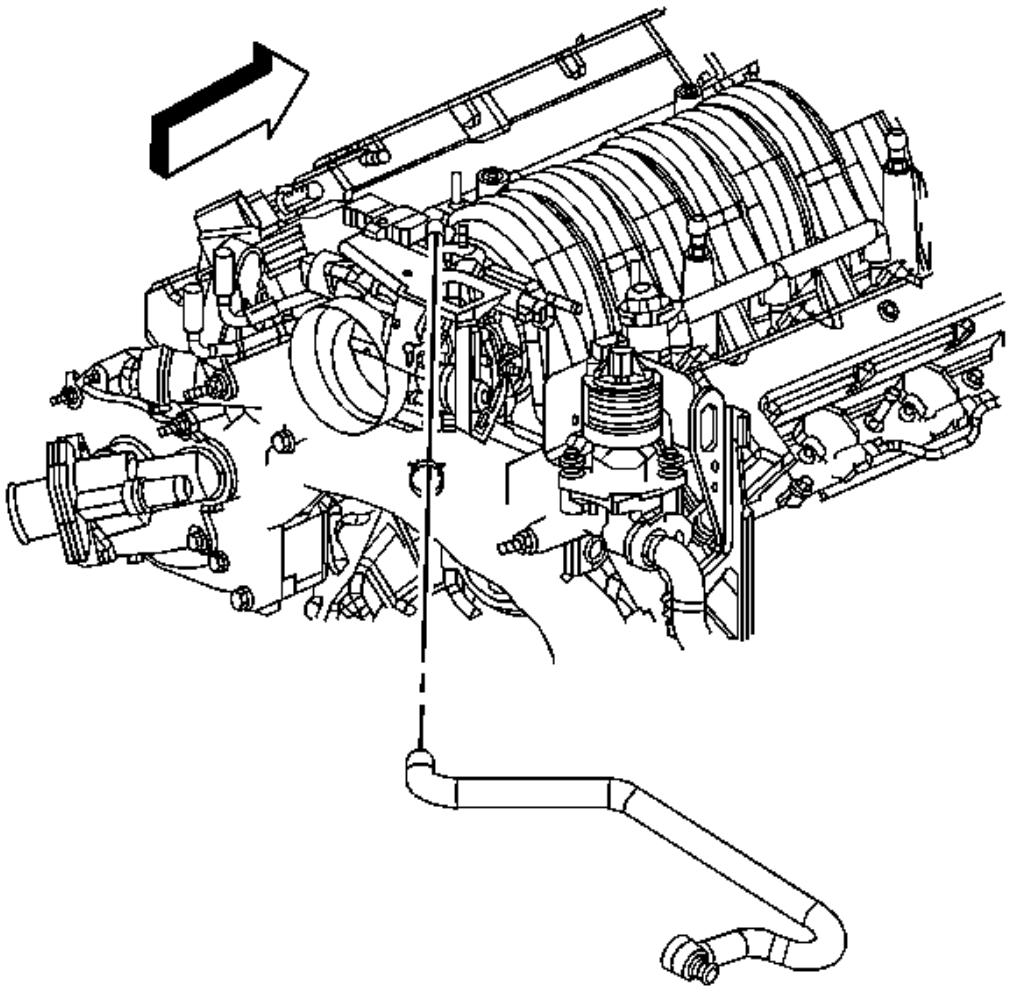

Fig. 164: Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

156. Connect the brake booster vacuum hose to the vacuum connection.
157. Position the brake booster vacuum hose clamp at the engine port.
158. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
159. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
160. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** or **Cooling System Draining and Filling (Vac-N-Fill)** .
161. Bleed the brake system. Refer to **Hydraulic Brake System Bleeding (Pressure)** or **Hydraulic Brake System Bleeding (Manual)** .

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162. Recharge the A/C refrigerant system. Refer to **Refrigerant Recovery and Recharging** .
163. Bleed the power steering system. Refer to **Power Steering System Bleeding** .
164. Check the wheel alignment. Refer to **Wheel Alignment Measurement** .
165. Pre-lube the engine. Refer to **Engine Prelubing** .
166. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement** .
167. With the ignition OFF or disconnected, crank the engine several times. Listen for any unusual noises or evidence that any parts are binding.
168. Start the engine and listen for abnormal conditions.
169. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
170. Run the engine at approximately 1000 RPM until the engine reaches normal operating temperature.
171. While the engine continues to idle raise and support the vehicle.
172. Inspect for oil, coolant and exhaust leaks while the engine is idling.
173. Lower the vehicle.
174. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .
175. Perform a final inspection for the proper engine oil and coolant levels.
176. Road test the vehicle.

ENGINE OIL AND OIL FILTER REPLACEMENT

REMOVAL PROCEDURE

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Position the oil drain pan under the engine oil drain plug.

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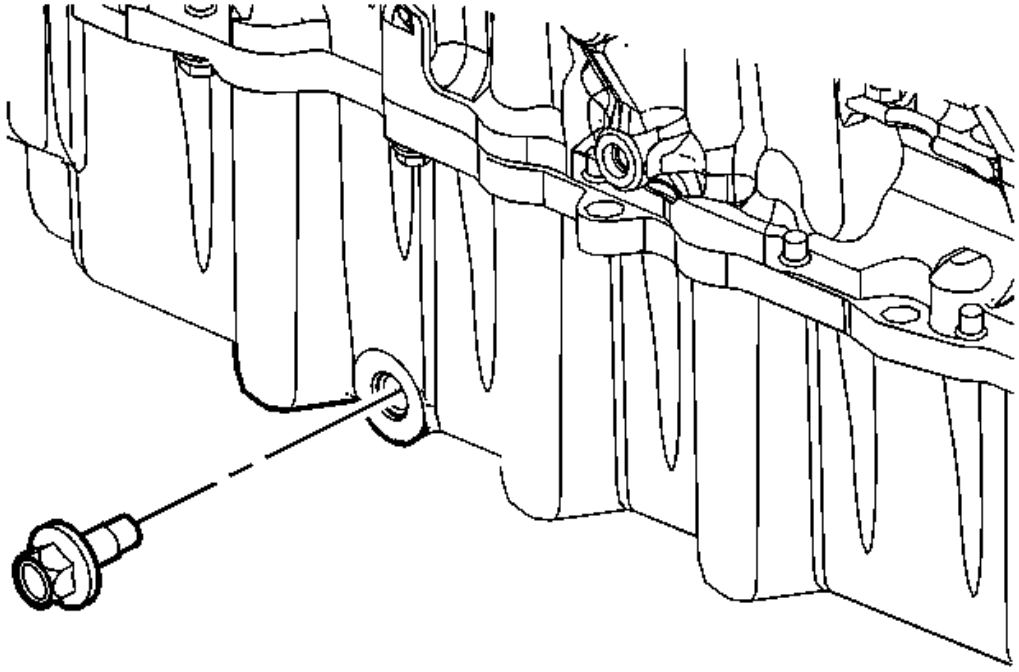

Fig. 165: Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil drain plug.
4. Clean and inspect the engine oil drain plug, replace if necessary.
5. Clean and inspect the engine oil drain plug sealing surface on the oil pan, repair or replace oil pan if necessary.

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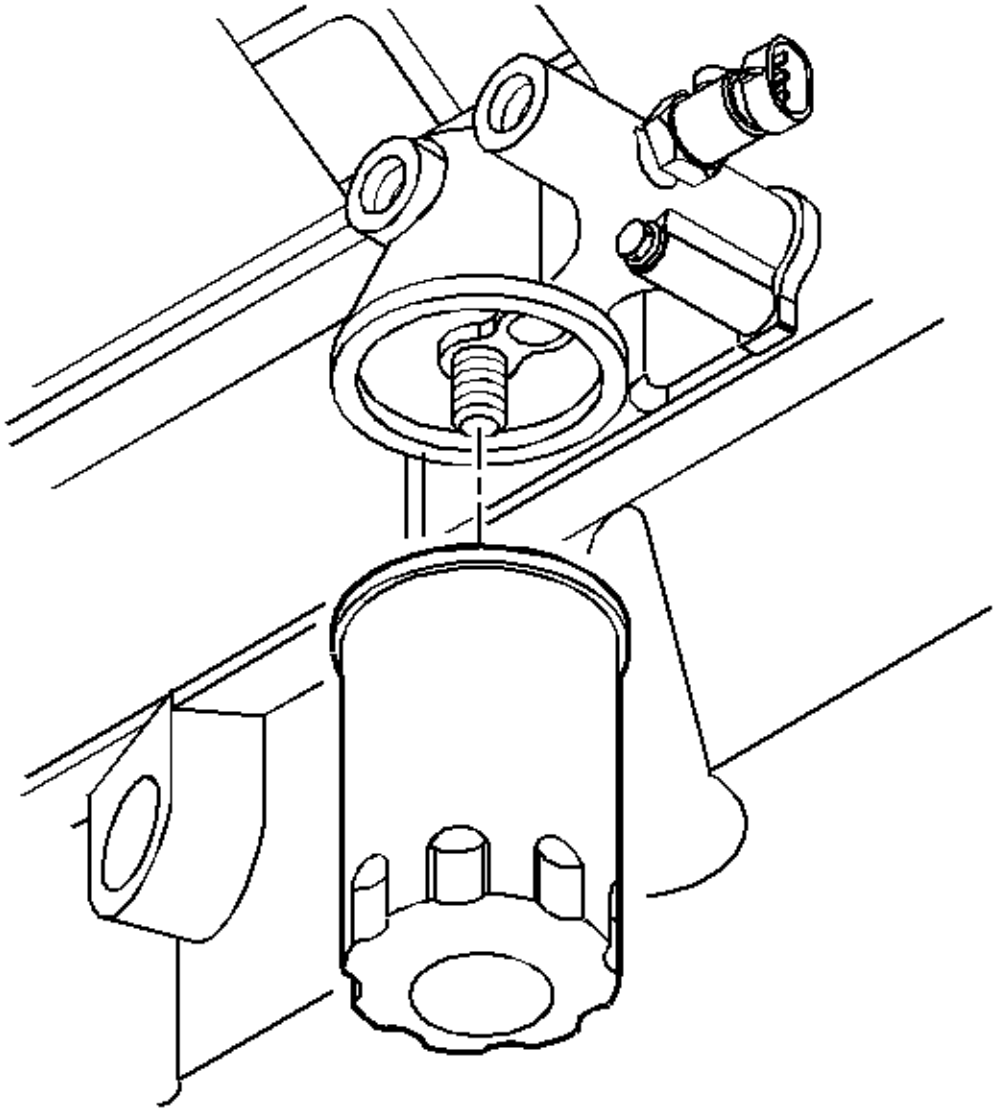

Fig. 166: Oil Filter Adapter & Filter
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil filter.
7. Clean and inspect the oil filter sealing area on the oil filter adapter, repair or replace if necessary.

INSTALLATION PROCEDURE

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1. Fill the oil filter with oil.
2. Lightly oil the replacement oil filter gasket with clean oil.

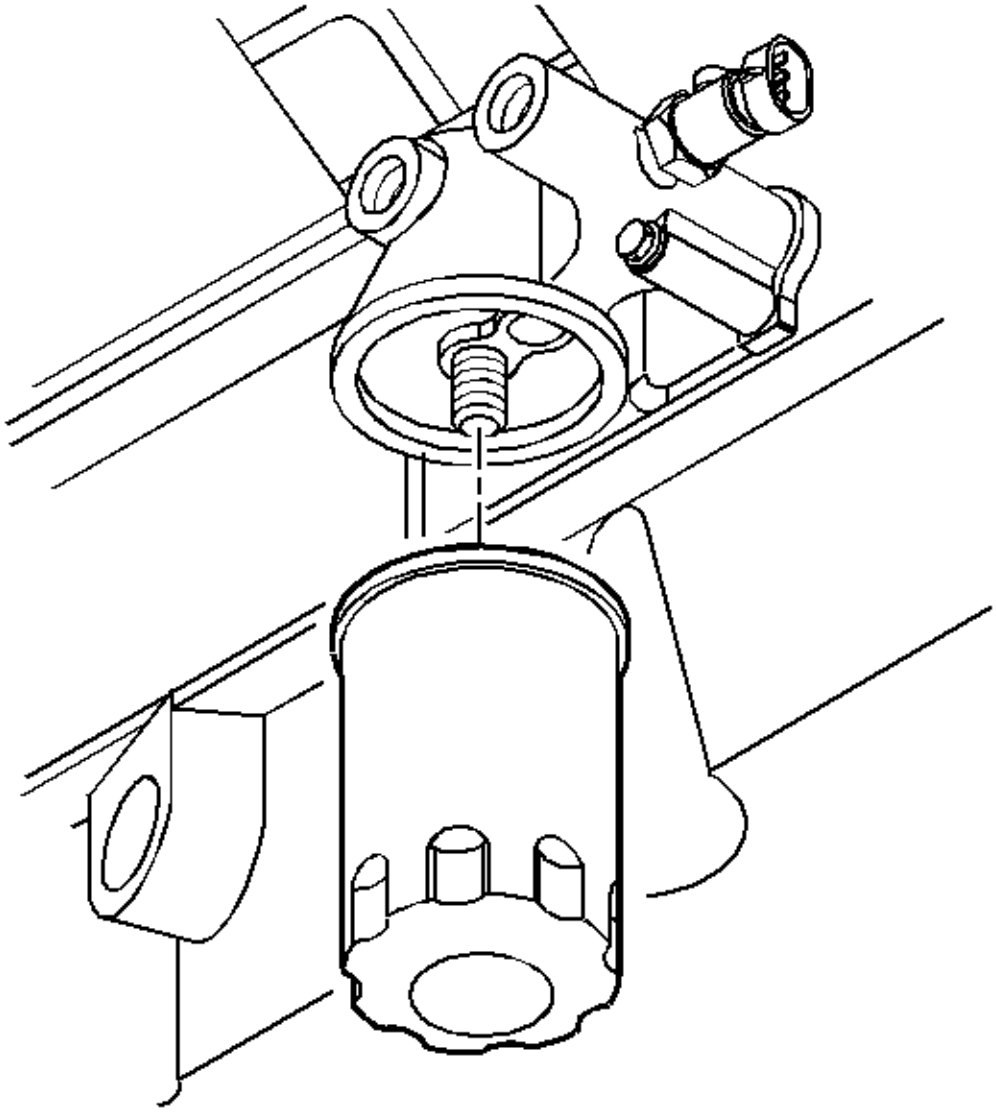

Fig. 167: Oil Filter Adapter & Filter
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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3. Install the new oil filter.

   Tighten: Tighten the new oil filter to 3/4 to 1 full turn, after the oil filter gasket contacts the oil filter mounting surface.

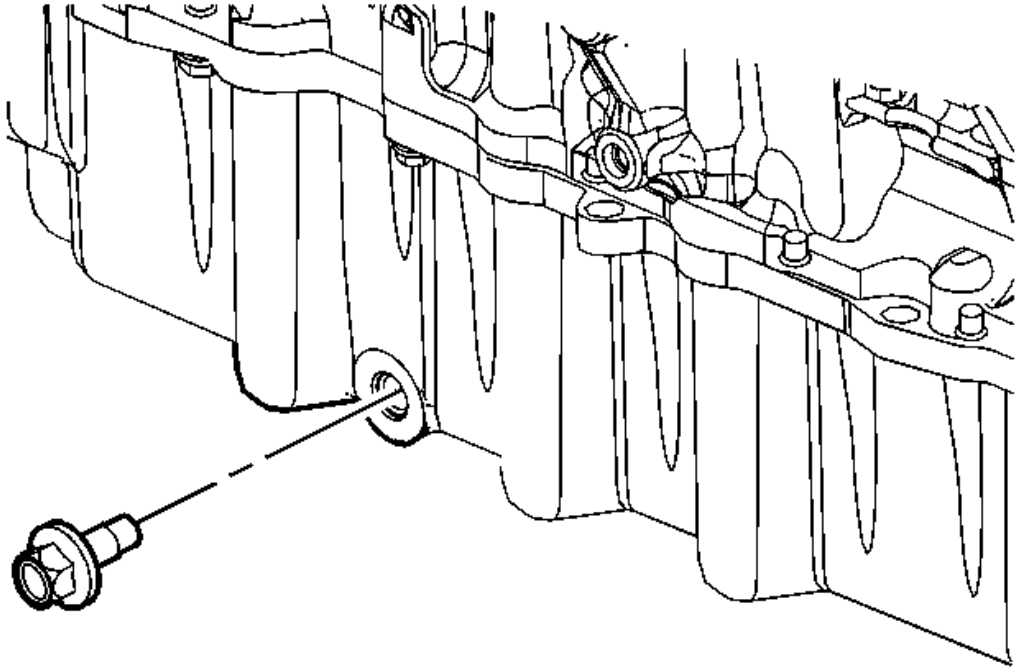

Fig. 168: Engine Oil Drain Plug
Courtesy of GENERAL MOTORS CORP.

4. Install the engine oil drain plug.

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

5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations (USA and Canada)** .
7. Inspect for oil leaks after engine start up.

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