

2004 ENGINE

Engine Mechanical - 4.6L (LH2) (Repair Instructions, 1 Of 5) - SRX

REPAIR INSTRUCTIONS

DRIVE BELT REPLACEMENT - GENERATOR

Removal Procedure

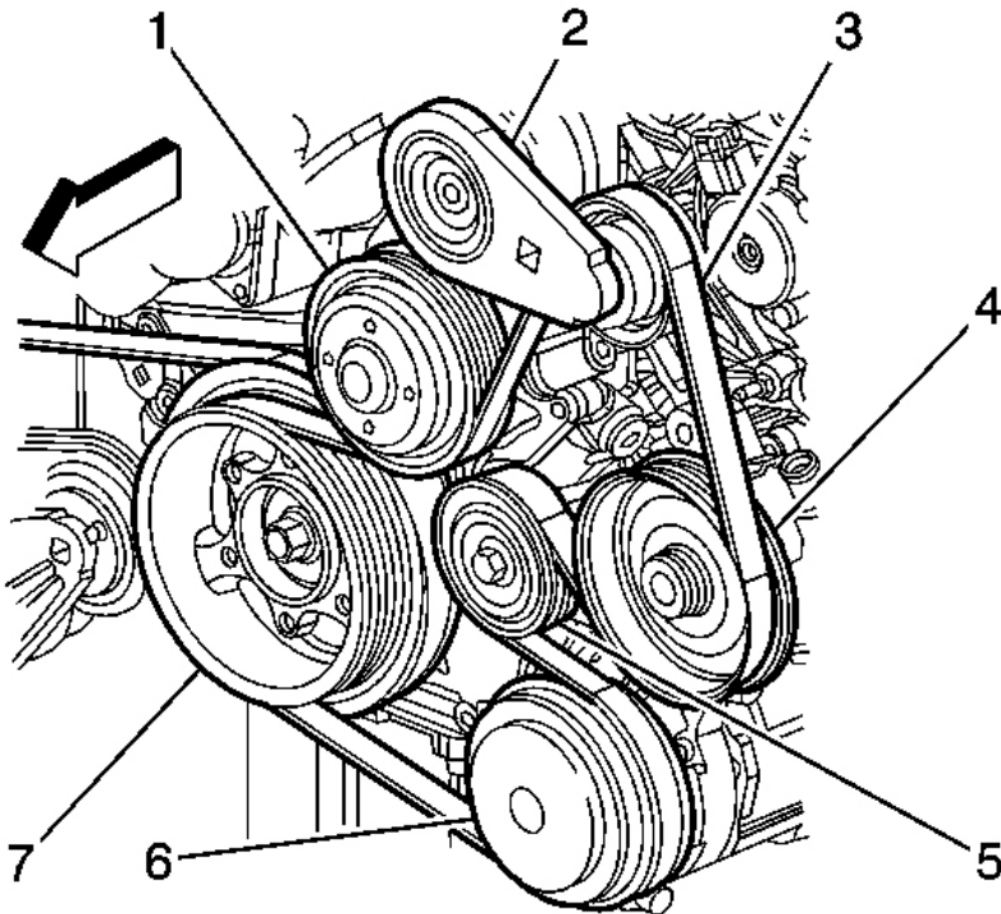


Fig. 1: View Of Air Conditioning, Power Steering & Water Pump Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning, power steering, and water pump belt (3). Refer to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump**.

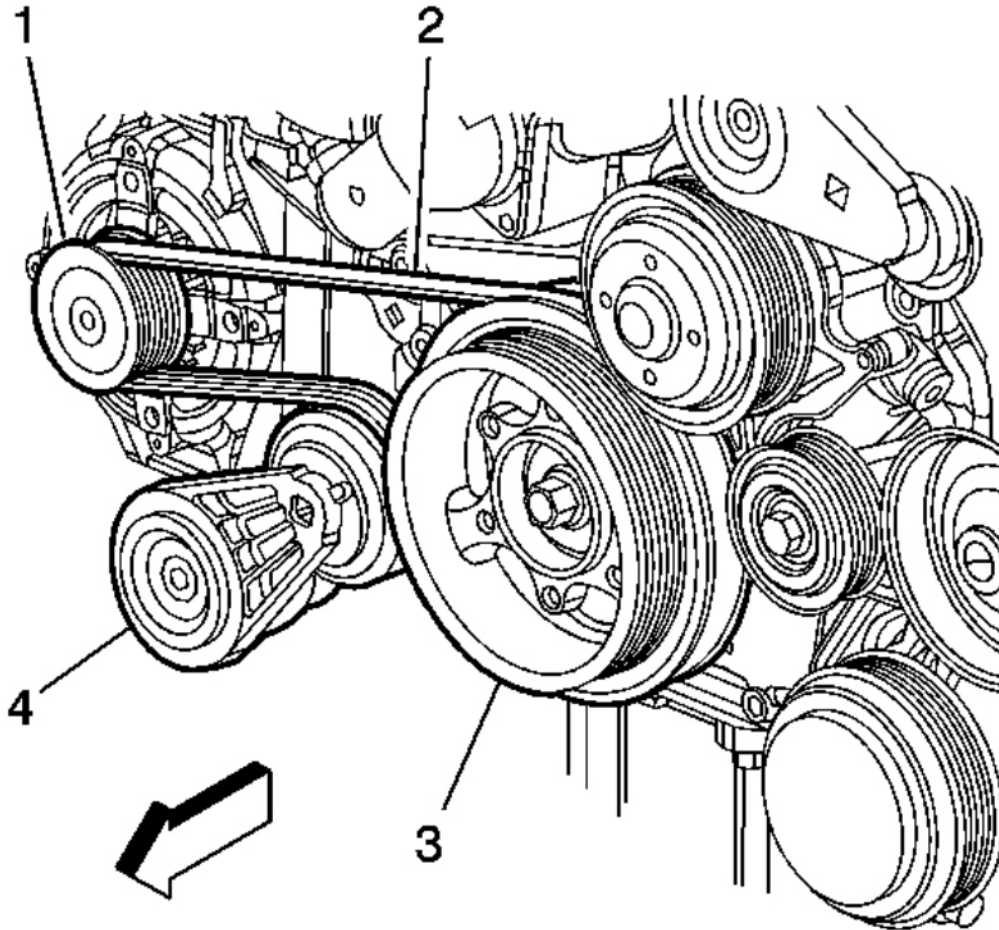


Fig. 2: View Of Generator Drive Belt
Courtesy of GENERAL MOTORS CORP.

2. Rotate the generator drive belt tensioner (4) clockwise to release drive belt tension.
3. Slide the generator drive belt from the generator pulley (1).
4. Allow the drive belt tensioner to return to the relaxed position.
5. Remove the generator drive belt from the pulleys.

Installation Procedure

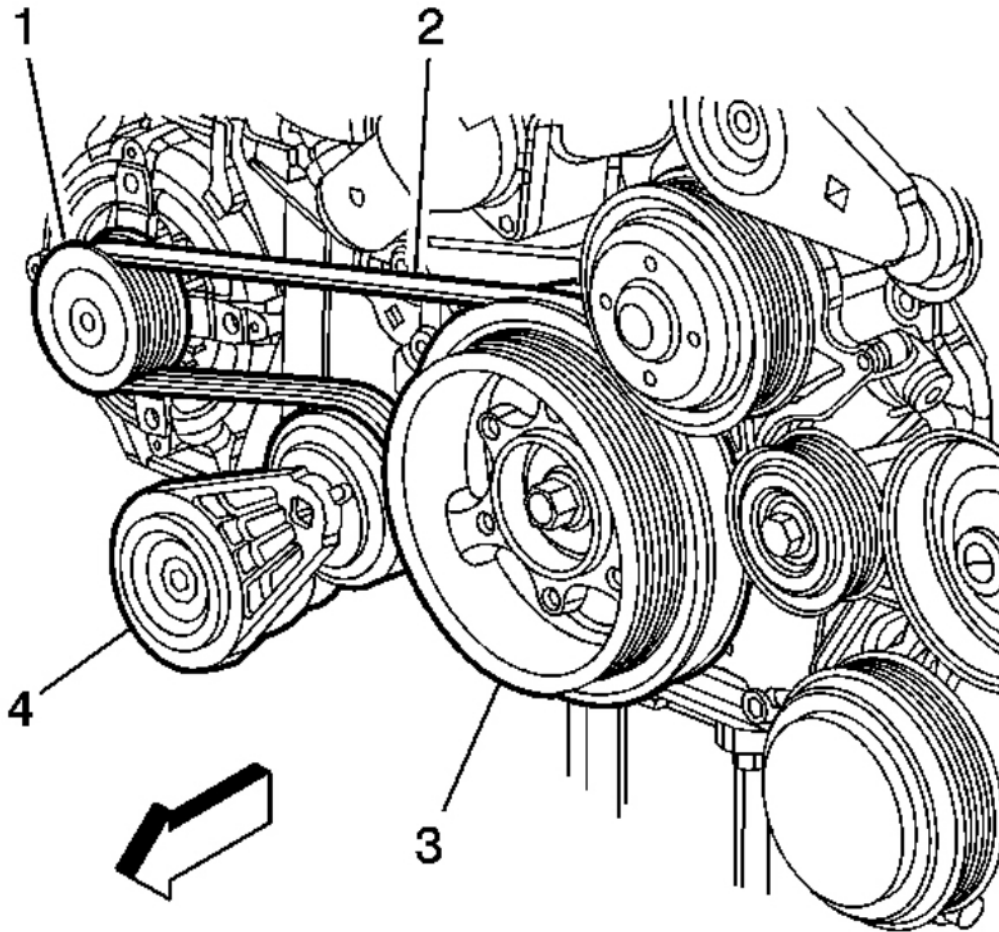


Fig. 3: View Of Generator Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Route the generator drive belt to the crankshaft pulley (3) and the tensioner (4).
2. Rotate the generator drive belt tensioner (4) clockwise.
3. Route the generator drive belt over the generator pulley (1).

IMPORTANT: Ensure that the generator drive belt is properly aligned and seated into the grooves of the accessory drive pulleys.

4. Release the drive belt tensioner and inspect the generator drive belt for proper seating in the accessory drive pulleys.

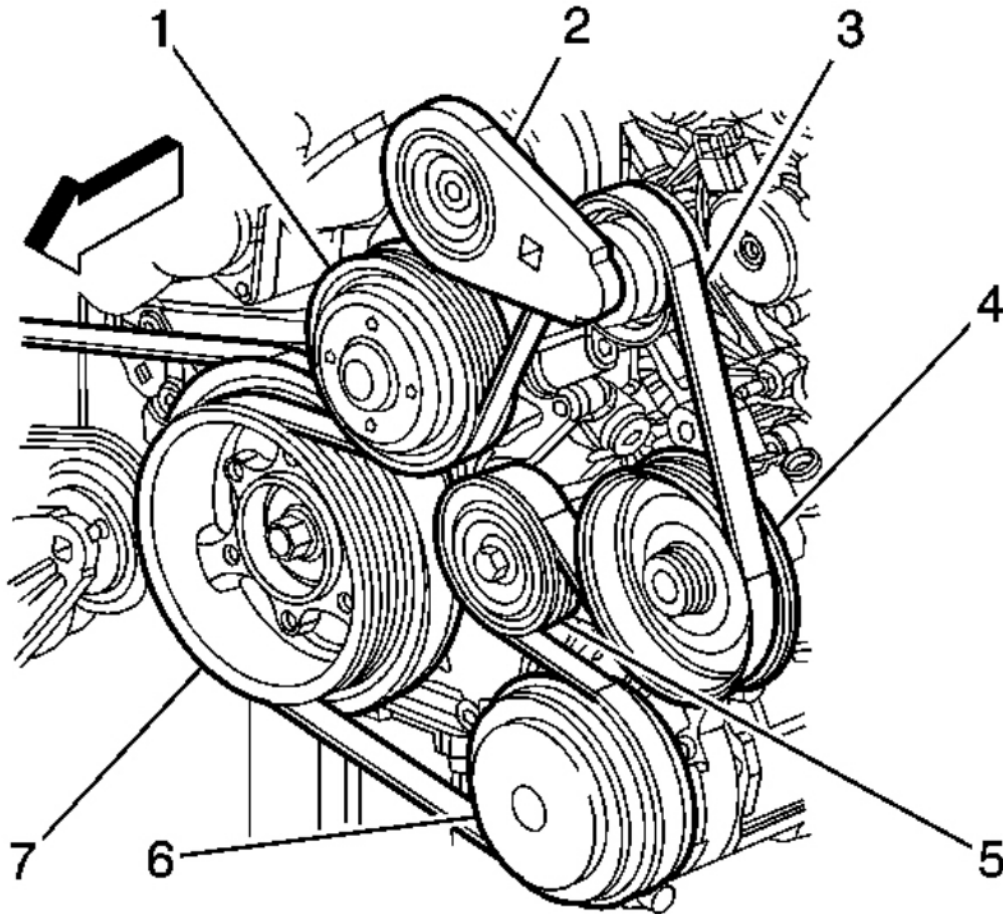


Fig. 4: View Of Air Conditioning, Power Steering & Water Pump Belt
Courtesy of GENERAL MOTORS CORP.

5. Install the air conditioning, power steering, and water pump belt (3). Refer to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump**.

DRIVE BELT REPLACEMENT - AIR CONDITIONING, POWER STEERING AND WATER PUMP PUMP

Removal Procedure

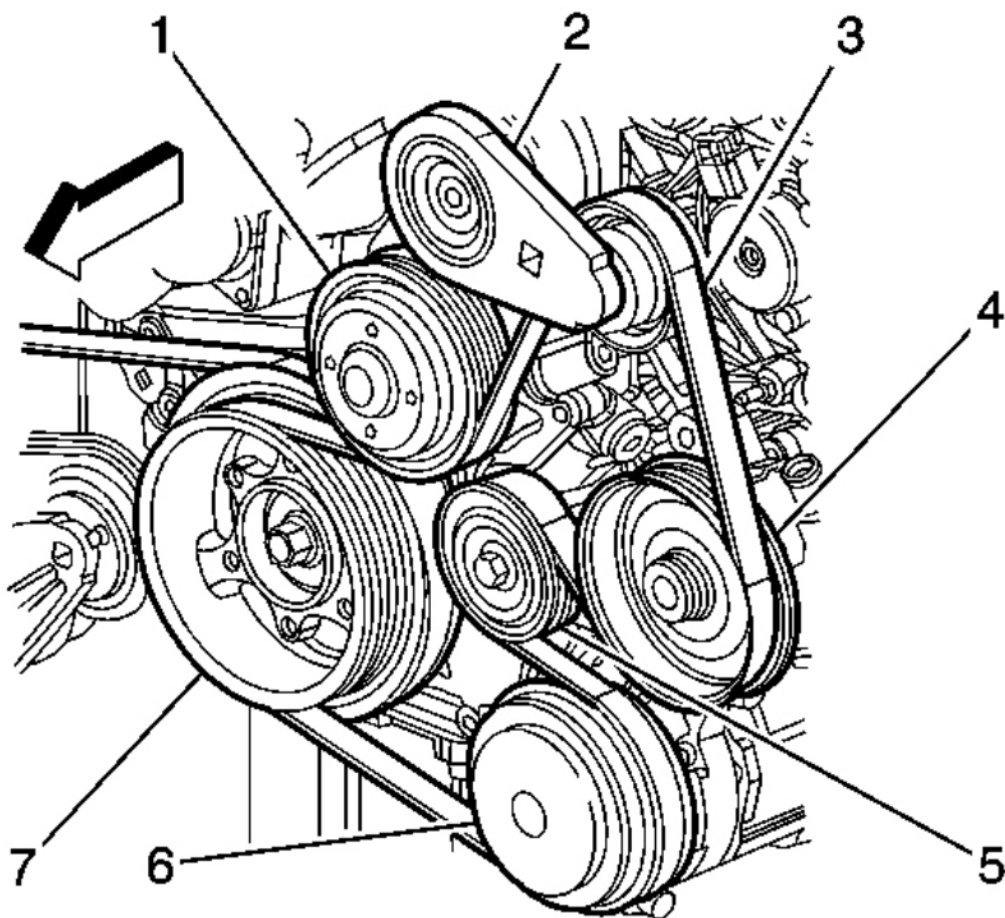


Fig. 5: View Of Air Conditioning, Power Steering & Water Pump Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** in Engine Controls 4.6L (LH2).
3. Remove the power steering fluid reservoir mounting nuts and position the reservoir aside. It is not necessary to remove the fluid lines. Refer to **Remote Power Steering Fluid Reservoir Replacement (LH2)** or **Remote Power Steering Fluid Reservoir Replacement (LY7)** in Power Steering System.
4. Rotate the drive belt tensioner (2) clockwise to release drive belt tension.

5. Slide the drive belt from the water pump pulley (1).
6. Slide the drive belt out from behind the drive belt tensioner. Access the belt from the side of the tensioner pulley in the location of the lower reservoir mounting nut.
7. Allow the drive belt tensioner to return to the relaxed position.
8. Remove the drive belt from the remaining pulleys.

Installation Procedure

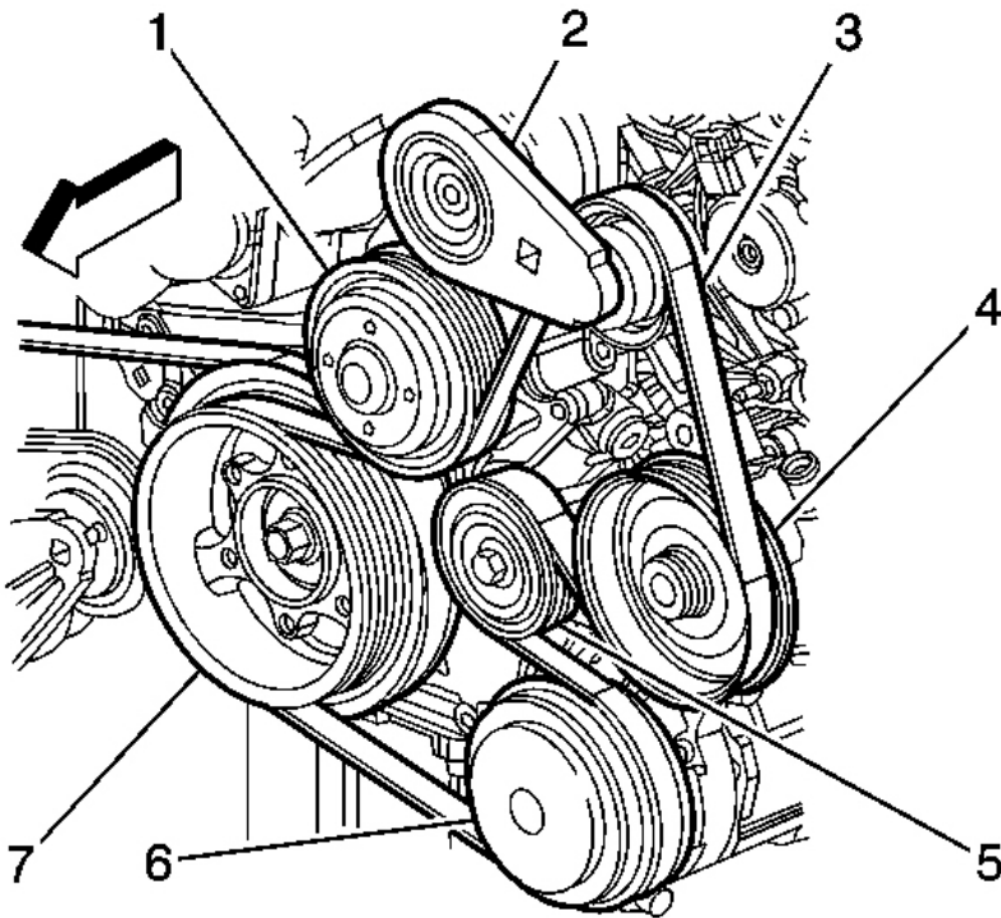


Fig. 6: View Of Air Conditioning, Power Steering & Water Pump Belt
Courtesy of GENERAL MOTORS CORP.

1. Route the drive belt to the accessory drive pulleys, excluding the tensioner (2) and the water

pump pulley (1).

2. Rotate the drive belt tensioner (2) clockwise.
3. Slide the drive belt behind the drive belt tensioner and around the tensioner pulley. Access the belt from the side of the tensioner pulley in the location of the lower reservoir mounting nut.
4. Route the drive belt under the water pump pulley (1).

IMPORTANT: Ensure the drive belt is properly aligned and seated into the grooves of the accessory drive pulleys.

5. Release the drive belt tensioner and inspect the drive belt for proper seating in the accessory drive pulleys.
6. Install the power steering fluid reservoir to the engine. Refer to **Remote Power Steering Fluid Reservoir Replacement (LH2)** or **Remote Power Steering Fluid Reservoir Replacement (LY7)** in Power Steering System.
7. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** in Engine Controls 4.6L (LH2).
8. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

DRIVE BELT TENSIONER REPLACEMENT - GENERATOR

Removal Procedure

1. Remove the air conditioning, power steering, and water pump drive belt. Refer to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump**.
2. Remove the generator drive belt. Refer to **Drive Belt Replacement - Generator**.

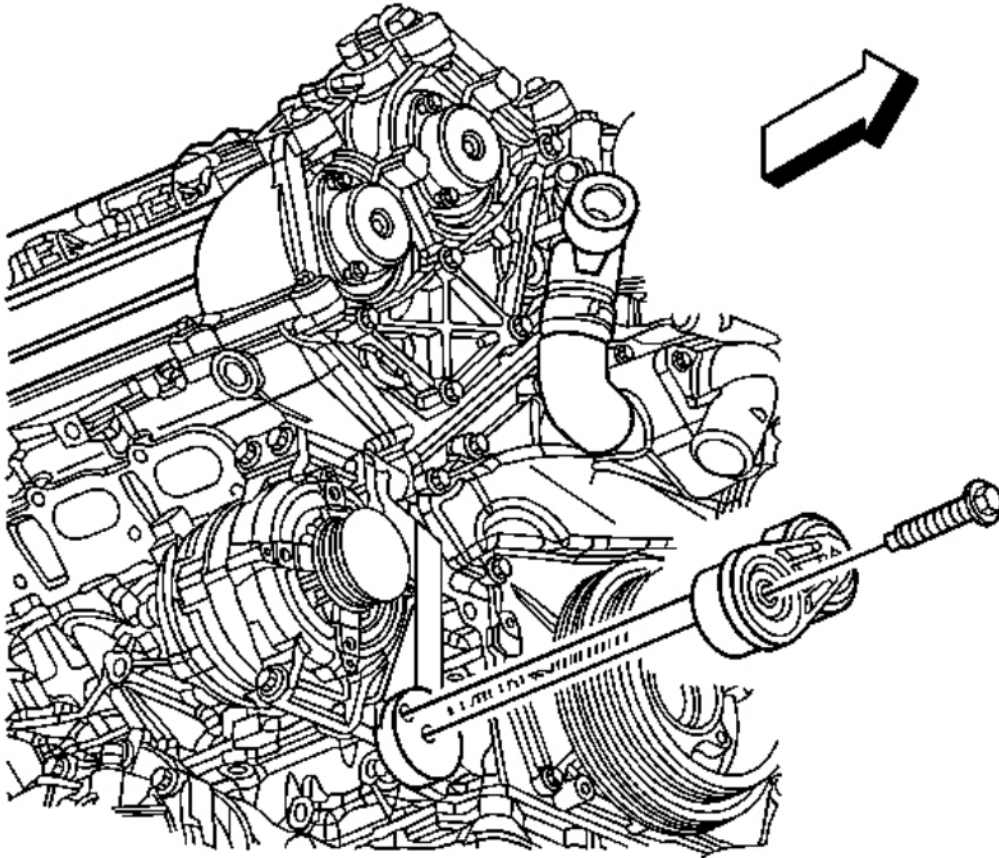


Fig. 7: View Of Generator Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Loosen the generator drive belt tensioner bolt.
4. Remove the drive belt tensioner and bolt from the engine.

Installation Procedure

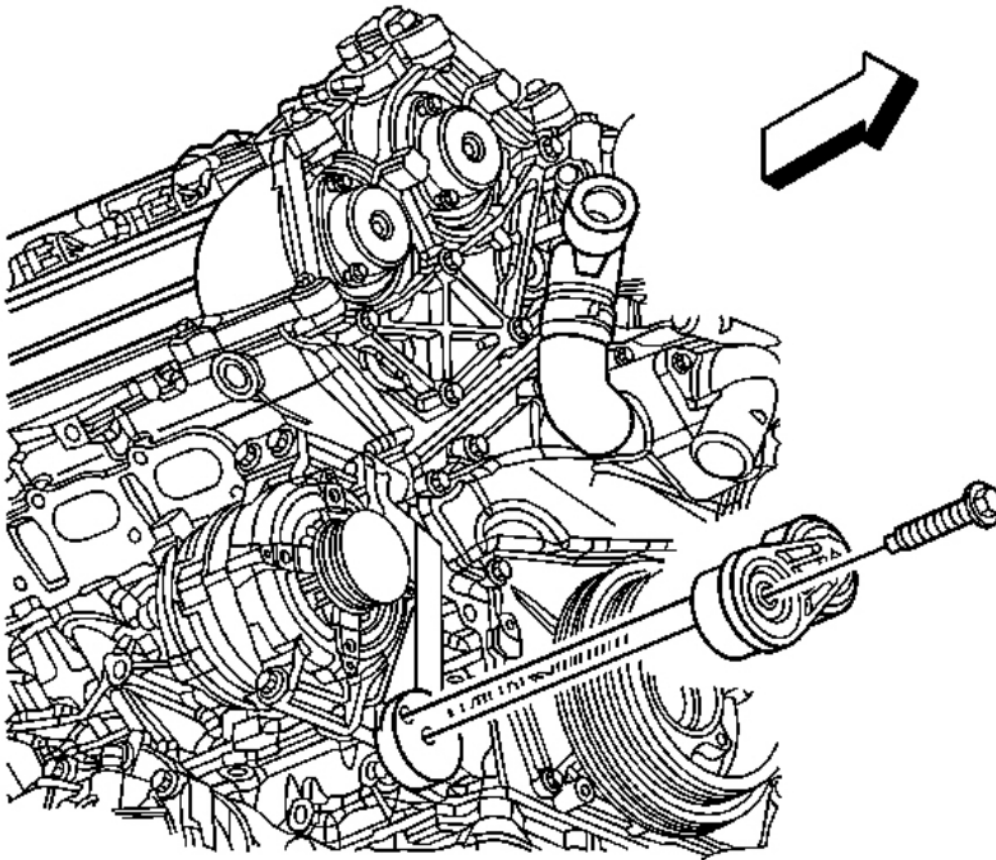


Fig. 8: View Of Generator Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the generator drive belt tensioner and bolt to the engine as an assembly.
2. Ensure that the alignment pin on the rear of the tensioner assembly is aligned with the locating hole on the engine.

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

3. Install the drive belt tensioner bolt.

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

4. Install the generator drive belt. Refer to **Drive Belt Replacement - Generator.**
5. Install the air conditioning, power steering, and water pump drive belt. Refer to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump.**

DRIVE BELT TENSIONER REPLACEMENT - AIR CONDITIONING, POWER STEERING AND WATER PUMP

Removal Procedure

1. Remove the air conditioning, power steering and water pump drive belt. Refer to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump.**

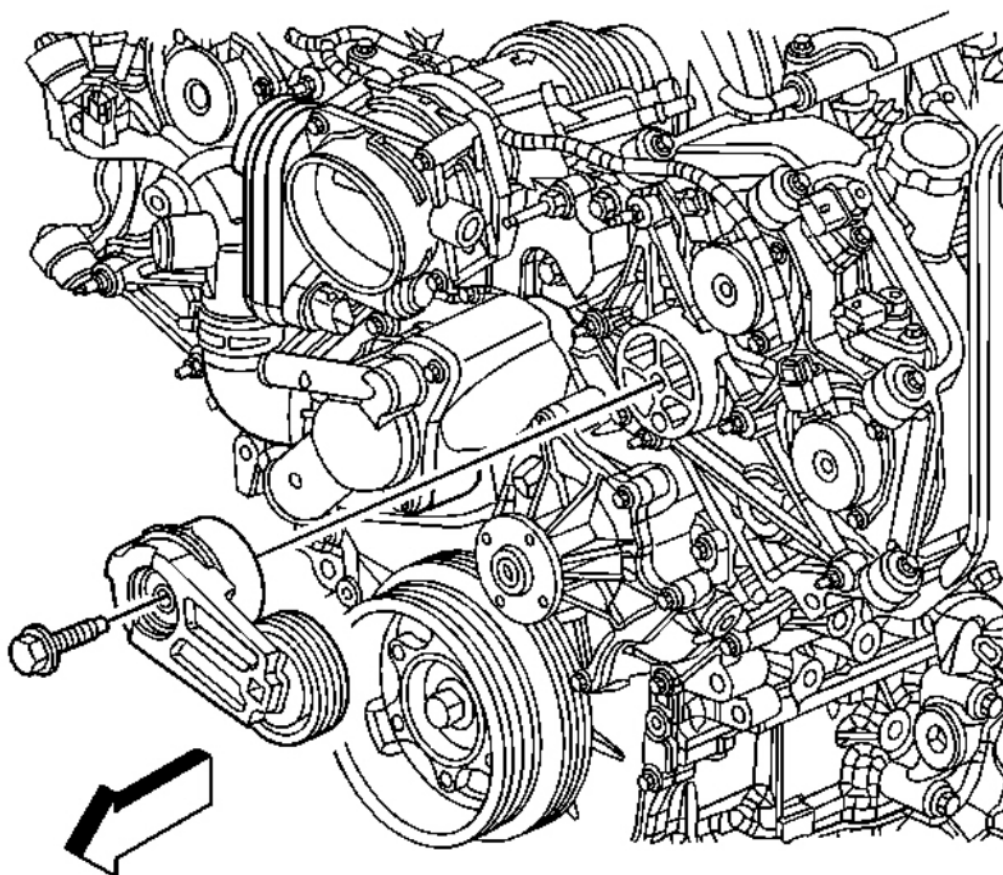


Fig. 9: View Of Air Conditioning, Power Steering & Water Pump Drive Belt Tensioner

Courtesy of GENERAL MOTORS CORP.

2. Loosen the drive belt tensioner bolt.
3. Remove the drive belt tensioner and bolt from the engine.

Installation Procedure

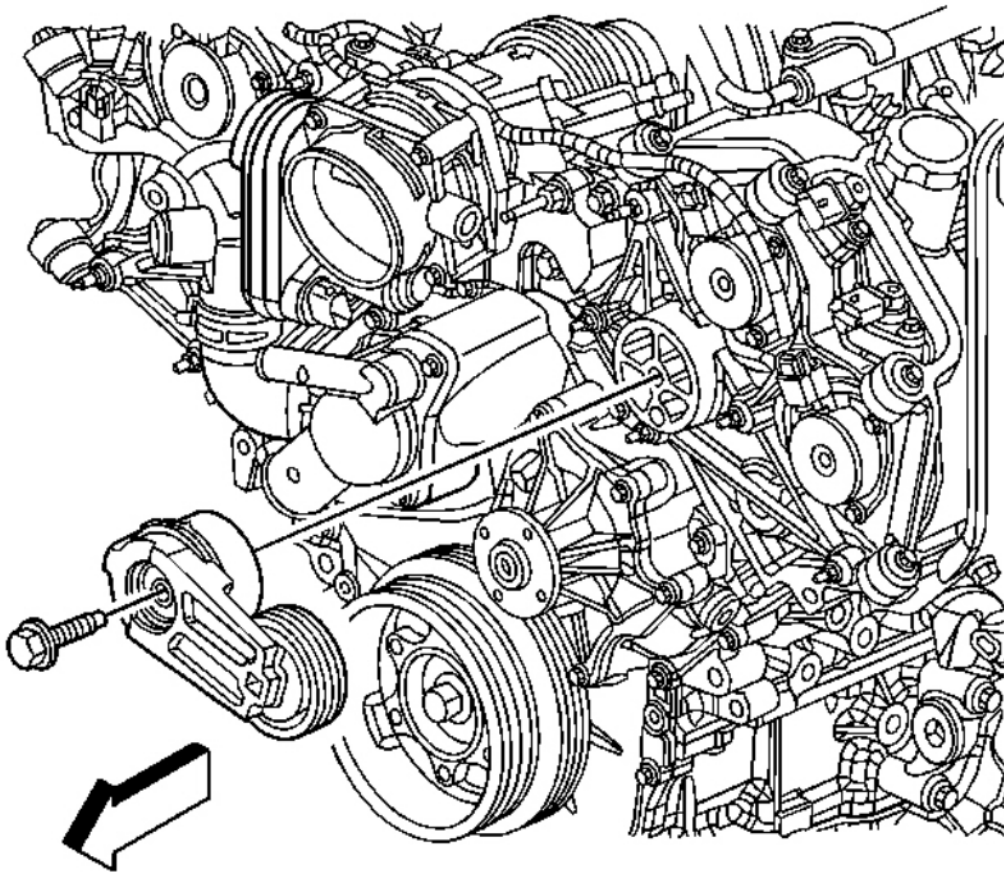


Fig. 10: View Of Air Conditioning, Power Steering & Water Pump Drive Belt Tensioner

Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner and bolt to the engine as an assembly.
2. Ensure that the alignment pin on the rear of the tensioner assembly is aligned with the locating hole on the engine.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the drive belt tensioner bolt.

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

4. Install the air conditioning, power steering and water pump drive belt. Refer to Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump.

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

1. Remove the air conditioning, power steering and water pump drive belt. Refer to Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump.

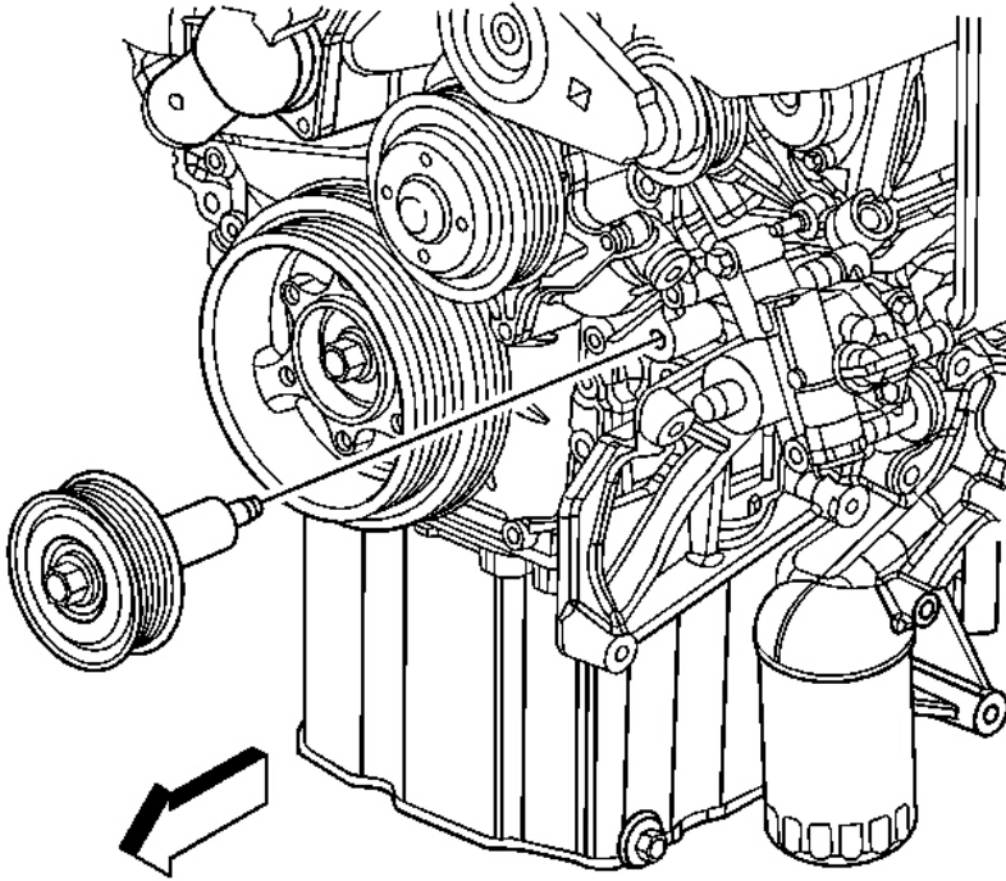


Fig. 11: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

2. Remove the drive belt idler pulley bolt.
3. Remove the drive belt idler pulley.

Installation Procedure

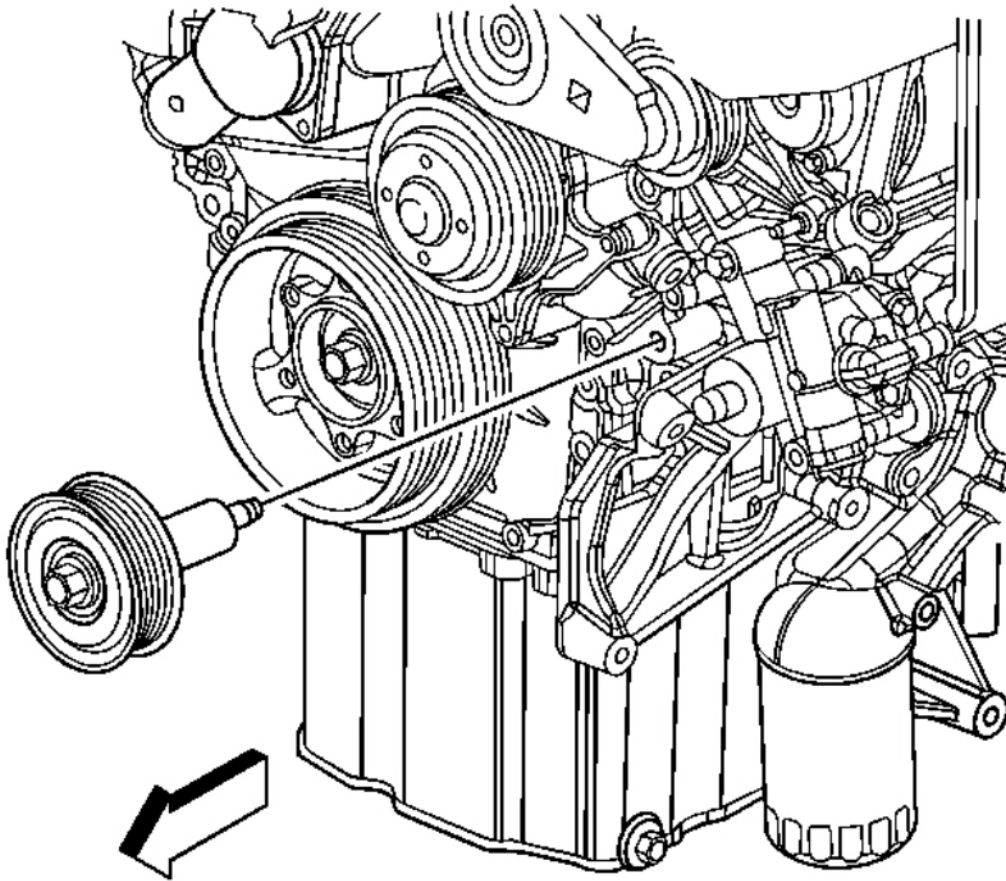


Fig. 12: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt idler pulley.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt idler pulley bolt.

Tighten: Tighten the drive belt idler pulley bolt to 50 N.m (37 lb ft).

3. Install the drive belt. Refer to Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump.

ENGINE SUPPORT FIXTURE

Tools Required

- **J 28467-15** Engine Support Adapter
- **J 28467-86** Engine Lift Bracket
- **J 28467-87** Engine Lift Bracket
- **J 28467-B** Universal Engine Support Fixture

Installation Procedure

IMPORTANT: The following procedure is for supporting the engine in vehicle. The J 28467-15 is for supporting the engine in vehicle only. It is not intended to be used for lifting the engine once the engine is removed. The J 28467-86 that bolts to the left front cylinder head is used for engine support in vehicle and engine lifting once the engine is removed. The J 28467-87 is only used to lift the engine once the engine is removed from the vehicle. The J 28467-87 can not be used for engine support in vehicle due to limited access to the rear of the right cylinder head in the area where the bracket mounts.

1. Instructions for the right rear **J 28467-87** are included at the end of this procedure.

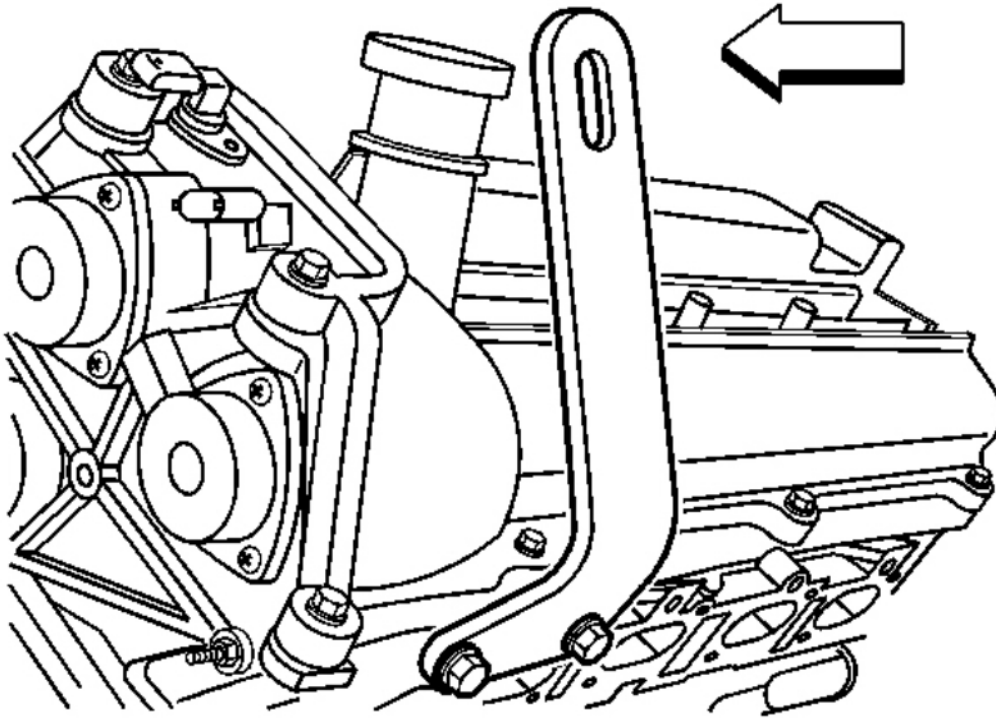


Fig. 13: View Of J 28467-86

Courtesy of GENERAL MOTORS CORP.

2. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
3. Remove the wiring harness push pin from the left front cylinder head bolt hole.
4. Install the **J 28467-86** to the left cylinder head.

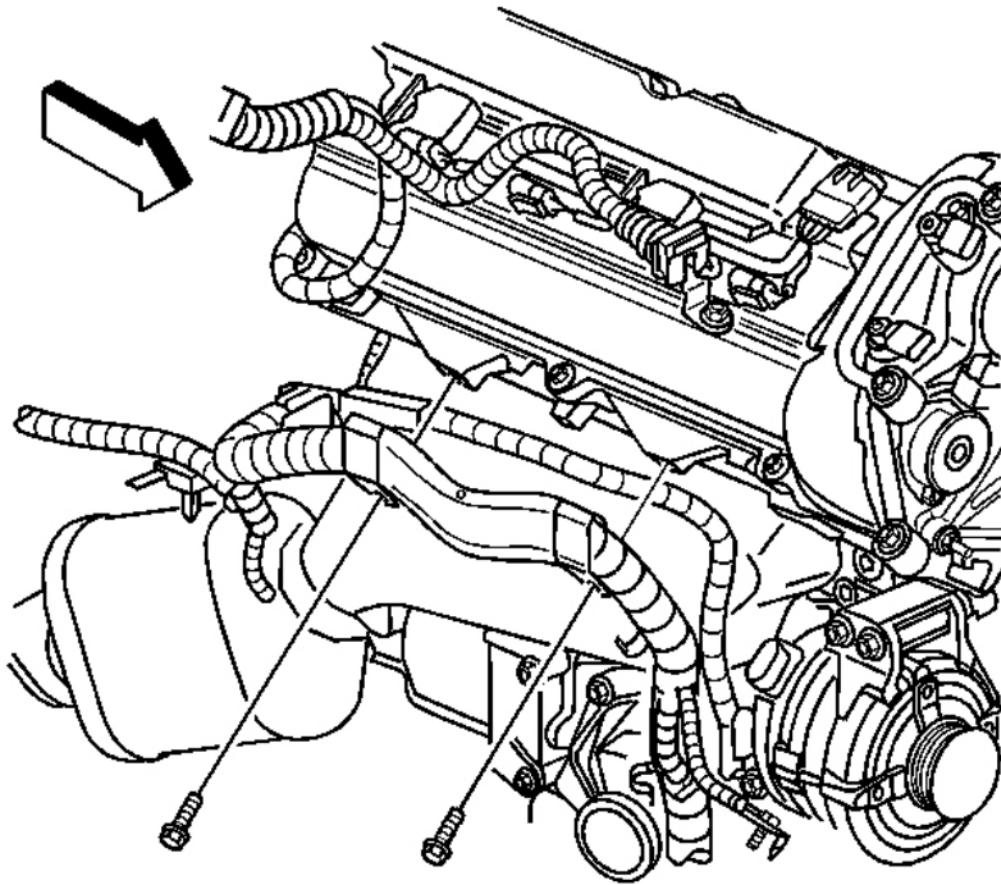


Fig. 14: View Of Right Cylinder Head Wiring Harness Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the front bolt securing the wiring harness bracket to the right cylinder head.

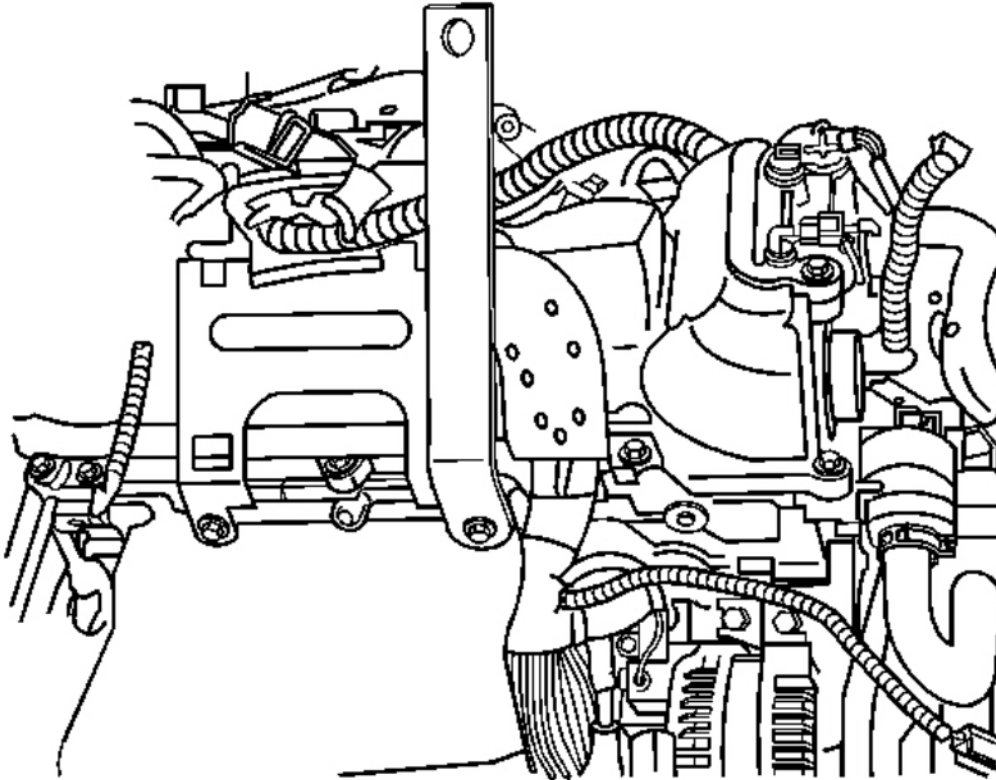


Fig. 15: Installing J 28467-15
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 28467-15** to the right cylinder head. The graphic shows the engine removed for clarity.

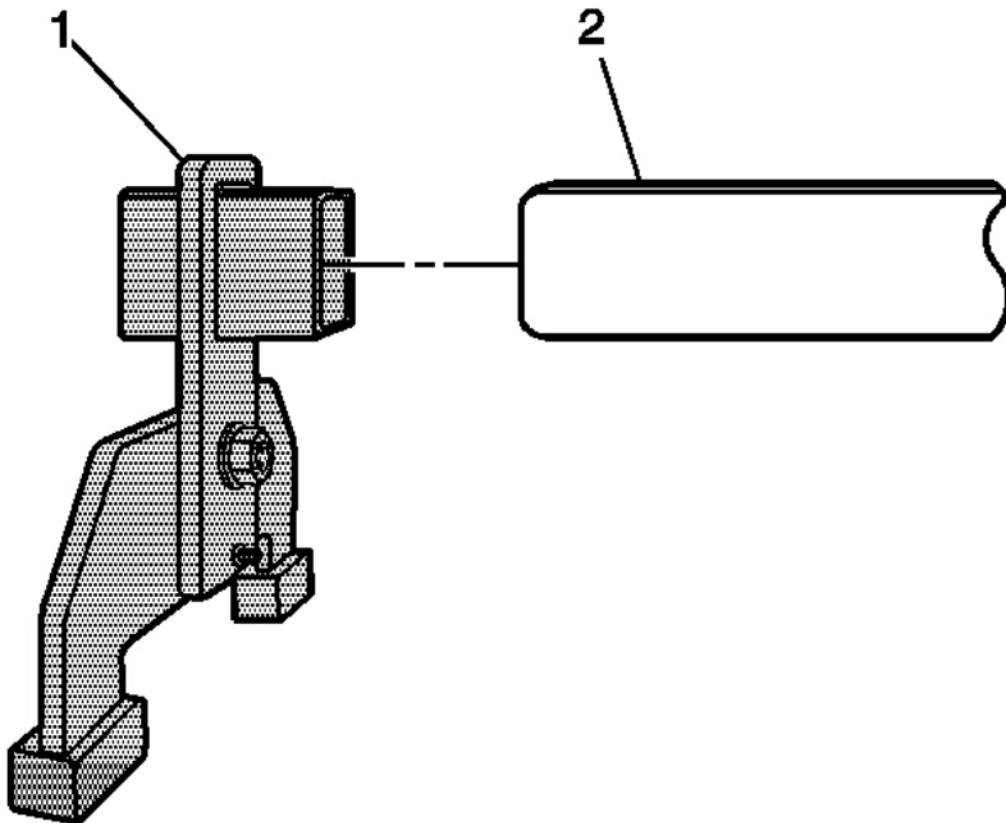


Fig. 16: Identifying J 28467-B & J 28467-3
Courtesy of GENERAL MOTORS CORP.

7. Assemble a J 28467-501A (1) to each end of the J 28467-518 (2).

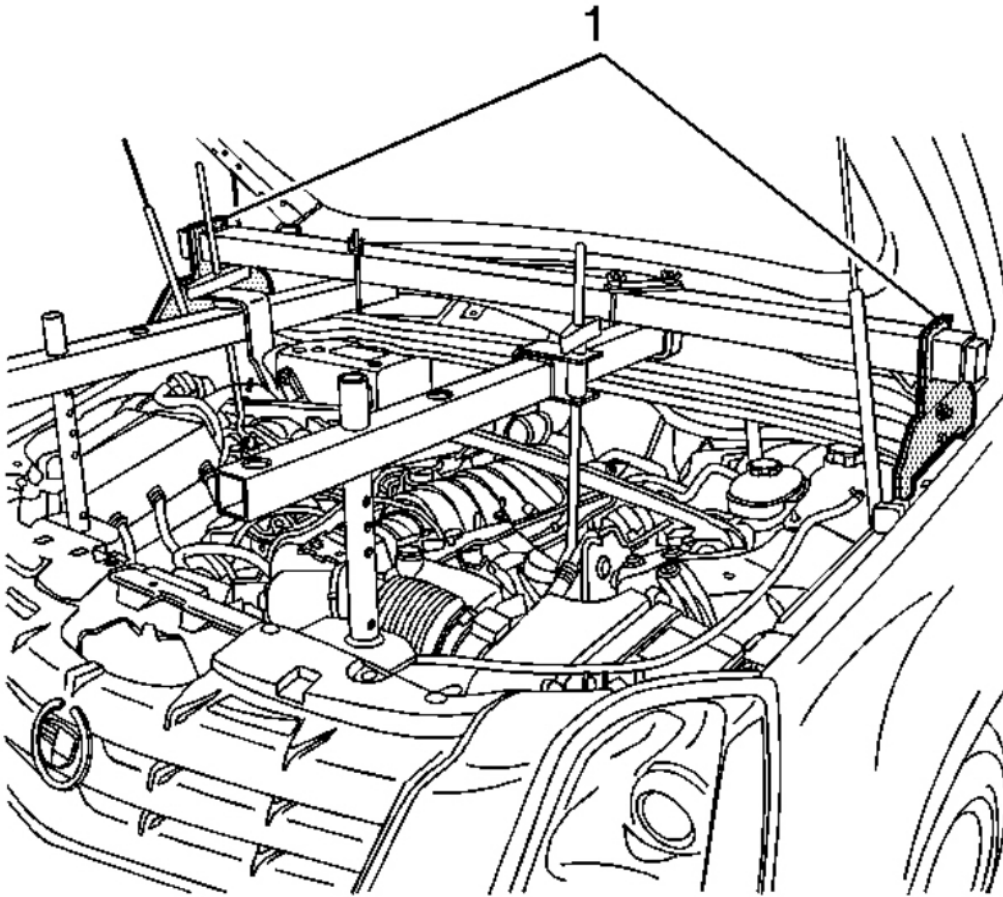


Fig. 17: View Of Main Support Beam & Rail Support Assembly
Courtesy of GENERAL MOTORS CORP.

8. Position the main support beam and rail support assembly (1) on the fender flange.

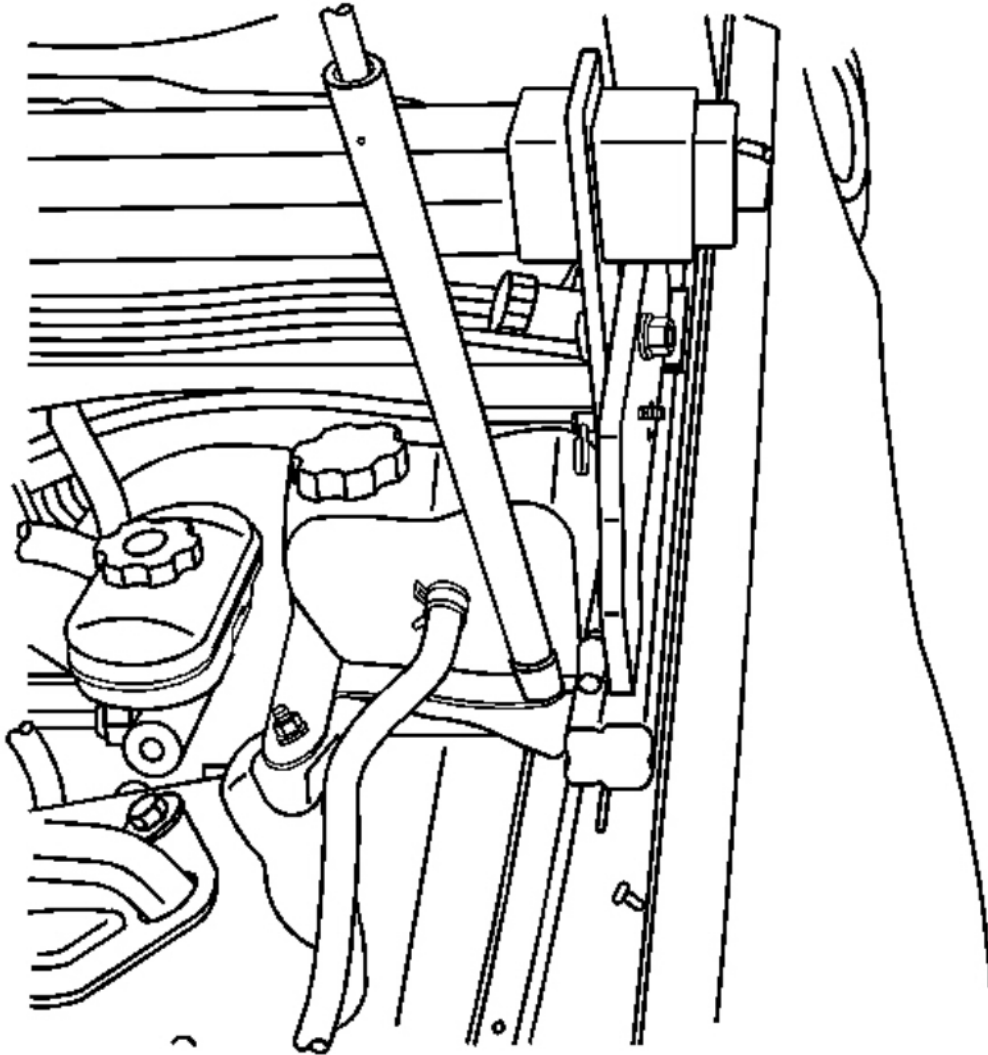


Fig. 18: Ensuring Proper Rail Support Seating
Courtesy of GENERAL MOTORS CORP.

9. Ensure that the rear portion of the rail support is resting on the reinforced section of the fender flange.

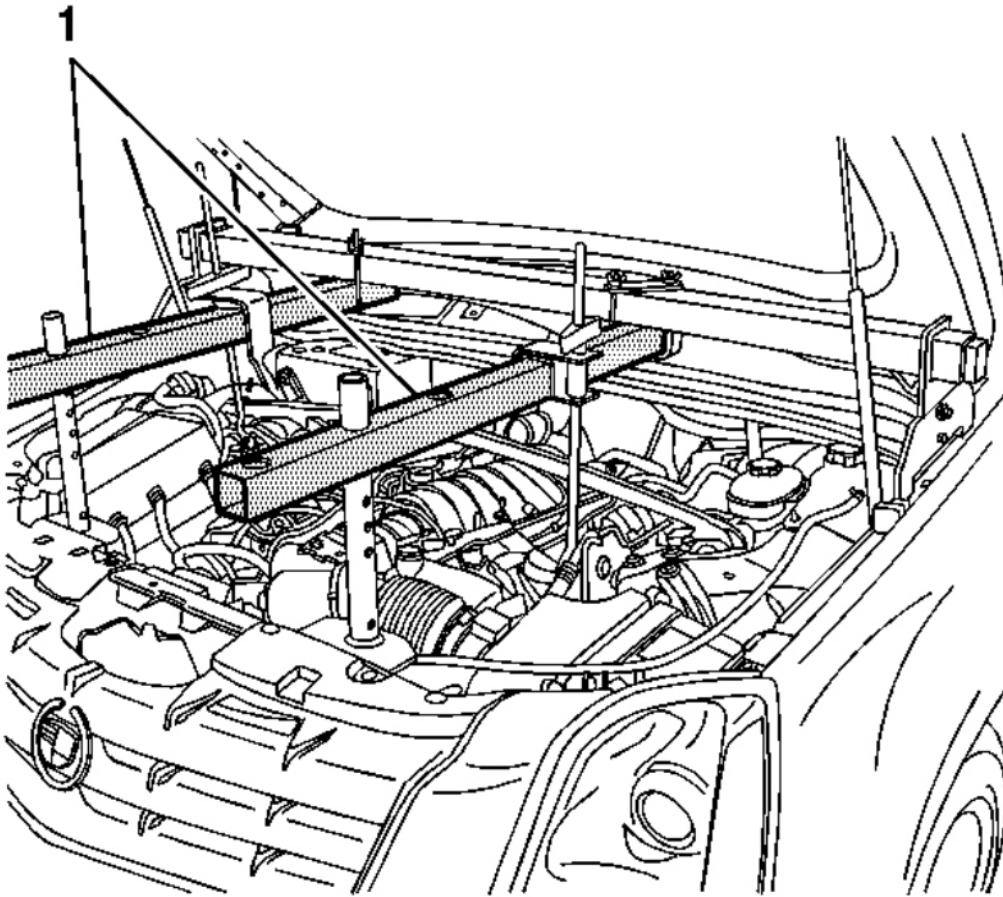


Fig. 19: View Of J 28467-16 Tube Assembly
Courtesy of GENERAL MOTORS CORP.

10. Assemble a J 28467-16 tube assembly (1) to each end of the J 28467-518, in line with the lift bracket and support bracket, using the J 28467-1 cross brackets.

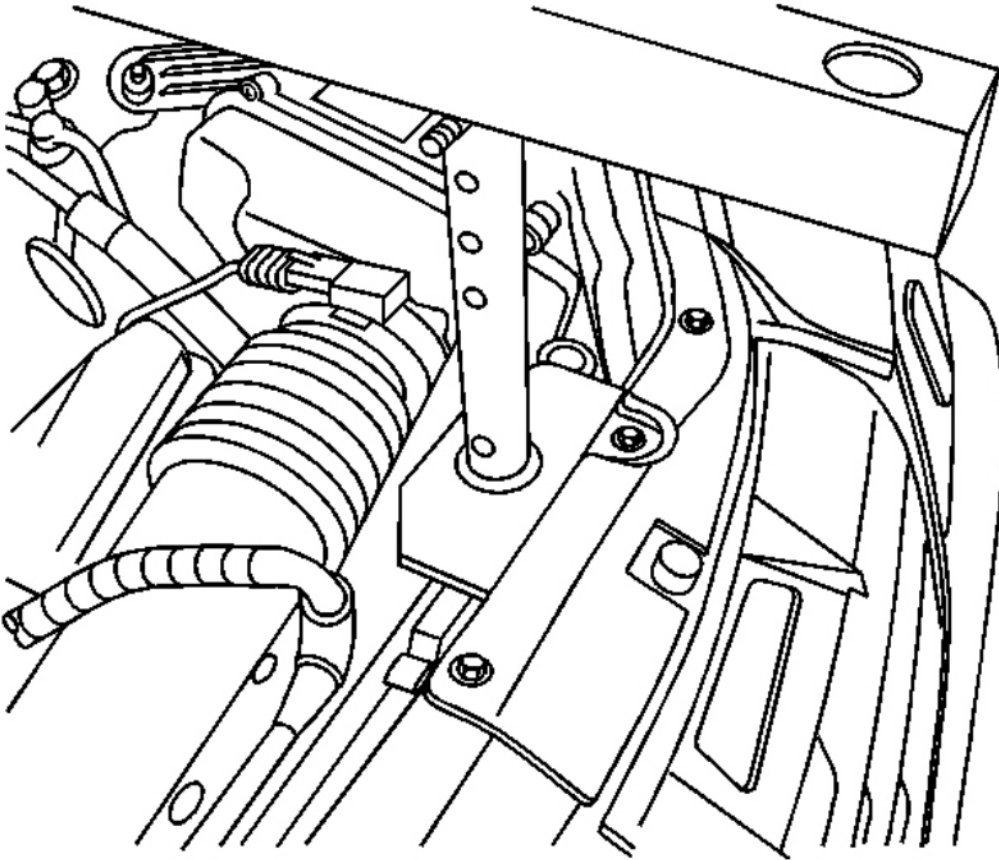


Fig. 20: Installing J 28467-4A To J 28467-16
Courtesy of GENERAL MOTORS CORP.

11. Install the J 28467-4A front support assemblies to the J 28467-16 using the J 28467-9 quick release pins. Ensure that the J 28467-16 are as level as possible by selecting the appropriate hole for the quick release pins.

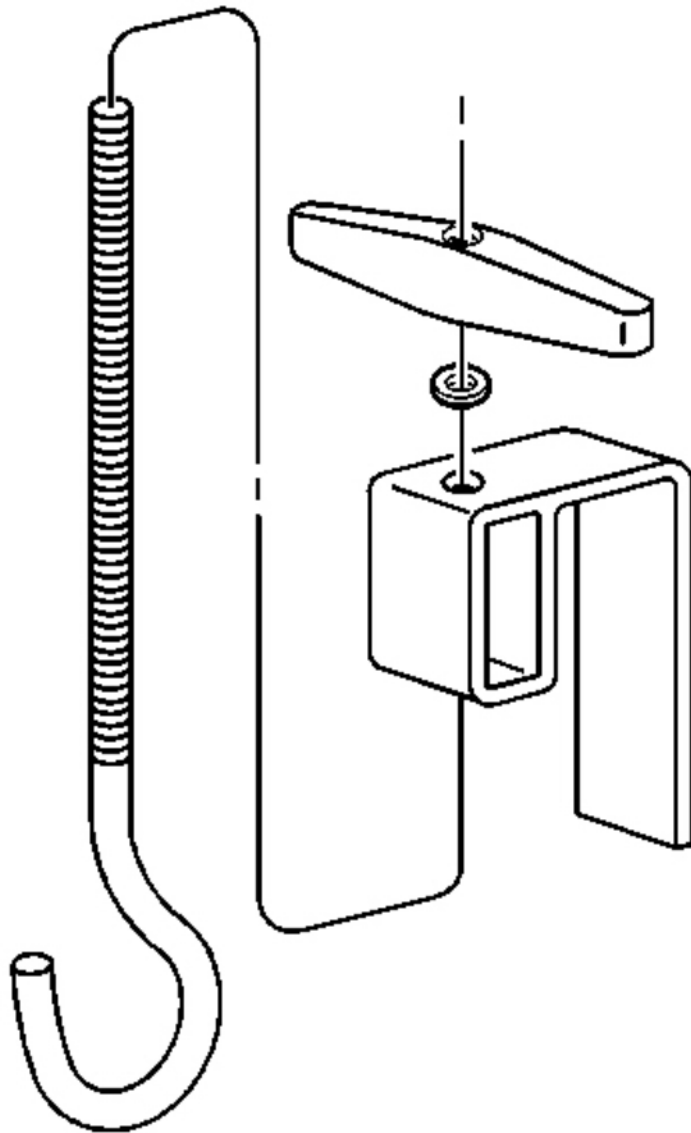


Fig. 21: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

12. Install the J 28467-7A , as required, to lift the hook through the J 28467-6A lift hook bracket.
13. Install the 1/2 inch lift hook washer and the J 28467-34 lift hook wing nut onto the J 28467-

7A lift hook.

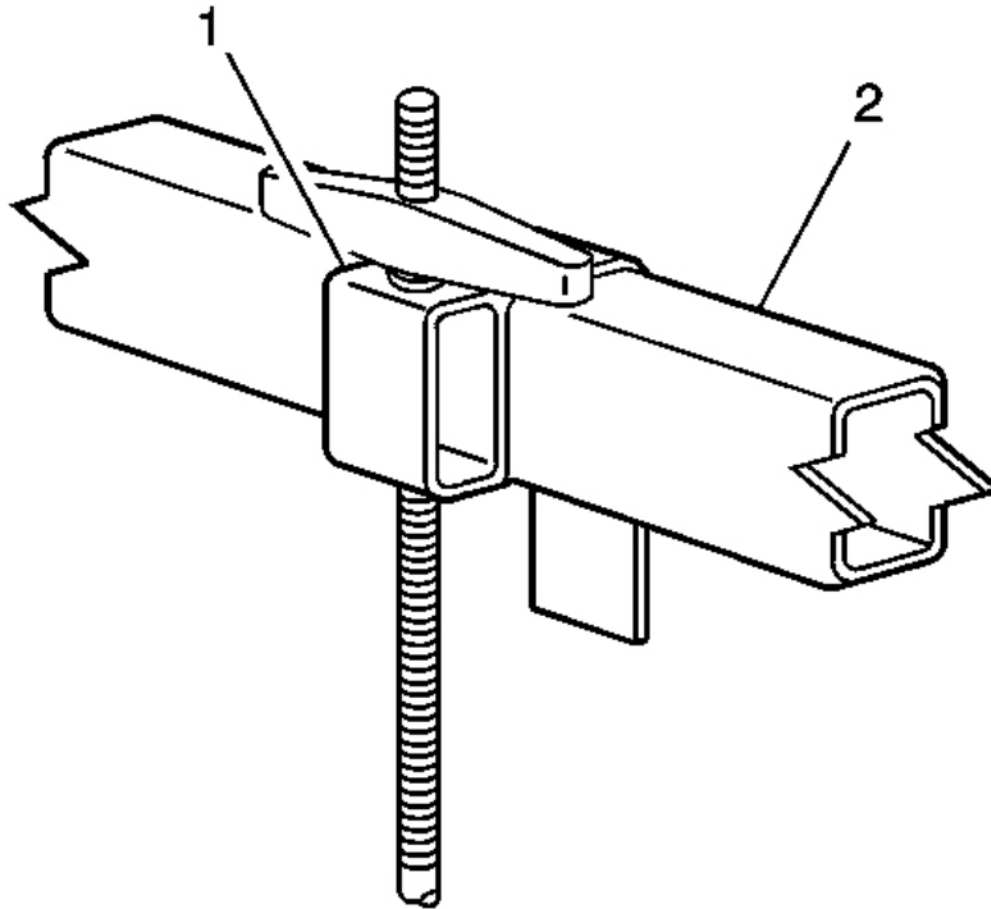


Fig. 22: View Of Lift Hook & Bracket Assembly At Longitudinal Mounted Cross Bar

Courtesy of GENERAL MOTORS CORP.

14. Install the J 28467-6A (1) over the J 28467-16 (2).
15. Adjust the J 28467-6A bracket (1) in order to align the hook with the left **J 28467-86** .
16. Repeat the previous step for the right **J 28467-15** .

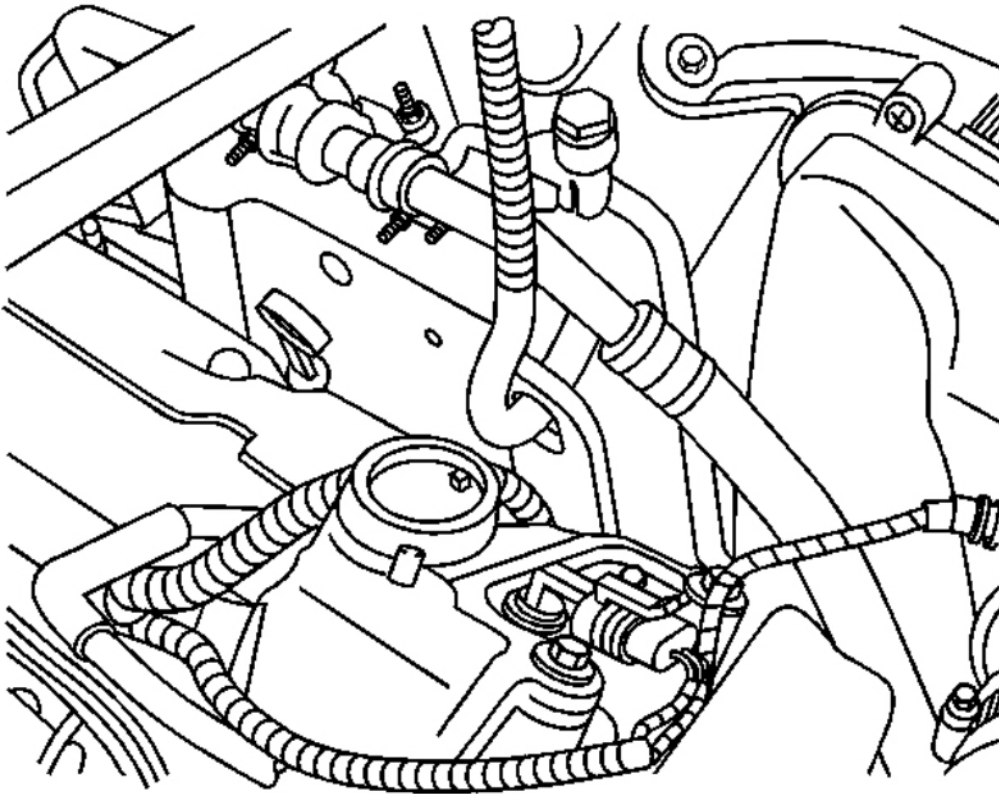


Fig. 23: Installing J 28467-7A Through Engine Lift Bracket & Engine Support Adapter
Courtesy of GENERAL MOTORS CORP.

17. Install each J 28467-7A through each engine lift bracket and engine support adapter. Ensure that the hooks do not damage the surrounding components.
18. Hand-tighten the J 28467-34 securely to remove all slack from the engine support fixture assembly.
19. The engine is now supported in vehicle to perform repairs that require front frame removal.

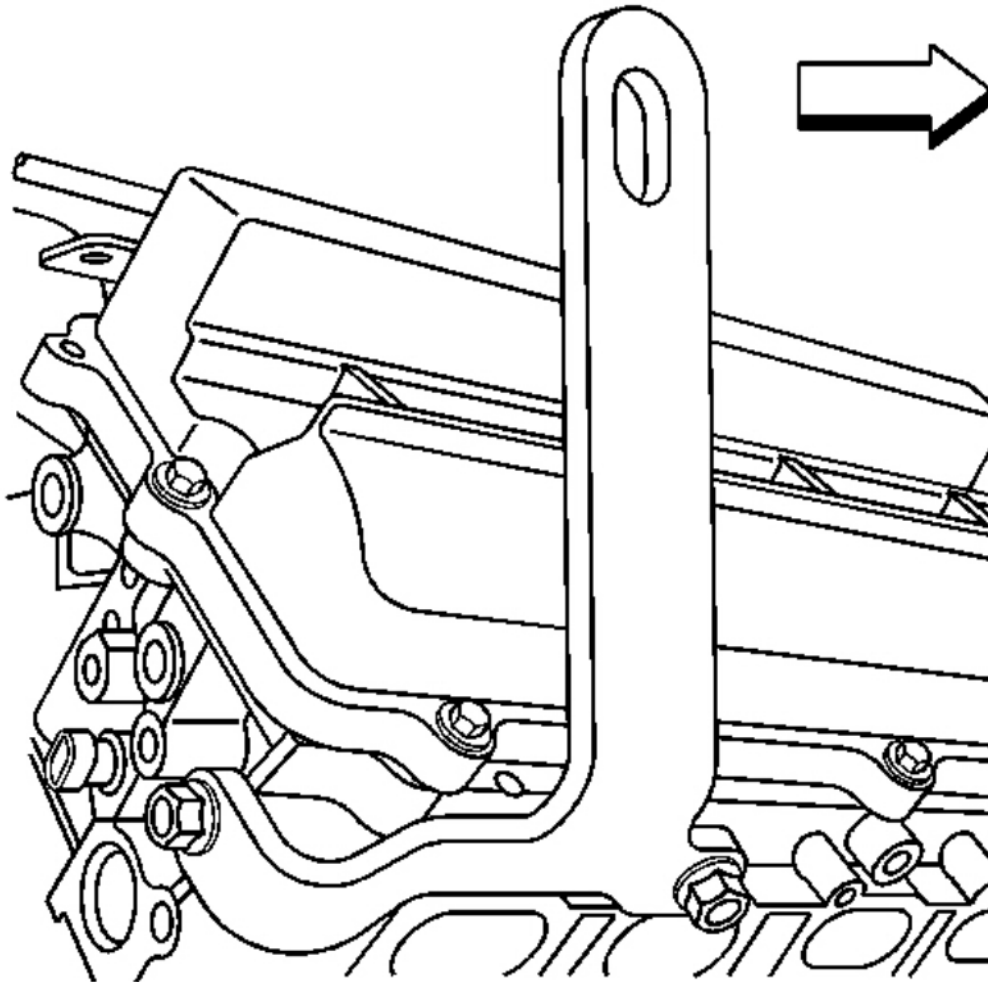


Fig. 24: View Of J 28467-87

Courtesy of GENERAL MOTORS CORP.

20. The **J 28467-87** is used to lift the engine once the engine is removed from the vehicle.
21. Remove the ground strap from the right rear cylinder head and bolt the **J 28467-87** in position.
22. The **J 28467-87** and the **J 28467-86** can now be used to lift the engine.

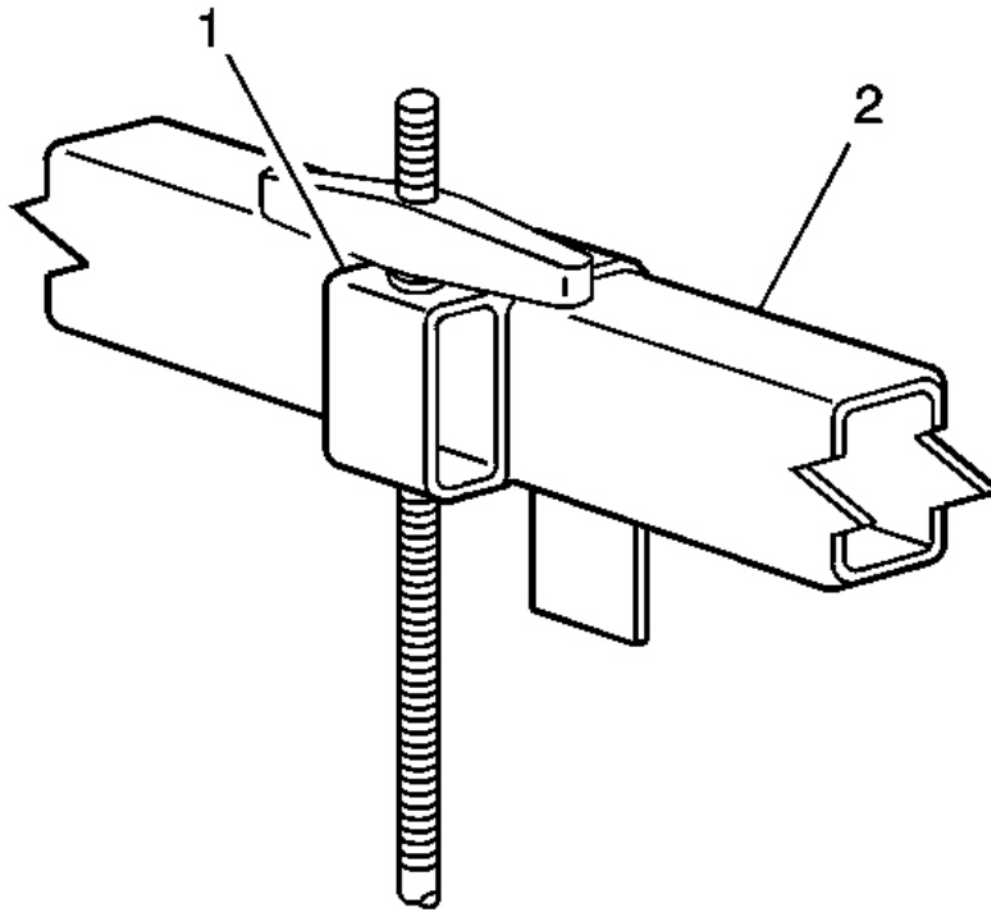


Fig. 25: View Of Lift Hook & Bracket Assembly At Longitudinal Mounted Cross Bar

Courtesy of GENERAL MOTORS CORP.

1. Unscrew the lift hooks (1) and remove them from the lift bracket and the support brackets. Remove the lift hooks from the tube assemblies.
2. Remove the front tube and support assemblies from the main support beam.
3. Remove the main support beam assembly.
4. Remove the **J 28467-15** from the right cylinder head.

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

5. Install the front wire harness bracket bolt.

Tighten: Tighten the wire harness bracket bolt to 45 N.m (33 lb ft).

6. Remove the **J 28467-86** from the left cylinder head.
7. Install the push pin securing the wiring harness to the left cylinder head.
8. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield 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.
 - The GLYCOL™ fluid is leaking from 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 Mount Replacement - Left** or **Engine Mount Replacement - Right (w/RWD)** or **Engine Mount Replacement - Right (w/AWD)**.

ENGINE MOUNT REPLACEMENT - LEFT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left**.

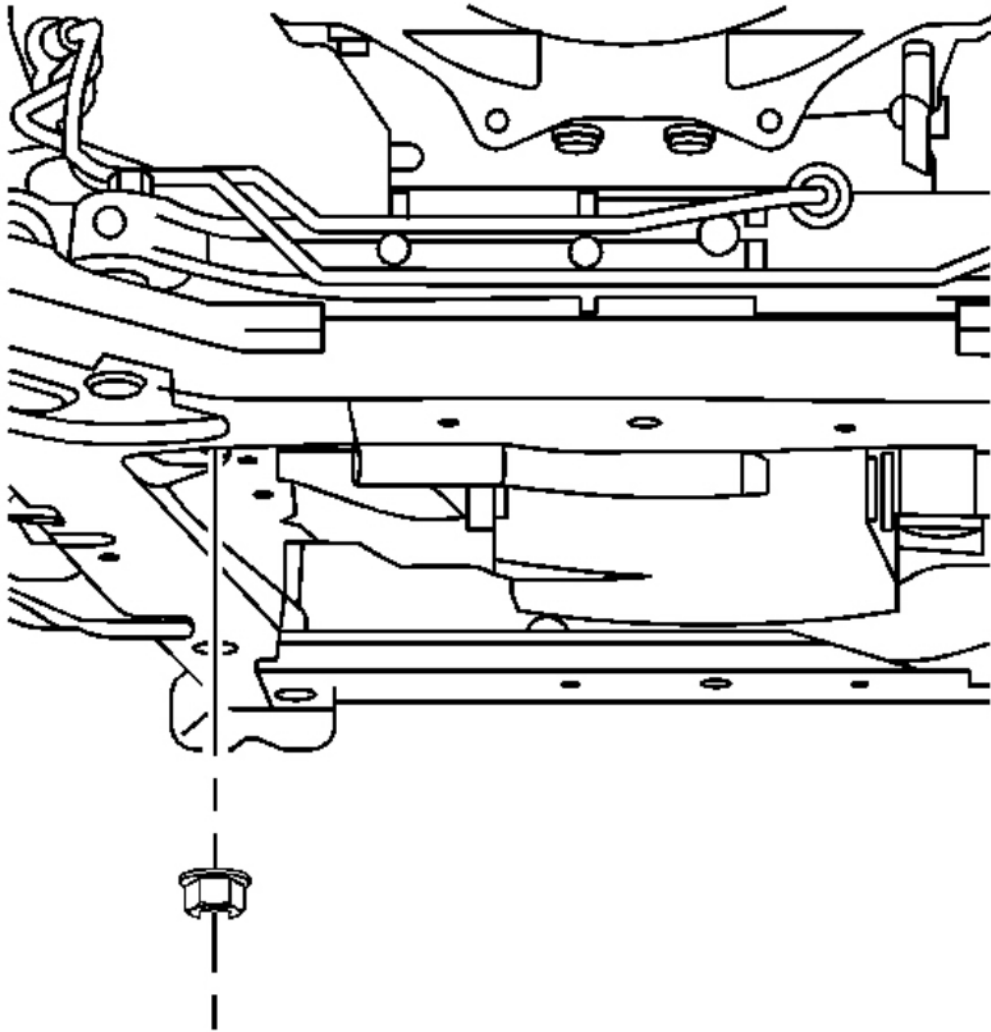


Fig. 26: View Of Left Lower Engine Mount Retaining Nut
Courtesy of GENERAL MOTORS CORP.

3. Remove the lower engine mount retaining nut.
4. Remove the engine mount from the vehicle.

Installation Procedure

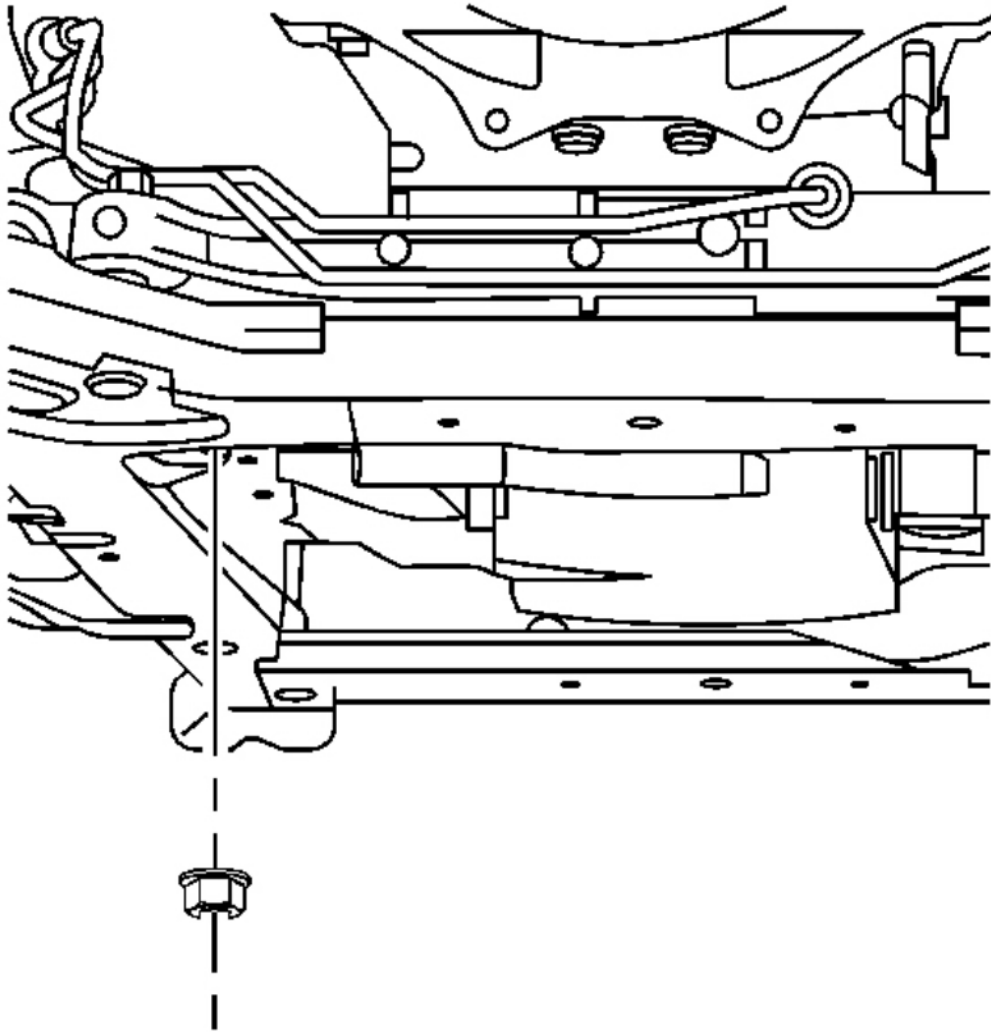


Fig. 27: View Of Left Lower Engine Mount Retaining Nut
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount to the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount lower retaining nuts.

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

3. Install the left engine mount bracket. Refer to Engine Mount Bracket Replacement - Left.
4. Lower the vehicle.

ENGINE MOUNT REPLACEMENT - RIGHT (W/RWD)

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the right engine mount bracket. Refer to Engine Mount Bracket Replacement - Right (w/RWD) or Engine Mount Bracket Replacement - Right (w/AWD).

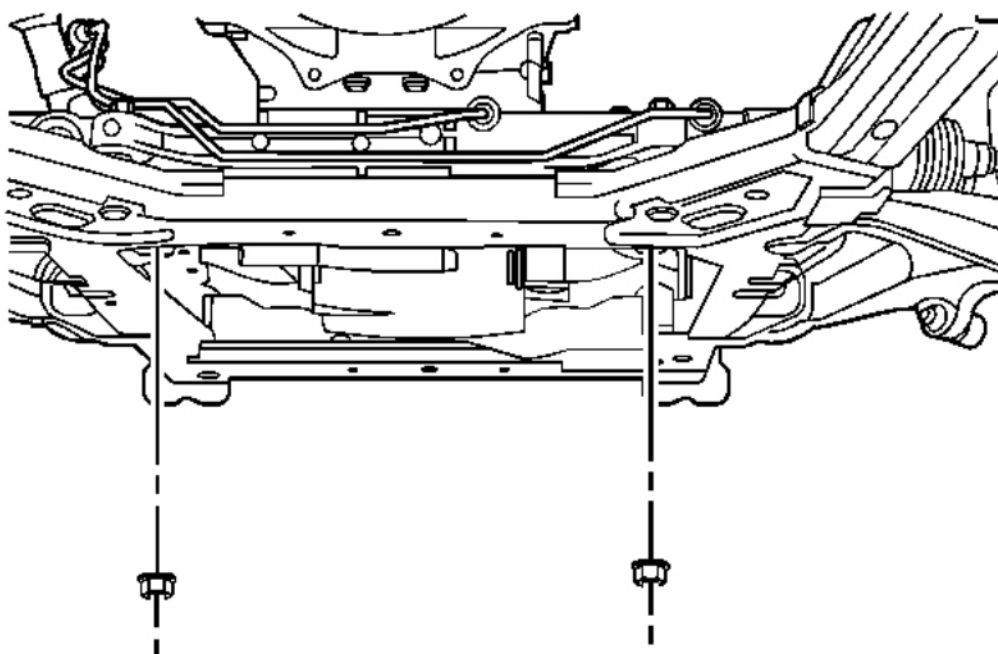


Fig. 28: View Of Right Engine Mount Retaining Nut - RWD
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine mount retaining nut.

4. Remove the engine mount from the vehicle.

Installation Procedure

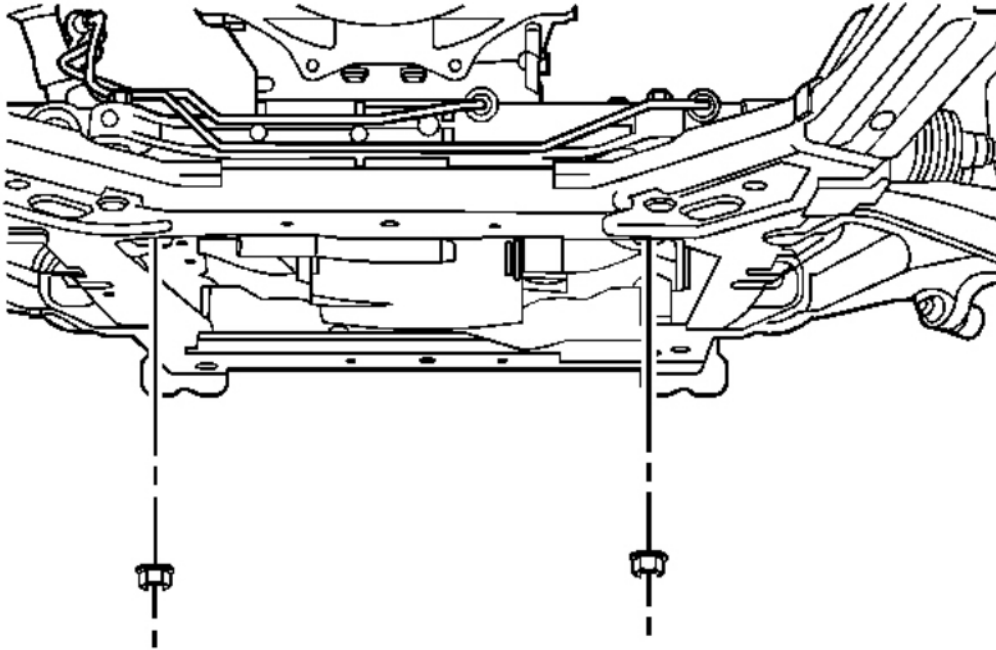


Fig. 29: View Of Right Engine Mount Retaining Nut - RWD
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount to the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount retaining nut.

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

3. Install the right engine mount bracket. Refer to Engine Mount Bracket Replacement - Right (w/RWD) or Engine Mount Bracket Replacement - Right (w/AWD).
4. Lower the vehicle.

ENGINE MOUNT REPLACEMENT - RIGHT (W/AWD)

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the right engine mount bracket. Refer to Engine Mount Bracket Replacement - Right (w/RWD) or Engine Mount Bracket Replacement - Right (w/AWD).

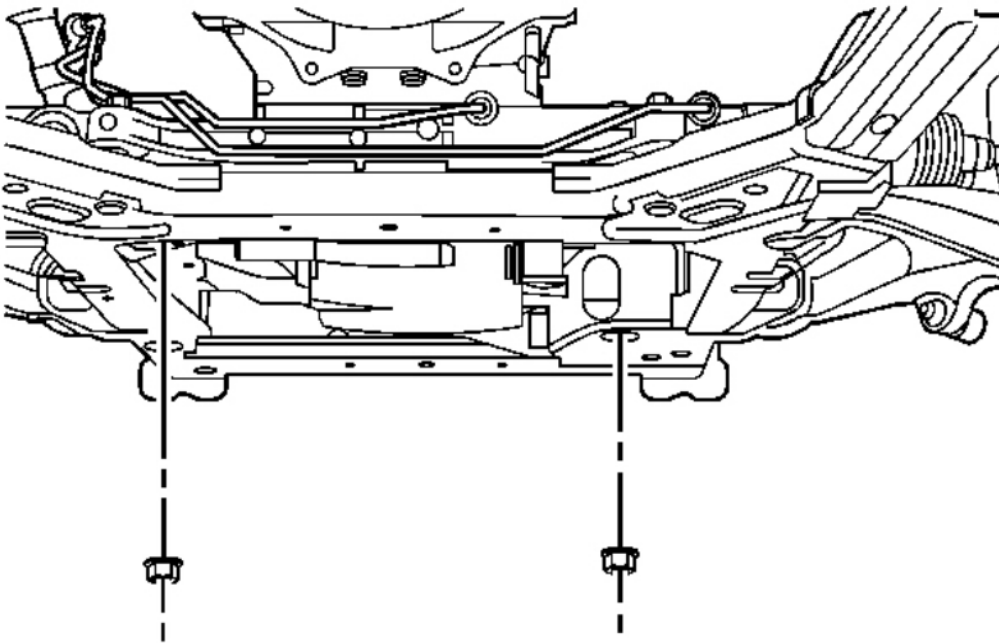


Fig. 30: View Of Engine Mount Lower Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine mount retaining nut.
4. Remove the engine mount from the vehicle.

Installation Procedure

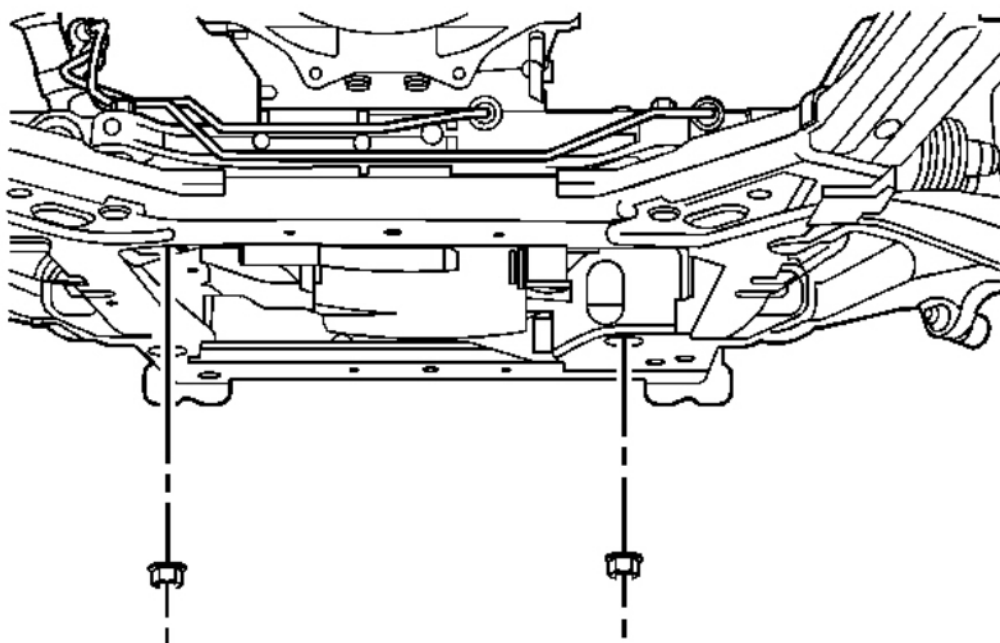


Fig. 31: View Of Engine Mount Lower Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount to the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount retaining nut.

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

3. Install the right engine mount bracket. Refer to Engine Mount Bracket Replacement - Right (w/RWD) or Engine Mount Bracket Replacement - Right (w/AWD).
4. Lower the vehicle.

ENGINE MOUNT BRACKET REPLACEMENT - LEFT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the left exhaust manifold. Refer to **Exhaust Manifold Removal - Left** .
3. Install a screw jack with a block of wood under the oil pan for support.

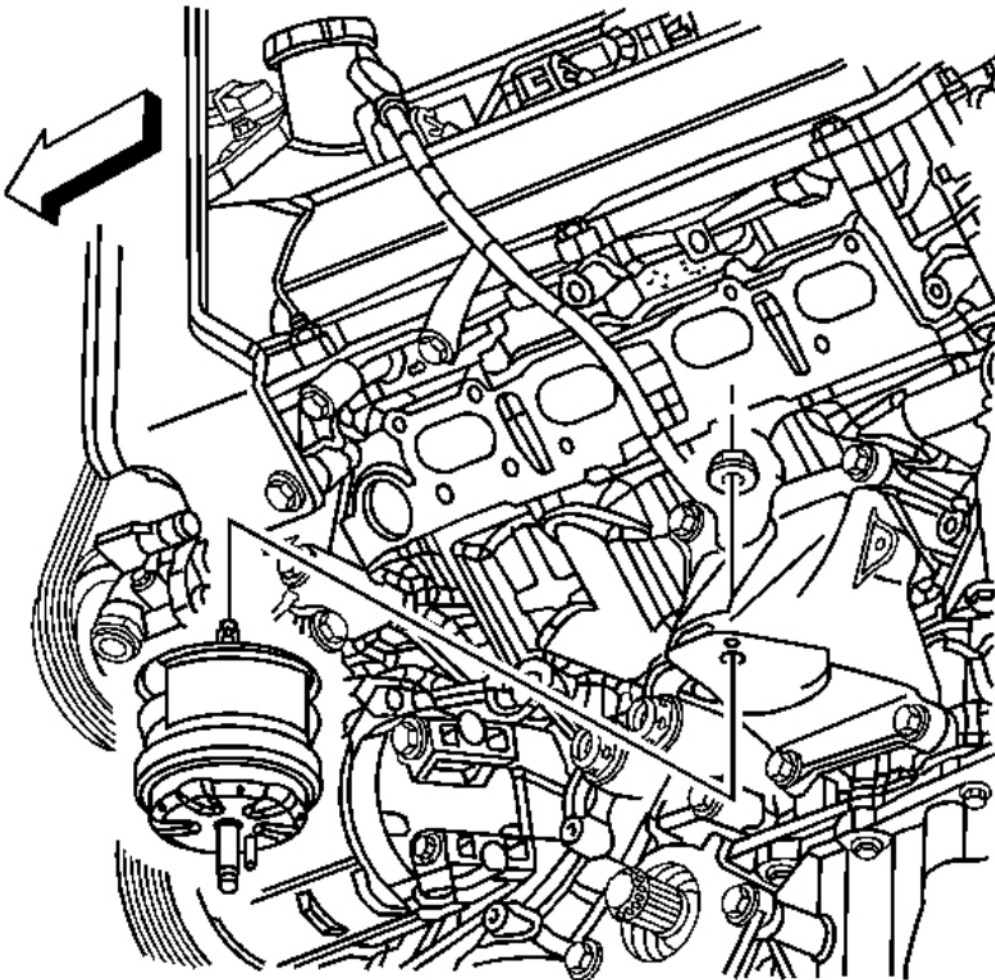


Fig. 32: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Remove the upper engine mount retaining nut.

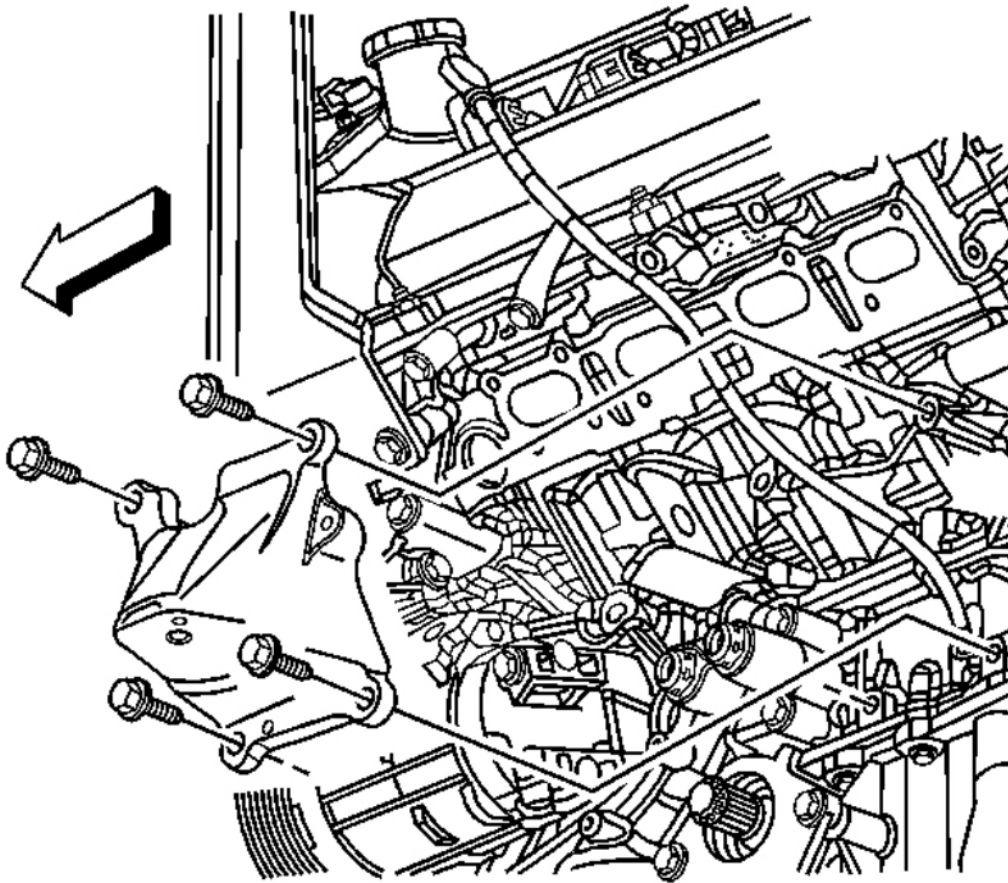


Fig. 33: View Of Left Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure not to distort or bend the engine mount heat shield.

5. Remove the left engine mount bracket retaining bolts.
6. Remove the left engine mount bracket.

Installation Procedure

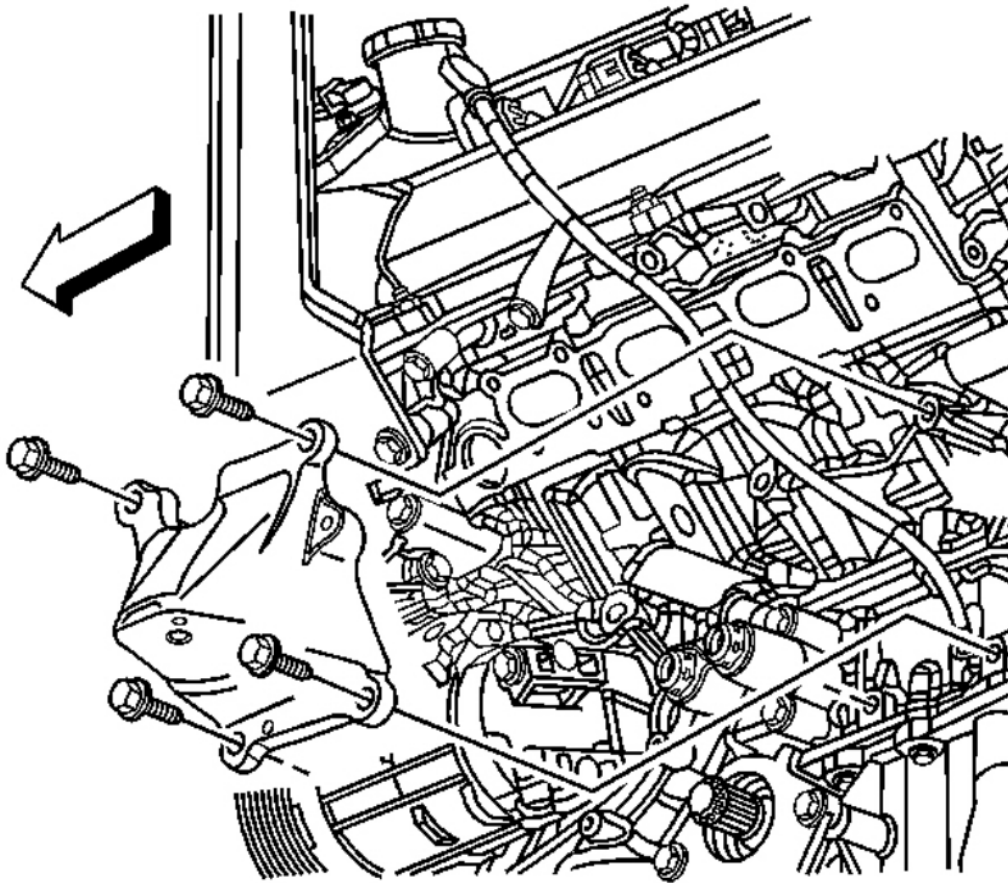


Fig. 34: View Of Left Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install the left engine mount brackets.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the left engine mount bracket retaining bolts.

Tighten: Tighten the bolts to 60 N.m (44 lb ft).

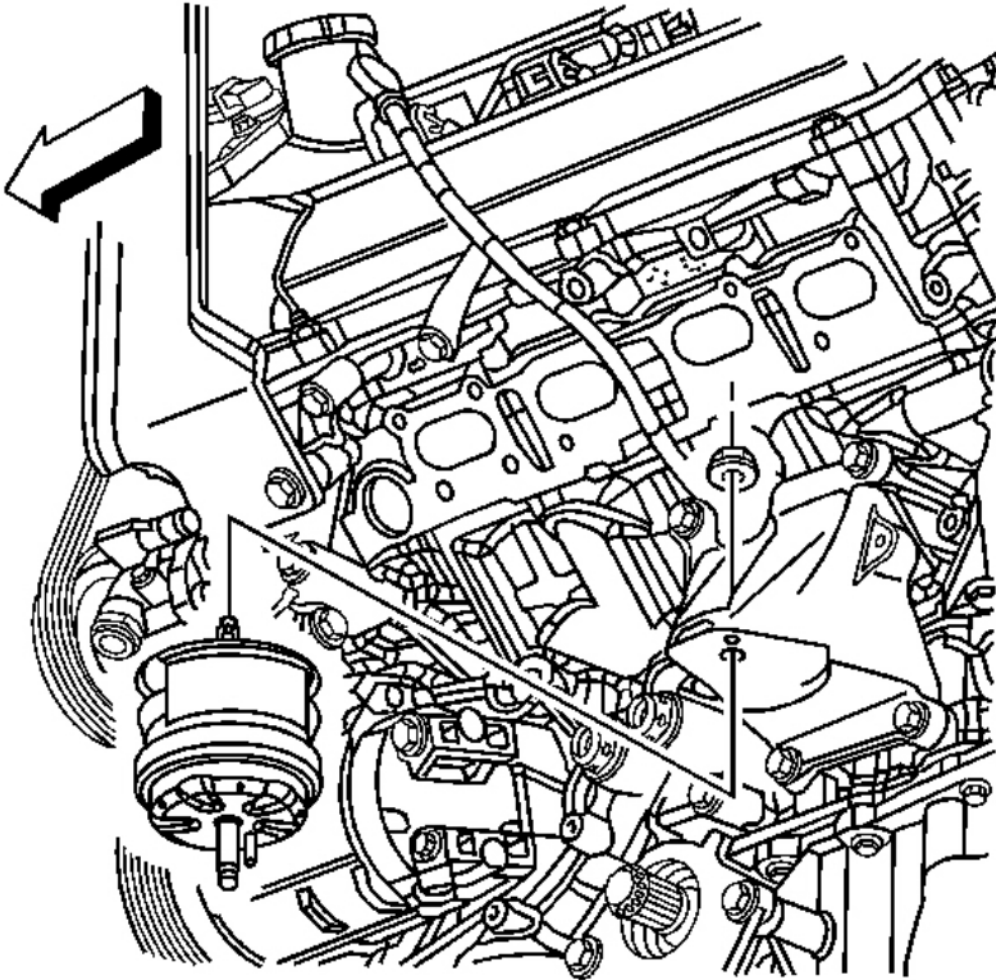


Fig. 35: View Of Left Engine Mount
Courtesy of GENERAL MOTORS CORP.

3. Install the upper engine mount retaining nut.

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

4. Remove the screw jack.
5. Install the left exhaust manifold. Refer to **Exhaust Manifold Removal - Left** .
6. Lower the vehicle.

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT (W/RWD)

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle in General Information.
2. Remove the right exhaust manifold. Refer to Exhaust Manifold Removal - Right (RWD) or Exhaust Manifold Removal - Right (AWD) .
3. Install a screw jack with a block of wood under the oil pan for support.

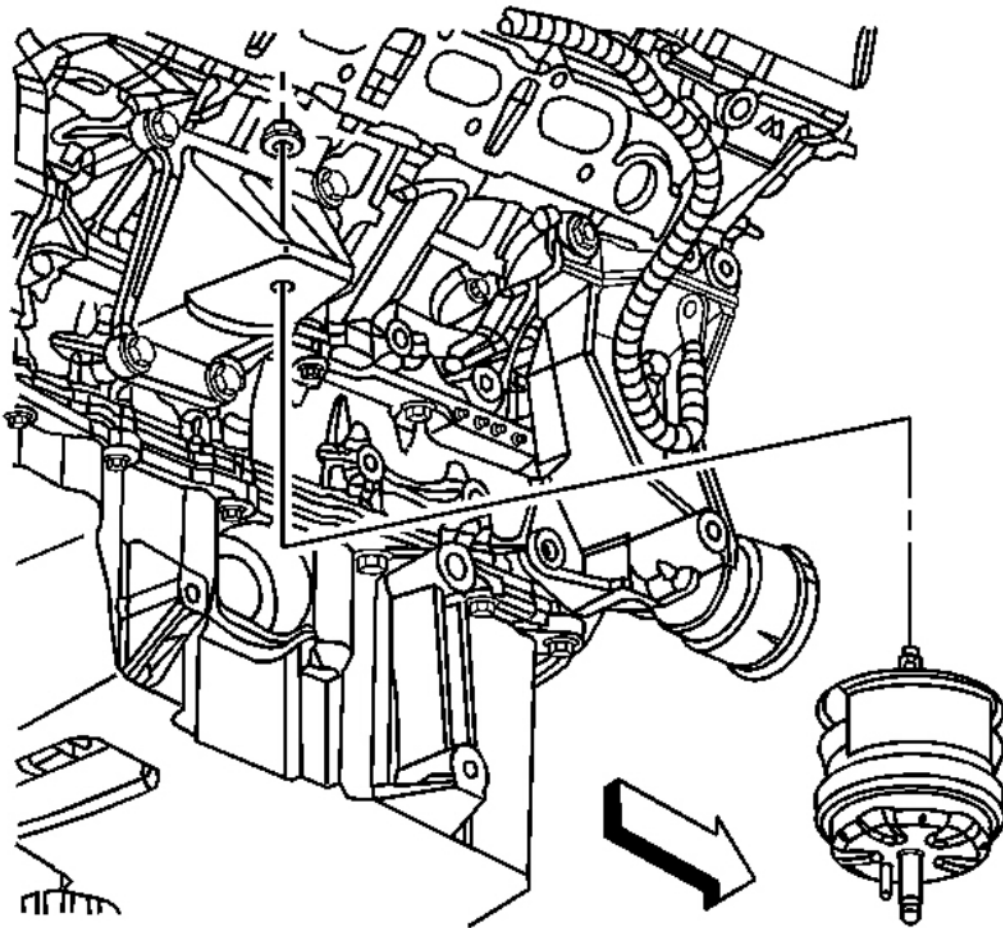


Fig. 36: View Of Right Engine Mount - RWD
Courtesy of GENERAL MOTORS CORP.

4. Remove the right engine mount upper retaining nut.

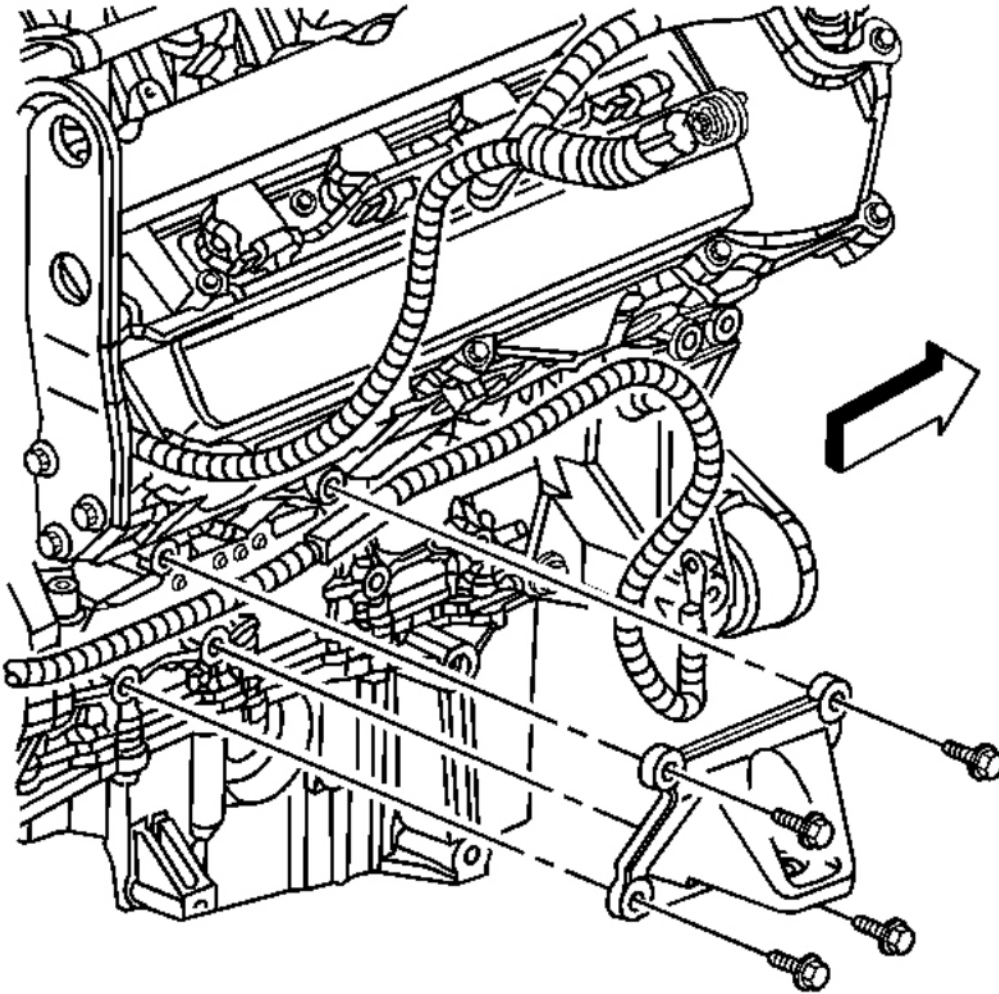


Fig. 37: View Of Right Engine Mount Bracket - RWD
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure not to distort or bend the engine mount heat shield.

5. Remove the right engine mount bracket mounting bolts.
6. Remove the engine mount bracket from the vehicle.

Installation Procedure

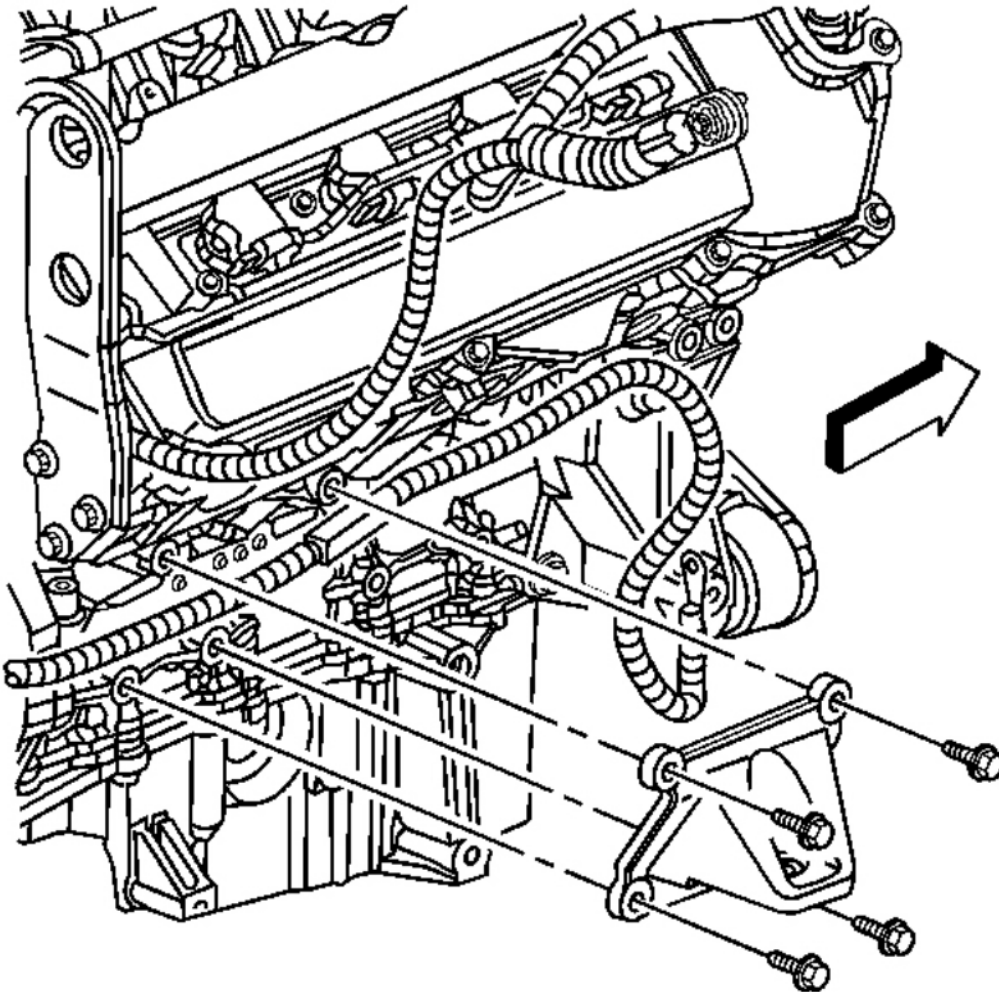


Fig. 38: View Of Right Engine Mount Bracket - RWD
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket to the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount bracket mounting bolts.

Tighten: Tighten the bolts to 60 N.m (44 lb ft).

3. Remove the screw jack.

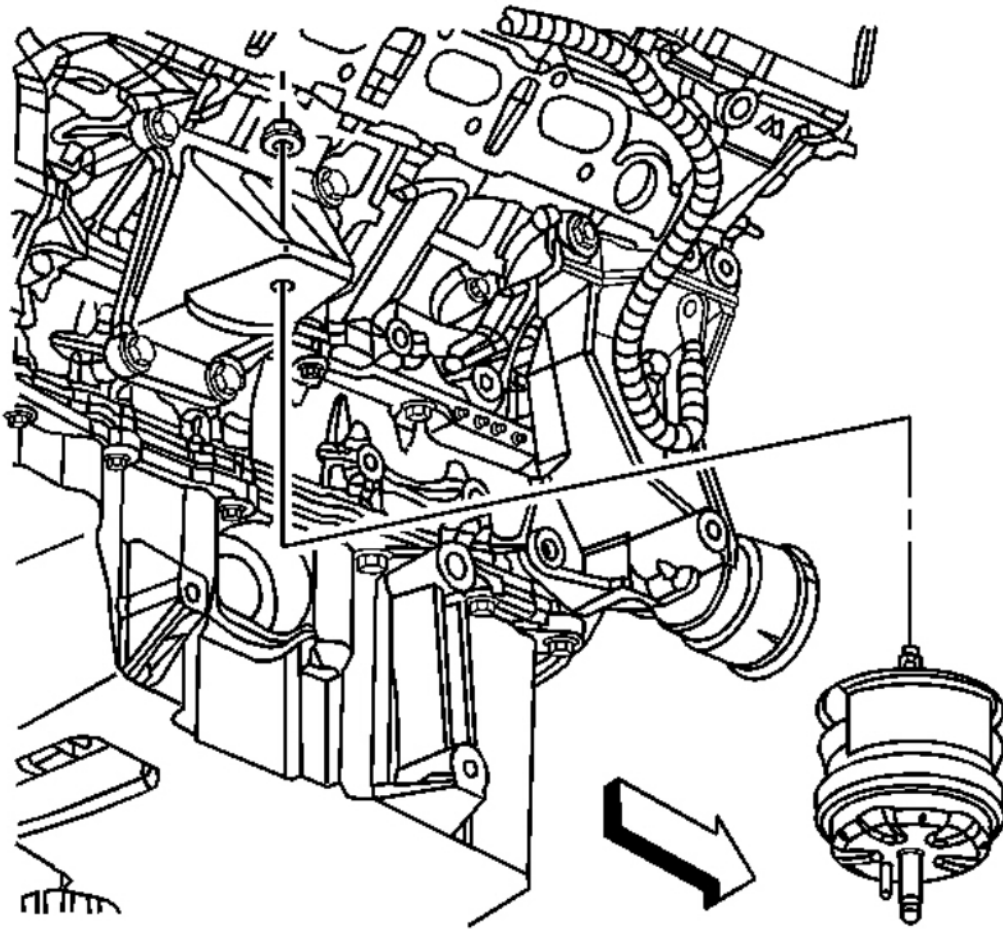


Fig. 39: View Of Right Engine Mount - RWD
Courtesy of GENERAL MOTORS CORP.

4. Install the upper engine mount retaining nut.

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

5. Install the right exhaust manifold. Refer to **Exhaust Manifold Removal - Right (RWD)**

or **Exhaust Manifold Removal - Right (AWD)** .

6. Lower the vehicle.

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT (W/AWD)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the right exhaust manifold. Refer to **Exhaust Manifold Removal - Right (RWD)** or **Exhaust Manifold Removal - Right (AWD)** .
3. Install a screw jack with a block of wood under the oil pan for support.

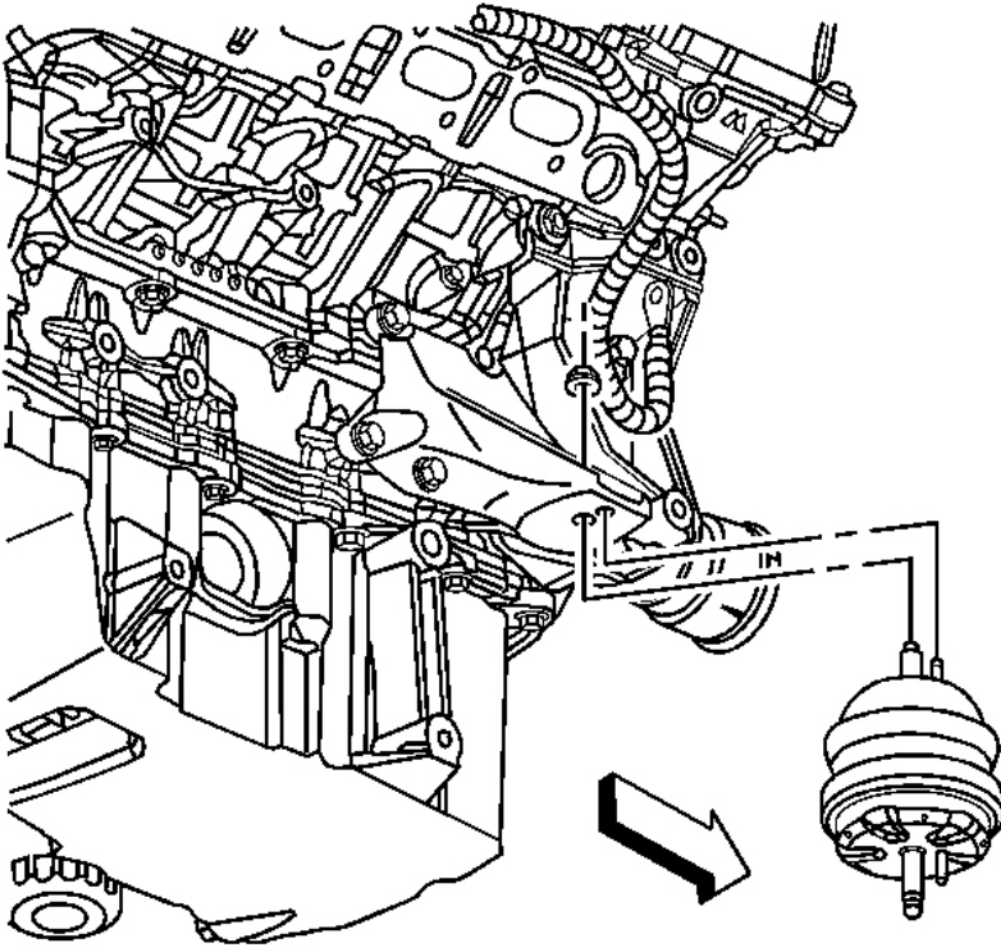


Fig. 40: View Of Right Engine Mount - AWD
Courtesy of GENERAL MOTORS CORP.

4. Remove the right engine mount upper retaining nut.

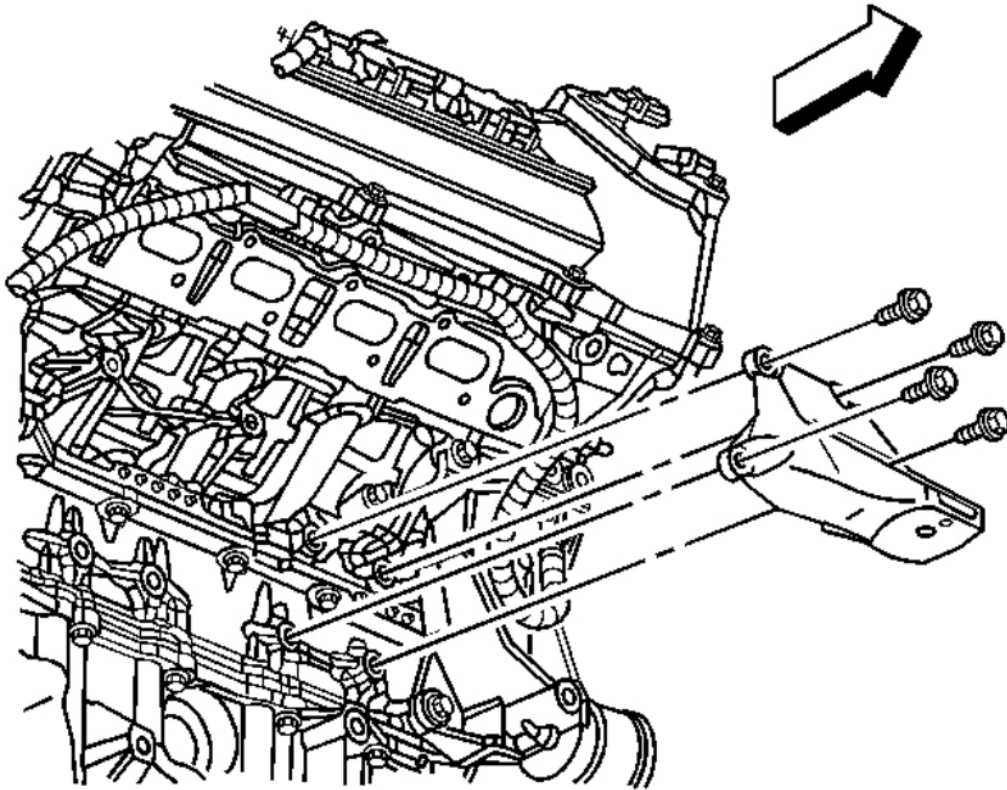


Fig. 41: View Of Right Engine Mount Bracket - AWD
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure not to distort or bend the engine mount heat shield.

5. Remove the right engine mount bracket mounting bolts.
6. Remove the engine mount bracket from the vehicle.

Installation Procedure

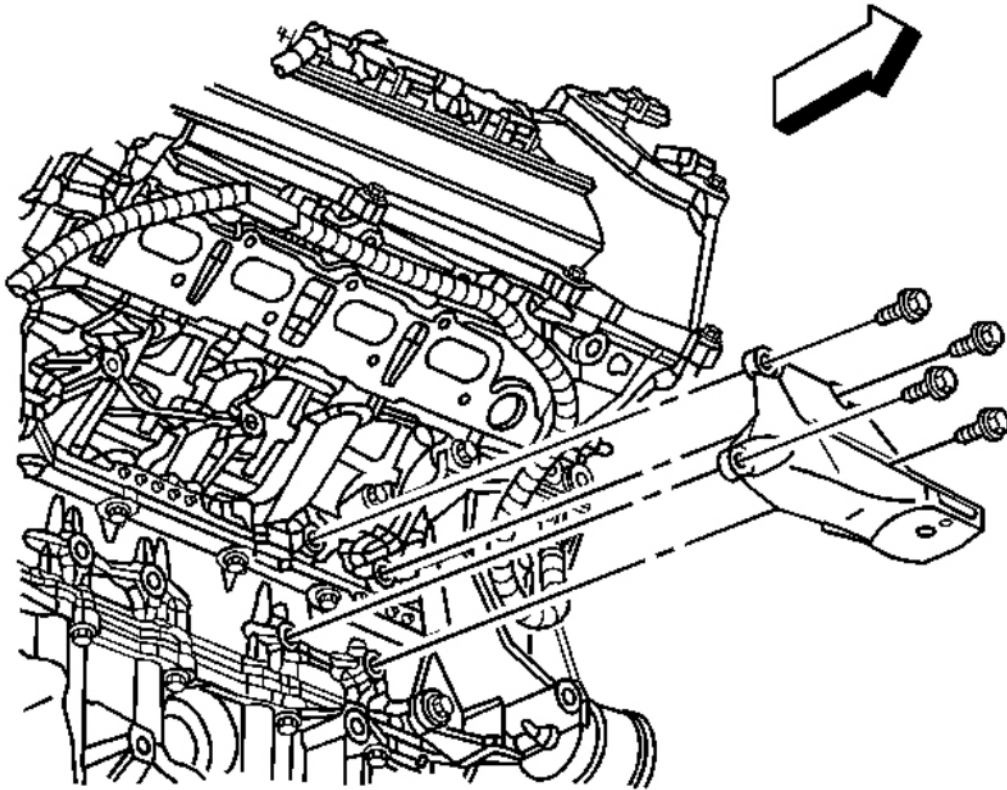


Fig. 42: View Of Right Engine Mount Bracket - AWD
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket to the vehicle.

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

2. Install the engine mount bracket mounting bolts.

Tighten: Tighten the bolts to 60 N.m (44 lb ft).

3. Remove the screw jack.

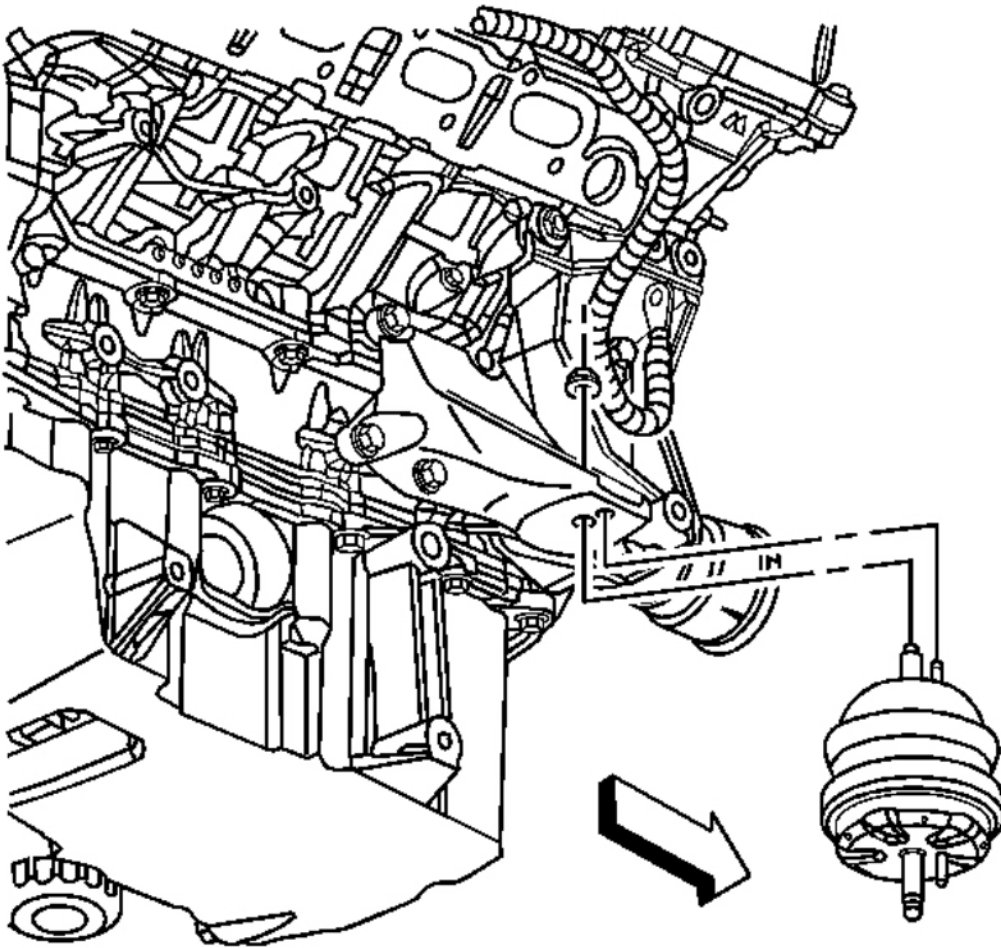


Fig. 43: View Of Right Engine Mount - AWD
Courtesy of GENERAL MOTORS CORP.

4. Install the upper engine mount retaining nut.

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

5. Install the right exhaust manifold. Refer to **Exhaust Manifold Removal - Right (RWD)** or **Exhaust Manifold Removal - Right (AWD)** .
6. Lower the vehicle.

Removal Procedure

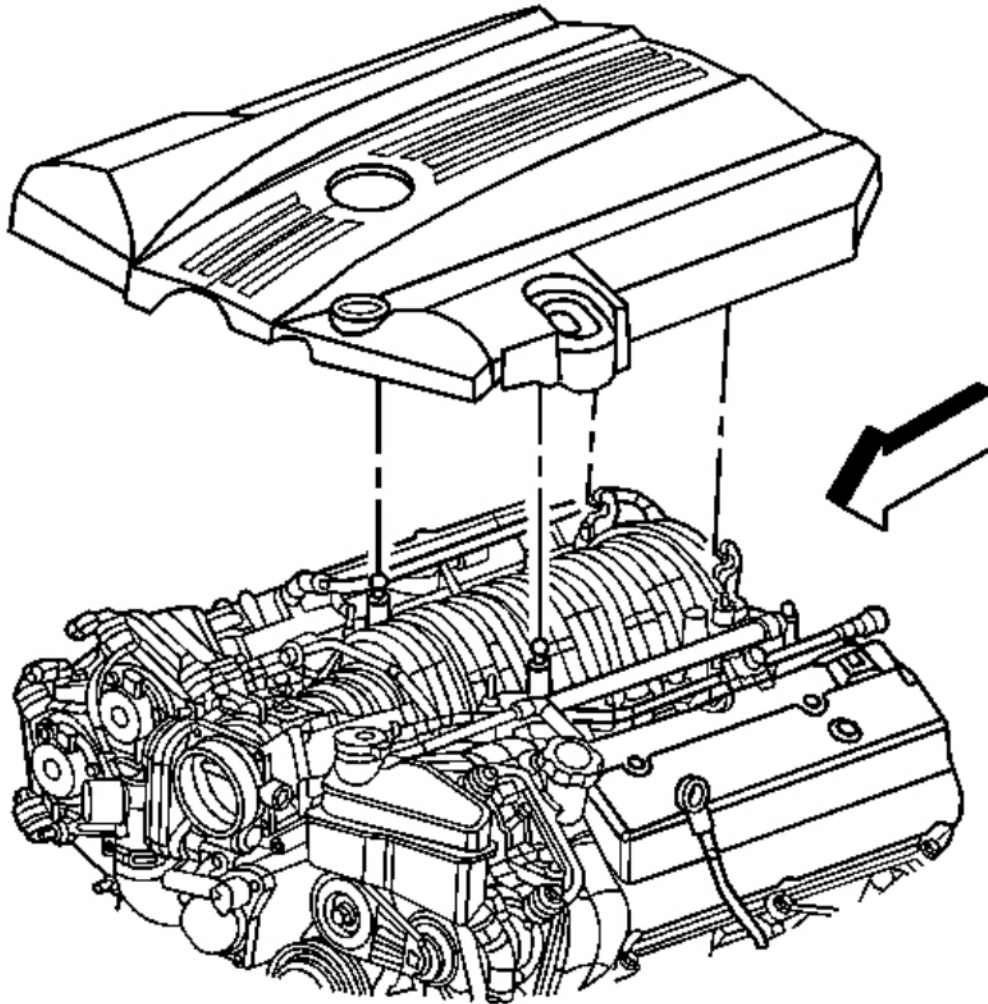


Fig. 44: View Of Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Clean the fuel injector sight shield at the power steering and engine oil fill cap locations.
2. Remove the power steering and engine oil fill caps.
3. Lift the sight shield up from the front and pull forward to disengage the rear tab from the bracket.

Installation Procedure

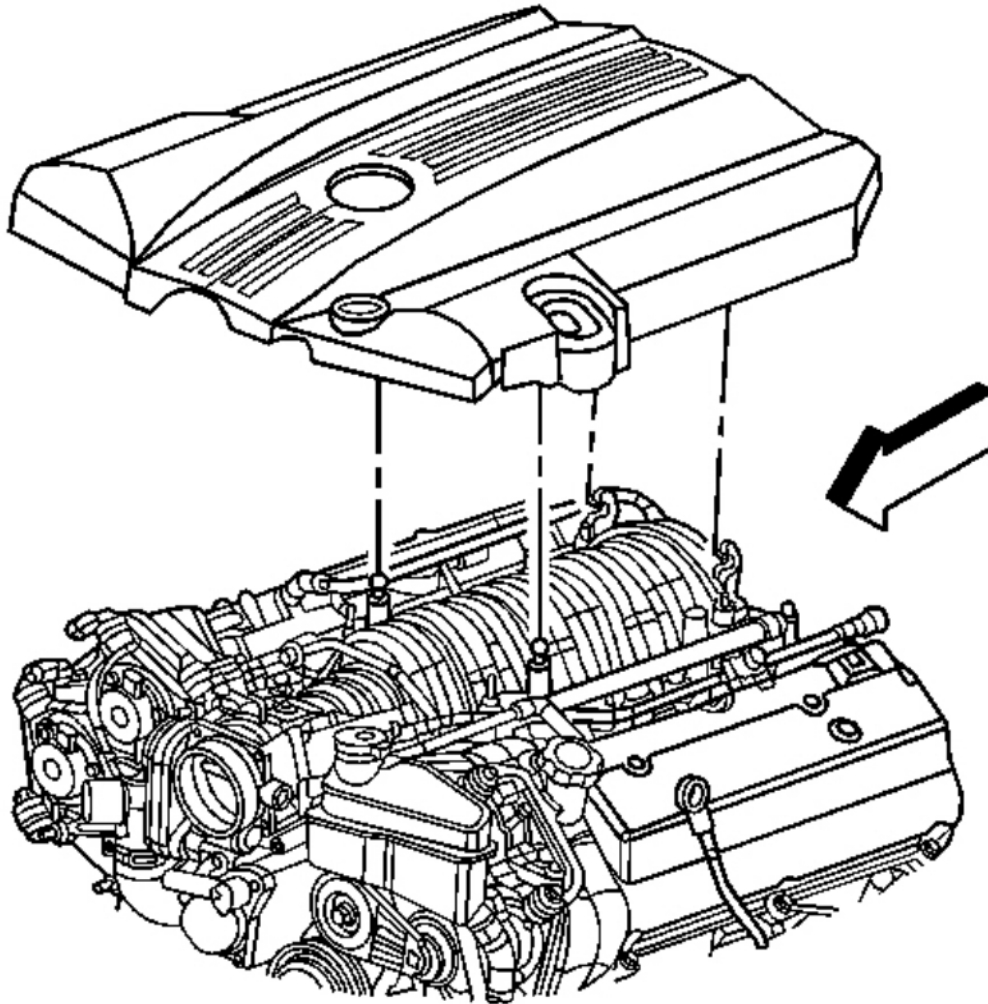


Fig. 45: View Of Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Align the rear tab with the slot in the rear bracket and push the sight shield inward to engage.
2. Push the sight shield down and align the ball studs on the engine with the holes in the sight shield.

3. Install the power steering and engine oil fill caps.

CRANKCASE VENTILATION HOSES/PIPES REPLACEMENT

Removal Procedure

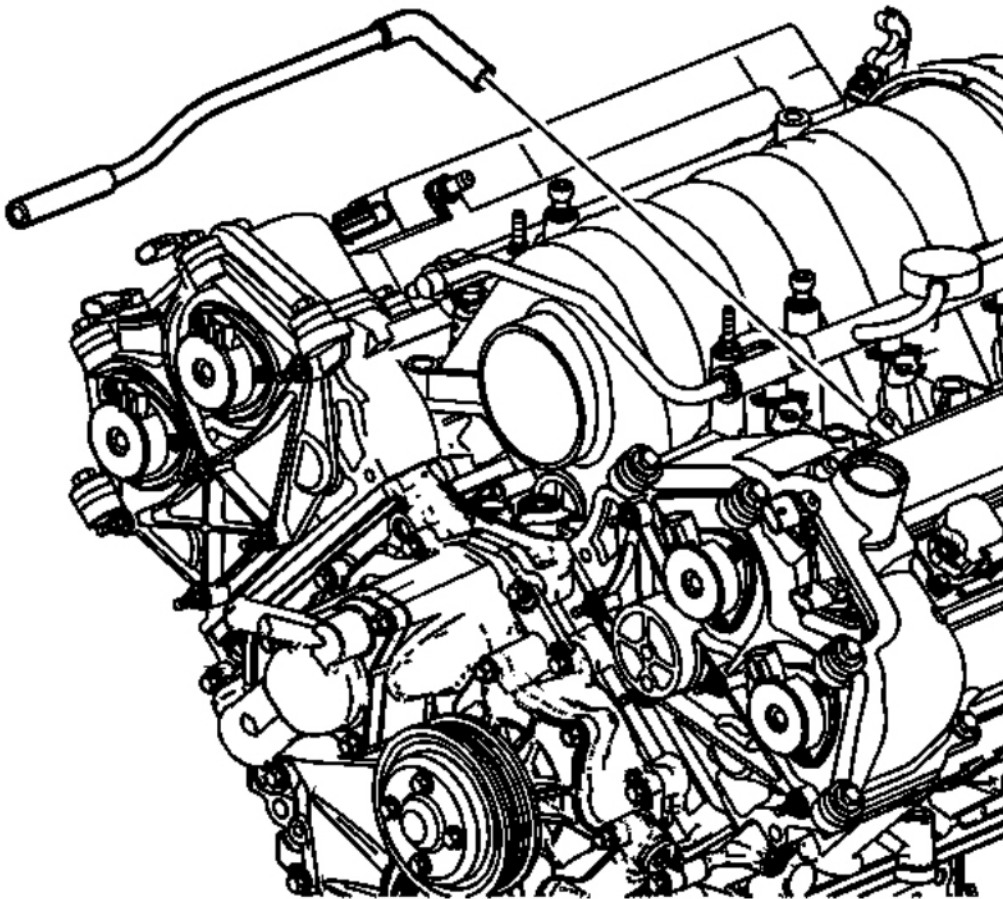


Fig. 46: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
2. Disconnect the PCV fresh air tube from the left camshaft cover.
3. Remove the PCV fresh air tube from the air cleaner outlet duct.

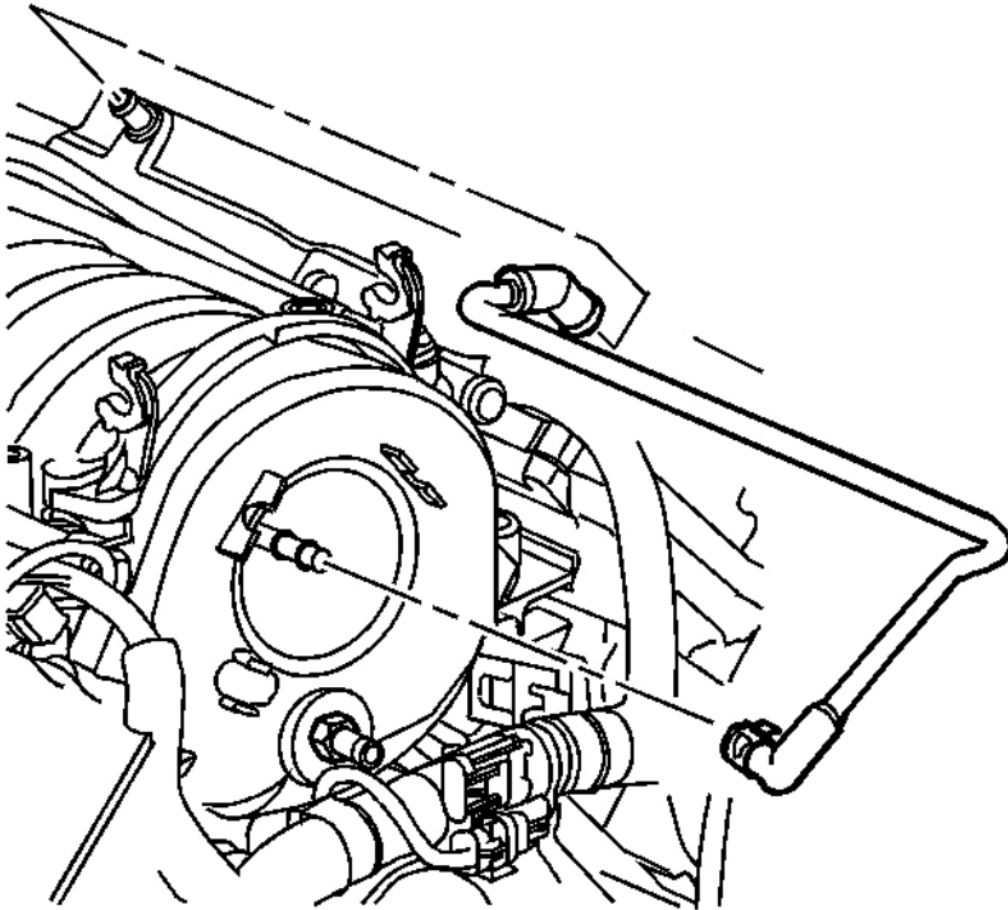


Fig. 47: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the retaining clip securing the PCV dirty air tube.
5. Disconnect the PCV dirty air tube from the PCV orificed tube.
6. Remove the PCV dirty air tube from the intake manifold.

Installation Procedure

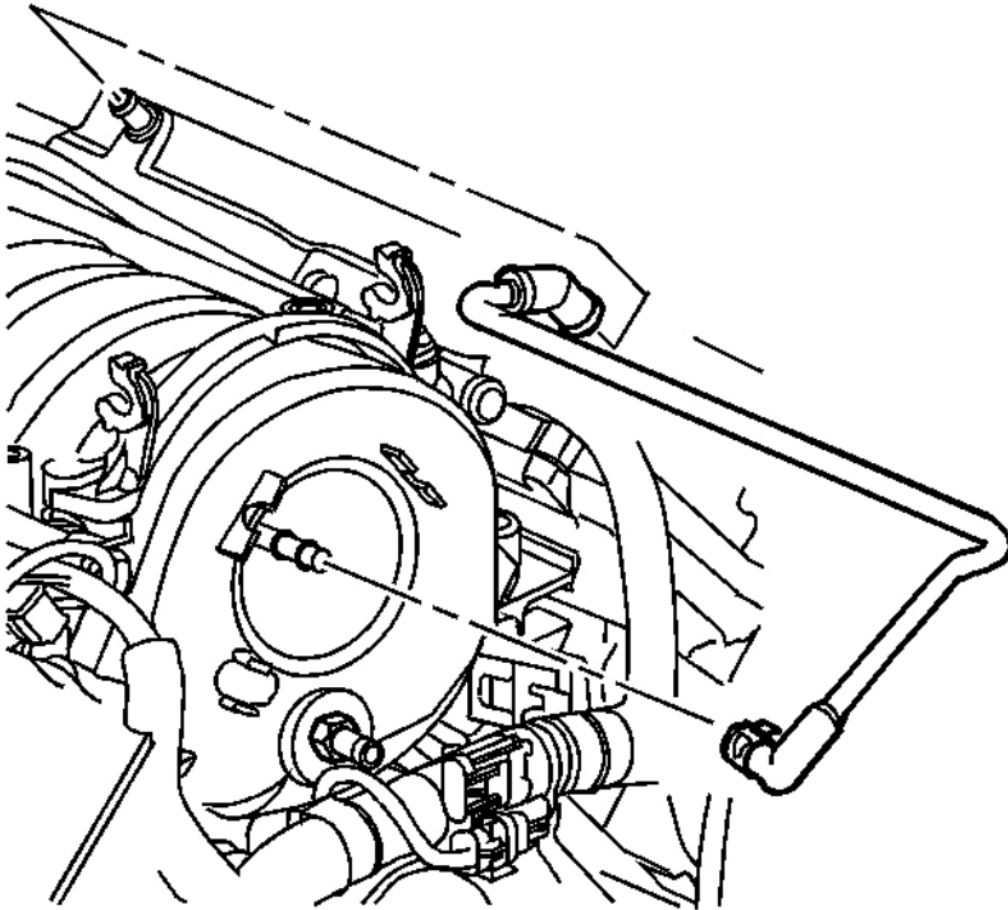


Fig. 48: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

1. Connect the PCV dirty air tube to the intake manifold fitting.
2. Connect the PCV dirty air tube to the PCV orificed tube.

IMPORTANT: Ensure that the PCV dirty air tube is located between the tabs of the intake manifold.

3. Attach the retaining clip to the intake manifold.

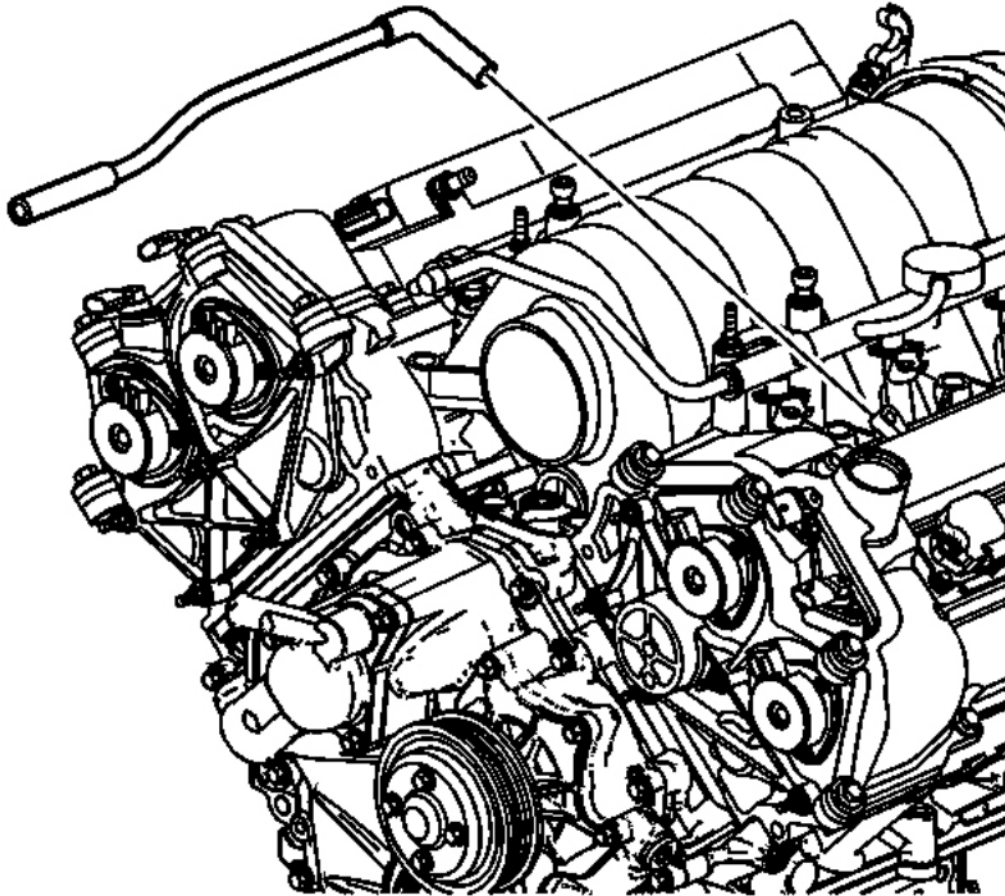


Fig. 49: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Connect the PCV fresh air tube to the left camshaft cover.
5. Connect the PCV fresh air tube to the air cleaner outlet duct.
6. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

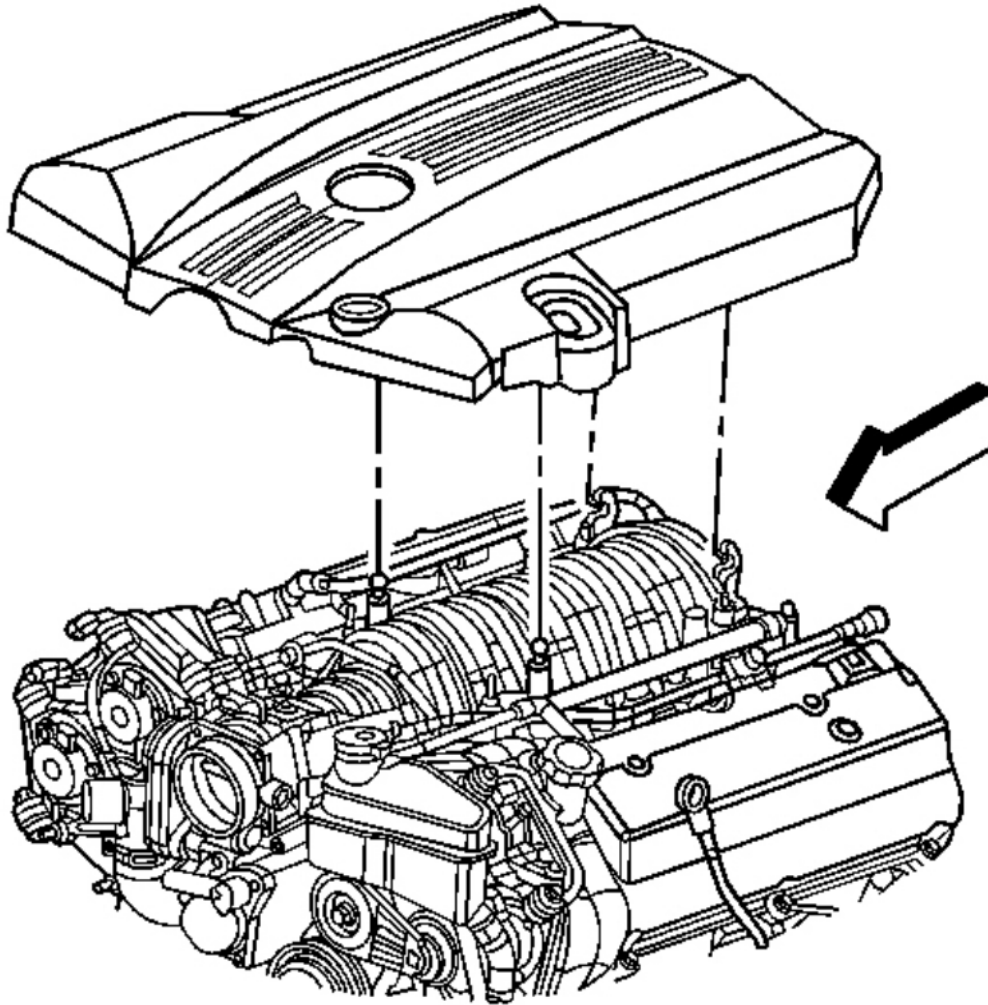


Fig. 50: View Of Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the cross car brace. Refer to **Brace Replacement - Cross Vehicle** in Body Front End.
2. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

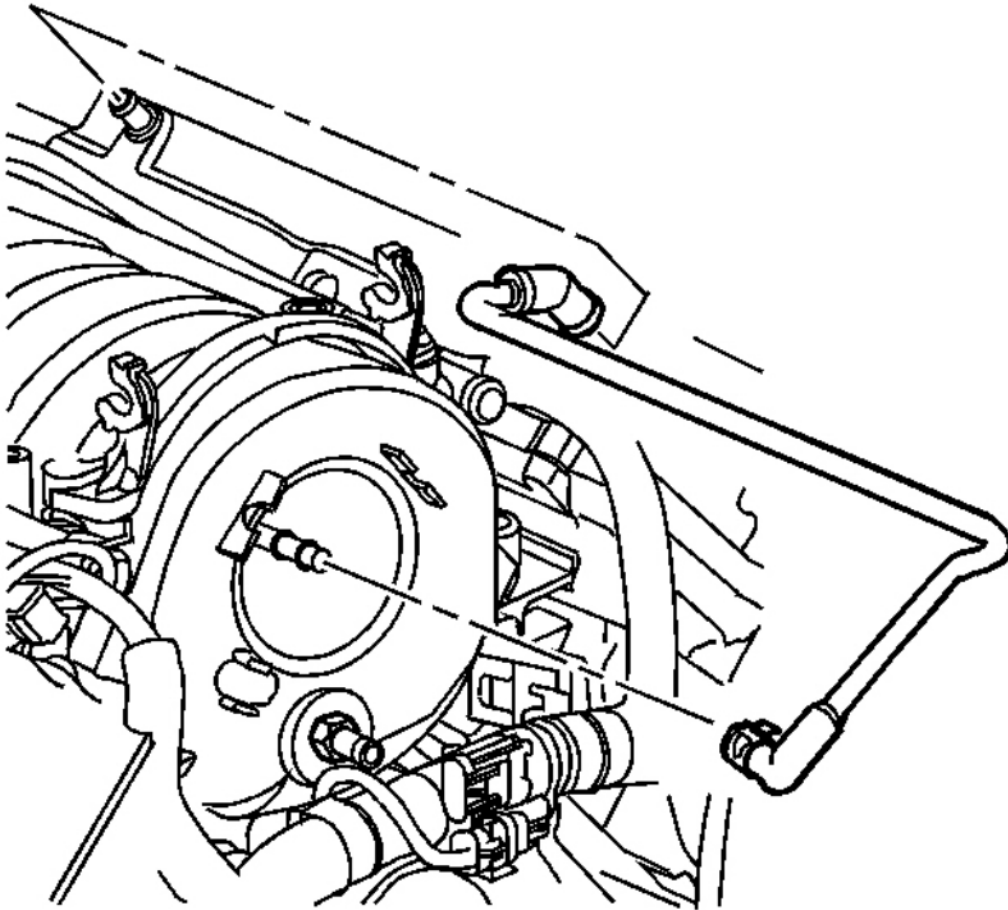


Fig. 51: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

3. Remove the PCV dirty air tube from the camshaft cover. Refer to **Crankcase Ventilation Hoses/Pipes Replacement**.

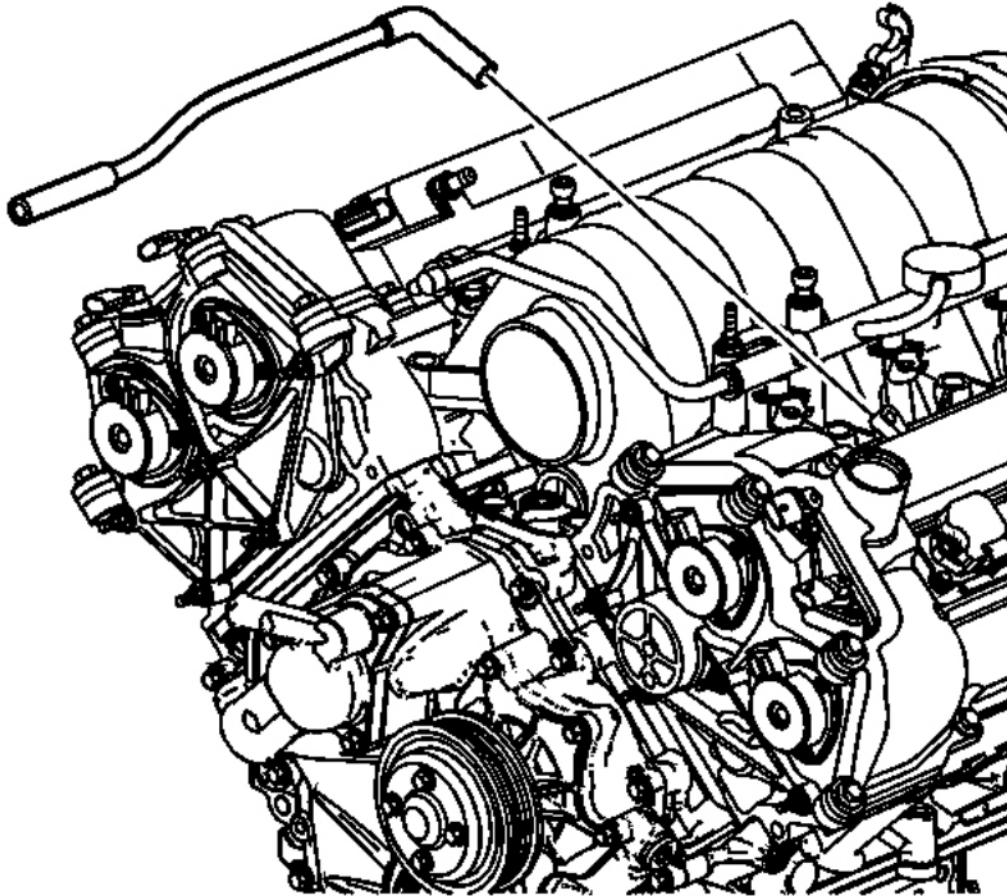


Fig. 52: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

4. Remove the PCV fresh air tube. Refer to Crankcase Ventilation Hoses/Pipes Replacement.

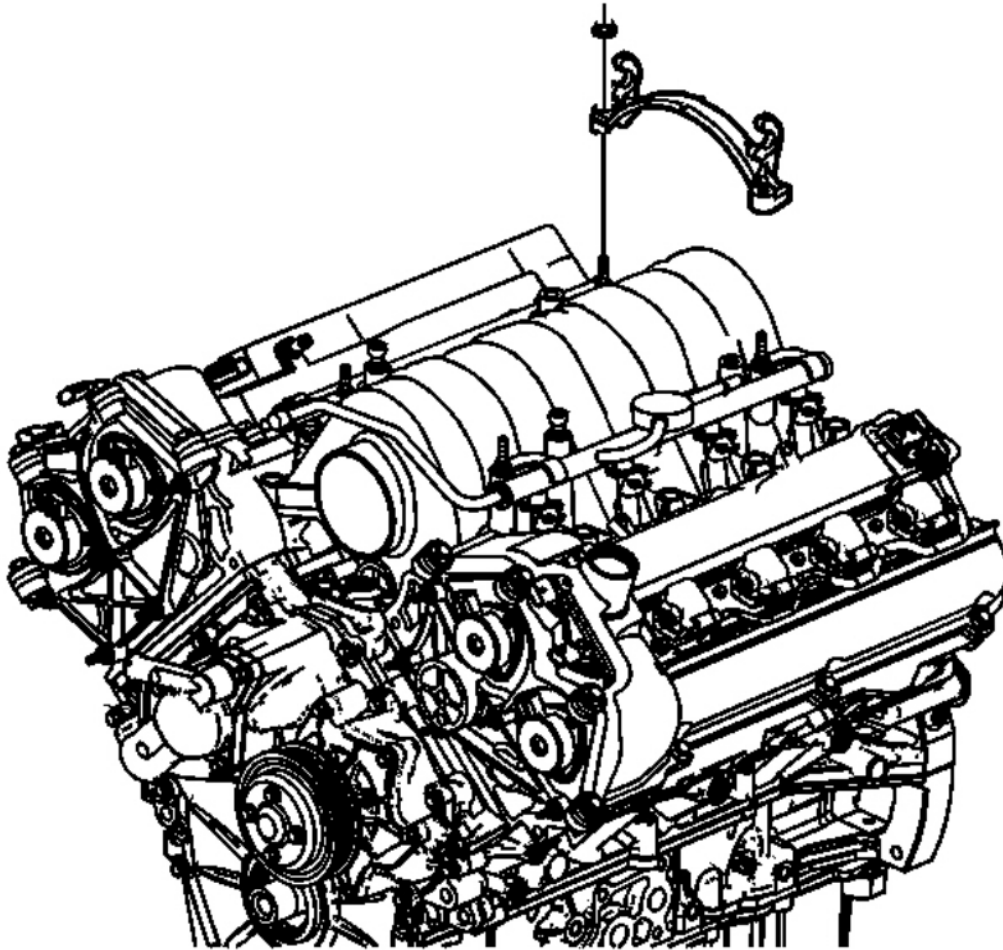


Fig. 53: View Of Sight Shield Bracket
Courtesy of GENERAL MOTORS CORP.

5. Remove the sight shield bracket nuts.
6. Remove the sight shield bracket.

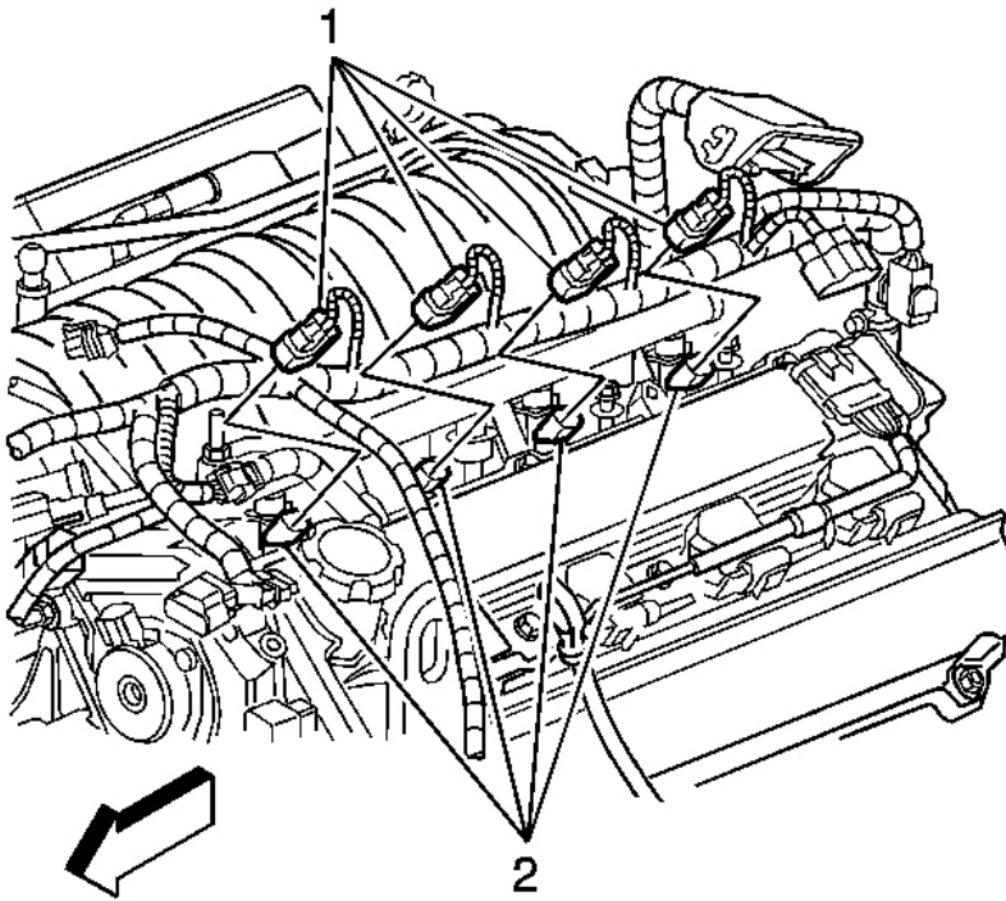


Fig. 54: View Of Left Side Fuel Injectors & Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the left side fuel injector electrical connectors (1) from the fuel injectors (2).

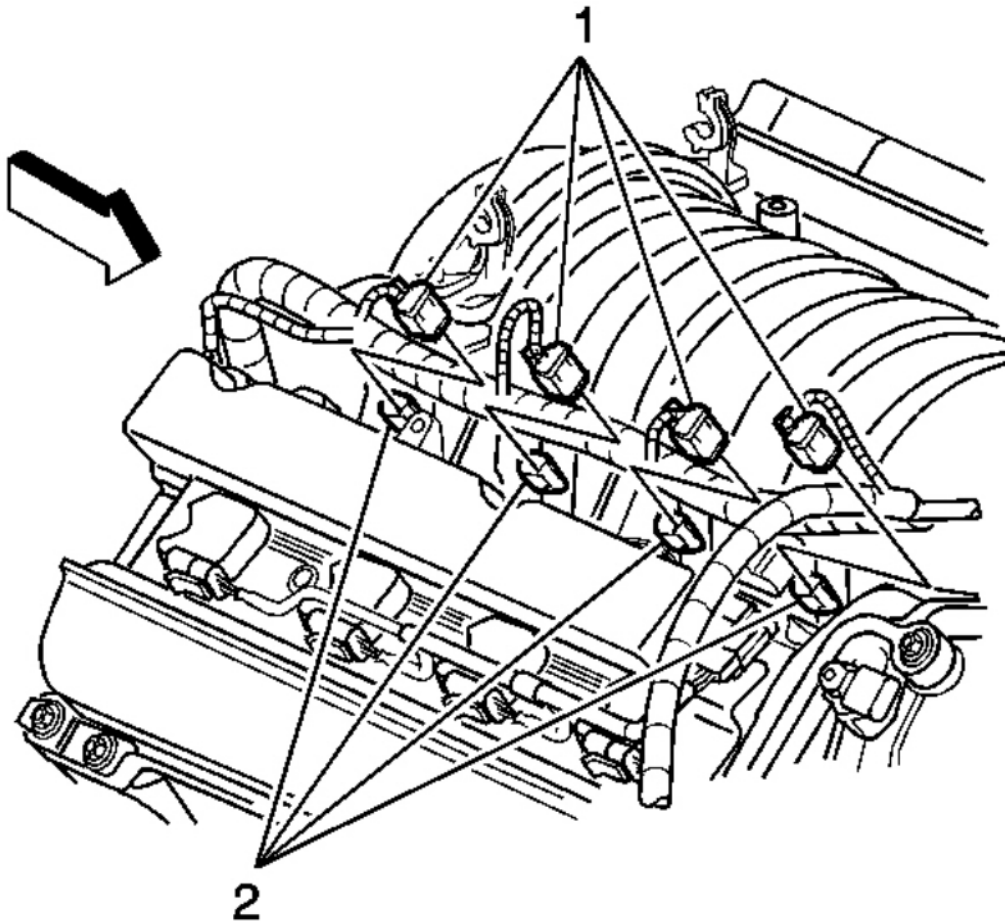


Fig. 55: View Of Right Side Fuel Injectors & Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the right side fuel injector electrical connectors (1) from the fuel injectors (2).

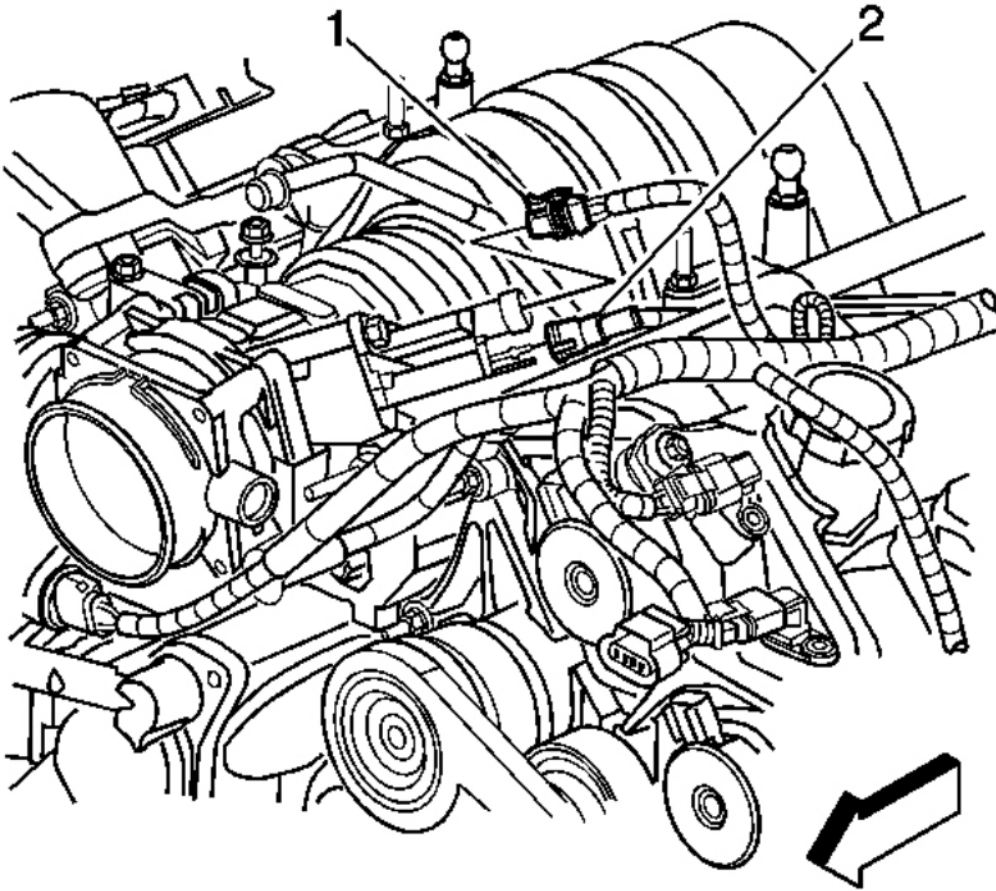


Fig. 56: View Of EVAP Emissions Purge Valve Line & Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the evaporative emissions purge valve line (2) and electrical connector (1).

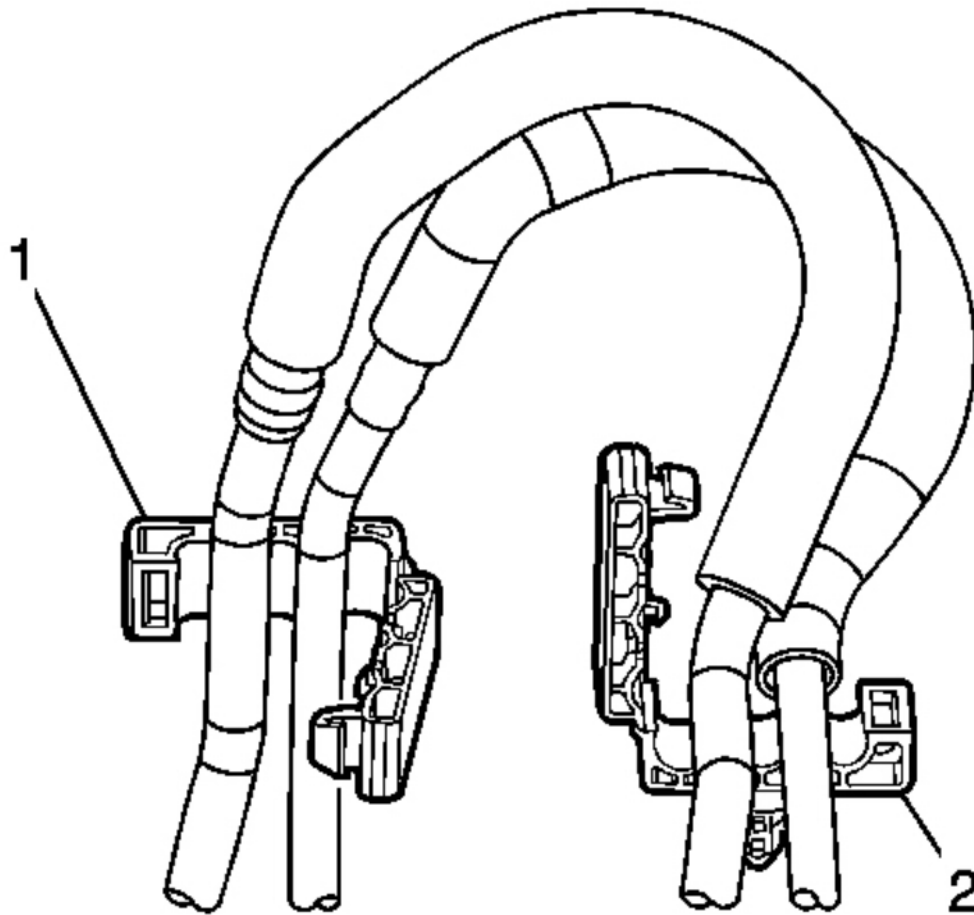


Fig. 57: View Of Hose Retainers
Courtesy of GENERAL MOTORS CORP.

10. Remove the EVAP line from the retaining feature (2) at the rear of the right head. Position the line aside.
11. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 4.6L (LH2).

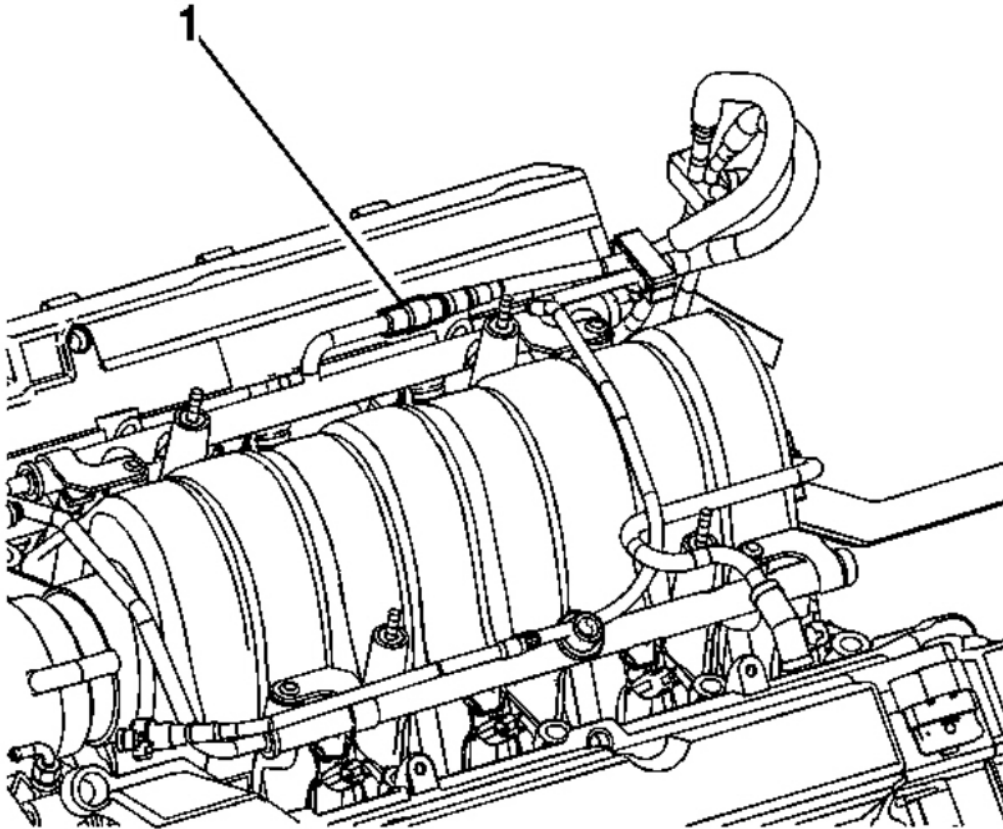


Fig. 58: View Of Fuel Line-To-Fuel Rail Connection
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the fuel line from the fuel rail (1). Refer to **Quick Connect Fitting(s) Service (Metal Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls - 4.6L (LH2).
13. Remove the fuel line from the retainer at the rear of the right head.

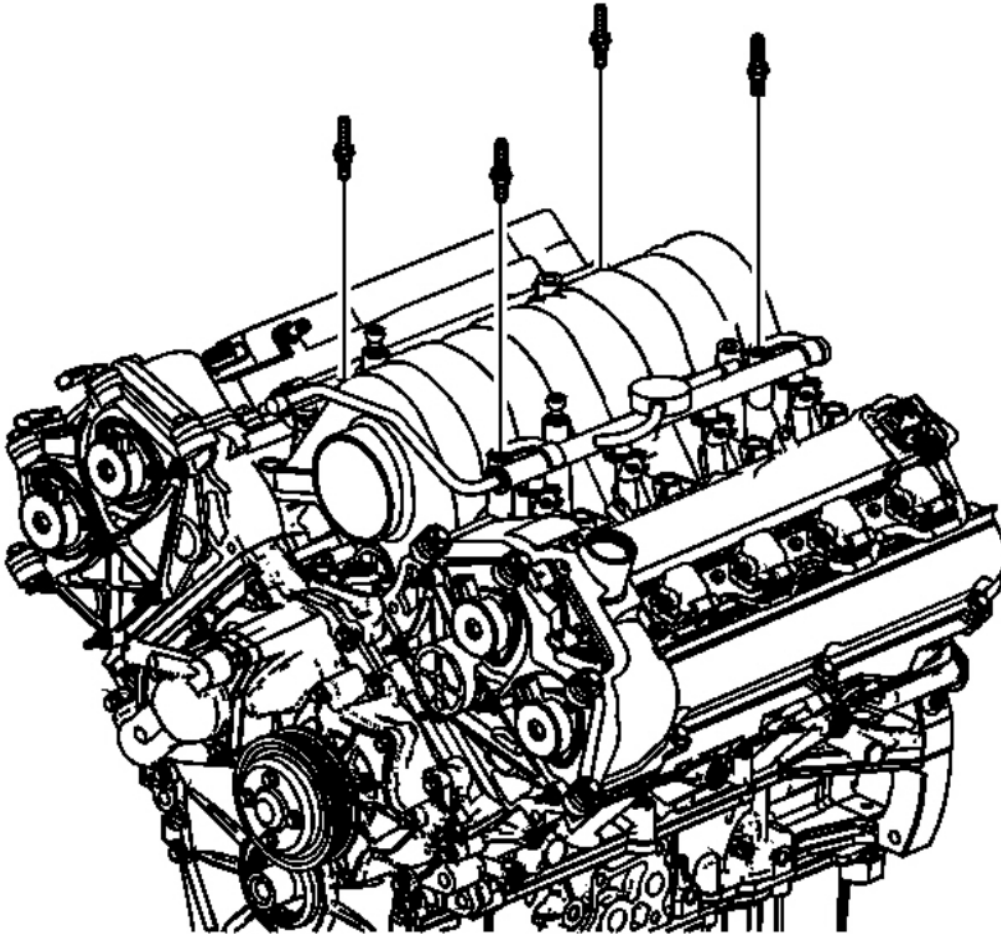


Fig. 59: View Of Fuel Rail-To-Intake Manifold Fasteners
Courtesy of GENERAL MOTORS CORP.

14. Remove the fasteners attaching the fuel rail to the intake manifold.

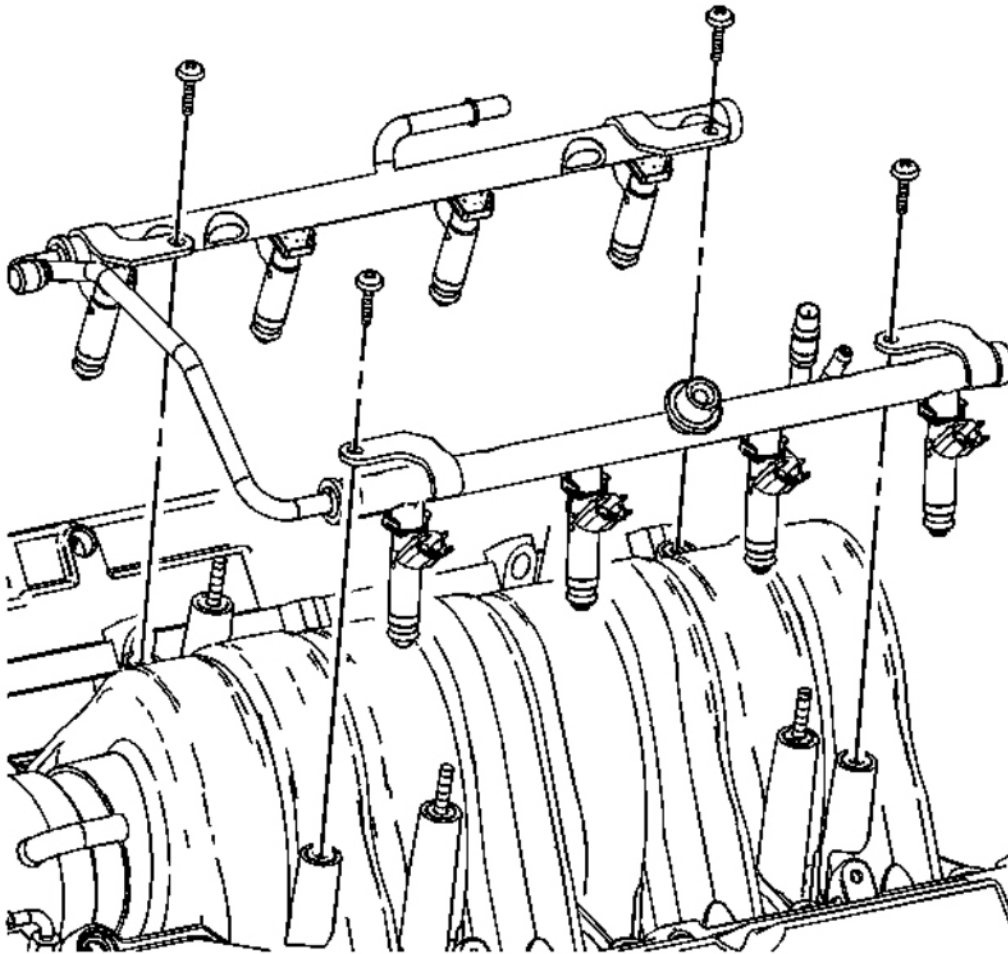


Fig. 60: View Of Fuel Rail & Injector Assembly
Courtesy of GENERAL MOTORS CORP.

15. Lift the entire fuel rail and injector assembly from the intake manifold.

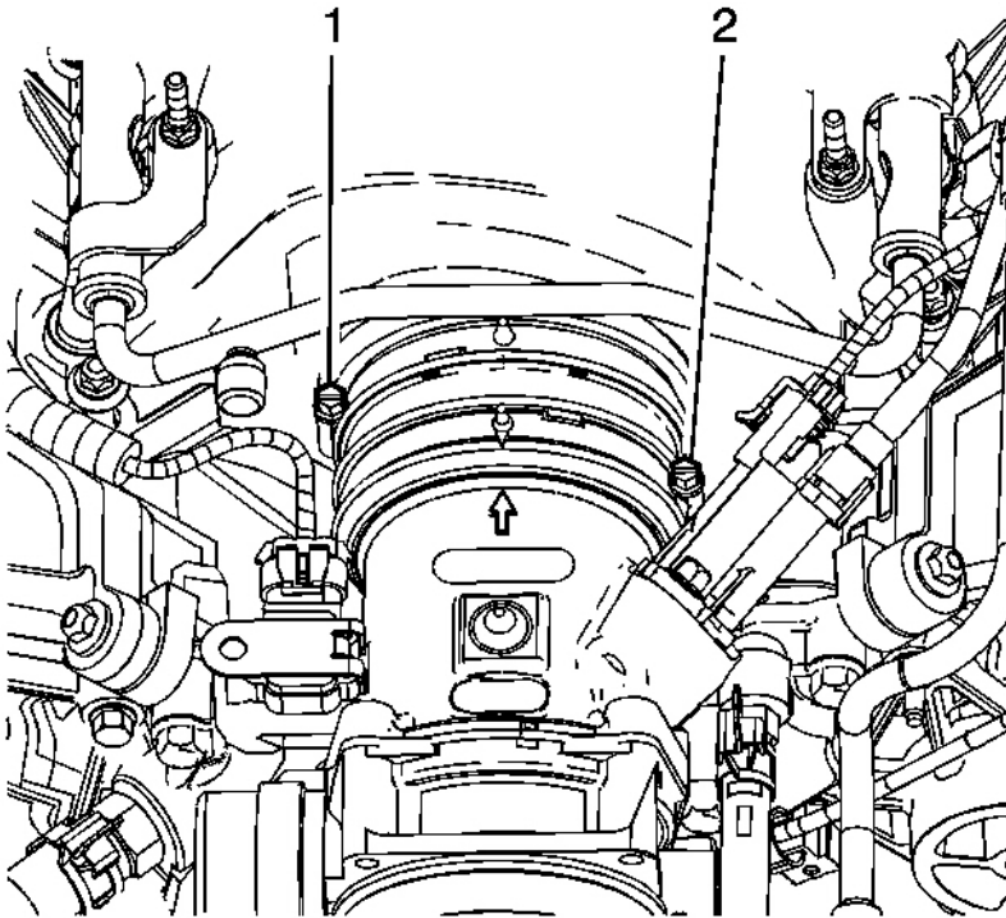


Fig. 61: Locating Plenum Duct Clamp
Courtesy of GENERAL MOTORS CORP.

16. Loosen the plenum duct clamp (1) at the front of the intake manifold.

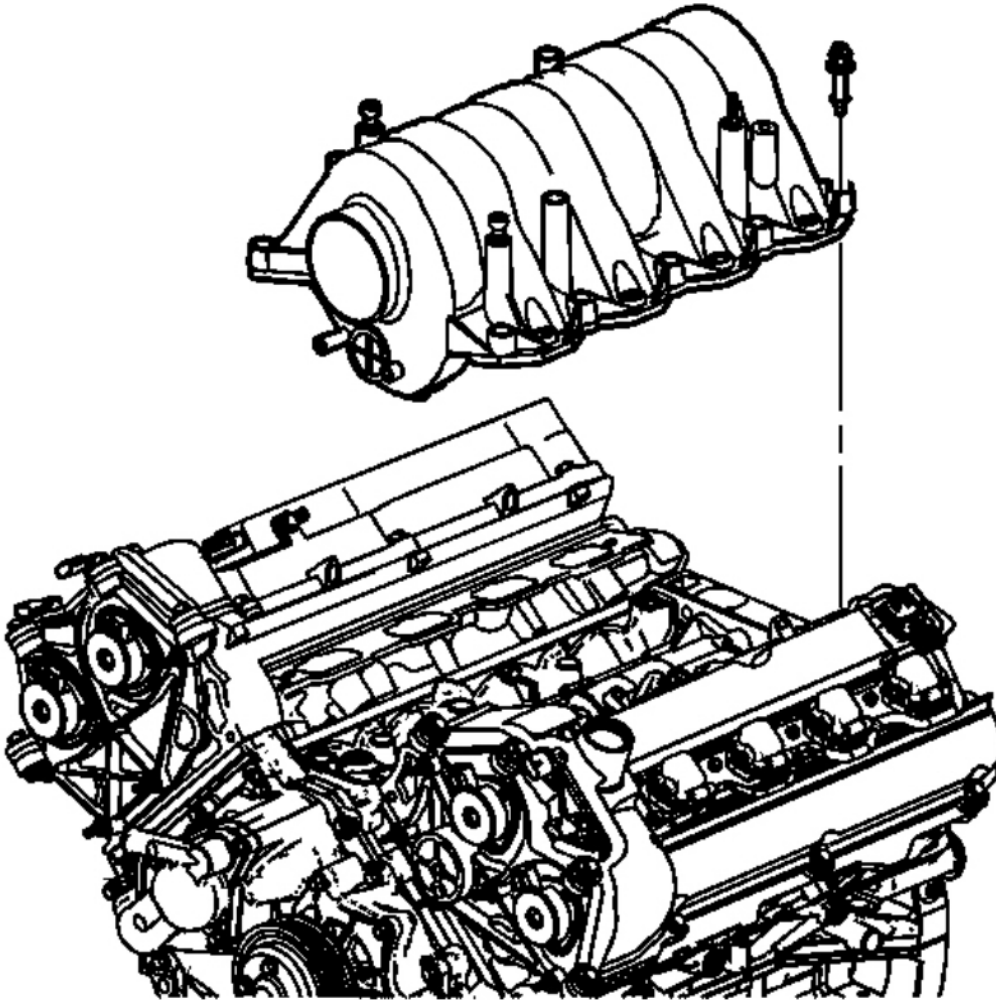


Fig. 62: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

17. Loosen the bolts attaching the intake manifold to the cylinder heads.
18. Remove the intake manifold by using an upward lifting motion at the rear of the manifold assembly.
19. Inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection** .

1. Transfer the necessary parts when replacing the intake manifold. Refer to **Intake Manifold Disassemble** and **Intake Manifold Assemble** .
2. Lightly grease the inside edge of the rubber plenum duct.

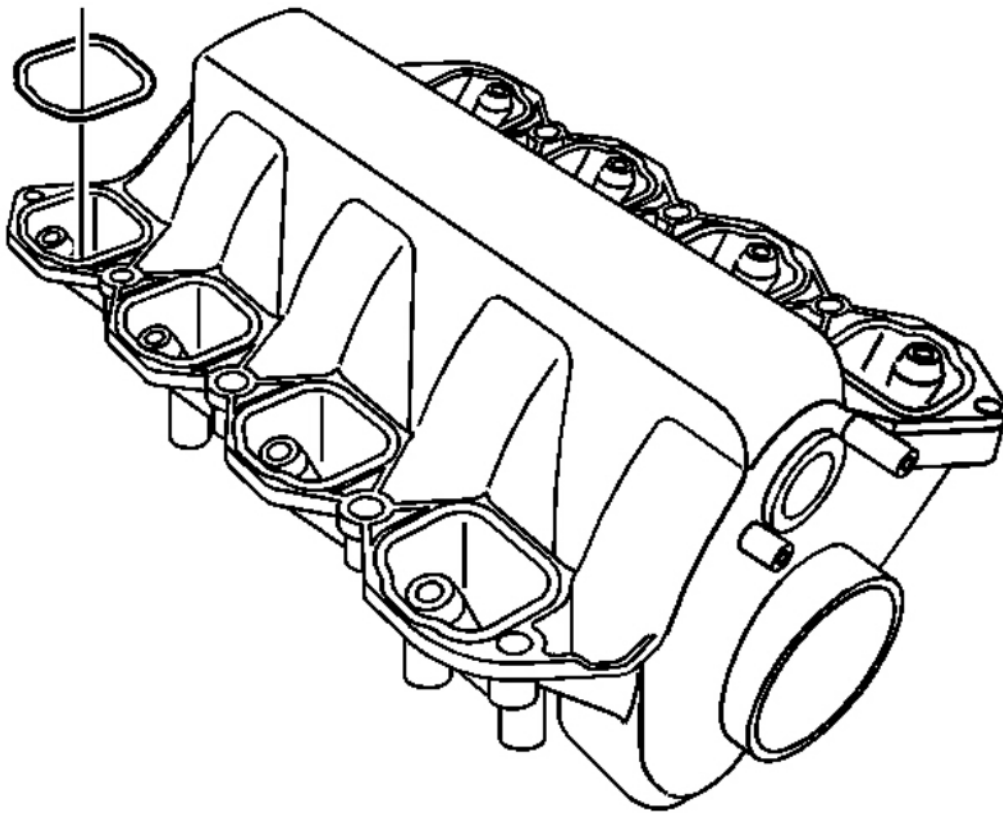


Fig. 63: View Of Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS CORP.

3. Ensure that the NEW gaskets are installed to the intake manifold.

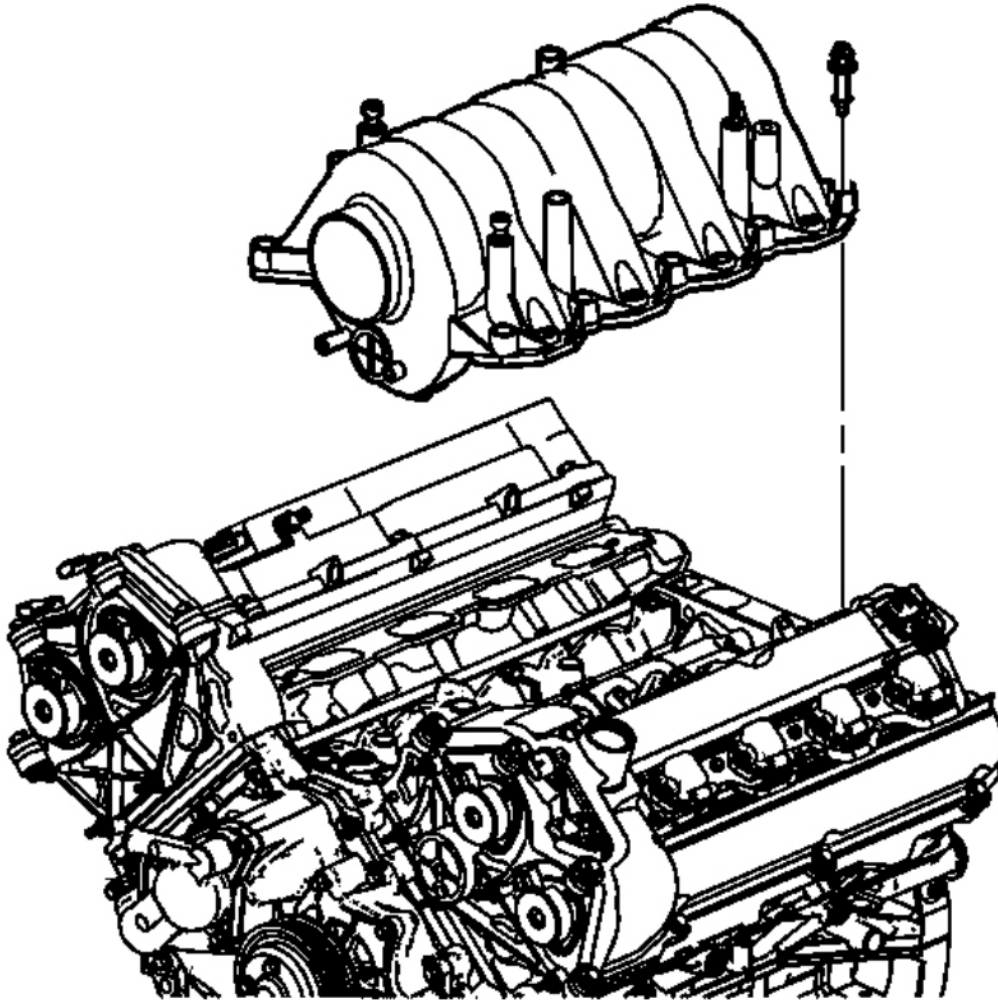


Fig. 64: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Place the intake manifold in position.
5. Position the front of the intake manifold into the plenum duct.
6. Position the rear of the intake manifold downward onto the cylinder heads.
7. Loosely install the 10 bolts attaching the intake manifold to the cylinder heads.

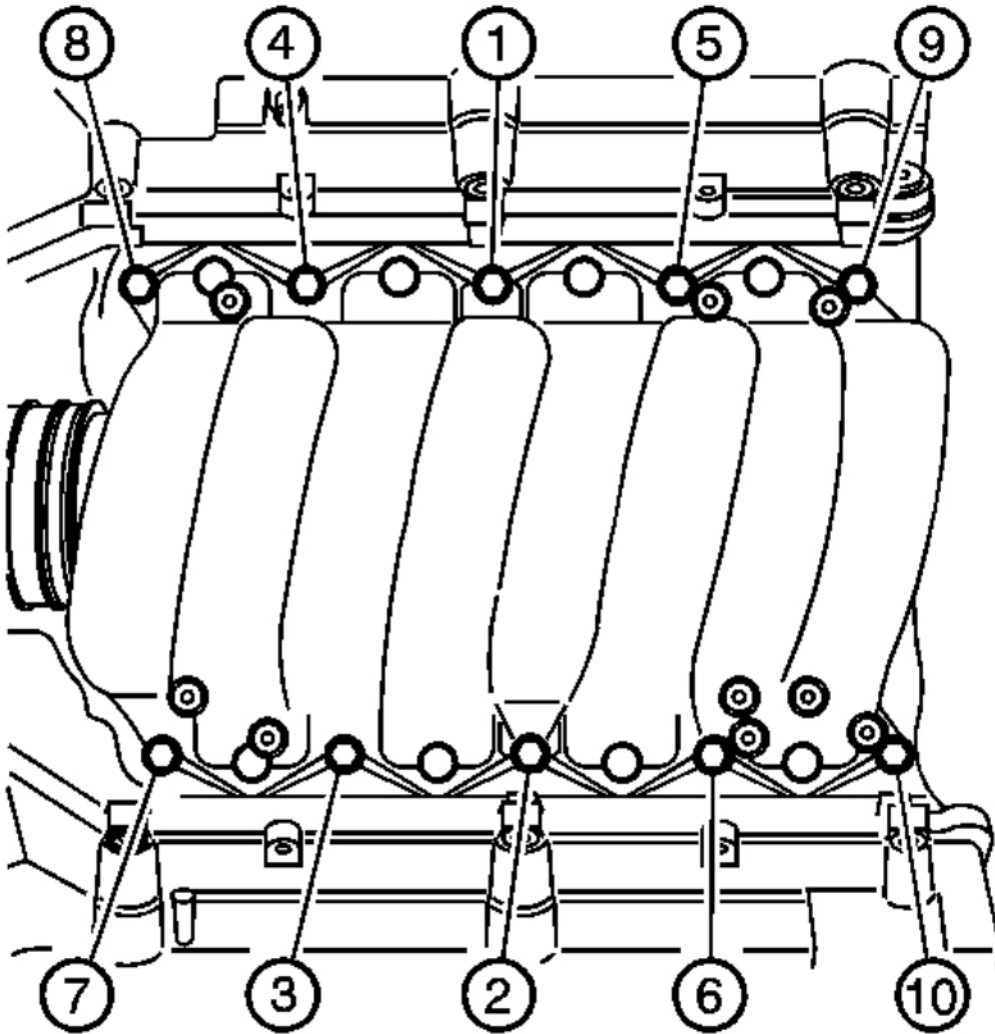


Fig. 65: Tightening Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the intake manifold bolts in sequence (1-10).

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

9. Ensure that the plenum duct is fully attached to the front of the intake manifold.

Tighten: Tighten the plenum duct clamp to 2.25 N.m (20 lb in).

10. Lubricate the intake manifold fuel injector bores with light mineral oil GM P/N 9981704, clean engine oil or equivalent.

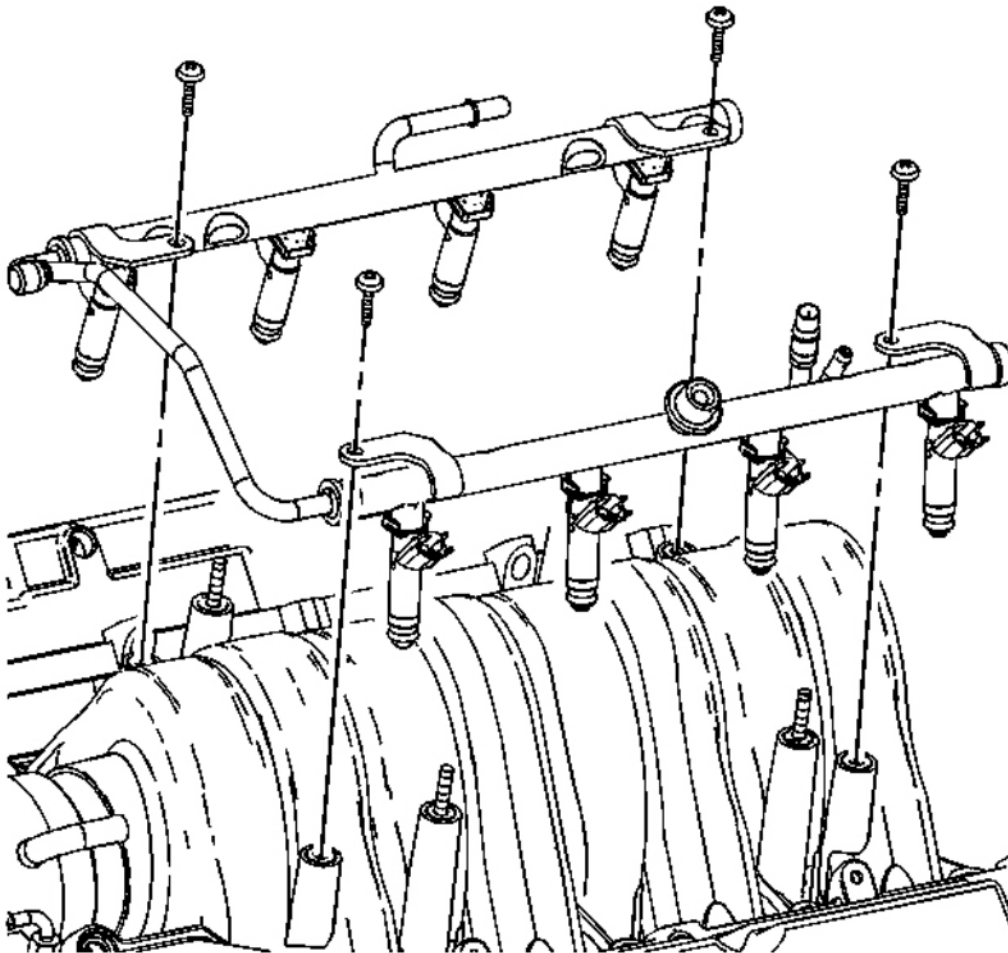


Fig. 66: View Of Fuel Rail & Injector Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT force the injectors into position.

11. Install the entire fuel rail and injector assembly into the intake manifold by pressing the fuel rail and injector simultaneously into the correct position.
12. Install the bolts attaching the fuel rail to the intake manifold.

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

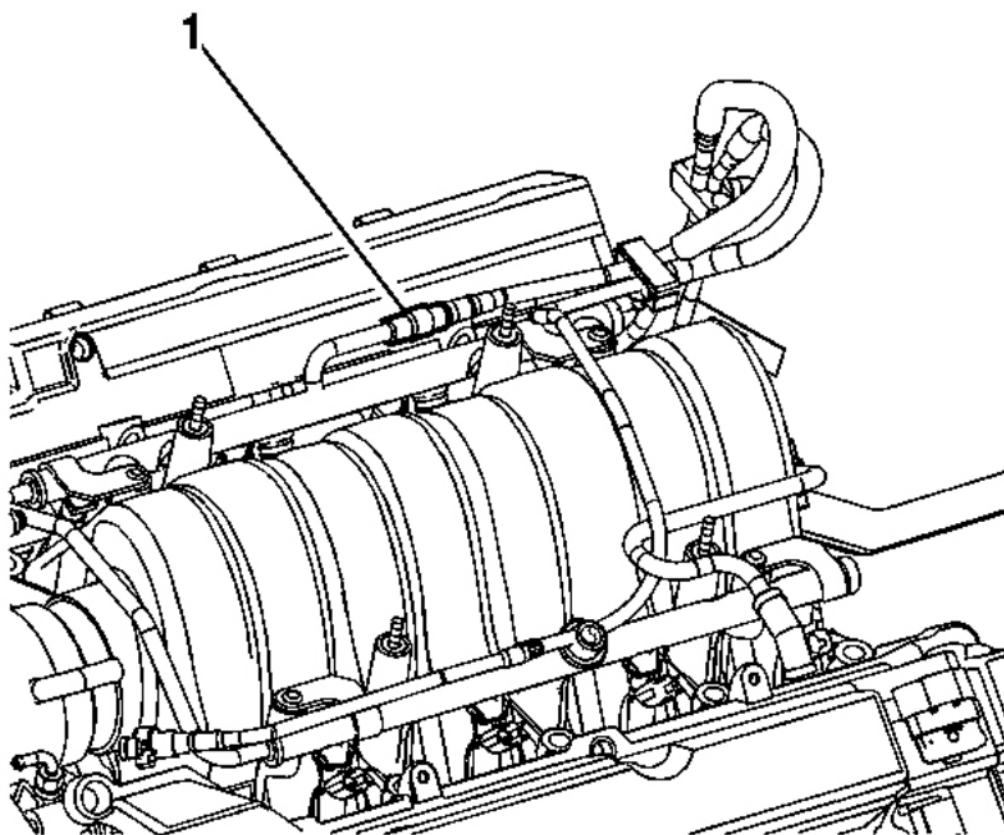


Fig. 67: View Of Fuel Line-To-Fuel Rail Connection
Courtesy of GENERAL MOTORS CORP.

13. Install the fuel line to the retainer at the rear of the right head.
14. Connect the fuel line to the fuel rail (1). Refer to **Quick Connect Fitting(s) Service (Metal Collar)** or **Quick Connect Fitting(s) Service (Plastic Collar)** in Engine Controls - 4.6L (LH2).

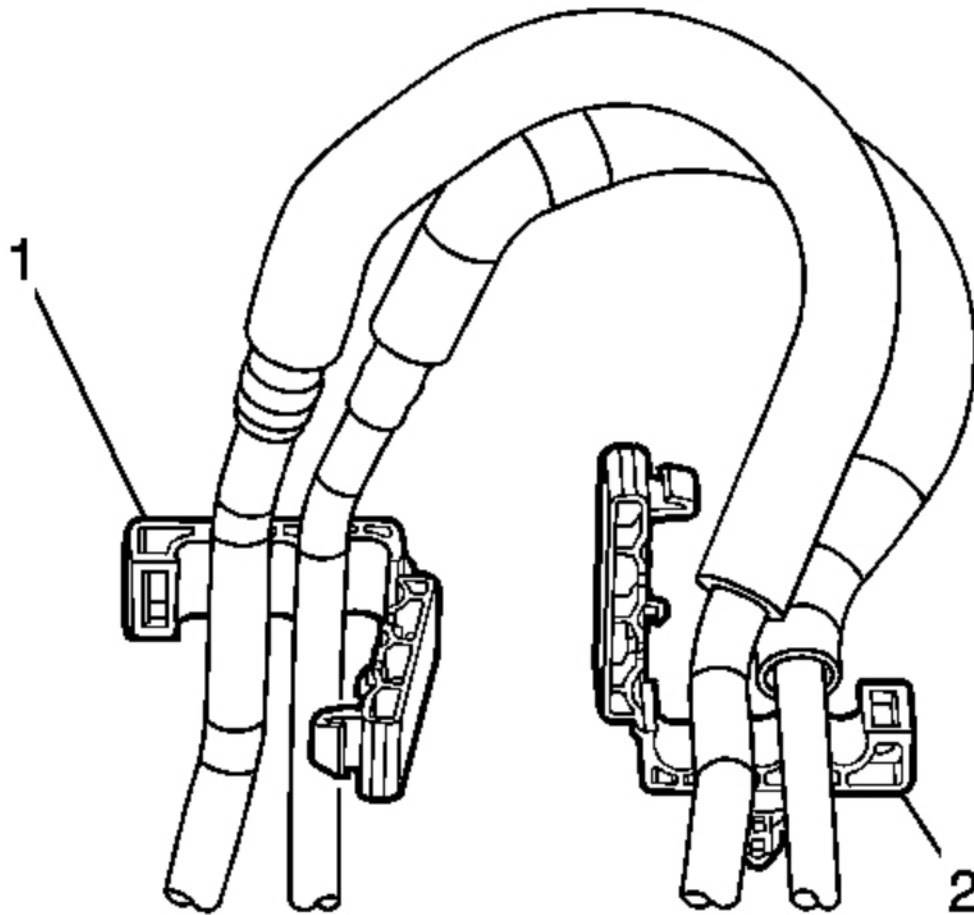


Fig. 68: View Of Hose Retainers
Courtesy of GENERAL MOTORS CORP.

15. Install the evaporative emissions purge valve line to the retainer (2) at the rear of the right head.

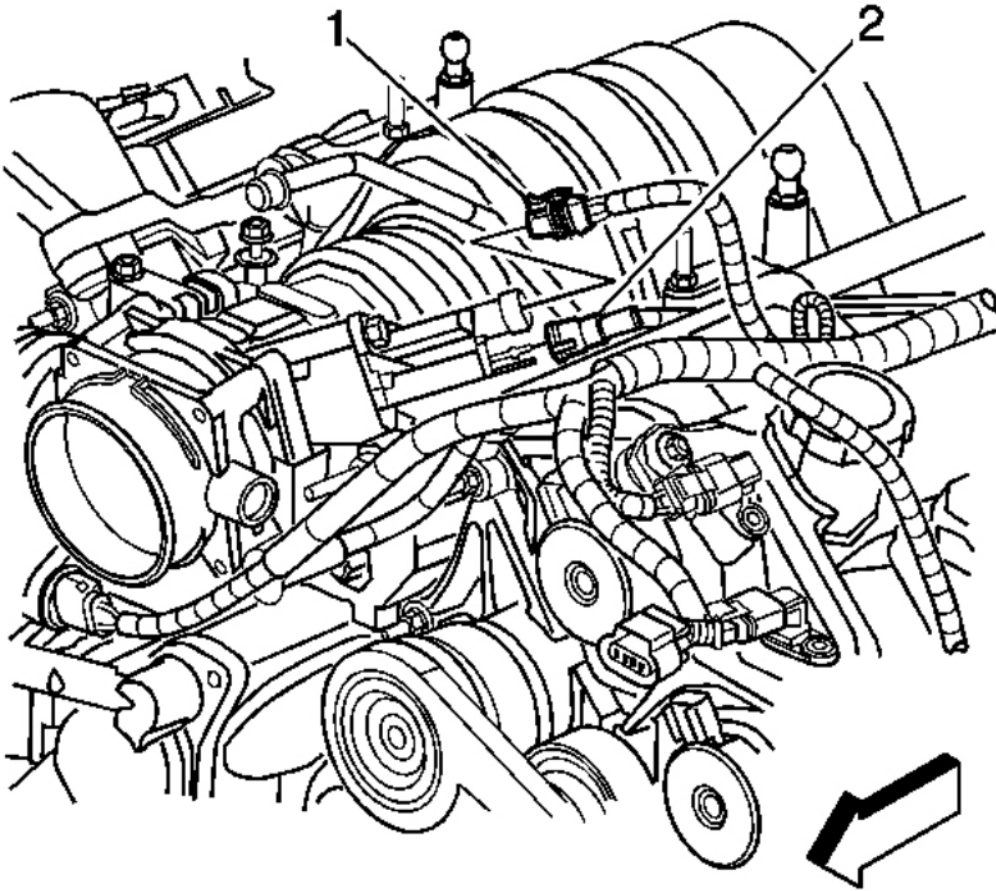


Fig. 69: View Of EVAP Emissions Purge Valve Line & Electrical Connector
Courtesy of GENERAL MOTORS CORP.

16. Install the evaporative emissions purge valve line (2) and electrical connector (1).

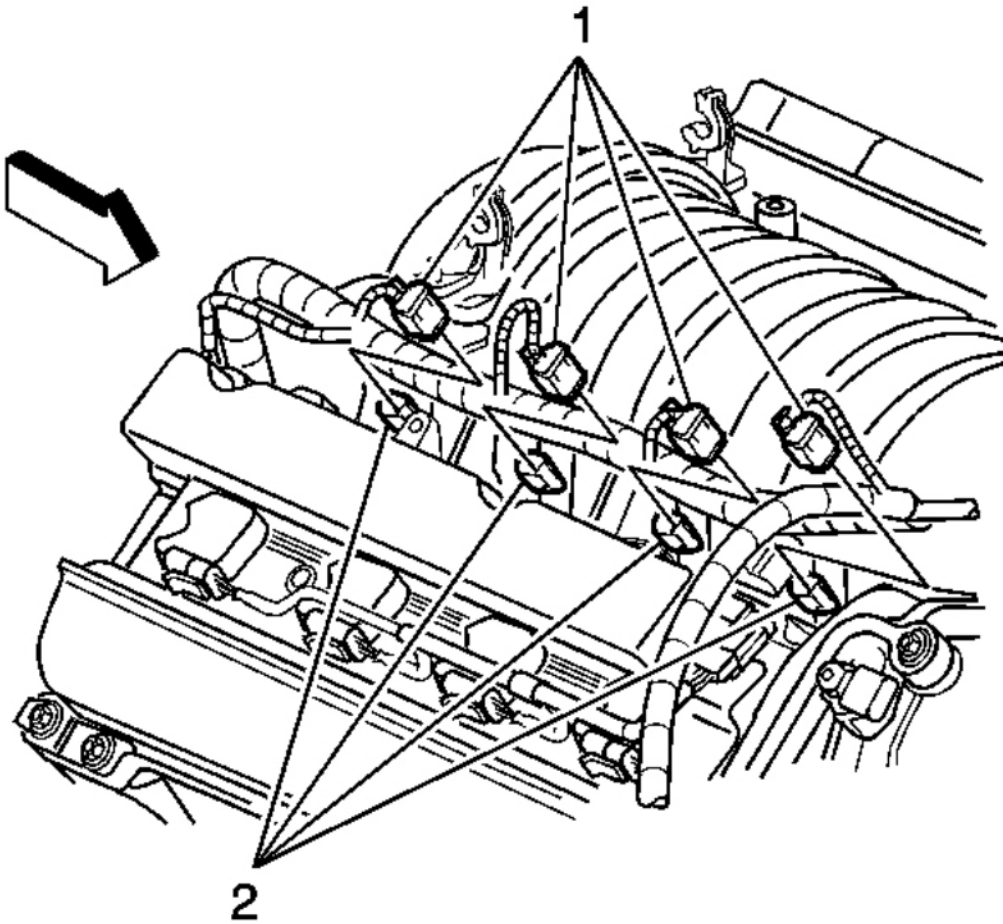


Fig. 70: View Of Right Side Fuel Injectors & Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

17. Connect the right side fuel injector electrical connectors (1) to the fuel injectors (2).

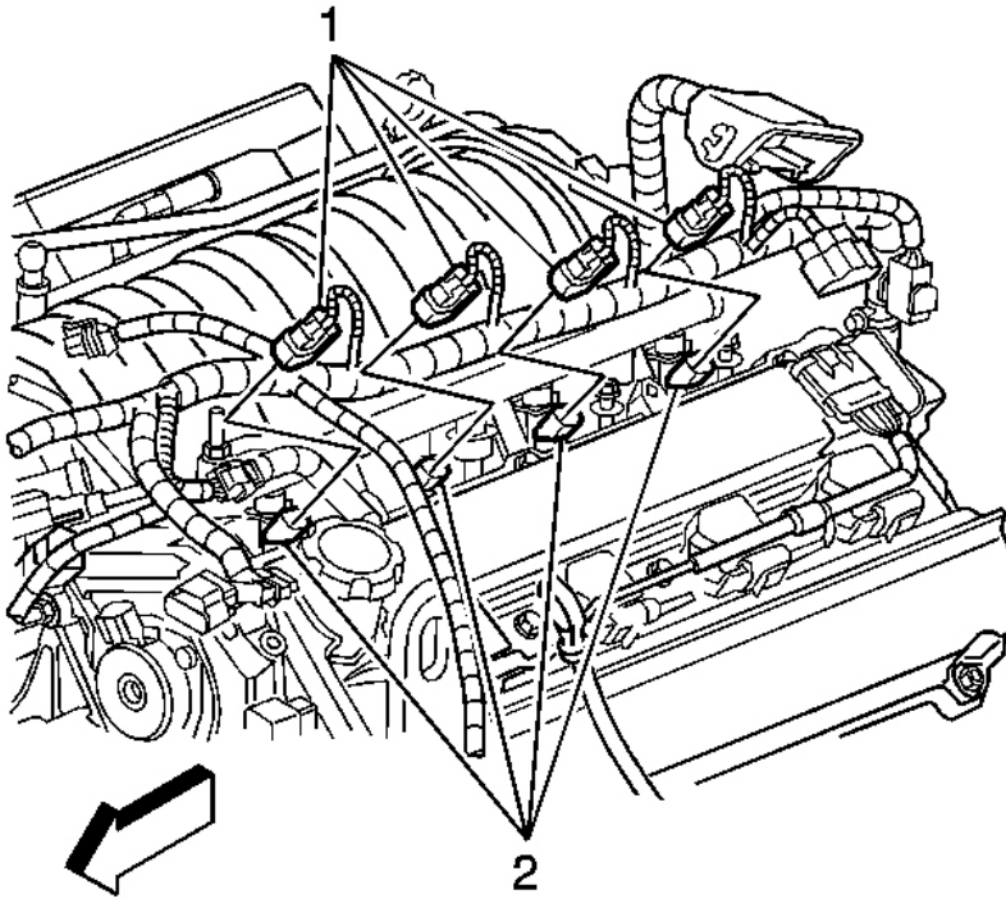


Fig. 71: View Of Left Side Fuel Injectors & Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Connect the left side fuel injector electrical connectors (1) to the fuel injectors (2).

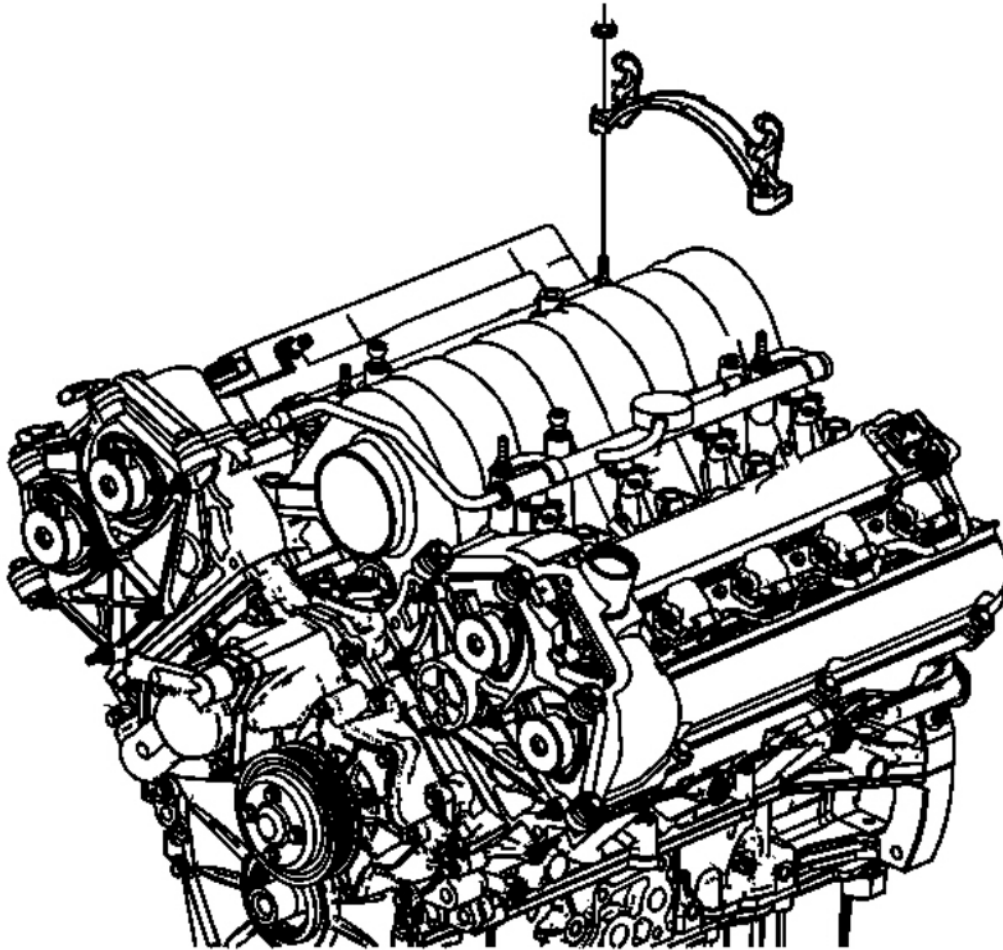


Fig. 72: View Of Sight Shield Bracket
Courtesy of GENERAL MOTORS CORP.

19. Install the sight shield bracket.
20. Install the sight shield bracket nuts.

Tighten: Tighten the sight shield bracket nuts to 10 N.m (89 lb in).

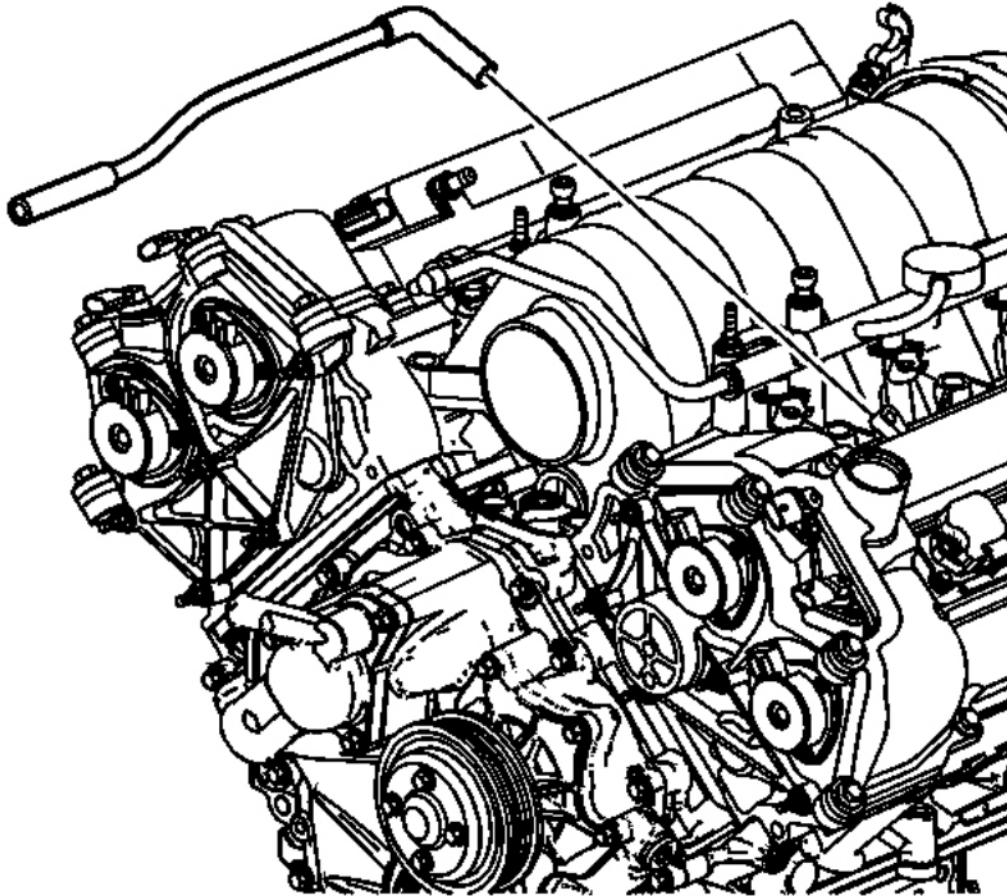


Fig. 73: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

21. Install the PCV fresh air tube to the engine.

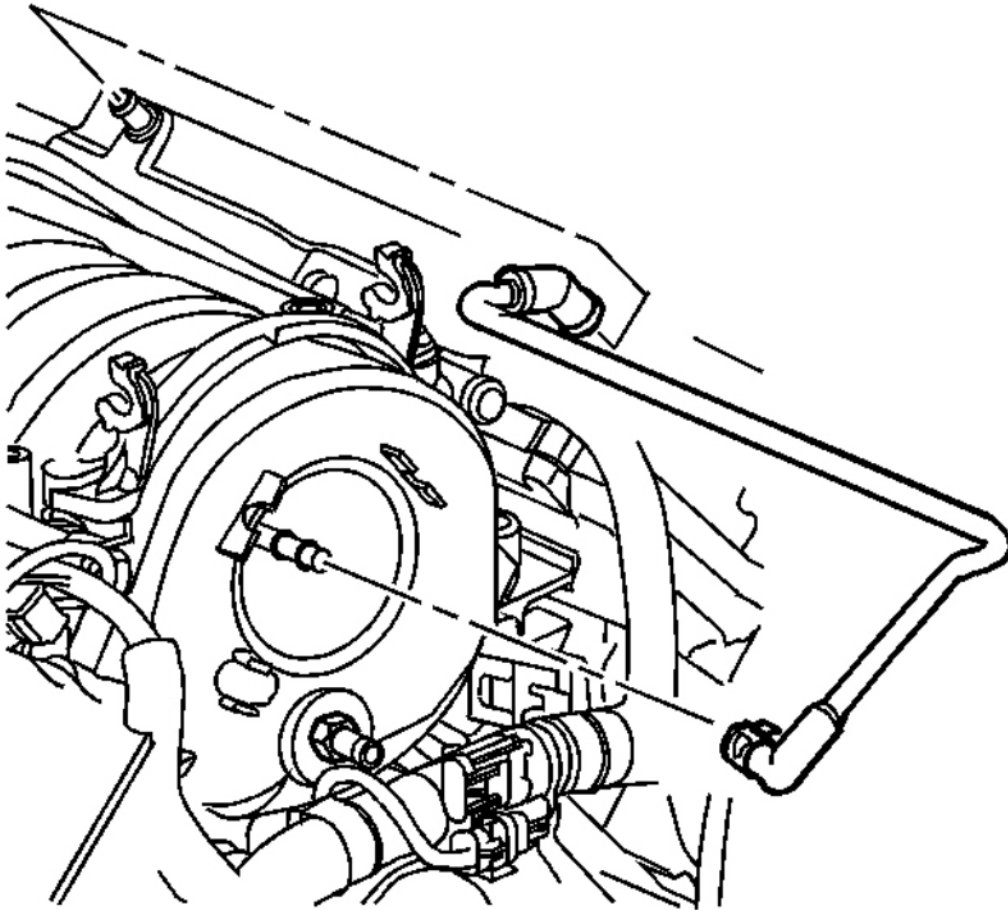


Fig. 74: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

22. Install the PCV dirty air tube to the engine.

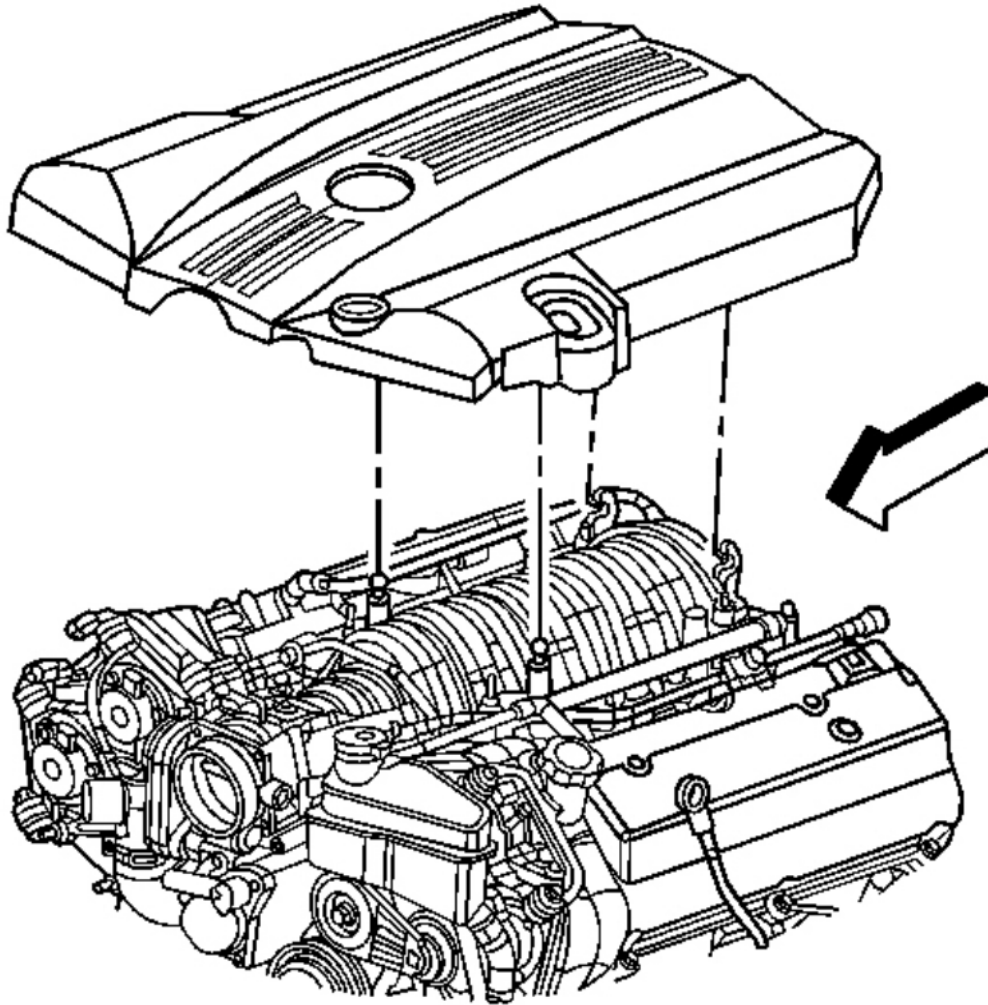


Fig. 75: View Of Fuel Injector Sight Shield
Courtesy of GENERAL MOTORS CORP.

23. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.
24. Install the cross car brace. Refer to **Brace Replacement - Cross Vehicle** in Body Front End.

OIL LEVEL INDICATOR AND TUBE REPLACEMENT

Removal Procedure

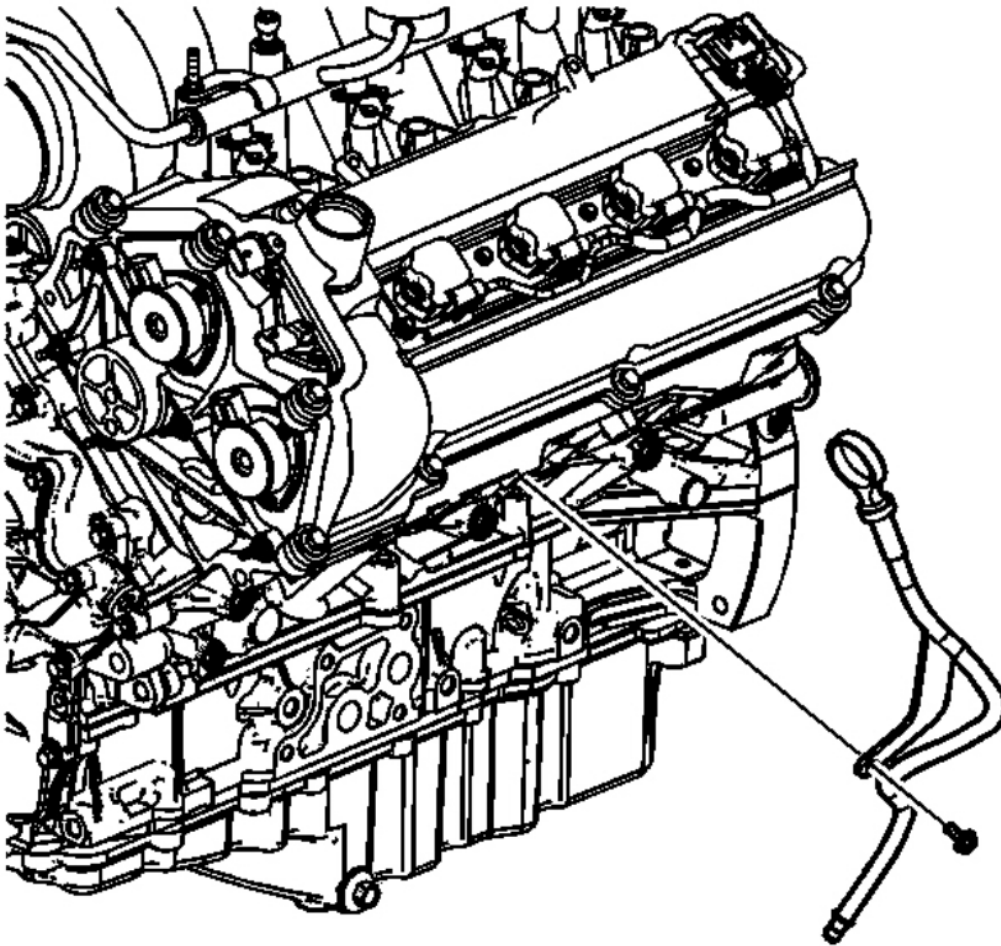


Fig. 76: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator.
2. Loosen the oil level indicator tube bolt.
3. Pull the oil level indicator tube from the crankcase.

Installation Procedure

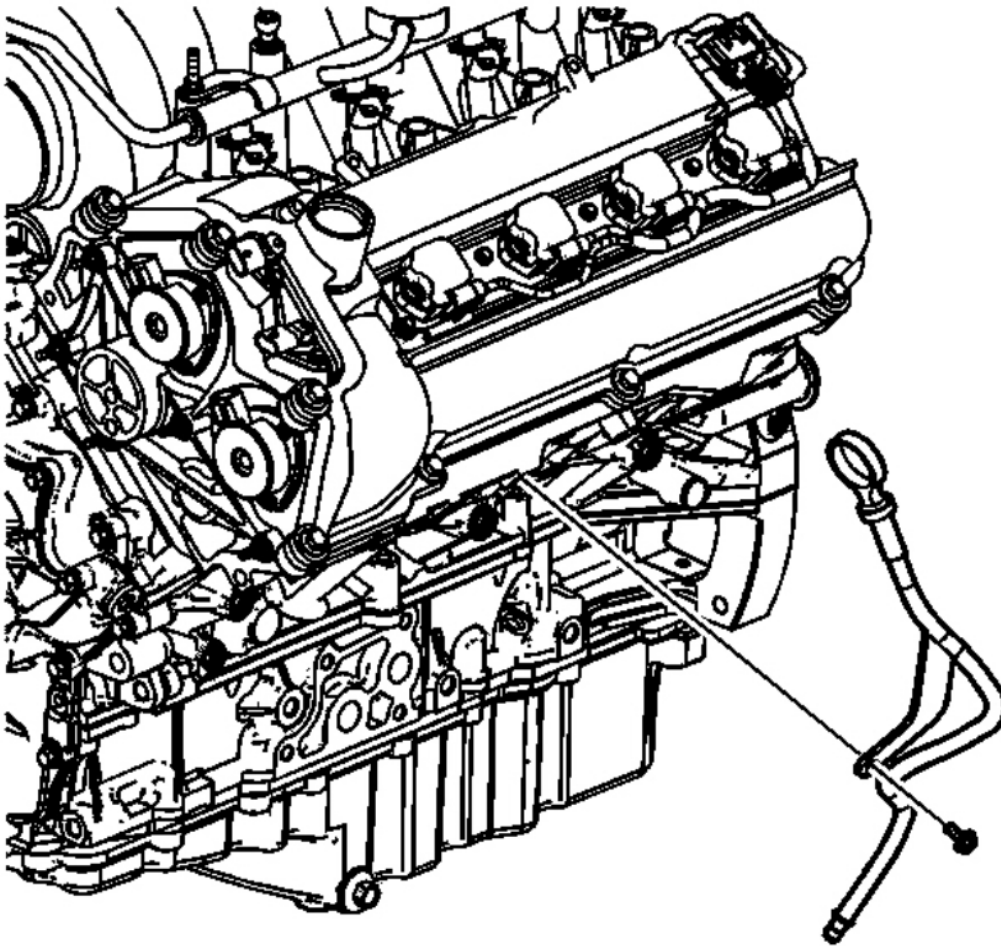


Fig. 77: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Replace the oil level indicator tube O-ring.
2. Install the oil level indicator tube.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil level indicator tube bolt.

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

4. Install the oil level indicator.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

1. Remove the left engine mount bracket. Refer to [Engine Mount Bracket Replacement - Left](#).

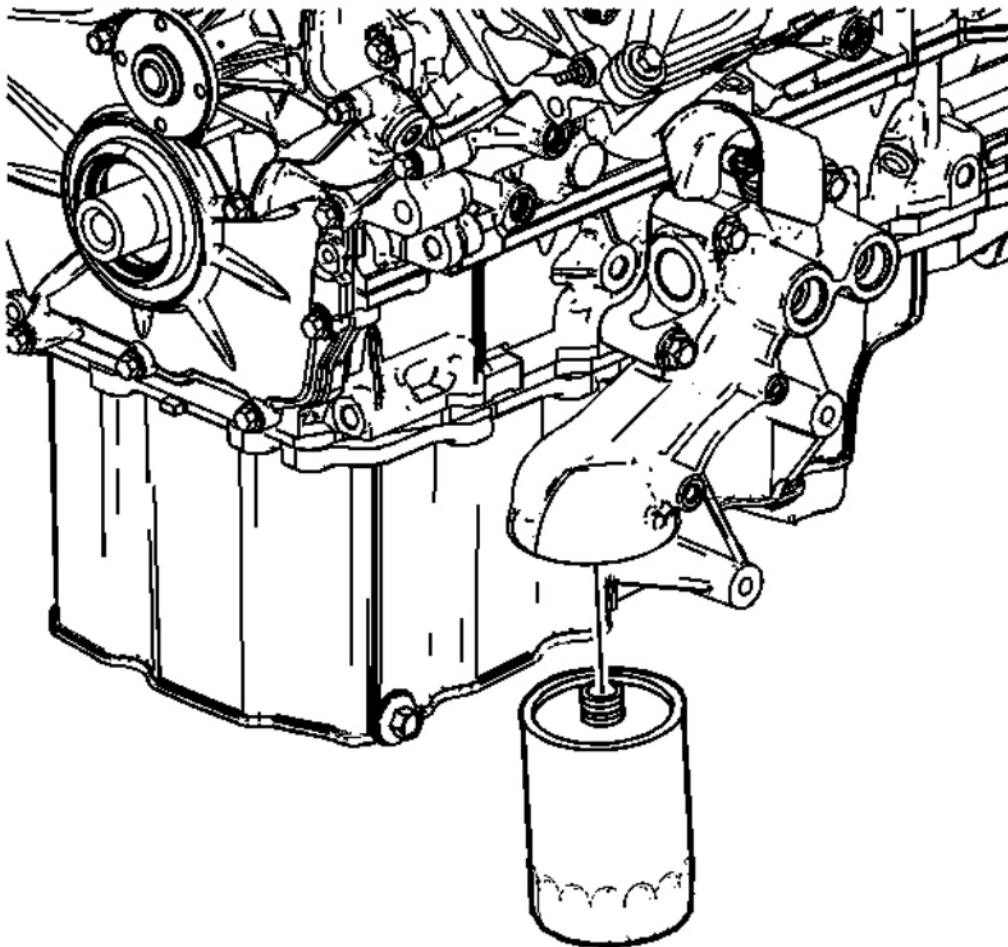


Fig. 78: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the engine oil cooler lines from the adapter, if equipped.
3. Disconnect the electrical connector from the engine oil pressure switch.
4. Remove the oil filter.

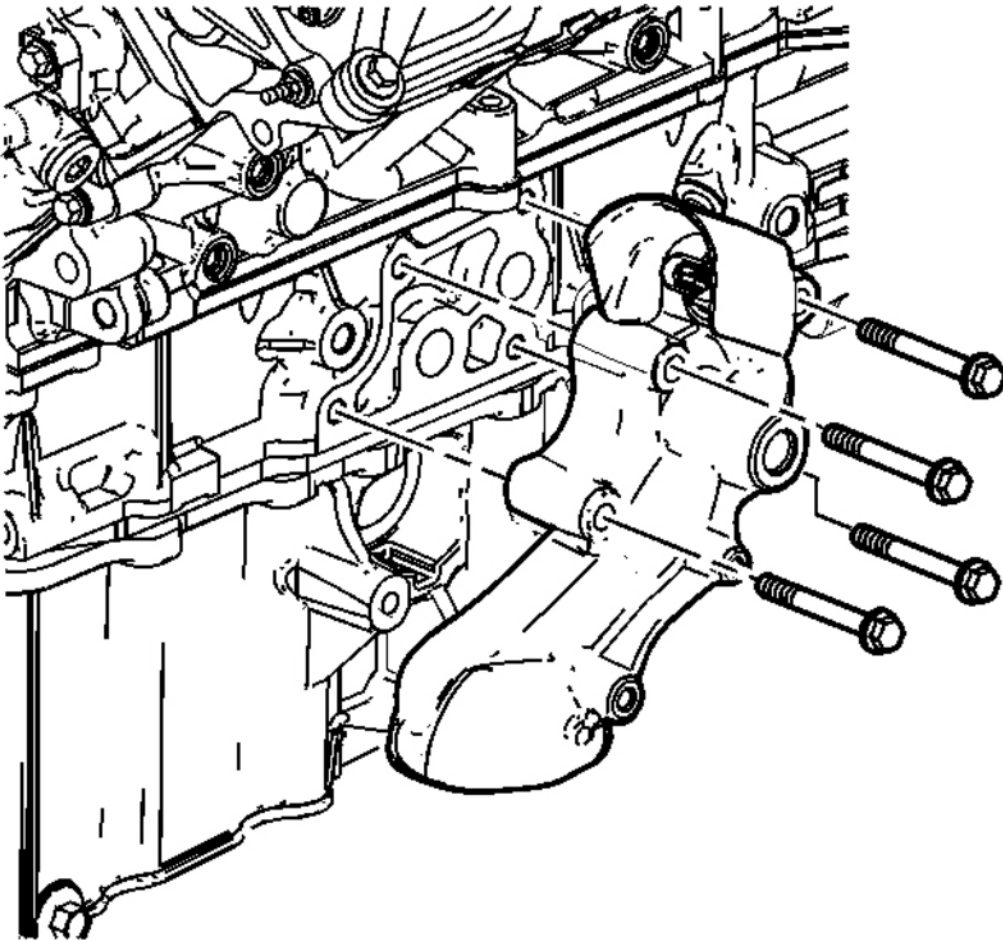


Fig. 79: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

5. Remove the adapter mounting bolts.
6. Remove the adapter and discard the gasket.
7. Remove the engine oil pressure switch from the oil filter adapter.
8. 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

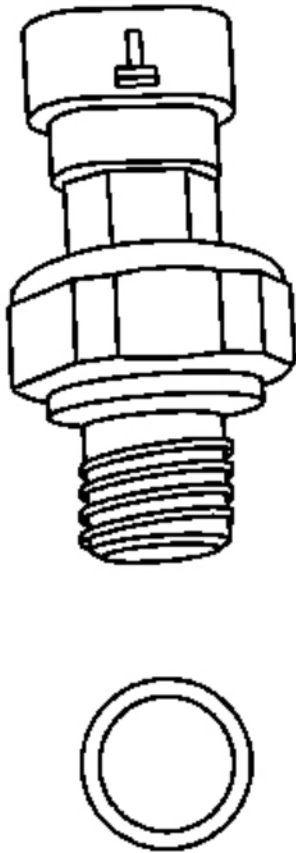


Fig. 80: View Of Engine Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

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

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).

2. Install the new gasket.

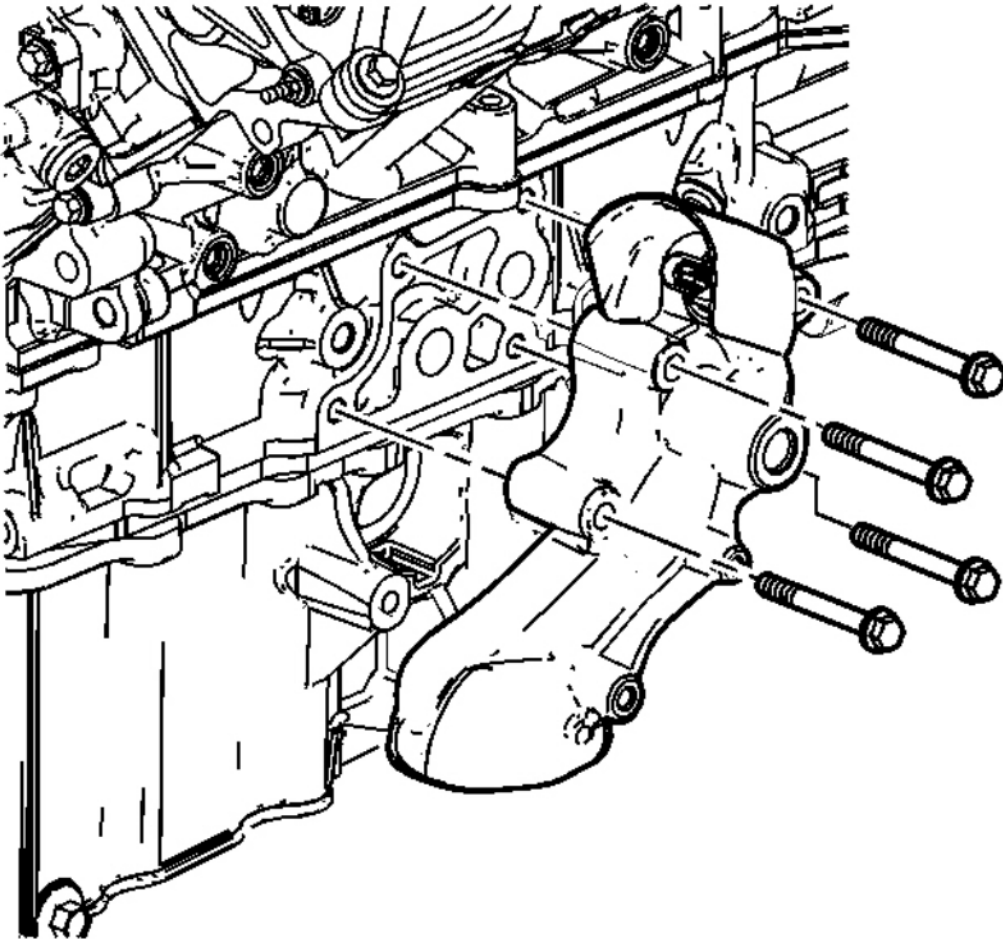


Fig. 81: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts attaching the oil filter adapter to the engine block.

Tighten: Tighten the oil filter adapter bolts to 16 N.m (12 lb ft).

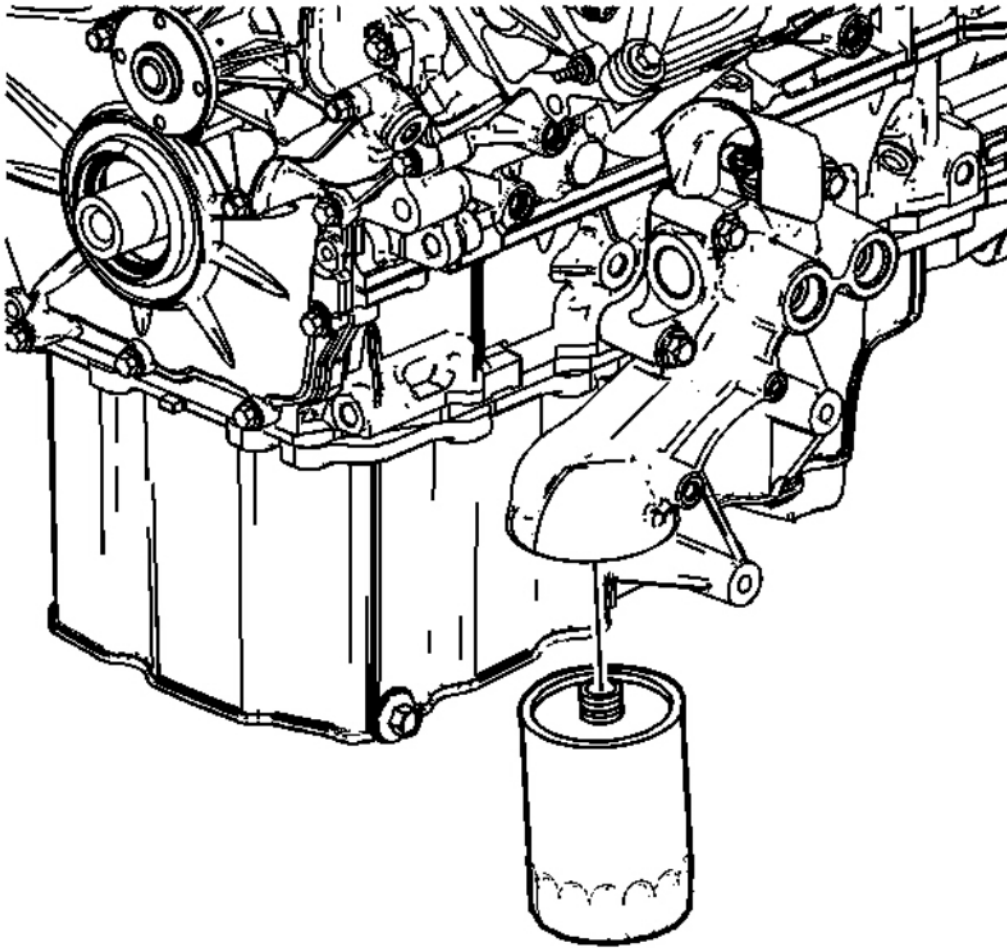


Fig. 82: View Of Oil Filter

Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Fill the oil filter with engine oil.

5. Install the oil filter.

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

6. Connect the electrical connector to the engine oil pressure switch.

7. Connect the engine oil cooler lines to the adapter, if equipped.
8. Install the left engine mount bracket. Refer to **Engine Mount Bracket Replacement - Left**.
9. Lower the vehicle.
10. Adjust the engine oil level to the full mark.
11. Inspect for oil leaks after engine start up.

CRANKSHAFT BALANCER REPLACEMENT

Tools Required

- **J 24420-C** Crankshaft Balancer Remover
- **J 38416-2** Crankshaft Button
- **J 41998-B** Crankshaft Balancer Installer
- **J 45059** Angle Meter
- **EN 46326** Flywheel Holding Tool

Removal Procedure

1. Remove the accessory drive belts. Refer to **Drive Belt Replacement - Generator** and to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump**.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

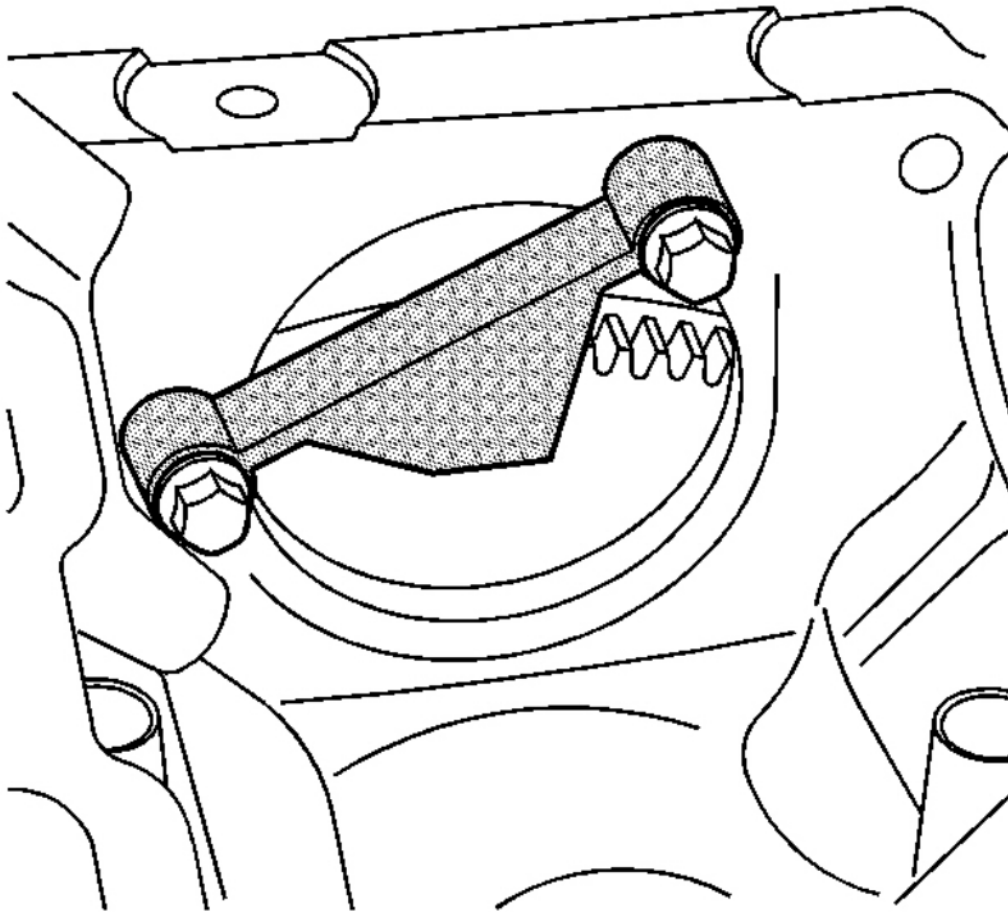


Fig. 83: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

3. Remove the starter motor. Refer to **Starter Motor Replacement (LH2)** or **Starter Motor Replacement (LY7)** in Engine Electrical.
4. Install the **EN 46326** .

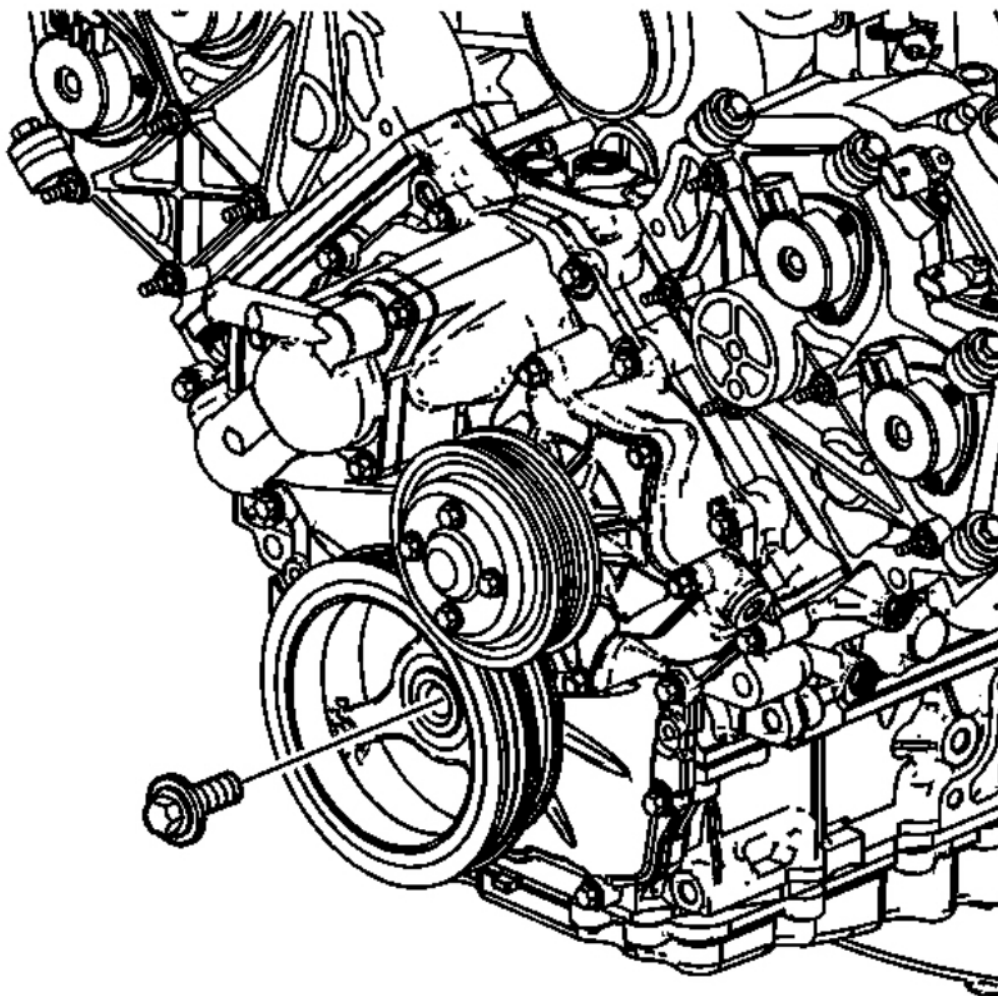


Fig. 84: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft balancer bolt.

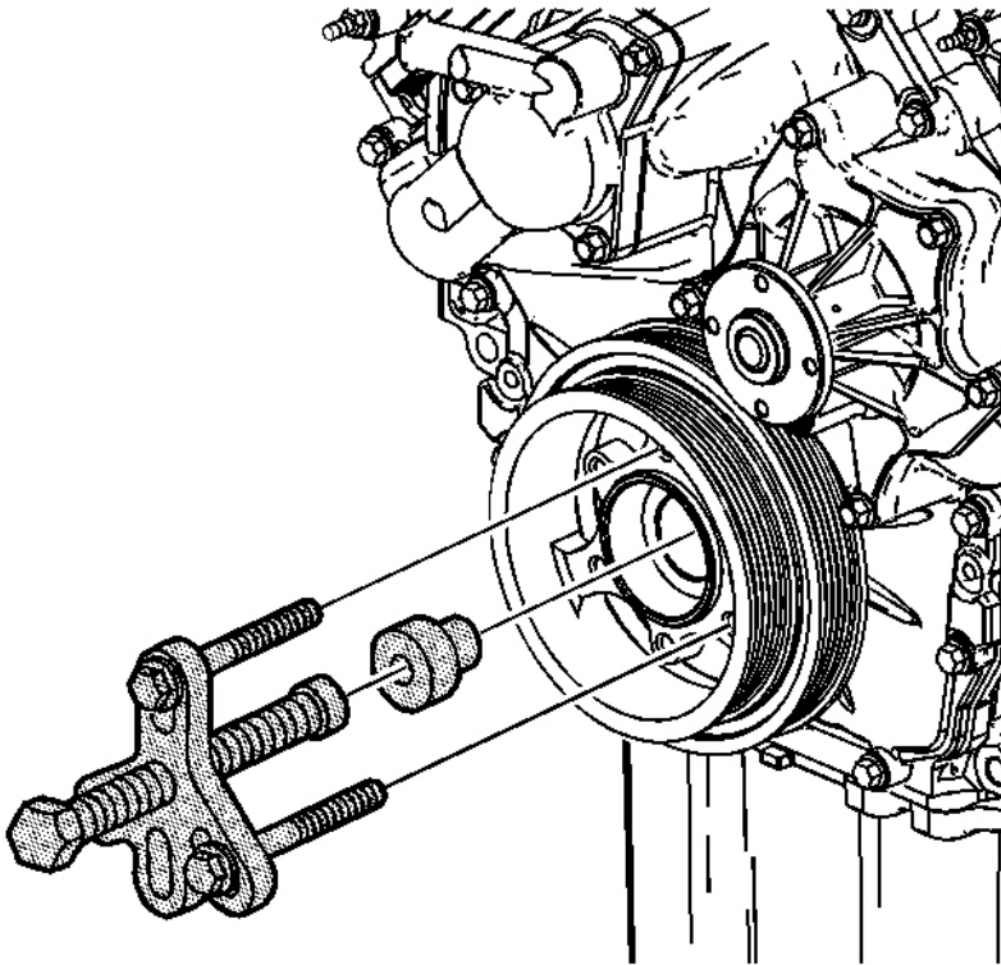


Fig. 85: View Of J 38416-2 & J 24420-C
Courtesy of GENERAL MOTORS CORP.

6. Place the **J 38416-2** crankshaft button into the end of the crankshaft.
7. Install the **J 24420-C** on the crankshaft balancer.

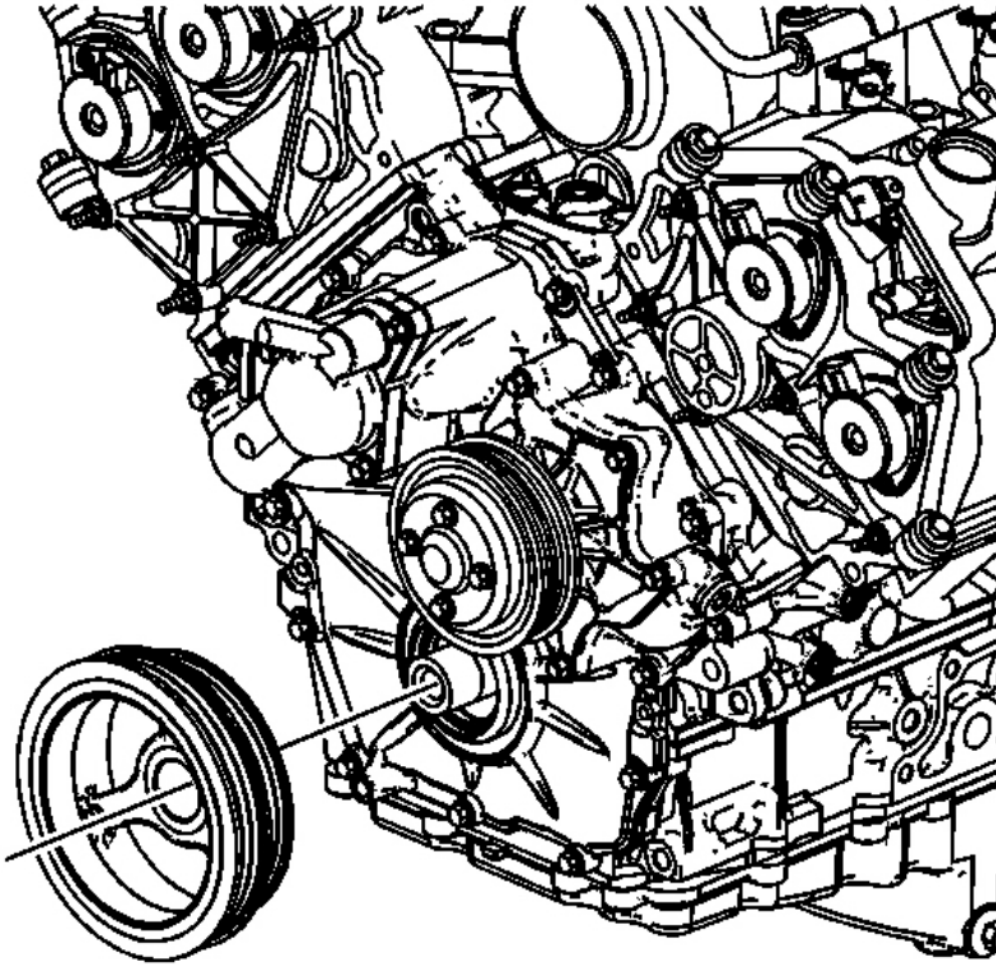


Fig. 86: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft balancer using the **J 24420-C** .

Cleaning and Inspection

Clean and inspect the crankshaft balancer. Refer to **Crankshaft Balancer Cleaning and Inspection** .

Installation Procedure

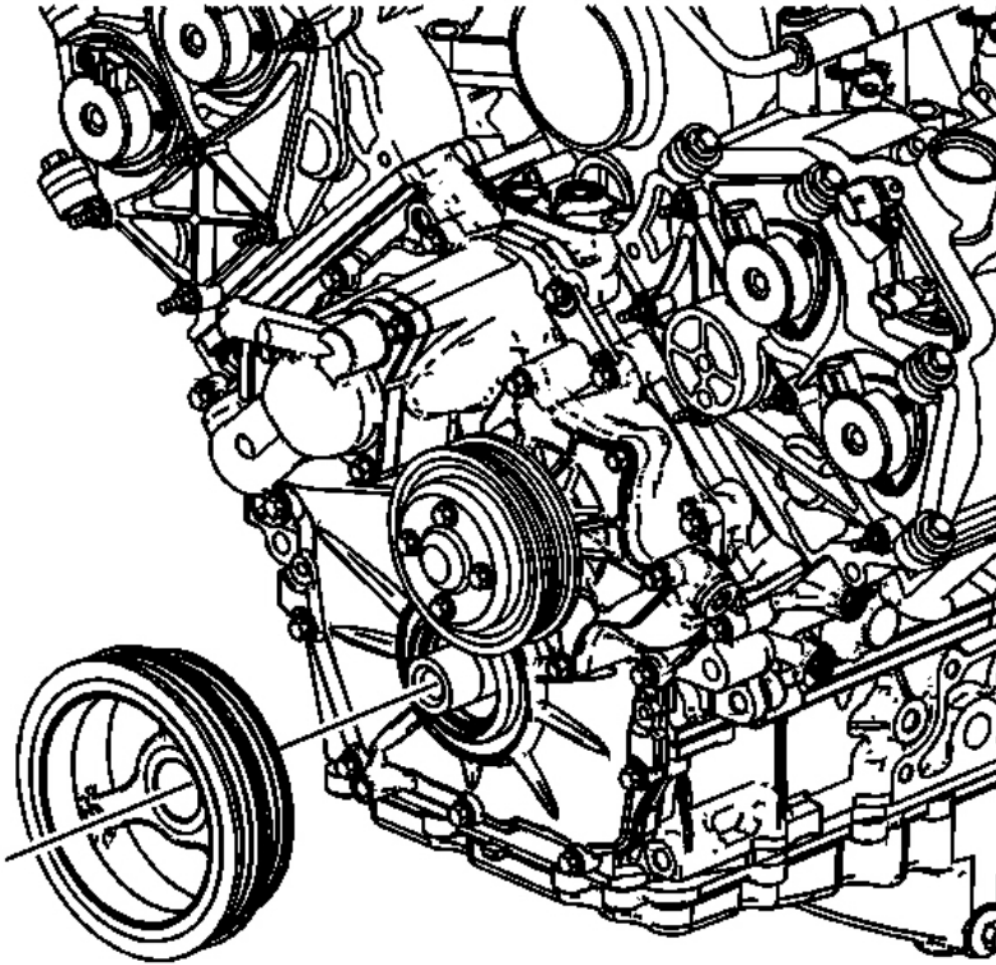


Fig. 87: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

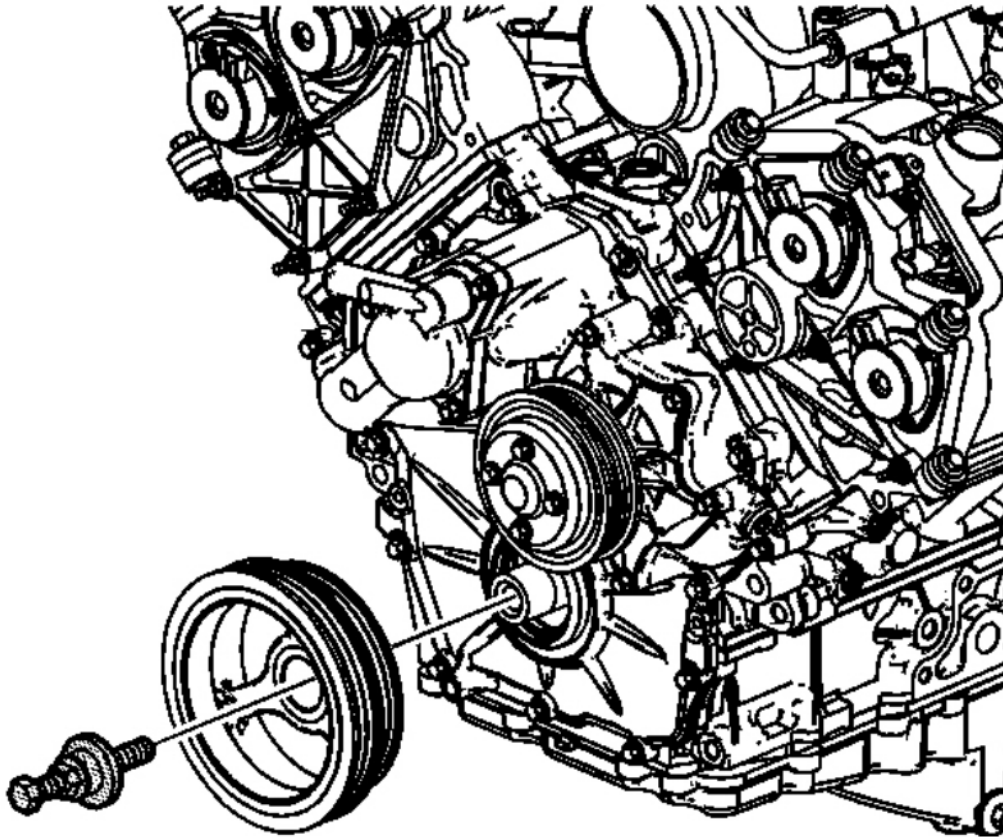


Fig. 88: Pressing Crankshaft Balancer In Place Using J 41998-B
Courtesy of GENERAL MOTORS CORP.

2. Press the crankshaft balancer in place using the J 41998-B .

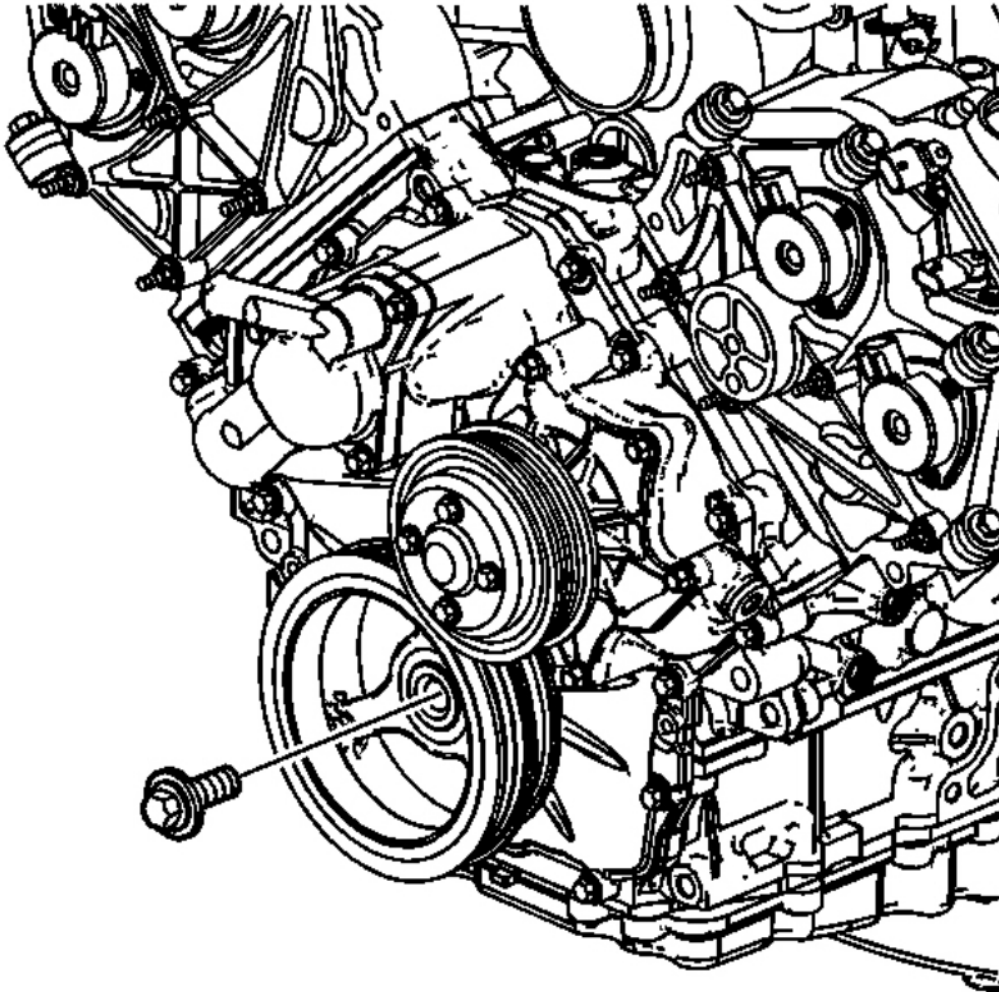


Fig. 89: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the crankshaft balancer bolt.
 1. First Pass

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

2. Final Pass

Tighten: Tighten the crankshaft balancer bolt an additional 120 degrees using the **J 45059** .

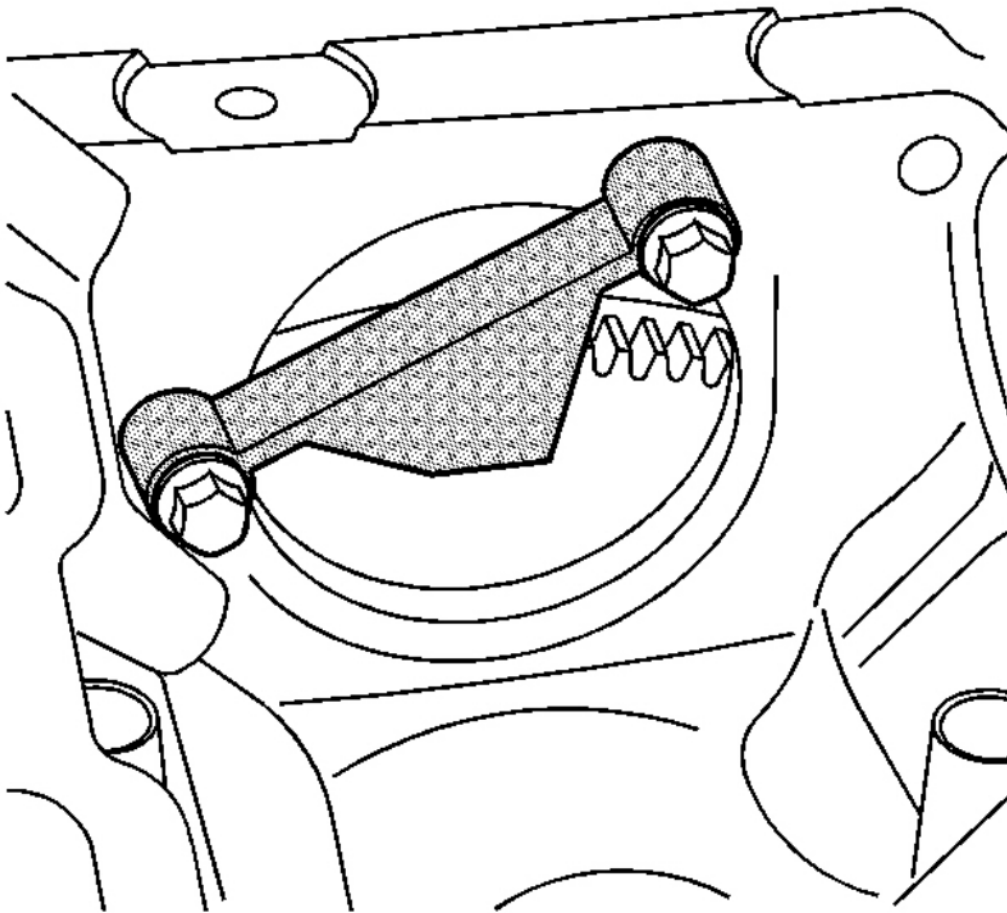


Fig. 90: View Of Flywheel Holder
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN 46326** .
7. Install the starter motor. Refer to **Starter Motor Replacement (LH2)** or **Starter Motor Replacement (LY7)** in Engine Electrical.

8. Install the accessory drive belts. Refer to **Drive Belt Replacement - Generator** and to **Drive Belt Replacement - Air Conditioning, Power Steering and Water Pump**.
9. Lower the vehicle.

ENGINE FRONT COVER REPLACEMENT

Tools Required

J 38185 Hose Clamp Pliers

Removal Procedure

1. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
2. Remove the air outlet duct in order to gain access to the thermostat housing. Refer to **Air Cleaner Outlet Duct Replacement** in Engine Controls - 4.6L (LH2).
3. Remove the heater hose from the thermostat housing using a **J 38185** .
4. Remove the coolant radiator hose from the thermostat housing. Refer to **Coolant Bypass Hose Replacement (LH2)** in Engine Cooling.
5. If equipped, remove the afterboil coolant pump. Refer to **Afterboil Coolant Pump Replacement** in Engine Cooling.
6. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Generator** and to **Drive Belt Tensioner Replacement - Air Conditioning, Power Steering and Water Pump**.

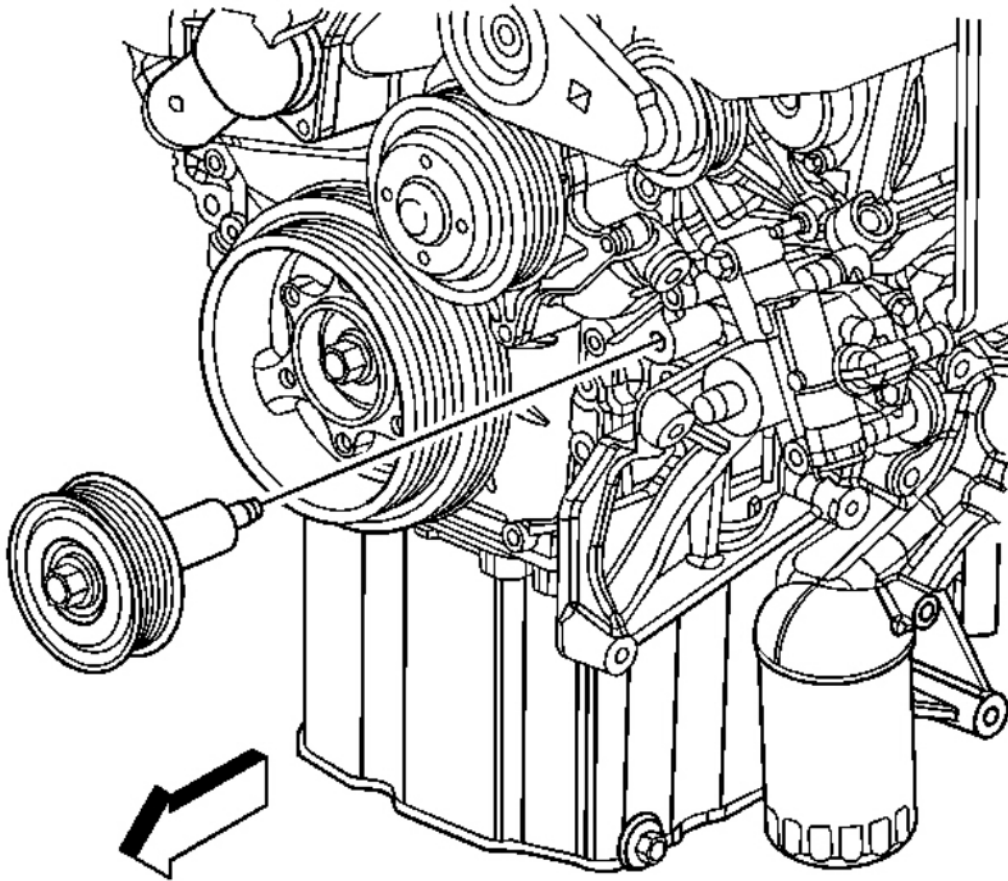


Fig. 91: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

7. Remove the drive belt idler pulley bolt.

Remove the drive belt idler pulley.

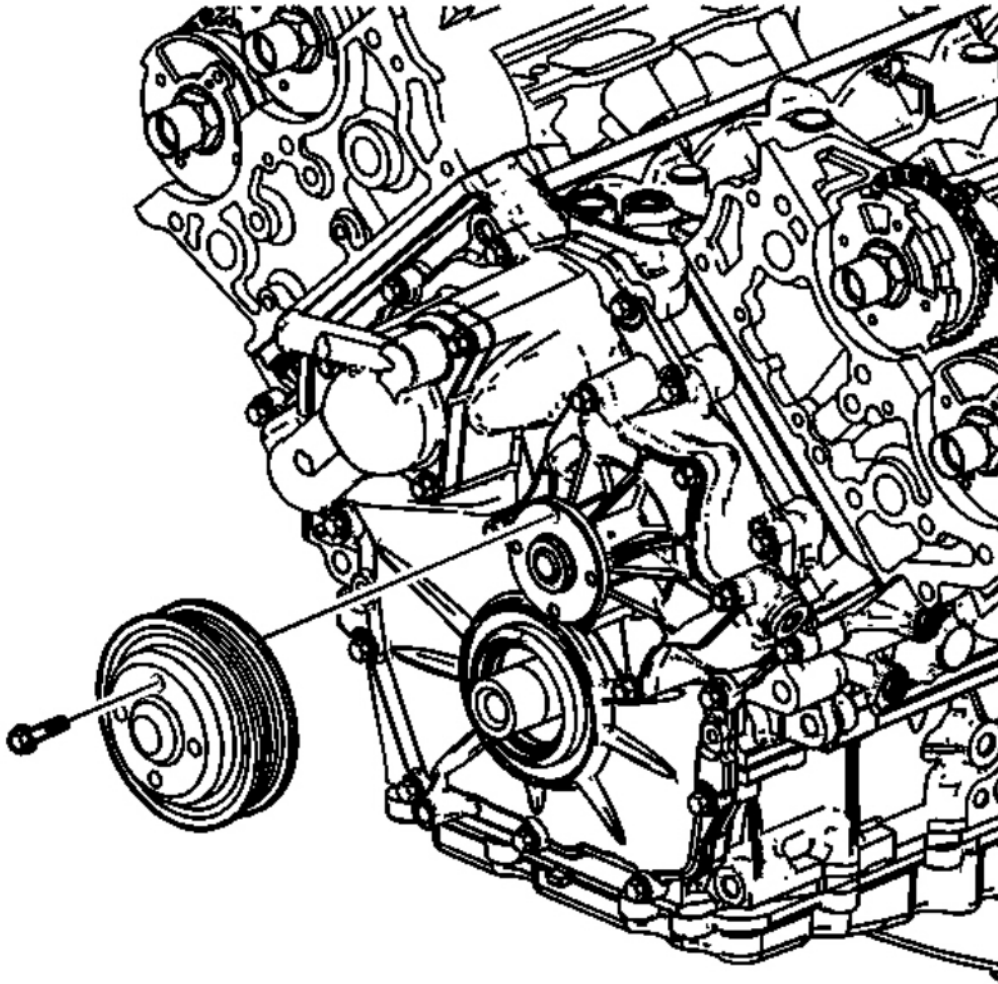


Fig. 92: View Of Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

8. Remove the water pump pulley.
9. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
10. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

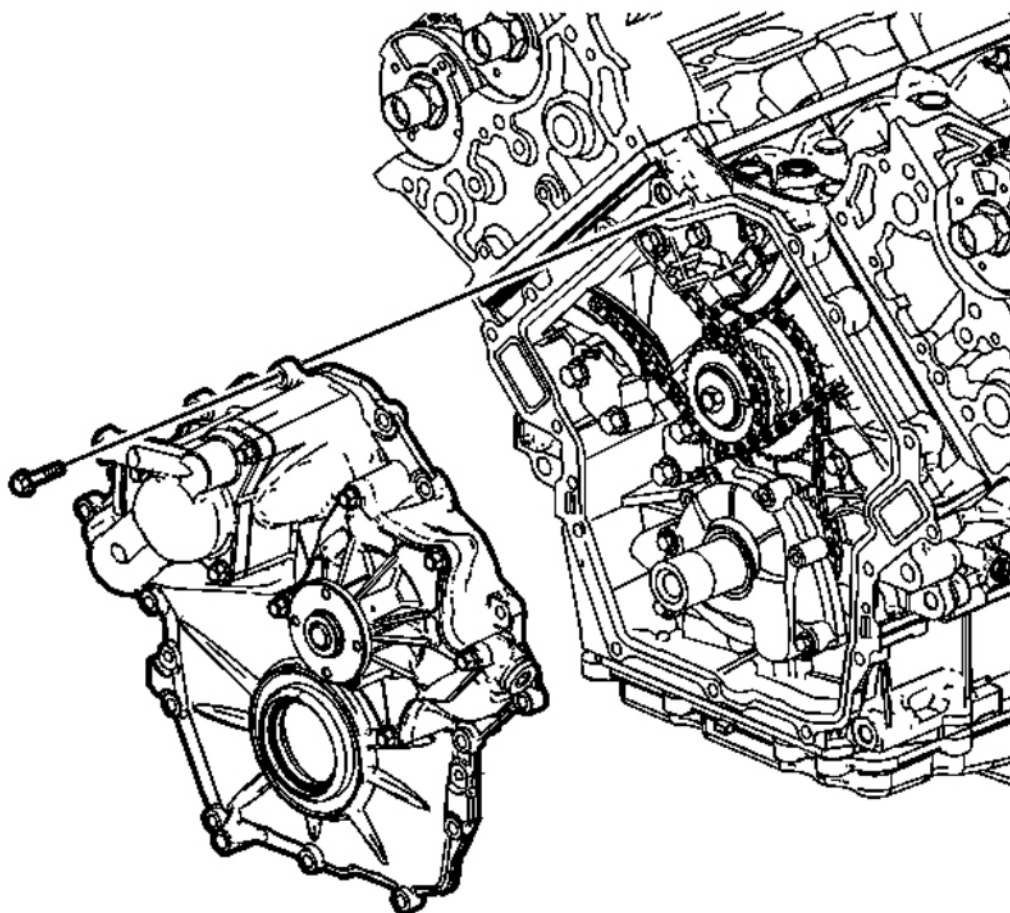


Fig. 93: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine front cover bolts.
12. Remove the engine front cover.

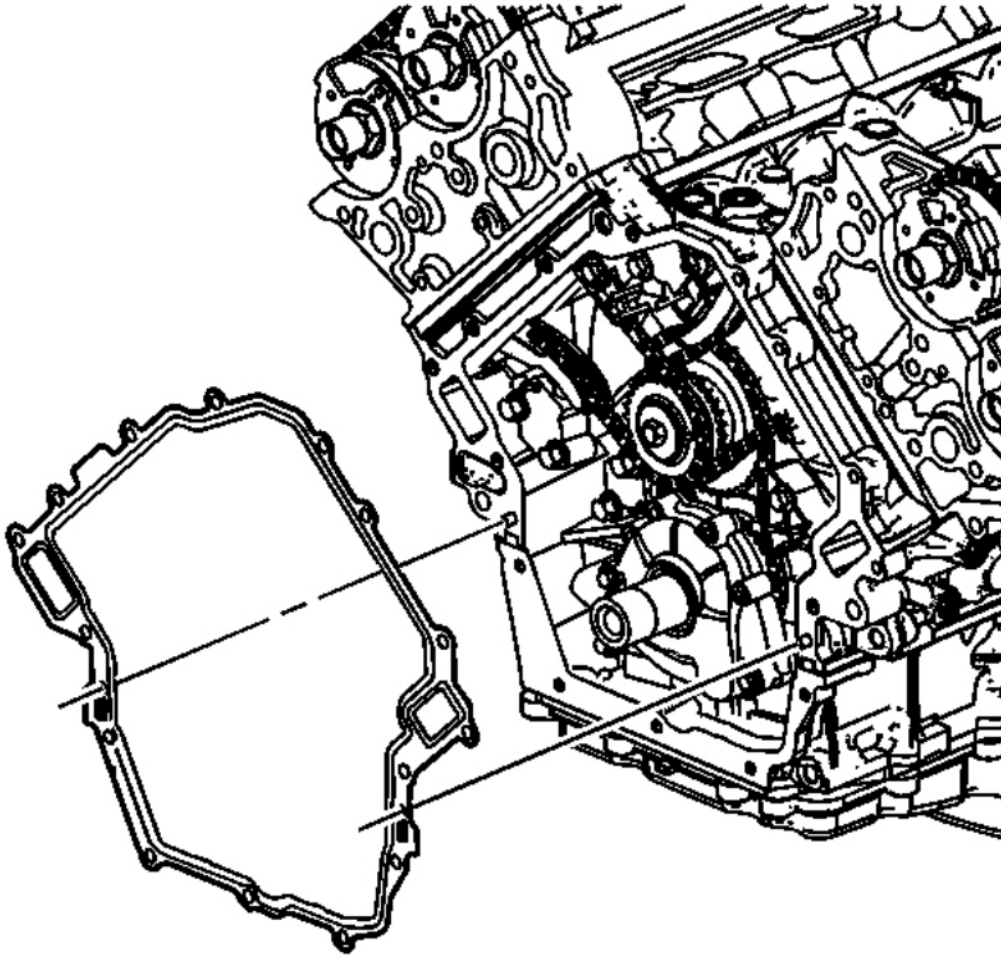


Fig. 94: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the engine front cover gasket.

Cleaning and Inspection

Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection** .

Installation Procedure

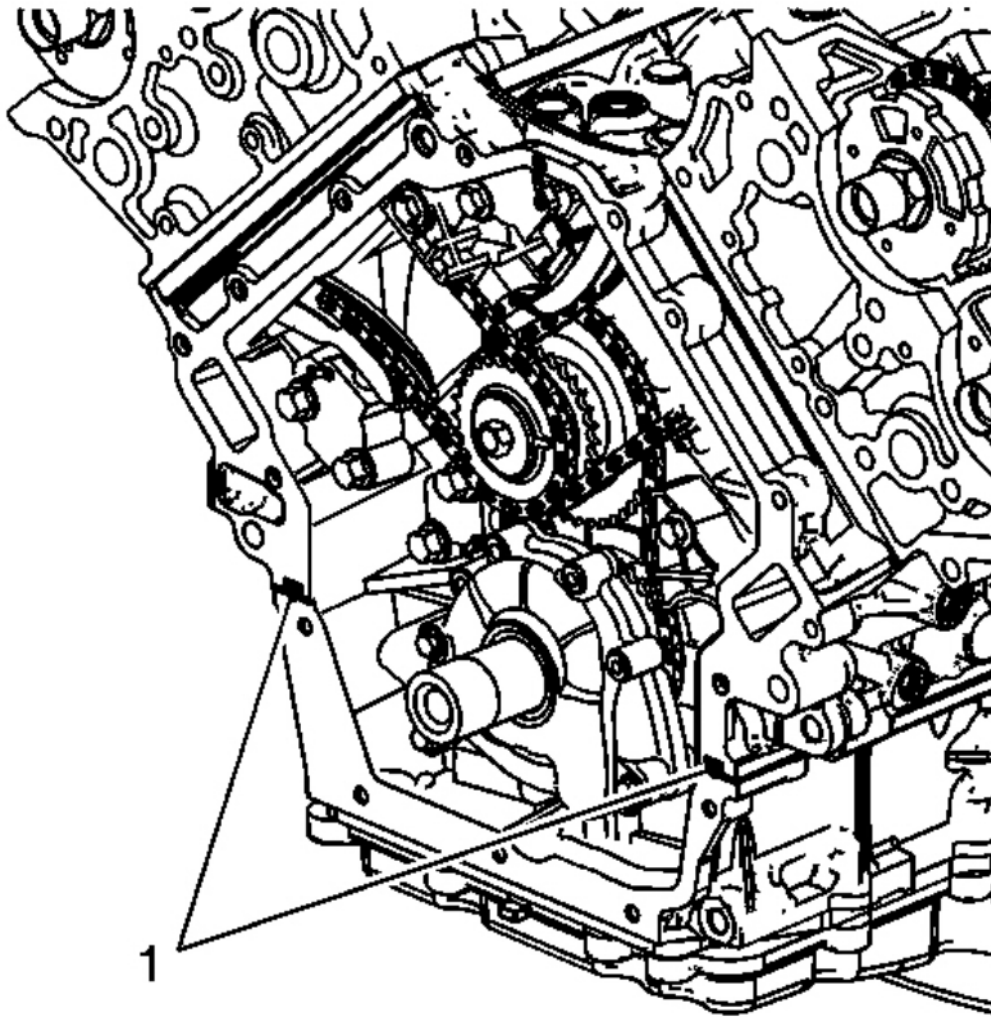


Fig. 95: Applying Sealant To Split Line Of Crankcases
Courtesy of GENERAL MOTORS CORP.

1. Place a small amount of sealant GM P/N 12578521 (Canadian P/N 88901148) or equivalent at the split line (1) of the upper and lower crankcases, and at the top of the block face.

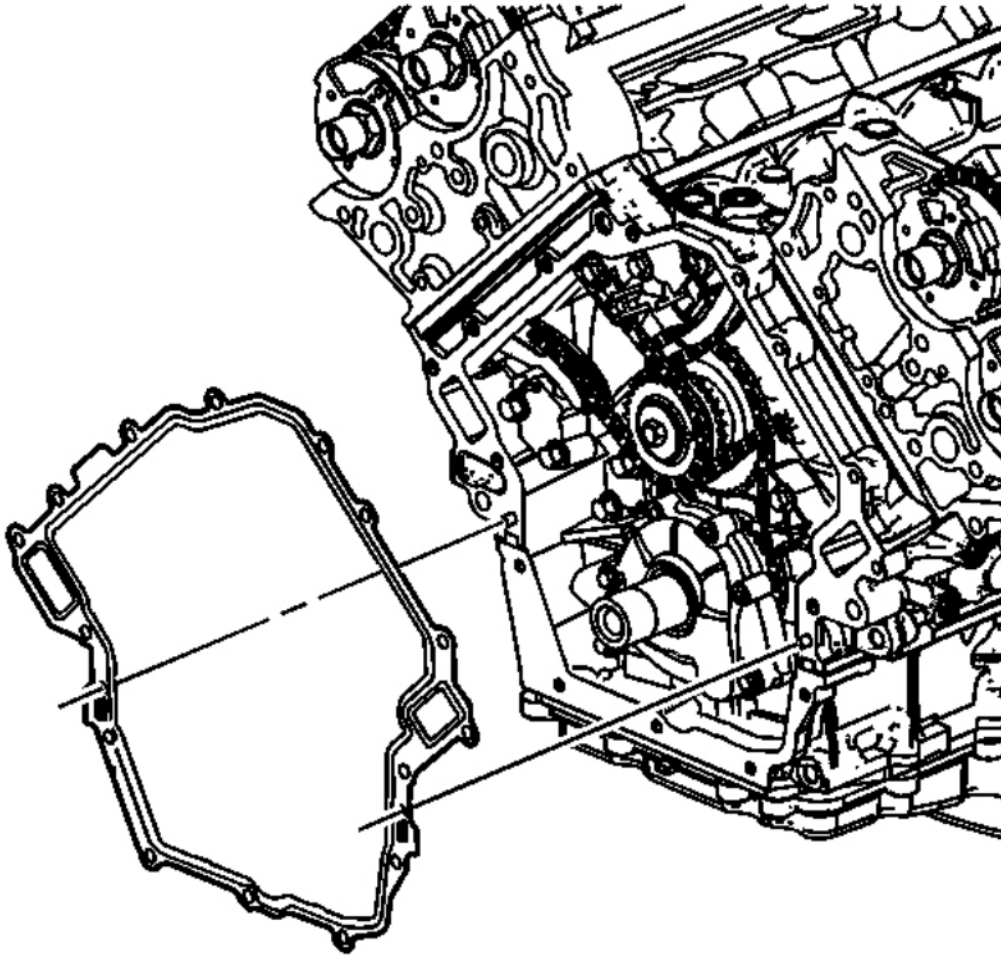


Fig. 96: View Of Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

2. Place the NEW engine front cover gasket over the crankcase dowel pins.

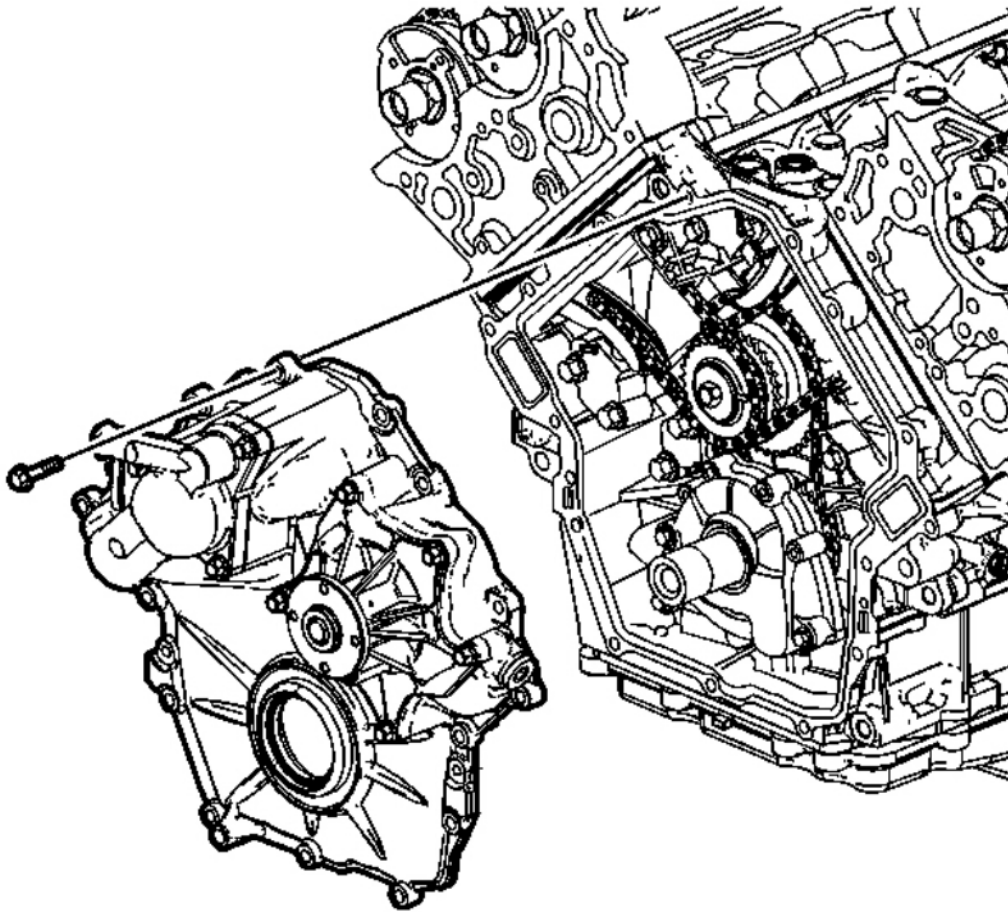


Fig. 97: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

3. Place the engine front cover in position on the crankcase.
4. Apply the thread locking compound GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the engine front cover bolts.
5. Install the engine front cover retaining bolts.

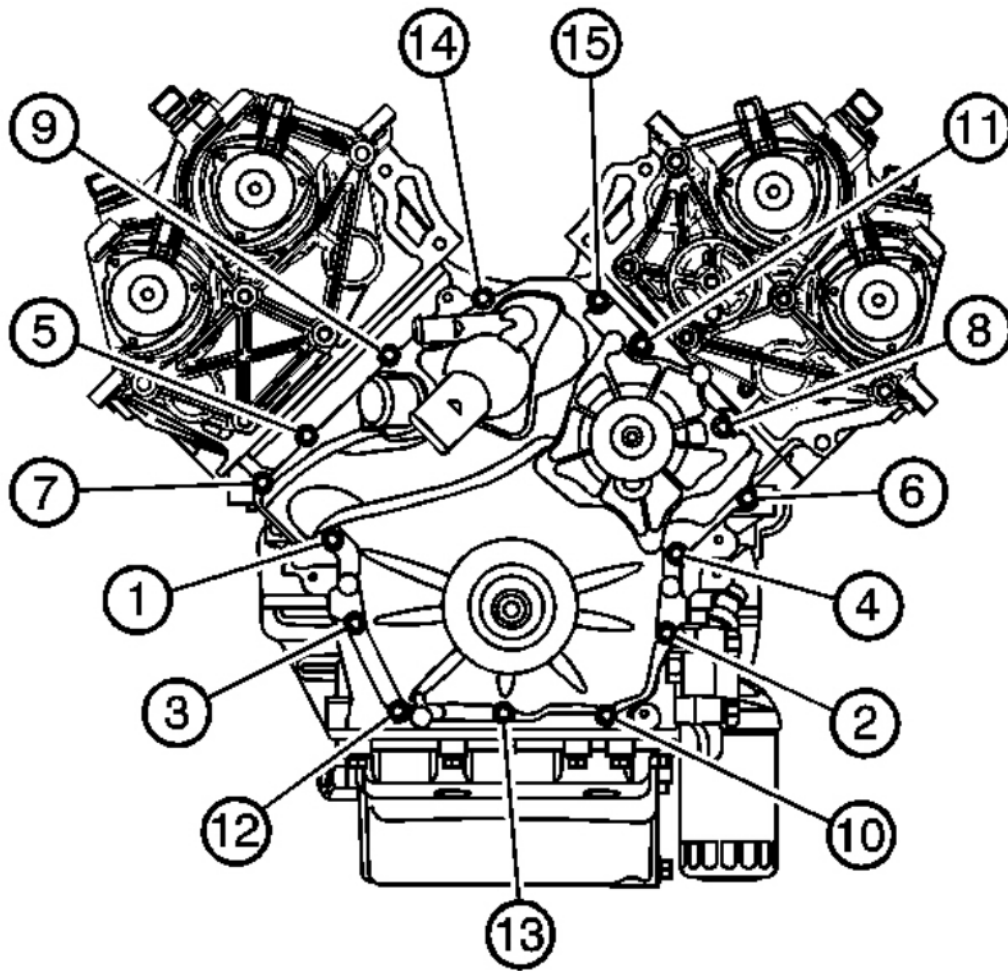


Fig. 98: Tightening Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the engine front cover bolts in the sequence shown.

Tighten: Tighten the engine front cover bolts in proper sequence to 15 N.m (11 lb ft).

7. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
8. Install the water pump pulley.

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

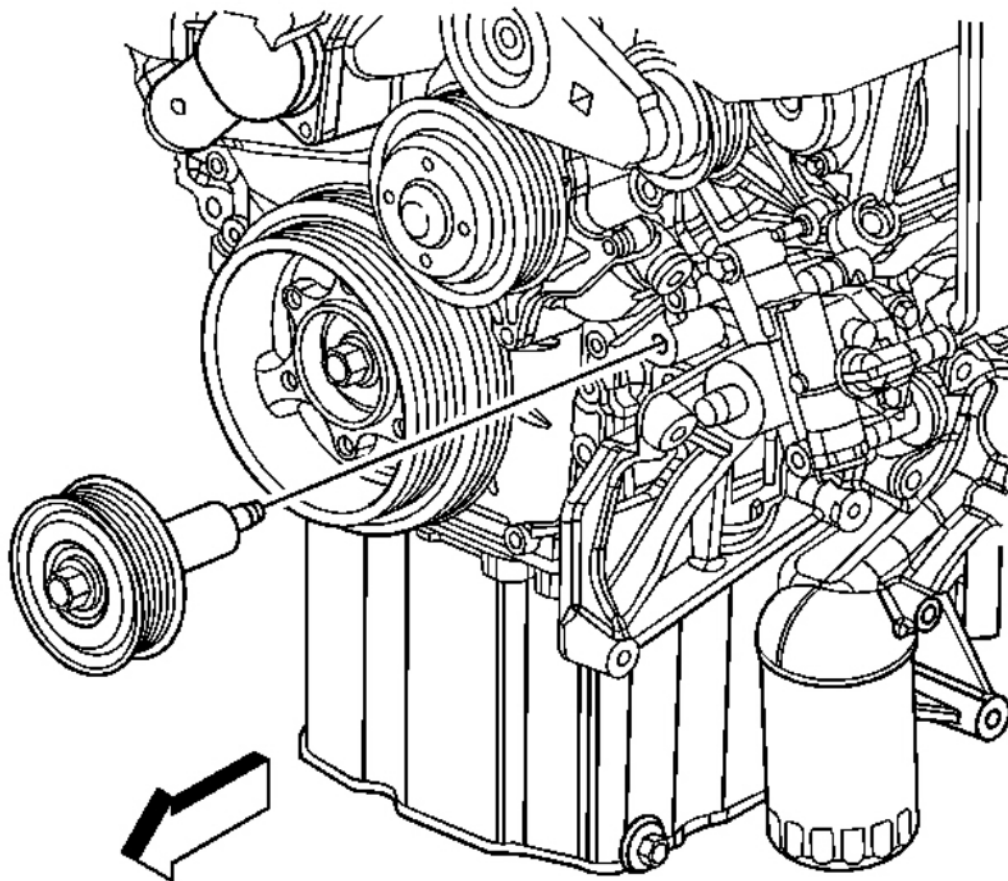


Fig. 99: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

9. Install the drive belt idler pulley.
10. Install the drive belt idler pulley bolt.

Tighten: Tighten the drive belt idler pulley bolt to 50 N.m (37 lb ft).

11. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Generator** and to **Drive Belt Tensioner Replacement - Air Conditioning, Power Steering and Water Pump.**

12. Install the coolant radiator hose to the thermostat housing. Refer to **Coolant Bypass Hose Replacement (LH2)** in Engine Cooling.
13. Install the heater hose to the thermostat housing using a **J 38185** .
14. If equipped, install the afterboil coolant pump. Refer to **Afterboil Coolant Pump Replacement** in Engine Cooling.
15. Install the air outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** in Engine Controls - 4.6L (LH2).
16. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

OIL PUMP REPLACEMENT

Tools Required

J 45059 Angle Meter

Removal Procedure

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

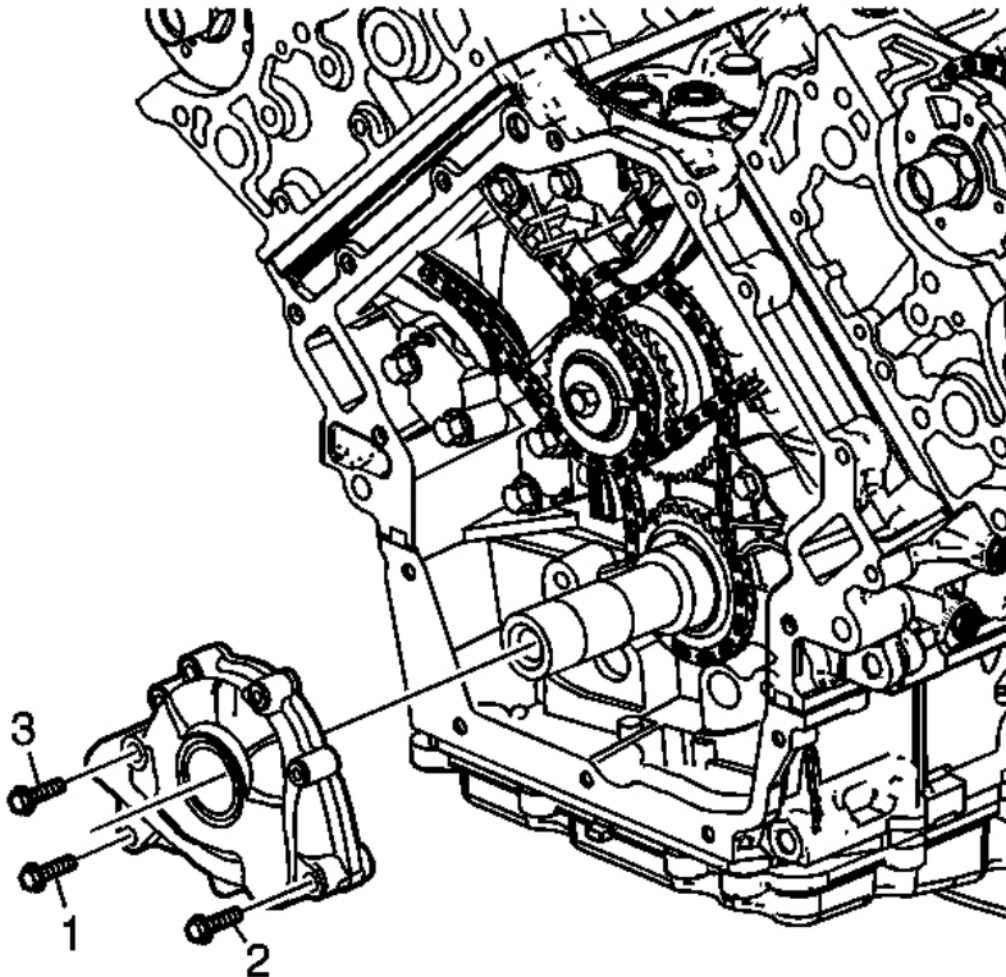


Fig. 100: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

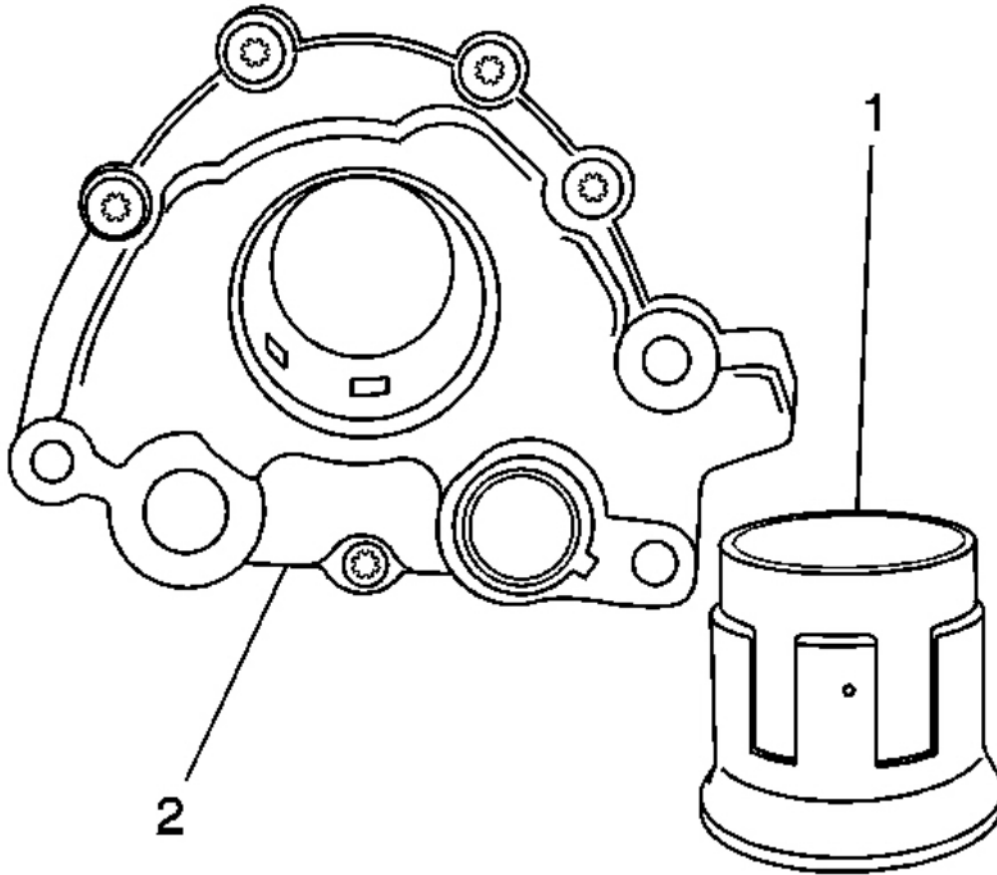


Fig. 101: Identifying Oil Pump & Drive Spacer
Courtesy of GENERAL MOTORS CORP.

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

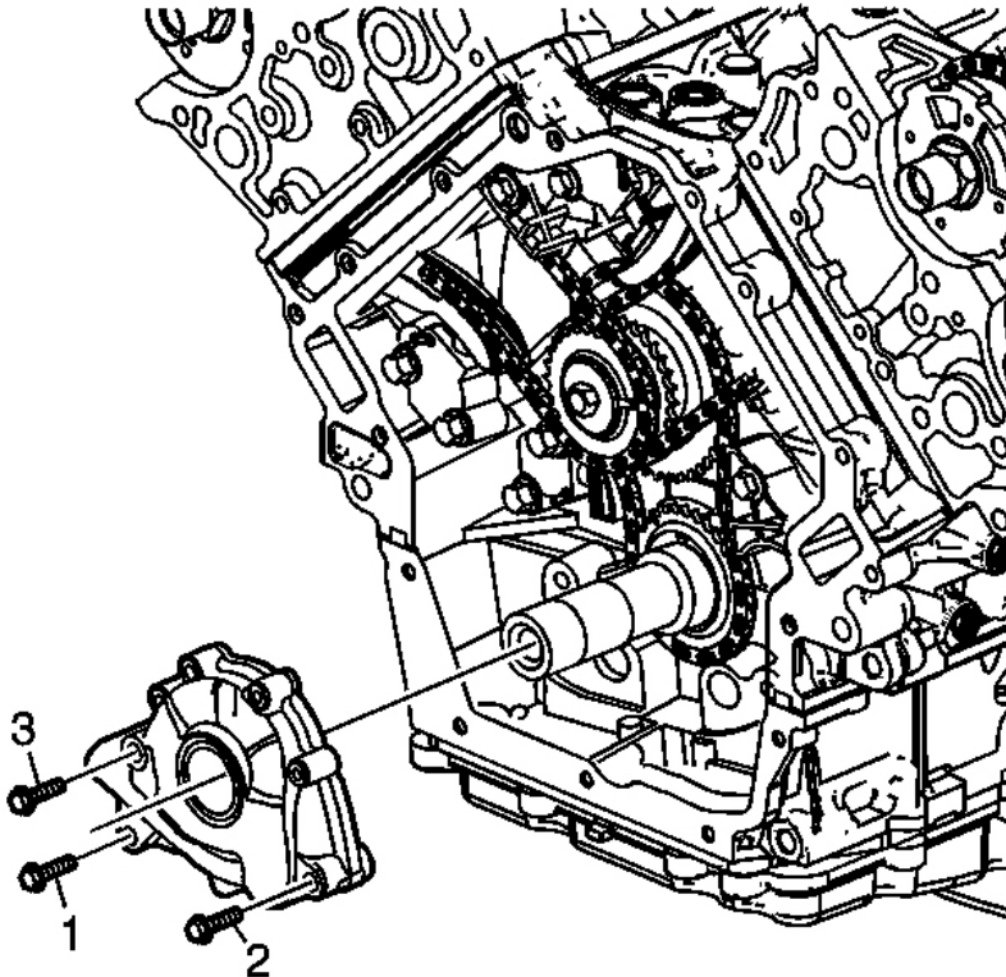


Fig. 102: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tighten:

1. First Pass

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

2. 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

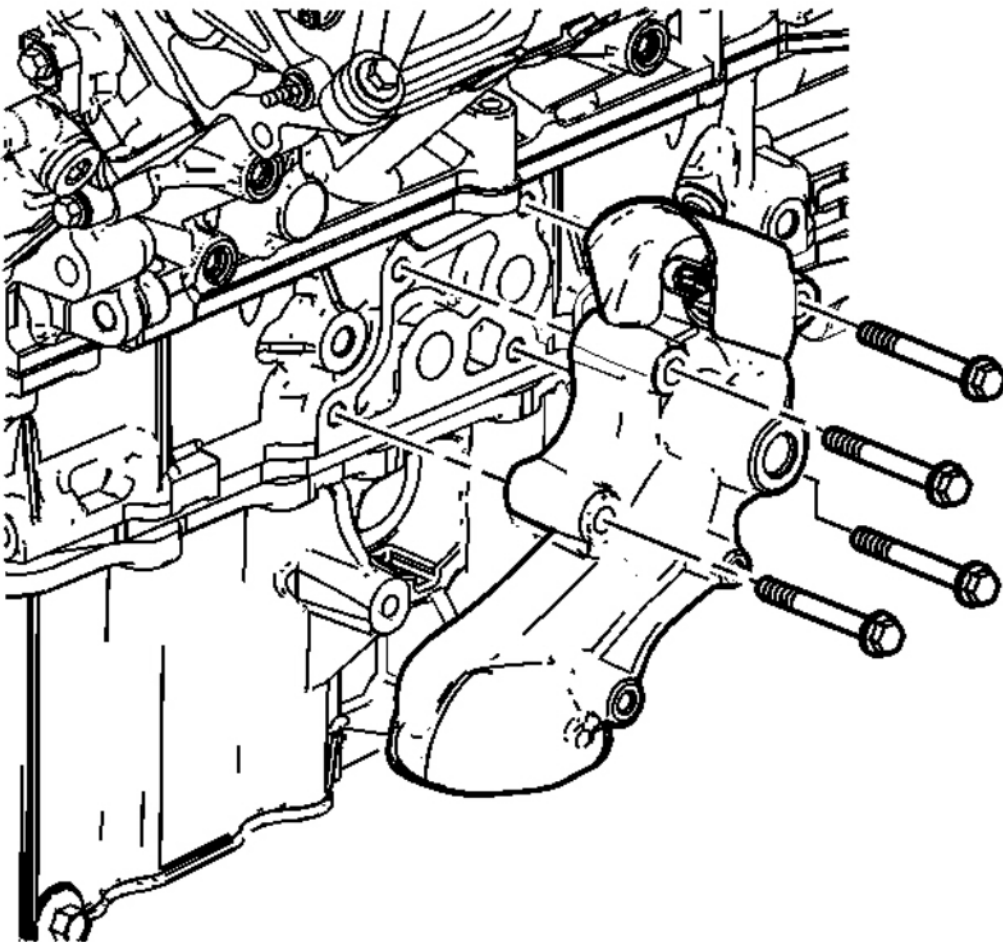


Fig. 103: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter adapter. Refer to **Oil Filter Adapter Replacement**.
2. Remove the oil pressure sensor and/or switch from the oil filter adapter.
3. 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

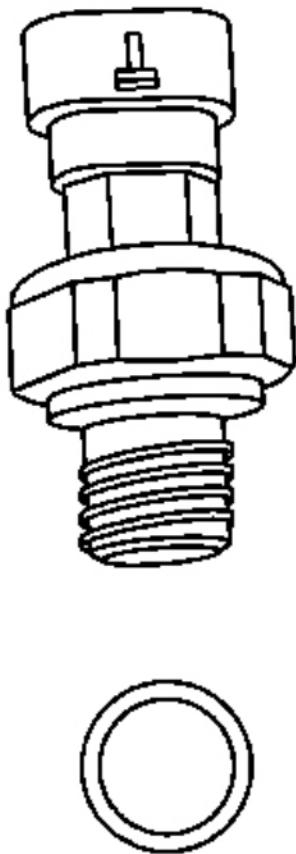


Fig. 104: View Of Oil Pressure Switch
Courtesy of GENERAL MOTORS CORP.

1. Install a new O-ring on the oil pressure switch.

NOTE: Refer to Component Fastener Tightening Notice in Cautions and Notices.

2. Install the oil pressure switch to the oil filter adapter.

Tighten: Tighten the oil pressure sensor and/or switch to 16 N.m (12 lb ft).

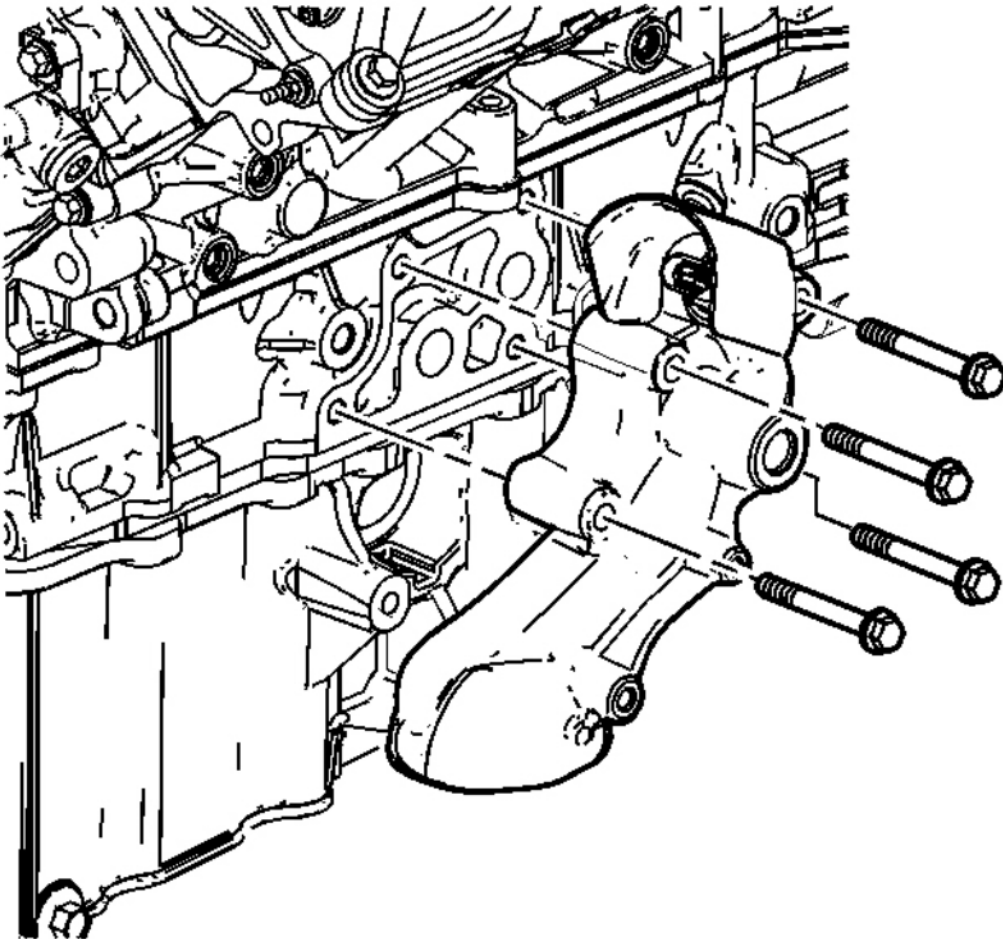


Fig. 105: View Of Oil Filter Adapter
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter adapter. Refer to Oil Filter Adapter Replacement.

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

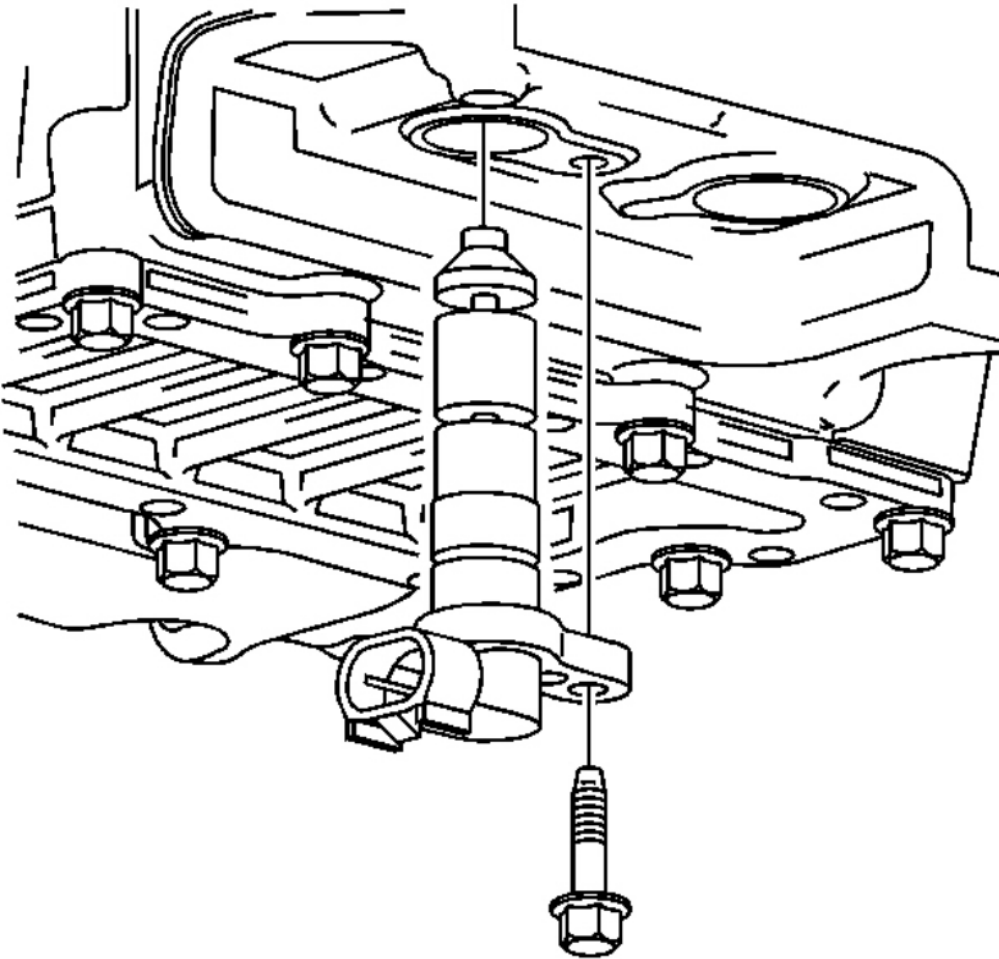


Fig. 106: Removing & Installing Oil Level Switch
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to Engine Oil and Oil Filter Replacement .
2. Disconnect the electrical connector from engine oil level switch.

3. Remove the engine oil level switch from the oil pan.

Installation Procedure

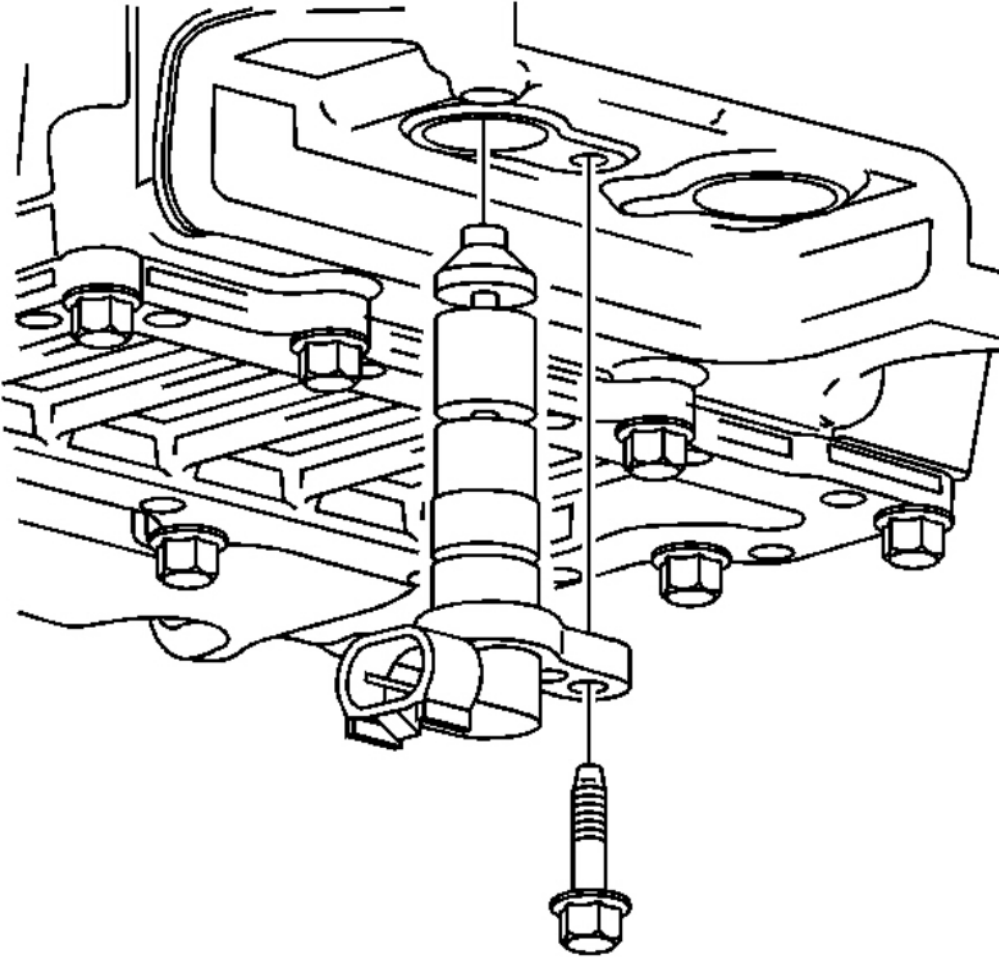


Fig. 107: Removing & Installing Oil Level Switch
Courtesy of GENERAL MOTORS CORP.

1. Install the engine oil level switch to the oil pan.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine oil level switch bolt.

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

3. Connect the electrical connector to engine oil level switch.
4. Fill the engine oil. Refer to Engine Oil and Oil Filter Replacement .
5. Inspect for oil leaks after engine start up.

OIL PUMP PIPE AND SCREEN ASSEMBLY REPLACEMENT

Removal Procedure

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

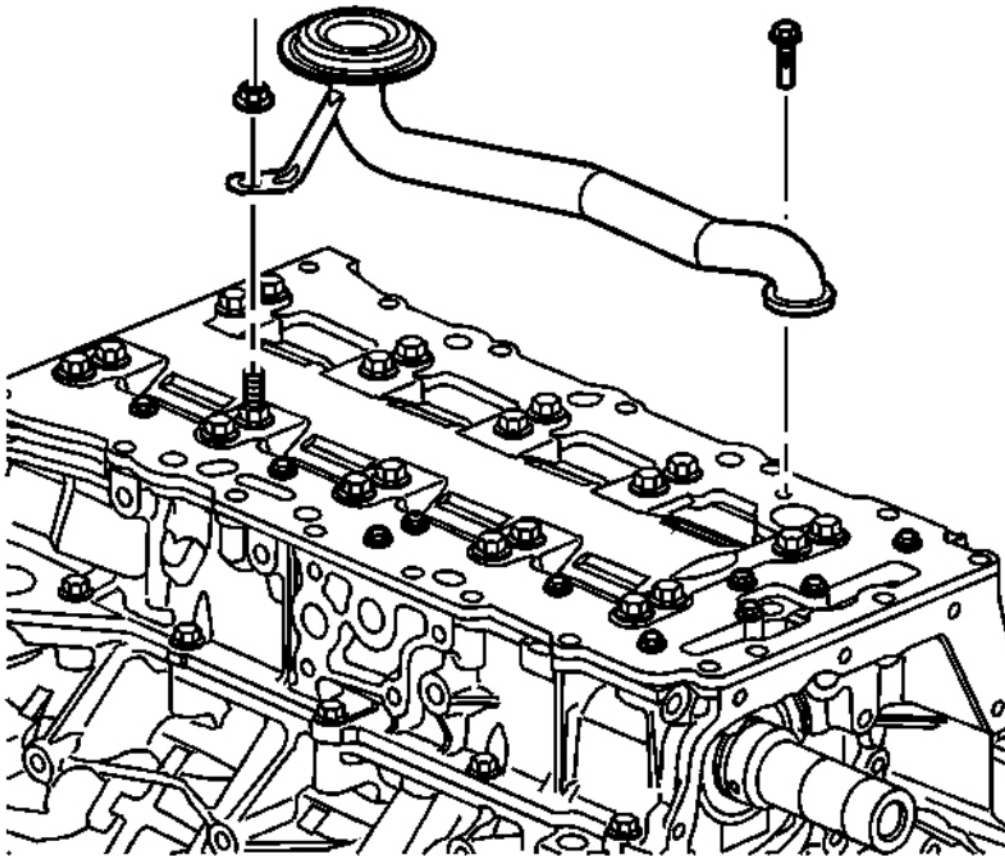


Fig. 108: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump pipe support bracket nut.
3. Remove the oil pump pipe bolt.
4. Remove the oil pump pipe and screen assembly.

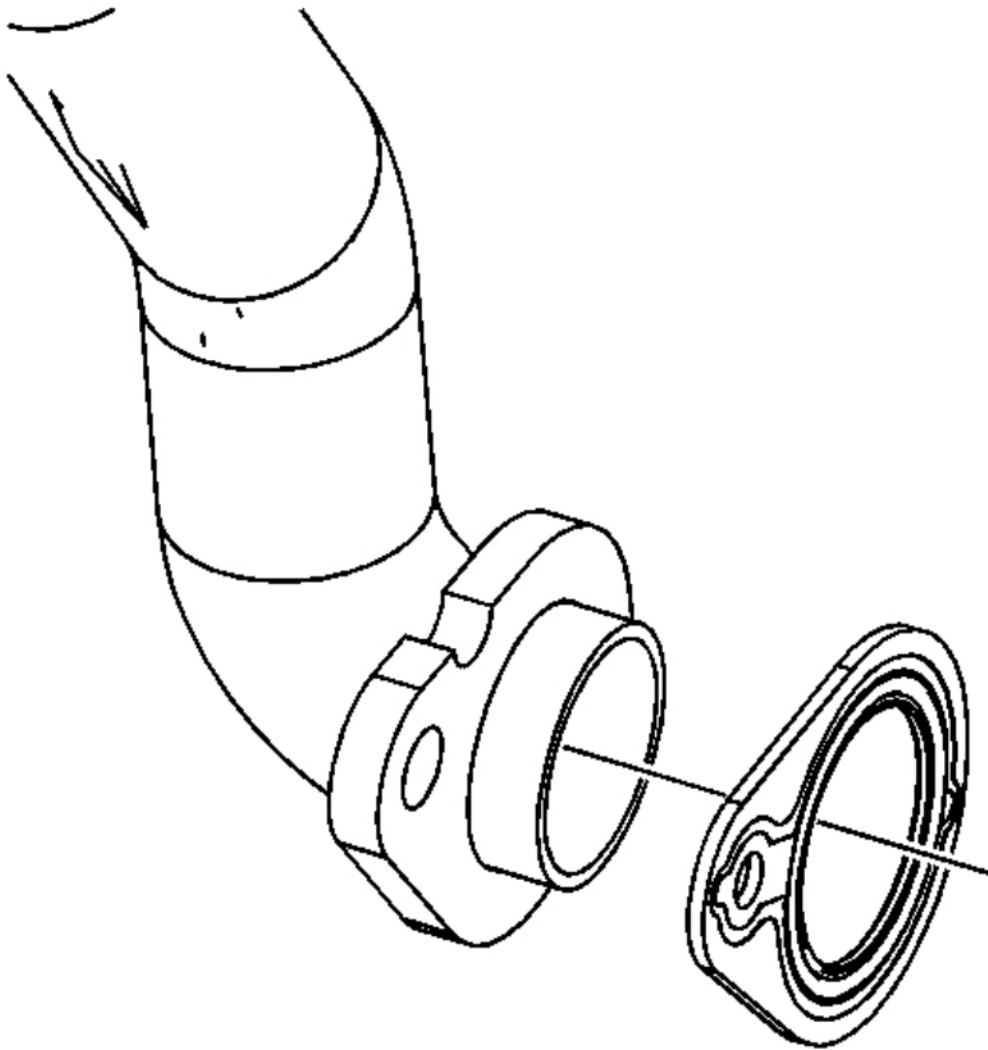


Fig. 109: View Of Oil Pump Pipe Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove and discard the oil pump pipe gasket.

Installation Procedure

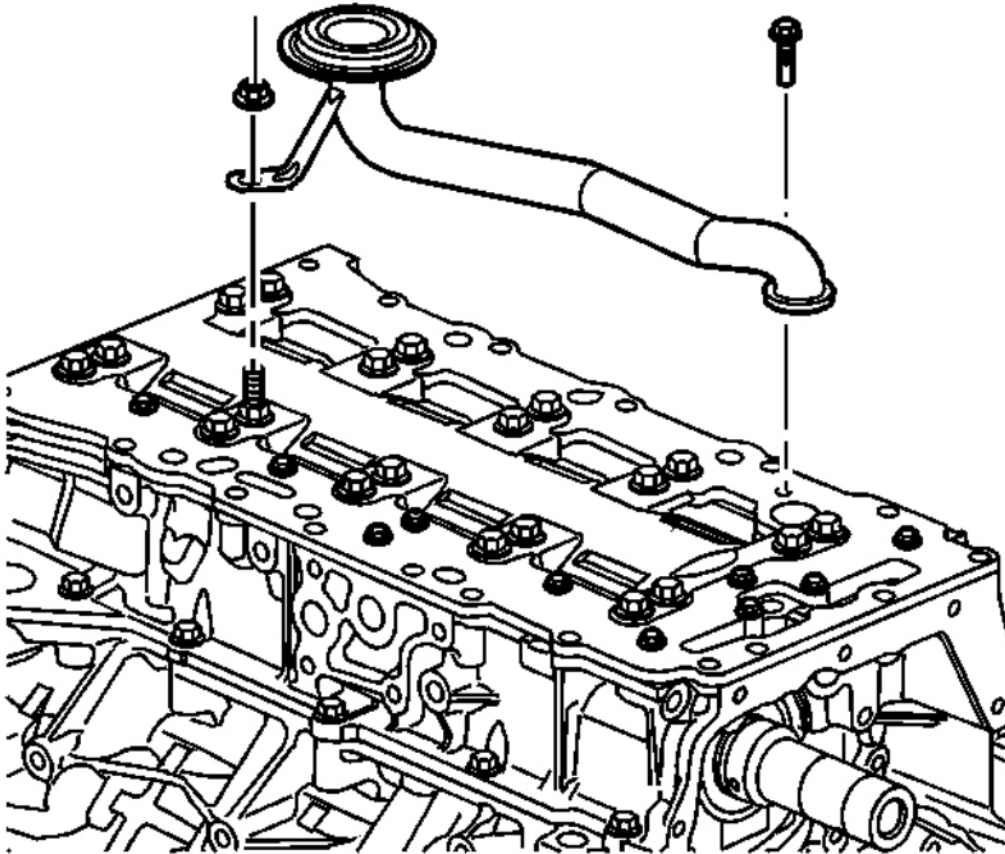


Fig. 110: View Of Oil Pump Pipe
Courtesy of GENERAL MOTORS CORP.

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

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

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

2. Install the oil pump pick-up retaining bolt and nut.

Tighten:

- 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

Removal Procedure

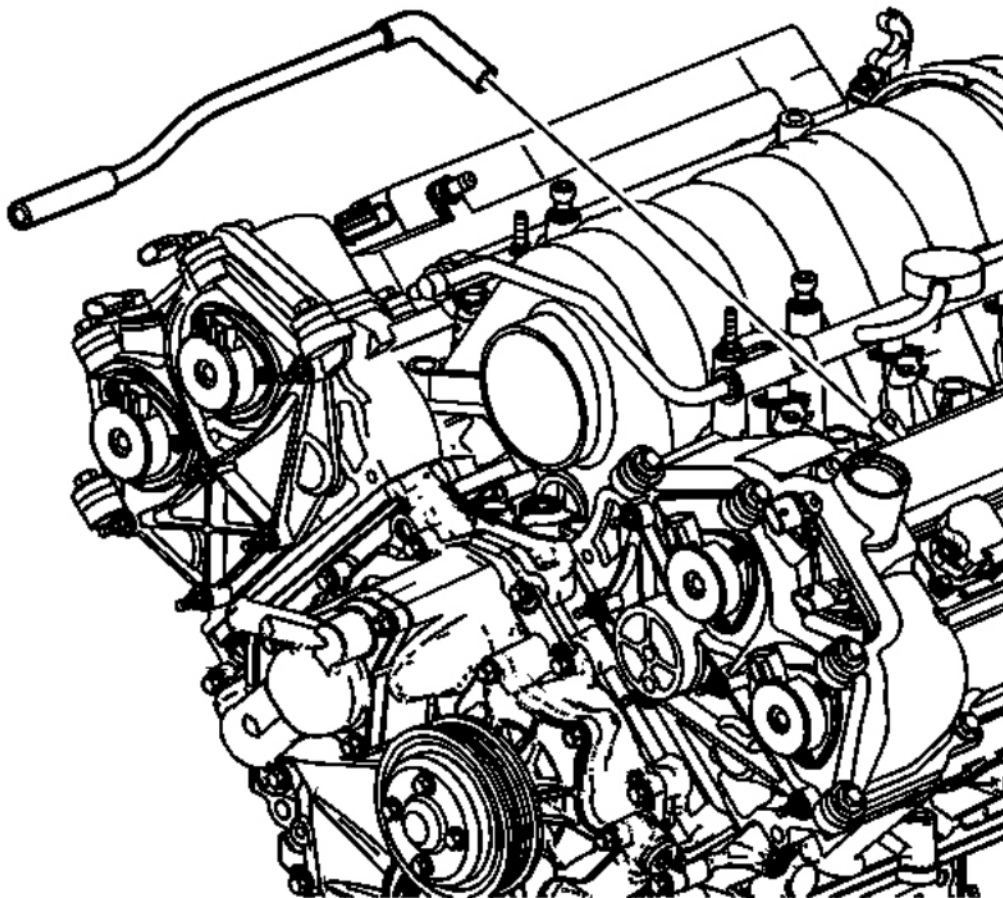


Fig. 111: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

2. Disconnect the positive crankcase ventilation (PCV) fresh air tube from the left camshaft cover.
3. Remove the left side ignition module. Refer to **Ignition Control Module Replacement - Bank 2** in Engine Controls - 4.6L (LH2).

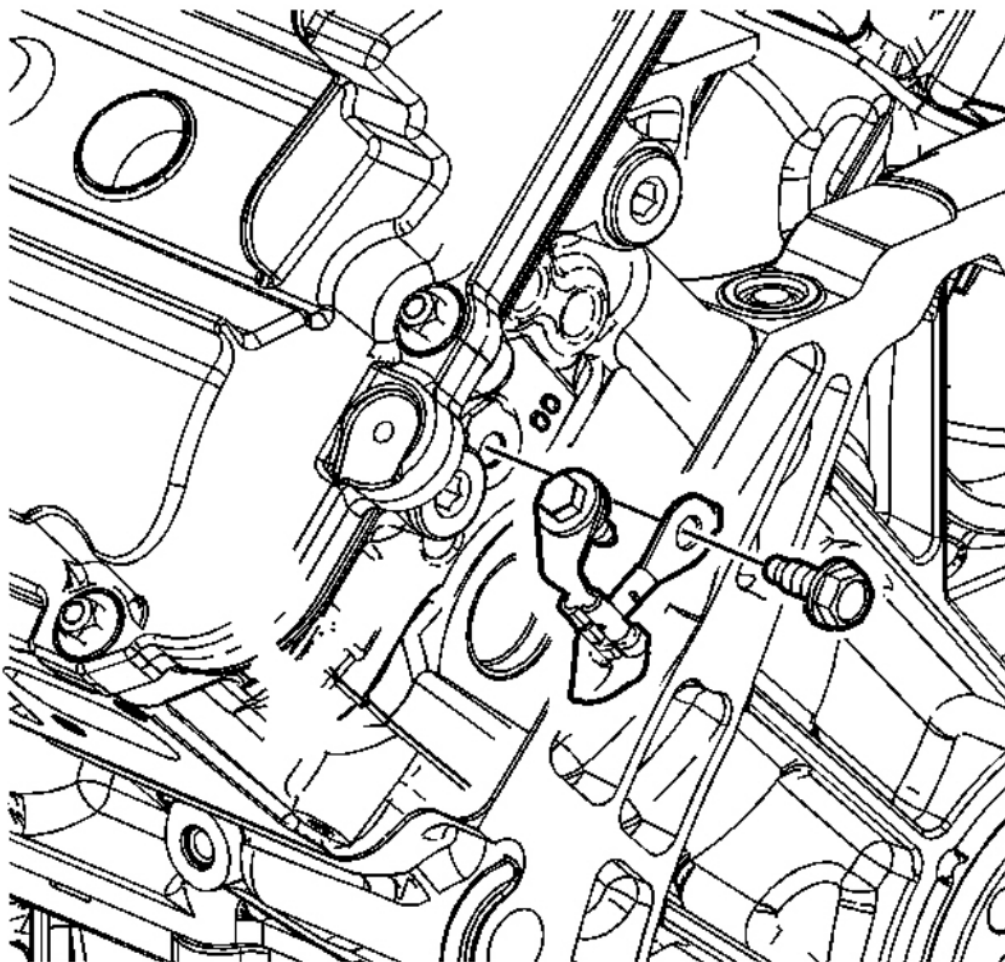


Fig. 112: View Of Left Camshaft Cover Ground Strap & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolt connecting the ground strap to the left camshaft cover.
5. Remove the bolt securing the oil level indicator tube to the left cylinder head and reposition the tube away from the camshaft cover.

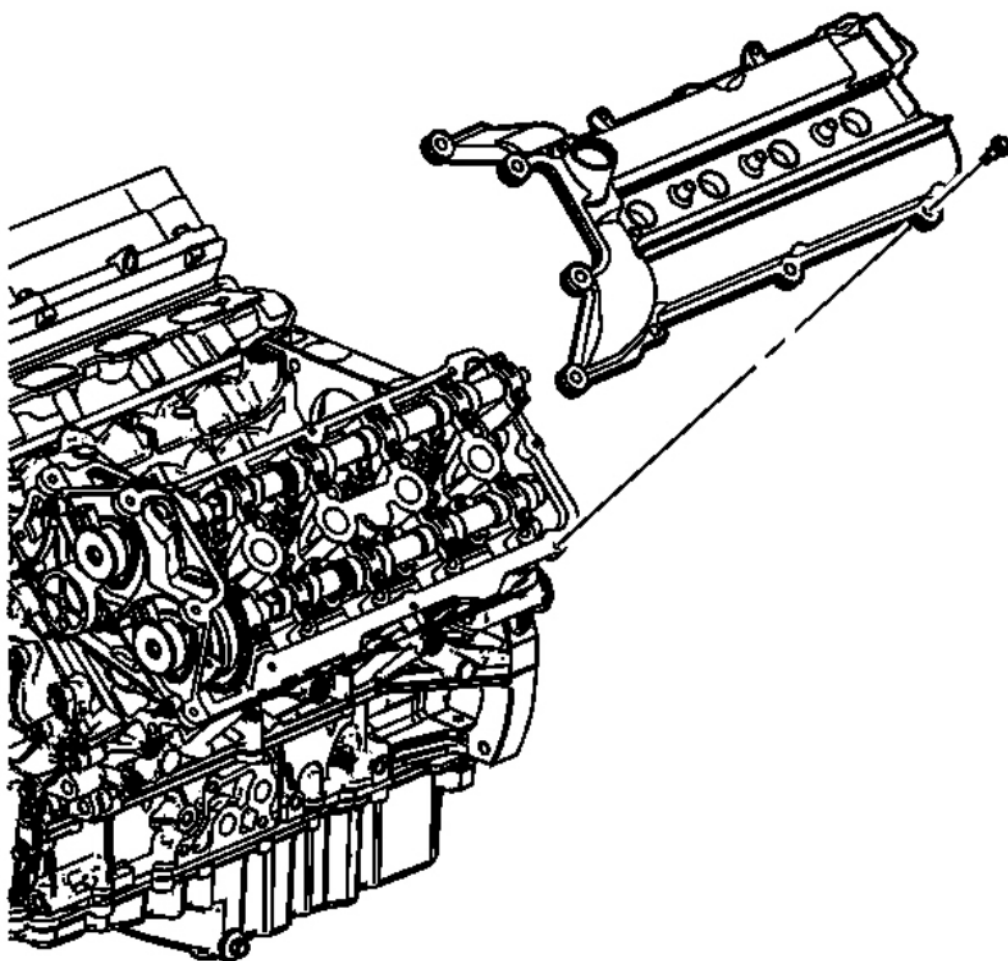


Fig. 113: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft cover bolts.
7. Lift the camshaft drive end of the camshaft cover up.
8. Remove the camshaft cover.
9. Discard the camshaft cover gasket and spark plug port seals if there is any evidence of damage or if the seal comes out of the groove in the cover during removal.
10. Clean the gasket mating surface on the cylinder head.
11. Clean and inspect the camshaft cover. Refer to **Camshaft Cover Cleaning and**

Inspection .

Installation Procedure

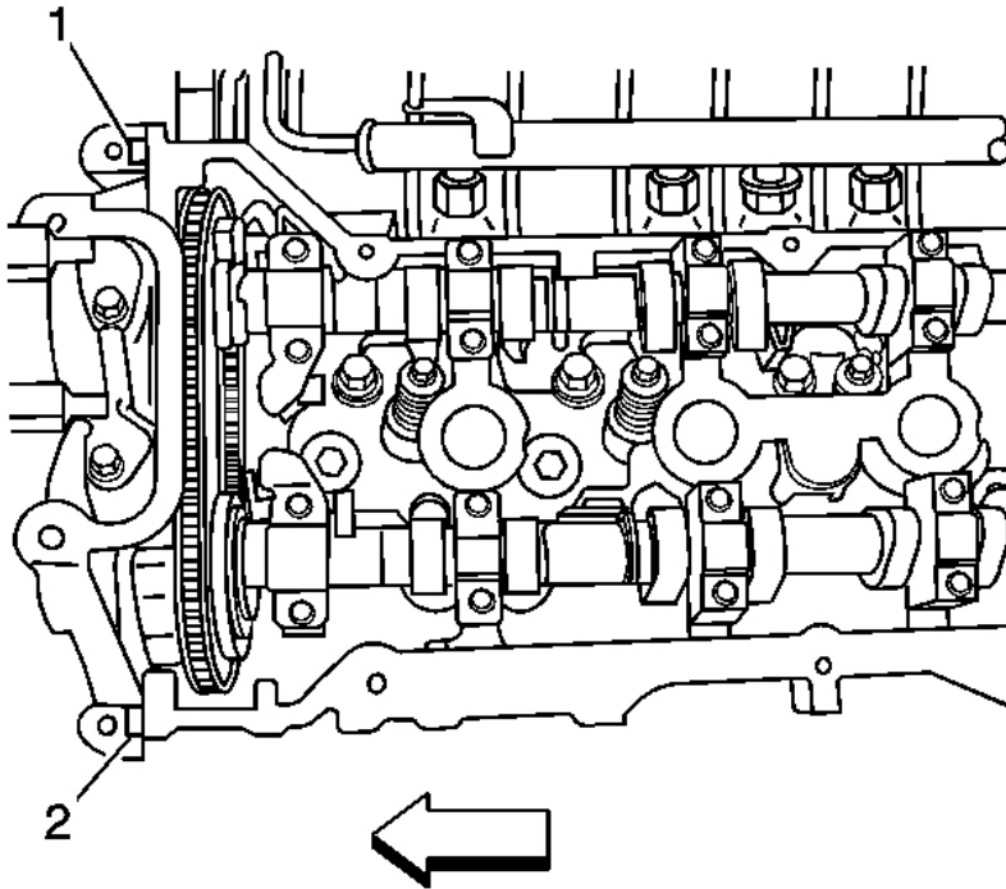


Fig. 114: Applying Sealant To Split Line Of Left Cylinder Head & Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Install a new camshaft cover gasket to the camshaft cover if necessary.
2. Place a small amount of sealant GM P/N 12345739 (Canadian P/N 10953541) or equivalent at the split line (1, 2) of the left cylinder head and the left camshaft position actuator housing.

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

3. Work the camshaft cover into position by pivoting the cover down and aligning the bolt holes.

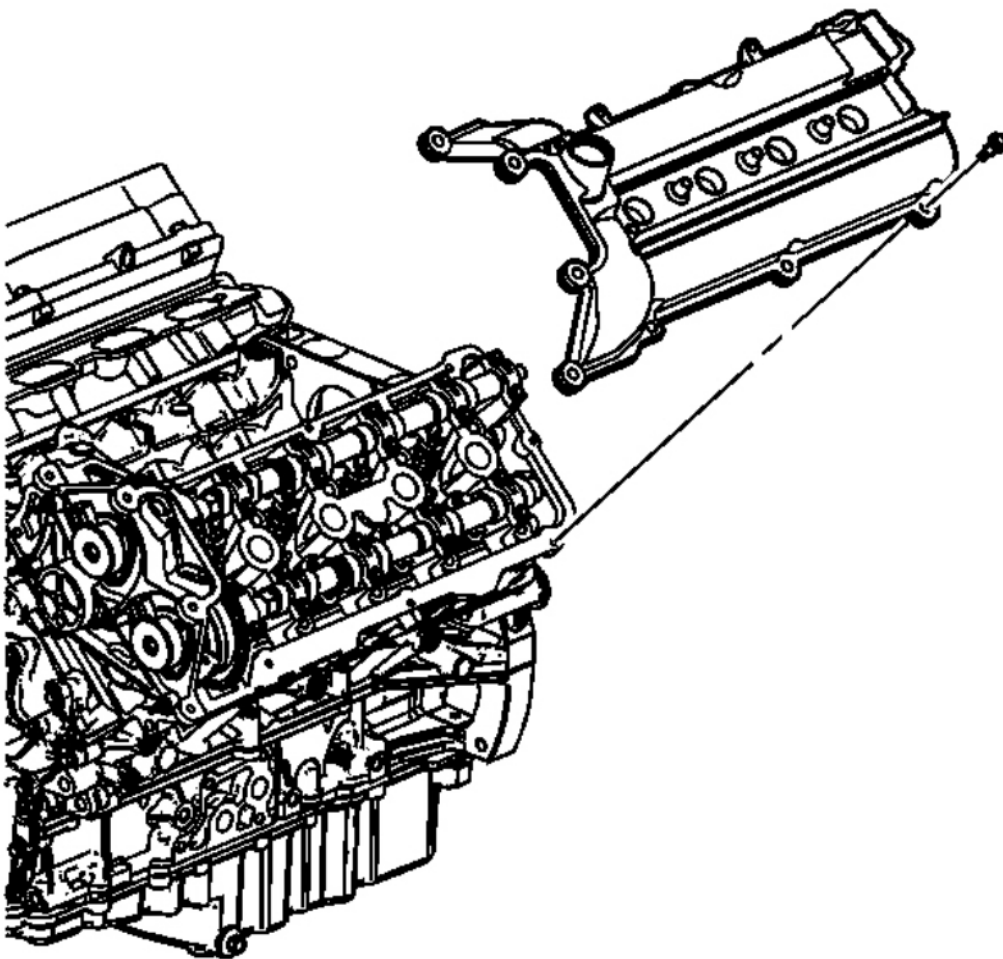


Fig. 115: View Of Left Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft cover bolts.

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

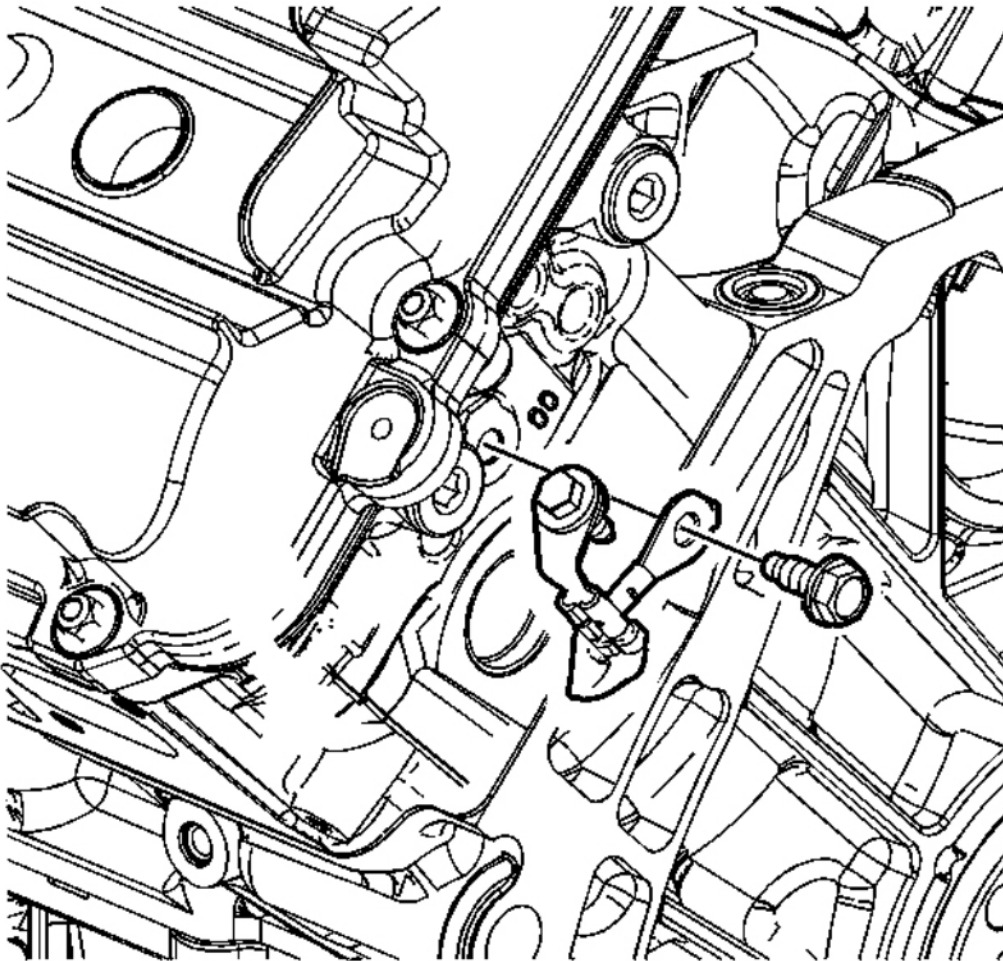


Fig. 116: View Of Left Camshaft Cover Ground Strap & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the bolt connecting the left camshaft cover ground strap to the left camshaft cover.

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

6. Rotate the oil level indicator tube back into its original position and install the bolt securing

the tube to the cylinder head.

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

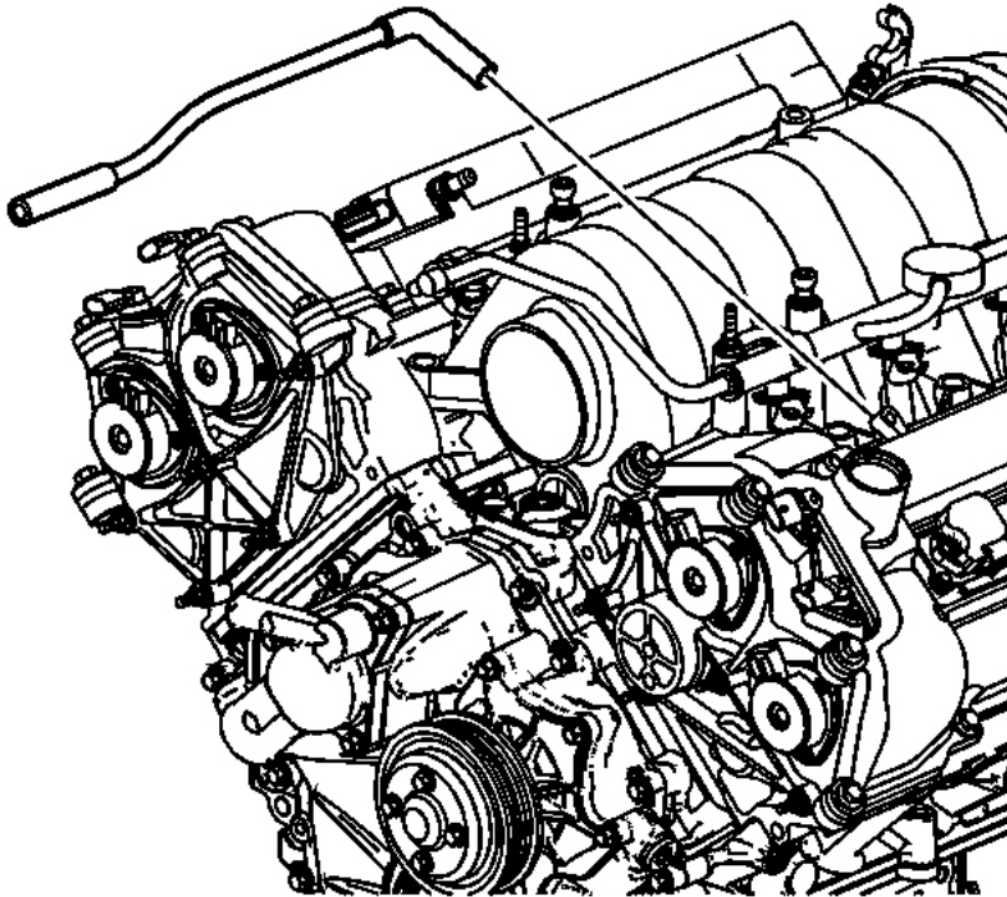


Fig. 117: View Of PCV Fresh Air Tube
Courtesy of GENERAL MOTORS CORP.

7. Install the ignition module. Refer to **Ignition Control Module Replacement - Bank 2** in Engine Controls - 4.6L (LH2).
8. Connect the PCV fresh air tube to the left camshaft cover.
9. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Removal Procedure

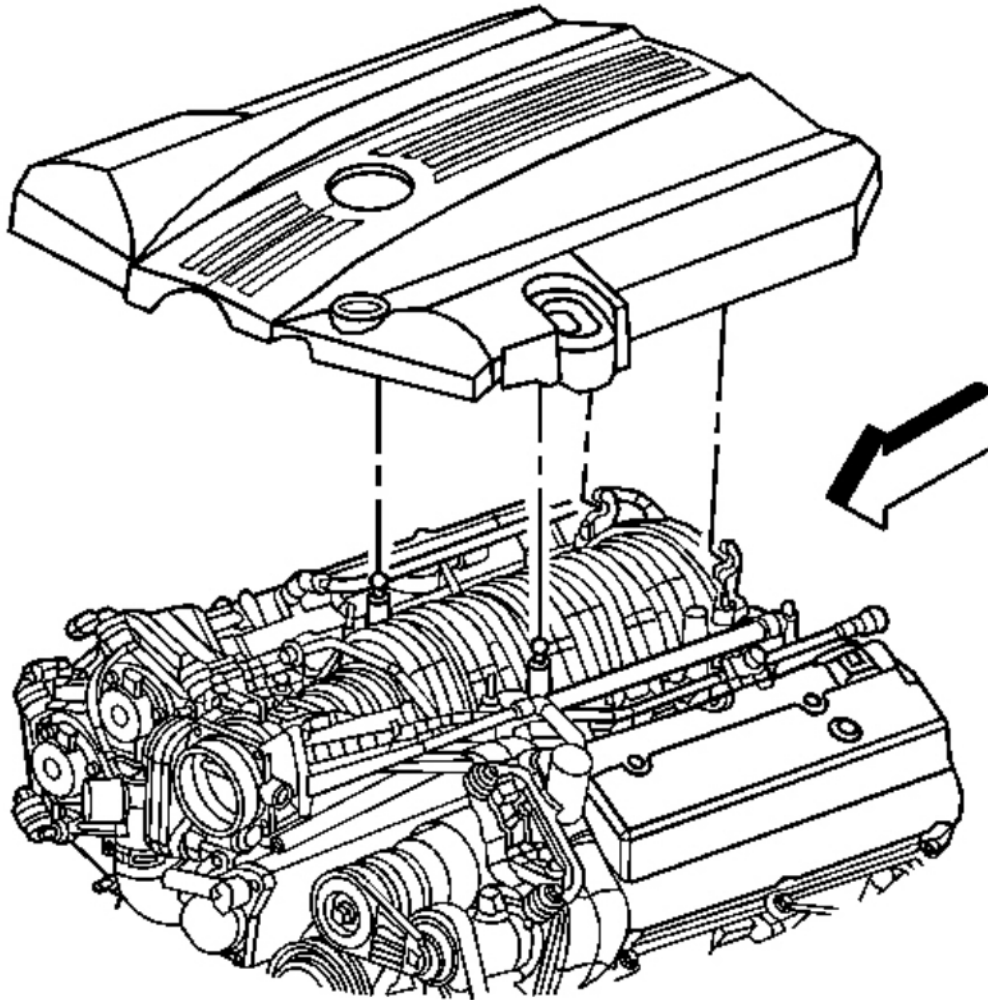


Fig. 118: View Of Fuel Injector Sight Shield/Top Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

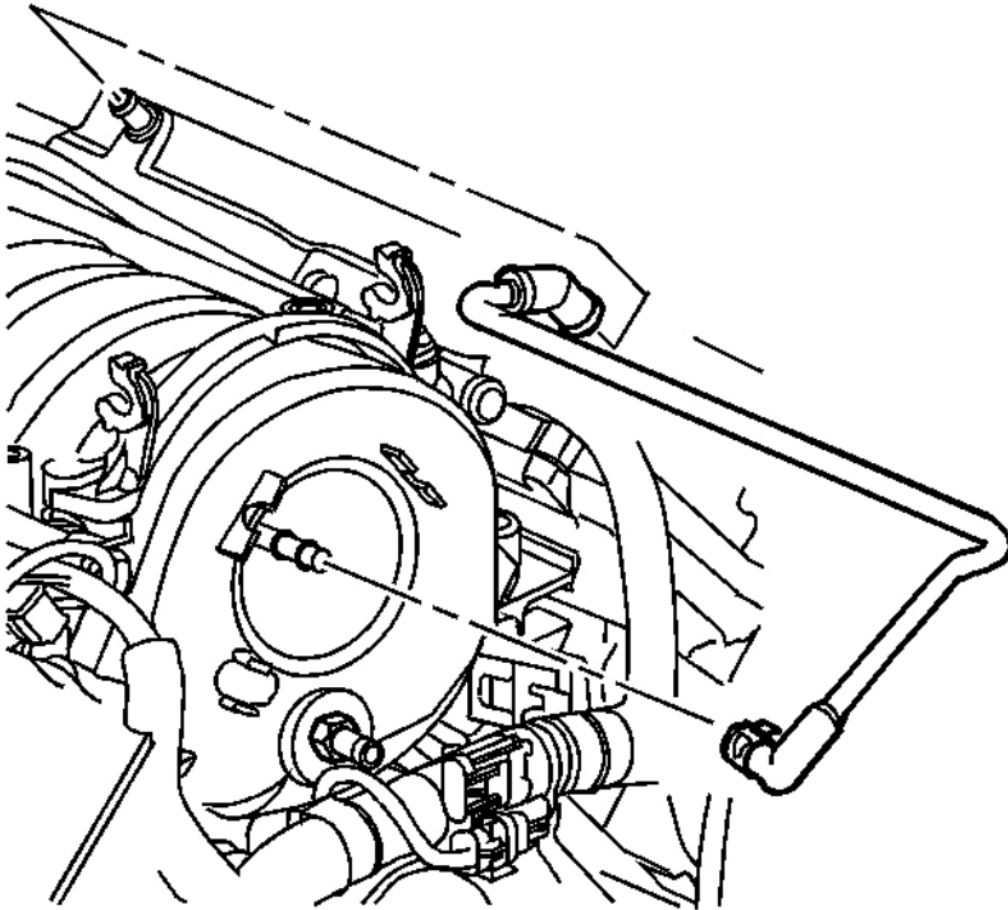


Fig. 119: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the positive crankcase ventilation (PCV) dirty air tube from the camshaft cover.
3. Remove the ignition module. Refer to **Ignition Control Module Replacement - Bank 1** in Engine Controls - 4.6L (LH2).
4. Disconnect the cable harness clips at the front of the camshaft cover and position the cable harness aside.

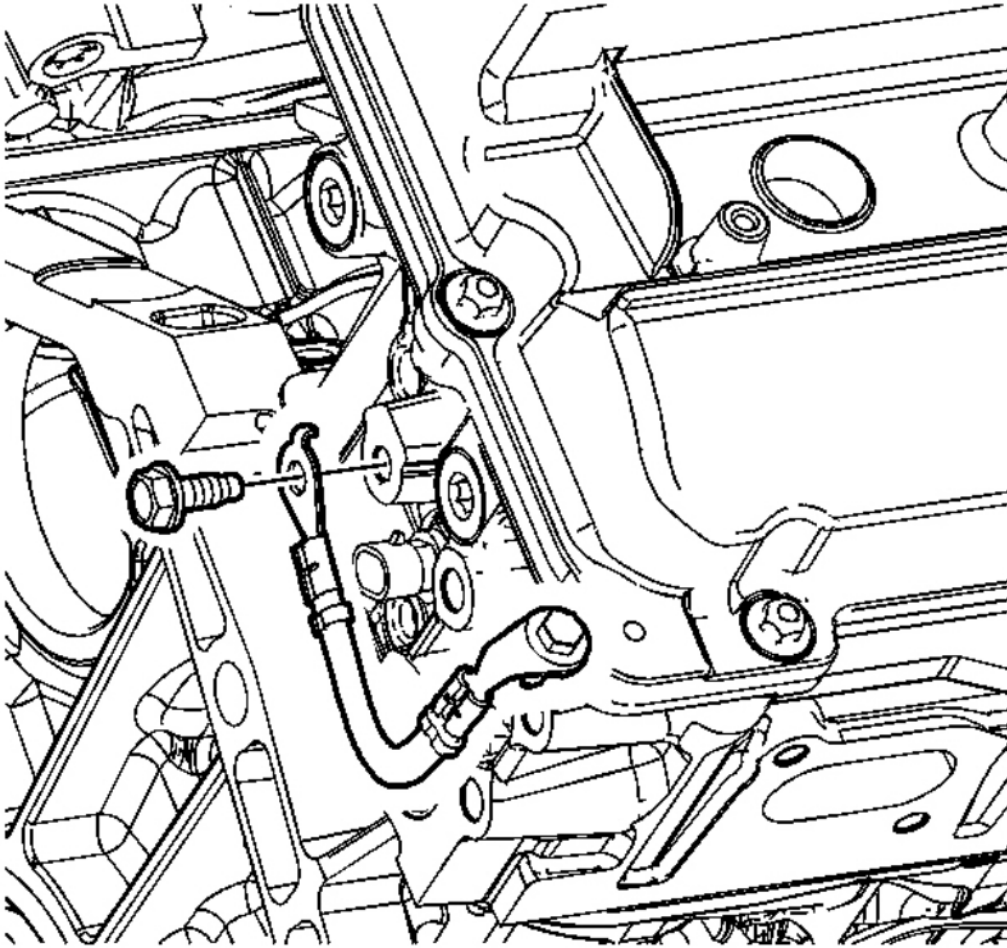


Fig. 120: View Of Ground Strap, Right Camshaft Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolt connecting the ground strap to the right camshaft cover.

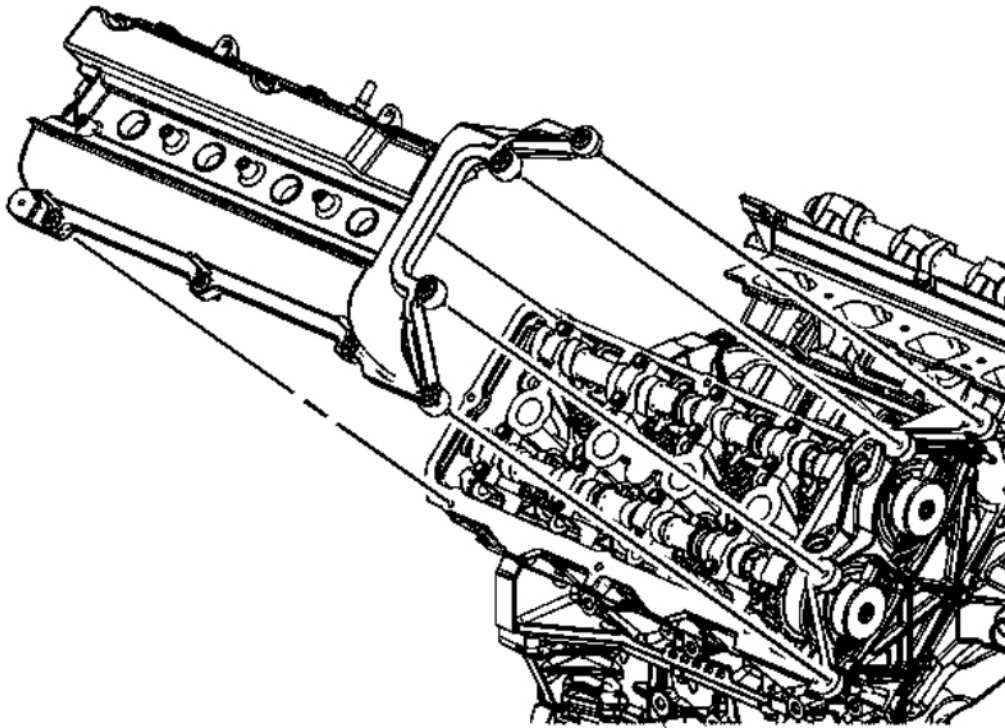


Fig. 121: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

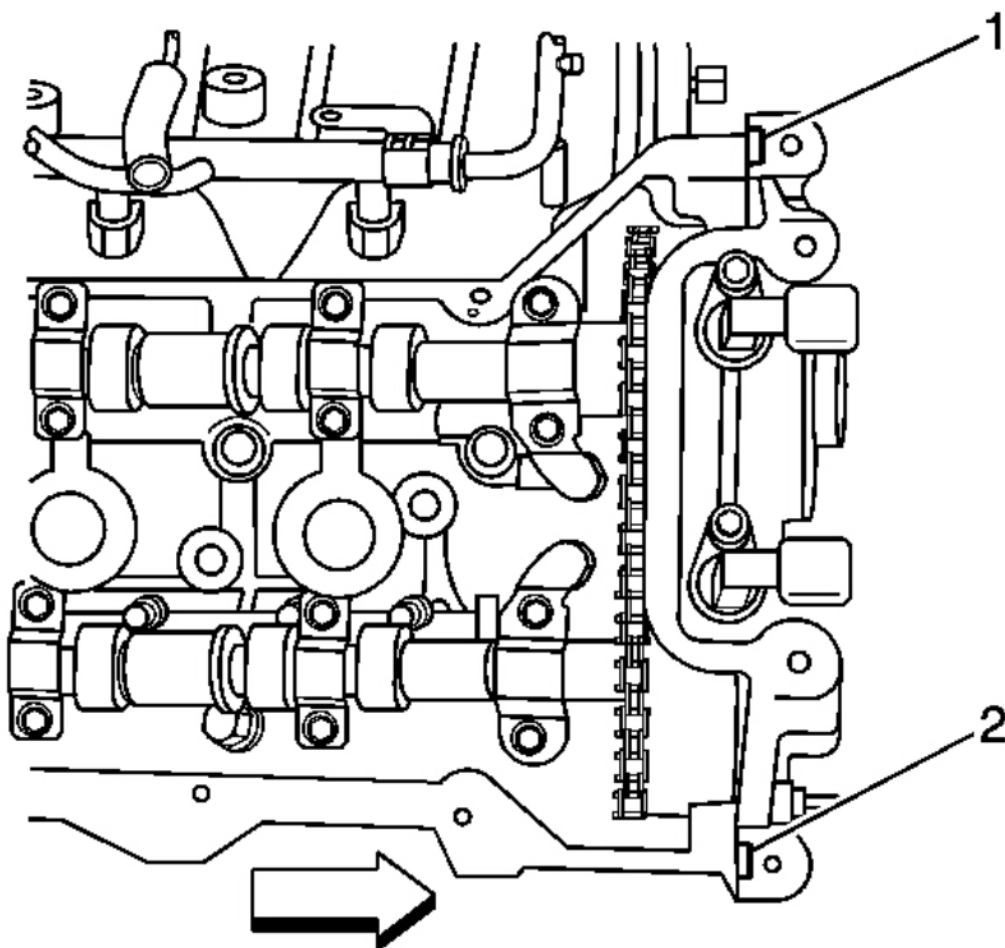


Fig. 122: Applying Sealant To Split Line Of Right Cylinder Head & Camshaft Position Actuator Housing

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 gasket as required.
2. Place a small amount of sealant GM P/N 12345739 (Canadian P/N 10953541) or equivalent at the split line (1, 2) of the right cylinder head and the right camshaft position

actuator housing.

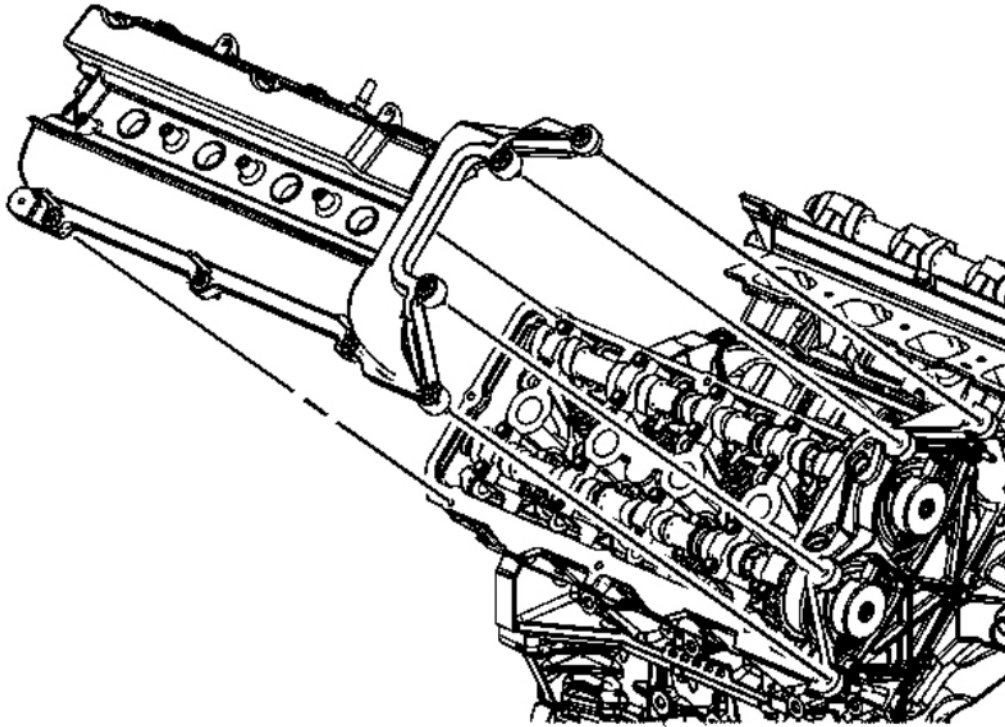


Fig. 123: View Of Right Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft cover.

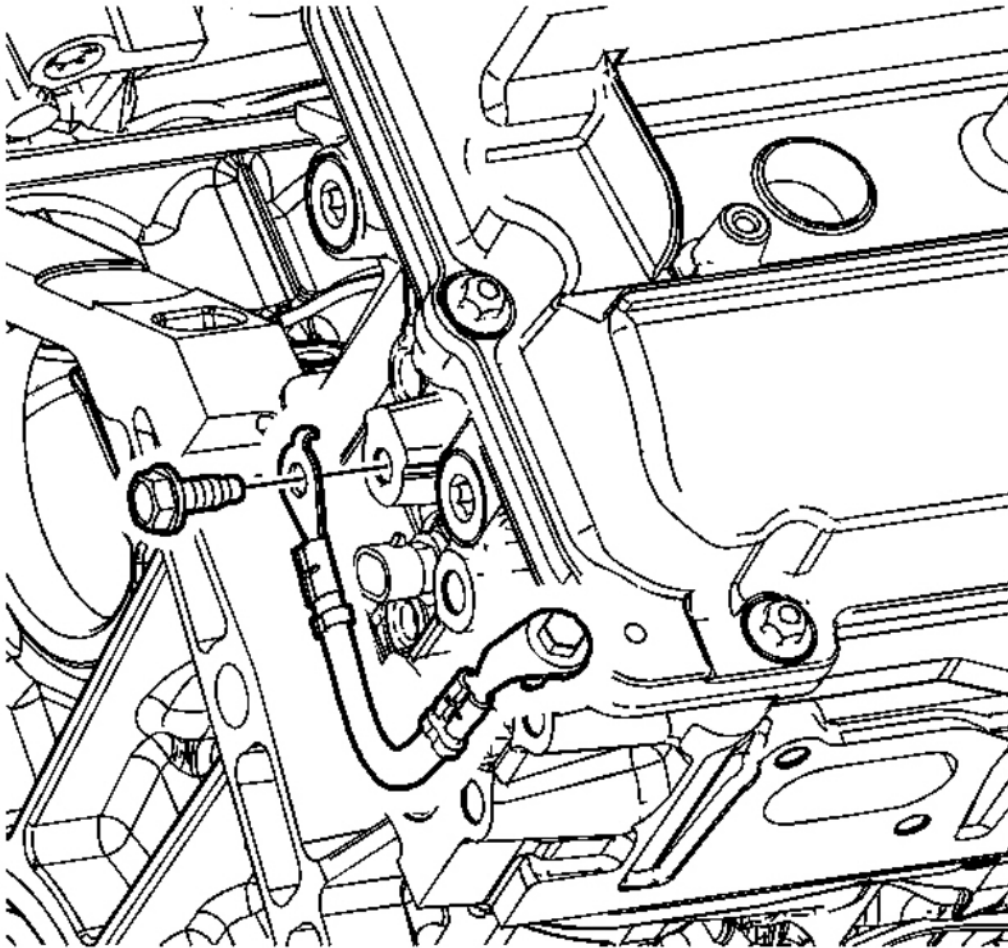


Fig. 124: View Of Ground Strap, Right Camshaft Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft cover bolts installing the ground strap to the camshaft cover.

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

5. Install the ignition module. Refer to Ignition Control Module Replacement - Bank 1 in Engine Controls - 4.6L.

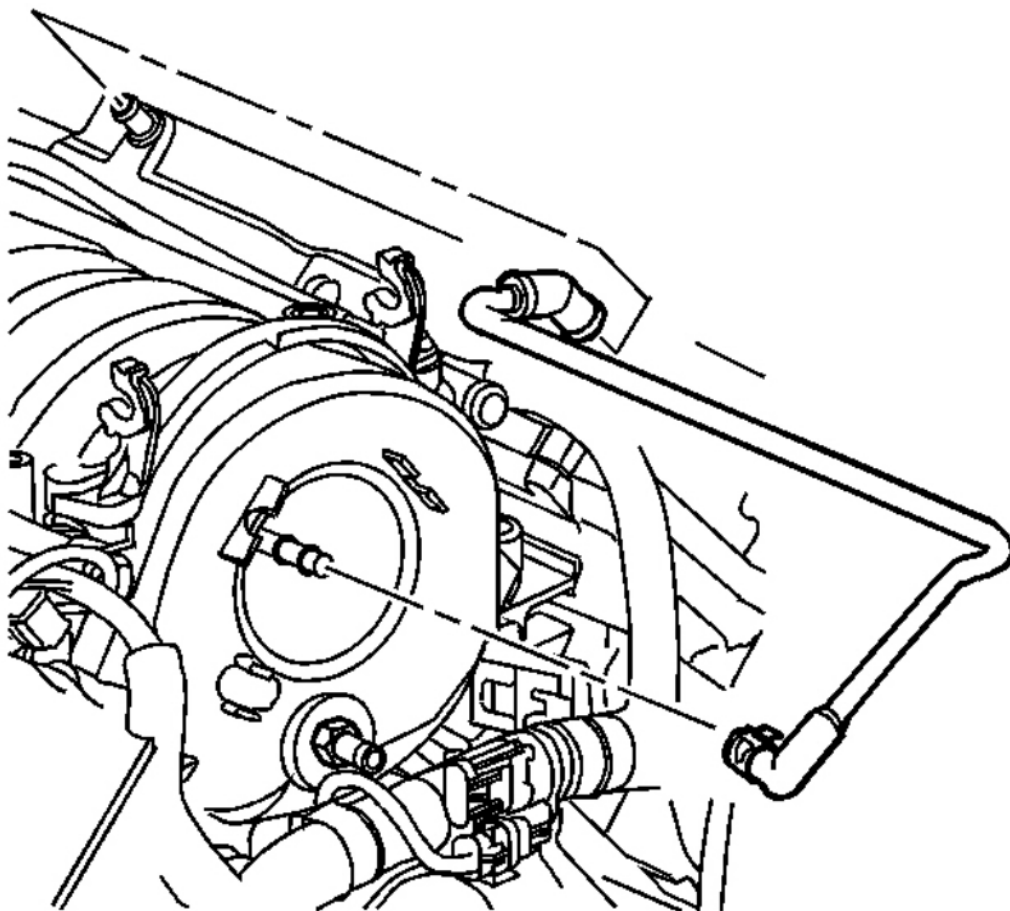


Fig. 125: View Of PCV Dirty Air Breather Tube
Courtesy of GENERAL MOTORS CORP.

6. Connect the PCV dirty air tube to the camshaft cover.

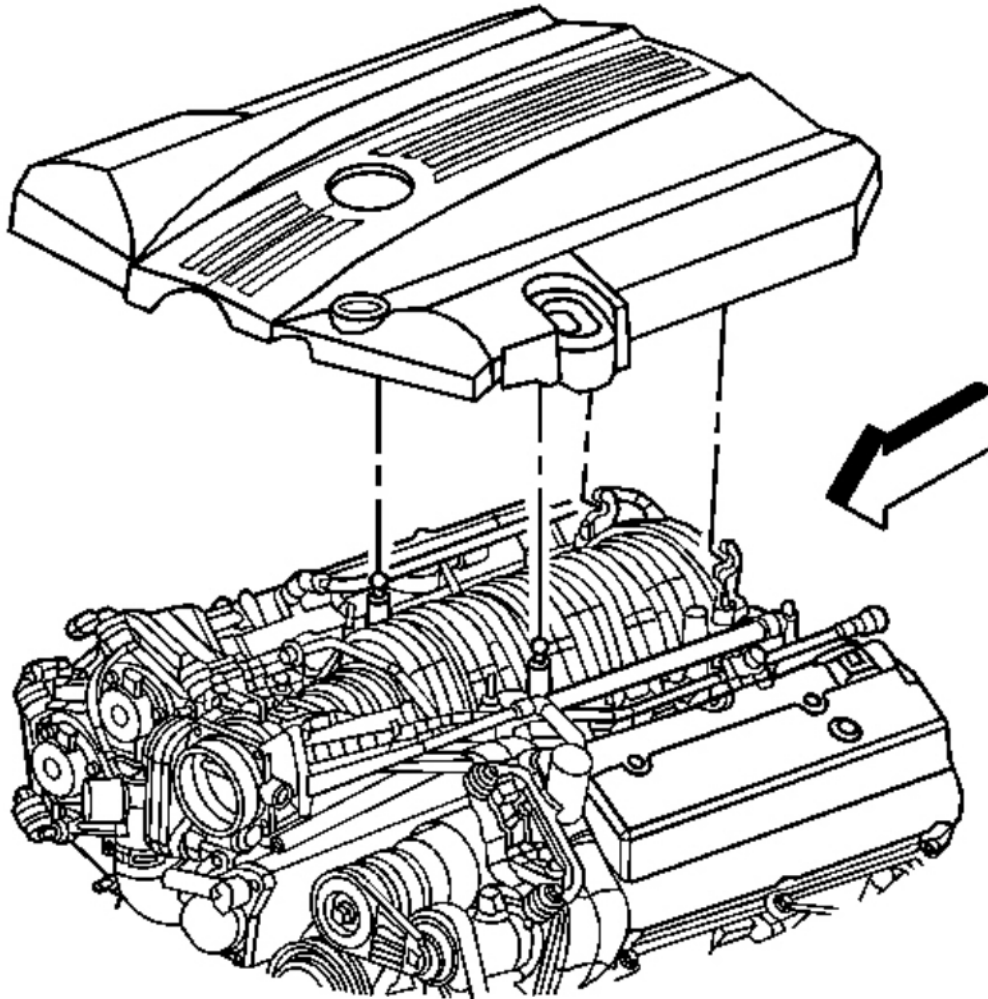


Fig. 126: View Of Fuel Injector Sight Shield/Top Cover
Courtesy of GENERAL MOTORS CORP.

7. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

CAMSHAFT POSITION (CMP) ACTUATOR HOUSING REPLACEMENT - LEFT

Removal Procedure

1. Remove the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

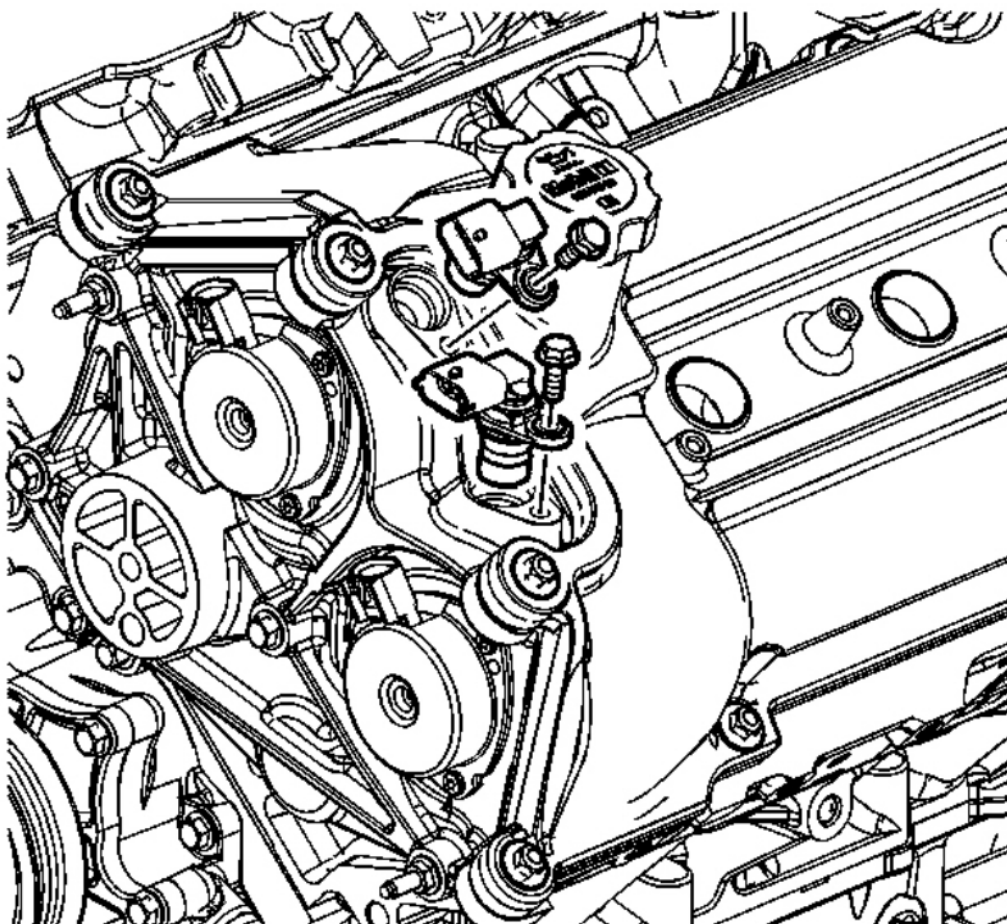


Fig. 127: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the left exhaust camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 2 (Left) Exhaust**.
3. Remove the left intake camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 2 (Left) Intake**.
4. Remove the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement (LH2)** or **Remote Power Steering Fluid Reservoir Replacement (LY7)** in Power Steering System.
5. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left**.

6. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Air Conditioning, Power Steering and Water Pump.**

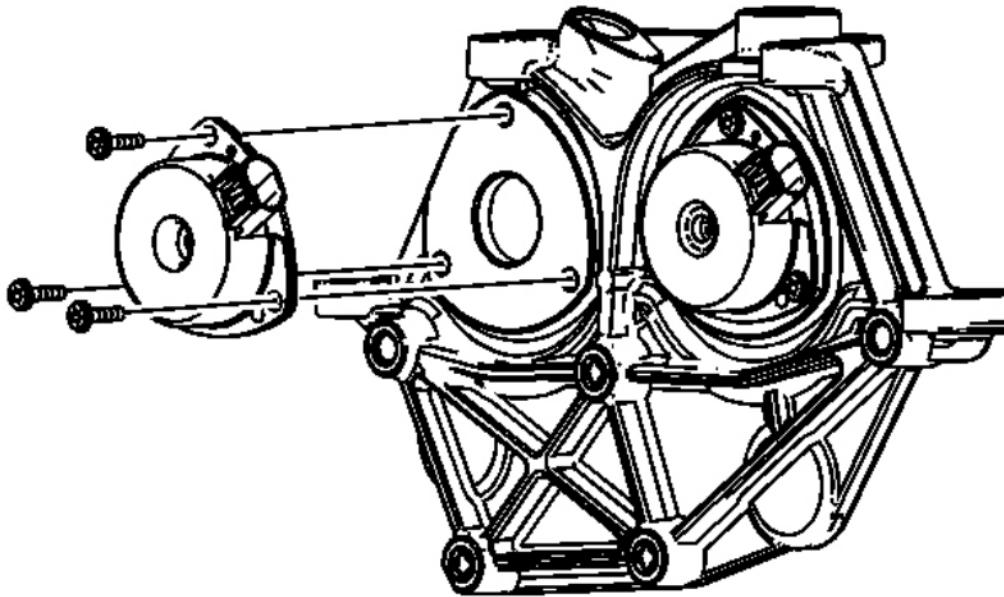


Fig. 128: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the left intake camshaft position actuator solenoid bolts.
8. Remove the left intake camshaft position actuator solenoid.
9. Remove the left intake camshaft position actuator solenoid alignment plug and discard.

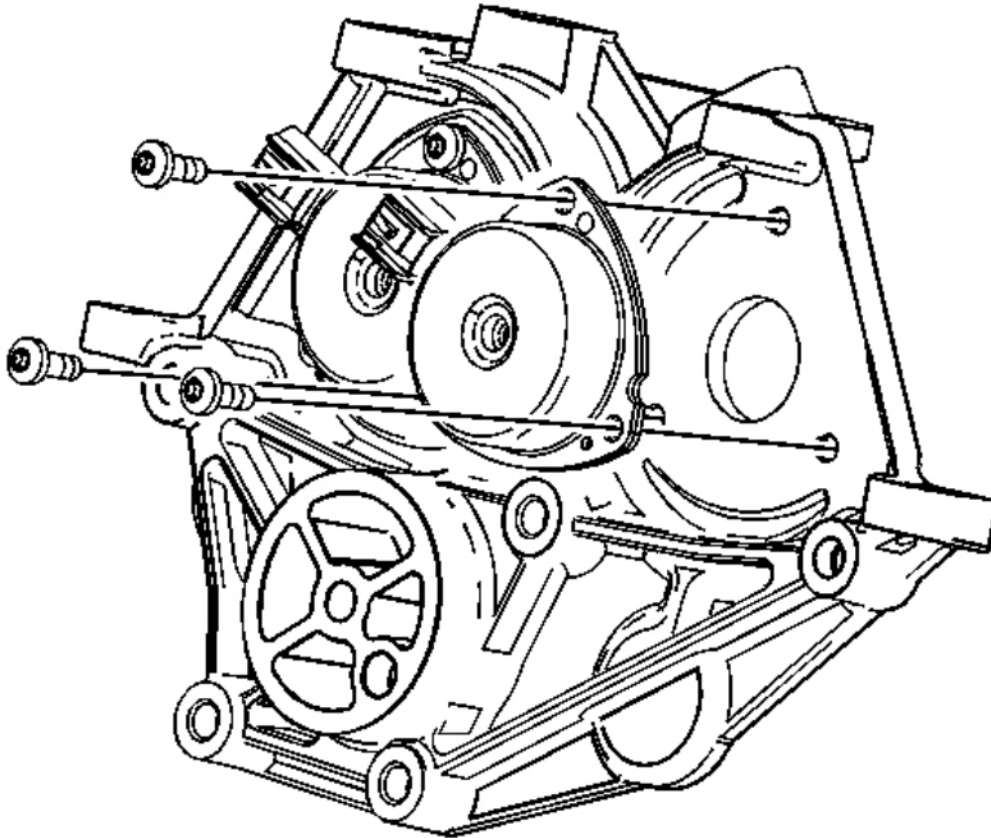


Fig. 129: View Of Left Exhaust Camshaft Position Actuator Solenoid
Courtesy of GENERAL MOTORS CORP.

10. Remove the left exhaust camshaft position actuator solenoid bolts.
11. Remove the left exhaust camshaft position actuator solenoid.
12. Remove the left exhaust camshaft position actuator solenoid alignment plug and discard.

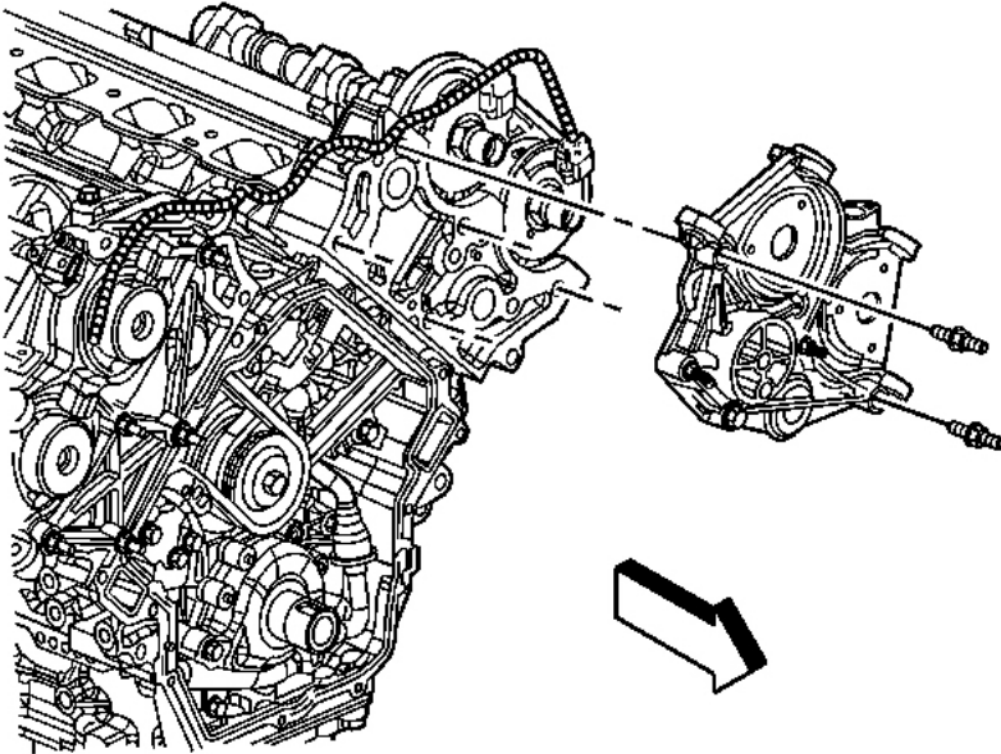


Fig. 130: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

13. Remove the left camshaft position actuator housing bolts.
14. Remove the left camshaft position actuator housing.

Installation Procedure

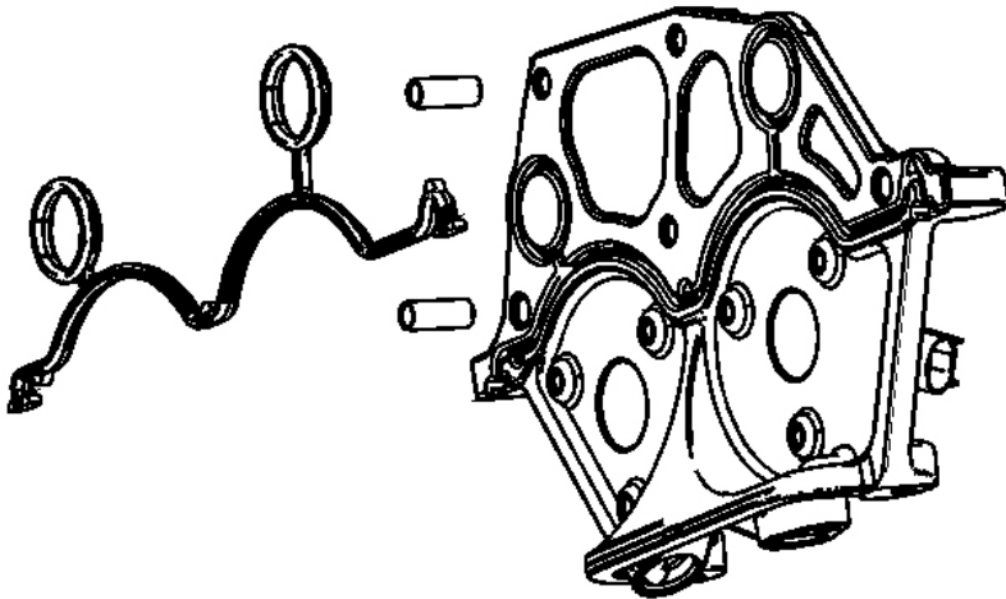


Fig. 131: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket to the camshaft position actuator housing.

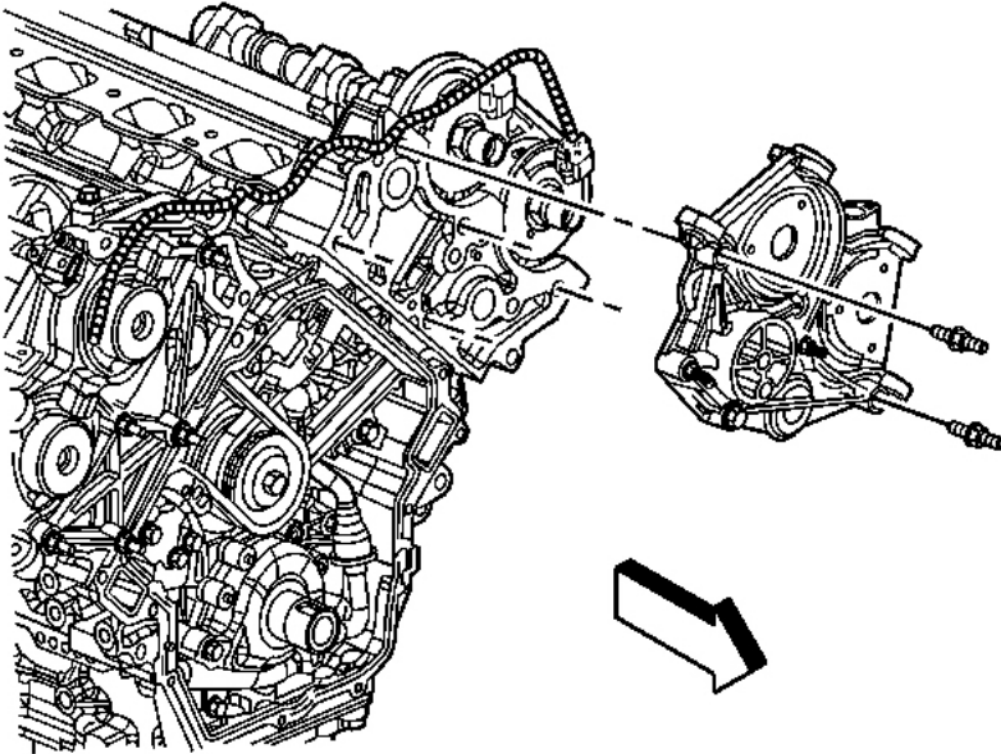


Fig. 132: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Install the left camshaft position actuator housing to the left cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the actuator housing bolts and studs.

Tighten: Tighten the actuator housing bolts and studs to 10 N.m (89 lb in).

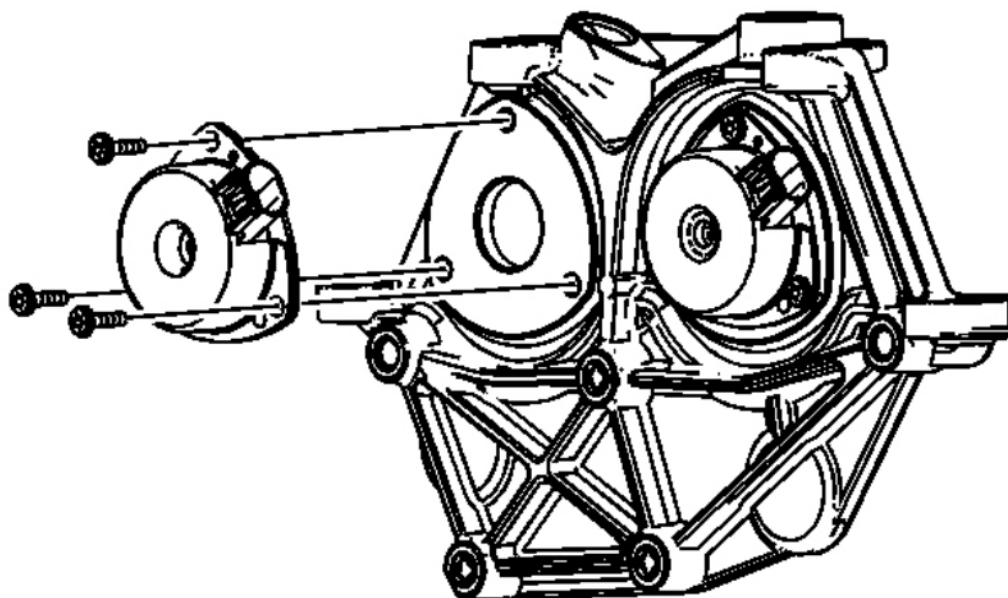


Fig. 133: View Of Camshaft Position Actuator Magnet & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft position actuator solenoids must be precisely aligned to the camshaft position actuator oil control valves on the end of the camshafts. This is accomplished with an alignment pin. Failure to align the camshaft position actuator solenoids to the camshaft position actuator oil control valves can lead to poor engine performance and engine component damage.

4. To allow for camshaft position actuator solenoid to camshaft position actuator oil control valve alignment, DO NOT install NEW camshaft position actuator solenoid alignment plugs at this time.
5. Use the following procedure for the camshaft position actuator solenoid alignment:
 1. Make an alignment pin from drill rod 15/64 inch diameter and at least 50 mm (1.97 in) long.
 2. Verify that the alignment pin will pass through the camshaft position actuator solenoid alignment hole.

3. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.
4. Apply a 2 mm (0.079 in) bead of RTV GM P/N 12378521 (Canadian P/N 88901148) around the flange of the camshaft position actuator solenoid.
5. Install the camshaft position actuator solenoid over the oil control valve.
6. Install the alignment pin through the solenoid alignment hole and into the oil control valve alignment hole.
7. With the alignment pin in place, install the camshaft position actuator solenoid bolts.

Tighten: Tighten the camshaft position actuator solenoid bolts to 8 N.m (71 lb in).

8. Remove the alignment pin.
 9. Install a NEW camshaft position actuator solenoid plug.
 10. Repeat steps 4 through 9 for the exhaust camshaft position actuator solenoid.
6. Install the left camshaft cover. Refer to **Camshaft Cover Replacement - Left**.

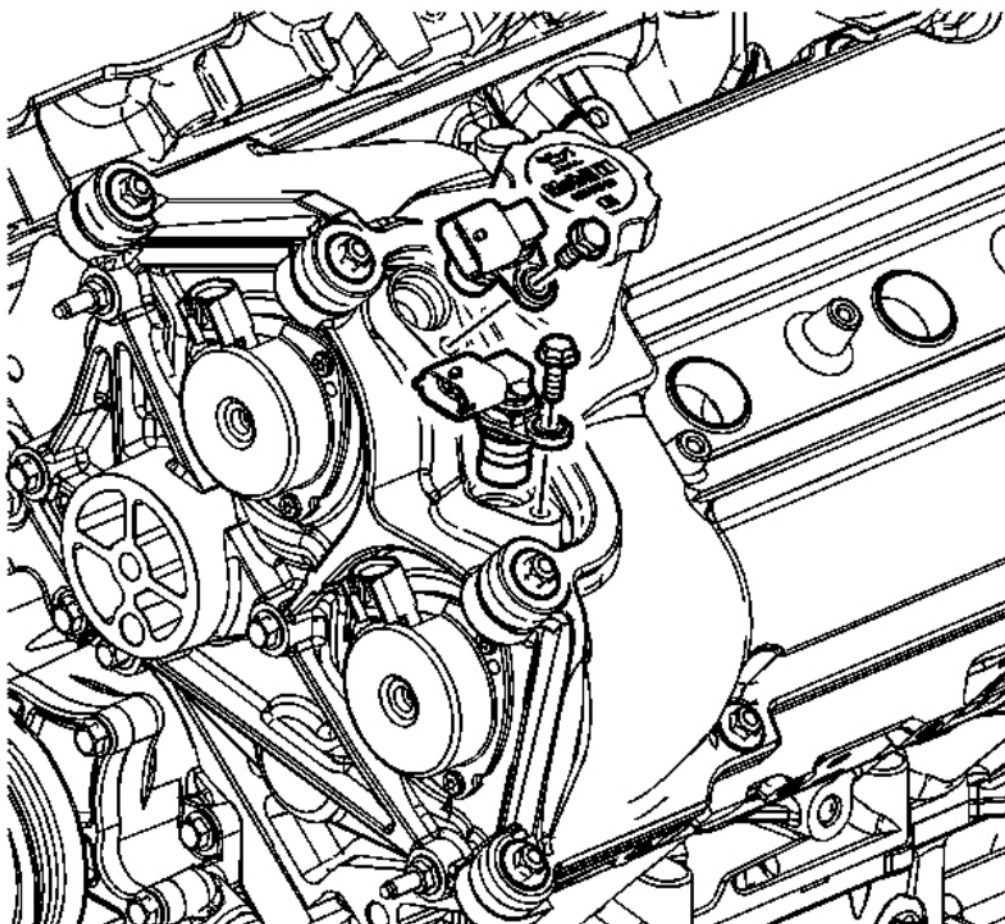


Fig. 134: View Of Left Intake Camshaft Sensor & Left Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the left intake camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 2 (Left) Intake** .
8. Install the left exhaust camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 2 (Left) Exhaust** .
9. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Air Conditioning, Power Steering and Water Pump**.
10. Install the power steering reservoir. Refer to **Remote Power Steering Fluid Reservoir Replacement (LH2)** or **Remote Power Steering Fluid Reservoir Replacement (LY7)**

in Power Steering System.

11. Install the fuel injector sight shield. Refer to Fuel Injector Sight Shield Replacement.

CAMSHAFT POSITION (CMP) ACTUATOR HOUSING REPLACEMENT - RIGHT

Removal Procedure

1. Remove the fuel injector sight shield. Refer to Fuel Injector Sight Shield Replacement.

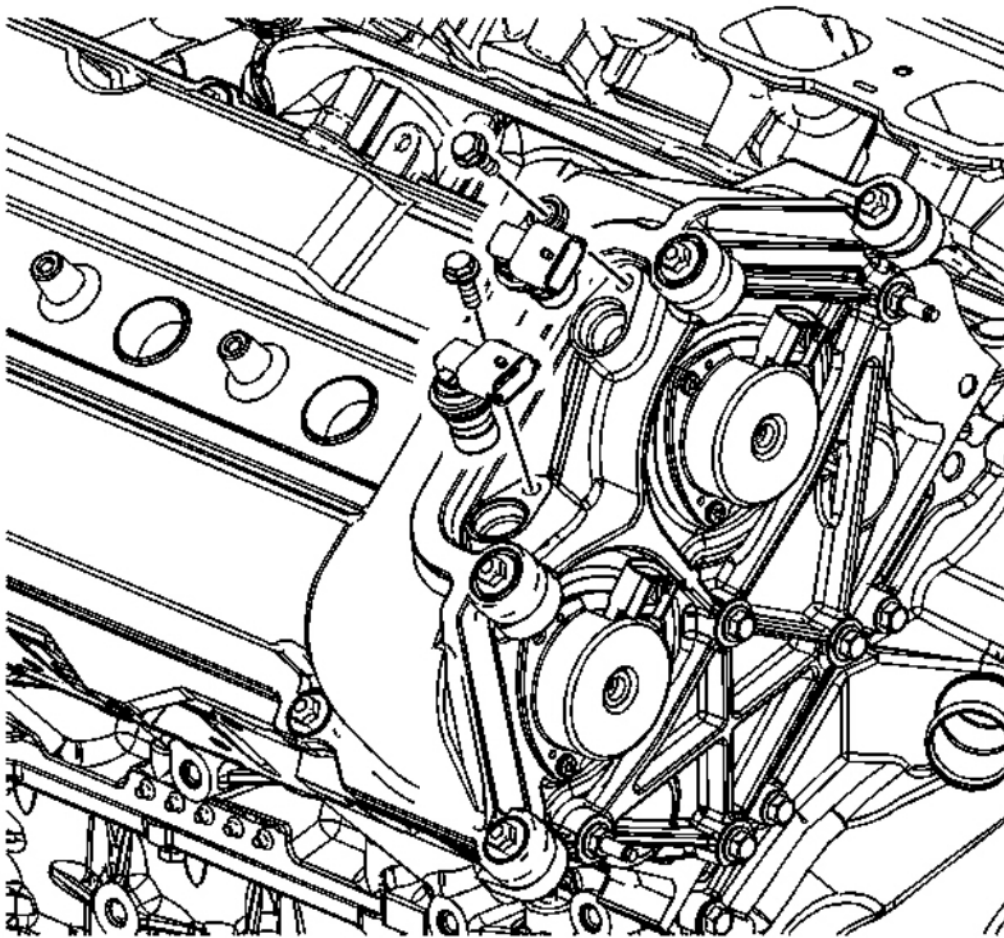


Fig. 135: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the right exhaust camshaft sensor. Refer to Camshaft Position (CMP) Sensor

Replacement - Bank 1 (Right) Exhaust .

3. Remove the right intake camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 1 (Right) Intake .**
4. Remove the right camshaft cover. Refer to **Camshaft Cover Replacement - Right.**
5. Remove the cam sensor harness from the retainers.

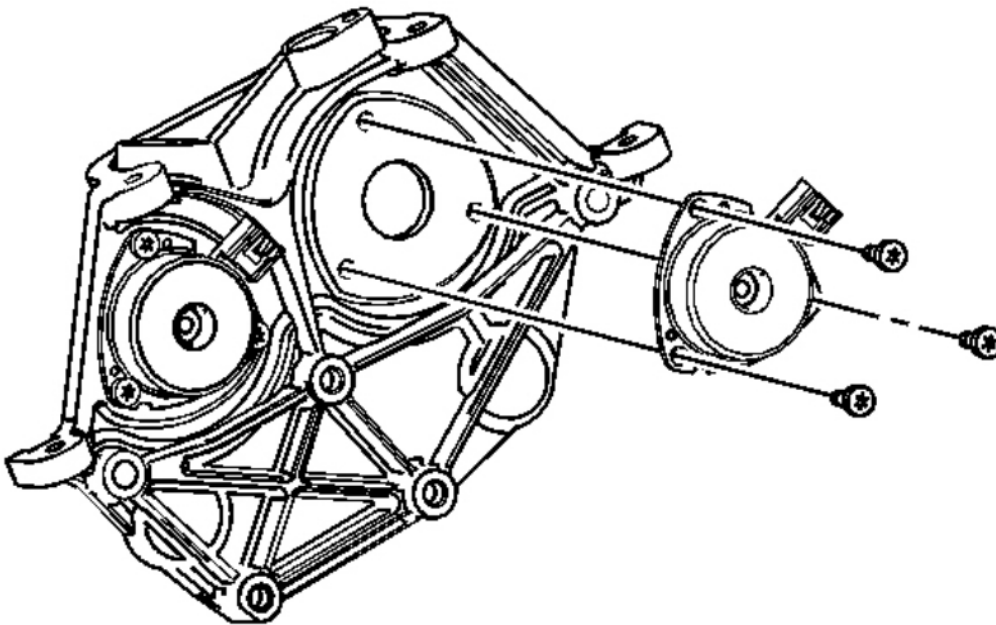


Fig. 136: View Of Right Intake Camshaft Position Actuator Solenoid
Courtesy of GENERAL MOTORS CORP.

6. Remove the right intake camshaft position actuator solenoid bolts.
7. Remove the right intake camshaft position actuator solenoid.
8. Remove the right intake camshaft position actuator solenoid alignment plug and discard.

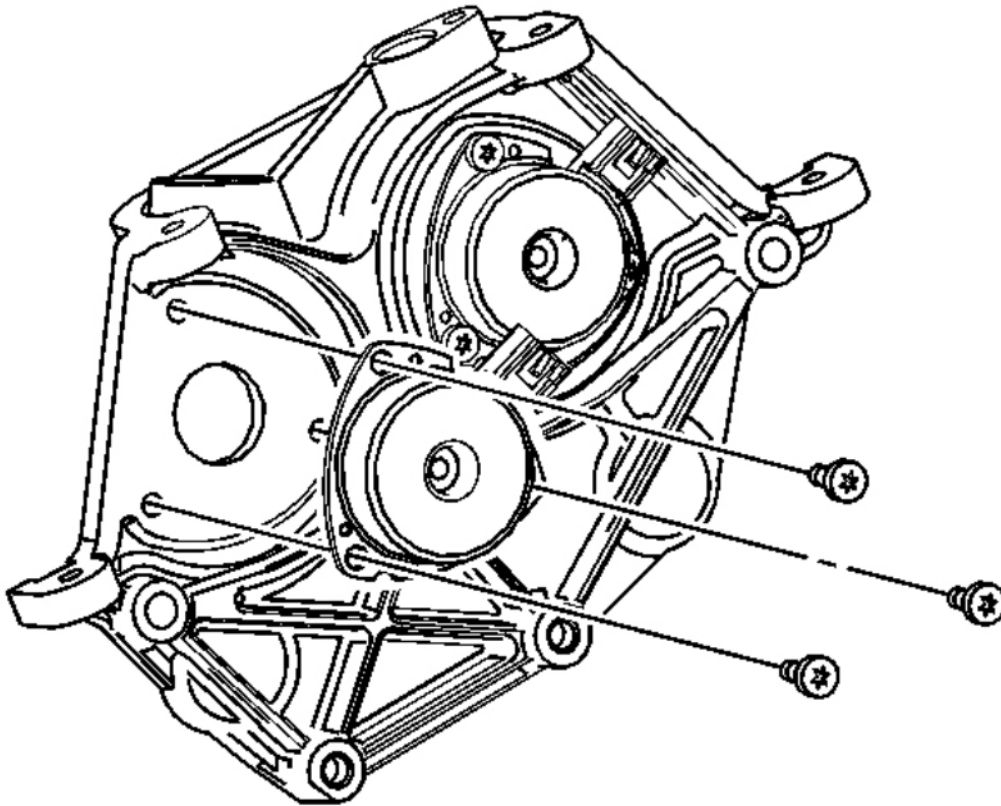


Fig. 137: View Of Right Exhaust Camshaft Position Actuator Solenoid
Courtesy of GENERAL MOTORS CORP.

9. Remove the right exhaust camshaft position actuator solenoid bolts.
10. Remove the right exhaust camshaft position actuator solenoid.
11. Remove the right exhaust camshaft position actuator solenoid alignment plug and discard.

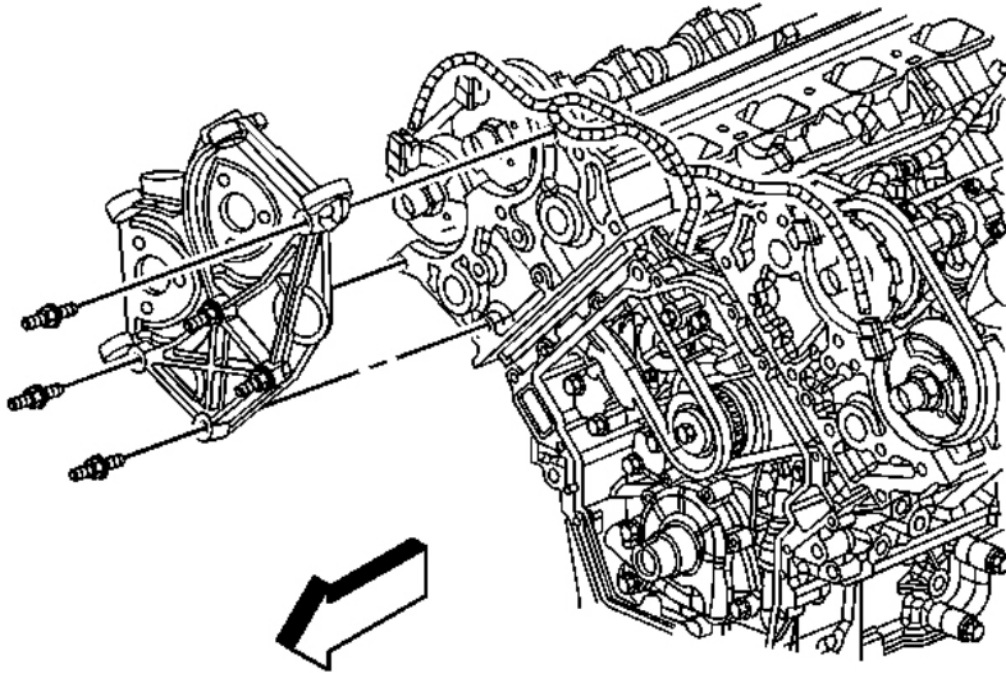


Fig. 138: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

12. Remove the right camshaft position actuator housing bolts.
13. Remove the right camshaft position actuator housing.

Installation Procedure

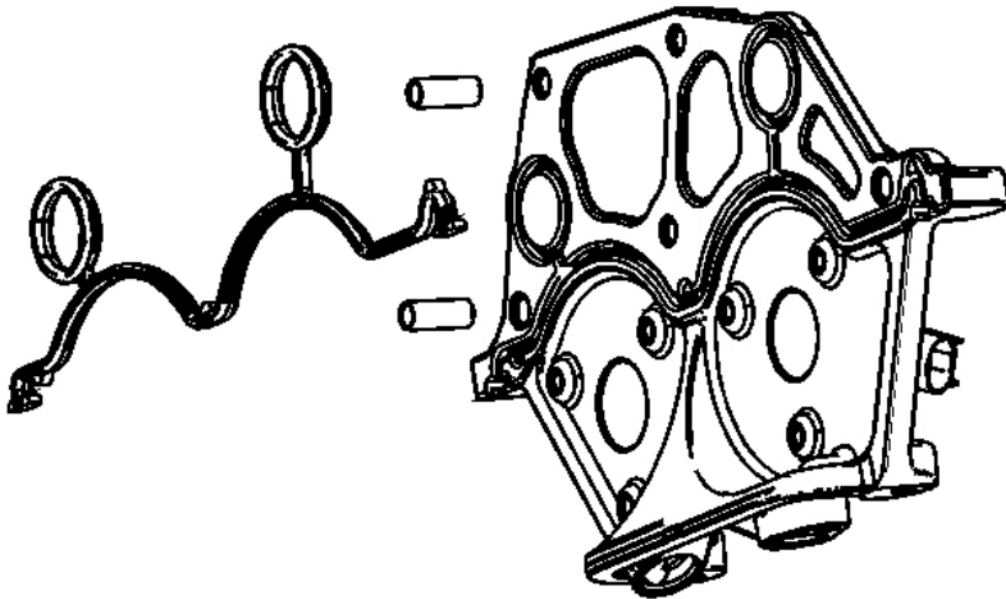


Fig. 139: View Of Camshaft Position Actuator Housing Gasket & Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW gasket to the camshaft position actuator housing.

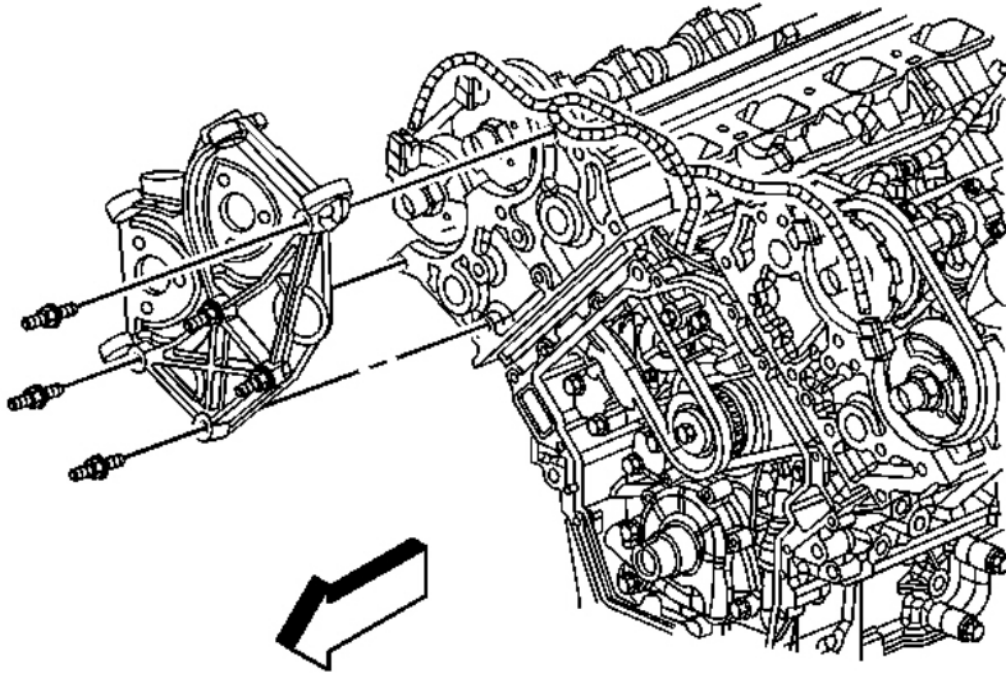


Fig. 140: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Install the right camshaft position actuator housing to the right cylinder head.

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

3. Install the actuator housing bolts and studs.

Tighten: Tighten the actuator housing bolts and studs to 10 N.m (89 lb in).

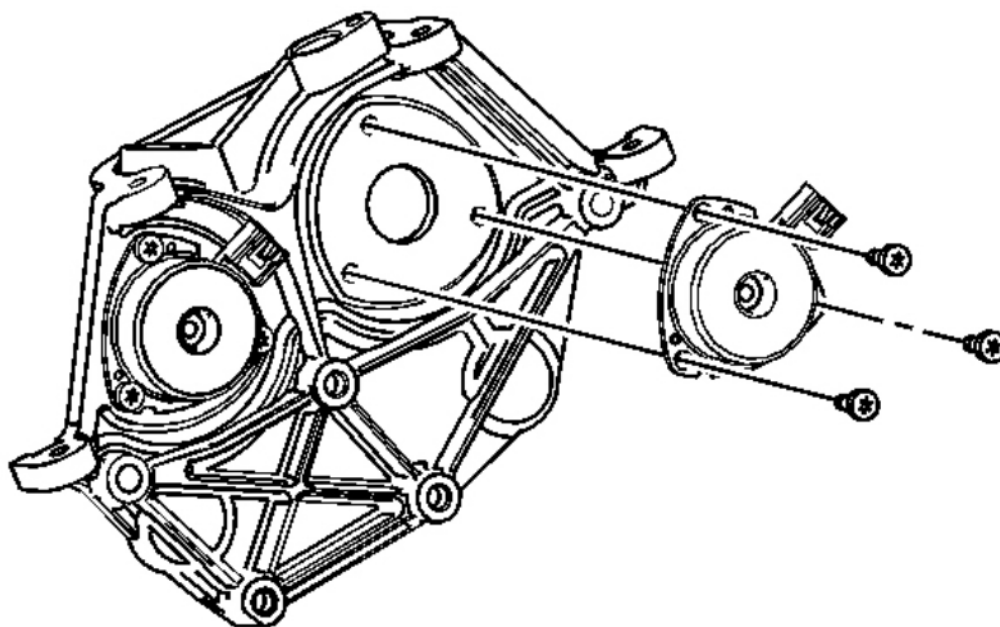


Fig. 141: View Of Right Intake Camshaft Position Actuator Solenoid
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft position actuator solenoids must be precisely aligned to the camshaft position actuator oil control valves on the end of the camshafts. This is accomplished with an alignment pin. Failure to align the camshaft position actuator solenoids to the camshaft position actuator oil control valves can lead to poor engine performance and engine component damage.

4. To allow for camshaft position actuator solenoid to camshaft position actuator oil control valve alignment, DO NOT install NEW camshaft position actuator solenoid alignment plugs at this time.
5. Use the following procedure for the camshaft position actuator solenoid alignment:
 1. Make an alignment pin from drill rod 15/64 inch diameter and at least 50 mm (1.97 in) long.
 2. Verify that the alignment pin will pass through the camshaft position actuator solenoid

alignment hole.

3. Verify that the alignment pin will fit into the alignment hole in the camshaft position actuator oil control valve.
4. Apply a 2 mm (0.079 in) bead of RTV GM P/N 12378521 (Canadian P/N 88901148) around the flange of the camshaft position actuator solenoid.
5. Install the camshaft position actuator solenoid over the oil control valve.
6. Install the alignment pin through the solenoid alignment hole and into the oil control valve alignment hole.
7. With the alignment pin in place, install the camshaft position actuator solenoid bolts.

Tighten: Tighten the camshaft position actuator solenoid bolts to 8 N.m (71 lb in).

8. Remove the alignment pin.
9. Install a NEW camshaft position actuator solenoid plug.
10. Repeat steps 4 through 9 for the exhaust camshaft position actuator solenoid.
6. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right.**

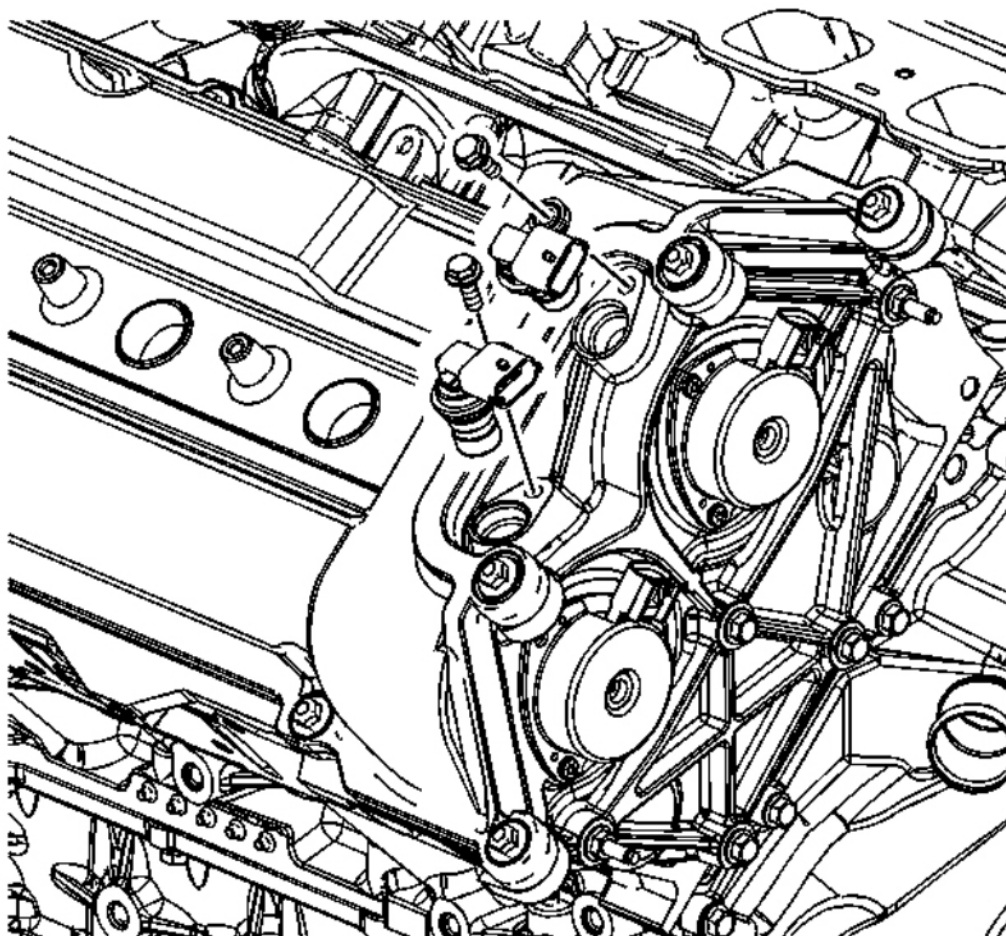


Fig. 142: View Of Right Intake Camshaft Sensor & Right Exhaust Camshaft Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the right intake camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 1 (Right) Intake** .
8. Install the right exhaust camshaft sensor. Refer to **Camshaft Position (CMP) Sensor Replacement - Bank 1 (Right) Exhaust** .
9. Install the camshaft sensor harness to the retainers.
10. Install the fuel injector sight shield. Refer to **Fuel Injector Sight Shield Replacement**.

Tools Required

- J 39946 Crankshaft Socket
- EN 46328 Camshaft Holding Tool

Removal Procedure

1. Remove the right secondary timing chain. Refer to Secondary Camshaft Drive Chain Replacement - Right.

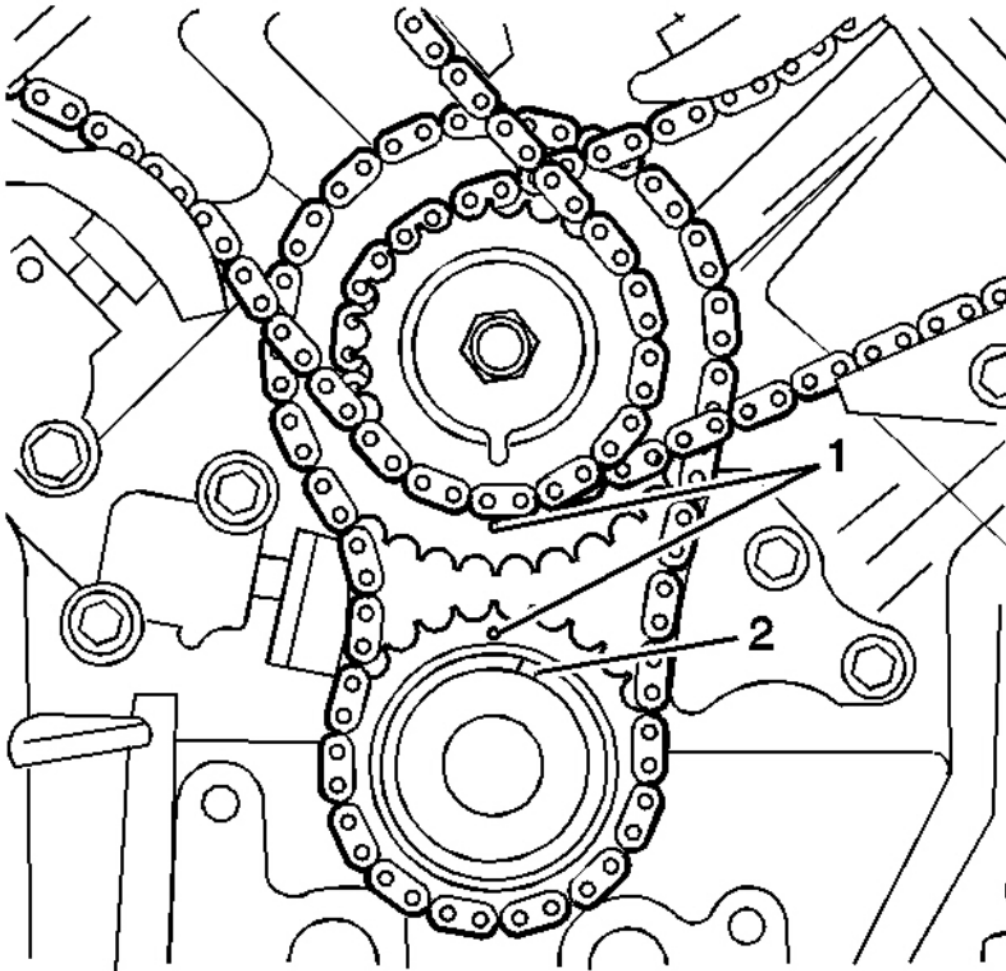


Fig. 143: Identifying Primary Timing Gear Alignment Marks

Courtesy of GENERAL MOTORS CORP.

2. Using the **J 39946** , rotate the crankshaft until the primary timing gear alignment marks (1) are adjacent to each other as shown.
3. Remove the left camshaft position actuator housing. DO NOT remove the actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left.**

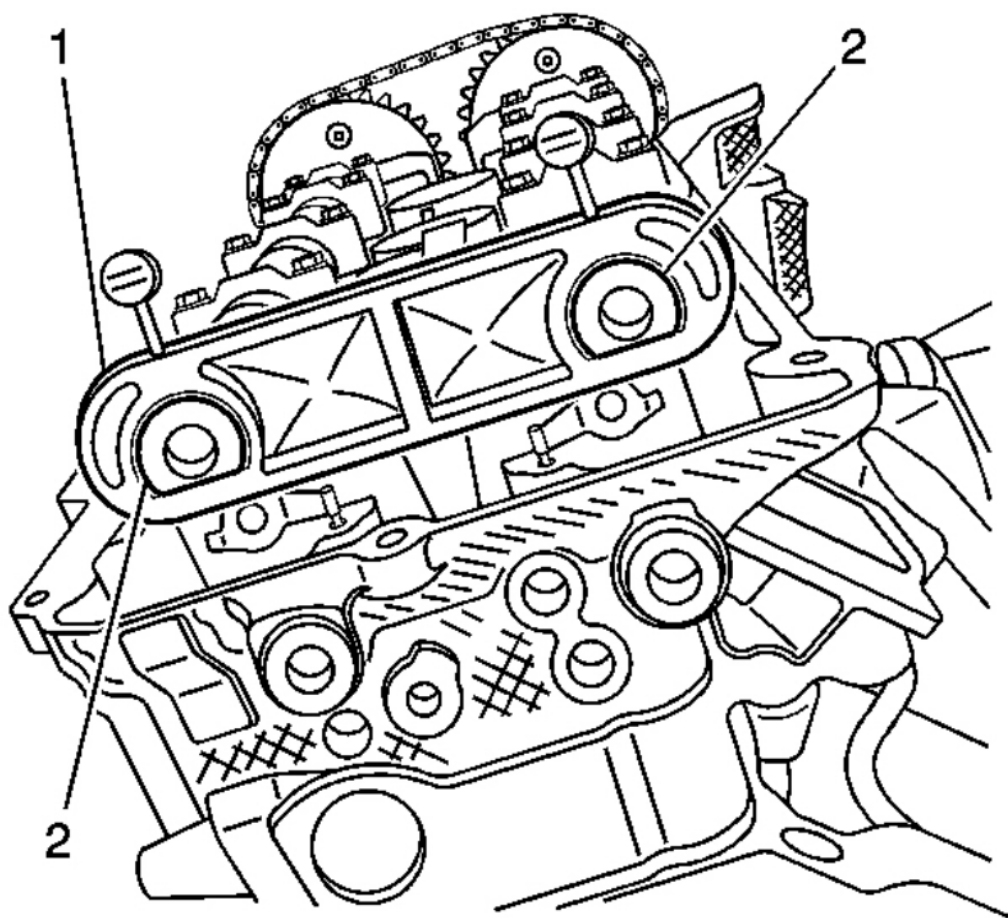


Fig. 144: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to **Camshaft Holding Tool Caution** in Cautions and

Notices.

4. Install the **EN 46328** (1) on the bank 2 (left) camshafts (2).

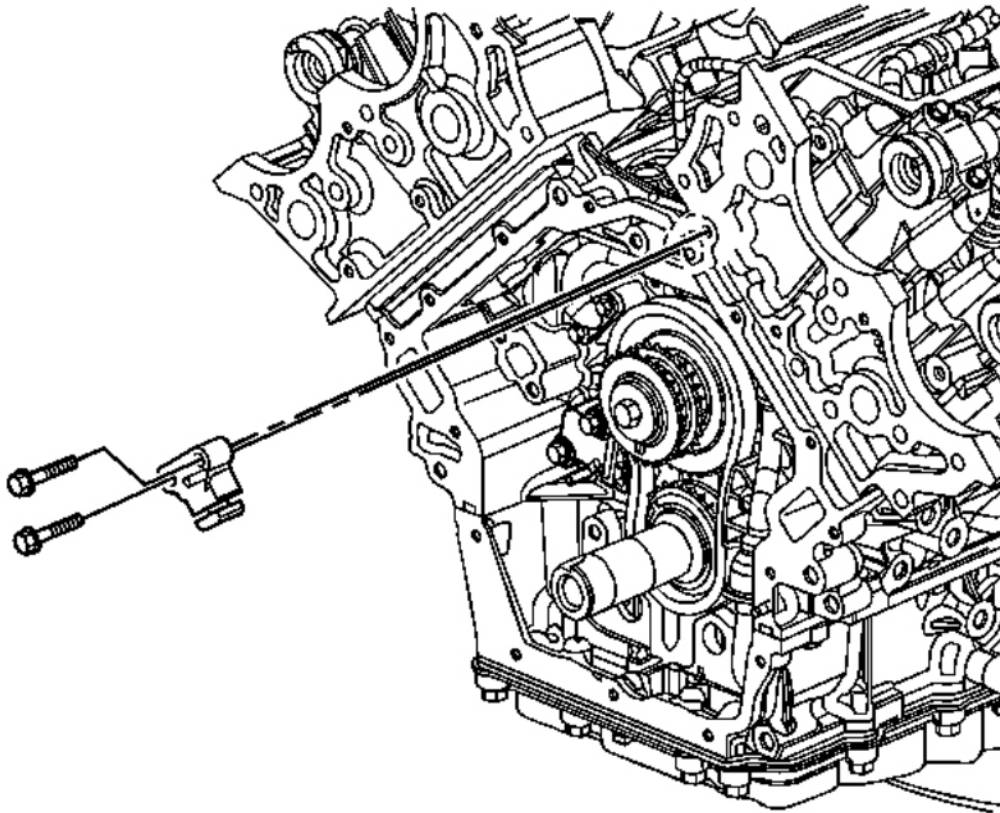


Fig. 145: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen and remove the left secondary timing chain tensioner bolts and tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left.**

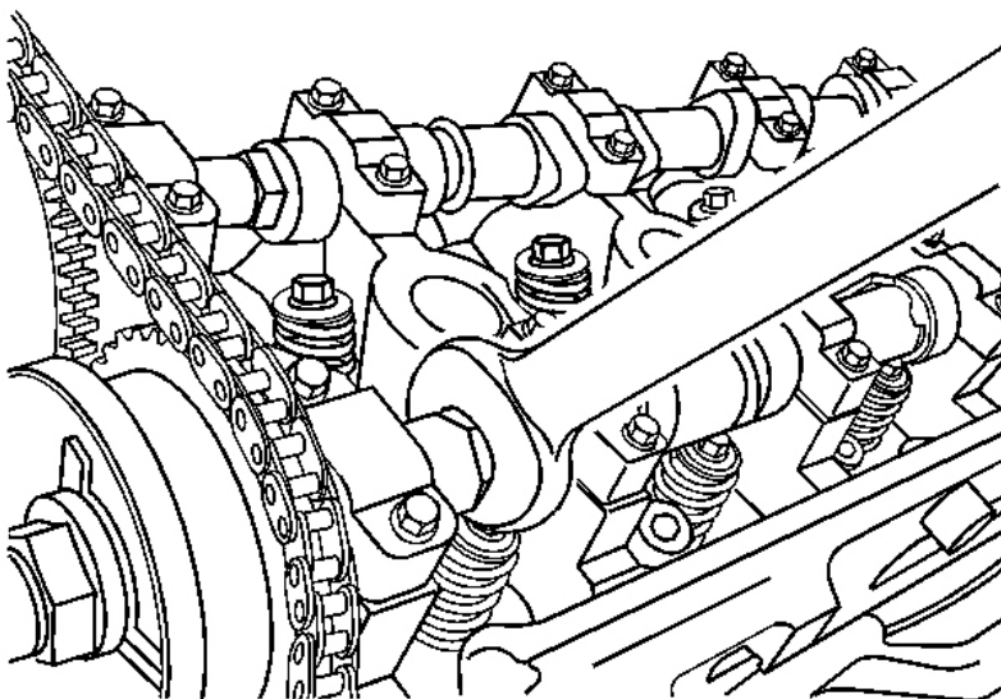


Fig. 146: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

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 oil control valve.
7. Loosen and remove the bank 2 (left) exhaust camshaft position oil control valve.
8. Slide the left exhaust camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.

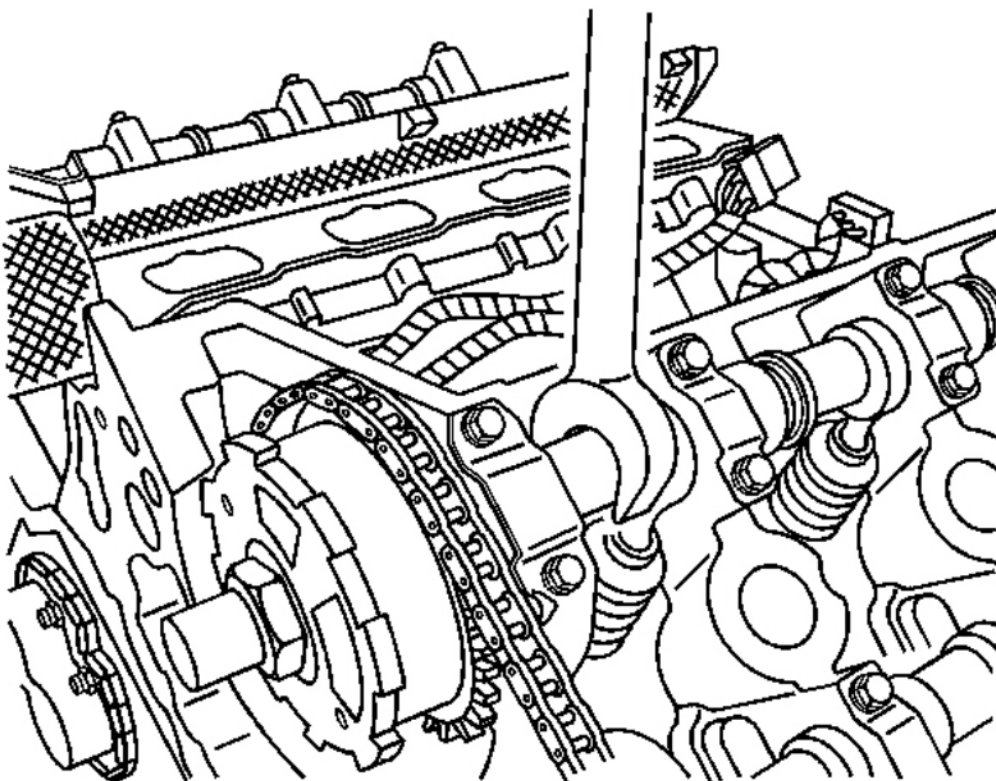


Fig. 147: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

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

9. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
10. Loosen and remove the bank 2 (left) intake camshaft position oil control valve.
11. Slide the left intake camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.
12. Remove the left secondary timing chain from the engine.
13. Clean and inspect the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection .

Installation Procedure

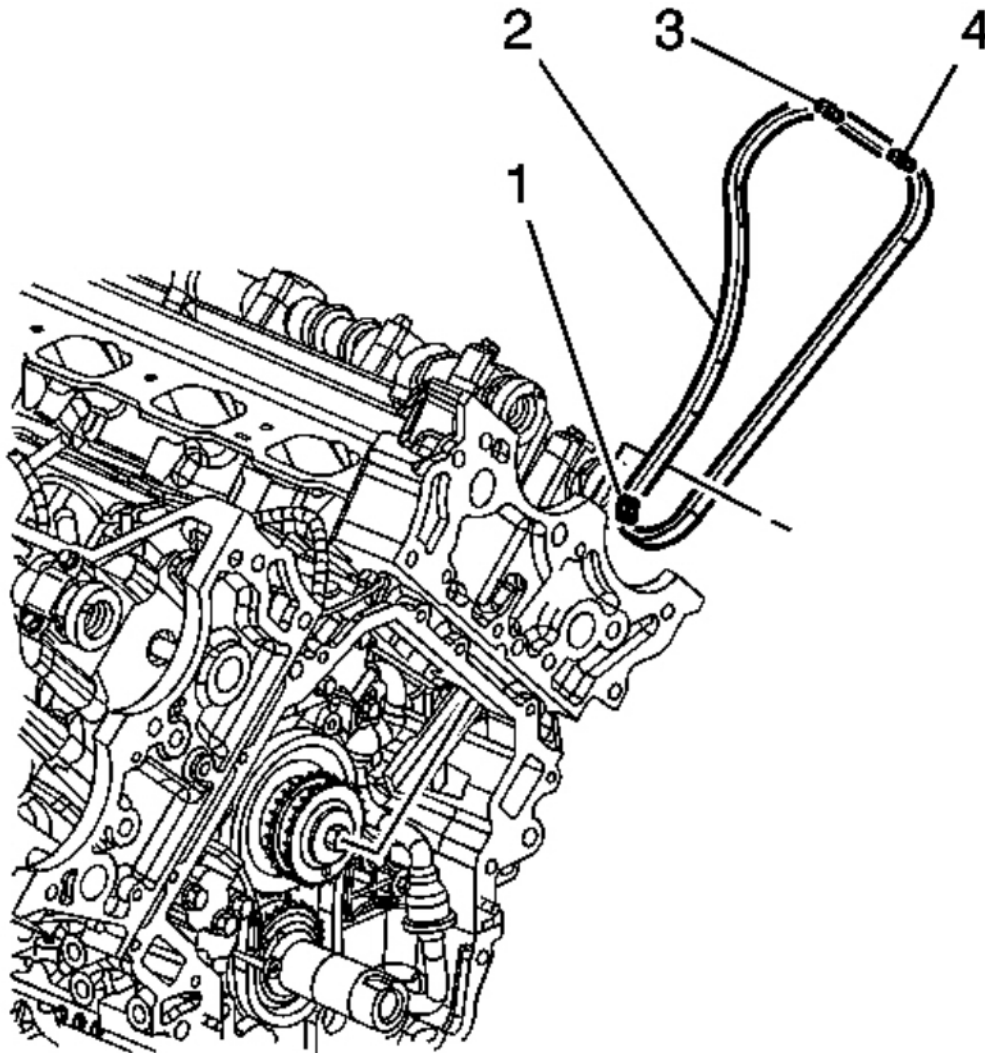


Fig. 148: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

1. The secondary timing chain (2) has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
2. The black link (4) is aligned with the bank 2 exhaust actuator timing mark. The black link

- (3) is aligned with the bank 2 intake actuator timing mark.
3. The black link (1) is aligned with the intermediate sprocket.

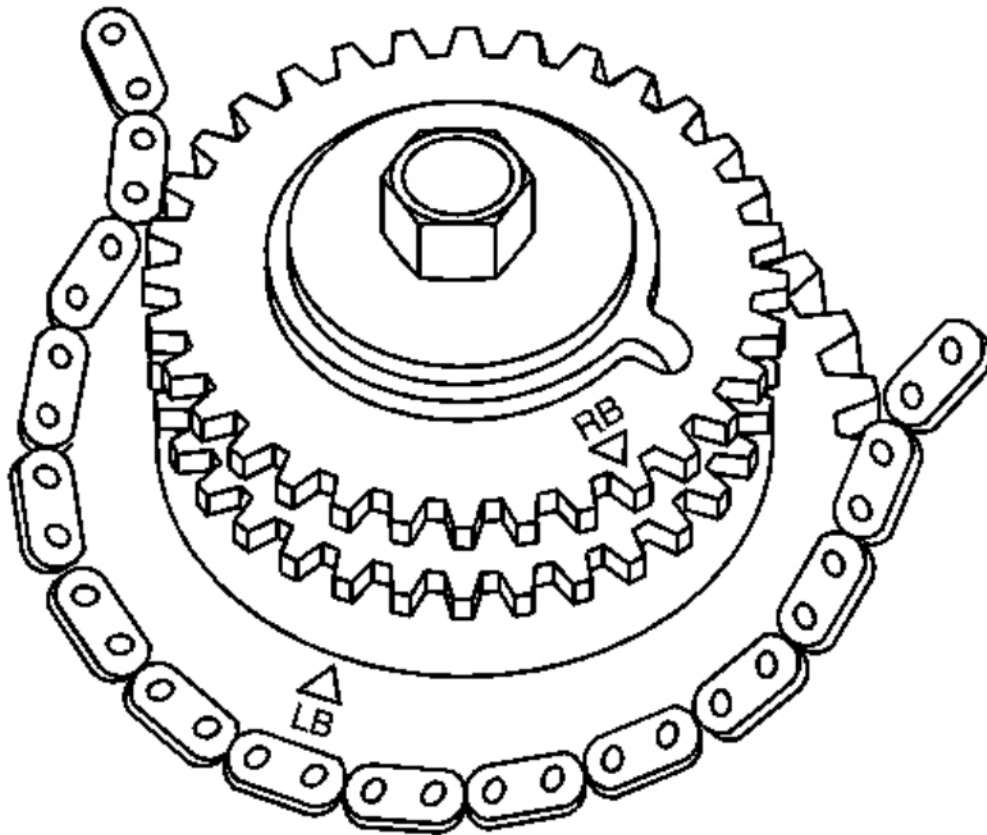


Fig. 149: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

4. The intermediate sprocket left bank timing mark is labeled left bank (LB) as shown.
5. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket LB timing mark to the timing chain black link.

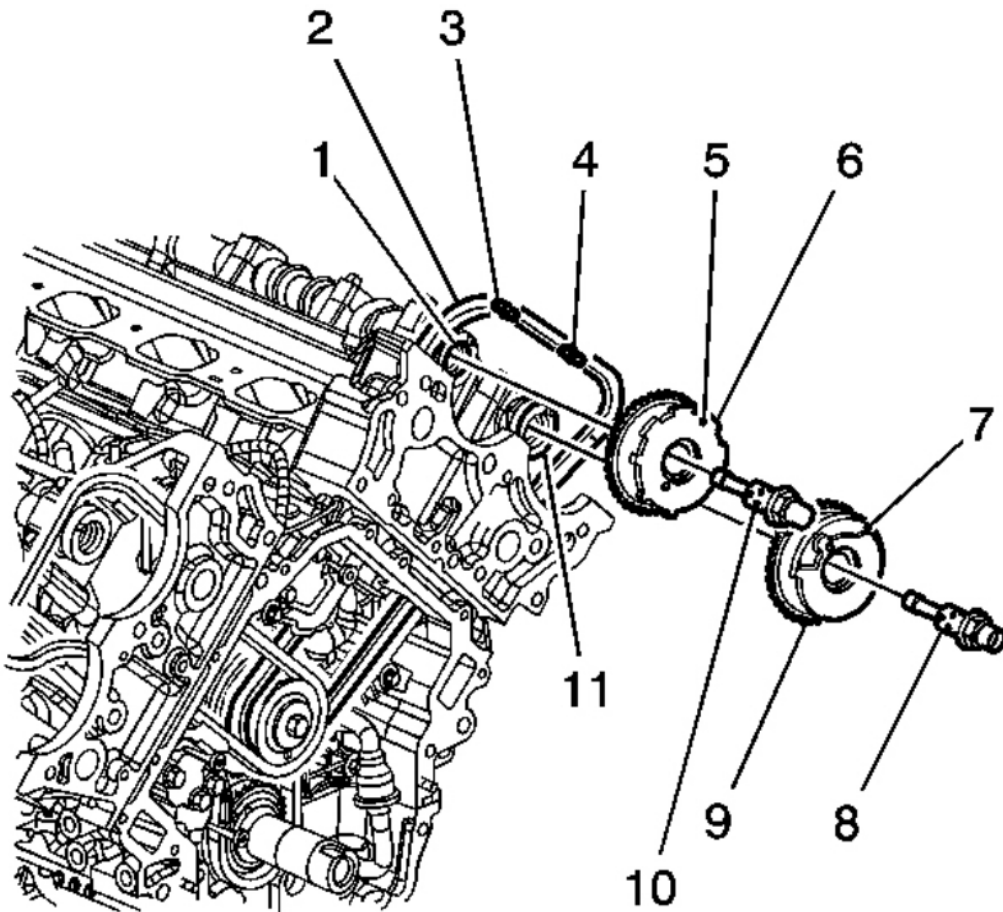


Fig. 150: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

6. Align the timing mark (5) of the LB intake camshaft position actuator with the timing chain black link (3) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation.
7. Loosely install the oil control valve (10) to secure the intake actuator.

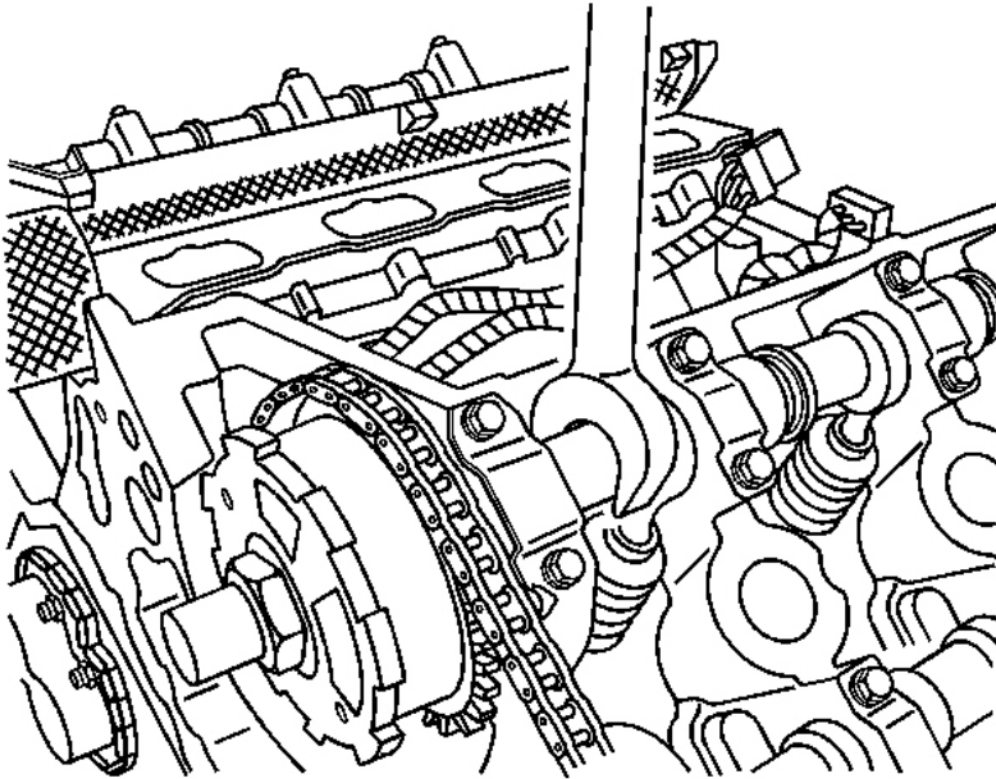


Fig. 151: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

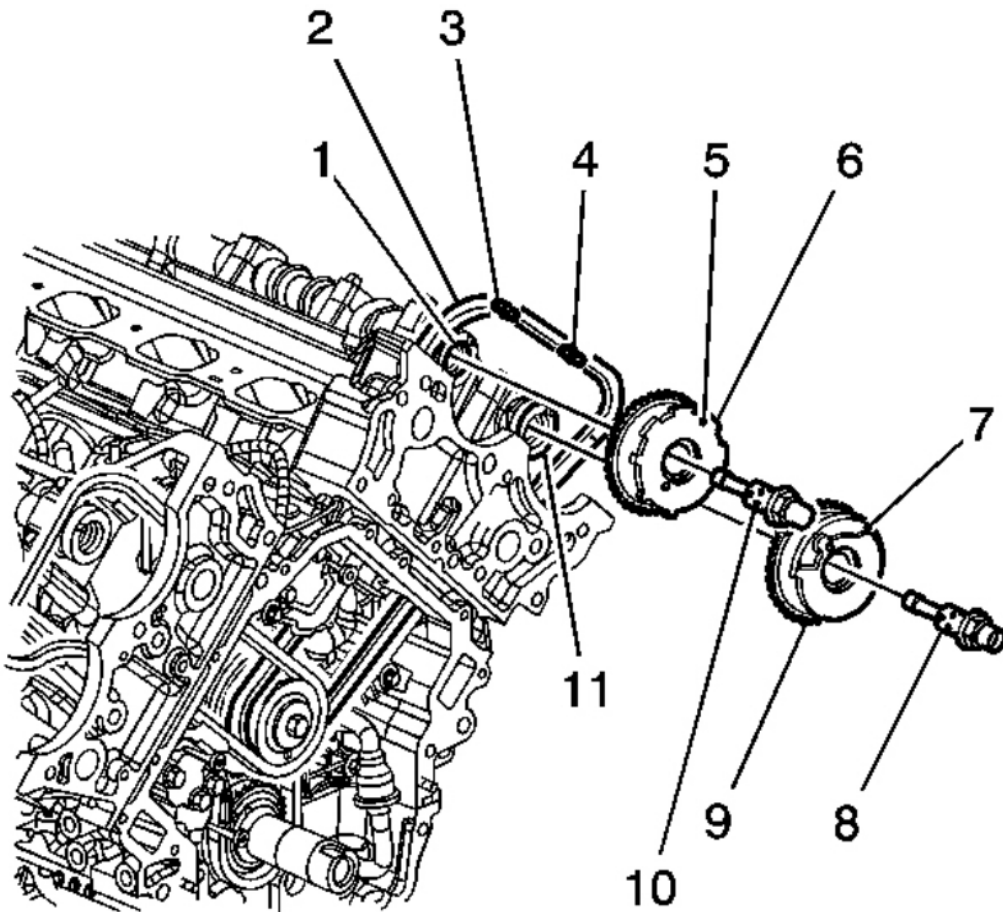


Fig. 152: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

9. Align the timing mark (7) of the LB exhaust camshaft position actuator with the timing chain black link (4) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation.
10. Loosely install the oil control valve (8) to secure the exhaust actuator.

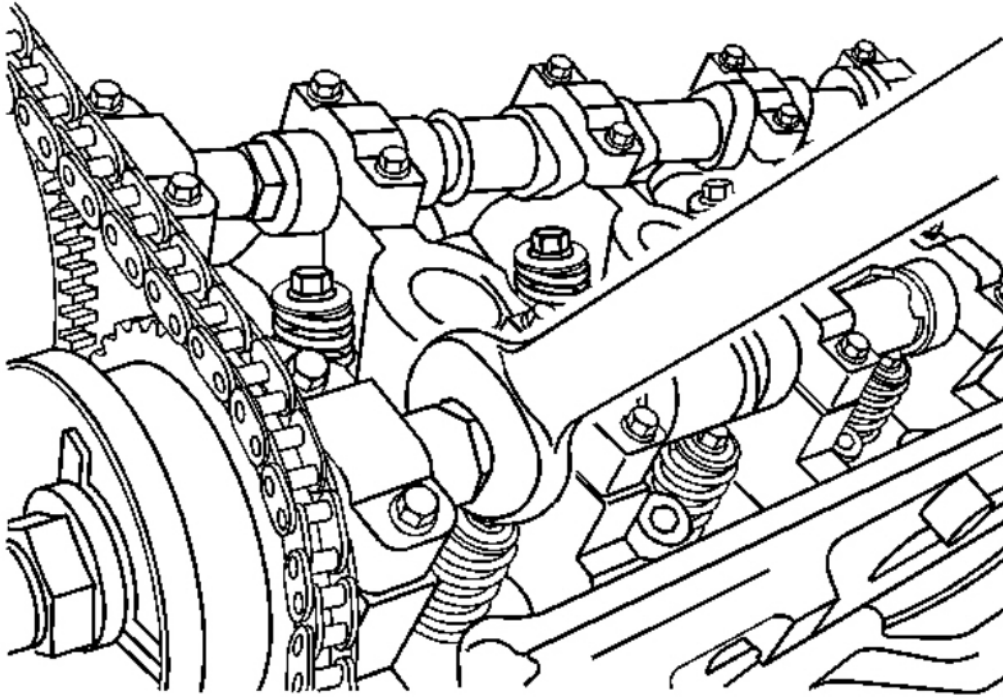


Fig. 153: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

11. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

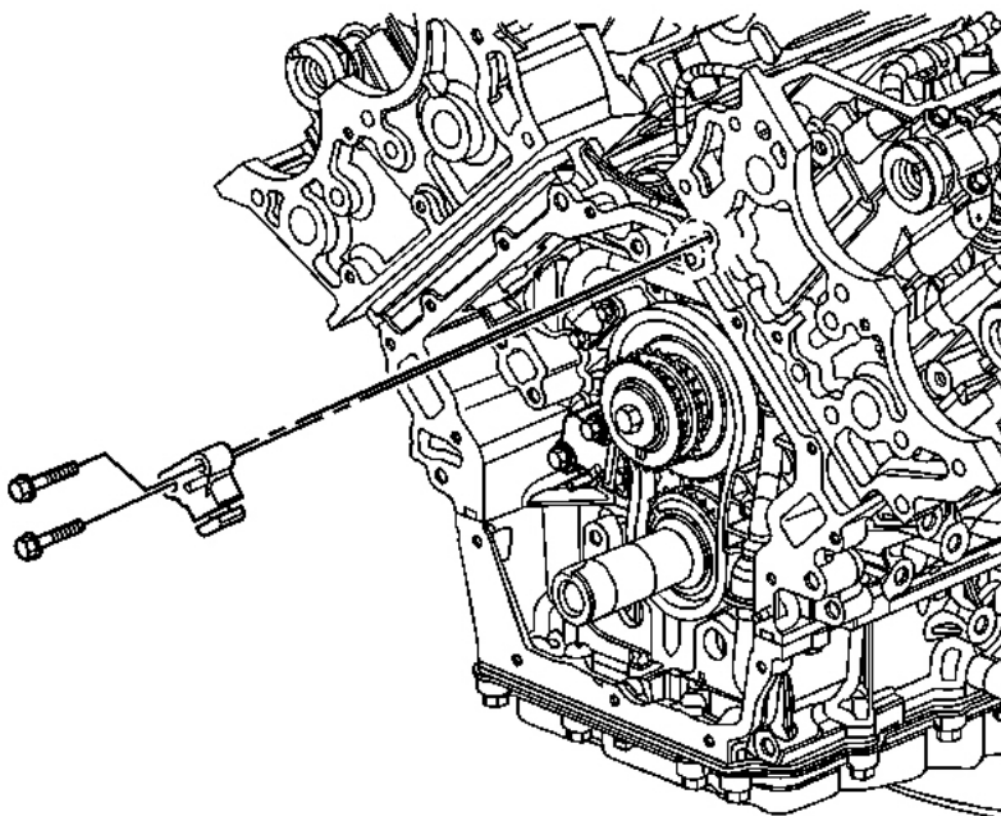


Fig. 154: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the left secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left**.
13. Install the right secondary timing chain. Refer to **Secondary Camshaft Drive Chain Replacement - Right**.
14. Remove the EN 46328 .
15. Install the left camshaft position actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

SECONDARY CAMSHAFT DRIVE CHAIN REPLACEMENT - RIGHT

Tools Required

- **EN 46328** Camshaft Holding Tool
- **J 39946** Crankshaft Socket

Removal Procedure

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

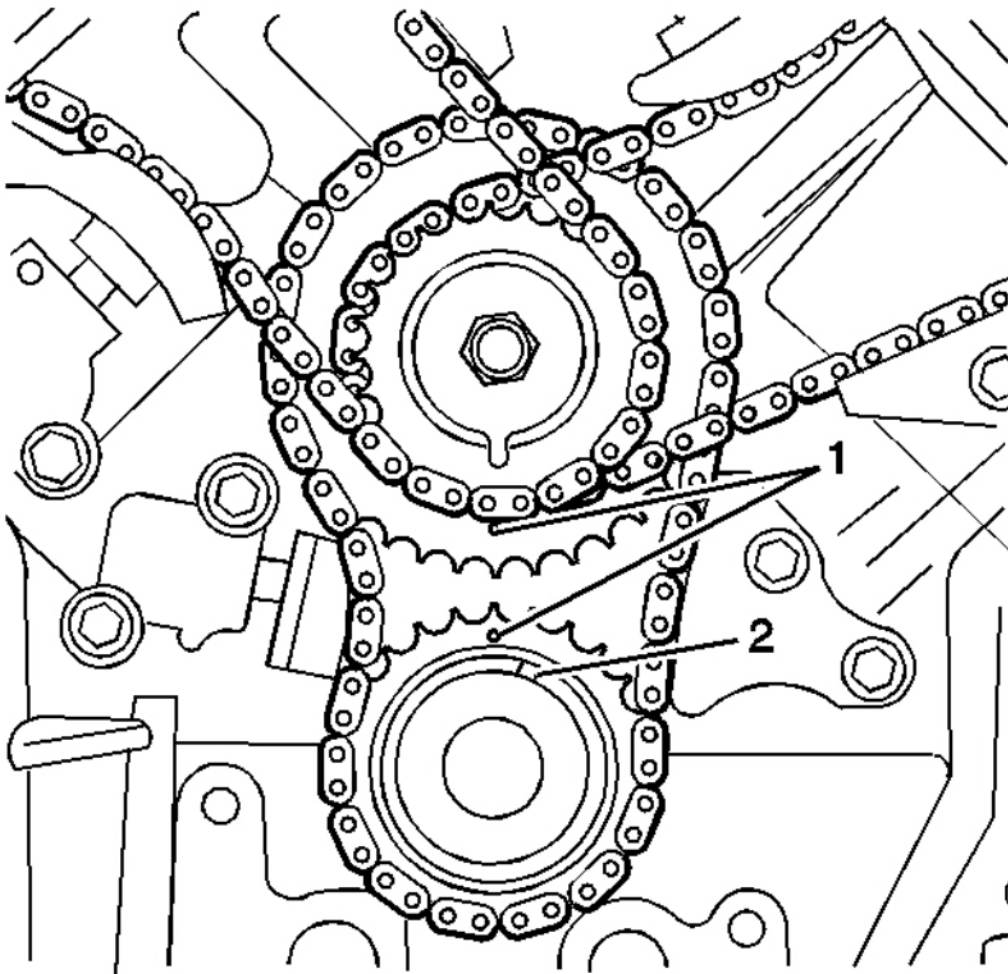


Fig. 155: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Using the **J 39946** , rotate the crankshaft until the primary timing gear marks (1) are

adjacent to each other as shown.

3. Remove the right camshaft position actuator housing. DO NOT remove the actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.

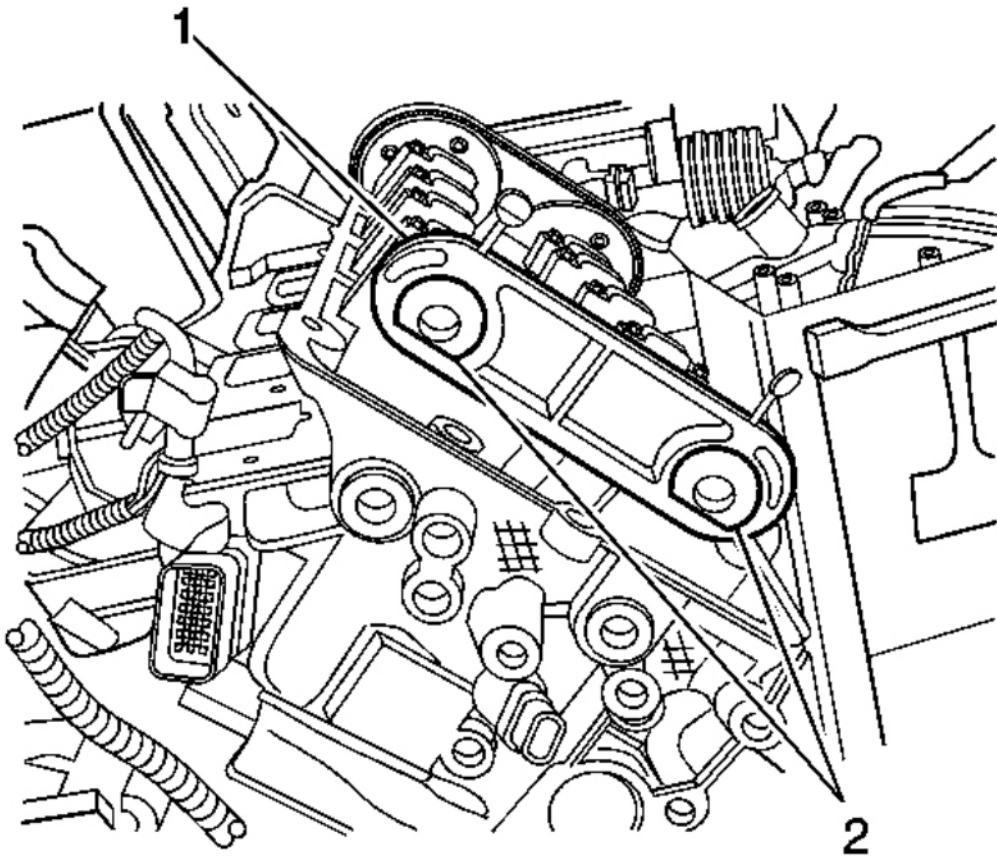


Fig. 156: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to **Camshaft Holding Tool Caution** in Cautions and Notices.

4. Install the **EN 46328** (1) on the bank 1 (right) camshafts (2).

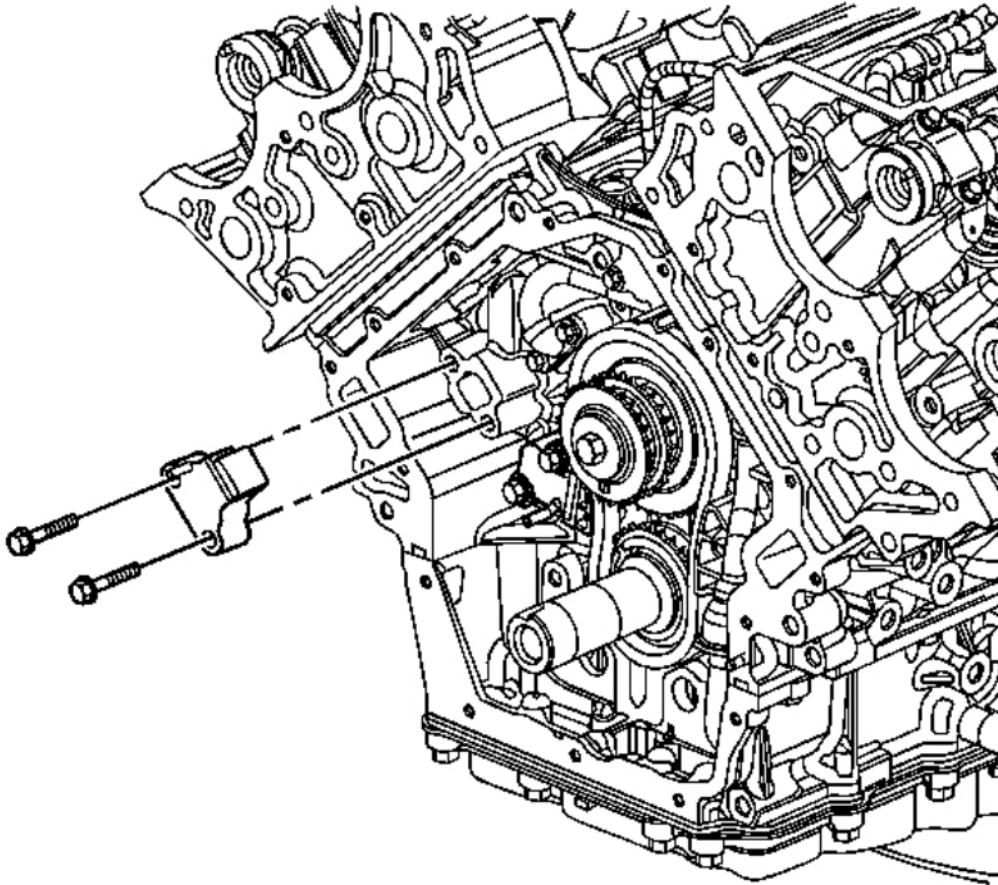


Fig. 157: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Loosen and remove the right secondary timing chain tensioner bolts and tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right.**

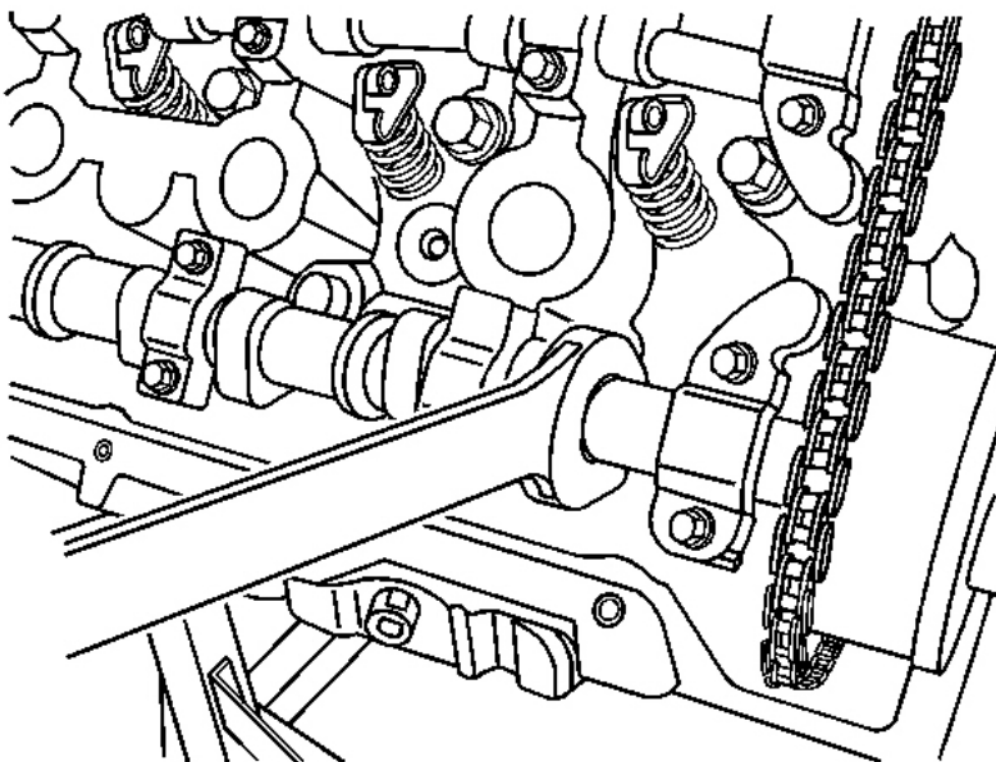


Fig. 158: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

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

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 oil control valve.
7. Loosen and remove the bank 1 (right) exhaust camshaft position oil control valve.
8. Slide the right exhaust camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.

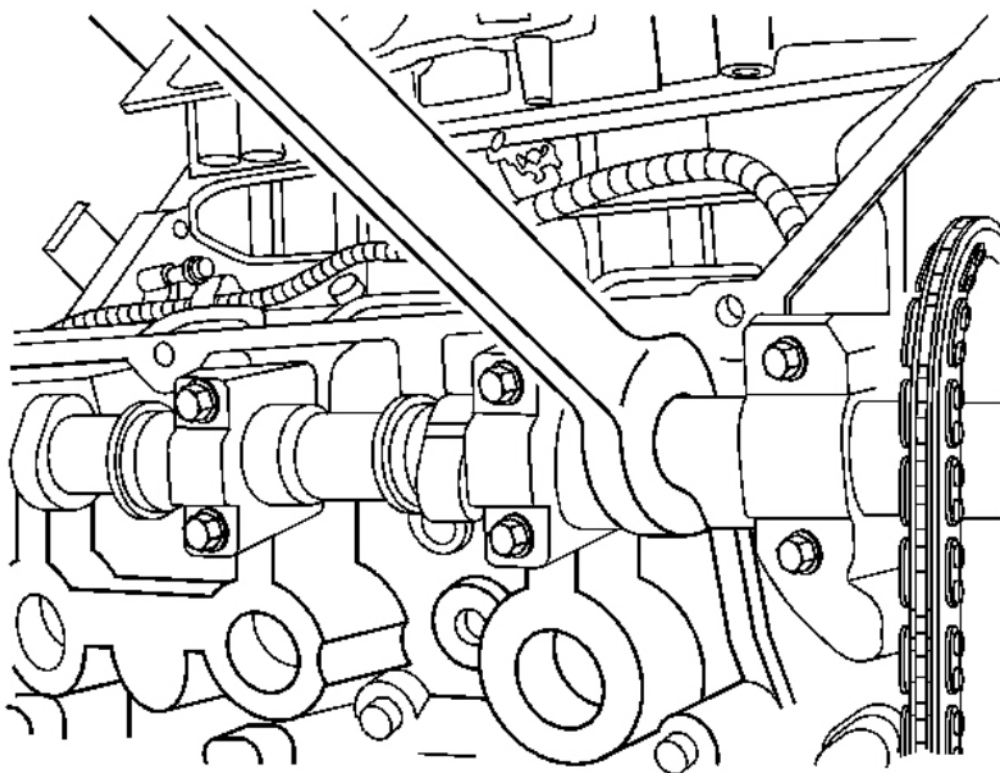


Fig. 159: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

9. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when removing the camshaft oil control valve.
10. Loosen and remove the bank 1 (right) intake camshaft position oil control valve.
11. Slide the right intake camshaft position actuator off of the camshaft and remove the secondary timing chain from the camshaft actuator teeth.
12. Remove the right secondary timing chain from the engine.
13. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

Installation Procedure

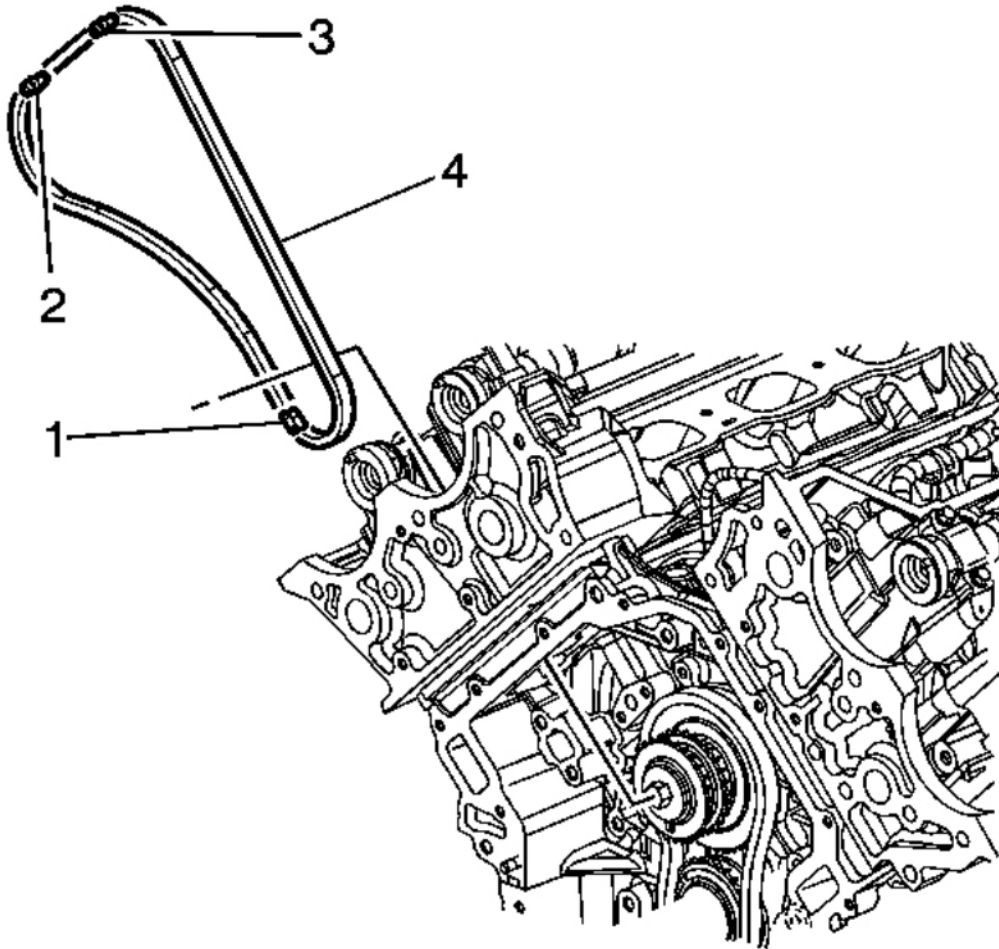


Fig. 160: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

1. The secondary timing chain has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
2. The black link (2) is aligned with the bank 1 exhaust actuator timing mark. The black link (3) is aligned with the bank 1 intake actuator timing mark.
3. The black link (1) is aligned with the intermediate sprocket.

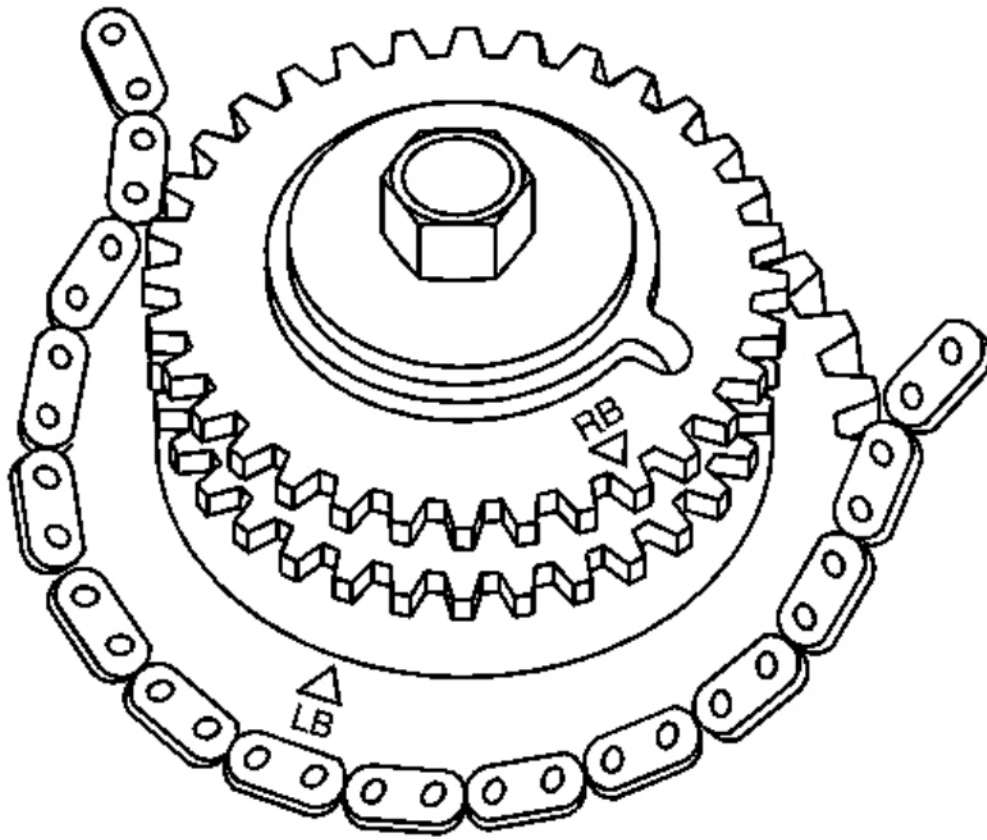


Fig. 161: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

4. The intermediate sprocket right bank timing mark is labeled right bank (RB) as shown.
5. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket RB timing mark to the timing chain black link.

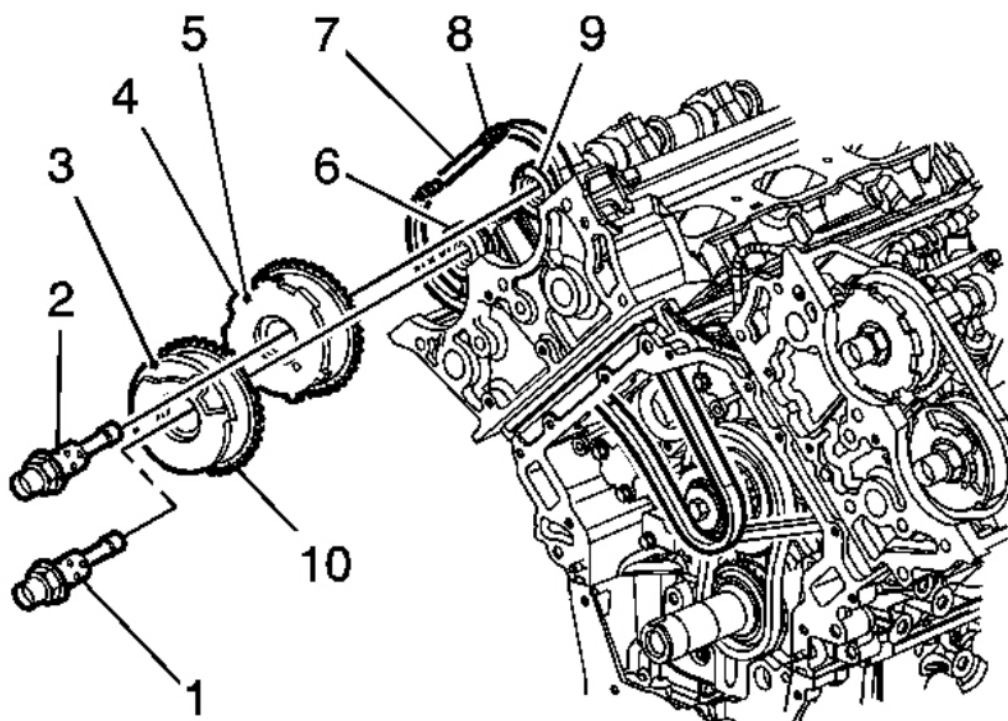


Fig. 162: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

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

6. Align the timing mark (5) of the RB intake camshaft position actuator with the timing chain black link (8) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation.
7. Loosely install the oil control valve (2) to secure the intake actuator.

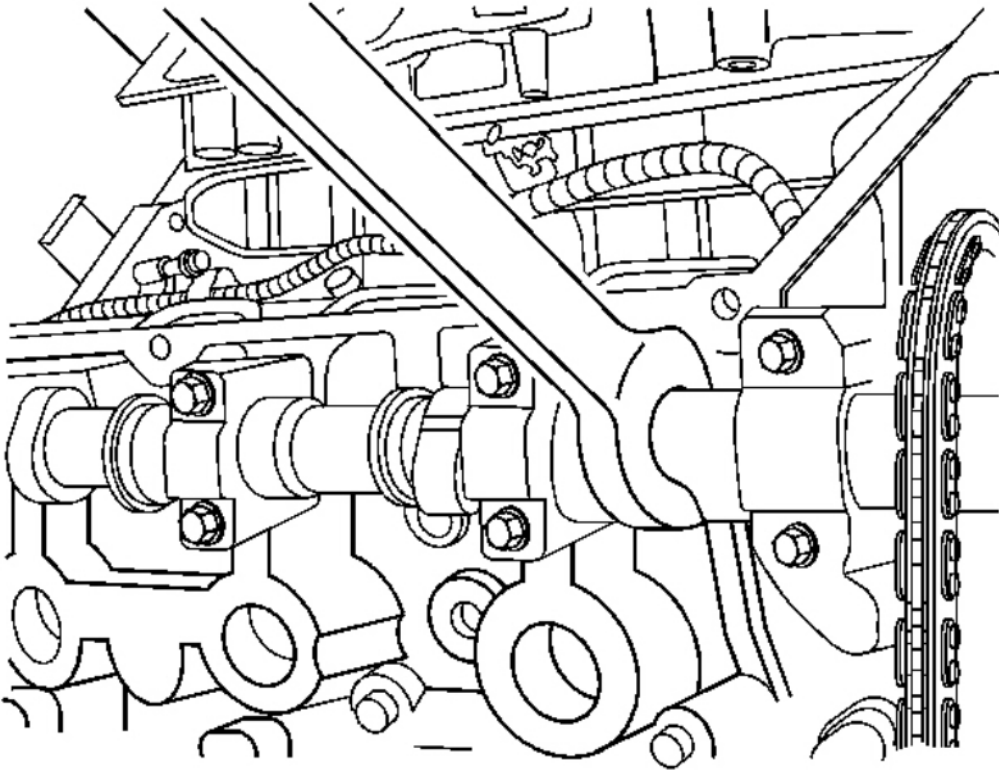


Fig. 163: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

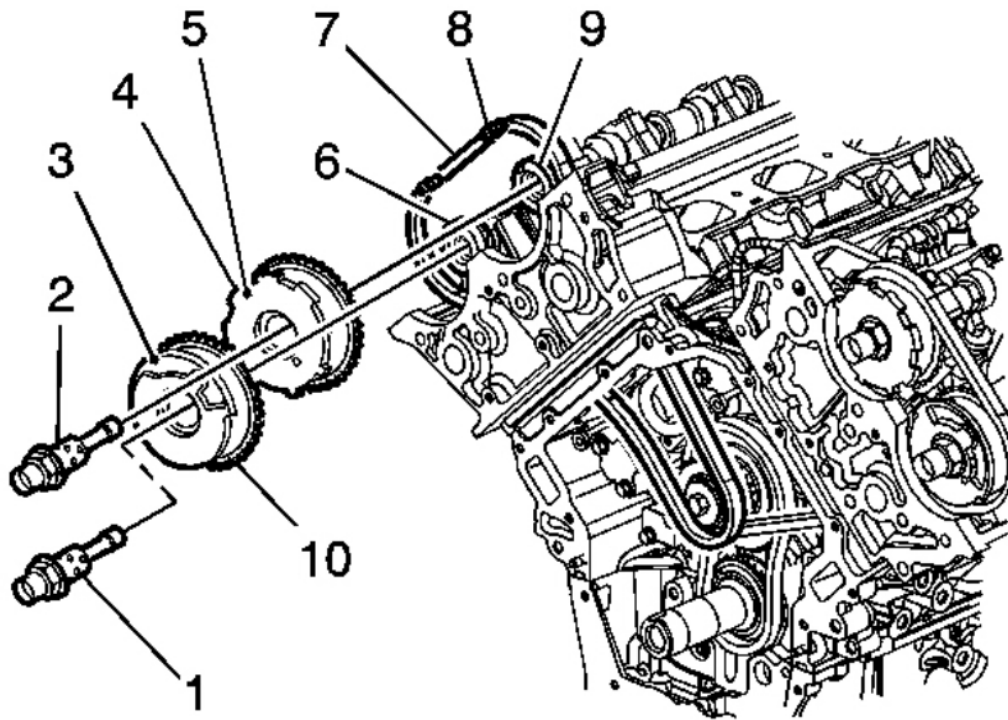


Fig. 164: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

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

9. Align the timing mark (3) of the RB exhaust camshaft position actuator with the timing chain black link and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation.
10. Loosely install the oil control valve (1) to secure the exhaust actuator.

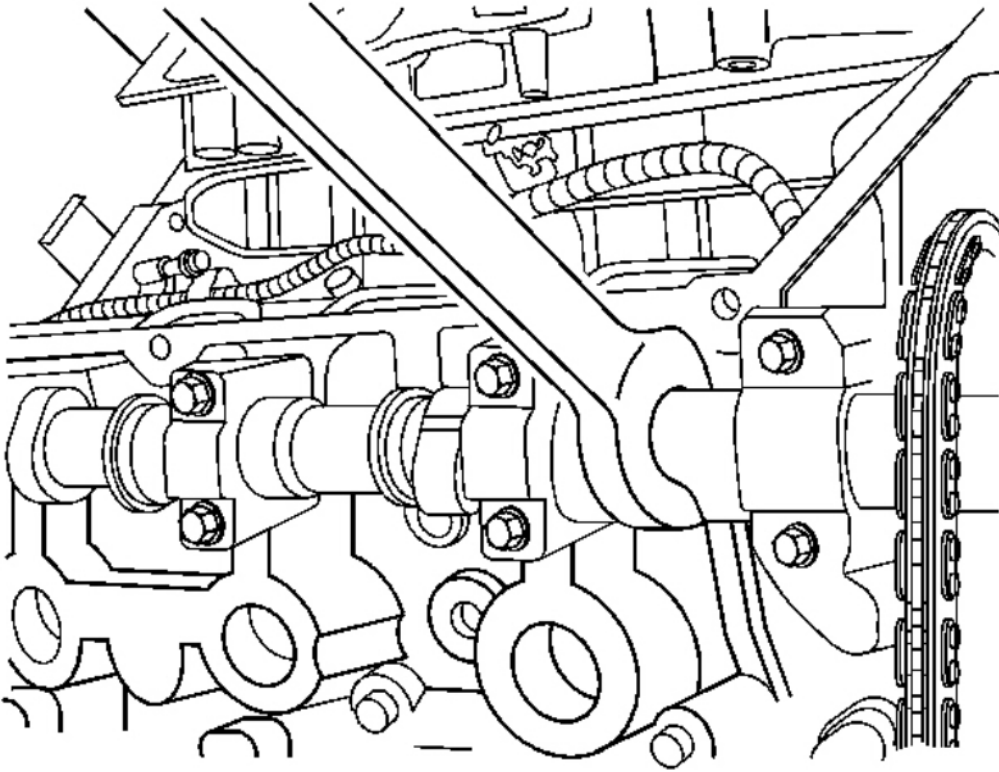


Fig. 165: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

11. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

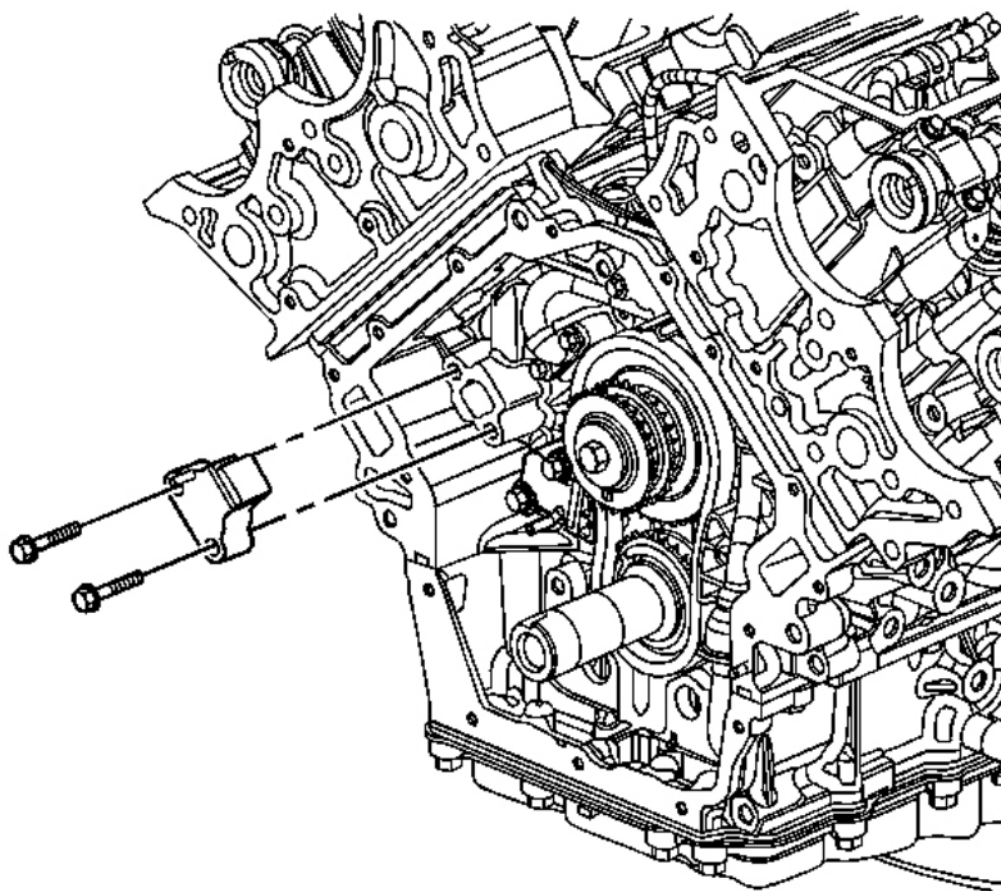


Fig. 166: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the right secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right**.
13. Remove the **EN 46328** .
14. Install the right camshaft position actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.
15. Install the oil pump. Refer to **Oil Pump Replacement**.

SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - LEFT

Tools Required

- **J 39946** Crankshaft Rotation Socket
- **EN 46328** Camshaft Holding Tool

Removal Procedure

1. Remove the left camshaft cover. Refer to **Camshaft Cover Replacement - Left.**
2. Remove the engine oil pump. Refer to **Oil Pump Replacement.**

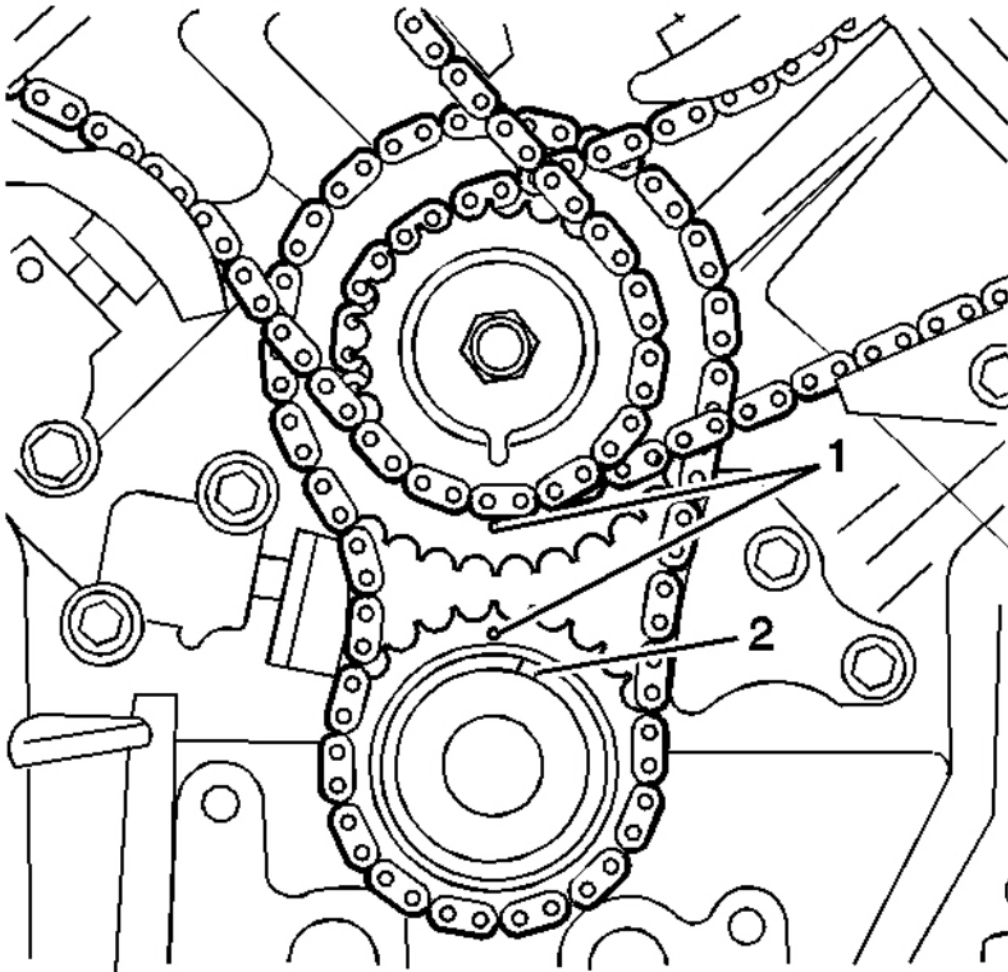


Fig. 167: Identifying Primary Timing Gear Alignment Marks

Courtesy of GENERAL MOTORS CORP.

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

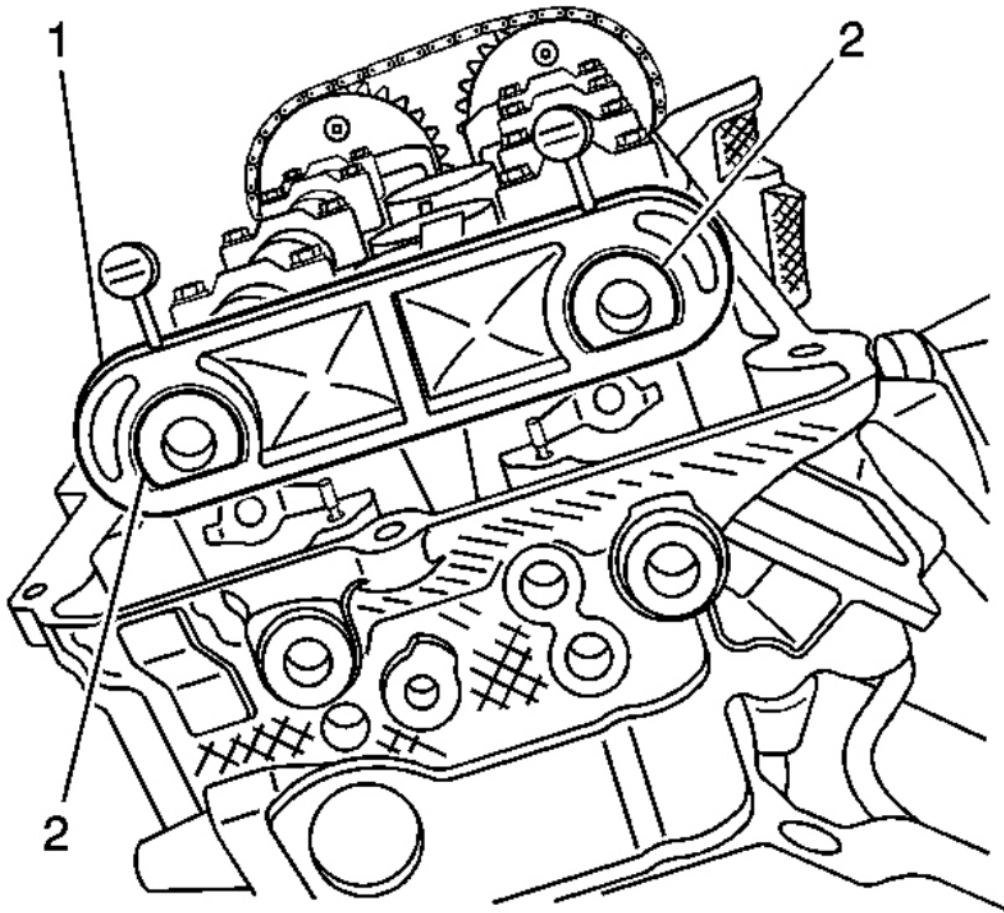


Fig. 168: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

4. Install the EN 46328 (1) on the left bank camshafts (2).

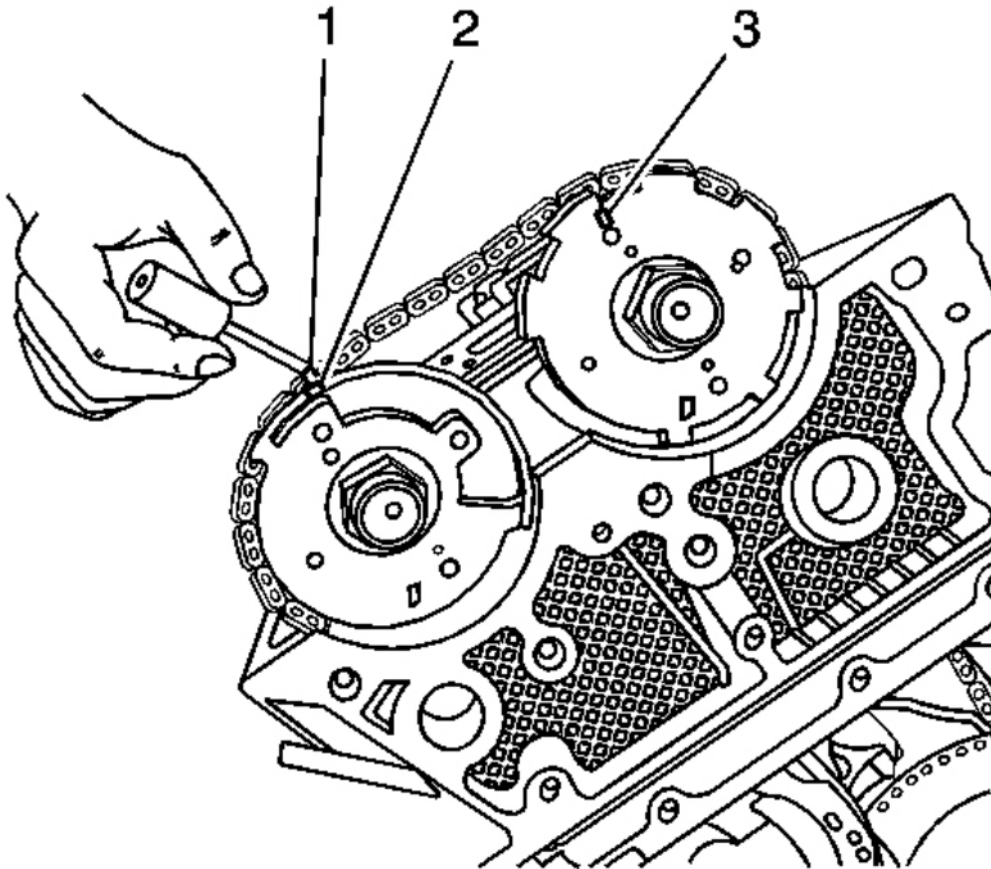


Fig. 169: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Create two reference marks (1) using a paint stick to identify the chain link adjacent to each actuator timing mark (2, 3).

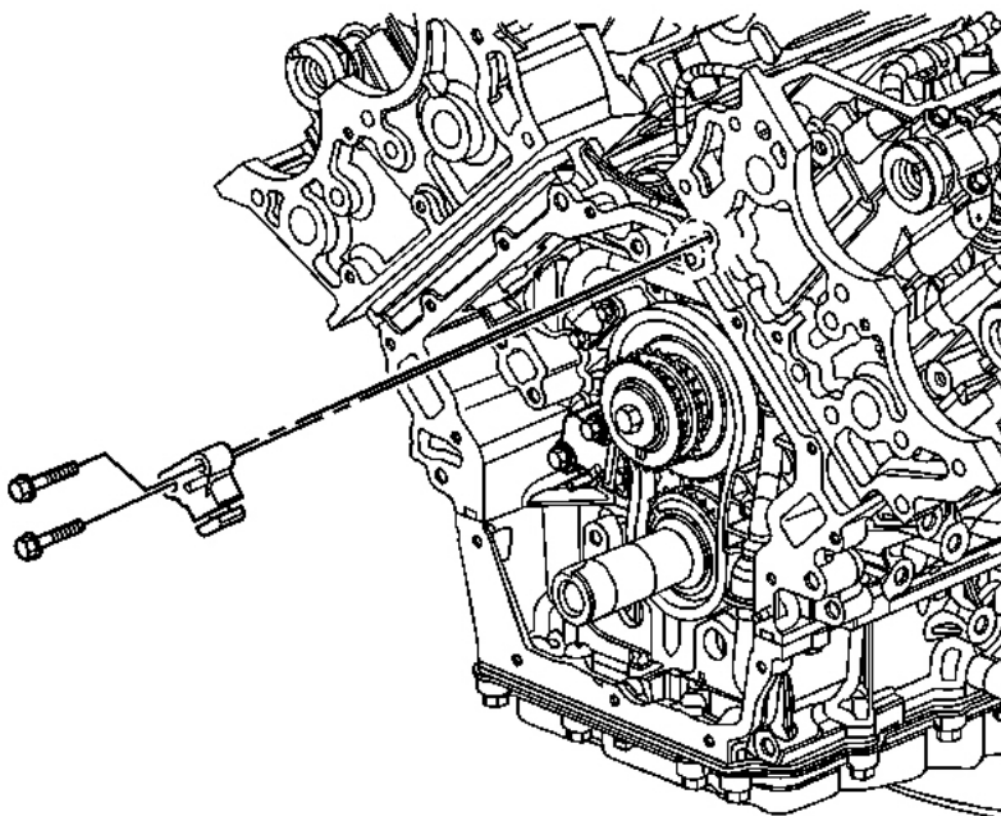


Fig. 170: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

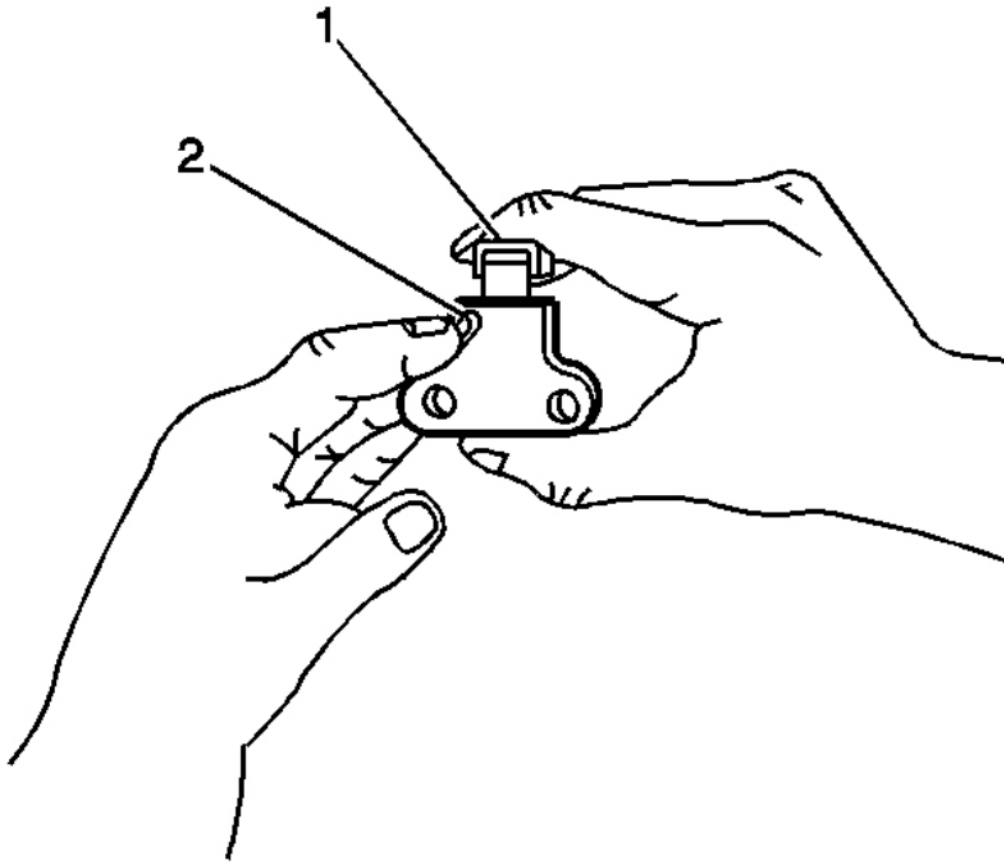


Fig. 171: View Of Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS CORP.

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.

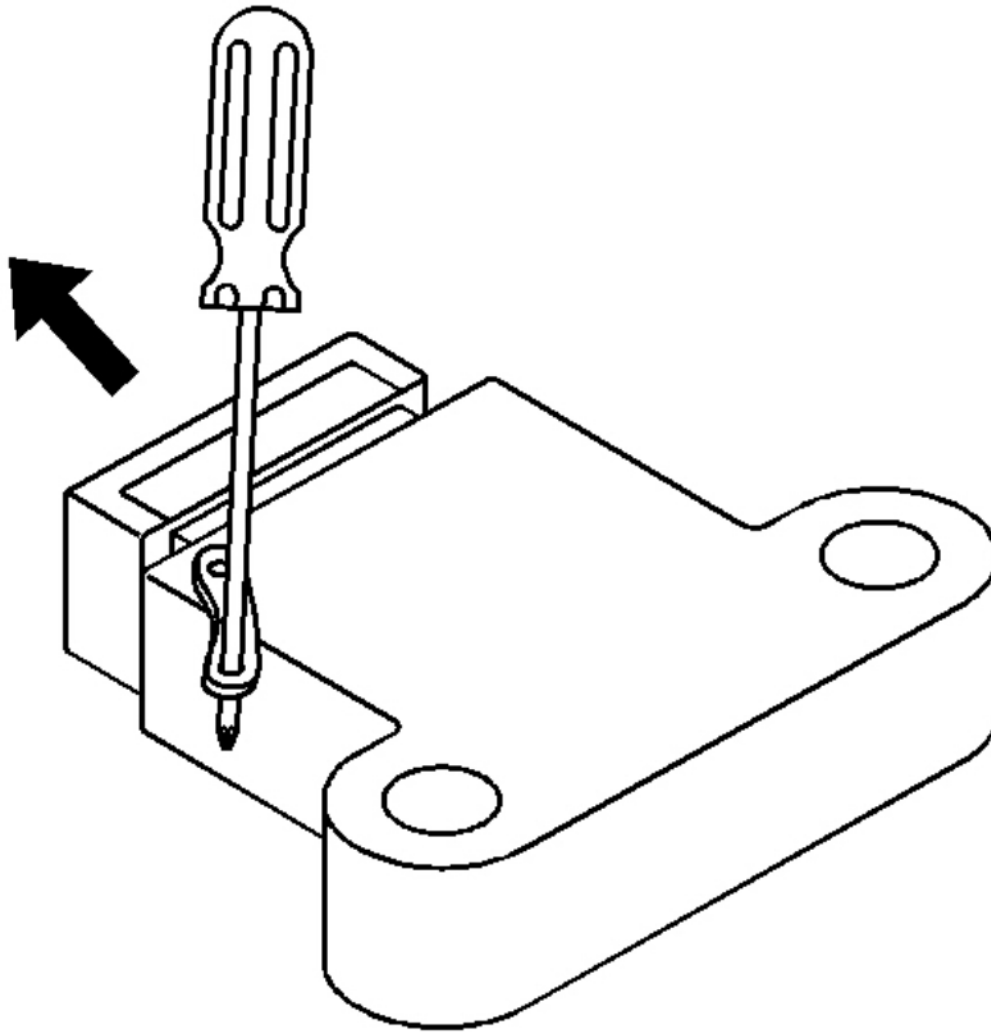


Fig. 172: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

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

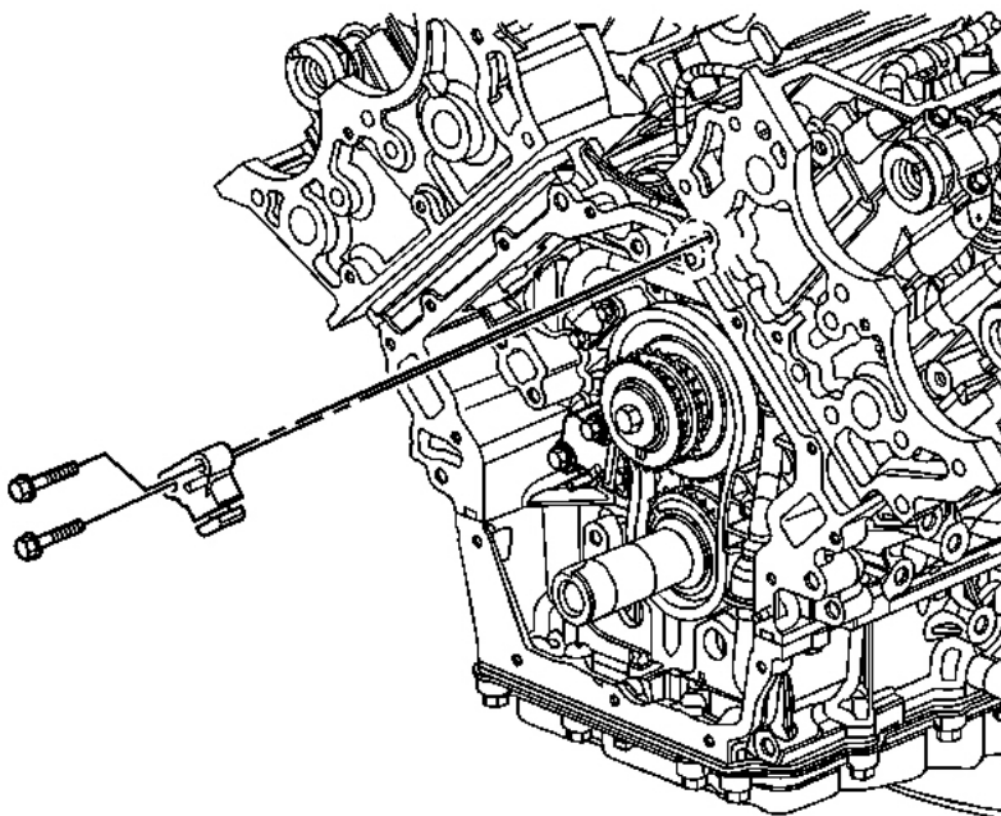


Fig. 173: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: 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.

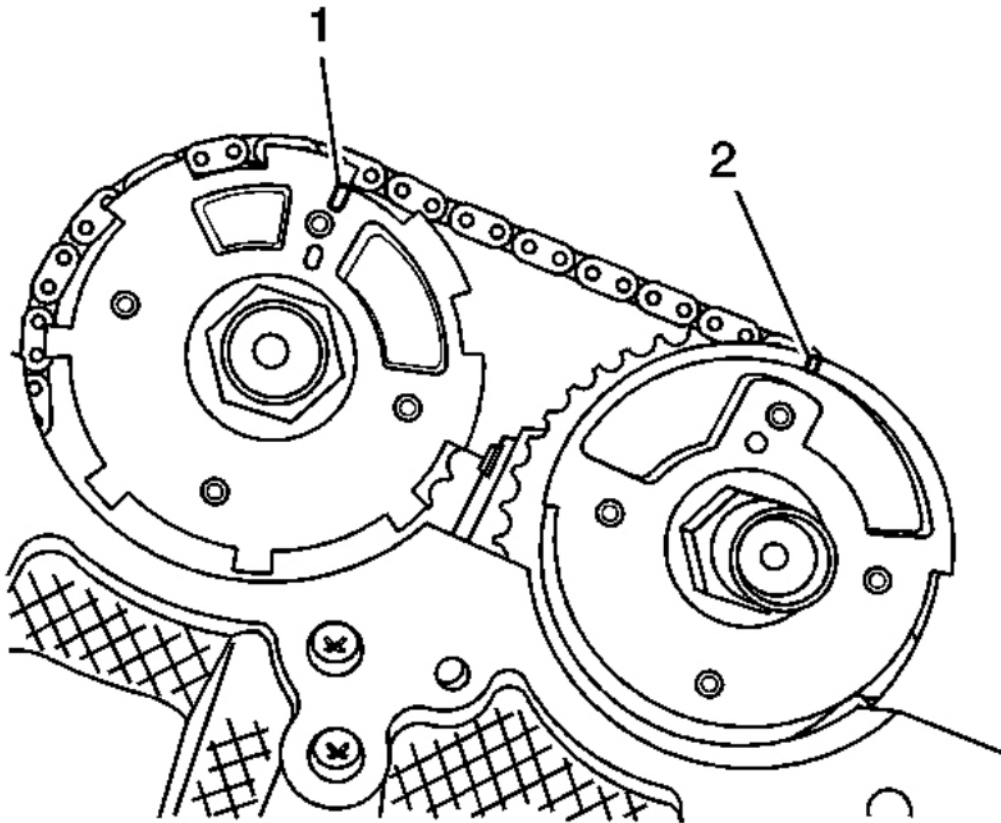


Fig. 174: Aligning Paint Marks With Actuator Timing Marks
Courtesy of GENERAL MOTORS CORP.

7. Inspect the two paint marks created previously to ensure they remain aligned with the timing marks (1, 2) on the actuator.
8. Install the engine oil pump. Refer to **Oil Pump Replacement**.

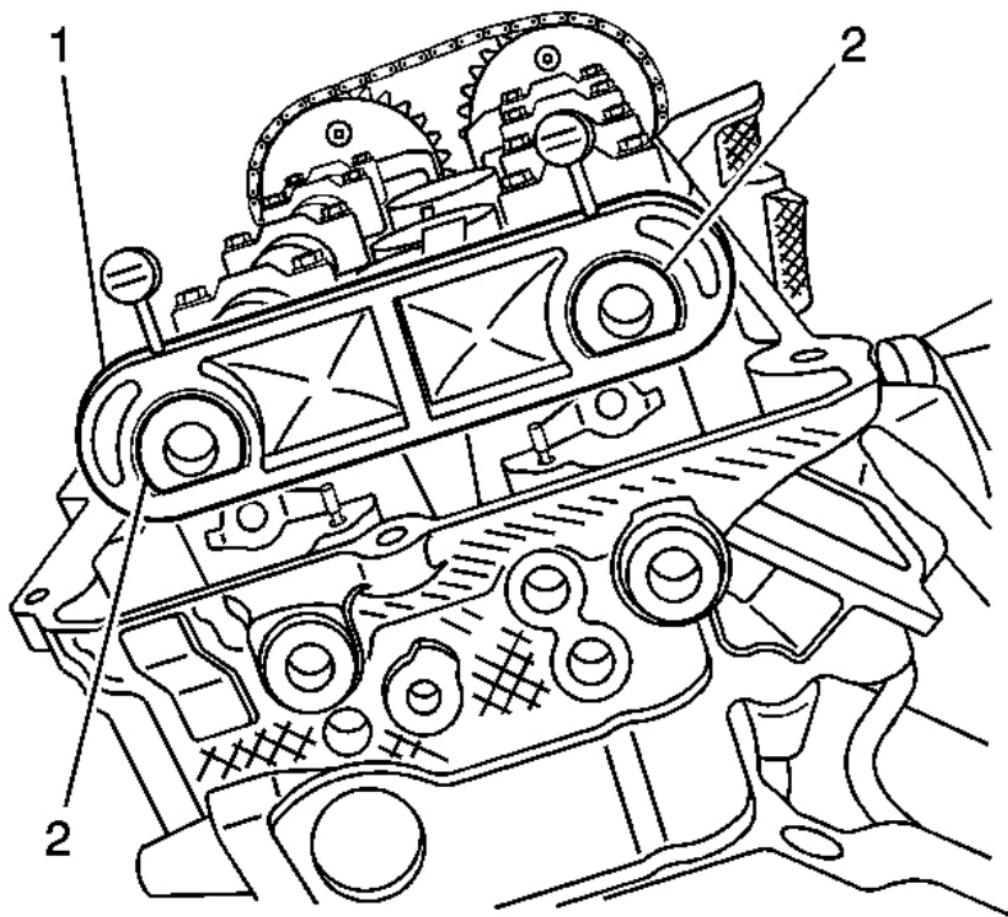


Fig. 175: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

9. Remove the **EN 46328** (1).
10. Install the camshaft cover. Refer to **Camshaft Cover Replacement - Left.**

SECONDARY CAMSHAFT DRIVE CHAIN TENSIONER REPLACEMENT - RIGHT

Tools Required

- **EN 46328** Camshaft Holding Tool
- **J 39946** Crankshaft Socket - 4.0L and 4.6L

Removal Procedure

1. Remove the right camshaft cover. Refer to Camshaft Cover Replacement - Right.
2. Remove the engine oil pump. Refer to Oil Pump Replacement.

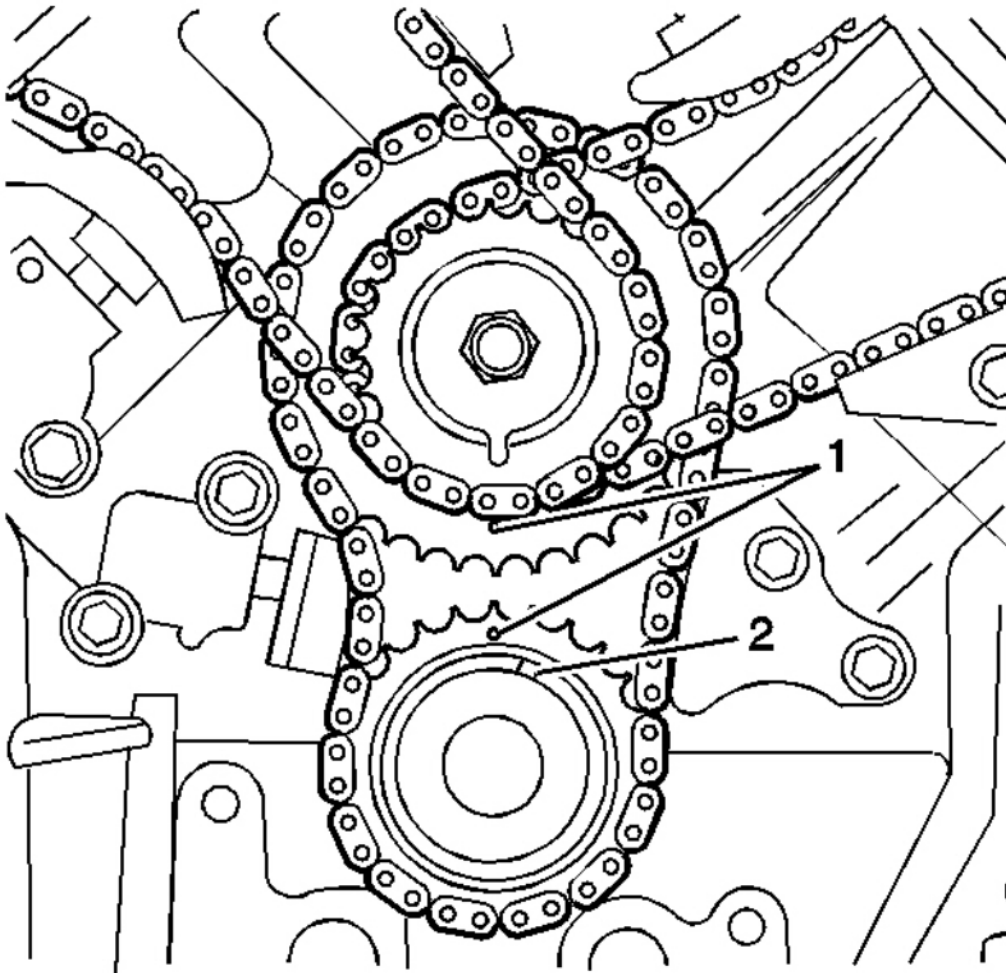


Fig. 176: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

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

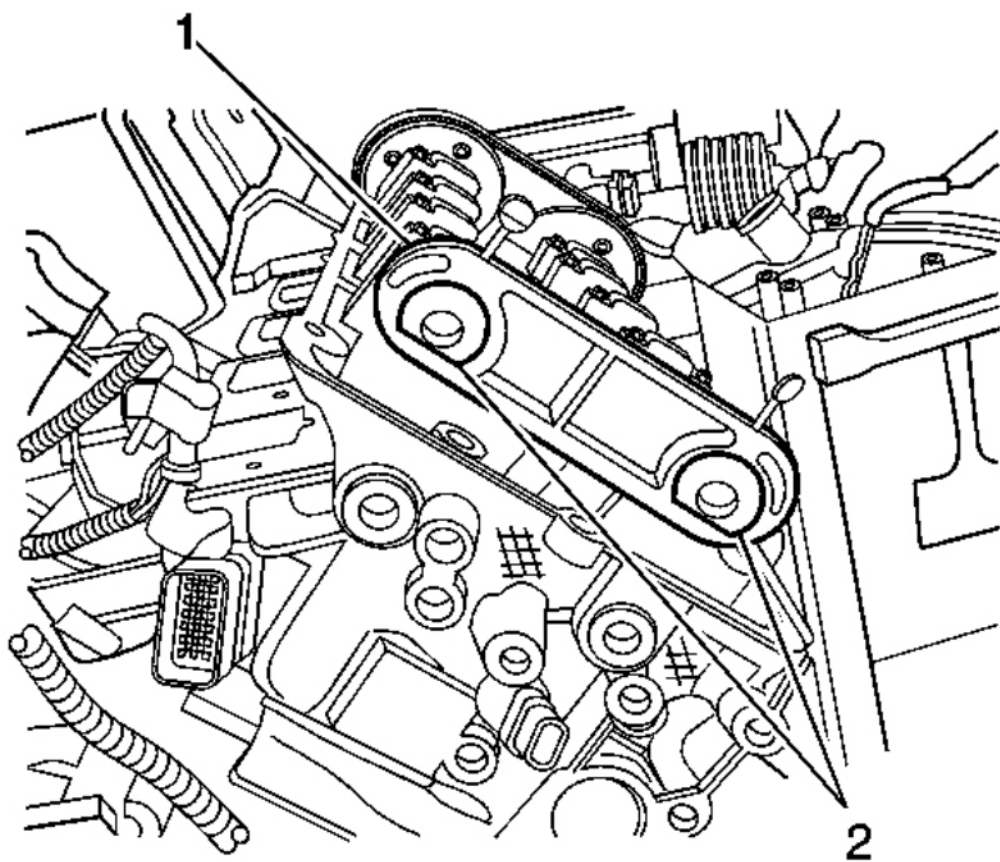


Fig. 177: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

4. Install the **EN 46328** (1) on the right bank camshafts (2).

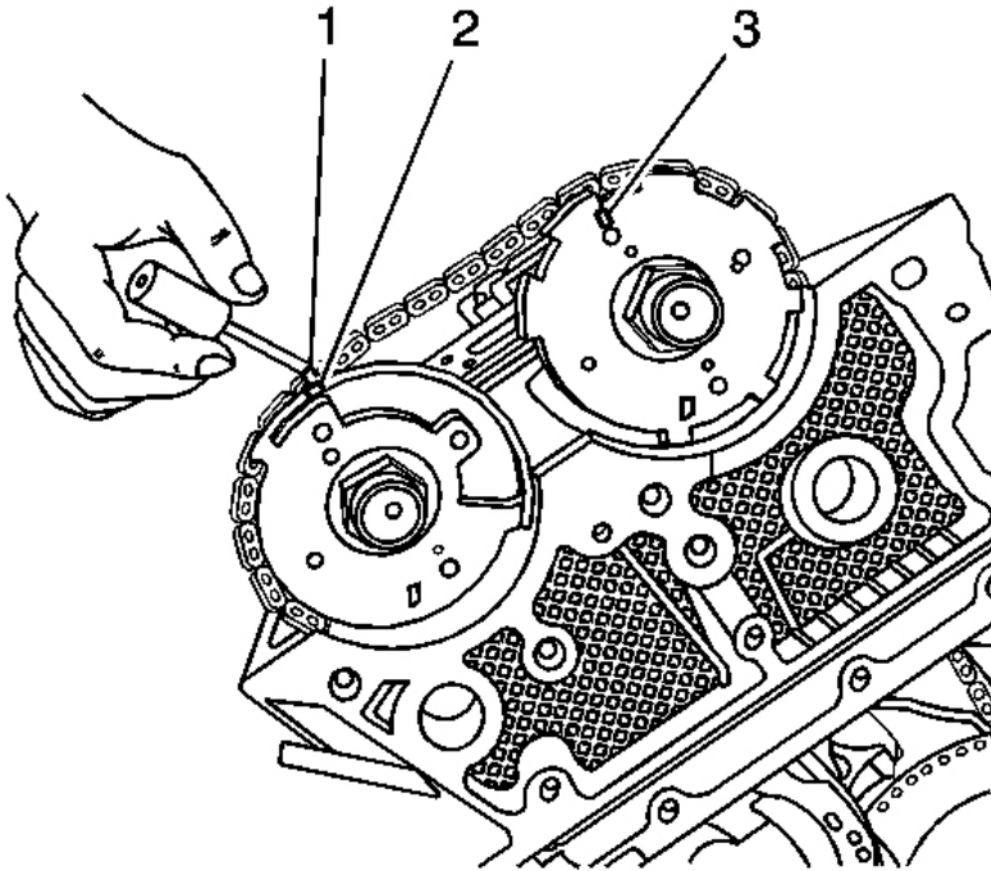


Fig. 178: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

5. Create two reference marks (1) using a paint stick to identify the chain link adjacent to each actuator timing mark (2, 3).

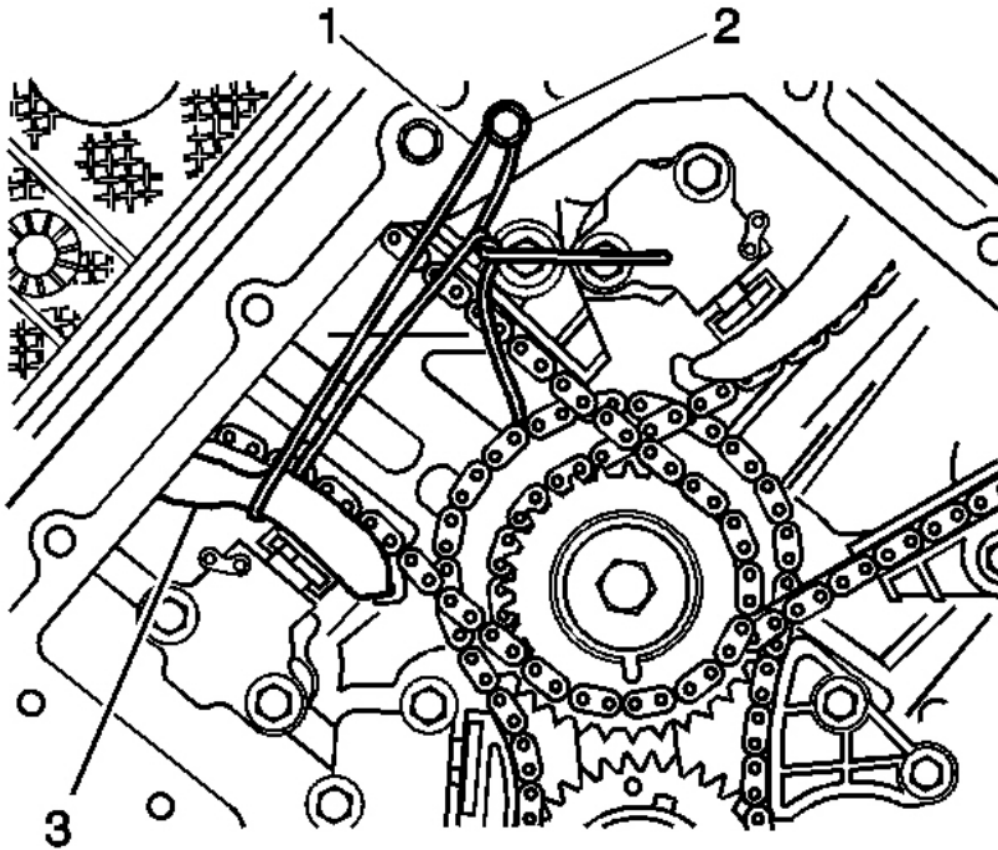


Fig. 179: View Of Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt

Courtesy of GENERAL MOTORS CORP.

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

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

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

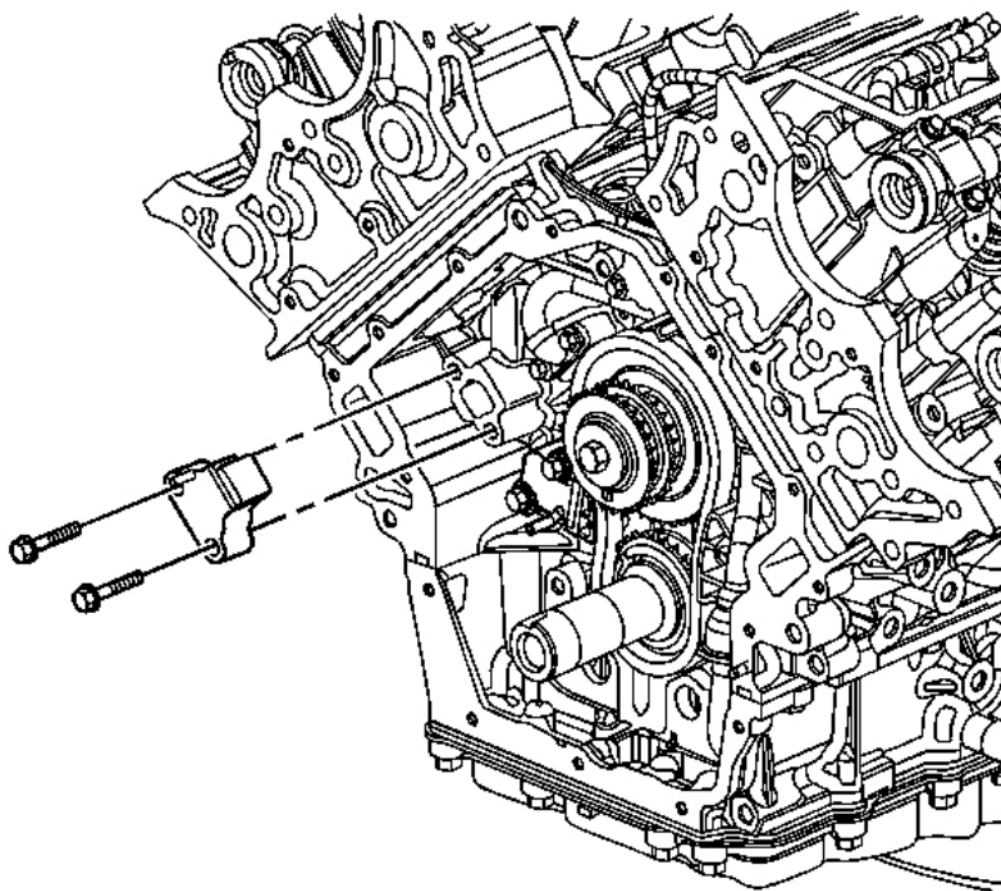


Fig. 180: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

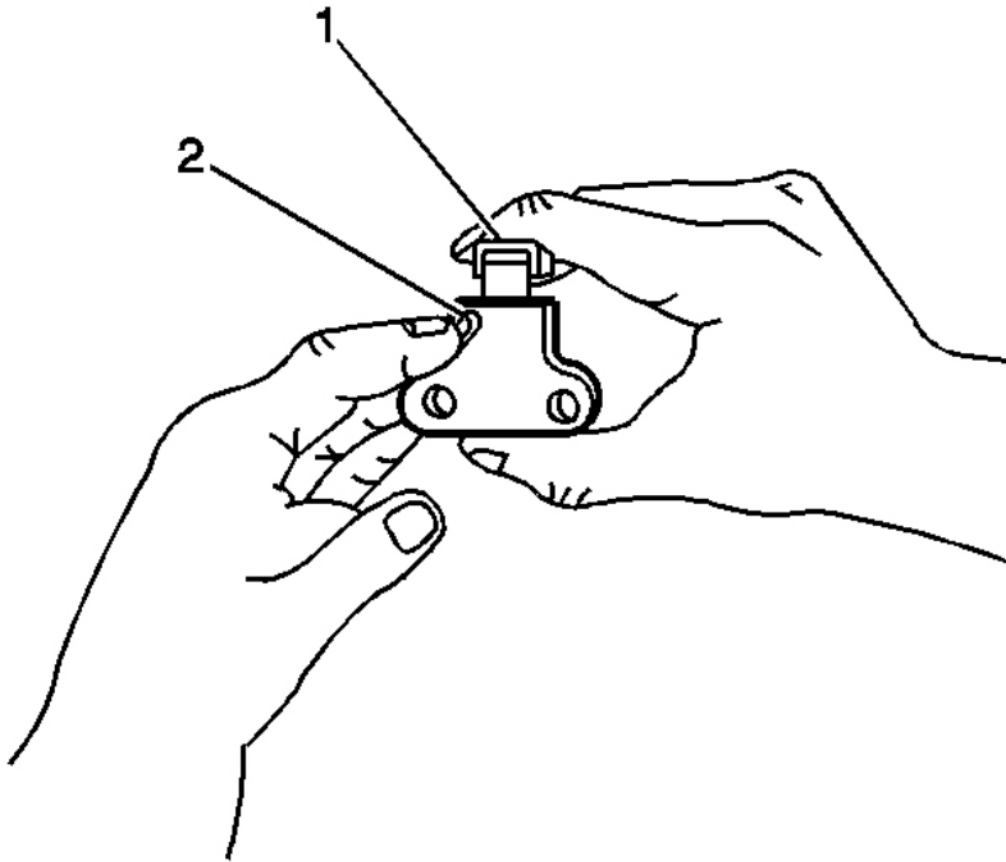


Fig. 181: View Of Tensioner Shoe & Ratchet Lever
Courtesy of GENERAL MOTORS CORP.

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.

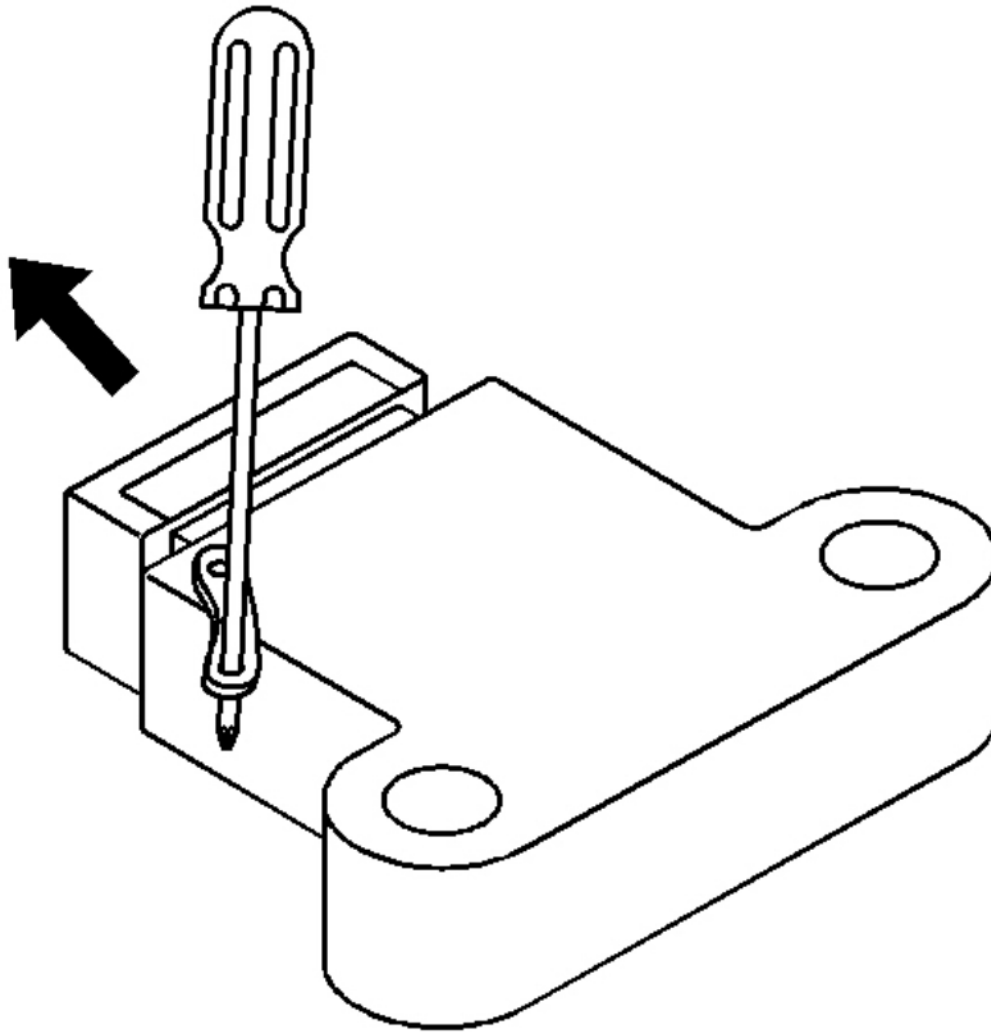


Fig. 182: Locking Tensioner Shoe In Collapsed Position
Courtesy of GENERAL MOTORS CORP.

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

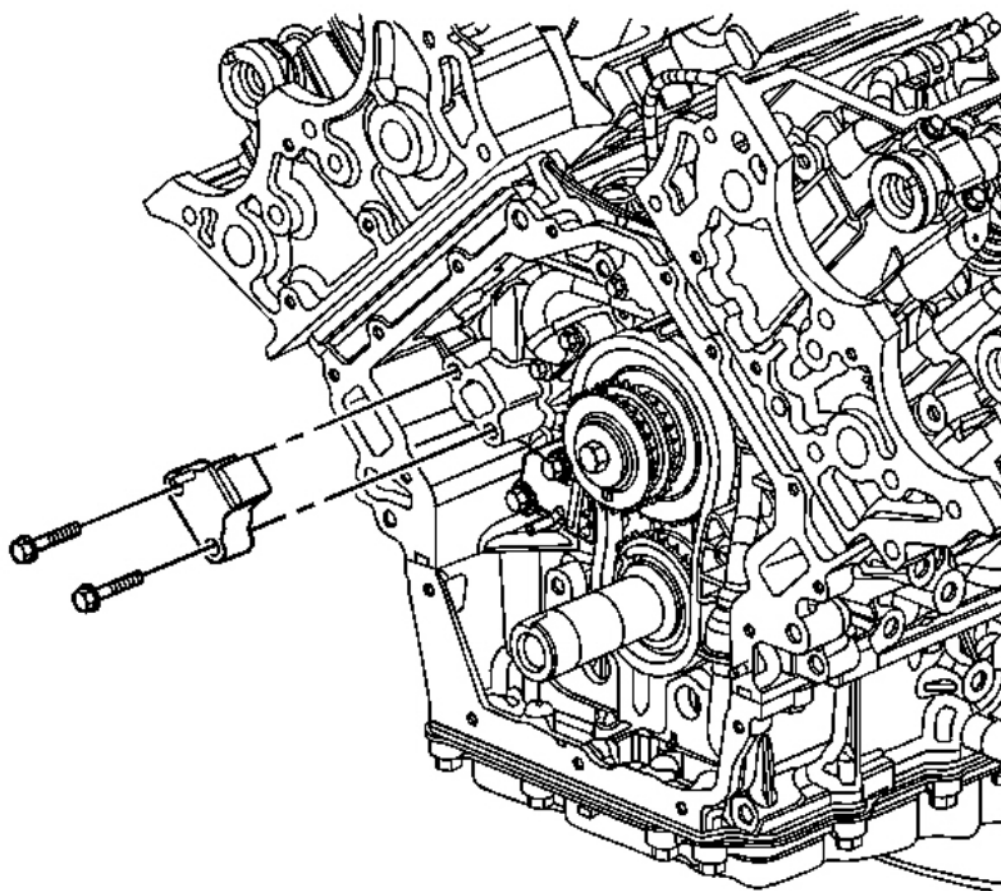


Fig. 183: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: 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.

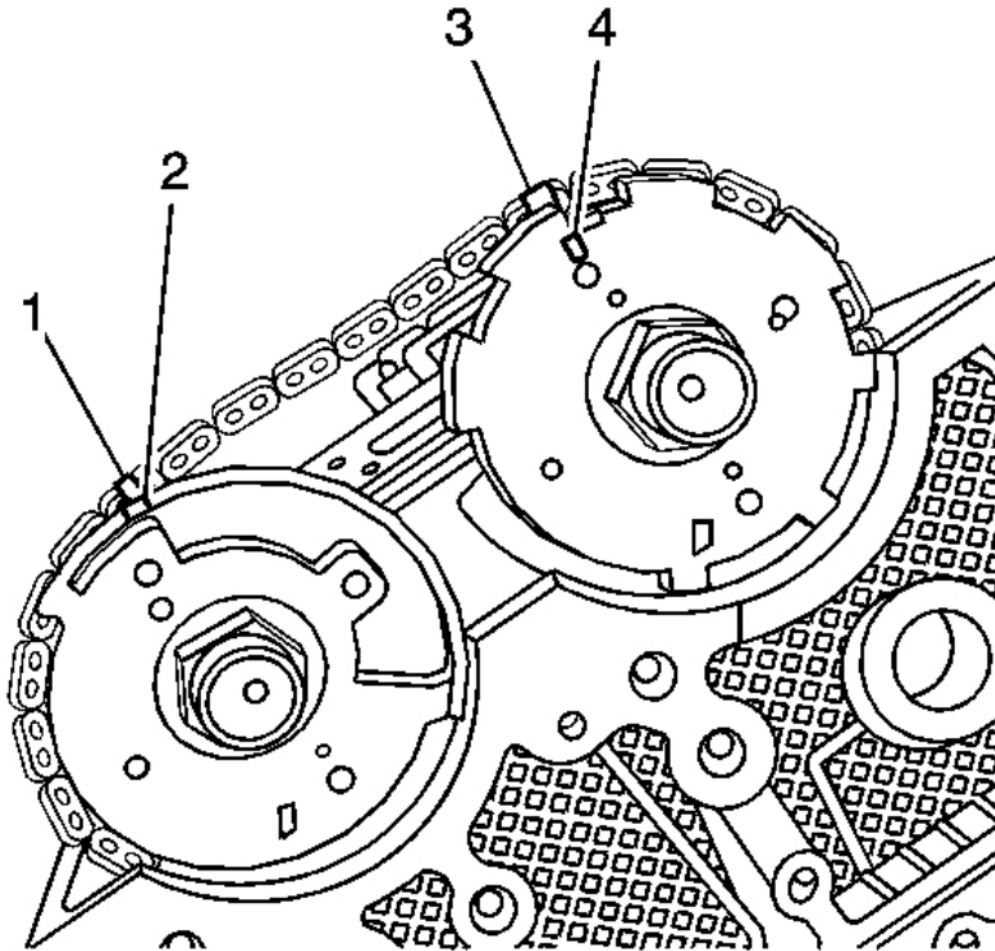


Fig. 184: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Inspect the two paint marks (1, 3) created previously to ensure they remain aligned with the timing marks (2, 4) on the actuator.

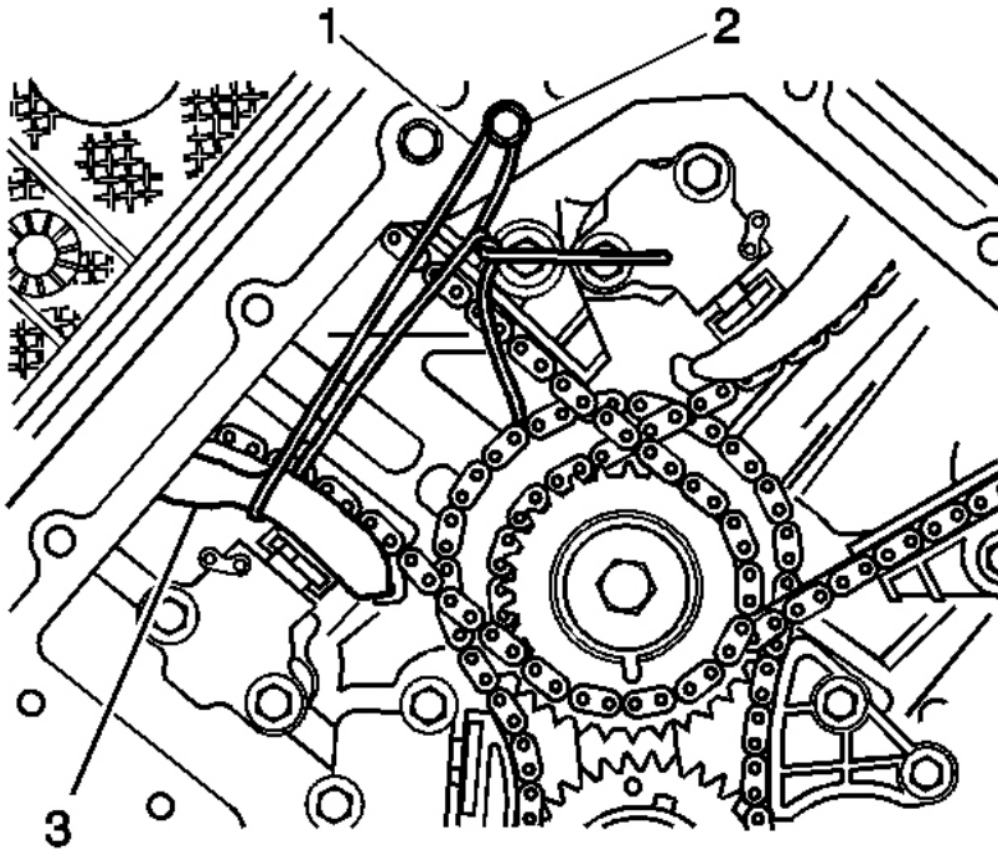


Fig. 185: View Of Mechanics Wire, Right Secondary Camshaft Drive Chain Shoe & Front Cover Bolt

Courtesy of GENERAL MOTORS CORP.

8. Remove the mechanics wire (1) supporting the right secondary camshaft drive chain shoe (3).
9. Remove the engine front cover bolt (2) from the front of the engine.
10. Install the engine oil pump. Refer to **Oil Pump Replacement**.

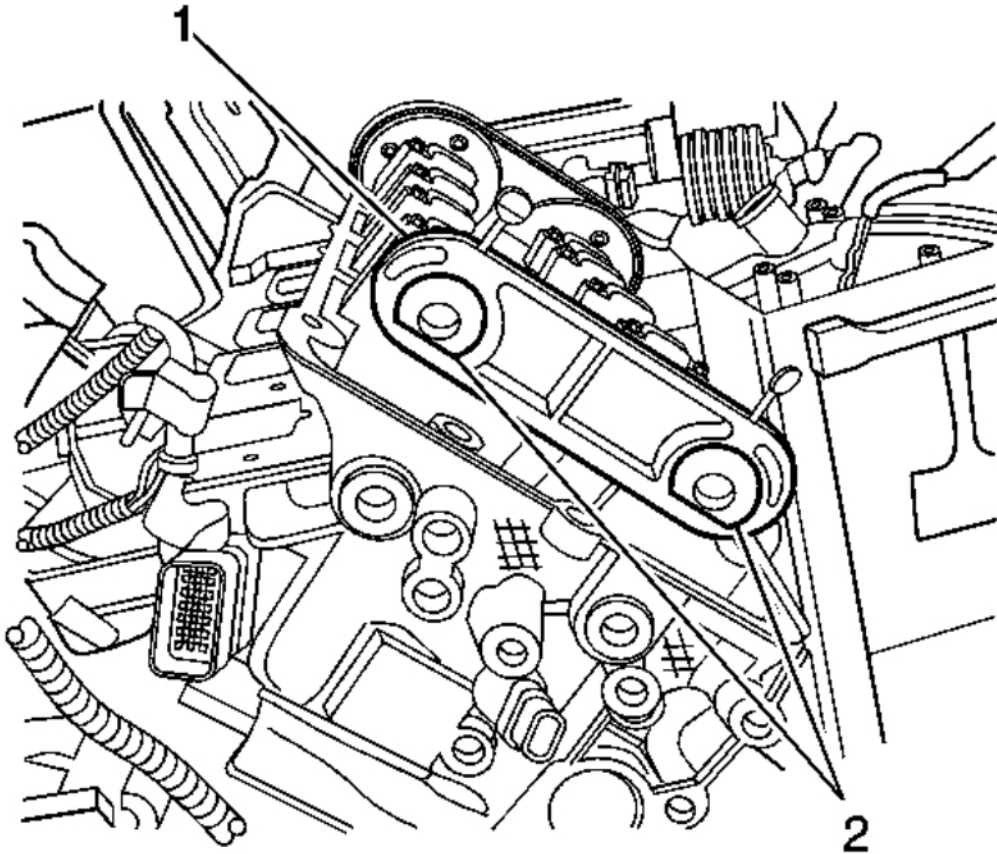


Fig. 186: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

11. Remove the **EN 46328** (1).
12. Install the right camshaft cover. Refer to **Camshaft Cover Replacement - Right**.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - LEFT

Tools Required

- **J 39946** Crankshaft Socket
- **EN 46328** Camshaft Holding Tool

Removal Procedure

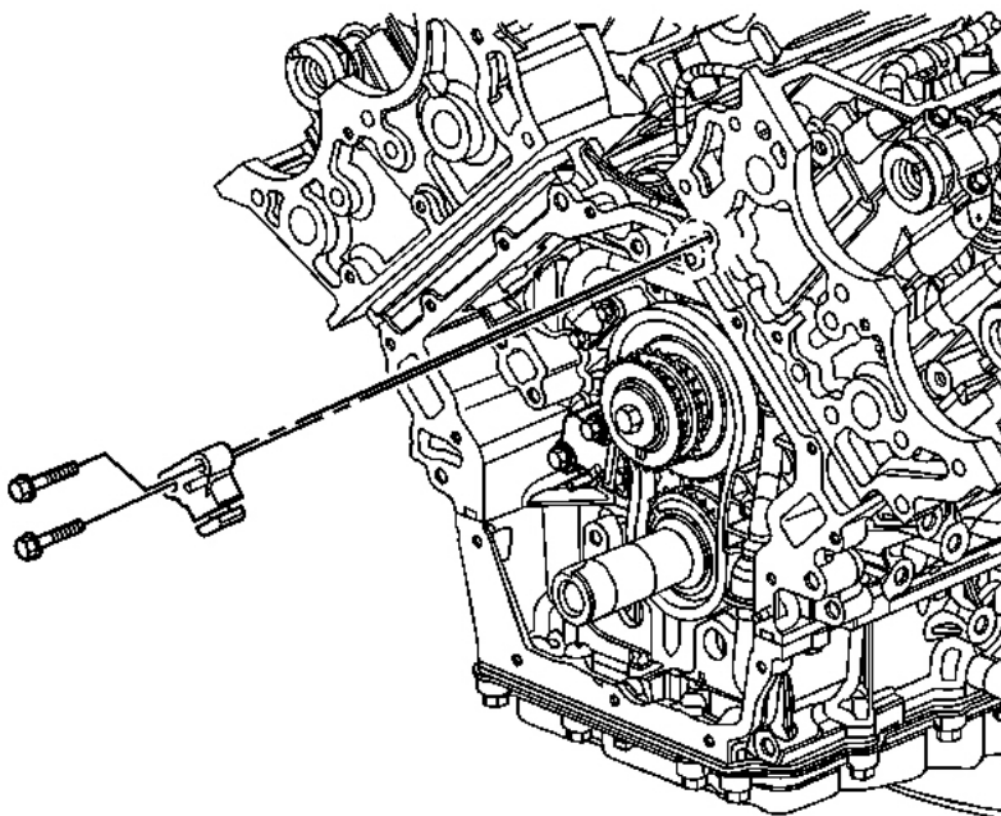


Fig. 187: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the left secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left**.
2. Remove the left camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

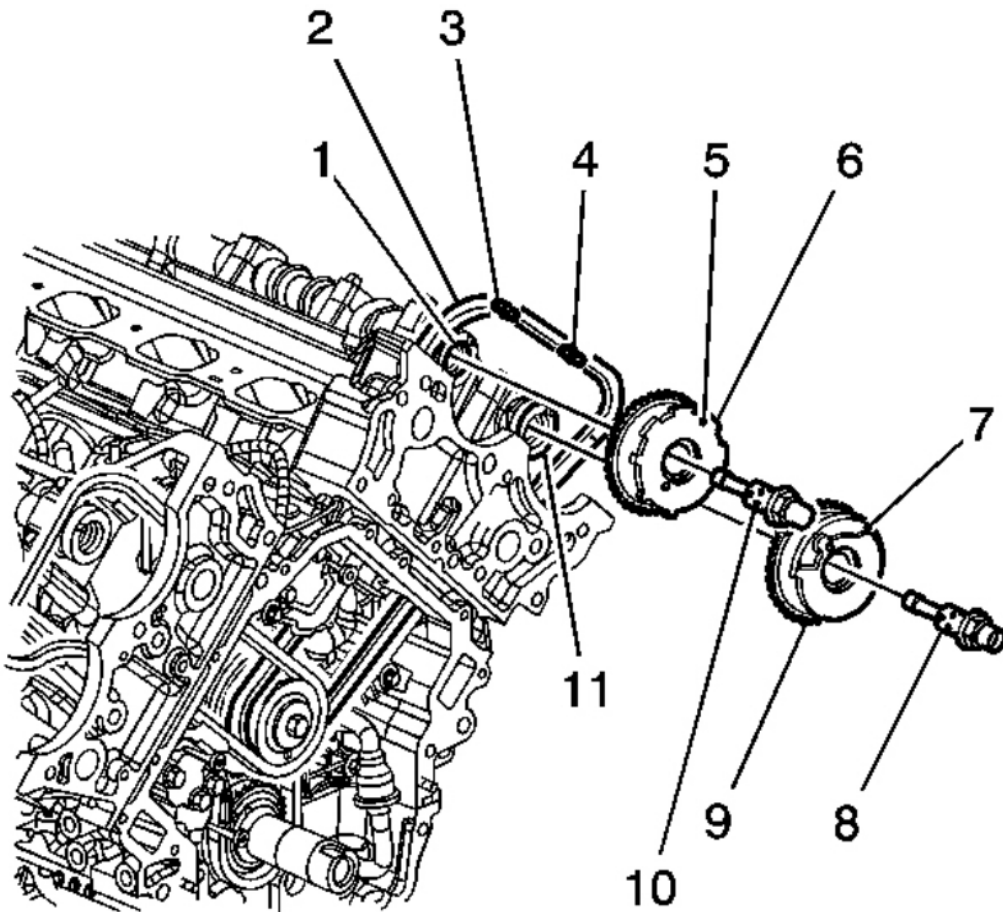


Fig. 188: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until both camshaft position actuator timing marks (5, 7) are at the top of their rotation.

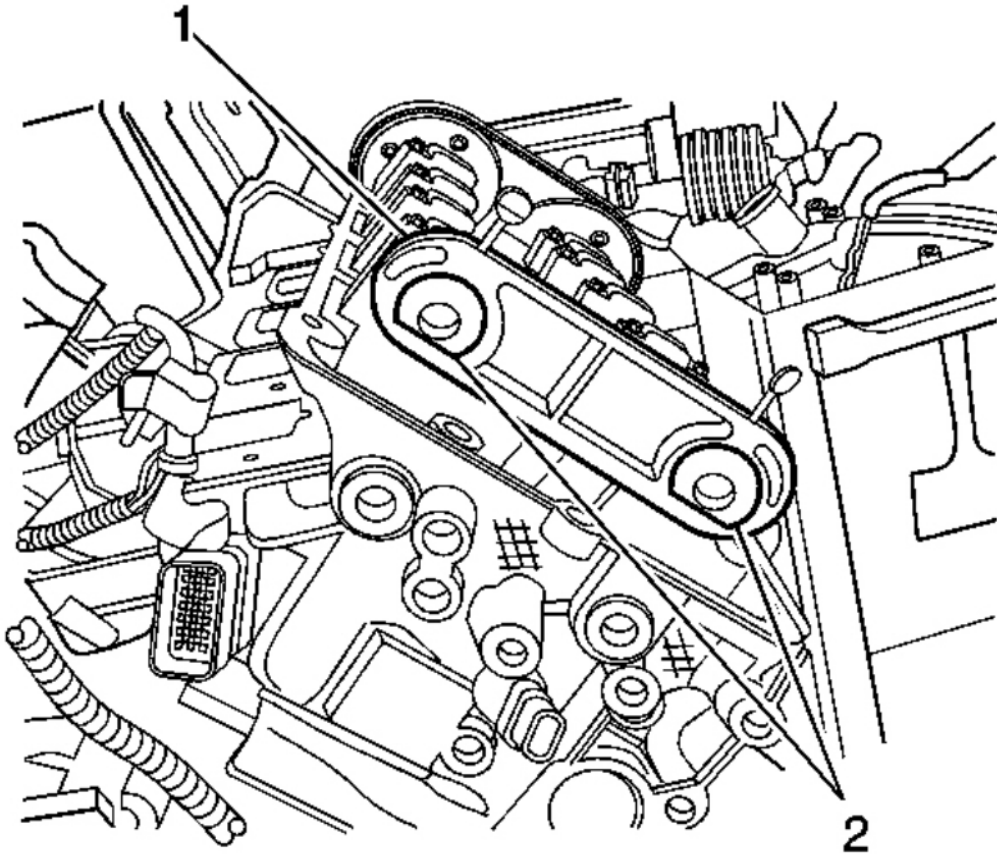


Fig. 189: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the EN 46328 (1) to the camshafts (2).

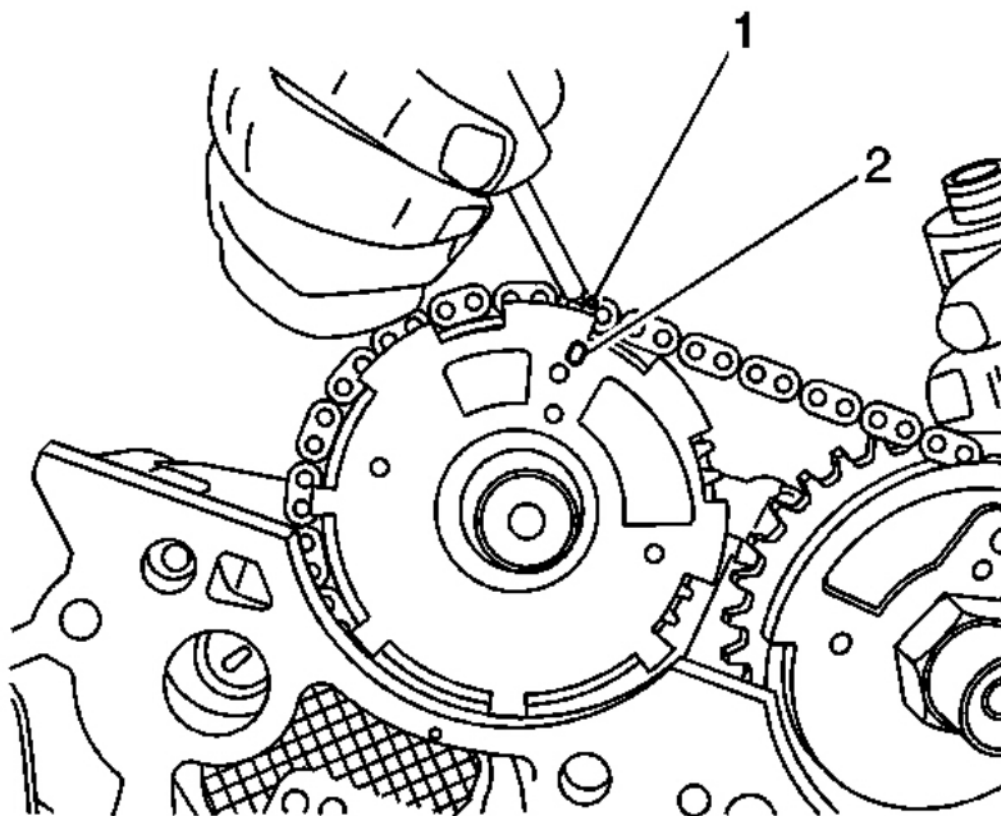


Fig. 190: Marking Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

5. Use a paint stick to create a mark (1) on the timing chain link adjacent to each camshaft position actuator timing mark (2).
6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

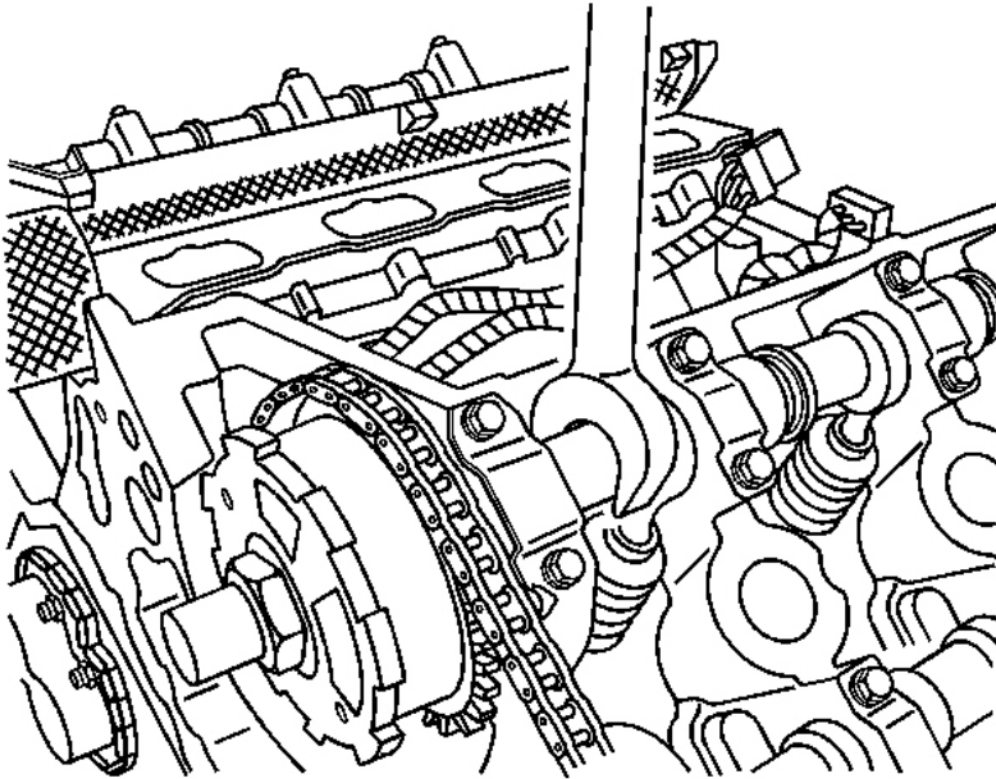


Fig. 191: Holding Camshaft

Courtesy of GENERAL MOTORS CORP.

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

7. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

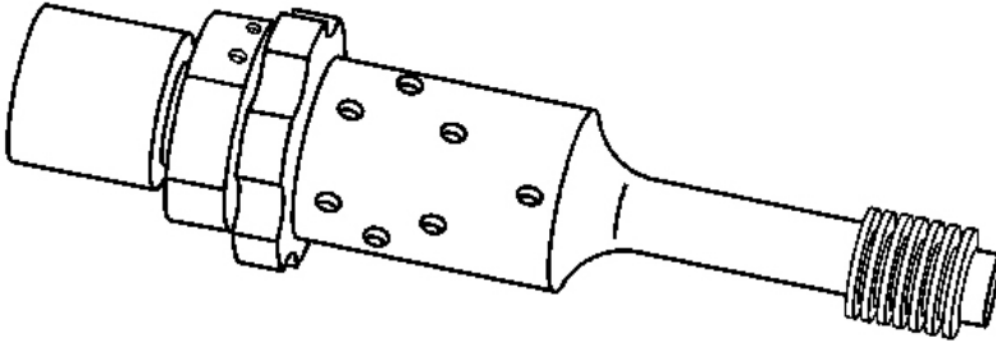


Fig. 192: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the left intake oil control valve.
9. Slide the left intake camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain, and remove the actuator.

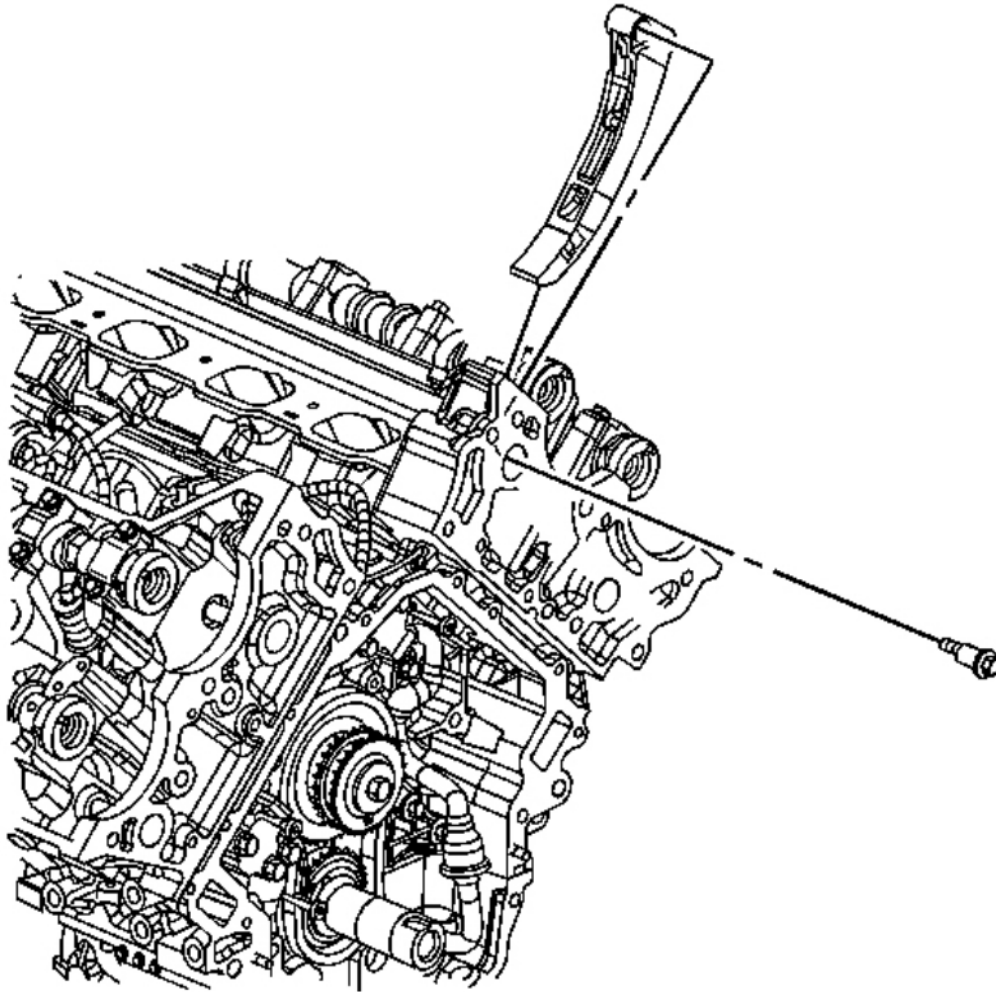


Fig. 193: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

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

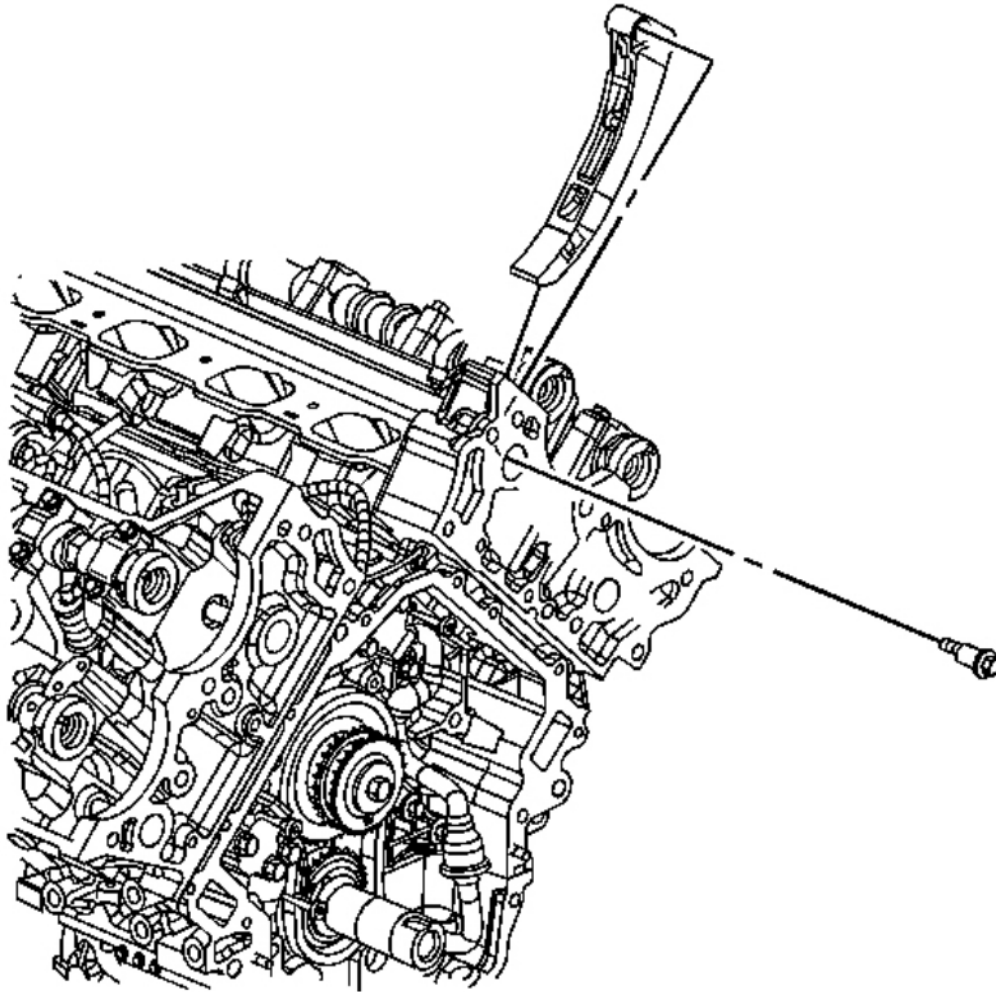


Fig. 194: View Of Left Secondary Camshaft Drive Timing Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain shoe in through the left front cylinder head as shown.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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).

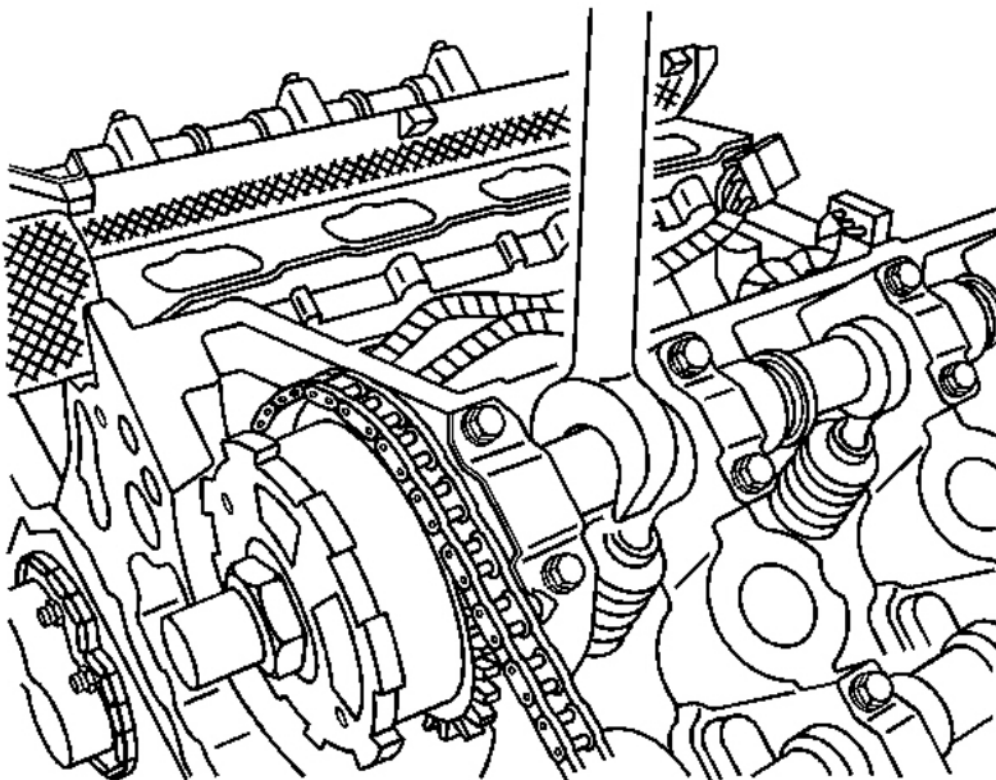


Fig. 195: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Install the left intake actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the intake actuator to the camshaft.

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

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

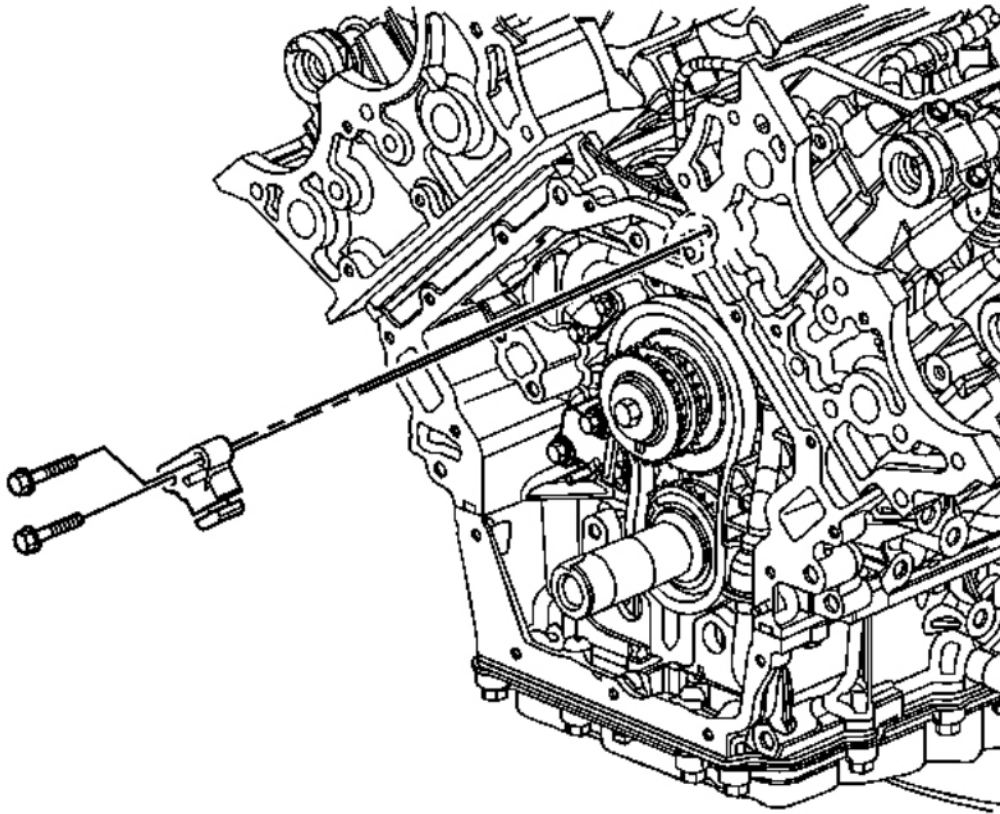


Fig. 196: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Left.**

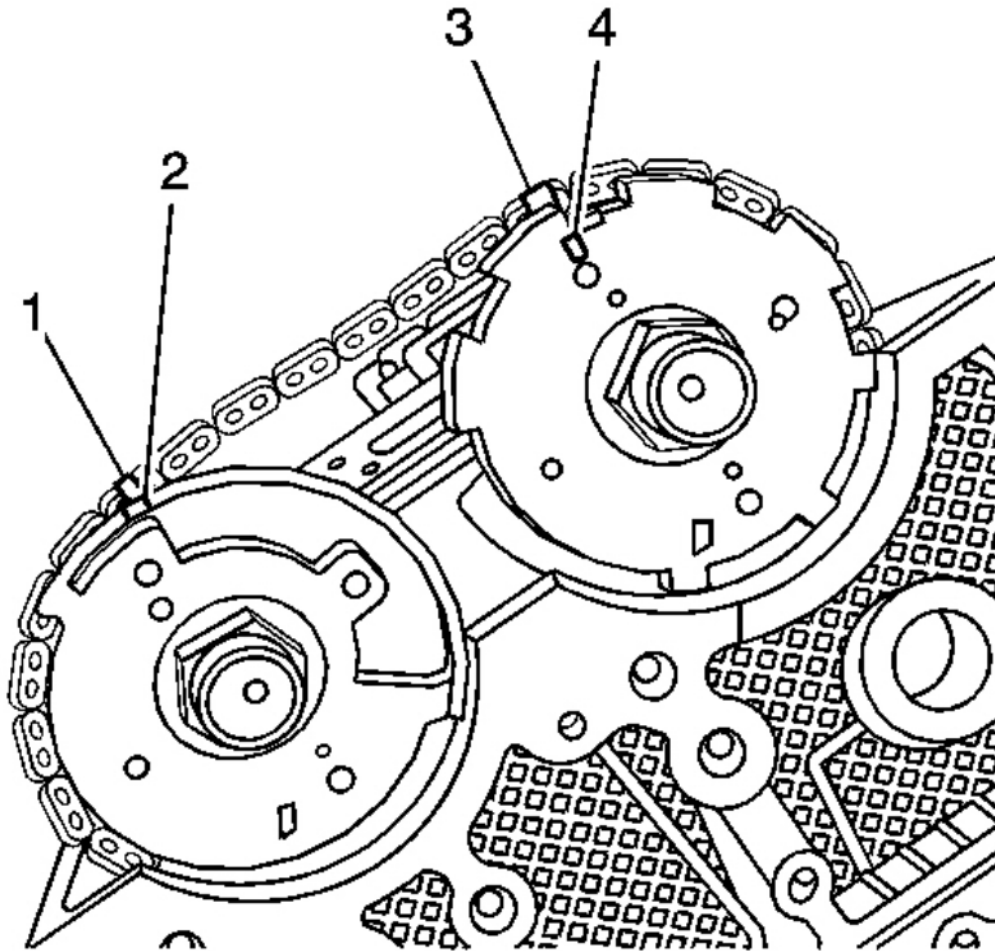


Fig. 197: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the left camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

SECONDARY CAMSHAFT DRIVE CHAIN SHOE REPLACEMENT - RIGHT

Tools Required

- **EN 46328** Camshaft Holding Tool
- **J 39946** Crankshaft Socket

Removal Procedure

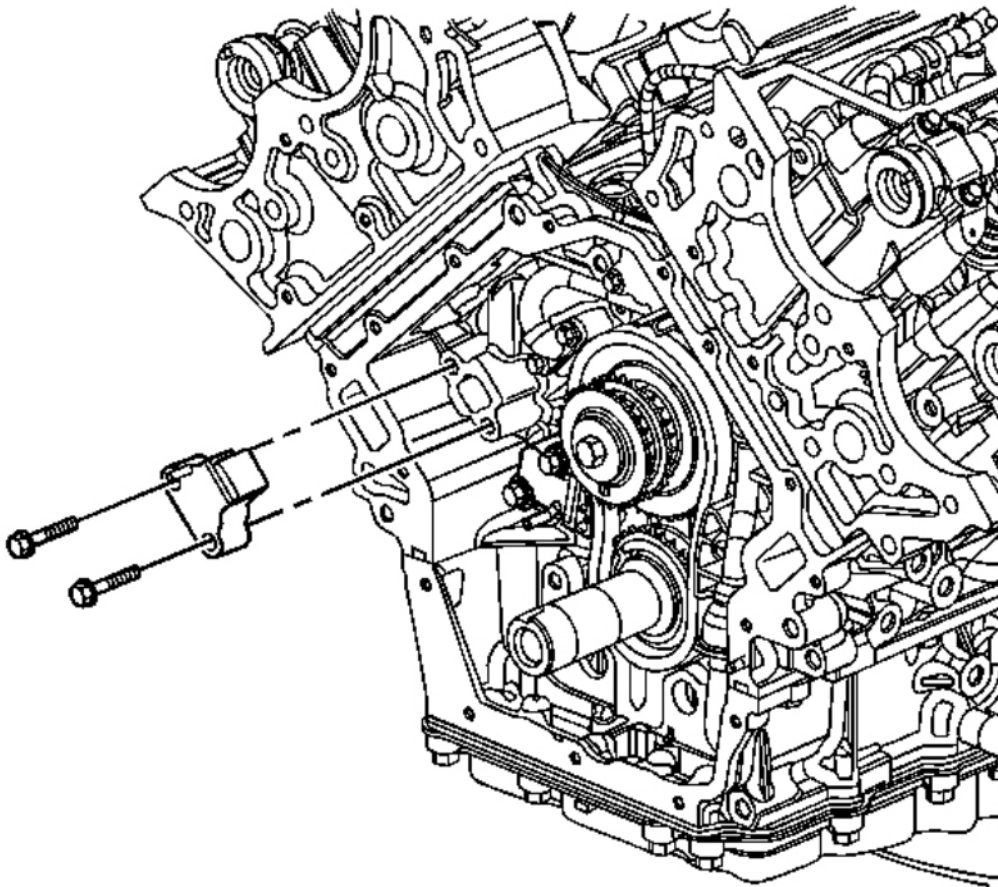


Fig. 198: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right.**

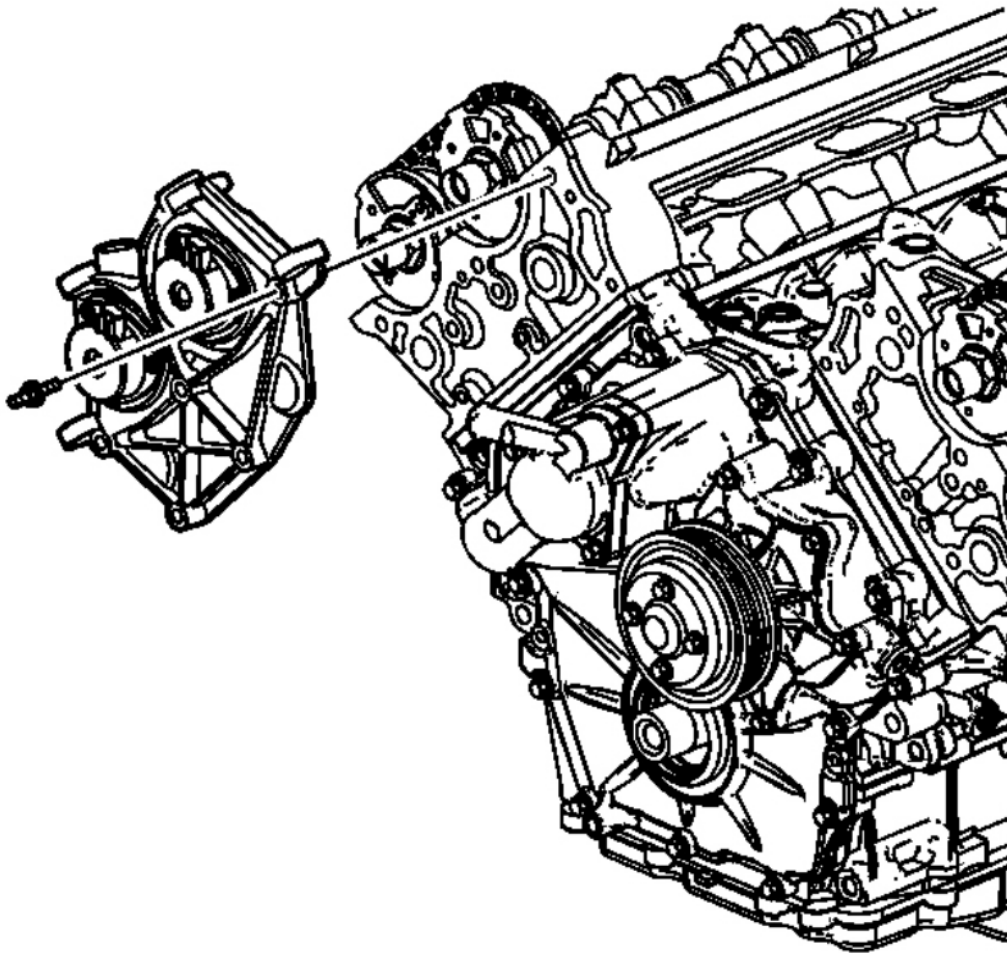
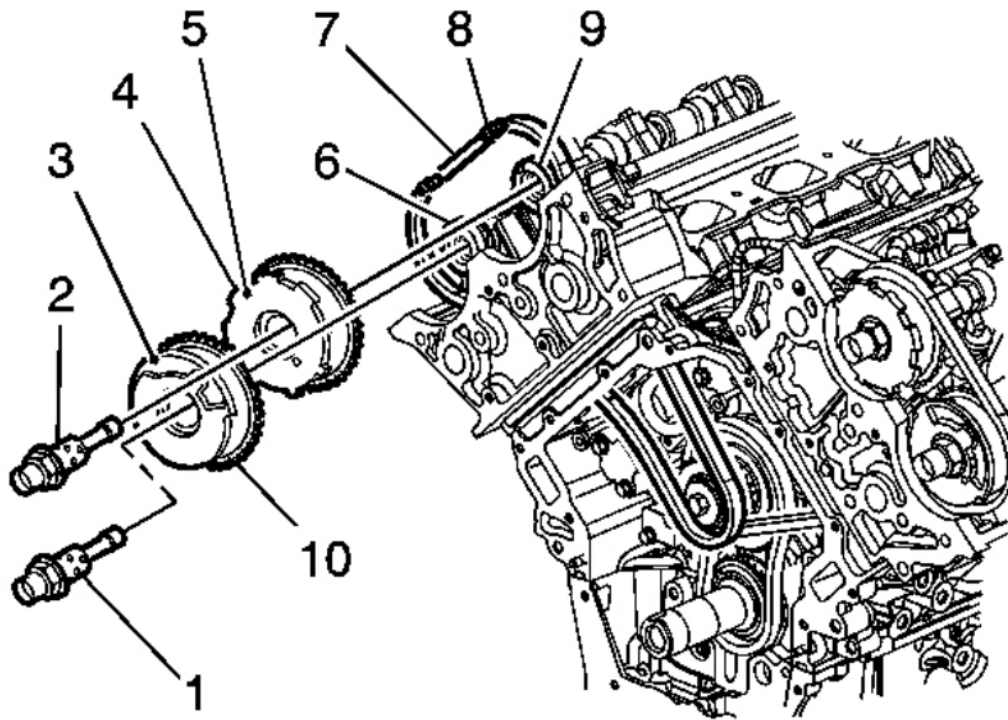


Fig. 199: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the right camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.



- Using the **J 39946**, rotate the crankshaft until both camshaft position actuator timing marks (3, 5) are at the top of their rotation.

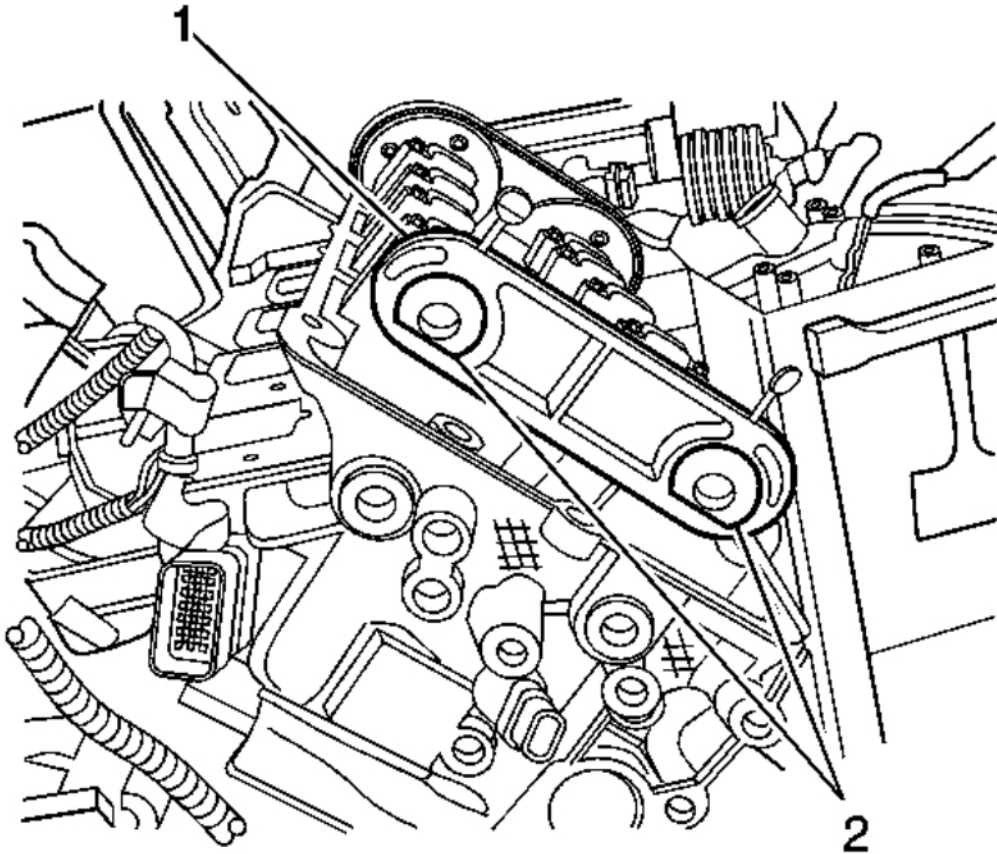


Fig. 201: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the EN 46328 (1) to the camshafts (2).

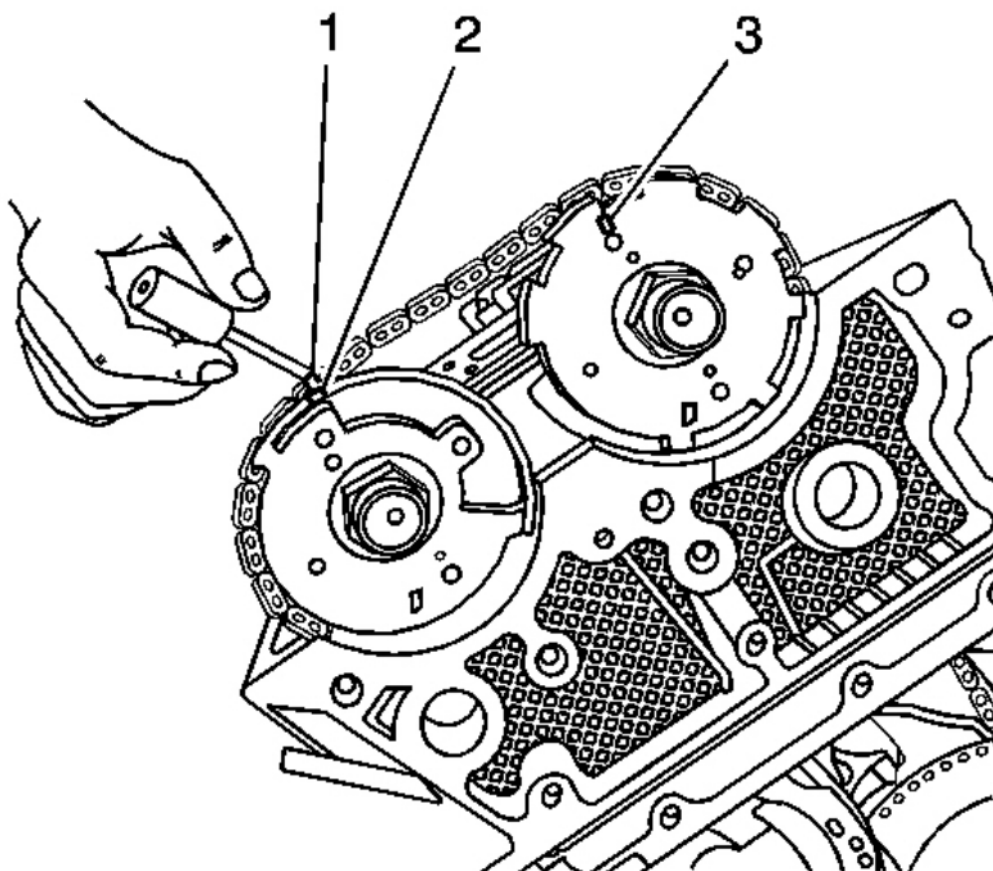


Fig. 202: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

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

6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

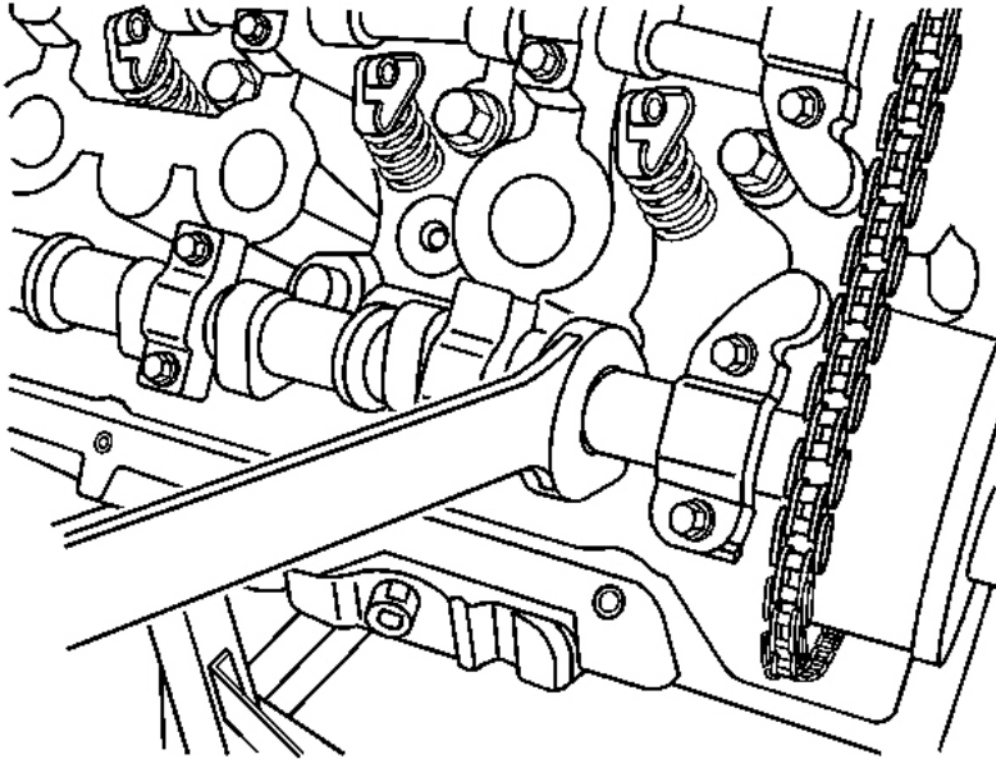


Fig. 203: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

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

7. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

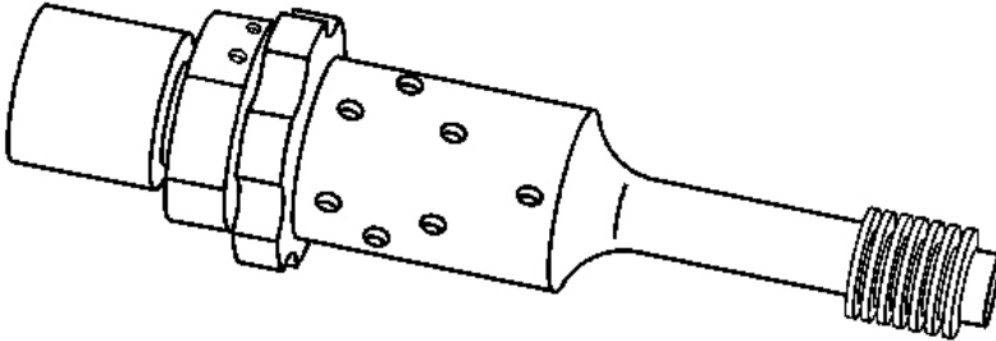


Fig. 204: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the right exhaust oil control valve.
9. Slide the right exhaust camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain, and remove the actuator.

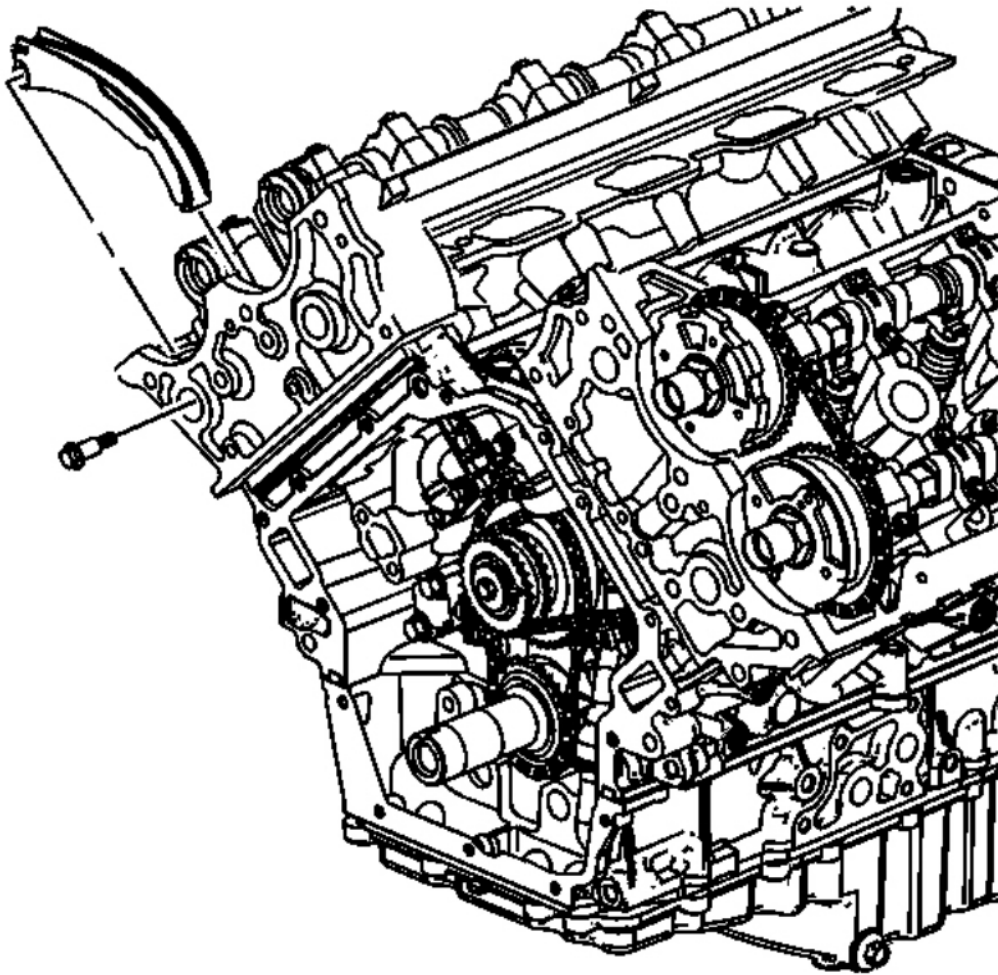


Fig. 205: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

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

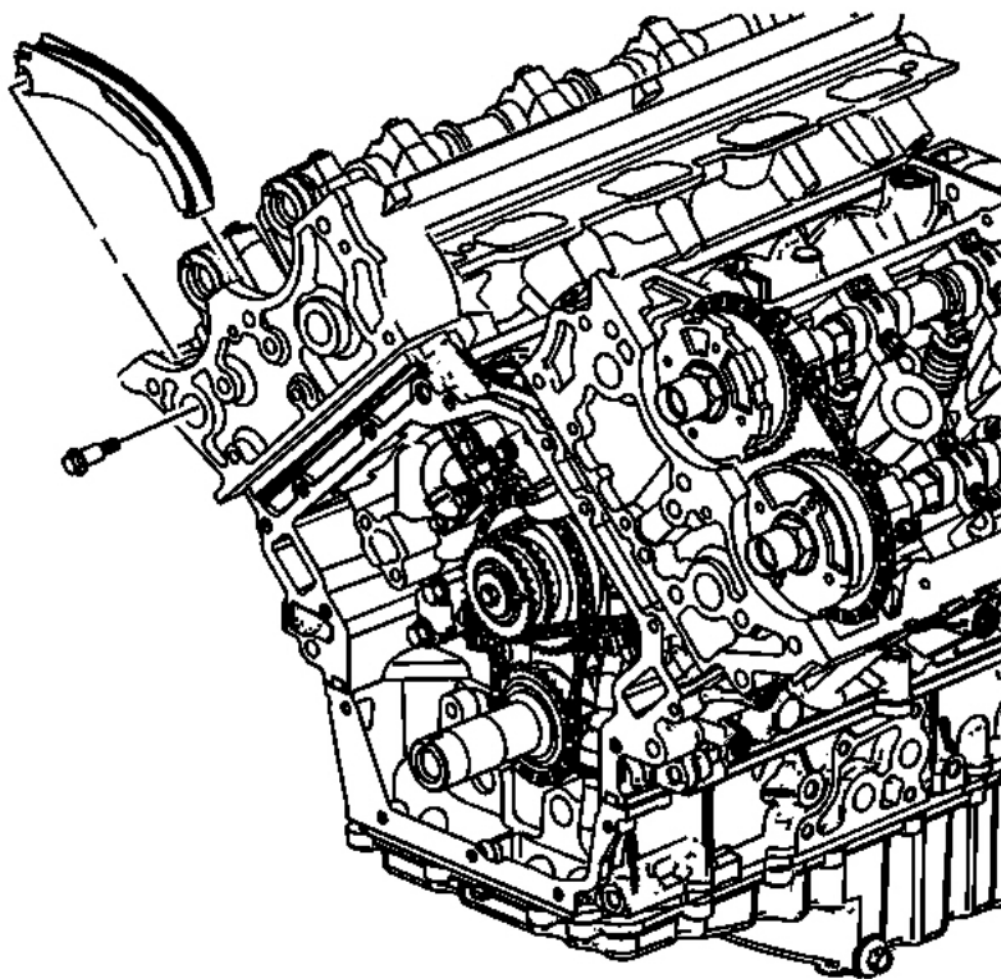


Fig. 206: View Of Right Secondary Camshaft Drive Timing Chain Shoe
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive timing chain shoe in through the right front cylinder head as shown.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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).

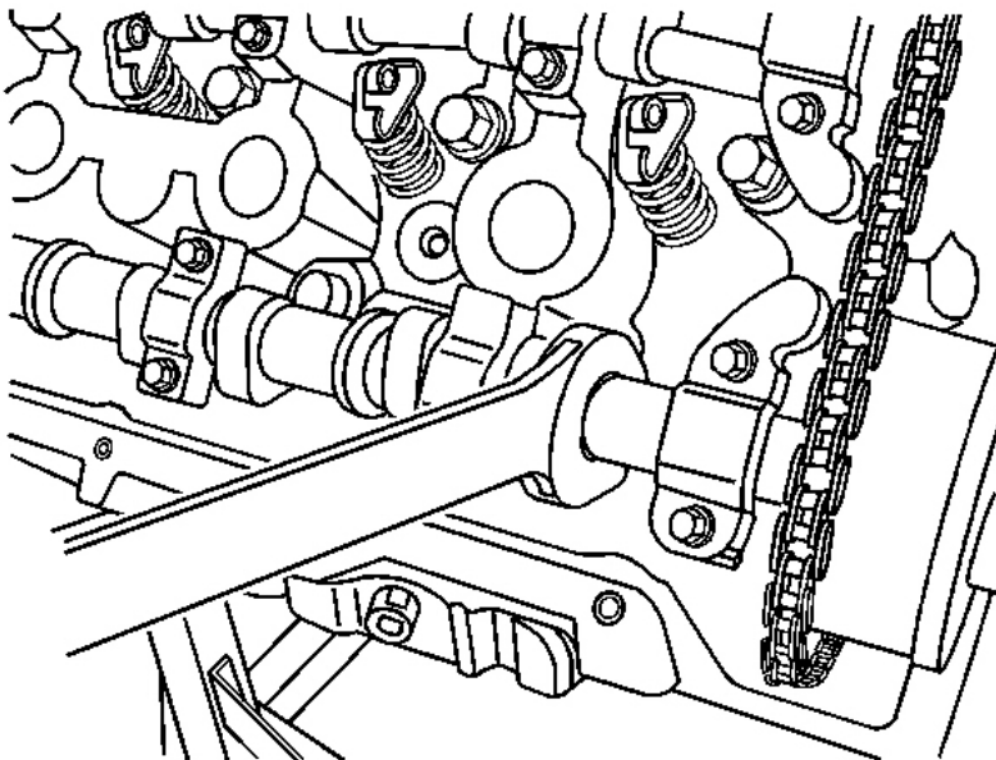


Fig. 207: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

3. Install the right exhaust actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the exhaust actuator to the camshaft.

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

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

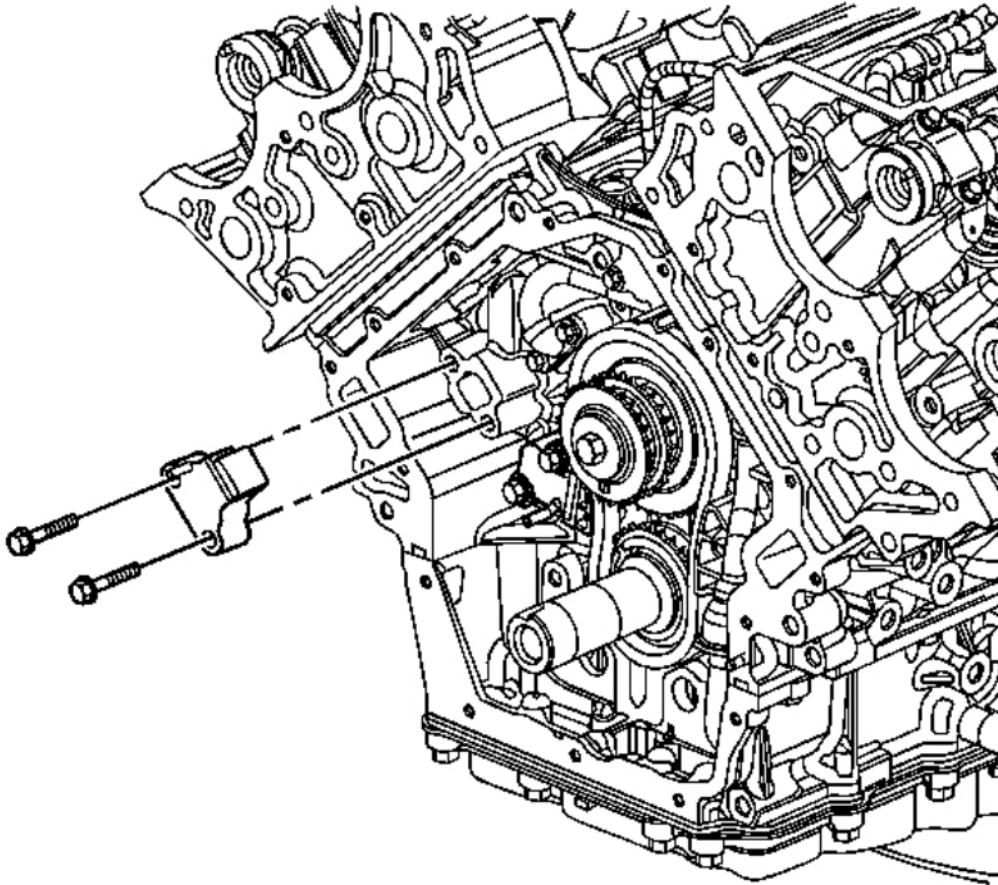


Fig. 208: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

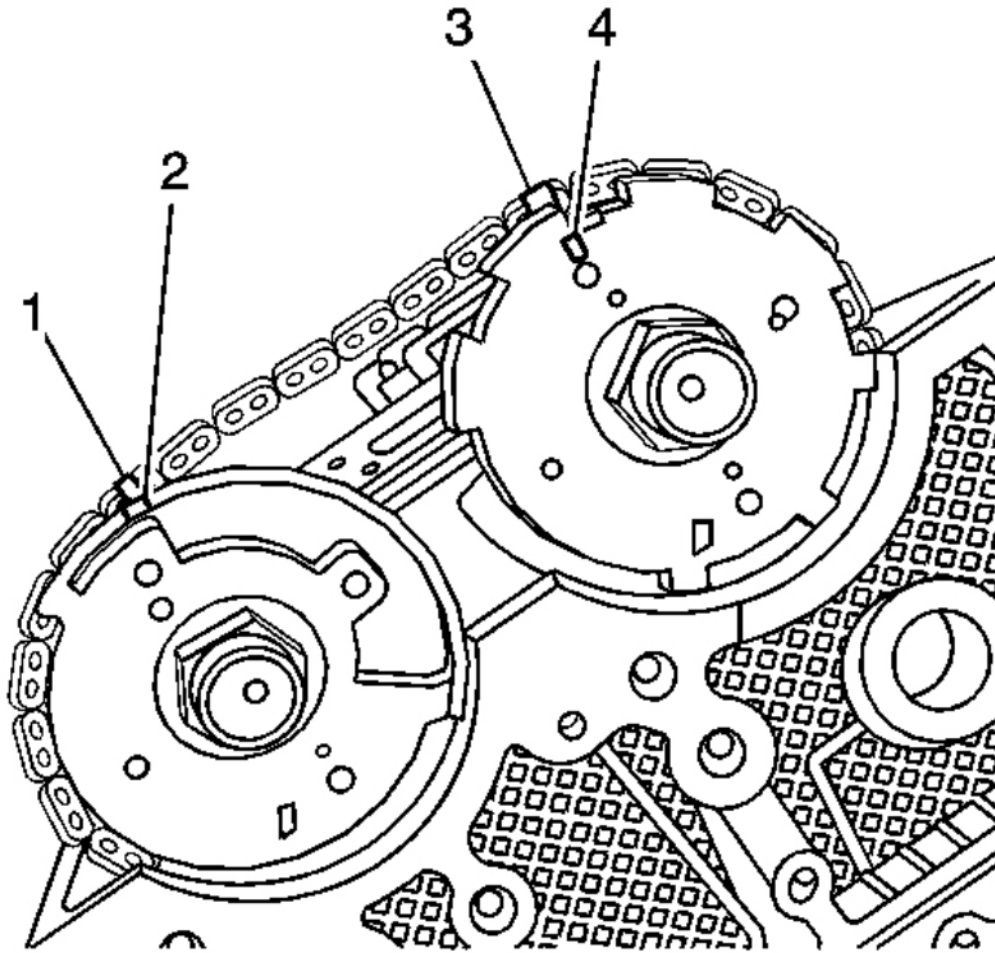


Fig. 209: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).

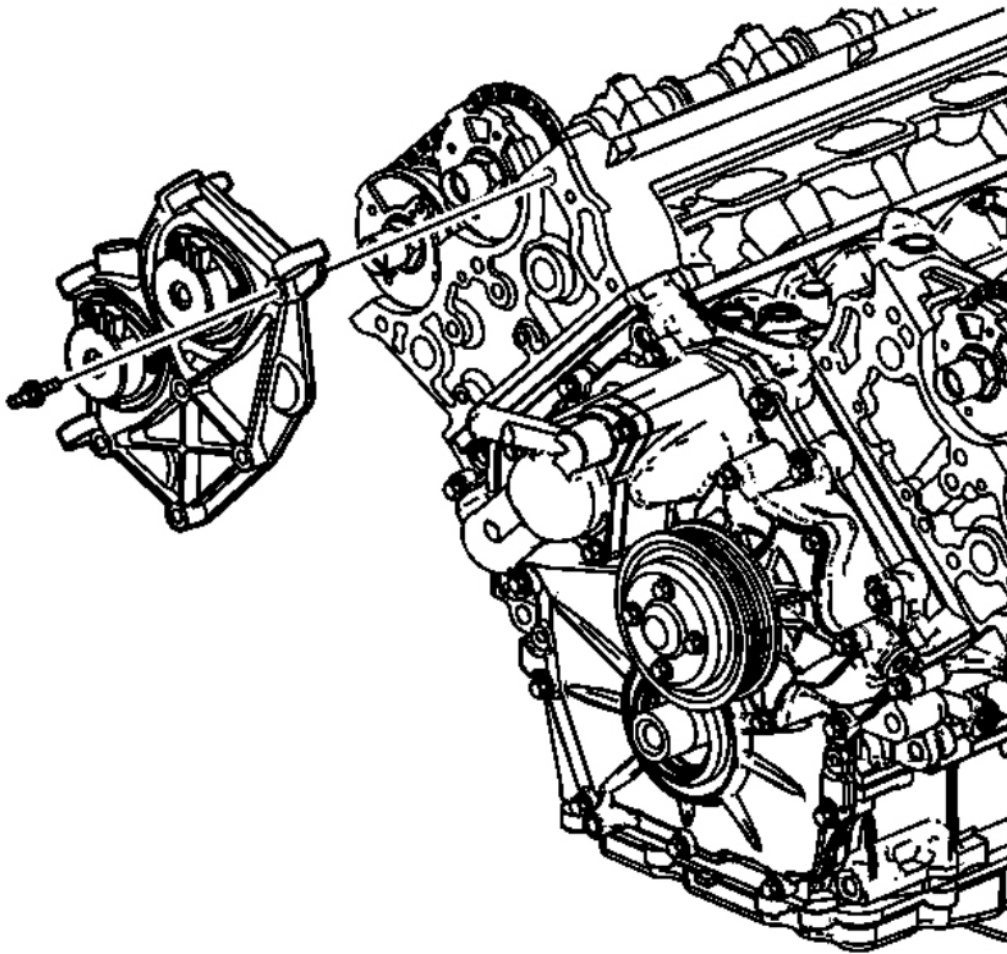


Fig. 210: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

8. Install the right camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.

SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - LEFT

Tools Required

- J 39946 Crankshaft Socket
- EN 46328 Camshaft Holding Tool

Removal Procedure

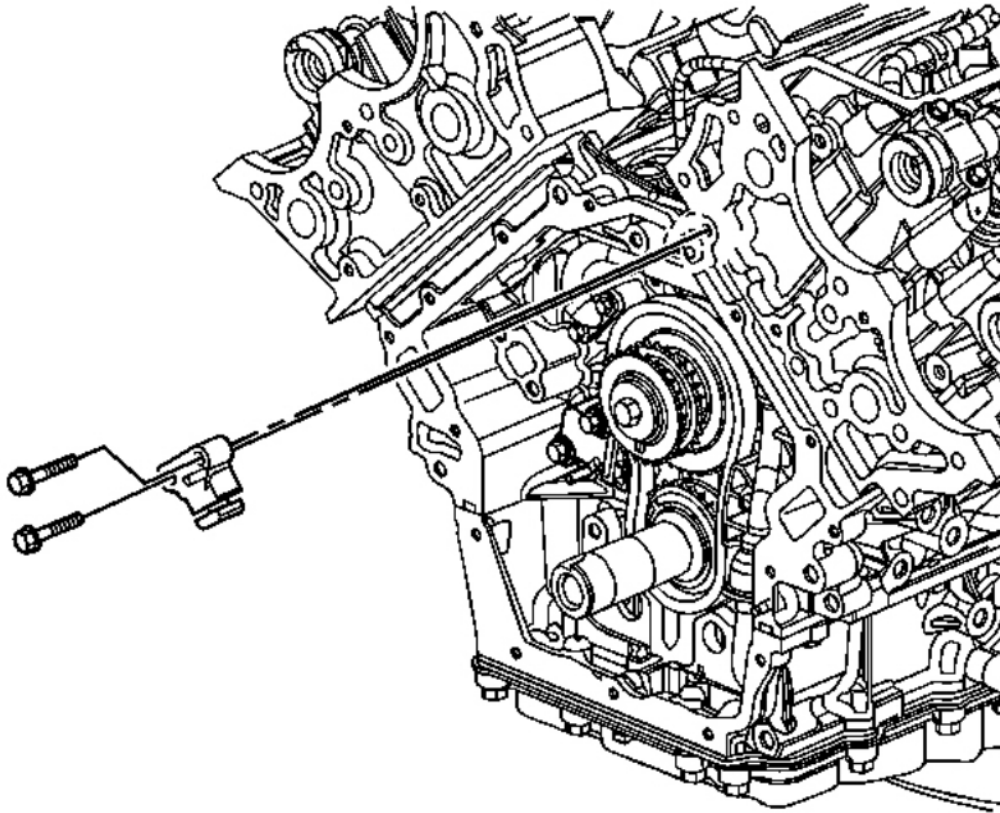


Fig. 211: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

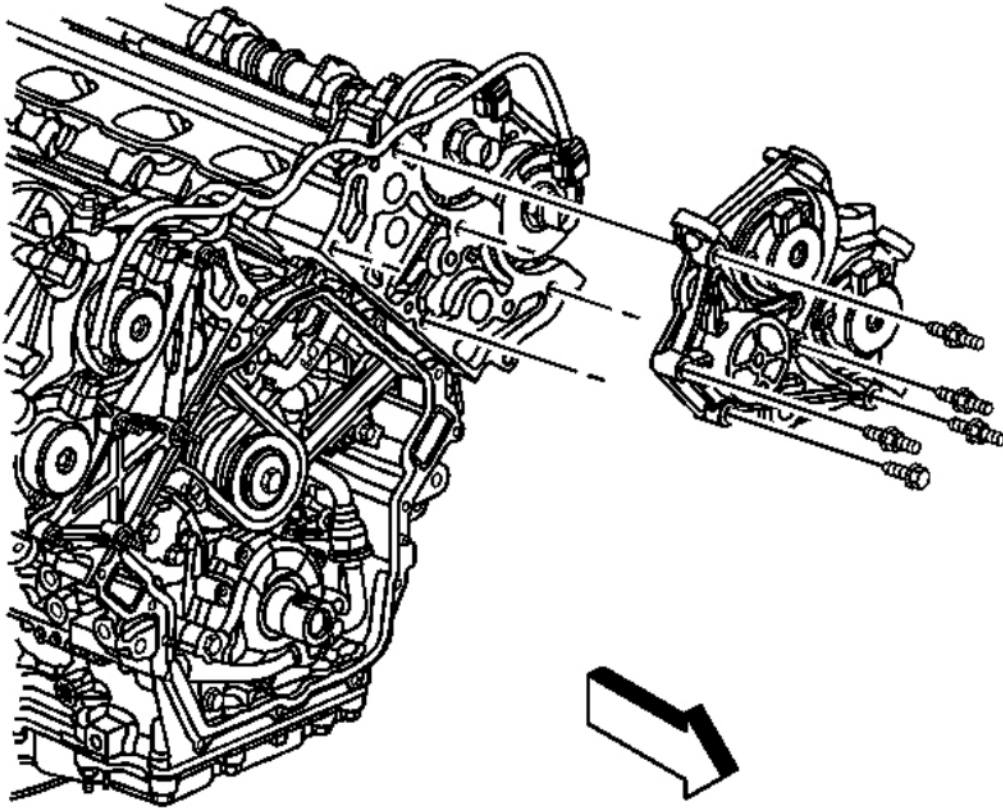


Fig. 212: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the left camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

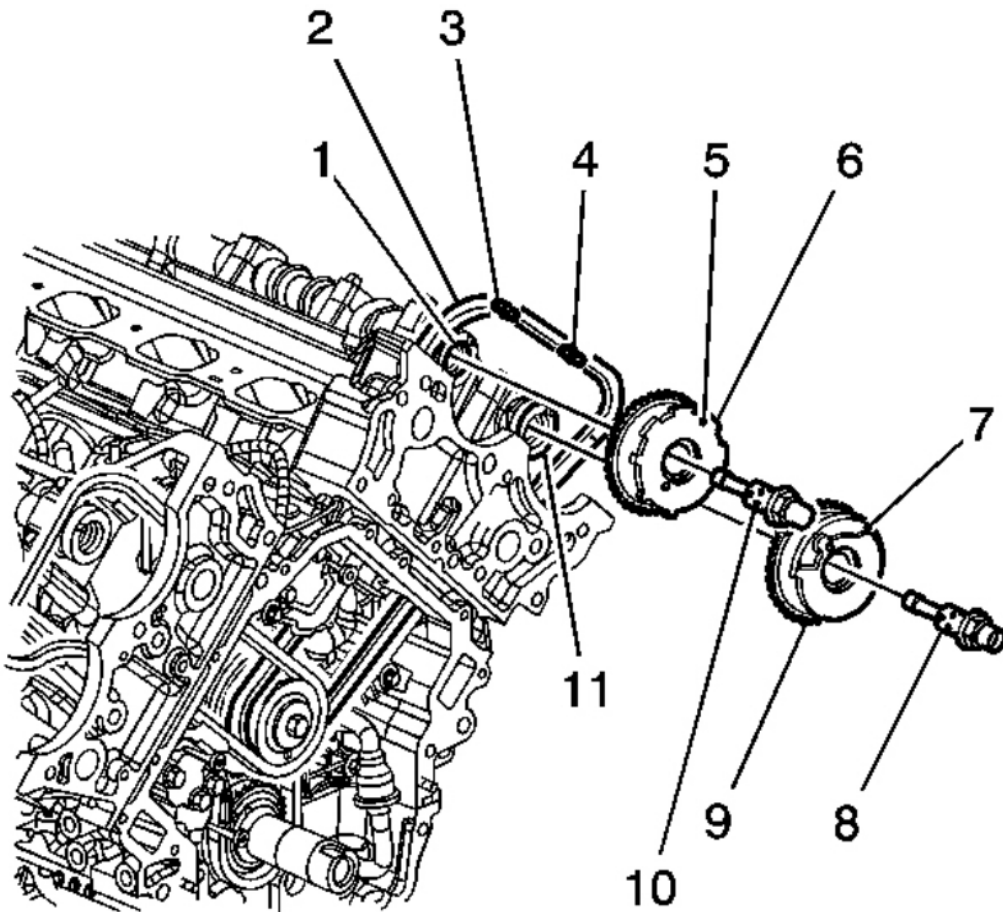


Fig. 213: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the J 39946 , rotate the crankshaft until both camshaft position actuator timing marks (5, 7) are at the top of their rotation.

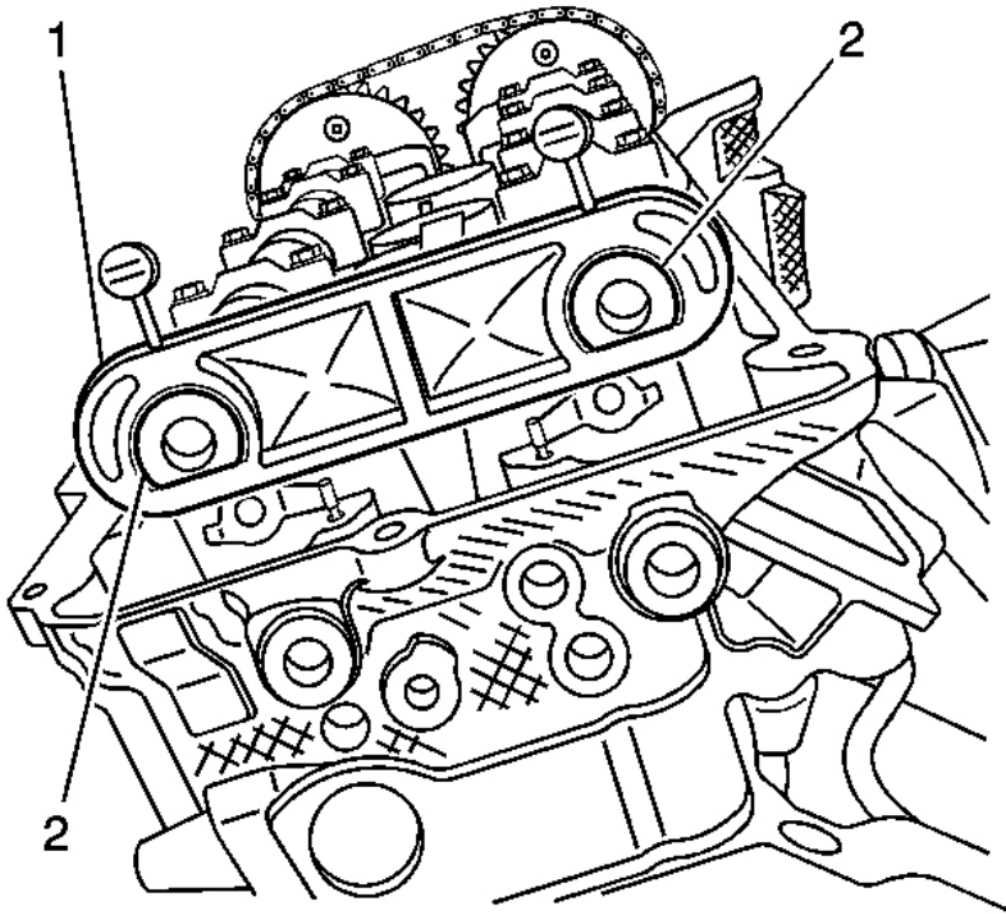


Fig. 214: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the **EN 46328** (1) to the camshafts (2).

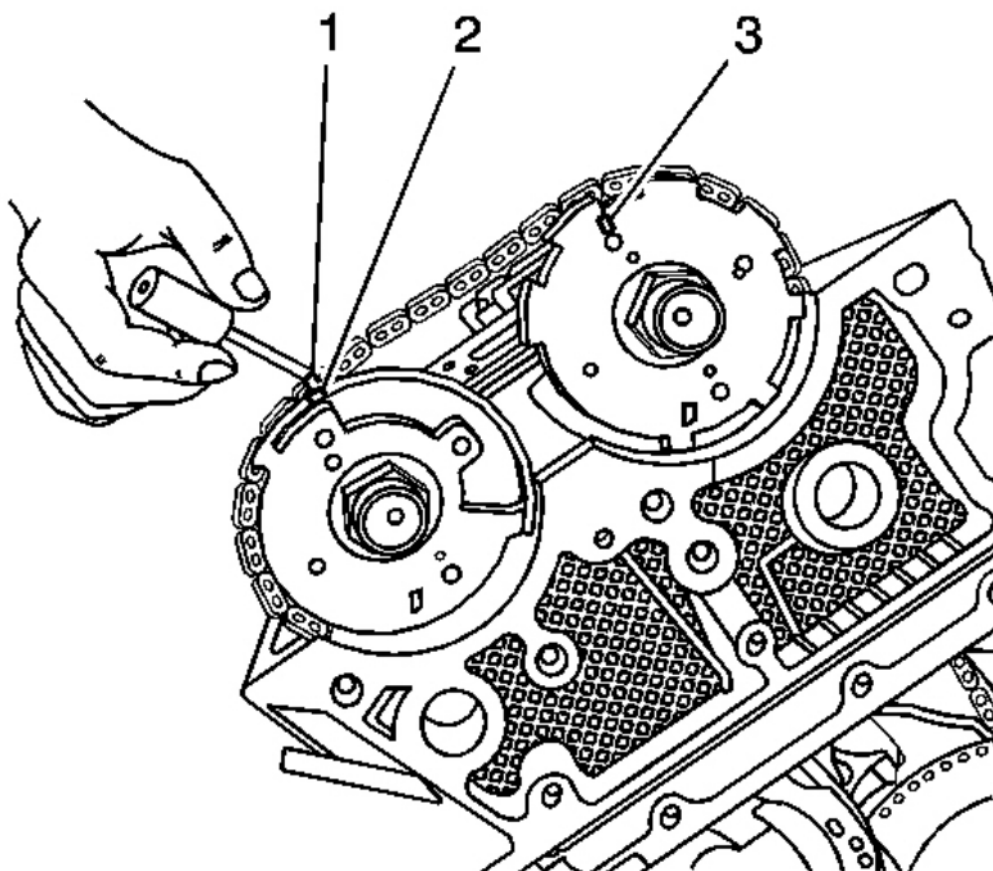


Fig. 215: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

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

6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

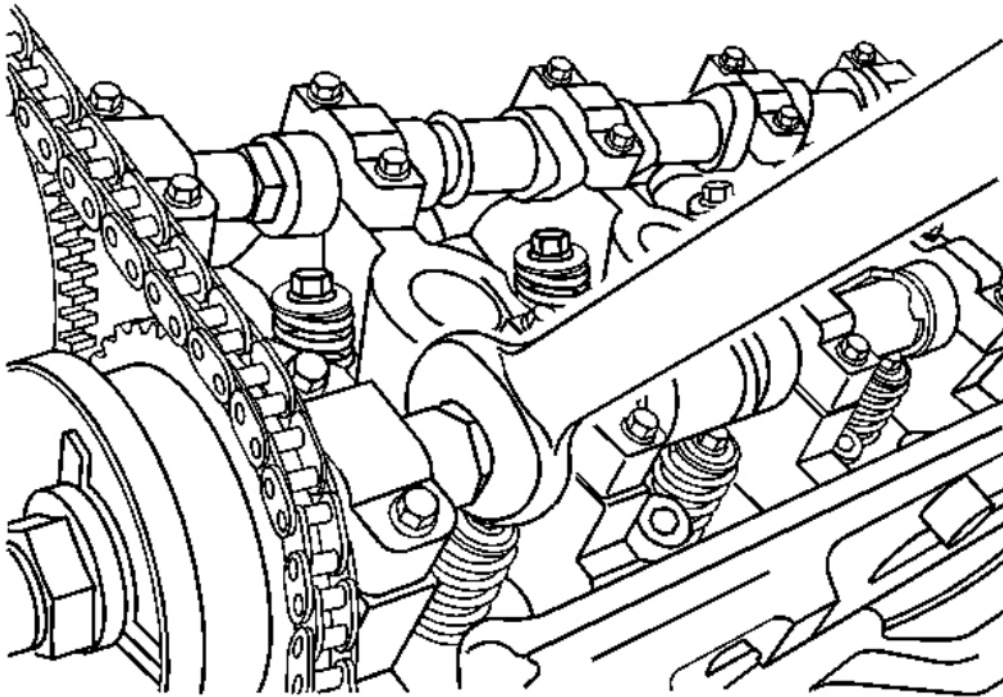


Fig. 216: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

7. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

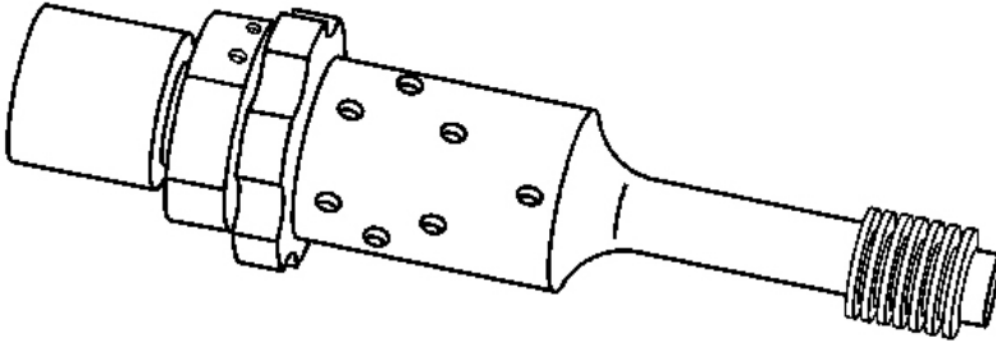


Fig. 217: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the left exhaust oil control valve.
9. Slide the left exhaust camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain, and remove the actuator.

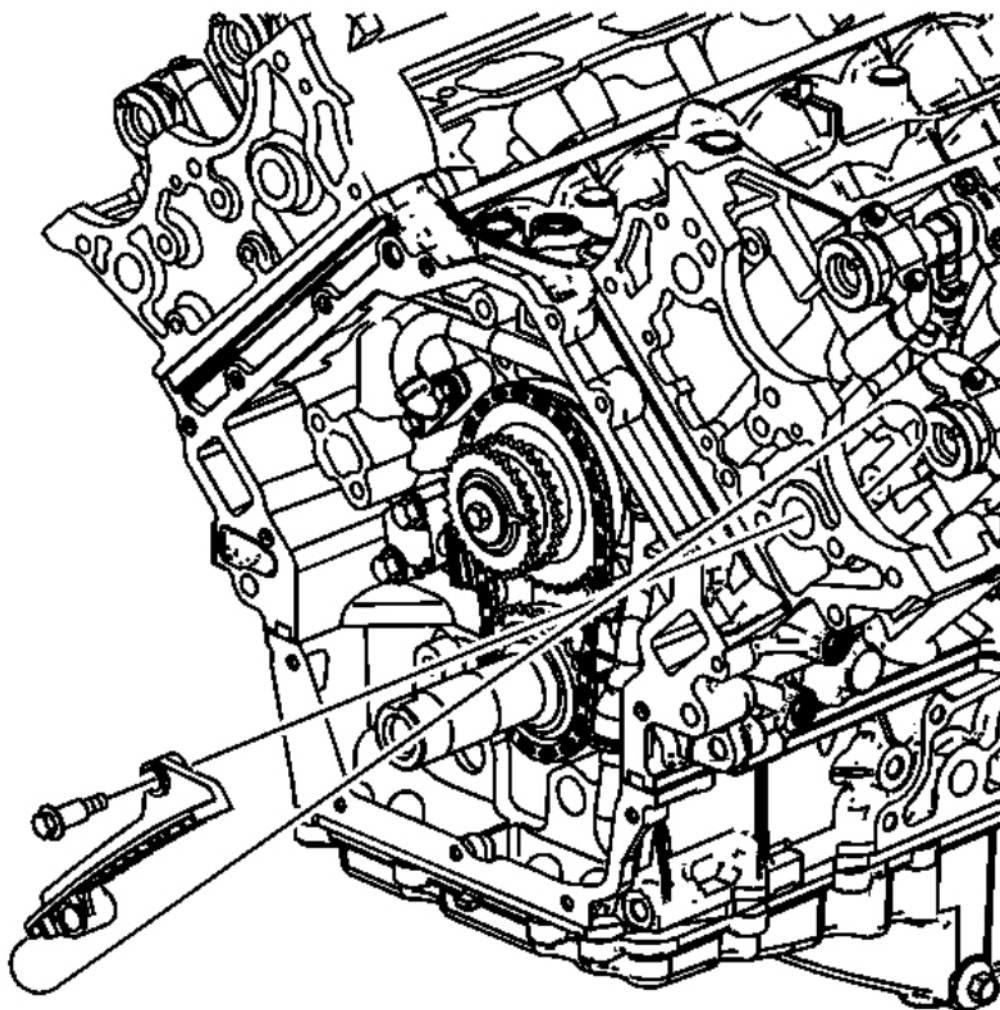


Fig. 218: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the secondary camshaft drive chain guide bolt.
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** .

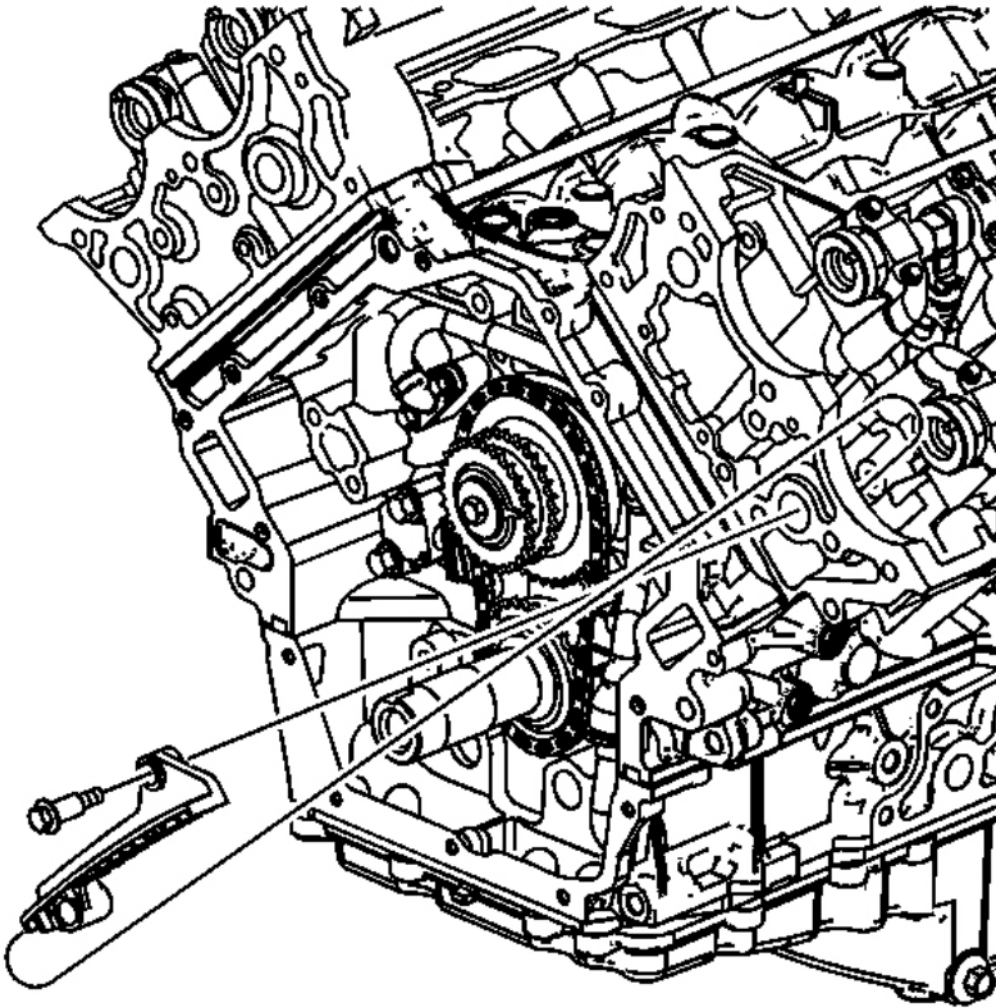


Fig. 219: View Of Left Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the left secondary camshaft drive chain guide in through the left front cylinder head as shown.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

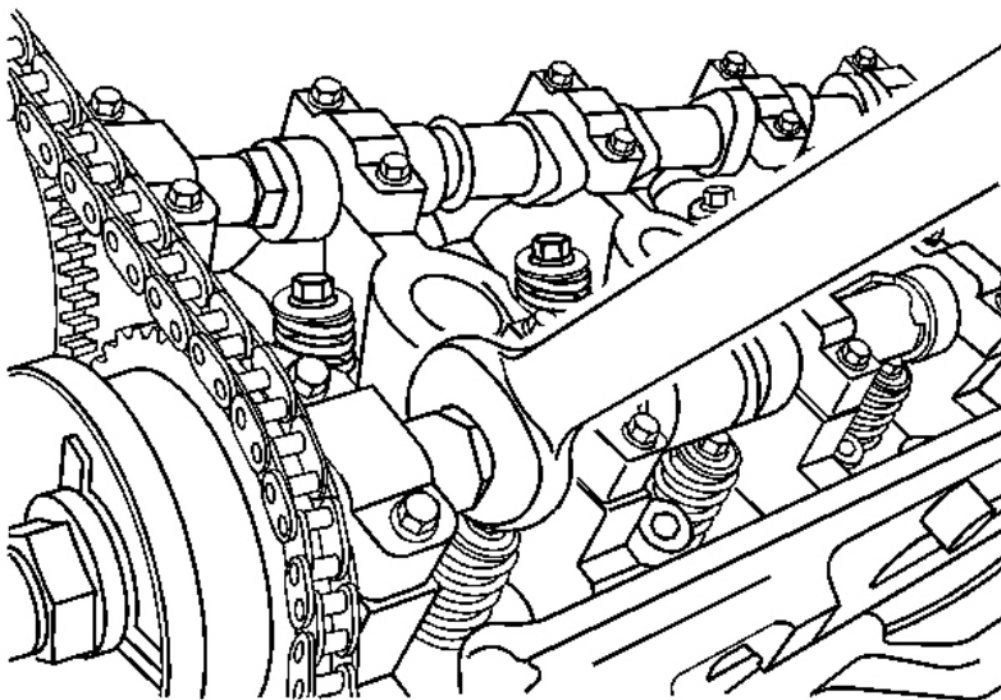


Fig. 220: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

3. Install the left exhaust actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the exhaust actuator to the camshaft.

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

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

6. Install the left secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left**.

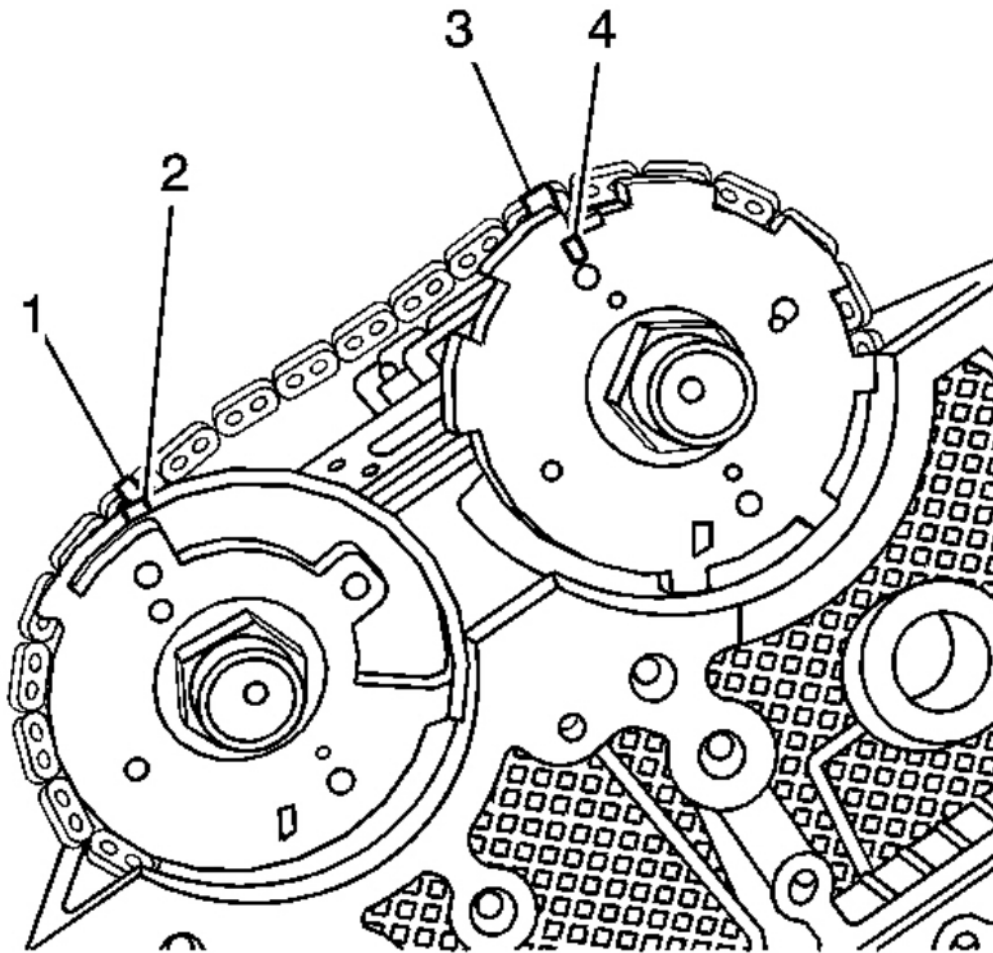


Fig. 221: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the left camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

SECONDARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT - RIGHT

Tools Required

- J 39946 Crankshaft Socket
- EN 46328 Camshaft Holding Tool

Removal Procedure

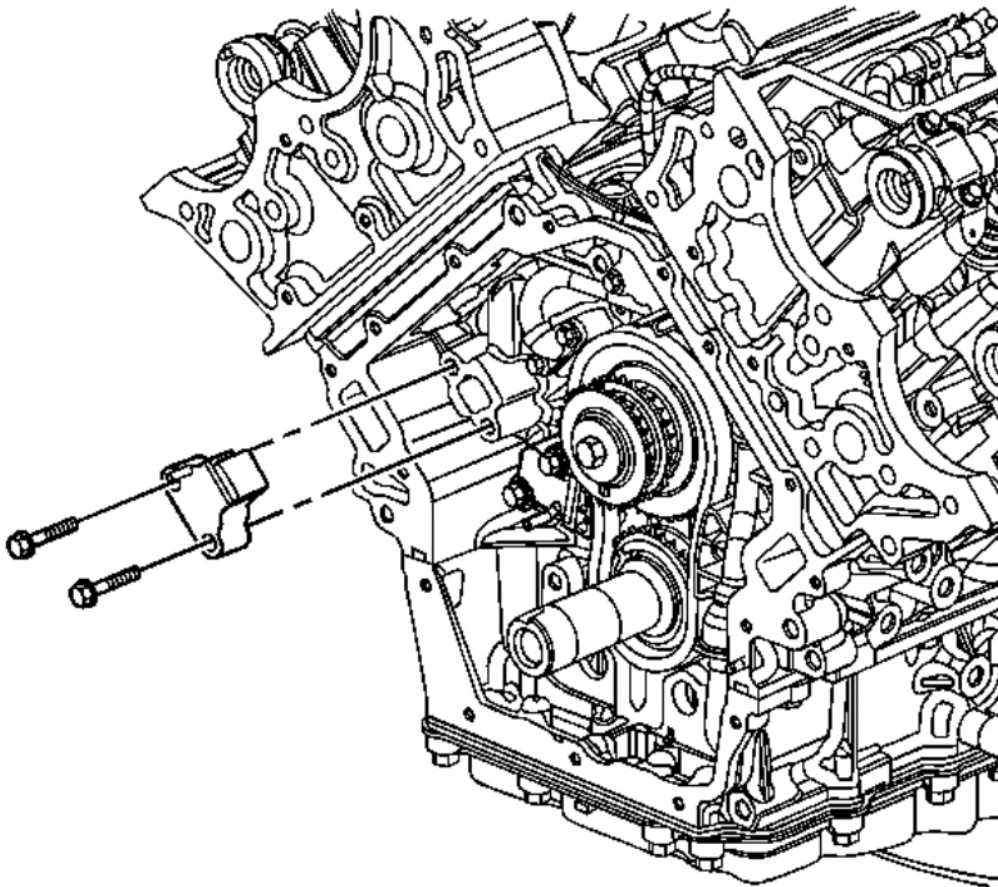


Fig. 222: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the right secondary camshaft tensioner. Refer to Secondary Camshaft Drive

Chain Tensioner Replacement - Right.

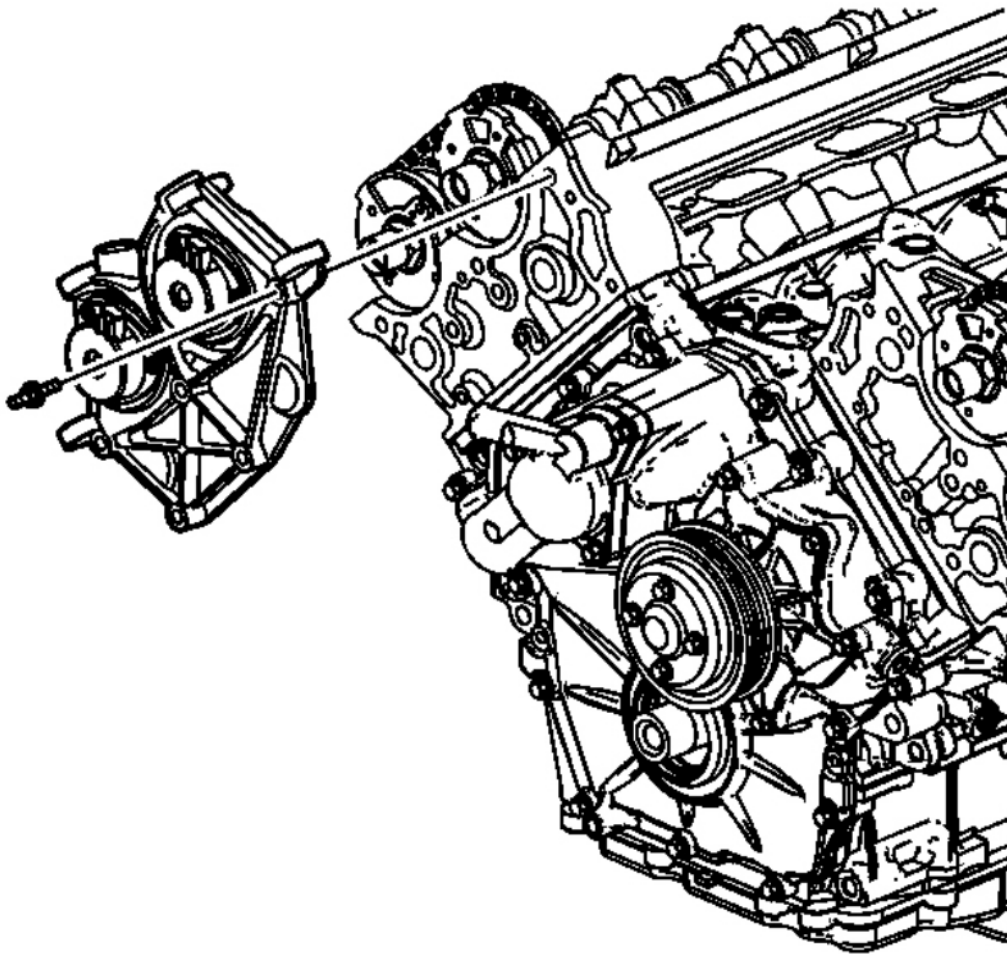


Fig. 223: View Of Right Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

2. Remove the right camshaft position actuator housing. DO NOT remove the camshaft actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right.**

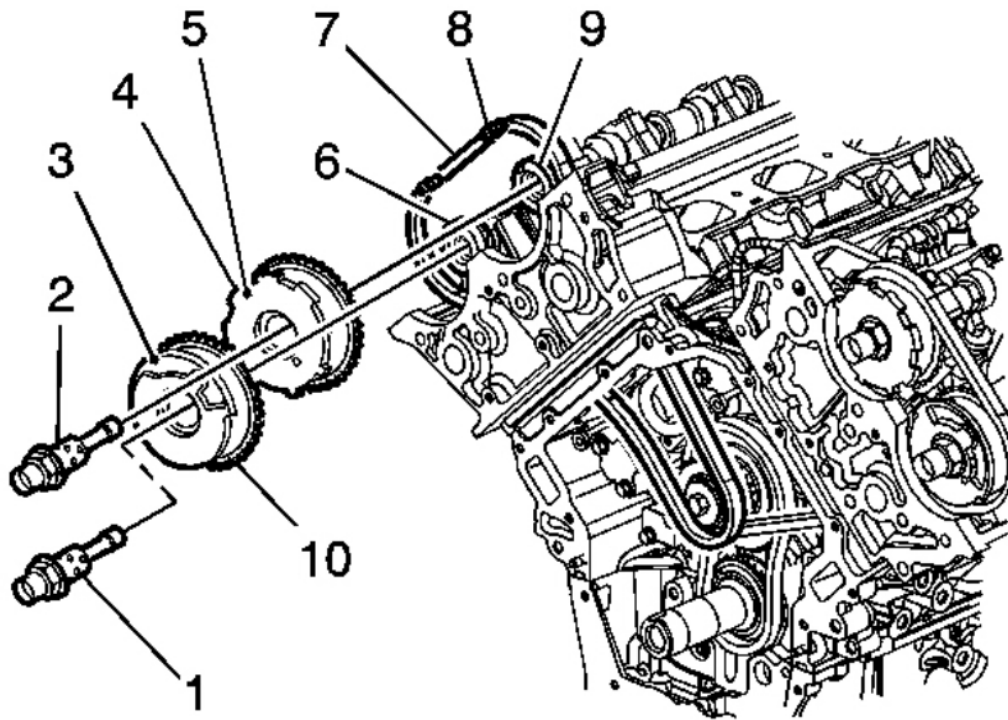


Fig. 224: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Using the J 39946 , rotate the crankshaft until both camshaft position actuator timing marks (3, 5) are at the top of their rotation.

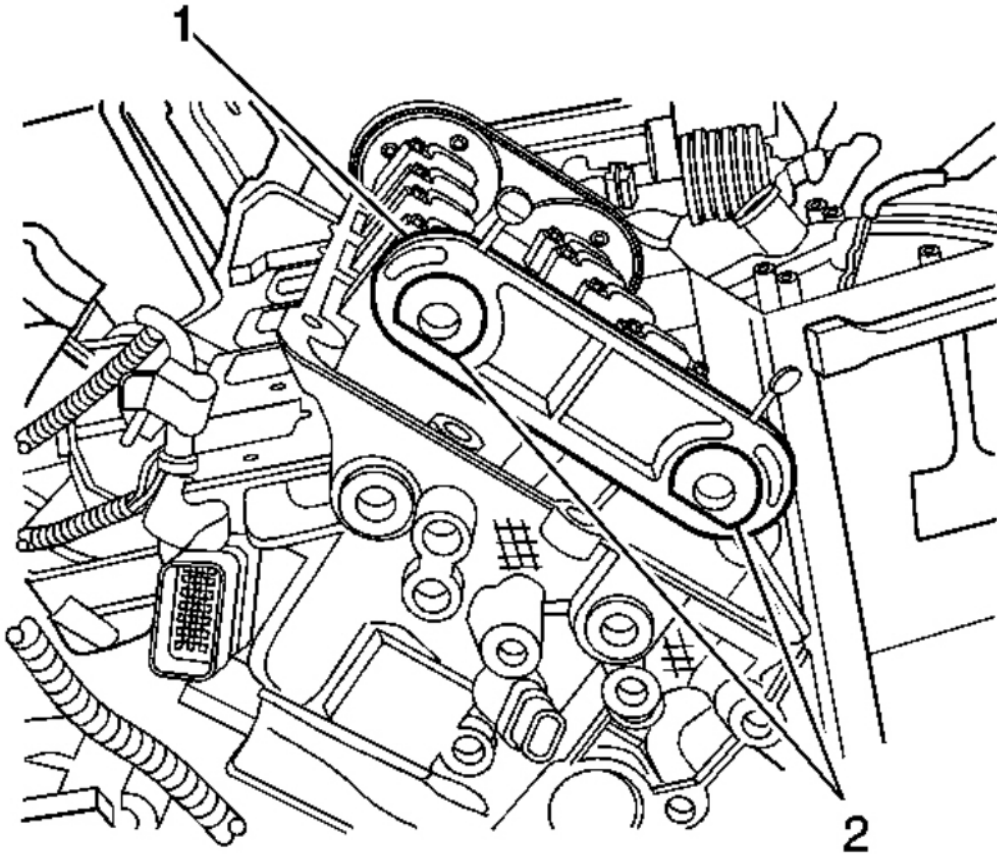


Fig. 225: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the EN 46328 (1) to the camshafts (2).

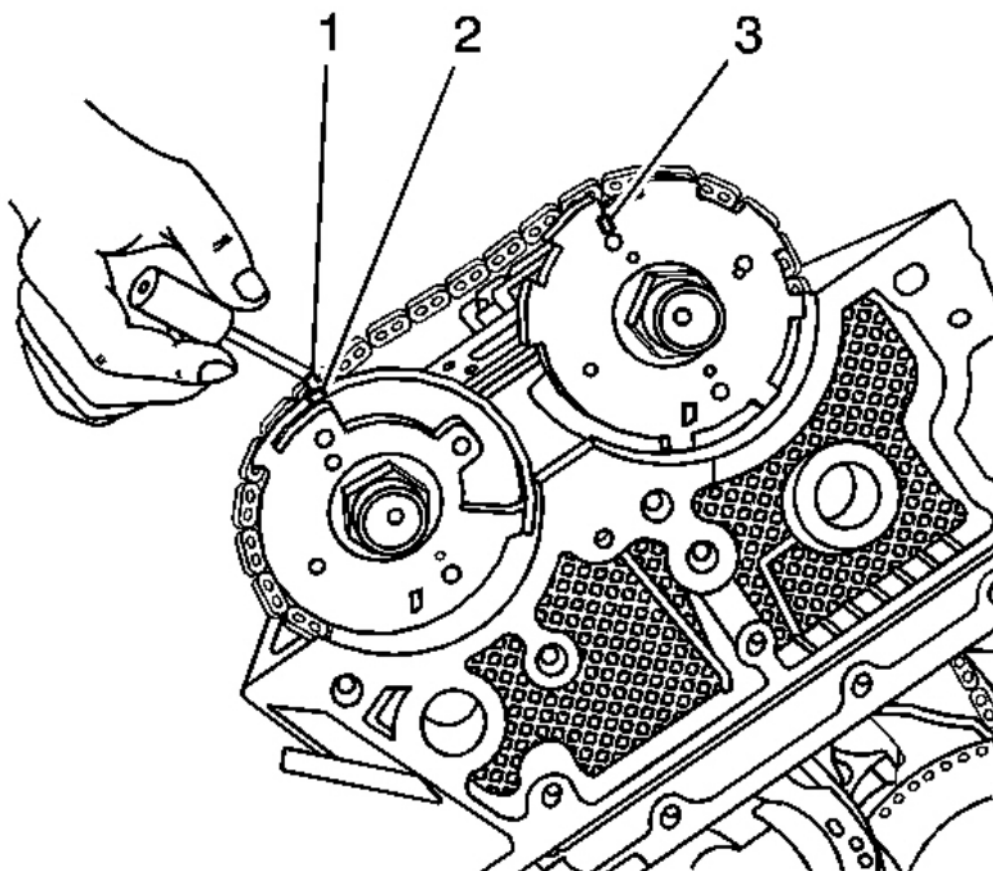


Fig. 226: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

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

6. Use a paint stick to create a mark on a primary chain link and intermediate primary chain sprocket tooth adjacent to the primary chain link.

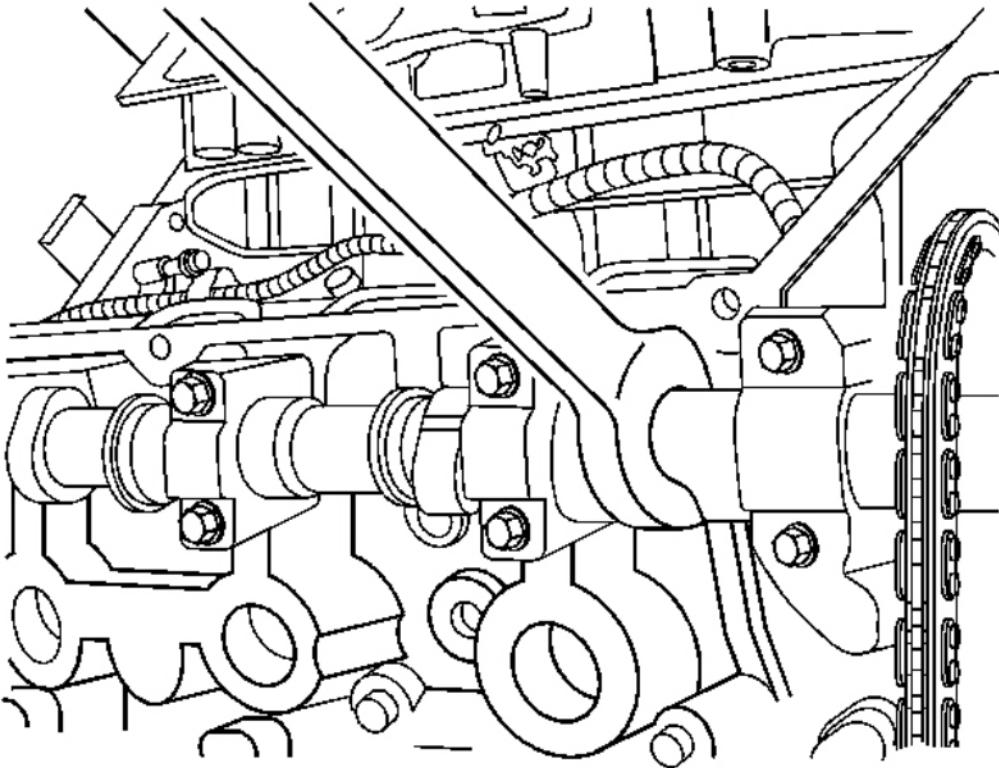


Fig. 227: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

7. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

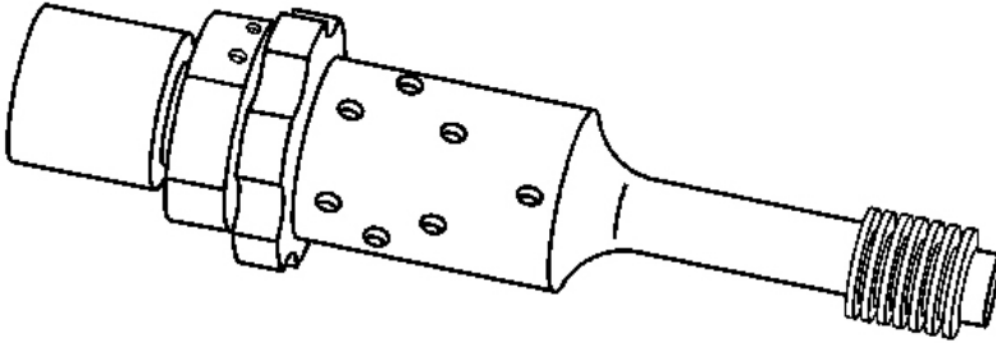


Fig. 228: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

8. Loosen and remove the right intake oil control valve.
9. Slide the right intake camshaft actuator off of the camshaft, disengage the sprocket teeth from the secondary timing chain, and remove the actuator.

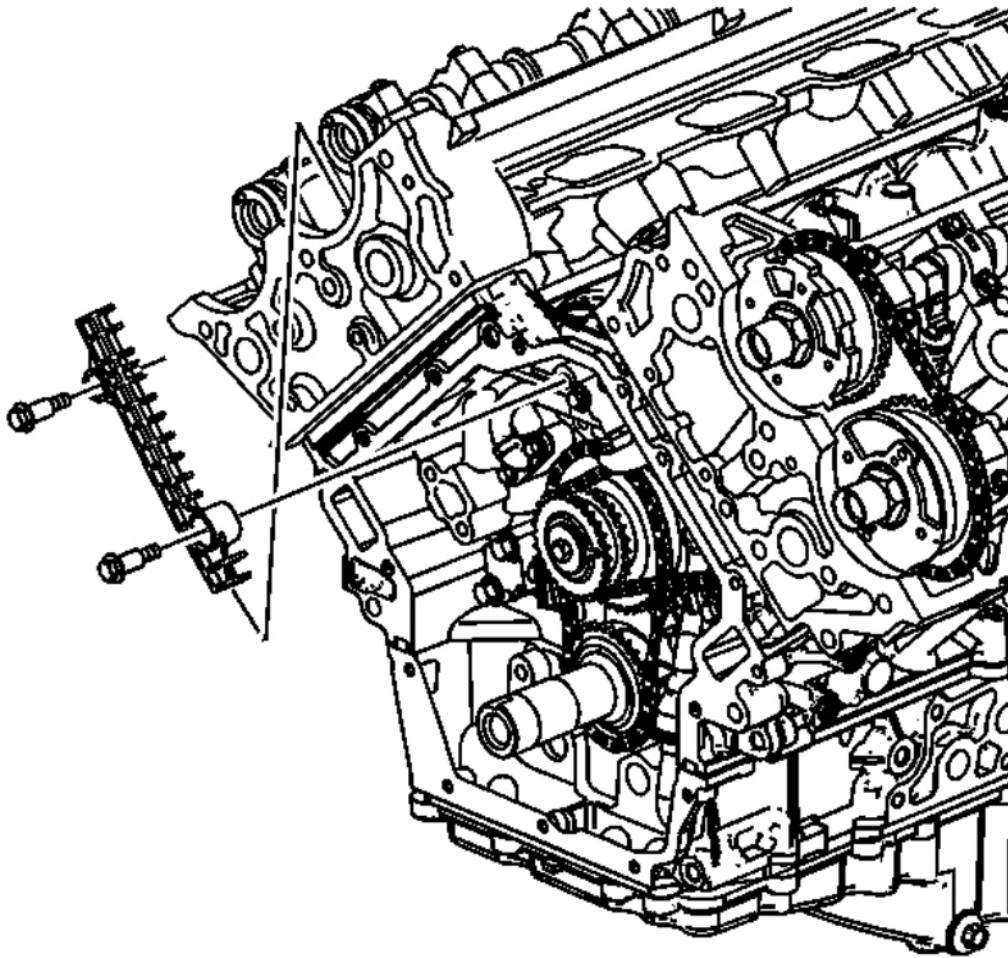


Fig. 229: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

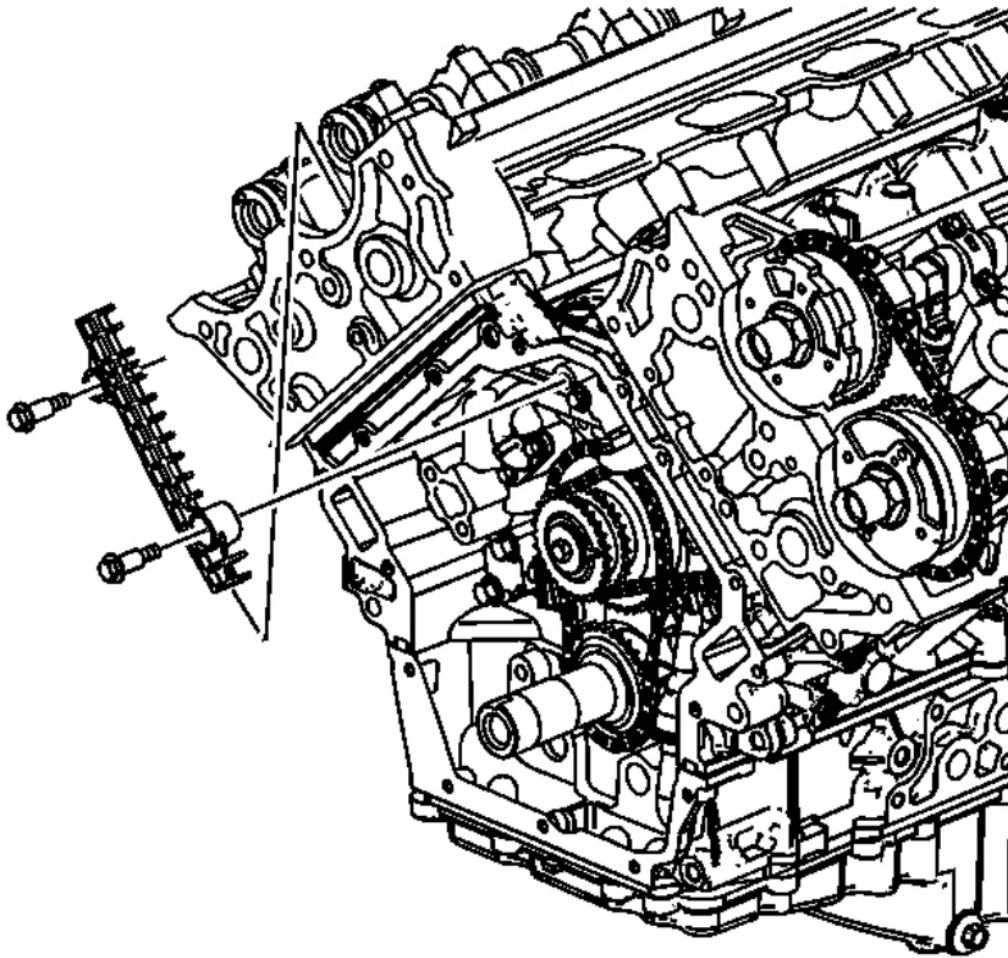


Fig. 230: View Of Right Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Position the right secondary camshaft drive chain guide in through the right front cylinder head as shown.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

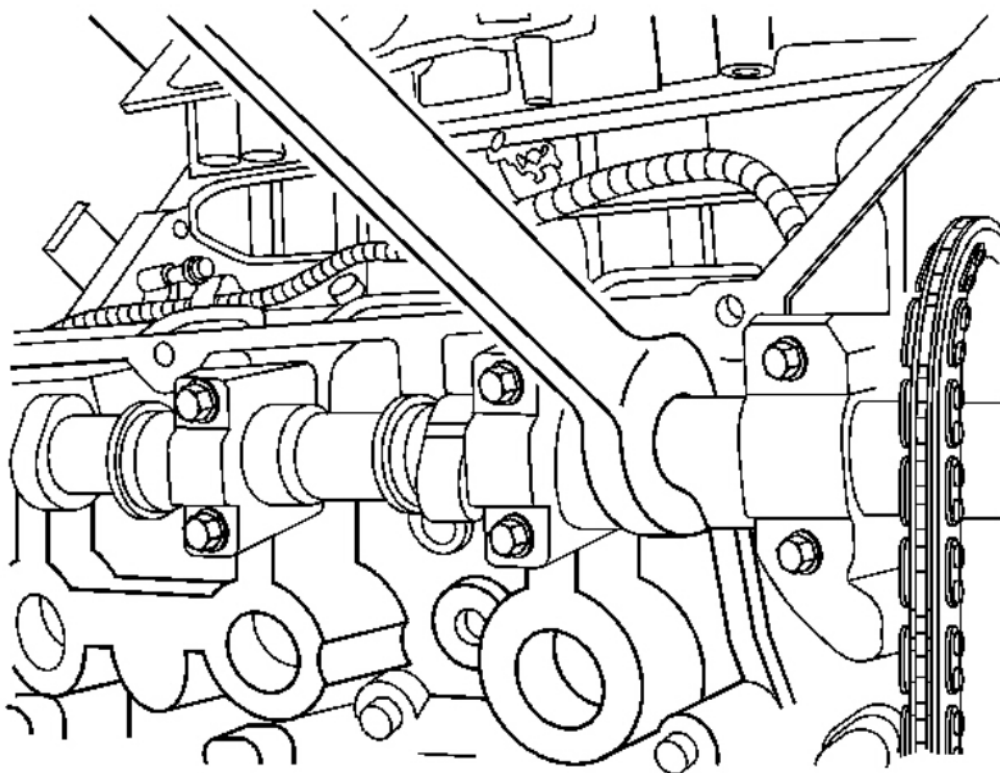


Fig. 231: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

3. Install the right intake actuator to the secondary chain, ensuring that the actuator timing mark is aligned with the chain link that was marked during disassembly.
4. Loosely install the oil control valve to secure the intake actuator to the camshaft.

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

5. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

6. Install the right secondary camshaft drive chain tensioner. Refer to **Secondary Camshaft**

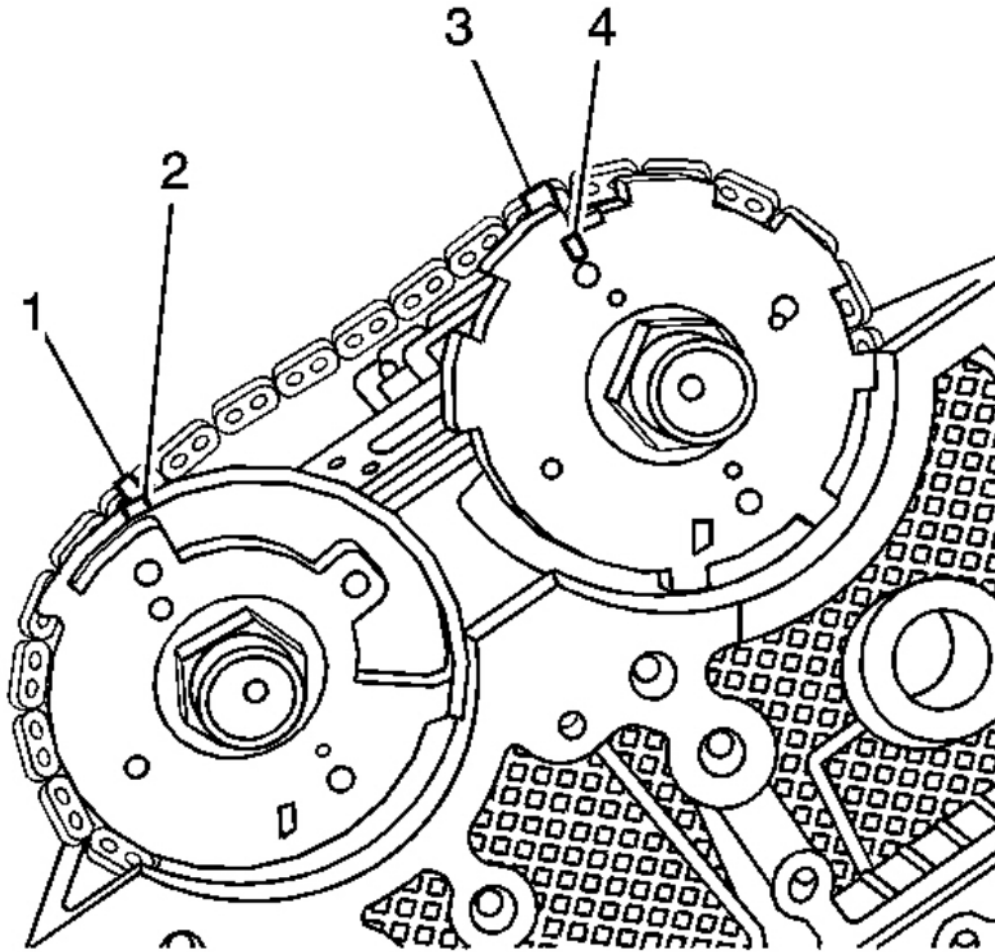
Drive Chain Tensioner Replacement - Right.

Fig. 232: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

7. Ensure that the previously created paint marks (1, 3) still line up with the sprocket timing marks (2, 4).
8. Install the right camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right.**

Tools Required

J 39946 Crankshaft Socket

Removal Procedure

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

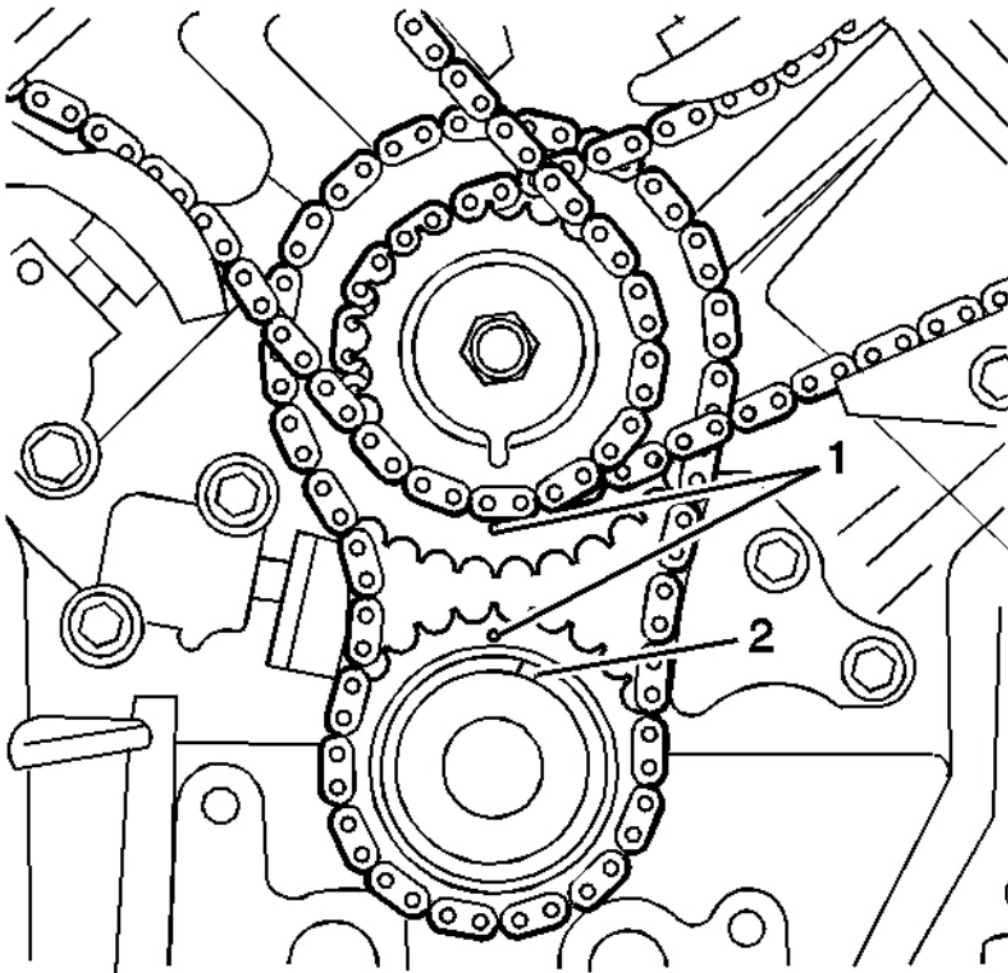


Fig. 233: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

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

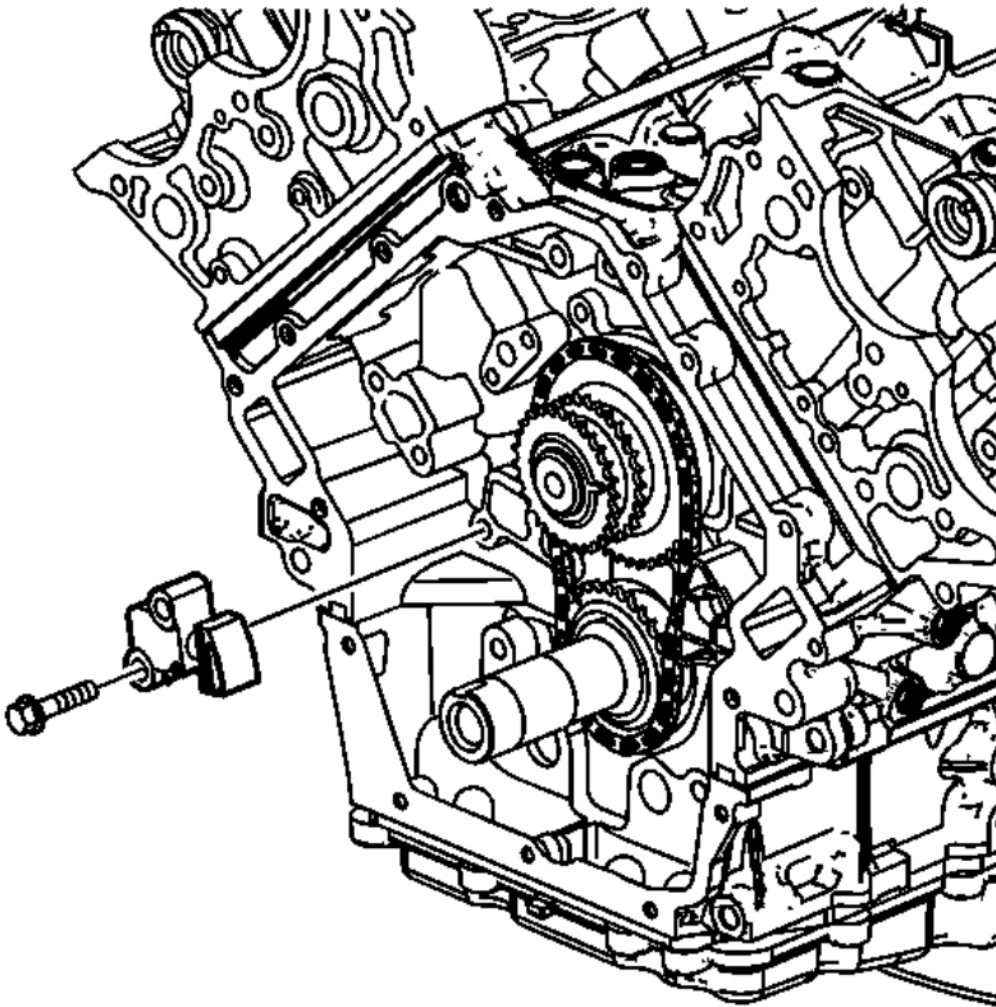


Fig. 234: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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** .

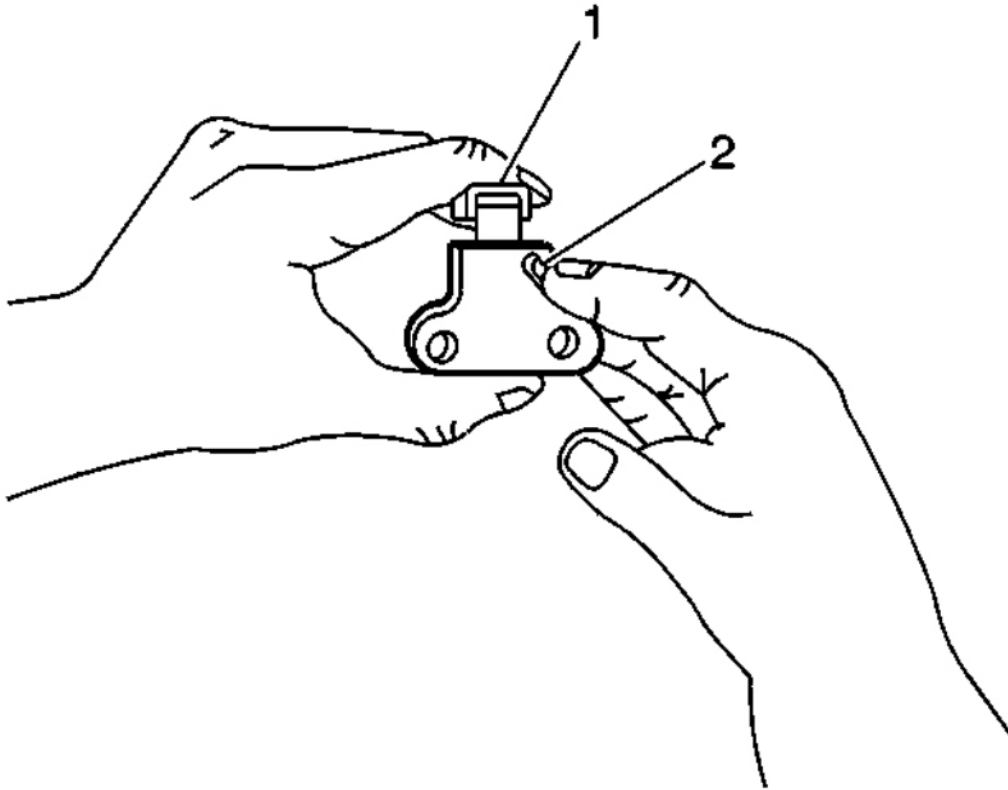
Installation Procedure

Fig. 235: View Of Primary Camshaft Drive Chain Tensioner Shoe & Ratchet Lever
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.

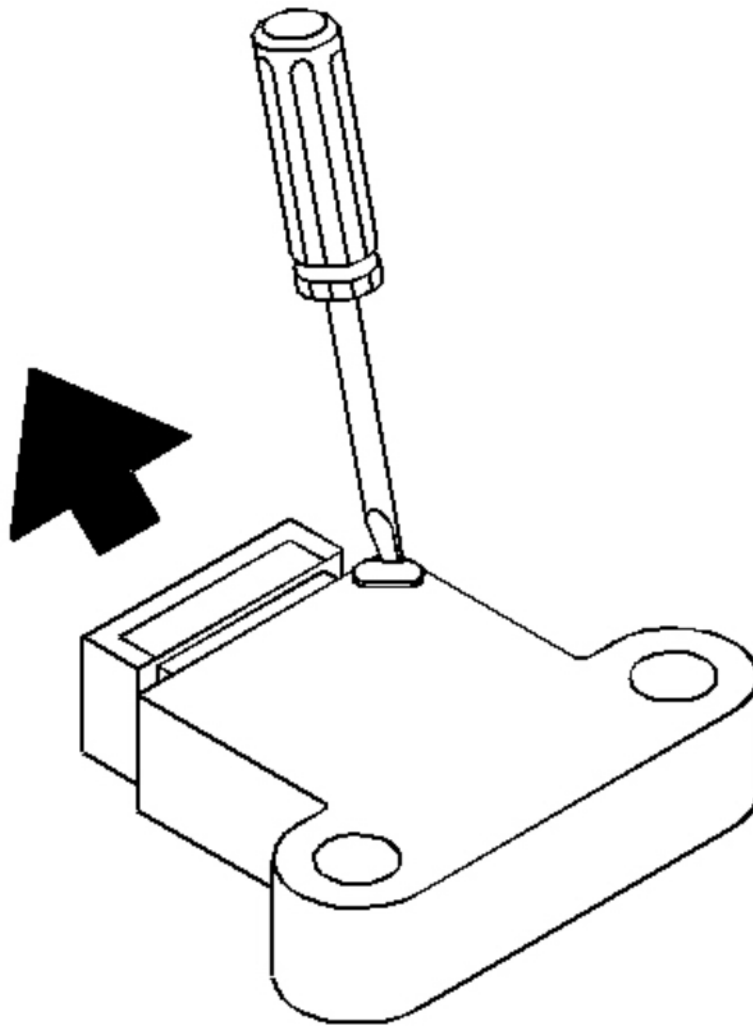


Fig. 236: Locking Primary Camshaft Drive Chain Tensioner Shoe Into Collapsed Position

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.

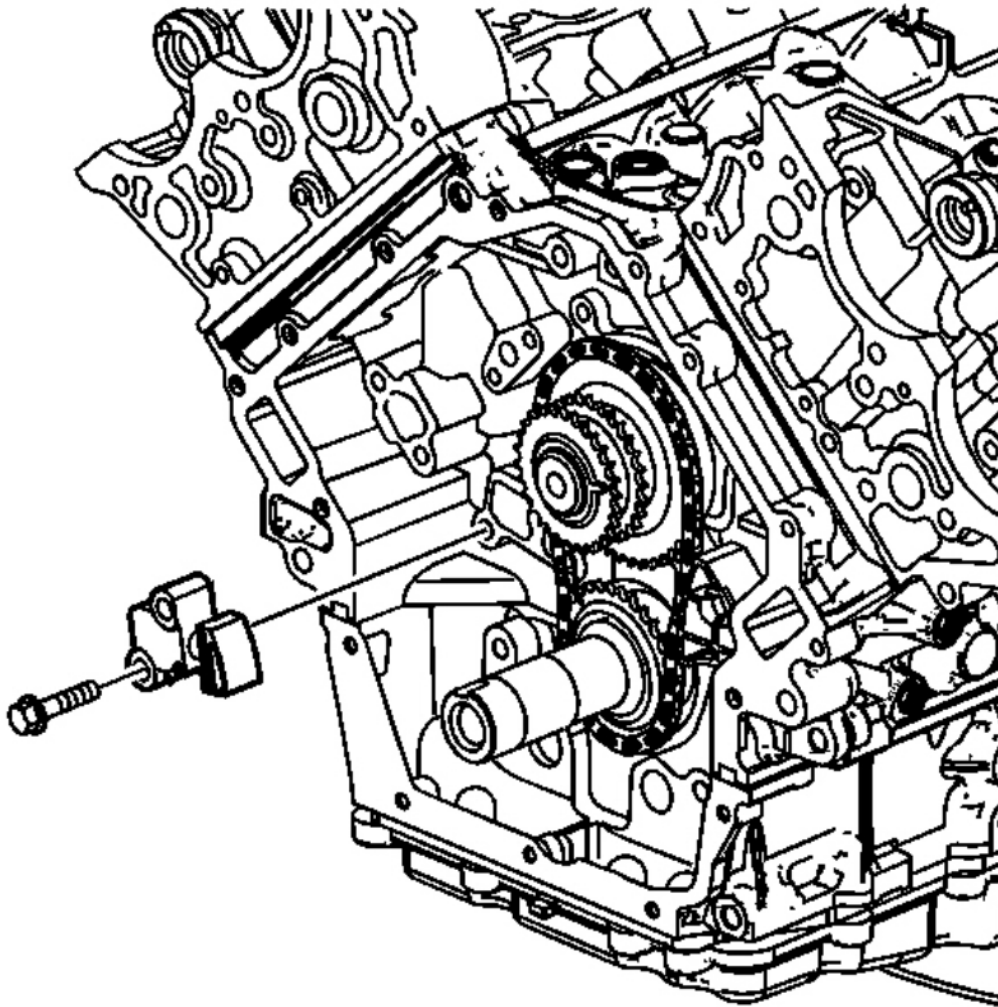


Fig. 237: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: 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.

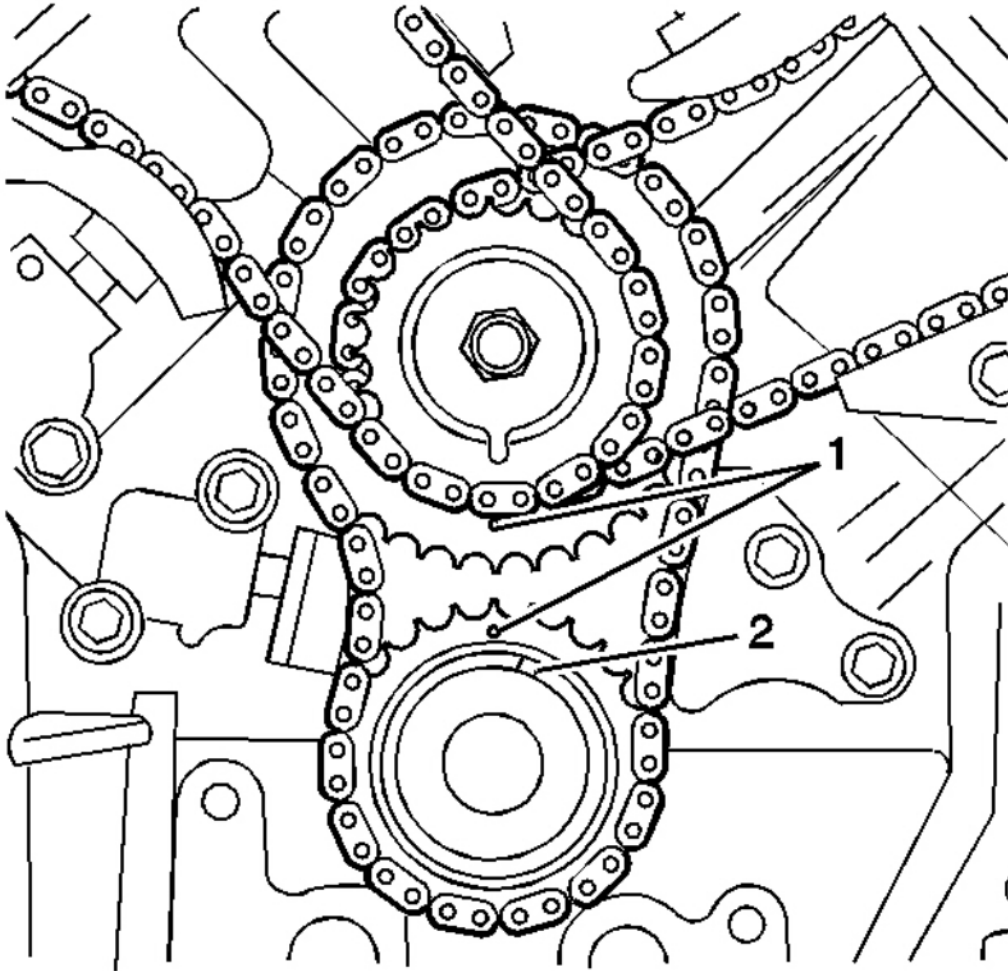


Fig. 238: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

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

PRIMARY CAMSHAFT DRIVE CHAIN GUIDE REPLACEMENT

Removal Procedure

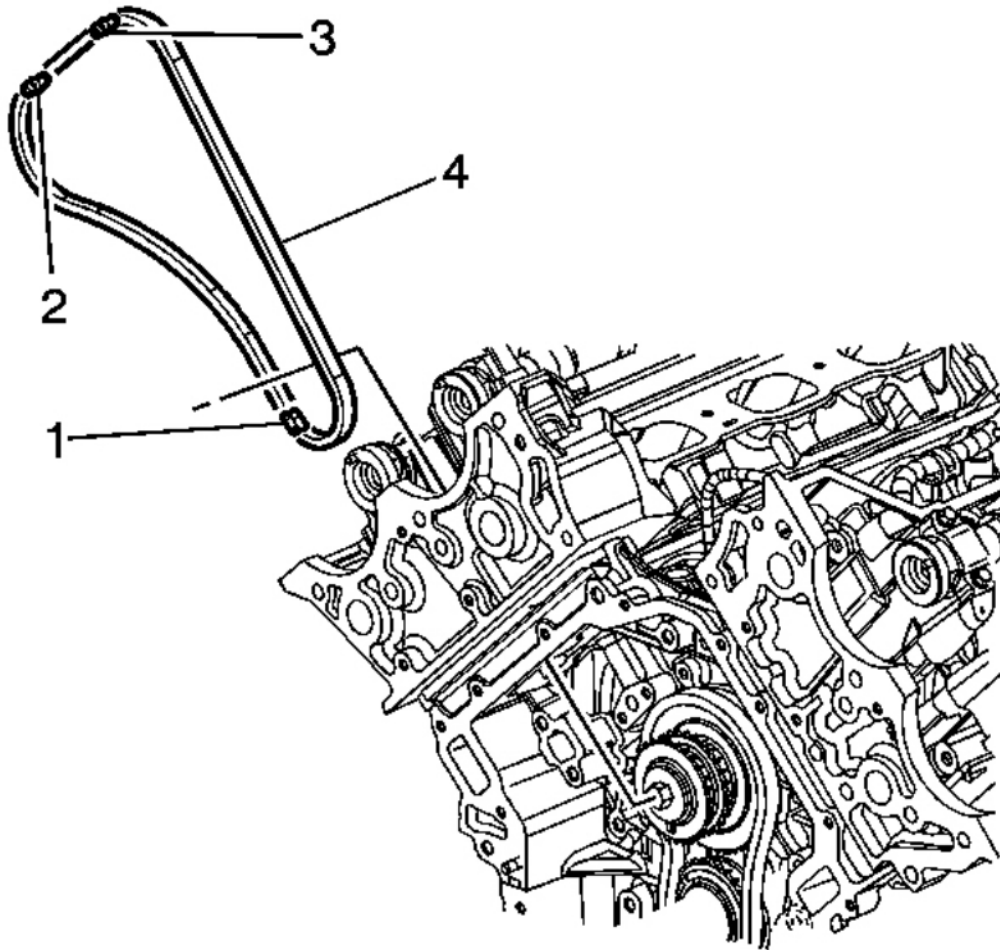


Fig. 239: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

1. Remove the right side secondary camshaft drive chain (4). Refer to **Secondary Camshaft Drive Chain Replacement - Right**.

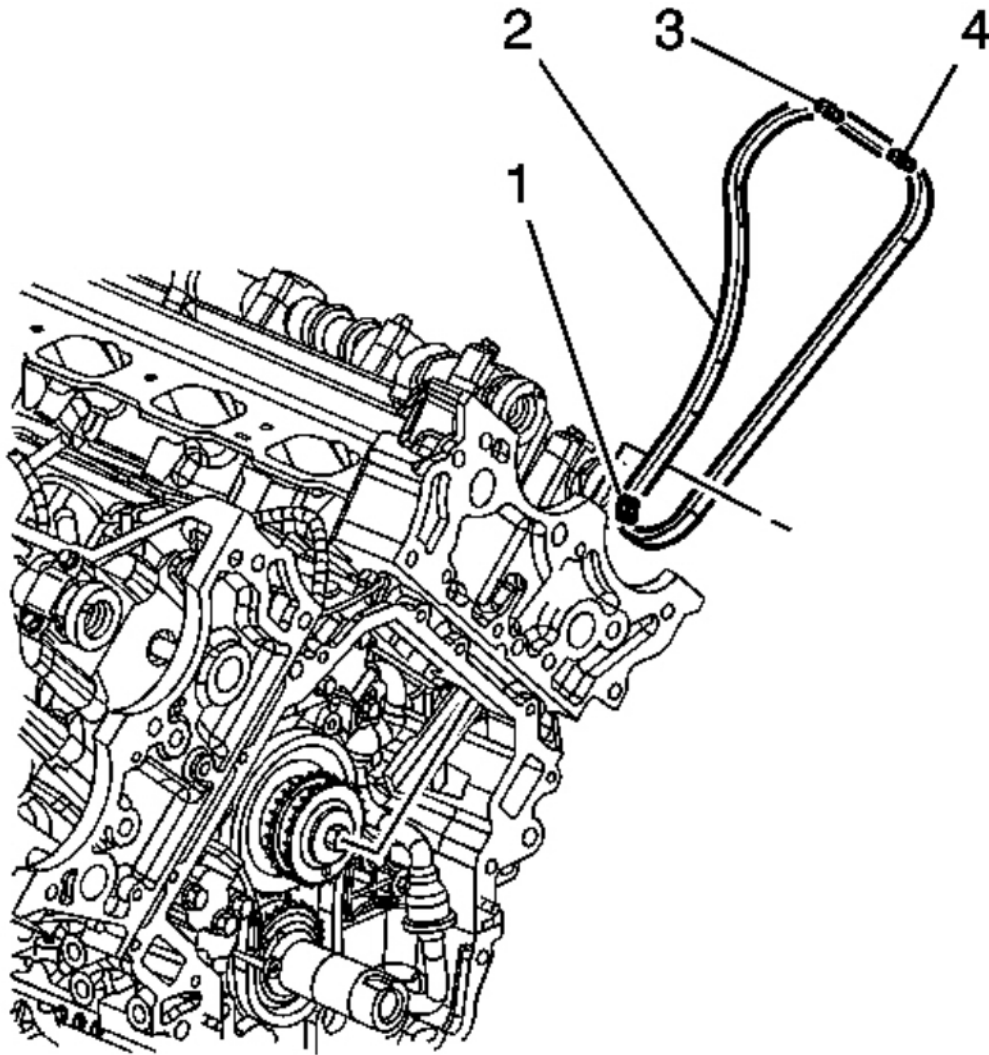


Fig. 240: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

2. Remove the left side secondary camshaft drive chain (2). Refer to **Secondary Camshaft Drive Chain Replacement - Left.**

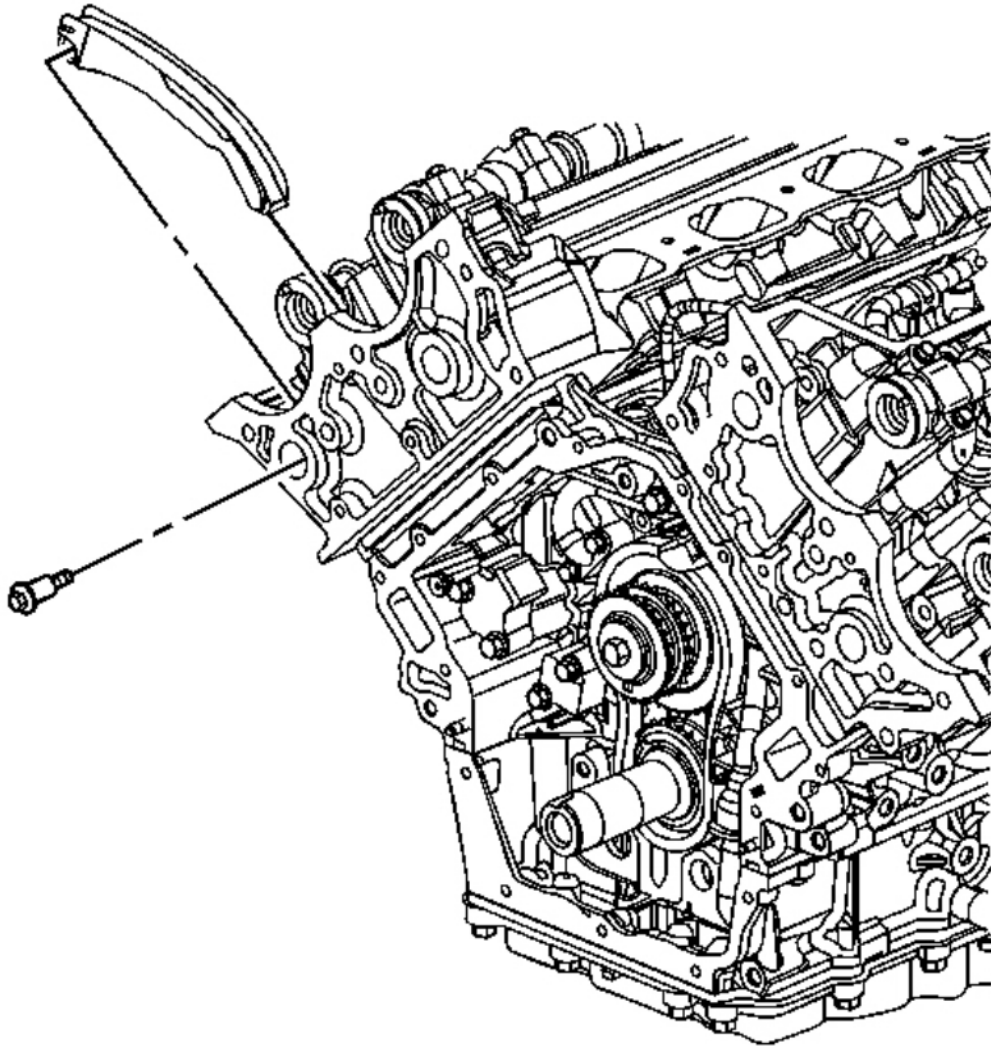


Fig. 241: View Of Right Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

3. Remove the right side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Right.**

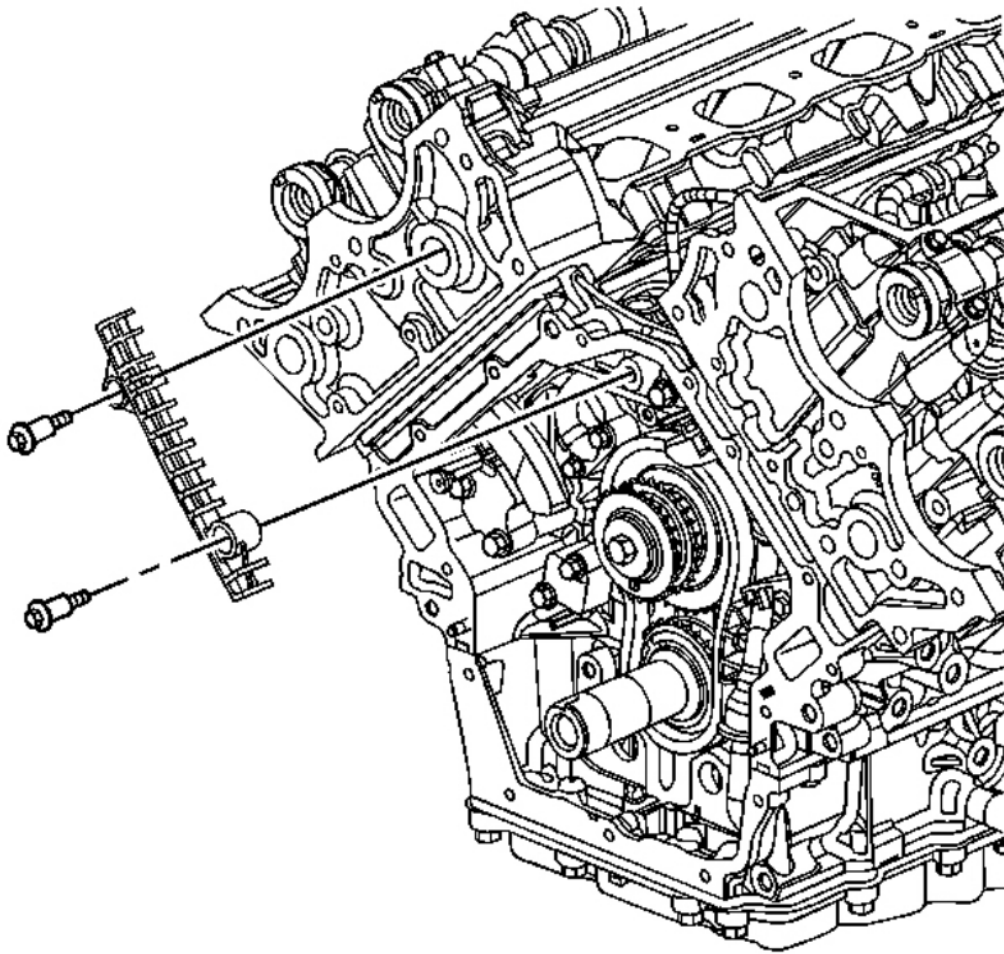


Fig. 242: View Of Right Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Remove the right side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Right.**

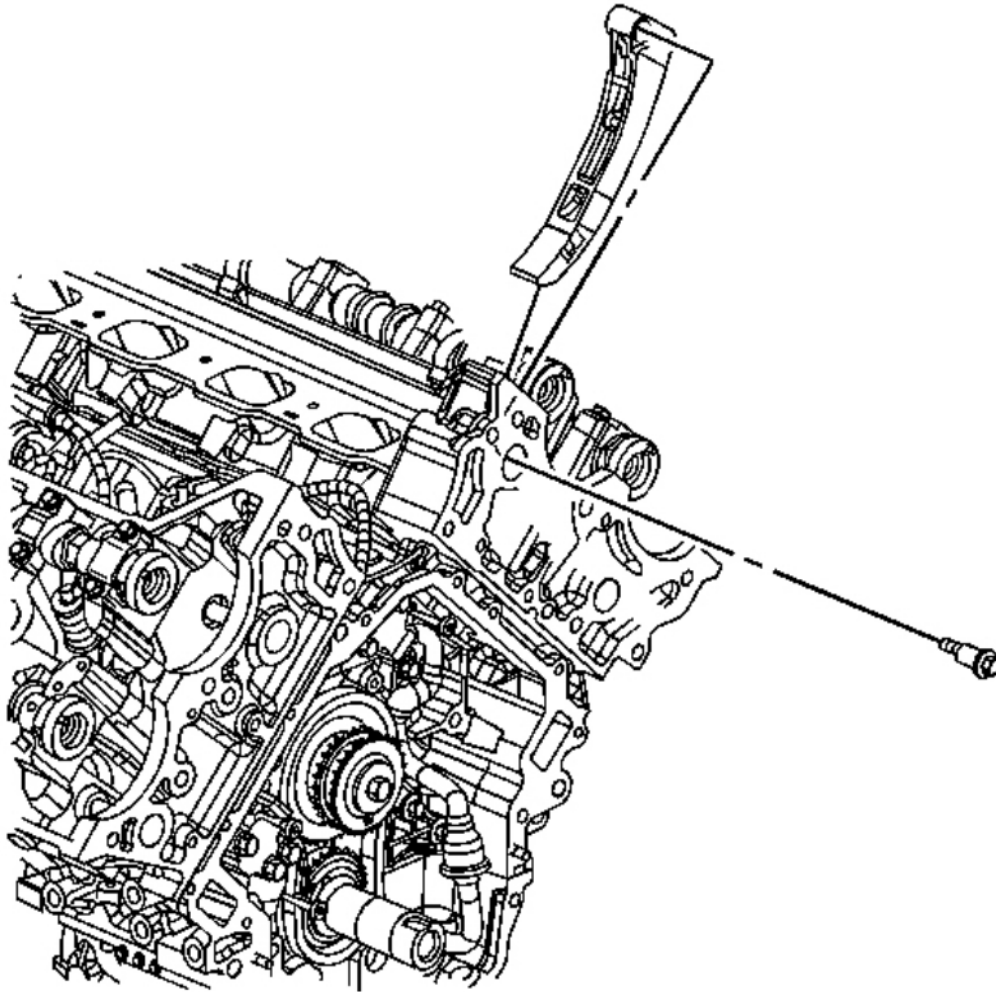


Fig. 243: View Of Left Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

5. Remove the left side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Left.**

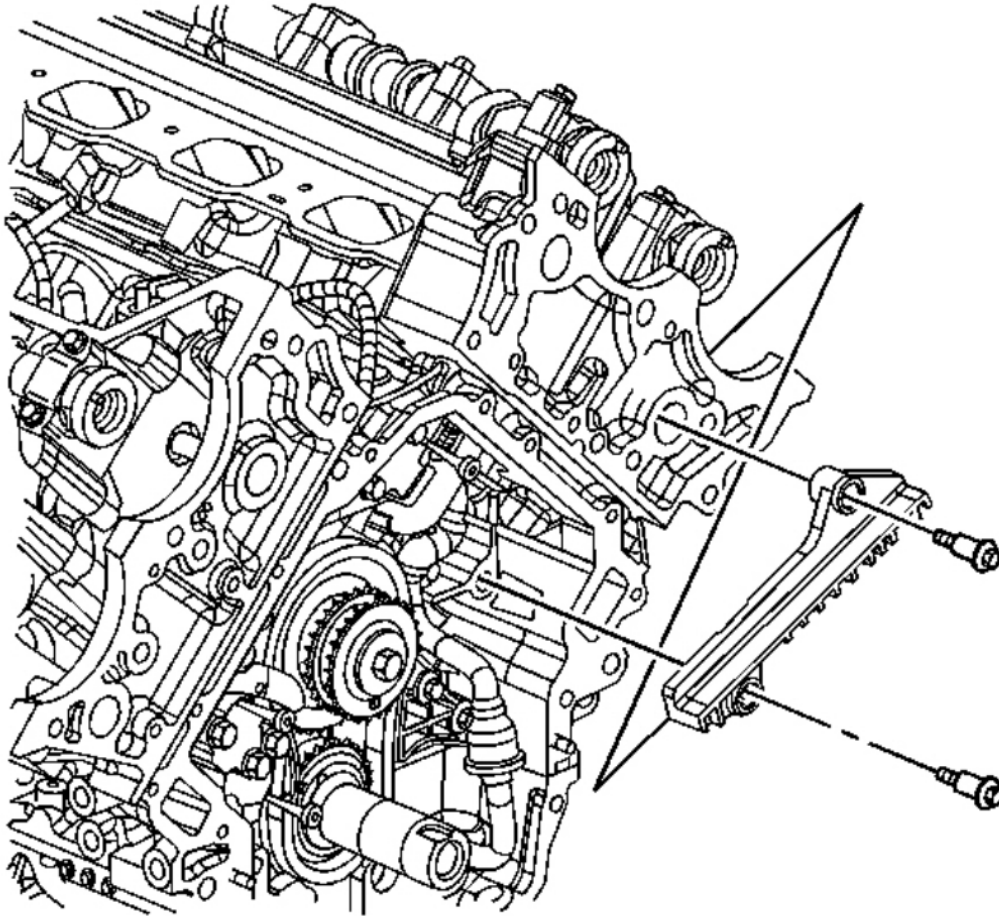


Fig. 244: View Of Left Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the left side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Left.**

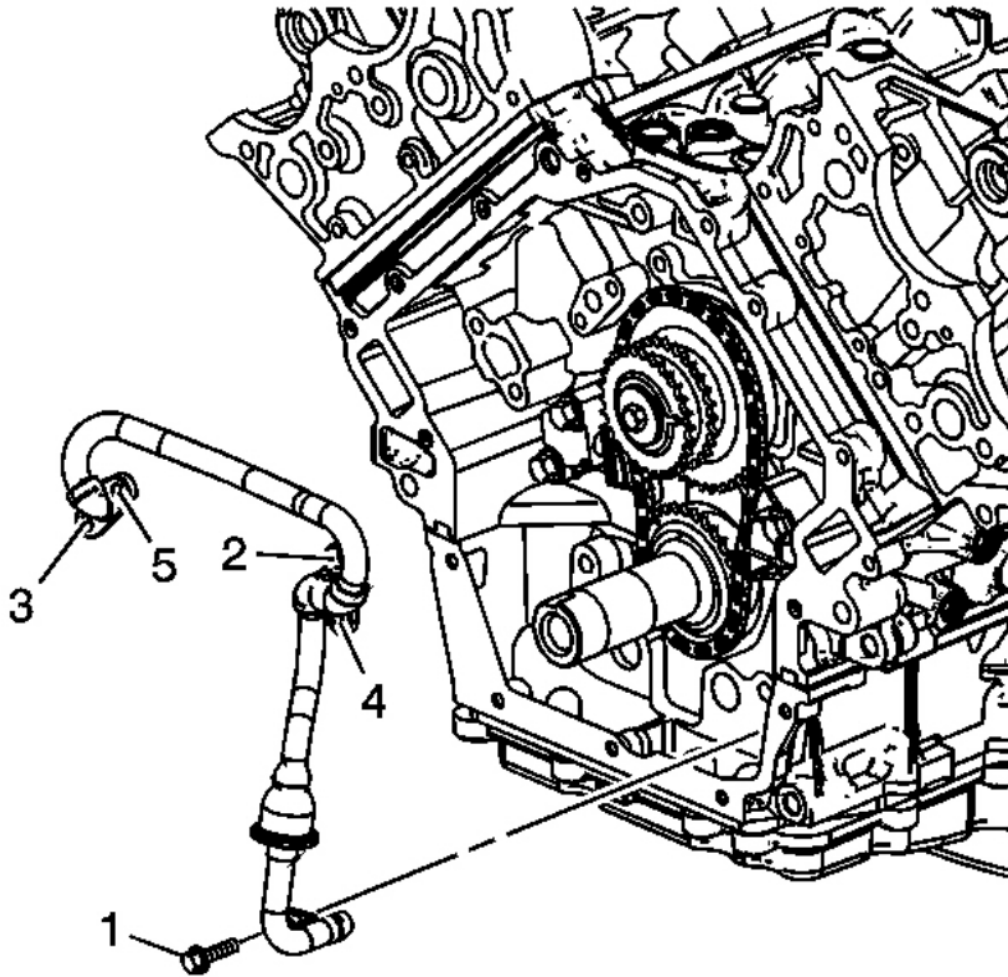


Fig. 245: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil outlet tube (4) from the engine. Refer to **Oil Outlet Tube Removal** .

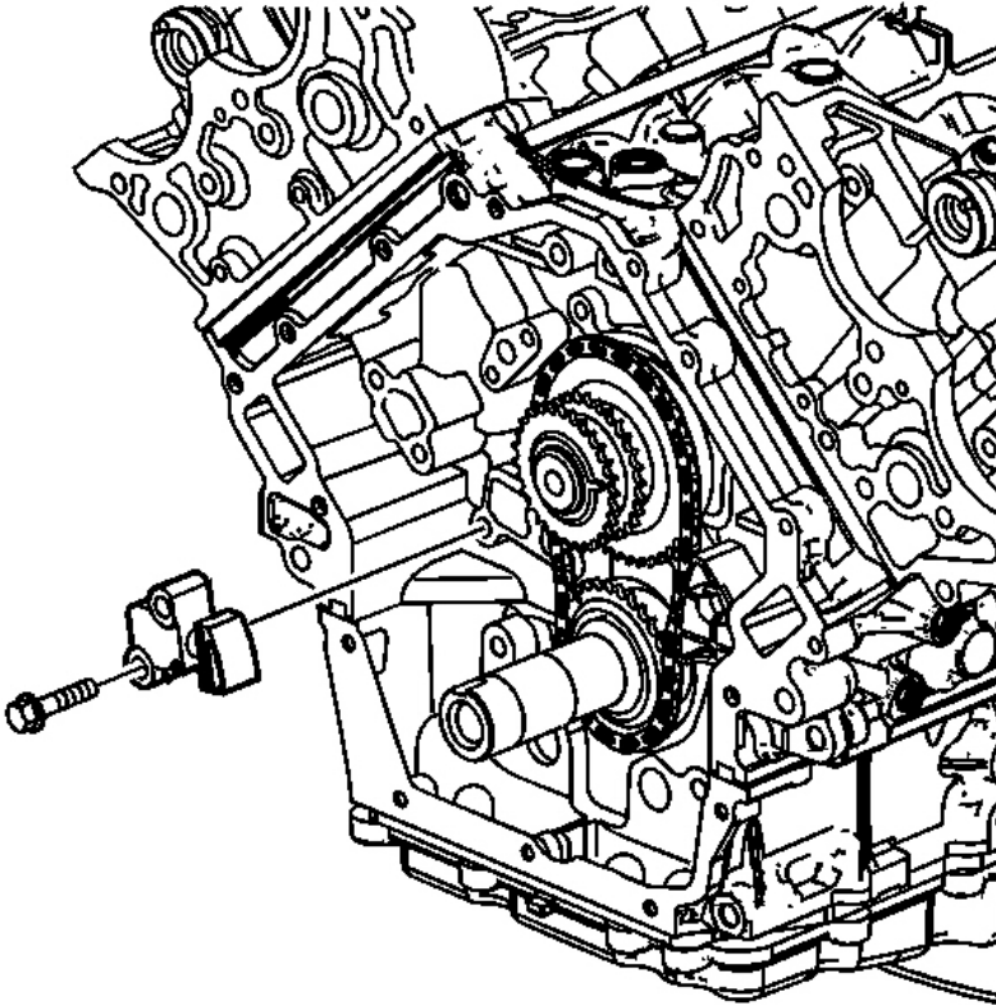


Fig. 246: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

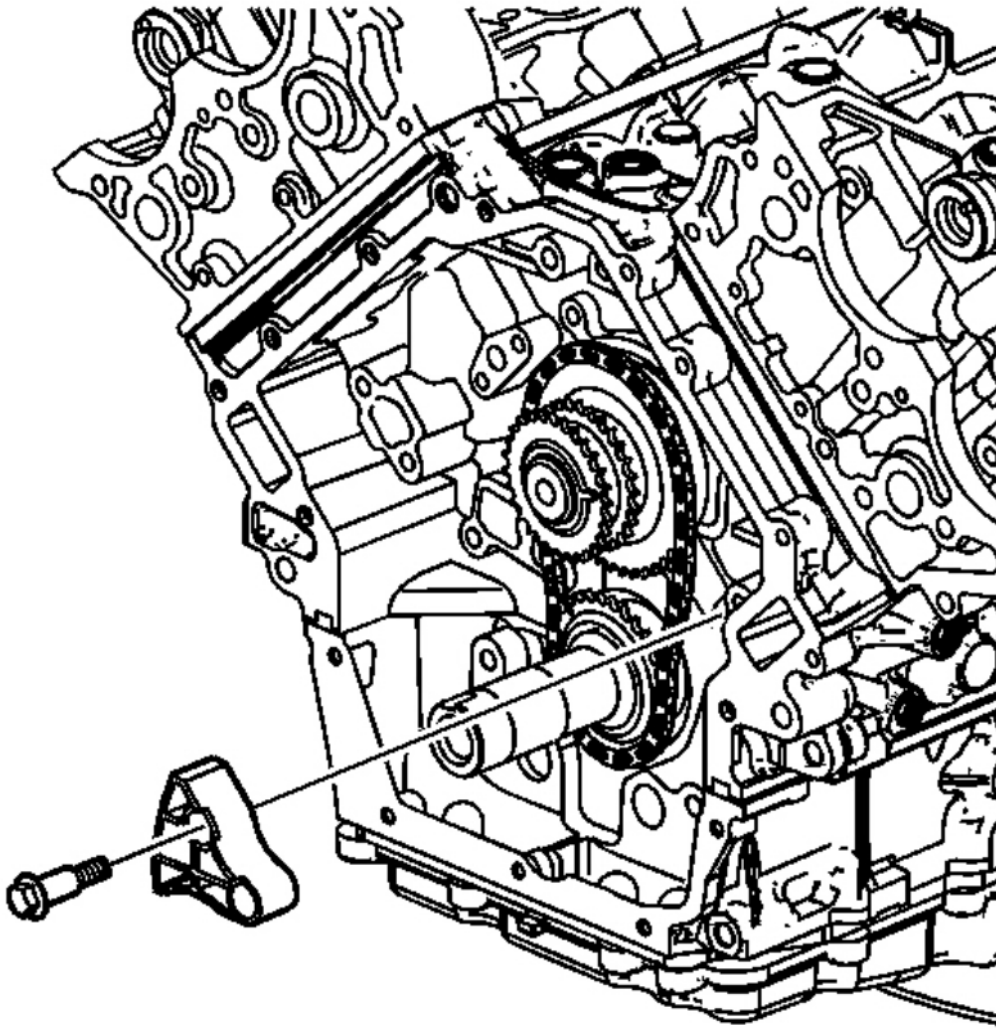


Fig. 247: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the bolts attaching the primary camshaft drive chain guide to the engine block.
10. Remove the primary camshaft drive chain guide.
11. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection** .

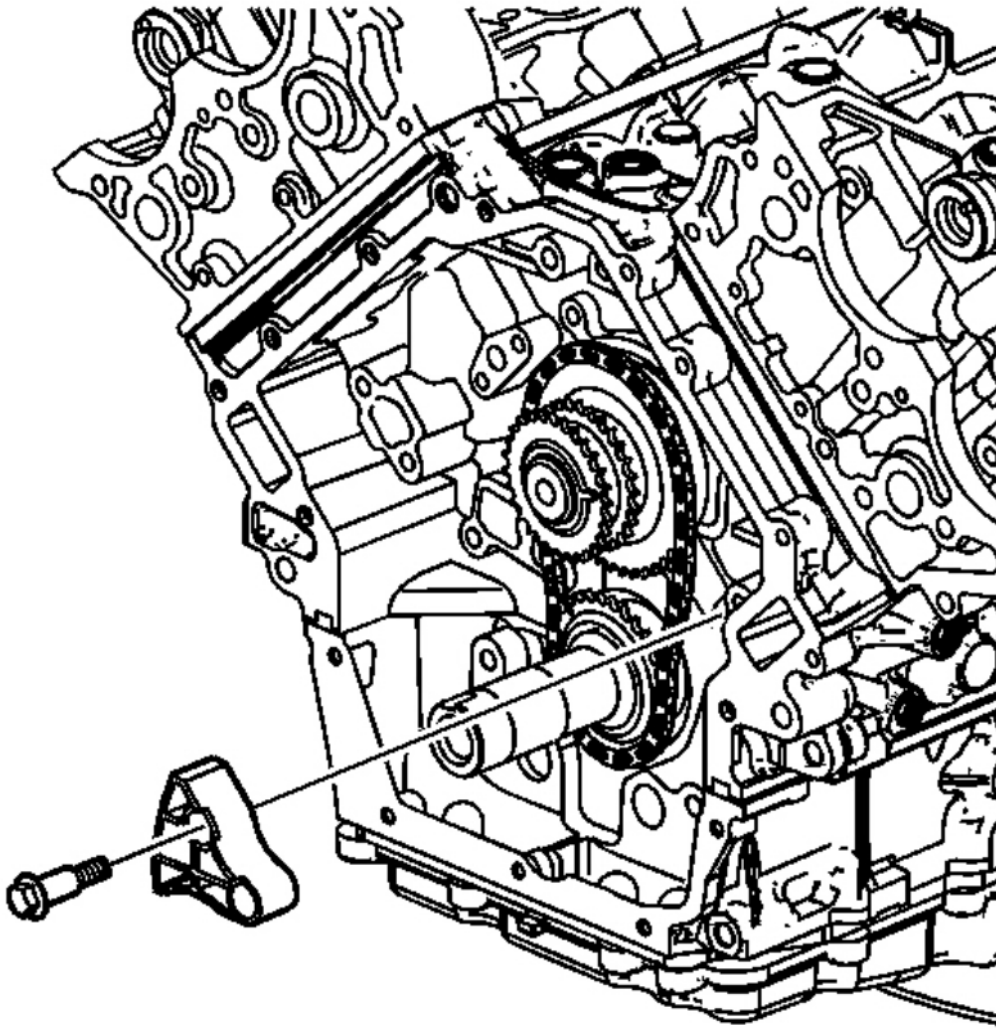


Fig. 248: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

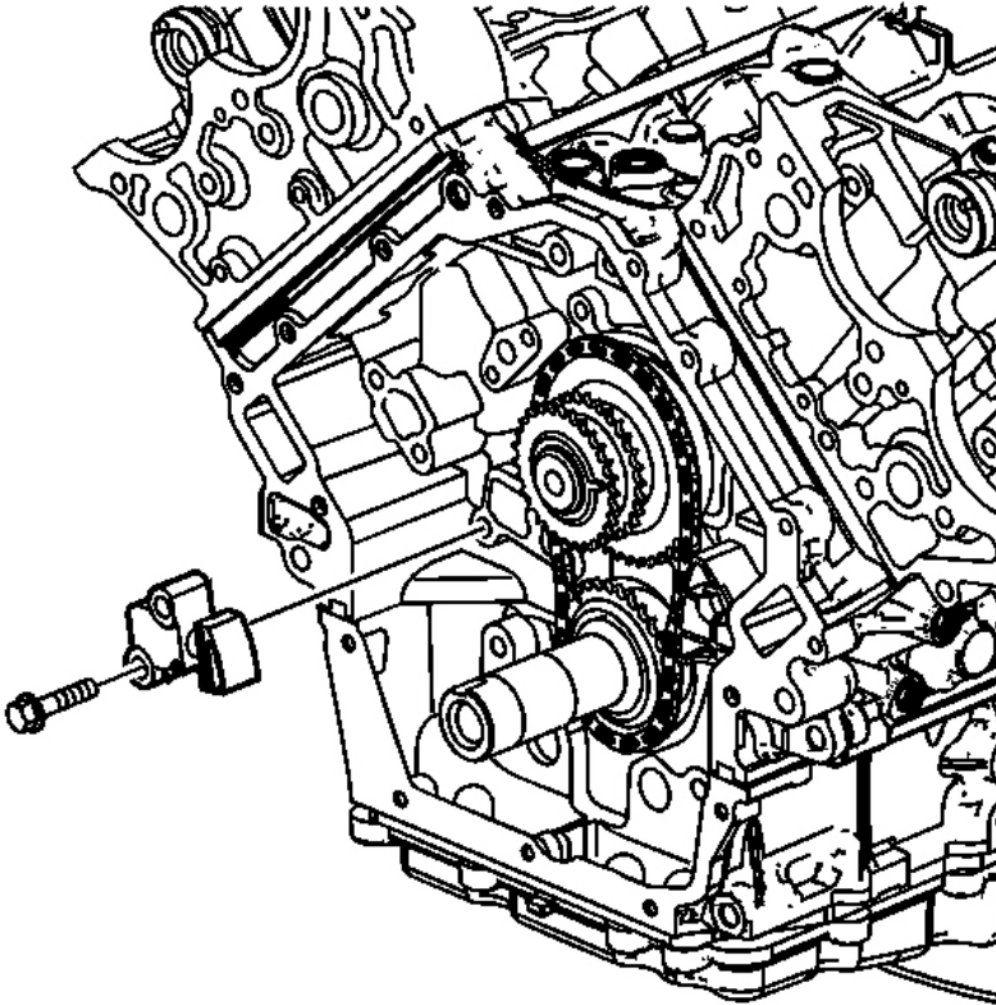


Fig. 249: View Of Primary Camshaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Install the primary camshaft drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

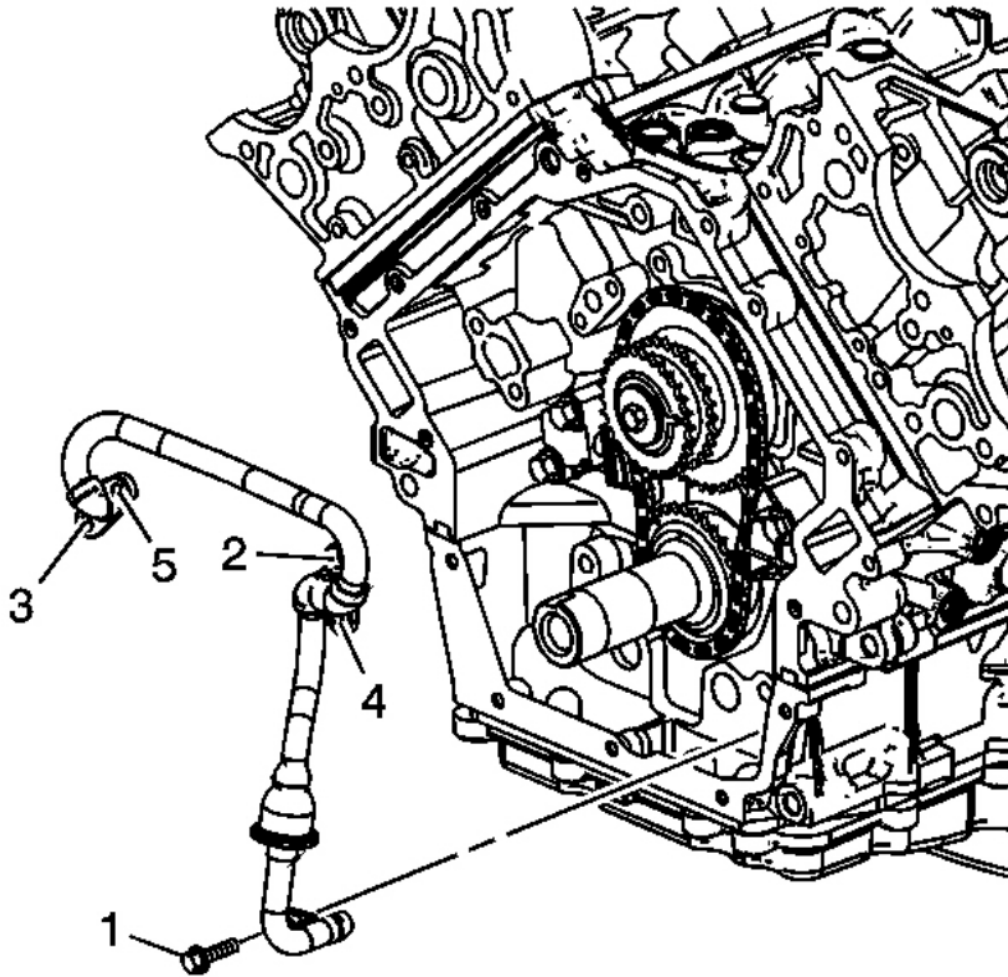


Fig. 250: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the oil outlet tube (4) to the engine. Refer to **Oil Outlet Tube Installation** .

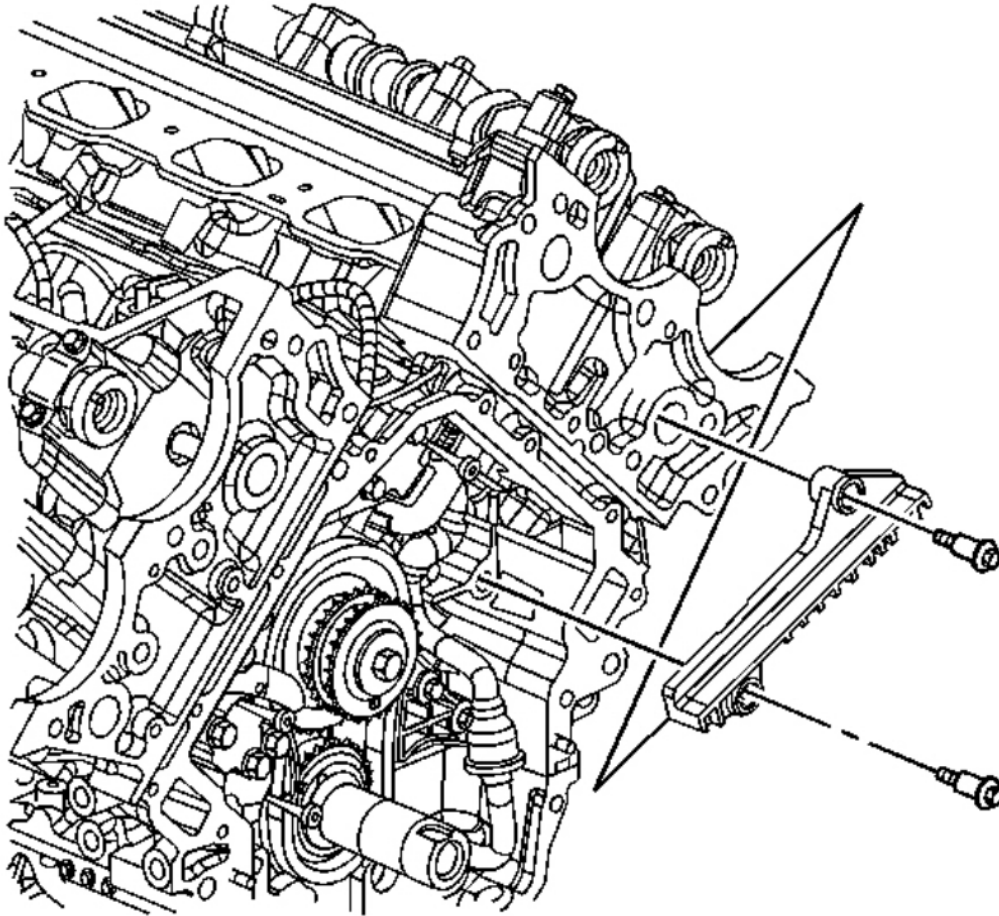


Fig. 251: View Of Left Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the left side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Left.**

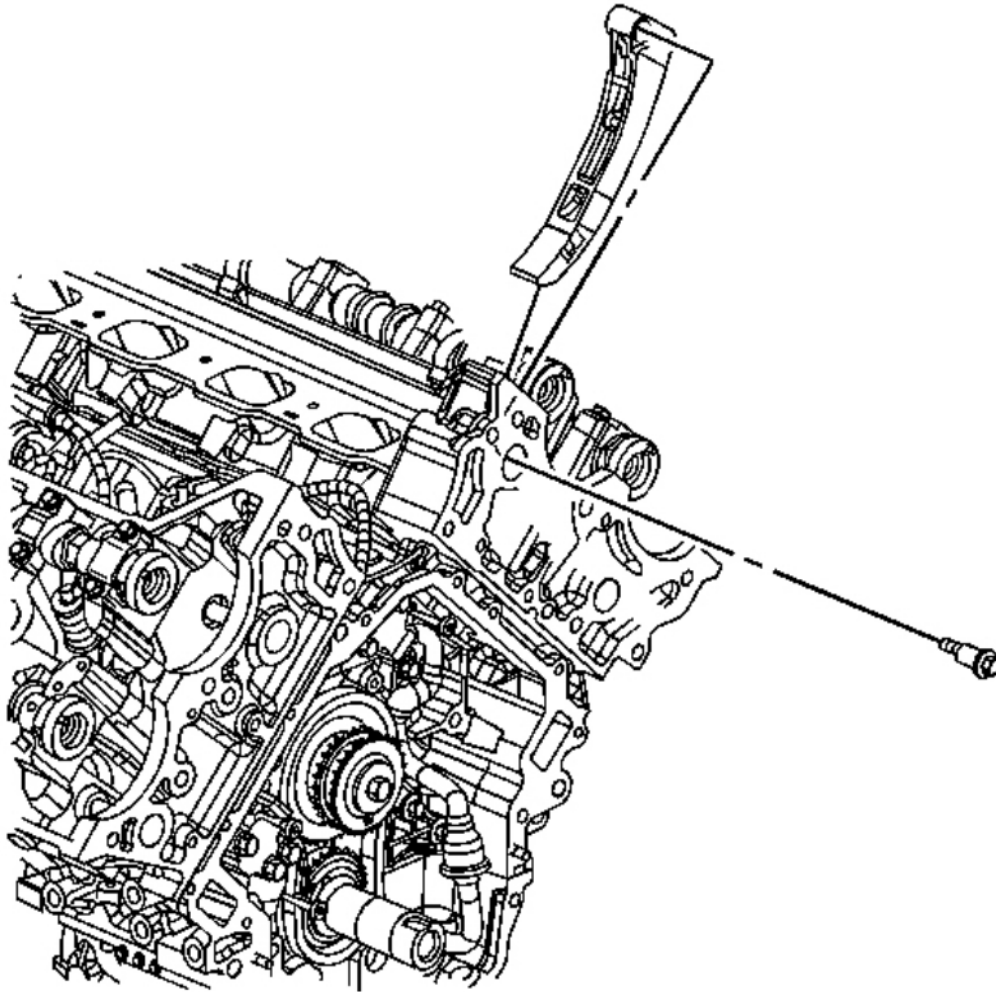


Fig. 252: View Of Left Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

5. Install the left side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Left.**

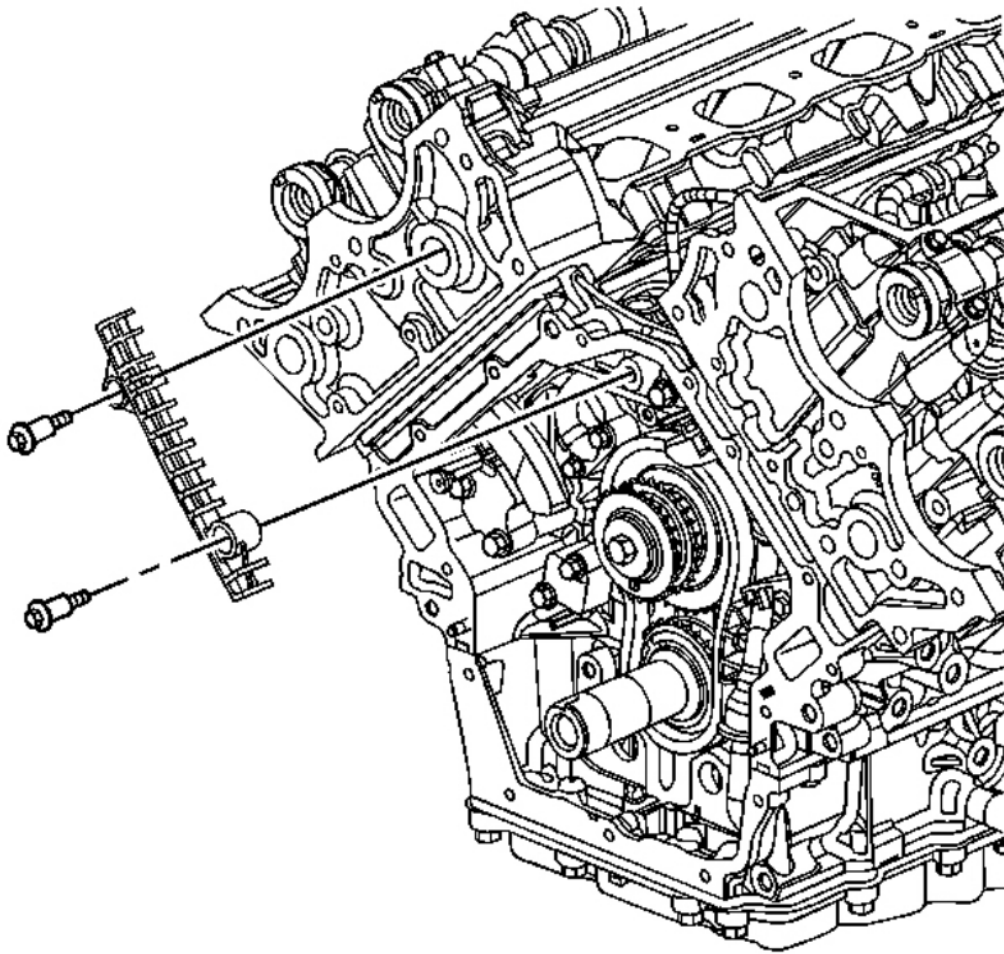


Fig. 253: View Of Right Side Secondary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the right side secondary camshaft drive chain guide. Refer to **Secondary Camshaft Drive Chain Guide Replacement - Right.**

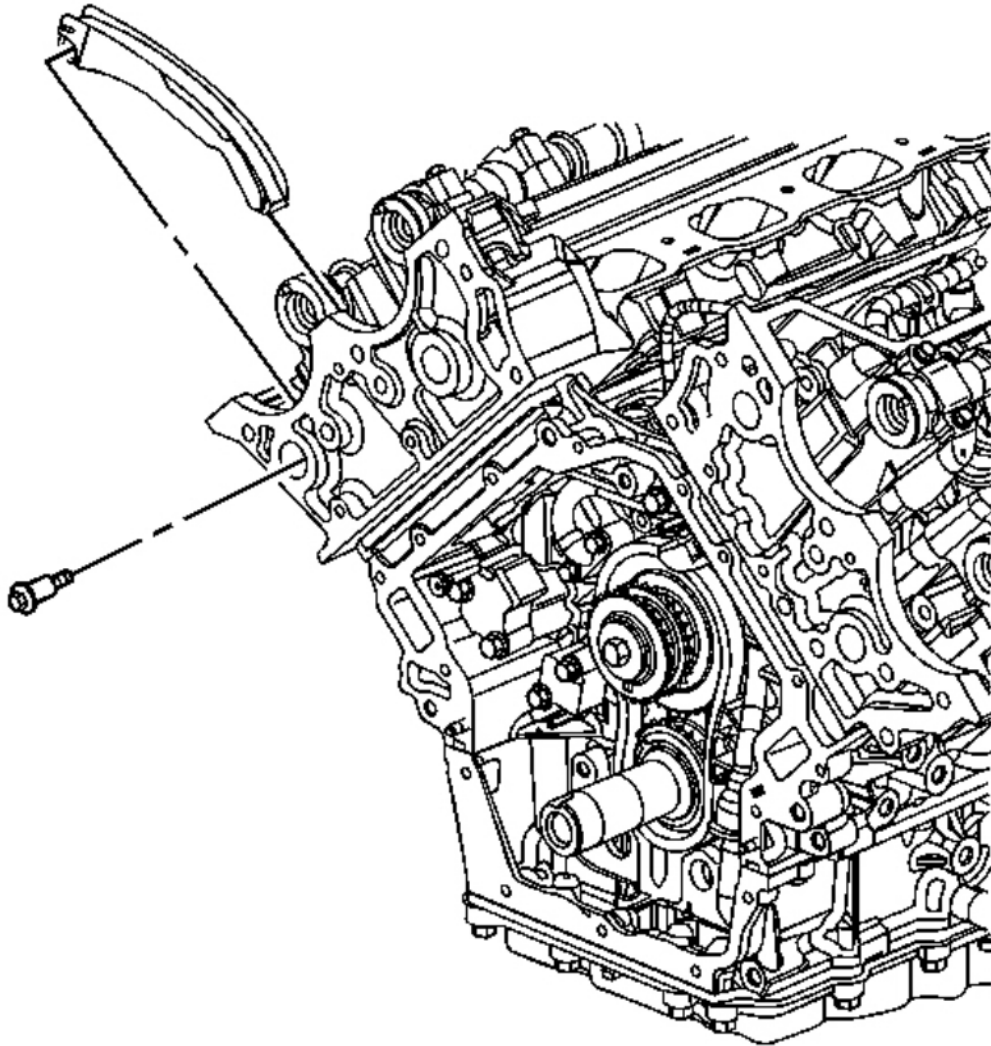


Fig. 254: View Of Right Side Secondary Camshaft Drive Chain Shoe
Courtesy of GENERAL MOTORS CORP.

7. Install the right side secondary camshaft drive chain shoe. Refer to **Secondary Camshaft Drive Chain Shoe Replacement - Right.**

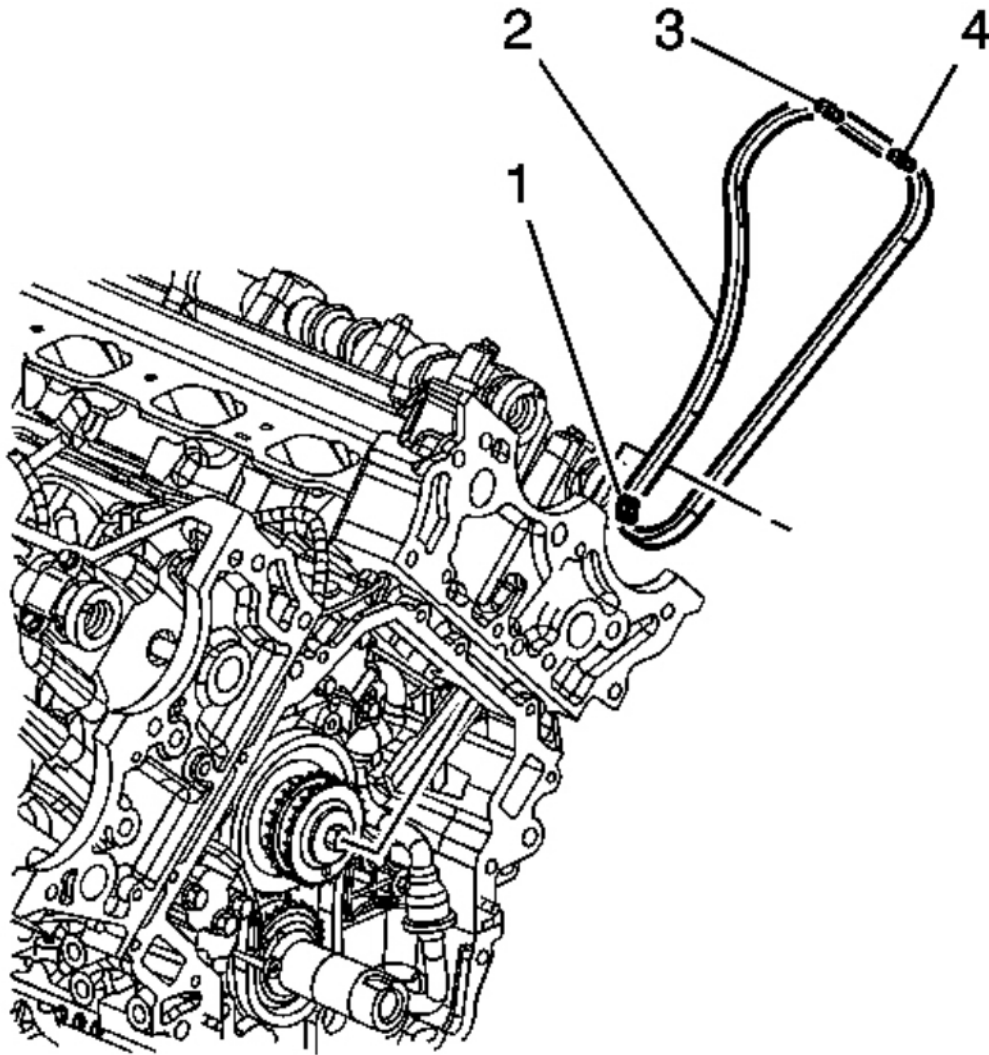


Fig. 255: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

8. Install the left side secondary camshaft drive chain (2). Refer to **Secondary Camshaft Drive Chain Replacement - Left.**

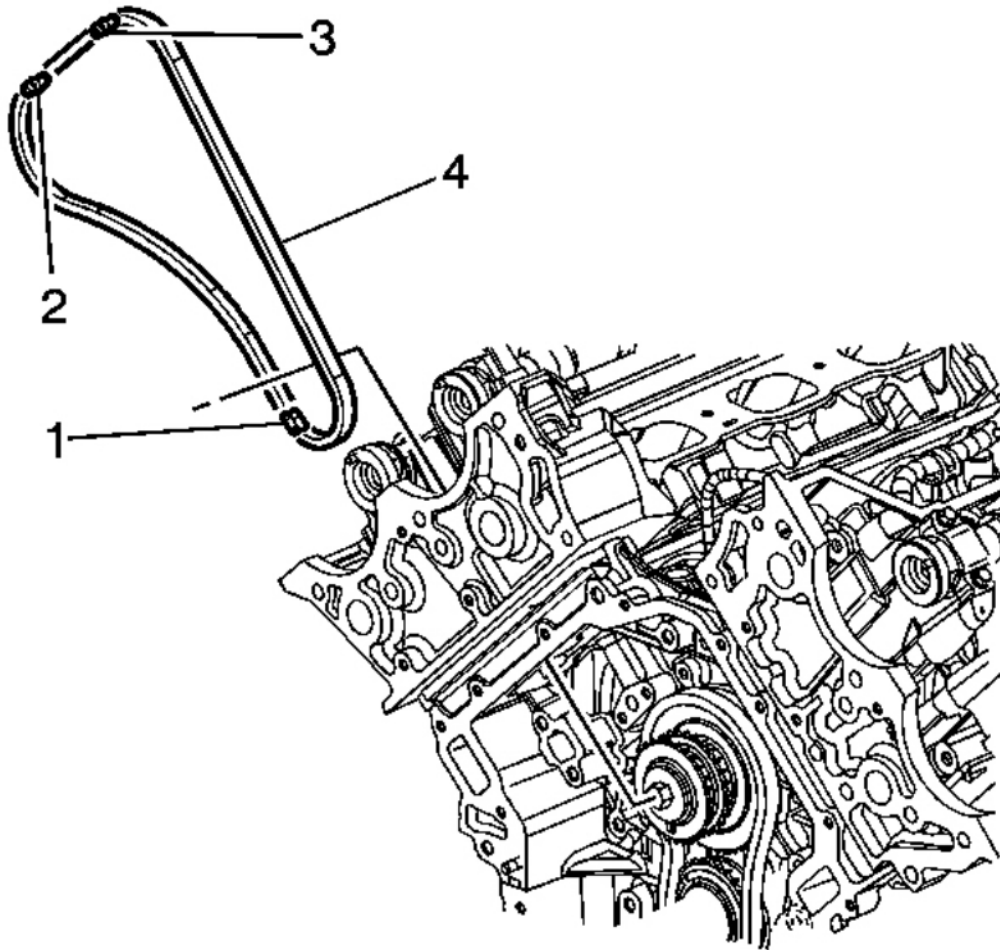


Fig. 256: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

9. Install the right side secondary camshaft drive chain (4). Refer to **Secondary Camshaft Drive Chain Replacement - Right**.

PRIMARY CAMSHAFT DRIVE CHAIN AND SPROCKETS REPLACEMENT

Tools Required

J 39946 Crankshaft Socket

Removal Procedure

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

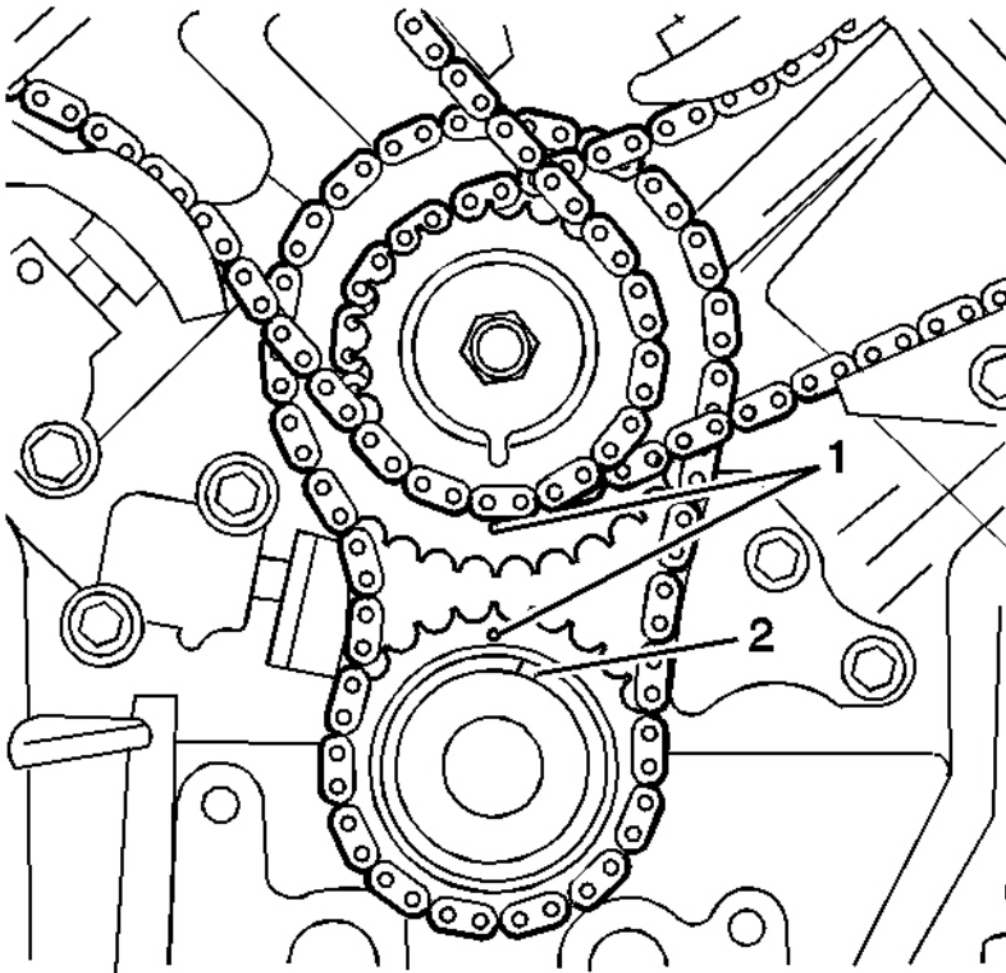


Fig. 257: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

2. Align the primary timing marks (1) using the J 39946 .
3. Remove the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Right** and **Secondary Camshaft Drive Chain Replacement - Left**.
4. Remove the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain**

Tensioner Replacement.

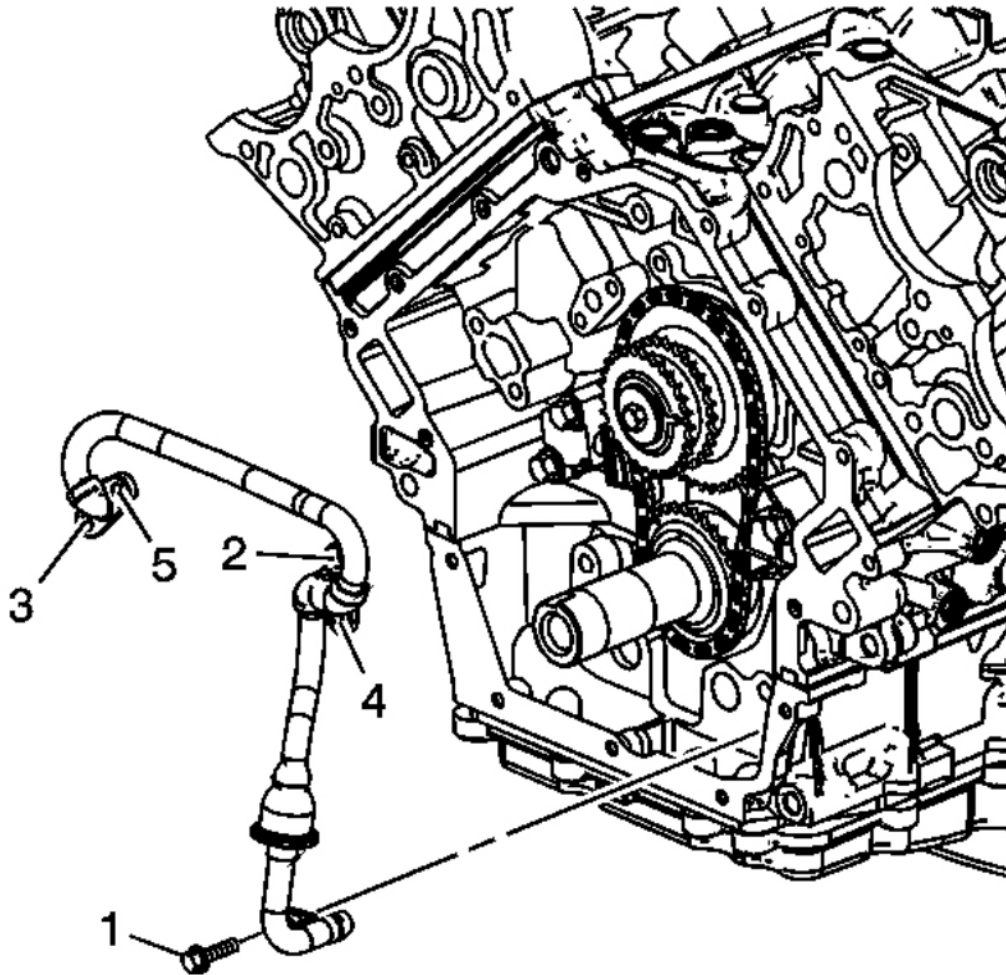


Fig. 258: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil outlet tube (4).

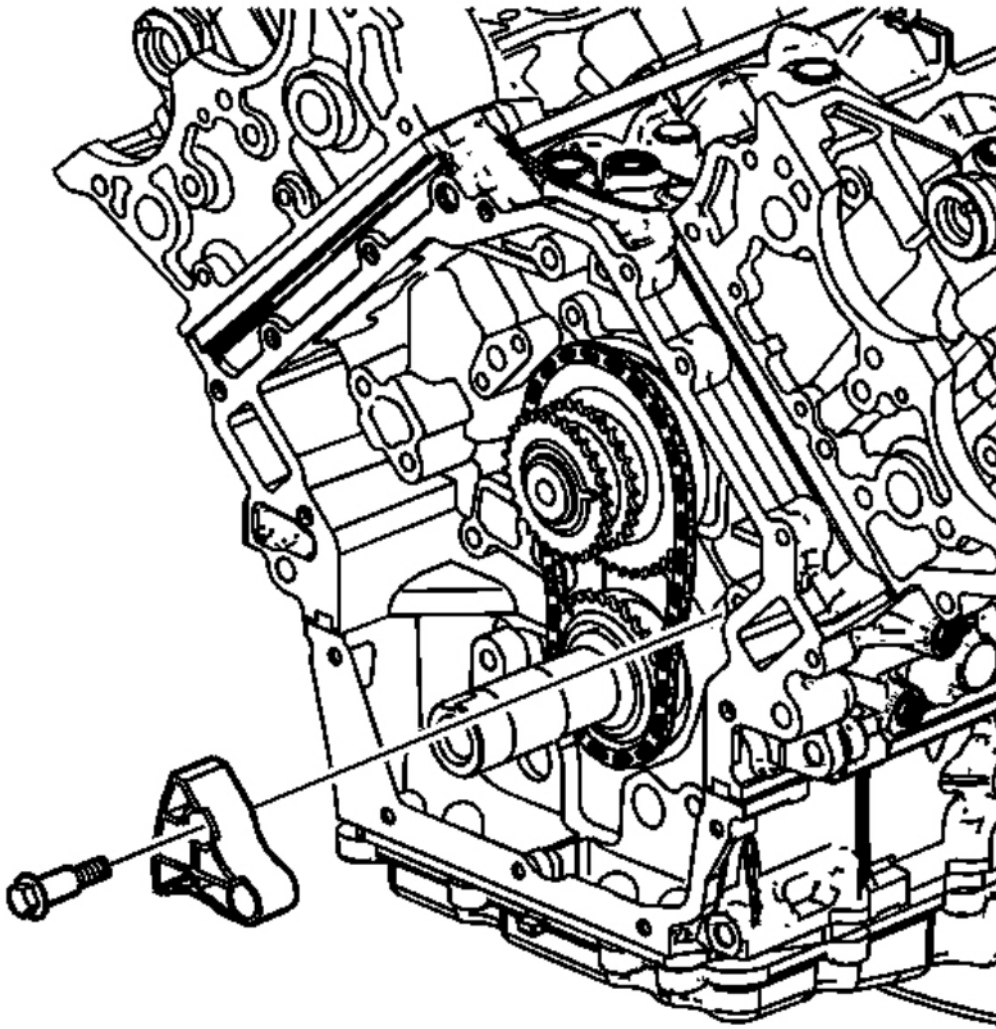


Fig. 259: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the primary camshaft drive chain guide bolts and guide.

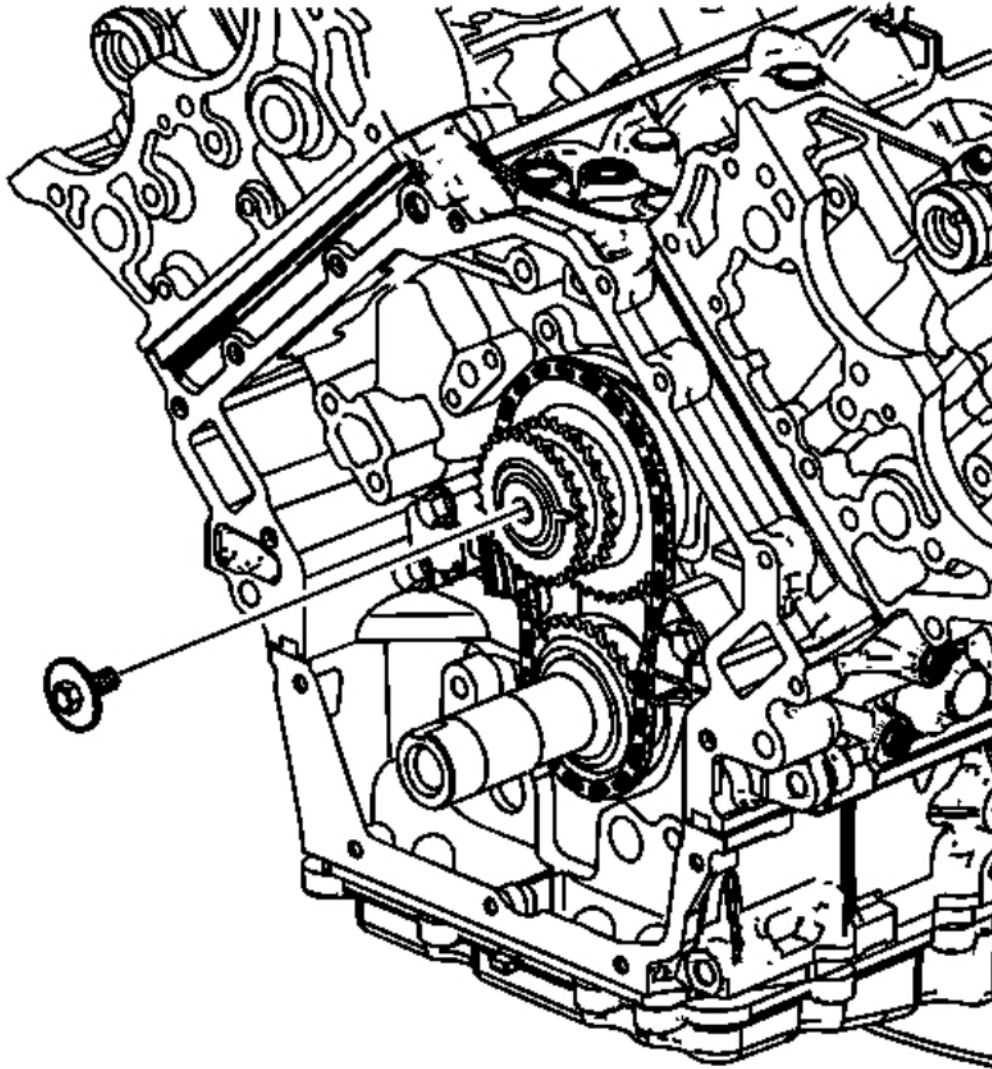


Fig. 260: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft intermediate sprocket retaining bolt.

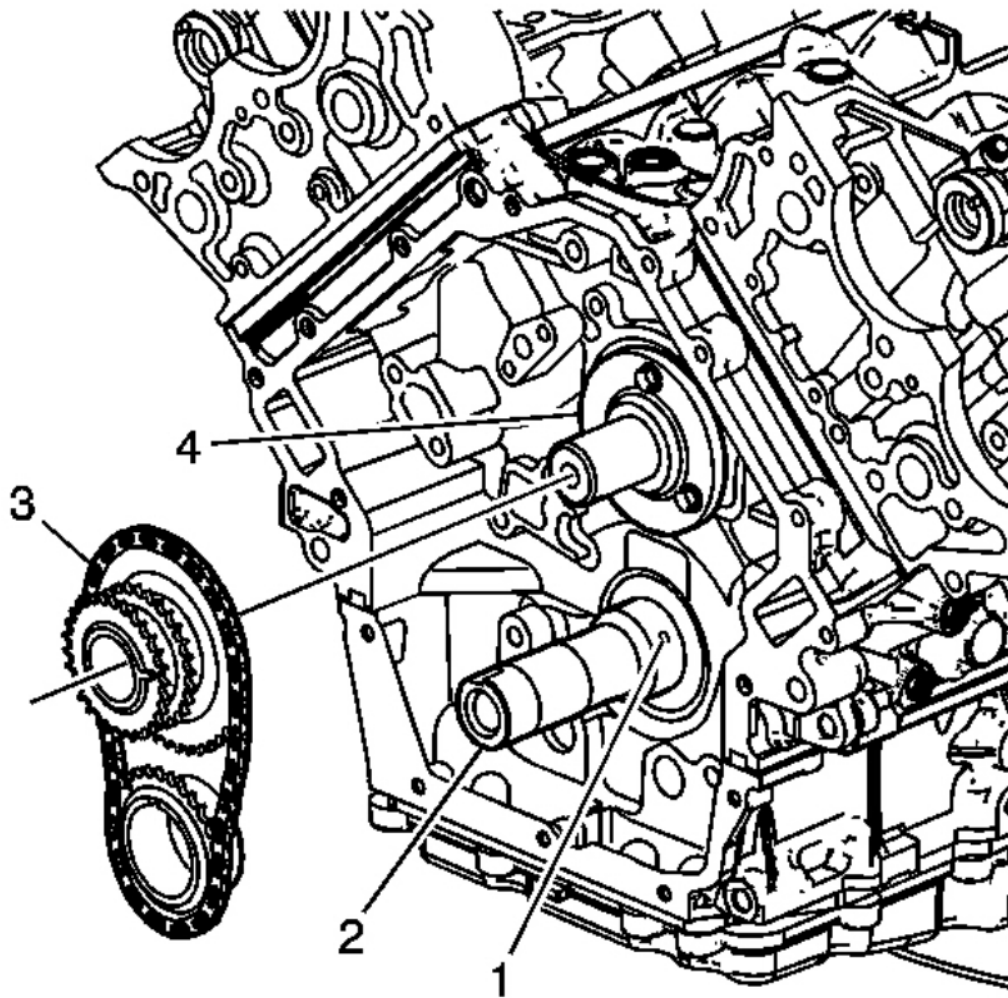


Fig. 261: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

8. Remove the following as an assembly:
 - The primary camshaft drive chain (3)
 - The crankshaft sprocket
 - The camshaft intermediate sprocket
9. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive**

Components Cleaning and Inspection .

Installation Procedure

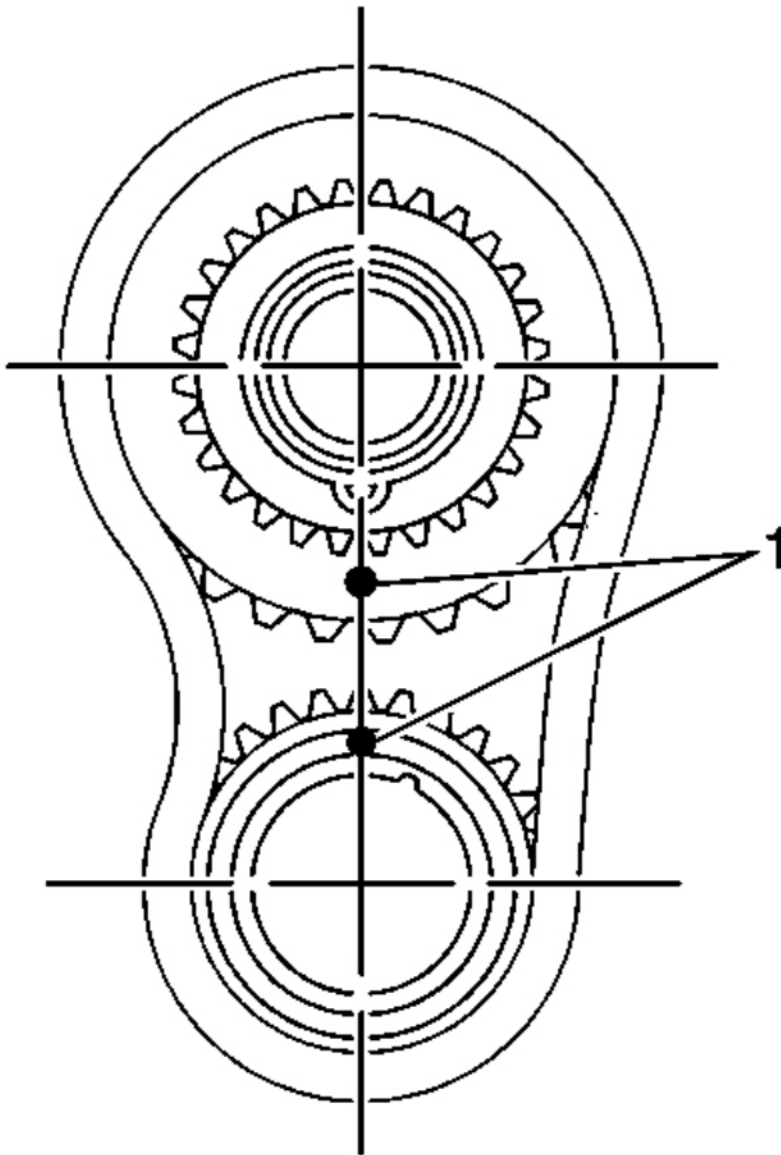


Fig. 262: Aligning Timing Marks Of Camshaft Intermediate & Crankshaft Sprockets

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.

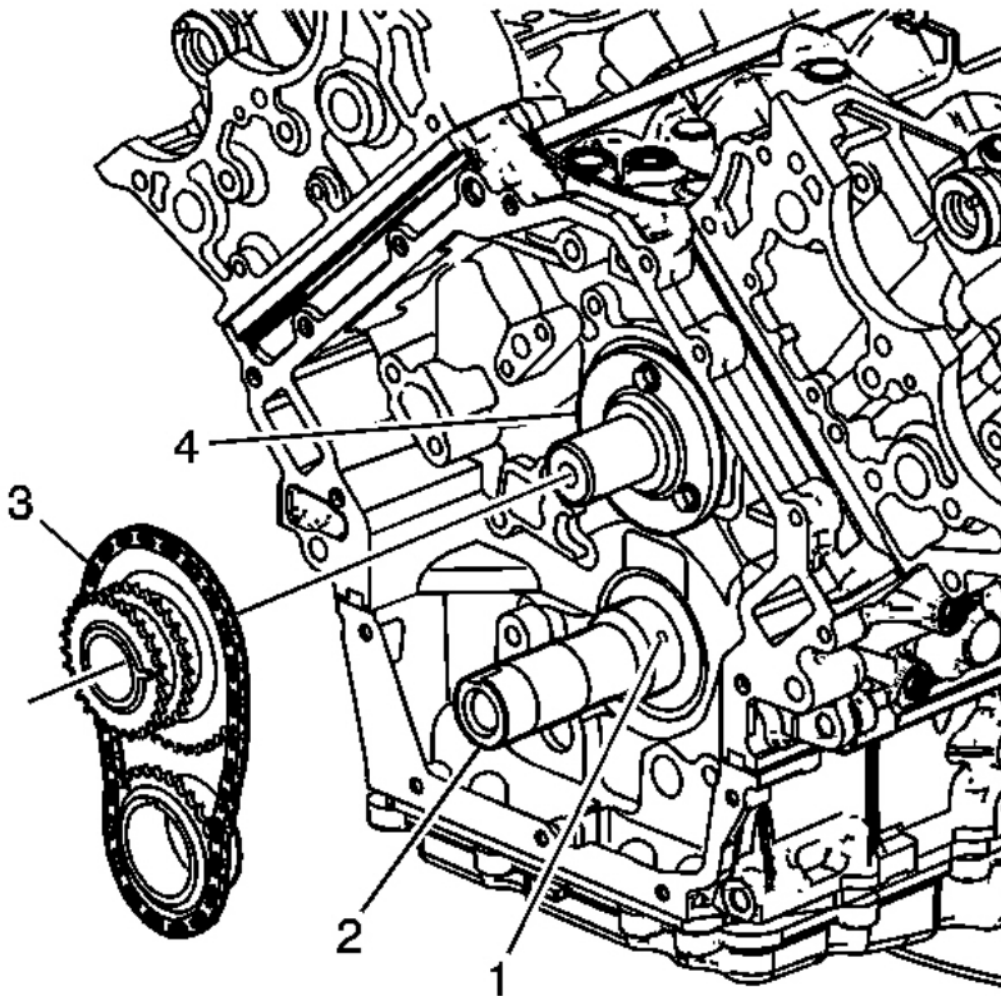


Fig. 263: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket

Courtesy of GENERAL MOTORS CORP.

3. Use the **J 39946** to rotate the crankshaft until the crankshaft keyway is approximately at the 1 o'clock position.
4. Install the following as an assembly:
 - The primary camshaft drive chain (3)
 - The crankshaft sprocket
 - The camshaft intermediate sprocket

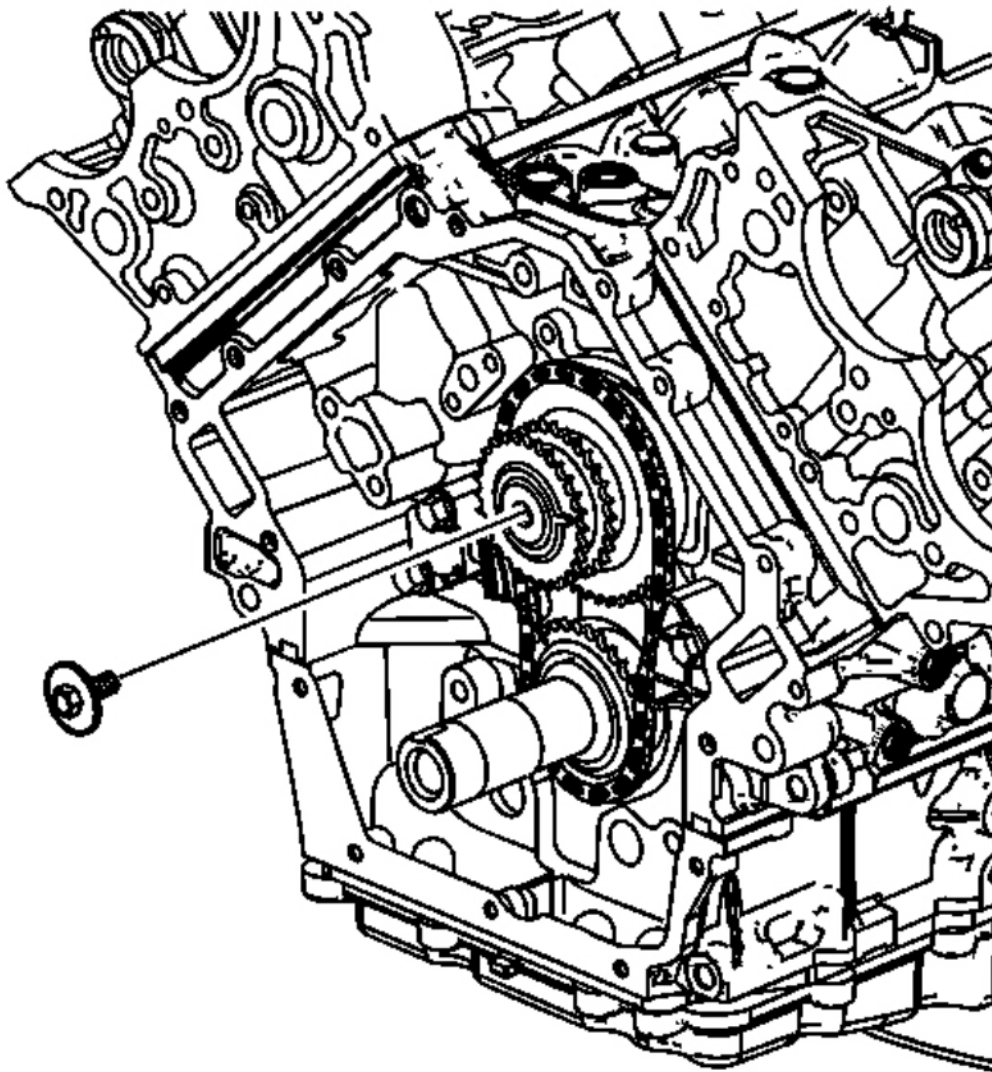


Fig. 264: View Of Camshaft Intermediate Sprocket Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the camshaft intermediate sprocket retaining bolt.

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

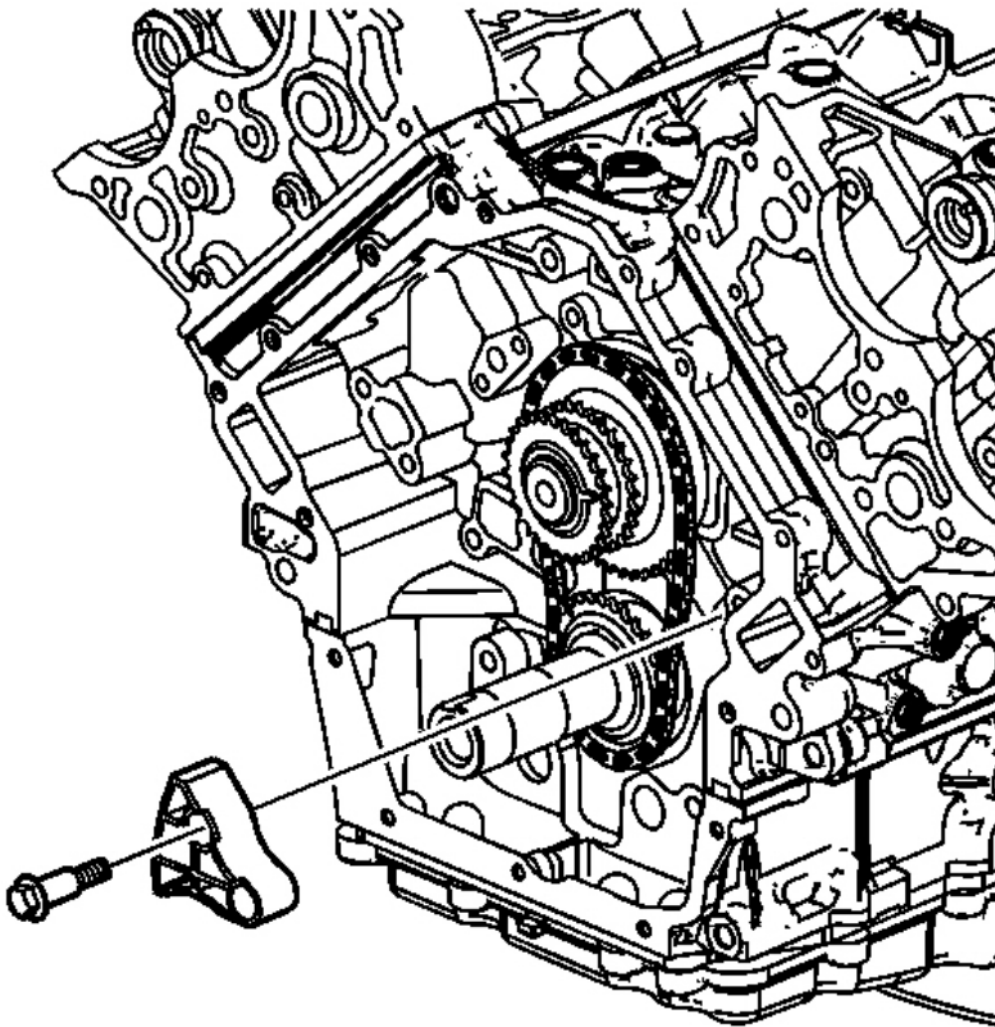


Fig. 265: View Of Primary Camshaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the primary drive chain guide.
7. Install the primary drive chain guide bolts.

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

8. Install the primary drive chain tensioner. Refer to **Primary Camshaft Drive Chain Tensioner Replacement**.

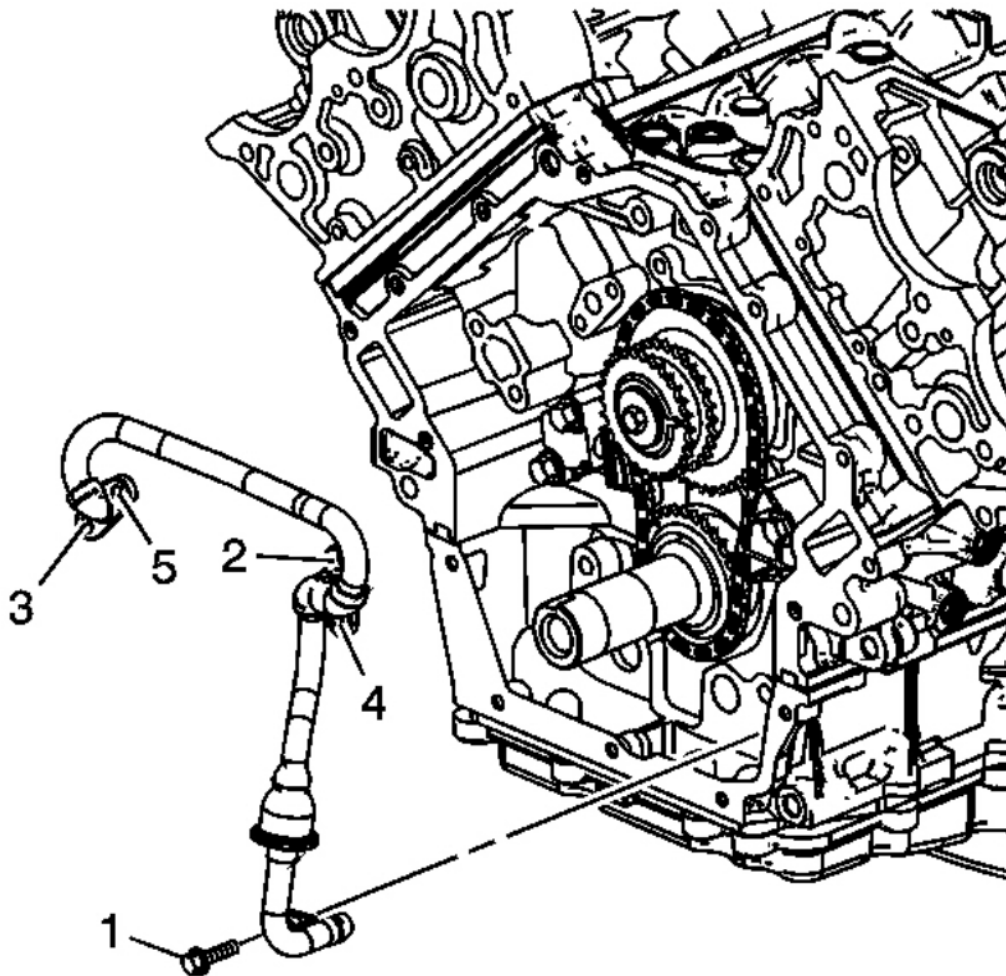


Fig. 266: View Of Oil Outlet Tube Bolts
Courtesy of GENERAL MOTORS CORP.

9. Install the oil outlet tube (4) and bolts.

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

10. Install the secondary camshaft drive chains. Refer to **Secondary Camshaft Drive Chain Replacement - Left** and **Secondary Camshaft Drive Chain Replacement - Right**.
11. Remove the pin from the primary timing chain tensioner release lever.

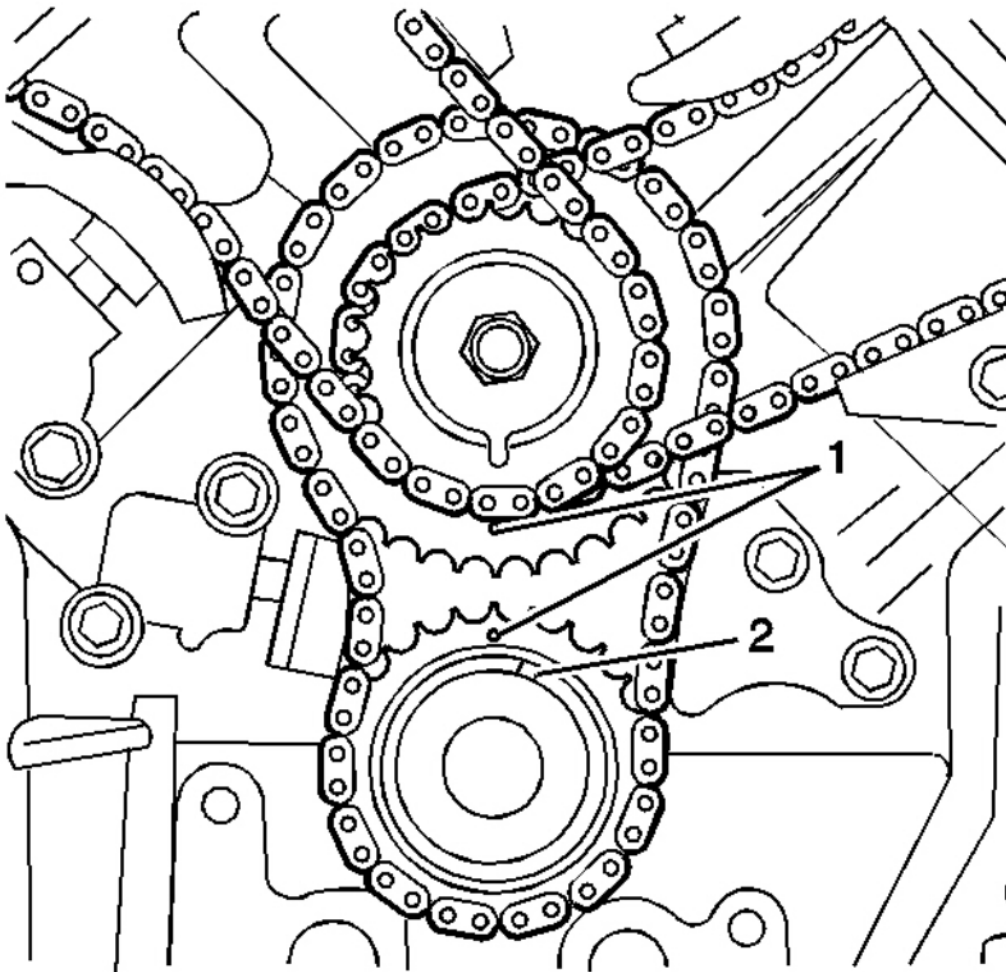


Fig. 267: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

12. Ensure the primary timing marks (1) are aligned vertically.
13. 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**.

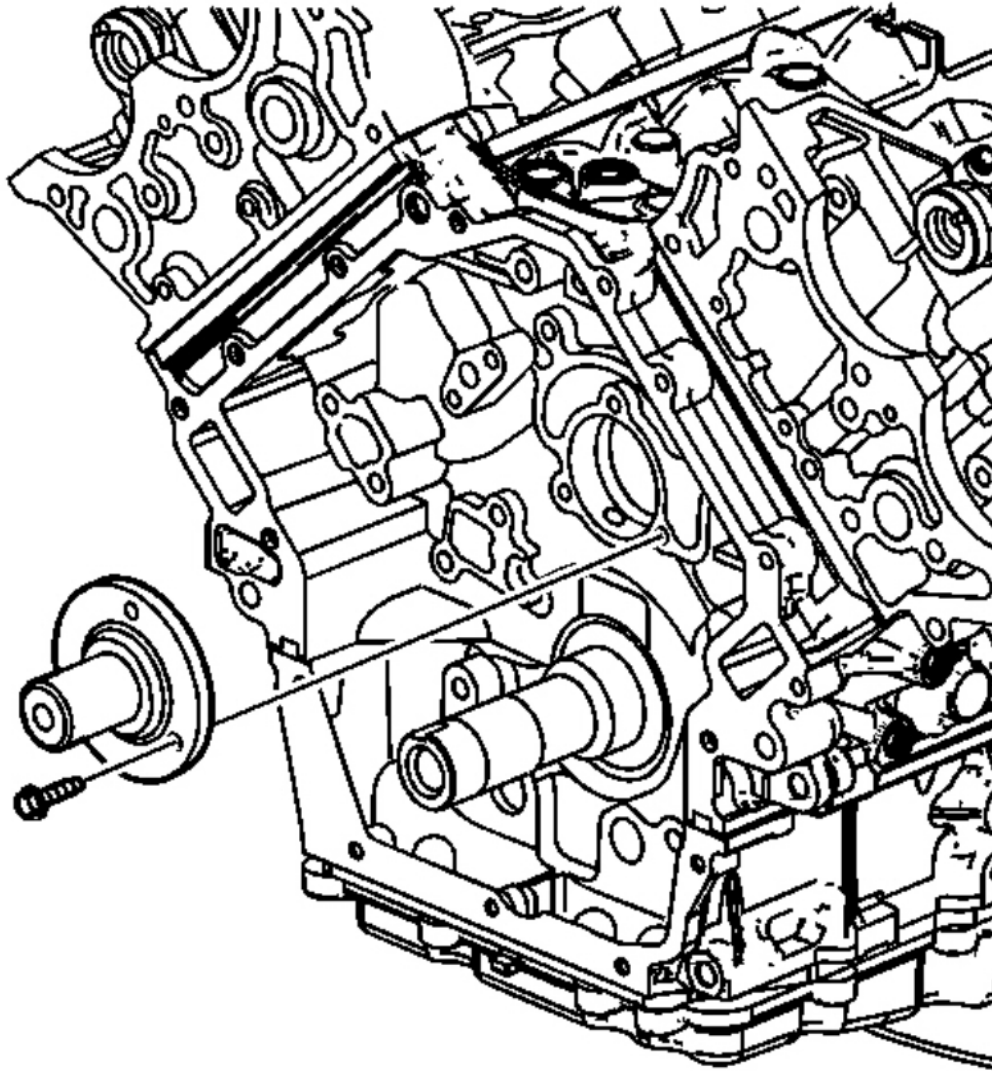


Fig. 268: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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 from the engine.
4. Clean and inspect the camshaft intermediate driveshaft. Refer to **Camshaft Intermediate Drive Shaft Cleaning and Inspection** .

Installation Procedure

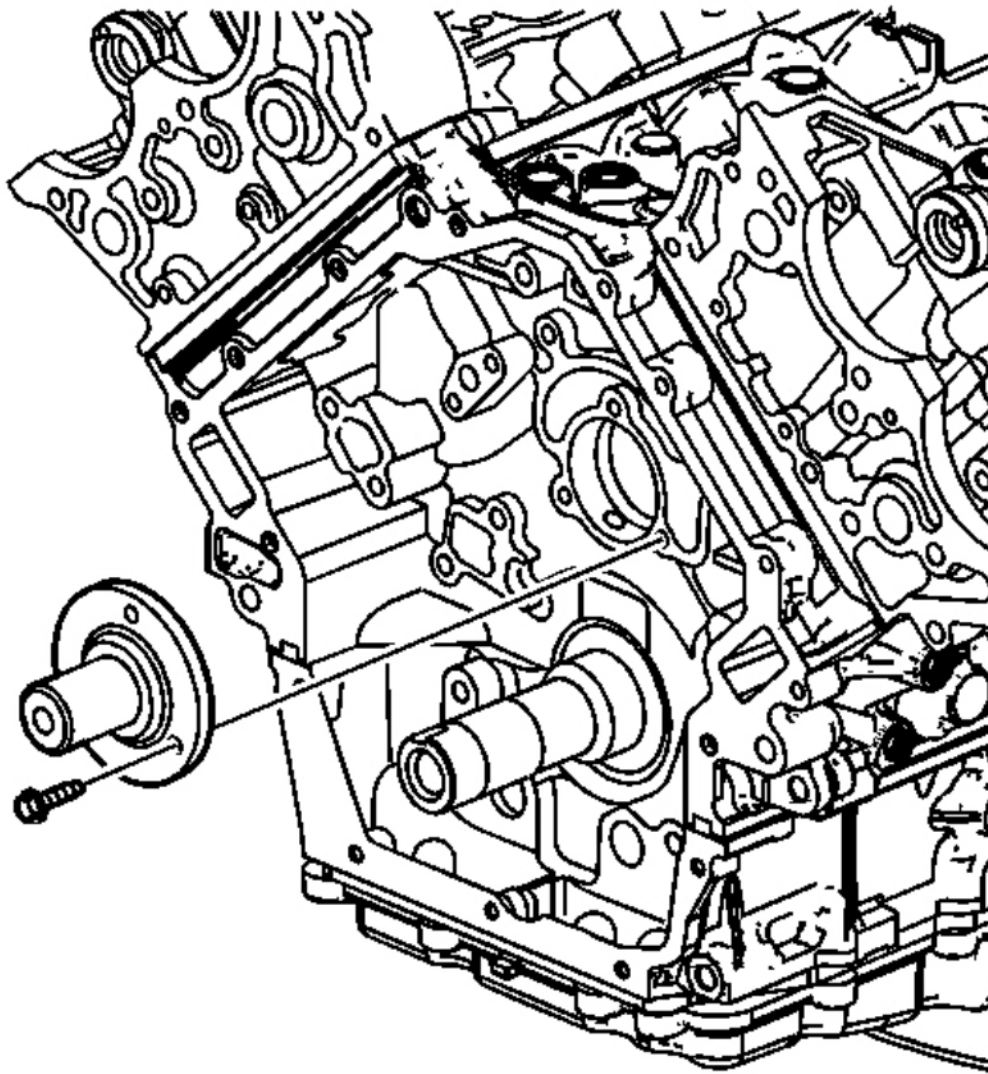


Fig. 269: View Of Intermediate Sprocket Shaft & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the camshaft intermediate drive shaft retaining bolts.

Tighten: Tighten the camshaft intermediate drive shaft retaining bolts to 10 N.m (89 lb in).

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

CAMSHAFT POSITION (CMP) ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK BANK 1 (RIGHT) INTAKE

Tools Required

- J 39946 Crankshaft Socket
- EN 46327 Timing Chain Retention Tool
- EN 46328 Camshaft Holding Tool

Removal Procedure

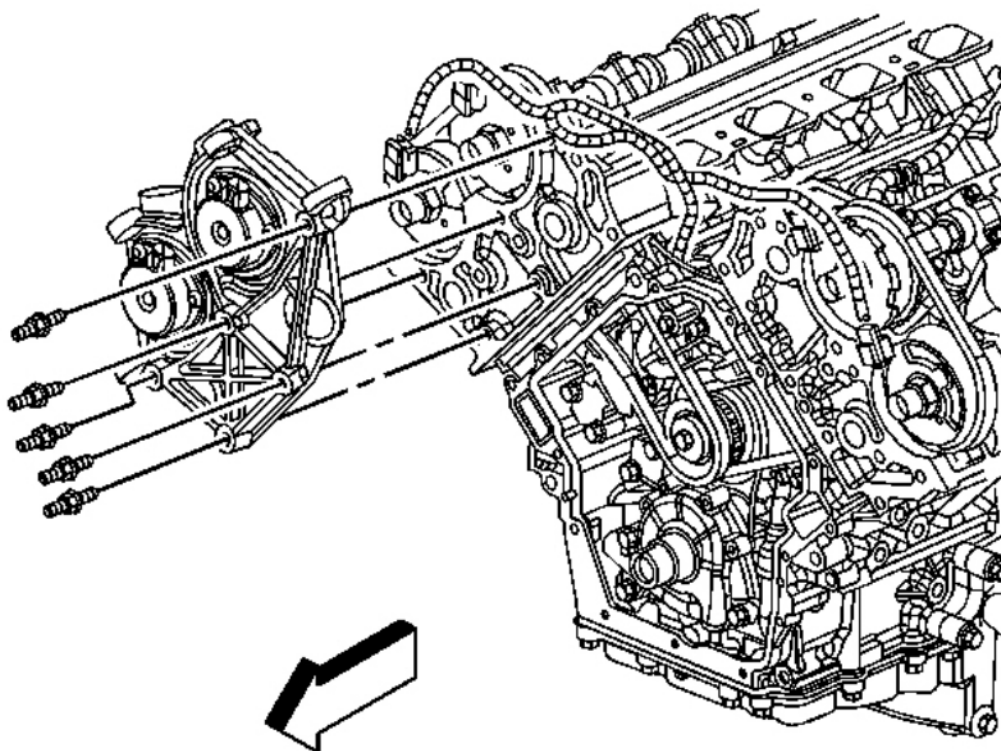


Fig. 270: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the right actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the J 39946 , rotate the crankshaft until both bank 1 (right) CMP actuator timing

marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation.

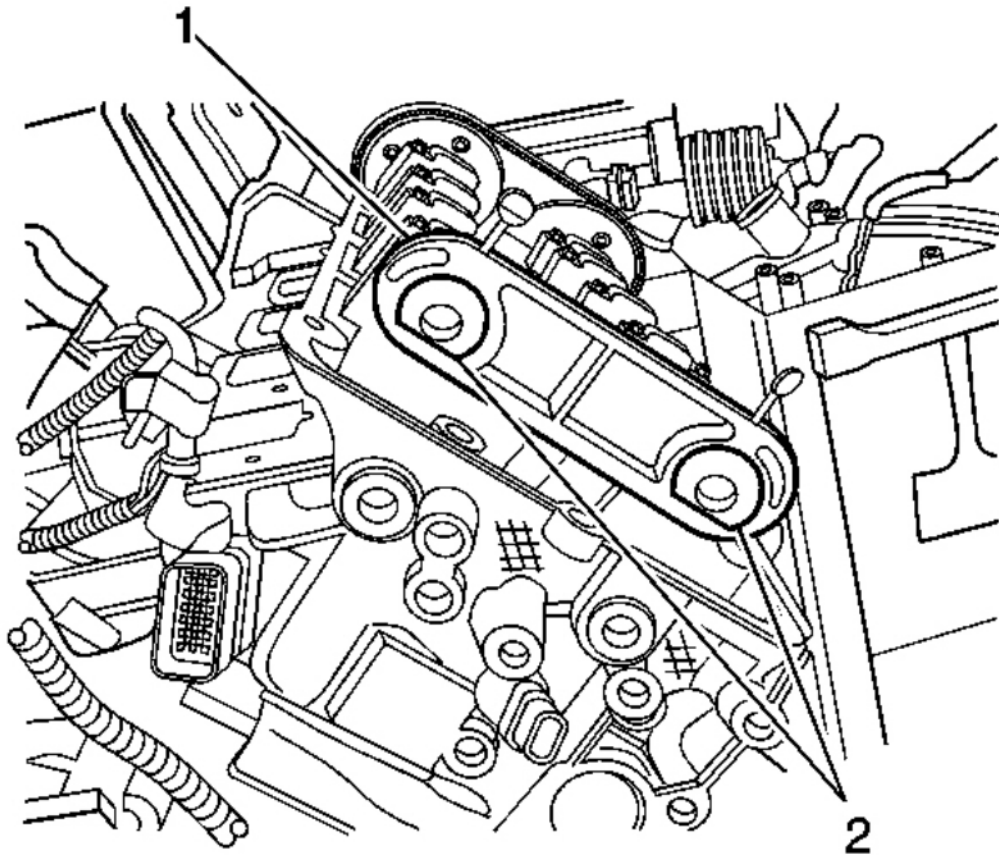


Fig. 271: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the EN 46328 (1) to the camshafts (2).

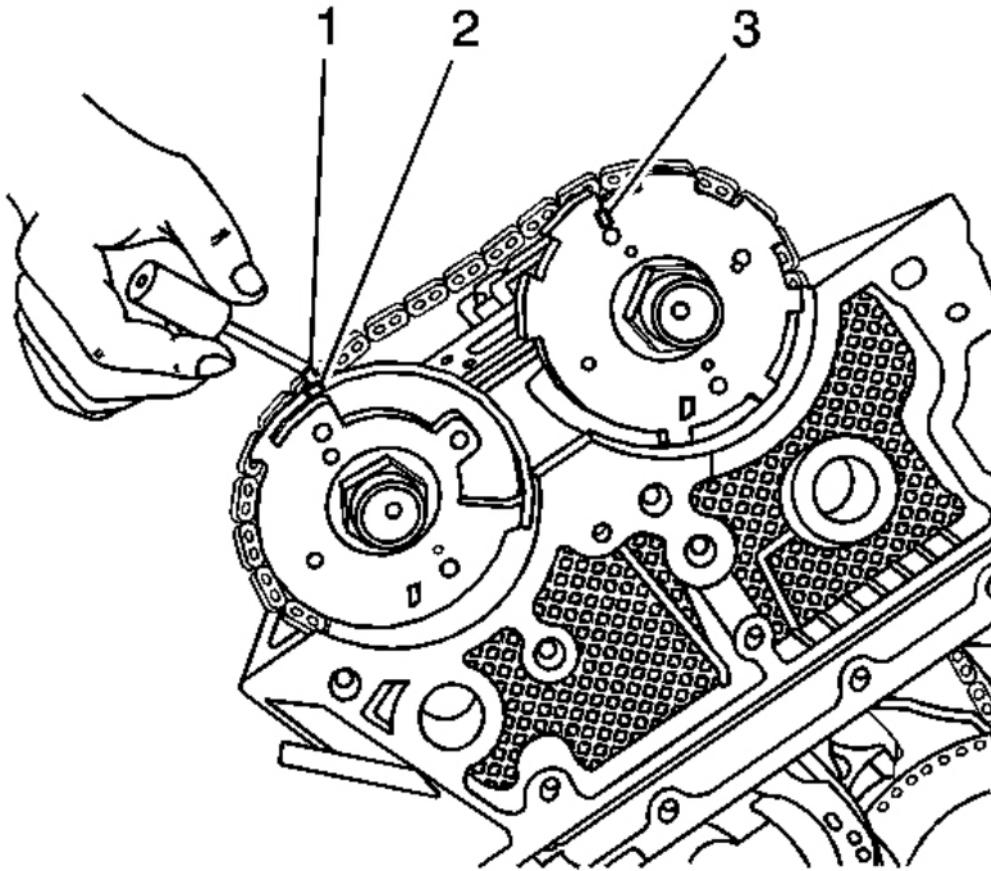


Fig. 272: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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

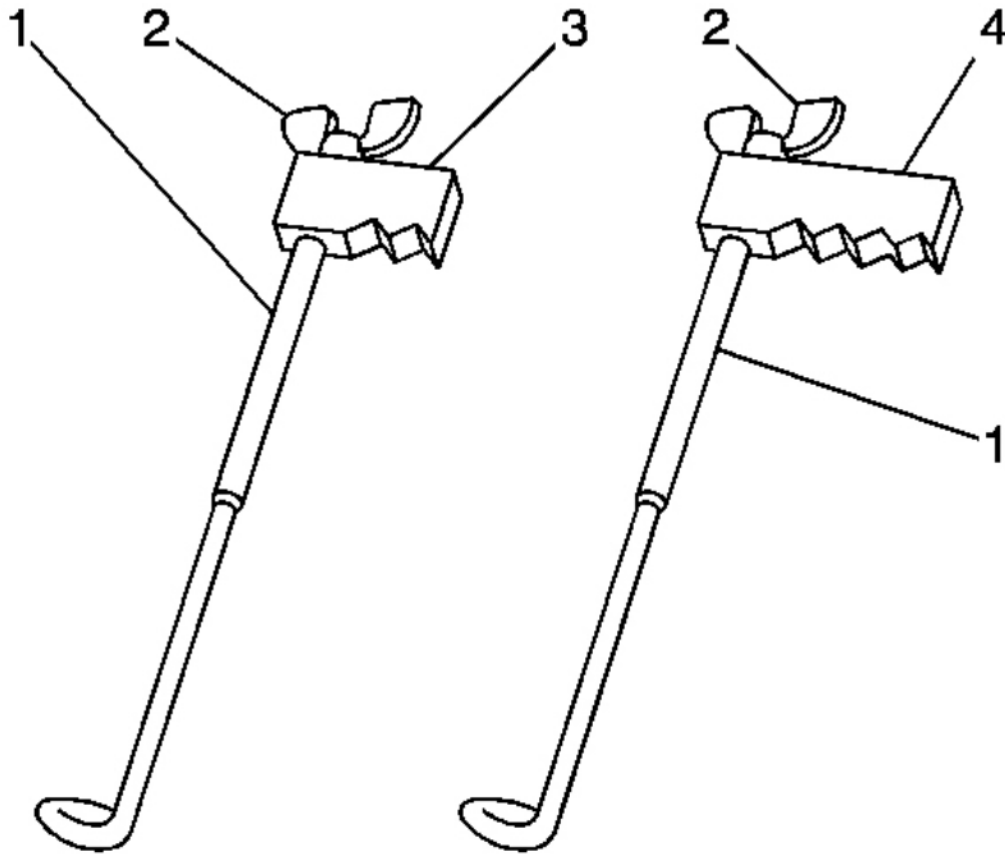


Fig. 273: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure.

Installation of the EN 46327 Timing Chain Retention Tool - Right Bank

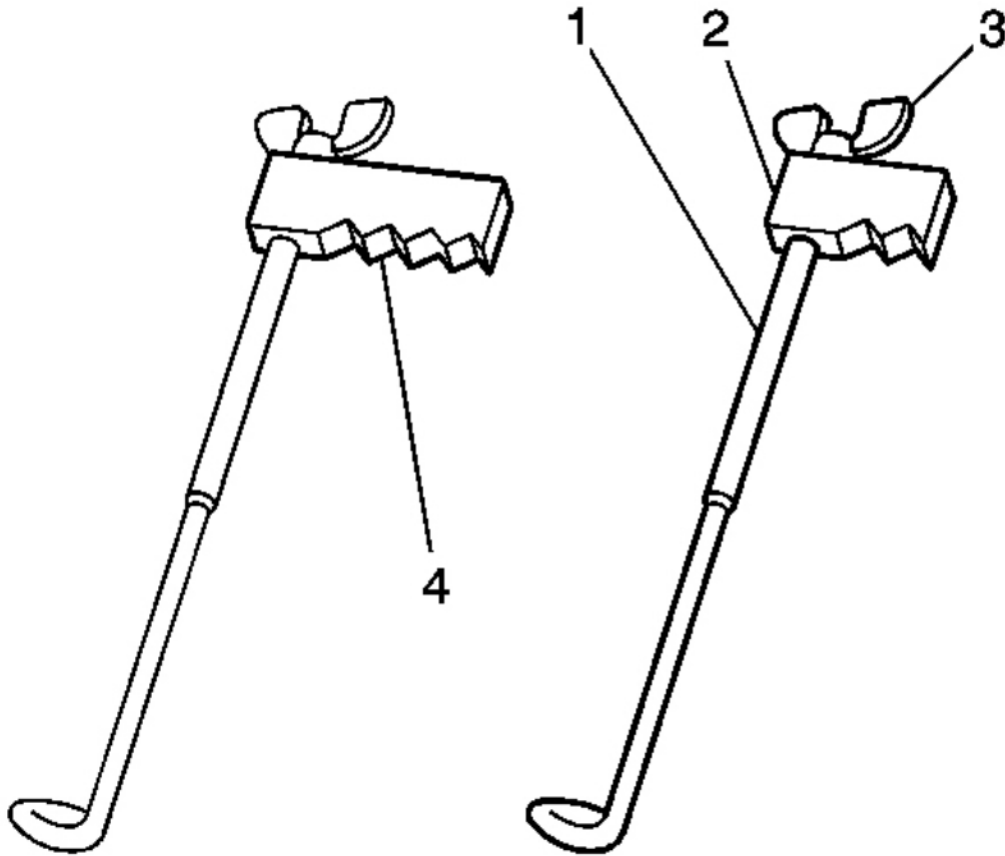


Fig. 274: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel.

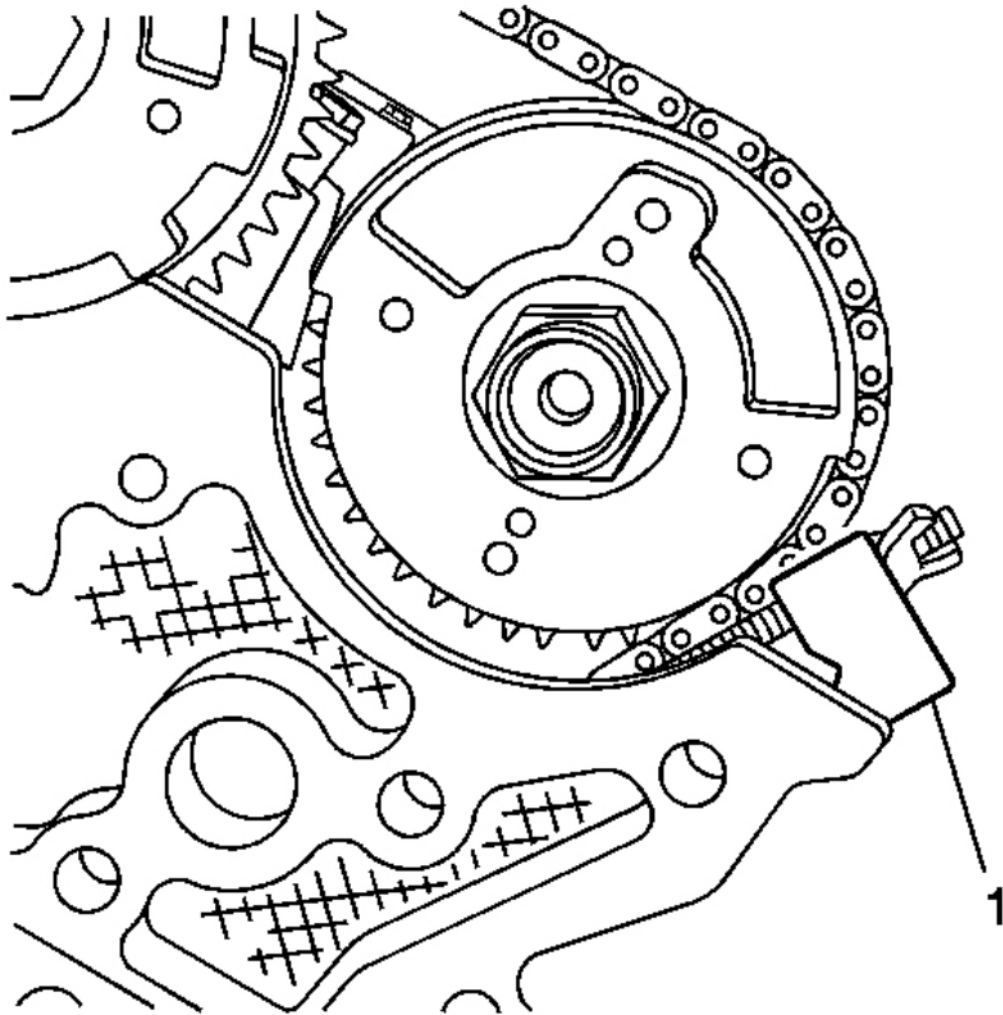


Fig. 275: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

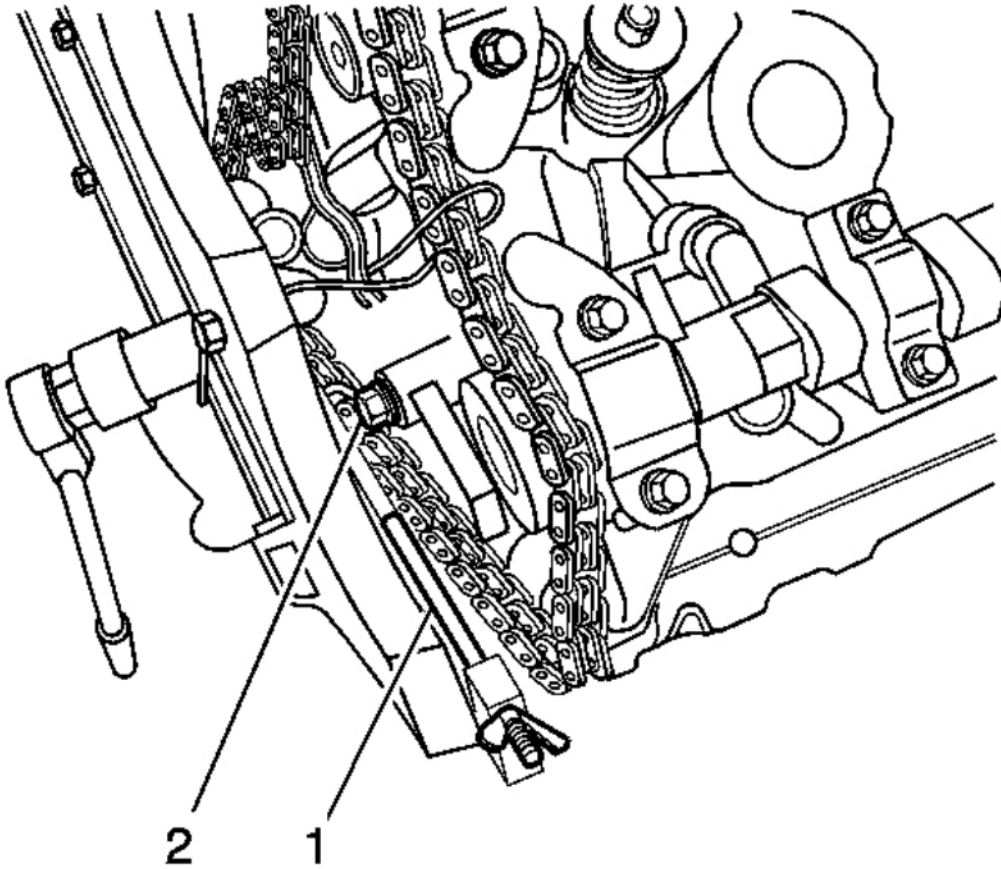


Fig. 276: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

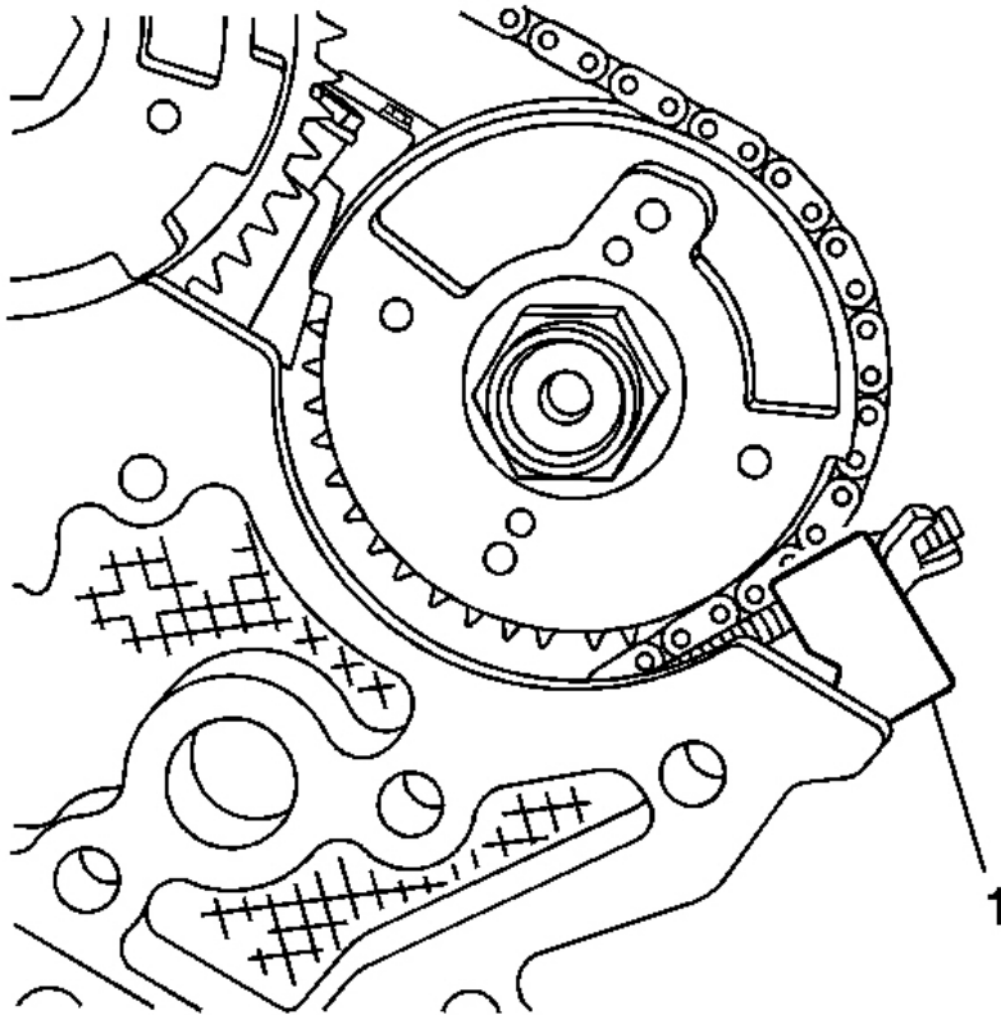


Fig. 277: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

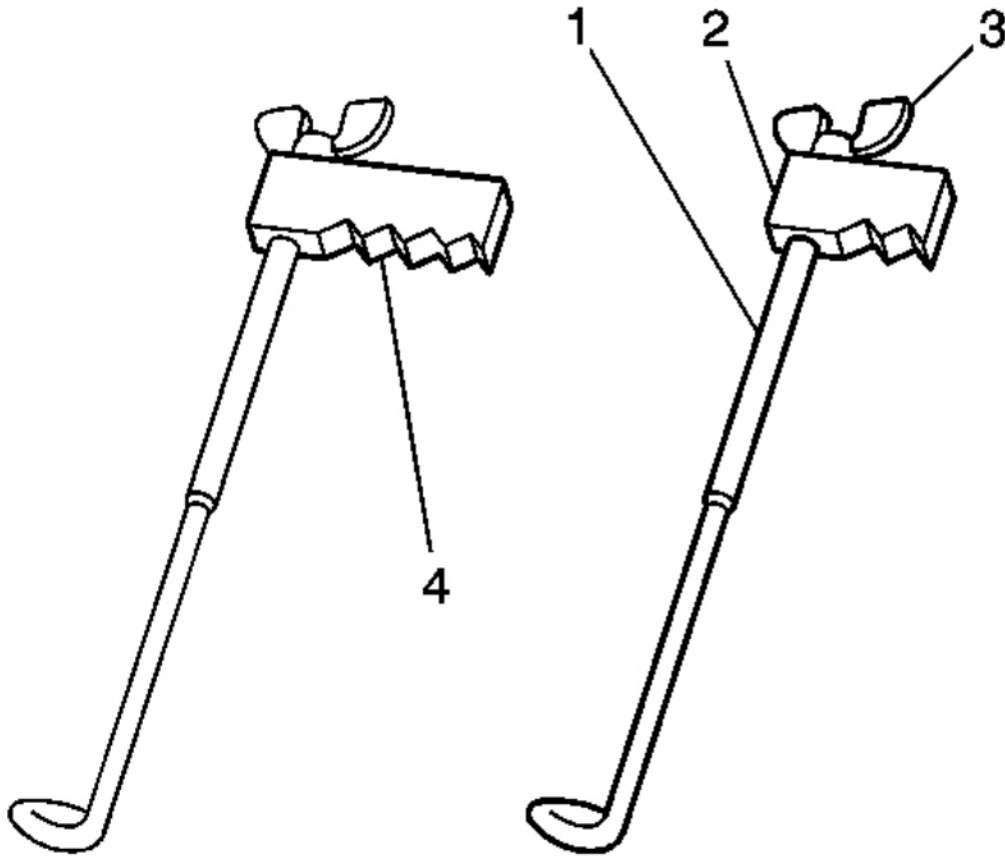


Fig. 278: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel.

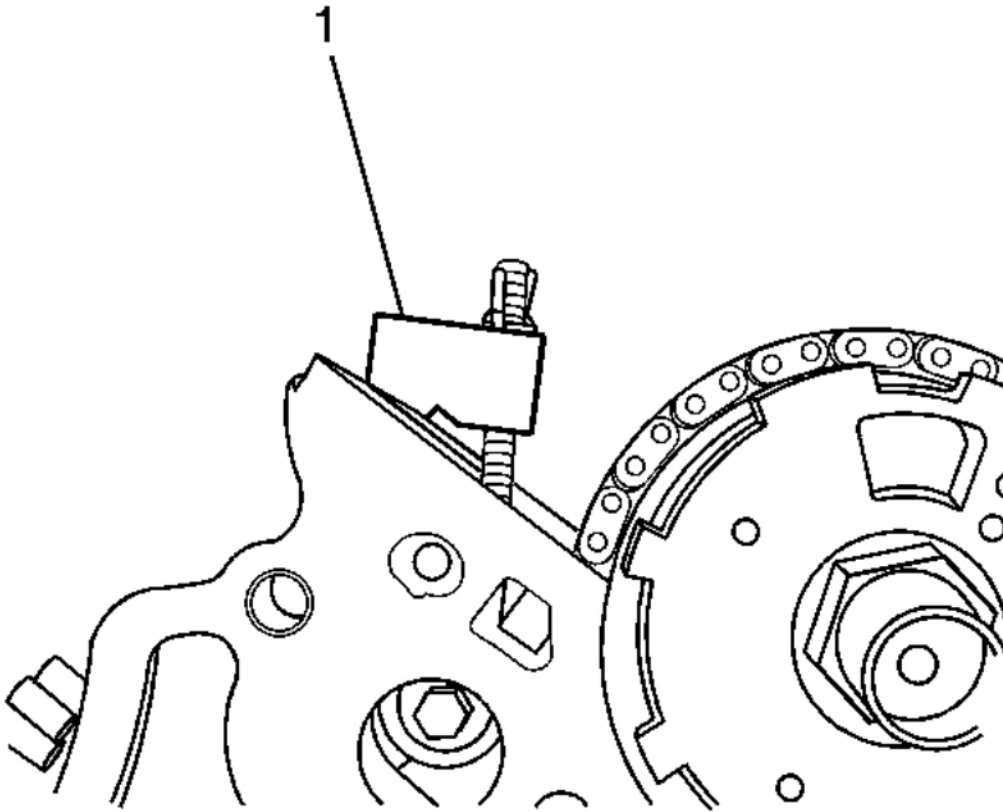


Fig. 279: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

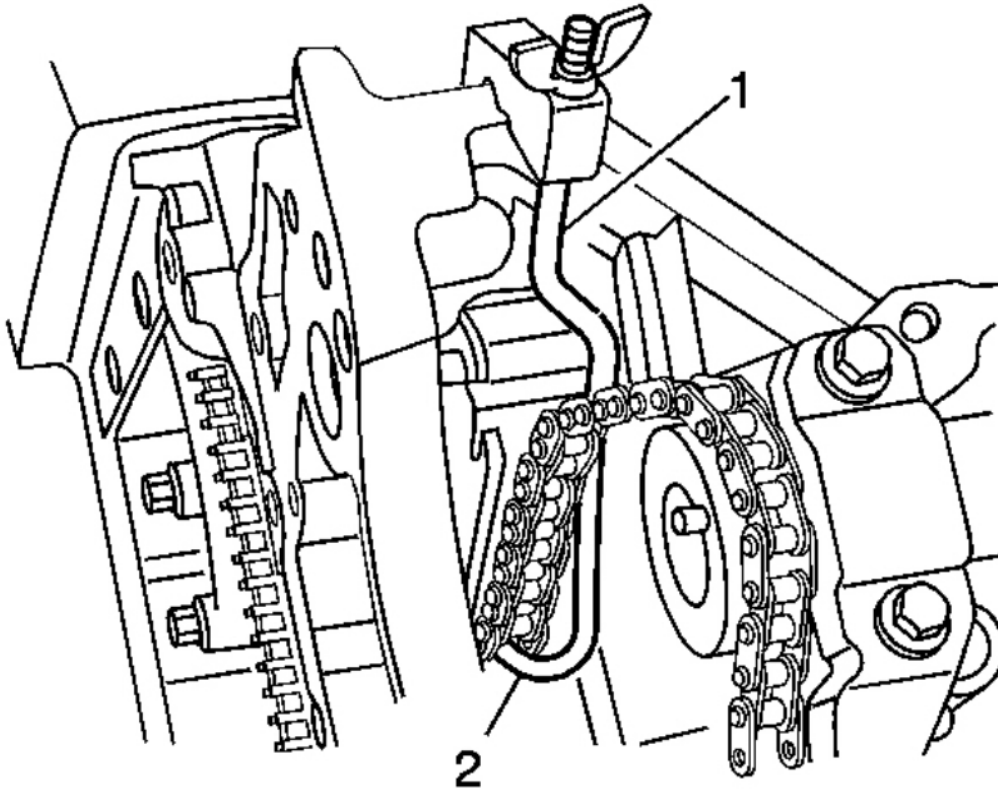


Fig. 280: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

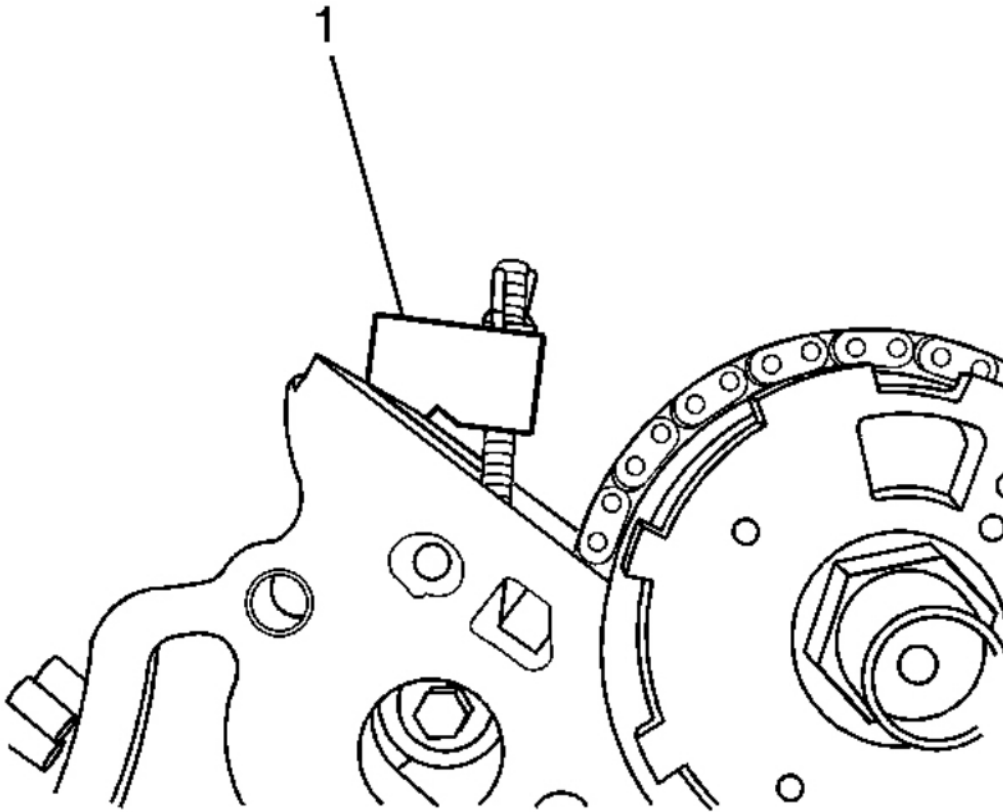


Fig. 281: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

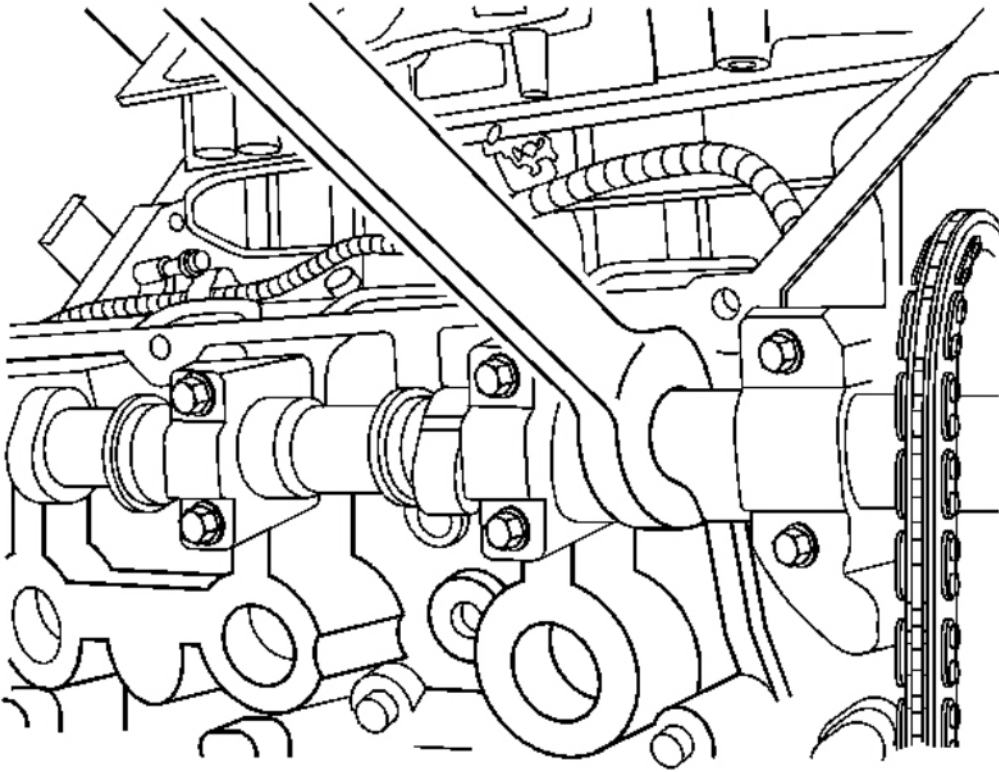


Fig. 282: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

9. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

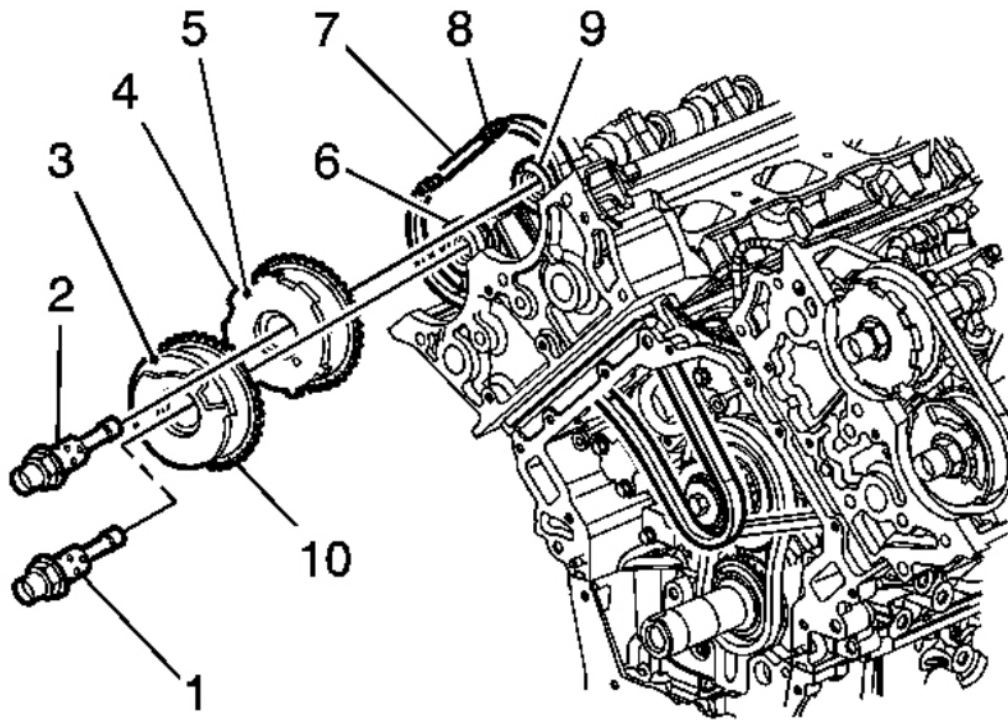


Fig. 283: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the right intake oil control valve (2).

Installation Procedure

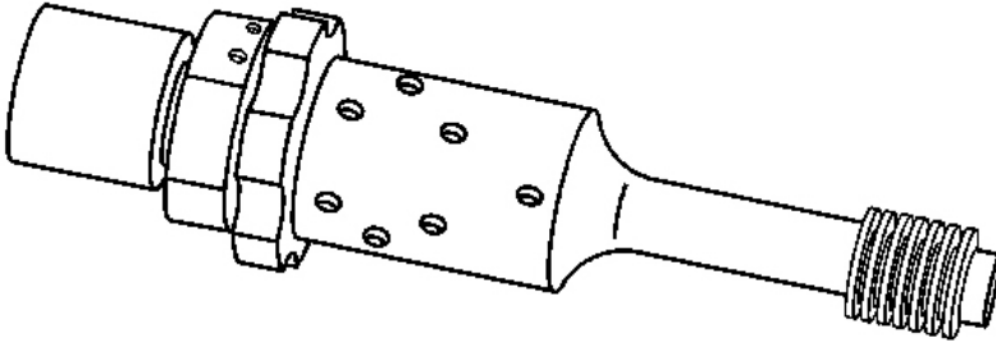


Fig. 284: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil control valve through the opening in the right intake camshaft position actuator and thread it into the right intake camshaft.

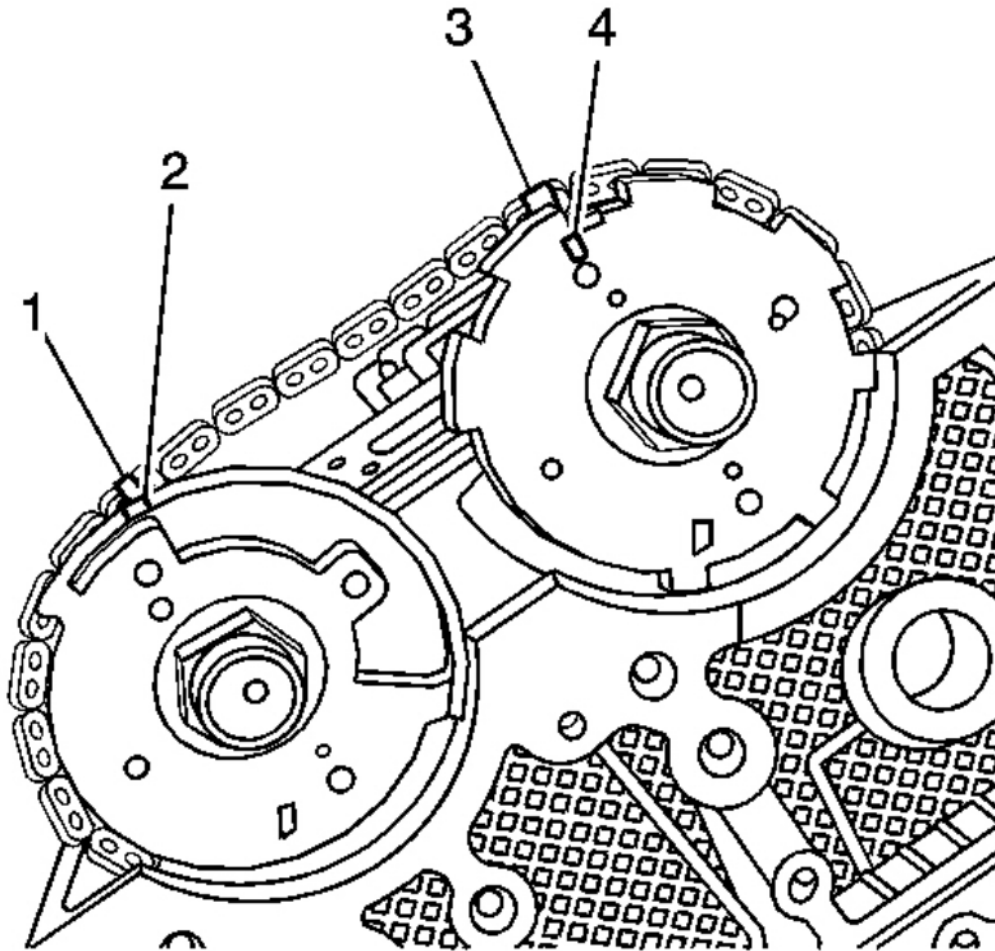


Fig. 285: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

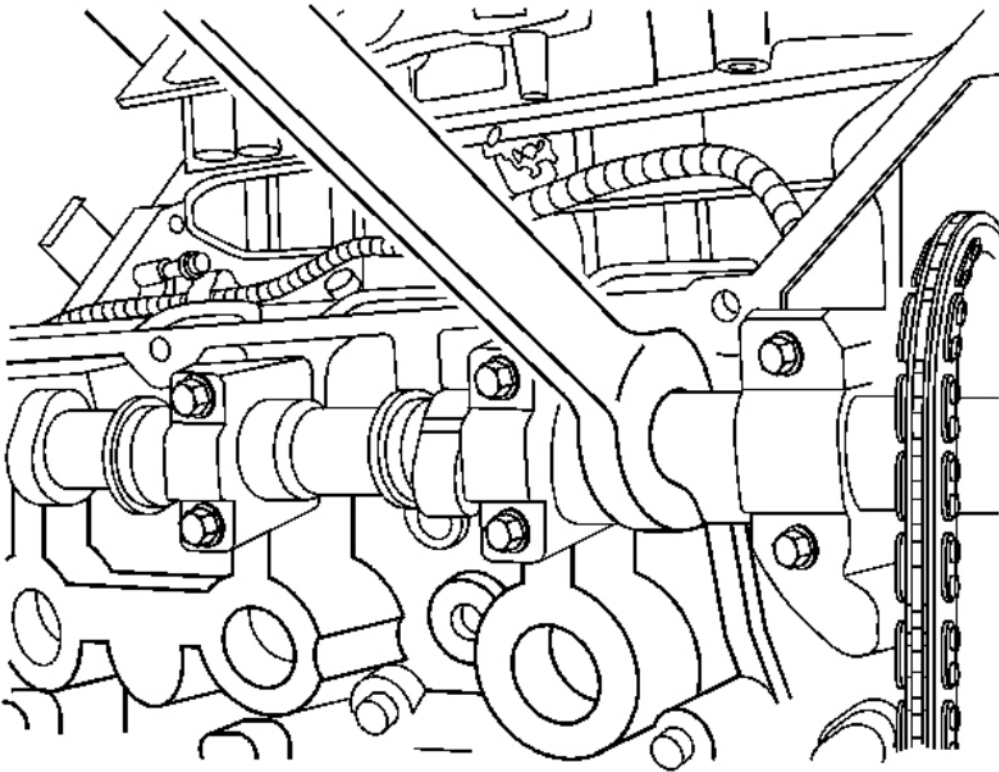


Fig. 286: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

3. Use an open end wrench on the hex cast into the right intake camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

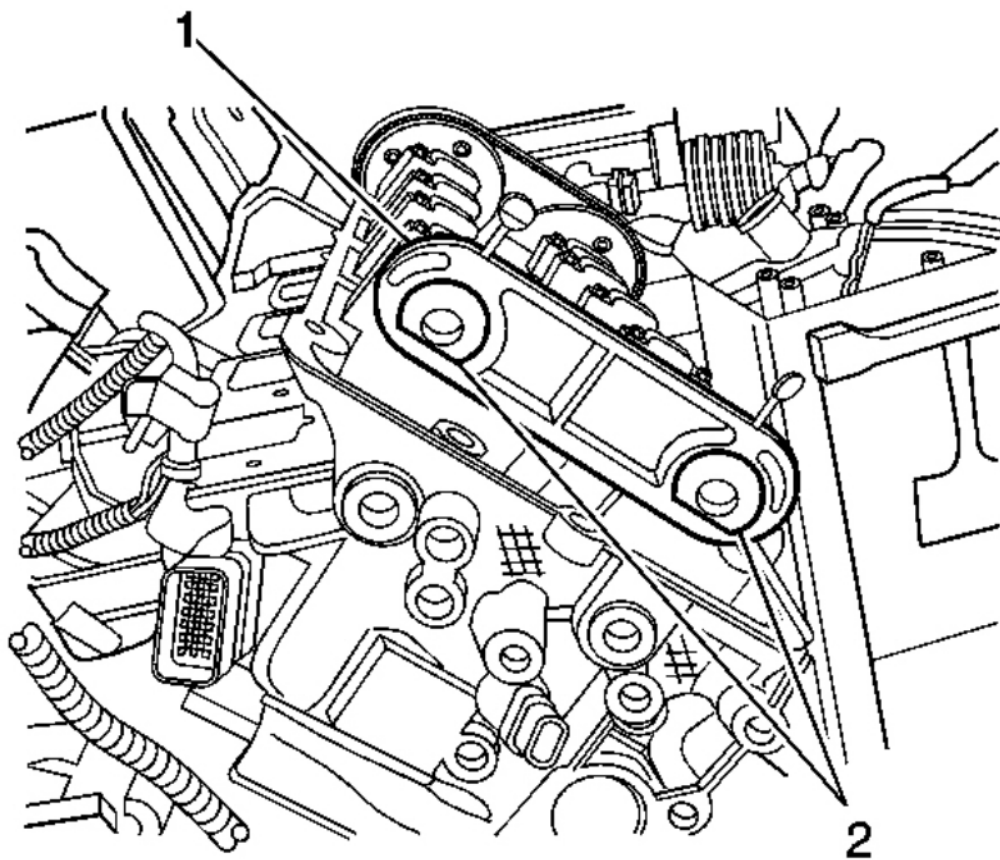


Fig. 287: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the EN 46327 (1).

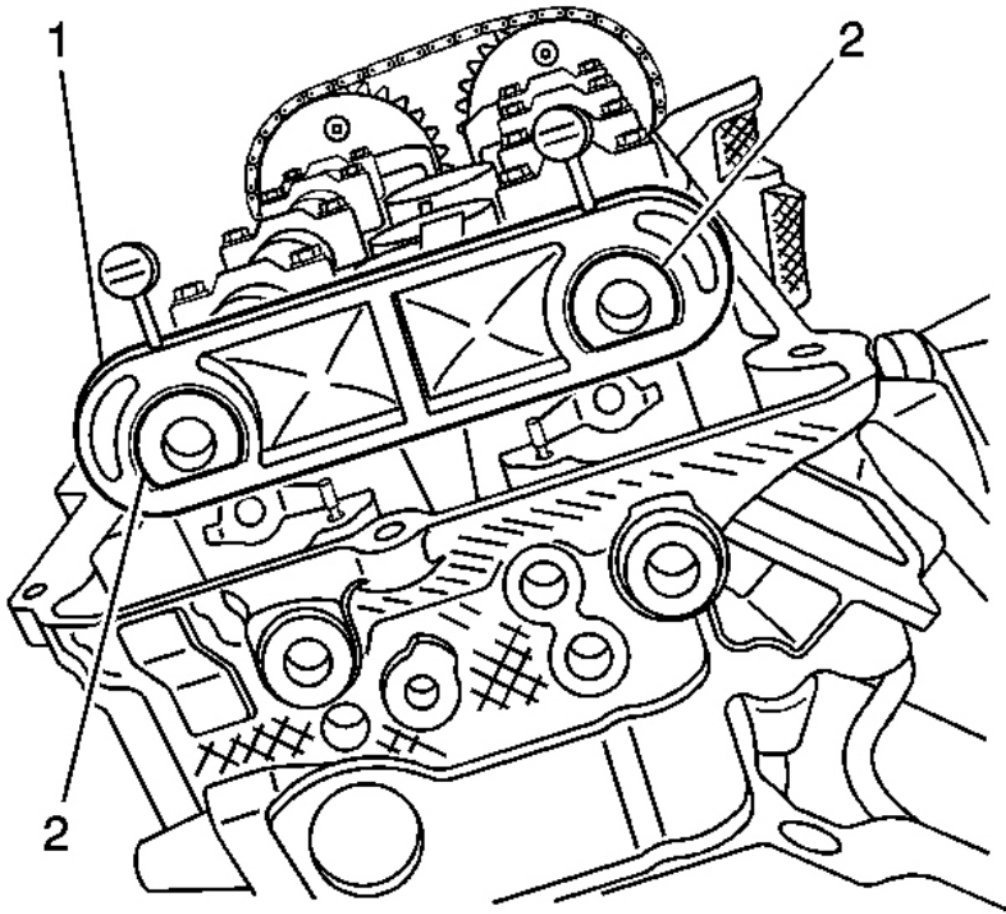


Fig. 288: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2).
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

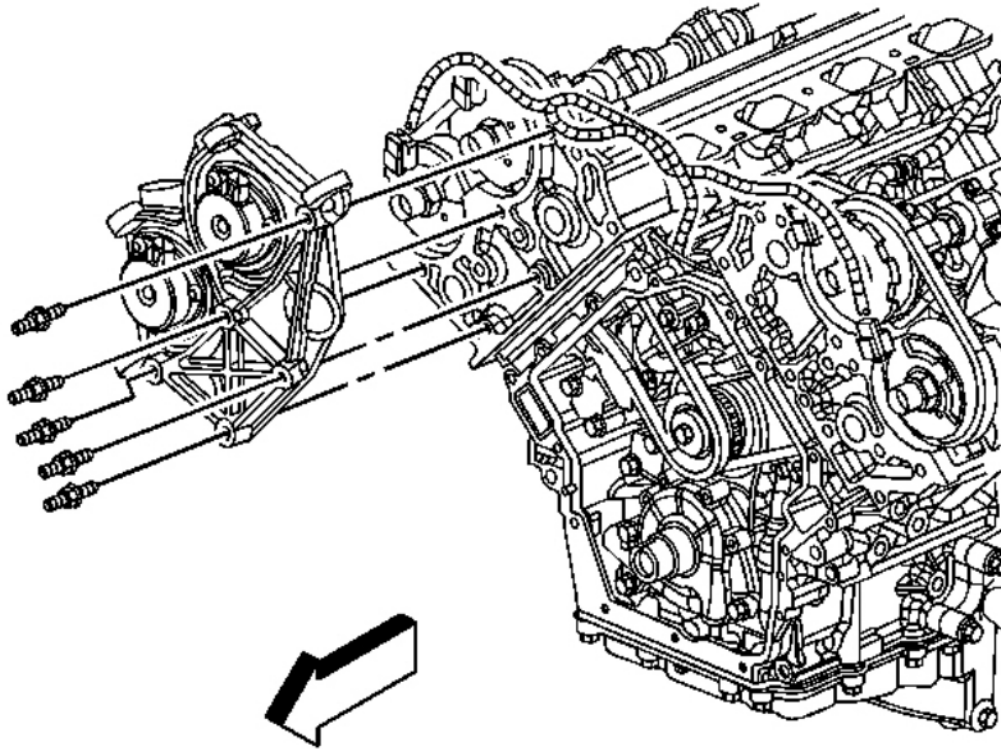


Fig. 289: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the right camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.

CAMSHAFT POSITION (CMP) ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK BANK 1 (RIGHT) EXHAUST

Tools Required

- J 39946 Crankshaft Socket
- EN 46327 Timing Chain Retention Tool
- EN 46328 Camshaft Holding Tool

Removal Procedure

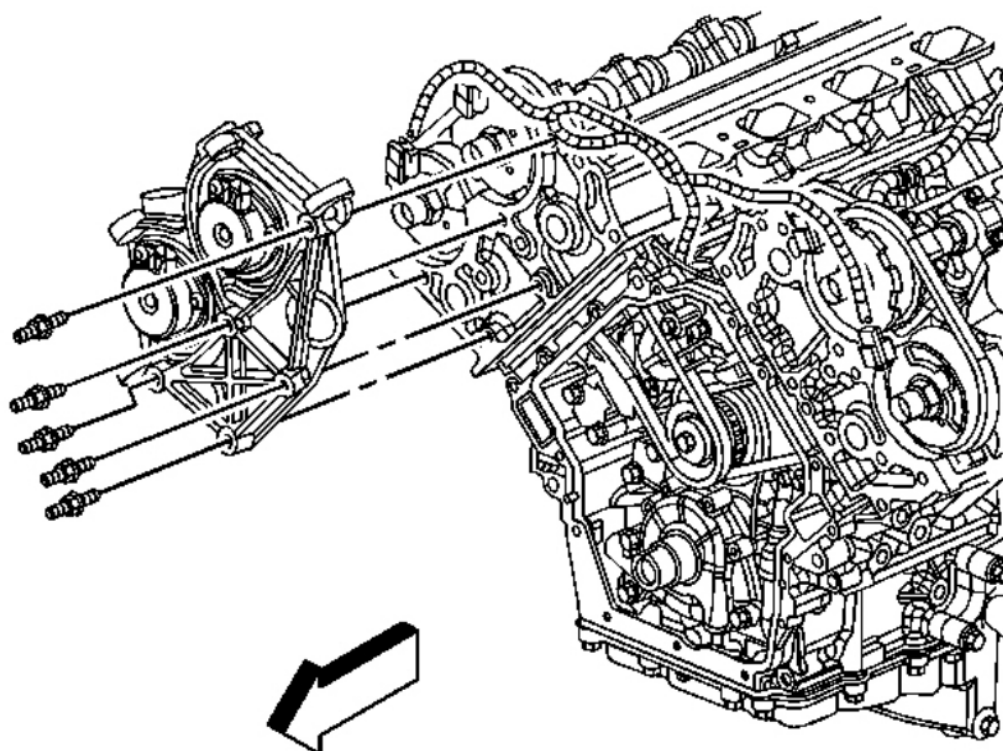


Fig. 290: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the right actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the J 39946 , rotate the crankshaft until both bank 1 (right) CMP actuator timing

marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation.

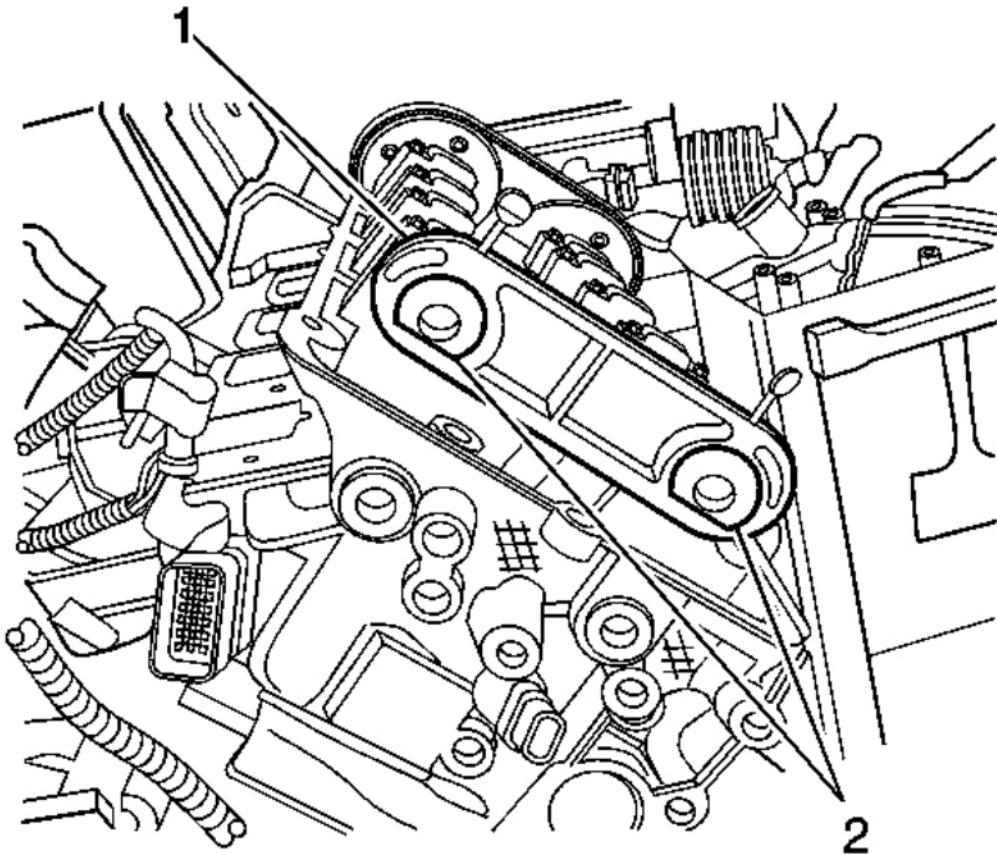


Fig. 291: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the **EN 46328** (1) to the camshafts (2).

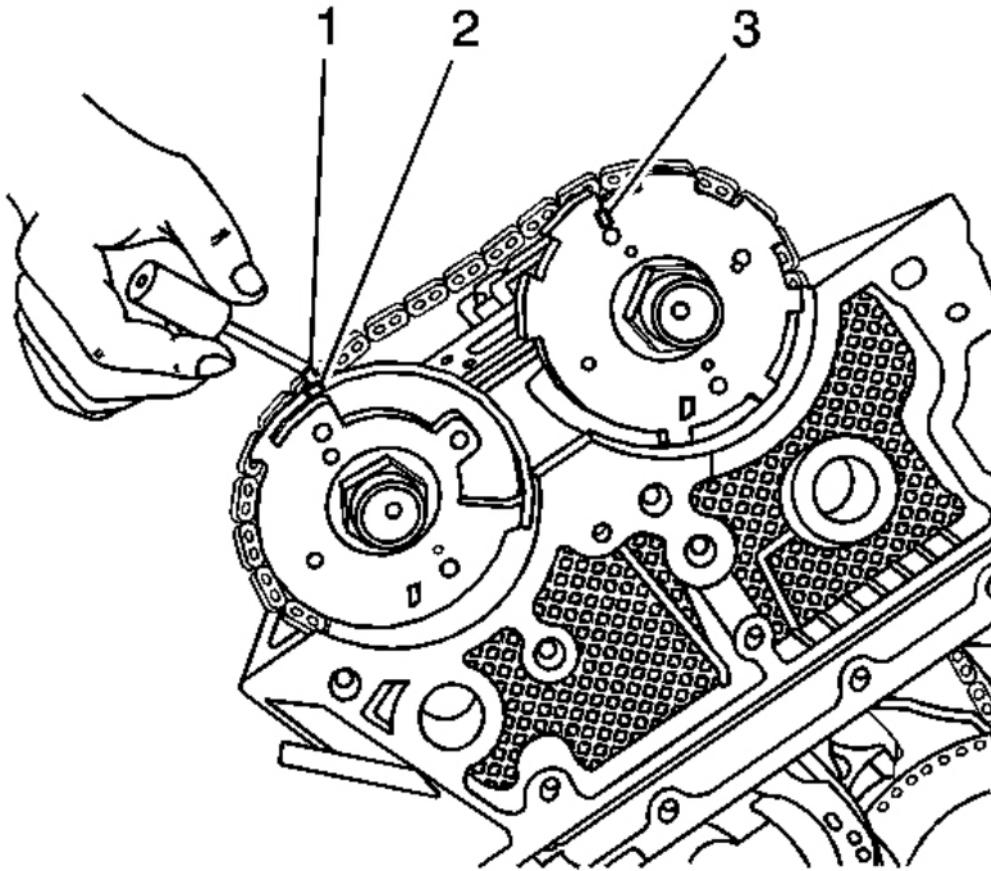


Fig. 292: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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

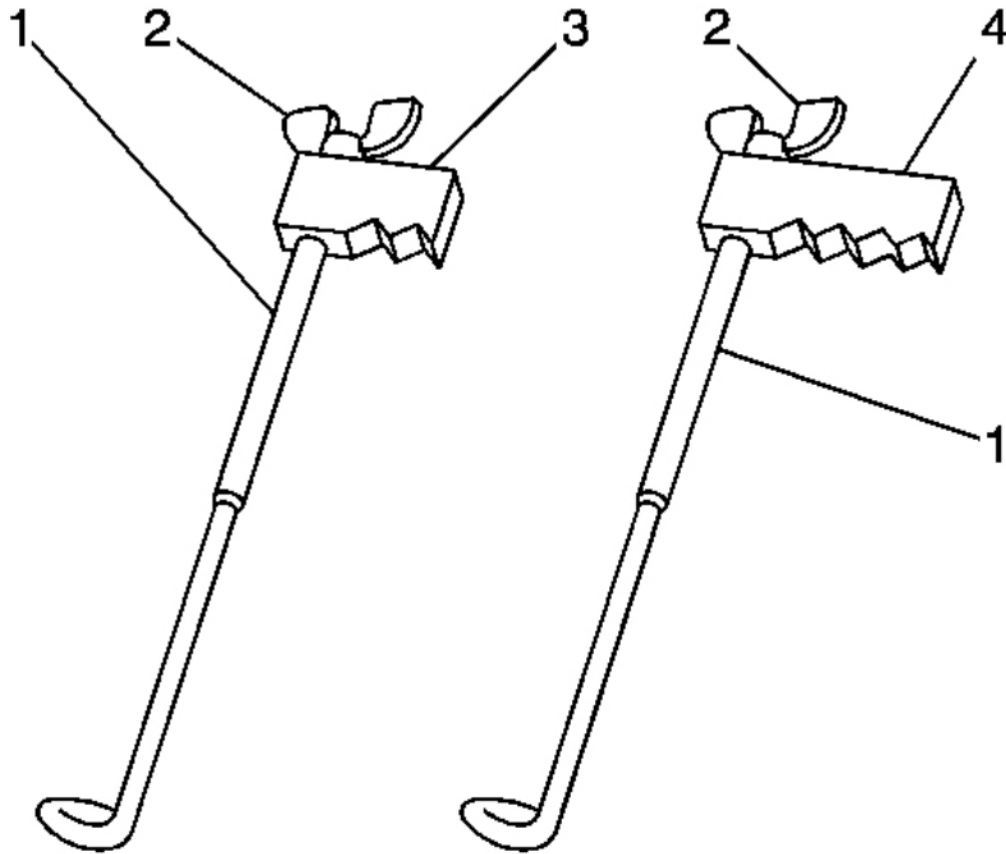


Fig. 293: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure.

Installation of the EN 46327 Timing Chain Retention Tool - Right Bank

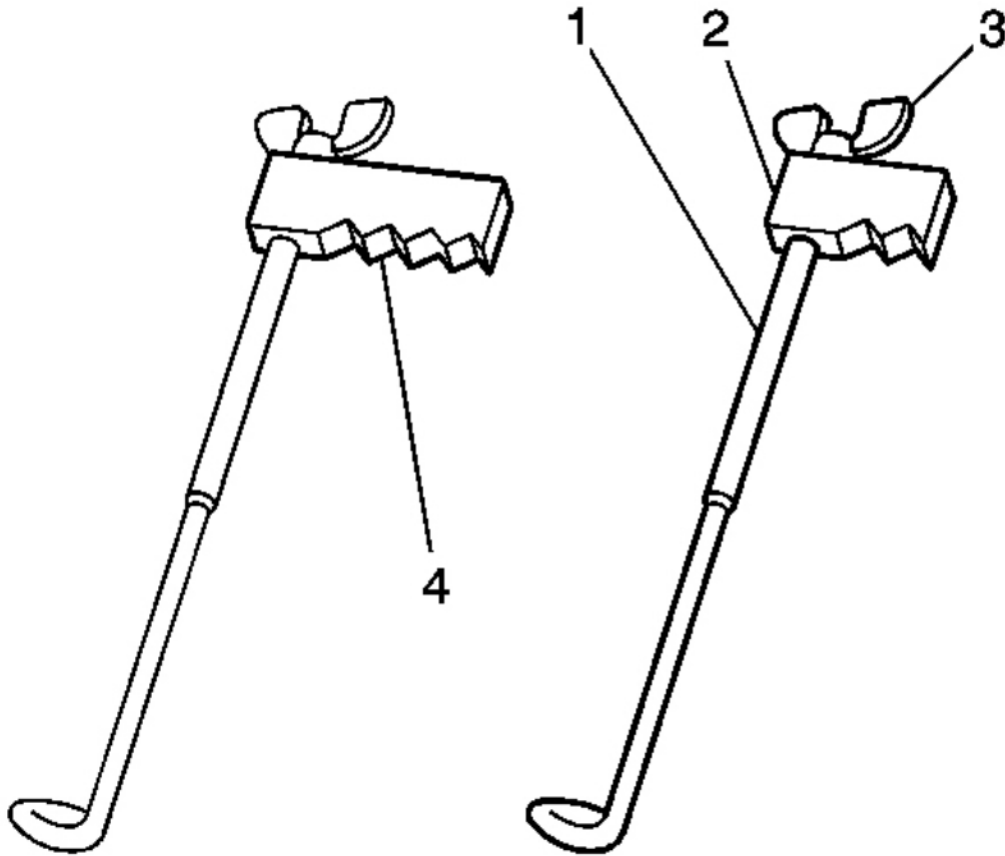


Fig. 294: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel.

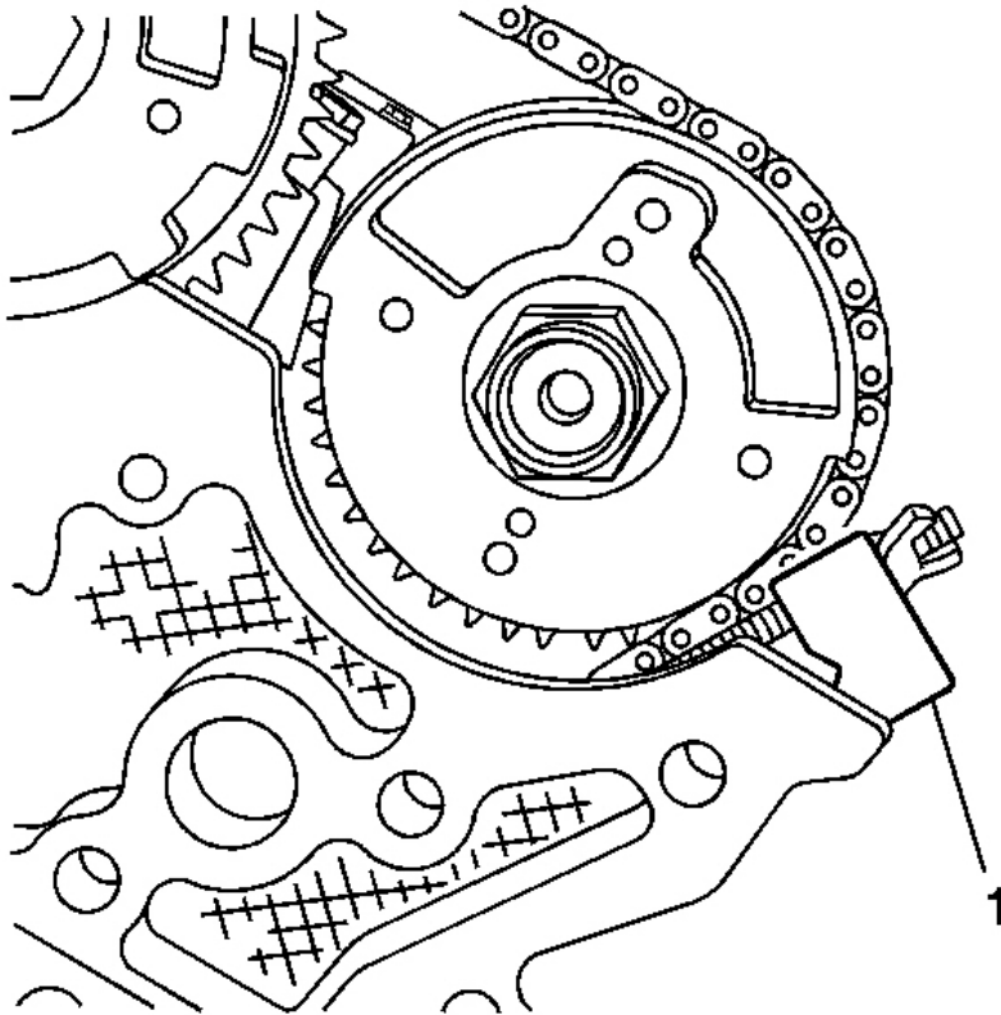


Fig. 295: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

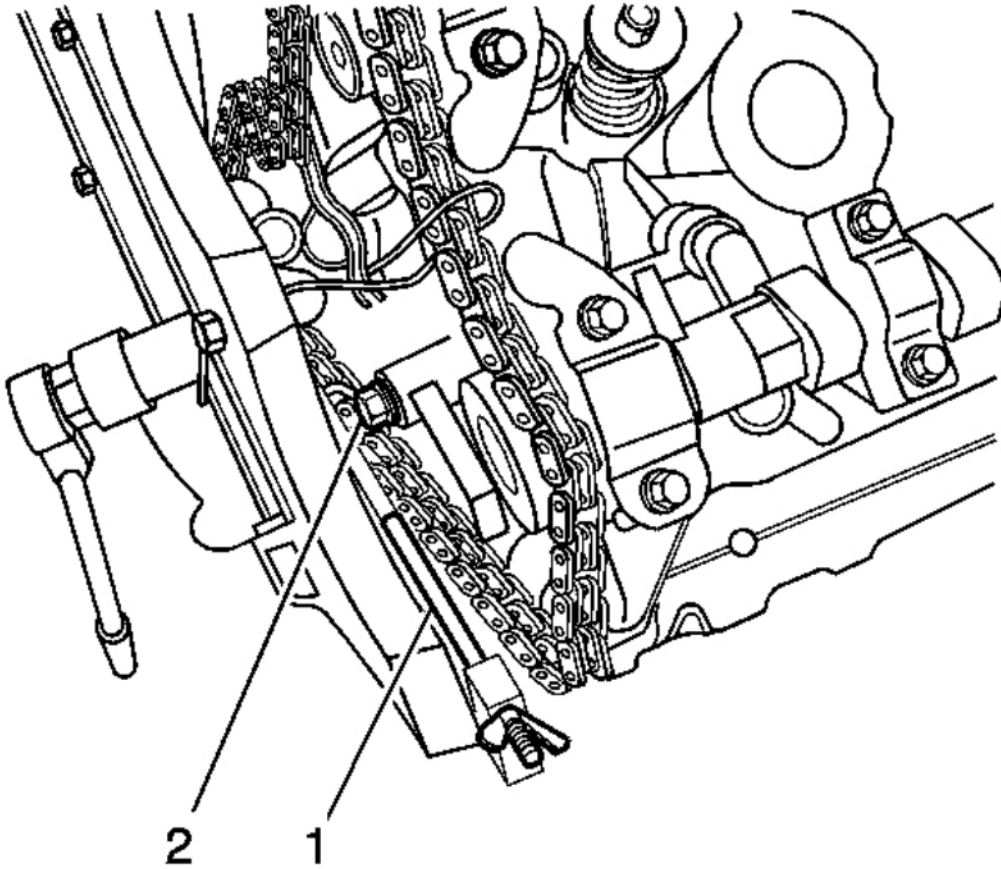


Fig. 296: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

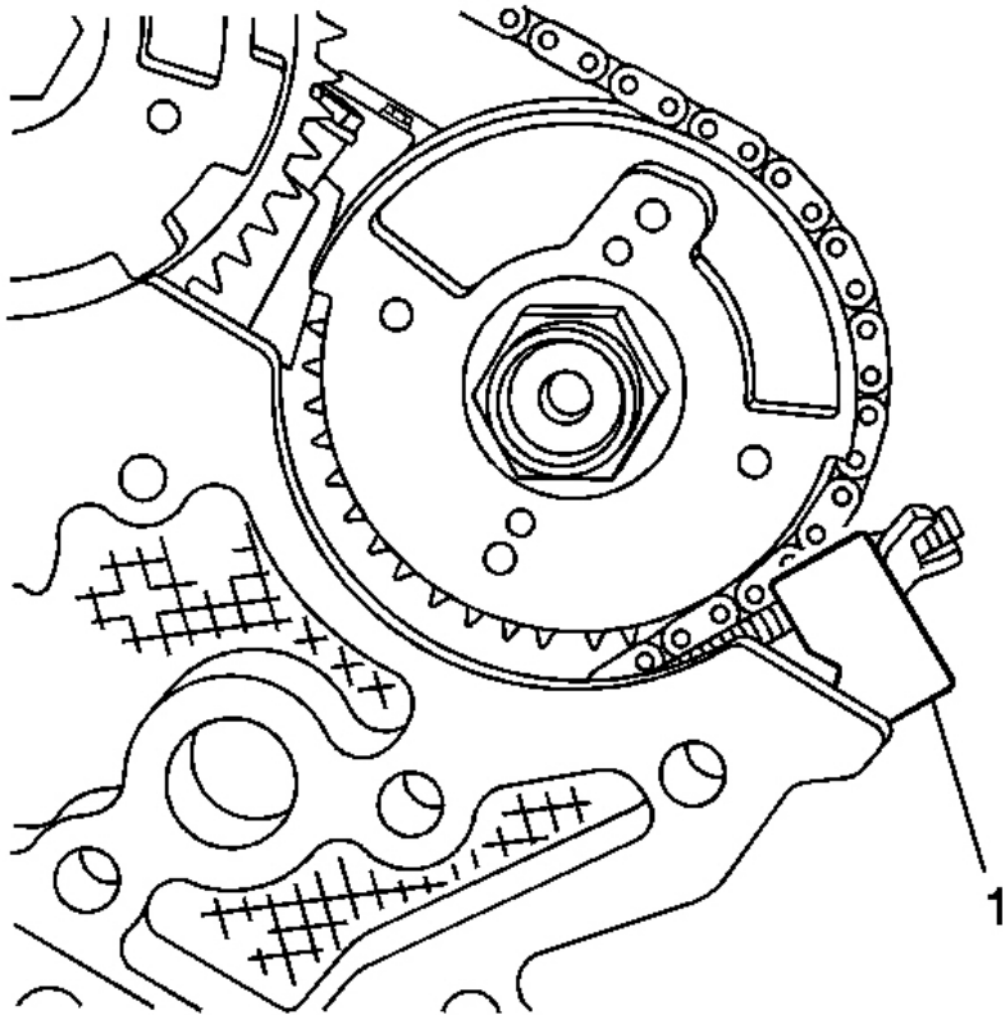


Fig. 297: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

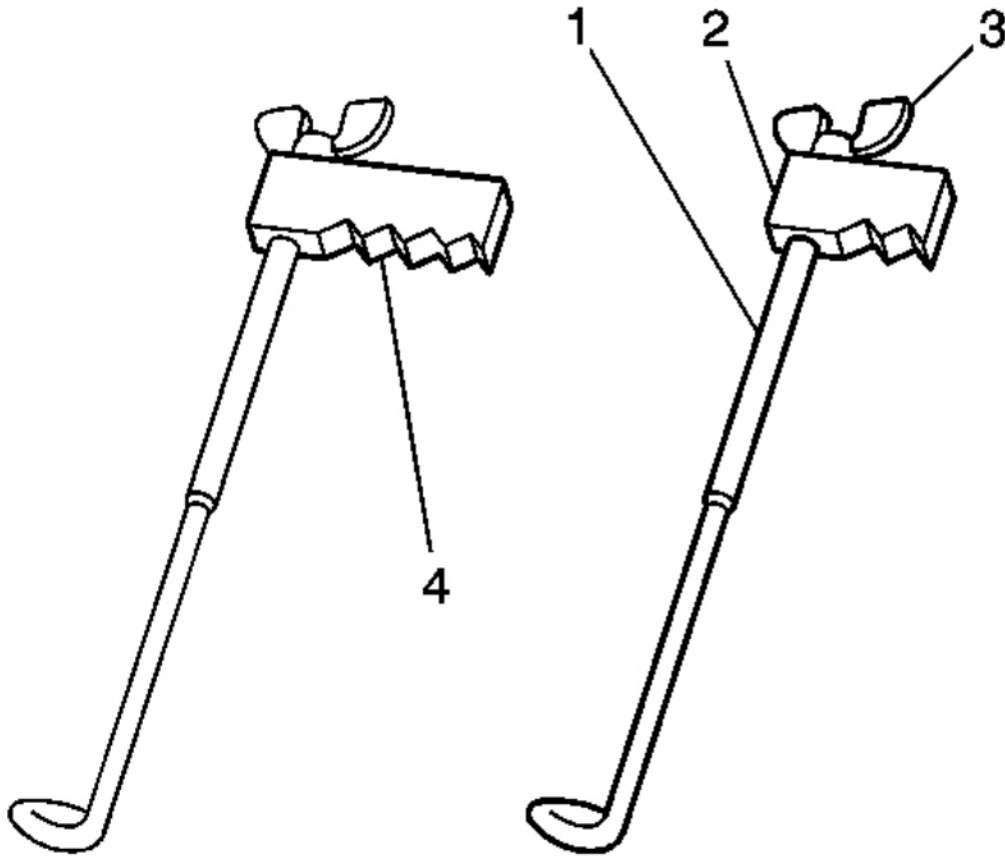


Fig. 298: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel.

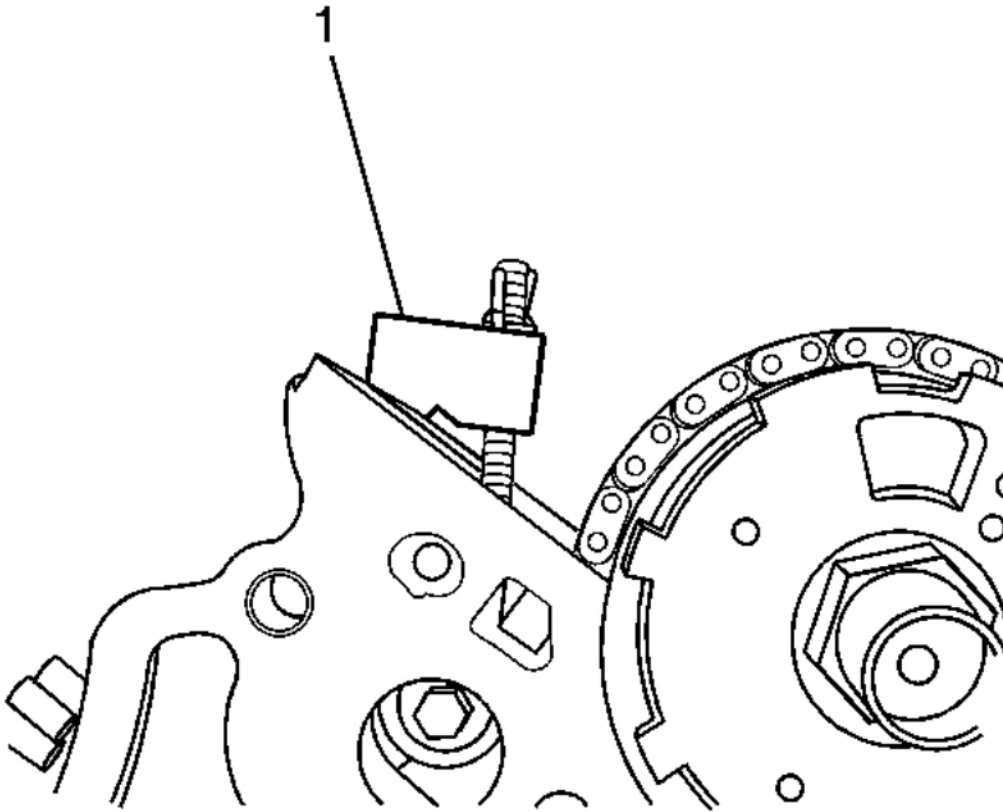


Fig. 299: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

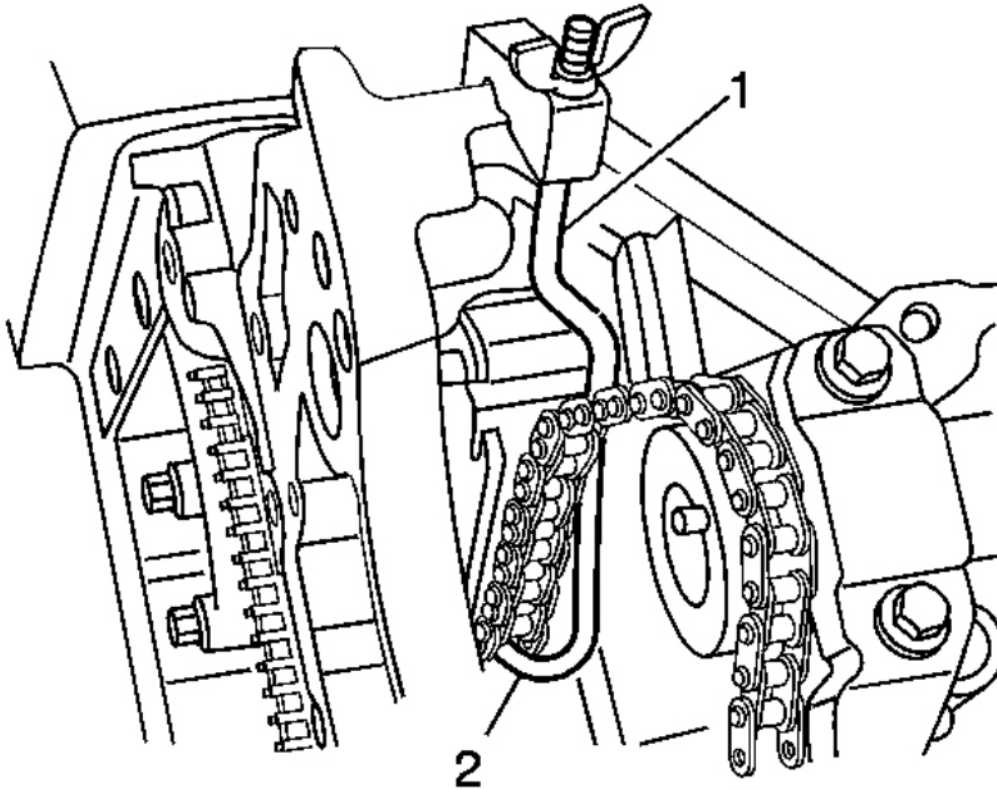


Fig. 300: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

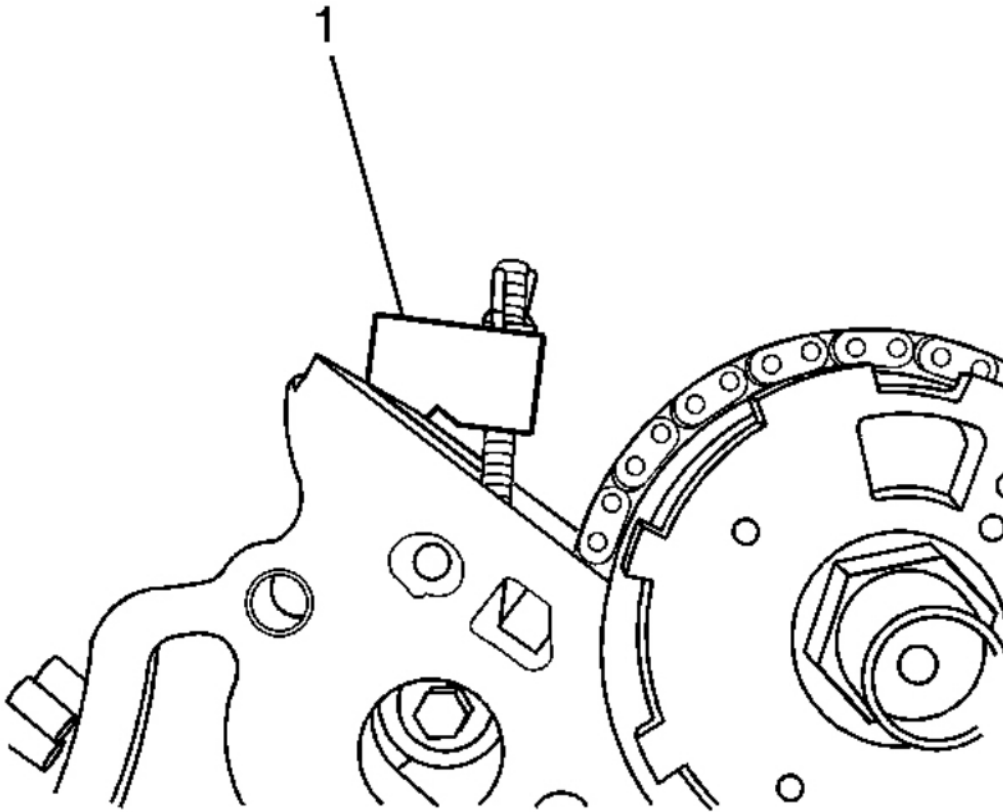


Fig. 301: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

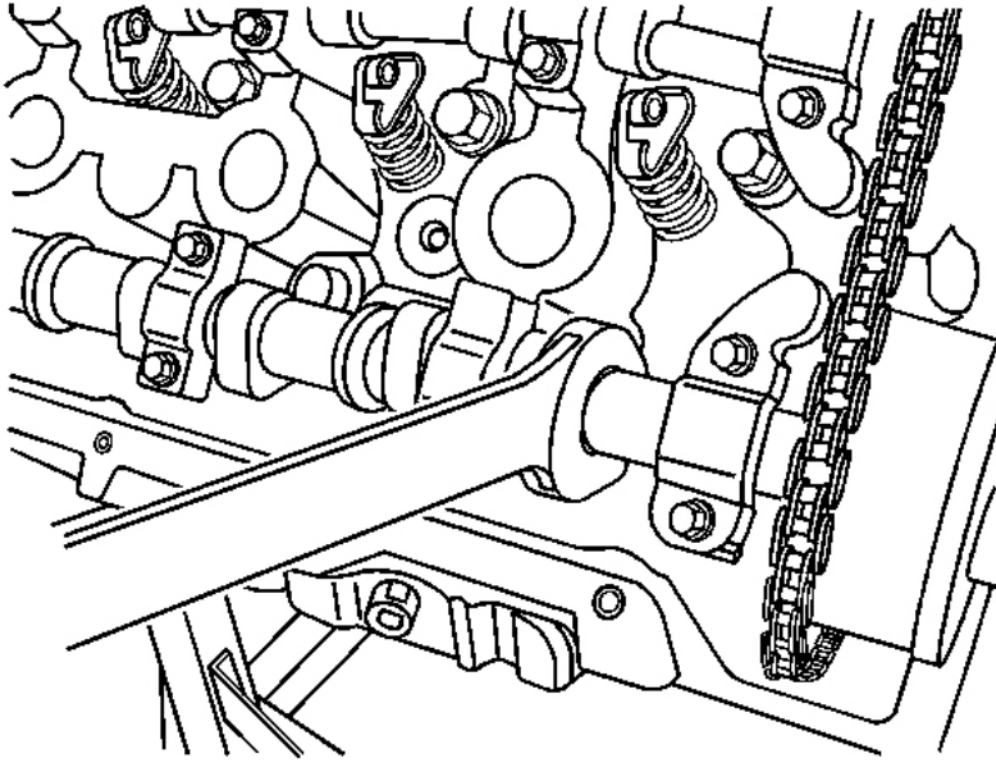


Fig. 302: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

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

9. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

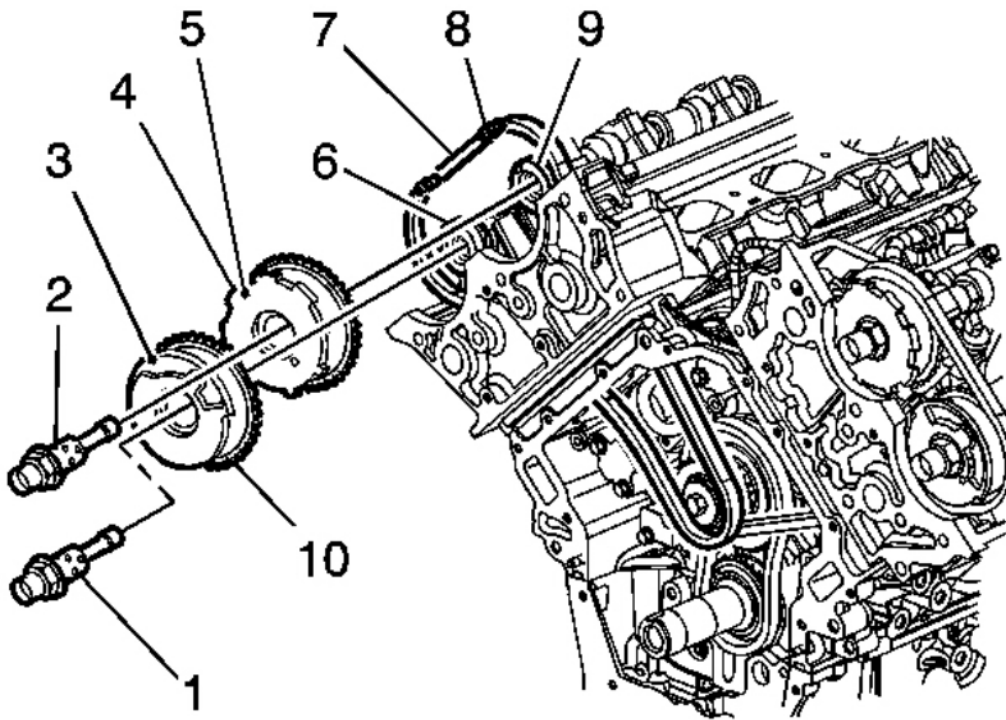


Fig. 303: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the right exhaust oil control valve (1).

Installation Procedure

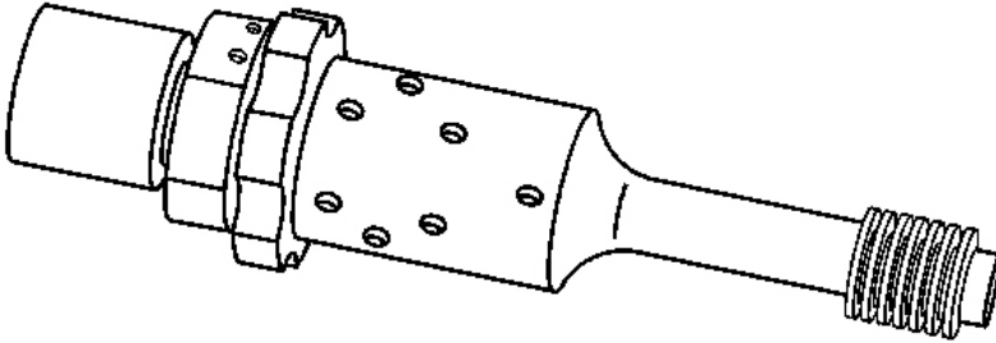


Fig. 304: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the right exhaust camshaft position actuator and thread it into the right exhaust camshaft.

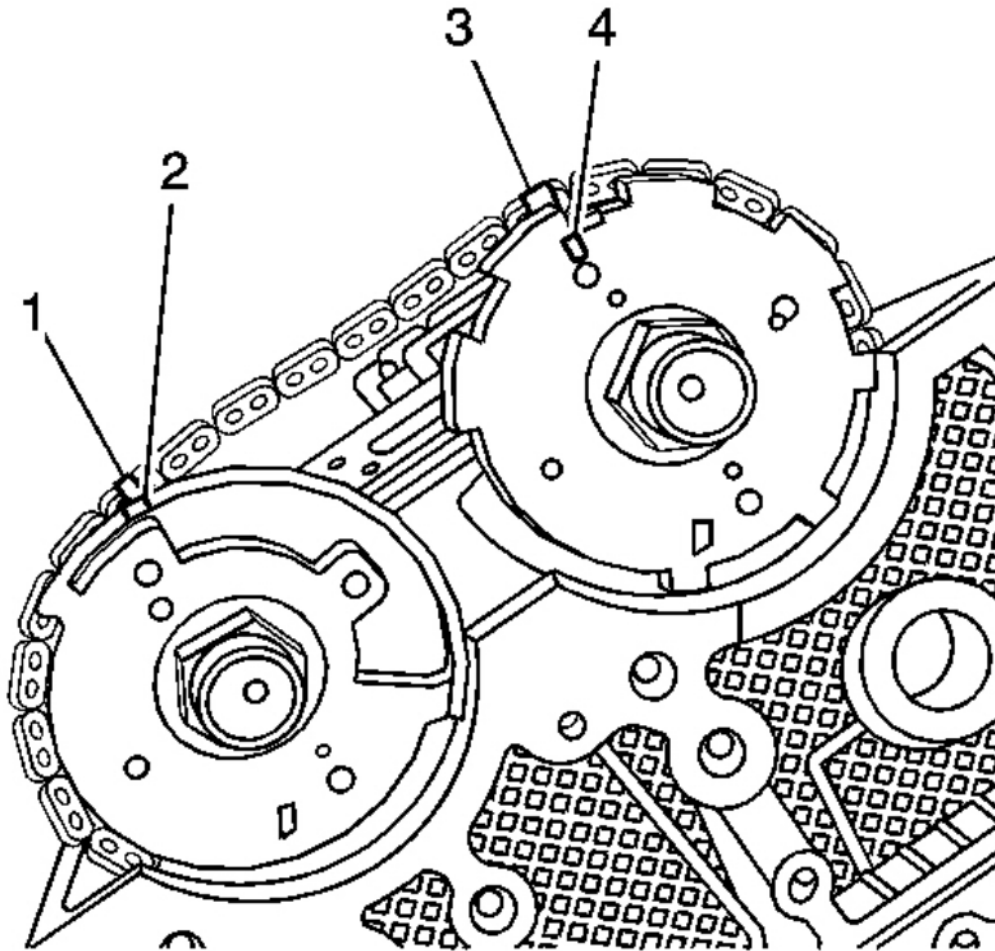


Fig. 305: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

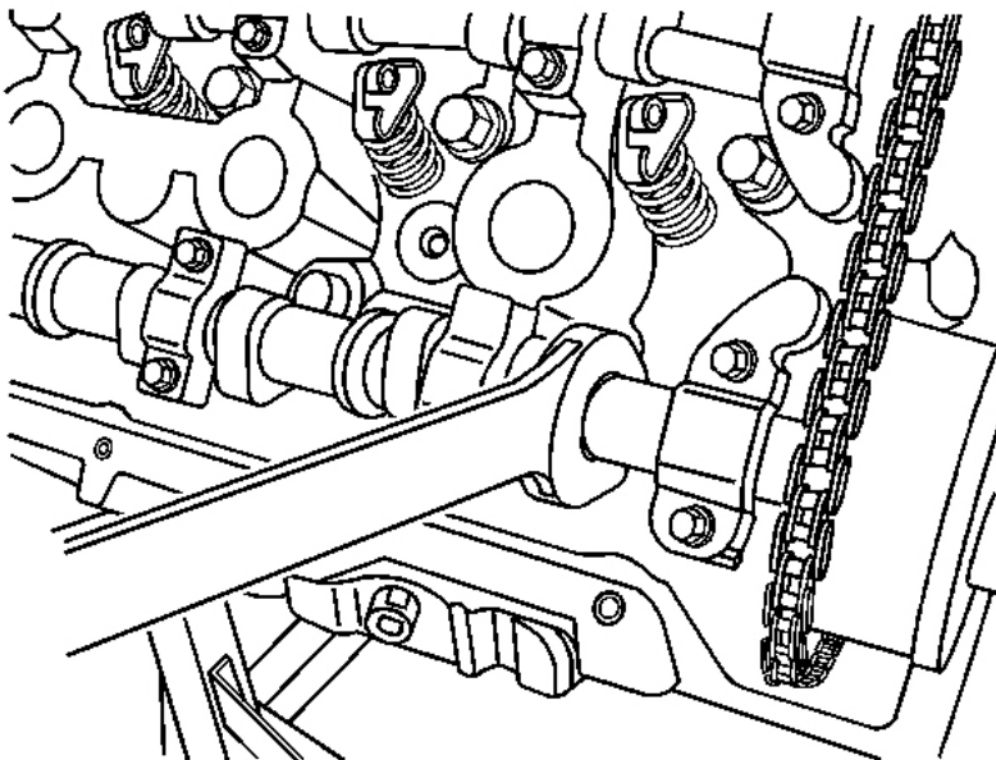


Fig. 306: Preventing Camshaft Rotation
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Use an open end wrench on the hex cast into the right exhaust camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

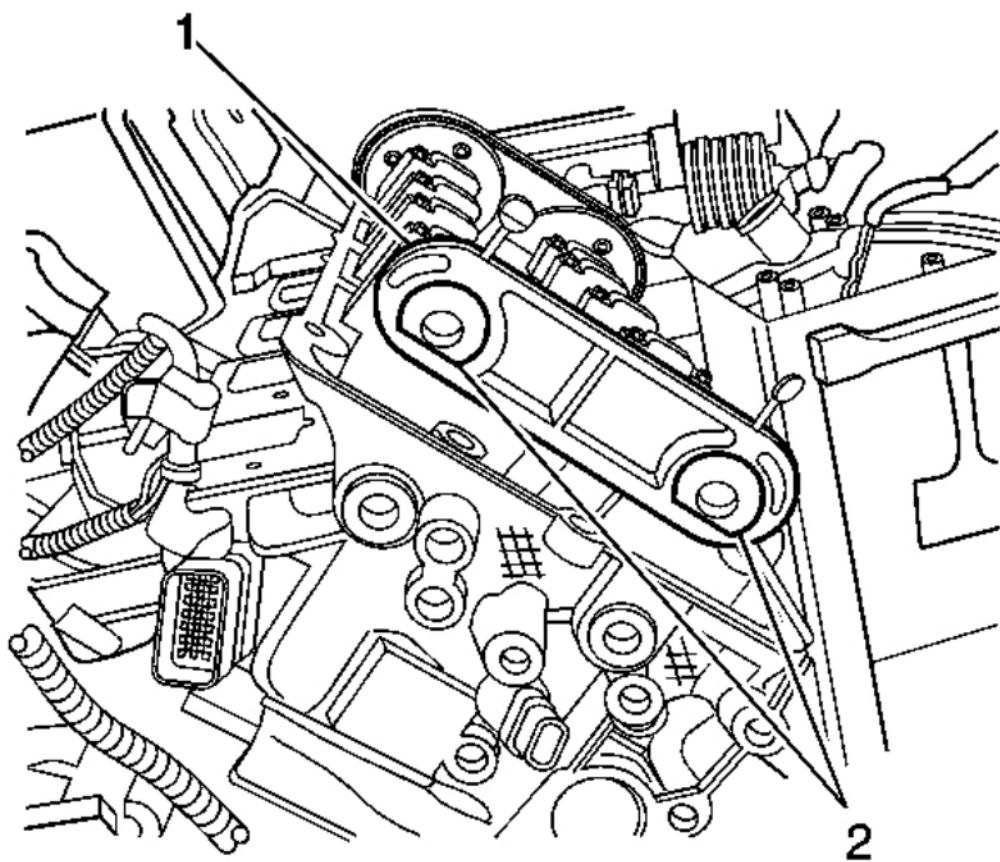


Fig. 307: Identifying EN 46328 Cam Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the EN 46327 (1).

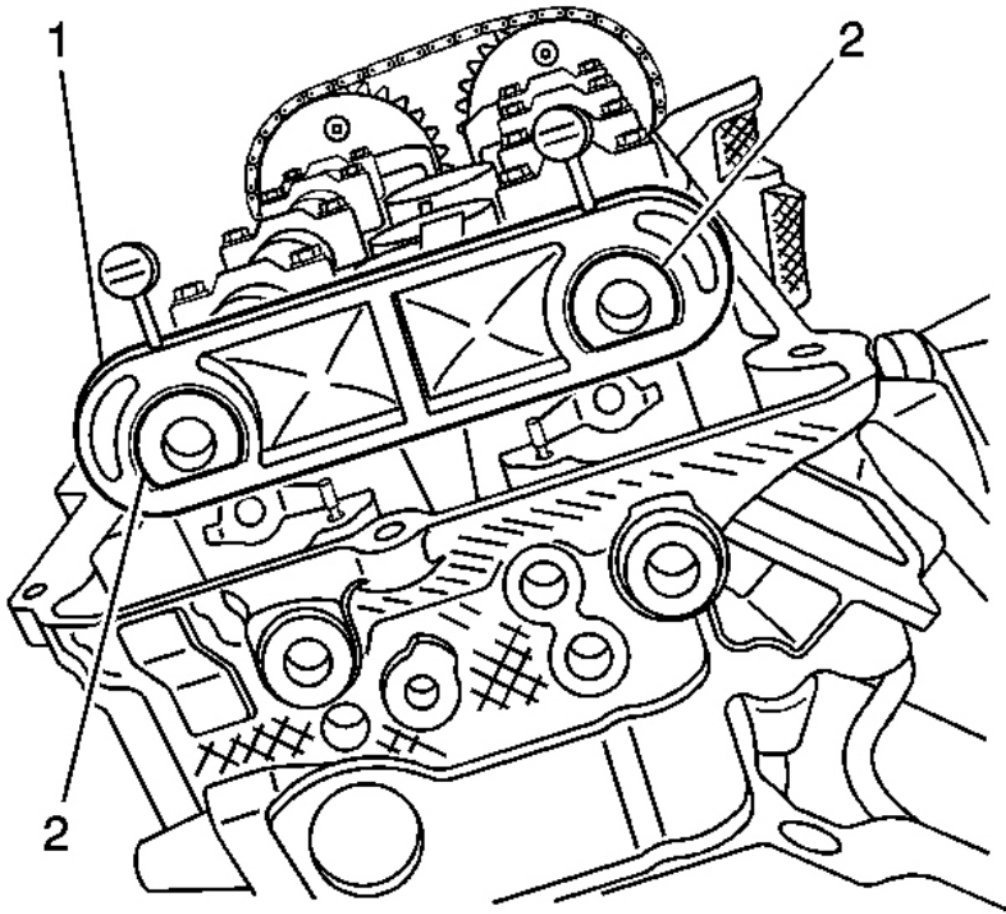


Fig. 308: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2).
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

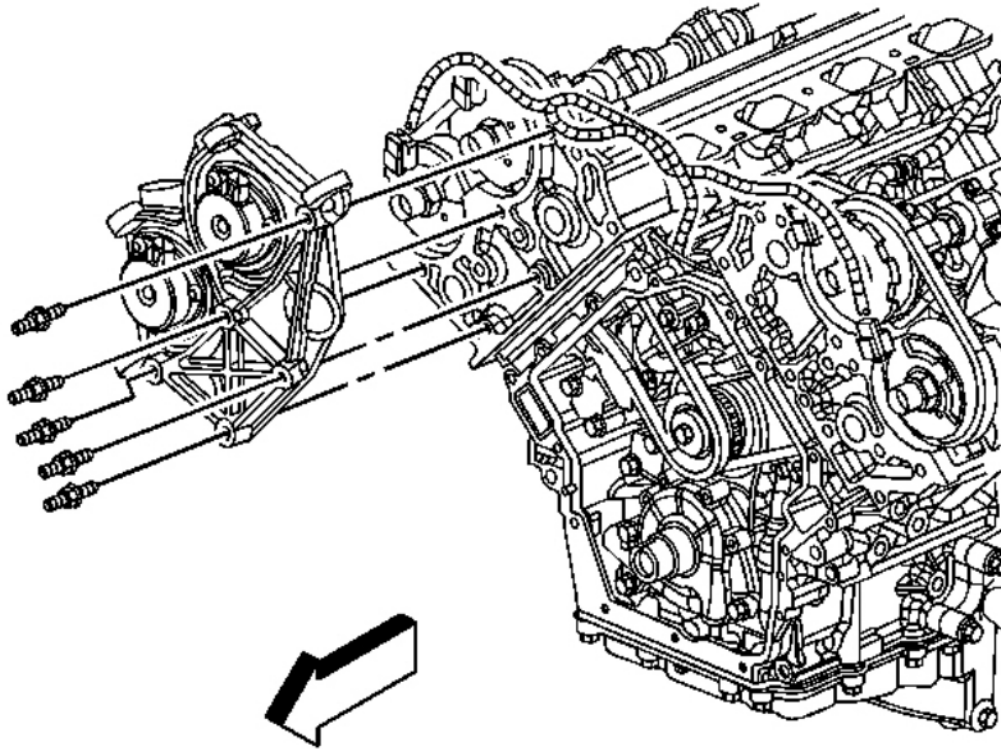


Fig. 309: View Of Right Camshaft Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the right camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.

CAMSHAFT POSITION (CMP) ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK BANK 2 (LEFT) INTAKE

Tools Required

- J 39946 Crankshaft Socket
- EN 46327 Timing Chain Retention Tool
- EN 46328 Camshaft Holding Tool

Removal Procedure

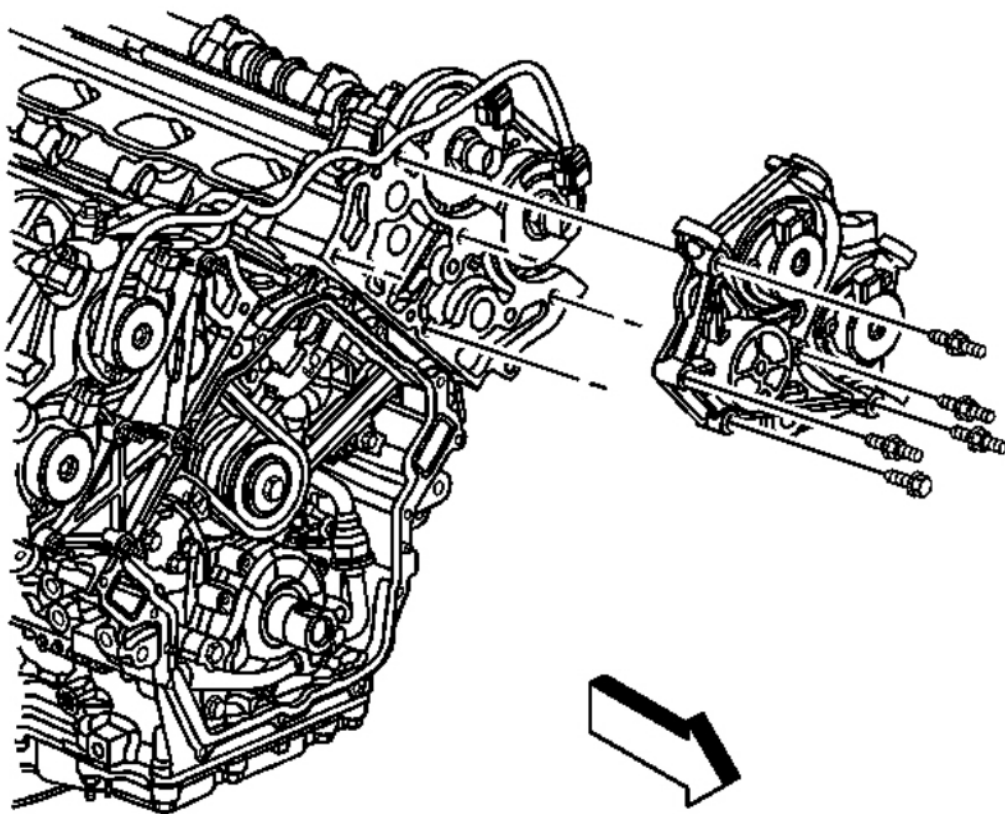


Fig. 310: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the left actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 2 (left) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation.

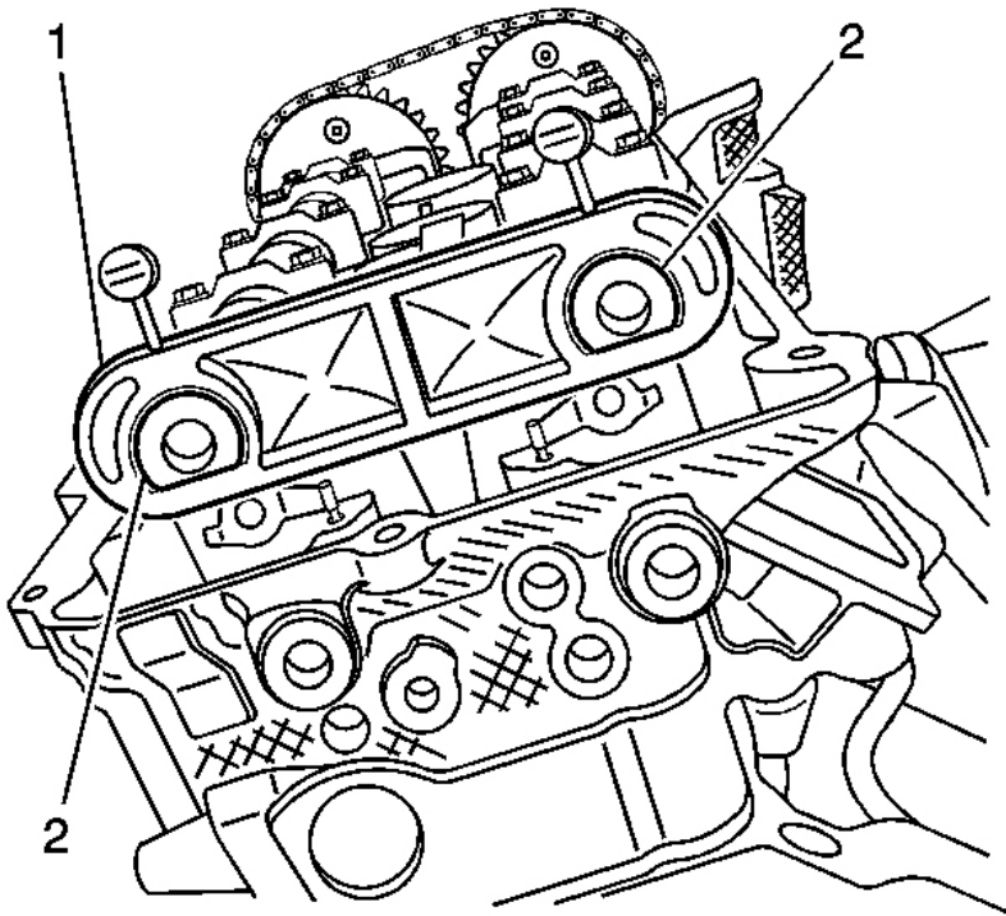


Fig. 311: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the **EN 46328** (1) to the camshafts (2).

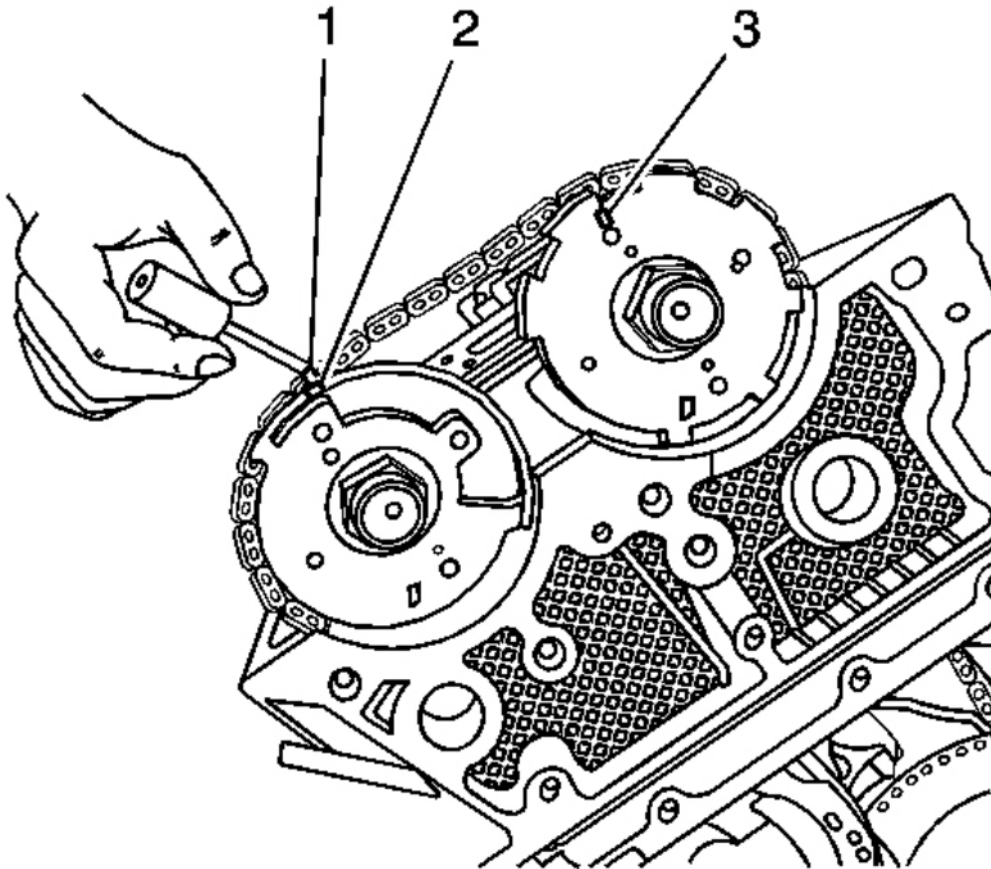


Fig. 312: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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

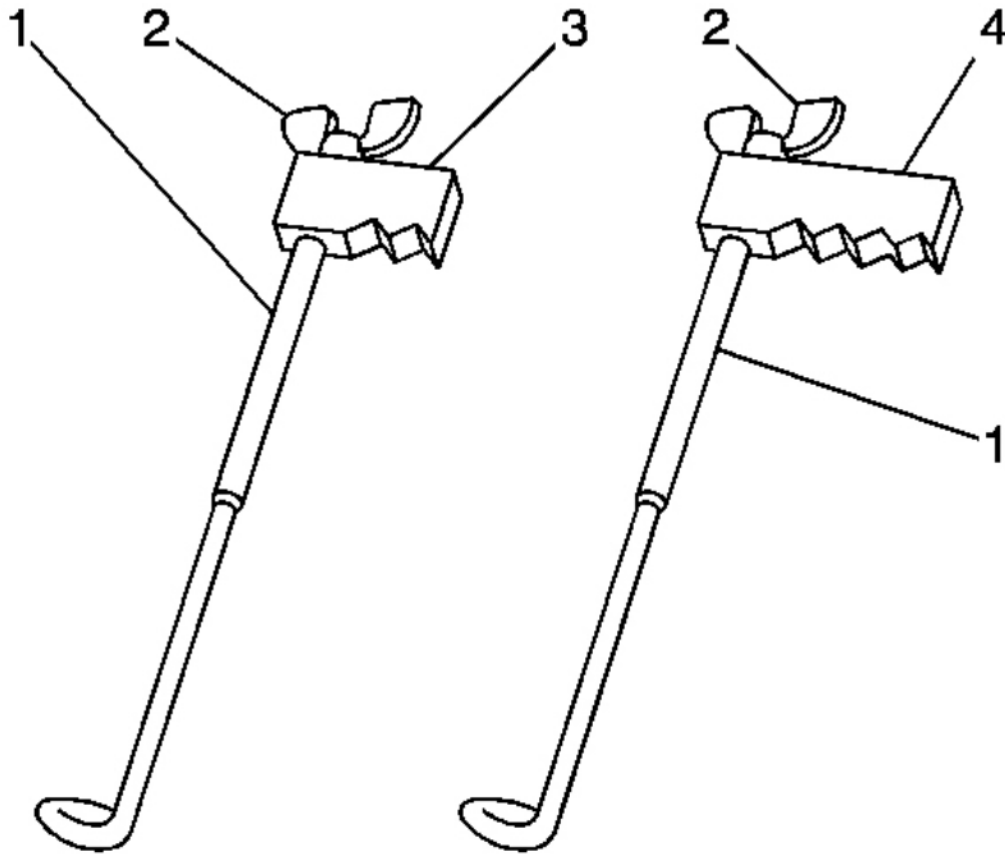


Fig. 313: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure.

Installation of the EN 46327 Timing Chain Retention Tool - Left Bank

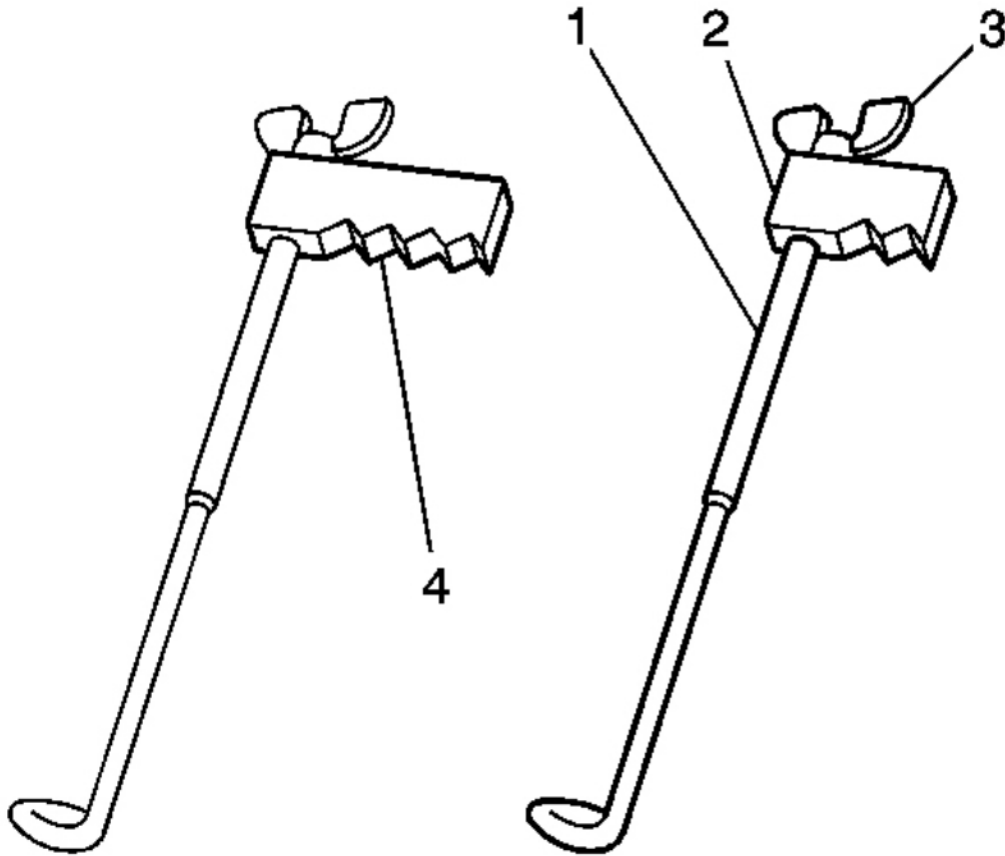


Fig. 314: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel.

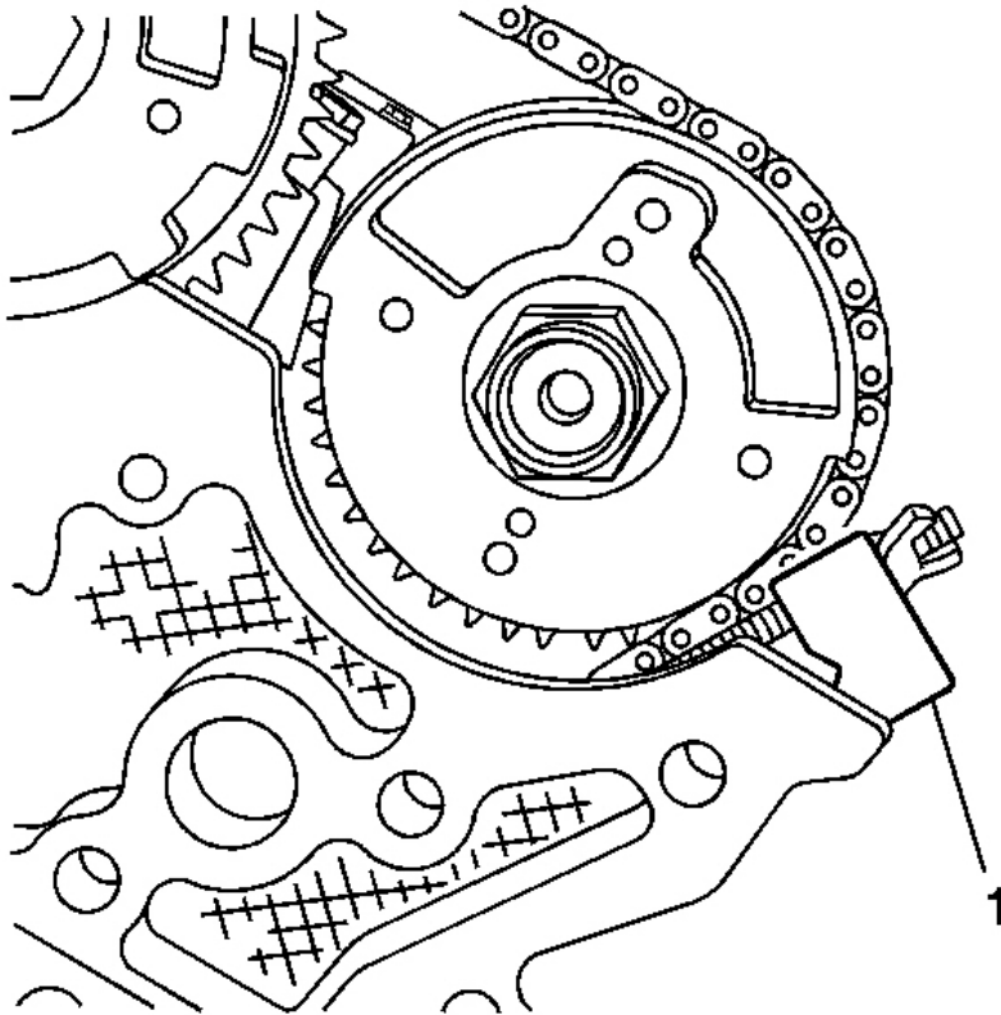


Fig. 315: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

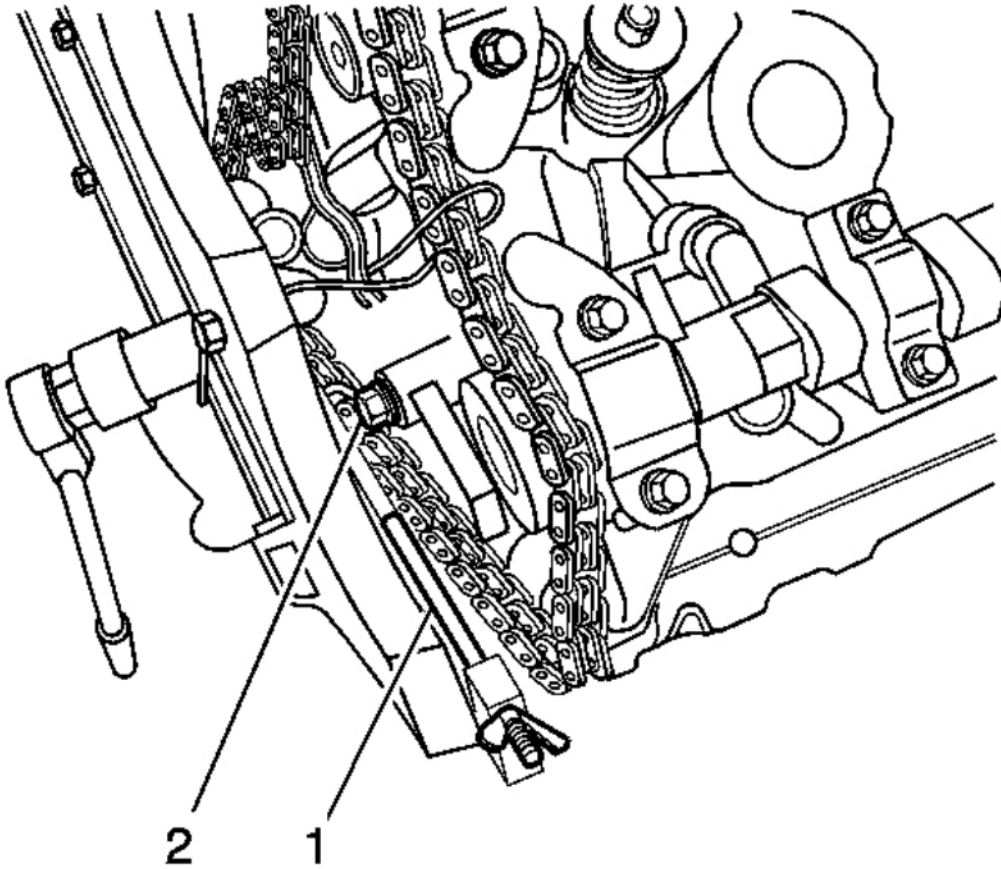


Fig. 316: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

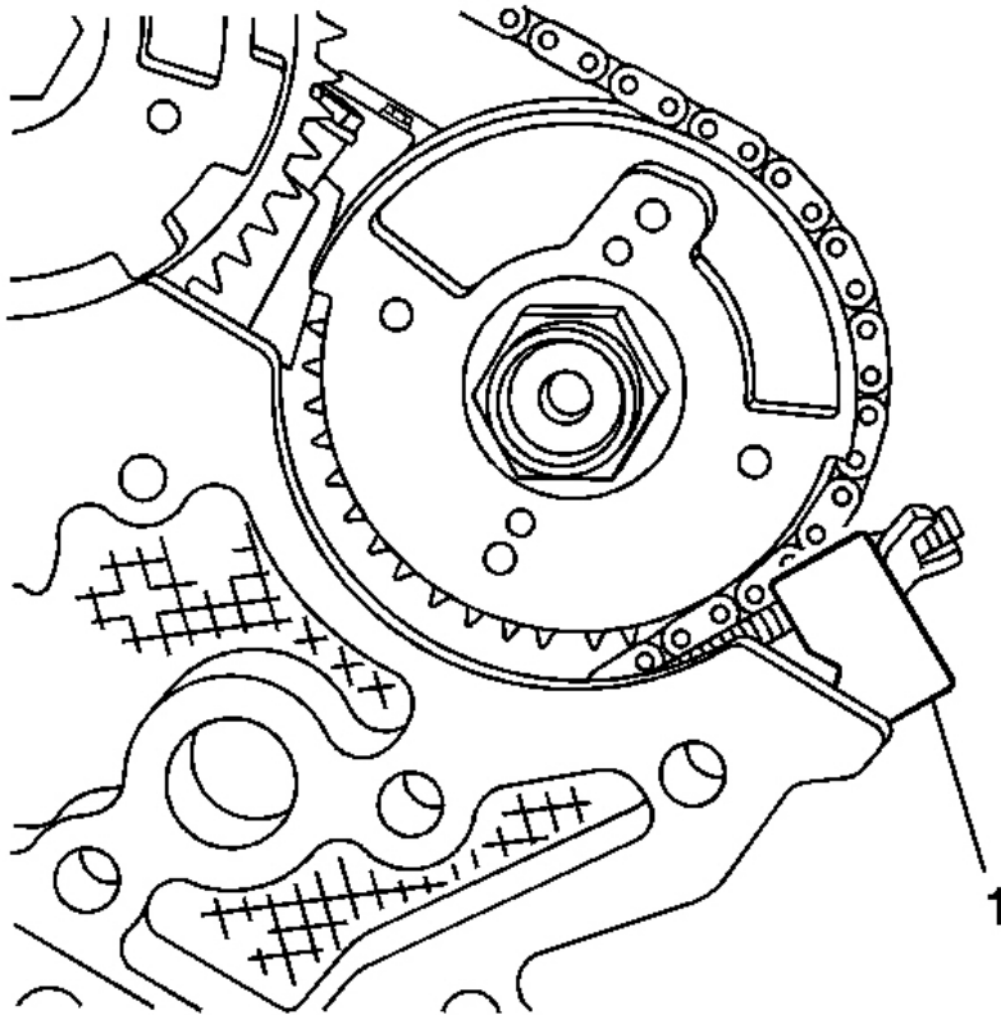


Fig. 317: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

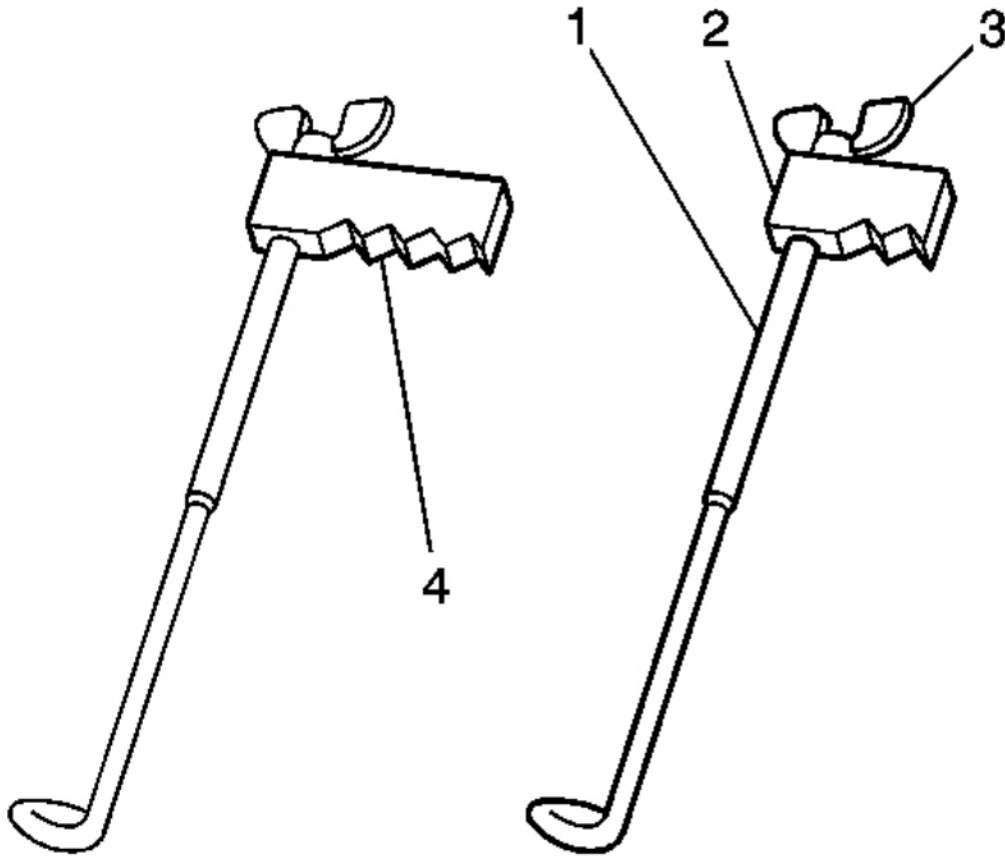


Fig. 318: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel.

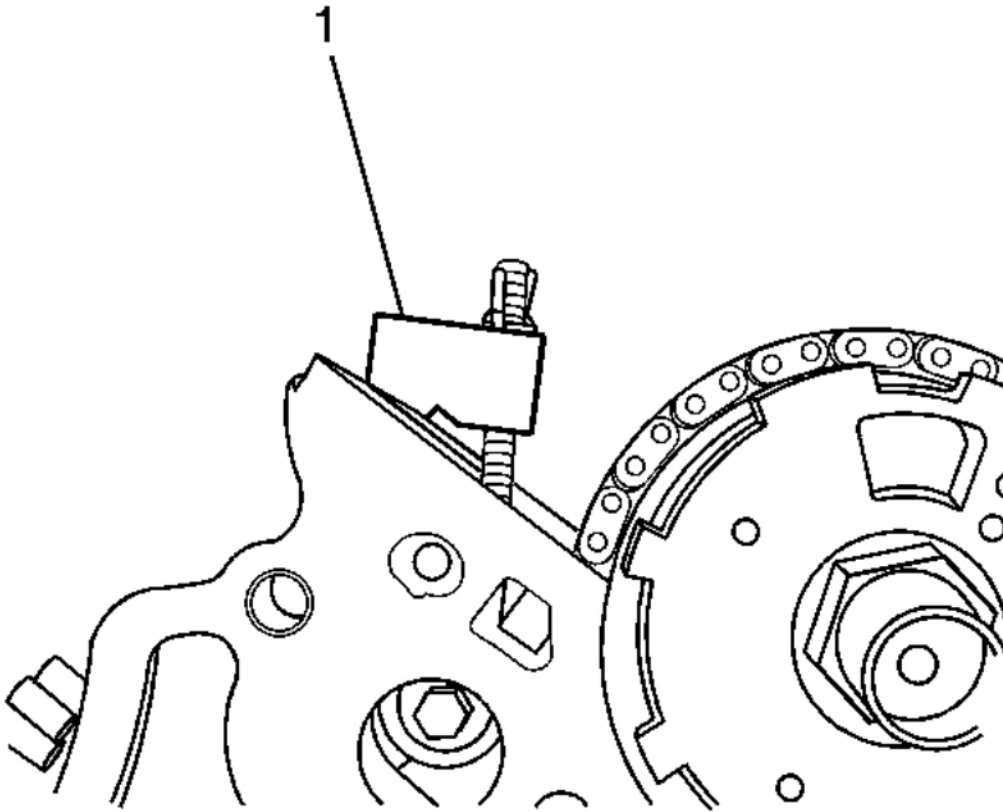


Fig. 319: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

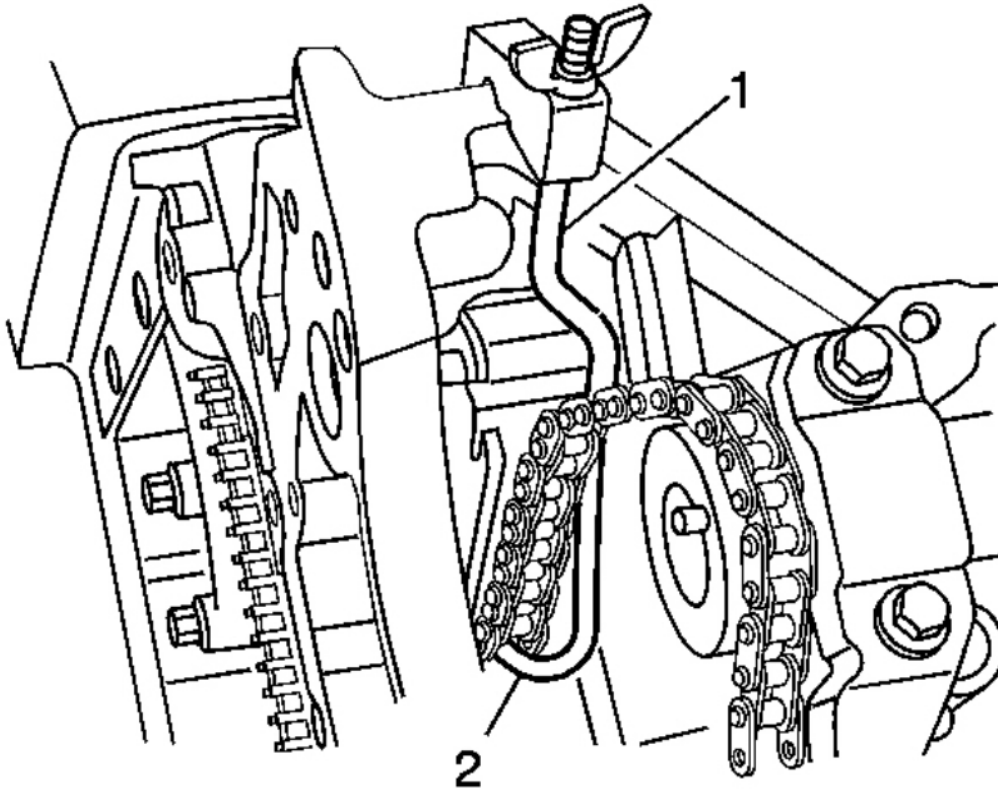


Fig. 320: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

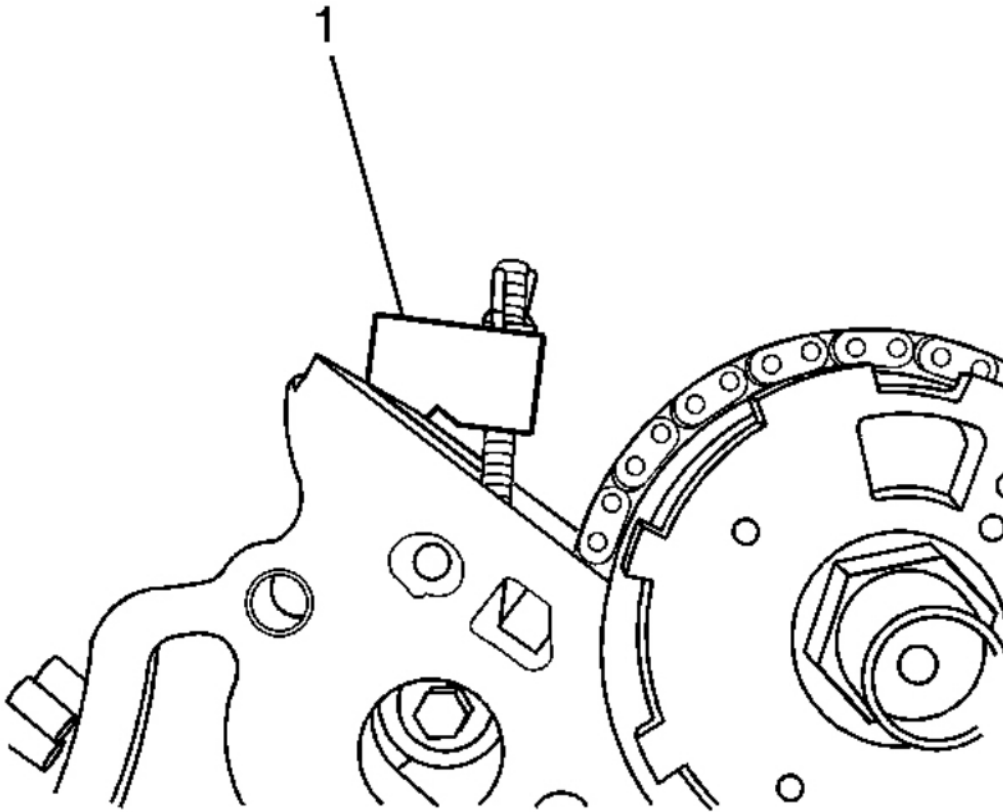


Fig. 321: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

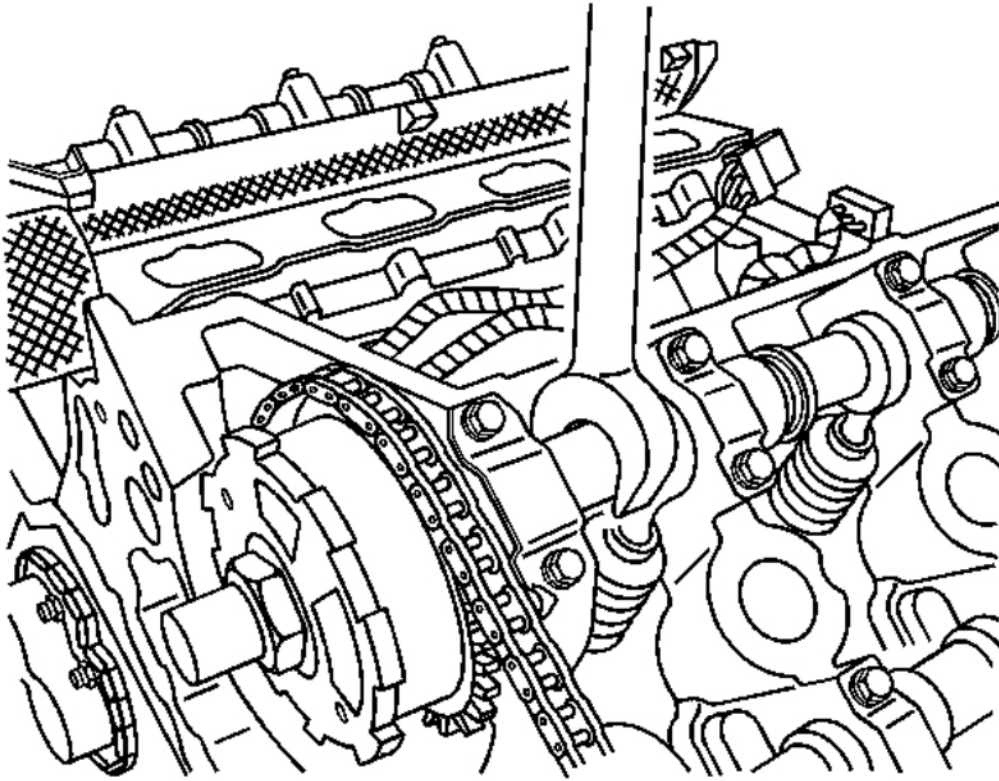
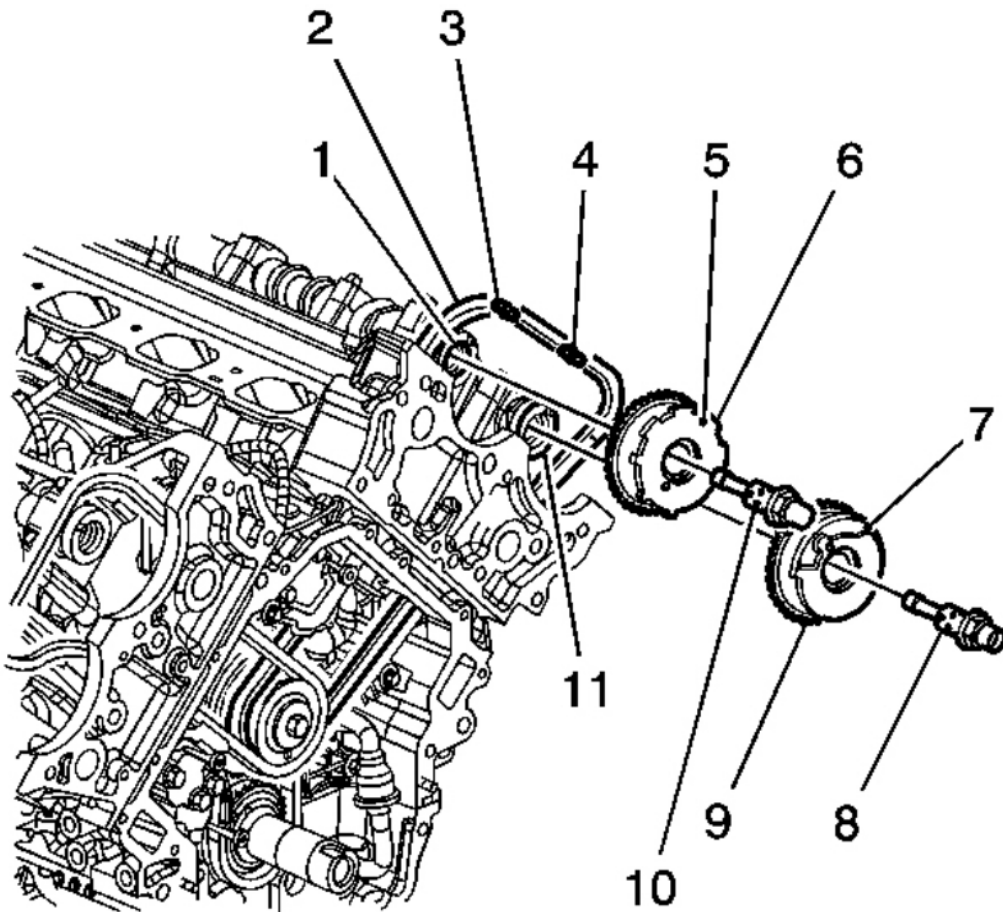


Fig. 322: Holding Camshaft

Courtesy of GENERAL MOTORS CORP.

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

9. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.



10. Loosen and remove the left intake oil control valve (10).

Installation Procedure

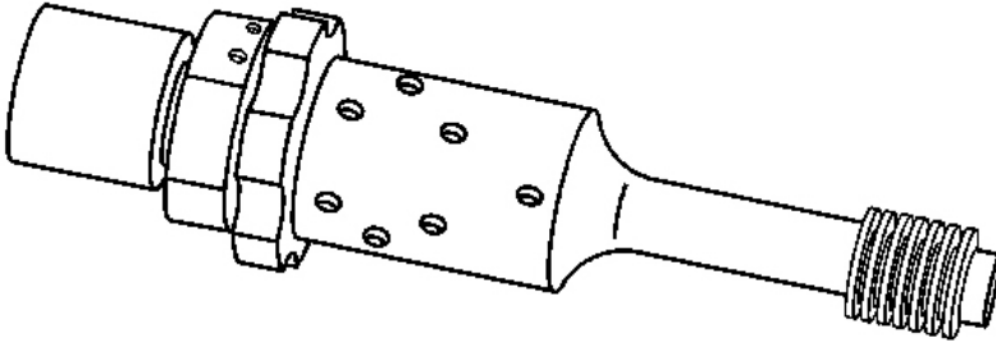


Fig. 324: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the left intake camshaft position actuator and thread it into the left intake camshaft.

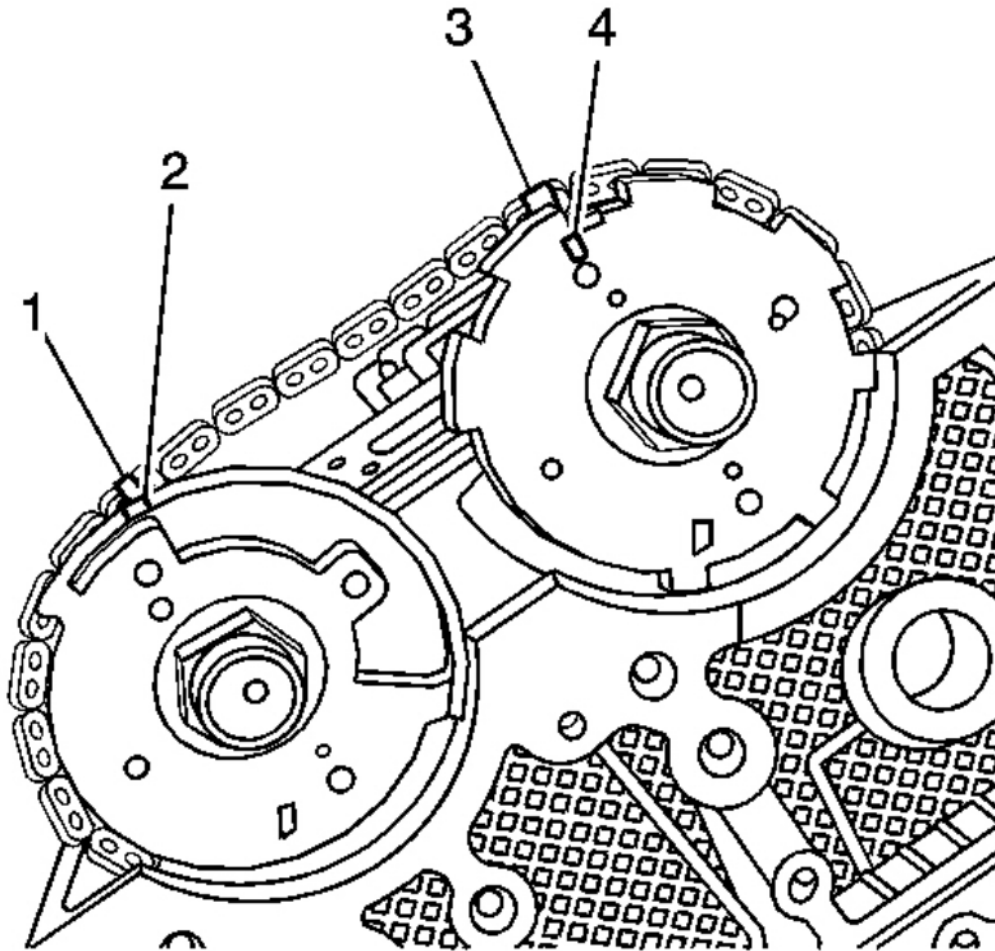


Fig. 325: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

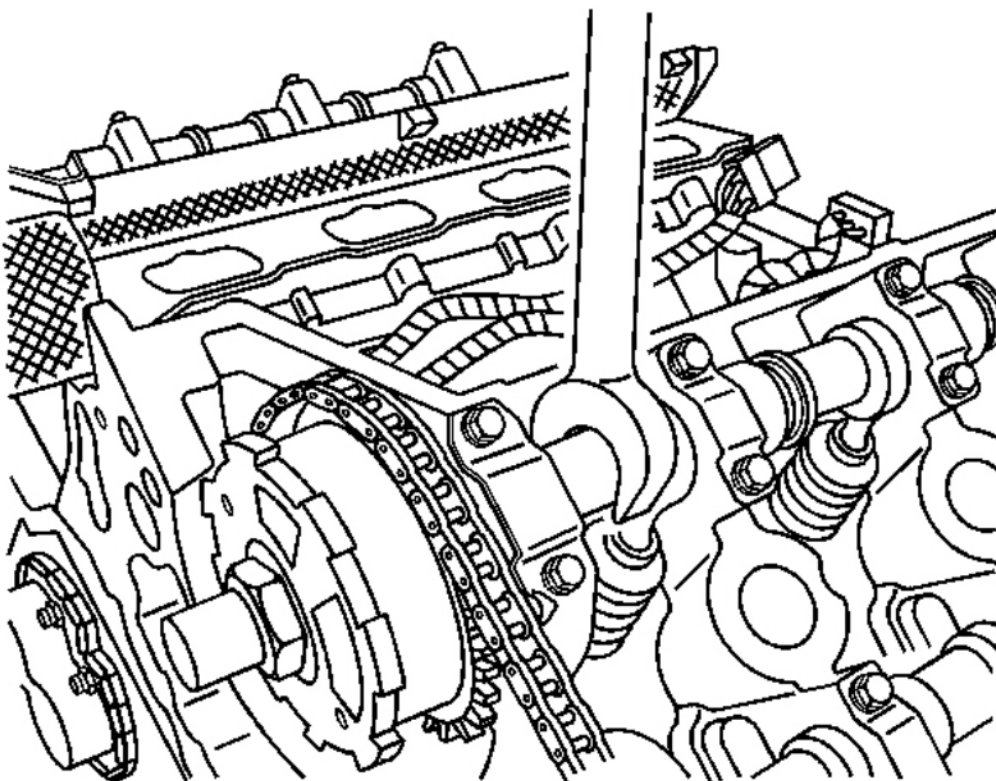


Fig. 326: Holding Camshaft

Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Use an open end wrench on the hex cast into the left intake camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

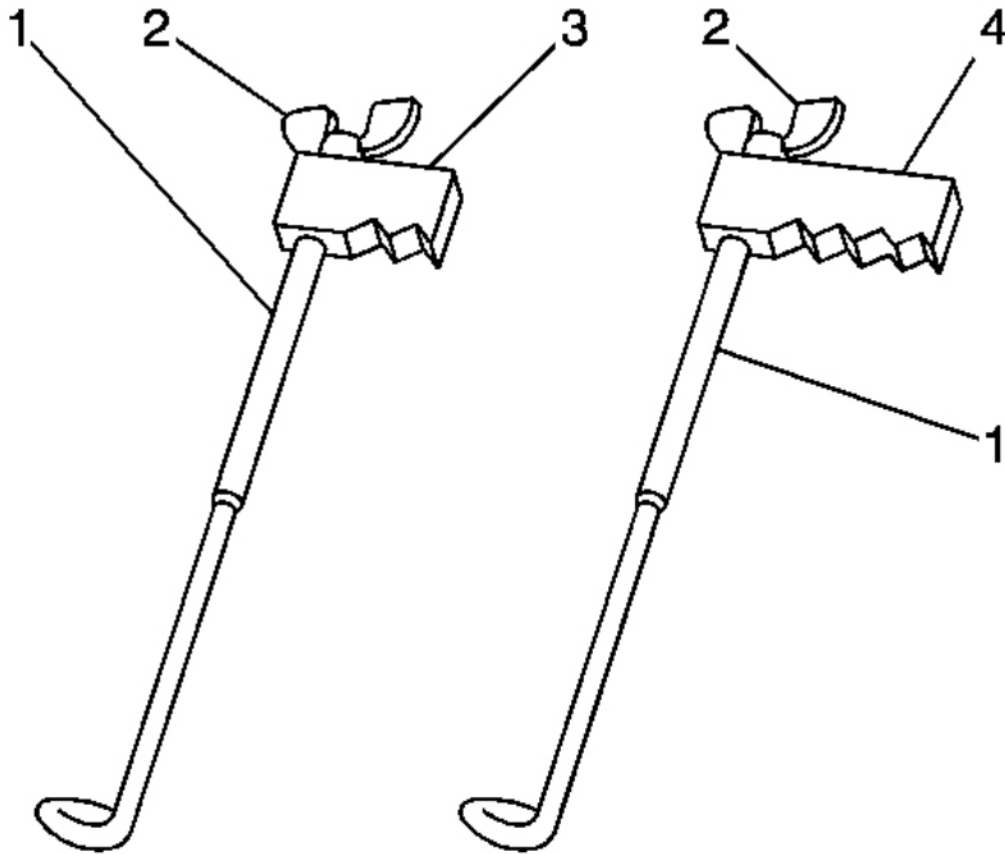


Fig. 327: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

4. Remove the EN 46327 (1).

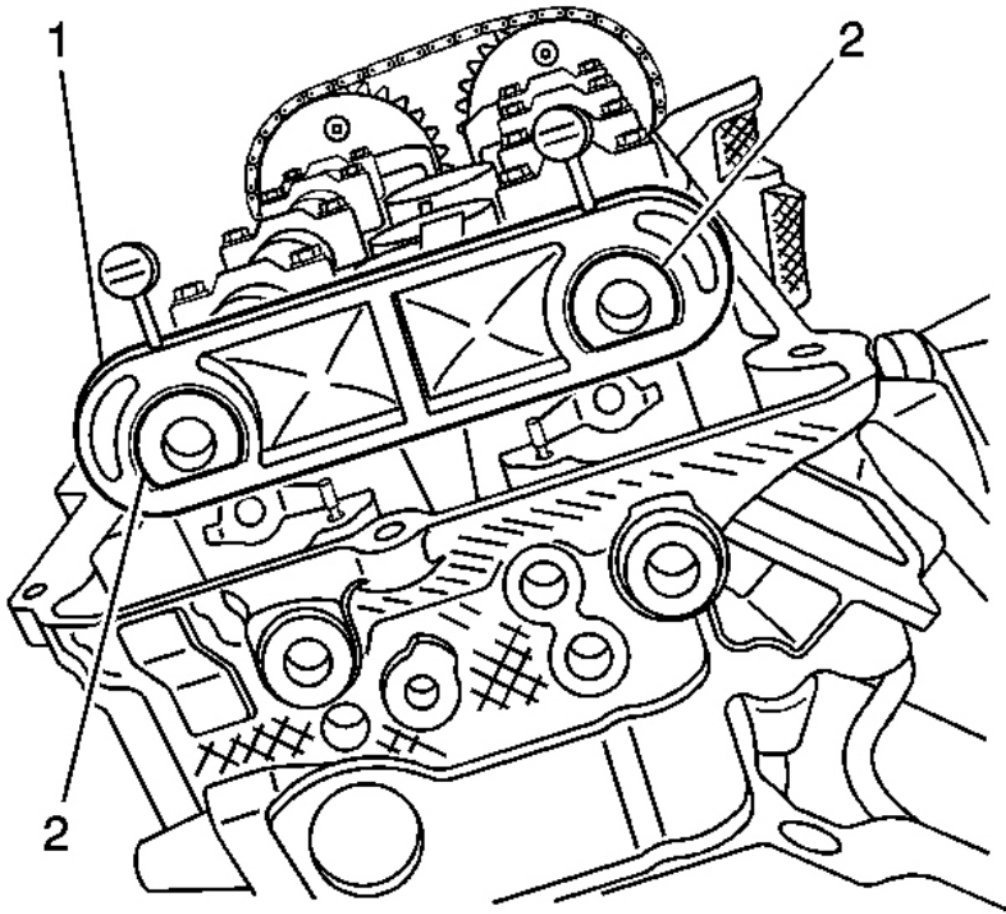


Fig. 328: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2).
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

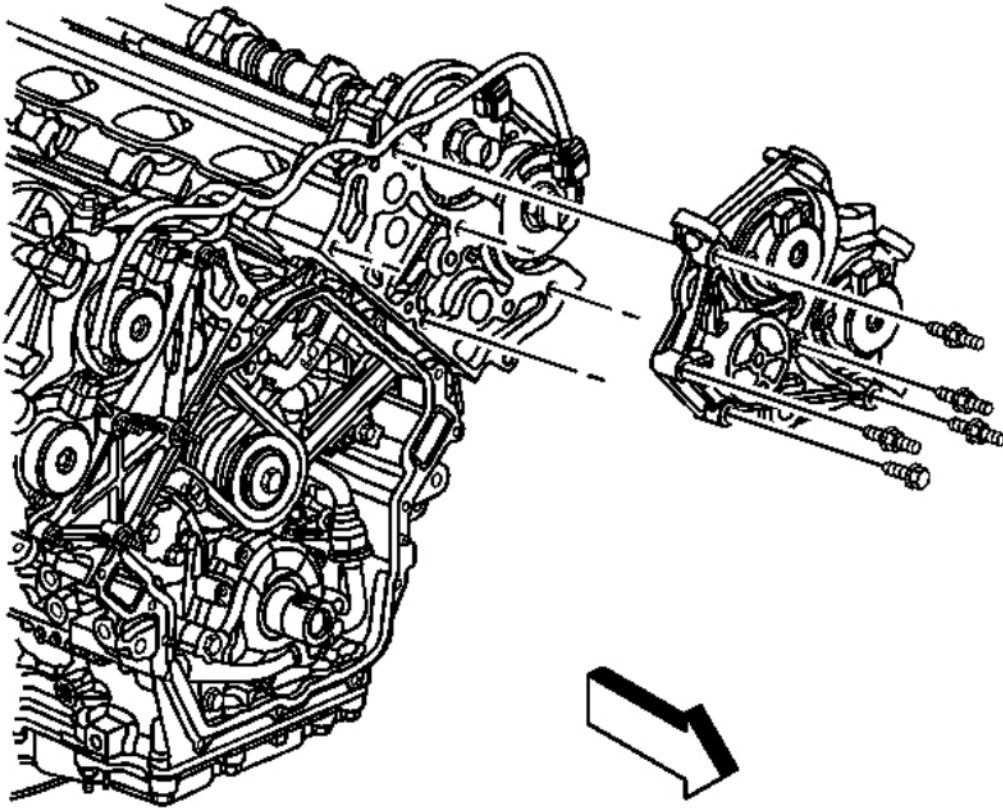


Fig. 329: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the left camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left.**

CAMSHAFT POSITION (CMP) ACTUATOR OIL CONTROL VALVE REPLACEMENT - BANK BANK 2 (LEFT) EXHAUST

Tools Required

- **J 39946** Crankshaft Socket
- **EN 46327** Timing Chain Retention Tool
- **EN 46328** Camshaft Holding Tool

Removal Procedure

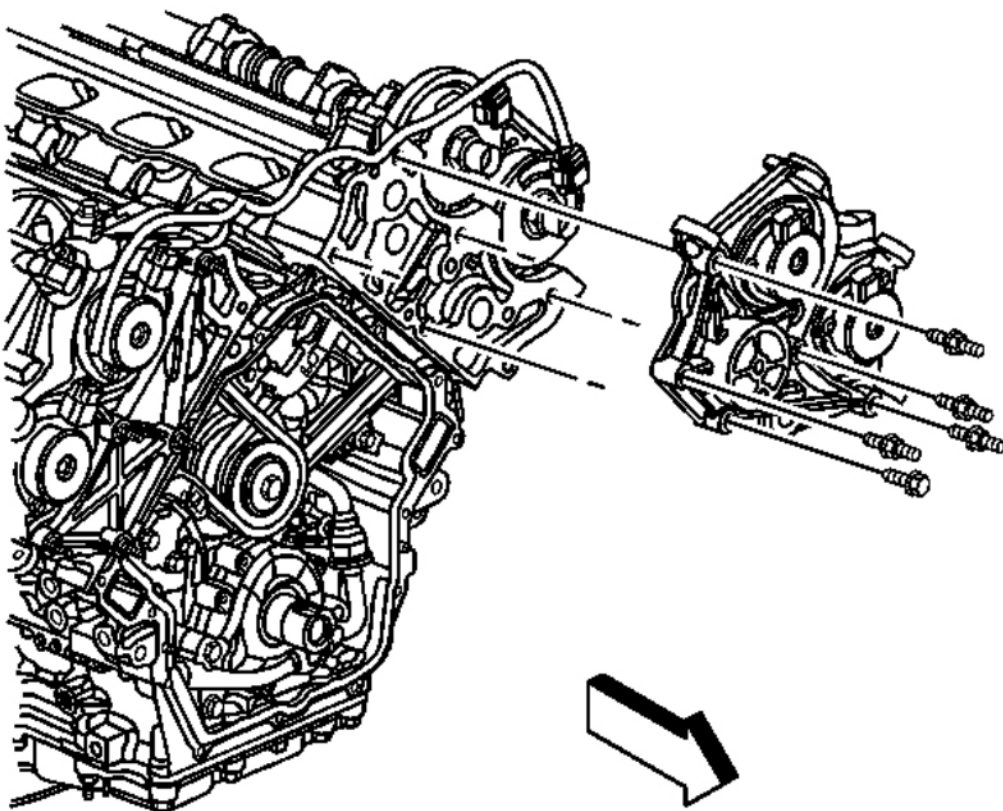


Fig. 330: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the left actuator housing. DO NOT remove the camshaft position (CMP) actuator solenoids from the housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

IMPORTANT: The secondary timing chain has black links that are used for alignment when the primary and secondary timing gear and chain assemblies are being installed together. IT IS NOT NECESSARY for the black chain links to be aligned with the camshaft actuator timing marks when the secondary chain

and gear components are being serviced separately.

3. Using the **J 39946** , rotate the crankshaft until both bank 2 (left) CMP actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface and near the top of their rotation.

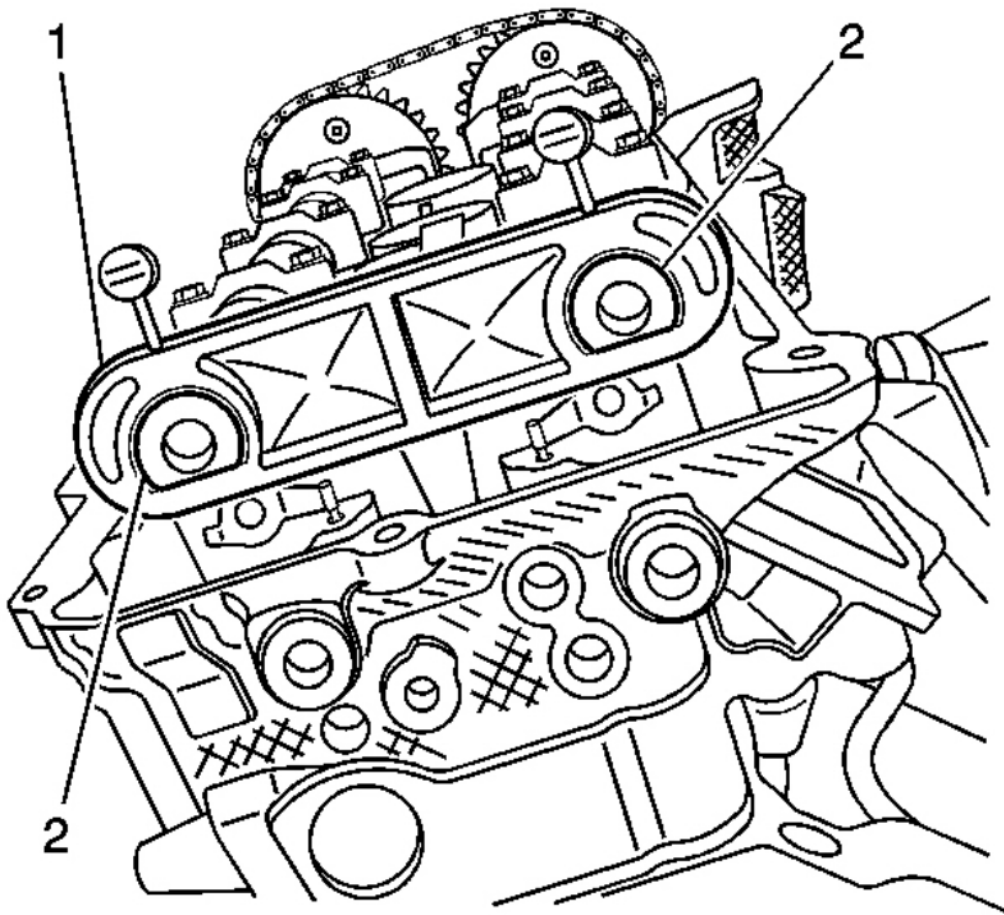


Fig. 331: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Holding Tool Caution in Cautions and Notices.

4. Install the **EN 46328** (1) to the camshafts (2).

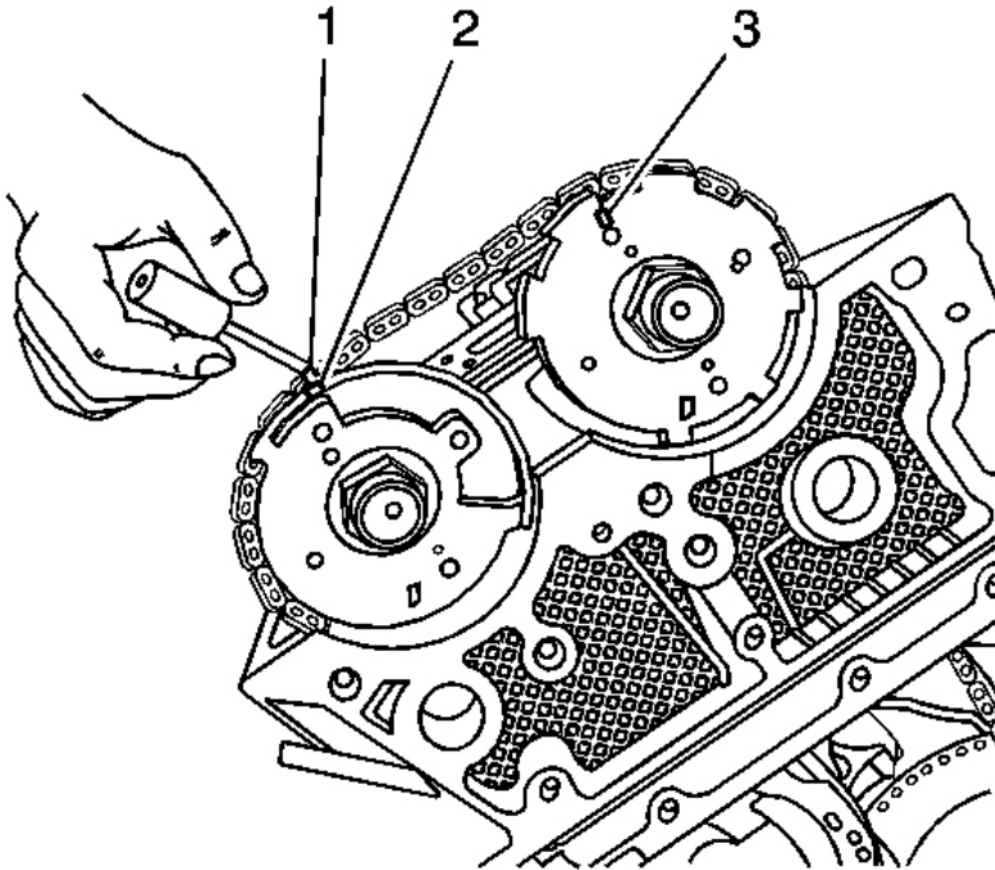


Fig. 332: Using A Paint Stick To Create A Mark On The Timing Chain Link Adjacent To Each Camshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

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

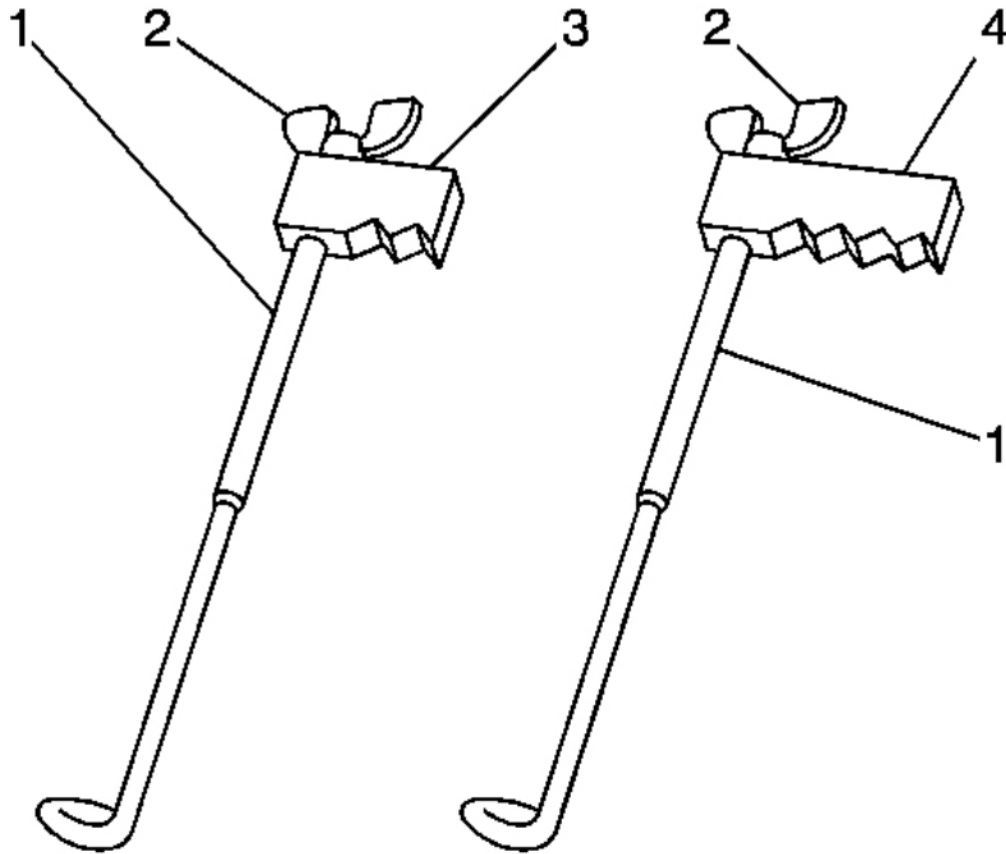


Fig. 333: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN 46327** (1) using the installation of the **EN 46327** timing chain retention tool procedure.

Installation of the EN 46327 Timing Chain Retention Tool - Left Bank

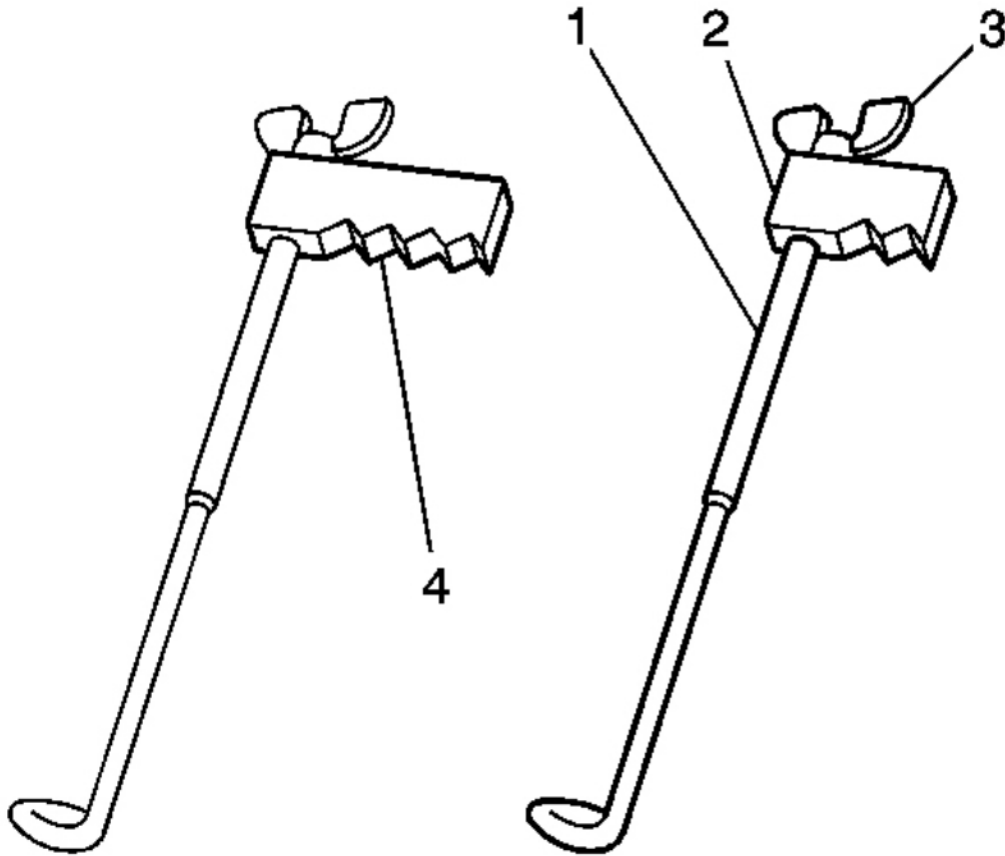


Fig. 334: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

1. Rotate the wing nut (3) of the **EN 46327** to the top of its travel.

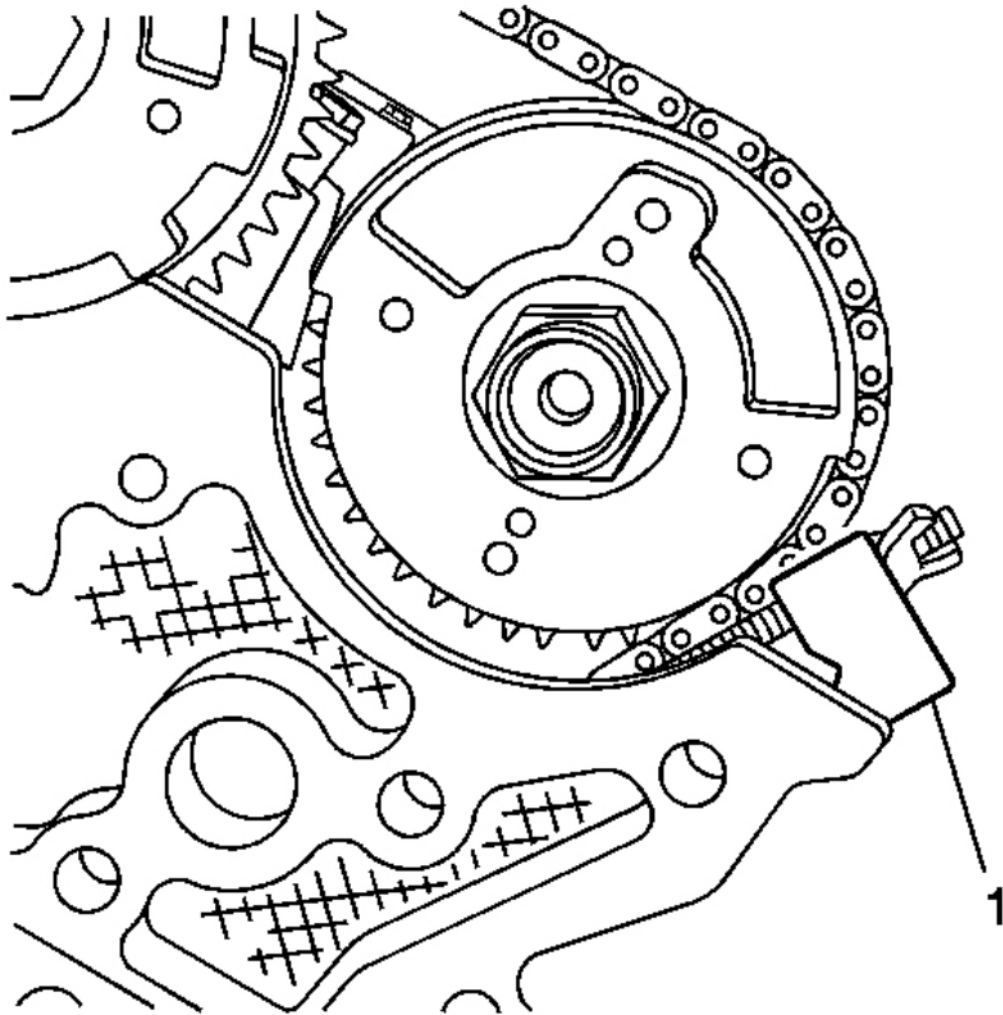


Fig. 335: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

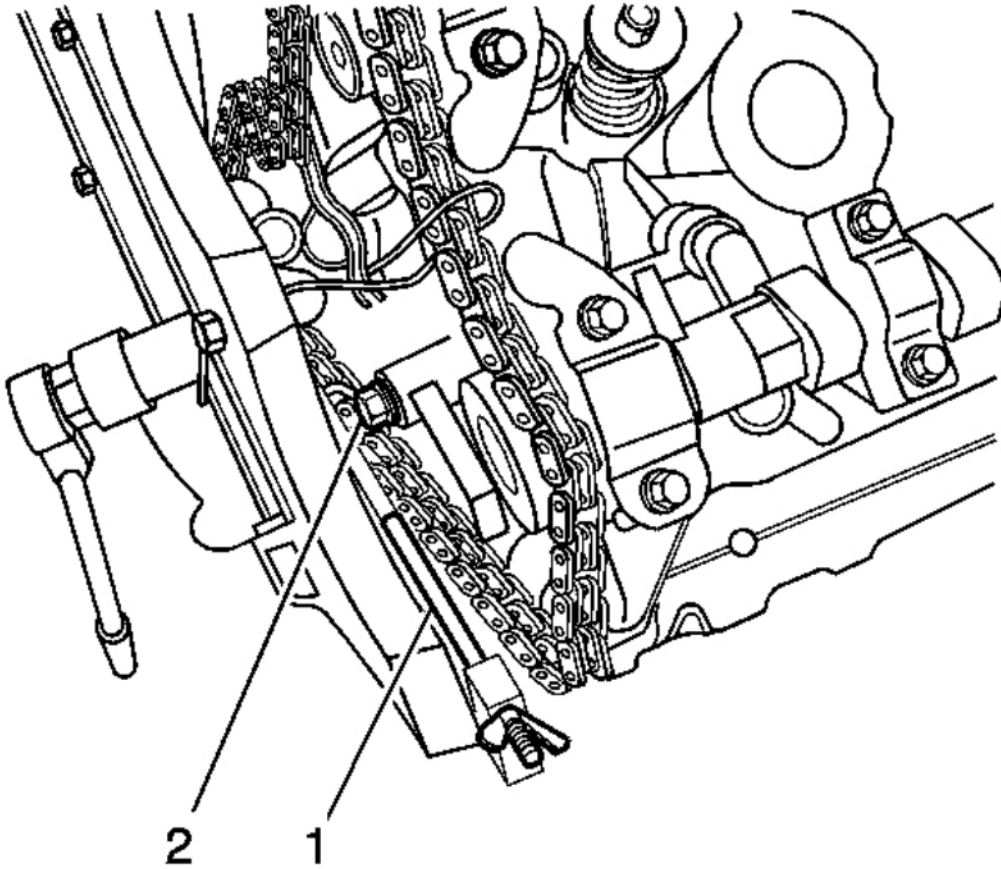


Fig. 336: Installing EN 46327 Hook End Into Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

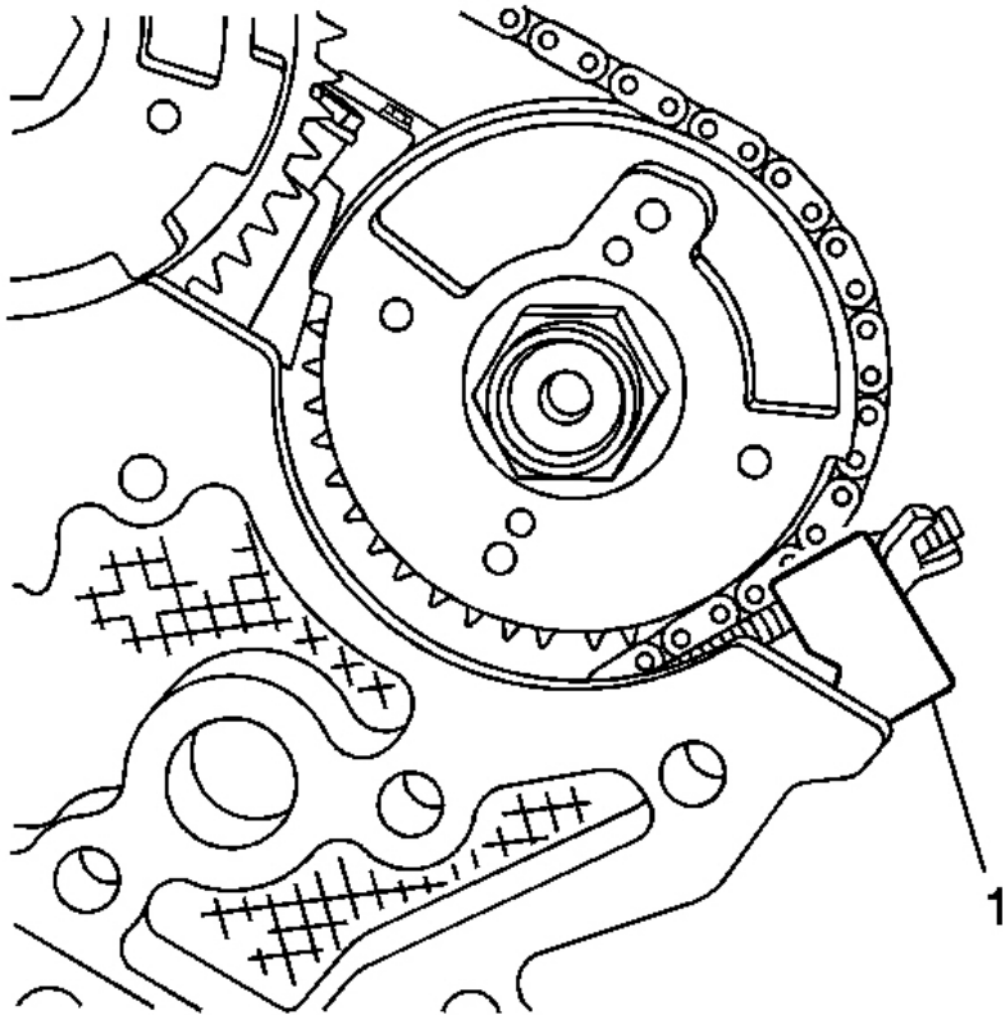


Fig. 337: Positioning EN 46327 On The Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

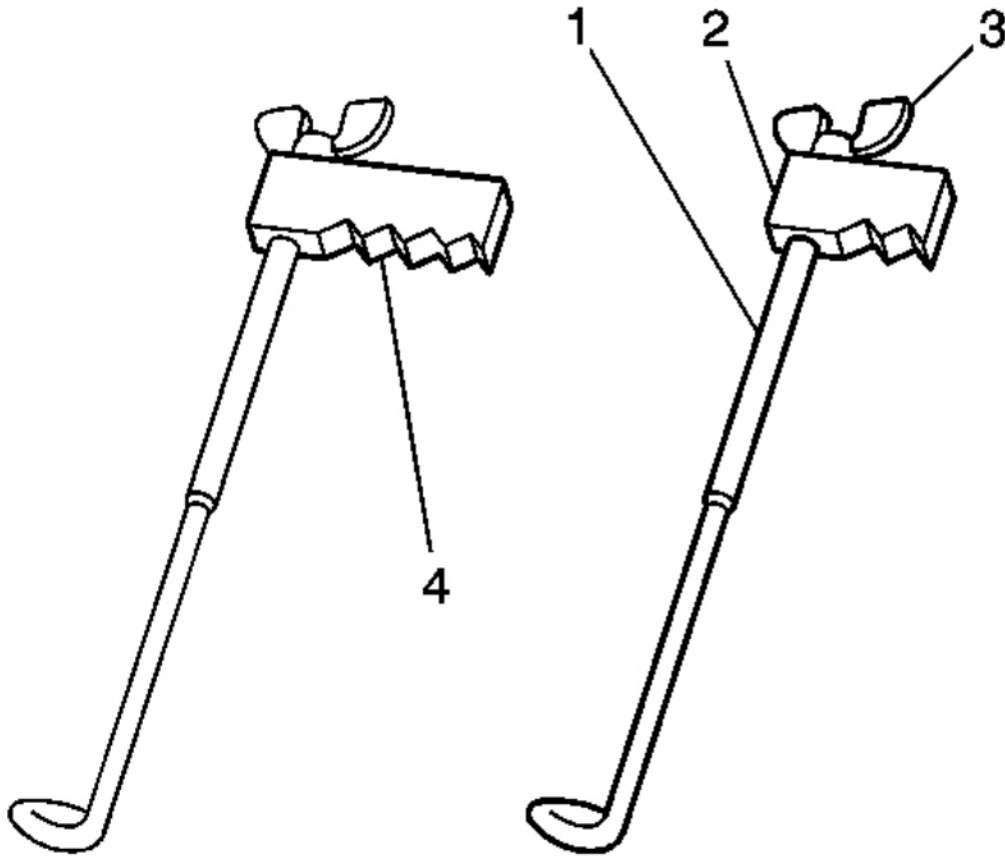


Fig. 338: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

5. Rotate the wing nut of the **EN 46327** (4) to the top of its travel.

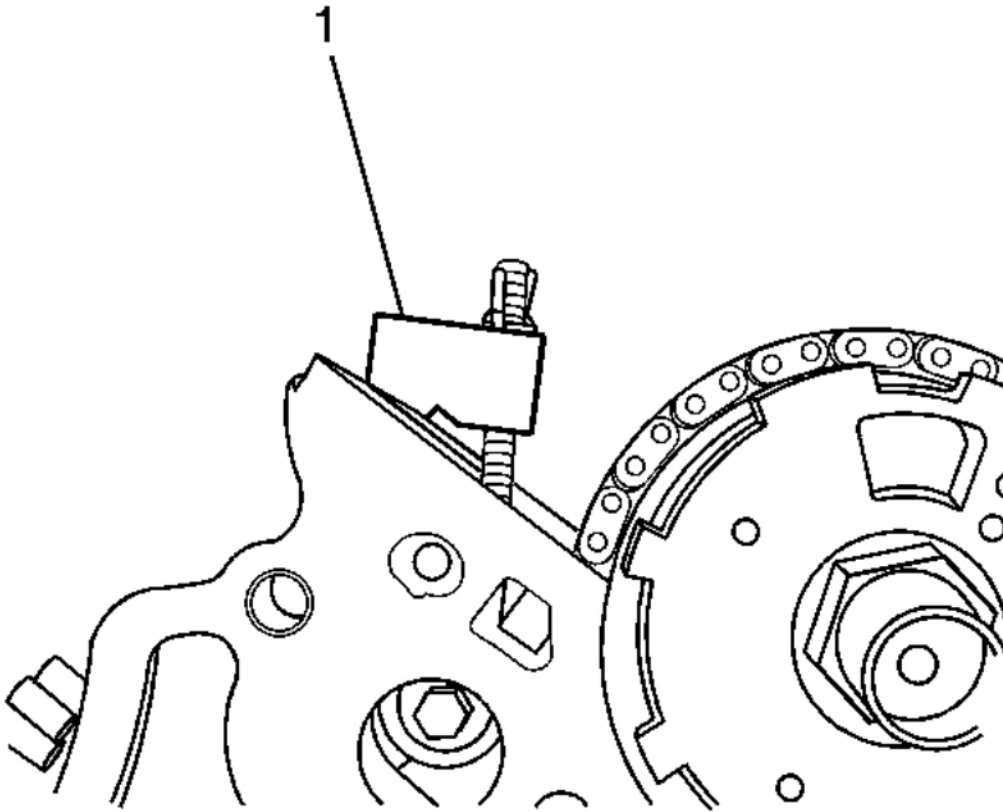


Fig. 339: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

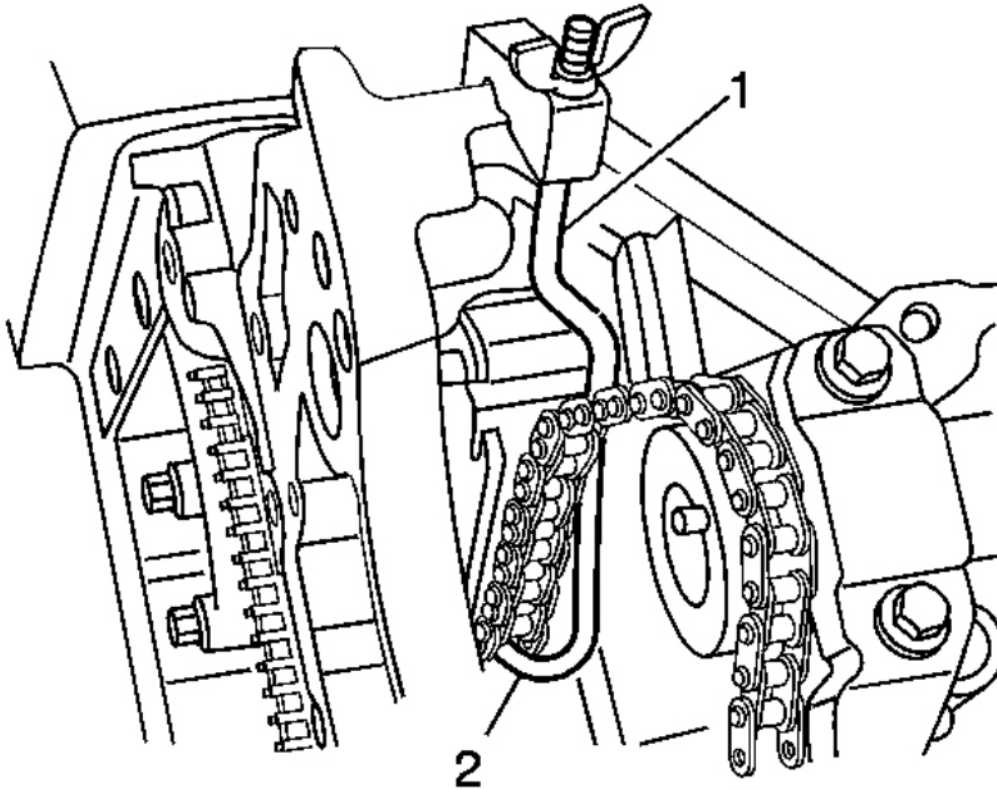


Fig. 340: View Of Hook End In Secondary Timing Chain Link
Courtesy of GENERAL MOTORS CORP.

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

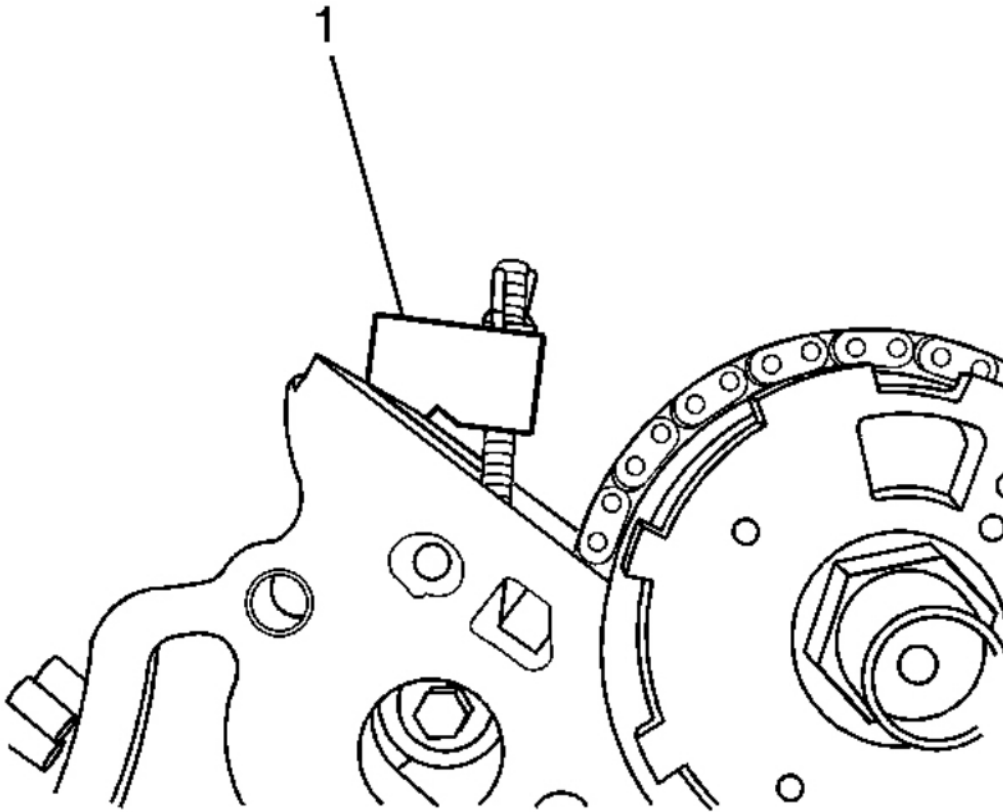


Fig. 341: Positioning Top Retention Tool On Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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

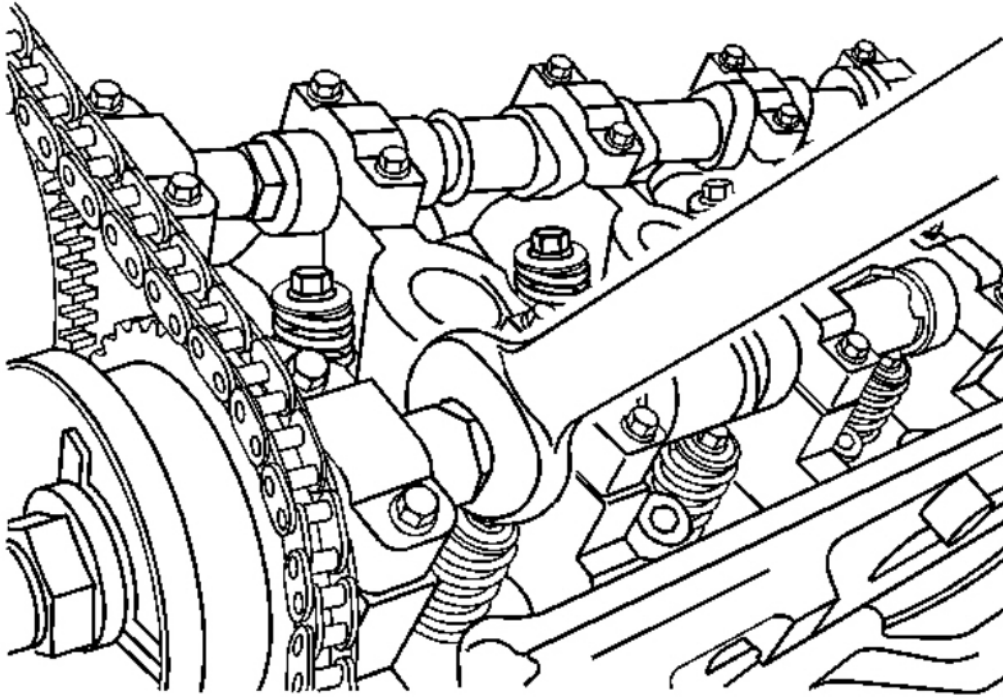


Fig. 342: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

9. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when loosening the camshaft oil control valve.

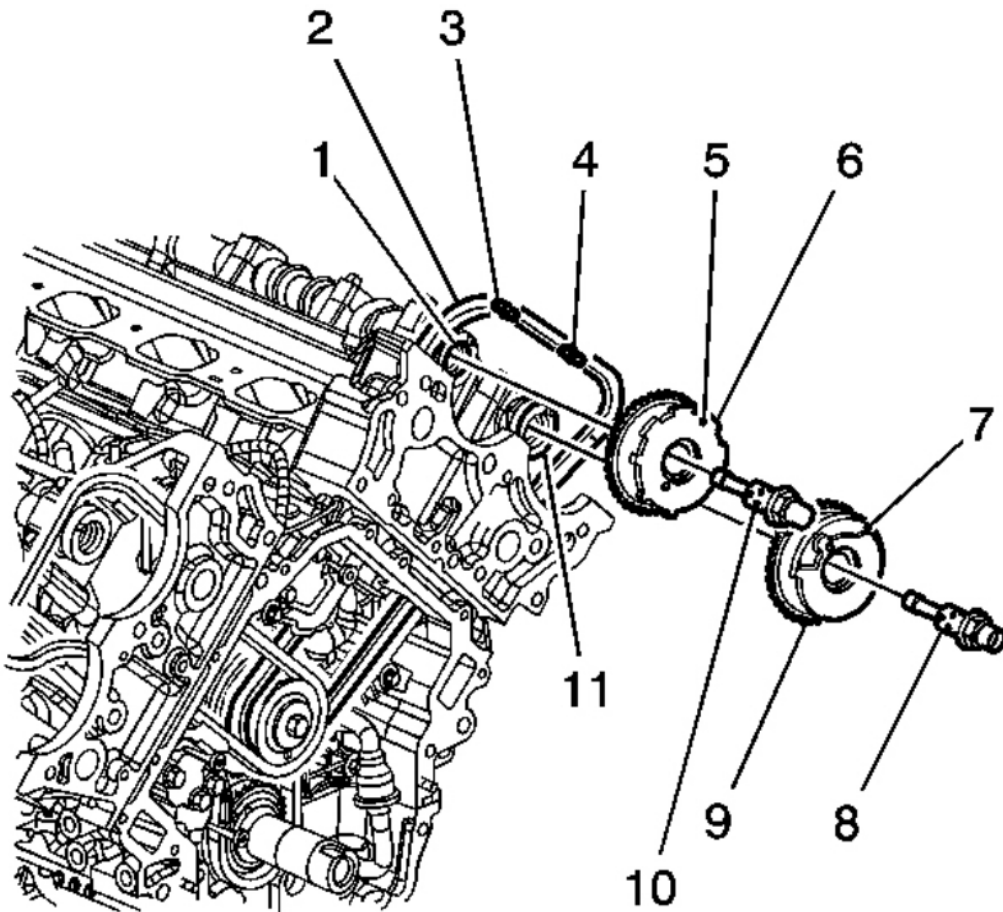


Fig. 343: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

10. Loosen and remove the left exhaust oil control valve (8).

Installation Procedure

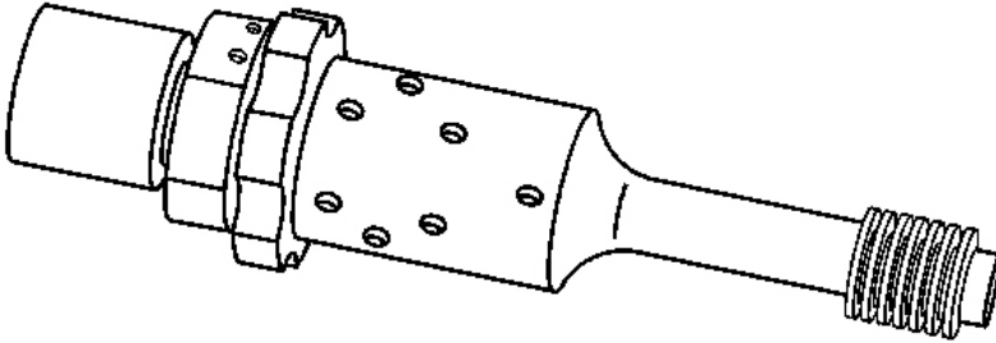


Fig. 344: View Of Camshaft Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the oil control valve through the opening in the left exhaust camshaft position actuator and thread it into the left exhaust camshaft.

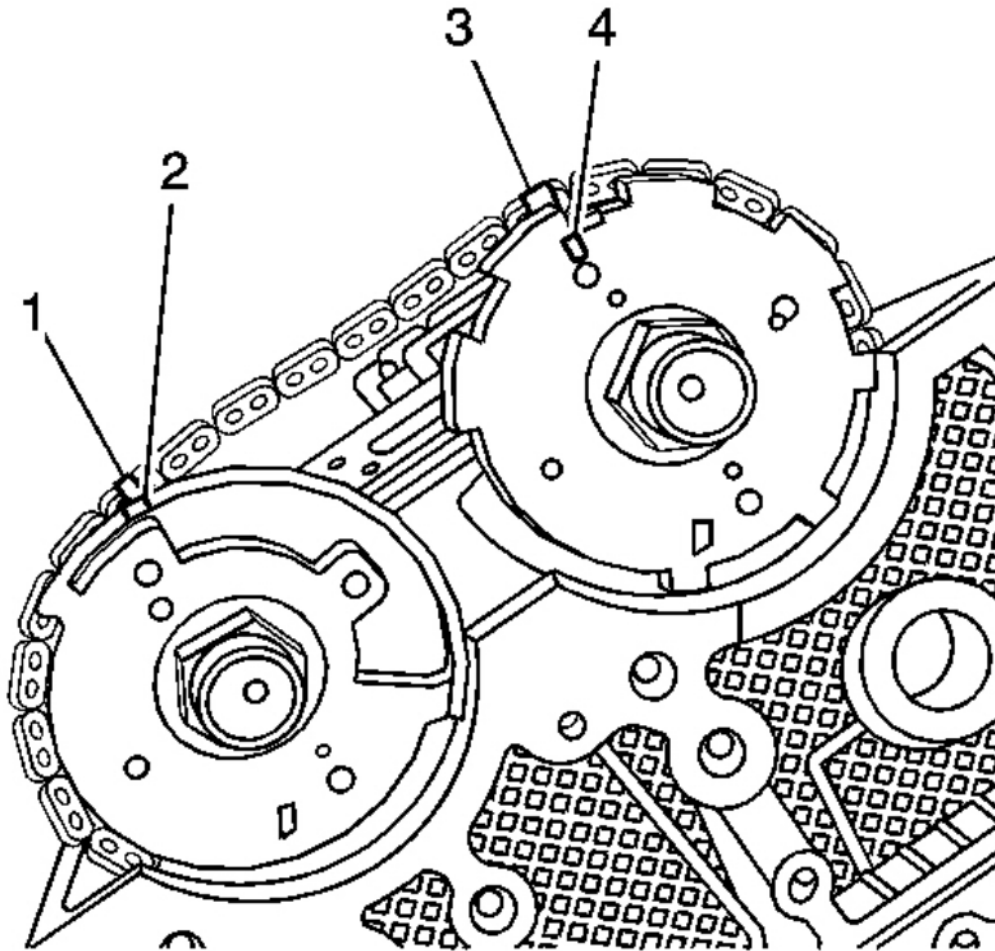


Fig. 345: Aligning Camshaft Sprocket & Timing Chain Paint Marks
Courtesy of GENERAL MOTORS CORP.

2. Ensure both camshaft actuator timing marks (1, 3) are aligned with the paint marks on the secondary timing chain previously created.

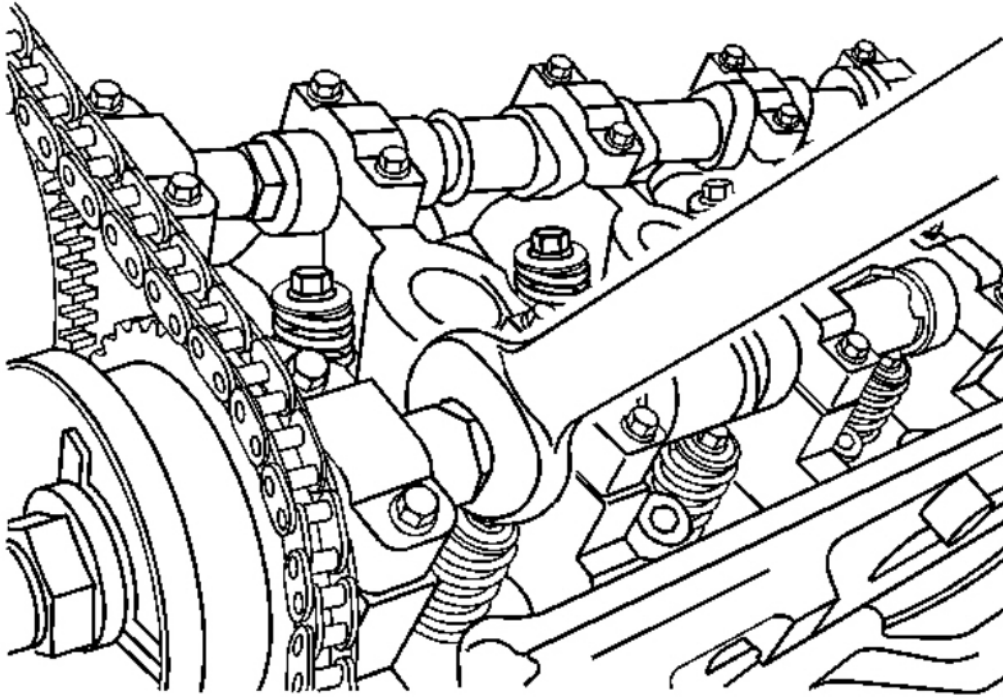


Fig. 346: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Use an open end wrench on the hex cast into the left exhaust camshaft to prevent the camshaft from rotating when tightening the camshaft oil control valve.

Tighten: Tighten the camshaft oil control valve to 120 N.m (89 lb ft).

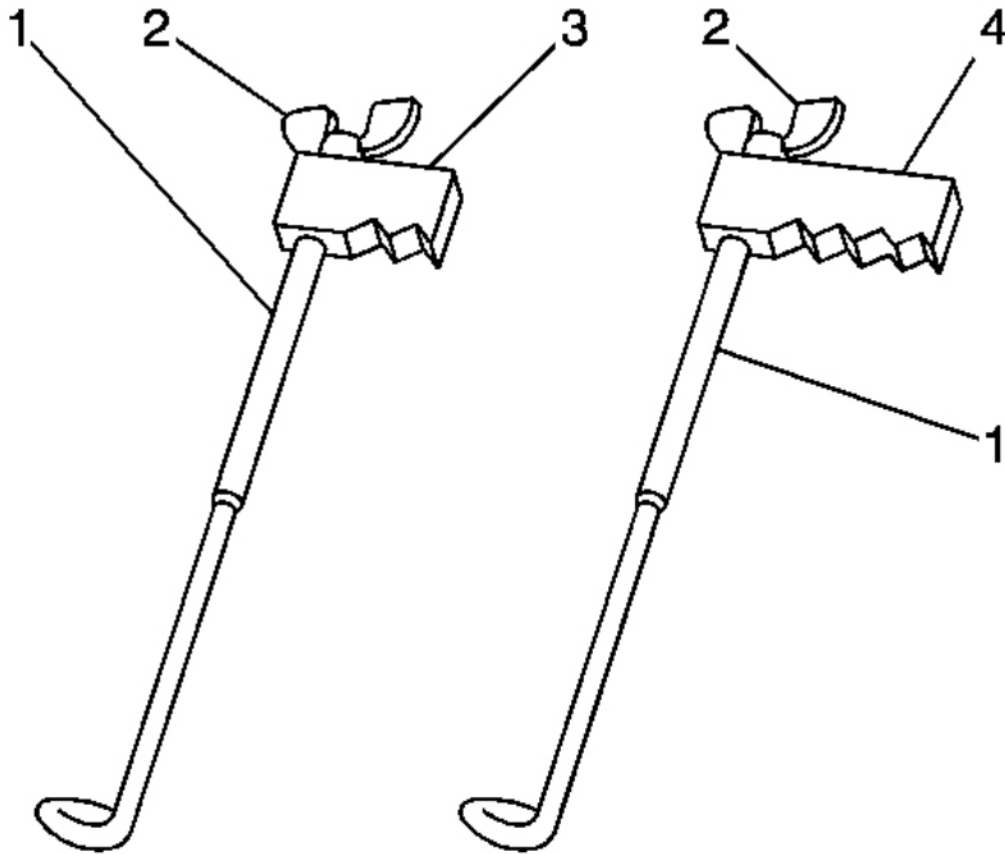


Fig. 347: Identifying Timing Chain Retention Tool Components
Courtesy of GENERAL MOTORS CORP.

4. Remove the EN 46327 (1).

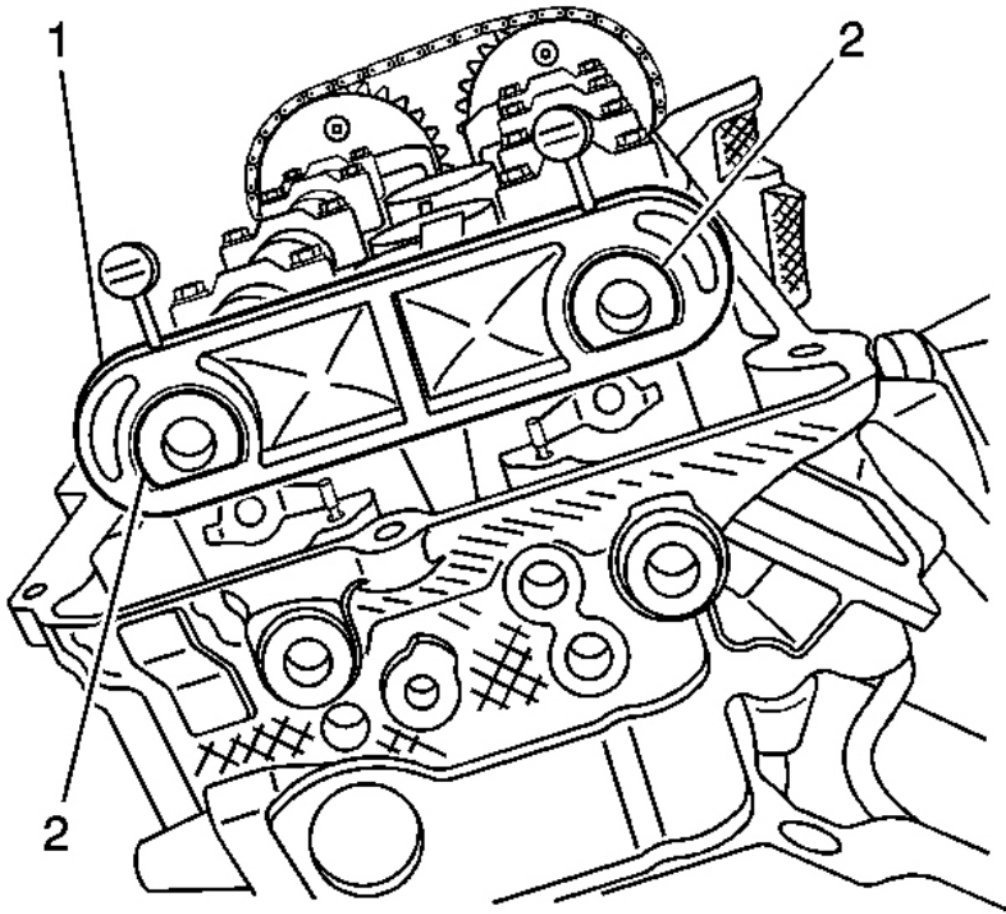


Fig. 348: View Of Special Tool & Camshafts (Rear Of Head)
Courtesy of GENERAL MOTORS CORP.

5. Remove the **EN 46328** (1) from the camshafts (2).
6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

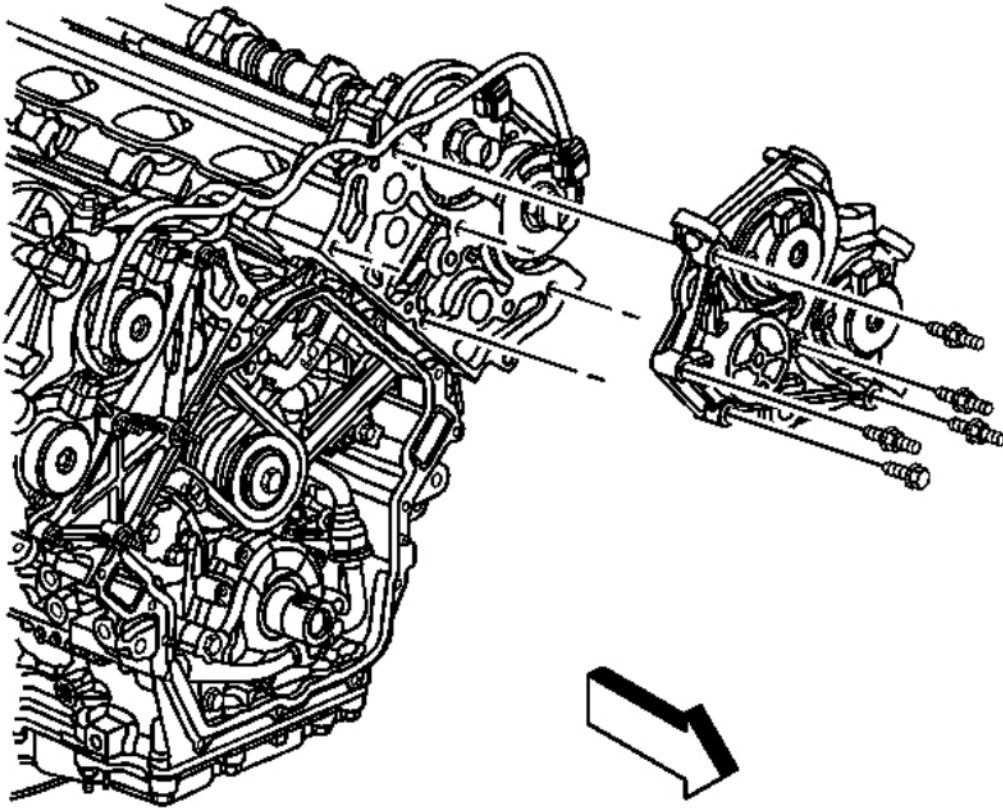


Fig. 349: View Of Left Camshaft Position Actuator Housing
Courtesy of GENERAL MOTORS CORP.

7. Install the left camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left.**

CAMSHAFT POSITION (CMP) ACTUATOR REPLACEMENT - BANK 1 (RIGHT) INTAKE

Removal Procedure

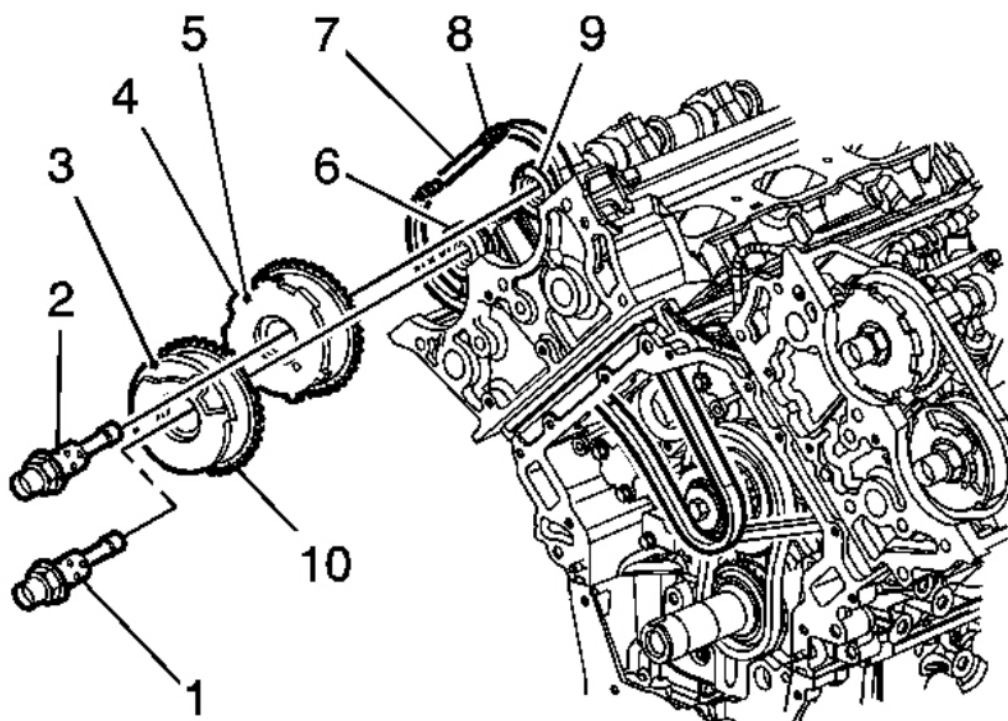


Fig. 350: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the right intake camshaft position actuator oil control valve (2). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 1 (Right) Intake**.
2. Pull the actuator forward to disengage the actuator from the camshaft alignment pin.
3. Disengage the secondary timing chain from the actuator and remove the actuator.
4. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection**.

Installation Procedure

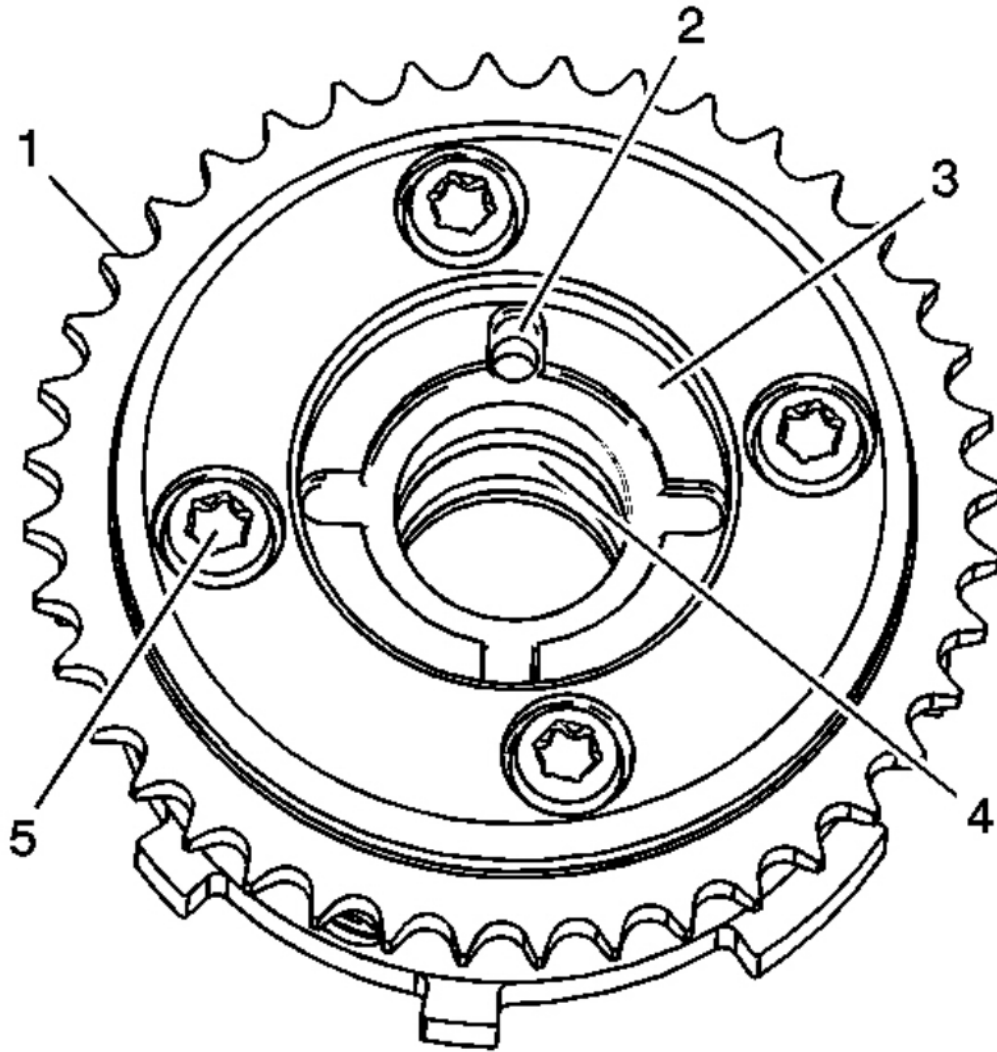


Fig. 351: Locating Camshaft Alignment Pin Hole
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator. This hole will mate with the camshaft alignment pin.

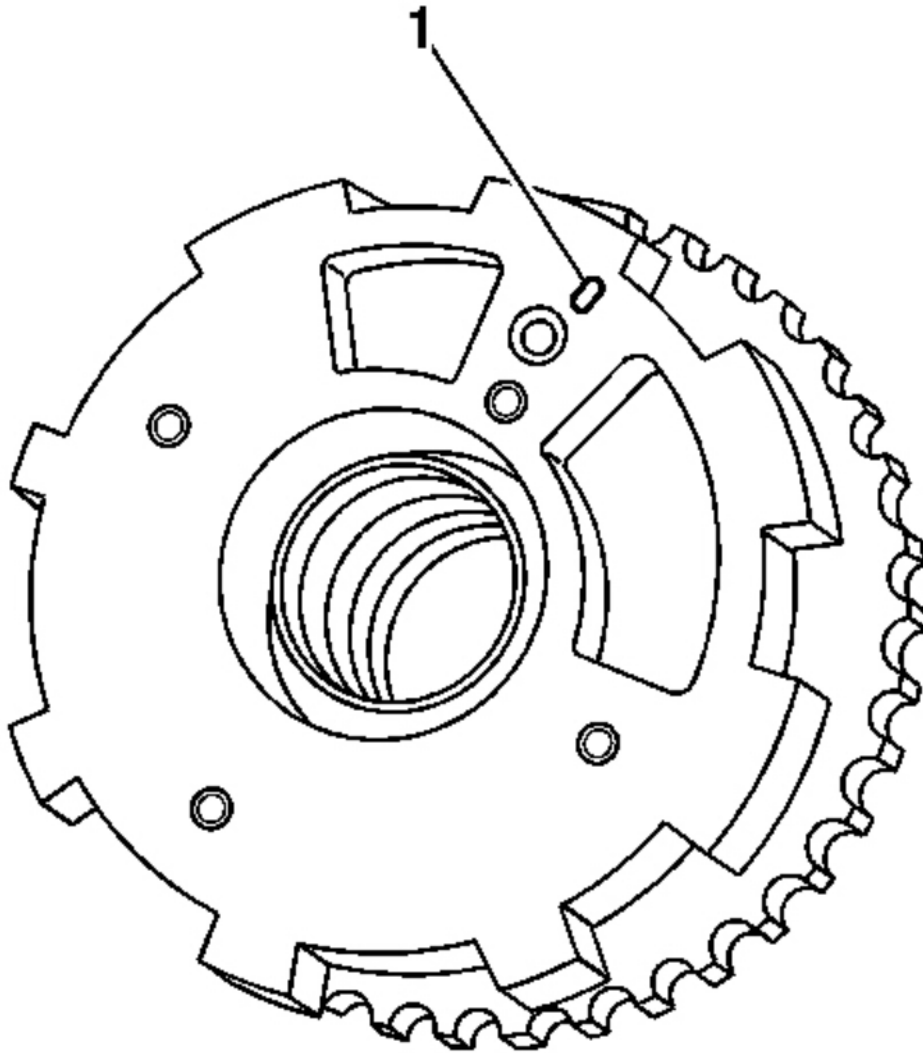


Fig. 352: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

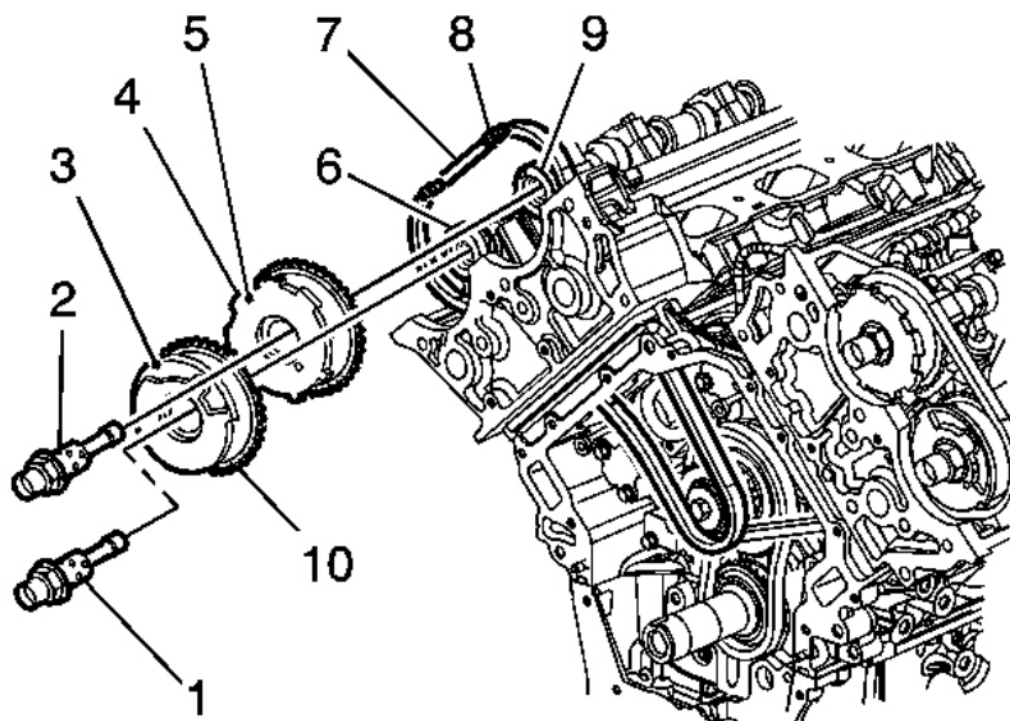


Fig. 353: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (5) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the right intake camshaft position actuator oil control valve. Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 1 (Right) Intake.**

CAMSHAFT POSITION (CMP) ACTUATOR REPLACEMENT - BANK 1 (RIGHT) EXHAUST

Removal Procedure

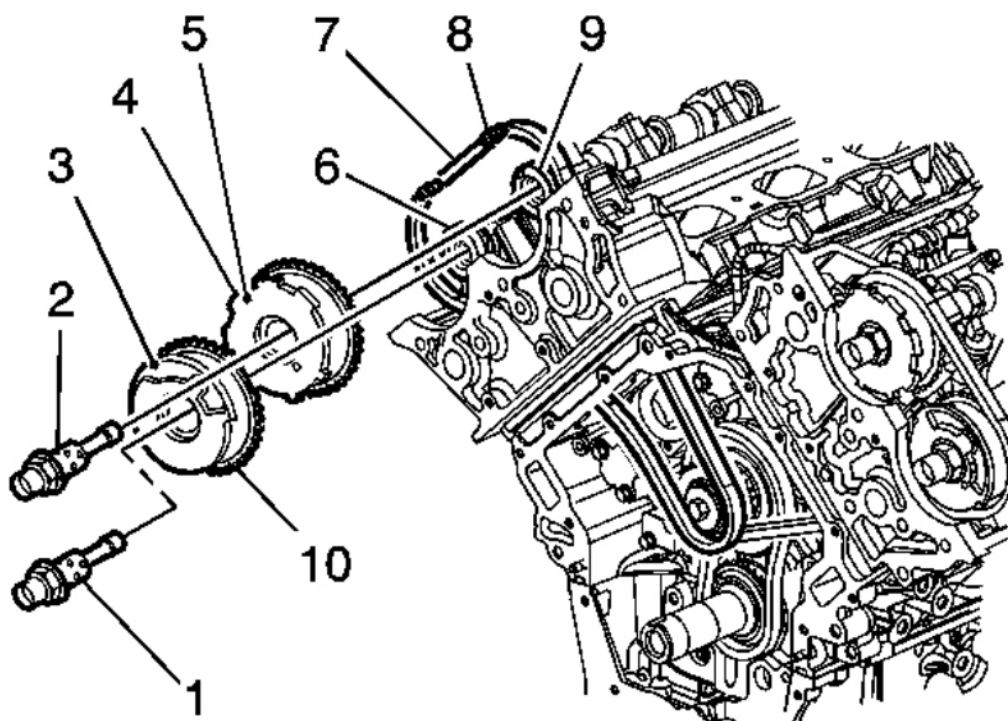


Fig. 354: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the right exhaust camshaft position actuator oil control valve (1). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 1 (Right) Exhaust.**
2. Pull the actuator forward to disengage the actuator from the camshaft alignment pin.
3. Disengage the secondary timing chain from the actuator and remove the actuator.
4. Clean and inspect the camshaft timing drive components. Refer to **Camshaft Timing Drive Components Cleaning and Inspection .**

Installation Procedure

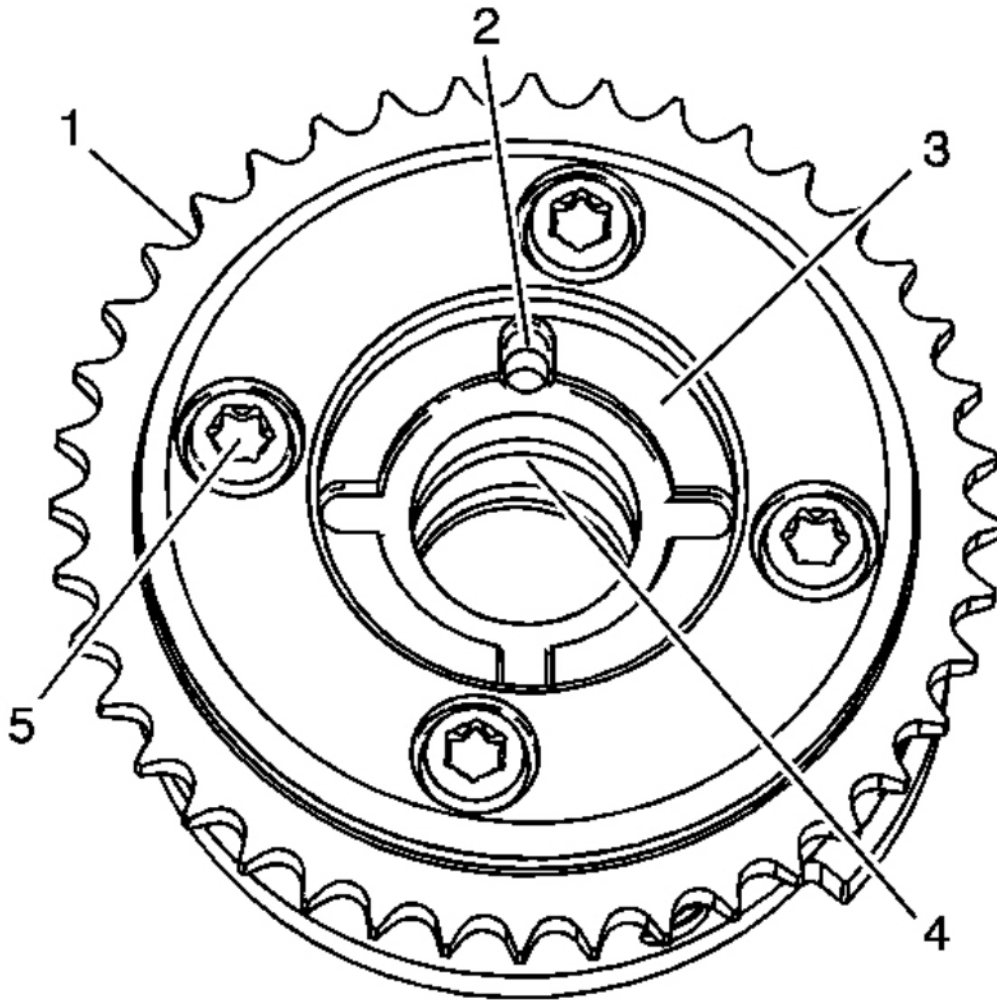


Fig. 355: Locating Camshaft Alignment Pin Hole On Back Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator. This hole will mate with the camshaft alignment pin.

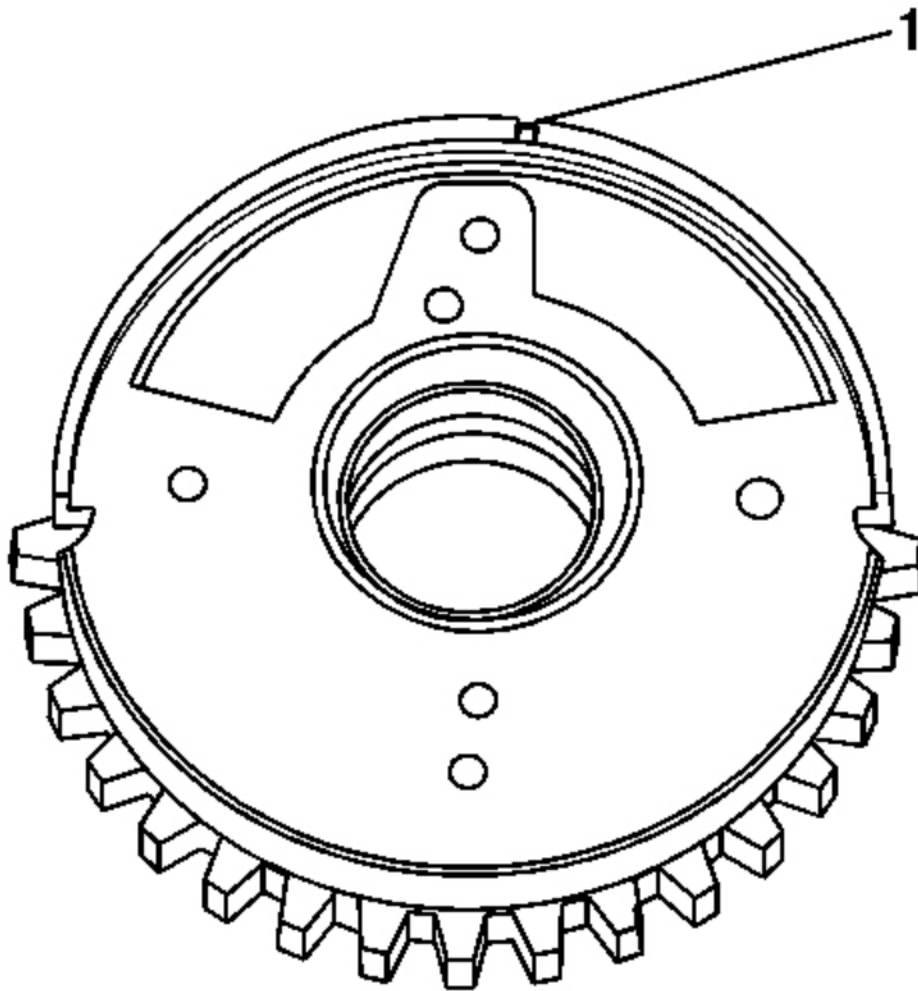


Fig. 356: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

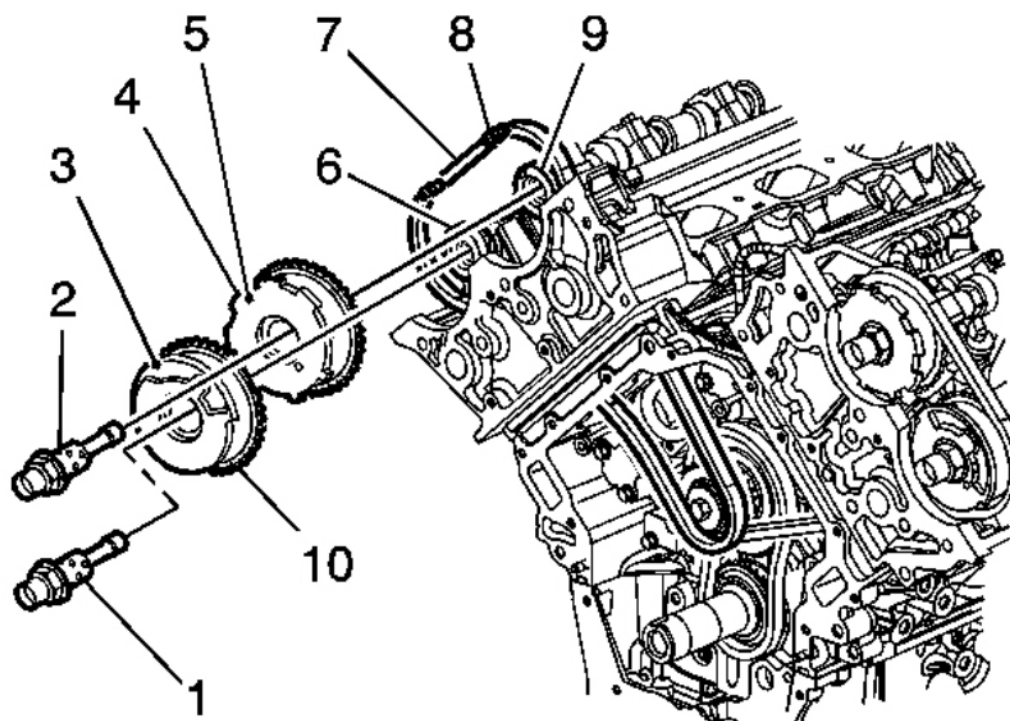


Fig. 357: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (3) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the right exhaust camshaft position actuator oil control valve. Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 1 (Right) Exhaust**.

CAMSHAFT POSITION (CMP) ACTUATOR REPLACEMENT - BANK 2 (LEFT) INTAKE

Removal Procedure

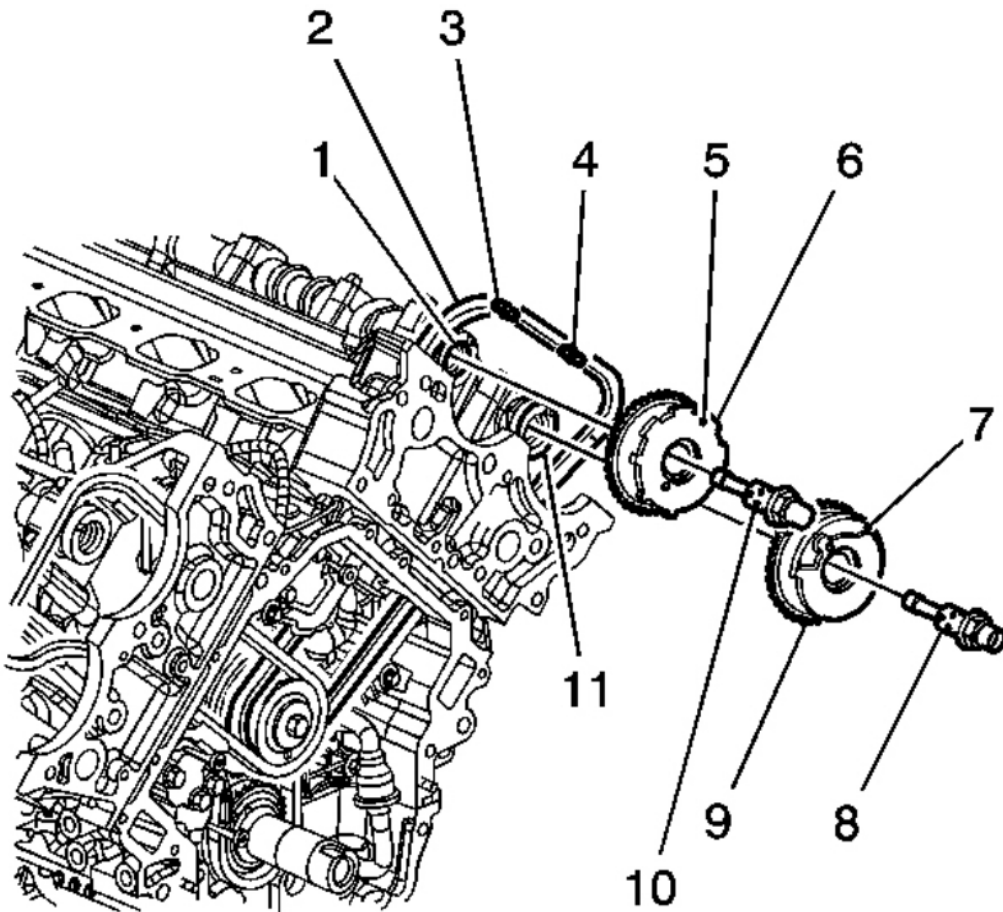


Fig. 358: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left intake camshaft position actuator oil control valve (10). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 2 (Left) Intake**.
2. Pull the actuator forward to disengage the camshaft alignment pin from the actuator.
3. Disengage the secondary timing chain from the actuator and remove the actuator.

Installation Procedure

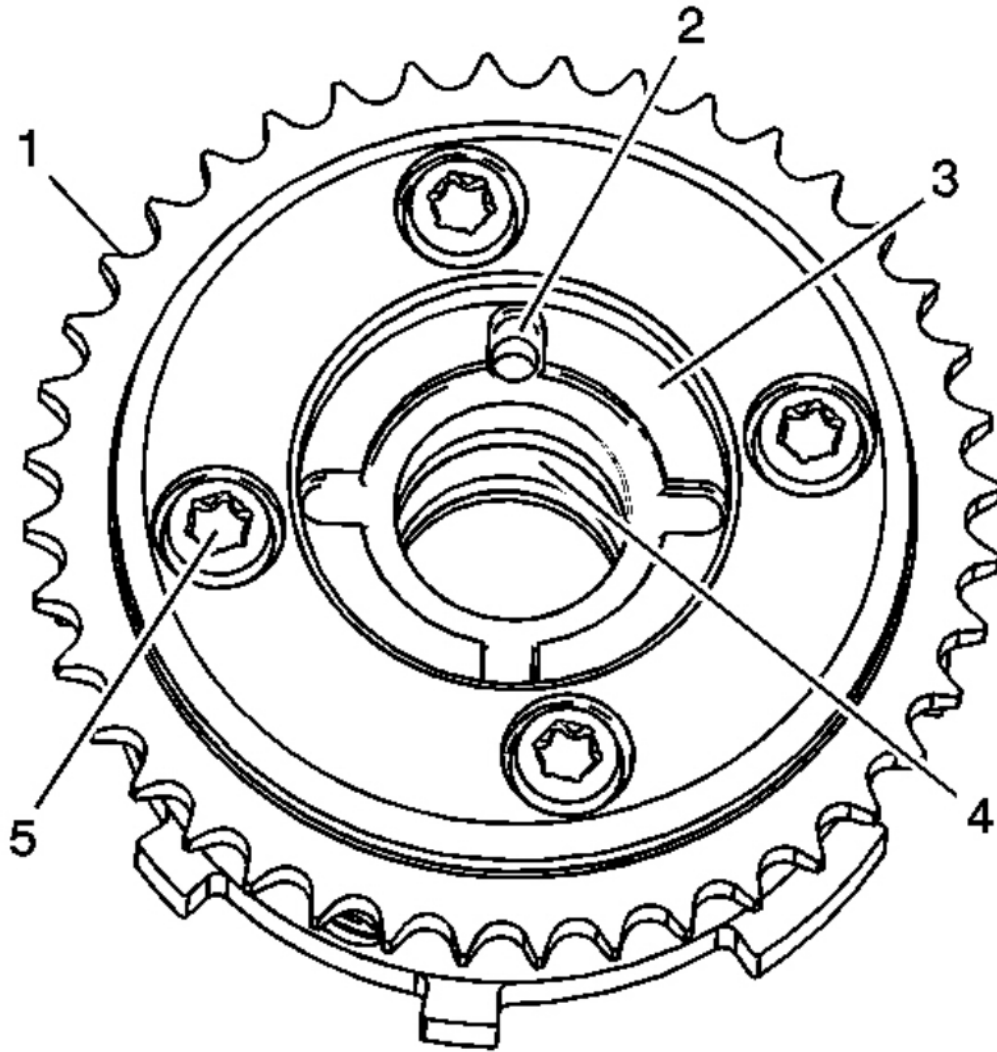


Fig. 359: Locating Camshaft Alignment Pin Hole
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator.

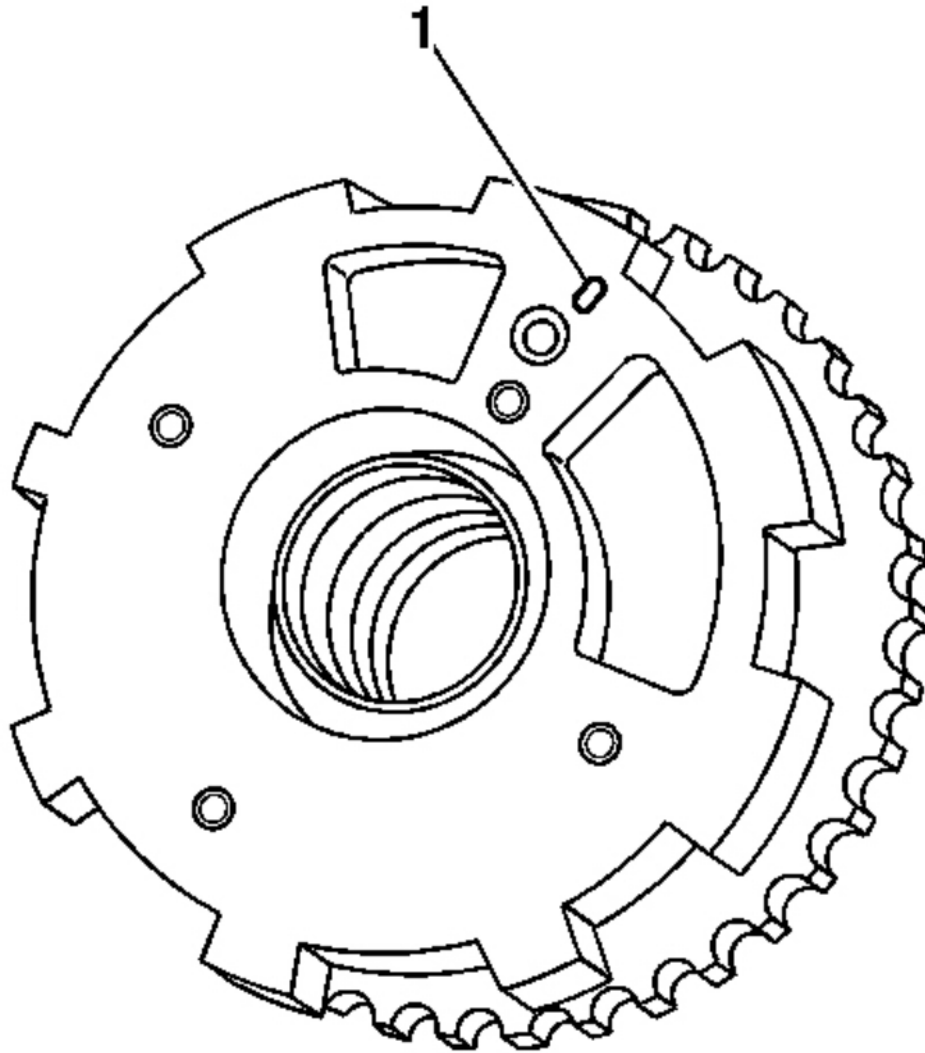


Fig. 360: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

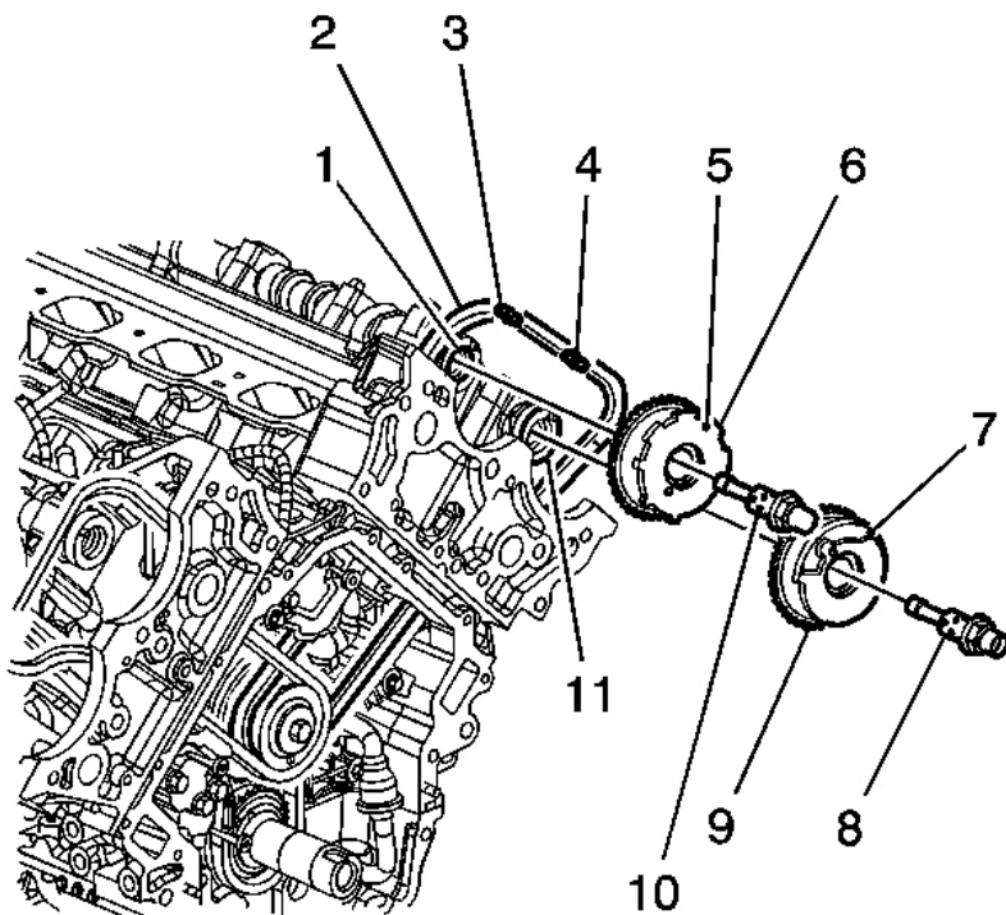


Fig. 361: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (5) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the left intake camshaft position actuator oil control valve (10). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 2 (Left) Intake.**

CAMSHAFT POSITION (CMP) ACTUATOR REPLACEMENT - BANK 2 (LEFT) EXHAUST

Removal Procedure

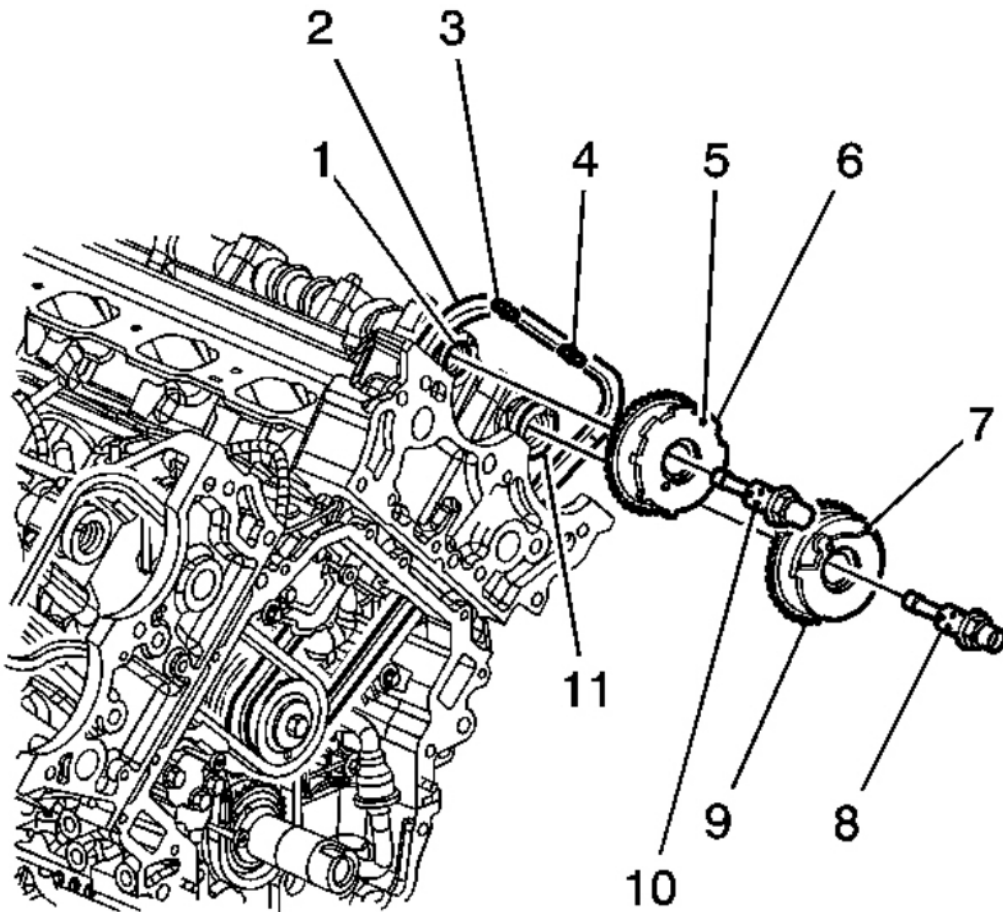


Fig. 362: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left exhaust camshaft position actuator oil control valve (8). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 2 (Left) Exhaust**.
2. Pull the actuator forward to disengage the camshaft alignment pin from the actuator.
3. Disengage the secondary timing chain from the actuator and remove the actuator.

Installation Procedure

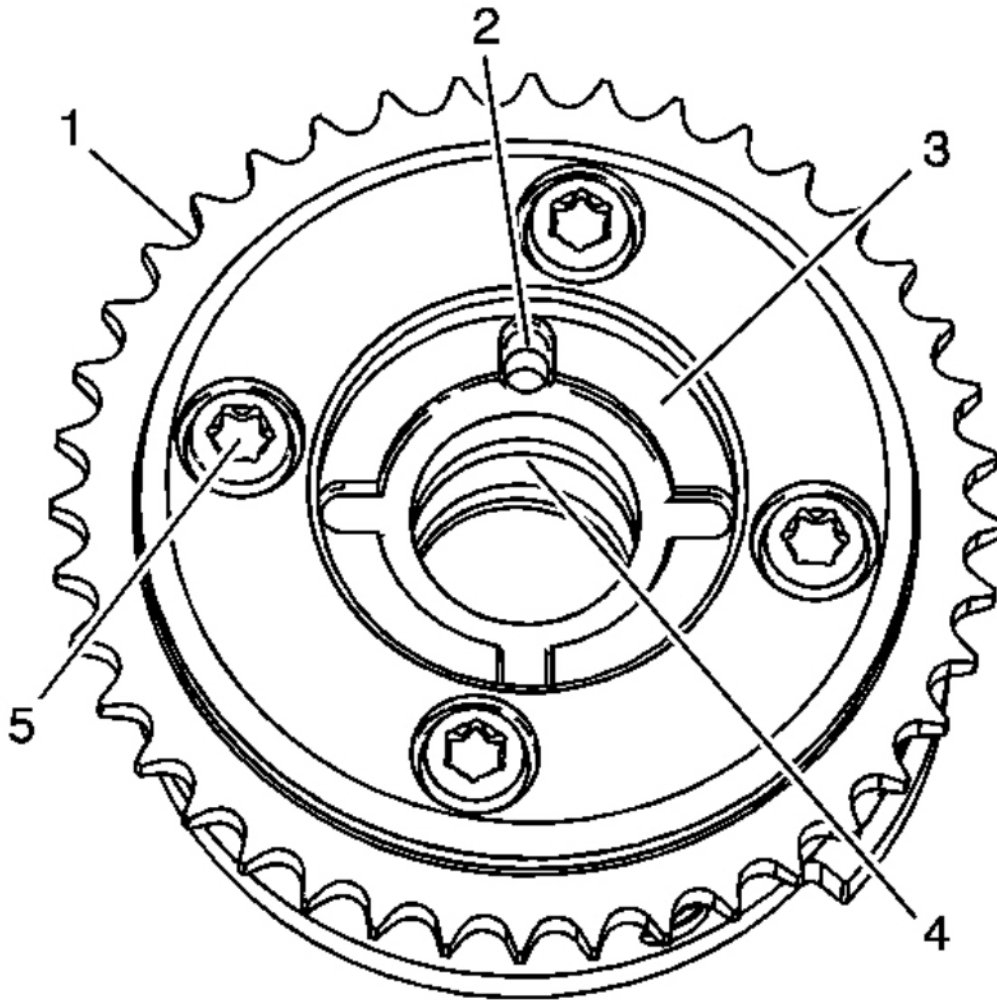


Fig. 363: Locating Camshaft Alignment Pin Hole On Back Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Locate the camshaft alignment pin hole (2) on the back of the actuator.

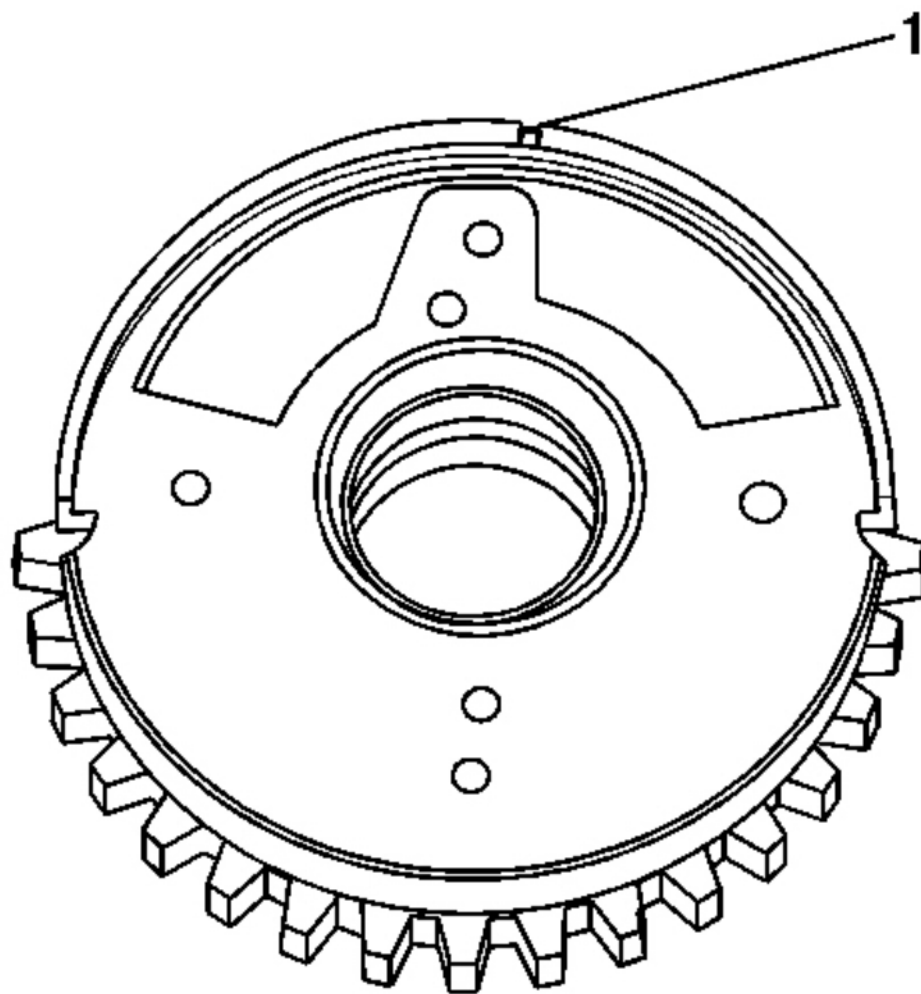


Fig. 364: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

2. Locate the timing alignment mark (1) on the front of the actuator.

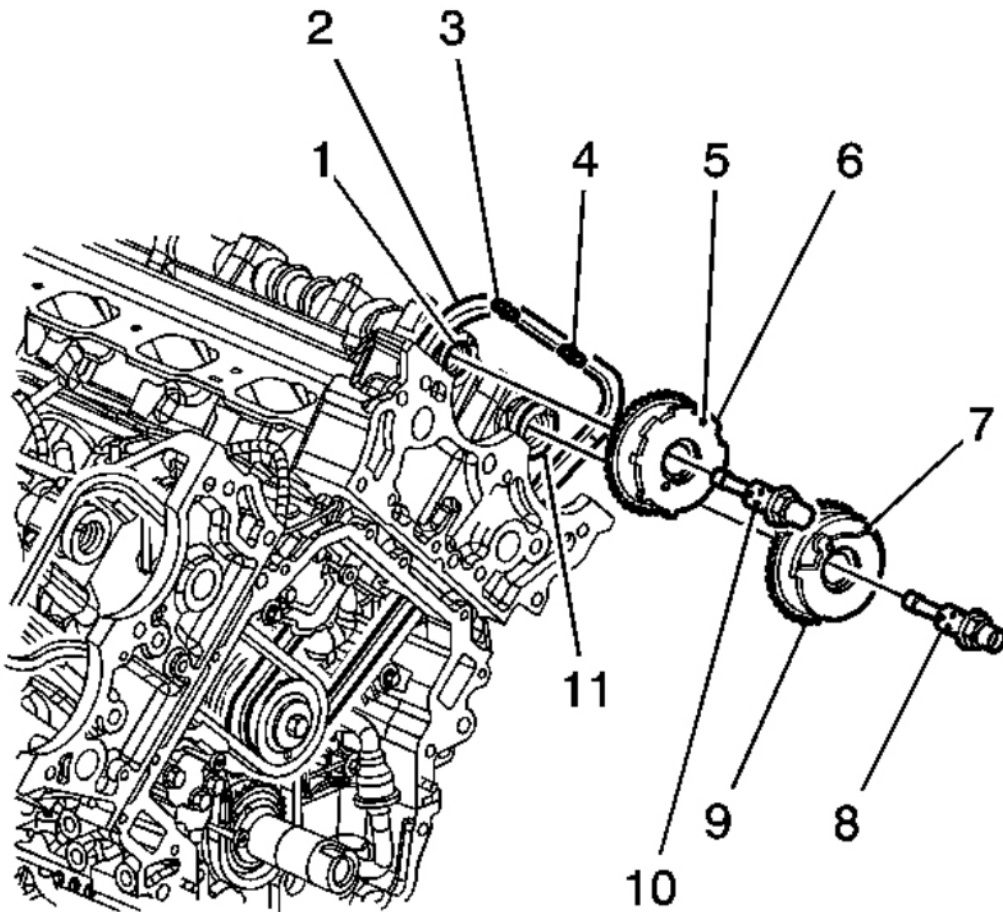


Fig. 365: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Engage the actuator timing gear teeth with the secondary timing chain ensuring that the actuator alignment mark (7) corresponds with the paint mark created on the chain link.
4. Slide the actuator over the camshaft alignment pin and install the actuator onto the camshaft.
5. Install the left exhaust camshaft position actuator oil control valve (8). Refer to **Camshaft Position (CMP) Actuator Oil Control Valve Replacement - Bank 2 (Left) Exhaust**.

SETTING CAMSHAFT TIMING

Tools Required:

J 39946 Crankshaft Socket

Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the alignment relationship between any chain and sprocket has been lost.

The crankshaft and camshafts are correctly timed when the crank sprocket and the intermediate shaft sprocket have their timing marks aligned and all 4 camshaft position actuator timing marks are perpendicular (90 degrees) to the cylinder head deck surface at the top of their rotation. The black timing chain links are used for assembly purposes. Do not reference these black links to determine if the engine timing components are properly aligned. The black links will only align with the actuator timing marks and the intermediate shaft sprocket, once every 126 revolutions. For this reason, it is not necessary to have the black secondary chain links aligned with the timing marks when servicing only one of the secondary timing components. Proper alignment is maintained by marking a chain link and sprocket gear tooth with a paint stick prior to disassembling individual components. When servicing individual components, refer to the appropriate procedure.

1. Remove the following components for access to the timing chains:

- The left camshaft actuator housing-Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left.**
- The right camshaft actuator housing-Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right.**
- The engine front cover-Refer to **Engine Front Cover Replacement.**
- The engine oil pump-Refer to **Oil Pump Replacement.**
- The right secondary camshaft drive chain-Refer to **Secondary Camshaft Drive Chain Replacement - Right.**
- The left secondary camshaft drive chain-Refer to **Secondary Camshaft Drive Chain Replacement - Left.**

IMPORTANT: The primary gears and chain must be properly timed prior to setting the left or right secondary camshaft timing.

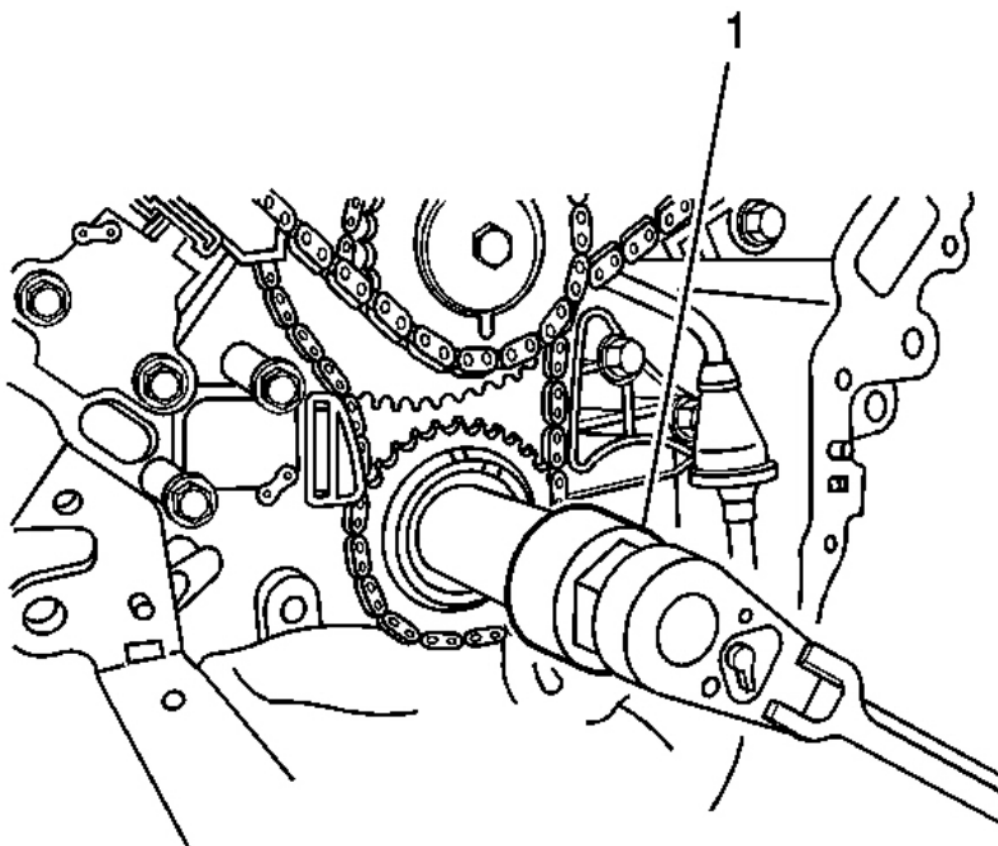


Fig. 366: Rotating Crankshaft Using J 39946
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 39946** (1) in order to rotate the crankshaft.

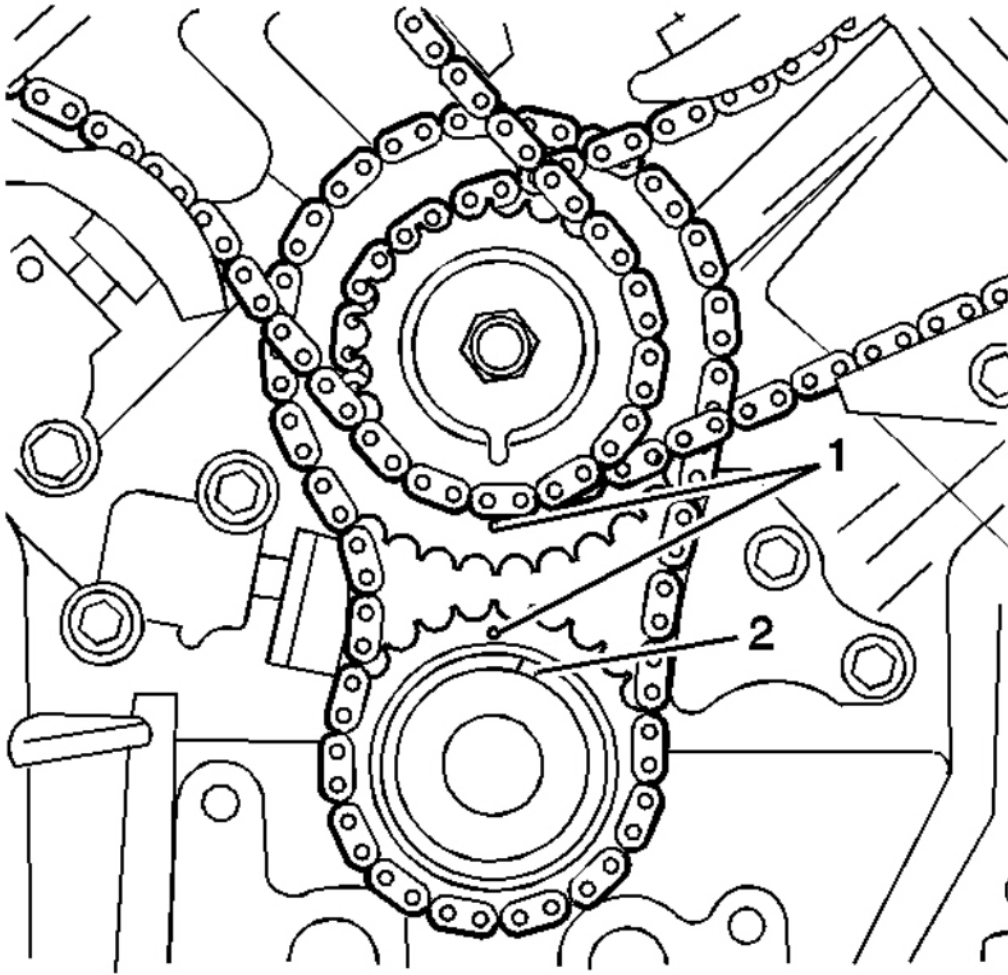


Fig. 367: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 39946** , rotate the crankshaft until:
 1. The primary timing gear alignment mark (1) is at the top of its position,
 2. The crankshaft keyway (2) is approximately at the 1 o'clock position,
 3. The intermediate sprocket timing mark (1) is at the bottom of its rotation, adjacent to the crank gear timing mark.

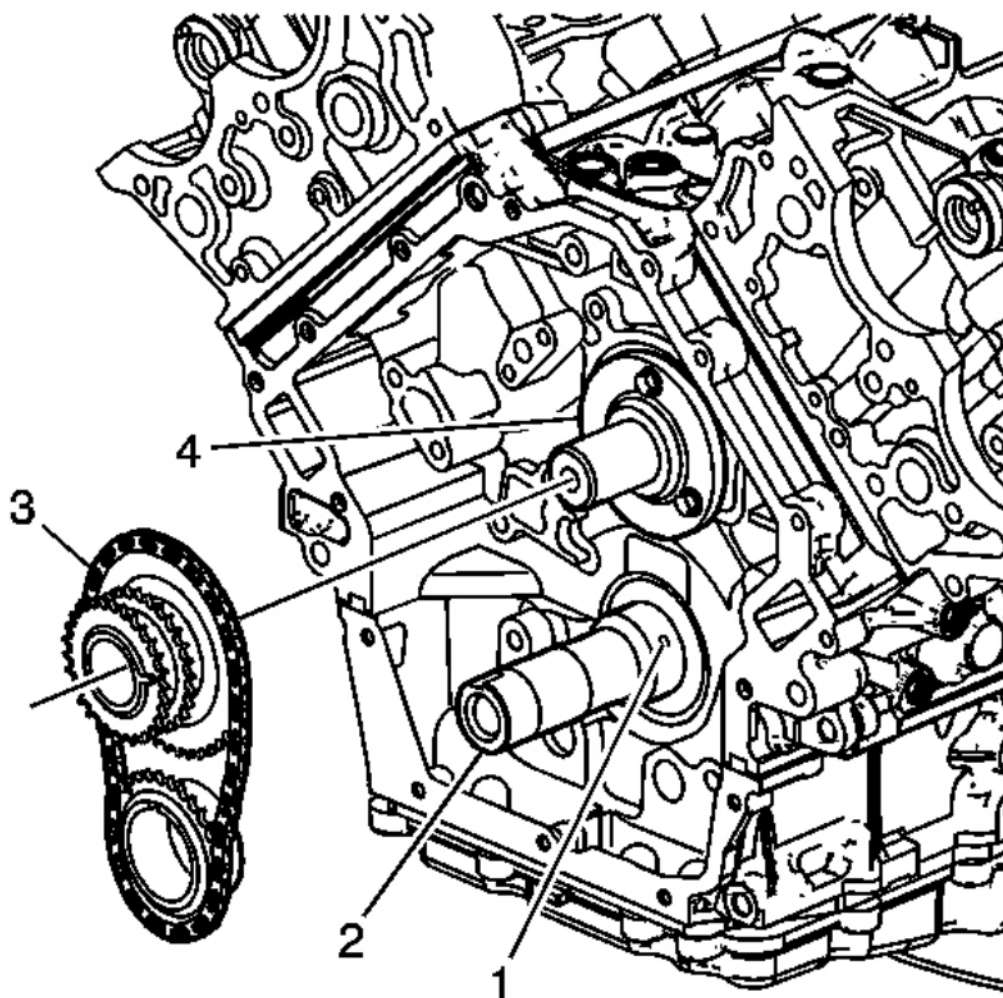


Fig. 368: View Of Primary Camshaft Drive Chain, Intermediate Drive Shaft Sprocket & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Timing the primary timing gears ensures that the #1 cylinder piston, bank 1 right front cylinder, is at top dead center (TDC) beginning its power stroke event. If this condition can not be accomplished while rotating the crankshaft (2), remove the primary gears and chain (3) and realign the primary timing marks. Refer to **Primary Camshaft Drive Chain Removal** and **Primary Camshaft Drive Chain Installation** .

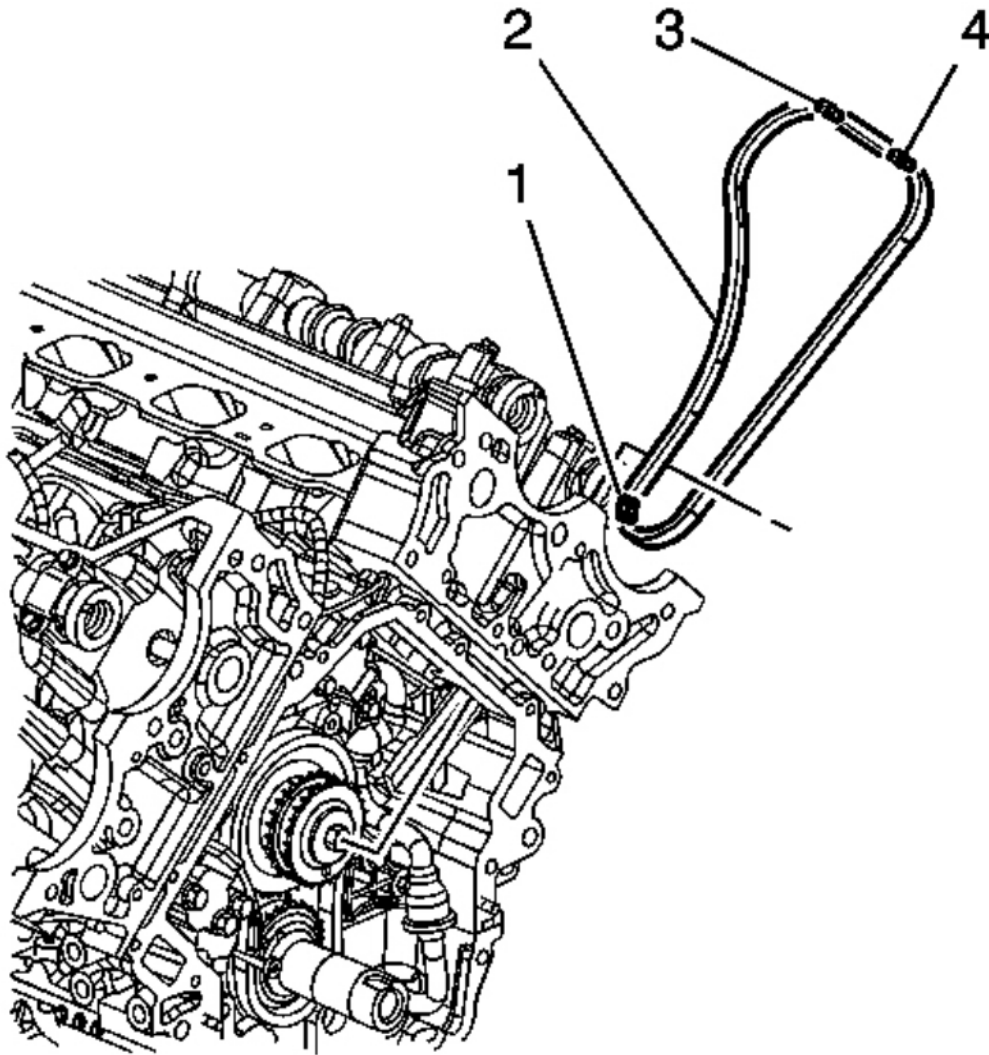


Fig. 369: Identifying Secondary Timing Chain Timing Marks
Courtesy of GENERAL MOTORS CORP.

5. The left bank 2 secondary timing chain (2) has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
6. The black link (4) is aligned with the bank 2 exhaust actuator timing mark. The black link (3) is aligned with the bank 2 intake actuator timing mark.
7. The black link (1) is aligned with the intermediate sprocket.

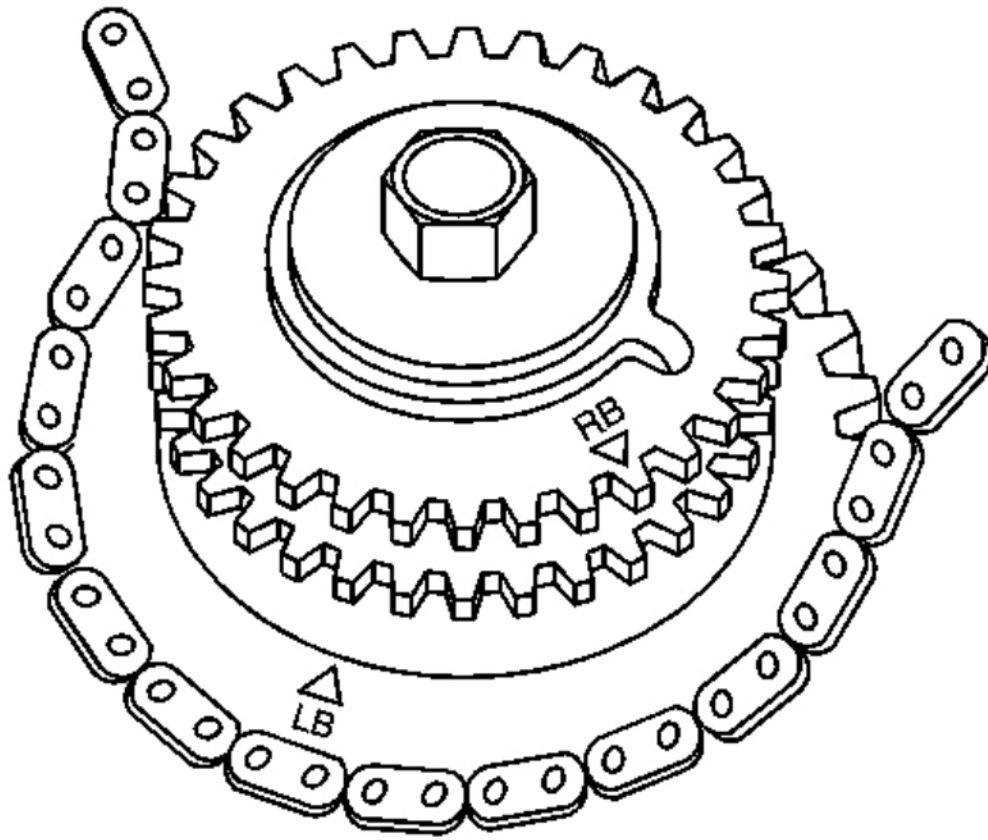


Fig. 370: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

8. The intermediate sprocket left bank 2 timing mark is labeled left bank (LB) as shown.
9. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket LB timing mark to the timing chain black link.

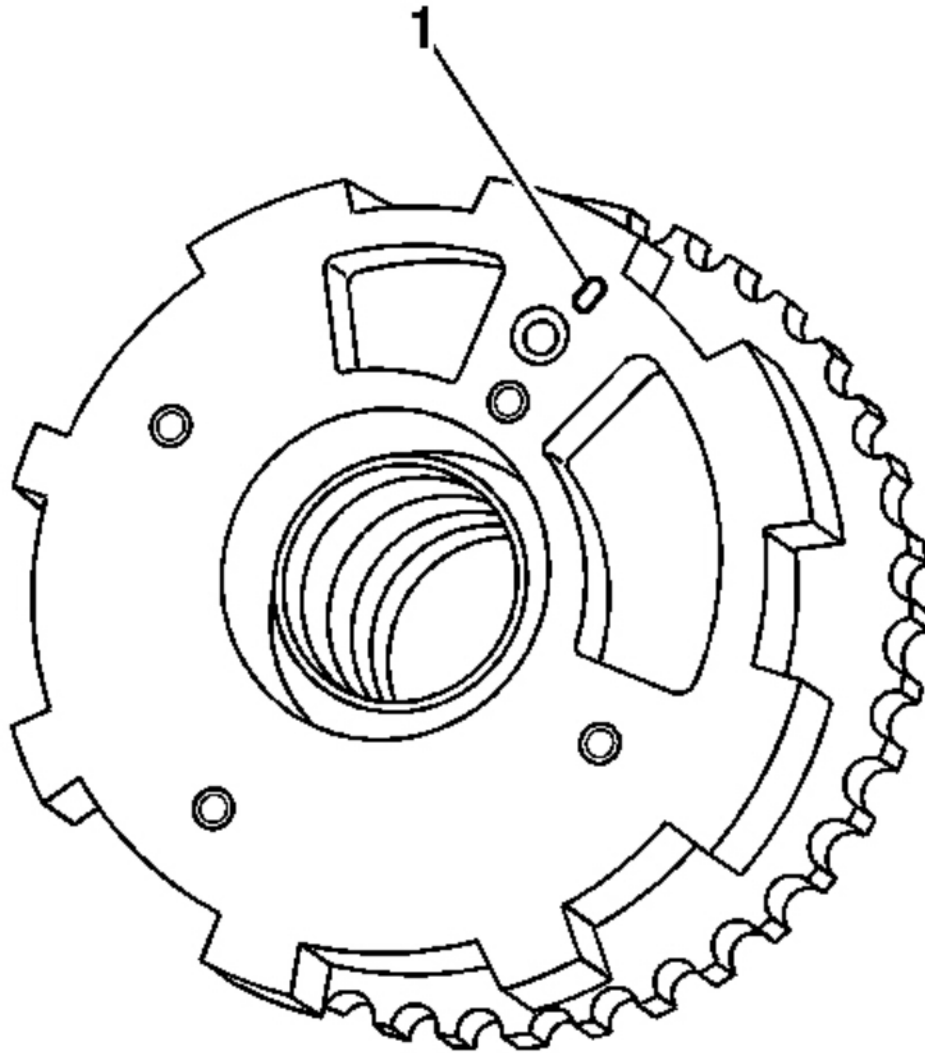


Fig. 371: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

10. Locate the timing mark (1) on the front of the intake actuator marked LI which stands for left intake.

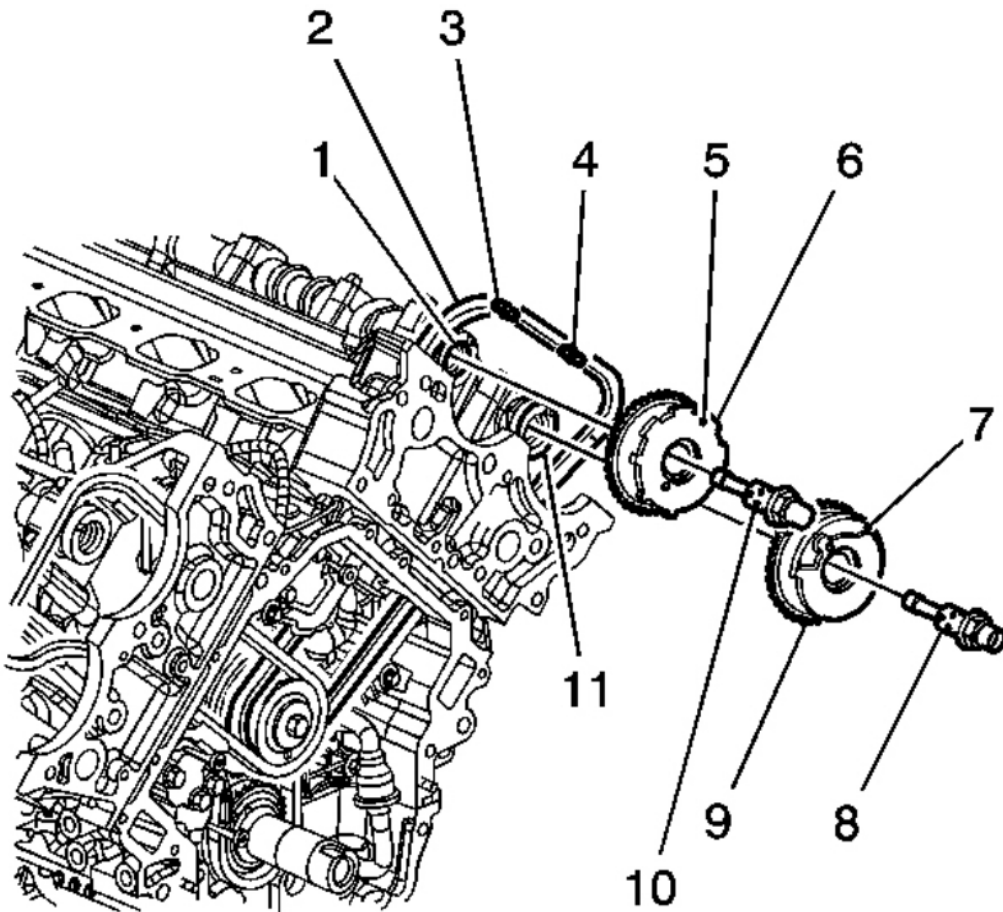


Fig. 372: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

11. Align the timing mark (5) of the left bank intake camshaft position actuator with the timing chain black link (3) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
12. Loosely install the oil control valve (10) to secure the intake actuator.

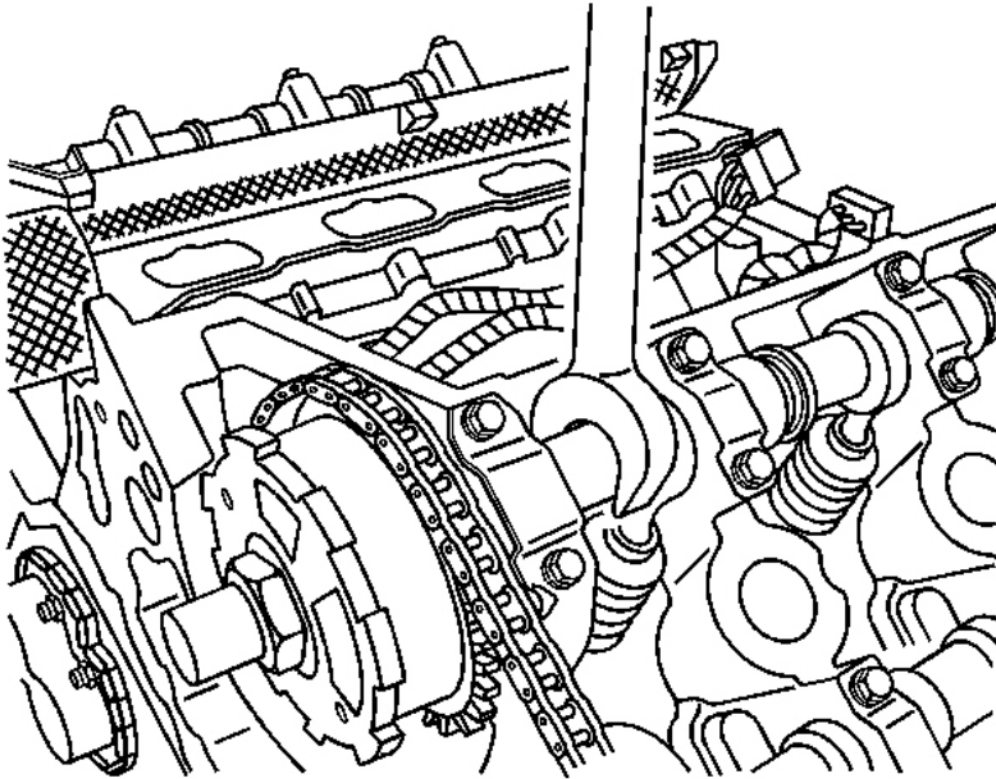


Fig. 373: Holding Camshaft
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

13. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

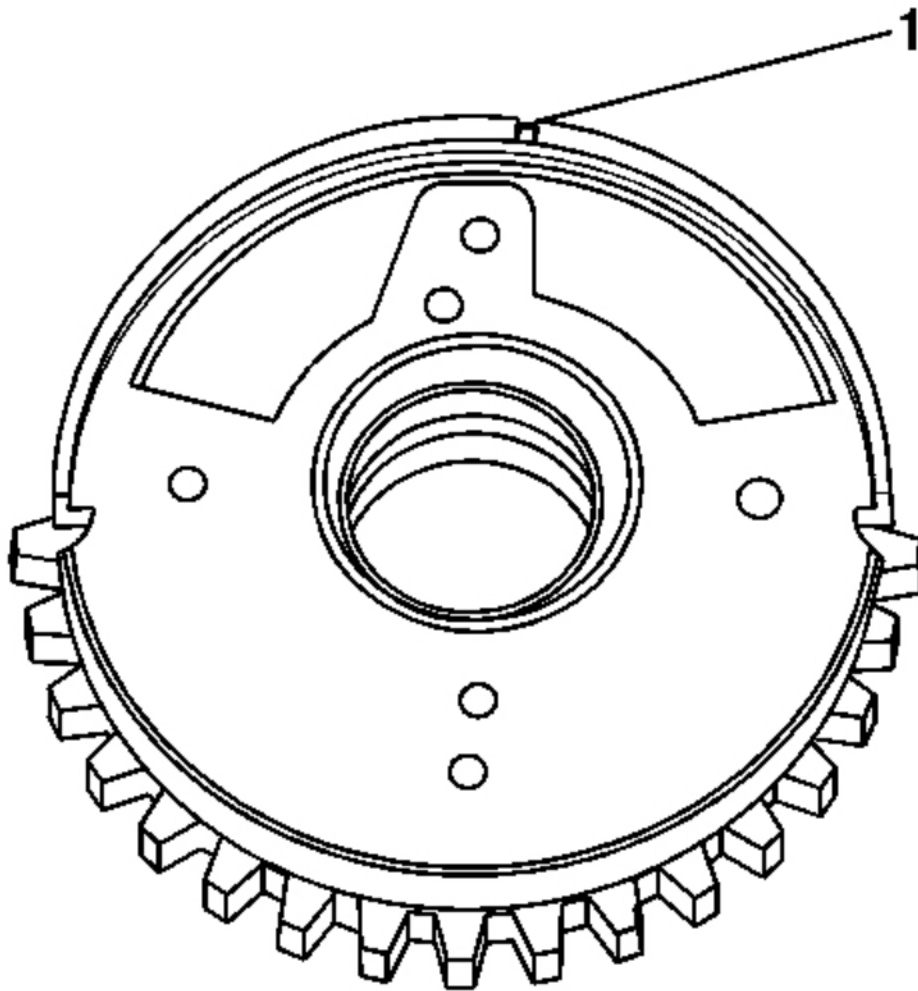


Fig. 374: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

14. Locate the timing mark (1) on the front of the exhaust actuator marked LE which stands for left exhaust.

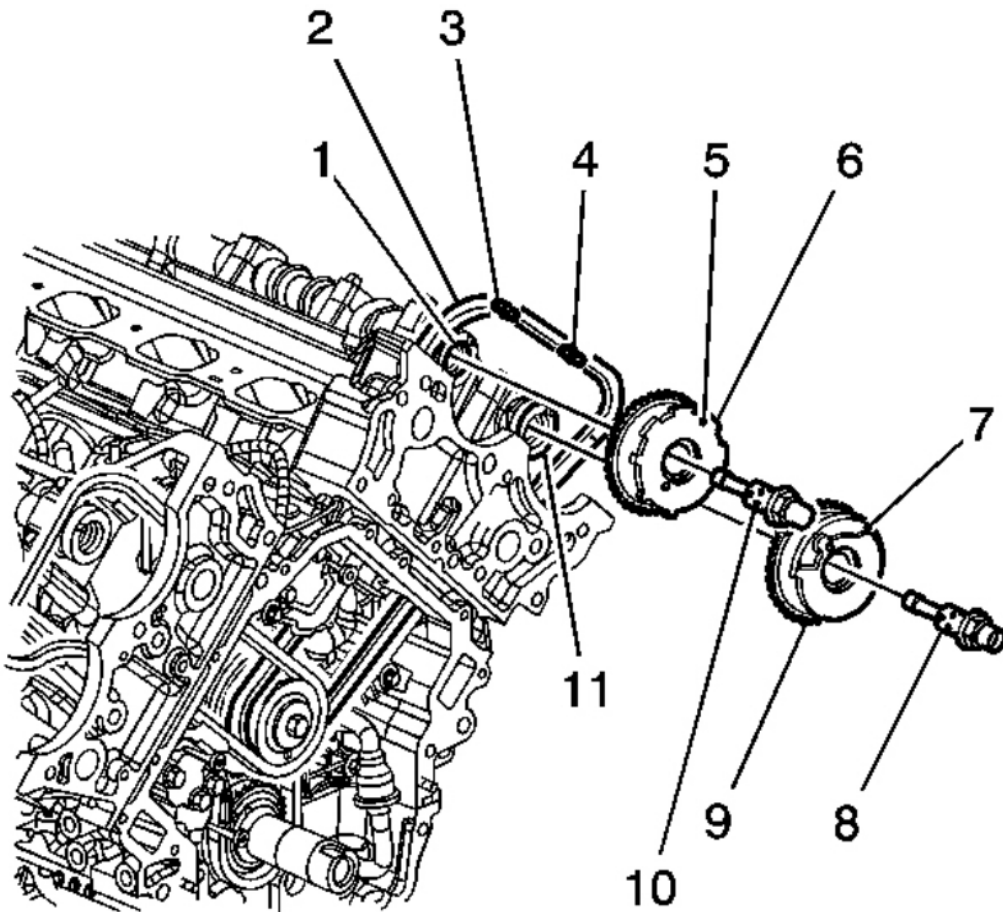


Fig. 375: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

15. Align the timing mark (7) of the left bank exhaust camshaft position actuator with the timing chain black link (4) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface at the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
16. Loosely install the oil control valve (8) to secure the exhaust actuator.

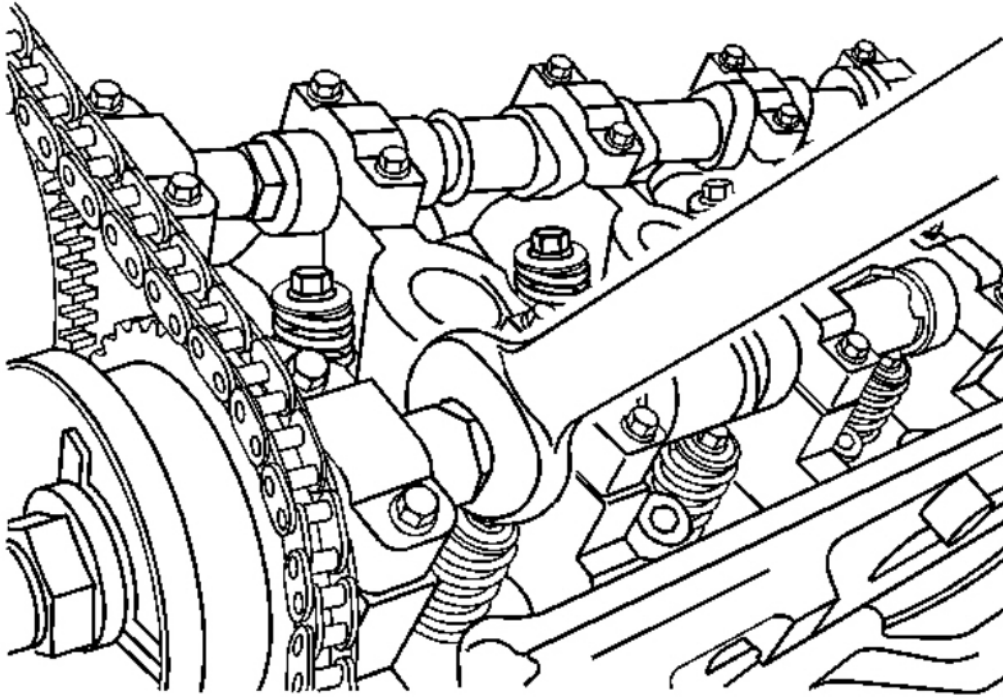


Fig. 376: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

17. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

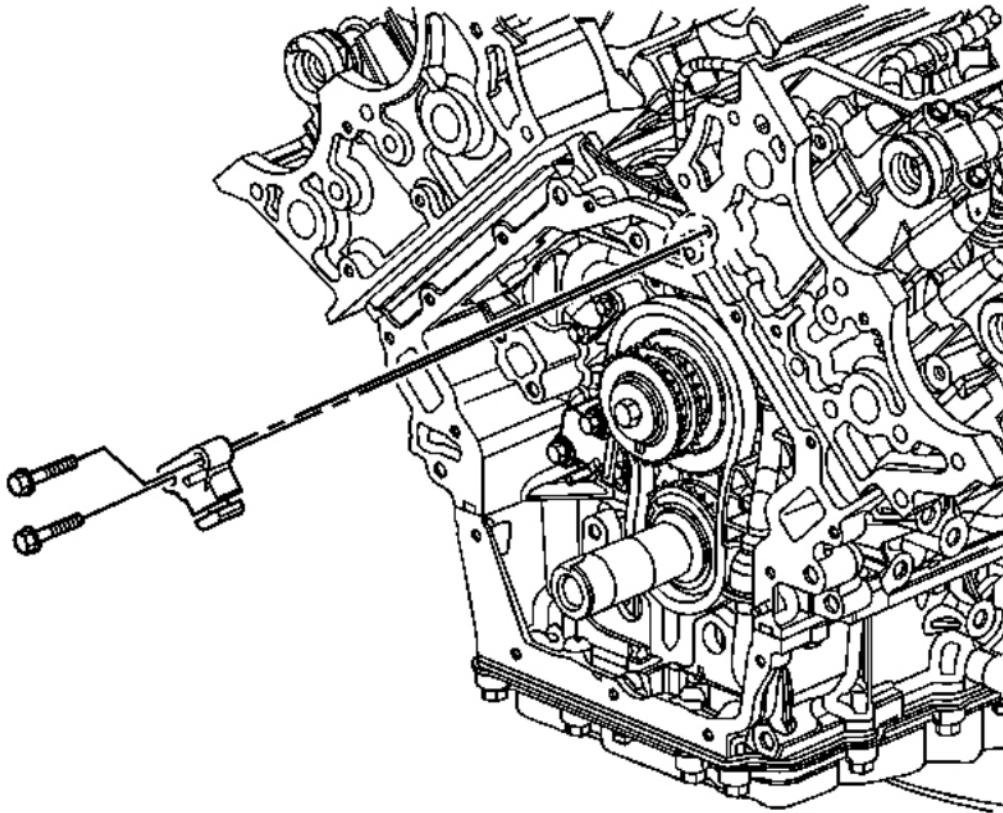


Fig. 377: View Of Left Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

18. Install the left secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Left**.

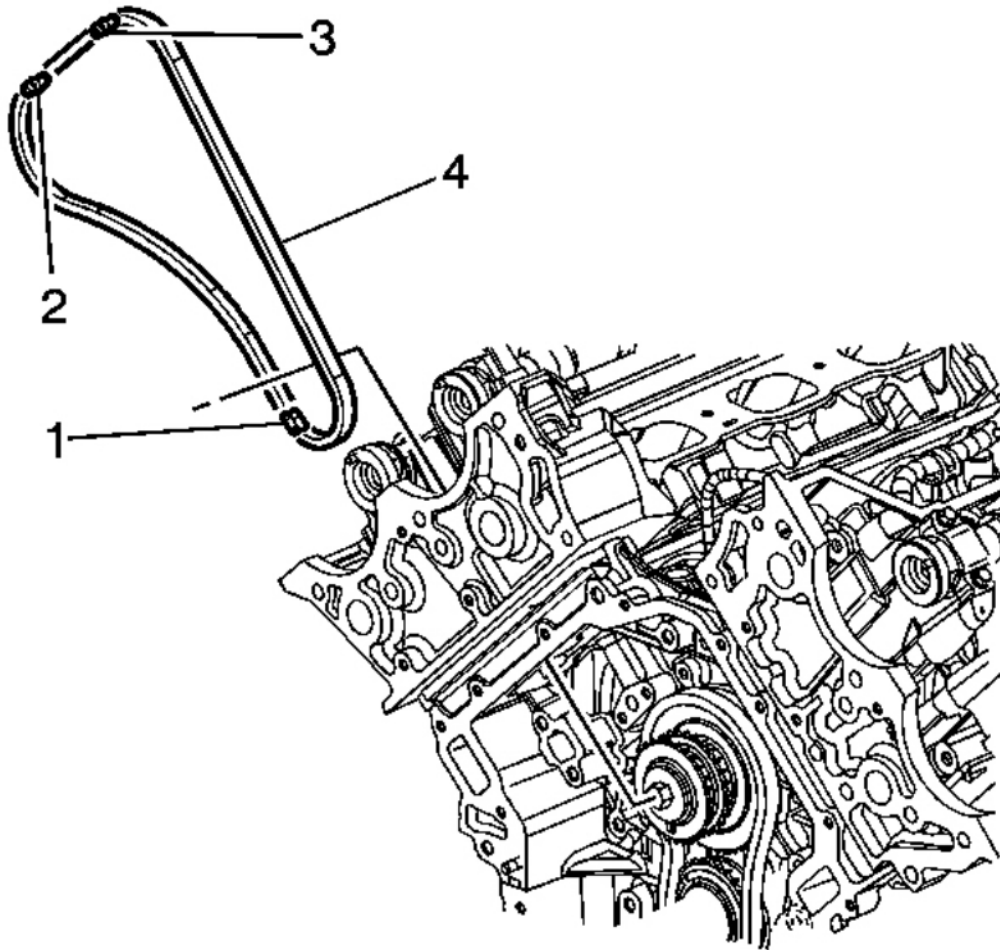


Fig. 378: Identifying Secondary Timing Chain Black Links
Courtesy of GENERAL MOTORS CORP.

19. The right bank 1 secondary timing chain has 3 black links that aid in timing the camshaft position actuators to the intermediate sprocket.
20. The black link (2) is aligned with the bank 1 exhaust actuator timing mark. The black link (3) is aligned with the bank 1 intake actuator timing mark.
21. The black link (1) is aligned with the intermediate sprocket.

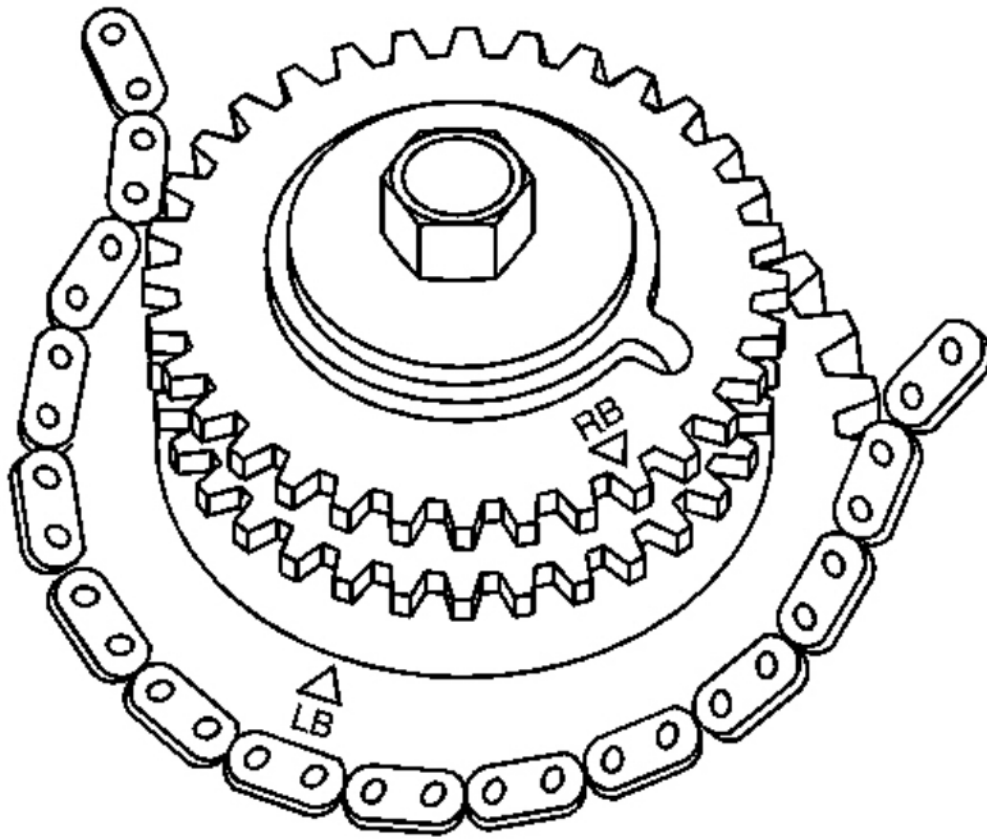


Fig. 379: Aligning Sprocket LB Timing Mark To Timing Chain Black Link
Courtesy of GENERAL MOTORS CORP.

22. The intermediate sprocket right bank timing mark is labeled right bank (RB) as shown.
23. Assemble the secondary timing chain to the intermediate sprocket aligning the sprocket RB timing mark to the timing chain black link.

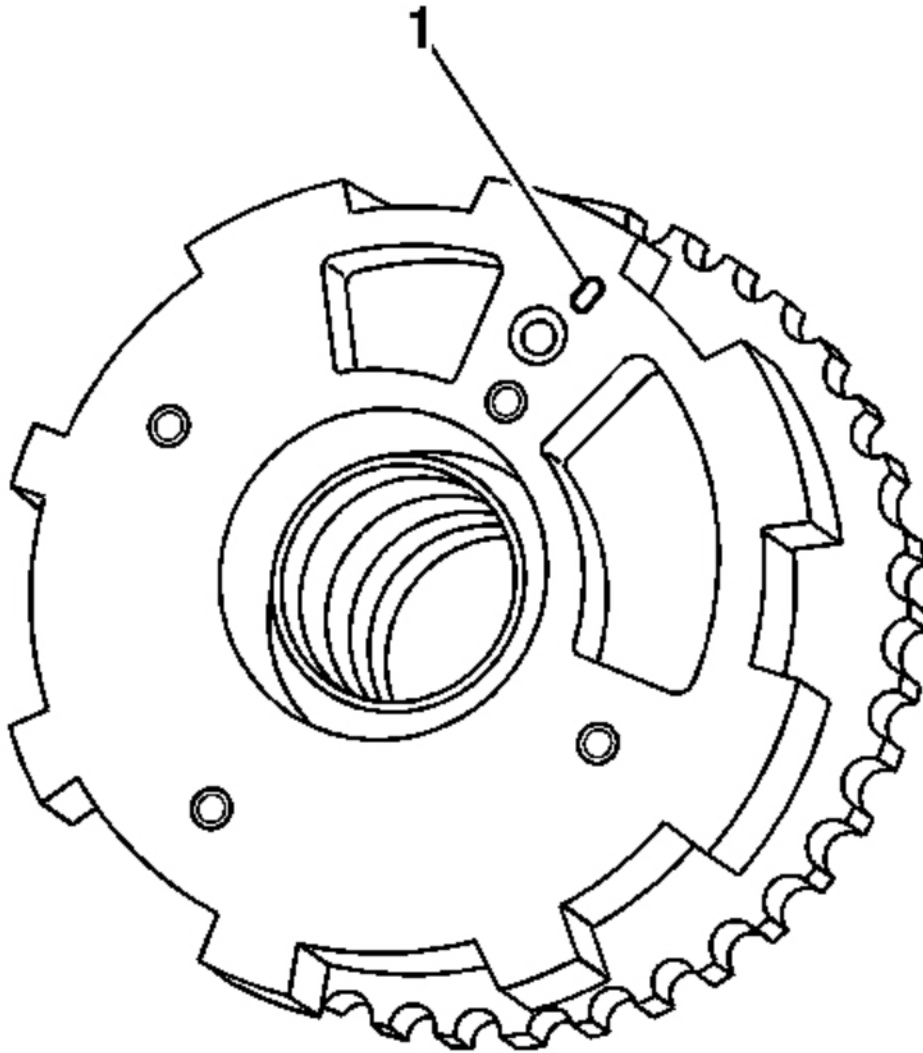


Fig. 380: Locating Timing Alignment Mark On Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

24. Locate the timing mark (1) on the intake actuator marked RI which stands for right intake.

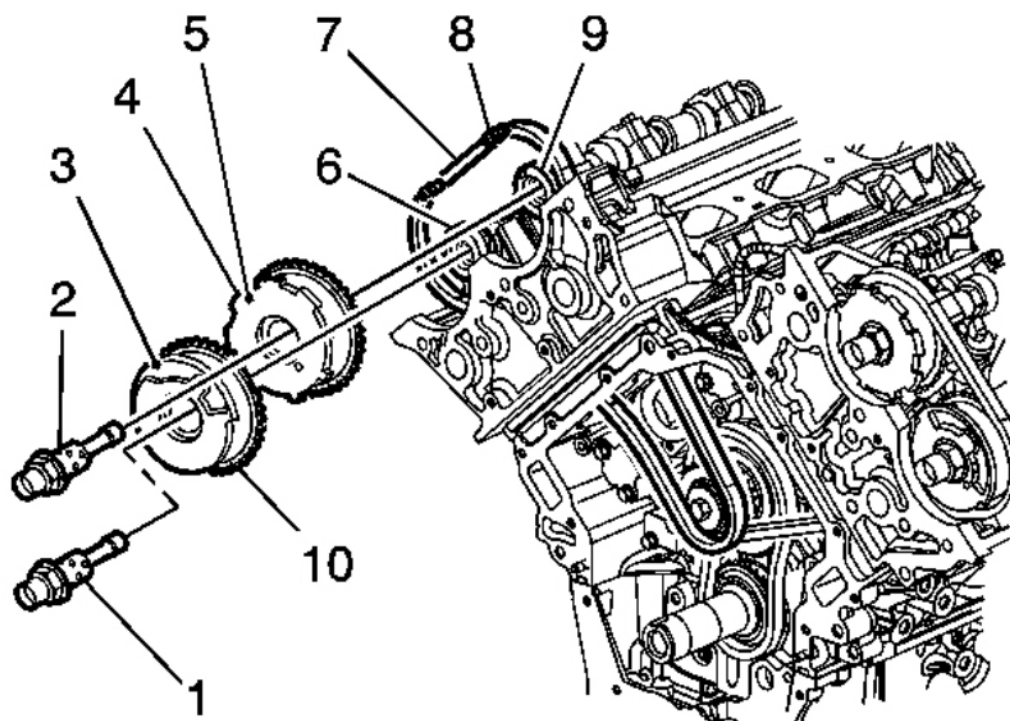


Fig. 381: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

25. Align the timing mark (5) of the right bank intake camshaft position actuator with the timing chain black link (8) and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
26. Loosely install the oil control valve (2) to secure the intake actuator.

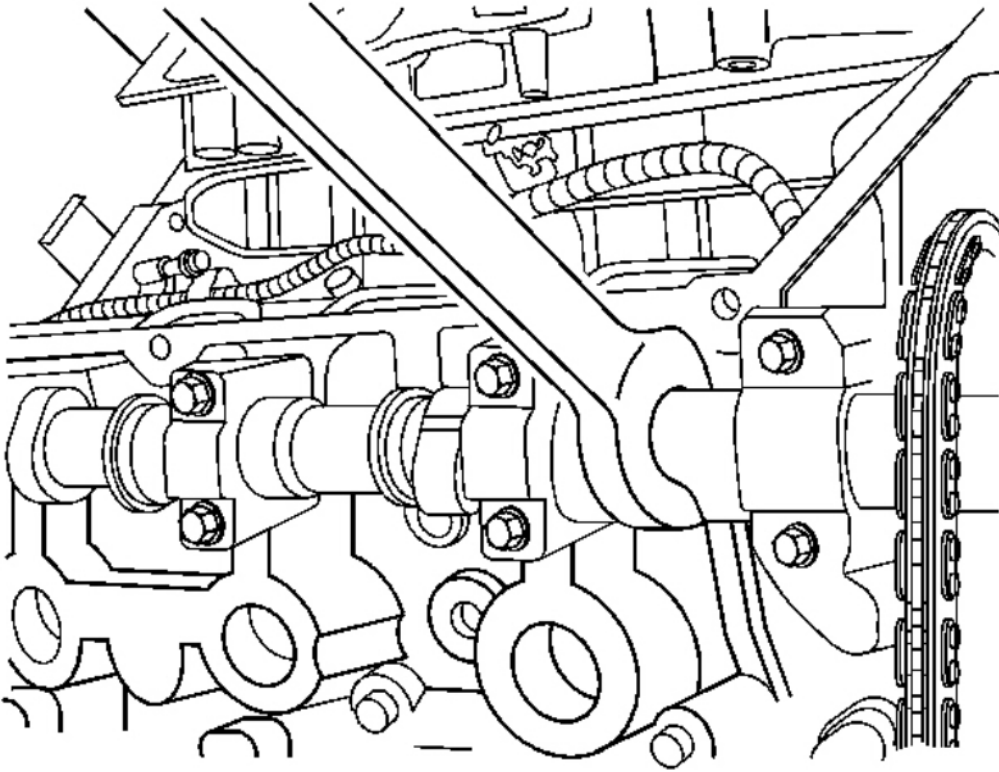


Fig. 382: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

27. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

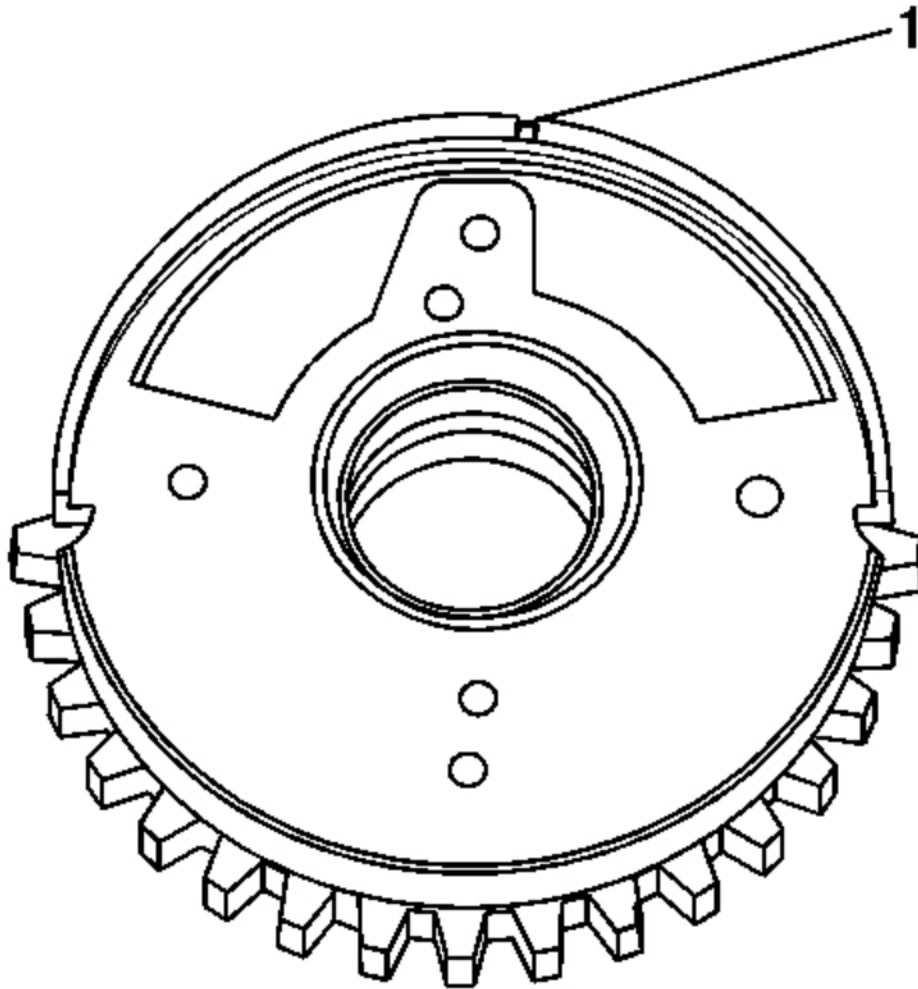


Fig. 383: Locating Timing Mark On Front Of Actuator
Courtesy of GENERAL MOTORS CORP.

28. Locate the timing mark (1) on the actuator marked RE which stands for right exhaust.

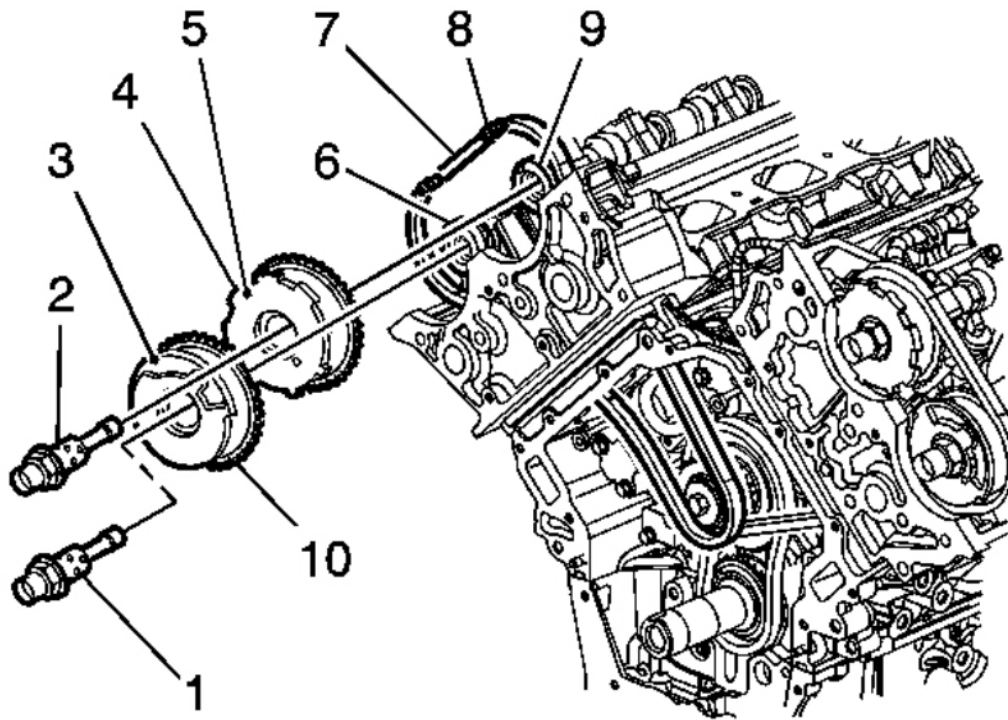


Fig. 384: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

29. Align the timing mark (3) of the right bank exhaust camshaft position actuator with the timing chain black link and install the actuator on the camshaft with the actuator timing mark perpendicular (90 degrees) to the cylinder head deck surface near the top of its rotation. Ensure that the camshaft alignment pin hole on the rear of the actuator engages with the camshaft alignment pin. If necessary, use an open-end wrench on the hex cast into the camshaft to obtain proper camshaft pin to actuator engagement.
30. Loosely install the oil control valve (1) to secure the exhaust actuator.

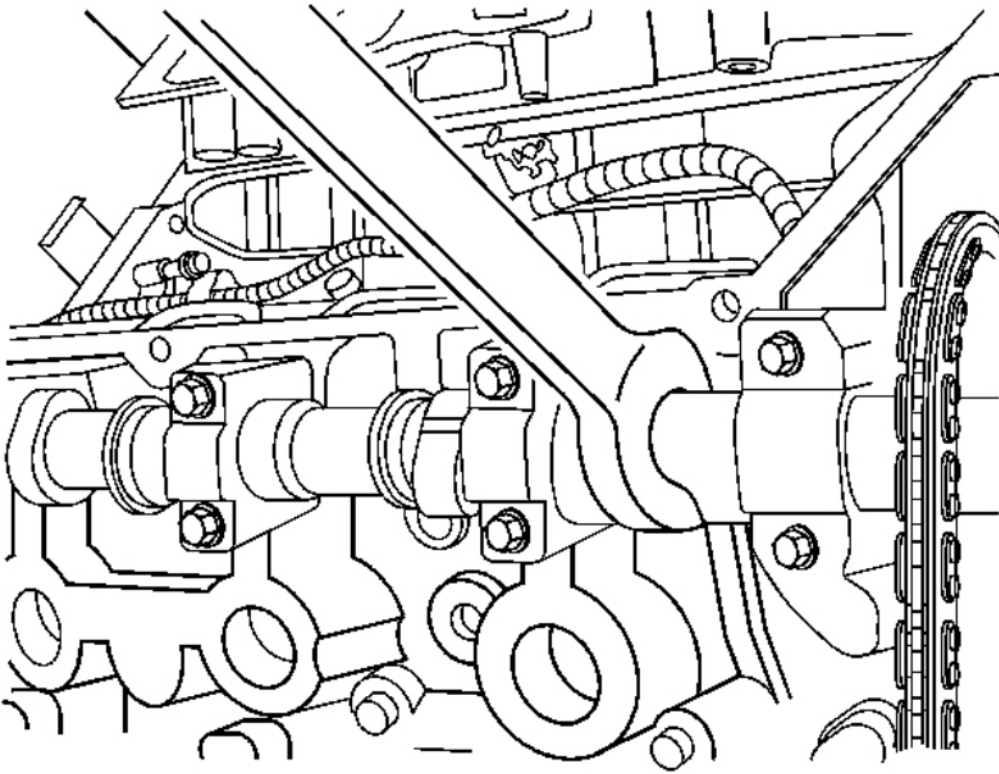


Fig. 385: Holding Camshaft In Position
Courtesy of GENERAL MOTORS CORP.

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

31. Use an open-end wrench on the hex cast into the camshaft in order to prevent the camshaft from rotating when tightening the oil control valve.

Tighten: Tighten the oil control valve to 120 N.m (89 lb ft).

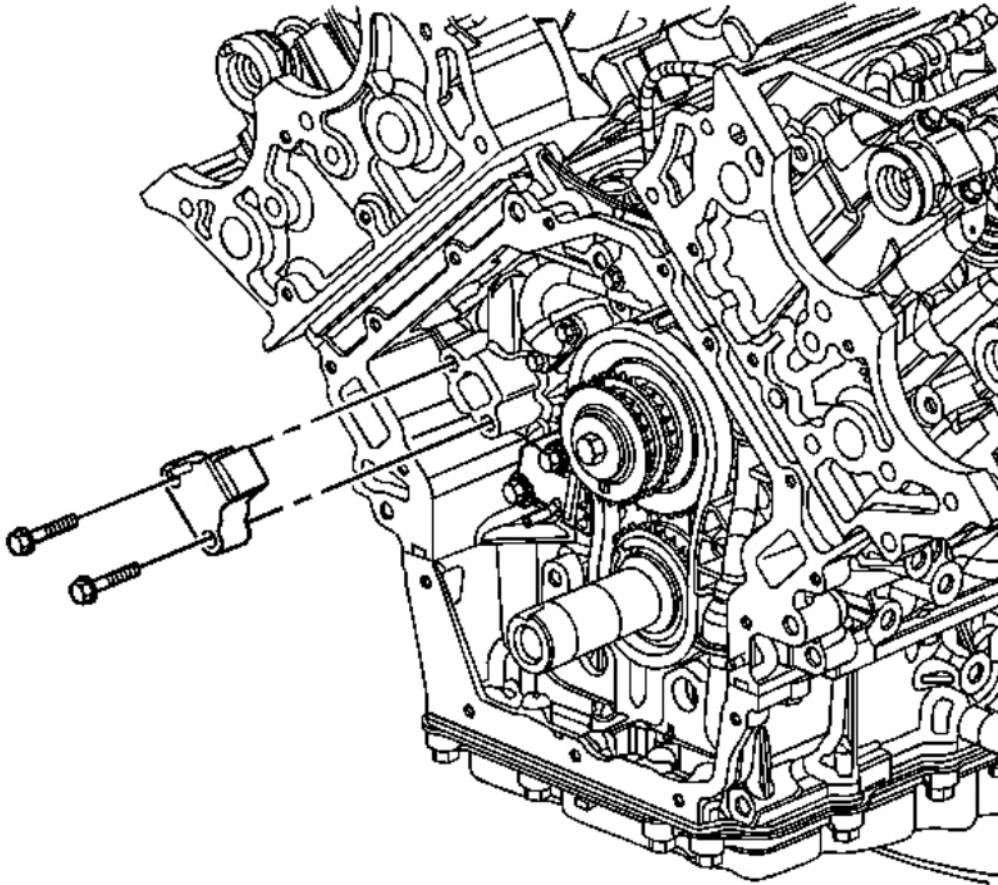


Fig. 386: View Of Right Secondary Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

32. Install the right secondary timing chain tensioner. Refer to **Secondary Camshaft Drive Chain Tensioner Replacement - Right.**
33. Remove the EN 46328 .

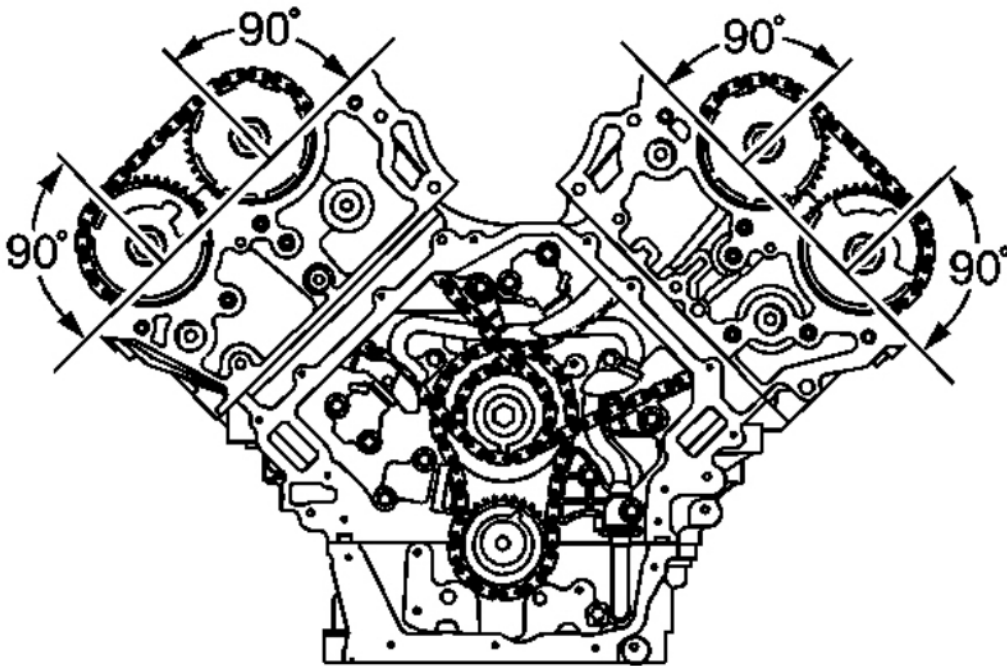


Fig. 387: Ensuring Correct Alignment Of All Secondary Timing Components
Courtesy of GENERAL MOTORS CORP.

34. Ensure the correct alignment of all secondary timing components.

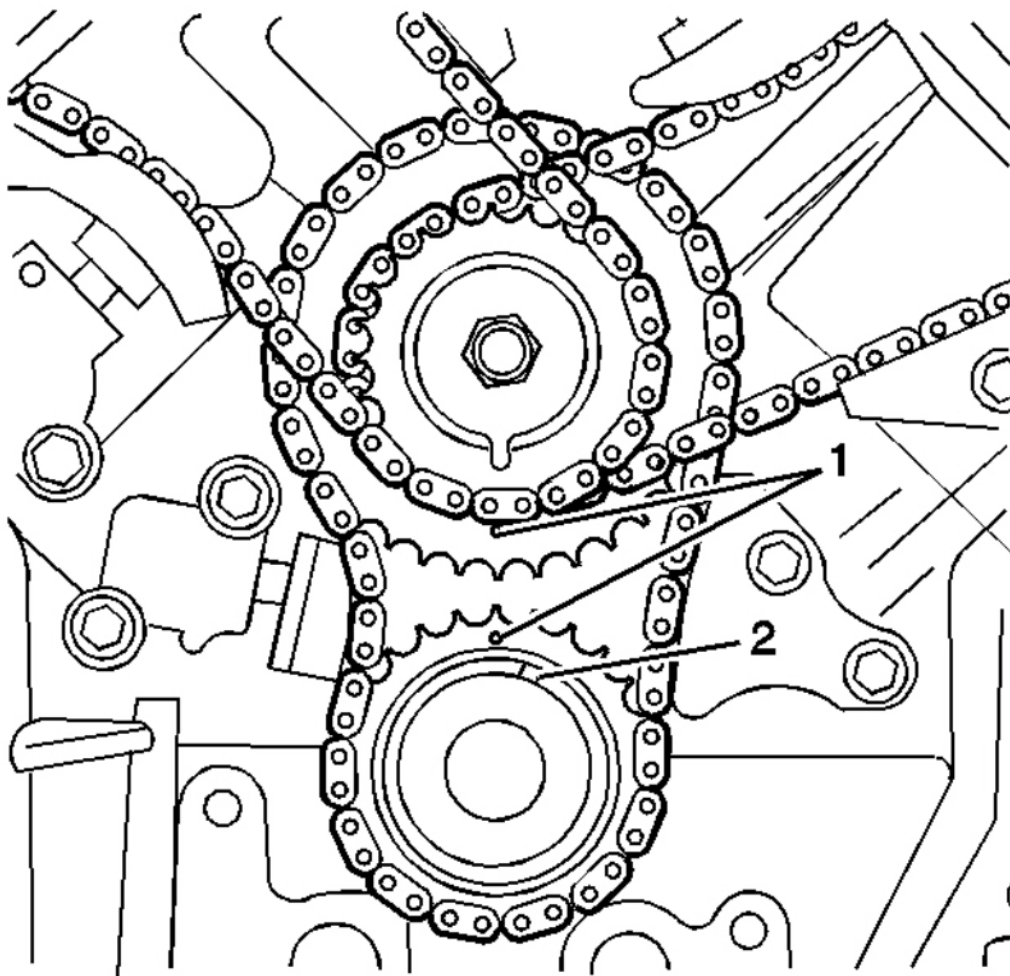


Fig. 388: Identifying Primary Timing Gear Alignment Marks
Courtesy of GENERAL MOTORS CORP.

35. Ensure the correct alignment of the primary timing drive components (1).
36. Install the engine oil pump. Refer to **Oil Pump Replacement**.
37. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
38. Install the right camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Right**.
39. Install the left camshaft actuator housing. Refer to **Camshaft Position (CMP) Actuator Housing Replacement - Left**.

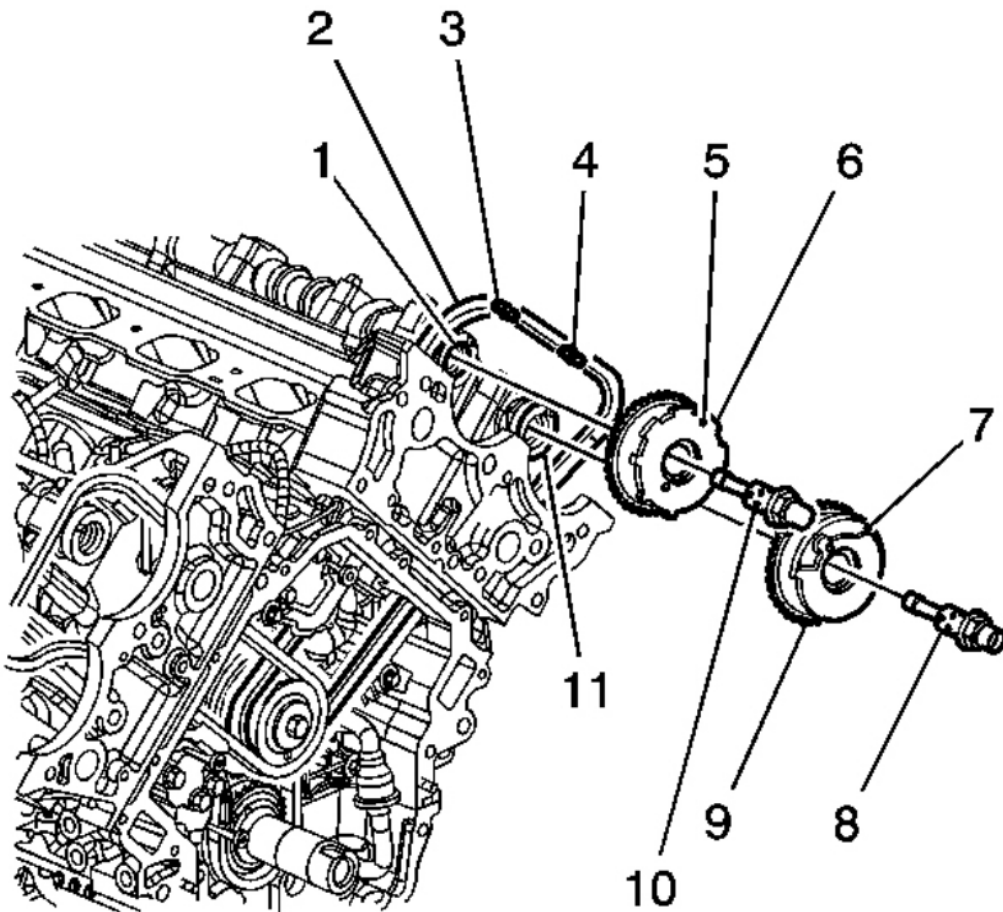
CAMSHAFT REPLACEMENT - LEFT**Removal Procedure**

Fig. 389: Identifying Camshaft Sprockets & Related Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the left intake camshaft actuator (6). Refer to **Camshaft Position (CMP) Actuator Replacement - Bank 2 (Left) Intake.**
2. Remove the left exhaust camshaft actuator (9). Refer to **Camshaft Position (CMP) Actuator Replacement - Bank 2 (Left) Exhaust.**

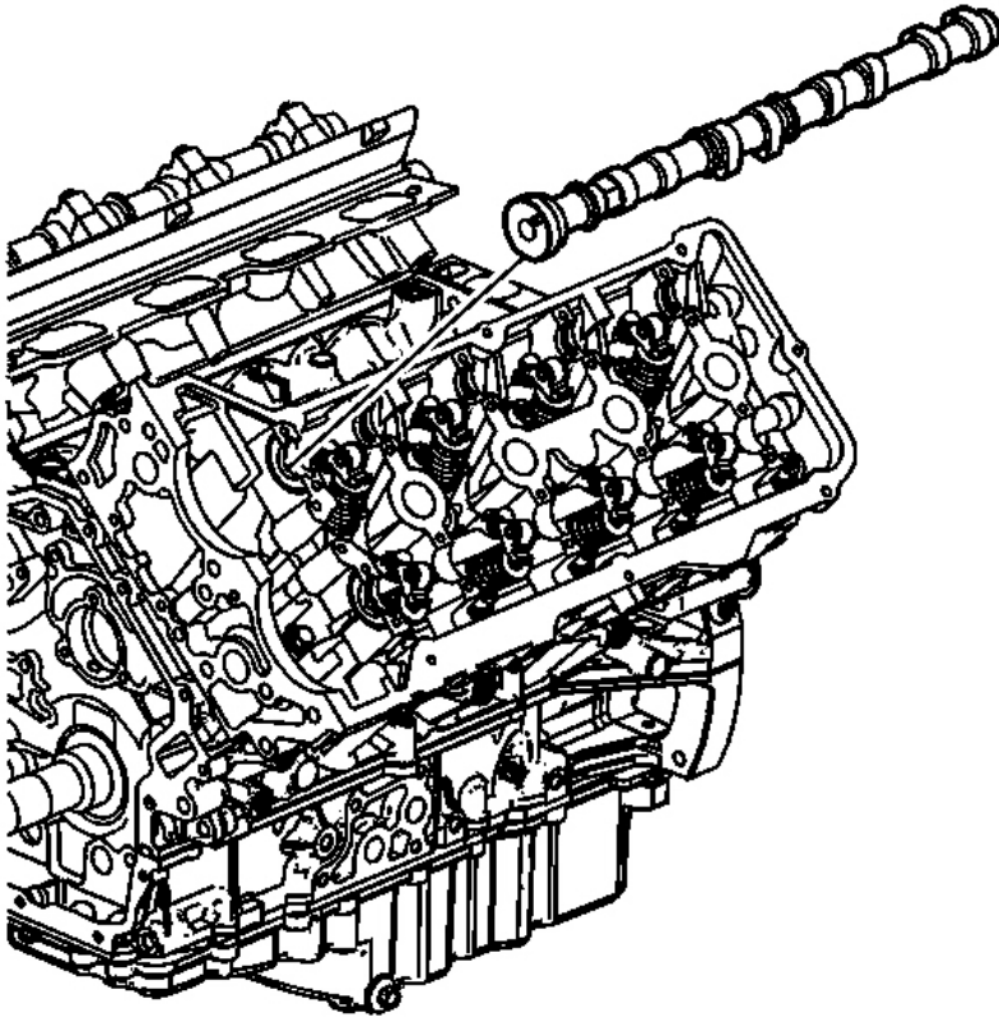


Fig. 390: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Remove the left intake camshaft. Refer to **Camshaft Removal - Left Intake** .

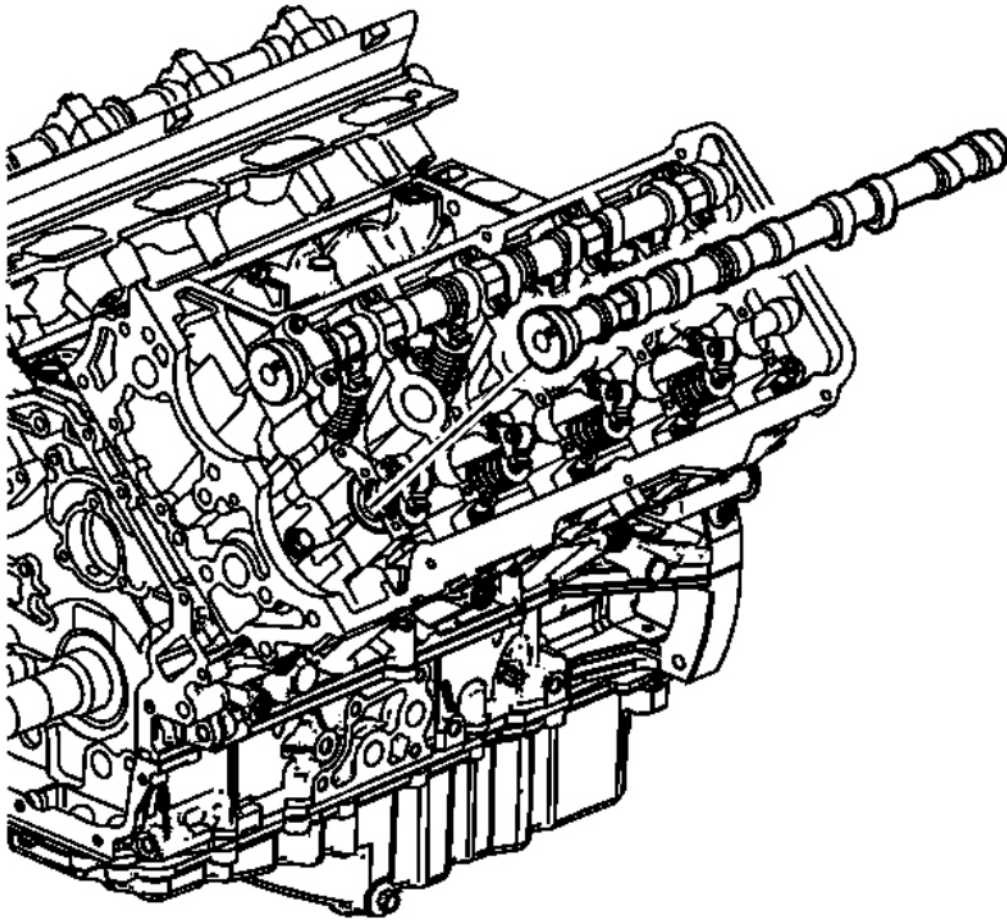


Fig. 391: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

4. Remove the left exhaust camshaft. Refer to **Camshaft Removal - Left Exhaust** .
5. Clean and inspect the camshafts. Refer to **Camshaft Cleaning and Inspection** .

Installation Procedure

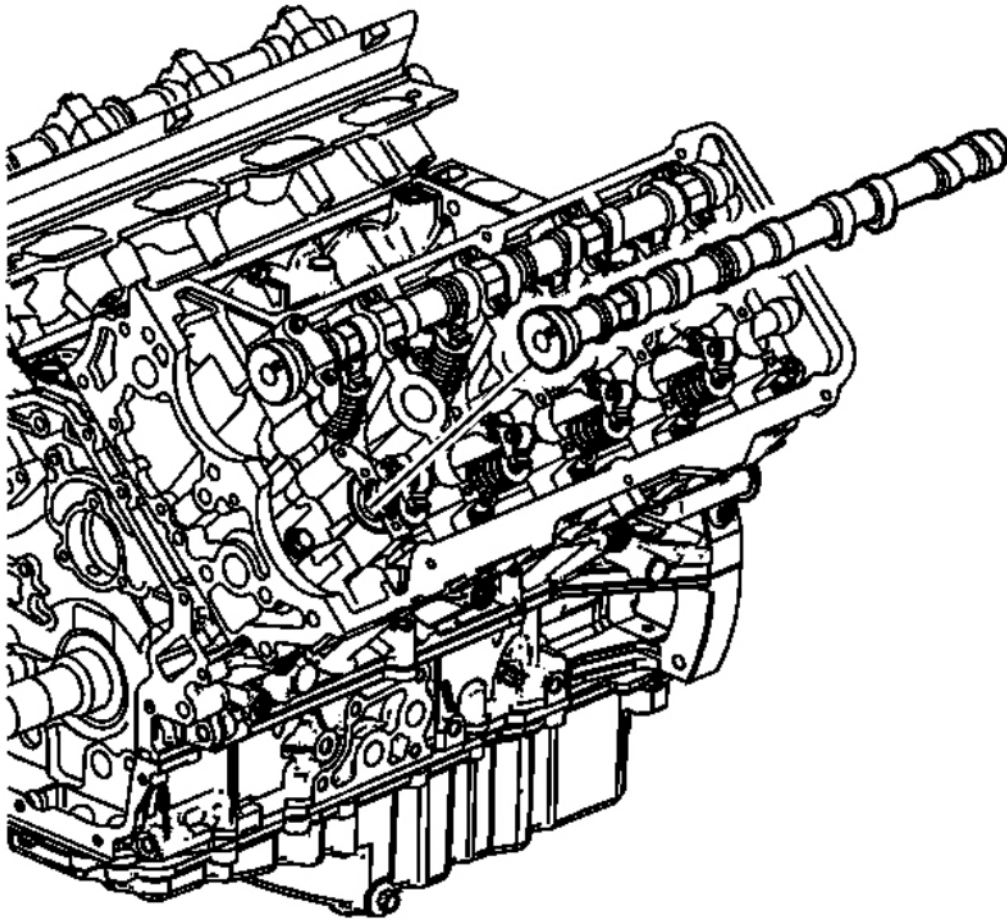


Fig. 392: View Of Left Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

1. Install the left exhaust camshaft. Refer to **Camshaft Installation - Left Exhaust** .

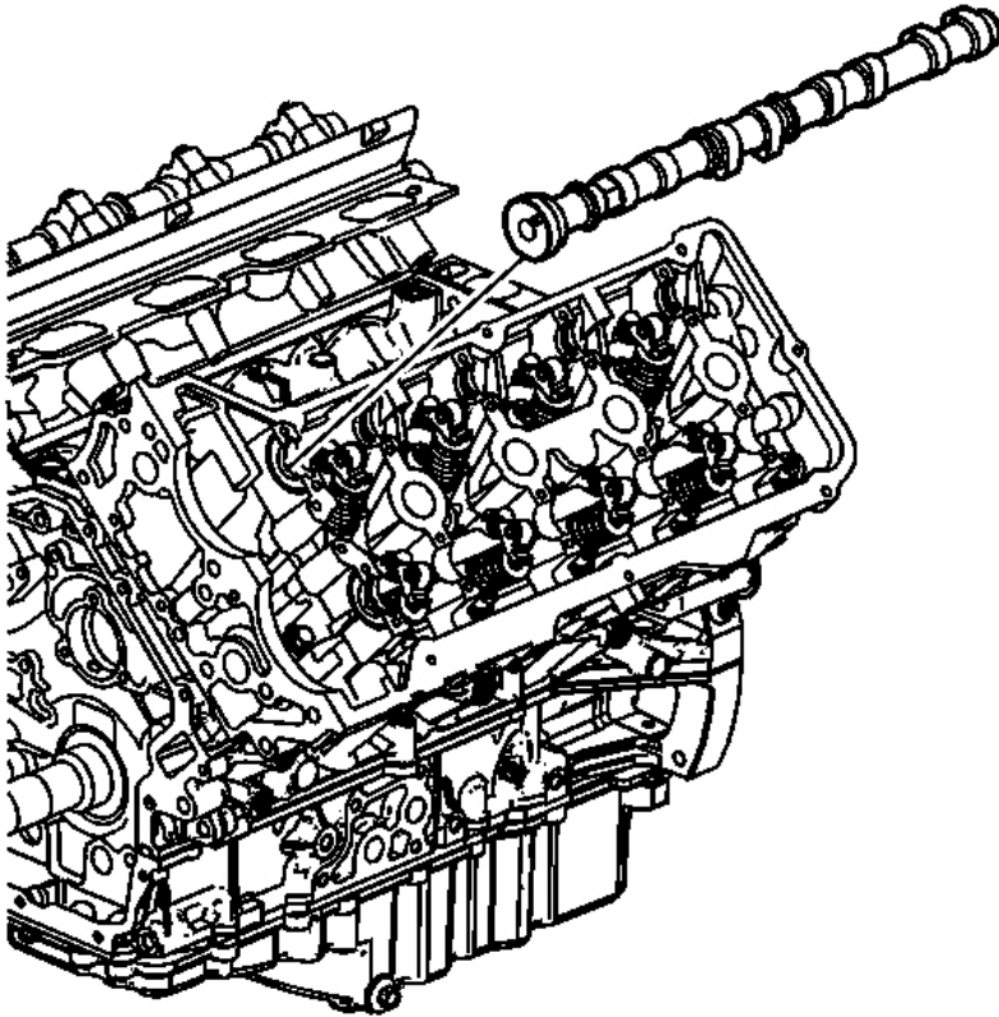


Fig. 393: View Of Left Intake Camshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the left intake camshaft. Refer to **Camshaft Installation - Left Intake** .

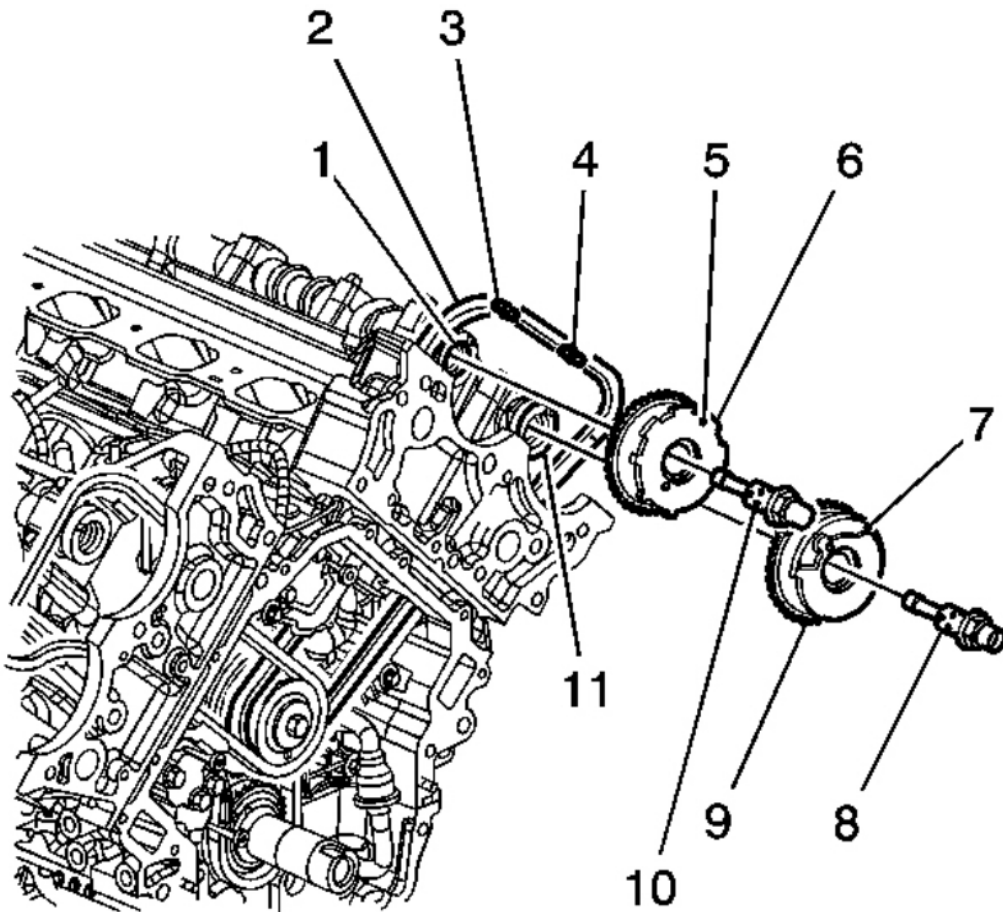


Fig. 394: Identifying Camshaft Sprockets & Related Components
 Courtesy of GENERAL MOTORS CORP.

3. Install the left exhaust camshaft actuator (9). Refer to **Camshaft Position (CMP) Actuator Replacement - Bank 2 (Left) Exhaust.**
4. Install the left intake camshaft actuator (6). Refer to **Camshaft Position (CMP) Actuator Replacement - Bank 2 (Left) Intake.**