

2008 Chevrolet Optra LT

2008 ENGINE Engine Mechanical - 1.6L - Optra

2008 ENGINE**Engine Mechanical - 1.6L - Optra****SPECIFICATIONS****FASTENER TIGHTENING SPECIFICATIONS**

Application	Specification	
	Metric	English
Air Cleaner Housing Bolts	10 N.m	89 lb in
Camshaft Cap Bolts	16 N.m	12 lb ft
Camshaft Cover Nuts	10 N.m	89 lb in
Connecting Rod Bearing Cap Bolts	25 N.m +30°+15°	18 lb ft +30°+15°
Coolant Temperature Sensor	20 N.m	15 lb ft
Crankshaft Bearing Cap Bolts	50 N.m +45°+15°	37 lb ft +45°+15°
Crankshaft Cover Nuts	5-8 N.m	44-71 lb in
Crankshaft Pulley Bolt	95 N.m +30°+15°	70 lb ft +30°+15°
Cylinder Head Bolts - Cylinder Head Mounting Bolts	25+70° +70°+50°	18+70° +70°+50°
Direct Ignition System Coil Mounting Bolts	10 N.m	89 lb in
Direct Ignition System Coil Mounting Bracket Bolts	10 N.m	89 lb in
Engine Mount Attaching Bolts	30 N.m	22 lb ft
Engine Mount Bracket Attaching Bolts/Nuts	50 N.m	37 lb ft
Exhaust Camshaft Gear Bolt	67.5 N.m	49 lb ft
Exhaust Flex Pipe-to-Catalytic Converter or Connecting Pipe Retaining Nut	35 N.m	26 lb ft
Exhaust Flex Pipe-to-Exhaust Manifold Retaining Nuts	35 N.m	26 lb ft
Exhaust Gas Recirculation Valve Adapter Bolts	25 N.m	18 lb ft
Exhaust Manifold Heat Shield Bolts	15 N.m	11 lb ft
Exhaust Manifold Retaining Nuts	25 N.m	18 lb ft
Flexible Plate Bolts	60 N.m	44 lb ft
Flexible Plate Inspection Cover Bolts	10 N.m	89 lb in
Flywheel Bolts	35 N.m +30°+15°	25 lb ft +30°+15°
Flywheel Inspection Cover Bolts	12 N.m	106 lb in
Front Timing Belt Cover Bolts - Upper and Lower	10 N.m	89 lb in
Fuel Rail Assembly Retaining Bolts	25 N.m	18 lb ft
Fuel Rail Retaining Bolts	25 N.m	18 lb ft
Generator Upper Retaining Bolt	20 N.m	15 lb ft

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Intake Camshaft Gear Bolt	67.5 N.m	49 lb ft
Intake Manifold Retaining Bolts/Nuts	25 N.m	18 lb ft
Intake Manifold Support Bracket Lower Bolt	25 N.m	18 lb ft
Intake Manifold Support Bracket Upper Bolts	25 N.m	18 lb ft
Lower Front Timing Belt Cover Bolts	10 N.m	89 lb in
Oil Pan Drain Plug	35 N.m	26 lb ft
Oil Pan Flange Bolts	75 N.m	55 lb ft
Oil Pan Retaining Bolts	10 N.m	89 lb in
Oil Pressure Switch	40 N.m	30 lb ft
Oil Pump Bolts	10 N.m	89 lb in
Oil Pump Rear Cover Bolts	8 N.m	71 lb in
Oil Pump Retaining Bolts	10 N.m	89 lb in
Oil Suction Pipe or Support Bracket Bolts	10 N.m	89 lb in
Rear Timing Belt Cover Bolts	10 N.m	89 lb in
Safety Relief Valve Bolt	30 N.m	22 lb ft
Spark Plugs	25 N.m	18 lb ft
Thermostat Housing Mounting Bolts	20 N.m	15 lb ft
Timing Belt Automatic Tensioner Bolts	25 N.m	18 lb ft
Timing Belt Idler Pulley Bolt	40 N.m	30 lb ft
Transaxle Bell Housing Bolts	75 N.m	55 lb ft
Transaxle Torque Converter Bolts	45 N.m	33 lb ft
Upper Front Timing Belt Cover Bolts	10 N.m	89 lb in
Water Pump Retaining Bolts	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
Block		
• Cylinder Bore Diameter	79 mm	3.1 in
• Cylinder Bore Out-of-Round - Maximum	0.0065 mm	0.0065 mm
• Cylinder Bore Taper - Maximum	0.0065 mm	0.0065 mm
Camshaft		
• Bearing Journal #1 OD	29.935-29.95 mm	1.1785-1.1791 in
• Bearing Journal #2-5 OD	26.935-26.95 mm	1.0604-1.0610 in
• Camshaft Lobe Lift - Exhaust	8.5 mm	0.335 in
• Camshaft Lobe Lift - Intake	8.5 mm	0.335 in
• End Play	0.10-0.25 mm	0.004-0.0089 in
Cooling System		

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• Capacity	7.2 L	7.6 qt
Crankshaft		
• Connecting Rod Bearing Clearance - All	0.019-0.071 mm	0.0007-0.0028 in
• Connecting Rod Bearing Side Clearance	0.070-0.242 mm	0.0027-0.009 in
• Connecting Rod Journal Diameter	42.971-72.987 mm	1.691-1.692 in
• Connecting Rod Journal Out-of-Round	0.004 mm	0.0001 in
• Connecting Rod Journal Taper	0.005 mm	0.0001 in
• Crankshaft End Play	0.05-0.28 mm	0.002-0.011 in
• Crankshaft Main Bearing Clearance - All	0.026-0.042 mm	0.001-0.002 in
• Crankshaft Main Journal Diameter	54.982-54.994 mm	2.164-2.165 in
• Crankshaft Main Journal Out-of-Round	0.004 mm	0.0001 in
• Crankshaft Main Journal Taper	0.005 mm	0.0001 in
Cylinder Head		
• Overall Height	134.08-134.23 mm	5.279-5.285 in
General Data		
• Bore	79 mm	3.1 in
• Compression Ratio	9.5:1	
• Displacement	1 598 cm ³	97.5 in ³
• Engine Type	Dual Overhead Cam L-4	
• Firing Order	1-3-4-2	
• Maximum Power at 5,800 RPM	80 kW	120.7 hp
• Maximum Torque	165 N.m	121.7 lb ft
• RPO	L91	
• Spark Plug Gap	1.0-1.1 mm	0.039-0.043 in
• Stroke	81.5 mm	3.21 in
• VIN	6	
Lubrication System		
• Lubricating Type	Forced Feed	
• Oil Capacity - With Filter	3.75 L	4 qt
Oil Pump		
• Gap Between Oil Pump Body and Outer Rotor	0.40-0.484 mm	0.0157-0.019 in
• Inner Rotor Side Clearance	0.035-0.085 mm	0.001-0.003 in
• Outer Rotor Side Clearance	0.45-0.10 mm	0.02-0.04 in
• Relief Valve Spring Free Length	81 mm	3.2 in

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Pin

• Piston Pin Diameter	18.0 mm	0.708 in
• Piston Pin Offset	0.7-0.9 mm	0.028-0.036 in

Piston

• Clearance to Bore	0.020-0.040 mm	0.0008-0.0016 in
• Piston Diameter	78.970 mm	3.1090 in

Piston Ring End Gap

• First Compression Ring	0.2-0.3 mm	0.008-0.012 in
• Second Ring Compression	0.5-0.6 mm	0.02-0.024 in

Piston Ring to Groove Clearance

• First Compression Ring	0.050-0.080 mm	0.002-0.003 in
• Second Compression Ring	0.050-0.082 mm	0.002-0.032 in

Sealants and Adhesives

• Camshaft Carrier to Cylinder Head	HN 1581 - Loctite® 515	
• Exhaust Manifold Studs/Nuts	Anti-Seize Compound - HMC Spec HN 1325	
• Oil Gallery Plug	HN 1256 - Loctite® 242	
• Oil Pan Bolts	HN 1256 - Loctite® 242	
• Oil Pan Pickup Tube Bolts	HN 1256 - Loctite® 242	
• Oil Pump Bolts	HN 1256 - Loctite® 242	
• Rear Main Bearing Cap	GE P/N RTV 159	

Valve Springs

• Valve Spring Load - Closed	247-273 N @ 32 mm	182-202 lb @ 1.25 in
• Valve Spring Load - Open	554-606 N @ 23 mm	409-447 lb @ 0.90 in

Valves

• Valve Diameter - Exhaust	27.10-27.38 mm	1.085-1.0795 in
• Valve Diameter - Intake	28.45-28.69 mm	1.1203-1.1297 in
• Valve Face Angle	45-45.25 degrees	
• Valve Face Runout	0.03 mm	0.00118 in
• Valve Guide Inside Diameter	6.0-6.02 mm	0.236-0.237 in
• Valve Lash Compensators	Hydraulic Tappet	
• Valve Seat Angle	44.5-45 degrees	
• Valve Seat Runout	0.05 mm	0.002 in
• Valve Seat Width - Exhaust	1.4-1.8 mm	0.055-0.071 in
• Valve Seat Width - Intake	1.17-1.57 mm	0.046-0.062 in

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• Valve Stem Diameter - Intake	5.955-5.970 mm	0.2344-0.2350 in
• Valve Stem Diameter - Exhaust	5.935-5.950 mm	0.2337-0.2343 in

Valve Guide Reaming Table

Size	Reamer	Production Code	Service Code
Normal	-	-	K
1.9 mm (0.075 in)	KM-805	1	K1
3.8 mm (0.150 in)	-	2	K2

COMPONENT LOCATOR

DISASSEMBLED VIEWS

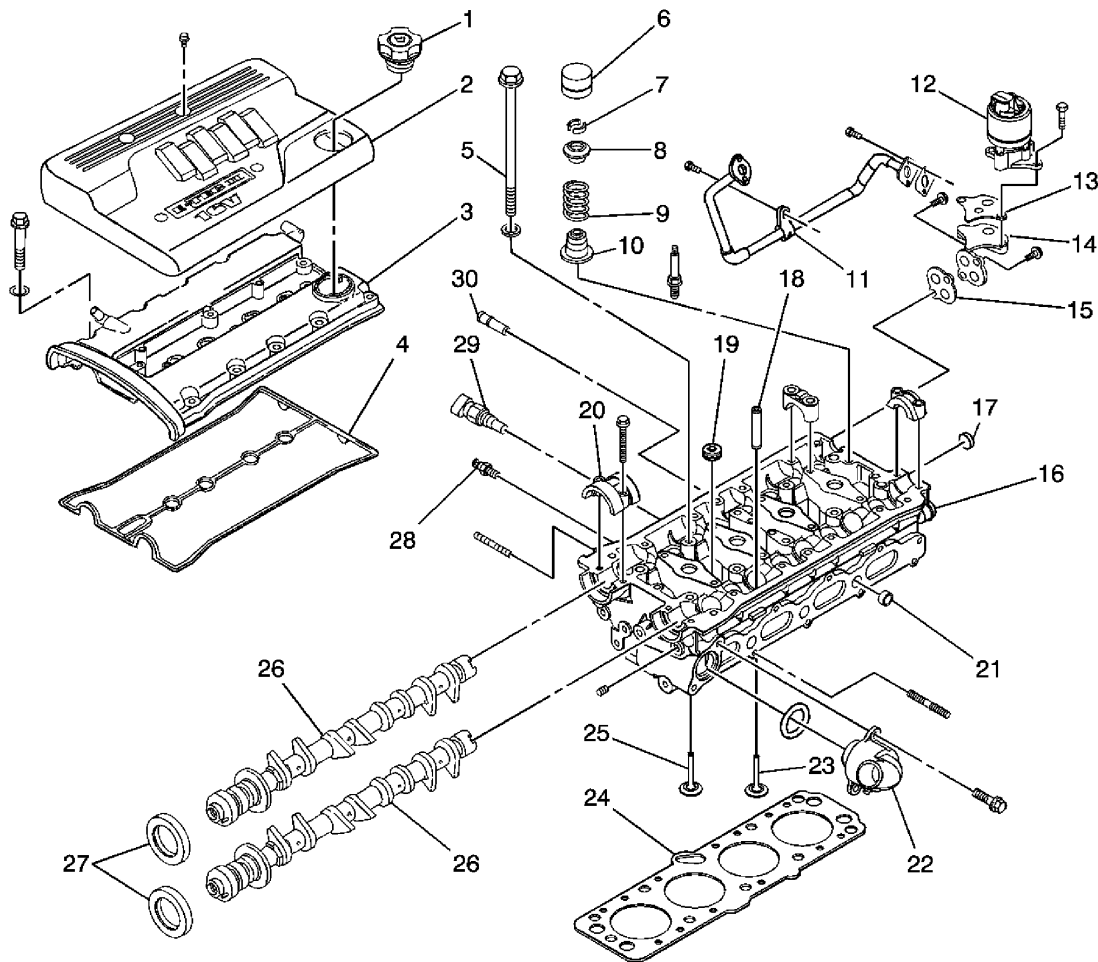


Fig. 1: Identifying Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

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Callout	Component Name
1	Oil Filler Cap
2	Engine Cover
3	Camshaft Cover
4	Camshaft Cover Gasket
5	Camshaft Cover Bolt
6	Hydraulic Tappet Adjuster
7	Valve Key
8	Valve Spring Cap
9	Valve Spring
10	Valve Stem Seal
11	EGR Vacuum Hose
12	EGR Valve
13	EGR Valve Gasket
14	EGR Valve Adaptor
15	EGR Valve Adaptor Gasket
16	Cylinder Head
17	Freeze Plug
18	Valve Guide
19	Plug
20	Front Camshaft Cap
21	Oil Duct Cap
22	Thermostat
23	Intake Valve
24	Cylinder Head Gasket
25	Exhaust Valve
26	Camshaft
27	Camshaft Seal
28	Engine Coolant Temperature Sensor
29	Coolant Temperature Sensor
30	Heat Take Off Pipe

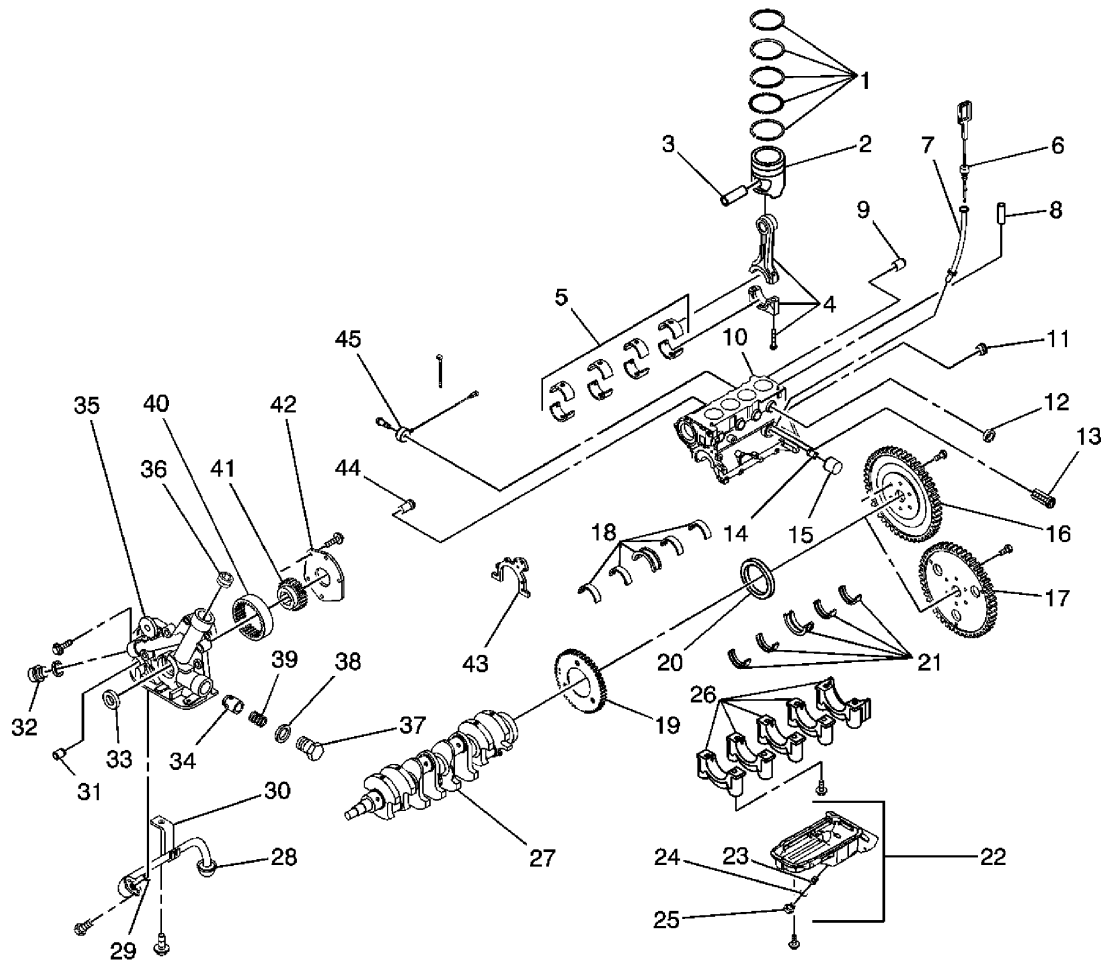


Fig. 2: Identifying Cylinder Block Components
 Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Piston Ring Set
2	Piston
3	Piston Pin
4	Connecting Rod
5	Connecting Rod Bearing Set
6	Oil Level Gage Stick
7	Gage Stick Tube
8	Sleeve
9	Clutch Housing Sleeve
10	Cylinder Block
11	Plug
12	Gap

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13	Bypass Valve
14	Connecting Piece
15	Oil Filter
16	Fly Wheel (M/T)
17	Flexible Plate (A/T)
18	Crankshaft Upper Bearing Set
19	Transmitter Disc
20	Shaft Seal Ring
21	Crankshaft Lower Bearing Set
22	Oil Pan
23	Threaded Ring
24	Washer
25	Oil Pan Drain Plug
26	Crankshaft Bearing Cap
27	Crankshaft
28	Oil Suction Pipe
29	Sealing
30	Oil Suction Pipe Bracket
31	Sleeve
32	Oil Pressure Switch
33	Shaft Sealing
34	Pressure Relief Valve Plunger
35	Oil Pump
36	Oil Pump Plug
37	Relief Valve
38	Sealing
39	Relief Valve Spring
40	Oil Pump Outer Rotor
41	Oil Pump Inner Rotor
42	Oil Pump Cover
43	Oil Pump Body Gasket
44	Water Inlet Neck
45	Knock Sensor

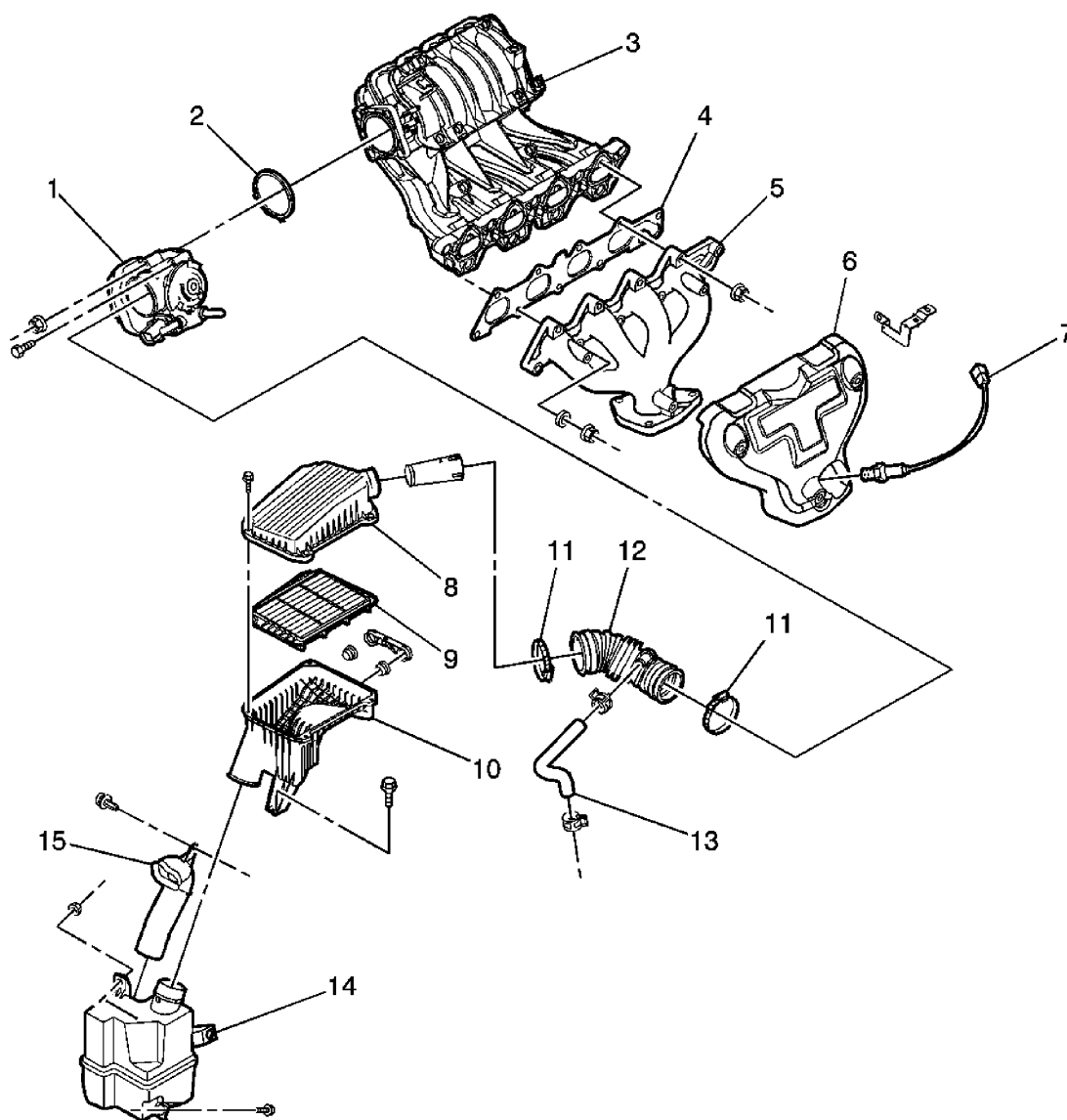


Fig. 3: Identifying Intake And Exhaust Manifold Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Main Throttle Idle Actuator (MTIA)/Throttle Body
2	Main Throttle Idle Actuator (MTIA) Gasket
3	Intake Manifold
4	Exhaust Manifold Gasket
5	Exhaust Manifold
6	Heat Shield
7	Oxygen Sensor
8	Air Cleaner Upper Housing

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9	Air Cleaner Element
10	Air Cleaner Lower Housing
11	Clamp
12	Intake Air Tube
13	Breathe Hose
14	Resonator
15	Air Inlet Hose

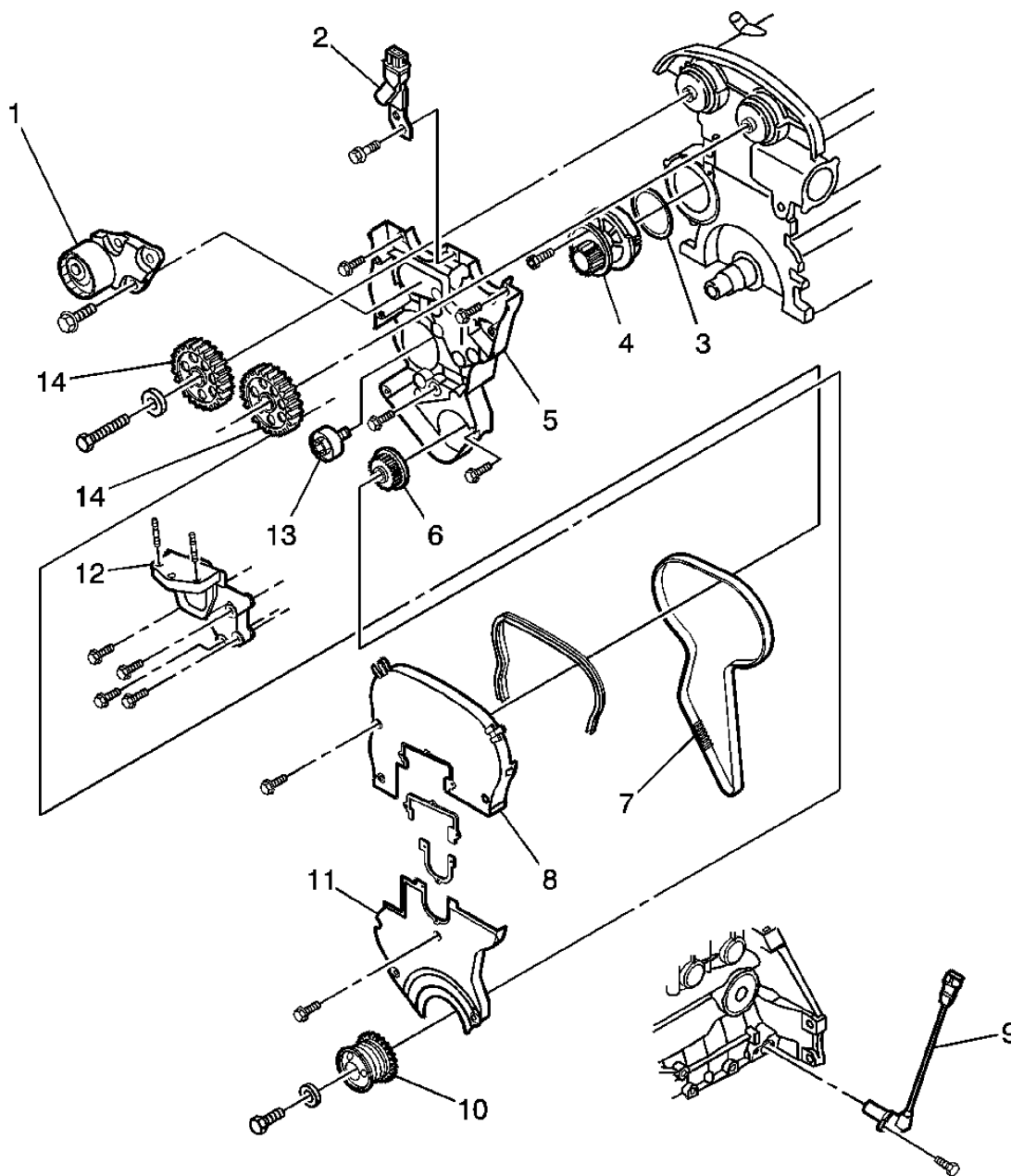


Fig. 4: Identifying Timing Belt Components

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Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Auto Tensioner
2	Camshaft Position Sensor
3	Water Pump Sealing
4	Water Pump
5	Timing Belt Rear Cover
6	Crankshaft Gear
7	Timing Belt
8	Timing Belt Front Upper Cover
9	Crankshaft Position Sensor
10	Crankshaft Pulley
11	Timing Belt Front Lower Cover
12	Torque Roll Axis Support
13	Idler Pulley
14	Camshaft Gear

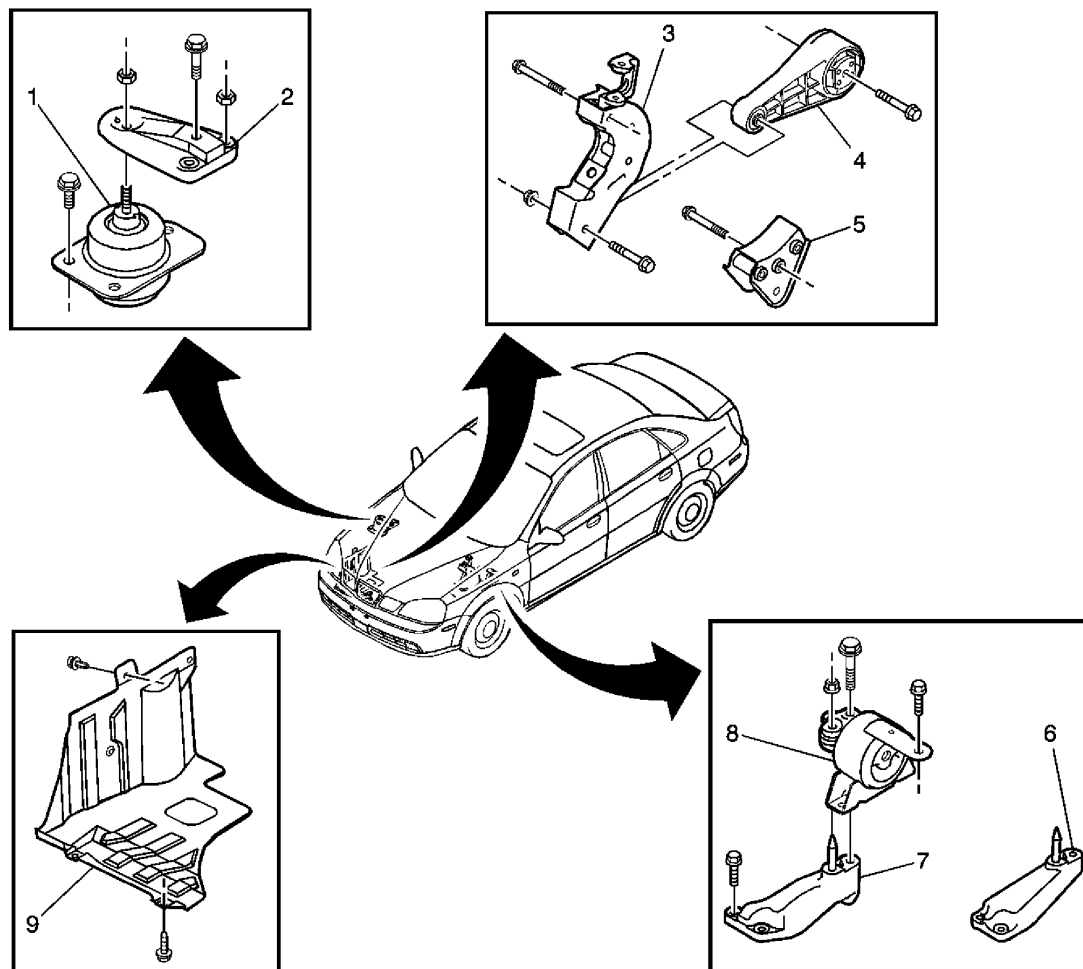


Fig. 5: Identifying Engine Mounting Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Hydro Mounting
2	Engine Mounting Bracket
3	Rear Transaxle Mounting Bracket (M/T)
4	Rear Power Unit Damping Block
5	Rear Transaxle Mounting Bracket (A/T)
6	Transaxle Mounting Bracket (A/T)
7	Transaxle Mounting Bracket (M/T)
8	Transaxle Mounting Cage
9	Engine Lower Cover

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing **Symptoms - Engine Mechanical**. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to **Engine Component Description** in order to identify the correct procedure for diagnosing the system and where the procedure is located.

SYMPTOMS - ENGINE MECHANICAL**Strategy Based Diagnostics**

1. Perform the Diagnostic System Check **Diagnostic System Check - Vehicle** before using the symptom tables, if applicable.
2. Review the system operation in order to familiarize yourself with the system functions. Refer to **Disassembled Views** and **Engine Component Description**.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Engine Noise Diagnosis**
- **Engine Knocks Cold and Continues for Two-Three Minutes and/or Knock Increases with Engine Torque**

- **Engine Noise Under Load**
- **Light Knock Hot**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Knocks at Idle Hot**
- **Main Bearing Noise**
- **Connecting Rod Bearing Noise Symptom**
- **Piston Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Engine Compression Test**

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **J 36648-A** (KM 135) Adapter
 - **J 21867** (KM 498-B) Pressure Gage
1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2-3 minutes, and measure for a low oil level.
 2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
 3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gage or light.
 4. Listen for a noisy valve train or a knocking noise.
 5. Inspect for the following:
 - Foamy oil
 - Slow idle speed
 - Plugged oil filter
 - Oil diluted by the following:
 - Water
 - Engine coolant
 - Unburned fuel mixtures
 - Malfunctioning oil filter bypass valve
 - Incorrect or faulty oil pressure gage
 - Incorrect or faulty oil pressure gage sensor
 - Improper engine oil viscosity for the expected temperature

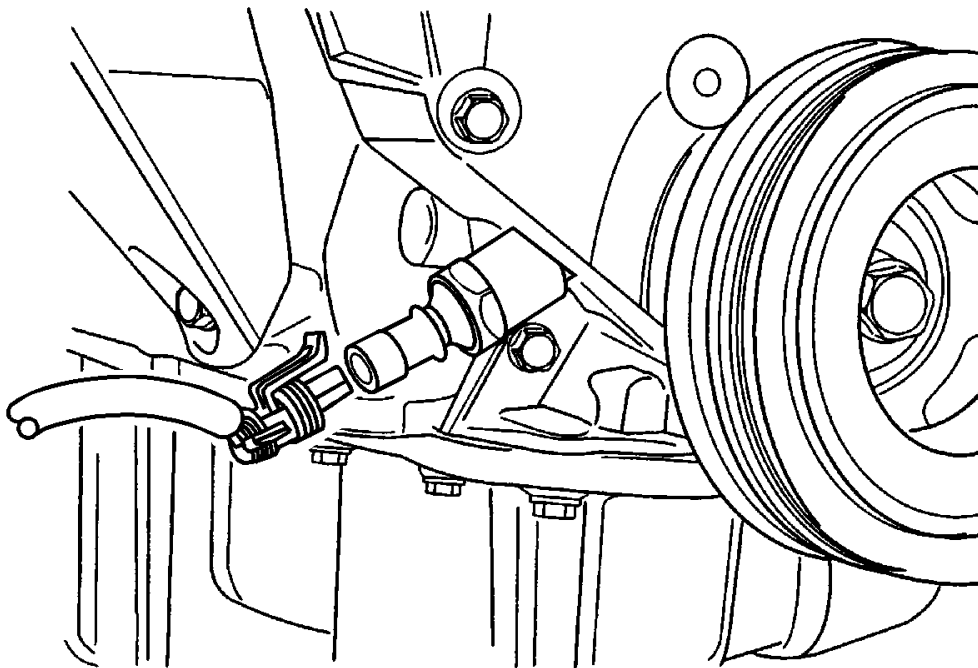


Fig. 6: View Of Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pressure gage sensor.

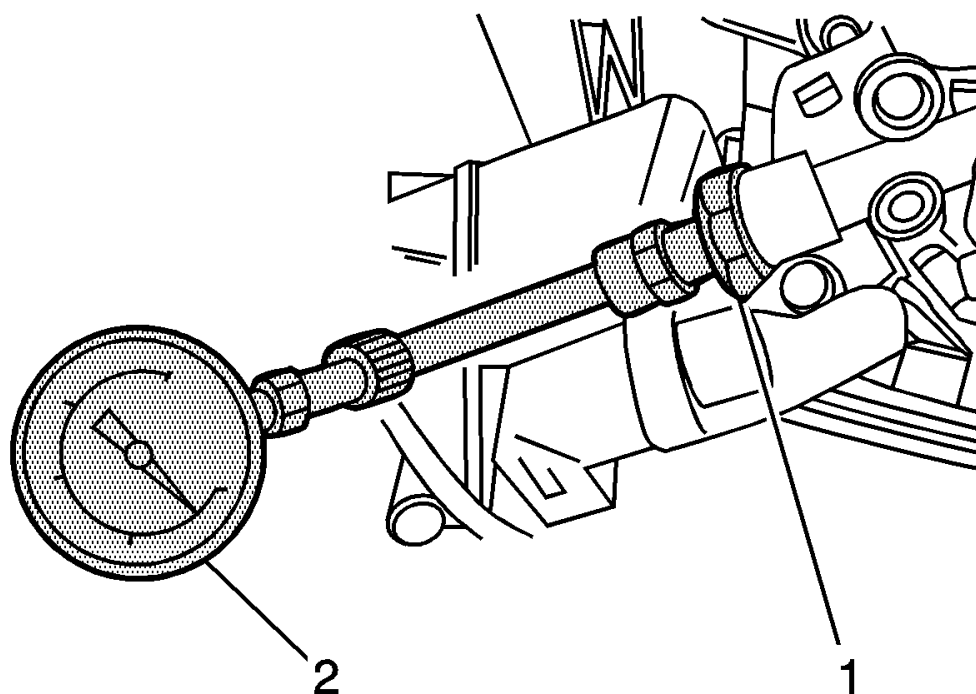


Fig. 7: View Of J 36648-A In Place Of Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 36648-A** (1) in place of the oil pressure sensor.
8. Connect the **J 21867** (2) to the **J 36648-A**.
9. Start the engine and check oil pressure at idle speed and engine temperature at 80° F (176° C).
10. Measure the engine oil pressure. The minimum oil pressure should be 30 kPa (8.88 psi).
11. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
 - Loose oil filter adapter bolts
 - Missing or damaged oil filter adapter O-ring seal or seals
 - Worn or dirty oil pump
 - Loose oil pump-to-engine block bolts
 - Loose, plugged or damaged oil pump screen
 - Missing or damaged oil pump screen O-ring seal
 - Damage or leak in the oil pump screen suction tube
 - Malfunctioning oil pump pressure regulator valve

- Missing or incorrectly installed oil gallery plugs
- Loose camshaft intermediate drive shaft bolts
- Excessive bearing clearance for the following:
 - Connecting rod or rods
 - Crankshaft
 - Camshaft or camshafts
 - Camshaft intermediate drive shaft sprocket
- Cracked, porous or restricted oil galleries
- Broken valve lifters

12. Repair or replace components as necessary.

OIL LEAK DIAGNOSIS

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions, a fluid leak may be difficult to locate or repair. The following procedures may help you in locating and repairing most leaks.

Finding the Leak:

1. Identify the fluid. Determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
2. Identify where the fluid is leaking from.
 1. After running, the vehicle at normal operating temperature, park the vehicle over a large sheet of paper.
 2. Wait a few minutes.
 3. Find the approximate location of the leak by the drippings of the paper.
3. Visually check around the suspected component. Check around all the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam, or spray solvent.
 1. Thoroughly clean the area.
 2. Dry the area.
 3. Operate the vehicle for several miles at normal operating temperature and varying speeds.
 4. After operating the vehicle, visually check the suspected component.
 5. If you still cannot locate the leak, try using the powder or black light and dye method.

Power Method

1. Clean the suspected area.
2. Apply an aerosol-type powder, such as foot powder, to the suspected area.
3. Operate the vehicle under normal operating conditions.

4. Visually inspect the suspected component. Trace the leak path over the white powder surface to the source.

Black Light and Dye Method

A dye and light kit is available for finding leaks. Refer to the manufacturer's directions when using the kit.

1. Pour the specified amount of dye into the engine oil fill tube.
2. Operate the vehicle under normal operating conditions as directions in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check for the following conditions and correct them as they may cause a leak.

Gaskets

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The fasteners are improperly tightened.
- The threads are dirty or damaged.
- The flanges or the sealing surface is warped.
- There are scratches, burrs or other damage to the sealing surface.
- The gasket is damaged or worn.
- There is cracking or porosity of the component.
- An improper seal was used, if applicable.

Seals

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The seal bore is damaged, scratched, burred or nicked.
- The seal is damaged or worn.
- Improper installation is evident.
- There are cracks in the component.
- The shaft surface is scratched, nicked or damaged.
- A loose or worn bearing is causing excess seal wear.

ENGINE NOISE DIAGNOSIS

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Engine knock refers to various types of engine noise. Heavy knock is usually very loud and the result of broken or excessively worn internal engine components. Light knock is a noticeable noise, but not as loud. Light knock can be caused by worn internal engine components. Loose or broken external engine components can also cause heavy or light knock.

ENGINE KNOCKS COLD AND CONTINUES FOR TWO-THREE MINUTES AND/OR KNOCK INCREASES WITH ENGINE TORQUE

Step	Action	Values	Yes	No
1	Does the engine knock when it is cold and continue for 2-3 minutes or does the knock increase with torque?	-	Go to Step 2	System OK
2	Inspect the flywheel. Is the flywheel contacting the splash shield?	-	Go to Step 3	Go to Step 4
3	Reposition the splash shield. Is the repair complete?	-	Go to Step 1	-
4	Inspect the balancer and the drive pulleys. Is either the balancer or the drive pulleys loose or broken?	-	Go to Step 5	Go to Step 6
5	Tighten or replace the balancer or the driver pulleys. Is the repair complete?	-	Go to Step 1	-
6	Inspect the piston-to-bore clearance. Is the clearance more than the value specified?	0.030 mm (0.001 in)	Go to Step 7	Go to Step 8
7	IMPORTANT: Cold engine piston knock usually disappears when the cylinder is grounded out. Cold engine piston knock, which disappears in about 1.5 minutes, is considered acceptable. 1. Bore the cylinder and hone to size. 2. Replace the piston. Is the repair complete?	-	Go to Step 1	-
8	Inspect the connecting rod. Is the connecting rod bent?	-	Go to Step 9	System OK
9	Replace the connecting rod. Is the repair complete?	-	Go to Step 1	-

ENGINE NOISE UNDER LOAD

Step	Action	Values	Yes	No
1	Is there a heavy knock when the engine is hot and torque is applied?	-	Go to Step 2	System OK

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2	Inspect the balancer and the pulley hub. Is the balancer of the pulley hub broken?	-	Go to Step 3	Go to Step 4
3	Replace the broken balancer on the pulley hub. Is the repair complete?	-	Go to Step 1	-
4	Inspect the torque converter bolts. Are the bolts tightened to value specified?	45 N.m (33 lb ft)	Go to Step 5	Go to Step 6
5	Tighten the torque converter bolts. Is the repair complete?	-	Go to Step 1	-
6	Inspect the accessory belts. Are the belts too tight or nicked?	-	Go to Step 7	Go to Step 8
7	Replace and/or tension the belts to specifications, as necessary. Is the repair complete?	-	Go to Step 1	-
8	Inspect the exhaust system. Is the system grounded?	-	Go to Step 9	Go to Step 10
9	Reposition the system, as necessary. Is the repair complete?	-	Go to Step 1	-
10	Inspect the flywheel. Is the flywheel cracked?	-	Go to Step 11	Go to Step 12
11	Replace the flywheel. Is the repair complete?	-	Go to Step 1	-
12	Inspect the main bearing clearance. Is the clearance more than the value specified?	0.046 mm (0.0018 in)	Go to Step 13	Go to Step 14
13	Replace the main bearings as necessary. Is the repair complete?	-	Go to Step 1	-
14	Inspect the rod bearing clearance. Is the clearance more than the specified value?	0.070 mm (0.0028 in)	Go to Step 15	System OK
15	Replace the rod bearings as necessary. Is the repair complete?	-	Go to Step 1	-

LIGHT KNOCK HOT

Step	Action	Values	Yes	No
1	Is there a light knock when the engine is hot?	-	Go to Step 2	System OK
2	Is detonation or spark knock evident?	-	Go to Step 3	Go to Step 4
3	Inspect the engine timing and the fuel quality. Was the problem found?	-	Go to Step 1	-
4	Inspect the torque converter bolts. Are the bolts loose?	-	Go to Step 5	Go to Step 6
5	Tighten the torque converter bolts. Is the repair complete?	-	Go to Step 1	-
6	Inspect the manifold. Is there an exhaust leak at the manifold?	-	Go to Step 7	Go to Step 8
7	Tighten the bolts or replace the gasket.	-		

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	Is the repair complete?		Go to Step 1	-
8	Measure the rod bearing clearance. Is the clearance within the specified range?	0.19-0.070 mm (0.0007-0.0028 in)	Go to Step 9	System OK
9	Replace the rod bearings, as necessary. Is the repair complete?	-	Go to Step 1	-

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Step	Action	Values	Yes	No
1	Does the engine knock during initial start-up but last only a few seconds?	-	Go to Step 2	System OK
2	Inspect the engine oil. Is the proper viscosity oil used in the crankcase?	-	Go to Step 4	Go to Step 3
3	Install oil of the proper viscosity for the expected seasonal temperatures. Is the repair complete?	-	Go to Step 1	-
4	Inspect the hydraulic lifters. Is there evidence of hydraulic lifter bleed-down?	-	Go to Step 5	Go to Step 6
5	IMPORTANT: When the engine is stopped, some valves will be open. Spring pressure against the lifters will tend to bleed the lifter down. Attempts to repair this should be made only if the problem is consistent. An engine that is operated for only short periods between start-ups may have lifter noise that lasts for a few minutes. This is a normal condition. Clean, test, and replace the lifters as necessary. Is the repair complete?	-	Go to Step 1	-
6	Inspect the crankshaft end clearance. Is the clearance more than specified value?	0.1 mm (0.0039 in)	Go to Step 7	Go to Step 8
7	Replace the crankshaft thrust bearing. Is the repair complete?	-	Go to Step 1	-
8	Inspect the front main bearing clearance. Is the clearance more than the specified value?	0.046 mm (0.0018 in)	Go to Step 9	System OK
9	Replace the worn parts of the front main bearing. Is the repair complete?	-	Go to Step 1	-

KNOCKS AT IDLE HOT

Step	Action	Values	Yes	No
1	Does the engine knock at idle when hot?	-	Go to Step 2	System OK

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2	Inspect the drive belts. Are the belt loose or worn?	-	Go to Step 3	Go to Step 4
3	Tension or replace the belts, as necessary. Is the repair complete?	-	Go to Step 1	-
4	Inspect the A/C compressor and the generator. Is either the compressor or the generator faulty?	-	Go to Step 5	Go to Step 6
5	Replace the faulty A/C compressor or the generator. Is the repair complete?	-	Go to Step 1	-
6	Inspect the valve train. Are valve train components faulty?	-	Go to Step 7	Go to Step 8
7	Replace faulty valve train components. Is the repair complete?	-	Go to Step 1	-
8	Inspect the engine oil. Is the proper viscosity oil used in the crankcase?	-	Go to Step 10	Go to Step 9
9	Install oil of the proper viscosity for the expected seasonal temperatures. Is the repair complete?	-	Go to Step 1	-
10	Inspect the piston pin clearance. Is the clearance more than the specified value?	0.020 mm (0.0008 in)	Go to Step 11	Go to Step 12
11	Replace the piston and the pin. Is the repair complete?	-	Go to Step 1	-
12	Inspect the connecting rod alignment. Is the alignment faulty?	-	Go to Step 13	Go to Step 14
13	Inspect and replace rods as necessary. Is the repair complete?	-	Go to Step 1	-
14	Inspect the piston-to-bore clearance. Is the clearance equal to the specified value?	0.03 mm (0.0012 in)	Go to Step 16	Go to Step 15
15	Hone the bore and fit a new piston. Is the repair complete?	-	Go to Step 1	-
16	Inspect the crankshaft balancer. Is the balancer loose?	-	Go to Step 17	Go to Step 18
17	Torque or replace worn parts. Is the repair complete?	-	Go to Step 1	-
18	Measure the piston pin offset toward the thrust side. Is the offset equal to the value specified?	0.4-0.6 mm (0.017-0.023 in)	Go to Step 19	System OK
19	Install the correct piston. Is the repair complete?	-	Go to Step 1	-

MAIN BEARING NOISE

Step	Action	Values	Yes	No
1	Are dull thuds or knocks heard with every	-		

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	engine revolution?		Go to Step 2	System OK
2	Measure the oil pump pressure. Is the oil pump pressure low?	-	Go to <u>Oil Pressure Diagnosis and Testing</u>	Go to Step 3
3	Inspect the crankshaft end play. Is the crankshaft end play greater than the given value?	0.28 mm (0.011 in)	Go to <u>Crankshaft Replacement</u>	Go to Step 4
4	Inspect the crankshaft journals. Are the crankshaft journals out-of-round?	-	Go to <u>Crankshaft Replacement</u>	Go to Step 5
5	Inspect the belt tension. Is there excessive belt tension?	-	Go to <u>Crankshaft Replacement</u>	Go to Step 6
6	Inspect the crankshaft pulley. Is the crankshaft pulley loose?	-	Go to <u>Crankshaft Replacement</u>	System OK

CONNECTING ROD BEARING NOISE SYMPTOM

Step	Action	Yes	No
1	Is a knock noise heard under all engine speeds?	Go to Step 2	System OK
2	Inspect the crankshaft connecting rod journal. Is the crankshaft connecting rod journal worn?	Go to <u>Oil Pressure Diagnosis and Testing</u>	Go to Step 3
3	Measure the oil pump pressure. Is the oil pump pressure low?	Go to <u>Crankshaft Replacement</u>	Go to Step 4
4	Inspect the crankshaft connecting rod journals. Are the journals out-of round?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	Go to Step 5
5	Inspect the connecting rods. Is there a misaligned connecting rod?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	Go to Step 6
6	Inspect the connecting rod bolts. Are the connecting rod bolts torqued properly?	System OK	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>

PISTON NOISES

Step	Action	Yes	No
	Listen for the following noises:		

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1	• A sharp double knock when the engine is idling • A light ticking with no load on the engine • A slapping noise when the engine is cold?		
	Are any of these noises heard?	Go to Step 2	System OK
2	Inspect the piston pin and the bushing. Is the piston pin or the bushing worn or loose?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	Go to Step 3
3	Inspect the piston. Is the piston broken or cracked?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	Go to Step 4
4	Inspect the connecting rods. Is there a misaligned connecting rod?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	Go to Step 5
5	Inspect the piston position. Is the piston 180 degrees out of position?	Go to <u>Piston, Connecting Rod, and Bearing Replacement</u>	System OK

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Step	Action	Yes	No
1	Is a light tapping sound heard from the engine?	Go to Step 2	System OK
2	Inspect the valve springs. Are the springs weak or broken?	Go to <u>Cylinder Head Disassemble</u>	Go to Step 3
3	Inspect the valves. Are the valves sticking or warped?	Go to <u>Cylinder Head Disassemble</u>	Go to Step 4
4	Inspect the valve lifters. Are the valve lifters dirty, stuck, or worn?	Go to <u>Cylinder Head Disassemble</u>	Go to Step 5
5	Inspect the camshaft lobes. Are the camshaft lobes damaged or improperly machined?	Go to <u>Camshaft Replacement</u>	Go to Step 6
6	Inspect the oil supply to the valve train. Is the oil supply insufficient or poor?	Go to <u>Cylinder Head Disassemble</u>	Go to Step 7
7	Inspect the valve guides. Are the valve guides worn?	Go to <u>Cylinder Head Disassemble</u>	Go to Step 8
8	Inspect the valve spring seat. Is the valve spring seat incorrect?	Go to <u>Cylinder Head Disassemble</u>	System OK

ENGINE COMPRESSION TEST**Special Tools****J 38722** Compression Tester

IMPORTANT: Disconnect the crankshaft position (CKP) sensor connector to disable the fuel and the ignition systems.

Test the compression pressure for each cylinder. Low compression pressure for each cylinder. Low compression pressure may be the fault of the valves or the pistons. The following conditions should be considered when you check the cylinder compression:

Test

- The engine should be at normal operating temperature.
 - The throttle must be wide open.
 - All the spark plugs should be removed.
 - The battery must be at or near full charge.
1. Place approximately 3 squirts of oil from a plunger-type oiler into each spark plug port.
 2. Insert the **J 38722** into each spark plug port.
 3. Crank test each cylinder with 4-5 compression strokes using the starter motor.
 4. The lowest reading should not be less than 70 percent of the highest reading. The compression gage reading should not be less than 689 kPa (100 psi) for any of the cylinders.
 5. Examine the gage readings obtained after the 4 "puffs" per cylinder are obtained from cranking the starter motor. The readings are explained in the following descriptions:
 - Normal condition-Compression builds up quickly and evenly to the specified compression on each cylinder.
 - Piston rings faulty-Compression is low on the first stroke and tends to build up on the following strokes, but the compression pressure does not reach normal. The compression pressure improves considerably with the addition of oil into the cylinder.
 - Valves faulty-Low compression pressure on the first stroke. The compression pressure does not tend to build up on the following strokes. The compression pressure does not improve much with the addition of oil into the cylinder.

REPAIR INSTRUCTIONS - ON VEHICLE**ENGINE MOUNT REPLACEMENT****Tools Required**

J 28467-B (DW-117) Universal Engine Support Fixture

Removal Procedure

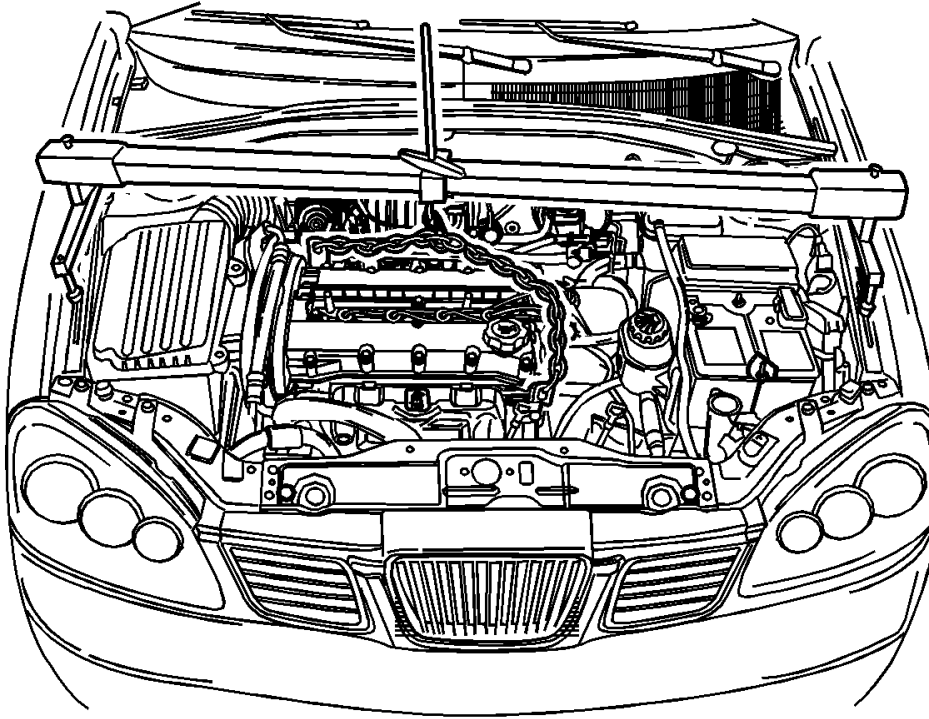


Fig. 8: View Of Engine Assembly And J 28467-B
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable.
2. Support the engine assembly using the **J 28467-B** .

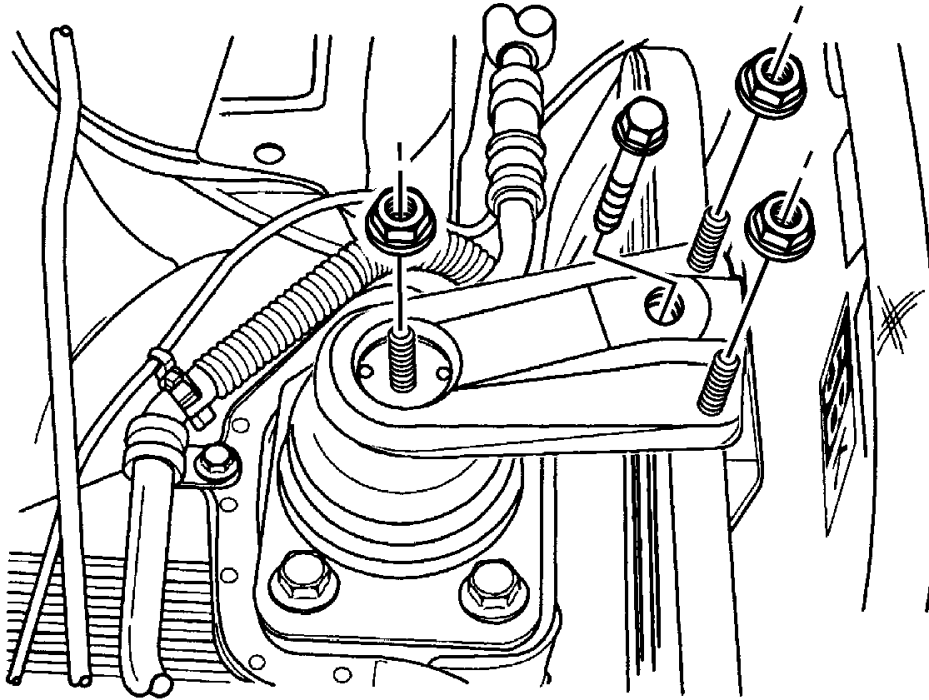


Fig. 9: View Of Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine mount bracket attaching bolts/nuts.
4. Remove the front timing belt cover. Refer to **Timing Belt Cover Replacement**.

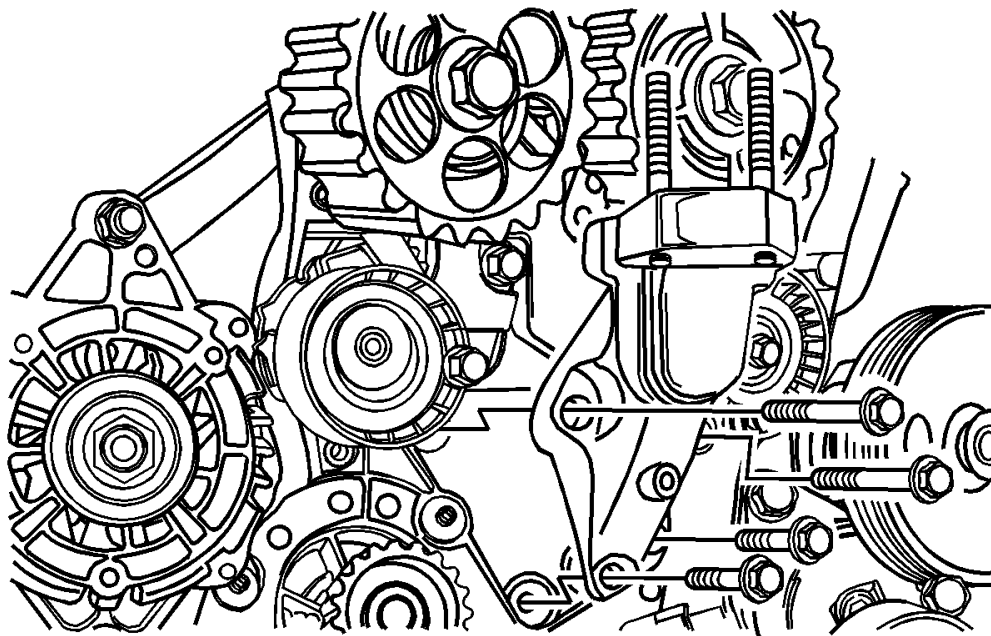


Fig. 10: View Of Engine Mount Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount attaching bolts/nuts.
6. Remove the engine mount.

Installation Procedure

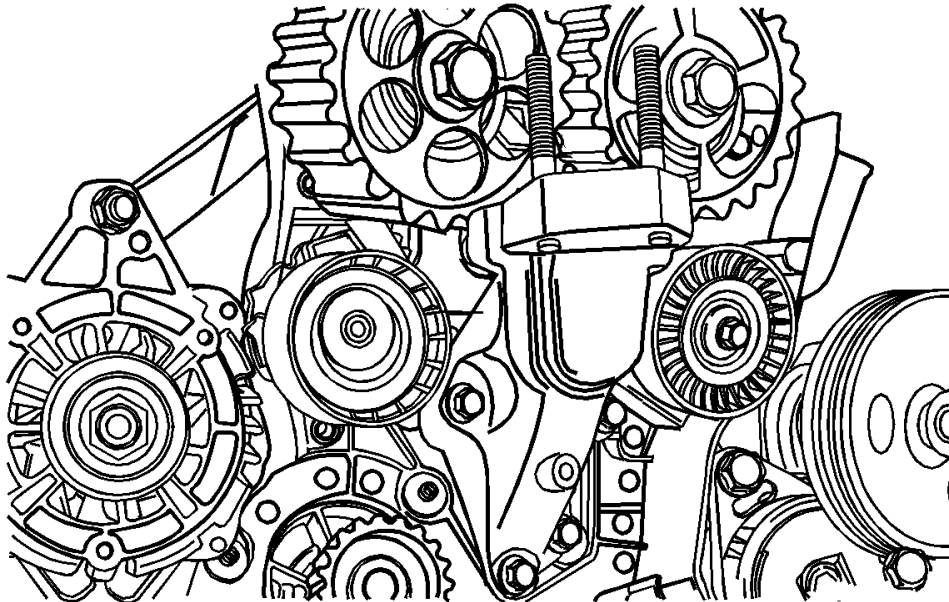


Fig. 11: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount.

NOTE: Refer to **Fastener Notice** .

2. Install the engine mount retaining bolts.

Tighten: Tighten the engine mount attaching bolts to **30 N.m (22 lb ft)** .

3. Install the front timing belt cover. Refer to **Timing Belt Cover Replacement**.

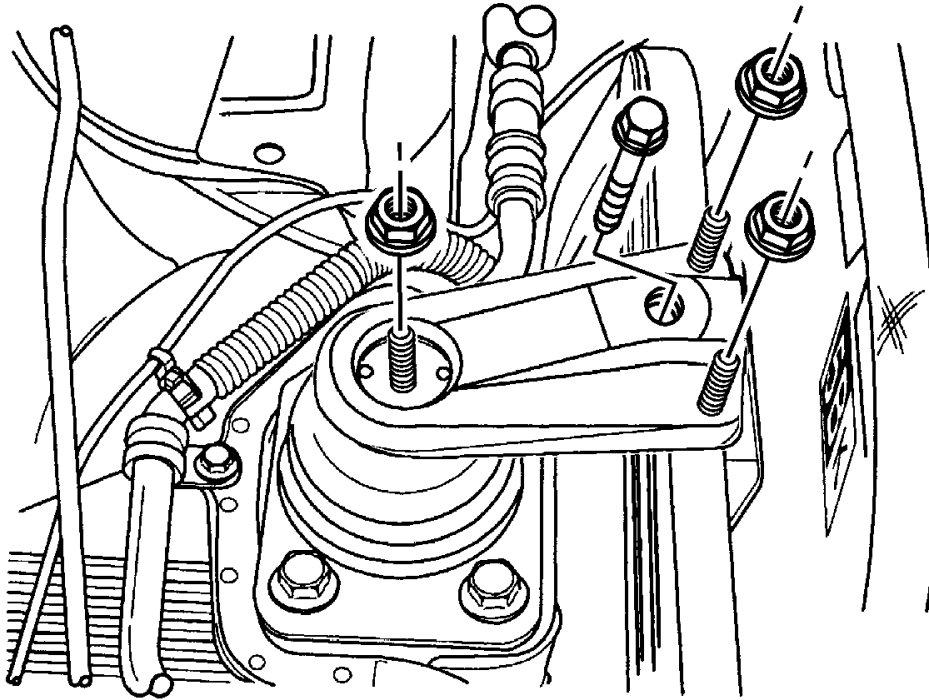


Fig. 12: View Of Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the engine mount bracket attaching bolts/nuts.

Tighten: Tighten the engine mount bracket attaching bolts/nuts to **55 N.m (41 lb ft)** .

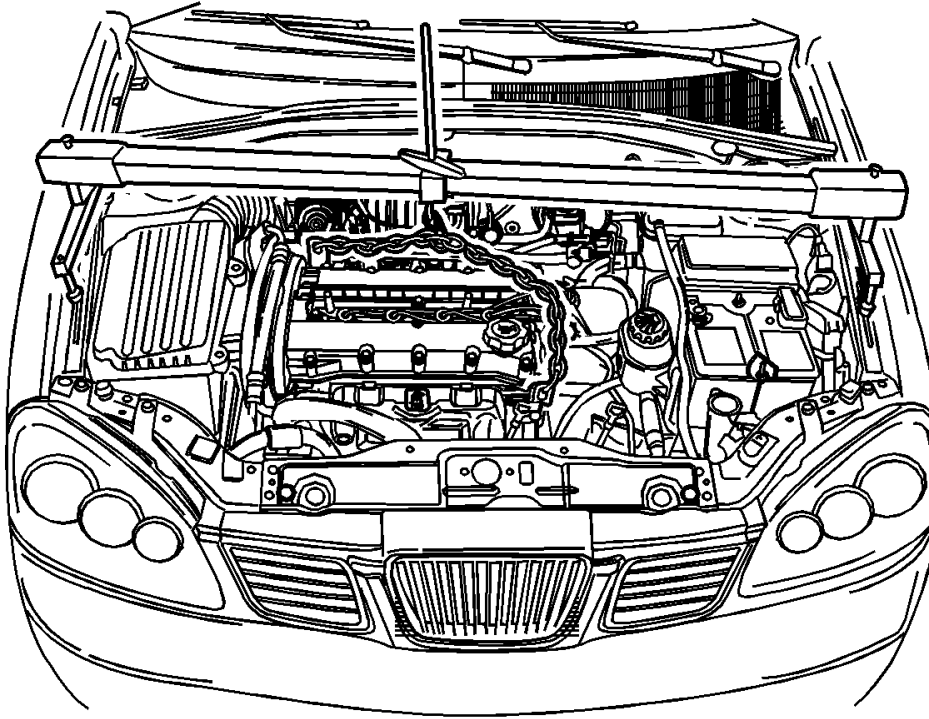


Fig. 13: View Of Engine Assembly And J 28467-B
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 28467-B**.
6. Connect the negative battery cable.

ENGINE COVER REPLACEMENT

Removal Procedure

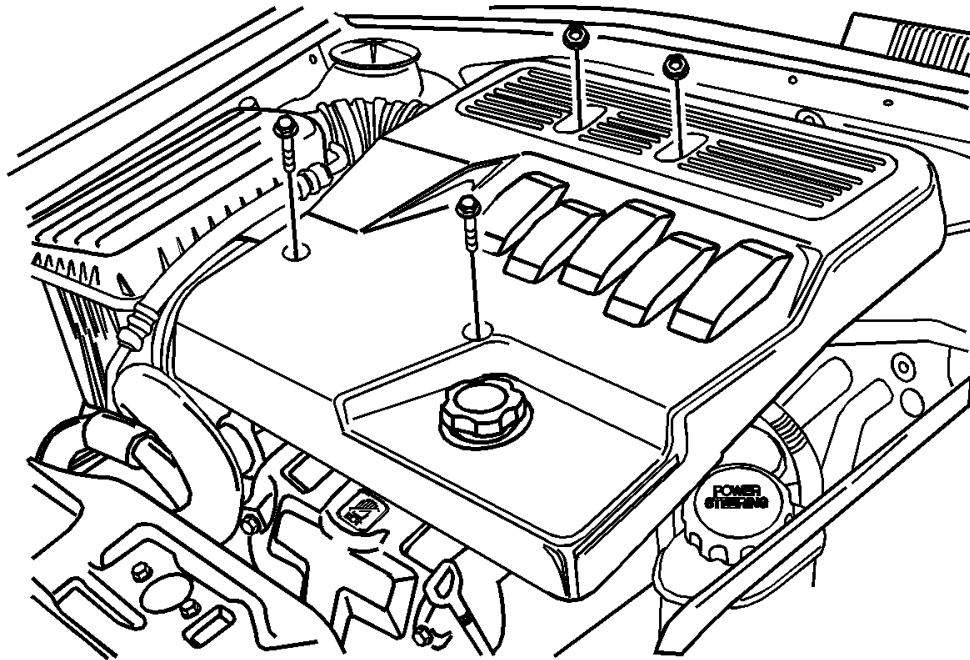


Fig. 14: View Of Engine Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts and nuts from the engine cover.
2. Remove the engine cover.

Installation Procedure

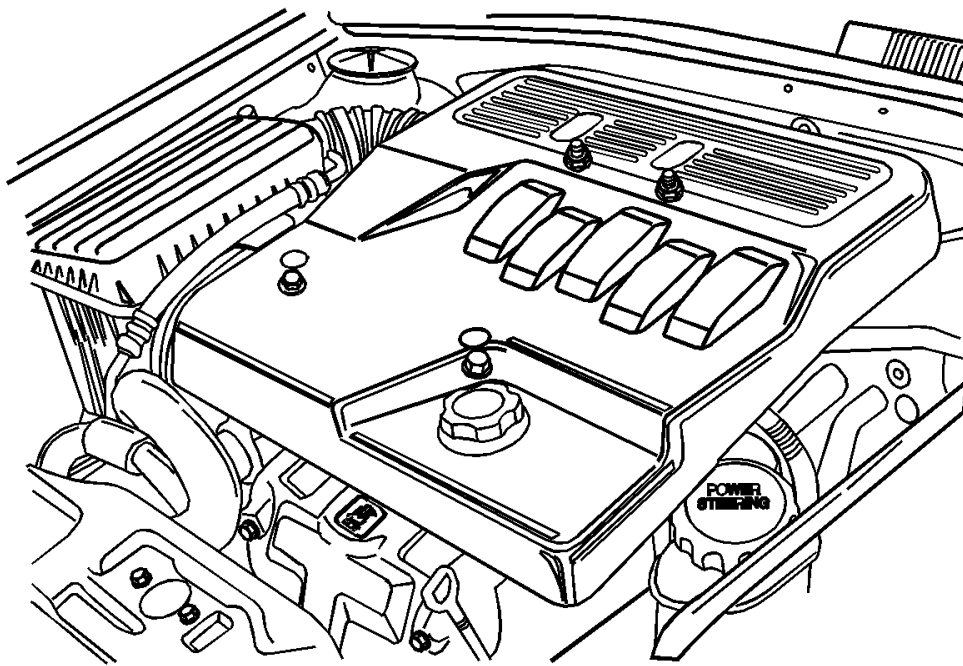


Fig. 15: View Of Engine Cover
Courtesy of GENERAL MOTORS CORP.

1. Position the engine cover on the engine.

NOTE: Refer to **Fastener Notice** .

2. Install the engine cover bolts and nuts.

Tighten: Tighten the engine under cover and nuts to **10 N.m (89 lb in)** .

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

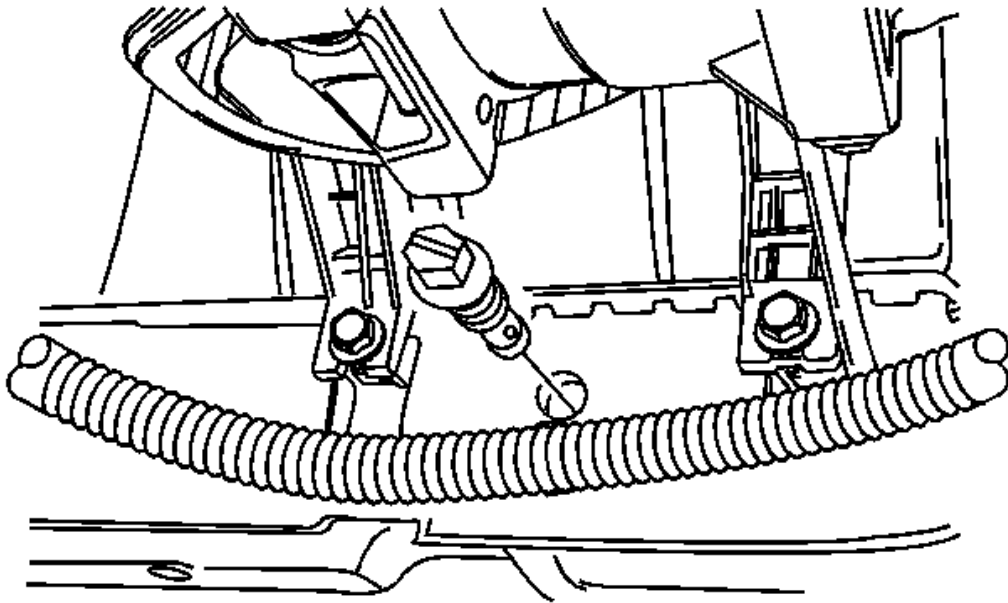


Fig. 16: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel pump fuse.
2. Start the engine. After it stalls, crank the engine for 10 seconds to rid the fuel system of fuel pressure.

CAUTION: Refer to Battery Disconnect Caution .

3. Disconnect the negative battery cable.
4. Disconnect the electronic control module (ECM) ground terminal from the intake manifold.

CAUTION: Refer to Safety Glasses Caution .

5. Drain the engine coolant. Refer to Cooling System Draining and Filling (Gasoline Engines) .

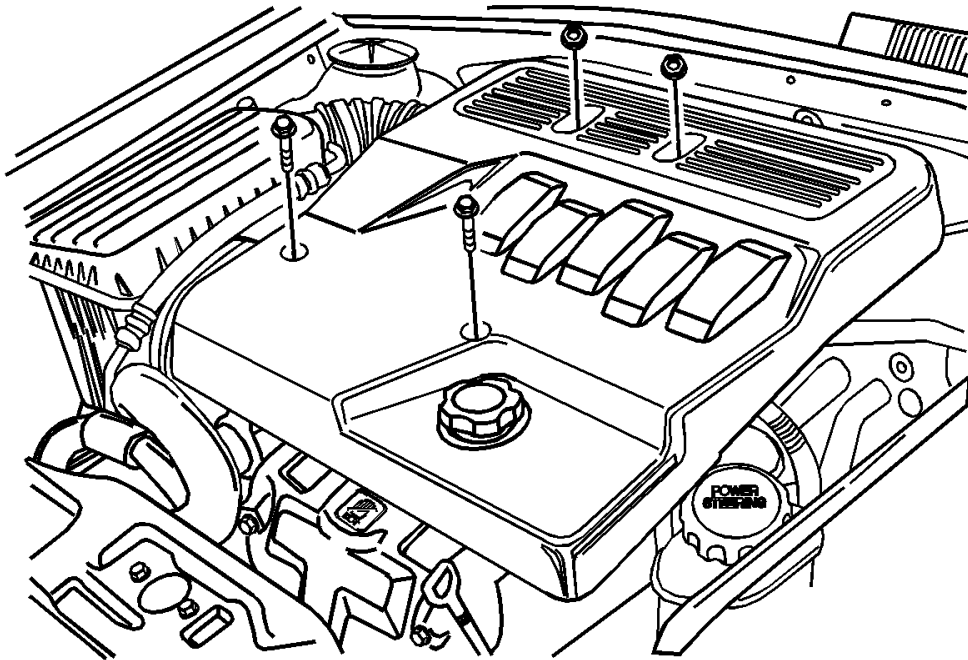


Fig. 17: View Of Engine Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine cover and throttle body. Refer to **Throttle Body Assembly Replacement** .

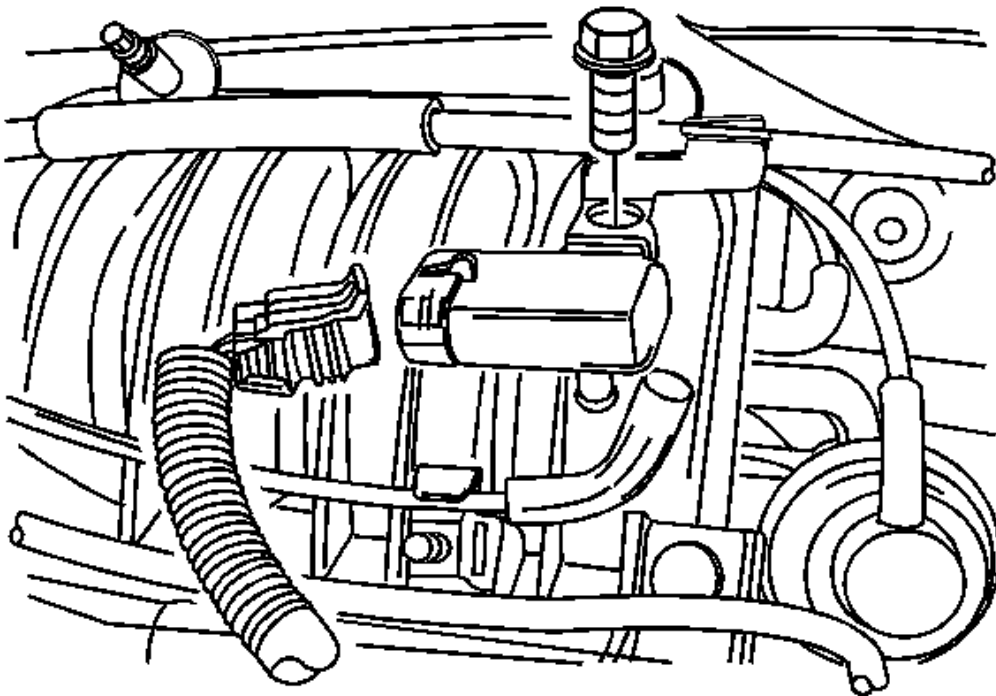


Fig. 18: View Of Intake Manifold Pressure Sensor Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the intake manifold pressure sensor connector, attaching bolt and vacuum hose.

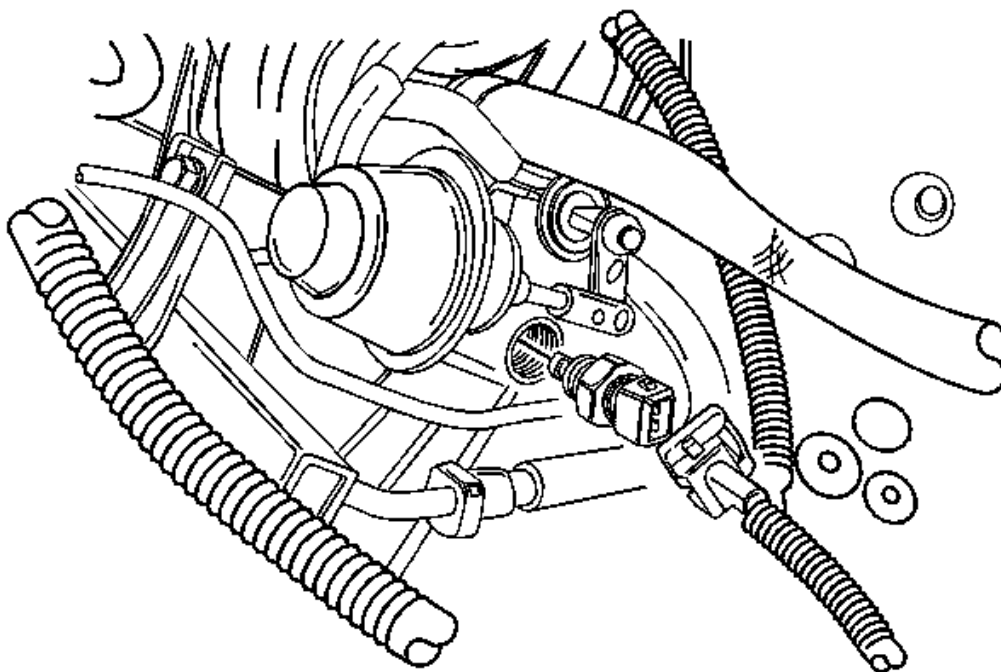


Fig. 19: View Of IAT Sensor And Connector
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the intake air temperature (IAT) sensor connector and remove the IAT sensor.

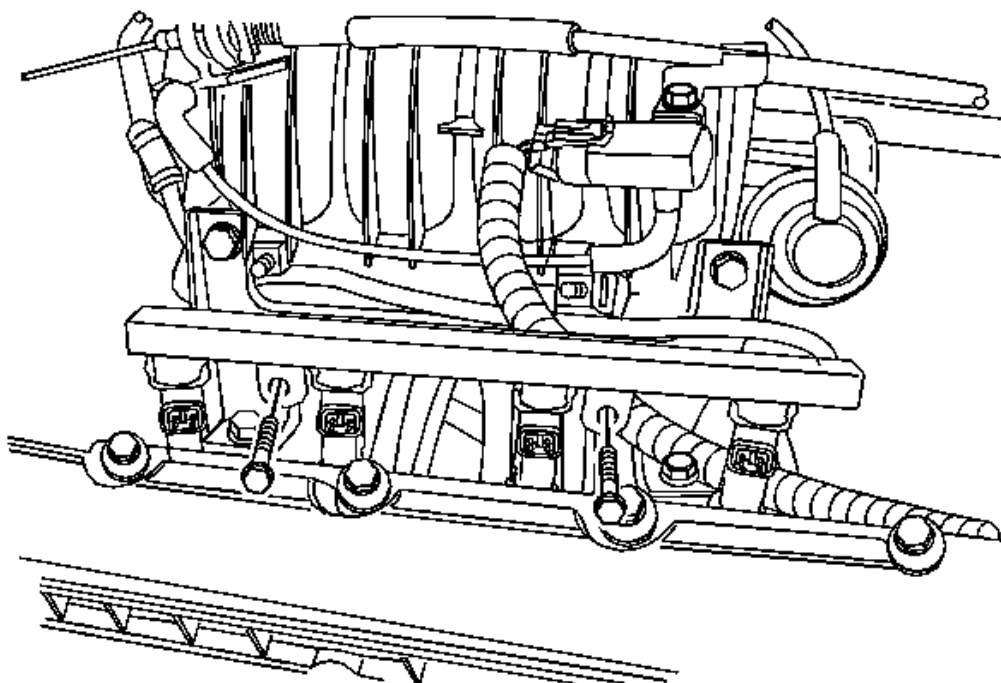


Fig. 20: View Of Fuel Rail And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the fuel rail bolts and the fuel rail.
10. Remove all the vacuum hoses from the intake manifold including the positive crankcase ventilation (PCV) hose and the brake booster vacuum hose.

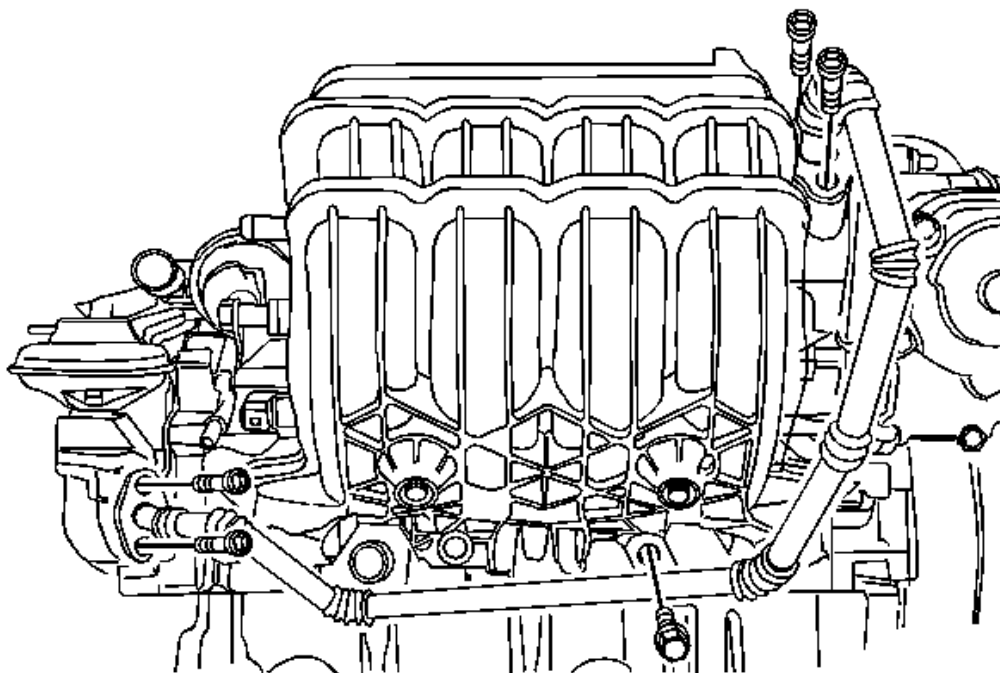


Fig. 21: Identifying EGR Pipe
Courtesy of GENERAL MOTORS CORP.

11. Remove the exhaust gas recirculation (EGR) pipe.

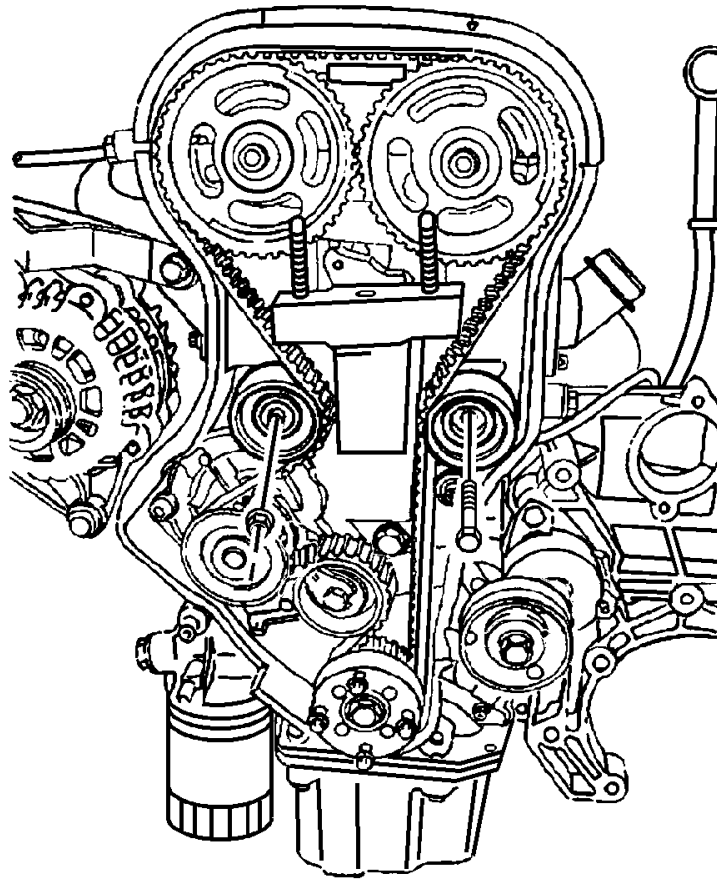


Fig. 22: View Of Alternator
Courtesy of GENERAL MOTORS CORP.

12. Remove the alternator. Refer to **Generator Replacement (1.6L)** .
13. Remove the intake manifold support bracket.

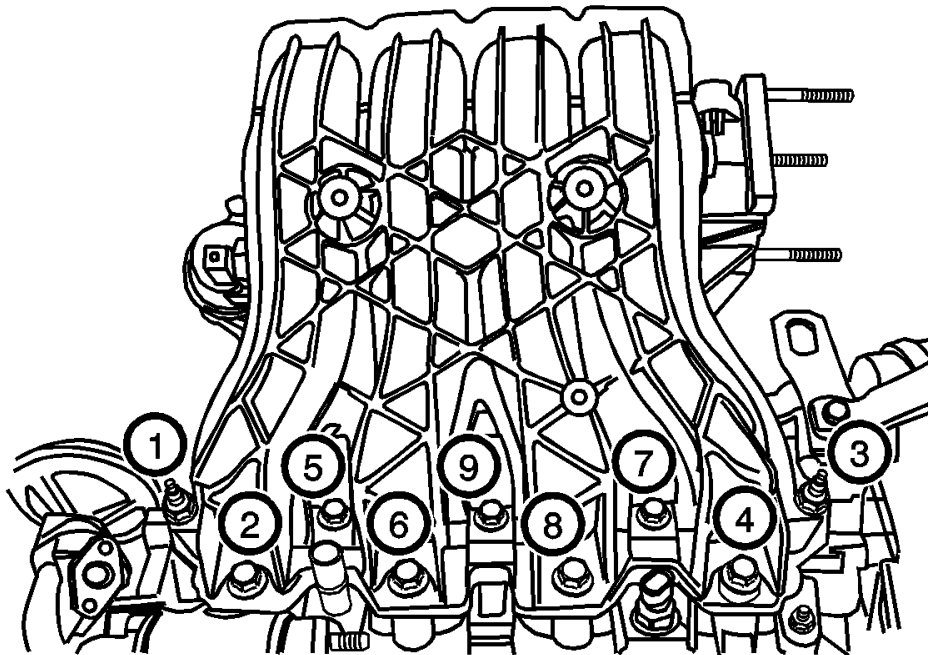


Fig. 23: Identifying Intake Manifold Retaining Nuts And Bolts Sequence
Courtesy of GENERAL MOTORS CORP.

14. Remove the intake manifold retaining bolts/nuts in the sequence shown.
15. Remove the intake manifold and gasket.
16. Clean the sealing surfaces of the intake manifold and the cylinder head.

Installation Procedure

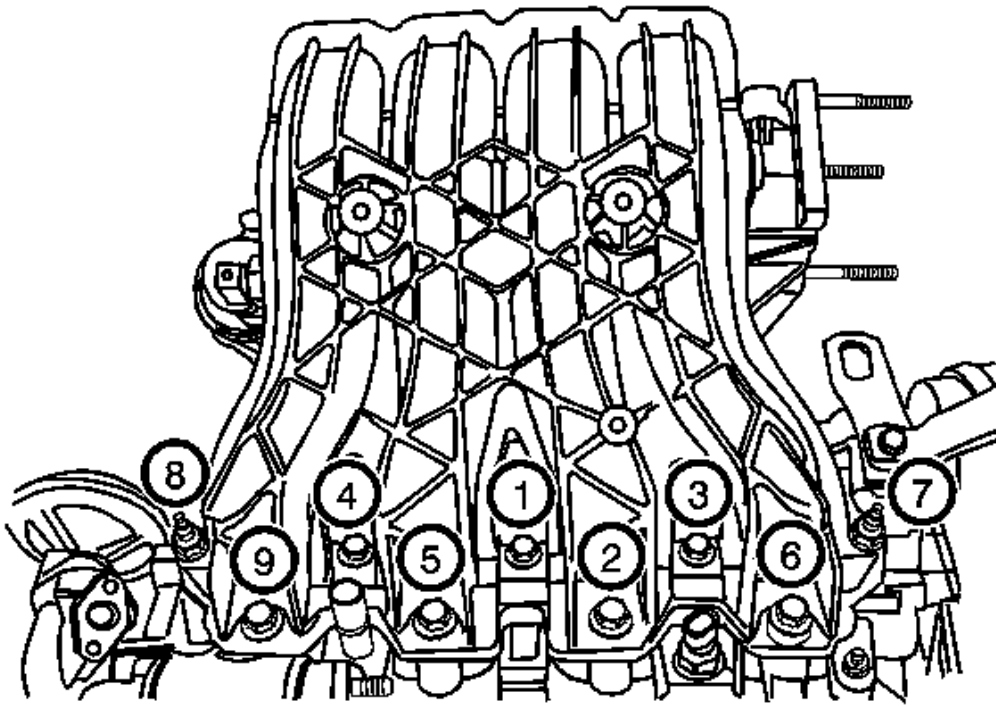


Fig. 24: Identifying Intake Manifold Retaining Nuts And Bolts Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the fuel rail.

Tighten: Tighten the fuel rail bolts to **25 N.m (18 lb ft)** .

2. Install the new intake manifold gasket and intake manifold.

Tighten: Tighten the intake manifold bolts and nuts to **25 N.m (18 lb ft)** .

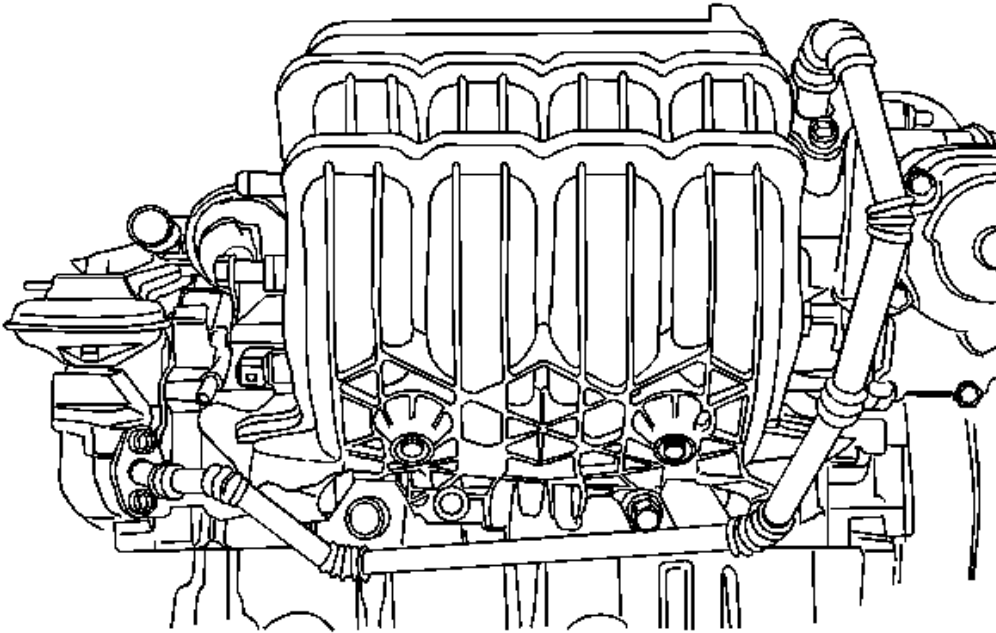


Fig. 25: Identifying EGR Pipe
Courtesy of GENERAL MOTORS CORP.

3. Install the exhaust gas recirculation (EGR) pipe.

Tighten: Tighten the exhaust gas recirculation (EGR) pipe bolts to **10 N.m (89 lb ft)** .

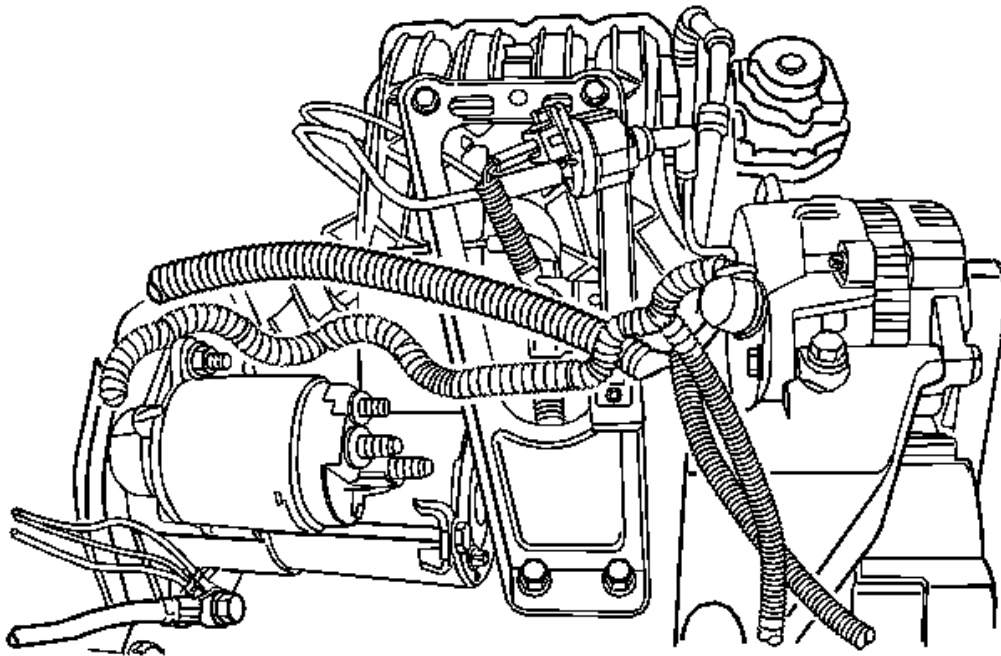


Fig. 26: View Of Intake Manifold Support Bracket And Alternator
Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold support bracket.

Tighten:

- Tighten the intake manifold support bracket upper bolts to **25 N.m (18 lb ft)** .
- Tighten the lower bolts to **45 N.m (33 lb ft)** .

5. Install the alternator.

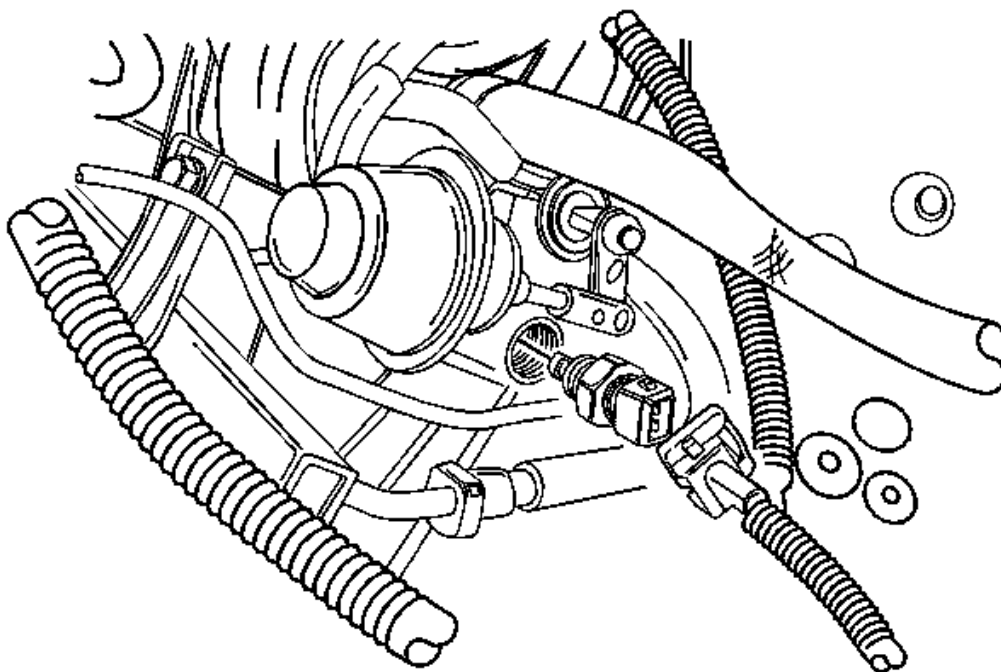


Fig. 27: View Of IAT Sensor And Connector
Courtesy of GENERAL MOTORS CORP.

6. Install the IAT and connect the IAT sensor connector.

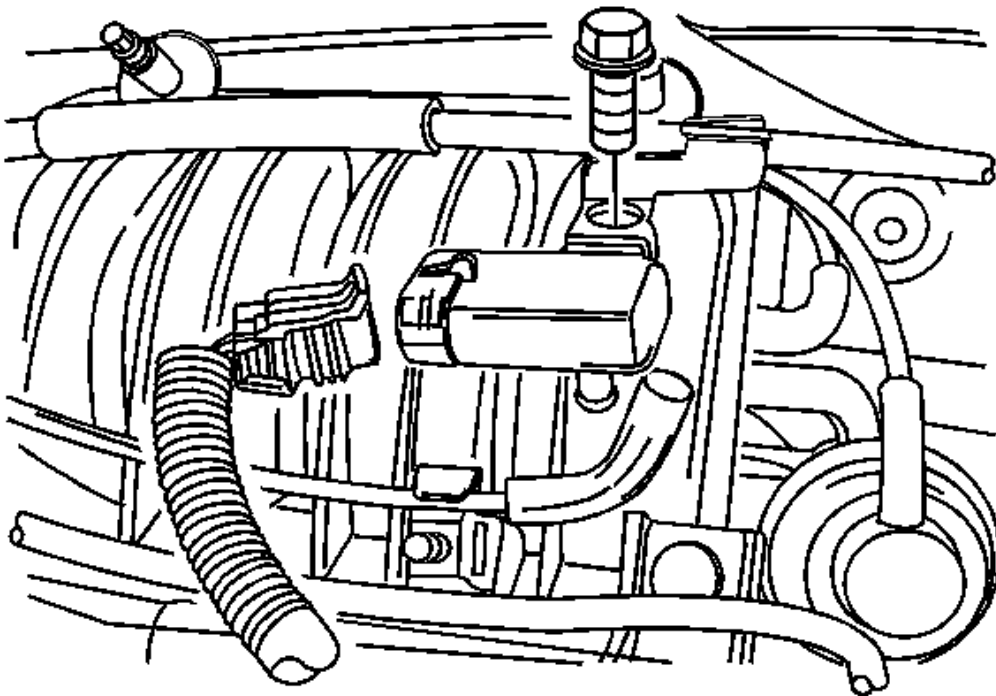


Fig. 28: View Of Intake Manifold Pressure Sensor Connector
Courtesy of GENERAL MOTORS CORP.

7. Install the intake manifold pressure sensor and vacuum hose.

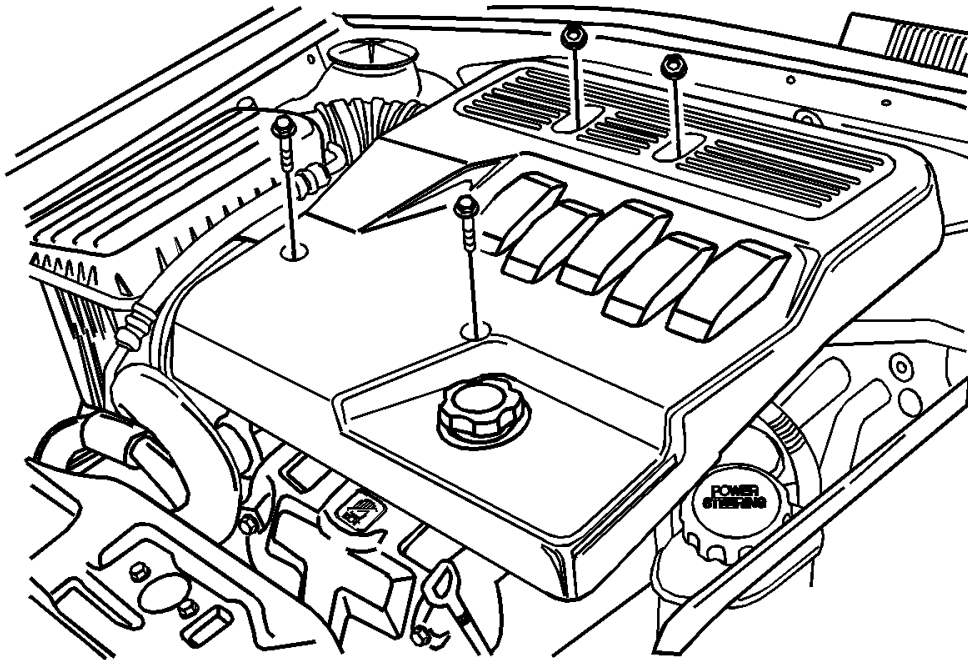


Fig. 29: View Of Engine Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the throttle body and engine cover.
9. Refill the engine cooling system. Refer to **Cooling System Draining and Filling (Gasoline Engines)** .
10. Install the fuel pump fuse and connect the negative battery cable.

TIMING BELT REPLACEMENT

Tools Required

J 42492-A (KM-421-A) Timing Belt Adjuster

Removal Procedure

CAUTION: Refer to **Battery Disconnect Caution** .

1. Disconnect the negative battery cable.

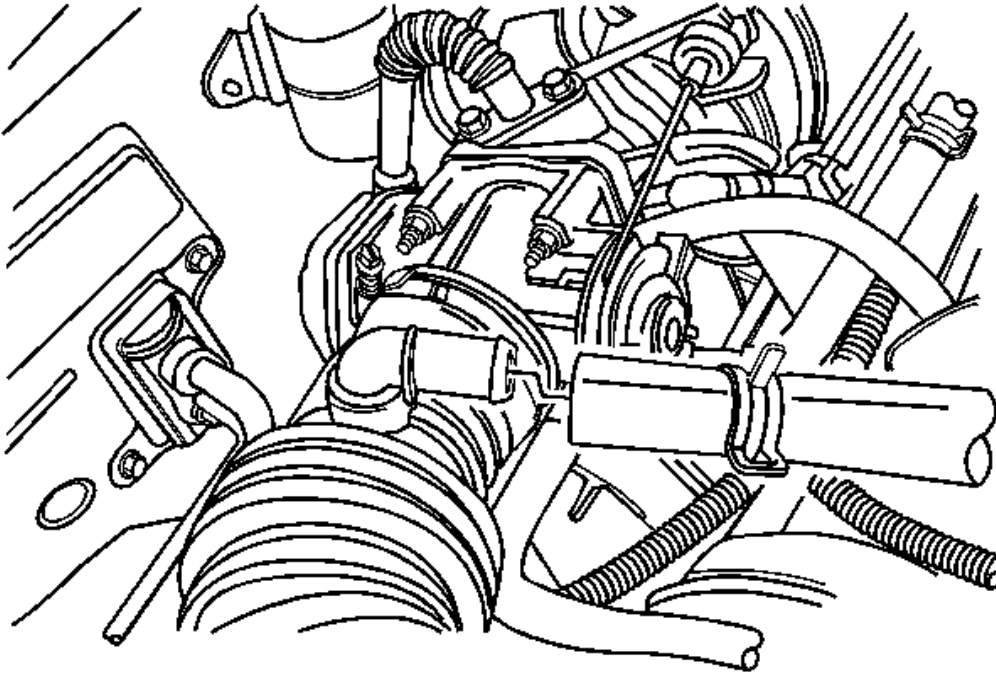


Fig. 30: View Of Air Cleaner Outlet Hose
Courtesy of GENERAL MOTORS CORP.

2. Remove the air cleaner outlet hose from the throttle body.
3. Remove the breather tube from the camshaft cover.

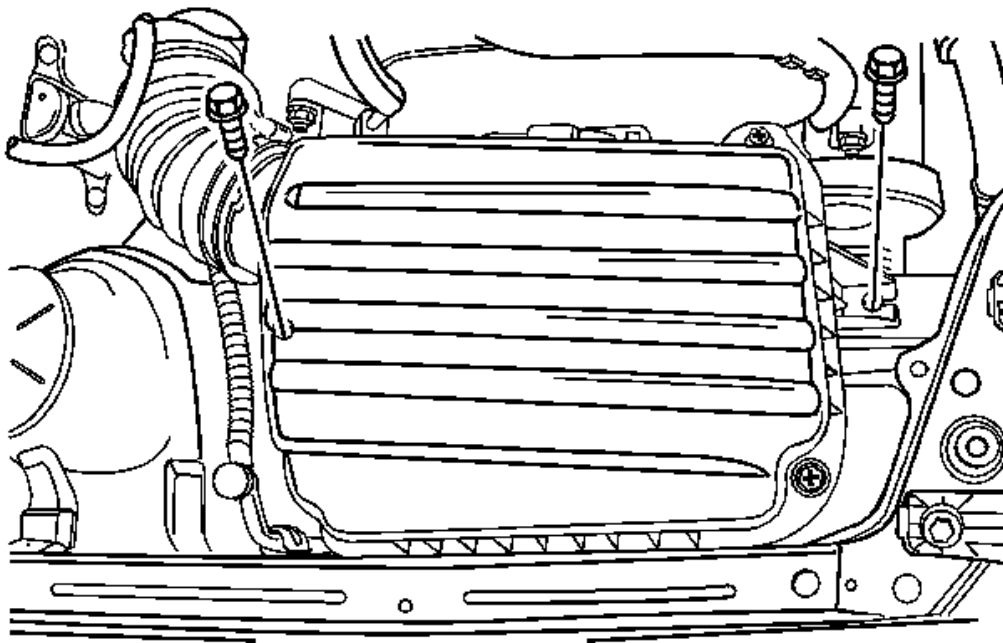


Fig. 31: View Of Air Cleaner Housing And Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the air cleaner housing bolts.
5. Remove the air cleaner housing.
6. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** .
7. Remove the right front wheel well splash shield.
8. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** .

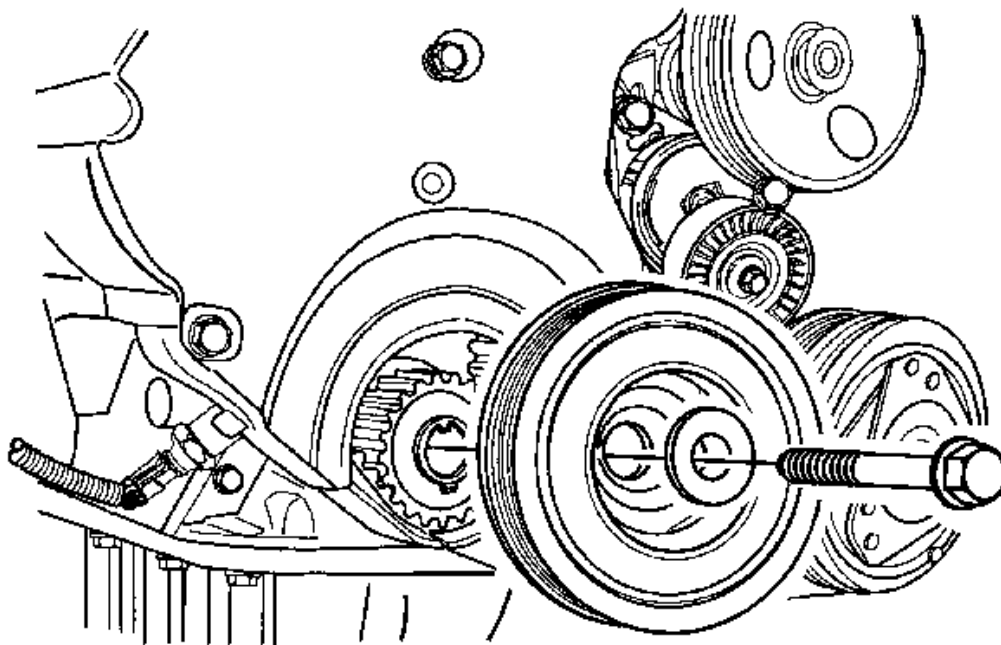


Fig. 32: Identifying Crankshaft Pulley And Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft pulley bolt.
10. Remove the crankshaft pulley.

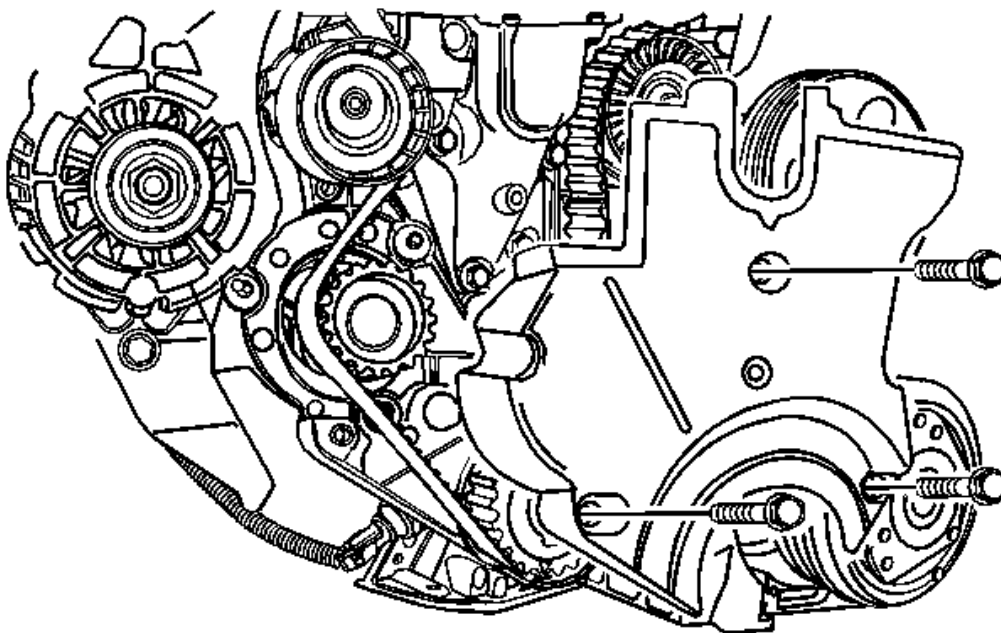


Fig. 33: View Of Front Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

11. Remove the upper front timing belt cover bolts.
12. Remove the upper front timing belt cover.
13. Remove the lower front timing belt cover bolts.
14. Remove the lower front timing belt cover.
15. Install the crankshaft pulley bolt.

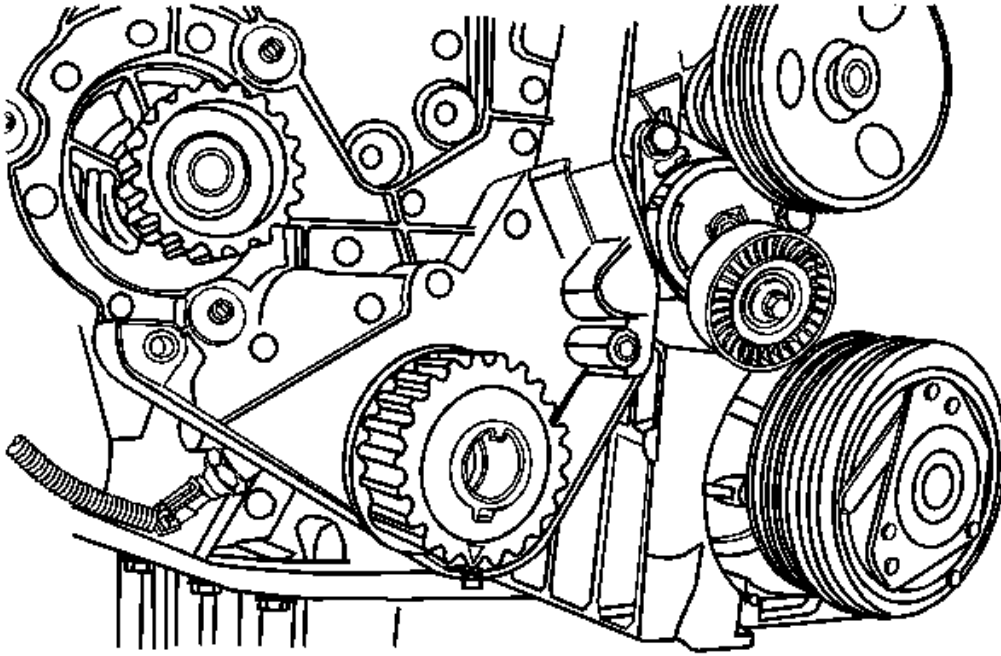


Fig. 34: View Of Camshaft Gear
Courtesy of GENERAL MOTORS CORP.

16. Rotate the crankshaft at least one full turn clockwise using the crankshaft pulley bolt.

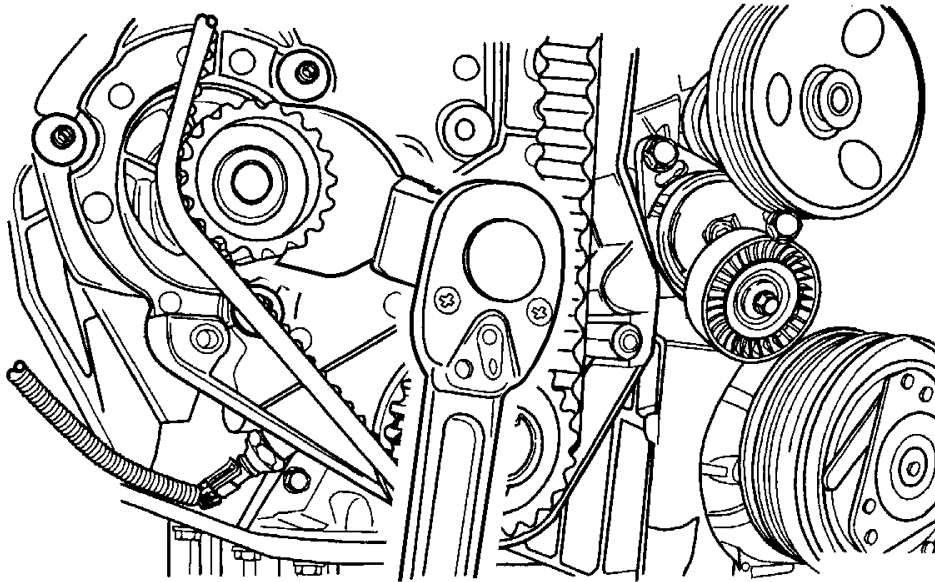


Fig. 35: Removing Timing Belt Tension Using J 42492-A
Courtesy of GENERAL MOTORS CORP.

17. Slightly loosen the water pump retaining bolts.
18. Rotate the water pump clockwise using the **J 42492-A**.
19. Remove the right engine mount. Refer to **Engine Mount Replacement**.

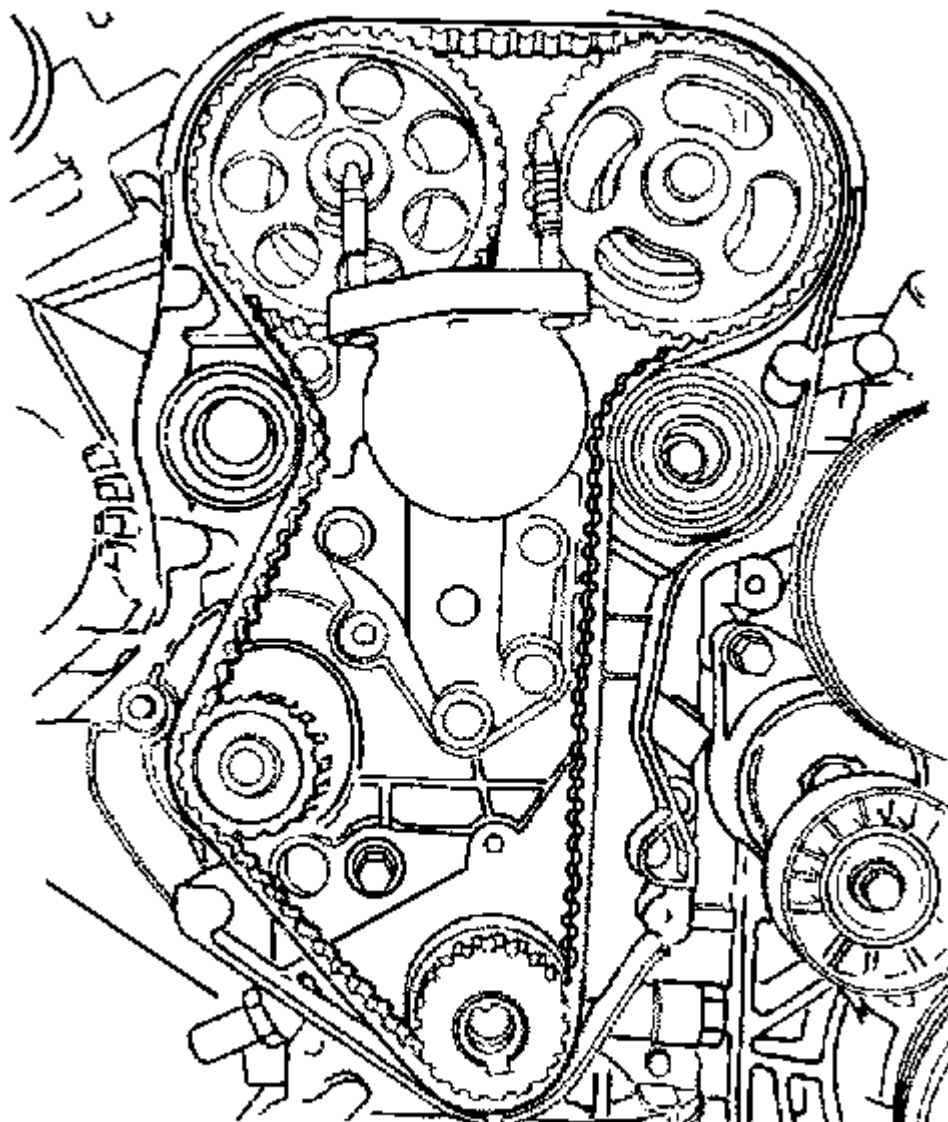


Fig. 36: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

20. Remove the timing belt.

Installation Procedure

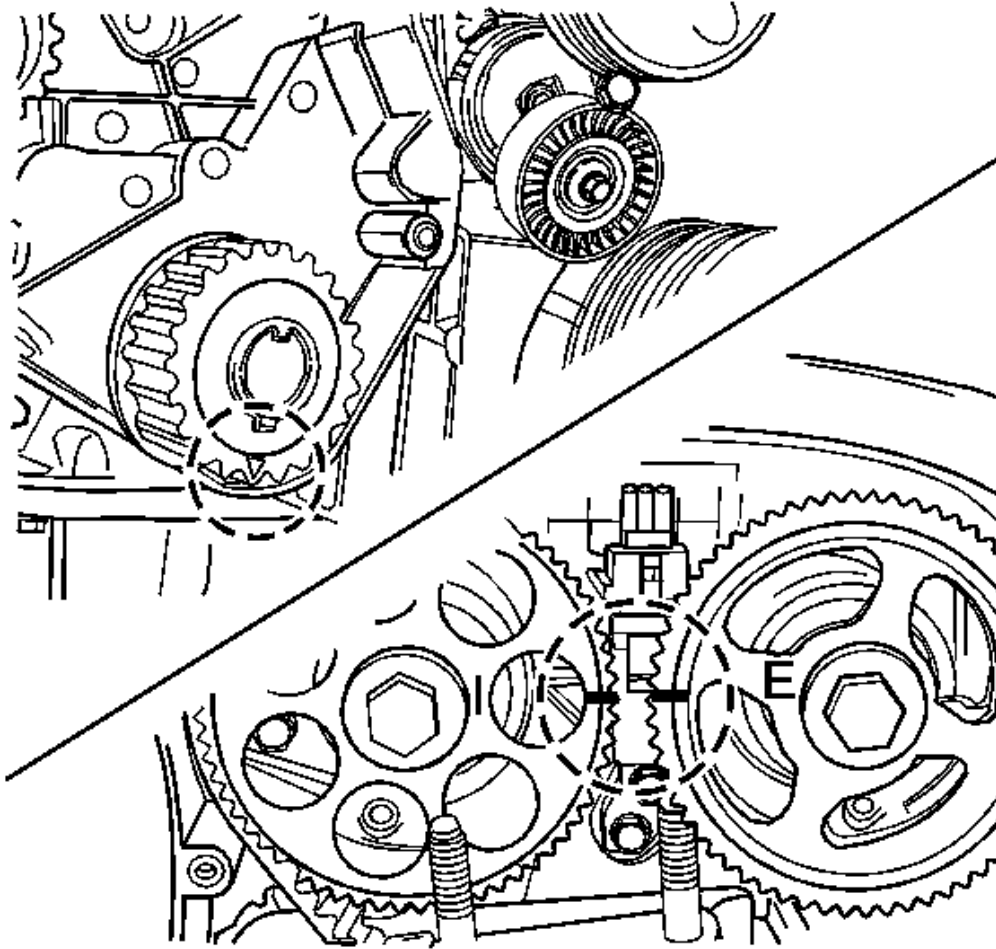


Fig. 37: Locating Gear Marks
Courtesy of GENERAL MOTORS CORP.

1. Align the timing mark on the crankshaft gear with the notch on the bottom of the rear timing belt cover.
2. Align the timing marks on the camshaft gears.

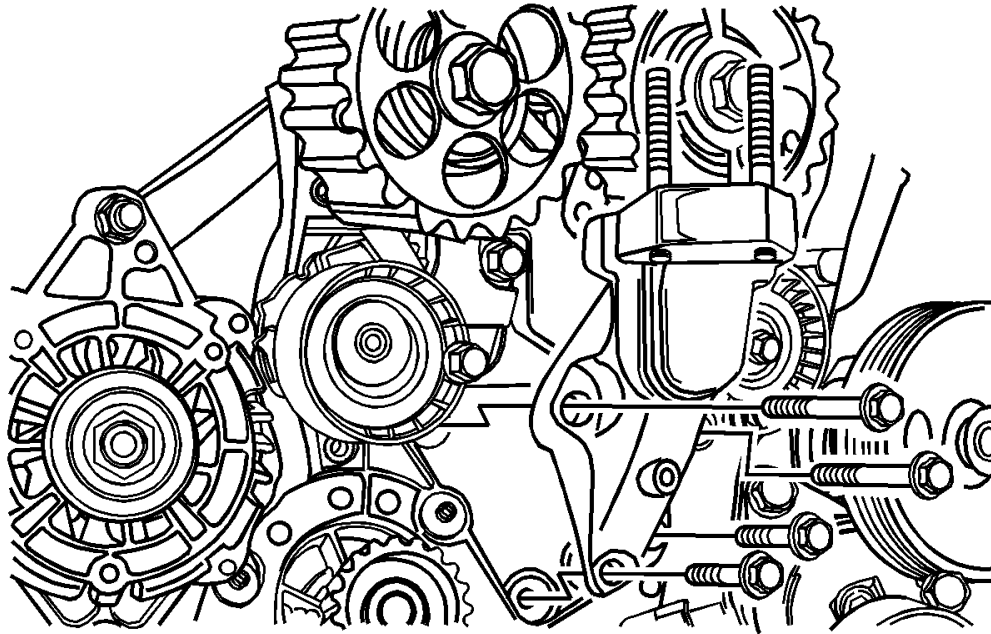


Fig. 38: View Of Engine Mount Attaching Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

3. Install the timing belt.
4. Install the right engine mount bracket. Refer to **Engine Mount Replacement**.
5. Rotate the water pump clockwise using the **J 42492-A**.

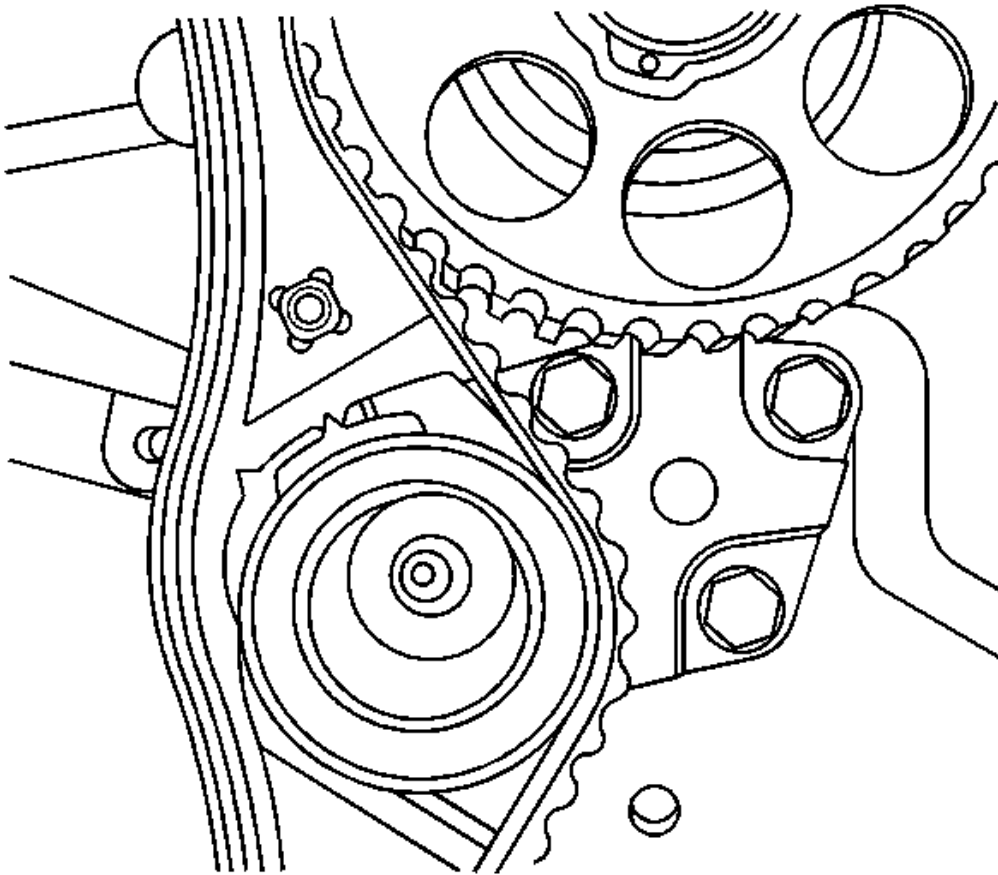


Fig. 39: Identifying Timing Belt Automatic Tensioner Arm Pointer And Bracket Notch
Courtesy of GENERAL MOTORS CORP.

6. Rotate the water pump clockwise until the adjust arm pointer of the timing belt automatic tensioner is aligned with the notch in the timing belt automatic tensioner bracket.
7. Tighten the water pump retaining bolts.
8. Rotate the crankshaft 2 full turns clockwise using the crankshaft pulley.
9. Loosen the water pump retaining bolts.

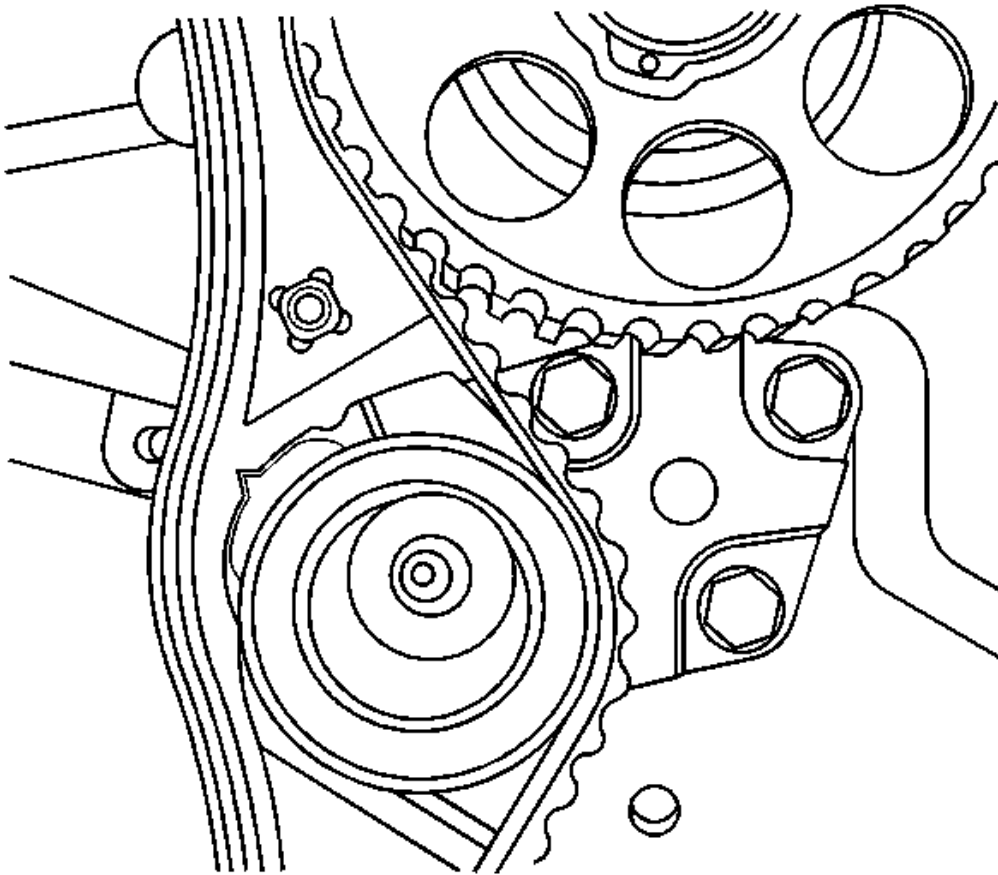


Fig. 40: View Of Timing Belt Automatic Tensioner Arm Pointer Aligned With Bracket Notch
Courtesy of GENERAL MOTORS CORP.

10. Using the **J 42492-A** , rotate the water pump until the adjuster arm pointer of the timing belt automatic tensioner is aligned with the pointer on the timing belt automatic tensioner bracket.

NOTE: Refer to **Fastener Notice** .

11. Tighten the water pump retaining bolts.

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

12. Remove the crankshaft pulley bolt.

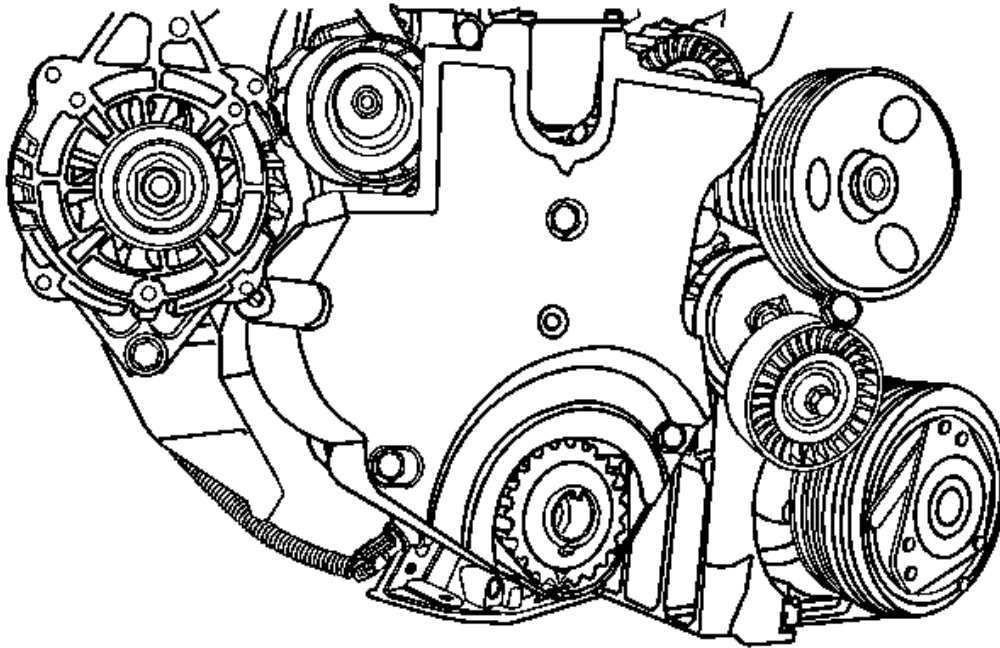


Fig. 41: View Of Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

13. Install the upper and lower front timing belt covers.
14. Install the upper and lower front timing belt cover bolts.

Tighten: Tighten the front timing belt cover bolts to **10 N.m (89 lb in)** .

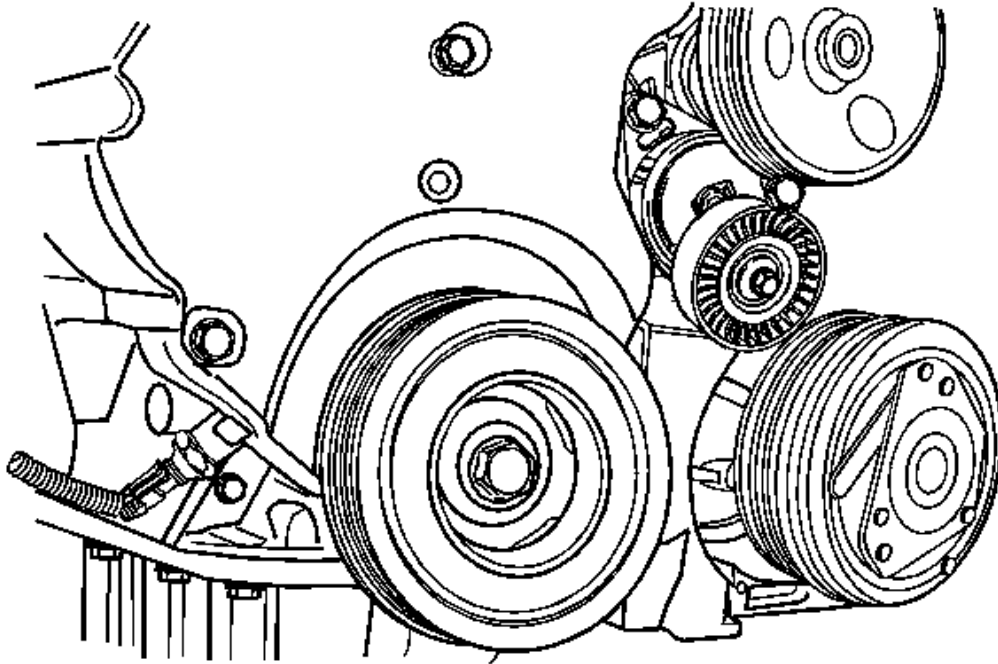


Fig. 42: Identifying Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

15. Install the crankshaft pulley.
16. Install the crankshaft pulley bolt.

Tighten: Tighten the crankshaft pulley bolt to **95 N.m (70 lb ft)** , and retighten 30 degrees plus 15 degrees.

17. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** .
18. Install the right front wheel well splash shield.
19. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** .

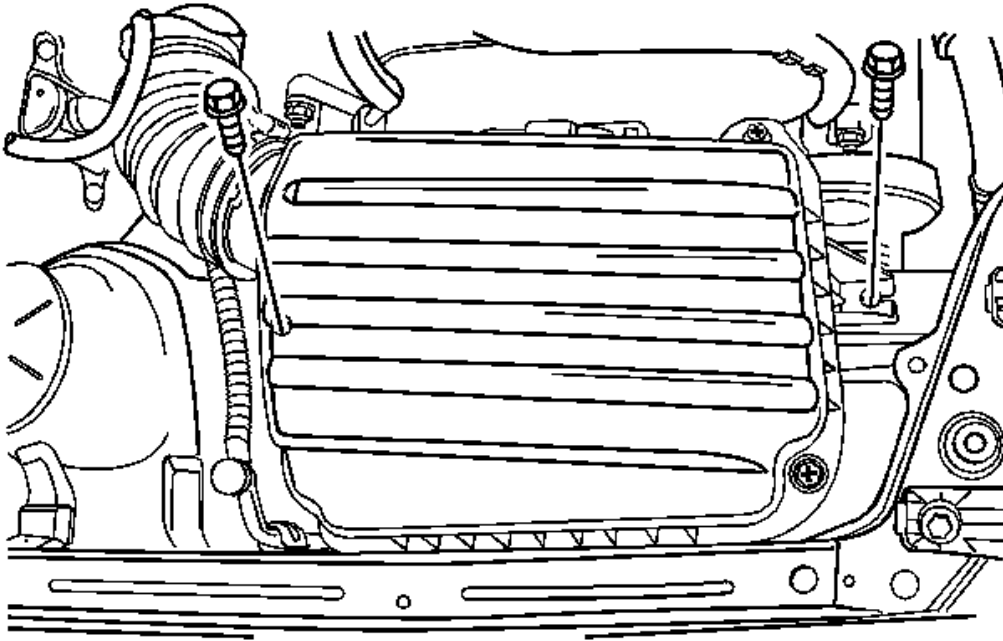


Fig. 43: View Of Air Cleaner Housing And Bolts
Courtesy of GENERAL MOTORS CORP.

20. Install the air cleaner housing.
21. Install the air cleaner housing bolts.

Tighten: Tighten the air cleaner housing bolts to **10 N.m (89 lb in)** .

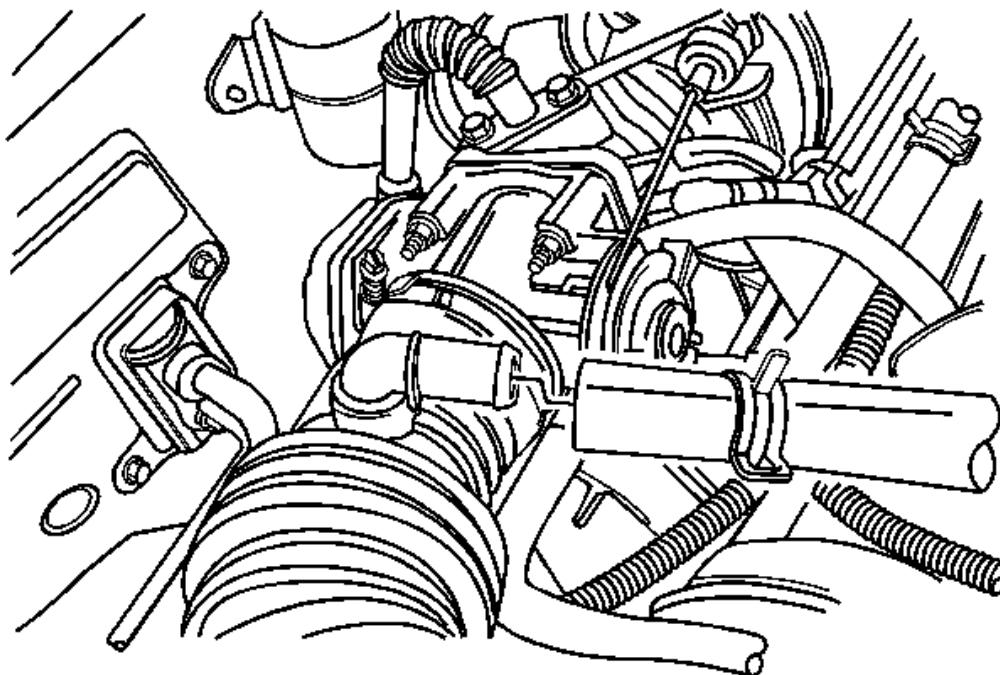


Fig. 44: View Of Air Cleaner Outlet Hose
Courtesy of GENERAL MOTORS CORP.

22. Connect the air cleaner outlet hose to the throttle body.
23. Connect the breather tube to the camshaft cover.
24. Connect the negative battery cable.

TIMING BELT COVER REPLACEMENT

Removal Procedure

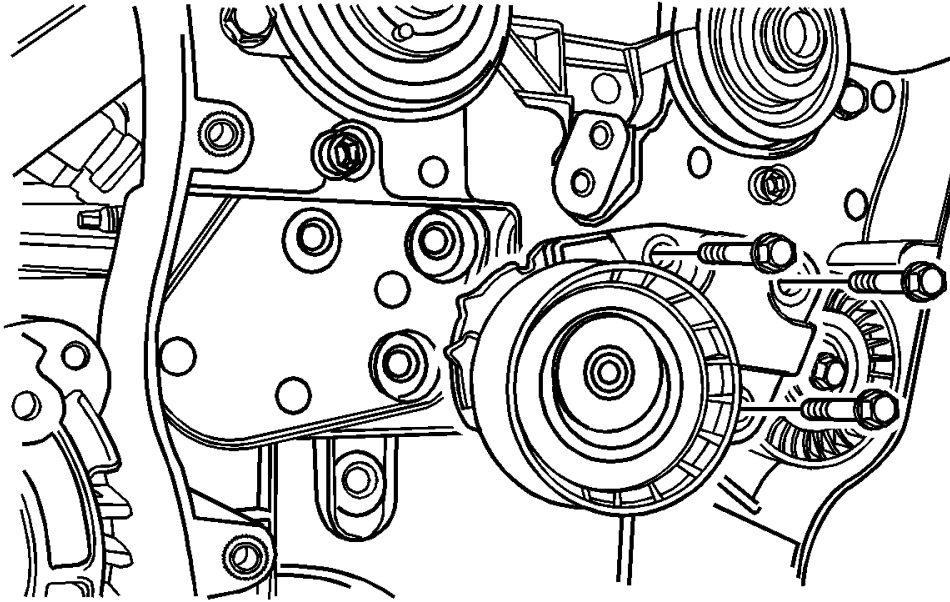


Fig. 45: View Of Timing Belt Automatic Tensioner And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the timing belt and the timing belt cover. Refer to **Timing Belt Replacement**.
2. Remove the camshaft gears. Refer to **Camshaft Gear Replacement**.
3. Remove the crankshaft gear.
4. Remove the timing belt automatic tensioner bolts.
5. Remove the timing belt automatic tensioner.

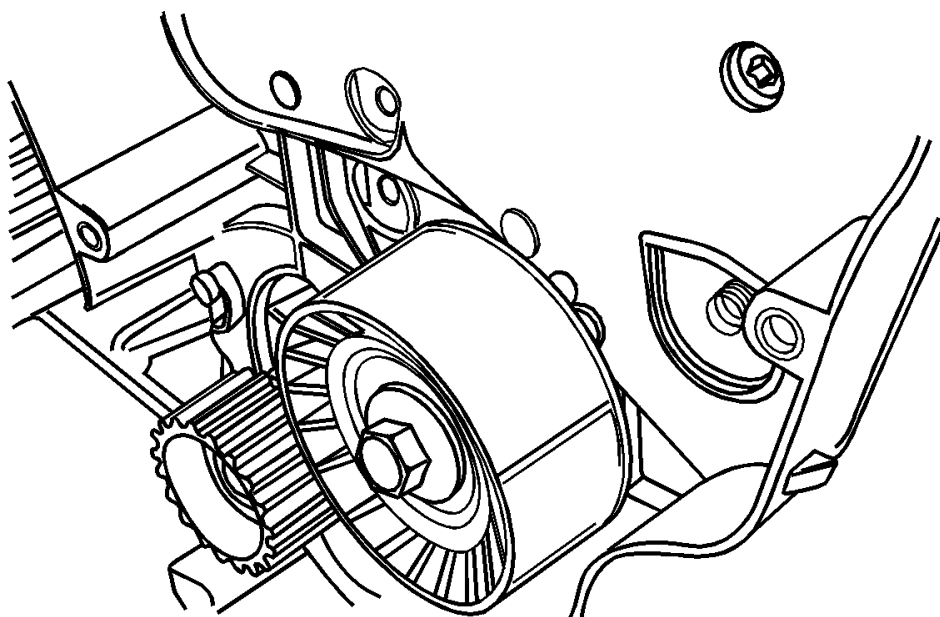


Fig. 46: View Of Timing Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing belt idler pulley bolt.
7. Remove the timing belt idler pulley.

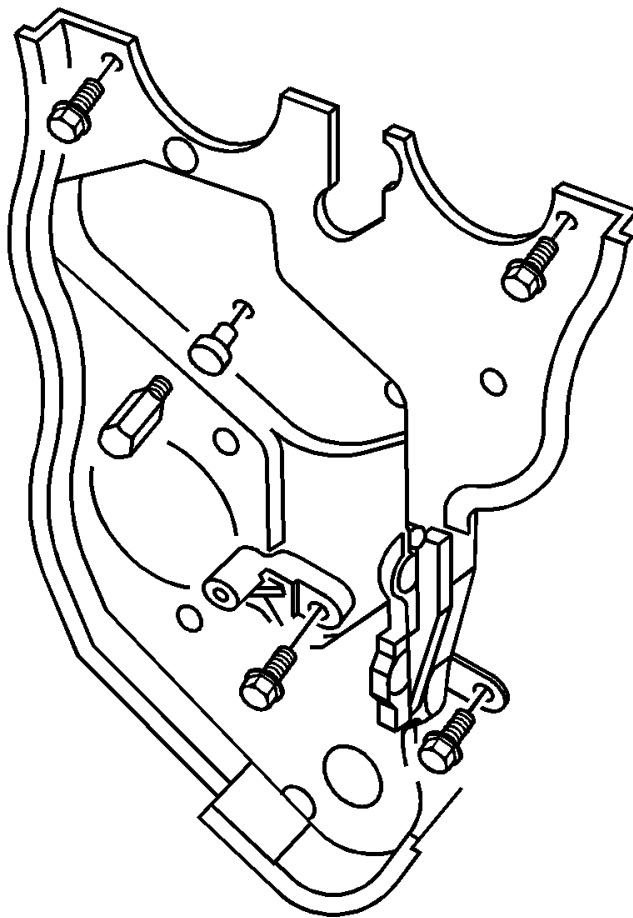


Fig. 47: View Of Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the rear timing belt cover bolts.
9. Remove the rear timing belt cover.

Installation Procedure

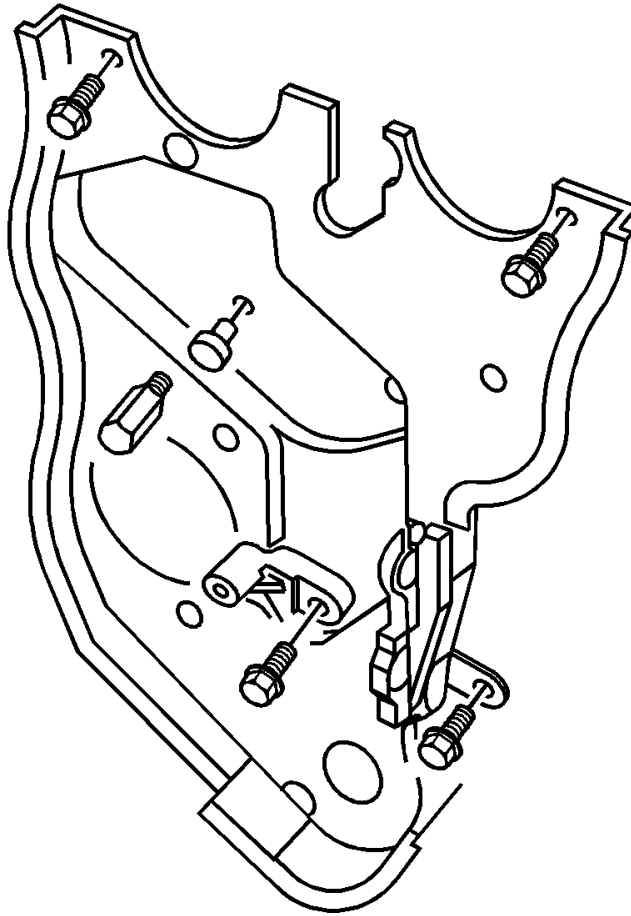


Fig. 48: View Of Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the rear timing belt cover.

NOTE: Refer to **Fastener Notice** .

2. Install the rear timing belt cover bolts.

Tighten: Tighten the rear timing belt cover bolts to **10 N.m (89 lb in)** .

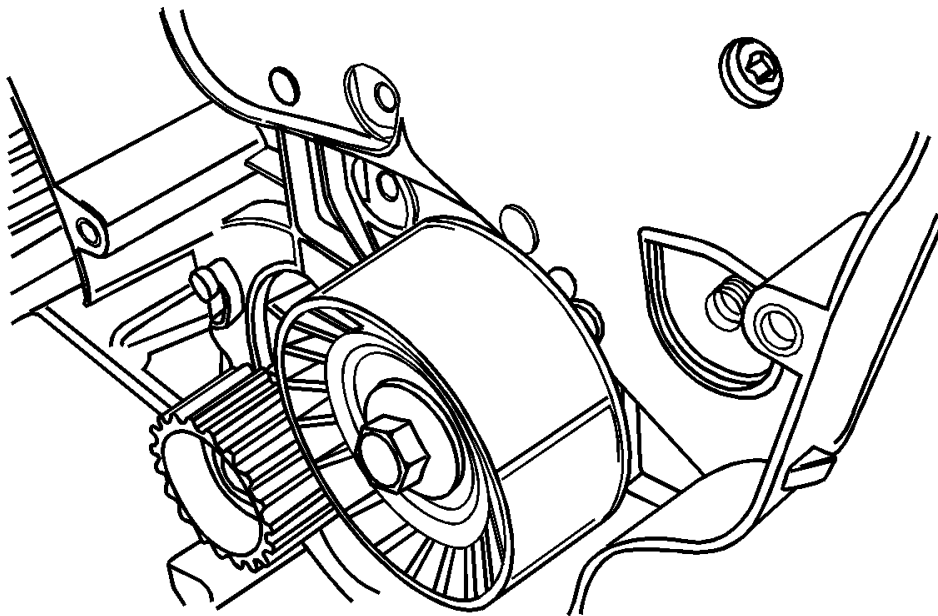


Fig. 49: View Of Timing Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

3. Install the timing belt idler pulley.
4. Install the timing belt idler pulley bolt.

Tighten: Tighten the timing belt idler pulley bolt to **40 N.m (30 lb ft)** .

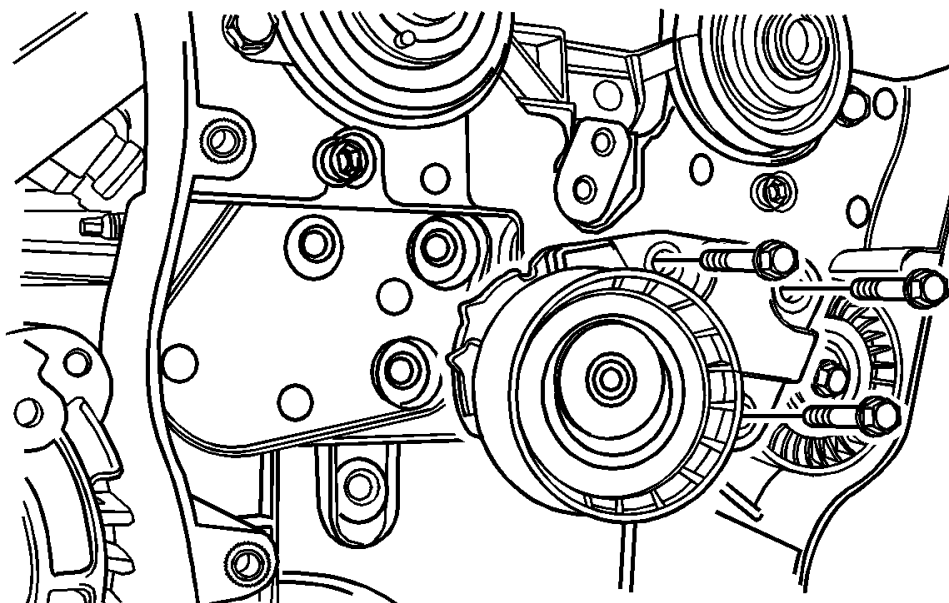


Fig. 50: View Of Timing Belt Automatic Tensioner And Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the timing belt automatic tensioner.
6. Install the timing belt automatic tensioner bolts.

Tighten: Tighten the timing belt automatic tensioner bolts to **25 N.m (18 lb ft)** .

7. Install the crankshaft gear.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

8. Install the camshaft gears. Refer to Camshaft Gear Replacement.
9. Install the timing belt and timing belt cover. Refer to Timing Belt Replacement.

VALVE ROCKER ARM COVER REPLACEMENT

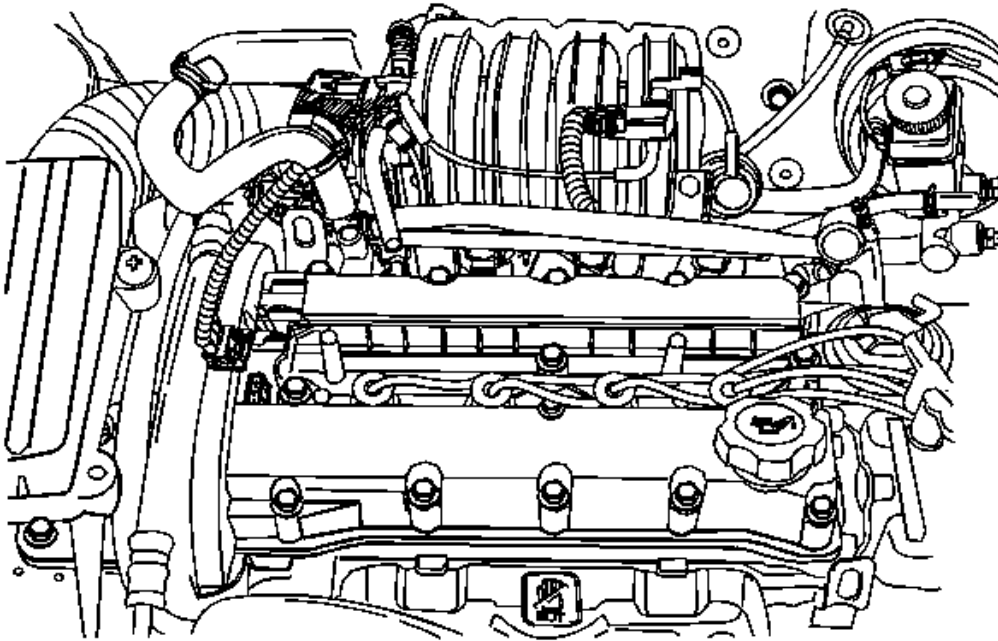
Removal Procedure

Fig. 51: View Of Valve Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable.
2. Remove the engine cover.
3. Remove the breather hose, ventilation hose, and cam position sensor wiring connector from the camshaft cover.

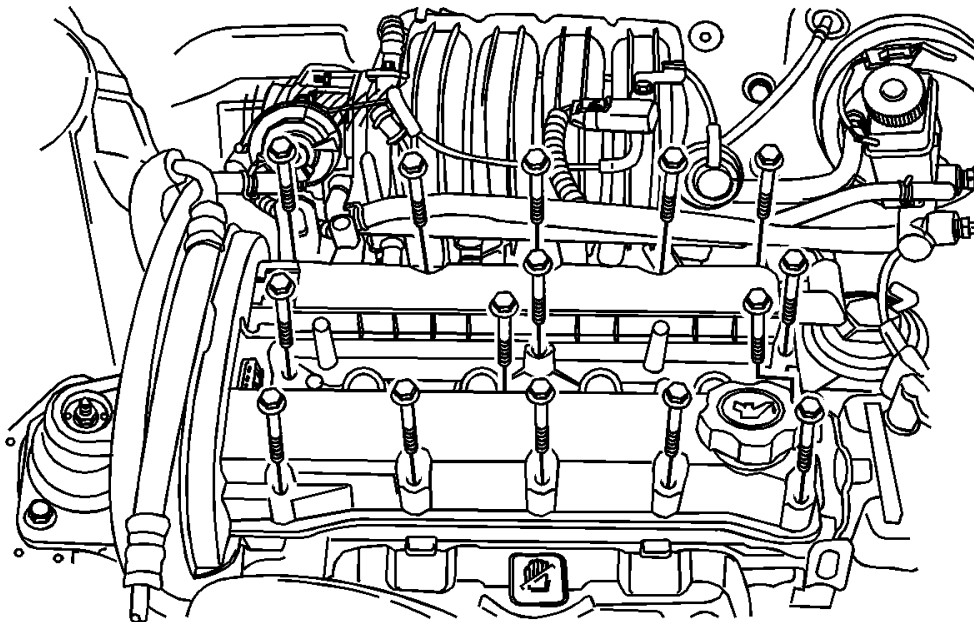


Fig. 52: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the ignition wires from the spark plug.
5. Remove the camshaft cover bolts and camshaft cover.
6. Remove the camshaft cover gasket.

Installation Procedure

1. Install the camshaft cover gasket on the camshaft cover.
2. Position the camshaft cover on the engine block.

NOTE: Refer to **Fastener Notice** .

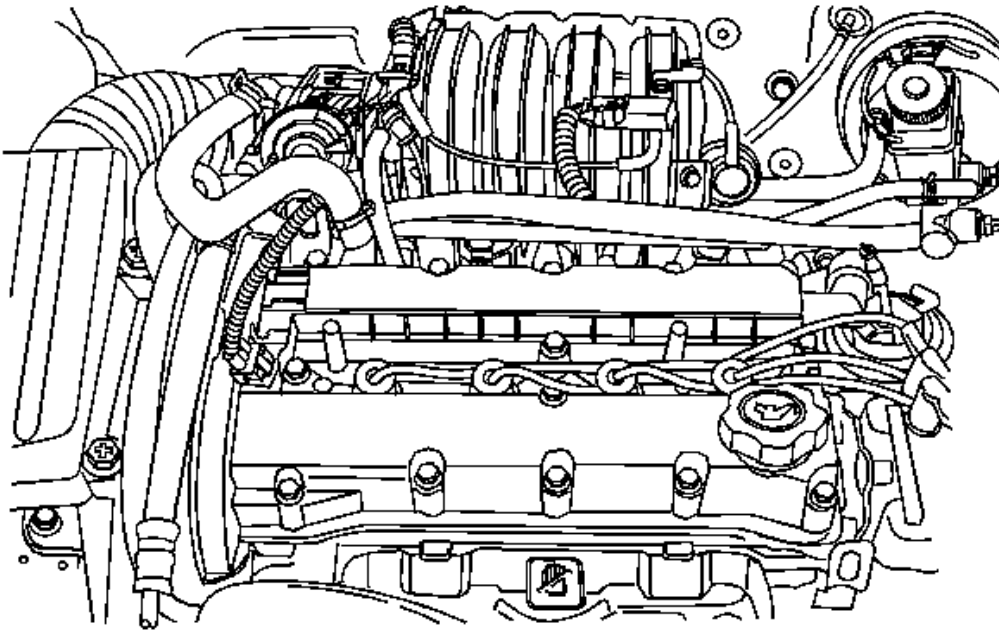


Fig. 53: View Of Valve Cover

Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft cover bolts.

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

4. Install the ignition wires to the spark plugs and connect the breather hose, ventilation hose and cam position sensor wiring connector to the camshaft cover.
5. Install the engine cover.
6. Connect the negative battery cable.

CYLINDER HEAD REPLACEMENT

Tools Required

- **J 42492-A (KM-421-A)** Timing Belt Adjuster
- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

Removal Procedure

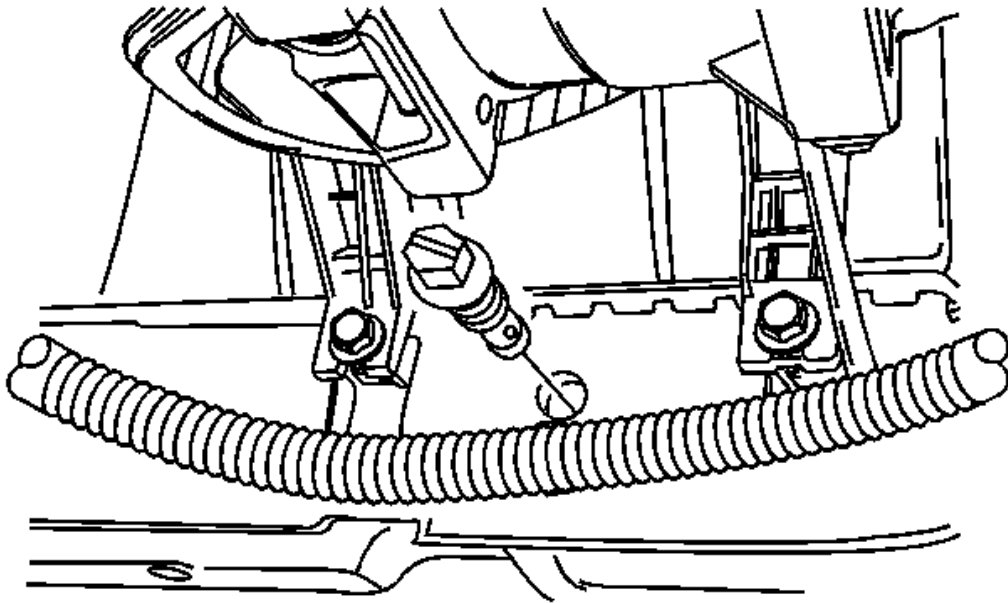


Fig. 54: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel pump fuse.
2. Start the engine. After it stalls, crank the engine for 10 seconds to rid the fuel system of fuel pressure.

CAUTION: Refer to Battery Disconnect Caution .

3. Disconnect the negative battery cable.
4. Disconnect the electronic control module (ECM) ground terminal from the intake manifold.
5. Drain the engine coolant. Refer to Cooling System Draining and Filling (Gasoline Engines) .

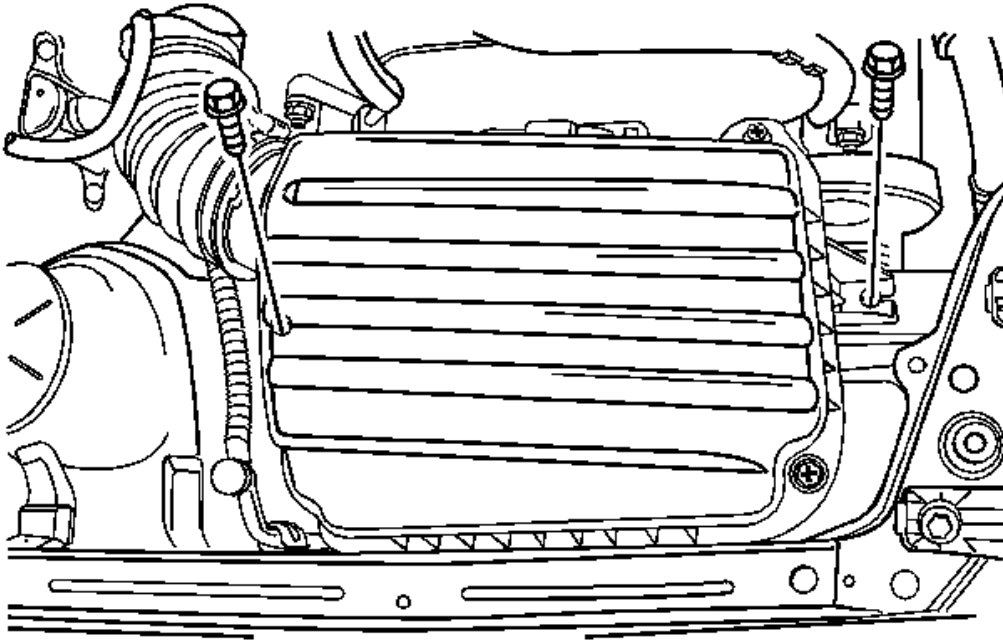


Fig. 55: View Of Air Cleaner Housing And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Drain the engine oil.
7. Remove the air cleaner housing.

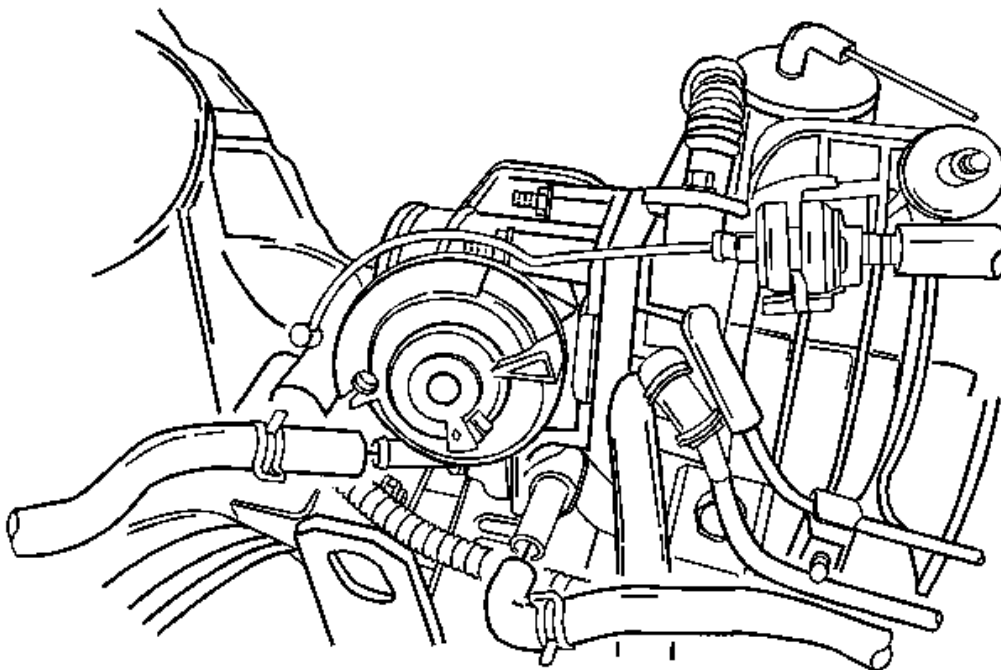


Fig. 56: Identifying Throttle Cable And Coolant Hoses
Courtesy of GENERAL MOTORS CORP.

8. Remove the throttle cable and inlet/outlet coolant hoses.

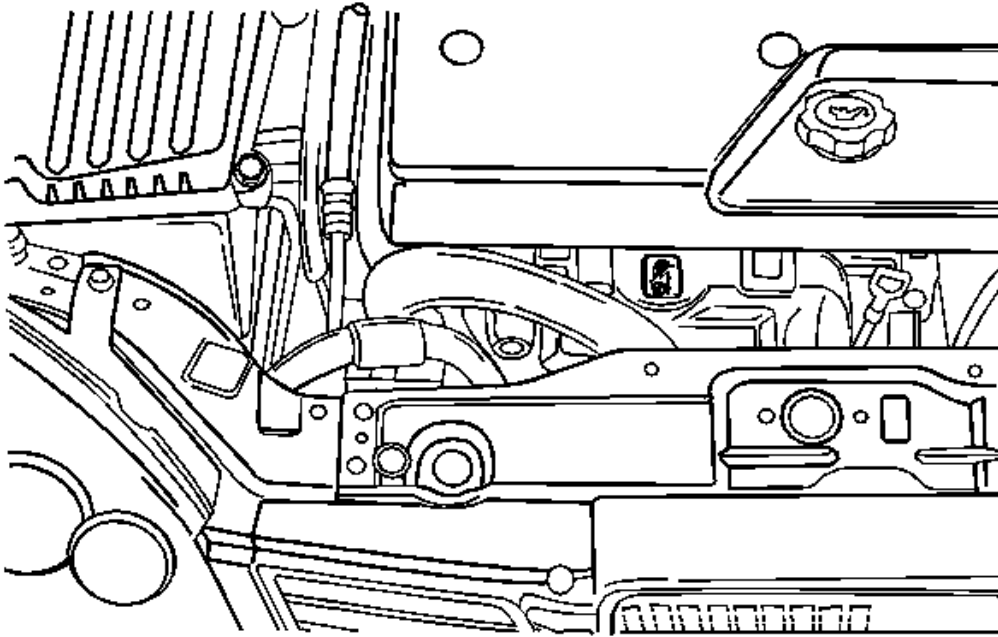


Fig. 57: Identifying Upper Thermostat Hose
Courtesy of GENERAL MOTORS CORP.

9. Remove the thermostat upper hose.
10. Remove the intake manifold pressure sensor, intake air temperature sensor and coolant temperature sensor.

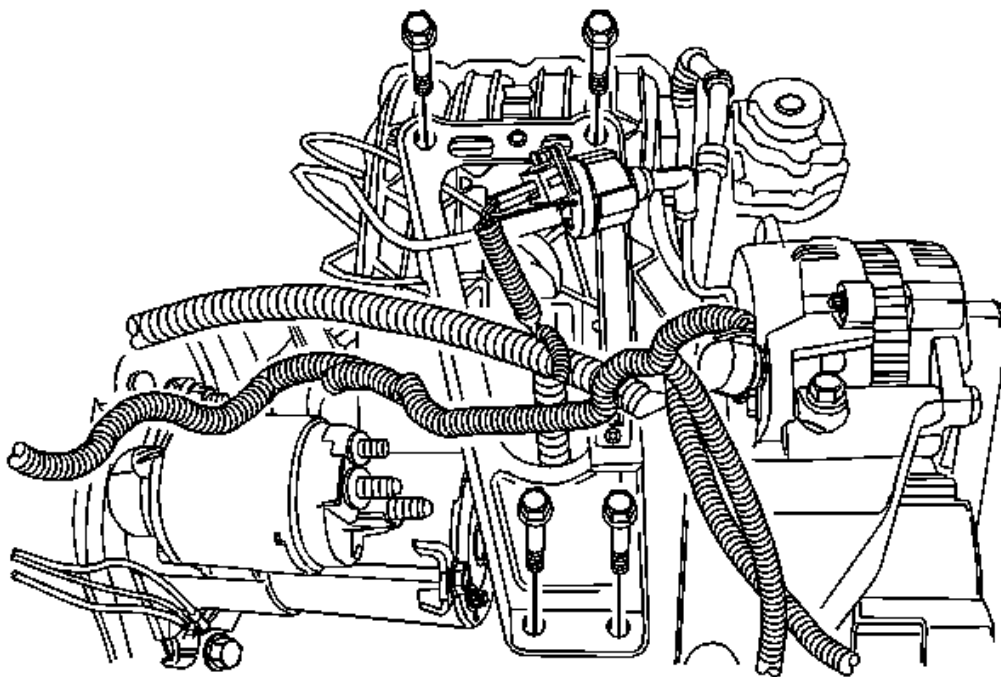


Fig. 58: Identifying Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold support bracket.

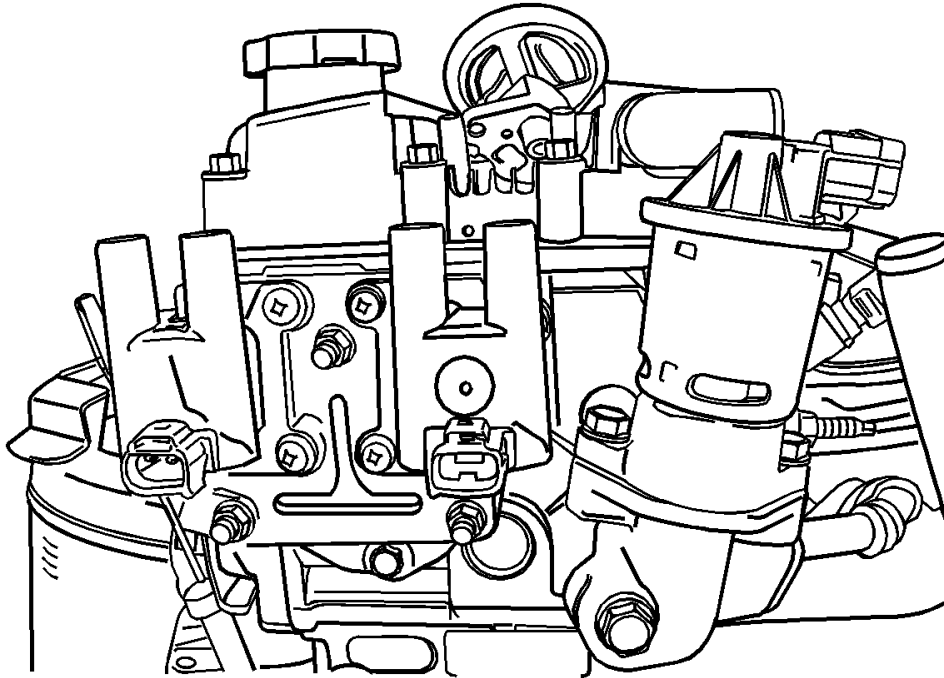


Fig. 59: View Of EGR Valve
Courtesy of GENERAL MOTORS CORP.

12. Remove the all the vacuum hoses from the intake manifold including brake booster vacuum hose.
13. Remove the ignition cables from the spark plugs.
14. Remove the direct ignition coil and the bracket from the cylinder head.

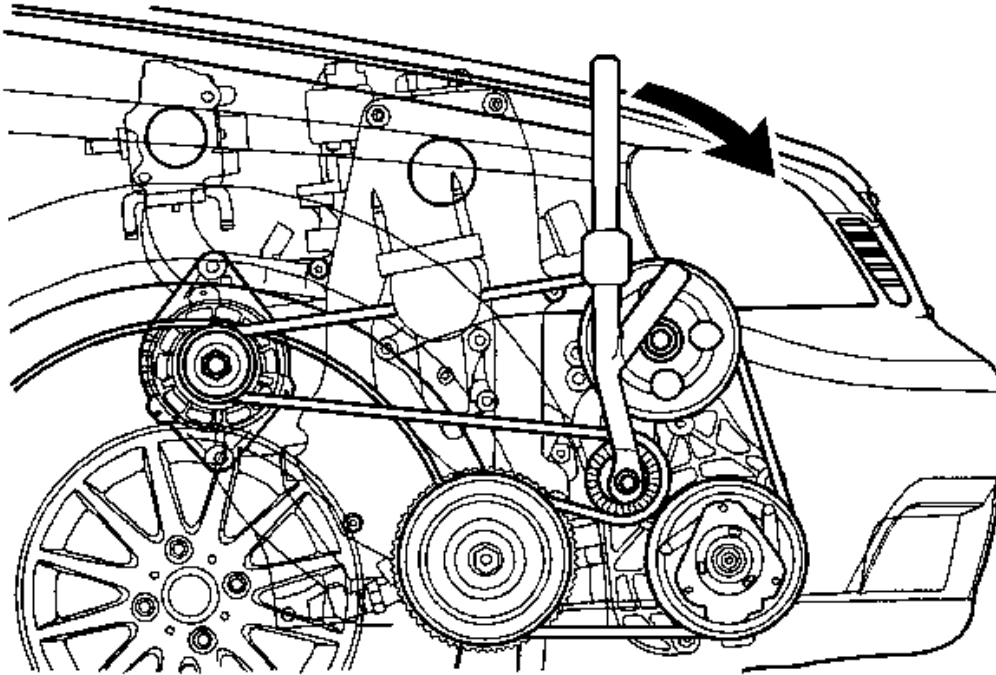


Fig. 60: Identifying Serpentine Accessory Drive Belt
Courtesy of GENERAL MOTORS CORP.

15. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** .
16. Remove the front passenger side tire. Refer to **Tire and Wheel Removal and Installation** .
17. Remove the front wheel housing shield.
18. Remove the upper front timing belt cover bolts.
19. Remove the upper front timing belt cover.
20. Align the camshaft gear timing marks.

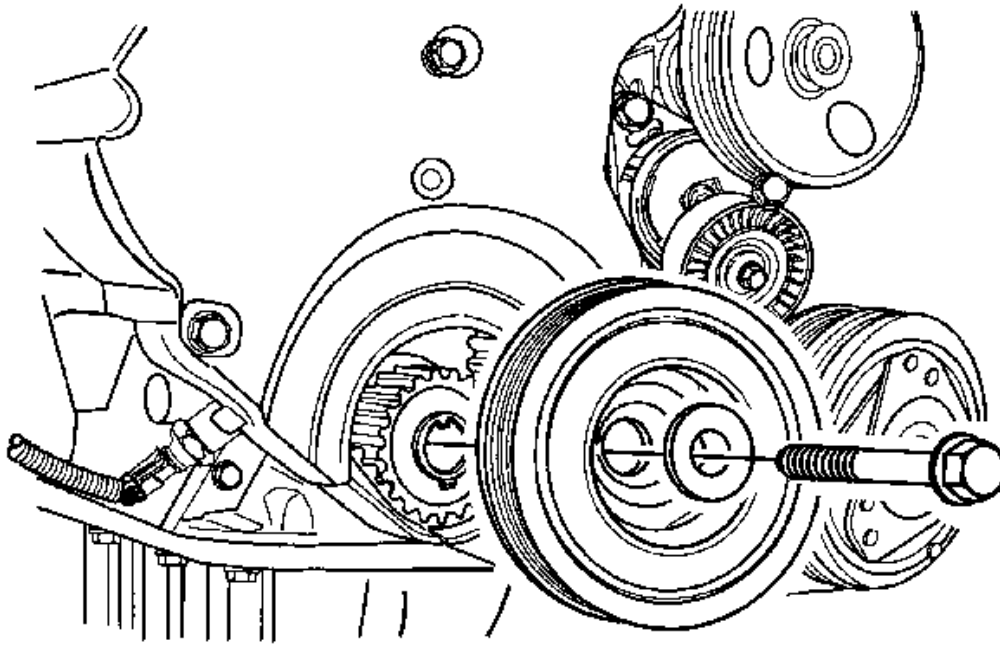


Fig. 61: Identifying Crankshaft Pulley And Bolt
Courtesy of GENERAL MOTORS CORP.

21. Remove the crank shaft pulley.
22. Remove the lower front timing belt cover bolts and cover.

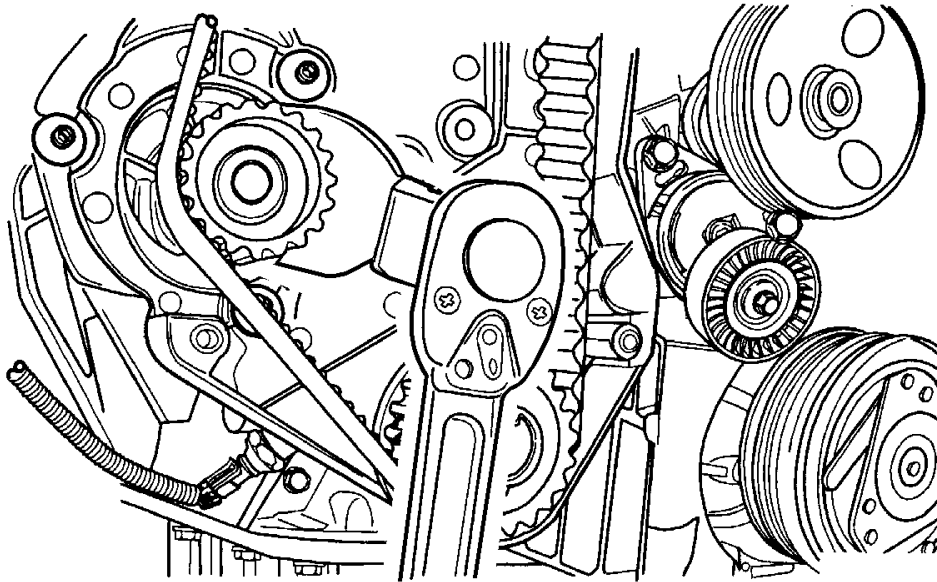


Fig. 62: Removing Timing Belt Tension Using J 42492-A
Courtesy of GENERAL MOTORS CORP.

23. Slightly loosen the water pump retaining bolts.
24. Rotate the water pump counterclockwise using **J 42492-A** To relieve the timing belt tension.
25. Remove the timing belt. Refer to **Timing Belt Replacement**.

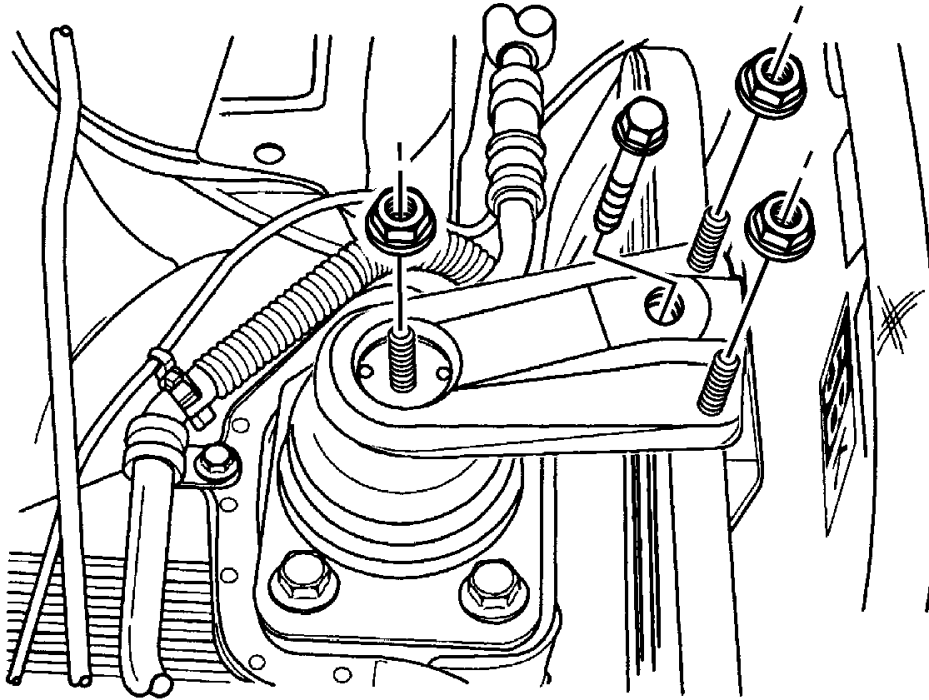


Fig. 63: View Of Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

26. Remove the engine mounting bracket. Refer to **Engine Mount Replacement**.
27. Remove the camshaft cover. Refer to **Valve Rocker Arm Cover Replacement**.

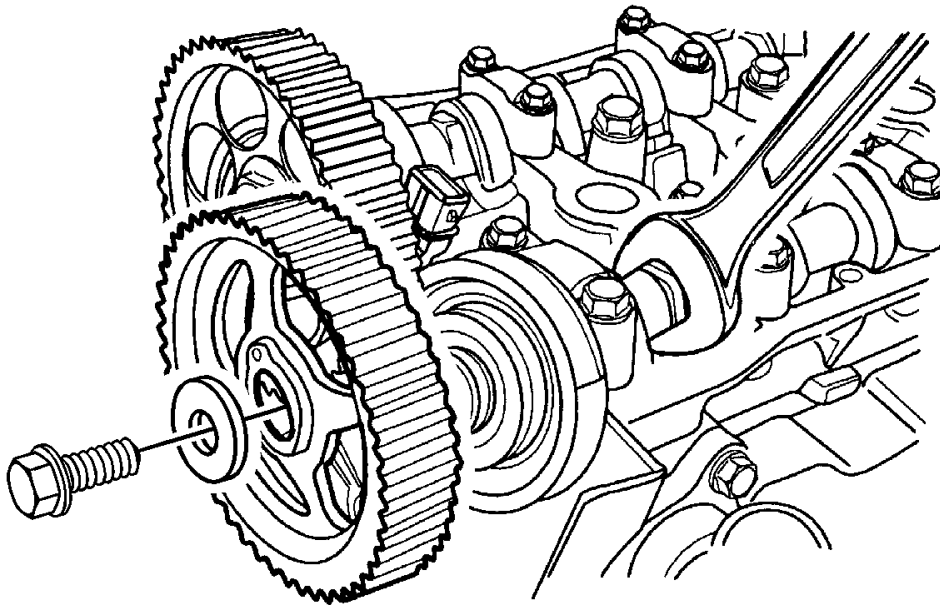


Fig. 64: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

28. While holding the intake camshaft firmly in place, remove the intake camshaft gear bolt and gear.
29. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft gear bolt and gear.

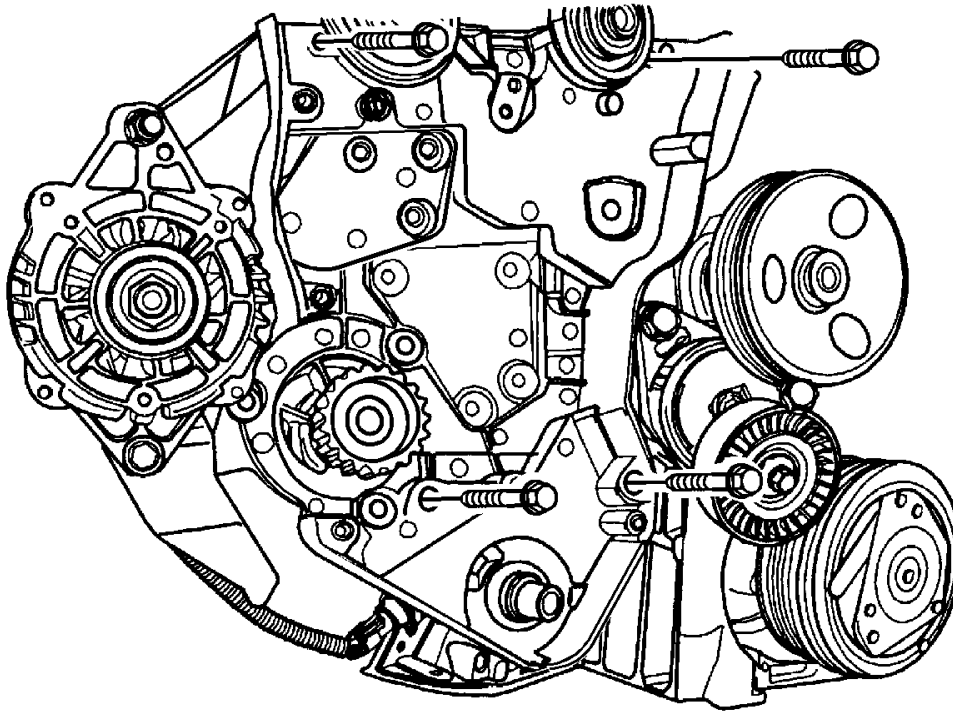


Fig. 65: View Of Rear Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

30. Remove the timing belt automatic tensioner.
31. Remove the timing belt idler pulley.
32. Remove the right engine mount. Refer to **Engine Mount Replacement**.
33. Remove the rear timing belt cover.
34. Remove the intake and exhaust manifold. Refer to **Intake Manifold Replacement** and **Exhaust Manifold Removal**.

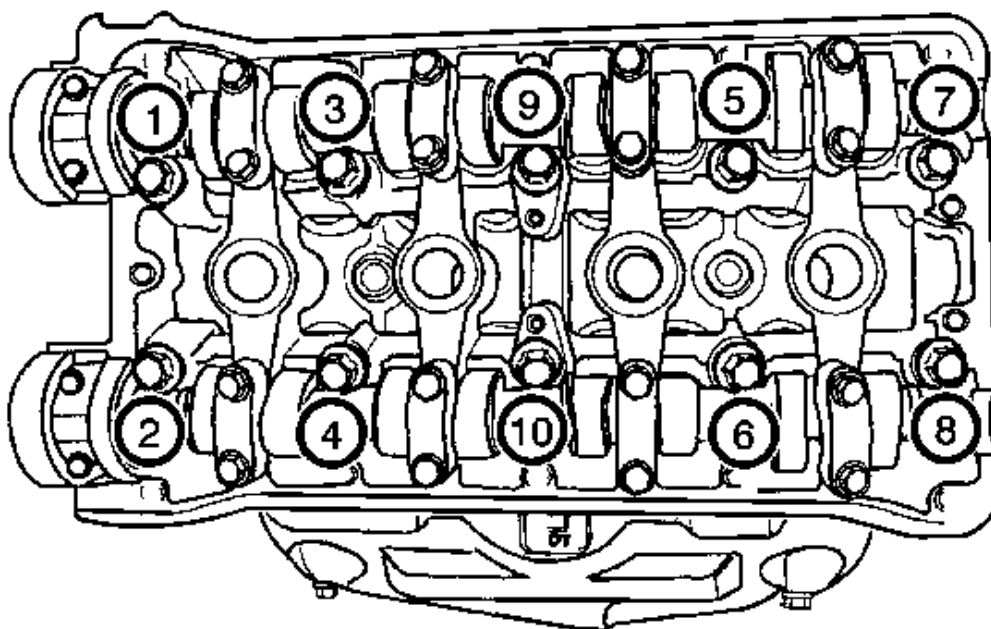


Fig. 66: View Of Cylinder Head Bolts And Sequence
Courtesy of GENERAL MOTORS CORP.

35. Remove the cylinder head bolts gradually in the sequence shown and remove the cylinder head.

NOTE: Use extreme care when removing the cylinder head to prevent any engine oil, dirt, or coolant from entering the engine. Damage to the engine could result.

36. Remove the cylinder head gasket.
37. Clean the gasket surfaces on the cylinder head and the engine block. Refer to Cylinder Head Cleaning and Inspection (Off Vehicle).

Installation Procedure

1. Install the new cylinder head gasket.
2. Install the intake/exhaust manifold to the cylinder head. Refer to Intake Manifold Replacement and Exhaust Manifold Removal.

NOTE: Refer to Fastener Notice .

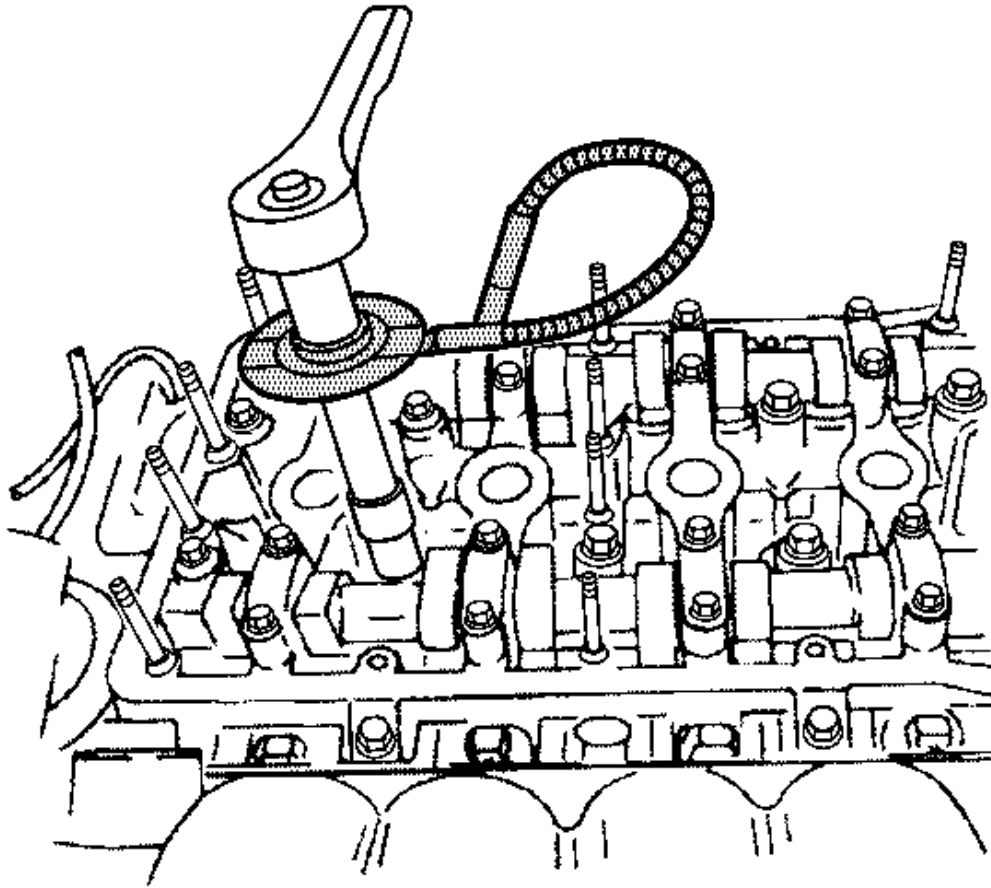


Fig. 67: View Of Cylinder Head Bolt Installation
Courtesy of GENERAL MOTORS CORP.

3. Install the cylinder head bolts gradually in the sequence shown using **J 45059** or **KM-470-B**.

Tighten: Tighten the cylinder head bolts to **25 N.m (18 lb ft)** and retighten the cylinder head bolts 70 degrees plus 70 degrees plus 50 degrees.

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

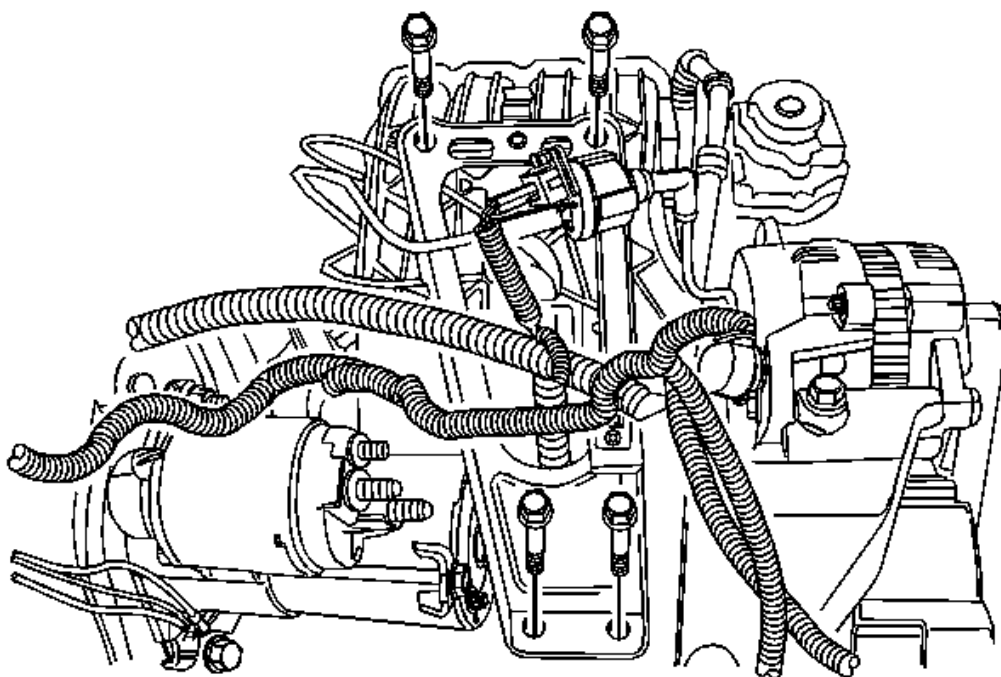


Fig. 68: Identifying Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

5. Connect the throttle cable at the throttle body and the intake manifold.
6. Install the intake manifold support bracket upper bolts to the intake manifold.

Tighten: Tighten the intake manifold support bracket upper bolts to the intake manifold to **25 N.m (18 lb ft)** .

7. Connect the surge tank coolant hose at the throttle body.
8. Connect the heater inlet hose to the cylinder head.
9. Install the generator upper retaining bolt.

Tighten: Tighten the generator upper retaining bolt to **20 N.m (15 lb ft)** .

10. Connect the fuel feed line at the fuel rail.

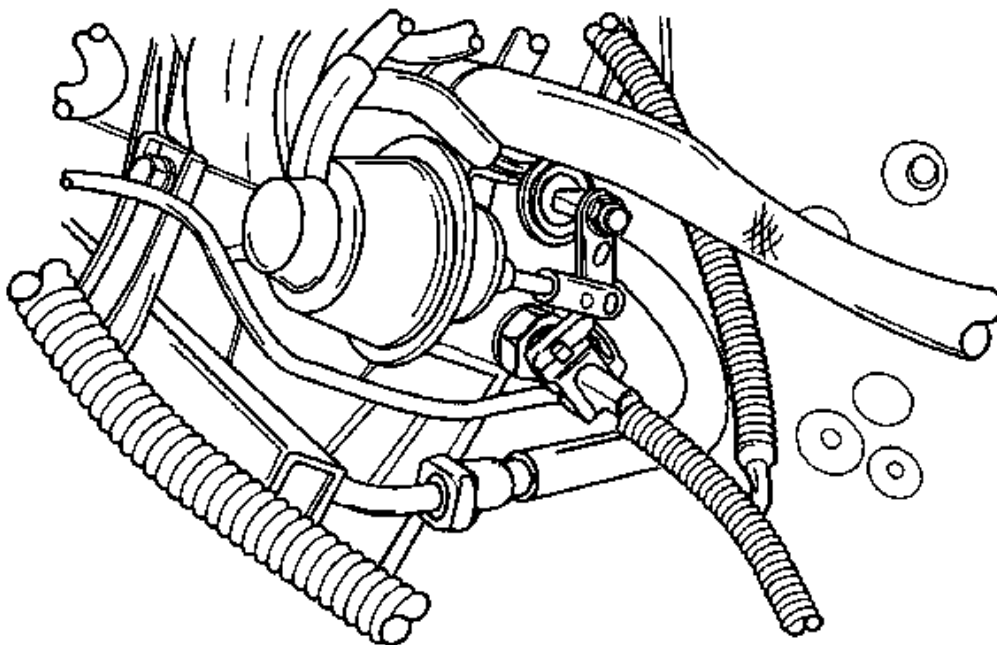


Fig. 69: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

11. Connect all the disconnected vacuum hoses and the brake booster vacuum hose at the intake manifold.

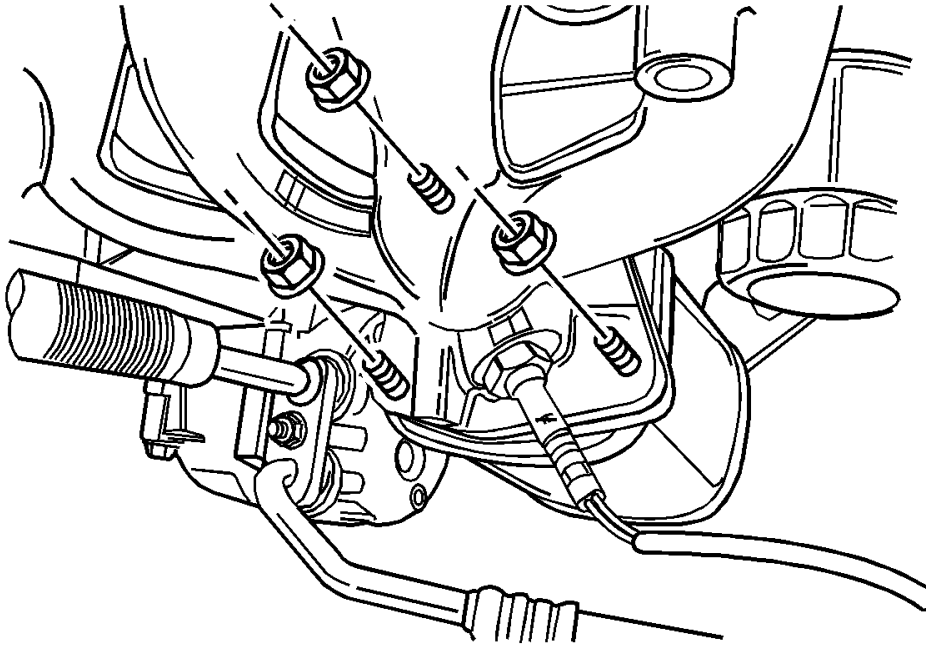


Fig. 70: View Of Exhaust Manifold Nuts
Courtesy of GENERAL MOTORS CORP.

12. Install the catalytic converter retaining nuts at the exhaust manifold flange.

Tighten: Tighten the catalytic converter to exhaust manifold flange nuts to **40 N.m (30 lb ft)** .

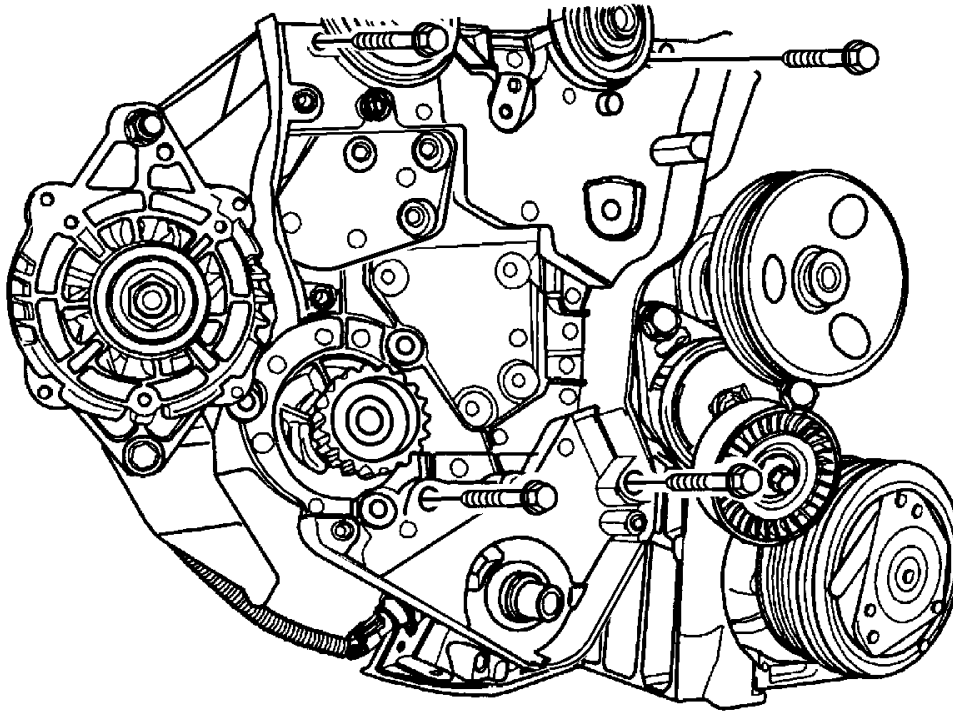


Fig. 71: View Of Rear Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

13. Install the rear timing belt cover.
14. Install the rear timing belt cover bolts.

Tighten: Tighten the rear timing belt cover bolts to **10 N.m (89 lb in)** .

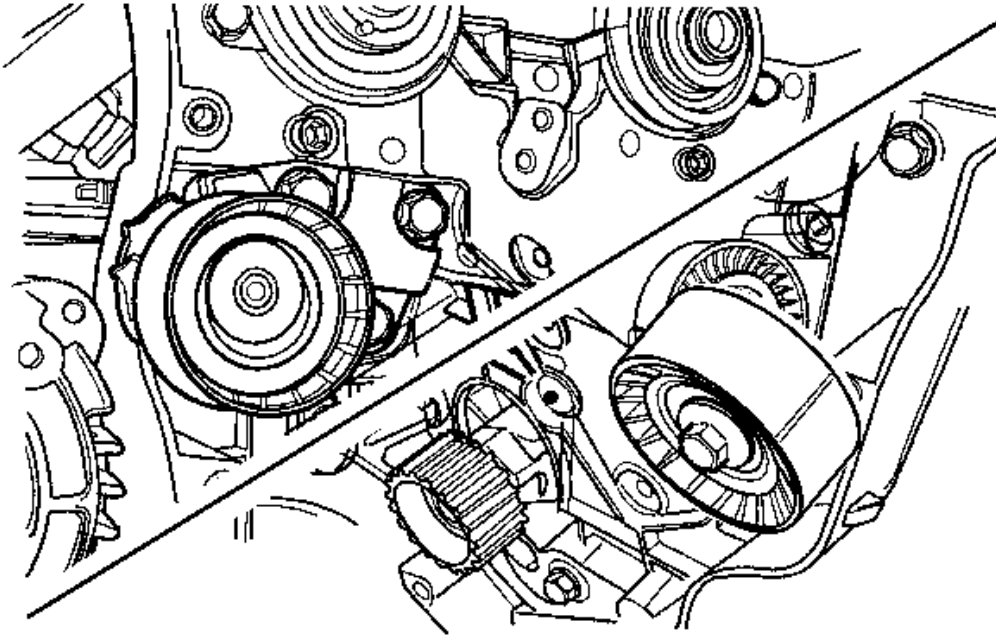


Fig. 72: View Of Automatic Tensioner And Idler Pulley
Courtesy of GENERAL MOTORS CORP.

15. Install the timing belt automatic tensioner.

Tighten: Tighten the timing belt automatic tensioner bolts to **25 N.m (18 lb ft)** .

16. Install the timing belt idler pulley.

Tighten: Tighten the timing belt idler pulley bolt to **25 N.m (18 lb ft)** .

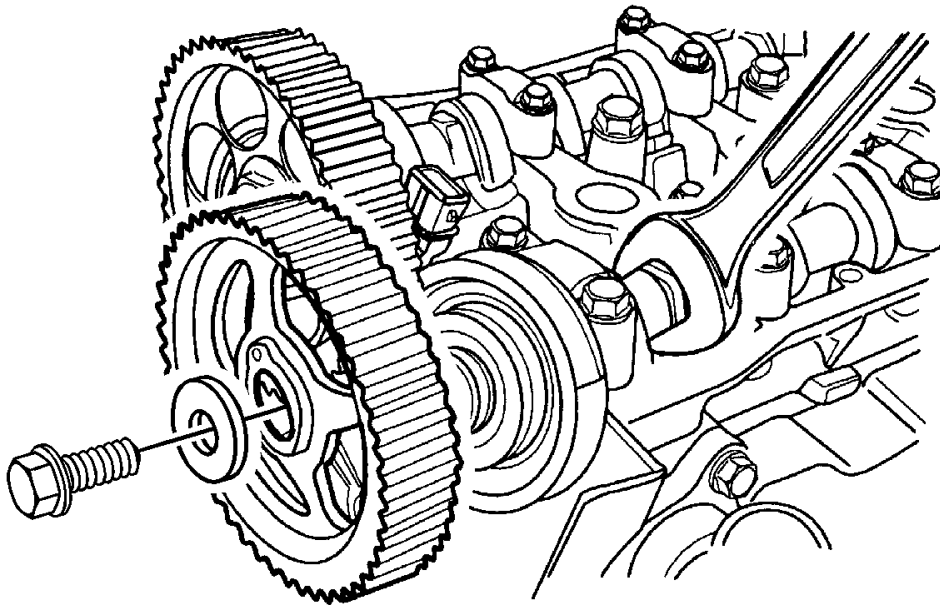


Fig. 73: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

17. Install the intake and exhaust camshaft gear.

Tighten: Tighten the intake and exhaust camshaft gear bolts to **67.5 N.m (49 lb ft)** .

18. Apply a small amount of gasket sealant to the corners of the front camshaft caps and the top of the rear camshaft cover-to-cylinder head seal.

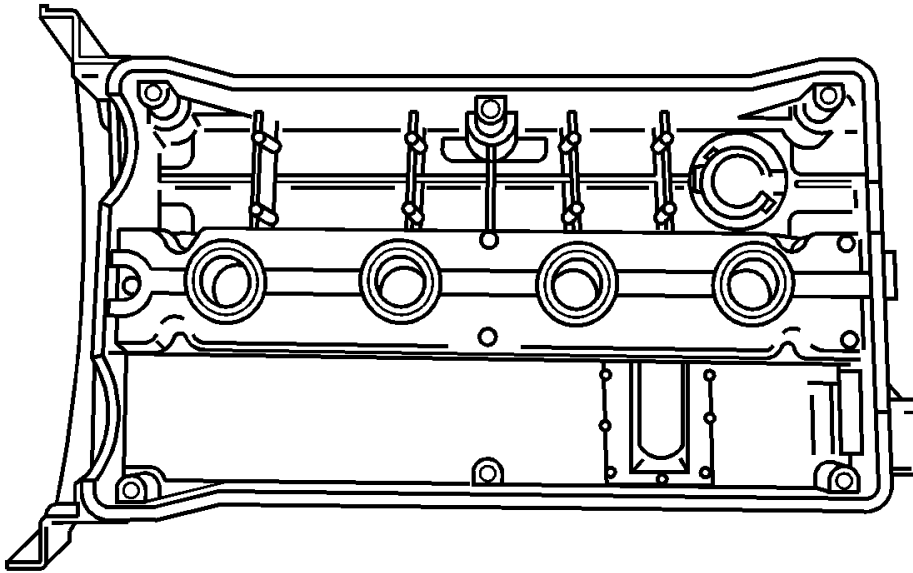


Fig. 74: View OF DIS Coil Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

19. Install the camshaft cover and the gasket. Refer to Valve Rocker Arm Cover Replacement.
20. Connect the ignition wires to the spark plugs.
21. Install the oil filler cap.
22. Connect the engine ventilation hose to the camshaft cover.

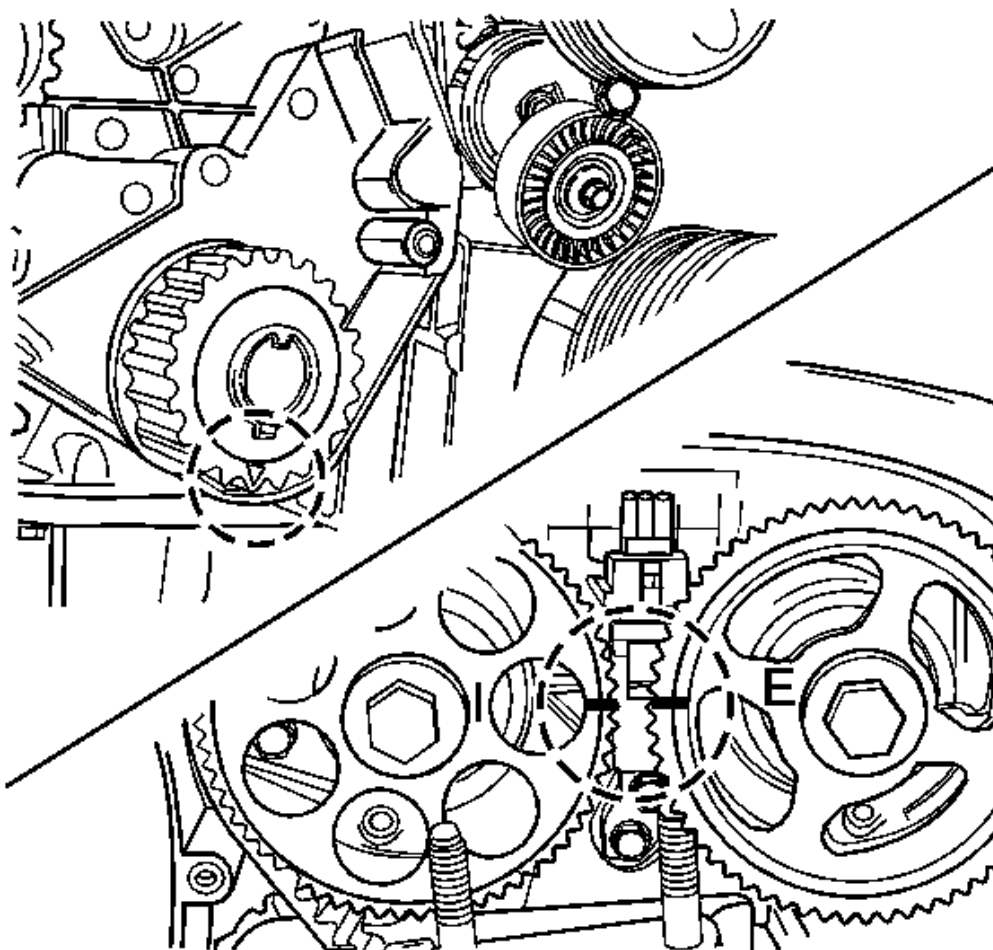


Fig. 75: Locating Gear Marks
Courtesy of GENERAL MOTORS CORP.

23. Align the timing marks on the camshaft gears.
24. Align the mark on the crank shaft gear with the notch at the bottom of the rear timing belt cover.

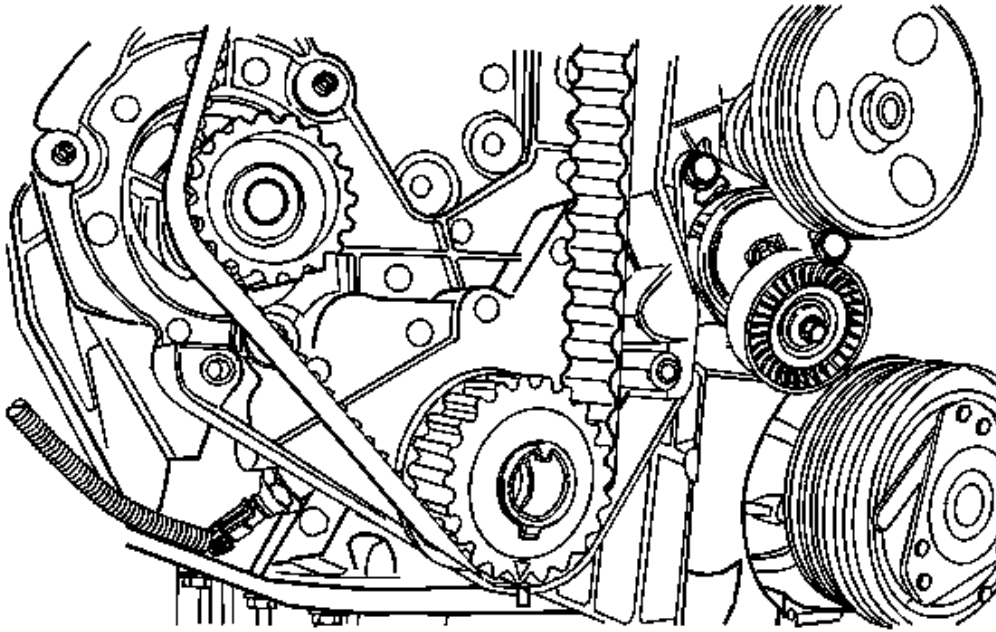


Fig. 76: View Of Timing Belt

Courtesy of GENERAL MOTORS CORP.

25. Install the timing belt.
26. Rotate the water pump clockwise using the **J 42492-A** to apply tension to the timing belt.

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

27. Check and adjust the timing belt tension. Refer to **Timing Belt Inspection**.
28. Install the upper and lower front timing belt covers.

Tighten: Tighten the upper and lower front timing belt cover bolts to **10 N.m (89 lb in)** .

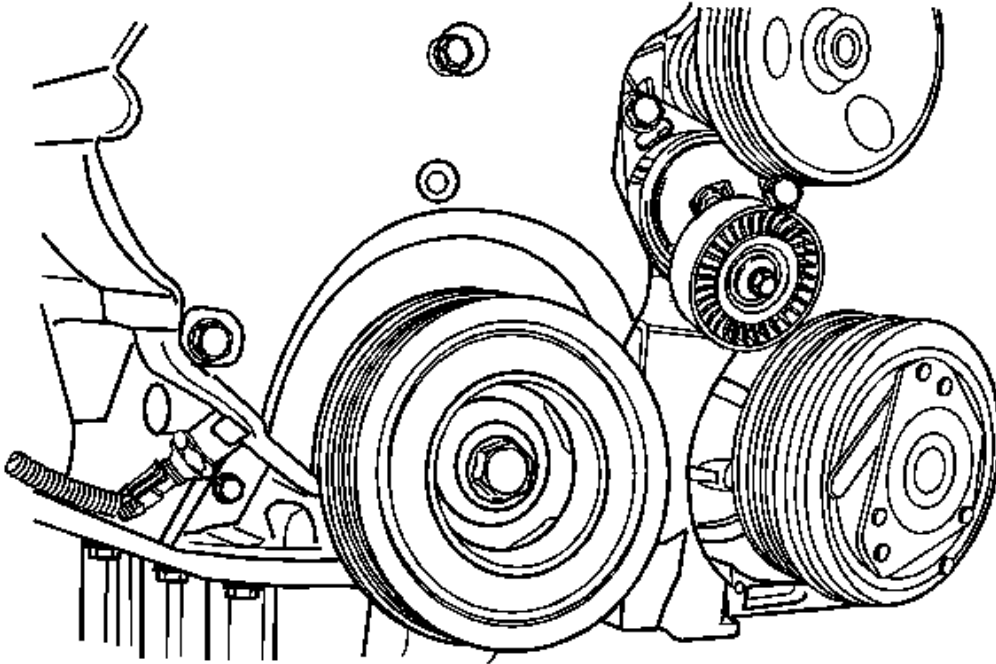


Fig. 77: View Of Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

29. Install the crank shaft pulley bolt.

Tighten: Tighten the crank shaft pulley bolt to **95 N.m (70 lb ft)** and retighten 30 degrees plus 15 degrees.

30. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** in Power Steering System.
31. Connect the upper radiator hose to the thermostat housing.
32. Install the front wheel and splash shield. Refer to **Tire and Wheel Removal and Installation** .

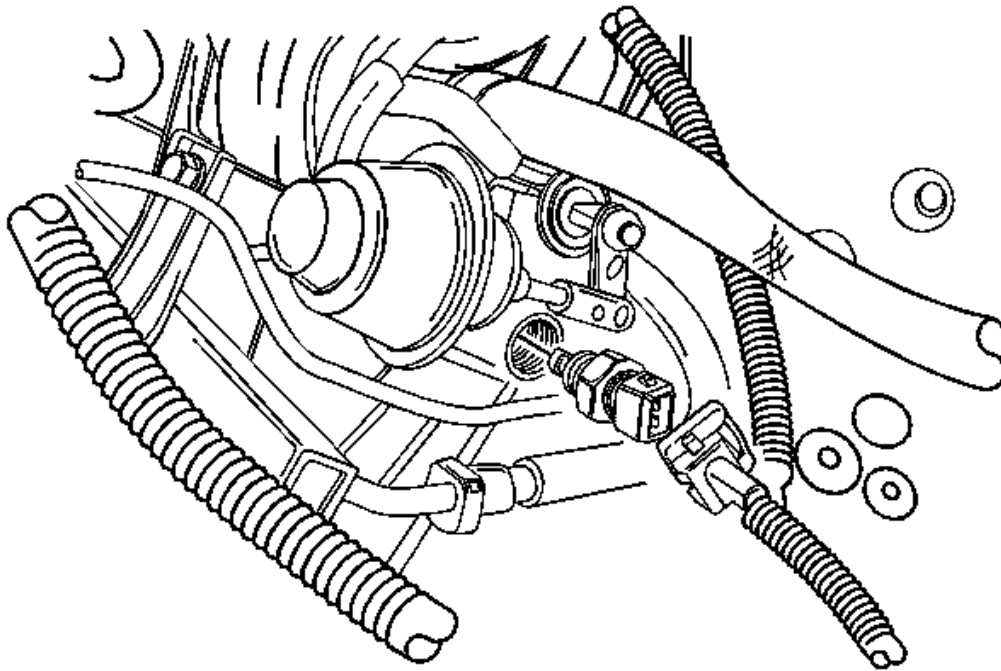


Fig. 78: View Of IAT Sensor And Connector
Courtesy of GENERAL MOTORS CORP.

33. Install the air cleaner housing.

Tighten: Tighten the air cleaner housing bolts to **10 N.m (89 lb in)** .

34. Connect the breather tube to the cam shaft cover.
35. Install the crank shaft pulley bolt.
36. Connect the IAT sensor connector.
37. Connect the intake manifold pressure sensor, intake air temperature sensor and coolant temperature sensor connector.

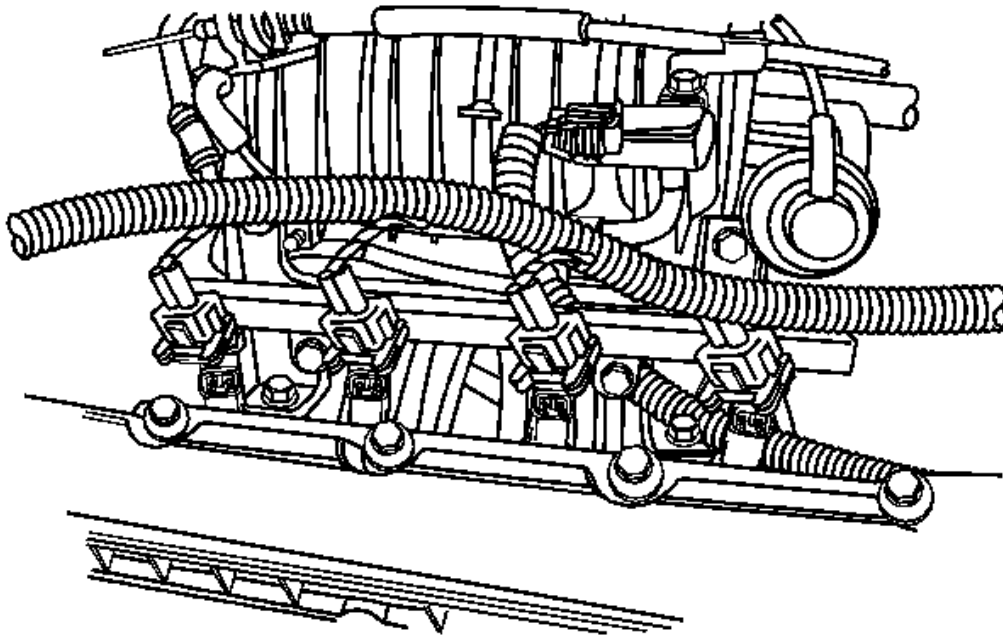


Fig. 79: View Of Direct Ignition Coil
Courtesy of GENERAL MOTORS CORP.

38. Connect the direct ignition coil connector.
39. Connect the fuel injector harness connectors.
40. Connect the oxygen sensor connector and the ECM ground terminal at the intake manifold.
41. Install the fuel pump fuse.
42. Connect the negative battery ground cable.
43. Refill the engine cooling system. Refer to **Cooling System Draining and Filling (Gasoline Engines)** .

OIL PAN REPLACEMENT

Removal Procedure

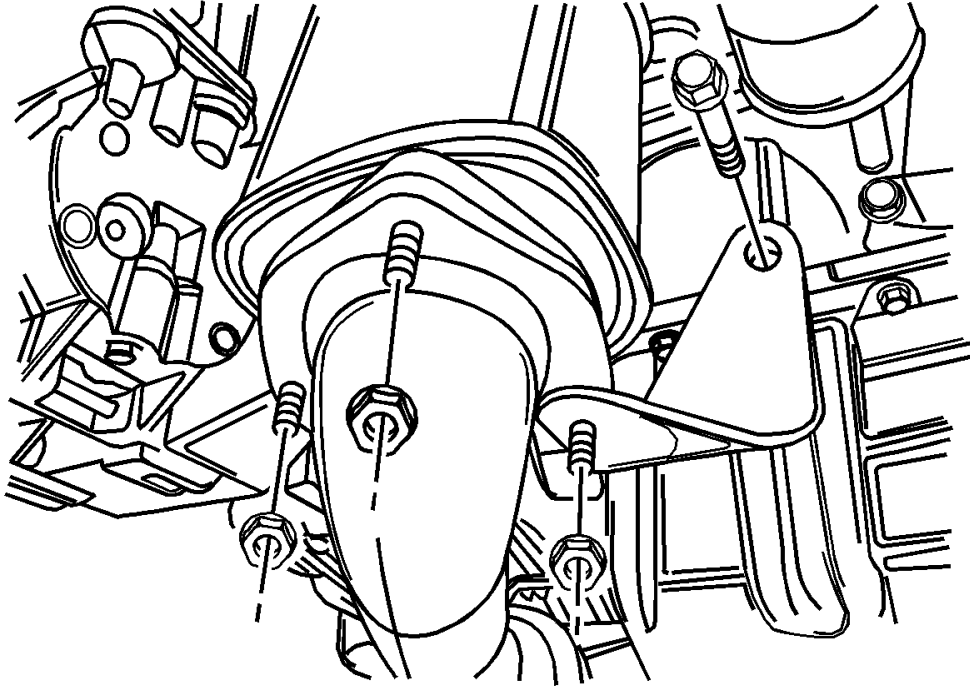


Fig. 80: View Of Exhaust Pipe Catalytic Converter Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable.

CAUTION: Refer to Safety Glasses Caution .

2. Drain the engine oil from the engine crankcase.
3. Remove the catalytic converter retaining nuts from the exhaust pipe.

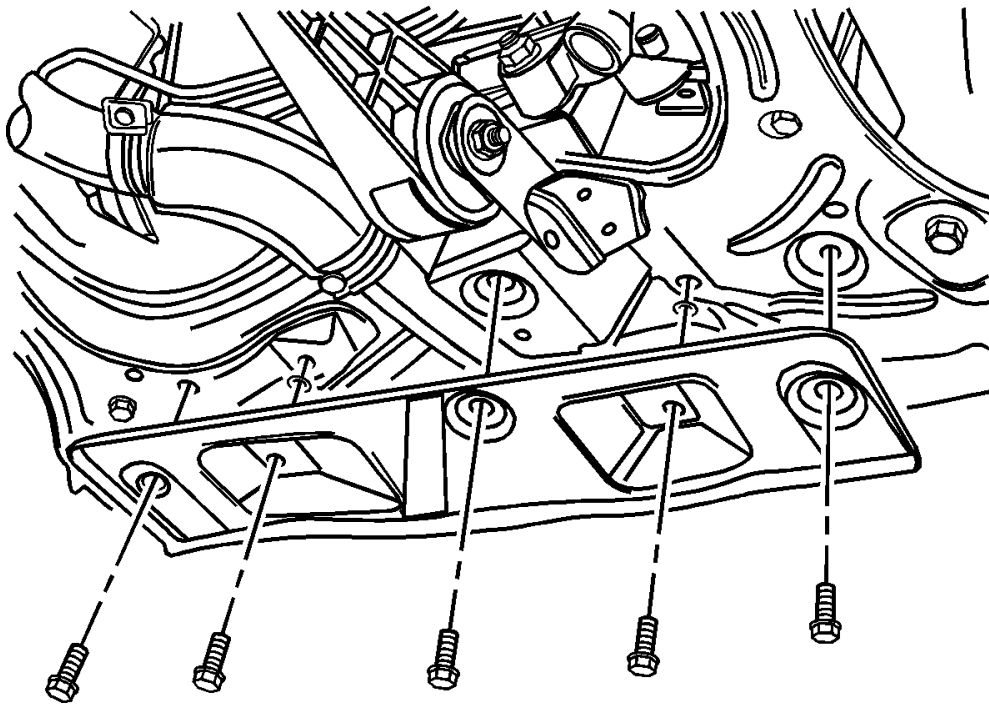


Fig. 81: View Of Lower Crossmember Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the lower crossmember bracket.

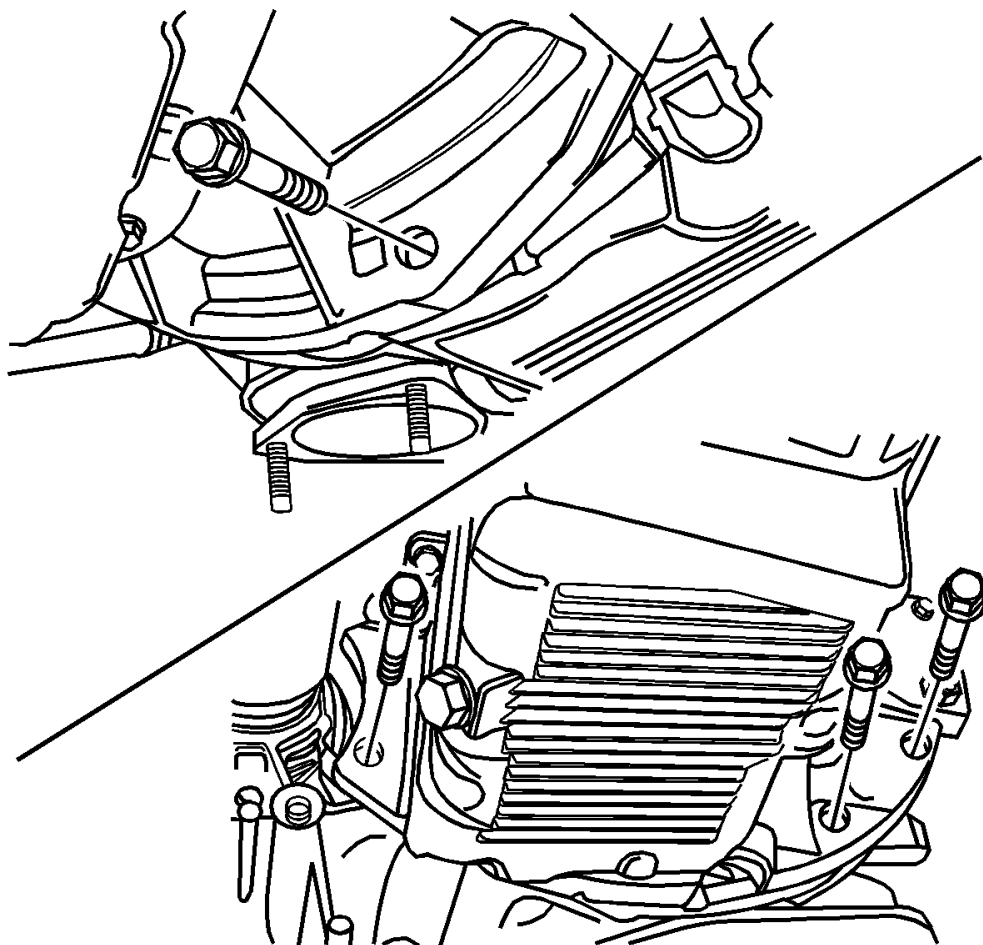


Fig. 82: View Of Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pan bolts to the transaxle case.

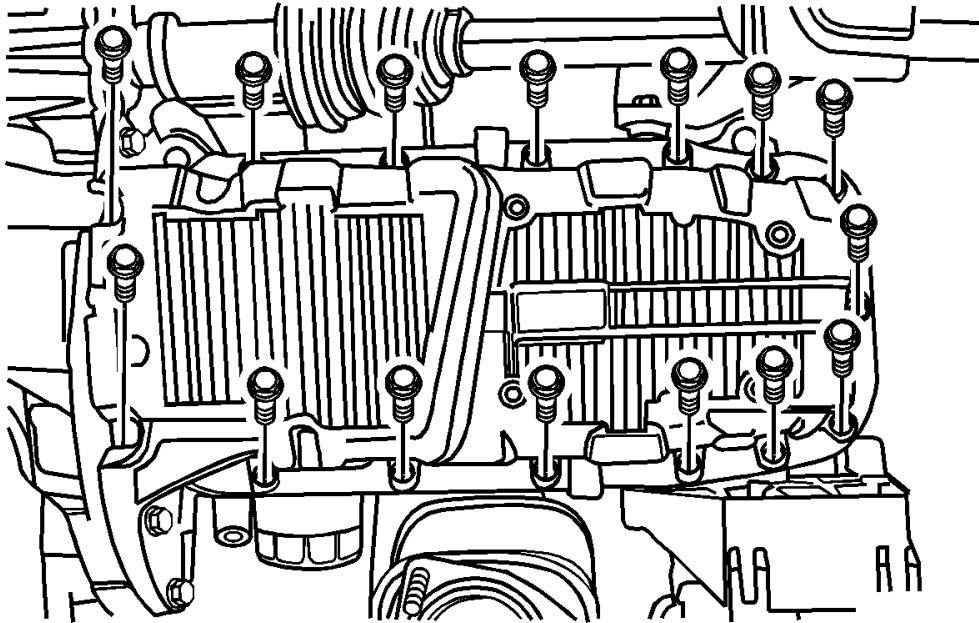


Fig. 83: View Of Oil Pan And Retaining Bolts From Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan retaining bolts to the engine block.
7. Remove the oil pan from the engine block.
8. Clean the gasket surfaces on the oil pan and the engine block. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

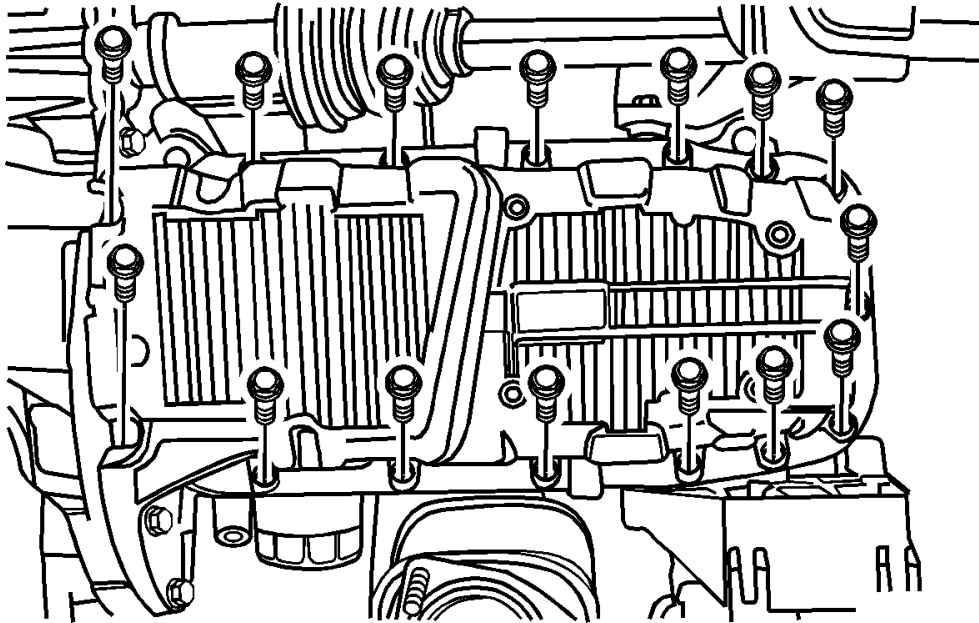


Fig. 84: View Of Oil Pan And Retaining Bolts From Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Coat the new oil pan gasket with sealant.

IMPORTANT: Install the oil pan within 5 minutes after applying the liquid gasket to the oil pan.

2. Install the oil pan to the engine block.

NOTE: Refer to Fastener Notice .

3. Install the oil pan retaining bolts.

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

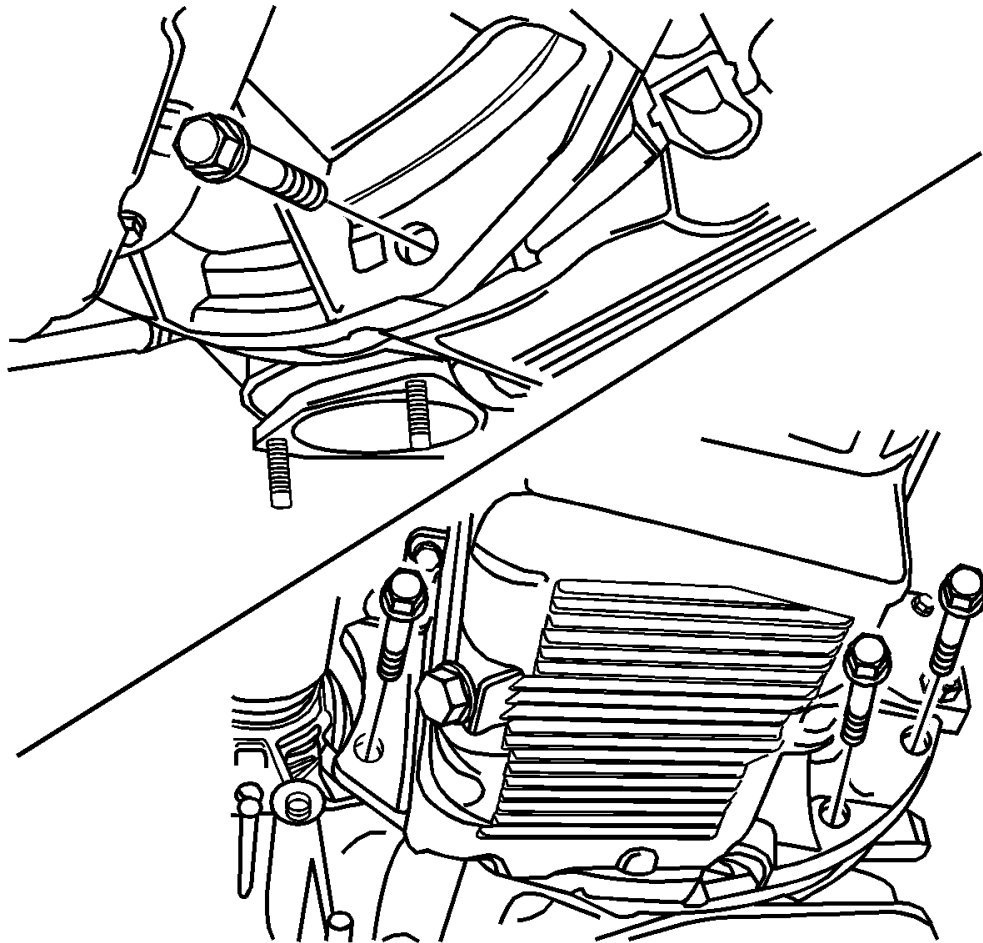


Fig. 85: View Of Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts to the transaxle case.

Tighten: Tighten the oil pan bolts to the transaxle case bolts to **31 N.m (23 lb ft)** .

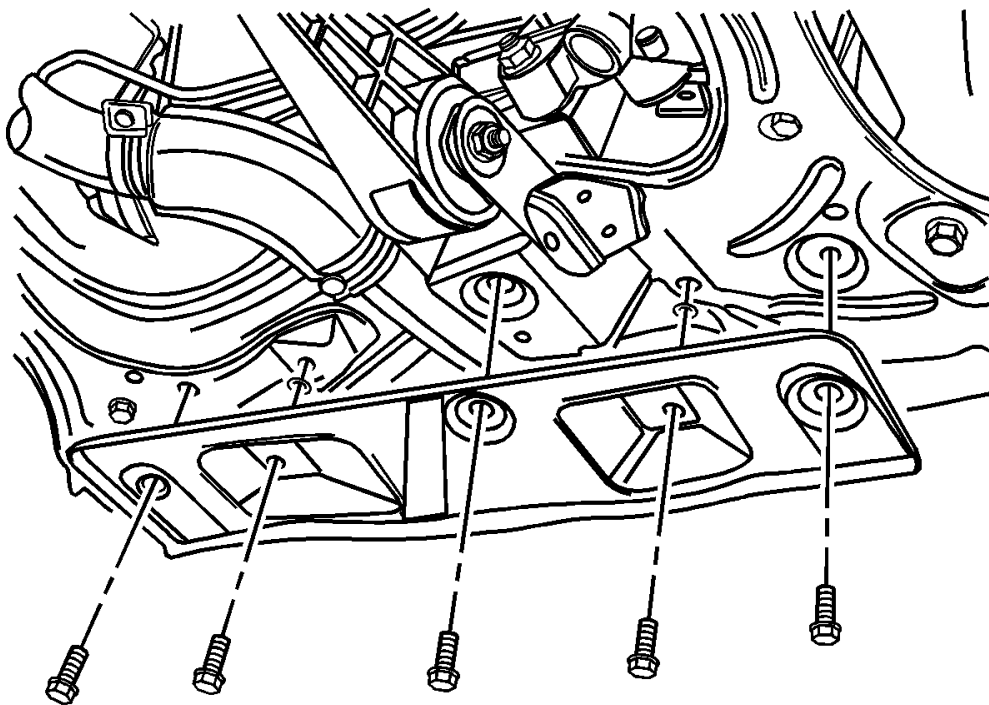


Fig. 86: View Of Lower Crossmember Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the catalytic converter retaining nuts to the exhaust pipe.

Tighten: Tighten the catalytic converter to exhaust pipe retaining nuts to **40 N.m (30 lb ft)** .

6. Install the lower crossmember bracket.
7. Connect the negative battery cable.
8. Discard the used oil pan drain plug washer and replace it with a new one.
9. Install the oil pan drain plug.

Tighten: Tighten the oil pan drain plug to **55 N.m (40 lb ft)** .

10. Refill the engine crankcase with engine oil.

OIL PUMP REPLACEMENT

Removal Procedure

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable.
2. Remove the power steering pump, if equipped. Refer to Power Steering Pump Replacement (Gasoline Engine)
3. Remove the timing belt. Refer to Timing Belt Replacement.
4. Remove the rear timing belt cover. Refer to Timing Belt Cover Replacement.

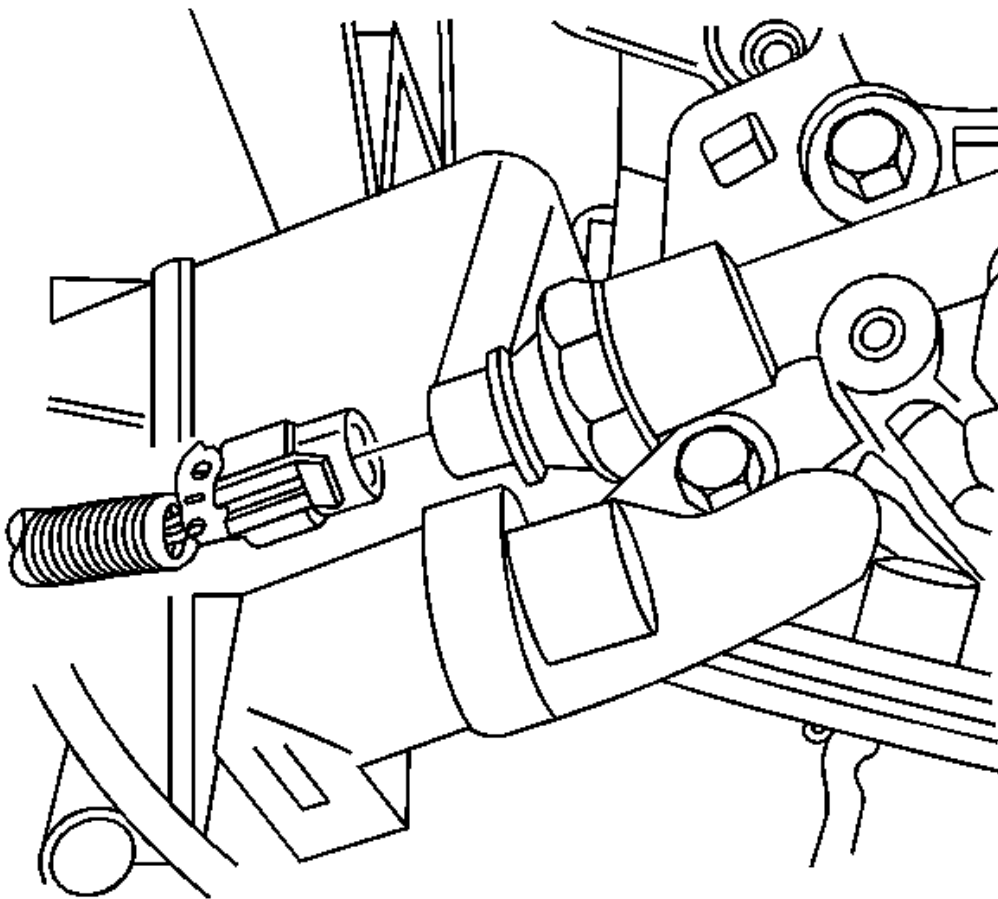


Fig. 87: View Of Oil Pressure Switch Connector
Courtesy of GENERAL MOTORS CORP.

5. Disconnect the oil pressure switch connector.

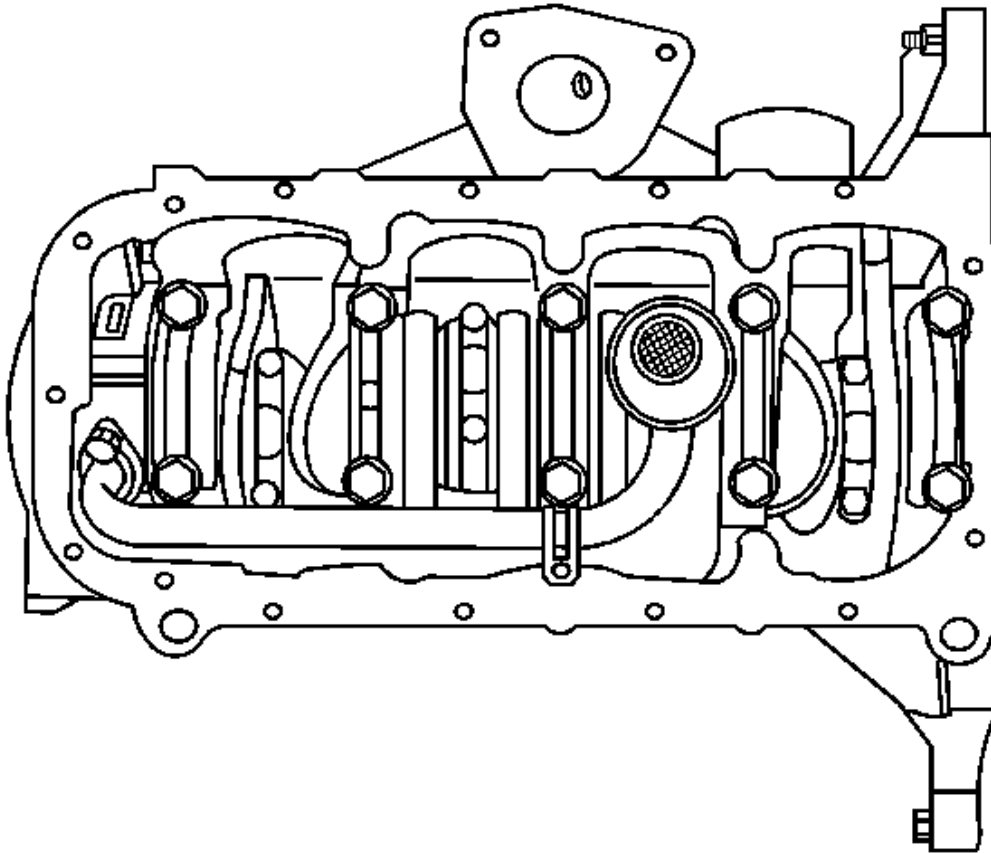


Fig. 88: View Of Oil Suction Pipe, Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan. Refer to **Oil Pan Replacement**.
7. Remove the oil suction pipe and support bracket bolts.
8. Remove the oil suction pipe.

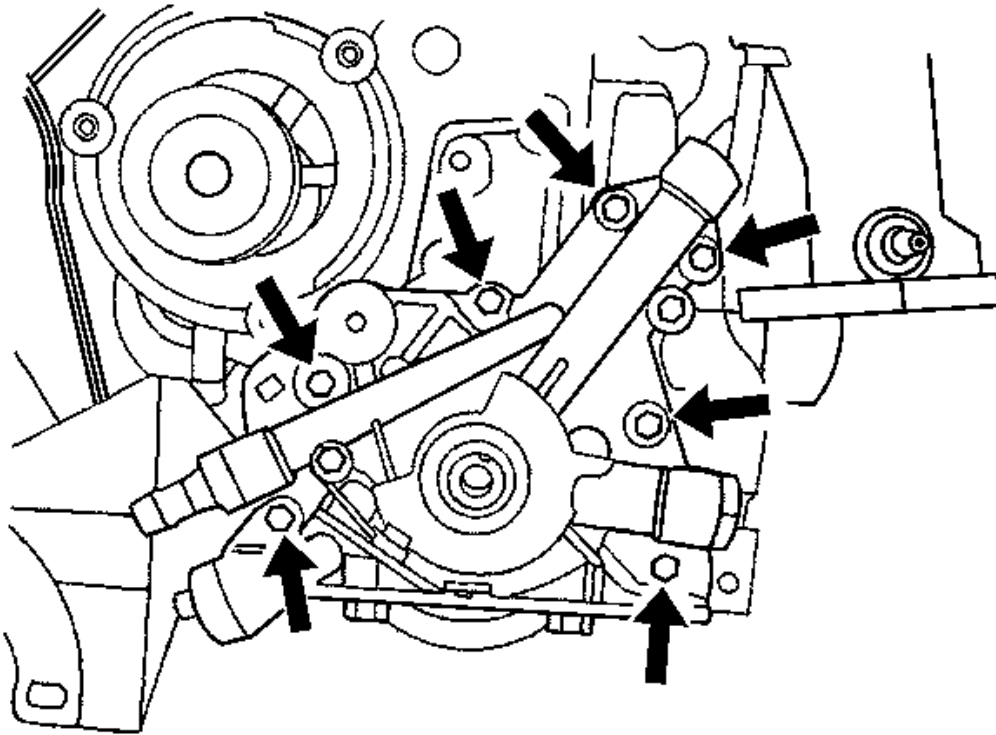


Fig. 89: Identifying Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pump retaining bolts.
10. Carefully separate the oil pump and gasket from the engine block and the oil pan.
11. Remove the oil pump.
12. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

Installation Procedure

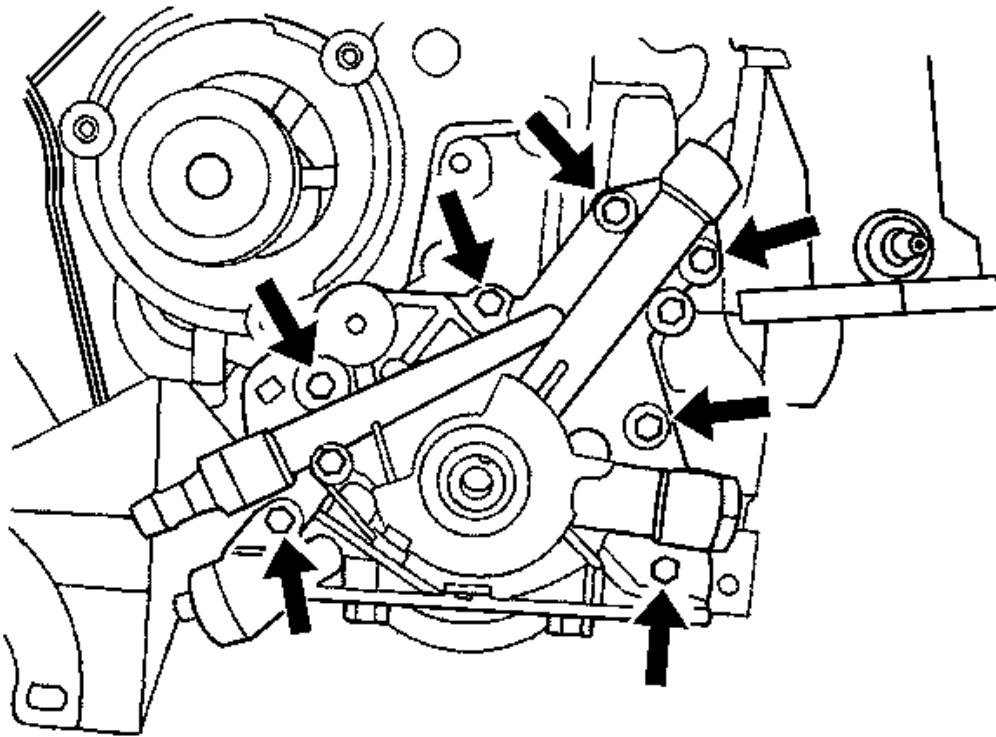


Fig. 90: Identifying Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

1. Apply Loctite® 242 to the oil pump bolts and room temperature vulcanizing (RTV) sealant to the new oil pump gasket.

NOTE: Refer to Fastener Notice .

2. Install the gasket to the oil pump and install the oil pump to the engine block with the bolts.

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

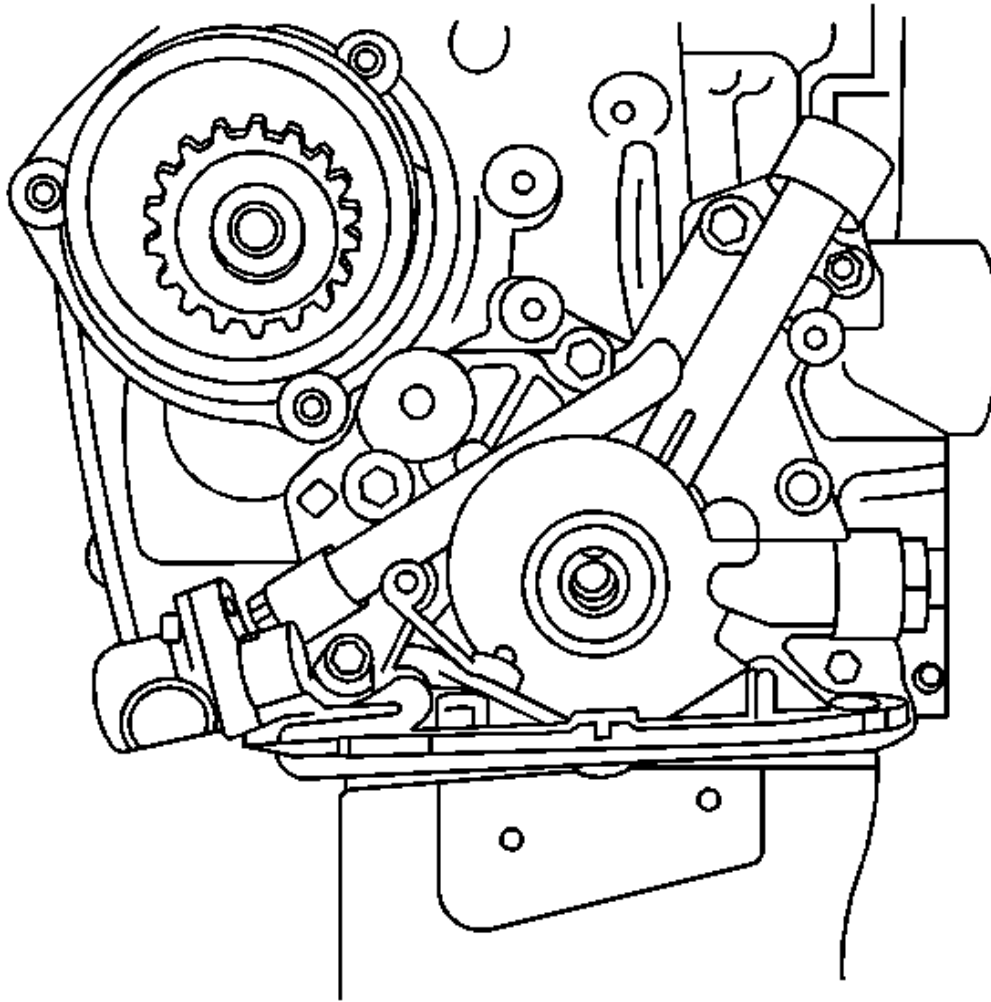


Fig. 91: View Of Oil Pump At Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Install a new oil pump-to-crankshaft seal. Coat the lip of the seal with a thin coat of grease.
4. Coat the threads of the oil suction pipe and support bracket bolts with Loctite® 242.

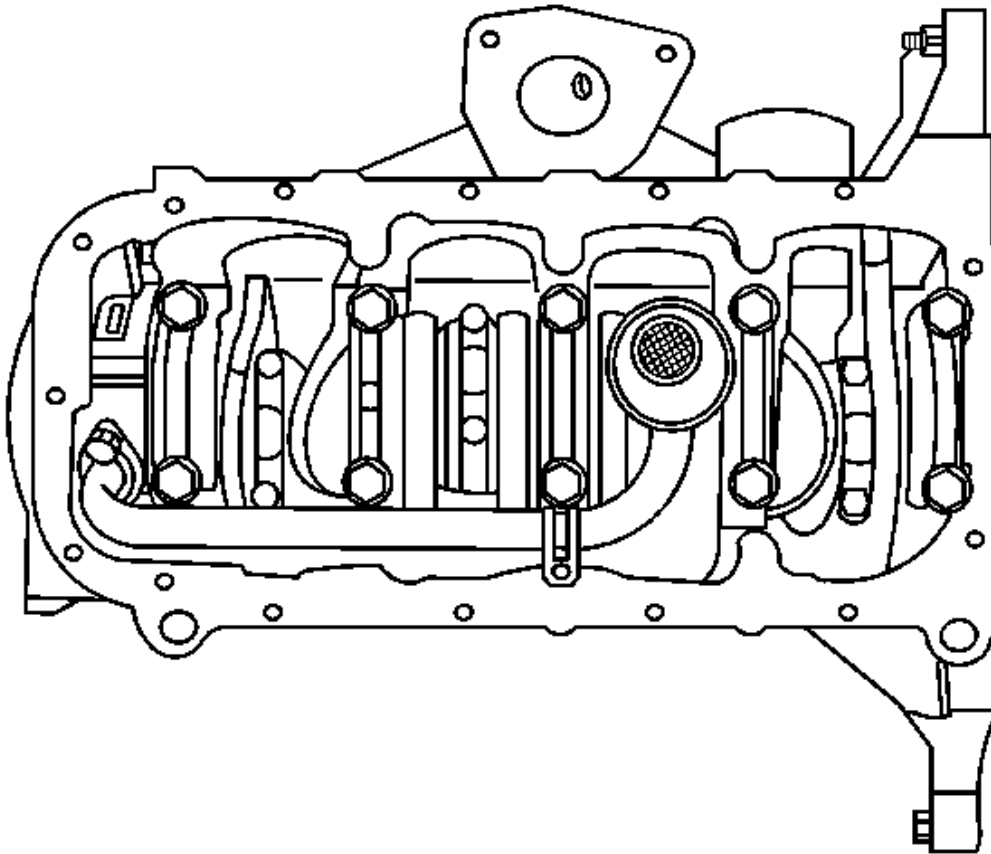


Fig. 92: View Of Oil Suction Pipe, Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the oil suction pipe and bolts.

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

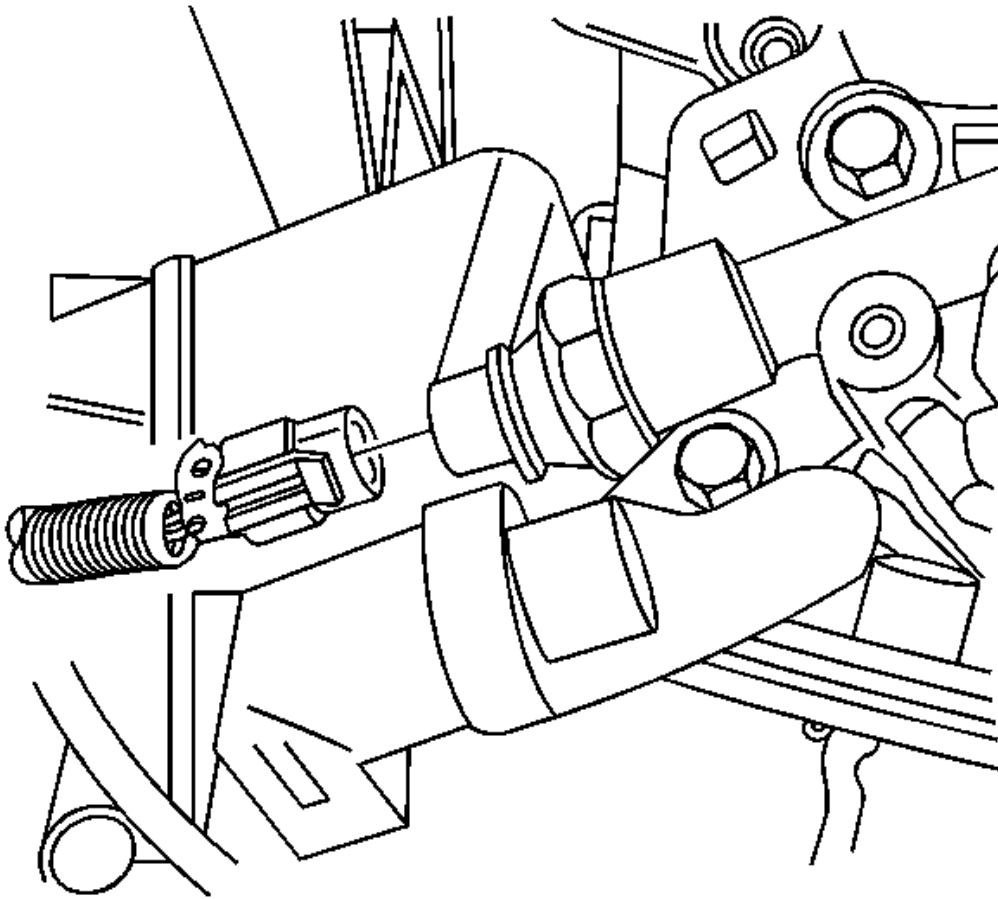


Fig. 93: View Of Oil Pressure Switch Connector
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan. Refer to **Oil Pan Replacement**.
7. Connect the oil pressure switch connector.
8. Install the rear timing belt cover. Refer to **Timing Belt Cover Replacement**.
9. Install the timing belt. Refer to **Timing Belt Replacement**.
10. Install the power steering pump, if equipped. Refer to **Power Steering Pump Replacement (Gasoline Engine)**.
11. Connect the negative battery cable.

ENGINE REPLACEMENT

Removal Procedure

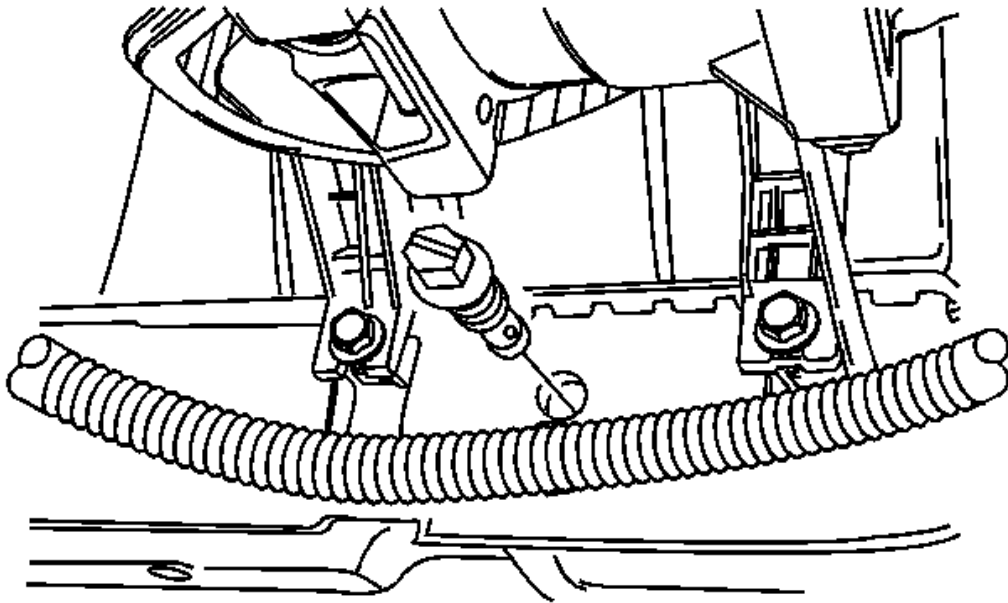


Fig. 94: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

1. Remove the fuel pump fuse.
2. Start the engine. After it stalls, crank the engine for 10 seconds to rid the fuel system of fuel pressure.
3. Remove the hood. Refer to **Hood Replacement** .
4. Drain the engine oil.

CAUTION: Refer to **Battery Disconnect Caution** .

5. Disconnect the negative battery cable.

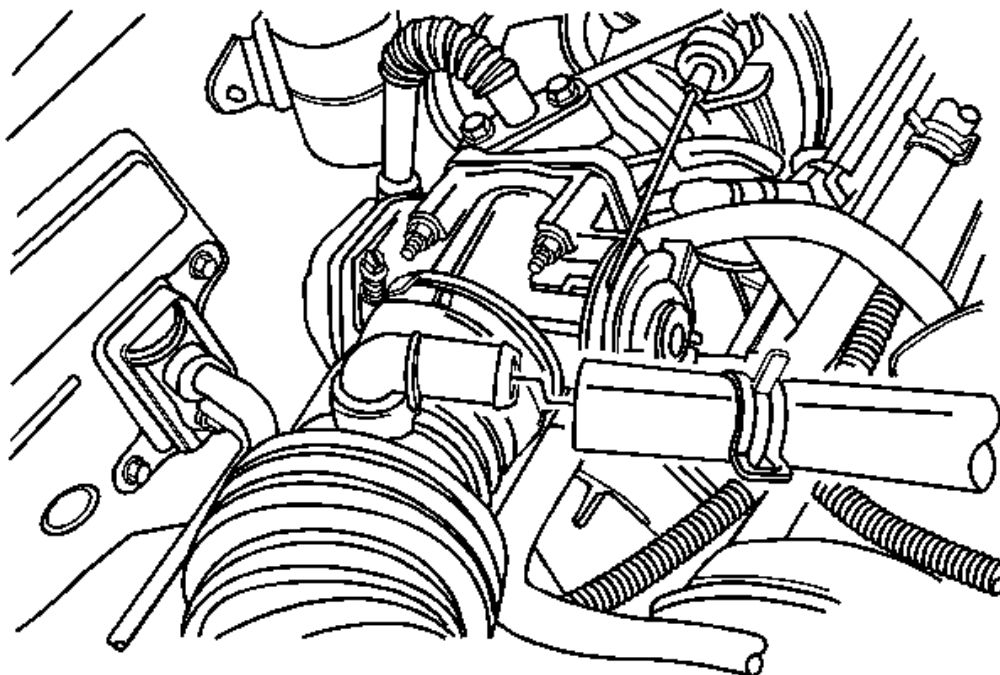


Fig. 95: View Of Air Cleaner Outlet Hose
Courtesy of GENERAL MOTORS CORP.

6. Remove the air cleaner outlet hose from the throttle body and air cleaner housing.
7. Disconnect the breather tubes from the camshaft cover.
8. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** .
9. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** .
10. Remove the right front wheel well splash shield.

CAUTION: Refer to Safety Glasses Caution .

11. Drain the engine coolant. Refer to **Cooling System Draining and Filling (Gasoline Engines)** .
12. Remove the cooling system radiator and the engine cooling fans. Refer to **Radiator Replacement (Gasoline Engines)** and **Engine Cooling Fan Replacement (Gasoline Engines)** .

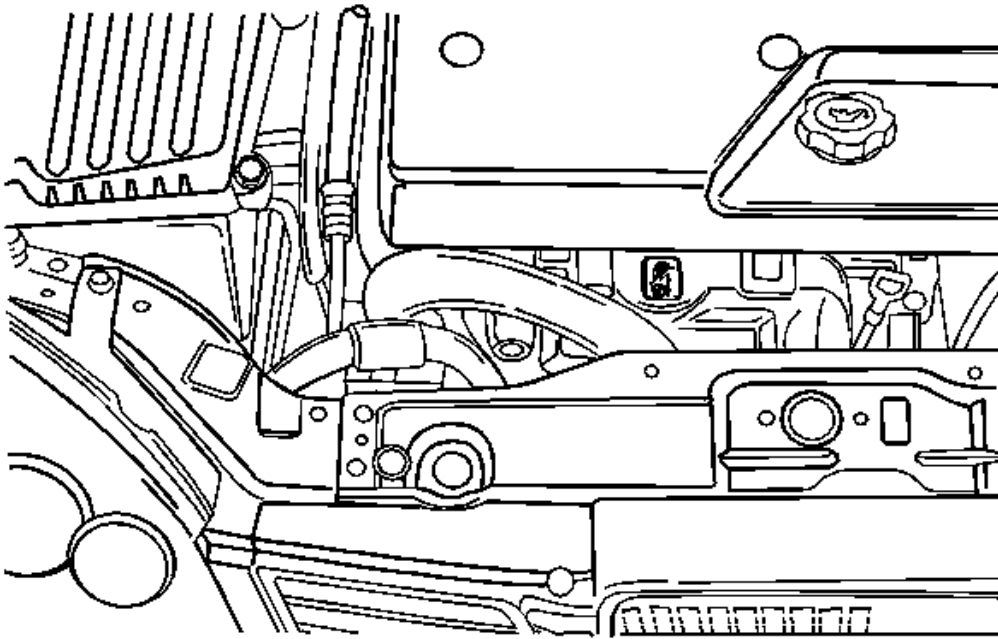


Fig. 96: Identifying Upper Thermostat Hose
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the upper radiator hose from the thermostat housing.
14. Disconnect the power steering return hose from the power steering pump.
15. Disconnect the power steering pressure hose from the power steering pump.
16. Disconnect the electrical connector at the direct ignition system coil and the electronic control module (ECM) ground terminal at the intake manifold and at the starter motor.

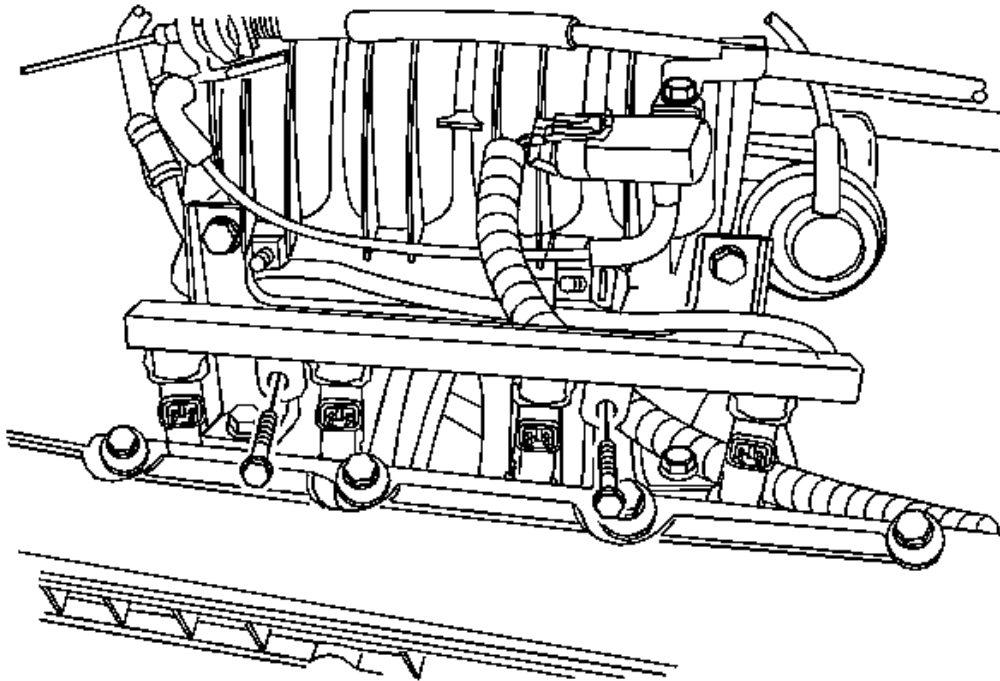


Fig. 97: View Of Fuel Rail And Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Oxygen Sensor Notice .

17. Disconnect the oxygen (O₂) sensor connector, if equipped.
18. Disconnect the fuel injector harness connectors.
19. Disconnect the intake air temperature (IAT) and manifold absolute pressure (MAP) sensor connectors.
20. Disconnect the throttle position (TP) sensor connector.
21. Disconnect the generator voltage regulator connector and power lead.
22. Remove the electrical harness clamp bolt.

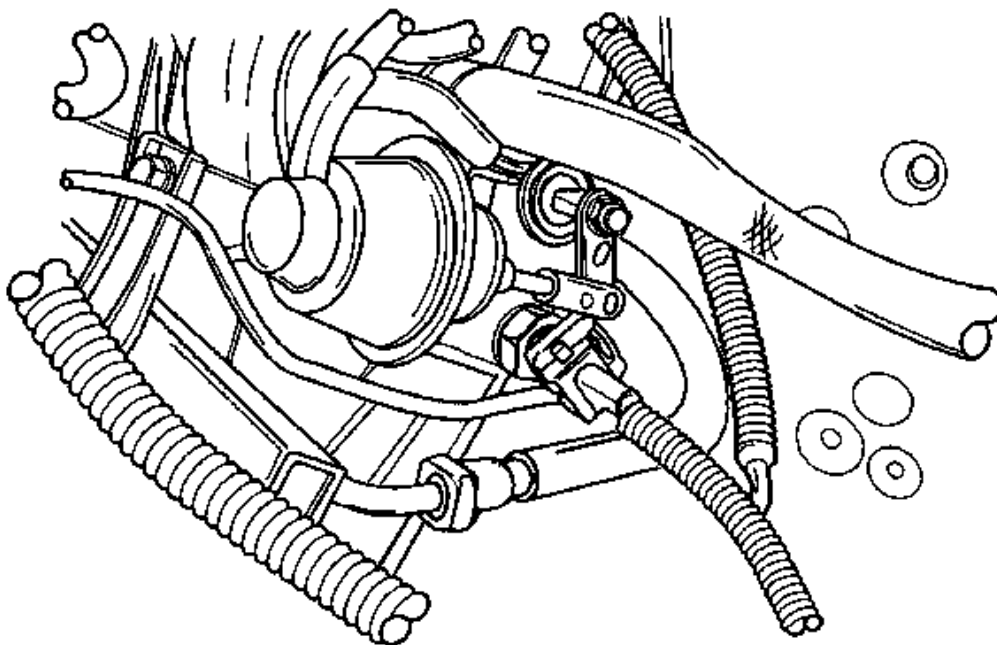


Fig. 98: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

23. Disconnect all of the necessary vacuum lines, including the brake booster vacuum hose.
24. Disconnect the fuel feed line at the fuel rail.
25. Disconnect the throttle cable from the throttle body and the intake manifold bracket.

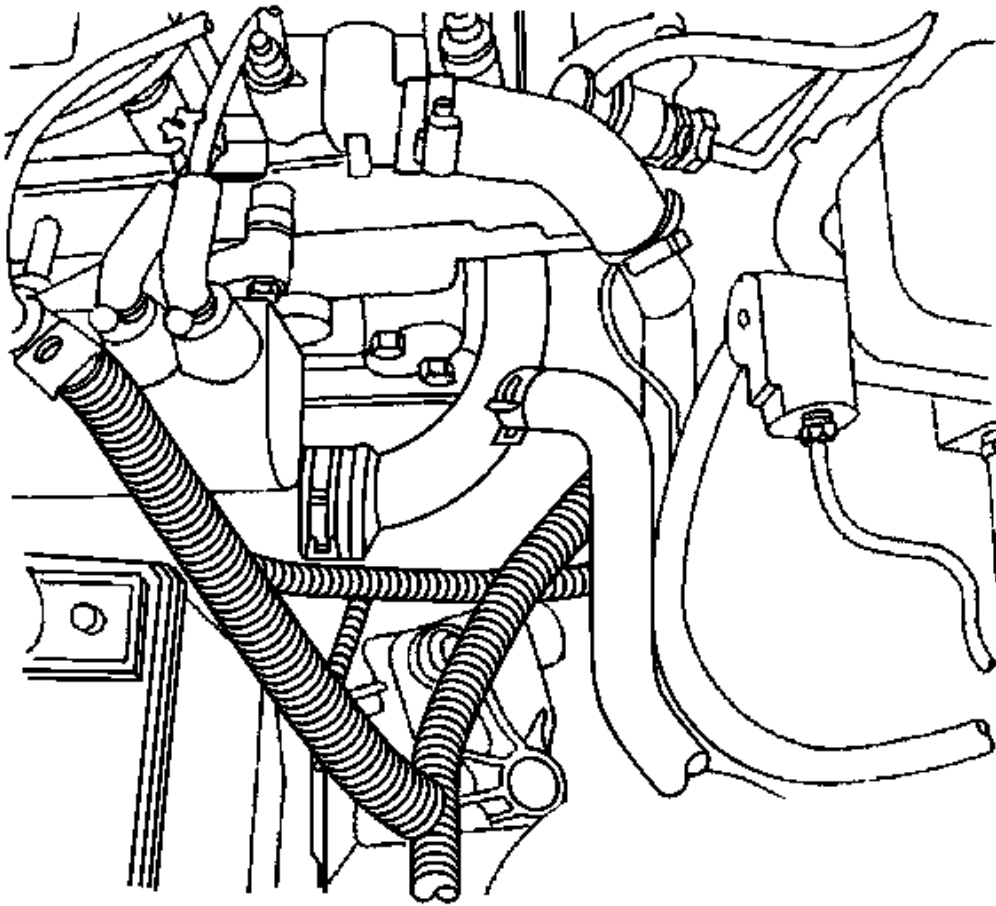


Fig. 99: Identifying Surge Tank Coolant Hose
Courtesy of GENERAL MOTORS CORP.

26. Disconnect the surge tank coolant hose at the throttle body.
27. Disconnect the heater outlet hose at the coolant pipe.
28. Disconnect the heater inlet hose from the cylinder head.
29. Disconnect the surge tank coolant hose from the coolant pipe.
30. Disconnect the lower radiator hose from the coolant pipe. Disconnect the starter solenoid "S" terminal wire. Remove the A/C compressor, if equipped.

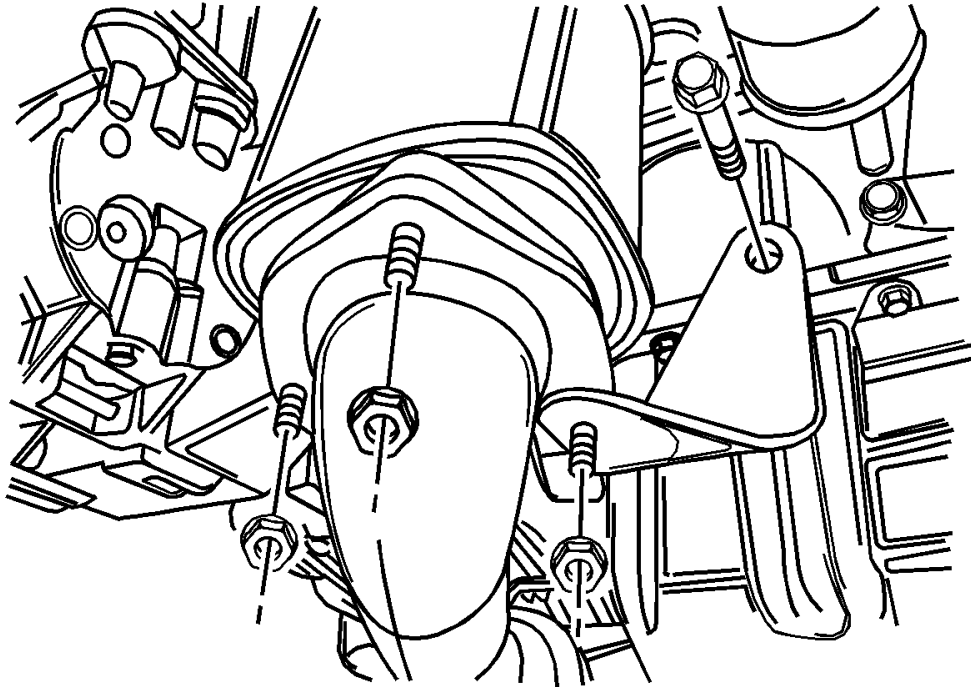


Fig. 100: View Of Exhaust Pipe Catalytic Converter Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

31. Remove the catalytic converter retaining nuts from the exhaust pipe.
32. Remove the exhaust pipe.

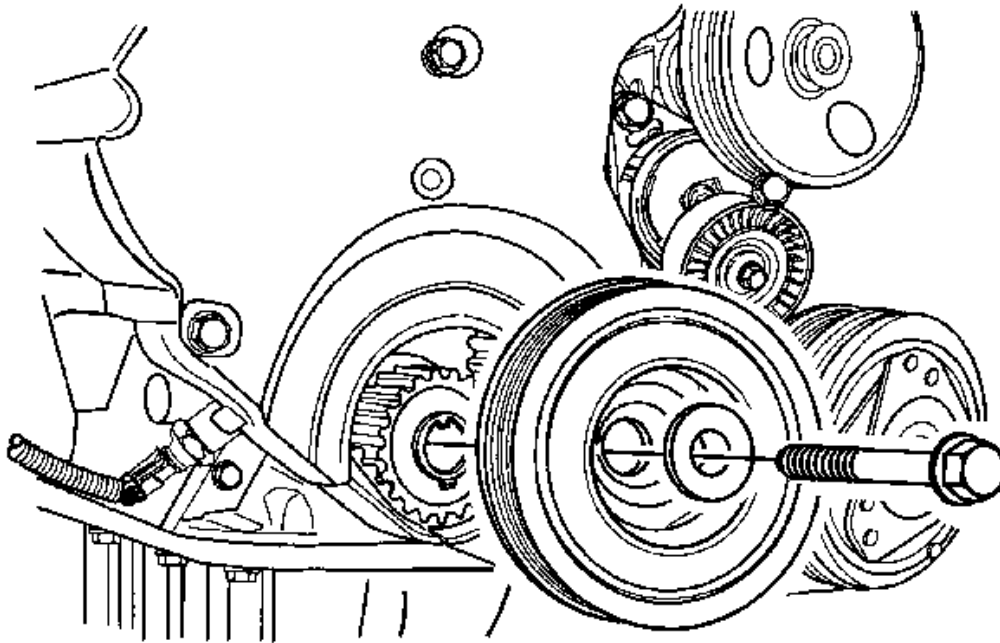


Fig. 101: Identifying Crankshaft Pulley And Bolt
Courtesy of GENERAL MOTORS CORP.

33. Remove the crankshaft pulley bolt.
34. Remove the crankshaft pulley.
35. Disconnect the vacuum lines at the charcoal canister purge solenoid.
36. Disconnect the electrical connector at the charcoal canister purge (CCP) solenoid and at the knock sensor.
37. Disconnect the electrical connector at the oil pressure switch and at the exhaust gas recirculation (EGR) solenoid.
38. Disconnect the crankshaft position (CKP) sensor connector.

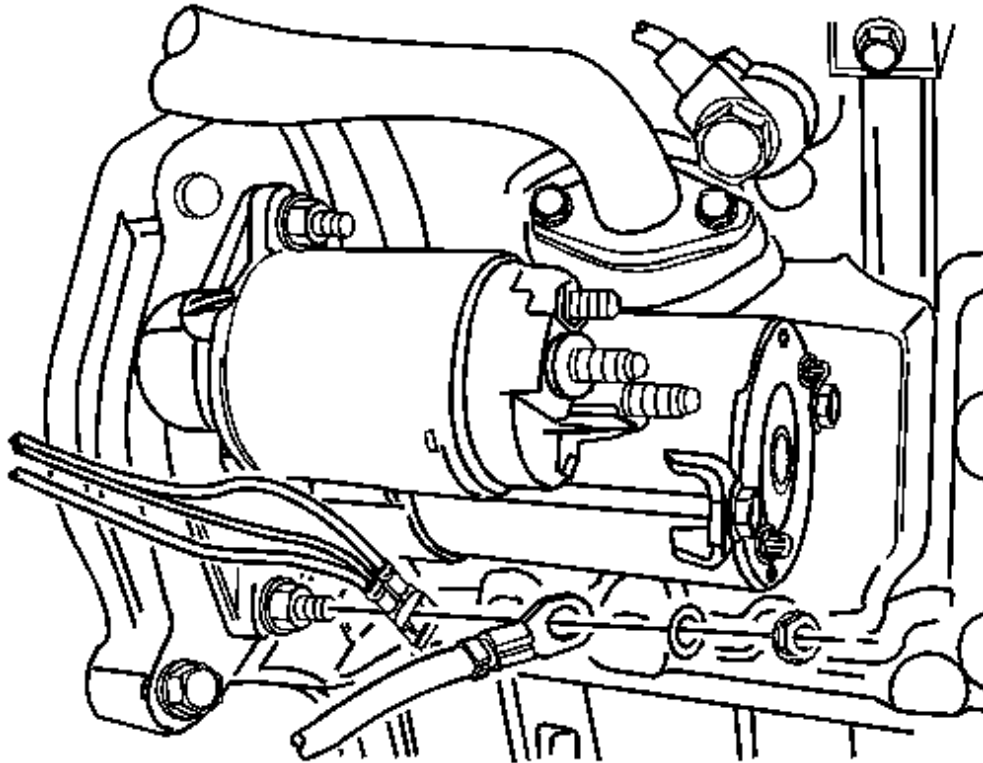


Fig. 102: View Of Starter Motor And Bolts
Courtesy of GENERAL MOTORS CORP.

39. Remove the transaxle torque converter bolts, if automatic transaxle equipped.
40. Remove the starter motor. Refer to **Starter Motor Replacement (1.4L/1.6L)** .
41. Remove the transaxle bell housing bolts.
42. Support the transaxle with a floor jack.
43. Install the engine lifting device.

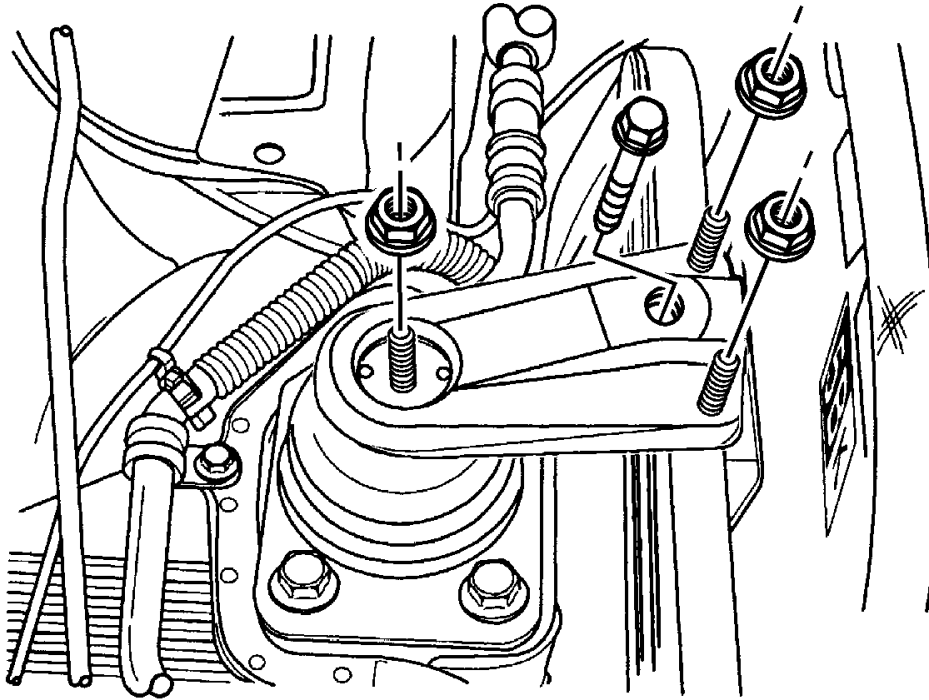


Fig. 103: View Of Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

44. Disconnect the right engine mount bracket from the engine mount and the engine by removing the attaching bolts and the nuts.
45. Remove the right engine mount from the engine block. Refer to **Engine Mount Replacement**.
46. Separate the engine block from the transaxle.
47. Remove the engine.

Installation Procedure

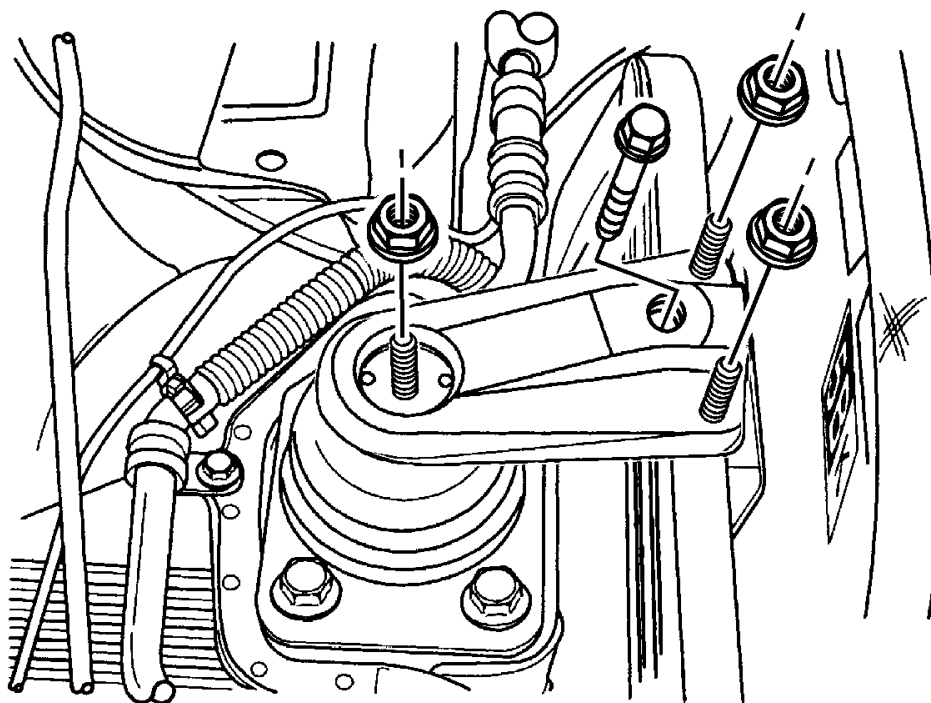


Fig. 104: View Of Engine Mount Bracket Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine into the engine compartment.
2. Align the engine alignment pins to the transaxle.

NOTE: Refer to Fastener Notice .

3. Install the transaxle bell housing bolts.

Tighten: Tighten the transaxle bell housing bolts to **75 N.m (55 lb ft)** .

4. Install the right engine mount to the engine block. Refer to Engine Mount Replacement.
5. Connect the right engine mount bracket to the engine mount and the engine by installing the attaching bolts and the nuts.

Tighten: Tighten the engine mount bracket attaching bolts and the nuts to **55 N.m (41 lb ft)** .

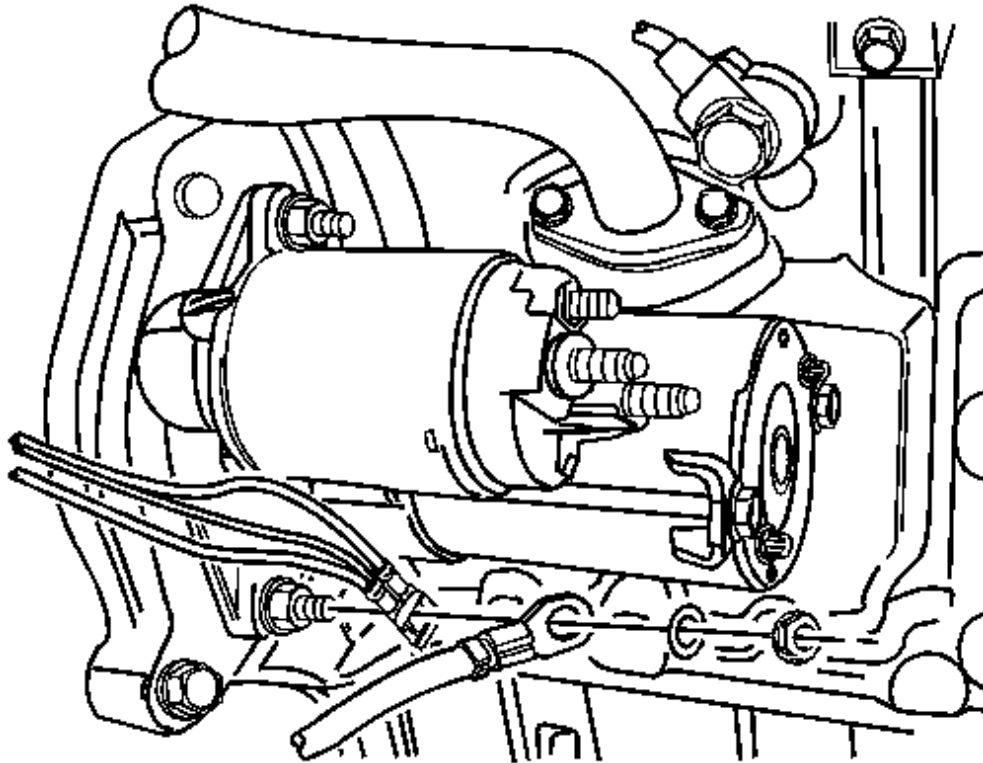


Fig. 105: View Of Starter Motor And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the floor jack used for support of the transaxle.
7. Remove the engine lifting device.
8. Install the transaxle torque converter bolts, if automatic transaxle equipped.

Tighten: Tighten the transaxle torque converter bolts to **45 N.m (33 lb ft)** .

9. Install the starter motor. Refer to **Starter Motor Replacement (1.4L/1.6L)** .

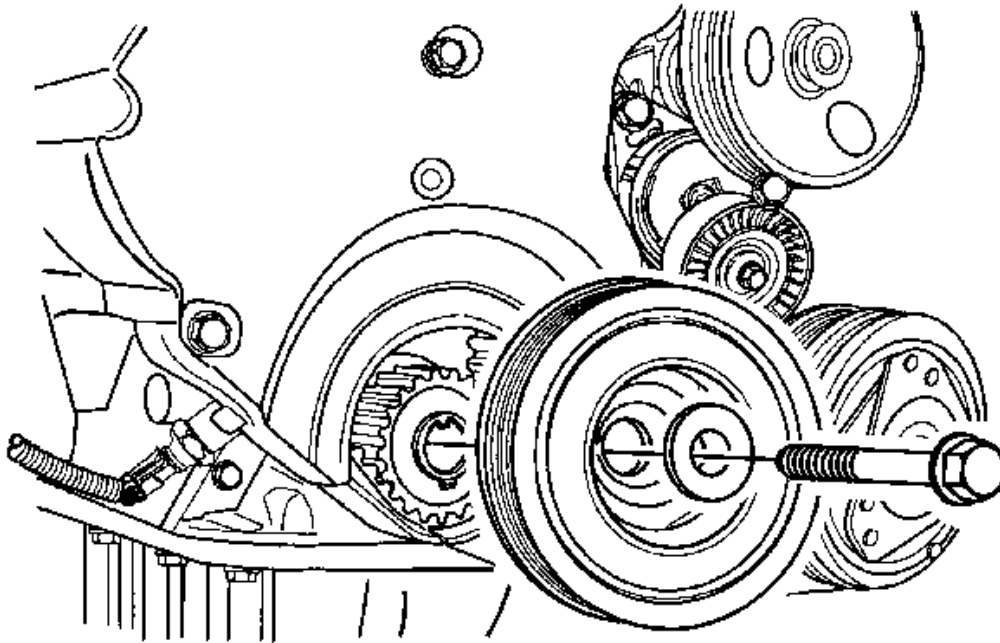


Fig. 106: Identifying Crankshaft Pulley And Bolt
Courtesy of GENERAL MOTORS CORP.

10. Connect the vacuum lines at the CCP solenoid.
11. Connect the electrical connector at the CCP solenoid and at the knock sensor.
12. Connect the oil pressure switch and the EGR solenoid connectors
13. Install the crankshaft pulley.
14. Install the crankshaft pulley bolt.

Tighten: Tighten the crankshaft pulley bolt to **95 N.m (70 lb ft)** and retighten 30 degrees plus 15 degrees.

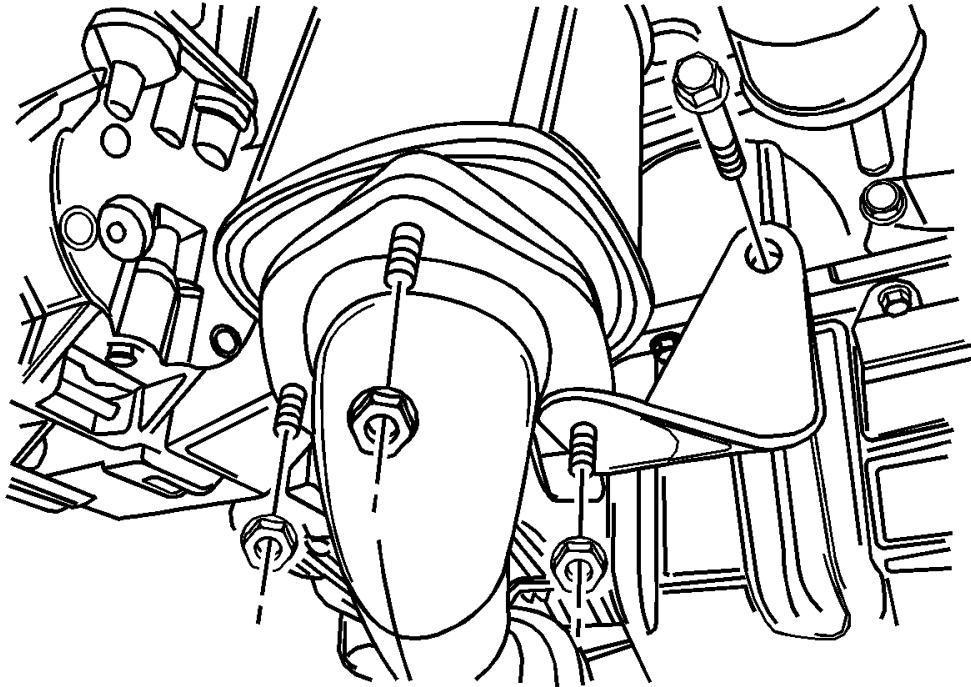


Fig. 107: View Of Exhaust Pipe Catalytic Converter Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

15. Connect the CKP sensor connector.
16. Install the exhaust front pipe.
17. Install the catalytic converter retaining nuts to the exhaust pipe.

Tighten: Tighten the catalytic converter to exhaust pipe retaining nuts to **35 N.m (26 lb ft)** .

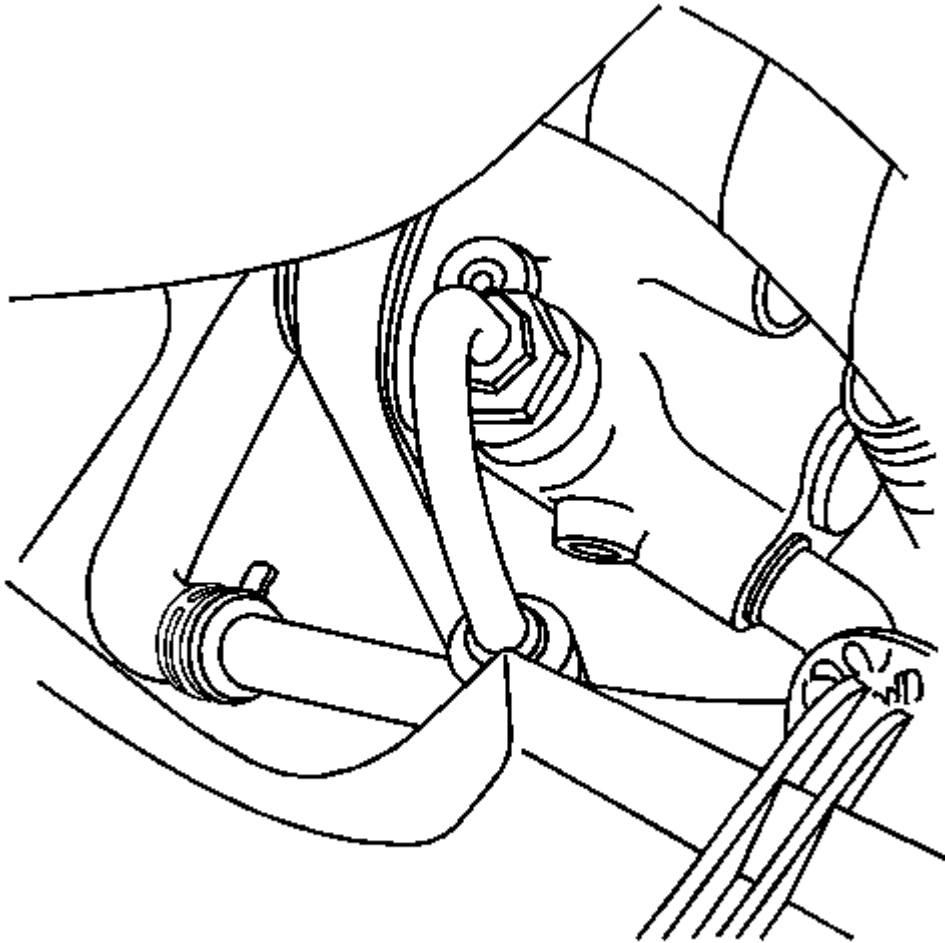


Fig. 108: Identifying Power Steering Pressure Hose
Courtesy of GENERAL MOTORS CORP.

18. Connect the power steering pressure hose.
19. Connect the power steering return hose.
20. Install the A/C compressor, if equipped.

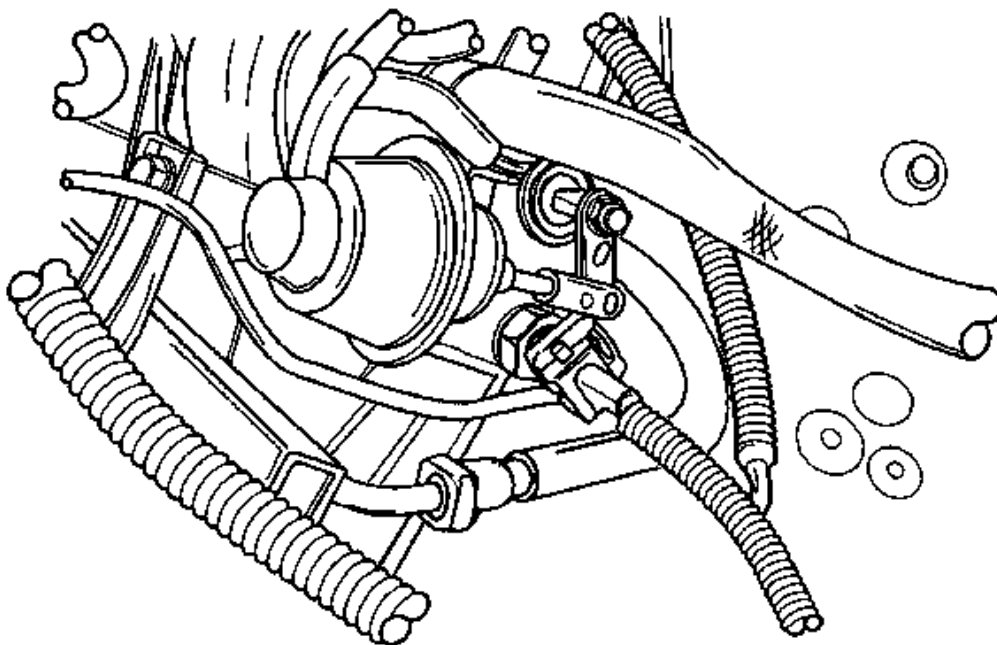


Fig. 109: View Of Brake Booster Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

21. Install the generator. Refer to **Generator Replacement (1.6L)** .
22. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Belt Replacement** .
23. Install the right front wheel well splash shield.
24. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** .
25. Connect the fuel feed line to the fuel rail.
26. Connect all of the necessary vacuum lines, including the brake booster vacuum hose.
27. Connect the O2 sensor connector, if equipped.
28. Connect the starter solenoid "S" terminal wire and power lead.
29. Connect the generator voltage regulator connector and power lead.
30. Connect the ECT sensor connector.
31. Connect the MAP and IAT sensor connectors.
32. Connect the TP sensor connector.

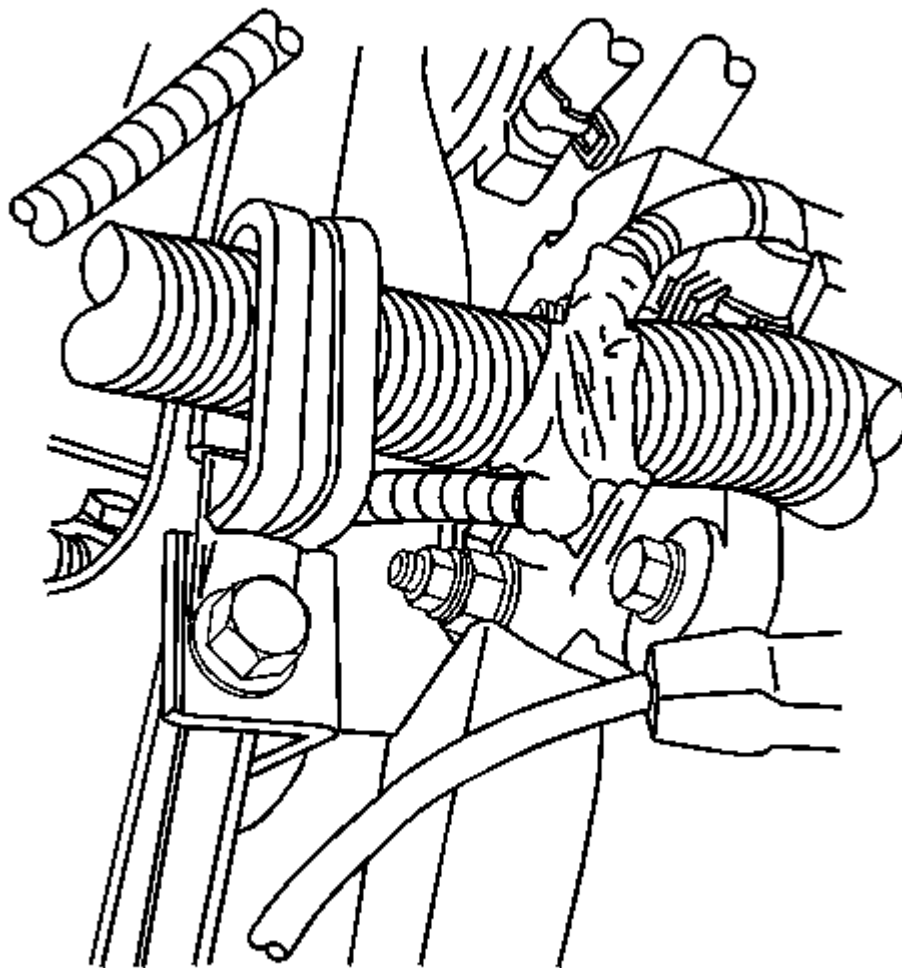


Fig. 110: View Of Electrical Harness Clamp And Bolt
Courtesy of GENERAL MOTORS CORP.

33. Install the electrical wiring harness clamp bolt at the intake manifold support bracket.

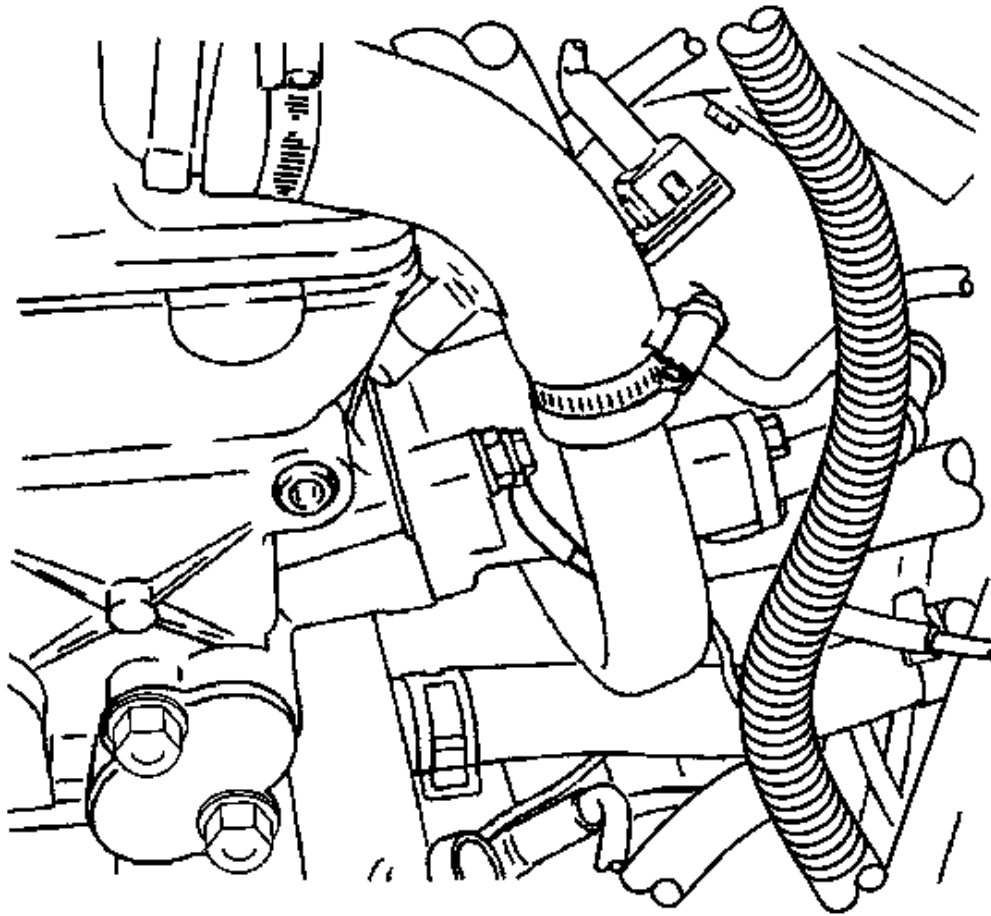


Fig. 111: View Of Air Cleaner Outlet Hose
Courtesy of GENERAL MOTORS CORP.

34. Connect the fuel injector harness connectors.
35. Connect the electrical connector at the direct ignition system coil and the ECM ground terminal at the intake manifold and at the starter.
36. Install the air cleaner outlet hose between the throttle body and the air cleaner housing.
37. Connect the breather tubes to the camshaft cover.
38. Install the cooling system radiator and the engine cooling fans. Refer to **Radiator Replacement (Gasoline Engines)** and **Engine Cooling Fan Replacement (Gasoline Engines)** .

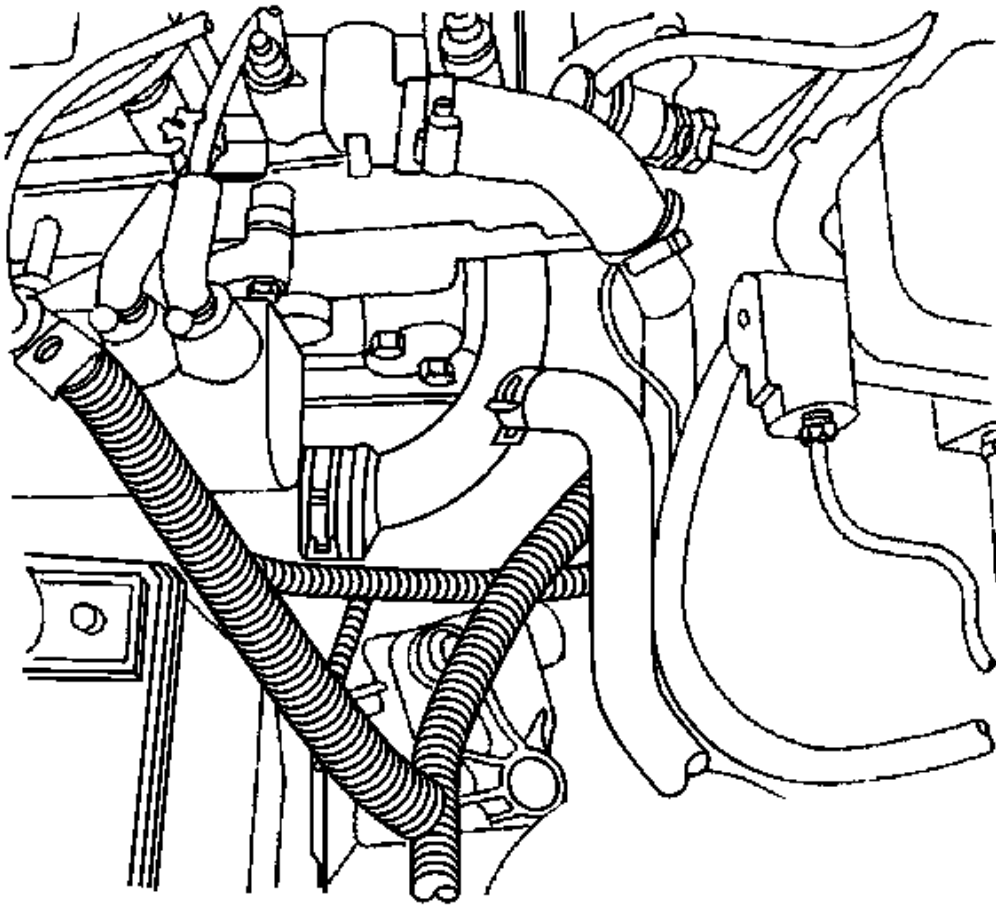


Fig. 112: Identifying Surge Tank Coolant Hose
Courtesy of GENERAL MOTORS CORP.

39. Connect the lower radiator hose to the coolant pipe.
40. Connect the upper radiator hose to the thermostat housing.
41. Connect the surge tank coolant hose to the radiator.
42. Connect the heater inlet hose to the cylinder head.
43. Connect the heater outlet hose to the coolant pipe.
44. Connect the coolant surge tank hose to the coolant pipe.
45. Connect the surge tank coolant hose to the throttle body.

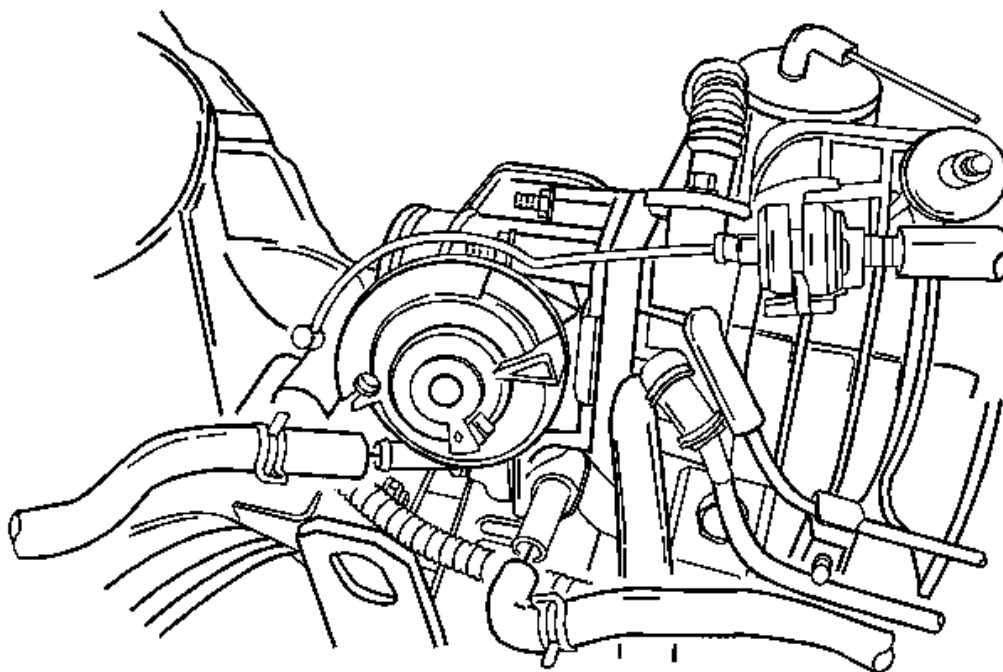


Fig. 113: Identifying Throttle Cable And Coolant Hoses
Courtesy of GENERAL MOTORS CORP.

46. Connect the throttle cable to the throttle body and the intake manifold bracket.
47. Install the fuel pump fuse.
48. Connect the negative battery cable.
49. Refill the engine crankcase with engine oil.
50. Refill the engine coolant system. Refer to **Cooling System Draining and Filling (Gasoline Engines)** .
51. Bleed the power steering system. Refer to **Power Steering System Bleeding** .
52. Refill the A/C refrigerant system, if equipped. Refer to **Refrigerant Recovery and Recharging** .
53. Install the hood. Refer to **Hood Replacement** .

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

1. Raise and properly support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Position an appropriate drain pan under the engine.
3. Remove the oil pan drain plug bolt.

4. Remove the oil filter.

Installation Procedure

NOTE: Refer to **Fastener Notice** .

1. Install the oil filter.

Tighten: Tighten the oil filter to **14 N.m (10 lb ft)** .

2. Discard the used oil pan drain plug washer and replace with a new oil pan drain plug washer.
3. Install the oil pan drain plug bolt.

Tighten: Tighten the oil pan drain plug bolt to **35 N.m (26 lb ft)** .

4. Lower the vehicle.
5. Fill the engine with oil to the appropriate mark.
6. Start engine and inspect for leaks.

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT**Tools Required**

- **J 24086-B** (KM-427) Piston Pin Remover/Installer Set
- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

Removal Procedure

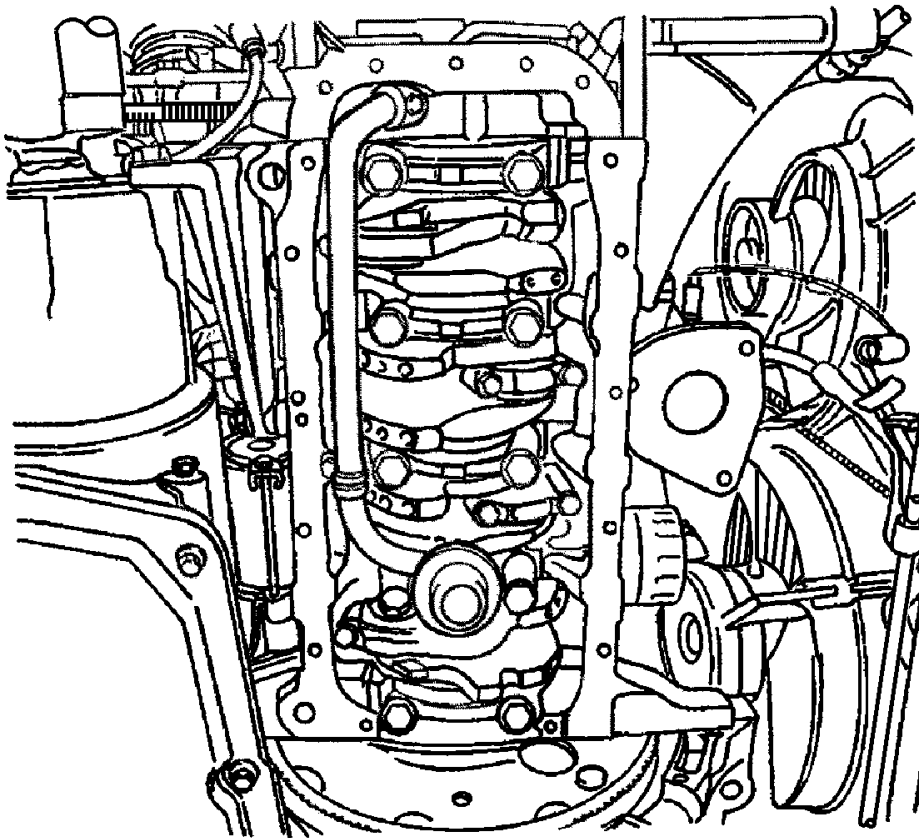


Fig. 114: View Of Oil Suction Pipe And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Cylinder Head Replacement**.
2. Remove the oil pan. Refer to **Oil Pan Replacement**.
3. Remove the oil suction pipe bolts.
4. Remove the oil suction pipe.
5. Move the piston to the bottom of the piston stroke.
6. Mark the connecting rod cap for position.

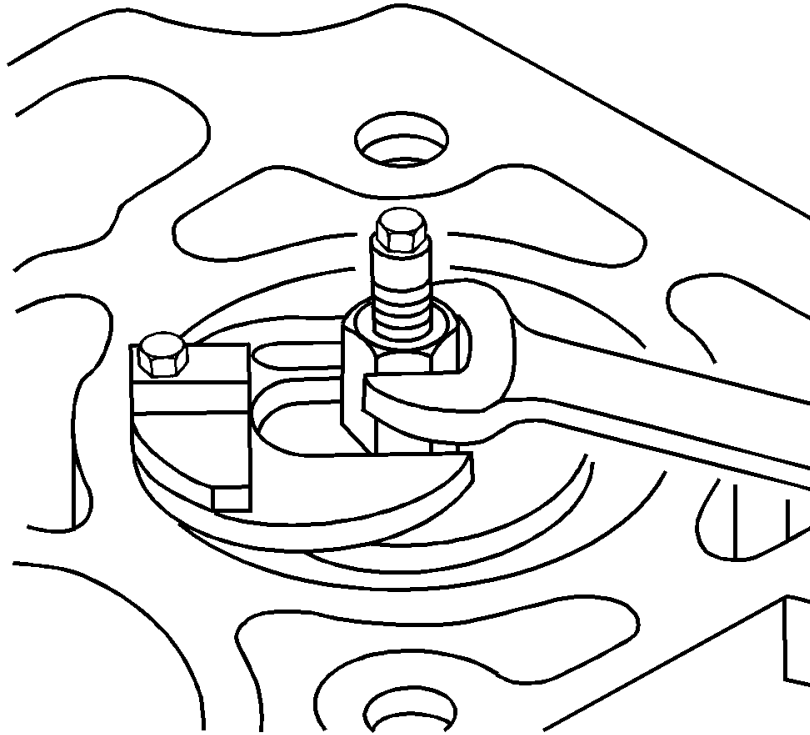


Fig. 115: View Of Connecting Rod Cap Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the connecting rod cap bolts.
8. Remove the connecting rod cap and the lower connecting rod bearing.
9. Remove the upper piston connecting rod bearing.
10. Ridge ream the cylinder wall.

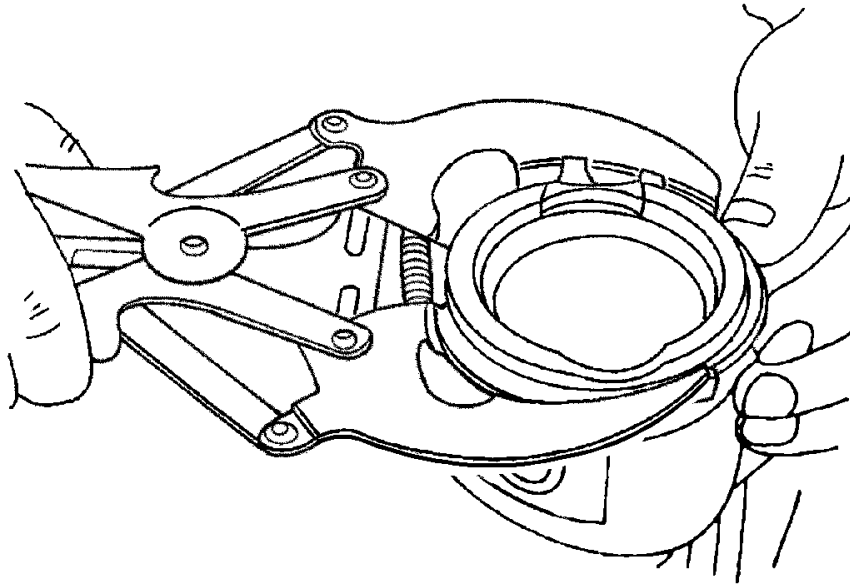


Fig. 116: Expanding Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

11. Remove the piston.
12. Use a piston ring expander tool to expand the piston rings.
13. Remove the piston rings.

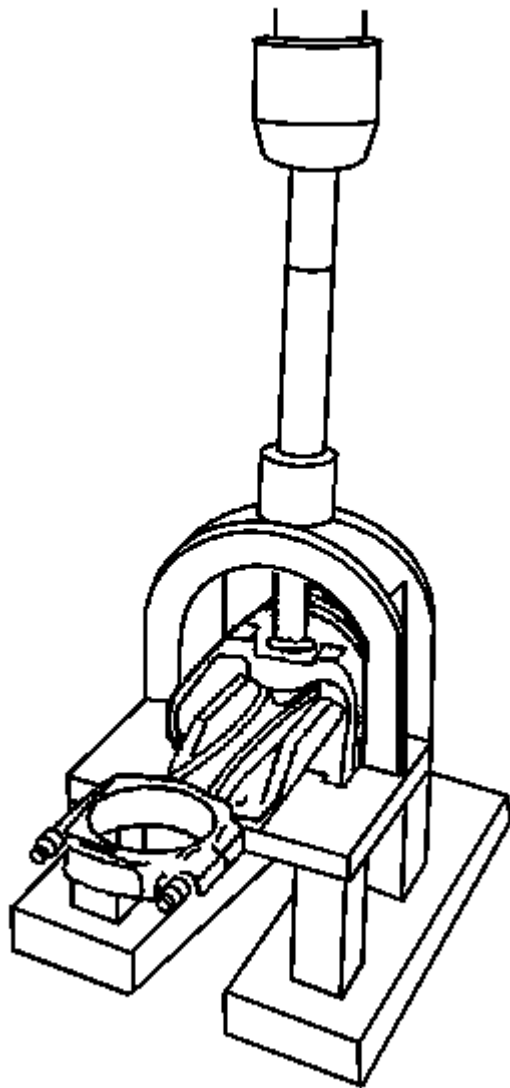


Fig. 117: View Of Piston Pin Removal Tool J 24086-B
Courtesy of GENERAL MOTORS CORP.

14. Remove the piston pin from the piston and connecting rod assembly using **J 24086-B**.
15. Separate the piston from the connecting rod.

Installation Procedure

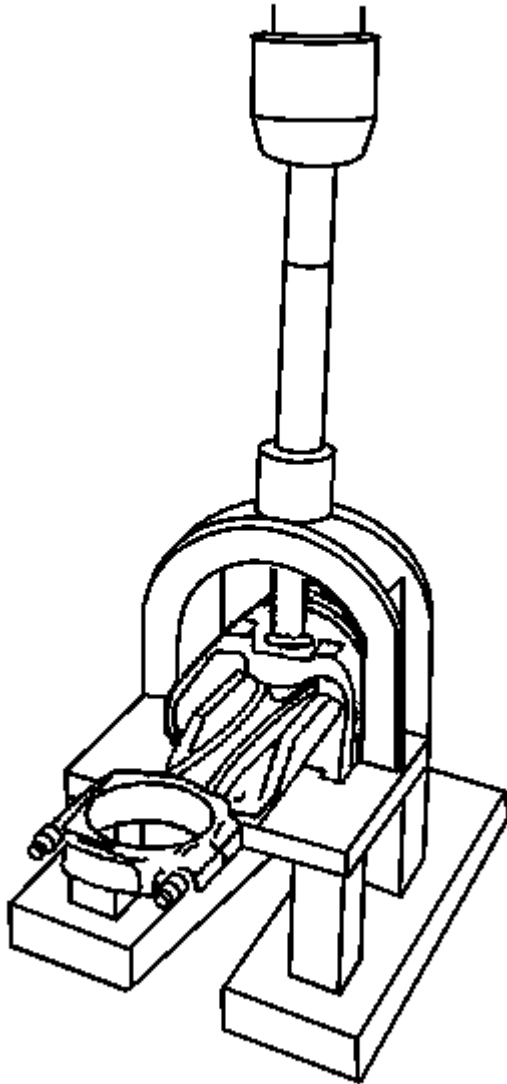


Fig. 118: View Of Piston Pin Removal Tool J 24086-B
Courtesy of GENERAL MOTORS CORP.

1. Align the notch on the piston and the connecting rod so that the proper sides will be facing the front of the engine.
2. Install the piston pin guide through the piston and the connecting rod.
3. Coat the piston pin with clean oil.
4. Install the piston pin into the opposite side of the piston.

5. Install the piston pin into the piston and connecting rod assembly using **J 24086-B**.
6. Select a set of new piston rings.

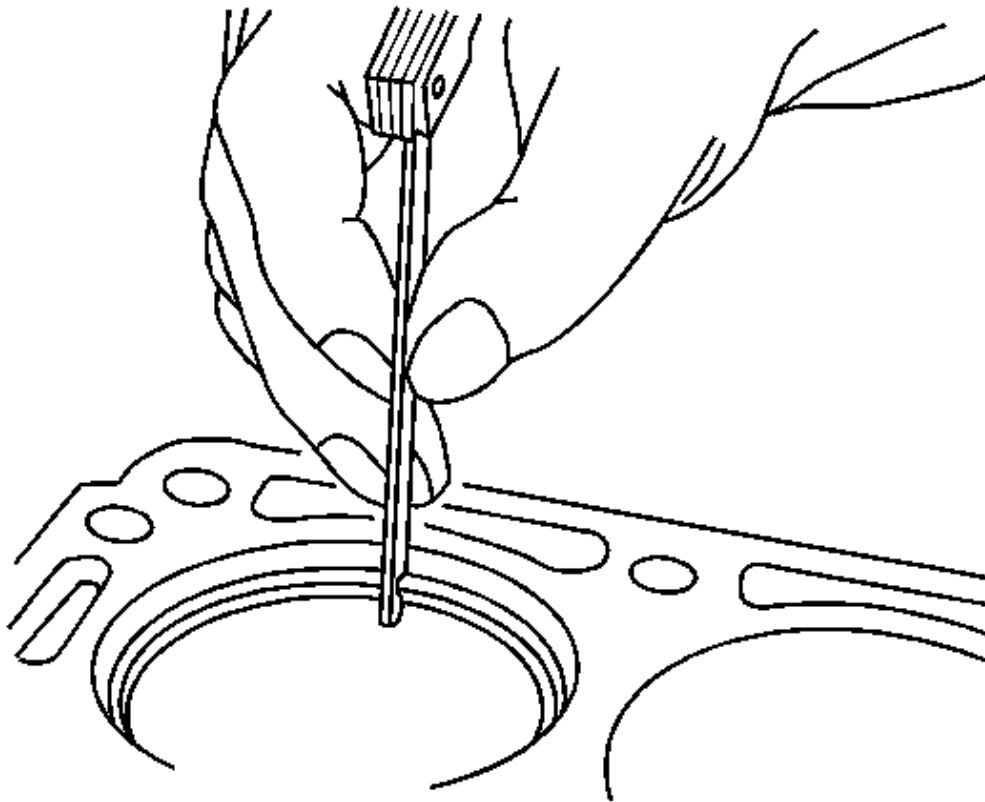


Fig. 119: Measuring Piston Ring Gap
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring gap using a feeler gauge. Refer to **Engine Mechanical Specifications**.
8. Increase the piston ring gap by carefully filing off excess material if the piston ring gap is below specifications.

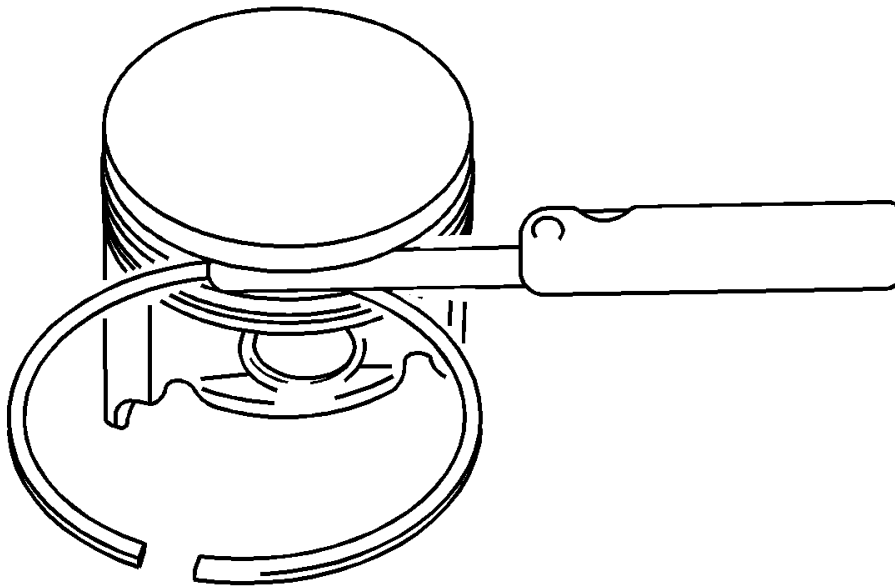


Fig. 120: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

9. Measure the piston ring side clearance using a feeler gage. Refer to **Engine Mechanical Specifications**.
10. If the piston ring is too thick, try another piston ring.
11. If no piston ring can be found that fits to specifications, the piston ring may be ground to size with emery paper placed on a sheet of glass.

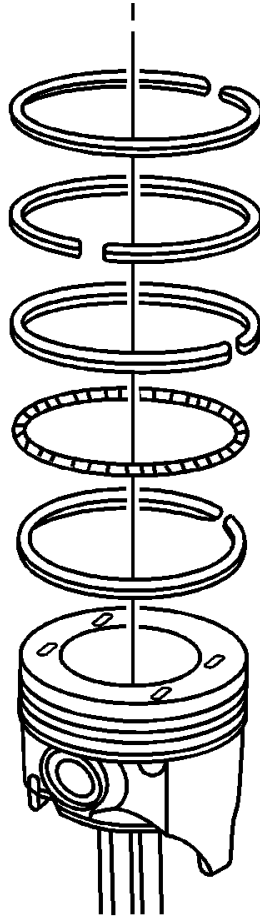


Fig. 121: Installing Piston Oil Rings, Second Compression Ring And Top Compression Ring
Courtesy of GENERAL MOTORS CORP.

12. Install a piston oil ring, the expander, then the second piston oil ring to the bottom ring groove of the piston.
13. Install the second compression ring to the middle ring groove of the piston.
14. Install the top compression ring to the top ring groove of the piston.

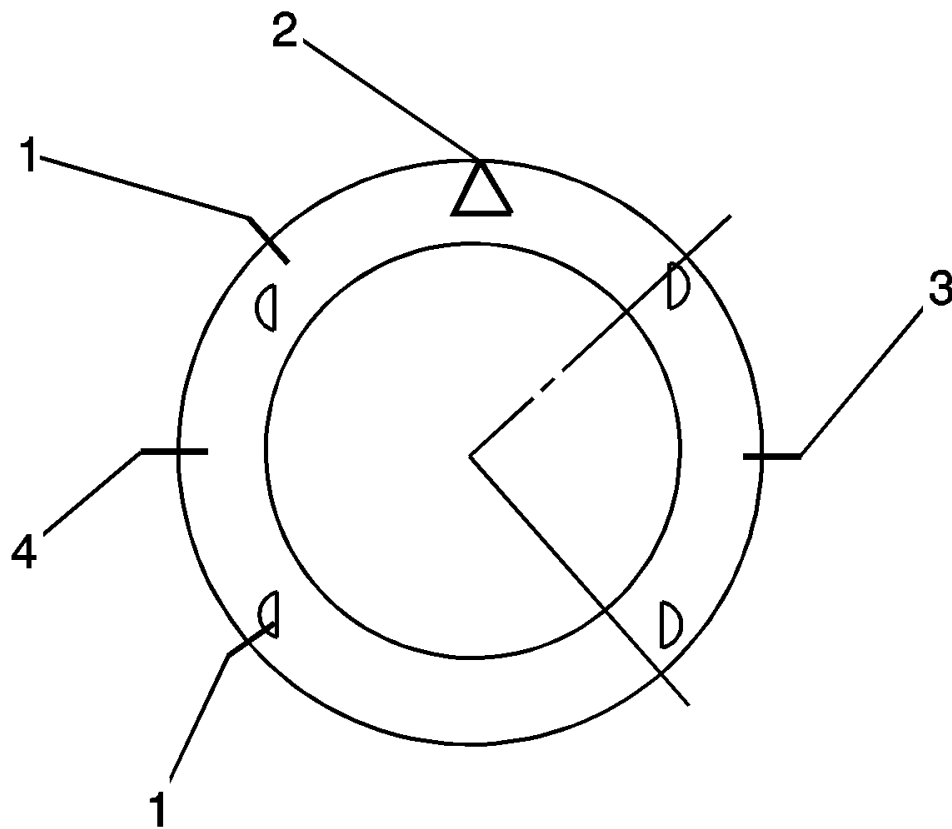


Fig. 122: View Of Piston Oil Rings, Oil Ring Rail Gaps, Second Compression Ring, Top Compression Ring And Piston Top Notch
Courtesy of GENERAL MOTORS CORP.

15. Use a piston ring expander to install the piston rings. Do not expand the piston rings beyond the expansion necessary for installation.
16. Stagger the piston oil rings (3), the oil ring rail gaps (1), the second compression ring (4), and the top compression ring (3) in relation to the notch on the top of the piston (2).

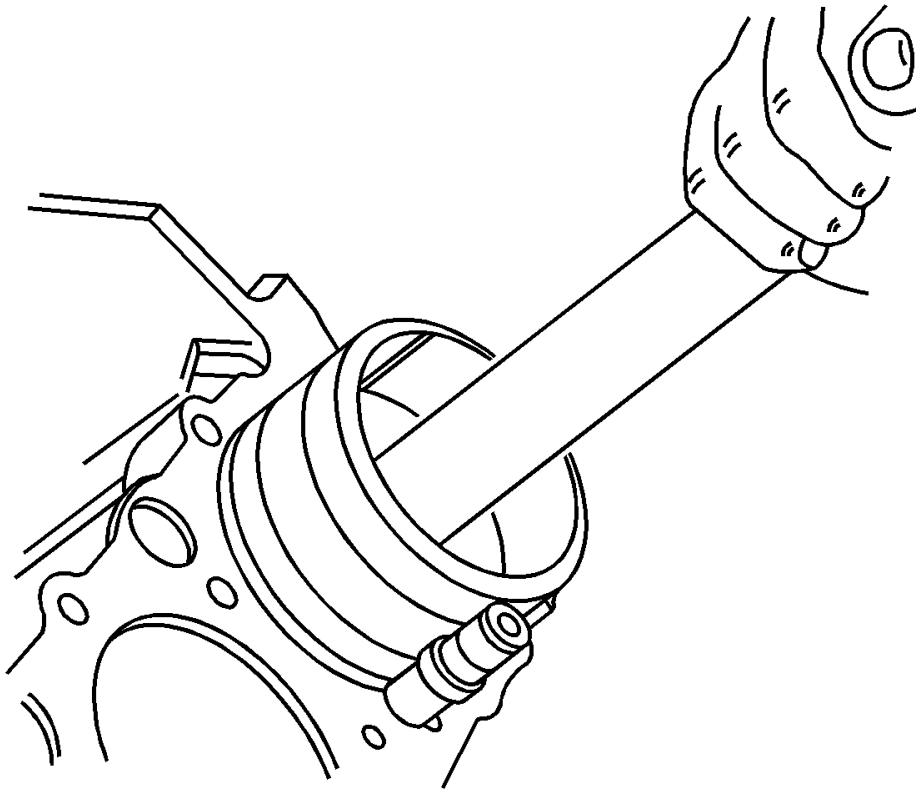


Fig. 123: Installing Piston Using Ring Compressor And Wood Handle
Courtesy of GENERAL MOTORS CORP.

17. Lubricate the cylinder wall and the piston rings with clean engine oil.
18. Install the piston using a ring compressor and a wood handle. Guide the lower connecting rod end to prevent damaging the crankshaft journal.
19. Install the connecting rod cap and bearings. Refer to **Crankshaft and Bearing Cleaning and Inspection.**

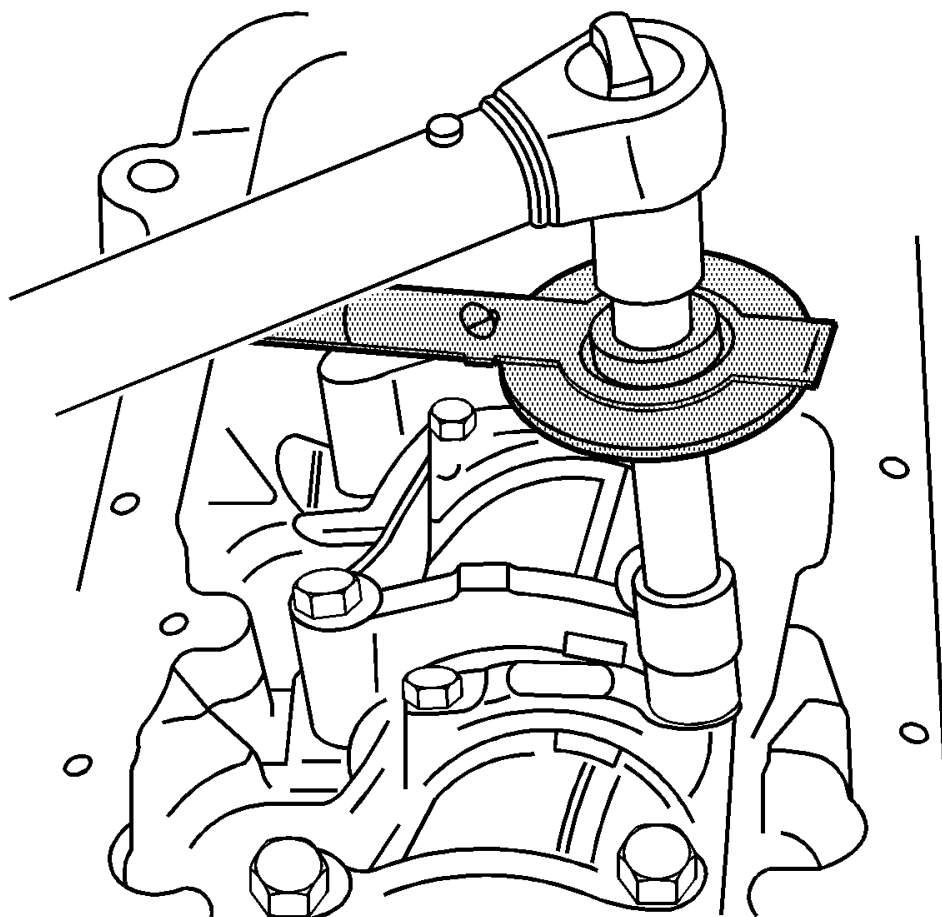


Fig. 124: Identifying J 45059 And KM-470-B
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

20. Install the connecting rod cap bolts using the **J 45059** or the **KM-470-B** .

Tighten: Tighten the connecting rod bearing cap bolts to **25 N.m (18 lb ft)** . Tighten the bolts one turn of 30 degrees plus one turn of 15 degrees.

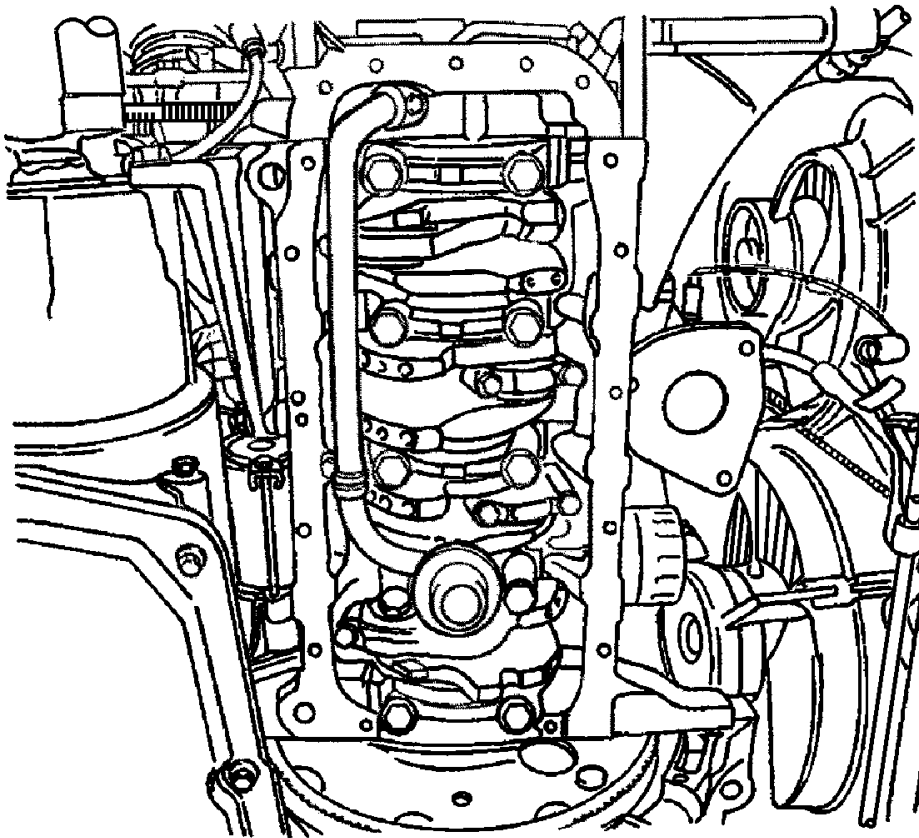


Fig. 125: View Of Oil Suction Pipe And Bolts
Courtesy of GENERAL MOTORS CORP.

21. Install the oil suction pipe.
22. Install the oil suction pipe bolts.

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

23. Install the oil pan. Refer to **Oil Pan Replacement**.
24. Install the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Cylinder Head Replacement**.

CAMSHAFT REPLACEMENT

Removal Procedure

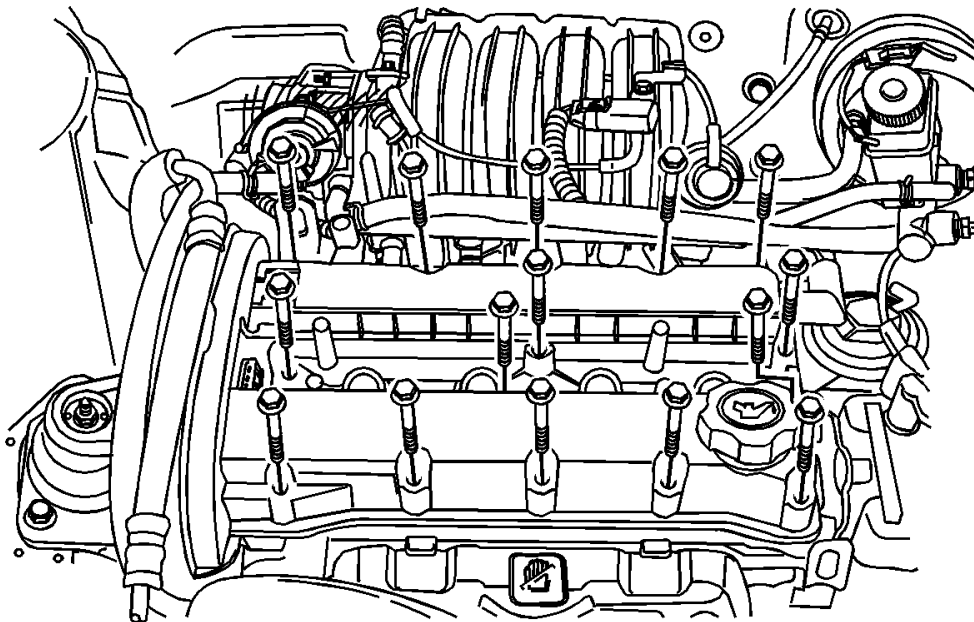


Fig. 126: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Valve Rocker Arm Cover Replacement**.
2. Remove the timing belt. Refer to **Timing Belt Replacement**.

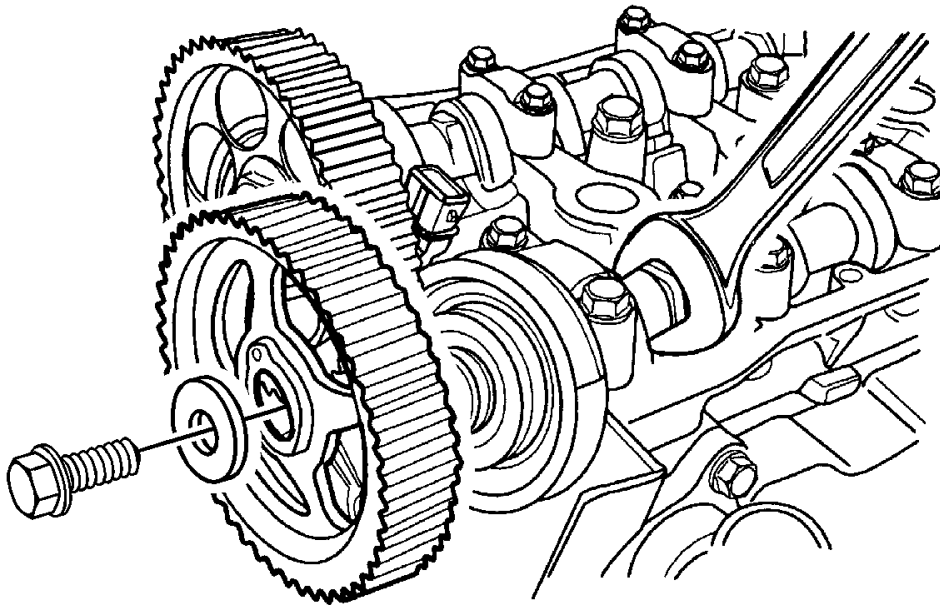


Fig. 127: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

3. While holding the intake camshaft firmly in place, remove the intake camshaft gear bolt and gear.
4. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft gear bolt and gear.

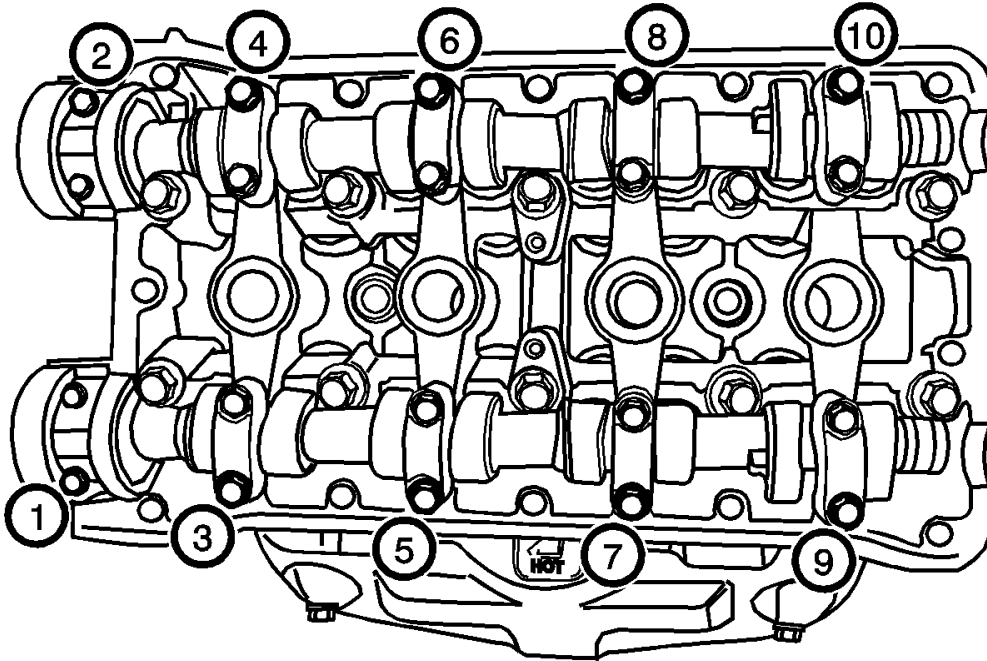


Fig. 128: View Of Camshaft Cap Bolt Sequence
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft cap bolts gradually in the sequence shown for each camshaft cap.

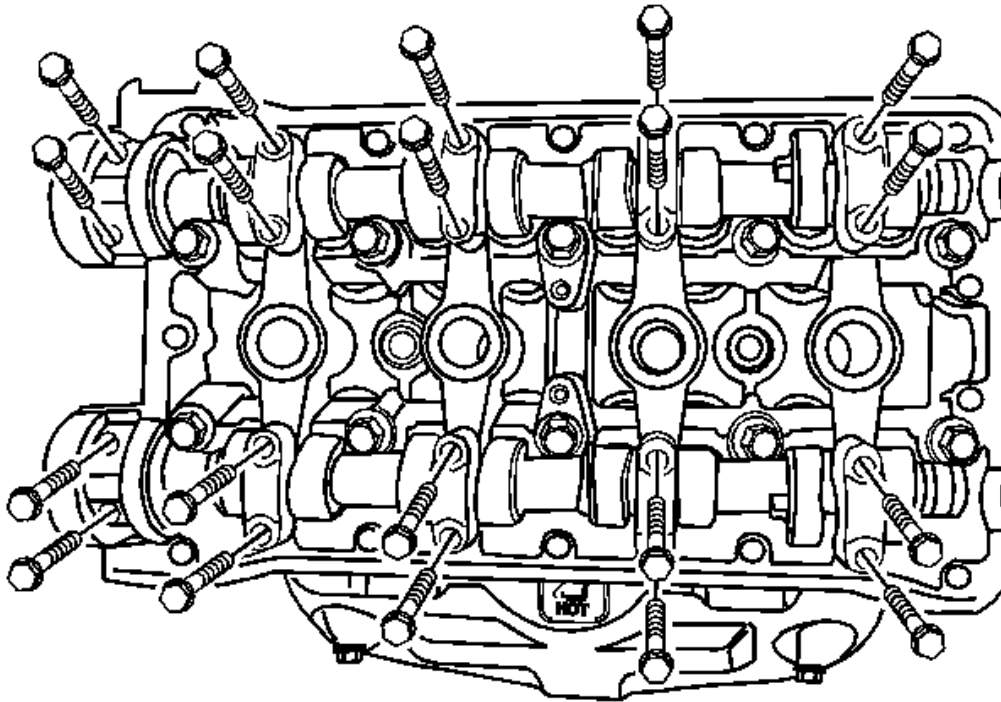


Fig. 129: View Of Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake and exhaust camshaft caps. Maintain the correct positions for installation.

NOTE: Use extreme care when removing the camshaft not to nick, scratch, or damage the camshaft lobes or bearing surfaces.

7. Remove the intake/exhaust camshaft.

Installation Procedure

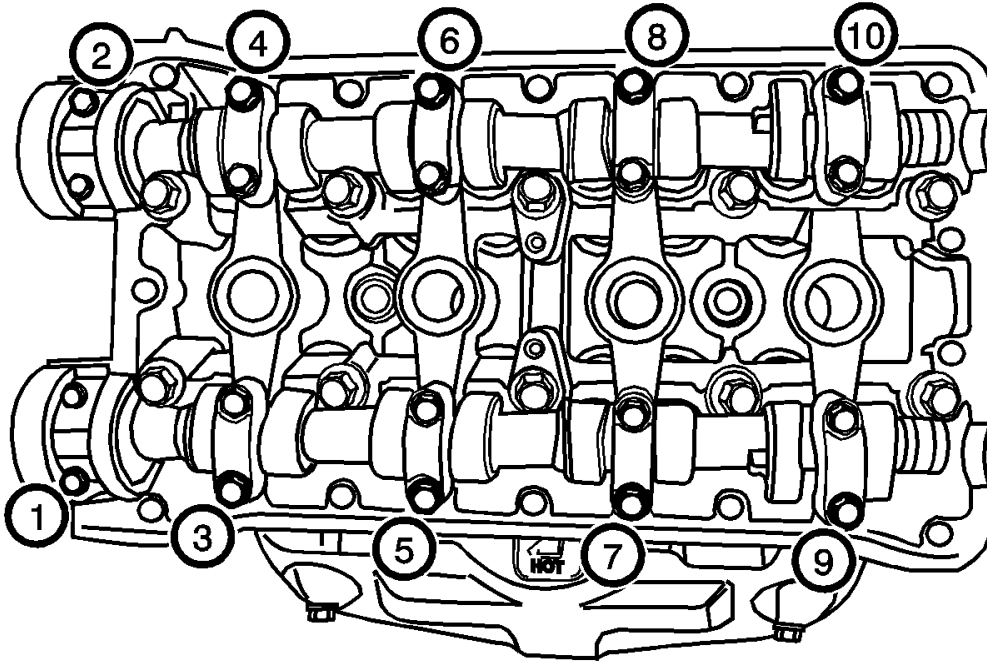


Fig. 130: View Of Camshaft Cap Bolt Sequence
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the camshaft journals and the camshaft caps with engine oil.
2. Install the intake and exhaust camshafts.

NOTE: Refer to Fastener Notice .

3. Install the intake and exhaust camshaft caps in their original positions.

Tighten: Tighten the intake/exhaust camshaft caps bolts to **16 N.m (12 lb ft)** .

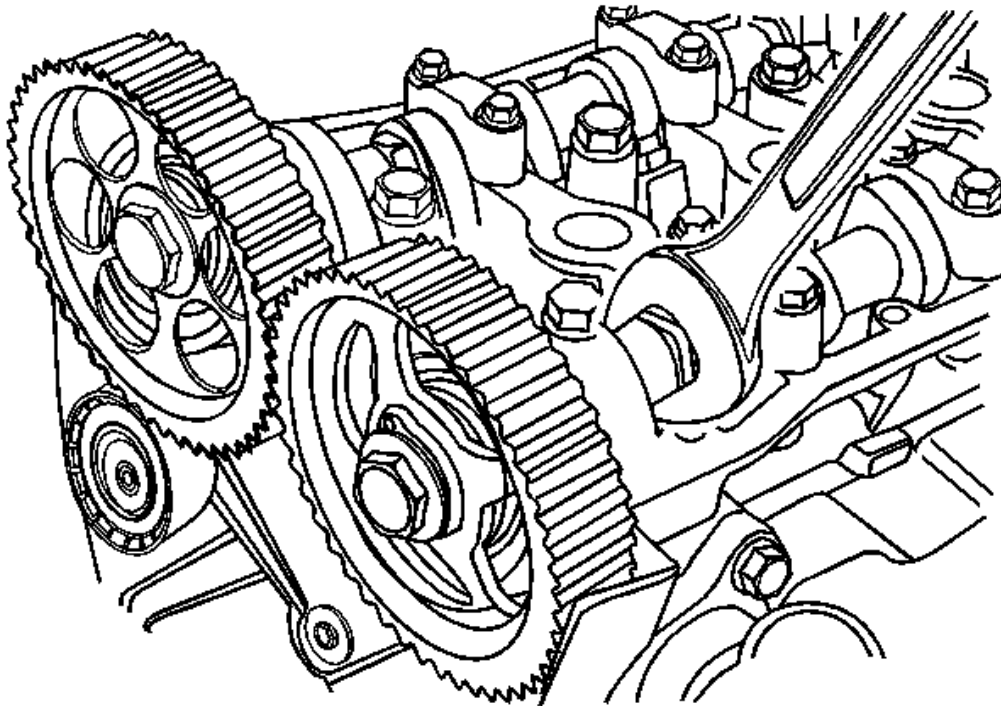


Fig. 131: Holding Camshaft In Place
Courtesy of GENERAL MOTORS CORP.

4. Measure the intake and exhaust camshaft end play. Refer to **Engine Mechanical Specifications**.
5. Install the intake and exhaust camshaft gear.
6. While holding the intake and exhaust camshafts firmly in place, install the intake and exhaust camshaft gear bolts.

Tighten: Tighten the intake and exhaust camshaft gear bolts to **67.5 N.m (49 lb ft)** .

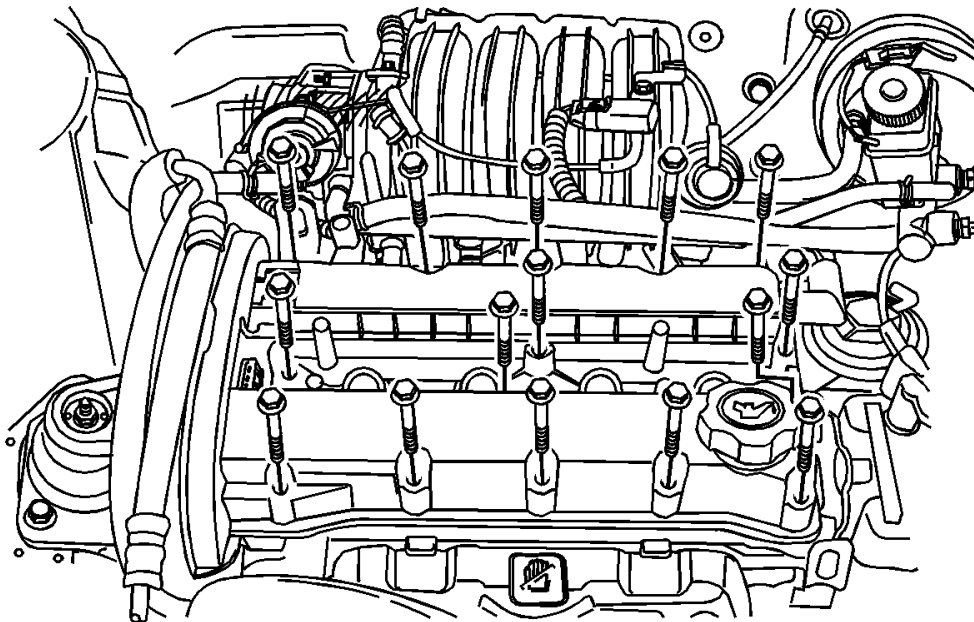


Fig. 132: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the timing belt. Refer to **Timing Belt Replacement**.
8. Install the camshaft cover. Refer to **Valve Rocker Arm Cover Replacement**.

CAMSHAFT GEAR REPLACEMENT

Removal Procedure

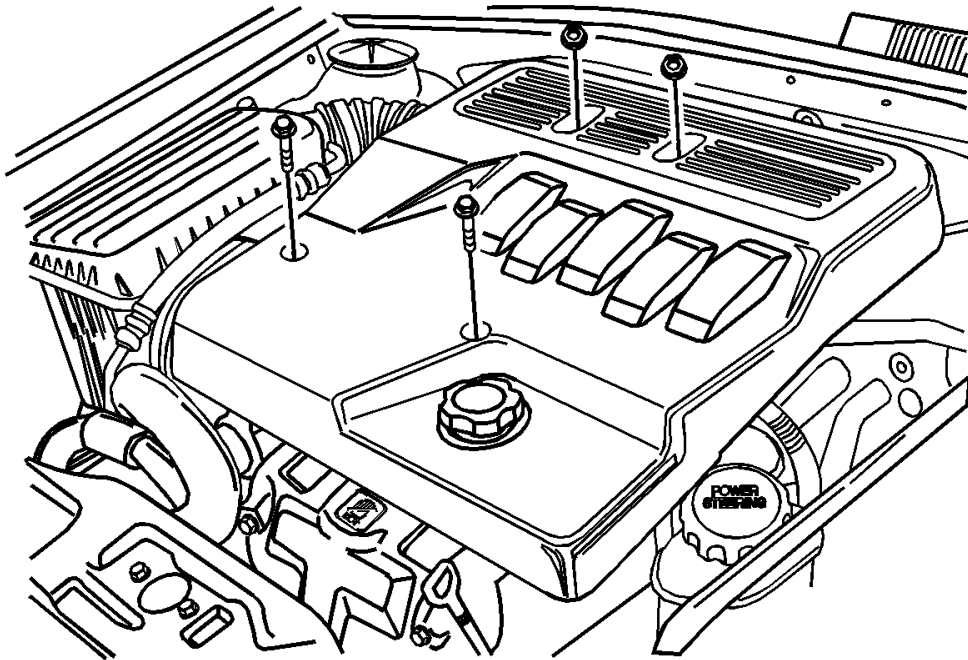


Fig. 133: View Of Engine Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to **Battery Disconnect Caution** .

1. Disconnect the negative battery cable.
2. Remove the engine cover. Refer to **Engine Cover Replacement**.
3. Remove the timing belt. Refer to **Timing Belt Replacement**.
4. Disconnect the ignition wires from the spark plugs.
5. Disconnect the engine ventilation hoses from the camshaft cover.

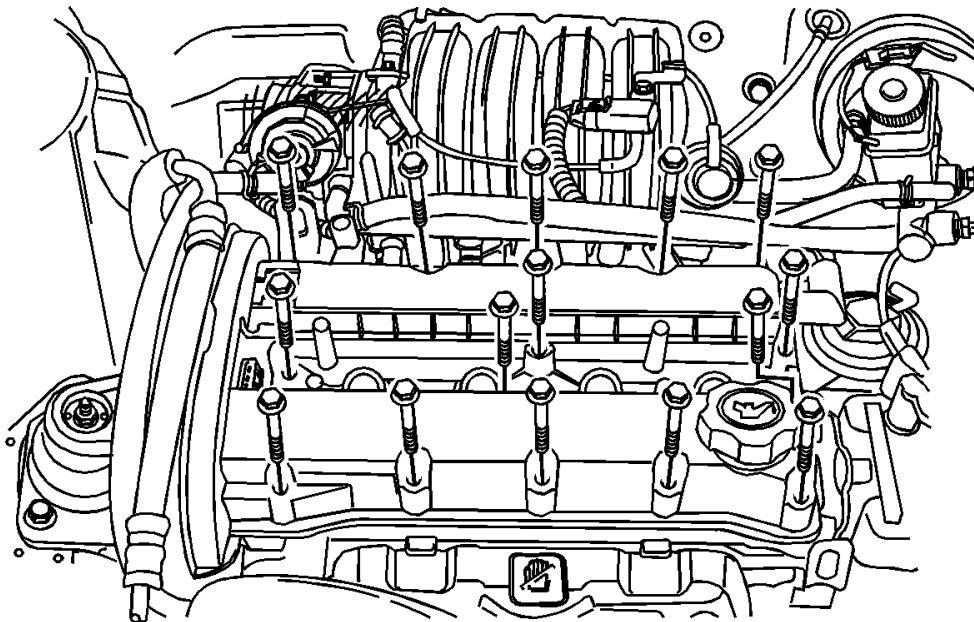


Fig. 134: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the camshaft cover bolts.
7. Remove the camshaft cover and the camshaft cover gasket.

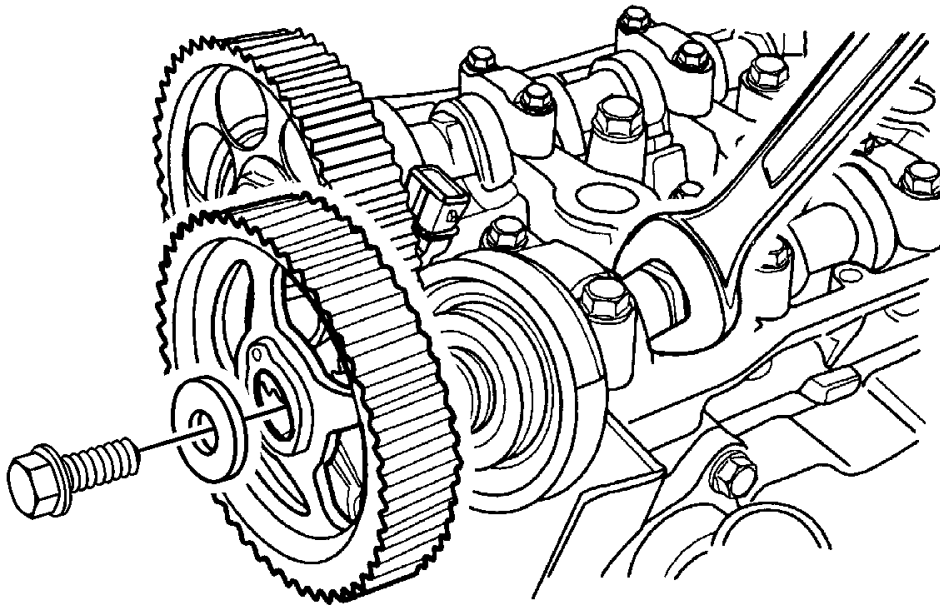


Fig. 135: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

8. While holding the intake camshaft firmly in place, remove the intake camshaft gear bolt.
9. Remove the intake camshaft gear.
10. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft gear bolt.
11. Remove the exhaust camshaft gear.

Installation Procedure

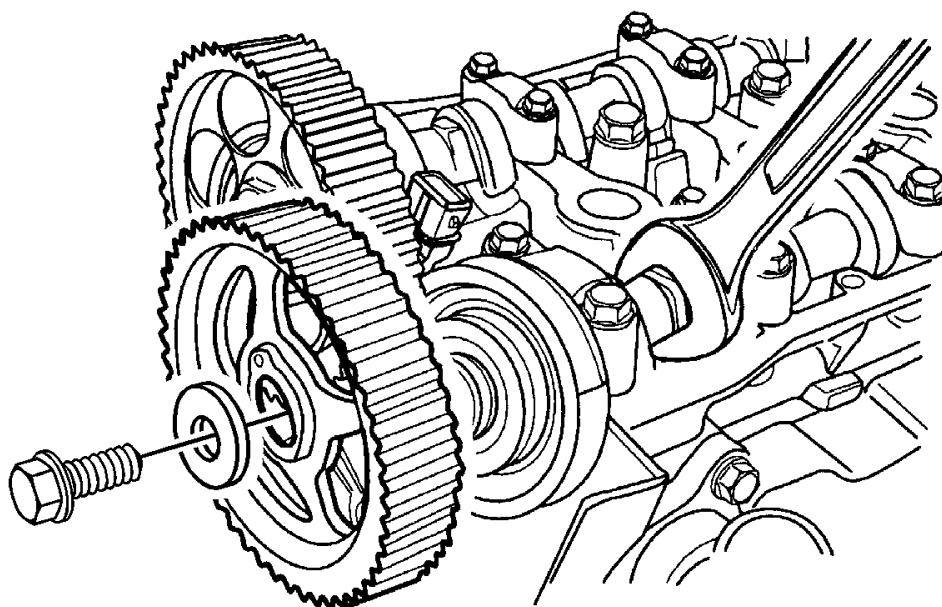


Fig. 136: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts

1. Install the intake camshaft gear.

NOTE: Refer to Fastener Notice .

2. While holding the intake camshaft firmly in place, install the intake camshaft gear bolt.

Tighten: Tighten the intake camshaft gear bolt to **67.5 N.m (49 lb ft)** .

3. Install the exhaust camshaft gear.
4. While holding the exhaust camshaft firmly in place, install the exhaust camshaft gear bolt.

Tighten: Tighten the exhaust camshaft gear bolt to **67.5 N.m (49 lb ft)** .

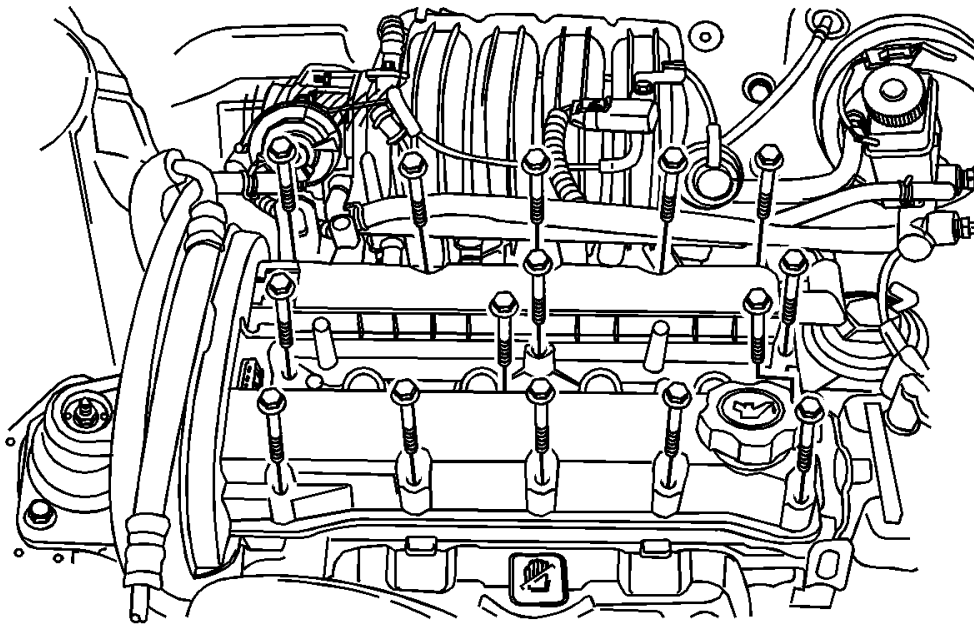


Fig. 137: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

5. Apply a small amount of gasket sealant to the corners of the front camshaft caps and to the top of the rear camshaft cover-to-cylinder head seal.
6. Install the camshaft cover and the camshaft cover gasket.
7. Install the camshaft cover bolts.

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

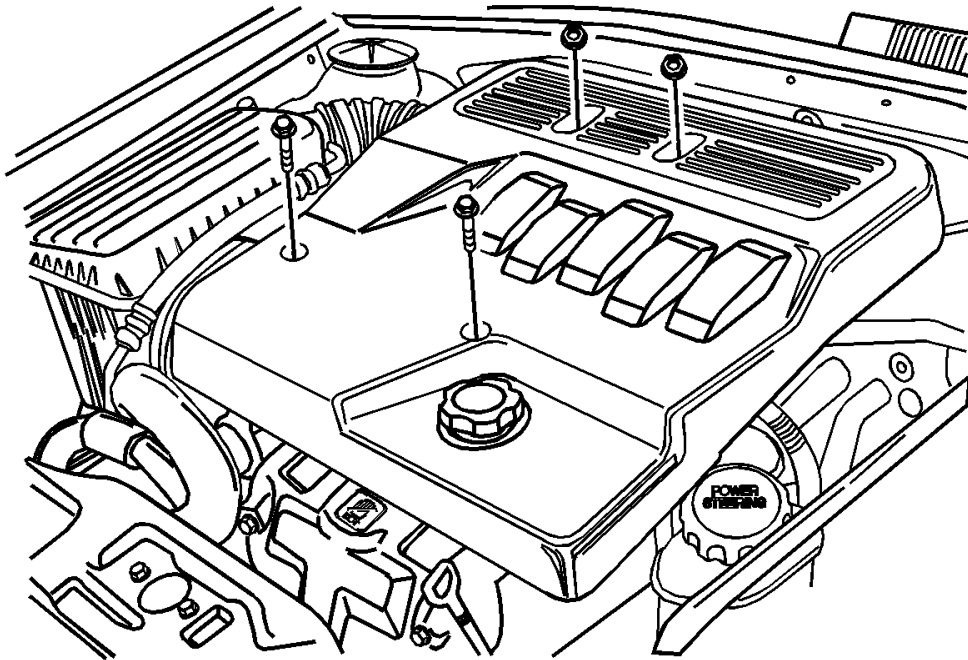


Fig. 138: View Of Engine Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

8. Connect the engine ventilation hoses to the camshaft cover.
9. Connect the ignition wires to the spark plugs.
10. Install the timing belt. Refer to **Timing Belt Replacement**.
11. Install the engine cover. Refer to **Engine Cover Replacement**
12. Connect the negative battery cable.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Tools Required

- **KM-571-B** Gage
- **KM-340-1-C** Cutter Set, Including tools KM-340-7, KM-340-B, KM-340-26

Guide Reaming and Valve and Seat Grinding Procedure

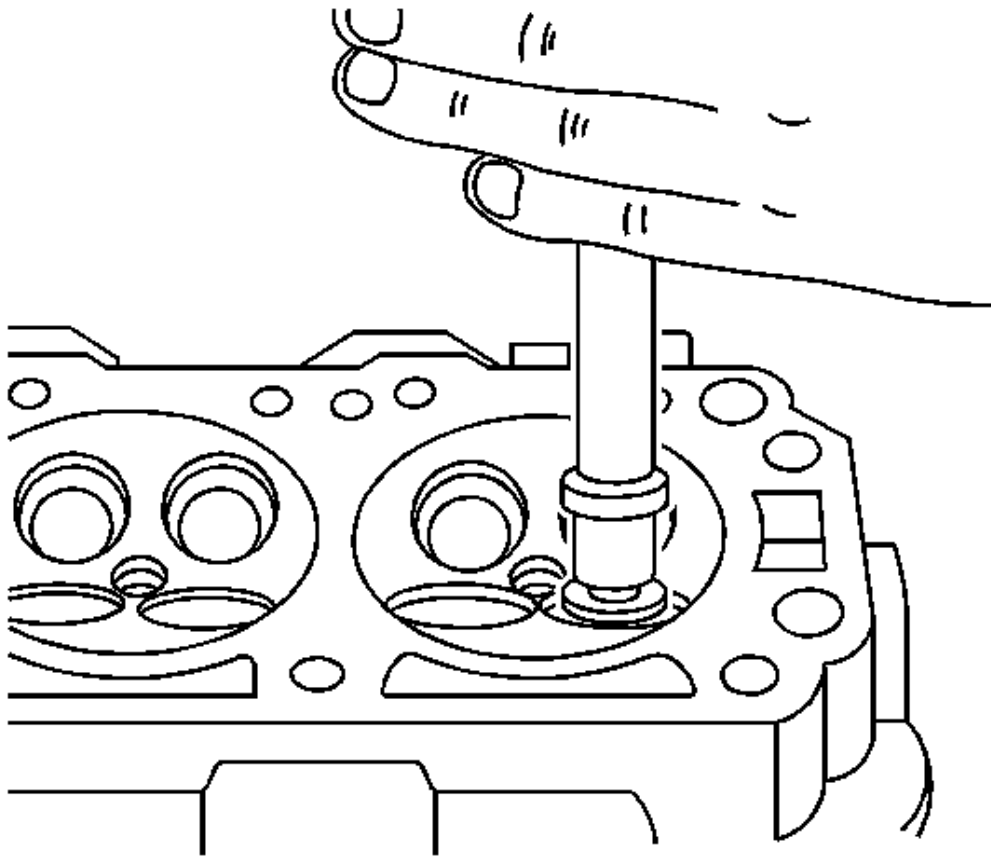


Fig. 139: View Of Valve Grinding Tool
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem using a fine-grained paste.
2. Lift the valve rhythmically from the seat with a commercially available valve grinding tool in order to distribute the paste.

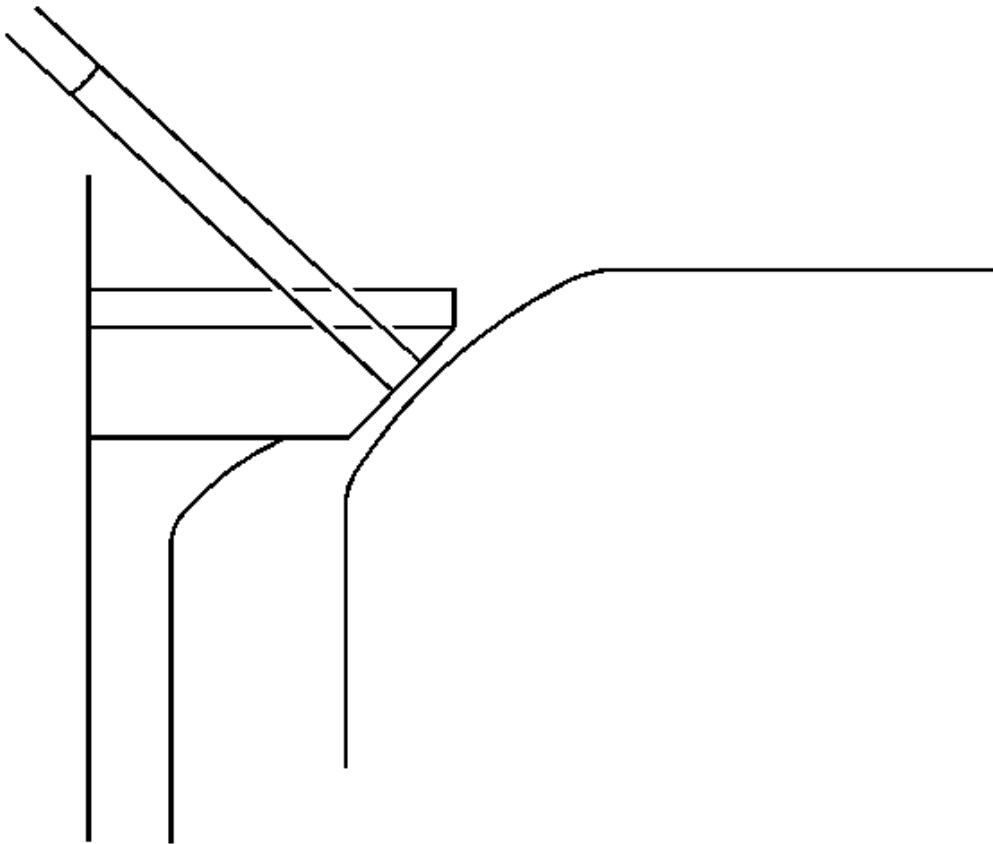


Fig. 140: Identifying Valve To Cylinder Head Contact Pattern
Courtesy of GENERAL MOTORS CORP.

3. Check the contact pattern on the valve head and in the cylinder head.

CAUTION: Refer to Safety Glasses Caution .

4. Clean the valves, the valve guides, and the cylinder head.

Valve Grind

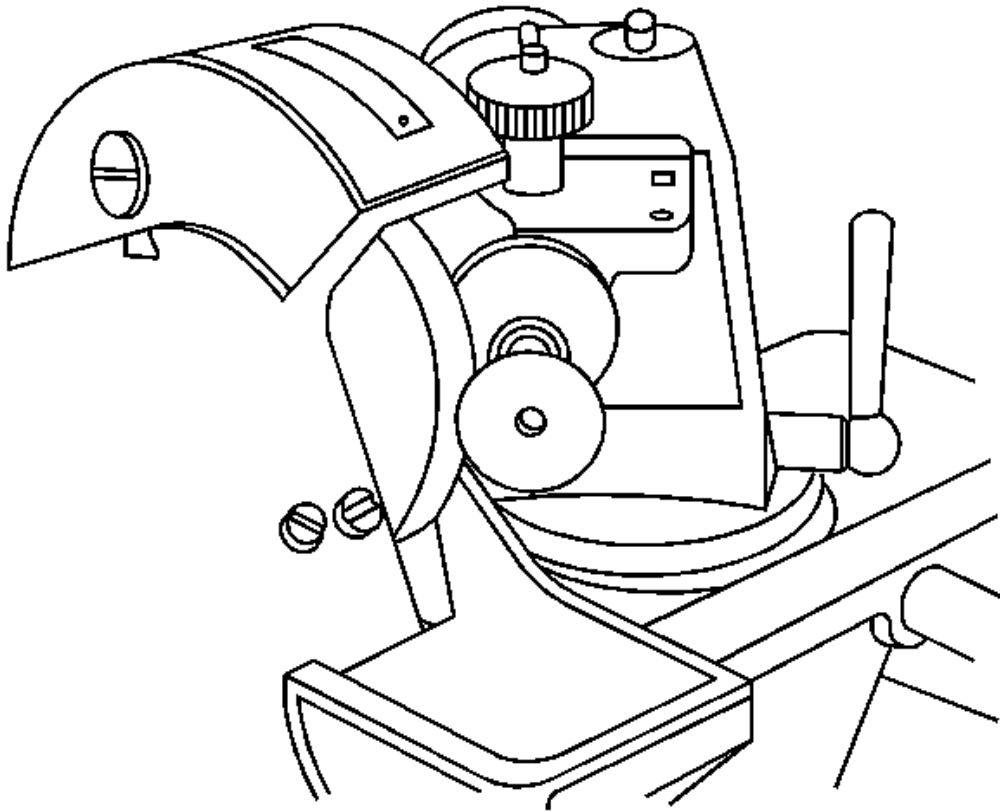


Fig. 141: View Of Valve And Grinder
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Ensure that there are no crater line burns on the valve cone.
2. The valve may be reground only 2 times. Do not grind the valve stem end.
3. The angle at the valve face is 45 degrees.
4. Inspect the assembly height of the intake valves and the exhaust valves.

Valve Guide - Ream

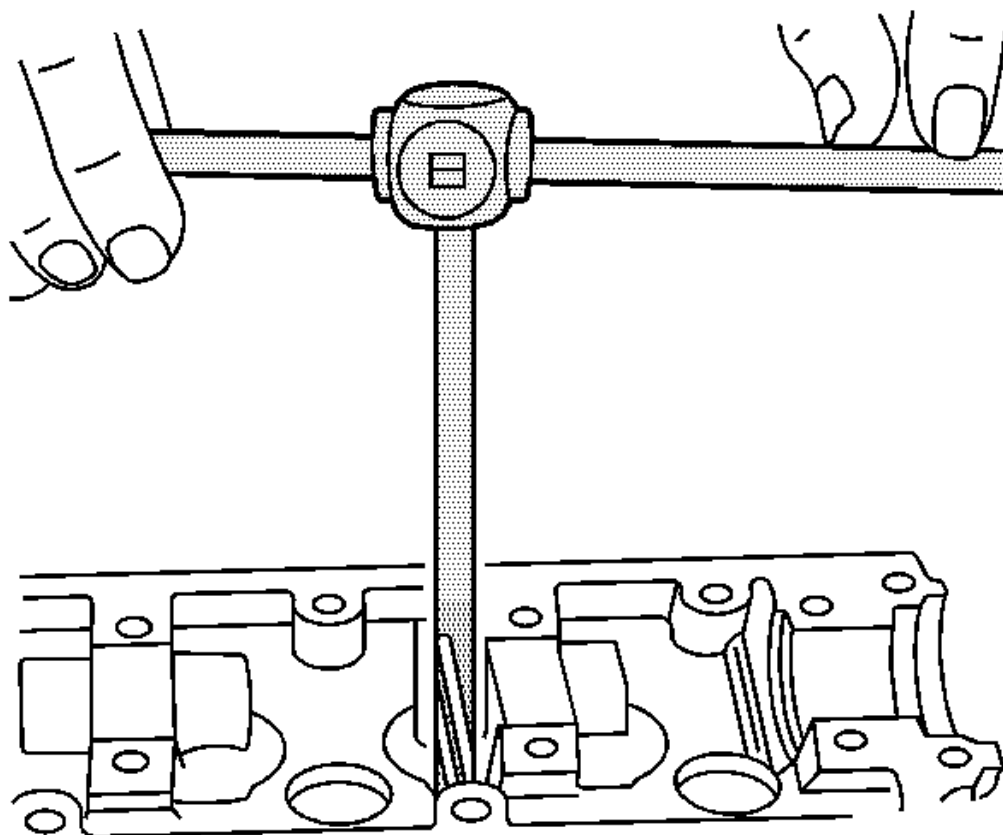


Fig. 142: View Of Special Tool KM-571-B
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Measure the diameter of the valve guide using **KM-571-B** and a commercially available inside micrometer.

IMPORTANT: Value oversizes may already have been fitted in production.

2. An oversize service code is on the valve guide and the valve stem end. The Valve Guide Reaming Table gives the correct size, reamer, and production code for each service size. Refer to Engine Mechanical Specifications.
3. Ream the valve guide from the upper side of the cylinder head to the next oversize.
4. After reaming, cross out the code and emboss the valve guide with the new code.

Valve Seat - Cut

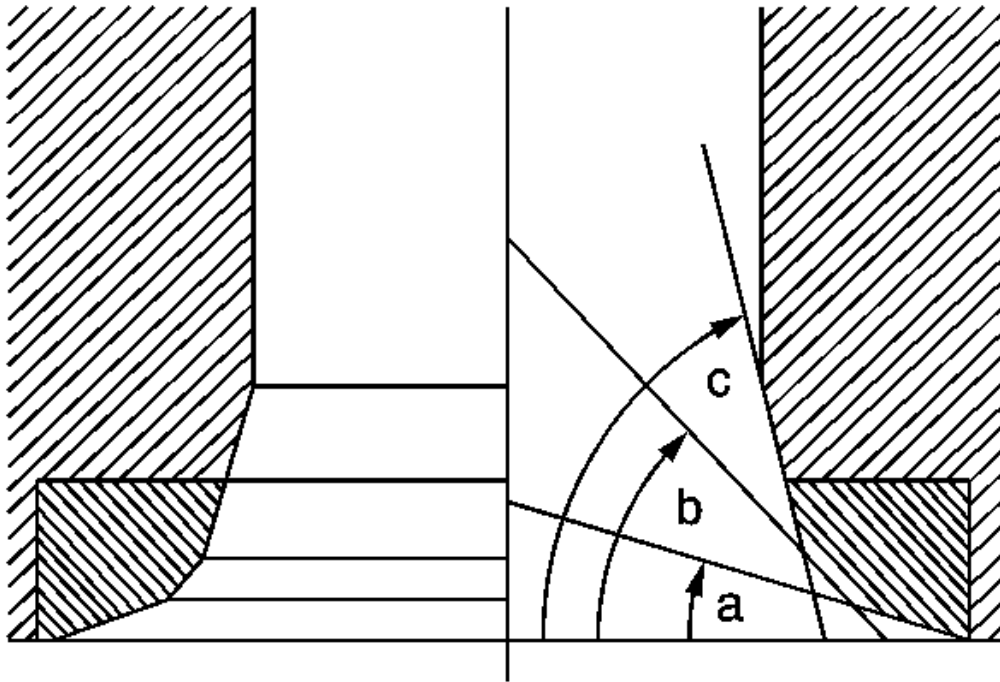


Fig. 143: Identifying Cut Angles
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Place the cylinder head on wooden blocks.
2. Cut the intake and the exhaust valve seats using the guide drift KM-340-7, part of kit **KM-340-1-C** , as follows:
 - Valve seat-A 45-degree surface using the cutter KM-340-13.
 - Upper correction angle-A 30-degree surface using the cutter KM-340-13.
 - Lower correction angle-A 60-degree surface using the cutter KM-340-26.
3. Clean the chippings from the cylinder head.
4. Inspect the dimension for the valve seat width.

Specifications:

- Intake: 1.17 to 1.57 mm (0.046 to 0.062 in)

- Exhaust: 1.4 to 1.8 mm (0.055 to 0.071 in)
5. Inspect the assembly height of the intake valves and the exhaust valves. If the dimension is exceeded, install new valves. Inspect the assembly height of the intake valves and the exhaust valves again. If the valve assembly height is still too large despite replacing the valves, replace the cylinder head.

CRANKSHAFT REPLACEMENT

Tools Required

- **OTC 1726** (KM-412) Engine Overhaul Stand.
- **J 42492-A** (KM-421-A) Timing Belt Adjuster
- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage
- **J 36972** Crankshaft Rear Oil Seal Installer
- **KM-635** Crankshaft Rear Oil Seal Installer

Removal Procedure

IMPORTANT: Take extreme care to prevent any scratches, nicks, or damage to the camshafts.

1. Remove the engine. Refer to **Engine Replacement**.

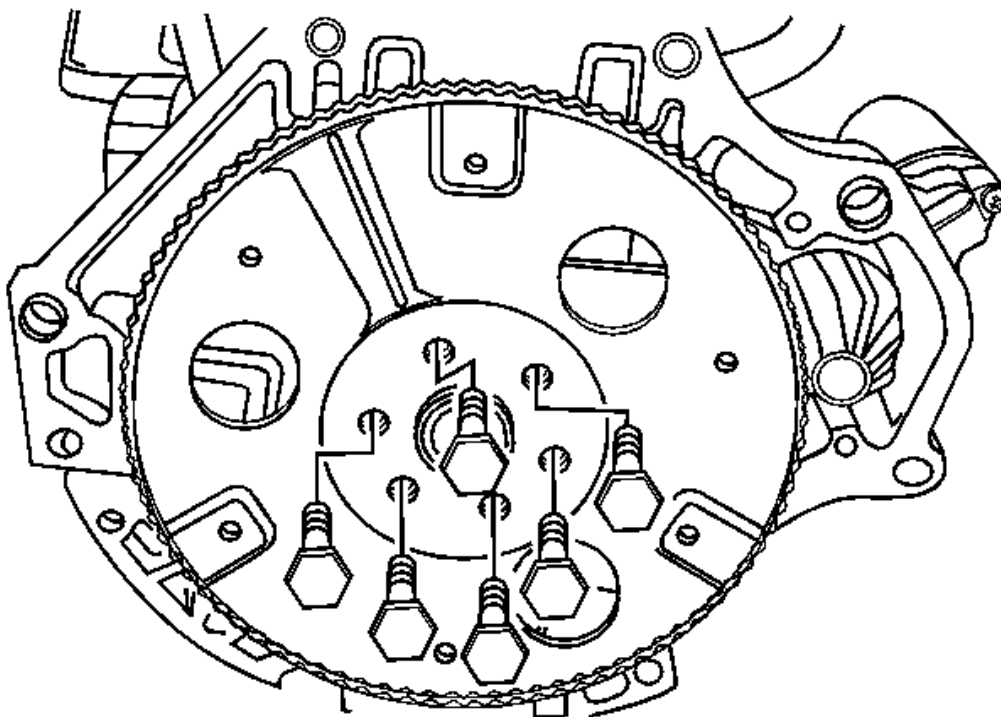


Fig. 144: View Of Flex Plate And Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel or flexible plate bolts.
3. Remove the flywheel or the flexible plate.

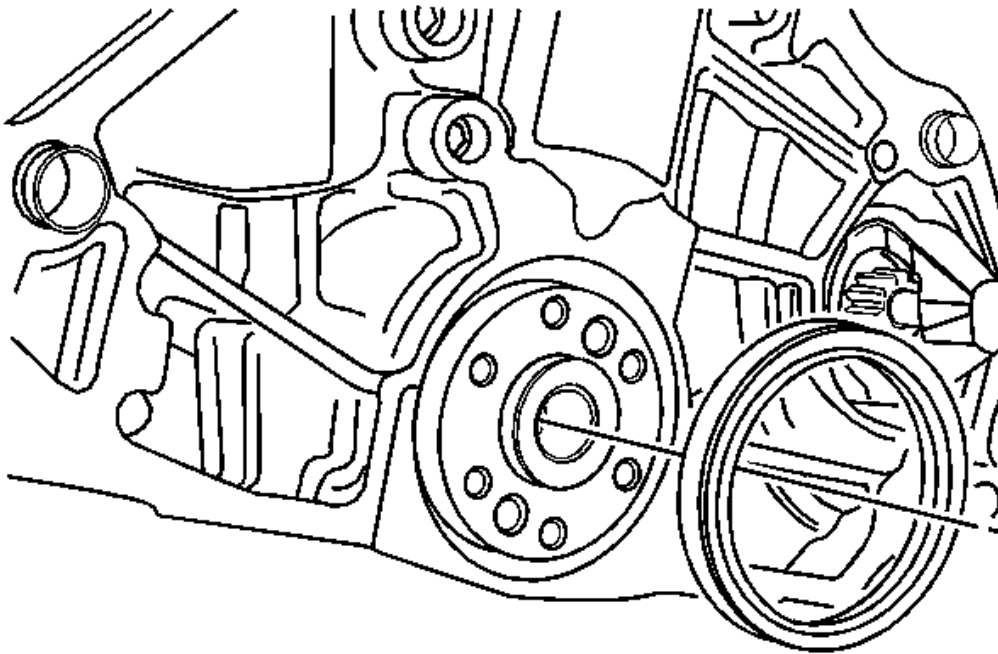


Fig. 145: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft rear oil seal.
5. Mount the engine assembly on the **OTC 1726** .

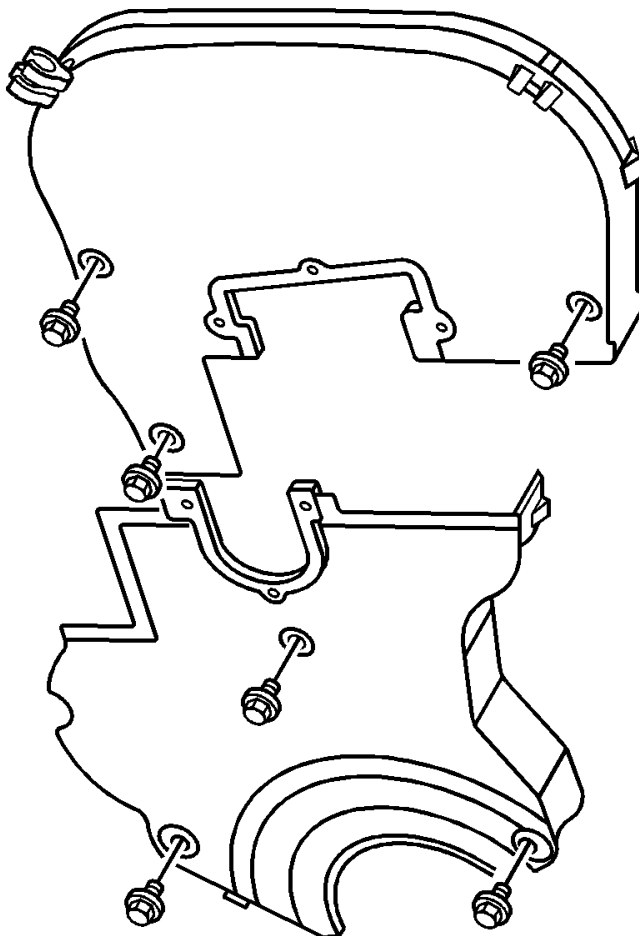


Fig. 146: Upper And Lower Front Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the upper and the lower front timing belt cover bolts.
7. Remove the upper and the lower front timing belt cover.

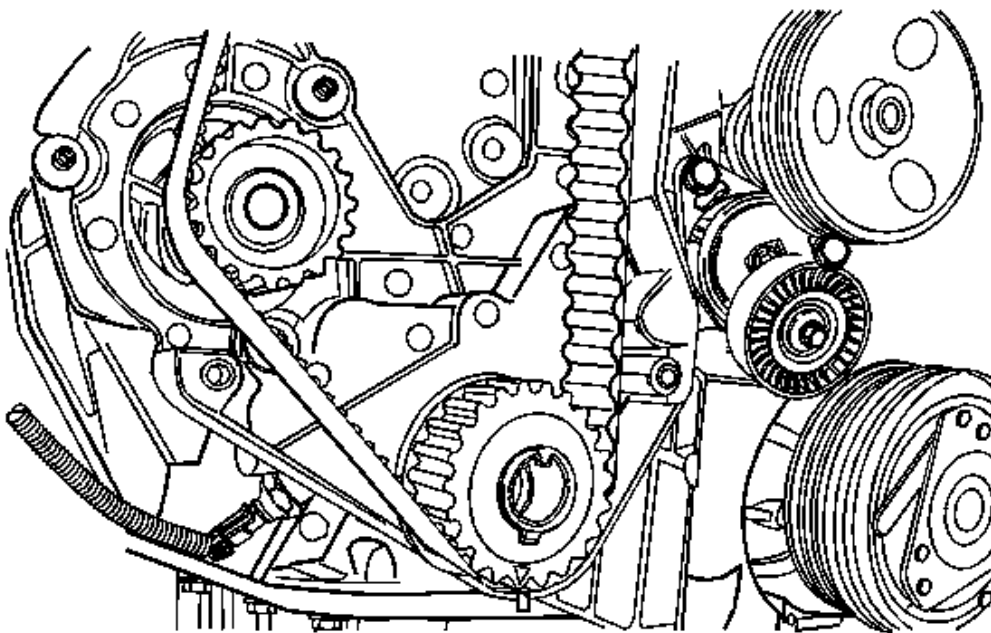


Fig. 147: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

8. Slightly loosen the water pump retaining bolts.

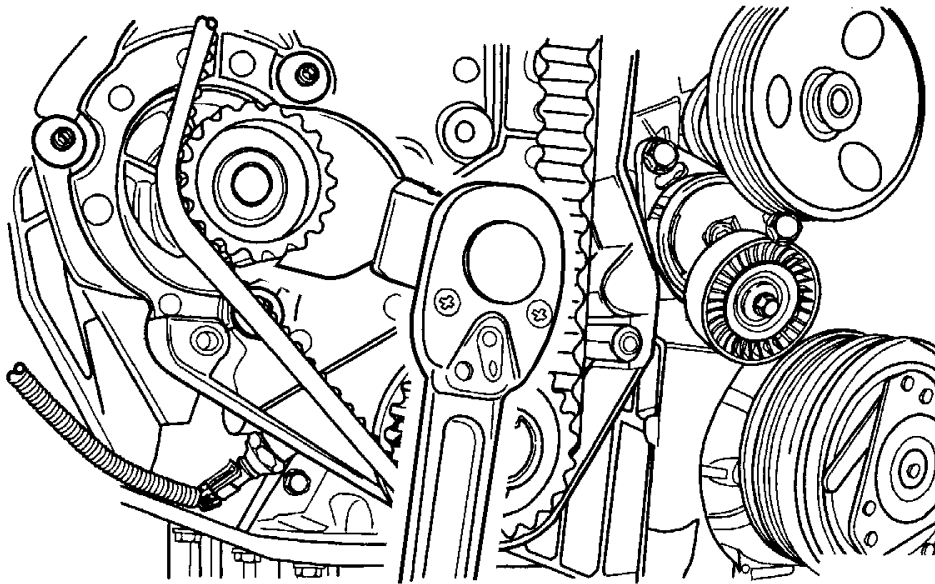


Fig. 148: Removing Timing Belt Tension Using J 42492-A
Courtesy of GENERAL MOTORS CORP.

9. Rotate the water pump using the **J 42492-A** to remove the tension from the timing belt.
10. Remove the spark plug cover bolts.

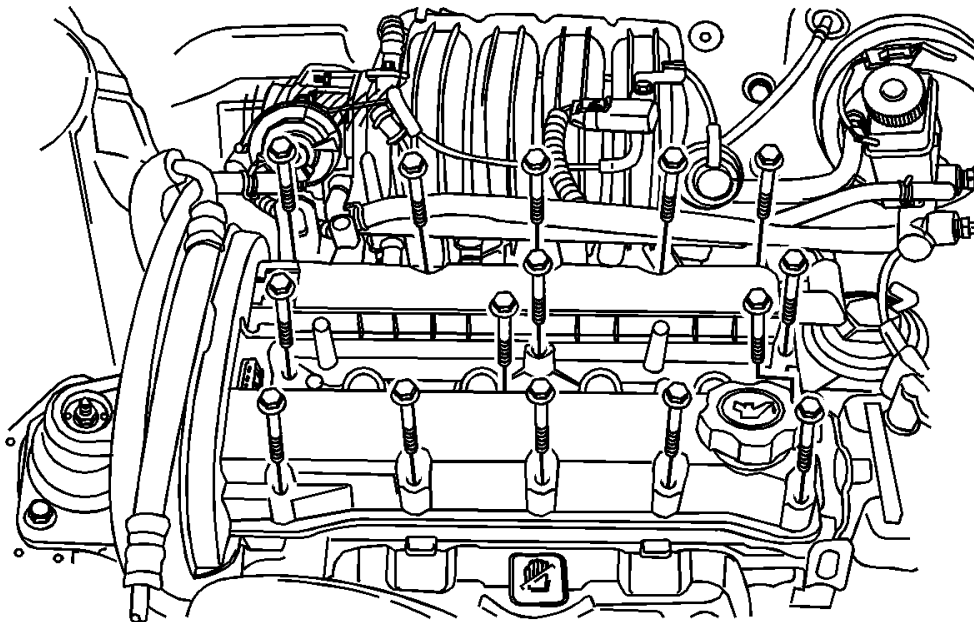


Fig. 149: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the engine ventilation hoses from the camshaft cover.
12. Disconnect the oil filler cap.
13. Remove the spark plug cover bolts.
14. Remove the spark plug cover.
15. Remove the spark plug cover.
16. Remove the camshaft cover nuts.
17. Remove the camshaft cover washers.
18. Remove the camshaft cover and the camshaft cover gasket.

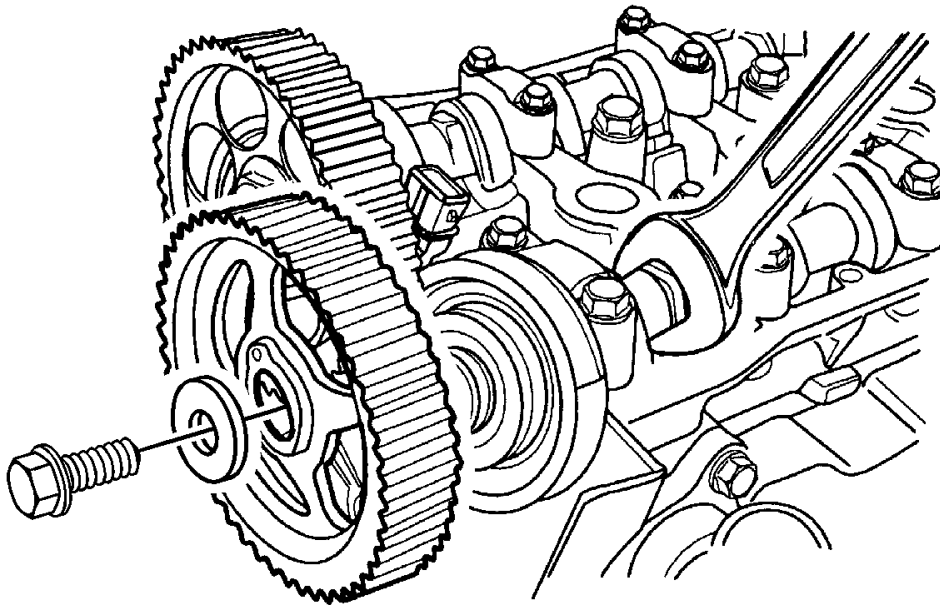


Fig. 150: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

19. While holding the intake camshaft firmly in place, remove the intake camshaft bolt.
20. Remove the intake camshaft gear.
21. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft bolt.
22. Remove the exhaust camshaft gear.

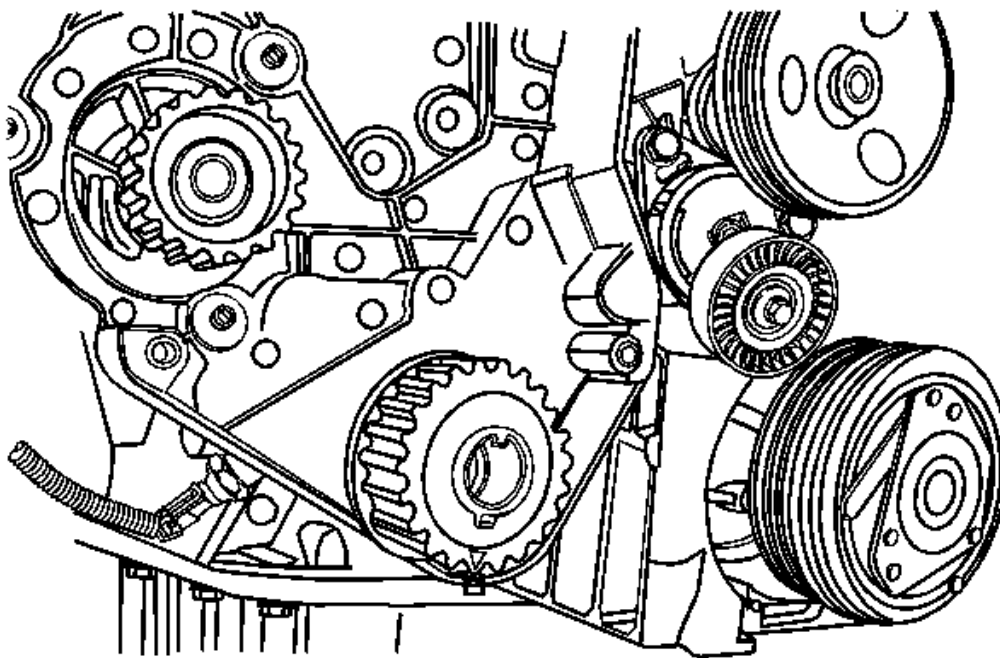


Fig. 151: View Of Camshaft Gear
Courtesy of GENERAL MOTORS CORP.

23. Remove the timing belt automatic tensioner bolts.
24. Remove the timing belt automatic tensioner.
25. Remove the timing belt idler pulley bolt.
26. Remove the timing belt idler pulley.

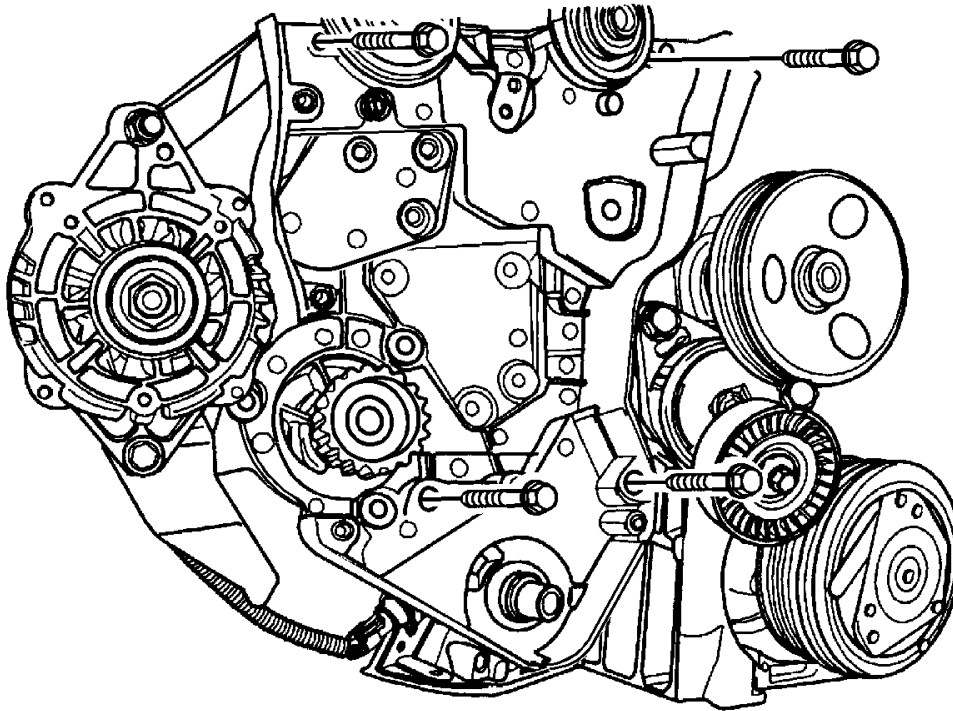


Fig. 152: View Of Rear Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

27. Remove the crankshaft timing belt gear.
28. Remove the rear timing belt cover bolts.
29. Remove the rear timing belt cover.

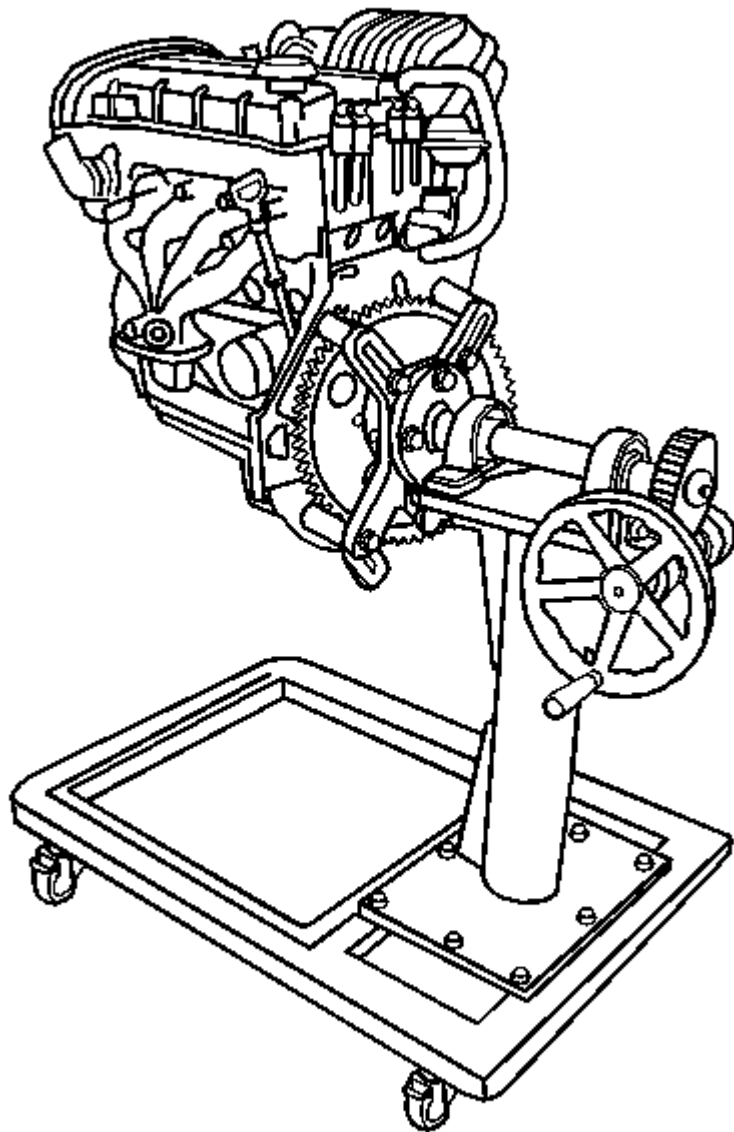


Fig. 153: View Of Engine On Overhaul Stand
Courtesy of GENERAL MOTORS CORP.

30. Rotate the engine on the engine overhaul stand **OTC 1726** .

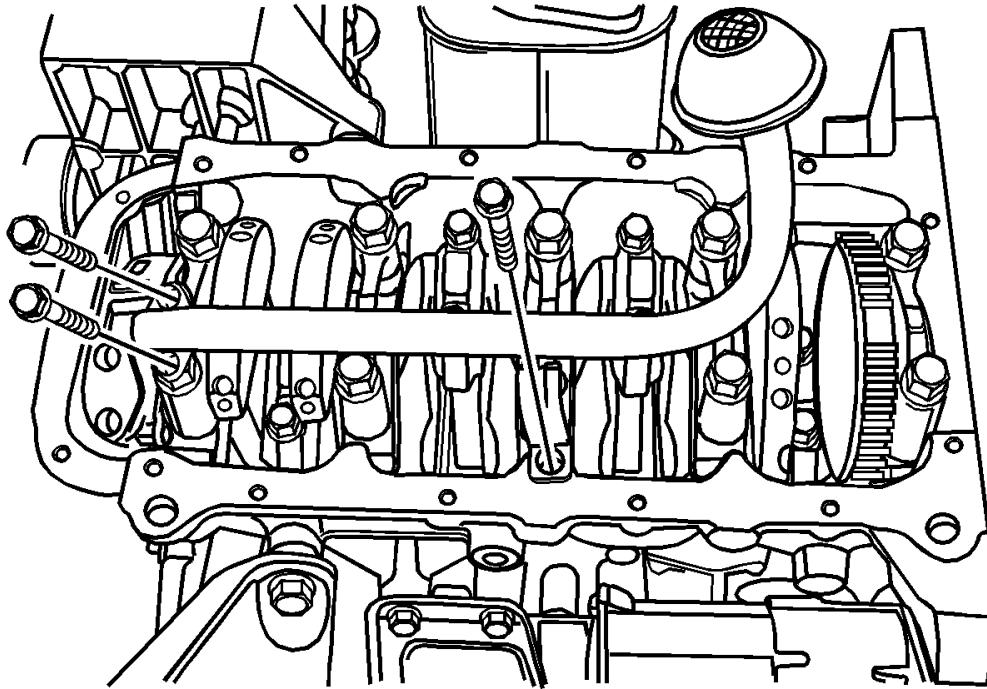


Fig. 154: View Of Oil Pan, Oil Pickup Tube And Bolts
Courtesy of GENERAL MOTORS CORP.

31. Remove the oil pan retaining bolts.
32. Remove the oil pan.
33. Remove the oil suction pipe bolts.
34. Remove the oil suction pipe.

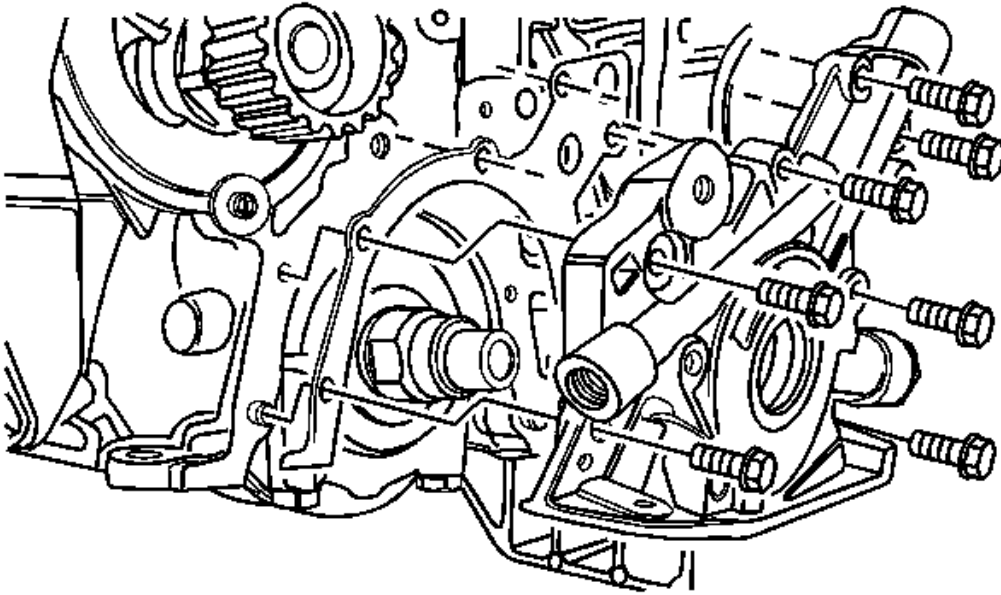


Fig. 155: Identifying Oil Pump And Bolts
Courtesy of GENERAL MOTORS CORP.

35. Remove the oil pump retaining bolts.
36. Remove the oil pump.

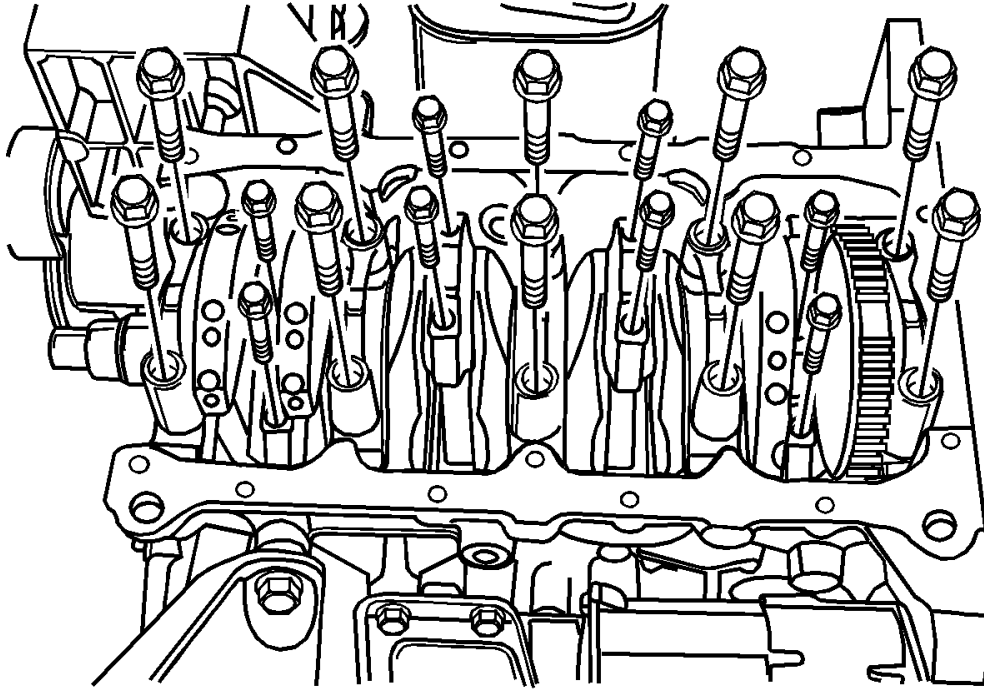


Fig. 156: View Of Connecting Rod Bearing Cap Rod Bolts
Courtesy of GENERAL MOTORS CORP.

37. Mark the order of the connecting rod bearing caps.
38. Remove the connecting rod bearing cap bolts for all of the pistons.
39. Remove the connecting rod bearing caps and the lower connecting rod bearings.
40. Remove the upper connecting rod bearings.

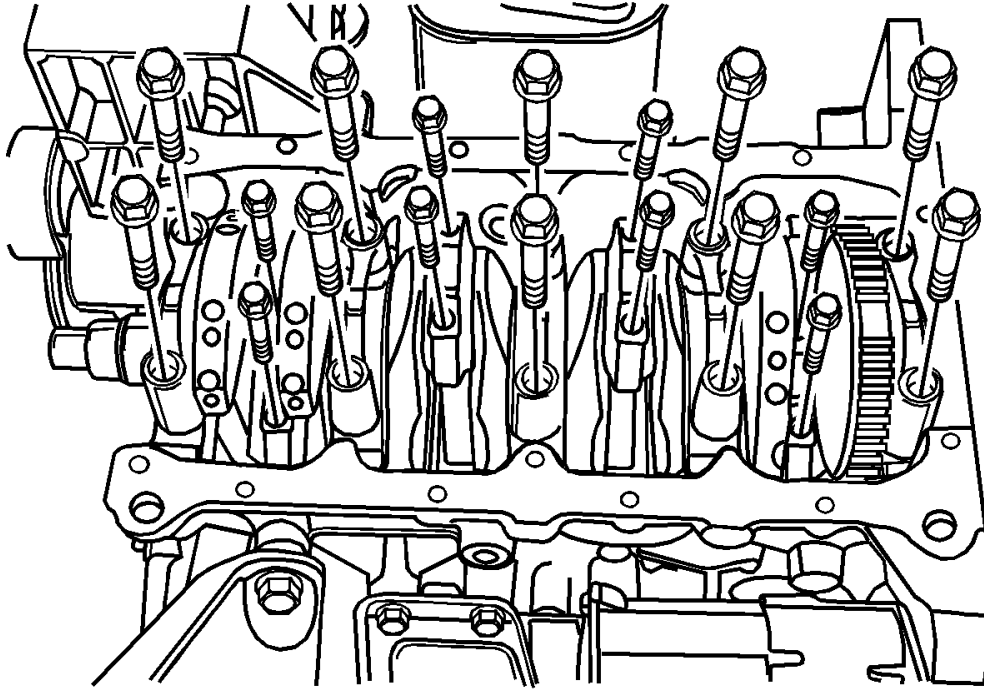


Fig. 157: View Of Connecting Rod Bearing Cap Rod Bolts
Courtesy of GENERAL MOTORS CORP.

41. Mark the order of the crankshaft bearing caps.
42. Remove the crankshaft bearing cap bolts.
43. Remove the crankshaft bearing caps and the lower crankshaft bearings.
44. Remove the crankshaft.
45. Remove the upper crankshaft bearings.

CAUTION: Refer to Safety Glasses Caution .

46. Clean the parts, as needed.

Installation Procedure

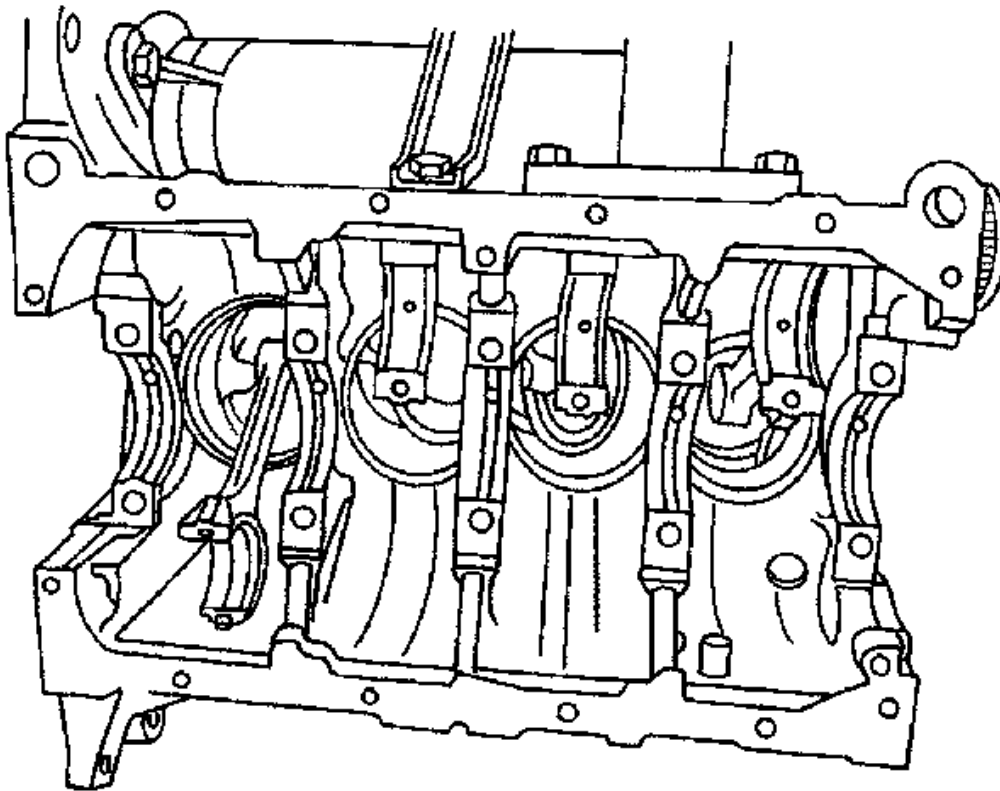


Fig. 158: Identifying Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

1. Coat the crankshaft bearings with the engine oil.
2. Install the upper crankshaft bearings in the engine block.

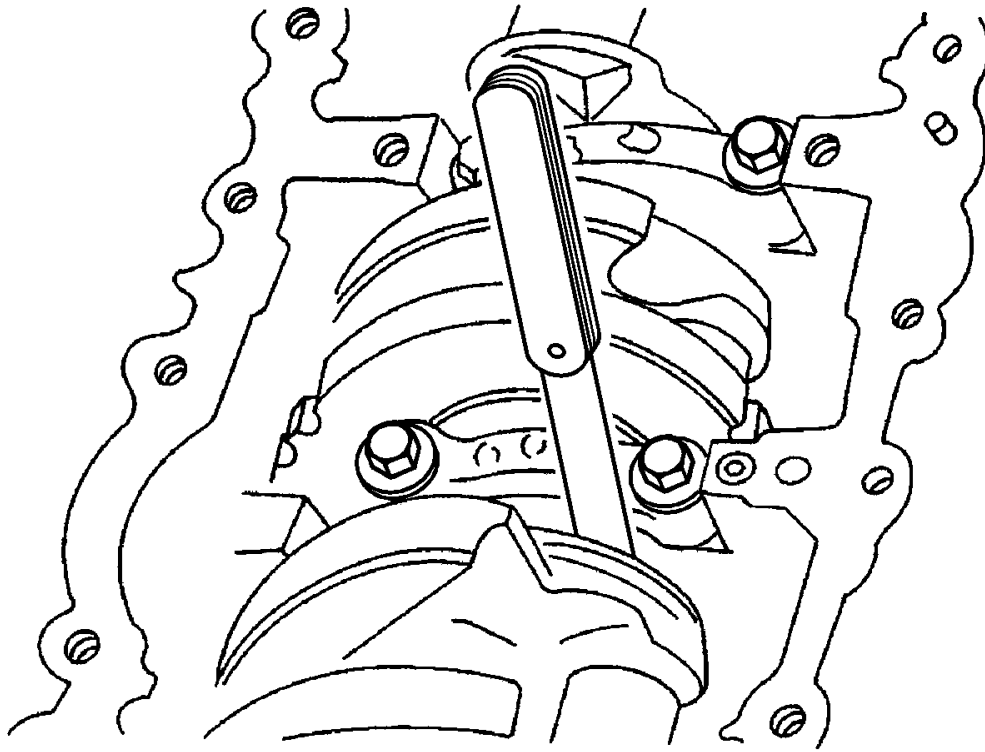


Fig. 159: Inspecting Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft.
4. Install the lower crankshaft bearings in the bearing caps.
5. Inspect the crankshaft end play with the crankshaft bearings installed.
6. Check for permissible crankshaft end play. Refer to **Engine Mechanical Specifications**.

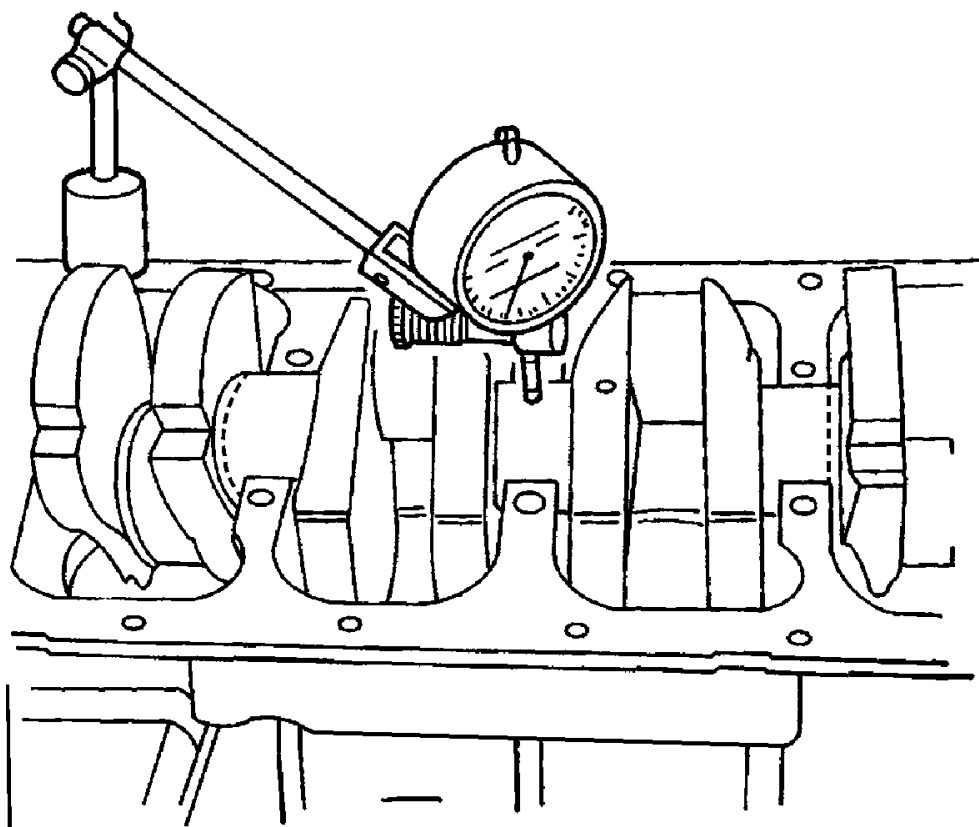


Fig. 160: Checking Middle Crankshaft Journal For Out-Of-Round Runout
Courtesy of GENERAL MOTORS CORP.

7. With the crankshaft mounted on the front and the rear crankshaft bearings, check the middle crankshaft journal for permissible out-of-round (runout). Refer to **Engine Mechanical Specifications**.

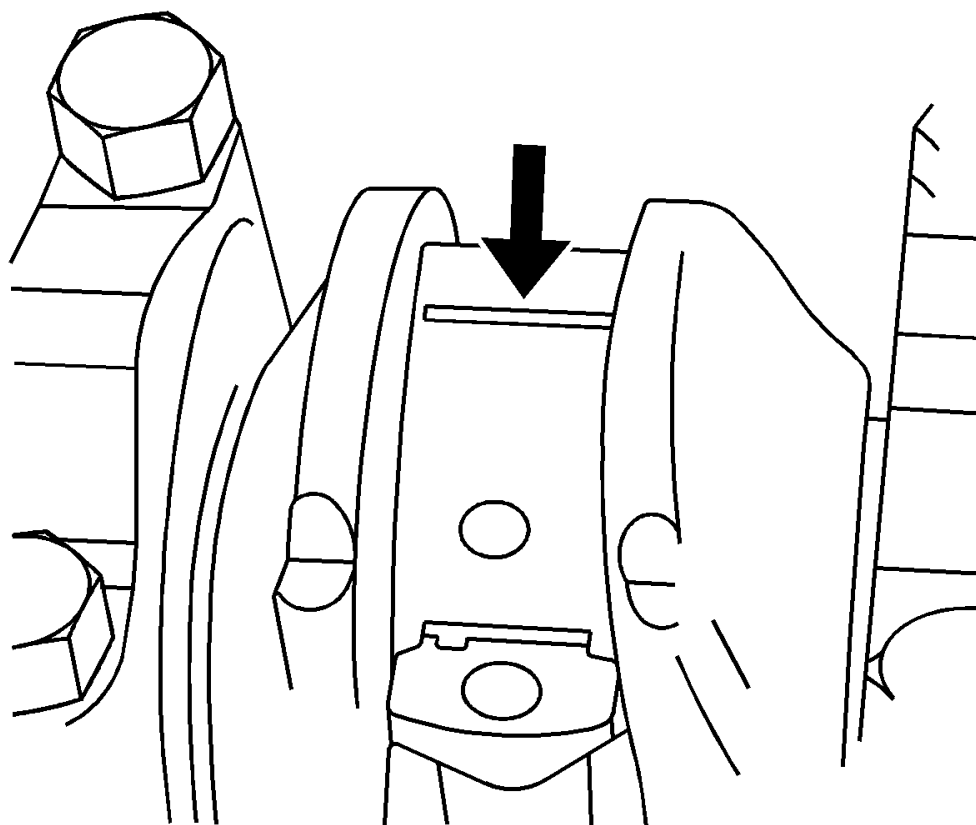


Fig. 161: Inspecting Crankshaft Bearing Clearances
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Grease the crankshaft journals and lubricate the crankshaft bearings slightly so that the plastic gaging thread does not tear when the crankshaft bearing caps are removed.

8. Inspect all of the crankshaft bearing clearances using a commercially available plastic gaging (ductile plastic threads).
9. Cut the plastic gauging threads to the length of the bearing width. Lay them axially between the crankshaft journals and the crankshaft bearings

NOTE: Refer to Fastener Notice .

10. Install the crankshaft bearing caps and the bolts.

Tighten: Tighten the crankshaft bearing cap bolts to **50 N.m (37 lb ft)** plus 45 degrees plus 15 degrees.

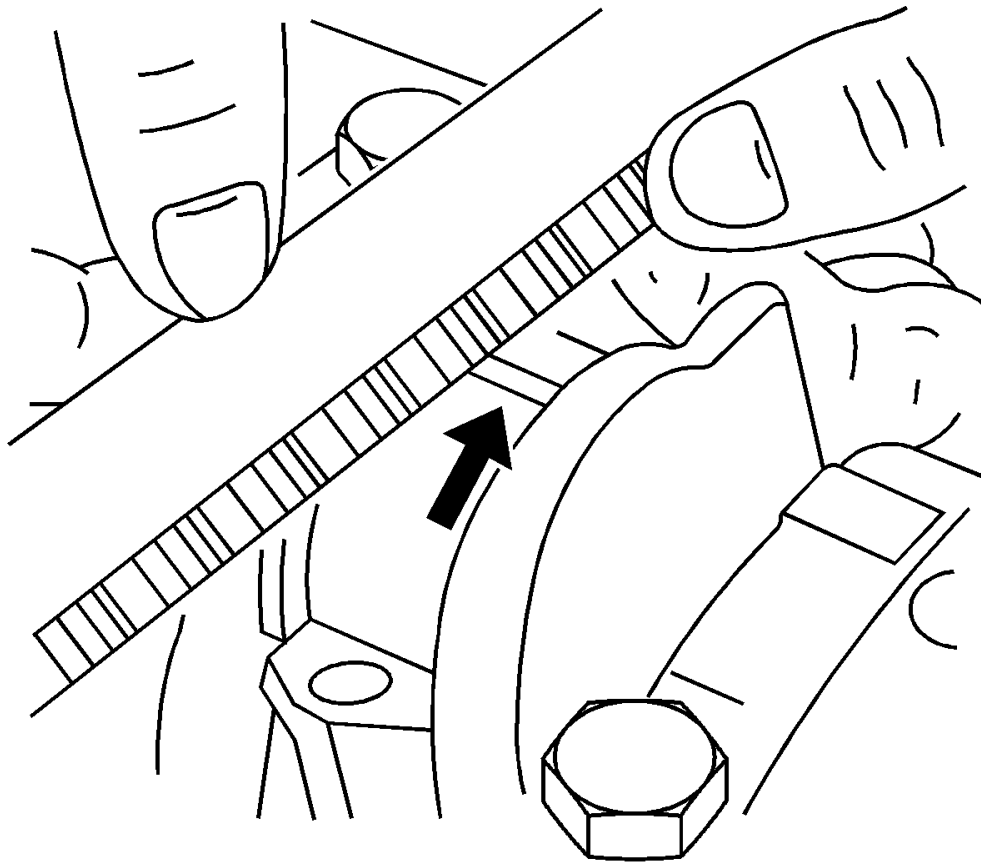


Fig. 162: View Of Plastic Thread
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft bearing cap bolts and the caps.
12. Measure the width of the flattened plastic thread of the plastic gaging using the scale printed on the plastic gaging package. Plastic gaging is available for different tolerance ranges.
13. Inspect the bearing clearance for permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

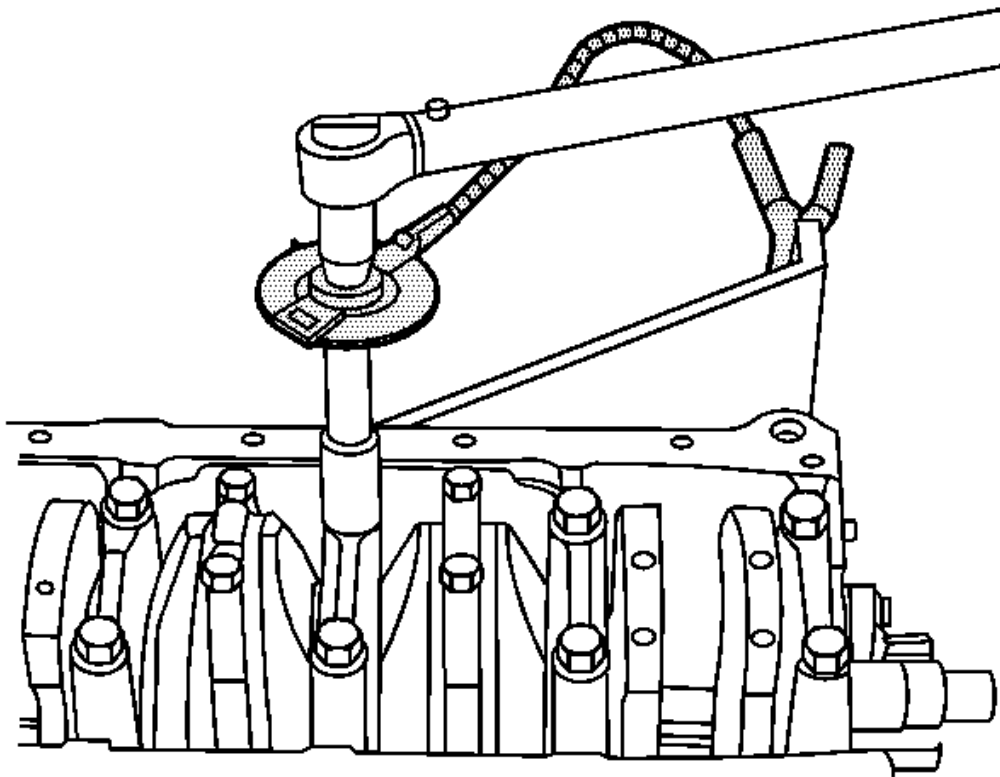


Fig. 163: View Of J 45059 And KM-470-B
Courtesy of GENERAL MOTORS CORP.

14. Apply a bead of adhesive sealing compound to the grooves of the crankshaft bearing caps.
15. Install the crankshaft bearing caps to the engine block.
16. Tighten the crankshaft bearing caps using new bolts using the **J 45059** or the **KM-470-B**.

Tighten: Tighten the crankshaft bearing cap bolts to **50 N.m (37 lb ft)** using a torque wrench. Tighten the crankshaft bearing 45 degrees plus 15 degrees.

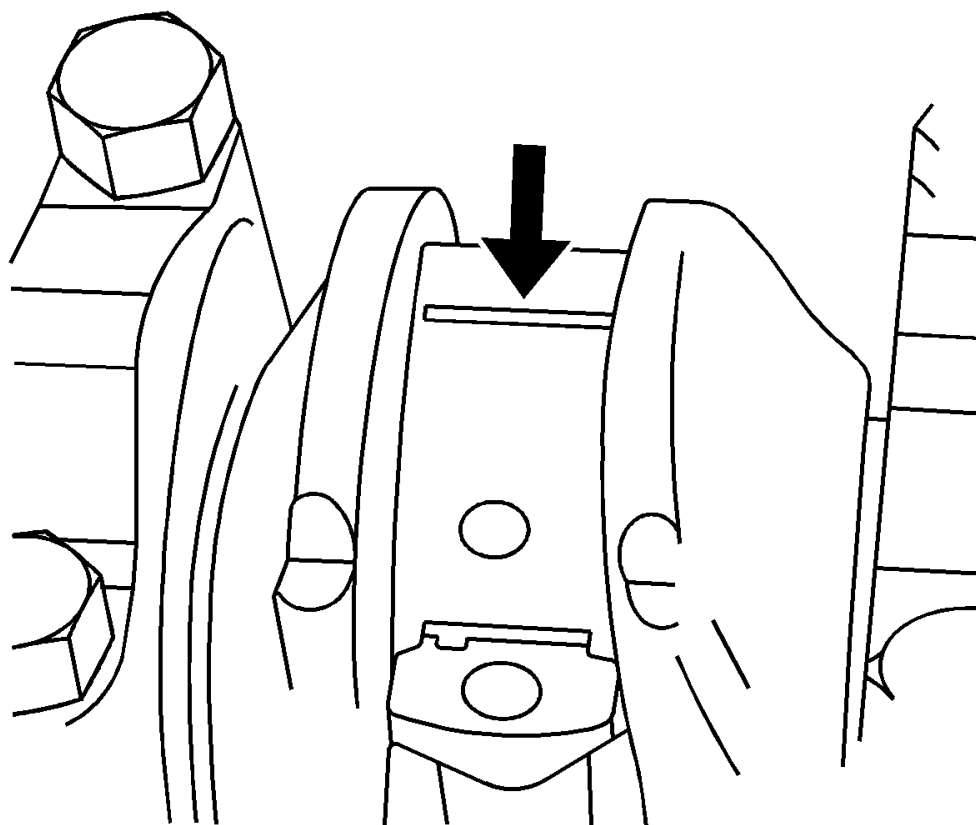


Fig. 164: Inspecting Crankshaft Bearing Clearances
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Grease the connecting rod journals and lubricate the connecting rod bearings slightly so that the plastic gaging thread does not tear when the connecting rod bearing caps are removed.

17. Inspect all of the connecting rod bearing clearances using a commercially available plastic gaging (ductile plastic threads).
18. Cut the plastic gaging threads to the length of the connecting rod bearing width. Lay them axially between the connecting rod journals and the connecting rod bearings.
19. Install the connecting rod bearing caps using the **J 45059** or the **KM-470-B**.

Tighten: Tighten the connecting rod bearing cap bolts to **25 N.m (18 lb ft)** using a torque wrench. Tighten the connecting rod bearing cap bolts 30 degrees plus 15 degrees.

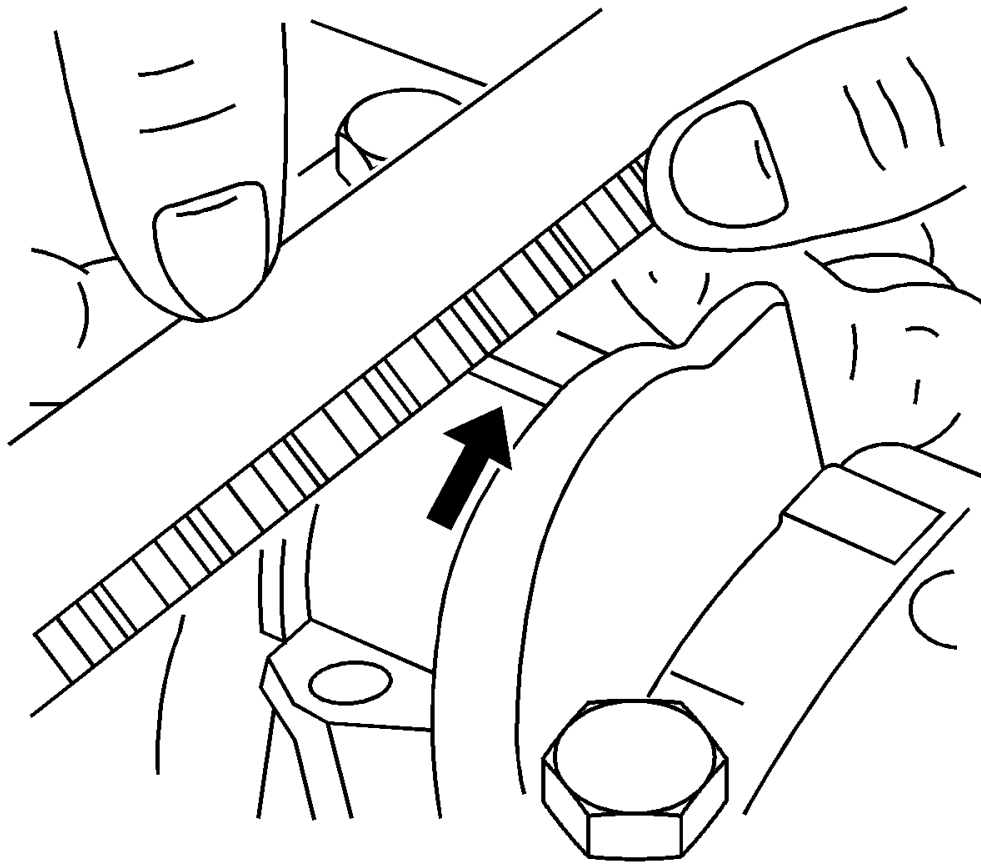


Fig. 165: View Of Plastic Thread
Courtesy of GENERAL MOTORS CORP.

20. Remove the connecting rod bearing caps.
21. Measure the width of the flattened plastic thread of the plastic gaging using the scale printed on the plastic gaging package. Plastic gaging is available for different tolerance ranges.
22. Inspect the bearing clearance for permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

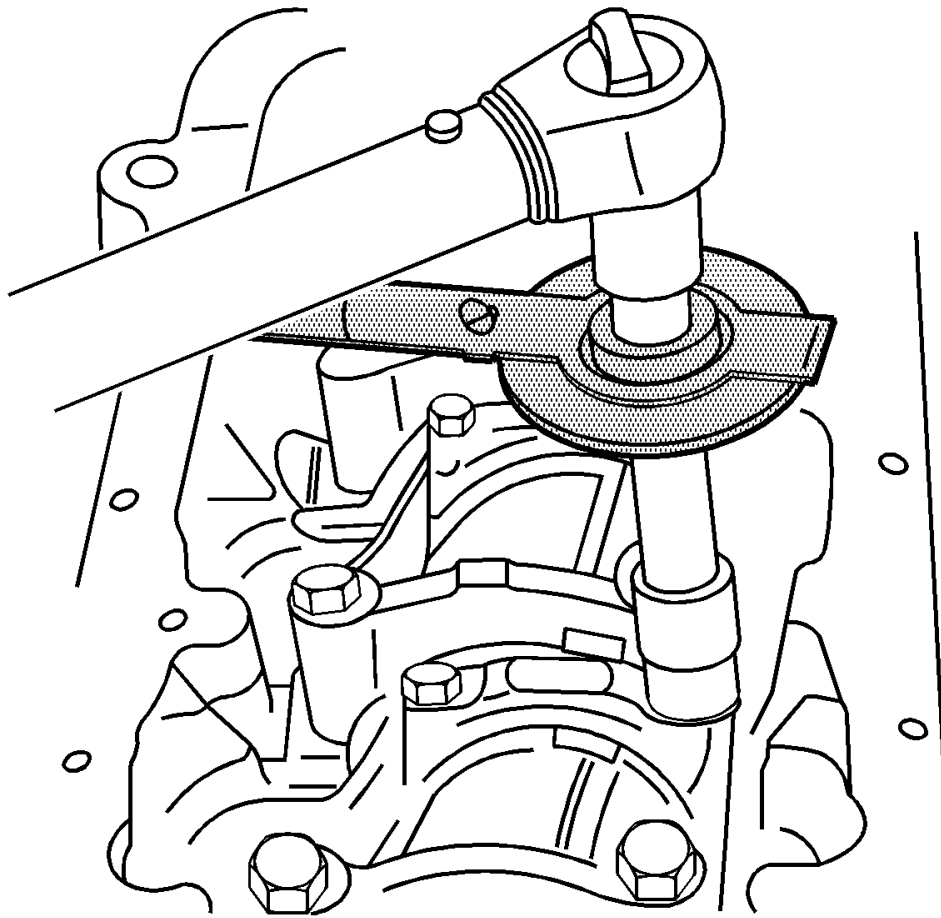


Fig. 166: Identifying J 45059 And KM-470-B
Courtesy of GENERAL MOTORS CORP.

23. Install the connecting rod bearing caps to the connecting rods.
24. Tighten the connecting rod bearing caps using new bolts using the **J 45059** or the **KM-470-B**.

Tighten: Tighten the connecting rod bearing cap bolts to **25 N.m (18 lb ft)** using a torque wrench. Tighten the connecting rod cap bolts 30 degrees plus 15 degrees.

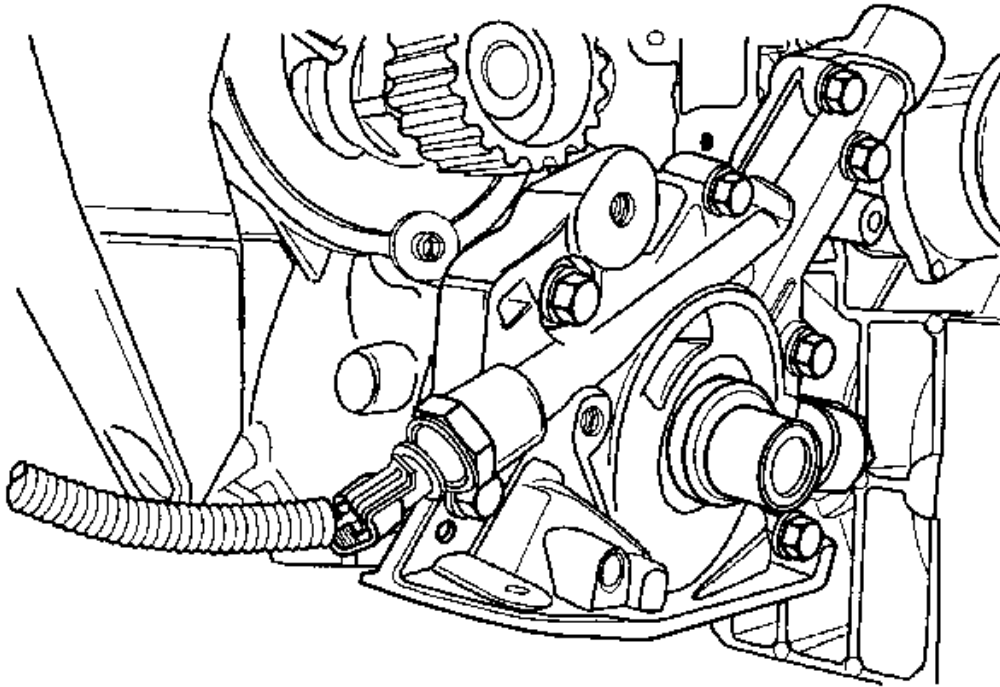


Fig. 167: View Of Oil Pump And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the oil pump.
26. Install the oil pump retaining bolts.

Tighten: Tighten the oil pump retaining bolts to **10 N.m (89 lb in)** .

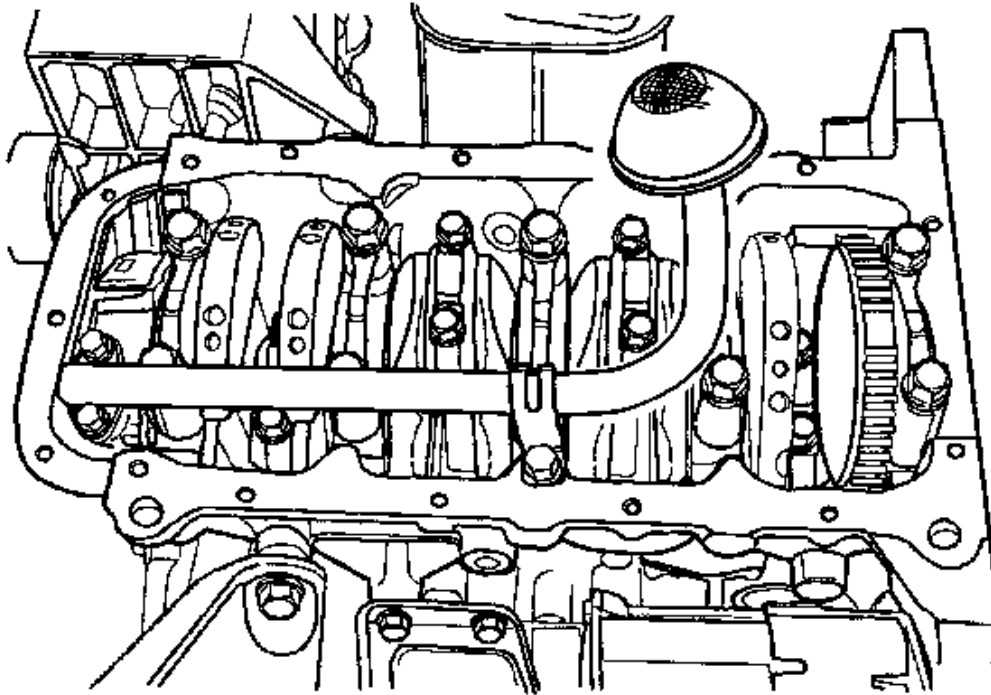


Fig. 168: Identifying Oil Suction Pipe And Bolts
Courtesy of GENERAL MOTORS CORP.

27. Install the oil suction pipe.
28. Install the oil suction pipe bolts.

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

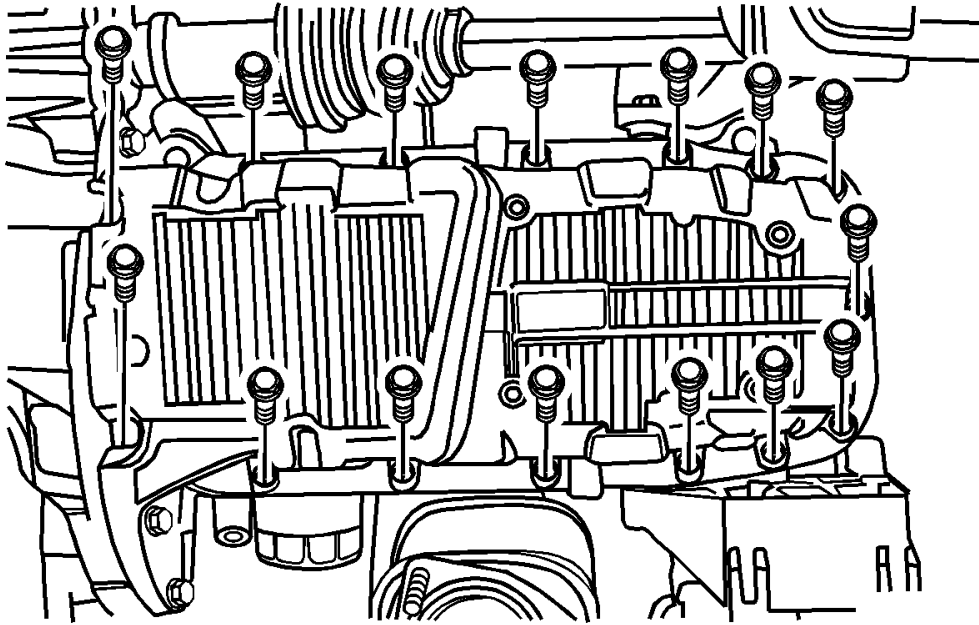


Fig. 169: View Of Oil Pan And Retaining Bolts From Engine Block
Courtesy of GENERAL MOTORS CORP.

29. Coat the new oil pan gasket with sealant.
30. Install the oil pan gasket to the oil pan.
31. Install the oil pan.
32. Install the oil pan retaining bolts.

Tighten: Tighten the oil pane retaining bolts to **10 N.m (89 lb in)** .

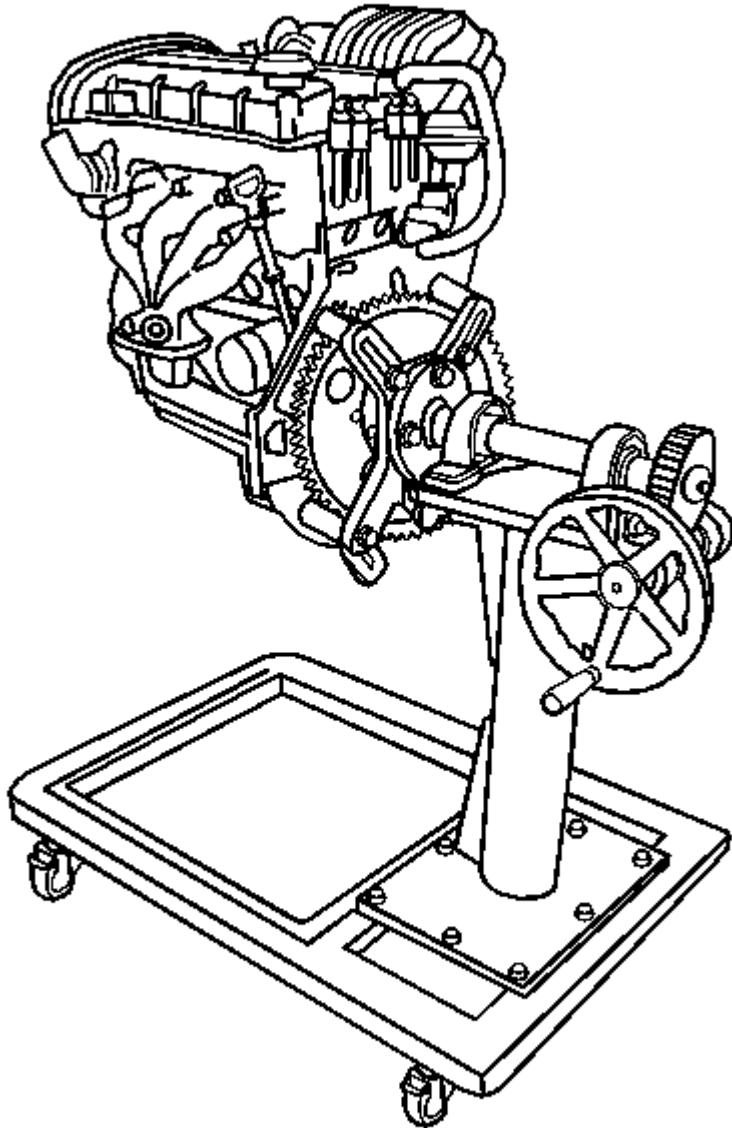


Fig. 170: View Of Engine On Overhaul Stand
Courtesy of GENERAL MOTORS CORP.

33. Rotate the engine on the engine overhaul stand **OTC 1726** .

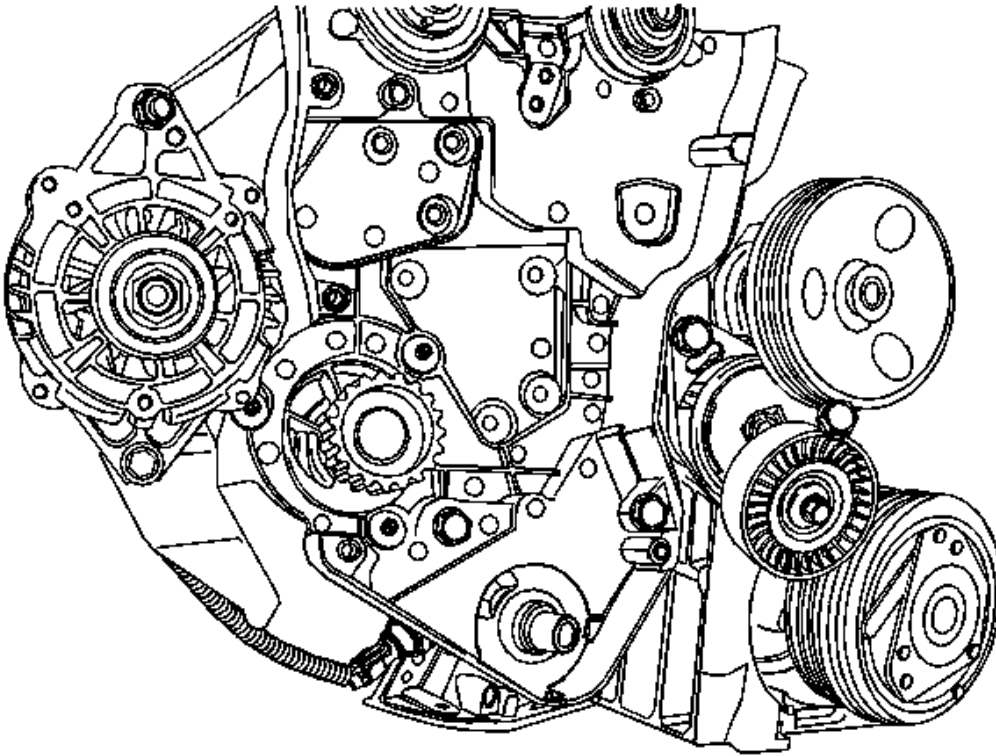


Fig. 171: View Of Rear Timing Belt Cover
Courtesy of GENERAL MOTORS CORP.

34. Install the rear timing belt cover.
35. Install the rear timing belt cover bolts.

Tighten: Tighten the rear timing belt cover bolts to **10 N.m (89 lb in)** .

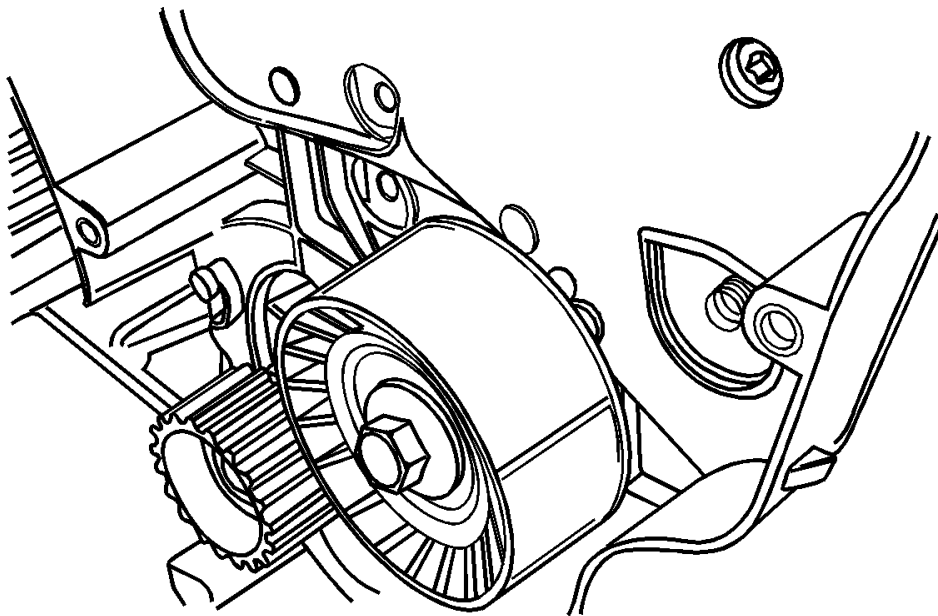


Fig. 172: View Of Timing Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

36. Install the crankshaft timing belt gear.
37. Install the timing belt automatic tensioner.
38. Install the timing belt automatic tensioner bolts.

Tighten: Tighten the timing belt automatic tensioner bolts to **25 N.m (18 lb ft)** .

39. Install the timing belt idler pulley.
40. Install the timing belt idler pulley bolt.

Tighten: Tighten the timing belt idler pulley bolt to **40 N.m (30 lb ft)** .

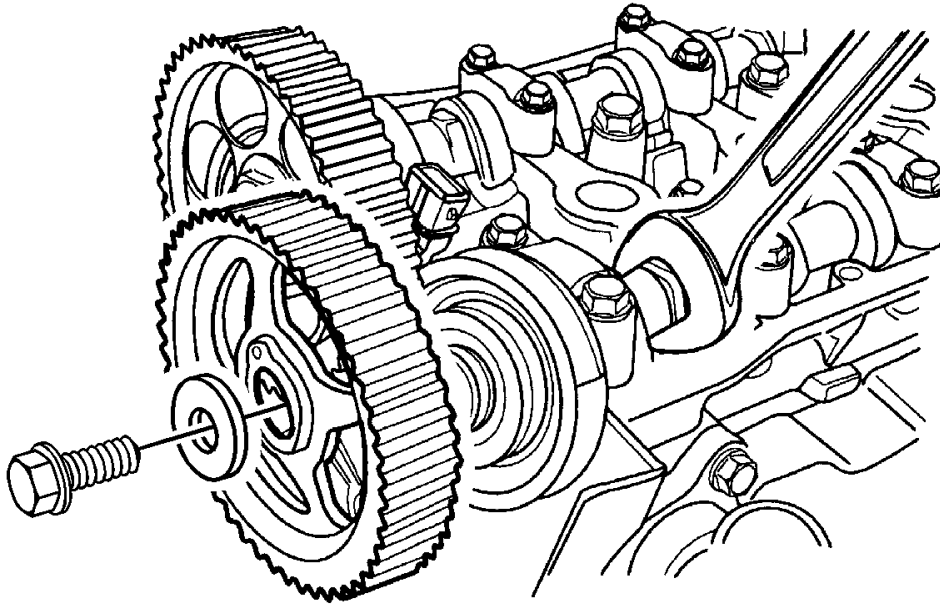


Fig. 173: Holding Camshaft To Tighten/Loosen Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Take extreme care to prevent any scratches, nicks or damage to the camshafts.

41. Install the intake camshaft gear.
42. Install the intake camshaft gear bolt while holding the intake camshaft firmly in place.

Tighten: Tighten the intake camshaft gear bolt to **67.5 N.m (49 lb ft)** .

43. Install the exhaust camshaft gear
44. Install the exhaust camshaft gear bolt while holding the exhaust camshaft firmly in place.

Tighten: Tighten the exhaust camshaft gear bolt to **67.5 N.m (49 lb ft)** .

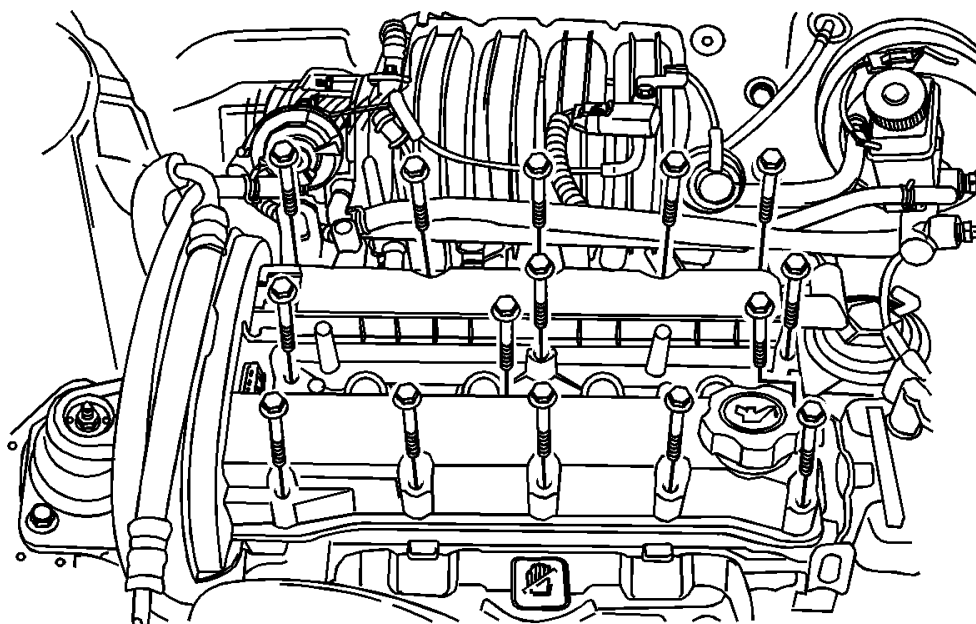


Fig. 174: Identifying Valve Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

45. Install the timing belt. Refer to **Timing Belt Replacement**.
46. Adjust the timing belt tension. Refer to **Timing Belt Inspection**.
47. Apply a small amount of gasket sealant to the corners of the front camshaft caps and to the top of the rear camshaft cover-to-cylinder head seal.
48. Install the camshaft cover and the camshaft cover gasket.
49. Install the camshaft cover washers.
50. Install the camshaft cover nuts.

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

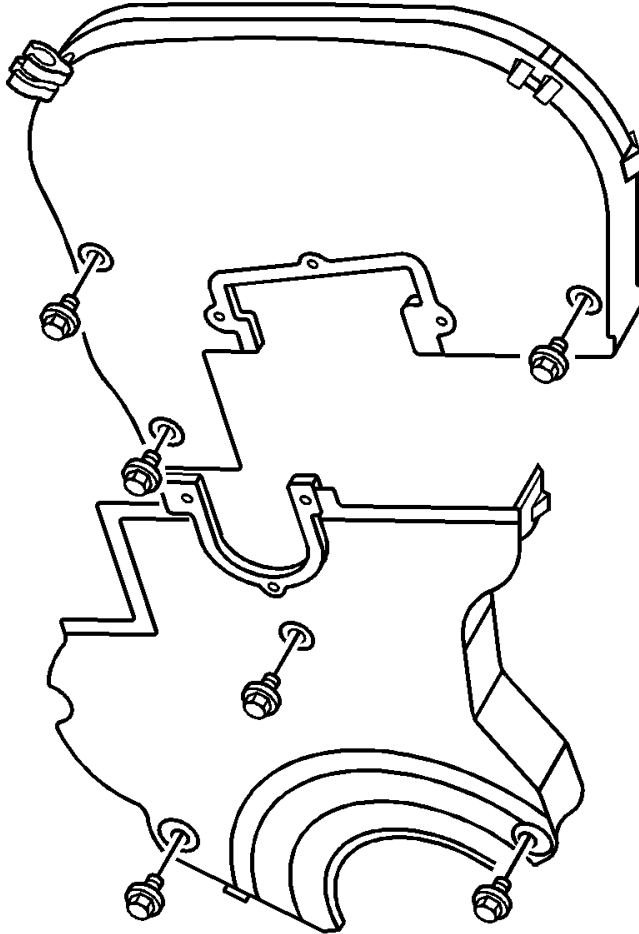


Fig. 175: Upper And Lower Front Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

51. Connect the ignition wires to the spark plugs
52. Connect the oil filler cap.
53. Connect the engine ventilation hose to the camshaft cover.
54. Install the upper and the lower front timing belt covers.
55. Install the upper and the lower front timing belt cover bolts.

Tighten: Tighten the upper and the lower front timing belt cover bolts to **10 N.m (89 lb in)** .

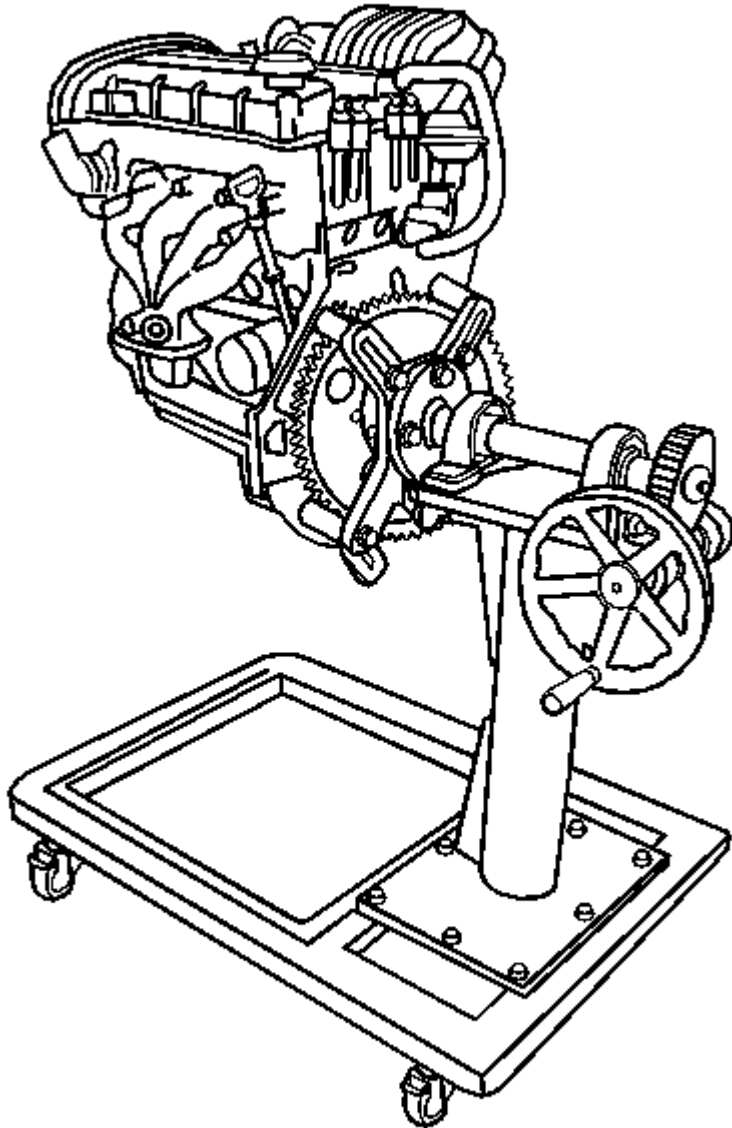


Fig. 176: View Of Engine On Overhaul Stand
Courtesy of GENERAL MOTORS CORP.

56. Install the engine lifting device.
57. Remove the engine from the engine overhaul stand **OTC 1726**.

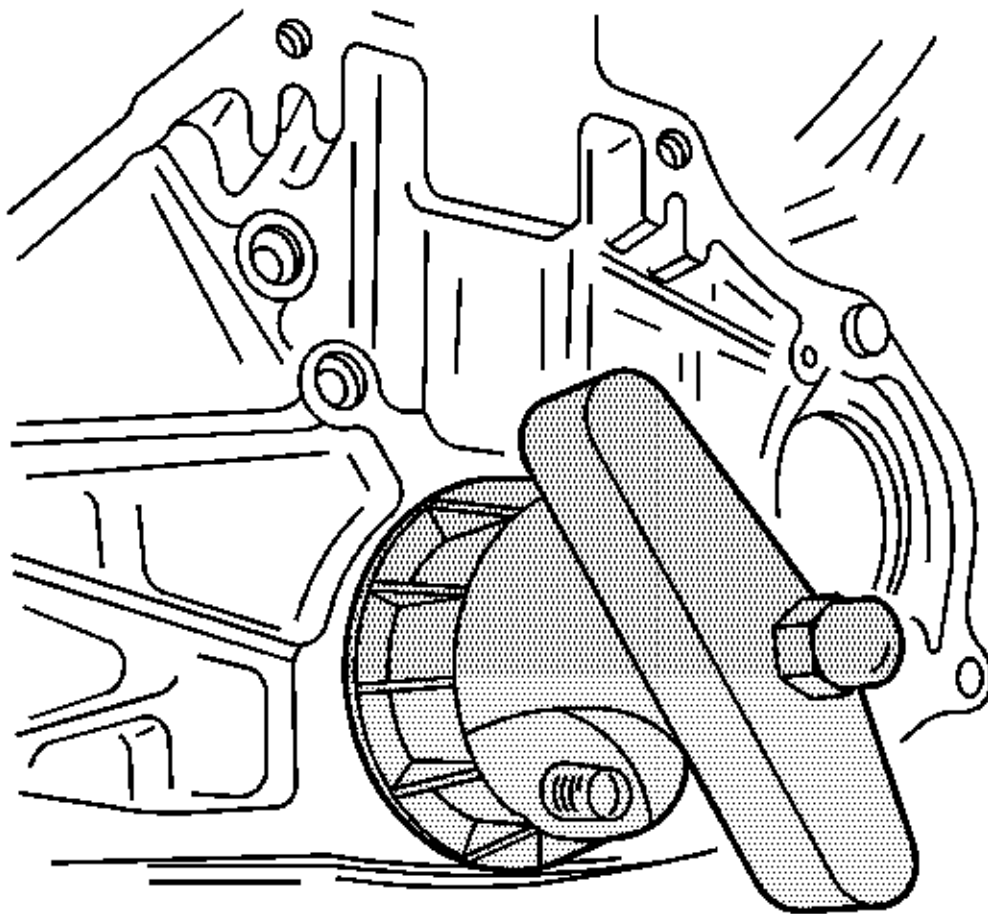


Fig. 177: View Of J 36972

Courtesy of GENERAL MOTORS CORP.

58. Install a new crankshaft rear oil seal using the **J 36972** or the **KM-635** .

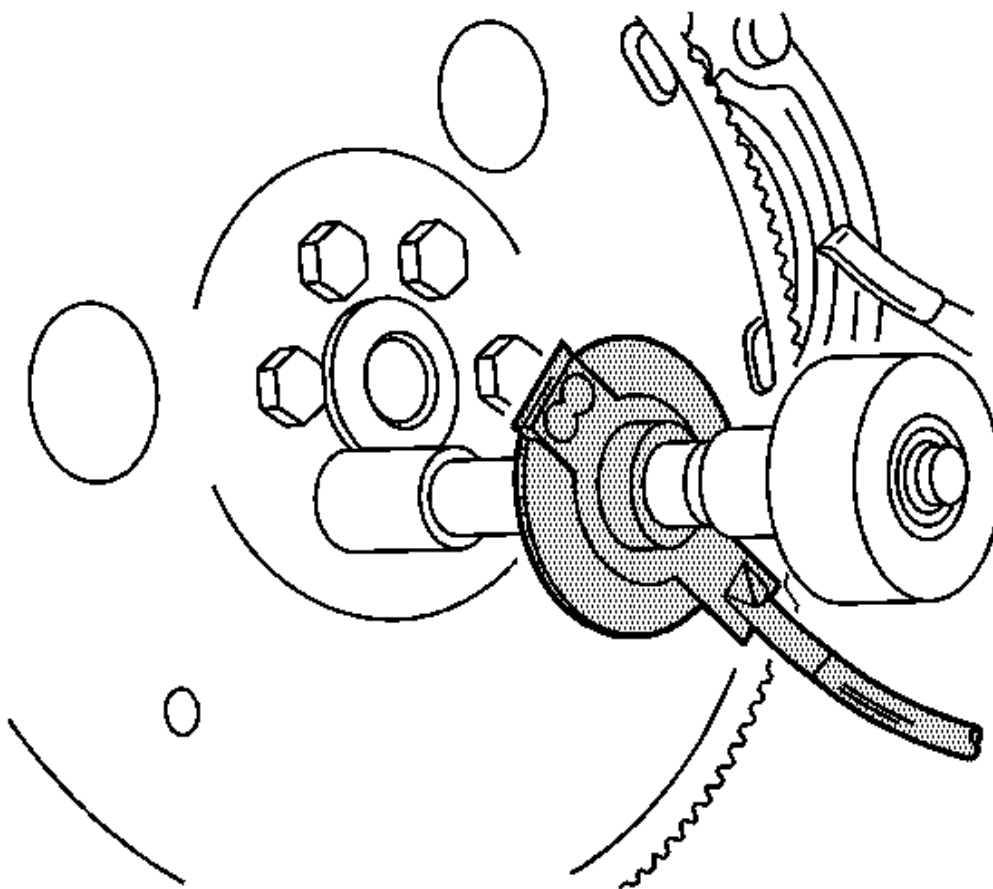


Fig. 178: View Of J 45059

Courtesy of GENERAL MOTORS CORP.

59. Install the flywheel or the flexible plate.
60. Install the flywheel or the flexible plate bolts using the **J 45059** or the **KM-470-B**.

Tighten: Tighten the flywheel bolts to **35 N.m (25 lb ft)**. Tighten the flywheel bolts another 30 degrees plus 15 degrees. If the vehicle is equipped with an automatic transaxle, tighten the flexible plate bolts to **45 N.m (33 lb ft)**.

61. Install the engine. Refer to **Engine Replacement**

REPAIR INSTRUCTIONS - OFF VEHICLE

TIMING BELT INSPECTION

IMPORTANT: The timing belt should be replaced immediately in the event that defects are found during routine timing belt inspections.

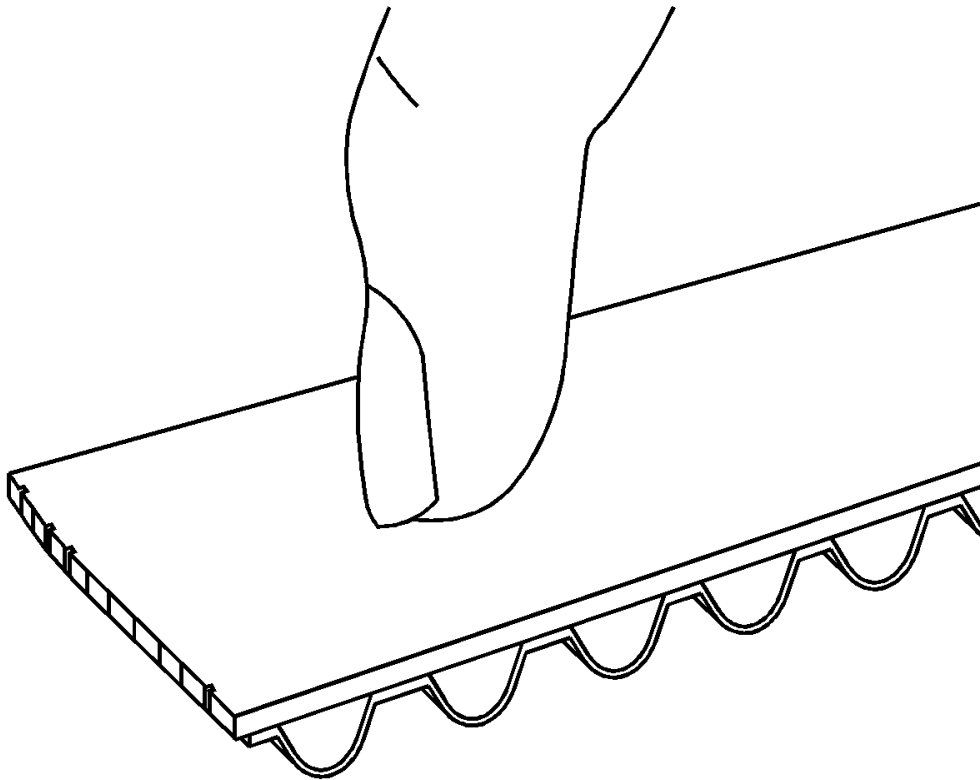


Fig. 179: Inspecting Belt For Hardening
Courtesy of GENERAL MOTORS CORP.

1. Inspect the belt for hardening. The belt will have a shiny appearance and will leave no mark when a fingernail is pressed into the backside of the belt.

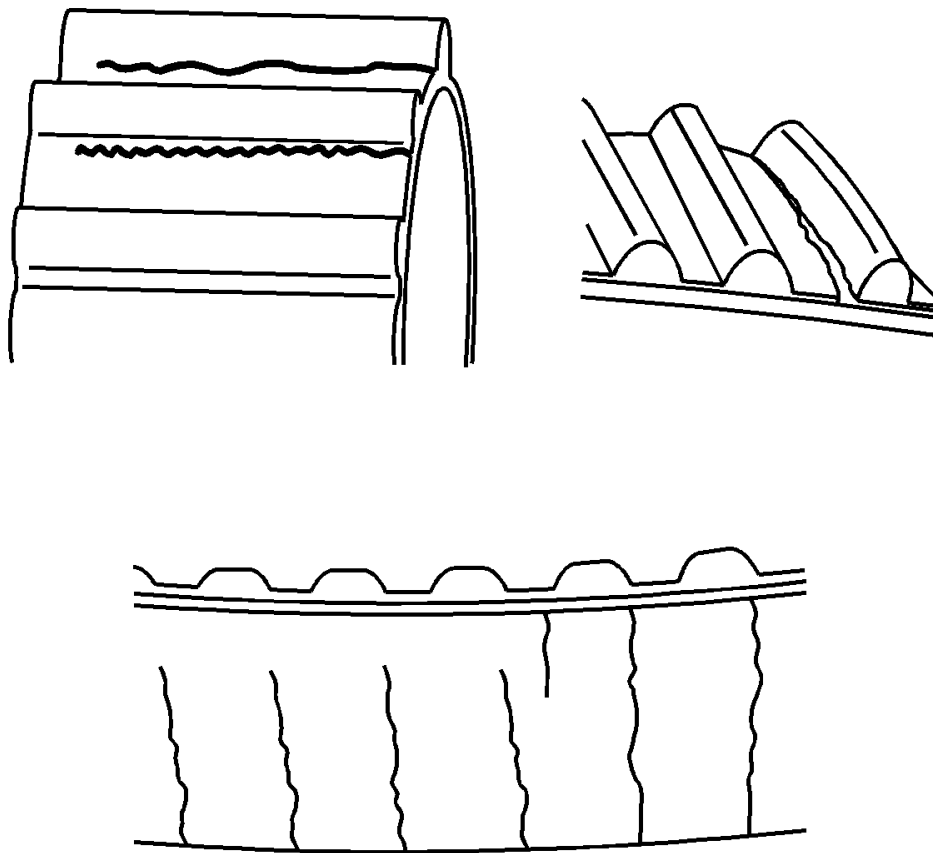


Fig. 180: Inspecting Belt For Tooth Separation And Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the belt for tooth separation and cracking on the backside of the belt.

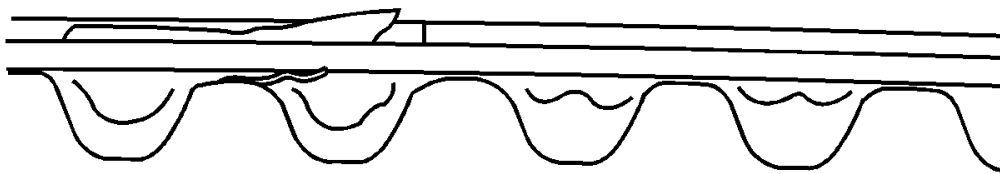


Fig. 181: Inspecting Belt For Abnormal Wear And Torn Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the belt for abnormal wear and torn areas on the edge of the belt.

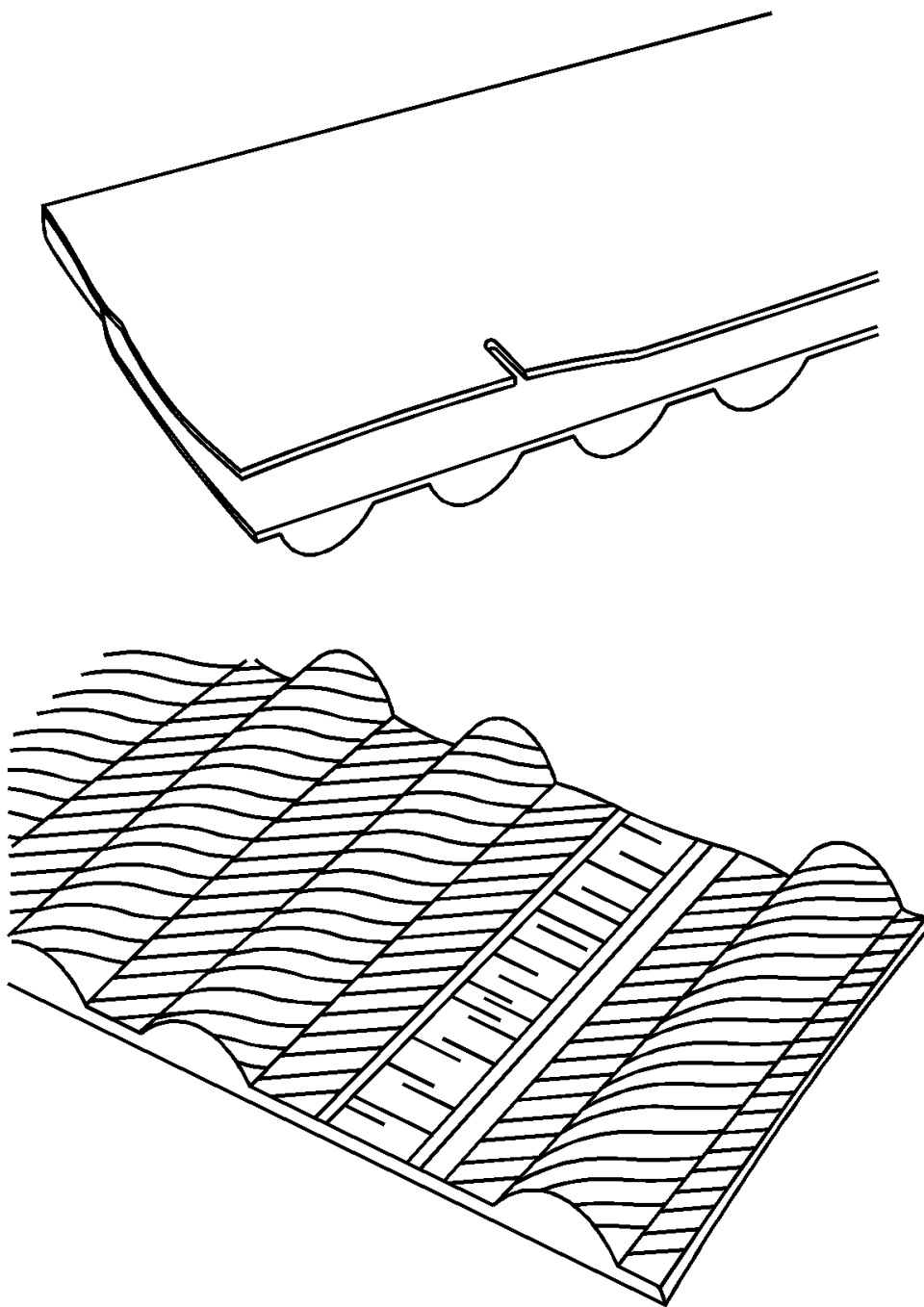


Fig. 182: Inspecting Belt For Missing Or Severely Worn Teeth
Courtesy of GENERAL MOTORS CORP.

4. Inspect the belt for missing or severely worn teeth and missing rubber or exposed fibers.

OIL PAN CLEANING AND INSPECTION

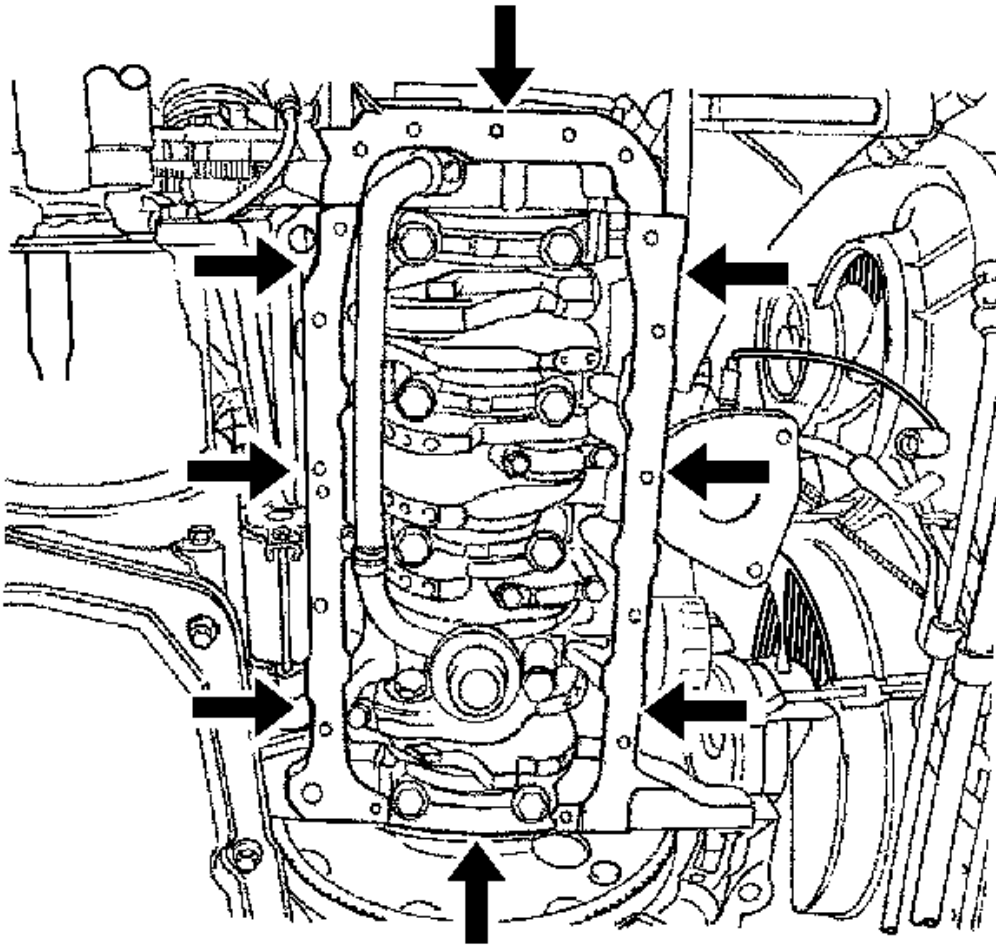


Fig. 183: Identifying Oil Pan Sealing Surface
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Clean the oil pan sealing surface.
2. Clean the engine block sealing surface.
3. Clean the oil pan retaining bolts.
4. Clean the oil pan retaining bolt holes in the engine block.

OIL PUMP CLEANING AND INSPECTION

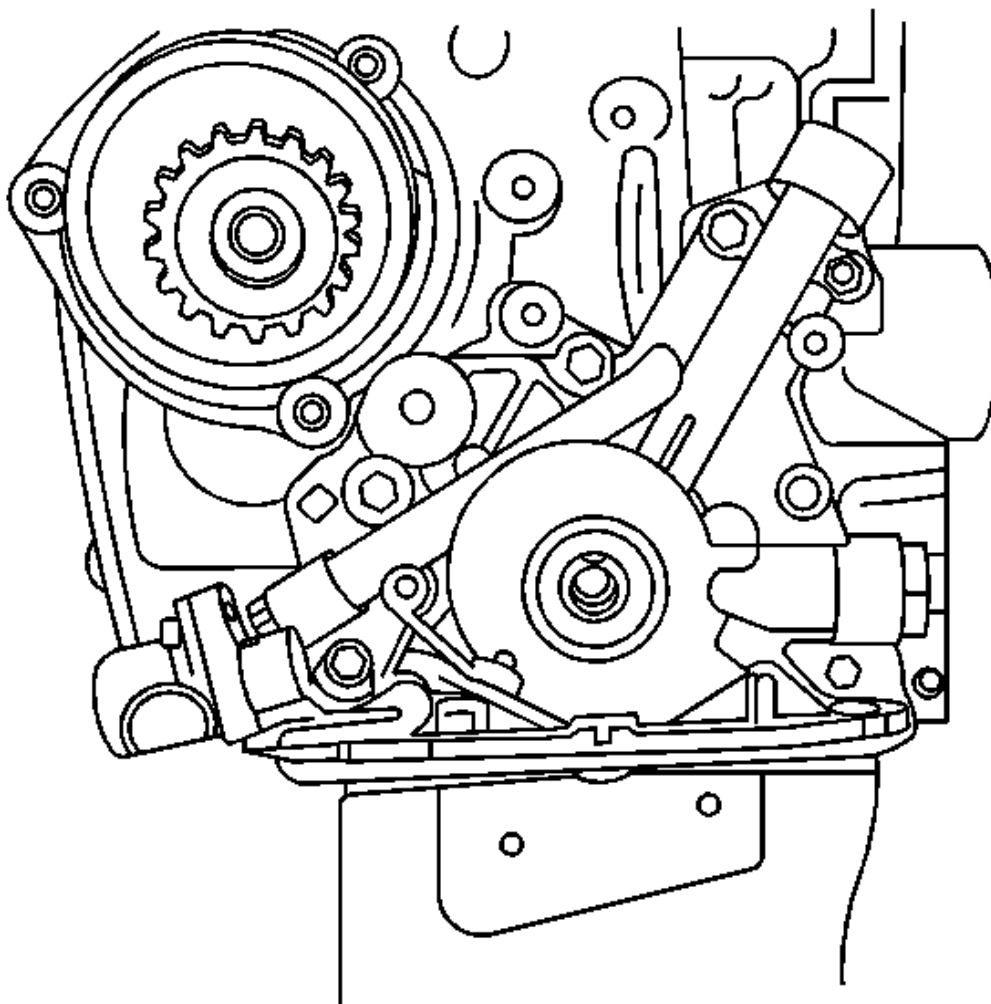


Fig. 184: View Of Oil Pump At Crankshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Clean the oil pump and the engine block gasket mating surface areas.
2. Remove the safety relief valve bolt.
3. Remove the safety relief valve and the spring.

4. Remove the oil pump-to-crankshaft seal.

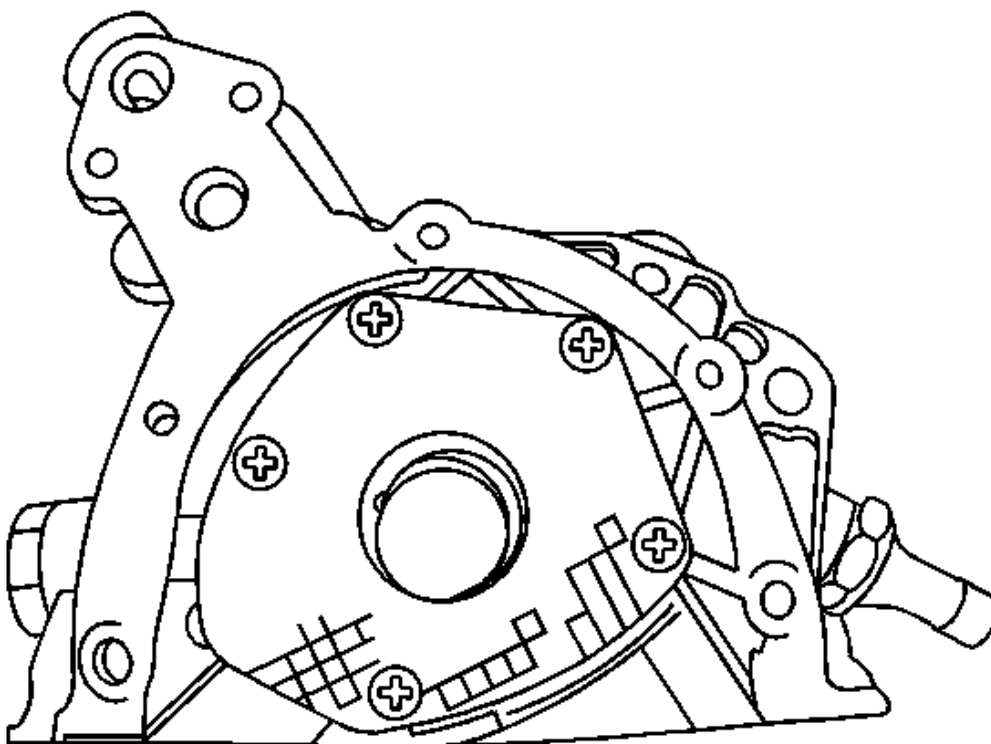


Fig. 185: View Of Oil Pump With Rear Cover Removed
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump rear cover bolts.
6. Remove the oil pump rear cover bolts.
7. Clean the oil pump housing and all the oil pump parts.
8. Inspect all the oil pump parts for signs of wear. Refer to **Engine Mechanical Specifications**. Replace the worn oil pump parts.

NOTE: Fill oil pump cavities with petroleum jelly prior to installation. This will ensure that there is oil pressure immediately on start-up and will prevent engine damage.

9. Coat all the oil pump parts with clean engine oil. Install the oil pump parts.

NOTE: Refer to Fastener Notice .

10. Apply Loctite® 242 to the oil pump rear cover bolts and install the cover and bolts.

Tighten: Tighten the oil pump rear cover bolts to **8 N.m (71 lb in)** .

11. Install the safety relief valve, spring, washer and bolt.

Tighten: Tighten the safety relief valve bolt to **30 N.m (22 lb ft)** .

EXHAUST MANIFOLD REMOVAL

Removal Procedure

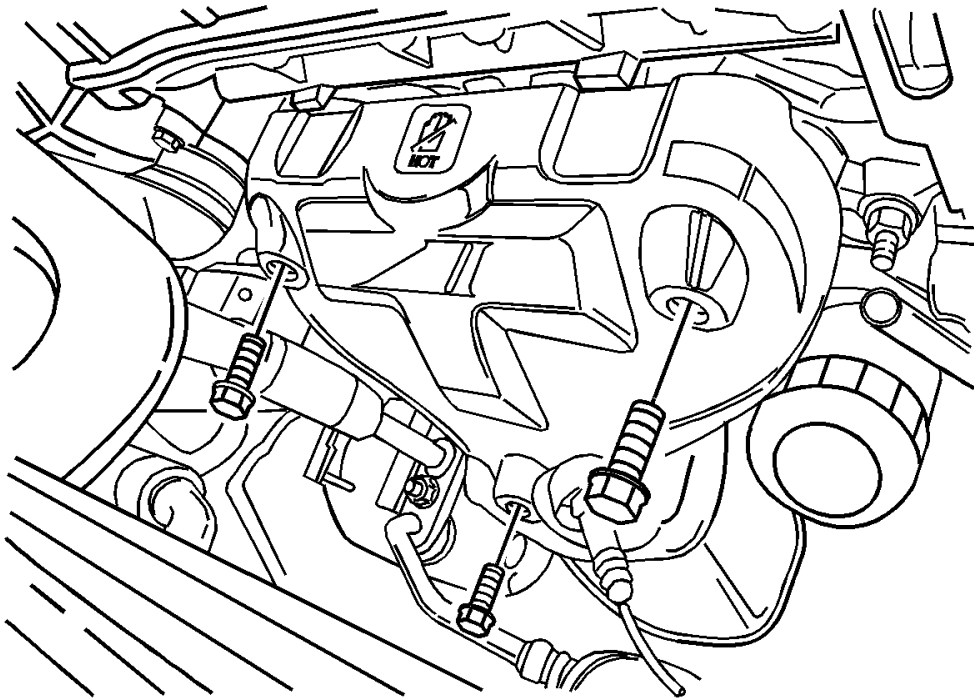


Fig. 186: View Of Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution .

1. Disconnect the negative battery cable.

NOTE: Refer to Oxygen Sensor Notice .

2. Disconnect the oxygen sensor connector.
3. Remove the exhaust manifold heat shield.

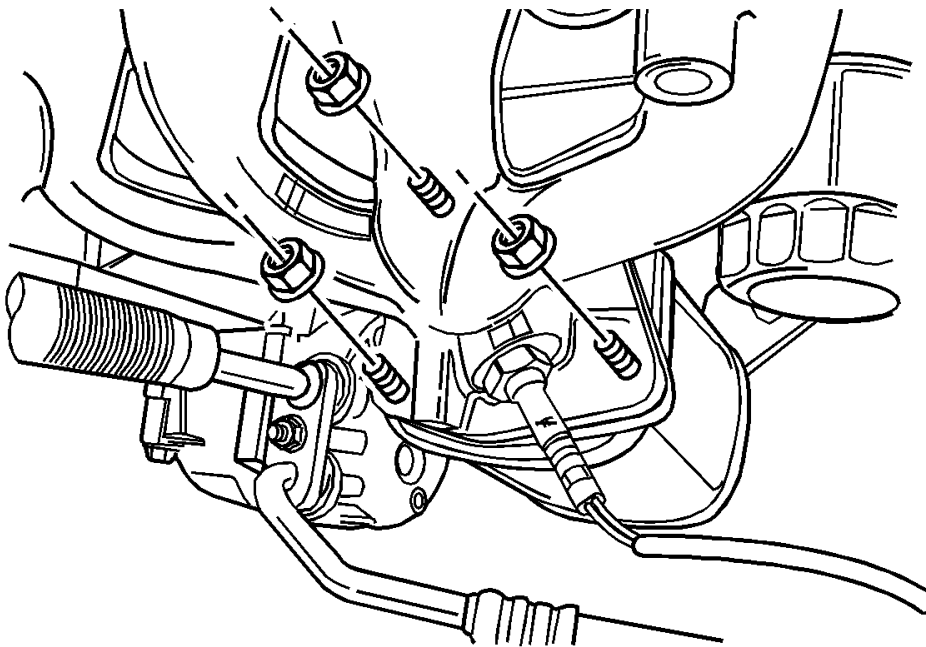


Fig. 187: View Of Exhaust Manifold Nuts
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold nuts from the pup converter.

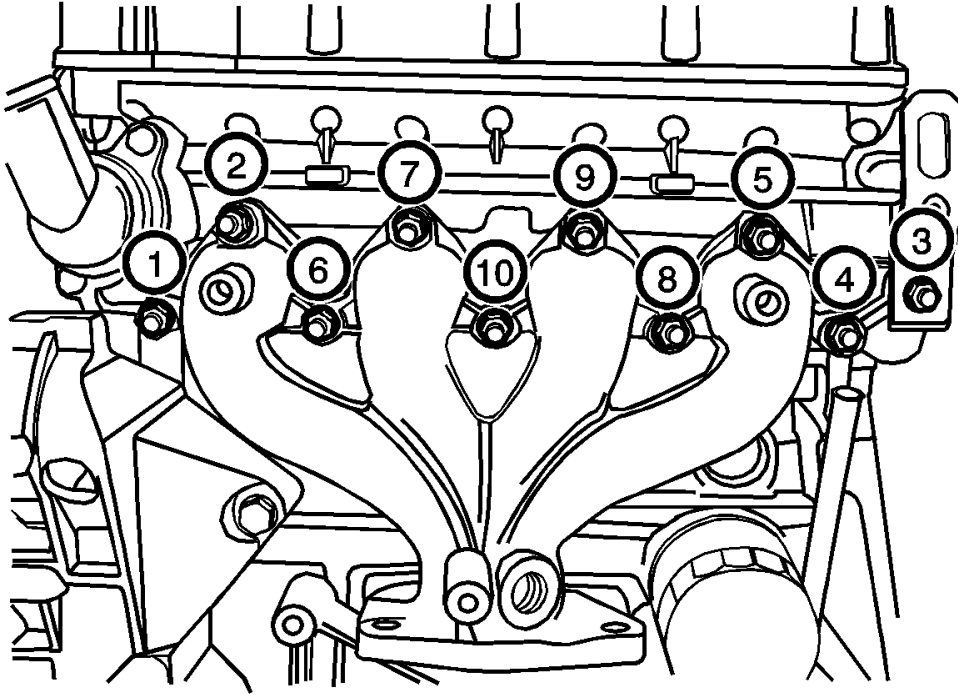


Fig. 188: Exhaust Manifold Retaining Nut Sequence
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust manifold retaining nuts in the sequence shown and remove the exhaust manifold.
6. Remove the exhaust manifold gasket.
7. Clean the sealing surfaces of the exhaust manifold and the cylinder head.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Tools Required

- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

Cleaning and Inspection

1. Coat the crankshaft bearings with engine oil.
2. Install the upper crankshaft bearings into the engine block crankshaft journals.

3. Install the lower crankshaft bearings into the crankshaft bearing caps.
4. Install the crankshaft.
5. Inspect the crankshaft end play with the crankshaft bearings installed.

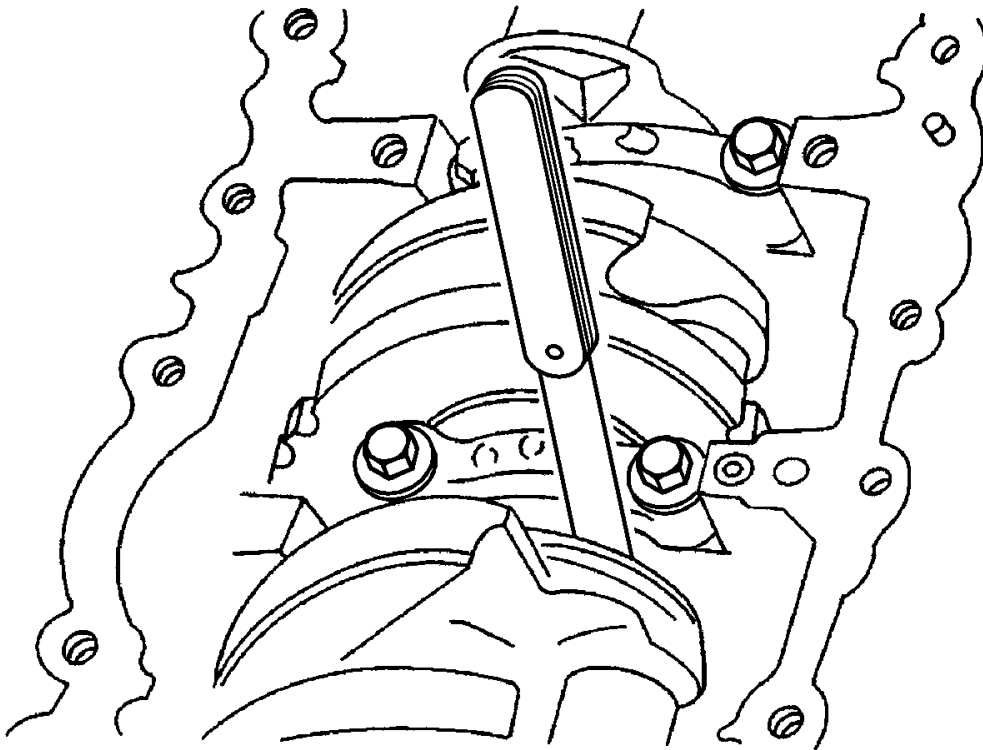


Fig. 189: Inspecting Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

6. Check for permissible crankshaft end play. Refer to **Engine Mechanical Specifications**.

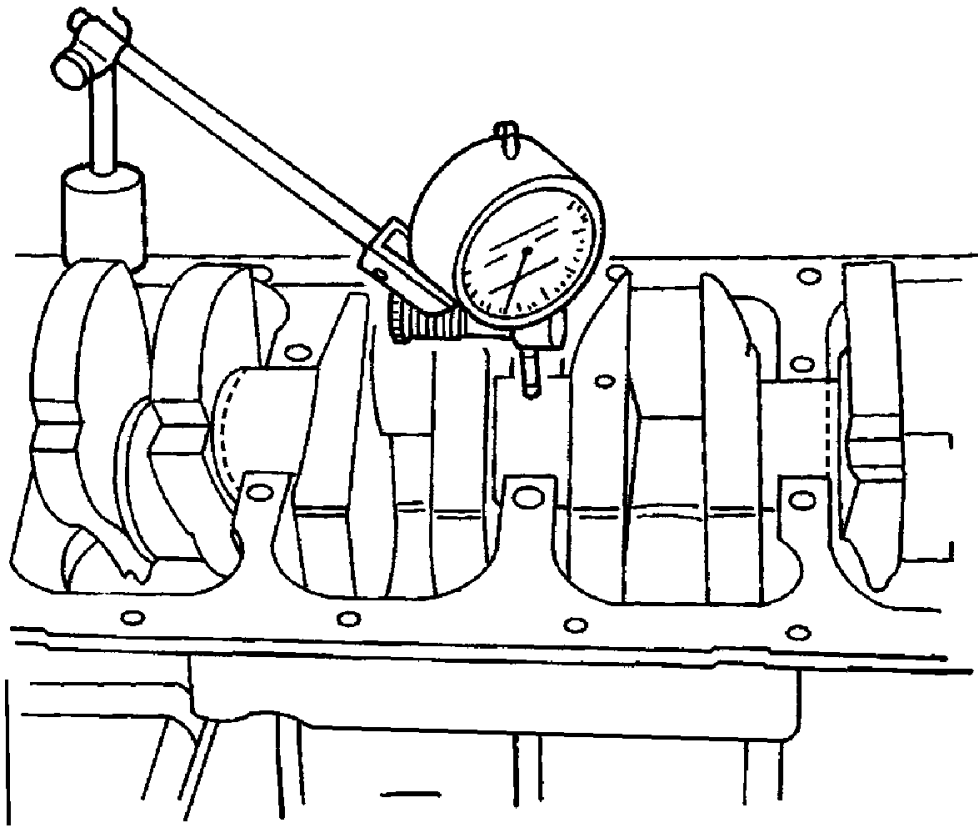


Fig. 190: Checking Middle Crankshaft Journal For Out-Of-Round Runout
Courtesy of GENERAL MOTORS CORP.

7. With the crankshaft mounted on the front and rear crankshaft bearings, check the middle crankshaft journal for permissible out-of-round (runout). Refer to **Engine Mechanical Specifications**.

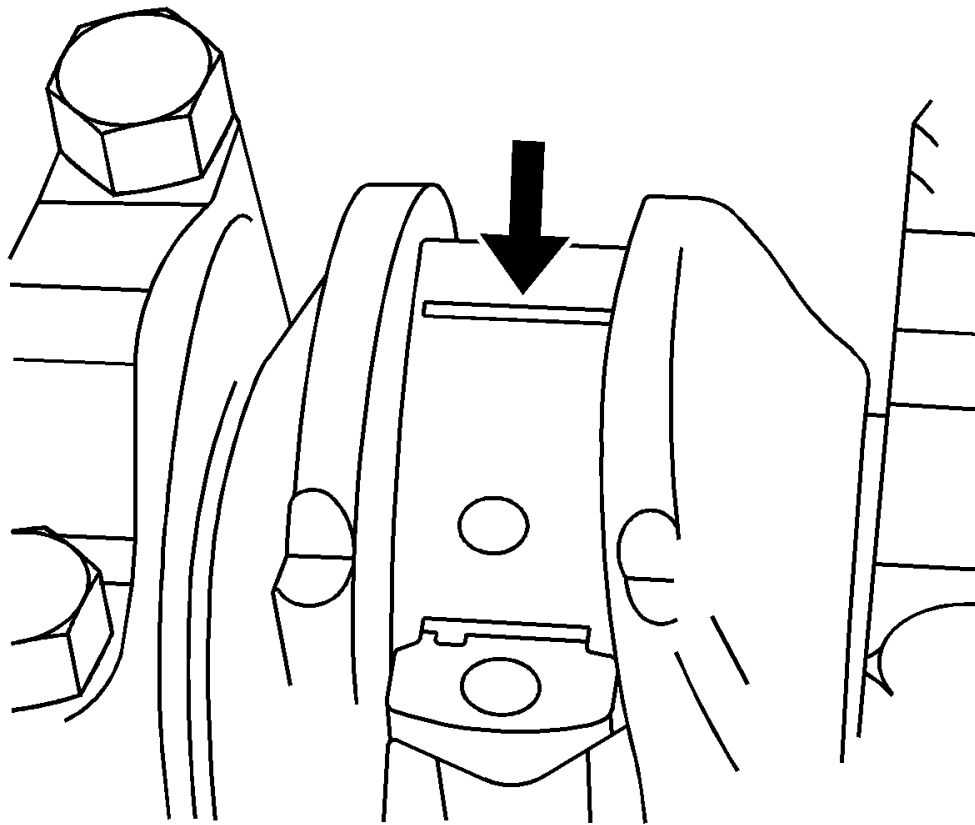


Fig. 191: Inspecting Crankshaft Bearing Clearances
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Grease the crankshaft journals and lubricate the crankshaft bearings slightly so that the plastic gaging thread does not tear when the crankshaft bearing caps are removed.

8. Inspect all of the crankshaft bearing clearances using a commercially available plastic gaging (ductile plastic threads).
9. Cut the plastic gaging threads to the length of the bearing width. Lay them axially between the crankshaft journals and the crankshaft bearings.

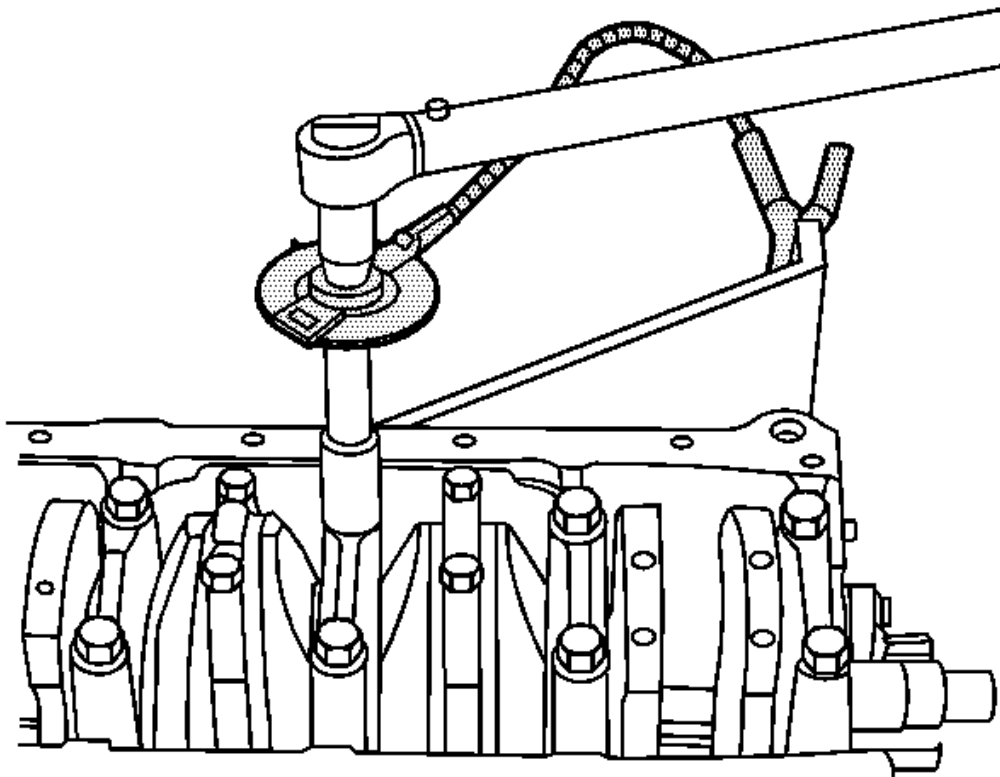


Fig. 192: View Of J 45059 And KM-470-B
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft bearing caps.

NOTE: Refer to Fastener Notice .

11. Install the crankshaft bearing cap bolts using the **J 45059** or the **KM-470-B** .

Tighten: Tighten the crankshaft bearing cap bolts to **50 N.m (37 lb ft)** . Tighten the crankshaft bearing cap bolts 45 degrees plus 15 degrees.

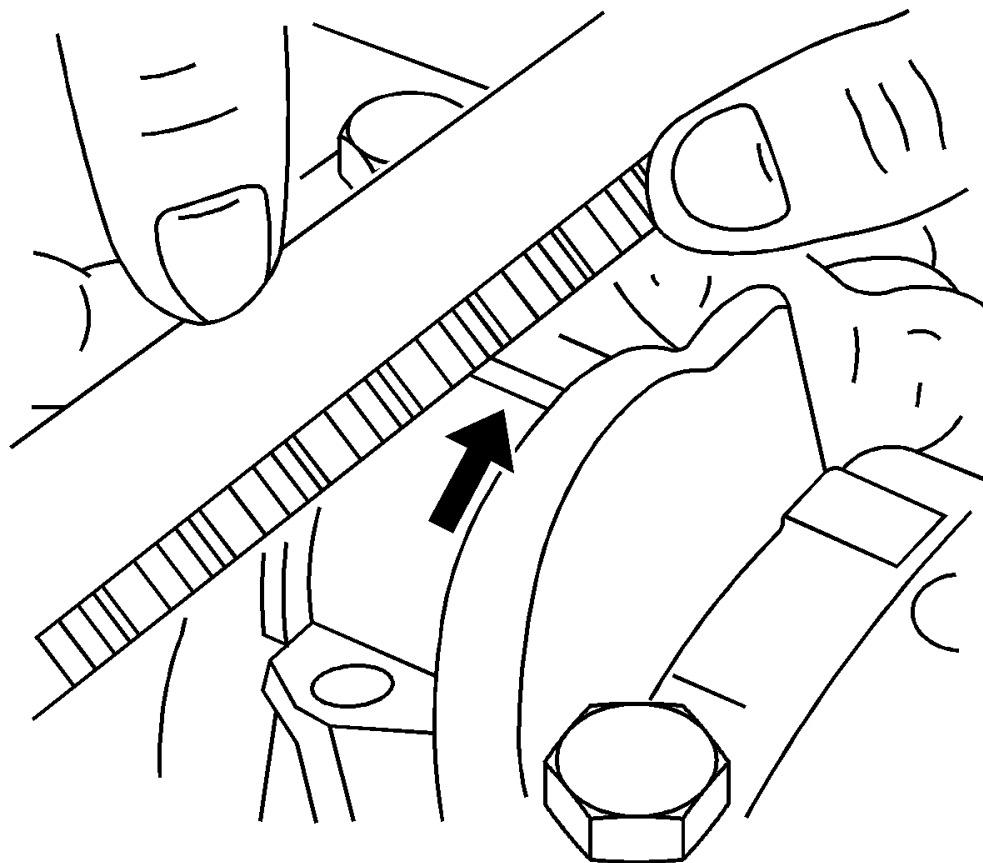


Fig. 193: View Of Plastic Thread
Courtesy of GENERAL MOTORS CORP.

12. Remove the crankshaft bearing caps.
13. Measure the width of the flattened plastic thread of the plastic gaging using a ruler. (Plastic gaging is available for different tolerance ranges.)
14. Inspect the bearing clearances for permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Tools Required

- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

Piston Inspection

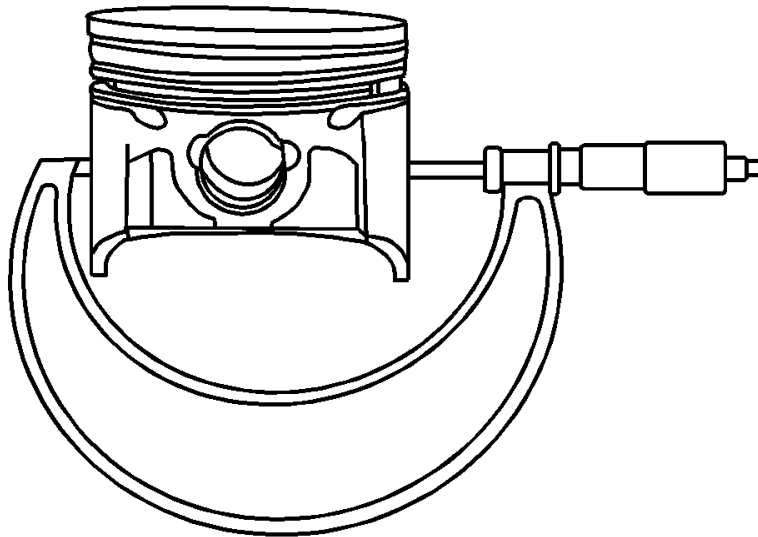


Fig. 194: Inspecting Piston
Courtesy of GENERAL MOTORS CORP.

1. Inspect the connecting rod for bending or twisting. If the connecting rod is bent or twisted, replace the connecting rod.
2. Inspect the connecting rod bearings.
3. Inspect the connecting rod lower end for wear.
4. Inspect the connecting rod upper end for scoring.
5. Inspect the crankshaft rod bearing journal for wear. Refer to **Engine Mechanical Specifications**.
6. Inspect the piston for scoring, cracks, and wear.
7. Inspect the piston for taper using a micrometer.

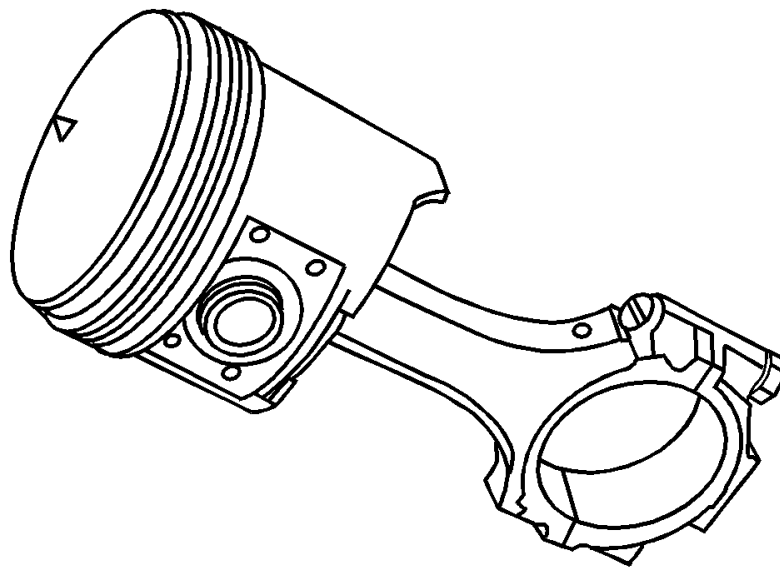


Fig. 195: View Of Piston

Courtesy of GENERAL MOTORS CORP.

8. Inspect the piston for fit to the connecting rod.

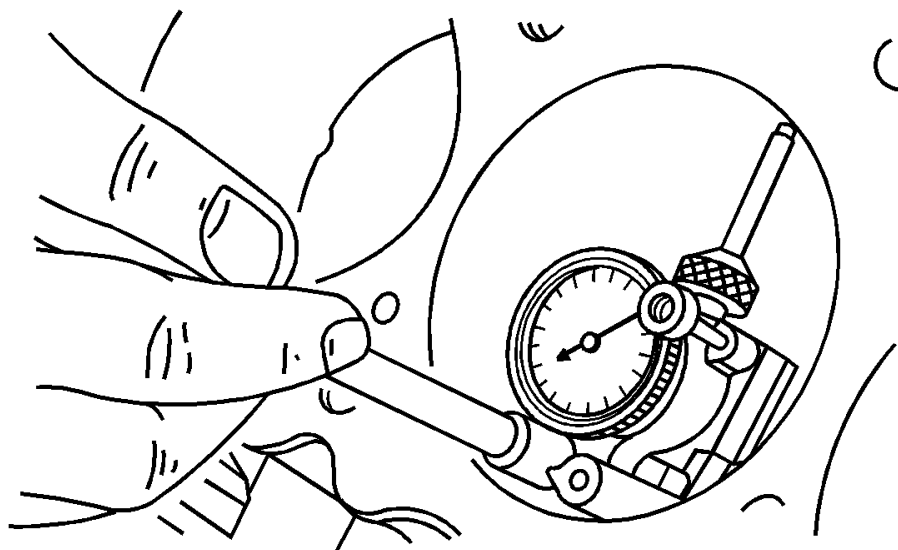


Fig. 196: Inspecting Engine Block Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

9. Inspect the engine block deck surface for flatness using a straight edge and a feeler gage. Refer to **Engine Mechanical Specifications**.
10. Inspect the bearing bore for concentricity and alignment using a bore gage. Refer to **Engine Mechanical Specifications**. If the bearing bore is beyond specifications, replace the engine block.
11. Inspect the engine block cylinder bore for wear, runout, ridging and taper using a bore gage. Refer to **Engine Mechanical Specifications**.
12. Inspect the engine block cylinder bore for glazing. Lightly hone the cylinder bore, as necessary.

Connecting Rod Inspection

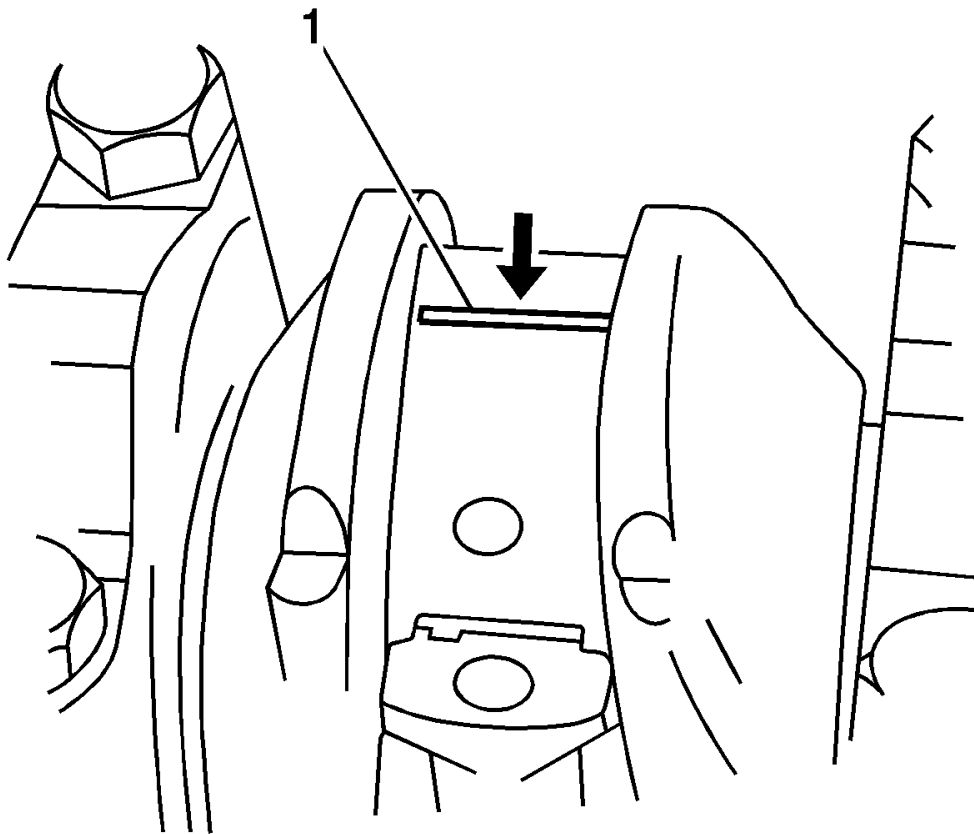


Fig. 197: Placement Of Plastigage On Journal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Coat the connecting rod bearings with engine oil.

IMPORTANT: Grease the connecting rod journals and lubricate the connecting rod bearings slightly so that the plastic gaging thread does not tear when the connecting rod bearing caps are removed.

2. Install the upper connecting rod bearings into the connecting rod journals.
3. Install the lower connecting rod bearings into the connecting rod bearing caps.
4. Measure all of the connecting rod bearing clearances using a commercially available plastic gaging, ductile plastic threads.

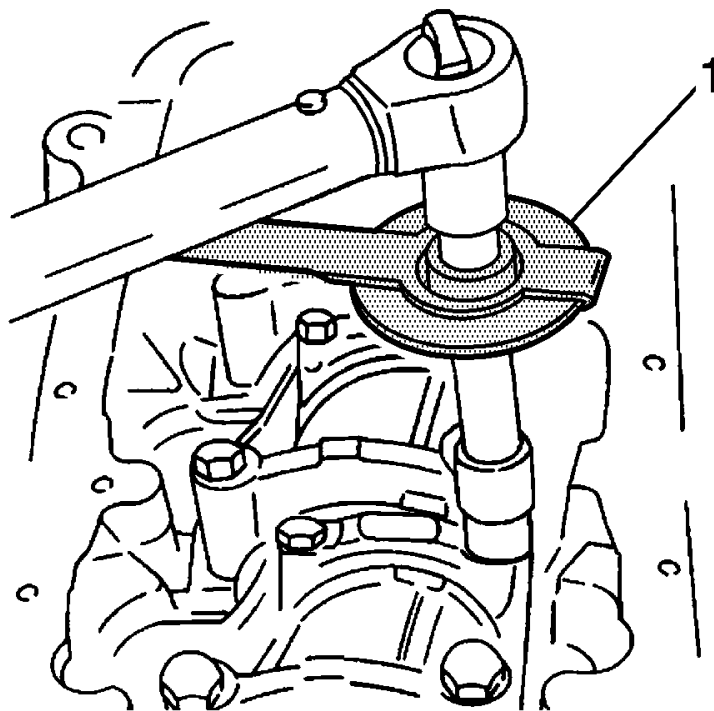


Fig. 198: Using J 45059 Or KM-470-B To Torque Rod Bolts
 Courtesy of GENERAL MOTORS CORP.

5. Cut the plastic gaging threads to the length of the bearing width. Lay them axially between the connecting rod journals and the connecting rod bearings.
6. Install the connecting rod bearing caps.

NOTE: Refer to Fastener Notice .

7. Install the connecting rod bearing cap bolts.

Tighten: Tighten the connecting rod bearing cap bolts to **25 N.m (18 lb ft)** .

8. Using the **J 45059** or the **KM-470-B (1)**, tighten the crankshaft bolts another 30 degrees plus 15 degrees.

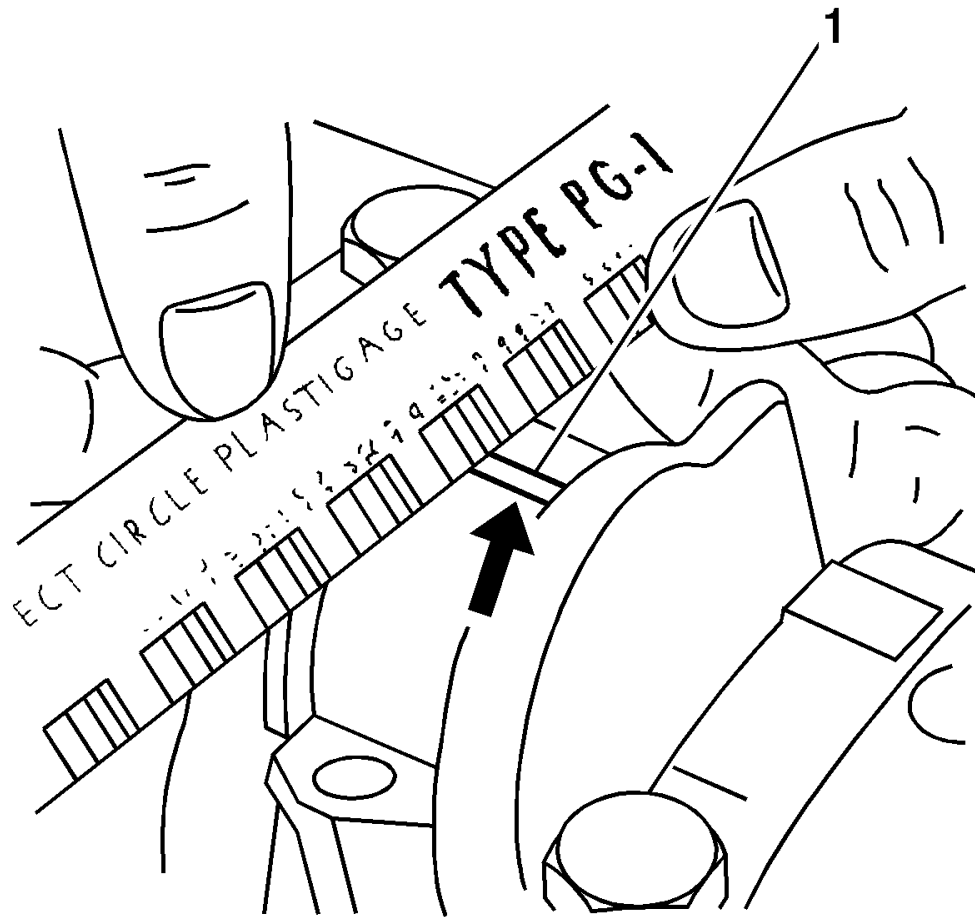


Fig. 199: Measuring Plastigage
Courtesy of GENERAL MOTORS CORP.

9. Remove the connecting rod bearing caps.
10. Measure the width of the flattened plastic thread of the plastic gaging (1) using the scale printed on the plastic gaging package. Plastic gaging is available for different tolerance ranges.
11. Inspect the bearing clearance for permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

VALVE ROCKER ARMS CLEANING AND INSPECTION

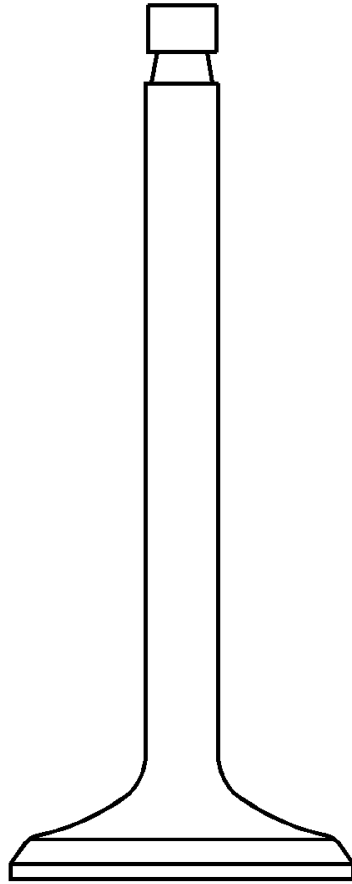


Fig. 200: View Of Valve Stem
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valve stem tip for wear.
2. Inspect the valve key grooves and the oil seal grooves for chips and wear.
3. Inspect the valves for burns or cracks.
4. Inspect the valve stem for burrs and scratches.
5. Inspect the valve stem. The valve stem must be straight.
6. Inspect the valve face for grooving. If the groove is so deep that refacing the valve would result in a sharp edge, replace the valve.

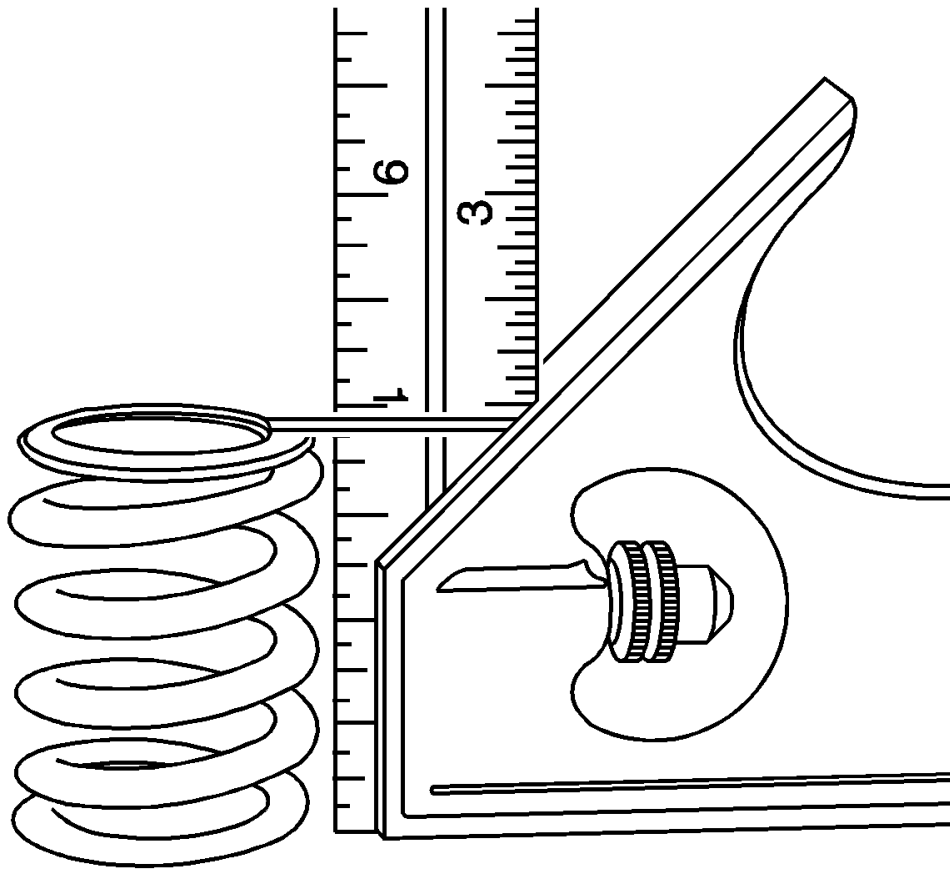


Fig. 201: Measuring Valve Spring Height
Courtesy of GENERAL MOTORS CORP.

7. Inspect the valve spring. If the valve spring ends are not parallel, replace the valve spring.
8. Measure the valve spring height. Refer to **Engine Mechanical Specifications**. If the valve spring height does not match the specifications, replace the valve spring.
9. Inspect the valve spring seating surface of the valve rotators for wear or gouges. Replace as required.

Cleaning Procedure

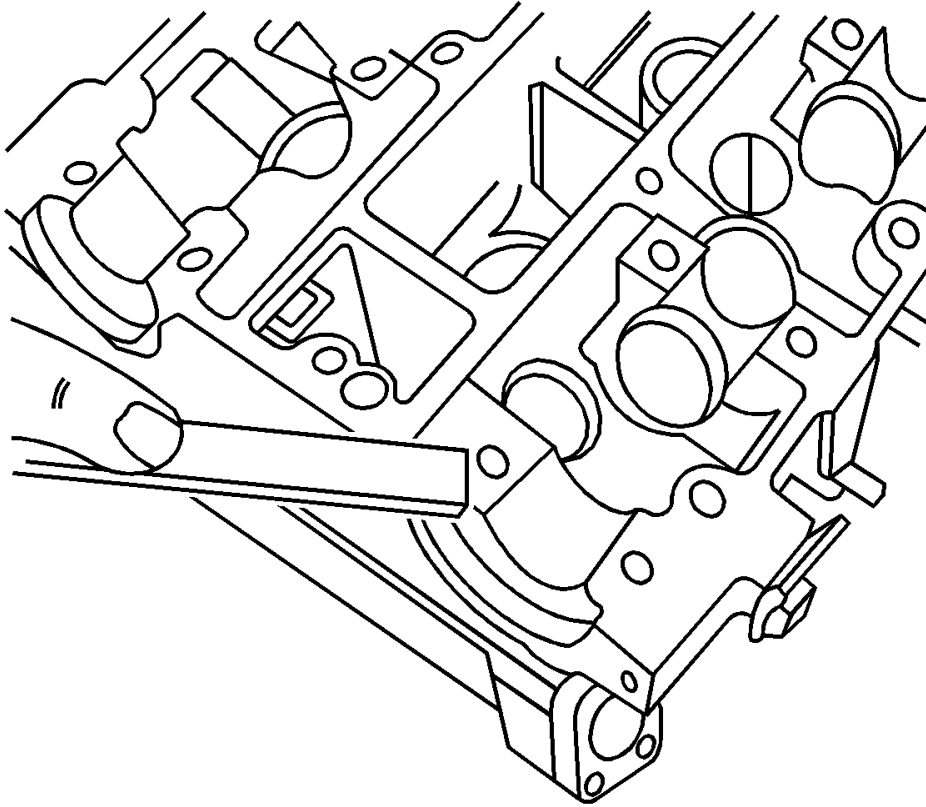


Fig. 202: View Of Cylinder Head And Valve Guide Cleaning Procedure
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

1. Clean the cylinder head.
2. Clean the valve guides.
3. Clean all of the threaded holes.
4. Clean the valves of carbon, oil, and varnish.

CYLINDER HEAD DISASSEMBLE

Tools Required

- **J 8062** (KM-348) Valve Spring Compressor
- **KM-653-A** Adaptor

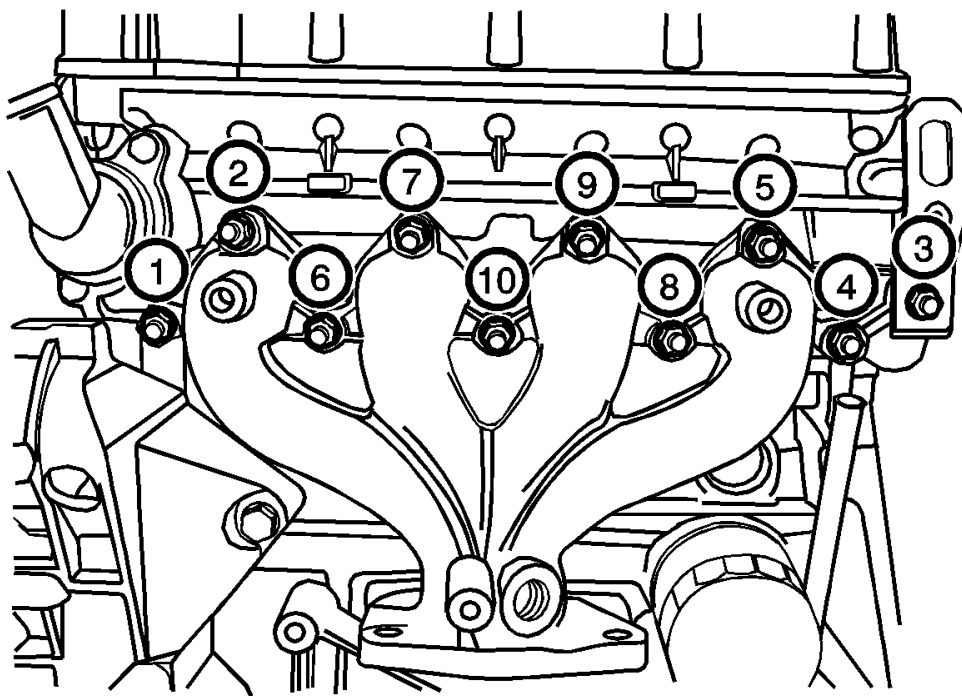
Disassembly Procedure

Fig. 203: Exhaust Manifold Retaining Nut Sequence
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Camshaft Replacement**.
2. Remove the coolant temperature sensor (CTS).
3. Remove the exhaust manifold heat shield bolts.
4. Remove the exhaust manifold heat shield.
5. Remove the exhaust manifold retaining nuts in the sequence shown.
6. Remove the exhaust manifold.
7. Remove the exhaust manifold gasket.
8. Remove the exhaust manifold studs.

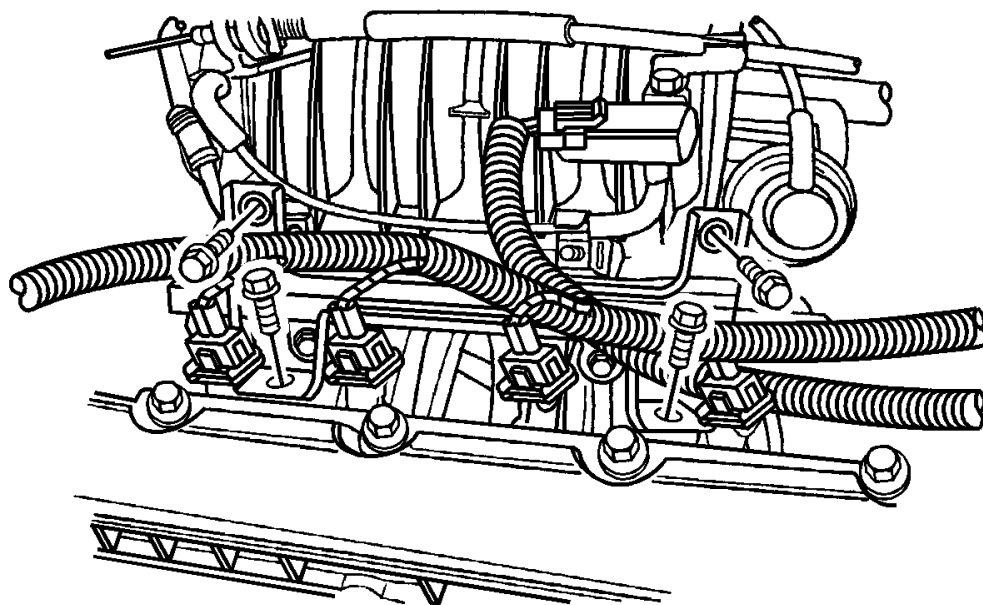


Fig. 204: View Of Thermostat Housing Assembly, Mounting Bolts, Fuel Rail Assembly And Retaining Bolts

Courtesy of GENERAL MOTORS CORP.

9. Remove the thermostat housing mounting bolts.
10. Remove the thermostat housing assembly.
11. Remove the fuel rail retaining bolts and the fuel rail assembly.

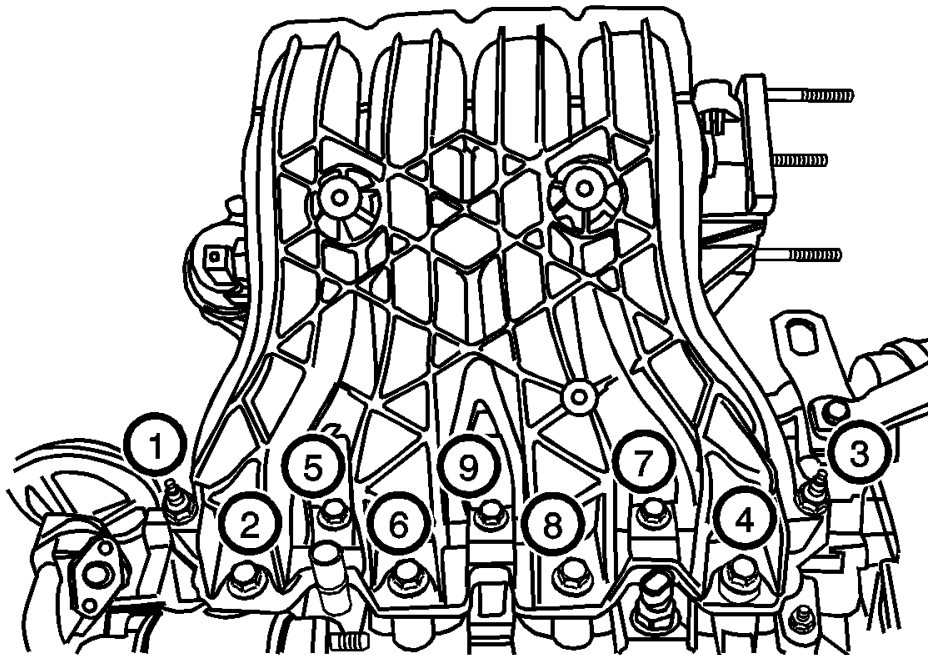


Fig. 205: Identifying Intake Manifold Retaining Nuts And Bolts Sequence
Courtesy of GENERAL MOTORS CORP.

12. Remove the intake manifold retaining nuts and retaining bolts in the sequence shown.
13. Remove the intake manifold.
14. Remove the intake manifold studs.

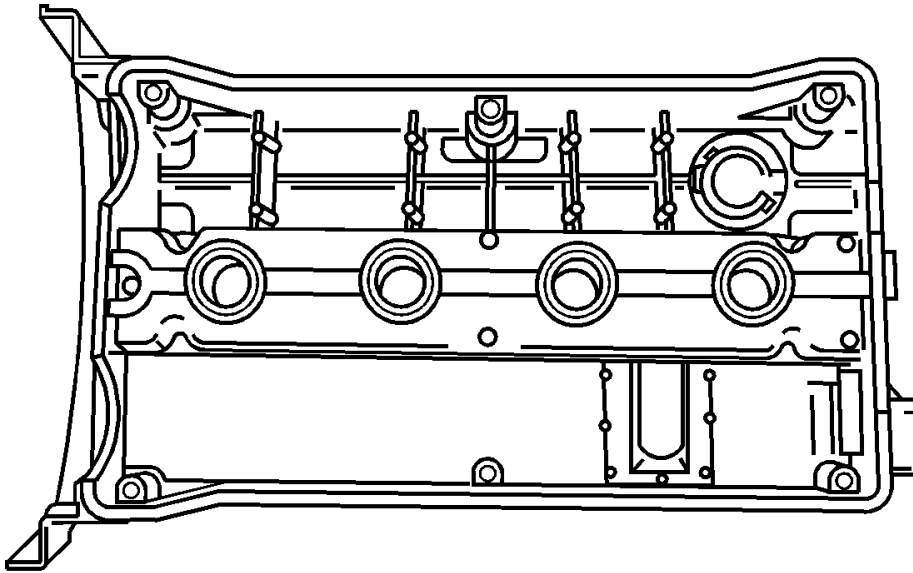


Fig. 206: View OF DIS Coil Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

15. Remove the direct ignition system (DIS) coil mounting bolts.
16. Remove the DIS coil with the ignition wires attached.
17. Remove the DIS coil mounting bracket bolts.
18. Remove the electrical exhaust gas recirculation (EEGR) valve adapter bolts.
19. Remove the electrical EEGR valve adapter bolts.
20. Remove the EEGR valve adapter.
21. Remove the EEGR valve adapter gasket.
22. Remove the spark plugs.

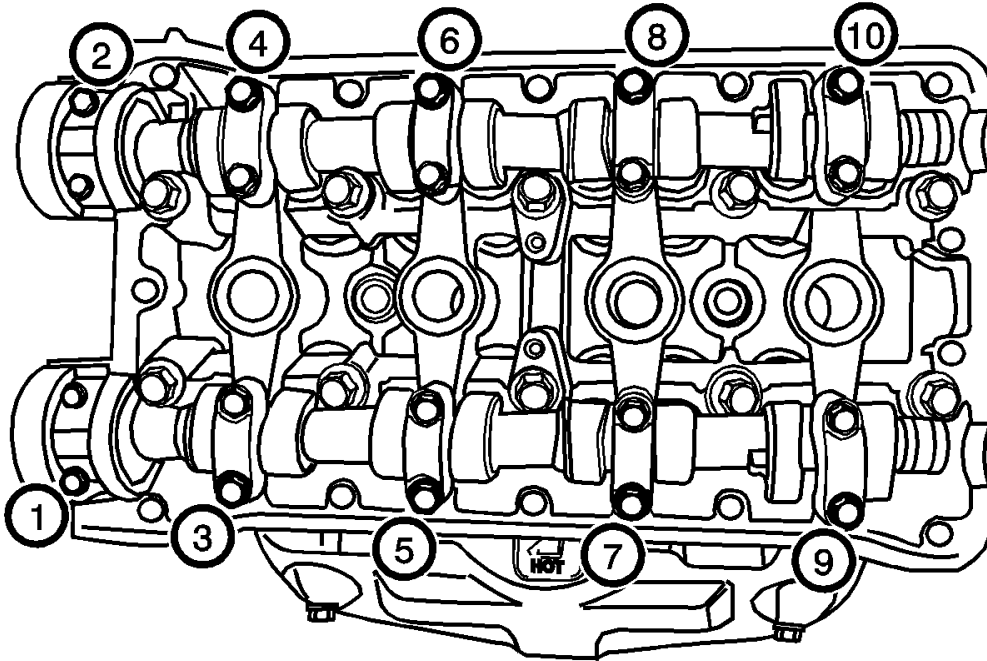


Fig. 207: View Of Camshaft Cap Bolt Sequence
Courtesy of GENERAL MOTORS CORP.

23. Remove the camshaft cap bolts gradually and in the sequence shown for each camshaft cap.

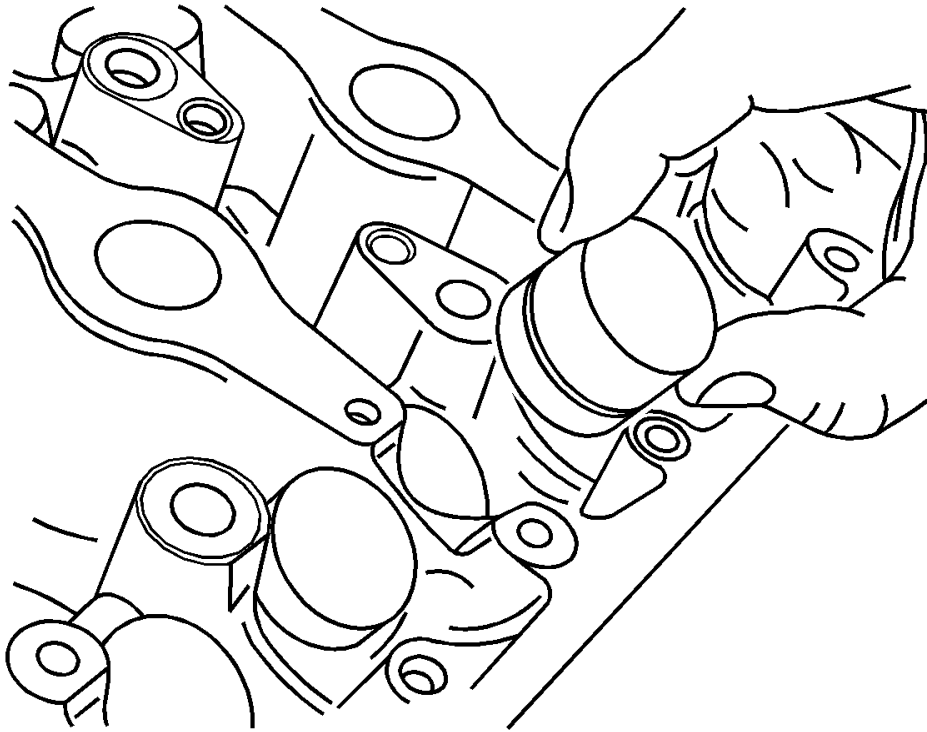


Fig. 208: View Of Intake Camshaft Cap
Courtesy of GENERAL MOTORS CORP.

24. Remove the intake camshaft caps. Maintain the correct positions for installation.
25. Remove the intake camshaft.
26. Remove the intake valve tappet adjusters.
27. Remove the exhaust camshaft caps. Maintain the correct positions for installation.
28. Remove the exhaust camshaft.
29. Remove the exhaust valve tappet adjusters.

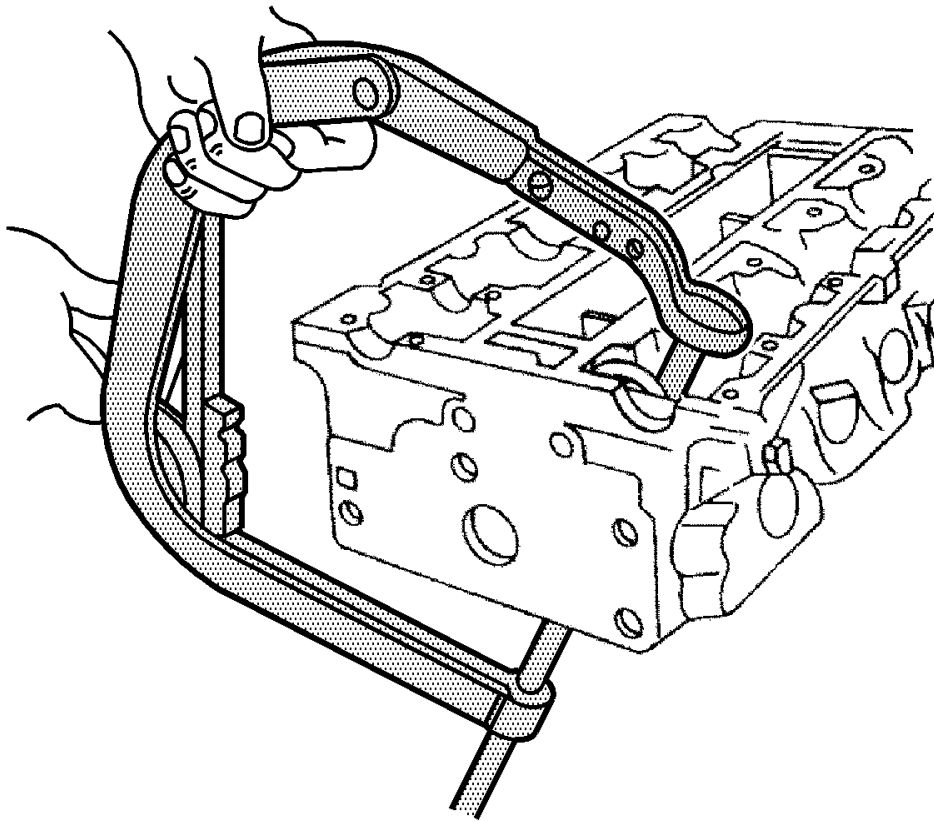


Fig. 209: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Valve springs can be tightly compressed. Use care when removing the retainers and plugs. Personal injury could result.

30. Compress the valve springs with the **J 8062** and the **KM-653-A**.
31. Remove the valve keys.
32. Remove the **J 8062** and **KM-653-A**.
33. Remove the valve spring caps.
34. Remove the valve springs. Maintain the original position of the valve springs for installation.

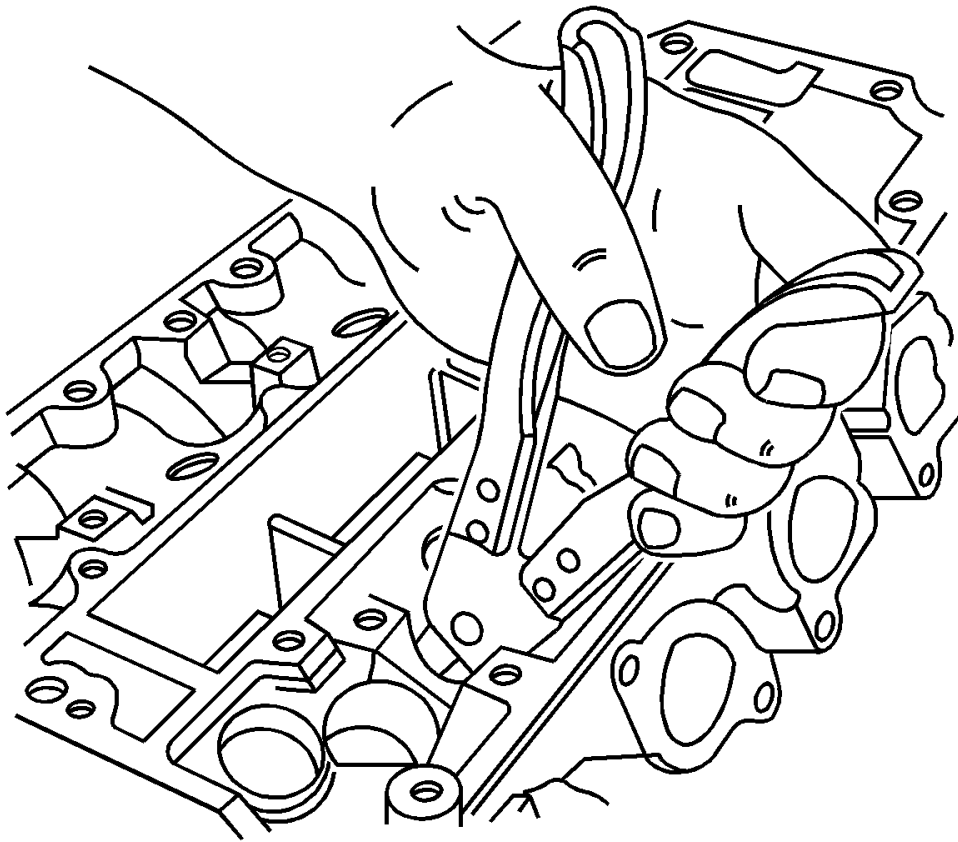


Fig. 210: Removal Of Valves
Courtesy of GENERAL MOTORS CORP.

35. Remove the valves. Maintain the original position of the valves for installation.
36. Remove the valve stem seals.

CYLINDER HEAD CLEANING AND INSPECTION (OFF VEHICLE)

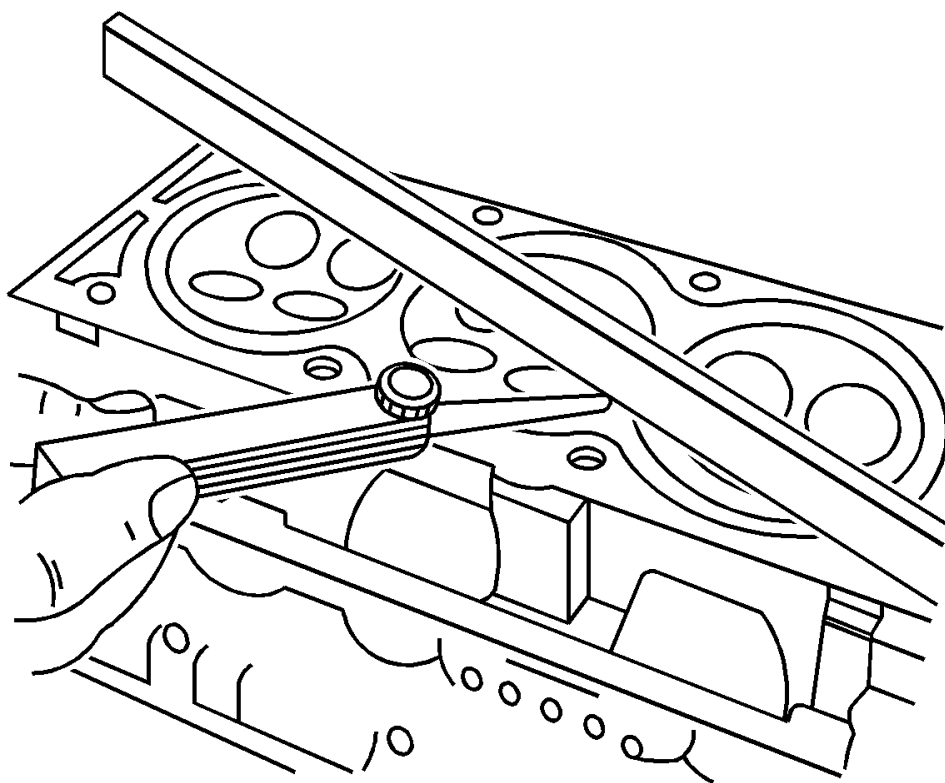


Fig. 211: Inspecting Cylinder Head
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT: Machining of the cylinder head for flatness is not recommended as this would increase the compression ratio of the engine. If the flatness or height measurements are not within the specifications, replace the cylinder head.

1. Clean the sealing surfaces.
2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion, and blowby.
3. Inspect the cylinder head for cracks.
4. Inspect the length and the width of the cylinder head using a feeler gage and a straight edge.
5. Check the sealing surfaces for damage. The cylinder head sealing surfaces must be flat within 0.050 mm (0.002 in) maximum.

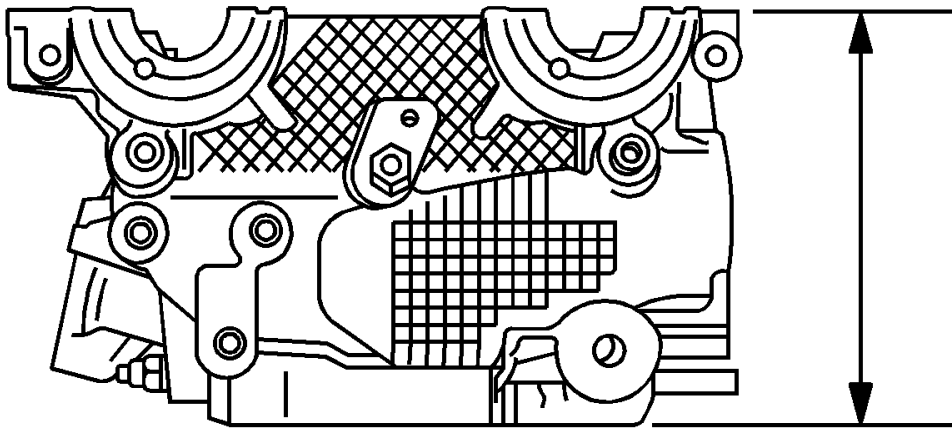


Fig. 212: Measuring Cylinder Head Height
Courtesy of GENERAL MOTORS CORP.

6. Measure the height of the cylinder head from sealing surface to sealing surface. The cylinder head height should be 138.13-138.18 mm (5.438-5.440 in). If the cylinder head height is less than this value, replace the cylinder head.
7. Inspect all threaded holes for damage.
8. Inspect valve seats for excessive wear and burned spots.

CYLINDER HEAD ASSEMBLE

Tools Required

- **J 8062** (KM-348) Valve Spring Compressor - Head Off
- **KM-653-A** Adaptor

Assemble Procedure

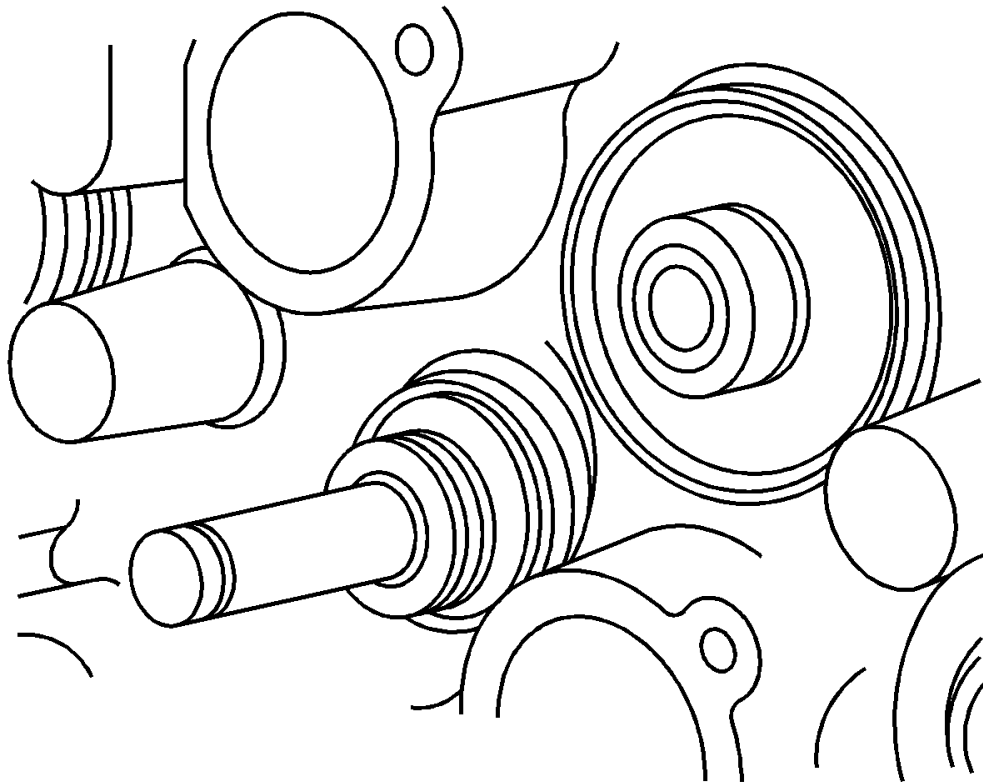


Fig. 213: View Of Valve Springs And Seals
Courtesy of GENERAL MOTORS CORP.

1. Install the valve stem seals.
2. Lubricate the valve stems with engine oil.
3. Carefully install the valves in their original positions. Do not damage the valve stem seals.
4. Install the valve springs in their original positions.
5. Install the valve spring caps.

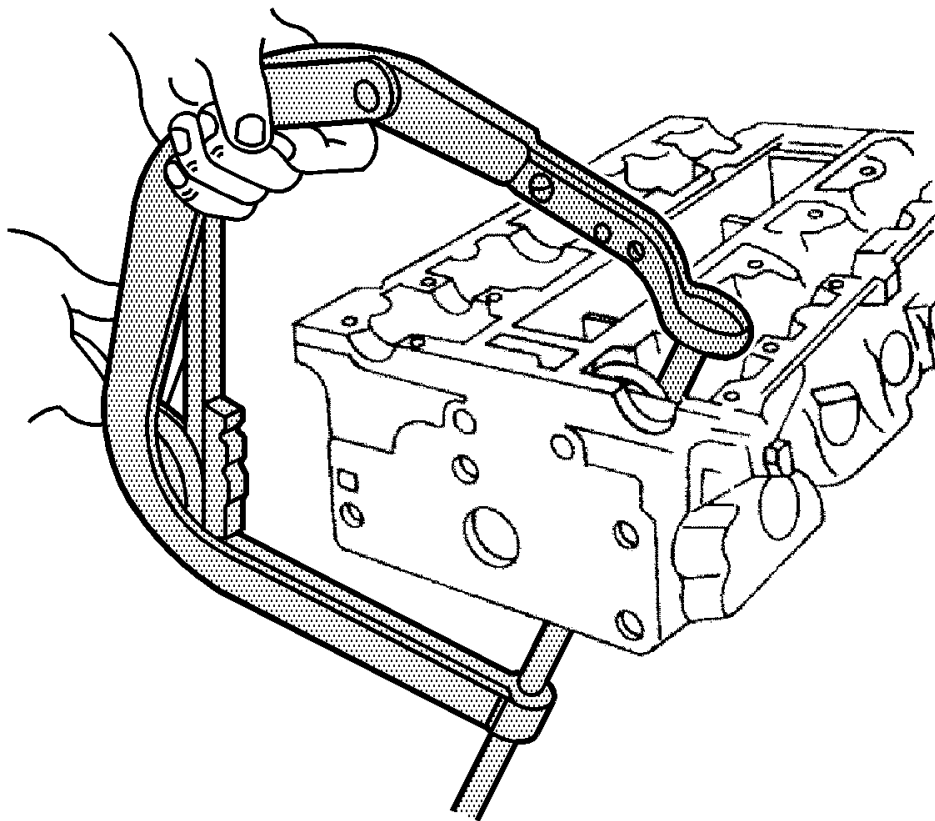


Fig. 214: Compressing Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve springs with **J 8062** and **KM-653-A**
7. Install the valve keys.
8. Remove **J 8062** and **KM-653-A** .

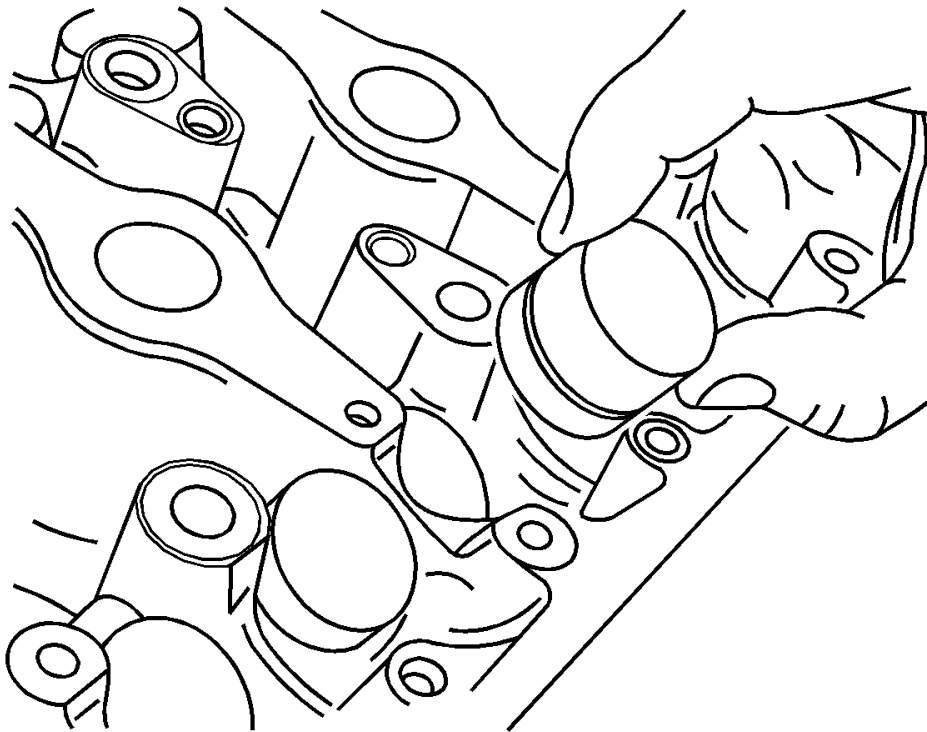


Fig. 215: View Of Intake Camshaft Cap
Courtesy of GENERAL MOTORS CORP.

9. Lubricate the valve tappet adjusters with engine oil.
10. Install the valve tappet adjusters.

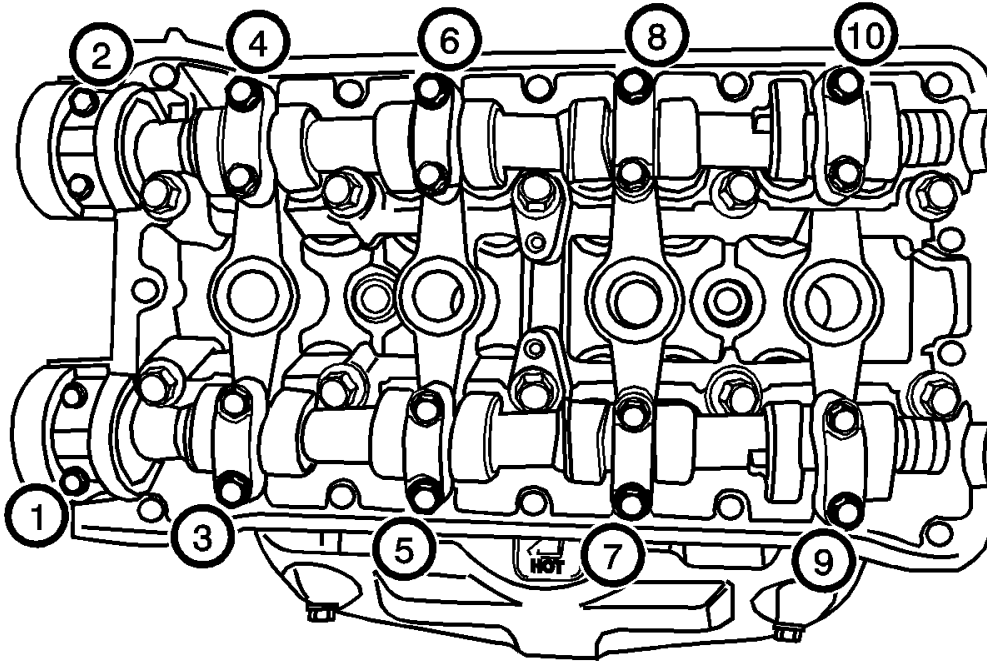


Fig. 216: View Of Camshaft Cap Bolt Sequence
Courtesy of GENERAL MOTORS CORP.

11. Install the intake camshaft.
12. Install the intake camshaft caps in their original positions.
13. Install the exhaust camshaft.
14. Install the exhaust camshaft caps in their original positions.
15. Install the camshaft cap bolts.

NOTE: Refer to Fastener Notice .

16. Tighten the camshaft cap bolts gradually and in the sequence shown for each camshaft cap.

Tighten: Tighten the camshaft cap bolts to **16 N.m (12 lb ft)** .

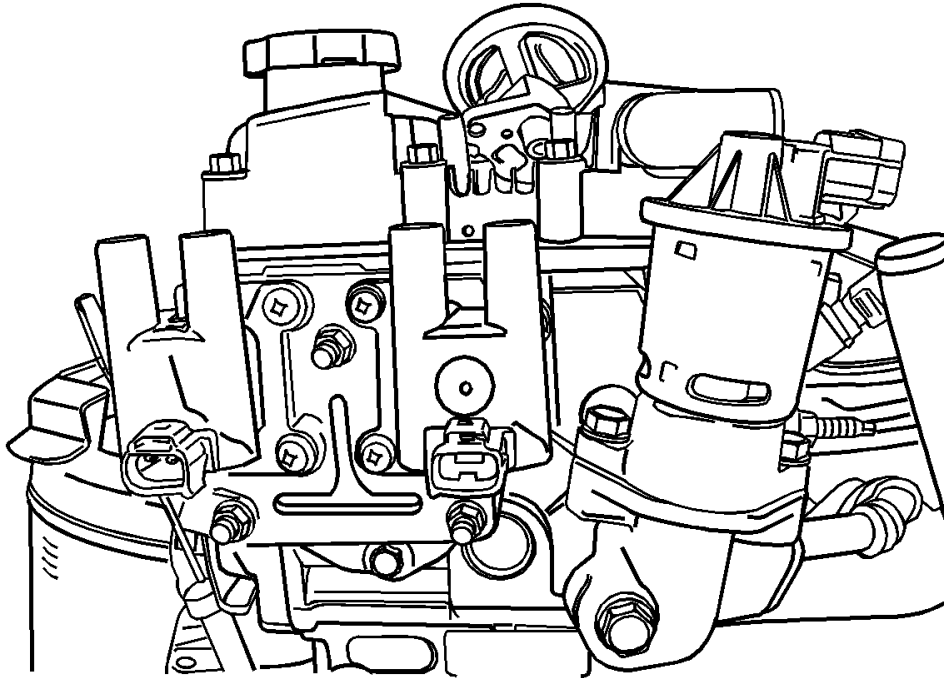


Fig. 217: View Of EGR Valve
Courtesy of GENERAL MOTORS CORP.

17. Install the spark plugs

Tighten: Tighten the spark plugs to **25 N.m (18 lb ft)** .

18. Install the EGR valve adapter gasket.
19. Install the EGR valve adapter.
20. Install the EGR valve adapter bolts.

Tighten: Tighten the exhaust gas recirculation valve adapter bolts to **25 N.m (18 lb ft)** .

21. Install the DIS coil mounting bracket.
22. Install the DIS coil mounting bracket bolts.

Tighten: Tighten the direct ignition system coil mounting bracket bolts to **10 N.m (89 lb in)** .

23. Install the DIS coil with the ignition wires attached.
24. Install the DIS coil mounting bolts.

Tighten: Tighten the direct ignition system coil mounting bolts to **10 N.m (89 lb in)** .

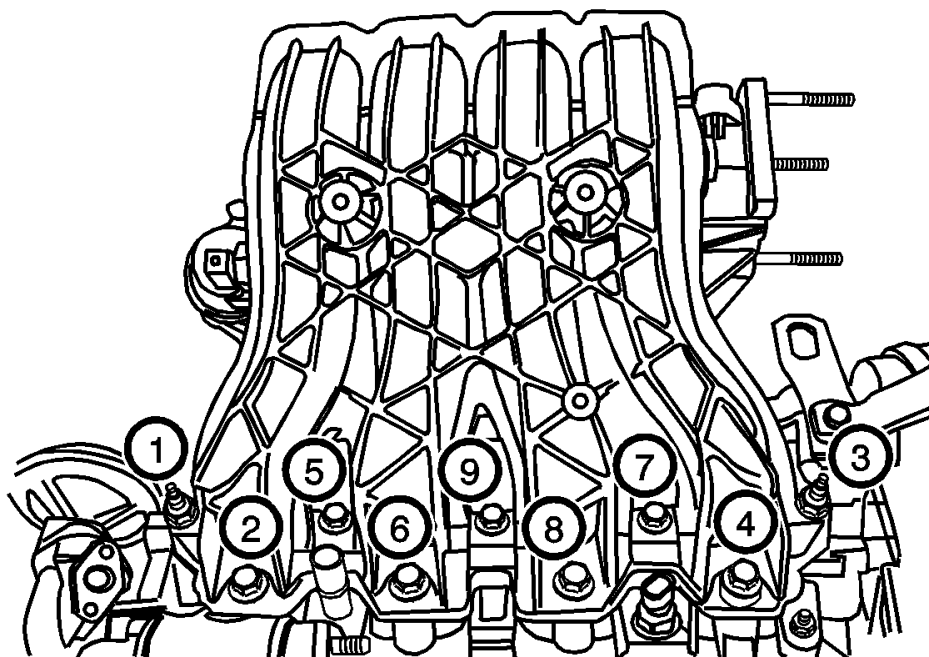


Fig. 218: Identifying Intake Manifold Retaining Nuts And Bolts Sequence
Courtesy of GENERAL MOTORS CORP.

25. Install the intake manifold studs.
26. Install the intake manifold.
27. Install the intake manifold retaining nuts and retaining bolts in the sequence shown.

Tighten: Tighten the intake manifold retaining nuts and retaining bolts to **25 N.m (18 lb ft)** .

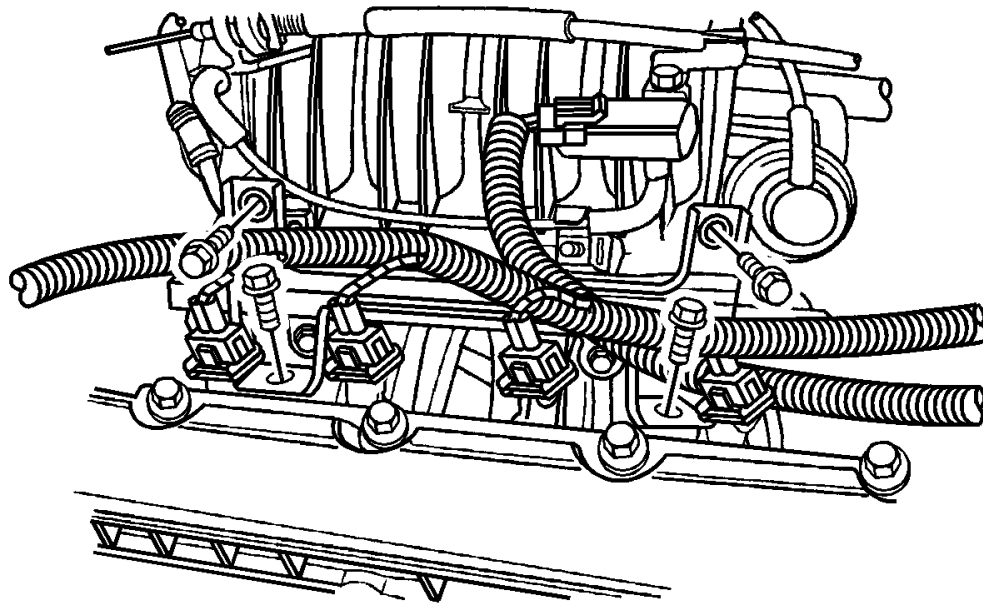


Fig. 219: View Of Thermostat Housing Assembly, Mounting Bolts, Fuel Rail Assembly, And Retaining Bolts

Courtesy of GENERAL MOTORS CORP.

28. Install the fuel rail assembly with the bolts.

Tighten: Tighten the fuel rail assembly retaining bolts to **25 N.m (18 lb ft)** .

29. Install the thermostat housing assembly.
30. Install the thermostat housing mounting bolts.

Tighten: Tighten the thermostat housing mounting bolts **20 N.m (15 lb ft)** .

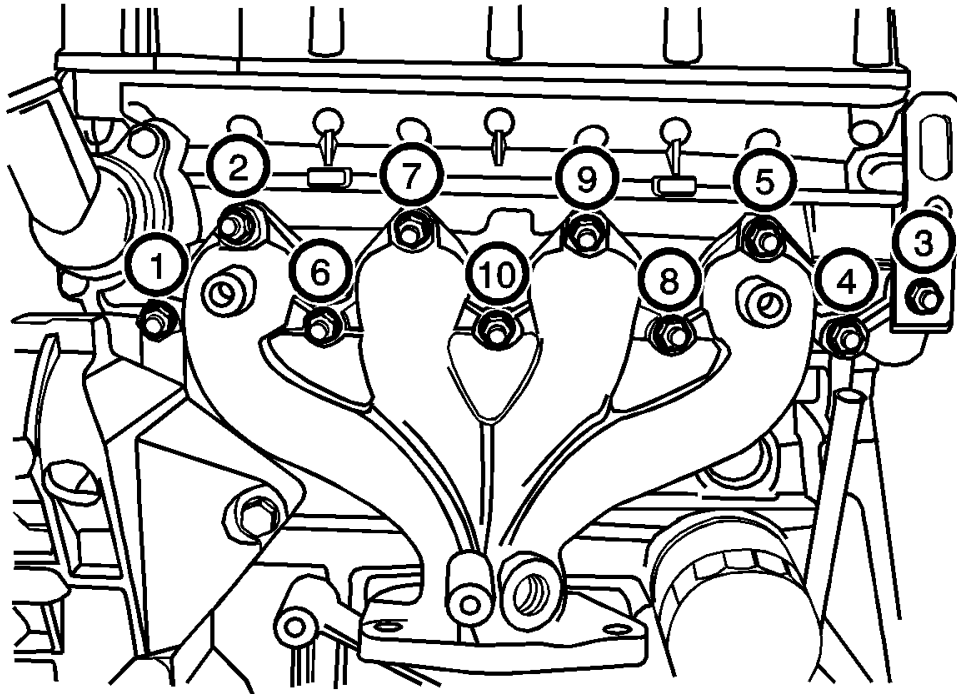


Fig. 220: Exhaust Manifold Retaining Nut Sequence
Courtesy of GENERAL MOTORS CORP.

31. Install the exhaust manifold studs.
32. Install the exhaust manifold gasket.
33. Install the exhaust manifold.
34. Install the exhaust manifold retaining nuts in the sequence shown.

Tighten: Tighten the exhaust manifold retaining nuts to **25 N.m (18 lb ft)** .

35. Install the exhaust manifold heat shield.
36. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the exhaust manifold heat shield bolts to **15 N.m (11 lb ft)** .

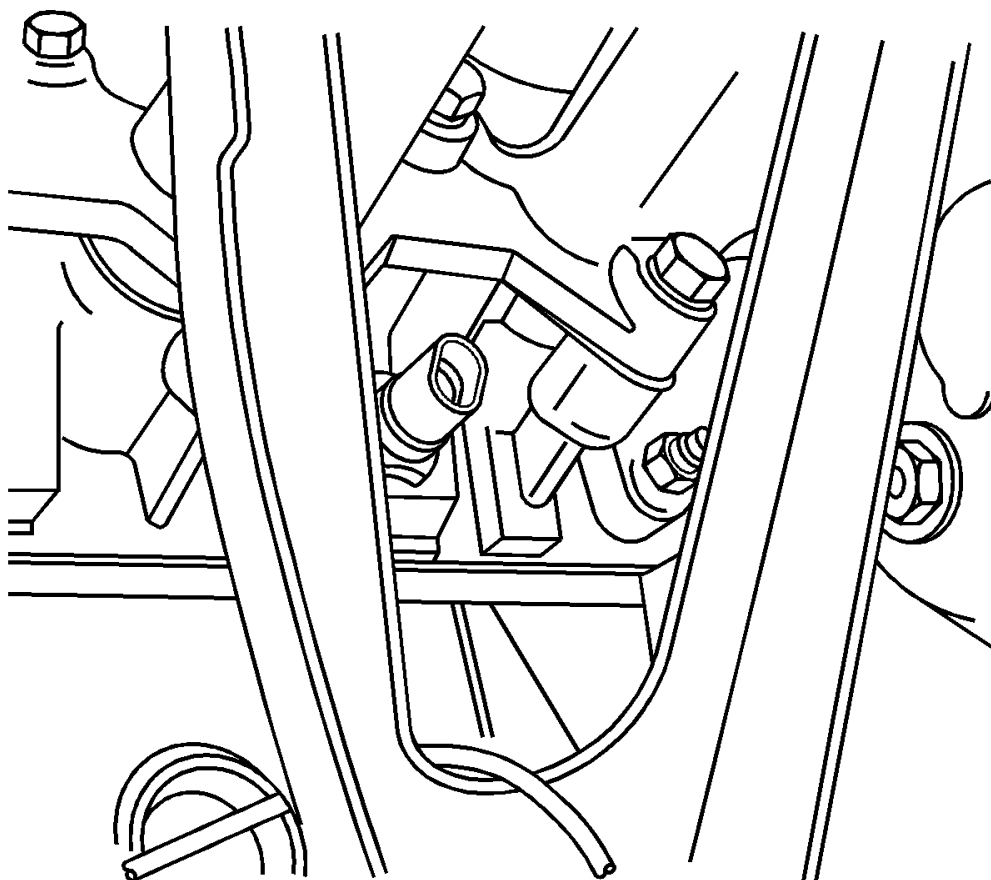


Fig. 221: View Of Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

37. Install the coolant temperature sensor.

Tighten: Tighten the coolant temperature sensor to **20 N.m (15 lb ft)** .

38. Install the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Cylinder Head Replacement**.

EXHAUST MANIFOLD INSTALLATION

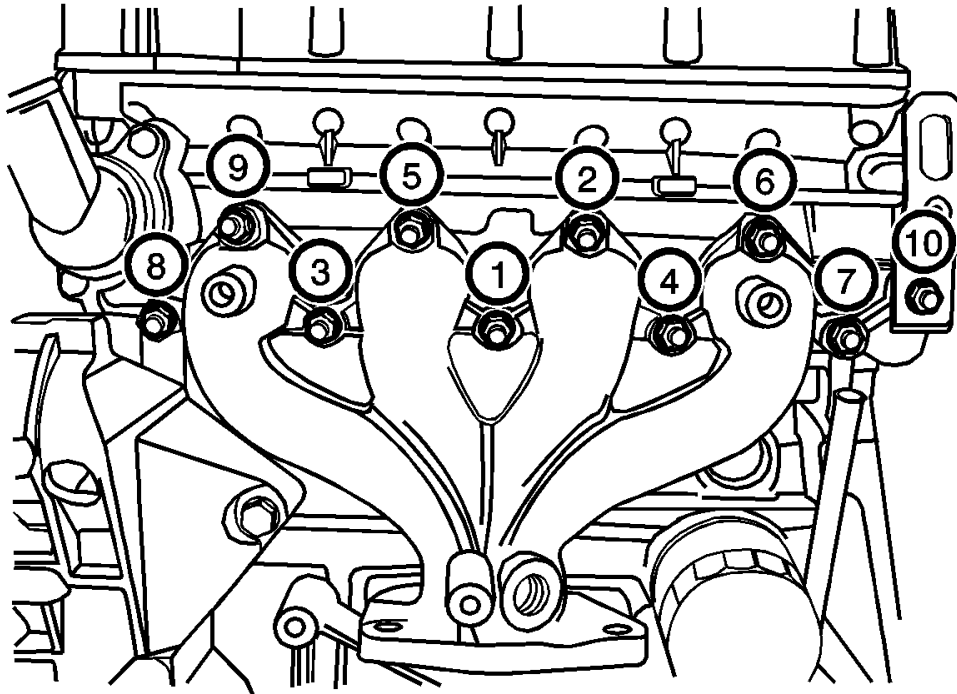


Fig. 222: View Of Exhaust Manifold Retaining Nut Sequence
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold and gasket.

NOTE: Refer to **Fastener Notice** .

2. Install the exhaust manifold retaining nuts and tighten in the sequence shown.

Tighten: Tighten the exhaust manifold retaining nuts to **25 N.m (18 lb ft)** .

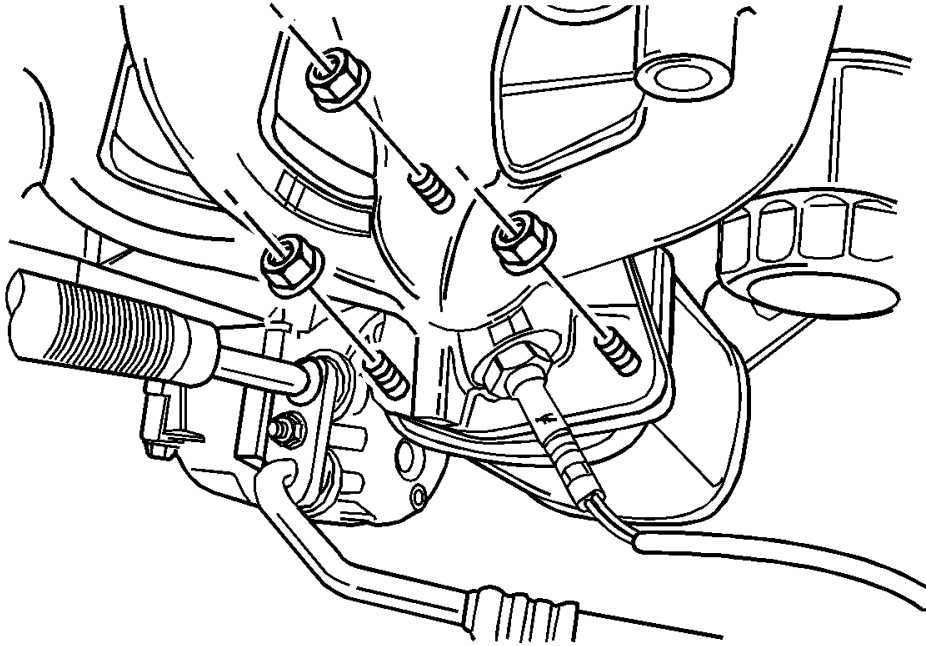


Fig. 223: View Of Exhaust Manifold Nuts
Courtesy of GENERAL MOTORS CORP.

3. Install the exhaust manifold nuts to the catalytic converter.

Tighten: Tighten the exhaust manifold nuts to **40 N.m (30 lb ft)** .

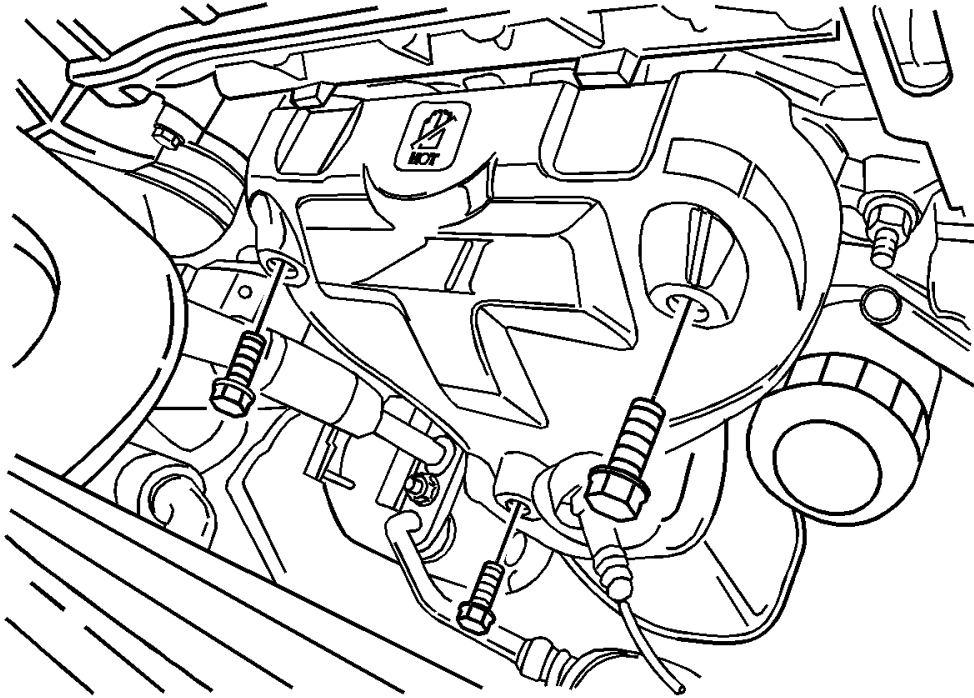


Fig. 224: View Of Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the heat shield.

Tighten: Tighten the heat shield bolts to **13 N.m (10 lb ft)** .

5. Connect the oxygen sensor connector.
6. Connect the negative battery cable.

DESCRIPTION AND OPERATION

ENGINE COMPONENT DESCRIPTION

Cylinder Head and Gasket

The cylinder head is made of an aluminum alloy. The cylinder head uses cross-flow intake and exhaust ports. A spark plug is located in the center of each combustion chamber. The cylinder head houses the dual camshafts.

Crankshaft

The crankshaft has eight integral weights which are cast with it for balancing. Oil holes run through the center of the crankshaft to supply oil to the connecting rods, the bearings, the pistons, and the other components. The end thrust load is taken by the thrust washers installed at the center journal.

Timing Belt

The timing belt coordinates the crankshaft and the dual overhead camshafts and keeps them synchronized. The timing belt also turns the water pump. The timing belt and the pulleys are toothed so that there is no slippage between them. There are two idler pulleys. An automatic tensioner pulley maintains the timing belt's correct tension. The timing belt is made of a tough reinforced rubber similar to that used on the serpentine accessory drive belt. The timing belt requires no lubrication.

Oil Pump

The oil pump draws engine oil from the oil pan and feeds it under pressure to the various parts of the engine. An oil strainer is mounted before the inlet of the oil pump to remove impurities which could clog or damage the oil pump or other engine components. When the drive gear rotates, the driven gear rotates. This causes the space between the gears to constantly open and narrow, pulling oil in from the oil pan when the space opens and pumping the oil out to the engine as it narrows.

At high engine speeds, the oil pump supplies a much higher amount of oil than is required for lubrication of the engine. The oil pressure regulator prevents too much oil from entering the engine lubrication passages. During normal oil supply, a coil spring and valve keep the bypass closed, directing all of the oil pumped to the engine. When the amount of oil being pumped increases, the pressure becomes high enough to overcome the force of the spring. This opens the valve of the oil pressure regulator, allowing the excess oil to flow through the valve and drain back to the oil pan.

Oil Pan

The engine oil pan is mounted to the bottom of the cylinder block. The engine oil pan houses the crankcase and is made of cast metal.

Engine oil is pumped from the oil pan by the oil pump. After it passes through the oil filter, it is fed through two paths to lubricate the cylinder block and the cylinder head. In one path, the oil is pumped through the oil passages in the crankshaft to the connecting rods, then to the pistons and the cylinders. It then drains back to the oil pan. In the second path, the oil is pumped through the oil passages to the camshaft. The oil passes through the internal passageways in the camshafts to lubricate the valve assemblies before draining back to the oil pan.

Exhaust Manifold

A single four-port, rear-takedown manifold is used with this engine. The manifold is designed to direct escaping exhaust gases out of the combustion chambers with a minimum of back pressure. The oxygen sensor is mounted to the exhaust manifold

Intake Manifold

The intake manifold has four independent long ports and uses inertial supercharging to improve engine torque at low and moderate speeds. The plenum is attached to the intake manifold. class

Camshafts

This engine is a dual overhead camshaft (DOHC) type, which means there are two camshafts. One camshaft operates the intake valves, and the other camshaft operates the exhaust valves. The camshafts sit in journals on the top of the engine in the cylinder head and are held in place by camshaft caps. The camshaft journals of the cylinder head are drilled to create oil passages. Engine oil travels to the camshafts under pressure where it lubricates each camshaft journal. The oil returns to the oil pan through drain holes in the cylinder head. The camshaft lobes are machined into the solid camshaft to open and close the intake and the exhaust valves precisely the correct amount at the correct time. The camshaft lobes are oiled by splash action from pressurized oil escaping from the camshaft journals.

Engine Under Covers

The engine under covers are molded pieces of plastic that serve as shields for the underside of the engine. The covers help protect the engine from small rocks, gravel and other objects that would otherwise come into contact with the engine during normal driving conditions.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in the ten-thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly, to protect and lubricate the surfaces on initial operation. Proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when they were removed.

Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to the wire harness or other electrical parts.

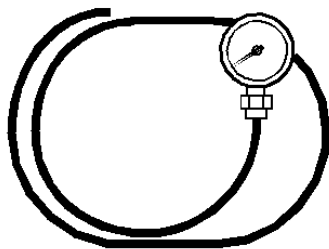
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

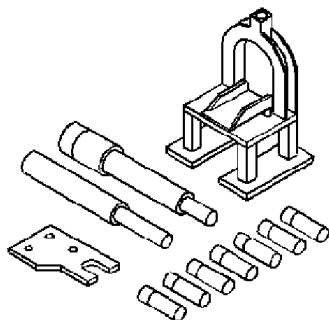
Illustration	Tool Number/ Description
	J 8062 (KM-348) Valve Spring Compressor

2008 Chevrolet Optra LT

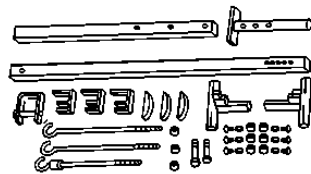
2008 ENGINE Engine Mechanical - 1.6L - Optra



J 21867
(KM-498-B)
Pressure Gage



J 24086-B
(KM-427)
Piston Pin Remover/Installer Set

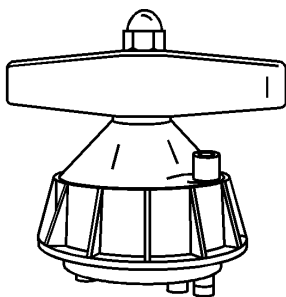
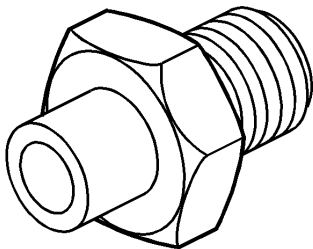


J 28467-B
(DW-117)
Universal Engine Support Fixture

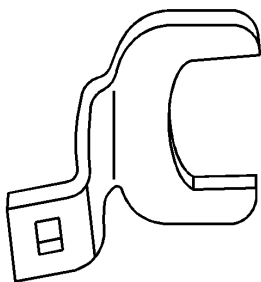
J 36648-A
(KM-135)
Adapter

2008 Chevrolet Optra LT

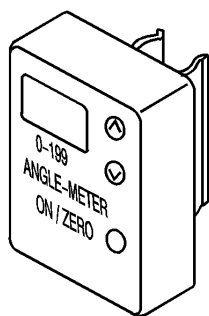
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J 36972
Crankshaft Rear Oil Seal Installer



J 42492-A
(KM-421-A)
Timing Belt Adjuster

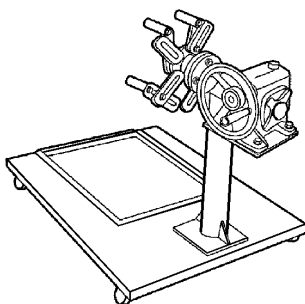
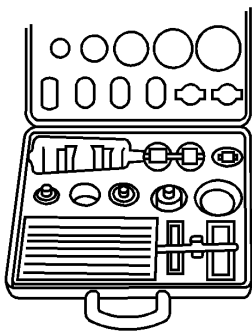


J 45059
Angle Meter

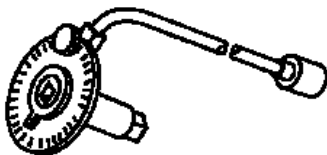
KM-340-1-C
Cutter Set

2008 Chevrolet Optra LT

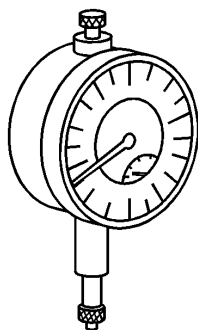
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KM-412
(OTC 1726)
Engine Overhaul Stand



KM-470-B
Angular Torque Gage

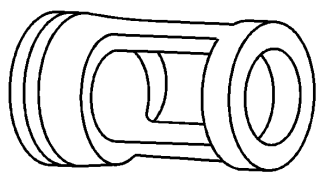
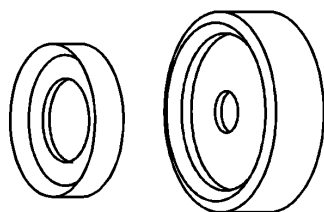


KM-571-B
Gage

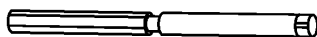
KM-635
Crankshaft Rear Oil Seal Installer

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KM-653-A
Adapter



KM-805
Valve Guide Reamer