2006 ENGINE

Engine Mechanical - 1.8L (L79) - Optra

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Air Cleaner Housing Bolts	10 N.m	89 lb in
Automatic Tensioner Bolt	25 N.m	18 lb ft
Camshaft Bearing Bridge and Oil Pan Scraper Bolts	20 + 45°	15 + 45°
Camshaft Bearing Cap Bolts	8 N.m	71 lb in
Camshaft Cover Bolts	8 N.m	71 lb in
Charcoal Canister Purge and Exhaust Gas Recirculation Solenoid Bracket Bolt	5 N.m	44 lb in
Connecting Rod Bearing Cap Bolts	35 + 45° + 15° N.m	26 + 45° + 15° lb ft
Coolant Bypass Housing and Mounting Bolts	15 N.m	11 lb ft
Crankshaft Bearing Cap Bolts	50 + 45° + 15° N.m	37 + 45° + 15° lb ft
Crankshaft Gear Bolt	145 + 30° + 15° N.m	107 + 30° + 15° lb ft
Crankshaft Pulley Bolts	20 N.m	15 lb ft
Cylinder Head Bolts	25+ 90° + 90° + 90° N.m	18 + 90° + 90° + 90° lb ft
Direct Ignition System Coil and Exhaust Gas Recirculation Mounting Bracket Bolts	25 N.m	18 lb ft
Engine Mount Bracket Retaining Bolts and Nuts	55 N.m	41 lb ft
Engine Mount Retaining Bolts	45 N.m	33 lb ft
Engine-to-Intake Manifold Support Bracket Bolts	20 N.m	15 lb ft
Exhaust Camshaft Gear Bolt	50 + 60° + 15° N.m	37 + 60° + 15° lb ft
Exhaust Flex Pipe-to-Catalytic Converter to Connecting Pipe Retaining Nuts	35 N.m	26 lb ft
Exhaust Flex Pipe-to-Exhaust Manifold Retaining Nuts	35 N.m	26 lb ft
Exhaust Manifold Heat Shield Bolts	8 N.m	71 lb in
Exhaust Manifold Retaining Nuts	22 N.m	16 lb ft
Flex Plate Bolts	45 N.m	33 lb ft
Flywheel Bolts	65 + 30° + 15° N.m	48 + 30° + 15° lb ft
Front Timing Belt Cover Bolts	6 N.m	53 lb in
Generator-to-Intake Manifold Strap Bracket Bolt	22 N.m	16 lb ft
Generator-to-Intake Manifold Support Bracket Bolts	37 N.m	27 lb ft
Intake Camshaft Gear Bolt	50 + 60° + 15° N.m	37 + 60° + 15° lb ft
Intake Manifold Retaining Bolt and Nuts	22 N.m	16 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 Block Support Bracket and Splash Shield Bolts	35 N.m	26 lb ft
Oil Pan Drain Plug	35 N.m	26 lb ft
Oil Pan Flange-to-Transaxle Bolts	40 N.m	30 lb ft
Oil Pan Retaining Bolts	10 N.m	89 lb in
Oil Pressure Switch	40 N.m	30 lb ft
Oil Pump Rear Cover Bolts	6 N.m	53 lb in
Oil Pump Retaining Bolts	10 N.m	89 lb in
Oil Suction Pipe Bolts	8 N.m	71 lb in
Oil Suction Pipe Support Bracket Bolts	16 N.m	53 lb in
Pulse Pickup Sensor Disc	13 N.m	115 lb in
Rear Timing Belt Cover Bolts	7 N.m	62 lb ft
Safety Relief Valve Bolt	30 N.m	22 lb ft
Spark Plug Cover Bolts	8 N.m	71 lb in
Spark Plugs	20 N.m	15 lb ft
Thermostat Housing Mounting Bolts	15 N.m	11 lb ft
Throttle Cable Bracket Bolts	8 N.m	71 lb in
Timing Belt Automatic Tensioner Bolts	25 N.m	18 lb ft
Timing Belt Idler Pulley Bolt	25 N.m	18 lb ft
Timing Belt Idler Pulley Nut	25 N.m	18 lb ft
Transaxle Bell Housing Bolts	75 N.m	55 lb ft
Transaxle Torque Converter Bolts	60 N.m	44 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	**English**
General Data		
• Engine Type	Dual Overhead Cam L-4	
• Displacement	1,799 cm^3	109.7 in^3
• RPO	L79	
• VIN	3	
• Bore	81.6 mm	3.21 in
• Stroke	86 mm	3.38 in
• Compression Ratio	9.1:1	
• Maximum Power at 5,800 RPM	90 kW	107.3 hp
• Maximum Torque	150 N.m	110.6 lb ft
• Firing Order	1-3-4-2	

• Spark Plug Gap	0.9-1.1 mm	0.035-0.043 in
Block		
• Cylinder Bore Diameter	81.575-81.625 mm	3.2116-3.2135 in
• Cylinder Bore Out-of-Round - Maximum	0.013 mm	0.0005 in
• Cylinder Bore Taper - Maximum	0.013 mm	0.0005 in
• Cylinder Head Deck Height - Minimum after machining	133.9 mm	5.27 in
Camshaft		
• Bearing Journal OD	42.455-43.470 mm	1.6714-1.7114 in
• End Play	0.040-0.14 mm	0.0015-0.0055 in
• Camshaft Lobe Lift - Exhaust	9.2 mm	0.36 in
• Camshaft Lobe Lift - Intake	9.2 mm	0.36 in
Cooling System		
• Capacity	7.4 L	7.8 qt
Crankshaft		
• Connecting Rod Journal Diameter	48.970-48.988 mm	1.9279-1.9287 in
• Connecting Rod Journal Out-of-Round	0.004 mm	0.00015 in
• Crankshaft End Play	0.070-0.302 mm	0.0027-0.0118 in
• Crankshaft Main Bearing Clearance - All	0.015-0.040 mm	0.00059-0.00157 in
• Crankshaft Main Bearing Service Oversize - Available in 2 sizes	0.25 mm and 0.50 mm	0.0098-0.0196 in
• Crankshaft Main Bearing Journal Diameter	57.974-57.995 mm	2.2824-2.2832 in
• Crankshaft Main Bearing Journal Out-of-Round	0.003 mm	0.0001 in
Cylinder Head		
• Overall Height	133.075-134.025 mm	5.239-5.276 in
• Valve Guide Height	13.7-14.0 mm	0.54-0.57 in
• Valve Stem Protrusion	39.2-39.8 mm	1.54-1.56 in
Lubrication System		
• Lubricating Type	Forced Feed	
• Oil Capacity - with Filter	4.0 L	4.2 qt
Oil Pump		
• End Clearance	0.030-0.10 mm	0.001-0.003 in
• Gears Lash	0.10-0.20 mm	0.003-0.007 in
• Inner Gear to Crescent Clearance	0.35-0.40 mm	0.013-0.015 in
• Outer Gear to Body Clearance	0.11-0.19 mm	0.004-0.007 in

• Outer Gear to Crescent Clearance	0.40-0.50 mm	0.015-0.019 in
Piston Ring End Gap		
• First Compression Ring	0.2-0.35 mm	0.007-0.013 in
• Second Compression Ring	0.33-0.48 mm	0.012-0.0176 in
Piston		
• Clearance to Bore	0.01-0.03 mm	0.00039-0.00100 in
• Piston Diameter	81.575-82.105 mm	3.2115-3.2325 in
• Piston Protrusion - Maximum	0.5 mm	0.019 in
• Piston Taper	0.013 mm	0.0005 in
• Piston Bore to Clearance	0.01-0.03 mm	0.00039-0.00100 in
Pin		
• Piston Pin Clearance to Piston Pin	0.0035-0.0140 mm	0.00013-0.00055 in
• Piston Pin Diameter	20.9970-20.9985 mm	0.82665-0.82671 in
• Piston Pin Length	61.5 mm	2.42 in
• Piston Pin Offset - Towards Thrust Side	0.8 mm	0.03 in
Valves		
• Valve Diameter - Exhaust	29±0.1 mm	1.1417±0.0039 in
• Valve Diameter - Intake	32±0.1 mm	1.2598±0.0039 in
• Valve Face Angle	44°	
• Valve Face Runout	0.03 mm	0.00118 in
• Valve Seat Width - Exhaust	1.7-2.2 mm	0.066-0.086 in
• Valve Seat Width - Intake	1.0-1.5 mm	0.039-0.059 in
• Valve Stem Diameter - Exhaust	5.945-5.960 mm	0.2341-0.2346 in
• Valve Stem Diameter - Intake	5.945-5.960 mm	0.2341-0.2346 in
• Valve Guide Inside Diameter	7.01-7.03 mm	0.276-0.277 in
• Valve Lash Compensators	Hydraulic Tappet	
Sealants and Adhesives		
• Camshaft Carrier to Cylinder Head	HN 1581 (Loctite® 515)	
• Exhaust Manifold Studs/Nuts	Anti-seize Compound (HMC Spec HN 1325)	
• Oil Pan Bolts	HN 1256 (Loctite® 242)	
• Oil Pump Bolts	HN 1256 (Loctite® 242)	
• Oil Pan Pickup Tube Bolts	HN 1256 (Loctite® 242)	
• Oil Gallery Plug	HN 1256 (Loctite® 242)	
• Rear Main Bearing Cap	GE P/N RTV 159	

Valve Guide Reaming

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

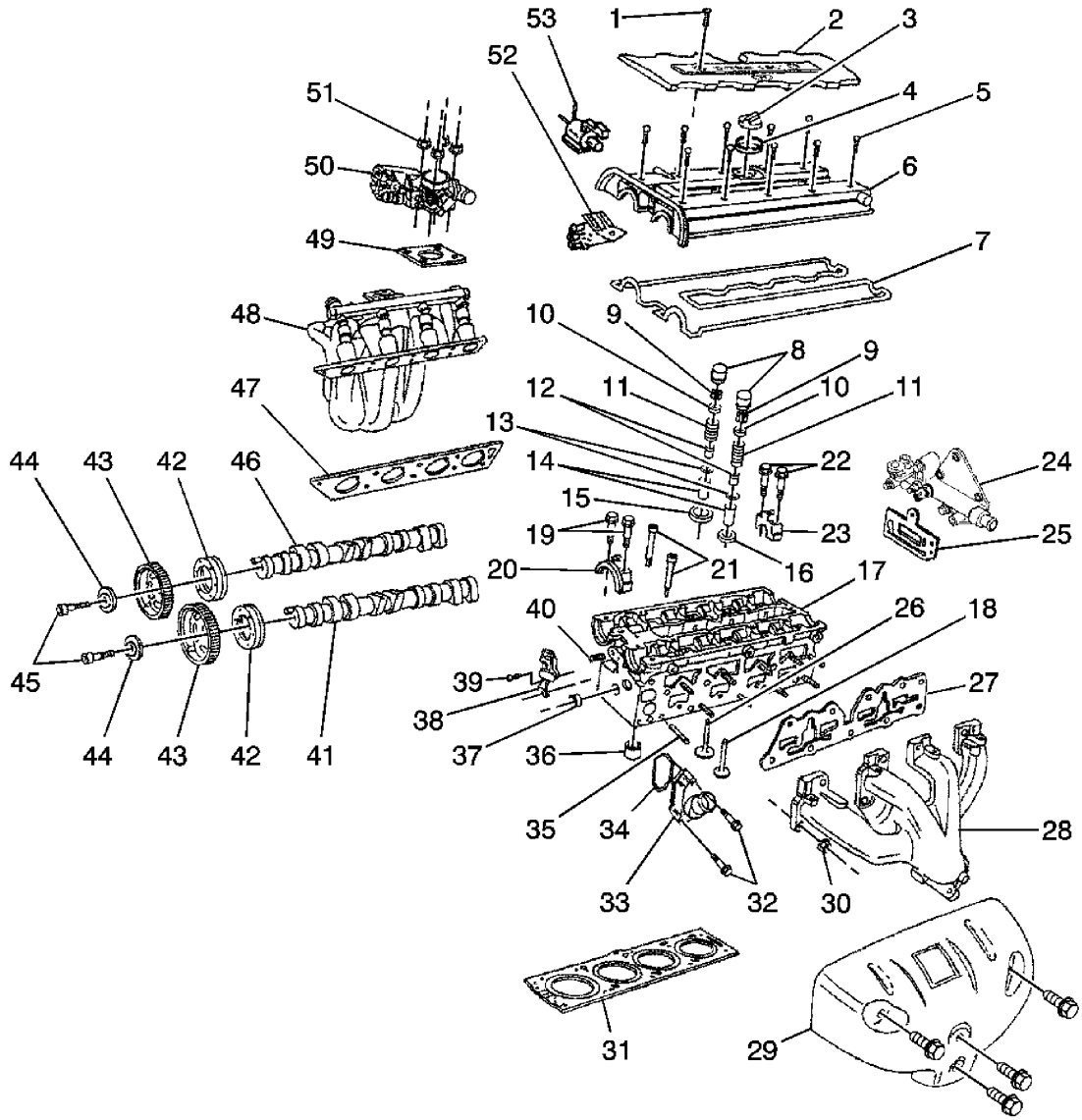


Fig. 1: View Of Upper End Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Bolt
2	Spark Plug Cover
3	Oil Filler Cap
4	Oil Filler Cap Seal
5	Bolt
6	Camshaft Cover
7	Camshaft Cover Gasket
8	Tappet Adjuster
9	Valve Key
10	Valve Spring Cap
11	Valve Spring
12	Valve Stem Seal
13	Valve Spring Seat
14	Valve Guide
15	Intake Valve Seat Ring
16	Exhaust Valve Seat Ring
17	Cylinder Head
18	Exhaust Valve
19	Bolt
20	Front Camshaft Cap
21	Head Bolt
22	Bolt
23	Intermediate Camshaft Cap
24	Exhaust Gas Recirculation Adapter
25	Exhaust Gas Recirculation Adapter Gasket
26	Intake Valve
27	Exhaust Manifold Gasket
28	Exhaust Manifold
29	Exhaust Manifold Heat Shield
30	Nut
31	Cylinder Head Gasket
32	Bolt
33	Thermostat Housing
34	Thermostat Housing Gasket
35	Stud
36	Sleeve
37	Plug
38	Camshaft Position Sensor
39	Bolt
40	Oil Gallery Plug

	Exhaust Camshaft
42	Seal Ring
43	Camshaft Gear
44	Washer
45	Camshaft Gear Bolt
46	Intake Camshaft
47	Intake Manifold Gasket
48	Intake Manifold
49	Throttle Body Gasket
50	Throttle Body
51	Nut
52	Charcoal Canister Purge Solenoid
53	Exhaust Gas Recirculation Solenoid

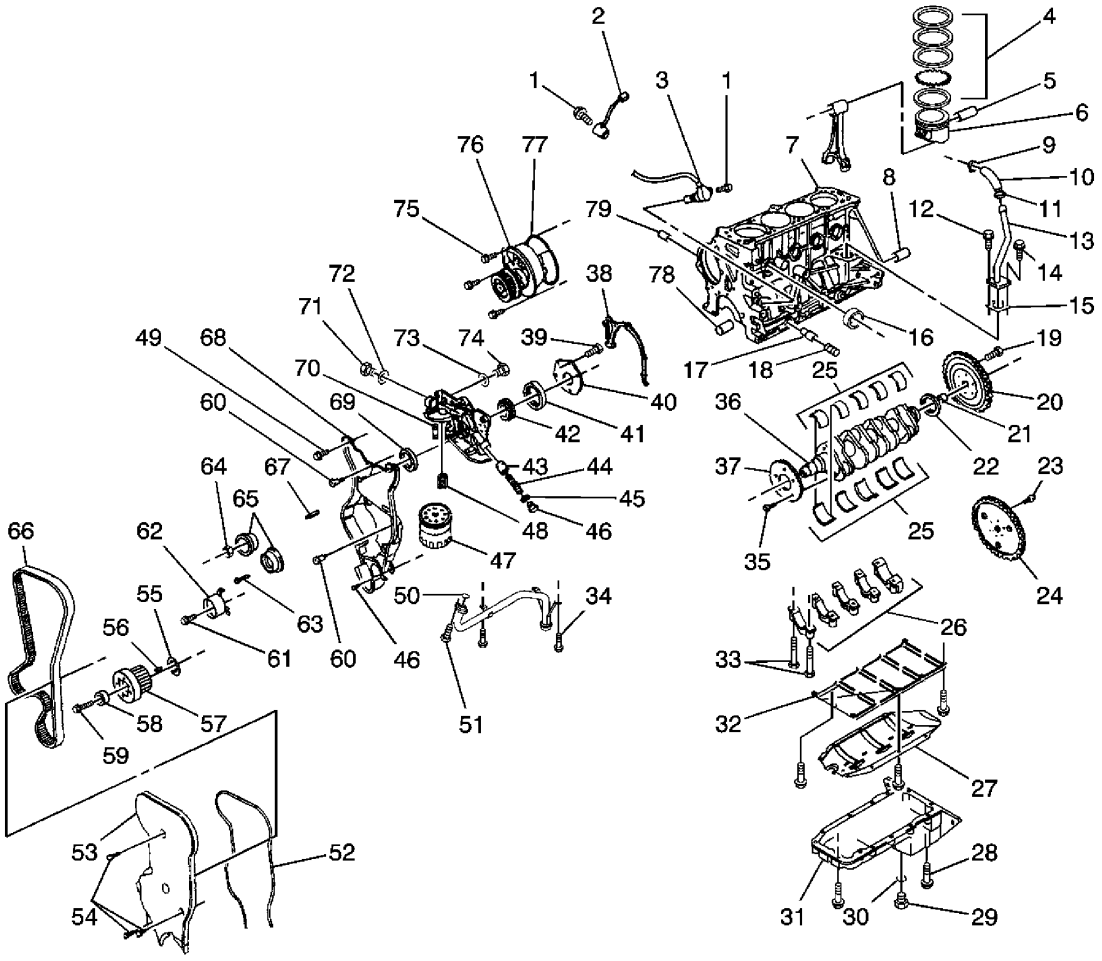


Fig. 2: View Of Lower End Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Bolt
2	Knock Sensor
3	Crankshaft Position Sensor
4	Piston Ring Set
5	Piston Pin
6	Piston
7	Engine Block
8	Sleeve
9	Clamp
10	Hose
11	30 Clamp
12	Bolt
13	Engine Ventilation Pipe
14	Bolt
15	Gasket
16	Water Jacket Cap
17	Bushing
18	Bushing Plug
19	Bolt (Manual Transaxle)
20	Flywheel (Manual Transaxle)
21	Needle Sleeve
22	Crankshaft Rear Seal
23	Bolt (Automatic Transaxle)
24	Flexible Plate (Automatic Transaxle)
25	Bearing Set
26	Connecting Rod
27	Oil Pan Scraper
28	Bolt
29	Drain Plug
30	Washer
31	Oil Pan
32	Crankshaft Bearing Bridge
33	Connecting Rod Bolt
34	Oil Suction Pipe
35	Bolt
36	Crankshaft
37	Transmitter Disk
38	Gasket
39	Bolt
40	Oil Pump Cover
41	

	Ring Gear
42	Gear
43	Pressure Relief Valve Plunger
44	Pressure Relief Valve Spring
45	Seal Ring
46	Pressure Relief Valve Plug
47	Oil Filter
48	Bypass Valve
49	Bolt
50	Seal Ring
51	Bolt
52	Gasket
53	Front Timing Belt Cover
54	Bolt
55	Thrust Inner Washer
56	Woodruff Key
57	Crankshaft Gear
58	Thrust Outer Washer
59	Bolt
60	Special Bolt
61	Bolt
62	Tensioner
63	Bolt
64	Nut
65	Idler Pulley
66	Camshaft Drive Belt
67	Stud
68	Rear Timing Belt Cover
69	Seal Ring
70	Connecting Piece
71	Oil Duct Outlet Plug
72	Washer
73	Washer
74	Oil Pressure Switch
75	Bolt
76	Water Pump
77	Seal Ring
78	Sleeve
79	Oil Gallery Plug

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

All diagnostics 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.
- Inspect 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 21867** Pressure Gage
- **J 36648-A** Oil Pressure Gage Adapter

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. Add the recommended grade engine oil and fill the crankcase until oil level measures full on the oil level indicator, if required.
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 conditions:
    - Foamy oil
    - Slow idle speed
    - Plugged oil filter
    - Oil diluted by the following items:
        - 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

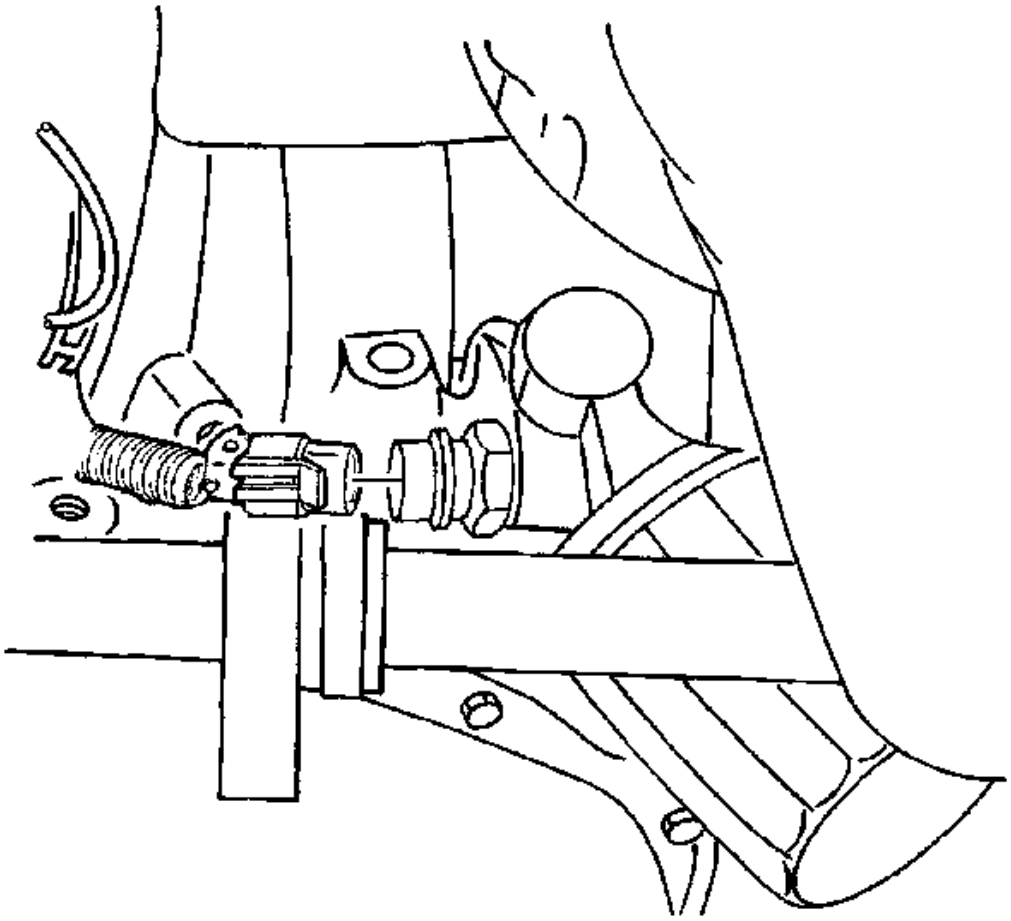


Fig. 3: Identifying Oil Pressure Gage Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pressure gage sensor.

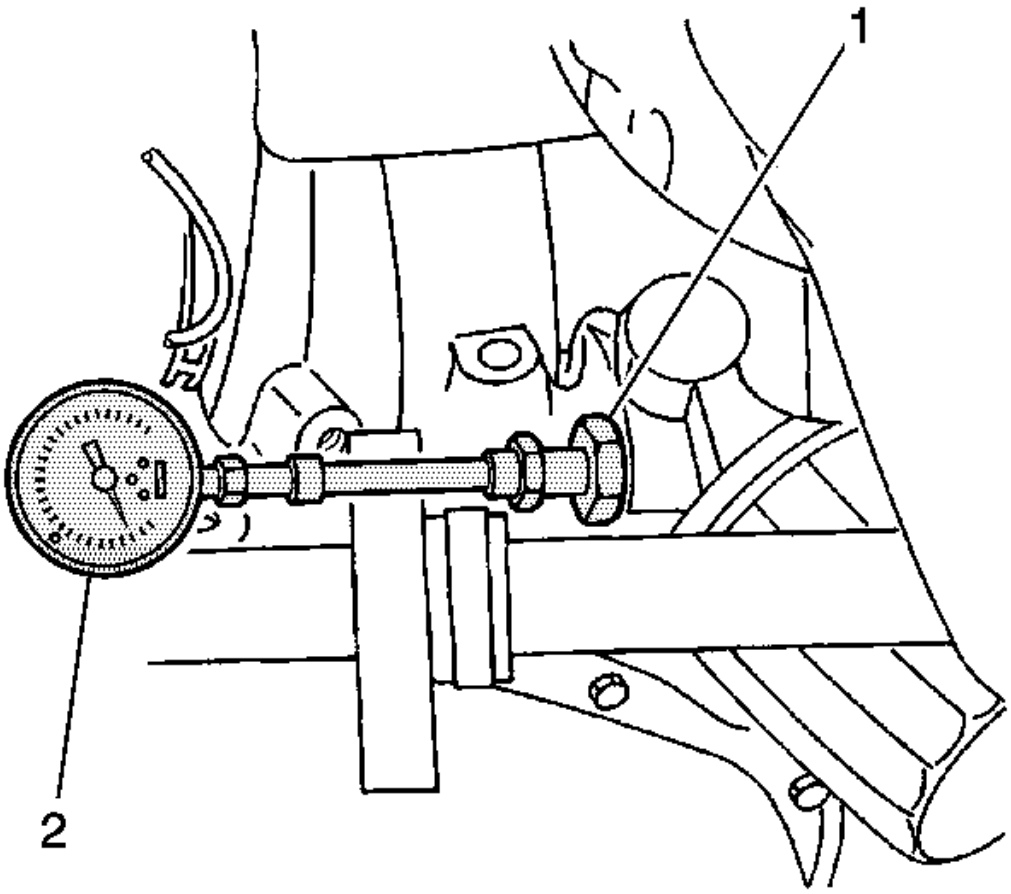


Fig. 4: View Of Special Tools J 36648-A And J 21867
Courtesy of GENERAL MOTORS CORP.

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 then allow the engine to reach normal operating temperature.
10. Measure the engine oil pressure.

Specification

- The minimum oil pressure should be 30 kPa (4.35 psi).
- The minimum oil pressure at idle should be 250 kPa (35 psi).

11. If the engine oil pressure is below specifications, inspect the engine for one or more of the following conditions:

- 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 items:
  - 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 CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of 1.9L (2 qts) or more of engine oil within 3 200 kilometers (2,000 mi). The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten bolts and/or replace gaskets and oil seals as necessary.
- Incorrect oil level or improper reading of oil level indicator. With the vehicle on a level surface, allow adequate drain down time and check for the correct oil level.
- Improper oil viscosity. Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage.
- Crankcase ventilation system restrictions or malfunctioning components.
- Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
- Piston improperly installed or miss-fitted.

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.
    - Thoroughly clean the area.
    - Dry the area.
    - Operate the vehicle for several miles at normal operating temperature and varying speeds.
    - After operating the vehicle, visually check the suspected component.
    - 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

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

Seals

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

ENGINE NOISE DIAGNOSIS

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
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?	60 N.m (44 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**	-
	Inspect the flywheel.			

10	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?	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 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. 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 (0.00186 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
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**	-
	Inspect the engine oil.			

8	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 engine revolution?	-	Go to **Step 2**	System OK
2	Measure the oil pump pressure. Is the oil pump pressure low?	-	Go to **Oil Pressure Diagnosis and Testing**	Go to **Step 3**
3	Inspect the crankshaft end play. Is there excessive crankshaft end play?	0.070-0.302 mm (0.0027-0.0119 in)	Go to **Crankshaft Replacement**	Go to **Step 4**
4	Inspect the crankshaft journals. Are the crankshaft journals out-of-round?	-	Go to **Crankshaft Replacement**	Go to **Step 5**
5	Inspect the belt tension. Is there excessive belt tension?	-	Go to **Crankshaft Replacement**	Go to **Step 6**
6	Inspect the crankshaft pulley. Is the crankshaft pulley loose?	-	Go to **Crankshaft Replacement**	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 **Oil Pressure Diagnosis and Testing**	Go to **Step 3**
3	Measure the oil pump pressure. Is the oil pump pressure low?	Go to **Crankshaft Replacement**	Go to **Step 4**
4	Inspect the crankshaft connecting rod journals. Are the journals out-of round?	Go to **Piston, Connecting Rod, and Bearing Replacement**	Go to **Step 5**
5	Inspect the connecting rods. Is there a misaligned connecting rod?	Go to **Piston, Connecting Rod, and Bearing Replacement**	Go to **Step 6**
6	Inspect the connecting rod bolts. Are the connecting rod bolts torqued properly?	System OK	Go to **Piston, Connecting Rod, and Bearing Replacement**

PISTON NOISES

Step	Action	Yes	No
1	Listen for the following noises: • 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 **Piston, Connecting Rod, and Bearing Replacement**	Go to **Step 3**
3	Inspect the piston. Is the piston broken or cracked?	Go to **Piston, Connecting Rod, and Bearing Replacement**	Go to **Step 4**
4	Inspect the connecting rods. Is there a misaligned connecting rod?	Go to **Piston, Connecting Rod, and Bearing Replacement**	Go to **Step 5**
5	Inspect the piston position. Is the piston 180 degrees out of position?	Go to **Piston, Connecting Rod, and Bearing Replacement**	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 **Cylinder Head Disassemble**	Go to **Step 3**
3	Inspect the valves. Are the valves sticking or warped?	Go to **Cylinder Head Disassemble**	Go to **Step 4**
4	Inspect the valve lifters. Are the valve lifters dirty, stuck, or worn?	Go to **Cylinder Head Disassemble**	Go to **Step 5**
5	Inspect the camshaft lobes. Are the camshaft lobes damaged or improperly machined?	Go to **Camshaft Replacement**	Go to **Step 6**
6	Inspect the oil supply to the valve train. Is the oil supply insufficient or poor?	Go to **Cylinder Head Disassemble**	Go to **Step 7**
7	Inspect the valve guides. Are the valve guides worn?	Go to **Cylinder Head Disassemble**	Go to **Step 8**
8	Inspect the valve spring seat. Is the valve spring seat incorrect?	Go to **Cylinder Head Disassemble**	System OK

ENGINE COMPRESSION TEST

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:

- 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 engine compression gage 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

ENGINE MOUNT REPLACEMENT

Tools Required

J 28467-B Universal Engine Support Fixture

Removal Procedure

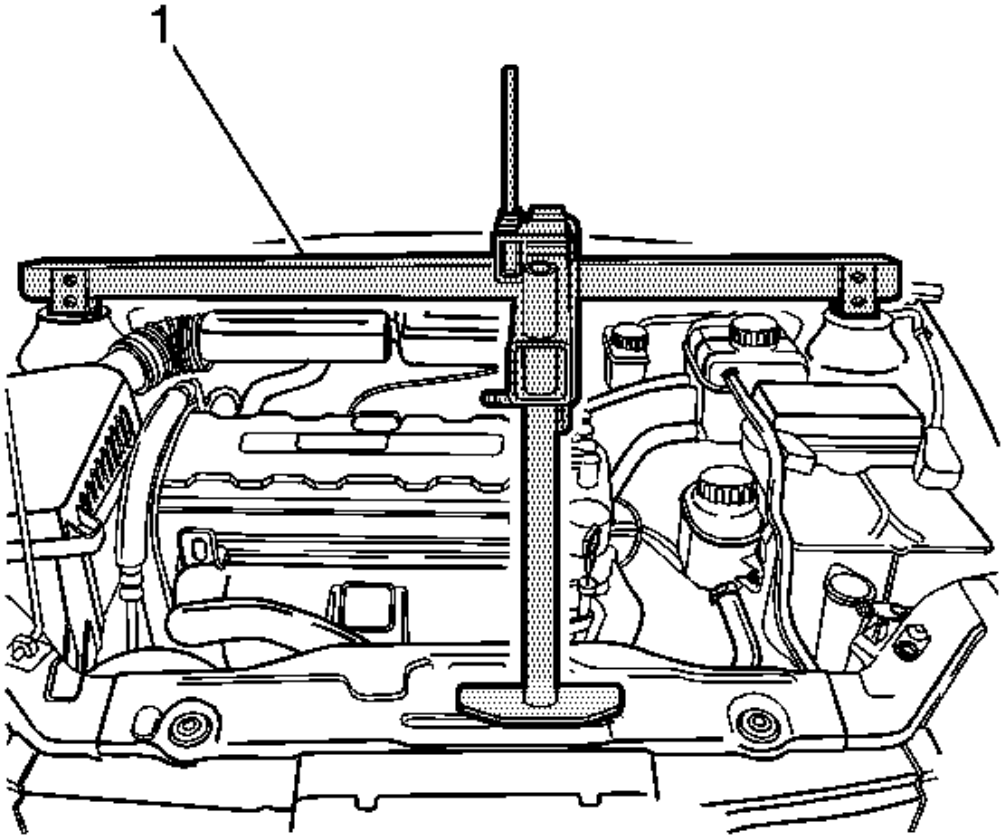


Fig. 5: View Of J 28467-B
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Support the engine assembly using **J 28467-B** (1).
3. Disconnect the intake air temperature (IAT) sensor connector.
4. Disconnect the air cleaner outlet hose from the throttle body.
5. Remove the air cleaner housing bolts.
6. Remove the air cleaner housing.

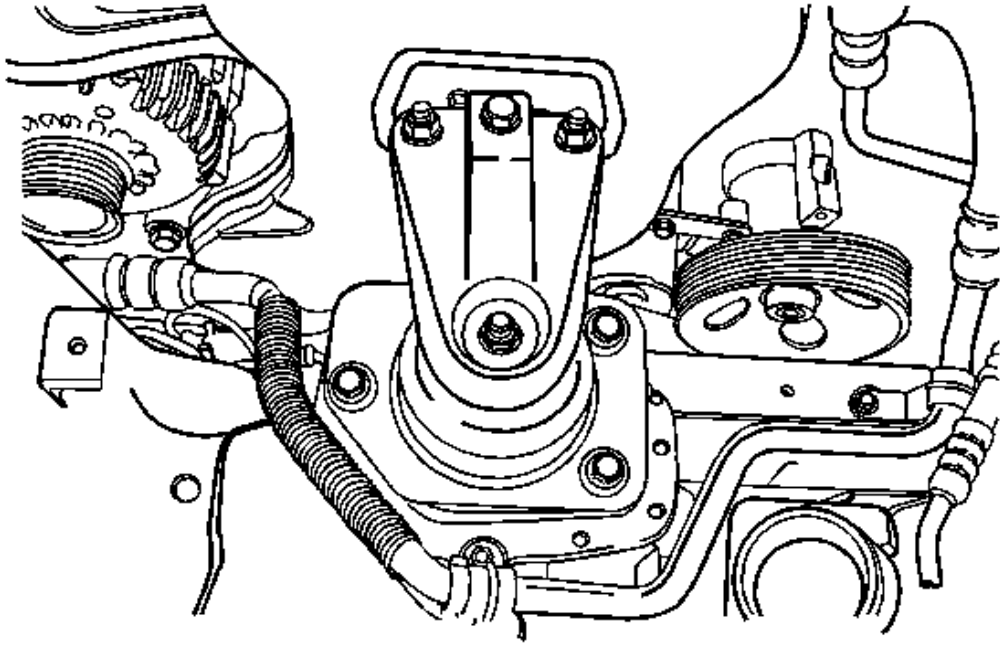


Fig. 6: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

7. Remove the right front splash shield. Refer to **Splash Shield Replacement - Wheelhouse** in Body Front End.
8. Remove the engine mount bracket retaining bolts.
9. Remove the engine mount bracket.
10. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.

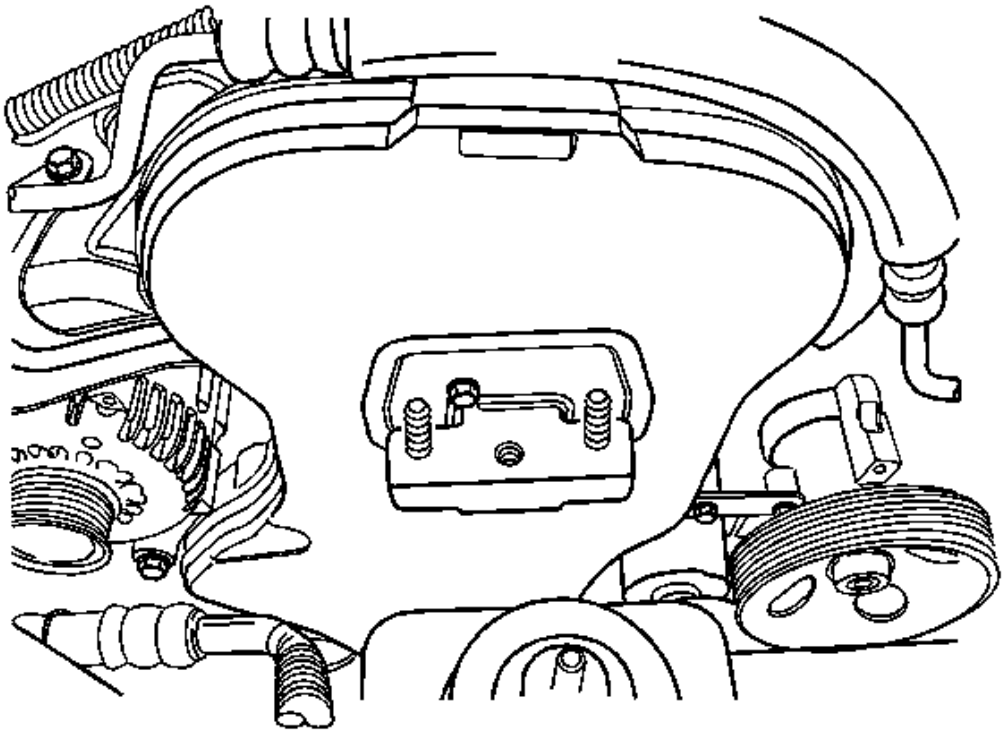


Fig. 7: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

11. Remove the front timing belt cover bolts.
12. Align the crankshaft pulley timing mark with the pointer, and the camshaft gears with the timing marks on the rear cover, by turning the crankshaft gear bolt.
13. Loosen the timing belt automatic tensioner bolt.
14. Turn the hex-key tab to relieve belt tension.
15. Remove the timing belt idler pulley bolt and nut.
16. Remove the timing belt idler pulley.
17. Remove the engine mount retaining bolts.
18. Remove the engine mount.

Installation Procedure

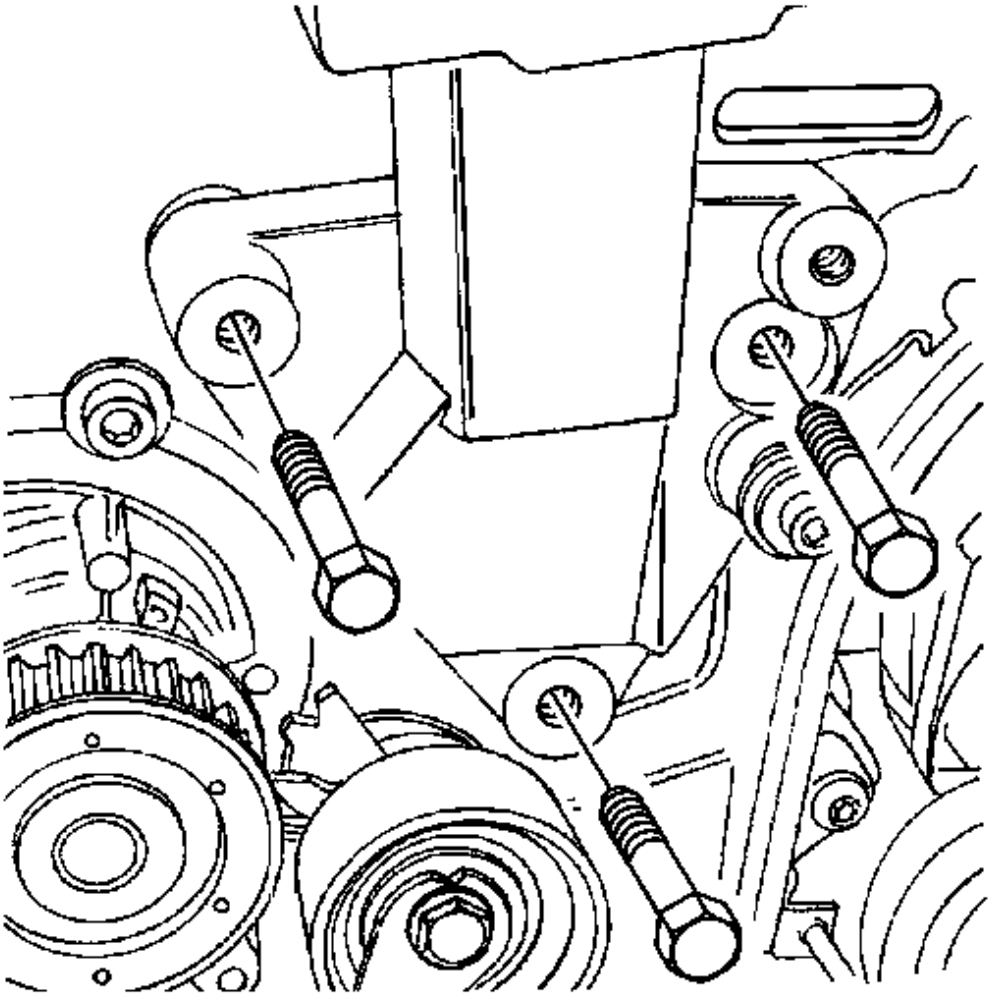


Fig. 8: View Of Engine Mount And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine mount retaining bolts.

Tighten: Tighten the engine mount retaining bolts to **45 N.m (33 lb ft)** .

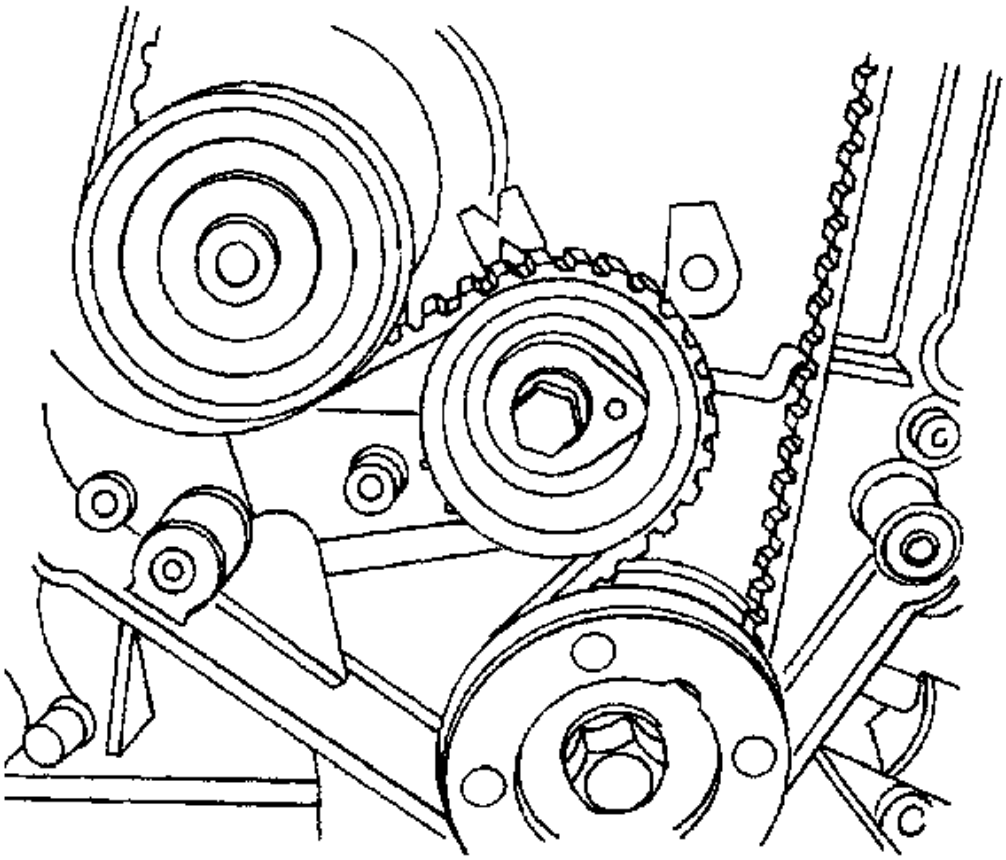


Fig. 9: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Install the timing belt idler pulleys.
4. Install the timing belt idler pulley bolt and nut.

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

5. Tension the timing belt by turning the timing belt automatic tensioner hex-key tab counterclockwise until the pointer is aligned to the indicator.

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

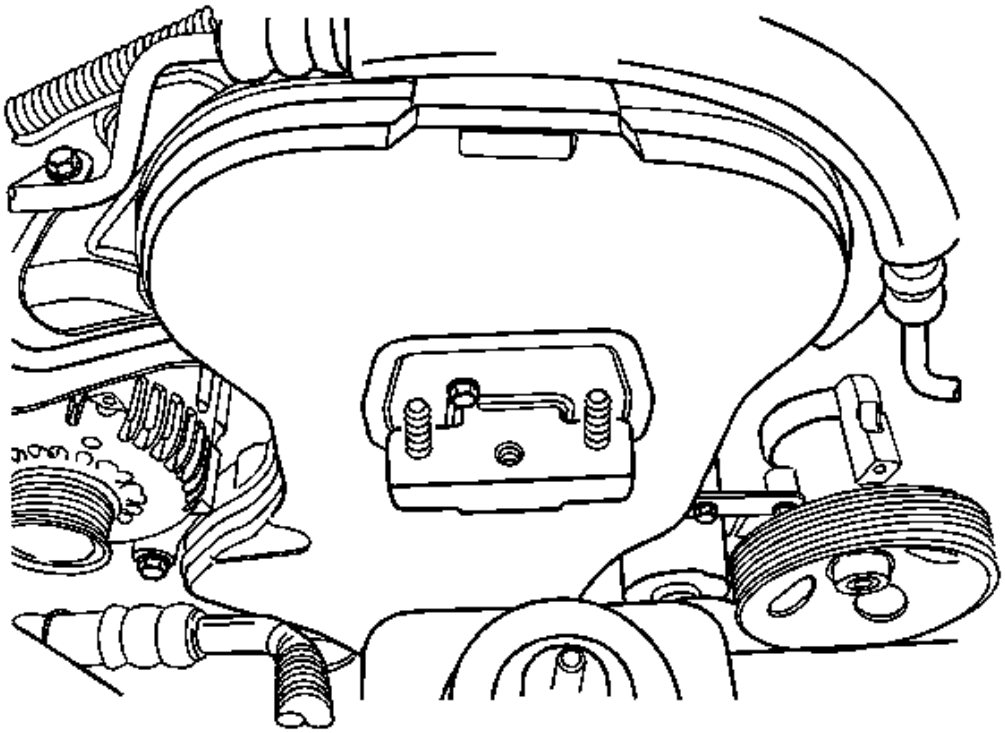


Fig. 10: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

6. Install the front timing belt cover.
7. Install the front timing belt cover bolts.

   Tighten: Tighten the front timing belt cover bolts to **6 N.m (53 lb in)** .

8. Install the engine mount bracket and retaining bolts.

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

9. Remove the **J 28467-B** .
10. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
11. Connect the negative battery cable.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

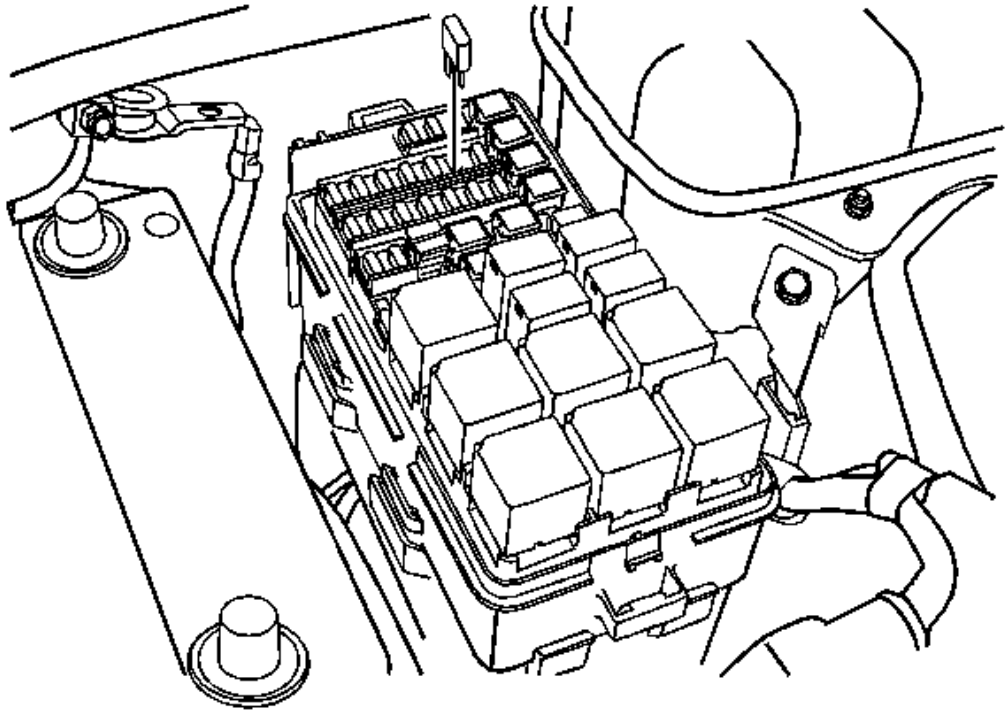


Fig. 11: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

3. Disconnect the negative battery cable.
4. Disconnect the charcoal canister purge (CCP) and exhaust gas recirculation (EGR) solenoid from the intake manifold and loosen the bracket bolt.
5. Drain the engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.

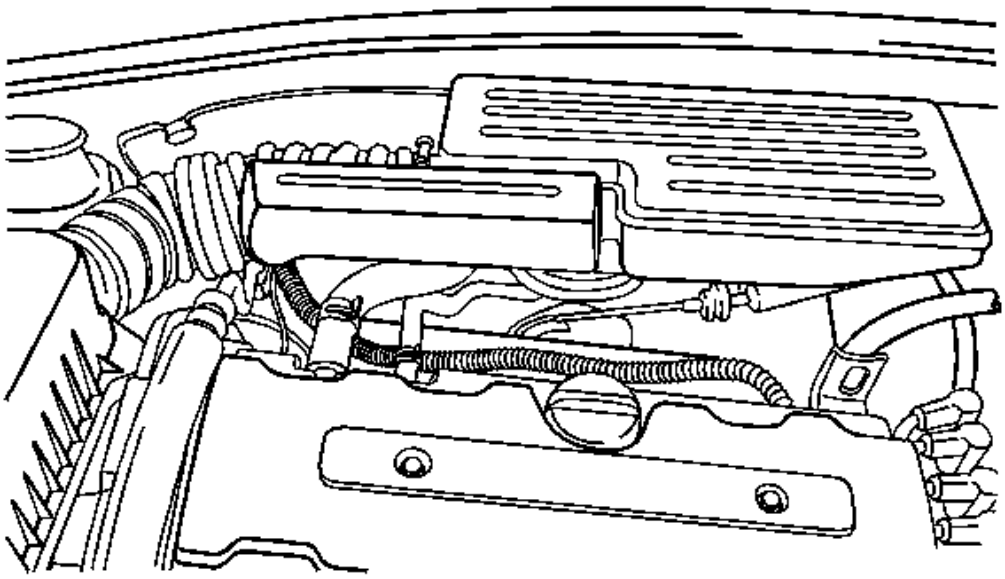


Fig. 12: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the intake air temperature sensor (IAT) connector.
7. Disconnect the air cleaner outlet hose from the throttle body.

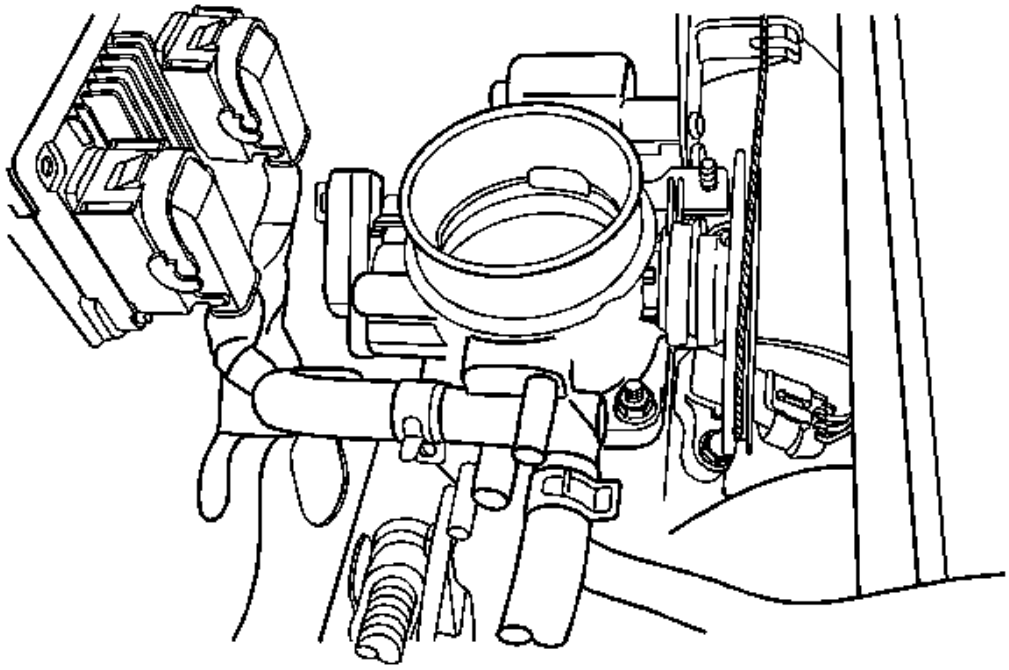


Fig. 13: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the idle air control (IAC) valve connector.
9. Disconnect the throttle position sensor (TPS) connector.
10. Disconnect the manifold absolute pressure (MAP) sensor connector.
11. Disconnect the coolant hoses at the throttle body.

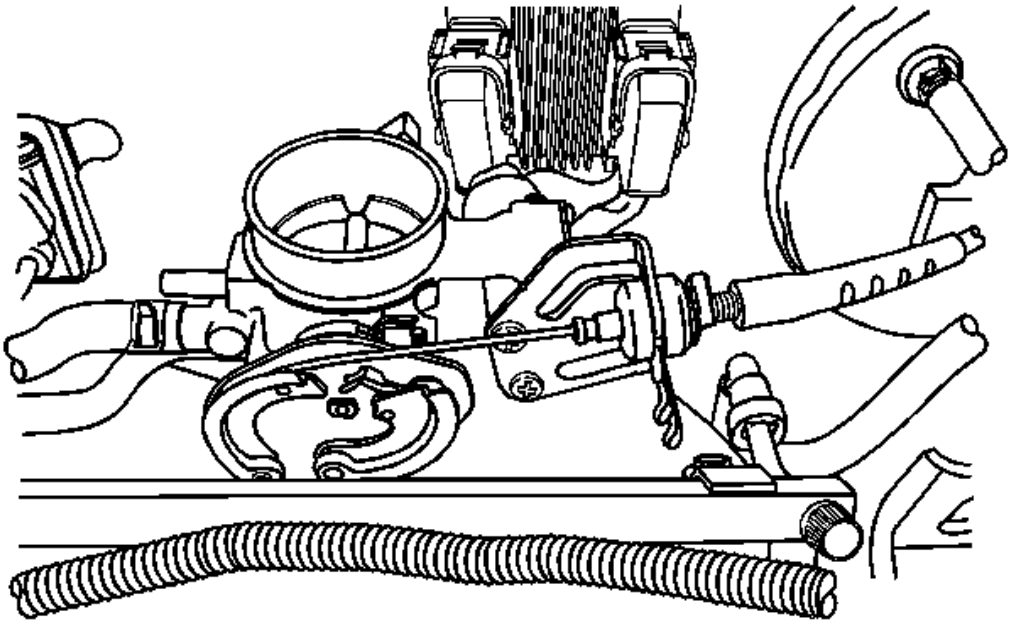


Fig. 14: Identifying Throttle Cable And Components
Courtesy of GENERAL MOTORS CORP.

12. Disconnect all of the necessary vacuum hoses, including the vacuum hose at the fuel pressure regulator and the brake booster vacuum hose at the intake manifold.
13. Disconnect the throttle cable from the throttle body and the intake manifold.
14. Remove the throttle cable bracket bolts from the intake manifold.
15. Remove the throttle cable bracket.
16. Remove the generator-to-intake manifold strap bracket bolts and strap.

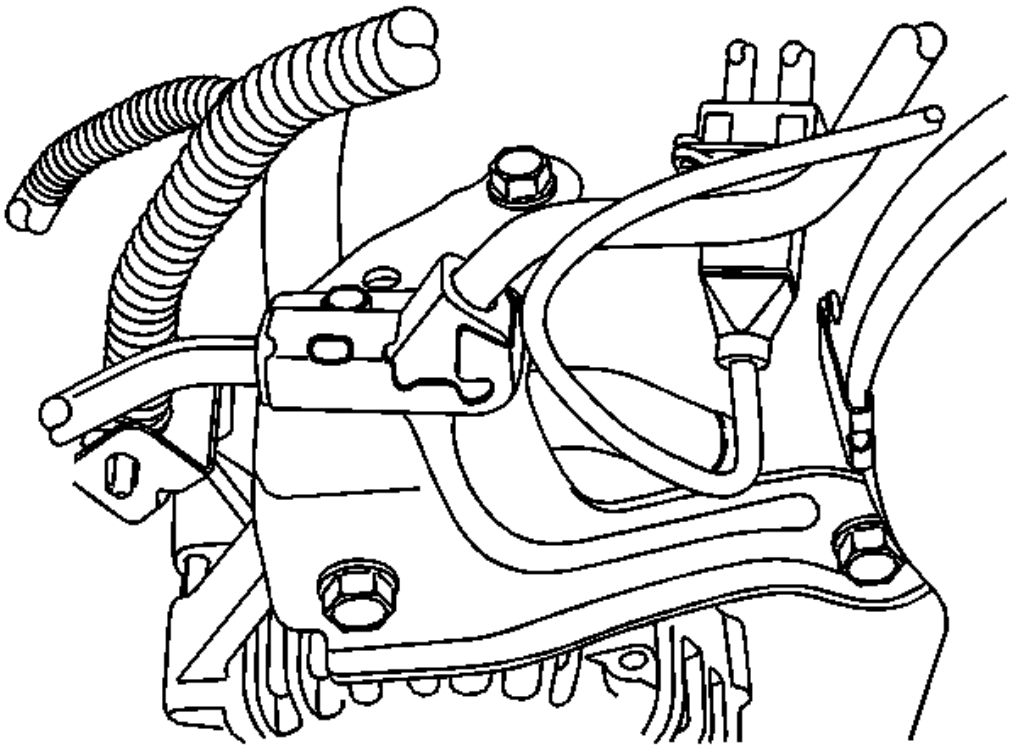


Fig. 15: View Of Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

17. Remove the fuel rail as an assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.
18. Remove the generator-to-intake manifold support bracket bolts.
19. Remove the generator-to-intake manifold support bracket.
20. Remove the intake manifold support bracket bolt at the engine block and the intake manifold.
21. Remove the intake manifold support bracket.

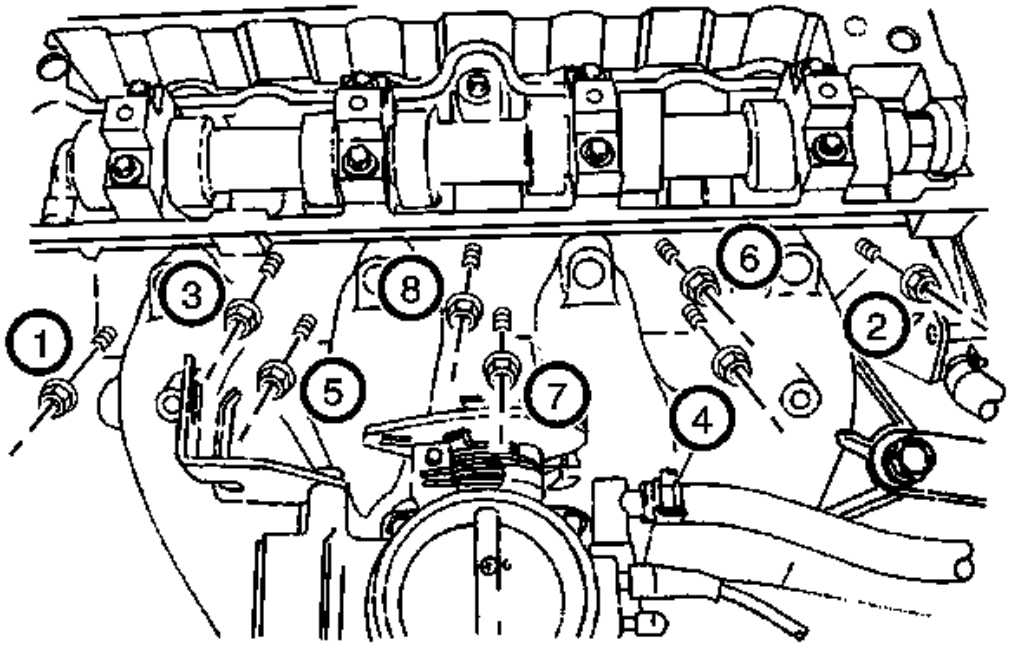


Fig. 16: View Of Intake Manifold Retaining Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

22. Remove the intake manifold retaining bolt and nuts in the sequence shown.
23. Remove the intake manifold.
24. Remove the intake manifold gasket.
25. Clean the sealing surfaces of the intake manifold and the cylinder head.

Installation Procedure

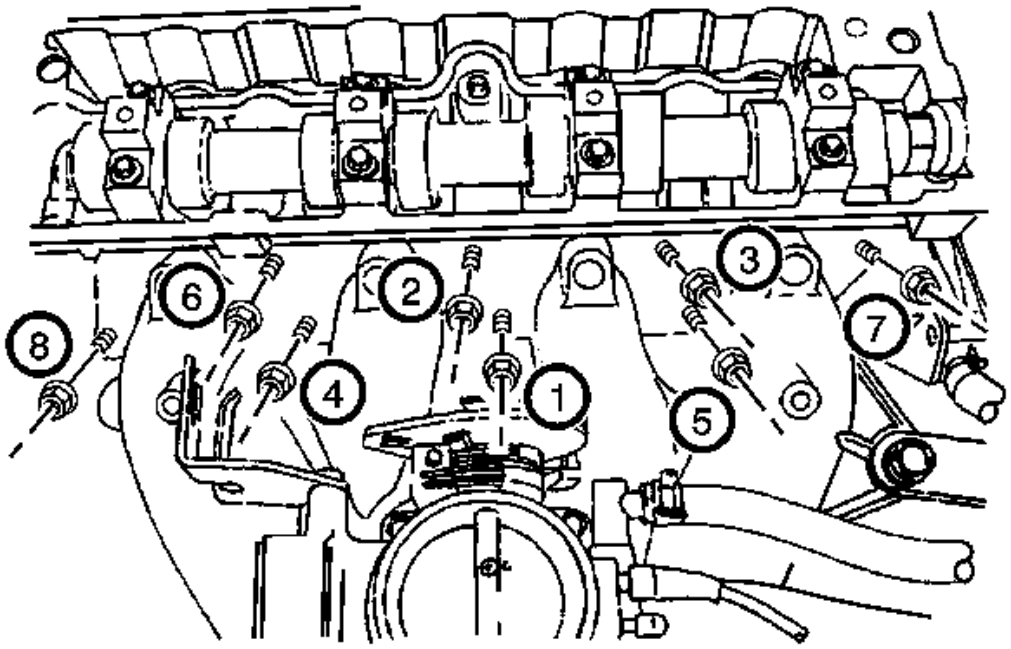


Fig. 17: View Of Intake Manifold Retaining Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

1. Install the intake manifold gasket.
2. Install the intake manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the intake manifold retaining bolt and nuts in the sequence shown.

   Tighten: Tighten the intake manifold retaining bolt and nuts to **22 N.m (16 lb ft)** .

4. Install the generator-to-intake manifold strap bracket bolts.

   Tighten: Tighten the generator-to-intake manifold strap bracket bolts to **22 N.m (16 lb ft)** .

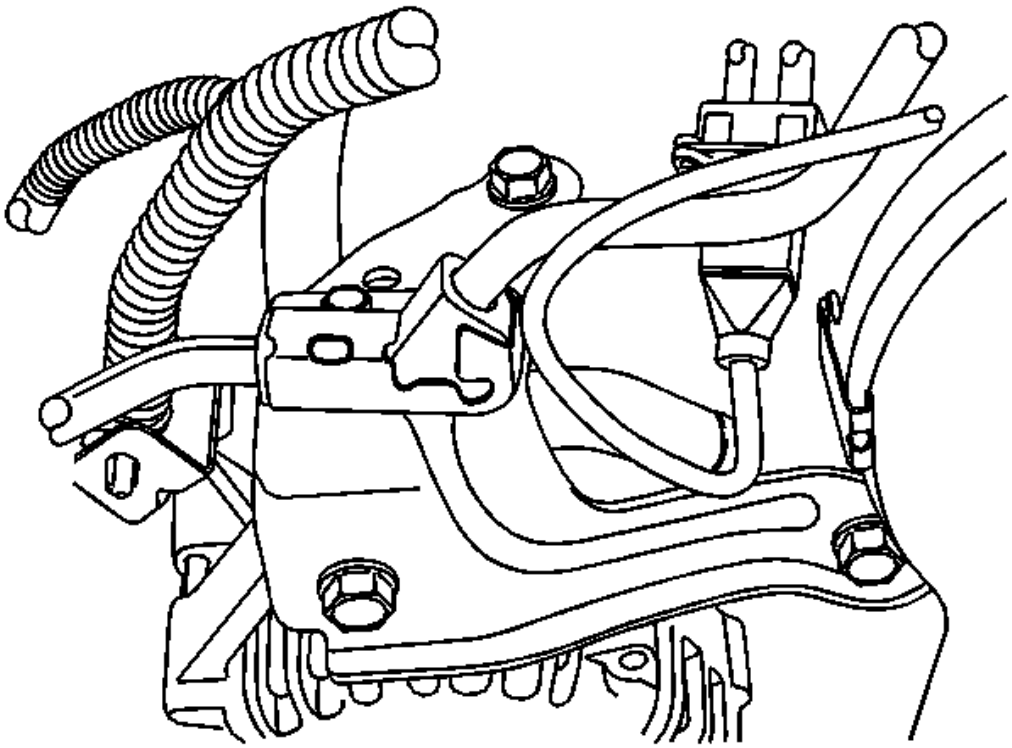


Fig. 18: View Of Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the intake manifold support bracket.
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. Install the intake manifold support bracket lower bolt to the engine block.

   Tighten: Tighten the intake manifold support bracket lower bolt to the engine block to **25 N.m (18 lb ft)** .

8. Install the generator-to-intake manifold support bracket bolts to **37 N.m (27 lb ft)** .

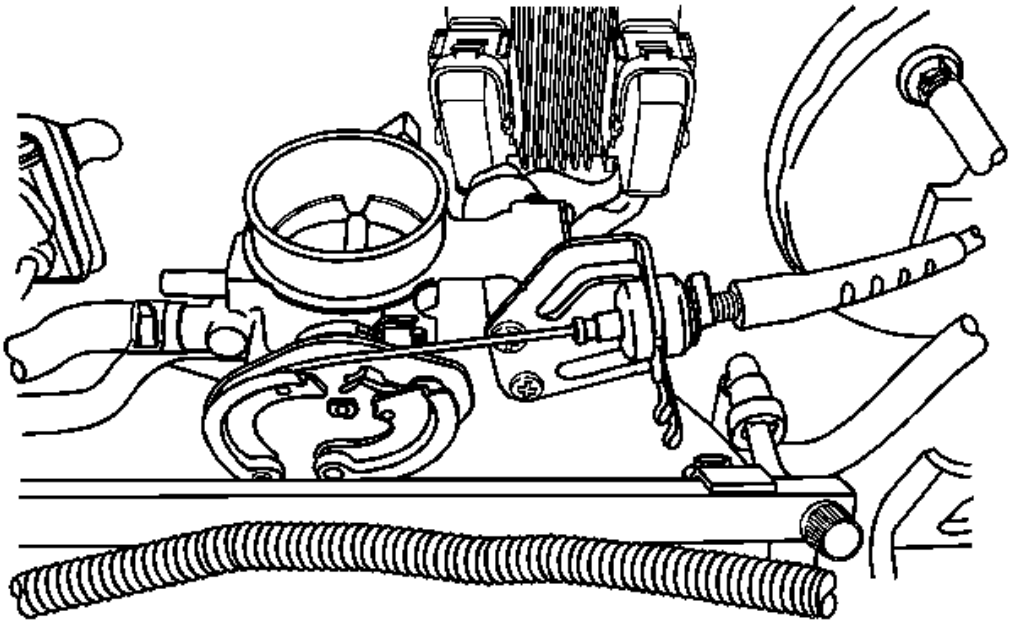


Fig. 19: Identifying Throttle Cable And Components
Courtesy of GENERAL MOTORS CORP.

9. Install the fuel rail and injector cover as an assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.
10. Install the throttle cable bracket.
11. Install the throttle cable bracket bolts.

    Tighten: Tighten the throttle cable bracket bolts to **8 N.m (71 lb in)** .

12. Connect the throttle cable to the intake manifold and the throttle body.
13. Connect all of the necessary vacuum lines that were previously disconnected.

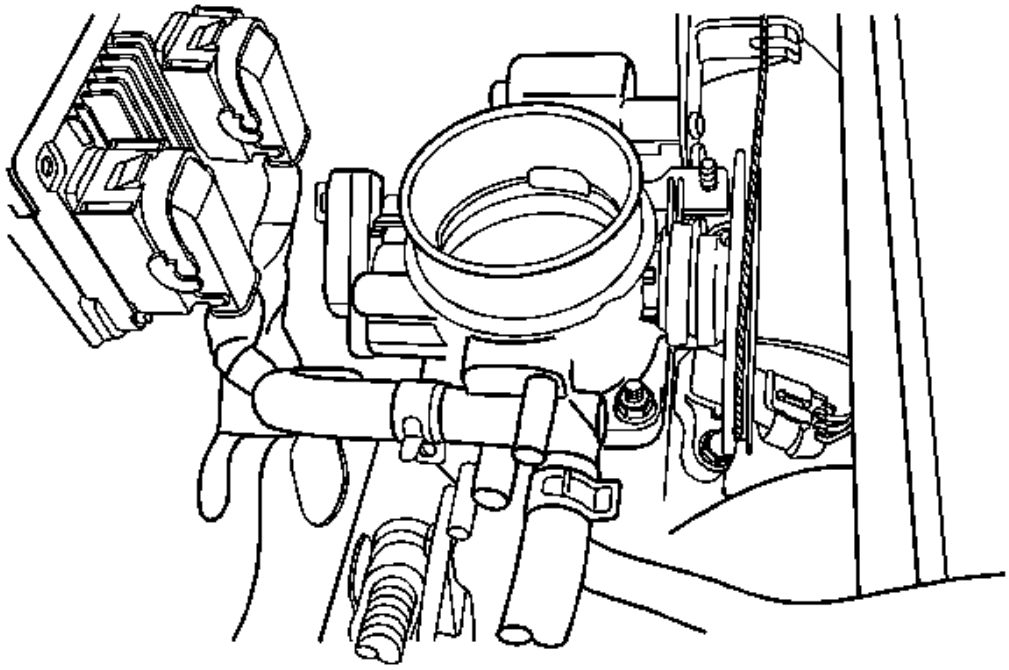


Fig. 20: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

14. Connect the MAP sensor connector.
15. Connect the coolant hoses to the throttle body.
16. Connect the IAC valve connector.
17. Connect the TP sensor connector.

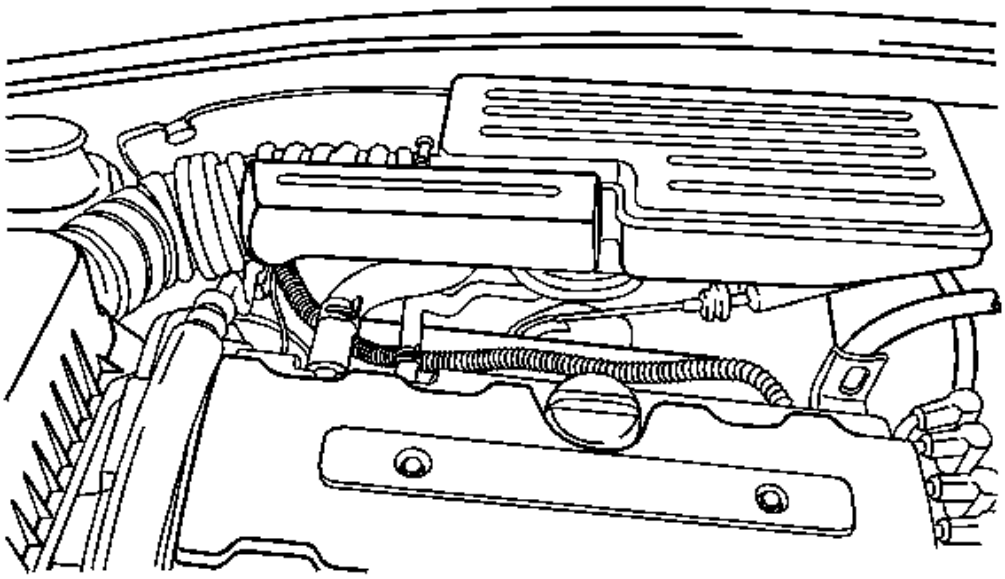


Fig. 21: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

18. Connect the air cleaner outlet hose to the throttle body.
19. Connect the IAT sensor connector.
20. Connect the CCP and EGR solenoid at the intake manifold and tighten the bracket bolt.

    Tighten: Tighten the charcoal canister purge and exhaust gas recirculation solenoid bracket bolt to **5 N.m (44 lb in)** .

21. Install the fuel pump fuse.
22. Connect the negative battery cable.
23. Refill the engine cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

TIMING BELT INSPECTION

Removal Procedure

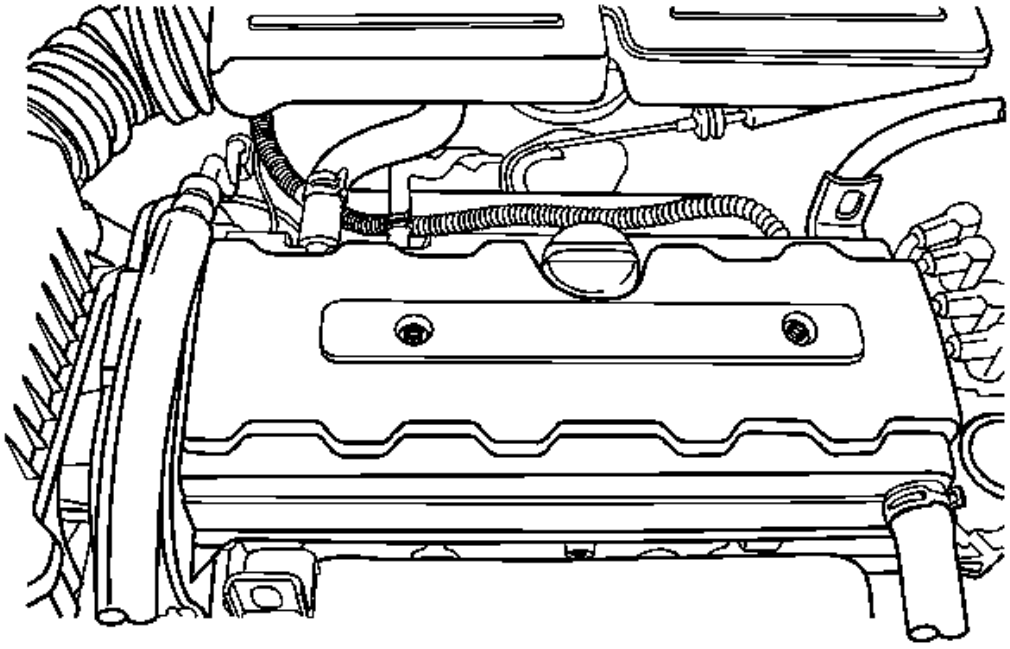


Fig. 22: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Remove the air cleaner outlet hose from the throttle body.
4. Remove the breather tube from the camshaft cover.

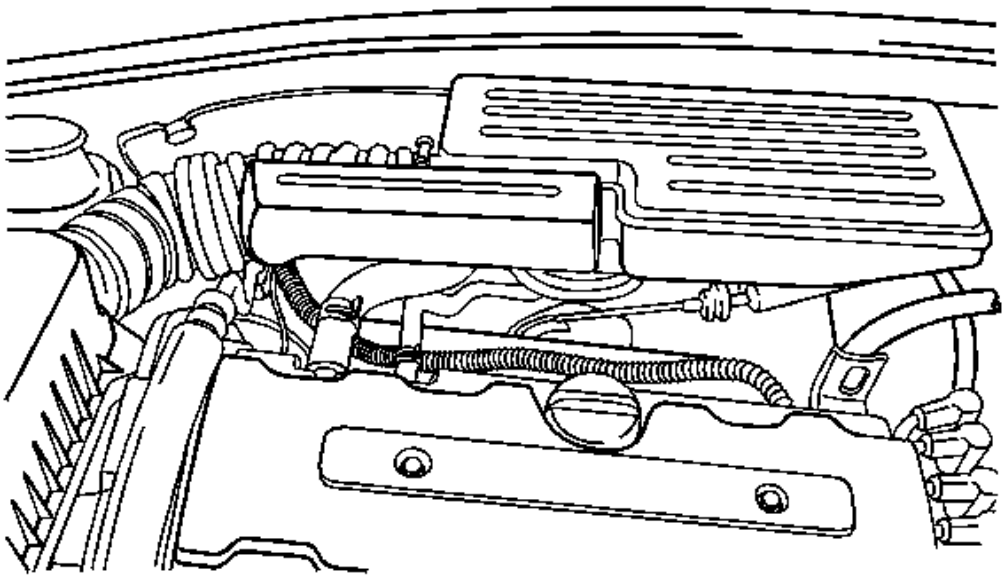


Fig. 23: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

5. Remove the air cleaner housing bolts.
6. Remove the air cleaner housing.
7. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
8. Remove the right front wheel well splash shield. Refer to **Splash Shield Replacement - Wheelhouse** in Body Front End.

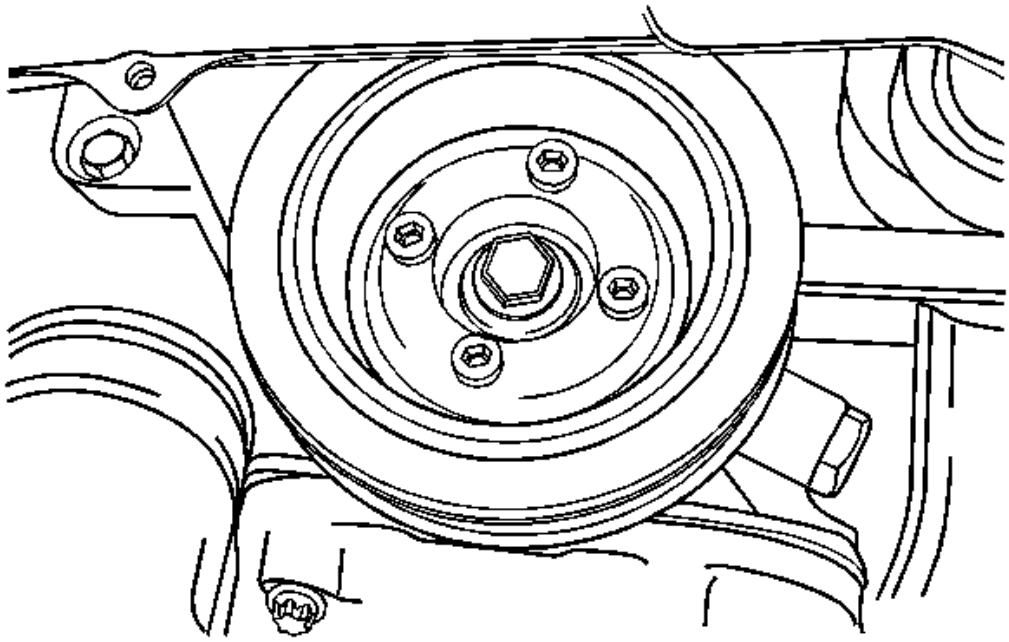


Fig. 24: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
10. Remove the crankshaft pulley bolts.
11. Remove the crankshaft pulley.
12. Remove the right engine mount bracket. Refer to **Engine Mount Replacement**.

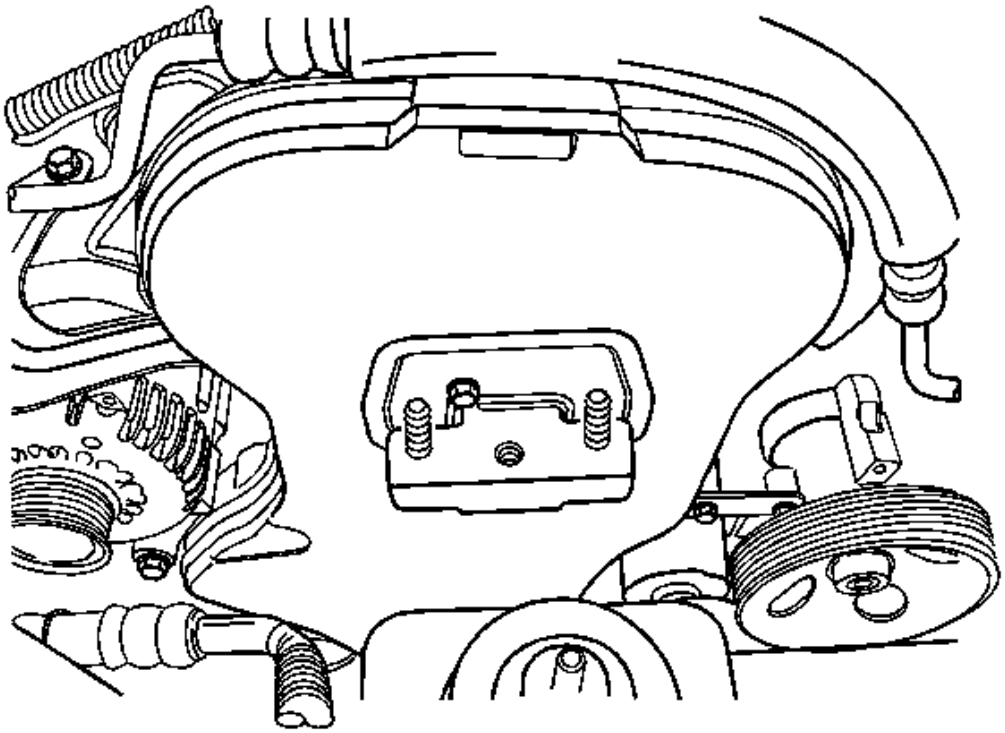


Fig. 25: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

13. Remove the front timing belt cover bolts.
14. Remove the front timing belt cover.

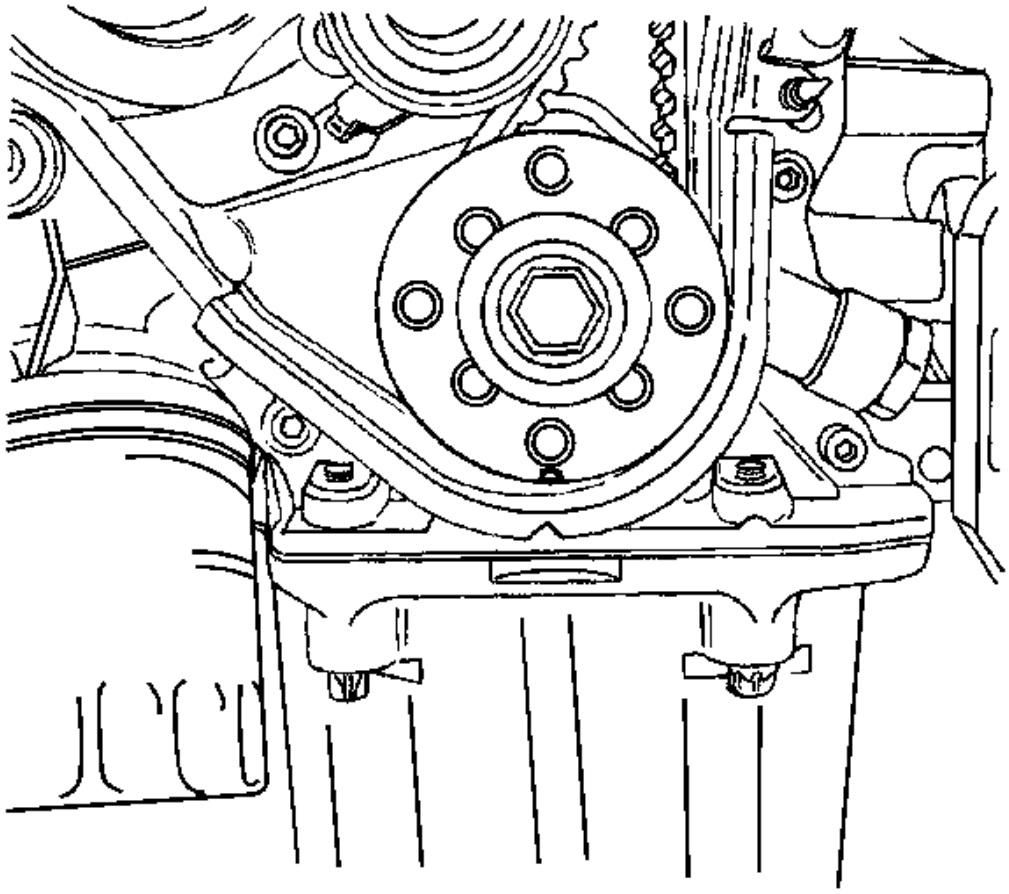


Fig. 26: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

15. Rotate the crankshaft at least one full turn clockwise using the crankshaft gear bolt.
16. Align the mark on the crankshaft gear with the notch at the bottom of the rear timing belt cover.

Adjustment Procedure

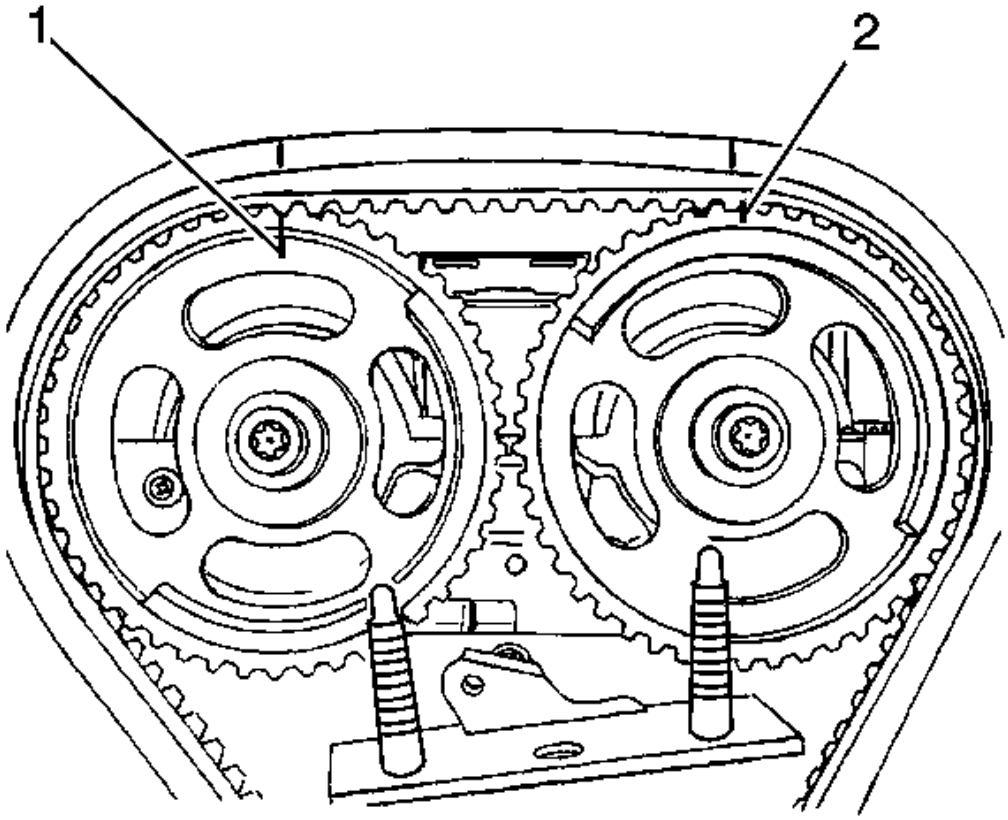


Fig. 27: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

1. Align the camshaft gear timing marks. Use the exhaust gear mark (2) for the exhaust gear and the intake gear mark (1) for the intake gear, since the gear are interchangeable.

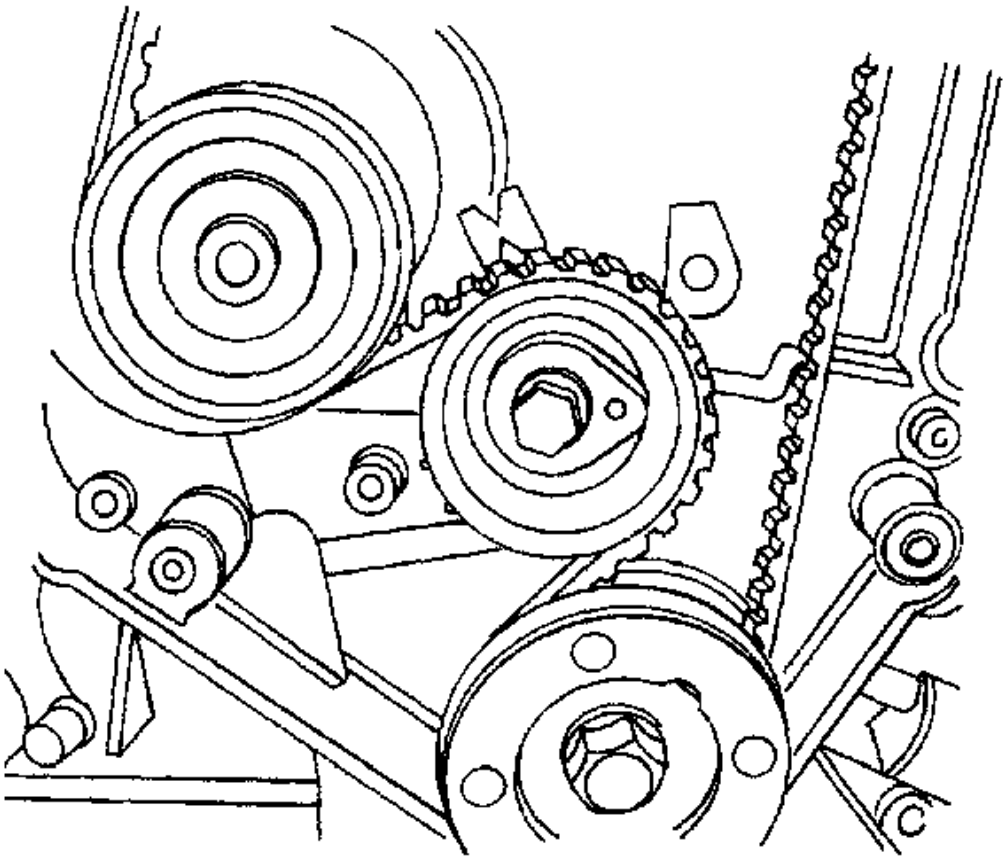


Fig. 28: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

2. Loosen the automatic tensioner bolt. To relieve the belt tension, turn the hex-key tab counterclockwise.
3. Rotate the automatic tensioner hex-key tab clock wise until the adjust arm pointer of the timing belt automatic tensioner is aligned with the notch in the timing belt automatic tensioner bracket.

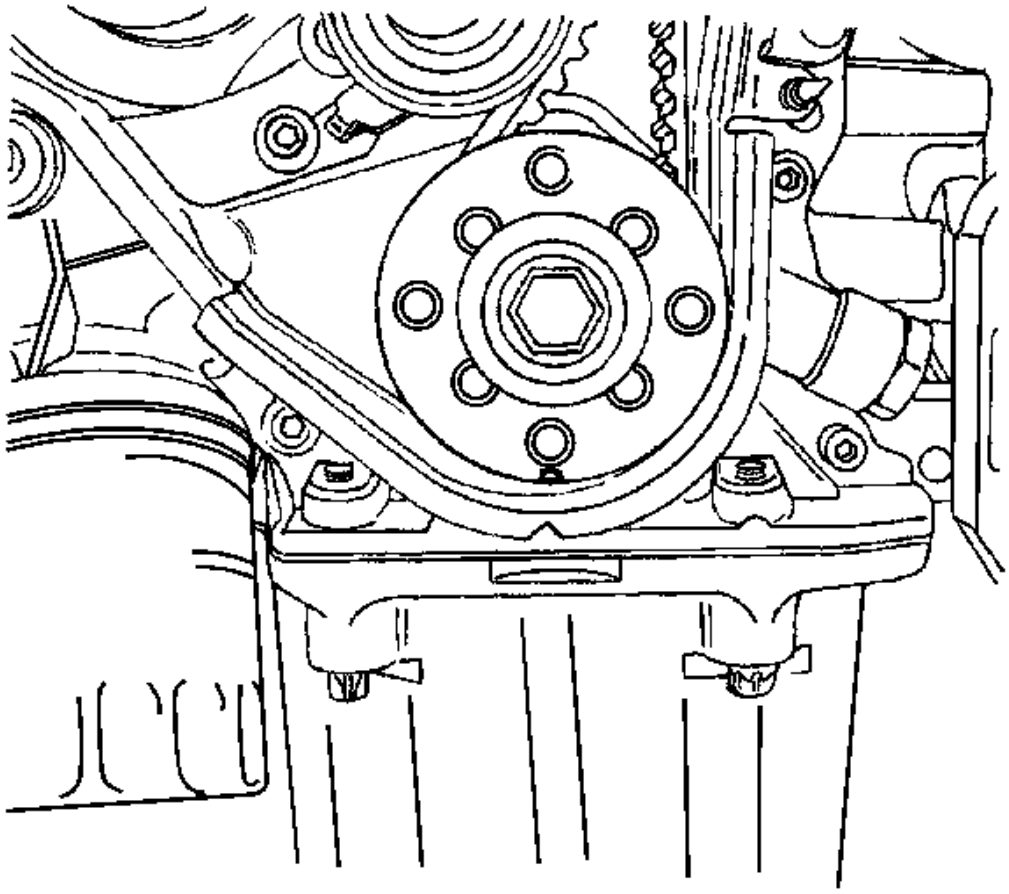


Fig. 29: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

4. Tighten the automatic tensioner bolt.
5. Rotate the crankshaft two full turns clockwise using the crankshaft gear bolt.
6. Check the automatic tensioner pointer.

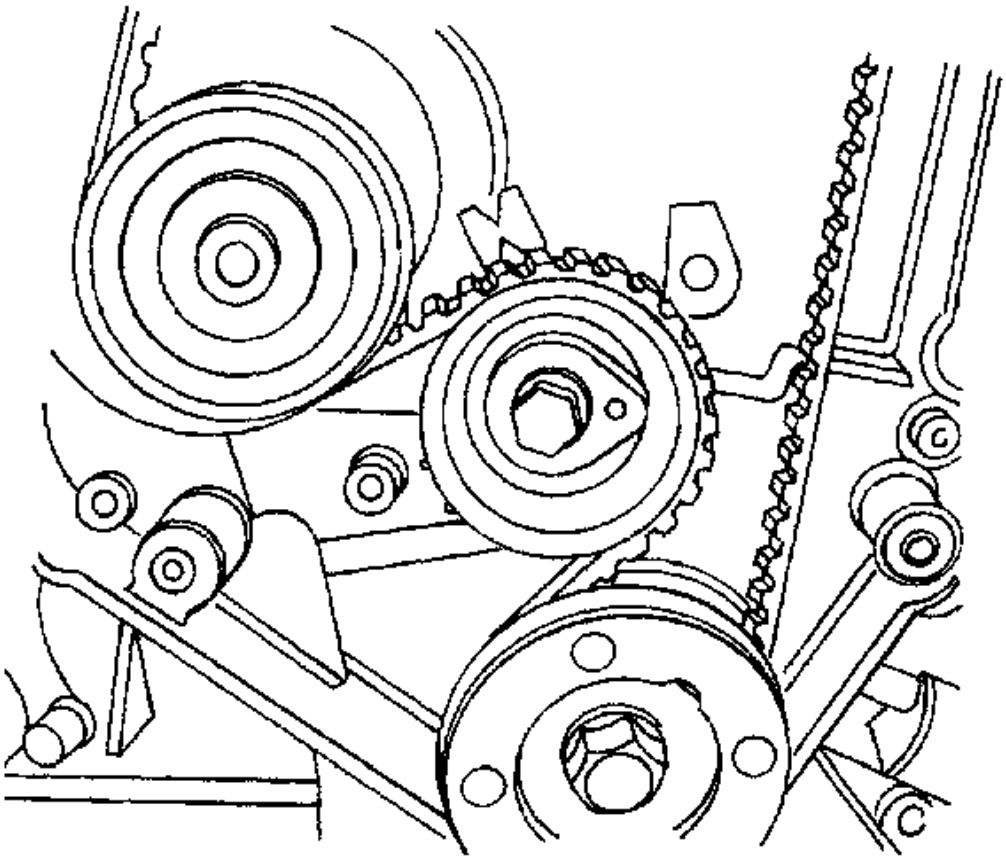


Fig. 30: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. When the adjust arm pointer of the timing belt automatic tensioner is aligned with the notch on the timing belt automatic tensioner bracket, the belt is tensioned correctly.

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

Installation Procedure

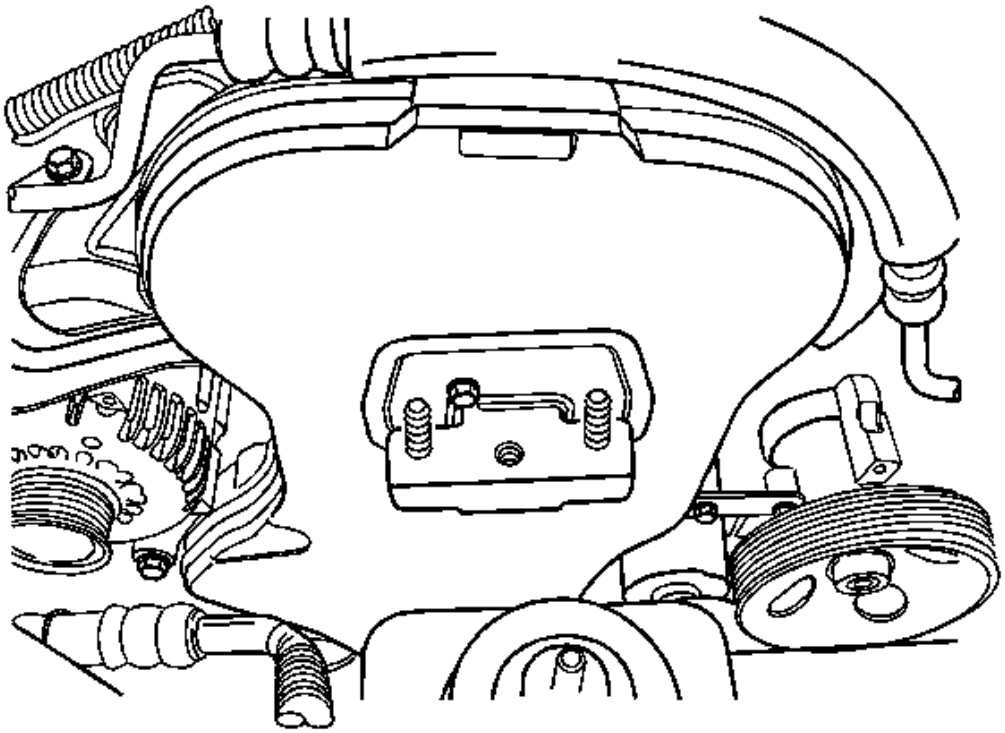


Fig. 31: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Install the front timing belt cover.
2. Install the front timing belt cover bolts.

Tighten: Tighten the front timing belt cover bolts to **6 N.m (53 lb in)** .

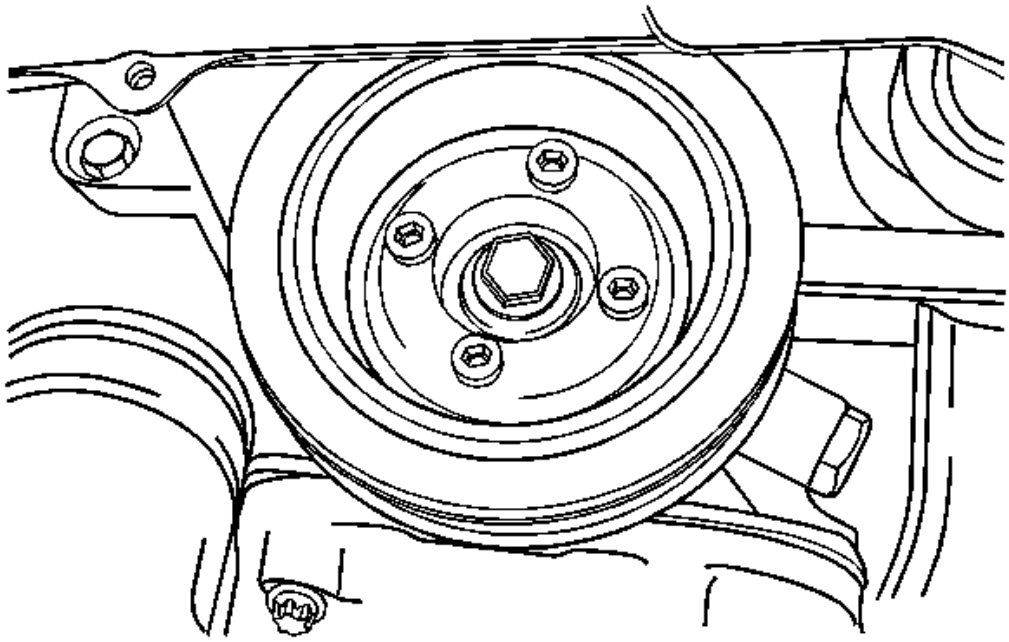


Fig. 32: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft pulley.
4. Install the crankshaft pulley bolt.

   Tighten: Tighten the crankshaft pulley bolt to **20 N.m (15 lb ft)** .

5. Install the right engine mount bracket. Refer to **Engine Mount Replacement**.
6. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.

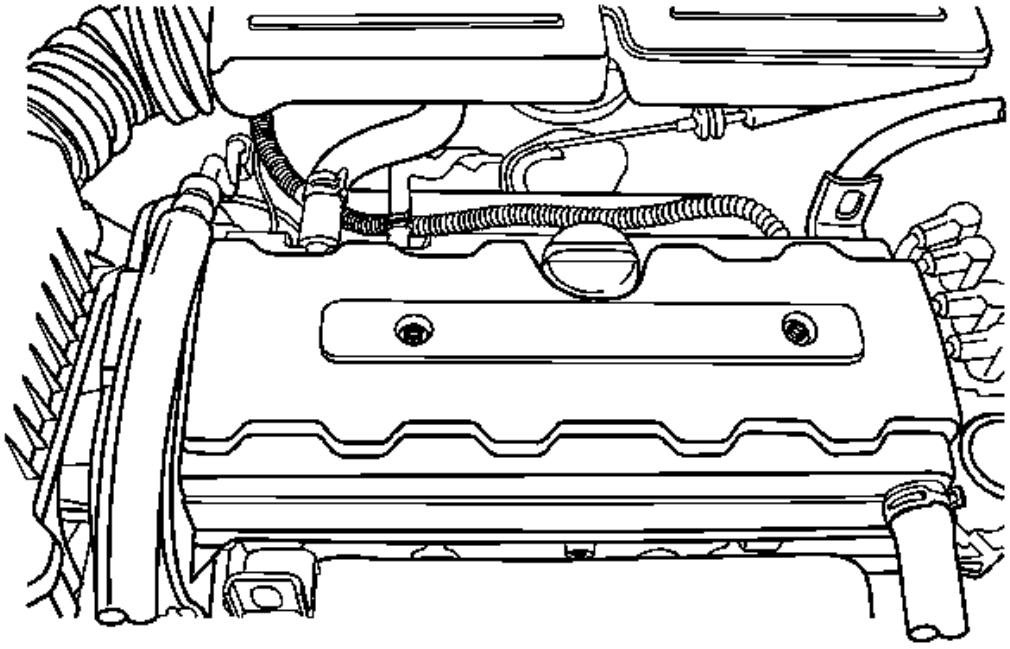


Fig. 33: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the right front wheel well splash shield. Refer to **Splash Shield Replacement - Wheelhouse** in Body Front End.
8. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
9. Install the air cleaner housing.
10. Install the air cleaner housing bolts.

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

11. Connect the air cleaner outlet hose to the throttle body.

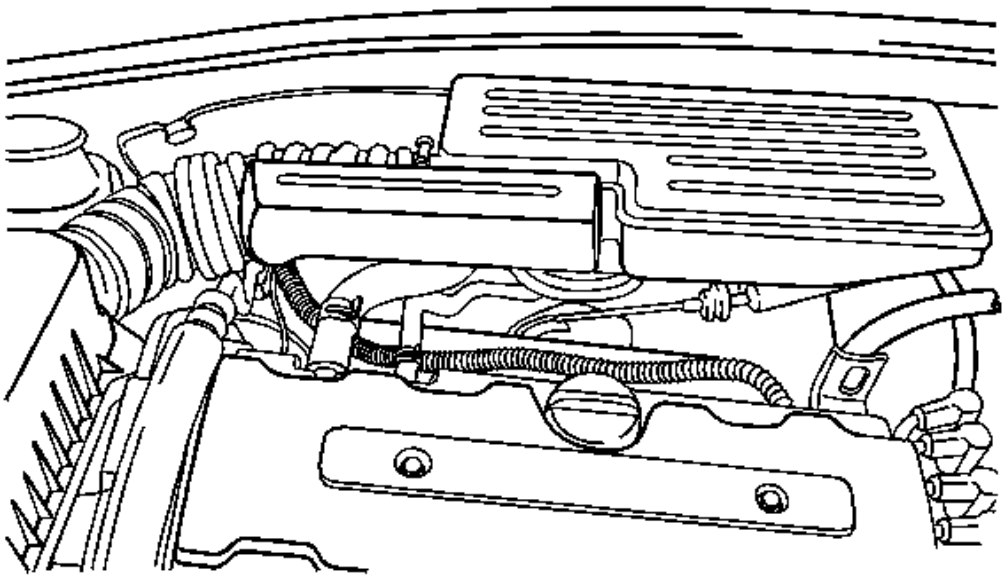


Fig. 34: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

12. Connect the breather tube to the camshaft cover.
13. Connect the IAT sensor connector.
14. Connect the negative battery cable.

TIMING BELT REPLACEMENT

Removal Procedure

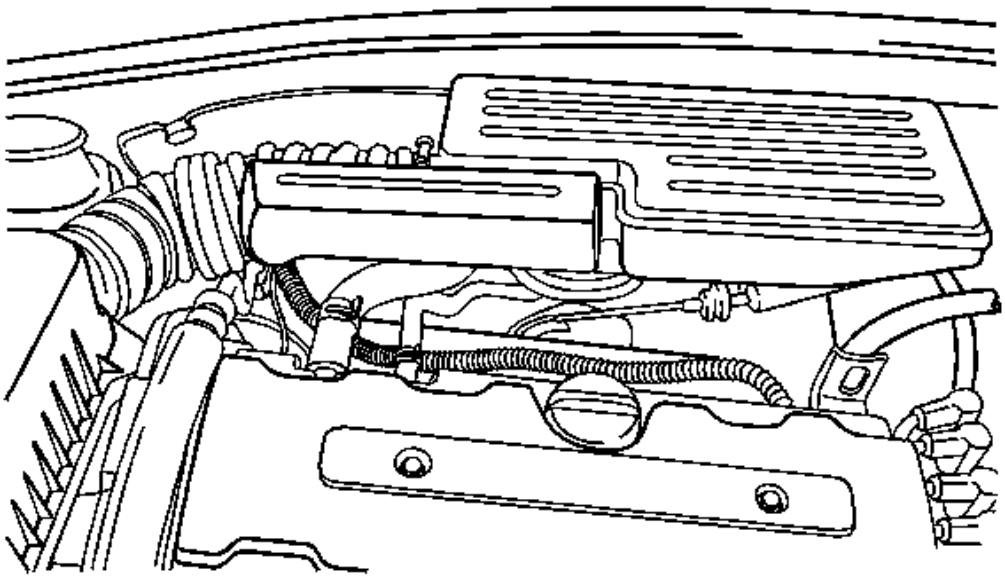


Fig. 35: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Disconnect the intake air temperature (IAT) sensor connector.
3. Disconnect the air cleaner outlet hose from the throttle body.
4. Disconnect the breather tube from the camshaft cover.

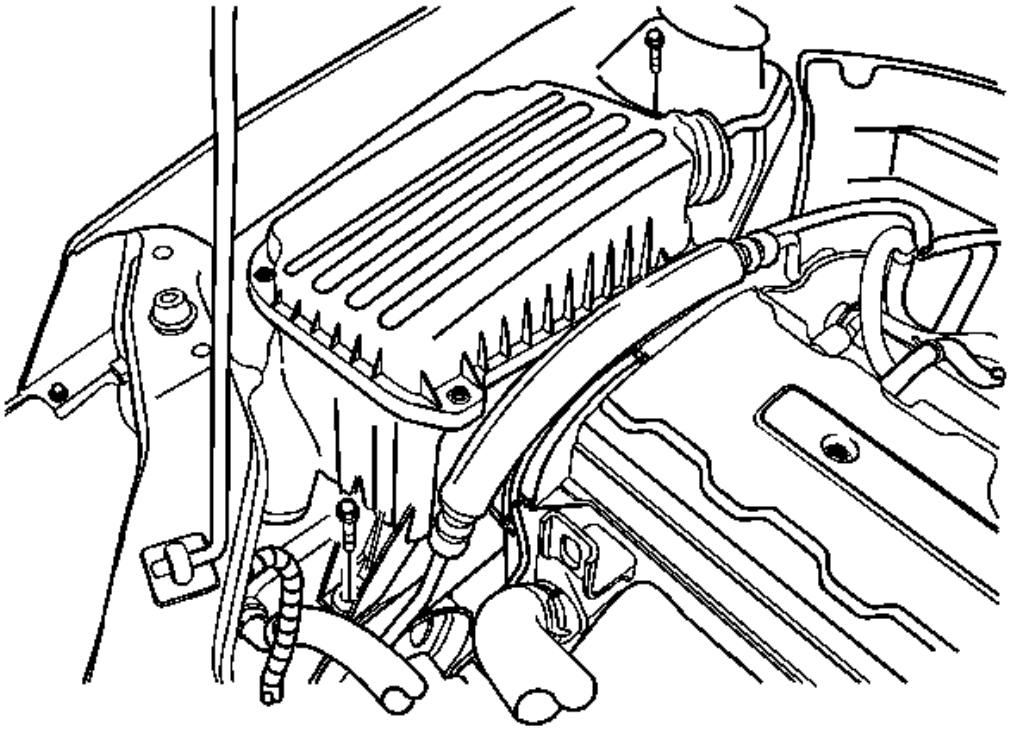


Fig. 36: View Of Air Cleaner Housing And Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the air cleaner housing bolts.
6. Remove the air cleaner housing.
7. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
8. Remove the right front wheel well splash shield. Refer to **Splash Shield Replacement - Wheelhouse** in Body Front End.

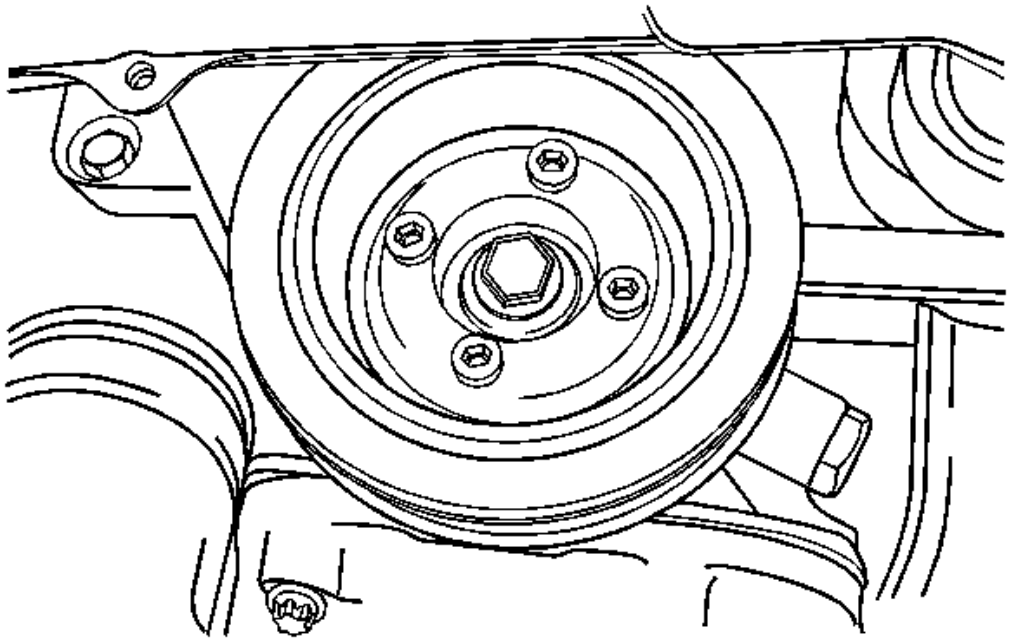


Fig. 37: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
10. Remove the crankshaft pulley bolts.
11. Remove the crankshaft pulley.
12. Remove the right engine mount bracket. Refer to **Engine Mount Replacement**.

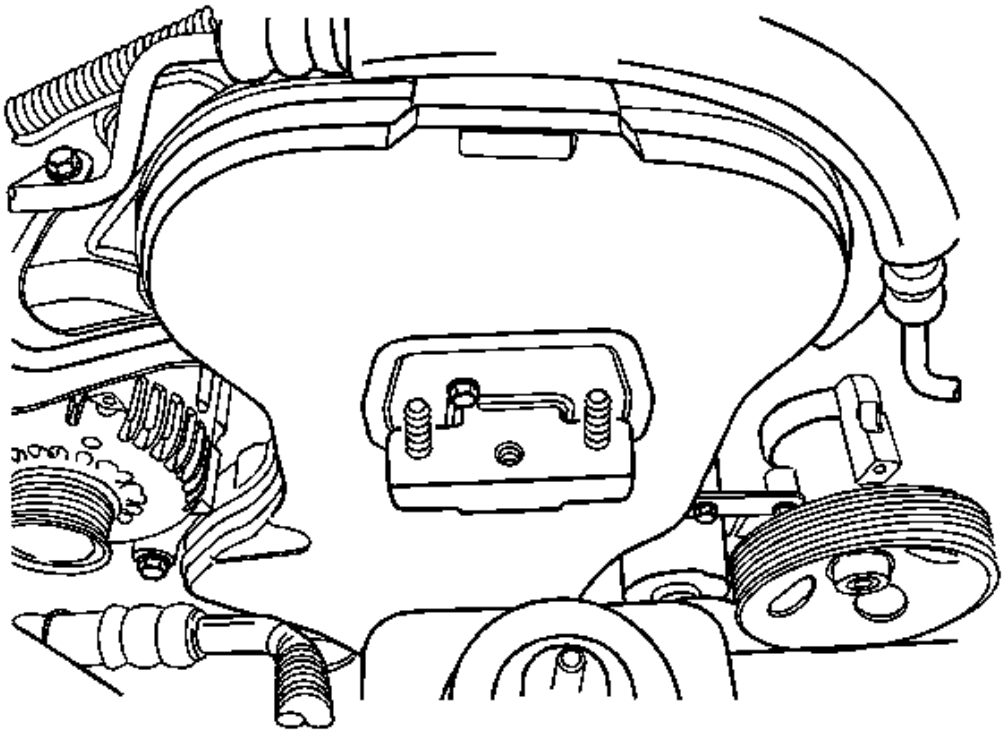


Fig. 38: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

13. Remove the front timing belt cover bolts.
14. Remove the front timing belt cover.

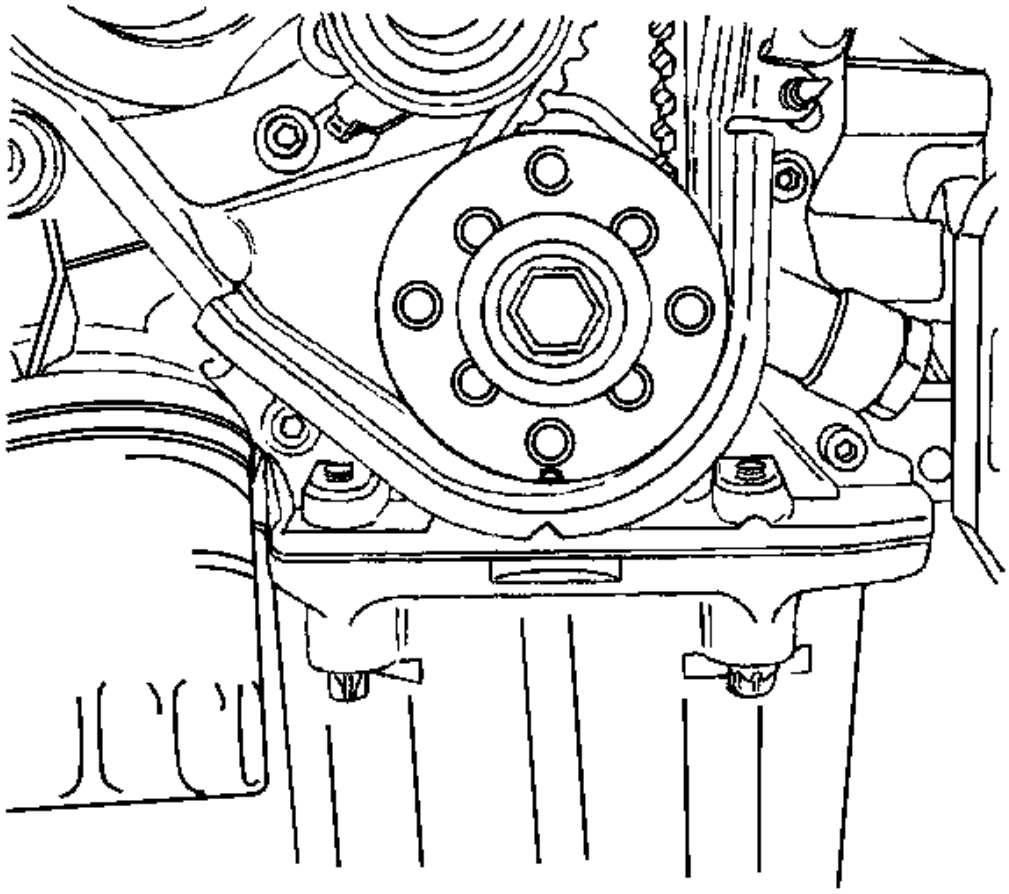


Fig. 39: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

15. Using the crankshaft gear bolt, rotate the crankshaft clockwise until the timing mark on the crankshaft gear is aligned with the notch at the bottom of the rear timing belt cover.

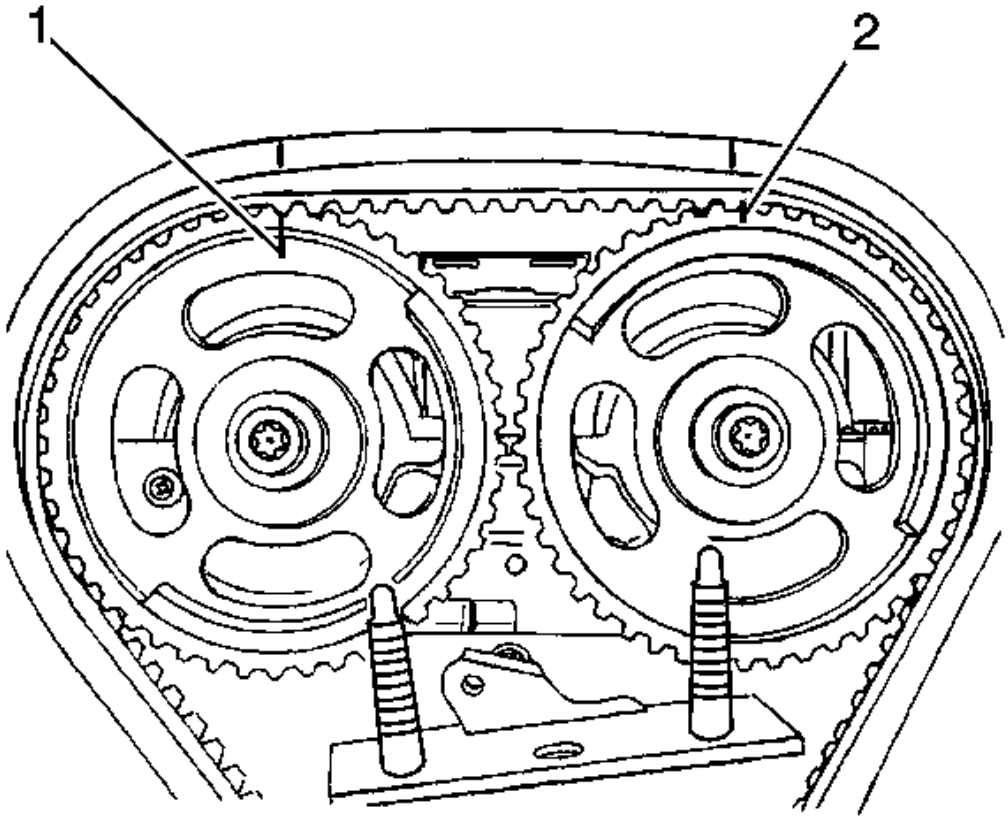


Fig. 40: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The camshaft gears must align with the notch on the camshaft cover or damage to the engine could result.

IMPORTANT: Use the intake gear mark for the intake camshaft gear and the exhaust gear mark for the exhaust camshaft gear since both gears are interchangeable.

16. Align the camshaft gear notch (1, 2) with the notch on the camshaft cover.

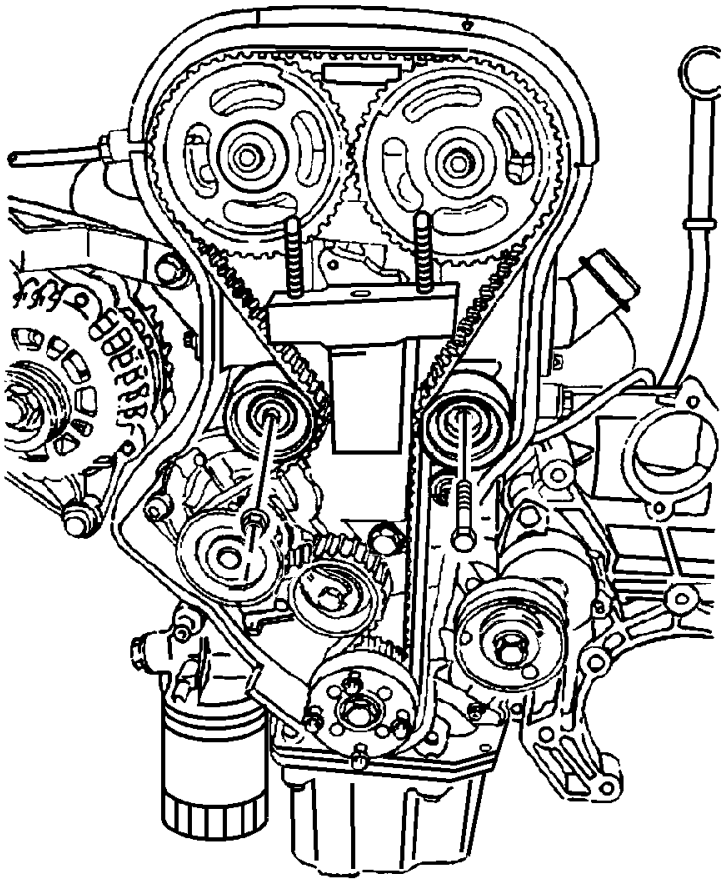


Fig. 41: View Of Timing Belt Idler Pulleys And Bolts
Courtesy of GENERAL MOTORS CORP.

17. Loosen the automatic tensioner bolt. Turn the hex-key tab to relieve belt tension.
18. Remove the timing belt.

Installation Procedure

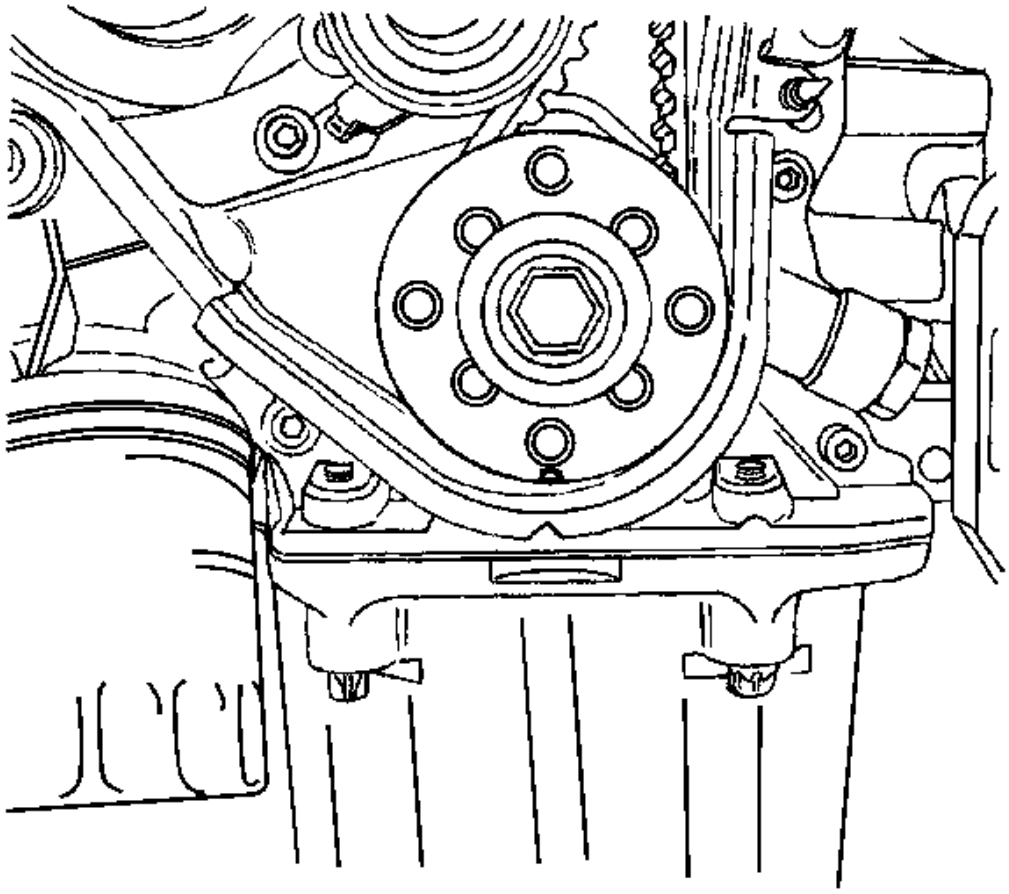


Fig. 42: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

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

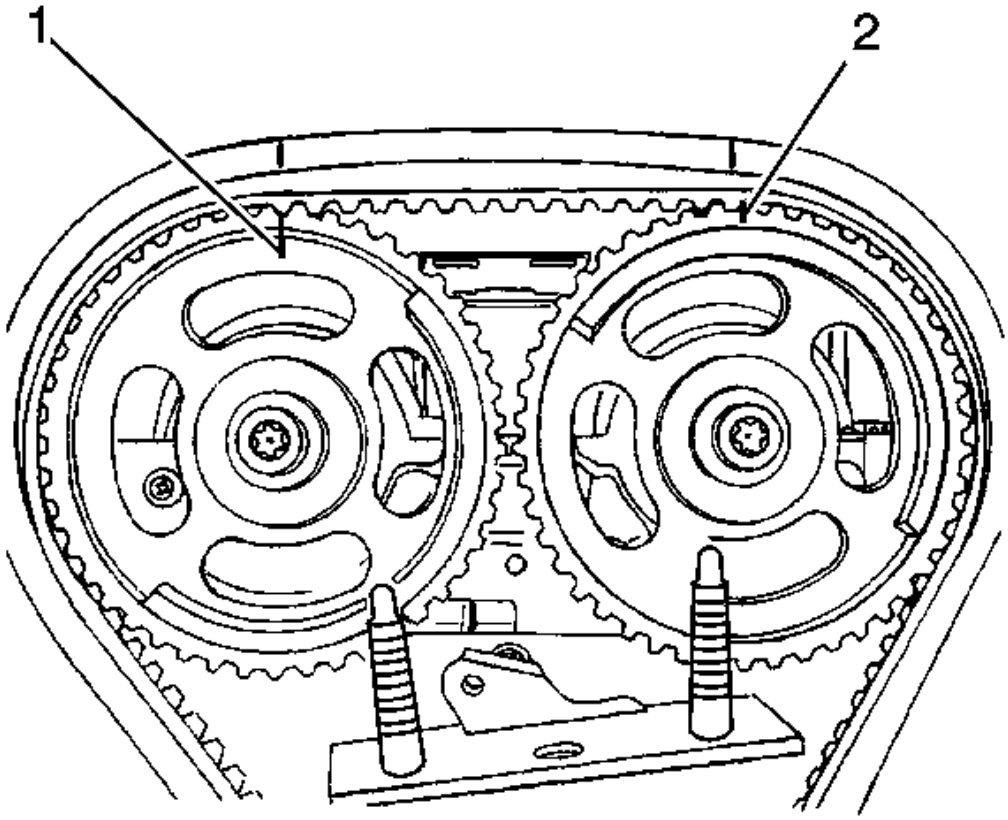


Fig. 43: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

2. Align the timing marks on the camshaft gears, using the intake gear mark (1) for the intake gear and the exhaust gear mark (2) for the exhaust gear.

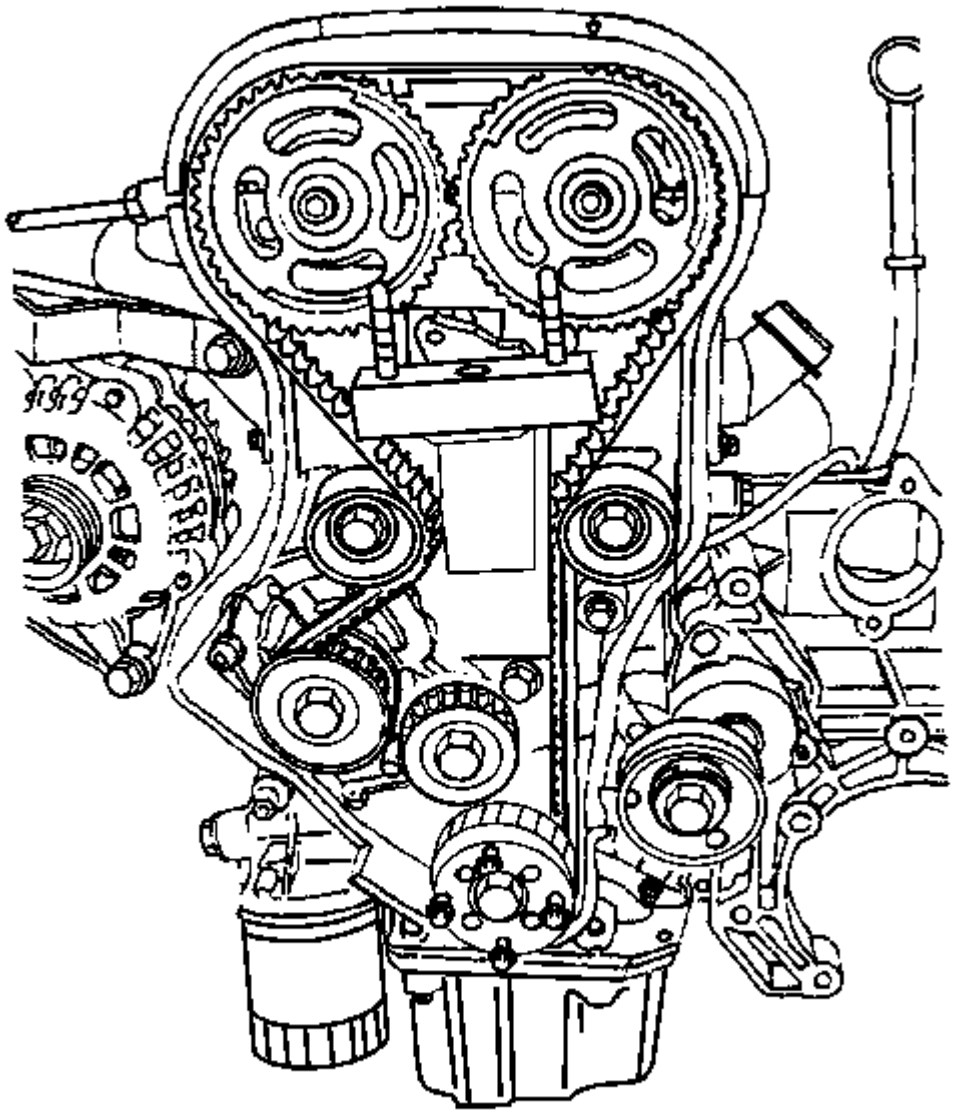


Fig. 44: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

3. Install the timing belt.

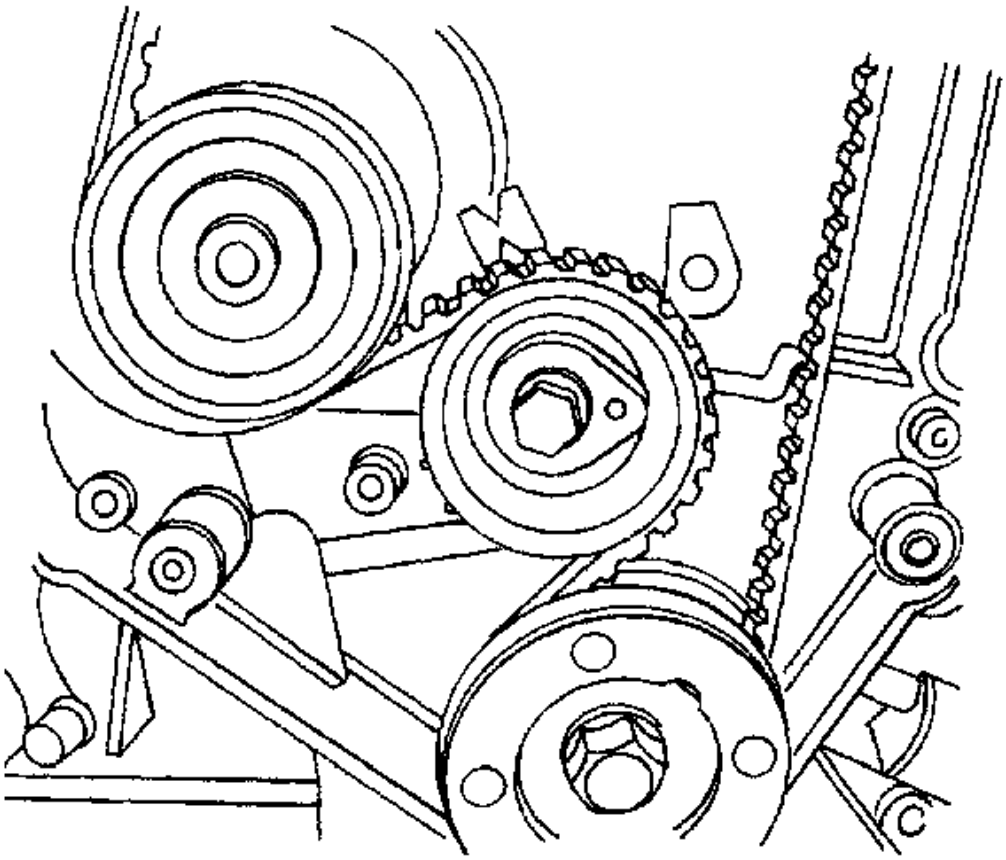


Fig. 45: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Turn the hex-key tab in a clockwise direction to tension the belt. Turn until the pointer aligns with the notch.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the automatic tensioner bolt.

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

6. Rotate the crankshaft 2 full turns clockwise using the crankshaft pulley bolt.
7. Recheck the automatic tensioner pointer.

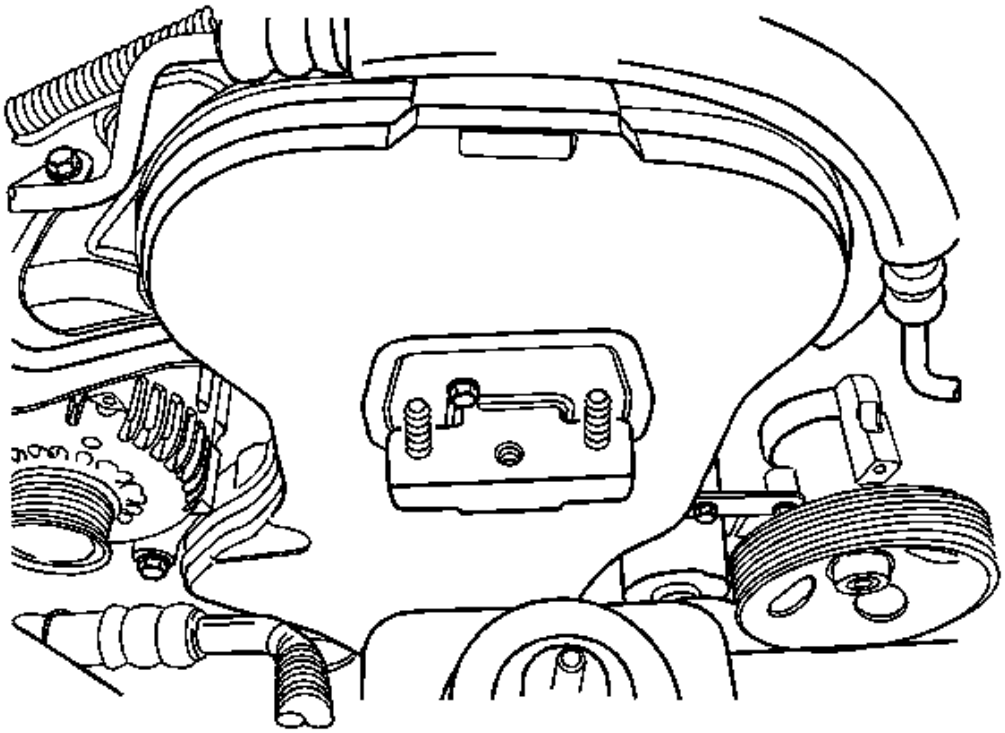


Fig. 46: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

8. Install the front timing belt cover.
9. Install the front timing belt cover bolts.

   Tighten: Tighten the front timing belt cover bolts to **6 N.m (53 lb in)** .

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

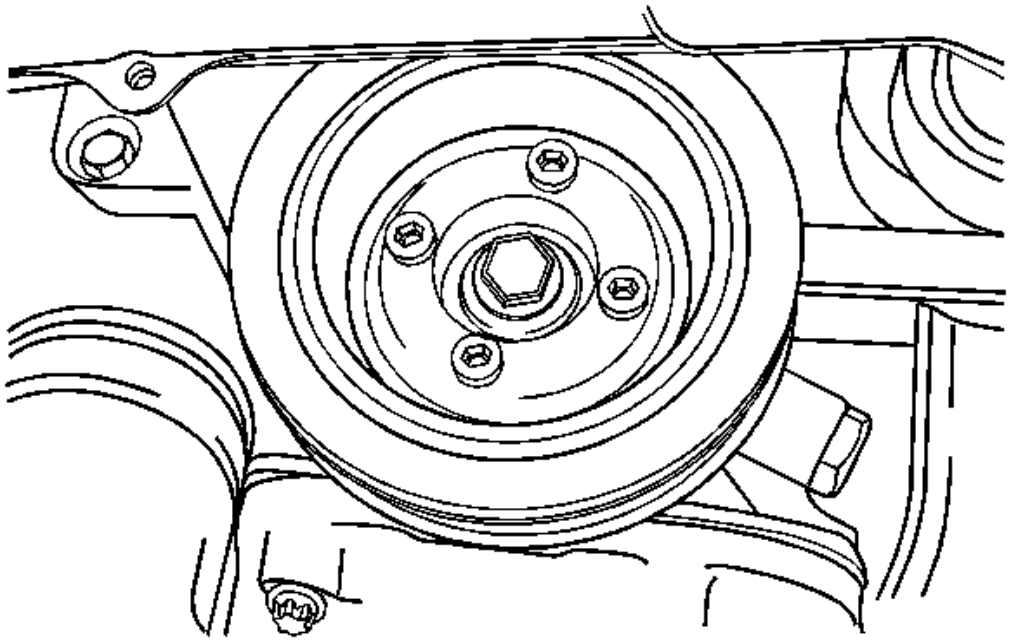


Fig. 47: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the crankshaft pulley.
12. Install the crankshaft pulley bolts.

    Tighten: Tighten the crankshaft pulley bolts to **20 N.m (15 lb ft)** .

13. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
14. Install the right front wheel well splash shield. Refer to **Splash Shield Replacement - Wheelhouse** in Body Front End.
15. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
16. Install the air cleaner housing.
17. Install the air cleaner housing bolts.

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

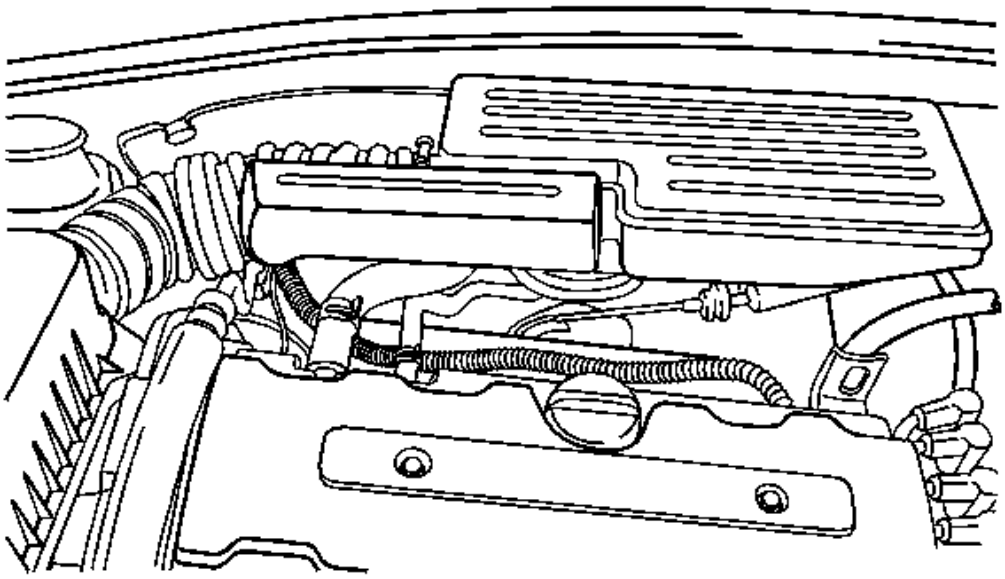


Fig. 48: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

18. Connect the air cleaner outlet hose to the throttle body.
19. Connect the breather tube to the camshaft cover.
20. Connect the IAT sensor connector.
21. Connect the negative battery cable.

TIMING BELT COVER REPLACEMENT

Tools Required

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

Removal Procedure

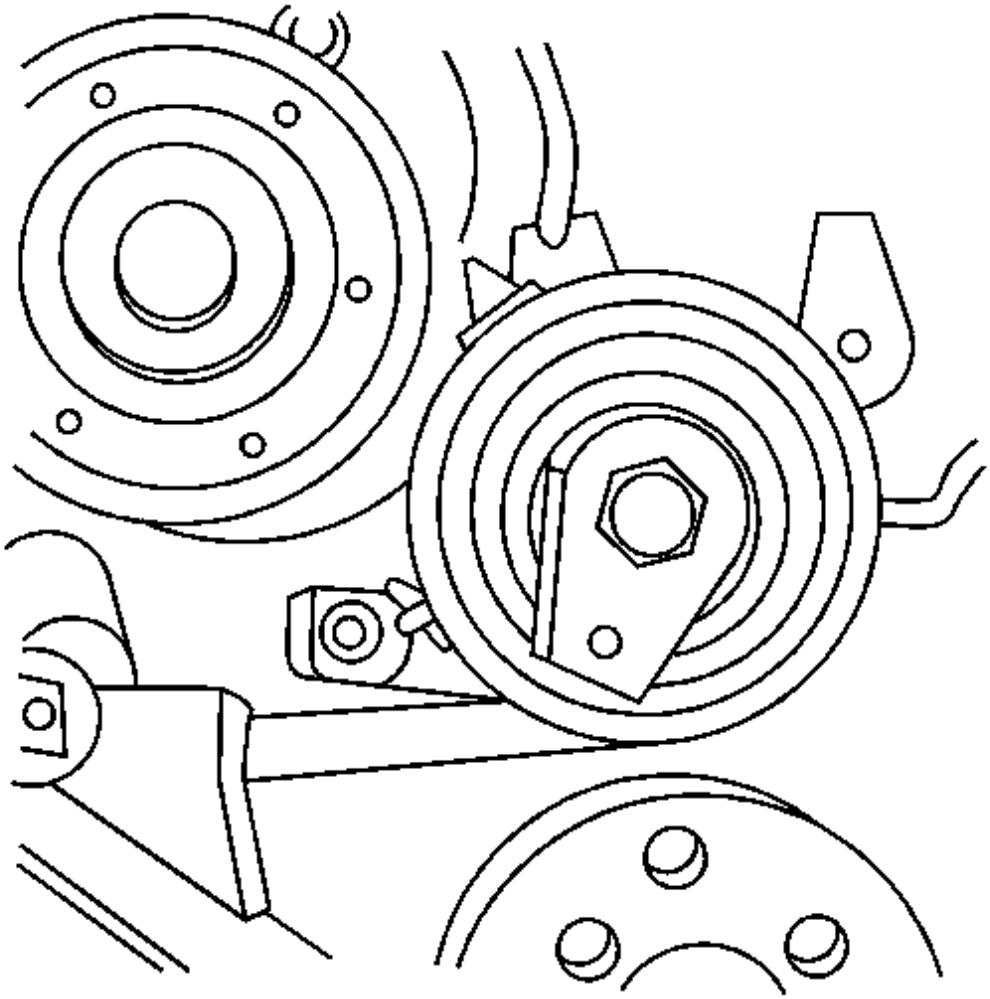


Fig. 49: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Remove the timing belt. Refer to **Timing Belt Replacement**.
3. Remove the camshaft gears. Refer to **Camshaft Gear Replacement**.
4. Remove the timing belt automatic tensioner bolt.

5. Remove the timing belt automatic tensioner.

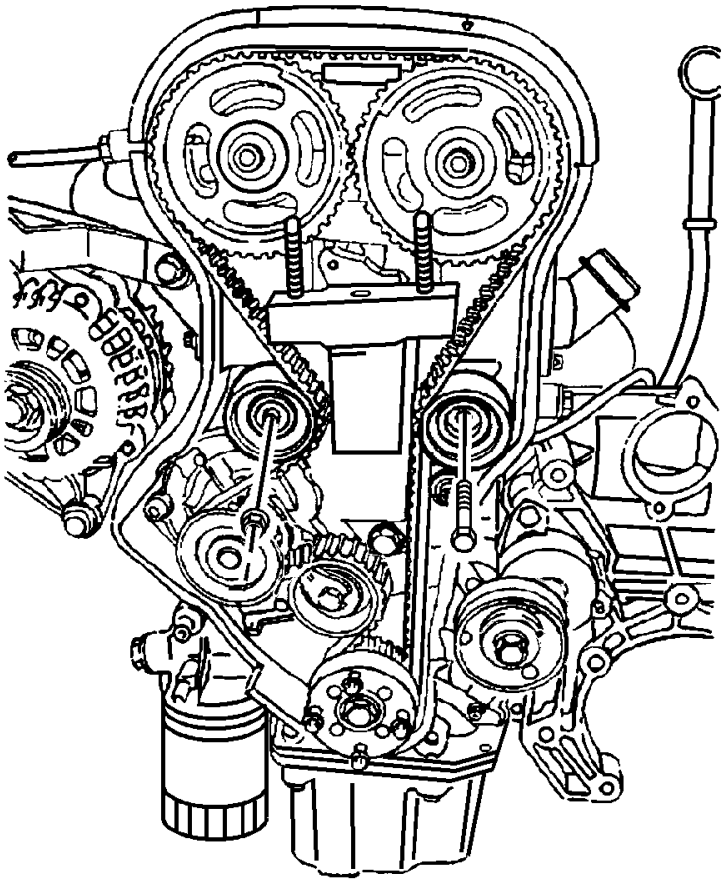


Fig. 50: View Of Timing Belt Idler Pulleys And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the timing belt idler pulley bolt and nut.
7. Remove the timing belt idler pulleys.
8. Remove the engine mount retaining bolts.
9. Remove the engine mount.
10. Remove the crankshaft gear bolt.
11. Remove the crankshaft gear.

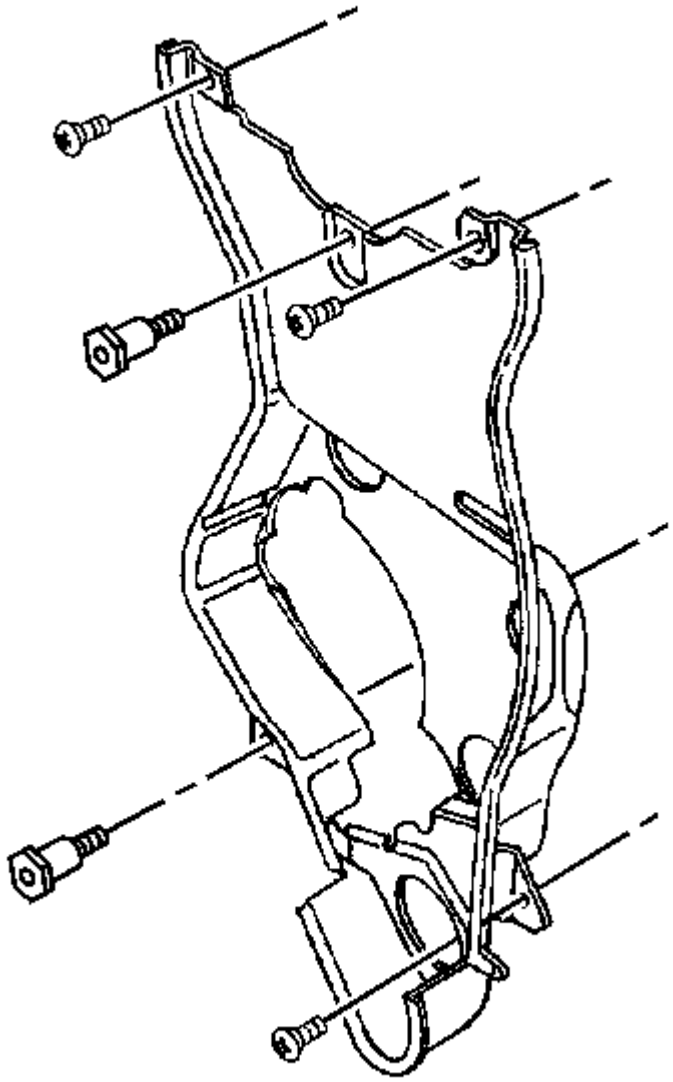


Fig. 51: View Of Rear Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the rear timing belt cover bolts.
13. Remove the rear timing belt cover.

Installation Procedure

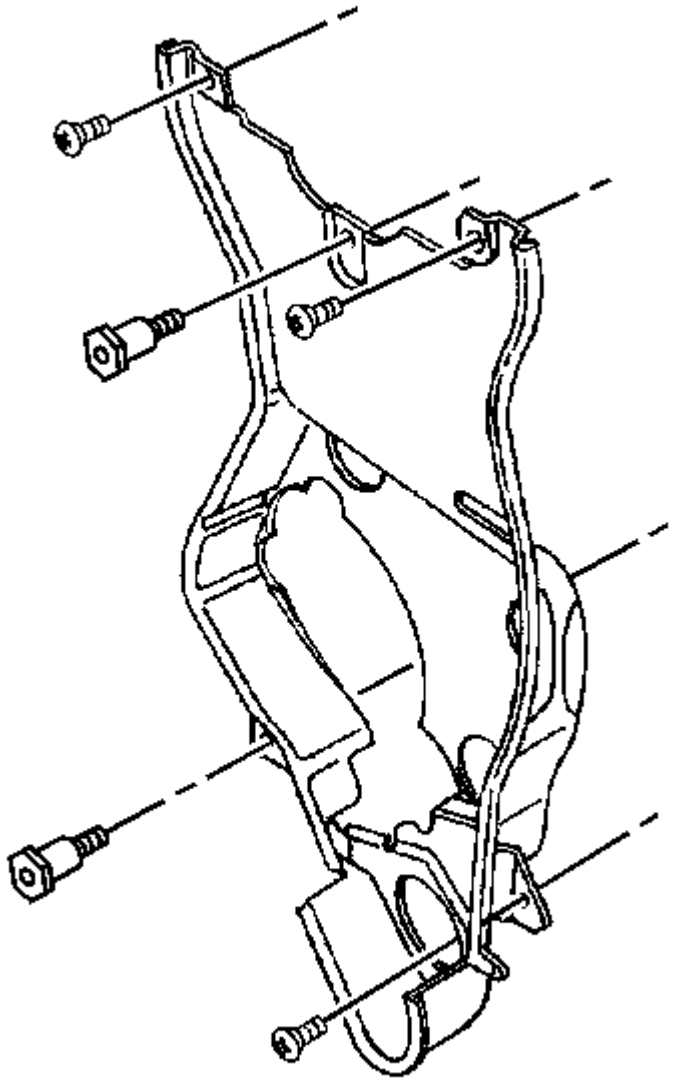


Fig. 52: View Of Rear Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the rear timing belt cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the rear timing belt cover bolts.

Tighten: Tighten the rear timing belt cover bolts to **7 N.m (62 lb in)** .

3. Install the engine mount and retaining bolts.

   Tighten: Tighten the engine mount retaining bolts to **45 N.m (33 lb ft)** .

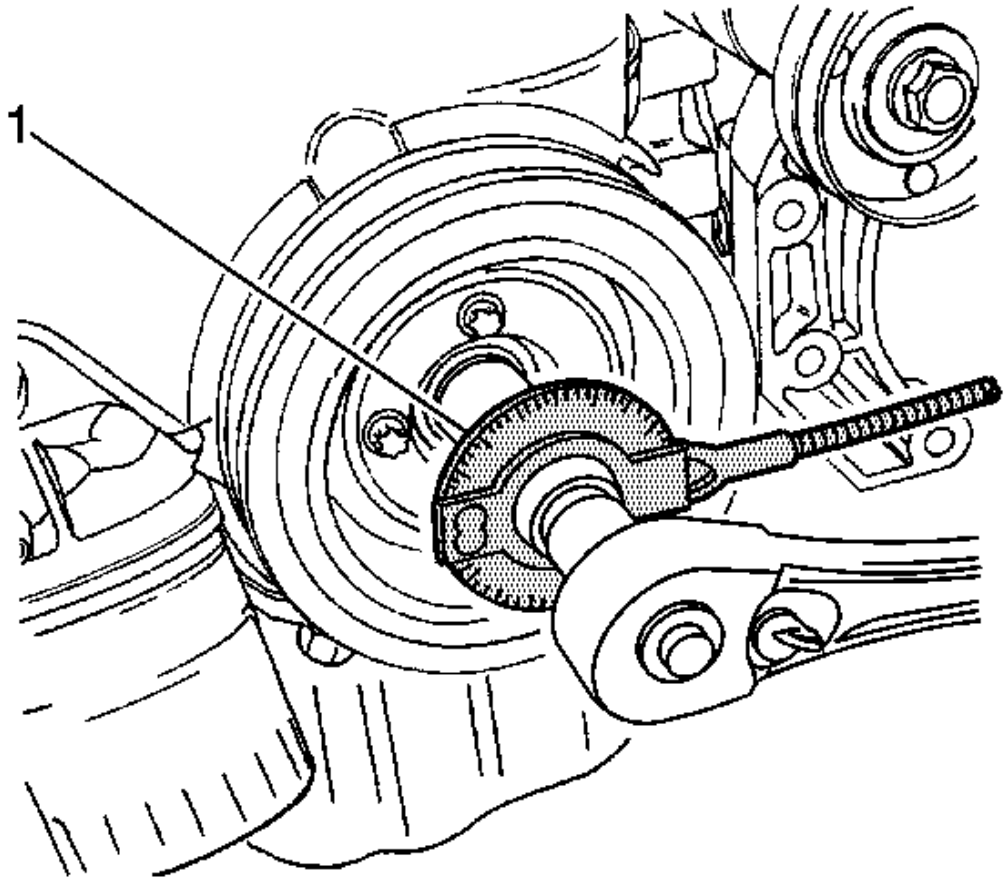


Fig. 53: Tightening Crankshaft Gear Bolt With KM-470-B
Courtesy of GENERAL MOTORS CORP.

4. Install the timing belt idler pulleys.
5. Install the timing belt idler pulley bolt and nut.

   Tighten:

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

6. Install the crankshaft timing belt drive gear and bolt.

   Tighten: Tighten the crankshaft gear bolt to **145 N.m (107 lb ft)** plus 30 degrees and plus 15 degrees using **J 45059** or the **KM-470-B** (1).

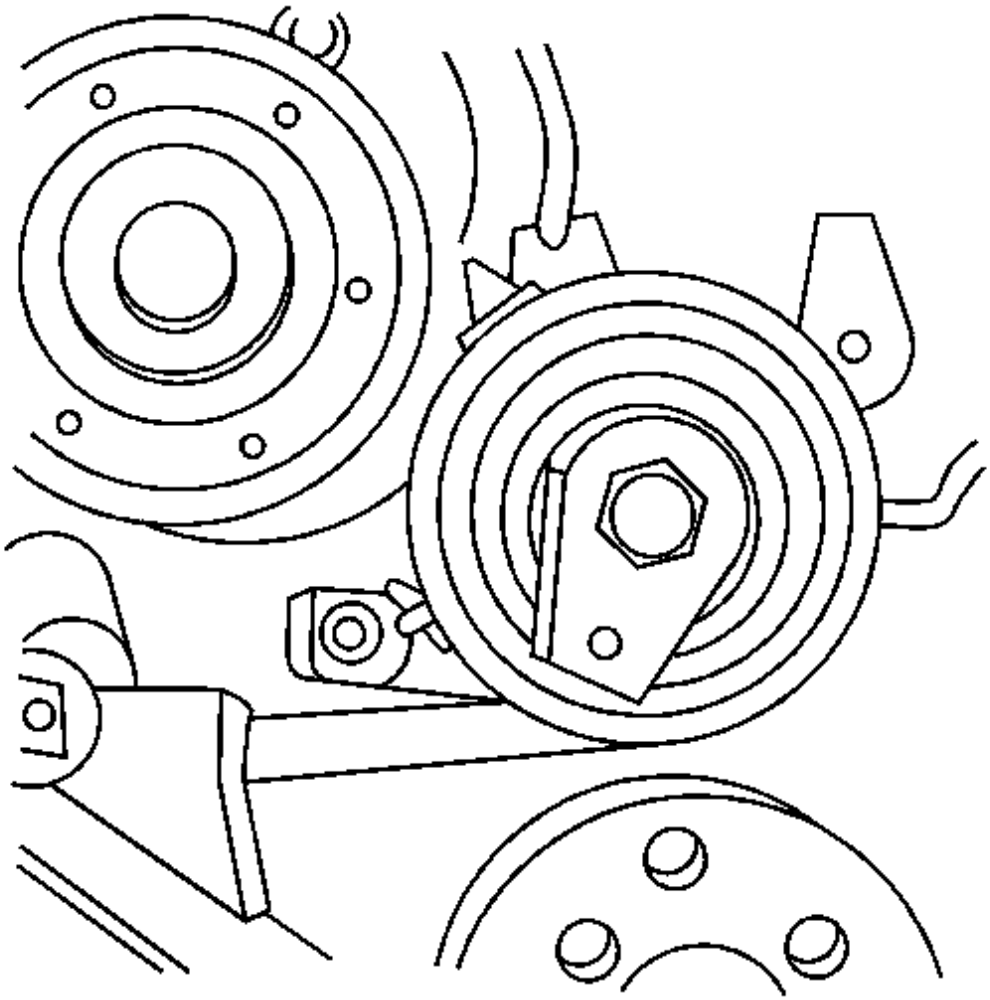


Fig. 54: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Install the timing belt automatic tensioner and bolt.
8. Install the camshaft gears. Refer to **Camshaft Gear Replacement**.
9. Install the timing belt and timing belt cover. Refer to **Timing Belt Replacement**.

10. Connect the negative battery cable.

VALVE ROCKER ARM COVER REPLACEMENT

Removal Procedure

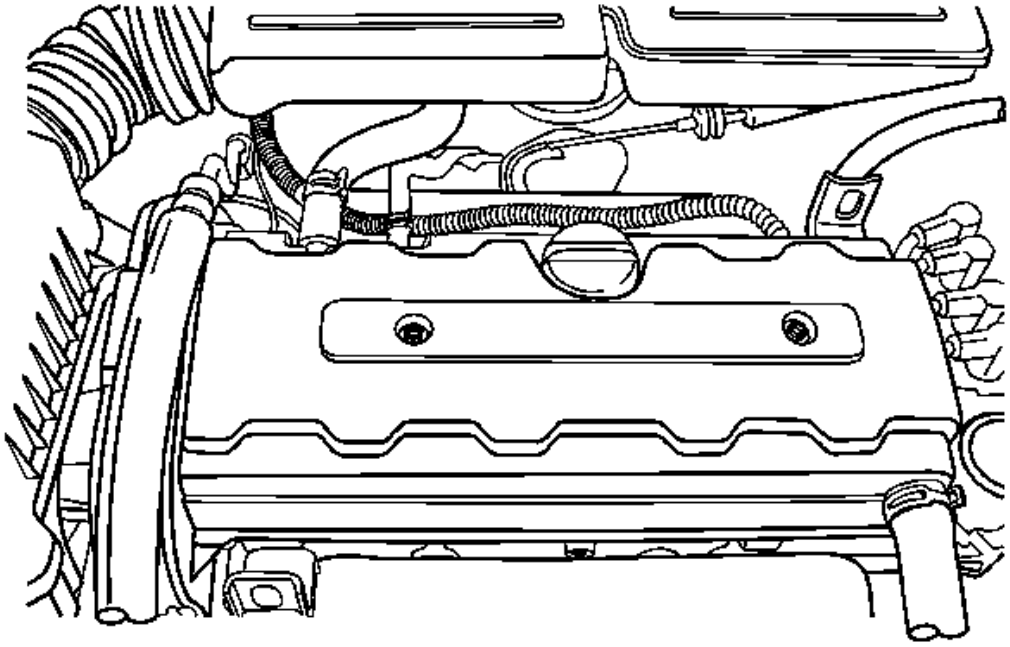


Fig. 55: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Disconnect the breather tube from the valve cover.
3. Disconnect all of the necessary vacuum lines.
4. Remove the spark plug cover bolts.
5. Remove the spark plug cover.

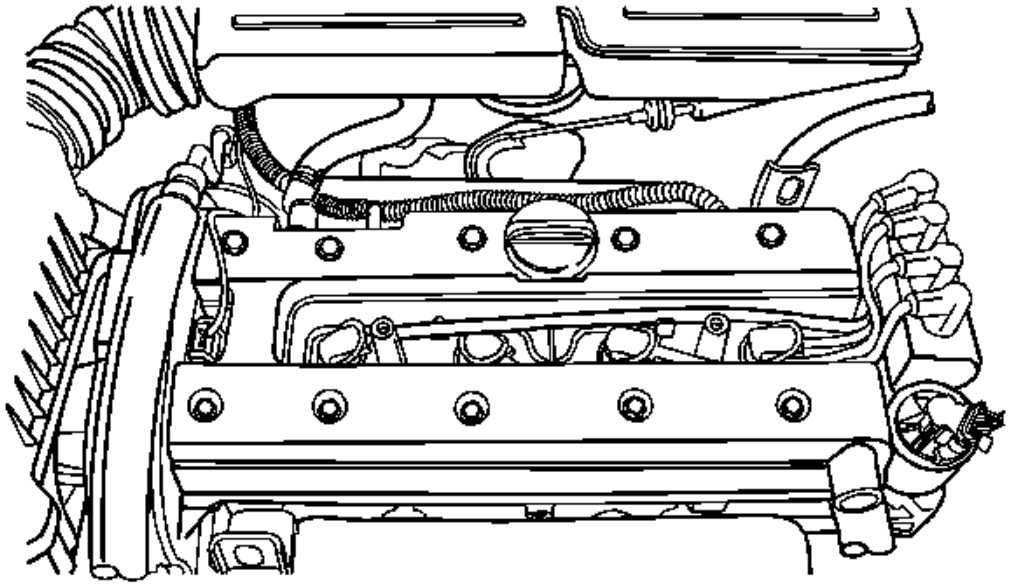


Fig. 56: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the ignition wires from the spark plugs.
7. Disconnect the camshaft position sensor connector.
8. Remove the camshaft cover bolts.

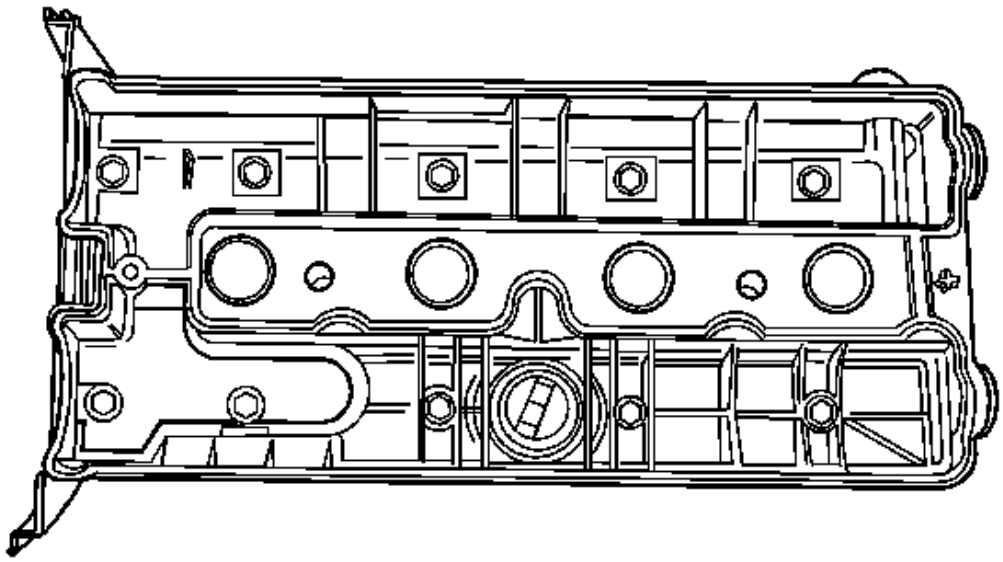


Fig. 57: View Of Camshaft Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft cover.
10. Remove the camshaft cover gasket from the camshaft cover.

Installation Procedure

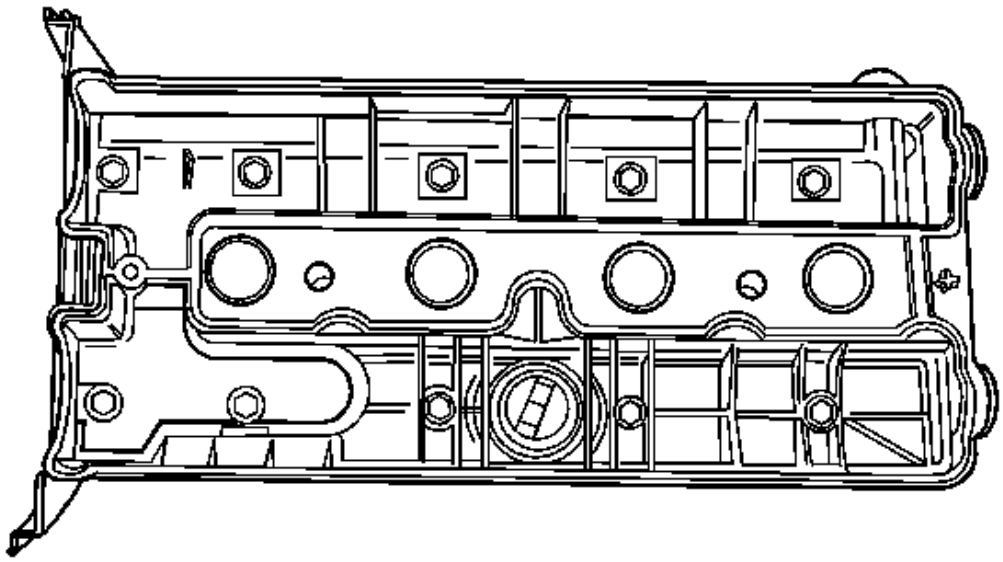


Fig. 58: View Of Camshaft Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

1. 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.
2. Install the new camshaft cover gasket to the camshaft cover.

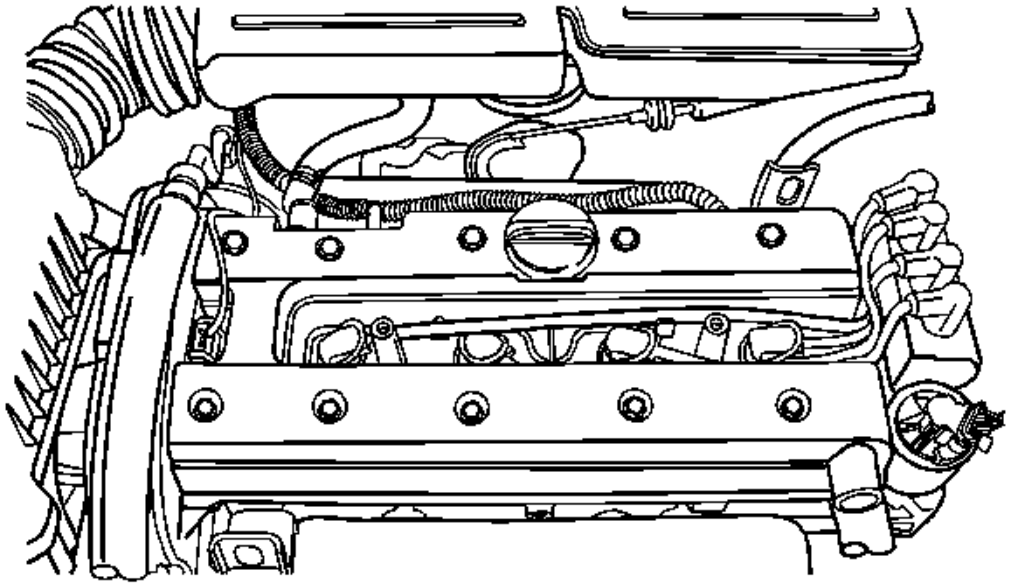


Fig. 59: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the camshaft cover.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the camshaft cover bolts.

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

5. Connect the ignition wires to the spark plugs.
6. Install the spark plug cover.

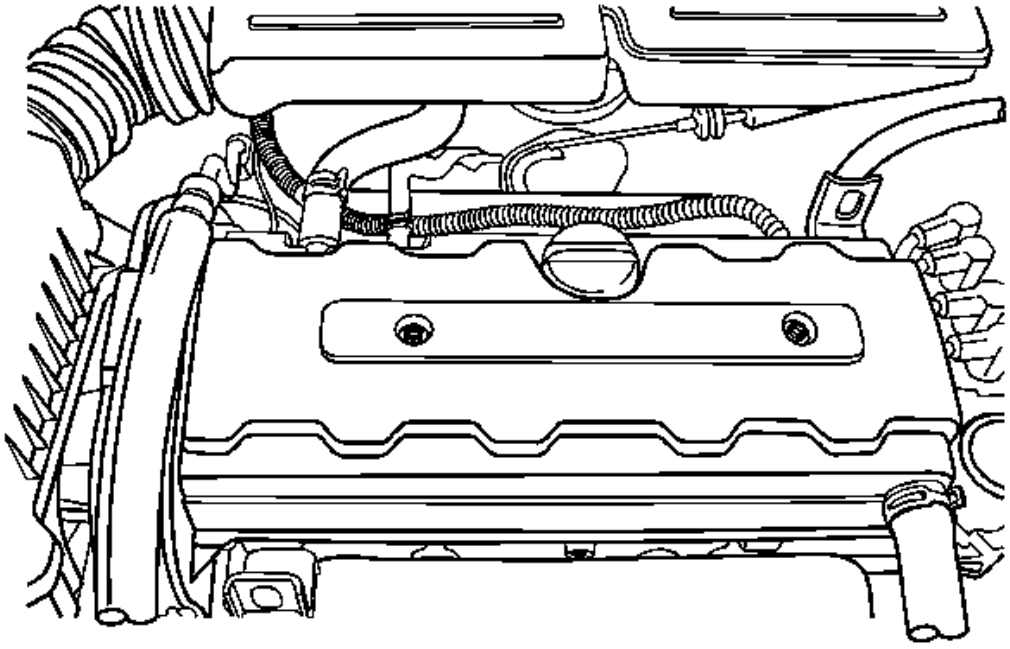


Fig. 60: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the spark plug cover bolts.

   Tighten: Tighten the spark plug cover bolts to **8 N.m (71 lb in)** .

8. Connect the camshaft position sensor connector.
9. Connect all of the necessary vacuum lines.
10. Connect the breather tube to the camshaft cover.
11. Connect the negative battery cable.

VALVE ROCKER ARM AND SHAFT CLEANING AND INSPECTION

Inspection Procedure

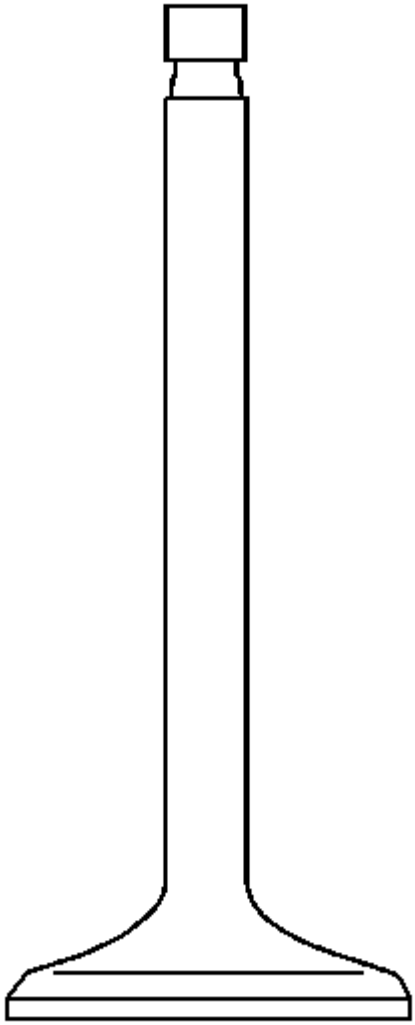


Fig. 61: View Of Valve
Courtesy of GENERAL MOTORS CORP.

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.

7. Inspect the valve spring. If the valve spring ends are not parallel, replace the valve spring.
8. Inspect the valve spring seating surface of the valve rotators for wear or gouges. Replace as required.

Cleaning Procedure

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

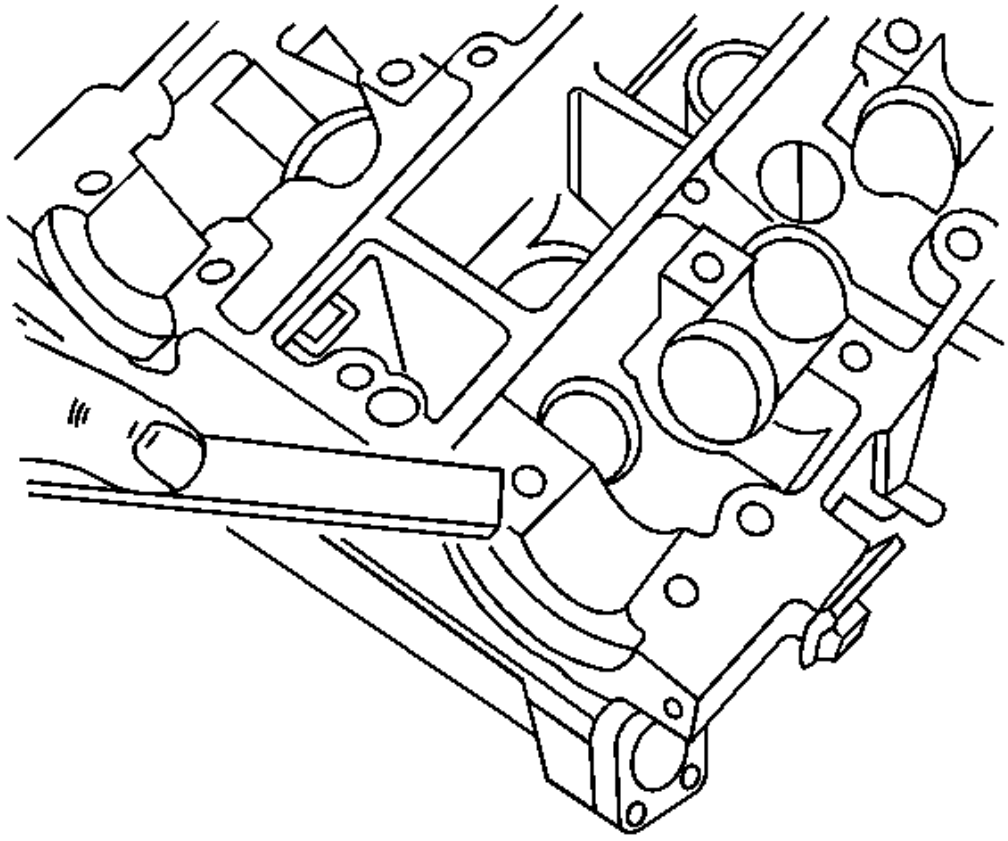


Fig. 62: Cleaning Cylinder Head
Courtesy of GENERAL MOTORS CORP.

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 REPLACEMENT

Tools Required

- **J 45059** Angle Meter
- **KM-470-B** Angular Meter Gage
- **J 28467-B** (DW 117) Universal Engine Support Fixture

Removal Procedure

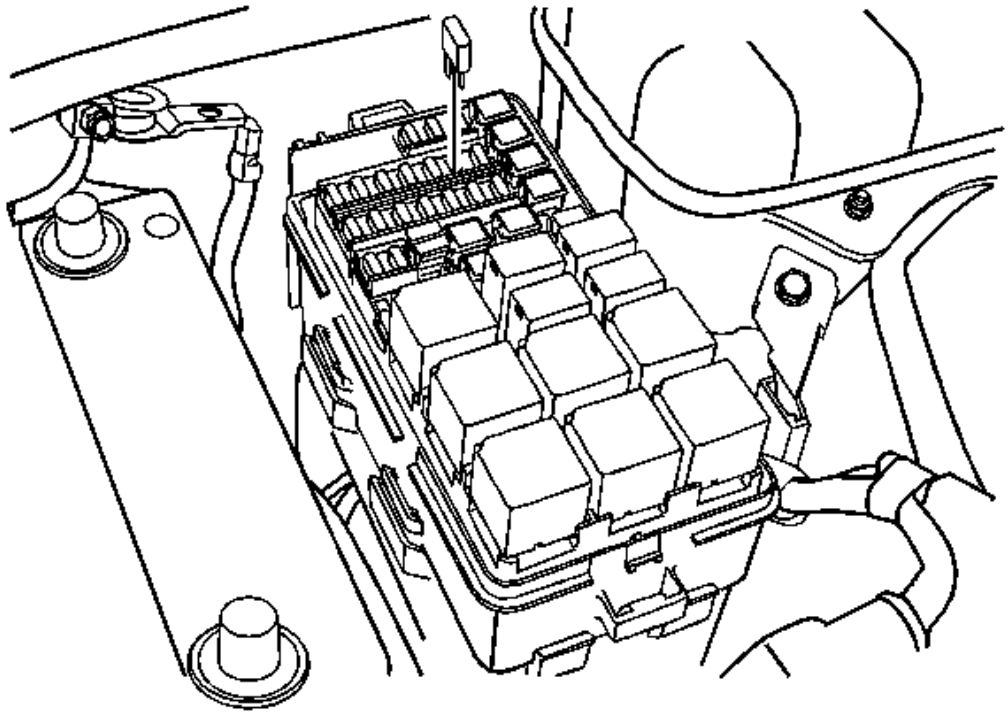


Fig. 63: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

3. Disconnect the negative battery cable.
4. Disconnect the electronic control module (ECM) ground terminal.
5. Drain the engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.

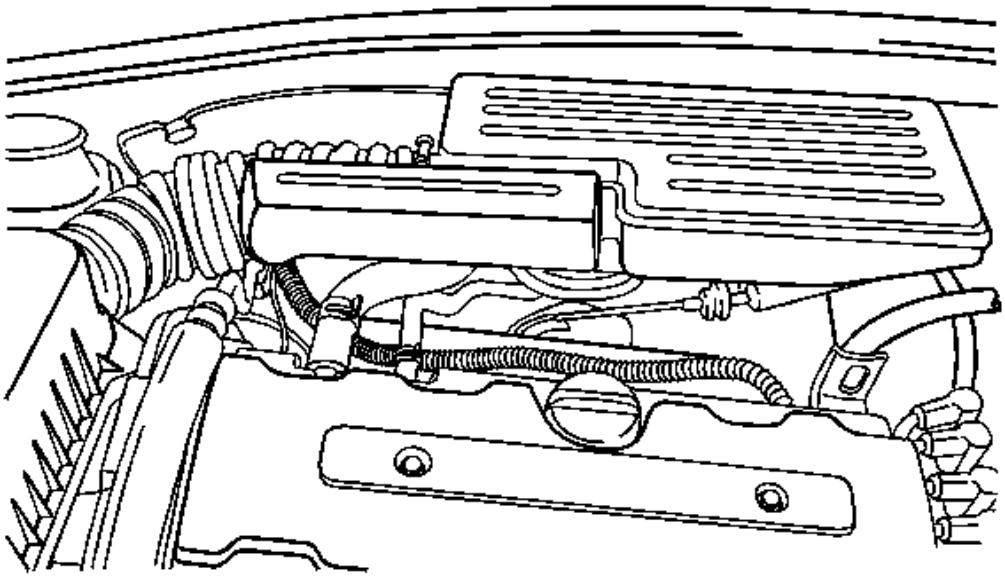


Fig. 64: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the intake air temperature (IAT) sensor connector.
7. Disconnect the breather tube from the camshaft cover.
8. Disconnect the air cleaner outlet hose from the throttle body.

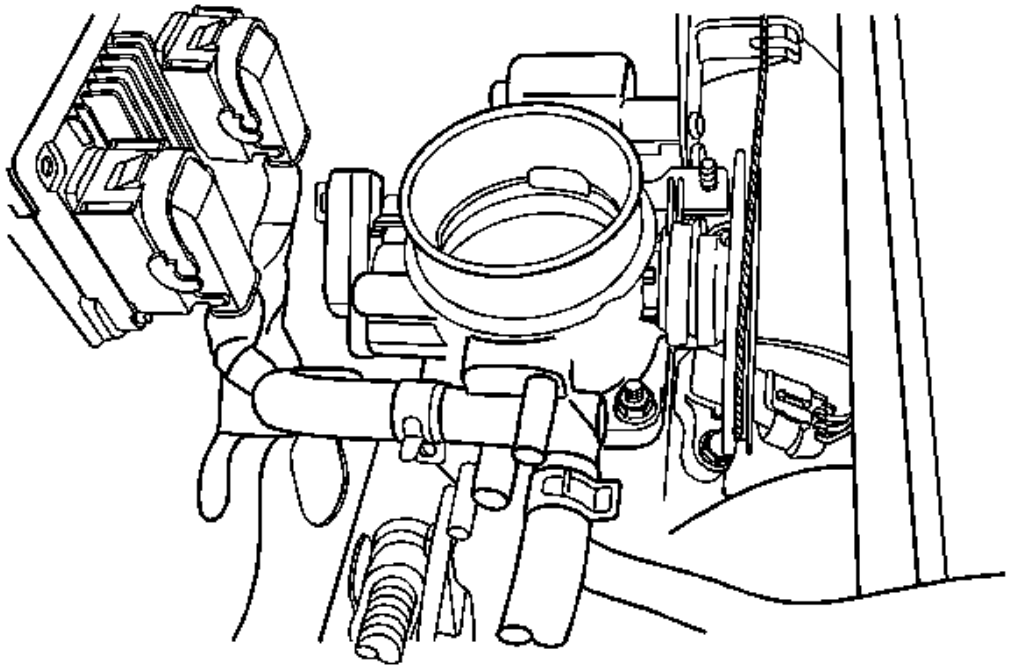


Fig. 65: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the direct ignition system (DIS) coil connector.
10. Disconnect the oxygen sensor (O2S) connector, if equipped.
11. Disconnect the idle air control (IAC) valve connector.
12. Disconnect the throttle position (TP) sensor connector.
13. Disconnect the engine coolant temperature (ECT) sensor connector.
14. Disconnect the coolant temperature sensor (CTS) connector.

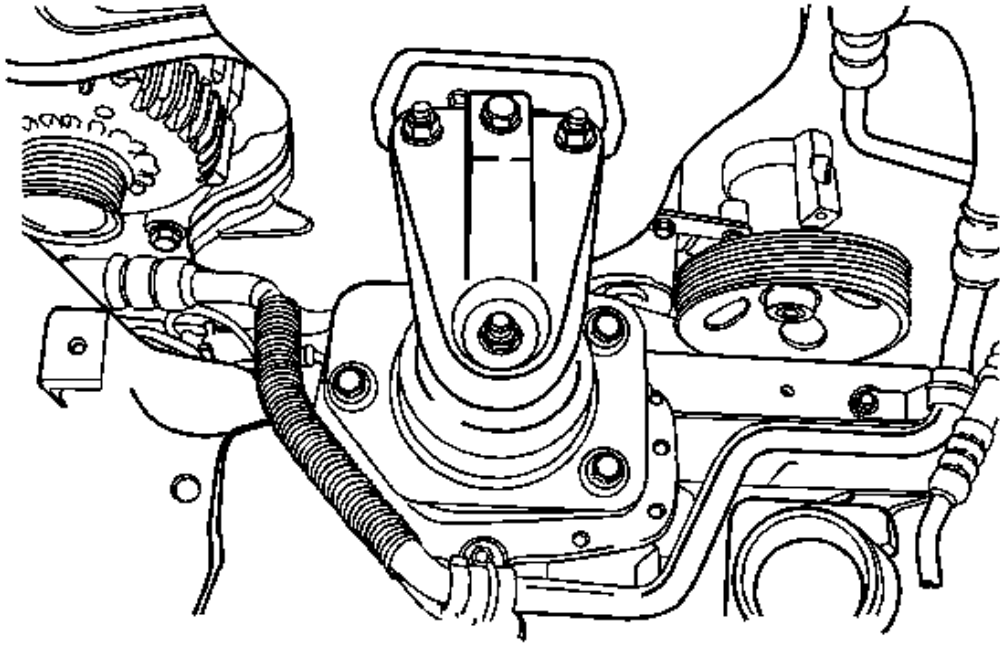


Fig. 66: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

15. Remove the air cleaner housing bolts.
16. Remove the air cleaner housing.
17. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
18. Remove the right front wheel well splash shield.
19. Install the **J 28467-B** .
20. Remove the right engine mount bracket and bolts. Refer to **Engine Mount Replacement**.

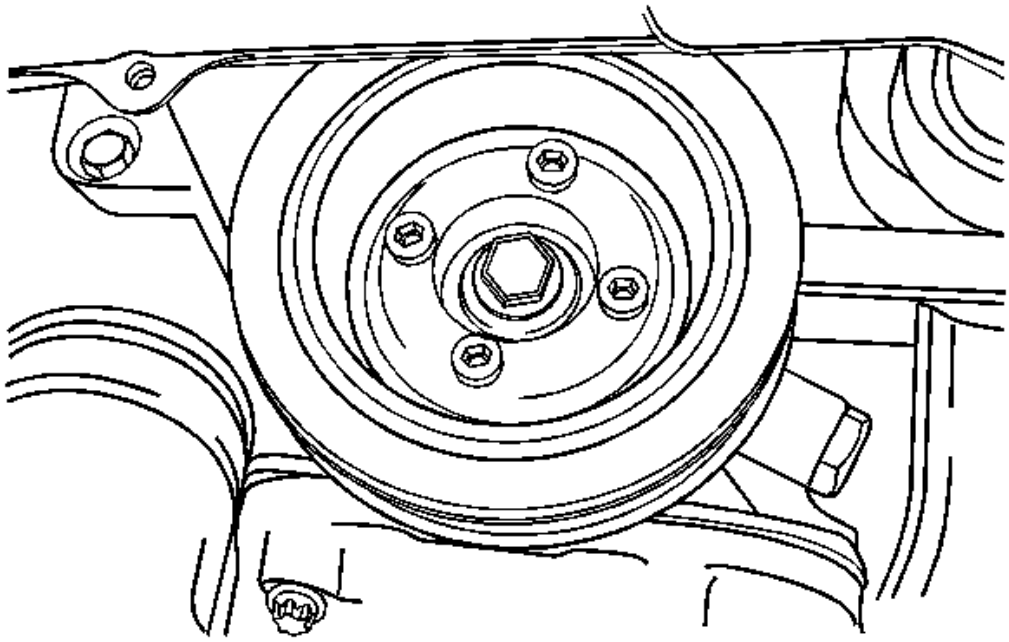


Fig. 67: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

21. Disconnect the upper radiator hose at the thermostat housing.
22. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
23. Remove the crankshaft pulley bolts.
24. Remove the crankshaft pulley.

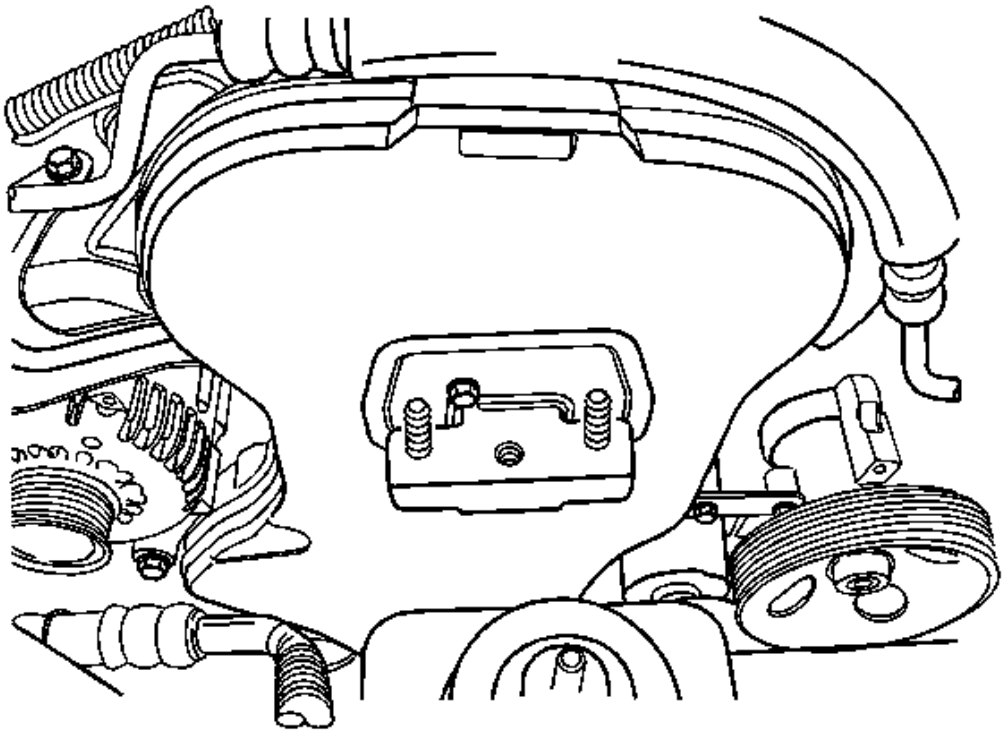


Fig. 68: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

25. Remove the front timing belt cover bolts.
26. Remove the front timing belt cover.

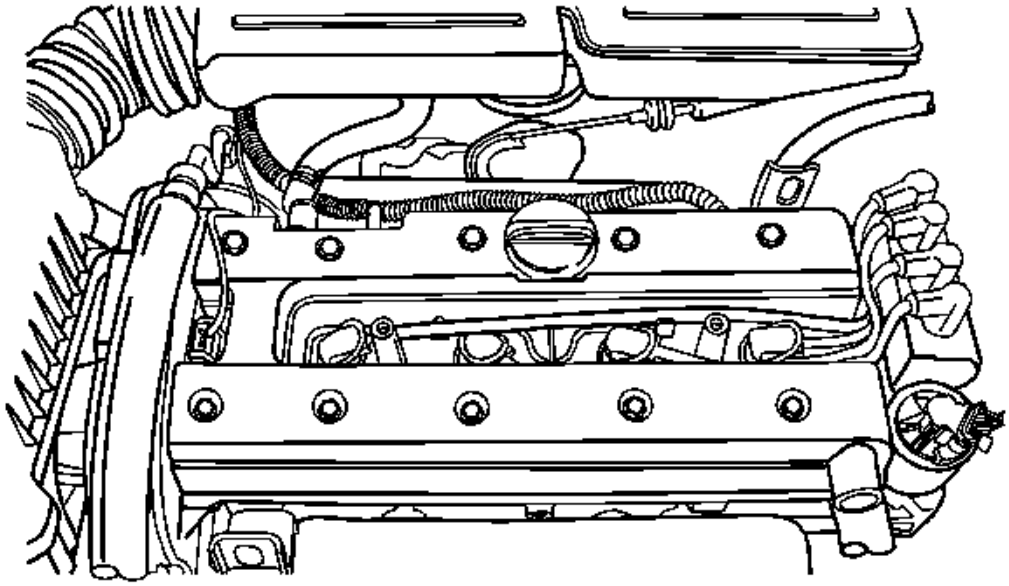


Fig. 69: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

27. Remove the timing belt. Refer to **Timing Belt Replacement**.
28. Disconnect the breather tube at the camshaft cover.
29. Remove the spark plug cover bolts.
30. Remove the spark plug cover.
31. Disconnect the ignition wires from the spark plugs.
32. Remove the camshaft cover bolts.
33. Remove the camshaft cover and the camshaft cover gasket.

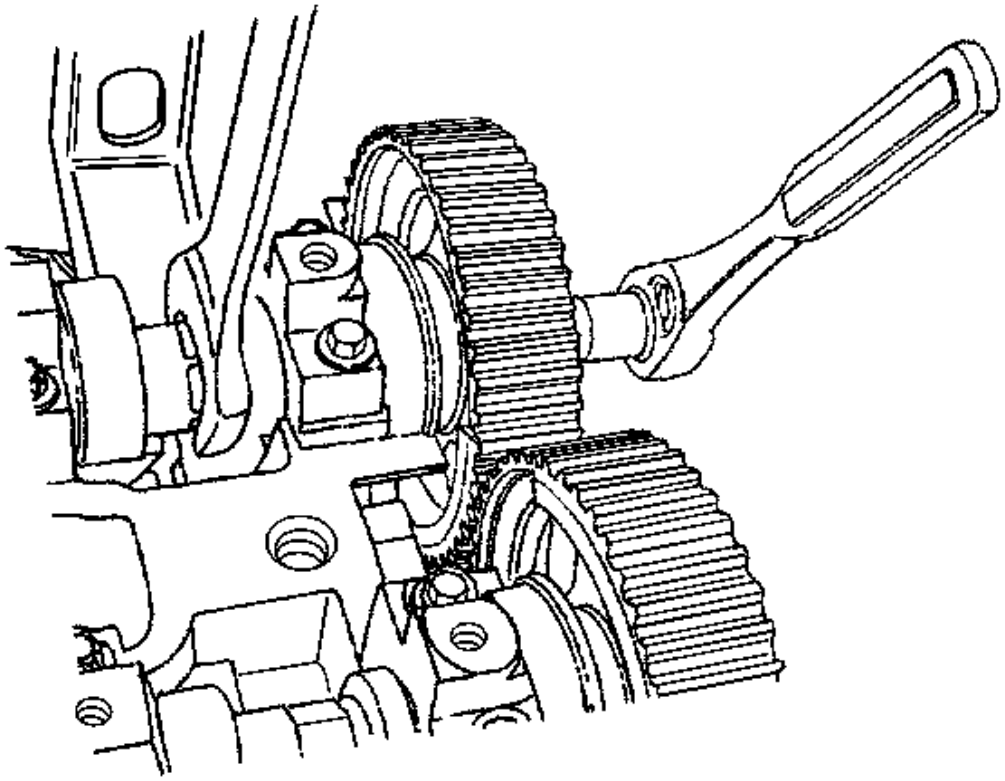


Fig. 70: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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

34. While holding the intake camshaft firmly in place, remove the intake camshaft gear bolt.
35. Remove the intake camshaft gear.
36. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft gear bolt.
37. Remove the exhaust camshaft gear.

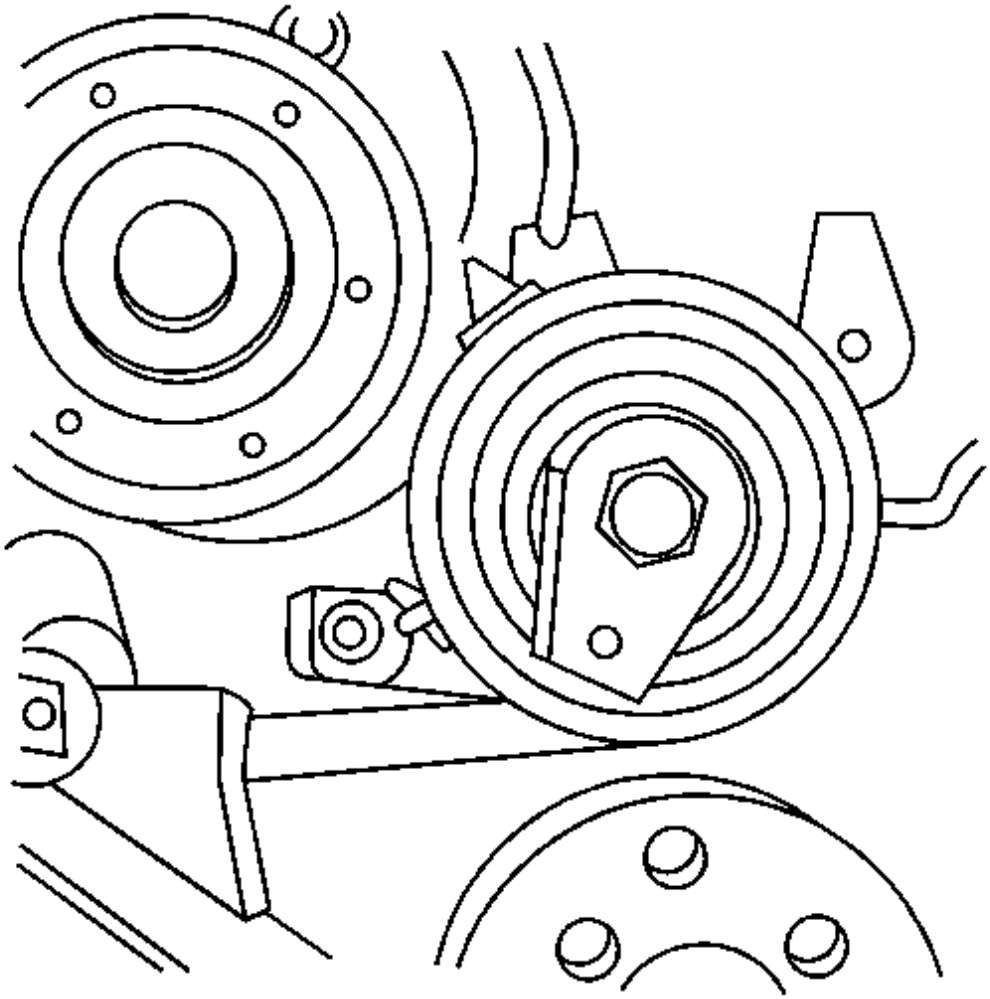


Fig. 71: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

38. Remove the timing belt automatic tensioner bolts.
39. Remove the timing belt automatic tensioner.

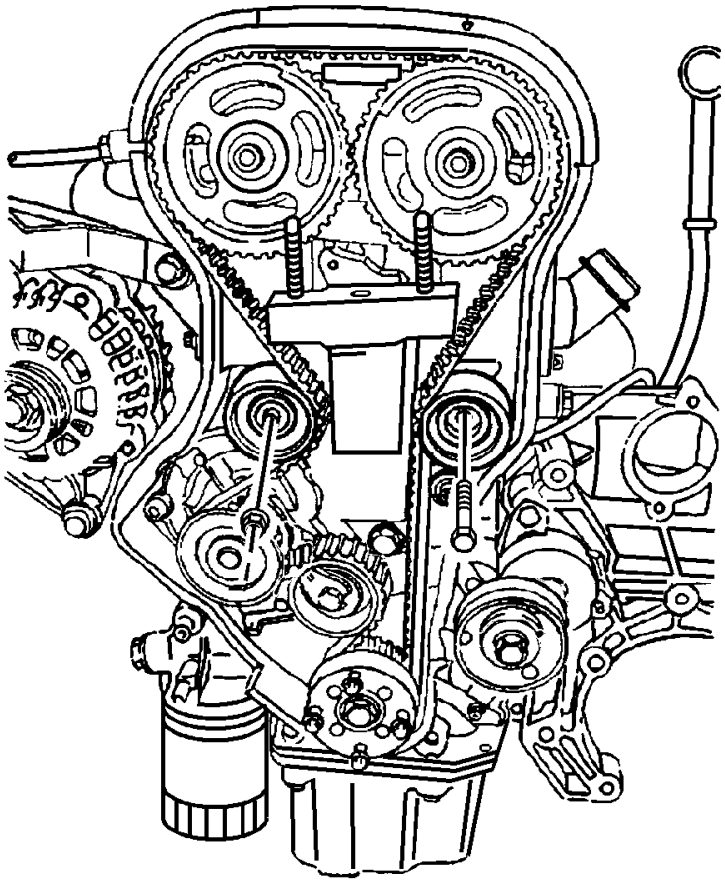


Fig. 72: View Of Timing Belt Idler Pulleys And Bolts
Courtesy of GENERAL MOTORS CORP.

40. Remove the timing belt idler pulley bolt and nut.
41. Remove the timing belt idler pulleys.
42. Remove the engine mount bolts.
43. Remove the engine mount.

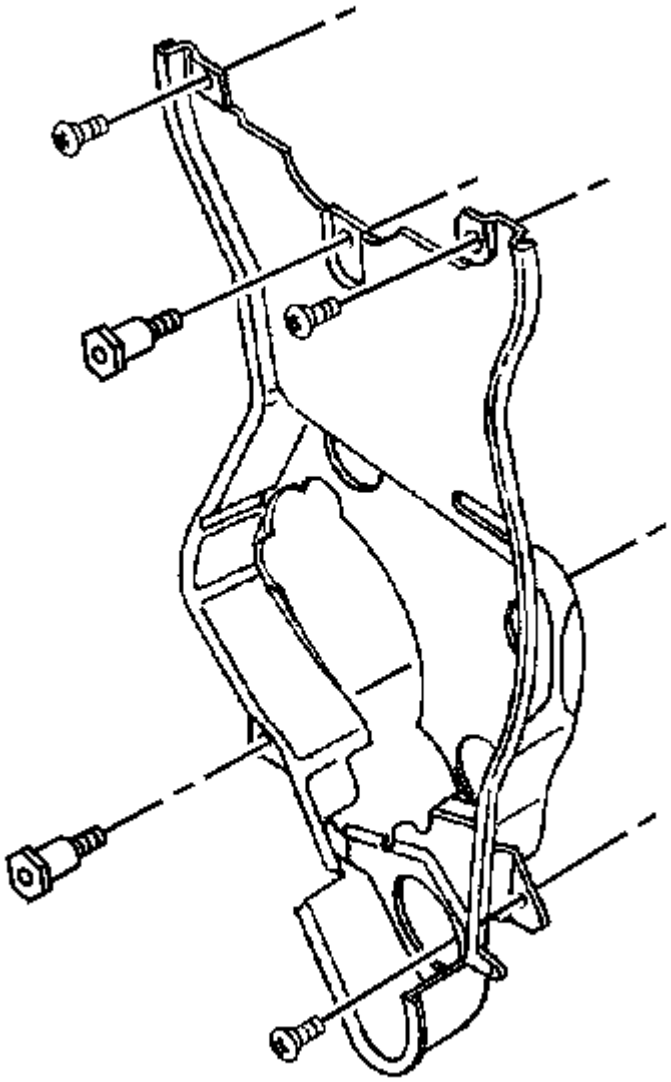


Fig. 73: View Of Rear Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

44. Remove the rear timing belt cover bolts.
45. Remove the rear timing belt cover.

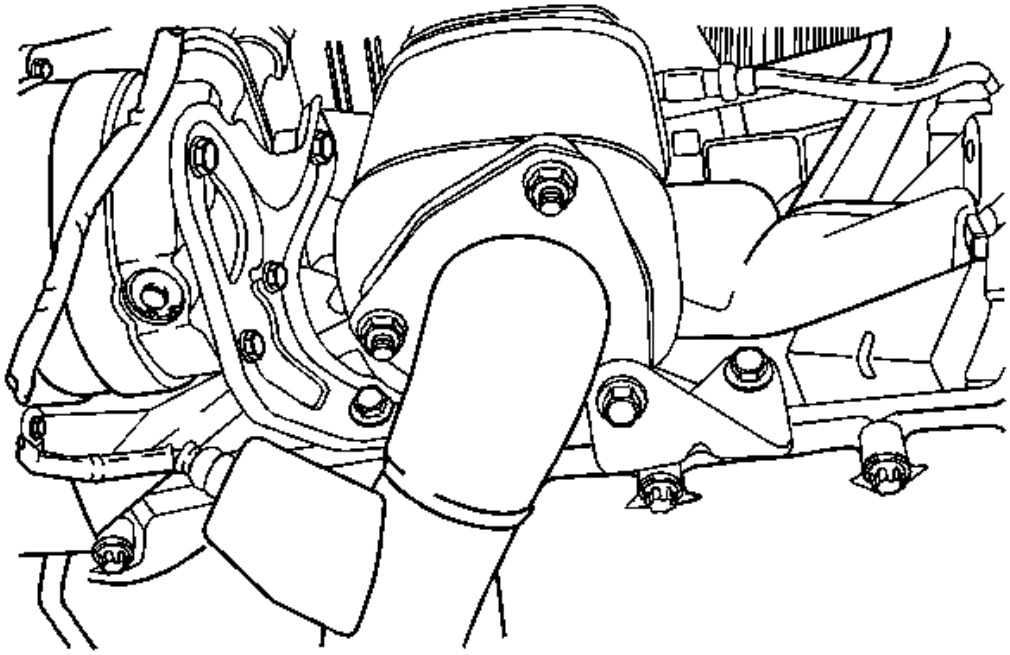


Fig. 74: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

46. Remove the exhaust flex pipe retaining nuts at the exhaust manifold studs.
47. Disconnect all of the necessary vacuum hoses.

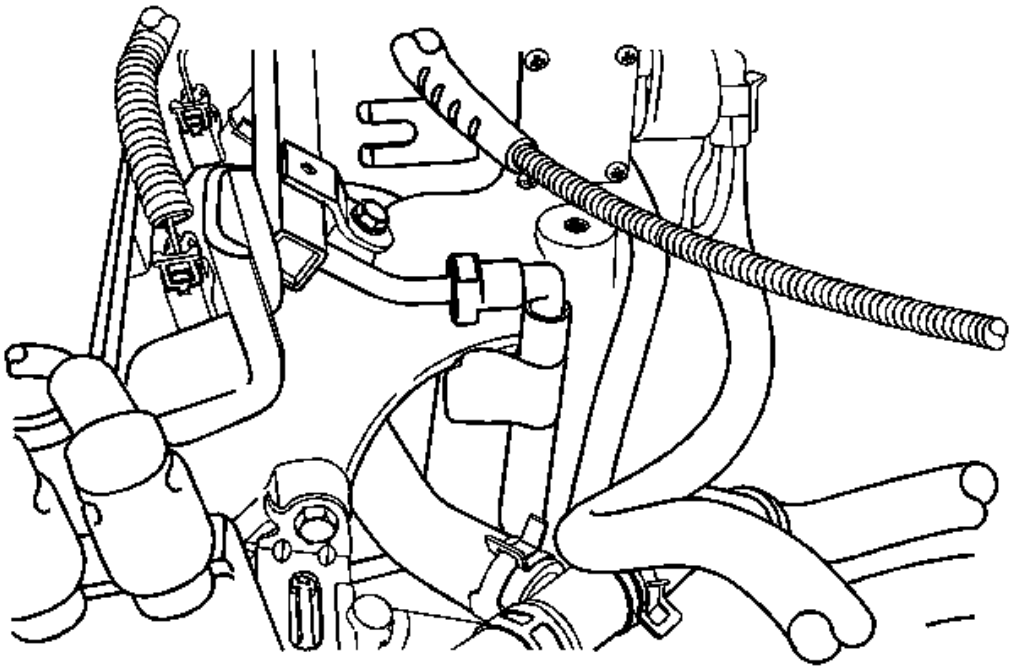


Fig. 75: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

48. Disconnect the fuel feed line at the fuel rail.
49. Remove the generator adjusting bracket retaining bolt and the bracket.
50. Disconnect the coolant hose at the rear cylinder head and ignition coil exhaust gas recirculation (EGR) bracket.
51. Disconnect the surge tank coolant hose at the throttle body.
52. Remove the fuel rail assembly. Refer to **Fuel Rail Assembly Replacement** .

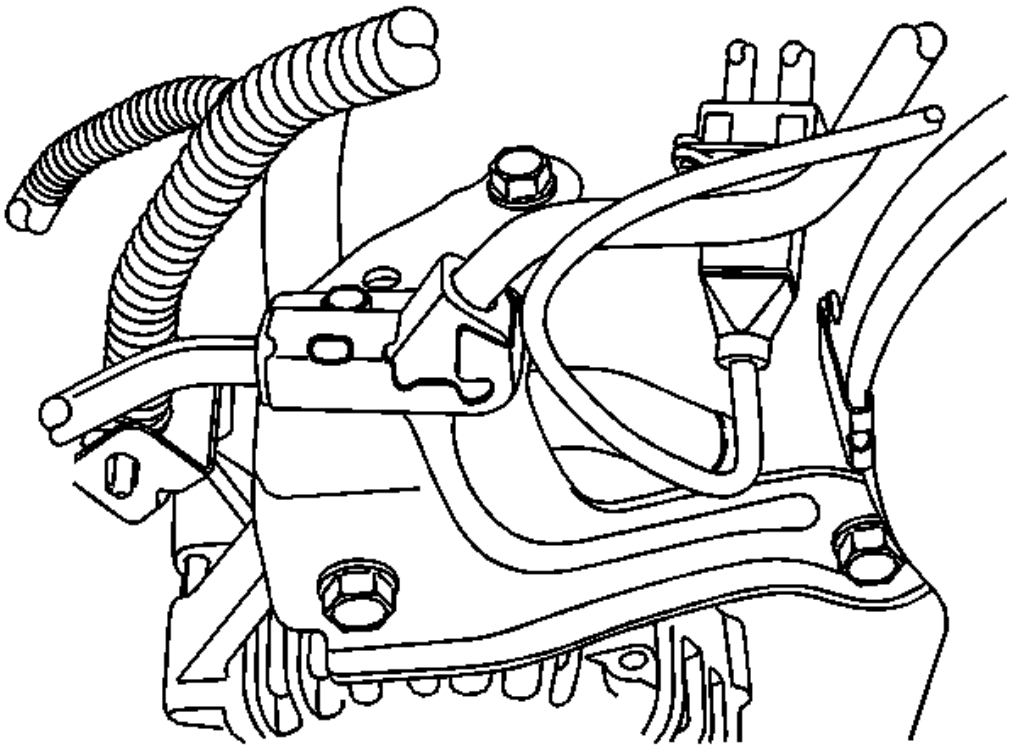


Fig. 76: View Of Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

53. Remove the generator-to-intake manifold support bracket bolts at the cylinder head and the intake manifold.
54. Remove the generator support bracket.
55. Remove the intake manifold-to-generator strap bracket bolt and loosen the bolt on the generator.
56. Move the strap clear of the intake manifold.
57. Remove the charcoal canister purge (CCP) and EGR solenoid bracket bolt and move the bracket clear.

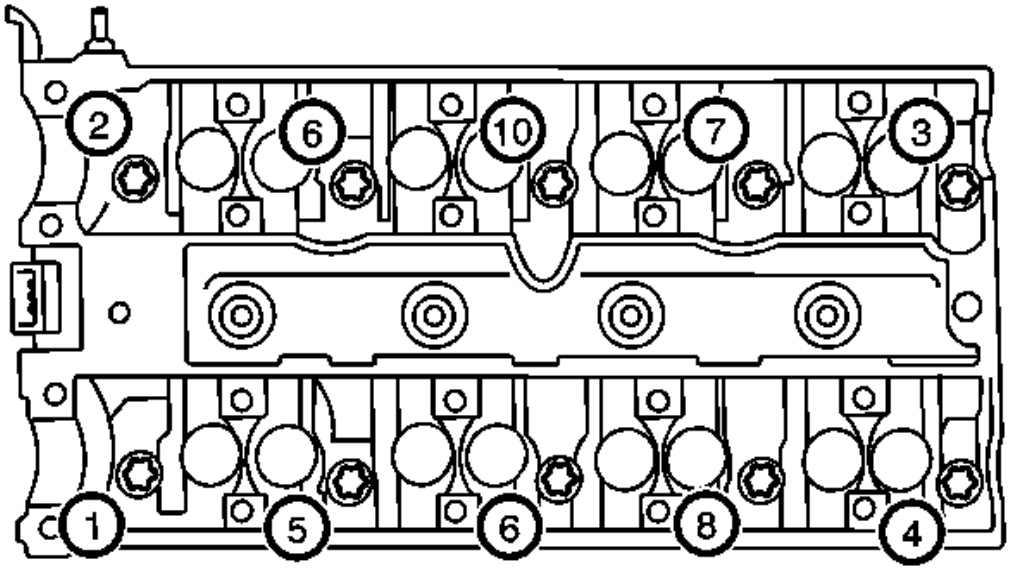


Fig. 77: Identifying Cylinder Head Bolt Loosening Sequence
Courtesy of GENERAL MOTORS CORP.

58. Disconnect the throttle cable at the throttle body and the intake manifold.
59. Loosen all of the cylinder head bolts gradually and in the sequence shown.
60. Remove the cylinder head bolts.
61. Remove the cylinder head with the intake manifold and the exhaust manifold attached.

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.

62. Remove the cylinder head gasket.
63. Clean the gasket surfaces on the cylinder head and the engine block. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

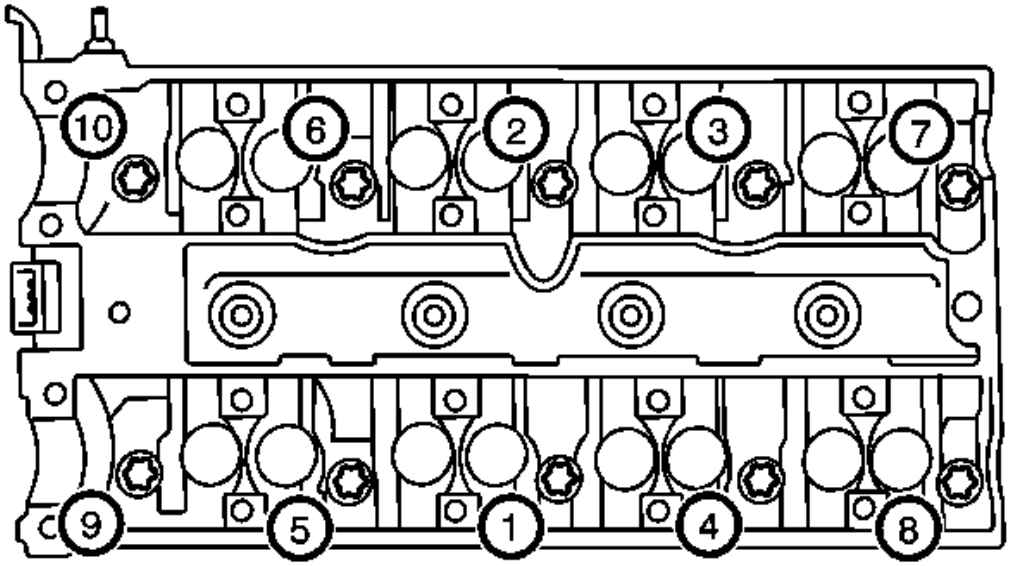


Fig. 78: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

1. Install the cylinder head gasket.
2. Install the cylinder head with the intake manifold and the exhaust manifold attached.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the cylinder head bolts.
4. Tighten the cylinder head bolts gradually and in the sequence shown.

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

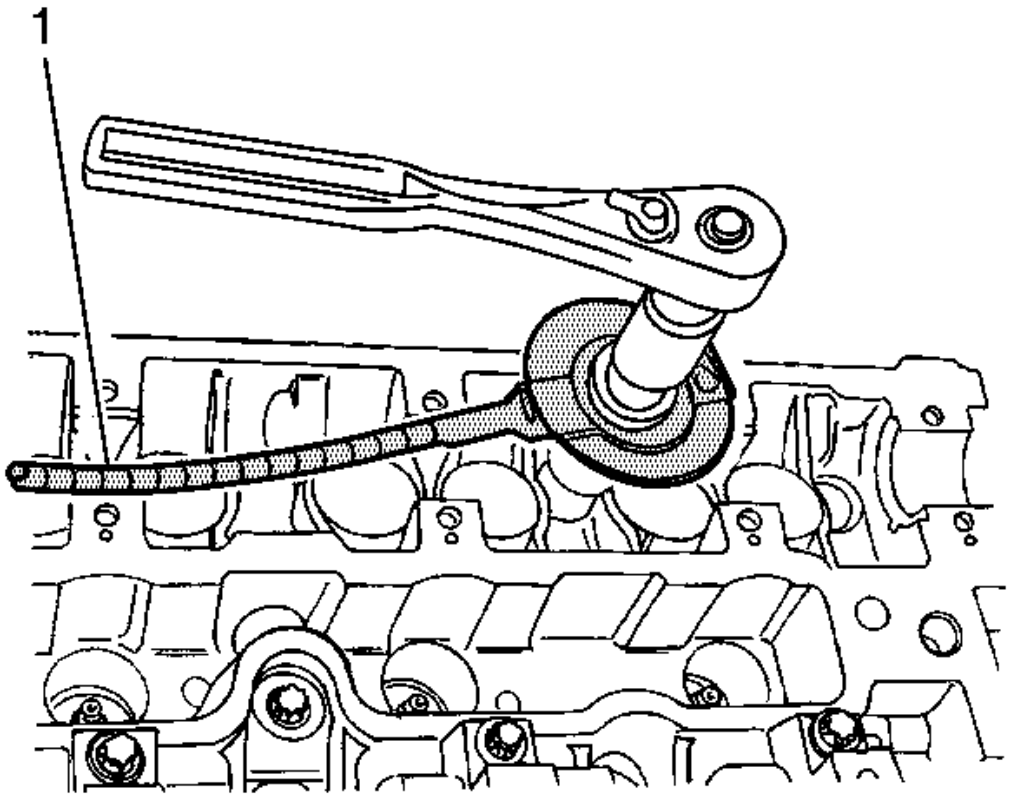


Fig. 79: View Of KM-470-B
Courtesy of GENERAL MOTORS CORP.

5. Use the **J 45059** or the **KM-470-B** to tighten the bolts another 3 turns of 90 degrees.

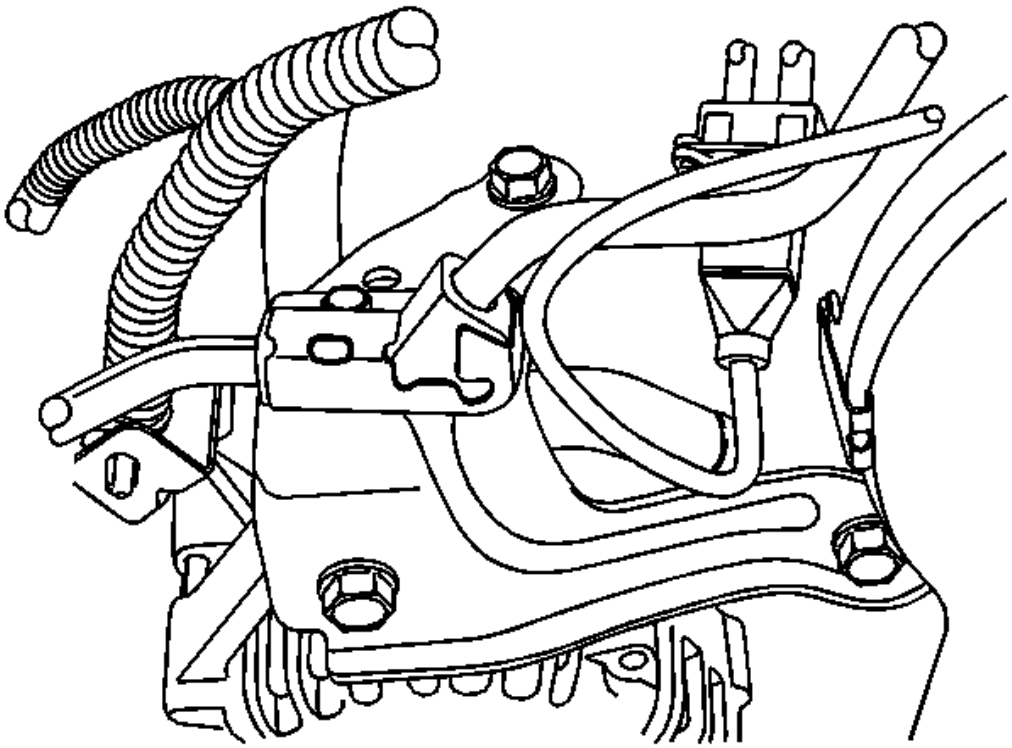


Fig. 80: View Of Intake Manifold Support Bracket
Courtesy of GENERAL MOTORS CORP.

6. Connect the throttle cable at the throttle body and the intake manifold.
7. Install the generator-to-intake manifold support bracket.
8. Install the intake generator-to-manifold support bracket bolts.

   Tighten: Tighten the bolt to the intake manifold to **22 N.m (16 lb ft)** .

9. Install the intake manifold support bracket bolt to the generator.

   Tighten: Tighten the bolt at the generator to **22 N.m (16 lb ft)** .

10. Connect the surge tank coolant hose at the throttle body.
11. Connect the coolant hose to the rear cylinder head and ignition coil EGR bracket.

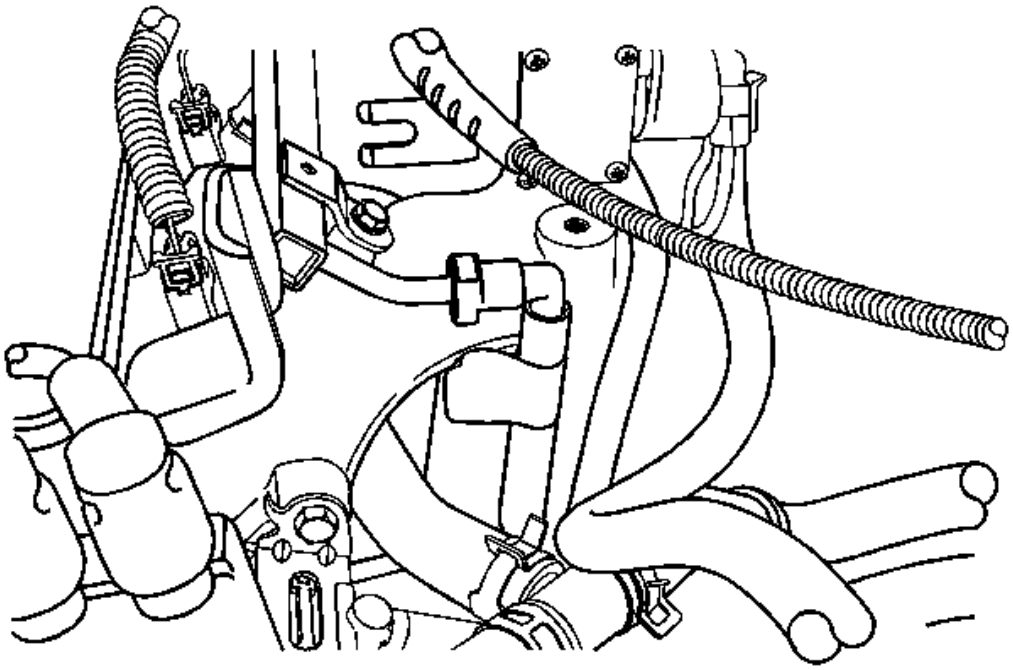


Fig. 81: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

12. Connect the fuel feed line at the fuel rail.
13. Connect the fuel return line at the fuel rail.
14. Connect all of the necessary vacuum hoses.
15. Install the fuel rail assembly. Refer to **Fuel Rail Assembly Replacement** .

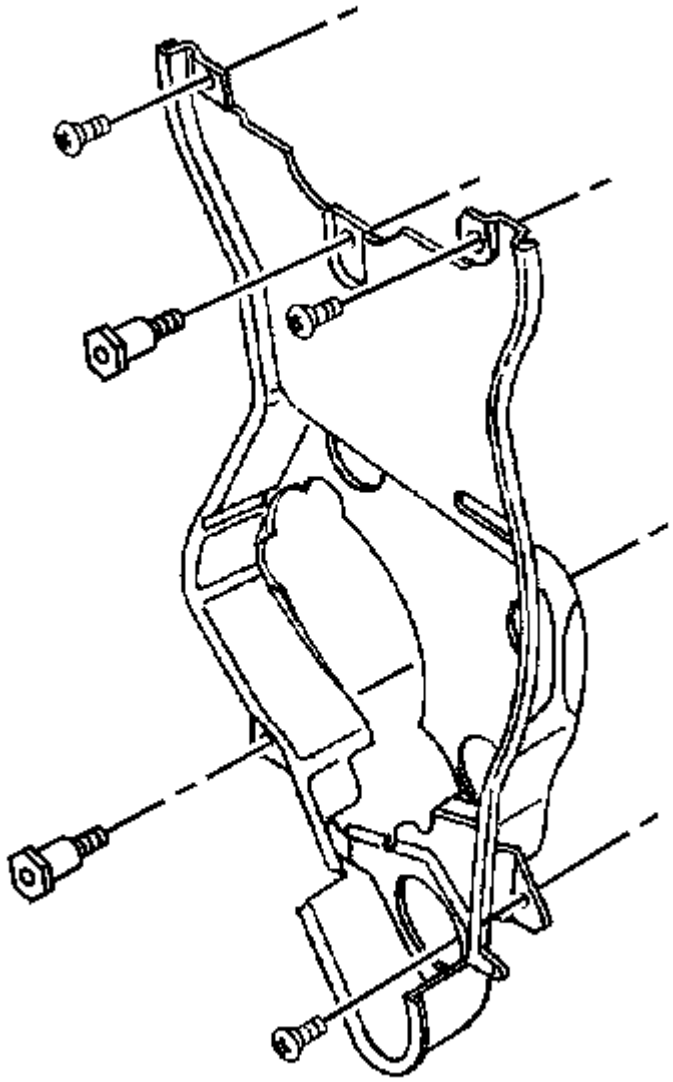


Fig. 82: View Of Rear Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the exhaust flex pipe retaining nuts at the exhaust manifold studs.

    Tighten: Tighten the nuts to **35 N.m (26 lb ft)** .

17. Install the rear timing belt cover.
18. Install the rear timing belt cover bolts.

Tighten: Tighten the bolts to **7 N.m (62 lb in)** .

19. Install the engine mount and the retaining bolts.

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

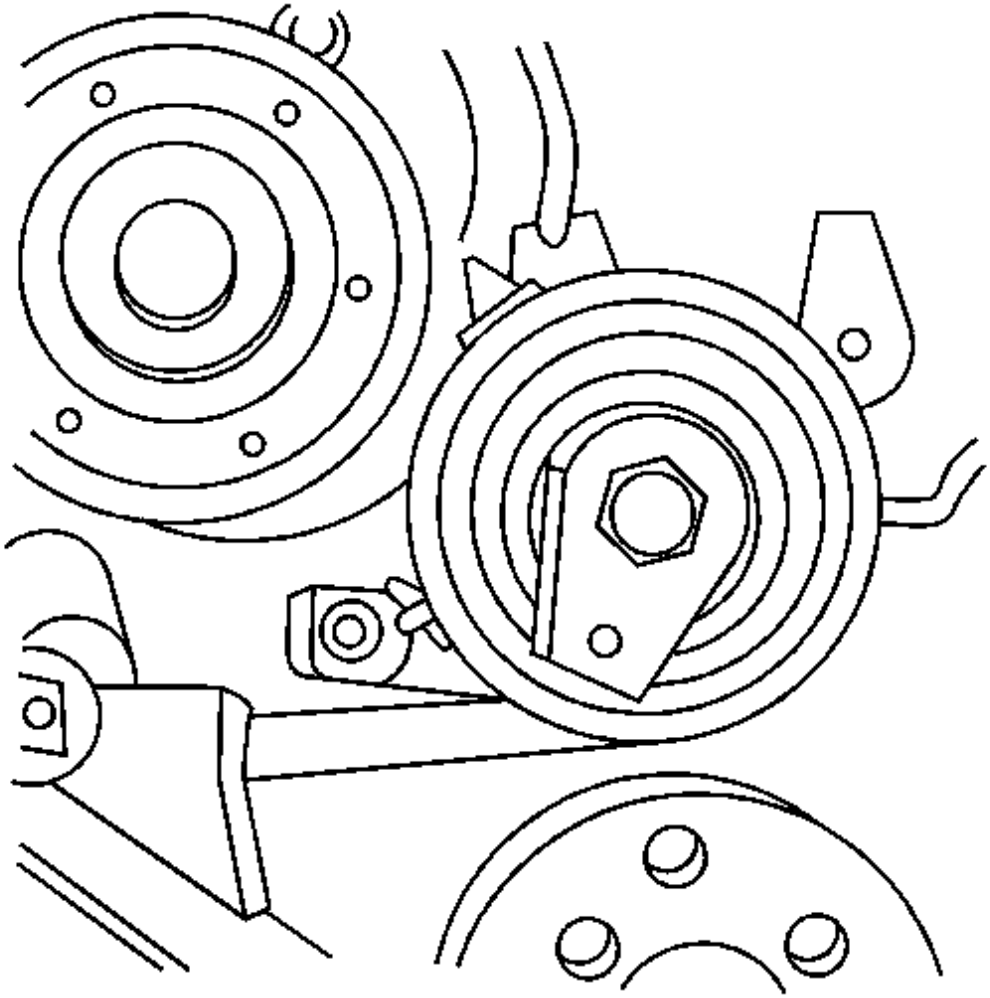


Fig. 83: Identifying Timing Belt Automatic Tensioner
Courtesy of GENERAL MOTORS CORP.

20. Install the timing belt automatic tensioner.
21. Install the timing belt automatic tensioner bolt.

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

22. Install the timing belt idler pulleys.
23. Install the timing belt idler pulley bolt and nut.

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

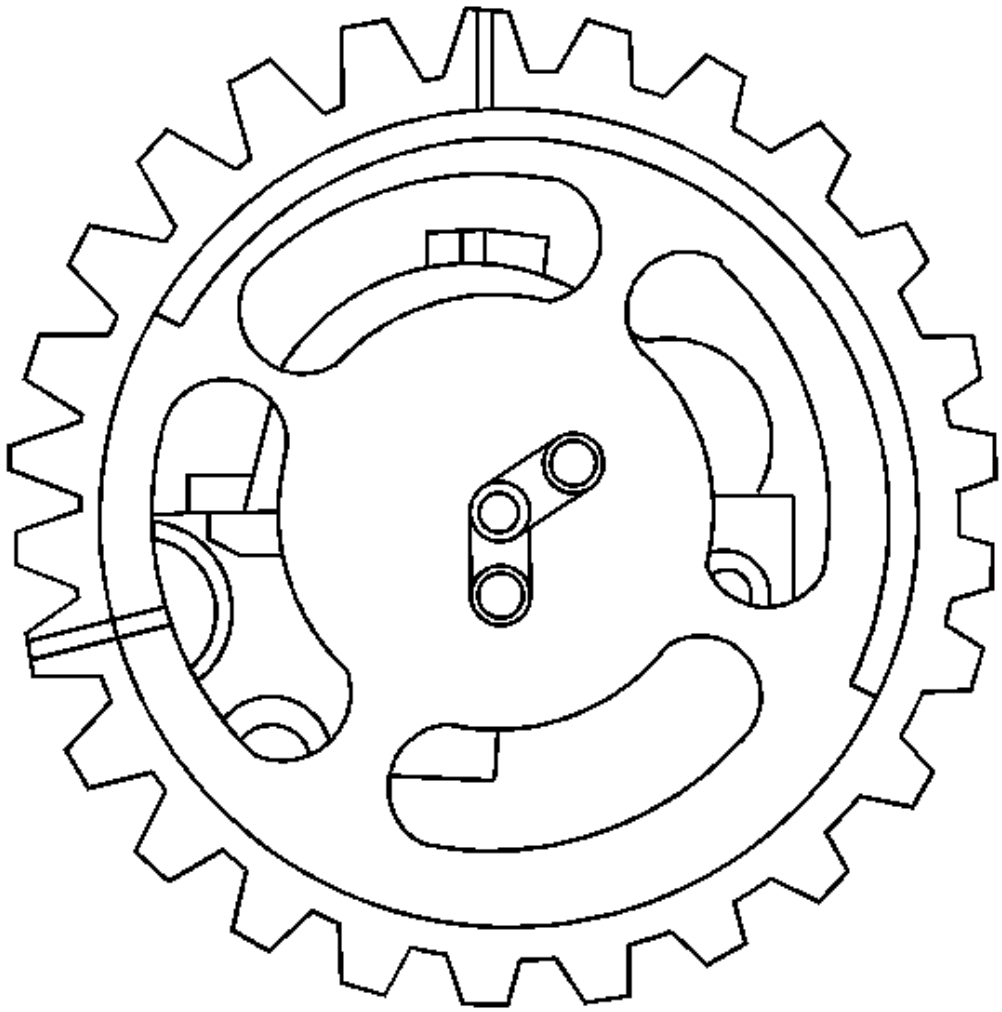


Fig. 84: View Of Camshaft Gear And Timing Marks
Courtesy of GENERAL MOTORS CORP.

24. Install the camshaft gears with the timing marks at the front.

25. Insert the guide pin of the intake camshaft into the IN bore.
26. Insert the guide pin of the exhaust camshaft into the EX bore.

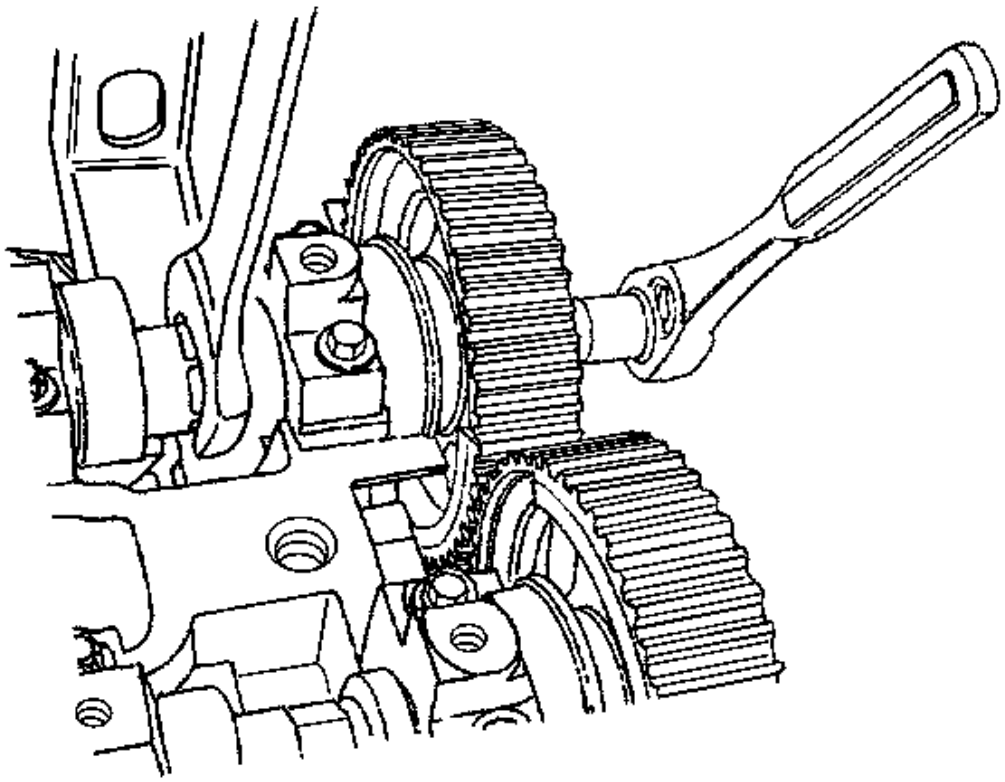


Fig. 85: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

27. Install the camshaft gears by counterholding on the hex of the camshaft with an open-ended wrench.
28. Install the camshaft gear with a new bolt to the camshaft.

    Tighten: Tighten the bolt to **50 N.m (37 lb ft)** . Turn the bolt another 60 degrees and 15 degrees using the angular torque gage.

29. While holding the exhaust firmly in place, install the exhaust camshaft gear bolt.

    Tighten: Tighten the bolt to **50 N.m (37 lb ft)** . Turn the bolt another 60 degrees and 15 degrees using the **J 45059** or the **KM-470-B** .

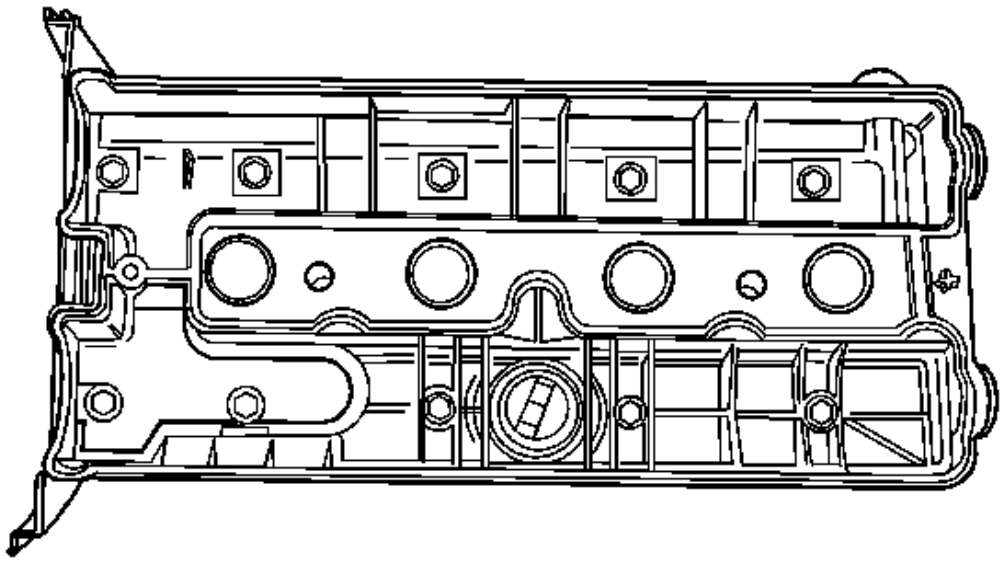


Fig. 86: View Of Camshaft Cover And Gasket
Courtesy of GENERAL MOTORS CORP.

30. 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.
31. Install the camshaft cover and the camshaft cover gasket.
32. Install the camshaft cover washers.
33. Install the camshaft cover bolts.

Tighten: Tighten the bolts to **8 N.m (71 lb in)** .

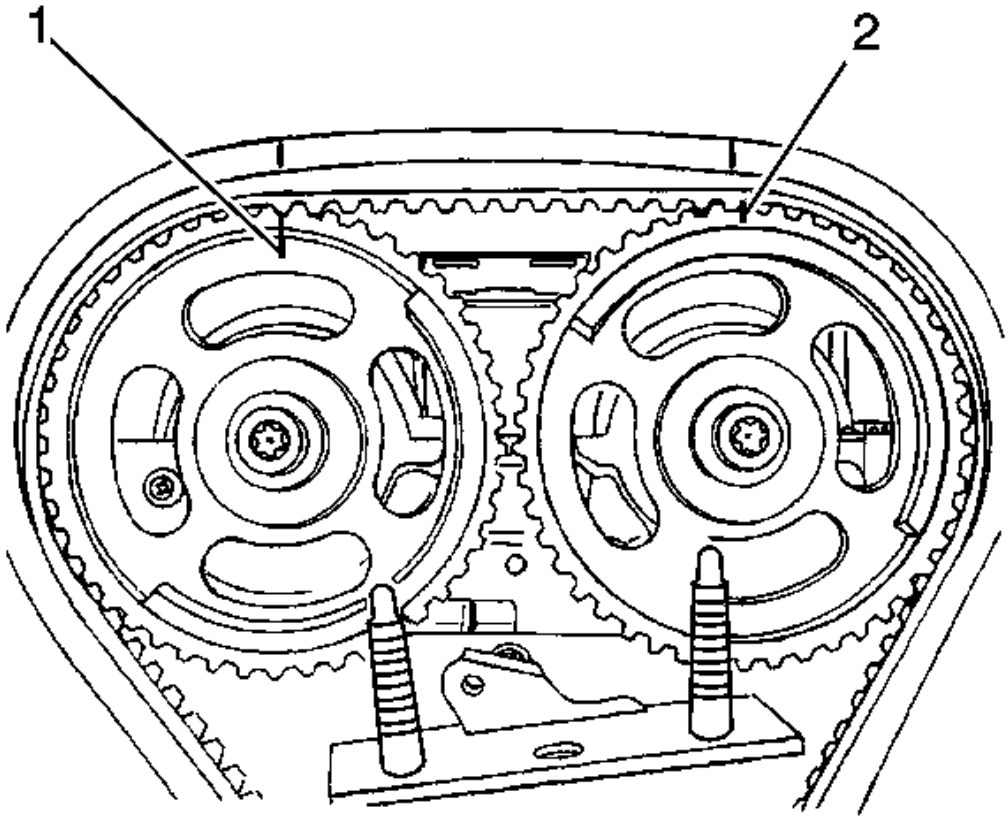


Fig. 87: View Of Camshaft Alignment Notches
Courtesy of GENERAL MOTORS CORP.

34. Connect the ignition wires to the spark plugs.
35. Install the spark plug cover.
36. Install the spark plug cover bolts.

    Tighten: Tighten the bolts to **8 N.m (71 lb in)** .

37. Connect the breather tube to the camshaft cover.
38. Align the timing marks on the camshaft gears to the notches on the camshaft cover, using the intake gear mark (1), for the intake gear and the exhaust gear mark (2) for the exhaust gear.

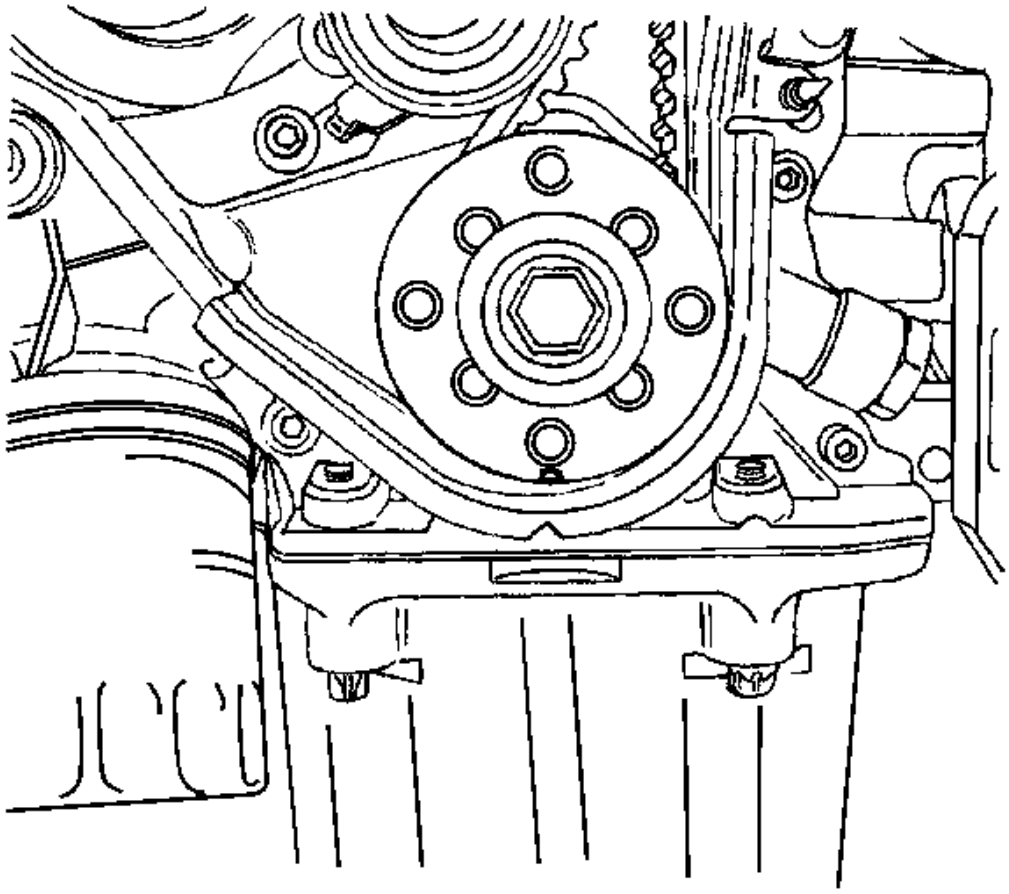


Fig. 88: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

39. Align the mark on the crankshaft gear with the notch at the bottom of the rear timing belt cover.

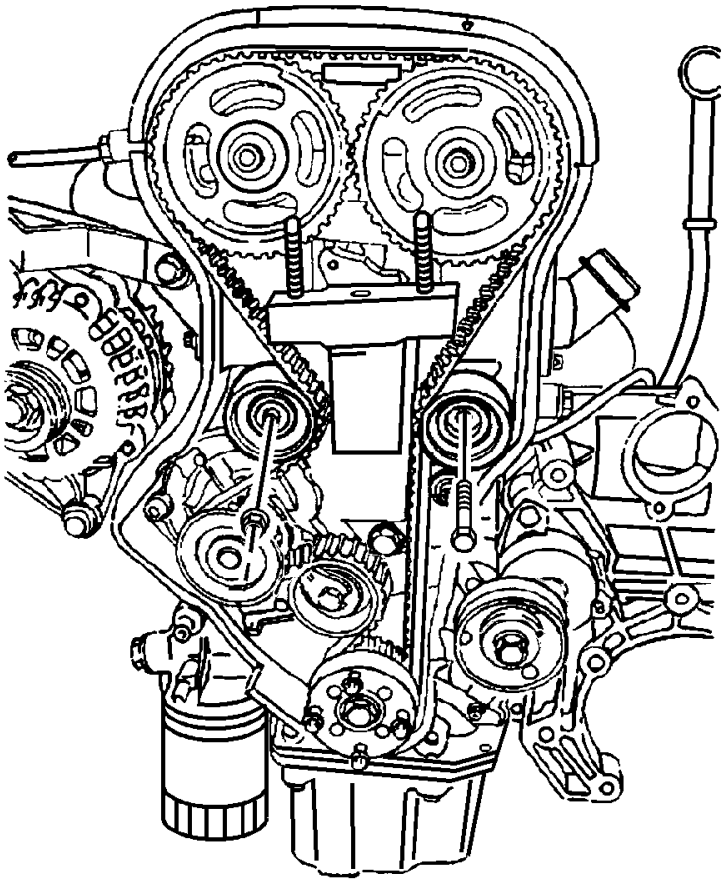


Fig. 89: View Of Timing Belt Idler Pulleys And Bolts
Courtesy of GENERAL MOTORS CORP.

40. Install the timing belt.
41. Check and adjust the timing belt tension. Refer to **Timing Belt Inspection**.

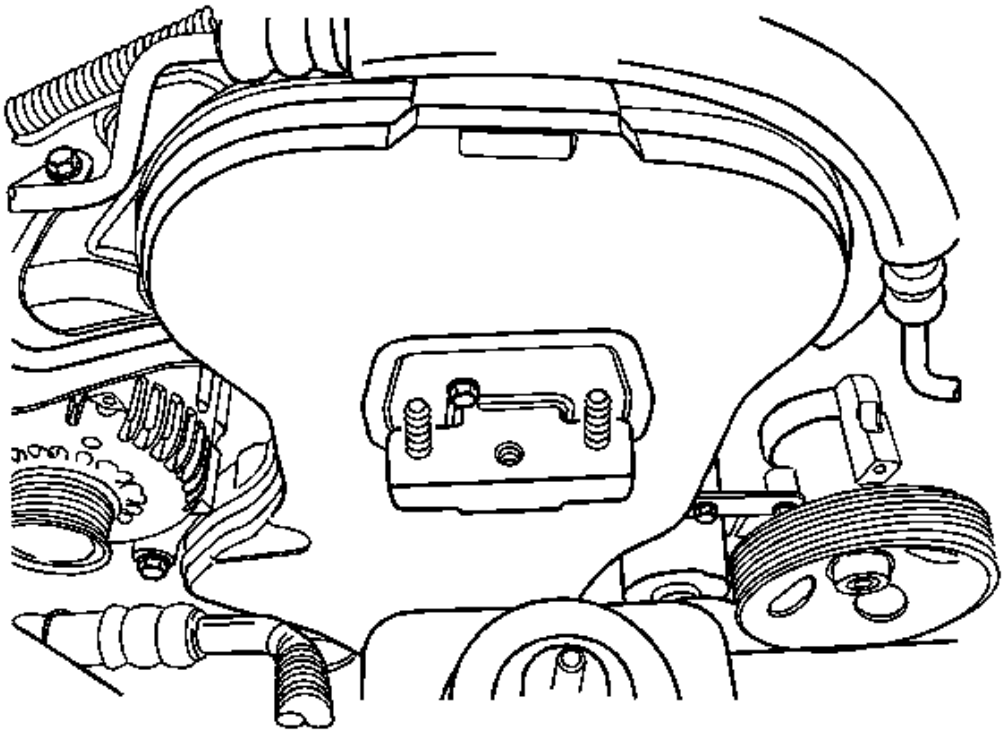


Fig. 90: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

42. Install the front timing belt cover.
43. Install the front timing belt cover bolts.

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

44. Install the crankshaft pulley.
45. Install the crankshaft pulley bolts.

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

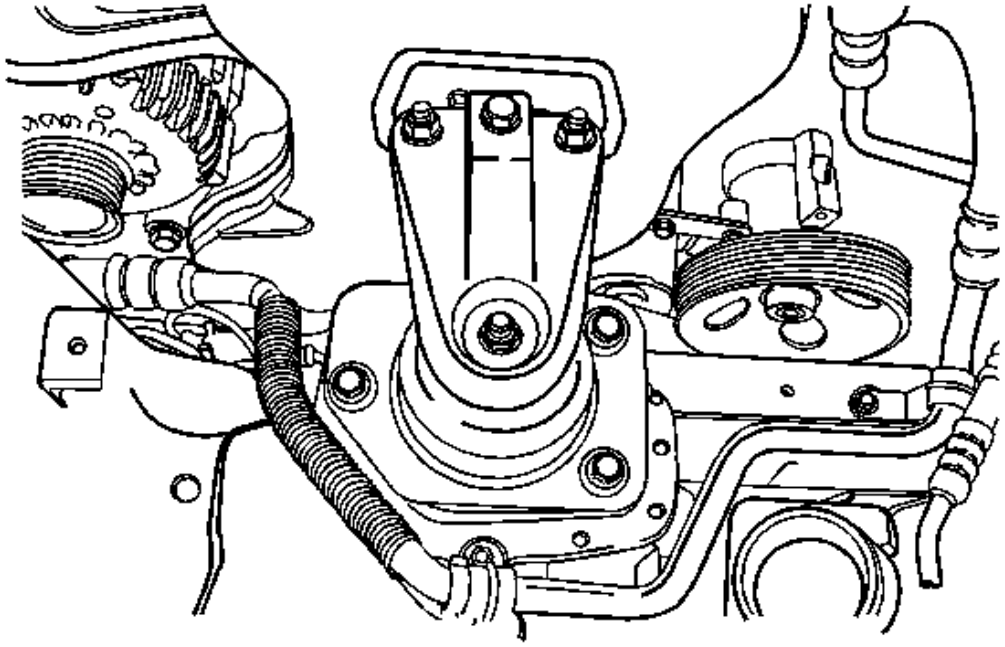


Fig. 91: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

46. Install the right engine mount bracket and retaining bolts. Refer to **Engine Mount Replacement**.

    Tighten: Tighten the bolts to **55 N.m (41 lb ft)** .

47. Remove the **J 28467-B** .
48. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
49. Connect the upper radiator hose to the thermostat housing.
50. Install the right front wheel well splash shield.
51. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.

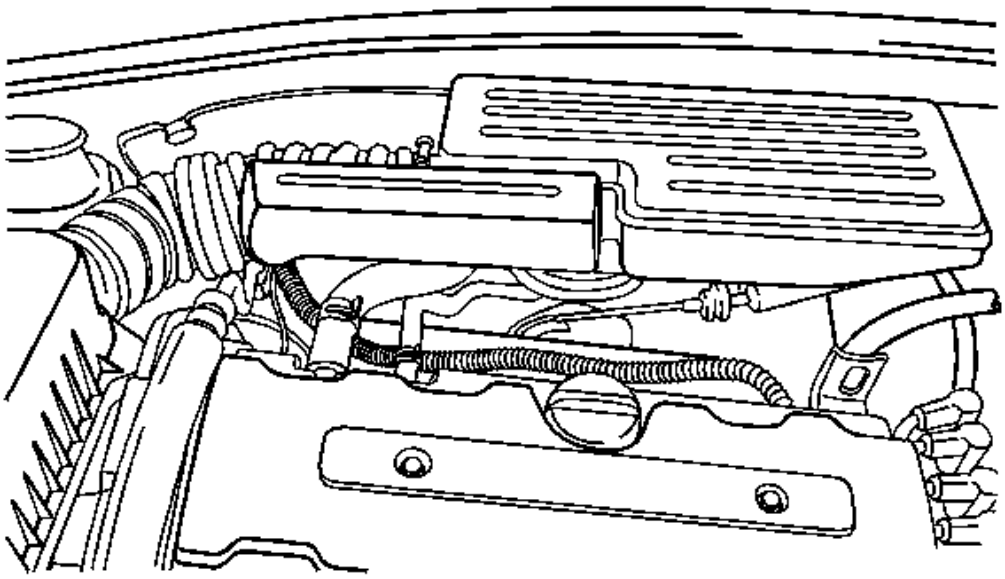


Fig. 92: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

52. Install the air cleaner housing.
53. Install the air cleaner housing bolts.

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

54. Connect the air cleaner outlet hose to the throttle body.
55. Connect the breather tube to the camshaft cover.
56. Connect the IAT sensor connector.

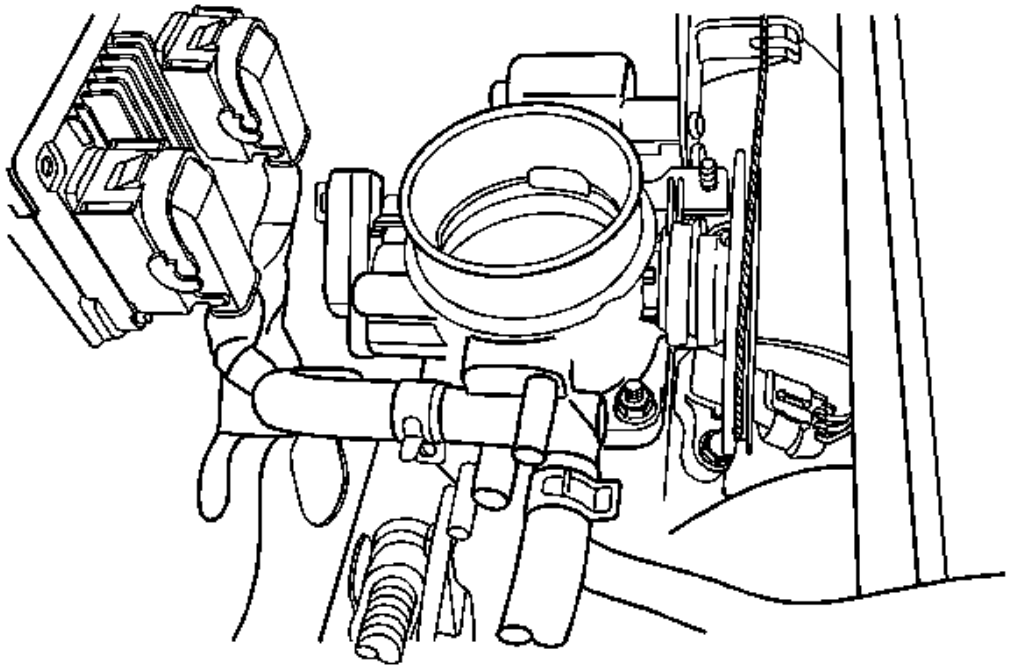


Fig. 93: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

57. Connect the CTS connector.
58. Connect the ECT sensor connector.
59. Connect the IAC valve connector.
60. Connect the TP sensor connector
61. Install the CCP and the EGR solenoid bracket bolt.

Tighten: Tighten the bolt to **5 N.m (44 lb in)** .

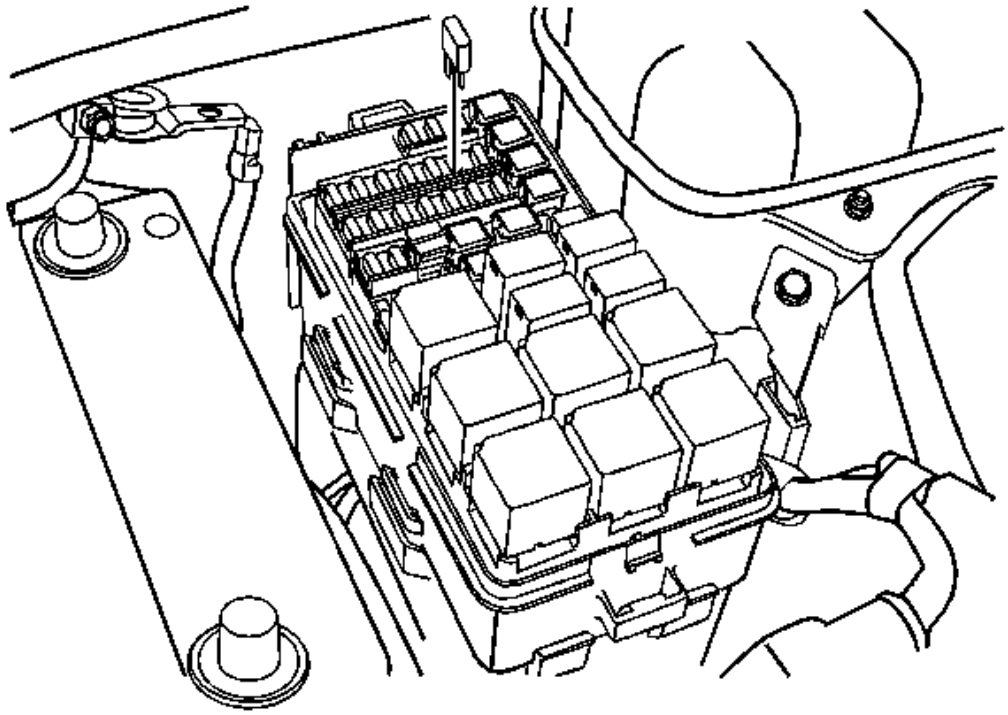


Fig. 94: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

62. Connect the DIS coil connector.
63. Connect the O2S connector, if equipped.
64. Connect the ECM ground terminal.
65. Install the fuel pump fuse.
66. Connect the negative battery ground cable.
67. Refill the engine cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

OIL PAN CLEANING AND INSPECTION

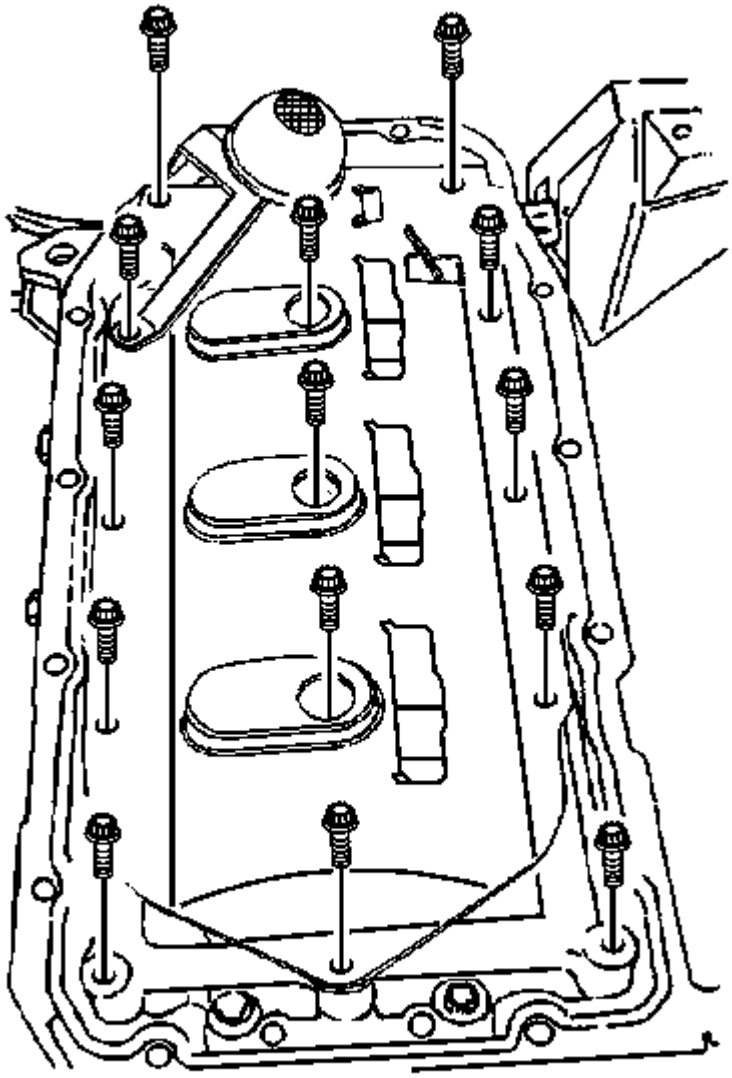


Fig. 95: View Of Oil Pan Components
Courtesy of GENERAL MOTORS CORP.

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

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 attaching bolt holes in the engine block.
5. Clean the oil pan scraper.

OIL PAN REPLACEMENT

Removal Procedure

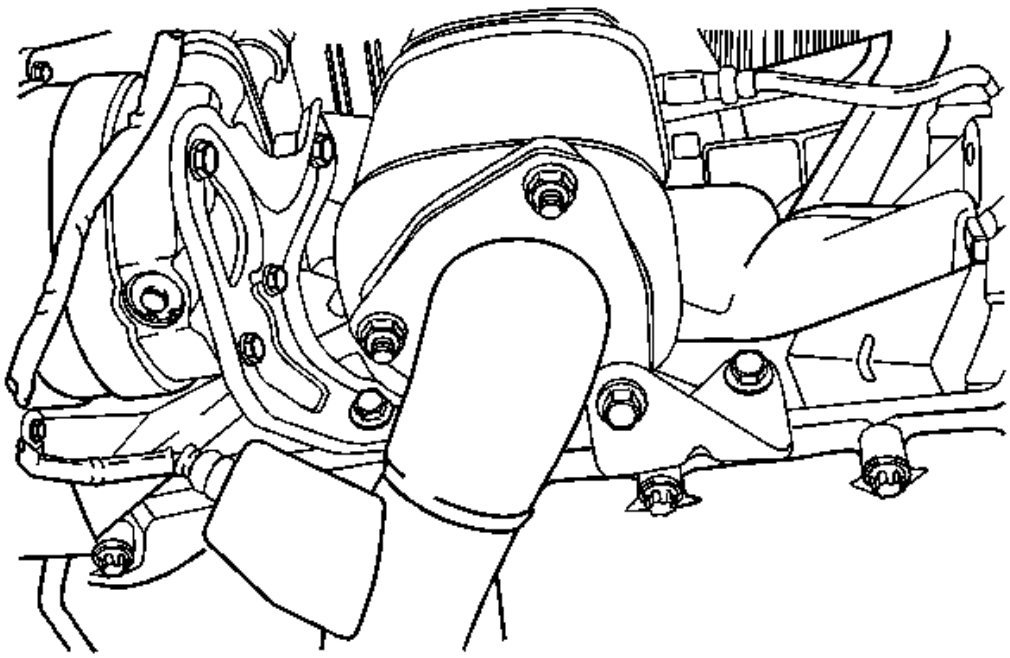


Fig. 96: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable.
2. Drain the engine oil from the engine crankcase.
3. Remove the exhaust flex pipe retaining nuts from the exhaust manifold.
4. Remove the exhaust flex pipe retaining nuts from the catalytic converter or the connecting pipe.
5. Remove the exhaust flex pipe.

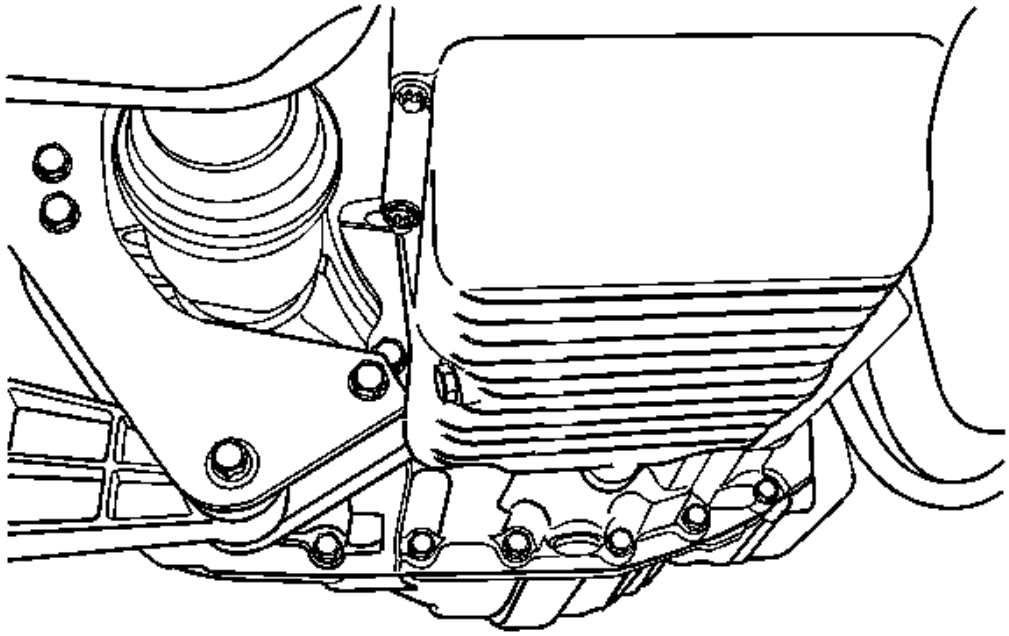


Fig. 97: Identifying Oil Pan Flange And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan flange-to-transaxle retaining bolts.

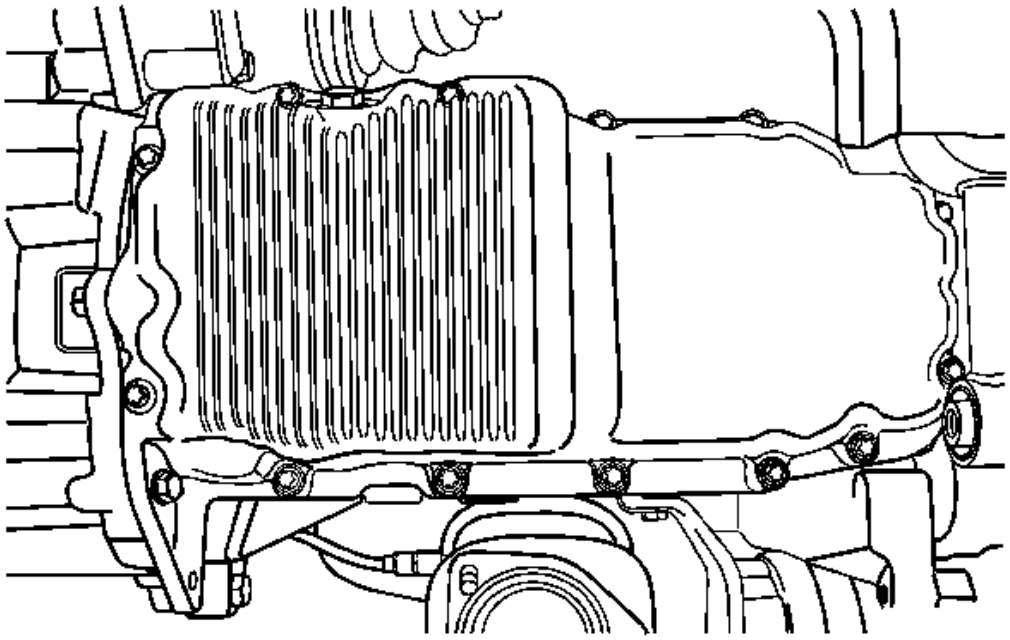


Fig. 98: View Of Oil Pan And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pan retaining bolts.
8. Remove the oil pan from the engine block.

Installation Procedure

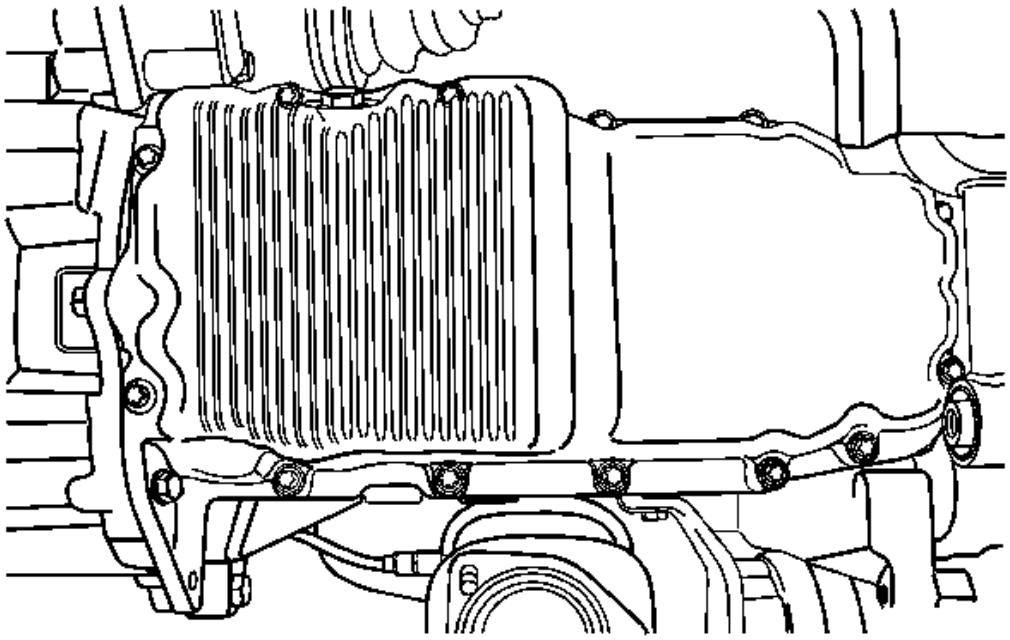


Fig. 99: View Of Oil Pan And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

3. Install the oil pan retaining bolts.

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

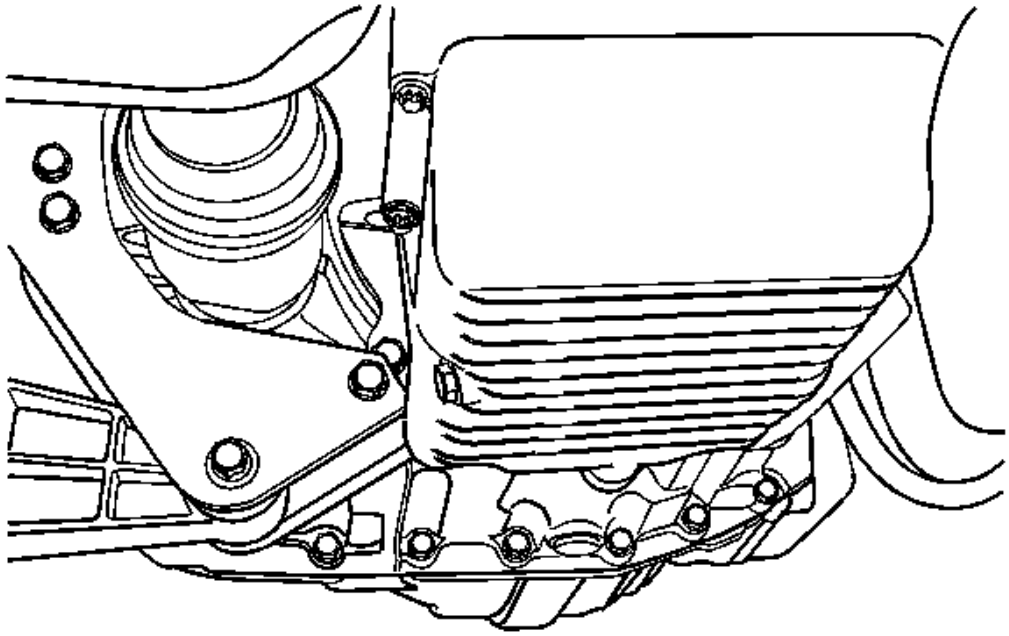


Fig. 100: Identifying Oil Pan Flange And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan flange-to-transaxle retaining bolts.

   Tighten: Tighten the oil pan flange-to-transaxle bolts to **40 N.m (30 lb ft)** .

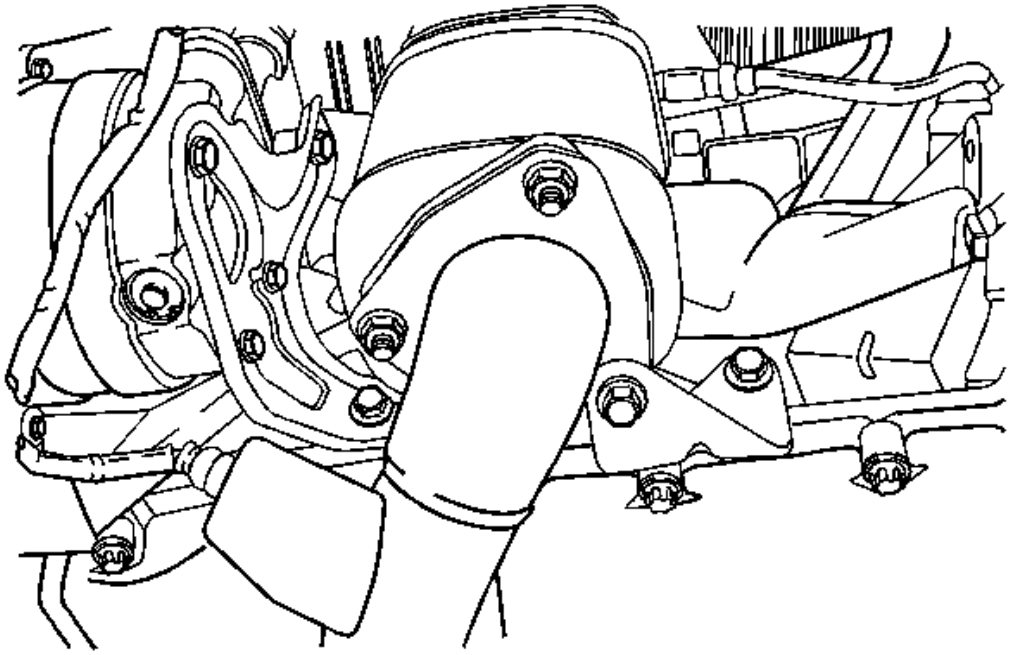


Fig. 101: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust flex pipe.
6. Install the exhaust flex pipe retaining nuts to the exhaust manifold.

   Tighten: Tighten the exhaust flex pipe-to-exhaust manifold retaining nuts to **35 N.m (26 lb ft)** .

7. Install the exhaust flex pipe retaining nuts to the catalytic converter of the connecting pipe.

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

8. Connect the negative battery cable.
9. Discard the used oil pan drain plug washer and replace it with a new one.
10. Install the oil pan drain plug.

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

11. Refill the engine crankcase with engine oil

OIL PUMP CLEANING AND INSPECTION

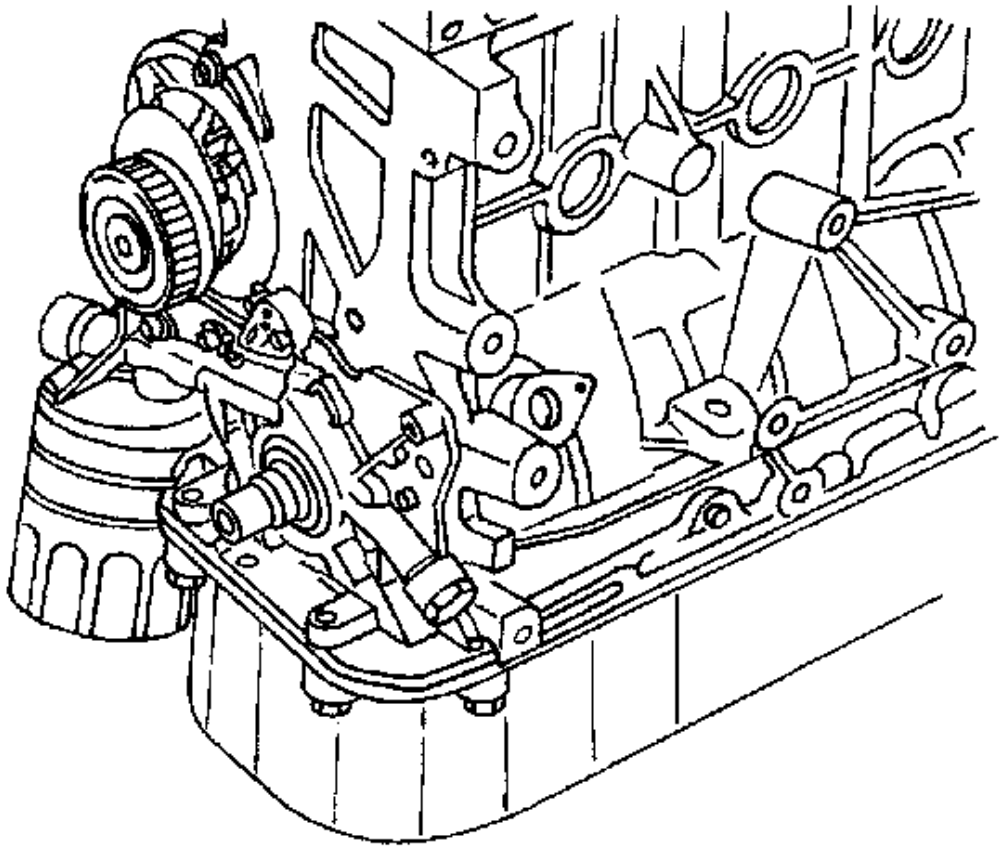


Fig. 102: View Of Oil Pump Installed At Crankshaft
Courtesy of GENERAL MOTORS CORP.

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

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.

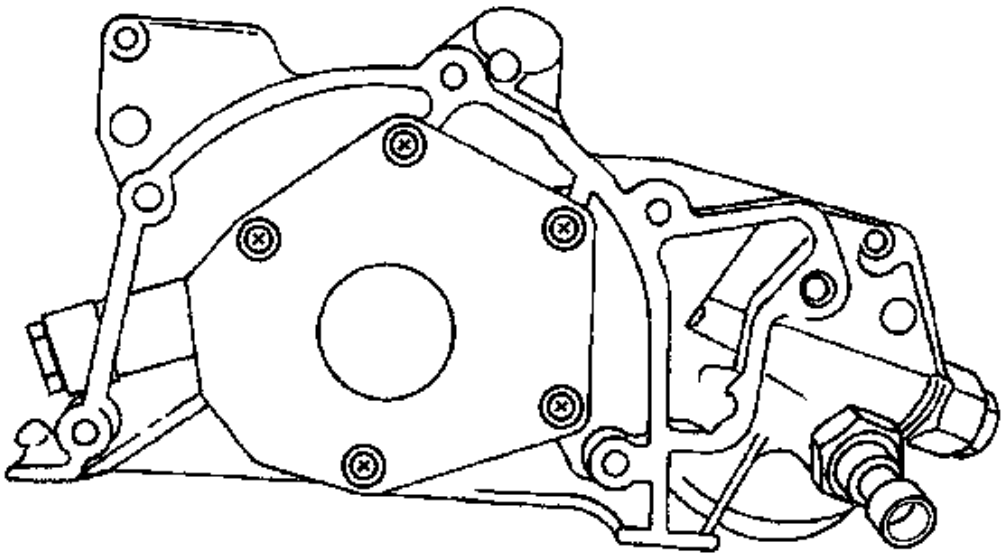


Fig. 103: View Of Oil Pump With Rear Cover Removed
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pump rear cover bolts.
6. Remove the rear cover.
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 in Cautions and Notices.

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 **6 N.m (53 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)** .

OIL PUMP REPLACEMENT

Removal Procedure

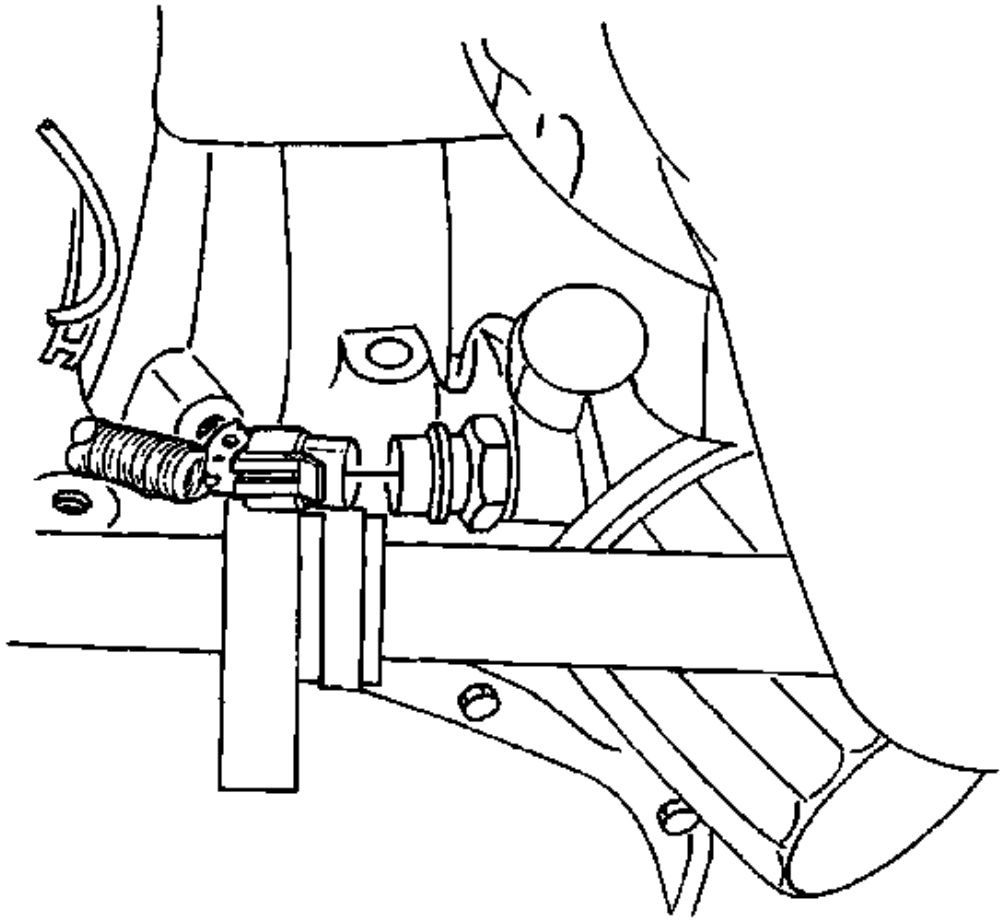


Fig. 104: Identifying Oil Pressure Switch Connector
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.

2. Remove the timing belt. Refer to **Timing Belt Replacement**.
3. Remove the rear timing belt cover. Refer to **Timing Belt Cover Replacement**.
4. Disconnect the oil pressure switch connector.

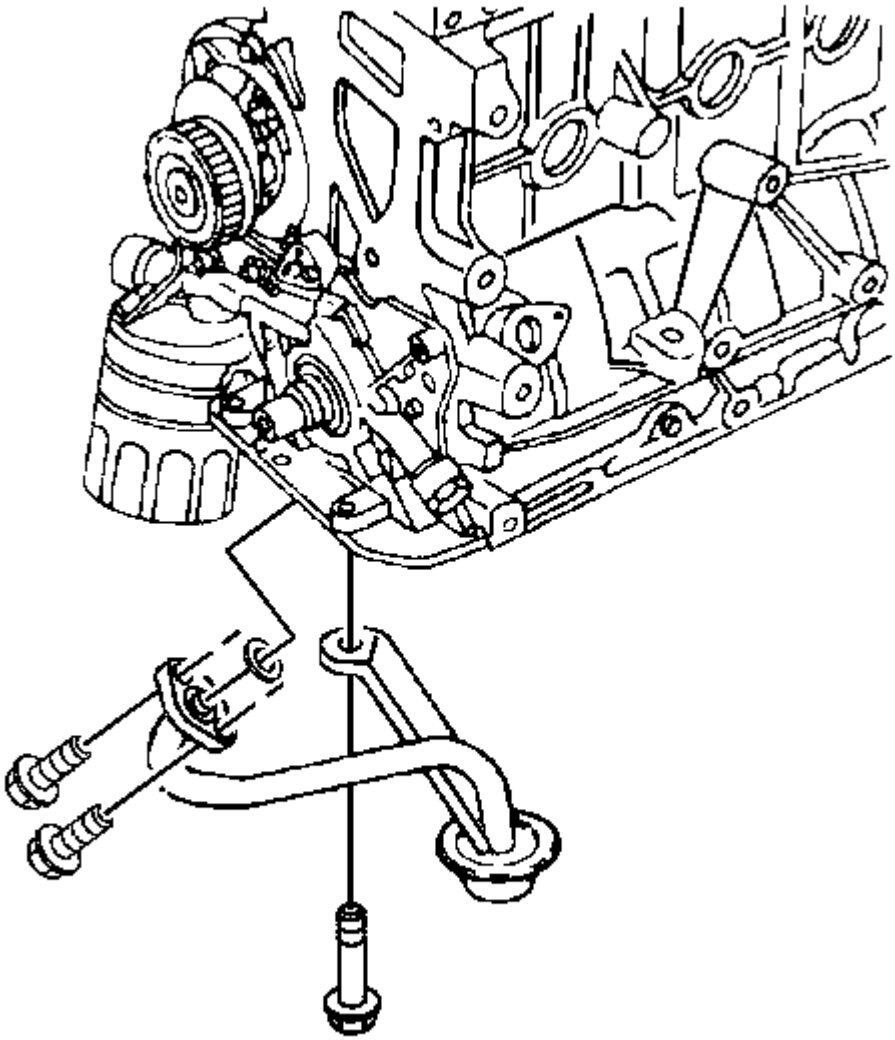


Fig. 105: View Of Oil Suction Pipe And Components
Courtesy of GENERAL MOTORS CORP.

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

7. Remove the oil suction pipe.

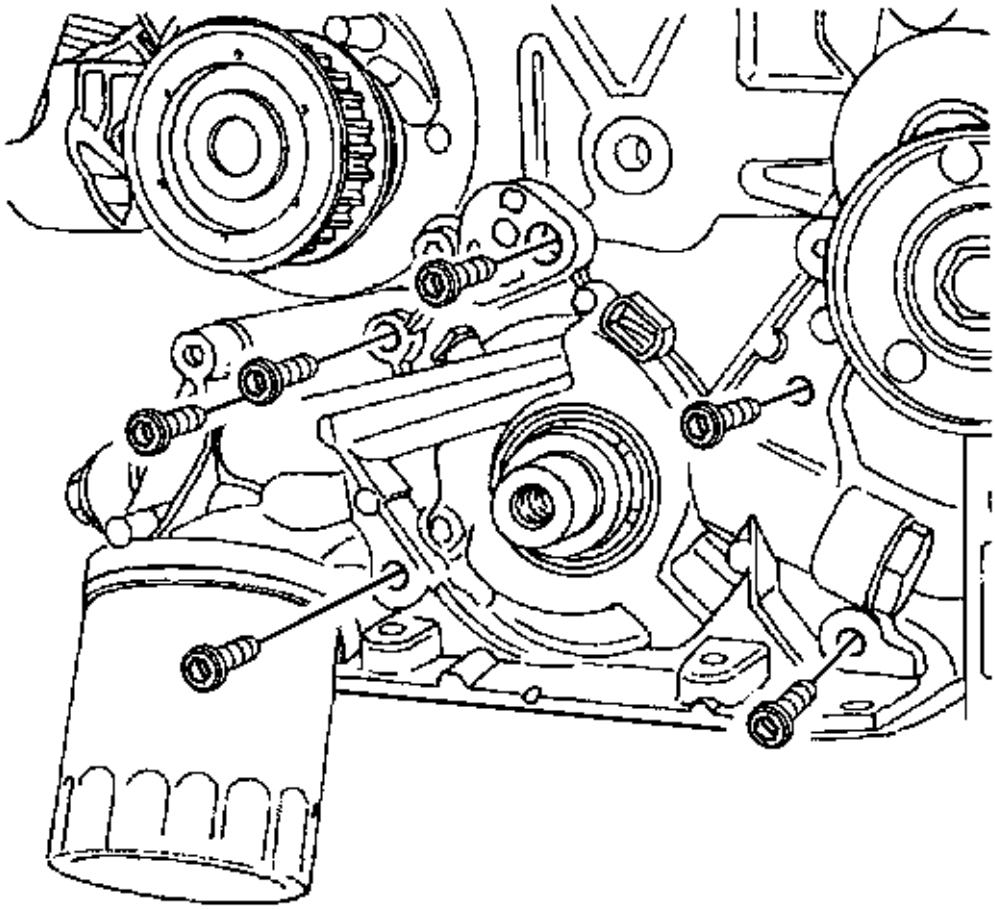


Fig. 106: Identifying Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pump retaining bolts.
9. Carefully separate the oil pump and gasket from the engine block and oil pan.
10. Remove the oil pump.

Installation Procedure

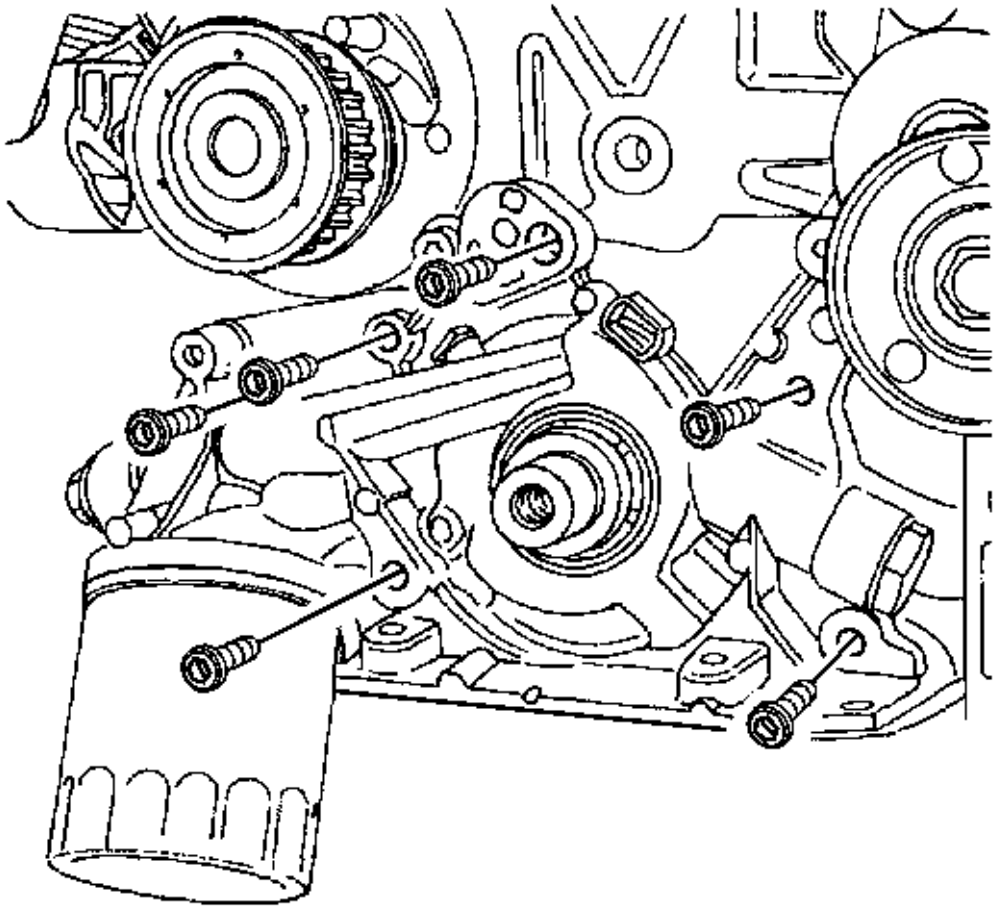


Fig. 107: Identifying Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

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 retaining bolts to **10 N.m (89 lb in)** .

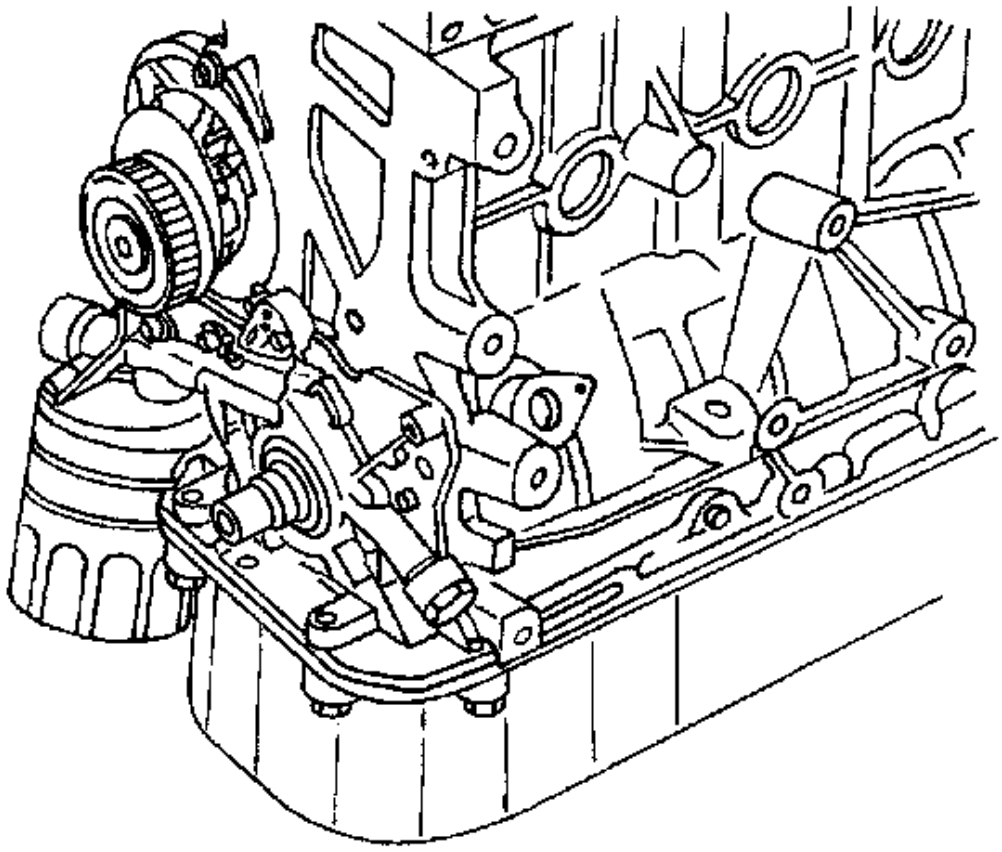


Fig. 108: View Of Oil Pump Installed At Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Install a new oil pump-to-crankshaft seal. Coat the lip of the seal with a thin coat of grease.

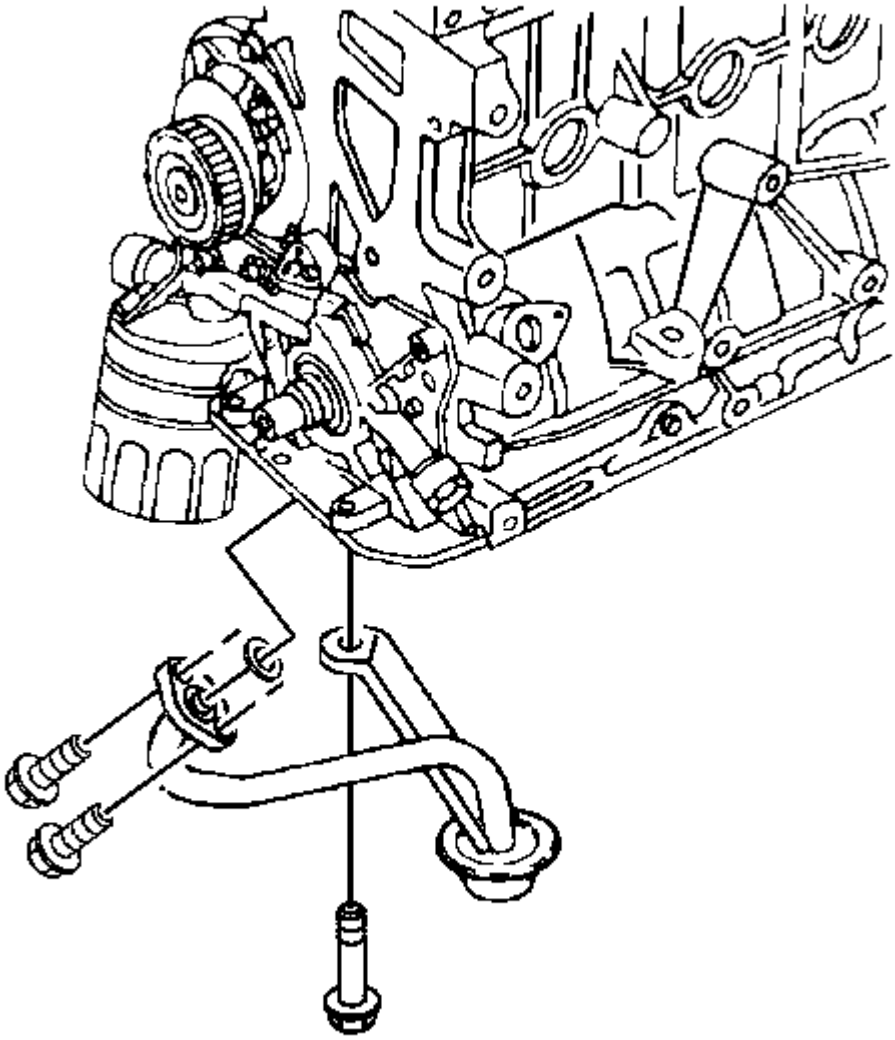


Fig. 109: View Of Oil Suction Pipe And Components
Courtesy of GENERAL MOTORS CORP.

4. Coat the threads of the oil suction pipe and support the bracket bolts with Loctite® 242.
5. Install the oil suction pipe and the bolts.

Tighten:

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

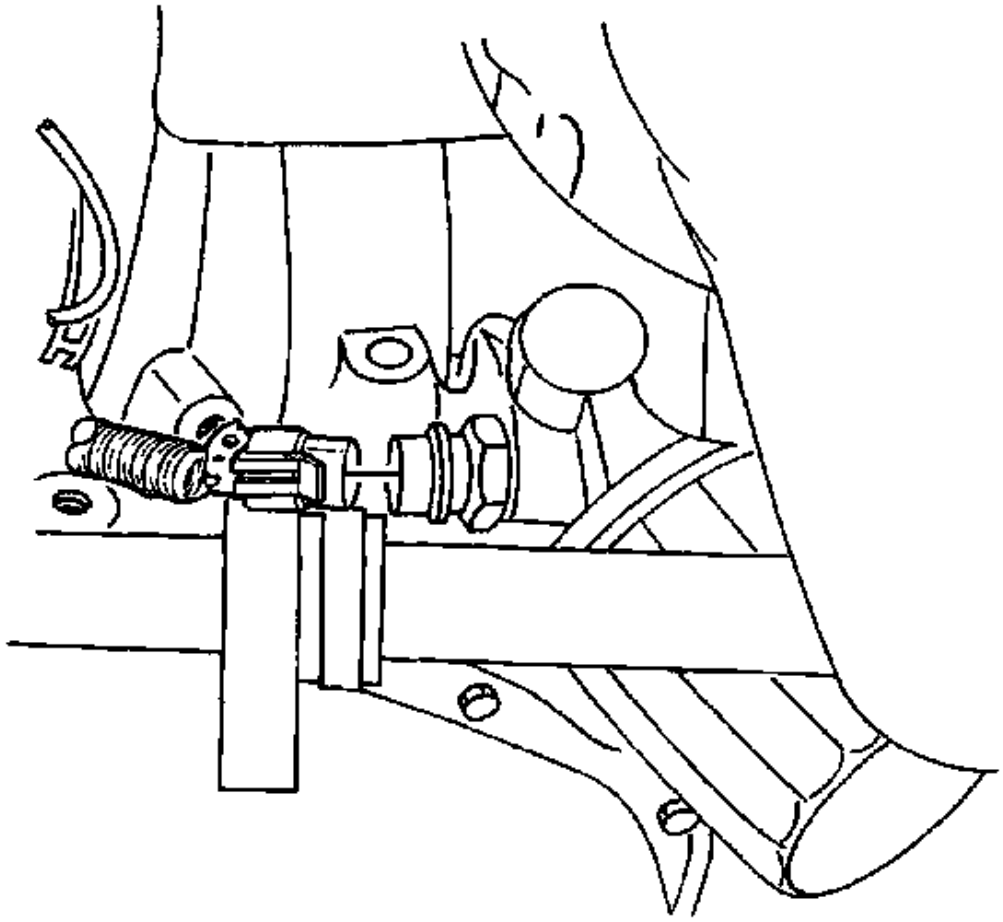


Fig. 110: Identifying Oil Pressure Switch Connector
Courtesy of GENERAL MOTORS CORP.

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. Connect the negative battery cable.

ENGINE REPLACEMENT

Removal Procedure

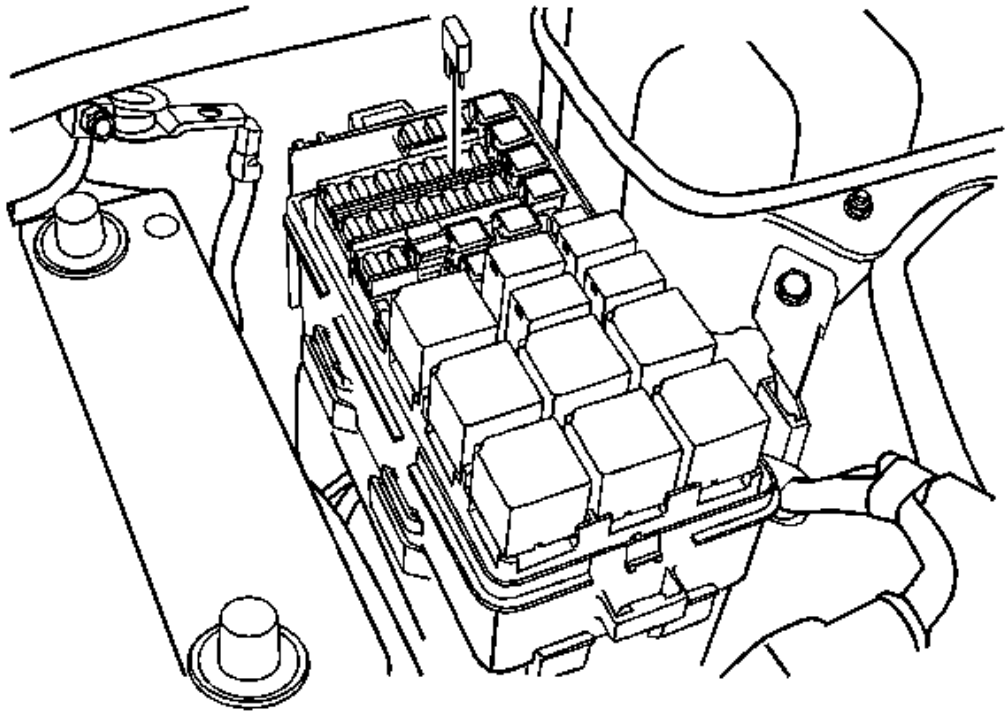


Fig. 111: Identifying Fuel Pump Fuse
Courtesy of GENERAL MOTORS CORP.

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** in Body Front End.
4. Drain the engine oil.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

5. Disconnect the negative battery cable.

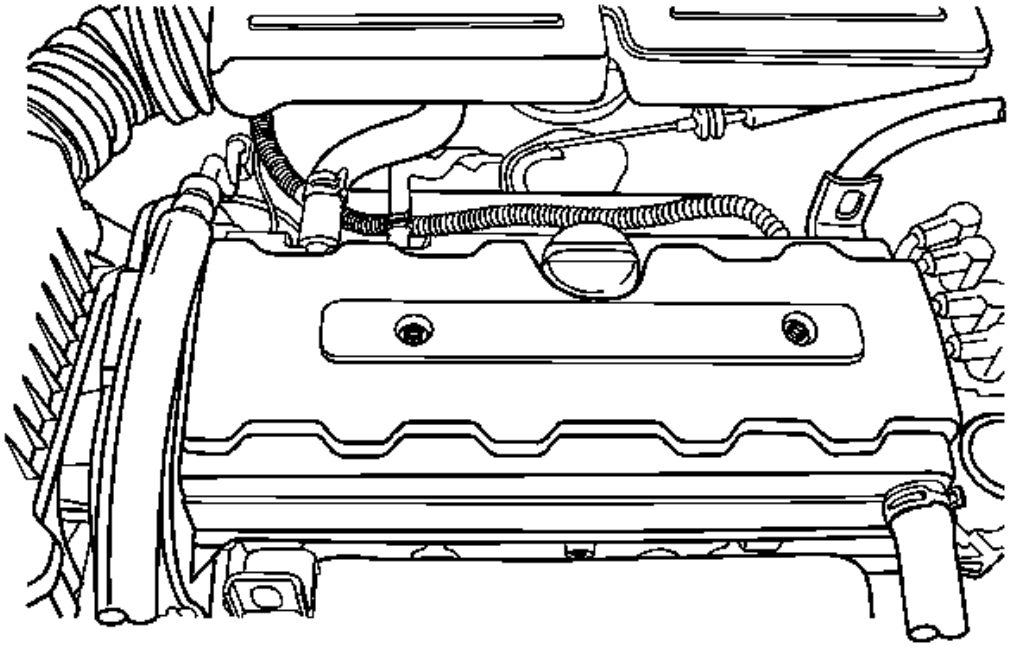


Fig. 112: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

6. Discharge the air conditioning (A/C) system. if equipped. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
7. Disconnect the intake air temperature (IAT) sensor connector.
8. Remove the air cleaner outlet hose from the throttle body and air cleaner housing.
9. Disconnect the breather tubes from the camshaft cover.
10. Remove the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
11. Remove the right front wheel well splash shield.
12. Remove the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.

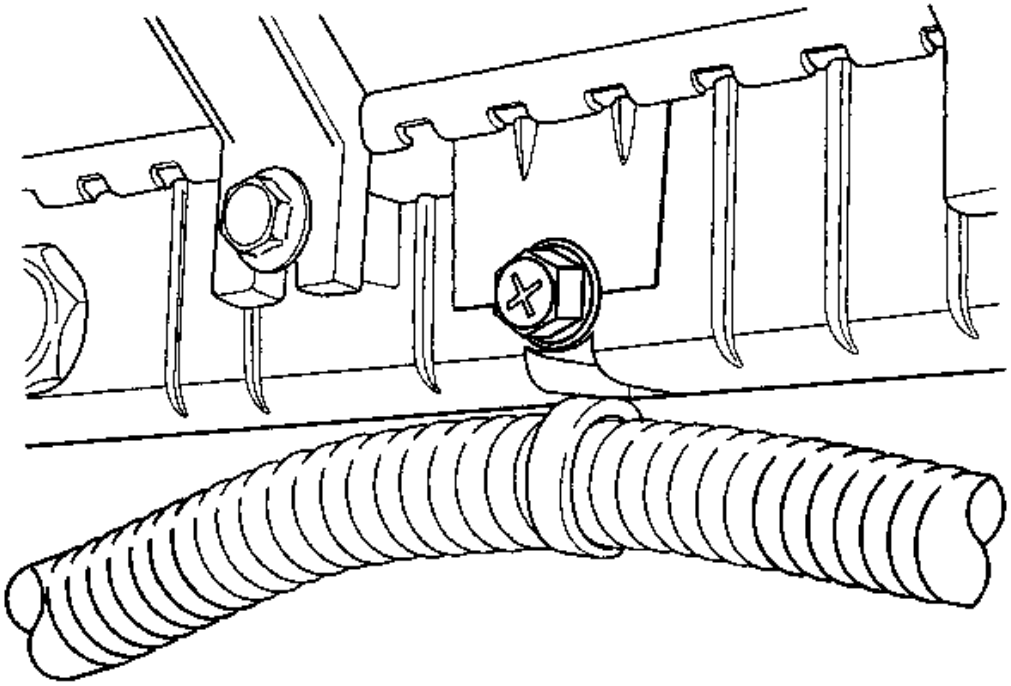


Fig. 113: View Of Drain Cock
Courtesy of GENERAL MOTORS CORP.

13. Drain the engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
14. Remove the cooling system radiator and the engine cooling fans. Refer to **Radiator Replacement** , and **Cooling Fan Replacement - Electric** in Engine Cooling.
15. Disconnect the upper radiator hose from the thermostat housing.
16. Disconnect the power steering return hose from the power steering pump.
17. Disconnect the power steering pressure hose from the power steering pump.
18. Disconnect the electrical connector at the direct ignition system (DIS) coil and the electronic control module (ECM) ground terminal and at the starter motor.

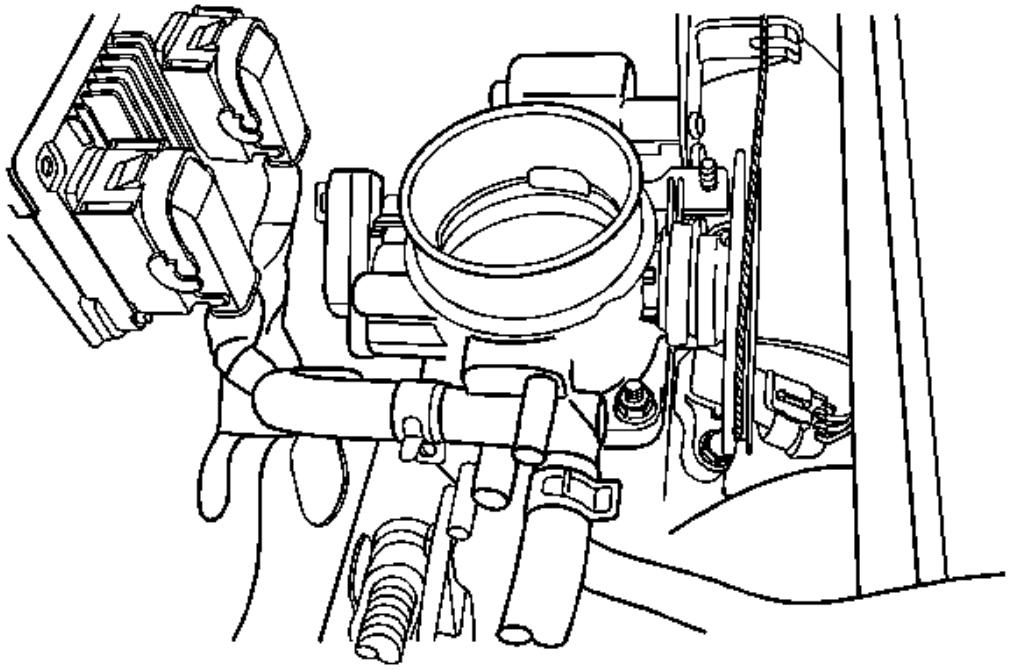


Fig. 114: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

NOTE: Handle the oxygen sensors carefully in order to prevent damage to the component. Keep the electrical connector and the exhaust inlet end free of contaminants. Do not use cleaning solvents on the sensor. Do not drop or mishandle the sensor.

19. Disconnect the oxygen sensor (O2S) connector, if equipped.
20. Disconnect the idle air control (IAC) valve connector.
21. Disconnect the throttle position (TP) sensor connector.
22. Disconnect the engine coolant temperature (ECT) sensor connector.
23. Disconnect the coolant temperature sensor (CTS) connector.
24. Disconnect the generator voltage regulator connector and power lead.

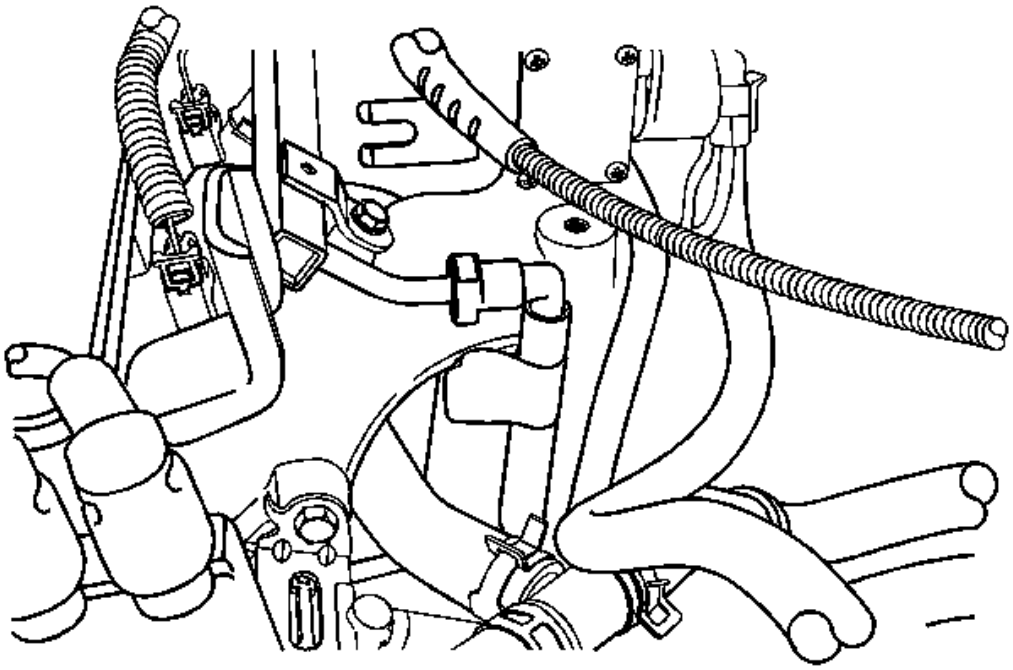


Fig. 115: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

25. Disconnect all of the necessary vacuum lines, including the brake booster vacuum hose.
26. Disconnect the fuel return line at the fuel rail.
27. Disconnect the fuel feed line at the fuel rail.
28. Remove the fuel rail and injectors assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.

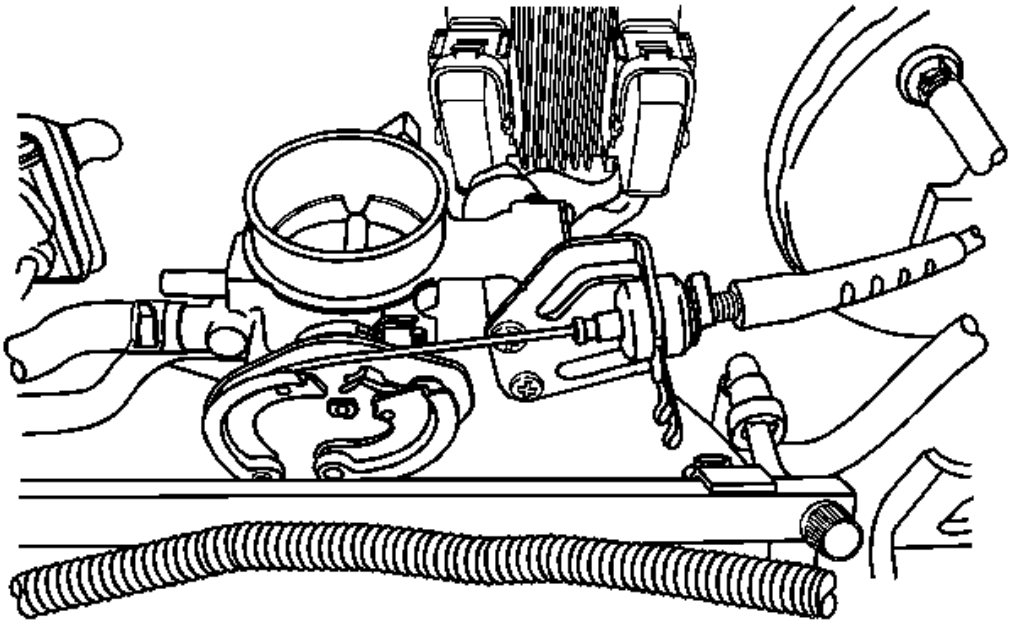


Fig. 116: Identifying Throttle Cable And Components
Courtesy of GENERAL MOTORS CORP.

29. Disconnect the throttle cable from the throttle body and the intake manifold bracket.
30. Disconnect the coolant hose at the throttle body.
31. Disconnect the heater outlet hose at the coolant pipe.
32. Disconnect the coolant bypass hose from the cylinder head.
33. Disconnect the surge tank coolant hose from the coolant pipe.
34. Disconnect the lower radiator hose from the coolant pipe.
35. Disconnect the starter solenoid "S" terminal wire and power lead.
36. Remove the A/C compressor. Refer to **Compressor Replacement** in Heating, Ventilation, and Air Conditioning.

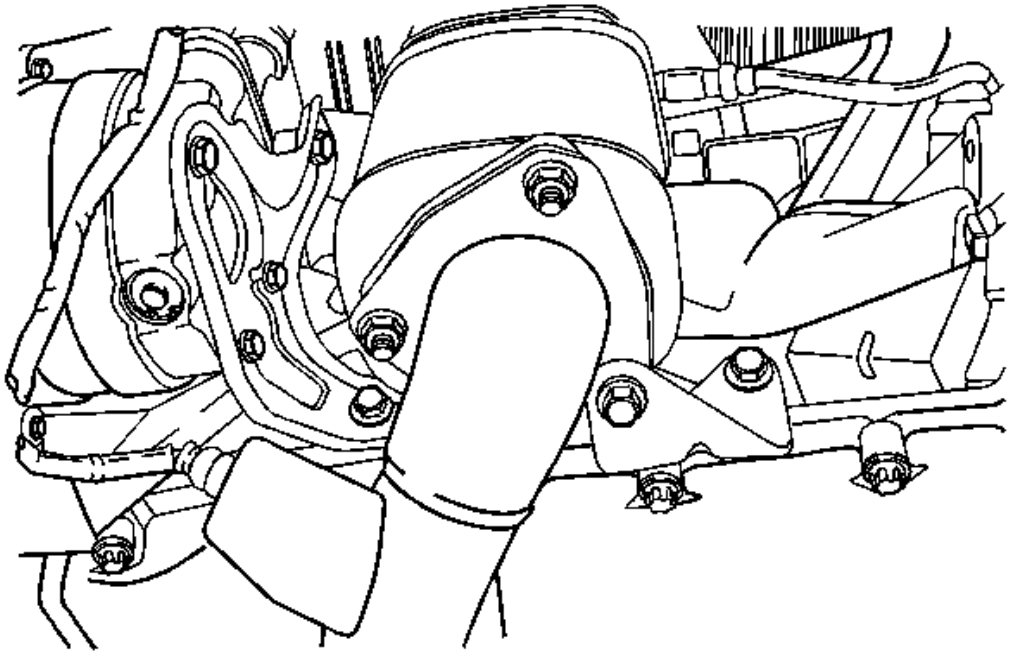


Fig. 117: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

37. Remove the exhaust flex pipe retaining nuts from the exhaust manifold studs.
38. Remove the exhaust flex pipe retaining nuts from the catalytic converter or the connecting pipe.
39. Remove the exhaust flex pipe.

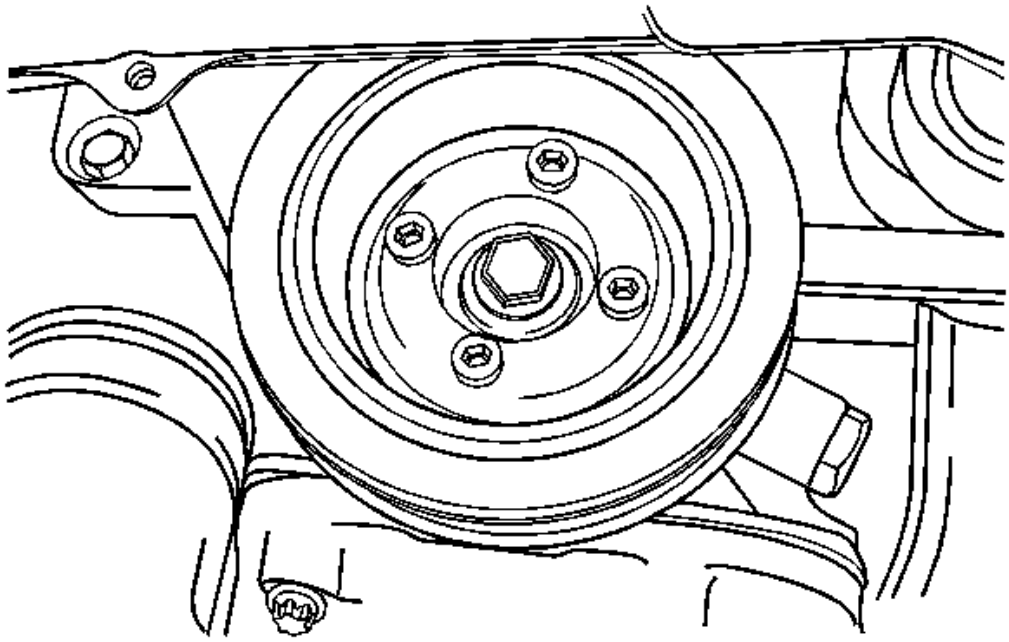


Fig. 118: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

40. Remove the crankshaft pulley bolts.
41. Remove the crankshaft pulley.
42. Disconnect the vacuum lines at the charcoal canister purge solenoid.
43. Disconnect the electrical connector at the charcoal canister purge
44. Disconnect the electrical connector at the oil pressure switch.
45. Disconnect the crankshaft position (CKP) sensor connector.
46. Disconnect the knock sensor connector.

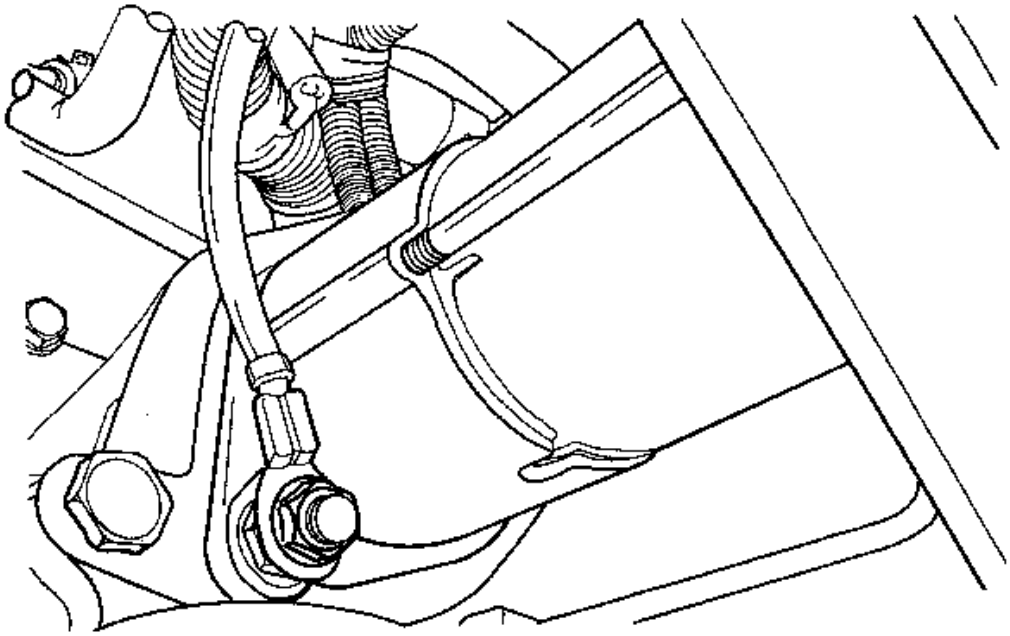


Fig. 119: View Of Transaxle Torque Converter Bolt
Courtesy of GENERAL MOTORS CORP.

47. Remove the transaxle torque converter bolts, if automatic transaxle equipped.
48. Remove the transaxle bell housing bolts and the oil pan flange bolts.
49. Support the transaxle with a floor jack.
50. Install the engine lifting device.

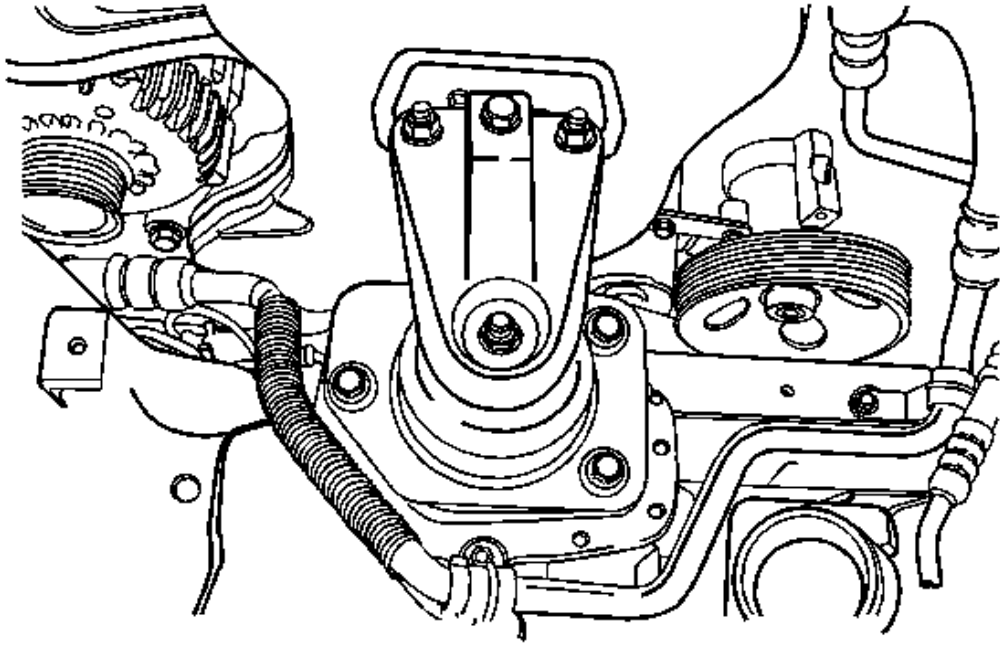


Fig. 120: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

51. Disconnect the right engine mount bracket from the engine mount by removing the retaining bolt.
52. Remove the right engine mount bracket from the engine block and frame mount. Refer to **Engine Mount Replacement**.
53. Separate the engine block from the transaxle. Remove the engine.

Installation Procedure

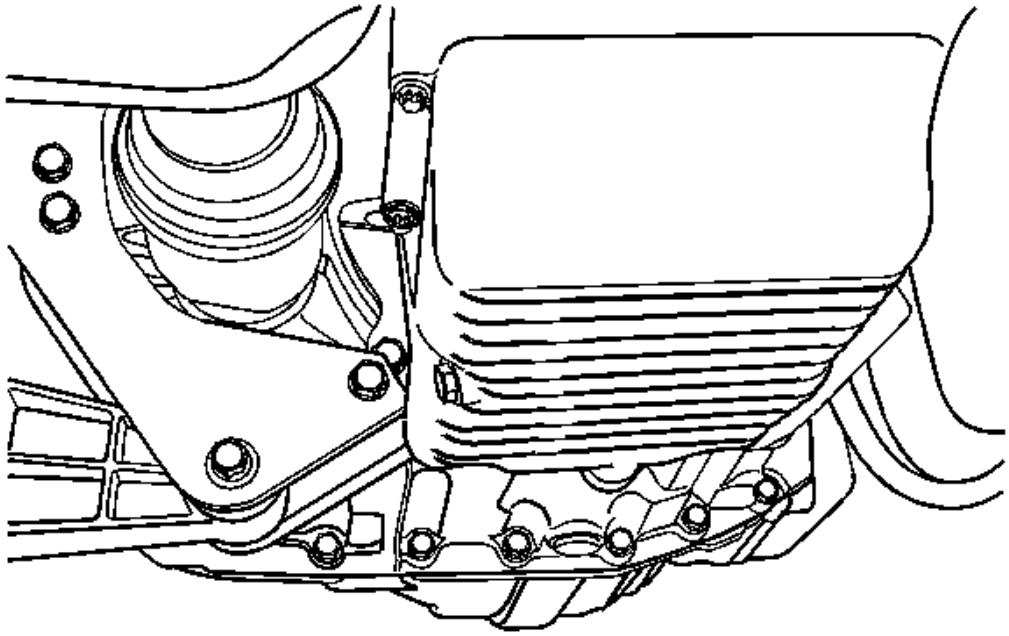


Fig. 121: Identifying Oil Pan Flange And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the transaxle bell housing bolts.

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

4. Install the oil pan flange-to-transaxle bolts.

   Tighten: Tighten the oil pan flange-to-transaxle bolts to **40 N.m (30 lb ft)** .

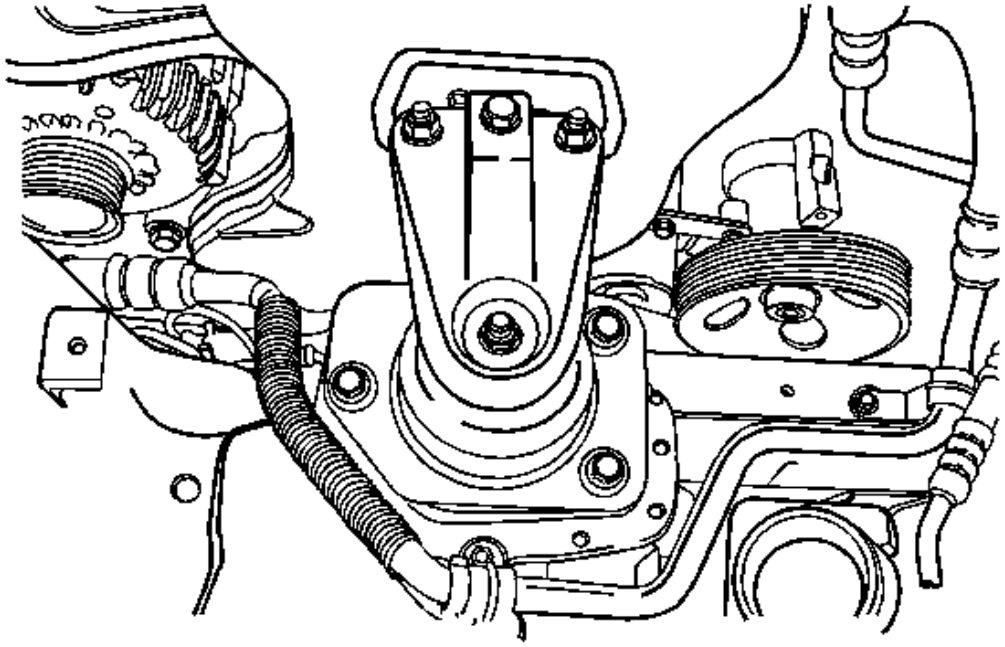


Fig. 122: View Of Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the right engine mount to the engine block mount and the frame mount.
6. Install the right engine mount bracket retaining bolts and nuts.

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

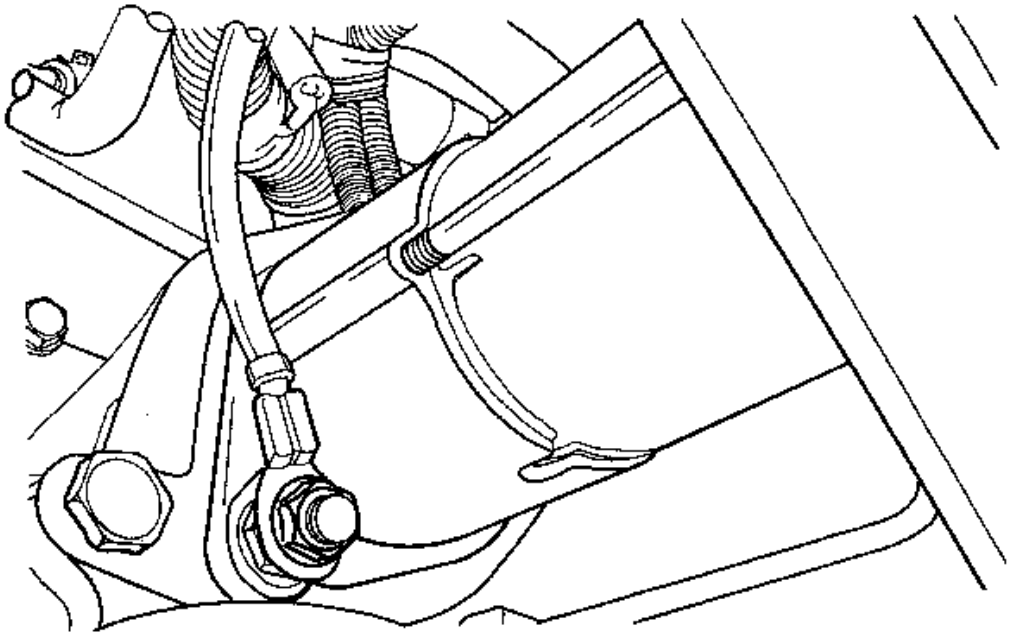


Fig. 123: View Of Transaxle Torque Converter Bolt
Courtesy of GENERAL MOTORS CORP.

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

   Tighten: Tighten the transaxle torque converter bolts to **60 N.m (44 lb ft)** .

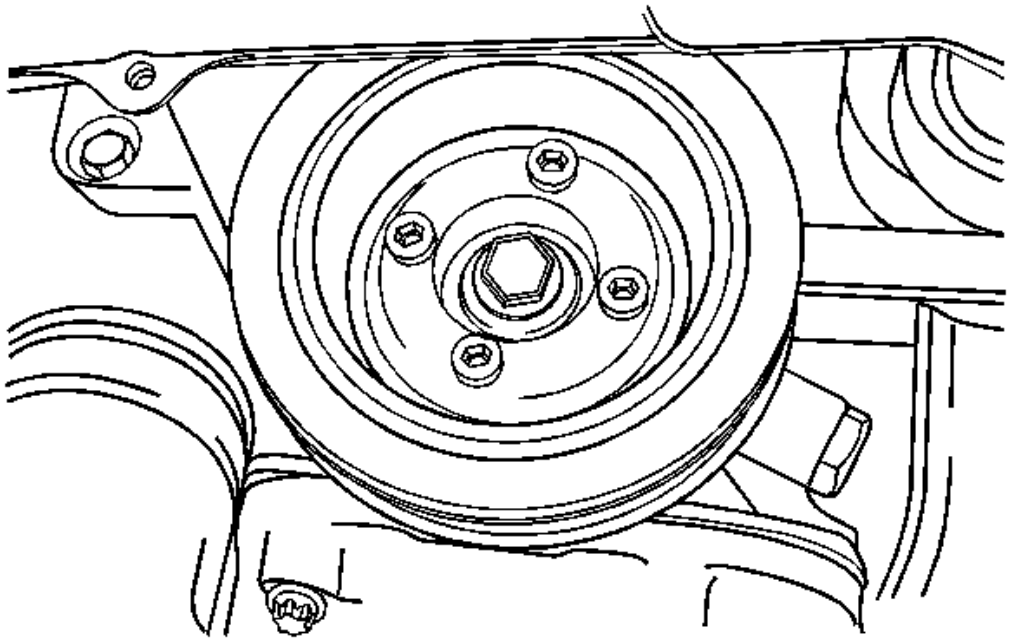


Fig. 124: View Of Crankshaft Pulley And Bolts
Courtesy of GENERAL MOTORS CORP.

10. Connect the vacuum lines at the charcoal canister purge solenoid.
11. Connect the electrical connector to the charcoal canister purge and the EGR solenoid.
12. Connect the oil pressure switch connector.
13. Install the crankshaft pulley.
14. Install the crankshaft pulley bolts.

Tighten: Tighten the crankshaft pulley bolts to **20 N.m (15 lb ft)** using a torque wrench.

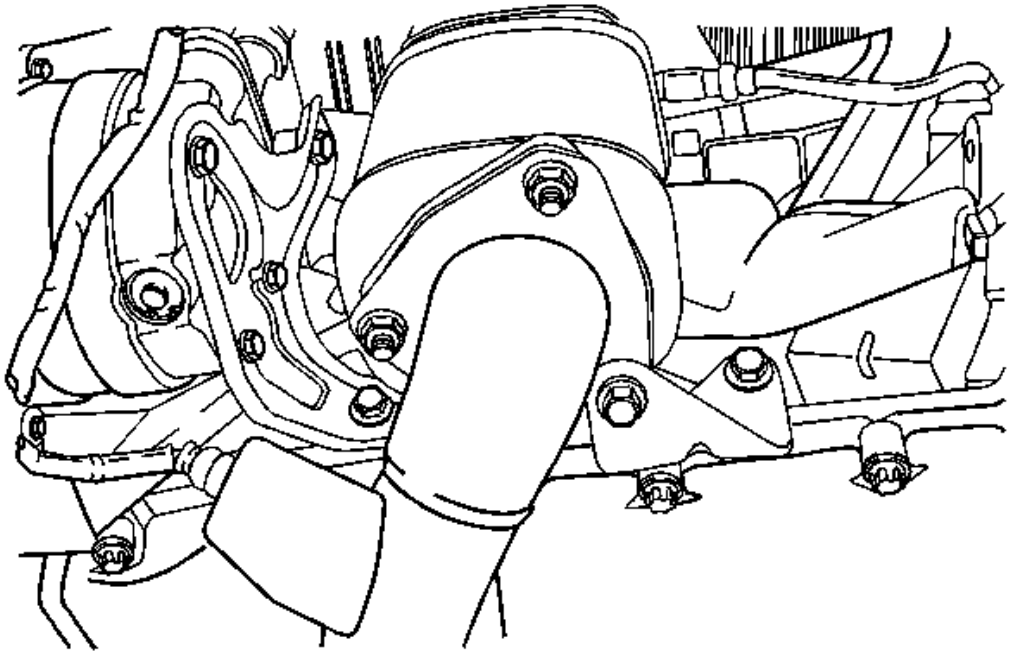


Fig. 125: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

15. Connect the CKP sensor connector.
16. Install the exhaust flex pipe.
17. Install the exhaust flex pipe retaining nuts to the exhaust manifold studs.

Tighten: Tighten the exhaust flex pipe-to-exhaust manifold retaining nuts to **35 N.m (26 lb ft)** .

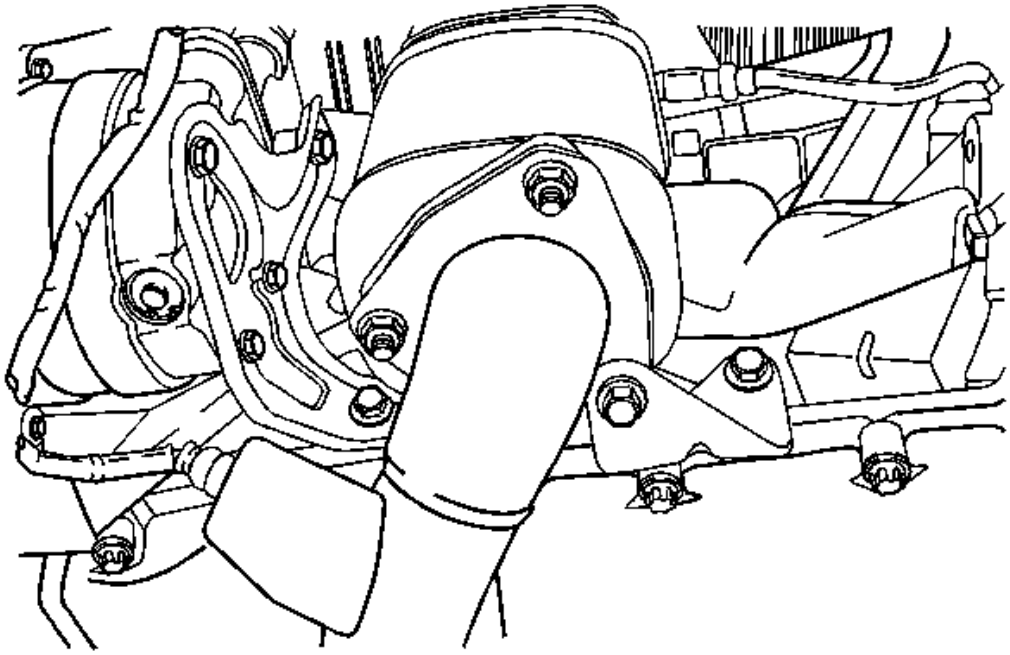


Fig. 126: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

18. Install the exhaust flex pipe retaining nuts to the catalytic converter or the connecting pipe.

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

19. Connect the power steering pressure hose.
20. Connect the power steering return hose.
21. Install the A/C compressor, if equipped. Refer to **Compressor Replacement** in Heating, Ventilation, and Air Conditioning.

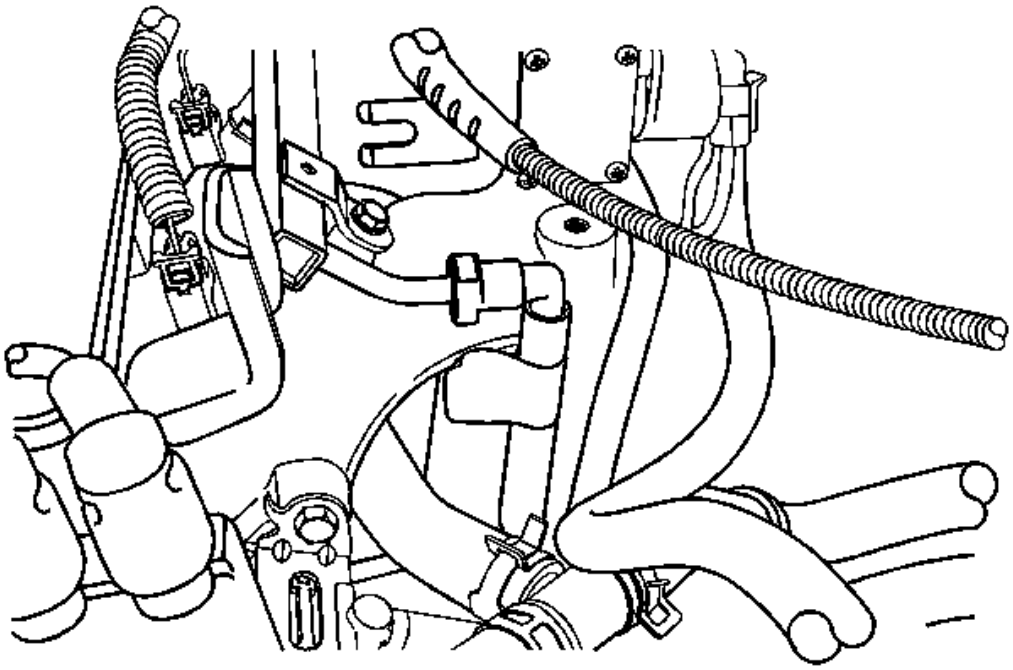


Fig. 127: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS CORP.

22. Install the serpentine accessory drive belt. Refer to **Power Steering Pump Drive Belt Replacement** in Power Steering System.
23. Install the right front wheel well splash shield.
24. Install the right front wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
25. Connect the fuel feed line to the fuel rail.
26. Connect the fuel return line to the fuel rail.
27. Install the fuel rail and injectors as an assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.

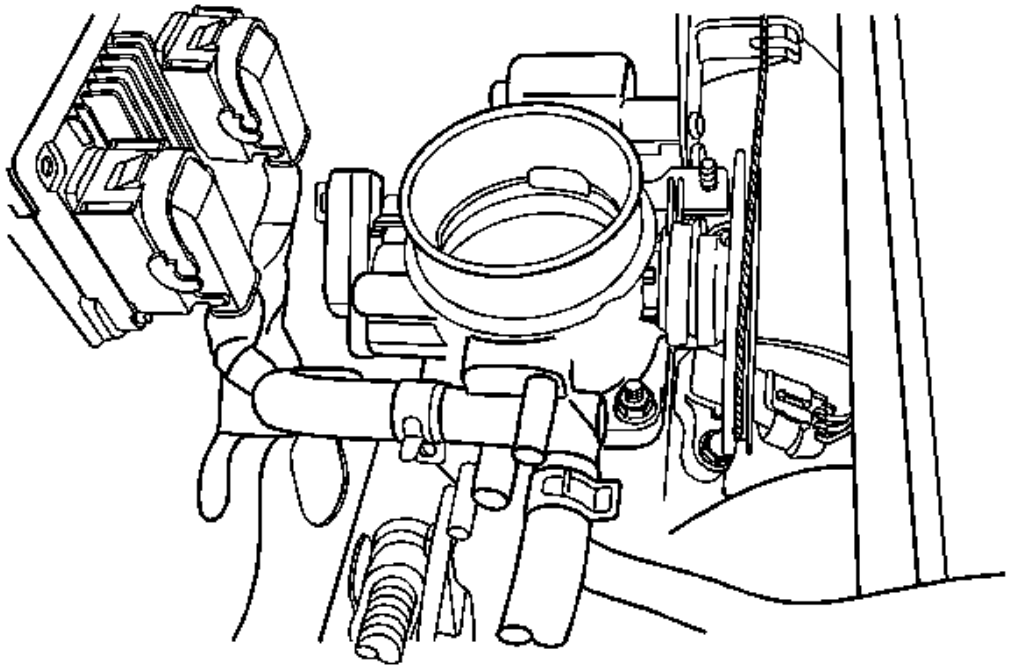


Fig. 128: View Of Throttle Body And Connectors
Courtesy of GENERAL MOTORS CORP.

28. Connect all of the necessary vacuum lines including the brake booster vacuum hose.
29. Connect the O2S connector, if equipped.
30. Connect the starter solenoid "S" terminal wire and power lead.
31. Connect the generator voltage regulator connector.
32. Connect the CTS connector.
33. Connect the ECT sensor connector.
34. Connect the TP sensor connector.
35. Connect the IAC valve connector.
36. Connect the MAP sensor connector.
37. Connect the knock sensor, if necessary.

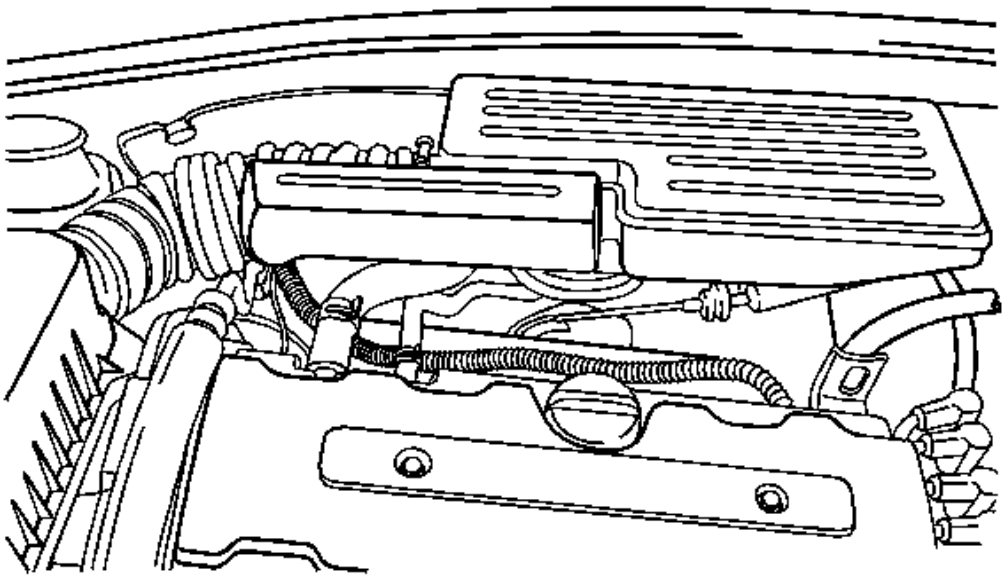


Fig. 129: Locating Intake Air Temperature Sensor (Inside Air Intake Tube)
Courtesy of GENERAL MOTORS CORP.

38. Connect the electrical connector at the DIS ignition coil and the ECM ground terminal and at the starter motor.
39. Install the air cleaner outlet hose between the throttle body and the air cleaner housing.
40. Connect the breather tubes to the camshaft cover.
41. Connect the IAT sensor connector.
42. Install the cooling system radiator and the engine cooling fans. Refer to **Radiator Replacement** in Engine Cooling.

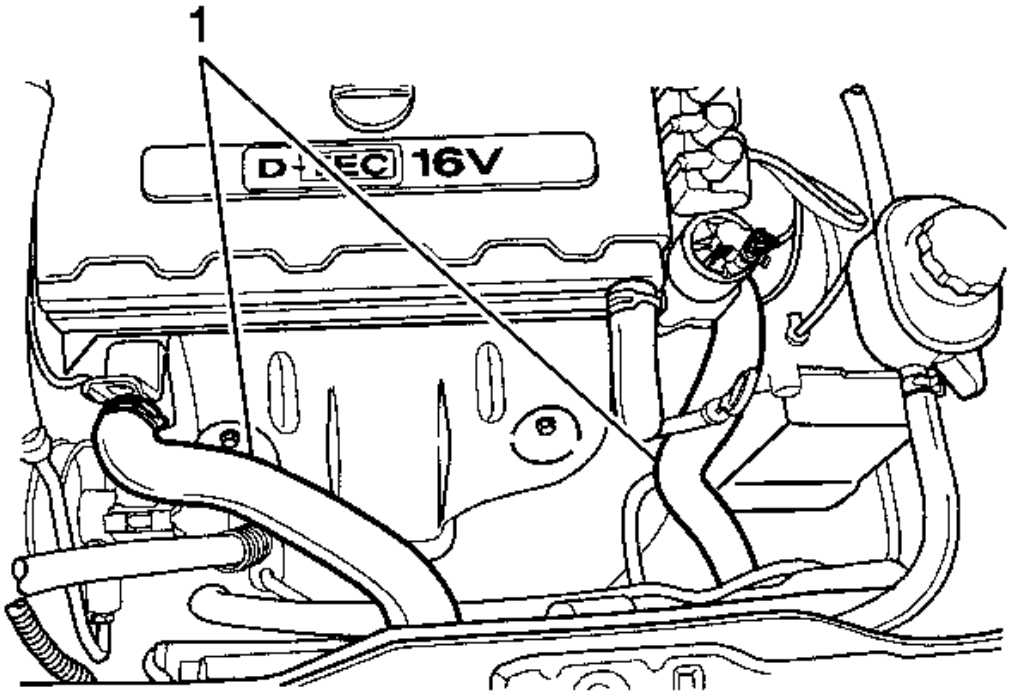


Fig. 130: View Of Heater And Coolant Hoses
Courtesy of GENERAL MOTORS CORP.

43. Connect the lower radiator hose to the coolant pipe.
44. Connect the upper radiator hose to the thermostat housing.
45. Connect the heater inlet hose to the cylinder head.
46. Connect the heater outlet hose to the coolant pipe.
47. Connect the coolant surge tank hose to the coolant pipe.
48. Connect the coolant hose to the throttle body.

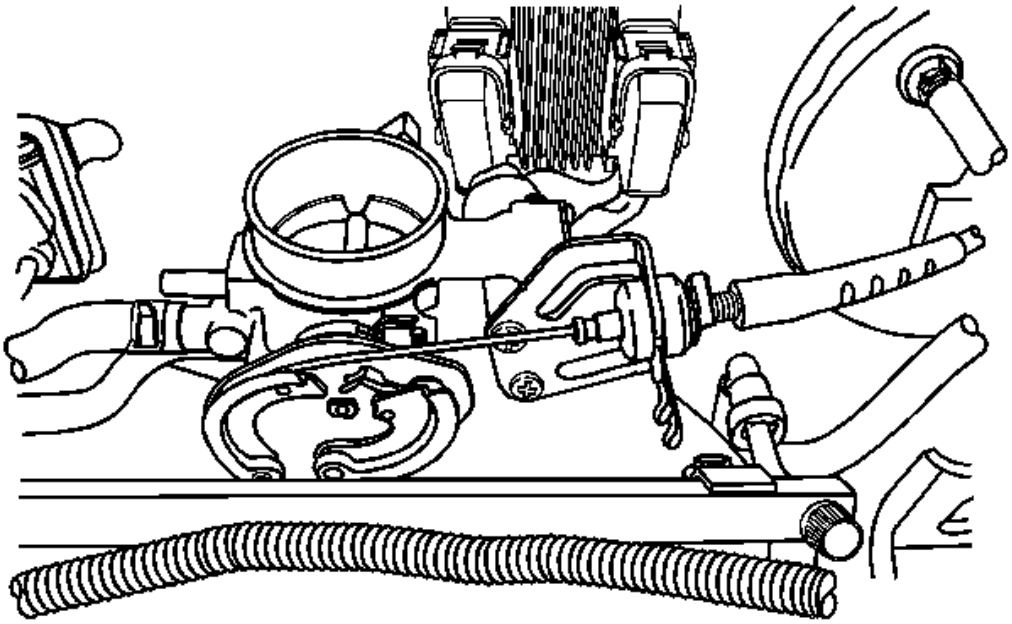


Fig. 131: Identifying Throttle Cable And Components
Courtesy of GENERAL MOTORS CORP.

49. Connect the throttle cable to the throttle body and the intake manifold bracket.
50. Install the fuel pump fuse.
51. Connect the negative battery cable.
52. Refill the engine crankcase with engine oil.
53. Refill the engine coolant system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
54. Bleed the power steering system. Refer to **Bleeding the Power Steering System** in Power Steering System.
55. Refill the A/C refrigerant system, if equipped. Refer to **Refrigerant Recovery and Recharging** in Heating, Ventilation and Air Conditioning.
56. Install the hood. Refer to **Hood Replacement** in Body Front End.

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.

EXHAUST MANIFOLD REMOVAL

Removal Procedure

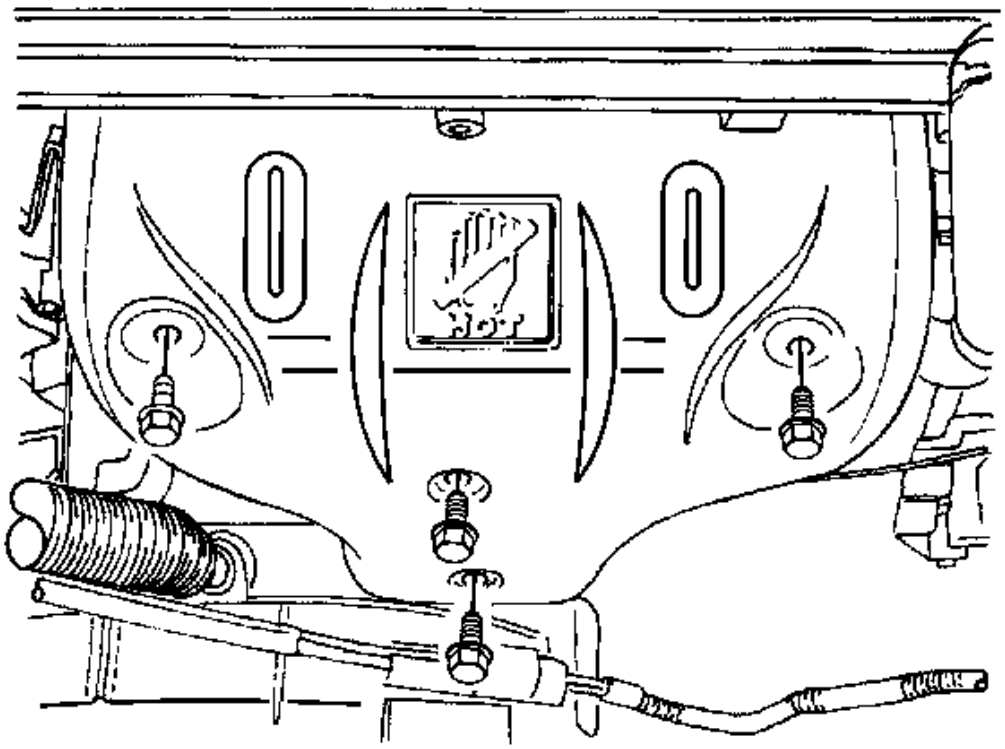


Fig. 132: View Of Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

NOTE: Handle the oxygen sensors carefully in order to prevent damage to the component. Keep the electrical connector and the exhaust inlet end free of contaminants. Do not use cleaning solvents on the sensor. Do not drop or mishandle the sensor.

1. Disconnect the negative battery cable
2. Disconnect the oxygen sensor (O2S) connector, if equipped.
3. Remove the exhaust manifold heat shield bolts.
4. Remove the exhaust manifold heat shield.

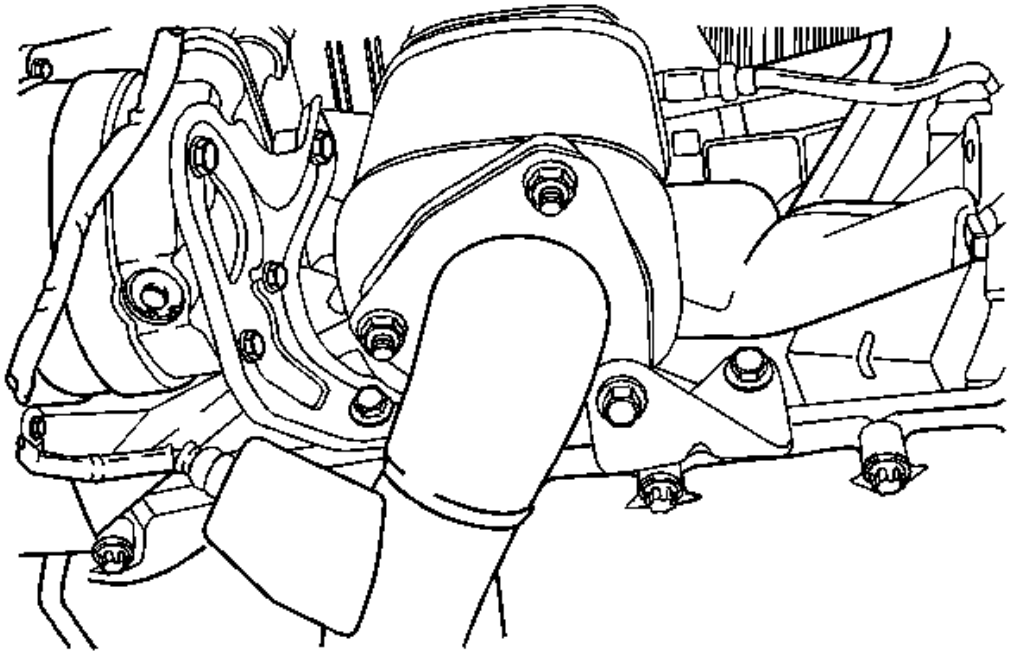


Fig. 133: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust flex pipe retaining nuts from the exhaust manifold studs.

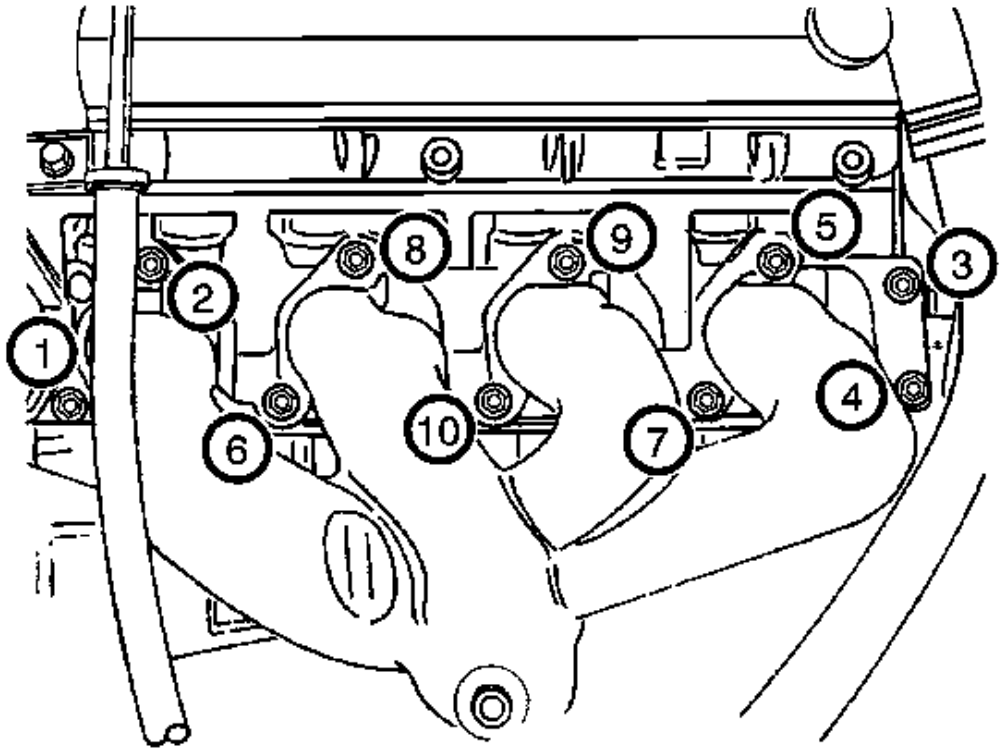


Fig. 134: View Of Exhaust Manifold Retaining Nut Removal Sequence
Courtesy of GENERAL MOTORS CORP.

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

CRANKSHAFT AND BEARINGS CLEANING AND INSPECTION

Tools Required

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

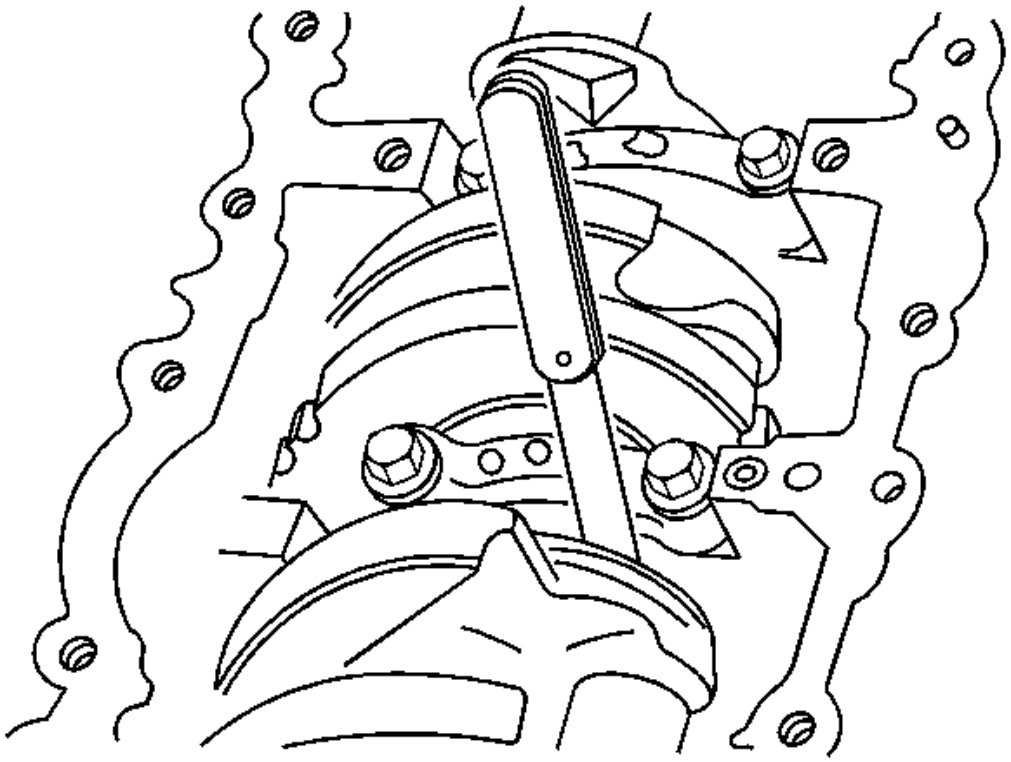


Fig. 135: Checking For Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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

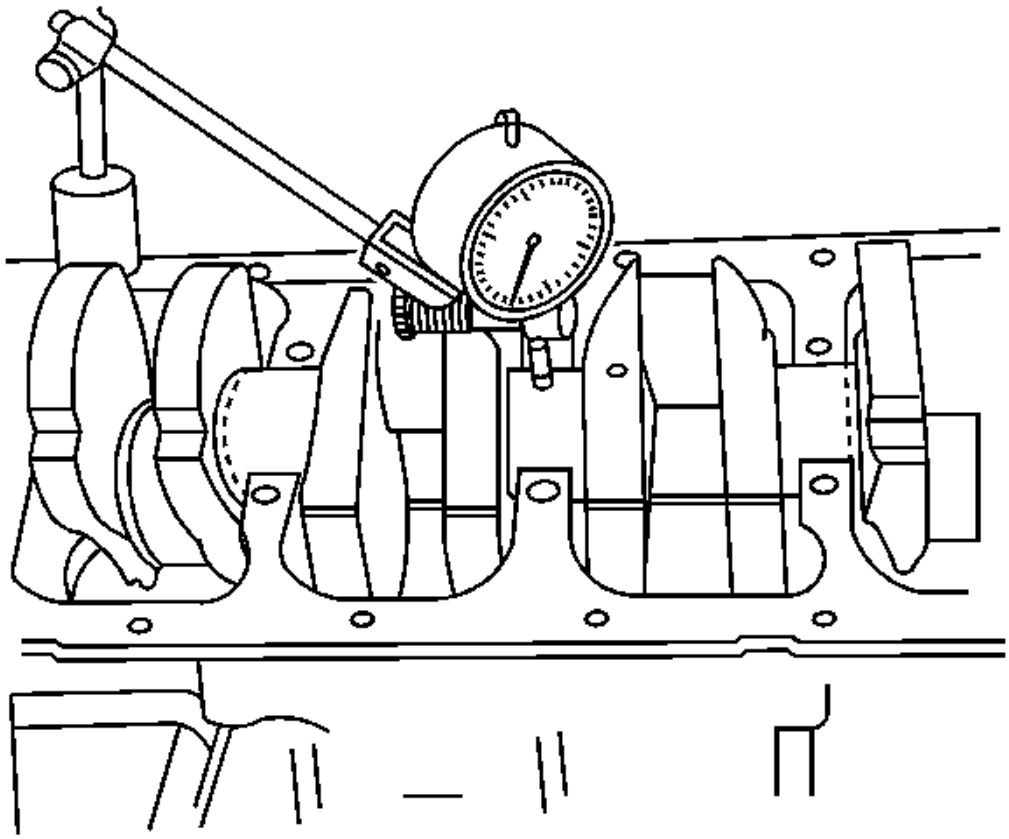


Fig. 136: View Of Middle Crankshaft Journal Runout Check
Courtesy of GENERAL MOTORS CORP.

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**.

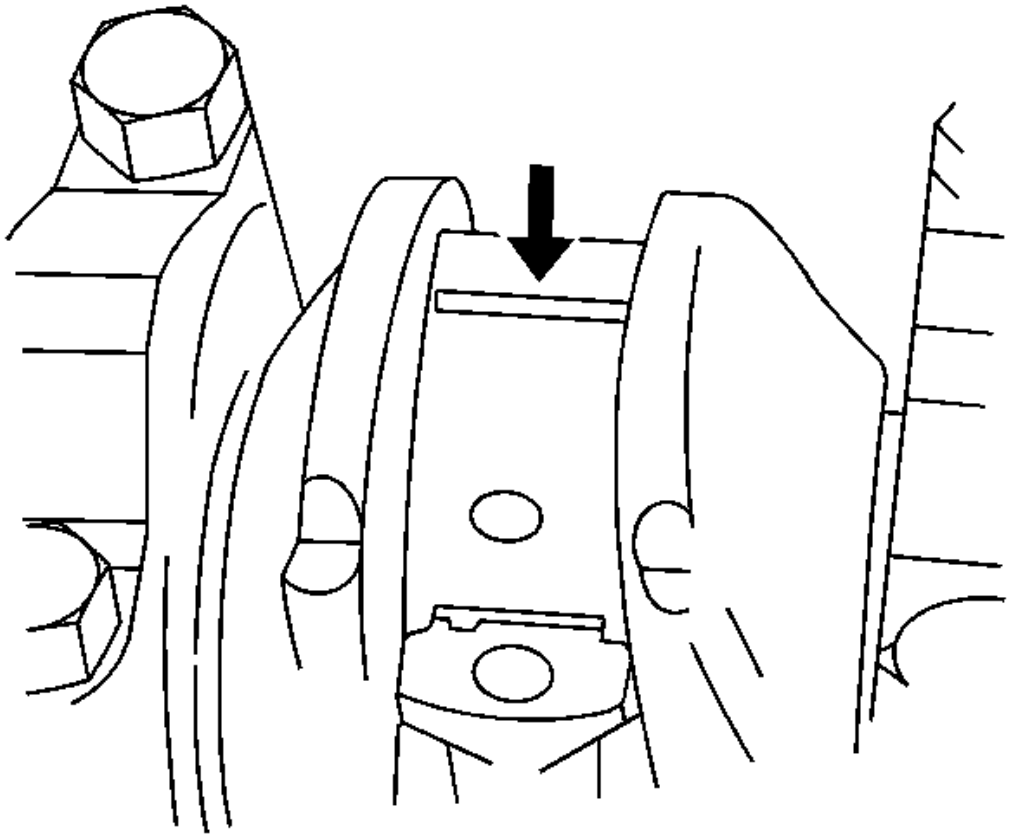


Fig. 137: View Of Plastic Gaging Thread On Bearing
Courtesy of GENERAL MOTORS CORP.

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.

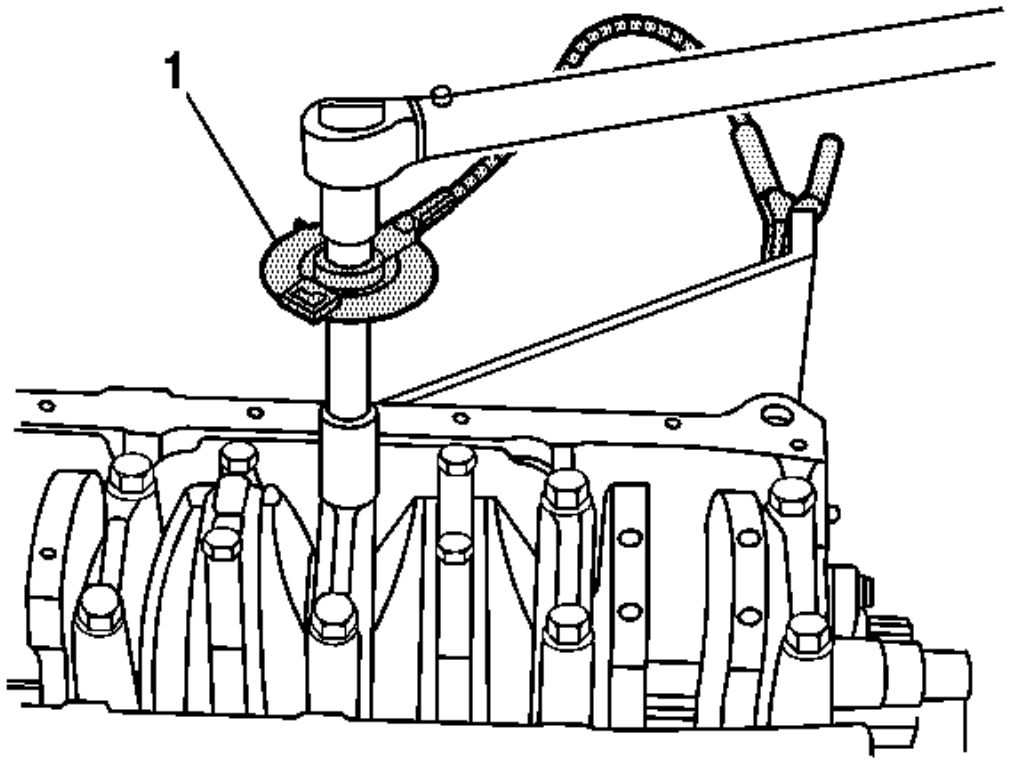


Fig. 138: View Of Torque Wrench And Special Tool
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft bearing caps.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Install the crankshaft bearing cap bolts.

Tighten: Tighten the crankshaft bearing cap bolts to **50 N.m (37 lb ft)** , using the **J 45059** or the **KM-470-B** (1), tighten the crankshaft bearing cap bolts another 45 degrees plus 15 degrees.

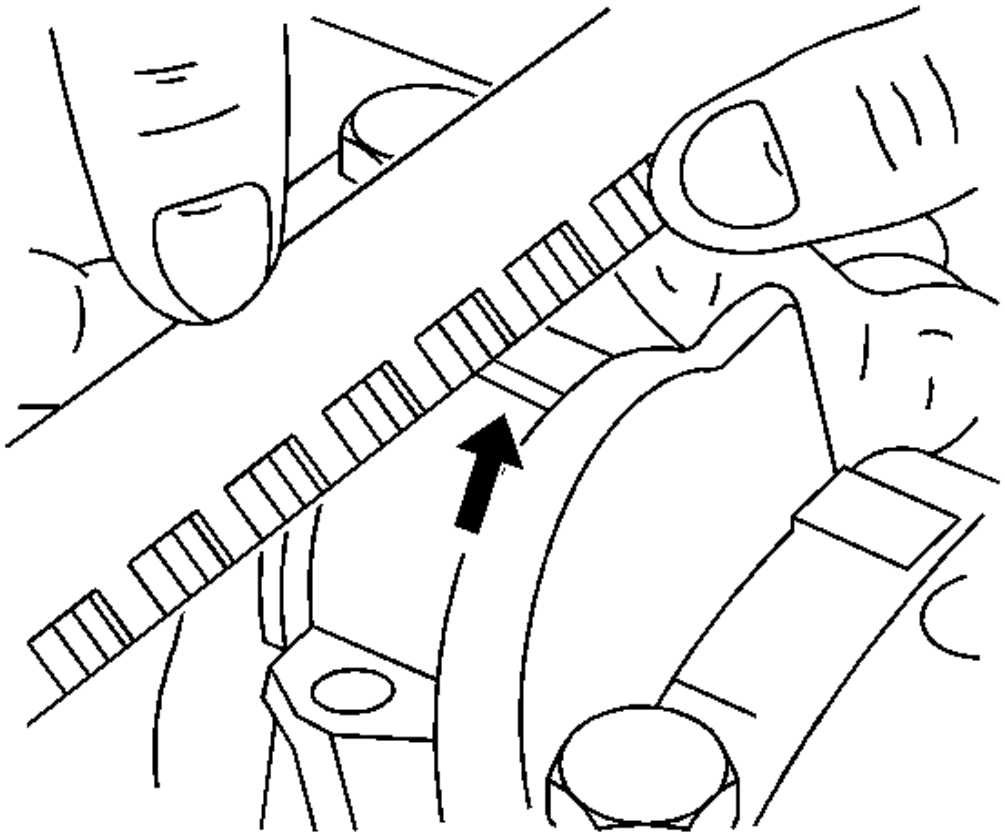


Fig. 139: Measuring Plastic Thread Using Scale
Courtesy of GENERAL MOTORS CORP.

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

CRANKSHAFT REPLACEMENT

Tools Required

- **J 36972** or **KM-635** Crankshaft Rear Oil Seal Installer
- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

- **OTC 1726** Engine Overhaul Stand

Removal Procedure

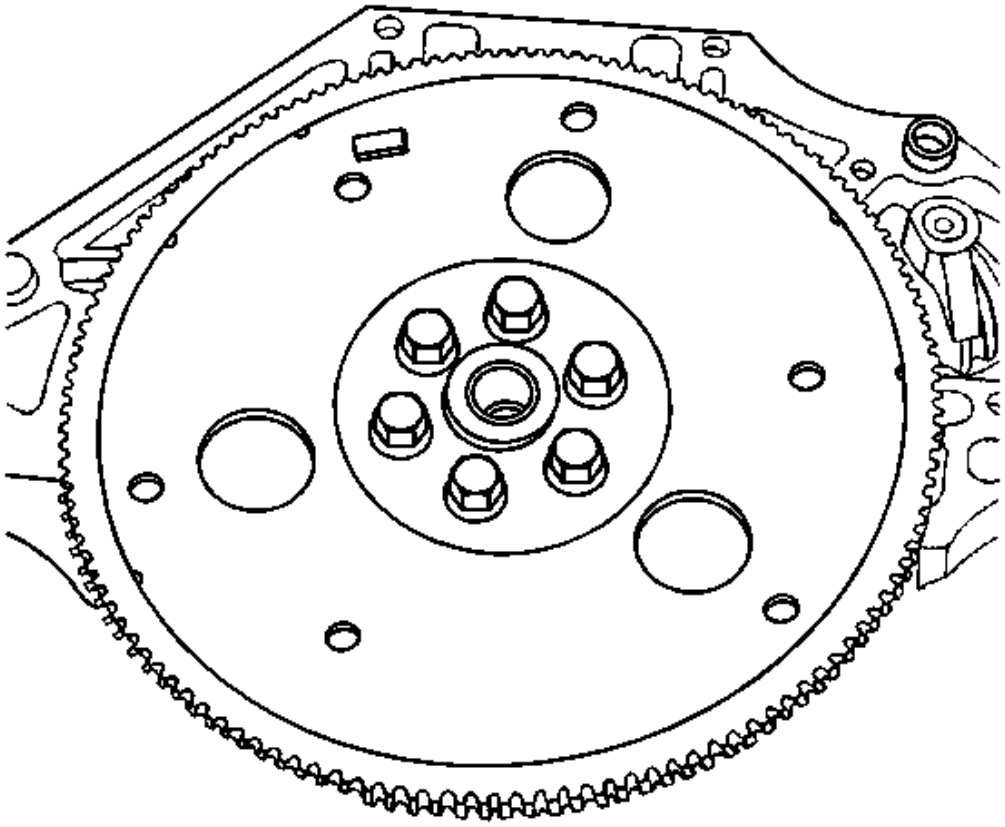


Fig. 140: View Of Flexplate And Bolts
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the engine. Refer to **Engine Replacement**.
2. Remove the flywheel or flexible plate bolts.
3. Remove the flywheel or the flexible plate.

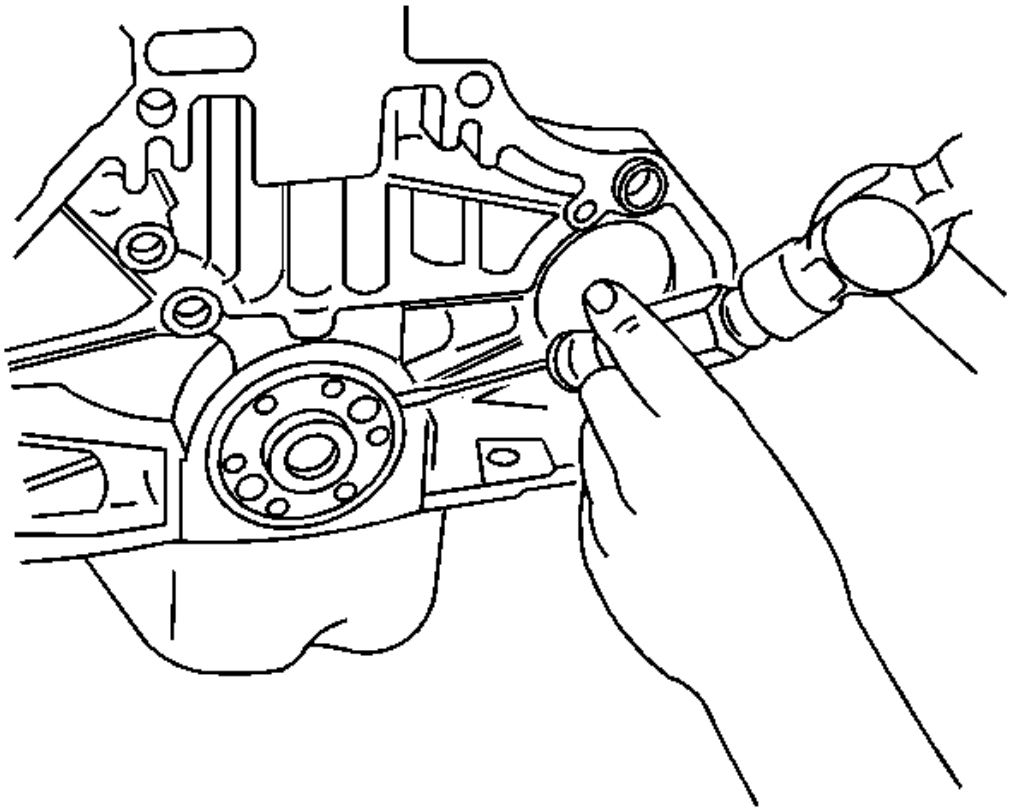


Fig. 141: Identifying Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

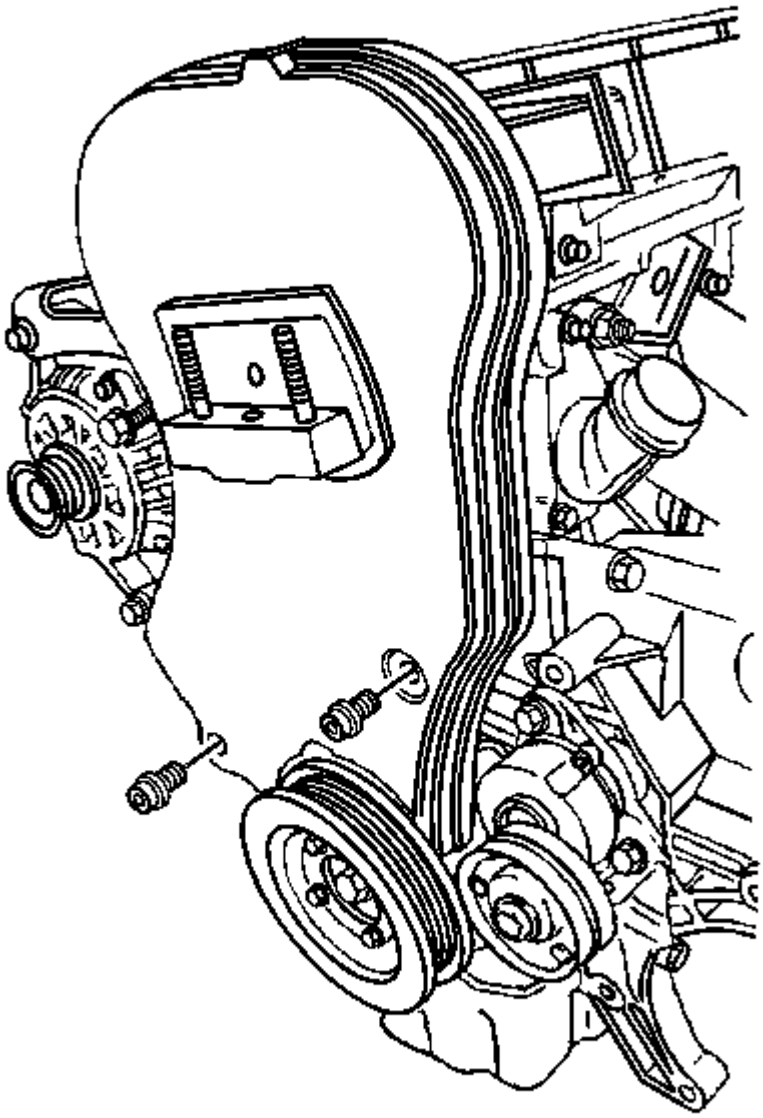


Fig. 142: View Of Front Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the front timing belt cover bolts.
7. Remove the front timing belt cover.
8. Remove the crankshaft pulley bolts.
9. Remove the crankshaft pulley.

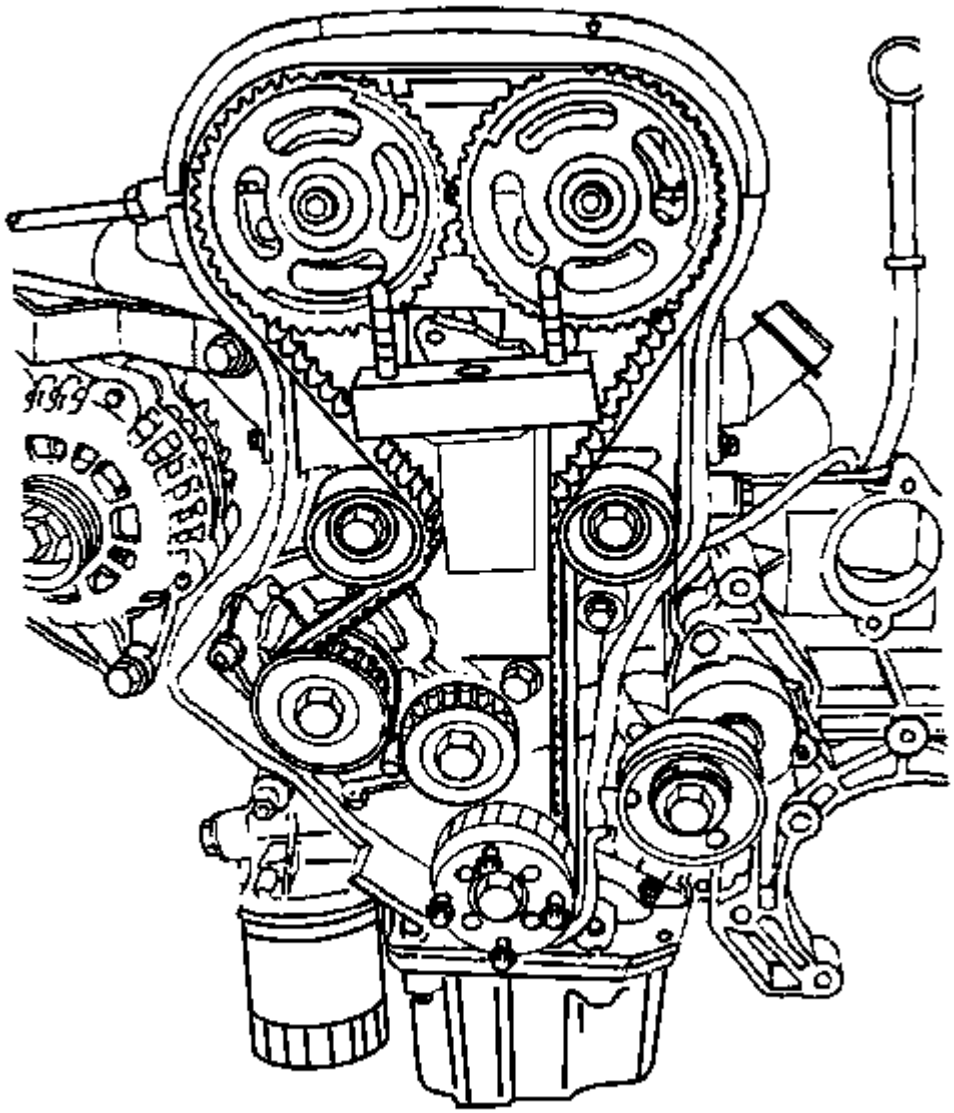


Fig. 143: View Of Timing Belt
Courtesy of GENERAL MOTORS CORP.

10. Loosen the timing belt automatic tensioner bolt.
11. Rotate the timing belt automatic tensioner hex-key clockwise to release the tension.
12. Remove the timing belt idler pulley bolt and nut.
13. Remove the timing belt idler pulleys.

14. Remove the timing belt.
15. Remove the engine mount retaining bolts.
16. Remove the engine mount.

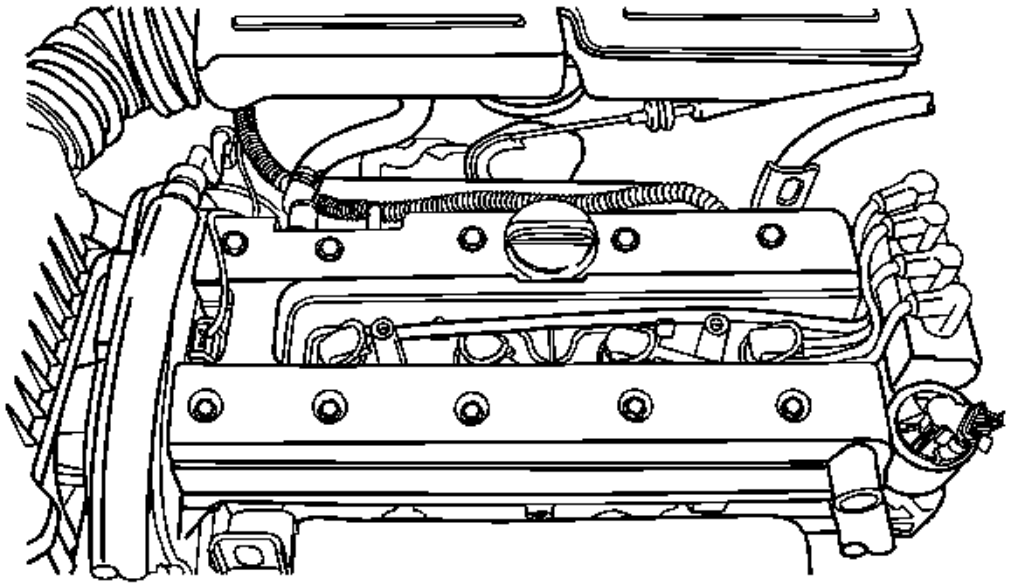


Fig. 144: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the breather tubes from the camshaft cover.
18. Remove the spark plug cover bolts.
19. Remove the spark plug cover.
20. Disconnect the ignition wires from the spark plugs.
21. Remove the camshaft cover bolts.
22. Remove the camshaft cover washers.
23. Remove the camshaft cover and the camshaft cover gasket.

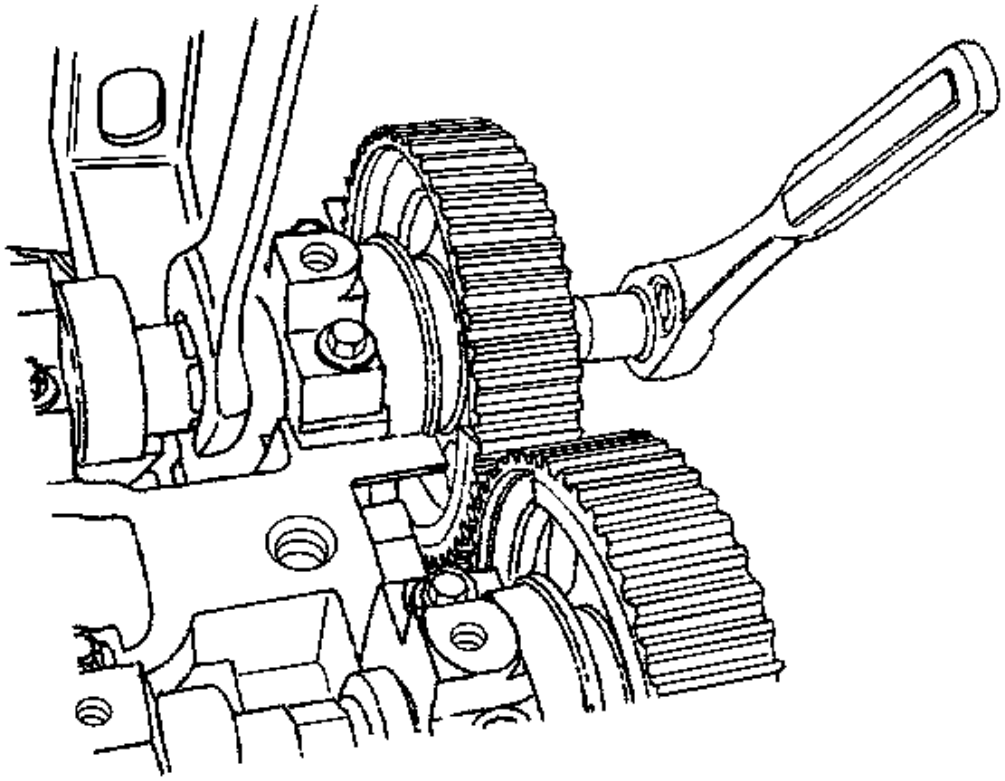


Fig. 145: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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

24. While holding the intake camshaft firmly in place, remove the intake camshaft bolt.
25. Remove the intake camshaft gear.
26. While holding the exhaust camshaft firmly in place, remove the exhaust camshaft bolt.
27. Remove the exhaust camshaft gear.

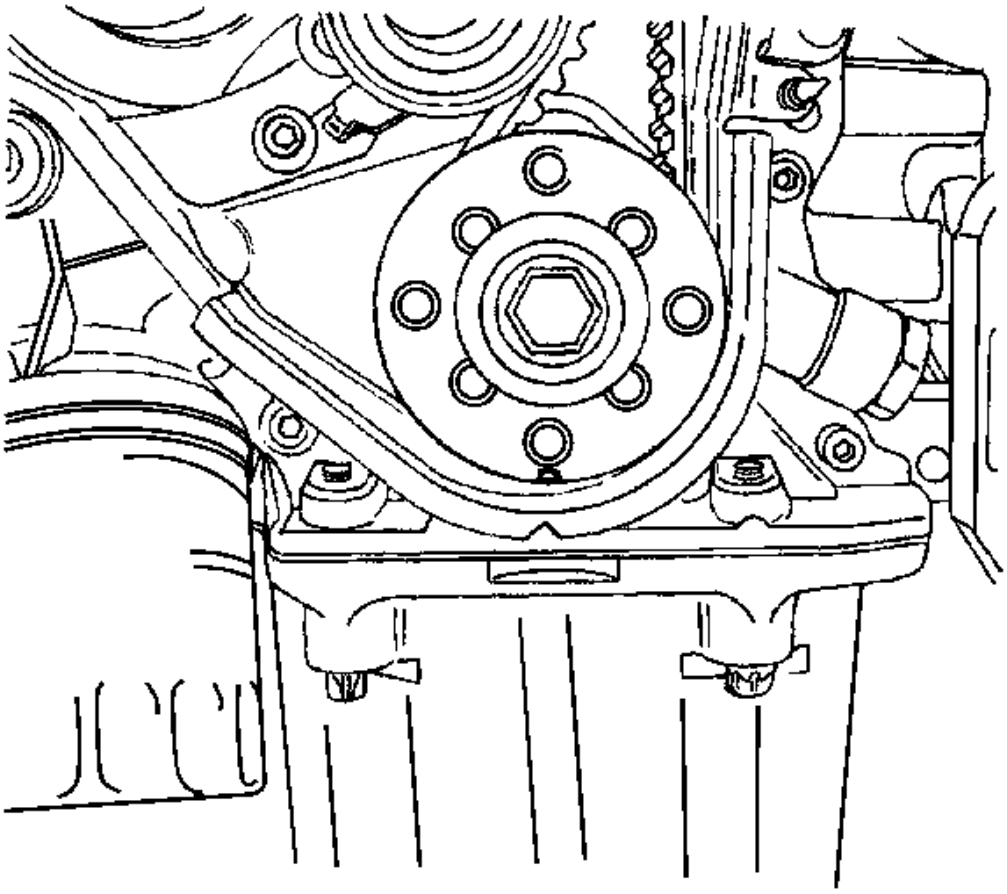


Fig. 146: View Of Crankshaft Gear Bolt And Timing Notch
Courtesy of GENERAL MOTORS CORP.

28. Remove the crankshaft timing belt gear.

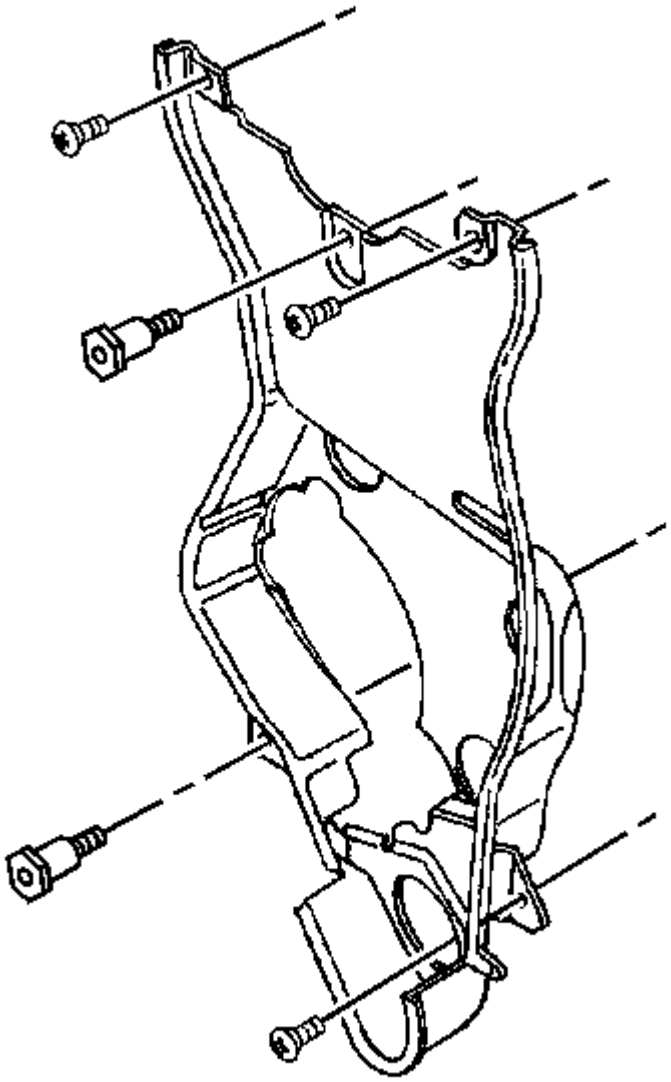


Fig. 147: View Of Rear Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

29. Remove the rear timing belt cover bolts and cover.

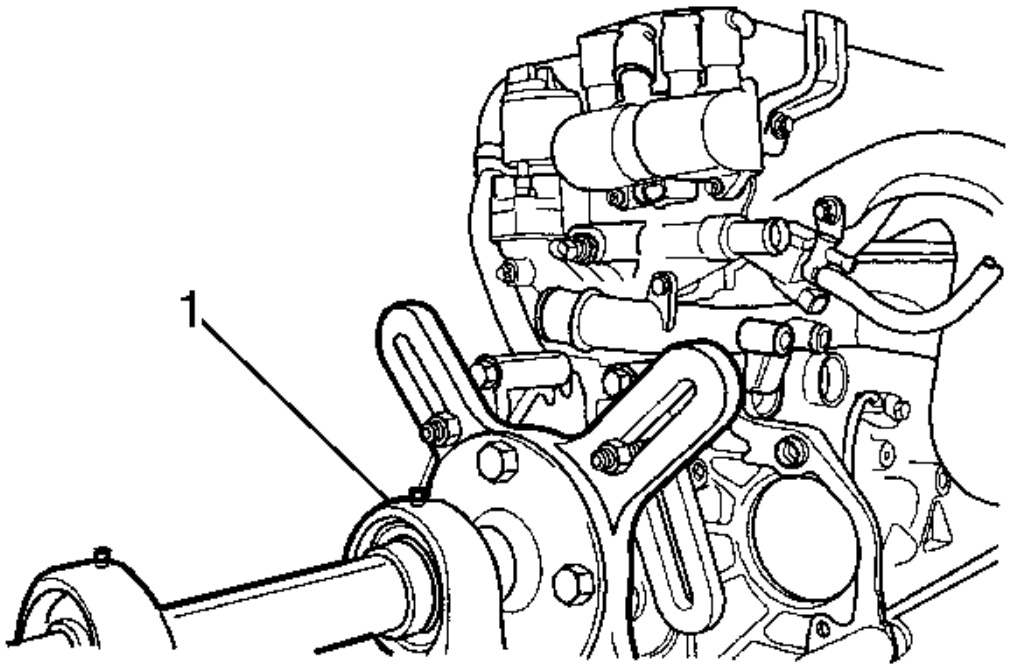


Fig. 148: View Of Engine And OTC 1726
Courtesy of GENERAL MOTORS CORP.

30. Rotate the engine on **OTC 1726** (1).

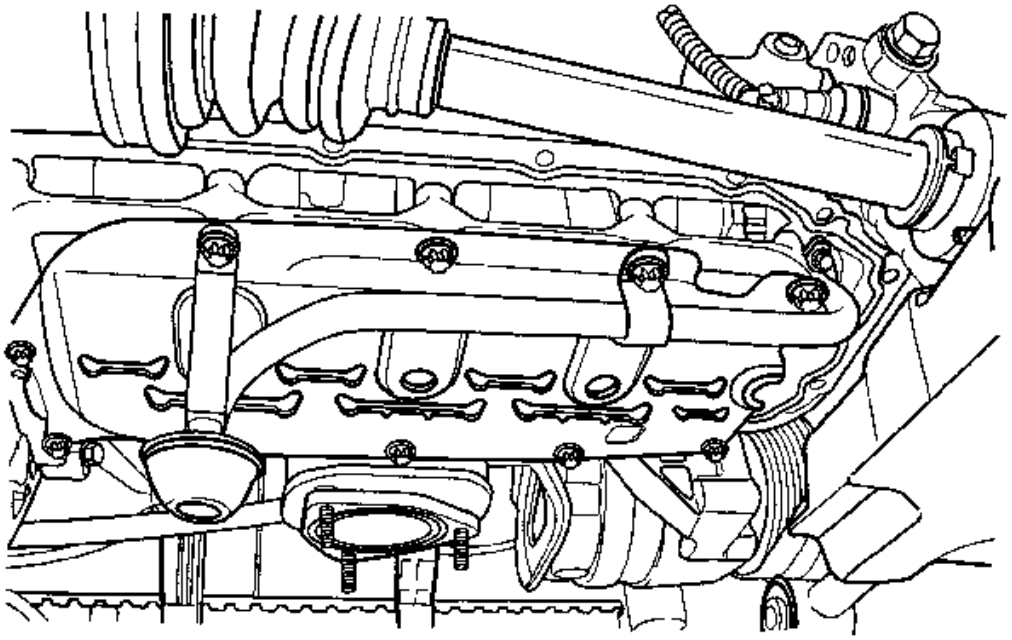


Fig. 149: View Of Oil Suction Pipe, Support Brackets And Bolts
Courtesy of GENERAL MOTORS CORP.

31. Remove the oil pan retaining bolts.
32. Remove the oil pan.
33. Remove the oil suction pipe and support bracket bolts.
34. Remove the oil suction pipe.
35. Remove the crankshaft bearing bridge and oil pan scraper bolts.
36. Remove the oil pan scraper.
37. Remove the crankshaft bearing bridge bolts.
38. Remove the crankshaft bearing bridge.

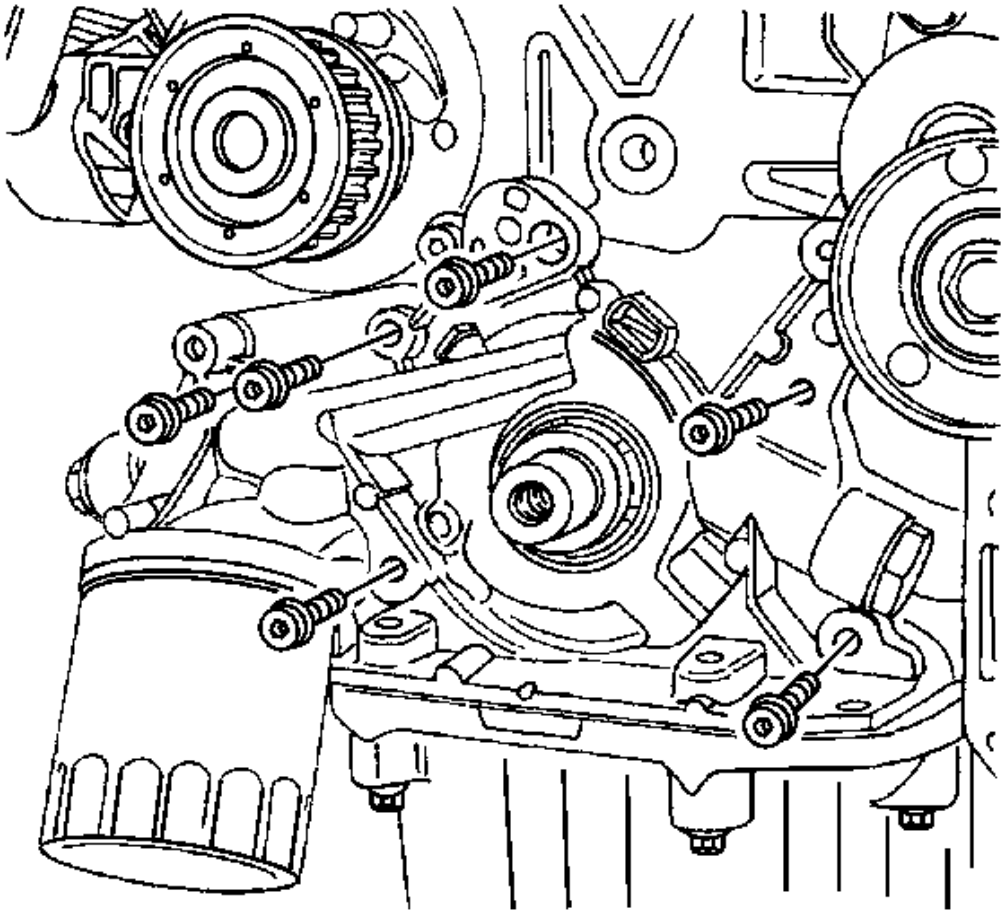


Fig. 150: View Of Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

39. Remove the oil pump retaining bolts.
40. Remove the oil pump.

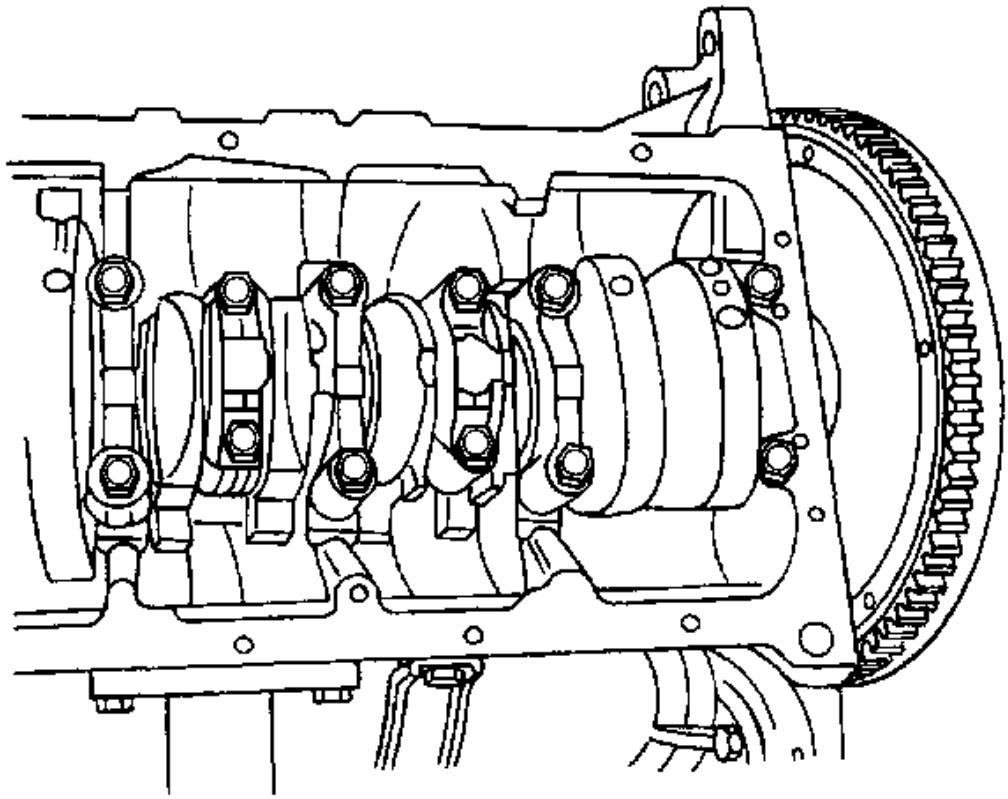


Fig. 151: View Of Connecting Rod Bearing Caps And Bolts
Courtesy of GENERAL MOTORS CORP.

41. Mark the order of the connecting rod bearing caps.
42. Remove the connecting rod bearing cap bolts for all of the pistons.
43. Remove the connecting rod bearing caps and the lower connecting rod bearings.

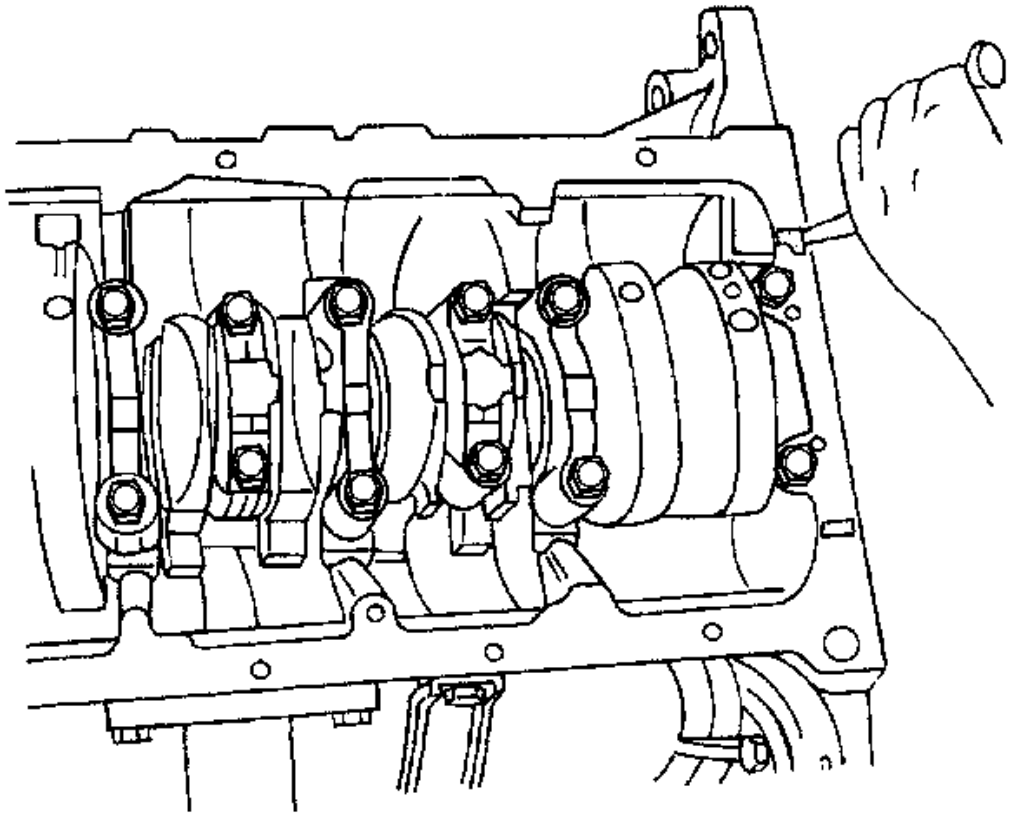


Fig. 152: View Of Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

44. Mark the order of the crankshaft bearing caps.
45. Remove the crankshaft bearing cap bolts.
46. Remove the crankshaft bearing caps and the lower crankshaft bearings.
47. Remove the crankshaft.

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

48. Clean the parts, as needed.

Installation Procedure

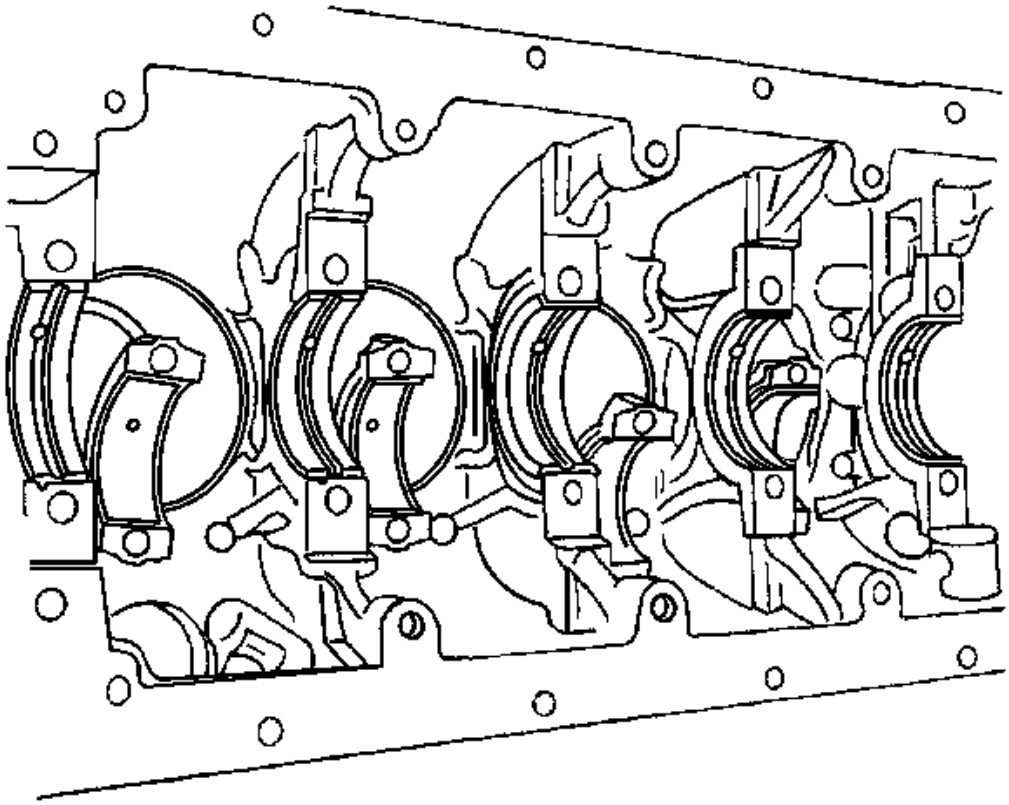


Fig. 153: View Of Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

1. Coat the crankshaft bearings with engine oil.
2. If replacing the crankshaft, transfer the pulse pickup sensor disc to the new crankshaft.

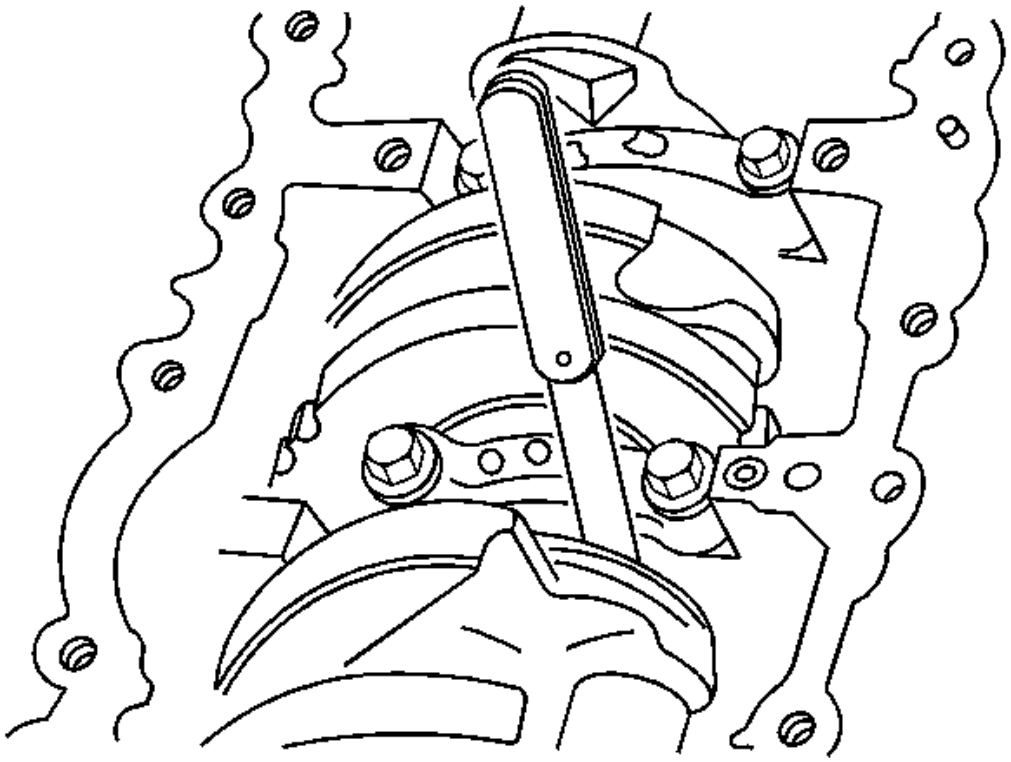


Fig. 154: Checking For Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

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**.

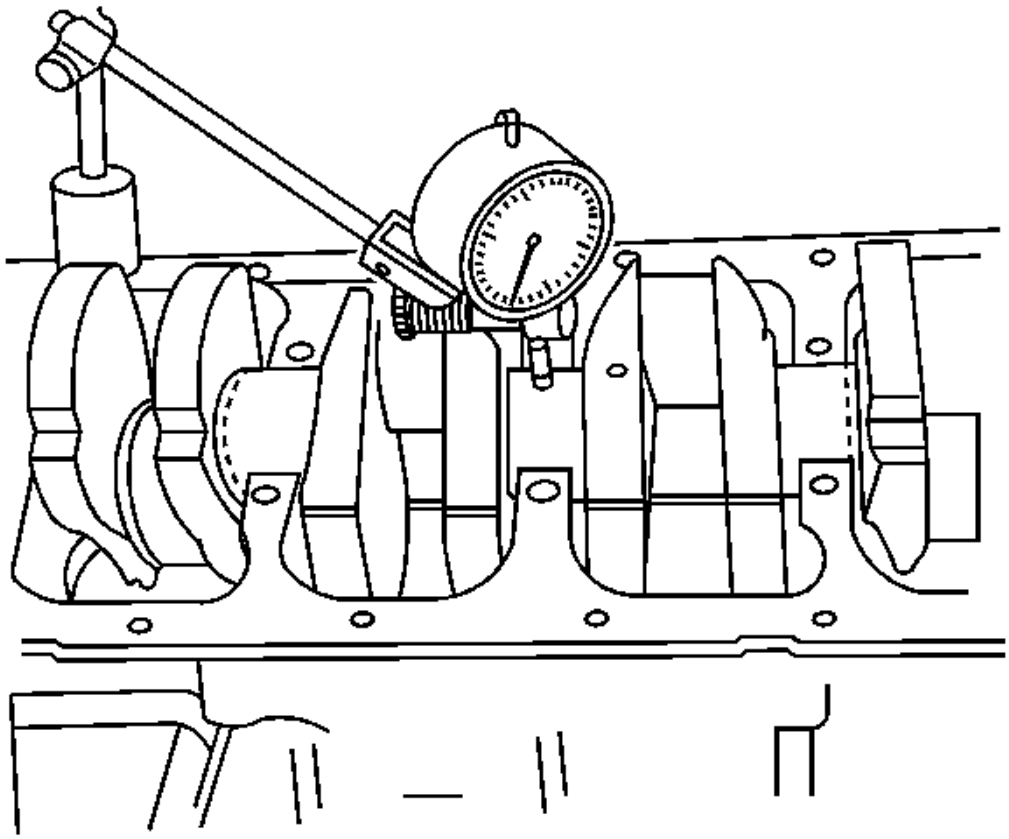


Fig. 155: View Of Middle Crankshaft Journal Runout Check
Courtesy of GENERAL MOTORS CORP.

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**.

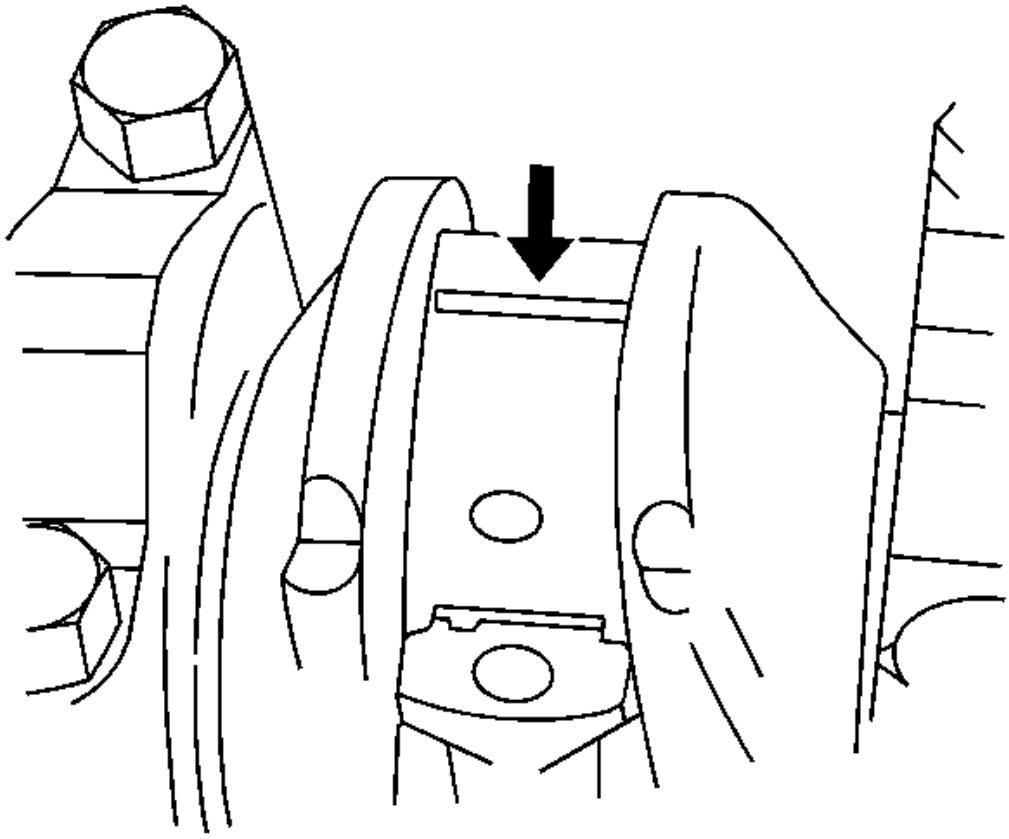


Fig. 156: View Of Plastic Gaging Thread On Bearing
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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 and 15 degrees.

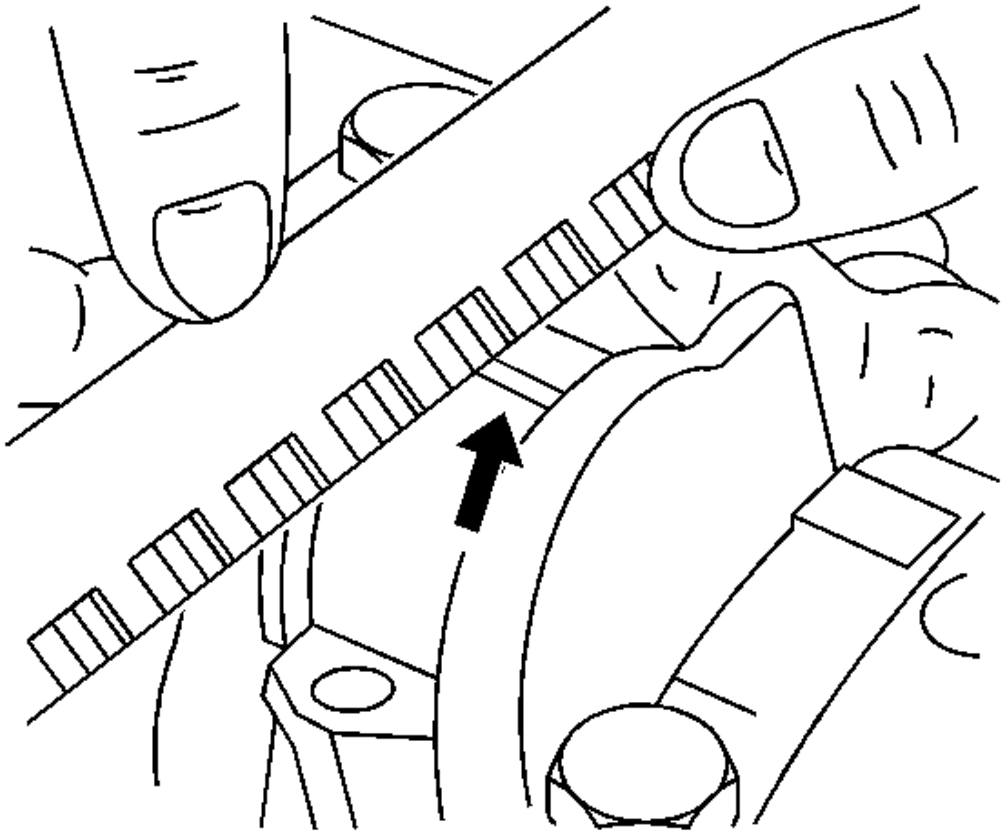


Fig. 157: Measuring Plastic Thread Using Scale
Courtesy of GENERAL MOTORS CORP.

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 of permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

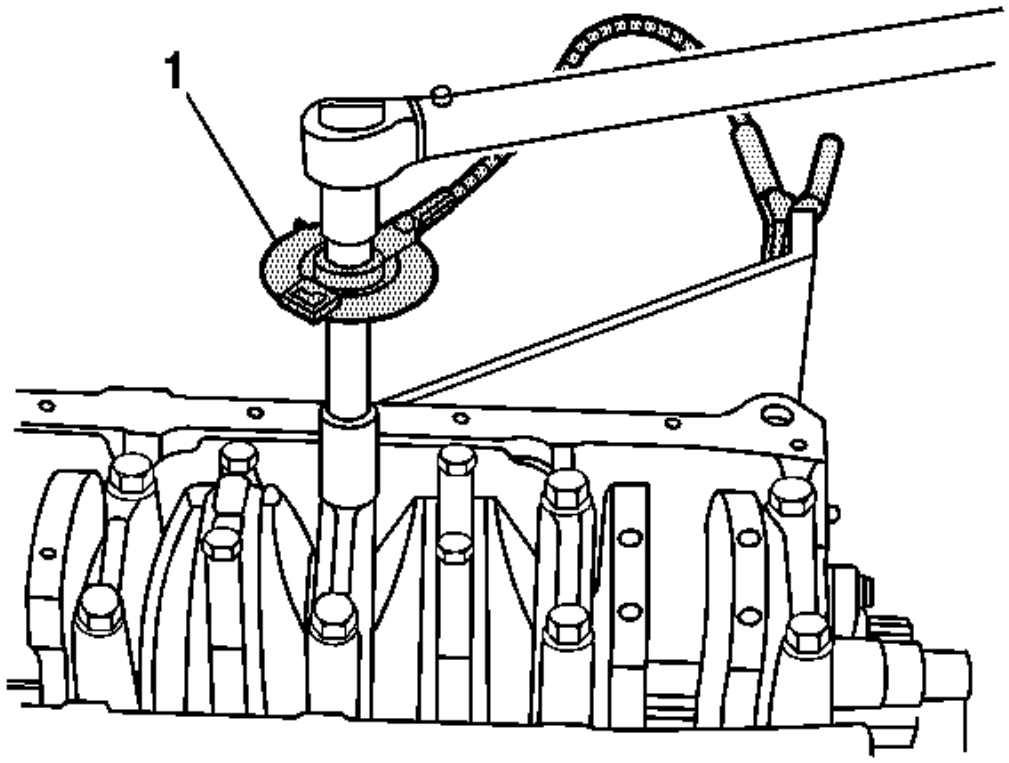


Fig. 158: View Of Torque Wrench And Special Tool
Courtesy of GENERAL MOTORS CORP.

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.

Tighten: Tighten the crankshaft bearing cap bolts to **50 N.m (37 lb ft)** using a torque wrench. Use the **J 45059** or the **KM-470-B** (1) to tighten the crankshaft bearings another 45 degrees and 15 degrees.

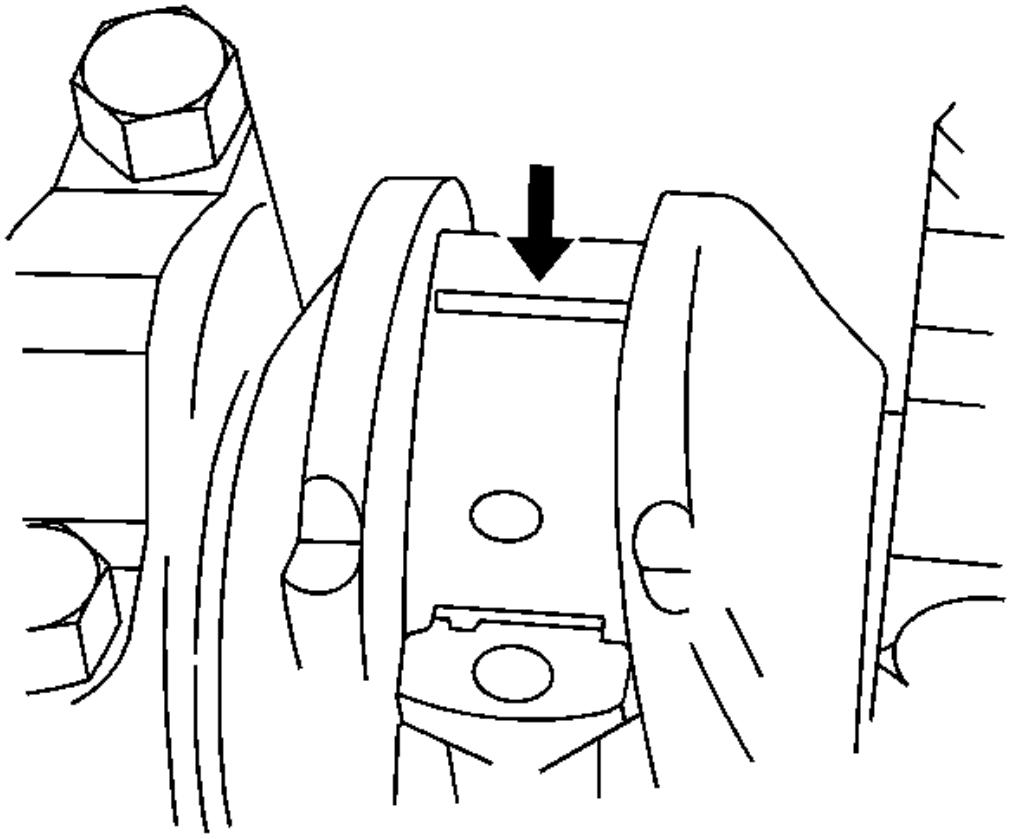


Fig. 159: View Of Plastic Gaging Thread On Bearing
Courtesy of GENERAL MOTORS CORP.

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.

    Tighten: Tighten the connecting rod bearing cap bolts to **35 N.m (26 lb ft)** using a torque wrench. Use the**J 45059** or the **KM-470-B** (1) to tighten the connecting rod bearing cap bolts another 45 degrees plus 15 degrees.

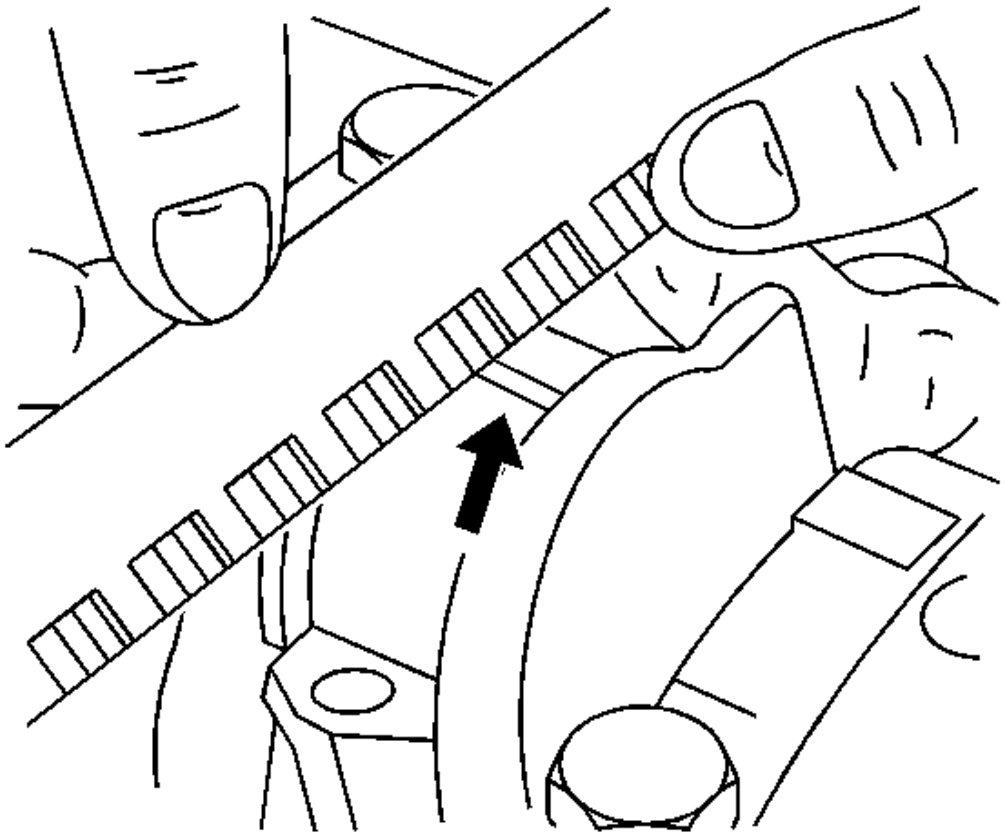


Fig. 160: Measuring Plastic Thread Using Scale
Courtesy of GENERAL MOTORS CORP.

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 gage is available for different tolerance ranges.
22. Inspect the bearing clearance for permissible tolerance ranges. Refer to **Engine Mechanical Specifications**.

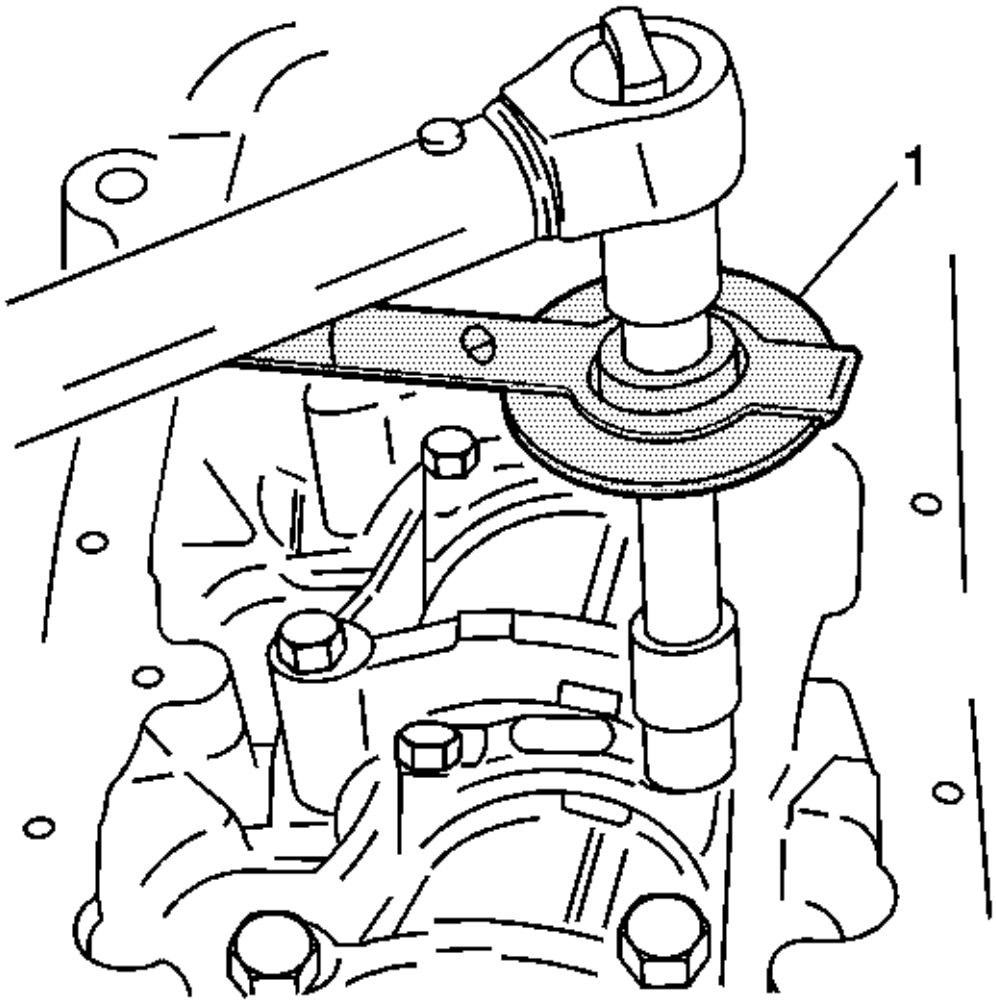


Fig. 161: Tightening Connecting Rod Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

23. Install the connecting rod bearing caps to the connecting rods.
24. Tighten the connecting rod bearing caps using new bolts.

Tighten: Tighten the connecting rod bearing cap bolts to **35 N.m (26 lb ft)** using a torque wrench. Use the**J 45059** or the **KM-470-B** (1) to tighten the connecting rod cap bolts another 45 degrees plus 15 degrees.

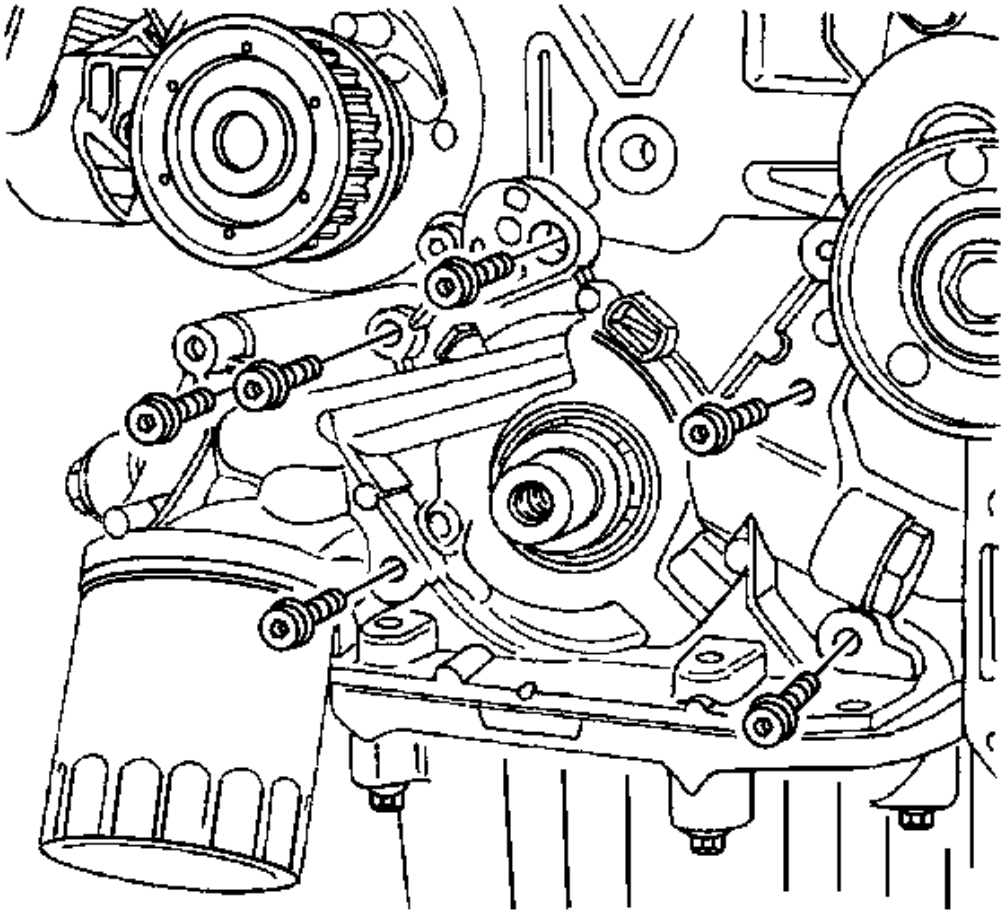


Fig. 162: View Of Oil Pump Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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)** .

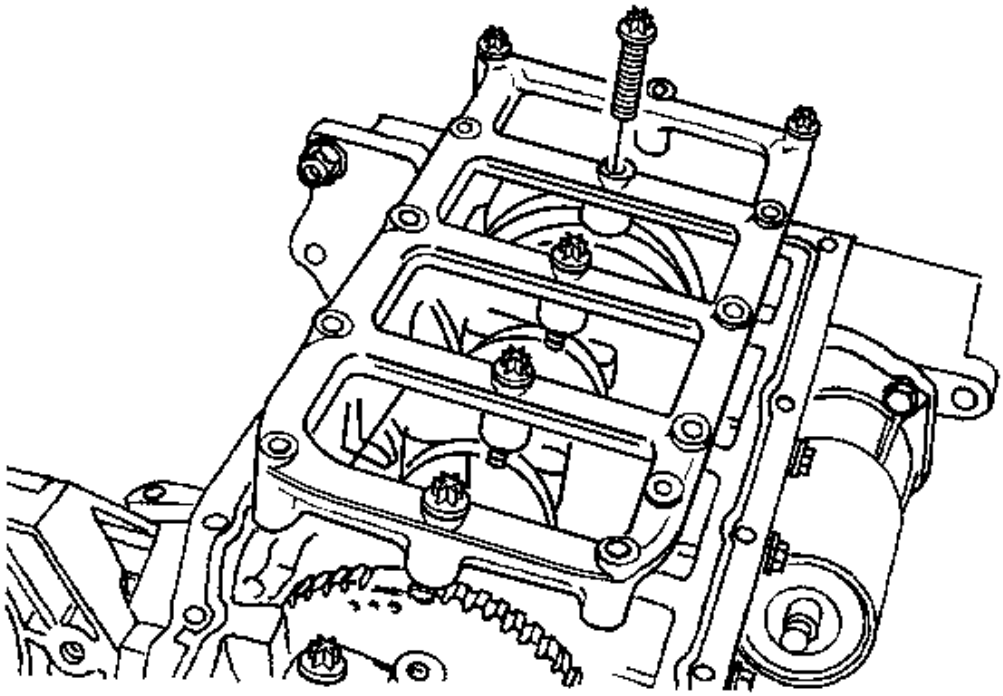


Fig. 163: View Of Crankshaft Bearing Bridge And Bolts
Courtesy of GENERAL MOTORS CORP.

27. Install the crankshaft bearing bridge and bolts.

    Tighten: Tighten the crankshaft bearing bridge bolts to **20 N.m (15 lb ft)** plus 45 degrees using **J 45059** or the **KM-470-B** .

28. Install the crankshaft bearing bridge and oil pan scraper bolts.

    Tighten: Tighten the crankshaft bearing bridge and oil scraper bolts to **20 N.m (15 lb ft)** plus 45 degrees using **J 45059** .

29. Install the oil suction pipe.
30. Install the oil suction pipe and support bracket bolts.

    Tighten: Tighten the oil suction pipe bolts to **8 N.m (81 lb in)** and oil suction pipe support bracket bolt to **6 N.m (53 lb in)** .

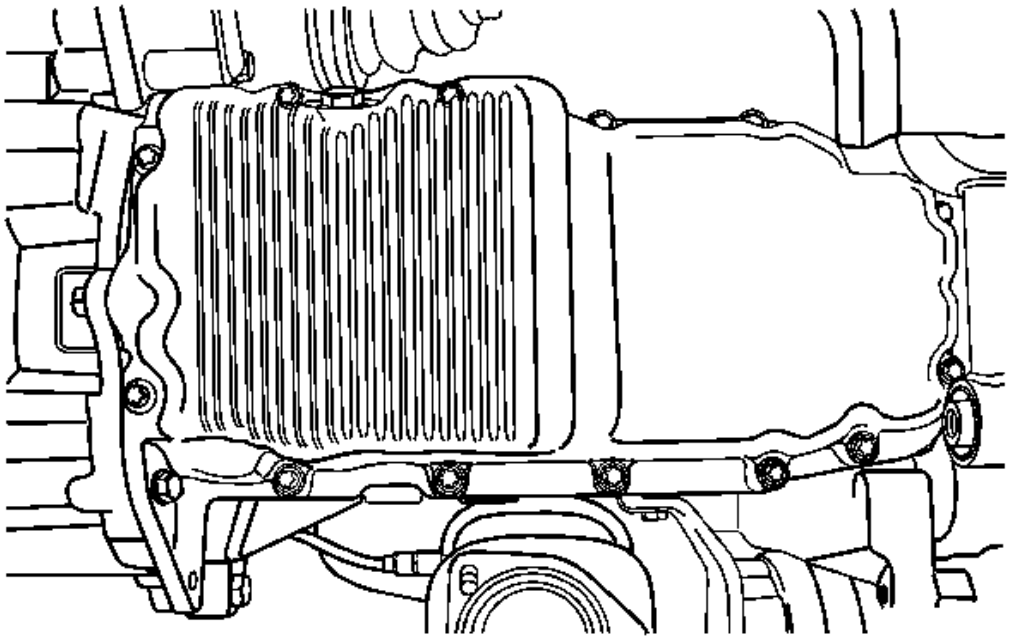


Fig. 164: View Of Oil Pan And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

31. Coat the new oil pan gasket with sealant.
32. Install the oil pan gasket to the oil pan.
33. Install the oil pan.
34. Install the oil pan retaining bolts.

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

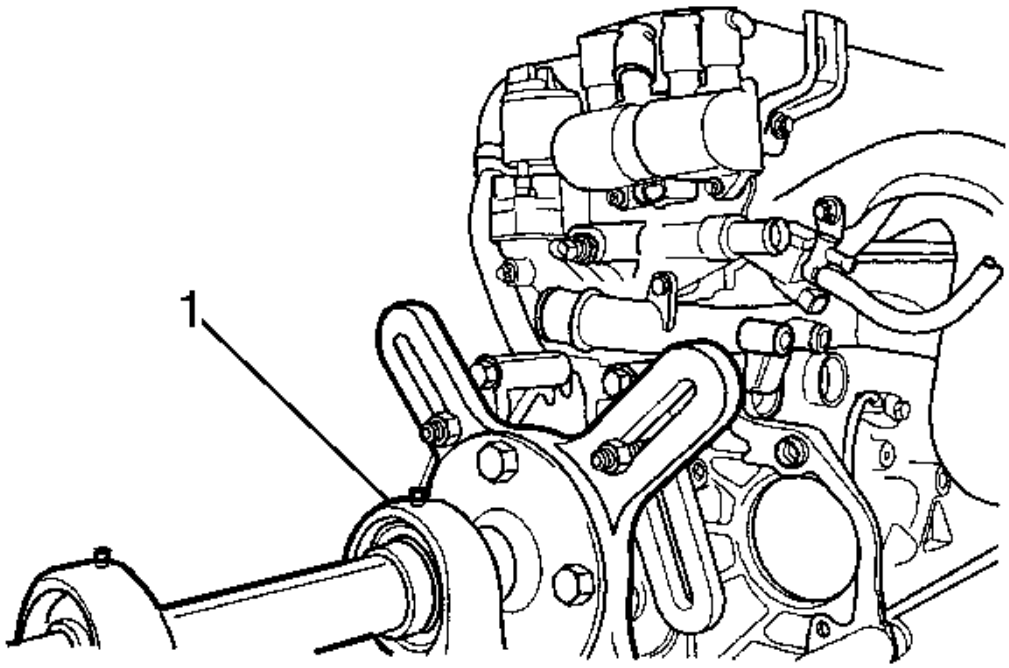


Fig. 165: View Of Engine And OTC 1726
Courtesy of GENERAL MOTORS CORP.

35. Rotate the engine on the **OTC 1726** (1).

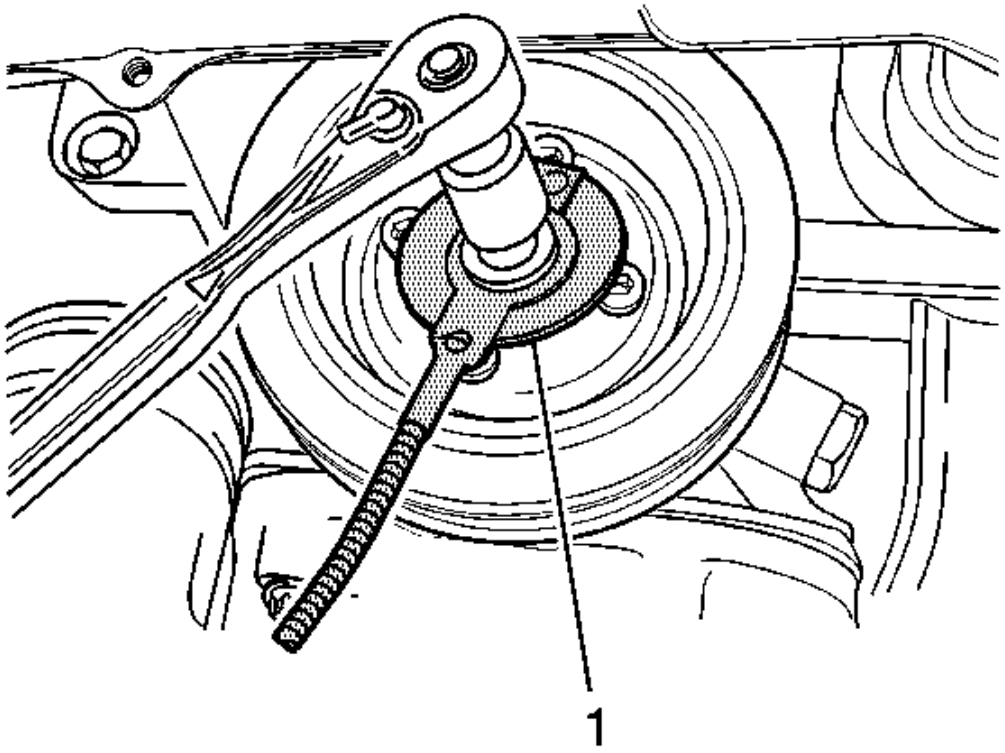


Fig. 166: View Of Crankshaft Gear Bolt Tightening Procedure
Courtesy of GENERAL MOTORS CORP.

36. Install the rear timing belt cover.
37. Install the rear timing belt cover bolts.

    Tighten: Tighten the rear timing belt cover bolts to **7 N.m (62 lb in)** .

38. Install the crankshaft gear and bolt.

    Tighten: Tighten the crankshaft gear bolt to **145 N.m (107 lb ft)** plus 30 degrees plus 15 degrees using **J 45059** or the **KM-470-B** (1).

39. Install the engine mount and retaining bolts.

    Tighten: Tighten the engine mount retaining bolts to **45 N.m (33 lb ft)** .

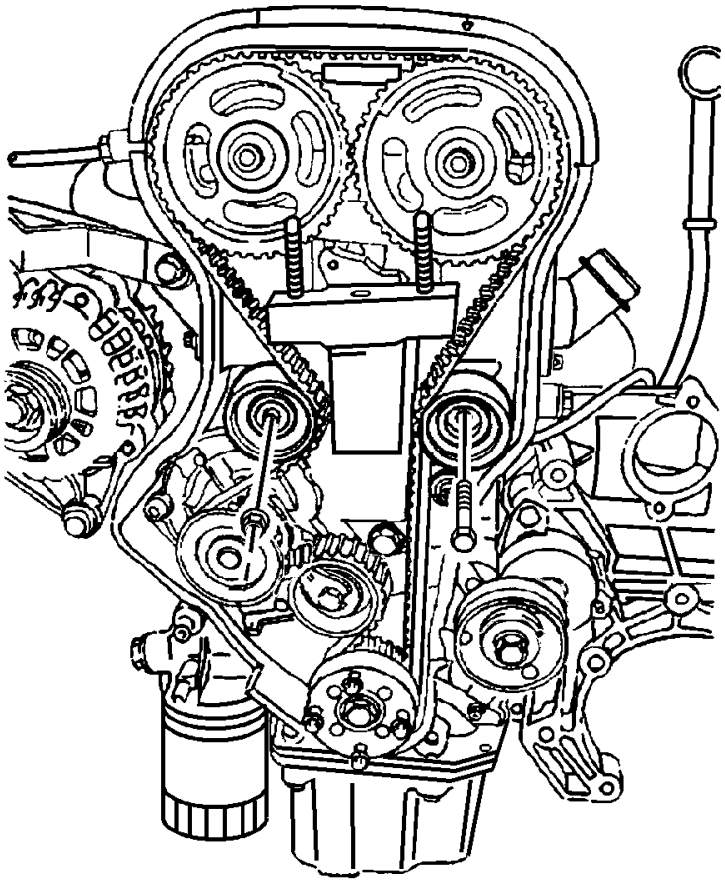


Fig. 167: View Of Timing Belt Idler Pulleys And Bolts
Courtesy of GENERAL MOTORS CORP.

40. Install the timing belt automatic tensioner.
41. Install the timing belt automatic tensioner bolts.

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

42. Install the timing belt idler pulley.
43. Install the timing belt idler pulley bolt and nut.

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

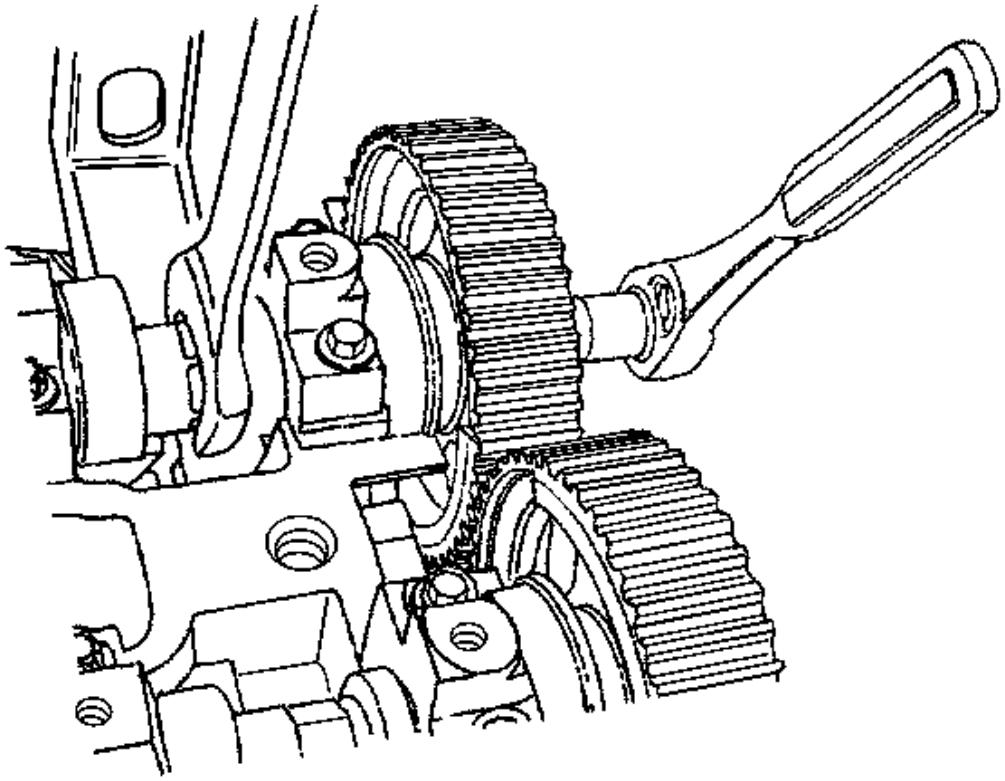


Fig. 168: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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

44. Install the intake camshaft gear.
45. Install the intake camshaft gear bolt while holding the intake camshaft firmly in place.

    Tighten: Tighten the intake camshaft gear bolt to **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees using **J 45059** or the **KM-470-B** .

46. Install the exhaust camshaft gear.
47. Install the exhaust camshaft gear bolt while holding the exhaust camshaft firmly in place.

    Tighten: Tighten the exhaust camshaft gear bolt to **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees using **J 45059** or the **KM-470-B** .

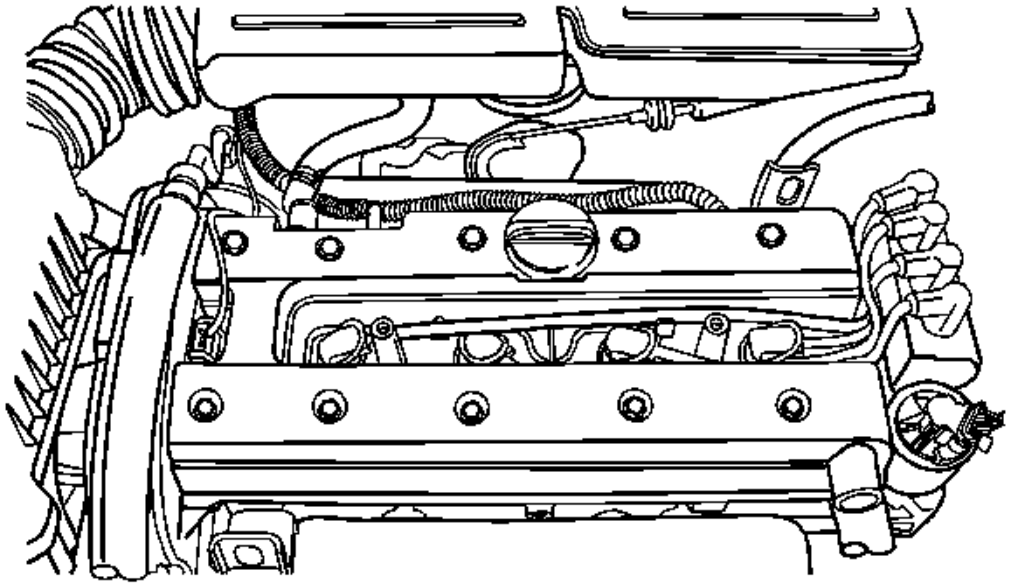


Fig. 169: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

48. Install the timing belt. Refer to **Timing Belt Replacement**.
49. Adjust the timing belt tension. Refer to **Timing Belt Inspection**.
50. 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.
51. Install the camshaft cover and the camshaft cover gasket.
52. Install the camshaft cover washers.
53. Install the camshaft cover bolts.

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

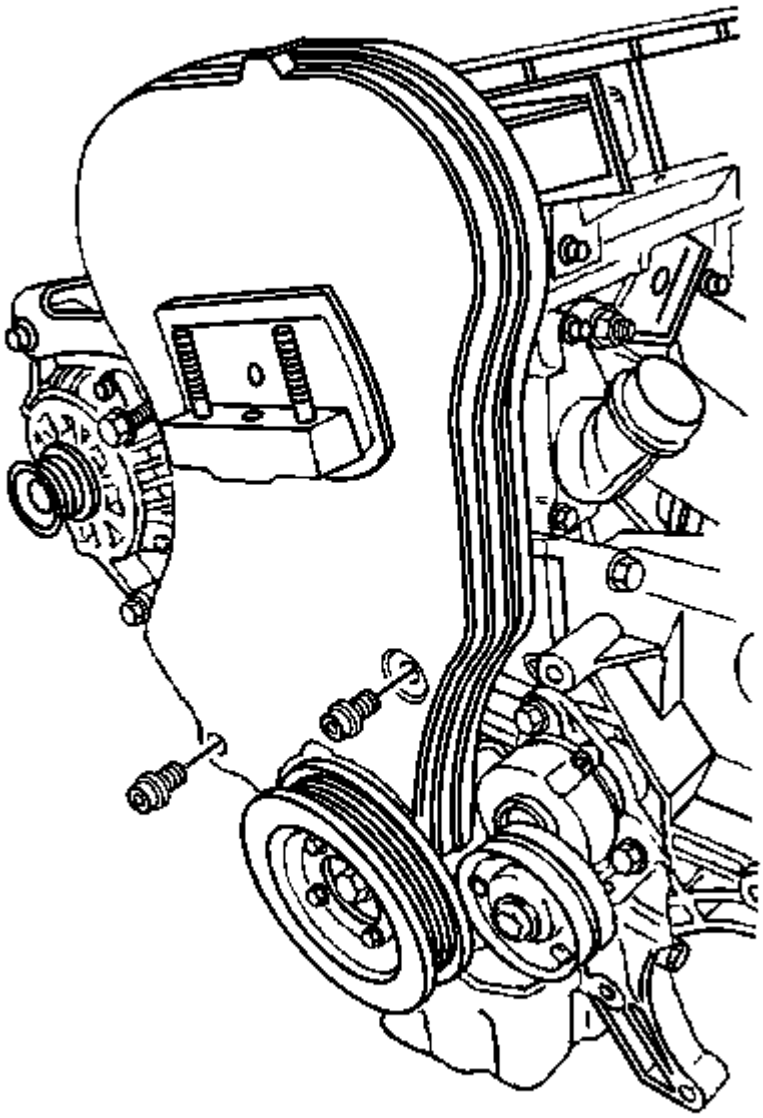


Fig. 170: View Of Front Timing Belt Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

54. Connect the ignition wires to the spark plugs.
55. Install the spark plug cover.
56. Install the spark plug cover bolts.

Tighten: Tighten the spark plug cover bolts to **8 N.m (71 lb in)** .

57. Connect the breather tube to the camshaft cover.
58. Install the front timing belt cover.
59. Install the front timing belt cover bolts.

    Tighten: Tighten the front timing belt cover bolts to **8 N.m (71 lb in)** .

60. Install the engine lifting device.
61. Remove the engine from the **OTC 1726** .

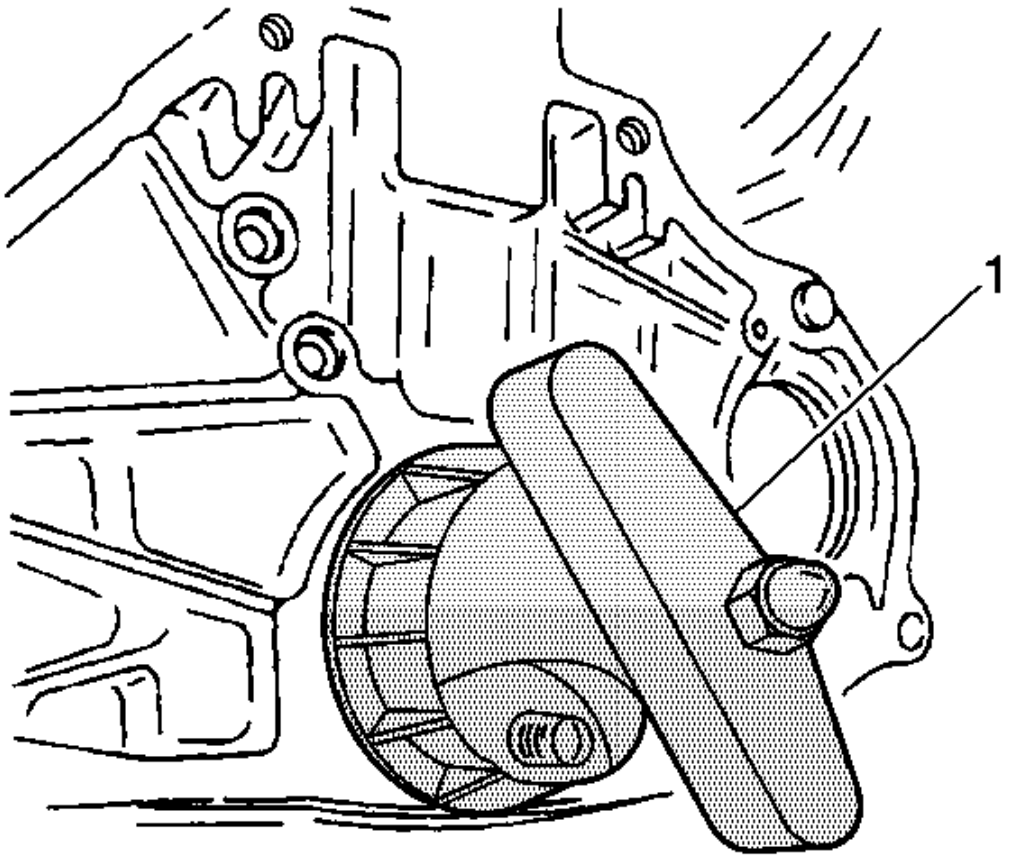


Fig. 171: View Of Crankshaft Rear Oil Seal Special Tool
Courtesy of GENERAL MOTORS CORP.

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

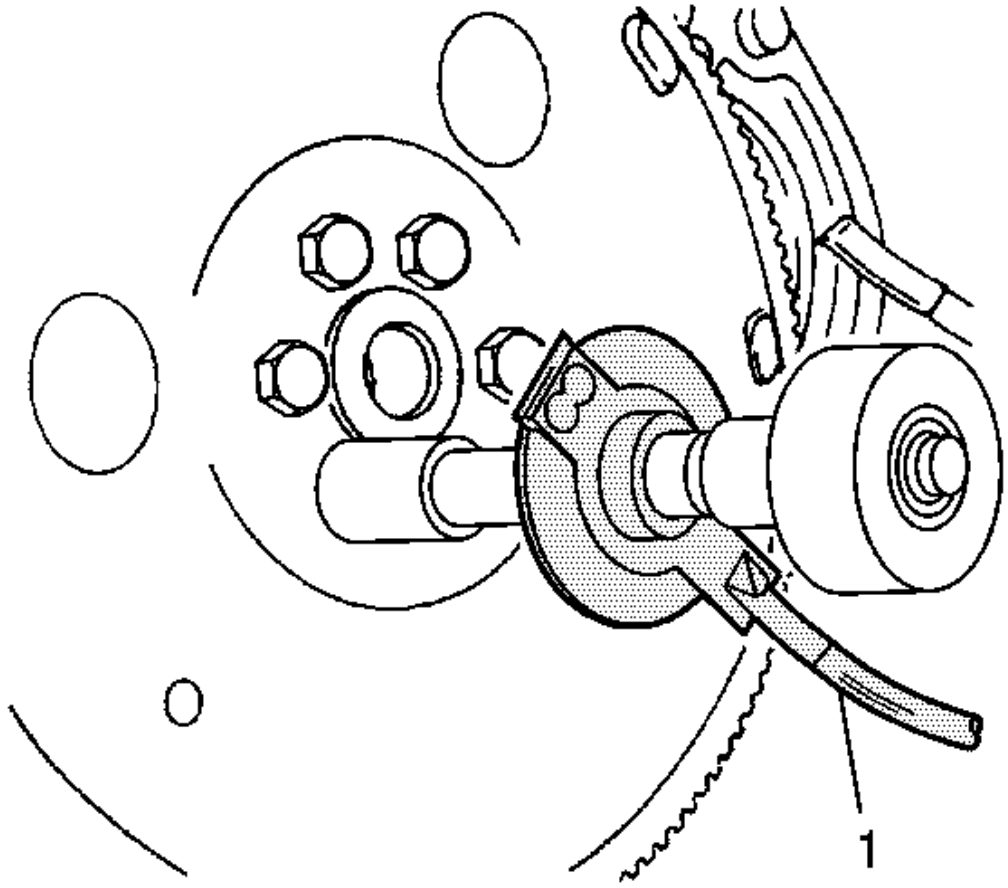


Fig. 172: View Of Flexplate And Special Tool
Courtesy of GENERAL MOTORS CORP.

63. Install the flywheel or flexible plate.
64. Install the flywheel or the flexible plate bolts.

    Tighten: Tighten the flywheel bolts to **65 N.m (48 lb ft)** . Use the **J 45059** or the **KM-470-B** (1) to tighten the flywheel bolts another 30 degrees plus 15 degrees. For the automatic transmission, tighten the flexible plate bolts to **45 N.m (33 lb ft)** .

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

PISTON, CONNECTING ROD, AND BEARINGS CLEANING AND INSPECTION

Tools Required

- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage
- **J 8087** Cylinder Bore Gage or Equivalent. See **Special Tools**.

Inspection Procedure - Connecting Rods

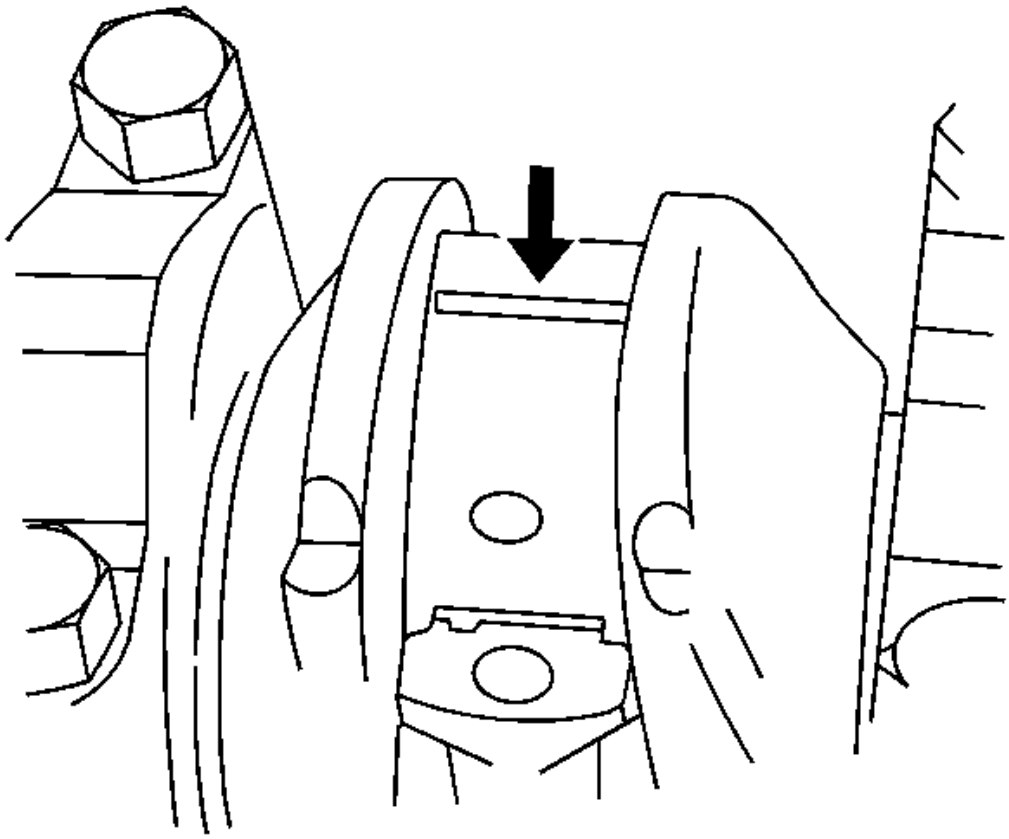


Fig. 173: View Of Plastic Gaging Thread On Bearing
Courtesy of GENERAL MOTORS CORP.

1. Coat the connecting rod bearings with engine oil.
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.

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.

4. Inspect all of the connecting rod bearing clearances using a commercially available plastic gaging, ductile plastic threads.
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.

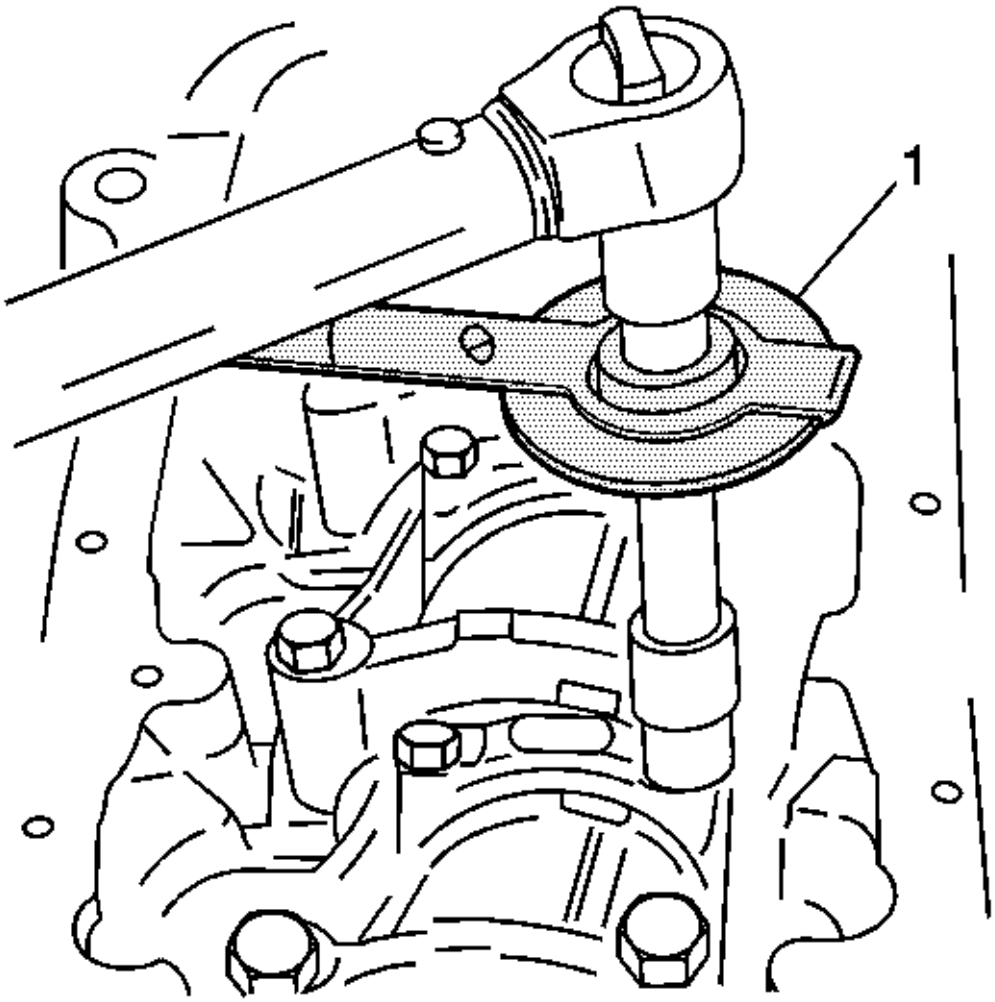


Fig. 174: Tightening Connecting Rod Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the connecting rod bearing caps.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the connecting rod bearing cap bolts.

   Tighten: Tighten the bolts to **35 N.m (26 lb ft)** using a torque wrench. Using **J 45059** and **KM-470-B** (1), tighten the bolts plus 45 degrees plus 15 degrees.

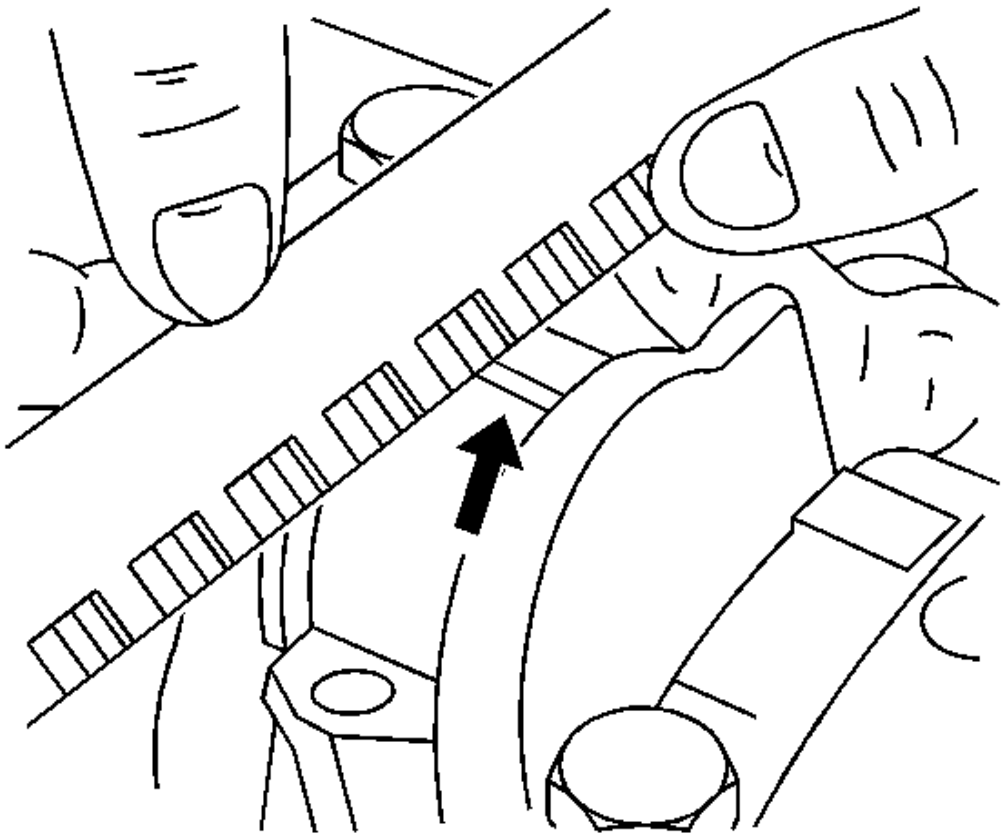


Fig. 175: Measuring Plastic Thread Using Scale
Courtesy of GENERAL MOTORS CORP.

8. Remove the connecting rod bearing caps.
9. Measure the width of the flattened plastic thread of the plastic gaging using a ruler. Plastic gaging is available for different tolerance ranges.
10. Inspect the bearing clearance for permissible tolerance ranges. Refer to.

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT

Tools Required

- **J 8037** Ring Compressor or Equivalent. See **Special Tools**.
- **J 24086-B** (KM 427) Piston Pin Remover/Installer Set
- **J 45059** Angle Meter
- **KM-470-B** Angular Torque Gage

Removal Procedure

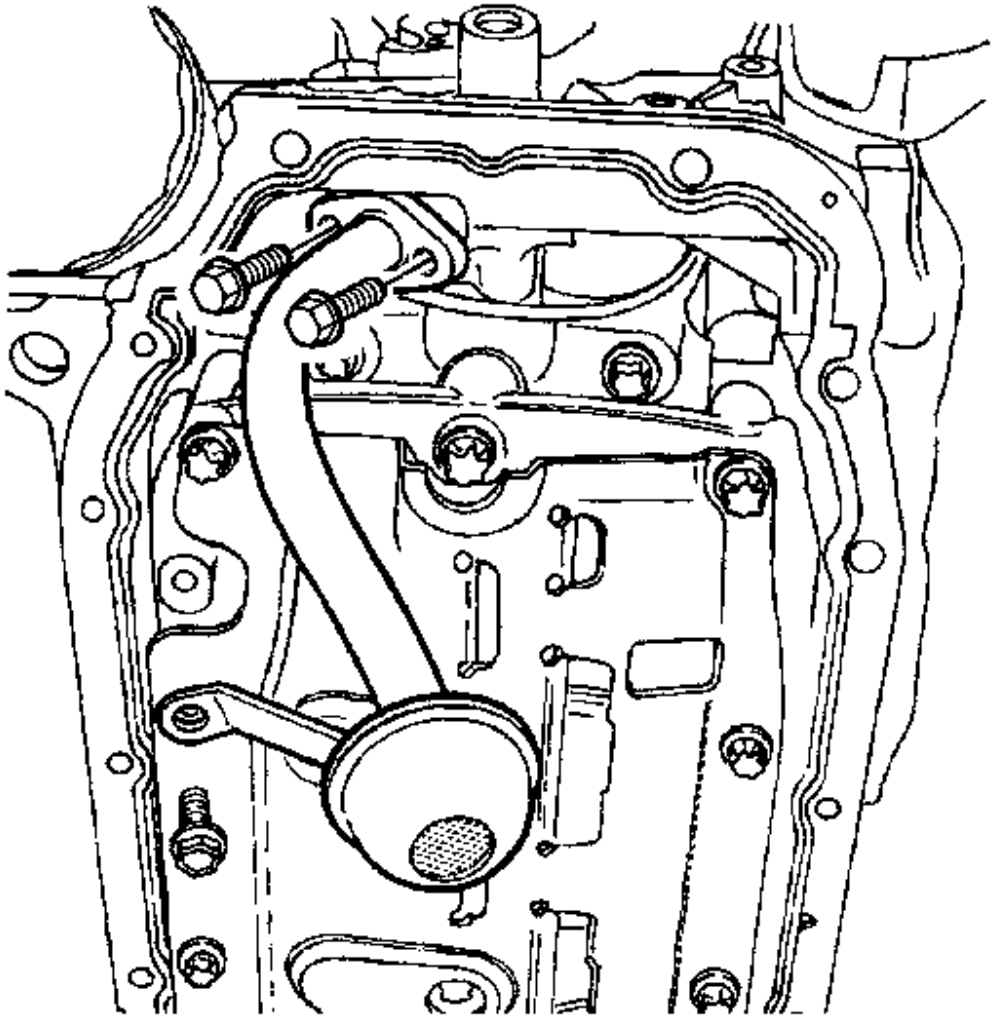


Fig. 176: View Of Oil Suction Pipe, Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head with the intake manifold and 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 and the support bracket bolts.
4. Remove the oil suction pipe.
5. Remove the crankshaft bearing bridge and the oil pan scraper bolts.
6. Remove the crankshaft bearing bridge and the oil pan scraper.

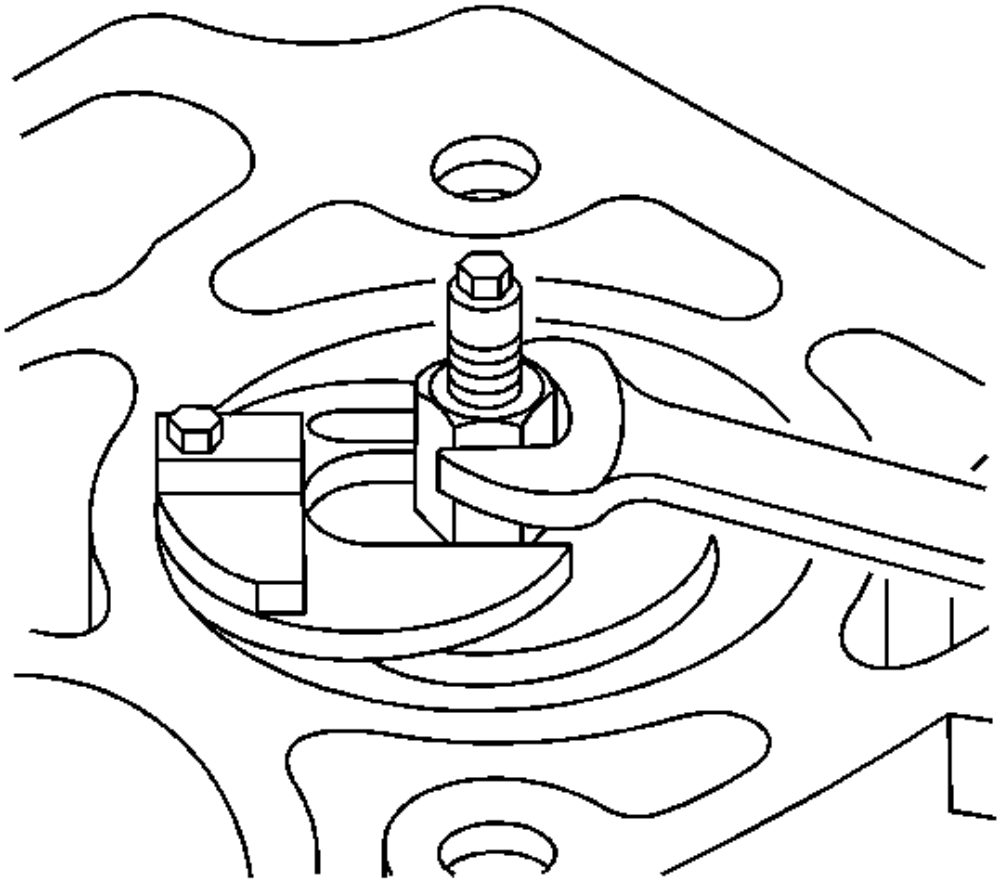


Fig. 177: View Of Connecting Rod Cap Bolt
Courtesy of GENERAL MOTORS CORP.

7. Move the piston to the bottom of the piston stroke.
8. Mark the connecting rod cap for position.

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

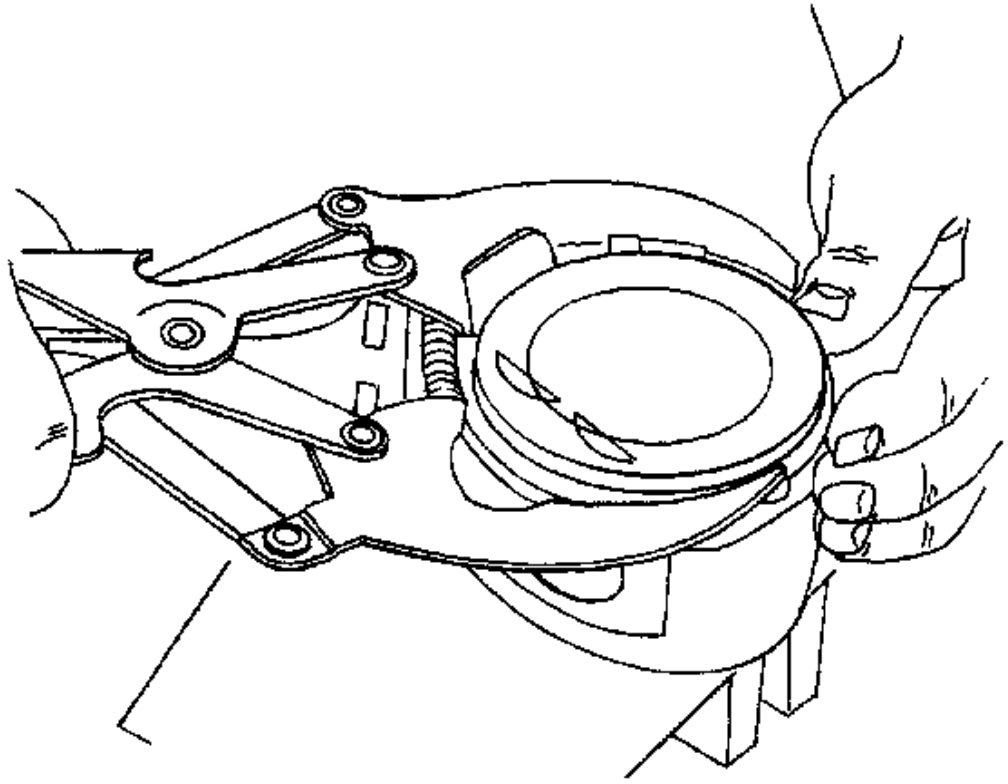


Fig. 178: Removing The Piston Rings
Courtesy of GENERAL MOTORS CORP.

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

13. Remove the piston.
14. Use a piston ring expander tool to expand the piston rings.
15. Remove the piston rings.

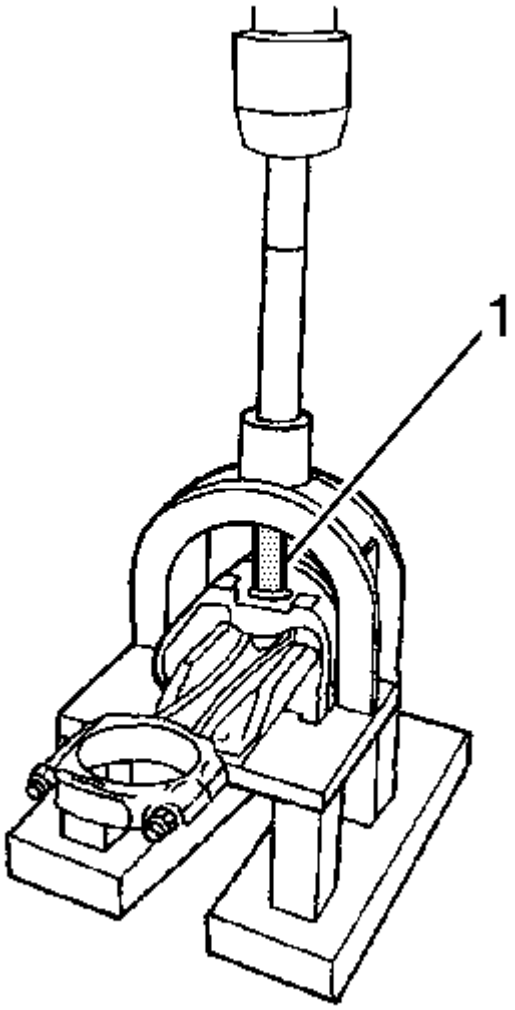


Fig. 179: View Of Piston Pin Removal/Installation Tool J 24086-B
Courtesy of GENERAL MOTORS CORP.

16. Remove the piston pin from the piston and connecting rod assembly using the**J 24086-B** (1).
17. Separate the piston from the connecting rod.

Installation Procedure

IMPORTANT: For ease of installation of the piston pin, the connecting rod should be heated to 280°C (536°F). Heat the upper connecting rod only. Use commercial thermocolor material to determine the correct temperature.

When the thermocolor material changes from black to green, the temperature is correct for installation.

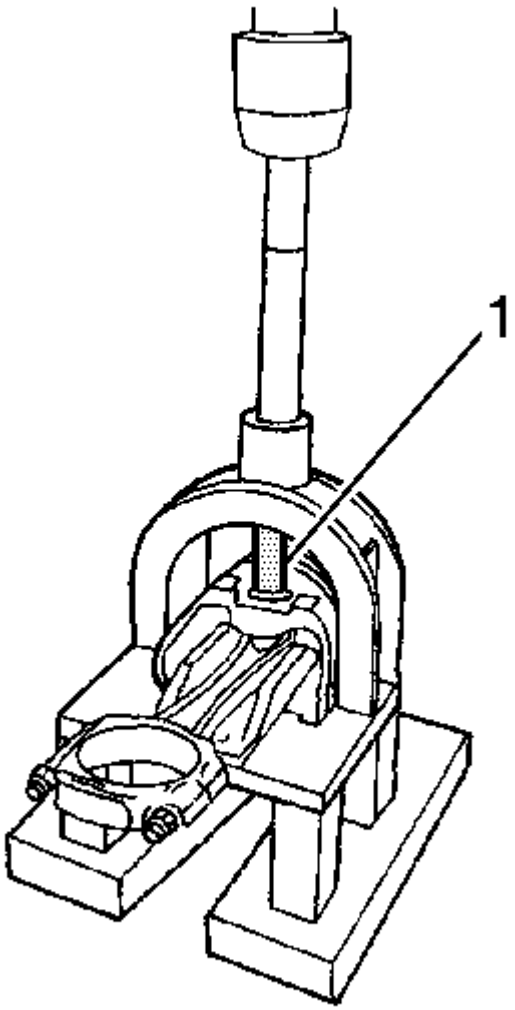


Fig. 180: View Of Piston Pin Removal/Installation Tool J 24086-B
Courtesy of GENERAL MOTORS CORP.

1. Align the notch on the piston and 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 the **J 24086-B** (1).

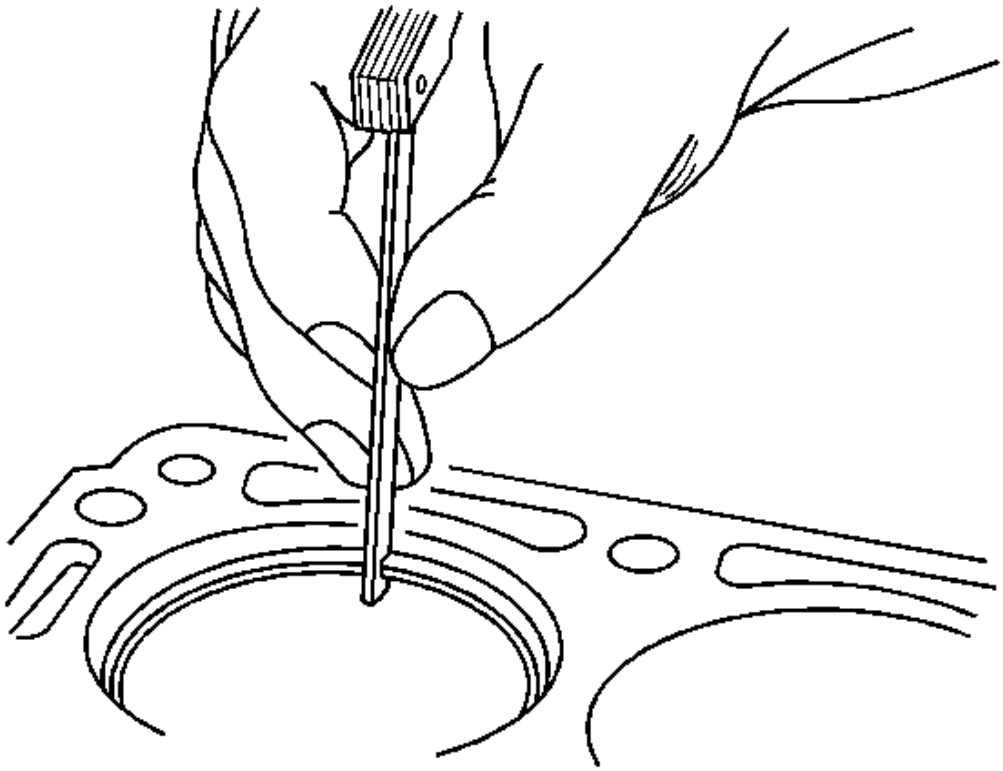


Fig. 181: Measuring Piston Ring Gap
Courtesy of GENERAL MOTORS CORP.

6. Select a set of new piston rings.
7. Measure the piston ring gap using a feeler gage. 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.

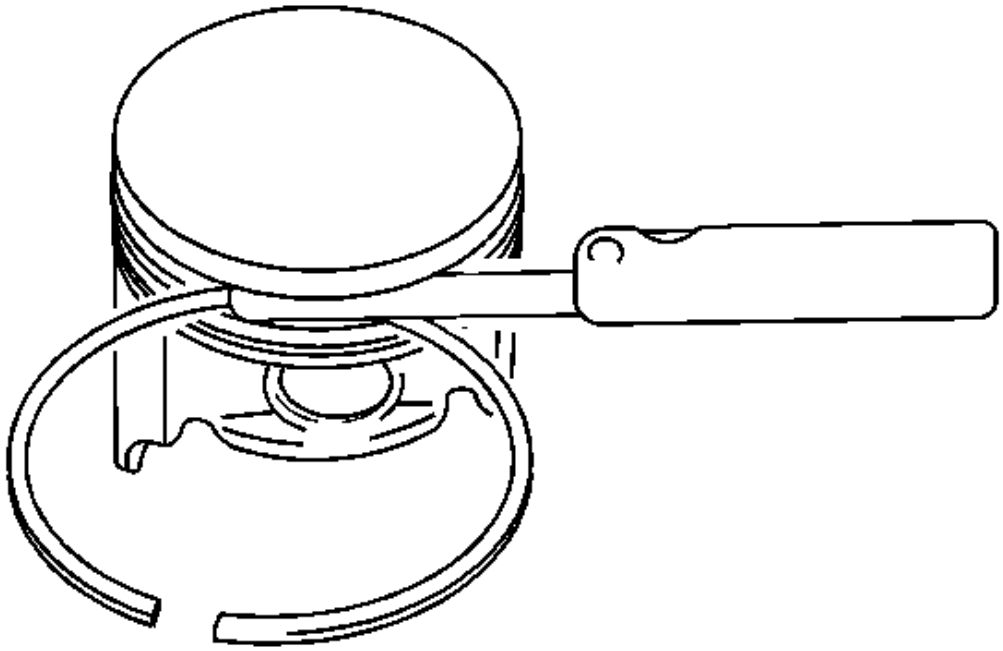


Fig. 182: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

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.

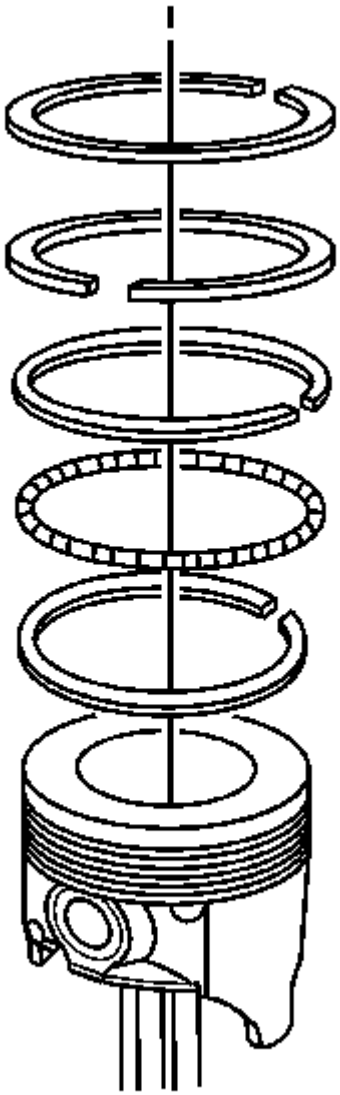


Fig. 183: View Of Piston Ring Installation Order
Courtesy of GENERAL MOTORS CORP.

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.

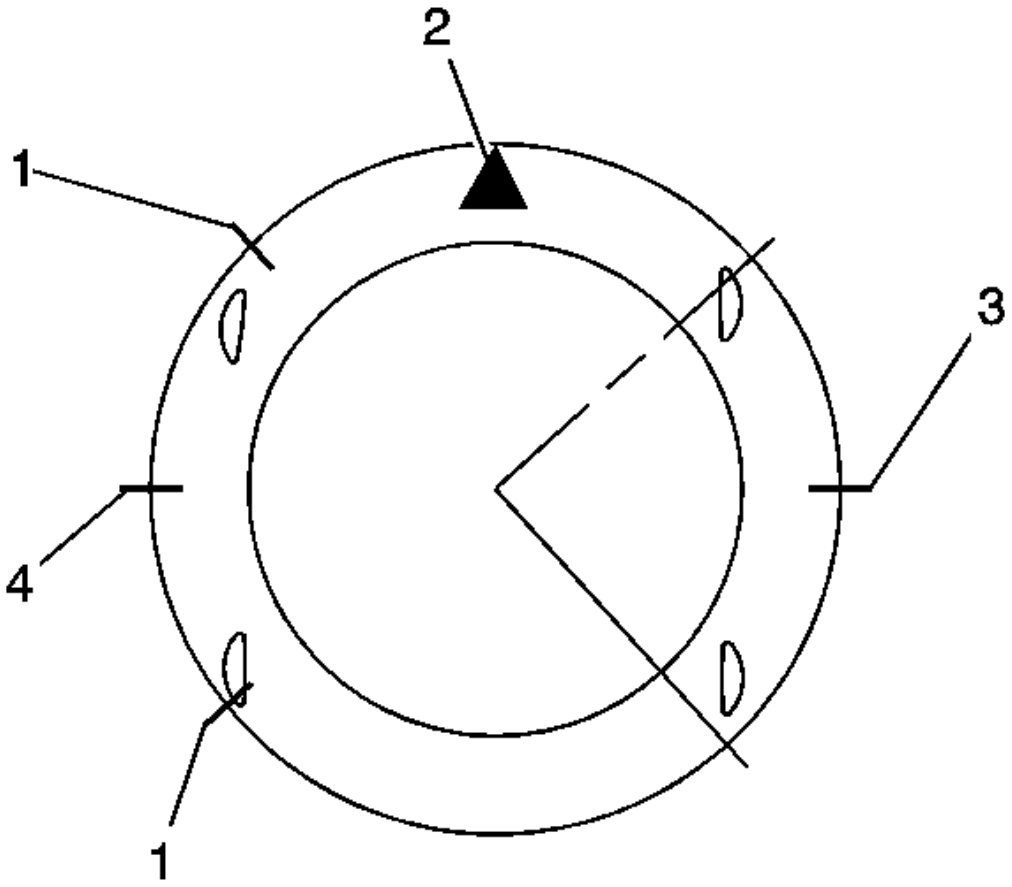


Fig. 184: Identifying Piston Head Components
Courtesy of GENERAL MOTORS CORP.

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, 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).

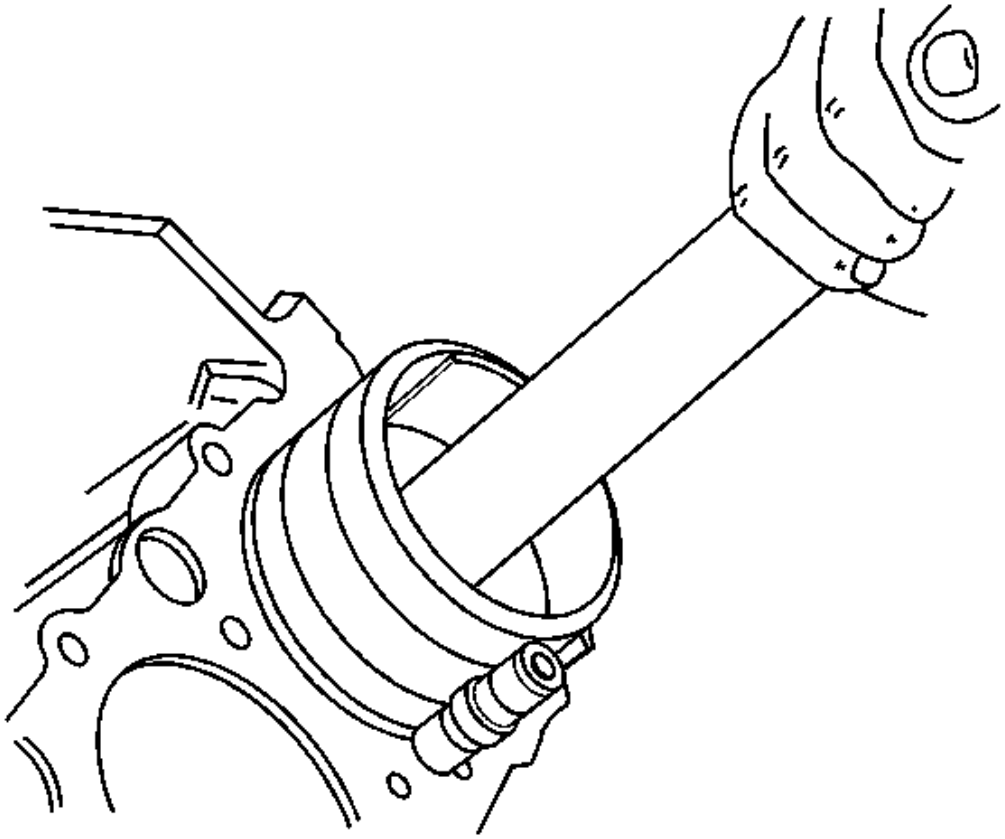


Fig. 185: View Of J 8037 And Wood Handle
Courtesy of GENERAL MOTORS CORP.

17. Lubricate the cylinder wall and the piston rings with clean engine oil.
18. Install the piston using **J 8037** and a wood handle. See **Special Tools**. Guide the lower connecting rod end to prevent damaging the crankshaft journal.
19. Install the connecting rod cap and bearings. Refer to **Crankshaft and Bearings Cleaning and Inspection**.

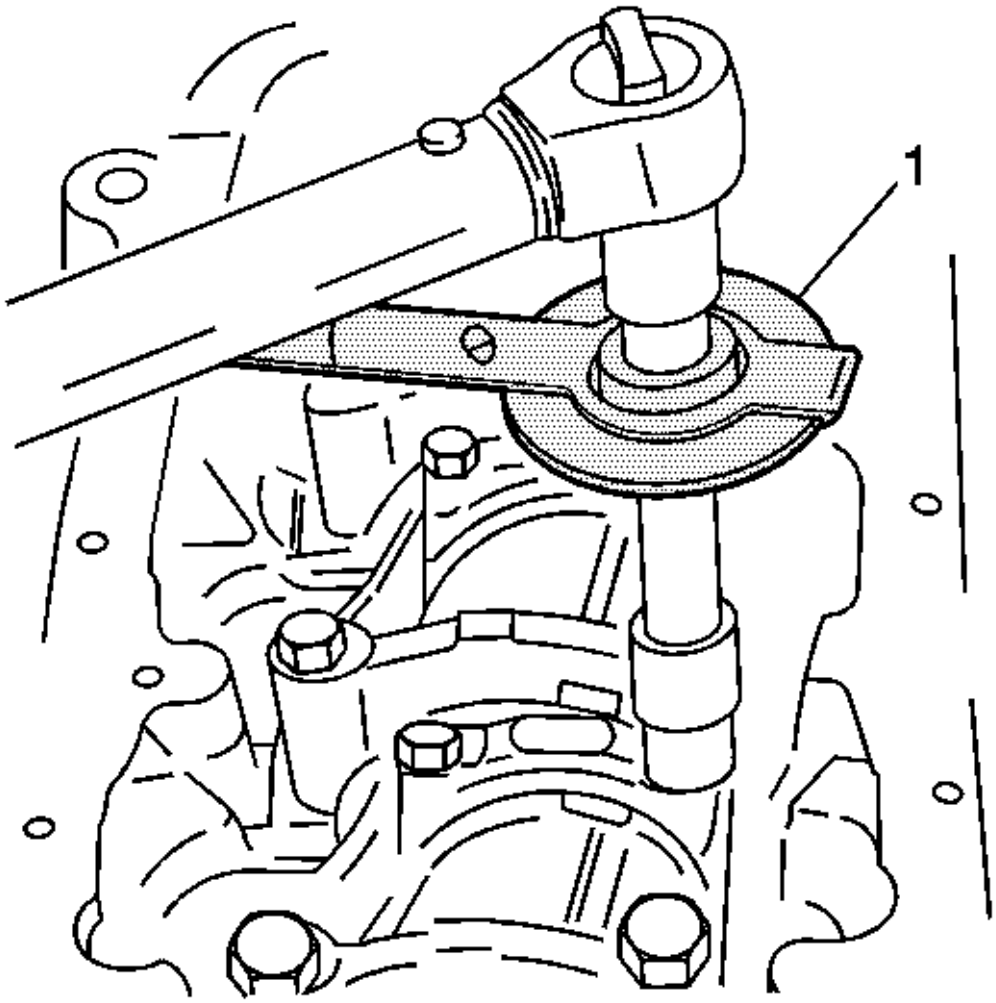


Fig. 186: Tightening Connecting Rod Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

20. Install the connecting rod cap bolts.

    Tighten: Tighten the connecting rod bearing cap bolts to **35 N.m (26 lb ft)** . Using the **J 45059** or the **KM-470-B** (1), tighten the bolts one turn of 45 degrees plus one turn of 15 degrees.

21. Install the crankshaft bearing bridge/oil pan scraper bolts.

Tighten: Tighten the crankshaft bearing bridge/oil pan scraper bolts to **20 N.m (15 lb ft)** plus 45 degrees using the **J 45059** or the **KM-470-B** (1).

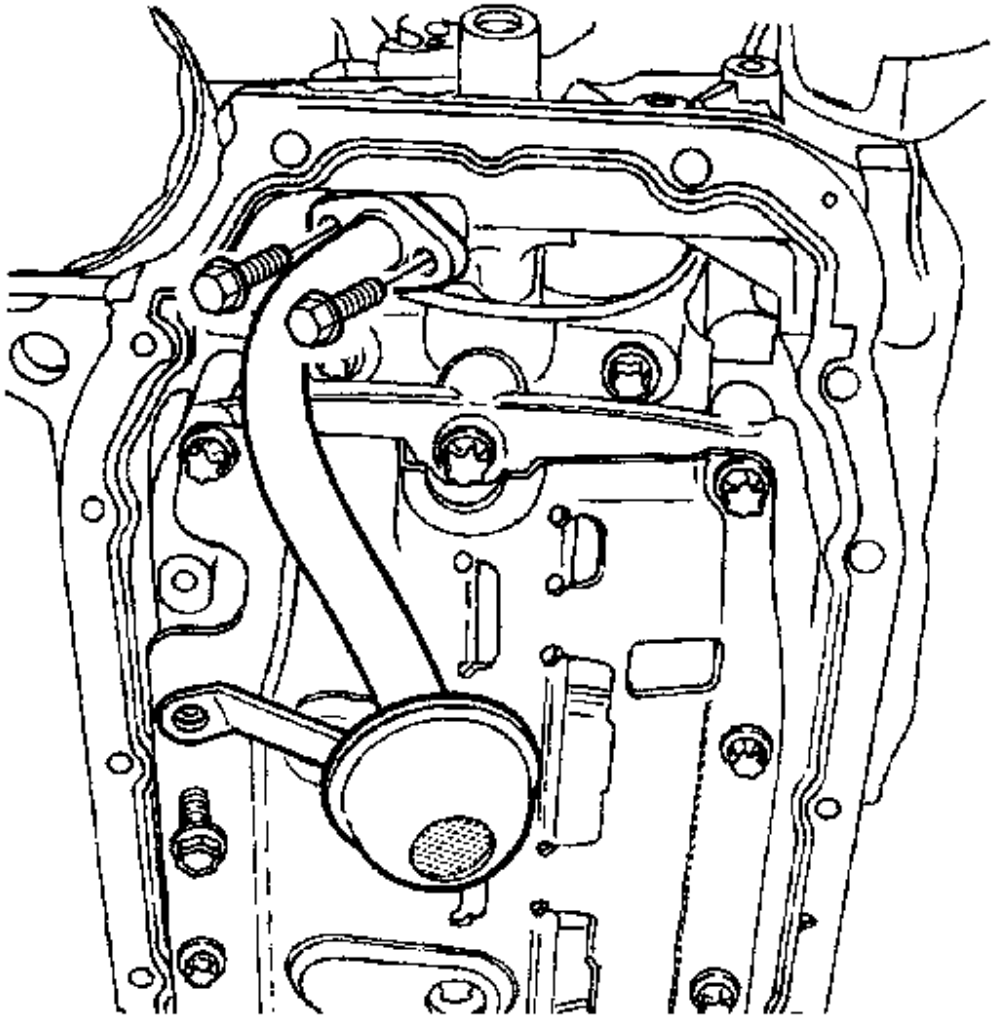


Fig. 187: View Of Oil Suction Pipe, Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

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

Tighten:

- Tighten the oil suction pipe bolts to **8 N.m (71 lb in)** .

- Tighten the oil suction pipe bracket bolt to **6 N.m (53 lb in)** .

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

CAMSHAFT REPLACEMENT

Removal Procedure

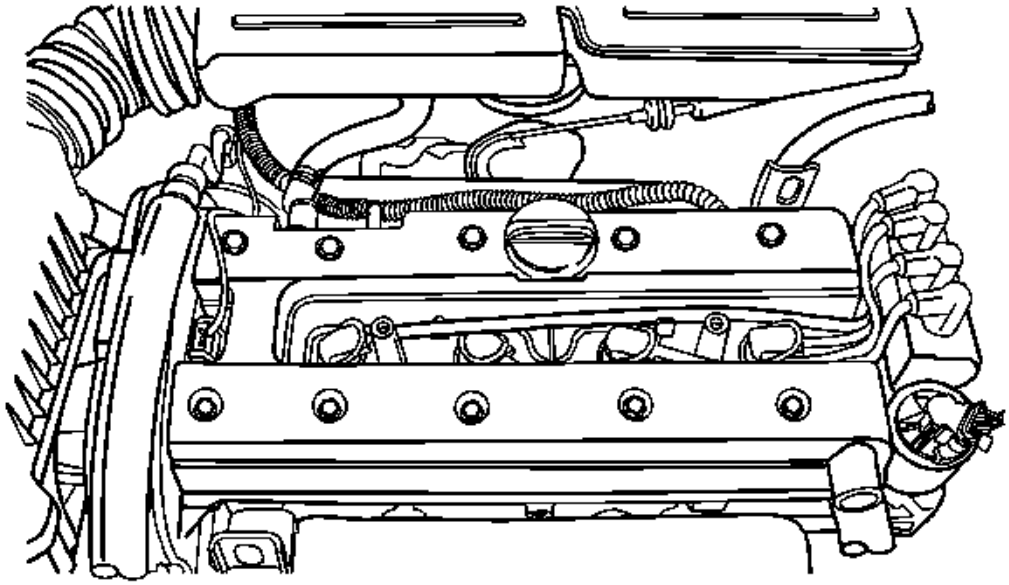


Fig. 188: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the timing belt. Refer to **Timing Belt Replacement**.
2. Disconnect the breather tube at the camshaft cover.
3. Disconnect the engine ventilation hose at the camshaft cover.
4. Remove the spark plug cover bolts.
5. Remove the spark plug cover.
6. Disconnect the ignition wires from the spark plugs.
7. Remove the camshaft cover bolts.
8. Remove the camshaft cover washers.

9. Remove the camshaft cover and the camshaft cover gasket.

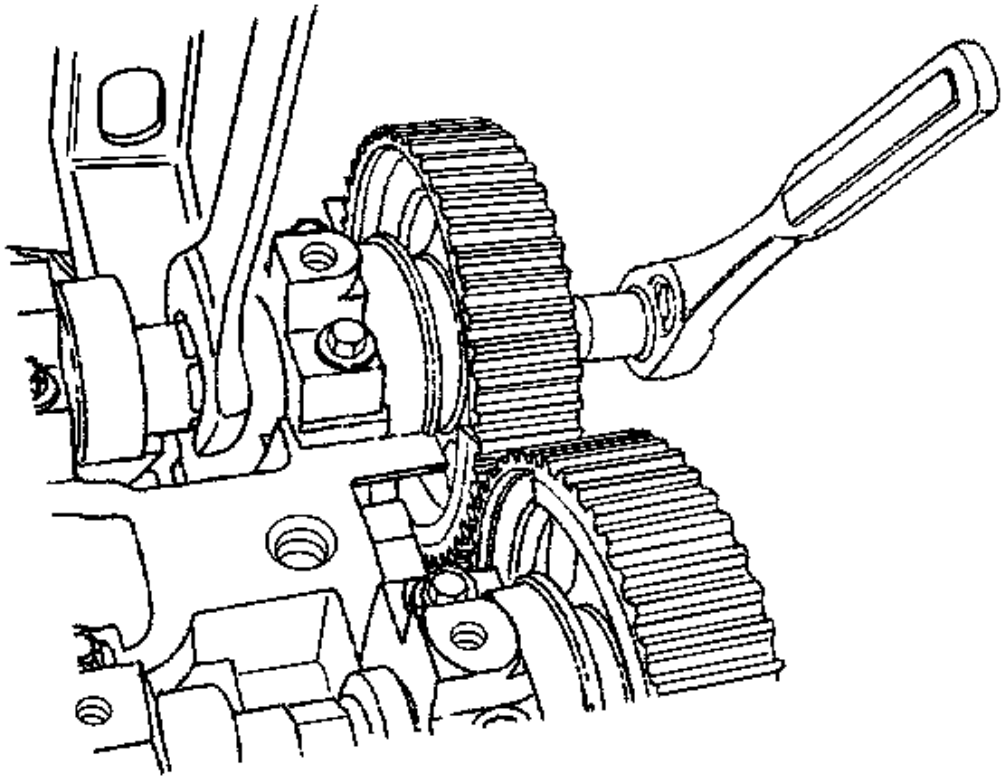


Fig. 189: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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

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

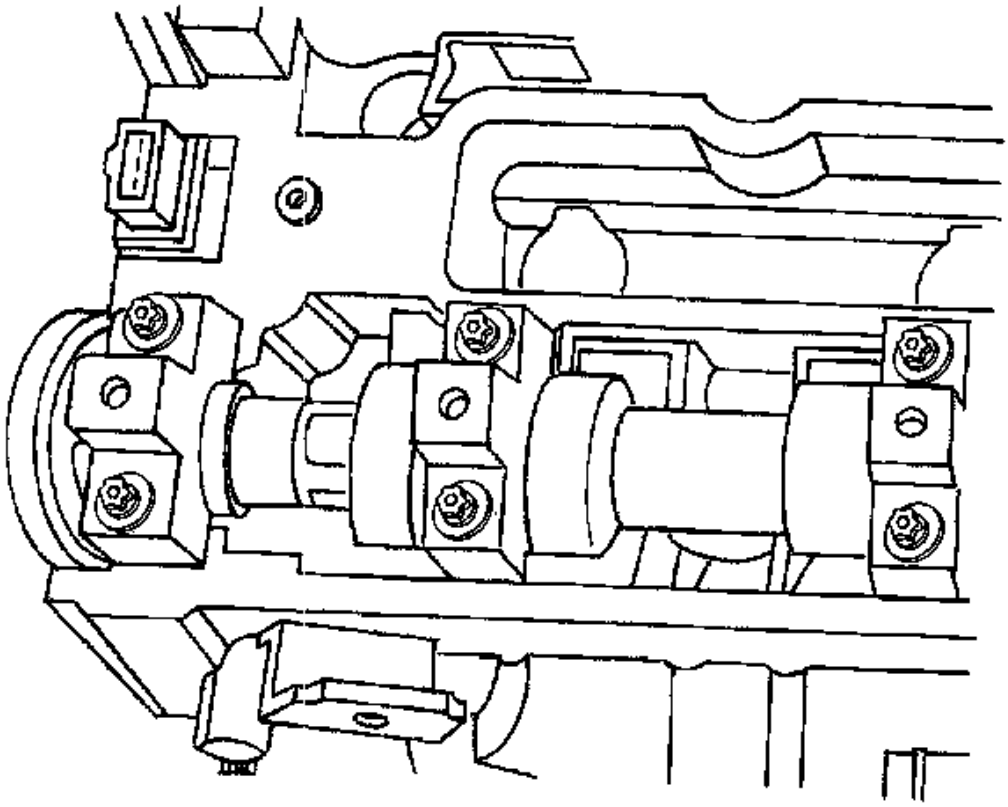


Fig. 190: View Of Camshaft Bearing Caps And Bolts
Courtesy of GENERAL MOTORS CORP.

14. Loosen the camshaft bearing cap bolts in stages of one-half to one turn.
15. Remove the camshaft bearing cap bolts from the cylinder head.
16. Remove the camshafts.
17. Remove the seal ring from the camshafts.

IMPORTANT: The camshaft must detach evenly from the bearing seats in the front guide bearing.

18. Check the camshaft and bearing seats for wear and replace them if necessary.

Installation Procedure

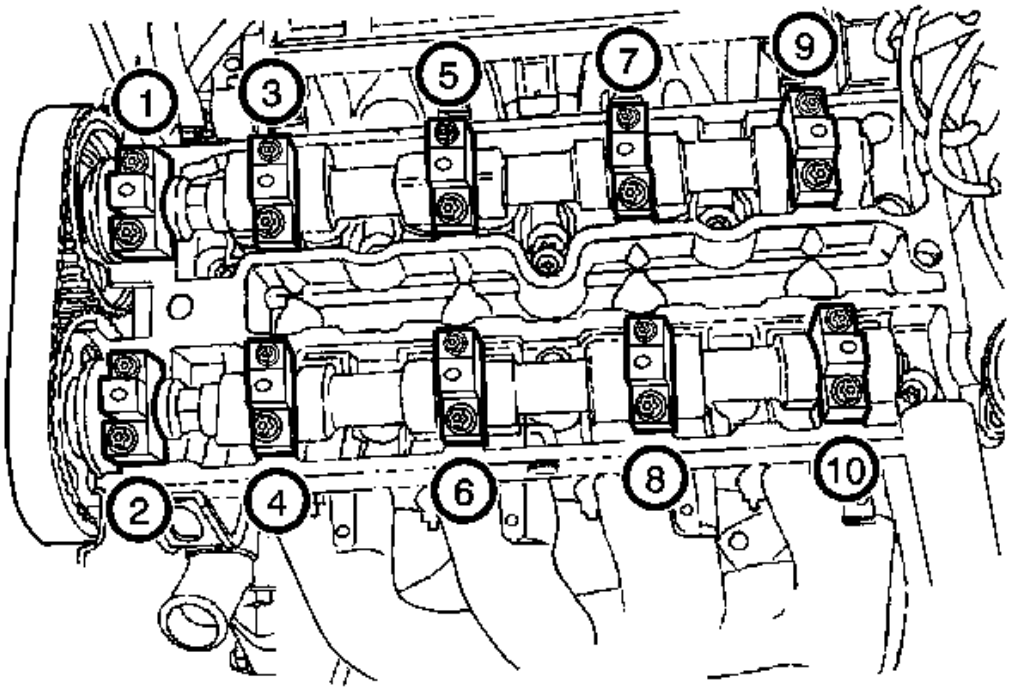


Fig. 191: Identifying Camshaft Bearing Cap Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

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

1. Lubricate the camshaft journals and the camshaft caps with engine oil.
2. Install the intake camshaft.
3. Install the intake camshaft caps in their original positions.
4. Install the intake camshaft cap bolts.
5. Install the exhaust camshaft.
6. Install the exhaust camshaft caps in their original positions.
7. Install the exhaust camshaft cap bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

Tighten: Tighten the bolts to **8 N.m (71 lb in)** .

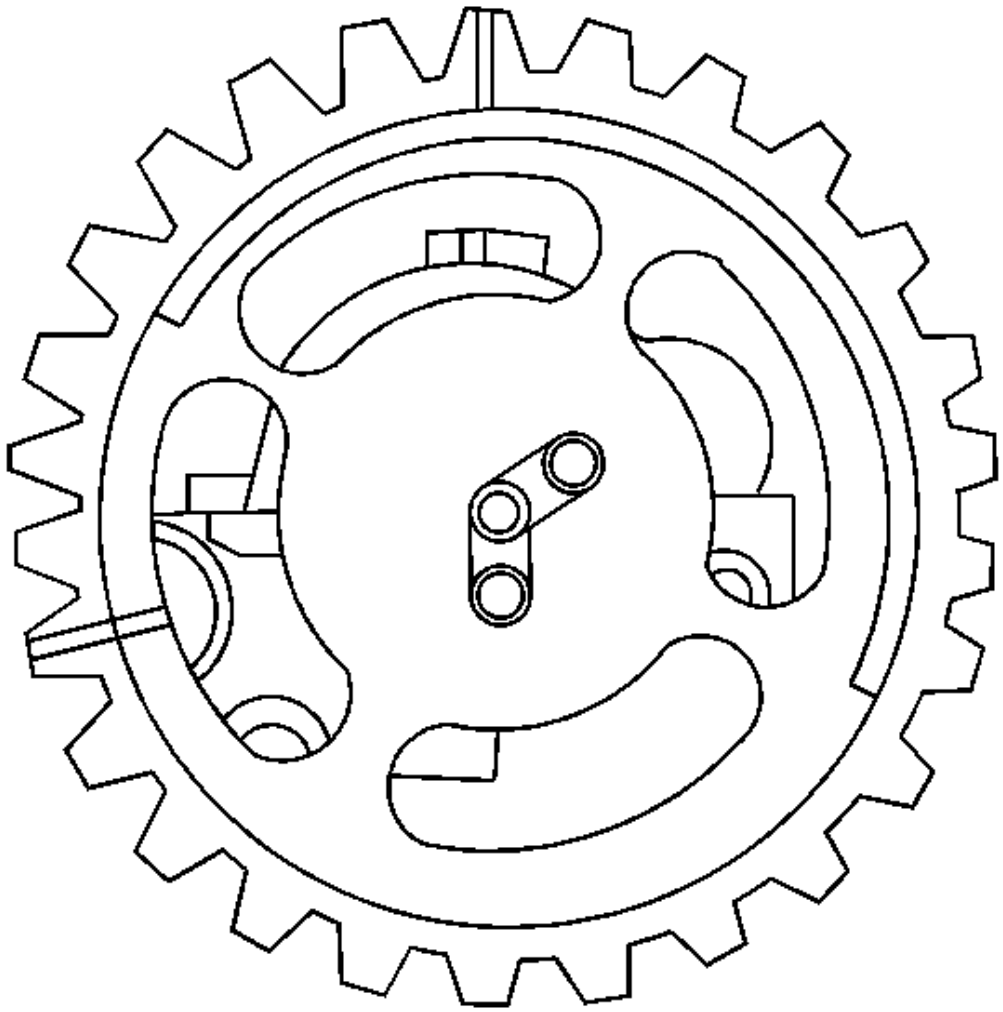


Fig. 192: View Of Camshaft Gear And Timing Marks
Courtesy of GENERAL MOTORS CORP.

9. Measure the intake camshaft end play and the exhaust camshaft end play. Refer to **Engine Mechanical Specifications**.
10. Install the intake camshaft gear.
11. While holding the intake camshaft firmly in place, install the intake camshaft gear bolt.

    Tighten: Tighten the bolt to **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees.

12. Install the exhaust camshaft gear.

13. While holding the exhaust camshaft firmly in place, install the exhaust camshaft gear bolt.

    Tighten: Tighten the bolt to **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees.

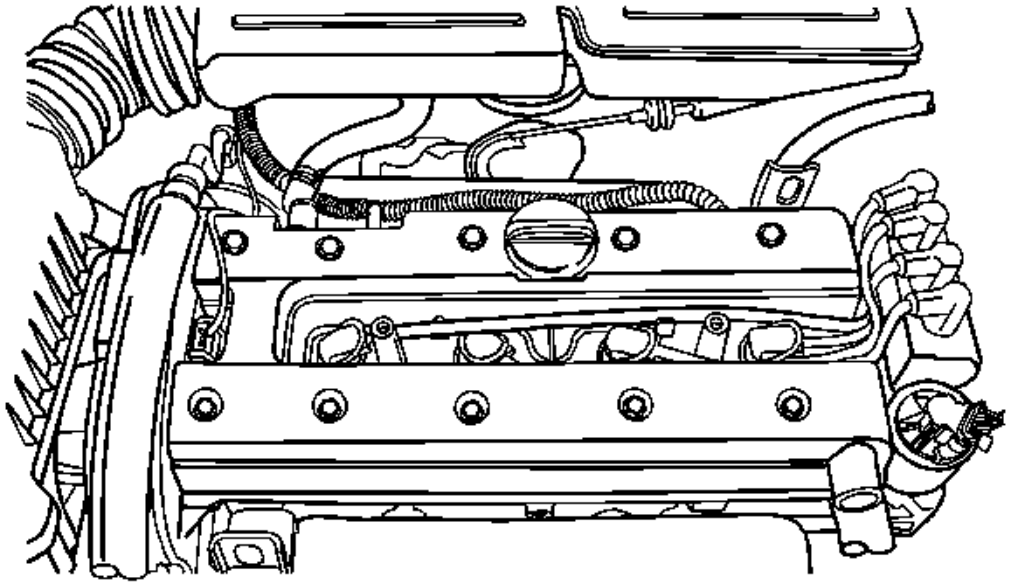


Fig. 193: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the camshaft cover and the camshaft cover gasket.
15. Install the camshaft cover washers.
16. Install the camshaft cover bolts.

    Tighten: Tighten the bolts to **8 N.m (71 lb in)** .

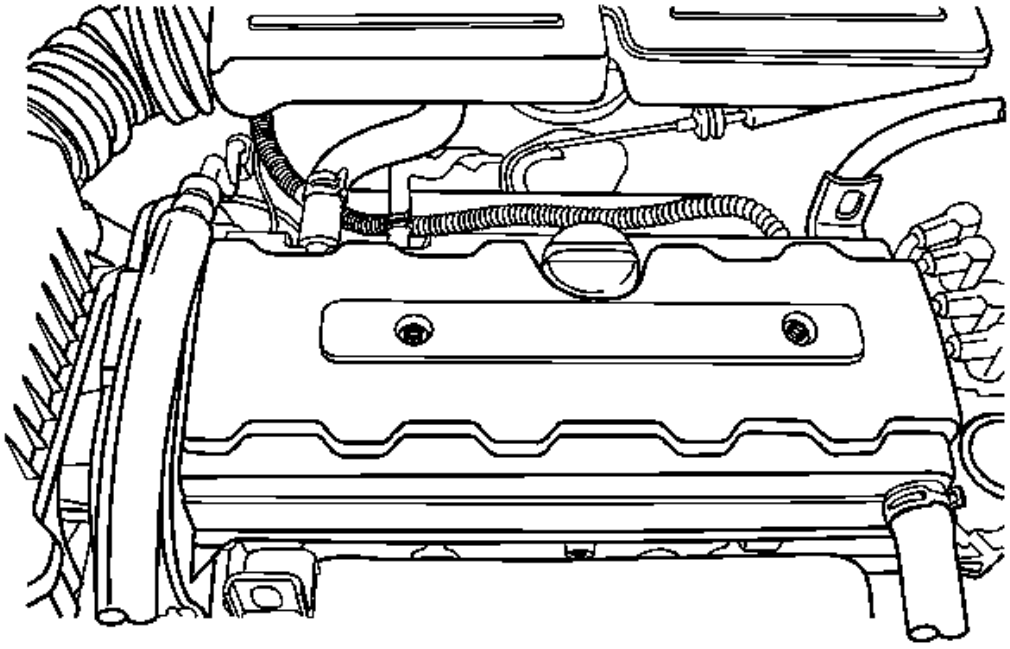


Fig. 194: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

17. Connect the ignition wires to the spark plugs.
18. Install the spark plug cover.
19. Install the spark plug cover bolts.

    Tighten: Tighten the bolts to **8 N.m (71 lb in)** .

20. Connect the breather tube to the camshaft cover.
21. Connect the engine ventilation hose to the camshaft cover.
22. Install the timing belt. Refer to **Timing Belt Replacement**

CAMSHAFT GEAR REPLACEMENT

Removal Procedure

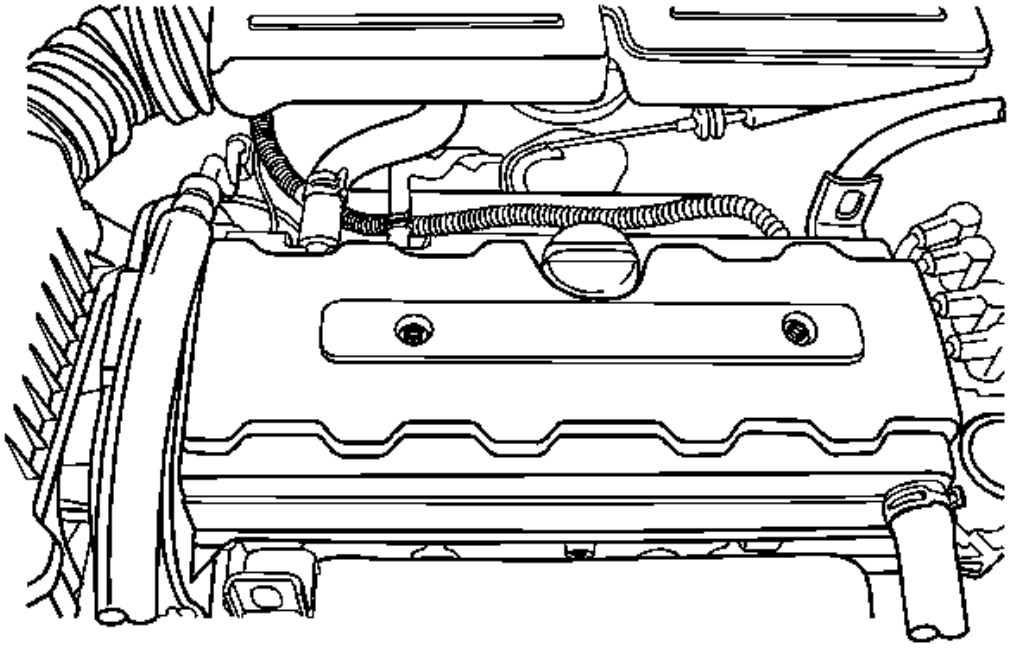


Fig. 195: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the negative battery cable.
2. Remove the timing belt. Refer to **Timing Belt Replacement**.
3. Remove the spark plug cover bolts.
4. Remove the spark plug cover.
5. Disconnect the ignition wires from the spark plugs.
6. Disconnect the breather tubes from the camshaft cover.

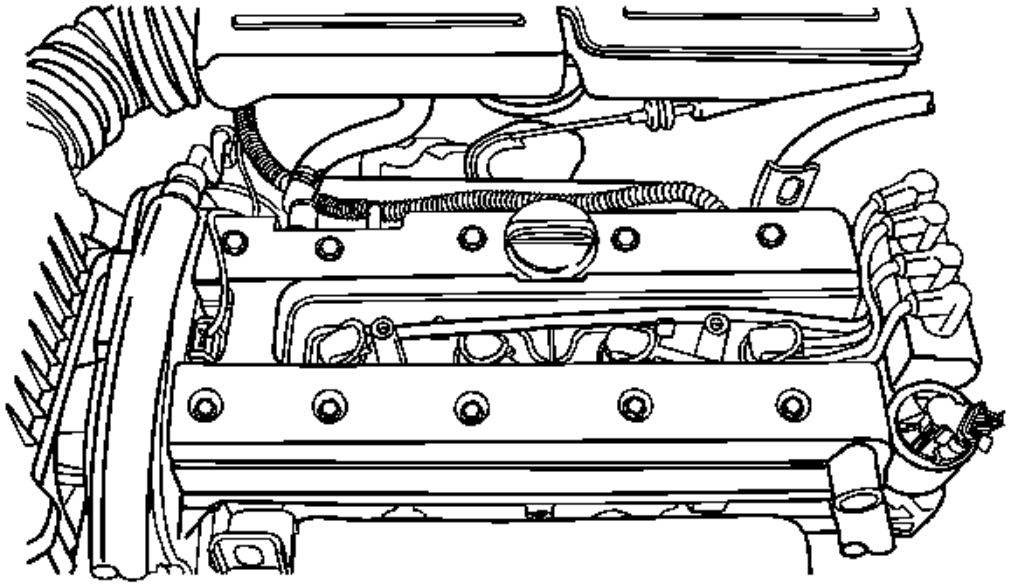


Fig. 196: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft cover bolts.
8. Remove the camshaft cover washers.
9. Remove the camshaft cover and the camshaft cover gasket.

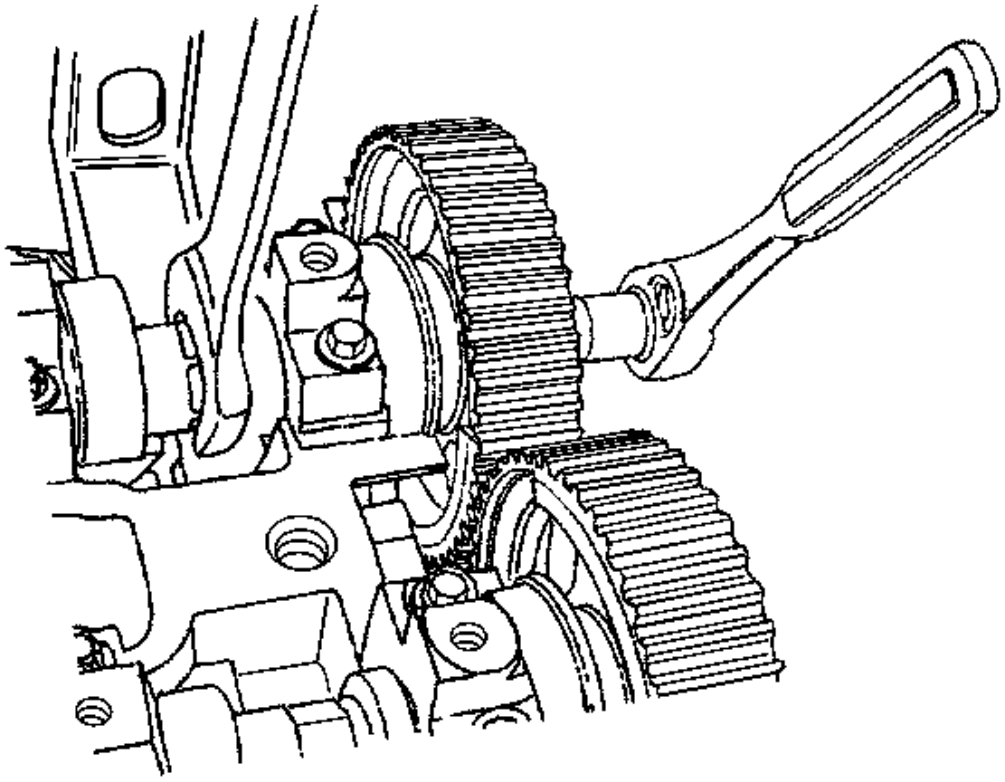


Fig. 197: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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

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

Installation Procedure

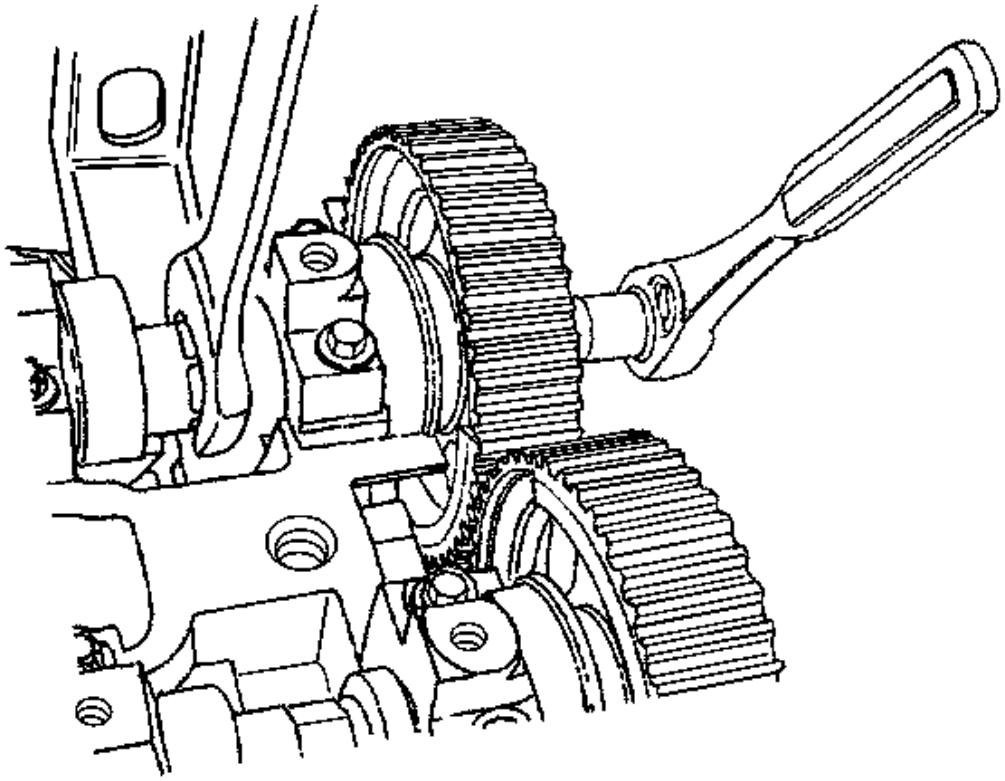


Fig. 198: View Of Camshaft Gear Removal/Installation Procedure
Courtesy of GENERAL MOTORS CORP.

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 in Cautions and Notices.

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

   Tighten: Tighten the intake camshaft gear bolt to **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees.

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 **50 N.m (37 lb ft)** plus 60 degrees and 15 degrees.

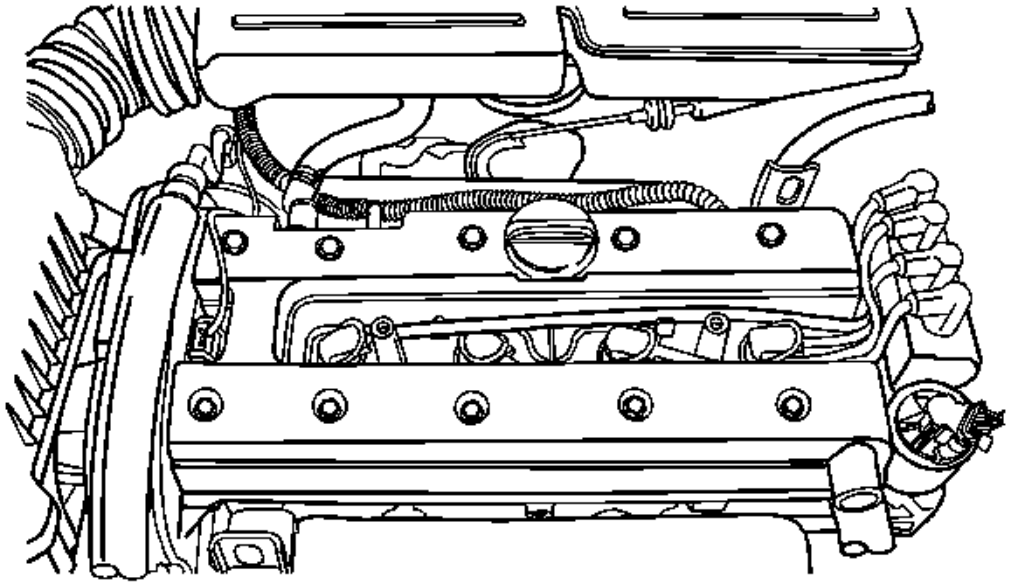


Fig. 199: View Of Camshaft Cover And Bolts
Courtesy of GENERAL MOTORS CORP.

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 washers.
8. Install the camshaft cover bolts.

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

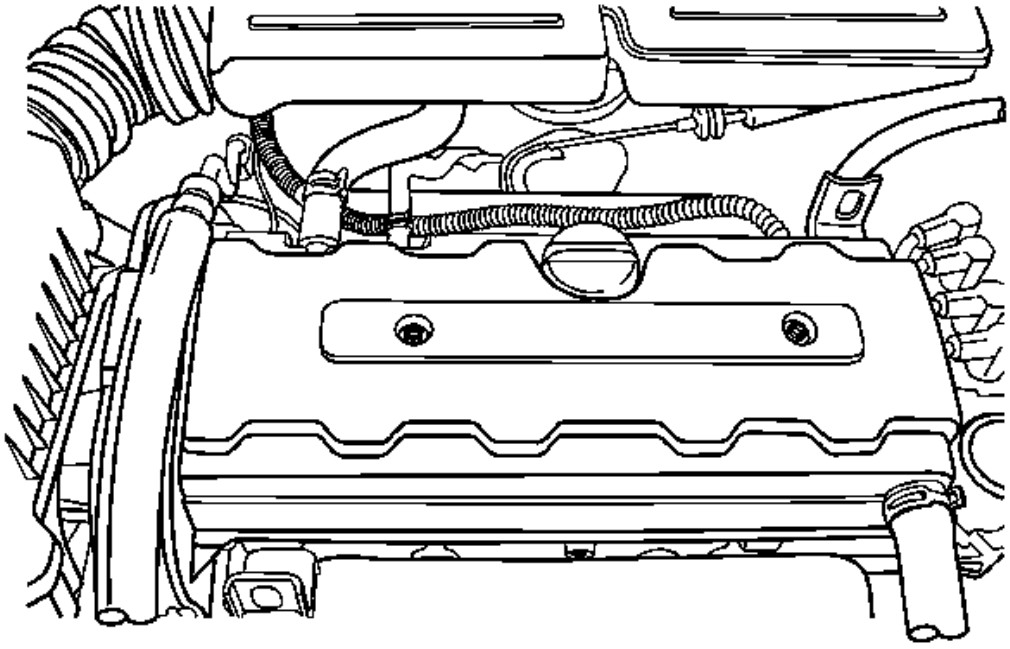


Fig. 200: View Of Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

9. Connect the crankcase breather tubes to the camshaft cover.
10. Connect the ignition wires to the spark plugs.
11. Install the spark plug cover.
12. Install the spark plug cover bolts.

    Tighten: Tighten the spark plug cover bolts to **8 N.m (71 lb in)** .

13. Install the timing belt. Refer to **Timing Belt Replacement**.
14. Connect the negative battery cable.

CYLINDER HEAD DISASSEMBLE

Tools Required

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

Disassembly Procedure

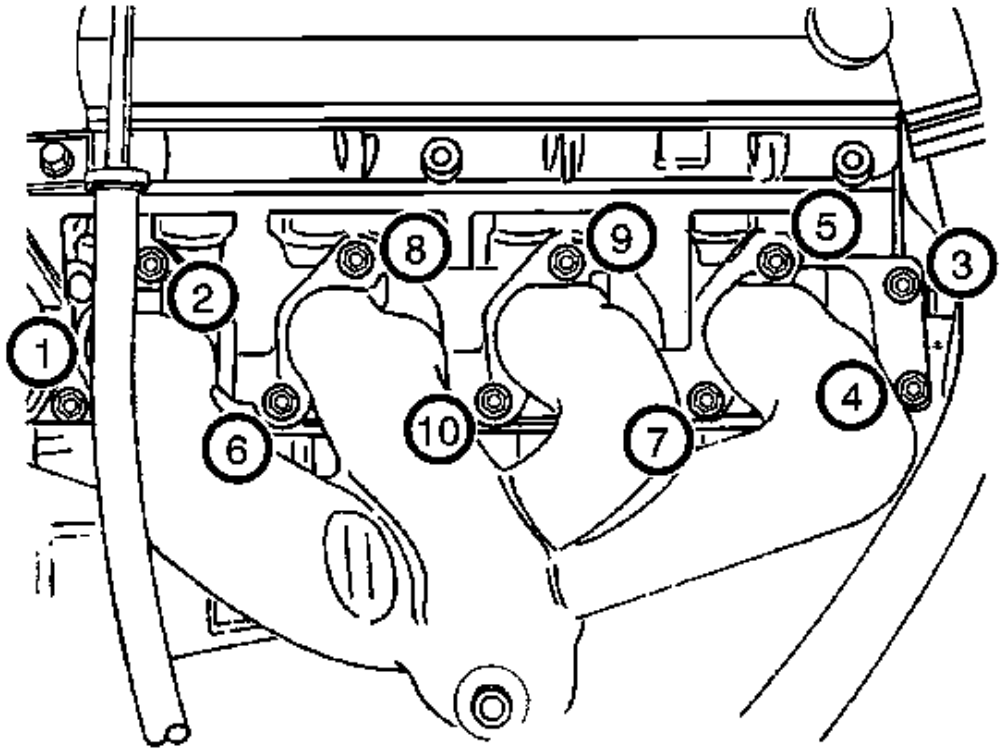


Fig. 201: View Of Exhaust Manifold Retaining Nut Removal Sequence
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Cylinder Head Replacement**.
2. Remove the exhaust manifold heat shield bolts.
3. Remove the exhaust manifold heat shield.
4. Remove the exhaust manifold retaining nuts in the sequence shown.
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket.
7. Remove the exhaust manifold studs.

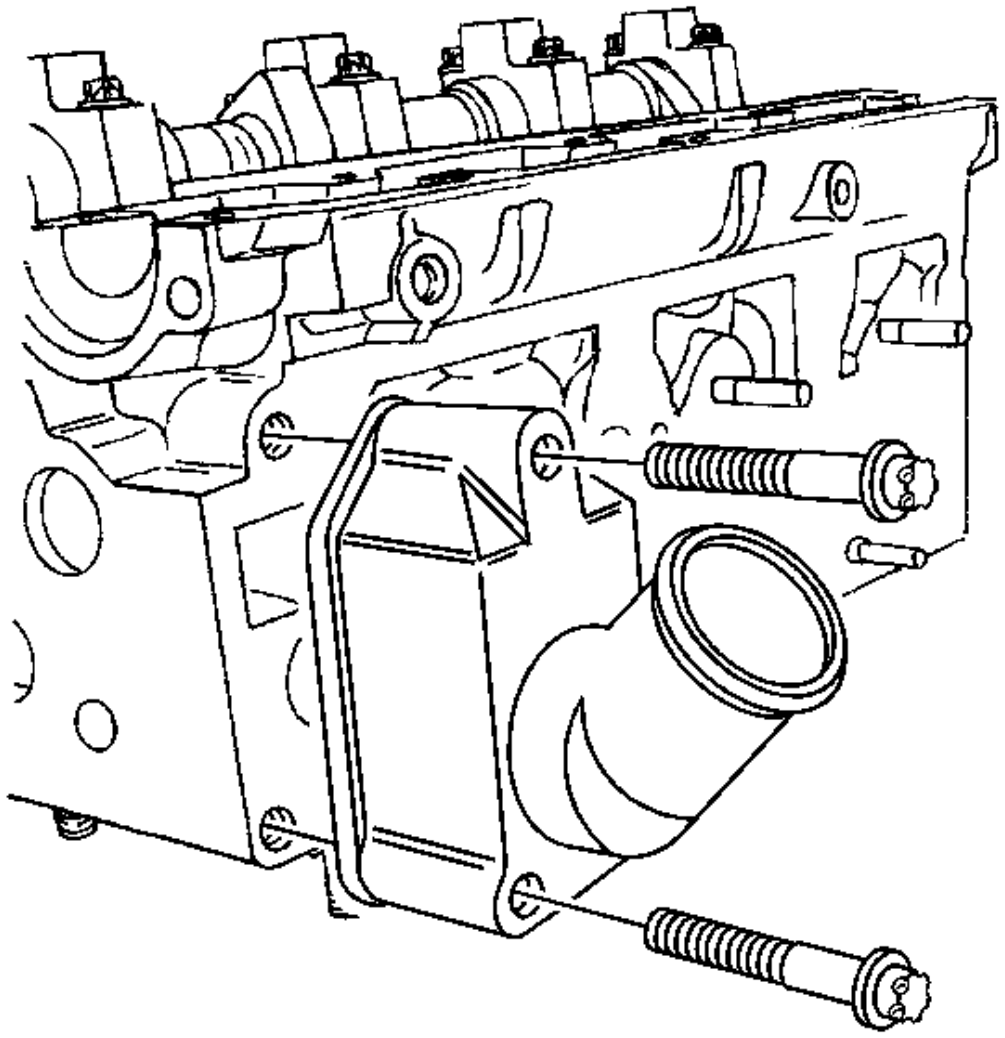


Fig. 202: View Of Coolant Bypass Housing And Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the thermostat housing mounting bolts.
9. Remove the thermostat housing assembly.
10. Remove the fuel rail assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.
11. Remove the coolant bypass housing mounting bolts and the housing.

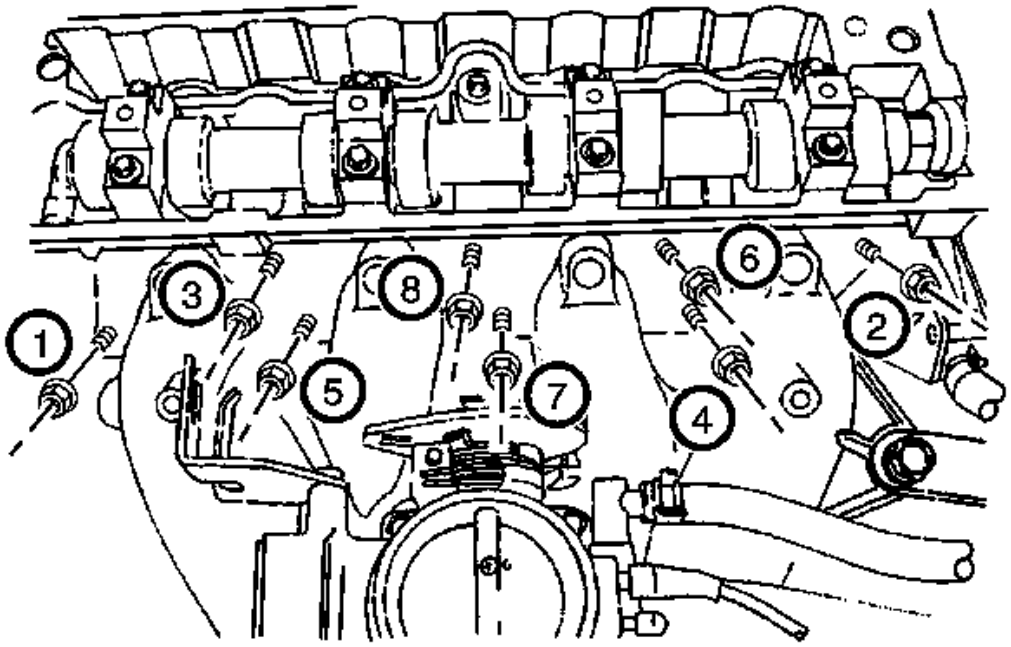


Fig. 203: View Of Intake Manifold Retaining Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

12. Remove the intake manifold retaining nuts and retaining bolt in the sequence shown.
13. Remove the intake manifold.
14. Remove the intake manifold gasket.

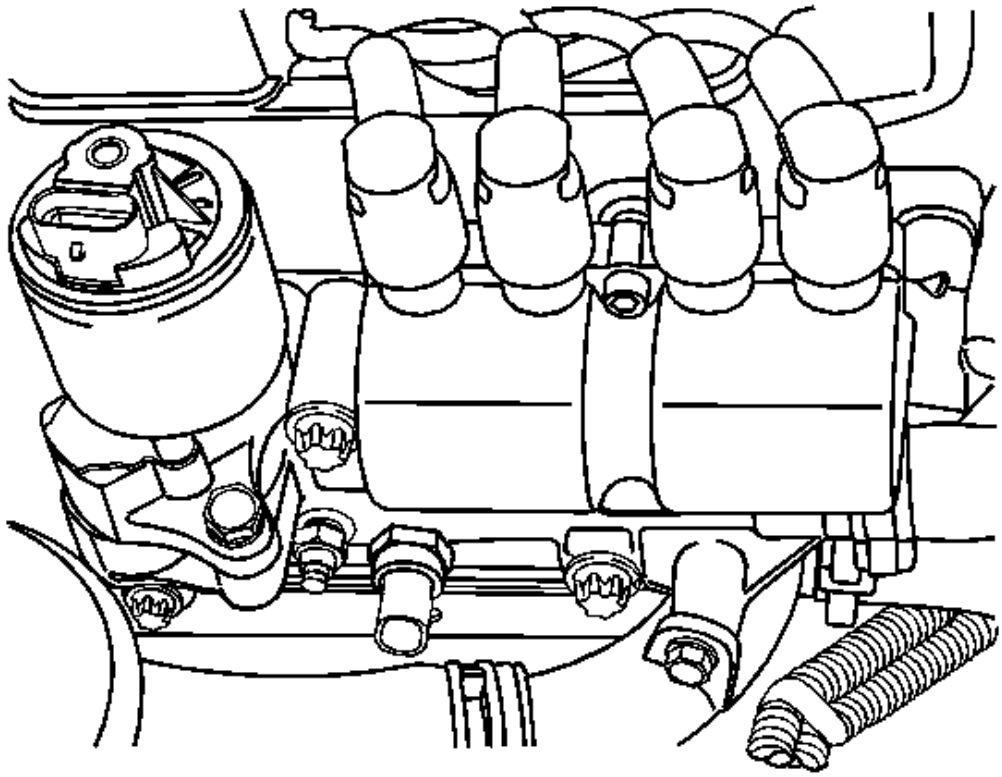


Fig. 204: View Of DIS Coil, EGR, Mounting Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

15. Remove the direct ignition system (DIS) coil and the exhaust gas recirculation (EGR) mounting bracket bolts.
16. Remove the DIS ignition coil and the EGR mounting bracket and ignition wires.
17. Remove the intake manifold studs.
18. Remove the spark plugs.

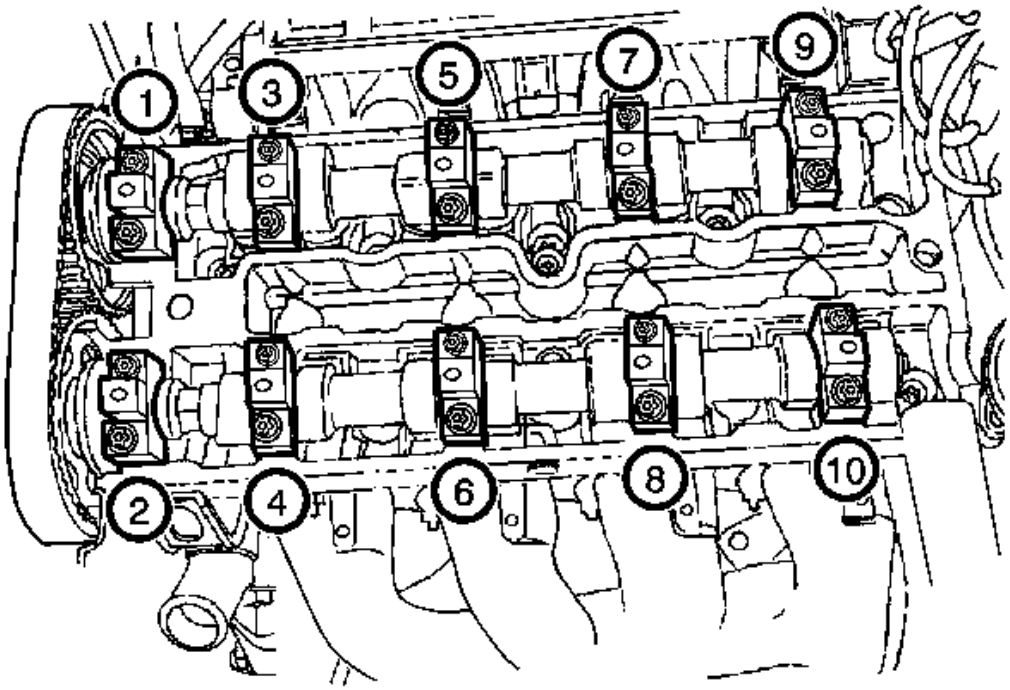


Fig. 205: Identifying Camshaft Bearing Cap Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

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

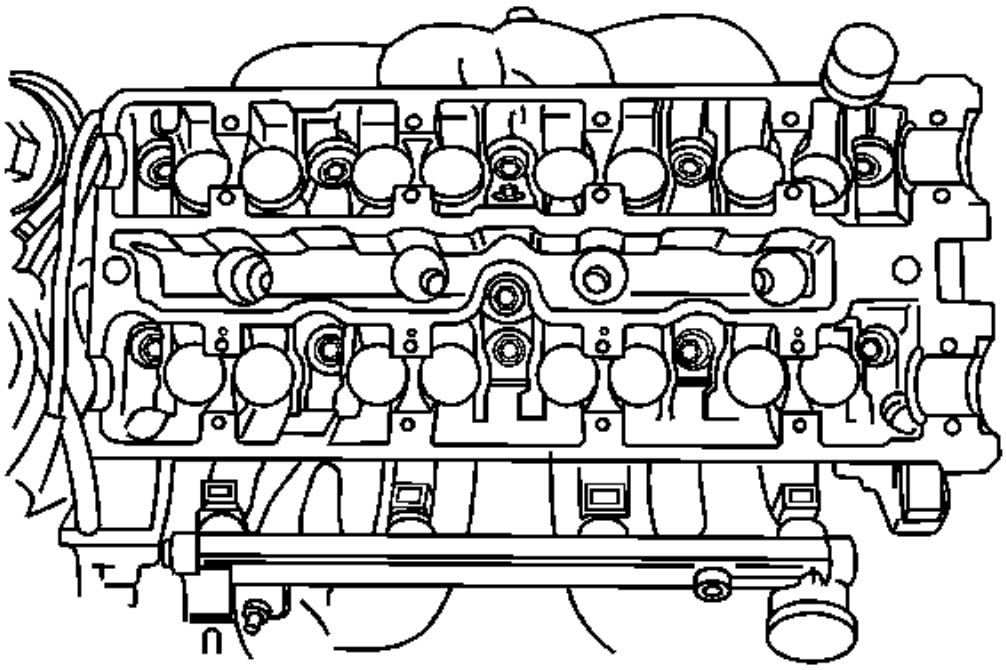


Fig. 206: View Of Valve Tappet Adjusters
Courtesy of GENERAL MOTORS CORP.

20. Remove the intake camshaft caps. Maintain the correct positions for installation.
21. Remove the intake camshaft.
22. Remove the intake valve tappet adjusters.
23. Remove the exhaust camshaft caps. Maintain the correct positions for installation.
24. Remove the exhaust camshaft.
25. Remove the exhaust valve tappet adjusters.

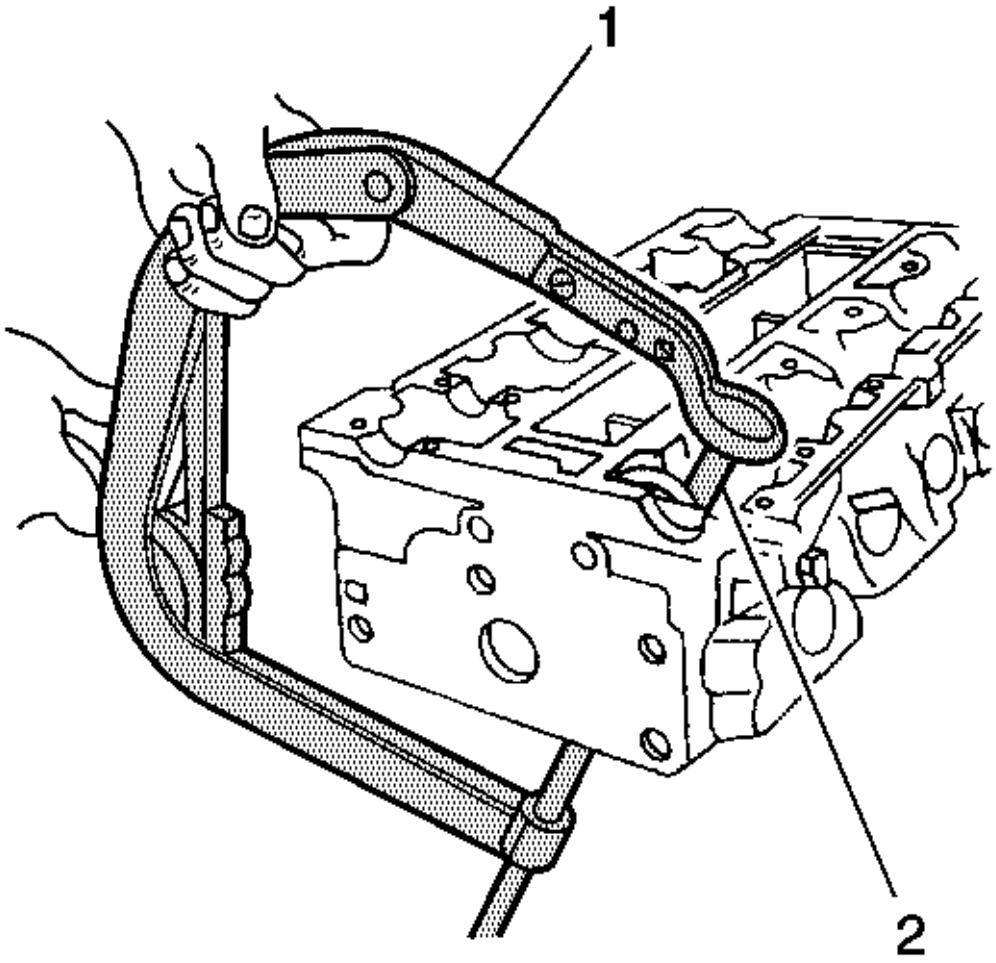


Fig. 207: View Of J 8062 And KM-653-A Valve Spring Compression Tools
Courtesy of GENERAL MOTORS CORP.

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

26. Compress the valve springs with **J 8062** (1) and the **KM-653-A** (2).
27. Remove the valve retainers.
28. Remove the **J 8062** (1) and the **KM-653-A** (2).
29. Remove the valve spring caps.
30. Remove the valve springs. Maintain the original position of the valve springs for installation.

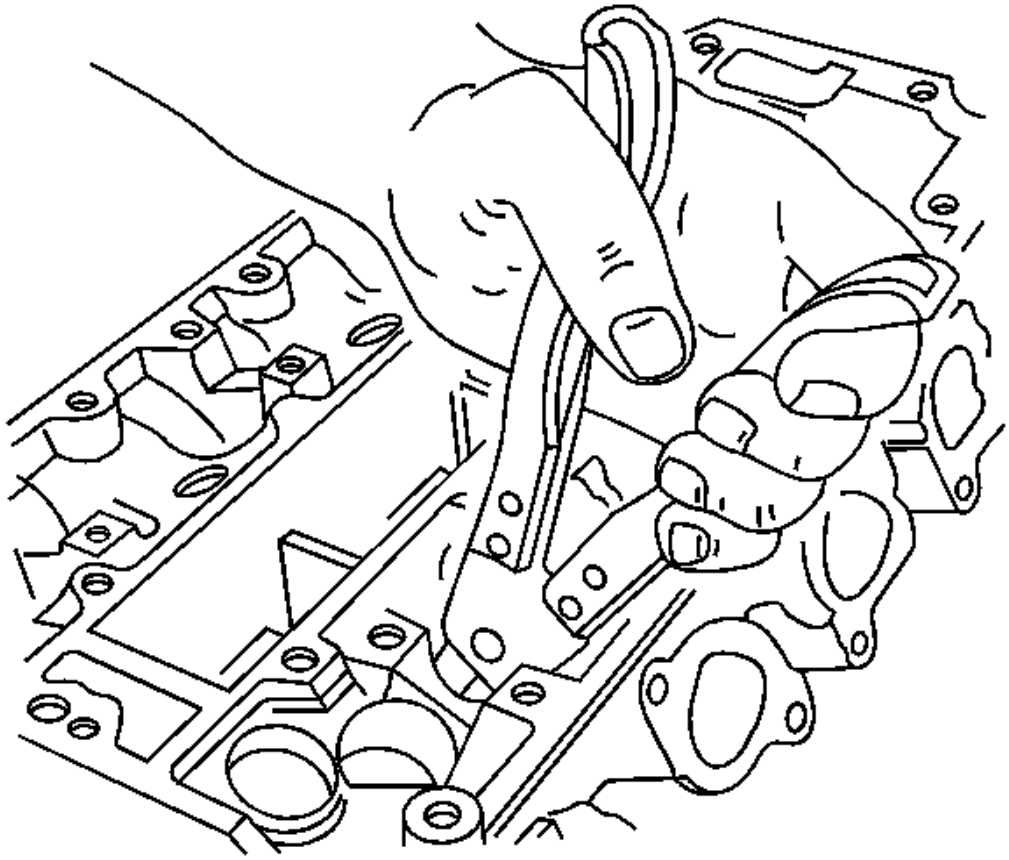


Fig. 208: Removing Valve Stem Seals
Courtesy of GENERAL MOTORS CORP.

31. Remove the valves. Maintain the original position of the valves for installation.
32. Remove the valve stem seals.

VALVE GUIDE REAMING/VALVE AND SEAT GRINDING

Tools Required

- **KM-340-1-C** Cutter Set
- **KM-571-B** Gage
- **KM-805** Valve Guide Reamer

Tool Usage

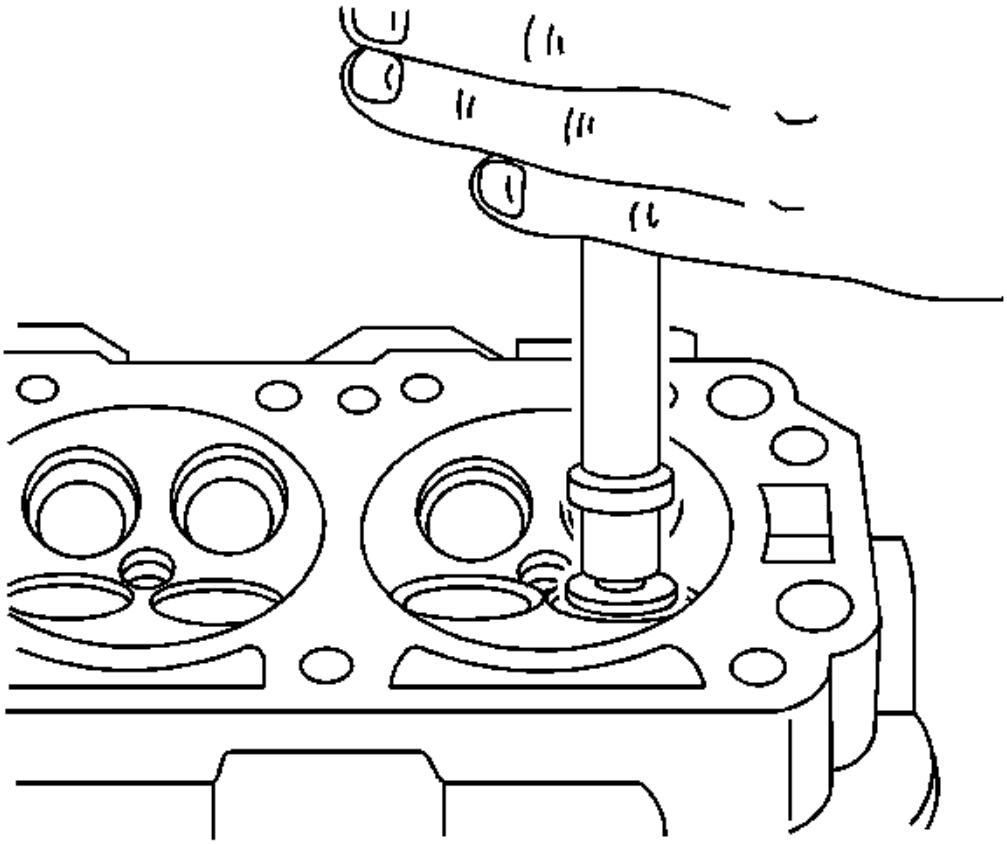


Fig. 209: View Of Valve Grinding Tool
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve seat 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.

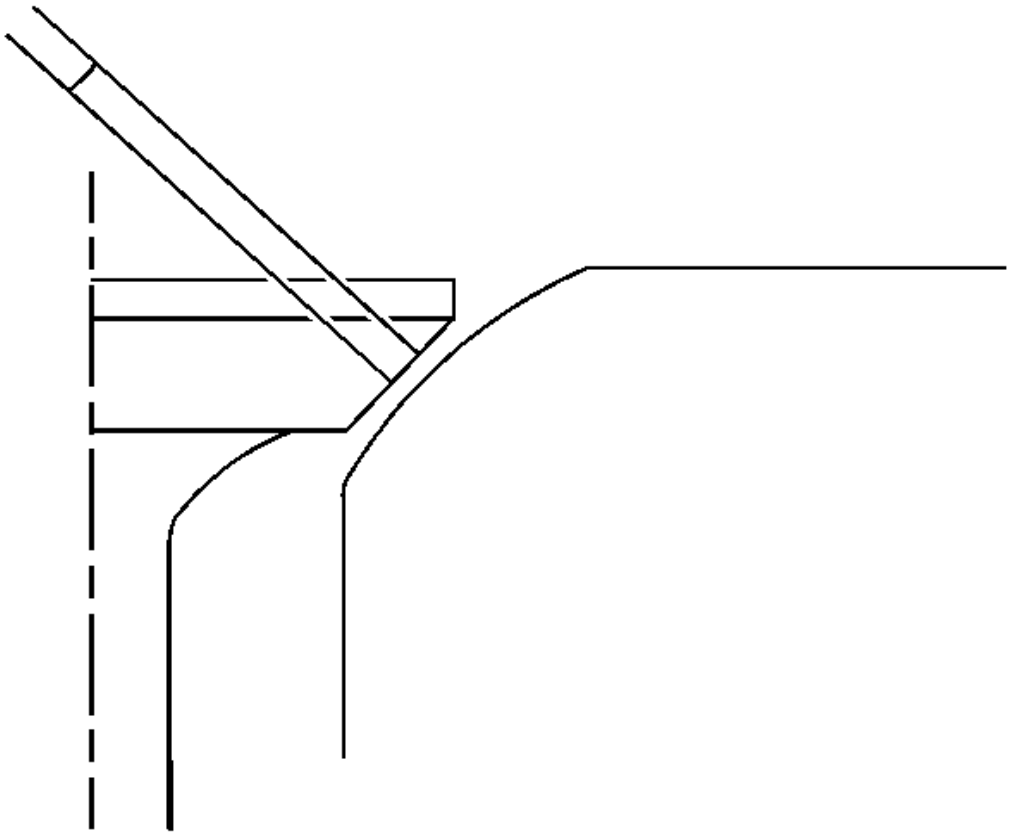


Fig. 210: View Of Valve Head To Cylinder Head Contact Pattern
Courtesy of GENERAL MOTORS CORP.

3. Check the contact pattern on the valve head and in the cylinder head.
4. Clean the valves the valve guides and the cylinder head.

Valve Grind

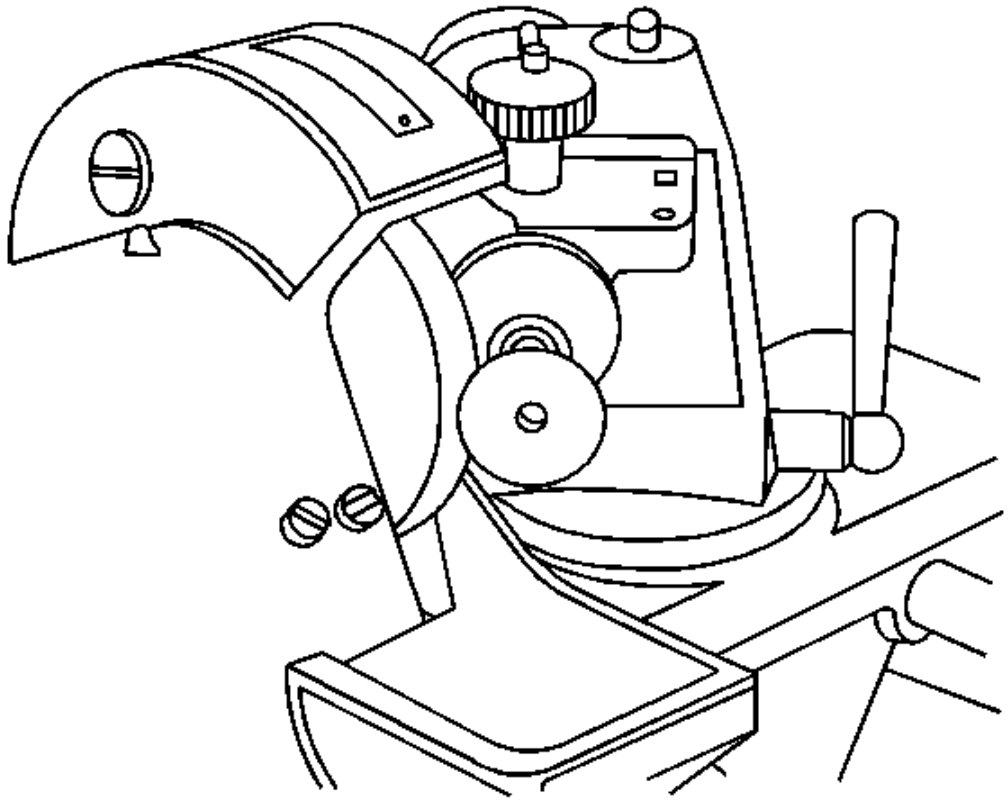


Fig. 211: View Of Valve Grinding Procedure
Courtesy of GENERAL MOTORS CORP.

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

1. Ensure that there are no crater line burns on the valve cone.
2. The valve may be reground only two times. Do not grind the valve stem end.
3. Ensure that 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

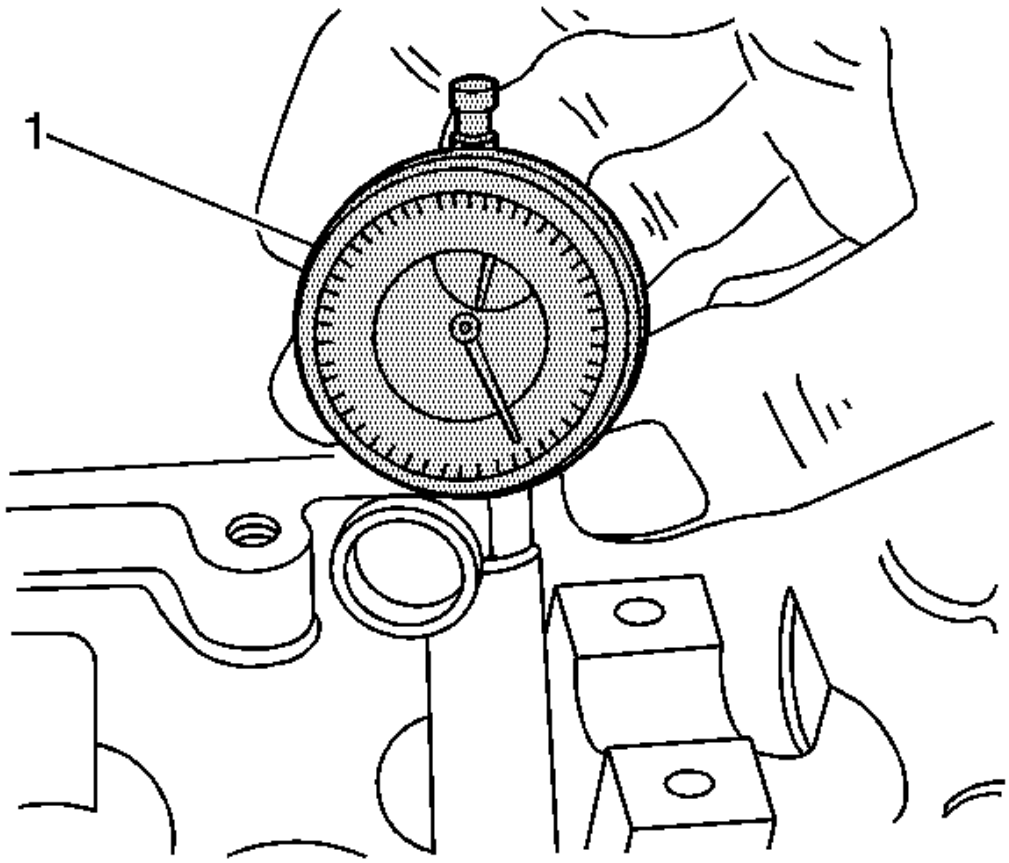


Fig. 212: View Of KM-571-B
Courtesy of GENERAL MOTORS CORP.

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

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

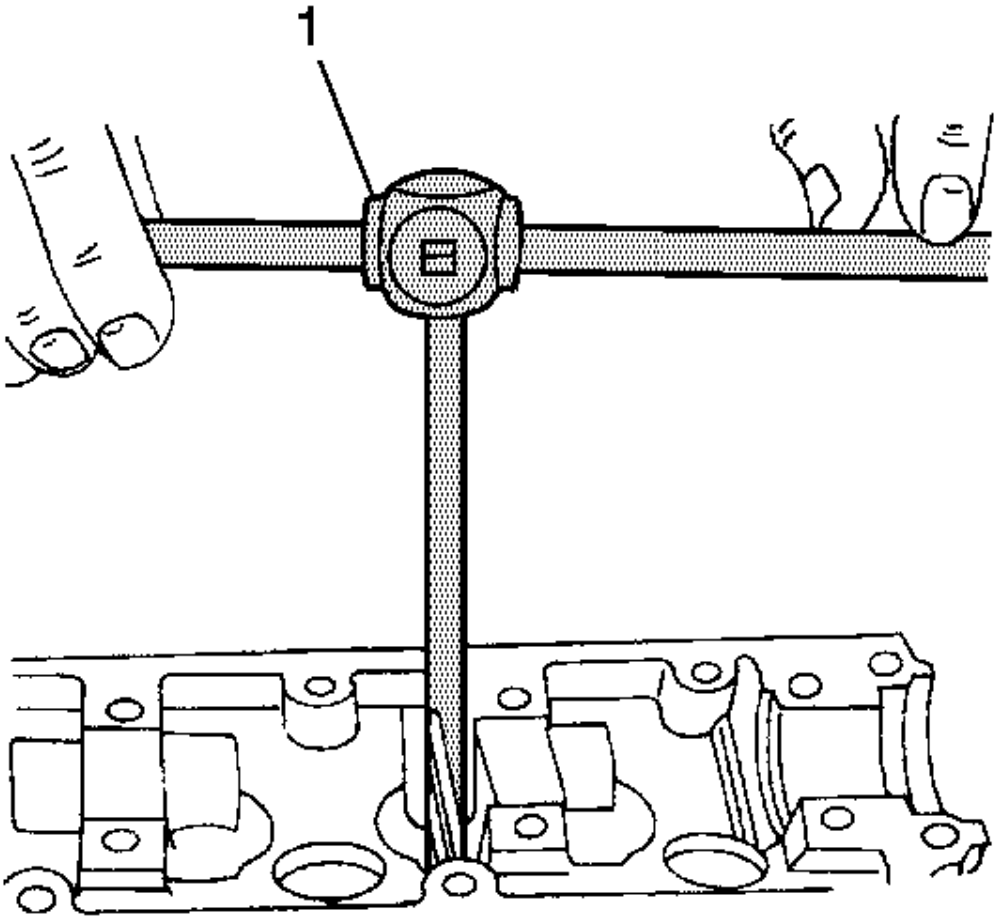


Fig. 213: View Of KM-805
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Oversized valves 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 code. Refer to the Valve Guide Reaming table in **Engine Mechanical Specifications**.
3. Using **KM-805** , 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

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

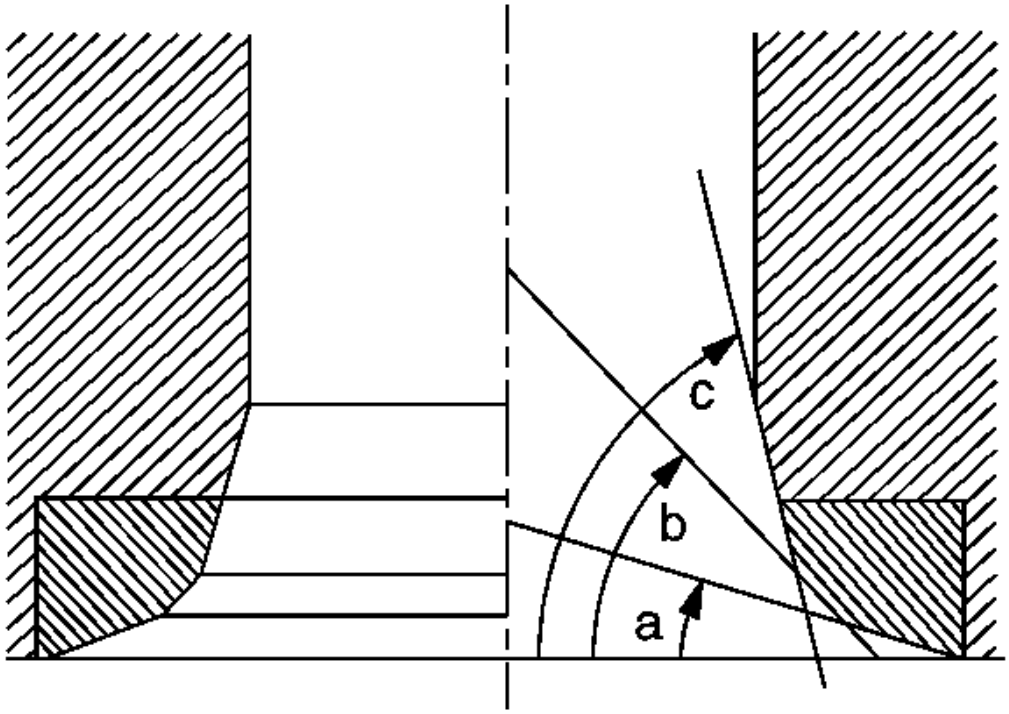


Fig. 214: Identifying Valve Seat Angles
Courtesy of GENERAL MOTORS CORP.

1. Place the cylinder head on wooden blocks.
2. Cut the intake and the exhaust valve seats using KM-340-7 Guide Drift as follows:
   - Valve seat - A 45-degree (b) surface using the cutter KM-340-13.
   - Upper correction angle - A 30-degree (a) surface using the cutter KM-340-13.
   - Lower correction angle - A 60-degree (c) 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: 1.2-1.4 mm (0.047-0.055 in)
- Exhaust: 1.4-1.8 mm (0.055-0.070 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.

CYLINDER HEAD CLEANING AND INSPECTION

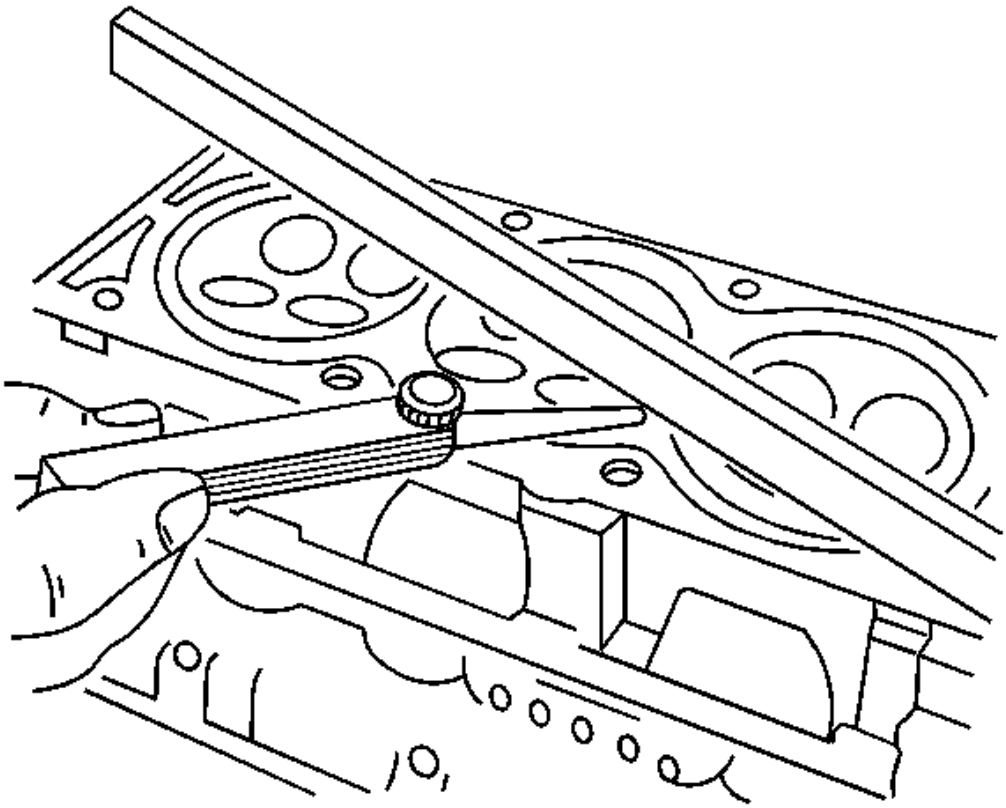


Fig. 215: View Of Cylinder Head Inspection Procedure
Courtesy of GENERAL MOTORS CORP.

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 deformation and warpage. The cylinder head sealing surfaces must be flat within 0.025 mm (0.001 in) maximum.

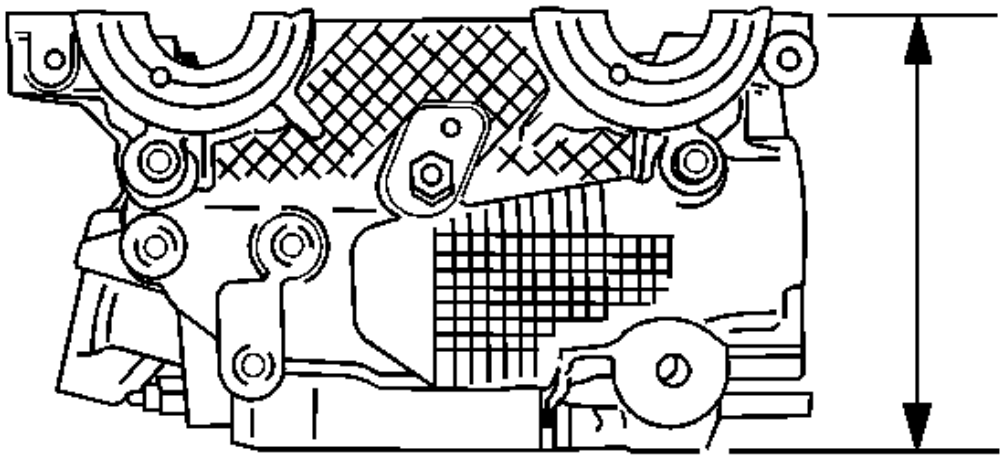


Fig. 216: Identifying Cylinder Head Height
Courtesy of GENERAL MOTORS CORP.

6. Measure the height of the cylinder head from sealing surface to sealing surface. The cylinder head height should be 133.975-134.025 mm (5.274-5.276 in). If the cylinder head height is less than 133.9 mm (5.271 in), 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** Adapter

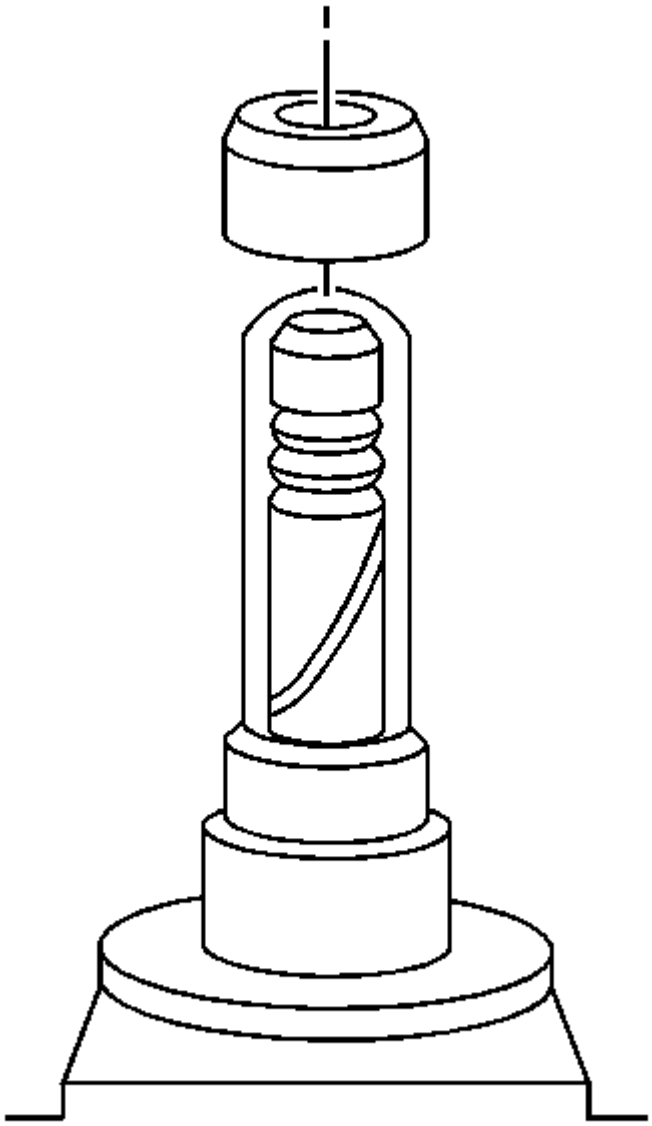


Fig. 217: View Of Oiled Valve Stem And Spring Seat
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve stems with engine oil.
2. Insert the valves in the cylinder head in their original positions.
3. Insert the valve spring seats.
4. Push the accompanying assembly sleeve onto the valve stem.

5. Insert the new valve stem seat.
6. Carefully drive the valve stem seal onto the stop with light taps.
7. Install the valve springs in their original positions.
8. Install the valve spring caps.

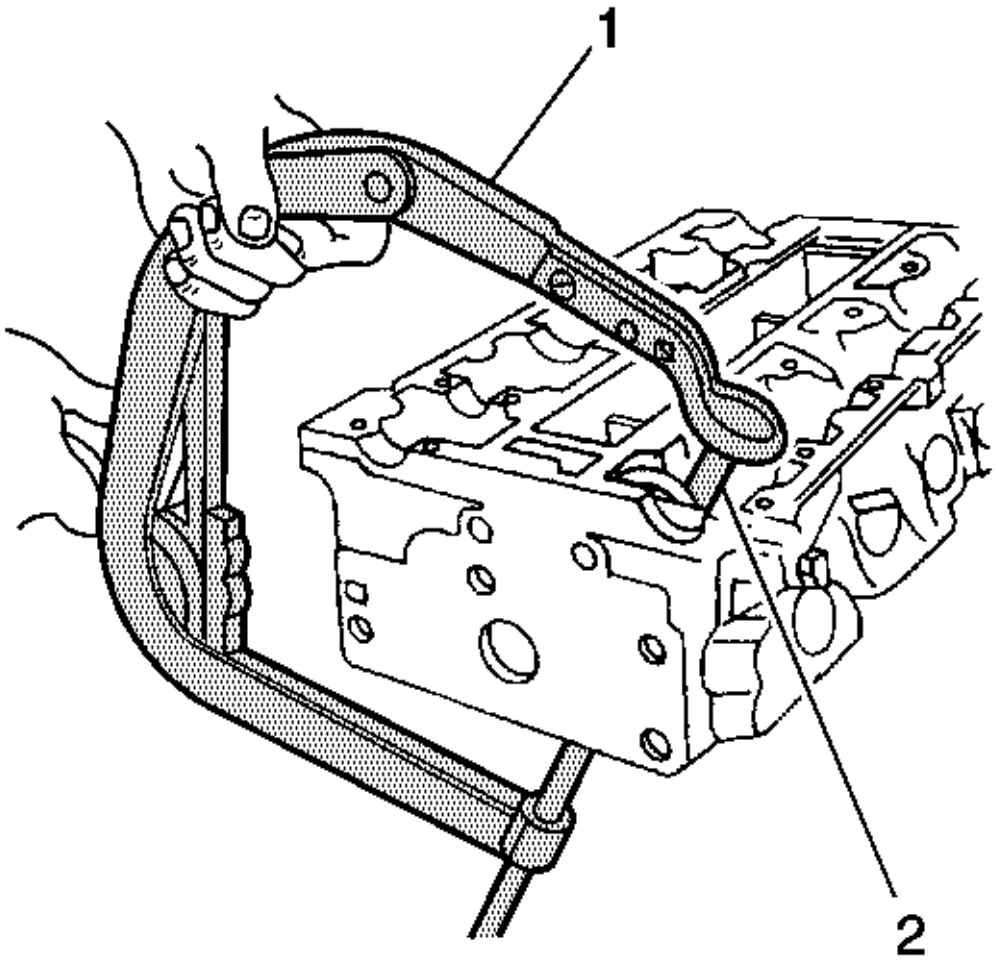


Fig. 218: View Of J 8062 And KM-653-A Valve Spring Compression Tools
Courtesy of GENERAL MOTORS CORP.

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

9. Compress the valve springs with **J 8062** (1) and adapter **KM-653-A** (2).
10. Install the valve keys.
11. Remove the **J 8062** (1) and the **KM-653-A** (2).

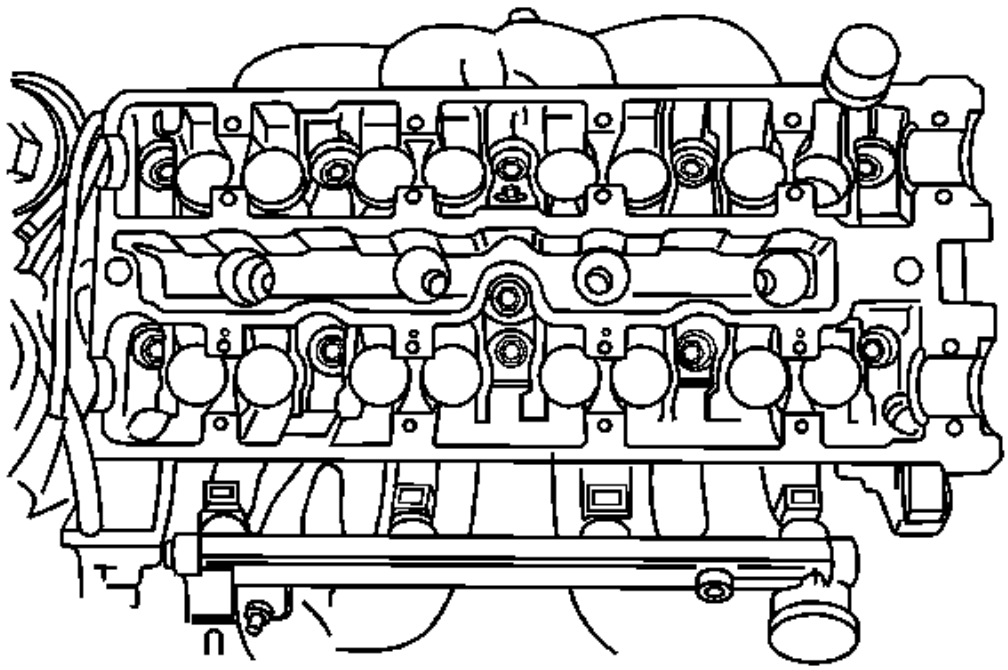


Fig. 219: View Of Valve Tappet Adjusters
Courtesy of GENERAL MOTORS CORP.

12. Lubricate the valve tappet adjusters with engine oil.
13. Install the valve tappet adjusters.

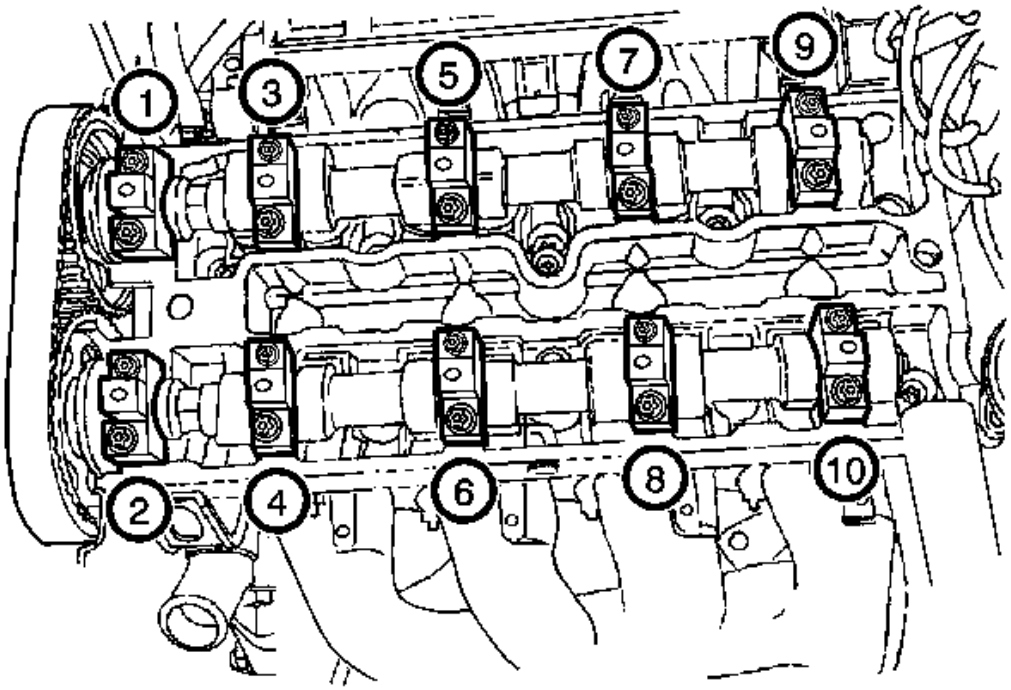


Fig. 220: Identifying Camshaft Bearing Cap Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

14. Install the intake camshaft.
15. Install the intake camshaft bearing caps in their original positions.
16. Install the exhaust camshaft.
17. Install the exhaust camshaft bearing caps in their original positions.
18. Install the camshaft bearing cap bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

    Tighten: Tighten the camshaft bearing cap bolts to **8 N.m (71 lb in)** .

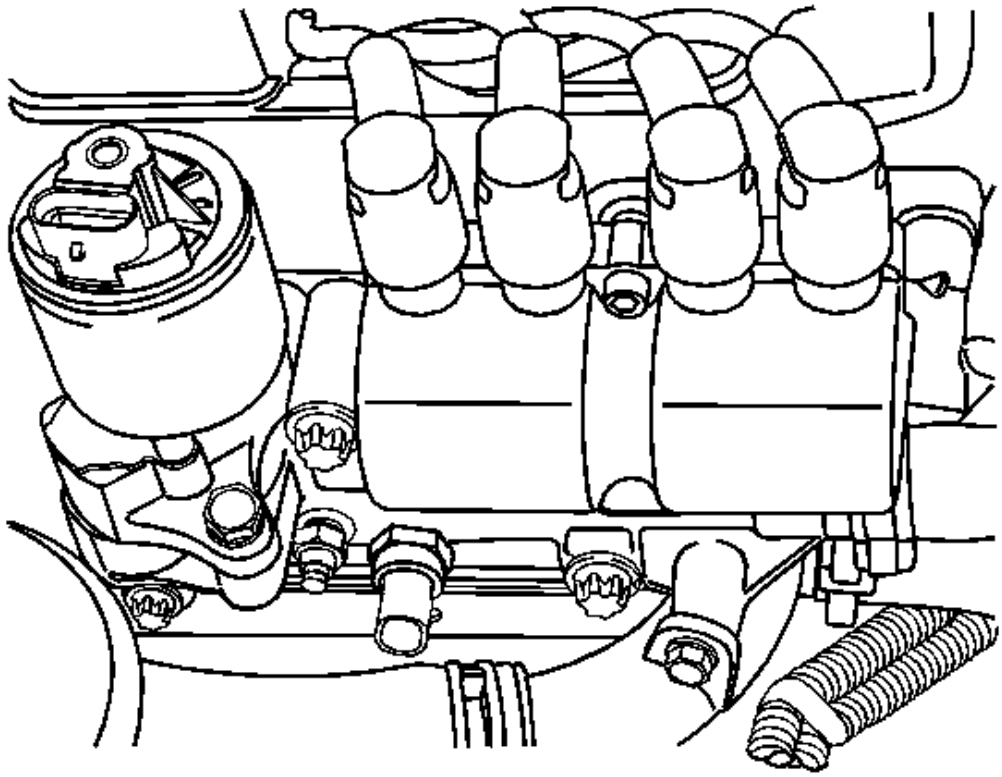


Fig. 221: View Of DIS Coil, EGR, Mounting Bracket And Bolts
Courtesy of GENERAL MOTORS CORP.

20. Install the spark plugs.

    Tighten: Tighten the spark plugs to **20 N.m (15 lb ft)** .

21. Install the direct ignition system (DIS) coil and exhaust gas recirculation (EGR) mounting bracket.
22. Install the DIS coil and EGR mounting bracket bolts.

    Tighten: Tighten the direct ignition system coil and exhaust gas recirculation mounting bracket bolts to **25 N.m (18 lb ft)** .

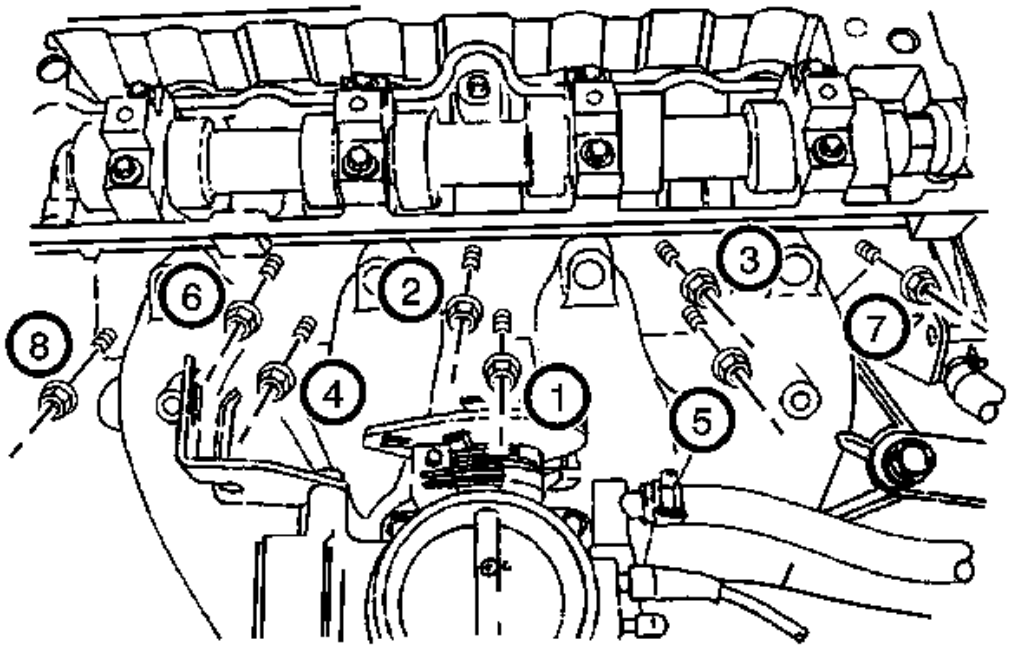


Fig. 222: View Of Intake Manifold Retaining Bolt Installation Sequence
Courtesy of GENERAL MOTORS CORP.

23. Install the intake manifold studs.
24. Install the intake manifold gasket.
25. Install the intake manifold
26. Install the intake manifold retaining nuts and retaining bolt in the sequence shown.

Tighten: Tighten the intake manifold retaining nuts and retaining bolt to **22 N.m (16 lb ft)** .

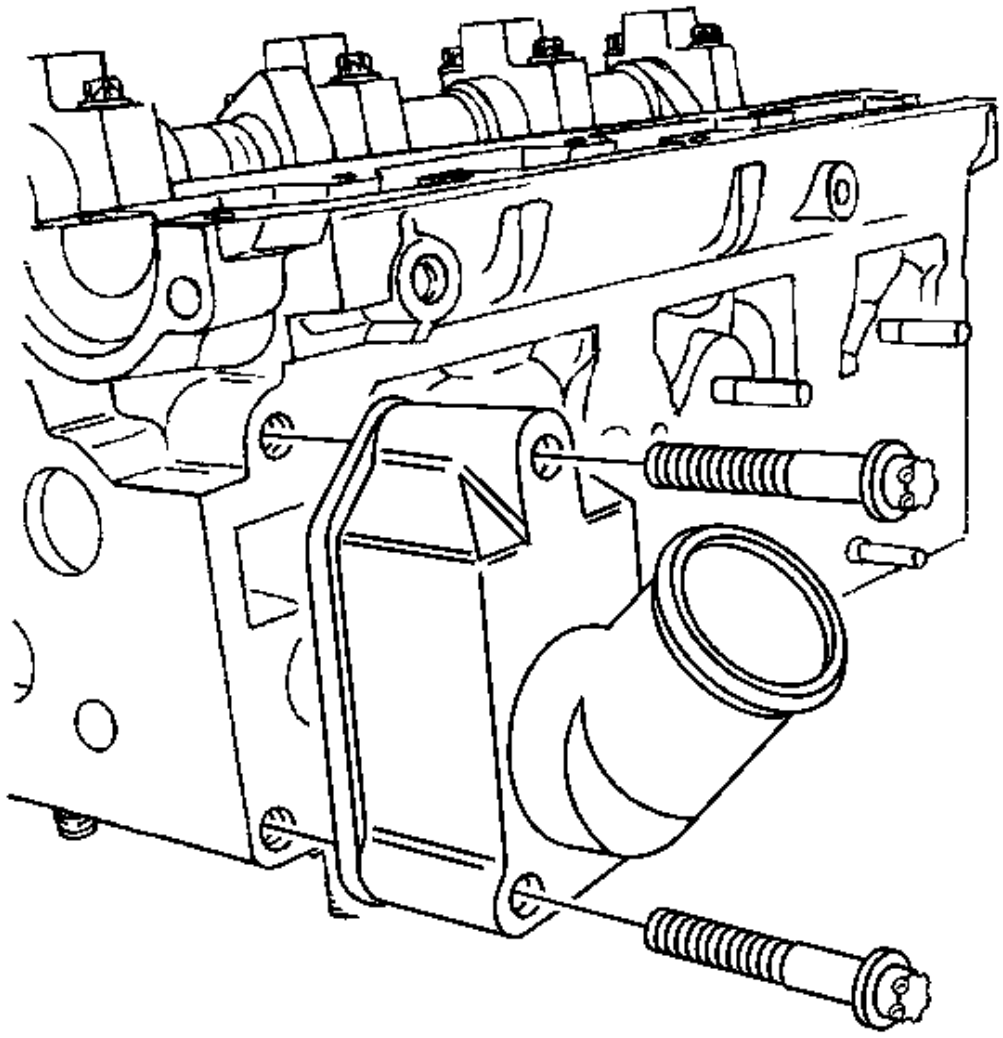


Fig. 223: View Of Coolant Bypass Housing And Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

27. Install the fuel rail assembly. Refer to **Fuel Rail Assembly Replacement** in Engine Controls - 1.8L.
28. Install the thermostat housing assembly.
29. Install the thermostat housing mounting bolts.

    Tighten: Tighten the thermostat housing mounting bolts to **15 N.m (11 lb ft)** .

30. Install the coolant bypass housing and mounting bolts.

Tighten: Tighten the coolant bypass housing bolts to **15 N.m (11 lb ft)** .

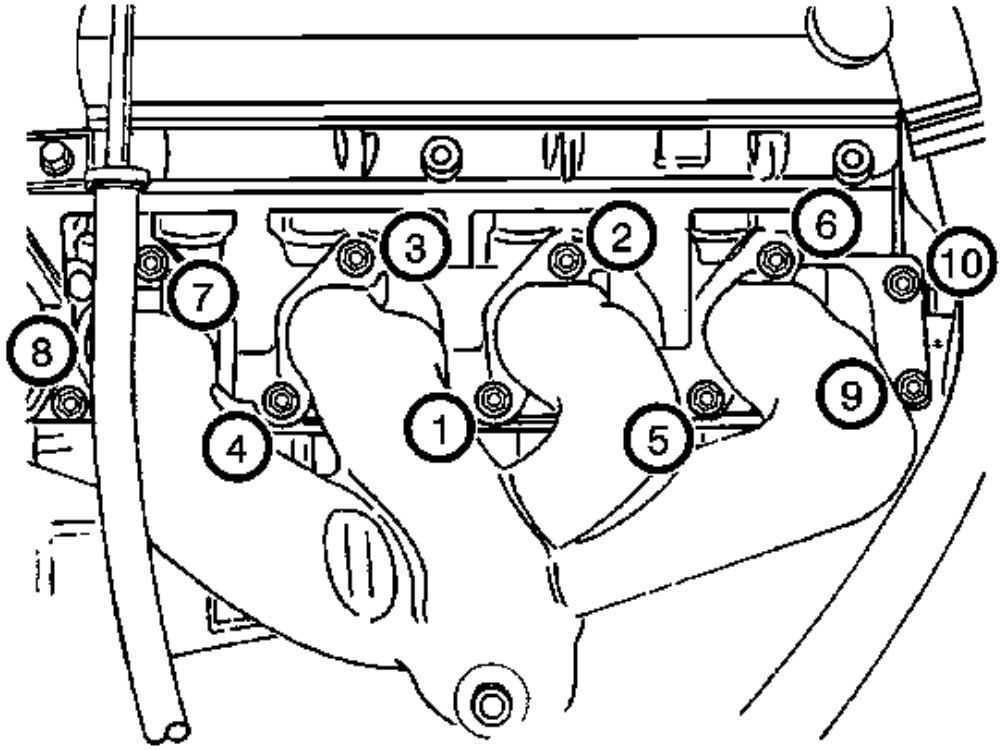


Fig. 224: View Of Exhaust Manifold Retaining Nut Installation Sequence
Courtesy of GENERAL MOTORS CORP.

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 **22 N.m (16 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 **8 N.m (71 lb in)** .

37. Install the cylinder head with the intake manifold and the exhaust manifold attached. Refer to **Cylinder**

Head Replacement.

EXHAUST MANIFOLD INSTALLATION

Installation Procedure

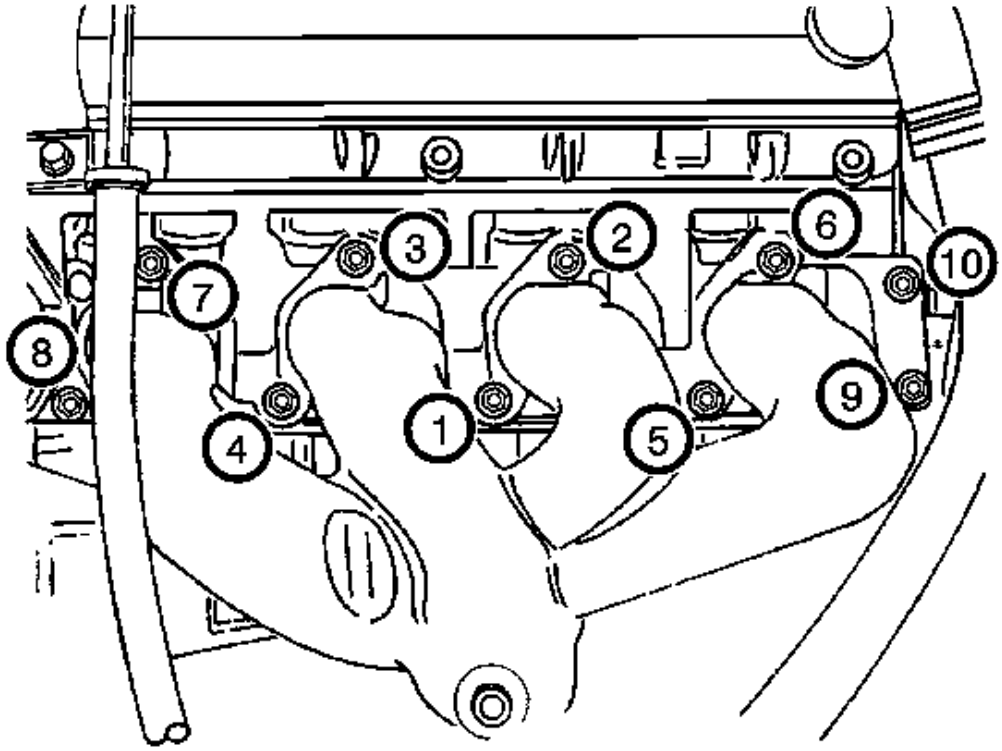


Fig. 225: View Of Exhaust Manifold Retaining Nut Installation Sequence
Courtesy of GENERAL MOTORS CORP.

1. Install the exhaust manifold gasket.
2. Install the exhaust manifold.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

   Tighten: Tighten the exhaust manifold retaining nuts **22 N.m (16 lb ft)** .

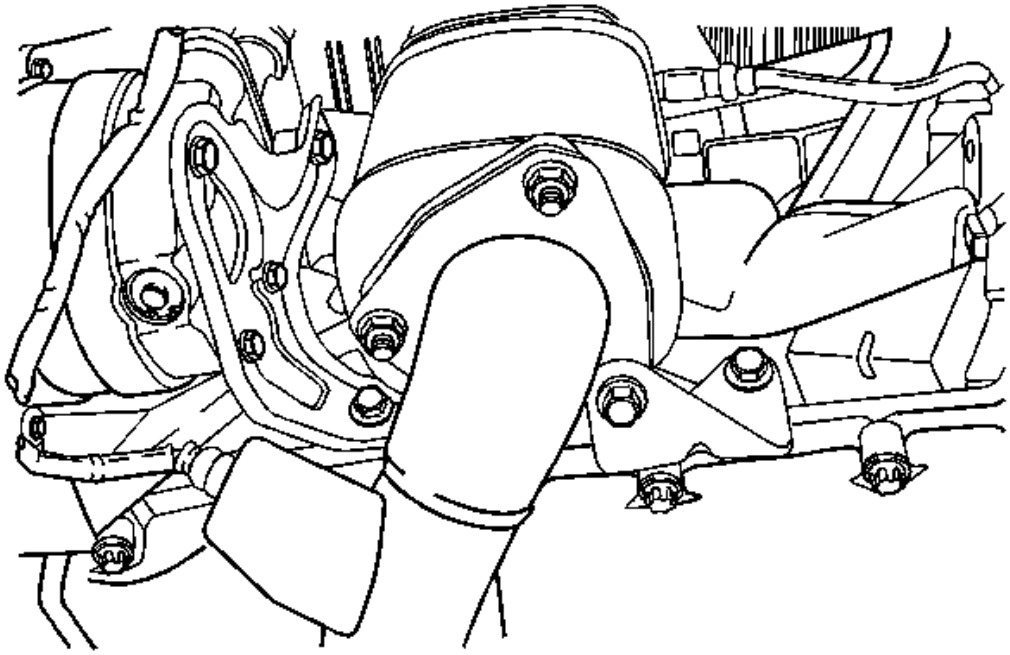


Fig. 226: View Of Exhaust Flex Pipe And Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust flex pipe retaining nuts to the exhaust manifold studs.

   Tighten: Tighten the exhaust flex pipe-to-exhaust manifold retaining nuts to **35 N.m (26 lb ft)** .

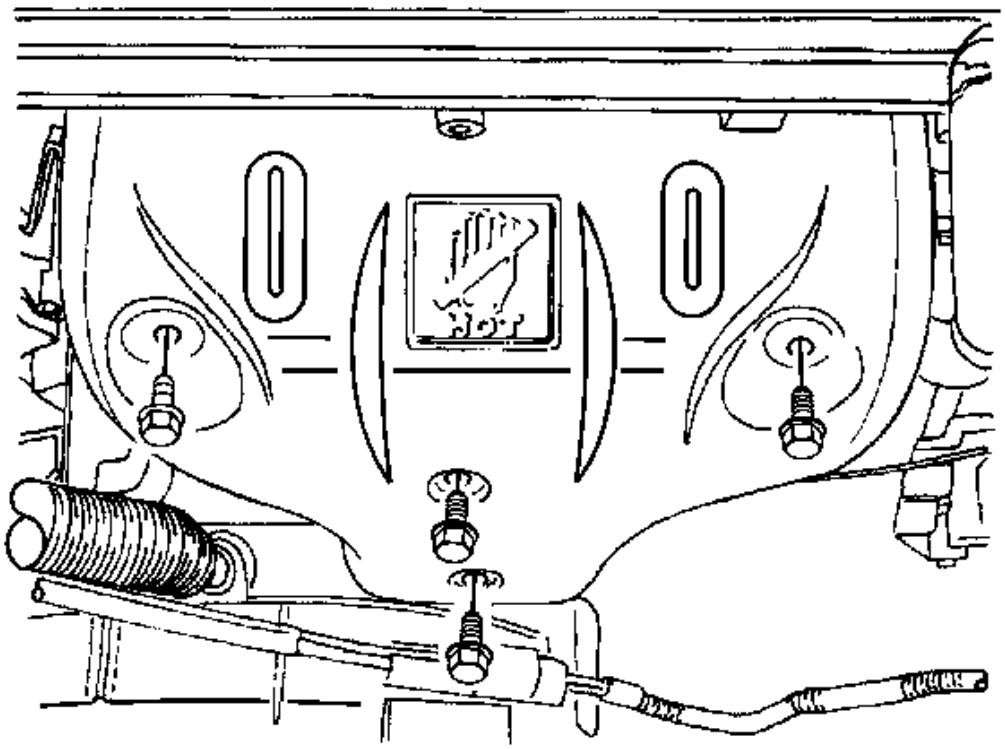


Fig. 227: View Of Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust manifold heat shield.
6. Install the exhaust manifold heat shield bolts.

   Tighten: Tighten the exhaust manifold heat shield bolts to **8 N.m (71 lb in)** .

7. Connect the oxygen sensor (O2S) connector, if equipped.
8. Connect the negative battery.

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 coolant 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 tough reinforced rubber similar to that used on the serpentine 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 crankshaft rotates, the oil pump 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 speeds, the oil pump supplies a much higher amount of oil then 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 aluminum.

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 cylinder head. In one path, the oil is pumped through passages to the camshaft. The oil passes through 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 utilizes an inertial supercharging effect to improve engine torque at low and moderate speeds.

Camshafts

This engine is a dual overhead camshaft (DOHC) type, which means there are two camshafts. One camshaft operates the intake 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 for 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 hoes in the cylinderhead. The camshaft lobes are machined into the solid camshaft to precisely open and close the intake and the exhaust valves the correct amount at the correct time. The camshaft lobes are oiled by splash action from pressurized oil escaping from the camshaft journals.

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.

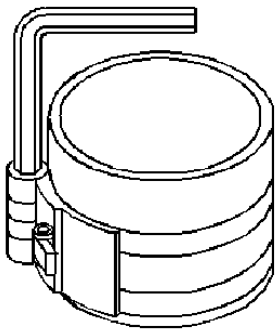
Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when they were removed.

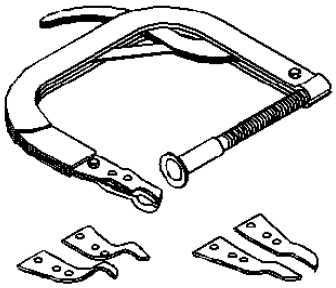
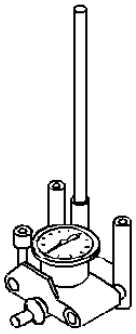
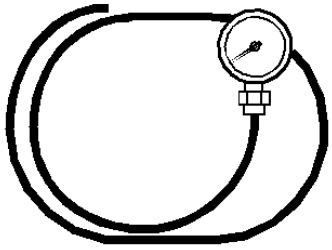
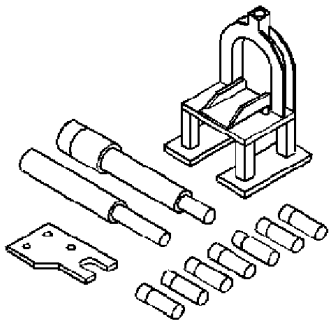
CAUTION: Refer to Battery Disconnect Caution in Cautions and Notices.

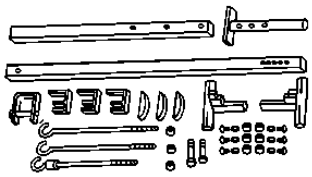
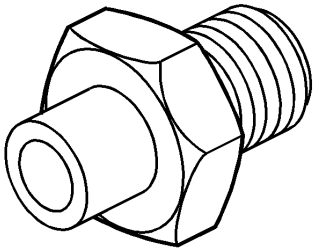
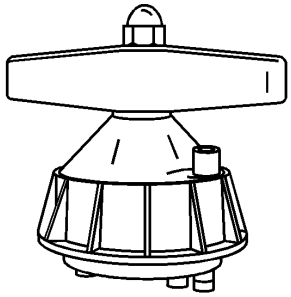
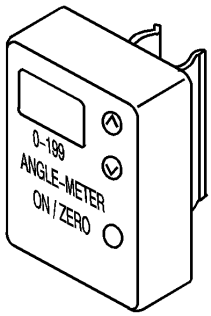
Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to the wire harness or other electrical parts.

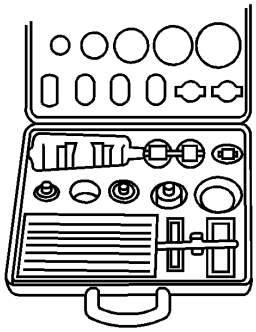
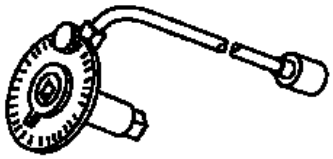
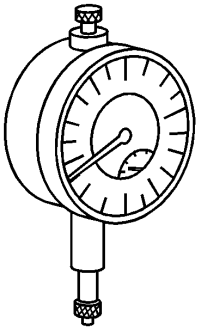
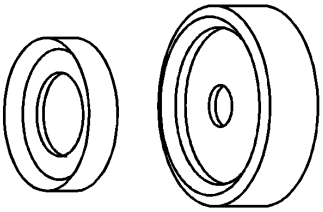
SPECIAL TOOLS AND EQUIPMENT

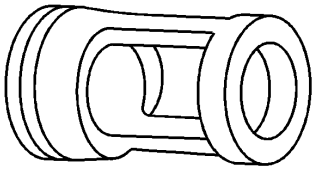
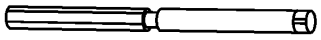
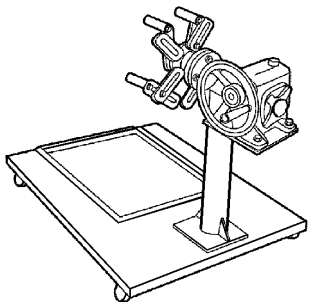
SPECIAL TOOLS

Illustration	Tool Number/ Description
	J 8037 Ring Compressor

	J 8062 (KM-348) Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage
	J 21867 (KM-498-B) Pressure Gage
	J 24086-B (KM-427) Piston Pin Remover/Installer Set
	J 28467-B, DW-117 (DW110-060) Universal Engine Support Fixture

	
	J 36648-A, (KM-135 A) Oil Pressure Gage Adapter
	J 36972 Crankshaft Rear Oil Seal Installer
	J 45059 Angle Meter
	KM-340-1-C Cutter Set

	
	KM-470-B Angular Torque Gage
	KM-571-B Gage
	KM-635 Crankshaft Rear Oil Seal Installer
	KM-653-A Adapter

	
	KM-805 Valve Guide Reamer
	OTC 1726, KM-412 Engine Overhaul Stand

