2004 ENGINE

Engine Mechanical - 2.0L - Tracker

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Cleaner (ACL) Mounting Bolts	10 N.m	89 lb in
Air Conditioner (A/C) Compressor Mounting Bolts	23 N.m	17 lb ft
Air Conditioner (A/C) Compressor Bracket Mounting Bolts	55 N.m	40 lb ft
Camshaft Bearing Cap Bolts	11 N.m	97 lb in
Camshaft Position Sensor Bolt	15 N.m	11 lb ft
Camshaft Timing Sprocket Bolts	80 N.m	58 lb ft
Connecting Rod Bearing Cap Nuts	45 N.m	33 lb ft
Coolant Bypass Pipe to Cylinder Head Bolt	15 N.m	11 lb ft
Crankshaft Position Sensor Bolt	6 N.m	53 lb in
Crankshaft Pulley Bolt	150 N.m	109 lb ft
Cylinder Head Cover Bolts	11 N.m	97 lb in
Cylinder Head Bolts		
• First Pass	53 N.m	39 lb ft
• Second Pass	84 N.m	61 lb ft
• Third Pass	Loosen to 0	
• Fourth Pass	53 N.m	39 lb ft
• Fifth Pass	84 N.m	61 lb ft
• Sixth Pass (Final Torque)	105 N.m	76 lb ft
Cylinder Head M 6 Bolt	11 N.m	97 lb in
Drive Belt Idler Pulley Nut	45 N.m	33 lb ft
Drive Belt Tensioner Bolts		
• Cooling Fan Drive Belt Tensioner Bolts	45 N.m	33 lb ft
• Accessory Drive Belt Tensioner Bolts	25 N.m	19 lb ft
Engine Cooling Fan Nuts	11 N.m	97 lb in
Engine Ground Wire Bolts	15 N.m	11 lb ft
Engine Mount Bracket Bolts (Engine Side)	50 N.m	37 lb ft
Engine Mount Bracket Bolts (Body Side)	85 N.m	62 lb ft
Engine Mount Nuts	50 N.m	37 lb ft
Engine Oil Drain Plug	35 N.m	26 lb ft

Engine Oil Pan Nuts and Bolts	11 N.m	97 lb in
Exhaust Manifold Flange Bolts	50 N.m	37 lb ft
Exhaust Manifold Heat Shield Bolts	15 N.m	11 lb ft
Exhaust Manifold-to-Cylinder Head Nuts	50 N.m	37 lb ft
Exhaust Manifold-to-Bracket Bolts	50 N.m	37 lb ft
Exhaust Pipe PUP Catalytic Converter Clamp Bolt	50 N.m	37 lb ft
Fuel Rail to Cylinder Head Bolts	23 N.m	17 lb ft
Fuel Rail Banjo Fitting	30 N.m	22 lb ft
Flywheel Retaining Bolts		
• Automatic Transmission	70 N.m	51 lb ft
• Manual Transmission	70 N.m	51 lb ft
Generator Mounting Bolts and Nuts	23 N.m	17 lb ft
Heated Oxygen (HO2S1 and HO2S2) Sensor	45 N.m	33 lb ft
Ignition Coil Bolts	10 N.m	89 lb in
Intake Manifold Bolts and Nuts	25 N.m	19 lb ft
Intake Manifold Front Support Bracket Bolts	45 N.m	33 lb ft
Intake Manifold Top Support Bracket Bolts	15 N.m	11 lb ft
Lower Crankcase Bolts		
• First Pass	19 N.m	14 lb ft
• Second Pass (Final Torque)	27 N.m	20 lb ft
Main Bearing Cap Bolts:		
• First Pass	42 N.m	31 lb ft
• Second Pass (Final Torque)	60 N.m	44 lb ft
Negative Battery Cable	15 N.m	11 lb ft
Oil Filter Adapter	23 N.m	17 lb ft
Oil Pressure Switch	14 N.m	11 lb ft
Oil Pump Sprocket Cover Bolts	11 N.m	97 lb in
Oil Pump Bolts	27 N.m	20 lb ft
Oil Pump Case Bolts	12 N.m	106 lb in
Oil Pump Strainer Bolts	11 N.m	97 lb in
Oil Pump Relief Valve Retainer	29 N.m	21 lb ft
Power Steering Pump Bolts	25 N.m	19 lb ft
Spark Plugs	25 N.m	18 lb ft
Starter Bolts	30 N.m	22 lb ft
Strut Tower Brace	50 N.m	37 lb ft
Throttle Body Bolts and Nuts	25 N.m	19 lb ft
Timing Chain Cover Nut and Bolts	11 N.m	97 lb in
Timing Chain Tensioner Bolts (Camshaft)	11 N.m	97 lb in
Timing Chain Tensioner Bolts (Crankshaft)	11 N.m	97 lb in
Timing Chain Tensioner Nut (Camshaft)	45 N.m	33 lb ft

Timing Chain Tensioner Guide Bolts (Crankshaft)	9 N.m	62 lb in
Timing Chain Tensioner Shoe Nut (Crankshaft)	25 N.m	19 lb ft
Torque Converter Bolts	65 N.m	47 lb ft
Transmission Bracket Bolts	50 N.m	37 lb ft
Transmission to Engine Mounting Bolts	85 N.m	62 lb ft
Water Pump Bolts	27 N.m	20 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General:		
• Engine Type	L4	
• RPO Code	L34	
• Displacement	1995 cc	122 CID
• Bore	84 mm	3.31 in
• Stroke	90 mm	3.54 in
• Compression Ratio	9.7:1	
• Firing Order	1-3-4-2	
• Spark Plug Type-Denso	SK16PR11 or PK16PR11	
• Spark Plug Type-NGK	IFR5G11 or PFR5G-11	
• Spark Plug Gap	1.0-1.1 mm	0.039-0.043 in
Compression:		
• Compression Pressure at 250 RPM-Standard	1400 kPa	199 psi
• Compression Pressure-Minimum	1200 kPa	170 psi
• Compression Pressure Difference Between Any Two Cylinders-Maximum	100 kPa	15 psi
Engine Vacuum:		
• Vacuum at Sea Level	52.6-65.8 kPa	15.7-19.7 in Hg
Lubrication System:		
• Oil Pressure at 4000 RPM	390-470 kPa	55.5-66.8 psi
• Oil Capacity with Filter Change	5.2 L	5.5 qt
• Oil Capacity without Filter Change	5.0 L	5.2 qt
Cooling System:		
• Cooling System Capacity	6.5 L	6.9 qt
• Temperature at which Thermostat begins to Open	83°C	179°F

• Temperature at which Thermostat Fully Open	95°C	203°F
• Thermostat Valve Lift	8 mm at 95°C	0.32 in at 203°F
• Cooling Fan Belt Deflection at 10 kg (22 lbs) of Force-New Belt	4-5 mm	0.16-0.20 in
• Cooling Fan Belt Deflection at 10 kg (22 lbs) of Force-Used Belt	5-7 mm	0.20-0.27 in
• Radiator Cap Relief Valve Pressure	108 kPa	15.7 psi
• Temperature at which Fan Clutch begins to Engage	50-70°C	122-158°F
Camshaft:		
• Journal Outside Diameter	25.959-25.980 mm	1.0220-1.0228 in
• Journal Bore Diameter	26.000-26.033 mm	1.0236-1.0249 in
• Journal Oil Clearance-Standard	0.020-0.074 mm	0.0008-0.0029 in
• Journal Oil Clearance-Maximum	0.12 mm	0.0047 in
• Lobe Height Exhaust-Standard	39.921-40.081 mm	1.5717-1.5780 in
• Lobe Height Exhaust-Minimum	39.721 mm	1.5638 in
• Lobe Height Intake-Standard	40.402-40.562 mm	1.5906-1.5969 in
• Lobe Height Intake-Minimum	40.202 mm	1.5827 in
• Runout	0.10 mm	0.0039 in
Connecting Rods and Bearings:		
• Connecting Rod Bearing Clearance-Standard	0.045-0.063 mm	0.0018-0.0025 in
• Connecting Rod Bearing Clearance-Maximum	0.080 mm	0.0031 in
• Connecting Rod Bushing Inside Diameter	21.003-21.011 mm	0.8269-0.8272 in
• Connecting Rod Bow-Maximum	0.050 mm	0.0020 in
• Connecting Rod Side Clearance-Maximum	0.45 mm	0.0177 in
• Connecting Rod Side Clearance-Standard	0.25-0.40 mm	0.0099-0.0157 in
• Connecting Rod Twist-Maximum	0.10 mm	0.0039 in
• Crankshaft Diameter Out-of-Round and Taper-Maximum	0.01 mm	0.0004 in
• Crankshaft Diameter-Standard	49.982-50.000 mm	1.9678-1.9685 in
• Crankshaft Diameter - 0.25 mm (0.0098 in) Undersize	49.732-49.750 mm	1.9580-1.9586 in
Crankshaft:		
• Journal Taper	0.01 mm	0.0004 in
• Journal Out-of-Round	0.01 mm	0.0004 in
• Runout at Center Journal	0.06 mm	0.0023 in
• Thrust Bearing Thickness-Standard	2.500 mm	0.0984 in

• Thrust Bearing Thickness - 0.125 mm (0.0049 in) Oversize	2.563 mm	0.1009 in
• Thrust Play-Standard	0.10-0.35 mm	0.0039-0.0138 in
• Thrust Play-Maximum	0.42 mm	0.0165 in
• Reground Journal Finished Diameter	57.732-57.750 mm	2.2729-2.2736 in
Cylinder Head:		
• Gasket Surface Distortion	0.05 mm	0.0020 in
• Seating Distortion Intake and Exhaust Manifolds	0.10 mm	0.004 in
Cylinder Block:		
• Cylinder Bore-Standard-Red Marking	84.01-84.02 mm	3.3075-3.3078 in
• Cylinder Bore-Standard-Blue Marking	84.00-84.01 mm	3.3071-3.3074 in
• Cylinder Bore-Maximum	84.050 mm	3.3090 in
• Cylinder Bore-Allowance for Honing	0.02 mm	0.008 in
• Gasket Surface Distortion-Maximum	0.06 mm	0.0024 in
• Taper and Out-of-Round-Maximum	0.10 mm	0.0039 in
Flywheel:		
• Flywheel Face Runout	0.2 mm	0.0078 in
Main Bearings:		
• Crankshaft Journal Diameter - "1" Stamping	57.994-58.000 mm	2.2832-2.2834 in
• Crankshaft Journal Diameter - "2" Stamping	57.988-57.994 mm	2.2830-2.2832 in
• Crankshaft Journal Diameter - "3" Stamping	57.982-57.988 mm	2.2828-2.2829 in
• Main Bearing Cap Bore Diameter - "A" Stamping	62.000-62.006 mm	2.4409-2.4411 in
• Main Bearing Cap Bore Diameter - "B" Stamping	62.006-62.012 mm	2.4412-2.4414 in
• Main Bearing Cap Bore Diameter - "C" Stamping	62.012-62.018 mm	2.4414-2.4416 in
• Main Bearing Clearance-Standard	0.026-0.046 mm	0.0010-0.0018 in
• Main Bearing Clearance-Maximum	0.060 mm	0.0023 in
• Main Bearing Thickness-Standard-Green	1.993-1.997 mm	0.0785-0.0786 in
• Main Bearing Thickness-Standard-Black	1.996-2.000 mm	0.0786-0.0787 in
• Main Bearing Thickness-Standard-Colorless	1.999-2.003 mm	0.0787-0.0788 in
• Main Bearing Thickness-Standard-Yellow	2.002-2.006 mm	0.0788-0.0789 in
• Main Bearing Thickness-Standard-Blue	2.005-2.009 mm	0.0789-0.0790 in
• Main Bearing Thickness-0.25 mm (0.0098 in) Undersize-Green and Red	2.118-2.122 mm	0.0834-0.0835 in
• Main Bearing Thickness-0.25 mm (0.0098 in) Undersize-Black and Red	2.121-2.125 mm	0.0835-0.0836 in

• Main Bearing Thickness-0.25 mm (0.0098 in) Undersize-Red Only	2.124-2.128 mm	0.0836-0.0837 in
• Main Bearing Thickness-0.25 mm (0.0098 in) Undersize-Yellow and Red	2.127-2.131 mm	0.0837-0.0838 in
• Main Bearing Thickness-0.25 mm (0.0098 in) Undersize-Blue and Red	2.130-2.134 mm	0.0838-0.0839 in
Oil Pump:		
• Housing-to-Oil Pump Gear Set Side Clearance-Maximum	0.11 mm	0.0043 in
• Outer Rotor-to-Oil Pump Body Radial Clearance-Maximum	0.15 mm	0.0059 in
• Outer Pressure Relief Valve-Relief Pressure	420 kPa	60 psi
• Outer Pressure Relief Spring Free Length	63.5 mm	2.5 in
• Outer Pressure Relief Spring Tension	86 Newtons at 52.0 mm	62.2 lb at 2.05 in
Pistons:		
• Diameter-Standard Marked 1	83.980-83.990 mm	3.3063-3.3066 in
• Diameter-Standard Marked 2	83.970-83.980 mm	3.3059-3.3062 in
• Diameter - 0.25 mm (0.0098 in) Oversize	84.220-84.240 mm	3.3157-3.165 in
• Diameter - 0.50 mm (0.0196 in) Oversize	84.470-84.490 mm	3.3256-3.3263 in
• Cylinder Bore Diameter-Maximum	84.050 mm	3.3090 in
• Cylinder Bore Taper-Maximum	0.10 mm	0.004 in
• Cylinder Bore Out-of-Round-Maximum	0.10 mm	0.004 in
• Pin Clearance	0.003-0.014 mm	0.0001-0.0005 in
• Pin Diameter	20.997-21.000 mm	0.8267-0.8267 in
• Piston-to-Cylinder Bore Clearance	0.02-0.04 mm	0.0008-0.0015 in
• Ring End Gap - Top Ring-Standard	0.20-0.35 mm	0.0079-0.0137 in
• Ring End Gap - Top Ring-Maximum	0.07 mm	0.0276 in
• Ring End Gap - Lower Ring-Standard	0.35-0.50 mm	0.0138-0.0196 in
• Ring End Gap - Lower Ring-Maximum	0.07 mm	0.0276 in
• Ring End Gap - Oil Ring-Standard	0.20-0.70 mm	0.0079-0.0275 in
• Ring End Gap - Oil Ring-Maximum	1.8 mm	0.0709 in
• Ring Groove Clearance - Lower Compression Ring	0.020-0.060 mm	0.0008-0.0023 in
• Ring Groove Clearance - Upper Compression Ring	0.030-0.070 mm	0.0012-0.0027 in
Valves:		
• Guide Inside Diameter	6.000-6.012 mm	0.2362-0.2366 in

• Valve Margin - Intake-Standard	1.0 mm	0.039 in
• Valve Margin - Intake-Minimum	0.6 mm	0.024 in
• Valve Margin - Exhaust-Standard	1.2 mm	0.047 in
• Valve Margin - Exhaust-Minimum	0.7 mm	0.028 in
• Valve Head Radial Runout-Maximum	0.8 mm	0.003 in
• Head Angles for Refinishing - Area Above Seat Contact Surface	15 Degrees	
• Head Angles for Refinishing - Area Below Seat Contact Surface-Exhaust Valve Only	60 Degrees	
• Head Angles for Refinishing - Seat Contact Surface	45 Degrees	
• Head Angles for Refinishing - Face Contact Surface	45 Degrees	
• Seating Contact Width-Seat	1.1-1.3 mm	0.0433-0.0512 in
• Seating Contact Width-Face	1.1-1.3 mm	0.0433-0.0512 in
• Inner Spring Free Length-Standard	36.08 mm	1.4204 in
• Inner Spring Free Length-Minimum	35.00 mm	1.3780 in
• Outer Spring Free Length-Standard	40.44 mm	1.5921 in
• Outer Spring Free Length-Minimum	39.22 mm	1.5441 in
• Inner Spring Preload-Standard	6.9-7.9 kg at 27.5 mm	15.2-17.4 lb at 1.08 in
• Inner Spring Preload-Minimum	6.2 kg at 27.5 mm	13.6 lb at 1.08 in
• Outer Spring Preload-Standard	15.4-17.8 kg at 31.7 mm	33.9-39.2 lb at 1.25 in
• Outer Spring Preload-Minimum	13.8 kg at 31.7 mm	30.4 lb at 1.25 in
• Spring Side Clearance-Maximum	2.0 mm	0.079 in
• Stem Outside Diameter - Exhaust Valves	5.940-5.955 mm	0.2339-0.2344 in
• Stem Outside Diameter - Intake Valves	5.965-5.980 mm	0.2348-0.2354 in
• Stem-to-Guide Clearance - Exhaust Valves-Standard	0.045-0.072 mm	0.0018-0.0028 in
• Stem-to-Guide Clearance - Exhaust Valves-Maximum	0.09 mm	0.0035 in
• Stem-to-Guide Clearance - Intake Valves-Standard	0.020-0.047 mm	0.0008-0.0018 in
• Stem-to-Guide Clearance - Intake Valves-Maximum	0.07 mm	0.0027 in
• Valve Guide-Oversize	0.03 mm	0.0012 in
• Valve Guide Protrusion	13.5 mm	0.53 in
• Hydraulic Valve Lash Adjuster - Outside Diameter	30.959-30.975 mm	1.2189-1.2194 in
• Hydraulic Valve Lash Adjuster - Cylinder Head Bore Diameter	31.000-31.025 mm	1.2205-1.2214 in

• Hydraulic Valve Lash Adjuster-to-Cylinder Head Oil Clearance-Standard	0.025-0.066 mm	0.0010-0.0025 in
• Hydraulic Valve Lash Adjuster-to-Cylinder Head Oil Clearance-Maximum	0.015 mm	0.0059 in
Valve Lash	Hydraulic - Non-Adjustable	

Standard Main Bearing Selection

Letter on Lower Crankcase	Number on Crankweb		
-	1	2	3
A	Green	Black	Colorless
B	Black	Colorless	Yellow
C	Colorless	Yellow	Blue

Undersize Main Bearing Selection

Letter on Lower Crankcase	Measured Journal Diameter		
-	57.744-57.750 mm (2.2734-2.2736 in)	57.738-57.744 mm (2.2731-2.2733 in)	57.732-57.738 mm (2.2729-2.2731 in)
A	Green and Red	Black and Red	Red only
B	Black and Red	Red Only	Yellow and Red
C	Red Only	Yellow and Red	Blue and Red

Piston Selection

Piston Type	Piston Diameter	Cylinder Bore Diameter	Number on Piston	Cylinder Color Code
Standard	83.970-83.980 mm (3.3059-3.3062 in)	84.00-84.01 mm (3.3071-3.3074 in)	2	Blue
Standard	83.980-83.990 mm (3.3063-3.3066 in)	84.01-84.02 mm (3.3075-3.3078 in)	1	Red
0.25 mm (0.0098 in) Oversize	84.220-84.240 mm (3.3157-3.3165 in)	-	-	-
0.50 mm (0.0196 in) Oversize	84.470-84.490 mm (3.3256-3.3263 in)	-	-	-

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number
Camshaft and Lifter Prelube	Lubricant	12345501
Chassis Grease	Lubricant	1051344
Coolant Sensor (ETC) Threads	Sealant	12346004
Cylinder Head Bolt Threads	Sealant	12346004

Engine Block Coolant Drain Plugs	Sealant	12346004
Engine Block Oil Gallery Plugs	Sealant	12346004
Engine Front Cover	Sealant	12345997
Engine Oil Supplement	Lubricant	1051396
MAP Sensor Seal	Lubricant	9985770
Oil Pan	Sealant	12345997
Oil Pressure Sensor Fitting Threads	Sealant	12346004
Oil Pressure Sensor Threads	Sealant	12346004
Oxygen Sensor Thread	Anti-seize Lubricant	12377953

COMPONENT LOCATOR

DISASSEMBLED VIEWS

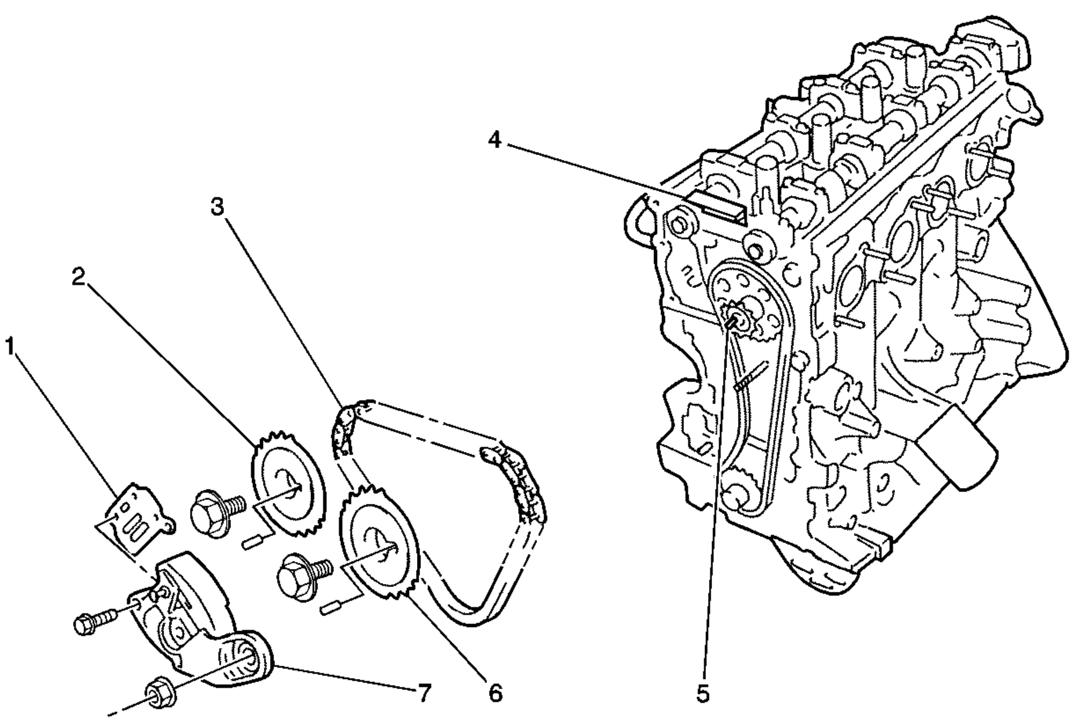


Fig. 1: Camshaft Timing Chain and Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Tensioner Adjuster Gasket
2	Intake Camshaft Timing Sprocket
3	Camshaft Timing Chain

4	Timing Chain Guide
5	Idler Sprocket
6	Exhaust Camshaft Timing Sprocket
7	Timing Chain Tensioner Adjuster

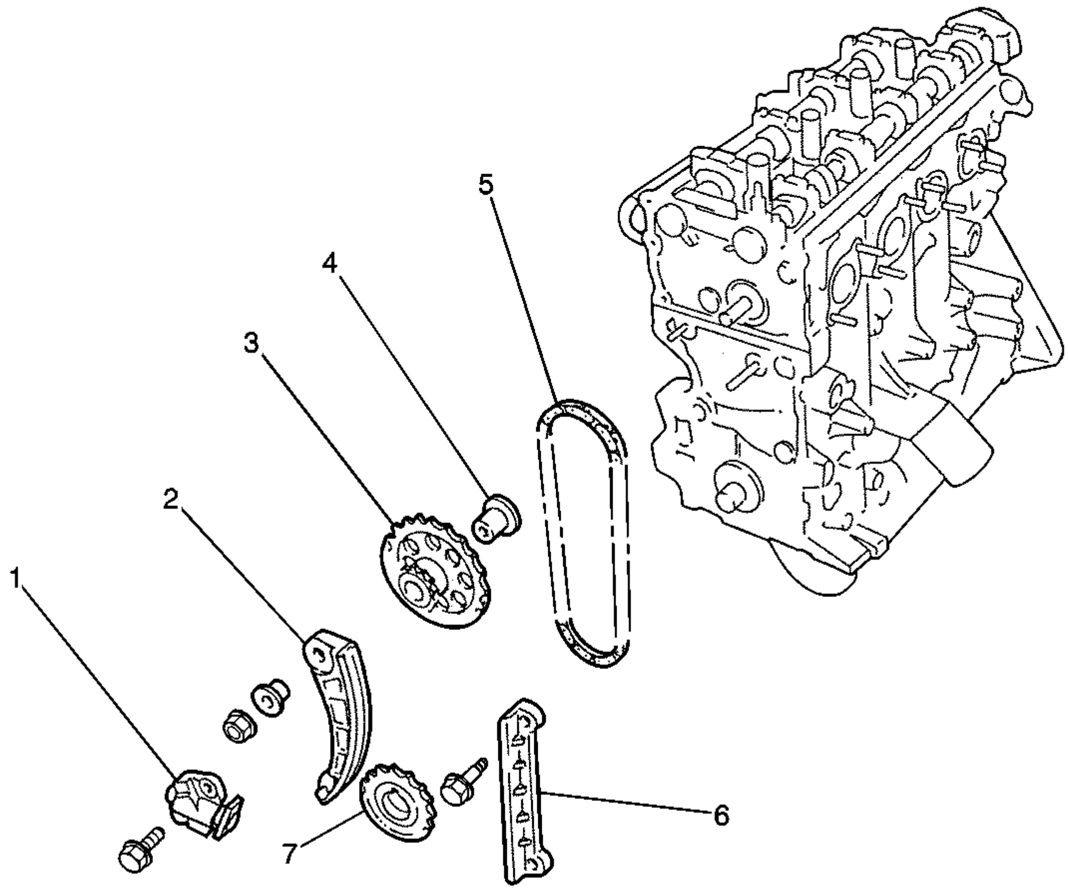


Fig. 2: Crankshaft Timing Chain and Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Timing Chain Tensioner
2	Timing Chain Guide-Adjustable
3	Idler Sprocket
4	Idler Sprocket Shaft
5	Crankshaft Timing Chain
6	Timing Chain Guide-Fixed
7	Crankshaft Timing Sprocket

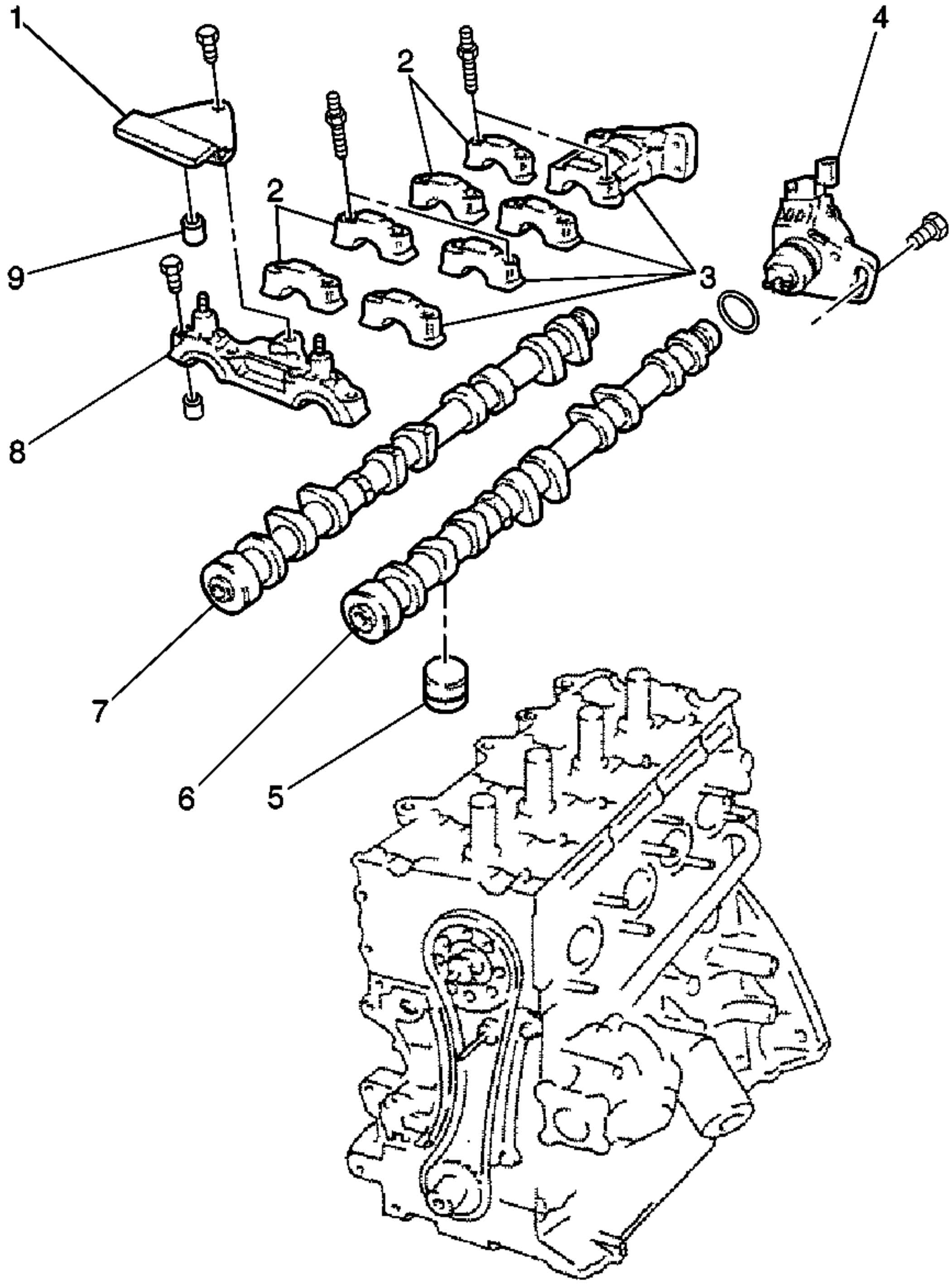


Fig. 3: Camshafts and Valve Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Timing Chain Guide
2	Intake Camshaft Housing
2	Intake Camshaft Housing
3	Exhaust Camshaft Housing
4	CMP Sensor
5	Valve Lifter
6	Exhaust Camshaft
7	Intake Camshaft
8	Camshaft Housing
9	Oil Relief Valve

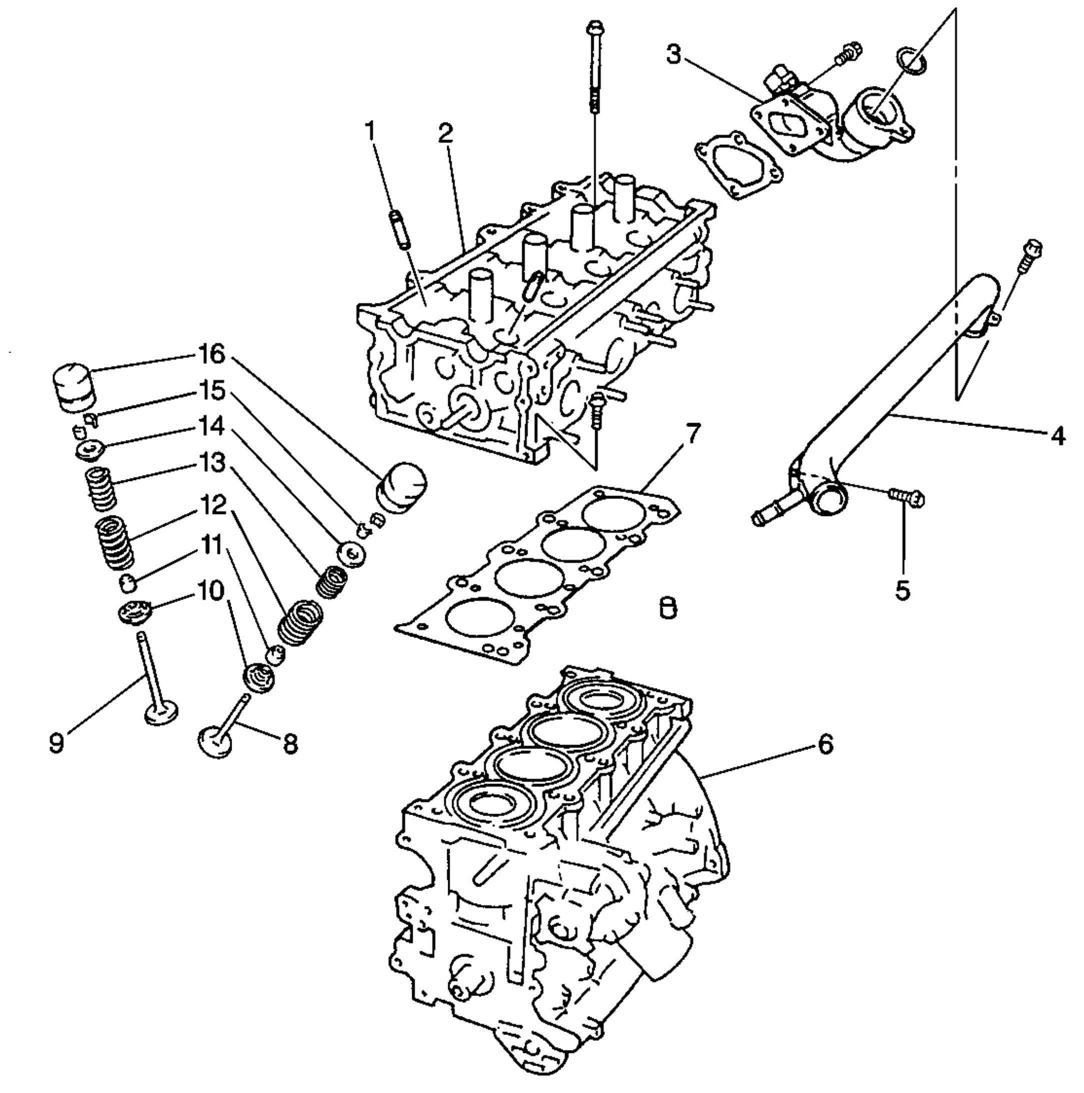


Fig. 4: Valves and Cylinder Head
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Valve Guide
2	Cylinder Head
3	Water Outlet Cap
4	Water Outlet Pipe
5	Water Outlet Pipe Attaching Screws
6	Cylinder Block
7	Cylinder Head Gasket
8	Exhaust Valve
9	Intake Valve
10	Valve Spring Seat
11	Valve Stem Seal
12	Valve Spring (Outer)
13	Valve Spring (Inner)
14	Valve Spring Retainer
15	Valve Cotter
16	Hydraulic Valve Lash Adjuster

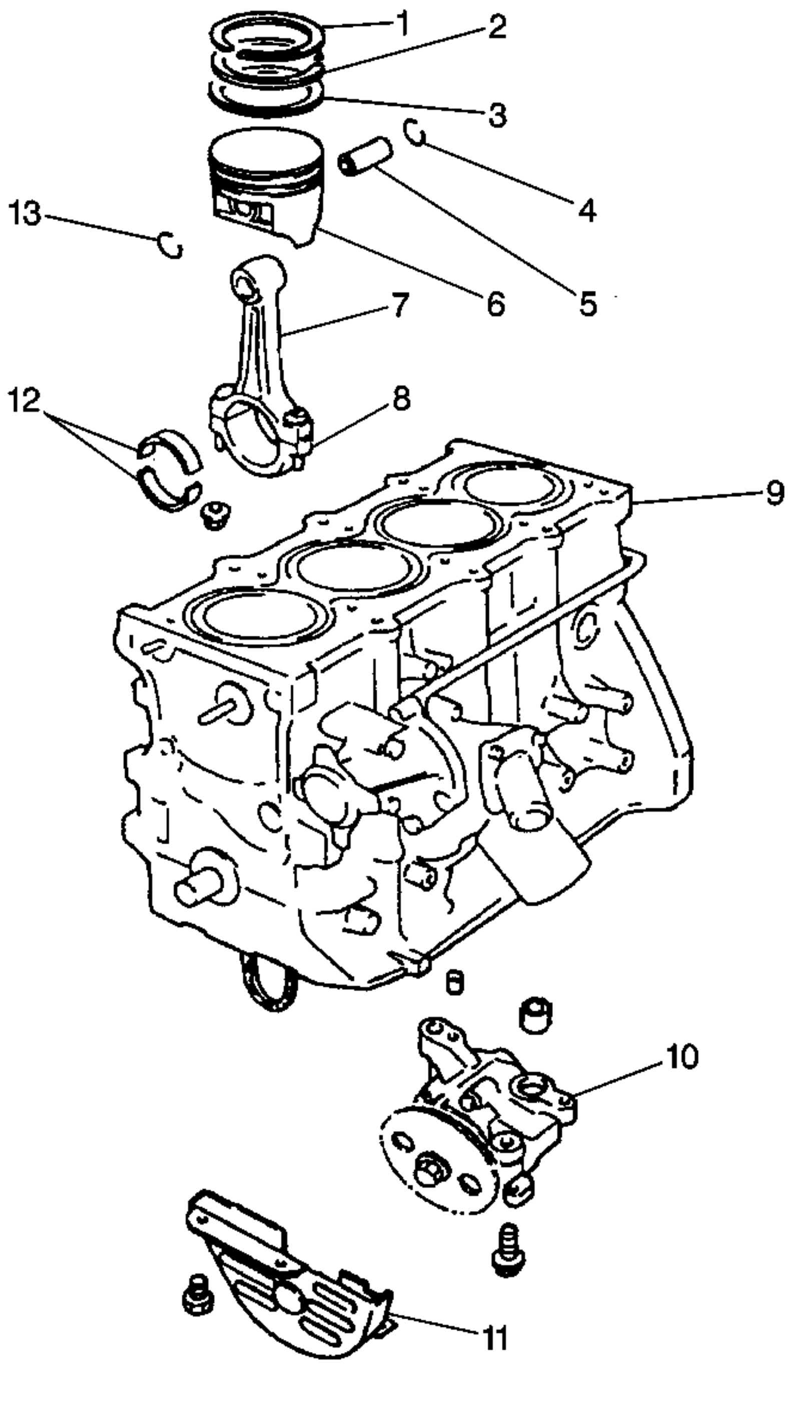


Fig. 5: Pistons, Piston Rings, Connecting Rods, and Cylinders
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name

1	Top Ring
2	Second Ring
3	Oil Ring
4	Piston Pin Snapring
5	Piston Pin
6	Piston
7	Connecting Rod
8	Connecting Rod Bearing Cap
9	Cylinder Block
10	Oil Pump
11	Oil Pump Sprocket Cover
12	Connecting Rod Bearing
13	Piston Pin Snapring

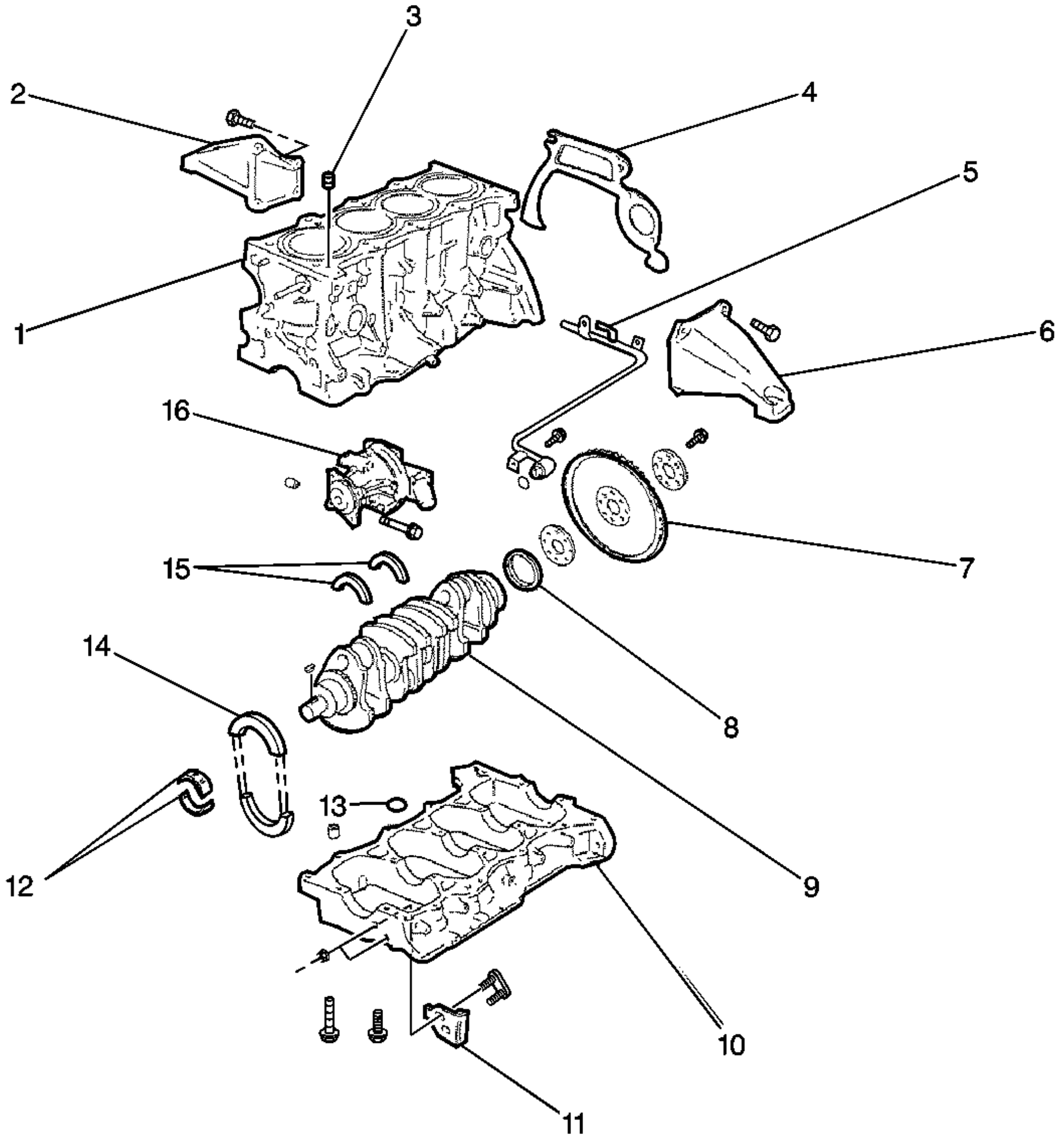


Fig. 6: Main Bearings, Crankshaft, and Cylinder Block
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Cylinder Block
2	Engine Block Mounting Bracket
3	Check Valve
4	Clutch Housing Plate
5	Heater Outlet Pipe
6	Engine Block Mounting Bracket

7	Flywheel (Manual Transmission)/Drive Plate (Automatic Transmission)
8	Rear Oil Seal
9	Crankshaft
10	Lower Crankcase
11	Oil Pump Chain Guide
12	Main Bearing
13	O-ring
14	Oil Pump Drive Chain
15	Thrust Bearing
16	Water Pump

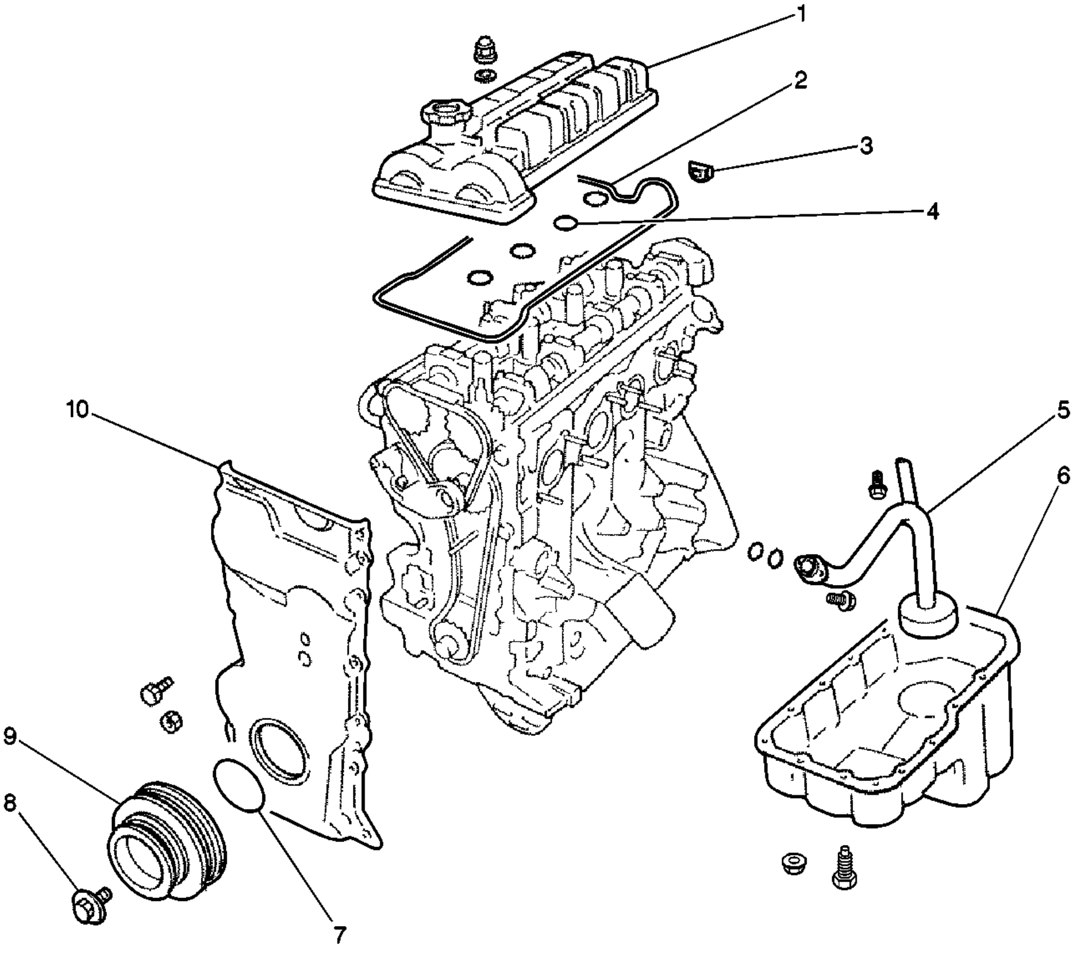


Fig. 7: Timing Chain Cover
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Cylinder Head Cover

2	Cylinder Head Cover Gasket
3	Cylinder Head Side Seal
4	O-ring
5	Oil Pump Strainer
6	Oil Pan
7	Oil Seal
8	Crankshaft Pulley Bolt
9	Crankshaft Pulley
10	Timing Chain Cover

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, and **Lubrication Description** in the 2.0L Section of the Engine Unit Repair Manual, and the **Drive Belt System Description**. 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 **Symptoms - Engine Mechanical** 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 A Diagnostic System Check in Engine Controls 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**, **Engine Component Description**, and **Lubrication Description** in the 2.0L Section of the Engine Unit Repair Manual, and to the **Drive Belt System Description**.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to Strategy Based Diagnostics in General Information.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the Engine. Refer to Checking Aftermarket Accessories in Wiring Systems.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.

- Compare the engine sounds (if applicable) to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Compression Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities (severe cracking, bumps, or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition).	Replace the drive belt. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout and may lead to a misfire DTC. (A misfire code may be present without an actual misfire condition.)	Inspect the components, and repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Pulley Replacement**.

misfire condition.)	
Restricted exhaust system (A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters).	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body.	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body as required.
Improperly installed or damaged MAP sensor (The sealing grommet of the MAP sensor should not be torn or damaged.)	Repair or replace the MAP sensor as required.
Damage to the MAP sensor housing and/or O-ring seal	Replace the intake manifold.
Worn or faulty lifters (The lifters may be worn on the camshaft or the valve tip surfaces or the lifters may be bleeding down)	Replace the lifters.
Stuck valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure (A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.)	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to A Diagnostic Starting Point - Engine Cooling. (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. Refer to Spark Plug Visual Inspection in Engine Controls. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn Piston Rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 2.0L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel	Replace the sensor and/or crankshaft as required.

(A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage.) Systems with electronic communication (DIS or coil per cylinder) and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt (Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.)	Replace the drive belt. Refer to **Drive Belt Replacement - Cooling Fan** or **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout (A misfire code may be present without an actual misfire condition.)	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer (A misfire code may be present without an actual misfire condition.)	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Pulley Replacement**.
Worn Piston Rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 2.0L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn Crankshaft Thrust Bearings (Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.)	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Stuck valves (Carbon buildup on the valve stem can cause the valve not to close properly.)	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking or worn lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to **Diagnostic Starting Point - Engine Cooling** . (Coolant consumption may or may not cause the engine to overheat.)	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls - 2.0L. • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 2.0L • Repair or replace as required.
Worn Piston Rings (Oil consumption may or may not cause the engine to misfire.)	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 2.0L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

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

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction

Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the lifters as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.
Damaged or faulty oil control valve	• Inspect the oil control valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.
Improper lubrication to the valve train	Inspect the following components, and repair or replace as required: • Restricted oil filter • The valve lifter • The valve lifter bore • The oil filter bypass valve • The oil control valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or damaged valve lifter bore	Repair or replace as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required:

	• The valves • The valve guides
Stuck Valves (Carbon on the valve stem or valve seat may cause the valve to stay open)	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn accessory drive components (Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.)	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Detonation/Spark Knock** in Engine Controls - 2.0L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods

	• The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation (Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.)	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Detonation/Spark Knock** in Engine Controls - 2.0L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair as required.
Cracked flywheel (automatic transmission)	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE COMPRESSION TEST

Perform a compression test in order to determine the cylinder compression pressure. Use a compression test in order to diagnose lack of power, excessive oil consumption, or poor fuel economy.

1. Verify that the battery is fully charged or close to fully charged.

NOTE: This engine is equipped with an aluminum cylinder head. Allow the engine to cool before removing spark plugs. Removing the spark plugs from an engine at operating temperature may damage the spark plug threads in the cylinder head. Also be sure to clean any dirt or debris from around spark plug holes prior to removing spark plugs.

IMPORTANT: The engine should be at room temperature.

2. Disconnect the fuel injector harness electrical connector.
3. Disconnect the electrical connectors at the ignition coils (1).
4. Remove the ignition coils (1).
5. Remove the spark plugs (2).

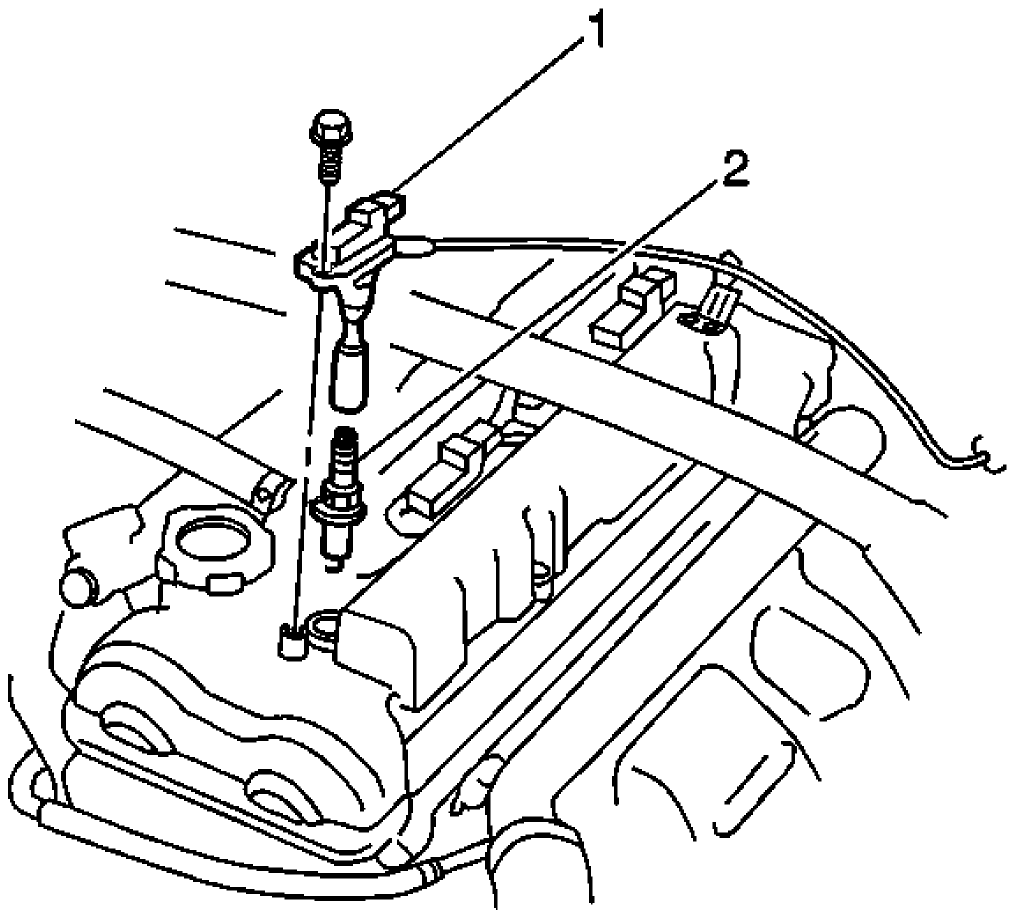


Fig. 8: View Of Ignition Coils & Spark Plugs
Courtesy of GENERAL MOTORS CORP.

6. Install a compression gage (2) into a spark plug hole.
7. Depress the clutch pedal on vehicles that are equipped with a manual transmission.
8. Depress the accelerator pedal to the floor for a wide open throttle.
9. Crank the engine through four compression strokes for each cylinder being tested.
10. Measure and record the highest pressure reading on the compression gauge.

Standard Compression Pressure: 1,400 kPa (199 psi)

Minimum Compression Pressure: 1,200 kPa (170 psi)

Compression Variance: The maximum allowable compression pressure difference between any two cylinders is 100 kPa (15 psi).

11. Repeat the compression test procedures for the remaining three cylinders.
12. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
    - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
    - Piston Rings Leaking - Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when oil is added.
    - Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when oil is added.
    - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the two cylinders.
13. Remove the compression gauge from the engine.
14. Install the four spark plugs.
15. Install the ignition coils.
16. Connect the electrical connectors at the ignition coils.
17. Connect the fuel injector harness connector.

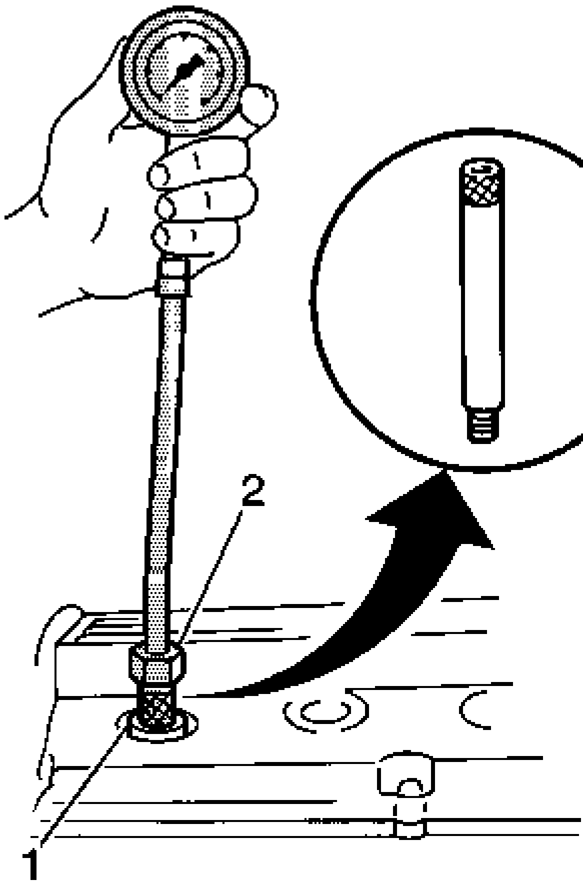


Fig. 9: View Of Compression Gage
Courtesy of GENERAL MOTORS CORP.

CYLINDER LEAKAGE TEST

Testing Procedure

Tools Required

J 35667-A Cylinder Head Leakdown Tester. See **Special Tools and Equipment**.

With the use of air pressure, a cylinder leakage test will aid in the diagnosis. Use the cylinder leakage test in conjunction with the engine compression test in order to isolate the cause of leaking cylinders.

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

1. Disconnect the negative battery cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
3. Install the **J 35667-A** . See **Special Tools and Equipment**.
4. Measure each cylinder on the compression stroke, with both valves closed.

IMPORTANT: Hold the crankshaft balancer bolt in order to prevent piston movement.

5. Apply air pressure, using the **J 35667-A** . See **Special Tools and Equipment**. Refer to the manufacturer's instructions.
6. Record the cylinder leakage readings for each cylinder.

IMPORTANT:

- **Normal cylinder leakage is from 12 to 18 percent.**
- **Make a note of any cylinder with more leakage than the other cylinders.**
- **Any cylinder with 30 percent leakage or more requires service.**

7. Inspect the 4 primary areas in order to properly diagnose a leaking cylinder.
8. If air is heard from the intake or exhaust system, perform the following procedure:
   - Remove the valve rocker arm cover of the suspect cylinder head.
     - Ensure that both valves are closed.
     - Inspect the cylinder head for a broken valve spring.
   - Remove and inspect the suspect cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.
9. If air is heard from the crankcase system at the crankcase oil filler tube, perform the following procedure:
   1. Remove the piston from the suspect cylinder.
   2. Inspect the piston and connecting rod assembly. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
   3. Inspect the engine block. Refer to **Engine Block Cleaning and Inspection**.
10. If bubbles are found in the radiator, perform the following procedure:
    - Remove and inspect both cylinder heads. Refer to **Cylinder Head Cleaning and Inspection**.
    - Inspect the engine block. Refer to **Engine Block Cleaning and Inspection**.
11. Remove the **J 35667-A** . See **Special Tools and Equipment**.
12. Install the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls.
13. Connect the negative battery cable. Refer to Battery Disconnect Caution in Cautions and Notices.

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 PRESSURE DIAGNOSIS AND TESTING

Oil Pressure Test

1. Remove the exhaust manifold heat shield.
2. Remove the oil pressure switch (2) from the engine block.
3. Install a pressure gauge in place of the oil pressure switch.
4. Start the engine and run at idle until normal operating temperature is reached.
5. Raise the engine speed to 4000 RPM and measure the oil pressure.

   Normal Oil Pressure: 390-470 kPa (56-67 psi) at 4000 RPM

6. If the oil pressure is below specification refer to the following table.
7. Stop the engine.
8. Remove the pressure gauge.
9. Install the oil pressure switch.

   Tighten: Tighten the oil pressure switch to 14 N.m (11 lb ft).

10. Install the exhaust manifold heat shield.
11. Run the engine and inspect for oil leaks from the oil pressure switch.

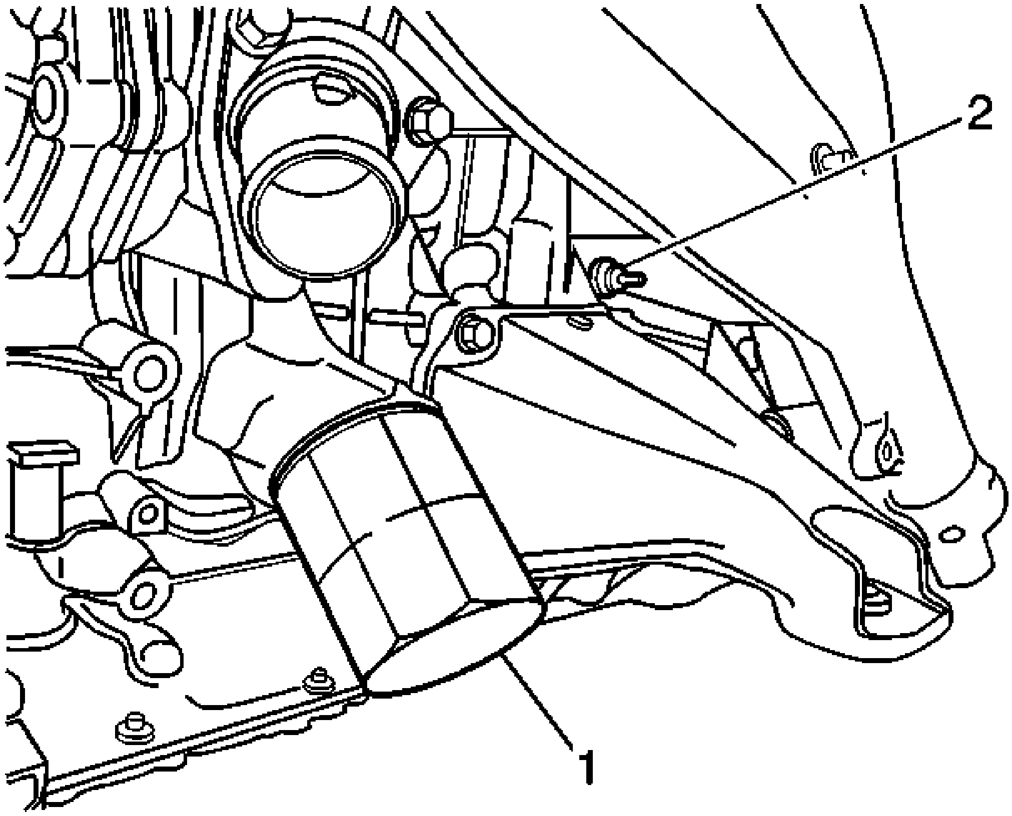


Fig. 10: View Of Oil Pressure Switch & Oil Filter
Courtesy of GENERAL MOTORS CORP.

Oil Pressure Diagnosis

Problem	Action
The oil level is low.	Fill the oil to the FULL mark on the oil level indicator.
The idle speed is slow.	Adjust the idle speed. Refer to Engine Controls.
The oil pressure switch is incorrect or malfunctioning.	Replace the oil pressure switch.
The oil pressure indicator is incorrect or malfunctioning.	Replace the oil pressure indicator.
The oil viscosity is improper.	Fill the oil tank. Use oil of the proper viscosity for the expected temperature.
The oil is diluted with one of the following materials: • Moisture	Fill with new oil. Investigate the cause of the oil dilution. Inspect the following: • The PCV system

• An unburned fuel mixture	• The ignition system • The fuel system • The engine mechanical condition
The oil pump is worn or dirty.	Replace or clean the oil pump as necessary.
The oil filter is plugged.	Replace the oil filter.
The oil pickup screen is loose or plugged.	Adjust or replace the screen as necessary.
The oil pickup tube has a hole.	Replace the tube.
The oil pickup tube O-ring is damaged.	Replace the O-ring.
The bearing clearance is excessive.	Replace the connecting rod or the main bearings as necessary.
The oil galleries display one of the following conditions: • Cracked • Porous • Restricted	Repair or replace the block as necessary.
The gallery plugs are missing or incorrectly installed.	Install the plugs or repair as necessary.
The oil pump pressure regulator valve is malfunctioning.	Replace the valve.
The camshaft is worn or poorly machined.	Replace the camshaft or the cylinder head and bearing caps.
The valve guides are worn.	Replace the guides.
Oil pump malfunction.	The oil pump is driven by a chain from the crankshaft. Inspect for a stretched or damaged chain and for correct pump output.

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Checks	Action
DEFINITION: Most fluid leaks can be solved by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.	
Visual Inspection Method	1. Operate the vehicle for several miles at varying speeds until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes and check for drippings. 4. Identify the type of fluid (engine oil, automatic transmission fluid, coolant etc.) and the approximate location of the leak.

	5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components. 7. If the leak cannot be found it may be necessary to completely clean the suspected area or components and perform the visual inspection method again. 8. If the leak still cannot be located, use the powder method or the black light and dye method in order to locate the leak. 9. See possible causes for leaks.
Powder Method	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at varying speeds until it reaches normal operating temperature. 4. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 5. Trace the leak path over the white powder surface to the source. 6. Identify the type of fluid (engine oil, automatic transmission fluid, coolant etc.) and the approximate location of the leak from the discolorations in the powder surface. 7. See possible causes for leaks.
Black Light and Dye Method	1. A **J 28428-E** High Intensity Black Light and. See **Special Tools and Equipment**.**J 28431-6** Fluorescent Oil Additive are available for finding fluid leaks. See **Special Tools and Equipment**. 2. Follow the manufacturer's instructions that are included with the **J 28431-6** . See **Special Tools and Equipment**. 3. Pour the specified amount of **J 28431-6** into the leaking component. See **Special Tools and Equipment**. Refer to the manufacturer's instructions for the proper amount of oil additive. 4. Operate the vehicle for several miles at varying speeds until it reaches normal operating temperature. 5. Shine the **J 28428-E** onto the suspected area. See **Special Tools and Equipment**. The **J 28431-6** fluid will appear as a yellow path leading to the source of the oil leak. See **Special Tools and Equipment**. 6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 7. See possible causes for leaks.
Possible Causes for Leaks	Inspect for the following conditions:

	• Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Malfunctions in the crankcase ventilation system • Improperly tightened fasteners • Dirty or damaged threads on the fasteners • Warped flanges or sealing surfaces • Scratches, burrs or other damage to the sealing surface • A damaged or worn gasket • Cracking or porosity of the component • An improper sealant • A loose or worn bearing

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Callouts For Fig. 11

Callout	Component Name
1	Breather Hose
2	Intake Manifold
3	Fresh Air
4	Blowby Gas
5	PCV Valve
6	Valve Cover

The compressed combustion gas which escapes past the piston rings into the crankcase is known as blowby gas. Blowby gas contains large amounts of carbon monoxide (CO) and hydrocarbon (HC). The positive crankcase ventilation (PCV) system prevents the blowby gas from being emitted into the atmosphere. The PCV system routes crankcase blowby gas back into the intake system where it becomes part of the combustion process. The PCV system consists of the following components:

- The PCV valve
- The crankcase vent or air inlet tube
- The air inlet filter or separator, if used
- Any hoses or couplers

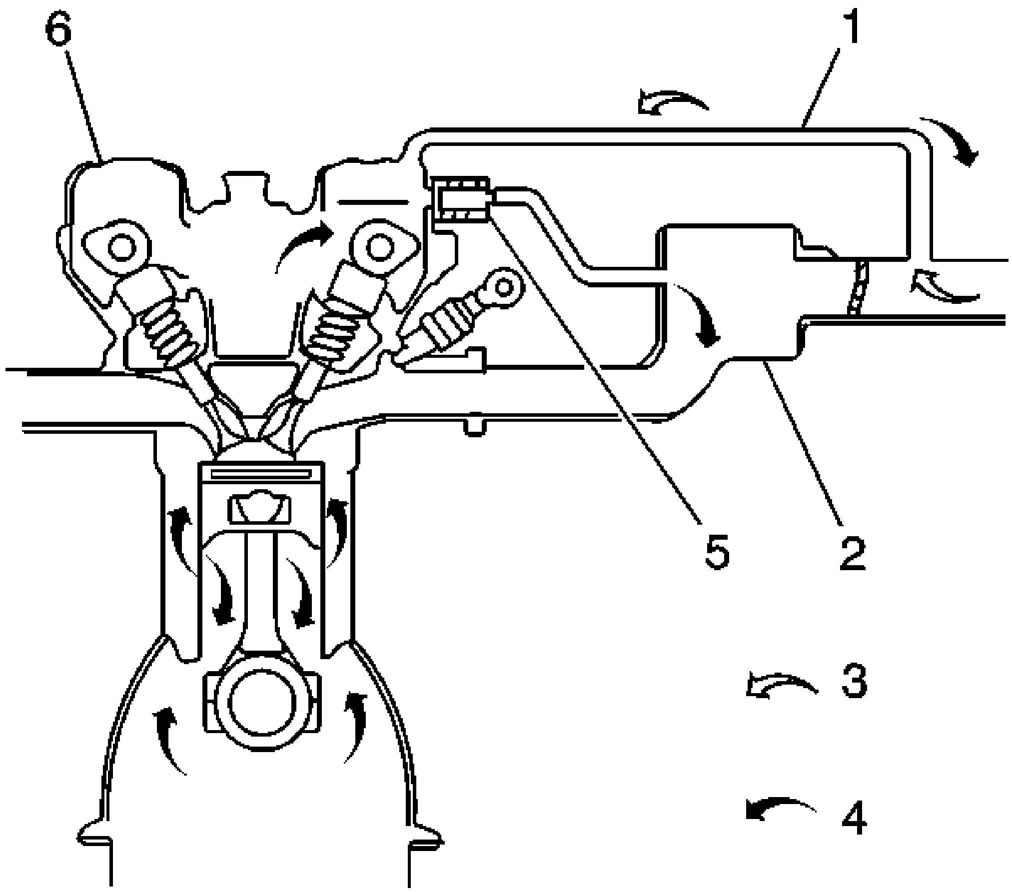


Fig. 11: View Of Crankcase & Components
Courtesy of GENERAL MOTORS CORP.

Operation

The primary control of engine crankcase blowby gas is the PCV valve. The PCV valve meters the flow of blowby gas according to the manifold vacuum signal.

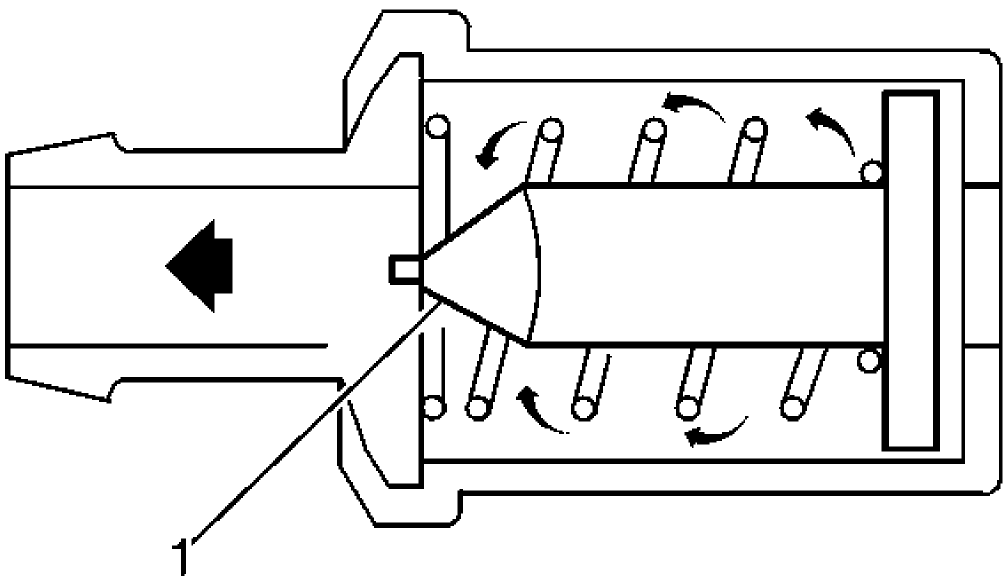


Fig. 12: PCV Valve
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Check Valve

In order to maintain idle quality, the PCV valve restricts the flow of blowby gas whenever intake manifold vacuum is high. Abnormally high crankcase pressure may cause the blowby gases to flow through the crankcase vent tube and into the air cleaner. The blowby gases are then drawn into the intake system and consumed in the normal combustion process. The relationship between the flow of blowby gas and engine manifold vacuum is charted in the following table:

PCV Valve Operation

Manifold Vacuum	PCV Valve Opening	Blowby Gas Flow
Low	Large	High
High	Small	Low

Results Of Incorrect Operation

A plugged valve or hose may cause any of the following conditions:

- A rough engine idle
- Engine stalling or low engine idle speed

- High engine crankcase pressure
- Engine oil leaks
- Engine oil in the air cleaner
- Oil sludge in the engine
- Engine oil consumption
- Excessive exhaust emissions

A leaking valve or hose may cause any of the following conditions:

- A rough engine idle
- Engine stalling
- High engine idle speed
- Incorrect engine crankcase pressure
- Excessive exhaust emissions

NOTE: Operating an engine without an effective crankcase ventilation system may damage the engine. Replace the Positive Crankcase Ventilation (PCV) valve at regular intervals. Use the correct PCV valve for the engine and equipment type. Wrong or substandard parts may damage the engine components.

Use the following procedure to check the function of the PCV system.

1. Start the engine.
2. Run the engine at idle.
3. Place your thumb over the end of the PCV valve (1) to check for vacuum. If there is no vacuum at the PCV valve, check for a plugged intake manifold port, PCV valve, or vacuum hose. Replace or repair as necessary.
4. Turn OFF the ignition.
5. Remove the PCV valve.

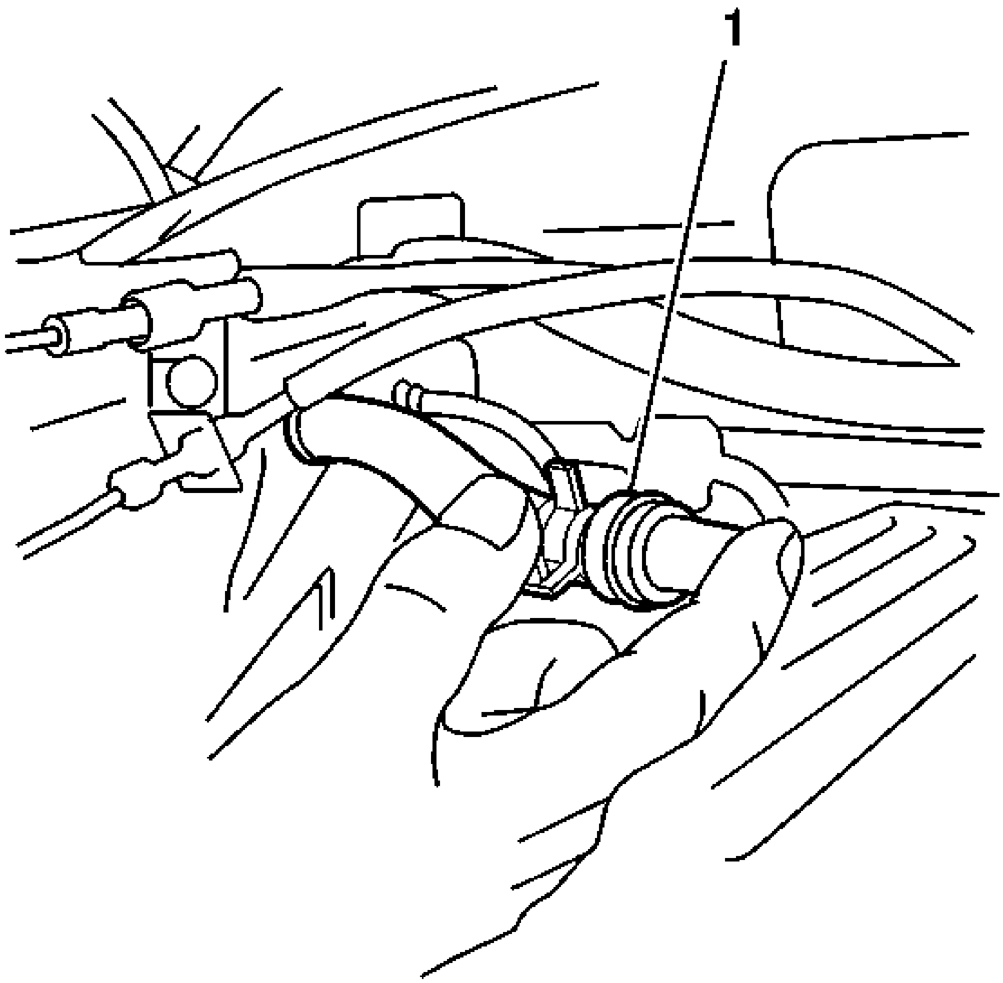


Fig. 13: View Of PCV Valve
Courtesy of GENERAL MOTORS CORP.

6. Shake the PCV valve while listening for the rattle of the needle inside. Replace the PCV valve if the valve does not rattle.
    - Proper operation of the PCV system is dependent upon a sealed engine with a freely flowing breather tube.
        - Check that the PCV breather tube and pipe are not blocked.
        - Check that the coolant passages at the breather pipe are becoming hot after the engine runs a short time.
    - Repair as necessary.
    - Build up of oil sludge or oil dilution is an indication of a leak in the PCV system or crankcase.

   - Inspect all the hoses and clamps in the PCV system for signs of damage or deterioration.
   - Inspect the engine for external oil leaks.
 - Repair as necessary.
7. Install the PCV valve to the PCV hose.
8. Install the PCV valve and hose into the valve cover.

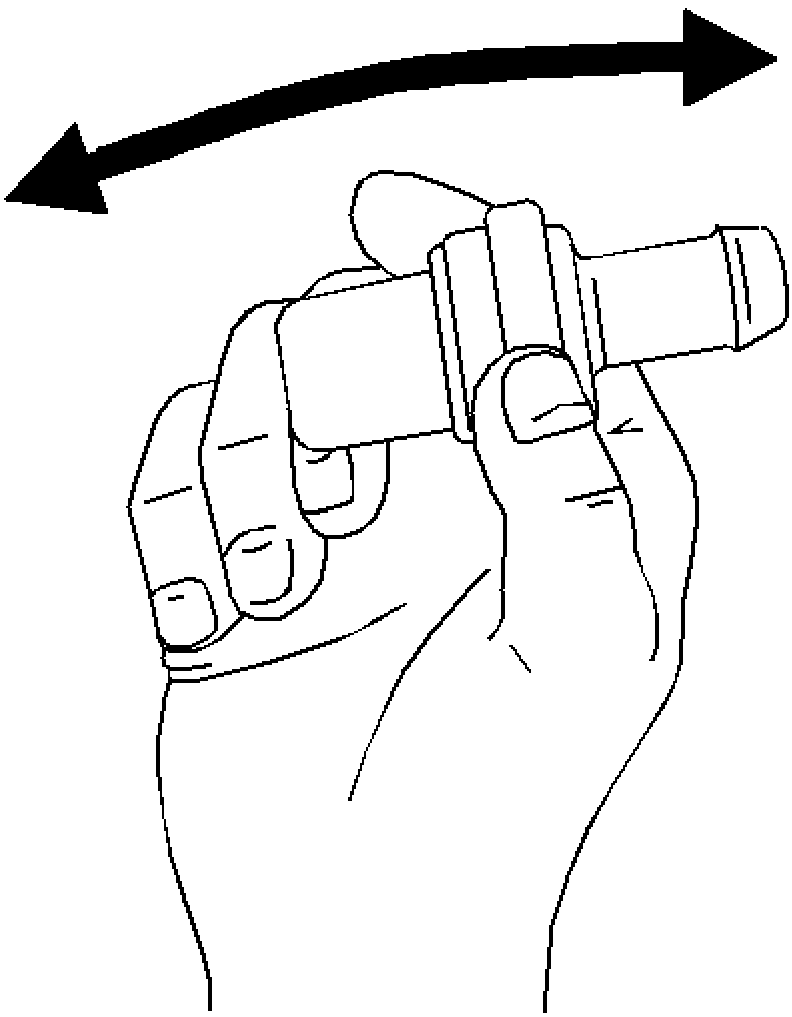


Fig. 14: Checking For Rattle Of Needle Inside
Courtesy of GENERAL MOTORS CORP.

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The symptom may be intermittent due to moisture on the drive belt or the pulleys. It may be necessary to spray a small amount of water on the drive belt in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulley may be the probable solution.

Loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause a chirping noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.

3: The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify if the noise is related to the drive belt. With the drive belt removed the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with a drive belt removed.

4: Inspect all drive belt and pulleys for pilling. Pilling are small balls, pills or strings in the drive belt grooves from the accumulation of rubber dust.

6: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of a pulley, a bent pulley or a bent pulley shaft. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper repair procedure.

10: Inspecting the fasteners can determine if a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or wrong fasteners may cause pulley misalignment. Improper tightening of the fasteners may cause misalignment of the accessory component bracket.

12: The inspection of the pulleys should include inspecting for any damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley.

14: Replacing the drive belt when it is not damaged or there is not excessive pilling may only be a temporary repair.

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. Chirping may occur on cold damp start up conditions and will subside once the vehicle reaches normal operating temperature. • It usually occurs on cold damp mornings.			

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	Inspect for severe pilling exceeding 1/3 of the belt groove depth. Does the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 15**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 15**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 15**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	Tighten any loose fasteners. Replace any improper or missing fasteners. Refer to **Fastener Tightening Specifications**. Did you complete the repair?	Go to **Step 15**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 13**	Go to **Step 14**
13	Replace the bent pulley. Did you complete the repair?	Go to **Step 15**	Go to **Step 14**
14	Replace the drive belt. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**. Did you complete the repair?	Go to **Step 15**	Go to Diagnostic Aids
15	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

Loose or improper installation of a body component, a suspension component, or other items of the vehicle may cause a squeal noise.

If the noise is intermittent, verify which accessory drive components is making the noise by varying their loads making sure they are operated to their maximum capacity. Some of the causes of component noise can be that the A/C system is over charged, the power steering system is restricted or has incorrect fluid, or that there is an extra load on the generator.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table

3: The noise may be an internal engine noise. Removing the drive belt and operating the engine for a brief period will verify that the squeal noise is a drive belt or an accessory drive component. With the drive belt removed the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4: This test is to verify that an accessory drive component does not have a seized bearing. With the belt removed test the bearings in the accessory drive components by turning the pulleys and verify that they turn smoothly. Also test the accessory drive components with the engine operating by varying the load on the components to verify that the components operate properly.

5: This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly the belt may slip causing a squealing noise.

6: This test is to verify that the drive belt is the correct length. If an incorrect length drive belt was installed it may not be possible to achieve the correct tension or it may not be routed properly and may be turning an accessory drive component in the wrong direction.

7: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of a pulley, a bent pulley or a bent pulley shaft. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper repair procedure.

8: This test is to verify that the pulleys are the correct diameter and width. Using a known good vehicle compare the pulley sizes.

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.			

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 5**
5	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 6**
6	Verify that the drive belt is the correct length. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 7**
7	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 8**
8	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 9**	Go to Diagnostic Aids
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT WHINE DIAGNOSIS

Drive Belt Whine Diagnosis

Step	Action	Yes	No
DEFINITION: A high pitched continuous noise that may be caused by a failed bearing.			
1	Check for a worn accessory component bearing. Is a bearing making the noise?	Go to **Step 2**	System OK
2	Install new part as necessary. Is the repair complete?	System OK	-

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise.

The drive belt may have a condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.

3: This test is to verify that a drive belt is causing the rumbling noise. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When the drive belt is removed the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with a drive belt removed.

4: Inspecting the drive belt determines if the belt has a condition which may cause a noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation can cause a noise and is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

5: Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation and may cause noise.

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No

NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.**
 	
DEFINITION:
• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
  o The separation of the drive belt
  o A damaged drive belt			

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
	Inspect the drive belt for damage, separation, or sections		

4	of missing ribs. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering** Did you complete the repair?	Go to **Step 9**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**. Did you complete the replacement?	Go to **Step 9**	Go to **Step 8**
8	Check for a component failure by varying the load on the different accessory drive components. Repair or Replace any failed component. Did you complete the repair or replacement?	Go to **Step 9**	-
9	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Some of the causes of component vibration can be that the A/C system is over charged, the power steering system is restricted or has incorrect fluid, or there is an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: This test is to verify that the symptom is present during diagnosing. Other vehicle components, such as the exhaust system or the drivetrain, may cause a similar symptom.

3: This test is to verify that the drive belt or accessory drive components may be causing the vibration. With the drive belt removed the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belt removed.

4: The drive belt may cause a vibration. The best time to inspect the condition of the drive belt is while it is removed from the vehicle.

6: Inspection of the fasteners can determine if a wrong bolt, nut, spacer, or washer was installed.

8: This step should only be performed if the fan is driven by the drive belt. Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smoothness and ease of turning. Inspect for a bent fan shaft or bent mounting flange.

9: This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump for a bent shaft. Also inspect the water pump bearings for smoothness and excessive play. Compare the water pump with a known good water pump.

10: Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to **Symptoms - Vibration Diagnosis and Correction** in Vibration Diagnosis and Correction	Go to **Step 4**
4	Inspect the drive belt for wear, damage, debris build-up and missing drive belt ribs. Did you find any of these conditions?	Go to **Step 5**	Go to **Step 6**
5	Install a new drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering** and **Drive Belt Tensioner Replacement - Cooling Fan**. Did you complete the replacement?	Go to **Step 11**	-
6	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 8**
7	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications**. Did you complete the repair?	Go to **Step 11**	-
	Inspect for damaged fan blades or bent fan clutch shaft, if		

8	the fan is belt driven. Refer to **Fan Clutch Replacement** in Engine Cooling. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
9	Inspect for a bent water pump shaft, if the water pump is belt driven. Refer to **Water Pump Replacement (2.0L Engine)** **Water Pump Replacement (2.5L Engine)** in Engine Cooling. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
10	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 11**	Go to Diagnostic Aids
11	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

Pulley misalignment can cause the drive belt to fall off the drive belt pulleys.

An extra load that is quickly applied and released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify that the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: This inspection is to verify the condition of the drive belt. Damage may have occurred to the drive belt when the drive belt fell off. A damaged drive belt may cause the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of a pulley, a bent pulley or pulley shaft. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper repair procedure.

5: The inspection of the pulleys should include inspecting for any damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley.

6: Accessory drive component brackets that are bent or cracked could cause the drive belt to fall off.

7: Inspecting the fasteners can determine if a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or wrong fasteners may cause pulley misalignment. Improper tightening of the fasteners may cause misalignment of the accessory component bracket.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No

NOTE:
Refer to Belt Dressing Notice in Cautions and Notices.

DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement - Cooling Fan** and **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	Tighten any loose fasteners. Replace improper or missing fasteners. Refer to **Fastener Tightening Specifications**. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Replacement - Cooling Fan** and **Drive Belt Tensioner Replacement - Generator, Air Conditioning, and Power Steering**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Cooling Fan** and **Drive Belt Tensioner Replacement - Generator, Air Conditioning, and Power Steering**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

Excessive wear on a drive belt is usually caused by incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys may not cause excessive wear, but could cause a drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2: The inspection is to verify that the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

3: The installation of a drive belt that is two wide or two narrow can cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

4: This inspection is to verify that the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering** and **Drive Belt Tensioner Replacement - Cooling Fan**. Did you find this condition?	Go to **Step 5**	Go to **Step 3**
3	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 5**	Go to **Step 4**
4	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 6**	Go to Diagnostic Aids
5	Replace the drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering** and **Drive Belt Tensioner Replacement - Cooling Fan**. Did you complete the replacement?	Go to **Step 6**	-
	Operate the system in order to verify the repair.		

6	Did you correct the condition?	System OK	Go to **Step 2**

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement - Cooling Fan

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Loosen the adjusting bolt (1) and the pivot bolt (3).
3. Remove the tension on the fan belt by rotating the tension bolt (2) counterclockwise.

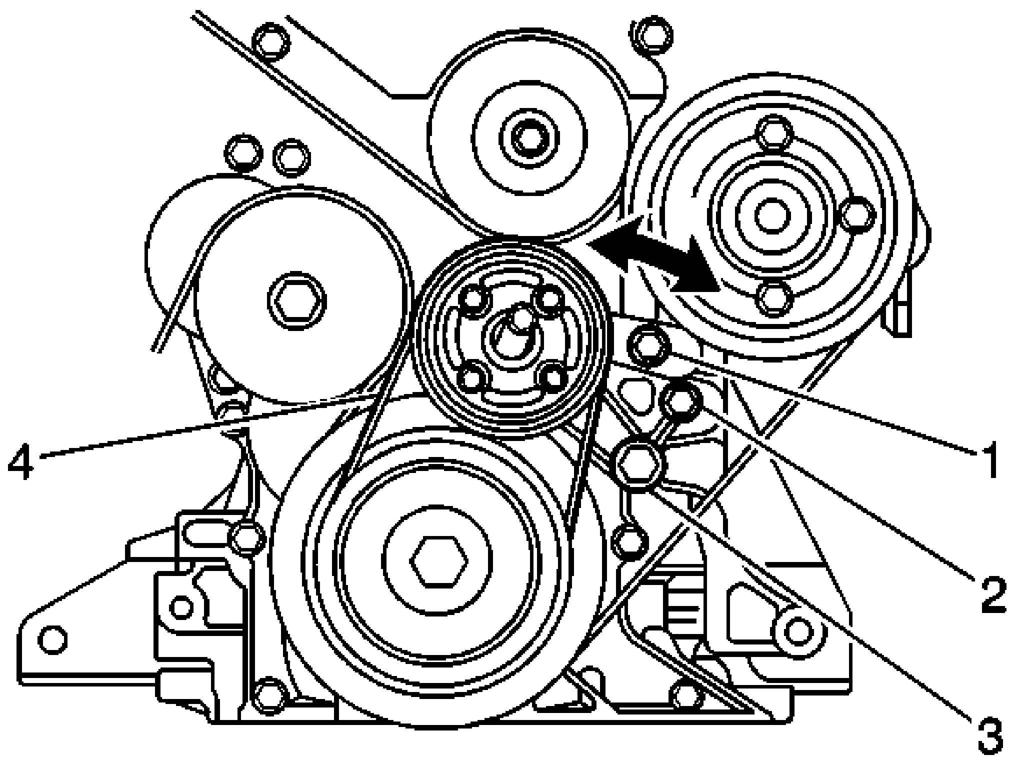


Fig. 15: Drive Belt Routing & View Of Tension, Adjusting & Pivot Bolts

Courtesy of GENERAL MOTORS CORP.

4. Remove the 4 fan nuts (1). Use a second wrench to hold the fan shaft.

IMPORTANT: Do not damage the radiator when removing the fan.

5. Detach the fan from the pulley hub and remove the fan belt.

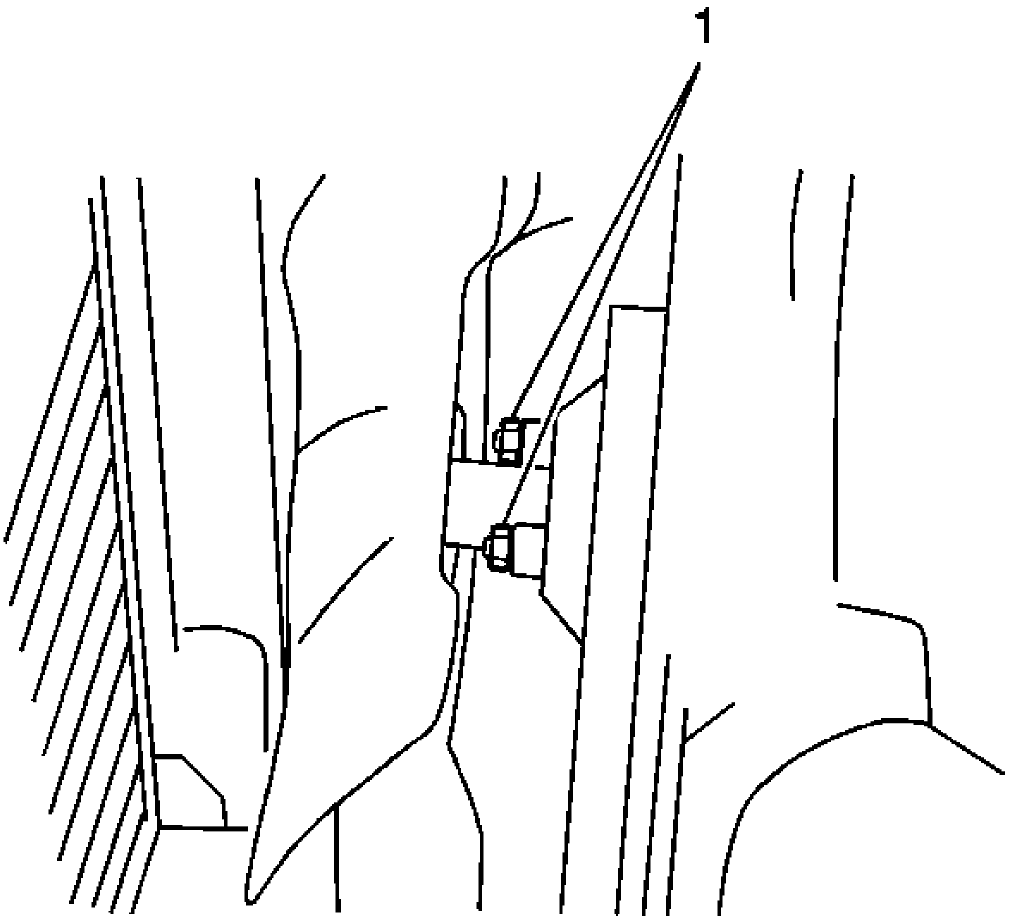


Fig. 16: Cooling Fan Mounting View
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the fan belt while holding the fan away from the pulley hub.

2. Install the fan to the hub.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the 4 fan nuts. Use a second wrench to hold the fan shaft.

   Tighten: Tighten the fan nuts to 11 N.m (97 lb in).

4. Install the fan belt properly on the pulleys.
5. Turn the tension bolt (2) clockwise in order to obtain the specified belt deflection (4) under 10 kg (22 lbs) of force.

   New Belt Deflection: 4-5 mm (0.16-0.20 in)

   Used Belt Deflection: 5-7 mm (0.20-0.27 in)

6. Tighten the adjusting bolt (1) and the pivot bolt (3) while holding the correct tension on the fan belt.

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

7. Connect the negative battery cable.

   Tighten: Tighten the battery cable bolt to 15 N.m (11 lb ft).

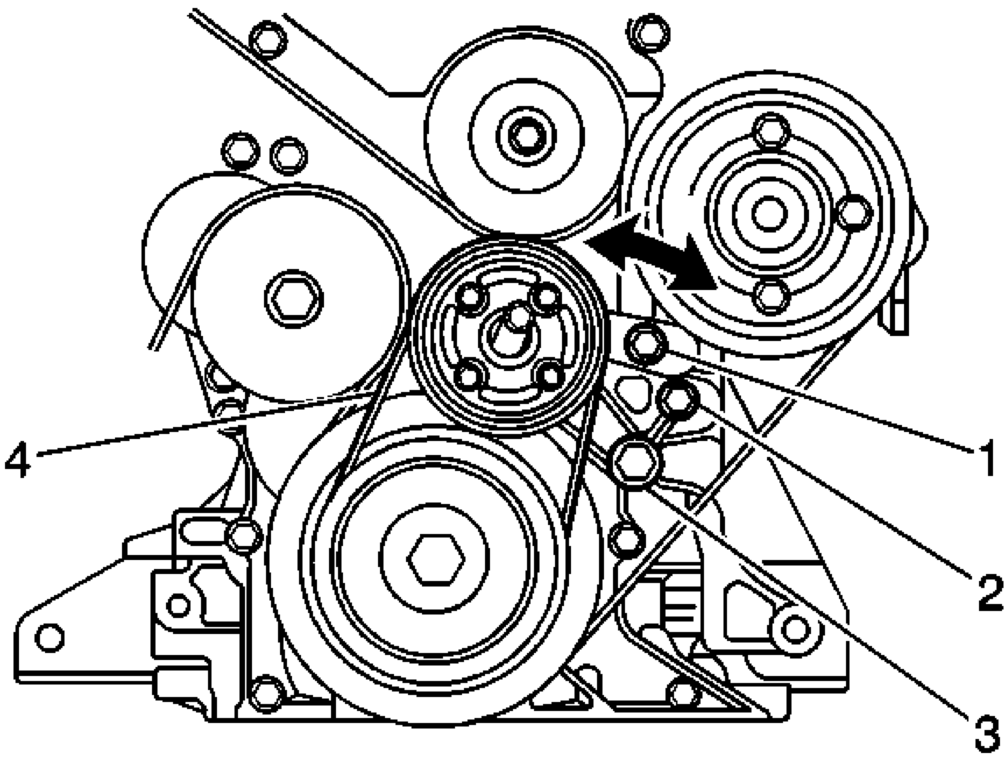


Fig. 17: Drive Belt Routing & View Of Tension, Adjusting & Pivot Bolts
Courtesy of GENERAL MOTORS CORP.

Drive Belt Replacement - Generator, Air Conditioning, and Power Steering

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Use a wrench and rotate the belt tensioner clockwise.
3. With pressure applied to the wrench, and tension relieved from the drive belt, remove the accessory drive belt.
4. Inspect the belt for cuts, cracks, wear, deformation or other abnormalities. Replace as necessary.

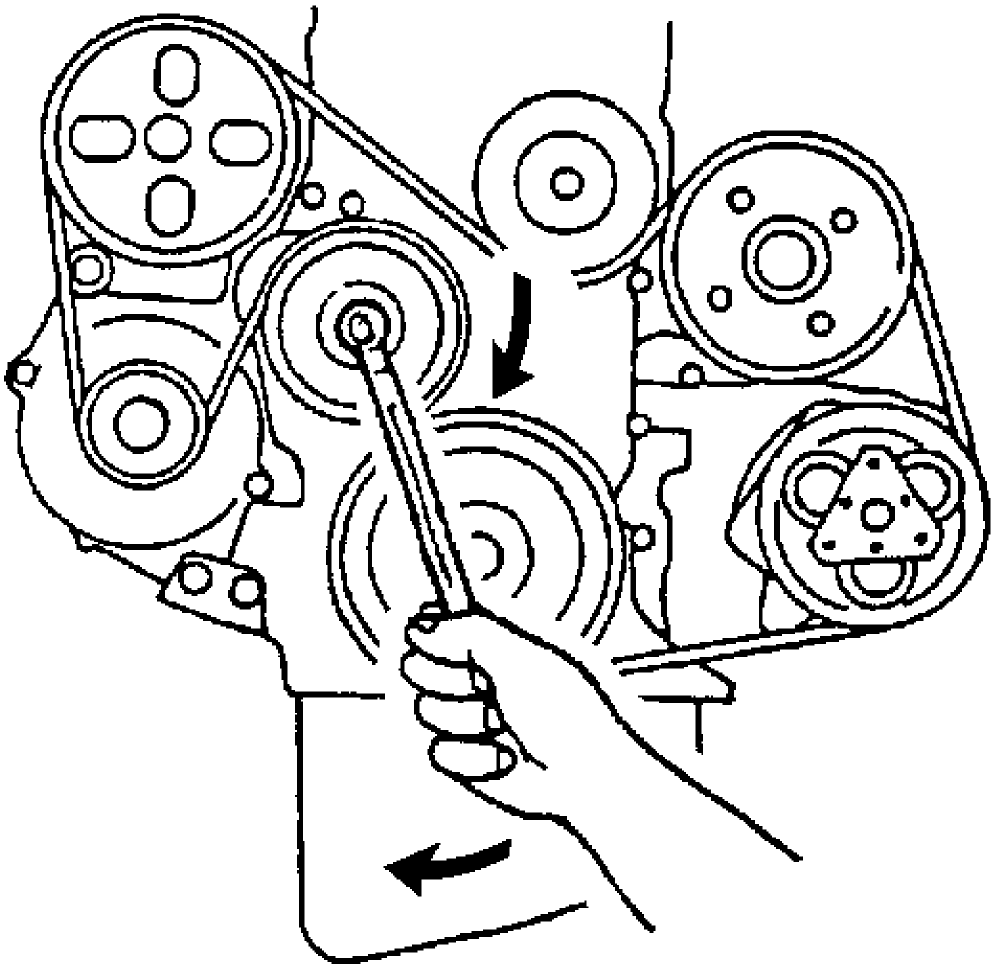


Fig. 18: Drive Belt Rotating
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Properly route and install the accessory drive belt onto the drive pulleys.
2. Use a wrench and rotate the belt tensioner clockwise.
3. With pressure applied to the wrench, install the accessory drive belt.
4. With the accessory drive belt installed properly, release the belt tensioner.

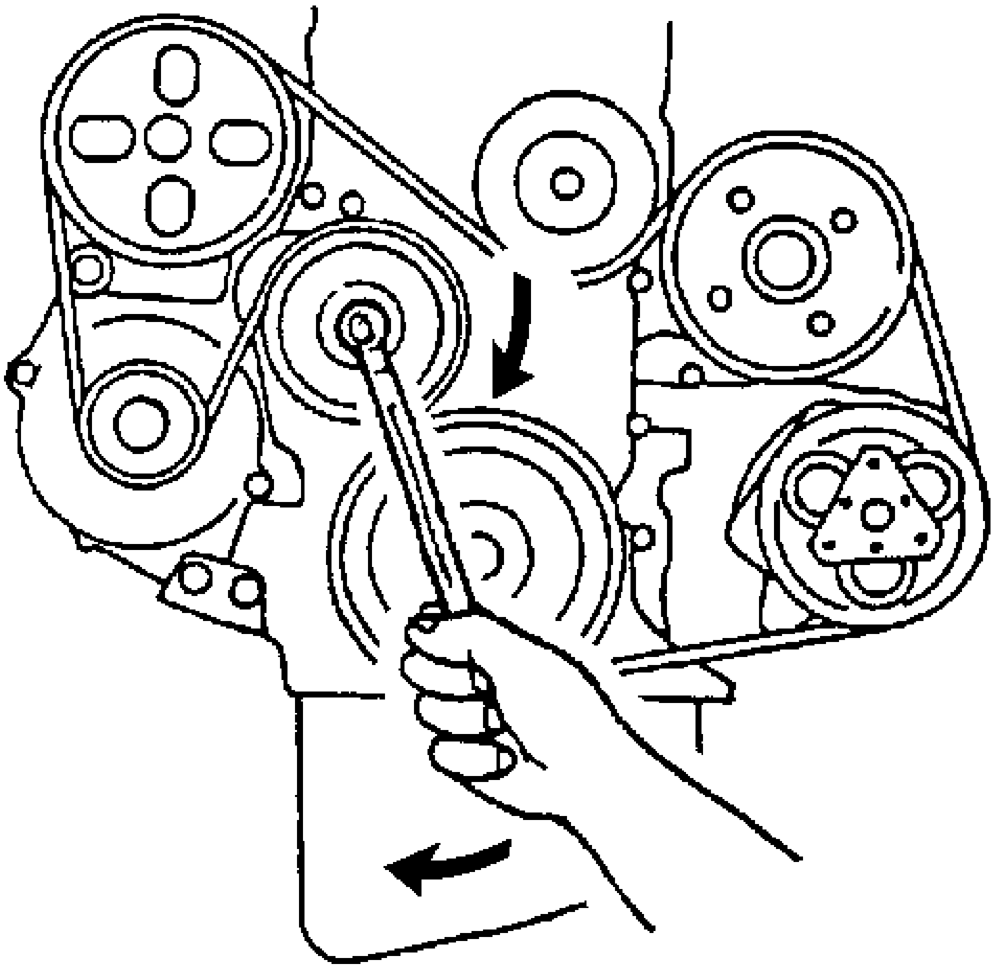


Fig. 19: Drive Belt Rotating
Courtesy of GENERAL MOTORS CORP.

5. Inspect for the following conditions:
   - That the belt is properly installed on all pulleys.
   - When a new belt is correctly installed, the hash mark (3) will be within the indicated range (2) on the tensioner.
   - If the tension indicator mark (4) is to the left of the hash mark (3), the belt must be replaced.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Connect the negative battery cable.

Tighten: Tighten the battery cable bolt to 15 N.m (11 lb ft).

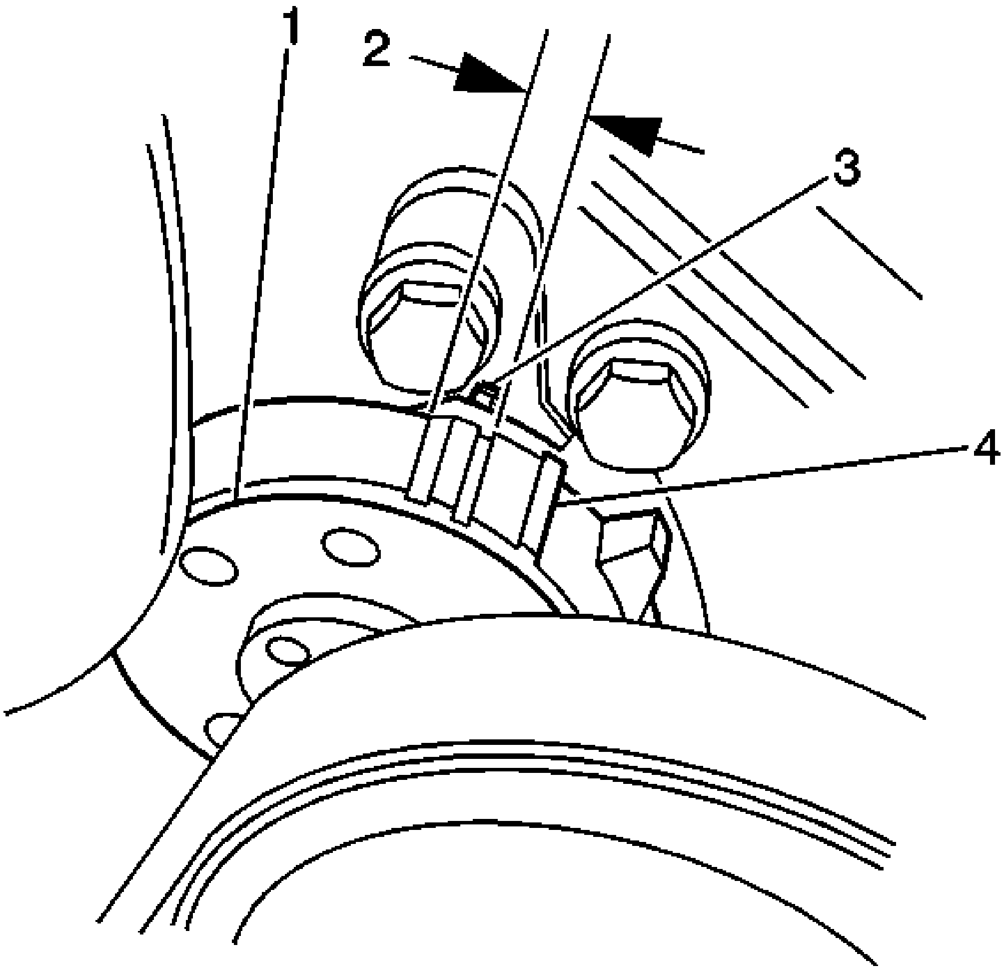


Fig. 20: View Of Tension Indicator Mark, Hash Mark & Indicated Range
Courtesy of GENERAL MOTORS CORP.

Drive Belt Tensioner Replacement - Cooling Fan

Removal Procedure

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

1. Disconnect the negative battery cable.

2. Remove the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.
3. Remove the 2 tensioner mounting bolts (1,3).
4. Remove the tensioner.

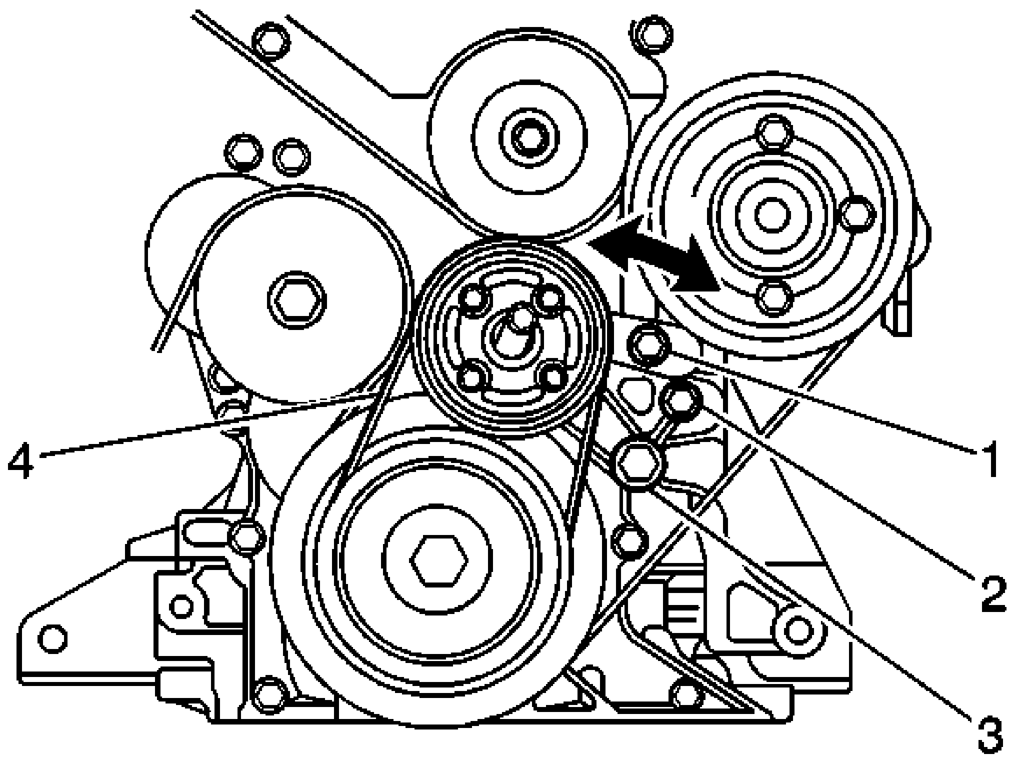


Fig. 21: View Of Tension, Adjusting & Pivot Bolts
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the tensioner. Secure with the two bolts (1,3).

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

2. Install and adjust the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.
3. Connect the negative battery cable.

Tighten: Tighten the bolt to 15 N.m (11 lb ft).

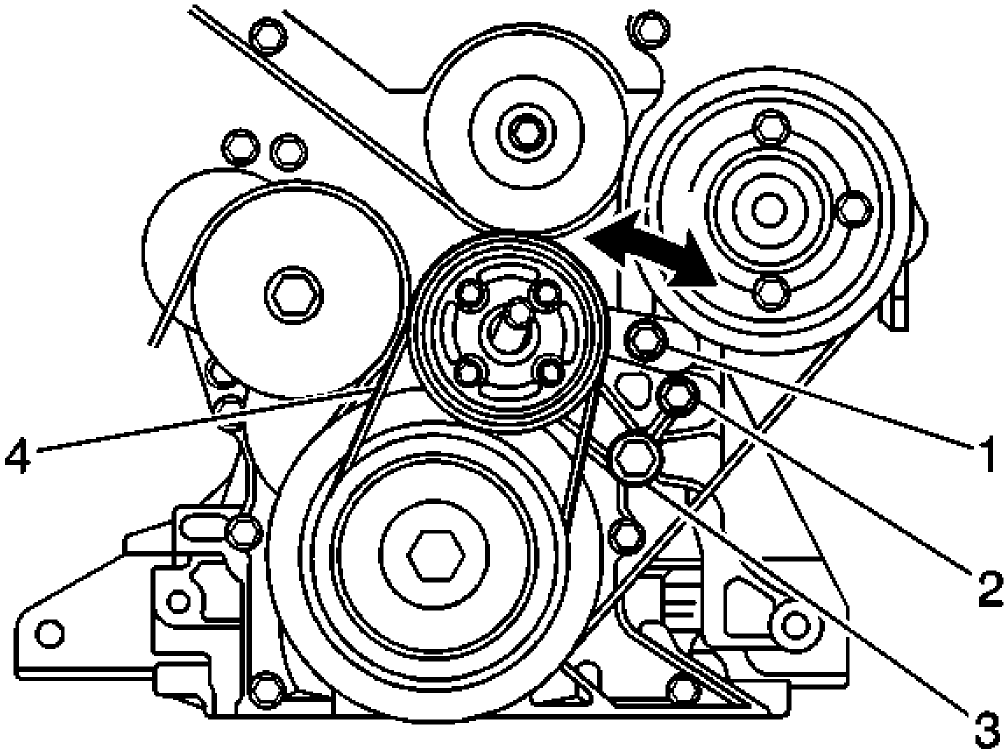


Fig. 22: View Of Tension, Adjusting & Pivot Bolts
Courtesy of GENERAL MOTORS CORP.

Drive Belt Tensioner Replacement - Generator, Air Conditioning, and Power Steering

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
3. Remove the 2 drive belt tensioner bolts.
4. Remove the drive belt tensioner (2).

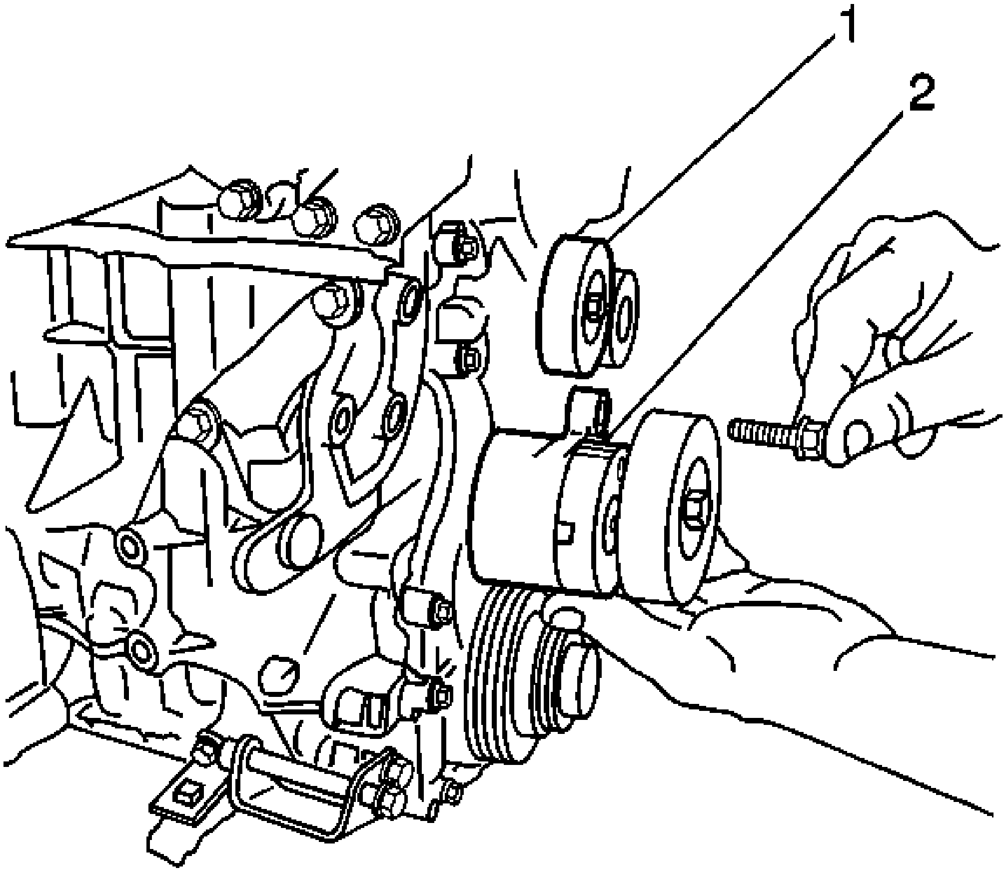


Fig. 23: View Of Drive Belt Tensioner Bolts & Idler Pulley
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the drive belt tensioner (2).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the drive belt tensioner bolts.

   Tighten: Tighten the 2 tensioner bolts to 25 N.m (19 lb ft).

3. Install the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
4. Connect the negative battery cable.

Tighten: Tighten the bolt to 15 N.m (11 lb ft).

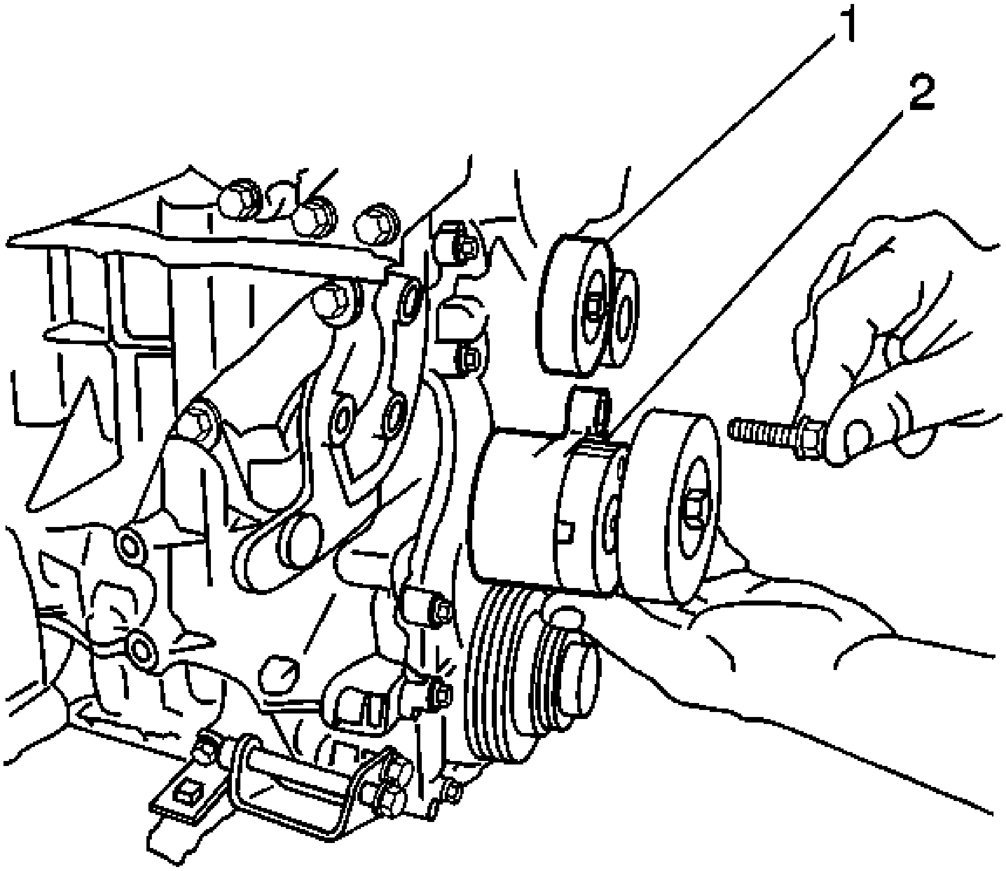


Fig. 24: View Of Drive Belt Tensioner Bolts & Idler Pulley
Courtesy of GENERAL MOTORS CORP.

Engine Mount Inspection

The engine mounts are the nonadjustable type and seldom require service. Broken or deteriorated mounts must be replaced immediately because of the added strain that is placed on the other mounts and the drive line components.

Use the following procedure to inspect for faulty engine mounts:

1. Raise the engine to remove the weight from the mounts and to place a slight tension in the rubber.
2. Observe the mounts while raising the engine.
3. Replace any mount that exhibits the following conditions:

- Hard rubber surfaces covered with heat check cracks
- Rubber that is separated from the metal plate of the mount
- Rubber that is split through the center

4. Perform the following procedure if there is movement between a metal plate of the mount and its attaching points:
    1. Lower the engine on the mounts.
    2. Tighten the bolts or nuts that secure the mount to the engine, frame or bracket.

Engine Mount Replacement - Left

Removal Procedure

1. Remove the nut from the top of the engine mount.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Support the engine using an engine support stand.
4. Remove the 2 nuts from the bottom of the engine mount.
5. Raise the engine slightly in order to provide clearance for the engine mount assembly removal.
6. Remove the left side engine mount (5).
7. Remove the 4 bolts and the engine block bracket (1) (if necessary).
8. Remove the 4 bolts and the body mount bracket (4) (if necessary).

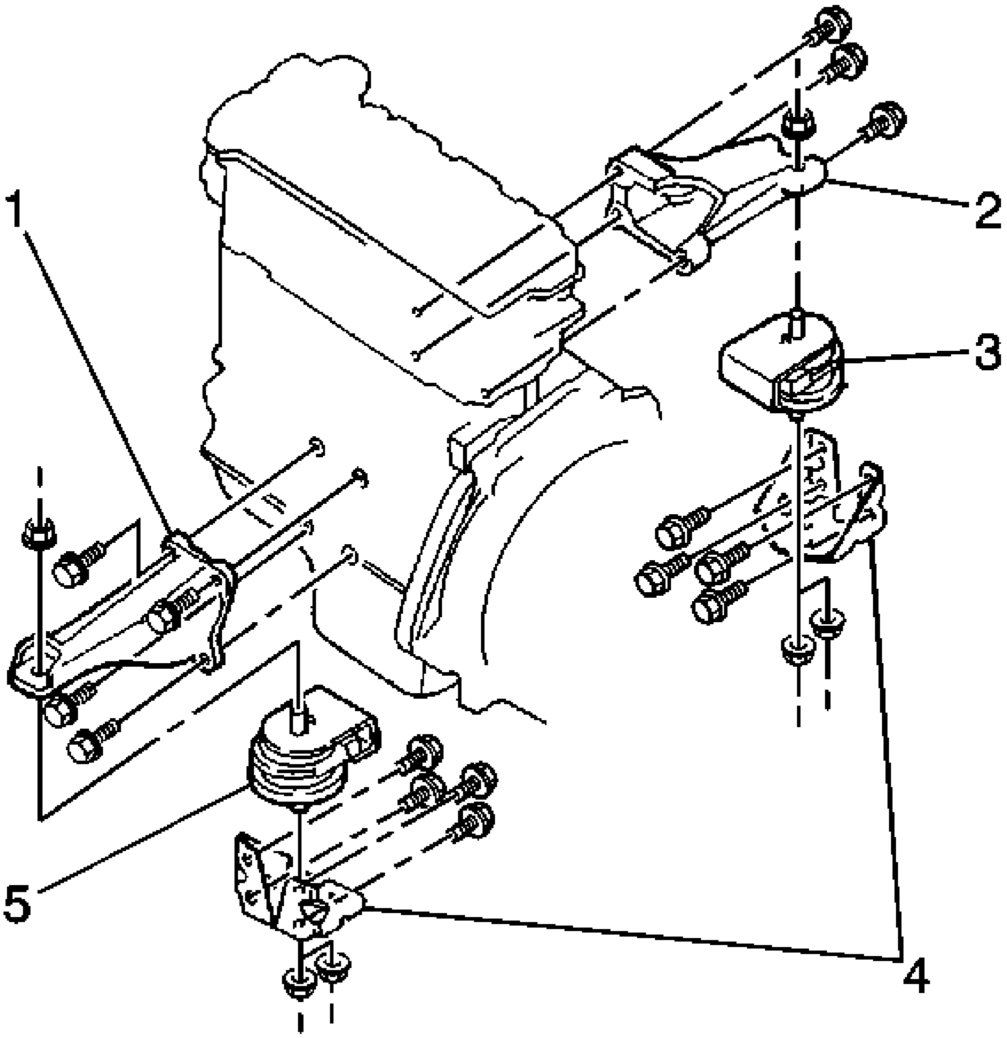


Fig. 25: View Of Left Side Engine Mount, Block Bracket & Body Mount Bracket
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the body mount bracket (4) (if removed).

   Tighten: Tighten the 4 bolts to 85 N.m (62 lb ft).

2. Install the engine block bracket (1) (if removed).

   Tighten: Tighten the 4 bolts to 50 N.m (37 lb ft).

3. Install the left side engine mount (5).
4. Lower the engine.
5. Install the 2 left side engine mount nuts.

   Tighten: Tighten the 2 nuts to 50 N.m (37 lb ft).

6. Lower the vehicle.
7. Install the upper engine mount nut.

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

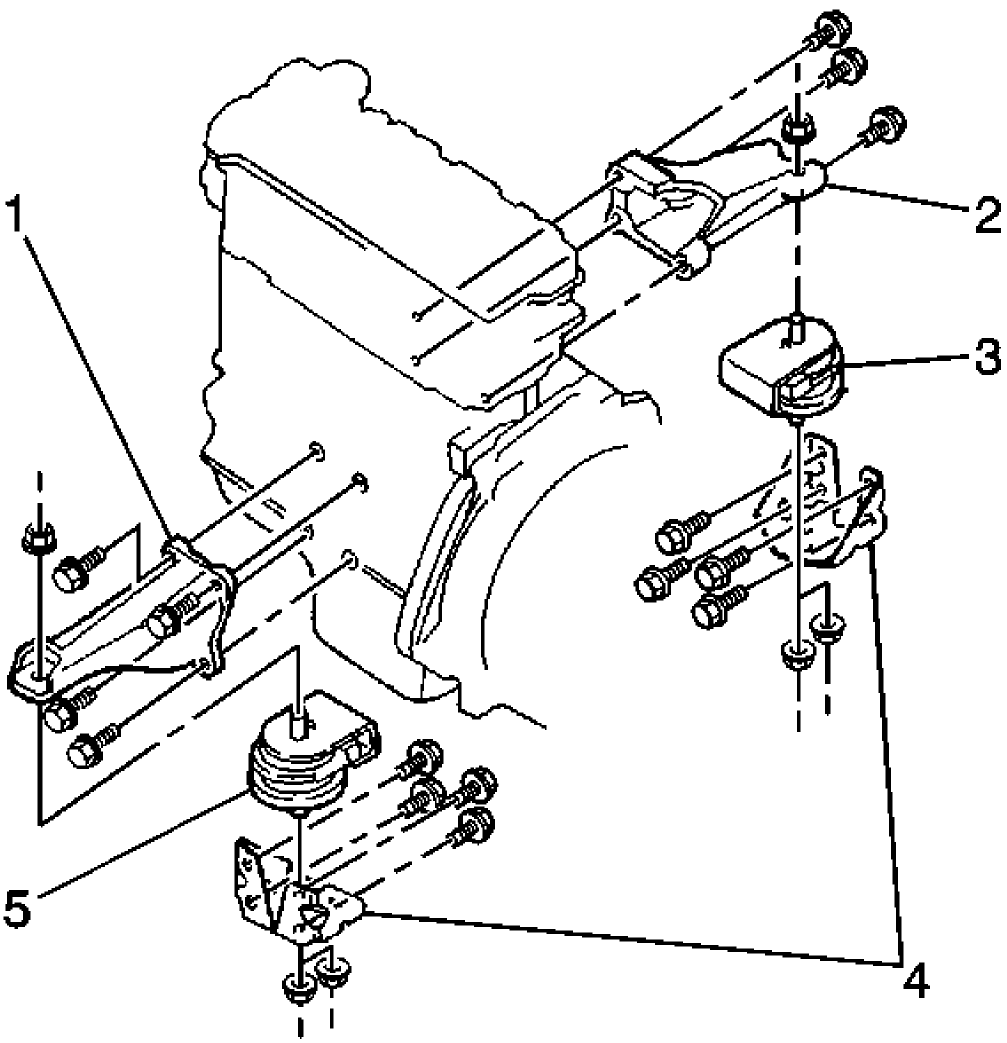


Fig. 26: View Of Left Side Engine Mount, Block Bracket & Body Mount Bracket
Courtesy of GENERAL MOTORS CORP.

Engine Mount Replacement - Right

Removal Procedure

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

1. Disconnect the negative battery cable.

2. Remove the nut from the top of the engine mount.
3. If it is necessary to remove the engine block bracket (2), remove 1 bolt and the starter motor wire harness from the engine block bracket.
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
5. Support the engine using an engine support stand.
6. Remove the 2 nuts from the bottom of the engine mount.
7. Raise the engine slightly in order to provide clearance for the engine mount assembly removal.
8. Remove the right side engine mount (3).
9. If it is necessary to remove the engine block bracket (2), remove the 2 bolts from the bottom of the engine block-to-transmission bracket.

   Remove the 4 bolts and the engine block bracket (2).

10. Remove the 4 bolts and the body mount bracket (4) (if necessary).

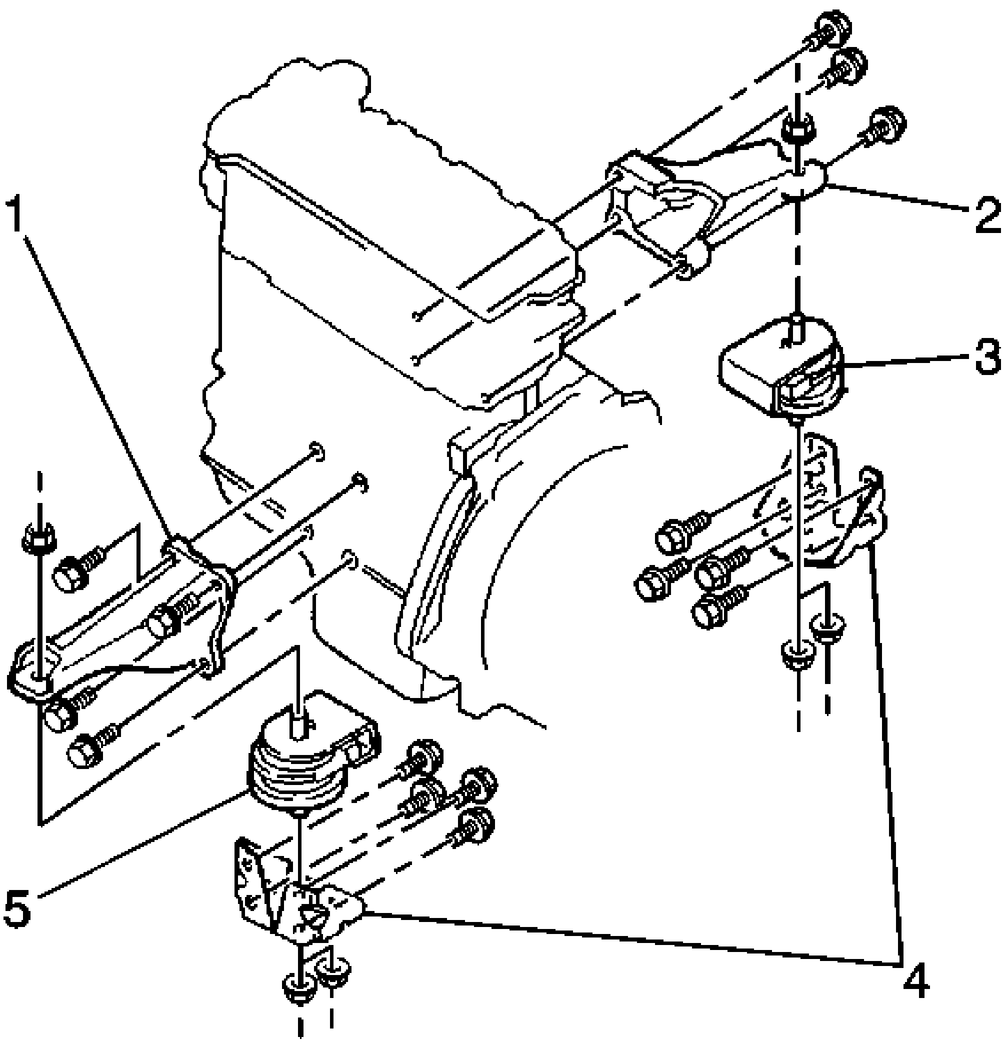


Fig. 27: View Of Left Side Engine Mount, Block Bracket & Body Mount Bracket
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the body mount bracket (4) (if removed).

   Tighten: Tighten the 4 bolts to 85 N.m (62 lb ft).

2. Install the engine block bracket (2) and 4 bolts (if removed).
3. Install the 2 bolts through the bottom of the engine block-to-transmission bracket.

   Tighten: Tighten the 6 bolts to 50 N.m (37 lb ft).

4. Install the right side engine mount (3).
5. Lower the engine.
6. Install the 2 right side engine mount nuts.

   Tighten: Tighten the 2 nuts to 50 N.m (37 lb ft).

7. Lower the vehicle.
8. Install the starter motor wire harness to the engine block bracket (2) (if removed). Secure with the 1 bolt.
9. Install the upper engine mount nut.

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

10. Connect the negative battery cable.

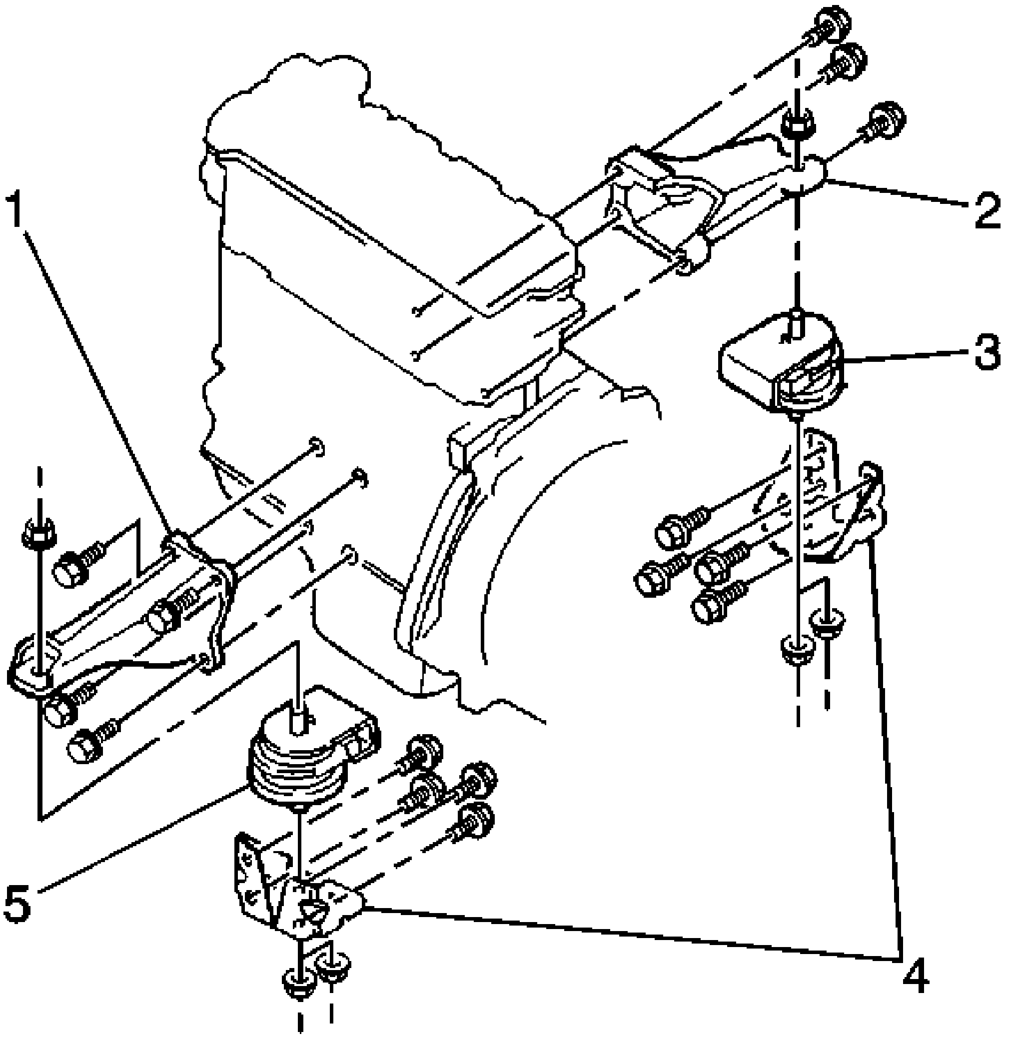


Fig. 28: View Of Left Side Engine Mount, Block Bracket & Body Mount Bracket
Courtesy of GENERAL MOTORS CORP.

Positive Crankcase Ventilation (PCV) Valve Replacement

Removal Procedure

1. Loosen the hose clamp (1) for the positive crankcase ventilation (PCV) valve.
2. Remove the intake manifold vacuum hose (3) from the PCV valve.
3. Remove the PCV valve from the valve cover (2).

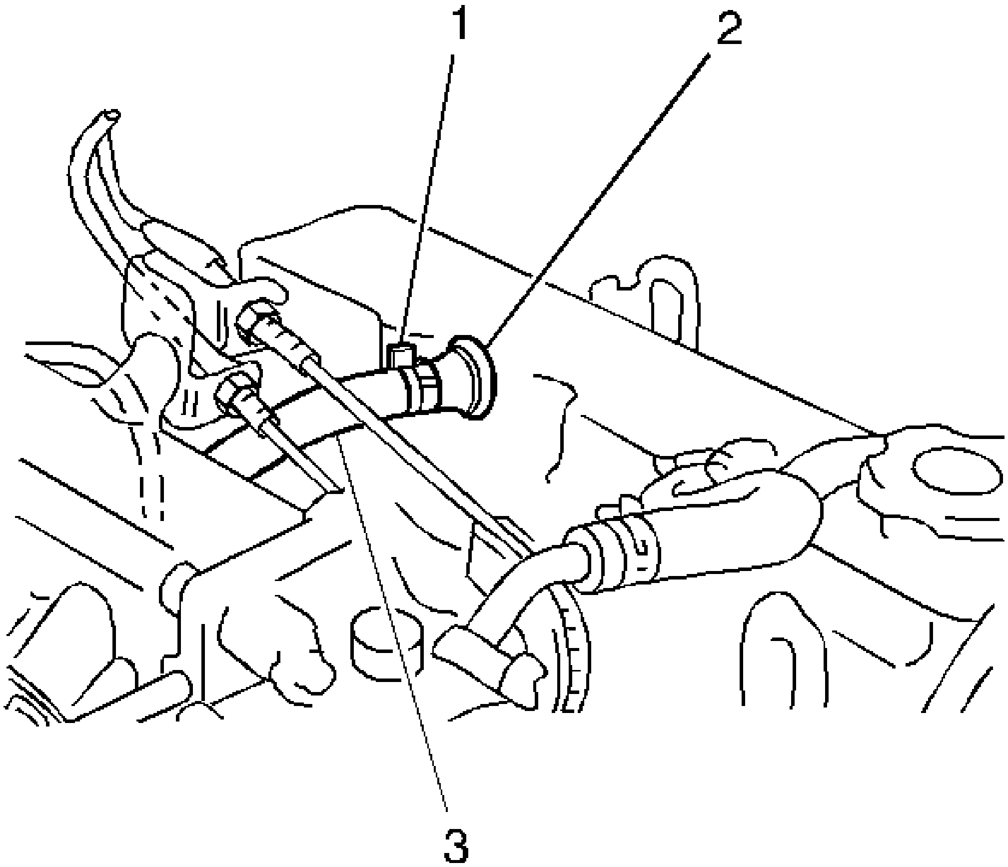


Fig. 29: View Of Intake Manifold Vacuum Hose, Clamp & Valve Cover
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the PCV valve into the valve cover (2).
2. Connect the intake manifold vacuum hose (3) to the PCV valve.
3. Secure the PCV valve with the hose clamp (1).

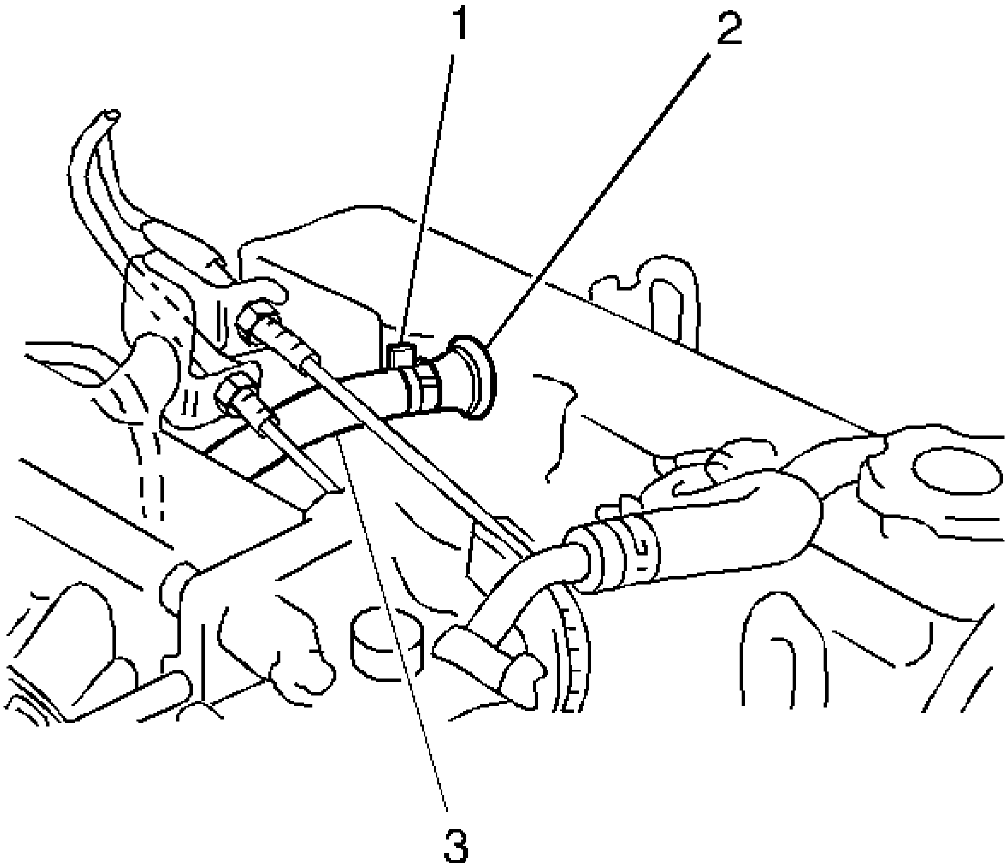


Fig. 30: View Of Intake Manifold Vacuum Hose, Clamp & Valve Cover
Courtesy of GENERAL MOTORS CORP.

Intake Manifold Replacement

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Relieve the fuel pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 2.0L.
3. Drain the engine coolant. Refer to **Draining and Filling Cooling System** in Engine Cooling.
4. Remove the air cleaner hose.
5. Remove the 1 bolt and the accelerator cable bracket (2) from the intake manifold.

6. Remove the cables from the throttle body bellcrank.

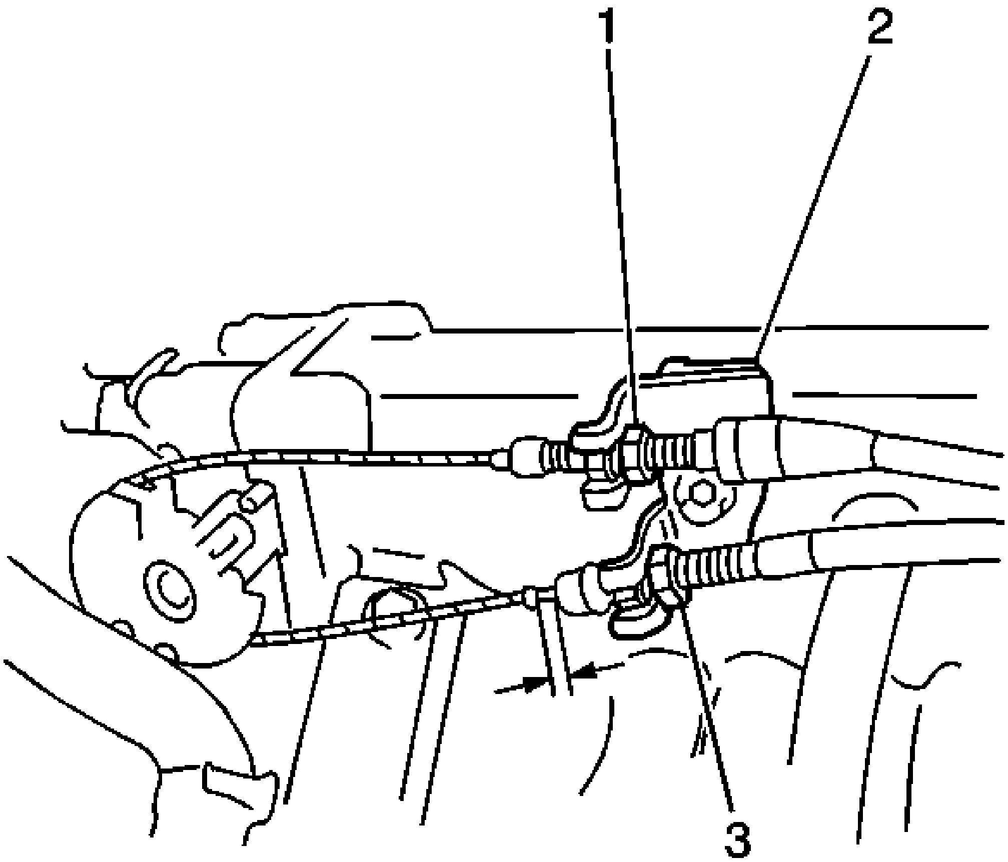


Fig. 31: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the following electrical connectors:
   - The fuel injector harness (3)
   - The manifold absolute pressure (MAP) sensor (11)
   - The throttle position (TP) sensor (8)
   - The idle air control (IAC) valve (6)
   - The EVAP canister purge valve (7)
   - The exhaust gas recirculation (EGR) valve (1)
8. Remove the bolt and the ground wires from the intake manifold (10).
9. Remove the EVAP canister purge hose from the intake manifold.

10. Remove the EVAP vacuum line from the intake manifold.
11. Remove 1 bolt and the EVAP canister purge valve from the intake manifold and position aside.
12. Remove the coolant hoses (4,5) from the throttle body and intake manifold.
13. Remove the 2 bolts and the coolant line (5) from underside of the intake manifold.
14. Remove the brake booster hose from the intake manifold.
15. Remove the PCV hose from the intake manifold.
16. Remove the breather hose from the intake manifold.
17. Remove the fuel pressure regulator vacuum hose from the intake manifold.
18. Remove the bolt that holds the fuel line bracket (9) to the intake manifold.
19. Disconnect the wiring harness from the retaining clamps.
20. Remove the banjo fitting and washer from the rear end of the fuel rail.

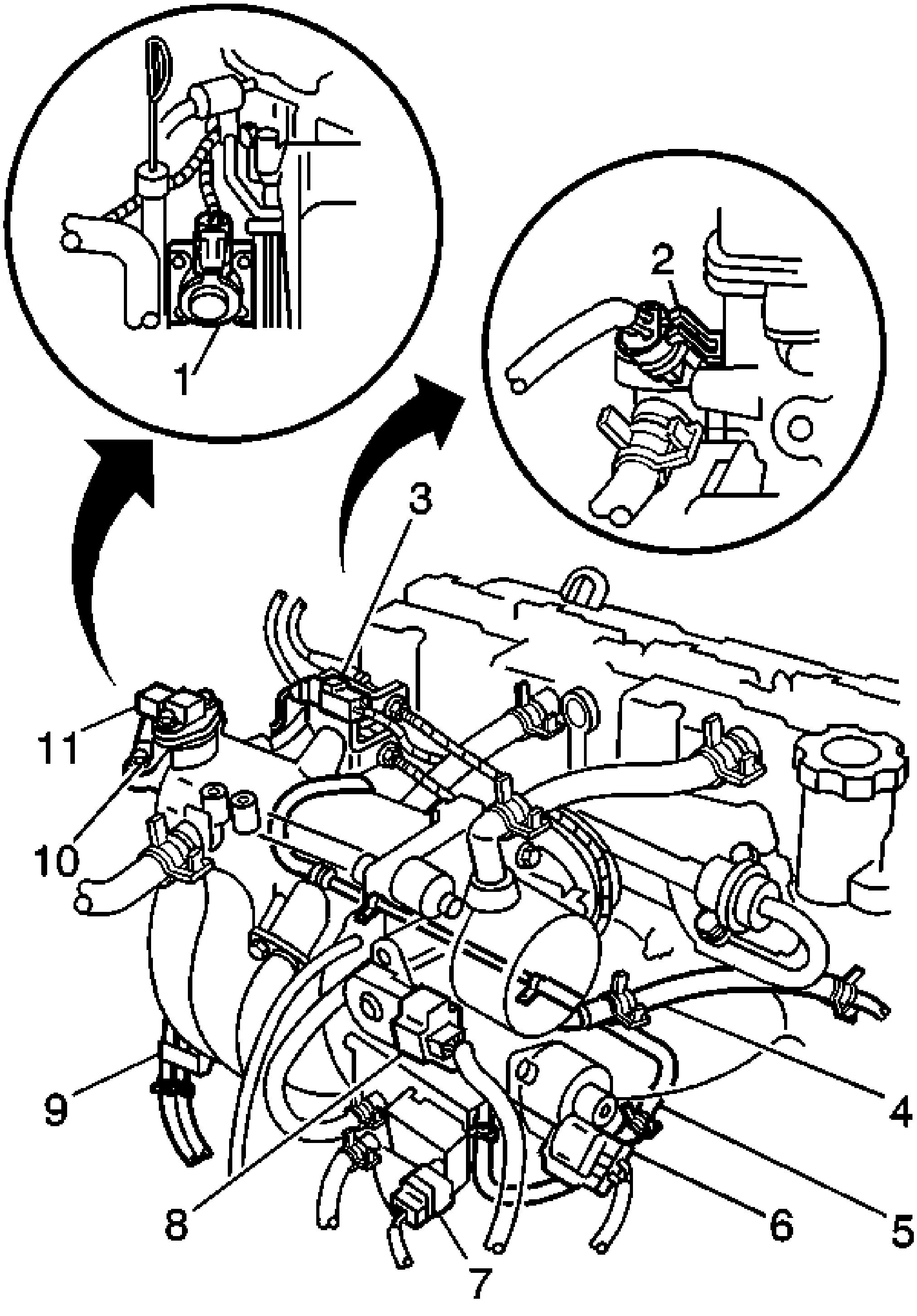


Fig. 32: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

21. Remove the 2 bolts that hold the fuel lines to the fuel rail.
22. Remove the 2 bolts and the intake manifold front support bracket.
23. Remove the 2 bolts and the intake manifold top support bracket.

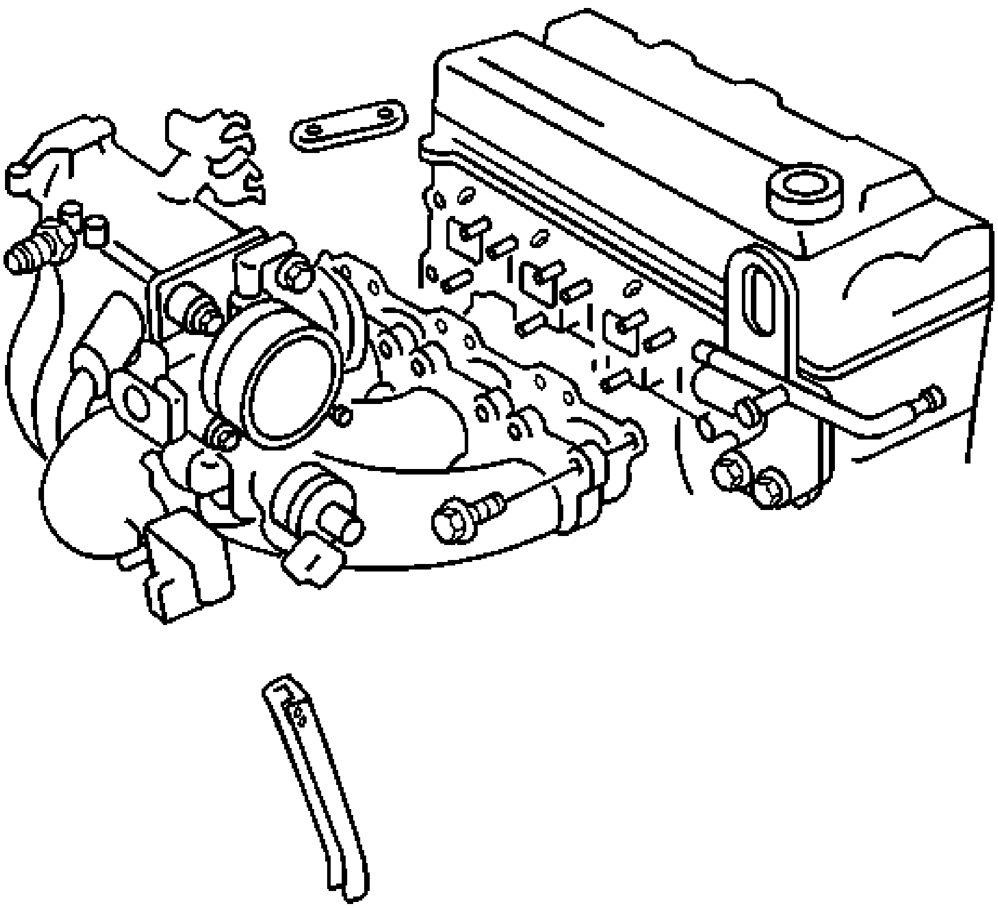


Fig. 33: View Of Front & Top Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

24. Remove the 9 nuts and 4 bolts from the intake manifold.
25. Remove the intake manifold from the cylinder head.
26. Remove the intake manifold gasket from the cylinder head.
27. Inspect the intake manifold for cracks, warpage or other damage.

28. Clean the gasket sealing surfaces.
29. Remove the following components from the intake manifold and transfer as necessary:
    - The Throttle Body (7)
    - The EGR valve (2)
    - The EGR pipe
    - The MAP sensor (3)

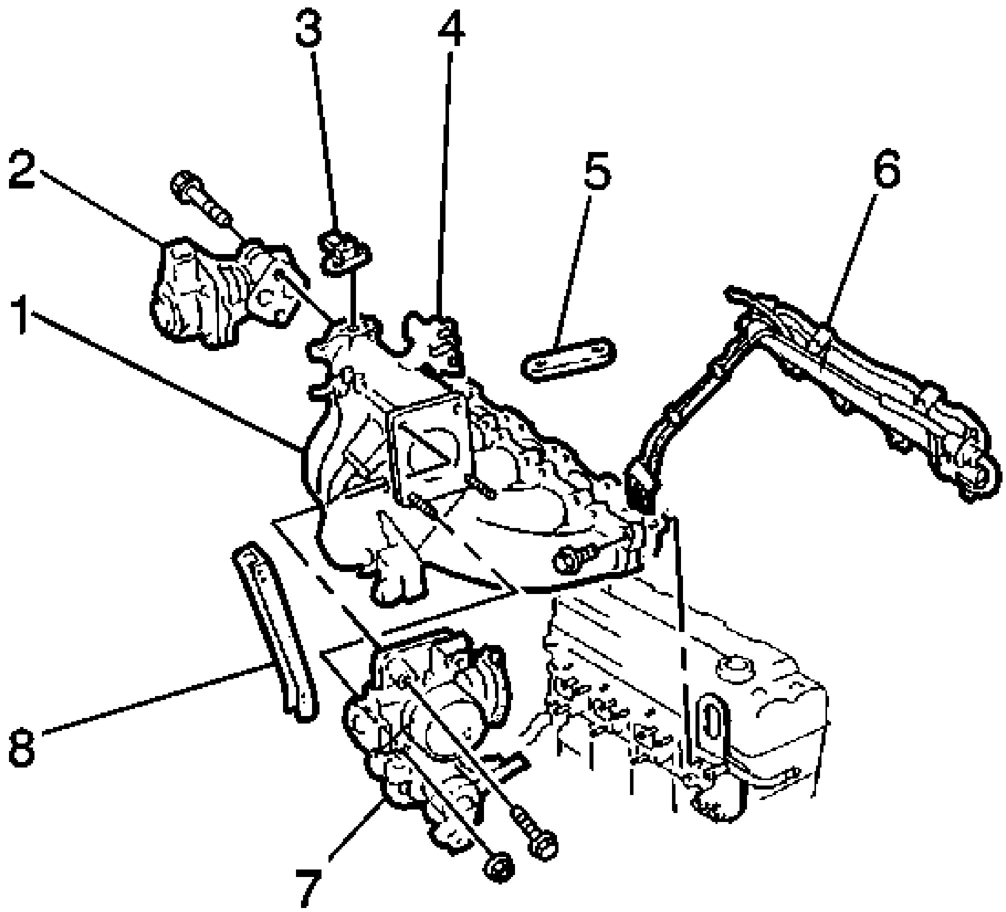


Fig. 34: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the following components to the intake manifold as necessary:

- The Throttle Body (7)
- The EGR valve (2)
- The EGR pipe
- The MAP sensor (3)

2. Install the new intake manifold gasket to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the intake manifold to the cylinder head. Secure the intake manifold with the 9 nuts and the 4 bolts.

Tighten: Tighten the nuts and bolts to 25 N.m (19 lb ft).

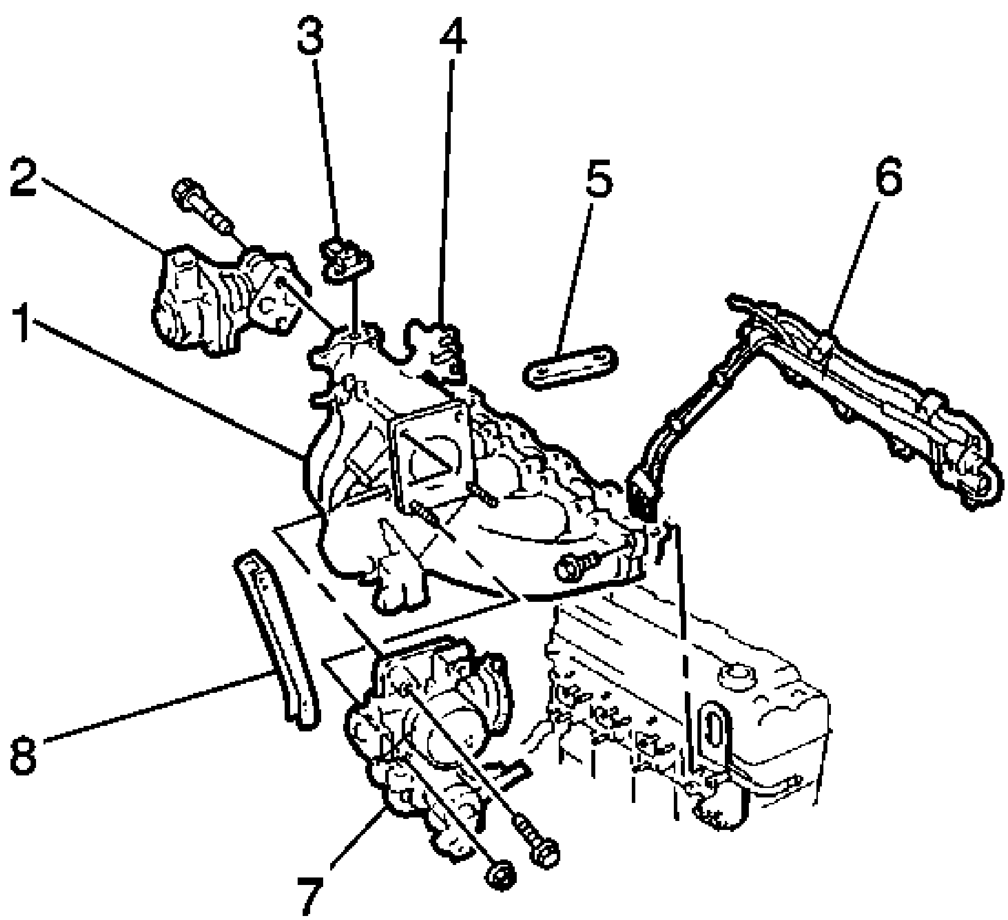


Fig. 35: View Of Intake Manifold & Components

Courtesy of GENERAL MOTORS CORP.

4. Install the intake manifold front support bracket. Secure with the 2 bolts.
5. Install the intake manifold top support bracket. Secure with the 2 bolts.

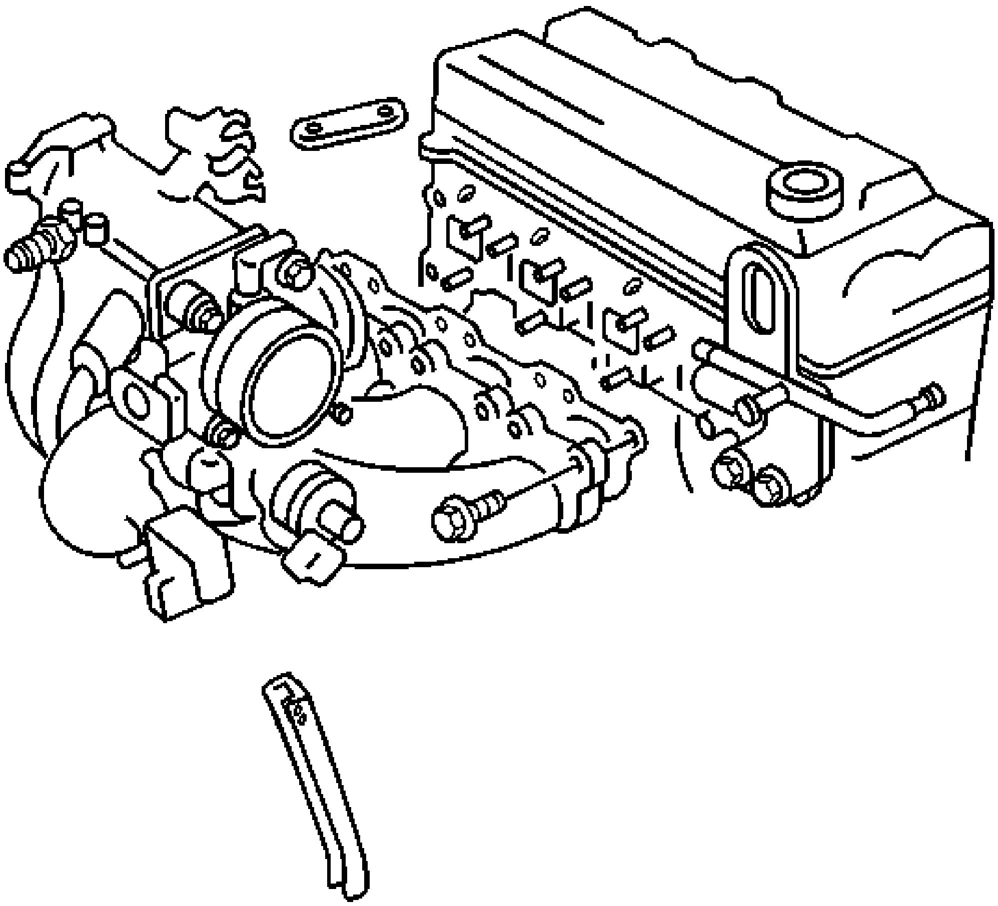


Fig. 36: View Of Front & Top Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

6. Install the fuel line bracket (9) to the intake manifold. Secure with 1 bolt.
7. Install the fuel lines to the fuel rail. Secure with the 2 bolts.
8. Install the washer and the banjo fitting to the rear end of the fuel rail.
9. Connect the fuel pressure regulator vacuum hose to the intake manifold.
10. Install the coolant line (5) to the underside of the intake manifold. Secure with the 2 bolts.

11. Connect the coolant hoses (4,5) to the throttle body and the intake manifold.
12. Install the EVAP canister purge valve to the intake manifold. Secure with 1 bolt.
13. Connect the canister purge hose to the intake manifold.
14. Connect the EVAP vacuum line to the intake manifold.
15. Connect the brake booster hose to the intake manifold.
16. Connect the PCV hose to the intake manifold.
17. Connect the breather hose to the intake manifold.
18. Install the ground wires to the intake manifold (10). Secure with the bolt.
19. Connect the following electrical connectors:
    - The fuel injector harness (3)
    - The manifold absolute pressure (MAP) sensor (11)
    - The throttle position (TP) sensor (8)
    - The idle air control (IAC) valve (6)
    - The EVAP canister purge valve (7)
    - The exhaust gas recirculation (EGR) valve (1)
20. Secure the wiring harness to the retaining clamps.

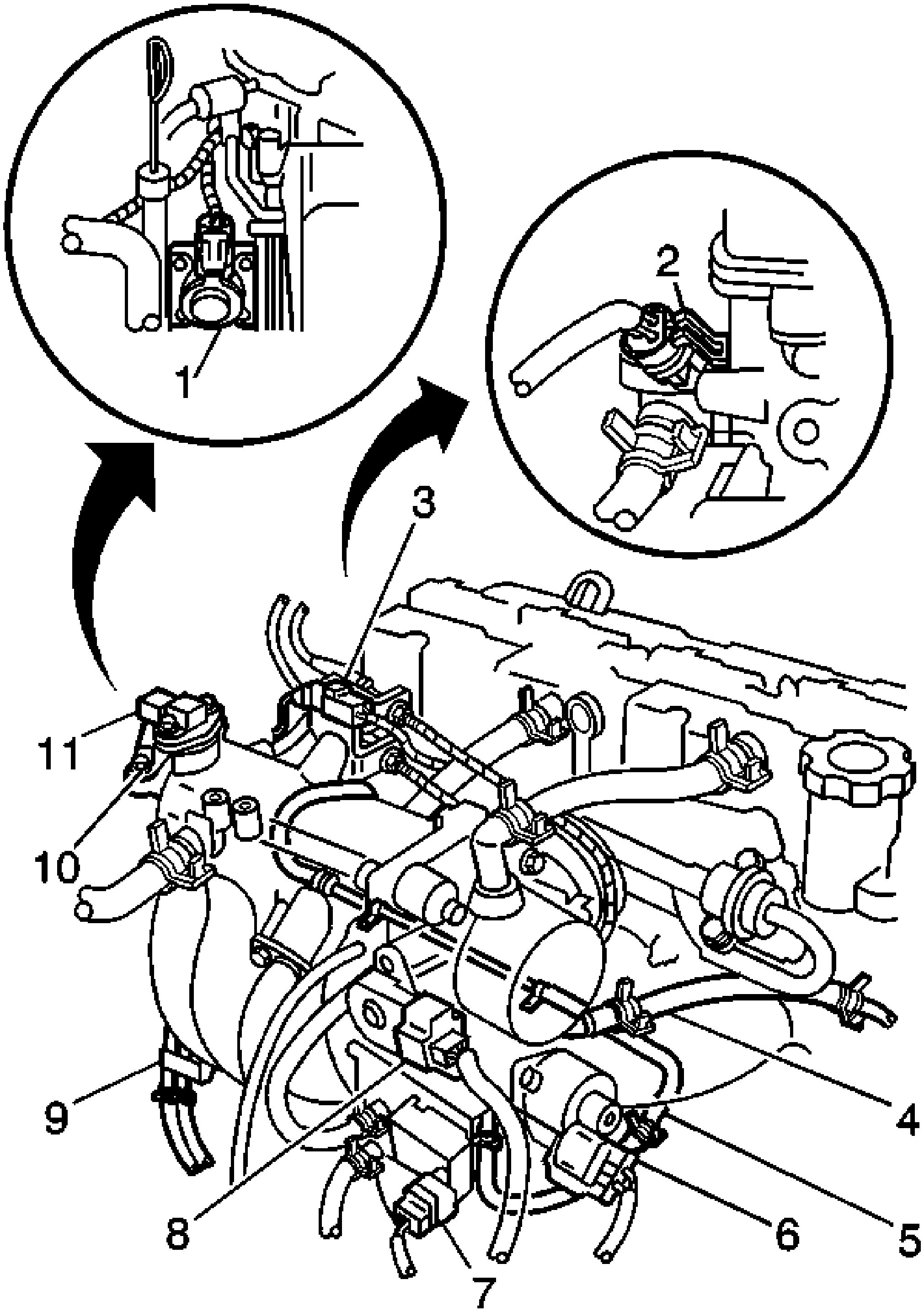


Fig. 37: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

21. Connect the cables to the throttle body bellcrank.
22. Connect the accelerator cable bracket (2) to the intake manifold. Secure with the 1 bolt.
23. Adjust the accelerator cable play to specifications if necessary. Refer to **Accelerator Cable Adjustment** in Engine Controls - 2.0L.
24. Install the air cleaner hose.
25. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
26. Upon completion of the installation, start the engine and check for fuel and engine coolant leaks.

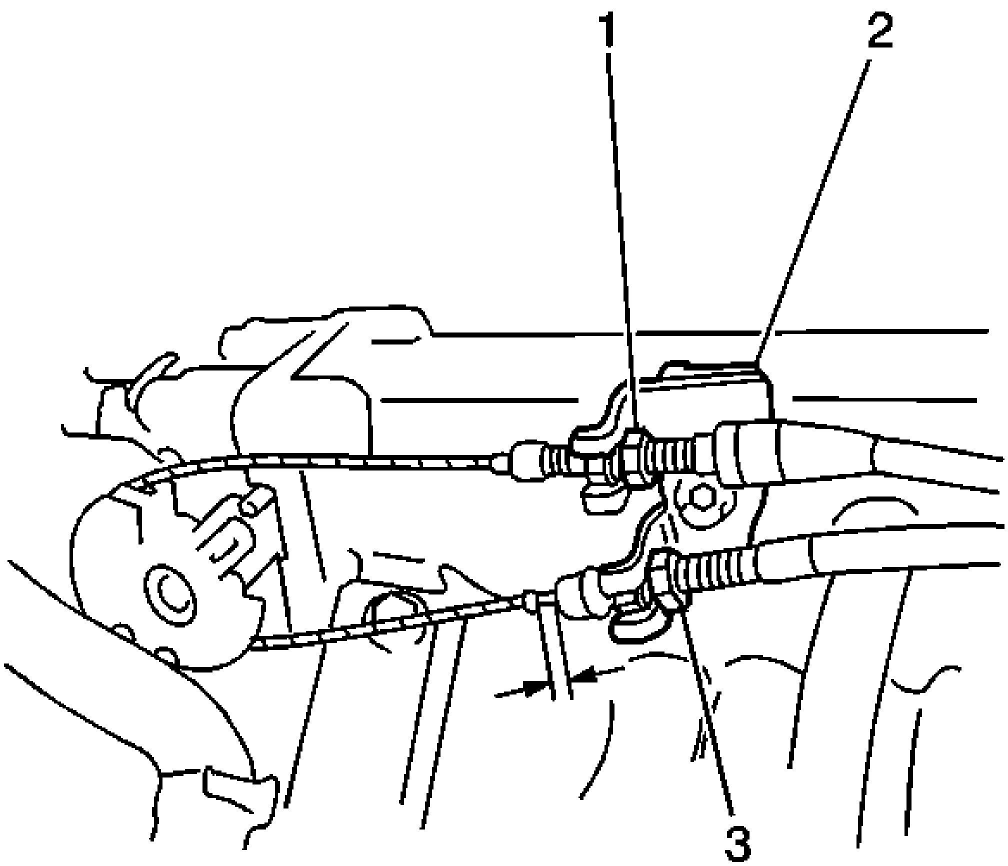


Fig. 38: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

Crankshaft Pulley Replacement

Tools Required

J 8614-01 Flange and Pulley Holding Tool

Removal Procedure

1. Remove the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.
2. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
3. Remove the cooling fan. Refer to **Fan Replacement** in Engine Cooling.
4. Remove the radiator. Refer to **Radiator Replacement** in Engine Cooling.

IMPORTANT: Do not damage the A/C condenser, if equipped, during crankshaft pulley service.

5. Remove the crankshaft pulley retaining bolt using the **J 8614-01** to prevent crankshaft rotation when loosening the bolt.

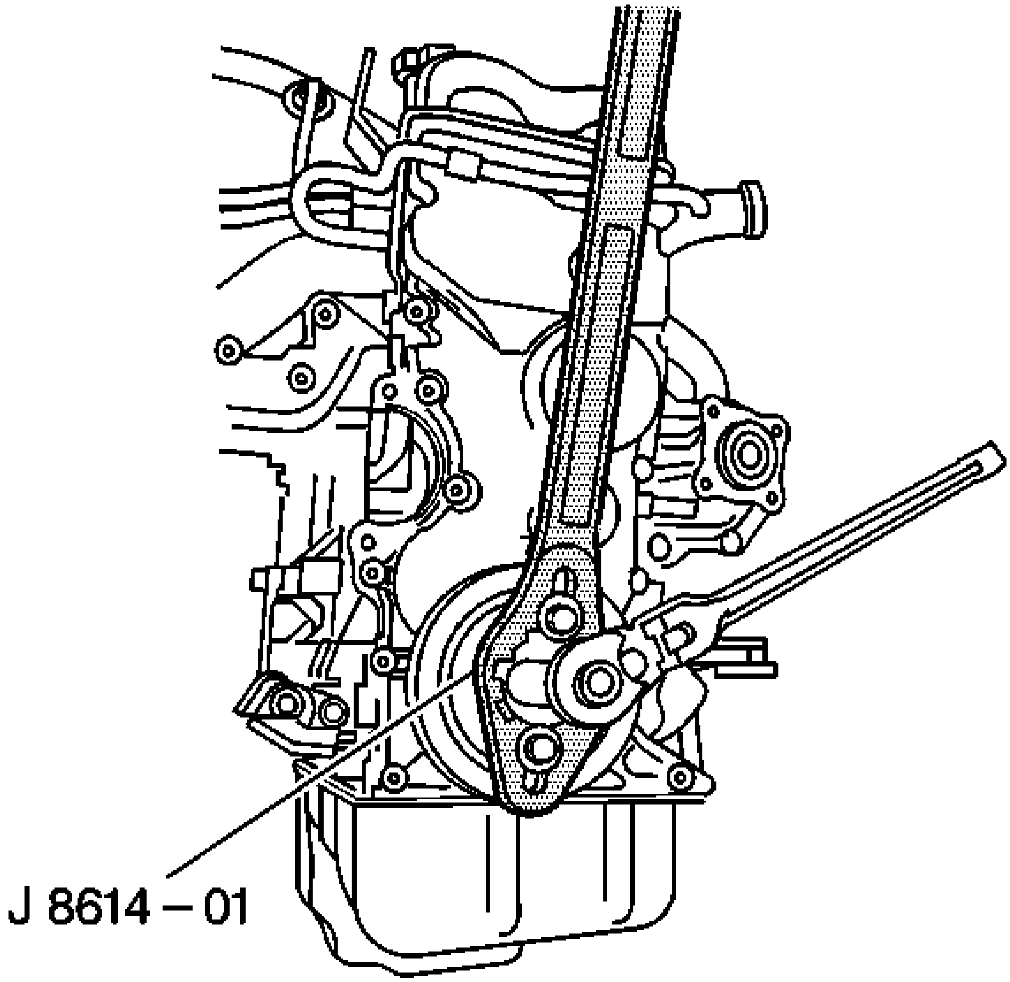


Fig. 39: View Of J 8614-01
Courtesy of GENERAL MOTORS CORP.

6. The crankshaft may also be held by locking the flywheel through the access hole (1).

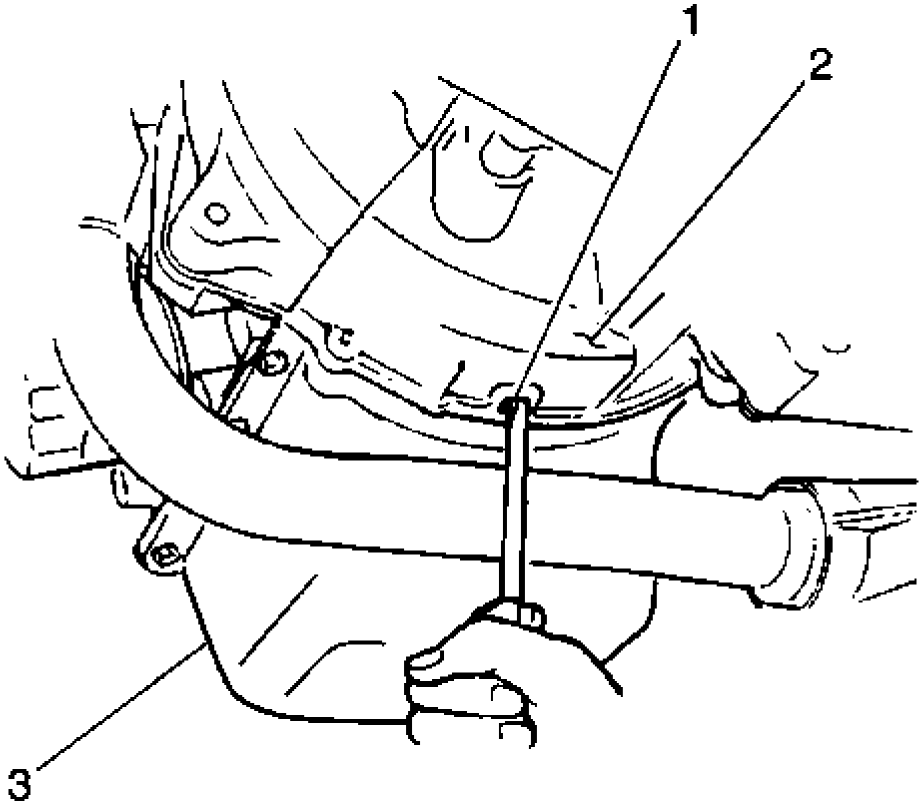


Fig. 40: View Of Access Hole
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft pulley.

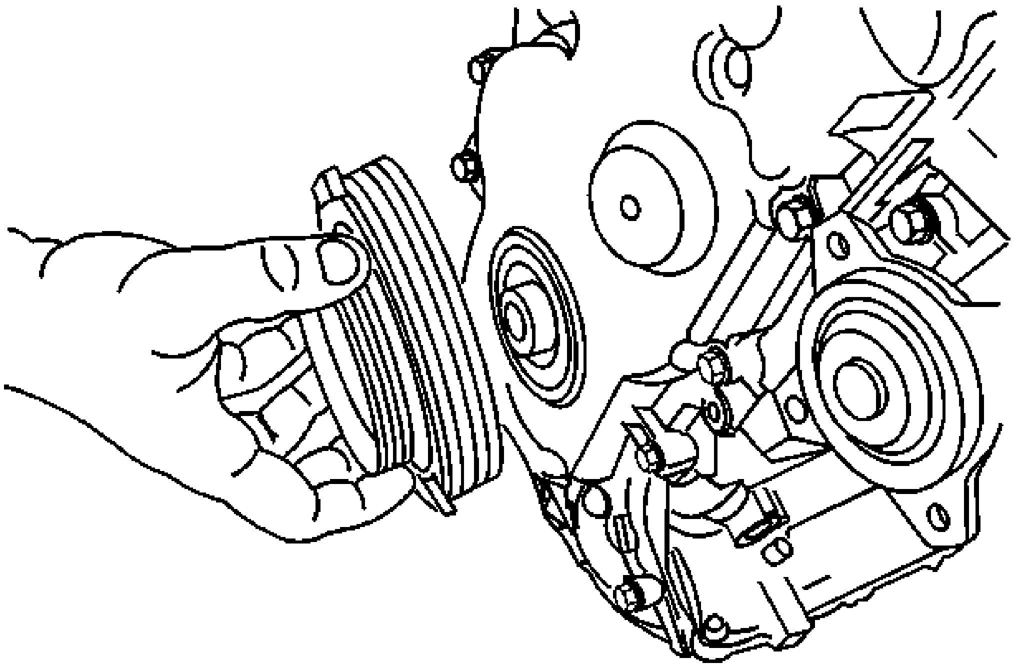


Fig. 41: Removing Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Lubricate the front seal and the sealing surface of the crankshaft pulley with Chassis Grease GM P/N 1051344 (Canadian P/N 993037) or equivalent.
2. Install the crankshaft pulley onto the crankshaft indexing the keyway.

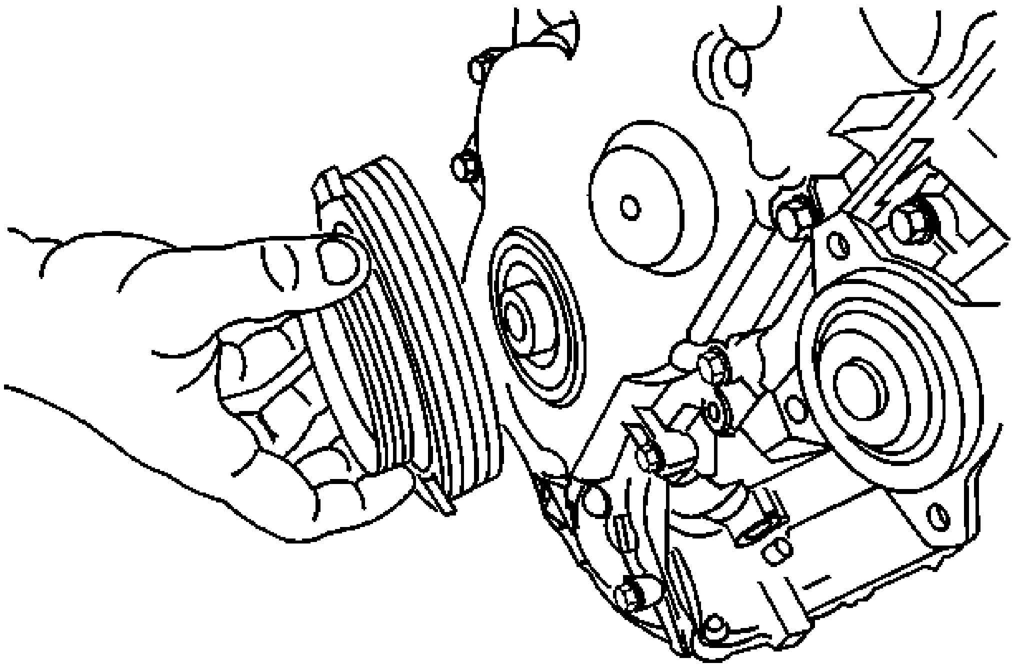


Fig. 42: Installing Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the crankshaft pulley retaining bolt using the **J 8614-01** to prevent crankshaft rotation when tightening the bolt.

   Tighten: Tighten the bolt to 150 N.m (109 lb ft).

4. Install the radiator. Refer to **Radiator Replacement** in Engine Cooling.
5. Install the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
6. Install the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.
7. Install the cooling fan. Refer to **Fan Replacement** in Engine Cooling.

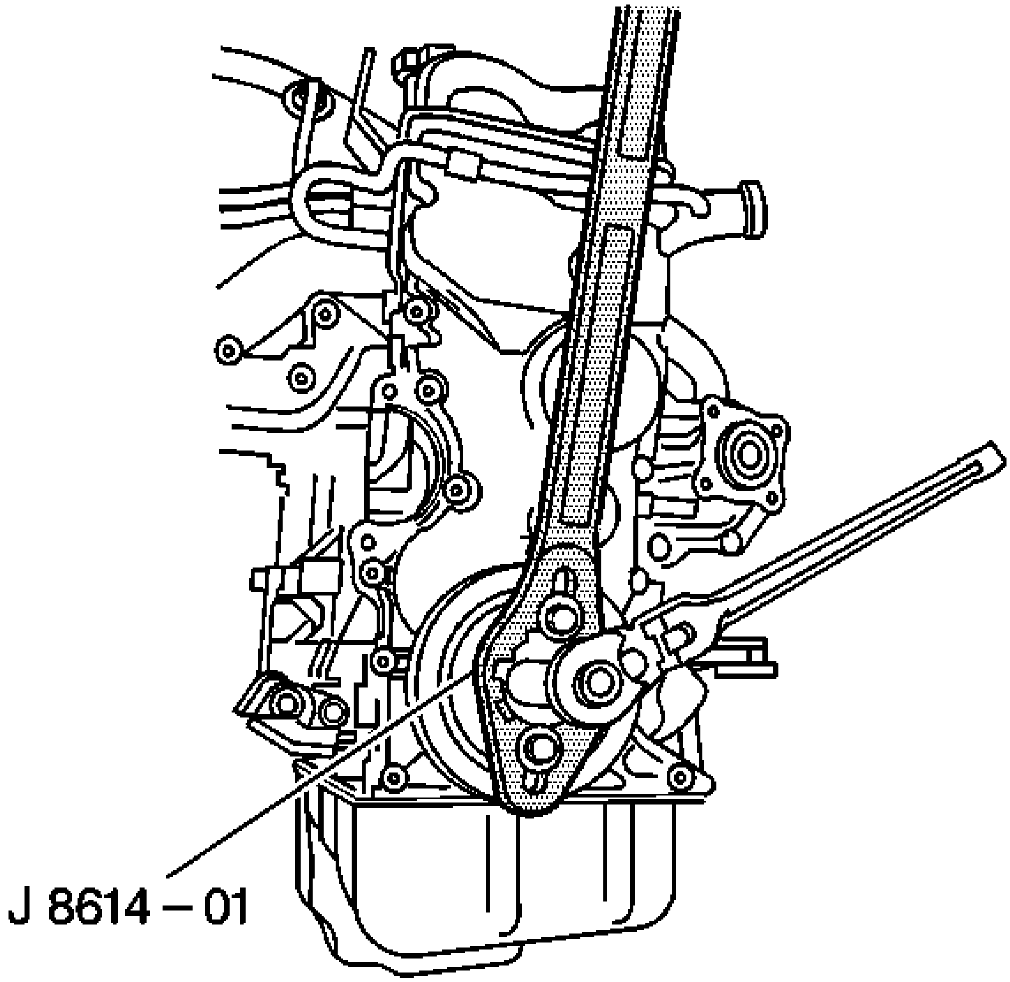


Fig. 43: View Of J 8614-01
Courtesy of GENERAL MOTORS CORP.

Crankshaft Front Oil Seal Replacement

Removal Procedure

1. Remove the crankshaft pulley. Refer to **Crankshaft Pulley Replacement**.

IMPORTANT: To protect the crankshaft from damage, wrap the tip of the screwdriver with tape.

2. Carefully pry out the crankshaft front oil seal using a screwdriver.

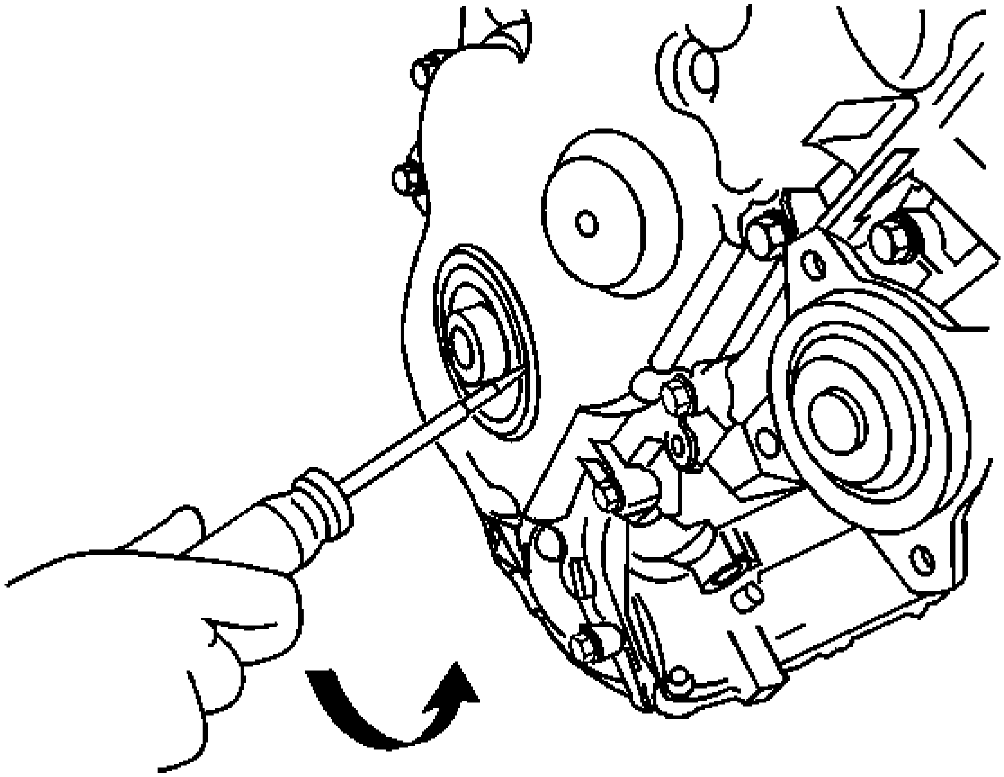


Fig. 44: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Lubricate the new crankshaft front oil seal with Chassis Grease GM P/N 1051344 or equivalent.

IMPORTANT: Tap the oil seal in until its surface is flush with the crankshaft front oil seal retainer edge.

2. Using a hammer and an appropriate driver, lightly tap the crankshaft front oil seal into place.
3. Install the crankshaft pulley. Refer to **Crankshaft Pulley Replacement**.

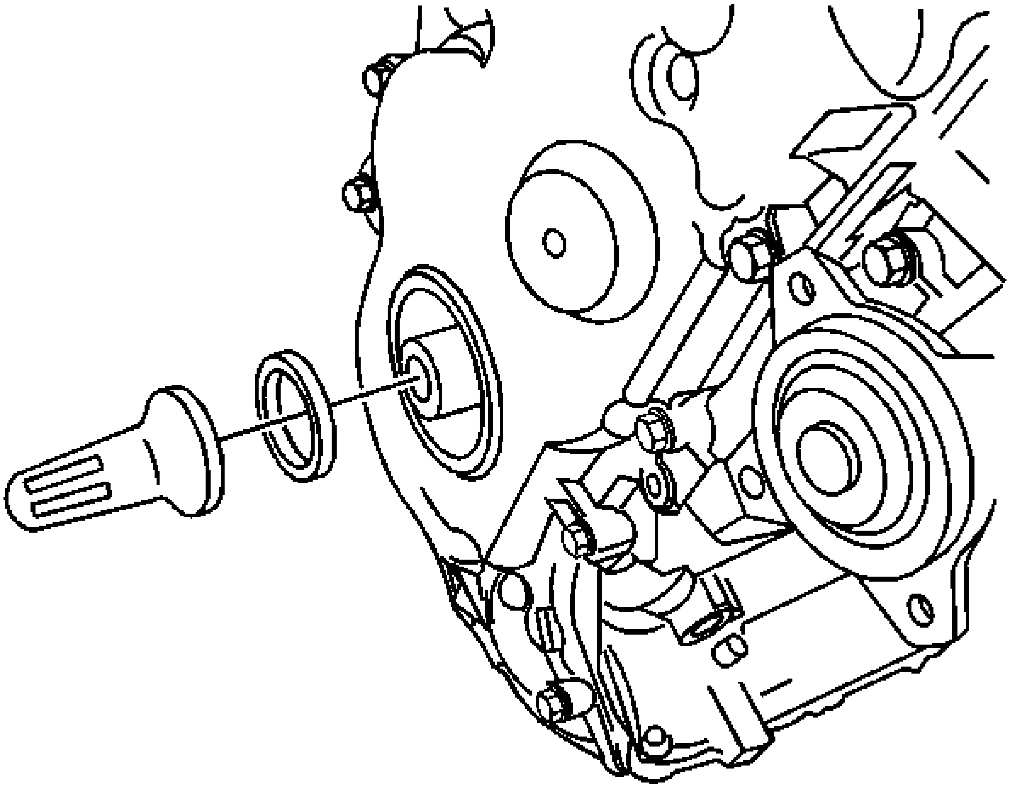


Fig. 45: Lubricating New Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Replacement - Camshaft

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
3. Remove the spark plugs in order to make rotating the crankshaft to line up the timing marks easier.

IMPORTANT: The timing marks must be correctly aligned before disassembly.

4. Rotate the crankshaft so that the following conditions are met:

- The number 1 (front most) cylinder is at the top dead center (TDC) position on the compression stroke.
- The keyway on the crankshaft (5) aligns with the mark on the engine block (4).
- The arrow (3) on the idler sprocket is pointing upward.
- The guide pins (1) on the camshaft sprockets line up with the notches (6) on the cylinder head.

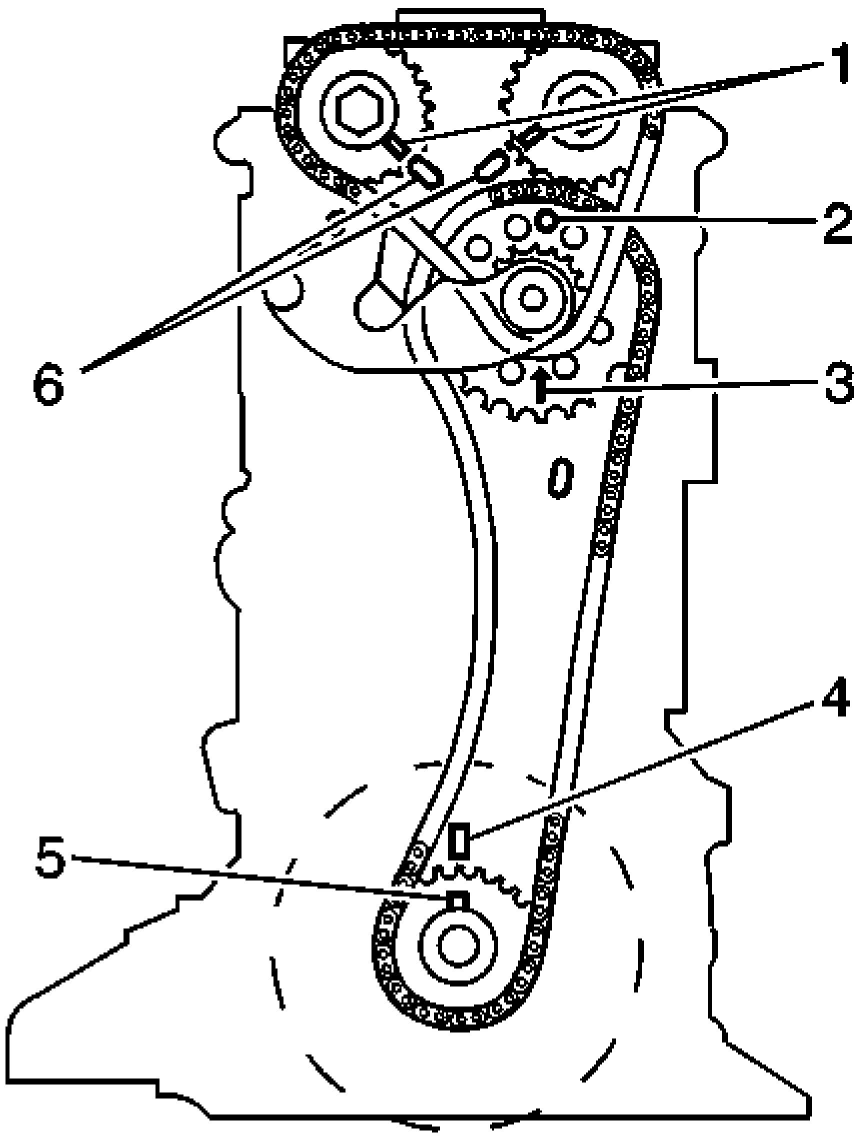


Fig. 46: Locating Timing Marks

Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not turn the crankshaft or camshaft once the tensioner is removed.

5. Relieve the tension on the camshaft timing chain by turning the intake camshaft slightly counterclockwise.
6. Remove the nut and 2 bolts (1, 2).
7. Remove the camshaft timing chain tensioner and the gasket.

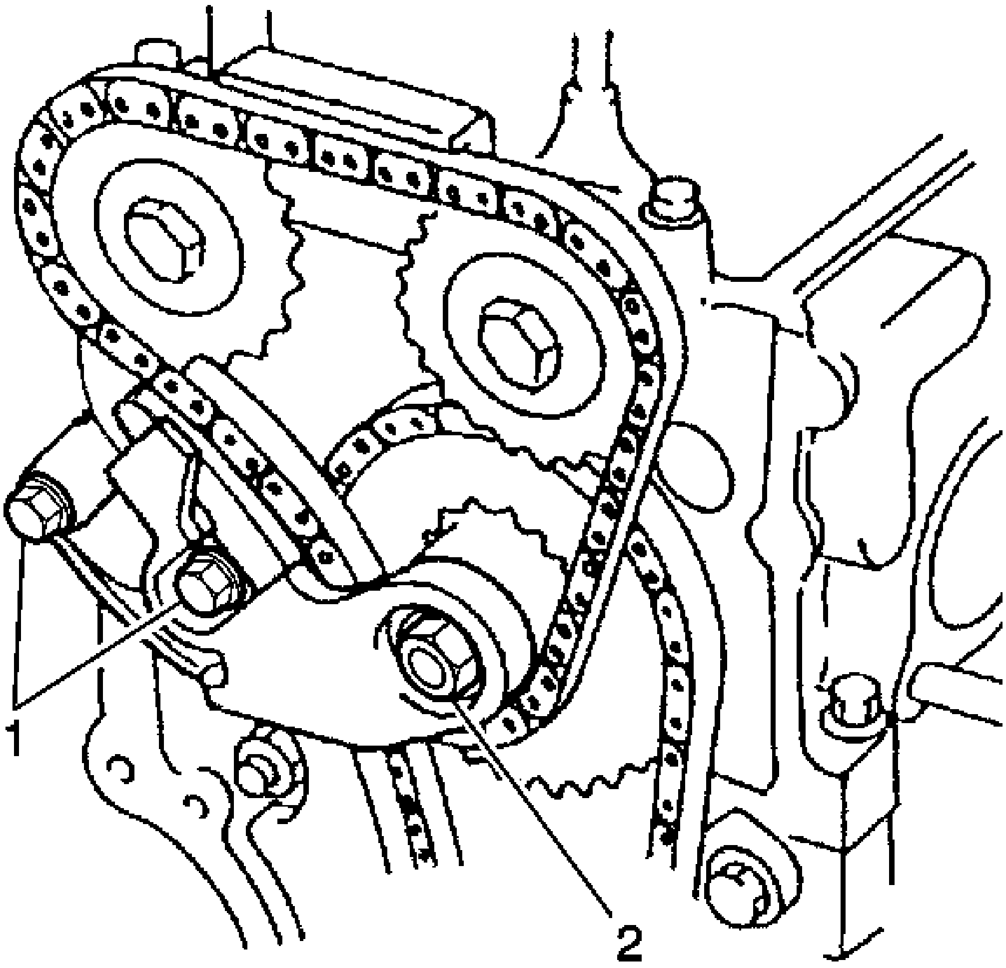


Fig. 47: View Of Tensioner
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Inspect the camshaft timing chain tensioner for wear, damage and correct operation. Replace as necessary.
2. Inspect the timing chain tensioner gasket and replace as necessary.
3. Compress the camshaft tensioner plunger into the body. Insert a retainer (a paper clip or similar tool) through the hole in the body in order to hold the plunger in place.

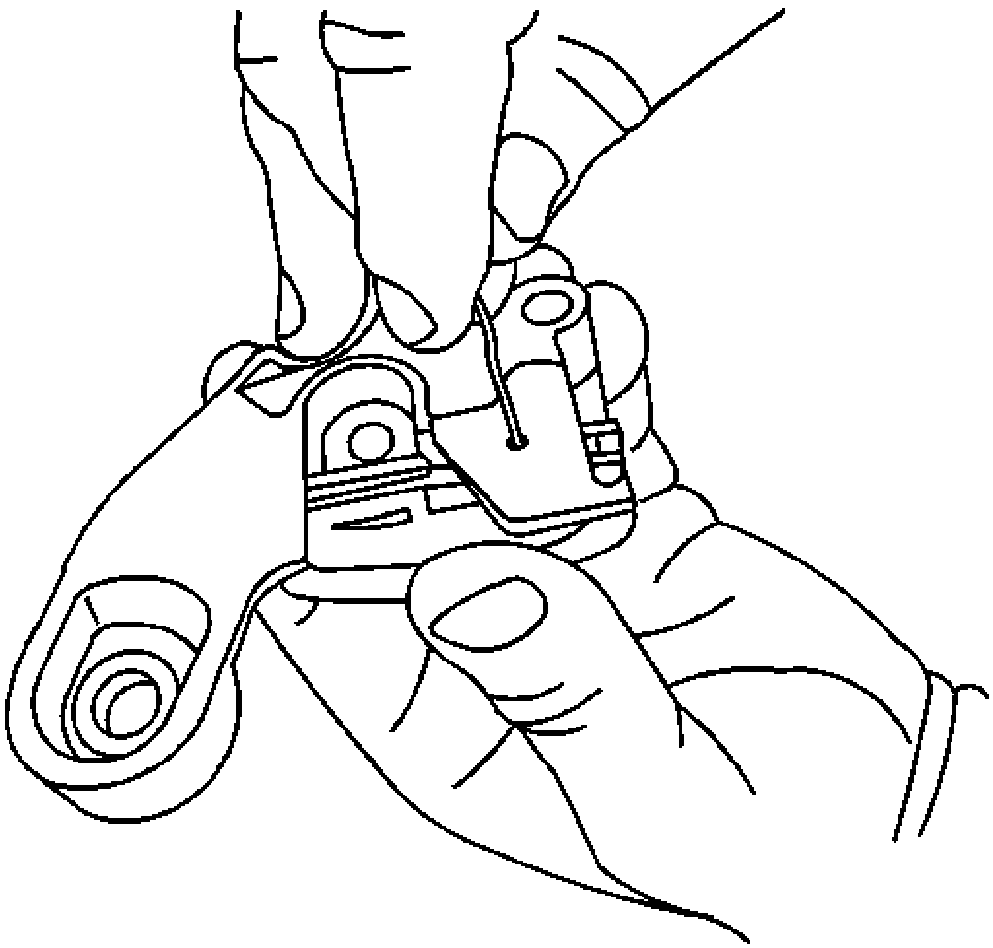


Fig. 48: Installing Camshaft Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the gasket and the camshaft timing chain tensioner.

Tighten:

- Tighten the bolts (1) to 11 N.m (97 lb in).
- Tighten the nut (2) to 45 N.m (33 lb ft).

5. Remove the retainer from the tensioner.

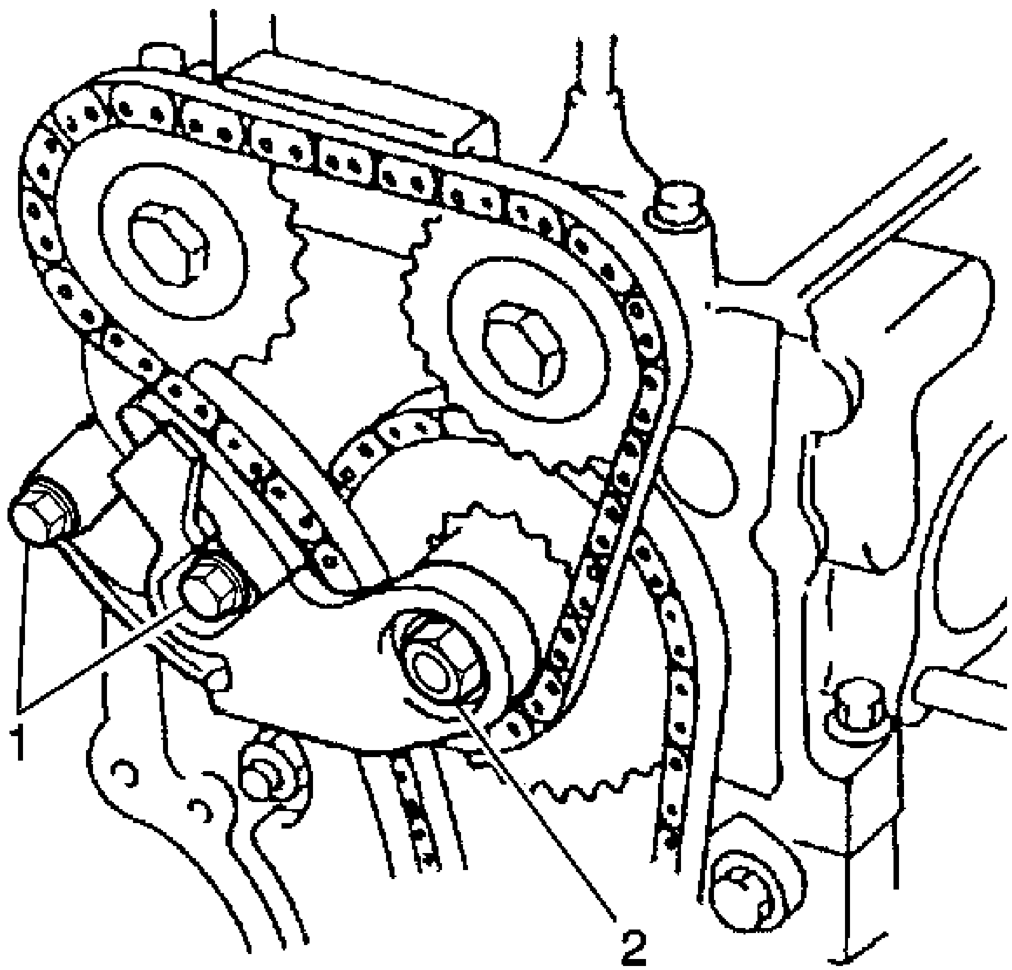


Fig. 49: View Of Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
7. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).

8. Apply engine oil to the following:
    - The timing chains
    - The tensioner
    - The guides
    - The sprockets
9. Install the spark plugs.

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

10. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.
11. Connect the negative battery cable.

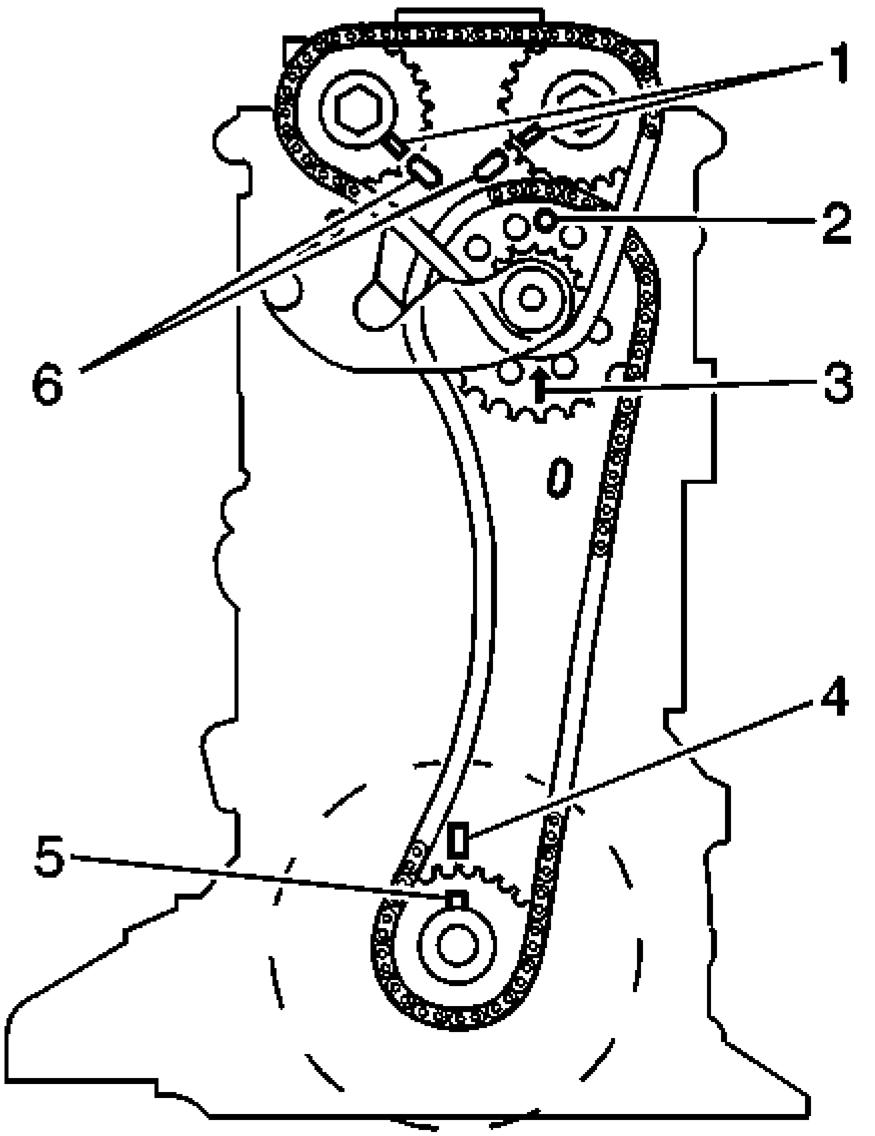


Fig. 50: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Replacement - Crankshaft

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
3. Remove the spark plugs in order to make rotating the crankshaft to line up the timing marks easier.

IMPORTANT: The timing marks must be correctly aligned before disassembly.

4. Rotate the crankshaft so that the following conditions are met:
   - The number 1 (front most) cylinder is at the top dead center (TDC) position on the compression stroke.
   - The keyway on the crankshaft (5) aligns with the mark on the engine block (4).
   - The arrow (3) on the idler sprocket is pointing upward.
   - The guide pins (1) on the camshaft sprockets line up with the notches (6) on the cylinder head.

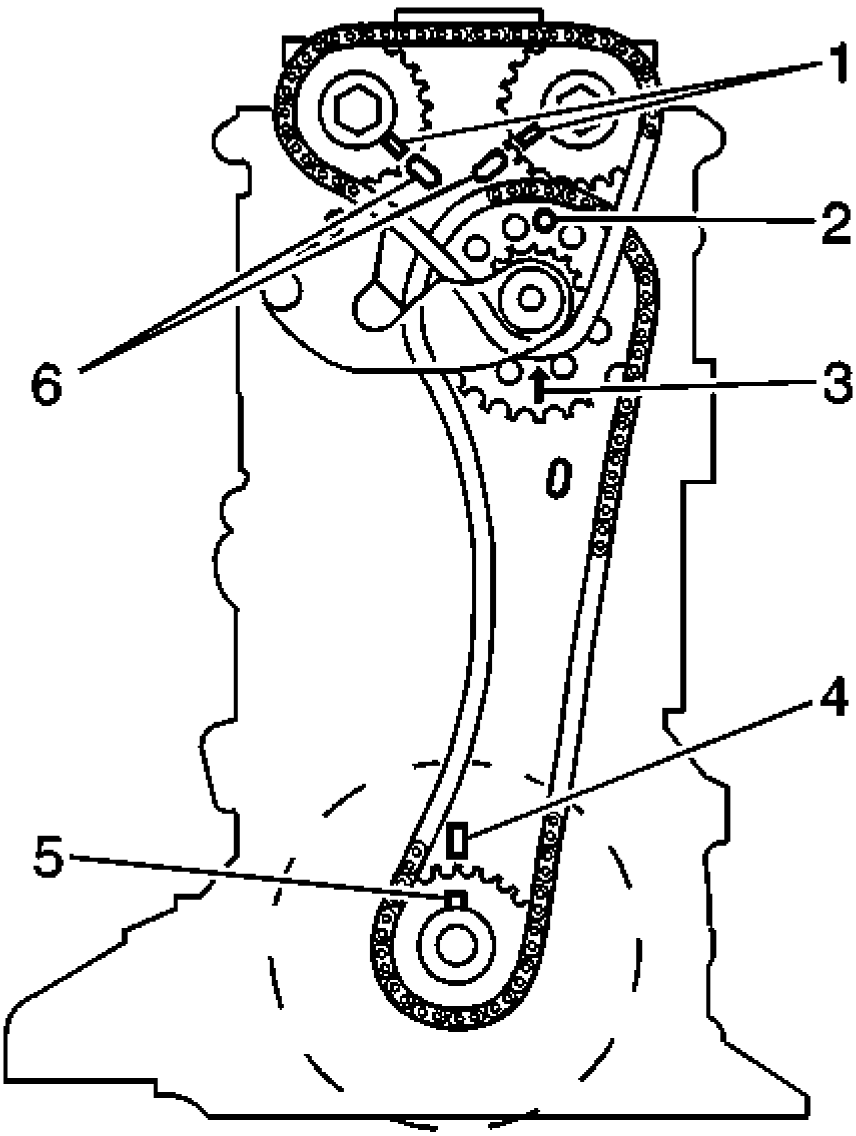


Fig. 51: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not turn the crankshaft or camshaft once the tensioner is removed.

5. Remove the 2 bolts (1) and the crankshaft timing chain tensioner.
6. Inspect that the latch and teeth of the crankshaft timing chain tensioner are undamaged and that the

tensioner functions correctly.

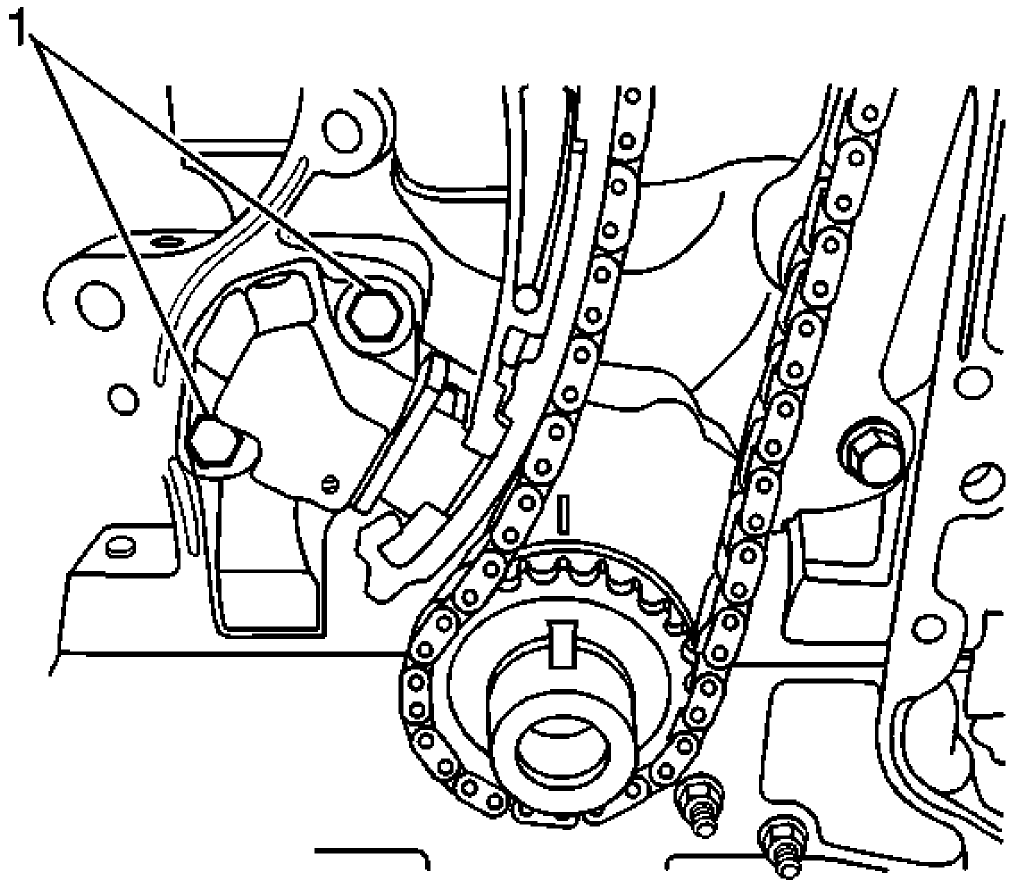


Fig. 52: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Hold back the latch, compress the plunger and install a retainer (a paper clip or similar tool) to hold the plunger in place.

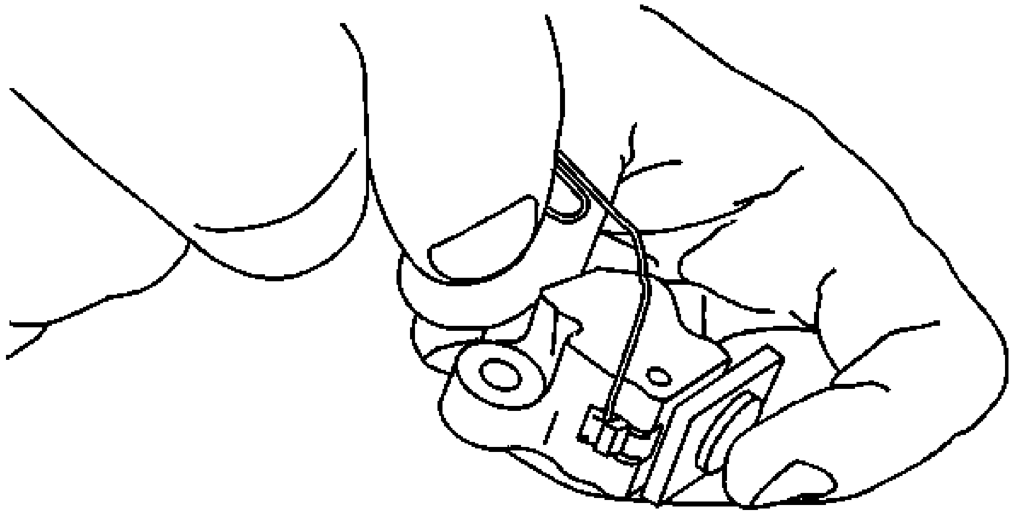


Fig. 53: View Of Plunger & Latch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the timing chain tensioner.

   Tighten: Tighten the 2 bolts (1) to 11 N.m (97 lb in).

3. Remove the retainer.

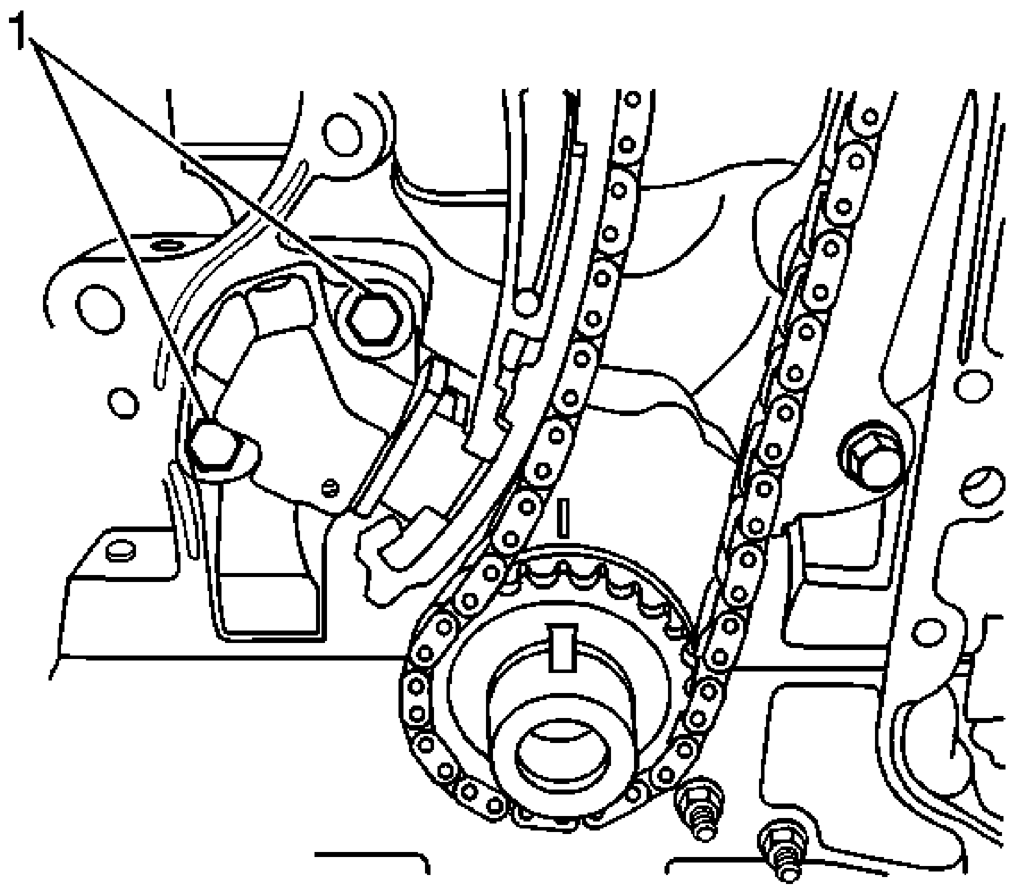


Fig. 54: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

4. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
5. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).
6. Apply engine oil to the following:
   - The timing chains
   - The tensioner
   - The guides
   - The sprockets
7. Install the spark plugs.

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

8. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.
9. Connect the negative battery cable.

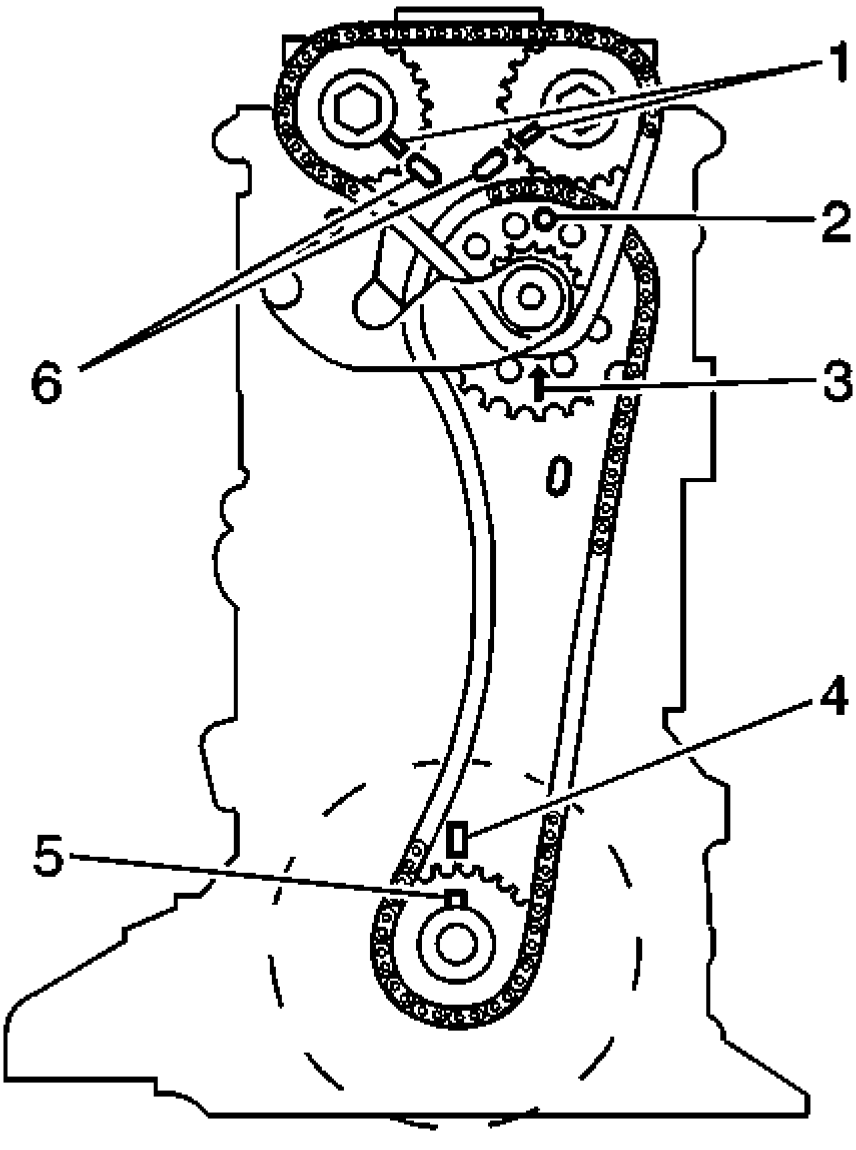


Fig. 55: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Replacement - Camshaft

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
3. Remove the spark plugs in order to make rotating the crankshaft to line up the timing marks easier.

IMPORTANT:

- **The timing marks must be correctly aligned before disassembly in order to correctly install the timing chains.**
- **If necessary, the camshafts (1) may be turned 15 degrees from the notches (6) on the cylinder head in either direction.**
- **If necessary, the crankshaft (5) may be turned 90 degrees from the mark (4) on the engine block in either direction.**

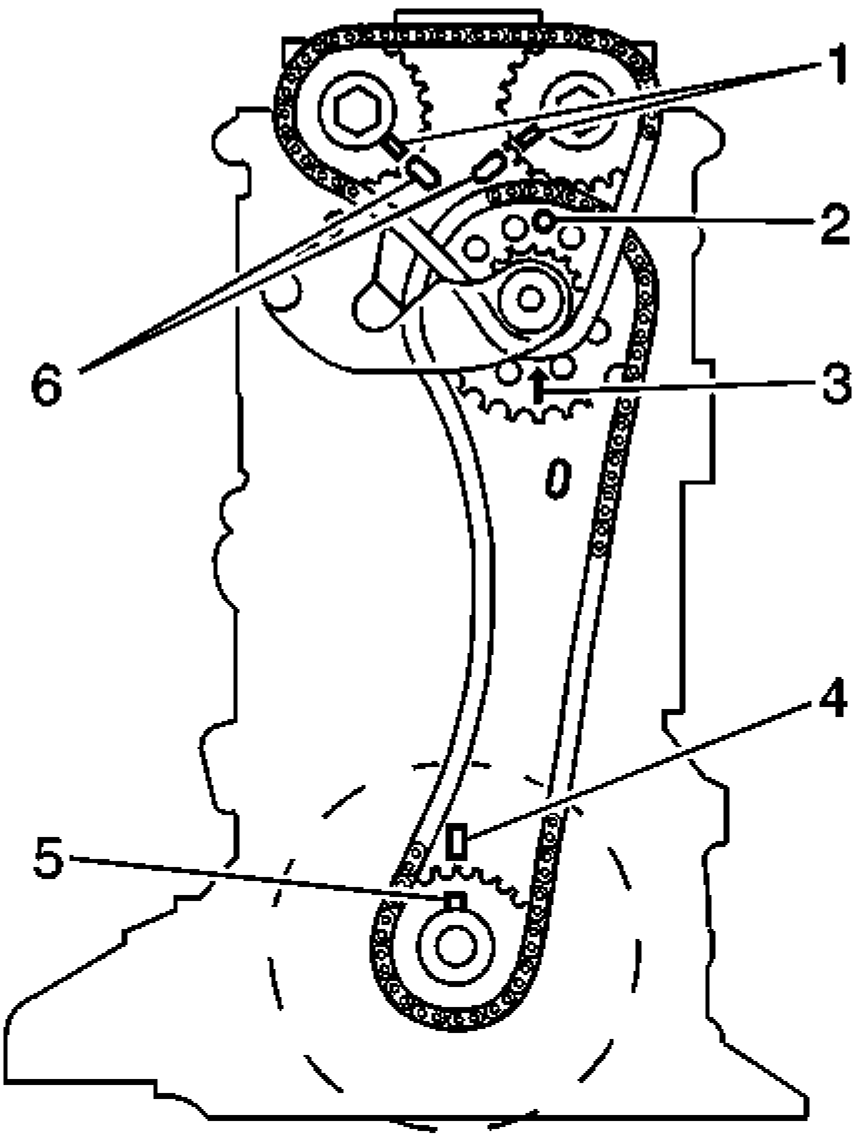


Fig. 56: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

4. Rotate the crankshaft so that the following conditions are met:
   - The number 1 (front most) cylinder is at the top dead center (TDC) position.
   - The keyway on the crankshaft (5) aligns with the mark on the engine block (4).
   - The arrow (3) on the idler sprocket is pointing upward.

- The guide pins (1) on the camshaft sprockets line up with the notches (6) on the cylinder head.

5. Relieve the tension on the camshaft timing chain by turning the intake camshaft slightly counterclockwise.
6. Remove the nut and 2 bolts (1, 2).

IMPORTANT: Do not turn the crankshaft or camshaft once the tensioner is removed.

7. Remove the camshaft timing chain tensioner and the gasket.

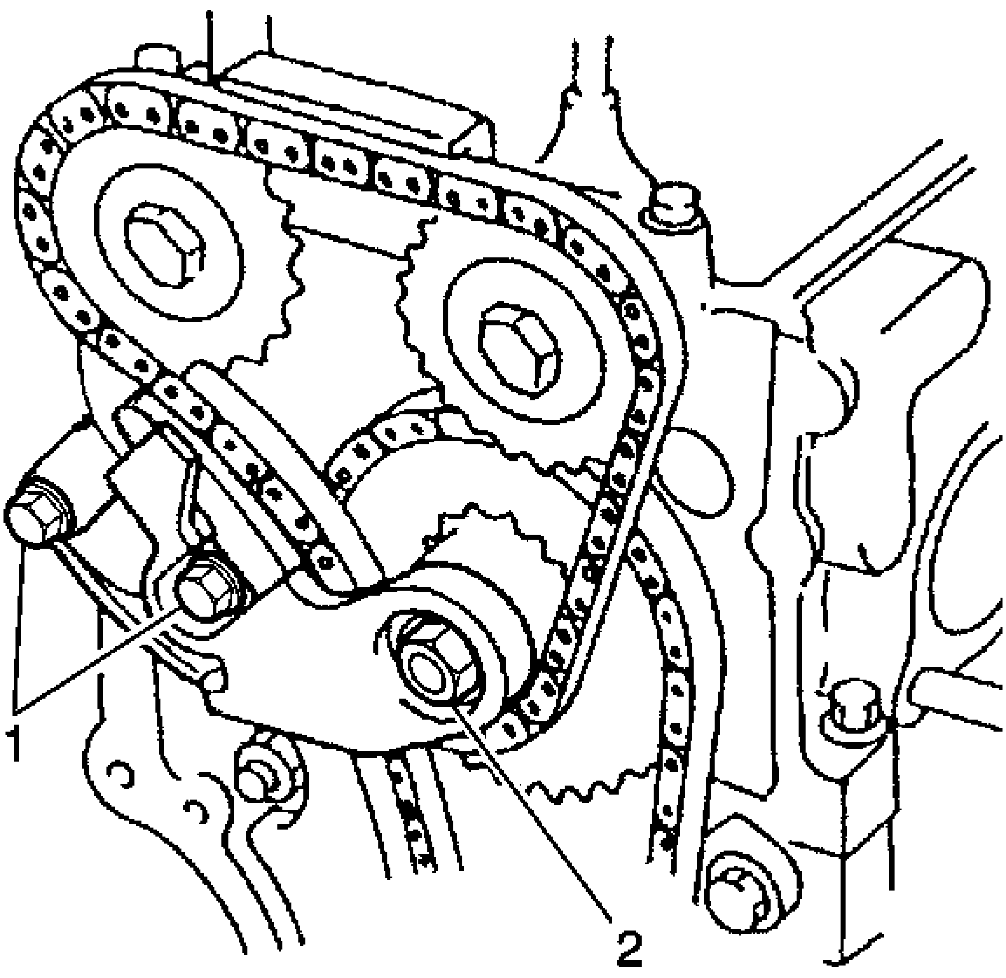


Fig. 57: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Hold the camshaft with a wrench and remove the camshaft sprocket bolts (1).
9. Remove the camshaft sprockets and chain.
10. Inspect the following components for wear and damage:
    - The camshaft timing chain upper guide
    - The camshaft timing chain tensioner
    - The camshaft timing chain tensioner gasket
    - The camshaft timing chain sprockets
    - The camshaft timing chain
11. Replace worn or damaged components as necessary.

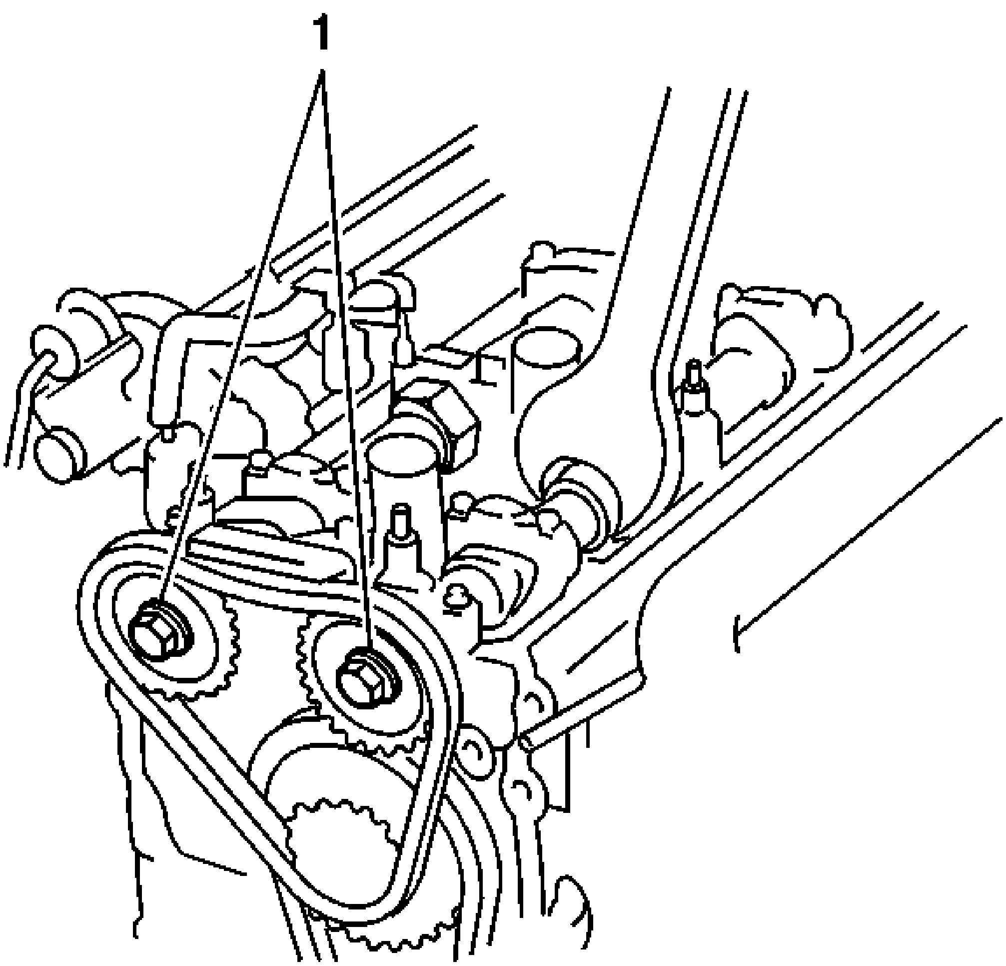


Fig. 58: View Of Camshaft Sprocket Bolts

Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Ensure that the crankshaft keyway is aligned with the mark on the engine block (3).

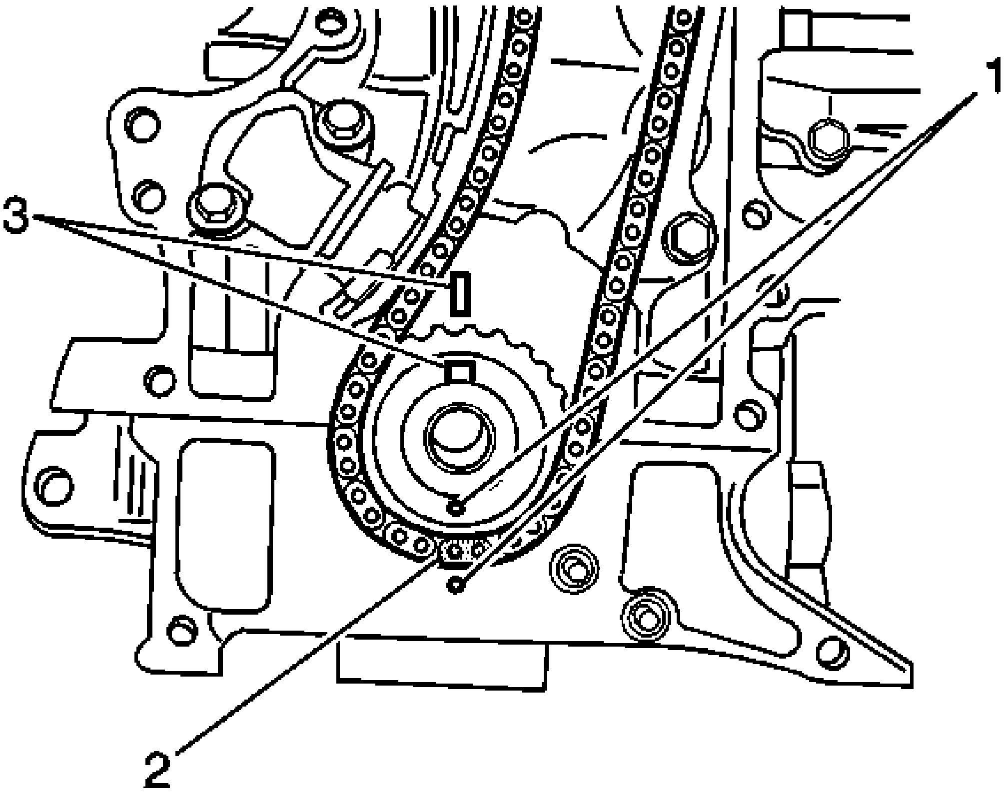


Fig. 59: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

2. Ensure that the idler sprocket arrow (2) is pointing upward.
3. Ensure that the camshaft guide pins (1) are aligned with the notches (3) on the cylinder head.

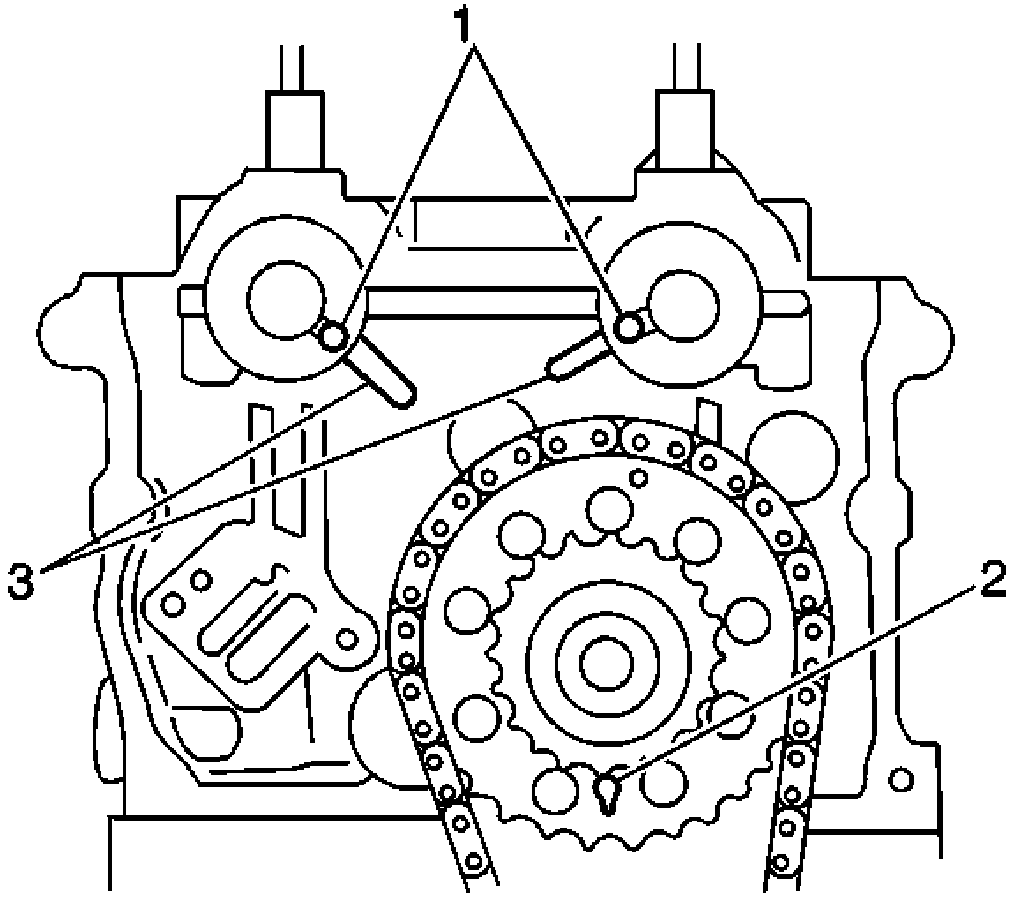


Fig. 60: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

4. Align the yellow link (1) of the camshaft timing chain with the arrow (2) on the idler sprocket.

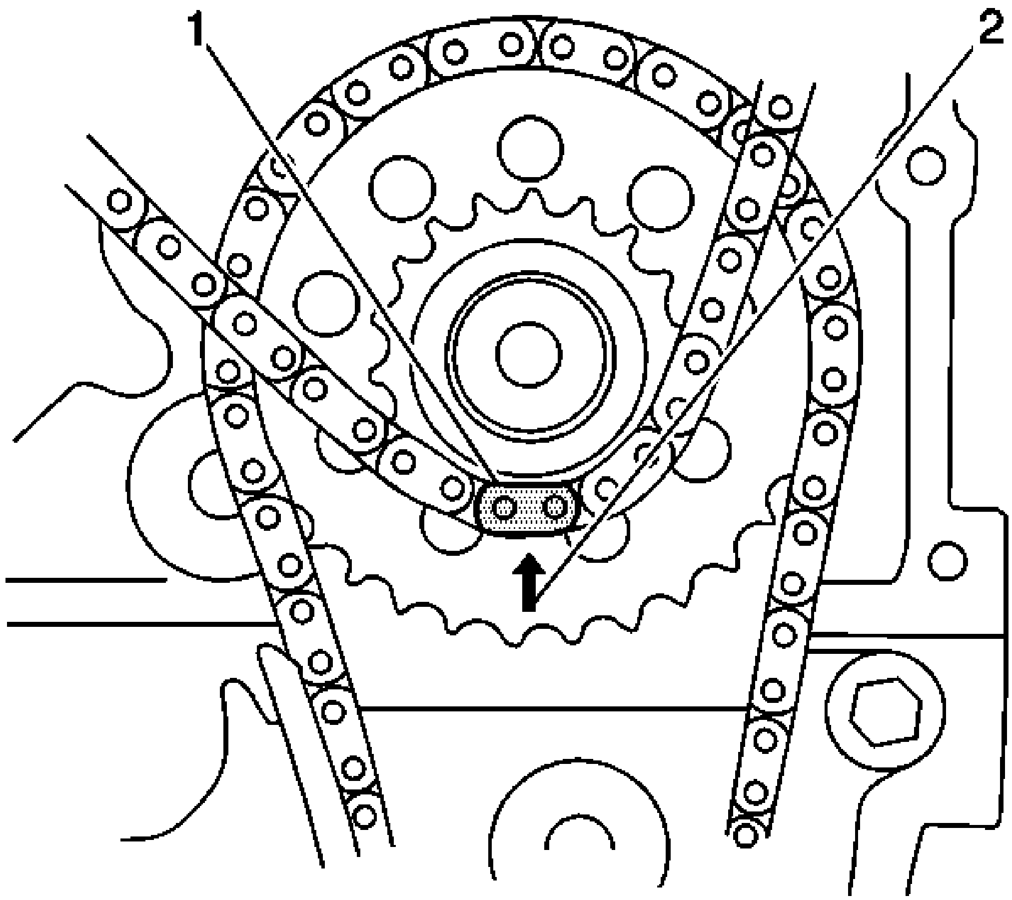


Fig. 61: View Of Yellow Link & Arrow On Idler Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Align the dark blue link (1) of the camshaft timing chain with the arrows (2, 3) on the camshaft sprockets.
6. Align the camshaft sprockets with the guide pins and install the camshaft timing sprockets and chain.

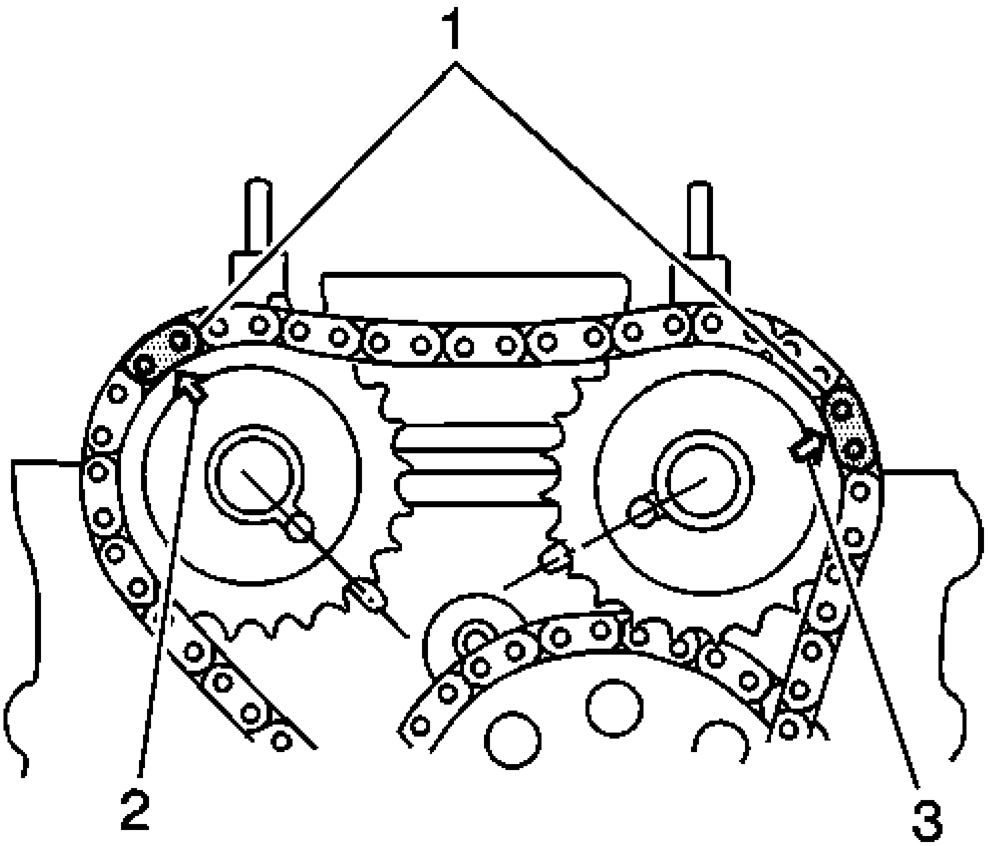


Fig. 62: View Of Dark Blue Link & Arrows
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the camshaft sprocket bolts (1).

   Tighten: Tighten the bolts to 80 N.m (58 lb ft).

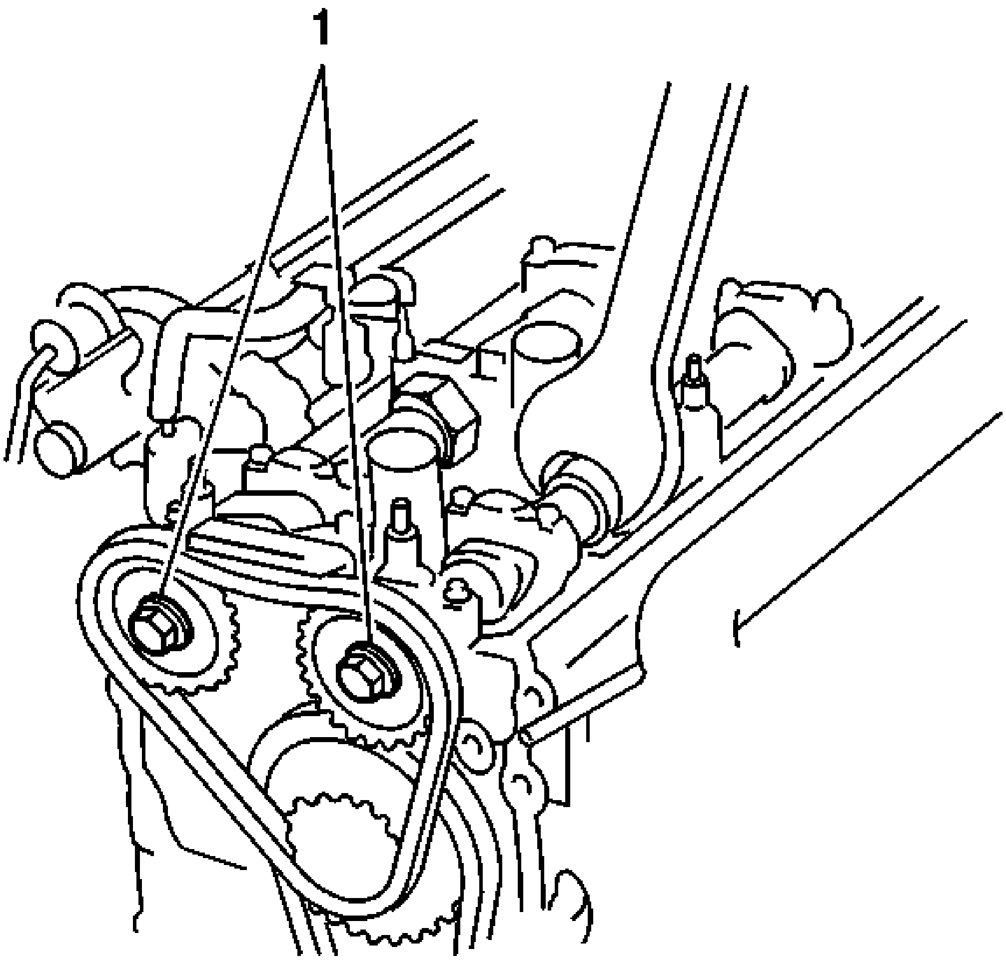


Fig. 63: View Of Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

8. Compress the camshaft tensioner plunger into the body. Insert a retainer (a paper clip or similar tool) through the hole in the body in order to hold the plunger in place.

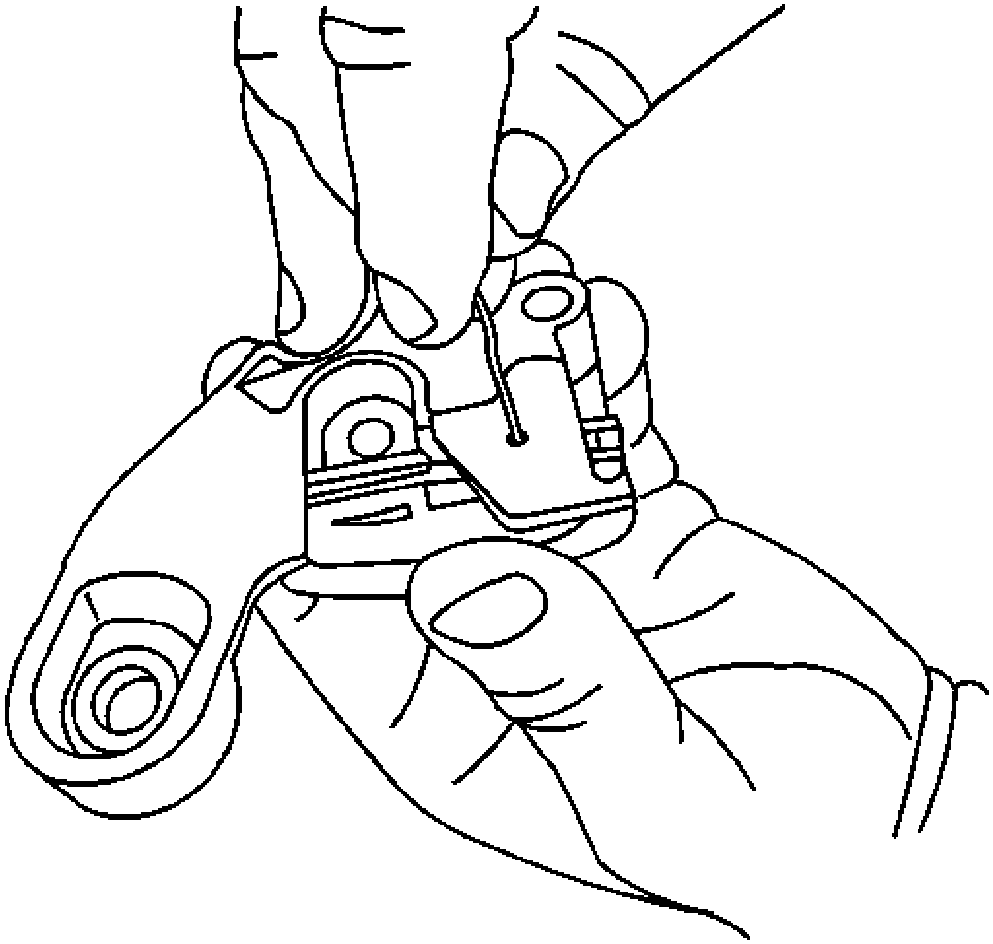


Fig. 64: Installing Camshaft Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

9. Install the gasket and the camshaft timing chain tensioner.

   Tighten:
   - Tighten the bolts (1) to 11 N.m (97 lb in).
   - Tighten the nut (2) to 45 N.m (33 lb ft).

10. Remove the retainer from the tensioner.

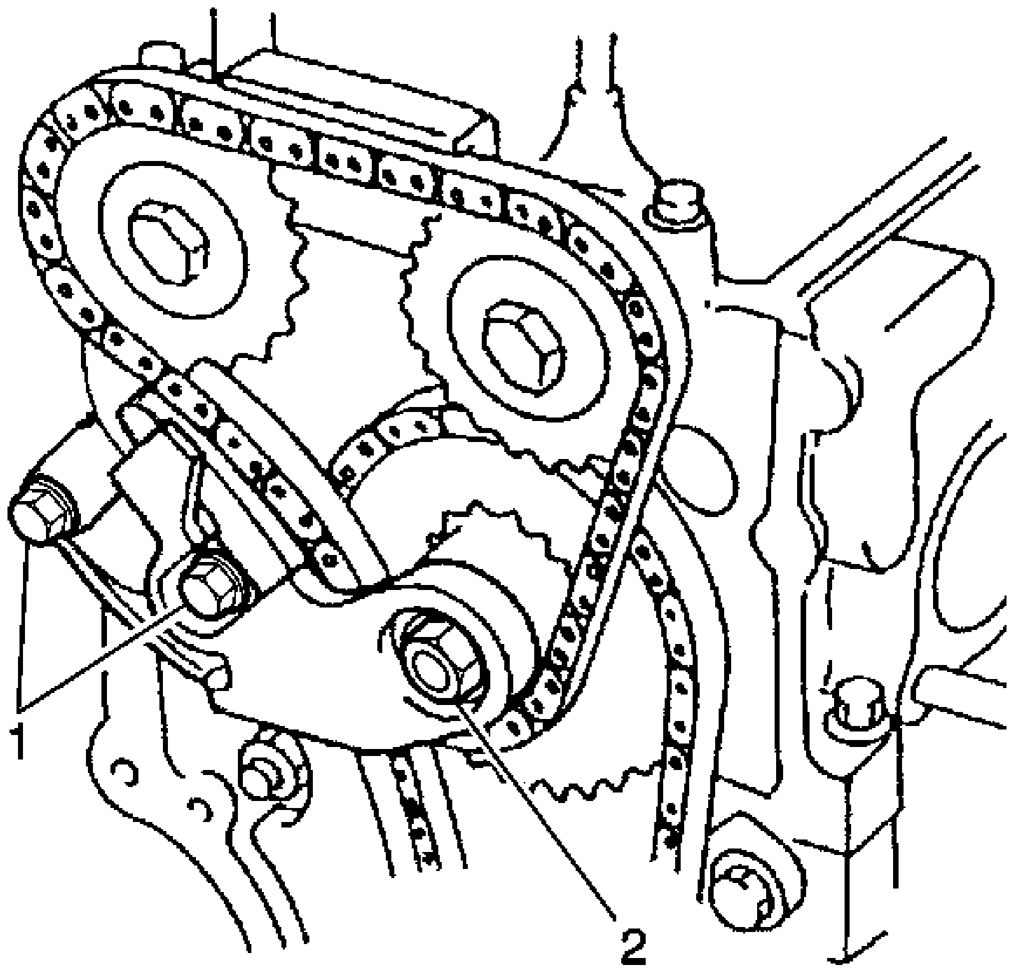


Fig. 65: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

11. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
12. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).
13. Apply engine oil to the following:
    - The timing chains
    - The tensioner
    - The guides
    - The sprockets
14. Install the spark plugs.

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

15. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.
16. Connect the negative battery cable.

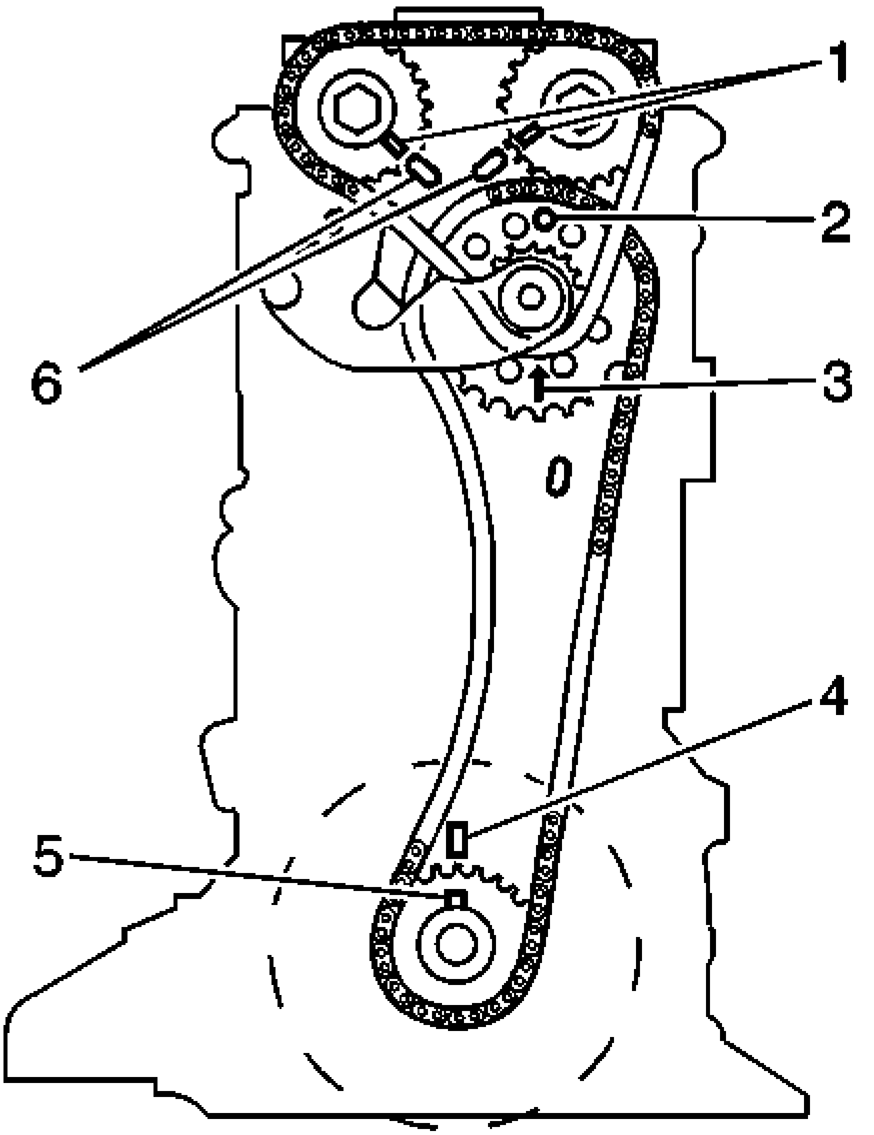


Fig. 66: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Replacement - Crankshaft

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the spark plugs in order to make rotating the crankshaft to line up the timing marks easier.
3. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.

IMPORTANT:

- **The timing marks must be correctly aligned before disassembly in order to correctly install the timing chains.**
- **If necessary, the camshafts (1) may be turned 15 degrees from the notches (6) on the cylinder head in either direction.**
- **If necessary, the crankshaft (5) may be turned 90 degrees from the mark (4) on the engine block in either direction.**

4. Rotate the crankshaft so that the following conditions are met:
   - The number 1 (front most) cylinder is at the top dead center (TDC) position.
   - The keyway on the crankshaft (5) aligns with the mark on the engine block (4).
   - The arrow (3) on the idler sprocket is pointing upward.
   - The guide pins (1) on the camshaft sprockets line up with the notches (6) on the cylinder head.

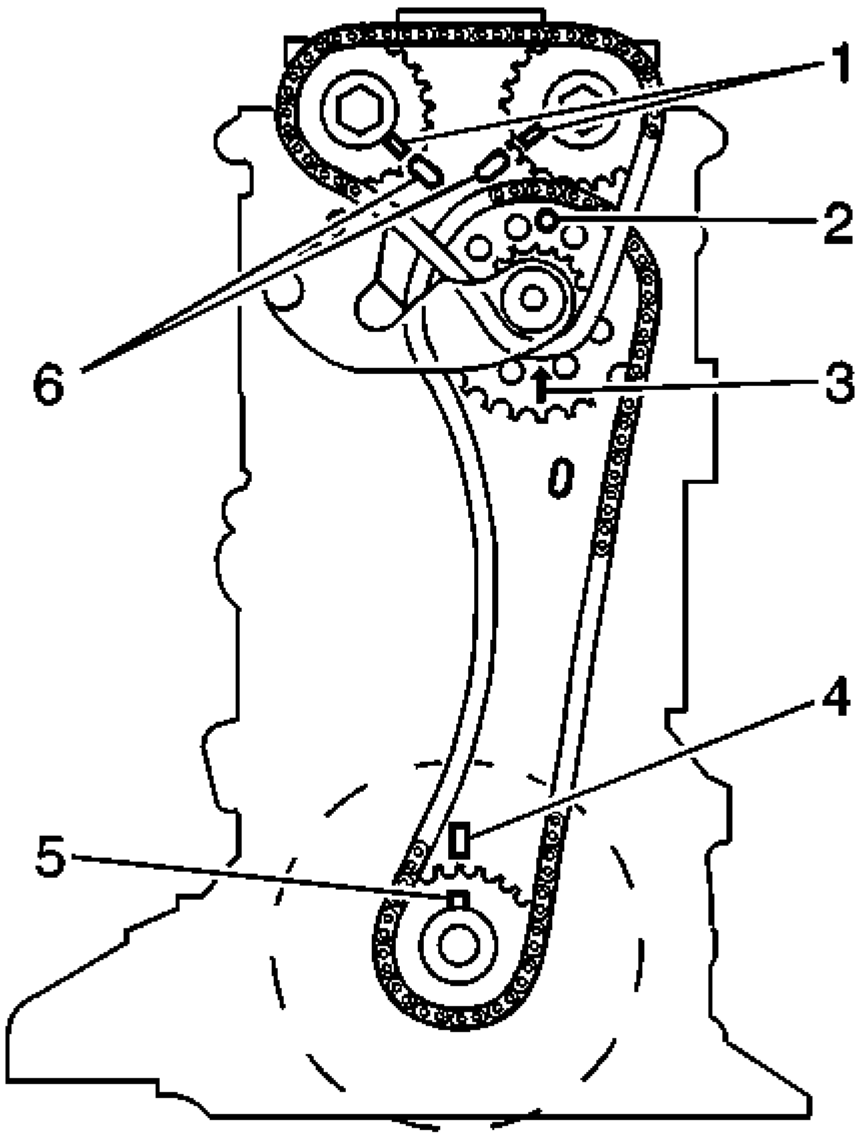


Fig. 67: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

5. Relieve the tension on the camshaft timing chain by turning the intake camshaft slightly counterclockwise.
6. Remove the nut and 2 bolts (1, 2).

IMPORTANT: Do not turn the crankshaft or camshaft once the tensioner is removed.

7. Remove the camshaft timing chain tensioner and the gasket.

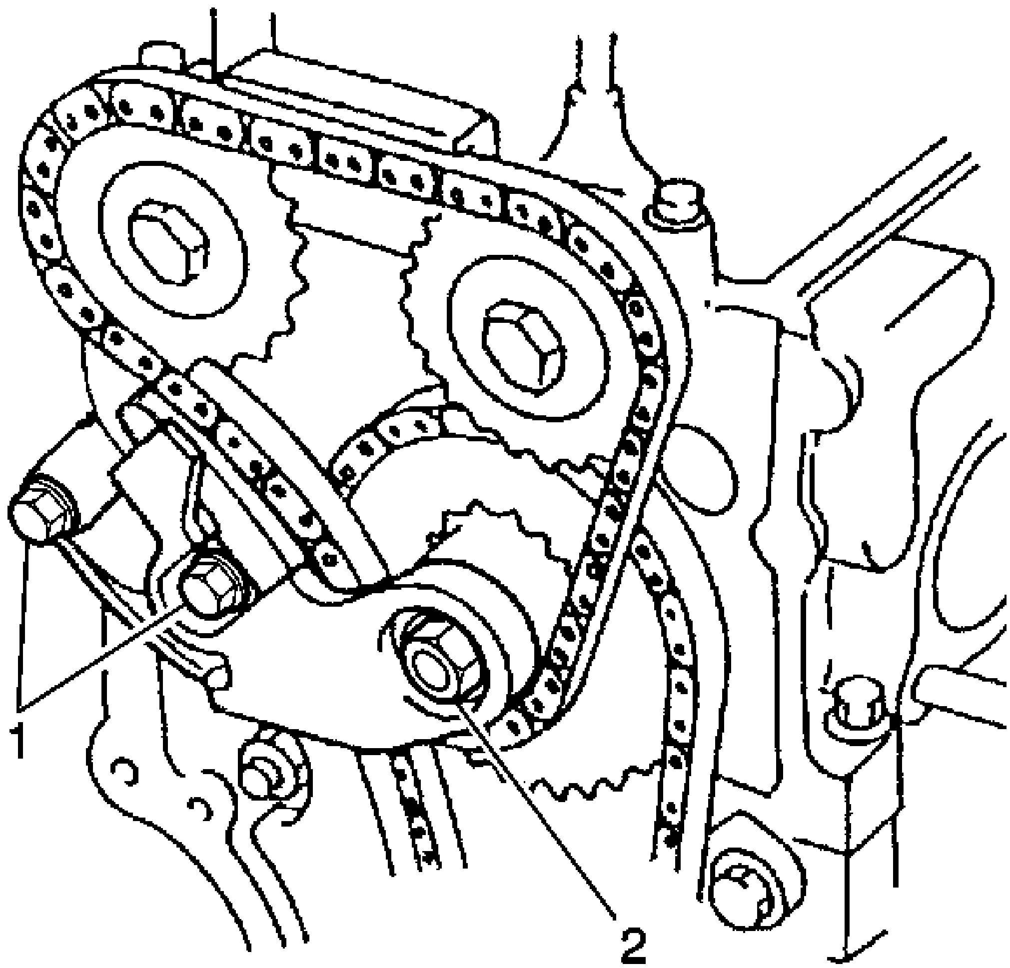


Fig. 68: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Hold the camshaft with a wrench and remove the camshaft sprocket bolts (1).
9. Remove the camshaft sprockets and chain.
10. Inspect the following components for wear and damage:
    - The camshaft timing chain upper guide
    - The camshaft timing chain tensioner

- The camshaft timing chain tensioner gasket
- The camshaft timing chain sprockets
- The camshaft timing chain

11. Replace any worn or damaged component.

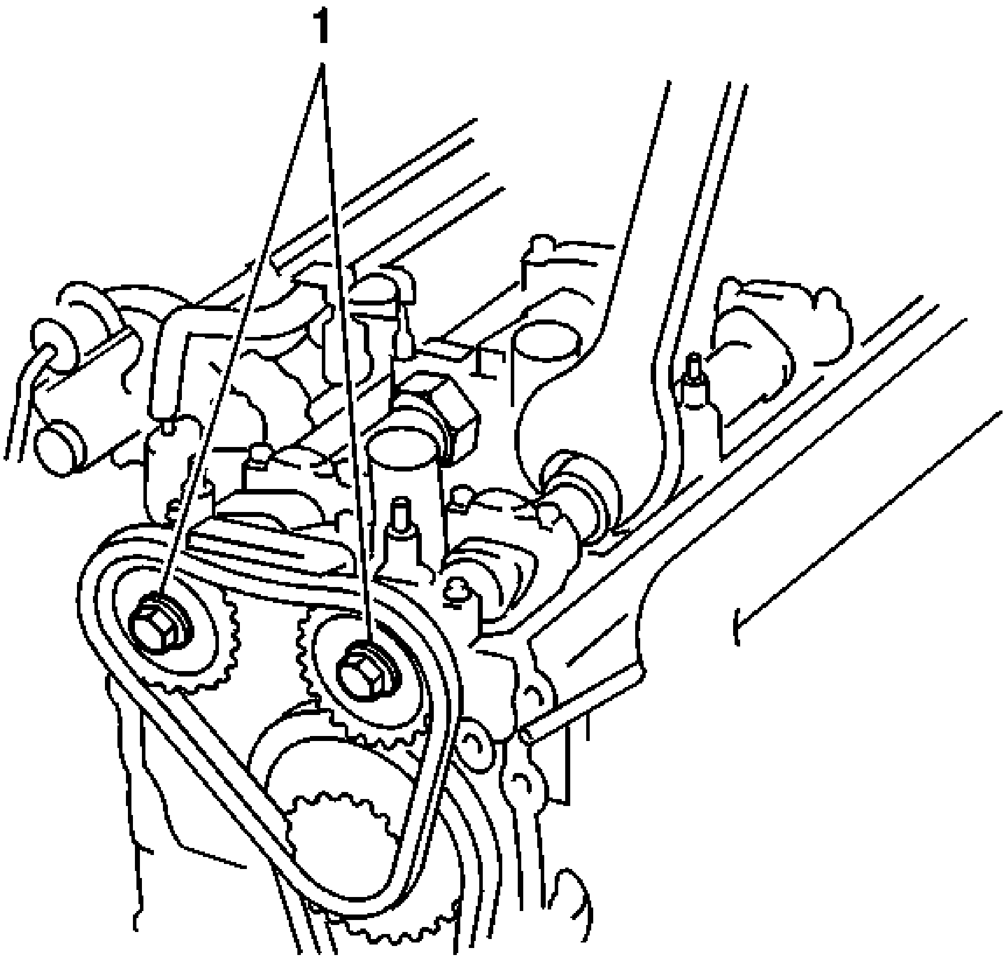


Fig. 69: View Of Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the 2 bolts and the crankshaft timing chain tensioner (3).
13. Remove the bolt and the crankshaft timing chain adjustable guide (1).
14. Remove the 2 bolts and the crankshaft timing chain fixed guide (2).
15. Remove the idler sprocket and the crankshaft timing chain.

16. Remove the crankshaft timing sprocket.
17. Inspect the following components for wear and damage:
    - The timing chain guides
    - The idler sprocket
    - The crankshaft timing sprocket
    - The crankshaft timing chain
18. Inspect that the latch and teeth of the crankshaft timing chain tensioner are undamaged and that the tensioner functions correctly.
19. Replace any worn or damaged component.

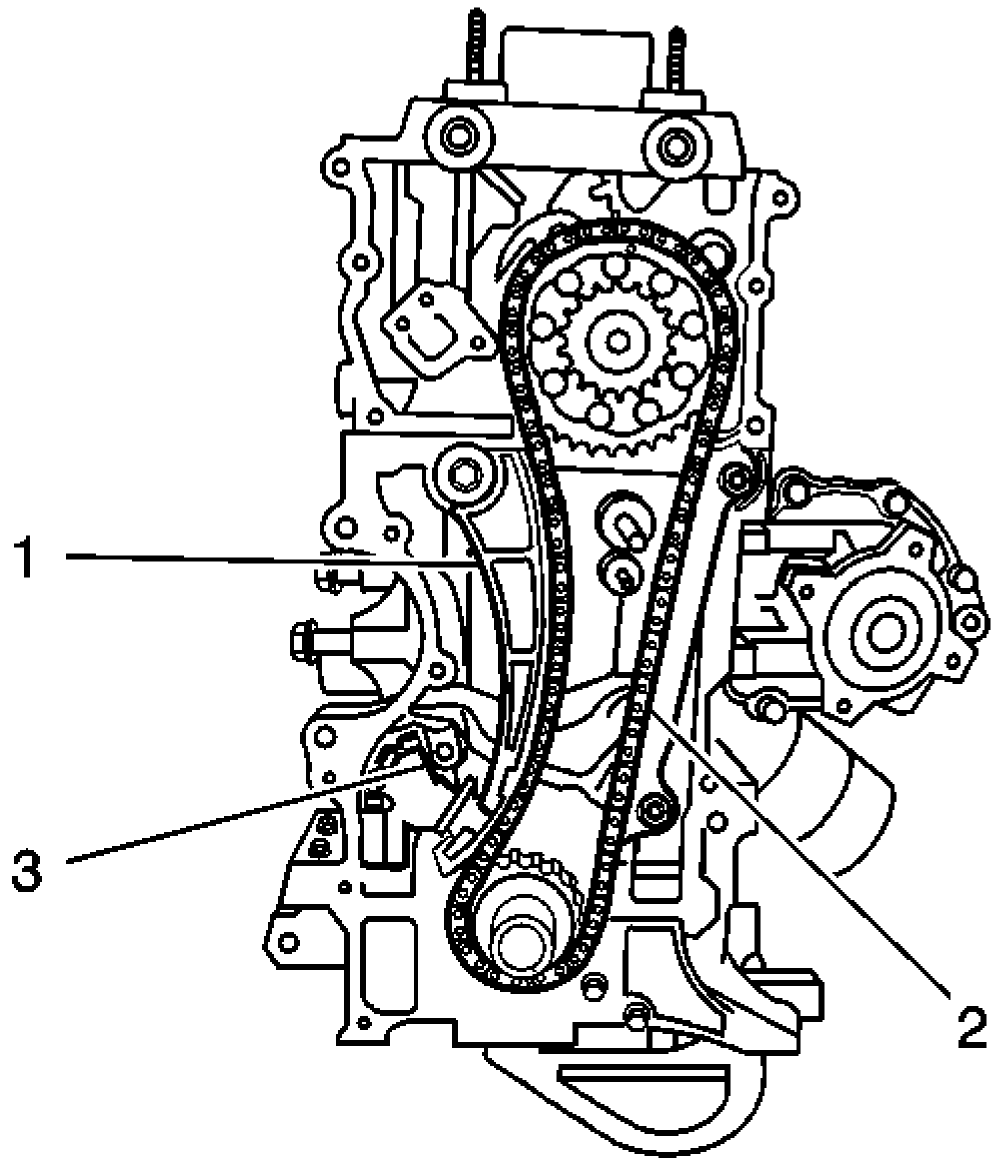


Fig. 70: View Timing Chain Tensioner, Adjustable Guide & Fixed Guide
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Inspect that the timing mark on the engine block (1) is aligned with the crankshaft keyway.
2. Install the crankshaft sprocket (2).

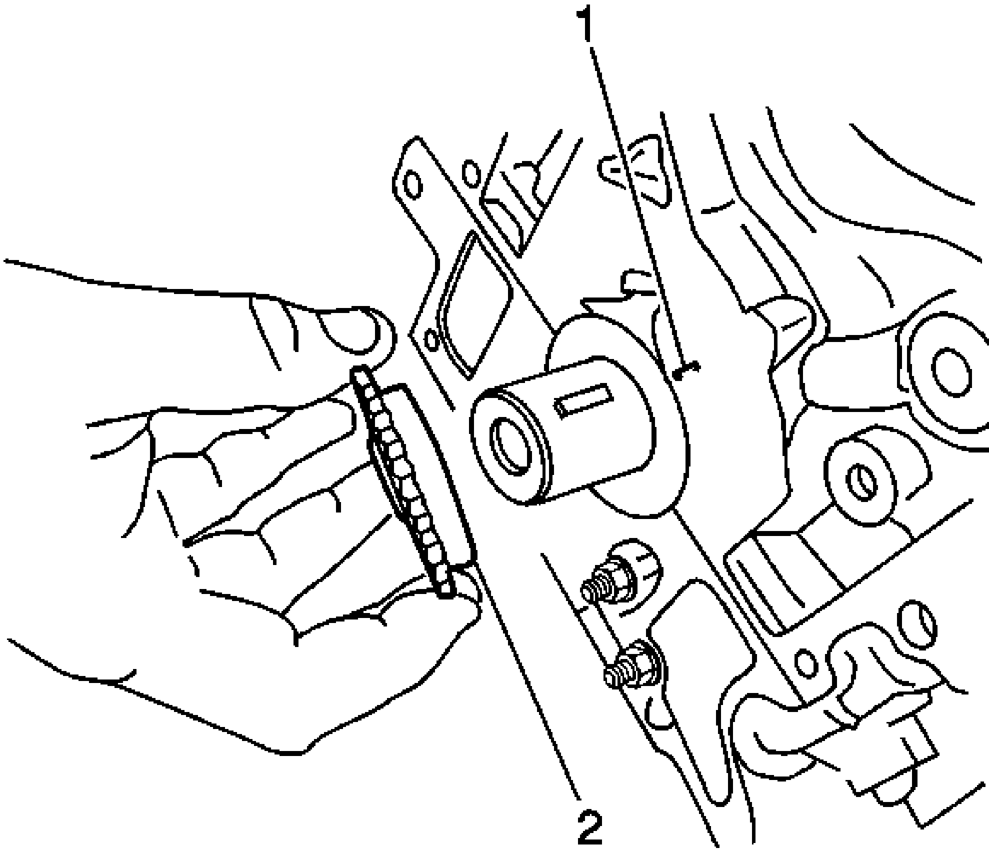


Fig. 71: View Of Engine Block Timing Mark & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Apply engine oil to the idler sprocket bushing.
4. Install the timing chain to the idler sprocket by aligning the dark blue link (1) of the timing chain with the mark on the sprocket (2).

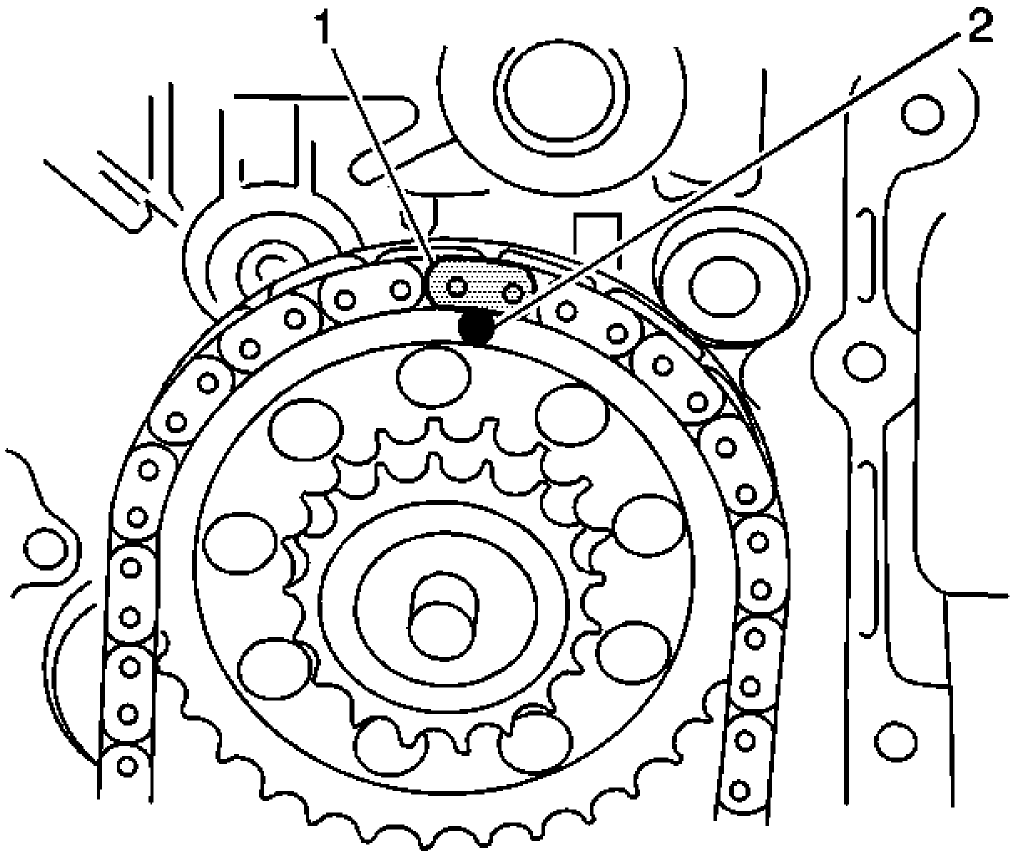


Fig. 72: Aligning Dark Blue Link With Sprocket Mark
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain to the crankshaft sprocket by aligning the yellow link (4) of the chain with the mark on the crankshaft sprocket (3).
6. Install the idler sprocket.

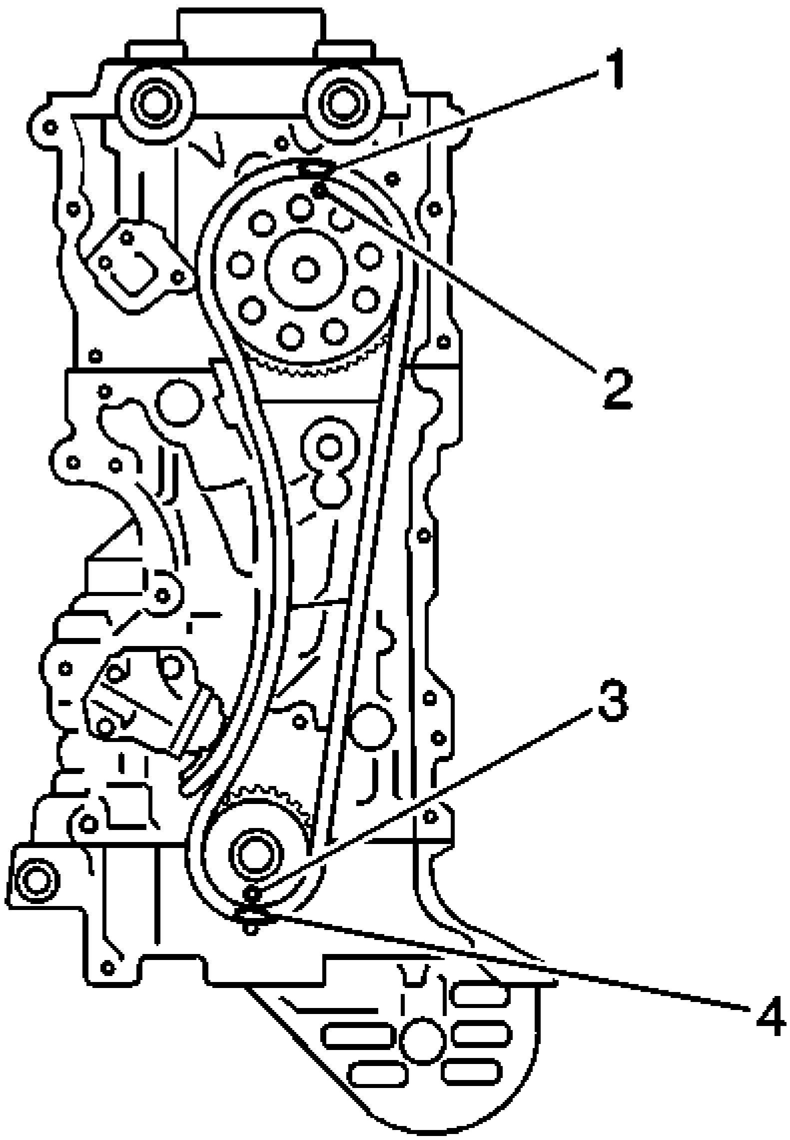


Fig. 73: Aligning Yellow Link With Crankshaft Sprocket Mark
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the timing chain fixed guide (2).

Tighten: Tighten the 2 bolts to 9 N.m (62 lb in).

8. Install the timing chain adjustable guide (1).

   Tighten: Tighten the bolt to 25 N.m (19 lb ft).

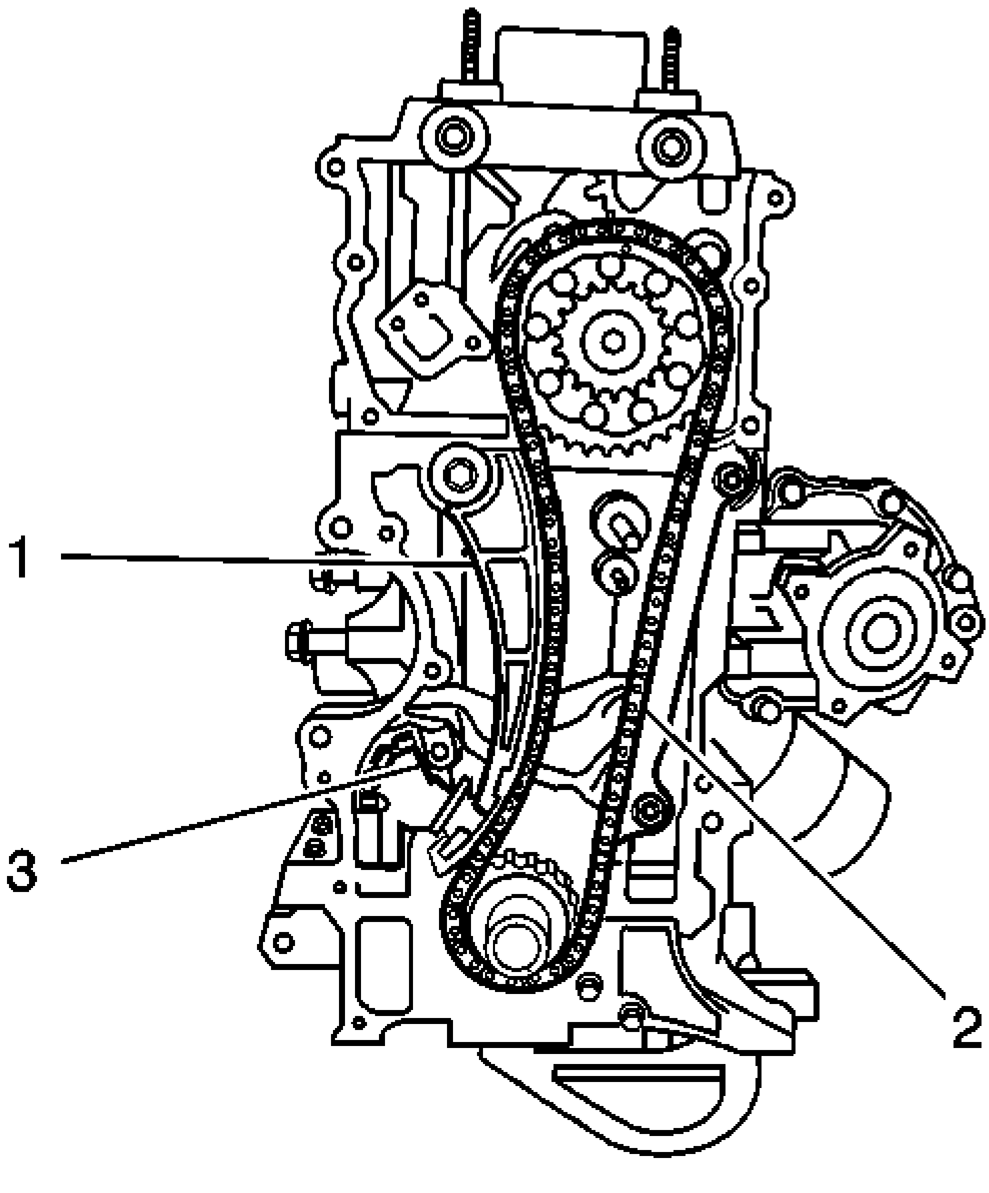


Fig. 74: View Timing Chain Tensioner, Adjustable Guide & Fixed Guide

Courtesy of GENERAL MOTORS CORP.

9. Hold back the latch, compress the plunger and install a retainer (paper clip or similar tool) to hold the plunger in place.

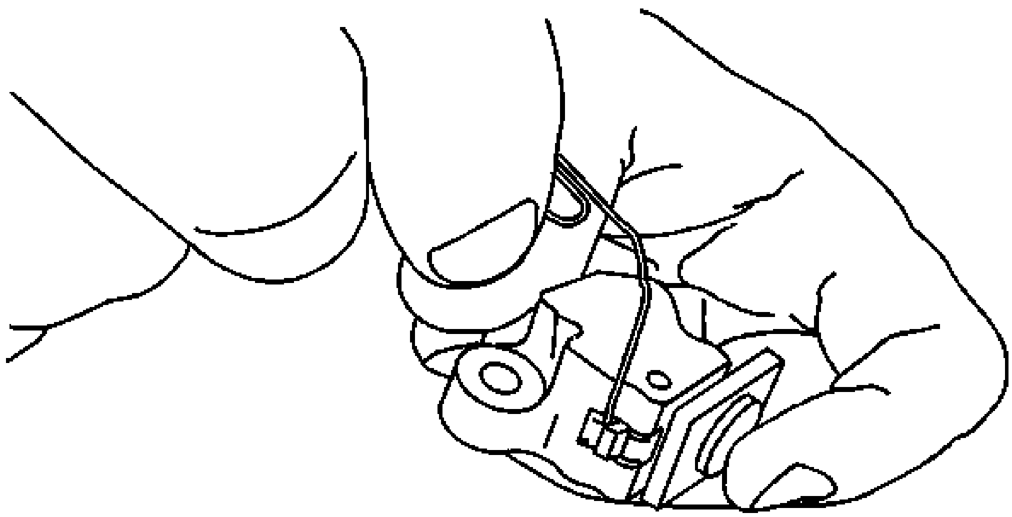


Fig. 75: View Of Plunger & Latch
Courtesy of GENERAL MOTORS CORP.

10. Install the timing chain tensioner.

    Tighten: Tighten the 2 bolts (1) to 11 N.m (97 lb in).

11. Remove the retainer from the tensioner.

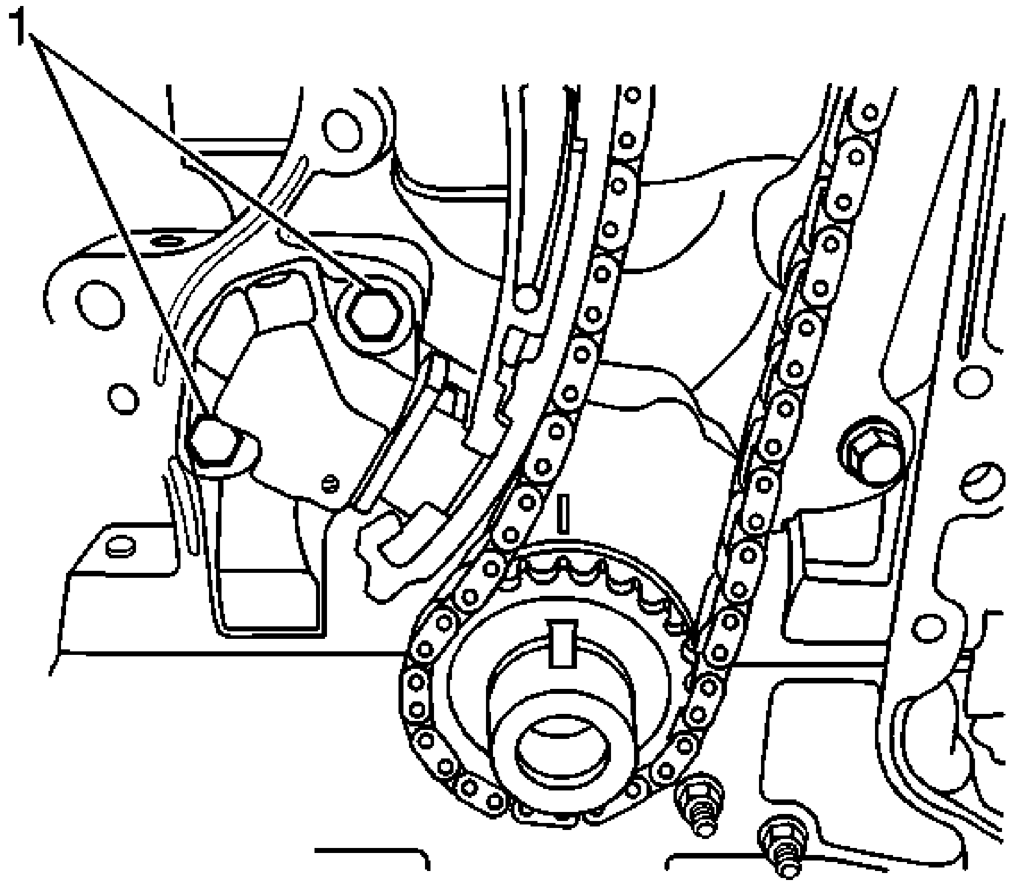


Fig. 76: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

12. Ensure that the following conditions exist:
    - The crankshaft keyway (3) is aligned with the mark on the engine block (3).
    - The yellow link of the crankshaft timing chain (2) is aligned with the crankshaft timing mark (1).
    - The dark blue link of the timing chain is aligned with the mark on the idler sprocket.

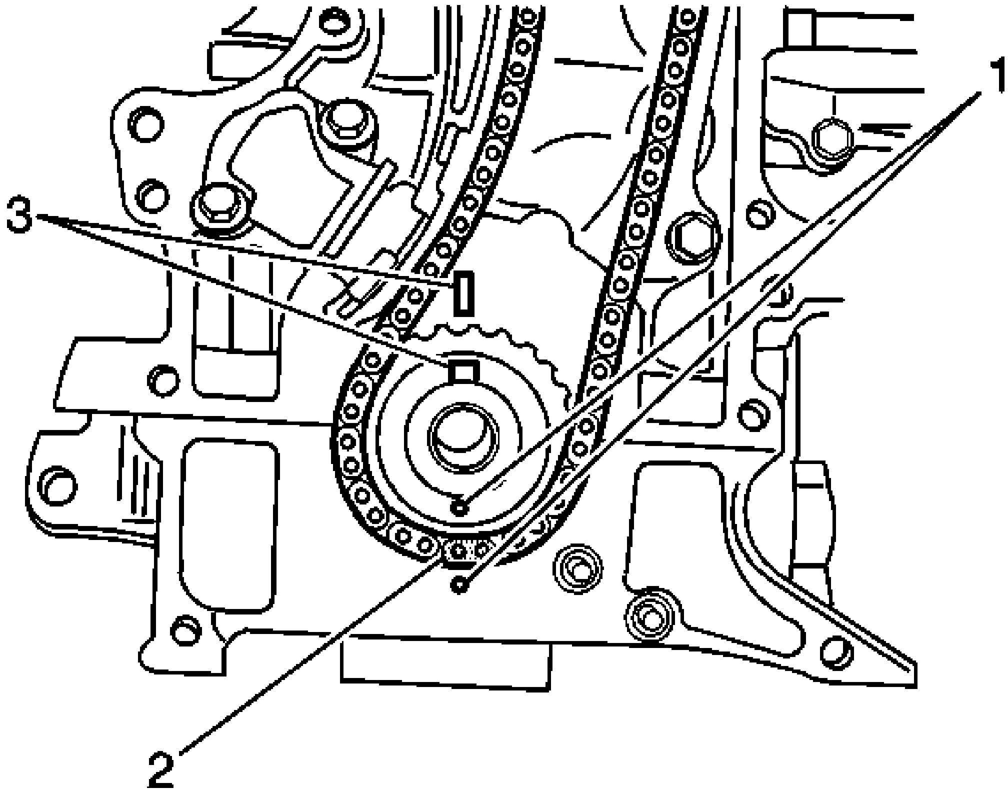


Fig. 77: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

13. Ensure that the guide pins (1) of the camshafts are aligned with the notches (3) on the cylinder head.
14. Ensure that the idler sprocket arrow (2) is pointing upward.

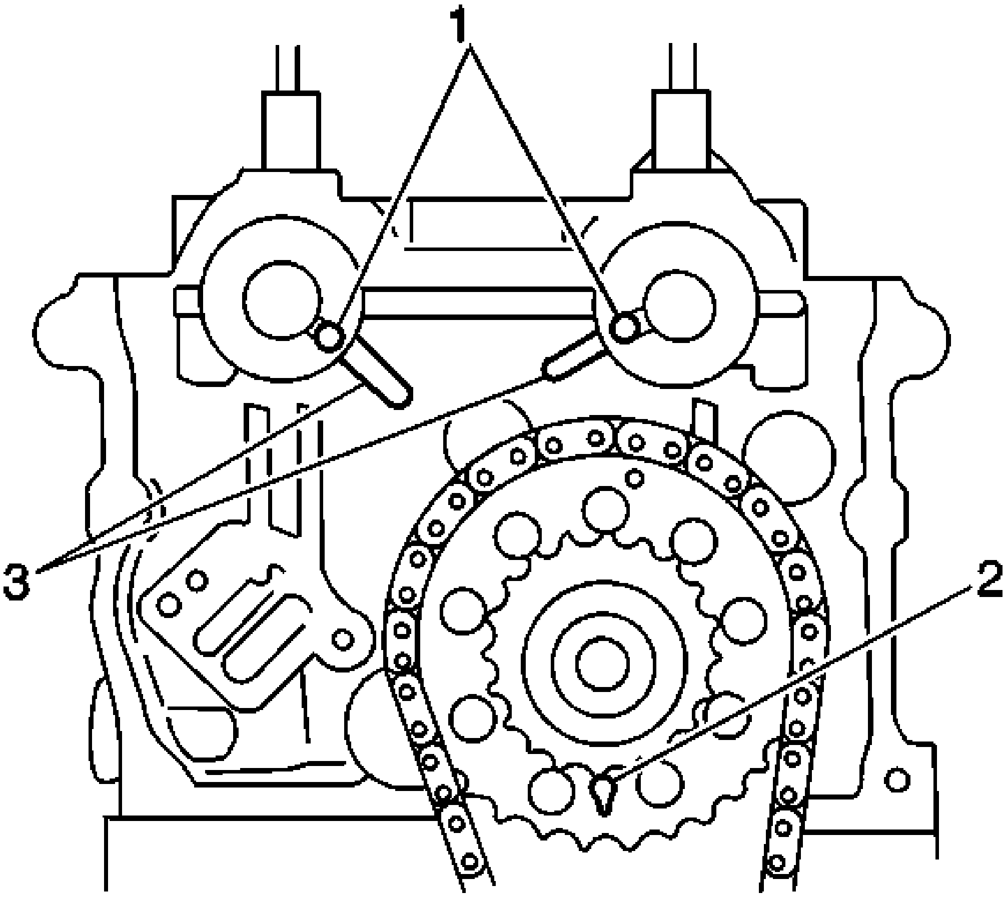


Fig. 78: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

15. Align the yellow link (1) of the camshaft timing chain with the arrow (2) on the idler sprocket.

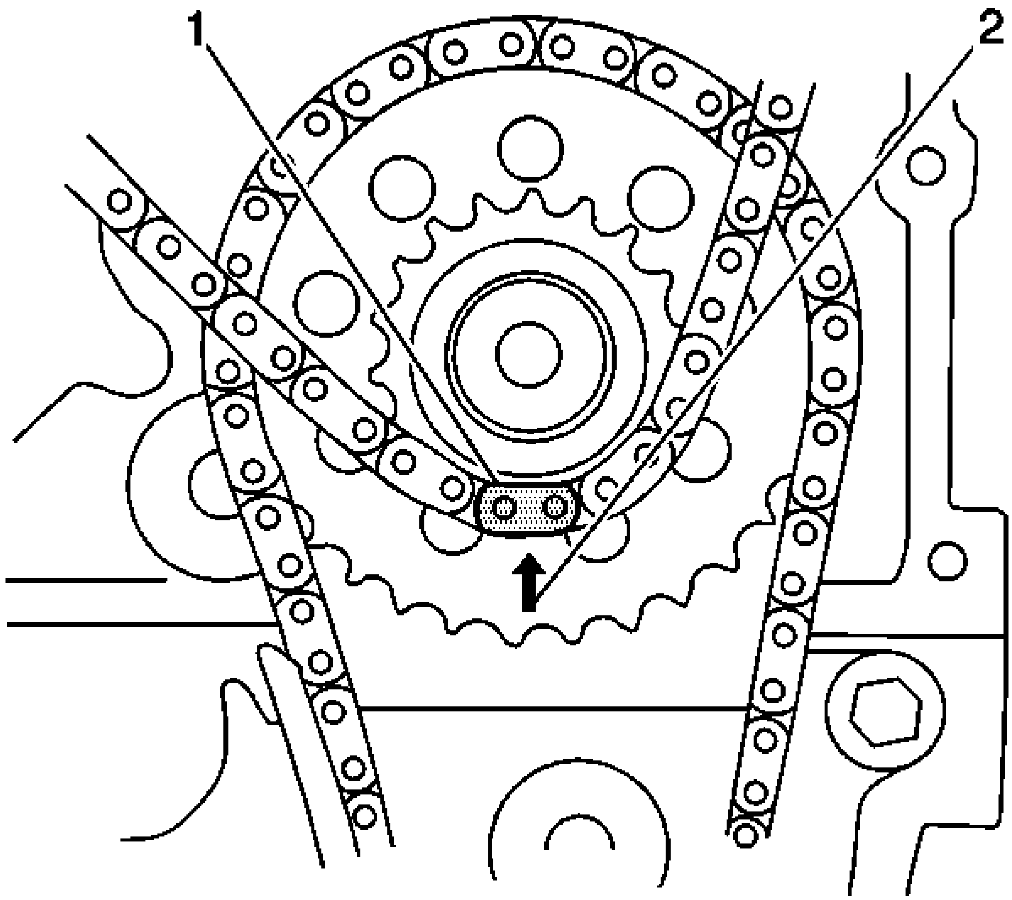


Fig. 79: View Of Yellow Link & Arrow On Idler Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Align the dark blue link (1) of the camshaft timing chain with the arrow (2, 3) on the camshaft sprockets.
17. Align the camshaft sprockets with the guide pins and install the camshaft timing sprockets and chain.

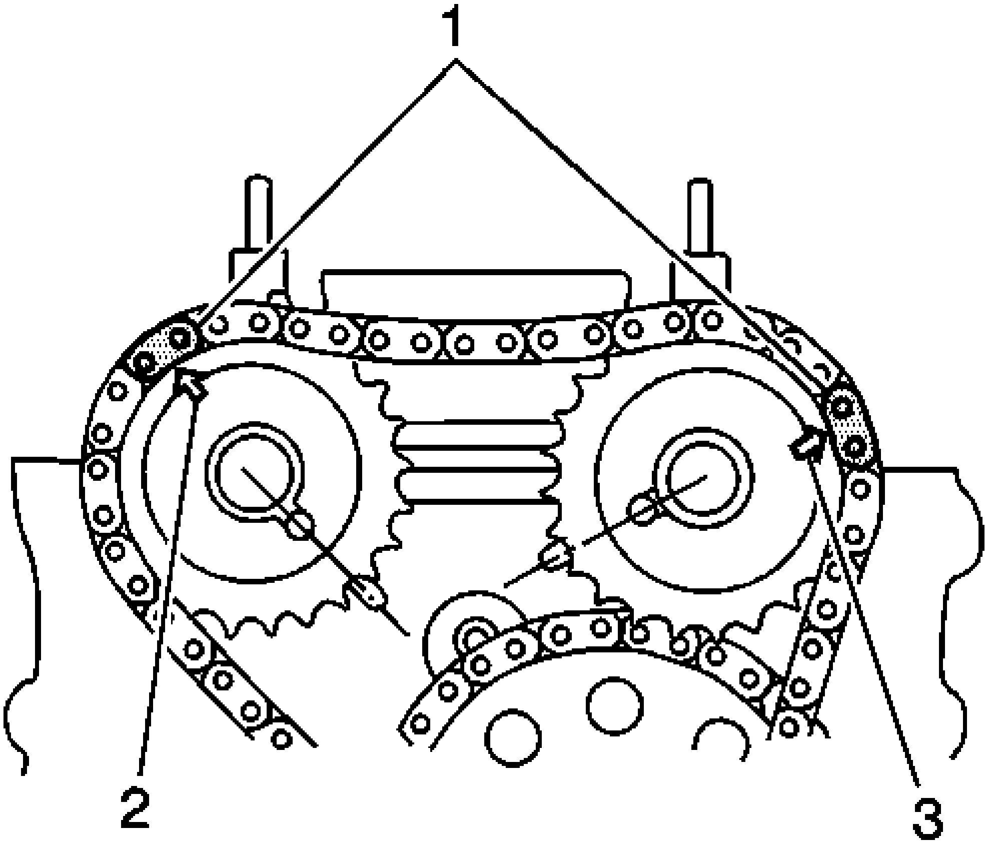


Fig. 80: View Of Dark Blue Link & Arrows
Courtesy of GENERAL MOTORS CORP.

18. Install the camshaft sprocket bolts (1).

    Tighten: Tighten the bolts to 80 N.m (58 lb ft).

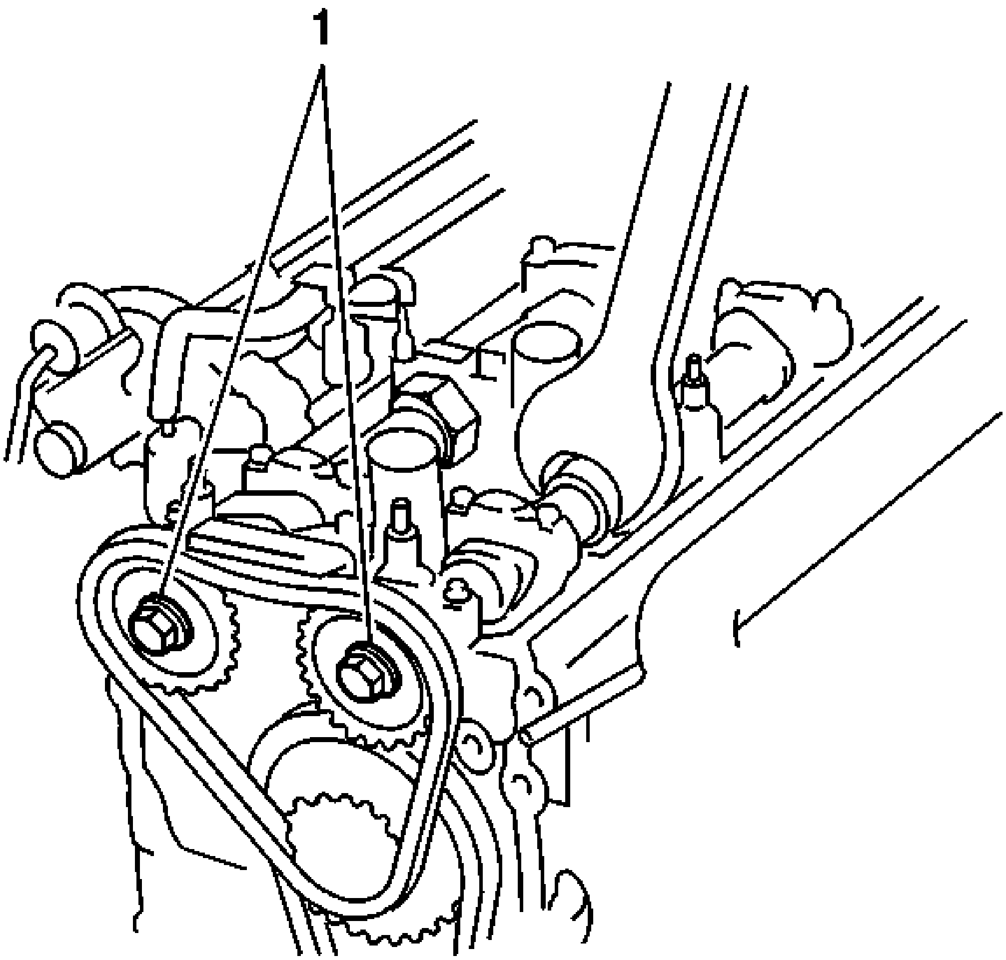


Fig. 81: View Of Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

19. Compress the camshaft tensioner plunger into the body. Insert a retainer (paper clip or similar tool) through the hole in the body in order to hold the plunger in place.

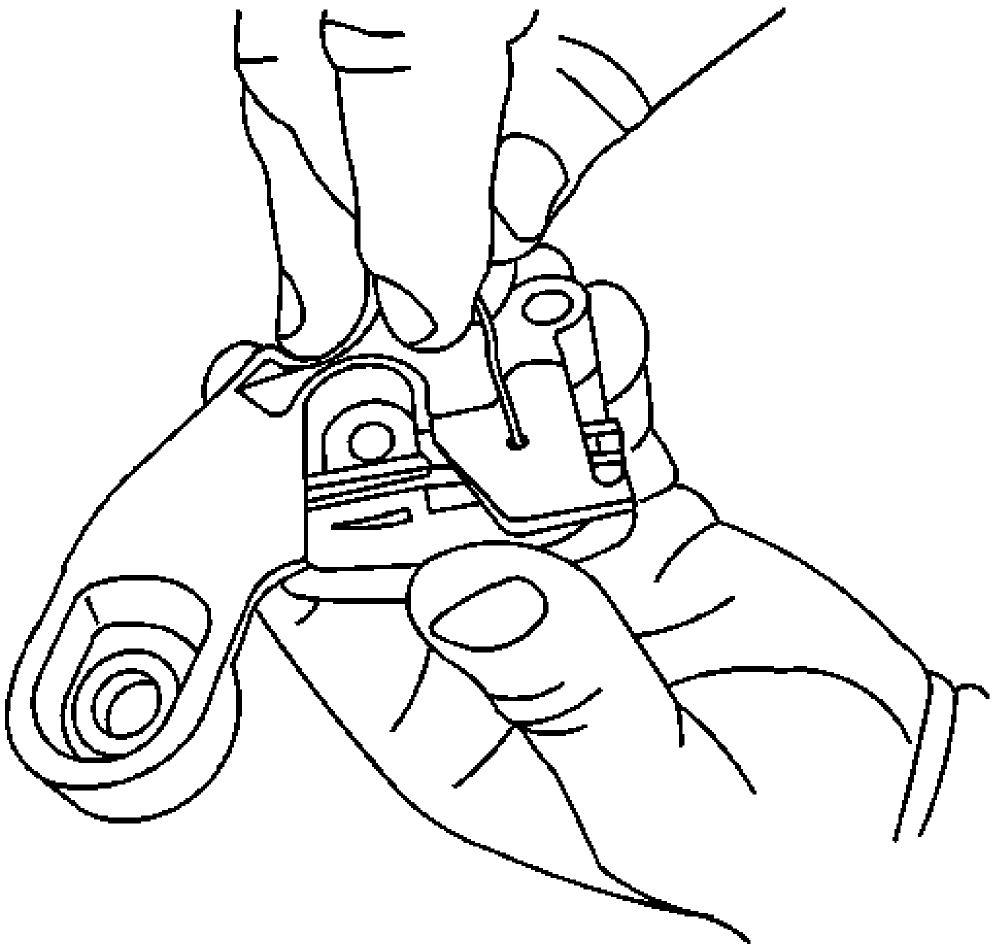


Fig. 82: Installing Camshaft Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

20. Install the camshaft timing chain tensioner.

    Tighten:
    - Tighten the bolts (1) to 11 N.m (97 lb in).
    - Tighten the nut (2) to 45 N.m (33 lb ft).

21. Remove the retainer from the tensioner.

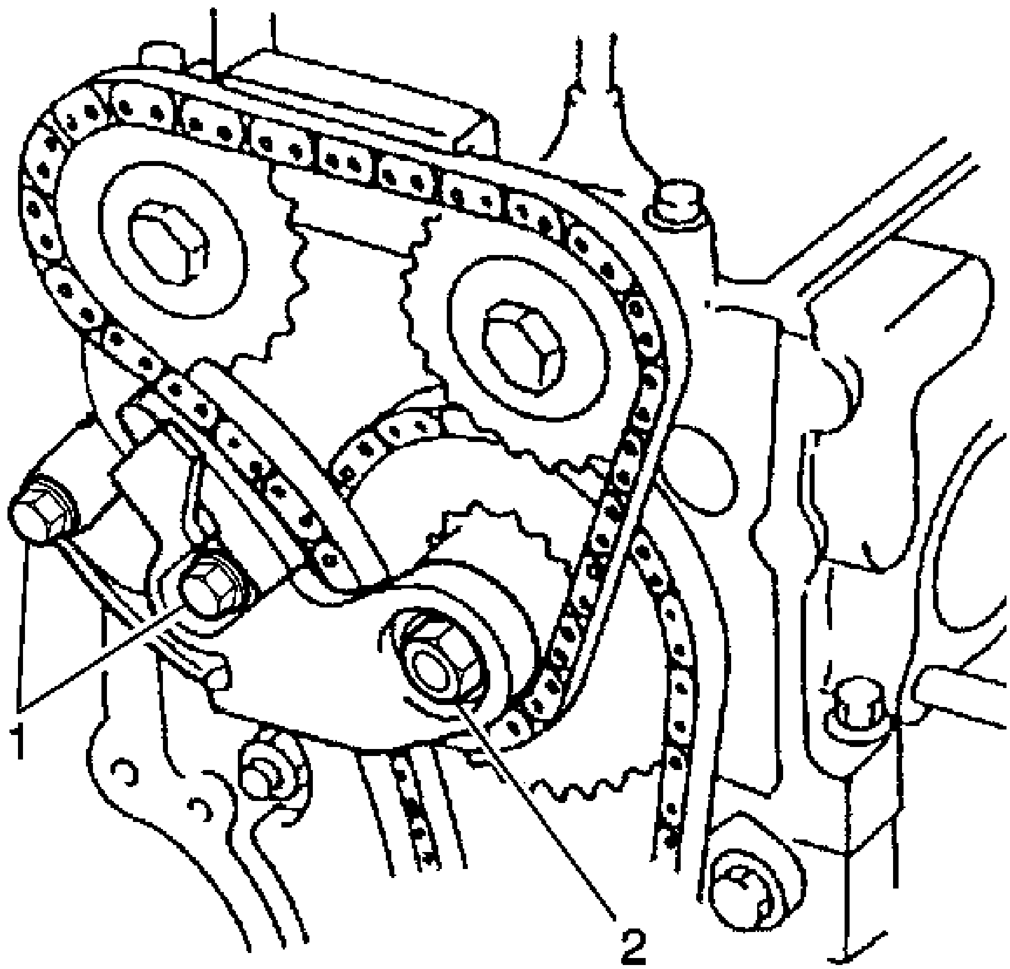


Fig. 83: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

22. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
23. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).
24. Apply engine oil to the following:
    - The timing chains
    - The tensioner
    - The guides
    - The sprockets
25. Install the spark plugs.

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

26. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.
27. Connect the negative battery cable.

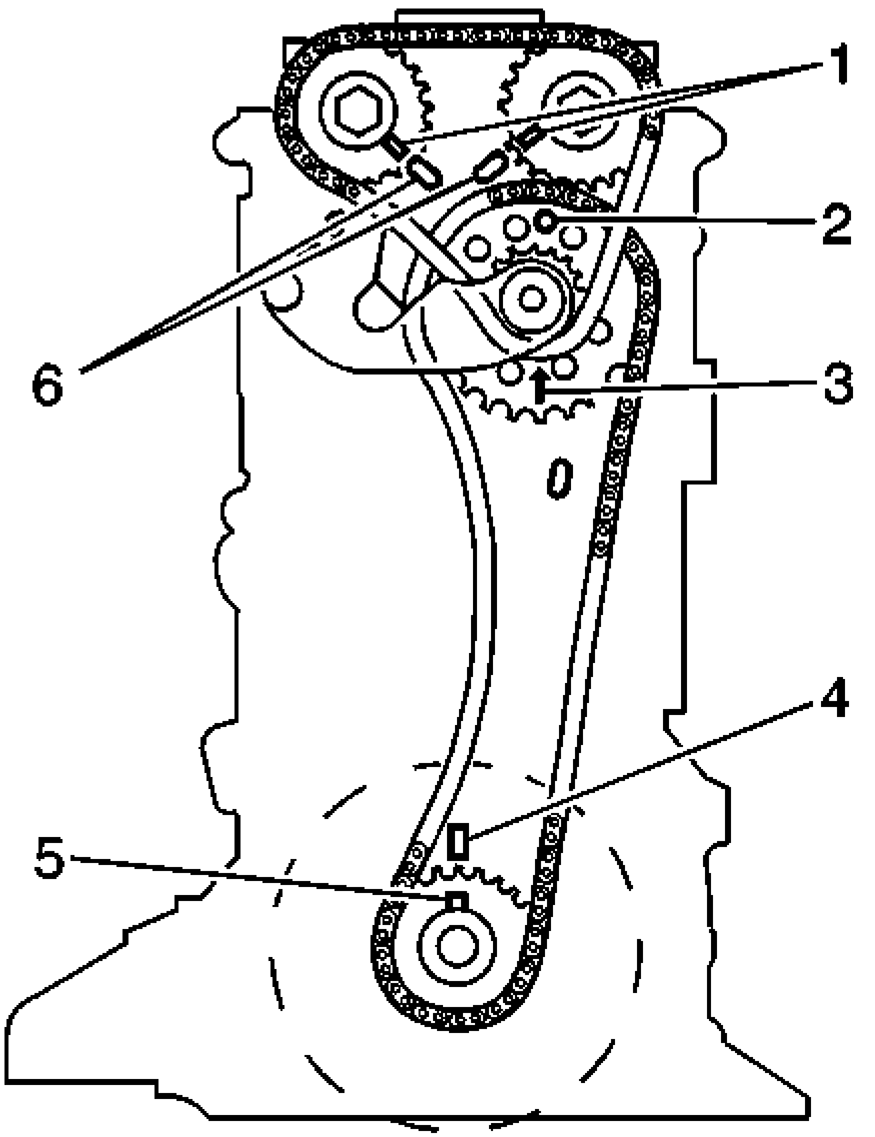


Fig. 84: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain Housing Replacement

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the front axle assembly, 4WD only. Refer to **Front Axle Housing Replacement** in Front Drive Axle.
3. Remove the rack and pinion assembly. Refer to **Power Steering Gear Replacement** in Power Steering.
4. Drain the engine oil.
5. Remove the oil pan. Refer to **Oil Pan Replacement**.
6. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

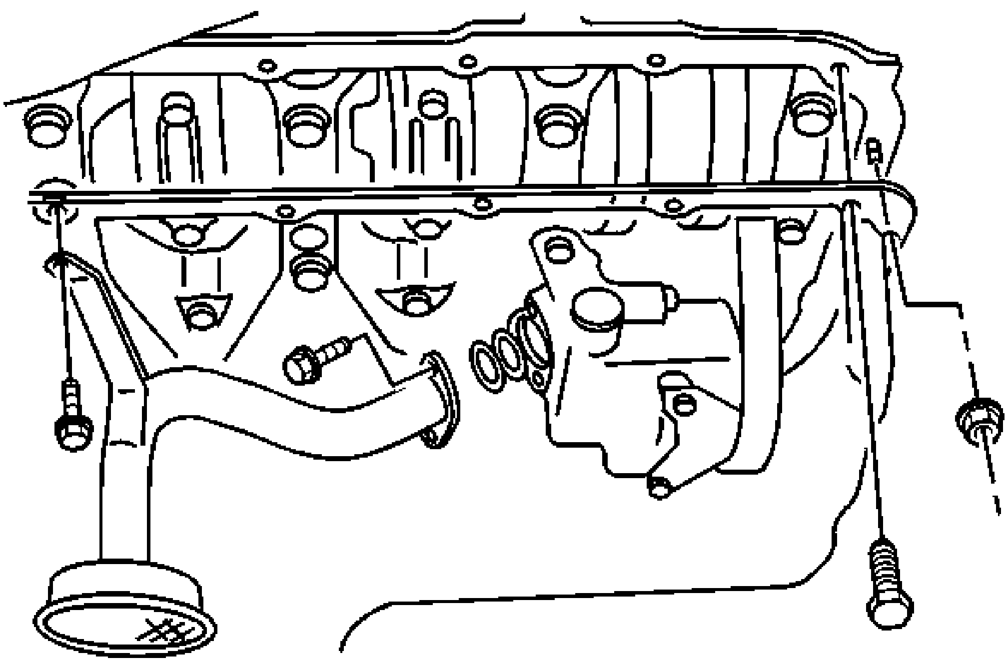


Fig. 85: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

7. Remove the cooling fan and shroud. Refer to **Fan Replacement** in Engine Cooling.
8. Remove the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.

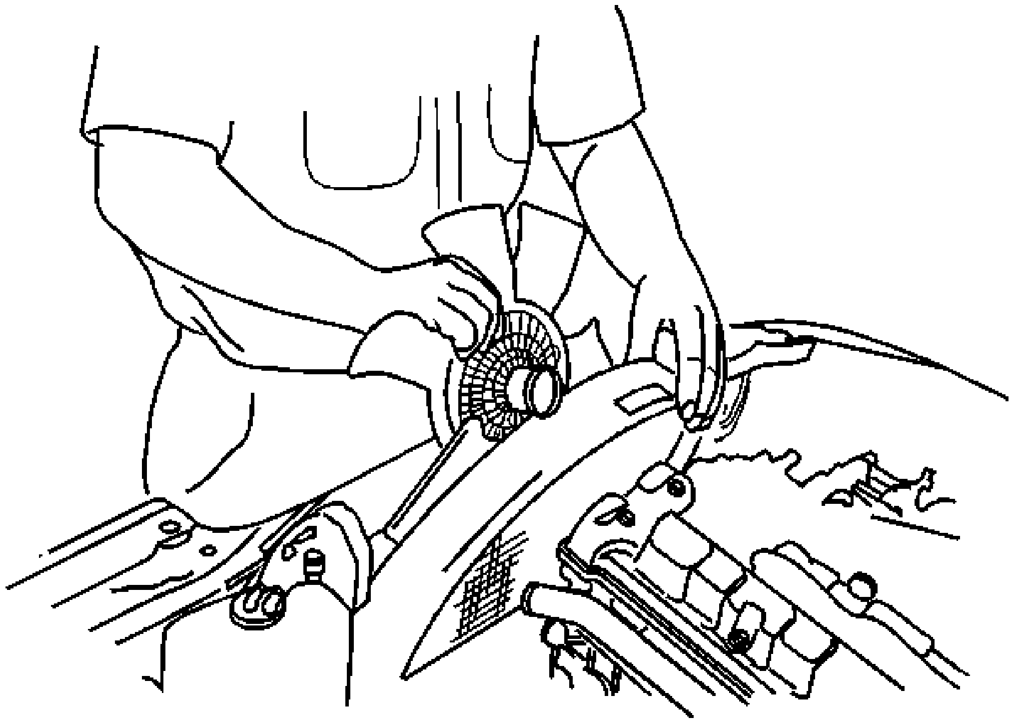


Fig. 86: Removing/Installing Fan Assembly
Courtesy of GENERAL MOTORS CORP.

9. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
10. Remove the cooling fan drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Cooling Fan**.

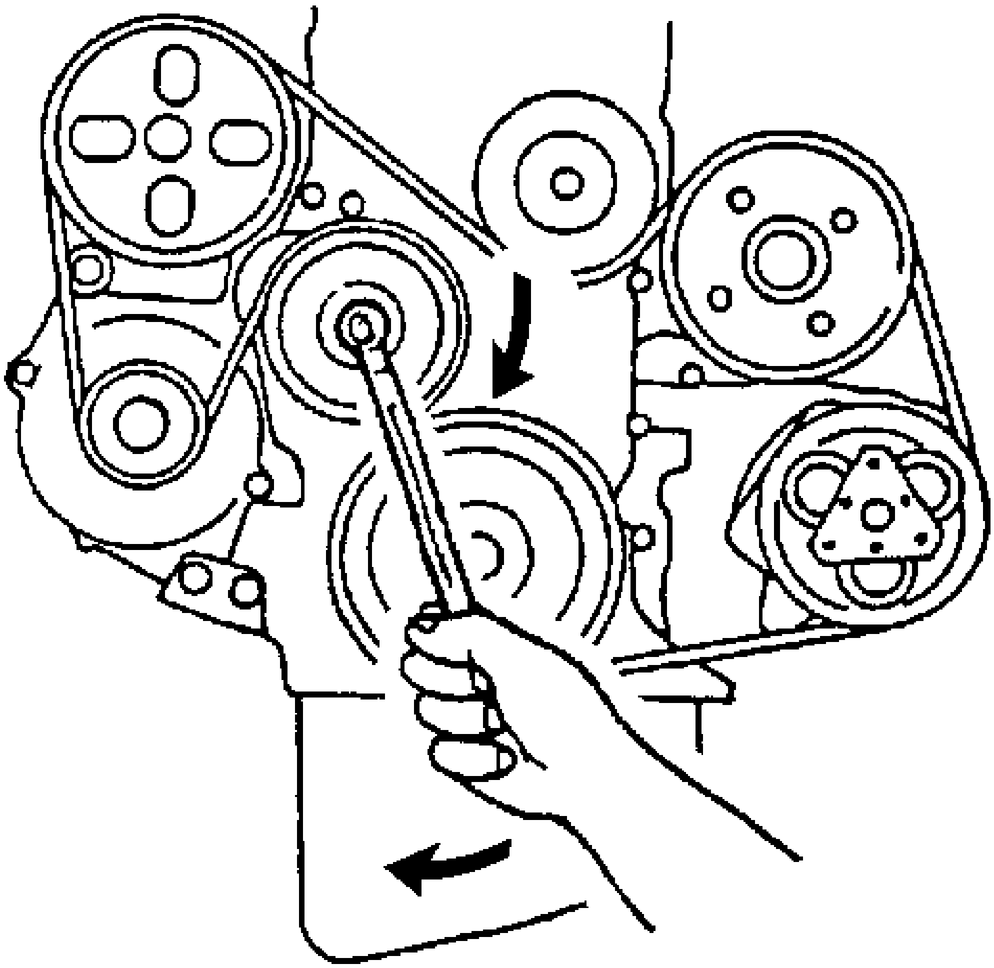


Fig. 87: Rotating Belt Tensioner Clockwise
Courtesy of GENERAL MOTORS CORP.

11. Remove the accessory drive belt tensioner (2). Refer to **Drive Belt Tensioner Replacement - Generator, Air Conditioning, and Power Steering**.
12. Remove the accessory drive belt idler pulley (1).

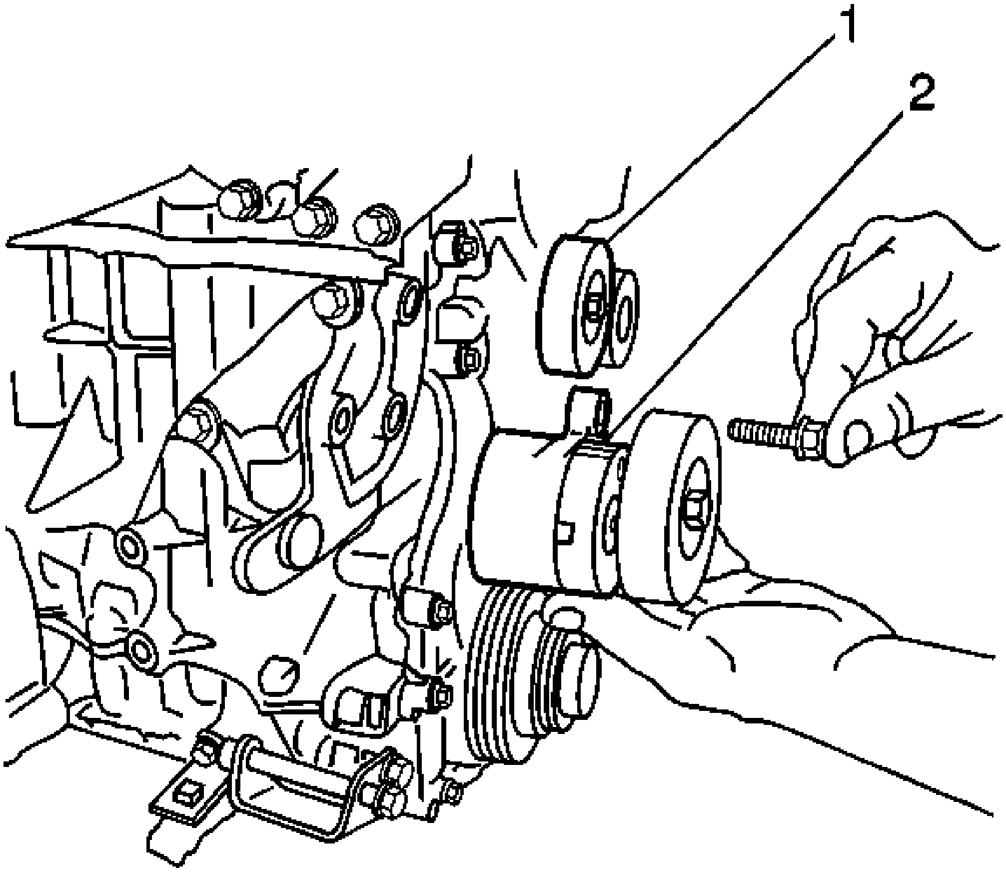


Fig. 88: View Of Drive Belt Tensioner Bolts & Idler Pulley
Courtesy of GENERAL MOTORS CORP.

13. Remove the 4 bolts and the water pump pulley.

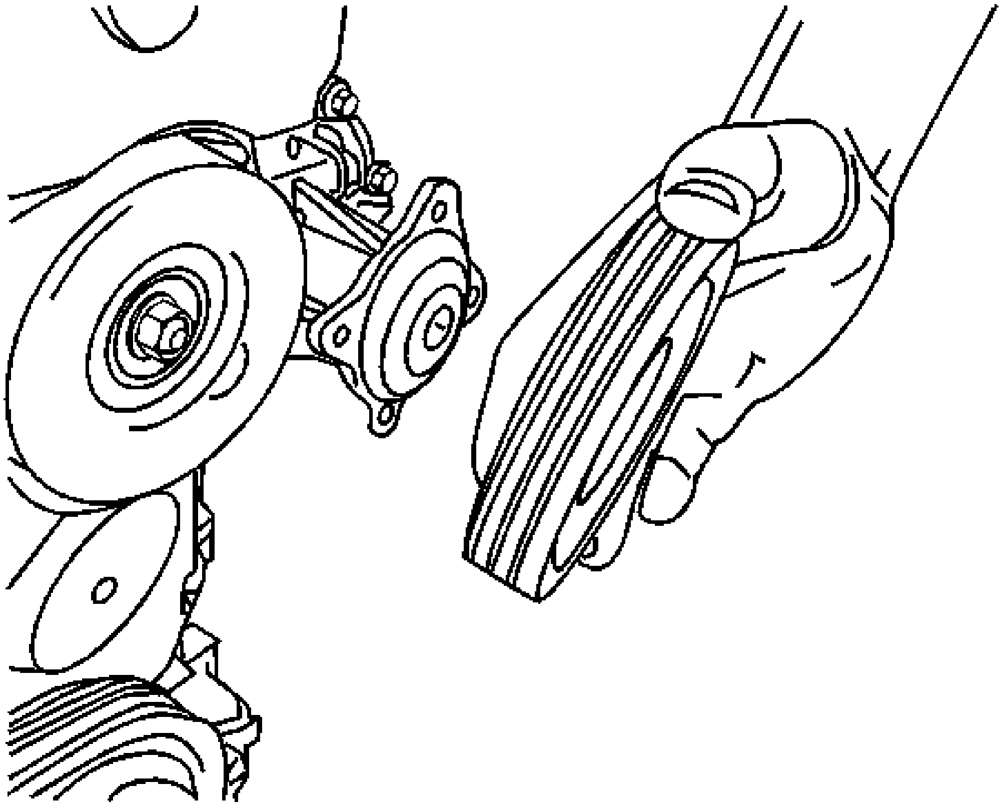


Fig. 89: Removing Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

14. Remove the bypass hose (3) from the coolant outlet pipe.
15. Remove the 2 bolts and the water bypass pipe bracket (2) from the cylinder head.
16. Remove the crankshaft bolt and pulley. Refer to **Crankshaft Pulley Replacement**.

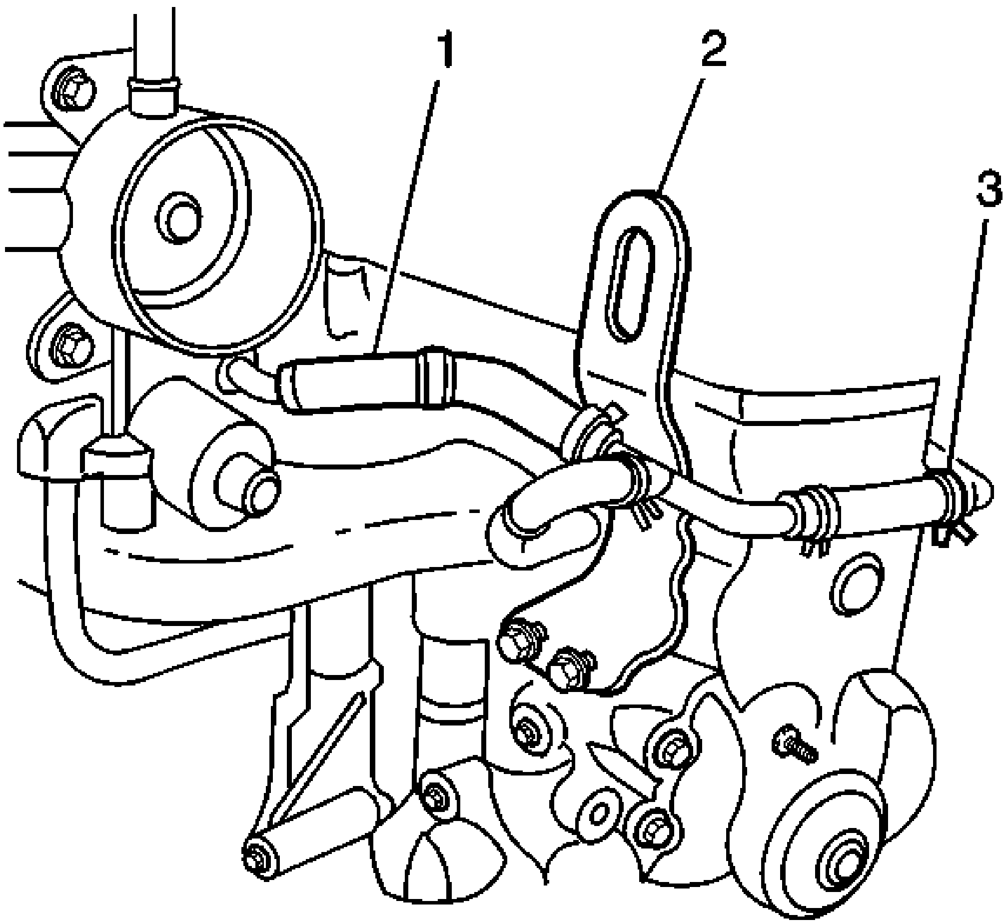


Fig. 90: View Of Water Bypass Pipe Bracket & Hose
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not discharge the A/C system, nor remove the refrigerant lines from the compressor.

17. Remove the 3 bolts (1) and the A/C compressor, if equipped, from its bracket and position aside. Refer to **Compressor Replacement (2.0L)** **Compressor Replacement (2.5L)** in HVAC Systems with A/C Manual.

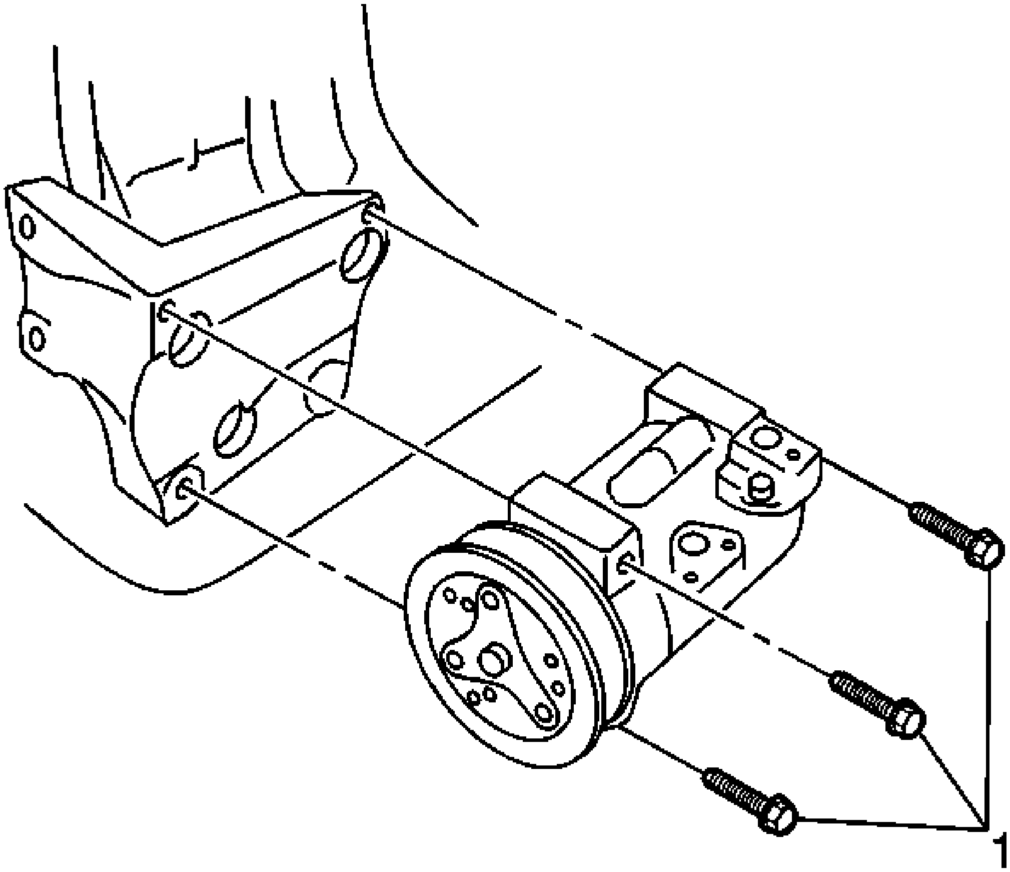


Fig. 91: Compressor Mounting View
Courtesy of GENERAL MOTORS CORP.

18. Remove the 4 bolts and the A/C compressor bracket, if equipped. Refer to **Compressor Mounting Bracket Replacement (2.0L)** **Compressor Mounting Bracket Replacement (2.5L)** in HVAC Systems with A/C Manual.

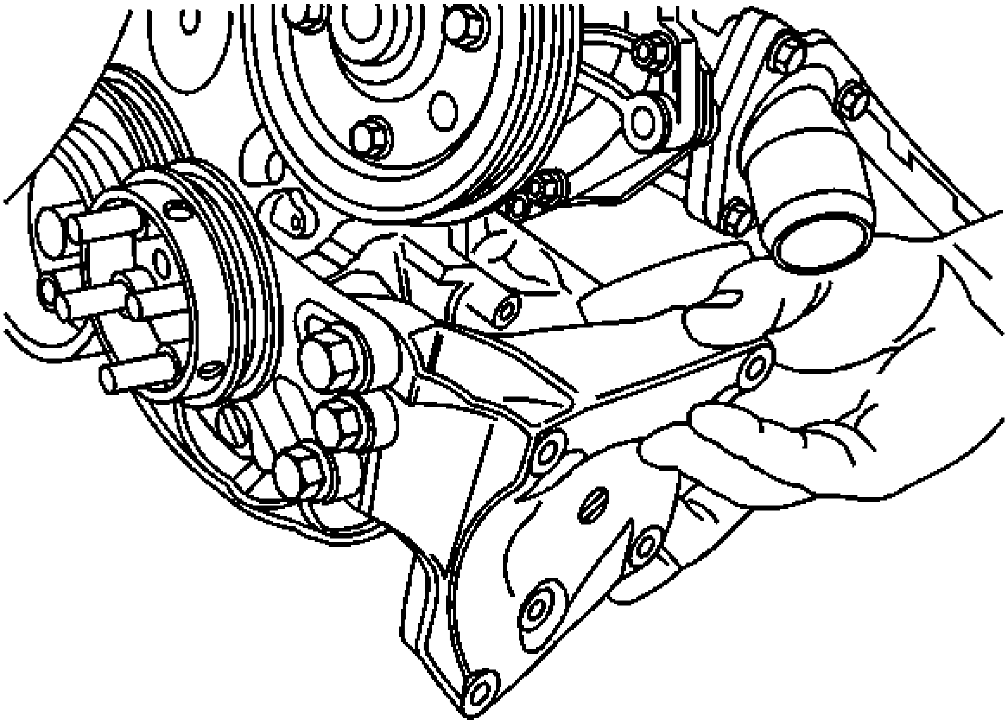


Fig. 92: Removing A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

19. Remove the cylinder head cover (1). Refer to **Cylinder Head Cover Replacement**.

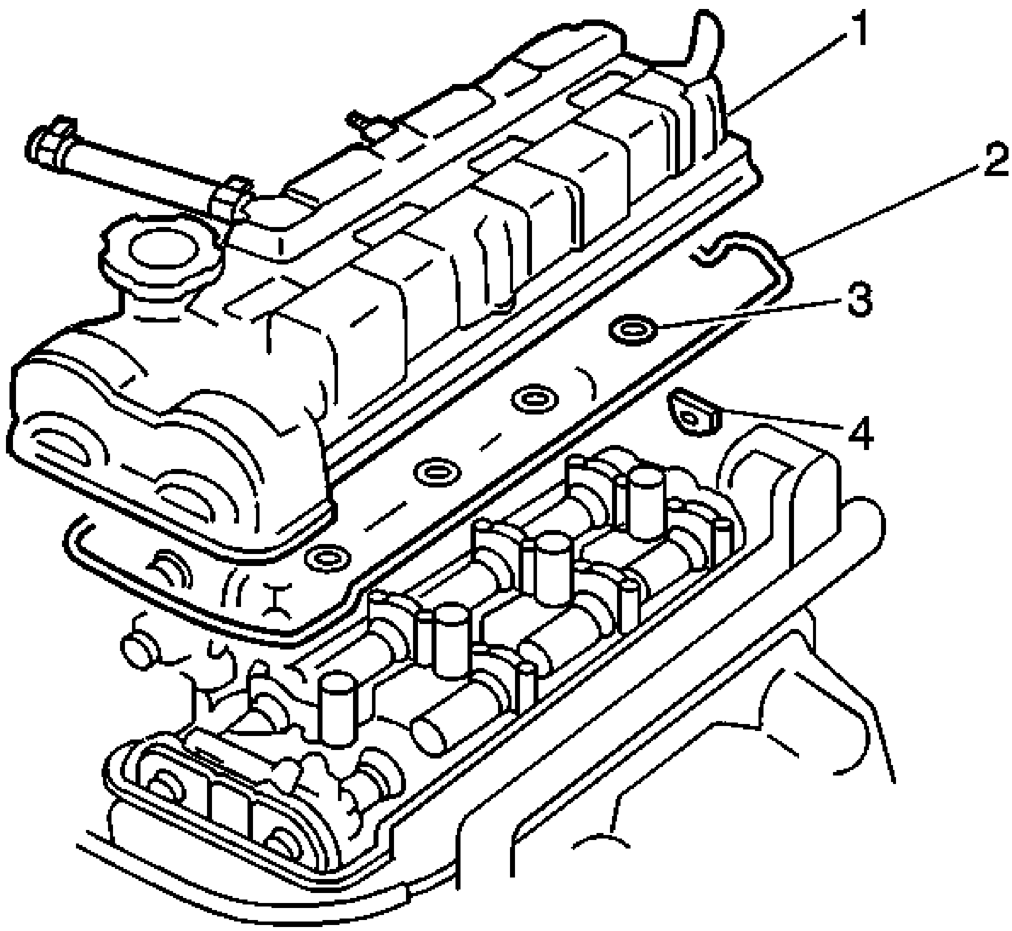


Fig. 93: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

20. Remove the nut and 15 bolts and the timing chain housing.

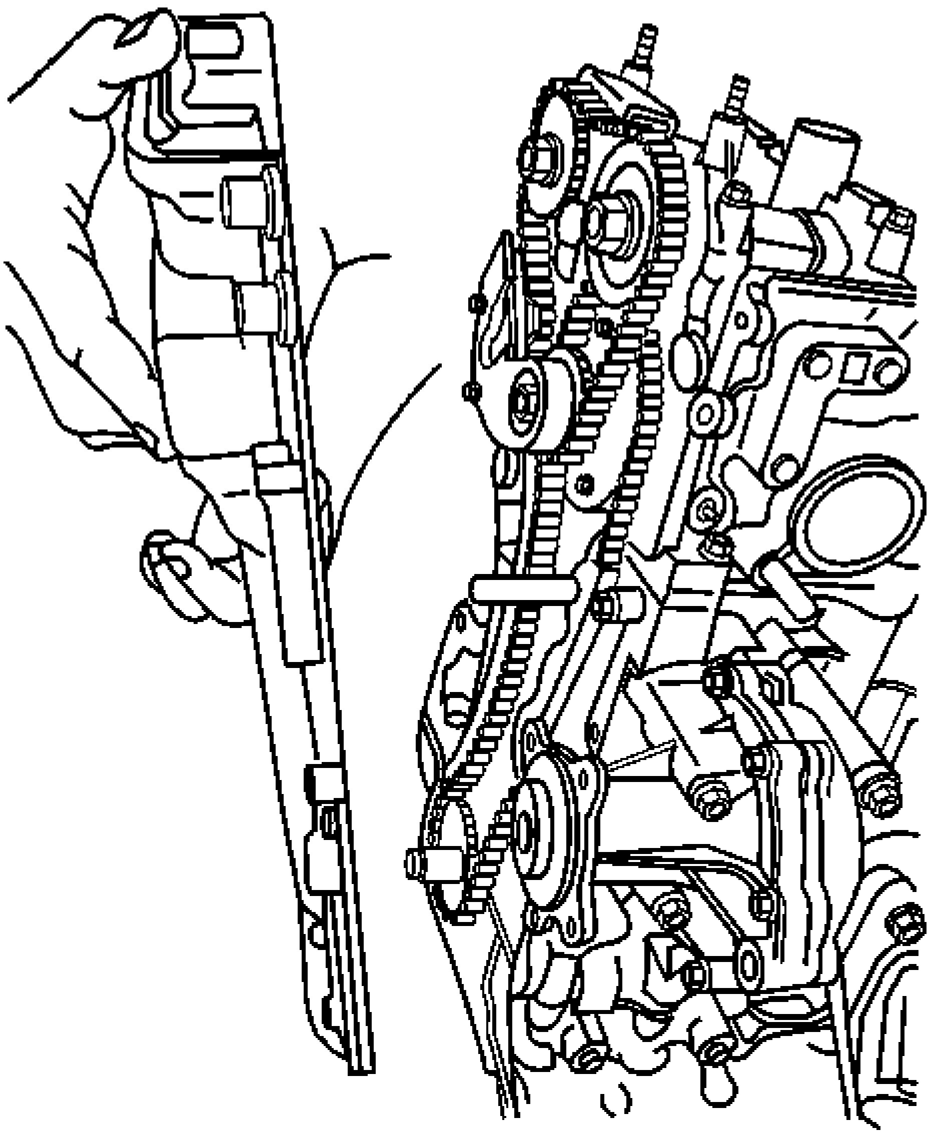


Fig. 94: Removing Timing Chain Housing
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Clean the sealing surfaces on the timing chain housing, the cylinder head, the oil pan, the engine block and the lower crankcase.
2. Inspect the front crank seal. Replace as necessary. Refer to **Crankshaft Front Oil Seal Replacement**.

3. Install the dowel pins to the timing chain housing (1).

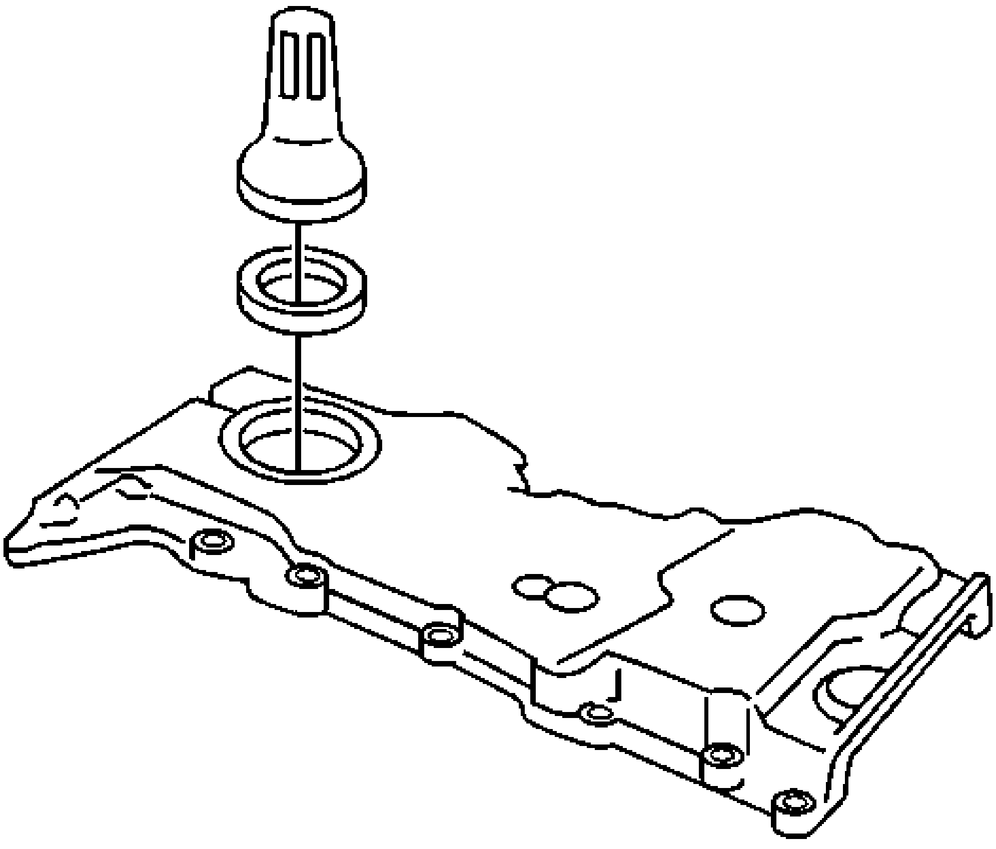


Fig. 95: Installing Dowel Pins To Timing Chain Housing
Courtesy of GENERAL MOTORS CORP.

4. Apply a continuous bead of GM P/N 12345997 or equivalent to the timing cover mating surface (2).
5. Apply a bead of GM P/N 12345997 or equivalent to the cylinder head-to-engine block mating points (3).
6. Lubricate the front crank seal lip with Chassis Grease GM P/N 1051344 (Canadian P/N 993037) or equivalent.

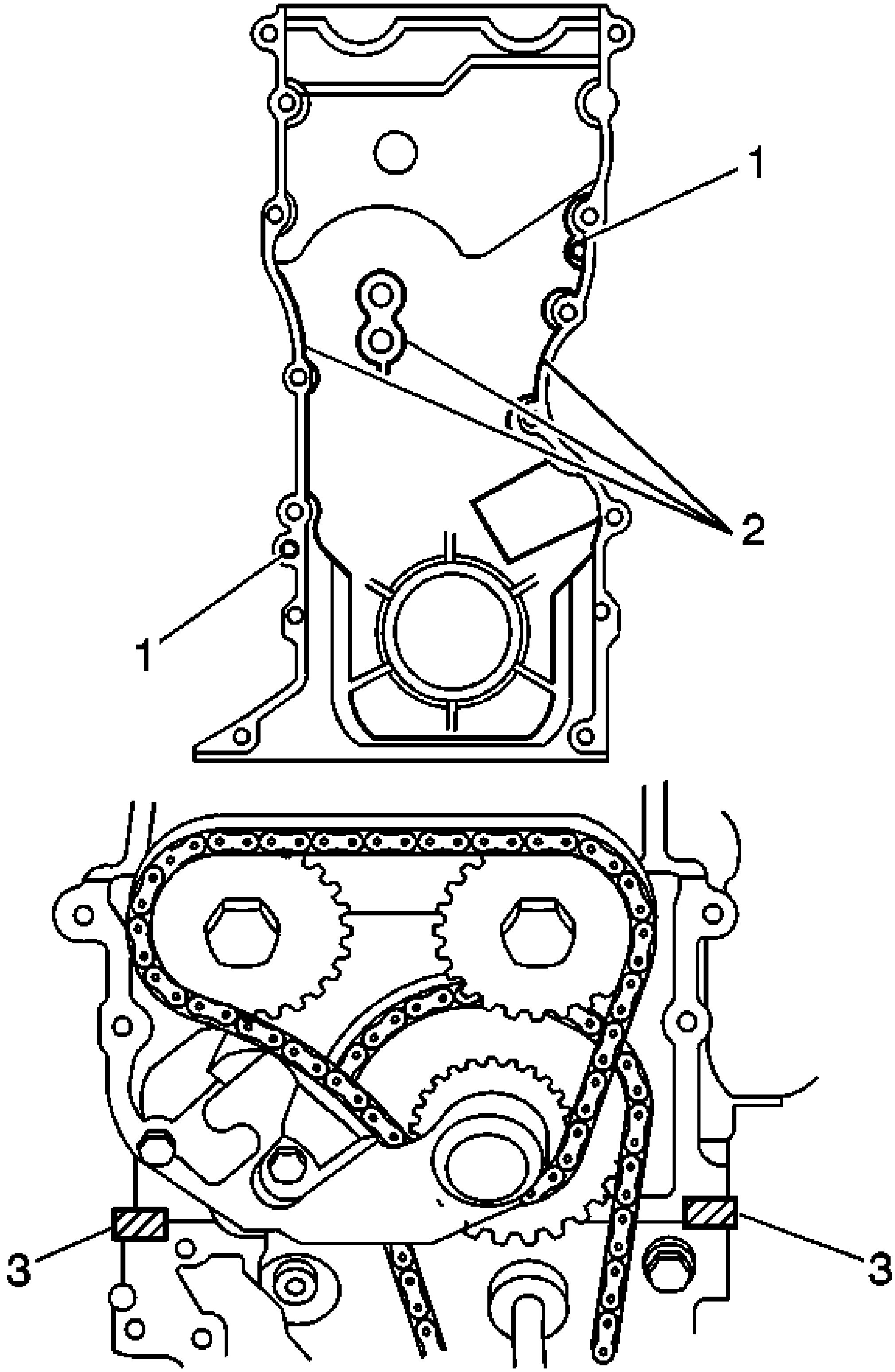

1
2
1
3
3

Fig. 96: View Of Timing Cover Mating Surface & Cylinder Head-To-Engine Block Mating Points
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the timing chain housing. Secure with the nut and 15 bolts.

   Tighten: Tighten the nut and bolts to 11 N.m (97 lb in).

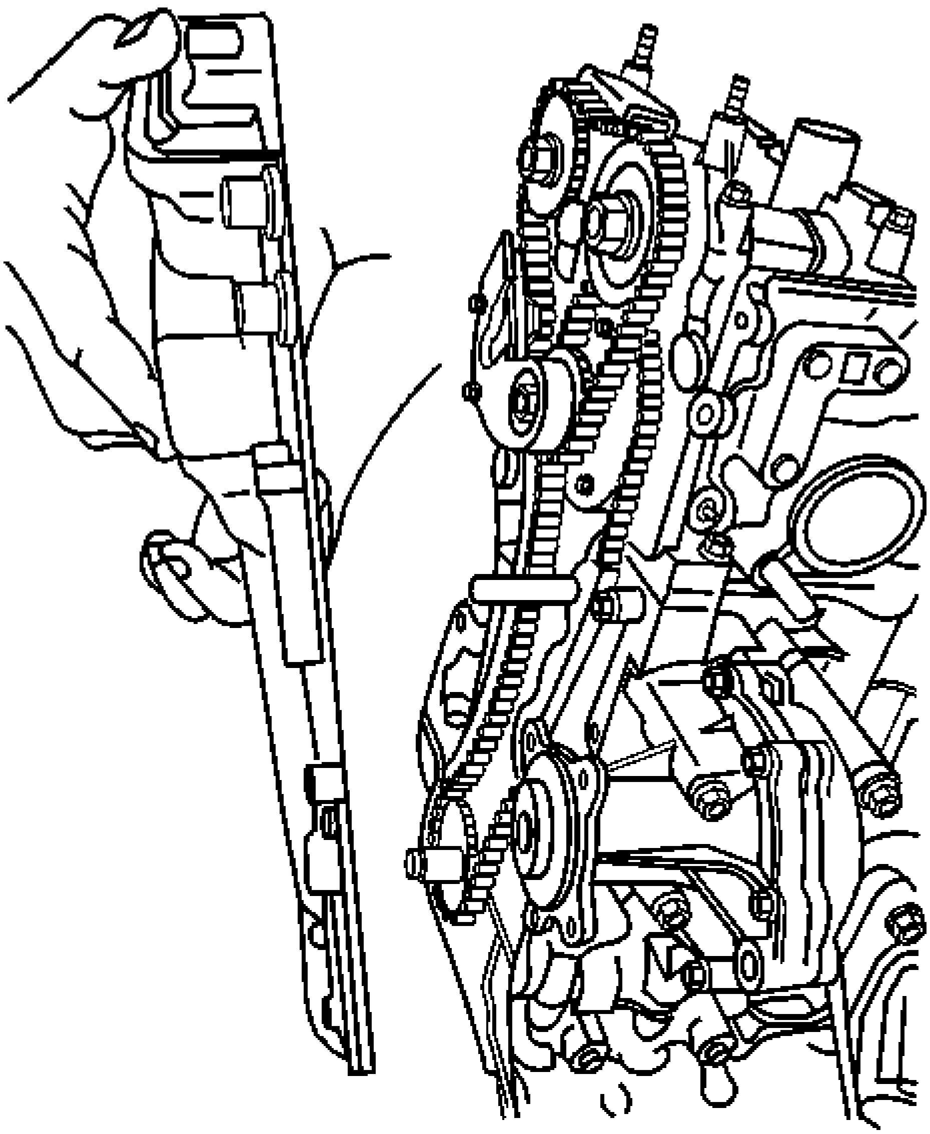


Fig. 97: Installing Timing Chain Housing
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head cover (1). Refer to **Cylinder Head Cover Replacement**.

   Tighten: Tighten the nuts to 11 N.m (97 lb in).

9. Install the crankshaft pulley and bolt. Refer to **Crankshaft Pulley Replacement**.

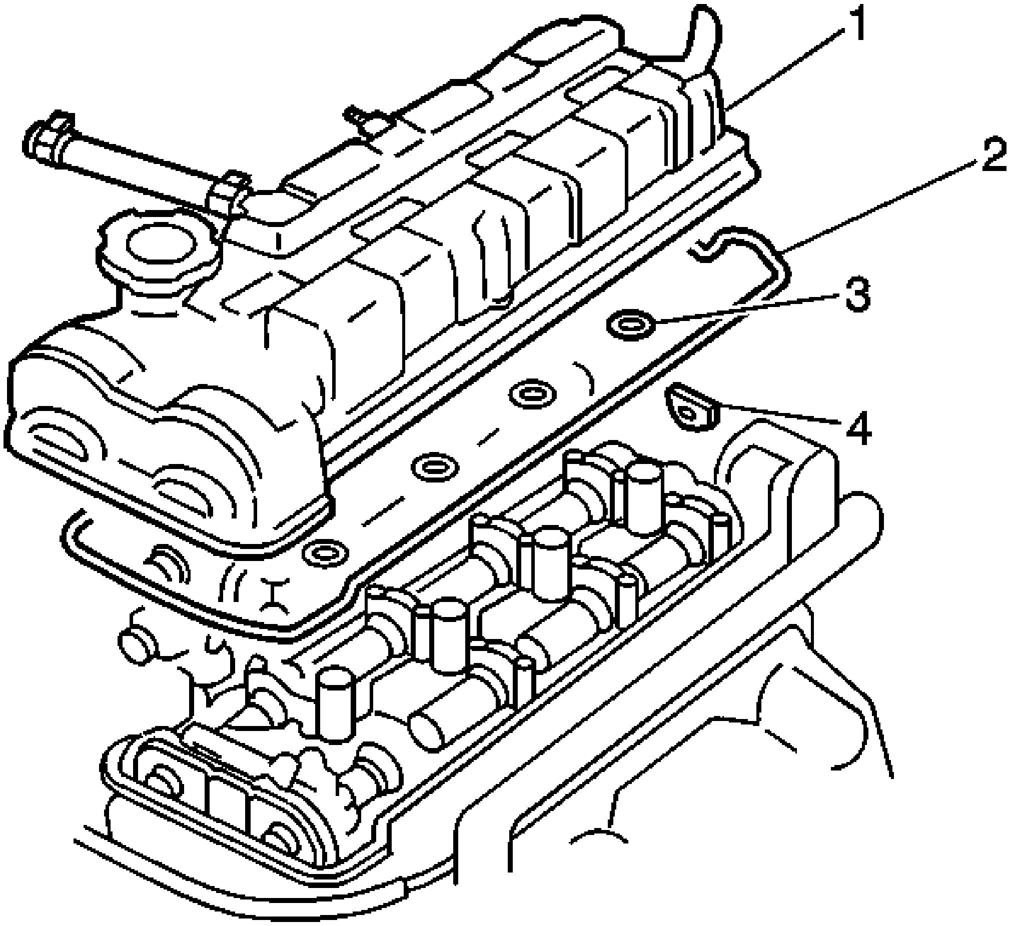


Fig. 98: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

10. Install the A/C compressor bracket, if equipped. Refer to **Compressor Mounting Bracket Replacement (2.0L)** **Compressor Mounting Bracket Replacement (2.5L)** in HVAC Systems with A/C Manual.

    Tighten: Tighten the bolts to 55 N.m (40 lb ft).

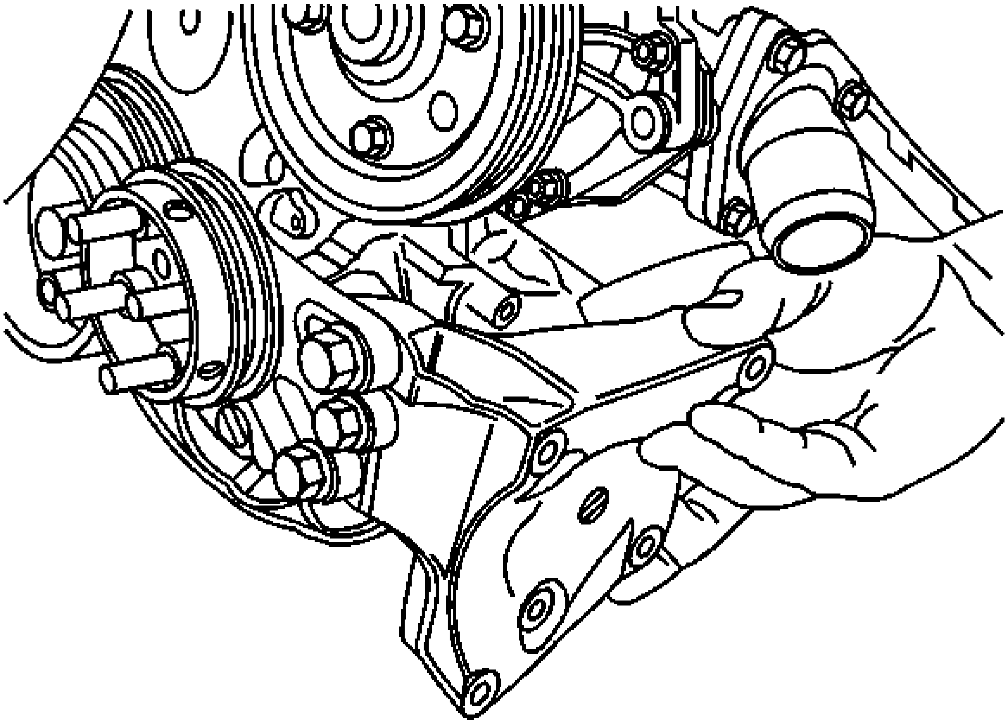


Fig. 99: Installing A/C Compressor Bracket
Courtesy of GENERAL MOTORS CORP.

11. Install the A/C compressor, if equipped, to its bracket and secure with the 3 bolts (1). Refer to **Compressor Replacement (2.0L)** **Compressor Replacement (2.5L)** in HVAC Systems with A/C Manual.

    Tighten: Tighten the bolts to 23 N.m (17 lb ft).

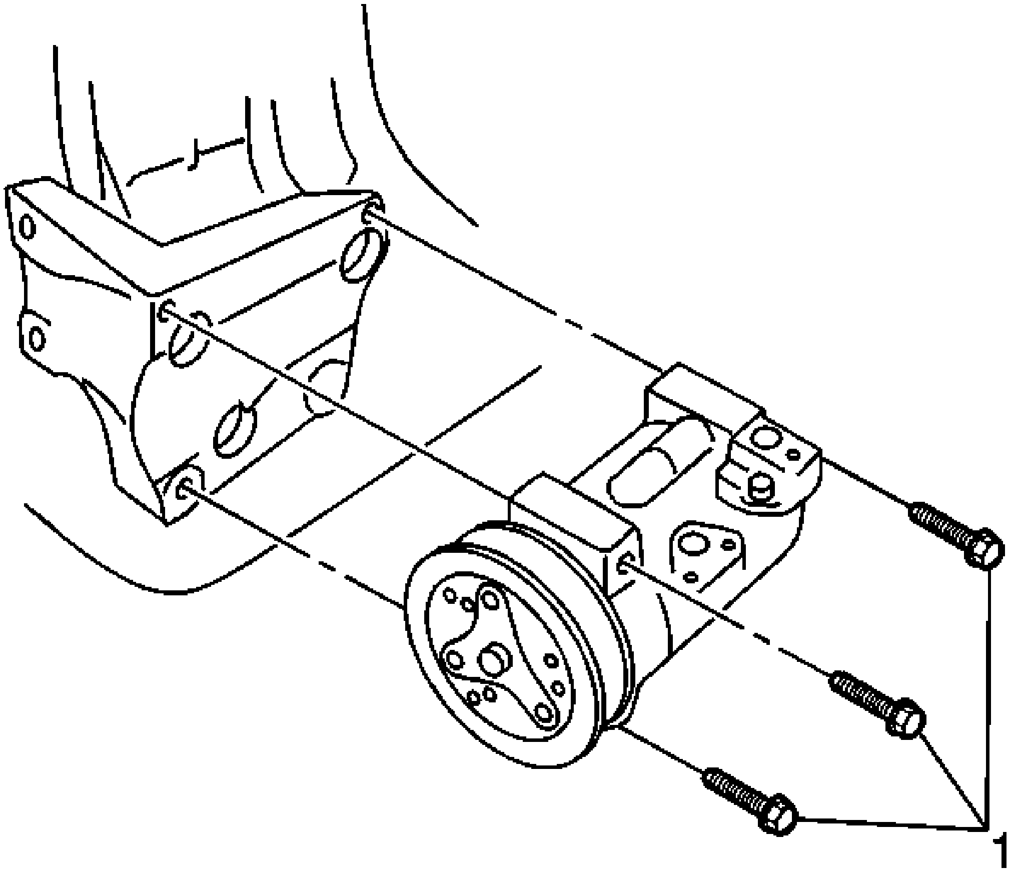


Fig. 100: Compressor Mounting View
Courtesy of GENERAL MOTORS CORP.

12. Install the water bypass pipe bracket (2) to the cylinder head. Secure with the 2 bolts.
13. Install the bypass hose (3) to the coolant outlet pipe.

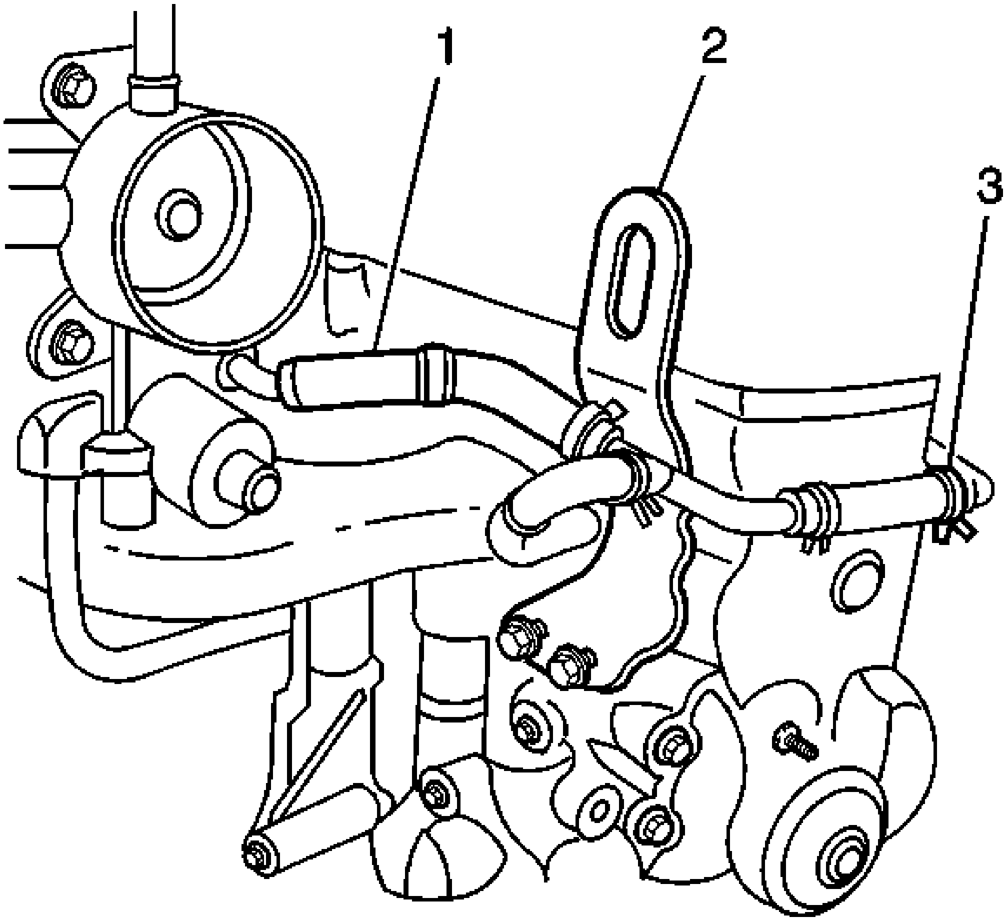


Fig. 101: View Of Water Bypass Pipe Bracket & Hose
Courtesy of GENERAL MOTORS CORP.

14. Install the water pump pulley. Secure with the 4 bolts.
15. Install the accessory drive belt idler pulley (1).

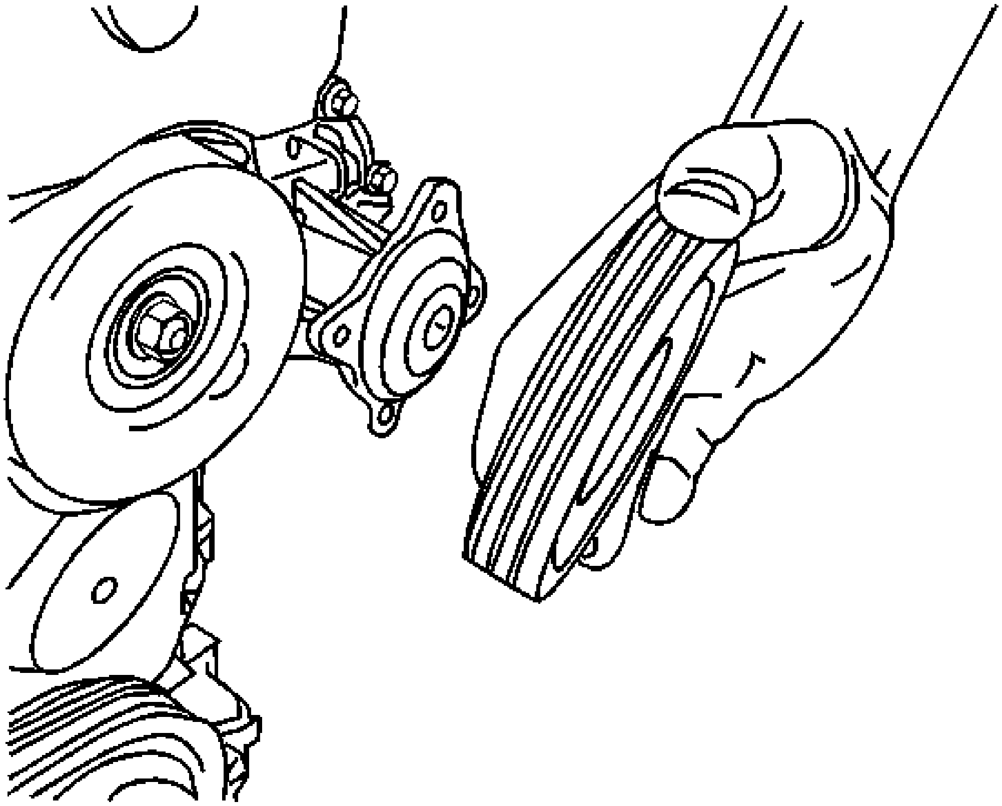


Fig. 102: Installing Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

16. Install the accessory drive belt tensioner (2). Refer to **Drive Belt Tensioner Replacement - Generator, Air Conditioning, and Power Steering**.
17. Install the cooling fan drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Cooling Fan**.

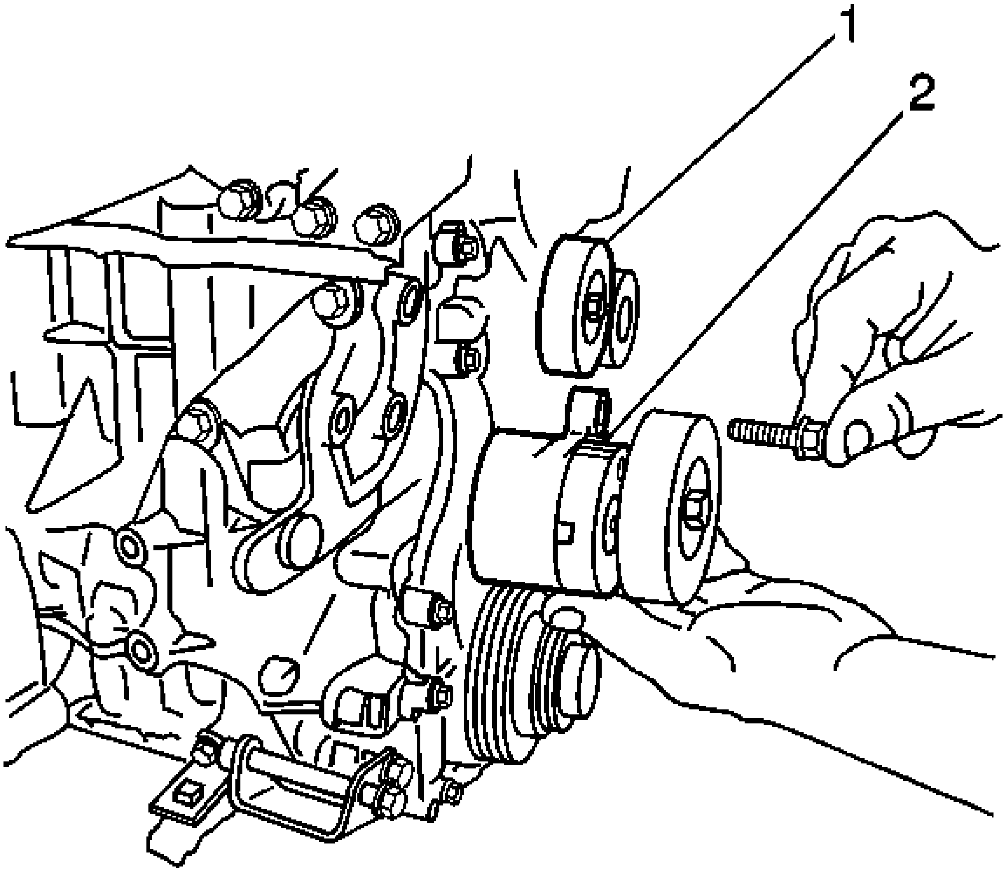


Fig. 103: View Of Drive Belt Tensioner Bolts & Idler Pulley
Courtesy of GENERAL MOTORS CORP.

18. Install the accessory drive belt. Refer to **Drive Belt Replacement - Generator, Air Conditioning, and Power Steering**.
19. Install the cooling fan drive belt. Refer to **Drive Belt Replacement - Cooling Fan**.

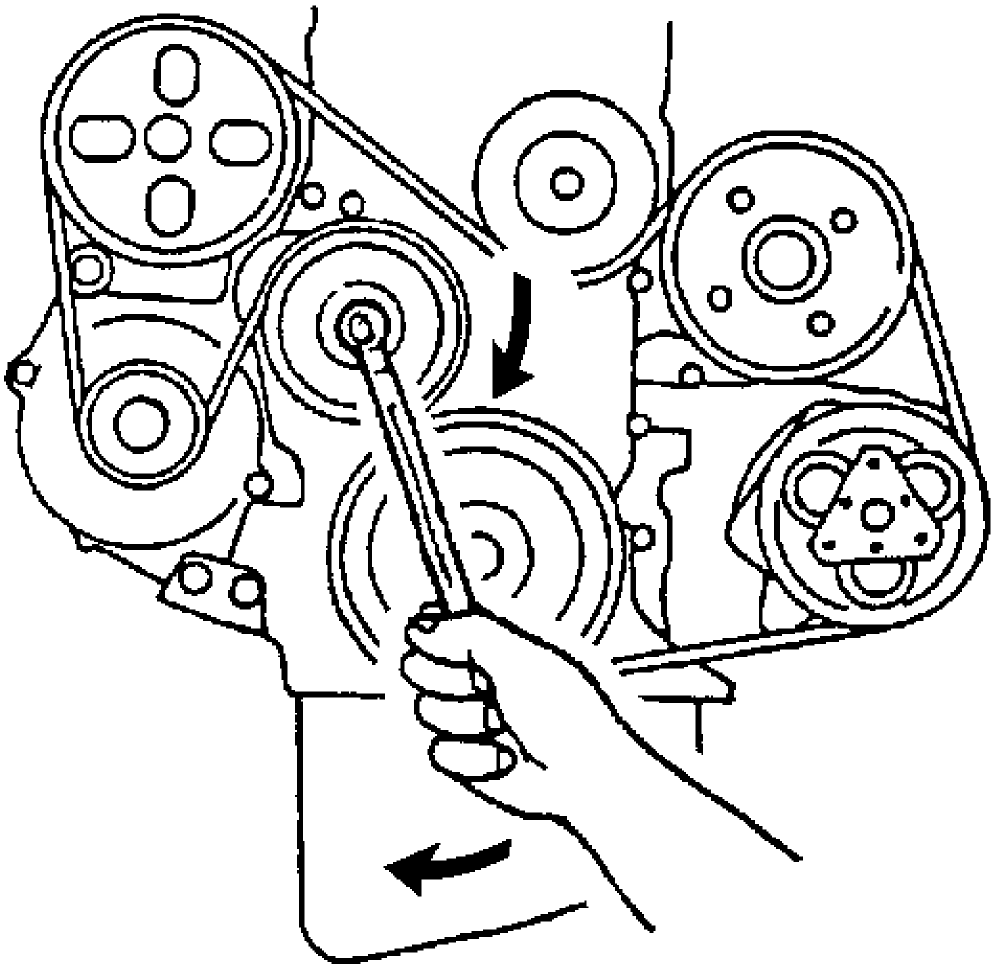


Fig. 104: Rotating Belt Tensioner Clockwise
Courtesy of GENERAL MOTORS CORP.

20. Install the cooling fan and shroud. Refer to **Fan Replacement** in Engine Cooling.

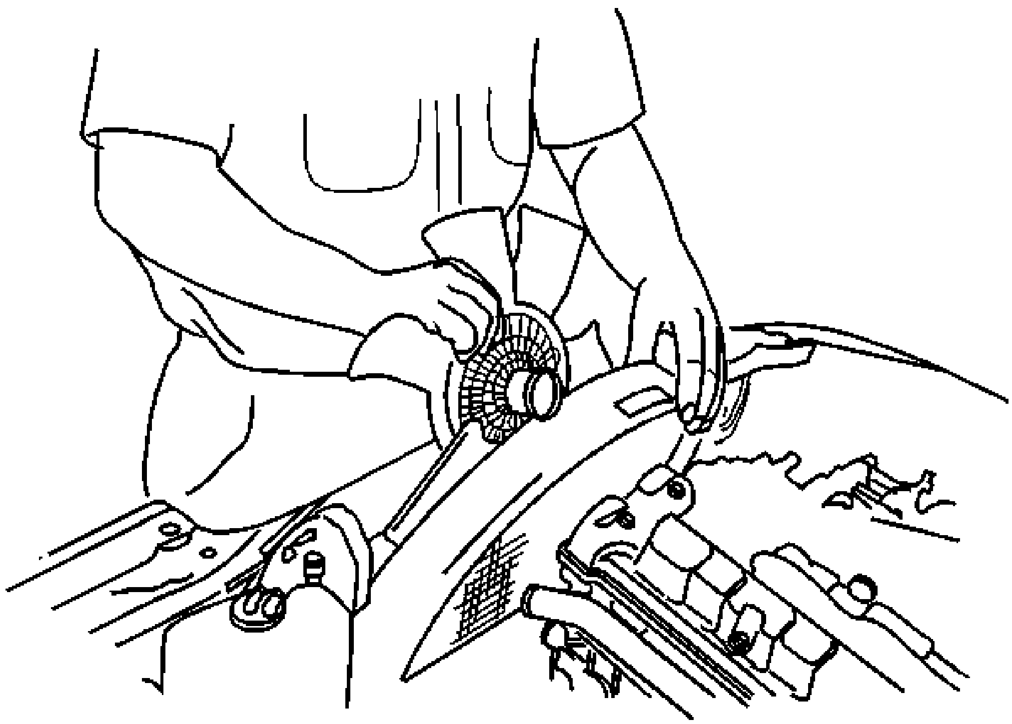


Fig. 105: Removing/Installing Fan Assembly
Courtesy of GENERAL MOTORS CORP.

21. Install the oil pan. Refer to **Oil Pan Replacement**.
22. Install the rack and pinion assembly. Refer to **Power Steering Gear Replacement** in Power Steering.
23. Install the front axle assembly on four wheel drive vehicles. Refer to **Front Axle Housing Replacement** in Front Drive Axle.
24. Fill the differential on four wheel drive vehicles. Refer to **Lubricant Level Inspection - Front Drive Axle** in Front Drive Axle.
25. Fill the power steering system. Refer to **Checking and Adding Power Steering Fluid** in Power Steering.
26. Bleed the power steering system. Refer to **Bleeding the Power Steering System** in Power Steering.
27. Fill the crankcase with engine oil.
28. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
29. Connect the negative battery cable.
30. Adjust the front toe-in. Refer to **Front Toe Adjustment** in Wheel Alignment.

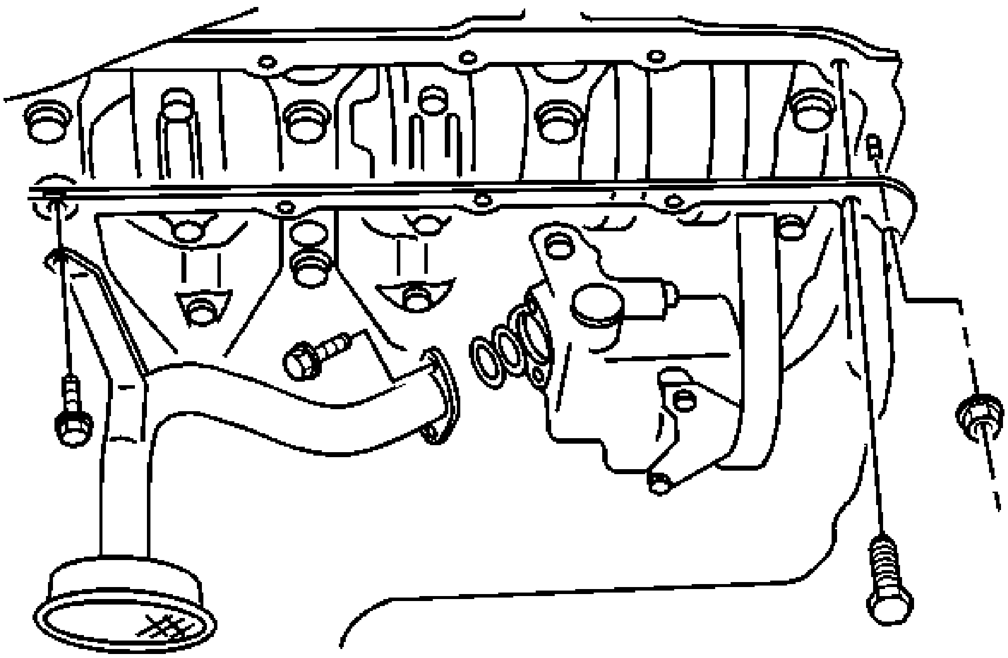


Fig. 106: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Cover Replacement

Removal Procedure

1. Disconnect the 4 ignition coils.
2. Remove the 4 ignition coils (1).
3. Remove the accelerator cable from the clip on the cylinder head cover.
4. Remove the oil level gauge.
5. Remove the positive crankcase ventilation (PCV) hose.
6. Remove the positive crankcase ventilation (PCV) breather hose.

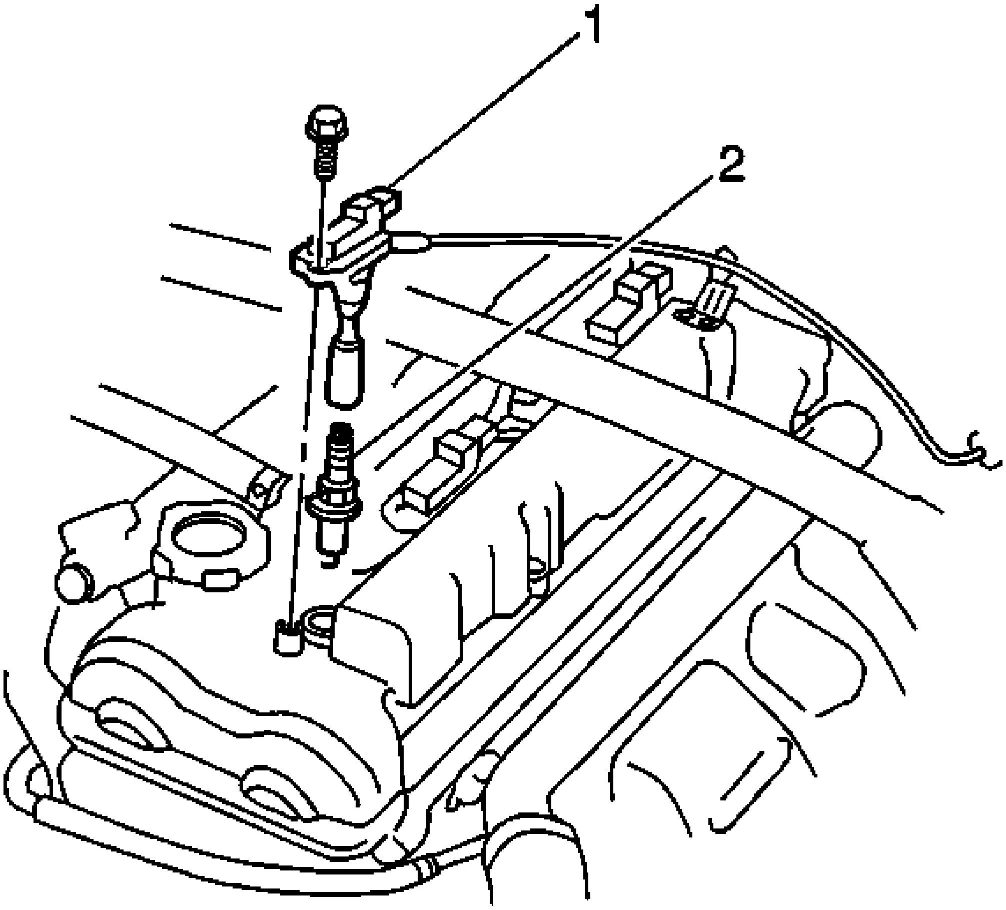


Fig. 107: View Of Ignition Coils & Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the 6 cap nuts and washers from the cylinder head.
8. Remove the cylinder head cover (1).
9. Remove the cylinder head cover gasket (2).
10. Remove the 4 O-rings (3).

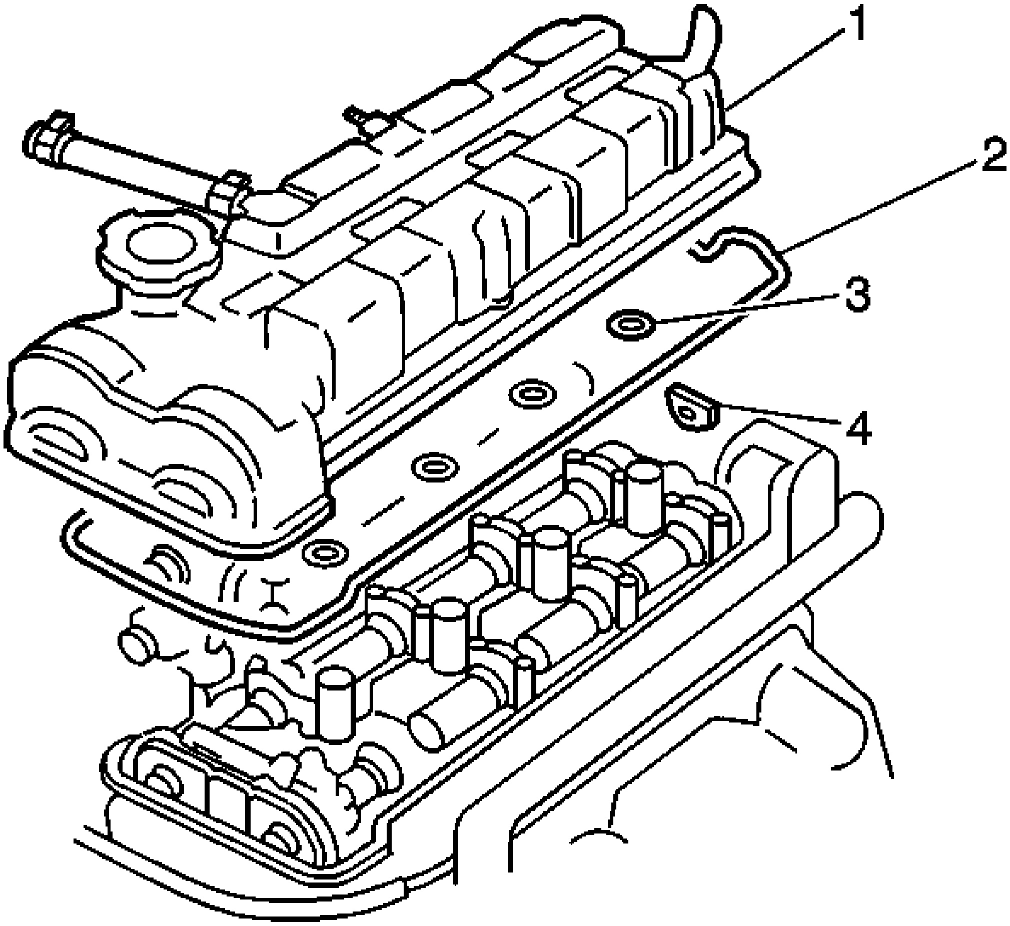


Fig. 108: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

IMPORTANT: Use a new cylinder head cover gasket, new O-rings and a new side seal whenever the cylinder head cover replacement procedure is performed.

1. Ensure that the new gasket, the new O-rings and the new side seal are correctly positioned during the cylinder head cover installation.
2. Clean the sealing surfaces on the cylinder head cover and the cylinder head.
3. Apply GM P/N 12346240 or equivalent to the cylinder head at the points indicated (1).

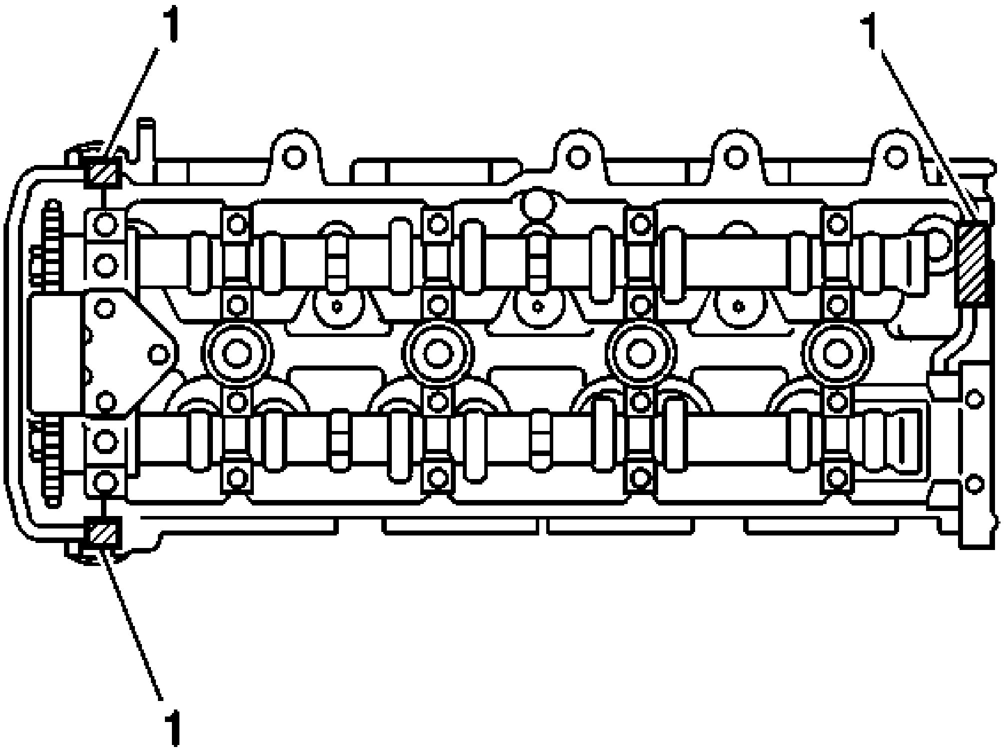


Fig. 109: Applying Sealant To Indicated Points
Courtesy of GENERAL MOTORS CORP.

4. Install the 4 new O-rings (3) to the cylinder head cover (1).
5. Install the new cylinder head cover gasket (2) to the cylinder head cover.
6. Install the new cylinder head side seal (4) to the cylinder head.
7. Install the cylinder head cover to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install new washers to the cylinder head cover and install the cap nuts.

   Tighten: Starting in the center, cross-tighten the cylinder head cover nuts evenly to 11 N.m (97 lb in).

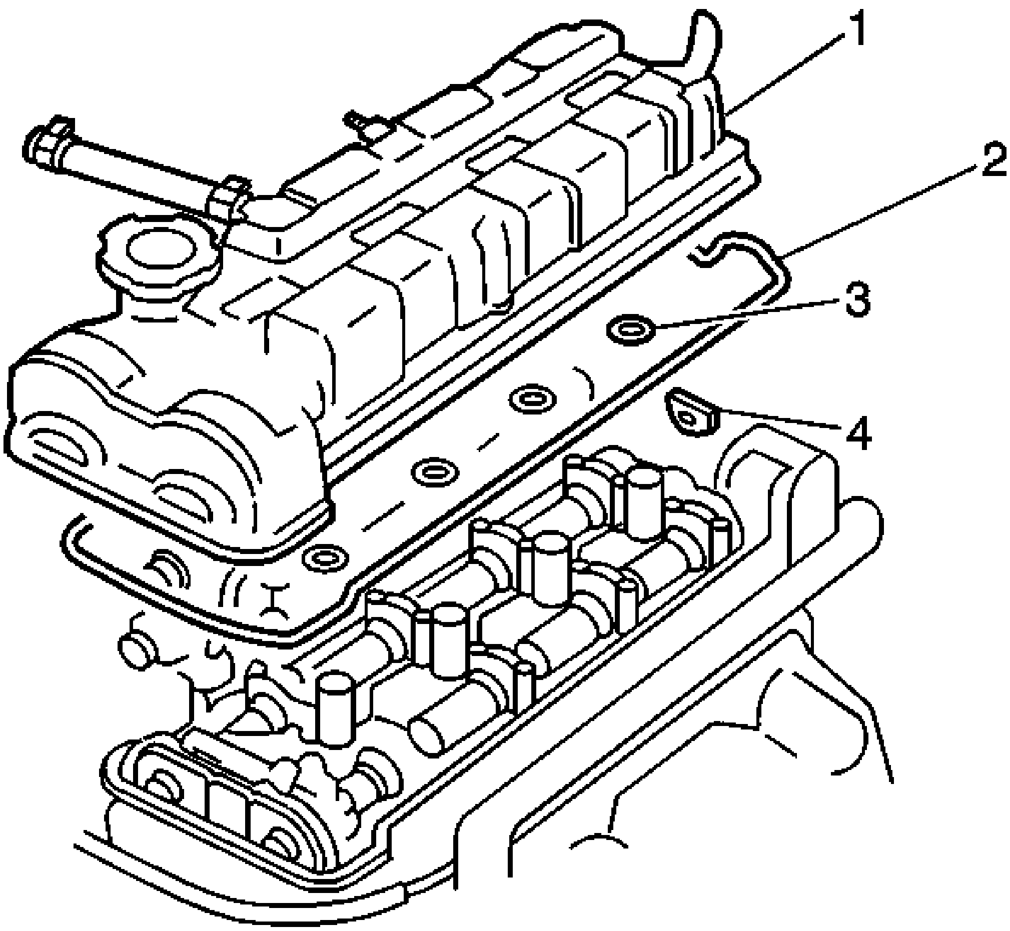


Fig. 110: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

9. Install the 4 ignition coils (1).
10. Connect the 4 ignition coils.
11. Install the accelerator cable to the clip on the cylinder head cover.
12. Install the oil level gauge.
13. Install the positive crankcase ventilation (PCV) hose.
14. Install the PCV breather hose.

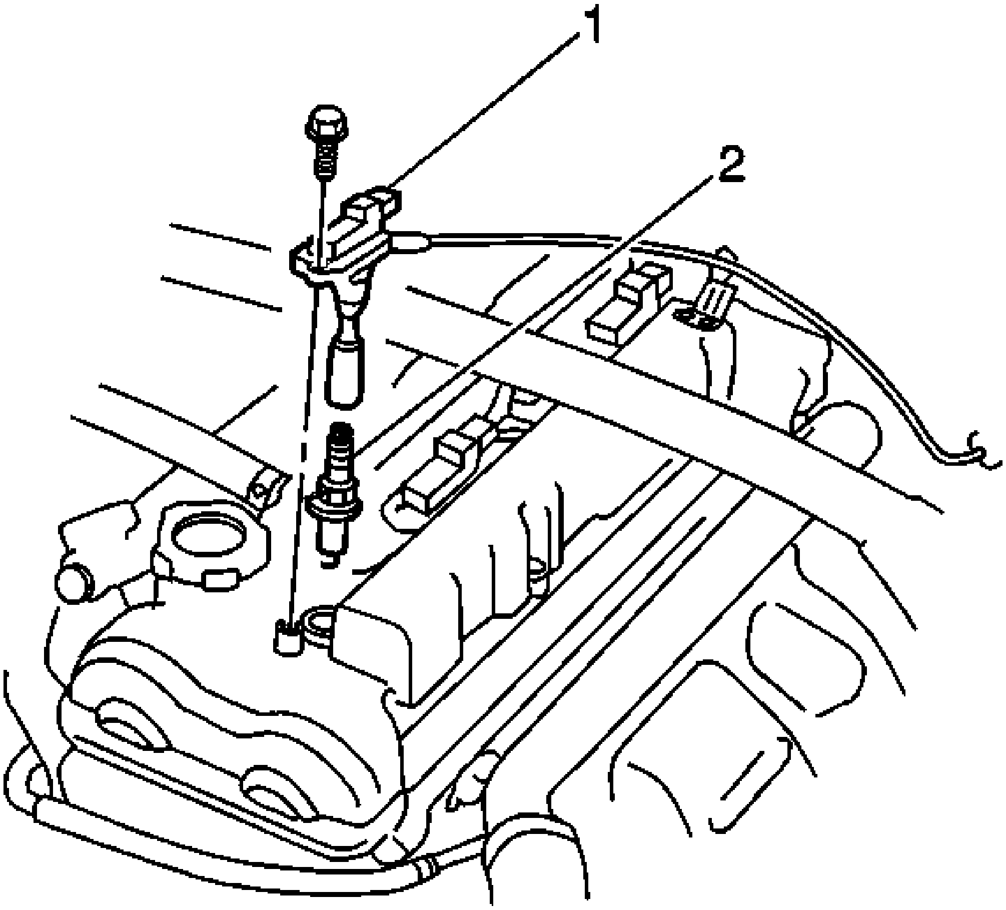


Fig. 111: View Of Ignition Coils & Spark Plugs
Courtesy of GENERAL MOTORS CORP.

Intake Camshaft and Lifter Replacement

Tools Required

- **J 26900-2** Combimike Micrometer. See **Special Tools and Equipment**.
- **J 8001** Dial Indicator Set. See **Special Tools and Equipment**.
- **J 26900-13** Magnetic Indicator Base. See **Special Tools and Equipment**.

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
3. Remove the camshaft timing chain and the intake camshaft sprocket. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.
4. Rotate the crankshaft 90 degrees to prevent interference between the valves and the pistons.

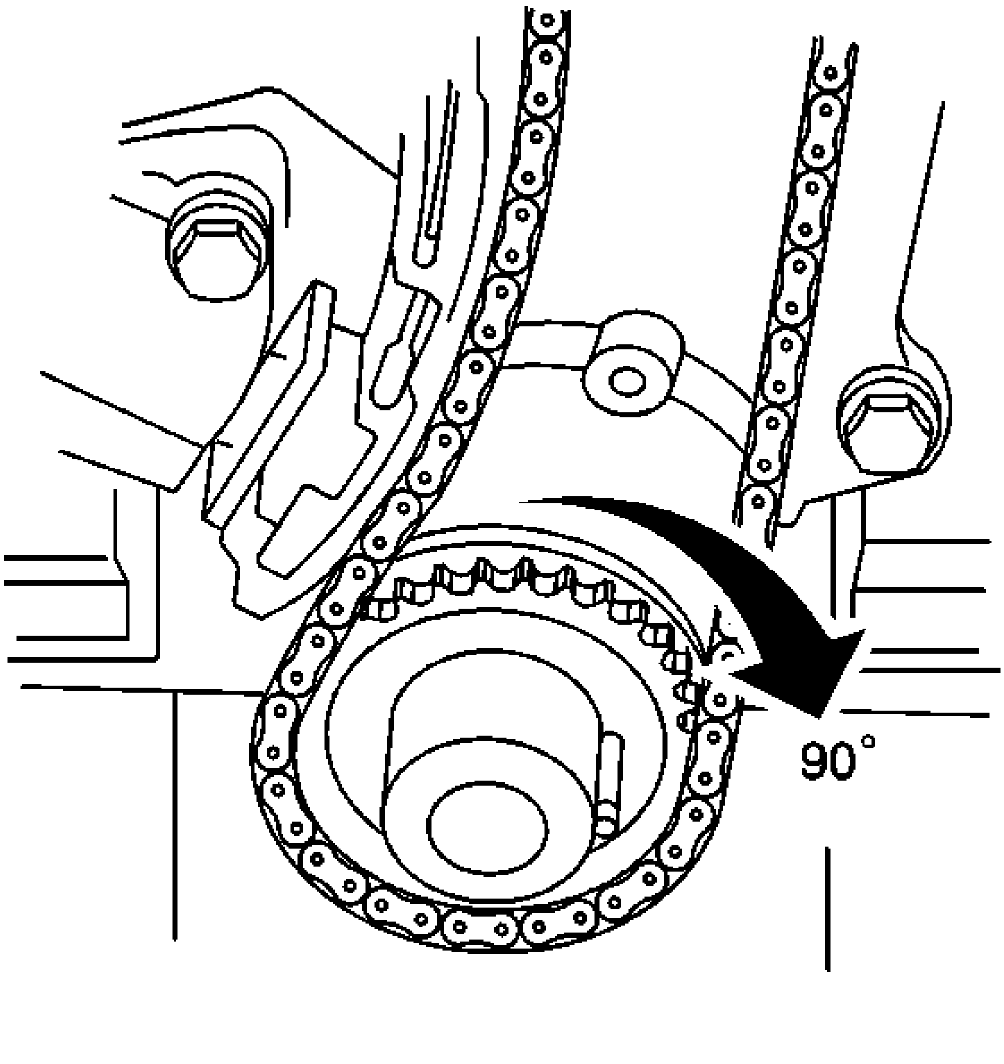


Fig. 112: Rotating Crankshaft
Courtesy of GENERAL MOTORS CORP.

5. Loosen the intake camshaft bearing caps in sequence.

6. Remove the intake camshaft bearing caps.
7. Remove the intake camshaft.

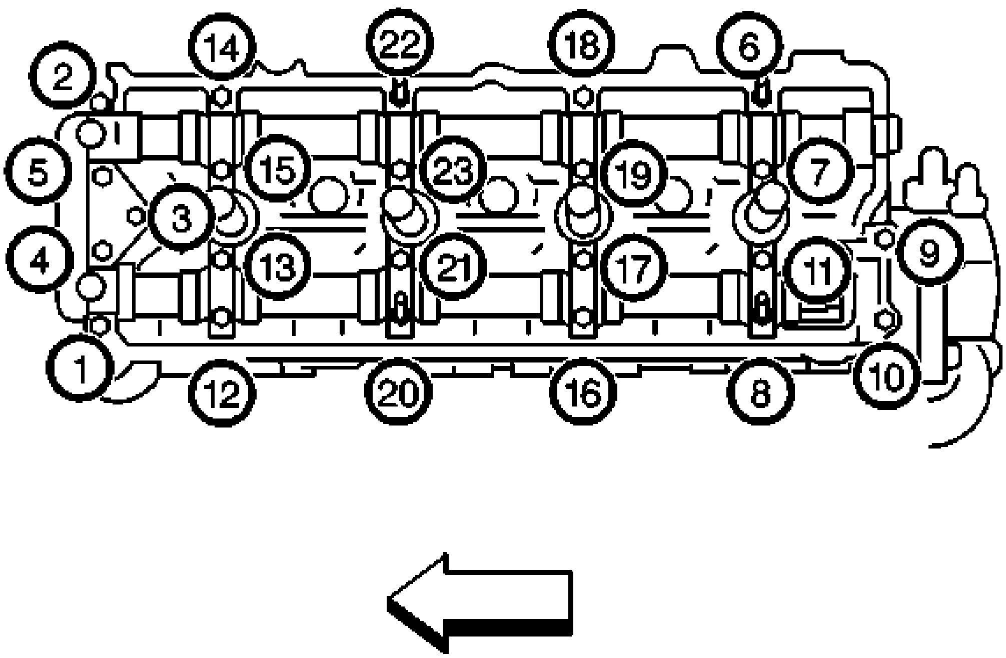


Fig. 113: View Of Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Store the valve lifters so that they can be installed in the same bore fr which they were removed.**
- **Do not disassemble the valve lifter.**
- **Do not apply force to the body or valve side of the valve lifter, this will force oil to leak out of the valve lifter.**
- **Store the valve lifters submerged in clean engine oil camshaft side do until installation.**
- **Store the valve lifters camshaft side up if left in air until installation. D not store in air with the camshaft side down or on the valve lifter side.**

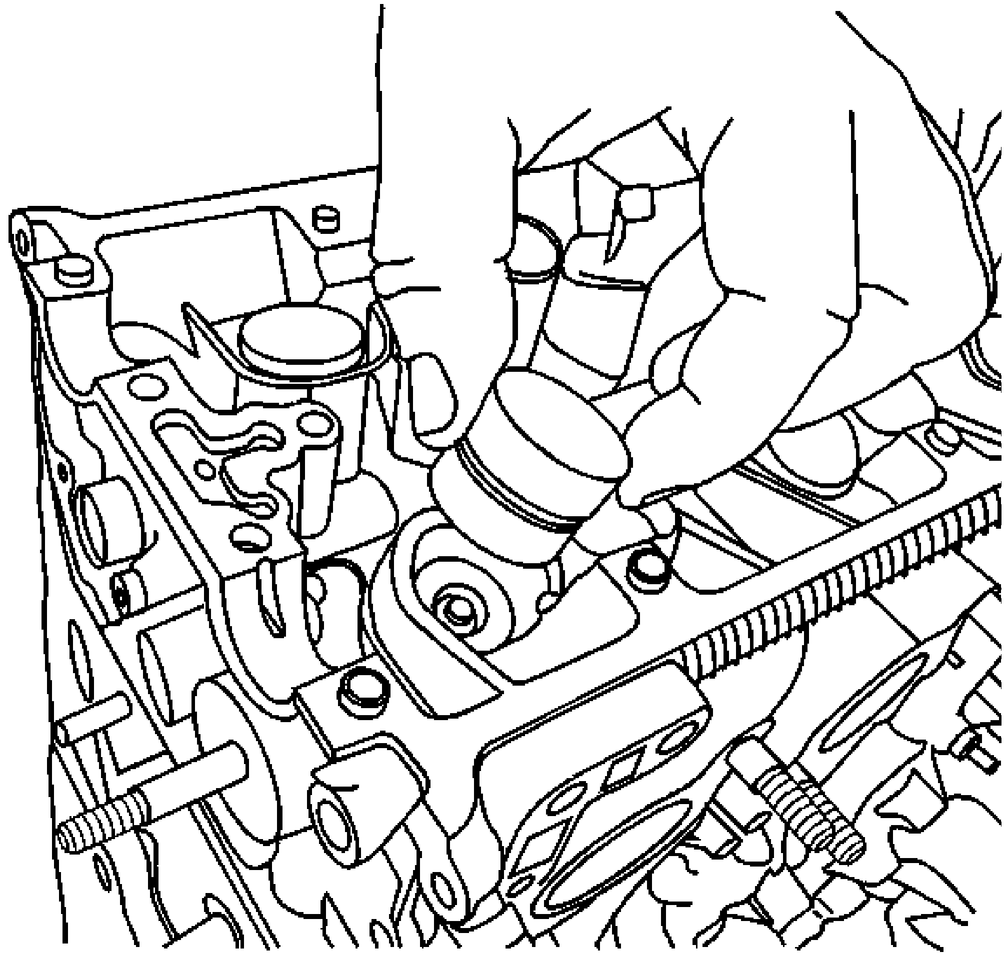


Fig. 114: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve lifters.

Inspection Procedure

1. Measure the camshaft lobe height using the **J 26900-2** . See **Special Tools and Equipment**. Replace the camshaft if any lobe is below the minimum.

   Standard Intake Camshaft Lobe Height: 40.402-40.562 mm (1.5906-1.5969 in)

   Minimum Intake Camshaft Lobe Height: 40.202 mm (1.5827 in)

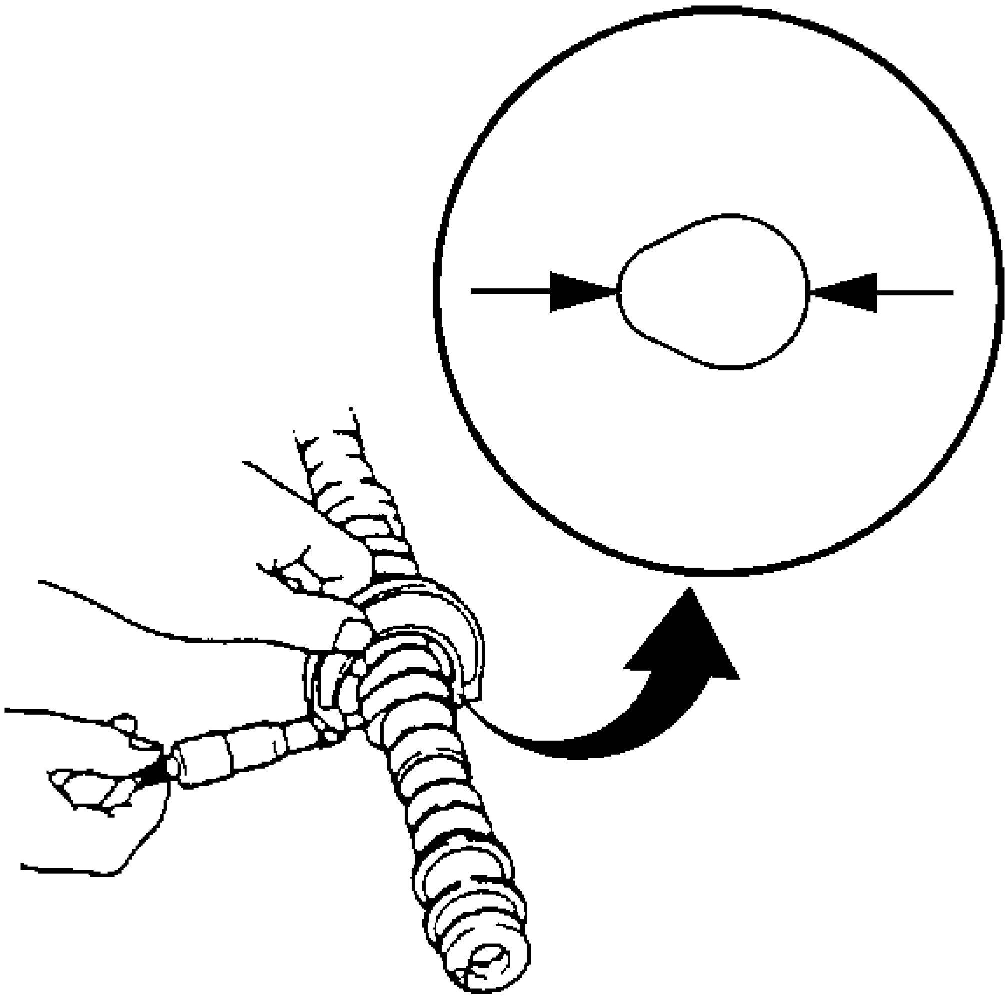


Fig. 115: View Of Camshaft Lobe
Courtesy of GENERAL MOTORS CORP.

2. Place the camshaft (1) onto V-blocks. Measure the camshaft runout using the **J 8001** with the **J 26900-13** . Replace the camshaft if the runout exceeds 0.10 mm (0.0039 in).

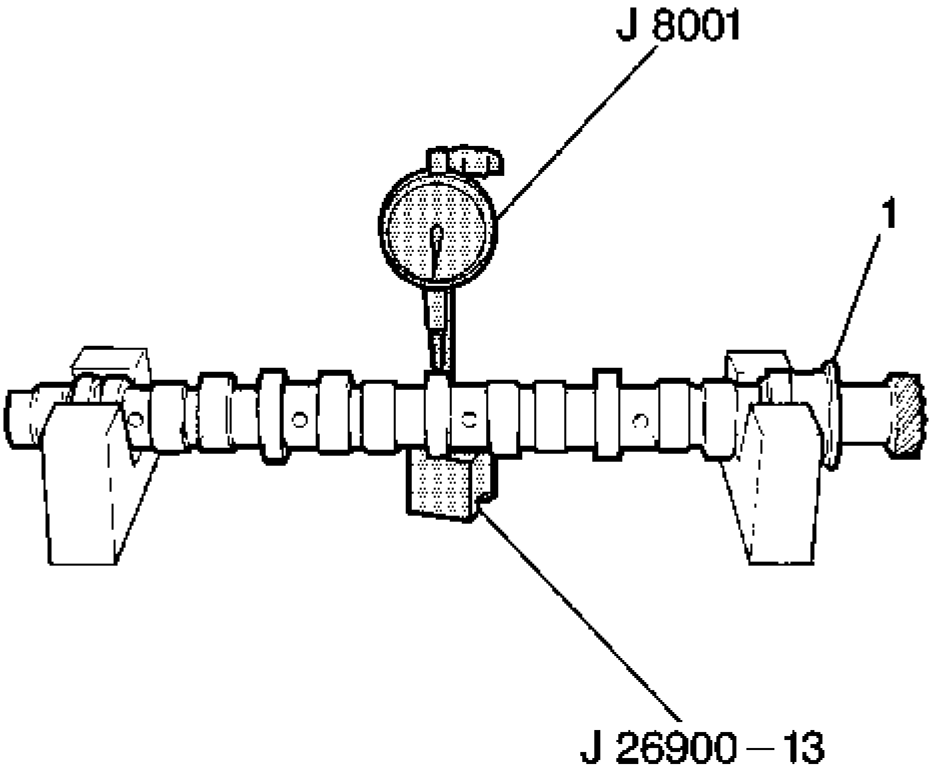


Fig. 116: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft bearing caps (1) for wear, cracks and scoring.
4. Inspect the camshaft bearing journals in the cylinder head for wear, cracks and scoring.
5. If excessive wear or scoring is present, or if the cylinder head is cracked, replace the cylinder head with bearing caps.
6. Clean the journals of the camshaft and the cylinder head.
7. Do not install the valve lifters.
8. Install the camshaft.

IMPORTANT: Do not turn the camshaft while the gauging plastic is installed.

9. Place a piece of gauging plastic across the full width of each camshaft journal.

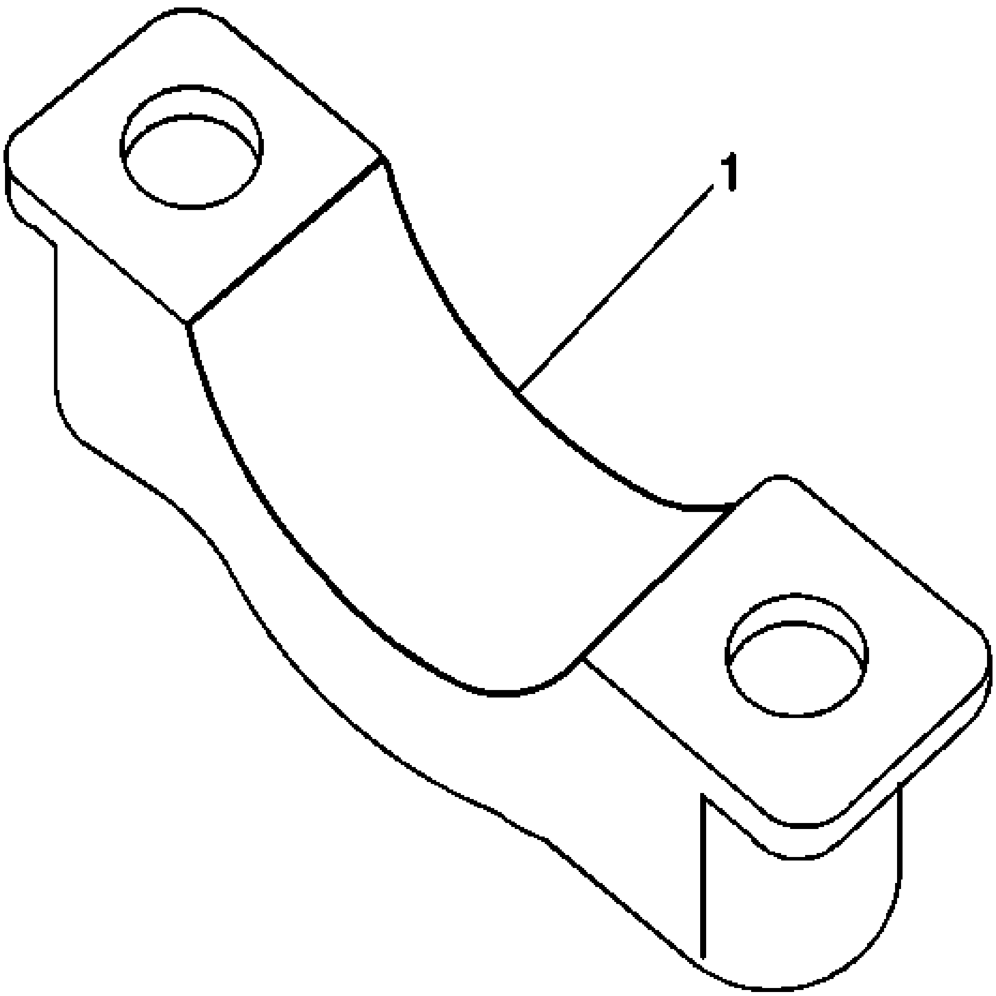


Fig. 117: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

10. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

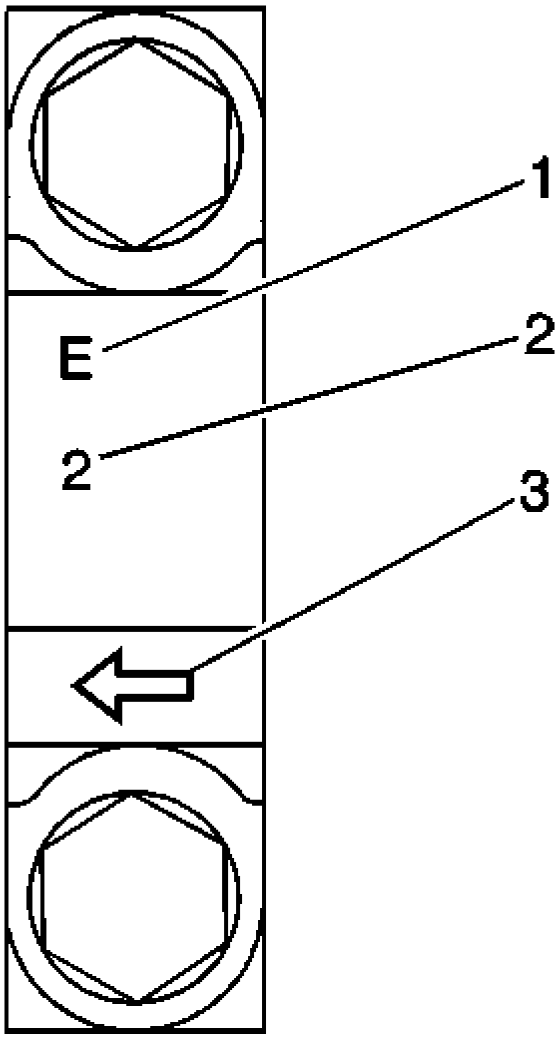


Fig. 118: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Use 3 progressive steps to tighten the camshaft bearing cap bolts in sequence.

    Tighten: Tighten the bolts to 11 N.m (97 lb in).

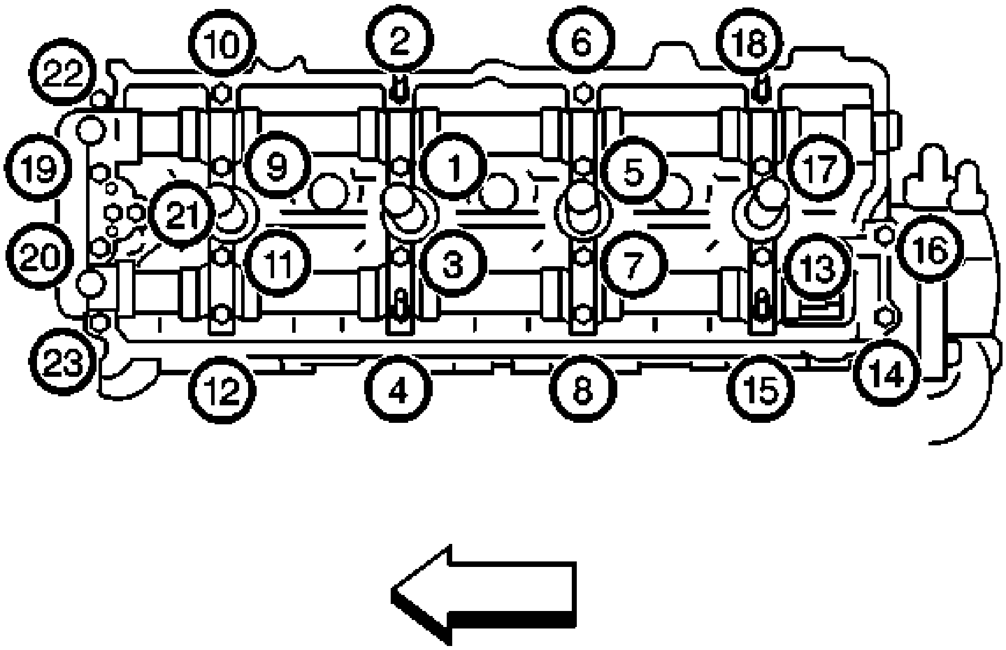


Fig. 119: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the camshaft bearing caps.
13. Measure the gauging plastic at its widest point (1).

    Standard Oil Clearance: 0.020-0.074 mm (0.0008-0.0029 in)

    Maximum Oil Clearance: 0.12 mm (0.0047 in)

14. If the clearance is greater than the maximum perform the following:
    1. Remove the camshaft.
    2. Measure the camshaft journal outside diameter with the **J 26900-2** . See **Special Tools and Equipment**.

       Camshaft Journal OD: 25.959-25.980 mm (1.0220-1.0228 in)

    3. Install the camshaft bearing caps and torque to 11 N.m (8 lb ft).
    4. Measure the camshaft journal inside (bore) diameter.

       Camshaft Bore ID: 26.000-26.033 mm (1.0236-1.0249 in)

15. Determine if the camshaft or the cylinder head shows more wear. Replace the component that shows the most wear.

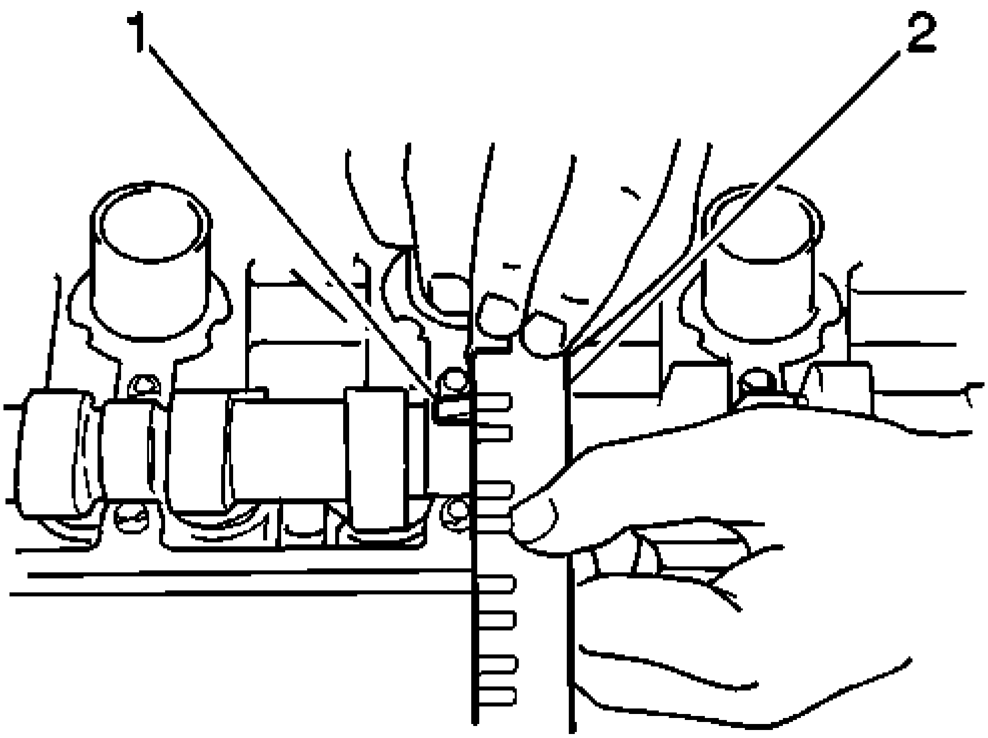


Fig. 120: Measuring Clearance of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

16. Inspect the valve lifters for wear, scoring and damage.
17. Measure the valve lifters with the **J 26900-2** . See **Special Tools and Equipment**.

    Valve Lifter OD: 30.959-30.975 mm (1.2189-1.2194 in)

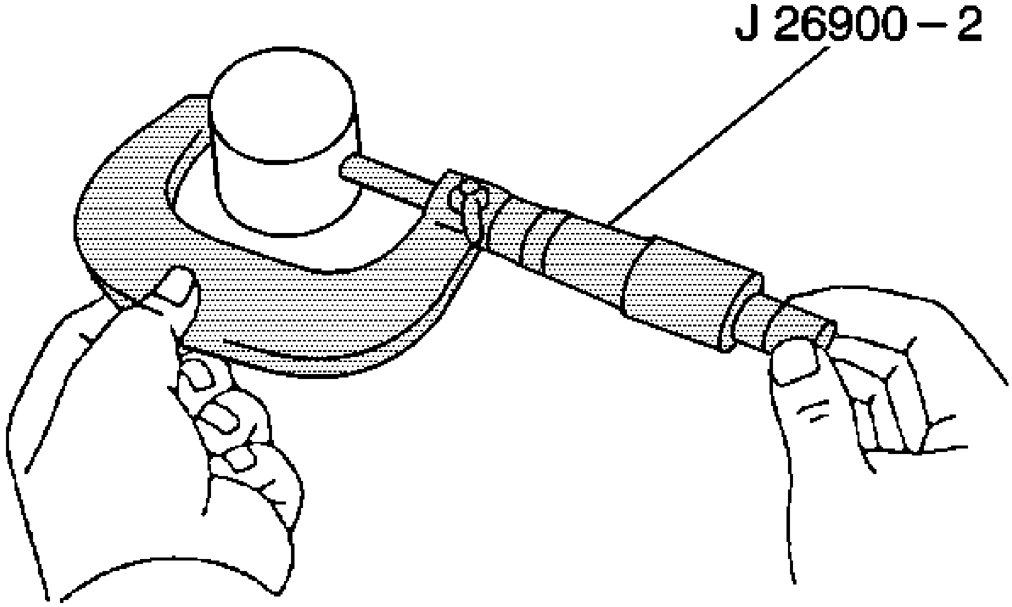


Fig. 121: View Of J 26900-2
Courtesy of GENERAL MOTORS CORP.

18. Measure the valve lifter bores in the cylinder head.

    Valve Lifter Bore ID: 31.000-31.025 mm (1.2205-1.2214 in)

19. The valve lifter-to-valve bore clearance is found by subtracting the valve lifter outside diameter from the valve lifter bore inside diameter.

    Standard Valve Lifter-to-Valve Bore Clearance: 0.025-0.066 mm (0.0010-0.0025 in)

    Maximum Valve Lifter-to-Valve Bore Clearance: 0.15 mm (0.0059 in)

20. If the oil clearance is greater than the maximum, replace the lifter. If the oil clearance is still greater than the maximum, replace the cylinder head.

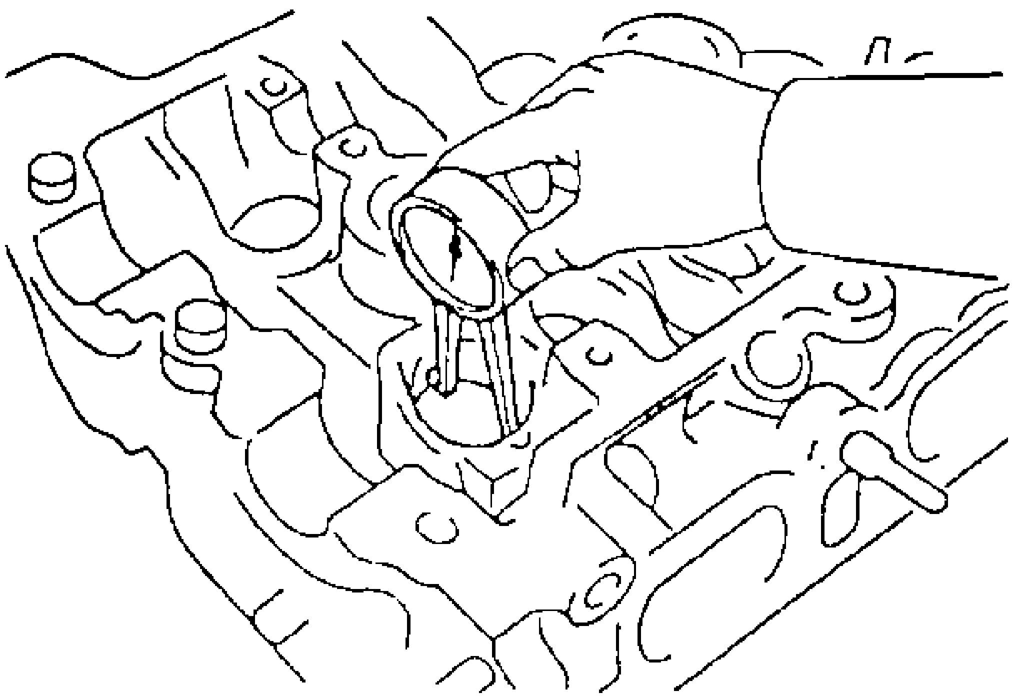


Fig. 122: Measuring Clearance Of Valve Lifter Bores
Courtesy of GENERAL MOTORS CORP.

21. Inspect that the oil control valve in the cylinder head is clean and that the check ball is free.

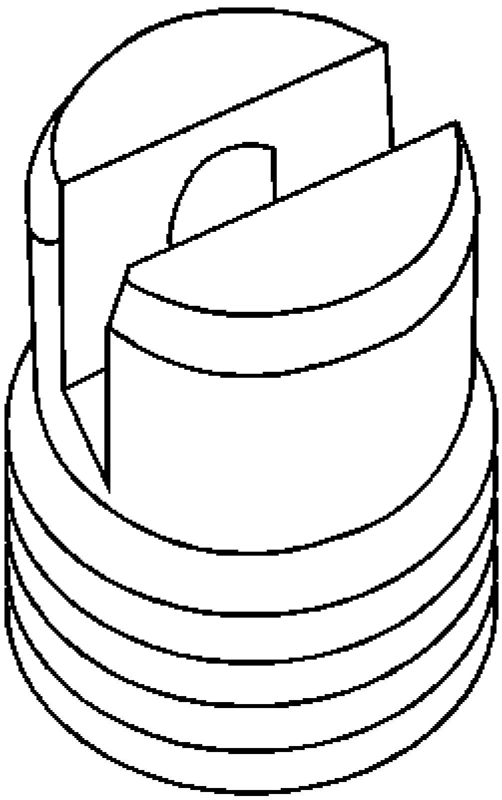


Fig. 123: View Of Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Pour engine oil into the oil feed hole in the valve lifter bore in order to flush any debris from the gallery and to prelube the bore.
2. Apply engine oil to the valve lifter and install the valve lifters in the same bore from which they were removed.

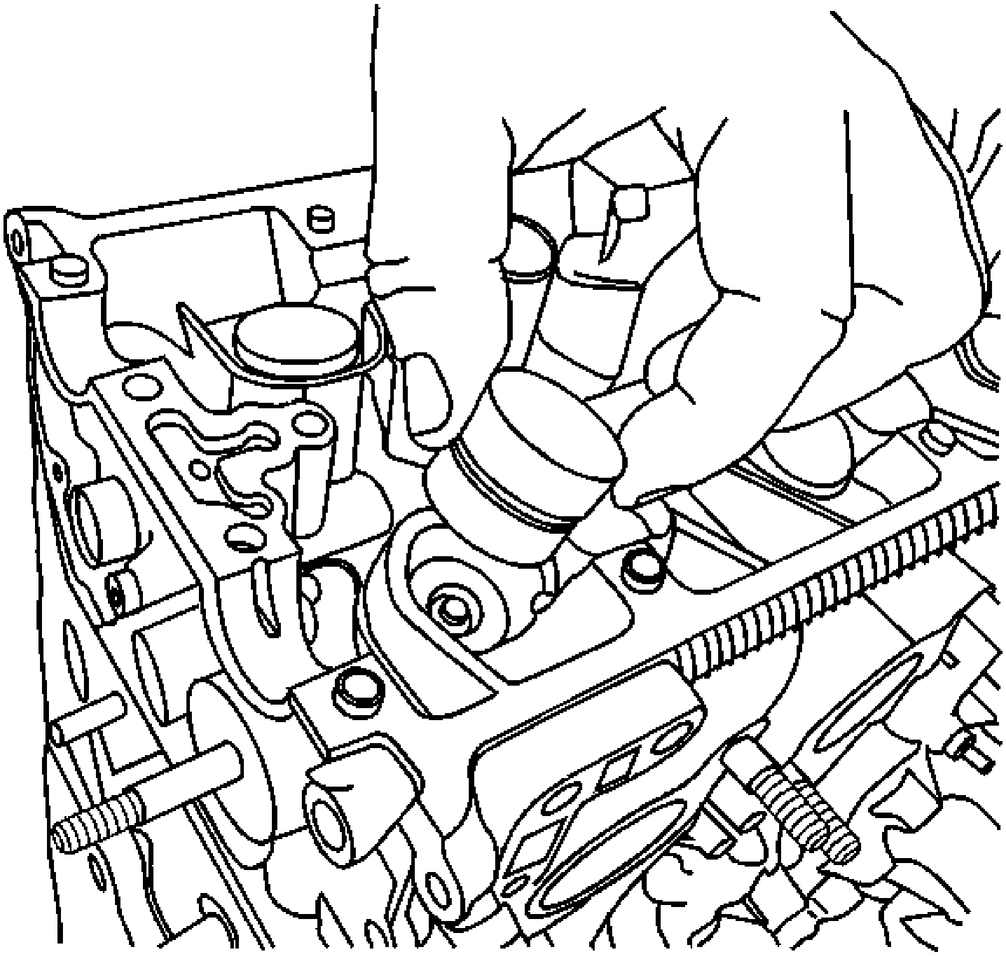


Fig. 124: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

3. Line up the crankshaft keyway with the timing mark on the engine block (3).

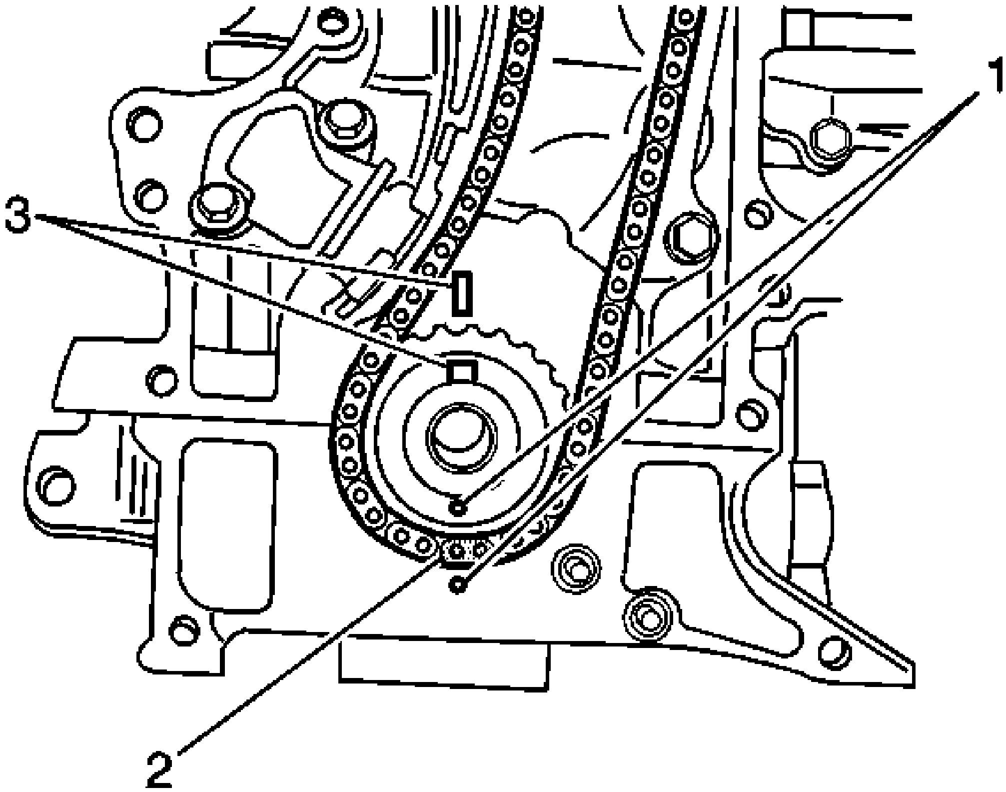


Fig. 125: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

4. Apply engine oil to the camshaft journals and lobes.
5. Install the camshaft aligning the guide pins (1) with the notches (3) on the cylinder head.

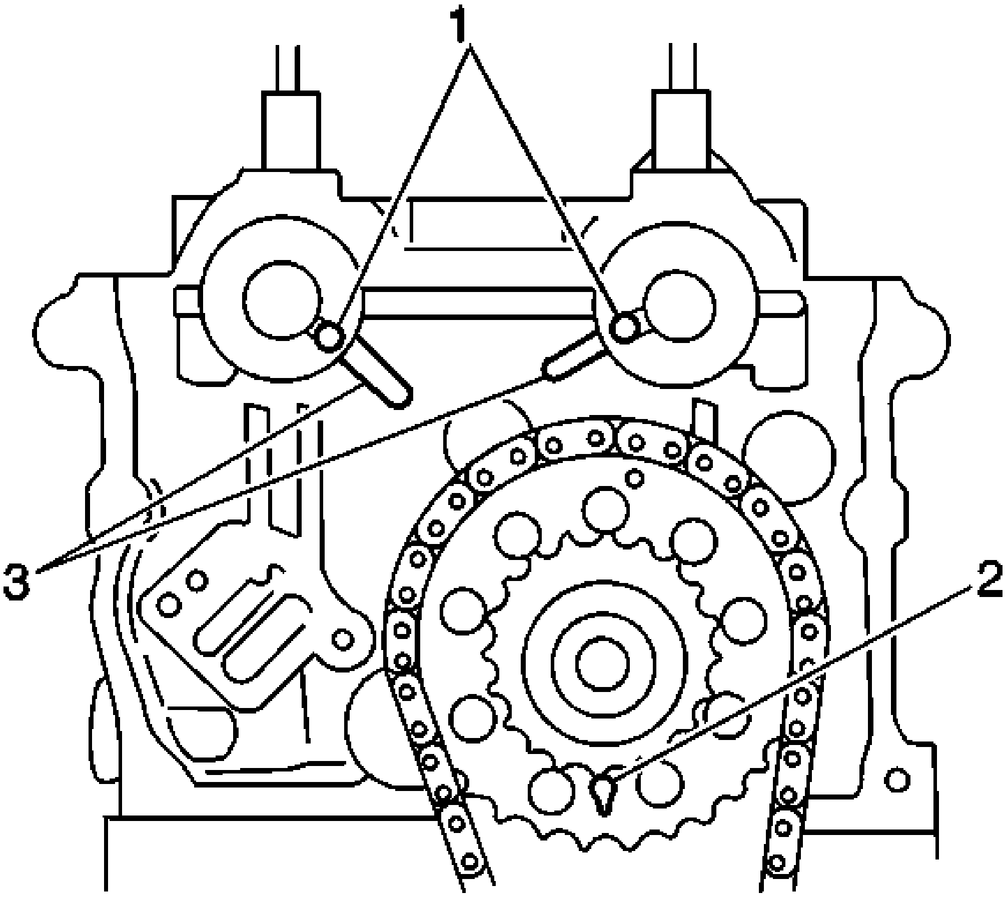


Fig. 126: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

6. Install the dowel pins (1) to the cylinder head.
7. Apply a bead of GM P/N 12346240 (Canadian P/N 10953493) or equivalent to the exhaust camshaft end housing (2).

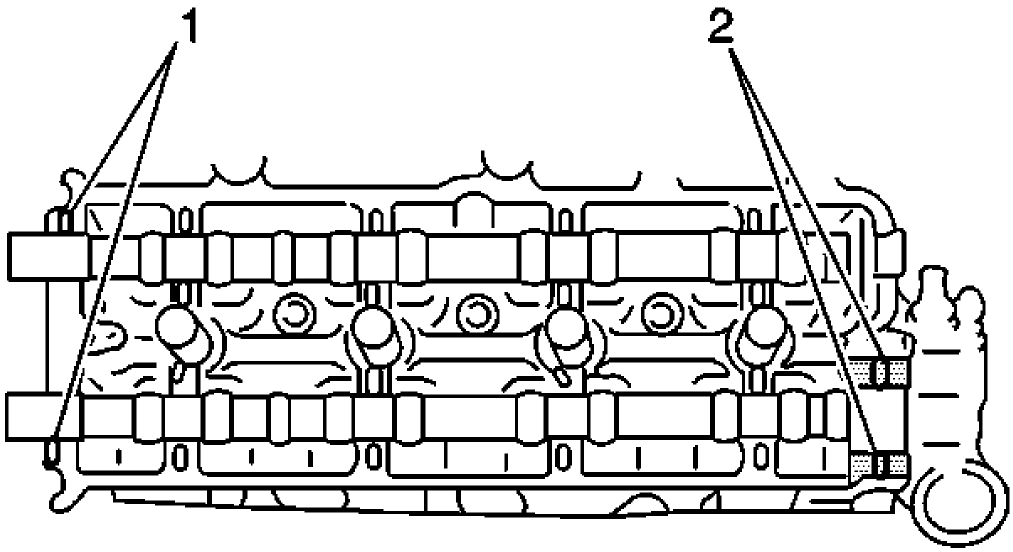


Fig. 127: View Of Exhaust Camshaft End Housing & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

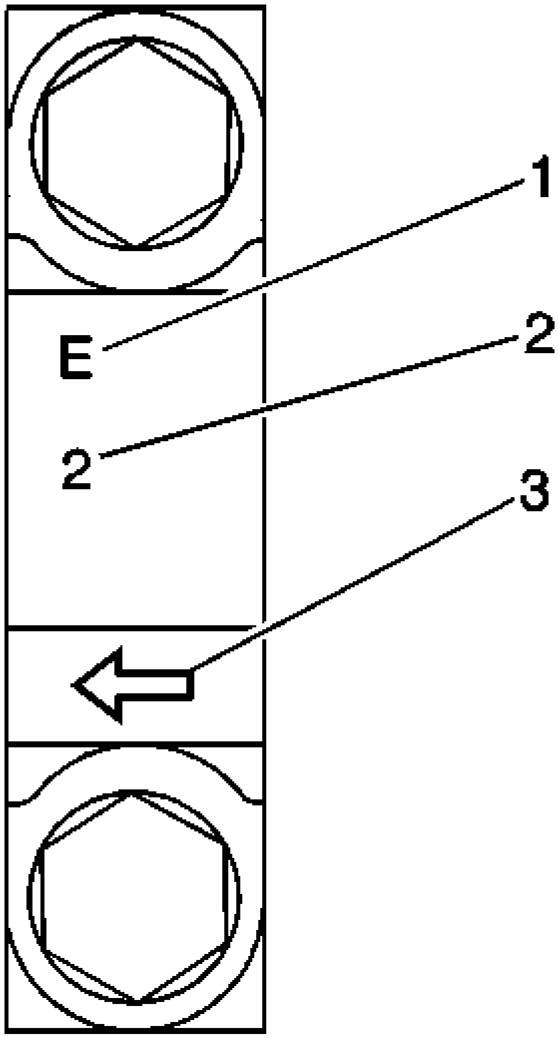


Fig. 128: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

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

9. Tighten the camshaft bearing caps.

   Tighten: Tighten the camshaft bearing caps in 3 progressive steps in the sequence shown to 11 N.m (97 lb in).

10. Install the intake camshaft sprocket and timing chain. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.
11. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.

NOTE: **Do not turn the camshafts or start the engine (valves should not be operated) for approximately 30 minutes after replacing the valve lifters and camshafts. Allow approximately 30 minutes for the valves to settle in place. Operating the valves before this time may cause valve or piston damage.**

IMPORTANT:

- **The valves may make a tapping/ticking sound after replacement if air is trapped in the valve lifter. Run the engine at 2000 RPM until the air is purged from the lifter.**
- **If the tapping/ticking does not stop, locate the defective lifter with a stethoscope and replace it. Or, remove the cylinder head cover with the engine stopped and push the lifter down by hand with a force less than 20 kg (44 lbs) when the camshaft is on the base circle. If clearance exists between the camshaft and the lifter, the lifter is defective and should be replaced.**

12. Connect the negative battery cable.
13. Inspect and adjust the ignition timing if necessary. Refer to **Ignition System Timing Adjustment Procedure** in Engine Controls.

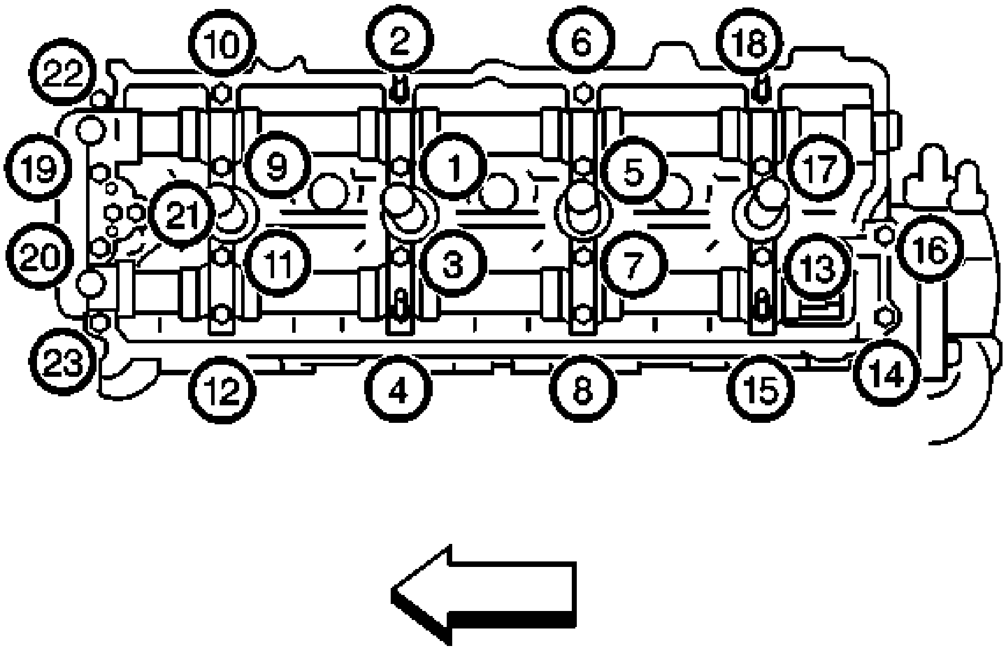


Fig. 129: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Exhaust Camshaft and Lifter Replacement

Tools Required

- **J 26900-2** Combimike Micrometer. See **Special Tools and Equipment**.
- **J 8001** Dial Indicator Set. See **Special Tools and Equipment**.
- **J 26900-13** Magnetic Indicator Base. See **Special Tools and Equipment**.

Removal Procedure

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

1. Disconnect the negative battery cable.
2. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
3. Remove the camshaft timing chain and the exhaust camshaft sprocket. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.

4. Apply matchmarks to the camshaft position sensor and the cylinder head and remove the camshaft position sensor.
5. Rotate the crankshaft 90 degrees to prevent interference between the valves and the pistons.

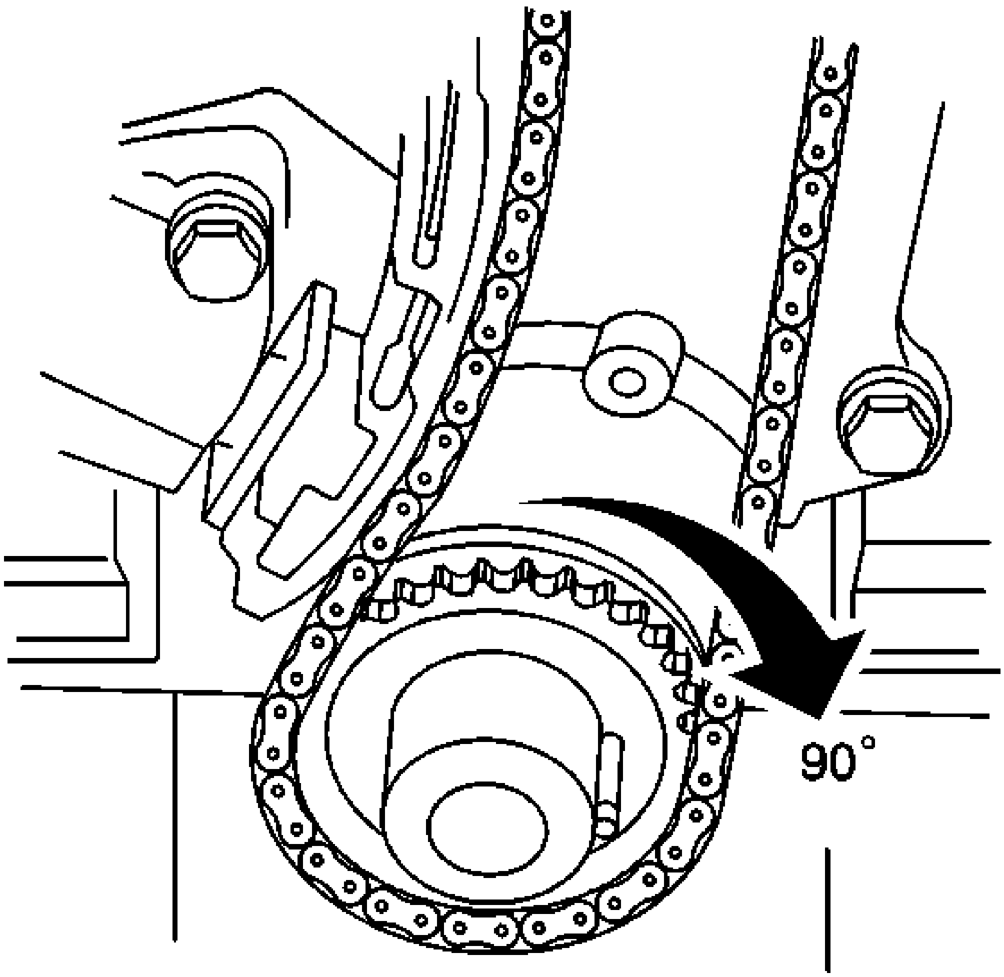


Fig. 130: Rotating Crankshaft
Courtesy of GENERAL MOTORS CORP.

6. Loosen the exhaust camshaft bearing caps in sequence.
7. Remove the exhaust camshaft bearing caps.
8. Remove the exhaust camshaft.

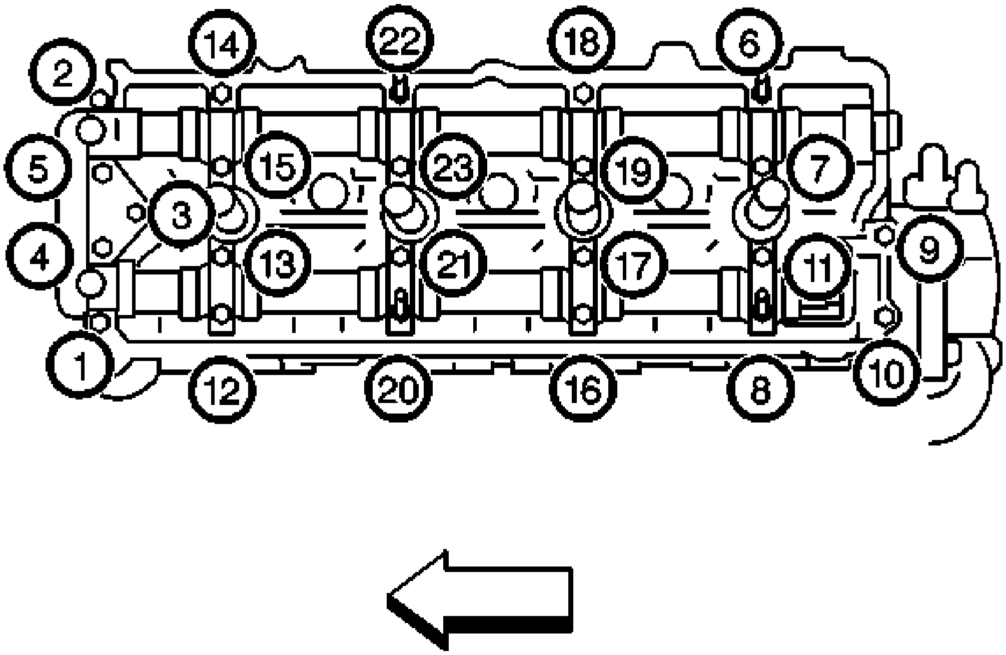


Fig. 131: View Of Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Store the valve lifters so that they can be installed in the same bore fr which they were removed.**
- **Do not disassemble the valve lifter.**
- **Do not apply force to the body or valve side of the valve lifter, this will force oil to leak out of the valve lifter.**
- **Store the valve lifters submerged in clean engine oil camshaft side do until installation.**
- **Store the valve lifters camshaft side up if left in air until installation. D not store in air with the camshaft side down or on the valve lifter side.**

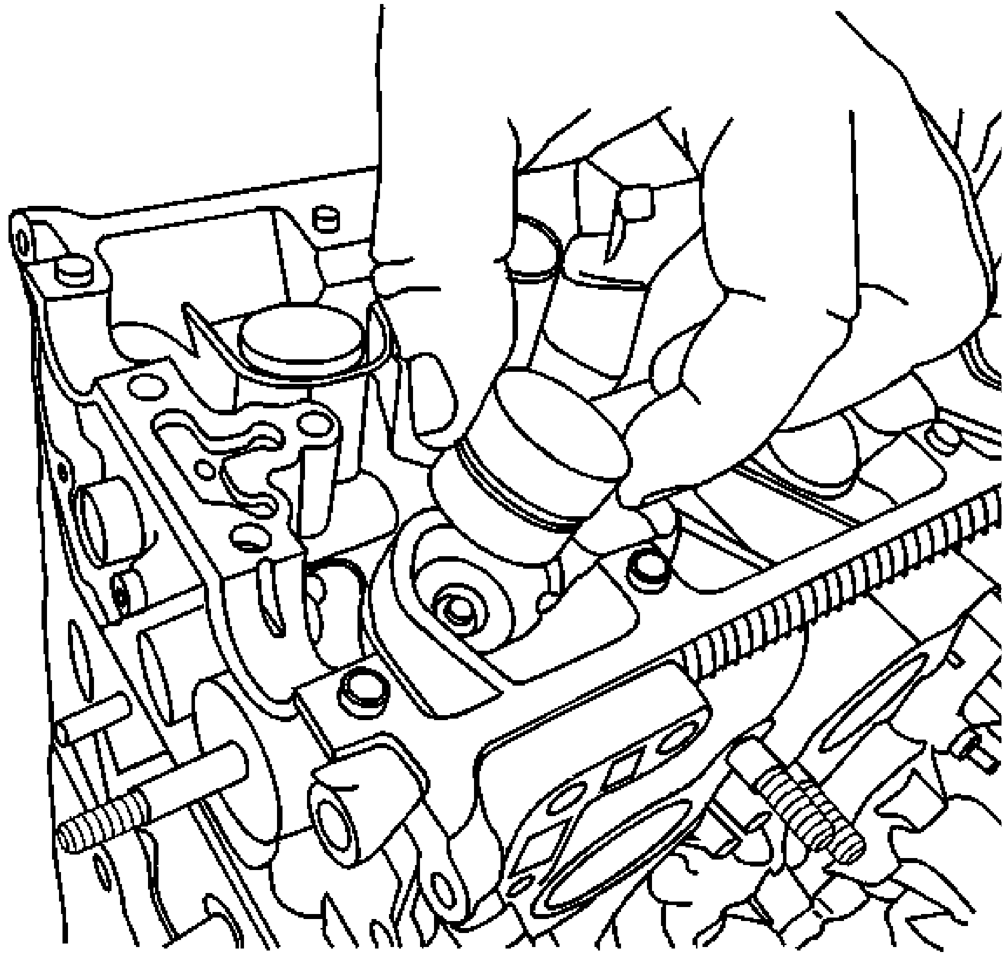


Fig. 132: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve lifters.

Inspection Procedure

1. Measure the camshaft lobe height using the **J 26900-2** . See **Special Tools and Equipment**. Replace the camshaft if any lobe is below the minimum.

   Standard Exhaust Camshaft Lobe Height: 39.921-40.081 mm (1.5717-1.5780 in)

   Minimum Exhaust Camshaft Lobe Height: 39.721 mm (1.5638 in)

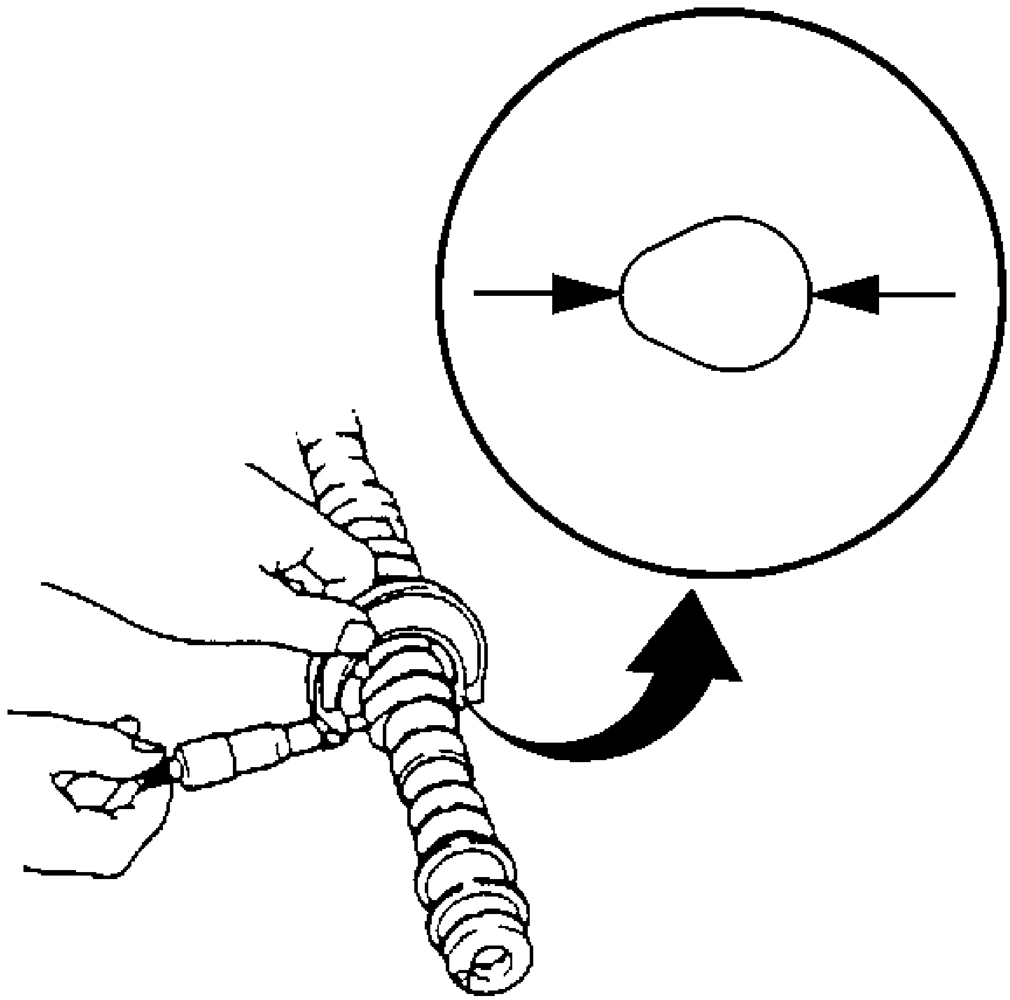


Fig. 133: View Of Camshaft Lobe
Courtesy of GENERAL MOTORS CORP.

2. Place the camshaft (1) onto V-blocks. Measure the camshaft runout using the **J 8001** with the **J 26900-13** . Replace the camshaft if the runout exceeds 0.10 mm (0.0039 in).

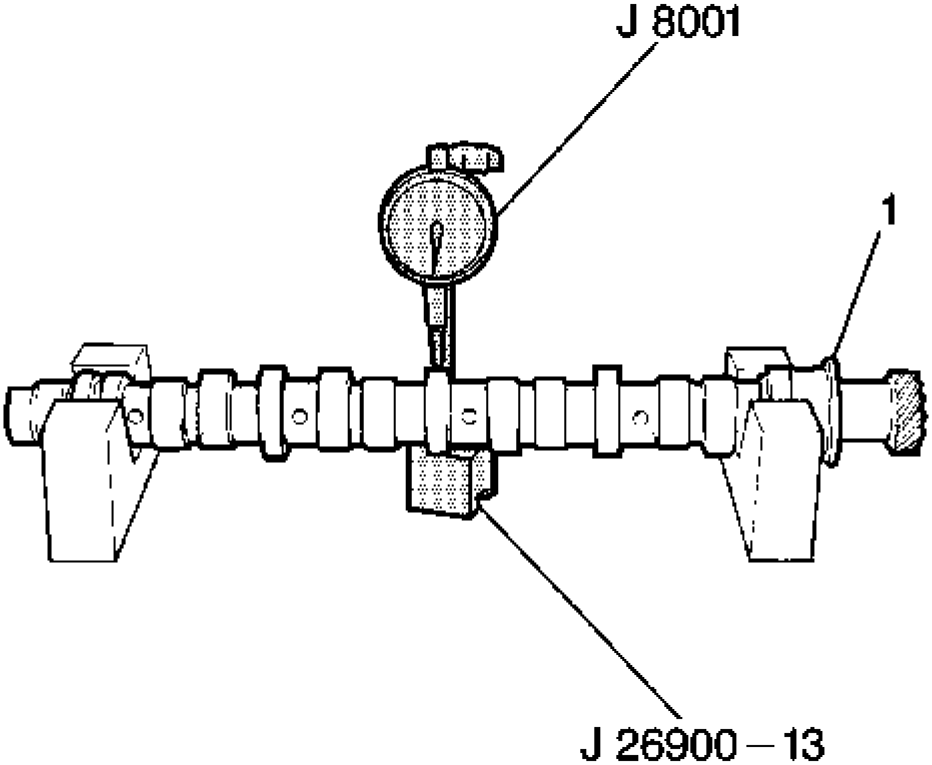


Fig. 134: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft bearing caps (1) for wear, cracks and scoring.
4. Inspect the camshaft bearing journals in the cylinder head for wear, cracks and scoring.
5. If excessive wear or scoring is present, or if the cylinder head is cracked, replace the cylinder head with bearing caps.
6. Clean the journals of the camshaft and the cylinder head.
7. Do not install the valve lifters.
8. Install the camshafts. The rear end of the exhaust camshaft is slotted to mate with the camshaft position sensor.

IMPORTANT: Do not turn the camshafts while the gauging plastic is installed.

9. Place a piece of gaging plastic across the full width of each camshaft journal.

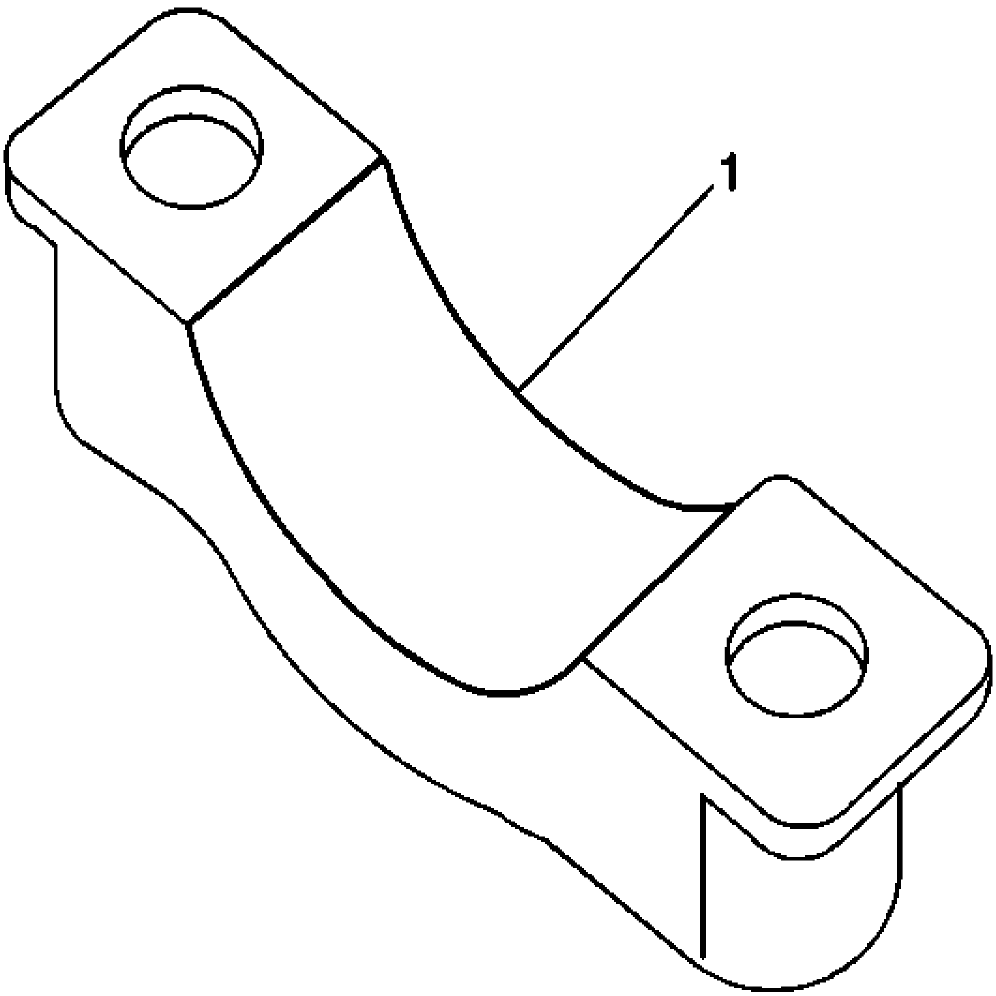


Fig. 135: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

10. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

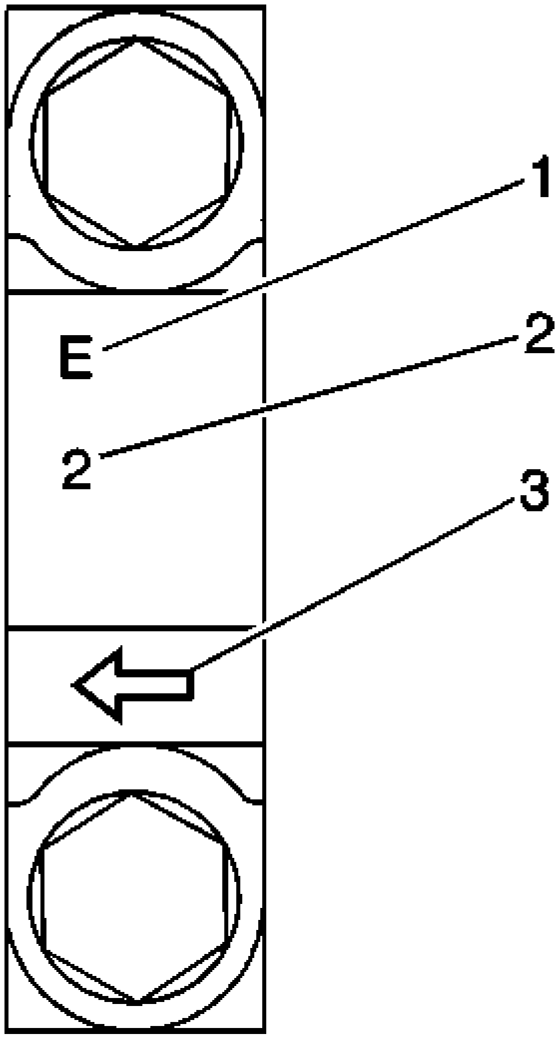
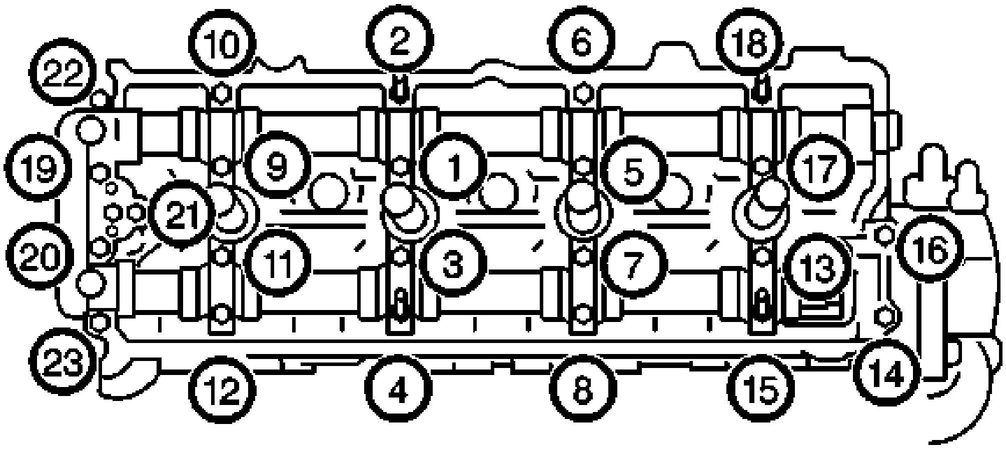


Fig. 136: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Use 3 progressive steps to tighten the camshaft bearing cap bolts in sequence.

    Tighten: Tighten the bolts to 11 N.m (97 lb in).



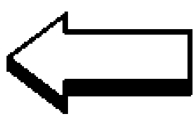


Fig. 137: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the camshaft bearing caps.
13. Measure the gaging plastic at its widest point (1).

    Standard Oil Clearance: 0.020-0.074 mm (0.0008-0.0029 in)

    Maximum Oil Clearance: 0.12 mm (0.0047 in)

14. If the clearance is greater than the maximum perform the following:
    1. Remove the camshaft.
    2. Measure the camshaft journal outside diameter with the **J 26900-2** . See **Special Tools and Equipment**.

       Camshaft OD: 25.959-25.980 mm (1.0220-1.0228 in)

    3. Install the camshaft bearing caps and torque to 11 N.m (97 lb in).
    4. Measure the camshaft journal inside (bore) diameter.

       Camshaft Bore ID: 26.000-26.033 mm (1.0236-1.0249 in)

15. Determine if the camshaft or the cylinder head shows more wear. Replace the component that shows the most wear.

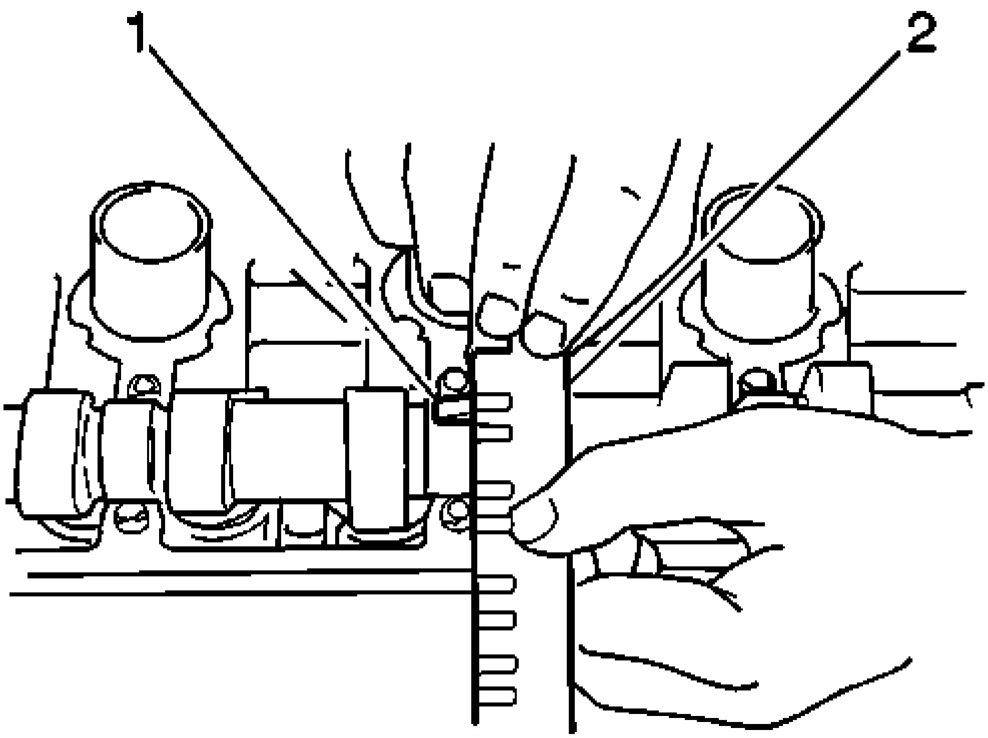


Fig. 138: Measuring Clearance of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

16. Inspect the valve lifters for wear, scoring and damage.
17. Measure the valve lifters with the **J 26900-2** . See **Special Tools and Equipment**.

    Valve Lifter OD: 30.959-30.975 mm (1.2189-1.2194 in)

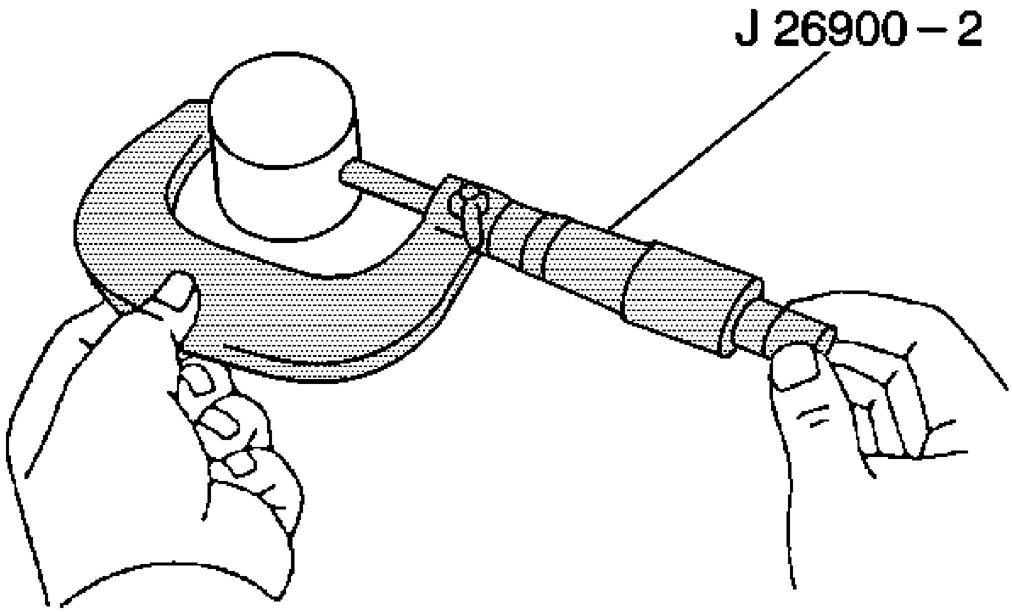


Fig. 139: View Of J 26900-2
Courtesy of GENERAL MOTORS CORP.

18. Measure the valve lifter bores in the cylinder head.

    Valve Lifter Bore ID: 31.000-31.025 mm (1.2205-1.2214 in)

19. The valve lifter-to-valve bore clearance is found by subtracting the valve lifter outside diameter from the valve lifter bore inside diameter.

    Standard Valve Lifter-to-Valve Bore Clearance: 0.025-0.066 mm (0.0010-0.0025 in)

    Maximum Valve Lifter-to-Valve Bore Clearance: 0.15 mm (0.0059 in)

20. If the oil clearance is greater than the maximum, replace the lifter. If the oil clearance is still greater than the maximum, replace the cylinder head.

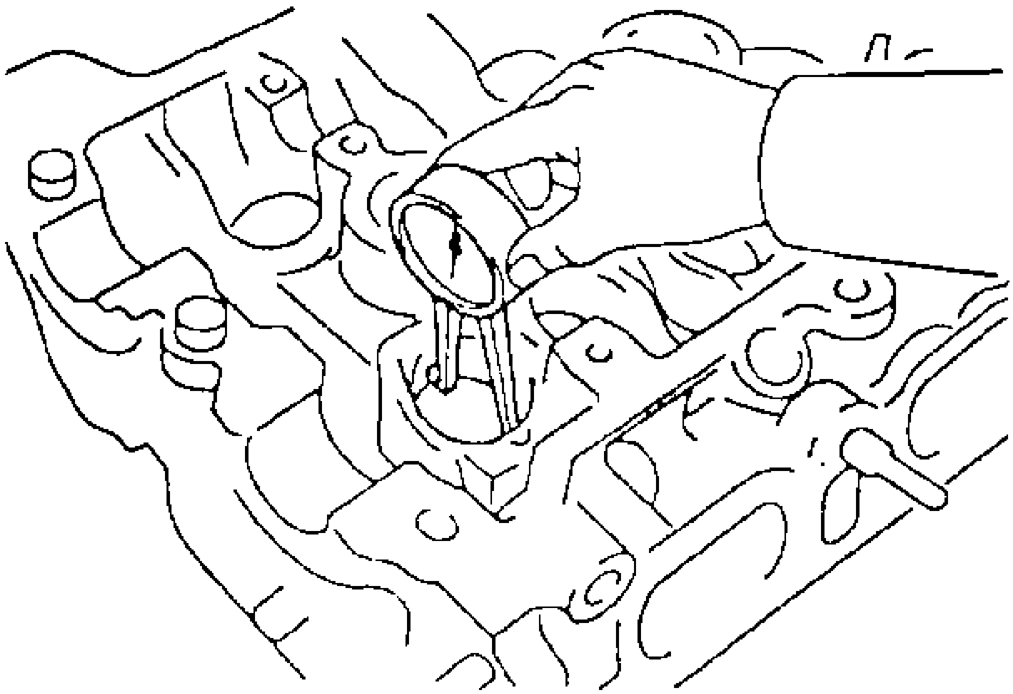


Fig. 140: Measuring Clearance Of Valve Lifter Bores
Courtesy of GENERAL MOTORS CORP.

21. Inspect that the oil control valve in the cylinder head is clean and that the check ball is free.

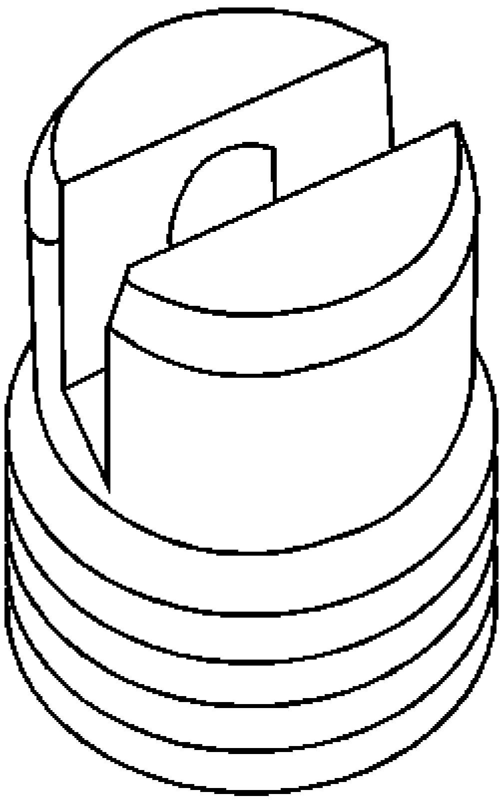


Fig. 141: View Of Oil Control Valve
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Pour engine oil into the oil feed hole in the valve lifter bore in order to flush any debris from the gallery and to prelube the bore.
2. Apply engine oil to the valve lifter and install the valve lifters in the same bore from which they were removed.

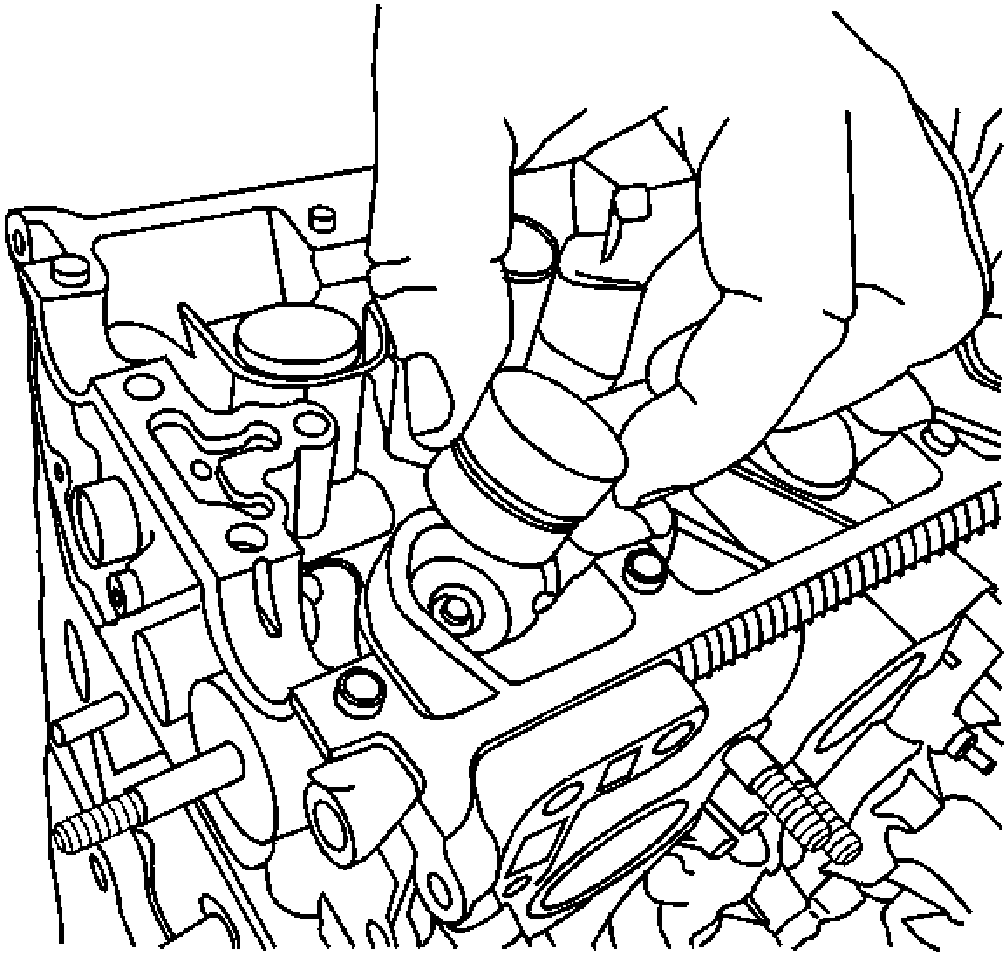


Fig. 142: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

3. Line up the crankshaft keyway with the timing mark on the engine block (3).

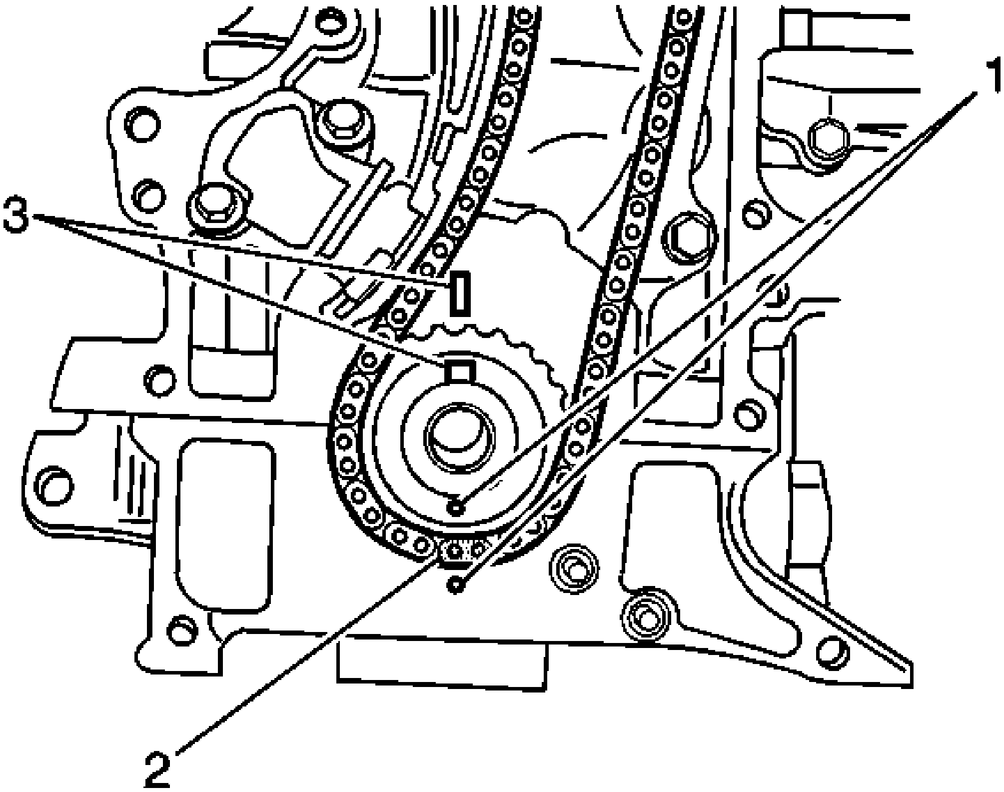


Fig. 143: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

4. Apply engine oil to the camshaft journals and lobes.
5. Install the camshafts aligning the guide pins (1) with the notches (3) on the cylinder head. The exhaust camshaft rear end is slotted to mate with the camshaft position sensor.

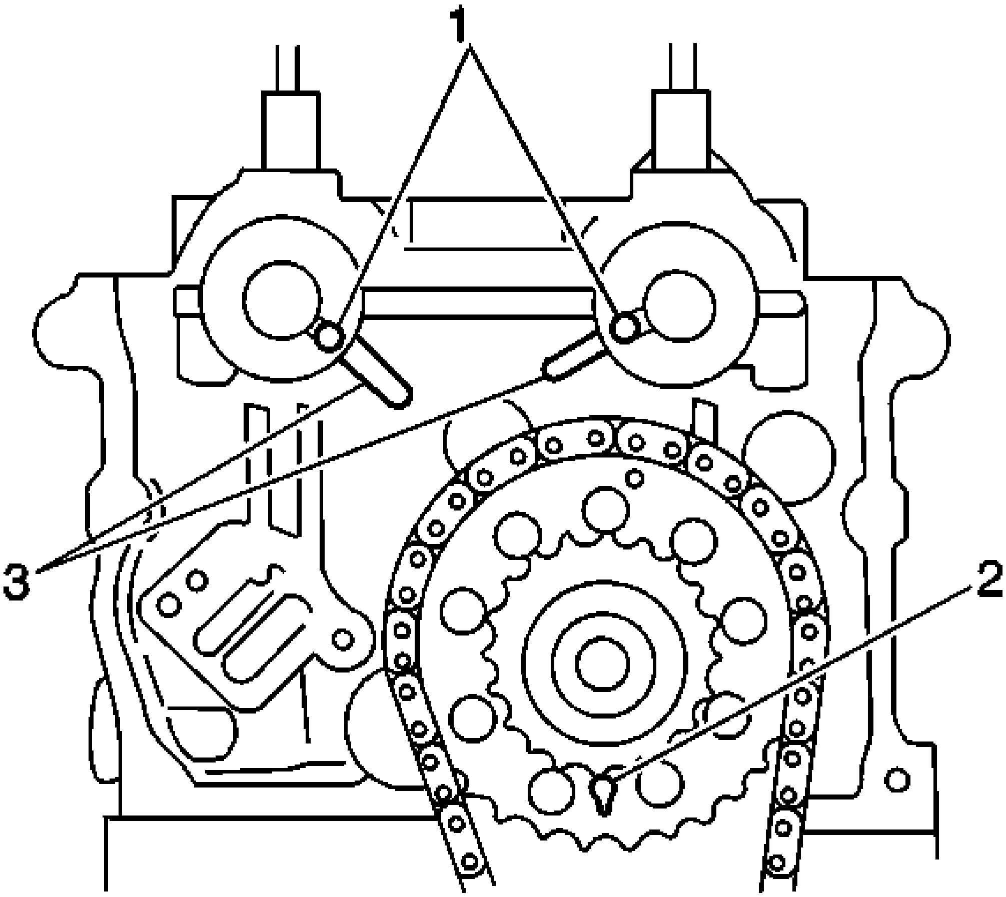


Fig. 144: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

6. Install the dowel pins (1) to the cylinder head.
7. Apply a bead of GM P/N 12346240 (Canadian P/N 10953493) or equivalent to the exhaust camshaft end housing (2).

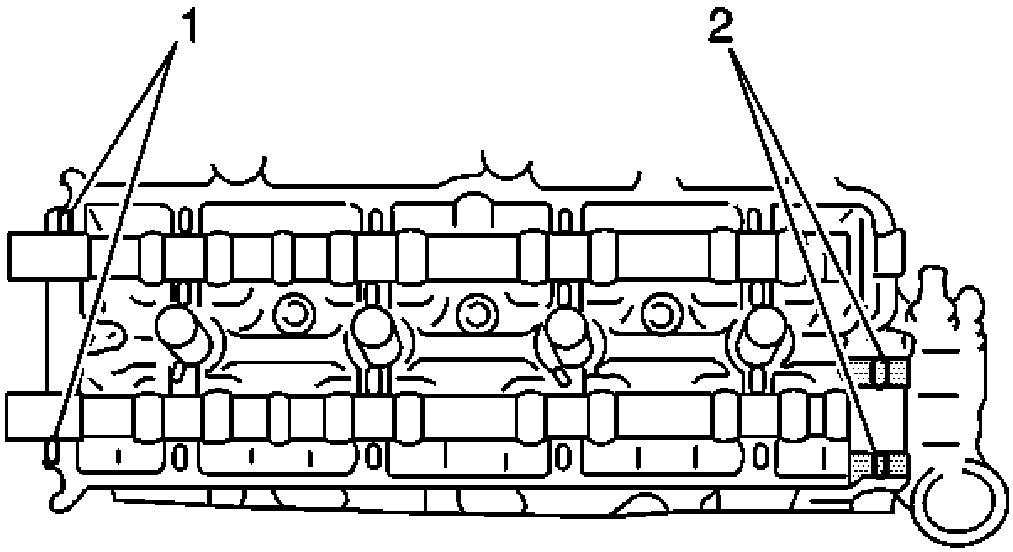


Fig. 145: View Of Exhaust Camshaft End Housing & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

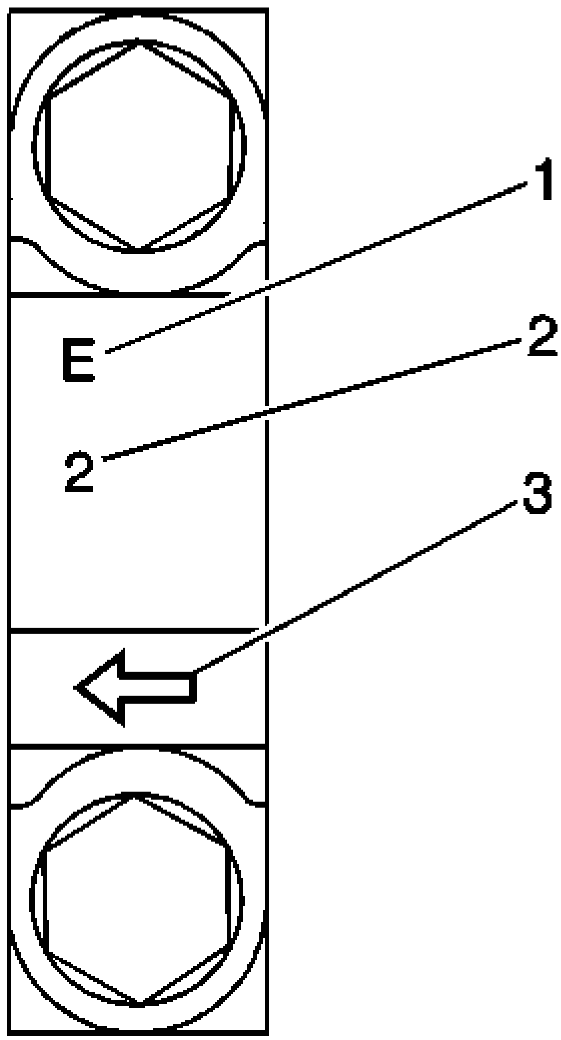


Fig. 146: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

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

9. Tighten the camshaft bearing caps.

   Tighten: Tighten the camshaft bearing caps in 3 progressive steps in the sequence shown to 11 N.m (97 lb in).

10. Align the matchmarks and install the camshaft position sensor (CMP). The sensor shaft is offset and can only be installed 1 way. Secure the CMP with the bolt.
11. Install the exhaust camshaft sprocket and the timing chain. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.
12. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.

NOTE: **Do not turn the camshafts or start the engine (valves should not be operated) for approximately 30 minutes after replacing the valve lifters and camshafts. Allow approximately 30 minutes for the valves to settle in place. Operating the valves before this time may cause valve or piston damage.**

IMPORTANT:

- **The valves may make a tapping/ticking sound after replacement if air is trapped in the valve lifter. Run the engine at 2000 RPM until the air is purged from the lifter.**
- **If the tapping/ticking does not stop, locate the defective lifter with a stethoscope and replace. Or, remove the cylinder head cover with the engine stopped and push the lifter down by hand with a force less than 20 kg (44 lbs) when the camshaft is on the base circle. If clearance exists between the camshaft and the lifter the lifter is defective and should be replaced.**

13. Connect the negative battery cable.
14. Inspect and adjust the ignition timing if necessary. Refer to **Ignition System Timing Adjustment Procedure** in Engine Controls.

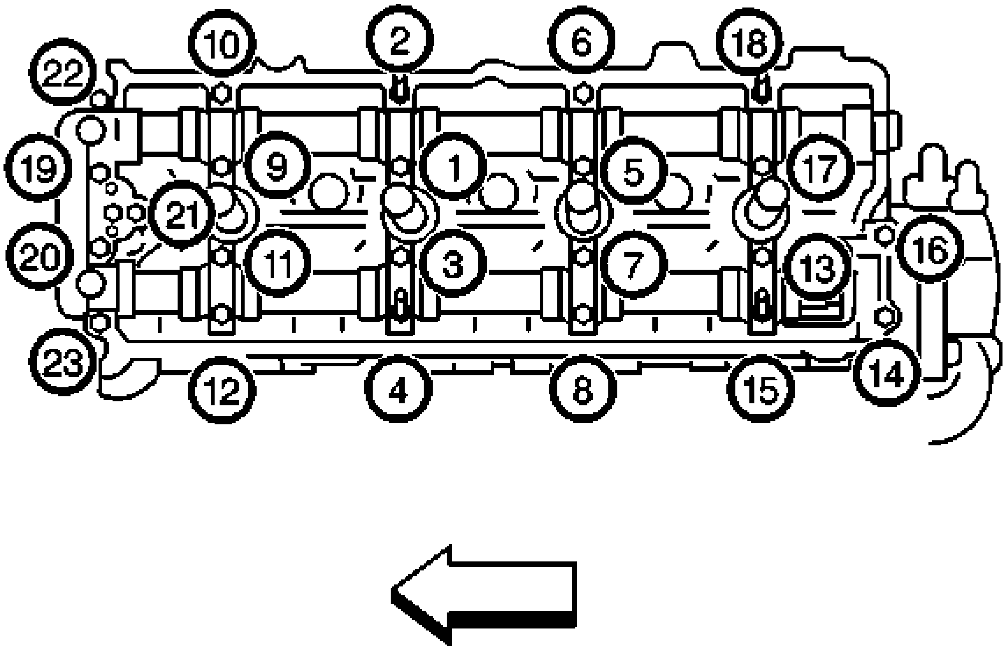


Fig. 147: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Replacement

Removal Procedure

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls.

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

2. Disconnect the negative battery cable.
3. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
4. Remove the air cleaner hose.
5. Remove the 1 bolt and the throttle cable bracket (2) from the intake manifold.
6. Remove the cables from the throttle body bellcrank and position aside.

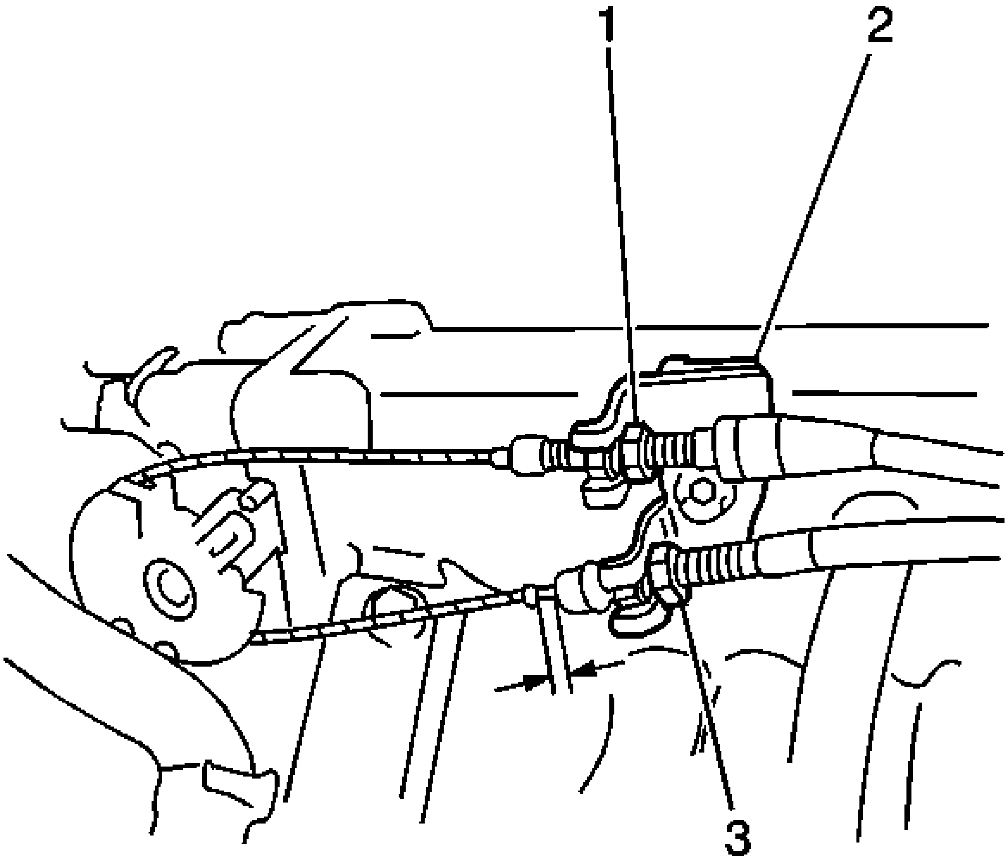


Fig. 148: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The vehicle should be supported on a hoist prior to removing the strut tower brace. This will facilitate installation of the brace.

7. Remove the strut tower brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.

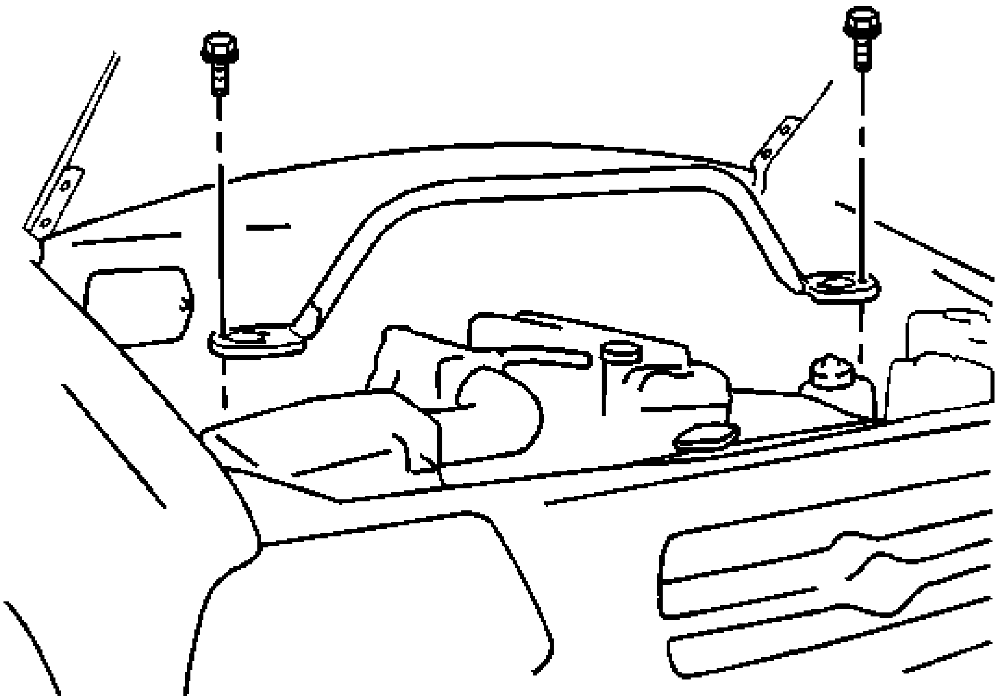


Fig. 149: View Of Strut Tower Brace
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the following electrical connectors:
   - The manifold absolute pressure (MAP) sensor (11)
   - The throttle position sensor (TPS) (8)
   - The idle air control (IAC) valve (6)
   - The EVAP canister purge valve (7)
   - The engine coolant temperature (ECT) sensor (2)
   - The exhaust gas recirculation (EGR) valve (1)
   - The fuel injector harness (3)
9. Disconnect the ground wires from the intake manifold (10)
10. Remove the EVAP canister purge hose from the intake manifold.
11. Remove the EVAP vacuum line from the intake manifold.
12. Remove the 1 bolt and the EVAP canister purge valve from the intake manifold and position aside.
13. Remove the coolant hoses (4,5) from the throttle body and intake manifold.
14. Remove the 2 bolts and the coolant line (5) from underside of the intake manifold.

15. Remove the brake booster hose from the intake manifold.
16. Remove the PCV hose from the intake manifold.
17. Remove the breather hose from the intake manifold.
18. Remove the fuel hoses from the fuel lines (9). Mark the pressure and return lines for correct assembly.
19. Disconnect the wiring harness from the retaining clamps.

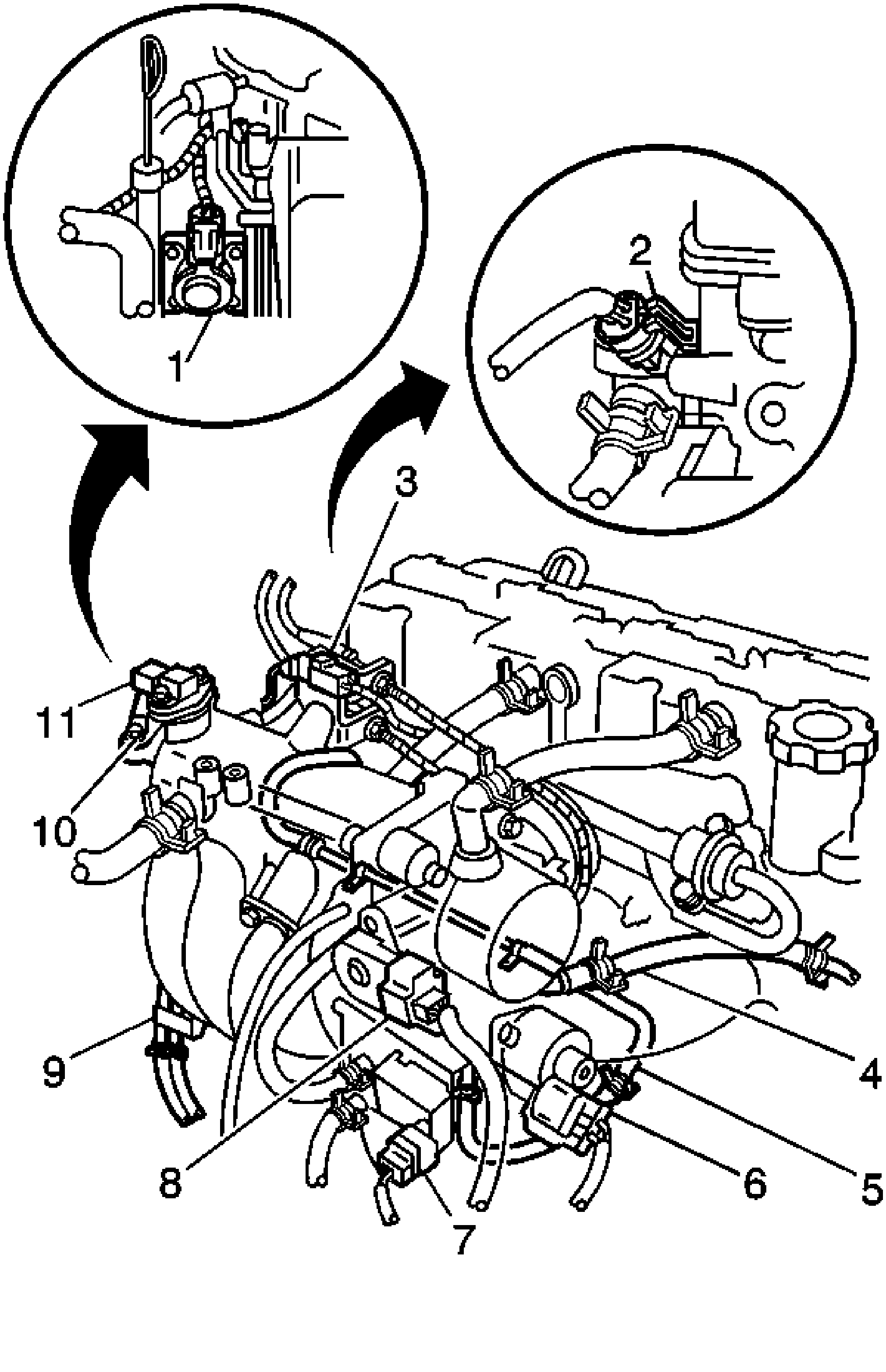


Fig. 150: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

20. Remove the 2 bolts and the intake manifold front support bracket.

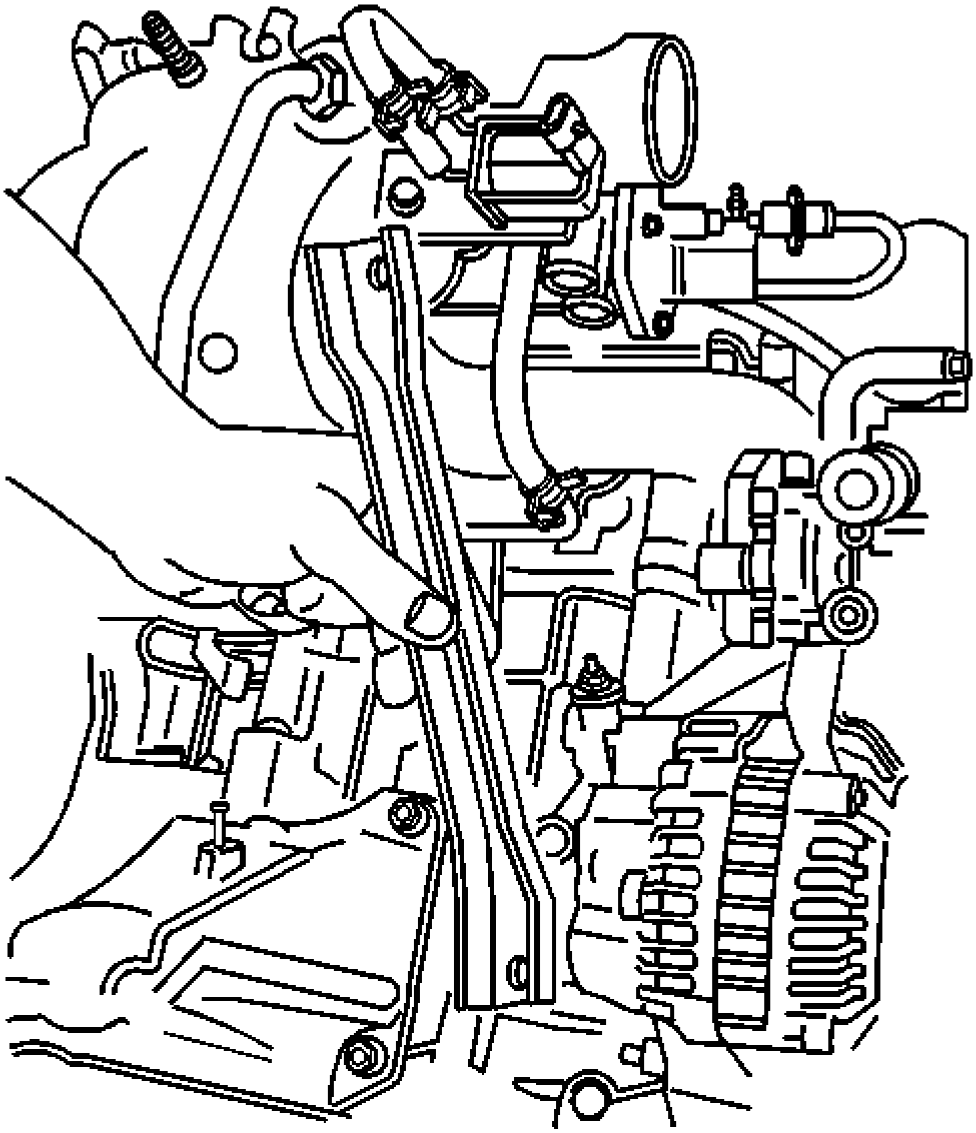


Fig. 151: View Of Intake Manifold Front Support Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

21. Remove the oxygen sensor connector from the exhaust manifold bracket. Disconnect the oxygen sensor.

22. Remove the exhaust manifold-to-engine block bracket.
23. Remove the 8 nuts and 1 bolt from the exhaust manifold. Detach the exhaust manifold from the cylinder head and position aside. Refer to **Exhaust Manifold Replacement (2.0L Engine)** in Engine Exhaust.

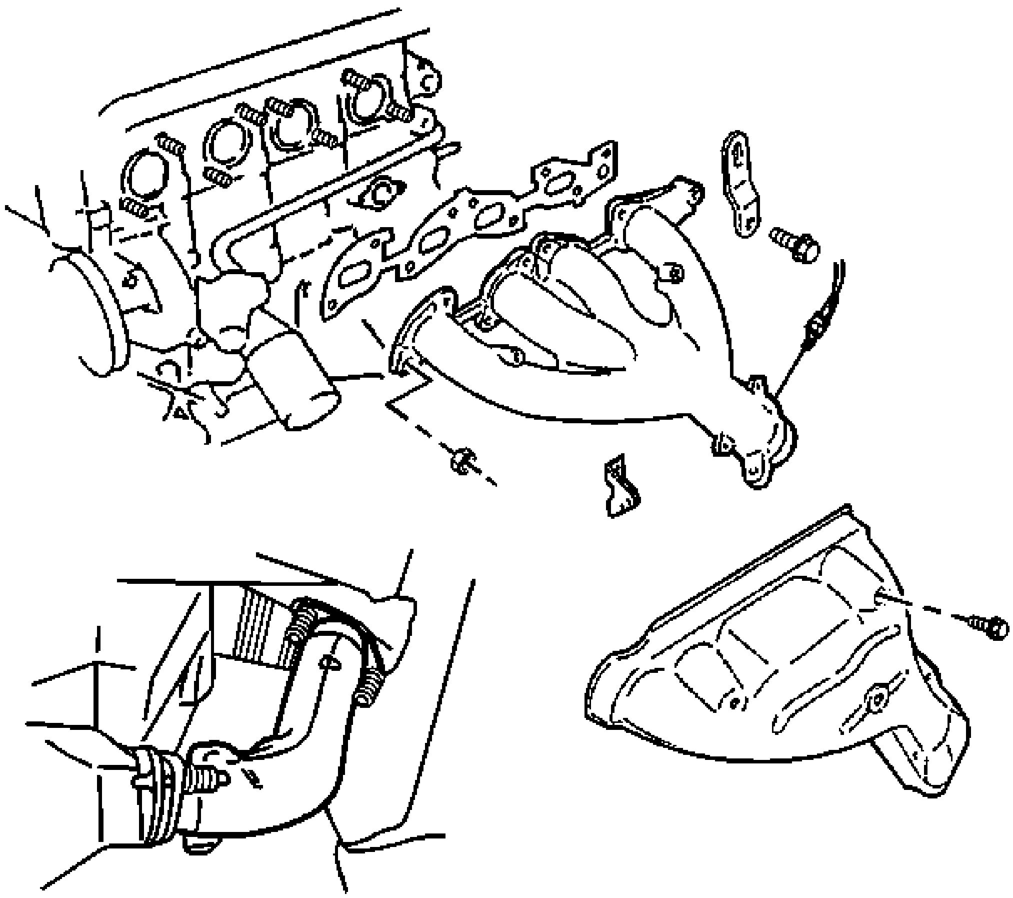


Fig. 152: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

24. Remove the heater hoses from the heater core. Mark the location of the hoses for correct installation.

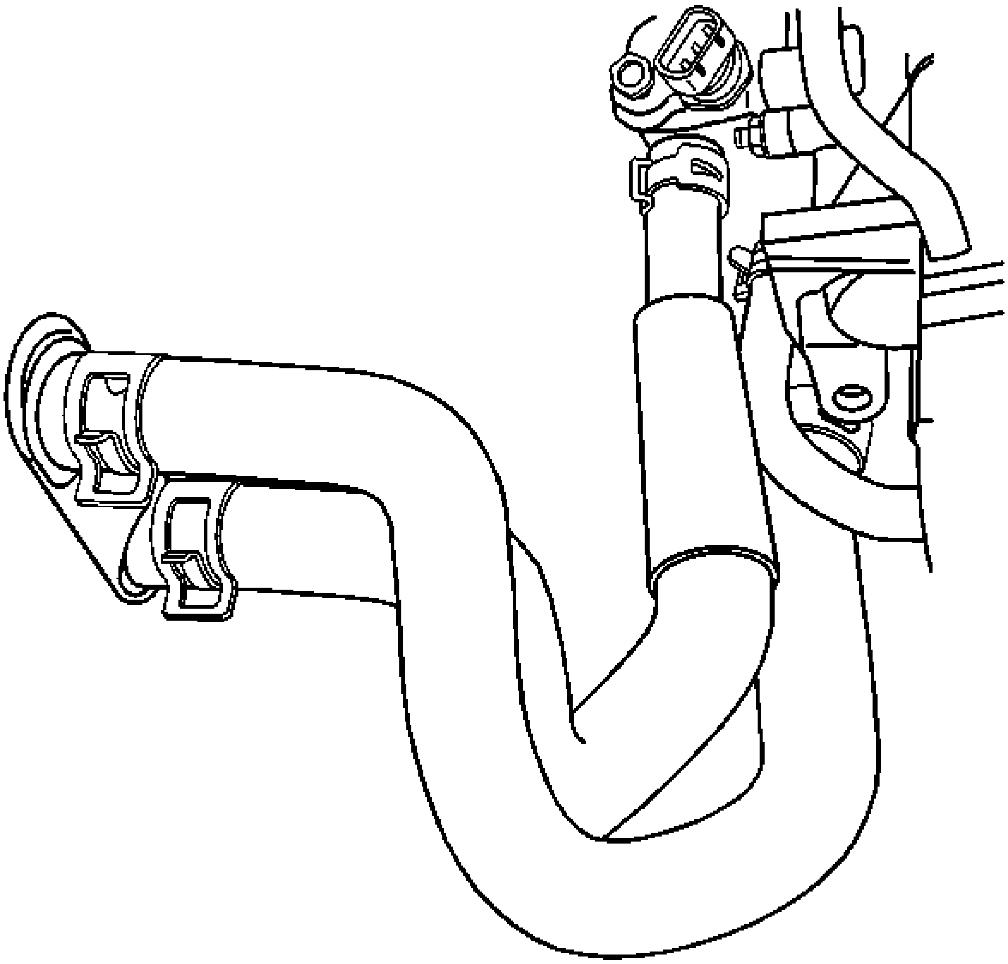


Fig. 153: Removing Heater Hoses From Heater Core
Courtesy of GENERAL MOTORS CORP.

25. Apply matchmarks (4) to the camshaft position sensor and the cylinder head and remove the camshaft position sensor.
26. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 2.0L.
27. Remove the cylinder head cover. Refer to **Cylinder Head Cover Replacement**.
28. Remove the timing chain housing. Refer to **Timing Chain Housing Replacement**.
29. Remove the camshaft timing chain and sprockets. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.
30. Remove the crankshaft timing chain and sprockets. Refer to **Timing Chain and Sprockets Replacement - Crankshaft**.

31. Remove the intake camshaft and the valve lifters. Keep the valve lifters in the correct order for assembly. Refer to **Intake Camshaft and Lifter Replacement**.
32. Remove the exhaust camshaft and the valve lifters. Keep the valve lifters in the correct order for assembly. Refer to **Exhaust Camshaft and Lifter Replacement**.

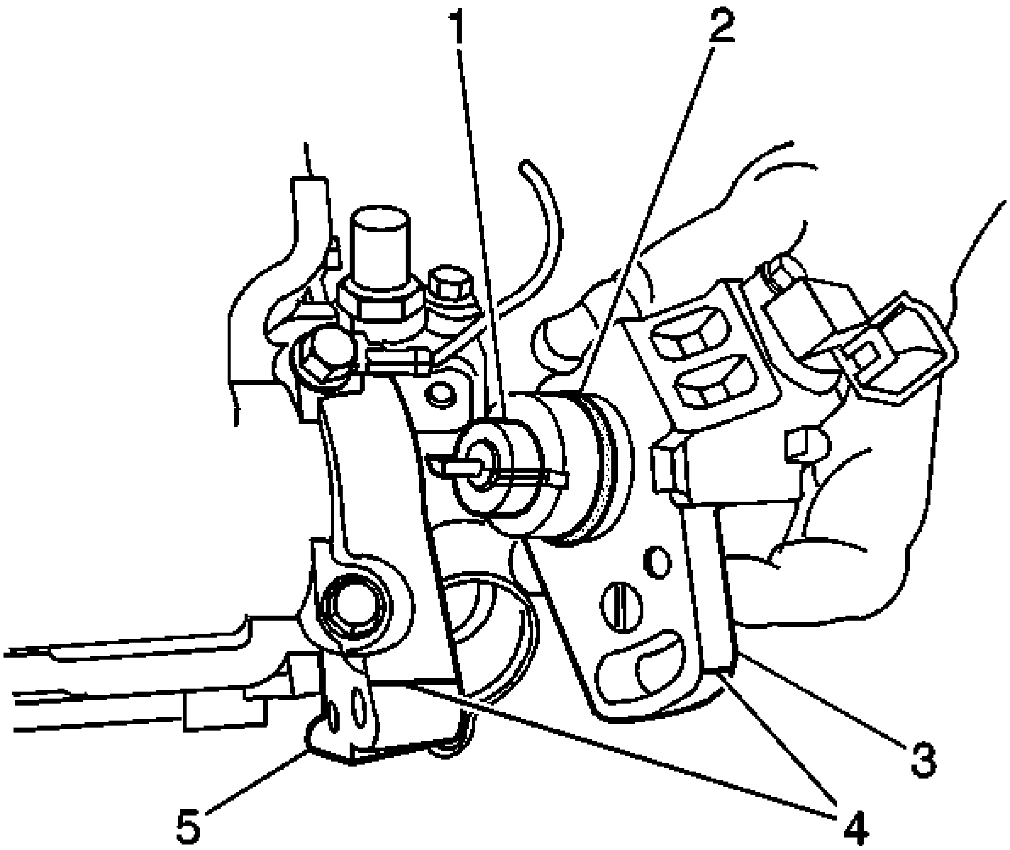


Fig. 154: Removing Camshaft Position Sensor & Components
Courtesy of GENERAL MOTORS CORP.

NOTE: **In order to prevent warpage of the cylinder head, follow the sequence shown whenever removing or installing the head.**

33. Remove the 11 cylinder head bolts in the sequence shown.

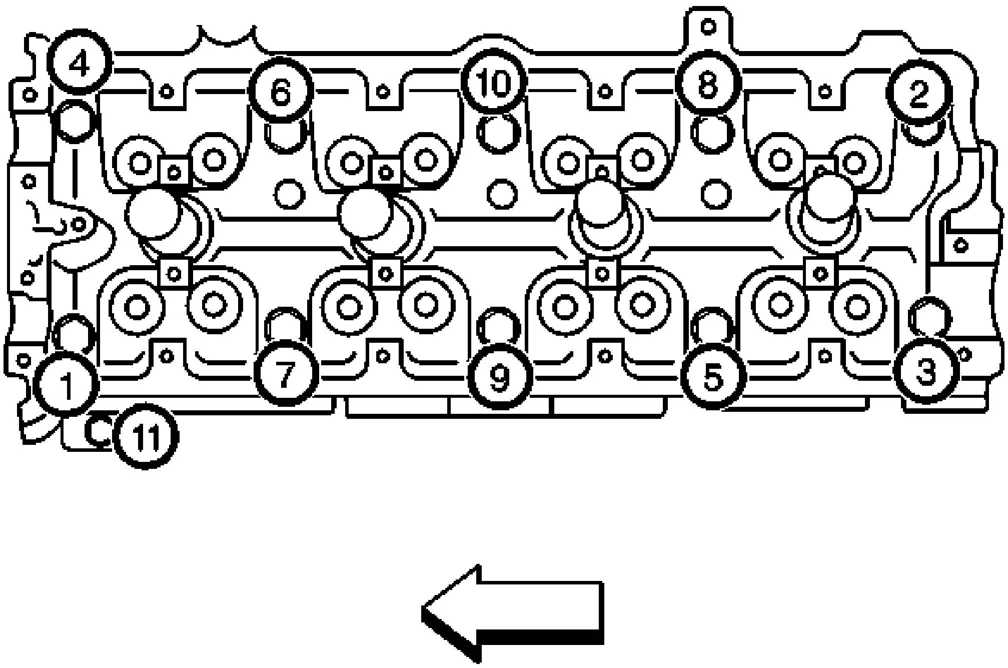


Fig. 155: Removing Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

34. Remove the cylinder head with the intake manifold attached.
35. Remove the cylinder head dowel pins (3).
36. Remove the cylinder head gasket (1).
37. Remove the following components from the cylinder head and transfer as necessary:
    - The cylinder head oil control valve
    - The fuel injector and rail assembly
    - The intake manifold
    - The coolant outlet pipe
    - The coolant outlet cap

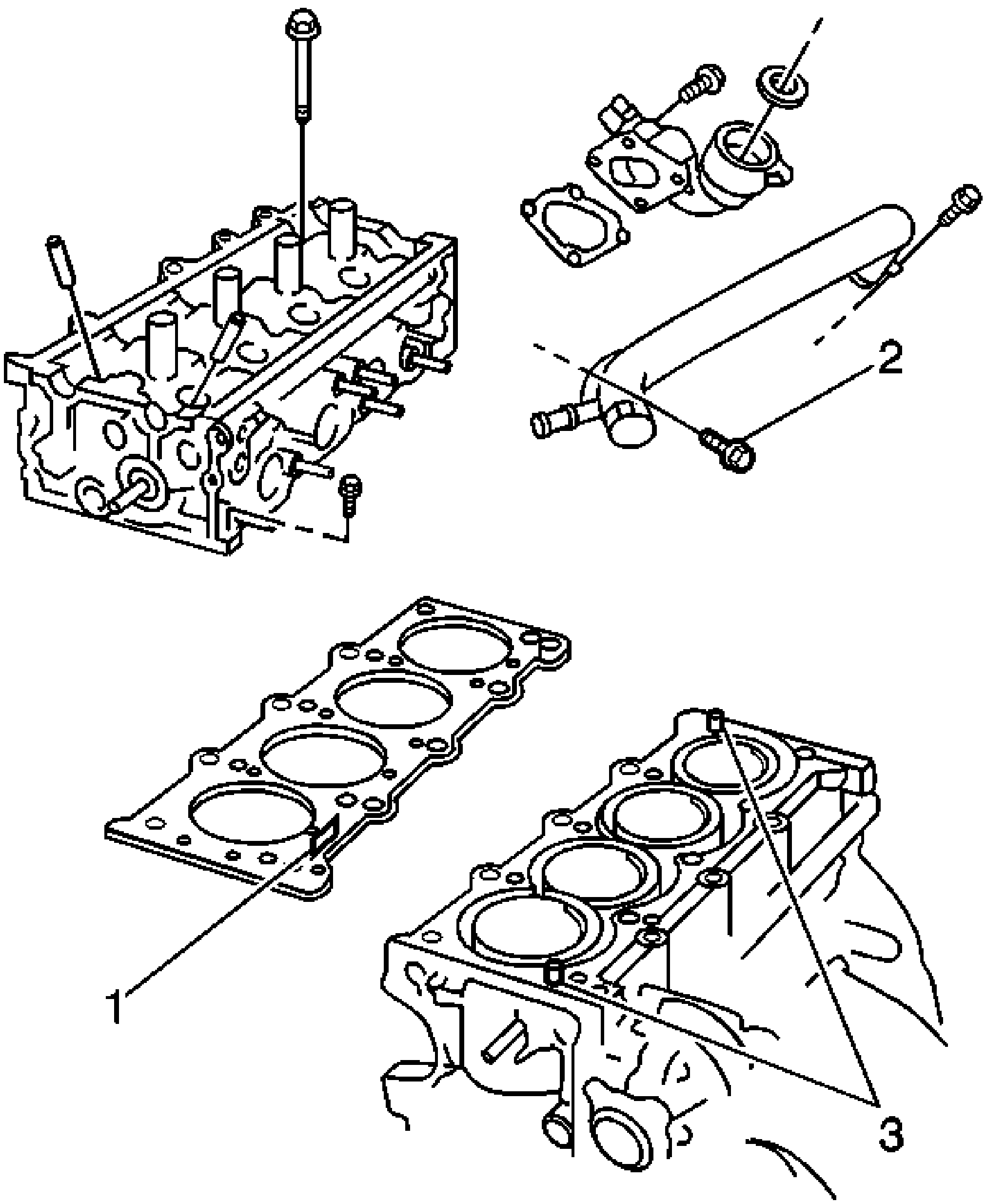


Fig. 156: View Of Cylinder Head Gasket & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

38. Inspect the cylinder head for cracks, warpage or other damage. Refer to **Cylinder Head Cleaning and Inspection**.
39. Replace the cylinder head if the cylinder block mating surface warpage exceeds 0.05 mm (0.002 in).

40. Replace the cylinder head if the manifold mating surface warpage exceeds 0.10 mm (0.004 in).
41. Clean the cylinder head mating surface.
42. Clean the cylinder block mating surface.
43. Clean the cylinder head bolt threads and bolts. Replace any stretched or damaged bolts.
44. Clean the cylinder block bolt holes of all debris, threadlocker, sealant etc. Installing a bolt to a blocked bolt hole will cause incorrect torque and may cause cylinder head/block damage.
45. Inspect that the oil control valve in the cylinder head is clean and that the check ball is free.

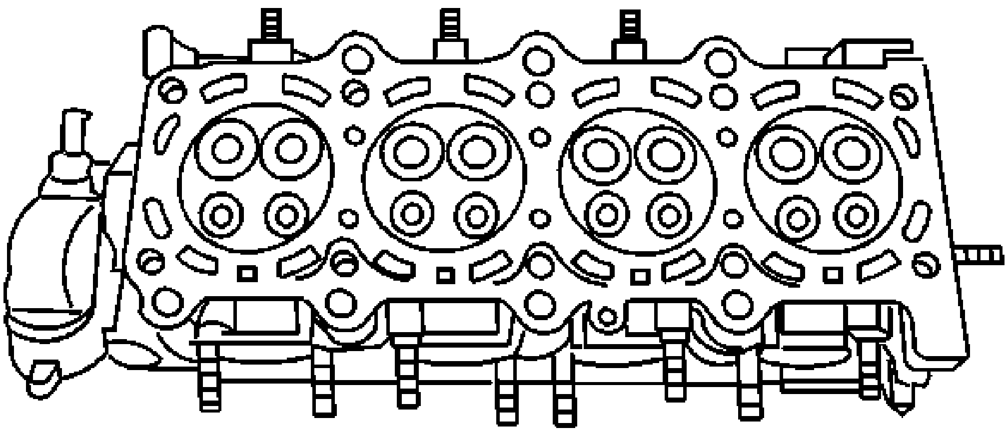


Fig. 157: Inspecting Cylinder Head
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the following components to the cylinder head as necessary:
   - The cylinder head oil control valve
   - The fuel injector and rail assembly
   - The intake manifold
   - The coolant outlet pipe
   - The coolant outlet cap
2. Install the cylinder head dowel pins (3).
3. Install the new cylinder head gasket to the cylinder block. The gasket is marked TOP (1).
4. Install the cylinder head with the intake manifold attached to the cylinder block.

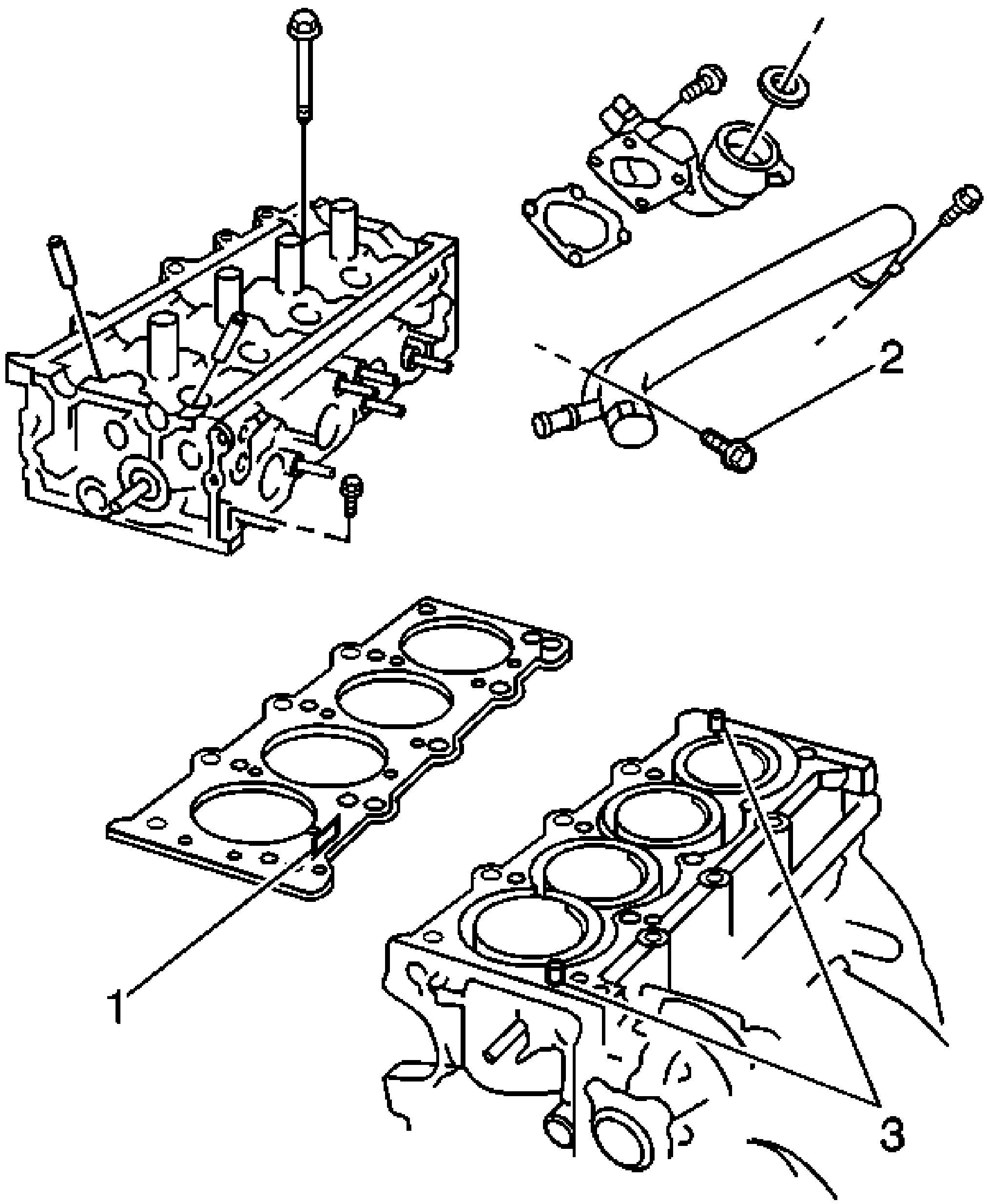


Fig. 158: View Of Cylinder Head Gasket & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **The cylinder head bolts must be torqued in 2 stages, loosened, and then retorqued in 3 stages in order to ensure against compression and coolant leaks.**

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

NOTE: **In order to prevent warpage of the cylinder head, follow the sequence shown whenever removing or installing the head.**

5. Apply clean engine oil to the bolt threads and install the cylinder head bolts.

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 53 N.m (39 lb ft).

6. Tighten the cylinder head bolts (1-10).

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 84 N.m (61 lb ft).

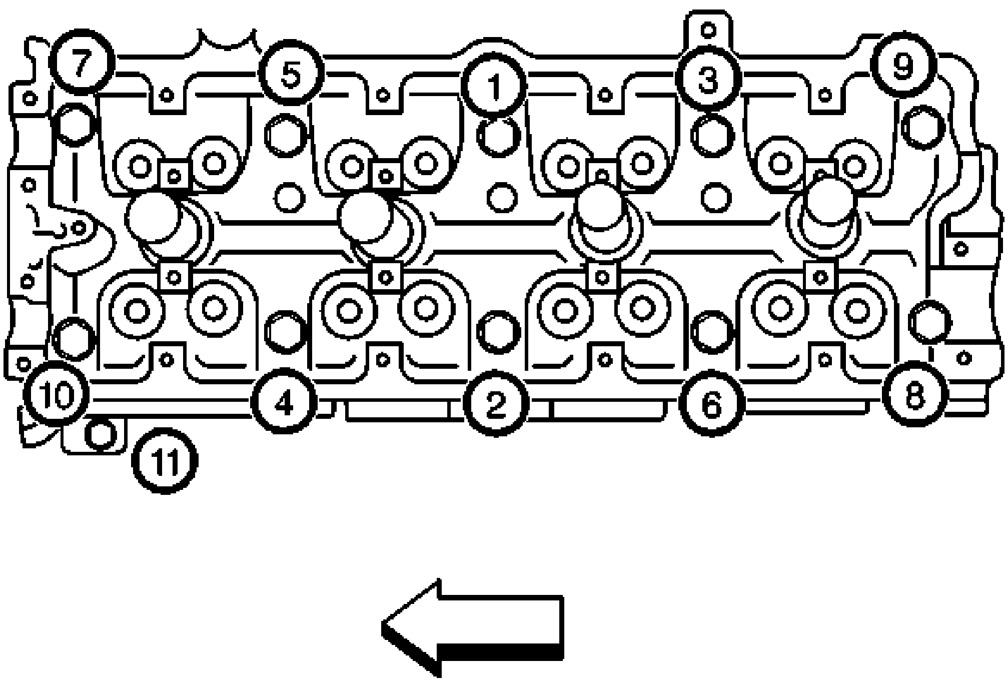


Fig. 159: Tightening Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the cylinder head bolts in the sequence shown to 0 torque.

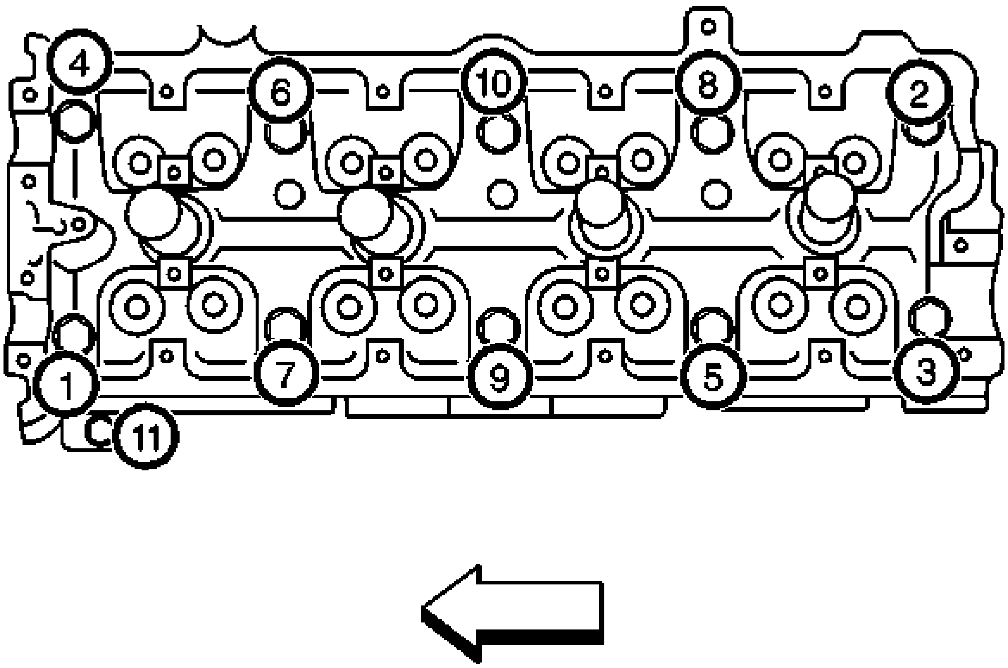


Fig. 160: Removing Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

8. Tighten the cylinder head bolts (1-10).

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 53 N.m (39 lb ft).

9. Tighten the cylinder head bolts (1-10).

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 84 N.m (61 lb ft).

10. Tighten the cylinder head bolts (1-10).

    Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 105 N.m (76 lb ft).

11. Tighten the M6 cylinder head bolt (11).

    Tighten: Tighten the M6 cylinder head bolt (11) to 11 N.m (97 lb in).

12. Install the valve lifters and the intake camshaft. Refer to **Intake Camshaft and Lifter Replacement**.
13. Install the valve lifters and the exhaust camshaft. Refer to **Exhaust Camshaft and Lifter Replacement**.

14. Install the crankshaft timing chain. Refer to **Timing Chain and Sprockets Replacement - Crankshaft**.
15. Install the camshaft timing chain. Refer to **Timing Chain and Sprockets Replacement - Camshaft**.
16. Install the timing chain housing. Refer to **Timing Chain Housing Replacement**.
17. Install the cylinder head cover. Refer to **Cylinder Head Cover Replacement**.
18. Install the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 2.0L.

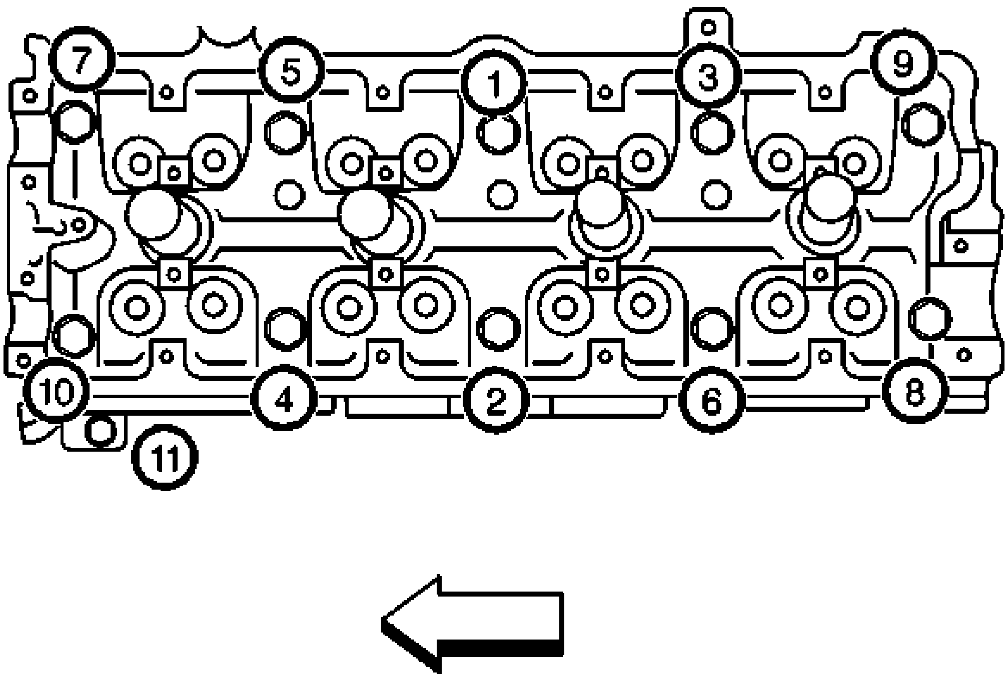


Fig. 161: Tightening Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

19. Align the matchmarks (4) and install the camshaft position sensor to the rear end of the exhaust camshaft. The sensor shaft is offset and can only be installed 1 way. Refer to **Camshaft Position (CMP) Sensor Replacement** in Engine Controls.

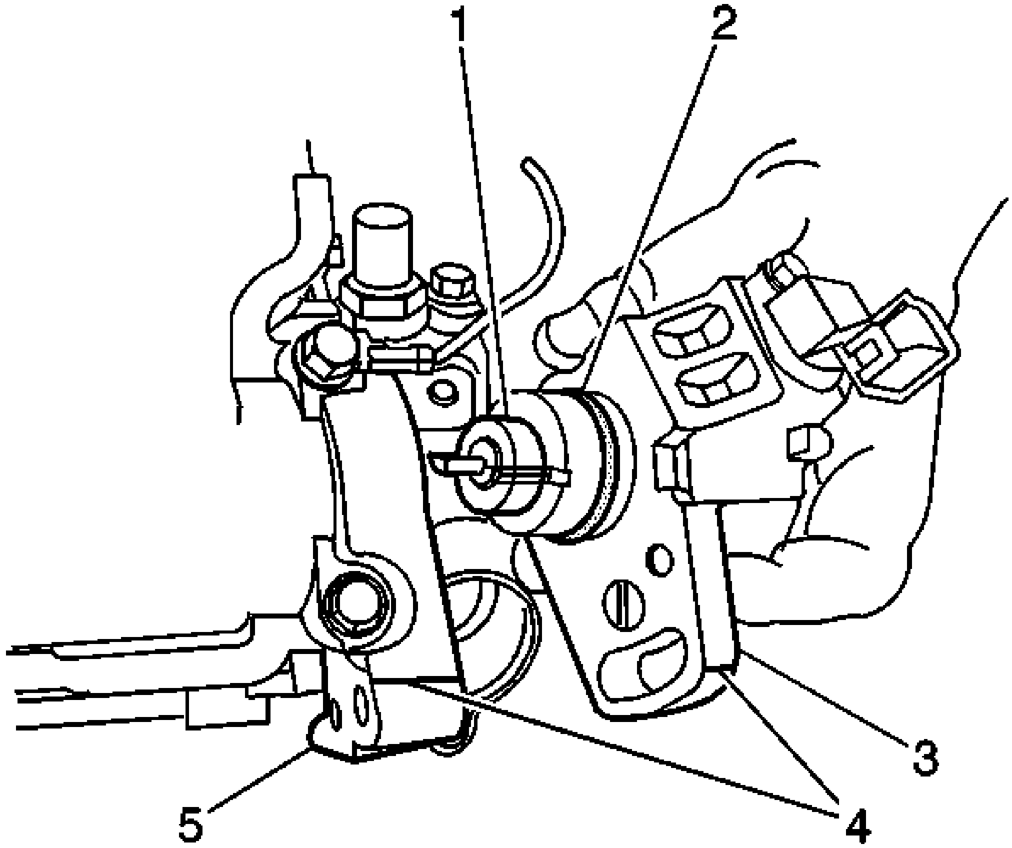


Fig. 162: Installing Camshaft Position Sensor & Components
Courtesy of GENERAL MOTORS CORP.

20. Install the heater hoses to the heater core.

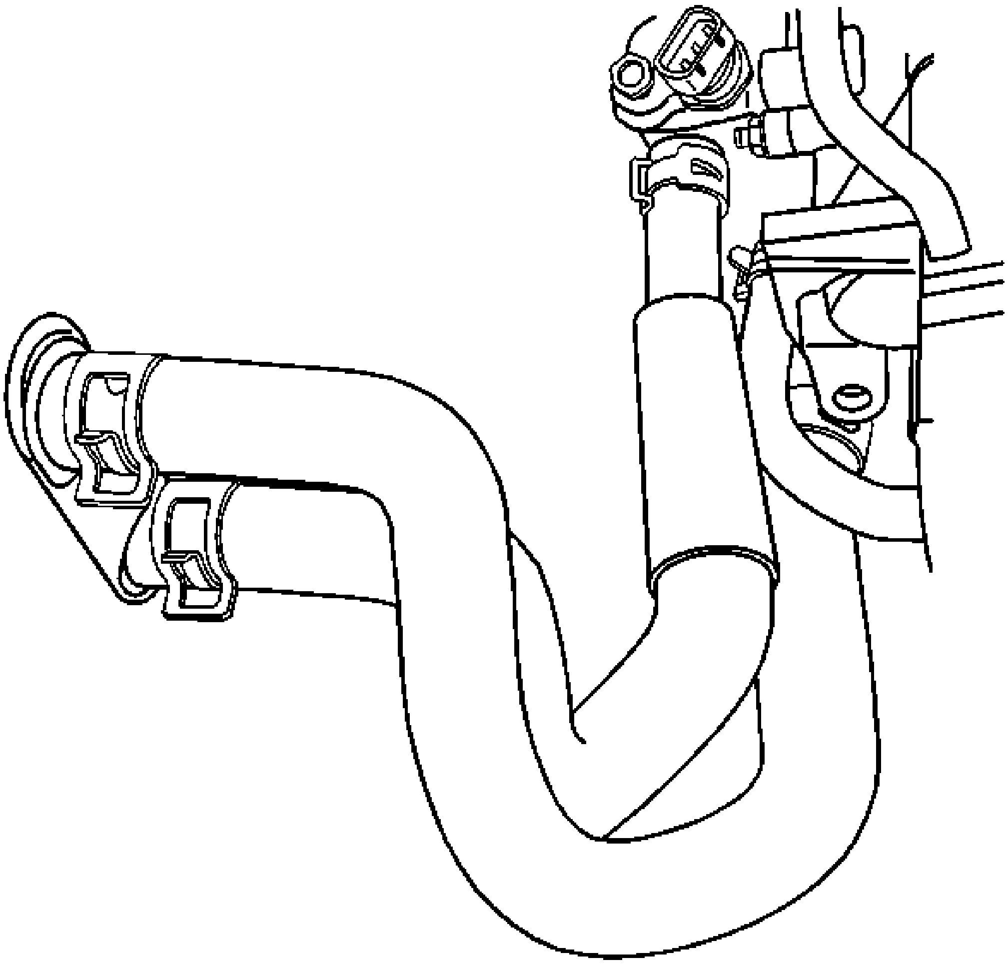


Fig. 163: Installing Heater Hoses From Heater Core
Courtesy of GENERAL MOTORS CORP.

21. Install the exhaust manifold to the cylinder head using a new gasket. Refer to **Exhaust Manifold Replacement (2.0L Engine)** in Engine Exhaust.
22. Install the exhaust manifold-to-engine block bracket.
23. Install the oxygen sensor connector to the exhaust manifold bracket. Connect the oxygen sensor.

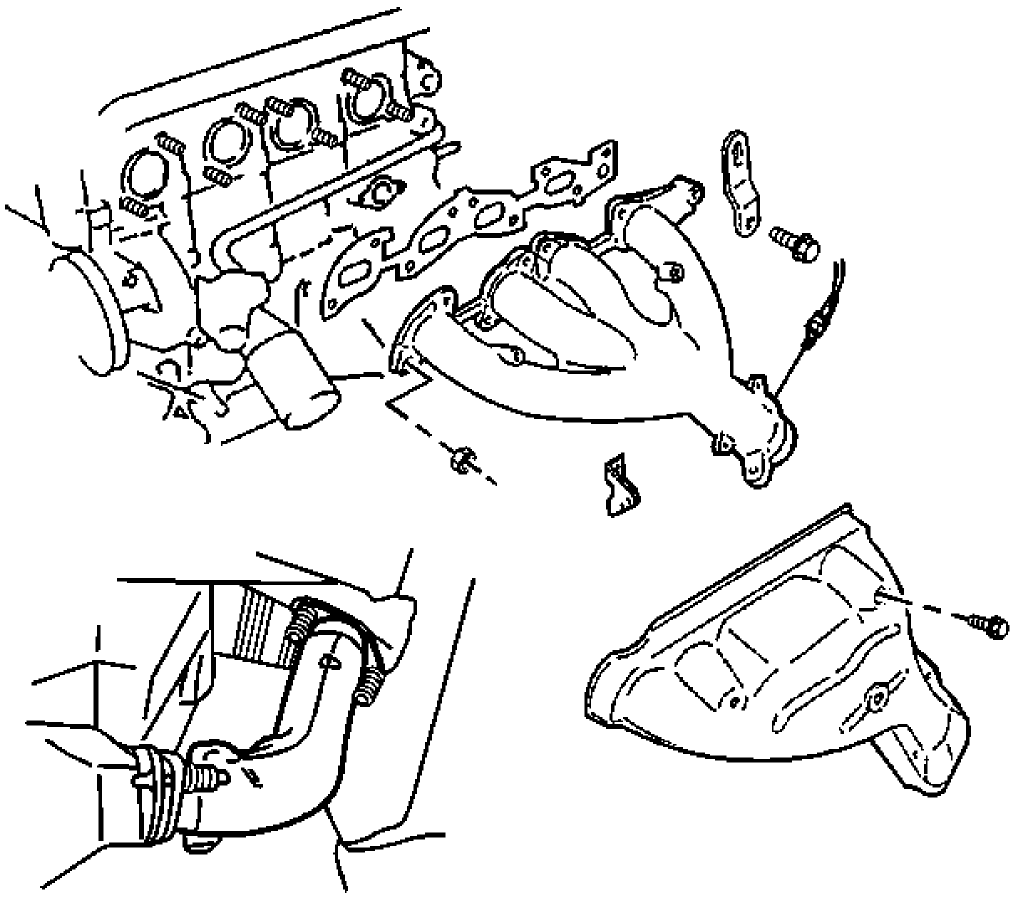


Fig. 164: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

24. Install the intake manifold front support bracket.

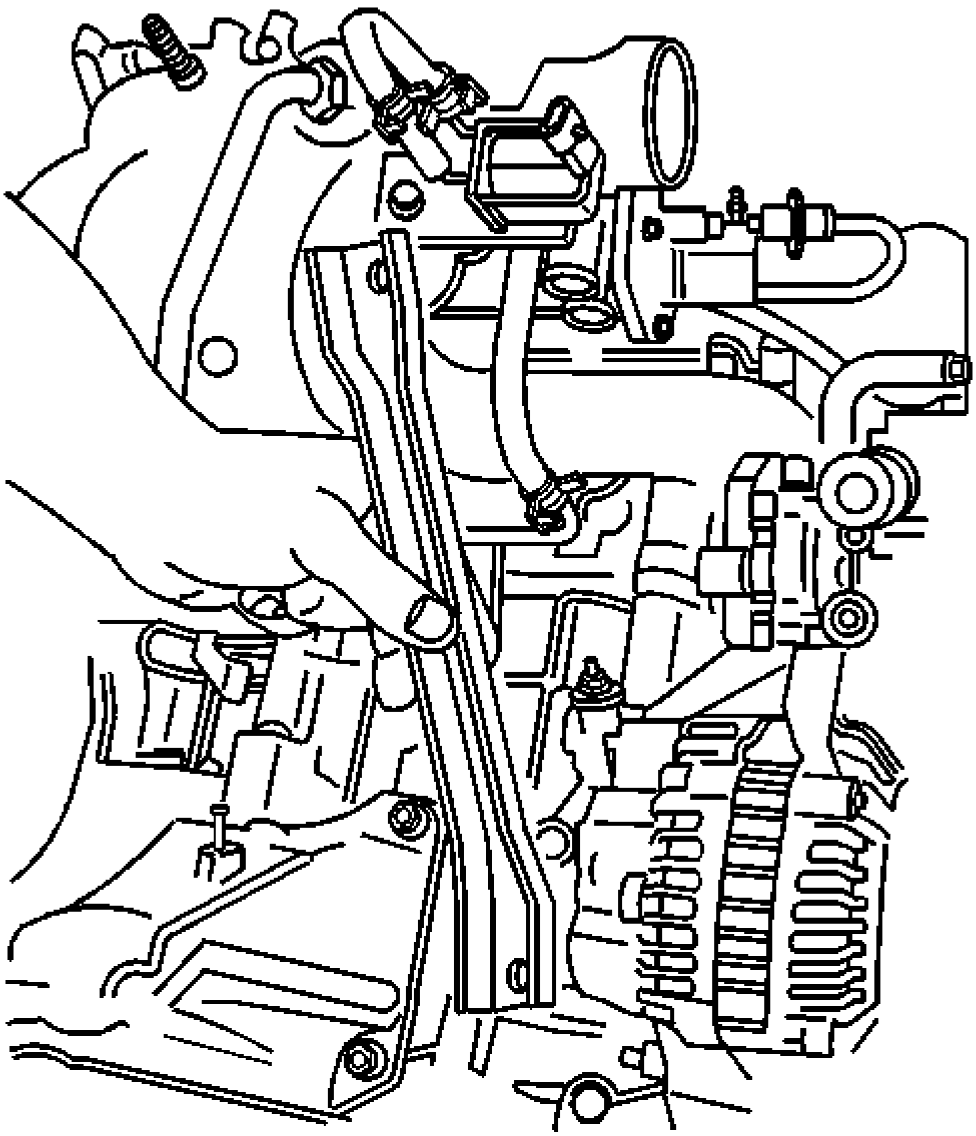


Fig. 165: View Of Intake Manifold Front Support Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the fuel hoses to the fuel lines (9).
26. Install the coolant line (5) to the underside of the intake manifold. Secure with the 2 bolts.
27. Install the coolant hoses (4,5) to the throttle body and the intake manifold.
28. Install the EVAP canister purge valve to the intake manifold. Secure with the bolt.

29. Install the EVAP vacuum line to the intake manifold.
30. Install the EVAP canister purge hose to the intake manifold.
31. Install the brake booster hose to the intake manifold.
32. Install the PCV hose to the intake manifold.
33. Install the breather hose to the intake manifold.
34. Connect the following electrical connectors:
    - The fuel injector harness (3)
    - The manifold absolute pressure (MAP) sensor (11)
    - The throttle position sensor (TPS) (8)
    - The idle air control (IAC) valve (6)
    - The EVAP canister purge valve (7)
    - The exhaust gas recirculation (EGR) valve (1)
    - The engine coolant temperature (ECT) sensor (2)
35. Connect the ground wires to the intake manifold (10)
36. Connect the wiring harness to the retaining clamps.

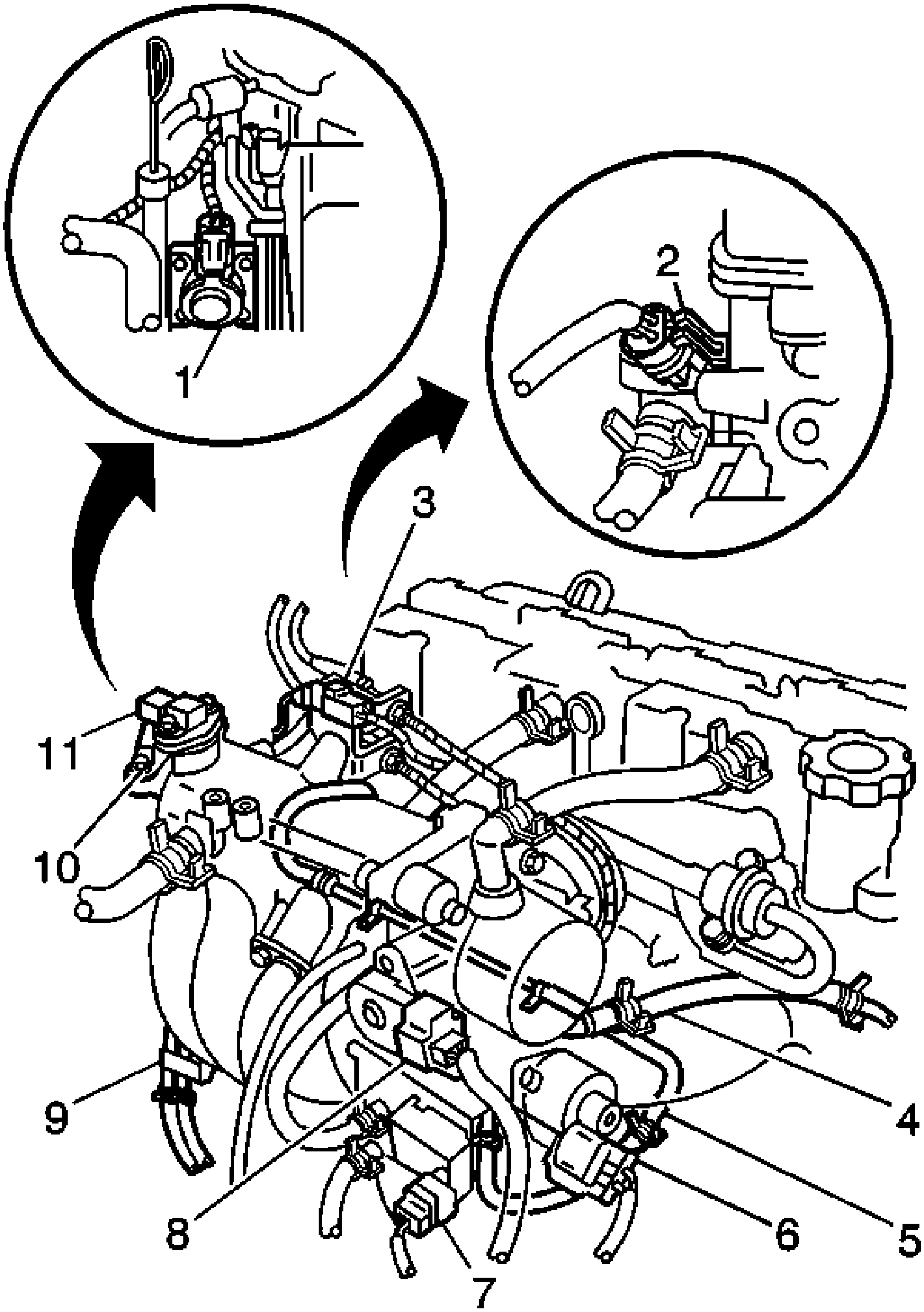


Fig. 166: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

37. Install the throttle cables to the throttle body bellcrank.
38. Install the throttle cable bracket (2) to the intake manifold. Secure with the 1 bolt.
39. Install the air cleaner hose.

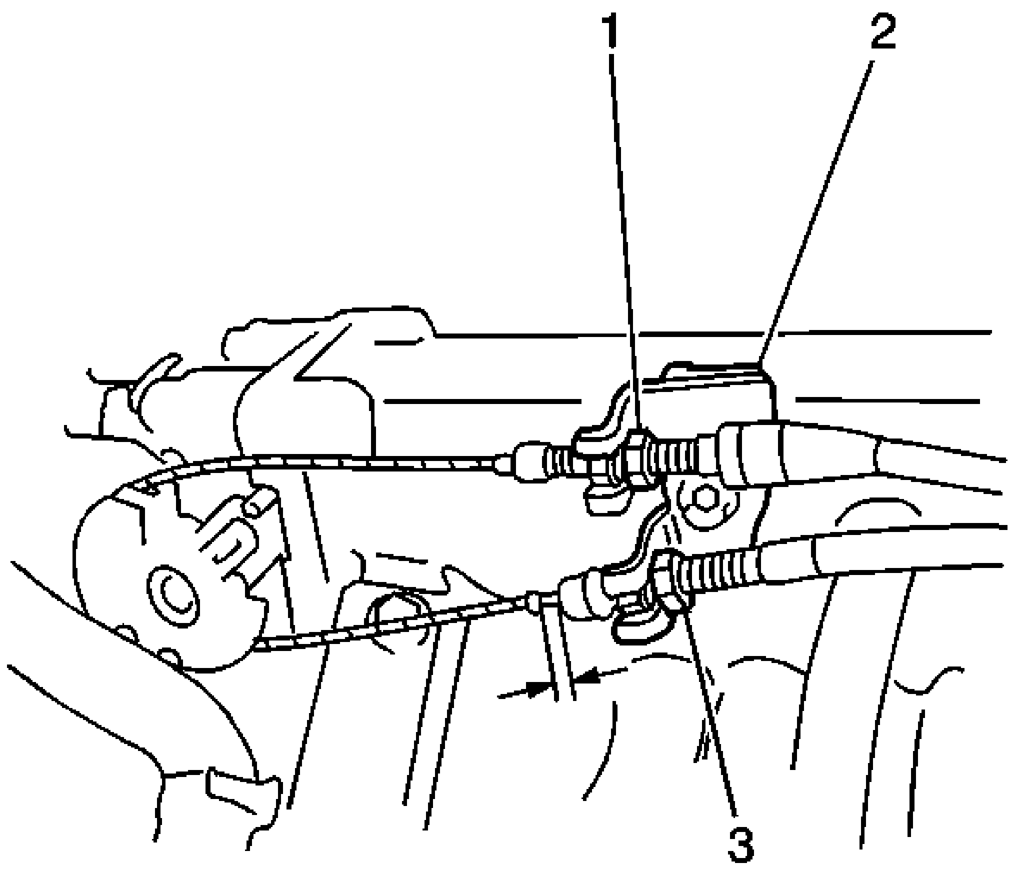


Fig. 167: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

40. Install the strut tower brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.
41. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
42. Connect the negative battery cable.
43. Adjust the ignition timing as necessary. Refer to **Ignition System Timing Adjustment Procedure** in Engine Controls.

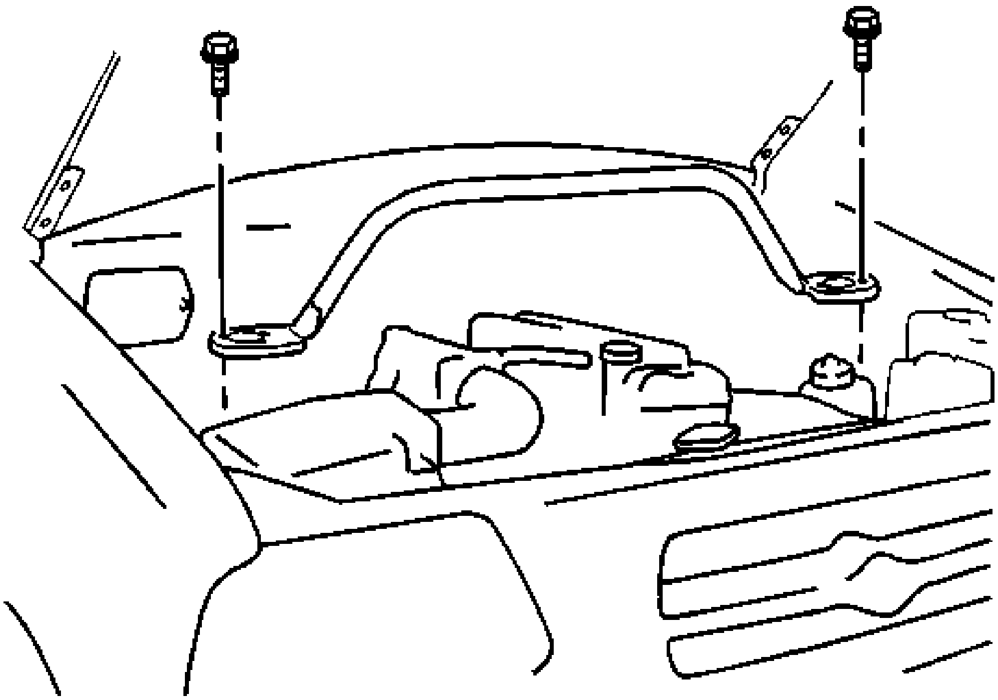


Fig. 168: View Of Strut Tower Brace
Courtesy of GENERAL MOTORS CORP.

Oil Pan Replacement

Removal Procedure

1. Remove the oil level indicator.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the front skid plate from the vehicle (if equipped).
4. Remove the front axle assembly from the chassis (4WD only). Refer to **Front Axle Housing Replacement** in Front Drive Axle.
5. Remove the steering gear. Refer to **Power Steering Gear Replacement** in Power Steering.
6. Drain the engine oil.
7. Remove the 4 bolts and the right side engine block-to-transmission support bracket (3).
8. Remove the flywheel cover.

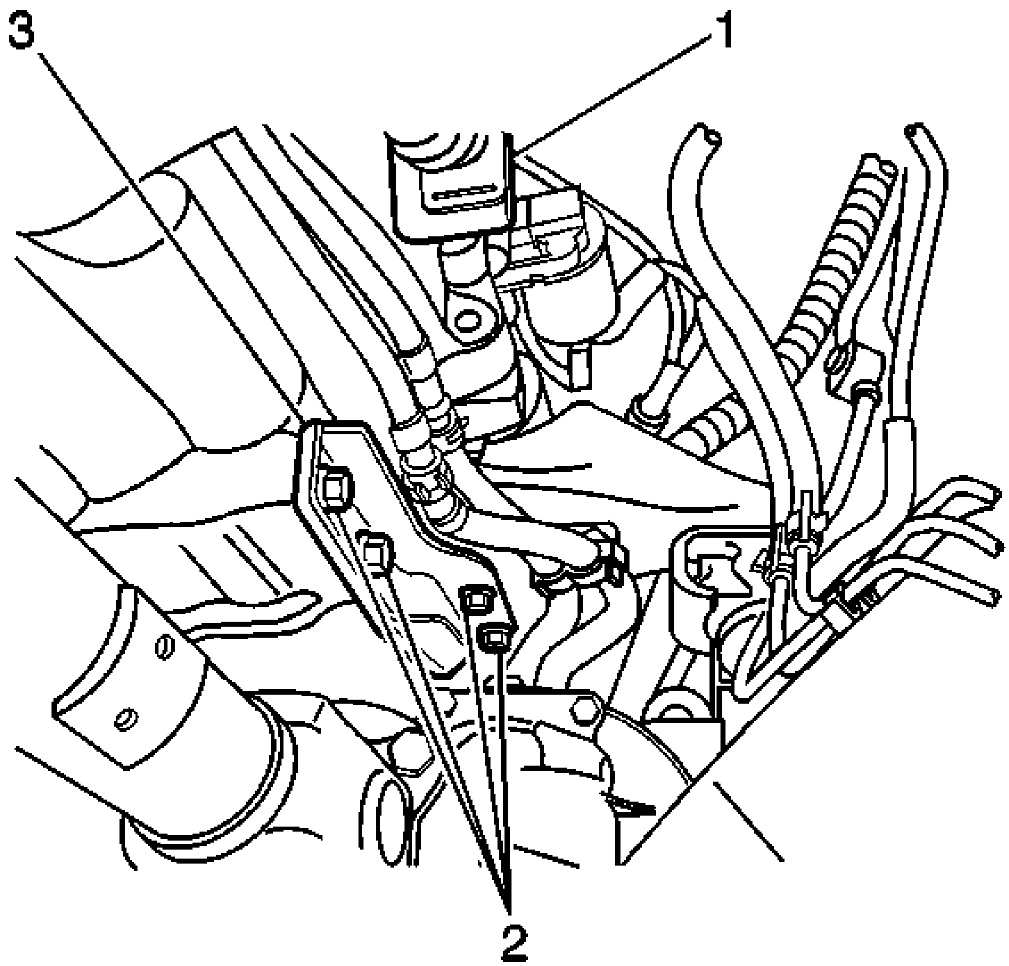


Fig. 169: View Above Differential
Courtesy of GENERAL MOTORS CORP.

9. Remove the 16 bolts and the 2 nuts from the lower cylinder block.

NOTE: Do not damage the oil pan contact surface of the lower cylinder block when removing the oil pan.

10. Carefully remove the engine oil pan.
11. Remove the 3 bolts and the oil pump strainer.
12. Clean the following components:
    - The inside of the engine oil pan

- The oil pump strainer screen
- The mating surfaces of the engine oil pan and the lower cylinder block

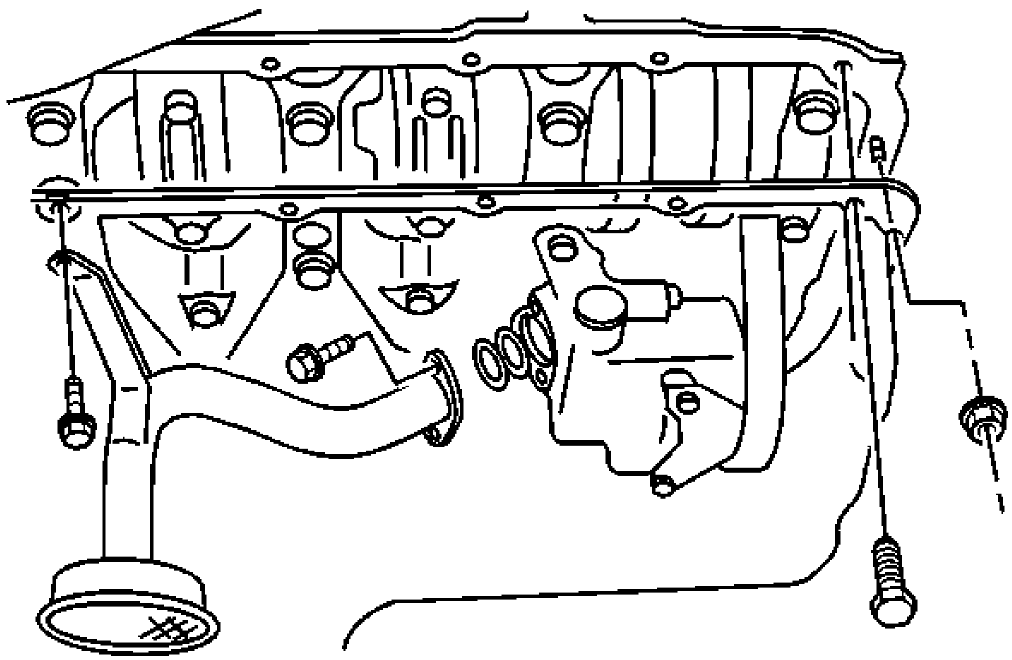


Fig. 170: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install new O-rings and install the oil pump strainer to the oil pump.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install and tighten the 2 strainer bolts first and then the bracket bolt.

   Tighten: Tighten the 3 bolts to 11 N.m (97 lb in).

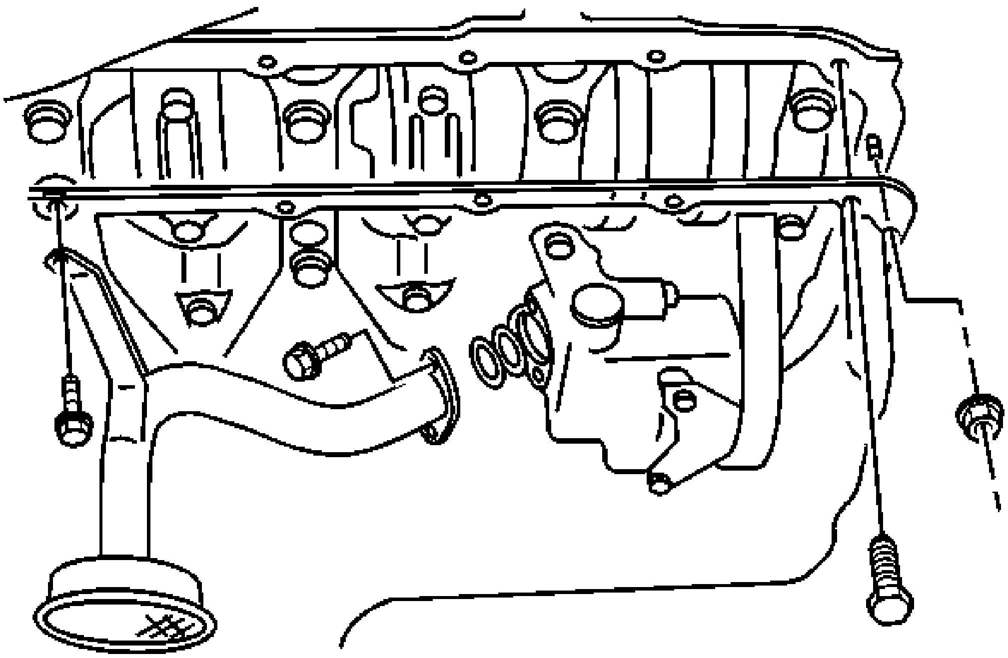


Fig. 171: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Apply a continuous bead of silicon sealant (1) GM P/N 12345997, or an equivalent, to the engine oil pan mating surface.

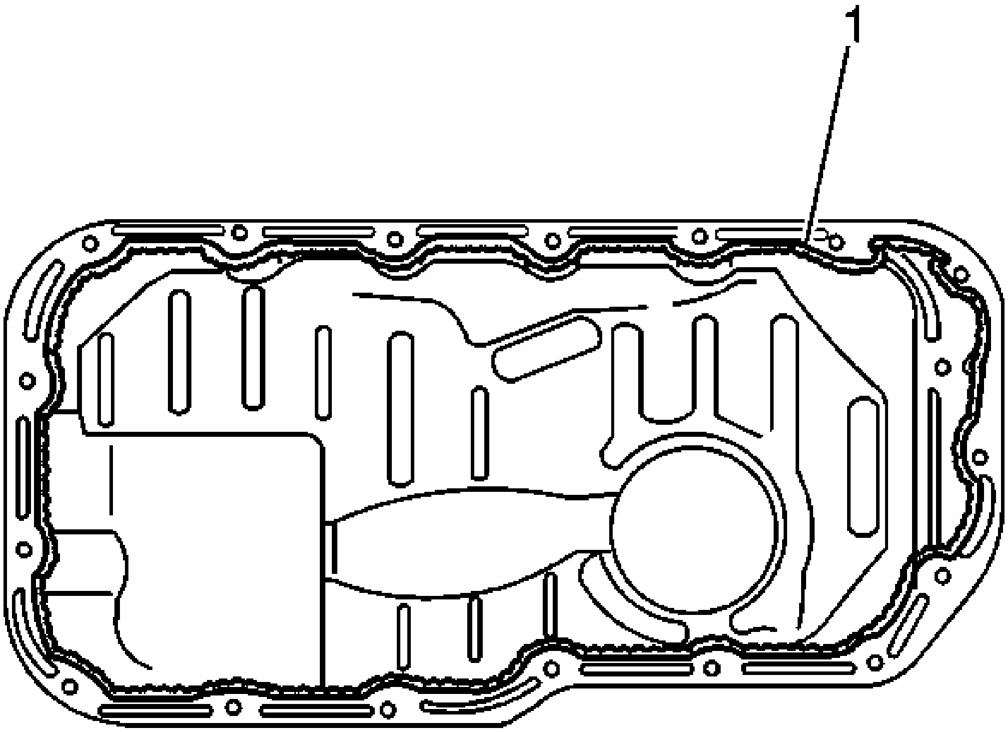


Fig. 172: Applying Silicon Sealant
Courtesy of GENERAL MOTORS CORP.

4. Install the engine oil pan. Secure with the 16 bolts and 2 nuts.

   Tighten: Tighten the engine oil pan bolts and nuts to 11 N.m (97 lb in).

5. Install the engine oil gasket and drain plug.

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

6. Install the flywheel cover.

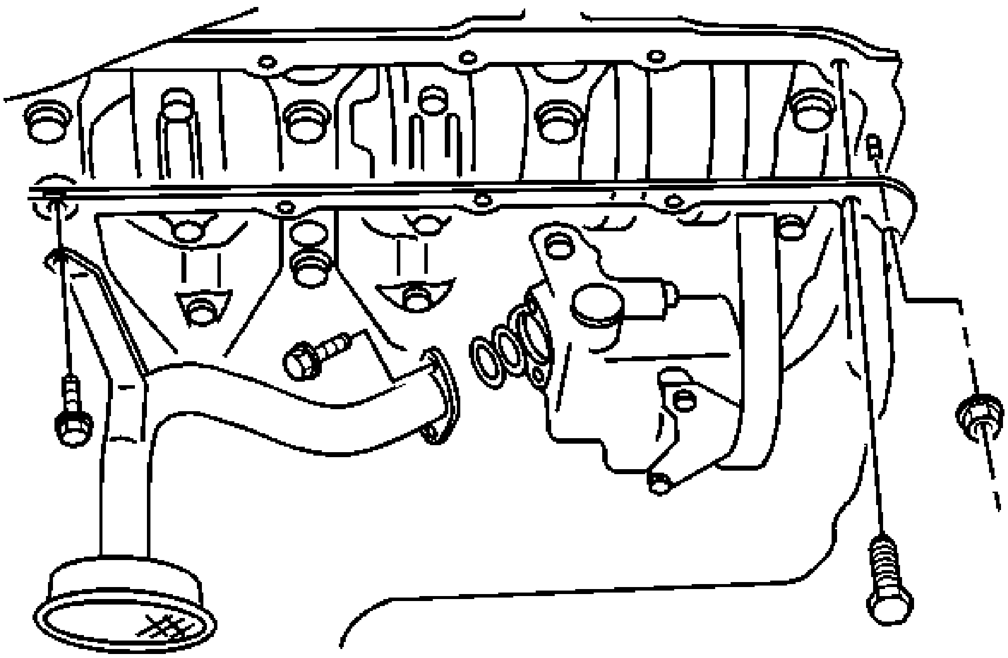


Fig. 173: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

7. Install the right side engine block-to-transmission support bracket (3).

   Tighten: Tighten the engine block-to-transmission support bracket bolts to 50 N.m (37 lb ft).

8. Install the front axle assembly to the chassis on four wheel drive vehicles. Refer to **Front Axle Housing Replacement** in Front Drive Axle.
9. Fill the differential on four wheel drive vehicles. Refer to **Lubricant Level Inspection - Front Drive Axle** in Front Drive Axle.
10. Install the steering gear. Refer to **Power Steering Gear Replacement** in Power Steering.
11. Bleed the power steering system. Refer to **Bleeding the Power Steering System** in Power Steering.
12. Install the front skid plate to the vehicle (if equipped).
13. Install the oil level indicator.
14. Lower the vehicle.
15. Fill the crankcase with engine oil.
16. Inspect for correct engine oil level and pressure, and for fluid leaks.
17. Adjust the front toe-in. Refer to **Front Toe Adjustment** in Wheel Alignment.

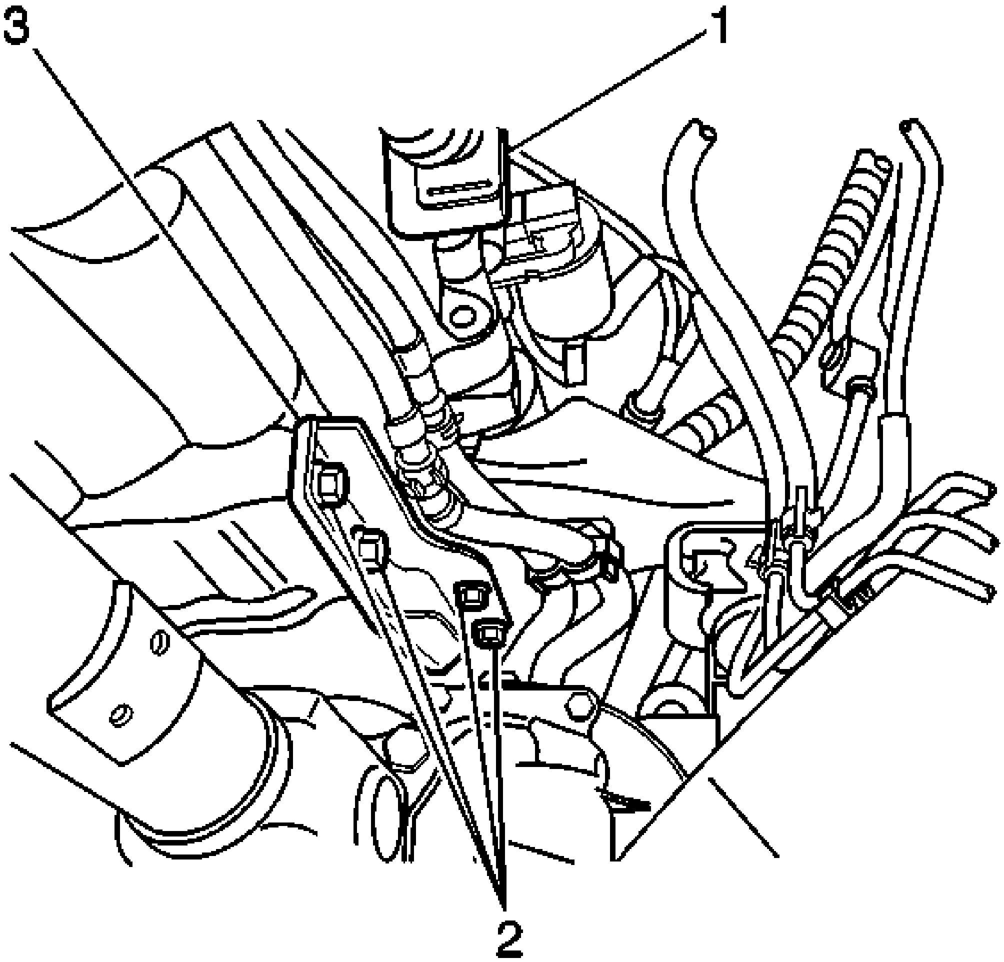


Fig. 174: View Above Differential
Courtesy of GENERAL MOTORS CORP.

Oil Pump Replacement

Removal Procedure

NOTE: Do not damage the oil pan contact surface of the lower cylinder block when removing the oil pan.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the 3 bolts and the oil pump strainer.

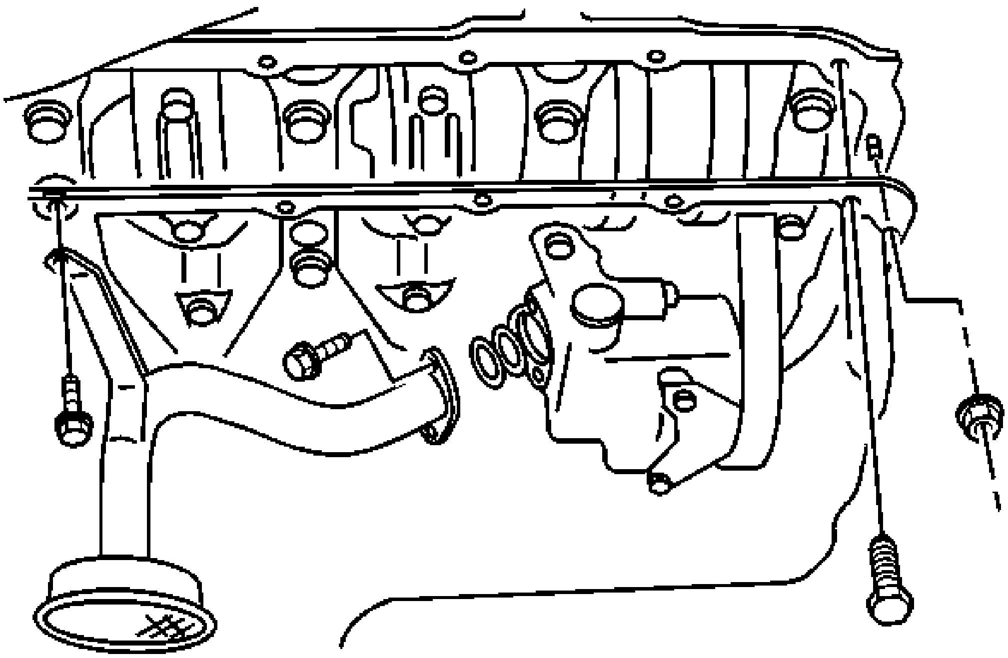


Fig. 175: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

3. Remove the 4 bolts and the oil pump drive chain cover (1).

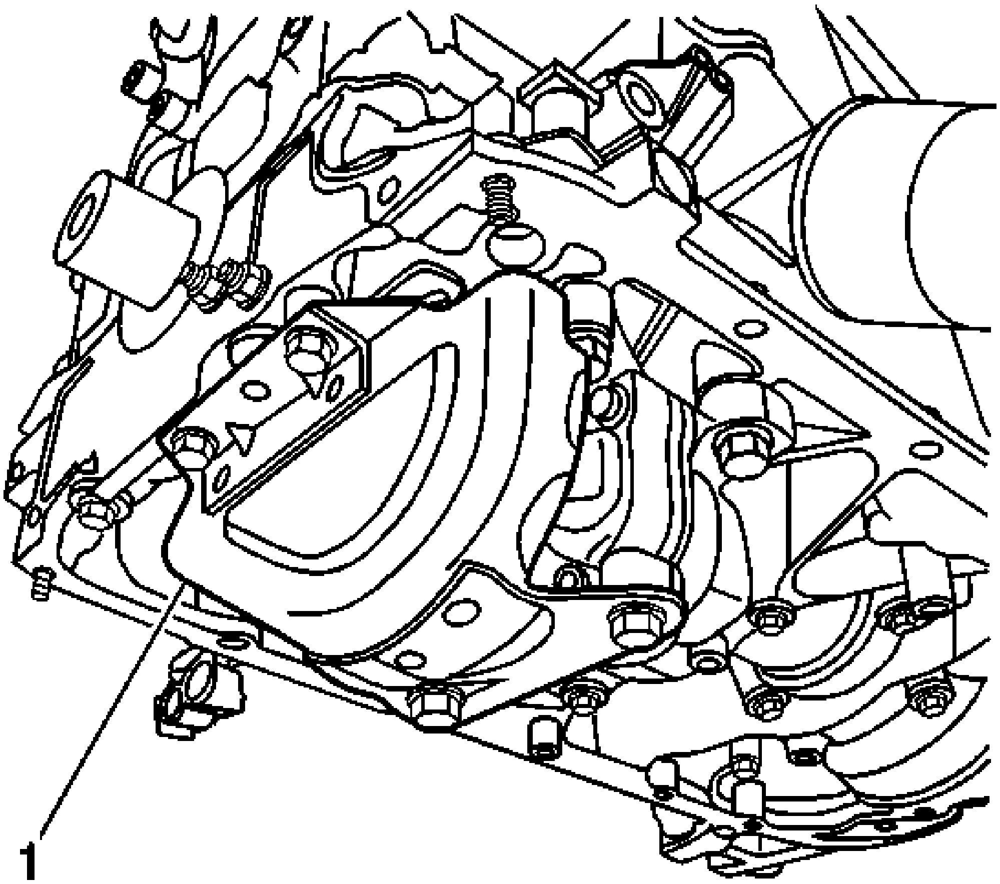


Fig. 176: View Of Oil Pump Drive Chain Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the 3 bolts and the oil pump.
5. Clean the following components:
   - The inside of the engine oil pan
   - The oil pump strainer screen
   - The mating surfaces of the engine oil pan and the lower cylinder block
   - The oil pump

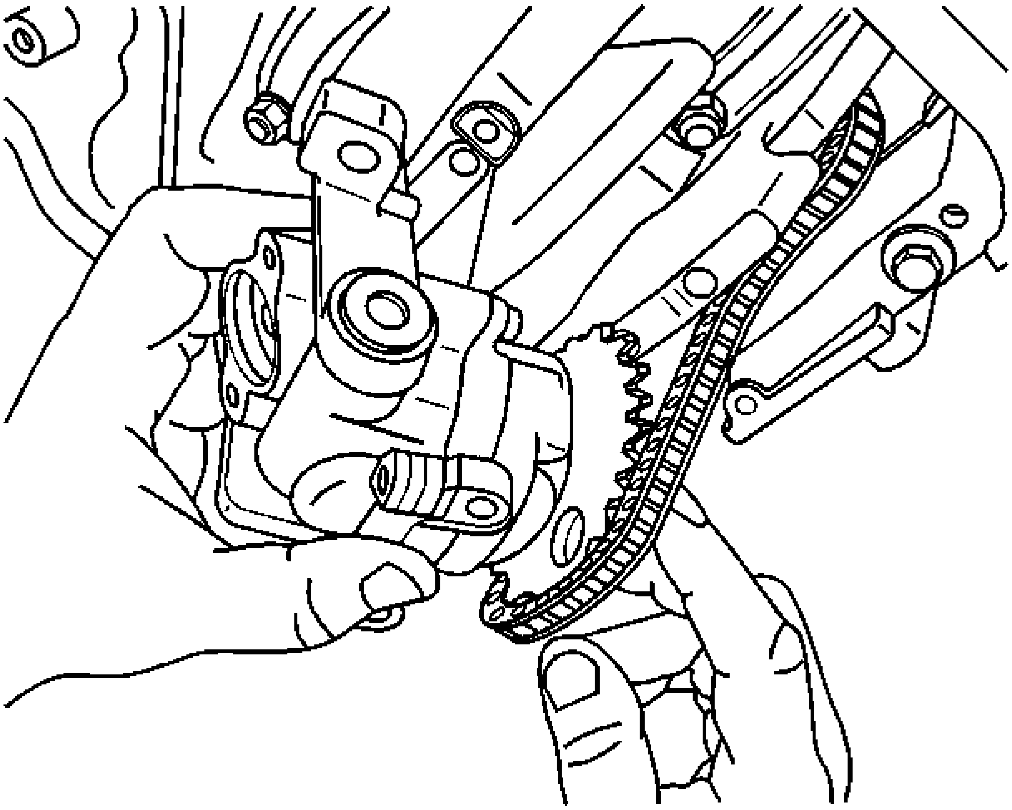


Fig. 177: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

6. If necessary, remove the 2 nuts (2) and the oil pump chain guide (1). The chain tension will have to be adjusted if the guide is removed or if the chain is replaced.

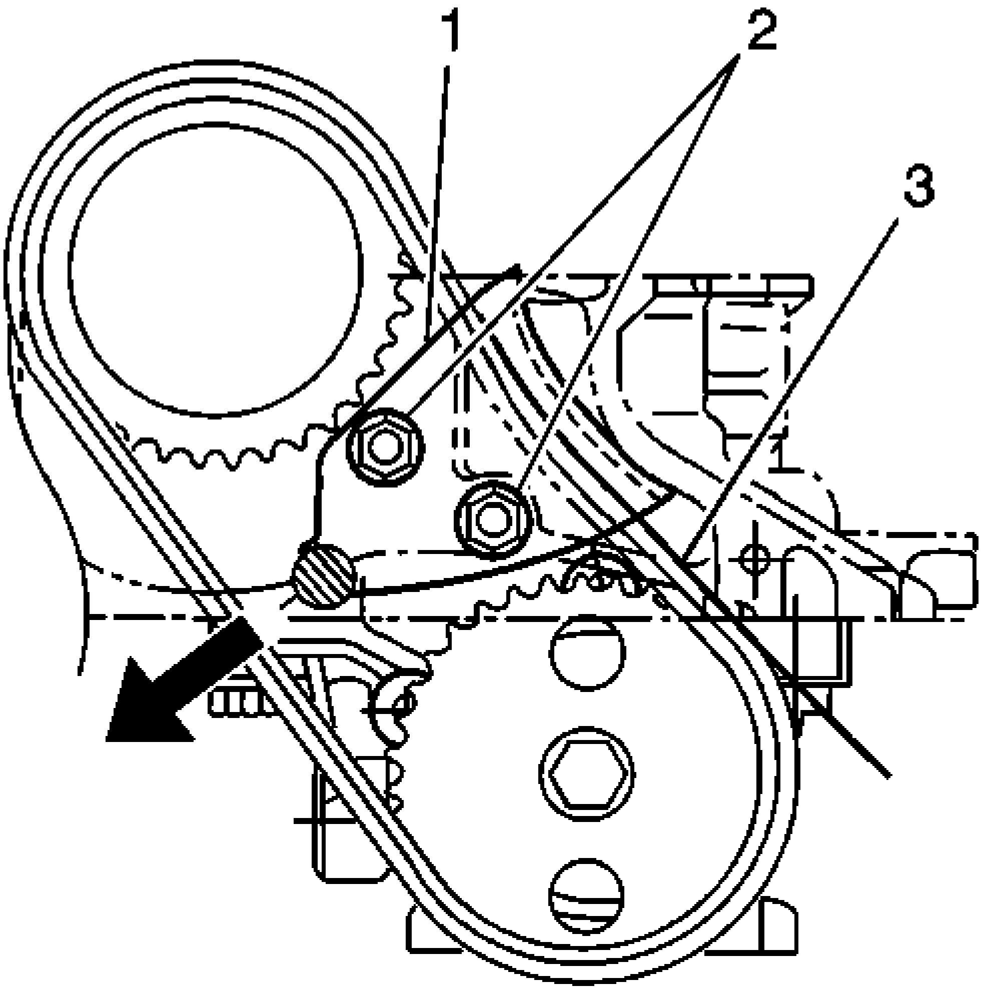


Fig. 178: View Of Oil Pump Chain Guide, Feeler Gauge & Nuts
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil pump to the lower crankcase. Secure with the 3 bolts.

   Tighten: Tighten the 3 bolts to 27 N.m (20 lb ft).

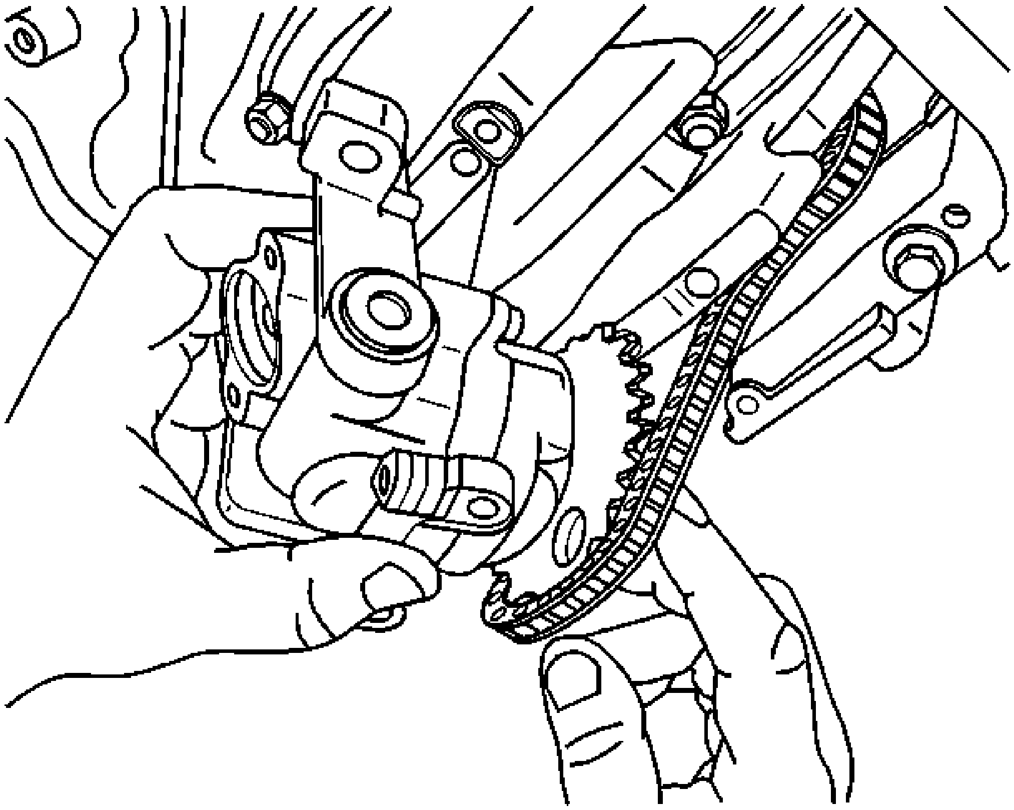


Fig. 179: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

2. If removed, install the oil pump chain guide (1). The chain tension will have to be adjusted if the guide is removed or if the chain is replaced. Install the 2 nuts finger tight.
3. Insert a 0.5 mm (0.020 in) feeler gauge (3) between the chain and the chain guide.
4. Adjust the chain tension by holding the chain guide against the chain with a force of 20- 30 Newtons (4.4-6.6 lb).
5. Tighten the nuts while holding this tension.

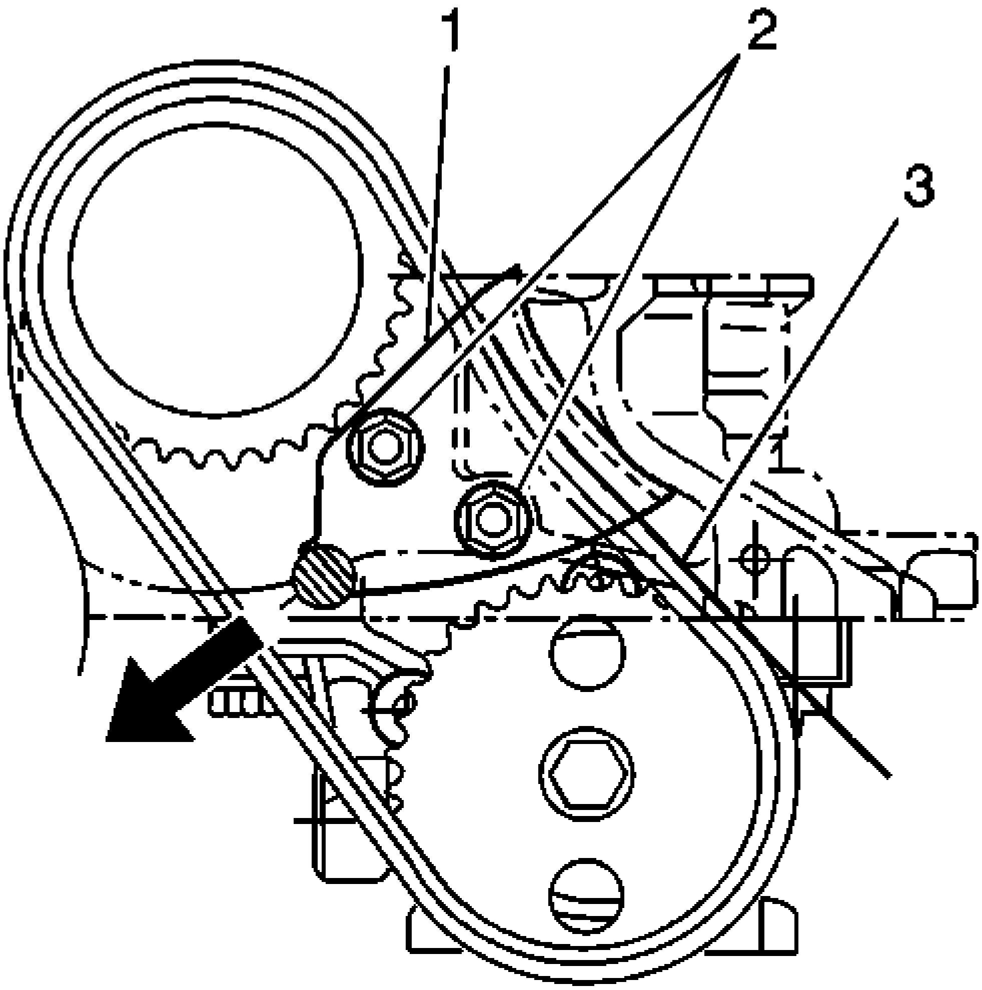


Fig. 180: View Of Oil Pump Chain Guide, Feeler Gauge & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pump drive chain cover (1). Secure with the 4 bolts.

   Tighten: Tighten the 4 bolts to 11 N.m (97 lb in).

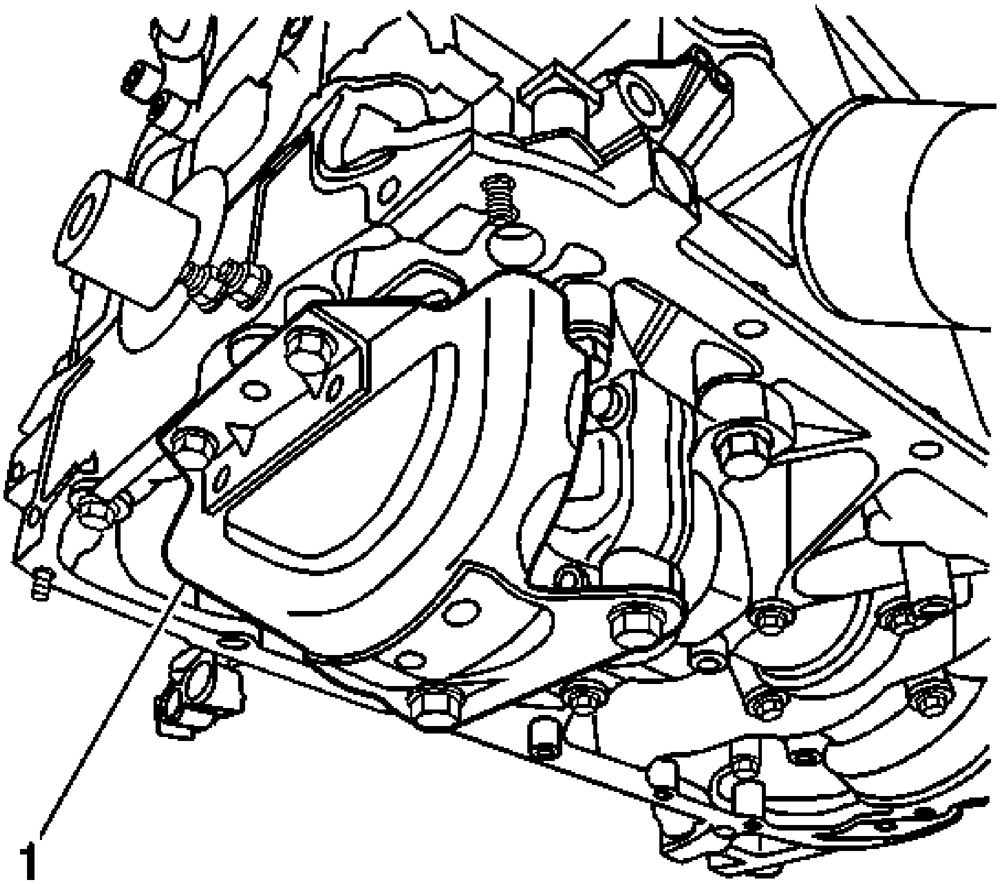


Fig. 181: View Of Oil Pump Drive Chain Cover
Courtesy of GENERAL MOTORS CORP.

7. Install new O-rings and install the oil pump strainer to the oil pump.
8. Install and tighten the 2 strainer bolts first and then the bracket bolt.

   Tighten: Tighten the 3 bolts to 11 N.m (97 lb in).

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

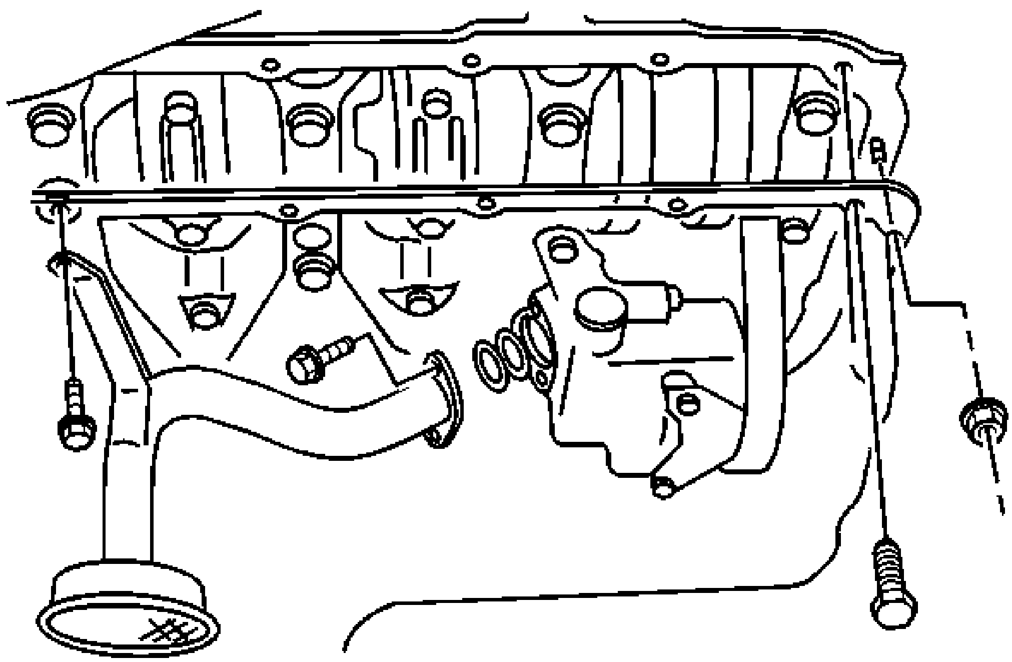


Fig. 182: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

Crankshaft Rear Oil Seal Replacement

Tool Required

J 41172 Oil Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the transmission assembly. Refer to **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Manual Transmission or **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Automatic Transmission.
2. Remove the clutch and pressure plate on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.
3. Mark the flywheel-to-engine position.
4. Remove the flywheel from the crankshaft. Refer to **Engine Flywheel Replacement**.

IMPORTANT: To protect the crankshaft from damage, wrap the tip of the screwdriver with tape.

5. Carefully pry out the crankshaft rear oil seal using a screwdriver.

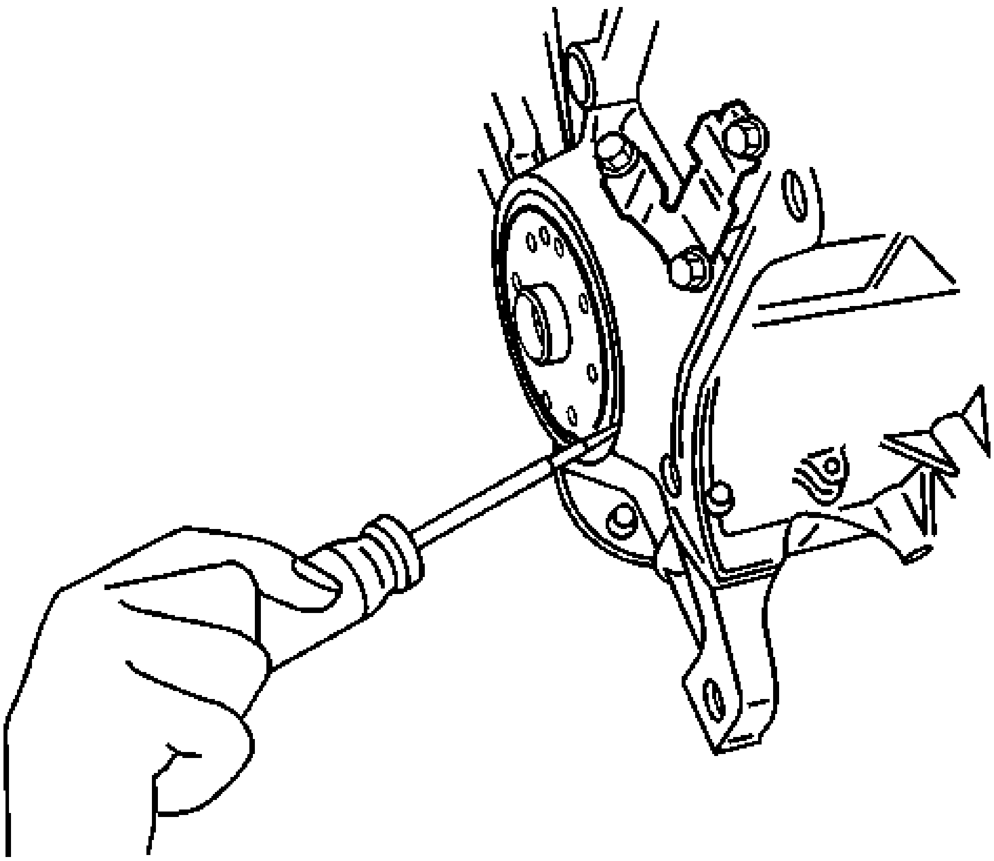


Fig. 183: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Apply GM P/N 1051344 Chassis Grease to the new crankshaft rear oil seal lip.

IMPORTANT: The J 41172 will install the seal to the correct installed depth. See Special Tools and Equipment. Other seal installers may not seat the seal properly and oil leakage may result.

2. Position the new seal in place over the end of the crankshaft.
3. Lightly tap the crankshaft rear oil seal into place using a hammer and the **J 41172** . See **Special Tools**

and Equipment.

4. Install the flywheel. Refer to **Engine Flywheel Replacement**.
5. Install the clutch and pressure plate on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.
6. Install the transmission assembly. Refer to **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Manual Transmission or **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Automatic Transmission.

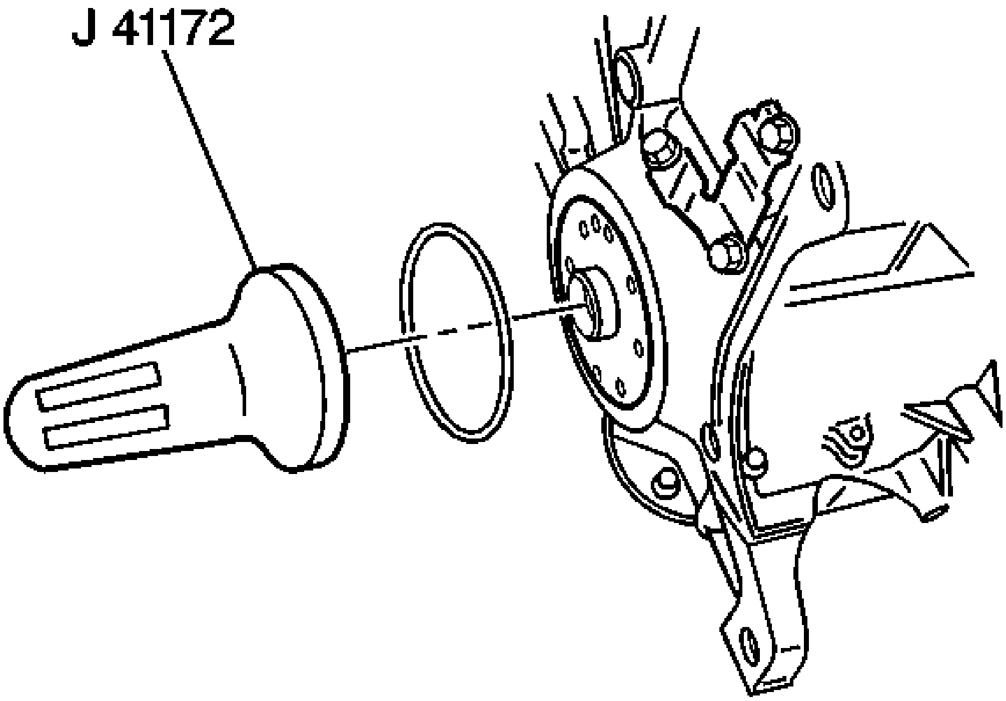


Fig. 184: Applying Lubricant To New Crankshaft Rear Oil Seal Lip
Courtesy of GENERAL MOTORS CORP.

Engine Flywheel Replacement

Tools Required

- **J 8001** Dial Indicator Set
- **J 26900-13** Magnetic Indicator Base. See **Special Tools and Equipment**.
- **J 35271** Flywheel Holder. See **Special Tools and Equipment**.

Removal Procedure

1. Remove the transmission assembly. Refer to **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Manual Transmission or **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Automatic Transmission.
2. Remove the clutch and pressure plate on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.
3. Inspect the ring gear (2). Replace the flywheel if the ring gear is damaged, cracked or worn.
4. Inspect the clutch disc contact surface on manual transmission equipped vehicles. Replace the flywheel if the surface is damaged or excessively worn.
5. Measure the flywheel face runout using a **J 8001** with a **J 26900-13** . See **Special Tools and Equipment**. Replace the flywheel if the runout exceeds specifications.

   Flywheel Runout: 0.2 mm (0.0078 in)

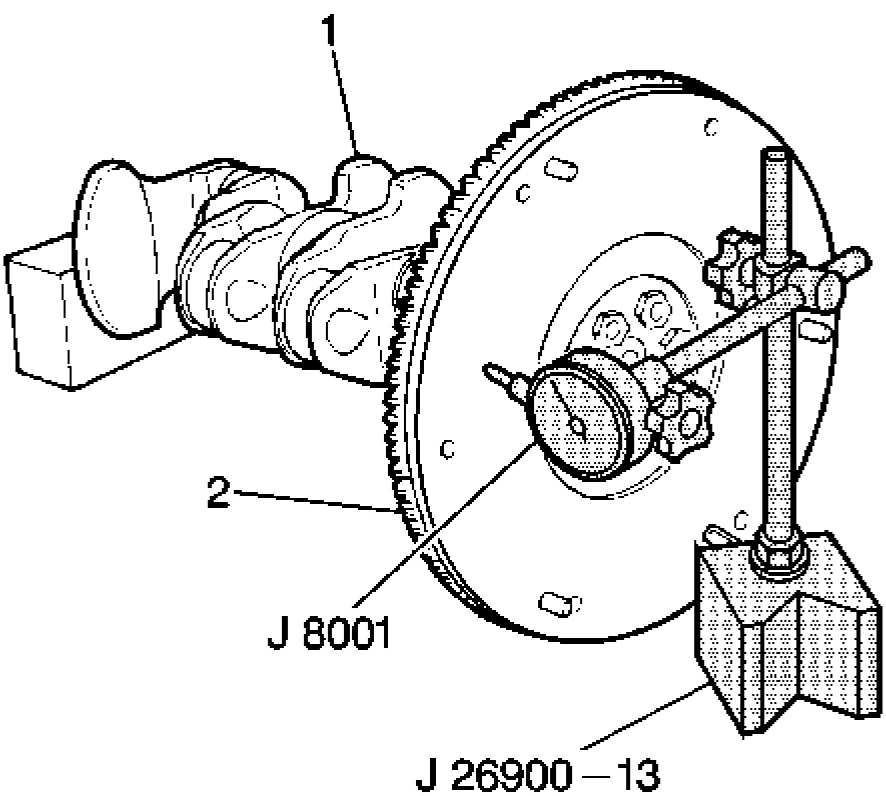


Fig. 185: View Of Rear Gear
Courtesy of GENERAL MOTORS CORP.

6. Mark the flywheel-to-engine position.
7. Lock the flywheel (1) in place with the **J 35271** . See **Special Tools and Equipment**.

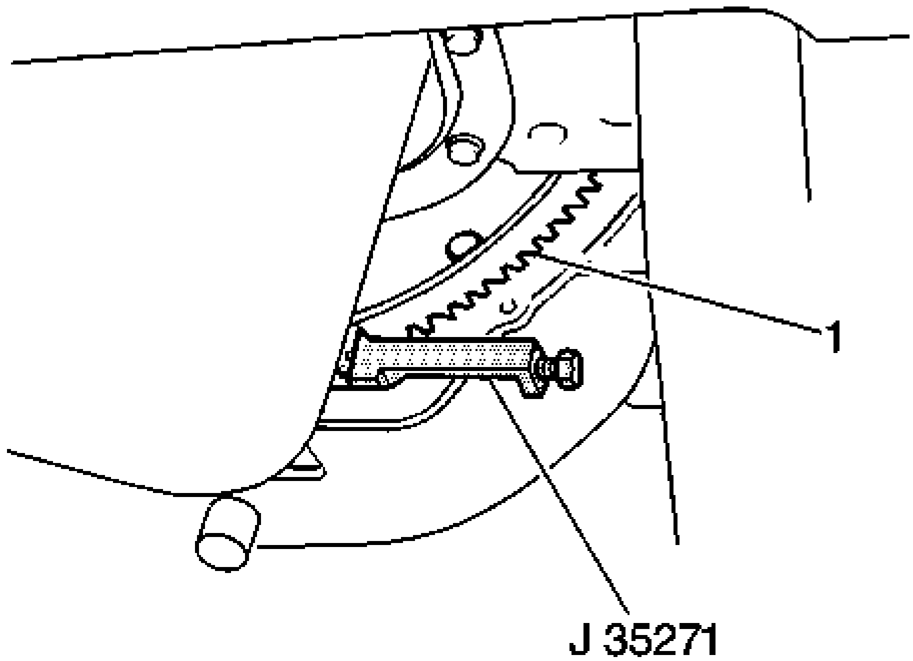


Fig. 186: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

8. Remove the 8 flywheel retaining bolts.
9. Remove the flywheel from the crankshaft.
10. Inspect the clutch pilot bushing. Replace if necessary. Refer to **Pilot Bearing Replacement** in Clutch.
11. Clean the grease and dirt from the flywheel outer surfaces using a suitable solvent.

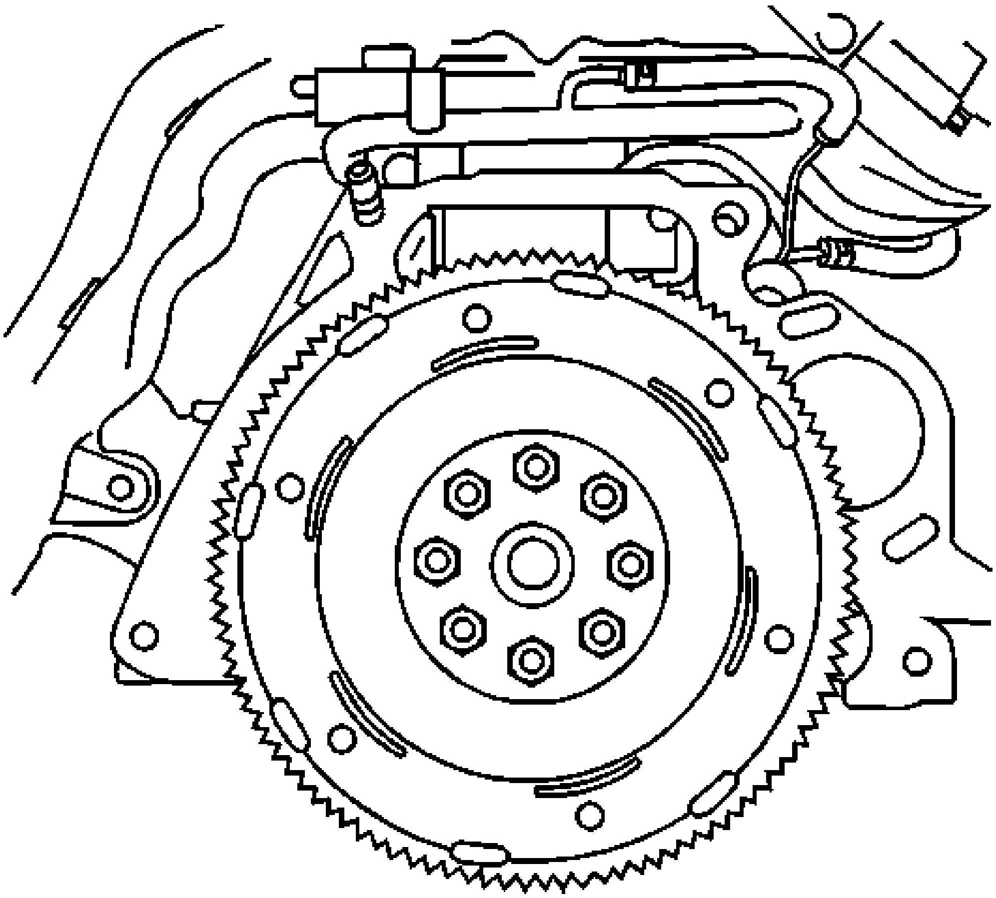


Fig. 187: Removing Flywheel
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Align the flywheel-to-engine marks and install the flywheel (3) to the crankshaft.

NOTE: Apply the proper amount of the sealant to the fastener when assembling this component. Excessive use of the sealant can prohibit the component from being assembled properly or allow the fastener to loosen. A component or fastener that is not assembled properly can loosen or fall off leading to extensive engine damage.

2. Apply GM P/N 12345493, or the equivalent, to the flywheel retaining bolt threads.

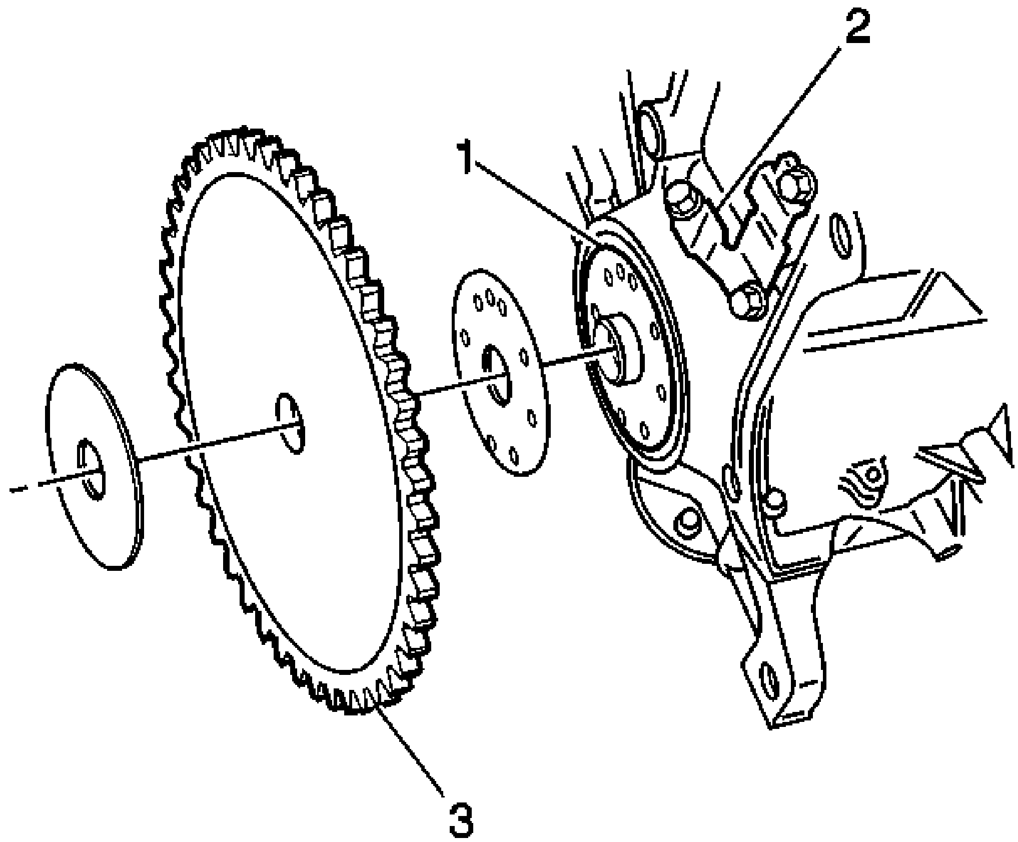


Fig. 188: View Of Crankshaft & Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the flywheel retaining bolts to the crankshaft. Use the **J 35271** to lock the flywheel. See **Special Tools and Equipment**.

   Tighten: Cross tighten the 8 flywheel retaining bolts to 70 N.m (51 lb ft).

4. Install the clutch and pressure plate on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.
5. Install the transmission assembly. Refer to **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Manual Transmission or **Transmission Replacement - 2WD** or **Transmission Replacement - 4WD** in Automatic Transmission.

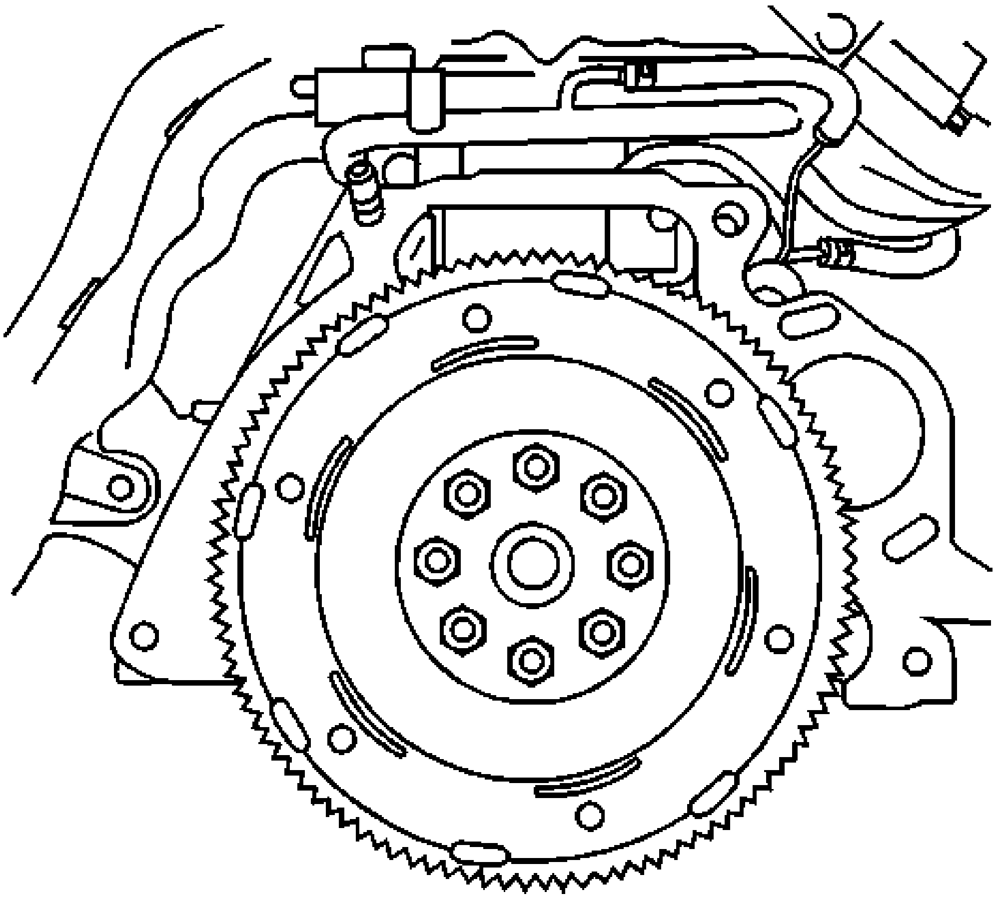


Fig. 189: Installing Flywheel
Courtesy of GENERAL MOTORS CORP.

Engine Replacement

Tools Required

- **J 35271** Flywheel Holder. See **Special Tools and Equipment**.
- **J 36854** Heavy Duty Automotive Engine Stand. See **Special Tools and Equipment**.

Removal Procedure

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls.

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

2. Disconnect the negative battery cable.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Remove the front skid plate (5) from the vehicle, if equipped.
5. Drain the engine cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
6. Drain the engine oil.

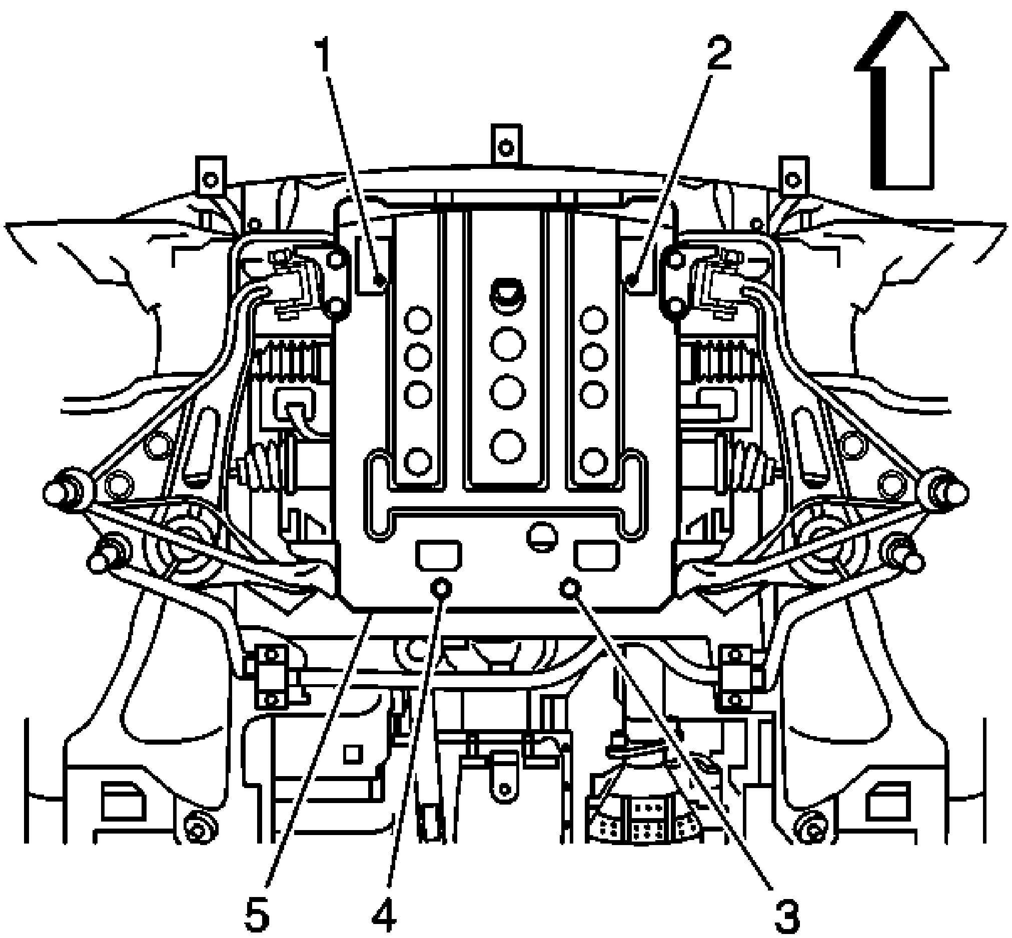


Fig. 190: View Of Front Skid Plate
Courtesy of GENERAL MOTORS CORP.

7. Remove the automatic transmission fluid cooler lines (1) from the radiator on automatic transmission equipped vehicles. Cap the open lines to prevent leakage.

8. Remove the flywheel cover.

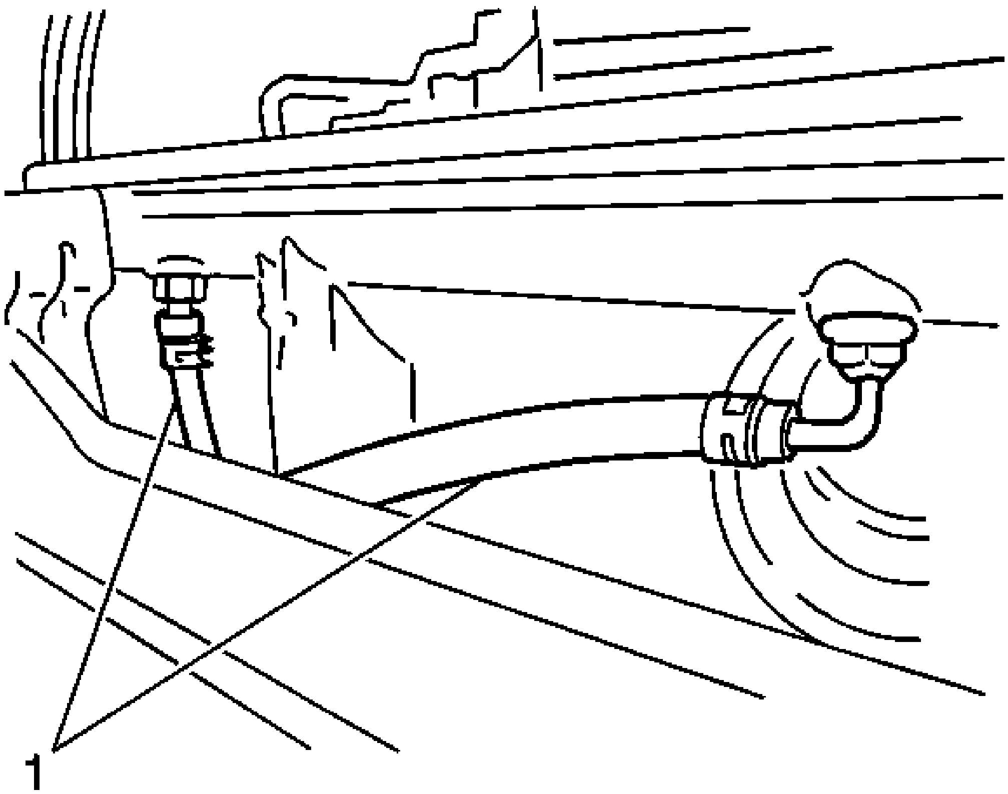


Fig. 191: View Of Automatic Transmission Fluid Cooler Lines
Courtesy of GENERAL MOTORS CORP.

9. Remove the torque converter bolts on automatic transmission equipped vehicles. Use the **J 35271** in order to lock the flywheel (1). See **Special Tools and Equipment**.

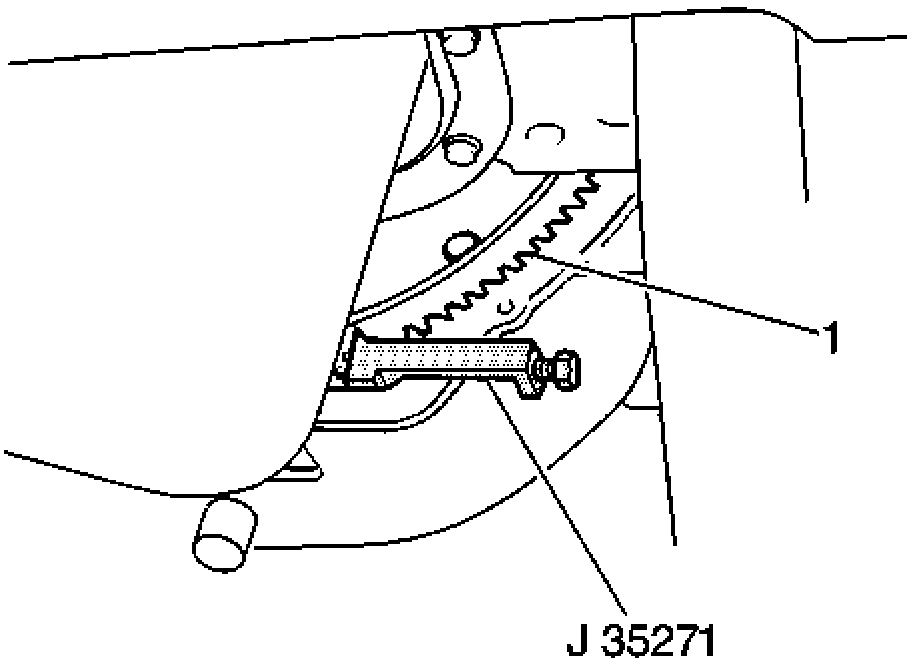


Fig. 192: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

10. Support the transmission. Remove the 4 bolts and the right side engine-to-transmission support bracket (3).

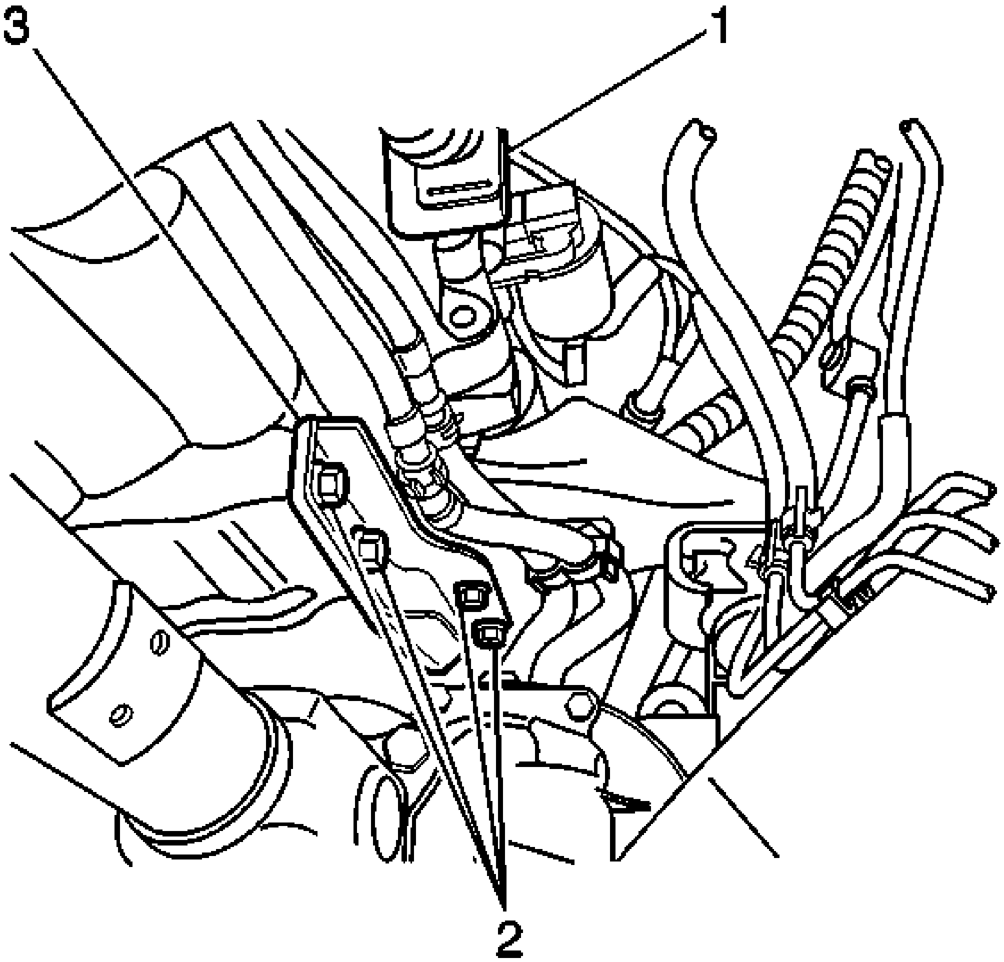


Fig. 193: View Above Differential
Courtesy of GENERAL MOTORS CORP.

11. Remove the 2 bolts and separate the front pipe assembly from the exhaust manifold on vehicles not equipped with the PUP catalytic converter.
12. Lower the vehicle.
13. Remove the hood from the vehicle. Refer to **Hood Replacement** in Body Front End.

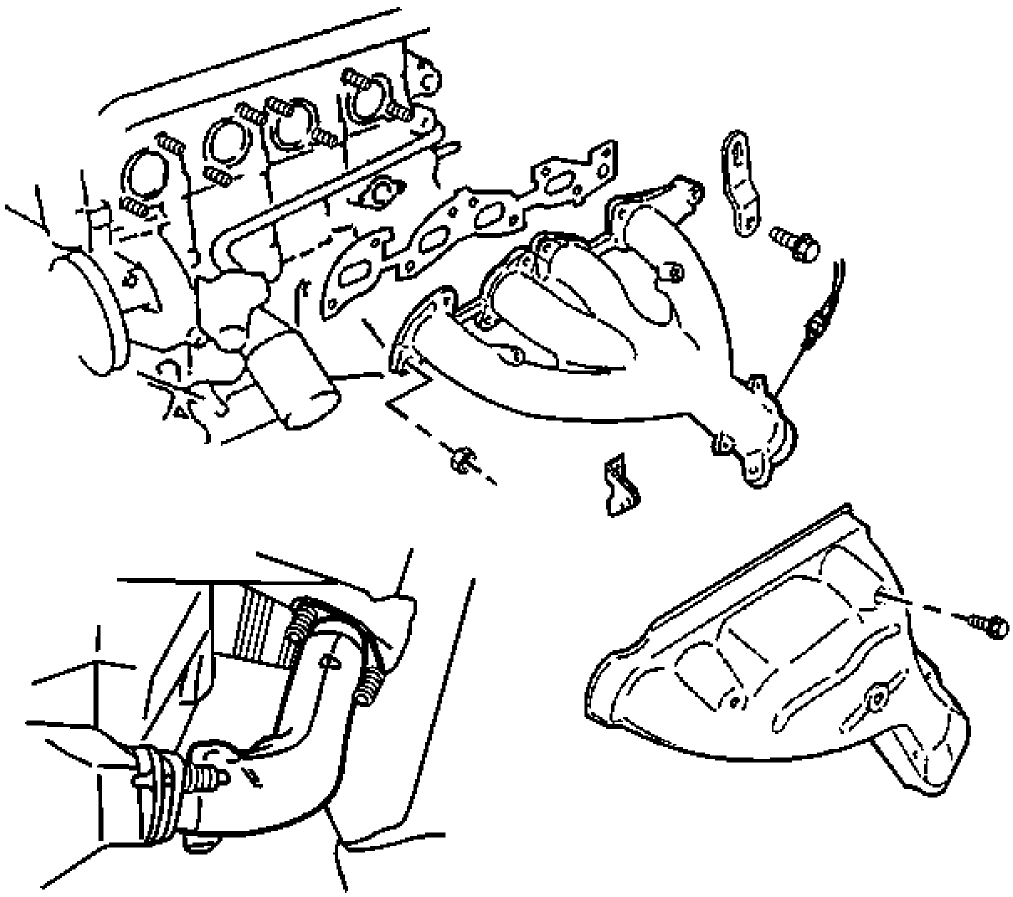


Fig. 194: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The vehicle should be supported on a hoist prior to removing the strut tower brace. This will facilitate removal and installation of the brace.

14. Remove the 6 bolts and the strut tower brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.

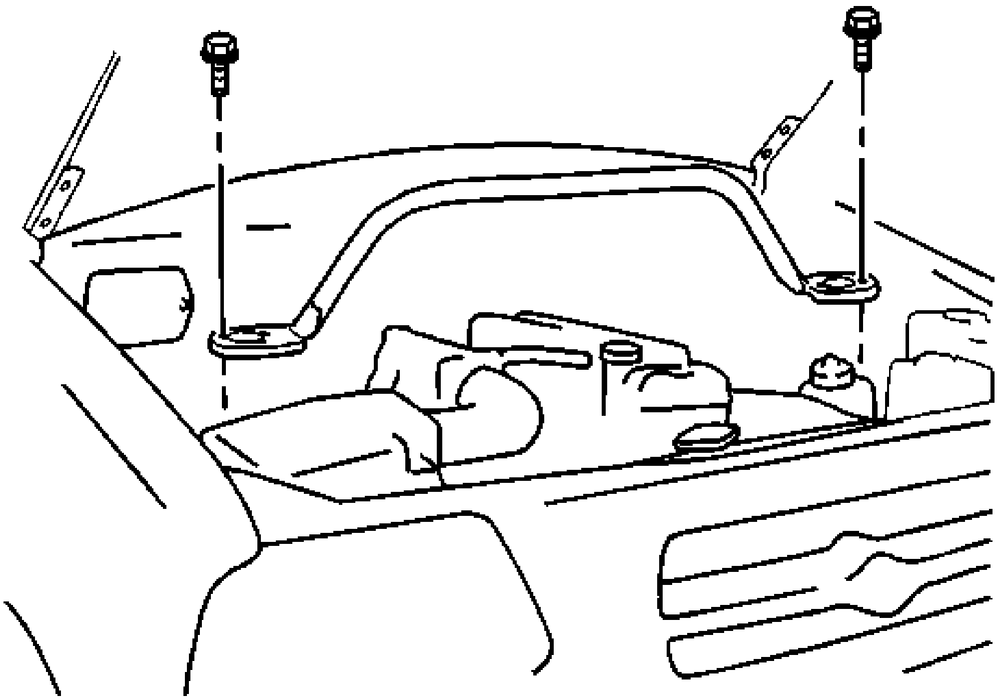


Fig. 195: View Of Strut Tower Brace
Courtesy of GENERAL MOTORS CORP.

15. Remove the 3 nuts and separate the front pipe assembly from the exhaust manifold on vehicles equipped with the PUP catalytic converter.
16. Remove the engine block-to-catalytic converter support bracket.

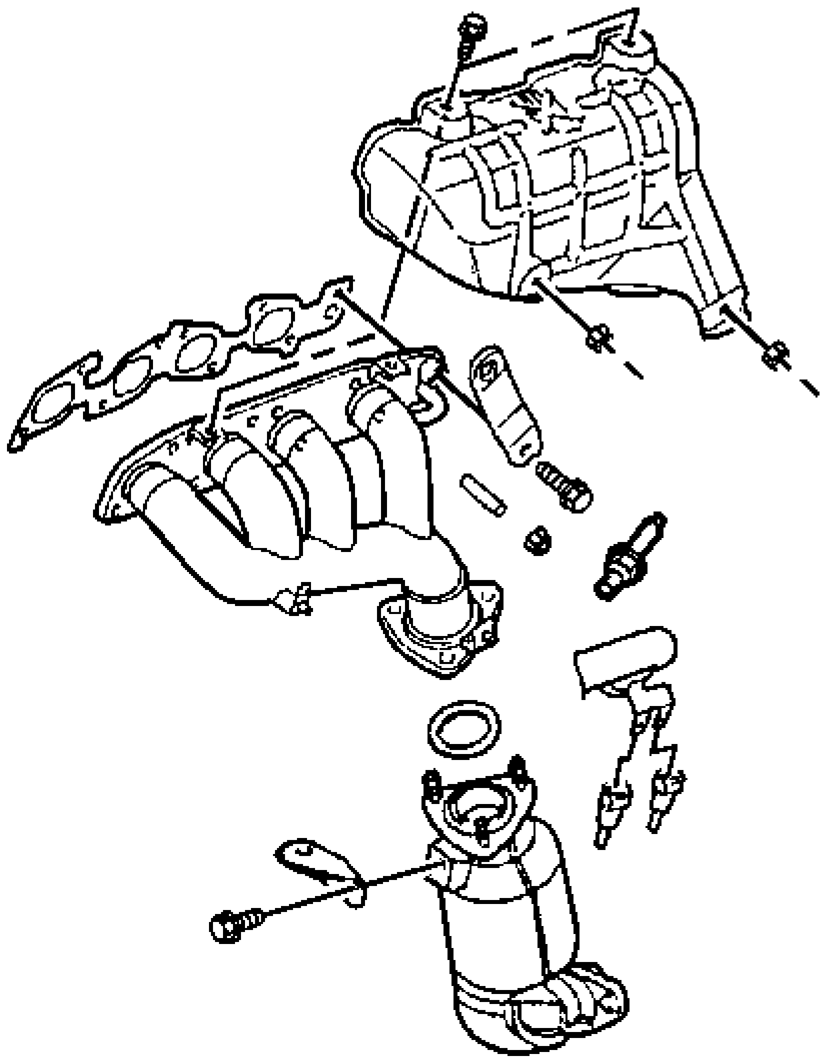


Fig. 196: View Of Exhaust Manifold & Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not discharge the A/C system nor remove the refrigerant lines from the compressor.

17. Remove the 3 bolts (1) and the A/C compressor, if equipped, from its bracket and position aside. Refer to **Compressor Replacement (2.0L)** **Compressor Replacement (2.5L)** in HVAC Systems with A/C Manual.

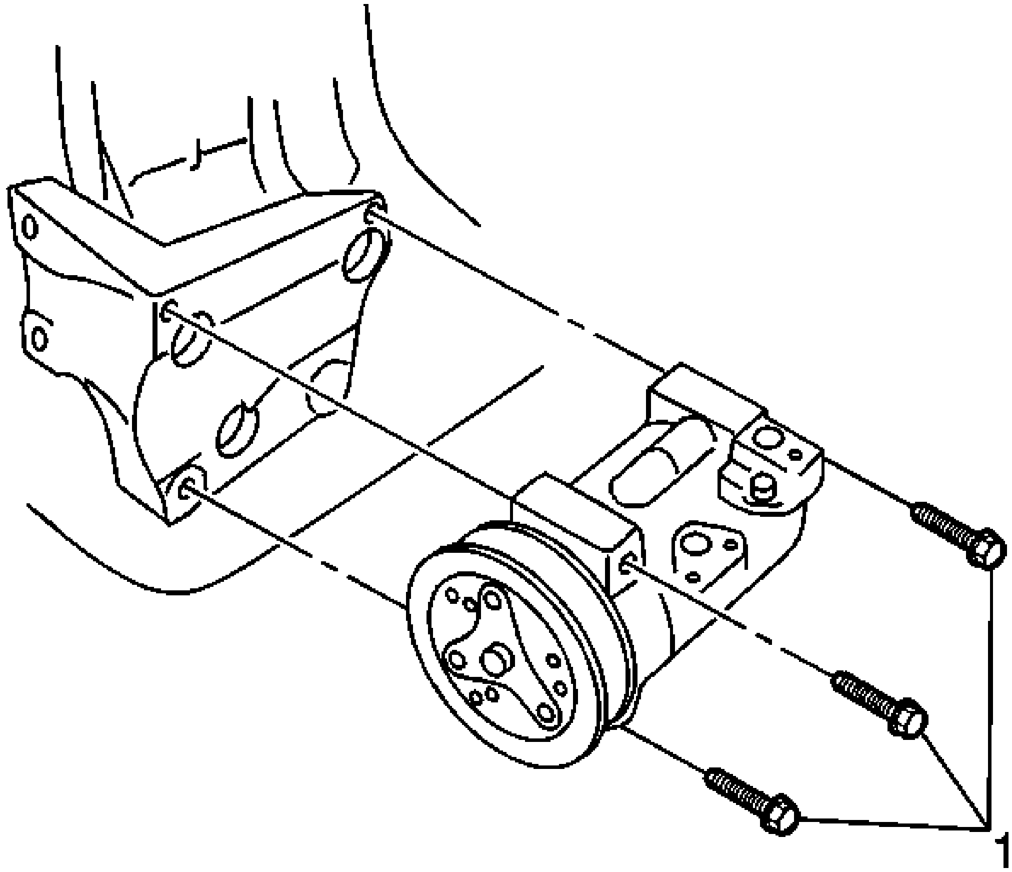


Fig. 197: Compressor Mounting View
Courtesy of GENERAL MOTORS CORP.

18. Remove the 4 bolts (2) and the A/C compressor bracket, if equipped. Refer to **Compressor Mounting Bracket Replacement (2.0L)** **Compressor Mounting Bracket Replacement (2.5L)** in HVAC Systems with A/C Manual.

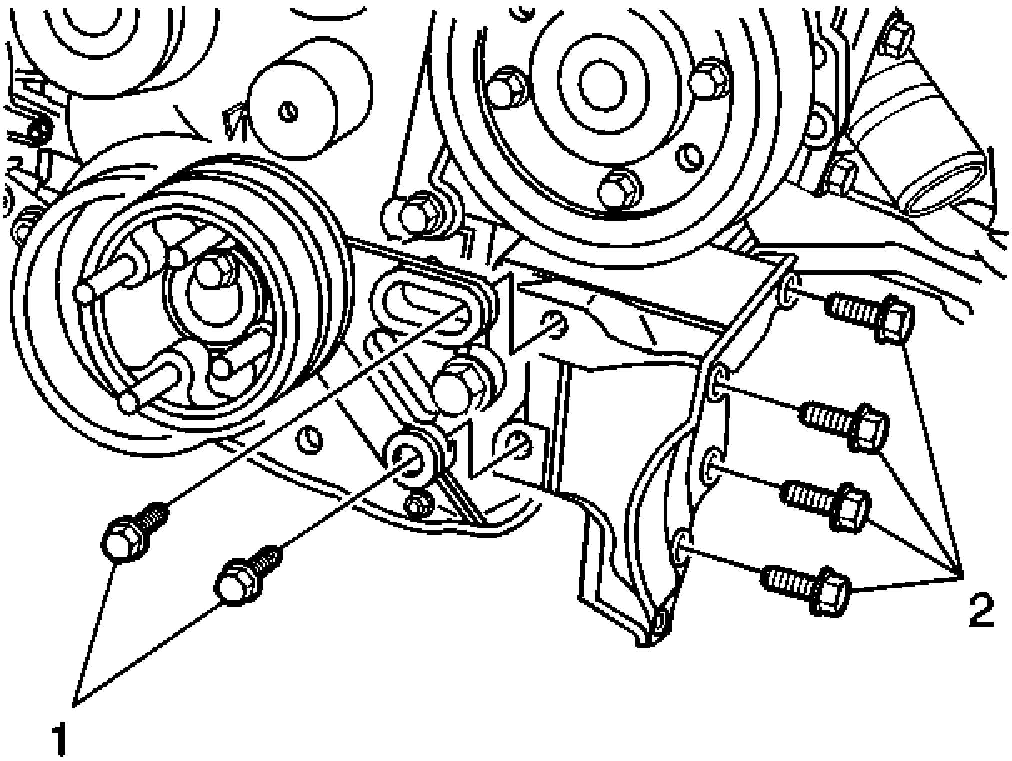


Fig. 198: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

19. Remove the upper radiator hose (2) from the vehicle.

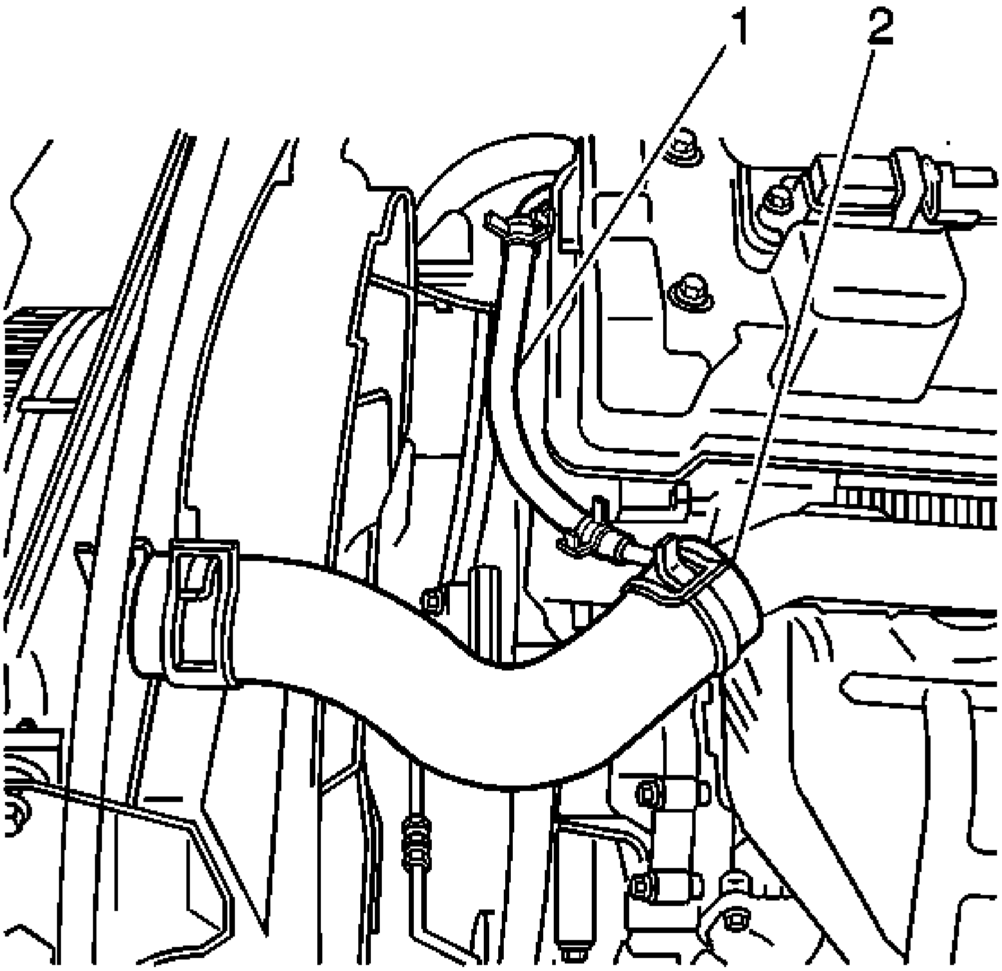


Fig. 199: View Of Upper Radiator Hose
Courtesy of GENERAL MOTORS CORP.

20. Remove the lower radiator hose (1) from the vehicle.
21. Remove the radiator overflow hose from the radiator.
22. Remove the 4 radiator shroud clips.
23. Remove 1 bolt from each side of the radiator upper support.

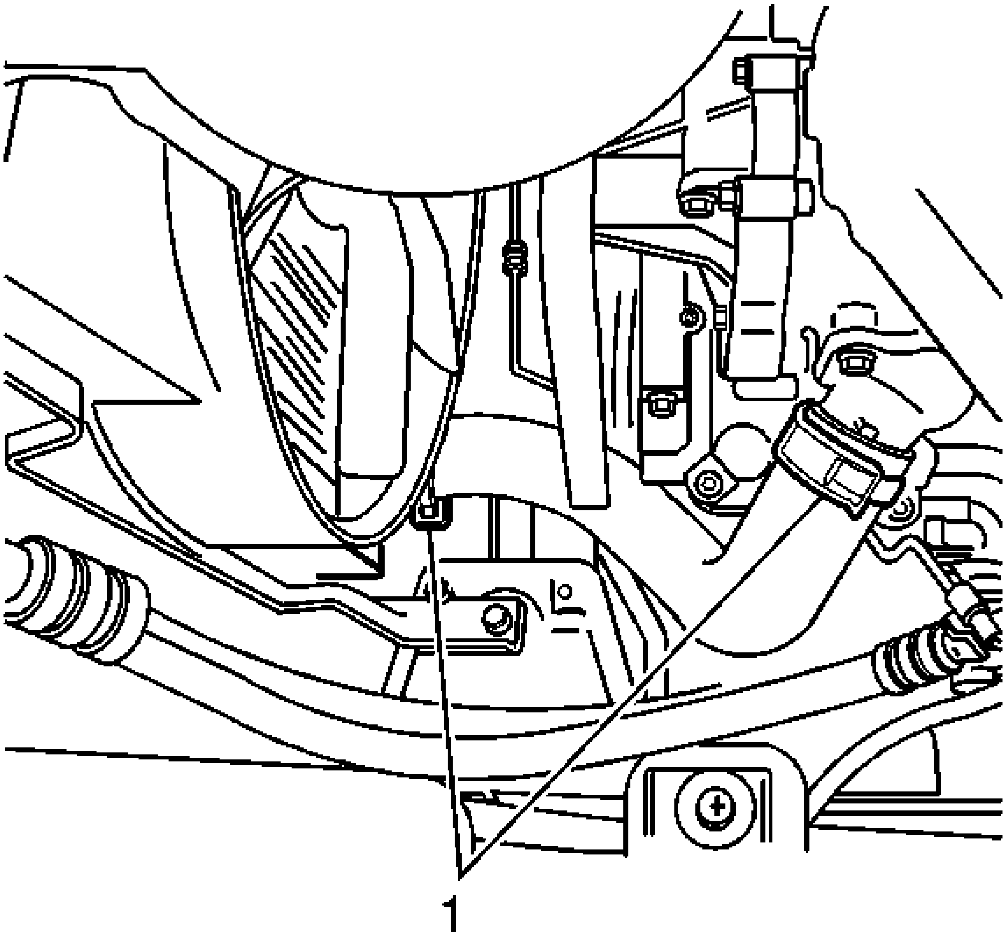


Fig. 200: View Of Lower radiator Hose Clamps
Courtesy of GENERAL MOTORS CORP.

24. Lean the fan shroud toward the engine and lift the radiator up and out of the vehicle.

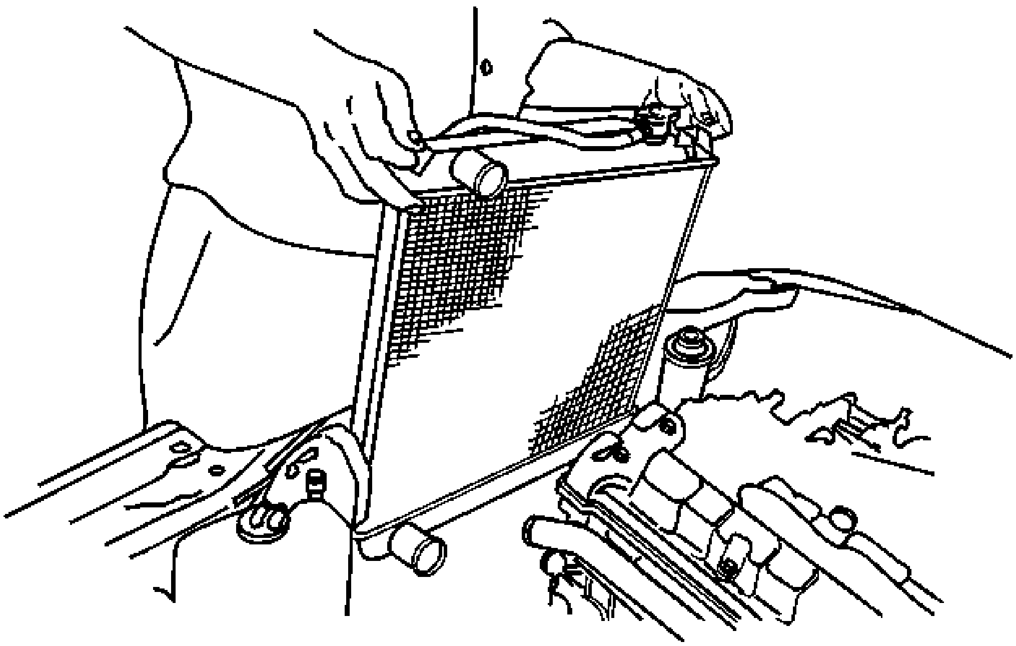


Fig. 201: View Of Radiator
Courtesy of GENERAL MOTORS CORP.

25. Remove the four fan mounting nuts (1). Use a second wrench to hold the fan shaft.

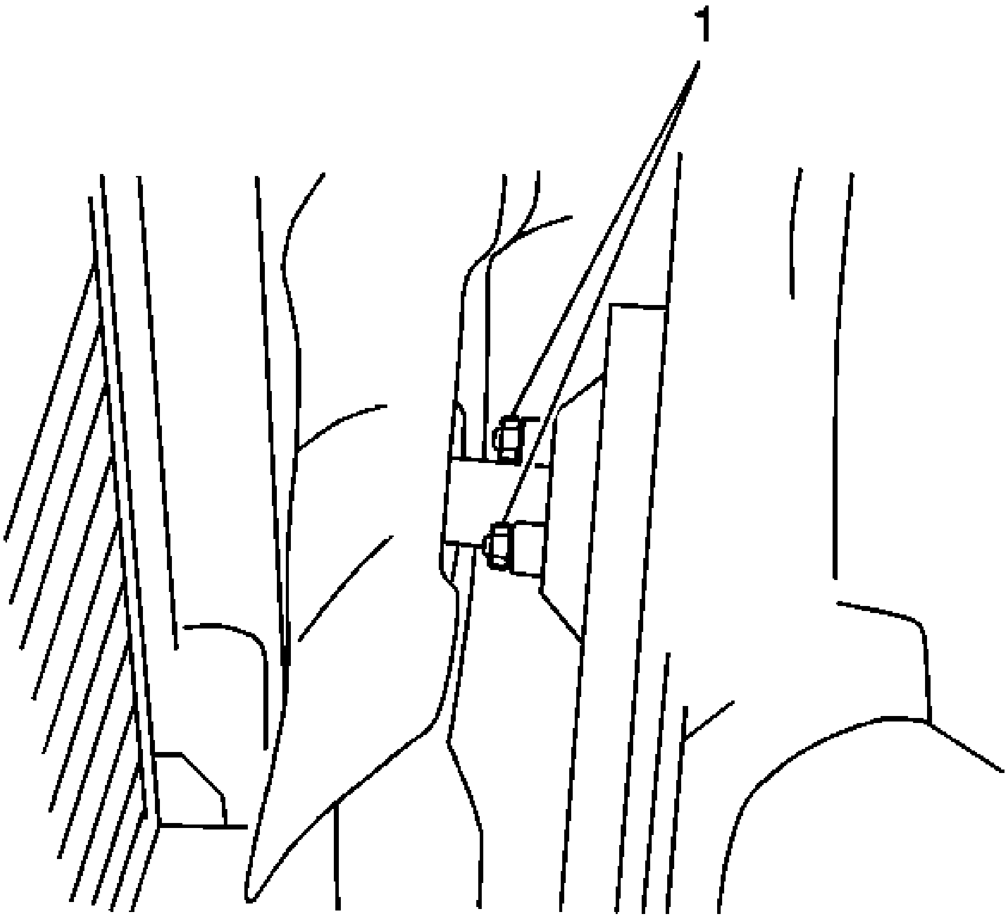


Fig. 202: Cooling Fan Mounting View
Courtesy of GENERAL MOTORS CORP.

26. Remove the fan and the fan shroud.

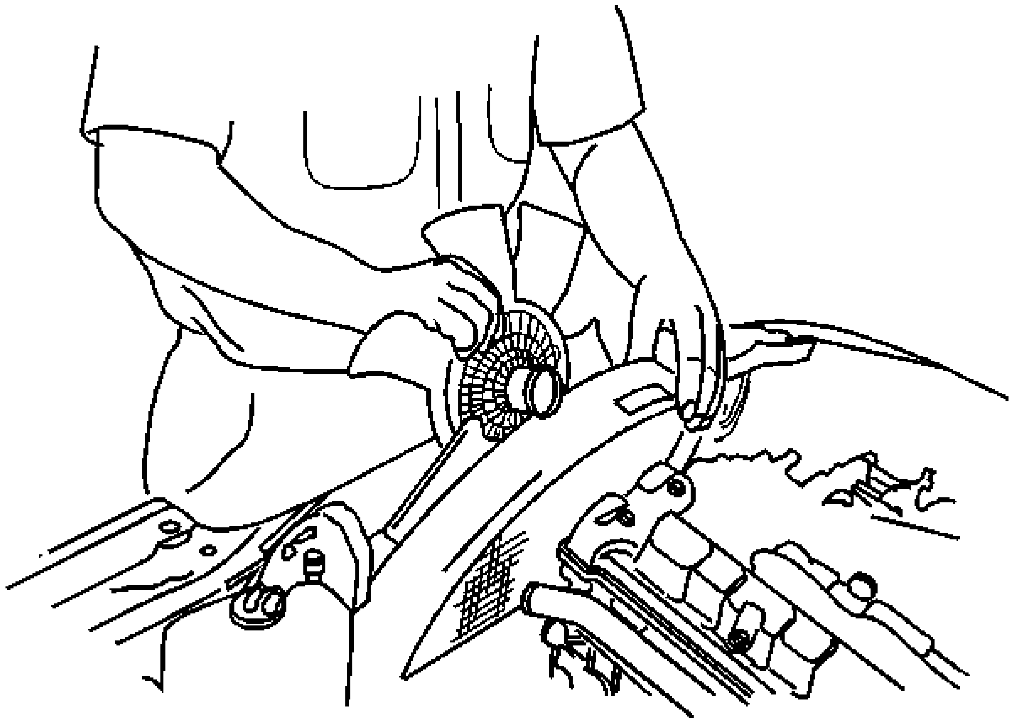


Fig. 203: Removing/Installing Fan Assembly
Courtesy of GENERAL MOTORS CORP.

27. Loosen the adjusting bolt (1) and the pivot bolt (3).
28. Remove the tension on the fan belt by rotating the tension bolt (2) counterclockwise.
29. Remove the fan belt.
30. Remove the 2 tensioner mounting bolts (1,3) and the tensioner.

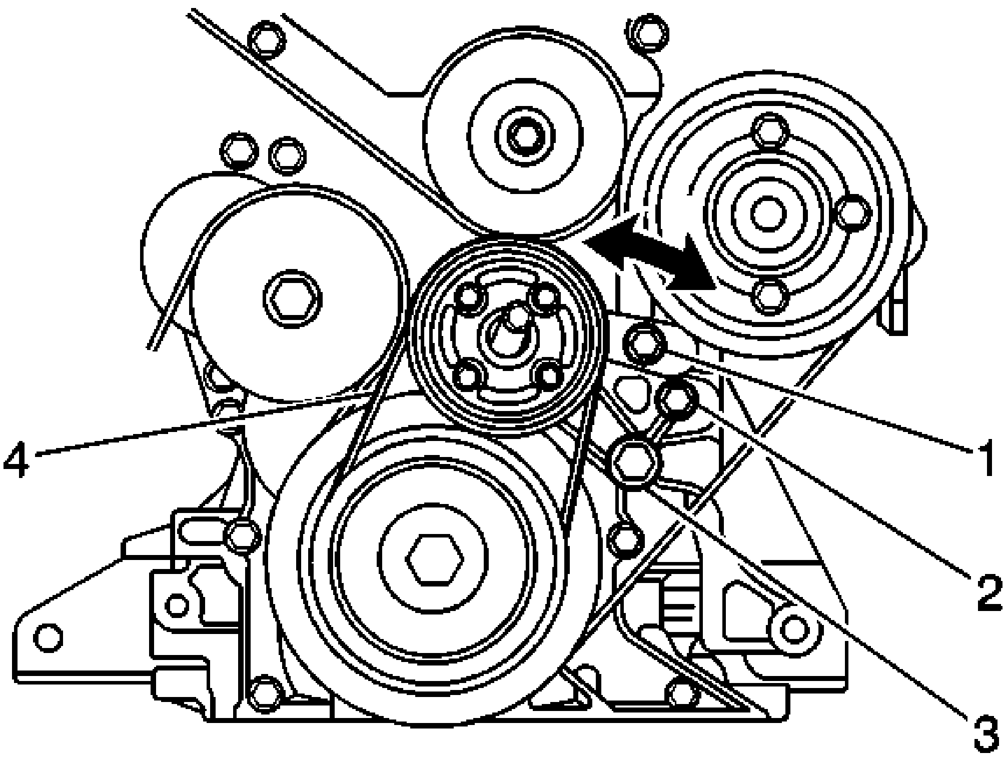


Fig. 204: View Of Tension, Adjusting & Pivot Bolts
Courtesy of GENERAL MOTORS CORP.

31. Rotate the belt tensioner clockwise and remove the accessory drive belt.

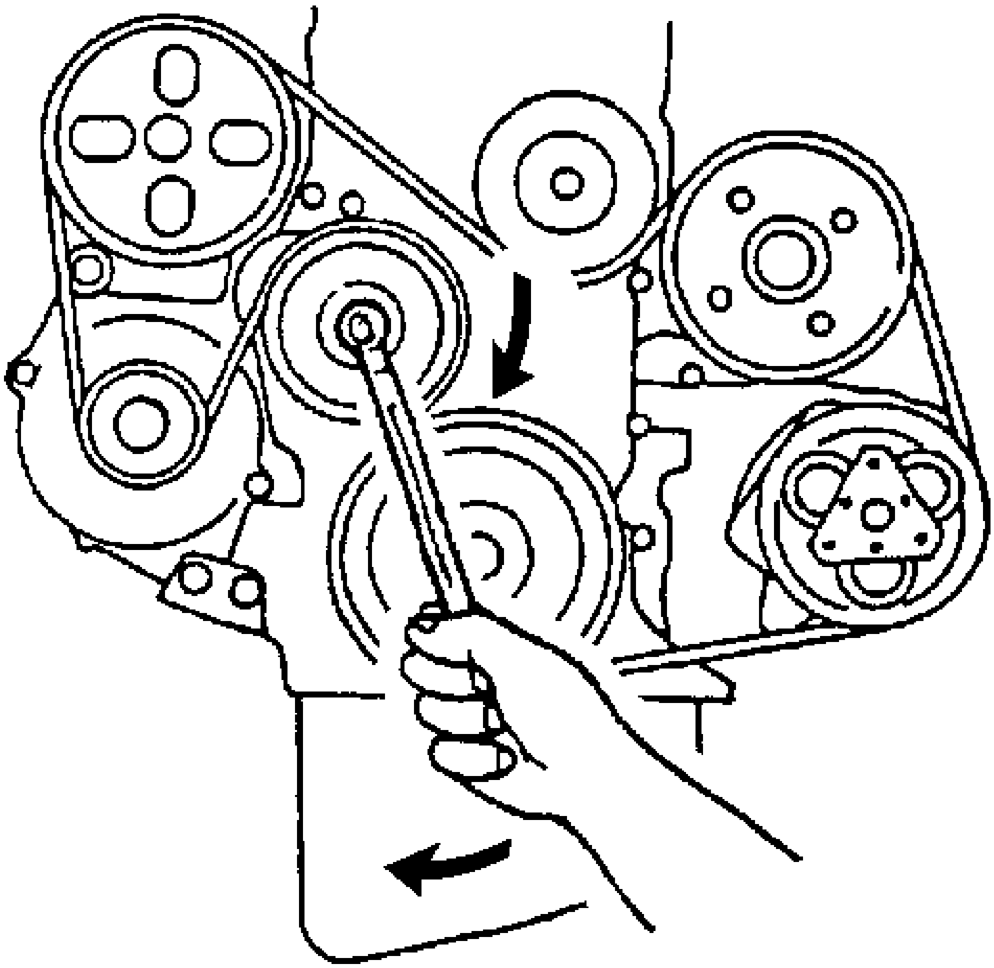


Fig. 205: Rotating Belt Tensioner Clockwise
Courtesy of GENERAL MOTORS CORP.

32. Remove the bolt and the throttle cable bracket (2) from the intake manifold.
33. Remove the cables from the throttle body bellcrank and position aside.
34. Remove the power steering pressure and return lines from the power steering pump and position aside. Cap the open lines to prevent leakage.
35. Disconnect the intake air temperature (IAT) sensor connector.
36. Disconnect the mass air flow (MAF) sensor connector.
37. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.

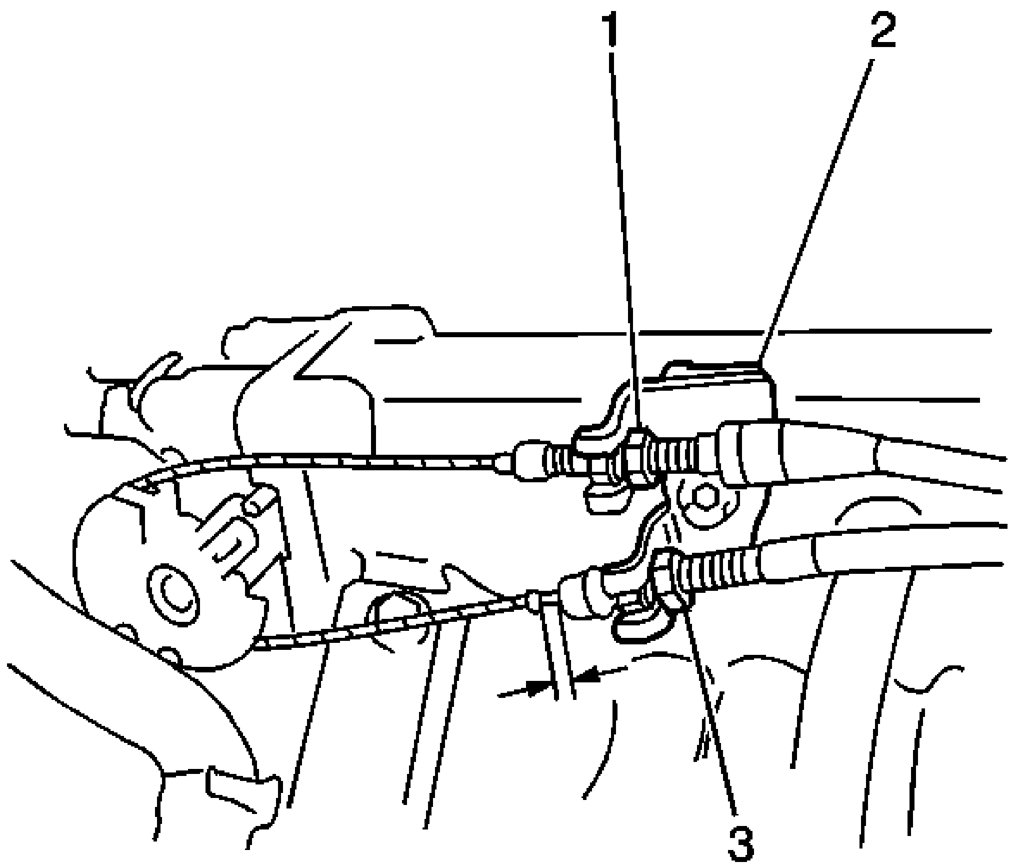


Fig. 206: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

38. Remove the heater hoses from the heater core. Mark the location of the inlet and outlet hoses for correct installation.

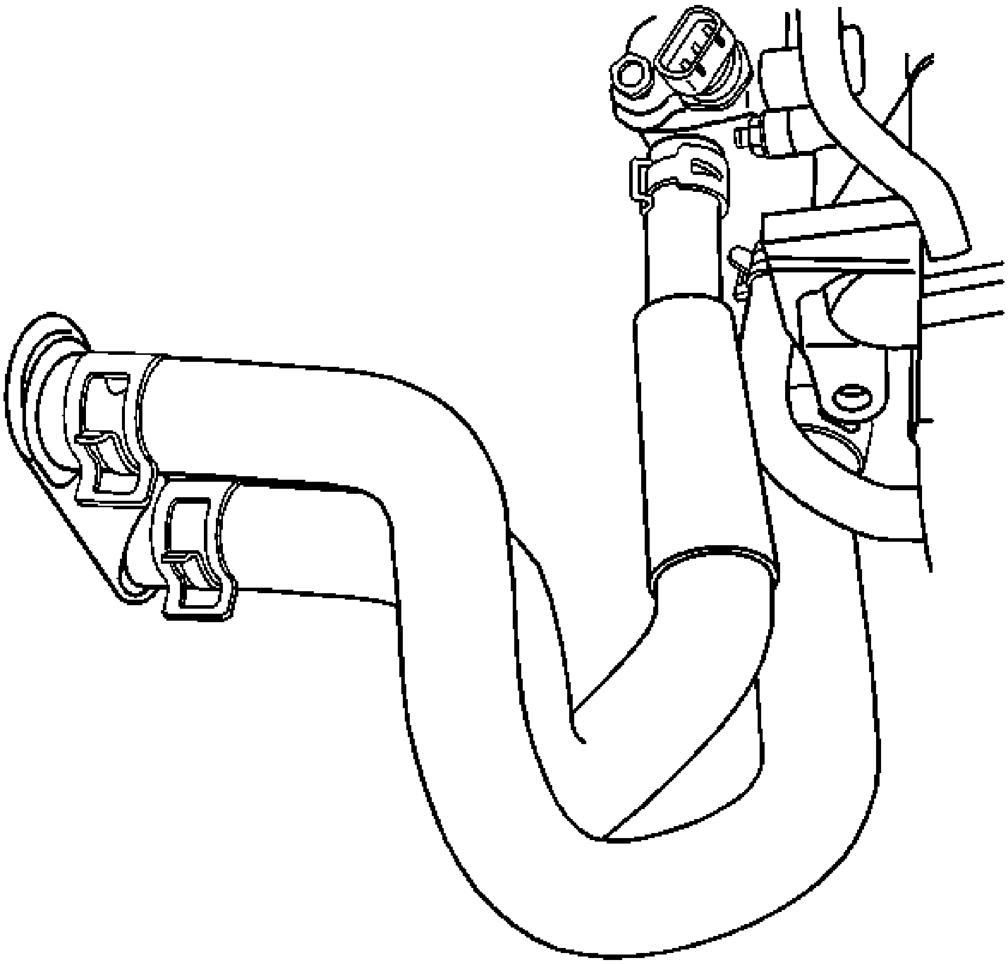


Fig. 207: Removing Heater Hoses From Heater Core
Courtesy of GENERAL MOTORS CORP.

39. Disconnect the fuel feed and return hoses (9). Label the feed and return hoses for correct installation.
40. Disconnect the following electrical connectors:
    - The 4 ignition coils
    - The fuel injector wiring harness (3)
    - The throttle position sensor (TPS) (8)
    - The manifold absolute pressure (MAP) sensor (11)
    - The idle air control (IAC) valve (6)
    - The exhaust gas recirculation (EGR) valve (1)
    - The engine coolant temperature (ECT) sensor (2)

- The EVAP canister purge valve (7)
- The heated oxygen sensor 1 (HO2S1)
- The camshaft position sensor (CMP)
- The power steering pressure (PSP) switch wire
- The generator wires
- The oil pressure switch wire

41. Remove the bolt and the ground wires from the intake manifold (10).
42. Remove the EVAP canister purge hose from the intake manifold.
43. Remove the wiring harness from the retaining clamps.
44. Remove the brake booster vacuum line from the intake manifold.

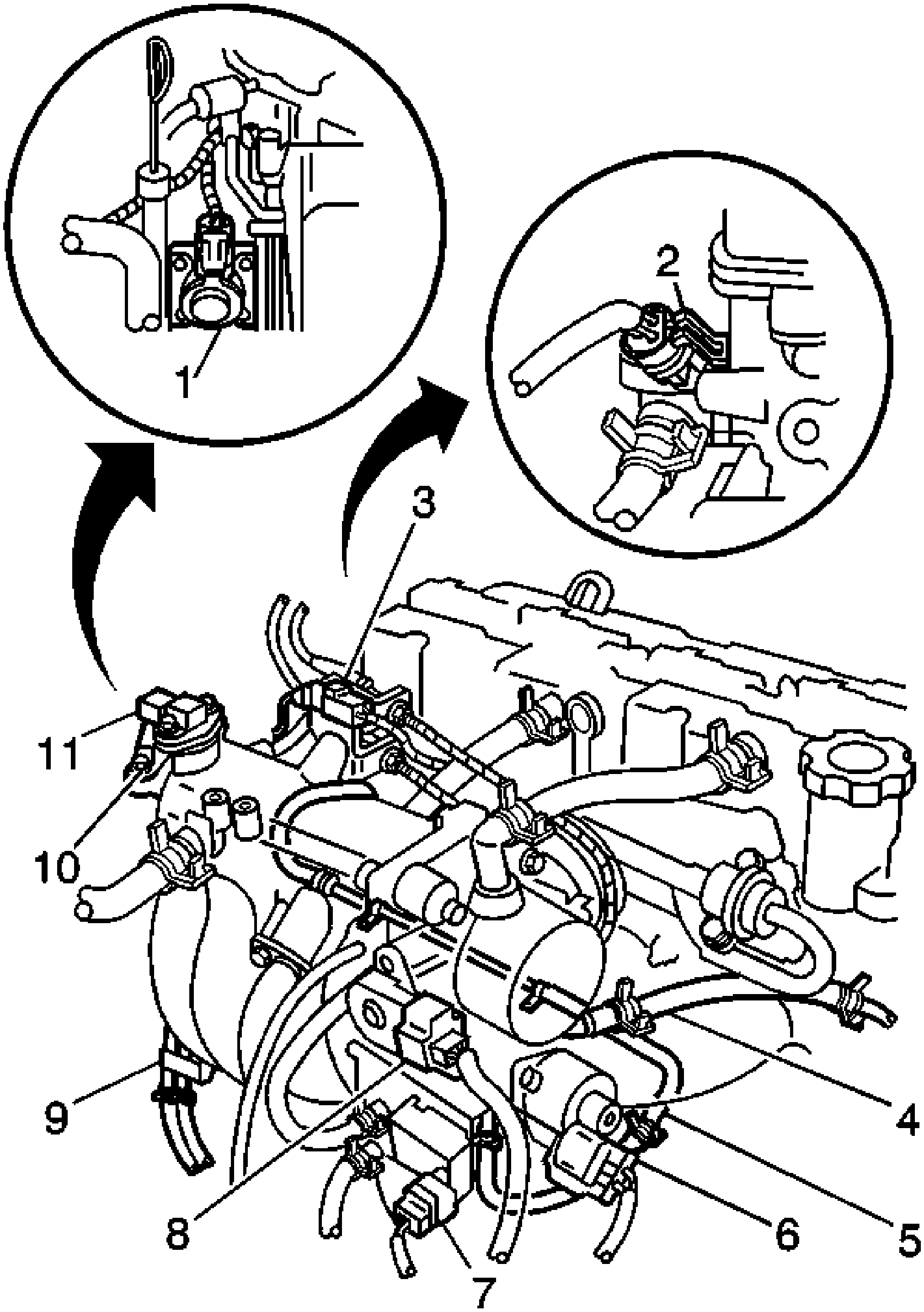


Fig. 208: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

45. Disconnect the starter solenoid electrical connector.
46. Remove the nut and the battery positive cable (3) from the starter solenoid.
47. Remove the 2 bolts (1) and the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
48. Disconnect the crankshaft position sensor (CKP) (2) connector.

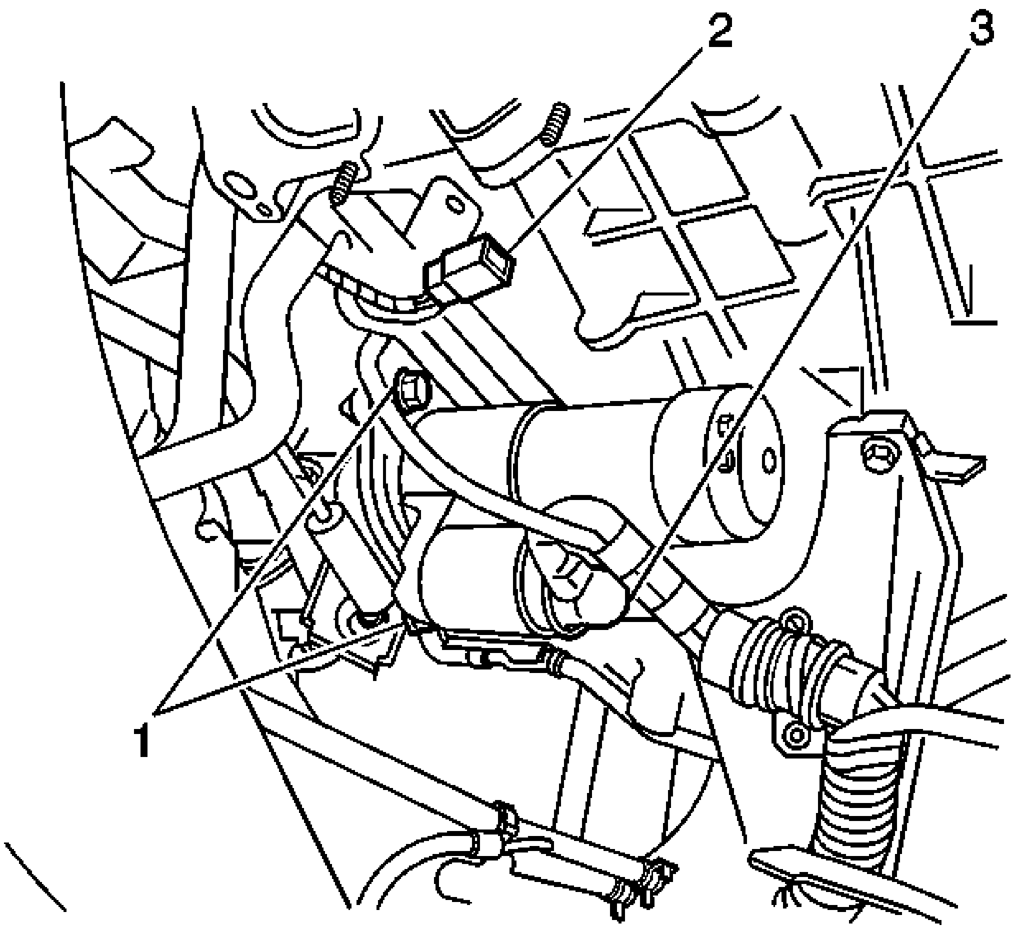


Fig. 209: Locating Starter Motor
Courtesy of GENERAL MOTORS CORP.

49. Remove the cylinder block-to-transmission bolt and nuts.

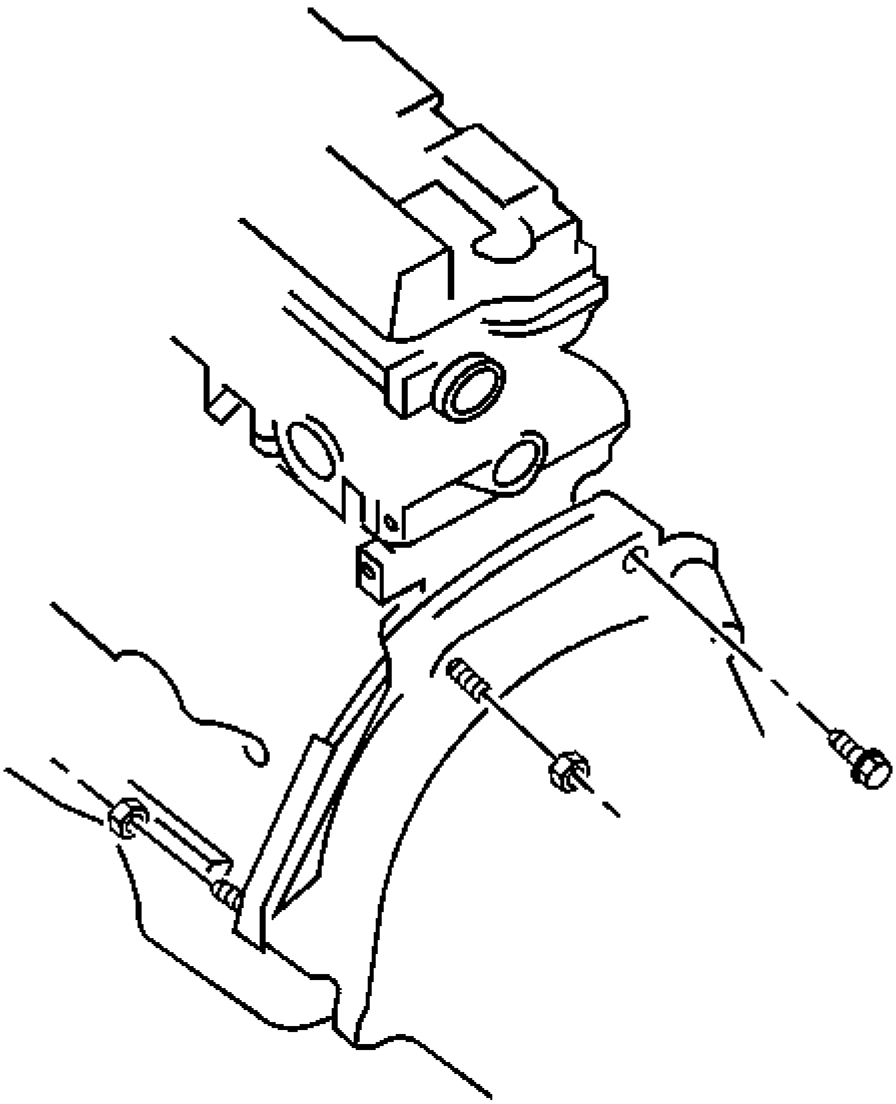


Fig. 210: View Of Cylinder Block-To-Transmission Bolt & Nuts
Courtesy of GENERAL MOTORS CORP.

50. Remove the 2 nuts from the top side of the engine mounts.
51. Install an engine hoist to the engine.

IMPORTANT: Before lifting the engine, ensure that all of the hoses, pipes, electrical wires and cables are disconnected from the engine and positioned aside.

52. Remove the engine assembly from the vehicle by sliding the assembly toward the front side of the engine compartment. Carefully lift the engine assembly from the vehicle verifying clearance on all sides.
53. Remove the pressure plate assembly and the clutch disc on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.

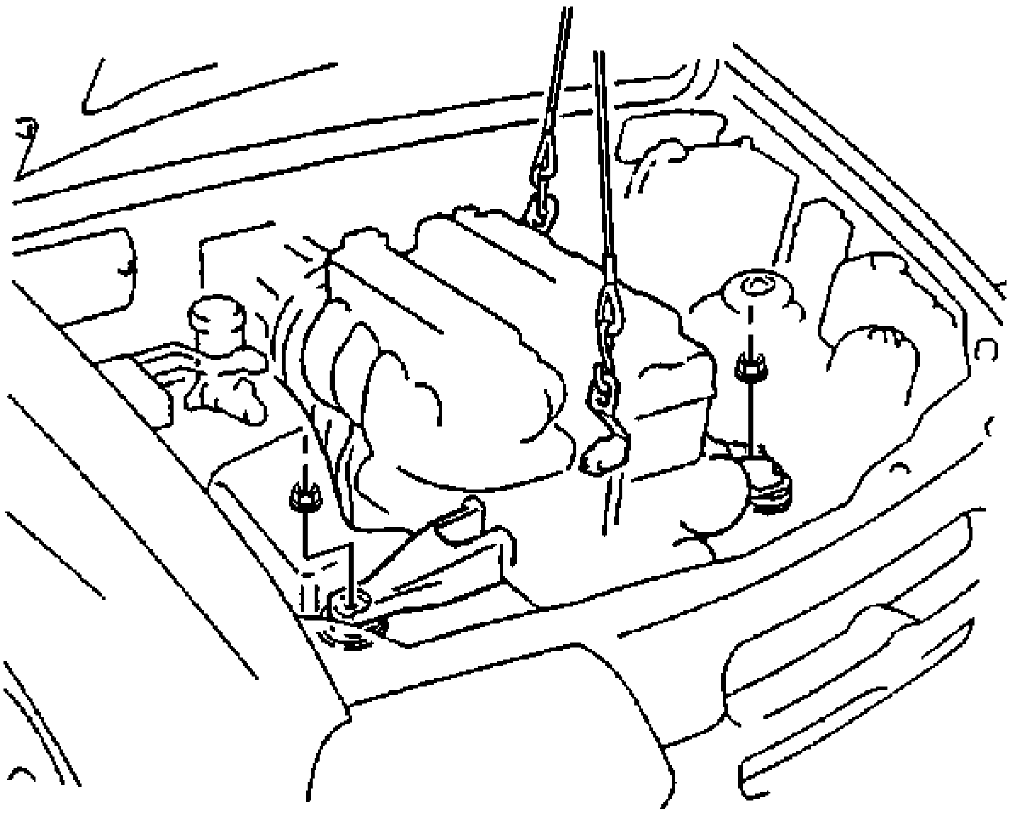


Fig. 211: Removing Engine Assembly
Courtesy of GENERAL MOTORS CORP.

54. Mark the flywheel-to-engine position.
55. Remove the 8 bolts and the flywheel (3) from the crankshaft.
56. Place the engine assembly onto the **J 36854** . See **Special Tools and Equipment**.
57. Remove the engine hoist.
58. Remove the crankshaft position sensor.

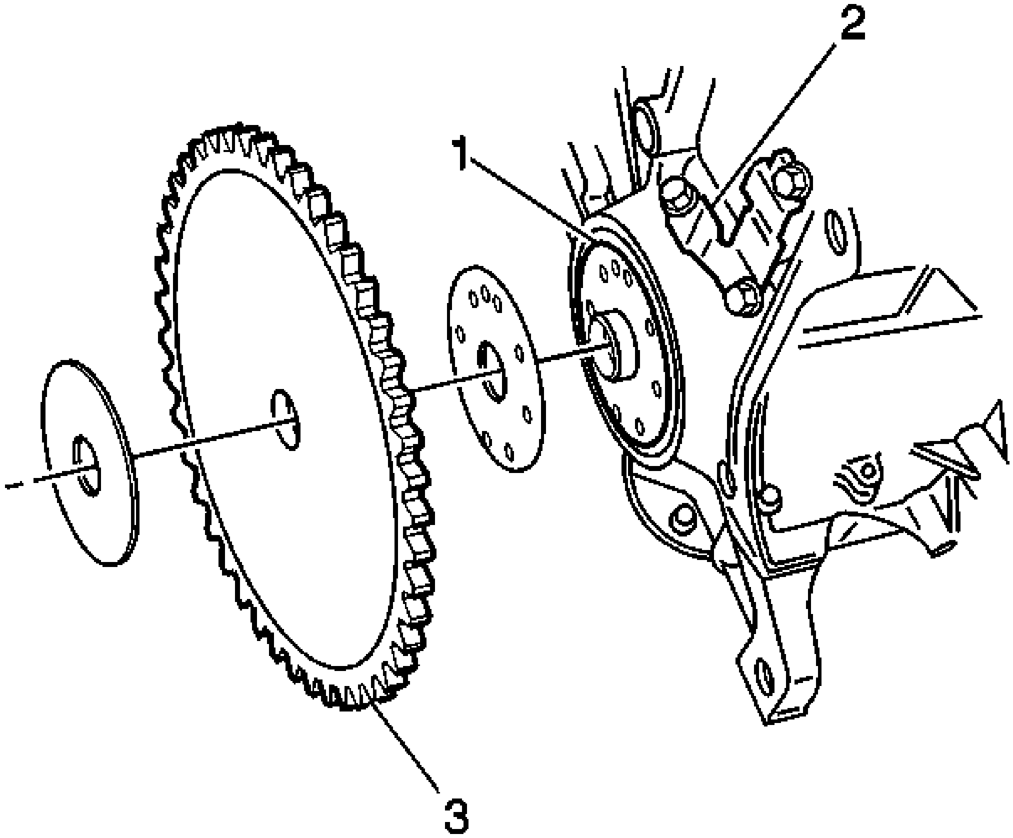


Fig. 212: View Of Crankshaft & Flywheel
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the engine hoist.
2. Remove the engine assembly from the **J 36854** . See **Special Tools and Equipment**.

NOTE: Apply the proper amount of the sealant to the fastener when assembling this component. Excessive use of the sealant can prohibit the component from being assembled properly or allow the fastener to loosen. A component or fastener that is not assembled properly can loosen or fall off leading to extensive engine damage.

3. Install the crankshaft position sensor.
4. Align the flywheel-to-engine marks and install the flywheel (3).

5. Apply GM P/N 12345493 (Canadian P/N 10953488) or the equivalent, to the flywheel retaining bolt threads.

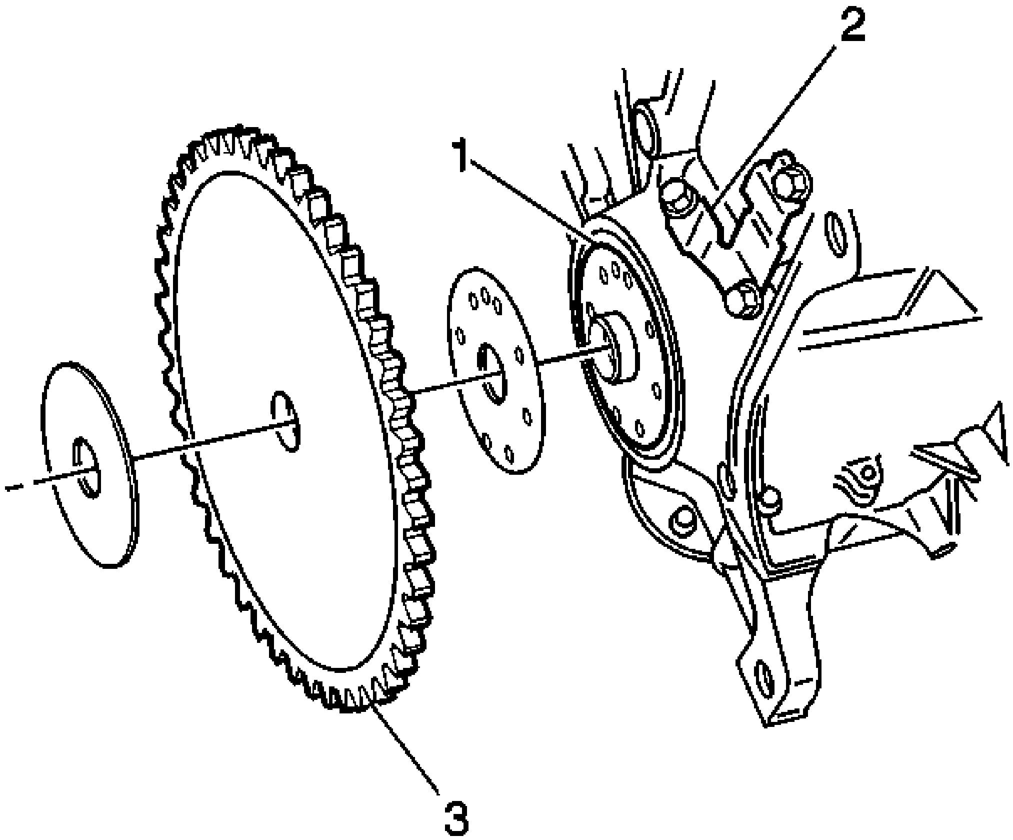


Fig. 213: View Of Crankshaft & Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the flywheel retaining bolts to the crankshaft. Use the **J 35271** to lock the flywheel. See **Special Tools and Equipment**.

   Tighten: Cross tighten the 8 flywheel retaining bolts to 70 N.m (51 lb ft).

7. Install the pressure plate assembly and the clutch disc on manual transmission equipped vehicles. Refer to **Clutch Assembly Replacement** in Clutch.

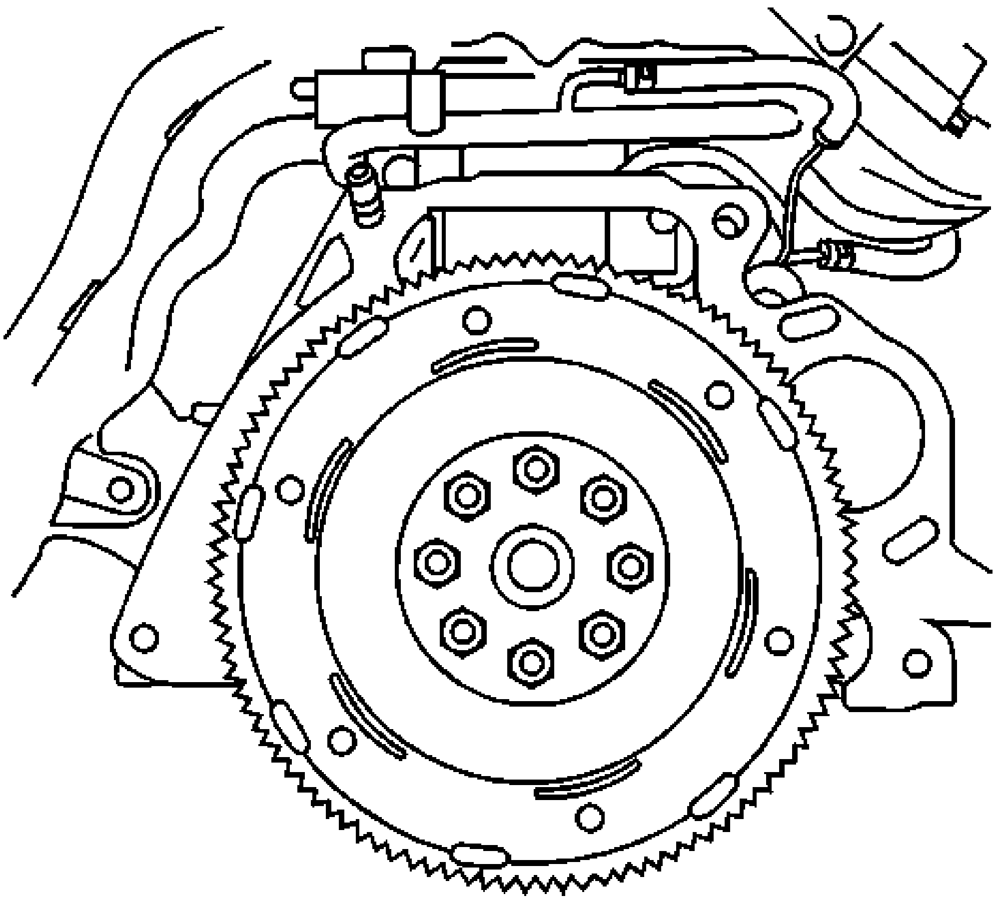


Fig. 214: Installing Flywheel
Courtesy of GENERAL MOTORS CORP.

8. Install the engine assembly. Lower the engine into the front of the engine compartment while ensuring clearance on all sides, slide the assembly rearward.
9. Install the engine mount nuts.

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

10. Remove the engine hoist.

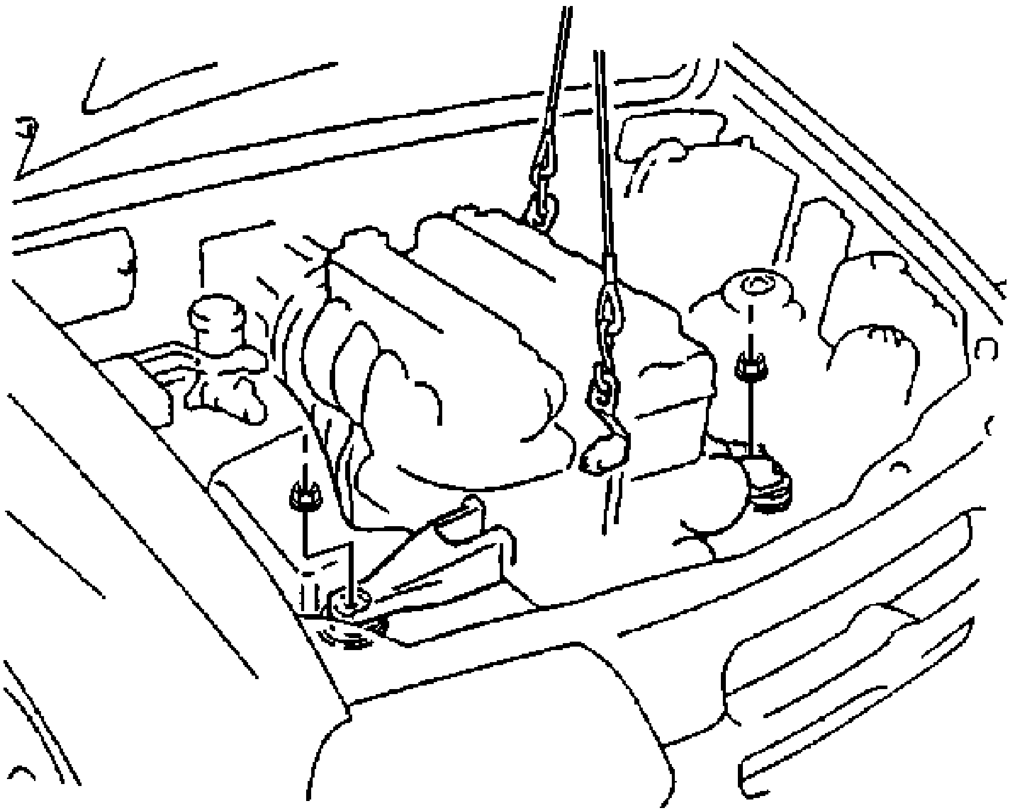


Fig. 215: Installing Engine Assembly
Courtesy of GENERAL MOTORS CORP.

11. Install the cylinder block-to-transmission bolt and nuts.

    Tighten: Tighten the bolt and nuts to 85 N.m (62 lb ft).

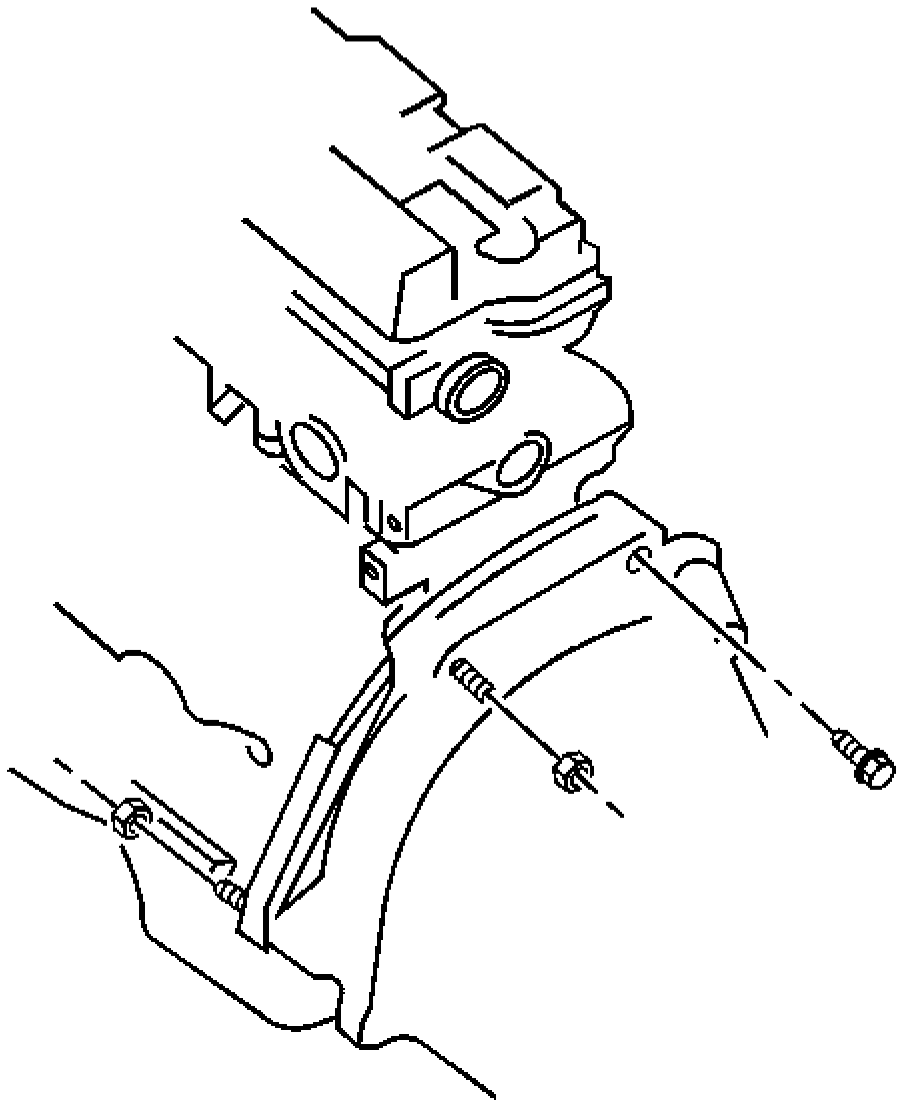


Fig. 216: View Of Cylinder Block-To-Transmission Bolt & Nuts
Courtesy of GENERAL MOTORS CORP.

12. Install the starter motor. Refer to **Starter Motor Replacement** in Engine Electrical.
13. Install the battery positive cable (3) to the starter solenoid.
14. Connect the starter solenoid electrical connector.
15. Connect the crankshaft position sensor (CKP) (2) connector.
16. Raise the vehicle.

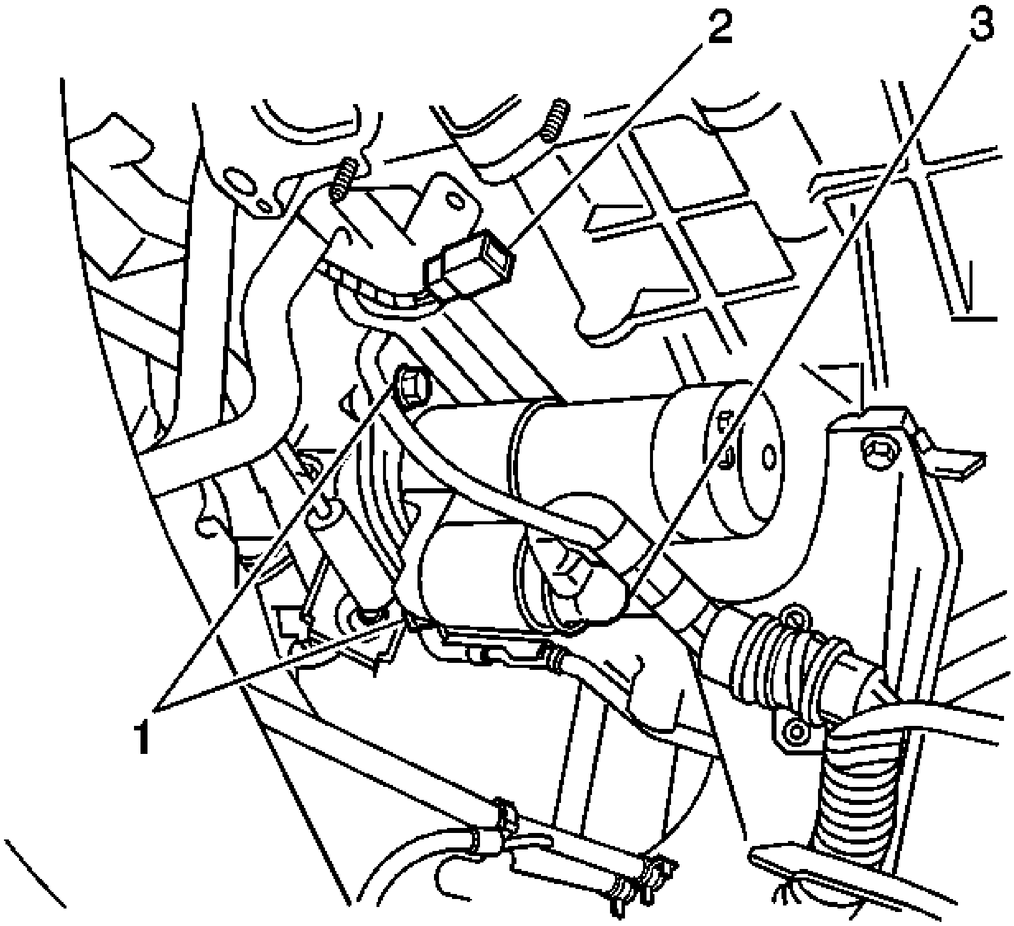


Fig. 217: Locating Starter Motor
Courtesy of GENERAL MOTORS CORP.

17. Install the torque converter bolts on automatic transmission equipped vehicles. Use the **J 35271** in order to lock the flywheel (1). See **Special Tools and Equipment**.

    Tighten: Tighten the bolts to 65 N.m (47 lb ft).

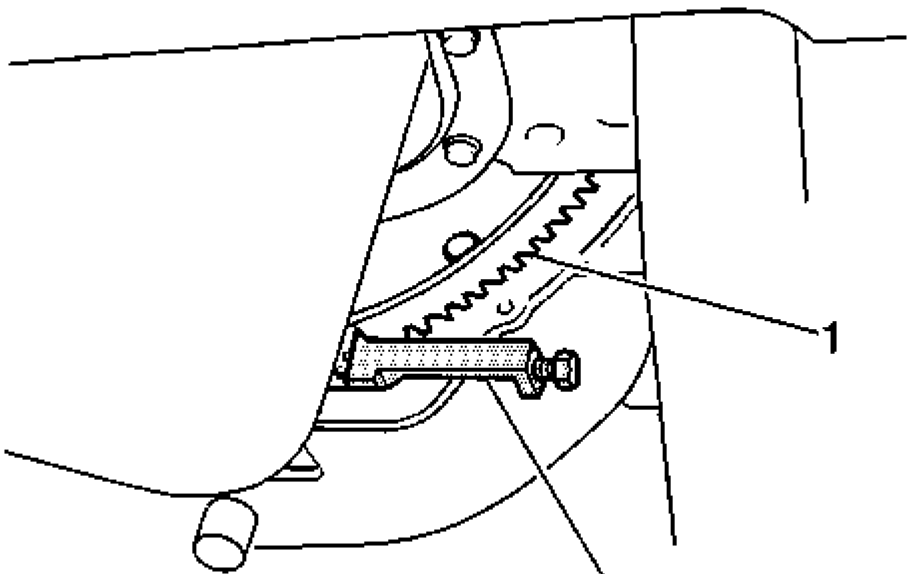


Fig. 218: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

18. Install the right side engine block-to-transmission support bracket (3).

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

19. Install the flywheel cover.

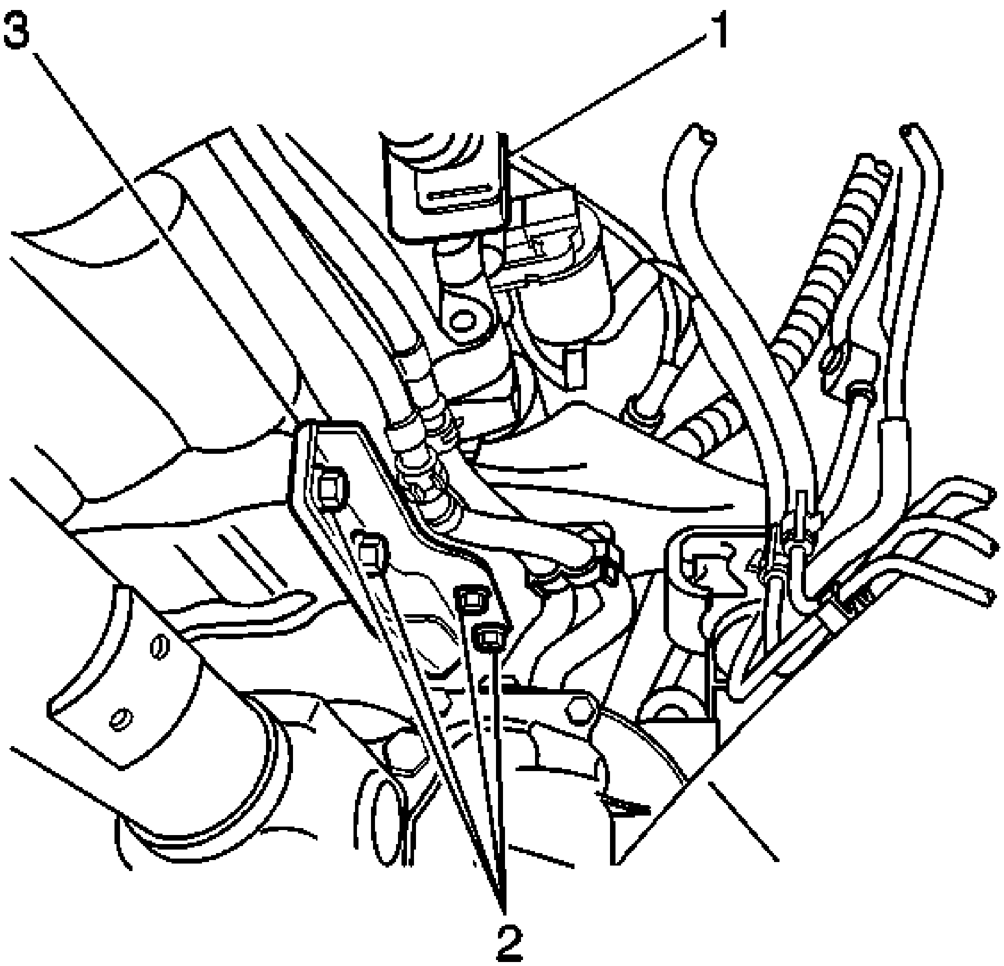


Fig. 219: View Above Differential
Courtesy of GENERAL MOTORS CORP.

20. Connect the front pipe assembly to the exhaust manifold on vehicles not equipped with the PUP catalytic converter.

    Tighten: Tighten the 2 bolts to 50 N.m (37 lb ft).

21. Lower the vehicle.

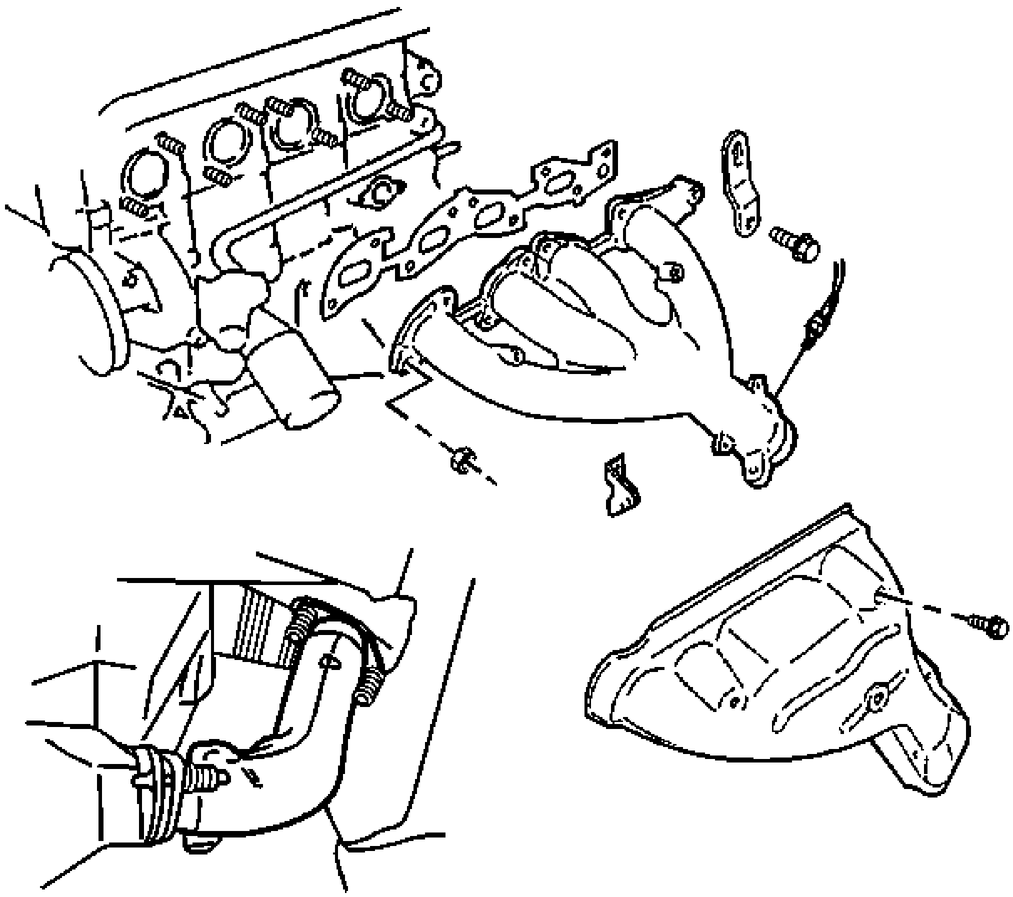


Fig. 220: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

22. Connect the front pipe assembly to the exhaust manifold on vehicles with the PUP catalytic converter.
23. Install the engine block-to-catalytic converter support bracket on vehicles with the PUP catalytic converter.

    Tighten: Tighten the 3 nuts to 50 N.m (37 lb ft).

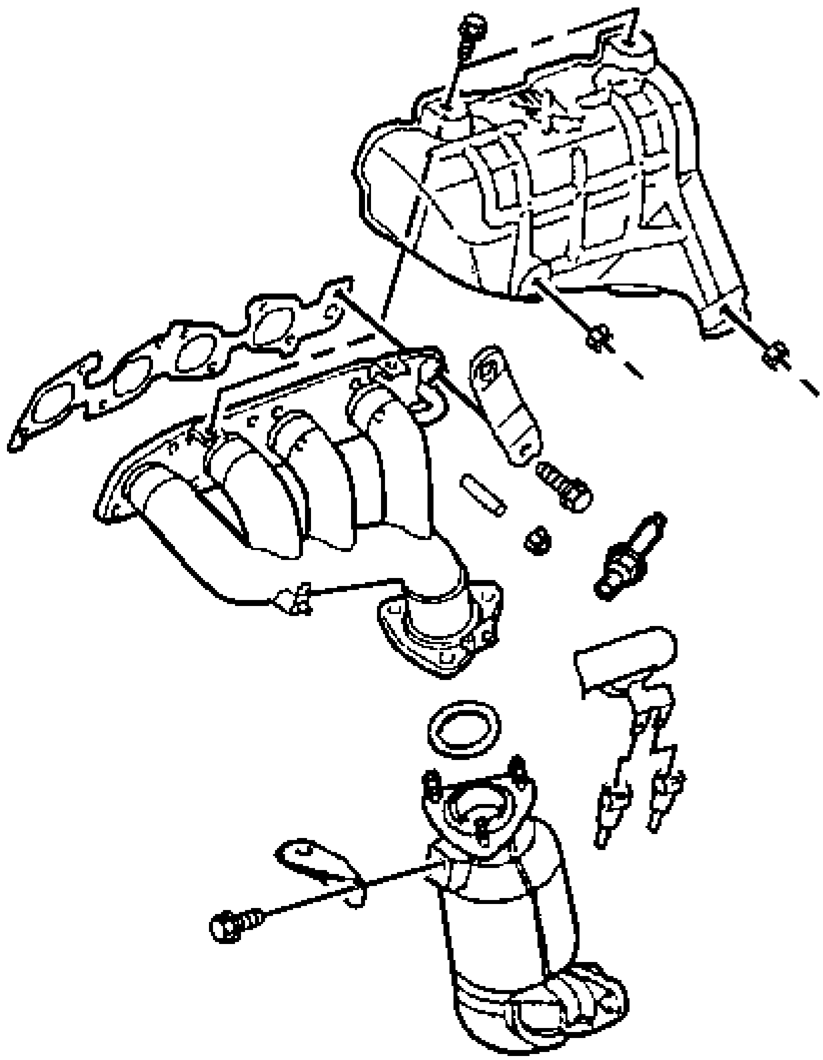


Fig. 221: View Of Exhaust Manifold & Components
Courtesy of GENERAL MOTORS CORP.

24. Install the A/C compressor bracket, if equipped. Secure with 4 bolts (2). Refer to **Compressor Mounting Bracket Replacement (2.0L)** **Compressor Mounting Bracket Replacement (2.5L)** in HVAC Systems with A/C Manual.

    Tighten: Tighten the 4 bolts to 55 N.m (40 lb ft).

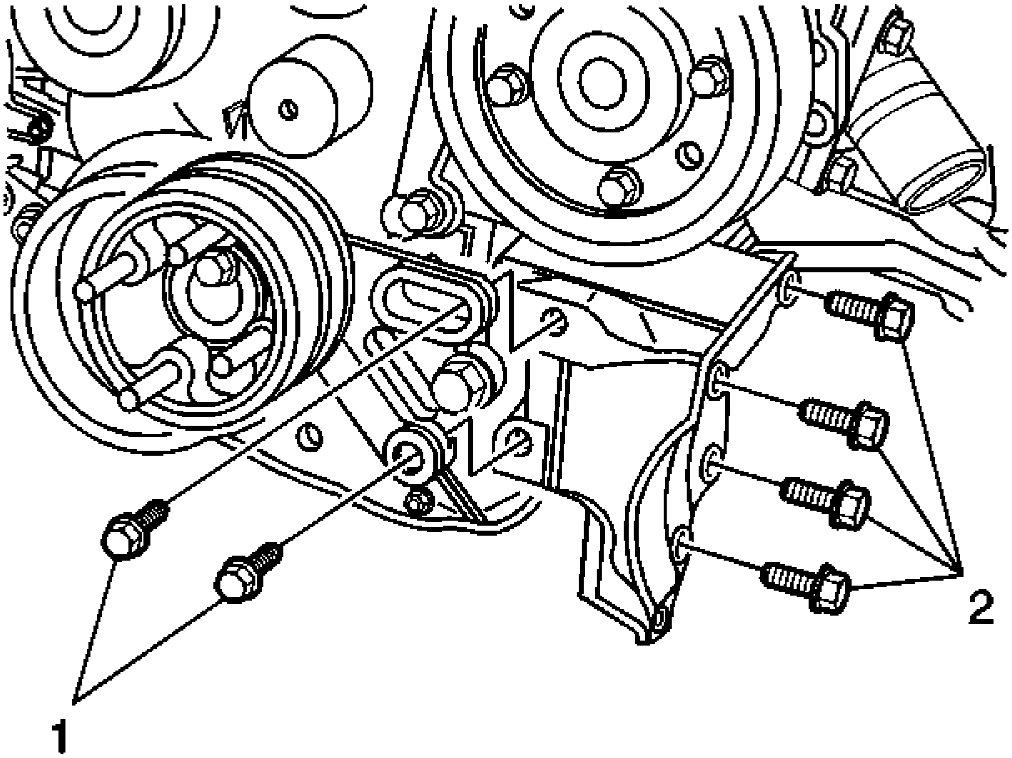


Fig. 222: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

25. Install the A/C compressor to its bracket, if equipped. Secure with 3 bolts (1). Refer to **Compressor Replacement (2.0L)** **Compressor Replacement (2.5L)** in HVAC Systems with A/C Manual.

    Tighten: Tighten the bolts to 23 N.m (17 lb ft).

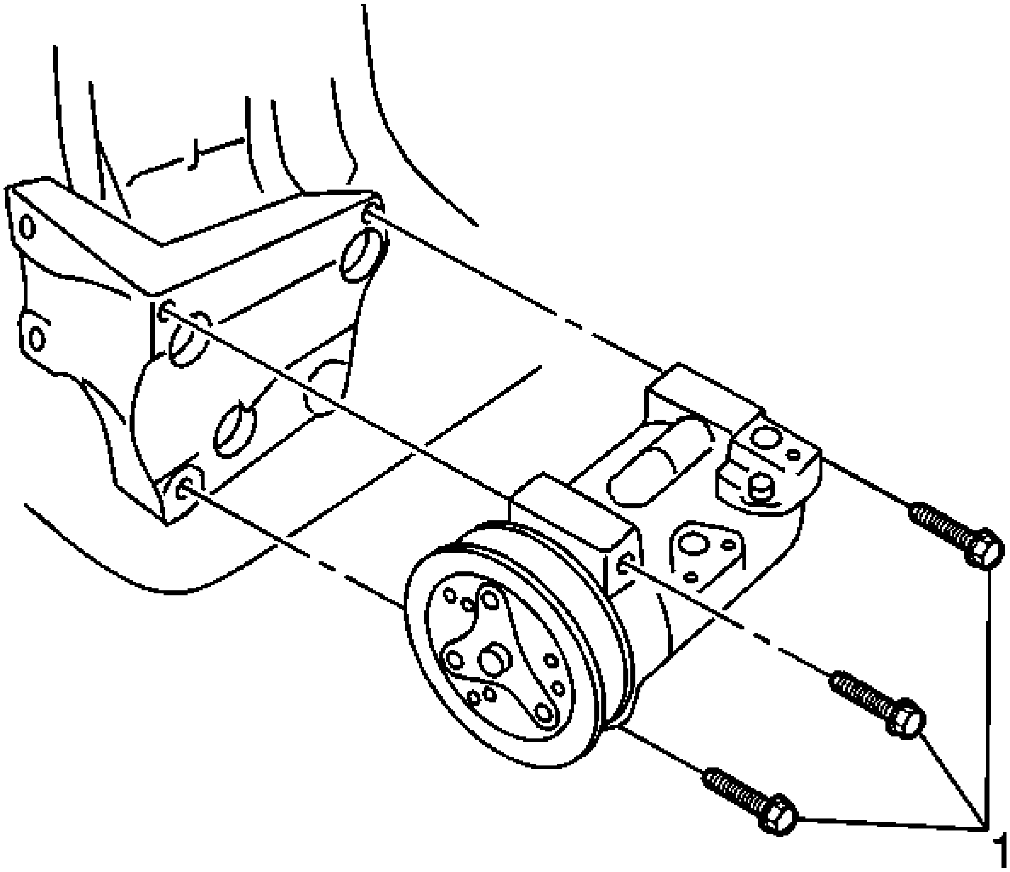


Fig. 223: Compressor Mounting View
Courtesy of GENERAL MOTORS CORP.

26. Install the heater hoses to the heater core.
27. Position the harness in the vehicle and connect the wiring harness to the retaining clamps.

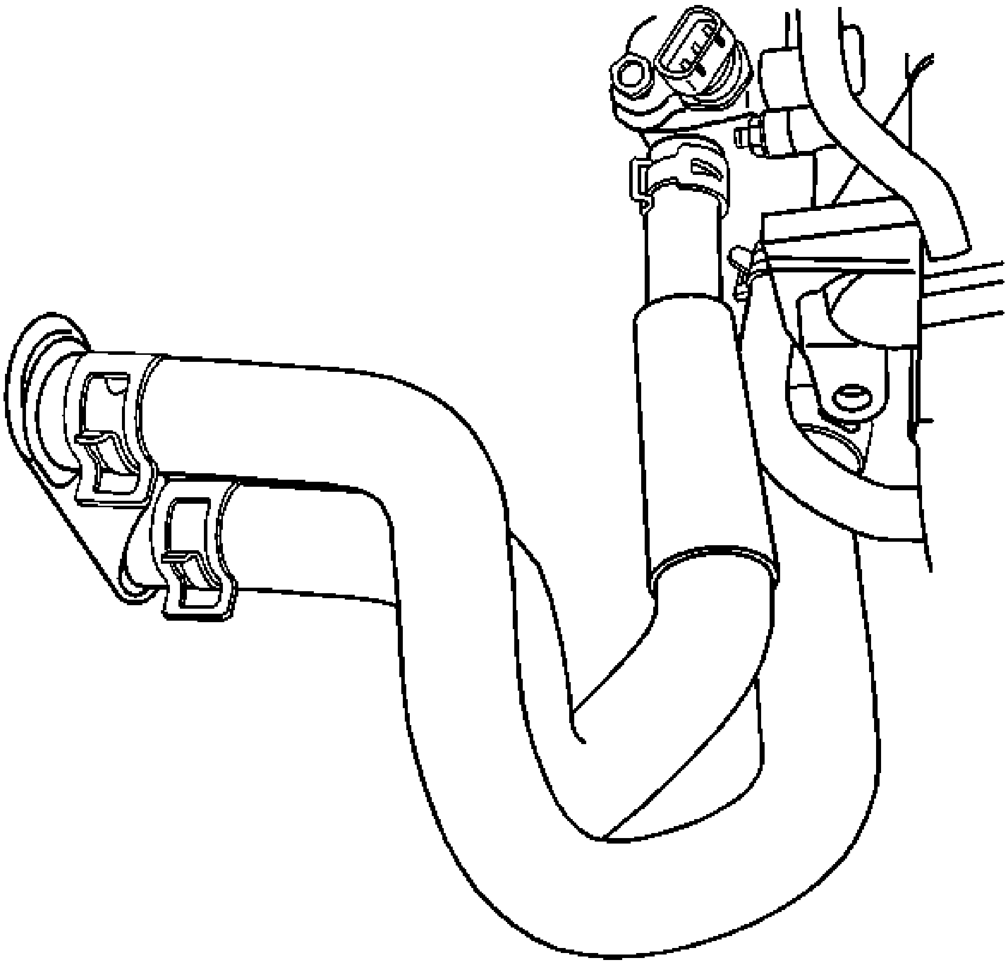


Fig. 224: Installing Heater Hoses From Heater Core
Courtesy of GENERAL MOTORS CORP.

28. Connect the fuel feed and return hoses (9).
29. Connect the following electrical connectors:
    - The 4 ignition coils
    - The fuel injector wiring harness (3)
    - The throttle position sensor (TPS) (8)
    - The manifold absolute pressure (MAP) sensor (11)
    - The idle air control (IAC) valve (6)
    - The exhaust gas recirculation (EGR) valve (1)
    - The engine coolant temperature (ECT) sensor (2)

- The EVAP canister purge valve (7)
- The heated oxygen sensor 1 (HO2S1)
- The power steering pressure (PSP) switch wire
- The generator wires
- The oil pressure switch wire
- The camshaft position sensor (CMP)

30. Connect the ground wires to the intake manifold (10).
31. Install the EVAP canister purge hose to the intake manifold.
32. Install the wiring harness to the retaining clamps.
33. Install the brake booster vacuum line to the intake manifold.
34. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** in Engine Controls.
35. Connect the intake air temperature (IAT) sensor connector.
36. Connect the mass air flow (MAF) sensor connector.

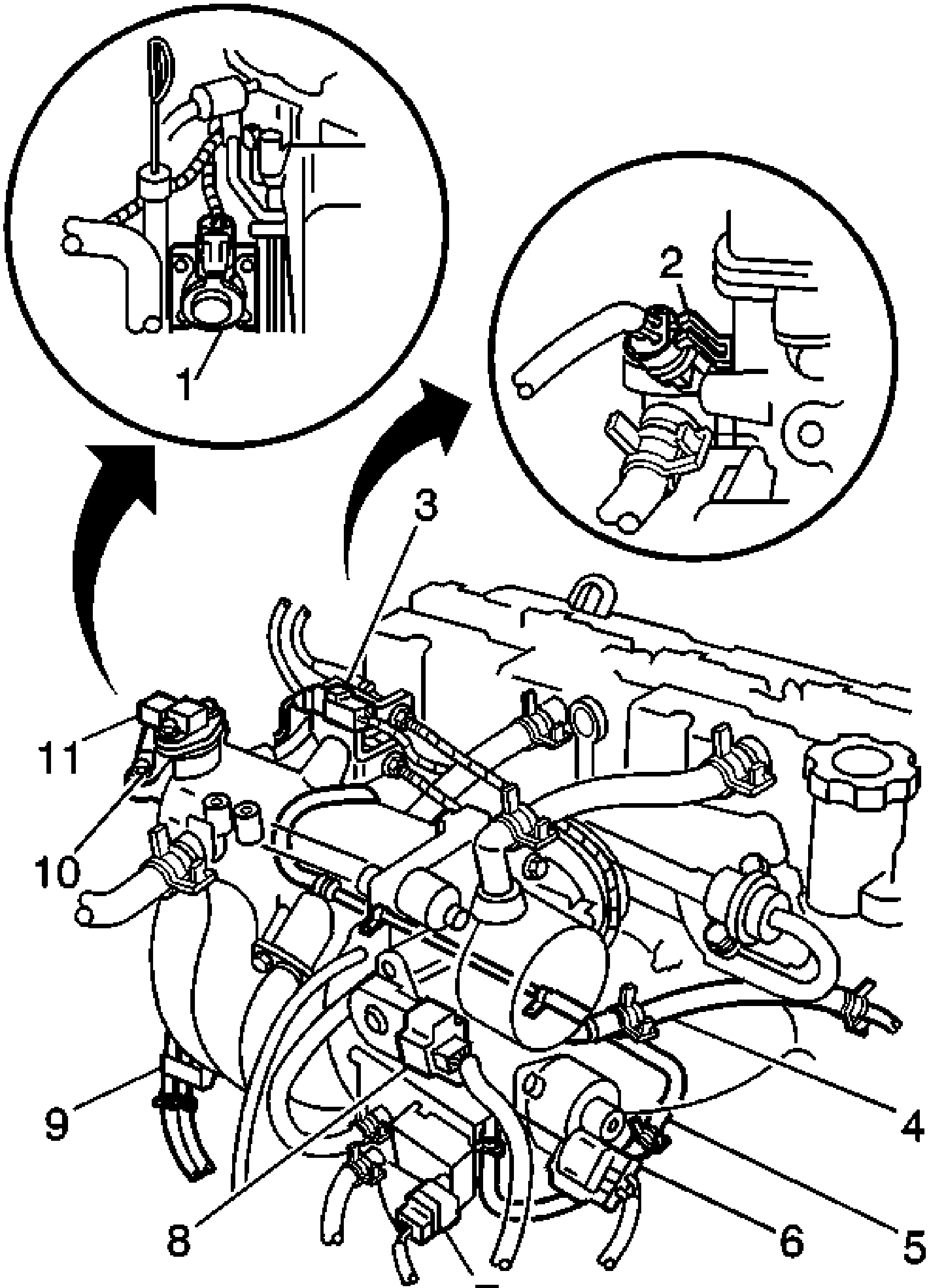


Fig. 225: ECT Sensor and EGR Valve

Courtesy of GENERAL MOTORS CORP.

37. Install the cables to the throttle body bellcrank.
38. Install the throttle cable bracket (2) to the intake manifold. Secure with the bolt.
39. Install the power steering pressure and return lines to the power steering pump.

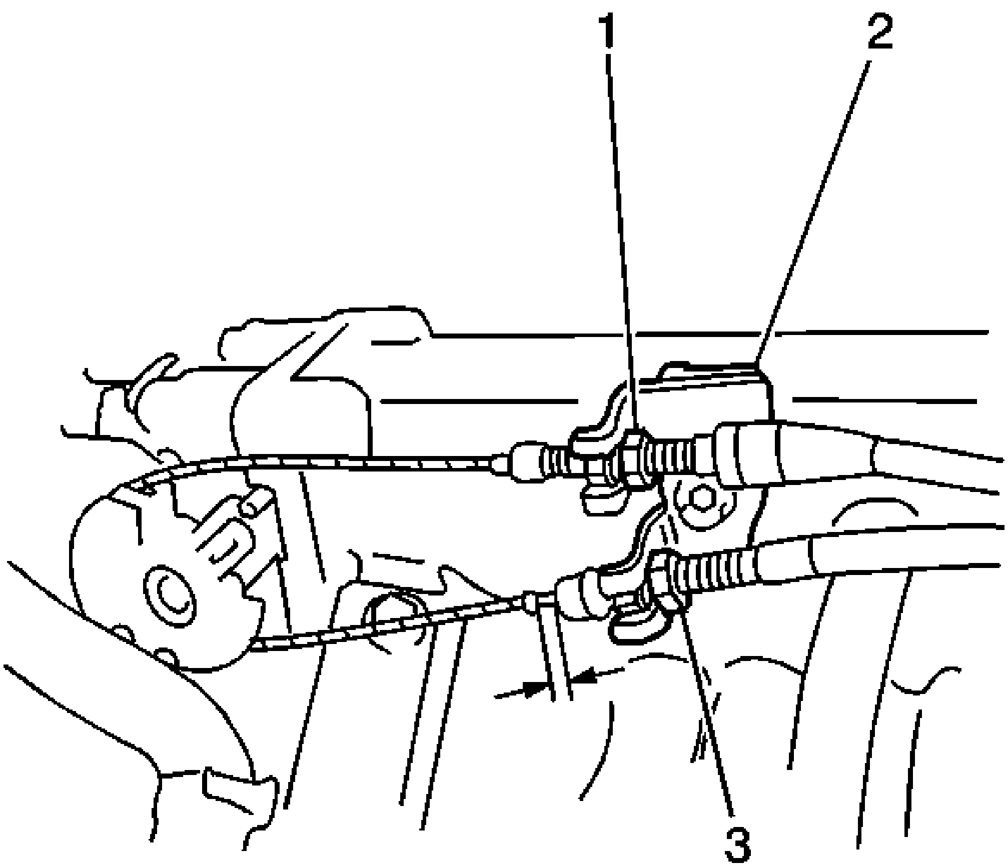


Fig. 226: Locating Cable Adjustment
Courtesy of GENERAL MOTORS CORP.

40. Rotate the belt tensioner clockwise and install the accessory drive belt.
41. Install the fan belt tensioner.
42. Install the 2 tensioner mounting bolts (1,3).
43. Install the fan belt.
44. Adjust the tension on the fan belt to specification by rotating the tension bolt (2) clockwise.

New Belt Deflection: 4-5 mm (0.16-0.20 in) at 10 kg (22 lbs) of force.

Used Belt Deflection: 5-7 mm (0.20-0.27 in) at 10 kg (22 lbs) of force.

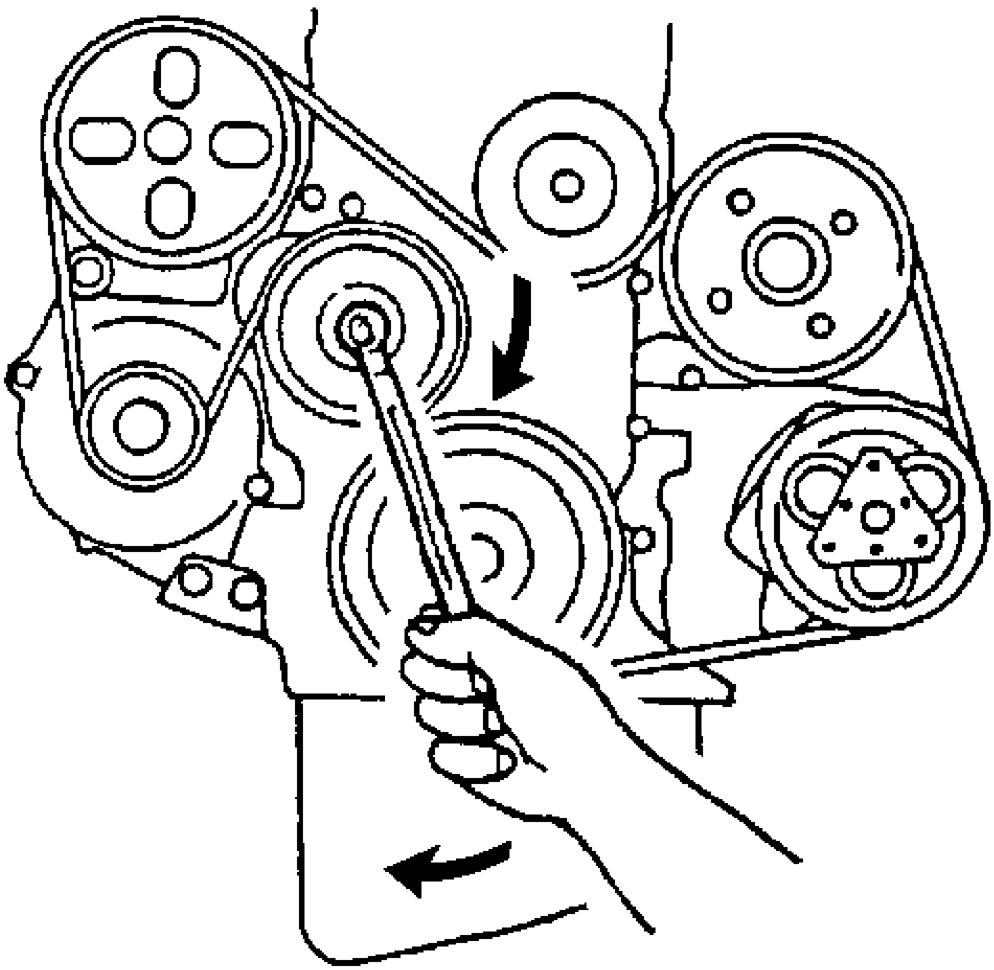


Fig. 227: Rotating Belt Tensioner Clockwise
Courtesy of GENERAL MOTORS CORP.

45. Tighten the adjusting bolt (1) and the pivot bolt (3) while holding the correct tension on the fan belt.

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

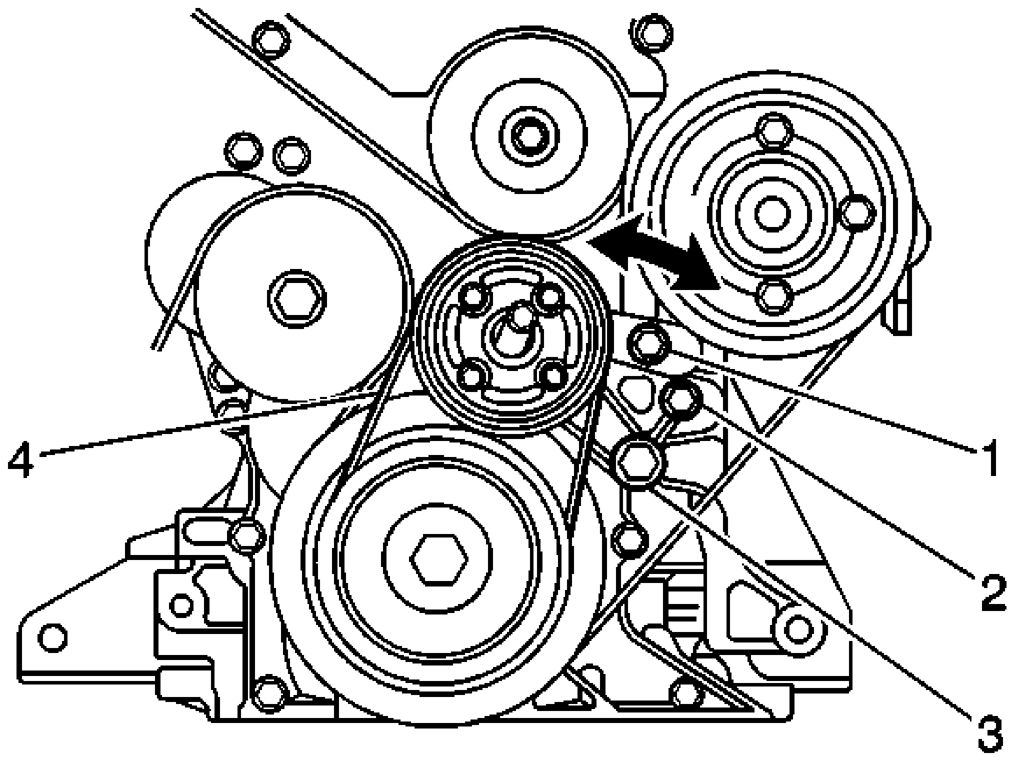


Fig. 228: View Of Tension, Adjusting & Pivot Bolts
Courtesy of GENERAL MOTORS CORP.

46. Install the fan and the fan shroud to the vehicle.
47. Install the fan to the hub.

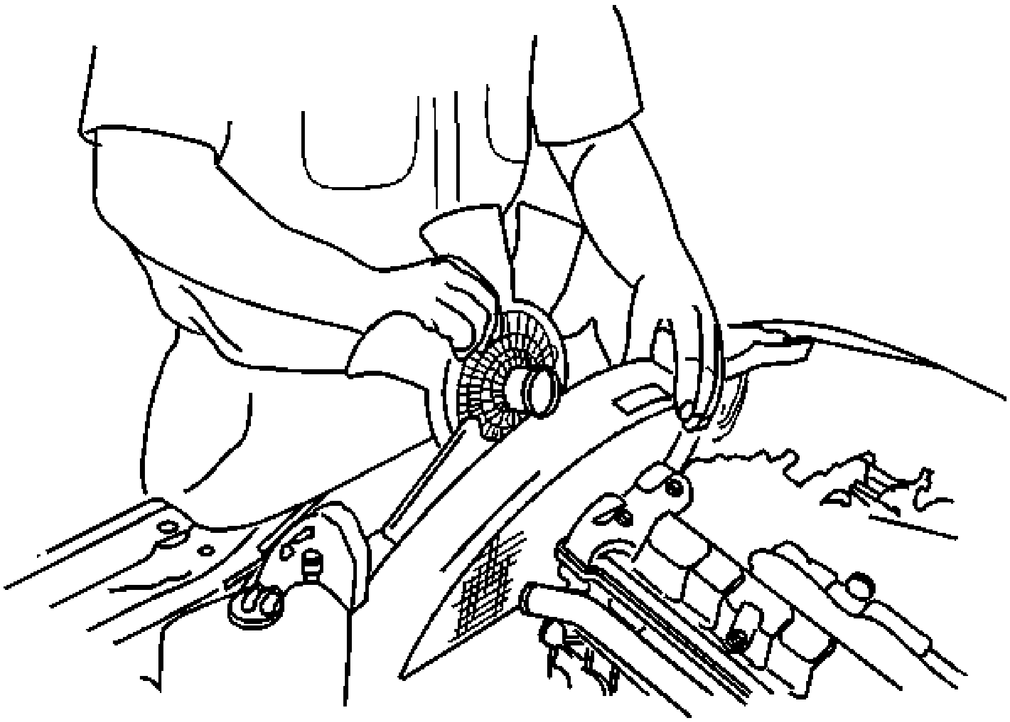


Fig. 229: Removing/Installing Fan Assembly
Courtesy of GENERAL MOTORS CORP.

48. Install the four fan mounting nuts (1). Use a second wrench to hold the fan shaft.

    Tighten: Tighten the nuts to 11 N.m (97 lb in).

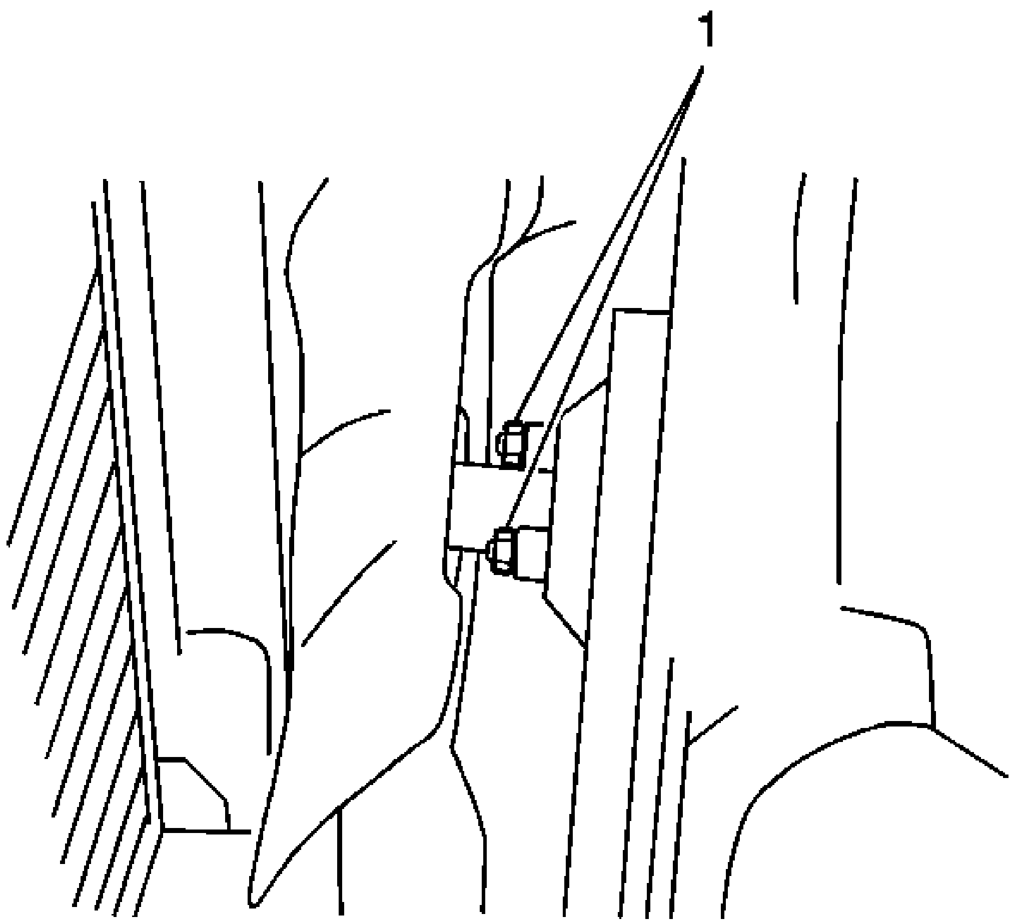


Fig. 230: Cooling Fan Mounting View
Courtesy of GENERAL MOTORS CORP.

49. Lean the fan shroud toward the engine and install the radiator.
50. Install 1 bolt to each side of the radiator upper support.
51. Align the shroud to the radiator and install the shroud clips.
52. Install the radiator overflow hose to the radiator.

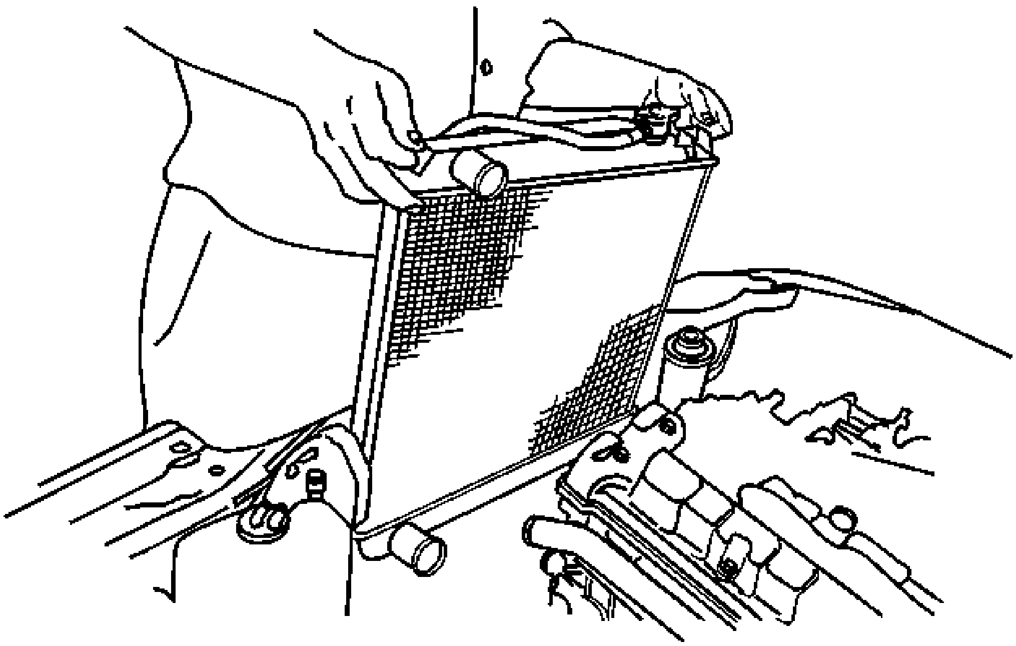


Fig. 231: View Of Radiator
Courtesy of GENERAL MOTORS CORP.

53. Install the upper radiator hose (2) to the vehicle.

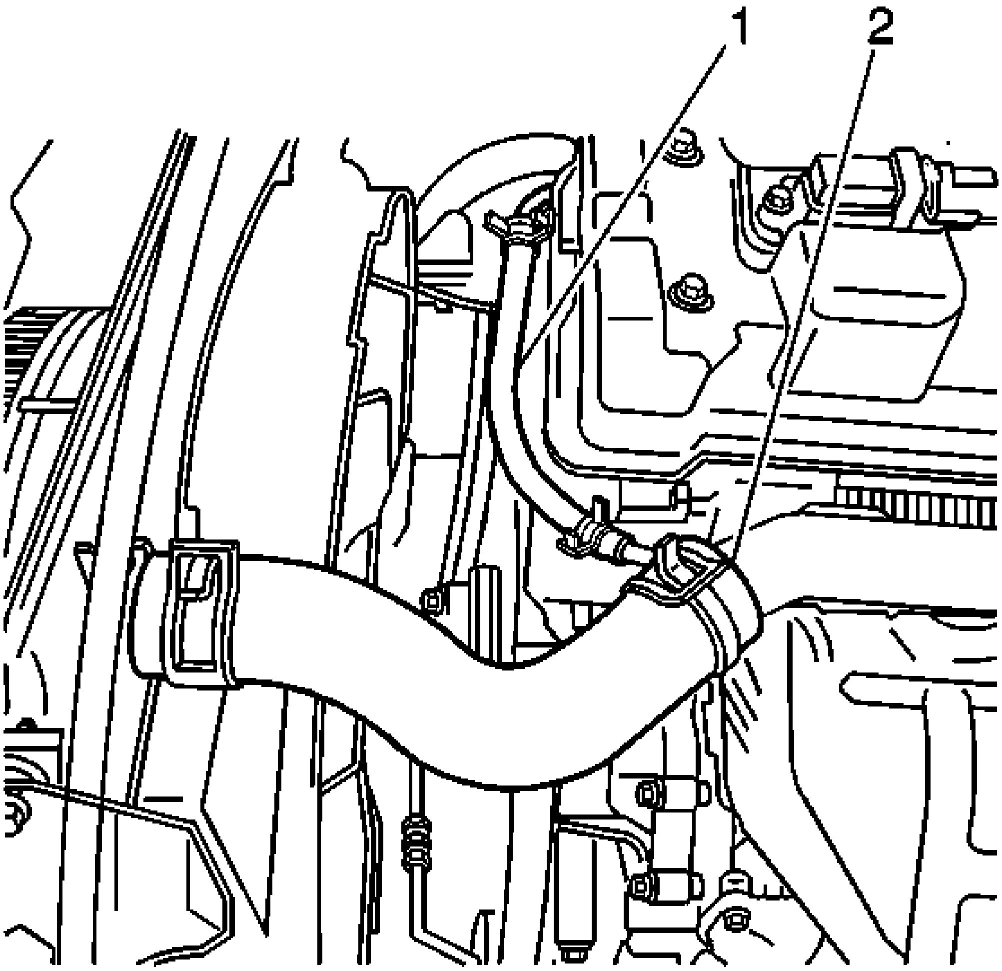


Fig. 232: View Of Upper Radiator Hose
Courtesy of GENERAL MOTORS CORP.

54. Install the lower radiator hose (1) to the vehicle.

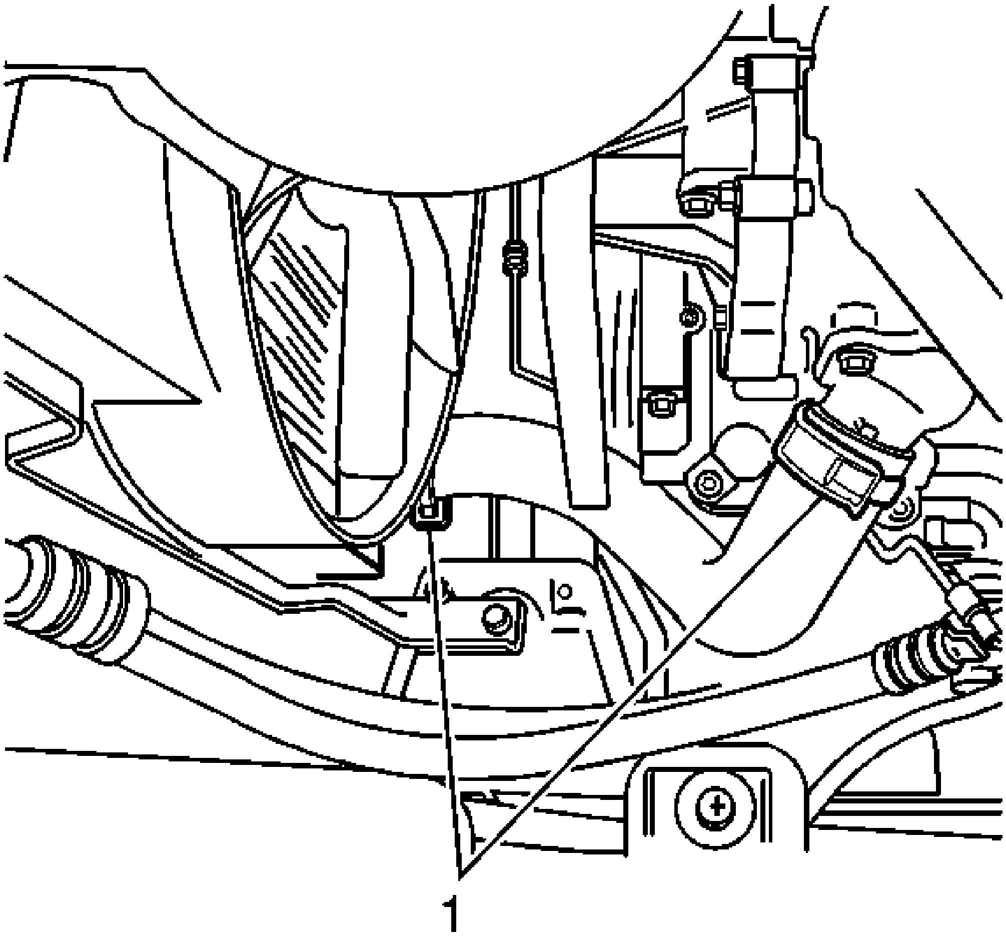


Fig. 233: View Of Lower radiator Hose Clamps
Courtesy of GENERAL MOTORS CORP.

55. Install the strut tower brace. Refer to **Front Suspension Support Brace Replacement** in Front Suspension.

    Tighten: Tighten the 6 bolts to 50 N.m (37 lb ft).

56. Install the hood to the vehicle. Refer to **Hood Replacement** in Body Front End.
57. Raise the vehicle.

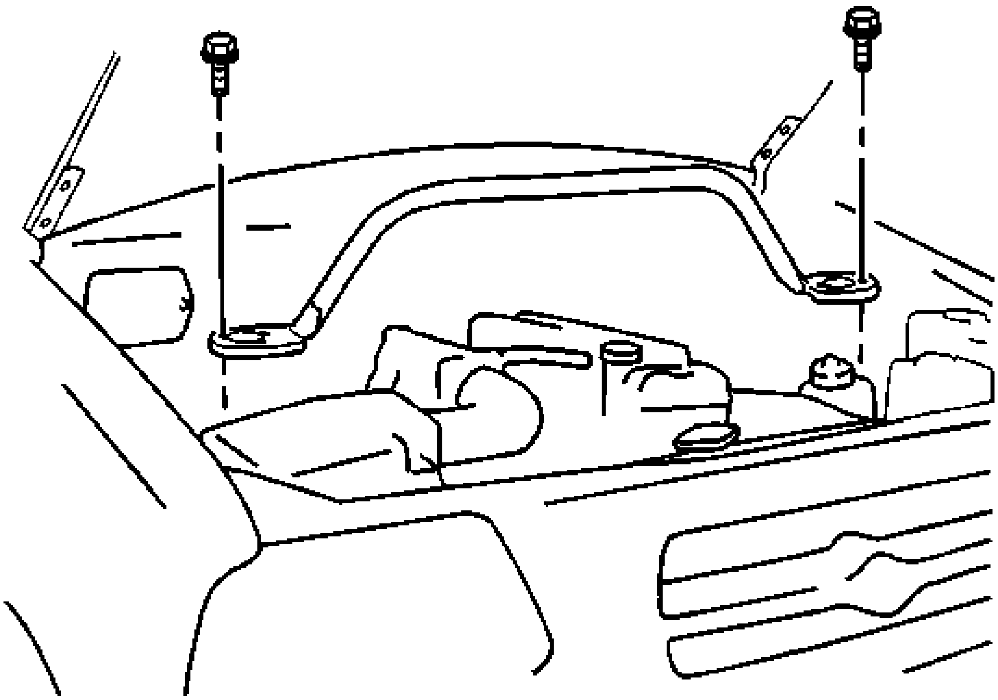


Fig. 234: View Of Strut Tower Brace
Courtesy of GENERAL MOTORS CORP.

58. Install the automatic transmission fluid cooler lines (1) to the radiator on automatic transmission equipped vehicles.
59. Install the front skid plate (if equipped). Secure the front skid plate with four bolts.

    Tighten: Tighten the front skid plate bolts to 55 N.m (40 lb ft).

60. Install the engine oil drain plug with a new gasket.

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

61. Lower the vehicle.
62. Fill the crankcase with engine oil.
63. Fill the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
64. Fill the automatic transmission fluid as necessary. Refer to **Transmission Fluid Checking Procedure** in Automatic Transmission.
65. Fill and bleed the power steering system as necessary. Refer to **Checking and Adding Power Steering**

Fluid and **Bleeding the Power Steering System** in Power Steering.

66. Connect the negative battery cable.
67. Run the engine and inspect for the following:
    - Engine oil leaks
    - Transmission fluid leaks
    - Engine coolant leaks
    - Fuel leaks

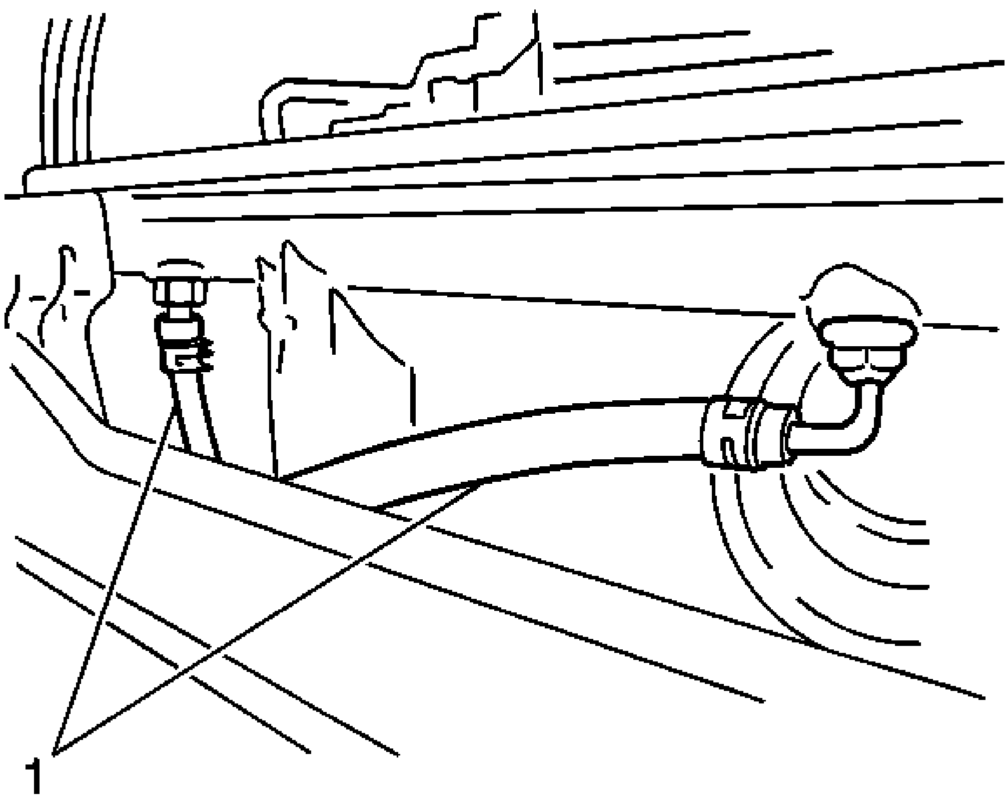


Fig. 235: View Of Automatic Transmission Fluid Cooler Lines
Courtesy of GENERAL MOTORS CORP.

Engine Oil and Oil Filter Replacement

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Position an appropriate drain pan under the engine.

3. Remove the oil pan drain plug bolt.
4. Remove the oil filter (1).

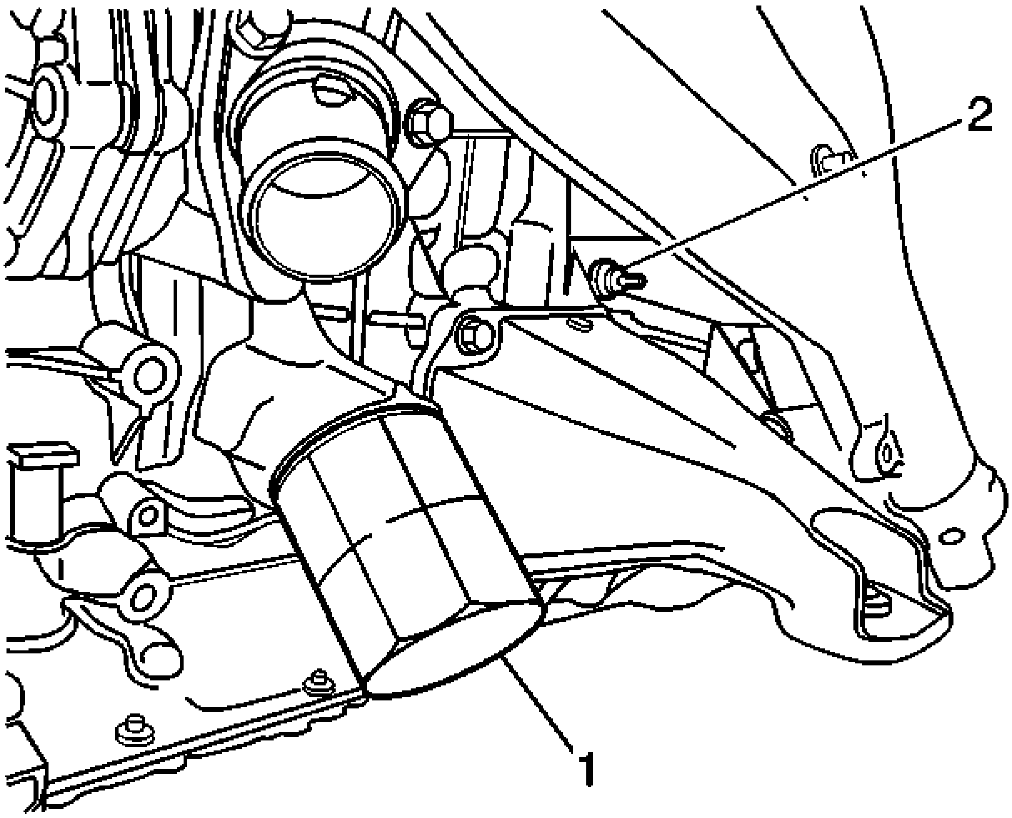


Fig. 236: View Of Oil Pressure Switch & Oil Filter
Courtesy of GENERAL MOTORS CORP.

Installation Procedure

1. Install the oil filter (1).

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil pan drain plug bolt.

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

3. Lower the vehicle.

4. Fill the engine with oil to the appropriate mark.

   Oil Capacity:
   - Oil capacity with oil and filter change is 5.2 liters (5.5 quarts)
   - Oil capacity with oil change only is 5.0 liters (5.2 quarts)

5. Start the engine and check for leaks.

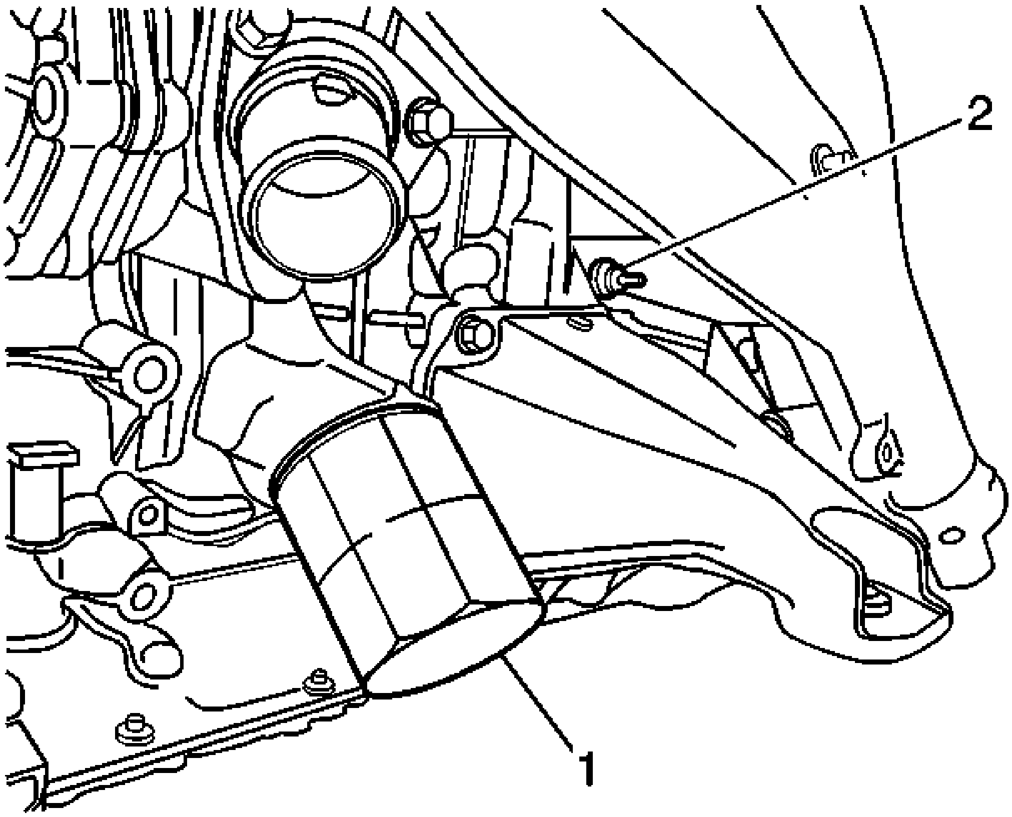


Fig. 237: View Of Oil Pressure Switch & Oil Filter
Courtesy of GENERAL MOTORS CORP.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

1. Position an appropriate drain pan under the engine.
2. Remove the oil pan drain bolt and allow oil to drain from the oil pan.

3. Remove the oil filter (1).
4. Remove coolant jacket drain plug and allow coolant to drain from the coolant jackets.
5. Install oil pan drain bolt.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

6. If cleaning or repairing the engine block it is not necessary to reinstall the plug.

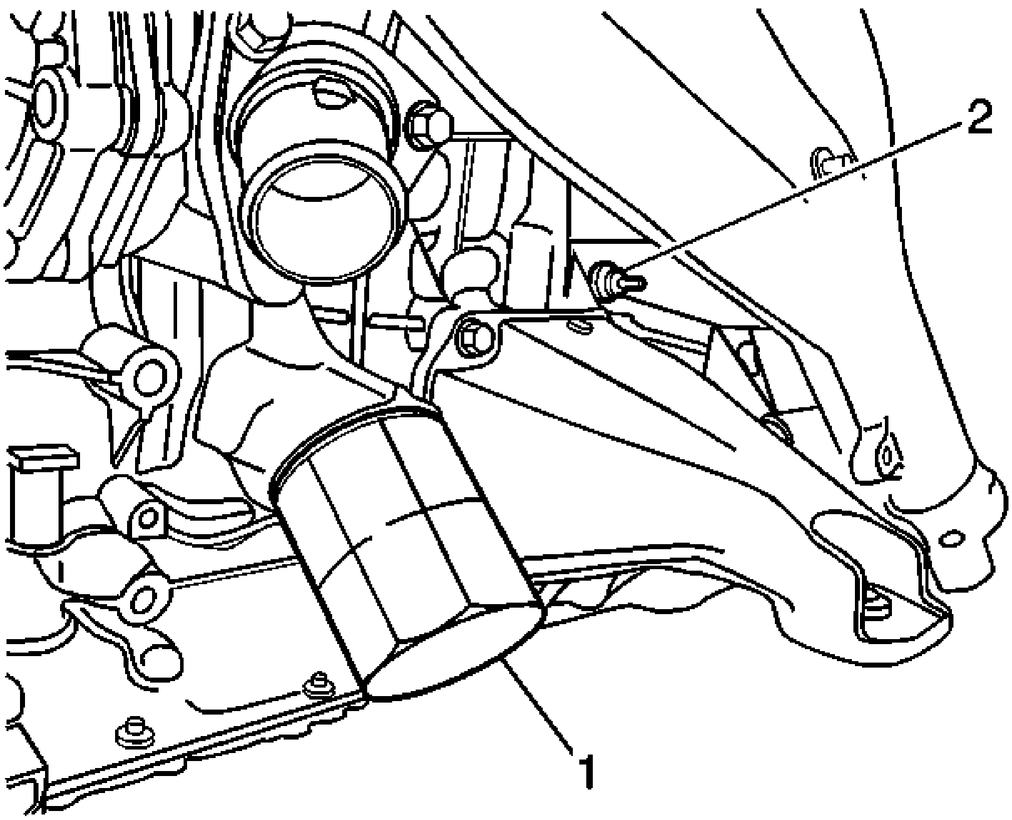


Fig. 238: View Of Oil Pressure Switch & Oil Filter
Courtesy of GENERAL MOTORS CORP.

Engine Flywheel Removal

Tool Required

J 35271 Flywheel Holder. See **Special Tools and Equipment**.

1. Mark the flywheel-to-engine position.
2. Lock the flywheel in place with the **J 35271** . See **Special Tools and Equipment**.
3. Remove the 8 flywheel retaining bolts.
4. Remove the flywheel from the crankshaft.
5. Inspect the clutch pilot bushing. Replace if necessary.
6. Clean the grease and dirt from the flywheel outer surfaces using a suitable solvent.

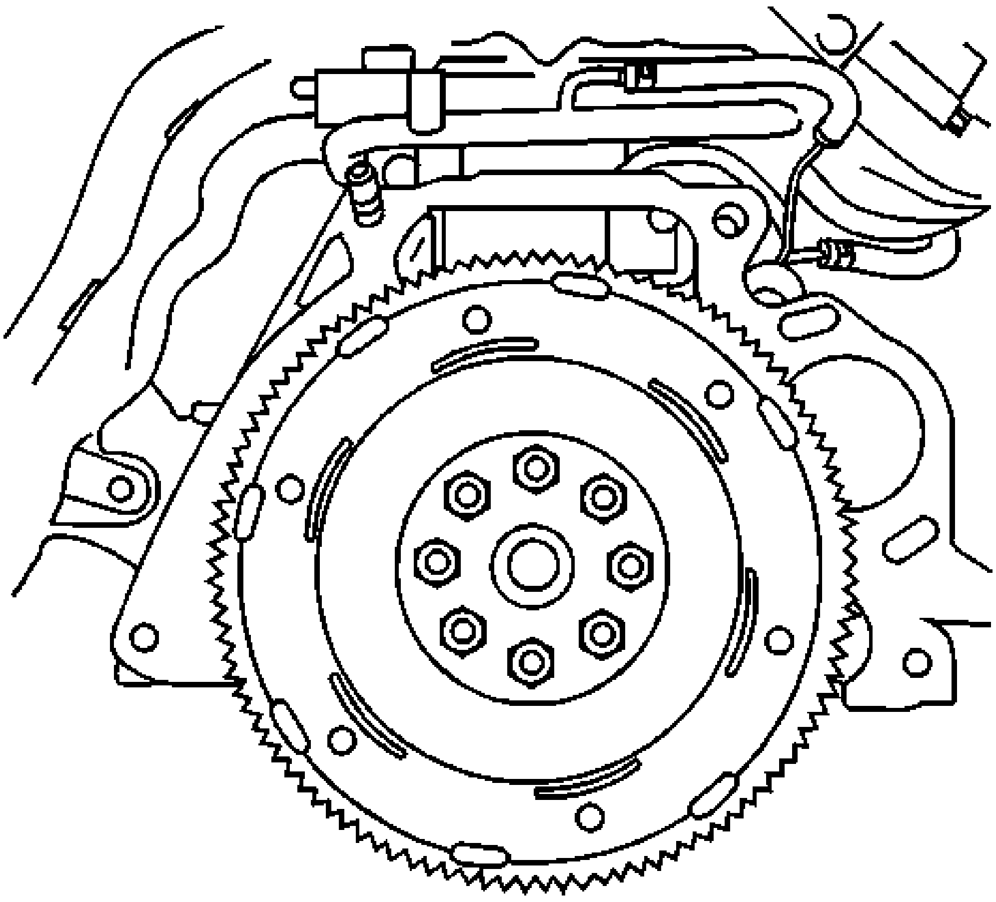


Fig. 239: Removing Flywheel
Courtesy of GENERAL MOTORS CORP.

Exhaust Manifold Removal

IMPORTANT: California emissions vehicles are equipped with an additional (PUP) catalytic converter and a different exhaust manifold from federal emissions vehicles.

1. Perform the following if the vehicle is equipped with the PUP catalytic converter:
    1. Remove the 3 bolts and 2 nuts and remove the exhaust manifold heat shield from the exhaust manifold.
    2. Remove the exhaust manifold-to-engine block bracket.
    3. Remove the oxygen sensor.
    4. Remove the 1 bolt and the 8 nuts from the exhaust manifold.
    5. Remove the exhaust manifold and gasket from the cylinder head.

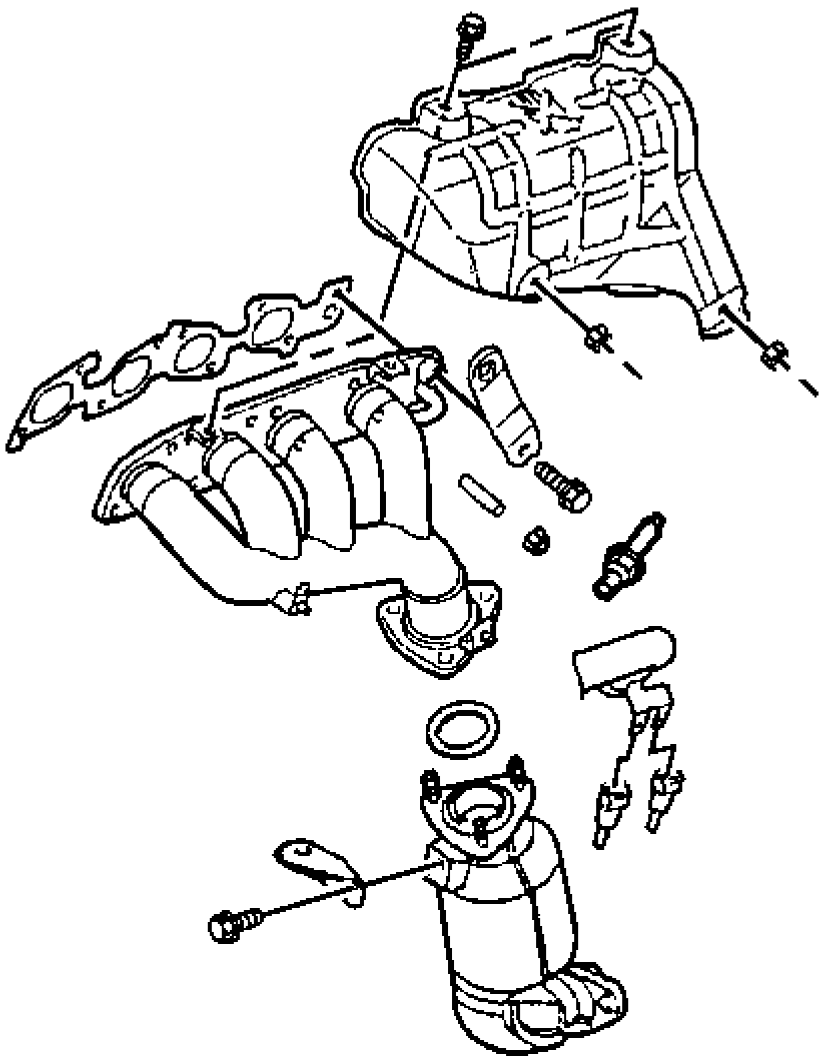


Fig. 240: View Of Exhaust Manifold & Components
Courtesy of GENERAL MOTORS CORP.

2. Perform the following if the vehicle is not equipped with the PUP catalytic converter:
    1. Remove the 4 bolts and 1 nut and the exhaust manifold heat shield.
    2. Remove the exhaust manifold-to-engine block bracket.
    3. Remove the oxygen sensor.
    4. Remove the 1 bolt and the 8 nuts from the exhaust manifold.
    5. Remove the exhaust manifold and gasket from the cylinder head.

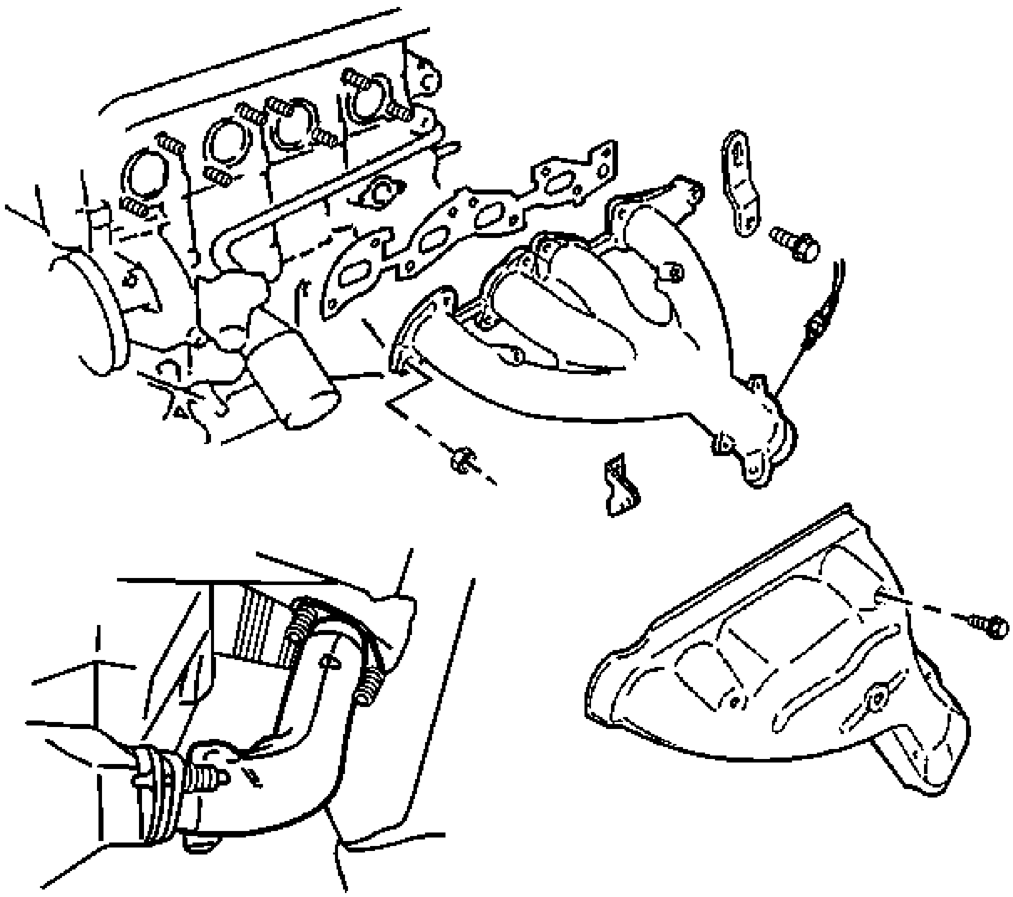


Fig. 241: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

Intake Manifold Removal

1. Remove the coolant hoses (3, 4) from the throttle body and intake manifold.
2. Remove the 2 bolts (5) and the coolant line from underside of the intake manifold.
3. Remove the PCV hose (1) from the intake manifold.
4. Remove the breather hose (2) from the intake manifold.
5. Remove the fuel pressure regulator vacuum hose from the intake manifold.
6. Remove the bolt that holds the fuel line bracket (6) to the intake manifold.
7. Remove the 2 bolts that hold the fuel lines to the fuel rail.
8. Remove the banjo fitting and washer from the rear end of the fuel rail.

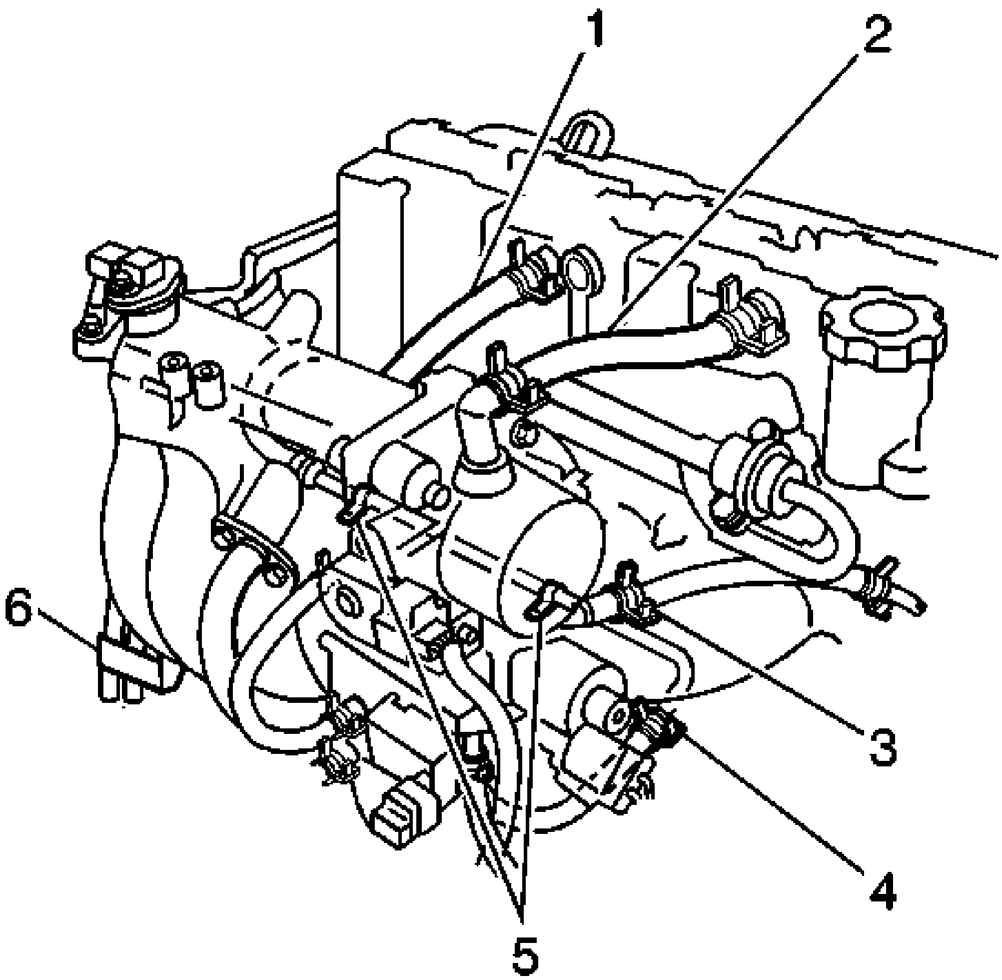


Fig. 242: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

9. Remove the 2 bolts and the intake manifold top support bracket (5).
10. Remove the 2 bolts and the intake manifold front support bracket (8).
11. Remove the 9 nuts and 4 bolts from the intake manifold.
12. Remove the intake manifold from the cylinder head.
13. Remove the intake manifold gasket from the cylinder head.

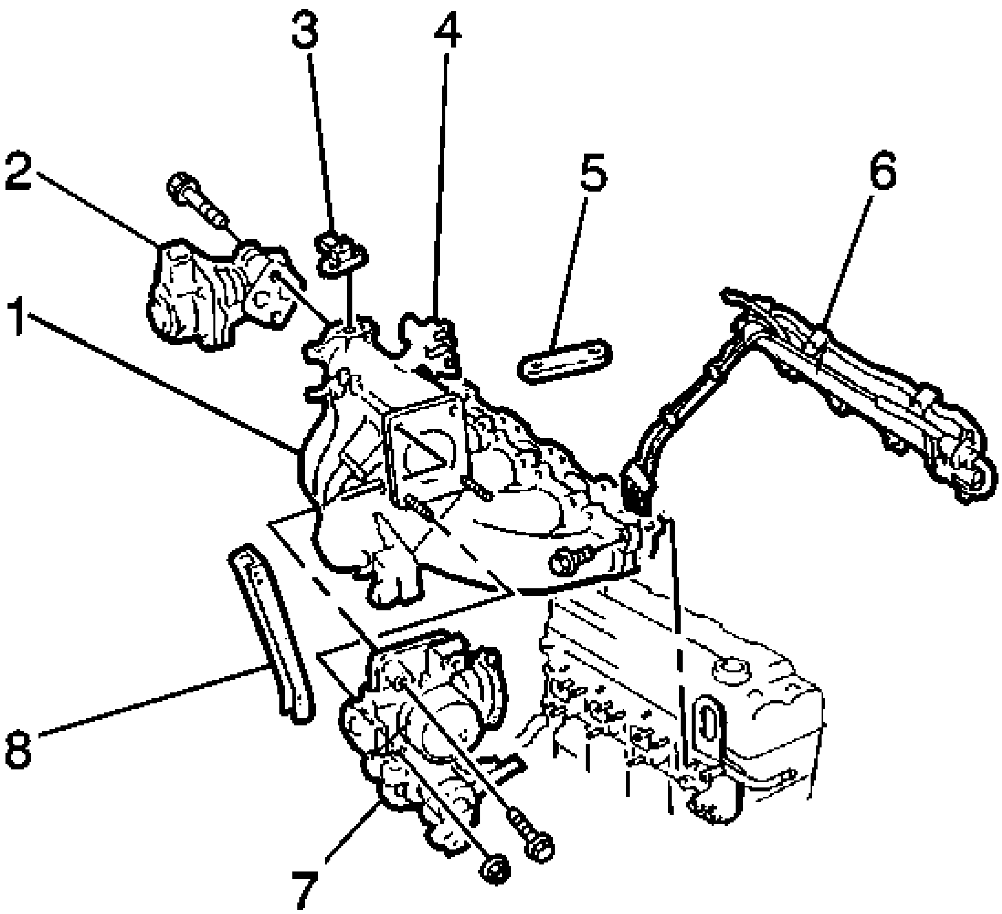


Fig. 243: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

Crankshaft Pulley Removal

Tools Required

J 8614-01 Flange and Pulley Holding Tool

1. Remove the crankshaft pulley retaining bolt using the **J 8614-01** to prevent crankshaft rotation when loosening the bolt.

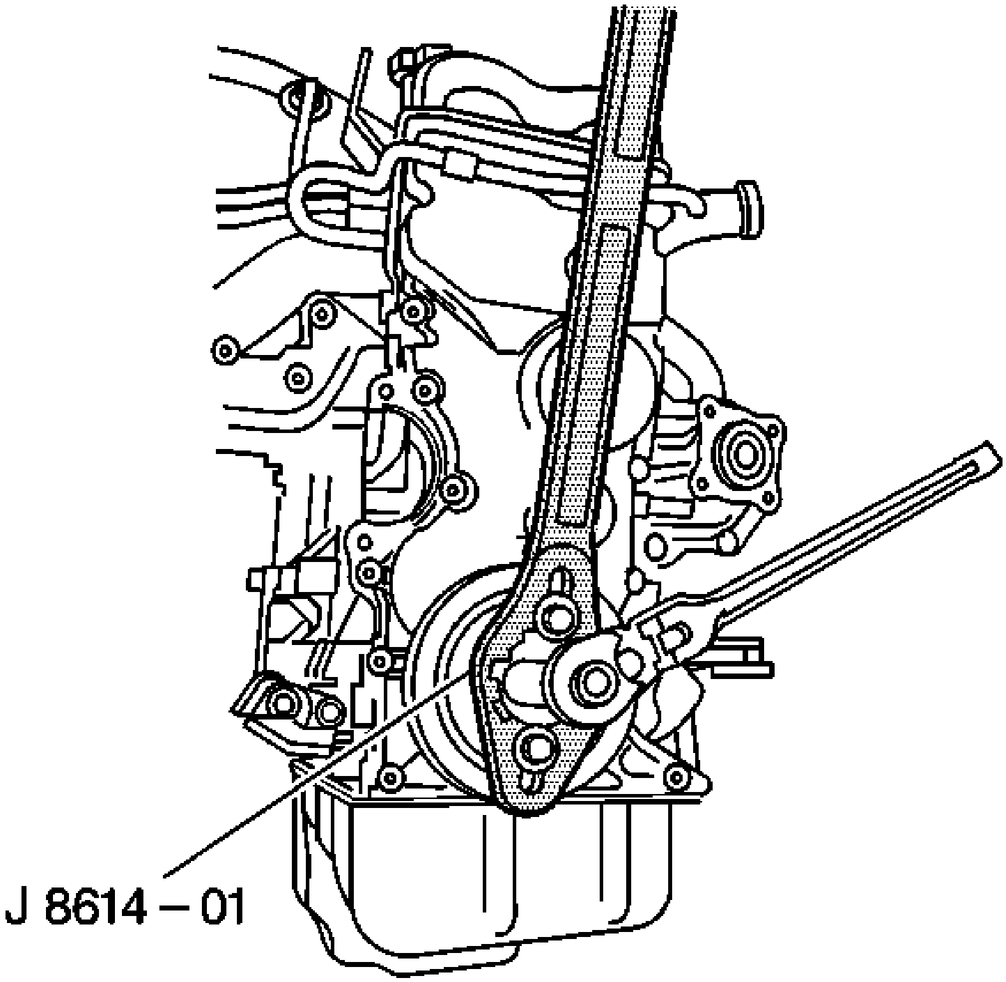


Fig. 244: View Of J 8614-01
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft pulley.

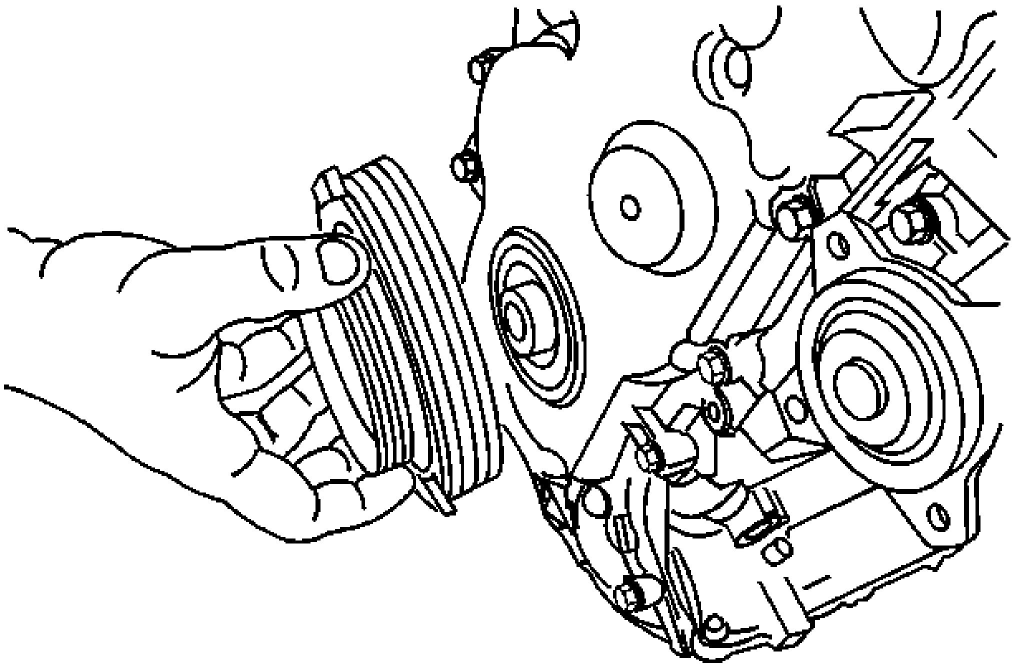


Fig. 245: Removing Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Cover Removal

1. Remove the 4 ignition coils.
2. Remove the oil level gauge.
3. Remove the positive crankcase ventilation (PCV) hose.
4. Remove the PCV breather hose.
5. Remove the 6 cap nuts and washers from the cylinder head.
6. Remove the cylinder head cover (1).
7. Remove the cylinder head cover gasket (2).
8. Remove the 4 O-rings (3).

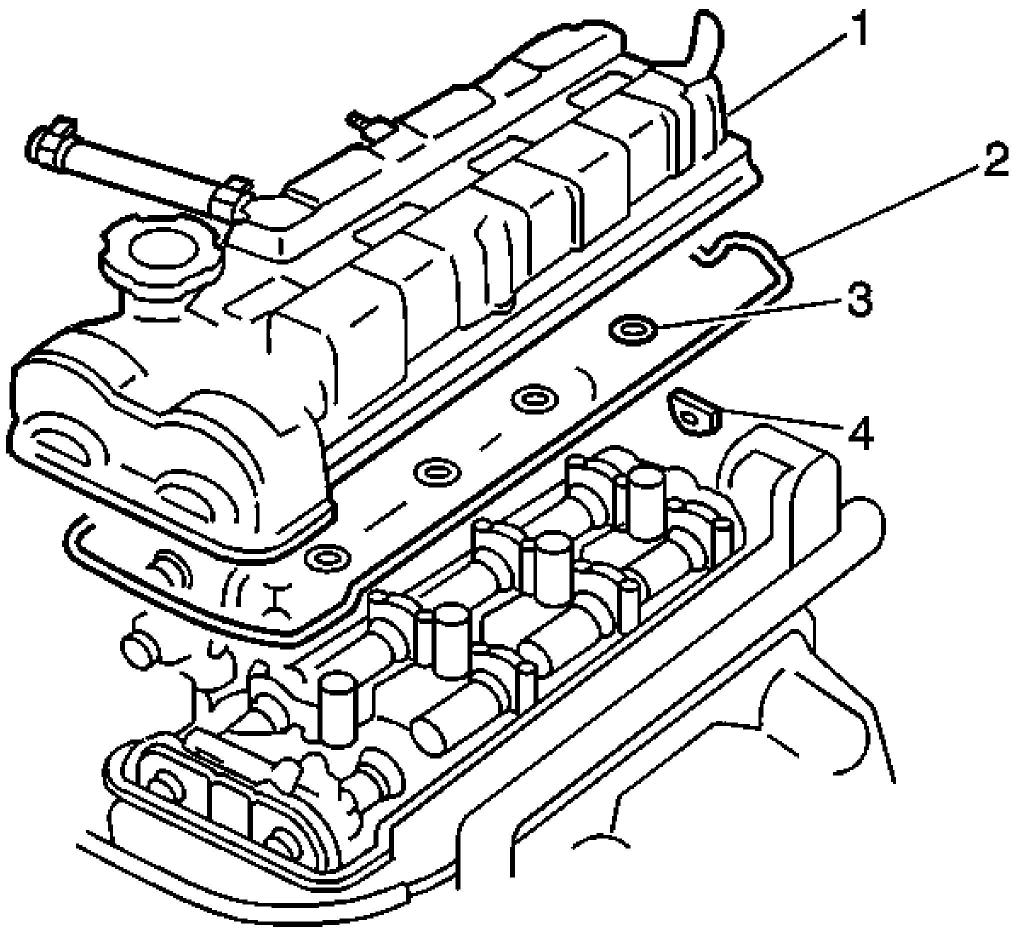


Fig. 246: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

Water Pump Removal

1. Remove the 1 bolt and the heater outlet line from the rear of the water pump housing.
2. Remove the 4 bolts (2) and the water pump from the engine block.
3. Remove the dowel pins from the engine block.

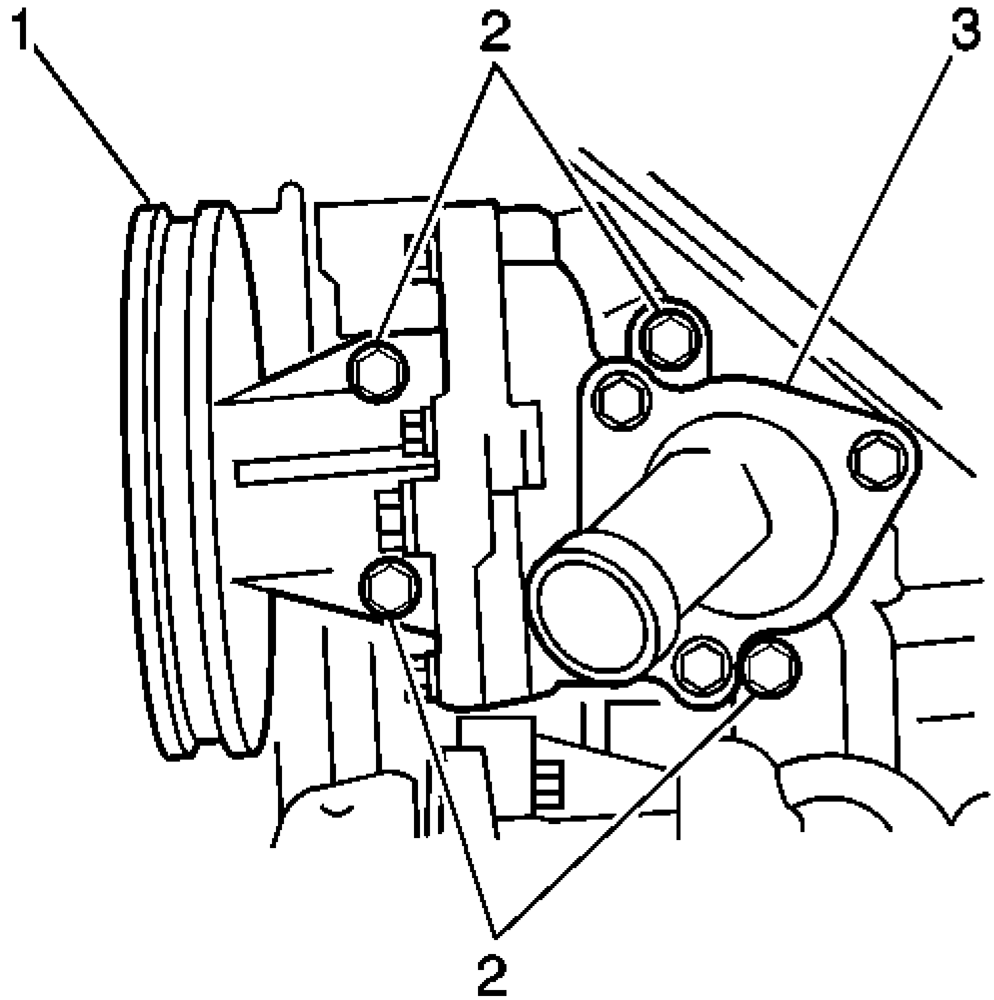


Fig. 247: View Of Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

Crankshaft Front Oil Seal Removal

1. Remove the crankshaft pulley. Refer to **Crankshaft Pulley Removal**.

IMPORTANT: To protect the crankshaft from damage, wrap the tip of the screwdriver with tape.

2. Carefully pry out the crankshaft front oil seal using a screwdriver.

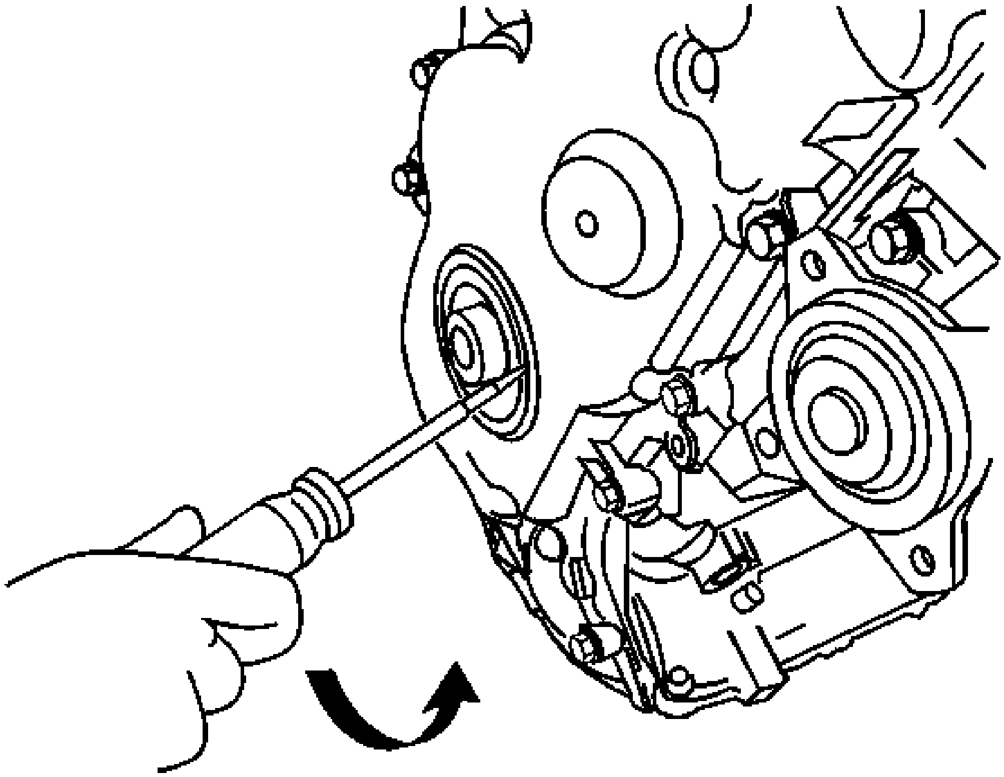


Fig. 248: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Timing Chain Housing Removal

1. Remove the oil pan. Refer to **Oil Pan Removal**.
2. Remove the 2 bolts and the accessory drive belt tensioner (2).
3. Remove the nut and the accessory drive belt idler pulley (1).

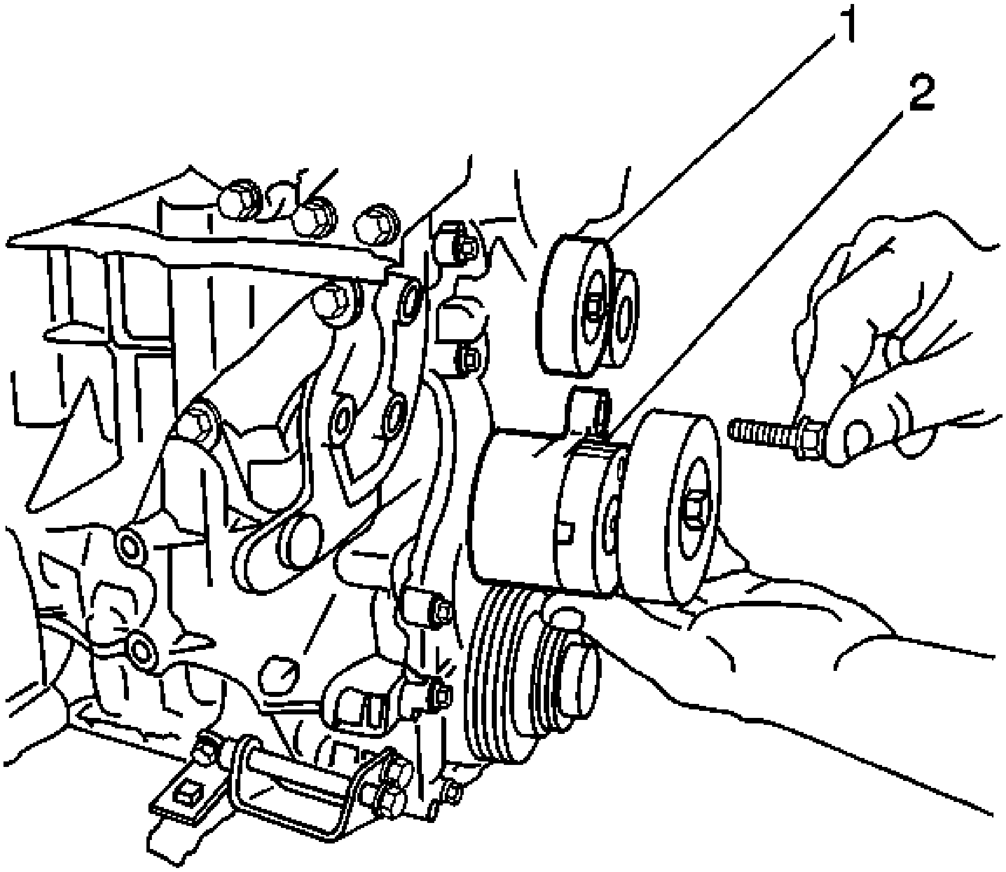


Fig. 249: View Of Drive Belt Tensioner Bolts & Idler Pulley
Courtesy of GENERAL MOTORS CORP.

4. Remove the bypass hose (3) from the coolant outlet pipe.
5. Remove the 2 bolts and the water bypass pipe bracket (2) from the cylinder head.

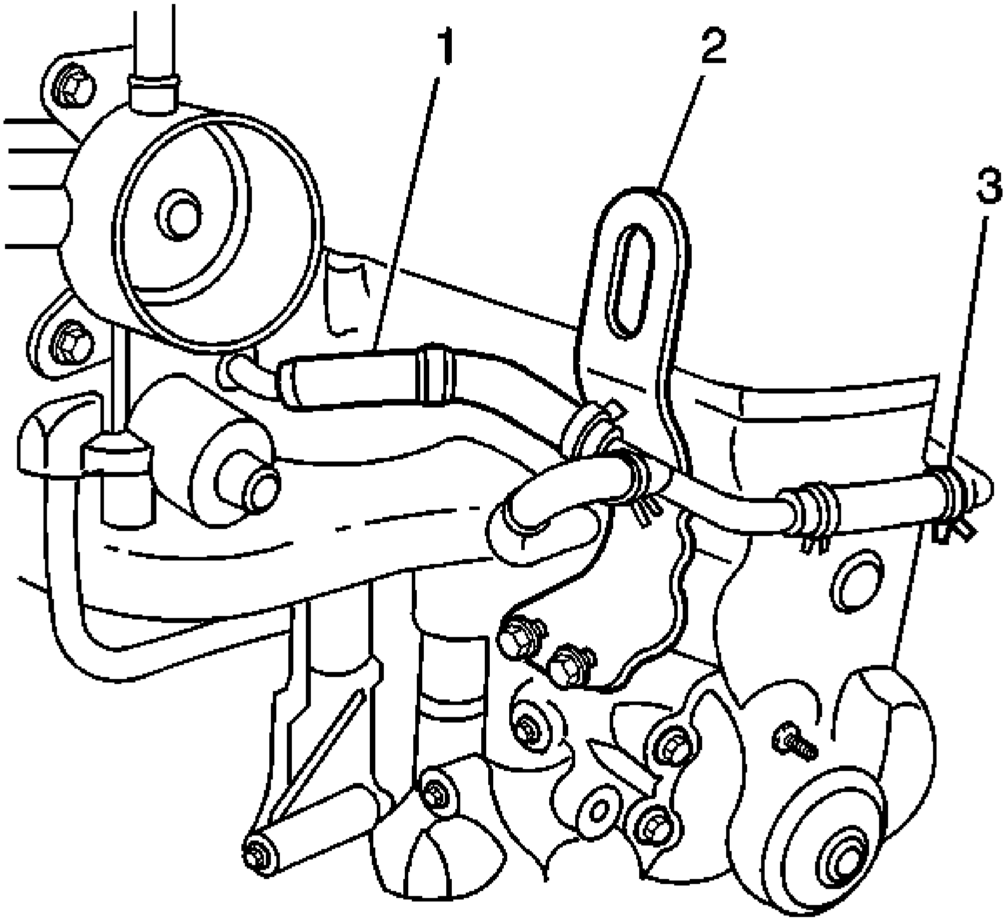


Fig. 250: View Of Water Bypass Pipe Bracket & Hose
Courtesy of GENERAL MOTORS CORP.

6. Remove the nut and 15 bolts and the timing chain housing.

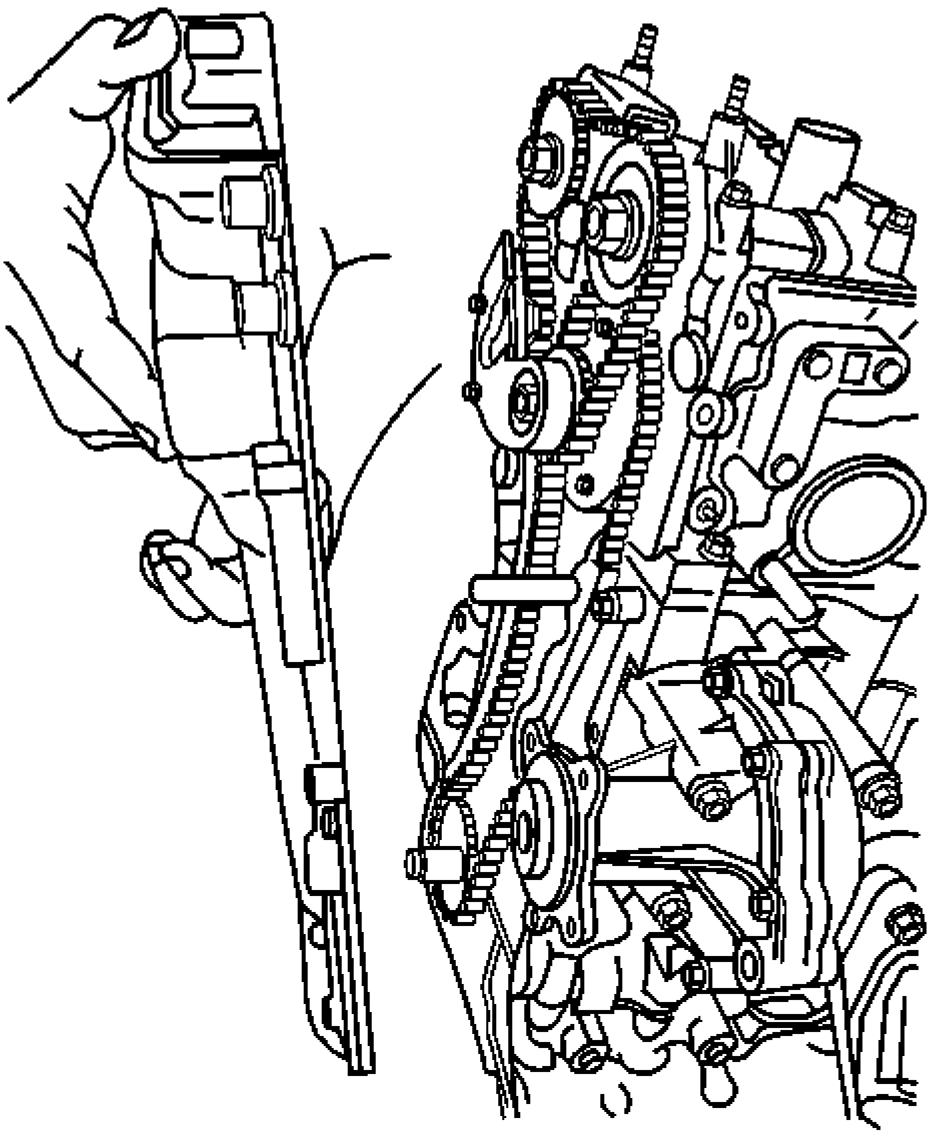


Fig. 251: Removing Timing Chain Housing
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Removal (Camshaft)

1. Remove the spark plugs in order to make rotating the crankshaft to line up the timing marks easier.

IMPORTANT:

- **Align the timing marks before disassembly.**
- **Do not turn the camshafts and the crankshaft once the timing chain tensioner is removed. Valve and piston damage may occur.**

2. Rotate the crankshaft so that the following conditions are met:
   - The number 1 (frontmost) cylinder is at the top dead center (TDC) position on the compression stroke.
   - The keyway on the crankshaft (5) aligns with the mark on the engine block (4).
   - The arrow (3) on the idler sprocket is pointing upward.
   - The guide pins (1) on the camshaft sprockets line up with the notches (6) on the cylinder head.

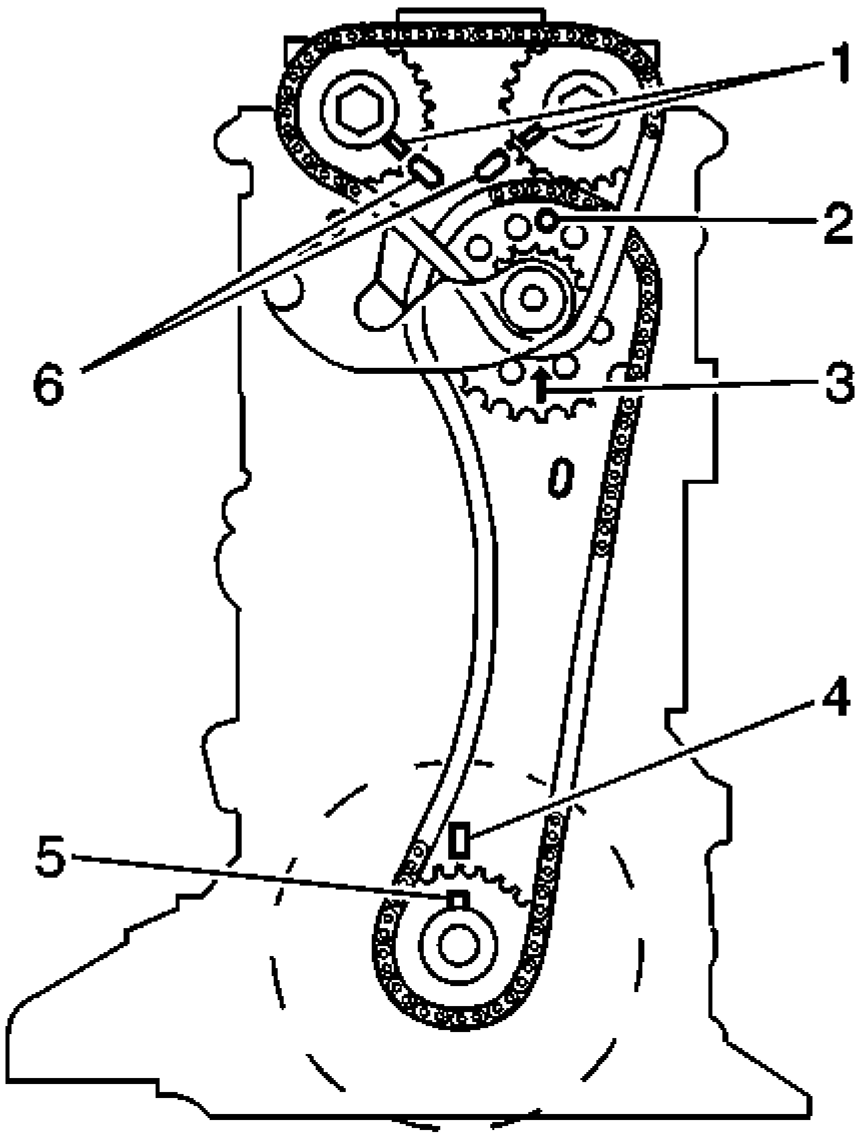


Fig. 252: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

3. Relieve the tension on the camshaft timing chain by turning the intake camshaft slightly counterclockwise.
4. Remove the nut and 2 bolts (1, 2).
5. Remove the camshaft timing chain tensioner.

6. Inspect the camshaft timing chain tensioner for wear, damage and correct operation. Replace as necessary.

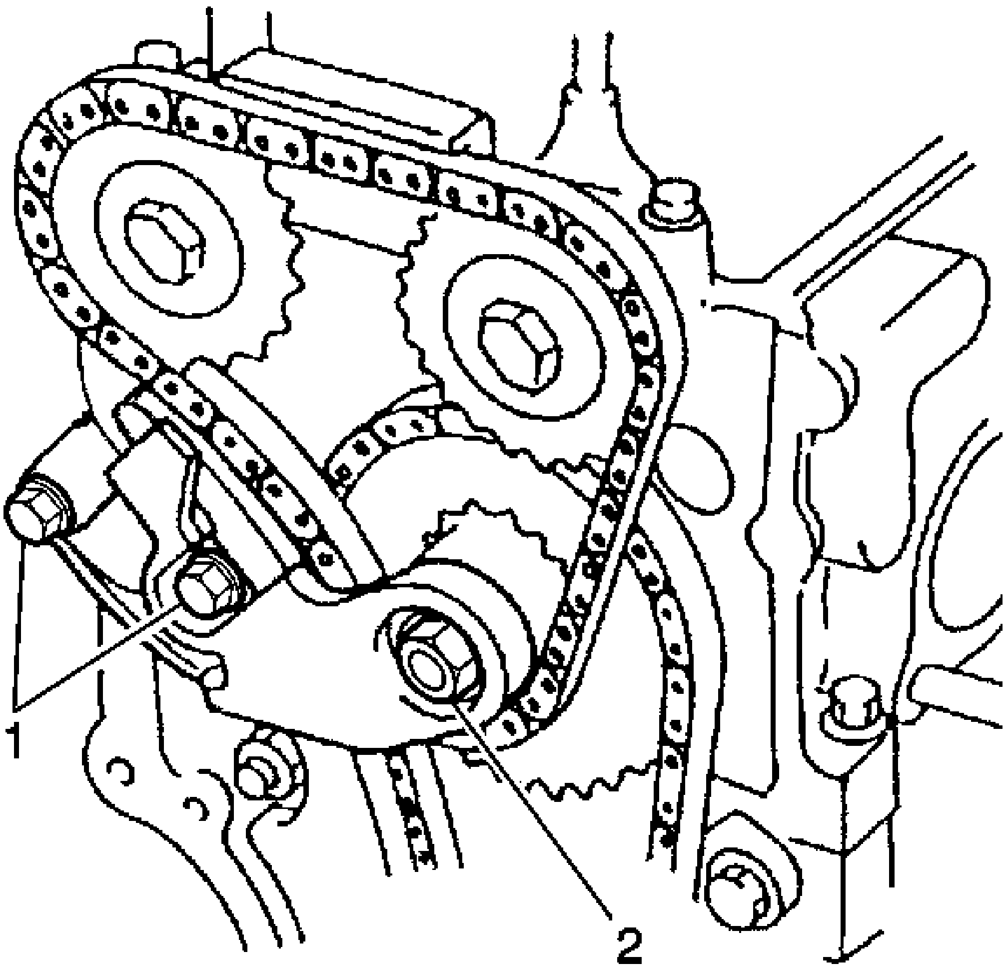


Fig. 253: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Removal (Crankshaft)

IMPORTANT:
- **Ensure that the timing marks are correctly aligned before disassembly.**
- **Do not turn the camshafts and the crankshaft once the timing chain tensioner is removed. Valve and piston damage may occur.**

1. Remove the 2 bolts (1) and the crankshaft timing chain tensioner.
2. Inspect that the latch and teeth of the crankshaft timing chain tensioner are undamaged and that the tensioner functions correctly. Replace as necessary.

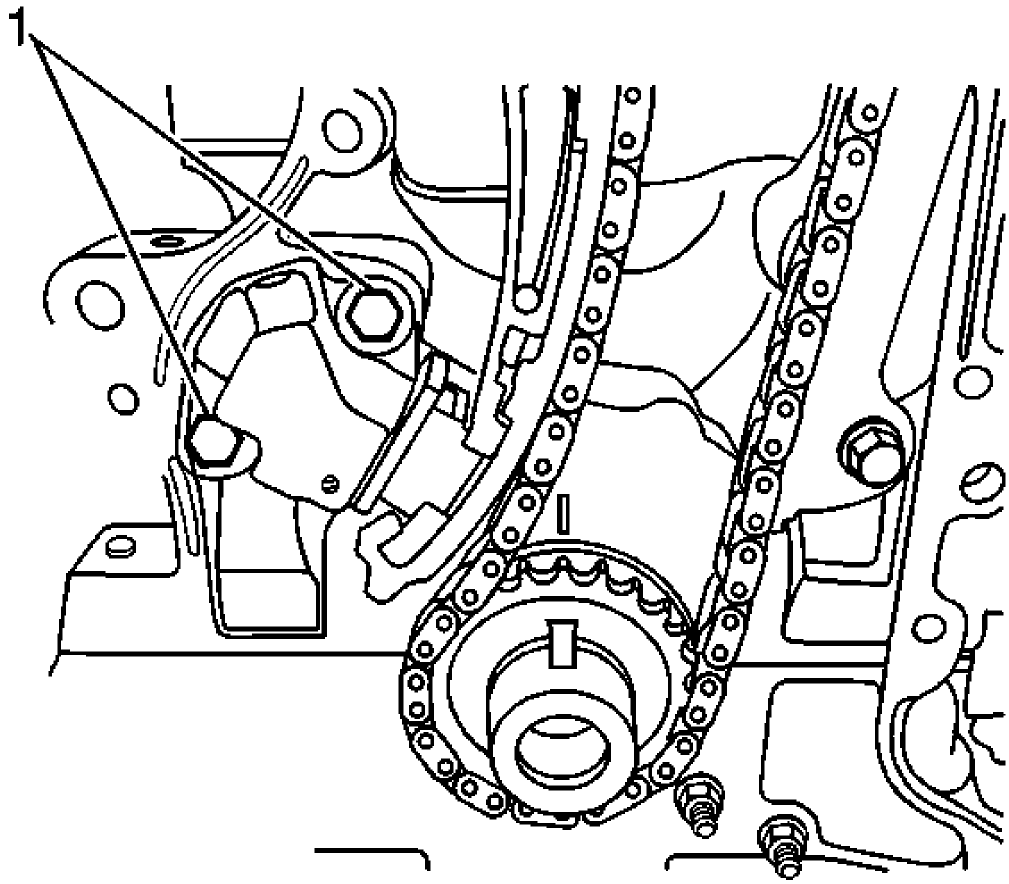


Fig. 254: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Removal (Camshaft)

IMPORTANT:

- **Ensure that the timing marks are correctly aligned before disassembly.**
- **Do not turn the camshafts and the crankshaft once the timing chain is removed. Valve and piston damage may occur.**

1. Hold the camshaft with a wrench and remove the camshaft sprocket bolts (1).
2. Remove the camshaft sprockets and chain.
3. Inspect the following components for wear and damage:
    - The camshaft timing chain upper guide
    - The camshaft timing chain tensioner
    - The camshaft timing chain sprockets
    - The camshaft timing chain
4. Replace damaged components as necessary.

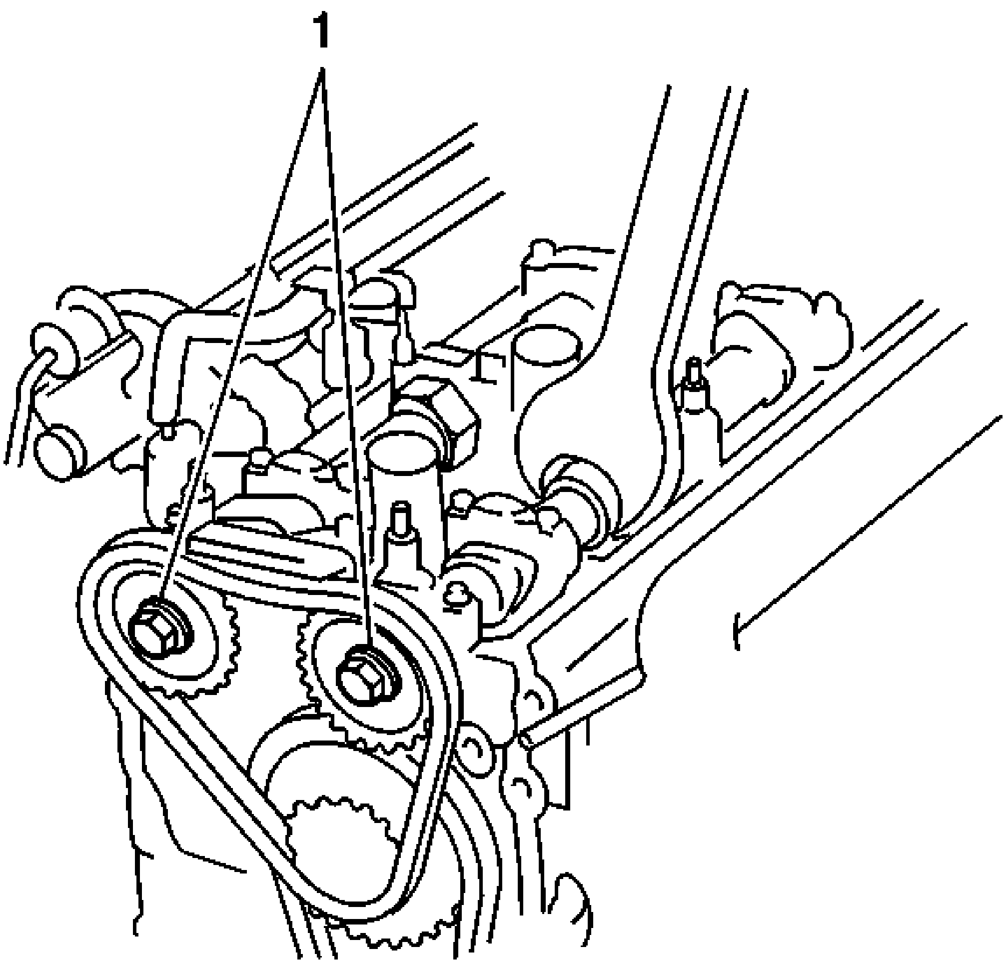


Fig. 255: View Of Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Removal (Crankshaft)

IMPORTANT:

- **Ensure that the timing marks are correctly aligned before disassembly.**
- **Avoid turning the camshafts and the crankshaft once the timing chain is removed. Valve and piston damage may occur.**
- **If necessary, the camshafts may be turned 15 degrees from the marks on the cylinder head in either direction.**
- **If necessary, the crankshaft may be turned 90 degrees from the mark on the engine block in either direction.**

1. Remove the 2 bolts and the crankshaft timing chain tensioner (3).
2. Remove the 2 bolts and the crankshaft timing chain fixed guide (2).
3. Remove the bolt and the crankshaft timing chain adjustable guide (1).
4. Remove the idler sprocket and the crankshaft timing chain.
5. Remove the crankshaft timing sprocket.
6. Inspect the following components for wear and damage:
    - The timing chain fixed guide
    - The timing chain adjustable guide
    - The idler sprocket
    - The crankshaft timing sprocket
    - The crankshaft timing chain
7. Inspect that the latch and teeth of the crankshaft timing chain tensioner are undamaged and that the tensioner functions correctly.

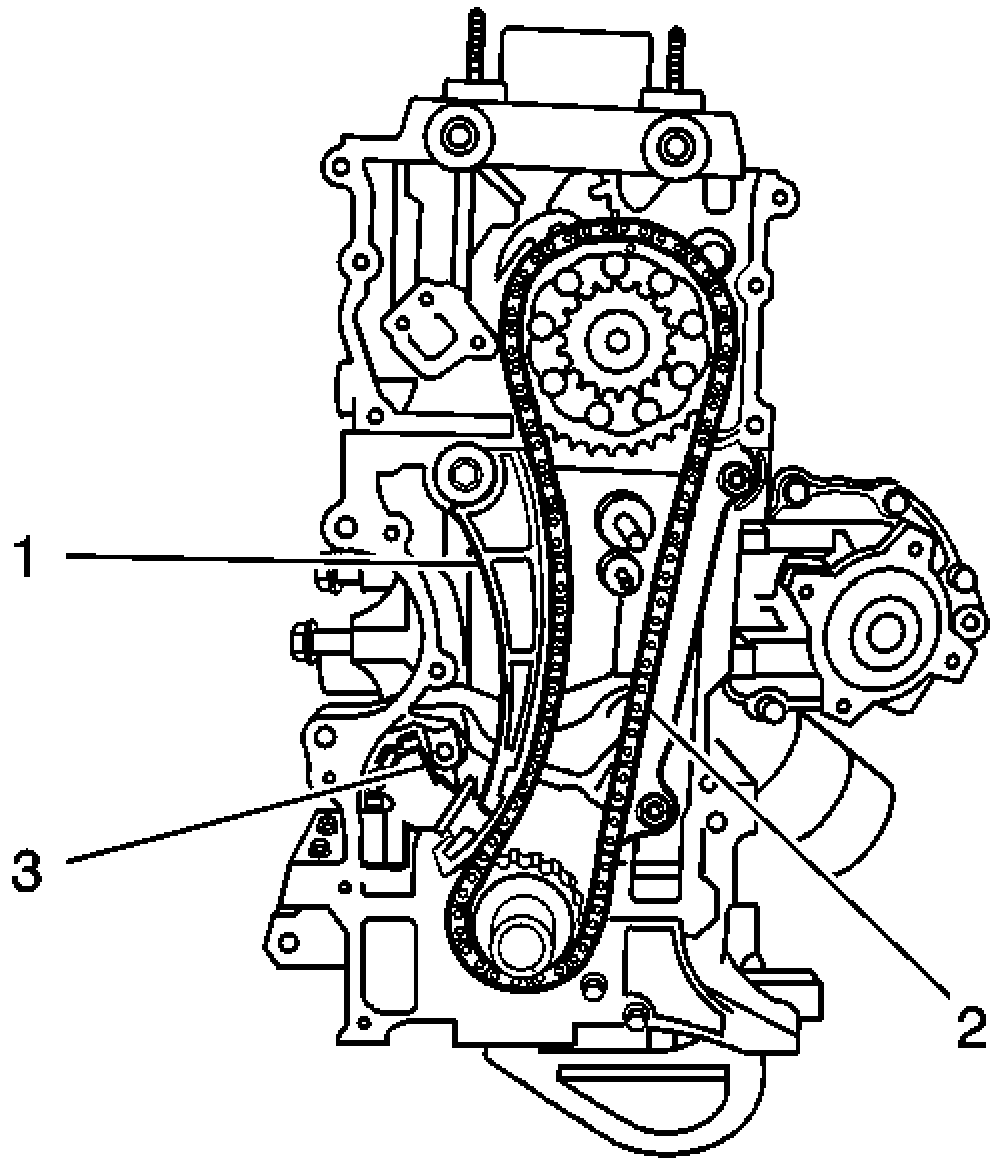


Fig. 256: View Timing Chain Tensioner, Adjustable Guide & Fixed Guide
Courtesy of GENERAL MOTORS CORP.

Intake Camshaft and Lifter Removal

1. Rotate the crankshaft 90 degrees clockwise in order to prevent interference between the valves and the pistons.

2. Loosen the camshaft bearing caps in sequence.
3. Remove the camshaft bearing caps.
4. Remove the camshaft.

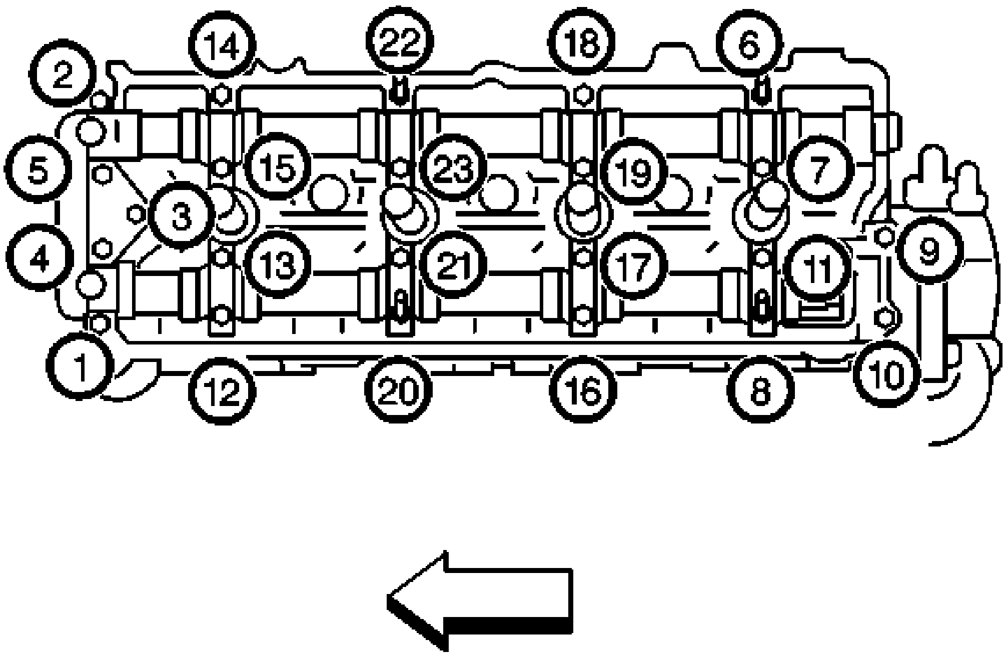


Fig. 257: View Of Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Store the valve lifters so that they can be installed in the same bore from which they were removed.**
- **Do not disassemble the valve lifter.**
- **Do not apply force to the body (valve side) of the valve lifter. This will force oil to leak out of the valve lifter.**
- **Store the valve lifters submerged in clean engine oil camshaft side down until installation.**
- **Store the valve lifters camshaft side up if left in air until installation. Do not store in air on the valve lifter side or with the camshaft side down.**

5. Remove the valve lifters.

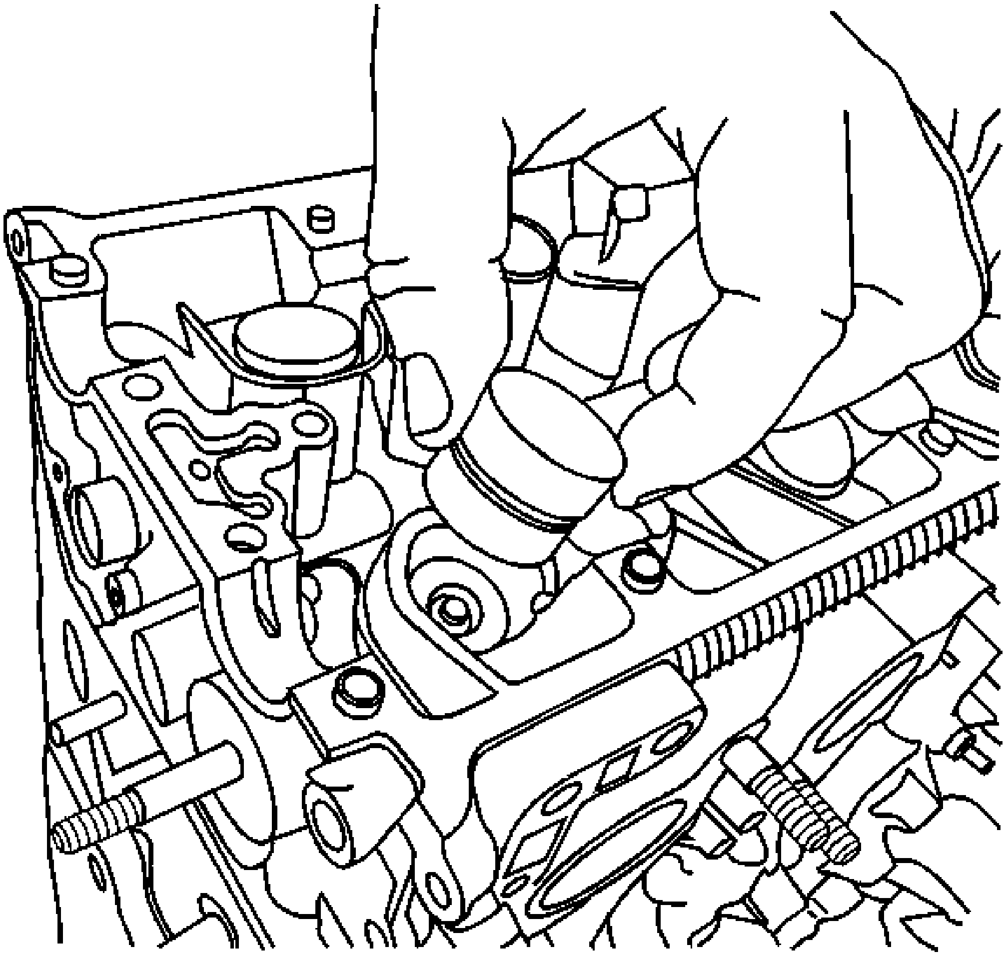


Fig. 258: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

Exhaust Camshaft and Lifter Removal

1. Rotate the crankshaft 90 degrees clockwise in order to prevent interference between the valves and the pistons.
2. Apply matchmarks (4) to the camshaft position sensor and the cylinder head.
3. Remove the bolt and the camshaft position sensor from the rear end of the exhaust camshaft.

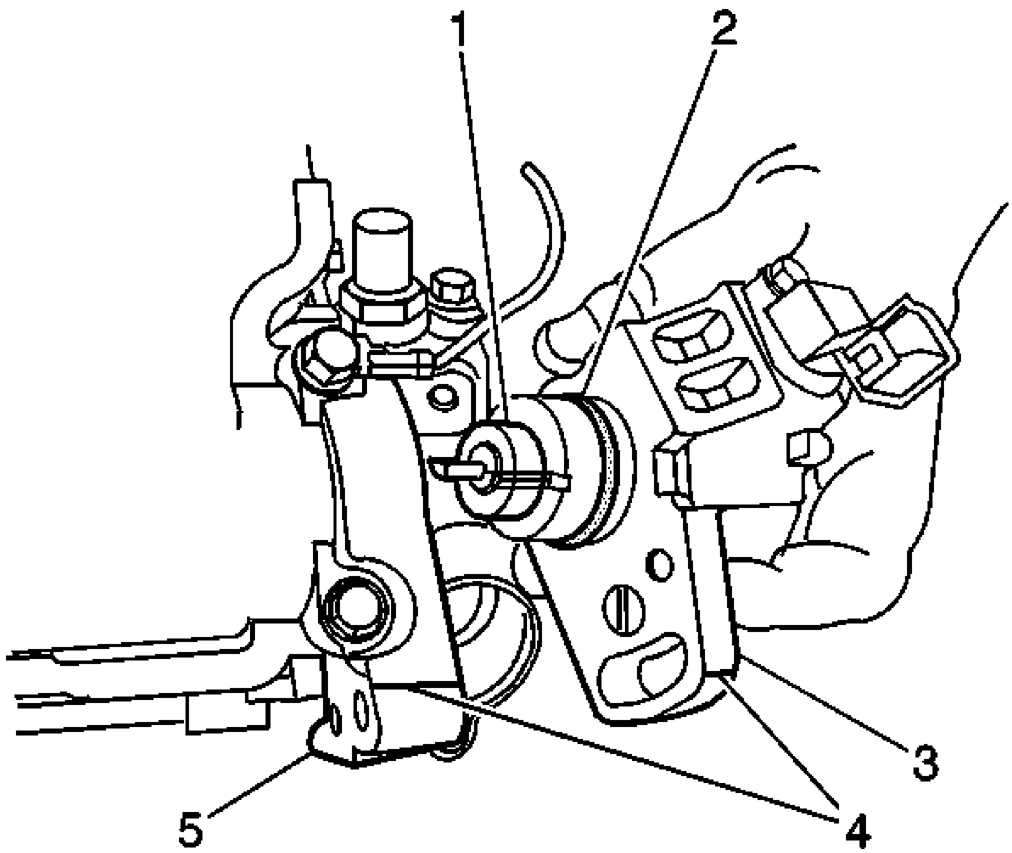


Fig. 259: Removing Camshaft Position Sensor & Components
Courtesy of GENERAL MOTORS CORP.

4. Loosen the camshaft bearing caps in sequence.
5. Remove the camshaft bearing caps.
6. Remove the camshaft.

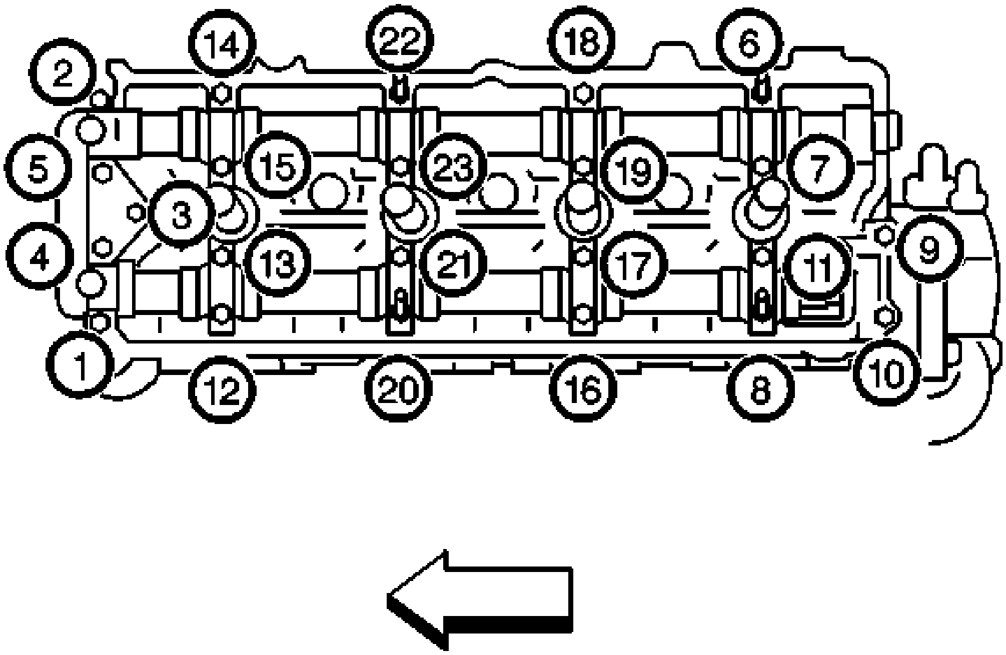


Fig. 260: View Of Intake Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Store the valve lifters so that they can be installed in the same bore fr which they were removed.**
- **Do not disassemble the valve lifter.**
- **Do not apply force to the body (valve side) of the valve lifter. This will force oil to leak out of the valve lifter.**
- **Store the valve lifters submerged in clean engine oil camshaft side do until installation.**
- **Store the valve lifters camshaft side up if left in air until installation. D not store in air on the valve lifter side or with the camshaft side down.**

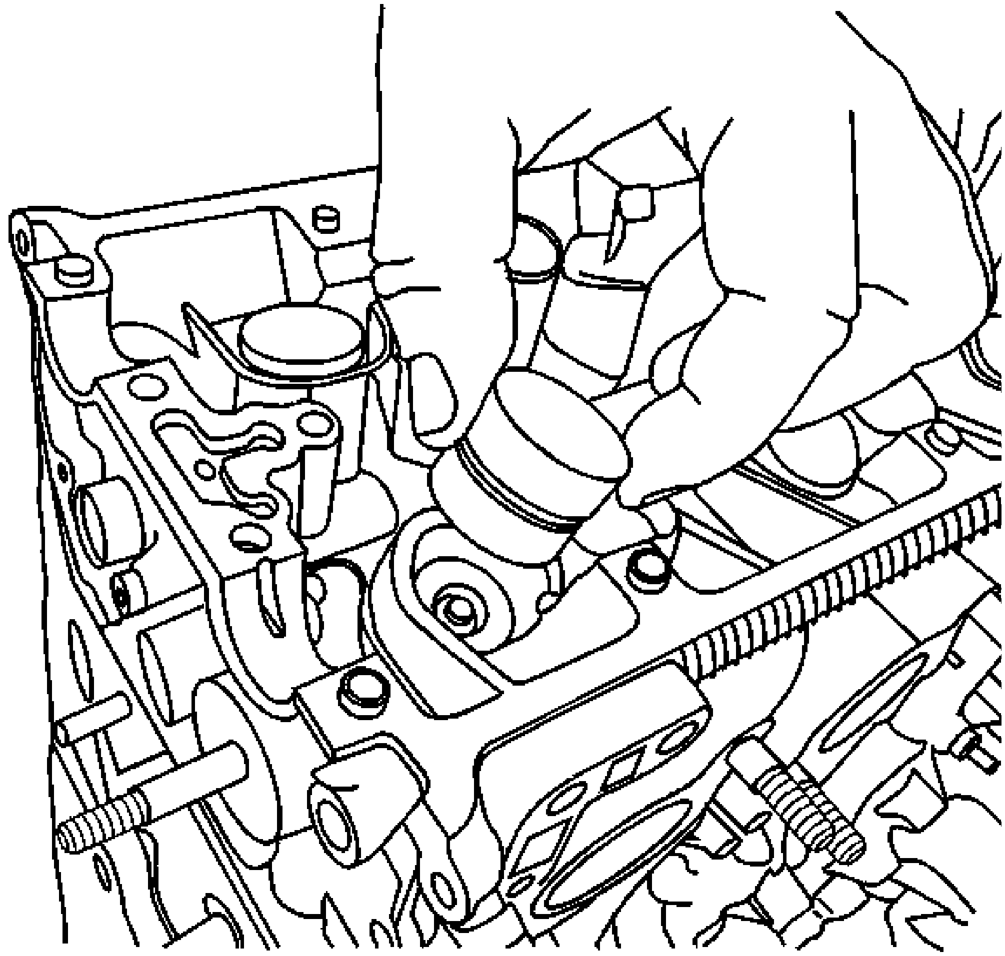


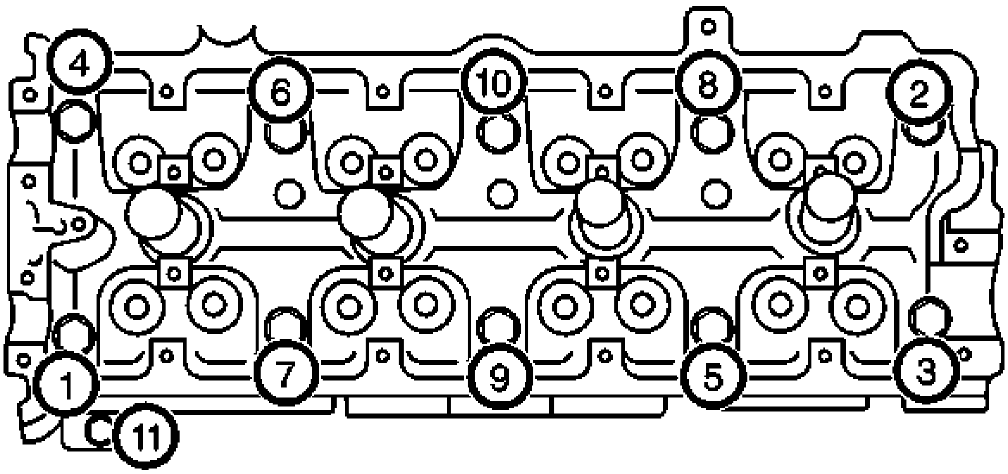
Fig. 261: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

7. Remove the valve lifters.

Cylinder Head Removal

NOTE: **In order to prevent warpage of the cylinder head, follow the sequence shown whenever removing or installing the head.**

1. Remove the 11 cylinder head bolts in the sequence shown.



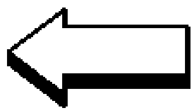


Fig. 262: Removing Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the cylinder head from the cylinder block.
3. Remove the cylinder head gasket (1).
4. Remove the coolant outlet pipe from the cylinder head.
5. Remove the engine coolant temperature (ECT) sensor and housing from the rear end of the cylinder head.
6. Remove the fuel injector rail from the cylinder head.

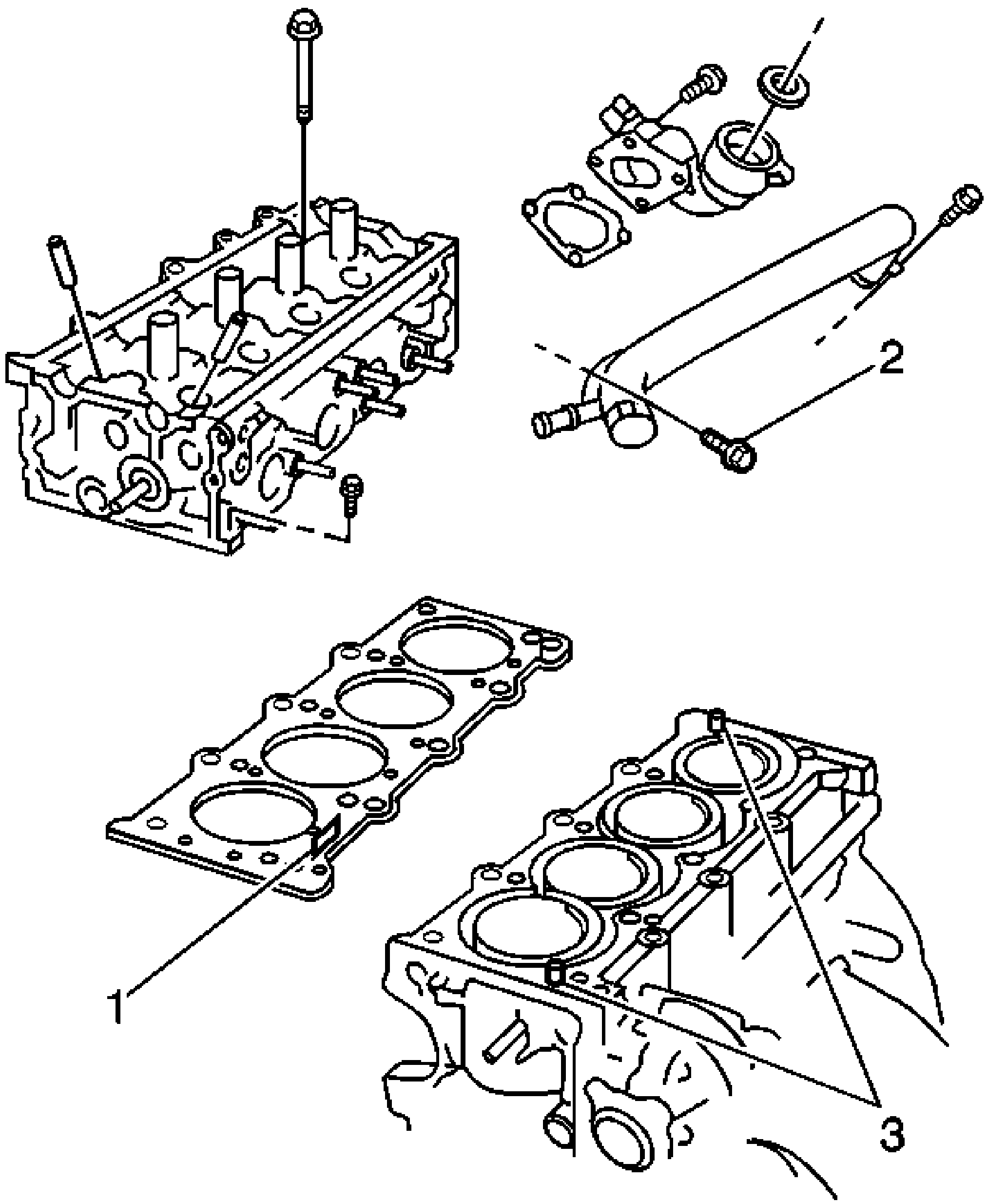


Fig. 263: View Of Cylinder Head Gasket & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

Oil Pan Removal

1. Remove the oil level indicator.

2. Drain the engine oil.
3. Remove the following fasteners from the lower cylinder block:
   - The 16 bolts
   - The 2 nuts

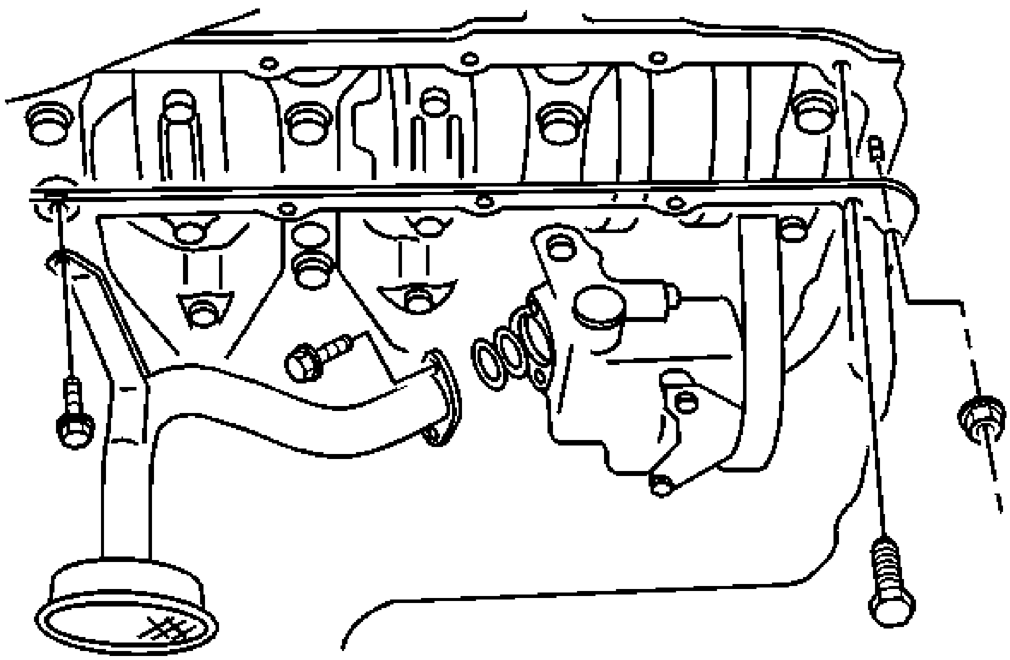


Fig. 264: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not damage the oil pan contact surface of the lower cylinder block when removing the oil pan.**

4. Carefully remove the engine oil pan.
5. Remove the 3 bolts and the oil pump strainer.
6. Clean the following components:
   - The inside of the engine oil pan.
   - The oil pump strainer screen.
   - The mating surfaces of the engine oil pan and the lower cylinder block.

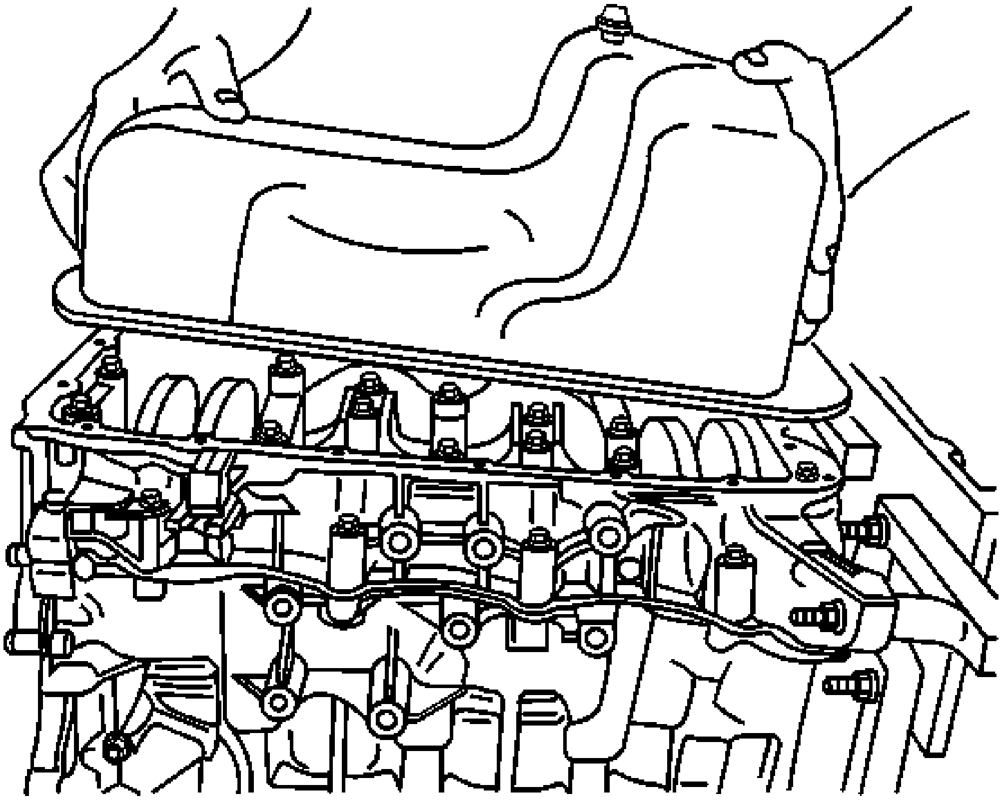


Fig. 265: View Of Engine Oil Pan
Courtesy of GENERAL MOTORS CORP.

Oil Pump Removal

1. Remove the 4 bolts and the oil pump drive chain cover (1).

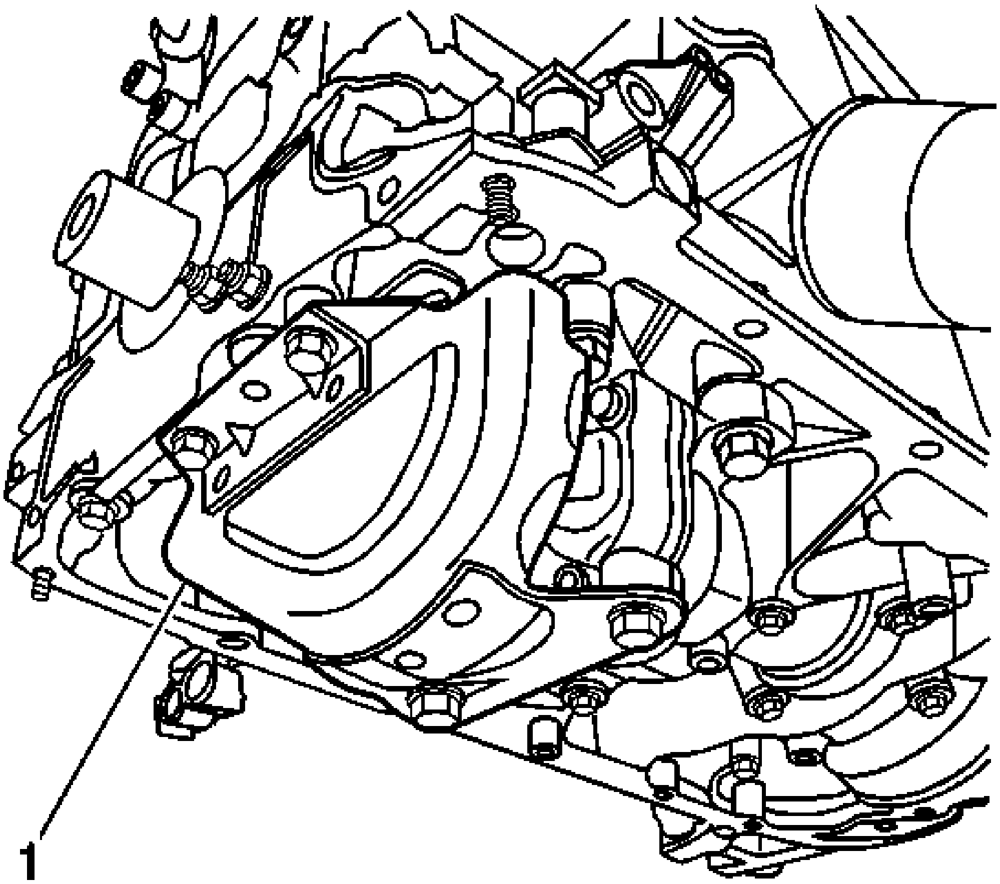


Fig. 266: View Of Oil Pump Drive Chain Cover
Courtesy of GENERAL MOTORS CORP.

2. Remove the 3 bolts and the oil pump.

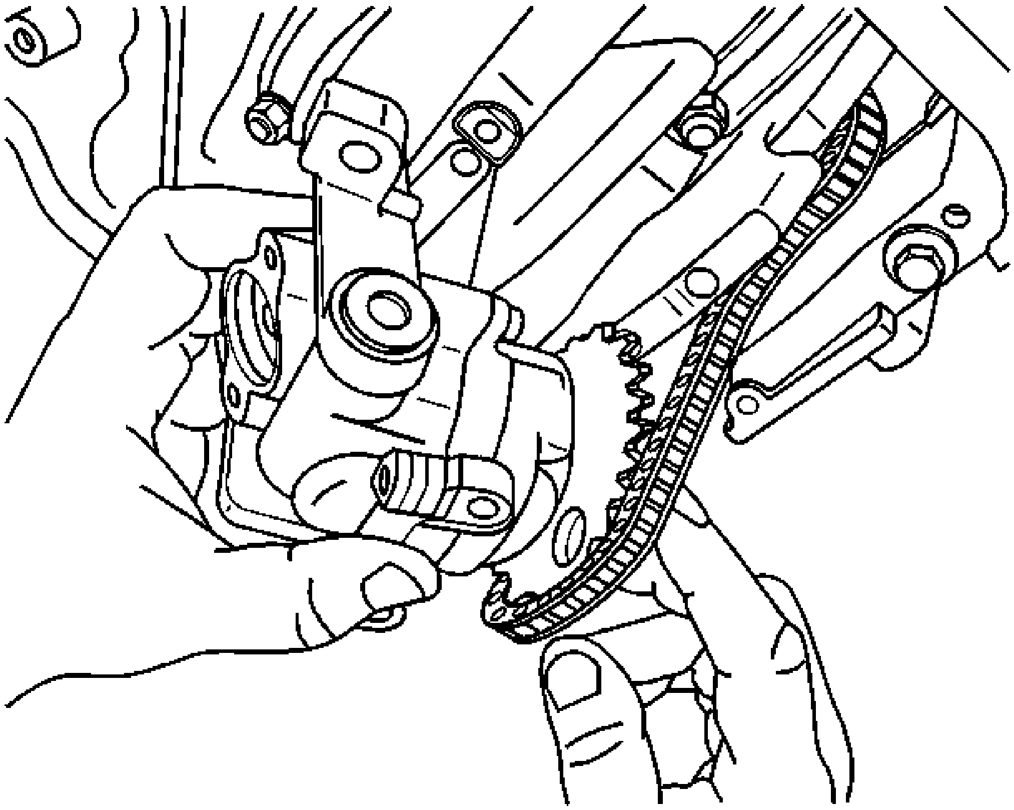


Fig. 267: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

3. If necessary, remove the oil pump chain guide. The chain tension will have to be adjusted if the guide is removed or if the chain is replaced.

Piston, Connecting Rod, and Bearing Removal

NOTE: If there is a pronounced ridge at the top of the piston travel, the ridge must be removed with a ridge reamer before the piston and connecting rod assembly are removed. Applying force may break the piston rings or damage the piston.

1. Mark the connecting rod, the cap and the piston with the cylinder number from which the piston assembly is being removed. Also mark the orientation to the front of the cylinder block. This will ensure that the pistons, caps and connecting rods are re-assembled correctly.
2. Rotate the crankshaft to the bottom dead center position for the cylinder being serviced.

3. Place a cloth over the piston to catch the debris.
4. Remove all of the ridge from the top of the cylinder using a ridge reamer.
5. Turn the crankshaft until the piston is at the top dead center position.
6. Remove the cloth with the metal shavings from the cylinder and piston.

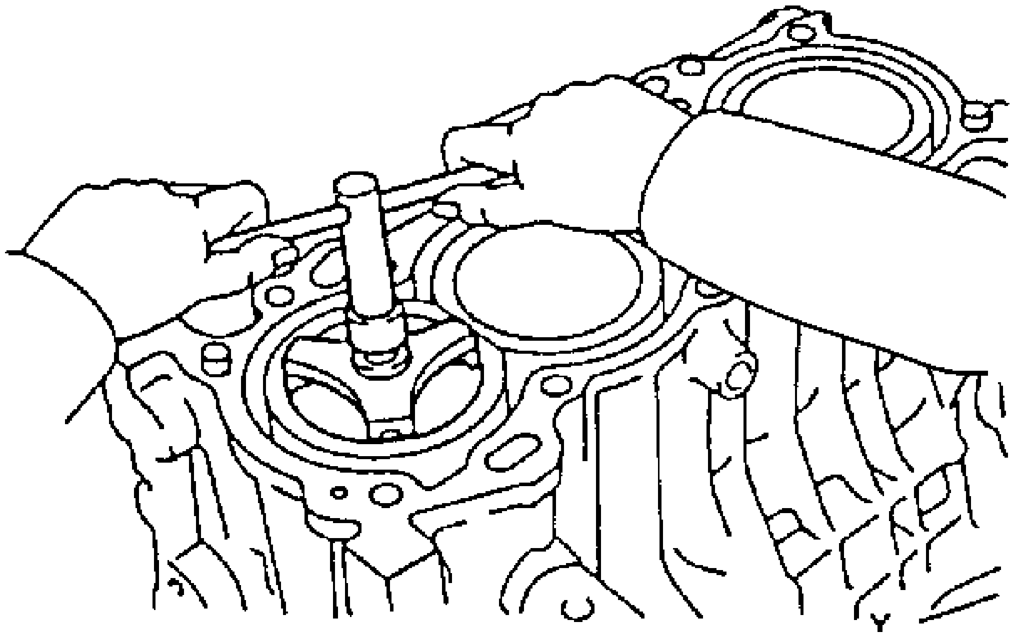


Fig. 268: View Ridge From Top Of Cylinder
Courtesy of GENERAL MOTORS CORP.

7. Rotate the crankshaft to a position where the connecting rod nuts are the most accessible.
8. Remove the connecting rod nuts.
9. Remove the connecting rod cap and bearing.
10. Install guide hoses over the connecting rod studs. This prevents damage to the crankshaft bearing journal and the connecting rod stud threads.
11. Remove the piston and connecting rod assembly from the cylinder.

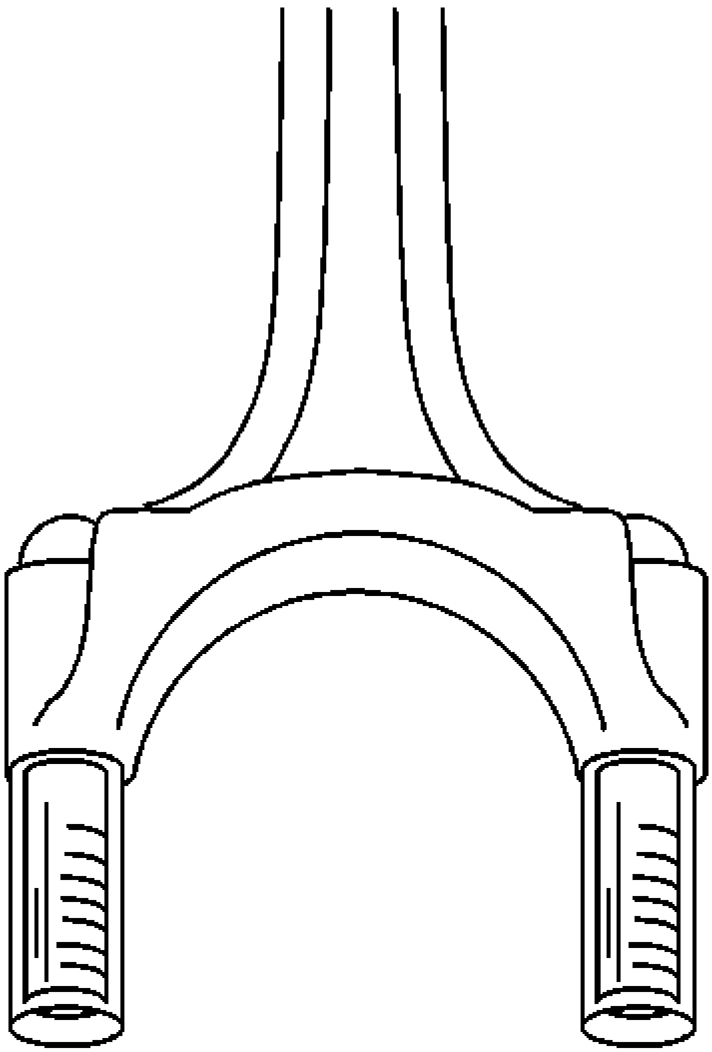


Fig. 269: Removing Connecting Rods
Courtesy of GENERAL MOTORS CORP.

Crankshaft Rear Oil Seal Removal

1. Wrap the tip of the screwdriver with tape in order to protect the crankshaft from damage.
2. Carefully pry out the crankshaft rear oil seal using a screwdriver.

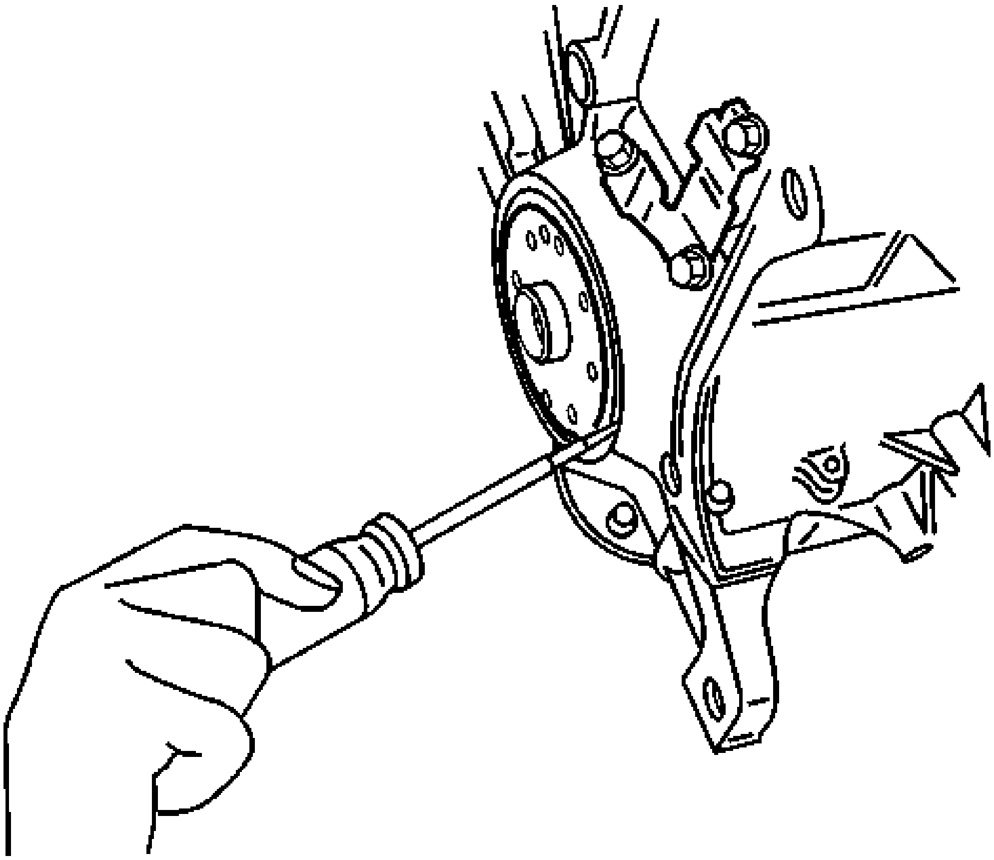


Fig. 270: Removing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

Crankshaft and Bearings Removal

1. Remove the lower crankcase (1-12) and the main bearing cap (13-22) bolts in the sequence shown.

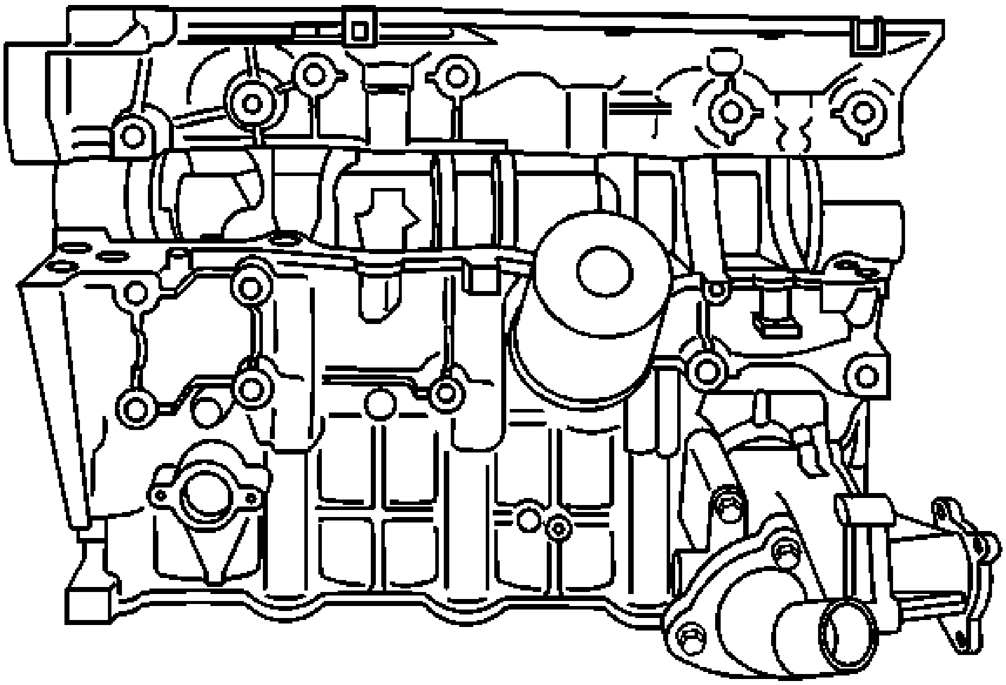


Fig. 271: View Of Lower Crankcase Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not gouge the sealing surfaces of the two halves of the cylinder block during disassembly.

2. Carefully pry the lower crankcase apart from the cylinder block using a screwdriver.
3. Carefully remove the lower crankcase with the lower bearing inserts.

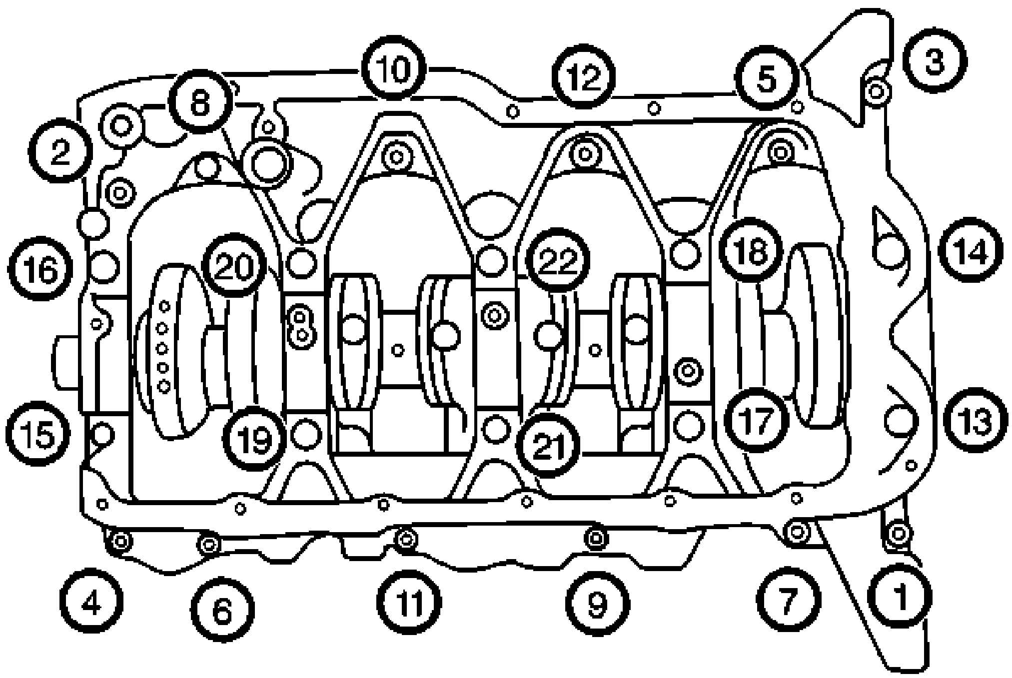


Fig. 272: View Of Lower Crankcase & Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Remove the crankshaft carefully in order to avoid damaging the crankshaft journals, the rod, the main bearing inserts, or the connecting rods.

4. Remove the crankshaft and the oil pump drive chain from the cylinder block.
5. Remove the bearing inserts from the block.

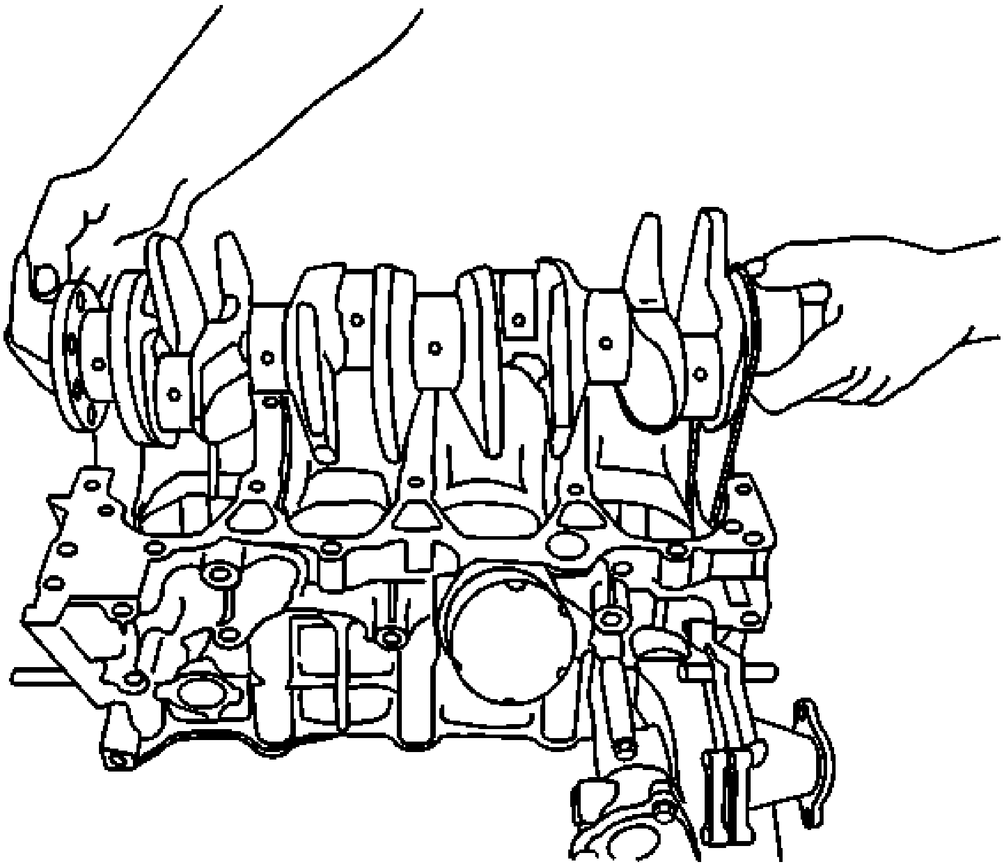


Fig. 273: Removing Crankshaft & Oil Pump Drive Chain From Cylinder Block
Courtesy of GENERAL MOTORS CORP.

Engine Block Cleaning and Inspection

Tool Required

J 8087 Cylinder Bore Gage

1. Clean the sealing material from the gasket mating surfaces.
2. Boil the engine block in caustic solution.
3. Flush the engine block with clean water or steam.

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

4. Clean the oil passages.
5. Clean the coolant passages.
6. Clean the blind holes.
7. Spray the cylinder bores and the machined surfaces with engine oil.
8. Inspect the threaded holes. Clean the threaded holes with a rifle brush. Refer to **Thread Repair**.
9. Measure the deck surface for flatness using a straight edge and a feeler gauge. Carefully machine minor irregularities. Replace the block if warpage exceeds 0.06 mm (0.0024 in).
10. Inspect the lower crankcase rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.
11. Inspect the cylinder block for any cracks.
12. Visually inspect the cylinder bores for excessive wear or excessive ridging.

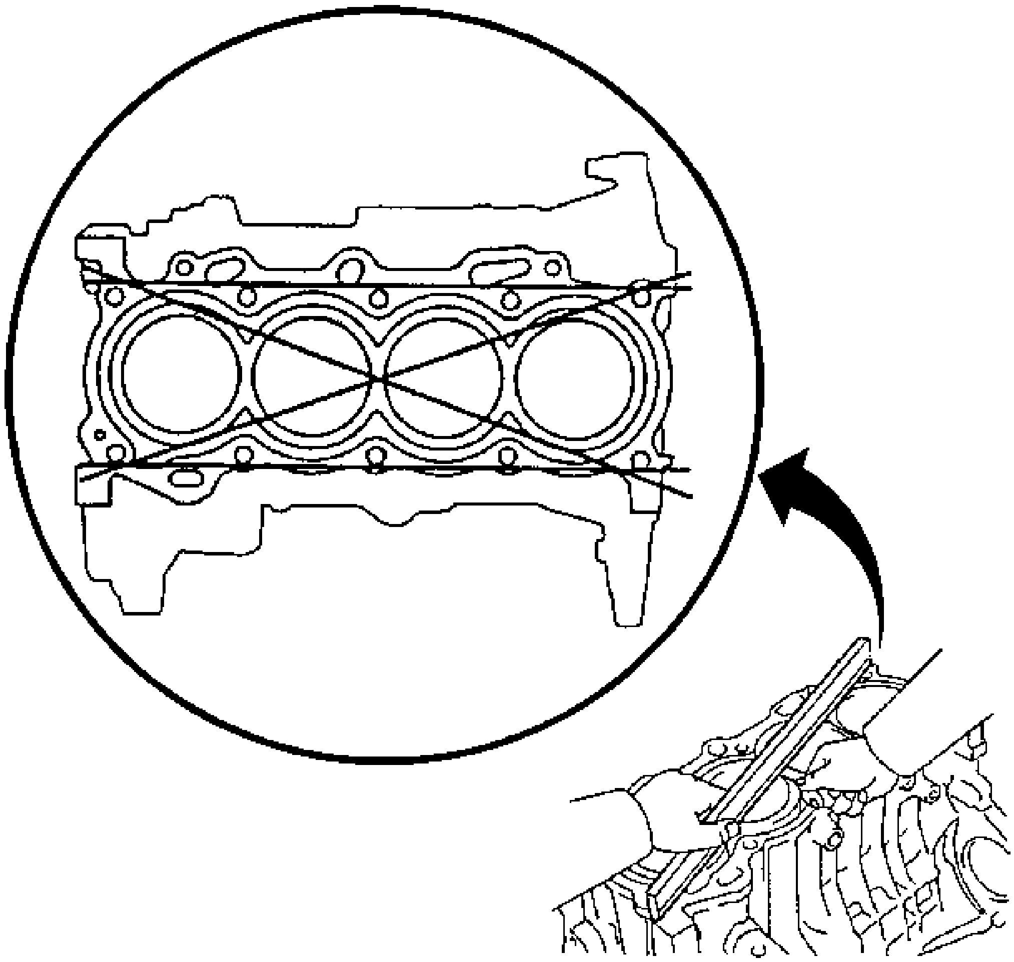


Fig. 274: Measuring Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

13. Measure the cylinder bore taper, out-of-round and size using the **J 8087** .

    Maximum Cylinder Taper: 0.10 mm (0.004 in)

    Maximum Cylinder Out-of-Round: 0.10 mm (0.004 in)

    Maximum Cylinder Bore Diameter: 84.050 mm (3.3090 in)

14. Measure the pistons. Refer to Piston, Connecting Rod and Bearings Clean/Inspect. Pistons are available in 2 standard and 2 oversizes.
    - **Standard Size Piston Diameter:**
        - 83.970-83.980 mm (3.3059-3.3062 in)
        - 83.980-83.990 mm (3.3063-3.3066 in)
    - **0.25 mm (0.0098 in) Oversize Piston Diameter:** 84.220-84.240 mm (3.3157-3.3165 in)
    - **0.50 mm (0.0196 in) Oversize Piston Diameter:** 84.470-84.490 mm (3.3256-3.3263 in)
15. Subtract the piston diameter from the cylinder bore diameter. The piston-to-cylinder bore clearance should be 0.02-0.04 mm (0.0008-0.0015 in) for each piston in its cylinder.

IMPORTANT: If the bore is worn beyond the limits, rebore all 4 cylinders and fit with oversized pistons. Select the smallest available oversize piston.

16. Leave sufficient material to allow honing when fitting the piston.
17. Calculate the cylinder bore diameter to be rebored. D = A+B-C when:
    - D = the cylinder bore diameter to be rebored
    - A = the measured piston diameter
    - B = the piston clearance: 0.02-0.04 mm (0.0008-0.0015 in)
    - C = the allowance for honing: 0.02 mm (0.0008 in)
18. Install the lower crankcase and torque to specifications before boring or honing. This will avoid distortion of the cylinder block.
19. Bore and hone the cylinders to the calculated dimension.
20. Measure the piston clearance after the honing is completed.

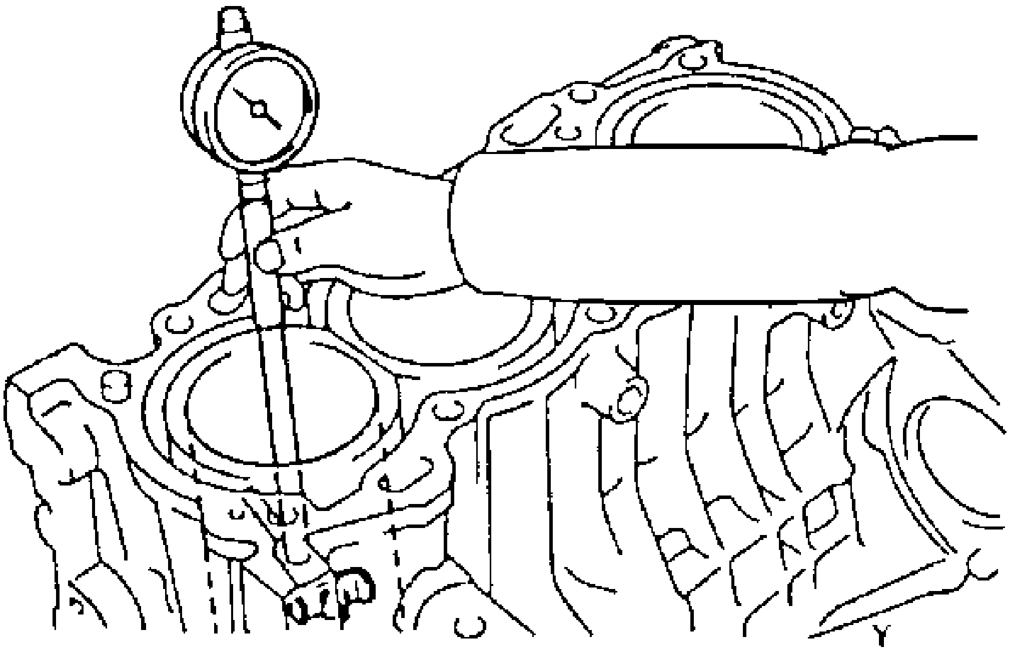


Fig. 275: Measuring Cylinder Bore Taper, Out-Of-Round & Size
Courtesy of GENERAL MOTORS CORP.

Cylinder Boring and Honing

Cylinder Boring

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

1. Before starting the honing or reboring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. File the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding use of the boring equipment.
4. When reboring the cylinders, make sure the lower crankcase is installed. Tighten the lower crankcase to the proper torque specifications in order to avoid distortion of the cylinder and bearing bores during final assembly.
5. When making the final cut with the boring bar, leave 0.02 mm (0.0008 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. Carefully perform the boring and honing operation in order to maintain the specified clearances between the pistons, the piston rings, and the cylinder bores.

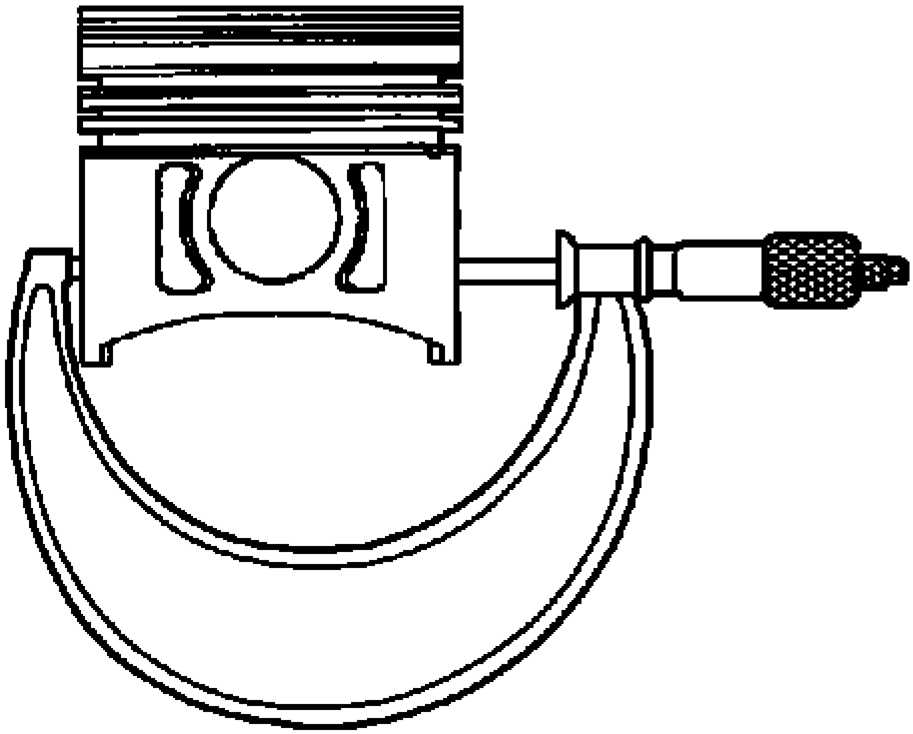


Fig. 276: Measuring Piston Outside Diameter Using Micrometer
Courtesy of GENERAL MOTORS CORP.

Cylinder Honing

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

1. When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning, and lubrication.
    - Use only clean sharp stones of the proper grade for the amount of material to be removed.
    - Dull, dirty stones cut unevenly and generate excessive heat.
    - DO NOT hone to a final grade with a coarse or medium-grade stone.
    - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
    - Perform the final honing with a fine-grade stone and hone the cylinder bore in a cross hatch pattern at 45-65 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly check the cylinder bore.
    - Repeatedly check the cylinder bore fit with the selected piston.

  - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.

3. When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.

   Repeatedly check the measurement at the top, the middle, and the bottom of the cylinder bore.

   - The finish marks should be clean but not sharp.
   - The finish marks should be free from imbedded particles or torn or folded metal.
4. By measuring the selected piston at the sizing point and then by adding the average of the clearance specification, the final cylinder bore honing dimension required can be determined.
5. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
6. After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.
   1. Scrub the cylinder bores with a stiff bristle brush.
   2. Rinse the cylinder bores thoroughly with clean hot water.
   3. Dry the cylinder bores with a clean, lint-free cloth.
   4. Do not allow any abrasive material to remain in the cylinder bores.
      - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
      - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
7. Perform final measurements of the piston and the cylinder bore.
8. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
9. Apply clean engine oil to each cylinder bore in order to prevent rusting.

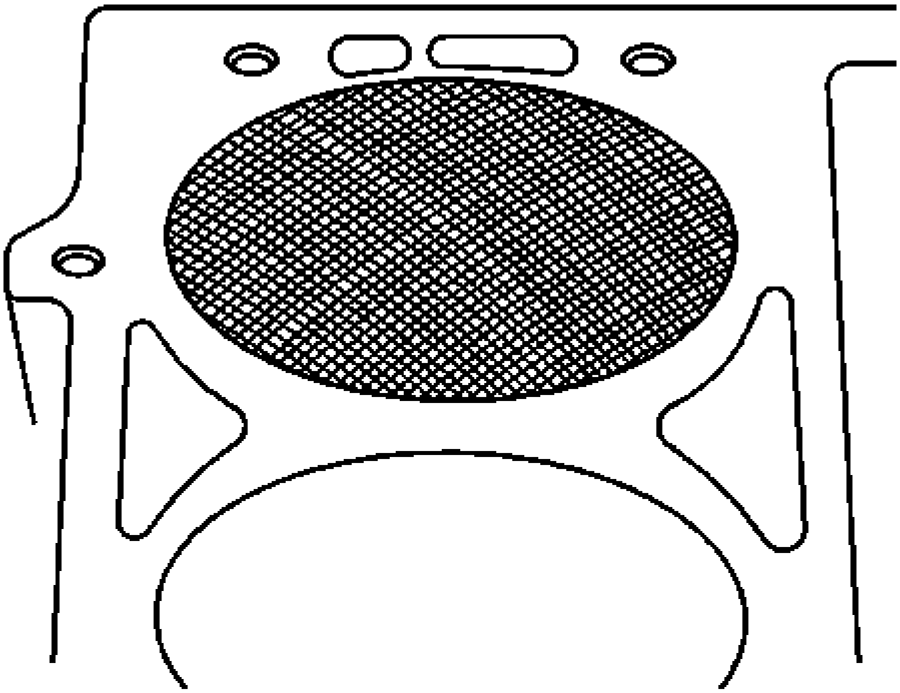


Fig. 277: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

Crankshaft Pulley Cleaning and Inspection

1. Clean the crankshaft pulley with a cloth and denatured alcohol.
2. Clean the belt grooves of all dirt or debris with a wire brush.

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

3. Dry the crankshaft pulley with compressed air.
4. Inspect the crankshaft pulley for the following:
   - Worn, grooved, or damaged hub seal surface.

     A crankshaft pulley hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

     Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

- Dirty or damaged belt grooves.

  The pulley belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

  Minor imperfections may be removed with a fine file.

- Worn, chunking or deteriorated rubber between the hub and pulley.

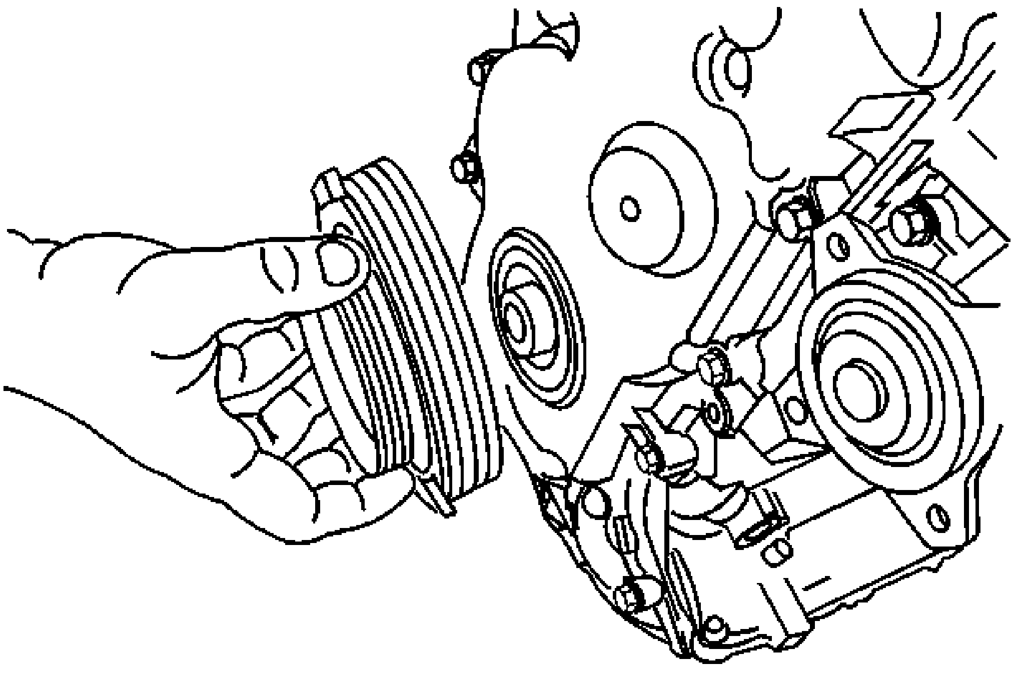


Fig. 278: Inspecting Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

Engine Flywheel Cleaning and Inspection

Tools Required

- **J 8001** Dial Indicator Set
- **J 26900-13** Magnetic Indicator Base. See **Special Tools and Equipment**.

1. Clean the flywheel in solvent.

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

2. Dry the flywheel with compressed air.
3. Inspect the manual transmission flywheel for the following:
   - Damaged ring gear teeth. Replace the flywheel if the ring gear is damaged, cracked or worn.
   - Loose or improperly positioned ring gear.

     The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.

   - A scored, grooved or damaged friction surface. Replace the flywheel if the surface is damaged or excessively worn.
4. Inspect the automatic transmission flywheel for the following:
   - Damaged ring gear teeth. Replace the flywheel if the ring gear is damaged, cracked or worn.
   - Stress cracks around the flywheel-to-crankshaft bolt hole locations.

     IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the flywheel plate. Install a new flywheel.

   - Welded areas that retain the ring gear onto the flywheel for cracking.

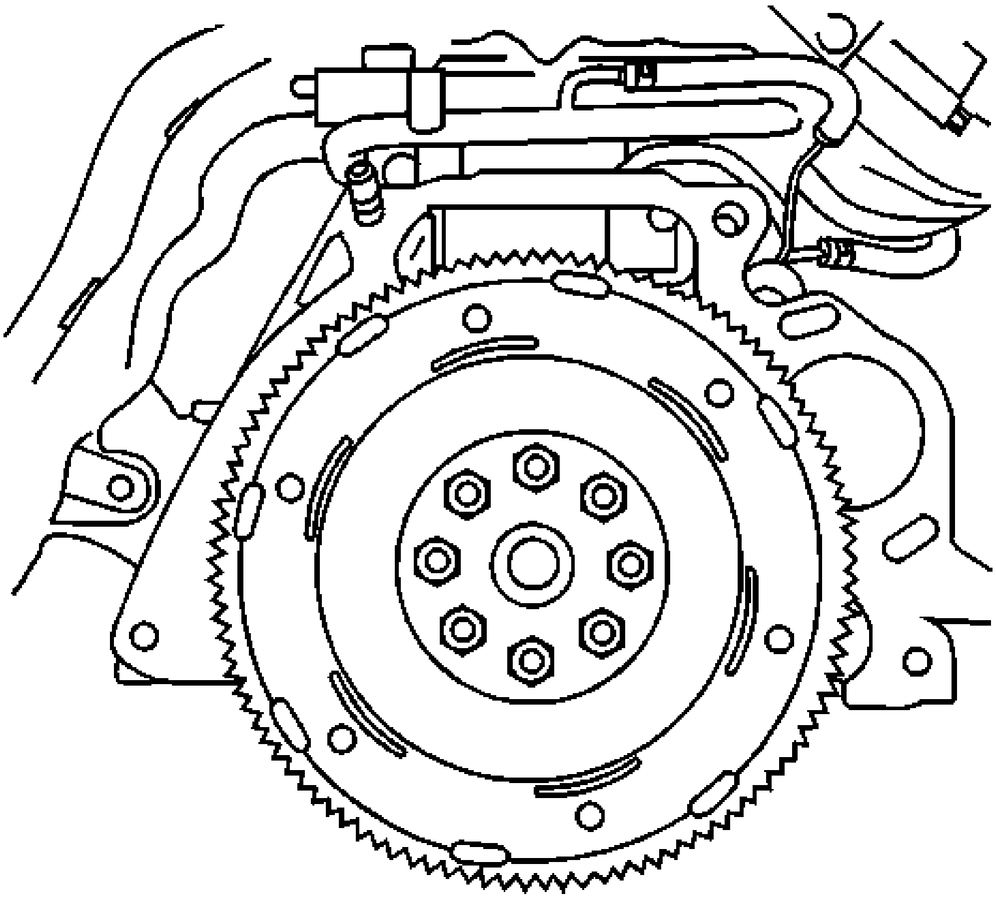


Fig. 279: Inspecting Flywheel
Courtesy of GENERAL MOTORS CORP.

5. Measure the flywheel face runout using a **J 8001** with a **J 26900-13** . See **Special Tools and Equipment**. Replace the flywheel if the runout exceeds 0.2 mm (0.0078 in).

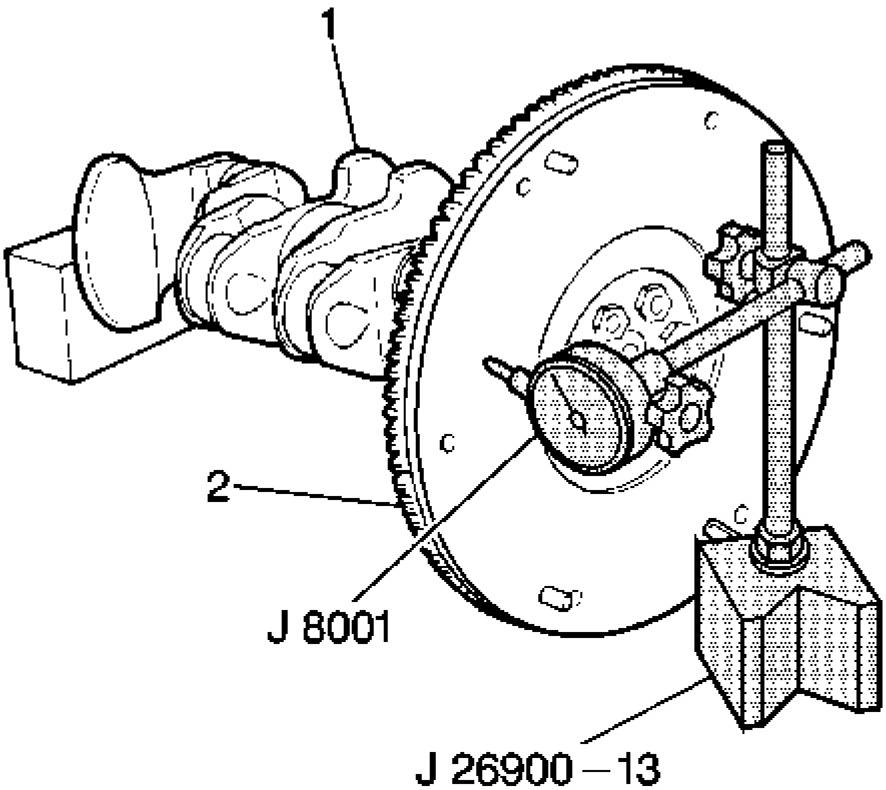


Fig. 280: View Of Rear Gear
Courtesy of GENERAL MOTORS CORP.

Crankshaft and Bearings Cleaning and Inspection

Crankshaft Cleaning and Inspection

Tools Required

J 7872 Magnetic Base Dial Indicator Set. See **Special Tools and Equipment**.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces.

1. Clean the oil, sludge, and carbon from the crankshaft with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions and burrs.

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

3. Dry the crankshaft with compressed air.
4. Inspect the keyway.
5. Perform a visual inspection of the crankshaft for damage.

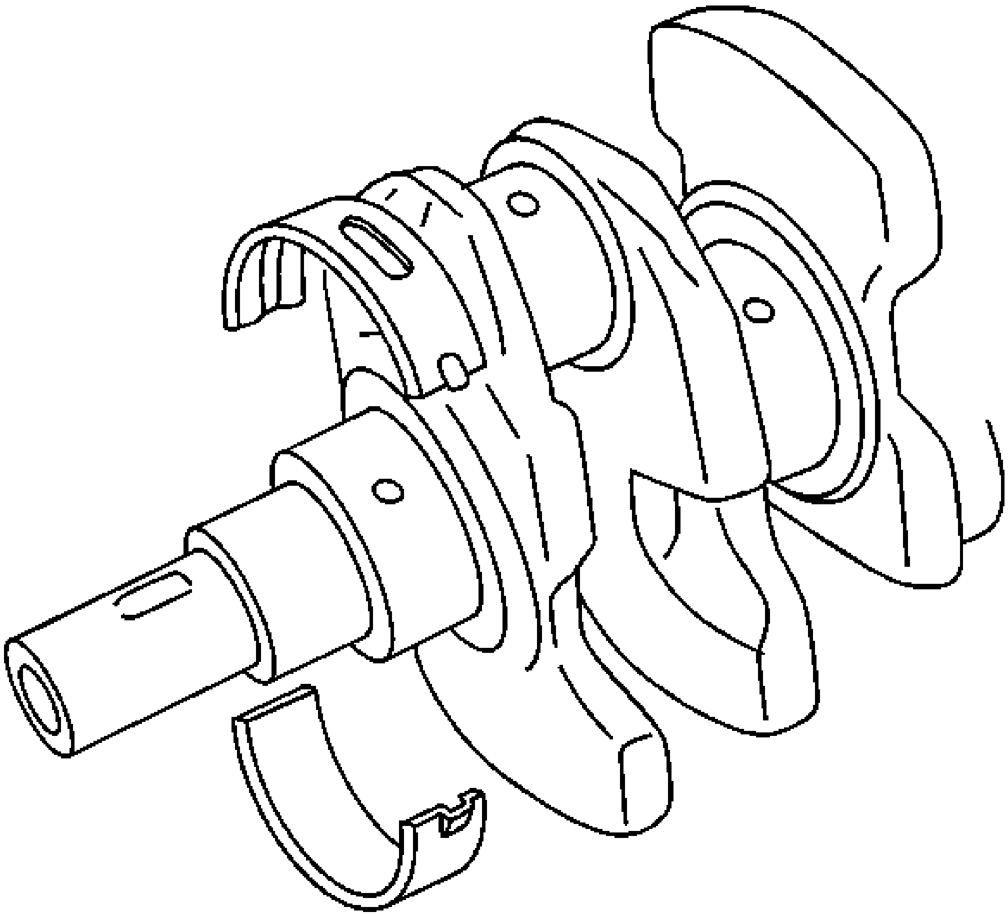


Fig. 281: Cleaning Oil, Sludge & Carbon From Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: **Replace the crankshaft if cracks, severe gouges or burned spots are found. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.**

6. Inspect the crankshaft journals (1) for wear. The journals should be smooth with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves and scoring (2).
8. Inspect the crankshaft journals for roughness and scratches (3).
9. Inspect the crankshaft journals for pitting or imbedded bearing material (4). Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

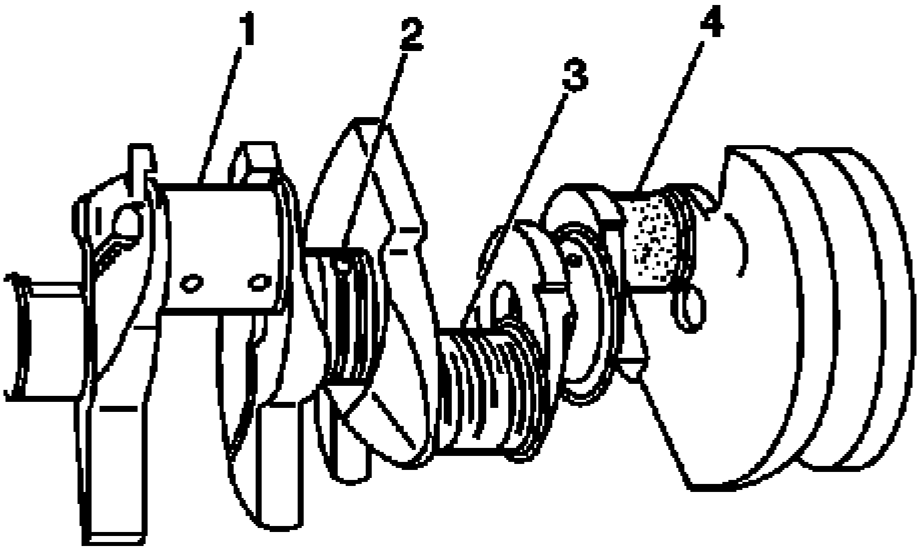


Fig. 282: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

10. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

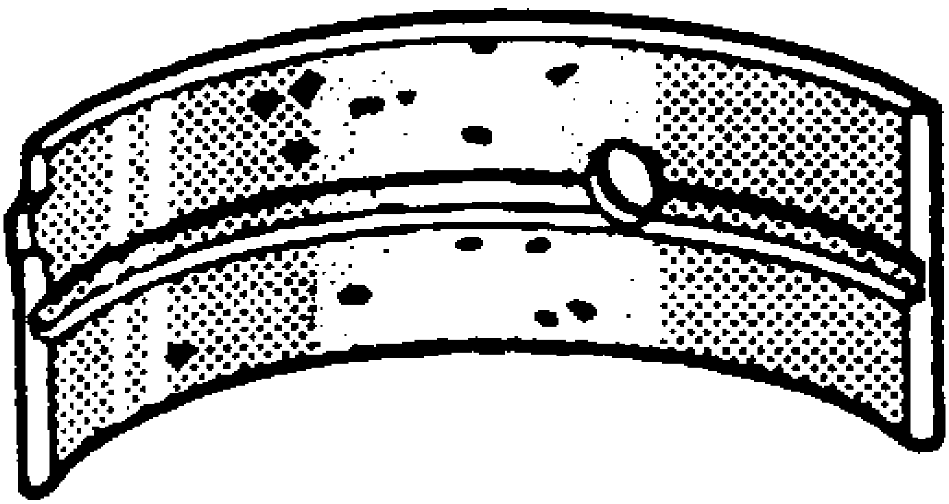


Fig. 283: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

11. Inspect the crankshaft bearings for excessive scoring or discoloration (overheating).

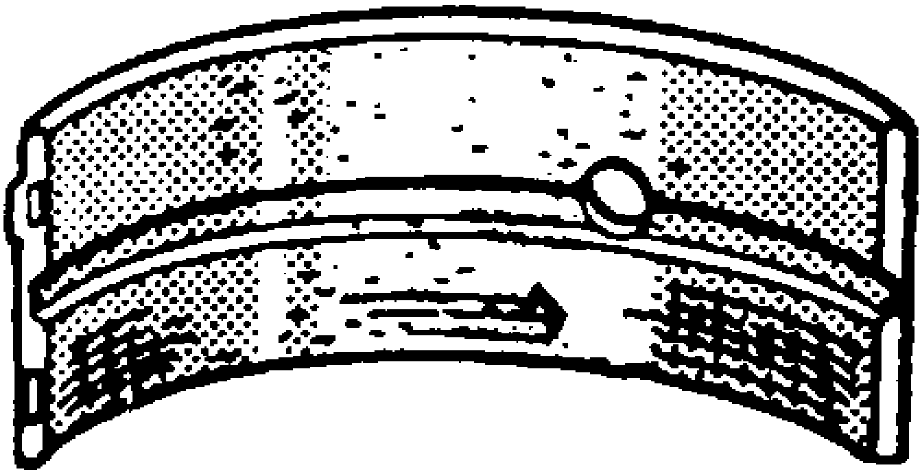


Fig. 284: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

12. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
13. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, replace both upper and lower halves.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

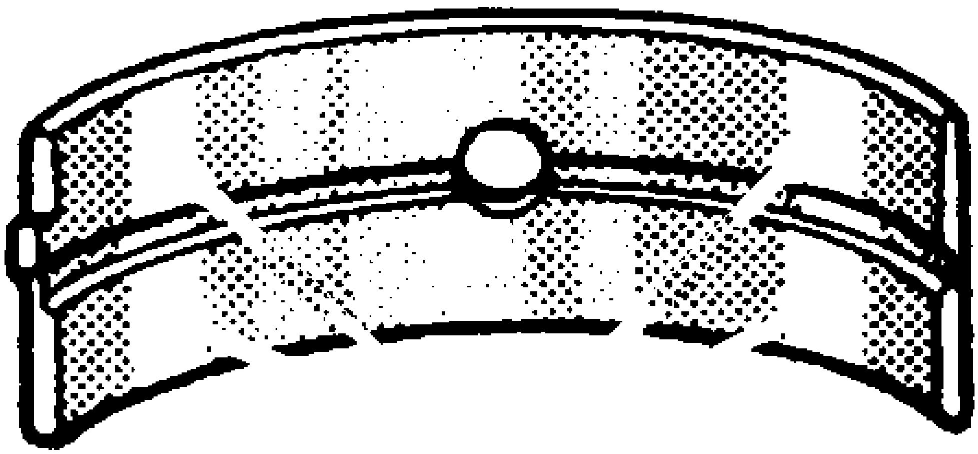


Fig. 285: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

14. Measure the crankshaft connecting rod and main bearing journals for out-of-round.

    Measure each journal in 2 places 90 degrees apart. The difference between these 2 measurements is the out-of-round of the journal.

    Maximum Out-of-Round: 0.01 mm (0.0004 in)

15. Measure the crankshaft journals for taper.

    Measure the journal at each end of the journal. The difference between these 2 measurements is the taper of the journal.

    Maximum Taper: 0.01 mm (0.0004 in)

16. Regrind or replace the crankshaft if the above measurements exceed specifications.
17. Note the location of the main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

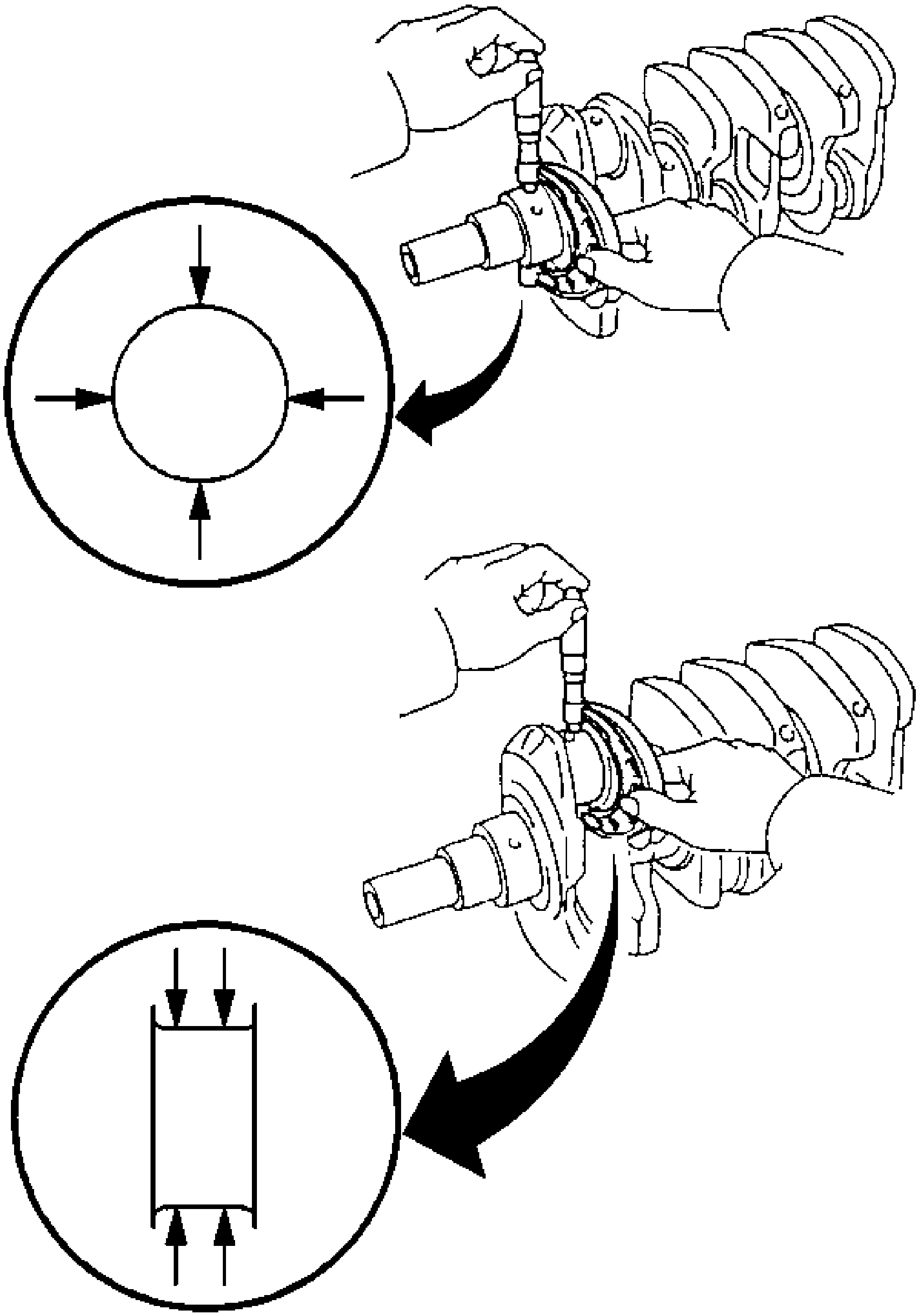


Fig. 286: Measuring Crankshaft Connecting Rod & Main Bearing Journals
Courtesy of GENERAL MOTORS CORP.

18. Measure the crankshaft runout.

    Support the crankshaft on the front and rear journals using wooden V blocks.

19. Measure the crankshaft runout at the center journal using the **J 7872** . See **Special Tools and Equipment**.
20. Replace the crankshaft if the measurements exceed specifications.

    Maximum Runout: 0.06 mm (0.0023 in)

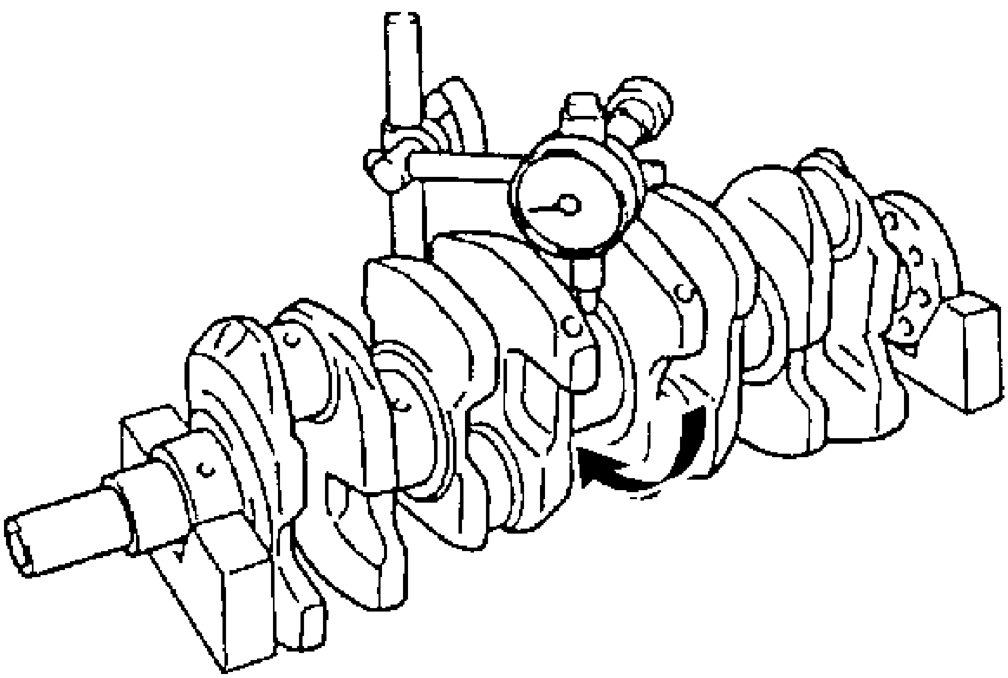


Fig. 287: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

21. Measure the flywheel (2) surface runout using the **J 7872** . See **Special Tools and Equipment**.
22. Replace or repair the flywheel if the runout exceeds specifications.

    Maximum Runout: 0.2 mm (0.0078 in)

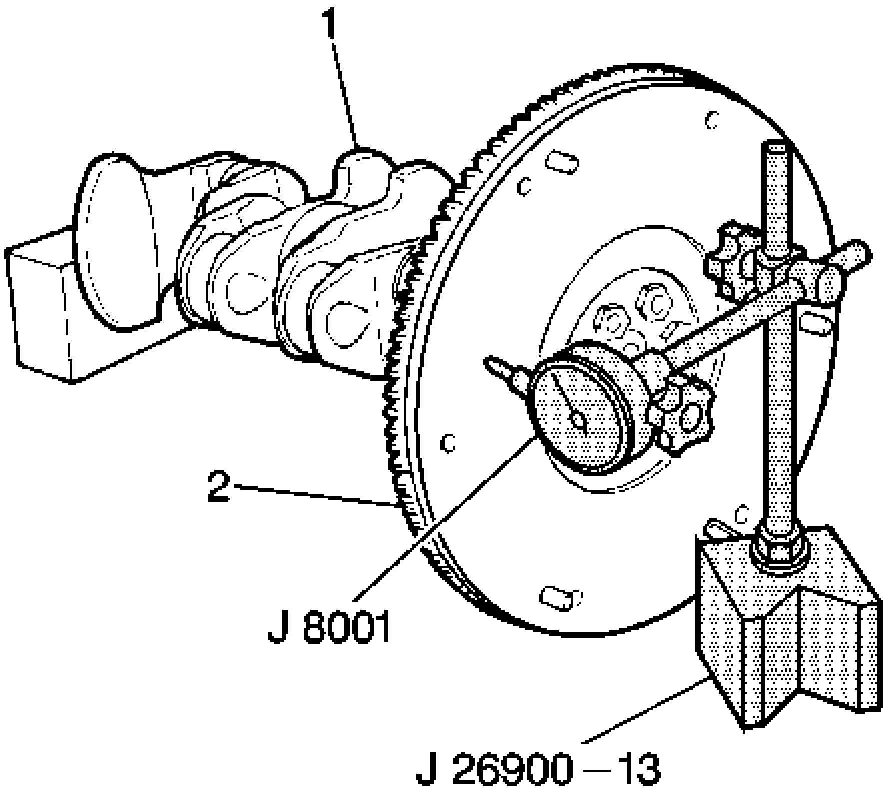


Fig. 288: View Of Rear Gear
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The lower crankcase must be installed and properly torqued in order to measure crankshaft end play.

23. Measure the crankshaft end play using the **J 7872** . See **Special Tools and Equipment**.

    Standard Crankshaft End Play: 0.10-0.35 mm (0.0039-0.0138 in)

    Maximum Crankshaft End Play: 0.42 mm (0.0165 in)

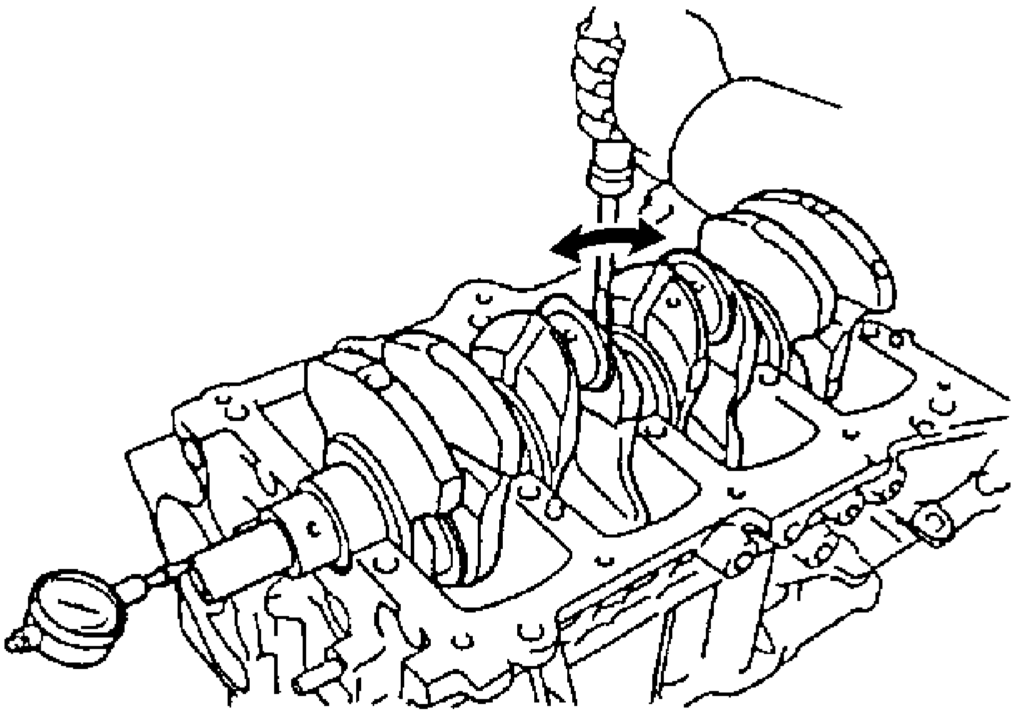


Fig. 289: Torquing Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

24. The crankshaft thrust bearing is available in standard and oversized.

    Standard Thrust Bearing Thickness: 2.500 mm (0.984 in)

    0.125 mm (0.0049 in) Oversize Thrust Bearing Thickness: 2.563 mm (0.1009 in)

25. If the end play exceeds the maximum replace the thrust bearing with a new standard size thrust bearing. If the end play still exceeds the maximum replace the thrust bearing with a new oversize thrust bearing.

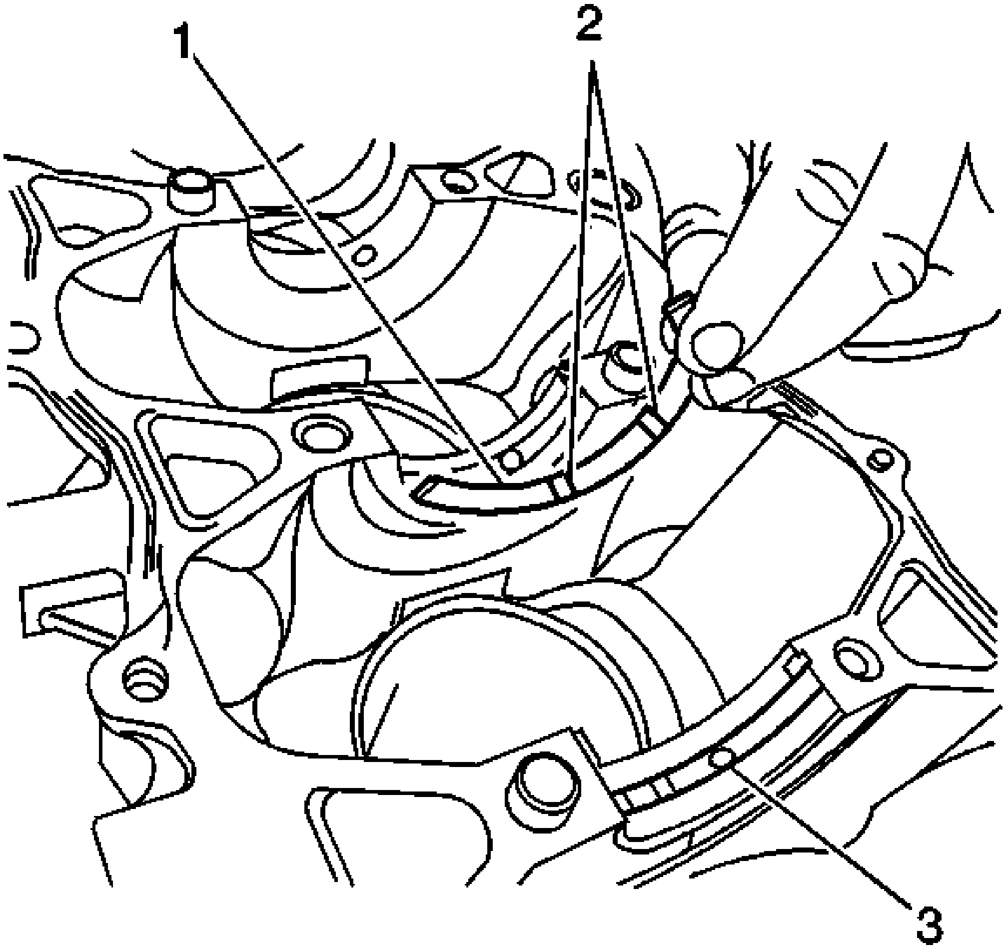


Fig. 290: View Of Oil Grooves
Courtesy of GENERAL MOTORS CORP.

Crankshaft Main Bearing Cap Bolts Cleaning and Inspection

1. Clean the main bearing cap bolts. Compare the main bearing cap bolts to a known good bolt (2) if necessary.
2. Inspect the main bearing cap bolts for the following:
   - Damaged threads
   - Stretching (1)
   - Damaged heads caused by improper use of tools
3. Replace the main bearing cap bolts as necessary.

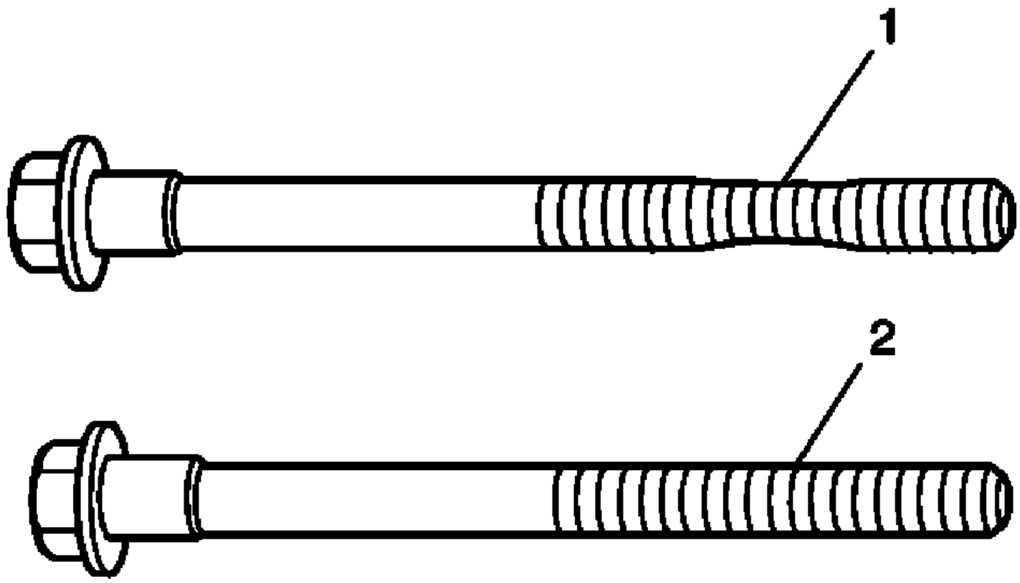


Fig. 291: Inspecting Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Crankshaft Main Bearing Selection

NOTE: **Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.**

1. The crankshaft bearings are of the precision insert type. The crankshaft bearings are available in standard and 0.25 mm (0.0098 in) undersized. Undersized refers to crankshaft diameter. Both standard and undersized bearings are each available in 5 sizes (tolerances) differing in thickness in the center of the bearing. The upper bearing half has an oil groove, the lower bearing half does not have an oil groove.

IMPORTANT: **If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft bearing bores.**

2. Inspect the crankshaft main bearing bores using the following procedure:
    1. Tighten the lower crankcase cap to specification.
    2. Measure the bearing bore for taper and out-of-round.
    3. No taper or out-of-round should exist.

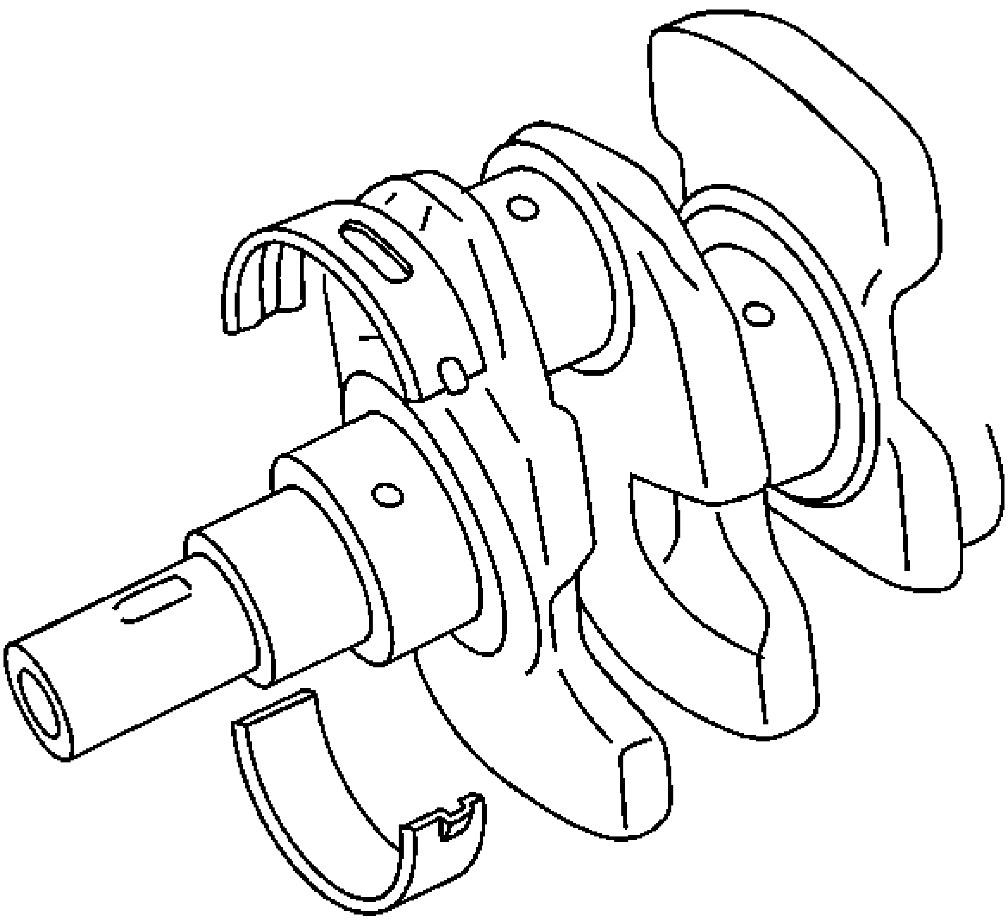


Fig. 292: Inspecting Oil, Sludge & Carbon From Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Install the original crankshaft main bearing inserts on to the cylinder block and the lower crankcase assembly.
4. Carefully place the crankshaft on to the bearing inserts in the cylinder block.

IMPORTANT: Do not turn the crankshaft while measuring the bearing clearance.

5. Lay a piece of gaging plastic across each crankshaft main journal (avoiding the oil hole).
6. Carefully place the lower crankcase assembly on to the cylinder block.

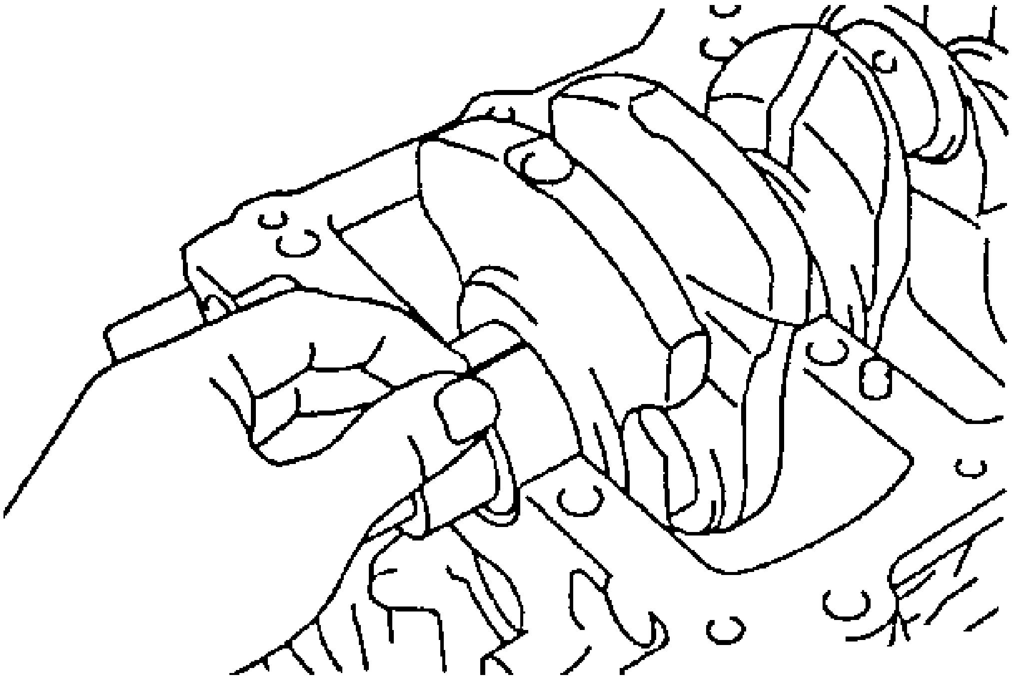


Fig. 293: Installing Original Crankshaft Main Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the 10 main bearing cap bolts (1-10). Progressively torque the main bearing cap bolts using 2 steps in the sequence shown.

   Tighten:
   1. Tighten the main bearing cap bolts to 42 N.m (31 lb ft).
   2. Tighten the main bearing cap bolts to 60 N.m (44 lb ft).

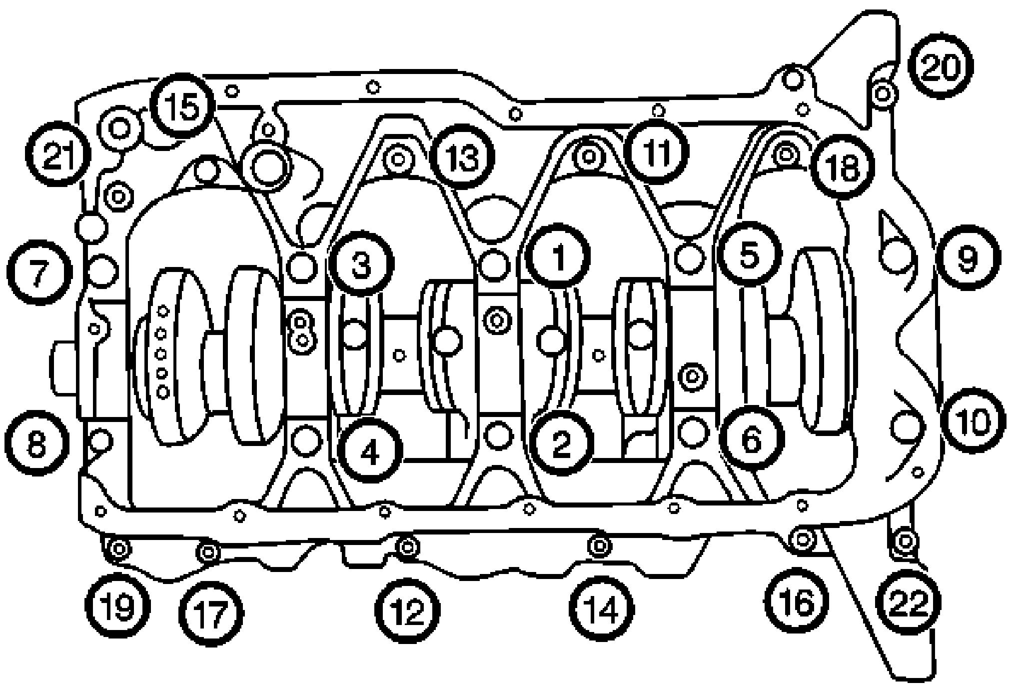


Fig. 294: Torquing Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the 12 lower crankcase bolts (11-22). Progressively torque the lower crankcase bolts using 2 steps in the sequence shown.

   Tighten:

   1. Tighten the 12 lower crankcase bolts to 19 N.m (14 lb ft).
   2. Tighten the 12 lower crankcase bolts to 27 N.m (20 lb ft).

9. After reaching the proper torque, remove the lower crankcase bolts and the crankshaft main bearing cap bolts.
10. Carefully remove the lower crankcase assembly from the cylinder block.
11. Measure the gaging plastic at its widest point.

    Standard Oil Clearance: 0.026-0.046 mm (0.0010-0.0018 in)

    Maximum Oil Clearance: 0.060 mm (0.0023 in)

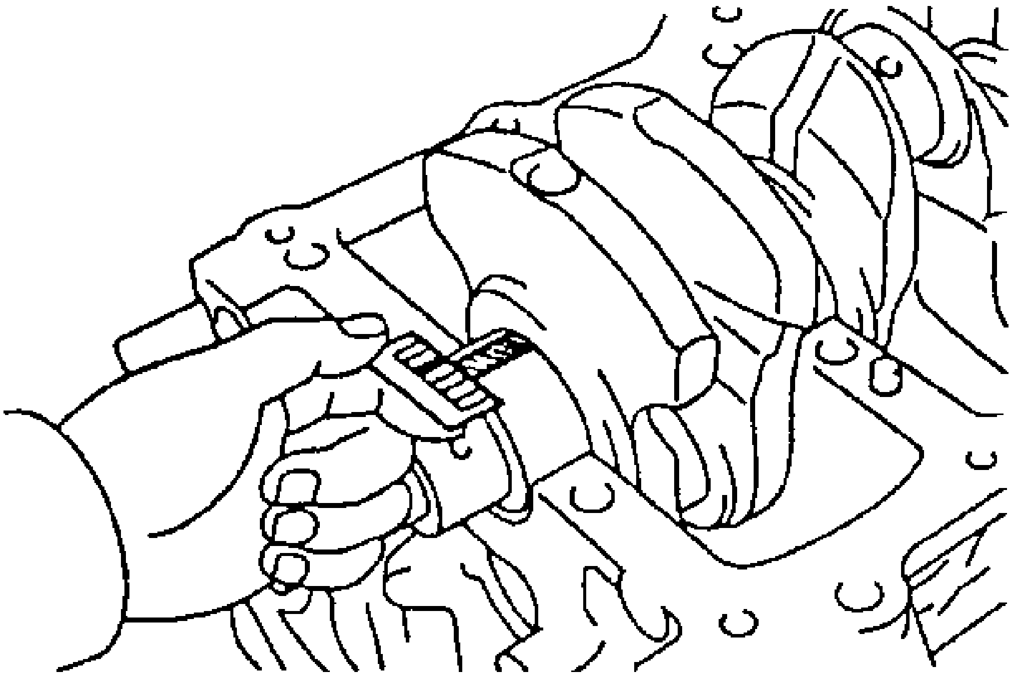


Fig. 295: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

12. A new standard bearing may produce the correct oil clearance. If not, regrind the crankshaft and install 0.25 mm (0.0098 in) underseas bearings.
13. Crankweb number 2 is stamped with numbers. The numbers represent the corresponding journal diameter marked with an arrow. If using a standard bearing, replace it with one having the same color. If the color of the bearing cannot be determined, select the correct bearing by interpreting the numbers and letters imprinted on the cylinder block and crankshaft.
    - Number 1 represents a journal diameter of 57.994-58.000 mm (2.2832-2.2834 in).
    - Number 2 represents a journal diameter of 57.988-57.994 mm (2.2830-2.2832 in).
    - Number 3 represents a journal diameter of 57.982-57.988 mm (2.2828-2.2829 in).

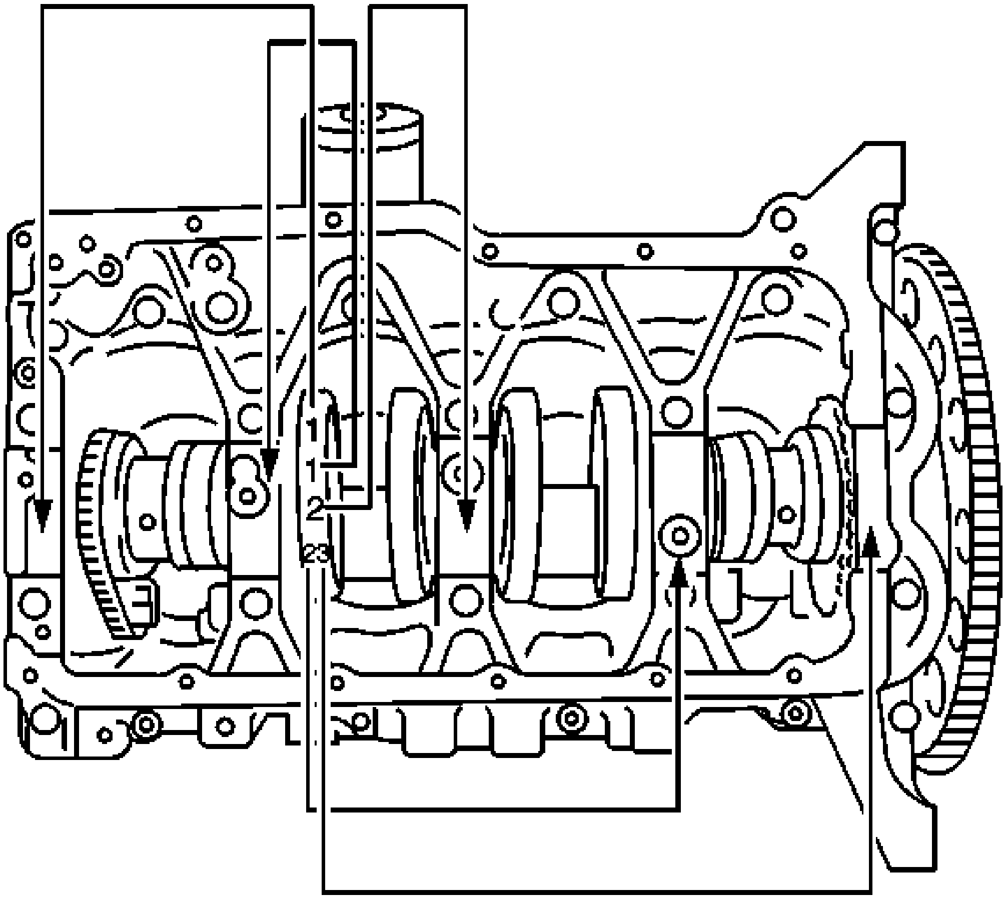


Fig. 296: Locating Numbers & Letters Imprinted On Cylinder Block & Crankshaft
Courtesy of GENERAL MOTORS CORP.

14. The lower crankcase is stamped with letters. The letters represent the crankshaft bearing cap bore diameter without the bearings installed.
    - Letter A represents a crankshaft bearing cap bore diameter of 62.000-62.006 mm (2.4409-2.4411 in).
    - Letter B represents a crankshaft bearing cap bore diameter of 62.006-62.012 mm (2.4412-2.4414 in).
    - Letter C represents a crankshaft bearing cap bore diameter of 62.012-62.018 mm (2.4414-2.4416 in).

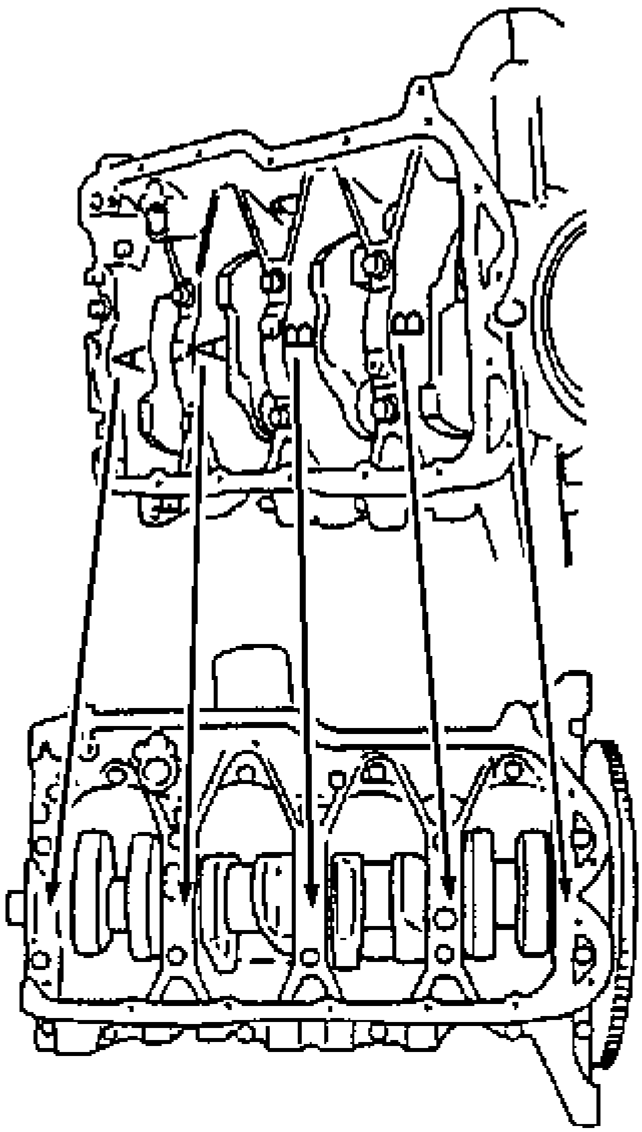


Fig. 297: Lower Crankcase Letters Represent Crankshaft Bearing Cap Bore Diameter Without Bearings
Courtesy of GENERAL MOTORS CORP.

15. There are 5 standard bearings available. The bearings differ in thickness at the center of the bearing. Each bearing is marked with paint (1). The color of the paint indicates the thickness of the bearing.
    - Green paint indicates a bearing thickness of 1.993-1.997 mm (0.0785-0.0786 in).

- Black paint indicates a bearing thickness of 1.996-2.000 mm (0.0786-0.0787 in).
- No paint (colorless) indicates a bearing thickness of 1.999-2.003 mm (0.0787-0.0788 in).
- Yellow paint indicates a bearing thickness of 2.002-2.006 mm (0.0788-0.0789 in).
- Blue paint indicates a bearing thickness of 2.005-2.009 mm (0.0789-0.0790 in).

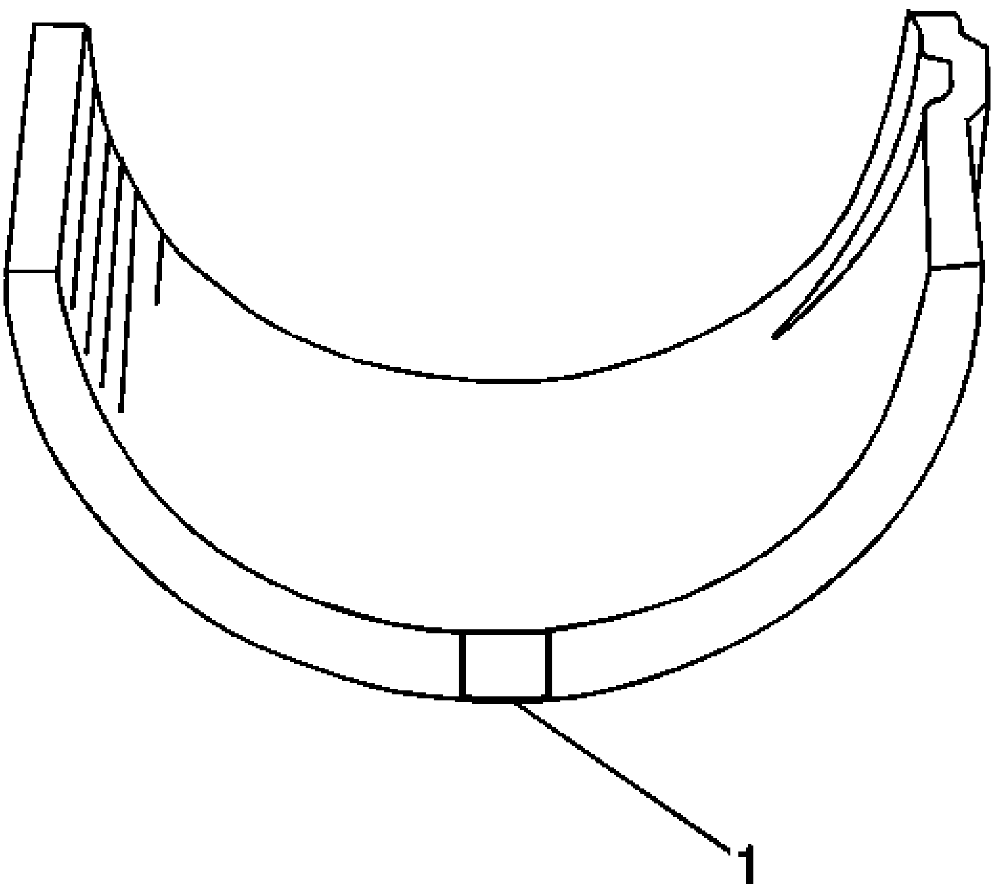


Fig. 298: View Of Paint Marking Bearings
Courtesy of GENERAL MOTORS CORP.

16. Refer to the standard main bearing selection table in **Engine Mechanical Specifications**. Using the intersection of the letters and numbers, select the correct bearing from the table. Measure the oil clearance. If the oil clearance is incorrect install the next thicker bearing and recheck the oil clearance.

Undersized Main Bearing Selection

1. If new standard bearings do not produce the correct oil clearance, regrind the crankshaft to a finished diameter of 57.732-57.750 mm (92.2729-2.2736 in) and install 0.25 mm (0.0098 in) undersized bearings. Undersized bearings are available in 5 sizes (tolerances) differing in thickness in the center of the bearing.
2. Undersized bearings are distinguished from standard size bearings by a double paint mark (1).
   - Green and red paint indicates a bearing thickness of 2.118-2.122 mm (0.0834-0.0835 in).
   - Black and red paint indicates a bearing thickness of 2.121-2.125 mm (0.0835-0.0836 in).
   - Red paint only indicates a bearing thickness of 2.124-2.128 mm (0.0836-0.0837 in).
   - Yellow and red paint indicates a bearing thickness of 2.127-2.131 mm (0.0837-0.0838 in).
   - Blue and red paint indicates a bearing thickness of 2.130-2.134 mm (0.0838-0.0839 in).

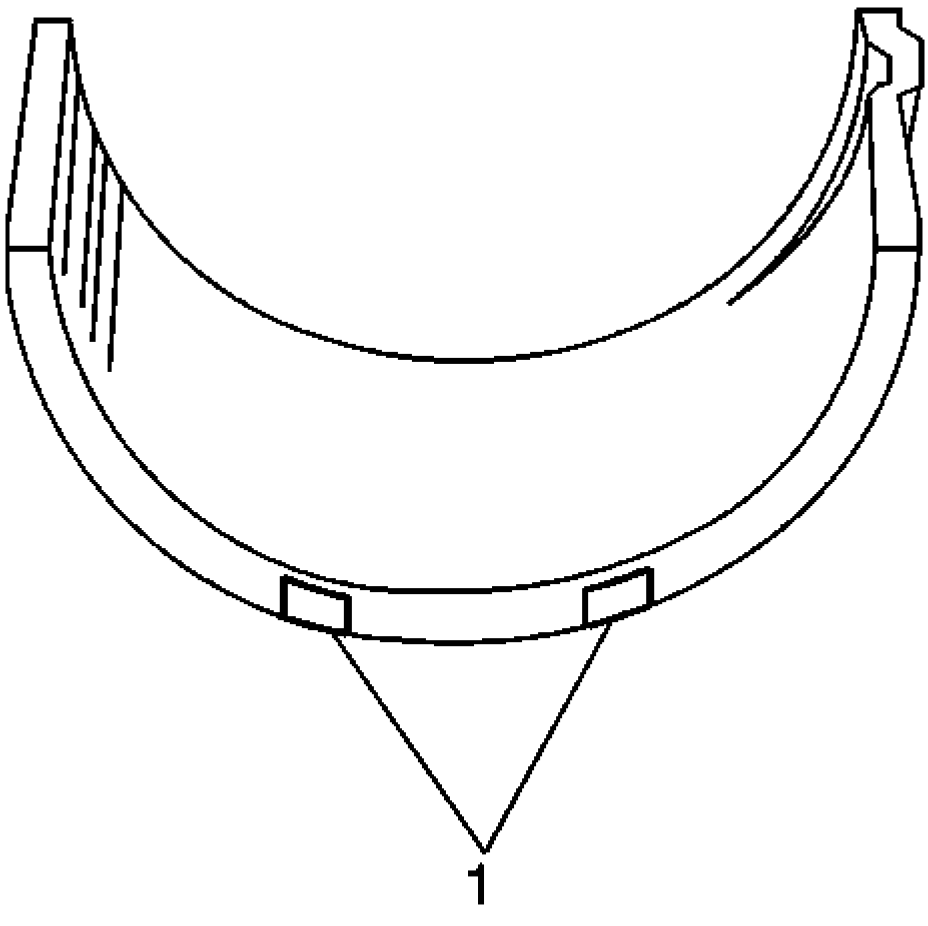


Fig. 299: Double Paint Marks Distinguishing Undersize Bearings From Standard Size
Courtesy of GENERAL MOTORS CORP.

3. Measure the reground crankshaft journals for out-of-round.

   Maximum Out-of-Round: 0.01 mm (0.0004 in)

4. Measure the reground crankshaft journals for taper.

   Maximum Taper: 0.01 mm (0.0004 in)

5. Measure the reground crankshaft journals for size.
6. Refer to the undersized main bearing selection table in **Engine Mechanical Specifications**. Using the intersection of the measured journal size and the letters on the lower crankcase select the correct sized bearing from the table. Measure the oil clearance. If the oil clearance is incorrect install the next thicker bearing and recheck the oil clearance.

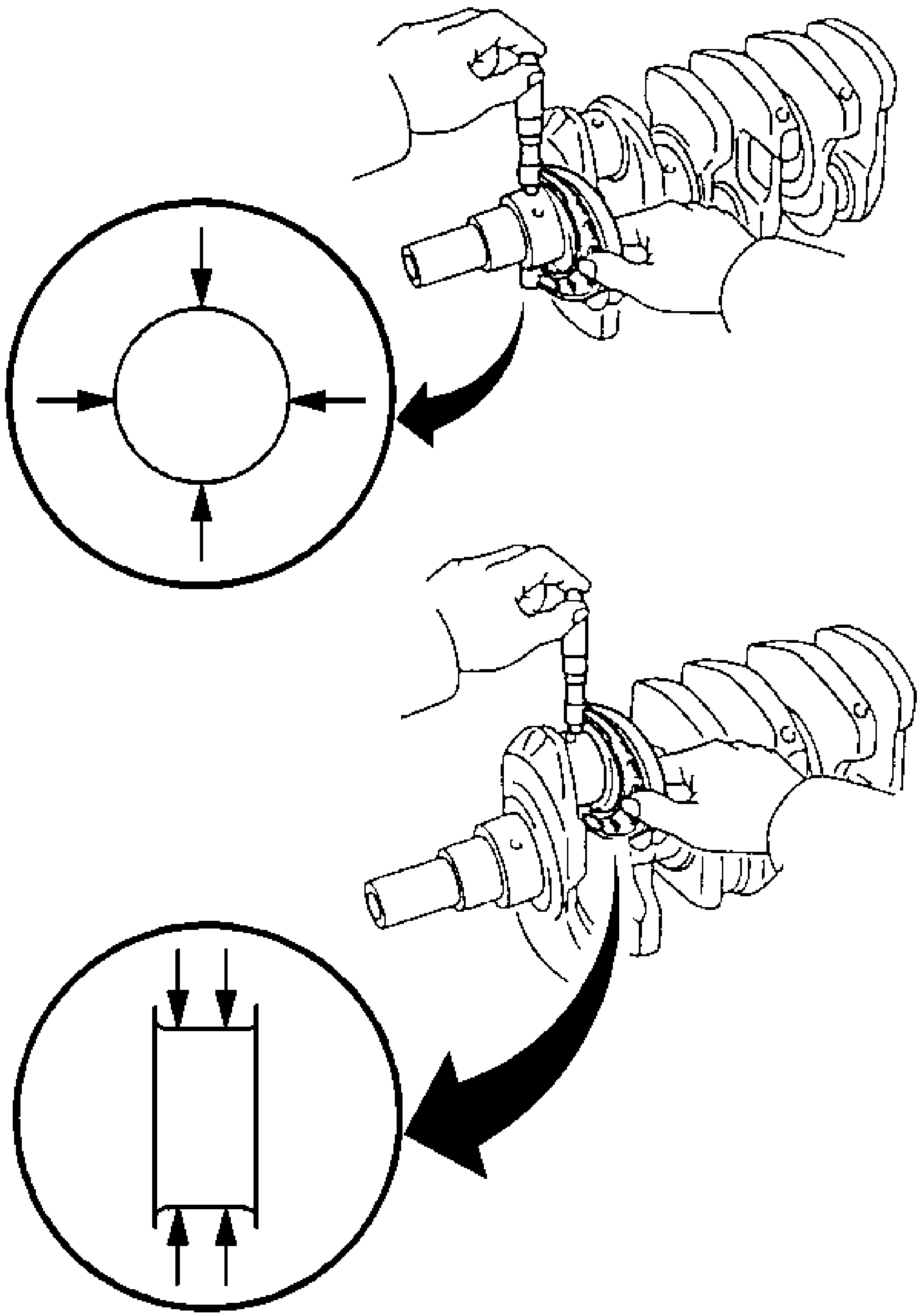


Fig. 300: Measuring Crankshaft Connecting Rod & Main Bearing Journals
Courtesy of GENERAL MOTORS CORP.

Piston and Connecting Rod Disassemble

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

1. The piston, piston pin and connecting rod assembly is of the full floating type.
2. Remove the piston rings from the pistons using a suitable piston ring expander tool. Do not reuse the piston rings.

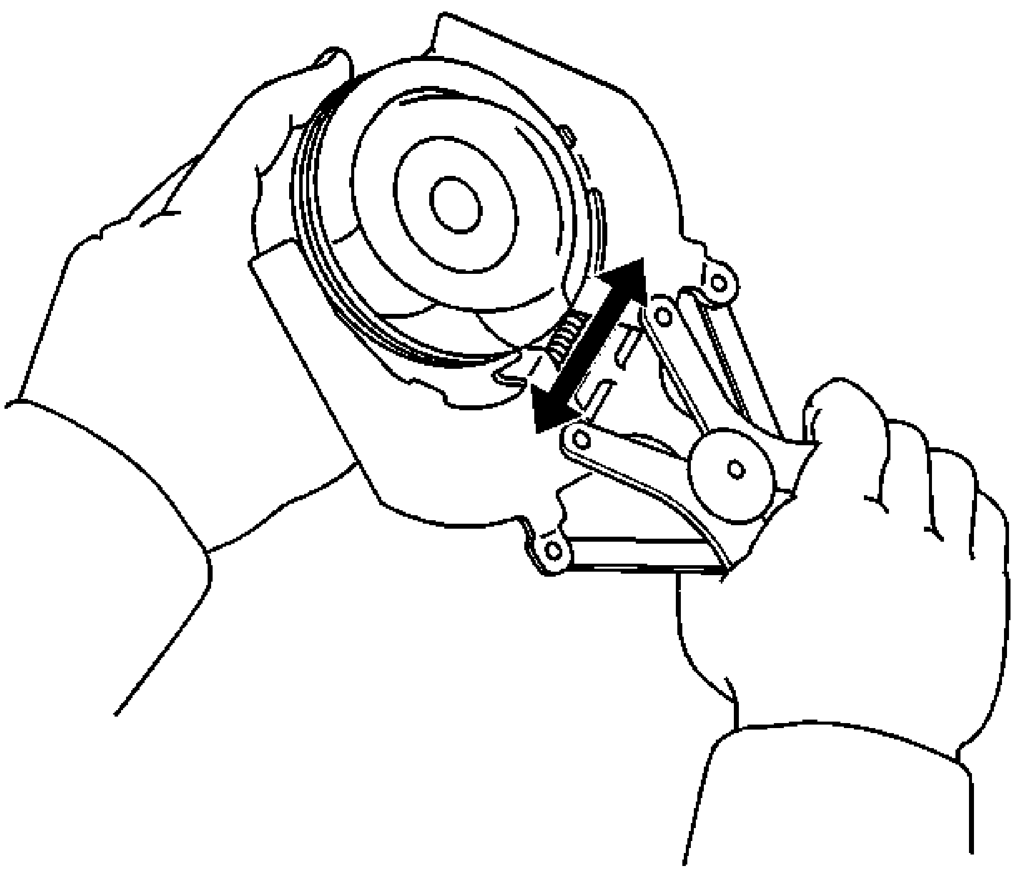


Fig. 301: Removing Piston Rings From Piston
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston snap rings (1) using a small screwdriver. Do not gouge the piston when removing the

snap rings.

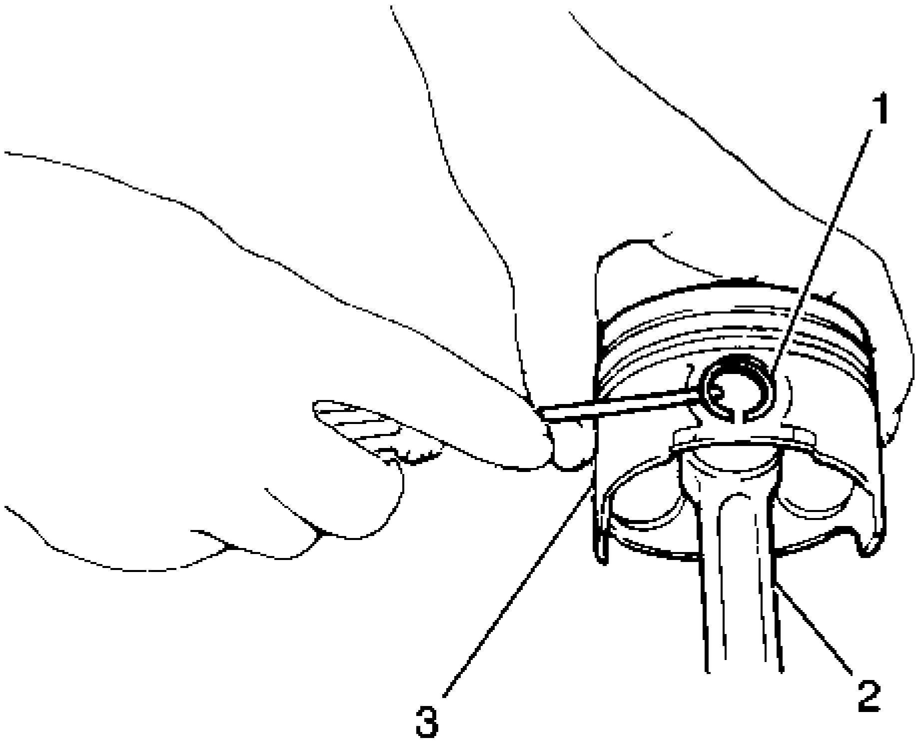


Fig. 302: View Of Piston Snap Rings
Courtesy of GENERAL MOTORS CORP.

4. Slide the piston pin out of the piston and connecting rod.
5. Arrange the pistons, pins, rings, connecting rods and bearings in correct order.

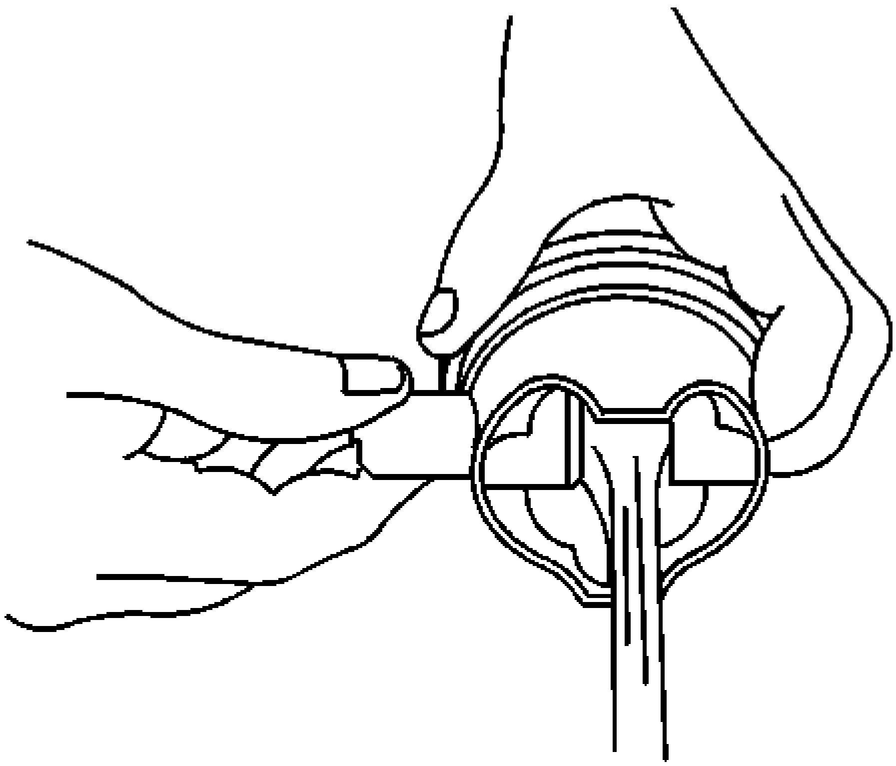


Fig. 303: View Of Piston, Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

Connecting Rod Measurement

1. Measure the connecting rod side clearance. If the side clearance is greater than the maximum replace the connecting rod.

   Standard Connecting Rod Side Clearance: 0.25-0.40 mm (0.0099-0.0157 in)

   Maximum Connecting Rod Side Clearance: 0.45 mm (0.0177 in)

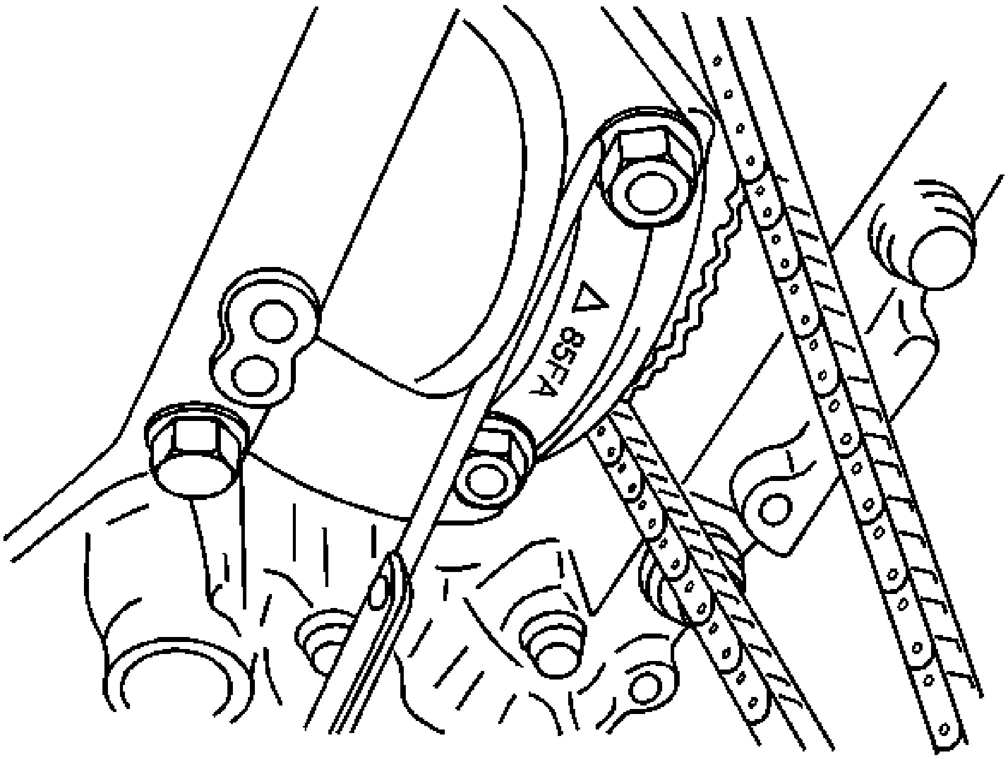


Fig. 304: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

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

2. Clean the connecting rods in solvent and dry with compressed air.
3. Inspect the connecting rods for signs of being twisted, bent, bowed, nicked, or cracked

   Maximum Connecting Rod Bow: 0.05 mm (0.0020 in)

   Maximum Connecting Rod Twist: 0.10 mm (0.0039 in)

4. Inspect the connecting rods for scratches or abrasion on the rod bearing seating surface. If the connecting rod bores contain minor scratches or abrasions, clean the bores by sanding in a circular direction with a light emery paper. Do not scrape the rod or rod cap.
5. If the connecting rod bores cannot be cleaned by sanding, or if the bow or twist exceeds specifications, replace the connecting rod.

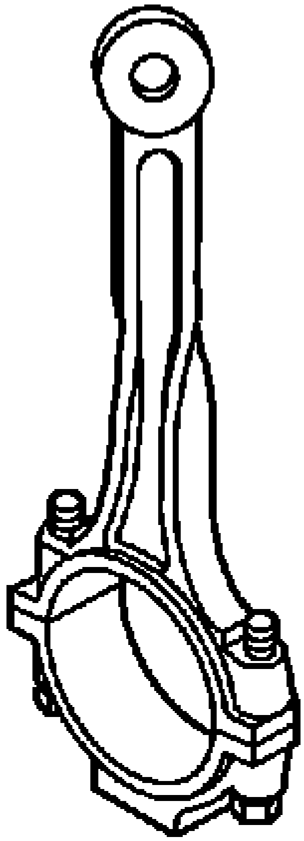


Fig. 305: Identifying Twisted Connecting Rod
Courtesy of GENERAL MOTORS CORP.

6. Measure the piston pin to connecting rod bore.
7. Measure the piston pin diameter in the area of connecting rod contact using an outside micrometer.
8. Measure the connecting rod piston pin bore using an inside micrometer.
9. Subtract the piston pin diameter from the piston pin bore diameter.

   Piston Pin-to-Piston Pin Bore Clearance: 0.003-0.014 mm (0.0001-0.0005 in)

   Piston Pin Diameter: 20.997-21.000 mm (0.8267-0.8268 in)

   Piston Pin Bore Diameter: 21.003-21.011 mm (0.8269-0.8272 in)

10. If there is excessive clearance replace the piston pin.
11. If there is still excessive clearance, replace the connecting rod.

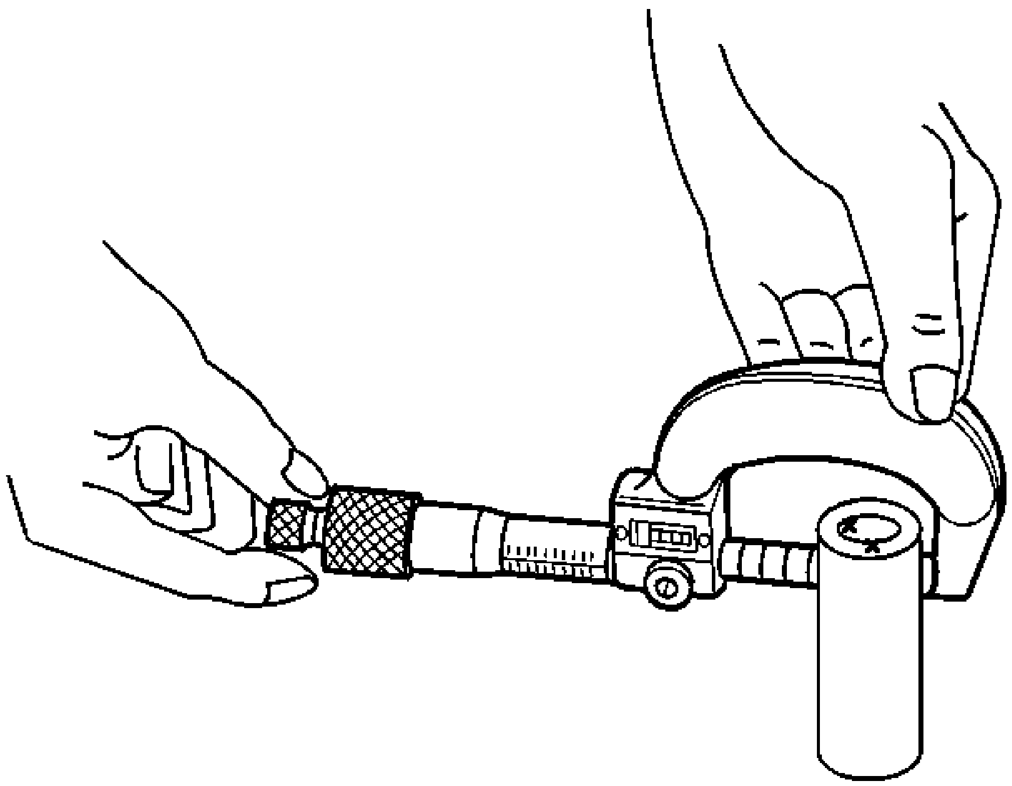


Fig. 306: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

Piston Measurement

1. Clean the piston skirts and the pins with a cleaning solvent. Do not wire brush any part of the piston.
2. Clean the piston ring grooves with a ring groove cleaner. Make sure the oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts, or pin bosses
   - Ring grooves for nicks and burrs that may cause binding
   - Warped or worn ring lands
   - Eroded areas at the top of the piston (1)
   - Scuffed or damaged skirts (2)
   - Worn or scuffed piston pin bores (3)
4. Replace pistons and piston pins that show any signs of damage or excessive wear.

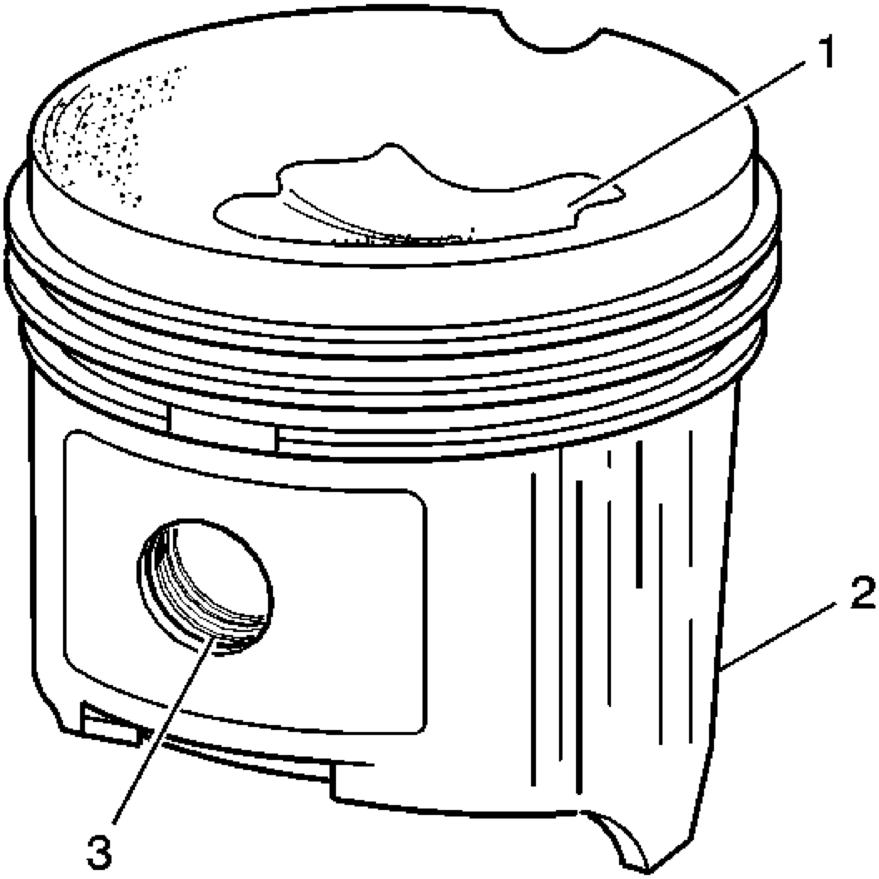


Fig. 307: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Measure the piston ring end gap.

   Place the piston ring in the area of the bore where the piston ring will travel (approximately 120 mm or 4.72 inches down from the deck surface).

6. Square the ring in the cylinder bore by positioning the ring with an inverted piston head.

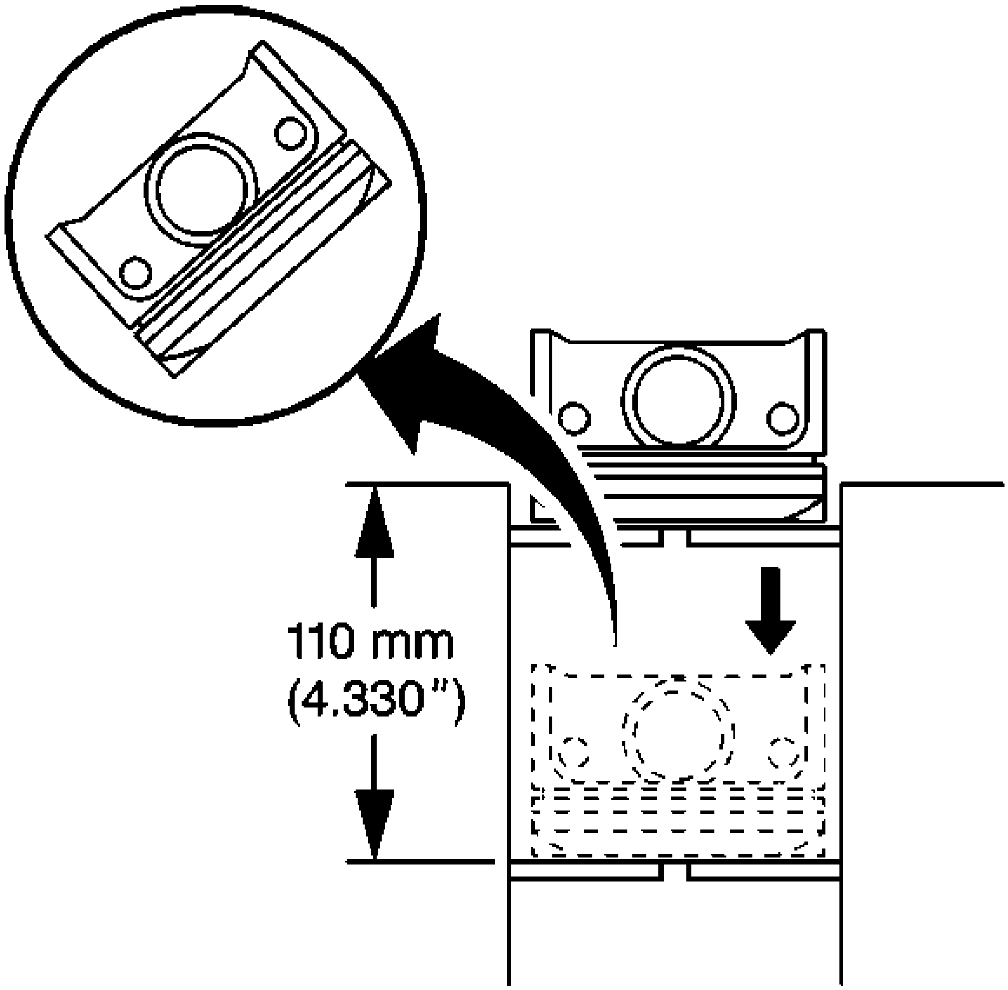


Fig. 308: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring end gap with feeler gages. If the end gap is greater than specifications replace the piston ring.

   Top Compression Ring End Gap: 0.20-0.35 mm (0.0079-0.0137 in)

   Maximum Top Compression Ring End Gap: 0.70 mm (0.0276 in)

   Second Compression Ring End Gap: 0.35-0.50 mm (0.0138-0.0196 in)

   Maximum Second Compression Ring End Gap: 0.70 mm (0.0276 in)

Oil Ring End Gap: 0.20-0.70 mm (0.0079-0.0275 in)

Maximum Oil Ring End Gap: 1.8 mm (0.0709 in)

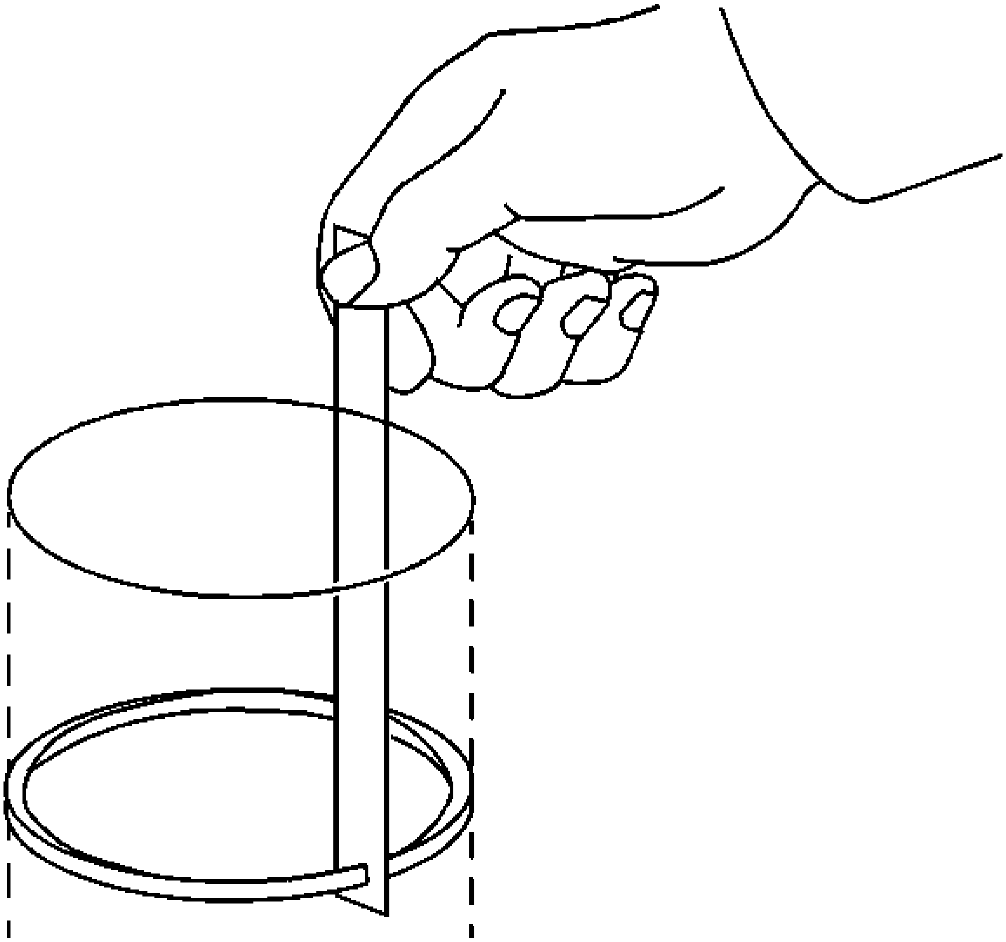


Fig. 309: Measuring Piston Ring End Cap With Feeler Gages
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance.

   Roll the top 2 piston rings entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring, replace the ring.

9. With the piston ring on the piston, use feeler gages to check clearance at multiple locations.

10. If the clearance is greater than specifications, replace the piston ring.
11. If the new ring does not produce the correct side clearance, replace the piston.

    Top Compression Ring Side Clearance: 0.030-0.070 mm (0.0012-0.0027 in)

    Second Compression Ring Side Clearance: 0.020-0.060 mm (0.0008-0.0023 in)

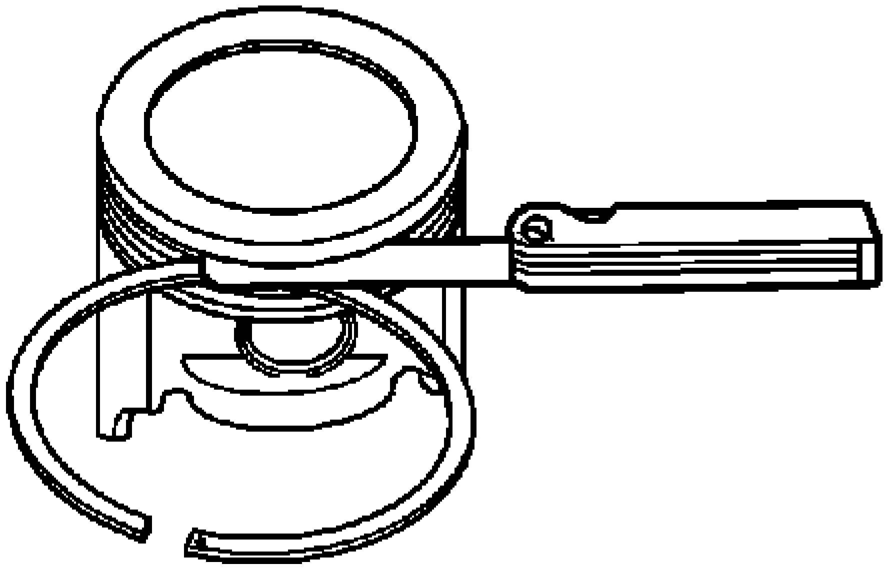


Fig. 310: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

12. Measure piston-to-cylinder bore clearance.

    Using an outside micrometer, measure the width of the piston 26.5 mm (1.04 in) below the top of the piston at the thrust surface perpendicular to the centerline of the piston pin.

13. Subtract the measured piston diameter from its original cylinder bore diameter.

    Piston-to-Cylinder Bore Clearance: 0.02-0.04 mm (0.0008-0.0015 in)

14. If the clearance obtained through measurement is greater than specifications and the cylinder bores are

within specification, replace the piston. If the cylinder bores are not within specification, rebore all 4 cylinders and fit with oversize pistons. Select the smallest available oversize pistons.

Standard Size Pistons: 83.970-83.990 mm (3.3059-3.3066 in)

0.25 mm (0.0098 in) Oversize Pistons: 84.220-84.240 mm (3.3157-3.3165 in)

0.50 mm (0.0196 in) Oversize Pistons: 84.470-84.490 mm (3.3256-3.3263 in)

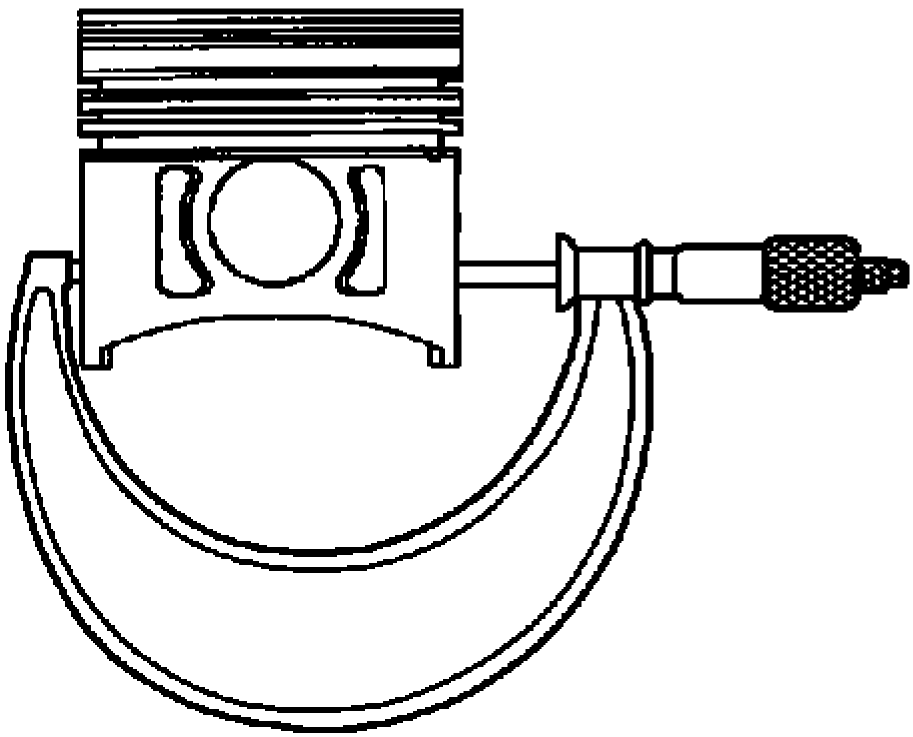


Fig. 311: Measuring Piston Outside Diameter Using Micrometer
Courtesy of GENERAL MOTORS CORP.

Connecting Rod Bearing Selection

IMPORTANT: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft and the connecting rod bearing bores.

NOTE: Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

1. The connecting rod bearings are of the precision insert type. The connecting rod bearings are available in standard and 0.25 mm (0.0098 in) undersized. Undersized refers to crankshaft diameter. The undersized bearings are marked with red paint (1).

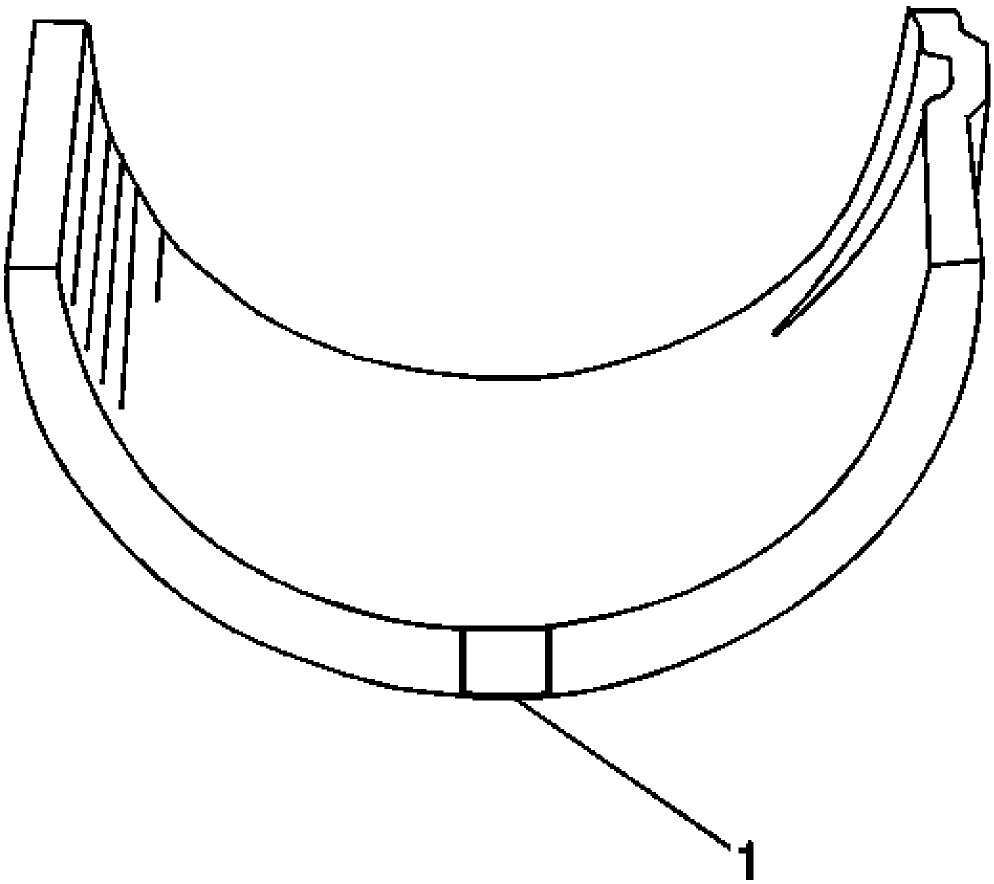


Fig. 312: View Of Paint Marking Bearings
Courtesy of GENERAL MOTORS CORP.

2. Measure the connecting rod journal for taper (3 minus 4) and out-of-round (1 minus 2).

   Maximum Crankshaft Taper: 0.01 mm (0.0004 in)

   Maximum Crankshaft Out-of-Round: 0.01 mm (0.0004 in)

3. Regrind or replace the crankshaft if the taper or out-of-round exceeds specifications.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the connecting rod cap to the rod and tighten the nuts to 45 N.m (33 lb ft).
5. Measure the connecting rod bearing bore for taper and out-of-round.
6. No taper or out-of-round should exist. If taper or out-of-round exists, replace the connecting rod.

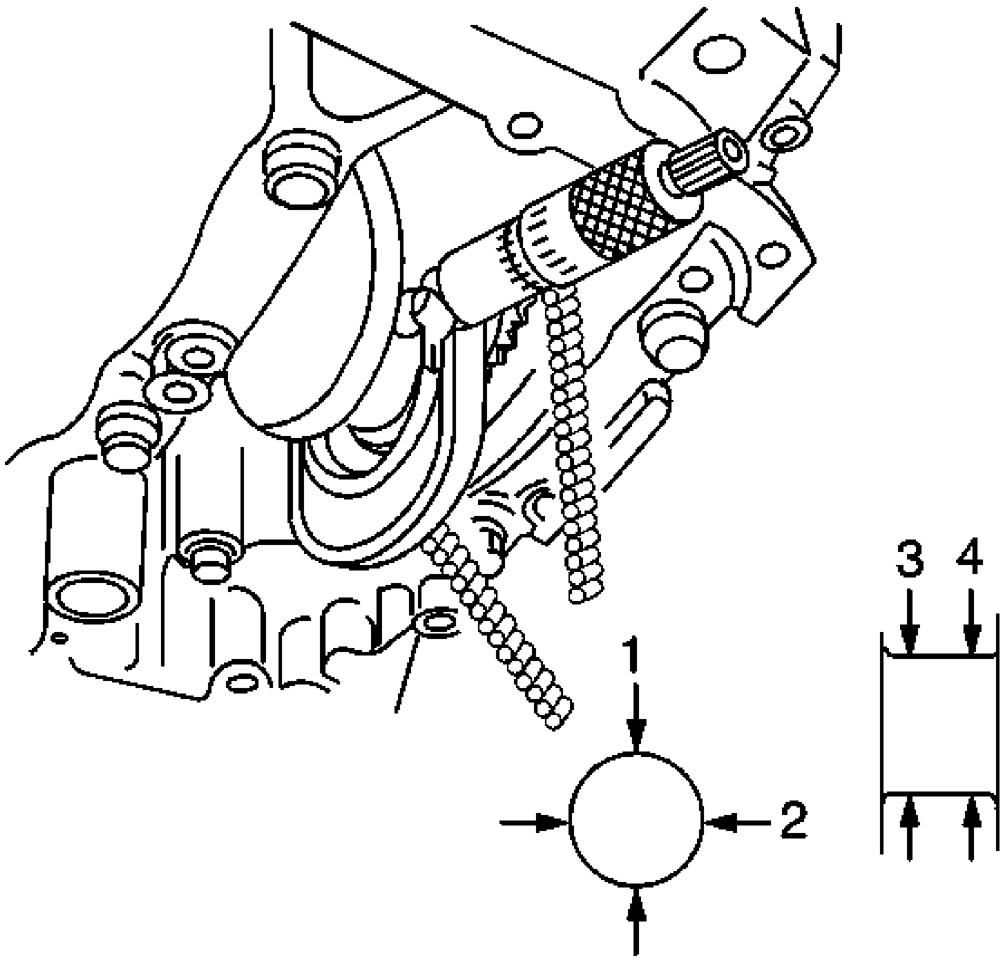


Fig. 313: Measuring Connecting Rod Journal For Taper & Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft and the lower crankcase assembly must be installed and properly torqued before measuring the connecting rod clearances.

7. Starting with the number one connecting rod, remove the connecting rod cap nuts.
8. Remove the connecting rod cap by wiggling the connecting rod cap left and right.

IMPORTANT: Do not turn the crankshaft while the gaging plastic is installed.

9. Lay a piece of gaging plastic across the crankshaft connecting rod journal (avoiding the oil hole).
10. Carefully place the connecting rod cap onto the connecting rod. The arrow on the rod cap should point towards the front of the engine.
11. Install the 2 connecting rod cap nuts.

    Tighten: Tighten the connecting rod cap nuts to 45 N.m (33 lb ft).

12. After reaching the proper torque, remove the two crankshaft connecting rod cap nuts.
13. Carefully remove the connecting rod cap from the connecting rod.

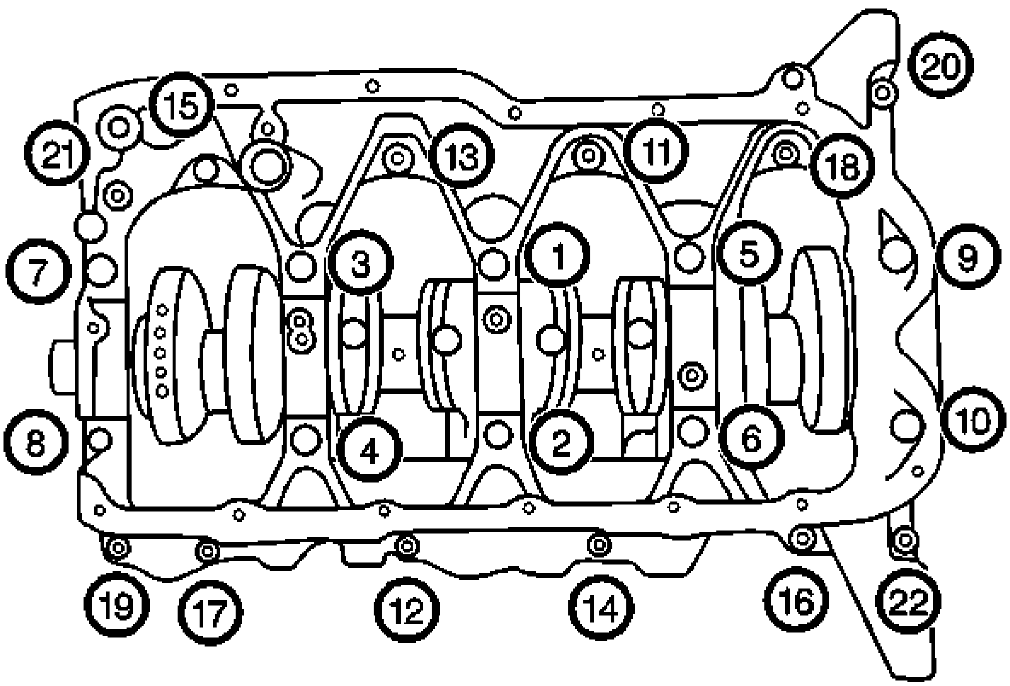


Fig. 314: Torquing Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

14. Measure the gaging plastic at its widest point.

Standard Oil Clearance: 0.045-0.063 mm (0.0018-0.0025 in)

Maximum Oil Clearance: 0.08 mm (0.0031 in)

15. If the oil clearance exceeds the maximum replace the bearing with a new standard size bearing.
16. If the oil clearance exceeds the maximum with a new standard size bearing replace the crankshaft or regrind the crankshaft.

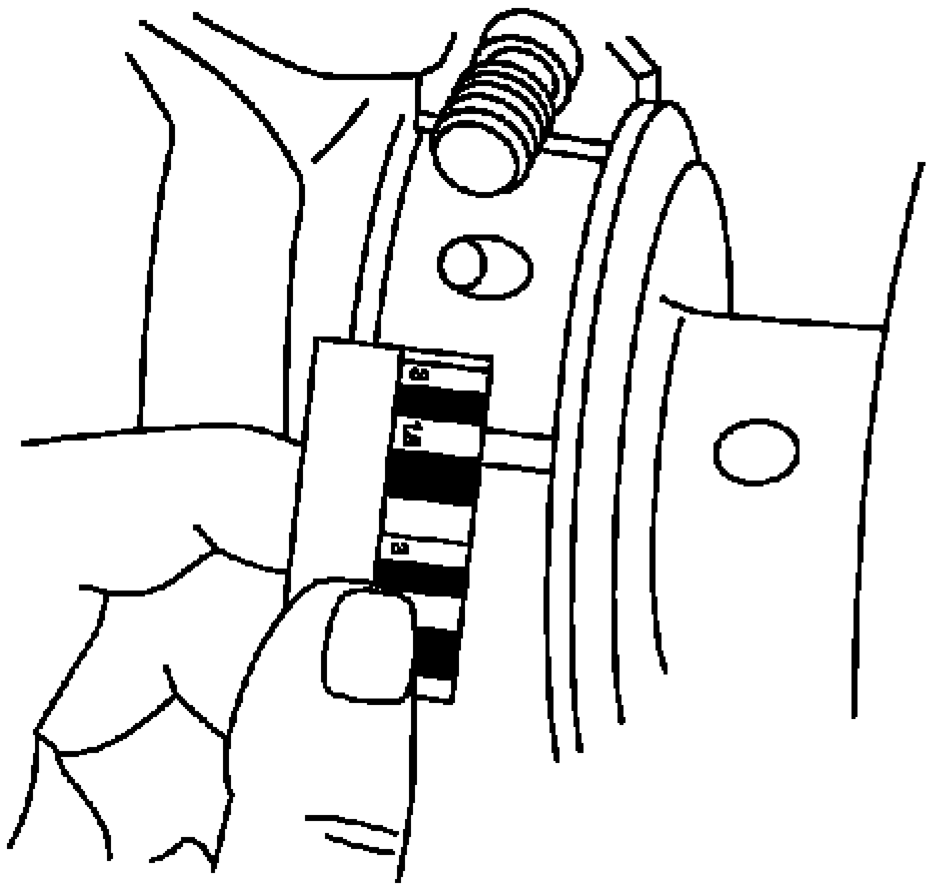


Fig. 315: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

17. Regrind the crankshaft.

    Regrind the crankshaft so that the finished crankpin diameter equals the measured connecting rod bore diameter minus 0.054 mm (0.0021 in).

    Install a new 0.25 mm (0.0098 in) undersized bearing to the connecting rod.

18. Install the connecting rod cap and torque the nuts to 45 N.m (33 lb ft).
19. Measure the connecting rod bore diameter with the undersized bearing installed.

20. Measure the crankpin diameter.
21. Ensure that the oil clearance is within specifications.

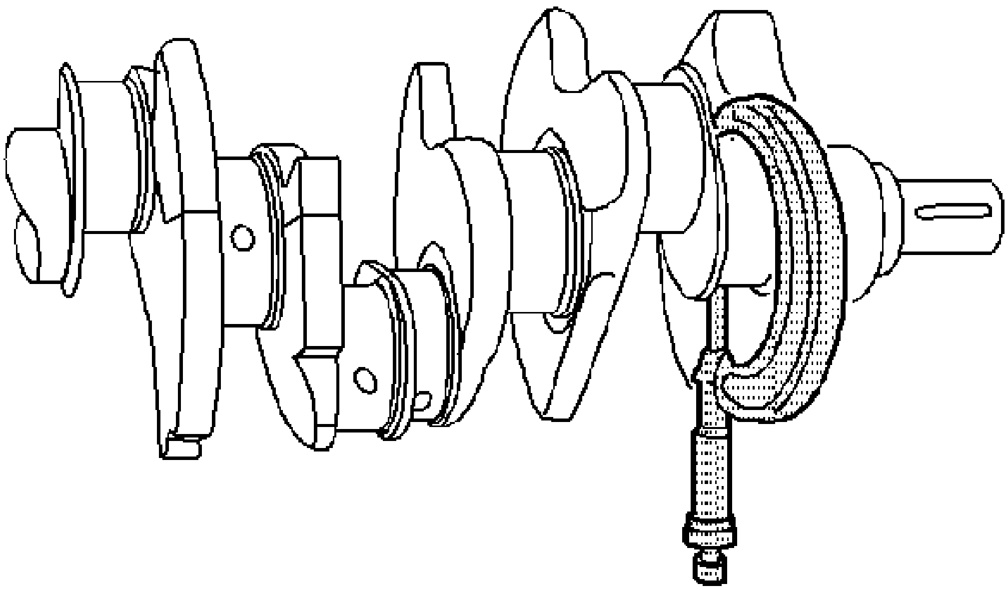


Fig. 316: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

Piston and Connecting Rod Assemble

IMPORTANT: Install the piston onto the connecting rod with the mark and the arrow (2) oriented toward the front of the engine.

1. Coat the piston pin with engine oil.
2. Align the connecting rod with the piston.

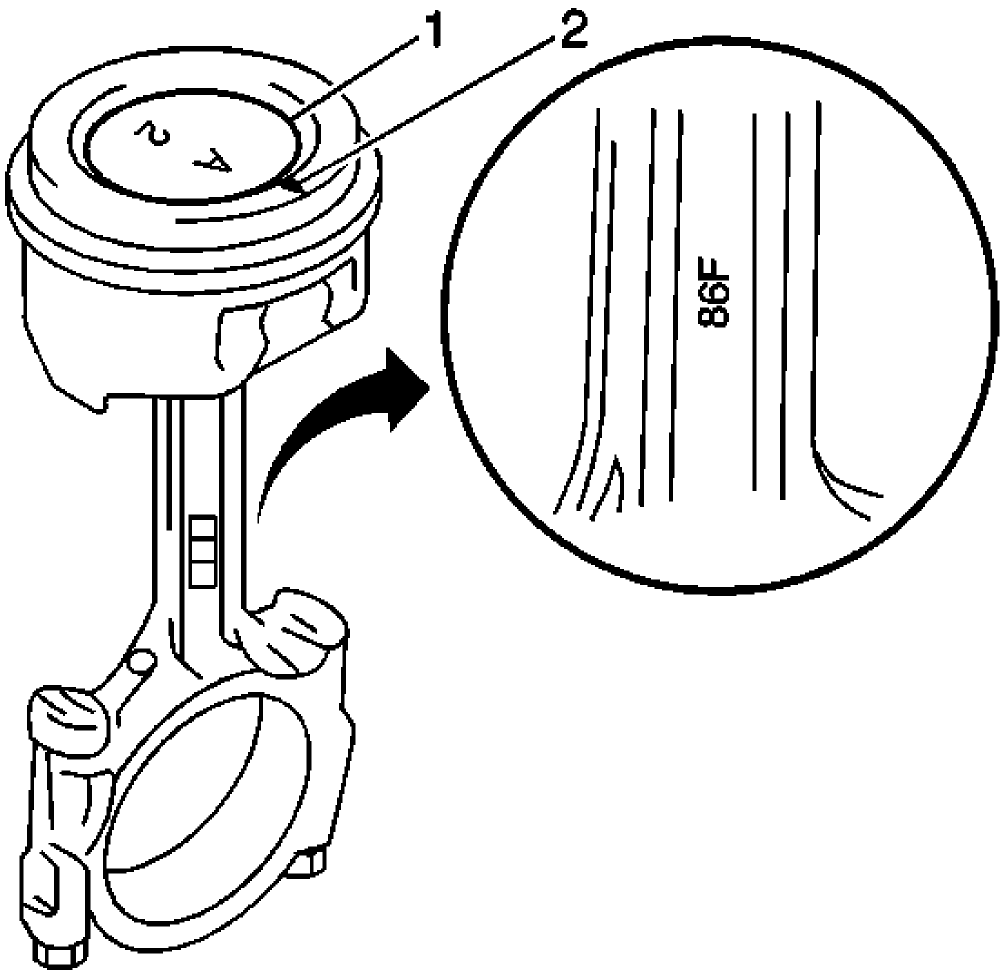


Fig. 317: Aligning Connecting Rod With Piston
Courtesy of GENERAL MOTORS CORP.

3. Push the piston pin through the connecting rod and the piston bore by hand.

IMPORTANT: The piston pin snap ring end gap should not be aligned with the pin hole cutout portion of the piston.

4. Install new snap rings using a small screwdriver. Do not gouge the piston (1) when installing the snap rings.

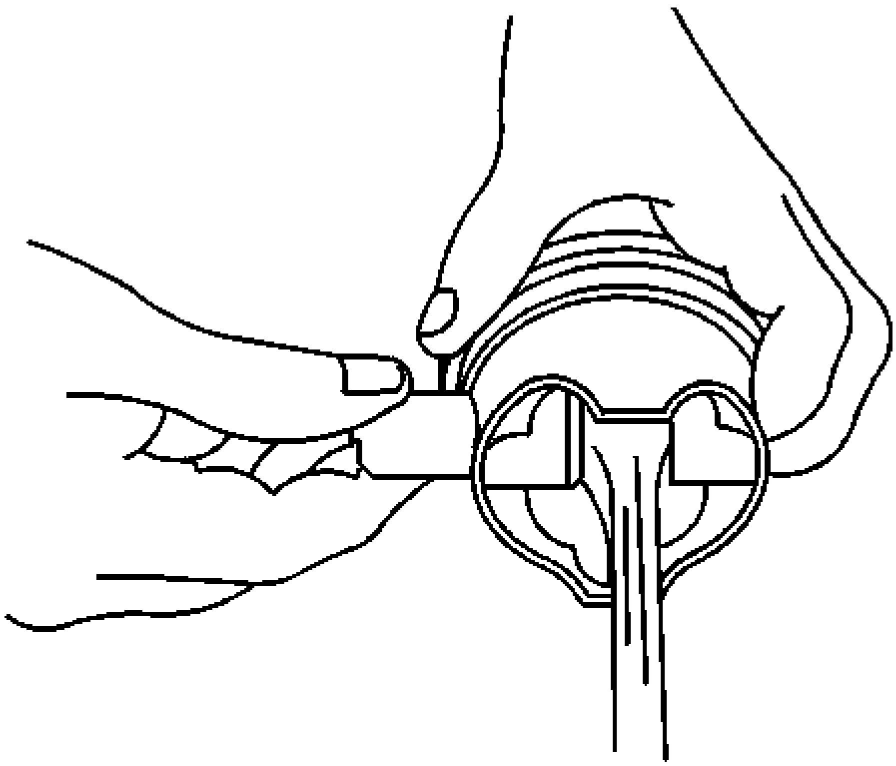


Fig. 318: View Of Piston, Pin & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

5. Ensure that the piston pin snap ring end gap is not aligned with the pin hole cutout portion of the piston.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

6. Lubricate the piston ring grooves and the piston rings with engine oil.

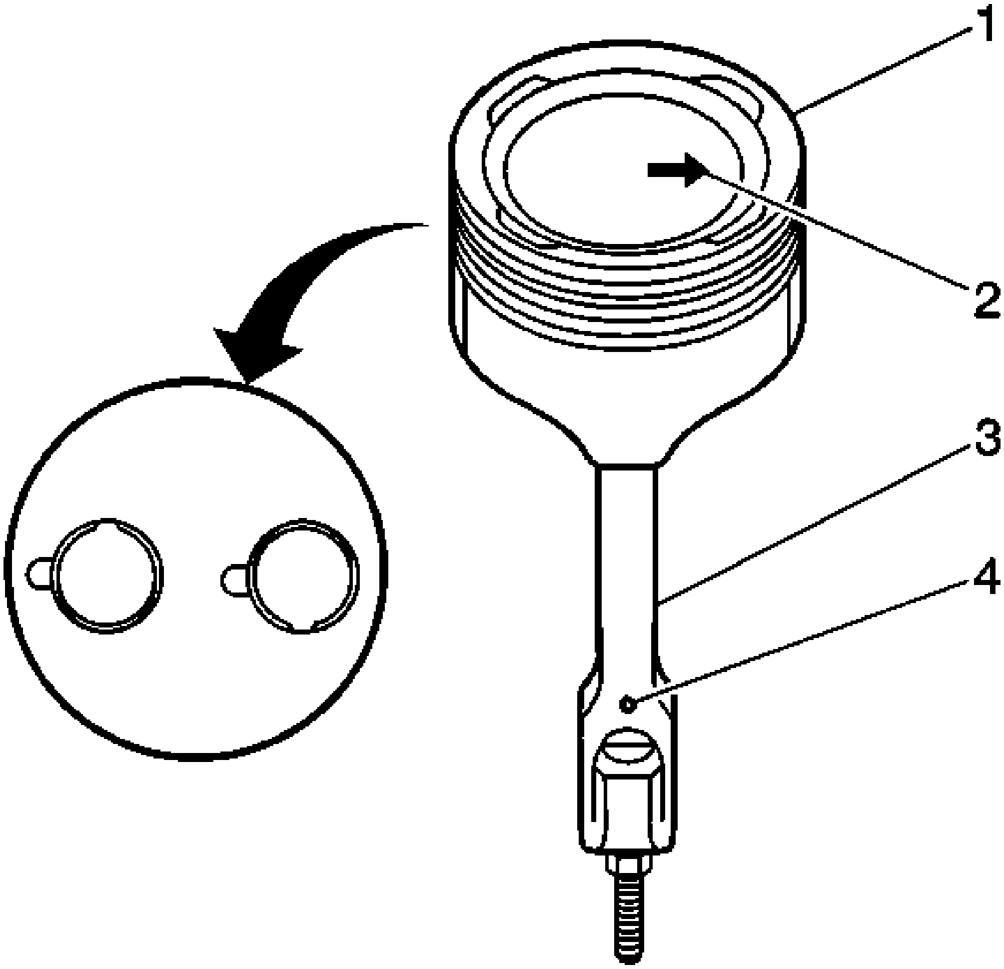


Fig. 319: Lubricating Piston Pin Snap Ring
Courtesy of GENERAL MOTORS CORP.

7. Install the oil control expander ring.
8. Install the lower oil control ring.
9. Install the upper oil control ring.

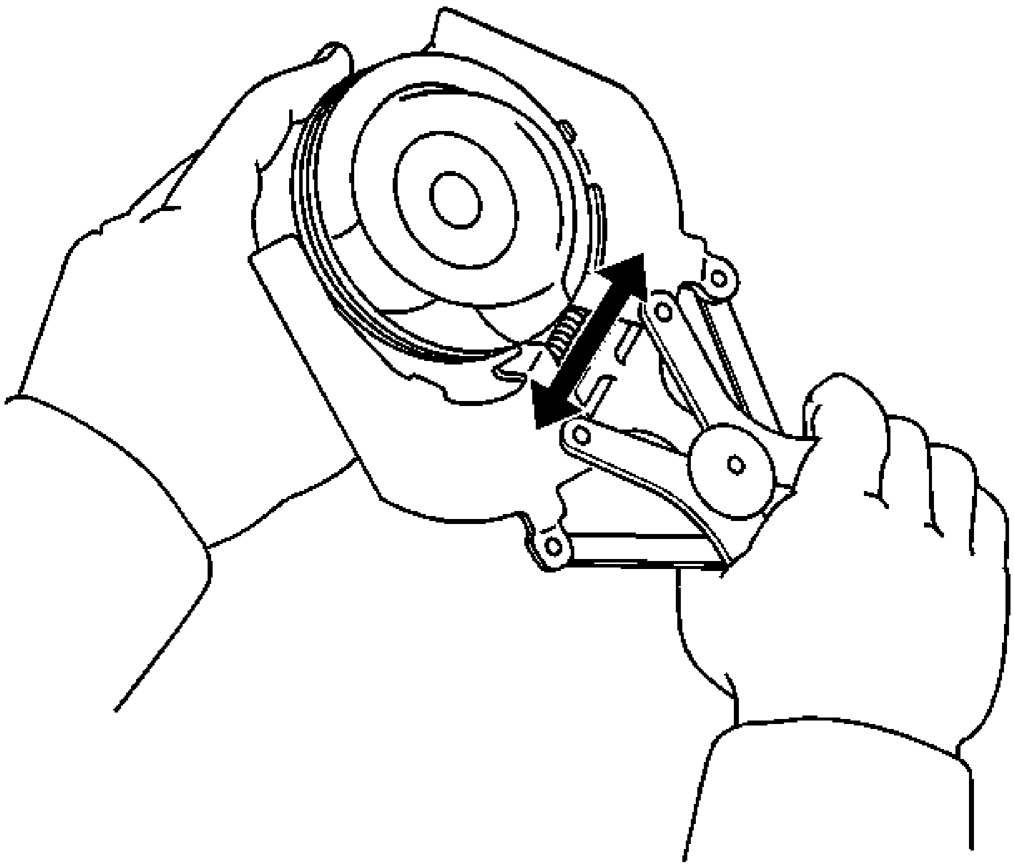


Fig. 320: Installing Piston Rings From Piston
Courtesy of GENERAL MOTORS CORP.

10. The lower and upper compression rings differ from each other in thickness, shape and cylinder wall contact surface color. The lower ring (2) is marked R and the upper ring is marked RN.

    Install the lower compression ring (2) (second ring) with the manufacturer's mark facing up.

11. Install the upper compression ring (1) (top ring) with the manufacturer's mark facing up.

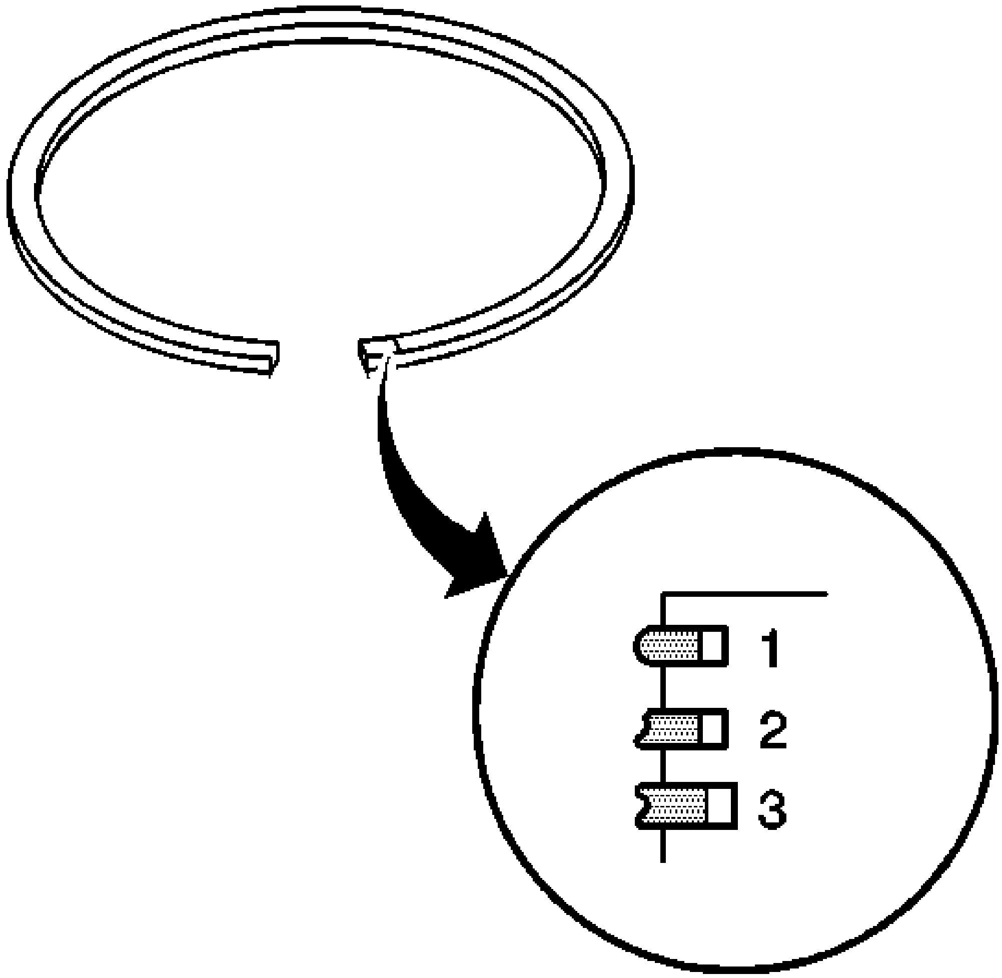


Fig. 321: View Of Lower & Upper Compression Ring
Courtesy of GENERAL MOTORS CORP.

12. The piston ring end gaps must be staggered in order to provide an effective compression seal. After the rings are installed distribute their end gaps as follows:
    1. Place the oil ring expander end gap (5) 45 degrees from the front of the piston (6) on the exhaust side of the engine.
    2. Place the upper oil ring end gap (7) 45 degrees from the front of the piston (6) on the intake side of the engine.
    3. Place the lower oil ring end gap (3) 180 degrees from the upper oil control ring end gap.
    4. Place the lower compression ring end gap (5) 45 degrees from the front of the piston (6) on the exhaust side of the engine.

5. Place the upper compression ring end gap (2) 180 degrees from the lower compression ring end gap.

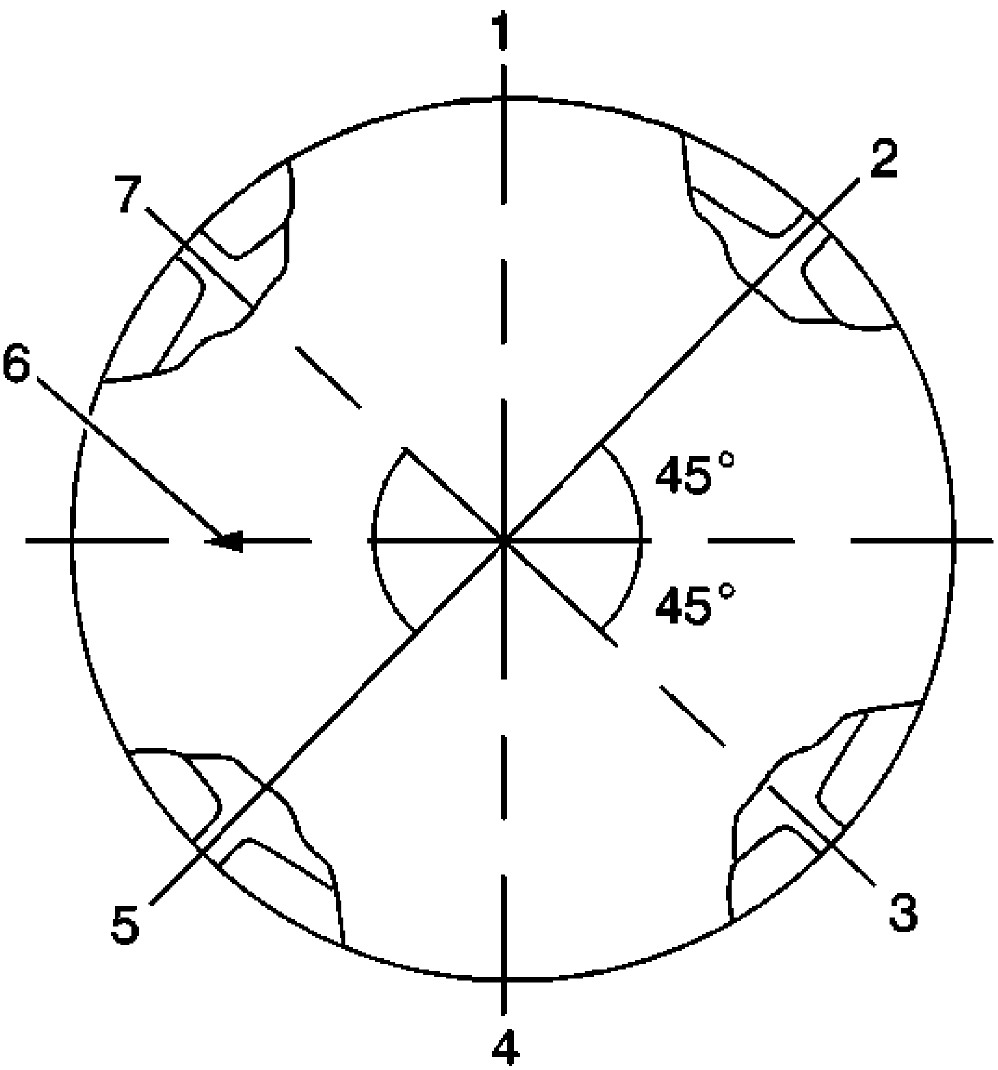


Fig. 322: Installing Piston Rings To Provide Effective Compression Seal
Courtesy of GENERAL MOTORS CORP.

Camshafts Cleaning and Inspection

Tools Required

- **J 26900-2** Combimike Micrometer. See **Special Tools and Equipment**.
- **J 8001** Dial Indicator Set. See **Special Tools and Equipment**.
- **J 26900-13** Magnetic Indicator Base. See **Special Tools and Equipment**.

1. Measure the camshaft lobe height using the **J 26900-2** . See **Special Tools and Equipment**. Replace the camshaft if any lobe is below the minimum.

   Standard Intake Camshaft Lobe Height: 40.402-40.562 mm (1.5906-1.5969 in)

   Minimum Intake Camshaft Lobe Height: 40.202 mm (1.5827 in)

   Standard Exhaust Camshaft Lobe Height: 39.921-40.081 mm (1.5717-1.5780 in)

   Minimum Exhaust Camshaft Lobe Height: 39.721 mm (1.5638 in)

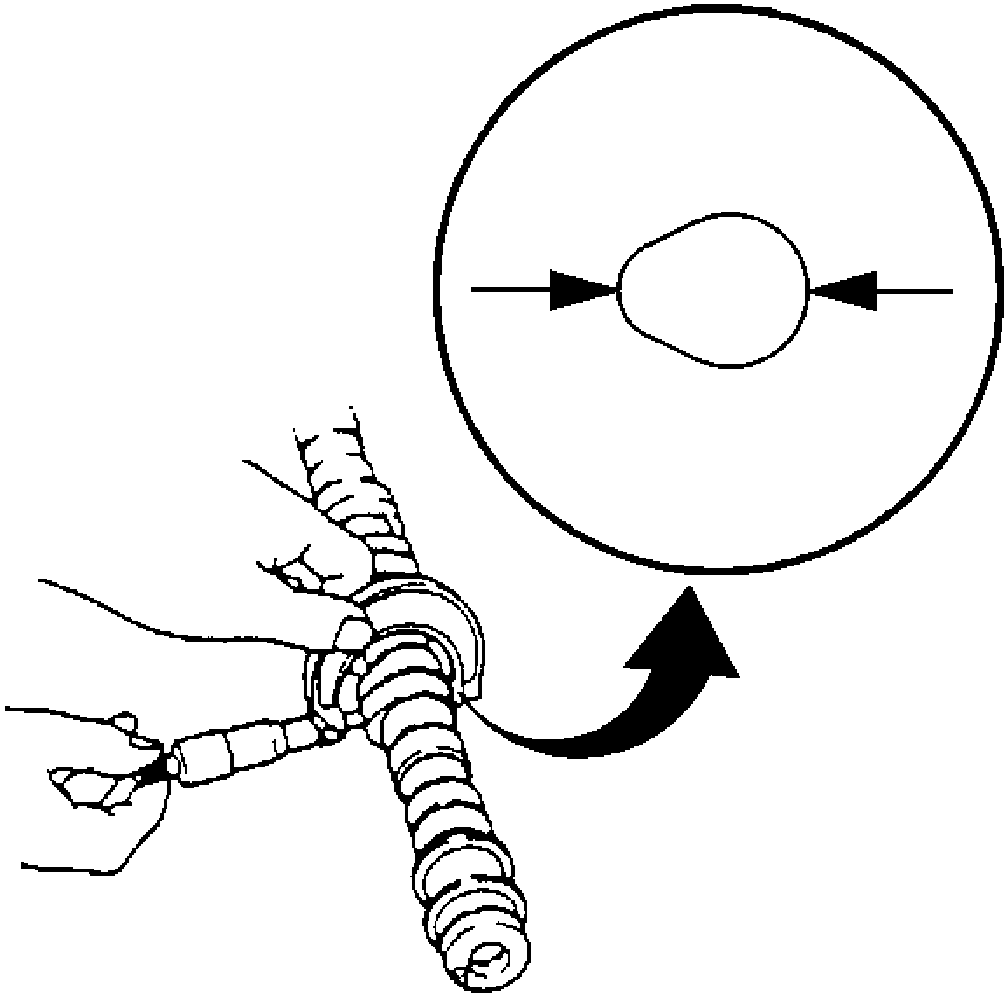


Fig. 323: View Of Camshaft Lobe
Courtesy of GENERAL MOTORS CORP.

2. Place the camshaft onto V-blocks. Measure the camshaft runout using the **J 8001** with the **J 26900-13** . Replace the camshaft if the runout exceeds specifications.

   Camshaft Runout: 0.10 mm (0.0039 in)

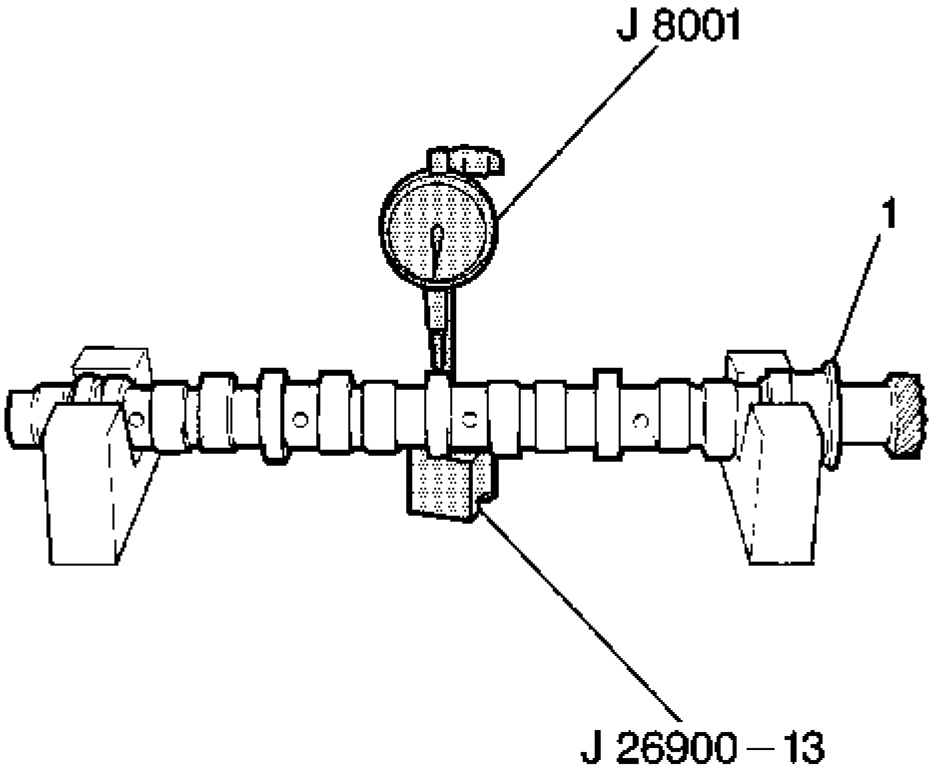


Fig. 324: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft bearing caps (1) for wear, cracks and scoring.
4. Inspect the camshaft bearing journals in the cylinder head for wear, cracks and scoring.
5. If excessive wear or scoring is present, or if the cylinder head is cracked, replace the cylinder head (with bearing caps).
6. Clean the journals of the camshaft and the cylinder head.
7. Do not install the valve lifters.
8. Install the camshafts. The rear end of the exhaust camshaft is slotted to mate with the camshaft position sensor.

IMPORTANT: Do not turn the camshafts while the gaging plastic is installed.

9. Place a piece of gaging plastic across the full width of each camshaft journal.

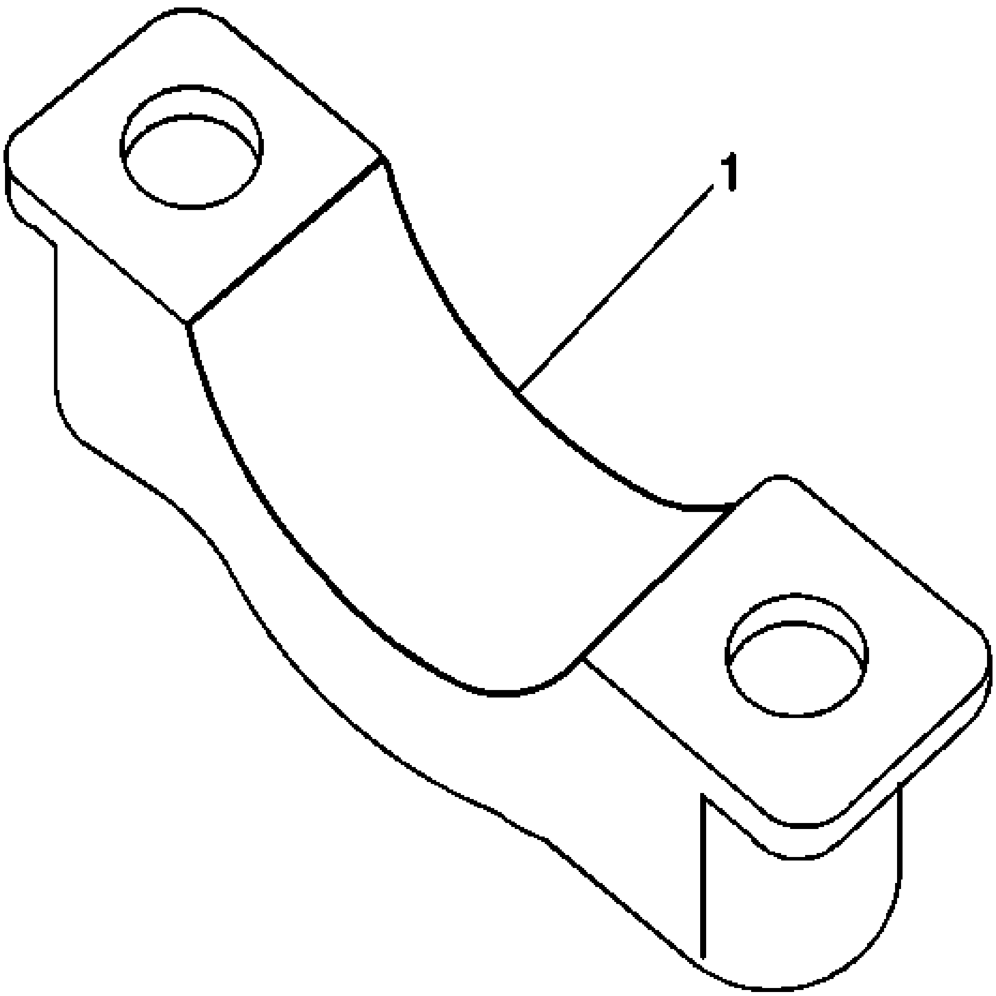


Fig. 325: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Cylinder head and camshaft damage may result if the bearing caps are incorrectly installed. The oil clearance measurement will also be incorrect.

10. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

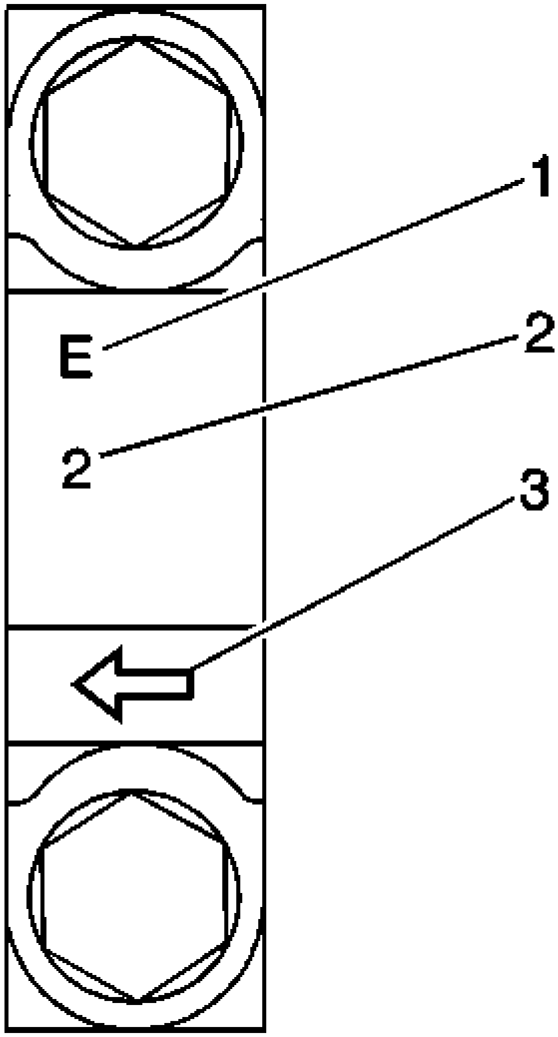


Fig. 326: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

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

11. Use 3 progressive steps to tighten the camshaft bearing cap bolts in sequence.

    Tighten: Tighten the bolts to 11 N.m (8 lb ft).

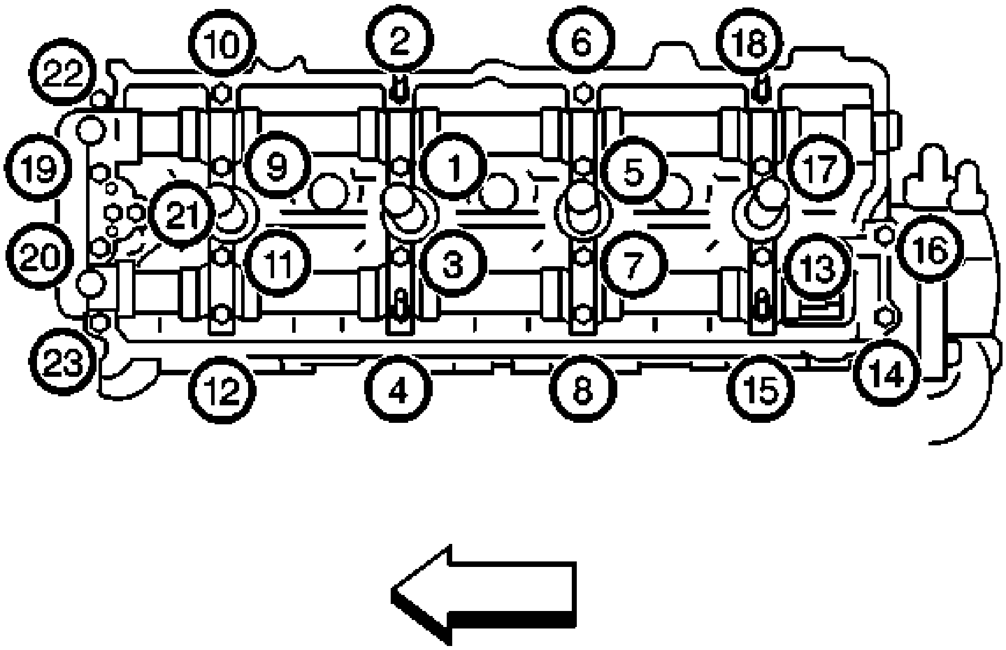


Fig. 327: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

12. Remove the camshaft bearing caps.
13. Measure the gaging plastic (1) at its widest point.

    Standard Oil Clearance: 0.020-0.074 mm (0.0008-0.0029 in)

    Maximum Oil Clearance: 0.12 mm (0.0047 in)

14. If the clearance is greater than the maximum perform the following:
    1. Remove the camshaft.
    2. Measure the camshaft journal outside diameter with the **J 26900-2** . See **Special Tools and Equipment**.

       Intake and Exhaust Camshaft Journal OD: 25.959-25.980 (1.0220-1.0228 in)

    3. Install the camshaft bearing caps and torque to 11 N.m (97 lb in).
    4. Measure the camshaft journal inside (bore) diameter.

       Intake and Exhaust Camshaft Bore ID: 26.000-26.033 (1.0236-1.0249 in)

15. Replace the component (camshaft or cylinder head with caps) that has the greatest difference from specification.

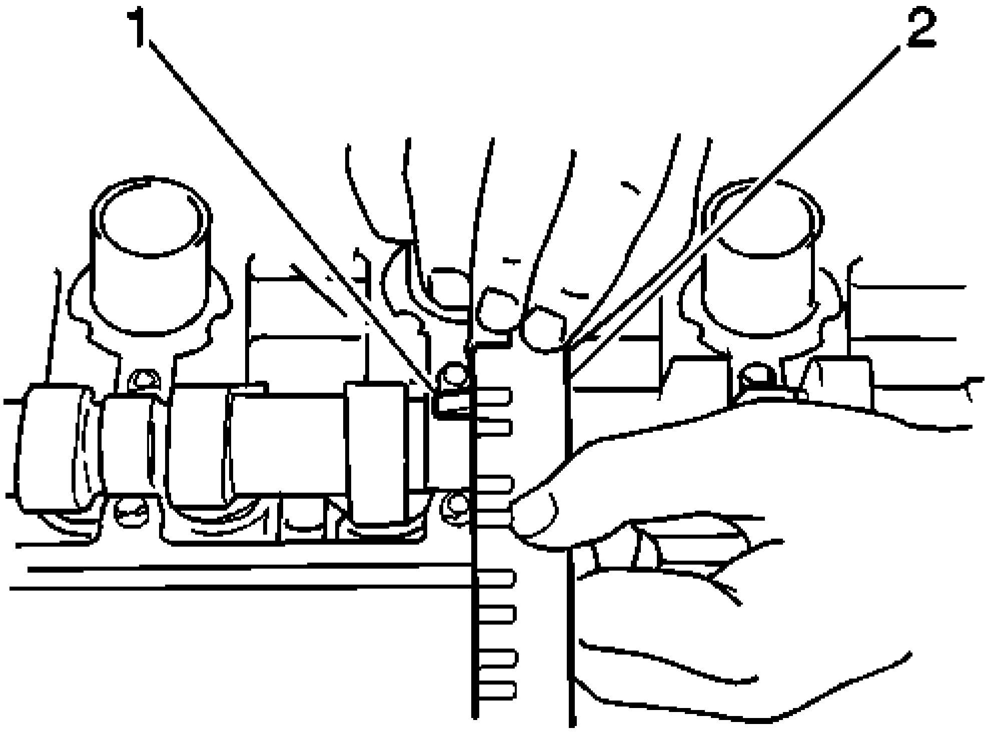


Fig. 328: Measuring Clearance of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

Valve Lifters and Guides Cleaning and Inspection

1. Measure the valve lifter bores in the cylinder head.

   Valve Lifter Bore ID: 31.000-31.025 mm (1.2205-1.2214 in)

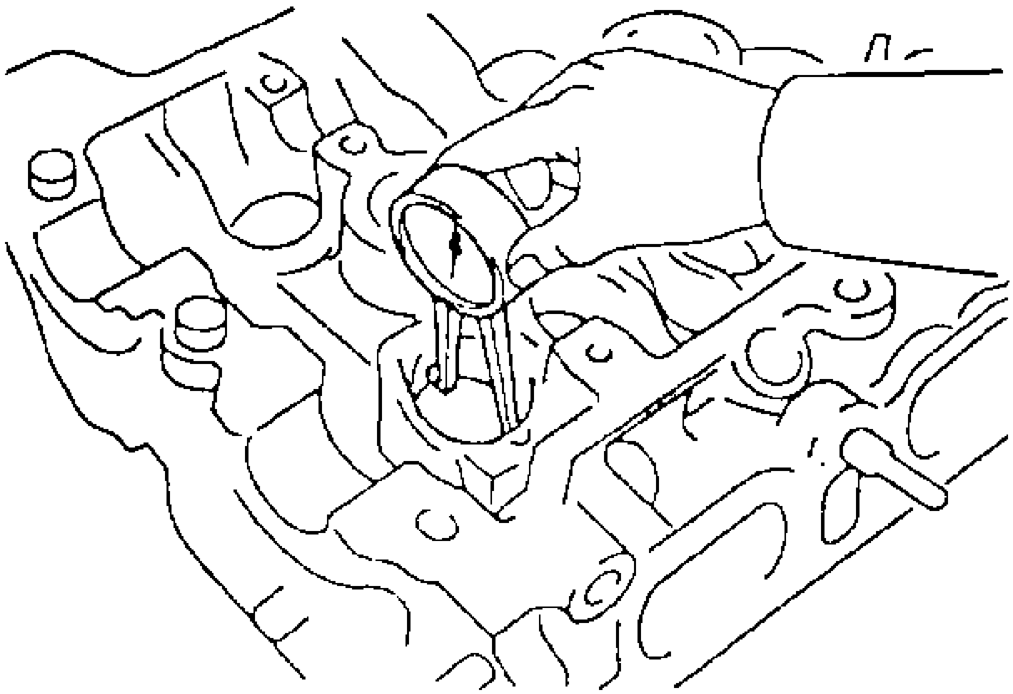


Fig. 329: Measuring Clearance Of Valve Lifter Bores
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve lifters for wear, scoring and damage.
3. Measure the valve lifters with the **J 26900-2** . See **Special Tools and Equipment**.

   Valve Lifter OD: 30.959-30.975 mm (1.2189-1.2194 in)

4. Subtract the valve lifter outside diameter measurement from the valve lifter bore inside diameter measurement to determine the oil clearance.

   Standard Valve Lifter-to-Valve Bore Clearance: 0.025-0.066 mm (0.0010-0.0025 in)

   Maximum Valve Lifter-to-Valve Bore Clearance: 0.15 mm (0.0059 in)

5. If the oil clearance is greater than the maximum, replace the lifter. If the oil clearance is still greater than the maximum, replace the cylinder head (with caps).

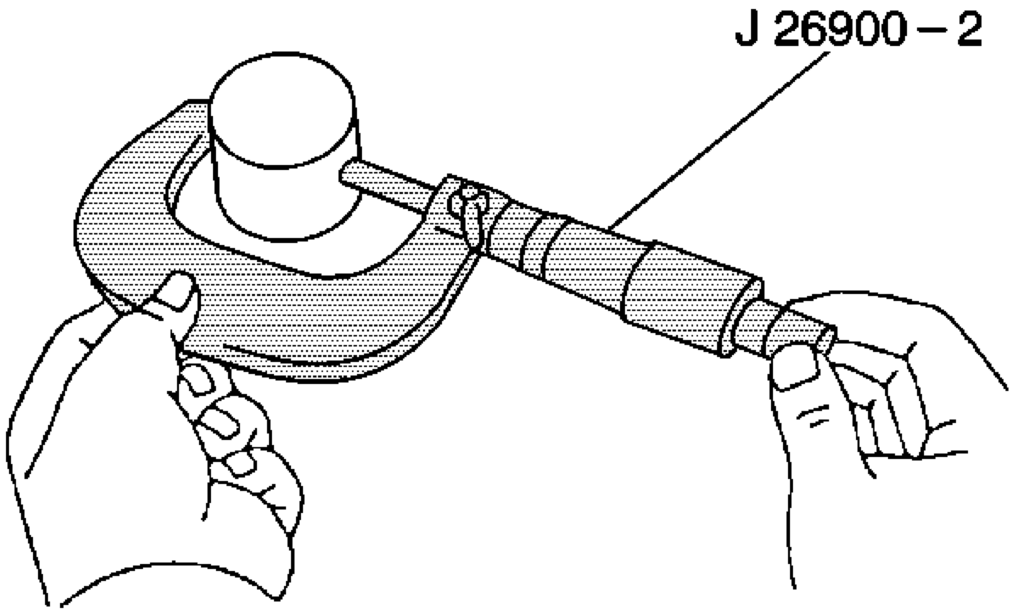


Fig. 330: View Of J 26900-2
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Cleaning and Inspection

1. Inspect the timing chain guides for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.0 mm (0.039 in).
3. Inspect the camshaft and crankshaft timing chains for elongation wear.

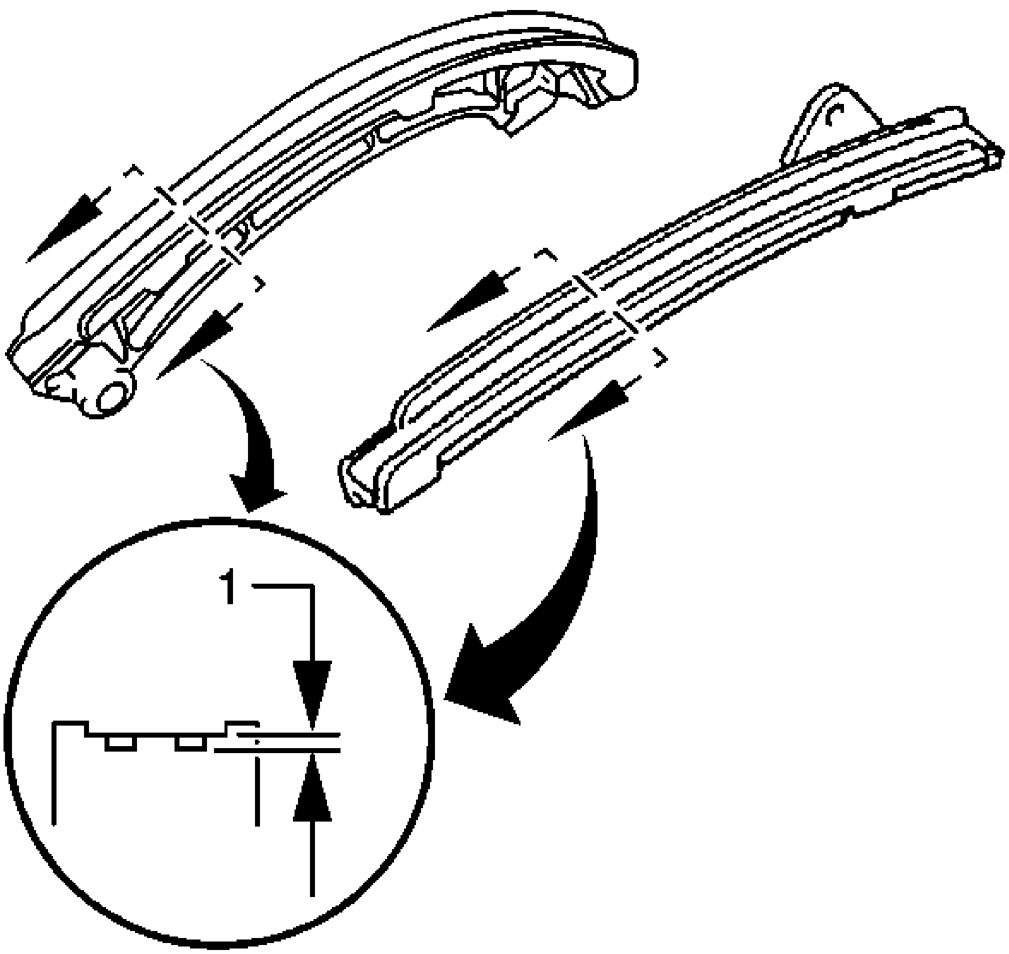


Fig. 331: Inspecting Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the camshaft sprocket teeth for signs of excessive wear, chipping (2), or seizure of the timing chain links.
5. Inspect the crankshaft sprocket for wear.
6. Inspect the camshaft tensioner for wear. The plunger movement should be firm and smooth when pressed inward.
7. Inspect the crankshaft tensioner for wear. Inspect that the latch teeth are not damaged and that the latch functions properly.
8. Replace any component that shows signs of wear or damage.

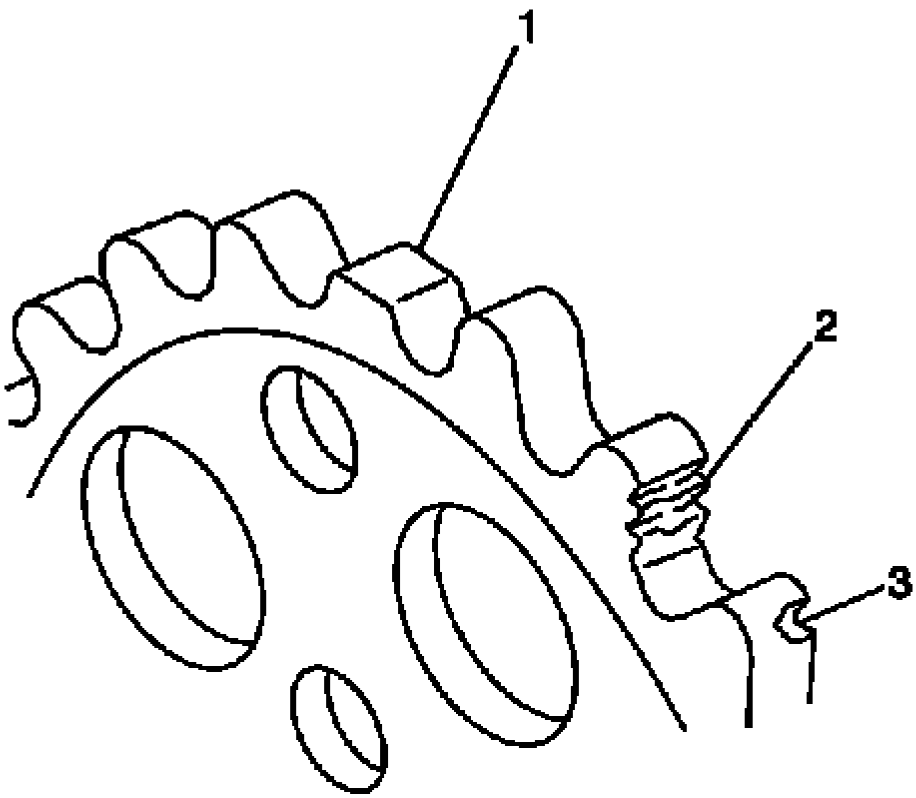


Fig. 332: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Disassemble

Tools Required

- **J 8062** Valve Spring Compressor. See Special Tools and Equipment.
- **J 37979** Valve Spring Compressor Adaptor. See Special Tools and Equipment.
- **J 36017** Valve Guide Seal Remover. See Special Tools and Equipment.

IMPORTANT: Keep the valve train components together and identified in order for proper installation in their original position.

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

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed

by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

1. Compress the valve spring using the **J 8062** and the. See **Special Tools and Equipment**.**J 37979** . See **Special Tools and Equipment**.
2. Remove the valve keepers using a magnet or small screwdriver.
3. Slowly release the **J 8062** from the valve spring assembly. See **Special Tools and Equipment**.

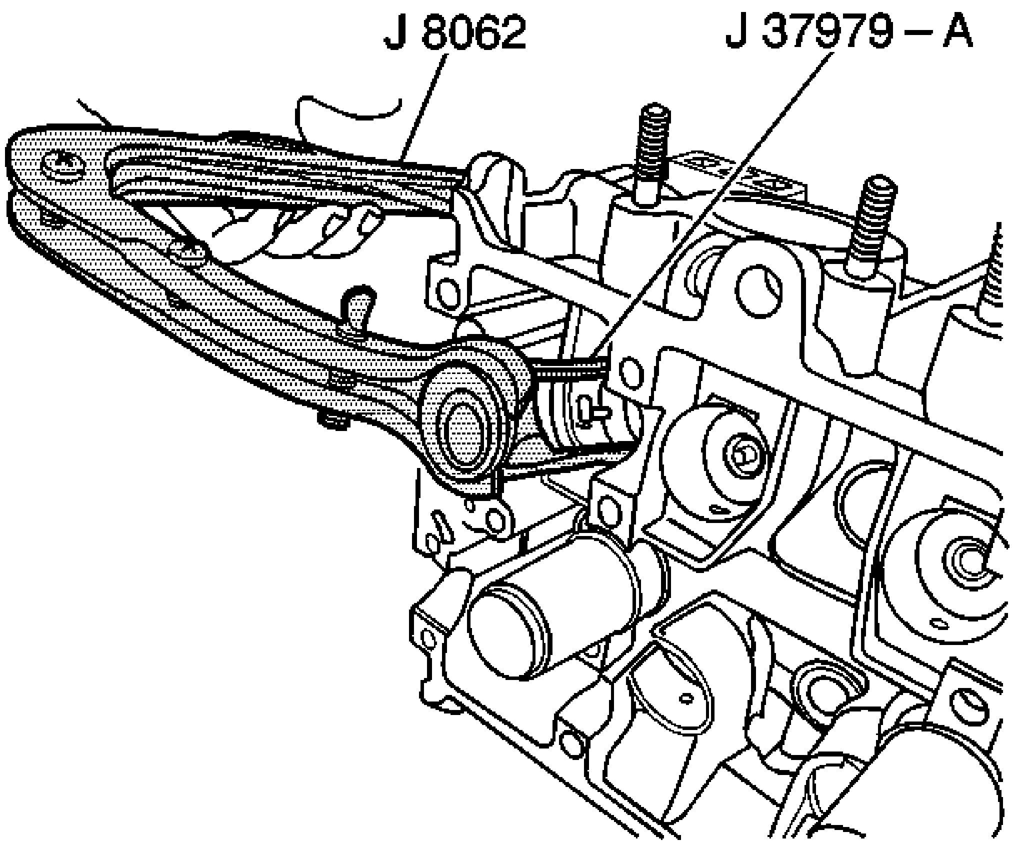


Fig. 333: View Of J 8062 & J 37979
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainer and the inner and the outer valve springs.

Both the inner and outer valve springs have a top (large-pitch) and bottom (small pitch) end. The small-pitch end is installed towards the valve spring seat.

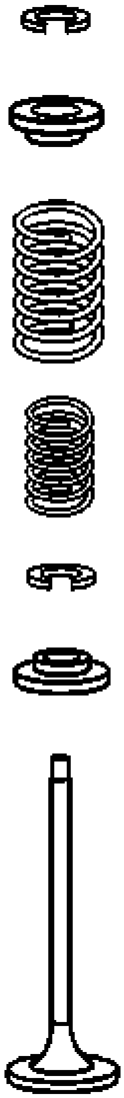


Fig. 334: Removing Retainer, Inner & Outer Valve Springs
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.**

5. Remove the valve seal (1) using the **J 36017** . See **Special Tools and Equipment**.
6. Remove the spring seat.

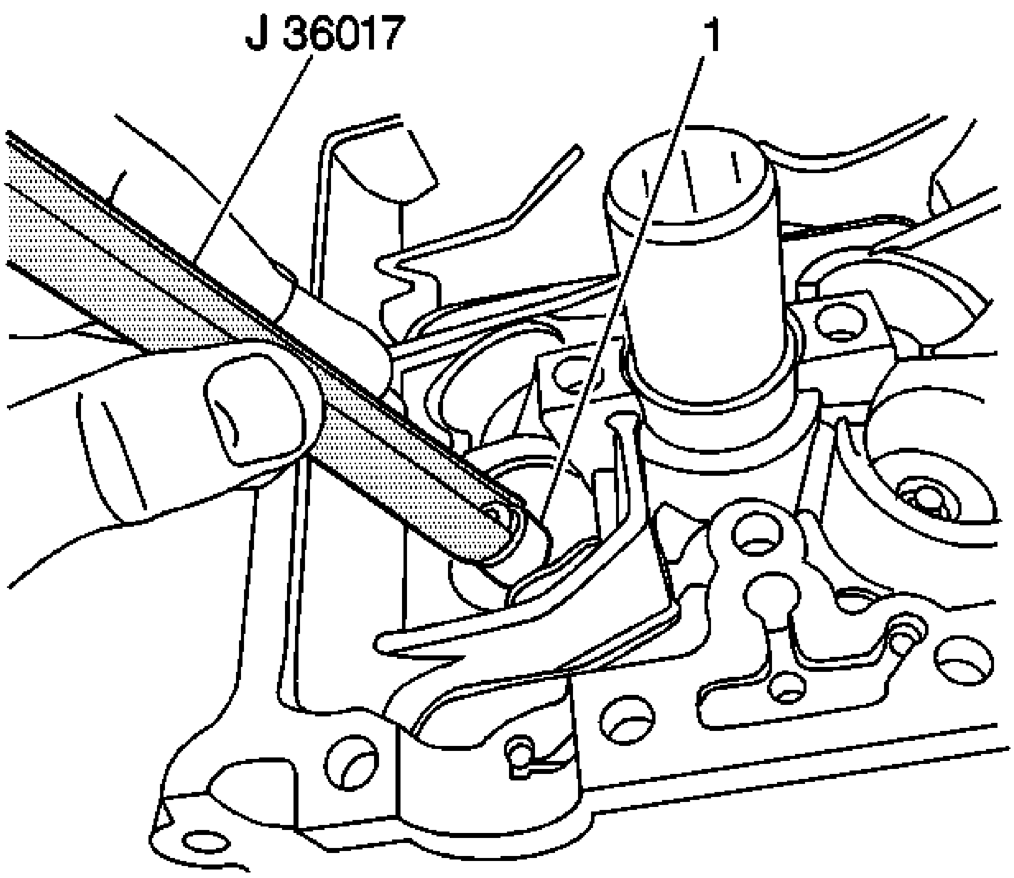


Fig. 335: View Of Valve Seal
Courtesy of GENERAL MOTORS CORP.

7. Remove the valve.
8. Remove the remaining valve springs and valves.

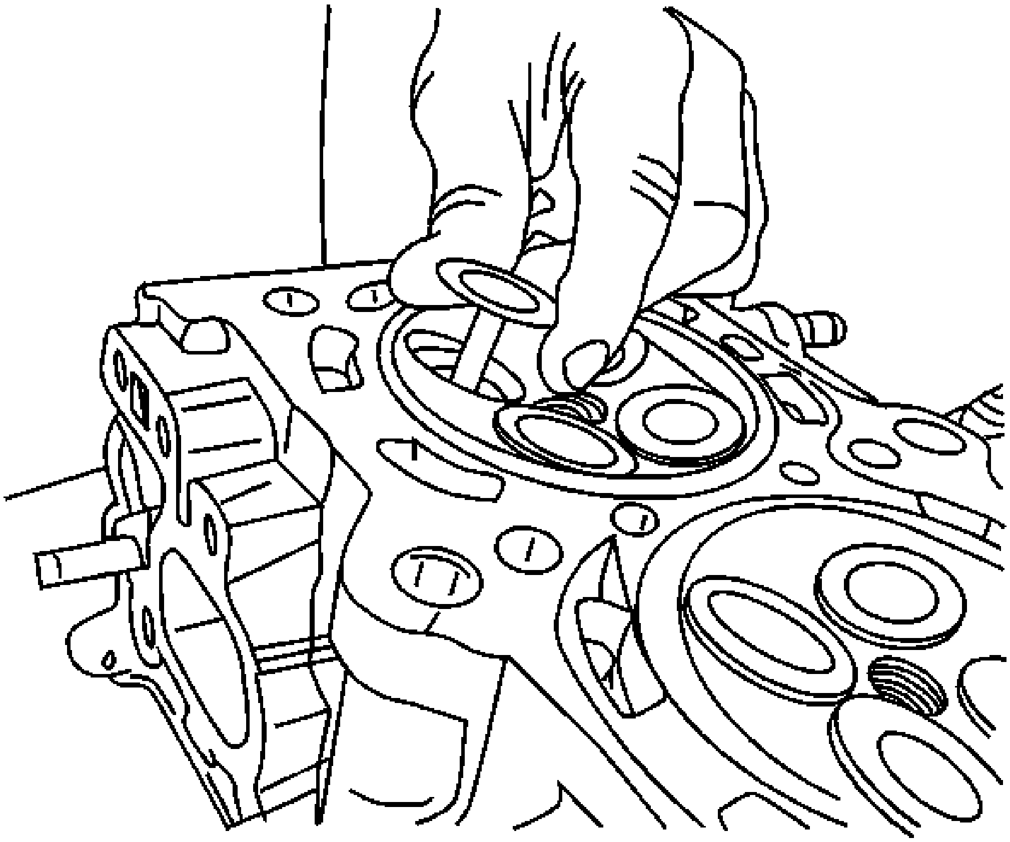


Fig. 336: Removing Valve & Valve Springs
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Cleaning and Inspection

1. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by.
2. If the gasket has failed, determine the cause. Gasket failure may be caused by the following:
    - Improper installation
    - Loose or warped cylinder head
    - Warped cylinder block surface
    - Missing, off location or not fully seated dowel pins
    - Corrosion in the seal area around the coolant passages
    - Chips or debris in the cylinder head bolt holes
    - Bolt holes in the cylinder block not drilled or tapped deep enough
    - Incorrect cylinder head bolt torque

- Incorrect cylinder head bolt length

3. Inspect the cylinder head gasket surface.
   - Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber.
   - Replace the cylinder head if the area between the valve seats is cracked.
   - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber.

IMPORTANT: Do not use a wire brush on any gasket sealing surface. Do not attempt to weld the cylinder head, replace it.

4. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
5. Clean the valve guides.
6. Inspect the valve guides for wear.
7. Inspect the valve seats for excessive wear and hot spots.
8. Inspect the valve seating surfaces.
9. Clean the threaded holes. Use a nylon bristle brush.
10. Clean the remains of the sealer from the plug holes.
11. Replace all suspect bolts.
12. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.
13. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.
14. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
15. Inspect the intake, the exhaust and the cylinder head deck sealing surfaces.

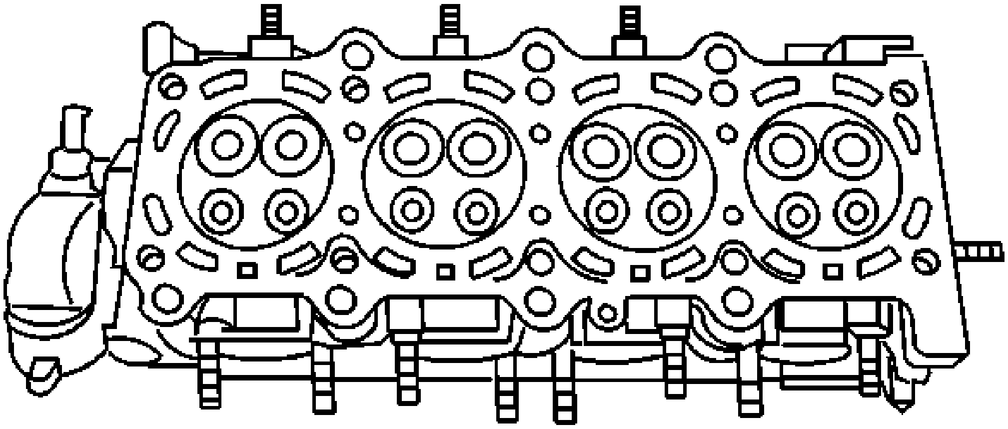


Fig. 337: Inspecting Cylinder Head
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder head deck surface for flatness.

    Maximum Cylinder Head Deck Warpage: 0.05 mm (0.002 in)

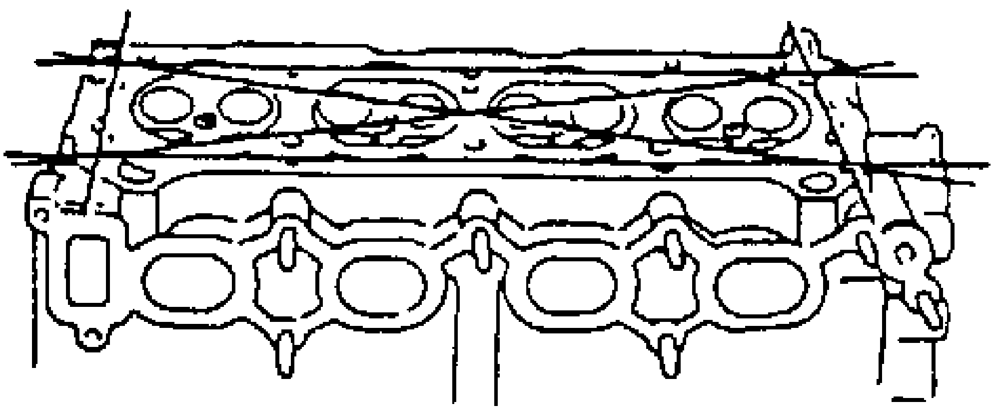


Fig. 338: Inspecting Cylinder Head Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

17. Inspect the cylinder head intake surface for flatness.

    Maximum Cylinder Head Intake Surface Warpage: 0.10 mm (0.004 in)

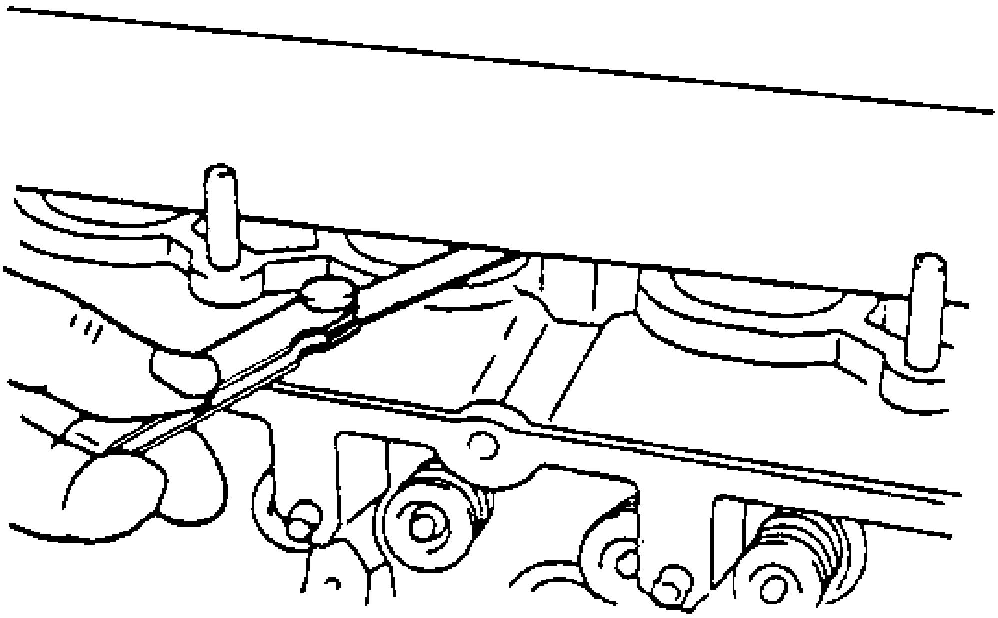


Fig. 339: Inspecting Cylinder Head Intake Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

18. Inspect the cylinder head exhaust surface for flatness.

    Maximum Cylinder Head Exhaust Surface Warpage: 0.10 mm (0.004 in)

19. If the warpage is greater than the maximum in any of the above measurements, replace the cylinder head.

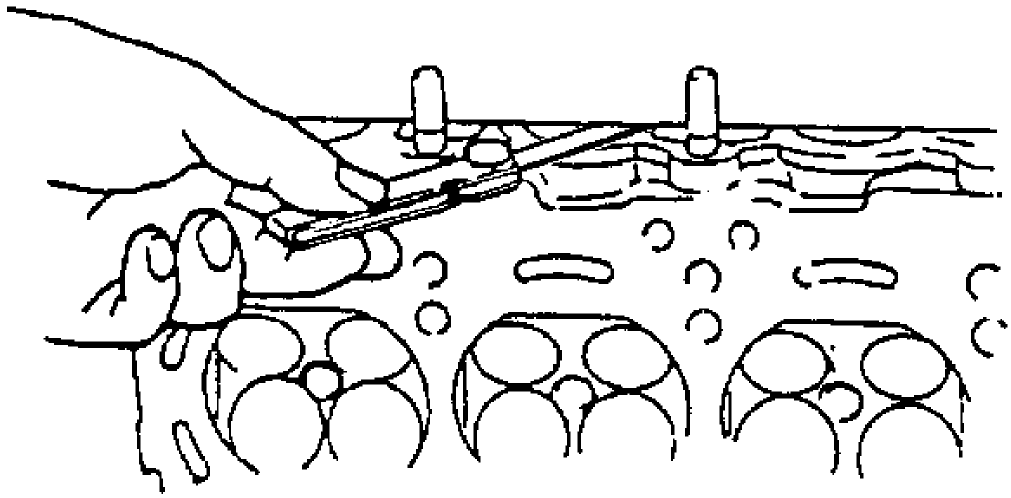


Fig. 340: Inspecting Cylinder Head Exhaust Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

20. Measure the free length of each valve spring using a Vernier caliper.

    Standard Inner Valve Spring Free Length: 36.08 mm (1.4204 in)

    Minimum Inner Valve Spring Free Length: 35.00 mm (1.3780 in)

    Standard Outer Valve Spring Free Length: 40.44 mm (1.5921 in)

    Minimum Outer Valve Spring Free Length: 39.22 mm (1.5441 in)

21. If the free length of any valve spring is not within specifications, replace the valve spring.

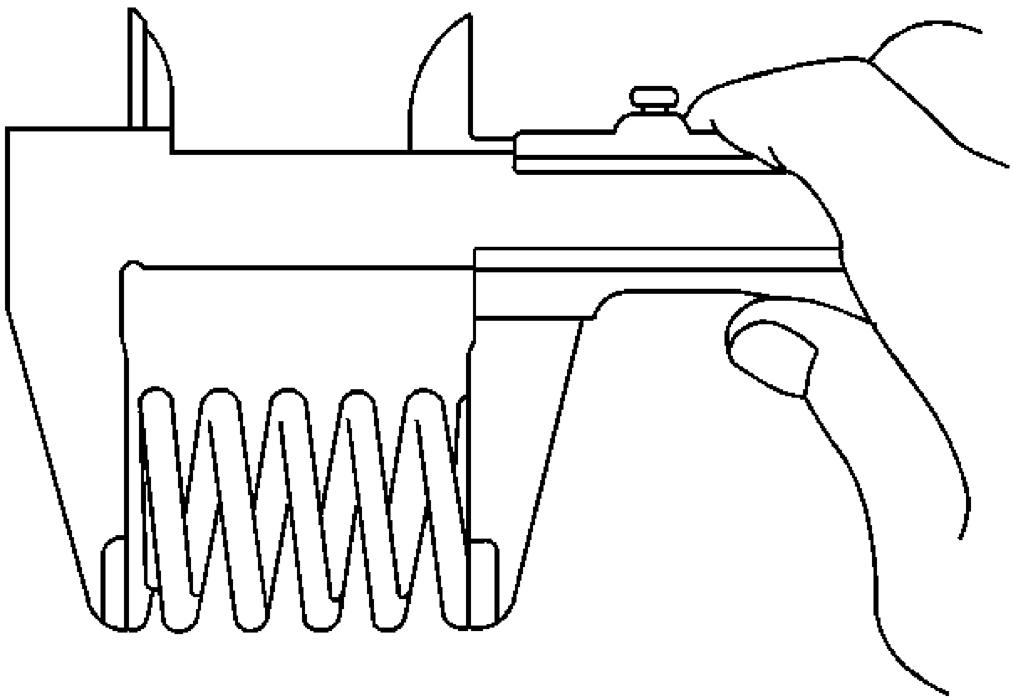


Fig. 341: Measuring Free Length Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

22. Measure the tension of the valve spring at the specified installed height using a spring tester.

    Standard Inner Valve Spring Tension: 6.9-7.9 kg (15.2-17.4 lb) at 27.5 mm (1.08 in)

    Minimum Inner Valve Spring Tension: 6.2 kg (13.6 lb) at 27.5 mm (1.08 in)

    Standard Outer Valve Spring Tension: 15.4-17.8 kg (33.9-39.2 lb) at 31.7 mm (1.25 in)

    Minimum Outer Valve Spring Tension: 13.8 kg (30.4 lb) at 31.7 mm (1.25 in)

23. If the installed tension of any valve spring is not within specifications, replace the valve spring.

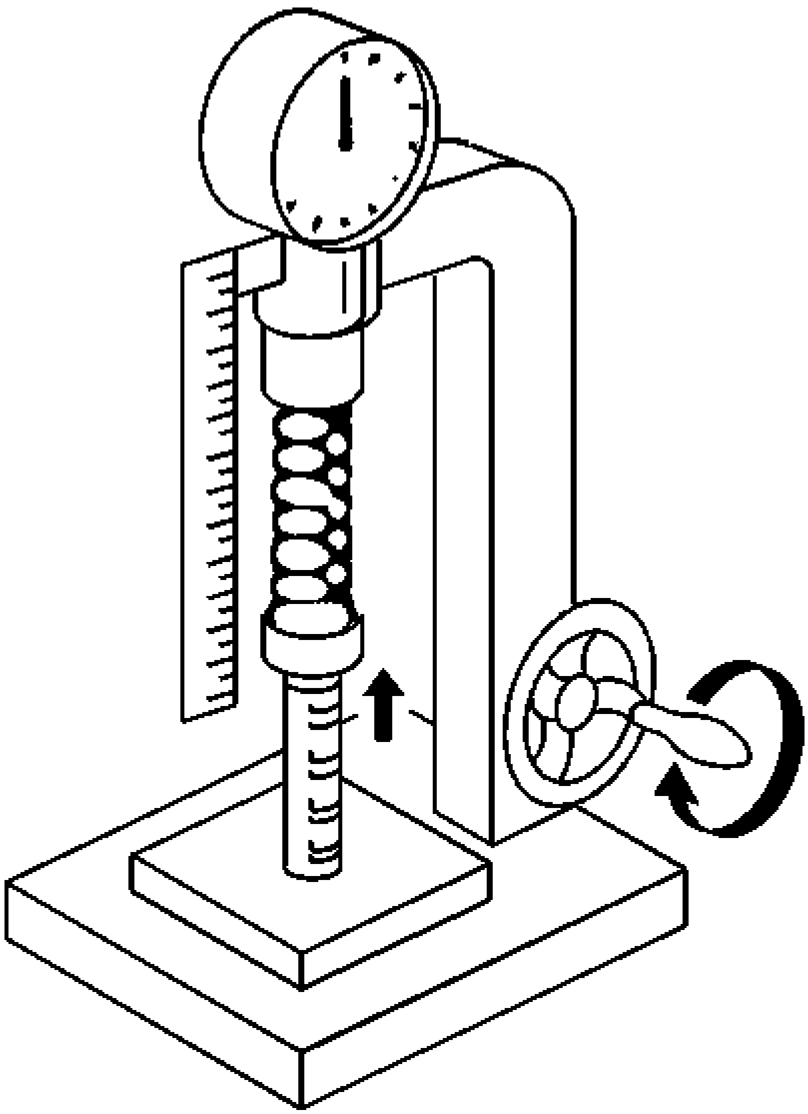


Fig. 342: Measuring Tension Of Valve Spring At Specified Installed Height
Courtesy of GENERAL MOTORS CORP.

24. Measure the valve spring squareness deviation using a steel square.

    Valve Spring Squareness Deviation: 2.0 mm (0.079 in)

25. If the deviation of any valve spring is greater than the specified maximum, replace the valve spring.

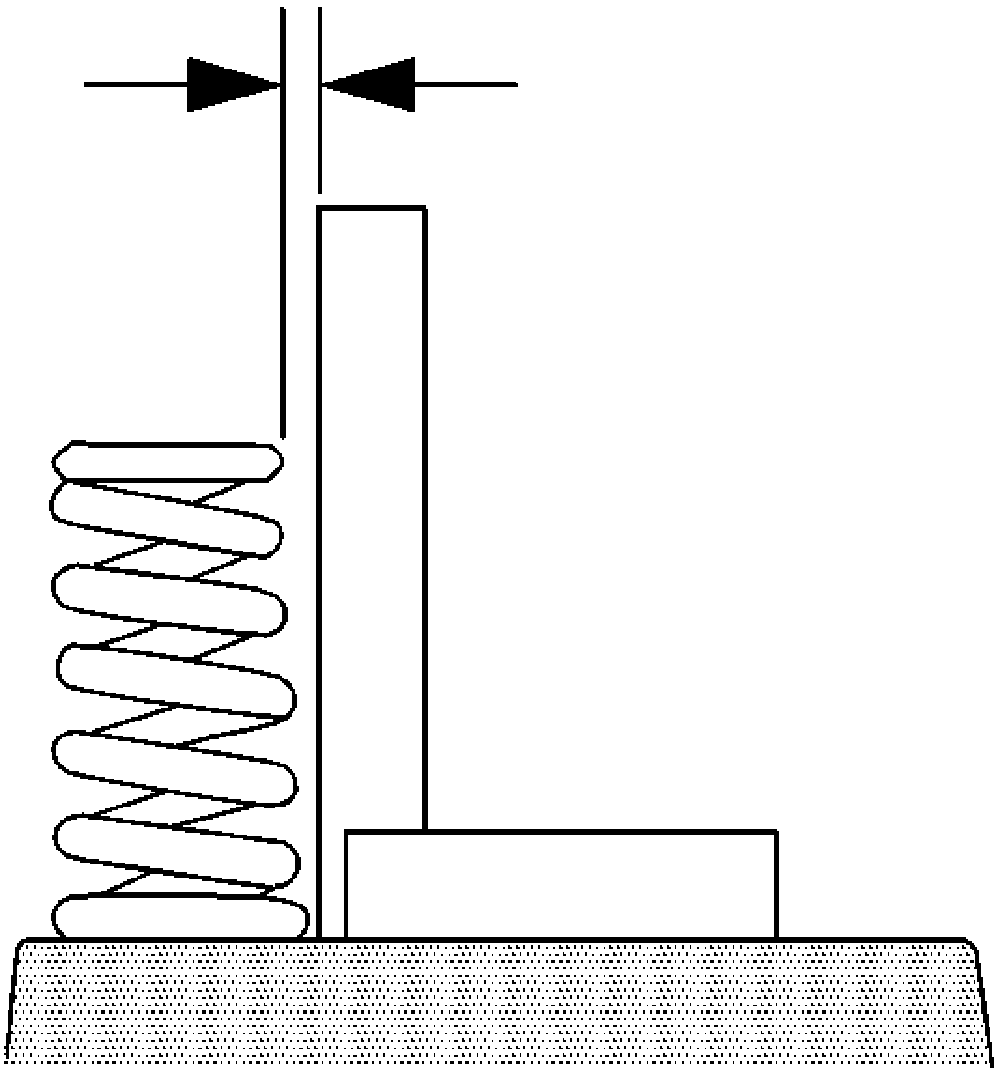


Fig. 343: Measuring Valve Spring Squareness Deviation
Courtesy of GENERAL MOTORS CORP.

26. Inspect the valve spring seating surface of the valve spring seats for wear or gouging. Replace as required.
27. Temporarily install the valves into the cylinder head.
28. Measure valve runout (valve face-to-valve seat contact pattern) by performing the following:
    1. Apply a light coating of Prussian blue to the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve

seat.

2. Clean all traces of Prussian blue.
3. Apply a light coating of Prussian blue to the valve seat and repeat the check. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.
4. Recondition the valve seat and/or replace the valves as necessary. Refer to **Valve Guide Reaming/Valve and Seat Grinding**.

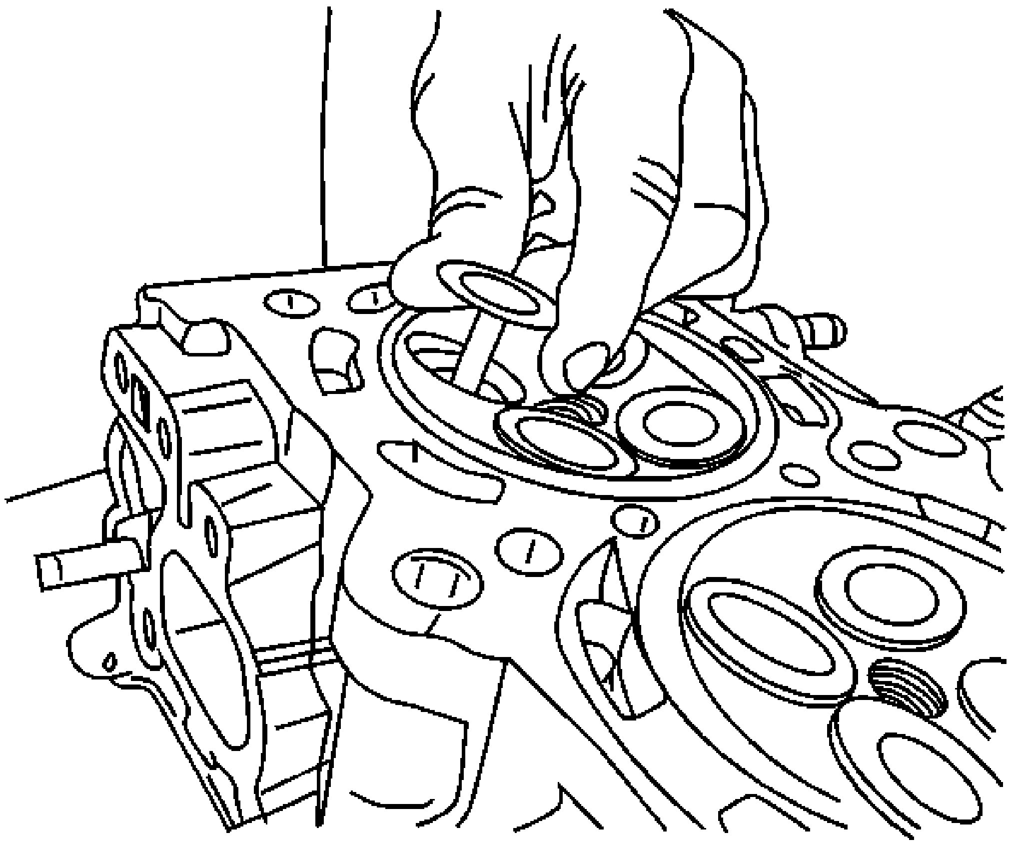


Fig. 344: Inspecting Valve & Valve Springs
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Bolts Cleaning and Inspection

1. Clean the cylinder head bolts.
2. Inspect the cylinder head bolts for the following:
   - Damaged threads
   - Stretching (1)

- Damaged heads caused by improper use of tools

3. Replace any damaged or suspect bolt.

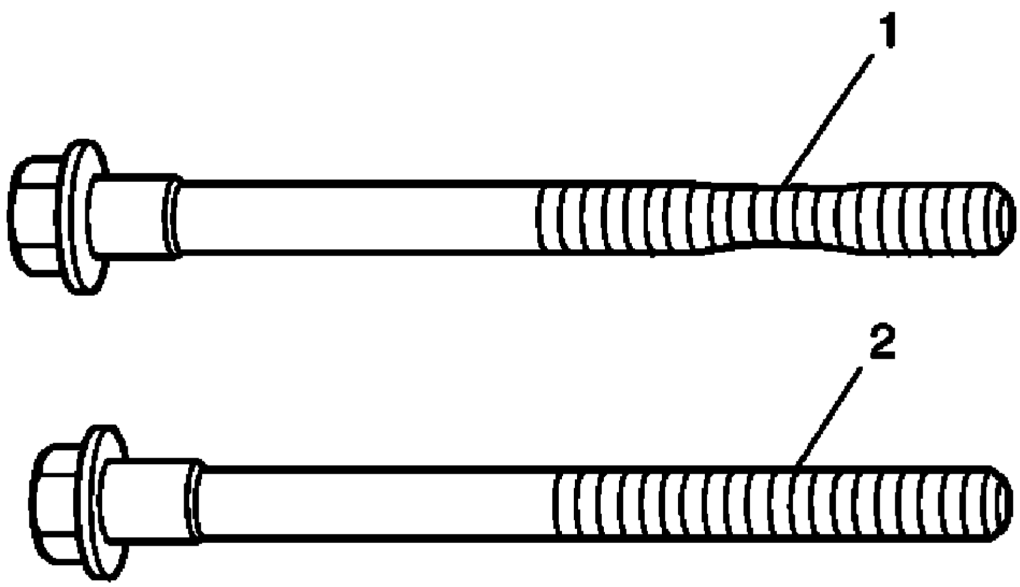


Fig. 345: Inspecting Connecting Rod Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Valve Guide Reaming/Valve and Seat Grinding

Valve Cleaning and Inspection

IMPORTANT:

- **Excessive valve stem to guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive oil consumption.**
- **Insufficient valve stem to guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.**

1. Inspect for excessive valve stem (1) to guide (2) clearance.

IMPORTANT: Do not scratch the valve stem with the wire brush.

2. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush, varnish can be removed by soaking in Parts Immersion Solvent GM P/N 12345368 or equivalent.
3. Clean the deposits from the valve face.

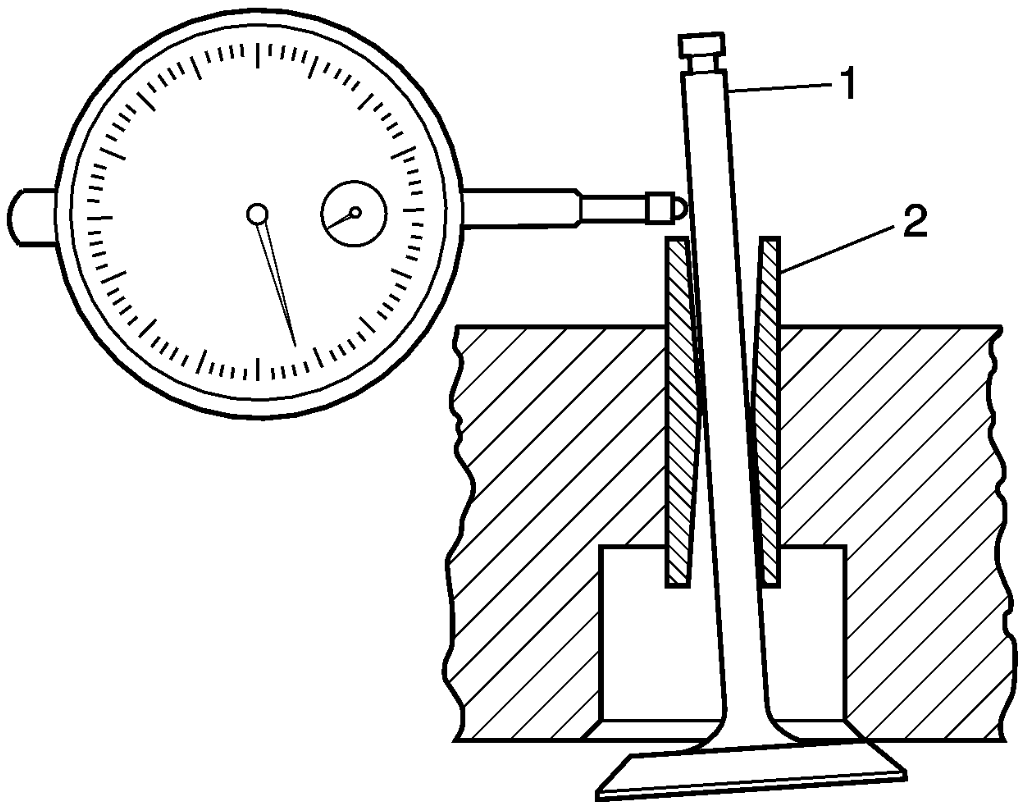


Fig. 346: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve face for the following:
   - Worn or no margin (1, 4)
   - Pitting (2)
   - Burnt or eroded areas (3)
   - Grooving
   - Deposits

5. If any of the above conditions exist, replace the valve.

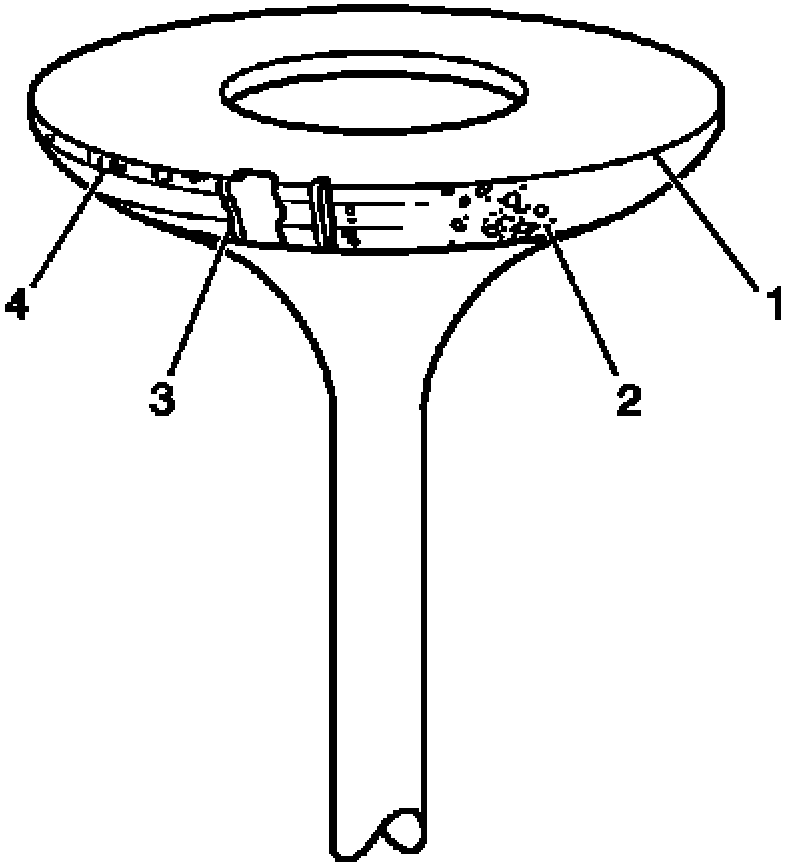


Fig. 347: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

6. Clean the valve guides with a rifle brush and a suitable solvent.
7. Inspect the valves for the following:
   - Burnt or eroded areas (1)
   - A worn margin (2)
   - A bent stem (3)
   - A worn or scored stem (4)
   - A worn or chipped valve keeper groove (5)
   - A worn stem end (6)
   - A bent valve head
8. If the valves are worn or damaged replace the valve.
9. Burrs and minor scratches on the valve stem may be removed with an oil stone.
10. The valve stem end may be reconditioned by grinding. Follow the grinder manufacturer's instructions.

11. If the valve face had pieces broken off, inspect the corresponding piston and cylinder head area for damage.
12. The valves may be lightly lapped to the valve seats.

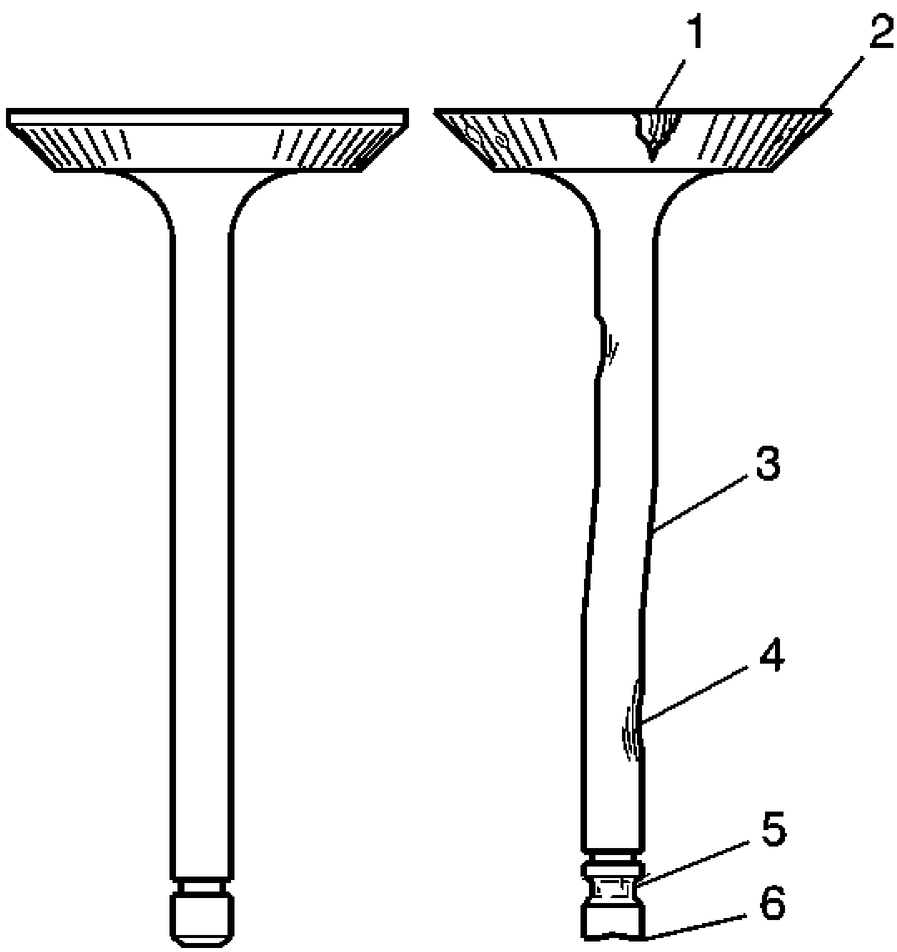


Fig. 348: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

Valve and Seat Inspection

Tools Required

J 8001 Dial Indicator Set. See **Special Tools and Equipment**.

1. Measure the radial runout of the valve head using V-blocks and the **J 8001** . If the runout exceeds specifications, replace the valve.

   Maximum Valve Head Radial Runout: 0.08 mm (0.003 in)

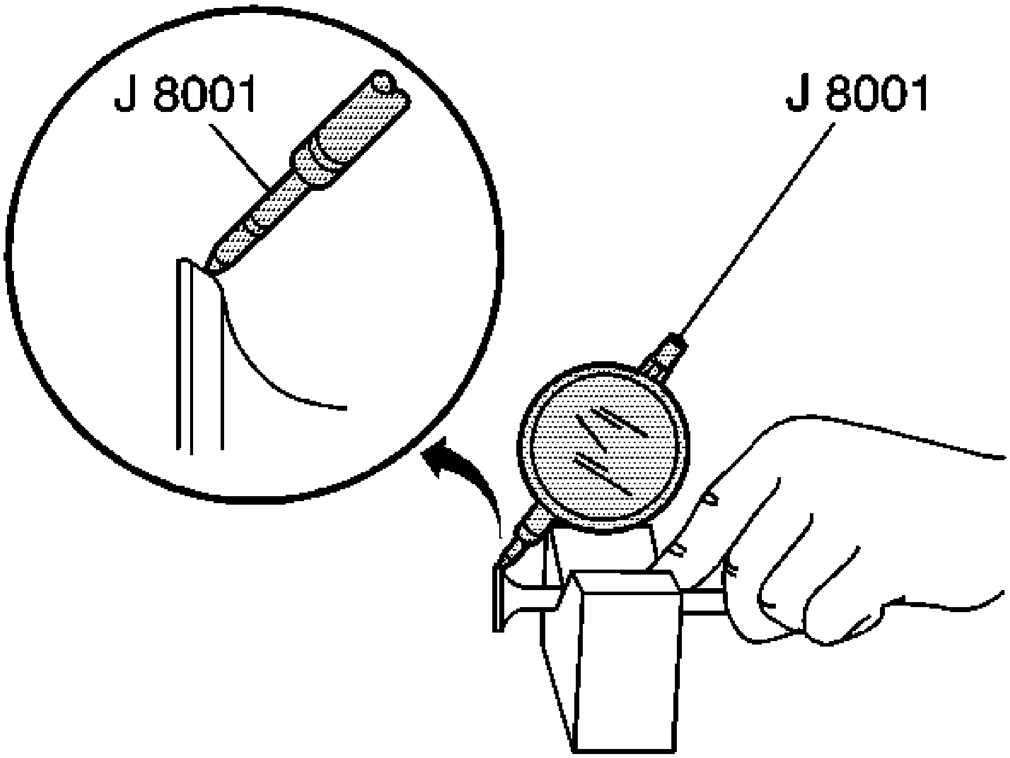


Fig. 349: Measuring Radial Runout Of Valve Head
Courtesy of GENERAL MOTORS CORP.

2. Measure the valve margin (1). If the margin is less than the minimum, replace the valve.

   Standard Intake Valve Margin: 1.0 mm (0.039 in)

   Minimum Intake Valve Margin: 0.6 mm (0.024 in)

   Standard Exhaust Valve Margin: 1.2 mm (0.047 in)

   Minimum Exhaust Valve Margin: 0.7 mm (0.028 in)

3. Use Prussian blue to create a valve face-to-valve seat contact pattern (2) on the valve face. The contact pattern should be uniform around the diameter of the valve, in the middle of the valve face and of the correct width.

   Valve Face-to-Valve Seat Contact Pattern Width: 1.1-1.3 mm (0.043-0.0512 in) for both intake and exhaust valves.

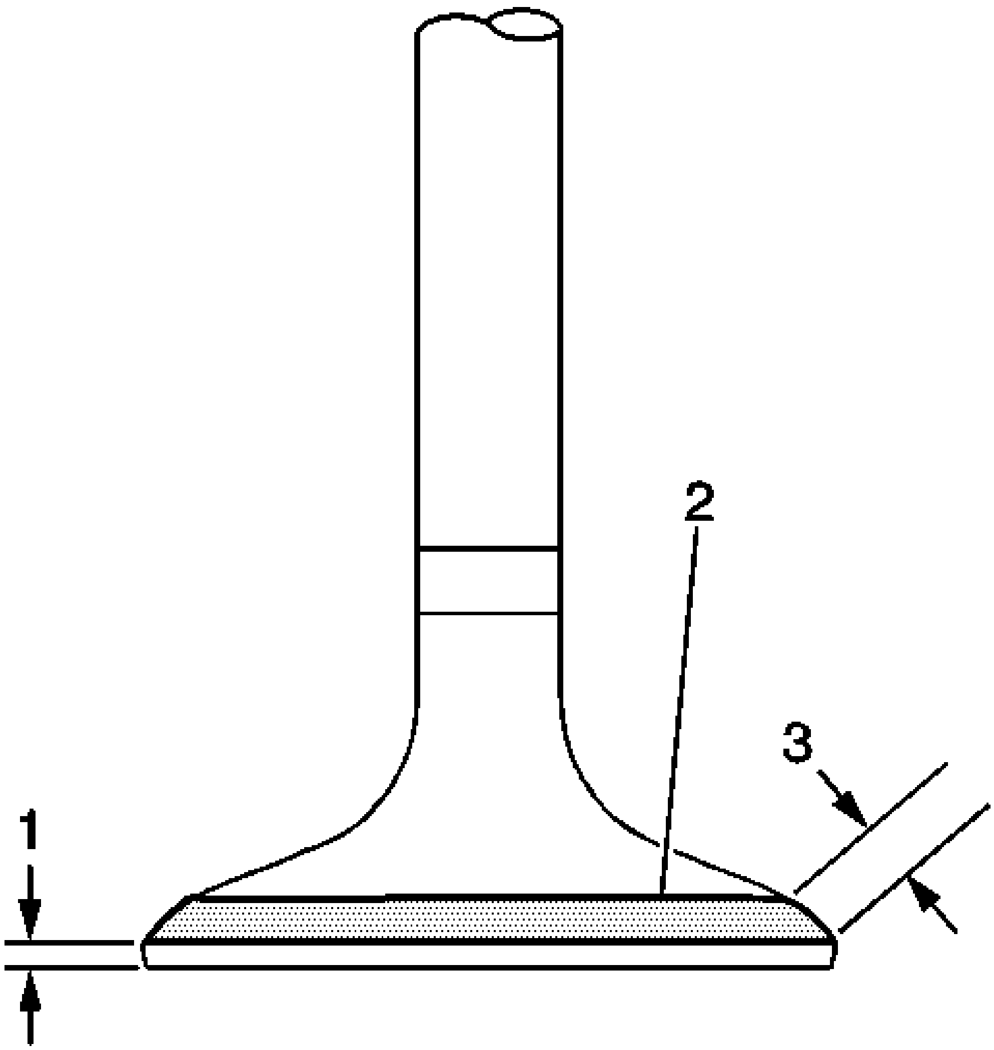


Fig. 350: Measuring Valve Margin
Courtesy of GENERAL MOTORS CORP.

4. Measure the valve contact pattern by performing the following:
    1. Apply a light coating of Prussian blue to the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.
    2. Clean all traces of Prussian blue.
    3. Apply a light coating of Prussian blue to the valve seat and repeat the check. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.

5. Recondition the valve seat and/or replace the valves as necessary.

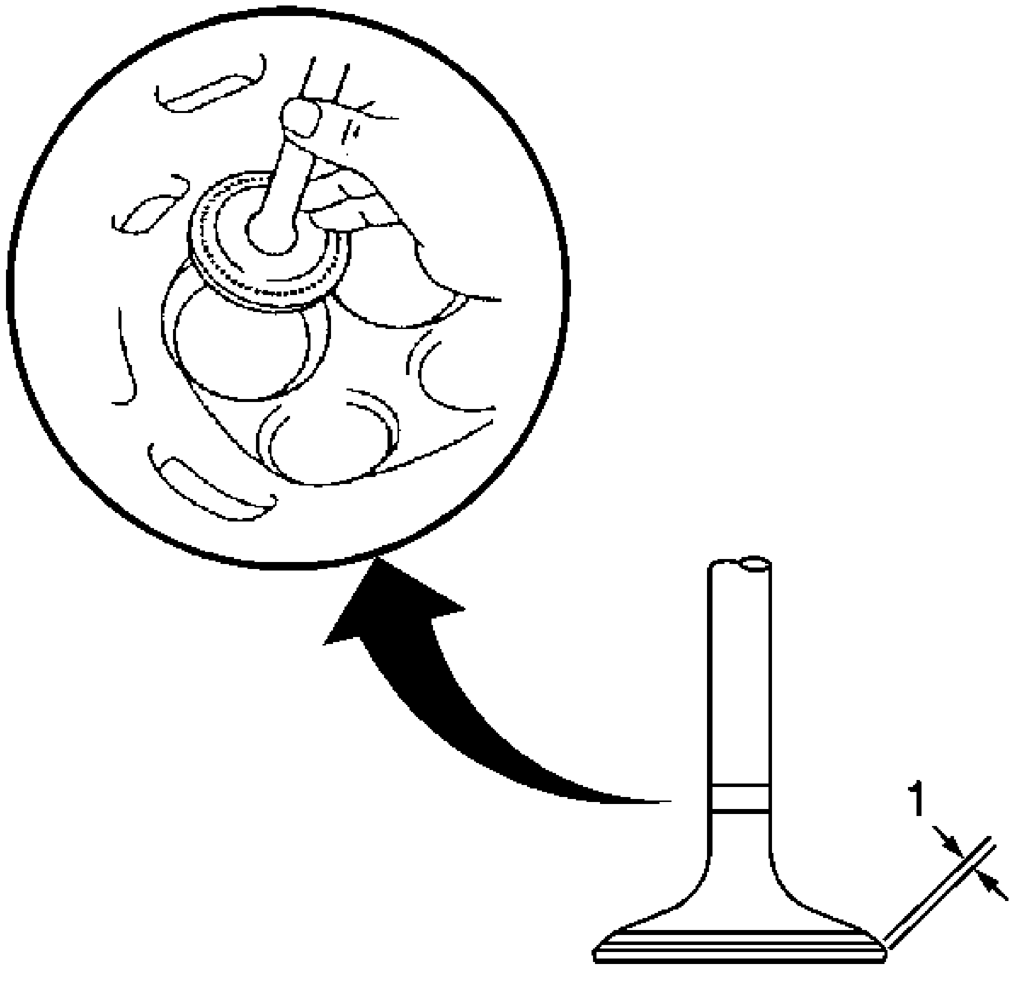


Fig. 351: Measuring Valve Contact Pattern
Courtesy of GENERAL MOTORS CORP.

Valve and Guide Inspection

1. Measure the inside diameter of the valve guide.

   Intake and Exhaust Valve Guide ID: 6.000-6.012 mm (0.2362-0.2366 in)

2. Excessive valve stem to guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive oil consumption.

Insufficient valve stem to guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

3. If the valve guide diameter exceeds specifications, replace the valve and the valve guide.

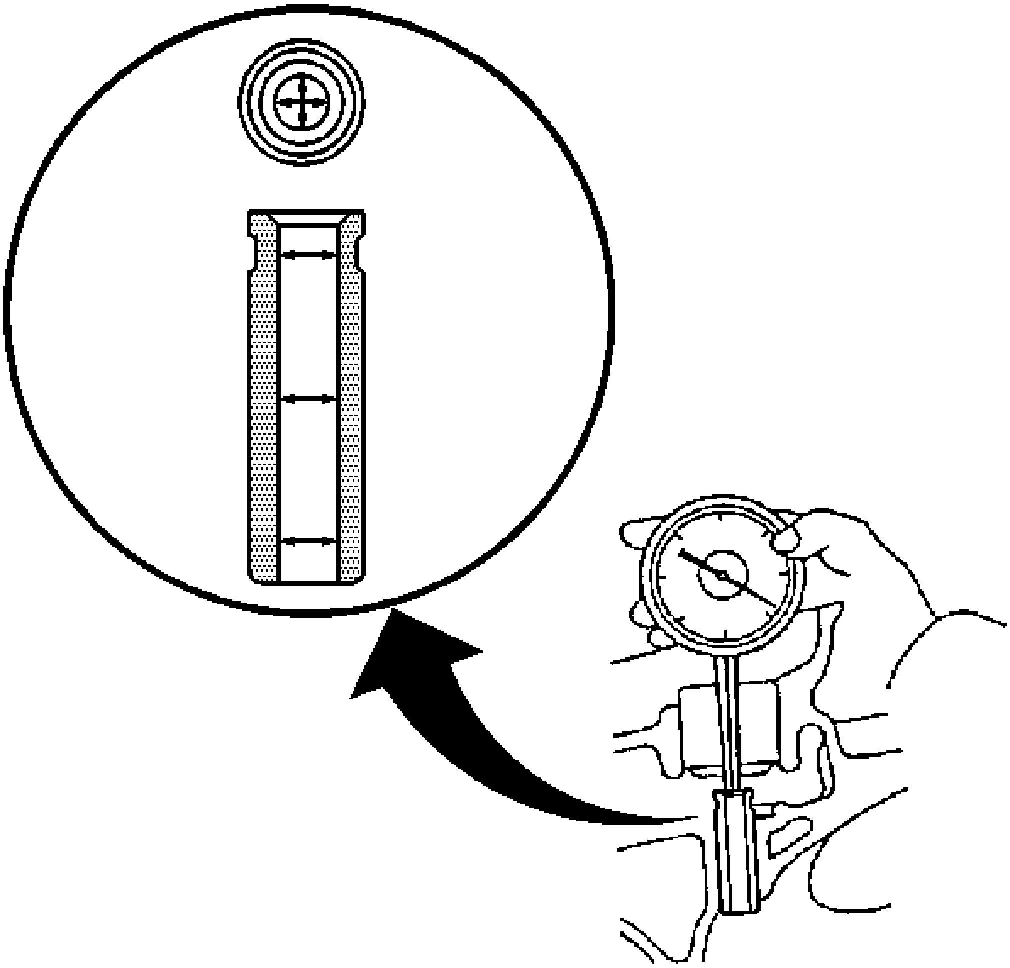


Fig. 352: Measuring Inside Diameter Of Valve Guide
Courtesy of GENERAL MOTORS CORP.

4. Measure the outside diameter of the valve stem using a micrometer.

   Intake Valve Stem OD: 5.965-5.980 mm (0.2348-0.2354 in)

   Exhaust Valve Stem OD: 5.940-5.955 mm (0.2339-0.2344 in)

5. To obtain the valve guide oil (stem-to-guide) clearance, subtract the valve stem outside diameter measurement from the valve guide inside diameter measurement.

   Standard Intake Valve Oil Clearance: 0.020-0.047 mm (0.0008-0.0018 in)

   Maximum Intake Valve Oil Clearance: 0.07 mm (0.0027 in)

   Standard Exhaust Valve Oil Clearance: 0.045-0.072 mm (0.0018-0.0028 in)

   Maximum Exhaust Valve Oil Clearance: 0.09 mm (0.0035 in)

6. If the clearance is greater than the maximum, replace the valve and the valve guide.

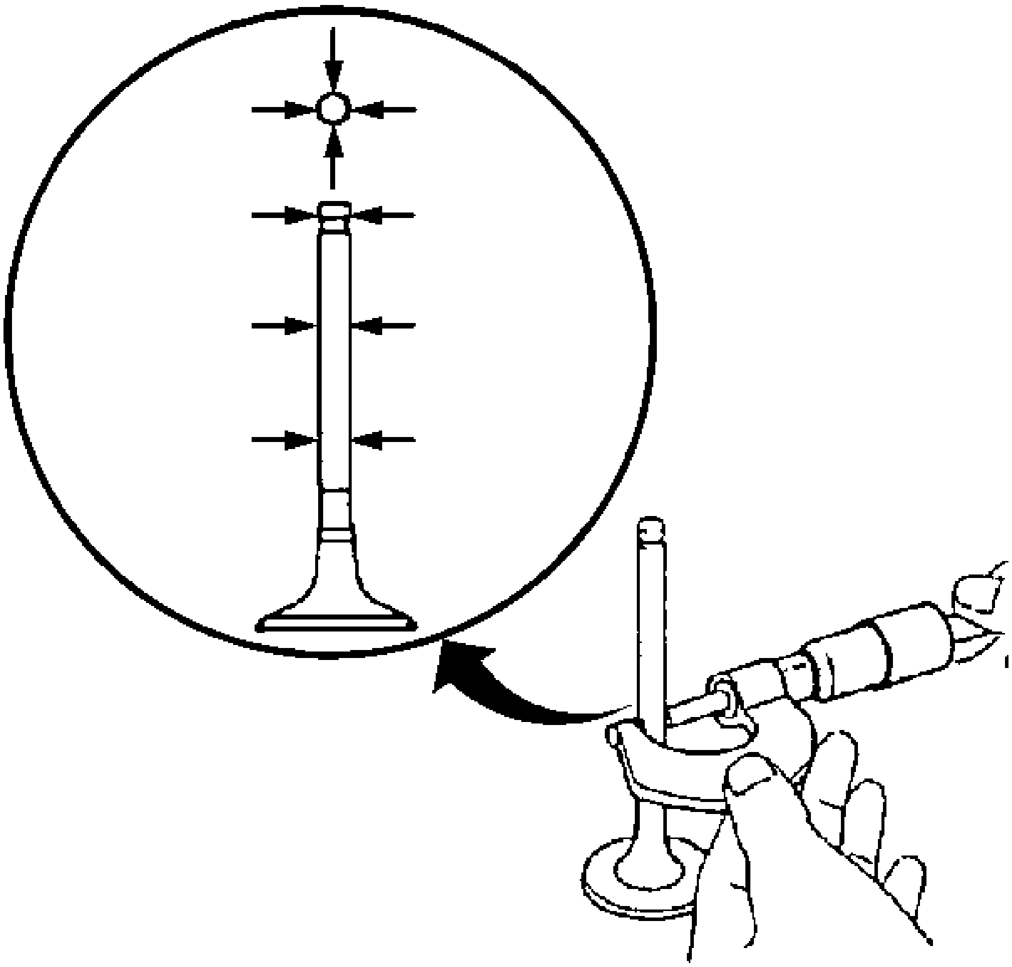


Fig. 353: Measuring Outside Diameter Of Valve Stem
Courtesy of GENERAL MOTORS CORP.

Valve Seat Repair

IMPORTANT: Proper reconditioning of the valve seats is very important. Because the valve guide (2) serves to support and center the valve grinder, it is essential that the valve guide is cleaned properly. If the valve guide requires reaming, this must be done first.

1. Use the following as a general guideline when reconditioning the cylinder head.
   - Ream the valve guide bores first and then recondition the valve seats.
   - Inspect the valve seats for excessive wear and burned spots. Valve seats may be reconditioned by grinding. If grinding results in the new seat being too wide it may be narrowed by using a 20 degree or 70 degree stone. The 20 degree stone will lower the seat and the 70 degree stone will raise the seat.
   - The valves must seat perfectly for the engine to deliver optimum power and performance.
   - Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to insure that the heat in the valve head is properly carried away.
   - Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.
   - The valve seats should be concentric to within 0.05 mm (0.031 in) total indicator reading.
   - Replace any valve that is not in serviceable condition.
   - Several different types of equipment are available for reconditioning valves and valve seats. Use the manufacturers recommendations to obtain proper results.

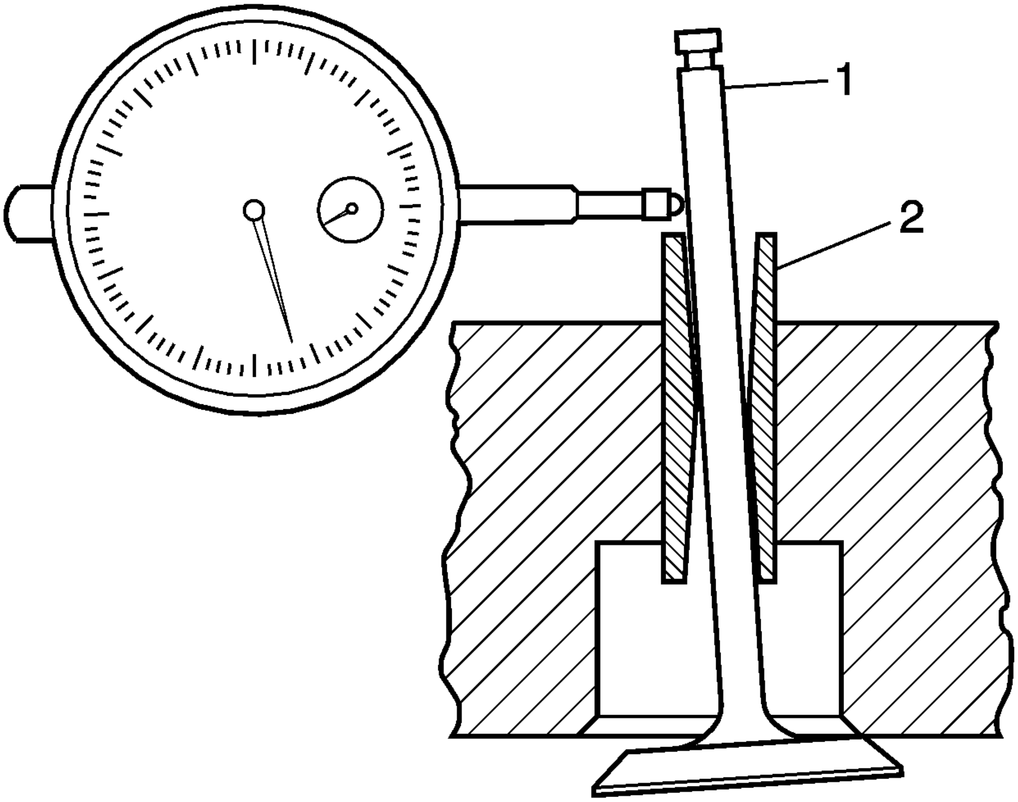


Fig. 354: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. Grind the exhaust valve seat first with a 15 degree stone (1) and then with a 45 degree stone (2).

   Exhaust Valve Seat Width: 1.1-1.3 mm (0.043-0.0512 in)

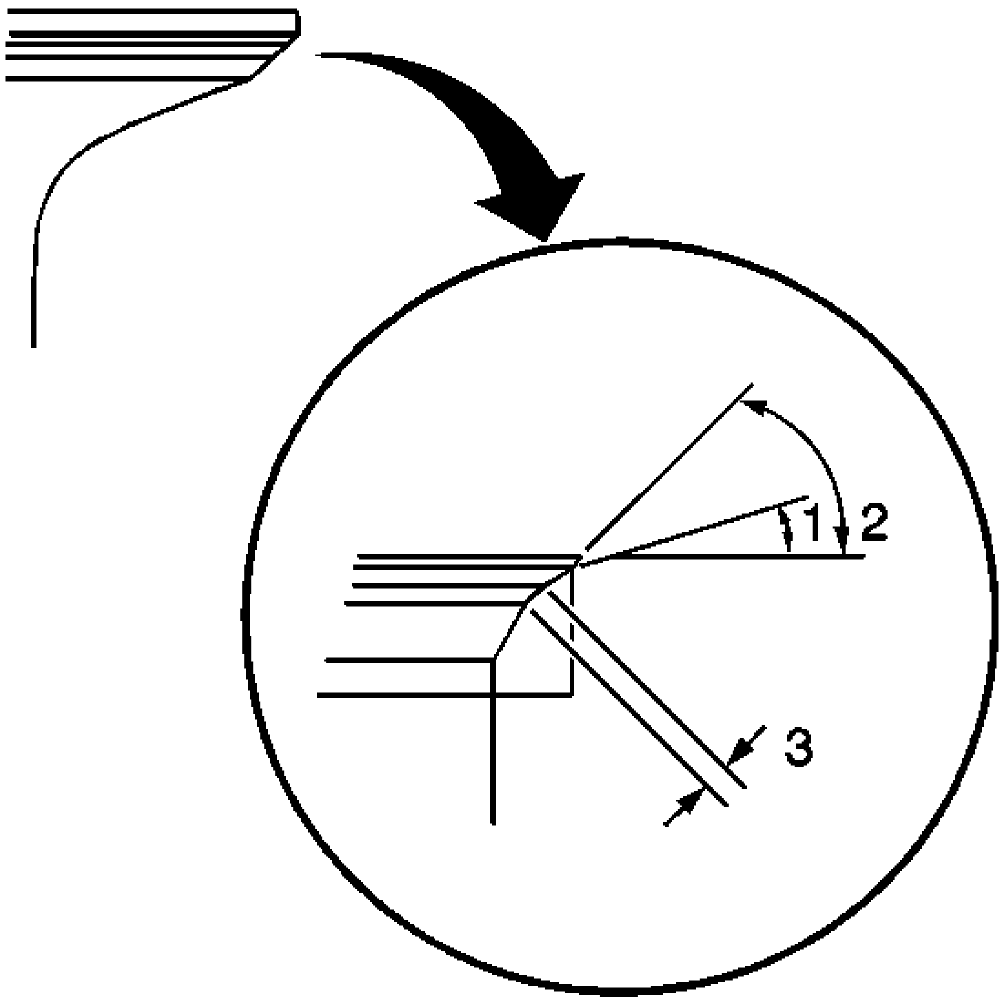


Fig. 355: Grinding Exhaust Valve Seat
Courtesy of GENERAL MOTORS CORP.

3. Grind the intake valve seat first with a 15 degree stone (1), then with a 60 degree stone (3) and then with a 45 degree stone (2).

   Intake Valve Seat Width: 1.1-1.3 mm (0.043-0.0512 in)

4. Lap the valves and seats with a coarse compound and then with a fine compound.
5. Clean all traces of the grinding compound from the valve components before final assembly.

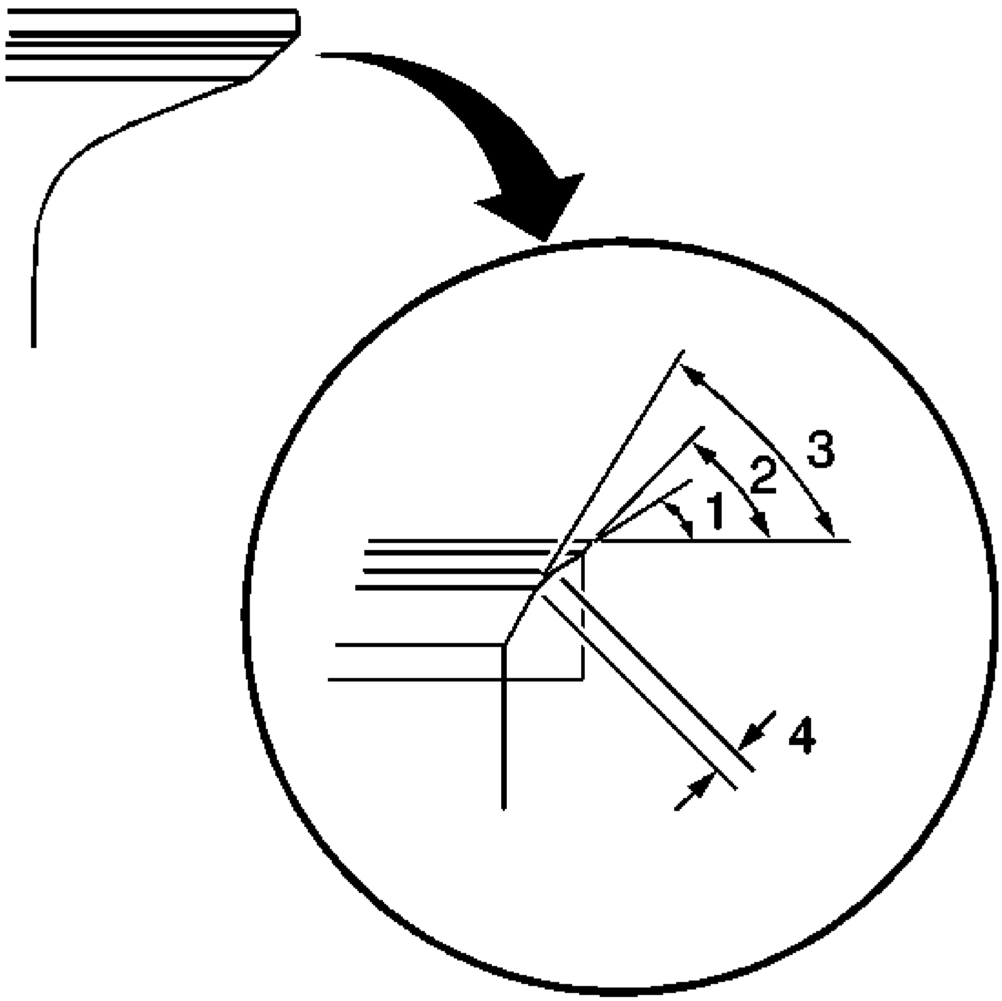


Fig. 356: Grinding Intake Valve Seat
Courtesy of GENERAL MOTORS CORP.

Valve Guide Replacement

Tools Required

- **J 37968** Valve Seal Installer Kit. See **Special Tools and Equipment**.
- **J 37972** Reamer. See **Special Tools and Equipment**.
- **J 43842** Valve Guide Installer. See **Special Tools and Equipment**.
- **J 38342** Reamer 6 mm. See **Special Tools and Equipment**.

1. Tap out the valve guide from the combustion chamber side of the cylinder head using a hammer and the **J 37968** . See **Special Tools and Equipment**.

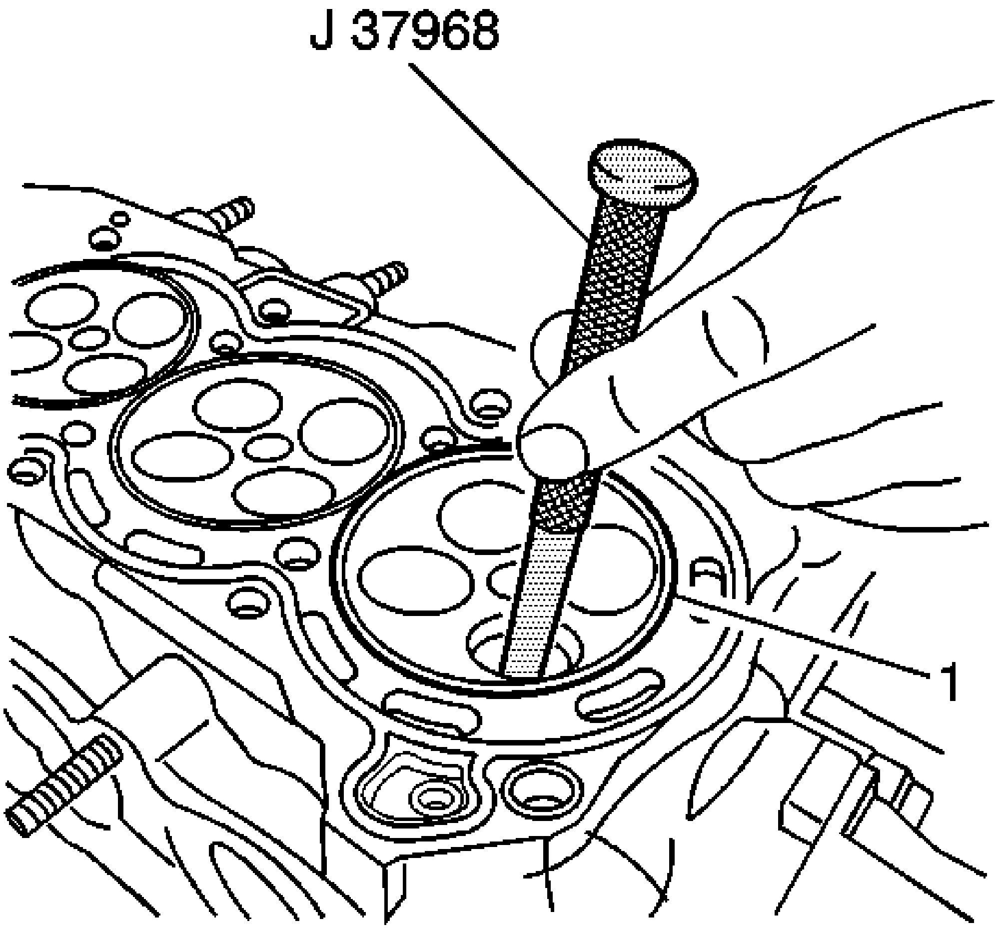


Fig. 357: View Of J 37968
Courtesy of GENERAL MOTORS CORP.

NOTE: **Clean the valve guides before reaming. Packing of chips or carbon may result in the reamer jamming into the valve guide or broken reamer flutes.**

2. Ream the valve guide bore with the **J 37972** 11 mm reamer (1). See **Special Tools and Equipment**.

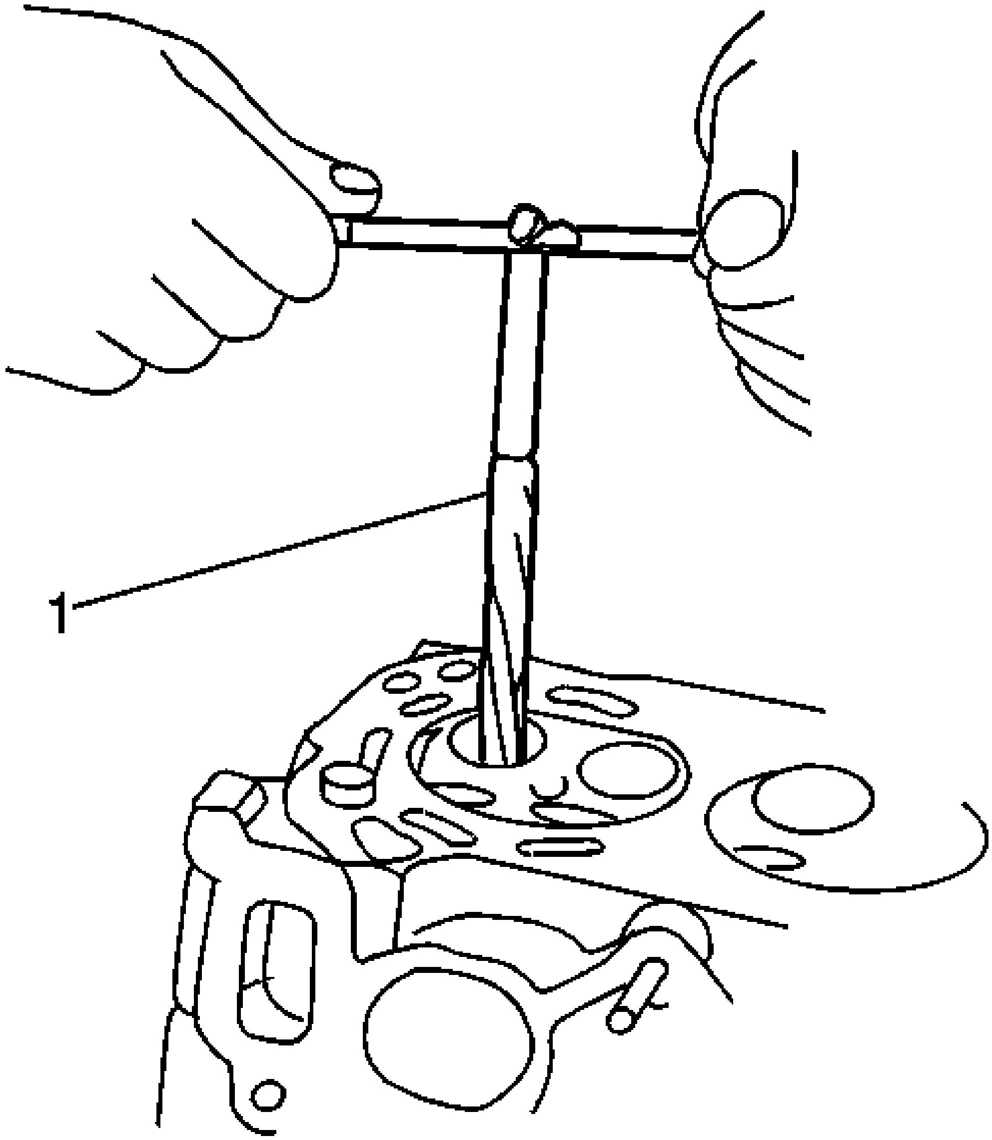


Fig. 358: View Of J 37972 11 mm Reamer
Courtesy of GENERAL MOTORS CORP.

3. Gradually heat the cylinder head to 80-100°C (176-212°F).

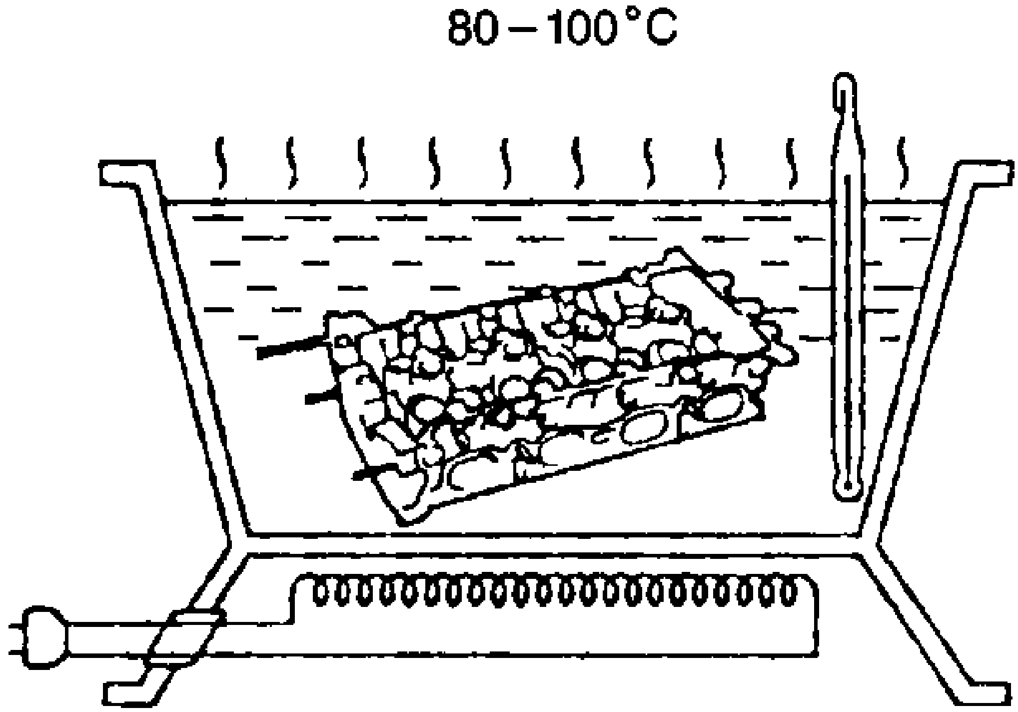


Fig. 359: Heating Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Intake and exhaust valve guides are identical. The new valve guide is 0.03 mm (0.0012 in) oversized. Intake and exhaust valve guides should protrude 13.5 mm (0.53 in) above the cylinder head surface.

4. Tap the new (oversized) valve guide into the cylinder head from the camshaft side using the **J 37968** , the. See **Special Tools and Equipment**.**J 43842** and a hammer. See **Special Tools and Equipment**.
5. Install the valve guide to the specified protrusion height of 13.5 mm (0.53 in). The **J 43842** should bottom out on the cylinder head when the specified protrusion height is reached. See **Special Tools and Equipment**.

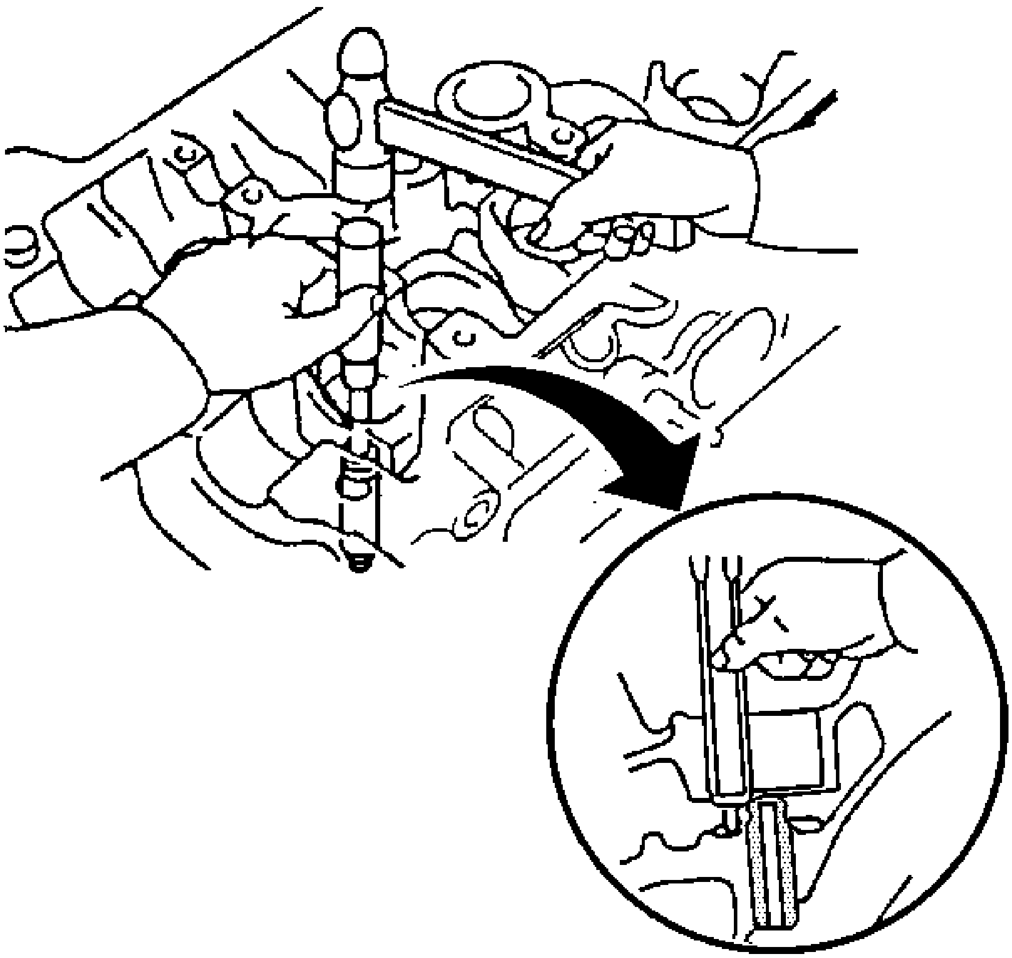


Fig. 360: Installing New Valve Guide Into Cylinder Head From Camshaft Side
Courtesy of GENERAL MOTORS CORP.

6. Ream the new valve guide with the **J 38342** 6 mm reamer. See **Special Tools and Equipment**.

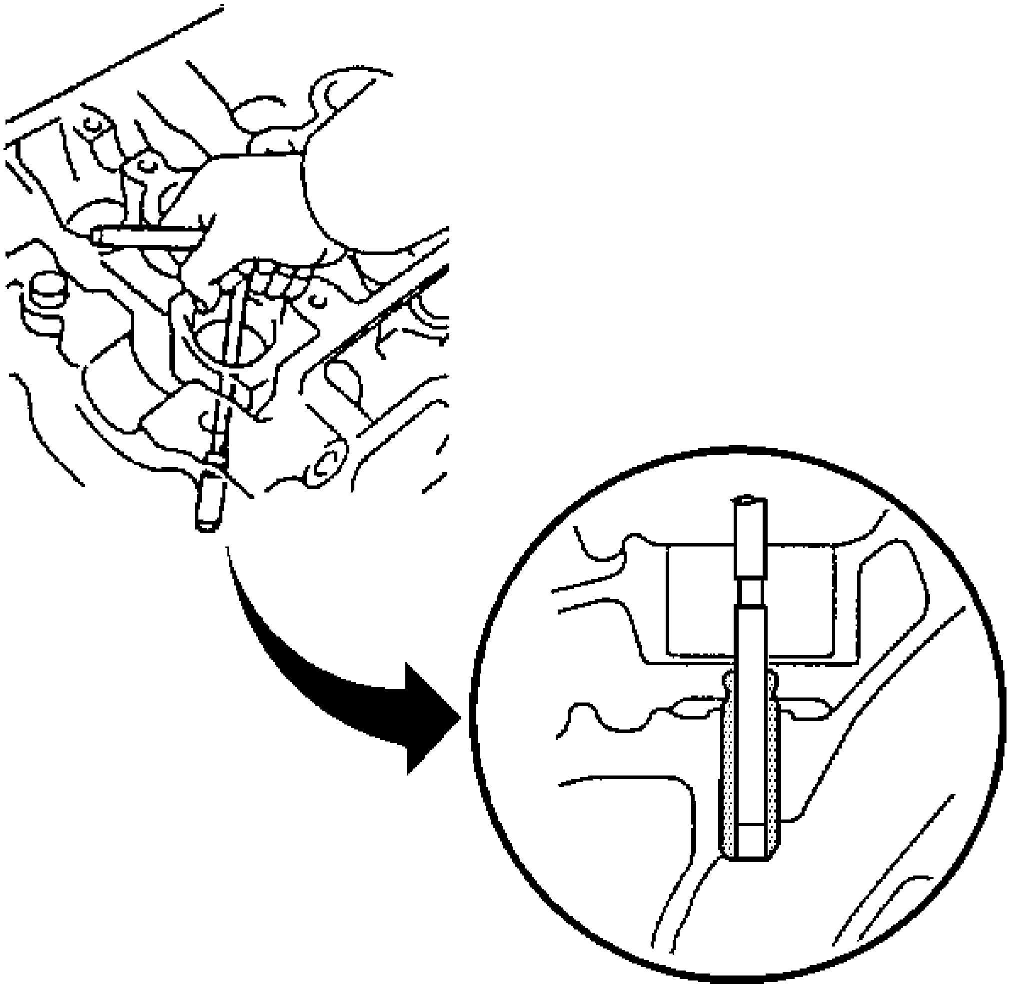


Fig. 361: Reaming New Valve Guide
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Assemble

Tools Required

- **J 8062** Valve Spring Compressor. See **Special Tools and Equipment**.
- **J 37979** Valve Spring Compressor Adaptor. See **Special Tools and Equipment**.
- **J 38232** Valve Guide Seal Installer. See **Special Tools and Equipment**.

1. Install the spring seat to the cylinder head.

2. Install the new valve seals using the **J 38232** . See **Special Tools and Equipment**. Fully seat the seals on the valve guides.
3. Apply engine oil to the valve stem. Install the valve.

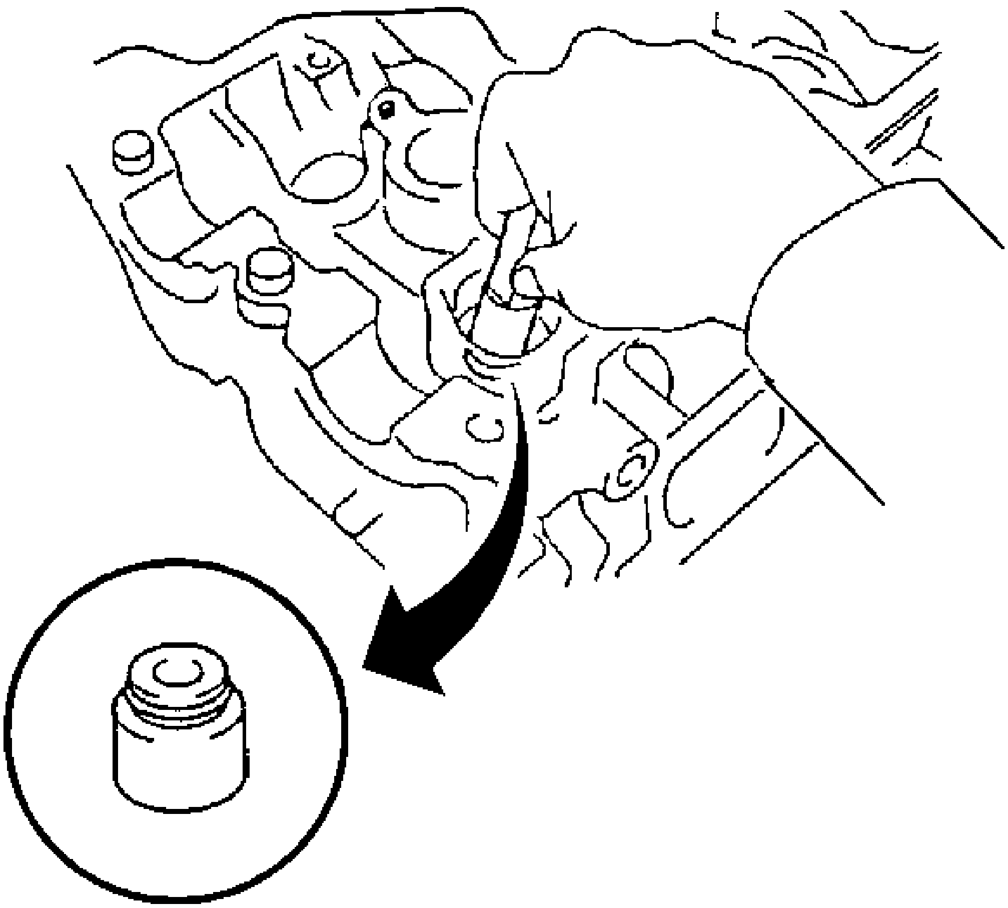


Fig. 362: Installing Spring Seat To Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Both the inner and outer valve springs have a top (large-pitch) and bottom (small pitch) end. Install the small-pitch end toward the valve spring seat.

4. Install the springs.
5. Install the retainer.

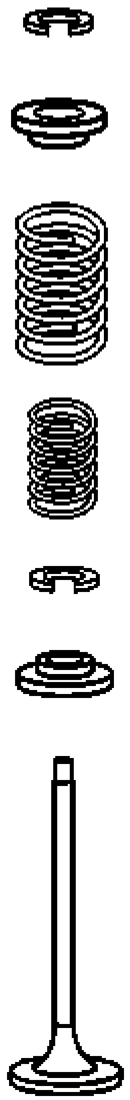


Fig. 363: Installing Retainer, Inner & Outer Valve Springs
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed

by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

6. Compress the valve spring using the **J 8062** and the. See **Special Tools and Equipment**.**J 37979** . See **Special Tools and Equipment**.
7. Install the valve keepers.
8. Slowly release the **J 8062** from the valve/spring assembly. See **Special Tools and Equipment**.

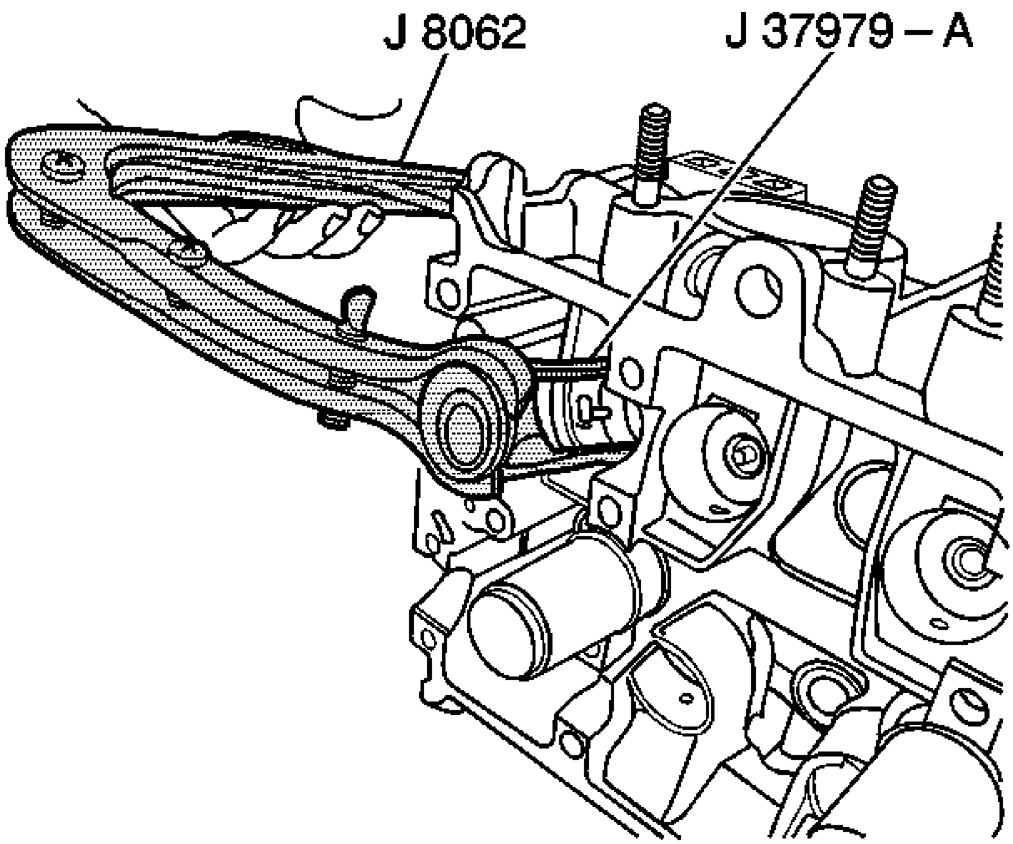


Fig. 364: View Of J 8062 & J 37979
Courtesy of GENERAL MOTORS CORP.

9. Lightly tap the valve stem tip with a plastic faced hammer and inspect for proper valve keeper seating.

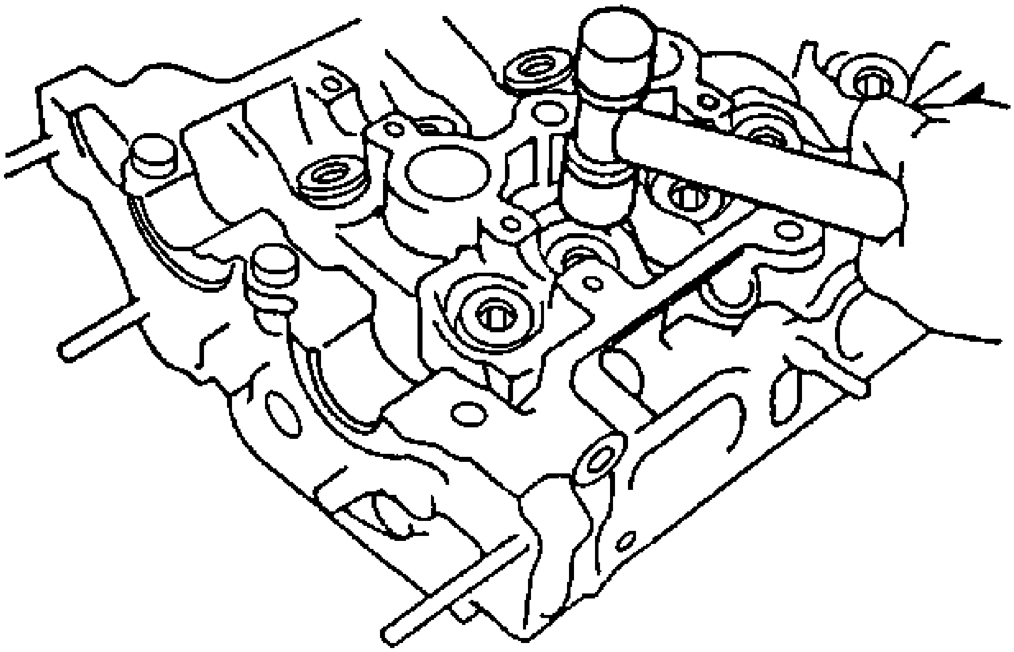


Fig. 365: Inspecting For Proper Valve Keeper Seating
Courtesy of GENERAL MOTORS CORP.

Oil Pump Disassemble

IMPORTANT:
- **Do not remove the oil pump sprocket. Damage to the oil pump drive shaft or abnormal oil pump operation may result.**
- **If the oil pump is found to be damaged or worn excessively replace the oil pump as an assembly.**

1. Remove the 5 bolts and separate the oil pump halves.

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

2. Remove the retainer (2), the spring (3) and the relief valve (4).
3. Apply light air pressure to the oil jet. Inspect the oil jet for damage or clogging.
4. Remove and inspect the relief valve. Coat the relief valve with oil and check that it falls smoothly into the valve hole by its own weight.

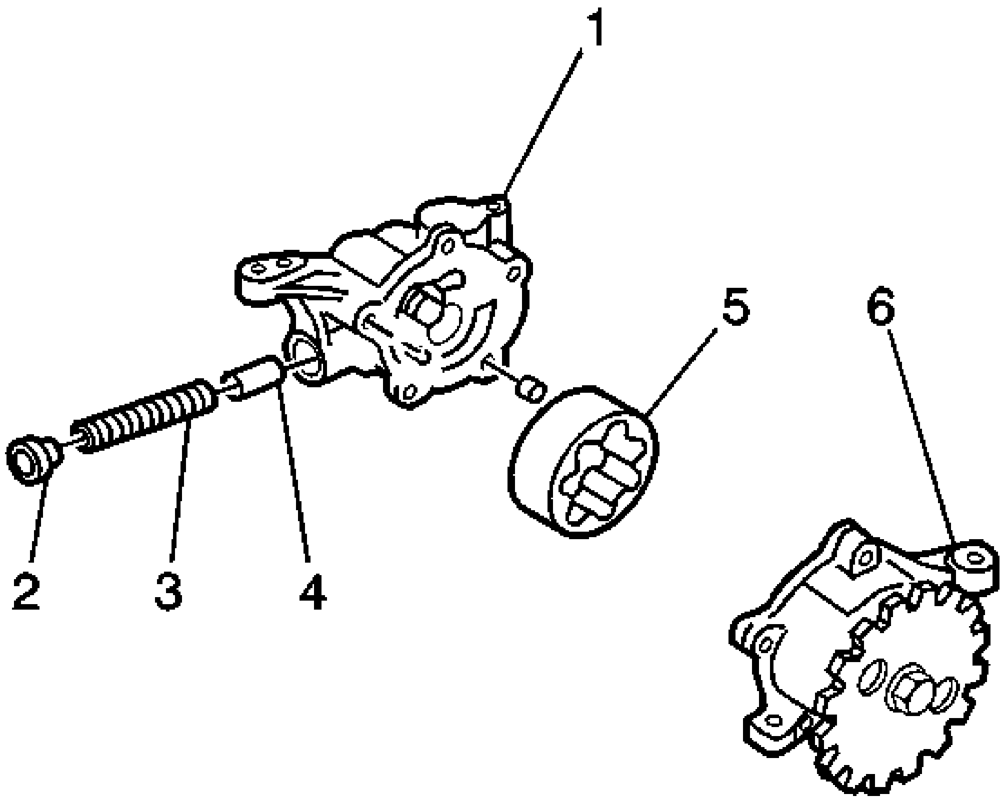


Fig. 366: View Of Relief Valve, Retainer & Spring
Courtesy of GENERAL MOTORS CORP.

Oil Pump Cleaning and Inspection

IMPORTANT: If the oil pump is found to be damaged or excessively worn replace the oil pump as an assembly.

1. Inspect the following for excessive wear or damage:
   - The oil pump outer gear
   - The oil pump inner gear
   - The oil pump cover
   - The oil pump body
2. Measure the radial clearance between the oil pump outer gear and the oil pump body using a feeler gauge.

   Replace the oil pump if the clearance exceeds 0.15 mm (0.0059 in).

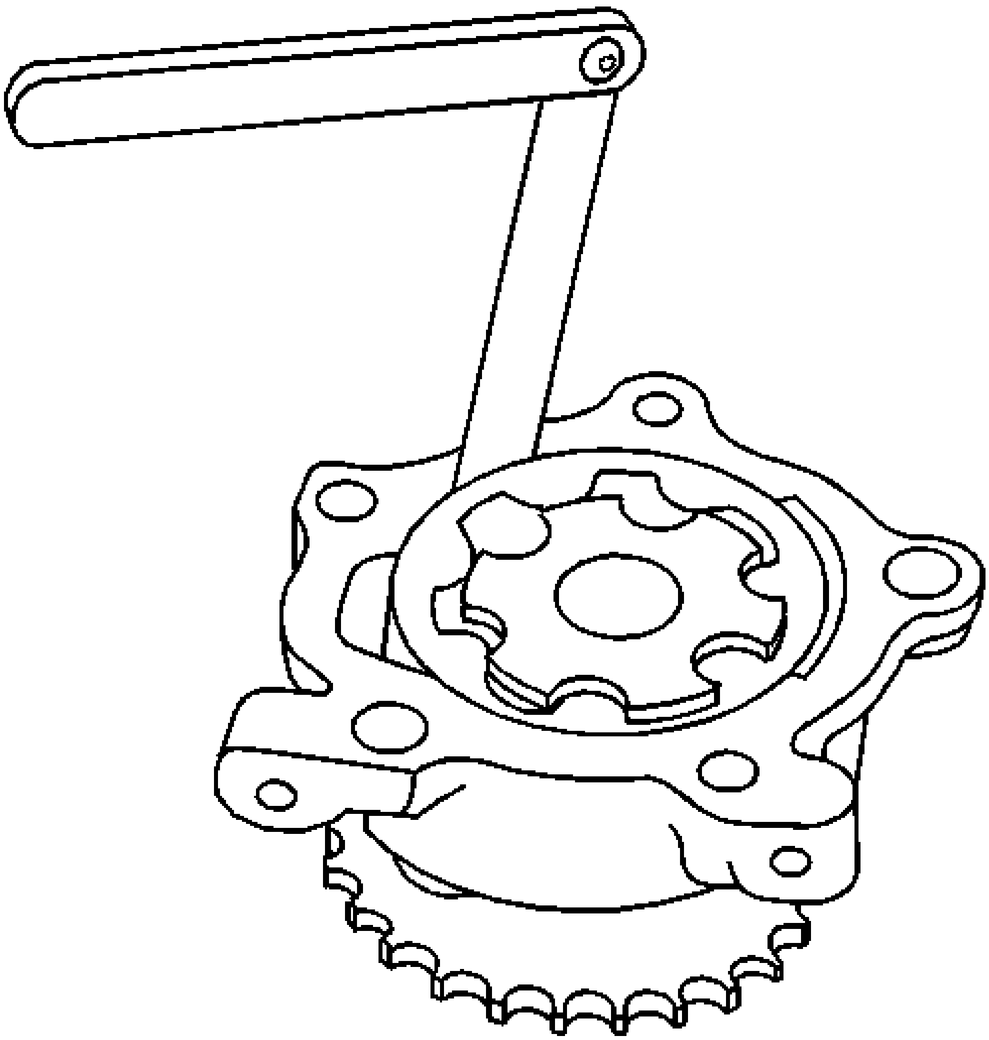


Fig. 367: Measuring Radial Clearance Between Oil Pump Outer Gear & Oil Pump Body
Courtesy of GENERAL MOTORS CORP.

3. Measure the side clearance between the oil pump gears and a straightedge using a feeler gauge.

   Replace the oil pump if the clearance exceeds 0.11 mm (0.0043 in).

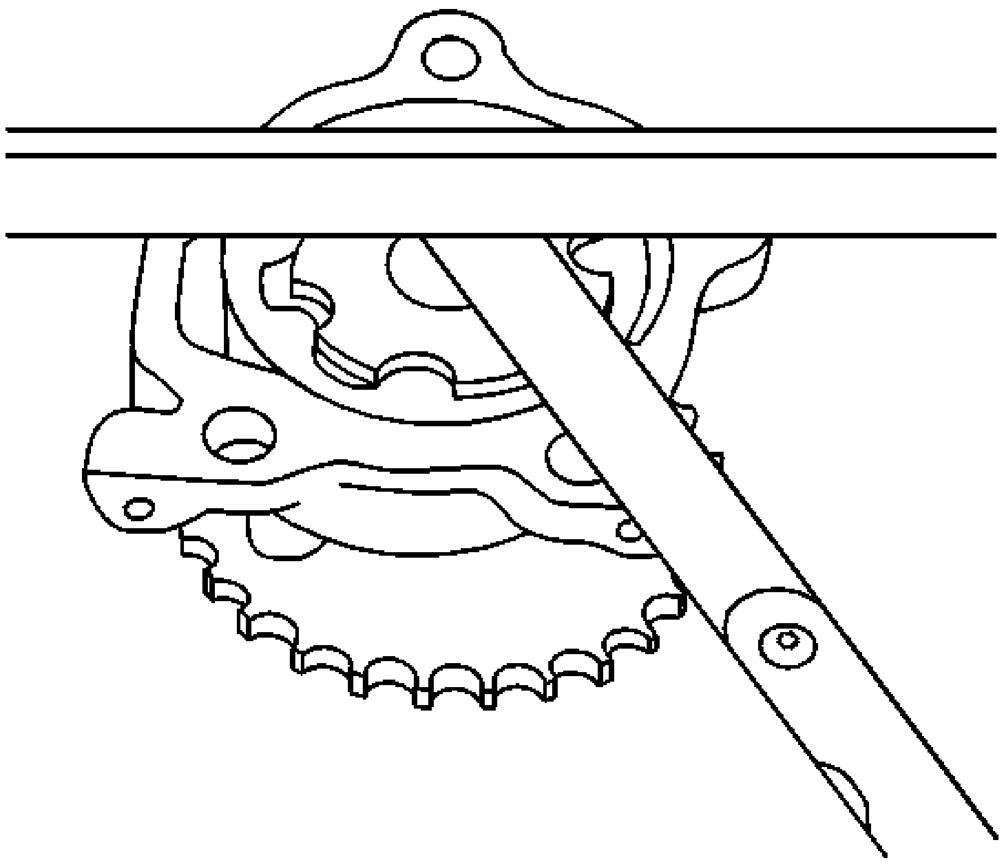


Fig. 368: Measuring Side Clearance Between Oil Pump Gears & Straightedge
Courtesy of GENERAL MOTORS CORP.

4. Measure the free length of the oil pressure relief spring.

   Replace the spring if the free length is less than 63.5 mm (2.5 in).

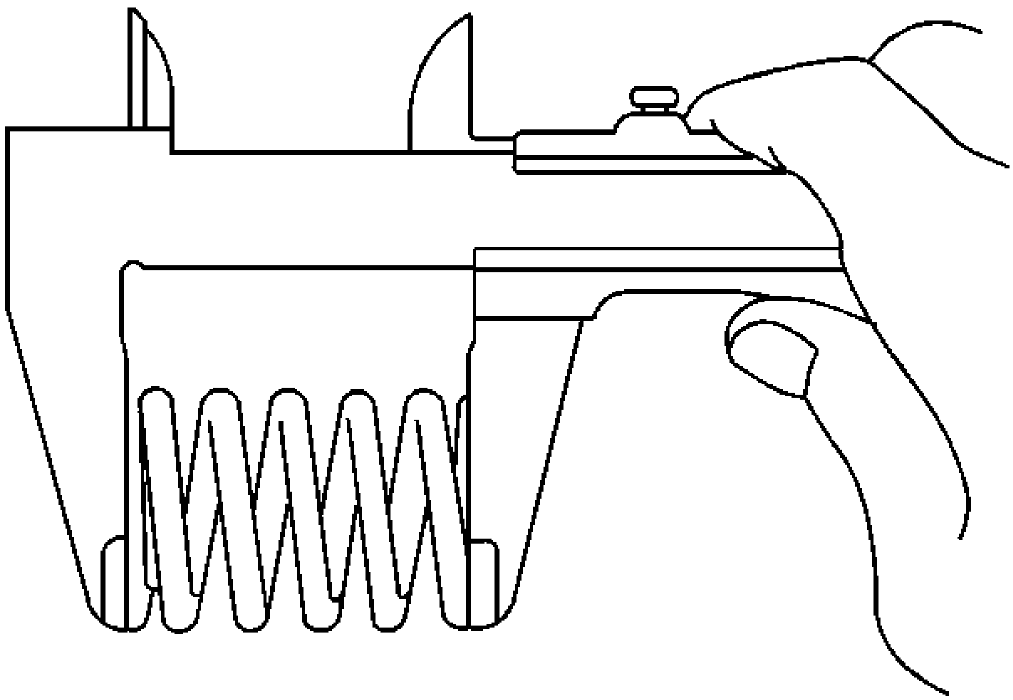


Fig. 369: Measuring Free Length Of Valve Springs
Courtesy of GENERAL MOTORS CORP.

5. Measure the oil pressure relief spring tension.

   Replace the spring if the tension is less than 86.0 N.m at 52 mm (62 lb at 2.05 in).

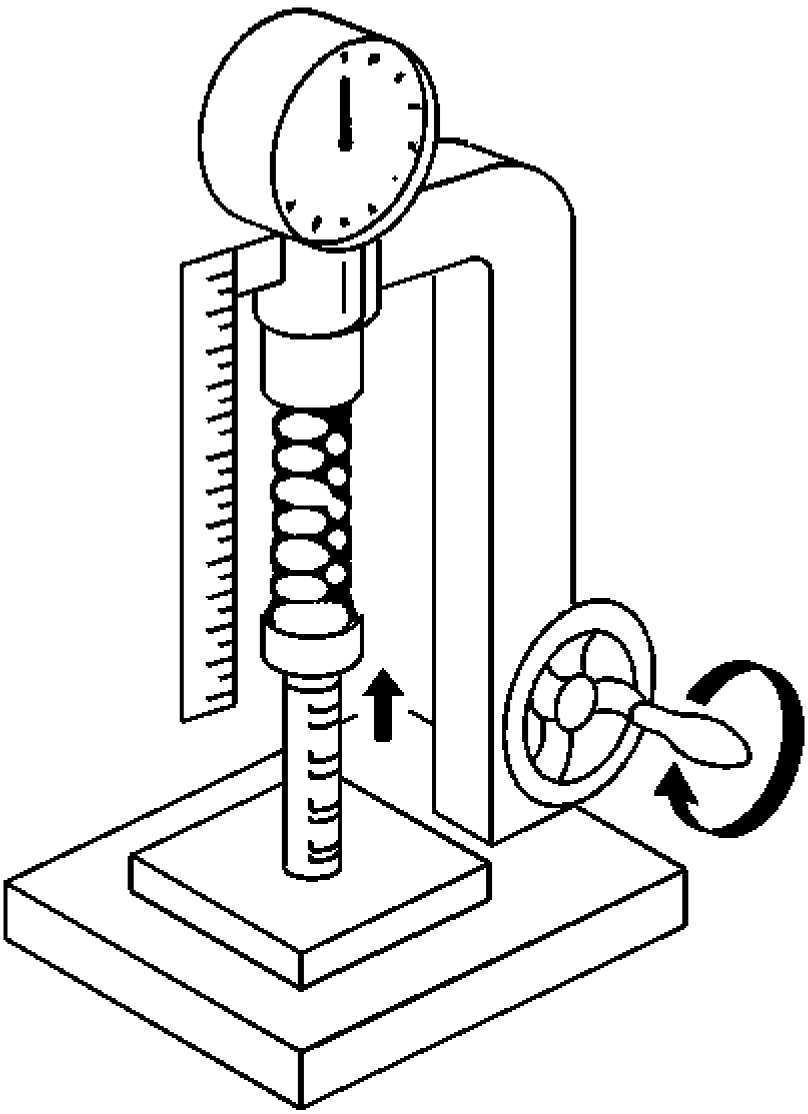


Fig. 370: Measuring Tension Of Valve Spring At Specified Installed Height
Courtesy of GENERAL MOTORS CORP.

Oil Pump Assemble

1. Lubricate the following with clean engine oil.
   - The oil pump inner gear
   - The oil pump outer gear

- The inside surface of the oil pump body

2. Install the oil pump outer and inner gears to the oil pump body.

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.

3. Fill the oil pump with petroleum jelly to prime the oil pump.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the relief valve (4), the spring (3) and the retainer (2).

   Tighten: Tighten the retainer to 29 N.m (21 lb ft).

5. Install the oil pump cover to the oil pump body. Secure the cover with 5 bolts.

   Tighten: Tighten the bolts to 12 N.m (9 lb ft).

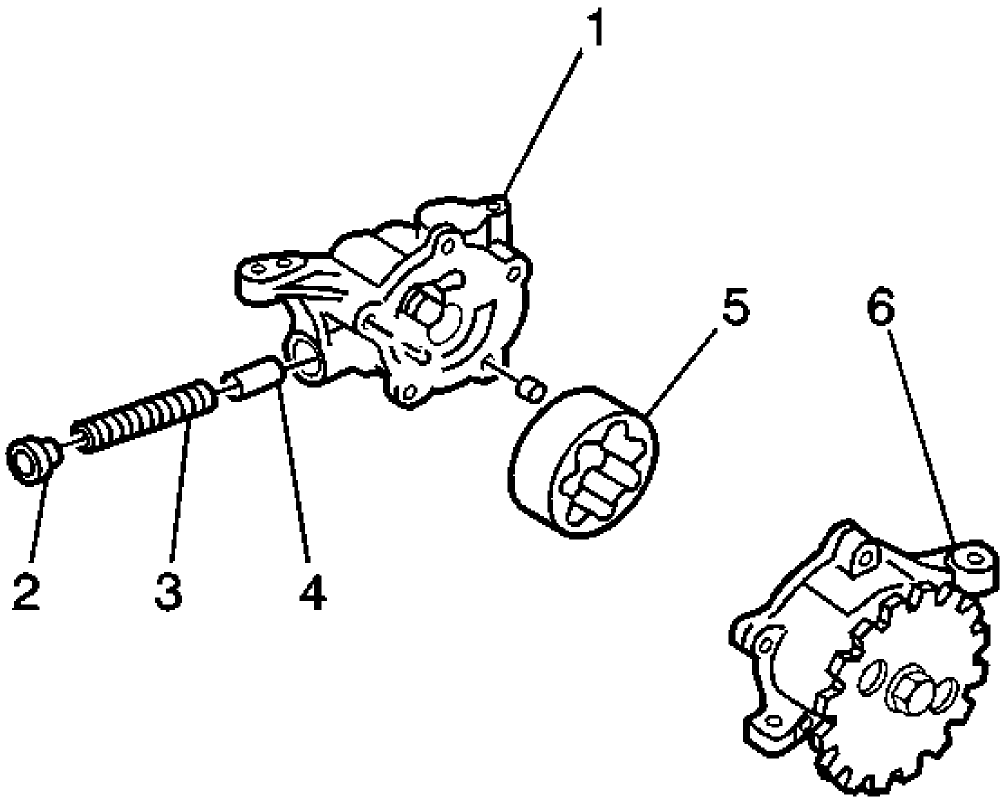


Fig. 371: View Of Relief Valve, Retainer & Spring
Courtesy of GENERAL MOTORS CORP.

Oil Pan Cleaning and Inspection

1. Clean the oil pan. Remove all the sludge and the oil deposits.
2. Clean the oil pan mating surface.
3. Inspect the threads for the engine oil drain plug.
4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
5. Inspect the oil pan for cracking resulting from impact or flying road debris.
6. Repair or replace the oil pan as necessary.

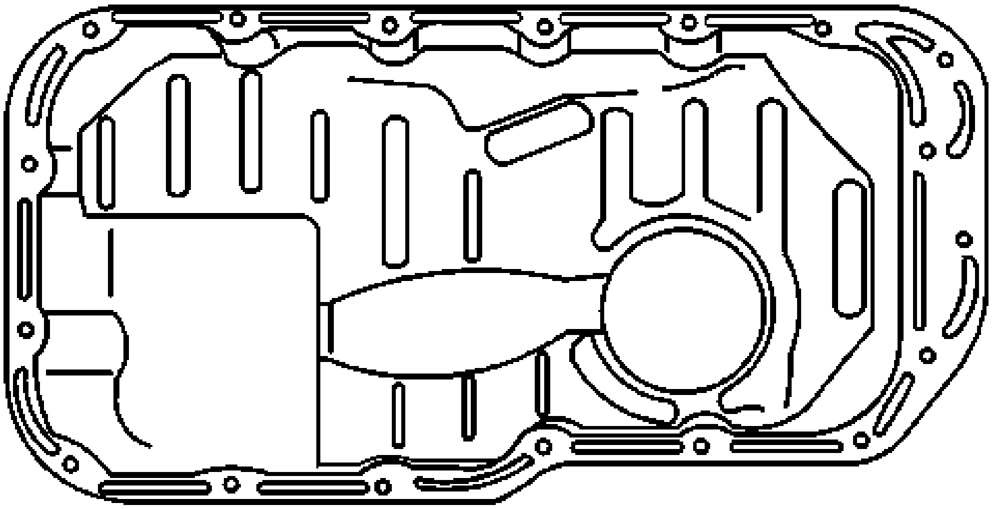


Fig. 372: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

Intake Manifold Cleaning and Inspection

1. Clean the intake manifold and the mating surfaces.
2. Inspect the intake manifold for the following:
   - Damage
   - Cracks near the mounting holes
   - Blockage in the crankcase ventilation passages
3. Use a straight edge and a feeler gauge and measure the intake manifold mounting surface for warpage.

   Intake Manifold Maximum Warpage: 0.10 mm (0.004 in)

4. If the warpage is greater than the maximum, replace the intake manifold.

Exhaust Manifold Cleaning and Inspection

IMPORTANT:
- **Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a new gasket.**
- **An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.**
- **For vehicles equipped with the PUP catalytic converter, do not splash any**

solvent into the converter element.

1. Clean the exhaust manifold with solvent.

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

2. Dry the exhaust manifold with compressed air.
3. Inspect for a loose or damaged heat shield.
4. Clean the exhaust manifold mating surface.
5. Measure the exhaust manifold mounting face for warpage using a straight edge and a feeler gauge.

   Exhaust Manifold Maximum Warpage: 0.10 mm (0.004 in)

6. If the warpage is greater than the maximum, replace the exhaust manifold.

Thread Repair

Damaged threads may be reconditioned by drilling out, rethreading and installing a suitable thread insert. General purpose thread repair kits are available commercially.

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

IMPORTANT: Refer to the kit manufacturer's instructions regarding the size of the drill and tap to be used.

1. Determine the size, pitch and depth of the damaged thread. If necessary, adjust the stop collars on the cutting tool and tap to the required depth.
2. Drill out the damaged thread.
3. Clean the drilling chips out of the hole.

IMPORTANT: Avoid a buildup of chips. Back out of the tap every few turns and remove the chips.

4. Tap the hole. Lubricate the tap with light engine oil (except aluminum).

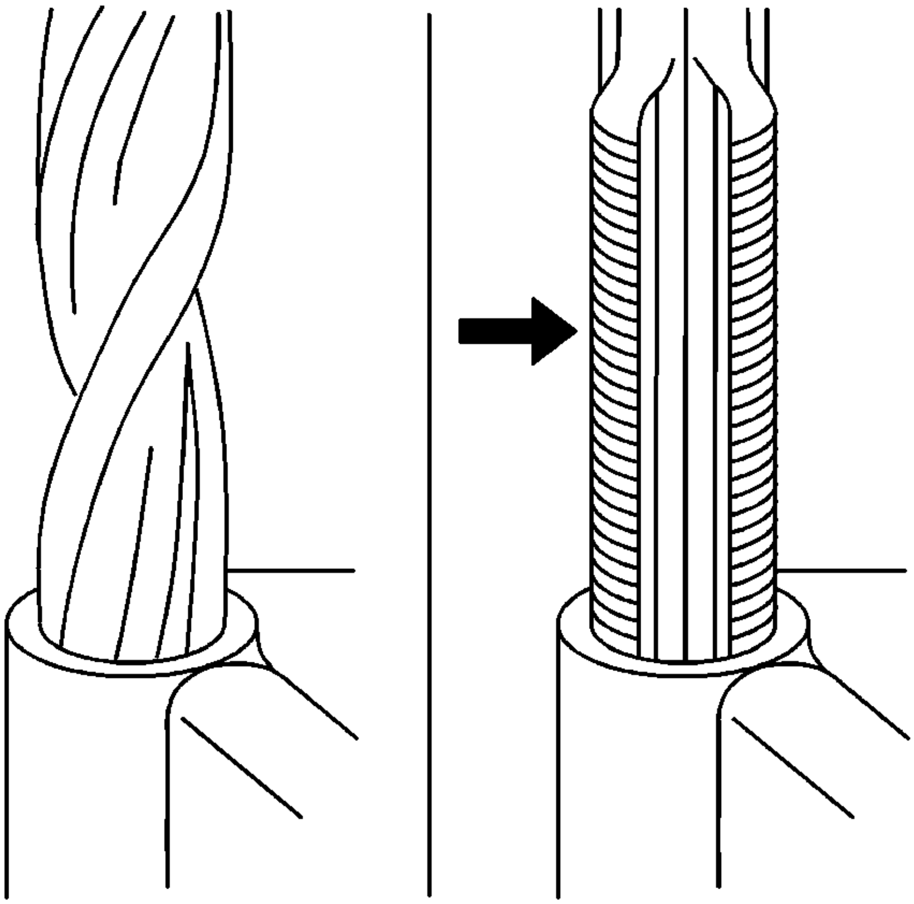


Fig. 373: Drilling & Tapping Damaged Threads
Courtesy of GENERAL MOTORS CORP.

5. Thread the insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

IMPORTANT: When correctly installed, the insert should be flush to one turn below the surface.

6. Lubricate the insert with light engine oil (except when installing into aluminum) and install the insert.
7. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift punch.

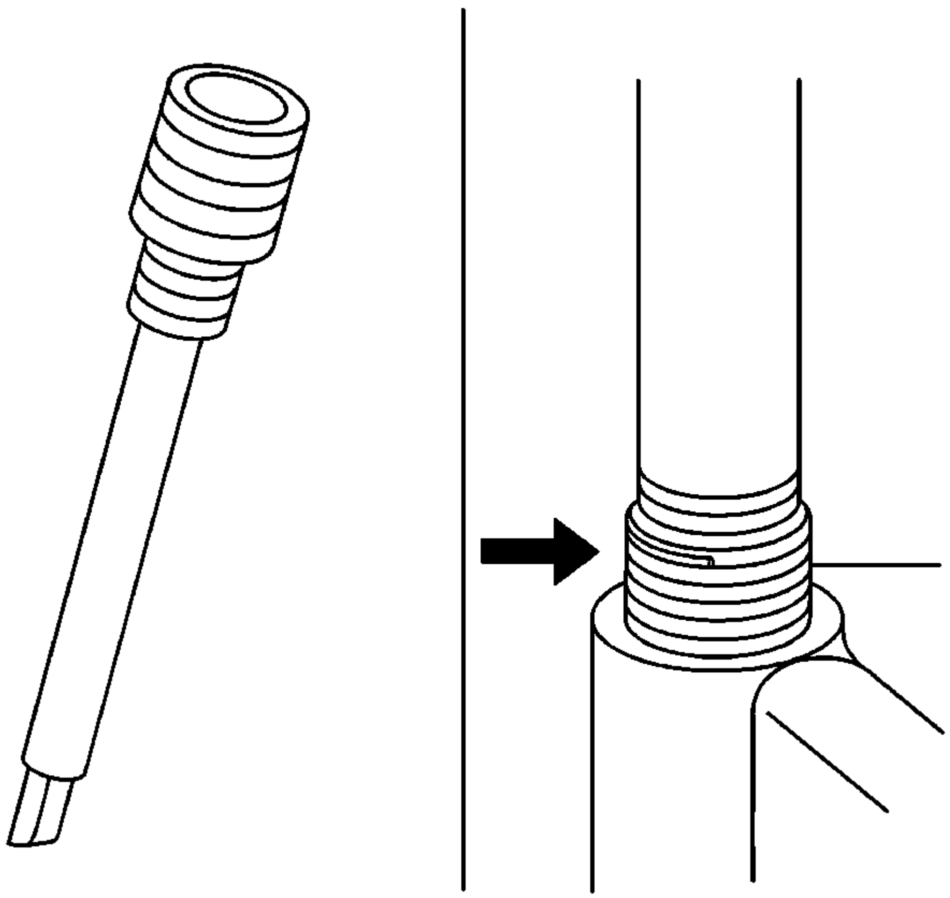


Fig. 374: Installing Thread Insert
Courtesy of GENERAL MOTORS CORP.

Service Prior to Assembly

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in 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 in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

Crankshaft and Bearings Installation

IMPORTANT: The upper main bearings have an oil groove and oil holes, the lower bearings do not have oil grooves or oil holes.

1. Install the upper main bearings into the cylinder block and lubricate with engine oil.

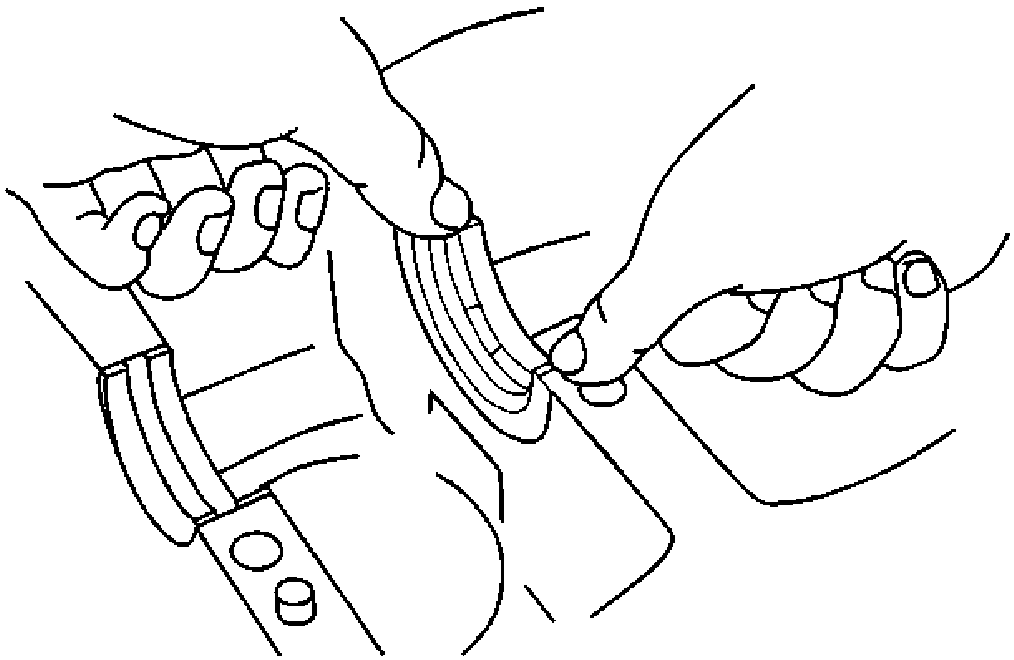


Fig. 375: Installing Upper Main Bearings Into Cylinder Block
Courtesy of GENERAL MOTORS CORP.

2. Install the lower main bearings into the lower crankcase and lubricate with engine oil.

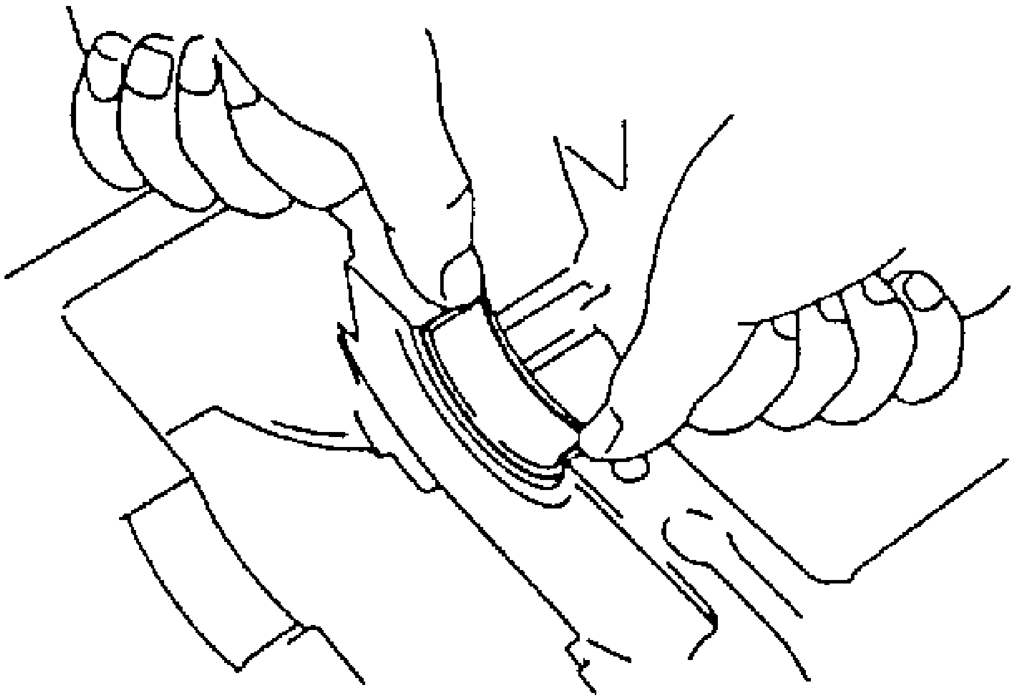


Fig. 376: Installing Lower Main Bearings Into Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the upper thrust bearing washers with the oil groove (2) facing outward.

3. Install the two upper thrust bearing washers into the cylinder block and lubricate with engine oil.

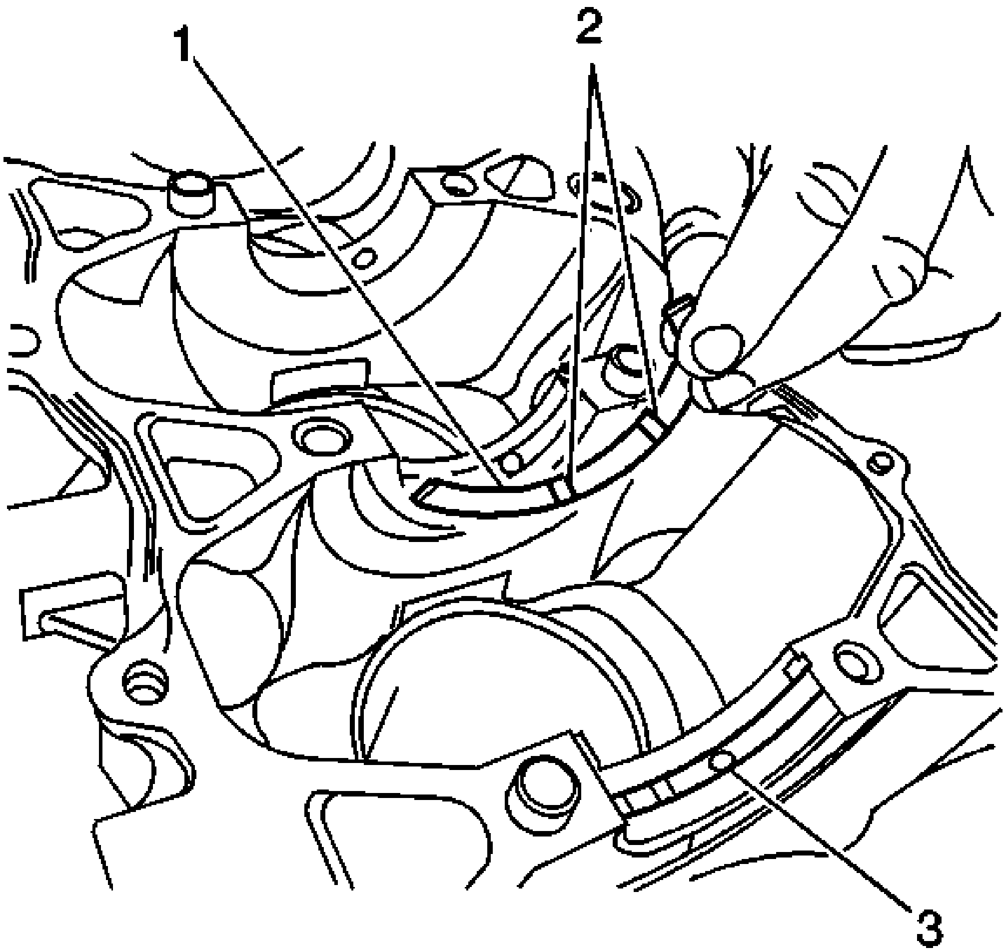


Fig. 377: View Of Oil Grooves
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pump drive chain to the crankshaft gear.
5. Carefully place the crankshaft on to the main bearings in the cylinder block.

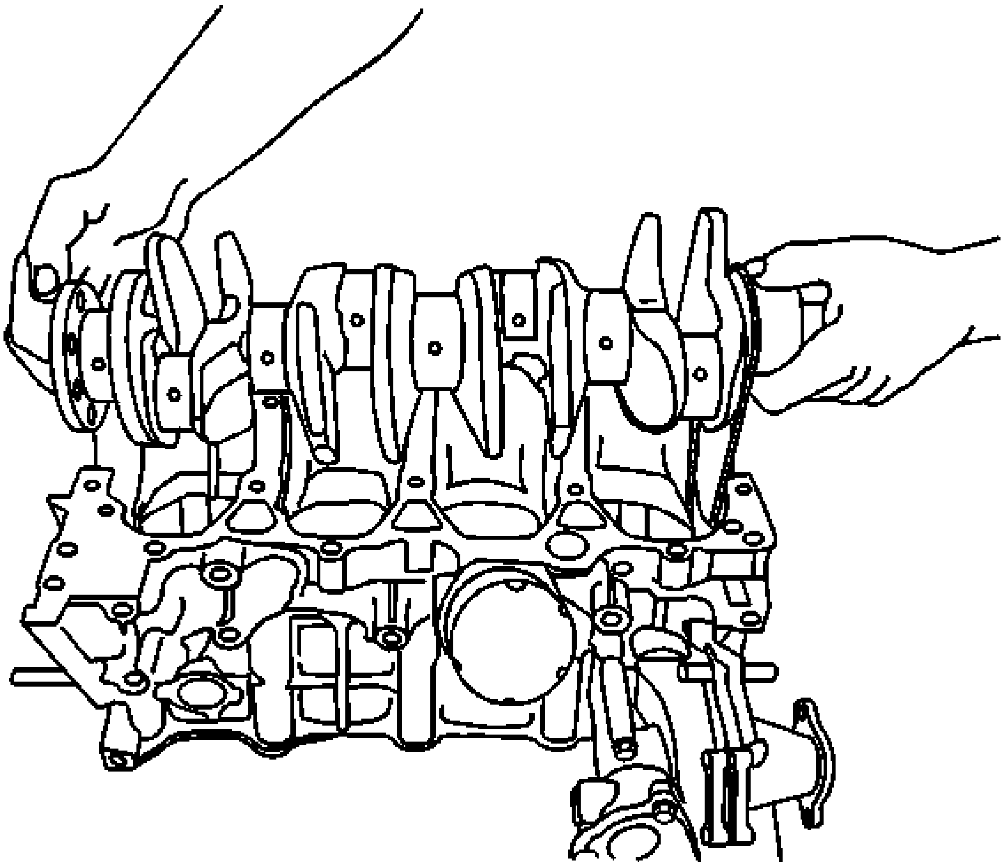


Fig. 378: Installing Crankshaft & Oil Pump Drive Chain From Cylinder Block
Courtesy of GENERAL MOTORS CORP.

6. Thoroughly clean and remove any oil residue from the cylinder block mating surfaces.

IMPORTANT: Avoid applying an excessive amount of sealant to the surface.

7. Apply a continuous bead of GM P/N 12345997 or equivalent sealant to the cylinder block mating rails.

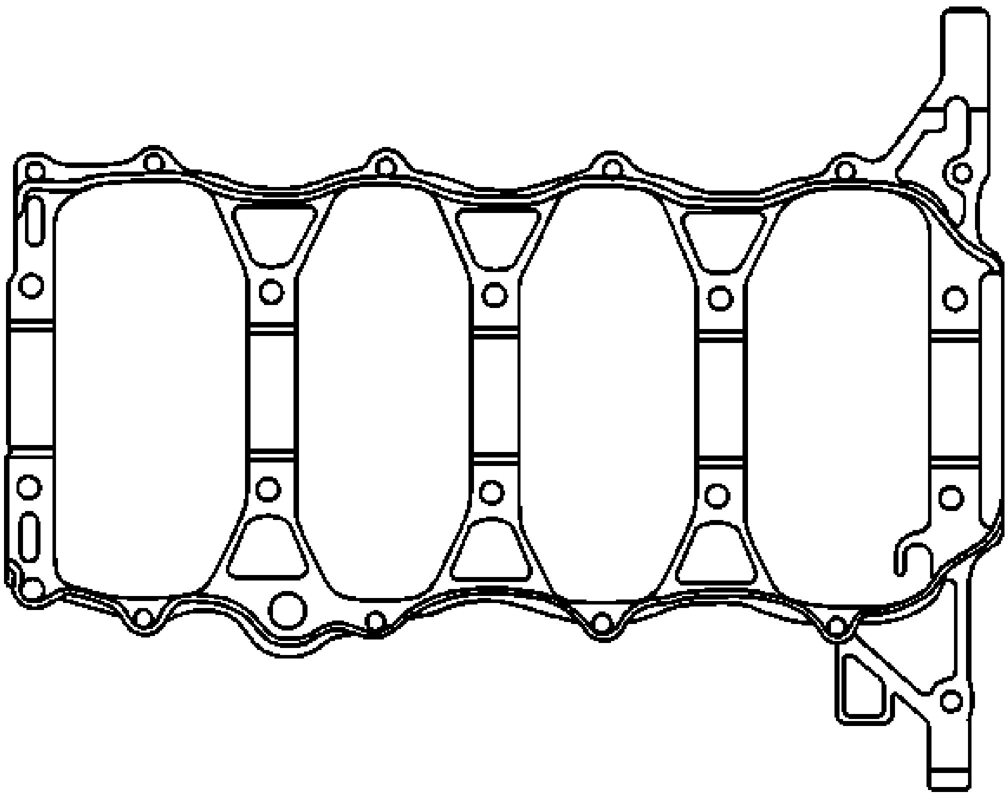


Fig. 379: View Of Cylinder Block Mating Surface
Courtesy of GENERAL MOTORS CORP.

8. Carefully place the lower crankcase assembly on to the cylinder block.
9. Gently tap the lower crankcase into place with a suitable tool.

IMPORTANT: Gradual and uniform tightening is important for the lower crankcase bolts.

10. Install the ten main bearing cap bolts finger tight.

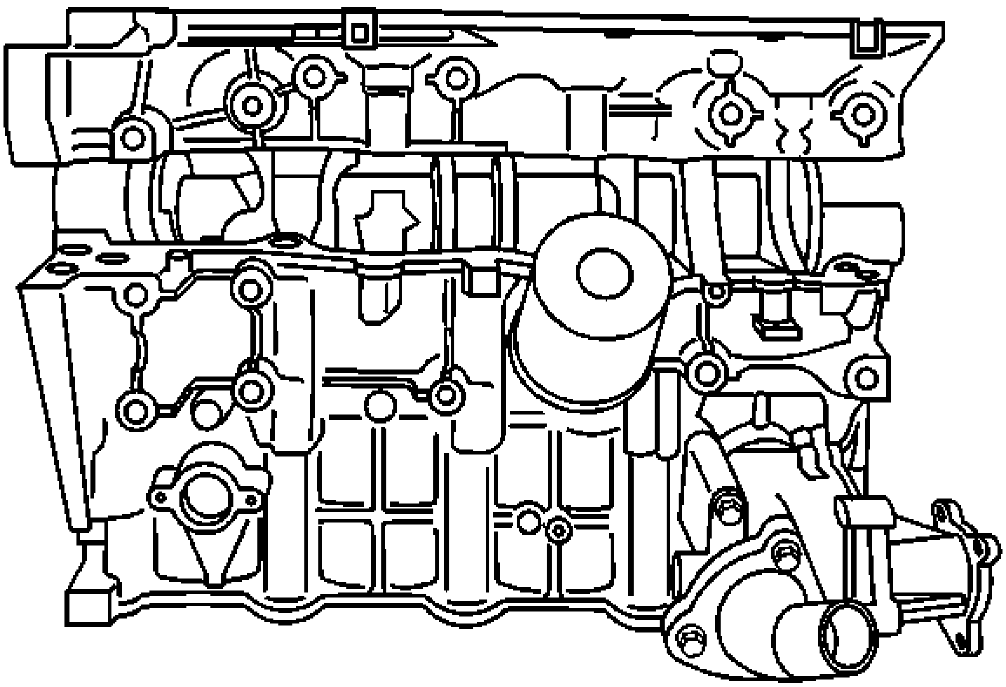


Fig. 380: View Of Lower Crankcase Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Progressively torque the main bearing cap bolts (1-10) using two steps in the sequence shown.

    Tighten:

    1. Tighten the main bearing cap bolts (1-10) to 42 N.m (31 lb ft).
    2. Tighten the main bearing cap bolts (1-10) to 60 N.m (44 lb ft).

12. Install the twelve lower crankcase bolts. Progressively torque the lower crankcase bolts (11-22) using two steps in the sequence shown.

    Tighten:

    1. Tighten the twelve lower crankcase bolts (11-22) to 19 N.m (14 lb ft).
    2. Tighten the twelve lower crankcase bolts (11-22) to 27 N.m (20 lb ft).

13. Inspect that the crankshaft rotates smoothly by hand.

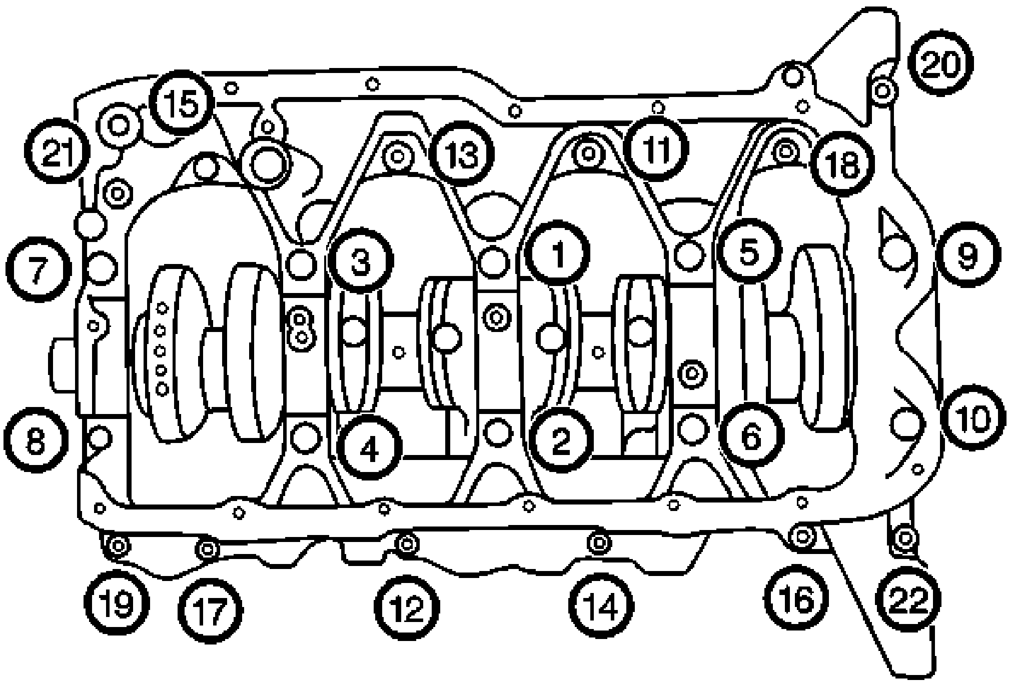


Fig. 381: Torquing Main Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Crankshaft Rear Oil Seal Installation

Tools Required

J 41172 Oil Seal Installer. See **Special Tools and Equipment**.

1. Lubricate the new crankshaft rear oil seal with Chassis Grease, GM P/N 1051344, Canadian P/N 993037, or equivalent.

IMPORTANT: The J 41172 will install the seal to the correct installed depth. See Special Tools and Equipment. Other seal installers may not seat the seal properly and oil leakage may result.

2. Position the new seal in place over the end of the crankshaft.
3. Lightly tap the crankshaft rear oil seal into place using a hammer and the **J 41172** . See **Special Tools and Equipment**.

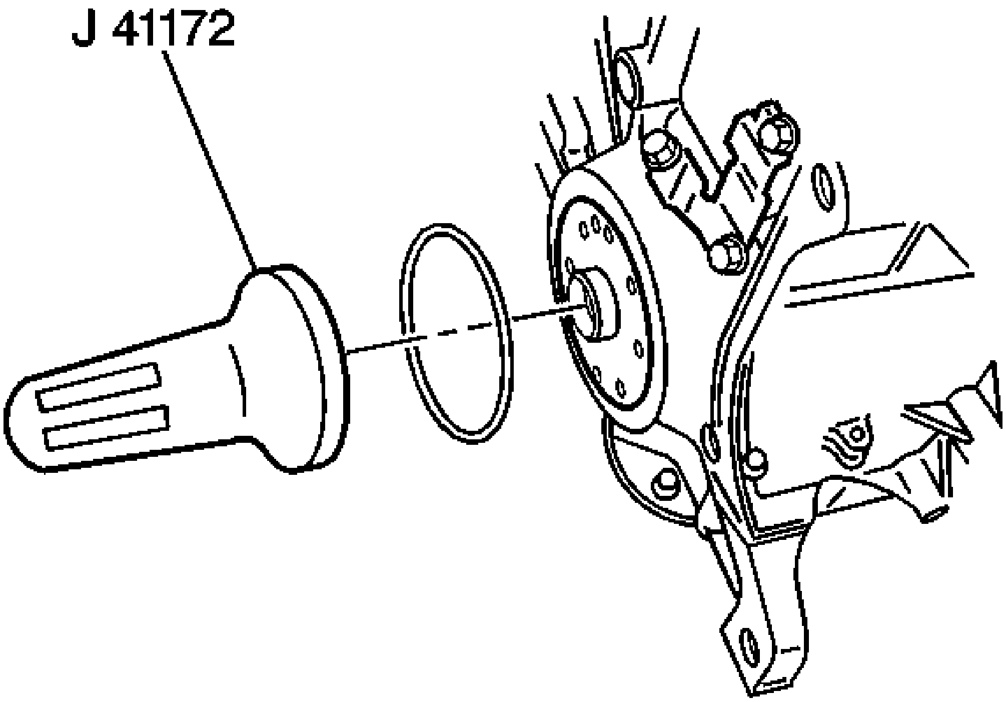


Fig. 382: Applying Lubricant To New Crankshaft Rear Oil Seal Lip
Courtesy of GENERAL MOTORS CORP.

Piston, Connecting Rod, and Bearing Installation

Tools Required

J 8037 Ring Compressor. See **Special Tools and Equipment**.

> **NOTE:** **Install a piece of hose over the threads of the rod bolts. This is to prevent damage to the bearing journal, the cylinder walls, or the rod bolt threads when removing the connecting rod. Remove the hose after the connecting rod is in place.**

1. Lubricate the following components with engine oil:
   - The pistons
   - The rings
   - The cylinder walls
   - The connecting rod bearings

- The crankshaft journals

2. Ensure that the piston ring end gaps are staggered equally around the piston.
3. Install the piston so that the mark on the top of the piston (1) faces the front of the engine.
4. Install the upper connecting rod bearing to the connecting rod.
5. Install a **J 8037** over the piston, ensuring it sits firmly against the cylinder block until all of the piston rings have entered the cylinder bore. See **Special Tools and Equipment**.

NOTE: Guide the lower connecting rod end carefully to avoid damaging the crankshaft journal.

6. Install the piston assembly into its matching cylinder bore.
7. Guide the connecting rod into place on the crankshaft.

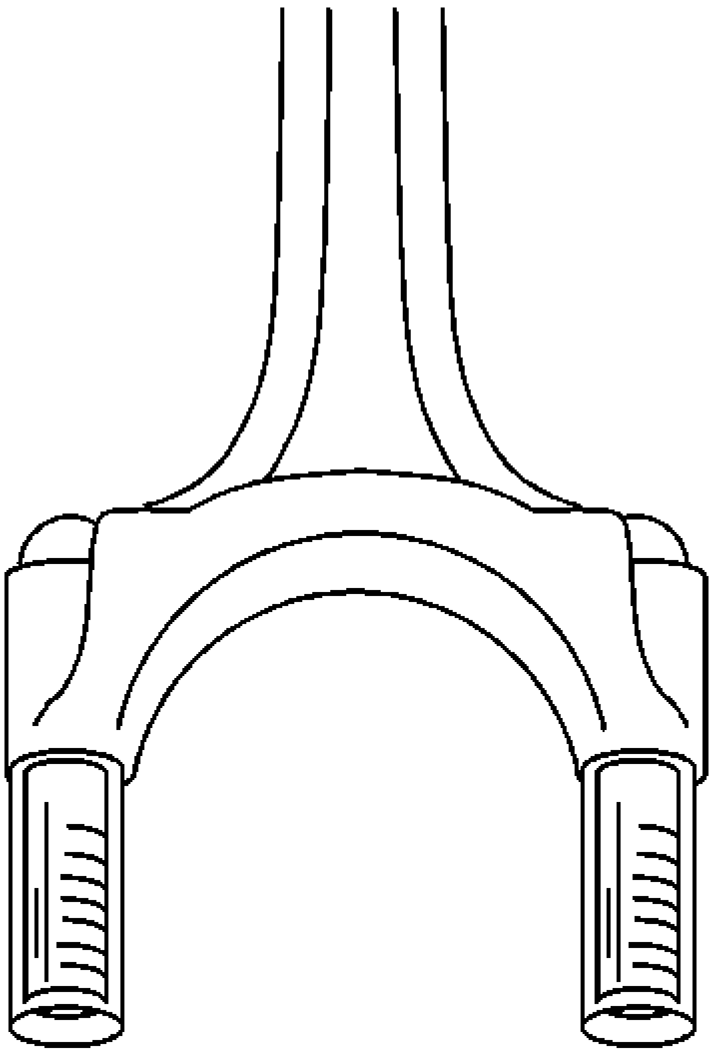


Fig. 383: Removing Connecting Rods
Courtesy of GENERAL MOTORS CORP.

8. Gently tap the piston into its cylinder bore with a hammer handle.

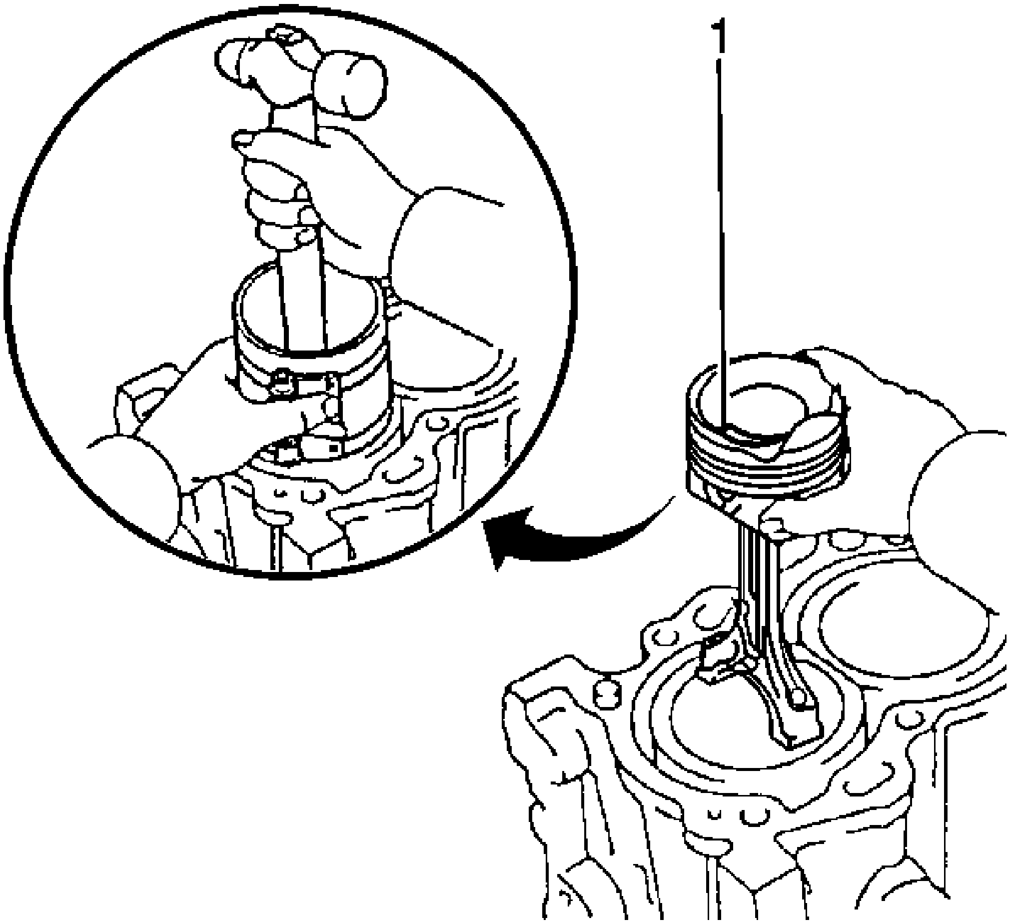


Fig. 384: Tapping Piston Into Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

9. Install the lower connecting rod bearing to the connecting rod cap.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Install the connecting rod cap (1) to its matching connecting rod with the arrow pointing towards the front of the engine. Secure with two connecting rod cap nuts.

    Tighten: Tighten the connecting rod cap nuts to 45 N.m (33 lb ft).

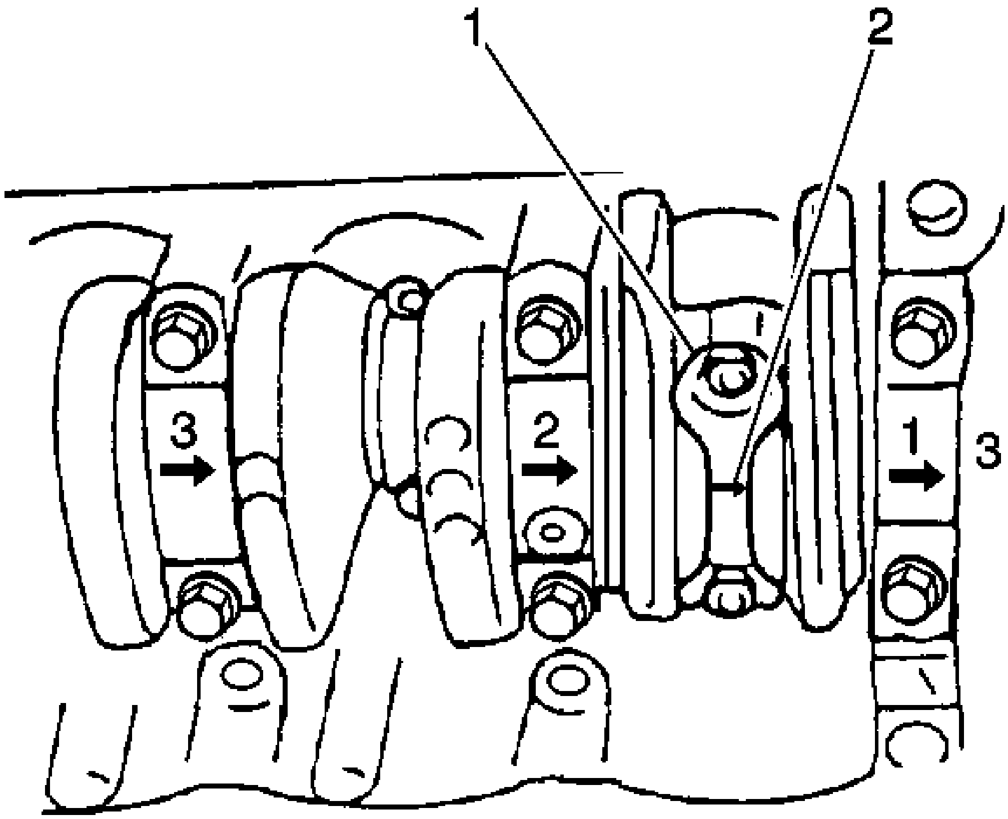


Fig. 385: View Of Connecting Rod Cap
Courtesy of GENERAL MOTORS CORP.

11. Pry the connecting rod back and forth in order to inspect for binding.
12. Measure the connecting rod side clearance.

    Standard Connecting Rod Side Clearance: 0.25-0.40 mm (0.0099-0.0157 in)

    Maximum Connecting Rod Side Clearance: 0.45 mm (0.0177 in)

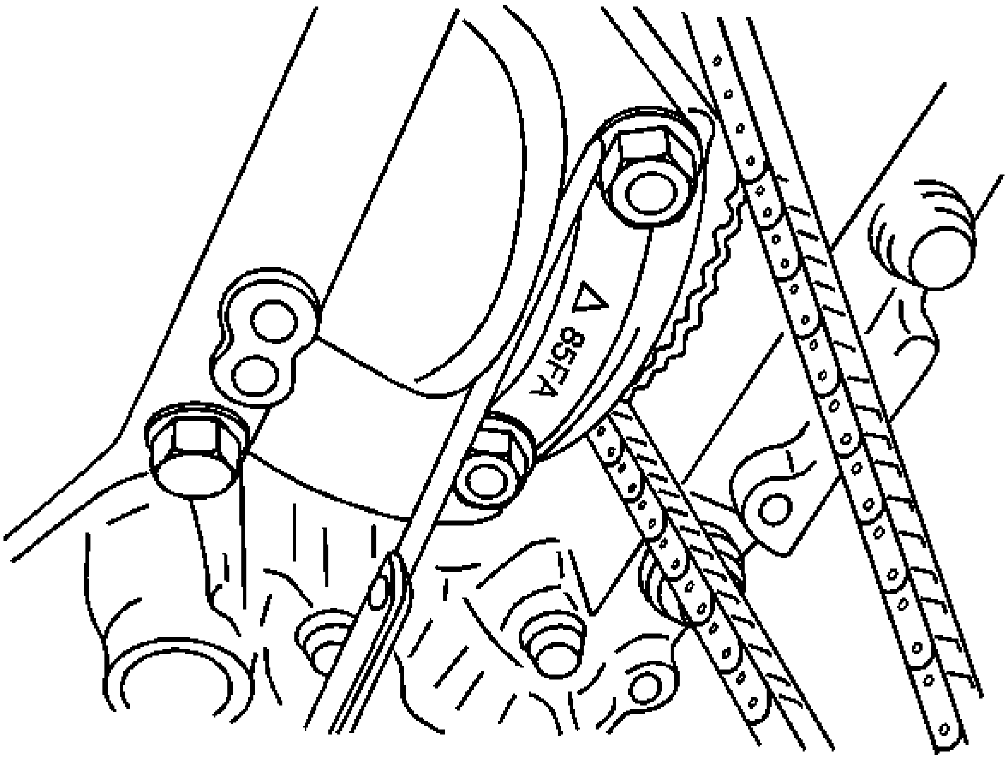


Fig. 386: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

Oil Pump Installation

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil pump to the lower crankcase with the 3 bolts.

   Tighten: Tighten the 3 bolts to 27 N.m (20 lb ft).

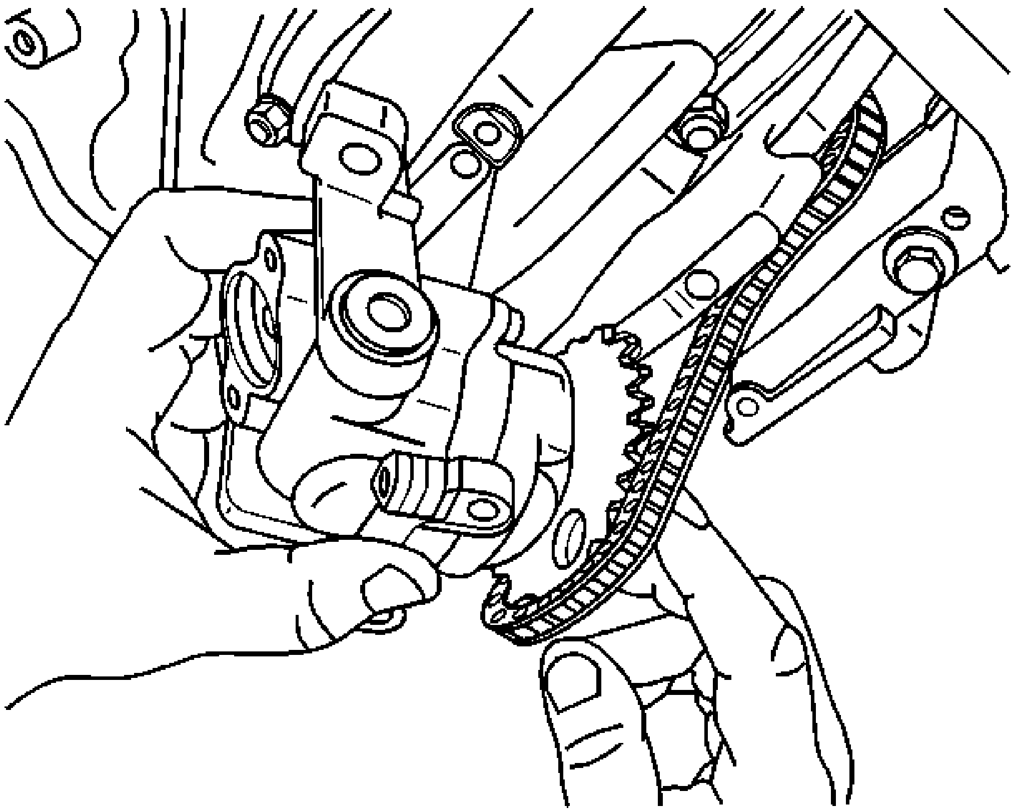


Fig. 387: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

2. If removed, install the oil pump chain guide (1). The chain tension will have to be adjusted if the guide is removed or if the chain is replaced. Install the 2 nuts finger tight.
3. Insert a 0.5 mm (0.020 in) feeler gauge (3) between the chain and the chain guide.
4. Adjust the chain tension by holding the chain guide against the chain with a force of 20-30 Newtons (4.4-6.6 lb).
5. Tighten the nuts while holding this tension.

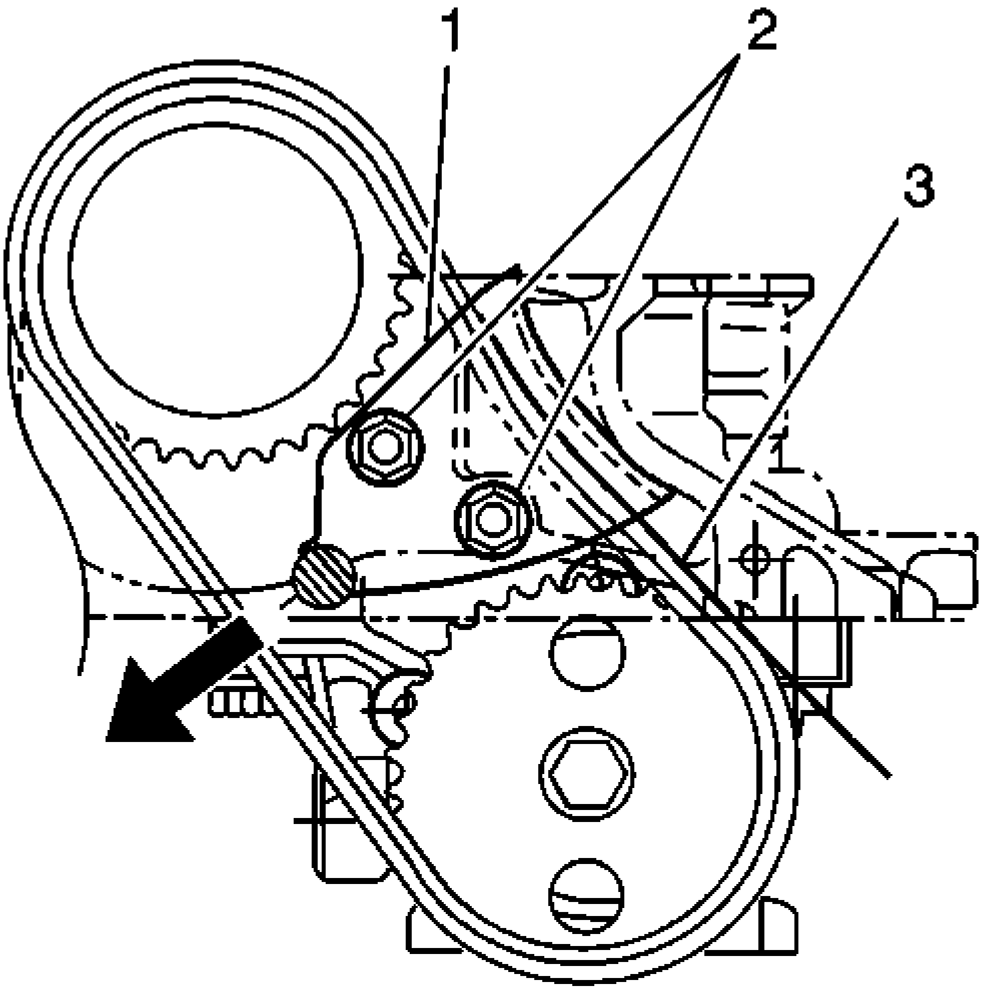


Fig. 388: View Of Oil Pump Chain Guide, Feeler Gauge & Nuts
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pump drive chain cover (1) with the 4 bolts.

   Tighten: Tighten the 4 bolts to 11 N.m (97 lb in).

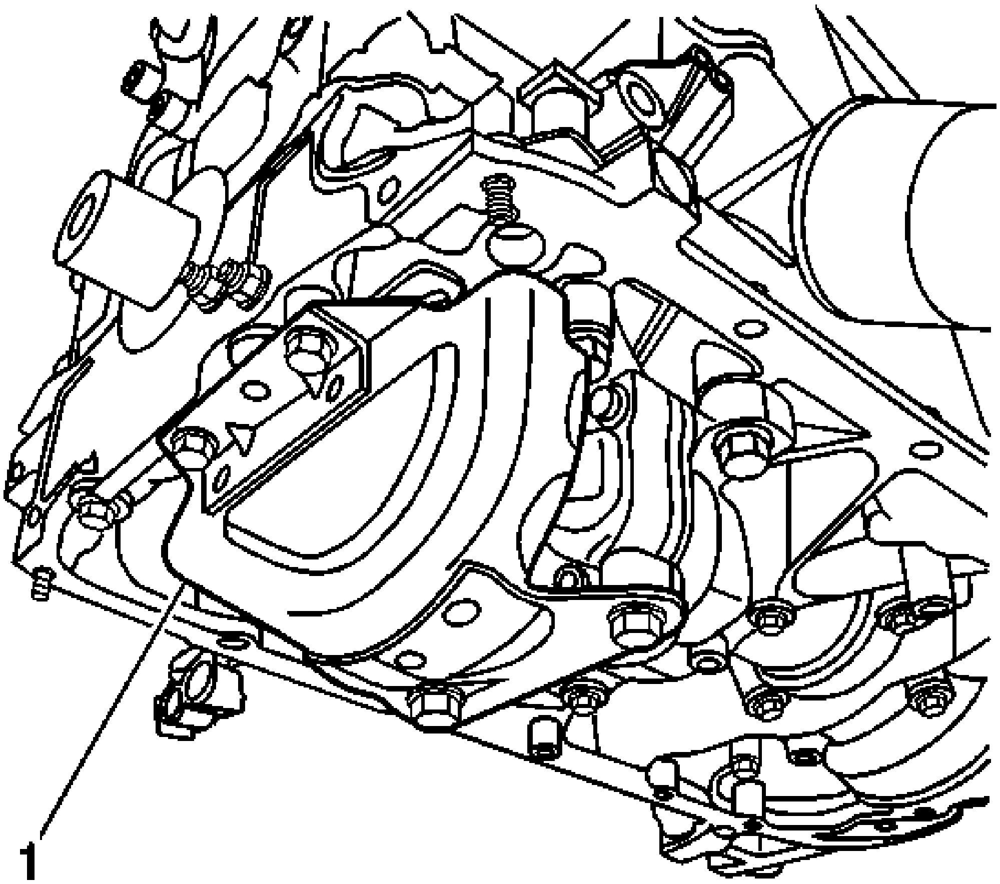


Fig. 389: View Of Oil Pump Drive Chain Cover
Courtesy of GENERAL MOTORS CORP.

7. Install new O-rings and install the oil pump strainer to the oil pump.
8. Install and tighten the 2 strainer bolts first and then the bracket bolt.

   Tighten: Tighten the 3 bolts to 11 N.m (97 lb in).

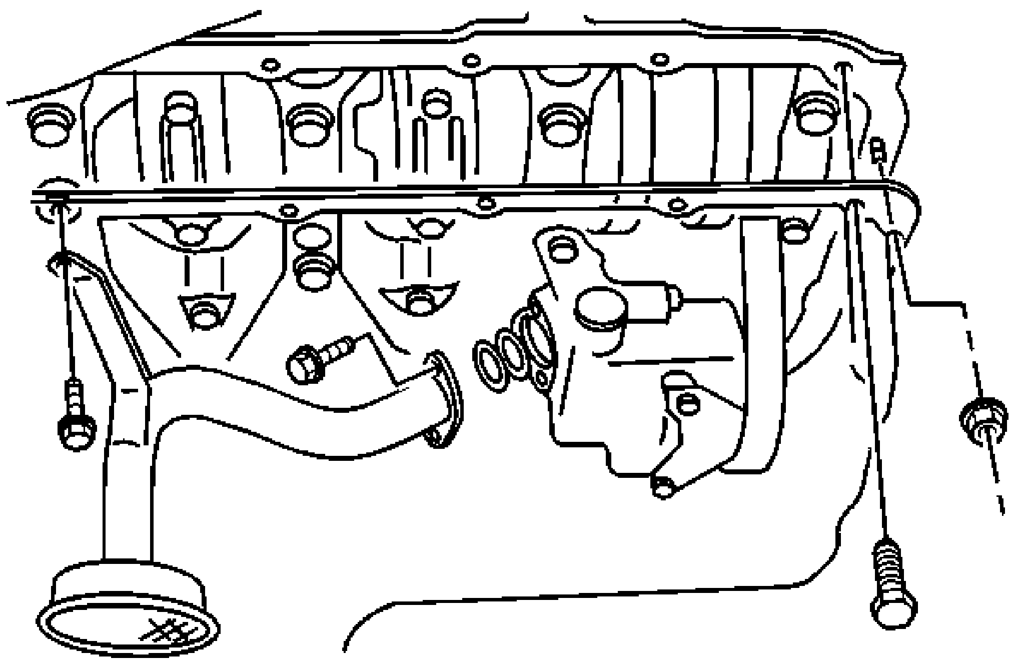


Fig. 390: Oil Pump & Related Components
Courtesy of GENERAL MOTORS CORP.

Oil Pan Installation

1. Apply a continuous bead (1) of silicon sealant, GM P/N 12345997, Canadian P/N 12345997 or equivalent, to the engine oil pan mating surface.

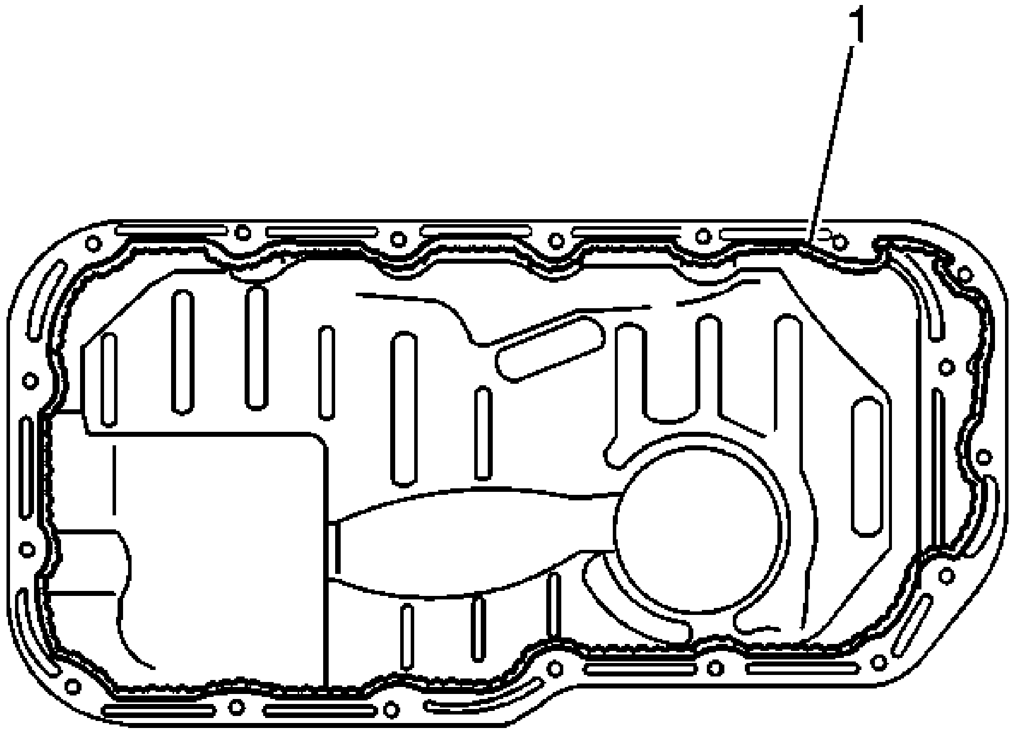


Fig. 391: Applying Silicon Sealant
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine oil pan. Secure the engine oil pan with the 16 bolts and the 2 nuts.

   Tighten: Tighten the engine oil pan bolts and nuts to 11 N.m (97 lb in).

3. Install the engine oil drain plug and gasket.

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

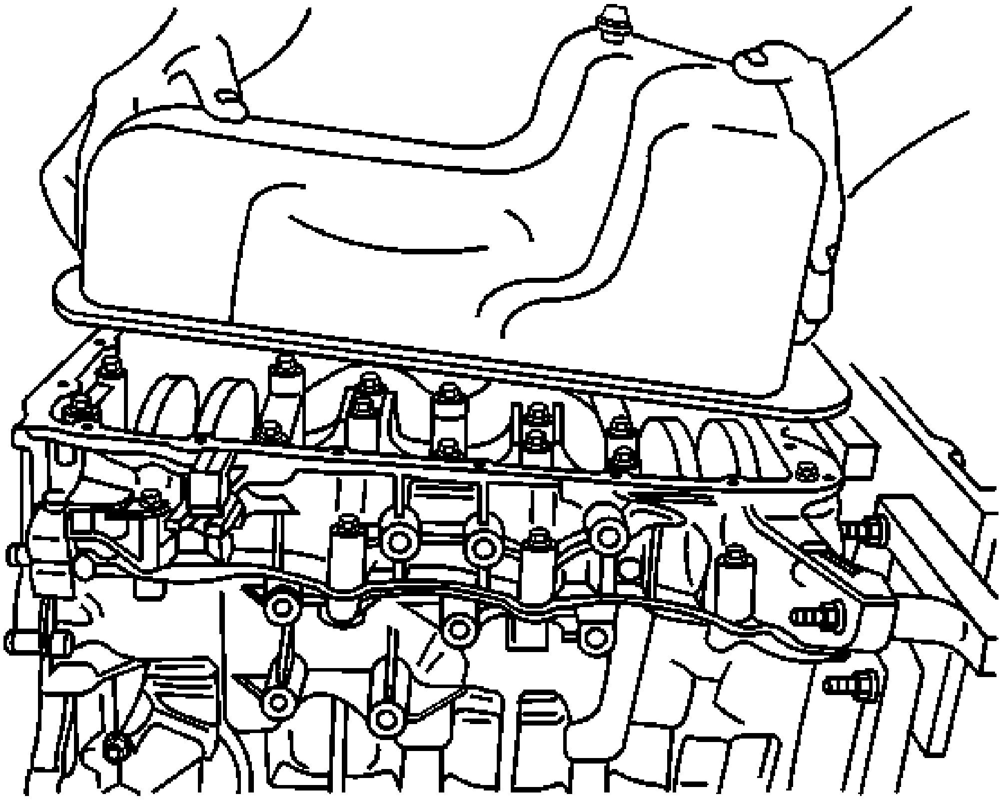


Fig. 392: View Of Engine Oil Pan
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Installation

1. Install the coolant outlet pipe to the cylinder head.
2. Install the engine coolant temperature (ECT) sensor and housing to the rear end of the cylinder head.
3. Install the fuel injector rail to the cylinder head.
4. Install the new cylinder head gasket to the cylinder block. The gasket is marked TOP (1).
5. Install the cylinder head to the cylinder block.

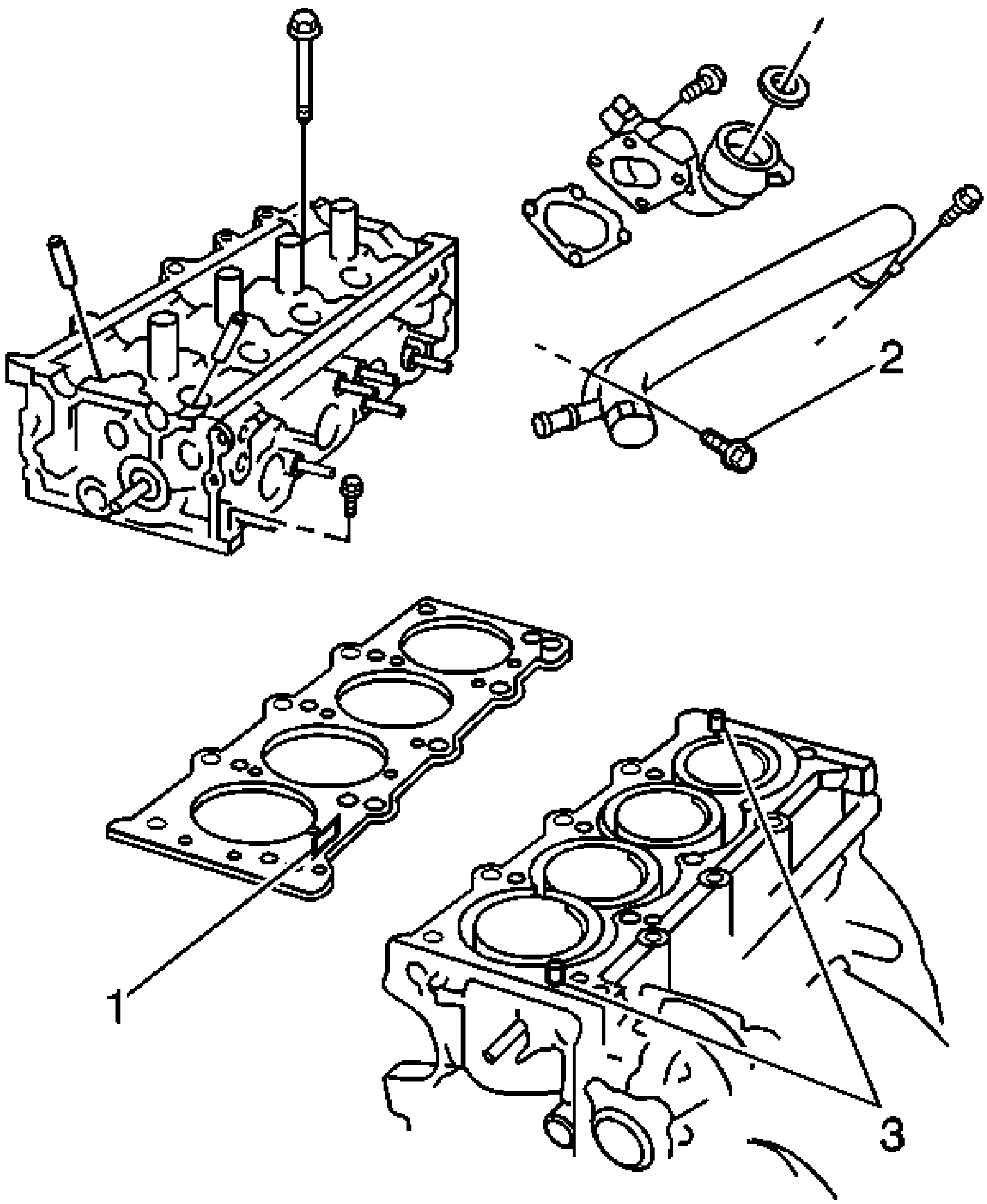


Fig. 393: View Of Cylinder Head Gasket & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts must be torqued in 2 stages, loosened, and then retorqued in 3 stages in order to ensure against compression and coolant leaks.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the cylinder head bolts.

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 53 N.m (39 lb ft).

7. Tighten the cylinder head bolts (1-10)

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 84 N.m (61 lb ft).

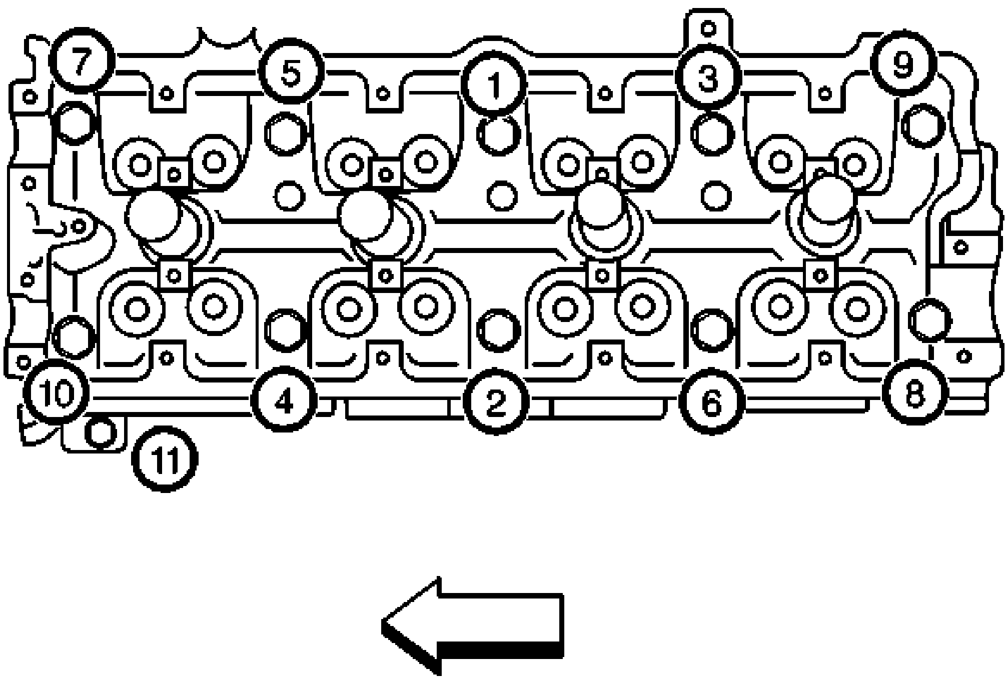


Fig. 394: Tightening Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

8. Loosen the cylinder head bolts in the sequence shown to 0 torque.

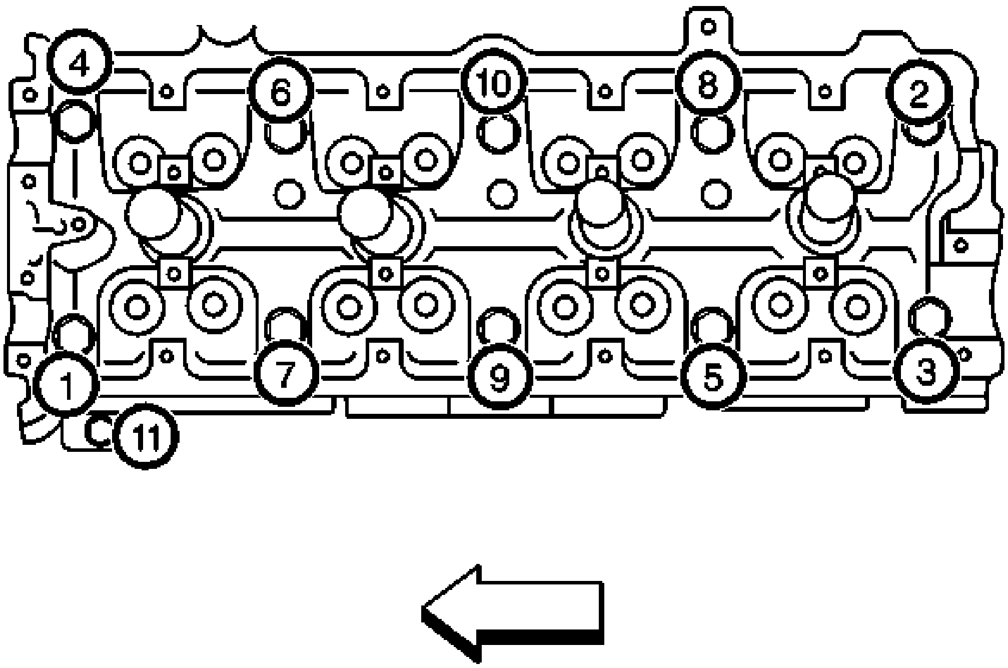


Fig. 395: Removing Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

9. Tighten the cylinder head bolts (1-10).

   Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 53 N.m (39 lb ft).

10. Tighten the cylinder head bolts (1-10).

    Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 84 N.m (61 lb ft).

11. Tighten the cylinder head bolts (1-10).

    Tighten: Tighten the cylinder head bolts (1-10) in the sequence shown to 105 N.m (76 lb ft) as shown.

12. Tighten the M 6 cylinder head bolt (11).

    Tighten: Tighten the cylinder head bolt (11) to 11 N.m (97 lb in) as shown.

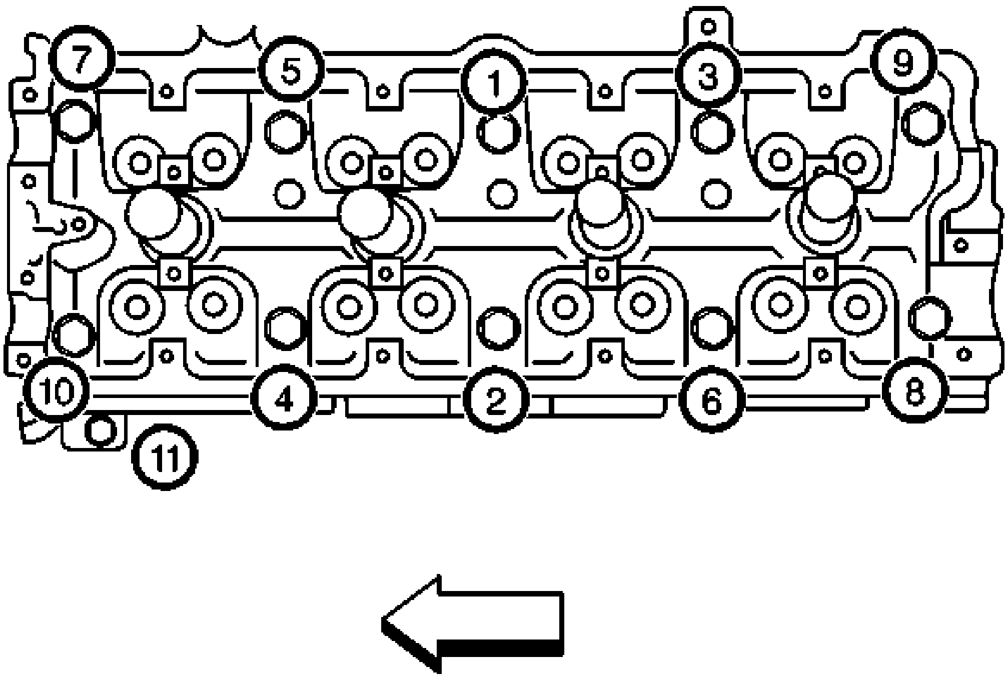


Fig. 396: Tightening Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

Intake Camshaft and Lifter Installation

IMPORTANT:

- **Do not turn the camshafts or start the engine for approximately 30 minutes after replacing the valve lifters and camshafts.**
- **Allow approximately 30 minutes for the valves to settle in place. Operating the valves before this time may cause valve or piston damage.**
- **The valves may make a tapping/ticking sound after replacement if air is trapped in the valve lifter. Run the engine at 2000 RPM until the air is purged from the lifter.**
- **If the tapping/ticking does not stop, locate the defective lifter with a stethoscope and replace. Or, remove the cylinder head cover with the engine stopped and push the lifter down by hand with a force less than 20 kg (44 lbs) when the camshaft is on the base circle. If clearance exists between the camshaft and the lifter, the lifter is faulty and should be replaced.**

1. Pour engine oil into the oil feed hole in the valve lifter bore in order to flush any debris from the gallery and to prelube the bore.
2. Apply engine oil to the valve lifter and install the lifter to the cylinder head in the same bore from which it was removed.
3. Line up the crankshaft keyway with the timing mark on the engine block.
4. Rotate the crankshaft 90 degrees clockwise in order to prevent interference between the valves and the pistons.

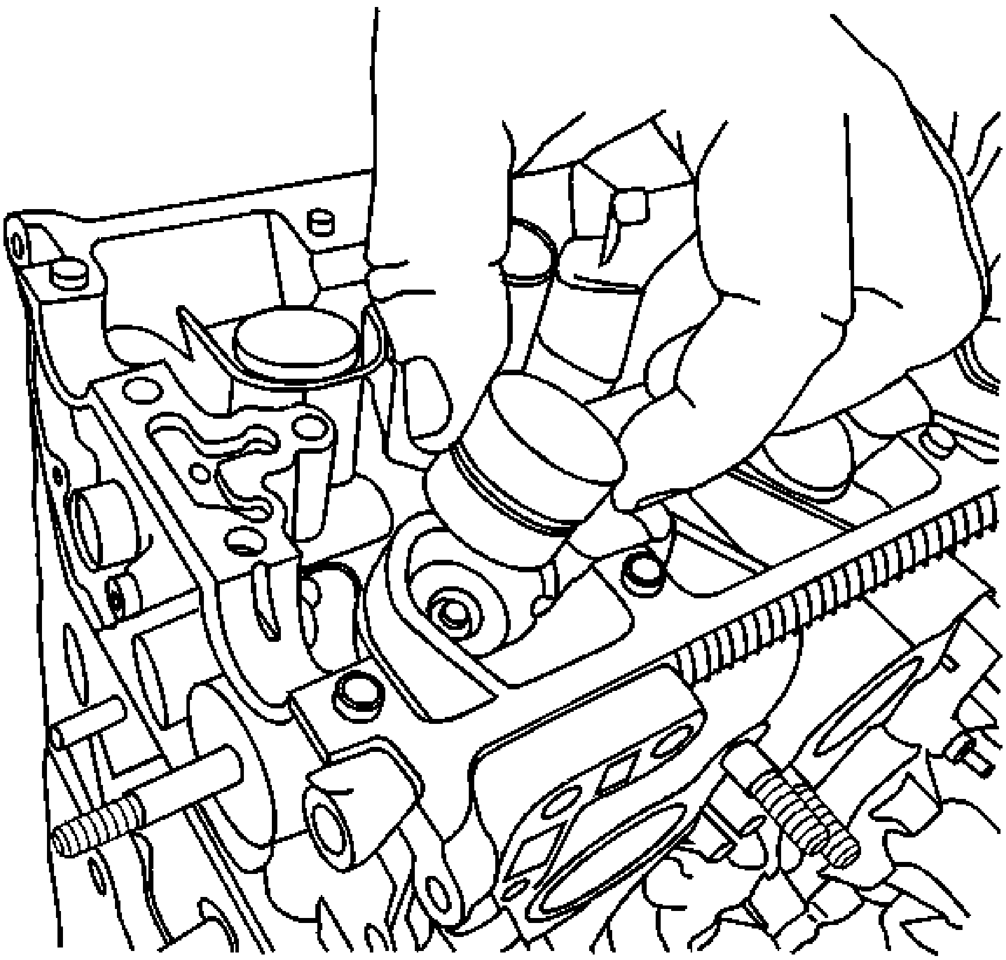


Fig. 397: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

5. Apply engine oil to the camshaft journals and lobes.

6. Install the camshaft aligning the guide pins (1) with the notches (3) on the cylinder head. The exhaust camshaft rear end is slotted to mate with the camshaft position sensor.

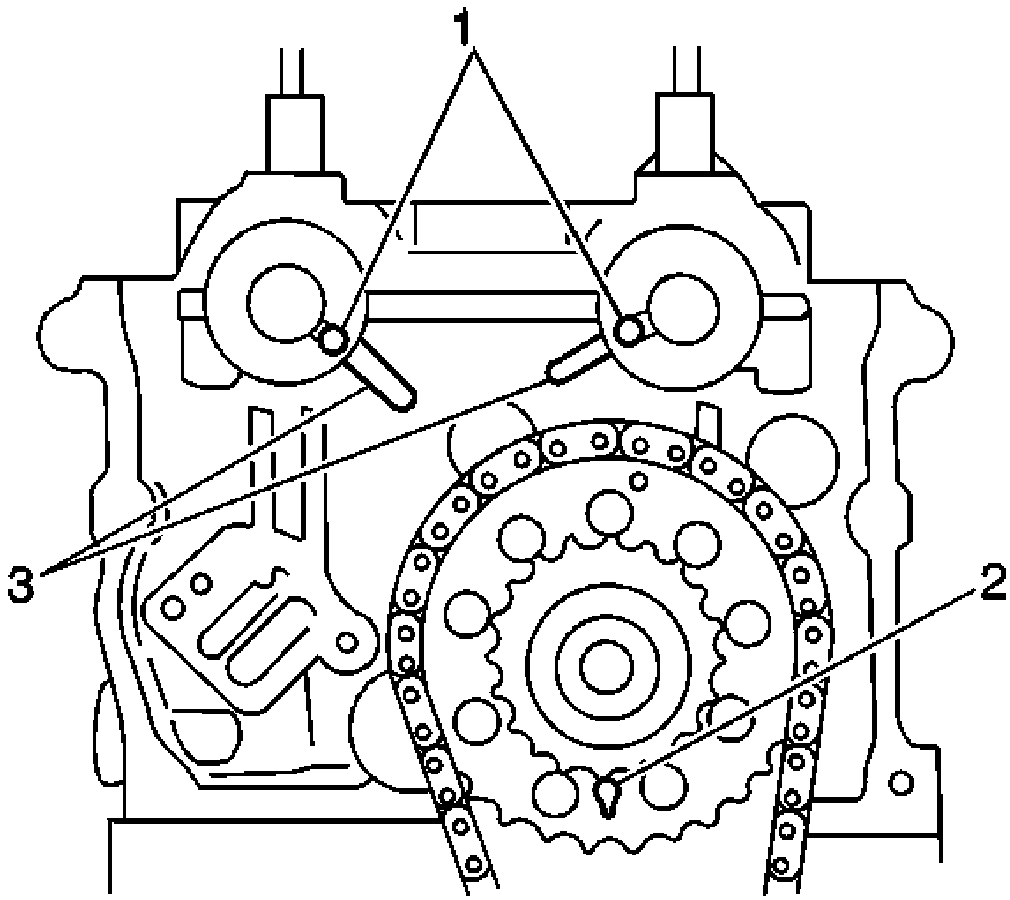


Fig. 398: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

7. Install the dowel pins (1) to the cylinder head.
8. Apply a bead of silicon sealant, GM P/N 12345997, Canadian P/N 12345997 or equivalent to the exhaust camshaft end housing (2).

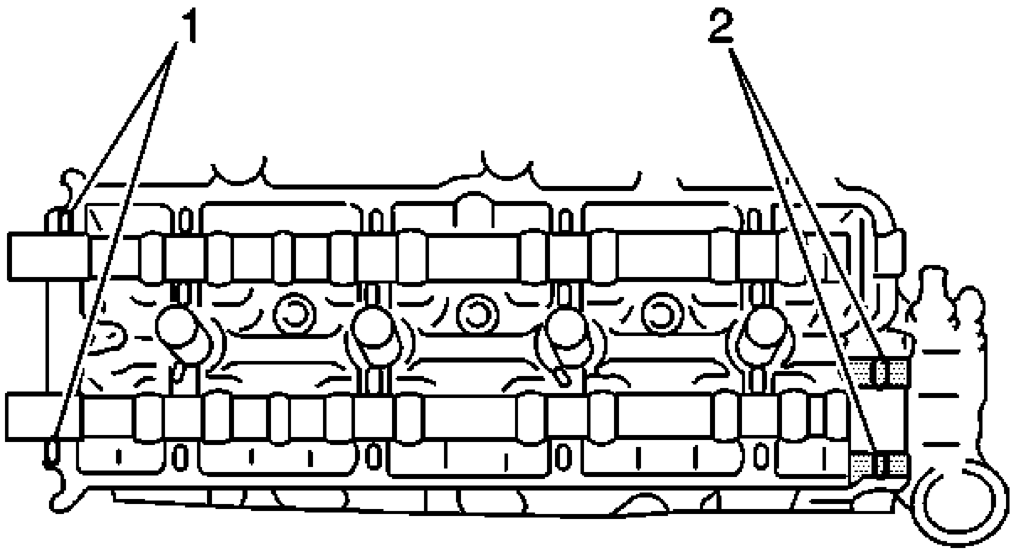


Fig. 399: View Of Exhaust Camshaft End Housing & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Cylinder head and camshaft damage may result if the bearing caps are incorrectly installed.

9. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

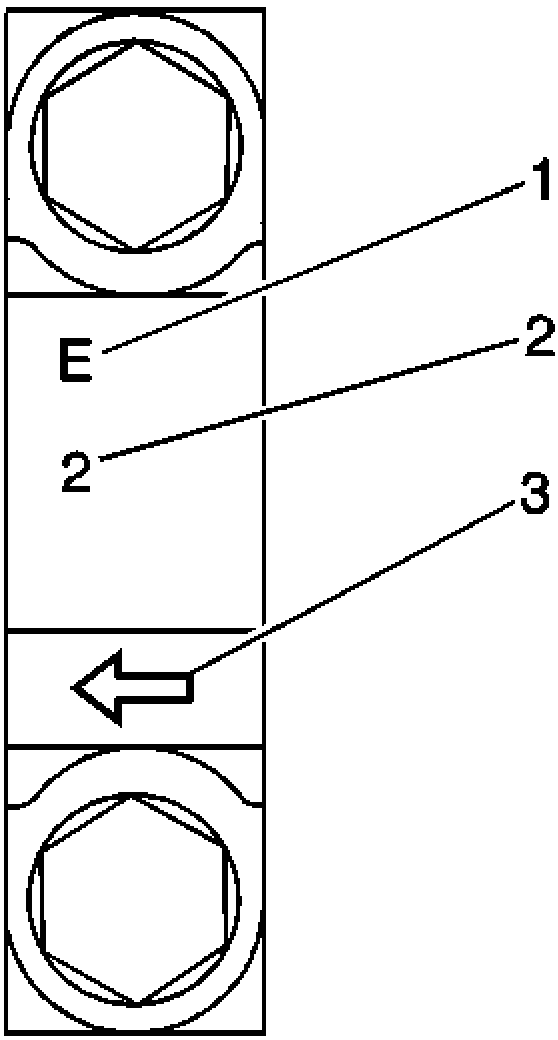


Fig. 400: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

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

10. Tighten the camshaft bearing caps.

    Tighten: Tighten the camshaft bearing caps in 3 progressive steps in the sequence shown to 11 N.m (97 lb in).

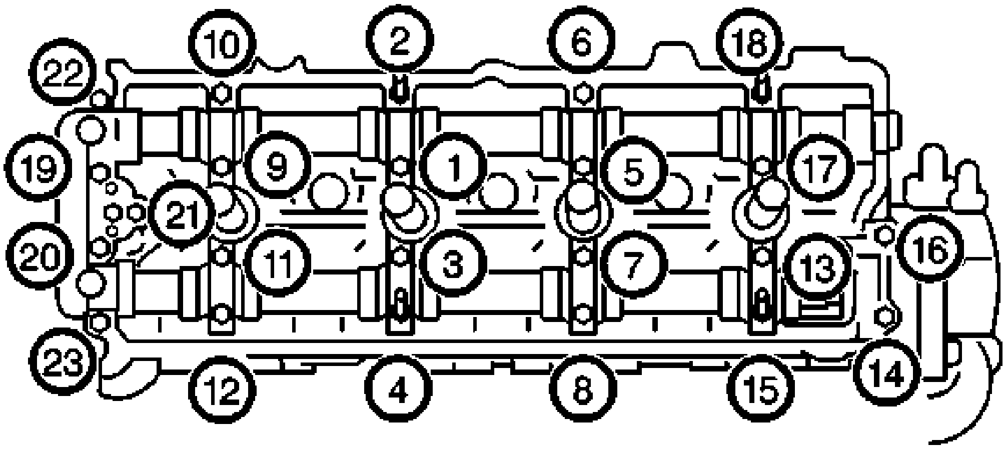


Fig. 401: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Exhaust Camshaft and Lifter Installation

IMPORTANT:

- **Do not turn the camshafts or start the engine for approximately 30 minutes after replacing the valve lifters and camshafts.**
- **Allow approximately 30 minutes for the valves to settle in place. Operating the valves before this time may cause valve or piston damage.**
- **The valves may make a tapping/ticking sound after replacement if air is trapped in the valve lifter. Run the engine at 2000 RPM until the air is purged from the lifter.**
- **If the tapping/ticking does not stop, locate the defective lifter with a stethoscope and replace. Or, remove the cylinder head cover with the engine stopped and push the lifter down by hand with a force less than 20 kg (44 lbs) when the camshaft is on the base circle. If clearance exists between the camshaft and the lifter the lifter is faulty and should be replaced.**

1. Pour engine oil into the oil feed hole in the valve lifter bore in order to flush any debris from the gallery

and to prelube the bore.

2. Apply engine oil to the valve lifter and install to the cylinder head.
3. Line up the crankshaft keyway with the timing mark on the engine block.
4. Rotate the crankshaft 90 degrees clockwise in order to prevent interference between the valves and the pistons.

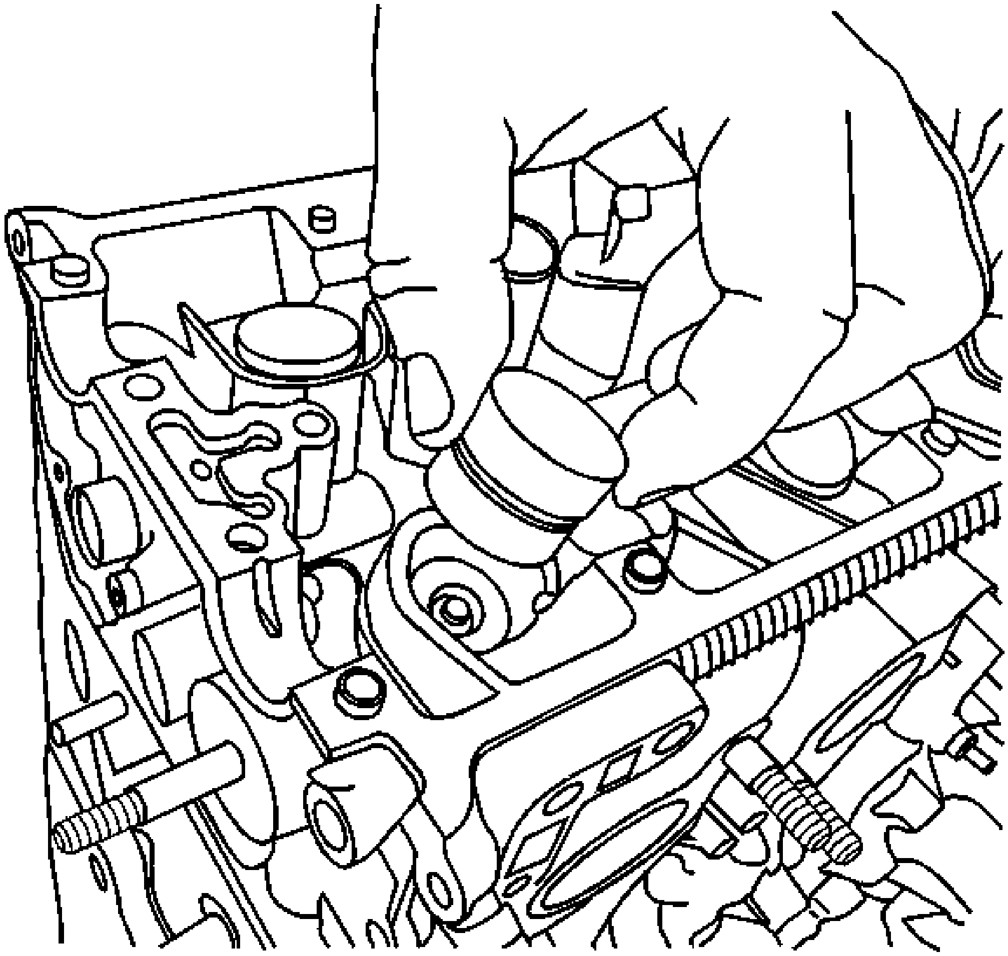


Fig. 402: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

5. Apply engine oil to the camshaft journals and lobes.
6. Install the camshaft aligning the guide pins (1) with the notches (3) on the cylinder head. The exhaust camshaft rear end is slotted to mate with the camshaft position sensor.

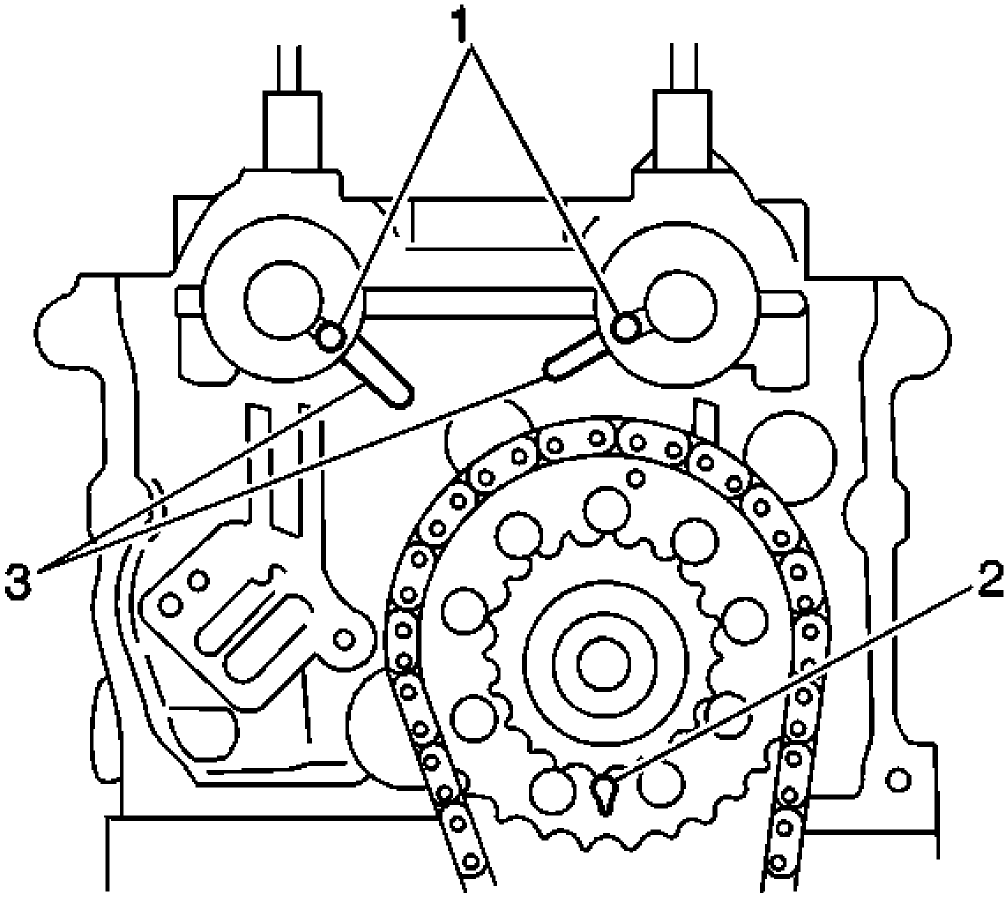


Fig. 403: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

7. Install the dowel pins (1) to the cylinder head.
8. Apply a bead of silicon sealant, GM P/N 12345997, Canadian P/N 12345997 or equivalent, to the exhaust camshaft end housing (2).

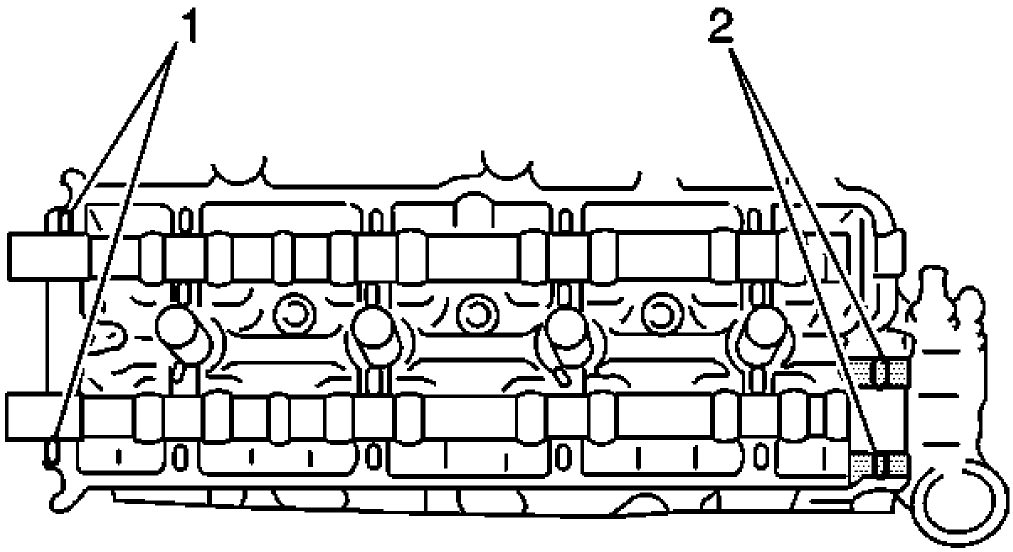


Fig. 404: View Of Exhaust Camshaft End Housing & Dowel Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Cylinder head and camshaft damage may result if the bearing caps are incorrectly installed.

9. Install the camshaft bearing caps. The caps are marked intake or exhaust (1), position away from the timing chain (2), and direction toward the timing chain (3).

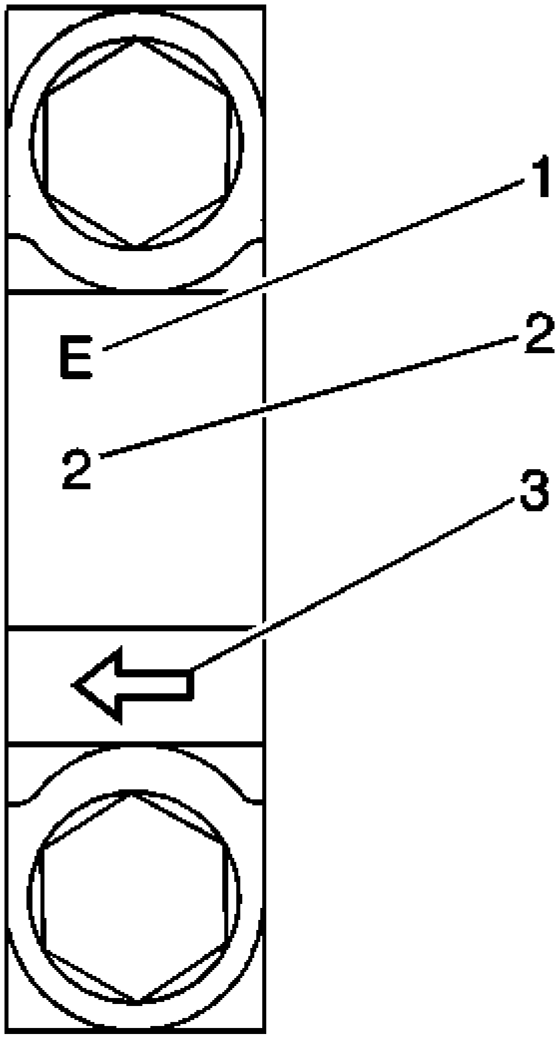


Fig. 405: Correct Orientation View
Courtesy of GENERAL MOTORS CORP.

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

10. Tighten the camshaft bearing caps.

    Tighten: Tighten the camshaft bearing caps in 3 progressive steps in the sequence shown to 11 N.m (97 lb in).

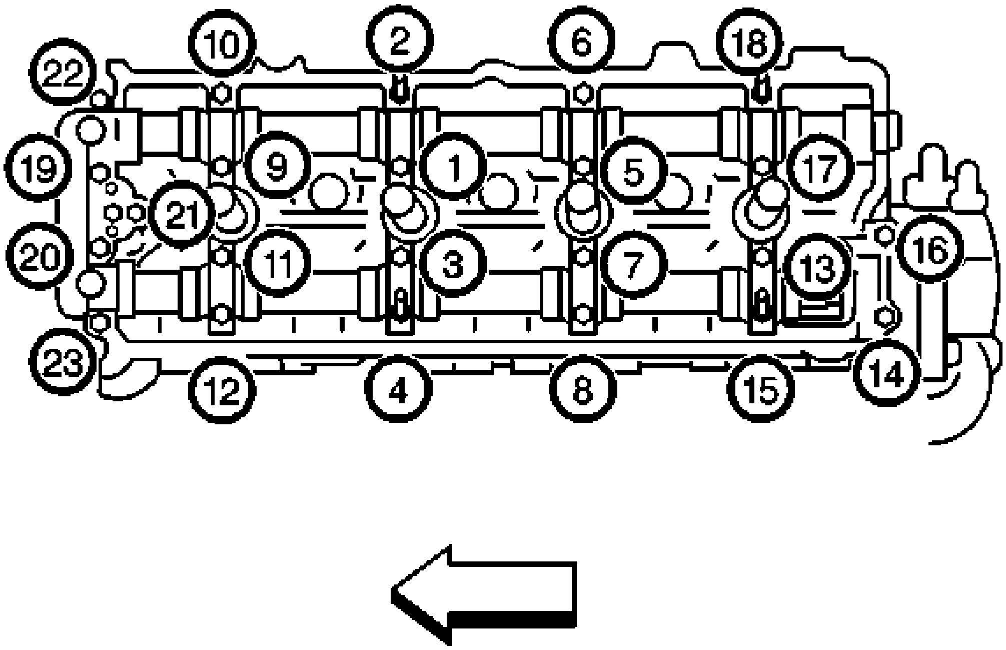


Fig. 406: View Of Camshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Installation (Crankshaft)

1. Inspect that the timing mark on the engine block (1) is aligned with the crankshaft keyway.
2. Install the crankshaft sprocket (2).

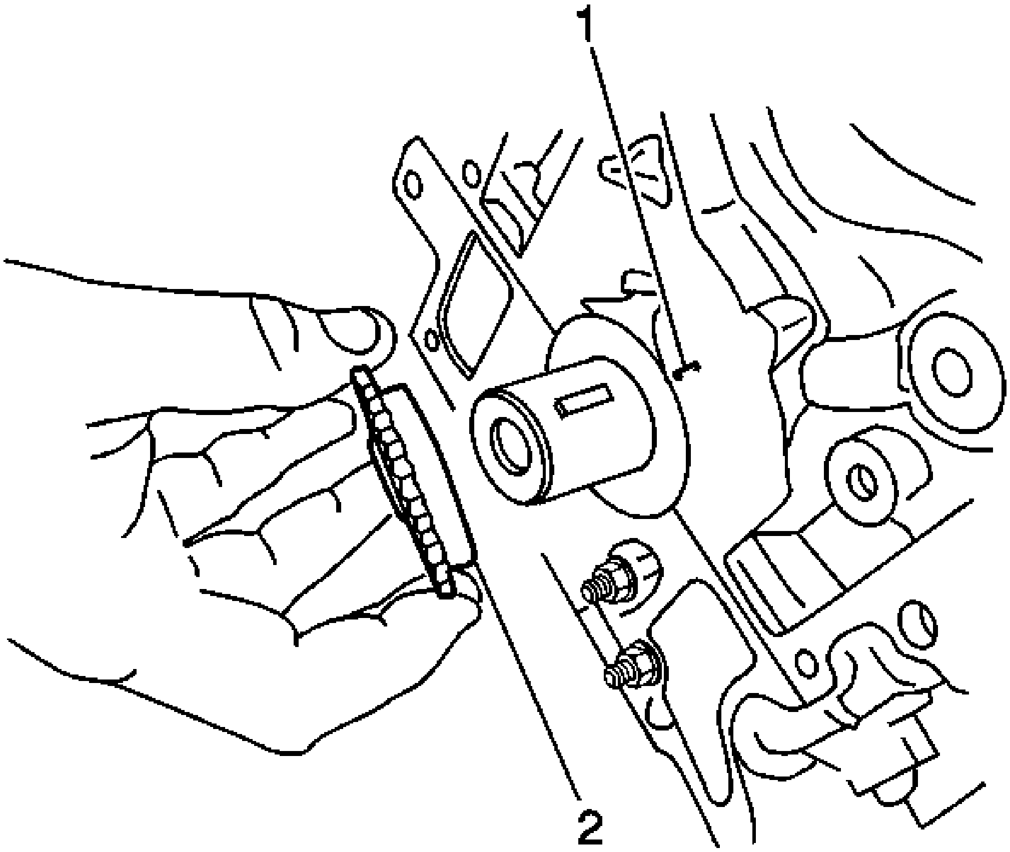


Fig. 407: View Of Engine Block Timing Mark & Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Apply engine oil to the idler sprocket bushing.
4. Install the timing chain to the idler sprocket by aligning the dark blue link (1) of the timing chain with the mark on the sprocket (2).

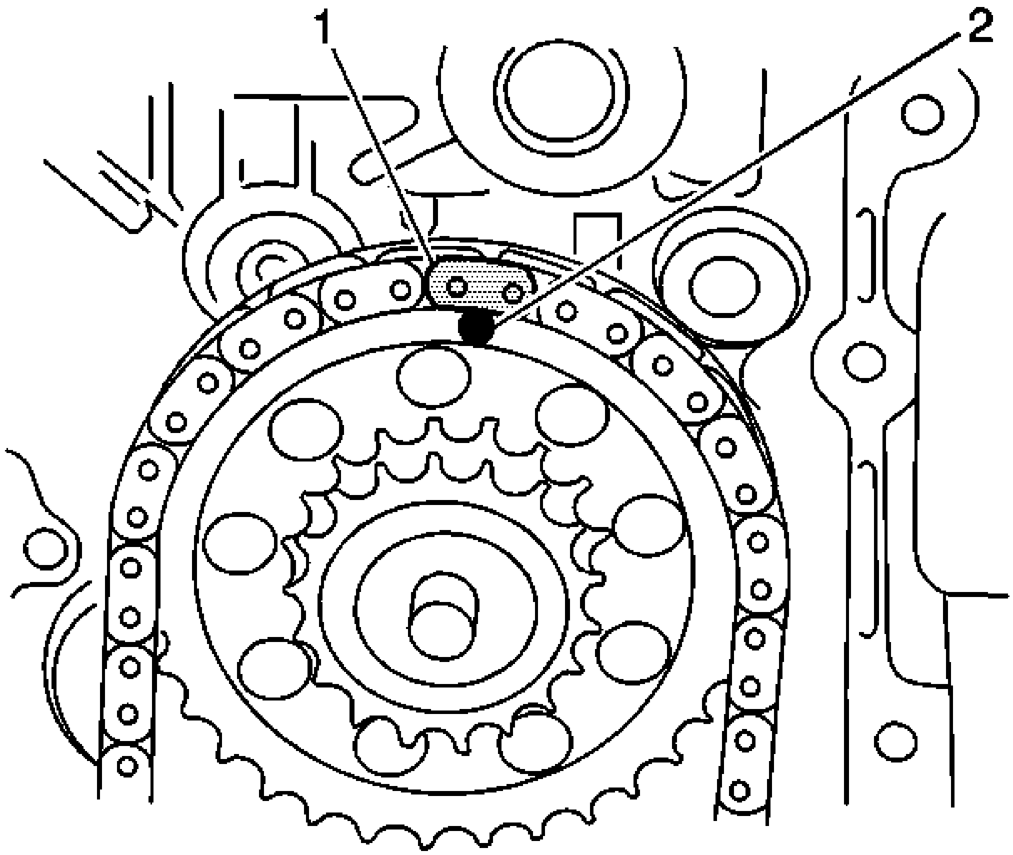


Fig. 408: Aligning Dark Blue Link With Sprocket Mark
Courtesy of GENERAL MOTORS CORP.

5. Install the timing chain to the crankshaft sprocket by aligning the yellow link (4) of the chain with the mark on the crankshaft sprocket (3).
6. Install the idler sprocket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the timing chain fixed guide (2).

   Tighten: Tighten the 2 bolts to 9 N.m (62 lb in).

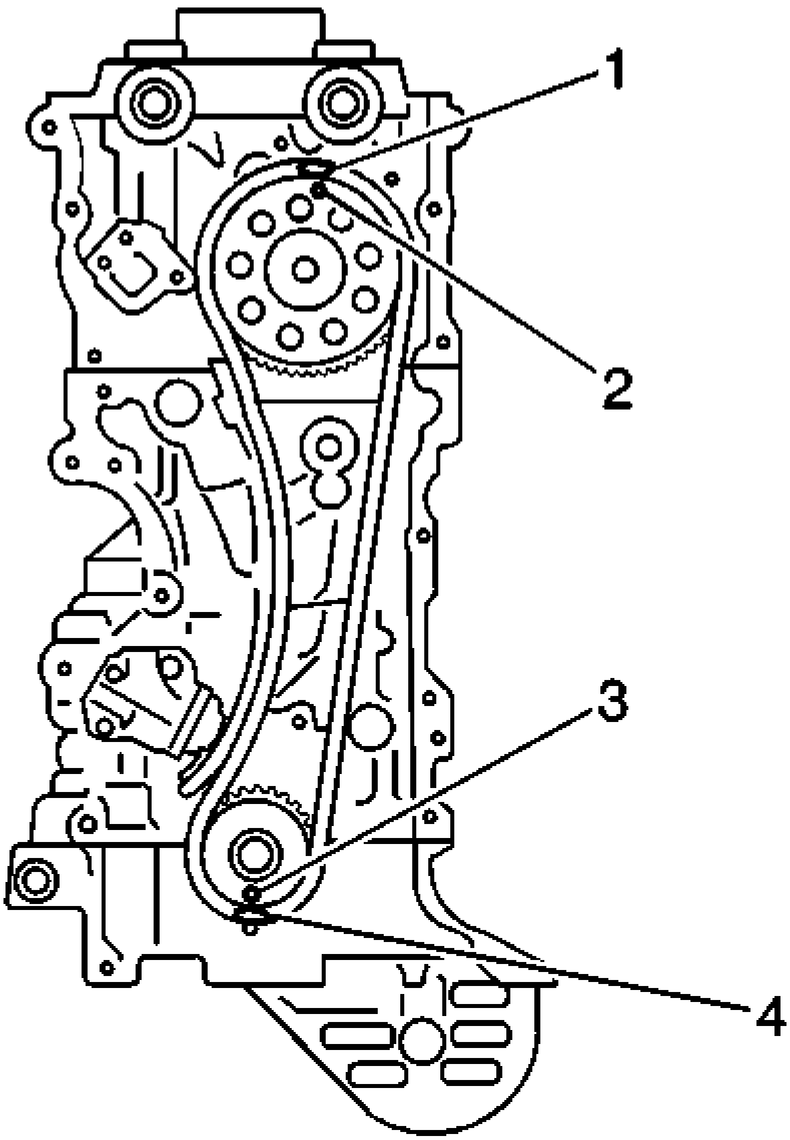


Fig. 409: Aligning Yellow Link With Crankshaft Sprocket Mark
Courtesy of GENERAL MOTORS CORP.

8. Install the timing chain adjustable guide (1).

   Tighten: Tighten the bolt to 25 N.m (19 lb ft).

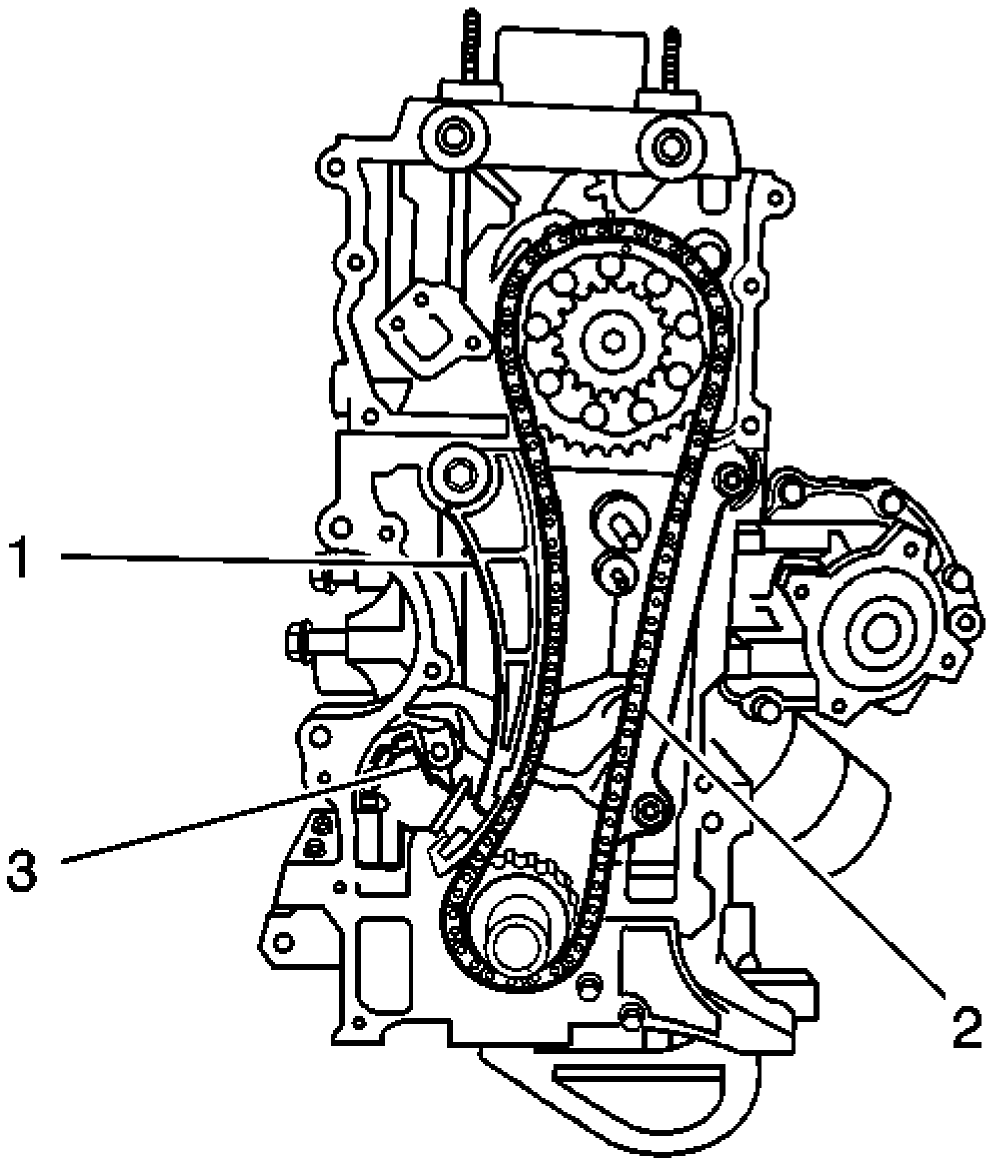


Fig. 410: View Timing Chain Tensioner, Adjustable Guide & Fixed Guide
Courtesy of GENERAL MOTORS CORP.

9. Hold back the latch, compress the plunger and install a retainer (a paper clip or similar tool) to hold the plunger in place.

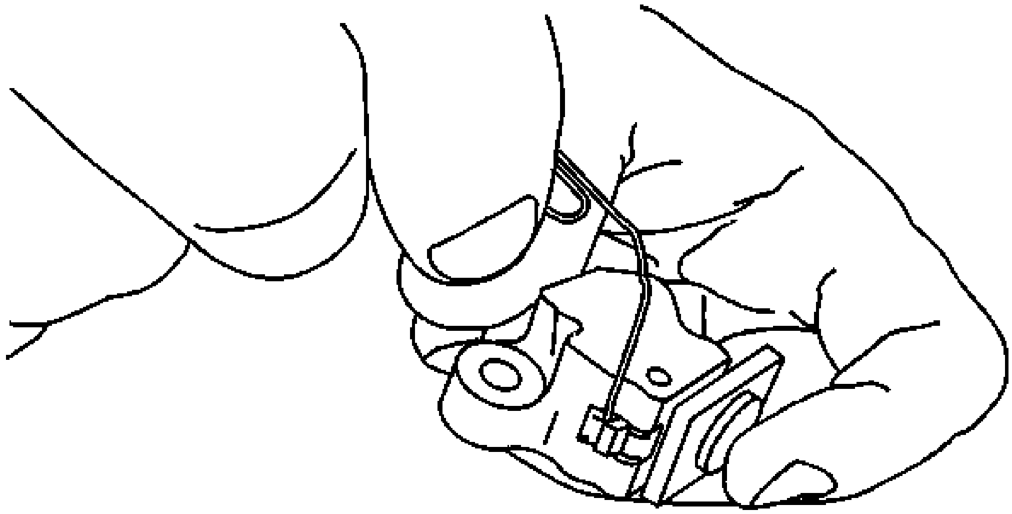


Fig. 411: View Of Plunger & Latch
Courtesy of GENERAL MOTORS CORP.

10. Install the timing chain tensioner.

    Tighten: Tighten the 2 bolts (1) to 11 N.m (97 lb in).

11. Remove the retainer.

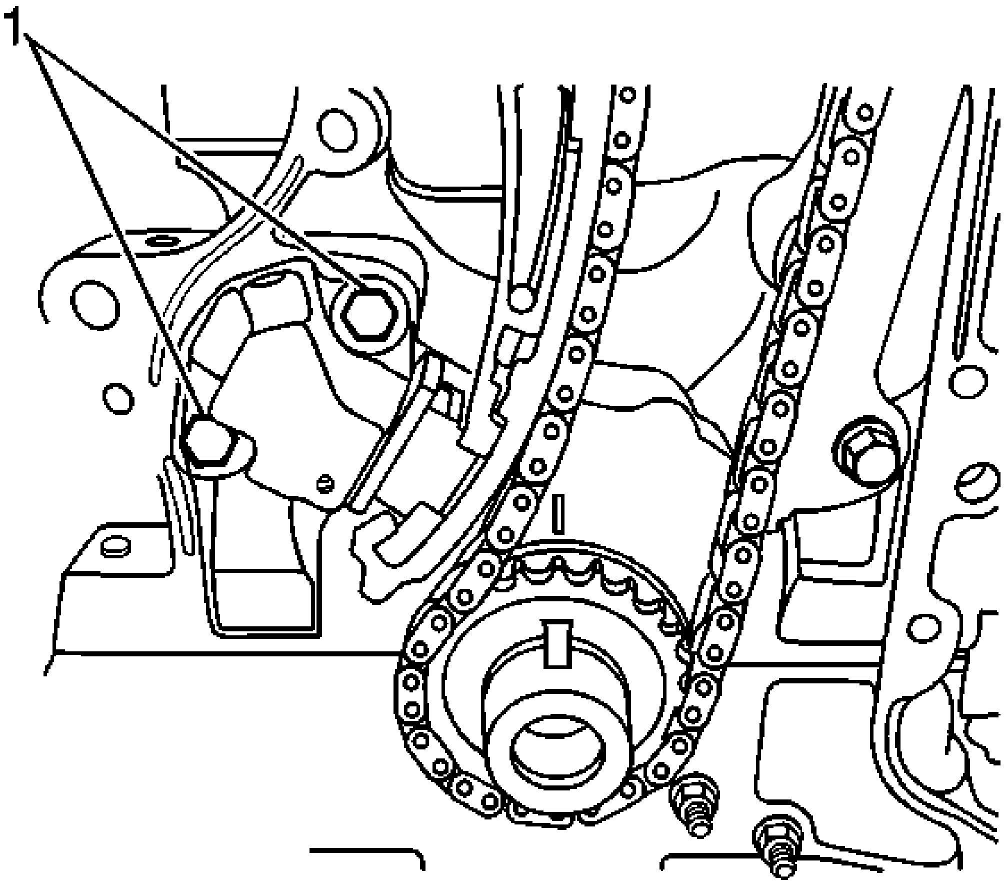


Fig. 412: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

12. Ensure that the crankshaft keyway is aligned with the mark on the engine block.
13. Ensure that the yellow link of the crankshaft timing chain (2) is aligned with the crankshaft timing mark (1).

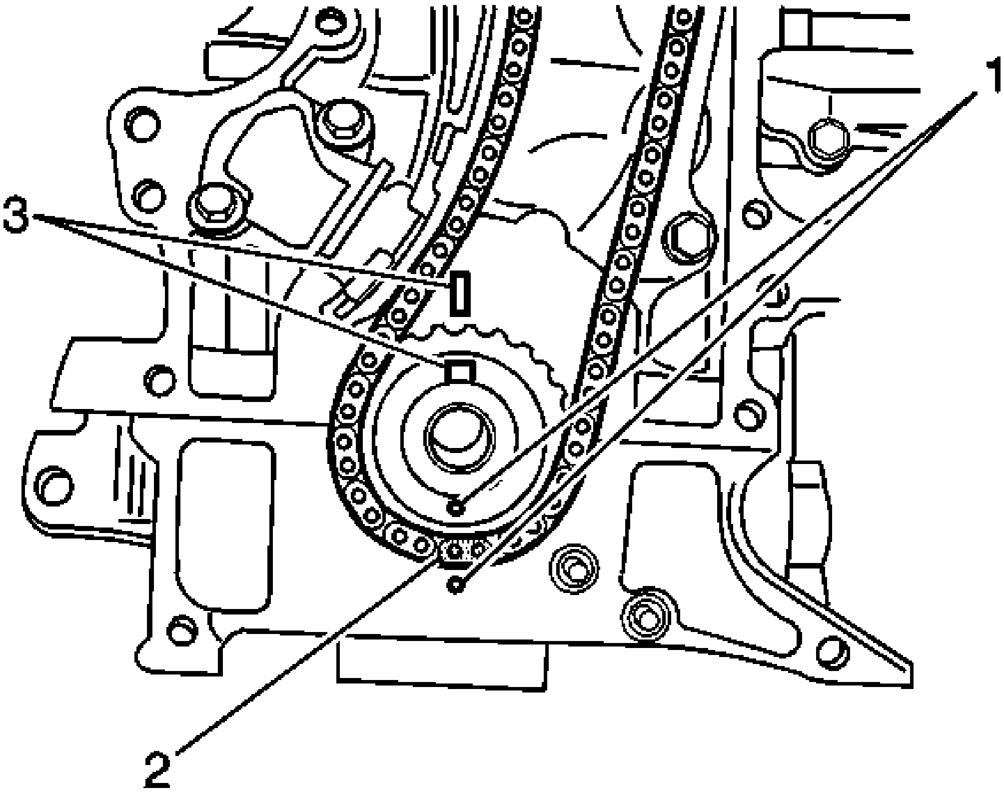


Fig. 413: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

14. Ensure that the guide pins (1) of the camshafts are aligned with the notches (3) on the cylinder head.
15. Ensure that the idler sprocket arrow (2) is pointing upward.
16. Ensure that the dark blue link of the timing chain is aligned with the mark on the idler sprocket.

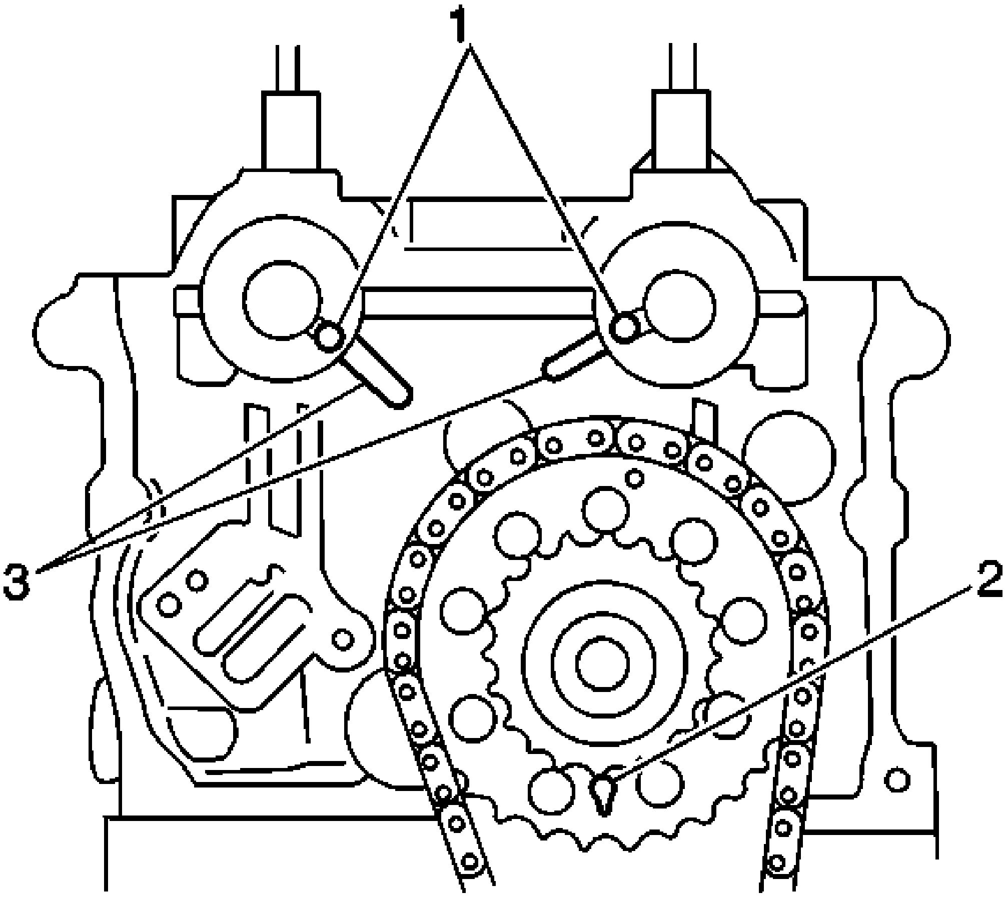


Fig. 414: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

Timing Chain and Sprockets Installation (Camshaft)

1. Ensure that the crankshaft keyway is aligned with the mark on the engine block.
2. Ensure that the yellow link of the crankshaft timing chain (2) is aligned with the crankshaft timing mark (1).

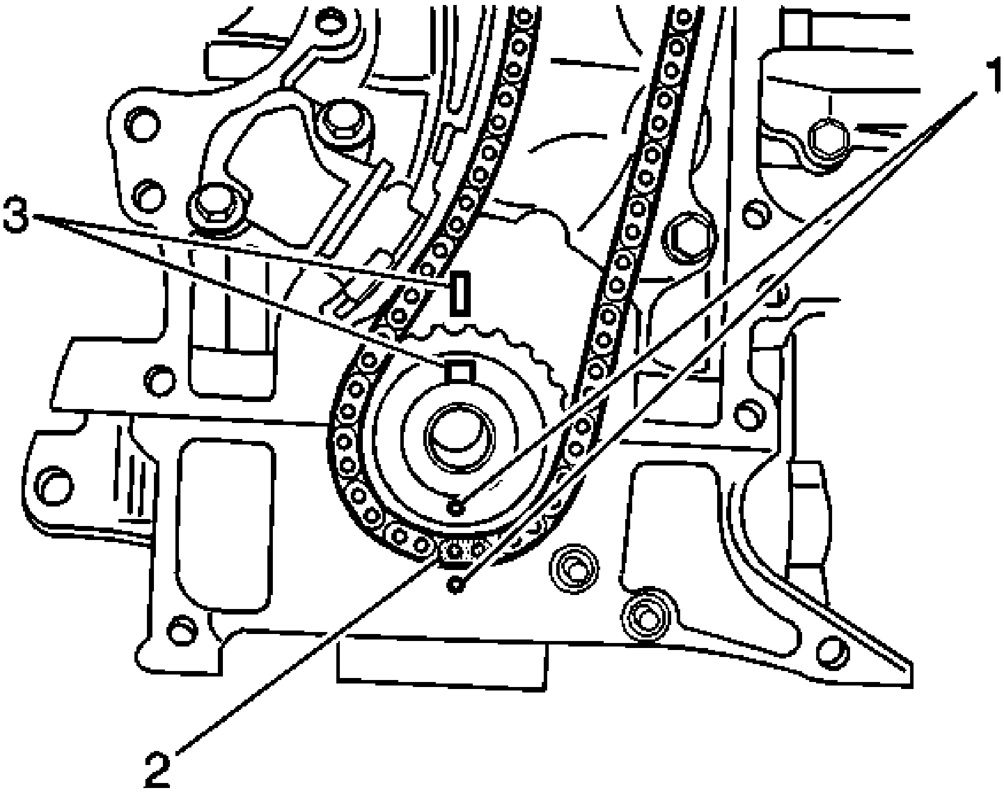


Fig. 415: View Of Engine Block, Timing Chain & Crankshaft Timing Mark
Courtesy of GENERAL MOTORS CORP.

3. Ensure that the idler sprocket arrow (2) is pointing upward.
4. Ensure that the dowel pins (1) of the camshafts are aligned with the notches (3) on the cylinder head.

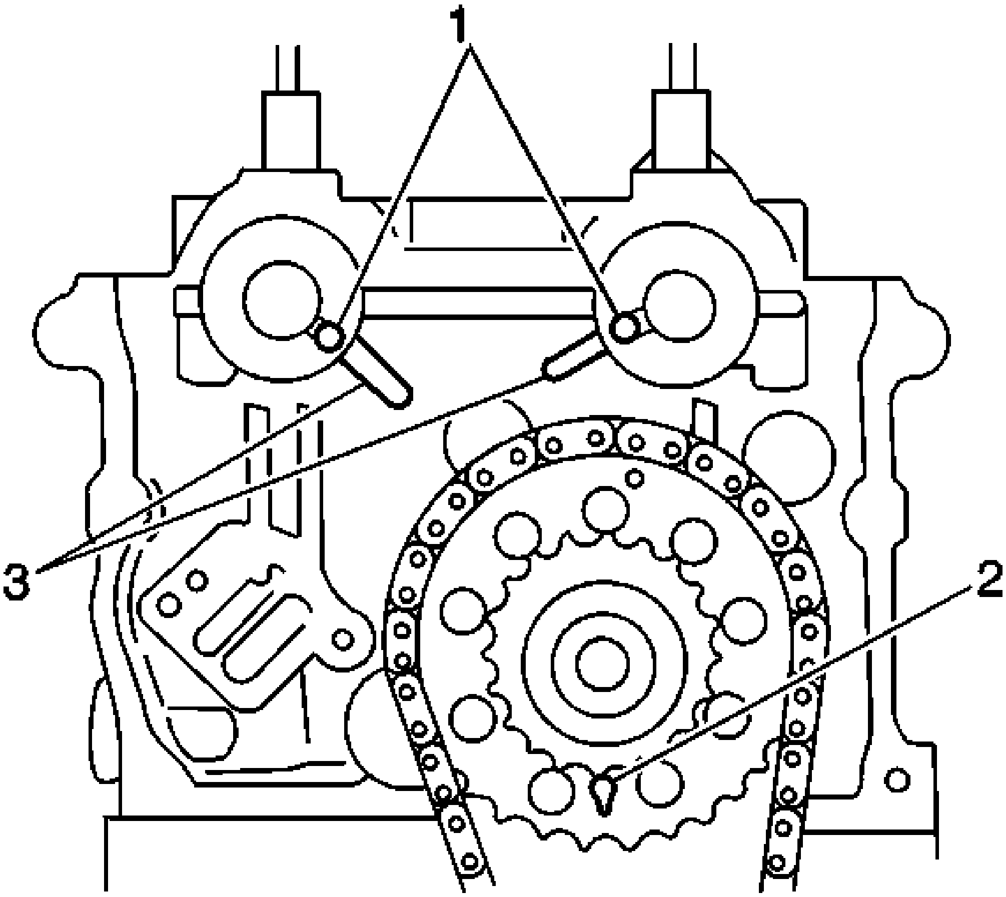


Fig. 416: View Of Camshaft Guide Pins, Notches & Idler Sprocket Arrow
Courtesy of GENERAL MOTORS CORP.

5. Align the yellow link (1) of the camshaft timing chain with the arrows (2) on the idler sprocket.

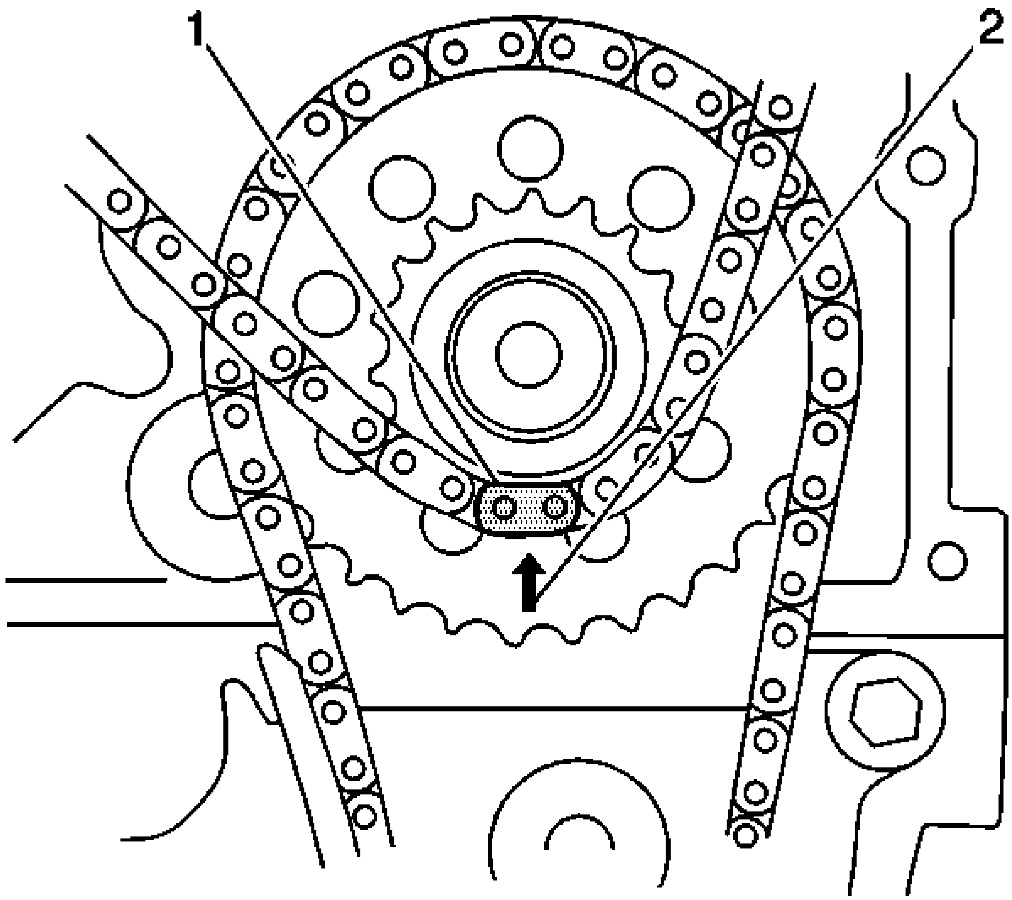


Fig. 417: View Of Yellow Link & Arrow On Idler Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Align the dark blue link (1) of the camshaft timing chain with the arrow (2,3) on the camshaft sprockets.
7. Install the camshaft timing sprockets and chain.

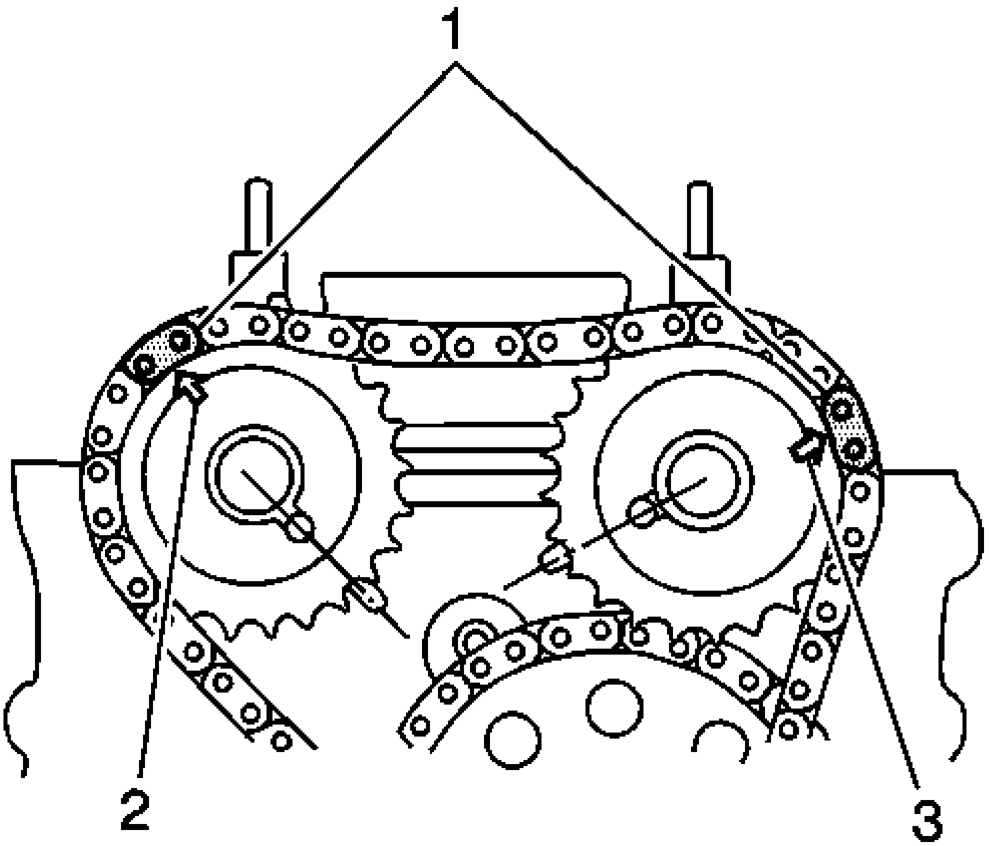


Fig. 418: View Of Dark Blue Link & Arrows
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the camshaft sprocket bolts (1).

   Tighten: Tighten the bolts to 80 N.m (58 lb ft).

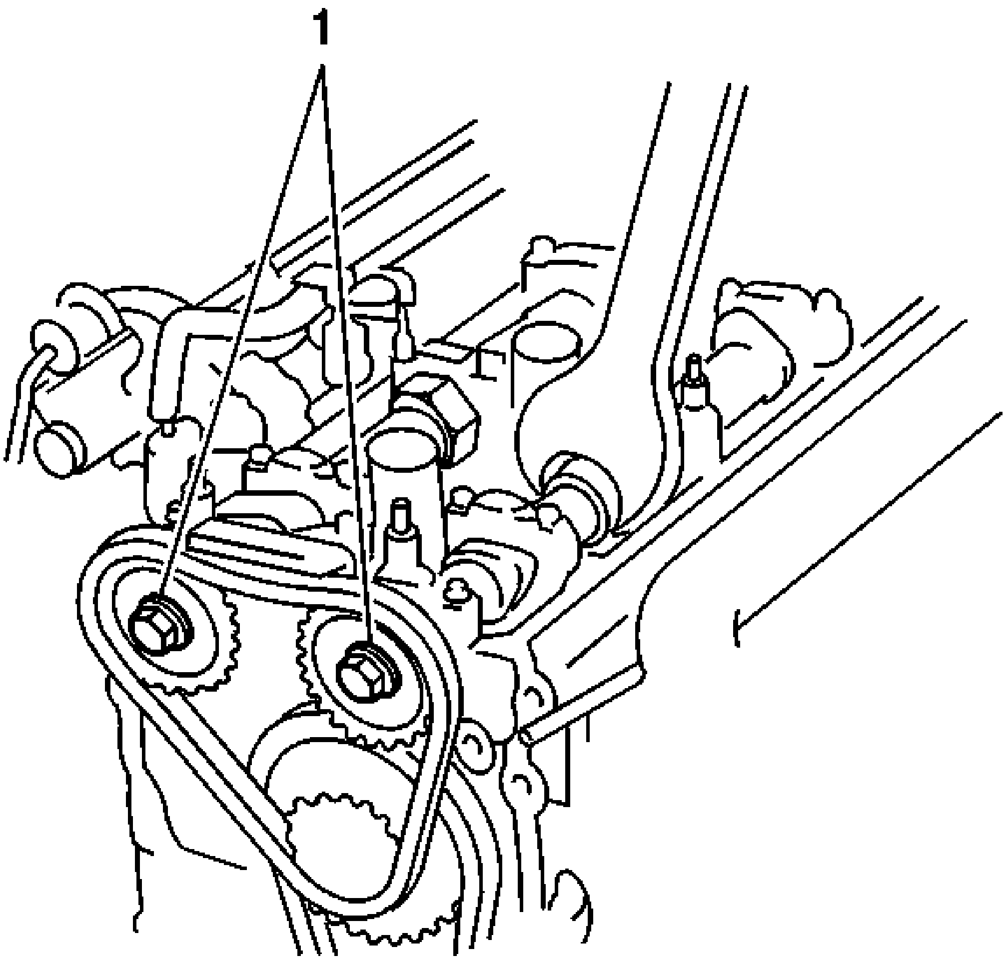


Fig. 419: View Of Camshaft Sprocket Bolts
Courtesy of GENERAL MOTORS CORP.

9. Compress the camshaft tensioner plunger into the body. Insert a retainer (a paper clip or similar tool) through the hole in the body in order to hold the plunger in place.

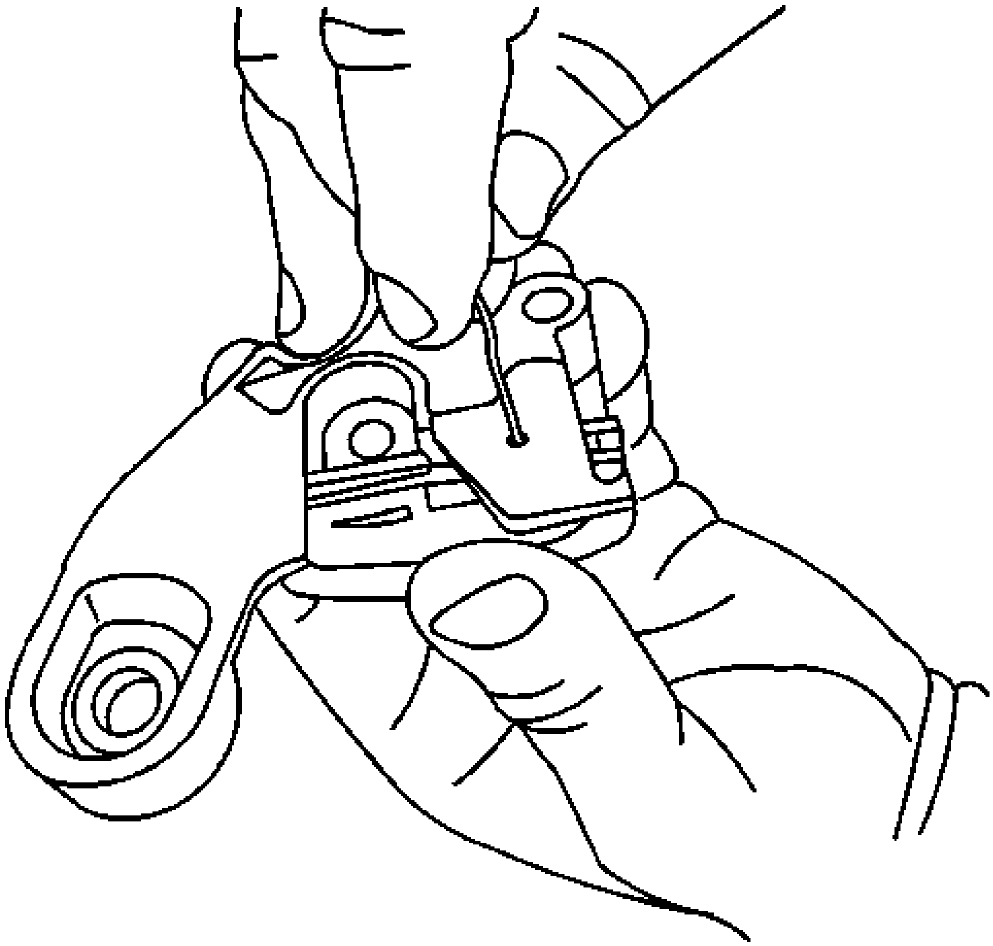


Fig. 420: Installing Camshaft Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

10. Install the gasket and the camshaft timing chain tensioner.

    Tighten:

    - Tighten the bolts (1) to 11 N.m (8 lb ft).
    - Tighten the nut (2) to 45 N.m (33 lb ft).

11. Remove the retainer from the tensioner.

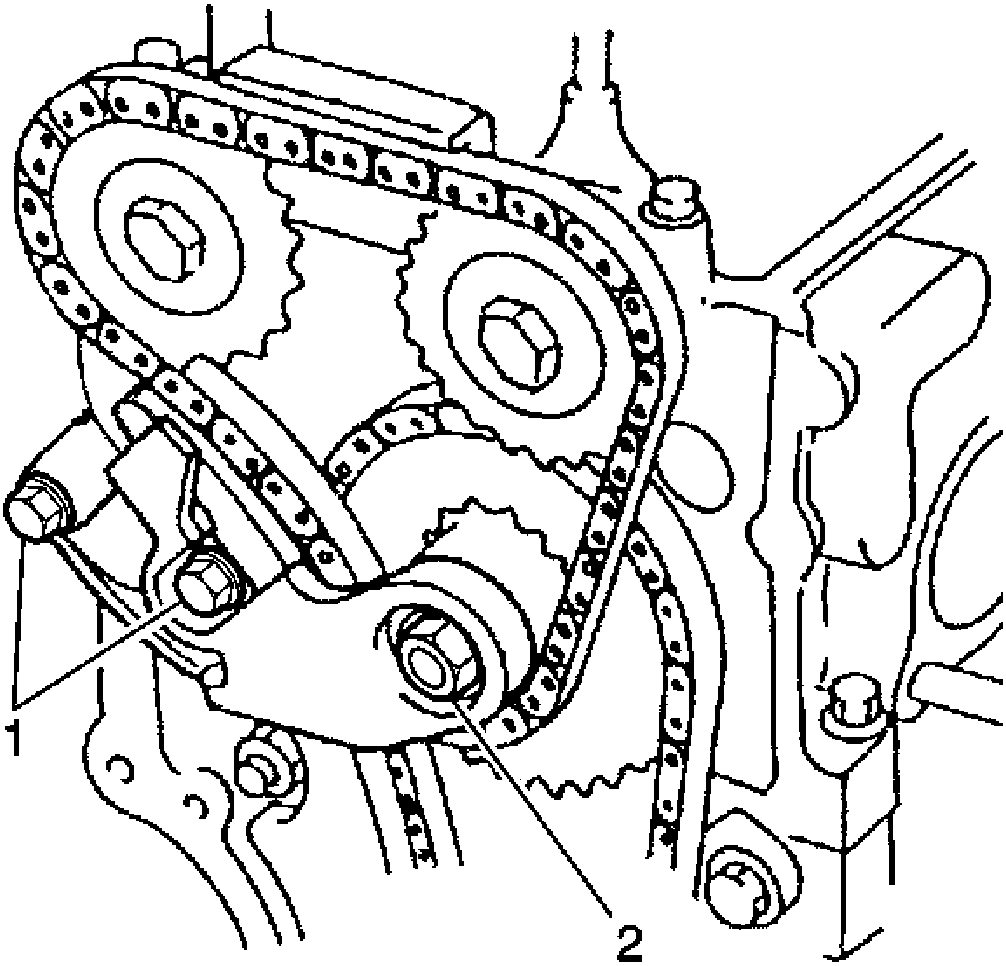


Fig. 421: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

12. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
13. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).
14. Apply engine oil to the following:
    - The timing chains
    - The tensioner
    - The guides
    - The sprockets

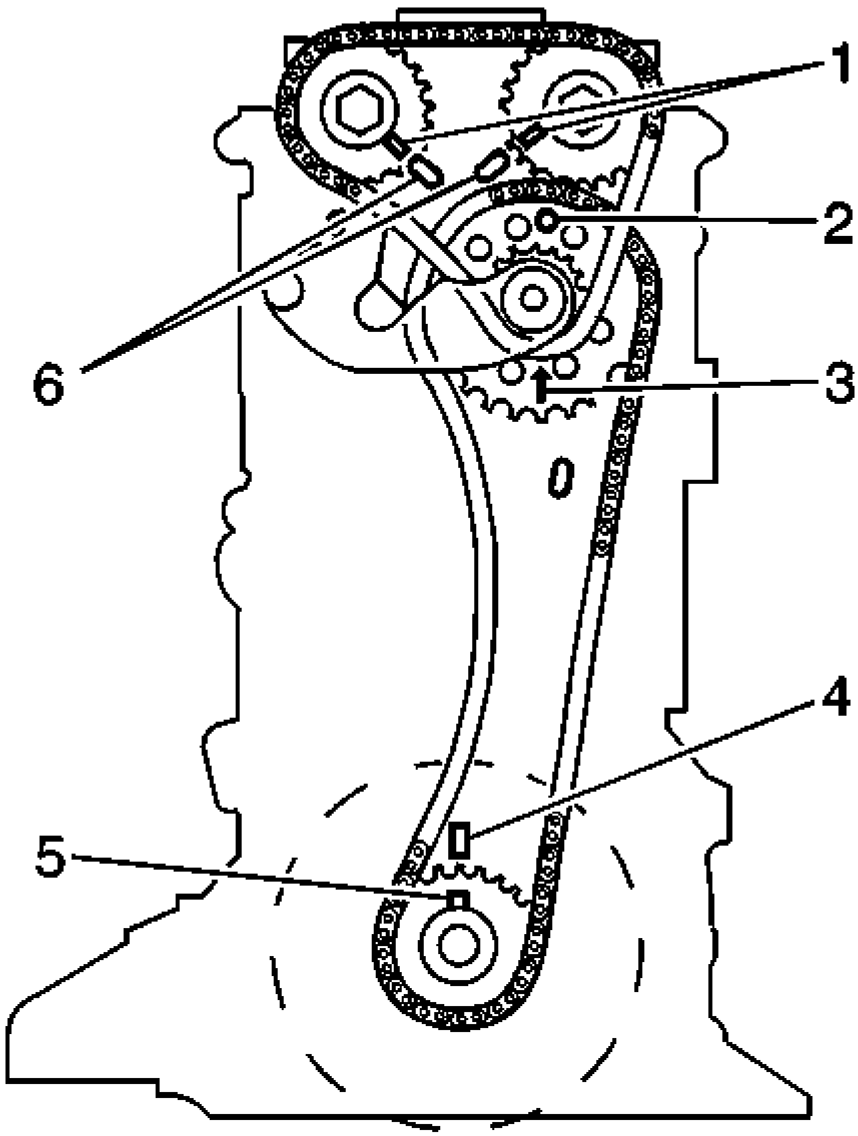


Fig. 422: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Installation (Crankshaft)

1. Hold back the latch, compress the plunger and install a retainer (a paper clip or similar tool) to hold the plunger in place.

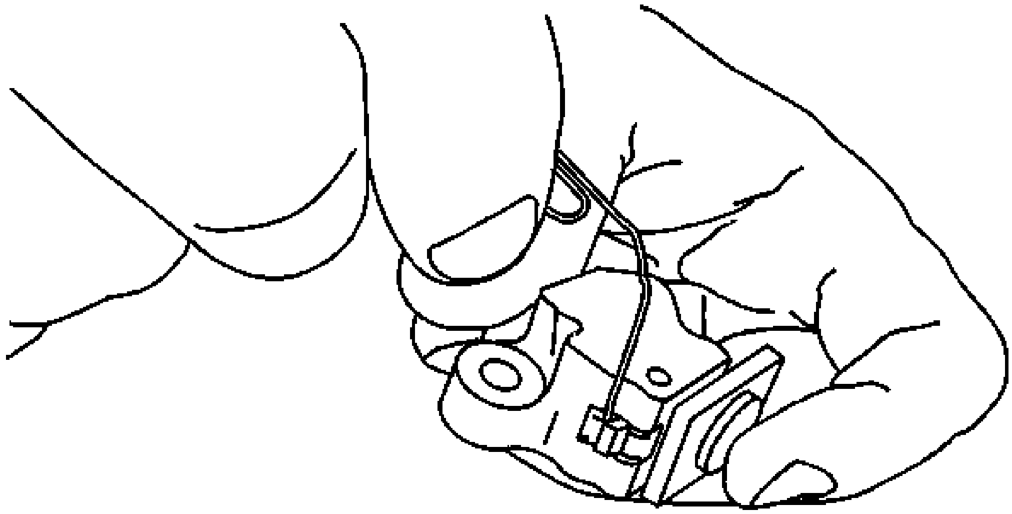


Fig. 423: View Of Plunger & Latch
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the gasket and the timing chain tensioner. Secure with the 2 bolts (1).

   Tighten: Tighten the 2 bolts to 11 N.m (97 lb in).

3. Remove the retainer.

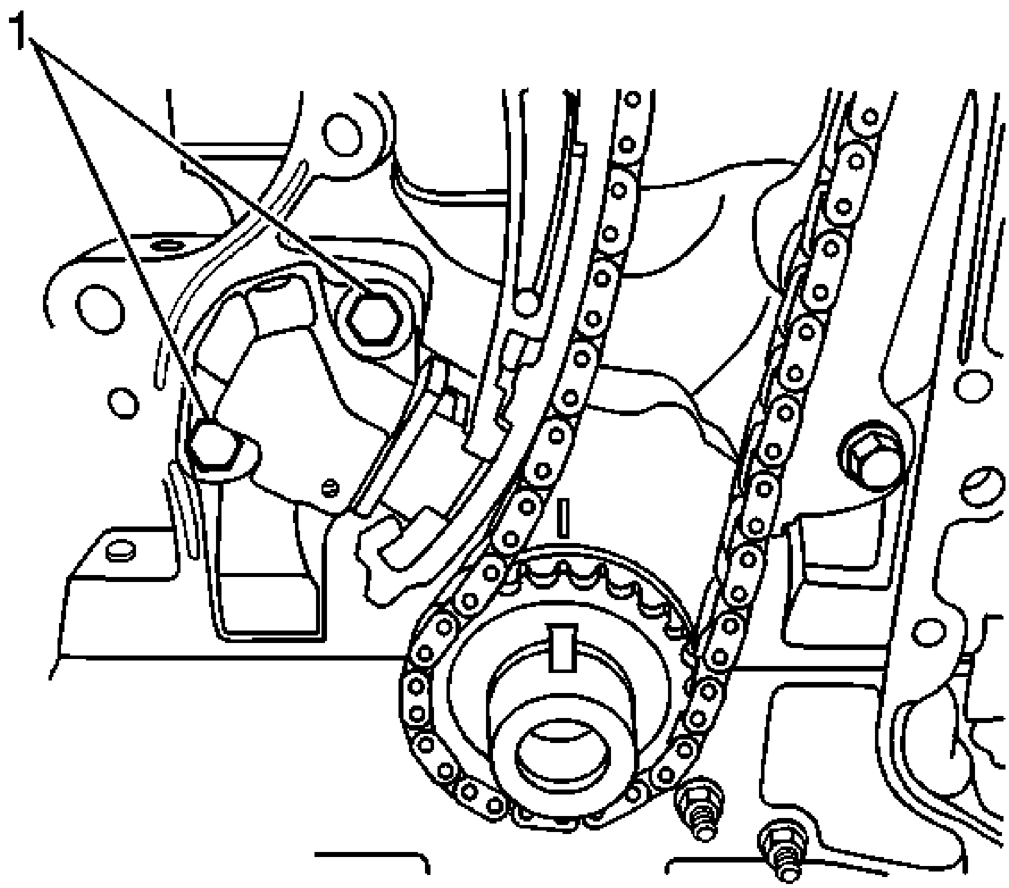


Fig. 424: View Of Crankshaft Timing Chain Tensioner Bolts
Courtesy of GENERAL MOTORS CORP.

Timing Chain Tensioner Installation (Camshaft)

1. Compress the camshaft tensioner plunger into the body. Insert a retainer (a paper clip or similar tool) through the hole in the body in order to hold the plunger in place.

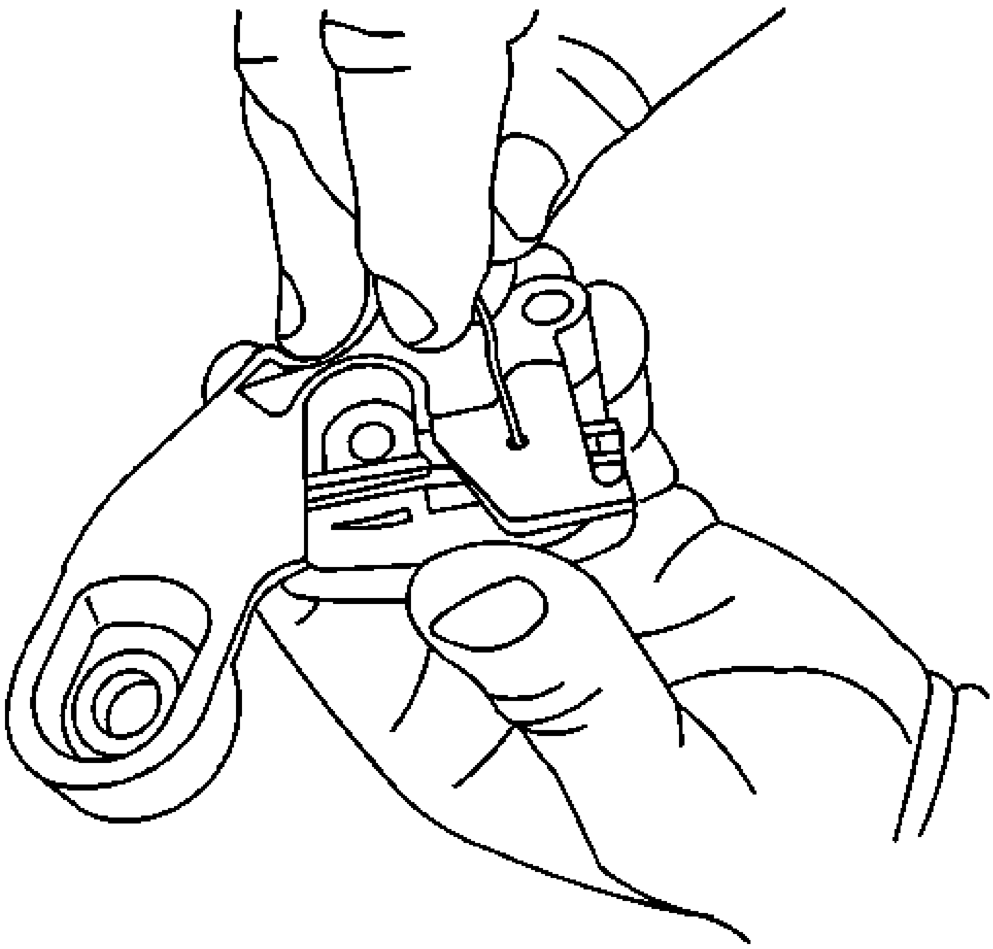


Fig. 425: Installing Camshaft Tensioner Plunger
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the gasket and the camshaft timing chain tensioner.

   Tighten:
   - Tighten the bolts (1) to 11 N.m (97 lb in).
   - Tighten the nut (2) to 45 N.m (33 lb ft).

3. Remove the retainer.

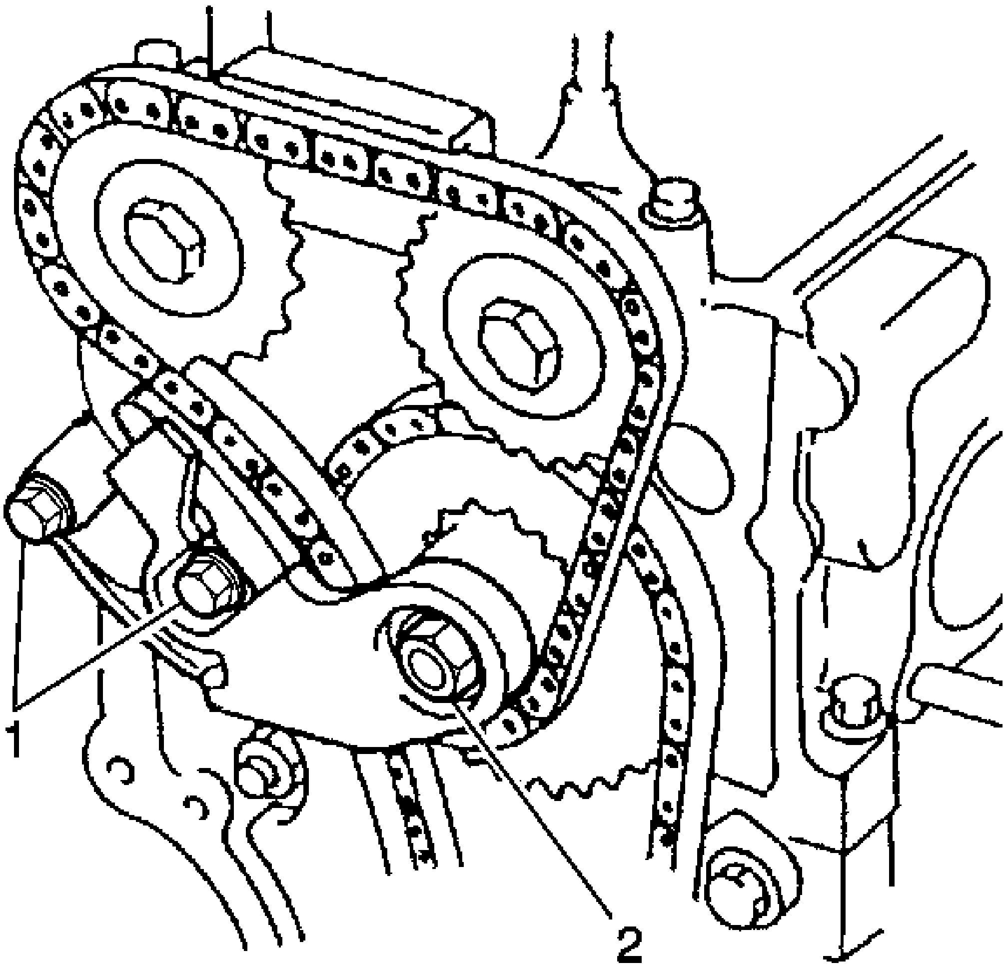


Fig. 426: View Of Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Turn the crankshaft 2 revolutions realigning the keyway on the crankshaft (5) with the timing mark on the engine block (4).
5. Ensure that the guide pins on the camshafts (1) are in line with the notches on the cylinder head (6).

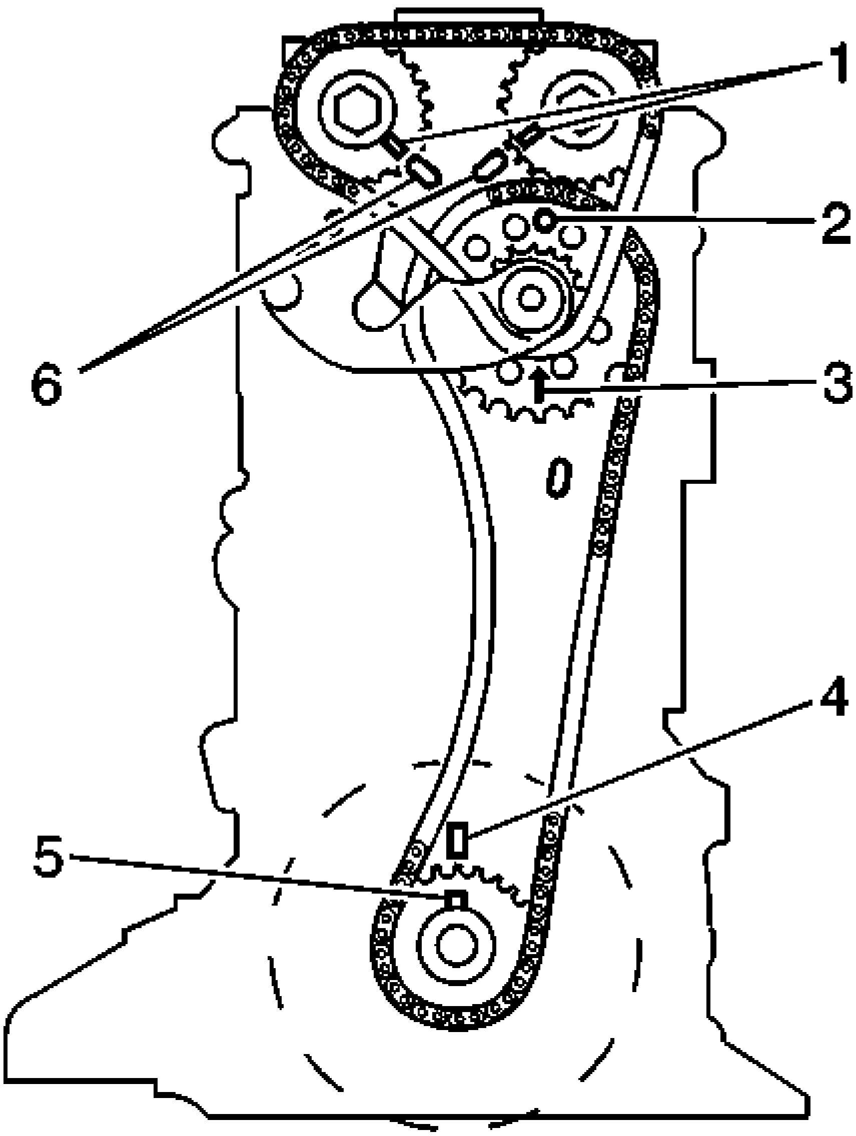


Fig. 427: Locating Timing Marks
Courtesy of GENERAL MOTORS CORP.

Timing Chain Housing Installation

1. Clean the sealing surfaces on the timing chain housing, the cylinder head, the oil pan, the engine block and the lower crankcase.
2. Inspect the front crank seal. Replace as necessary. Refer to **Crankshaft Front Oil Seal Replacement**.

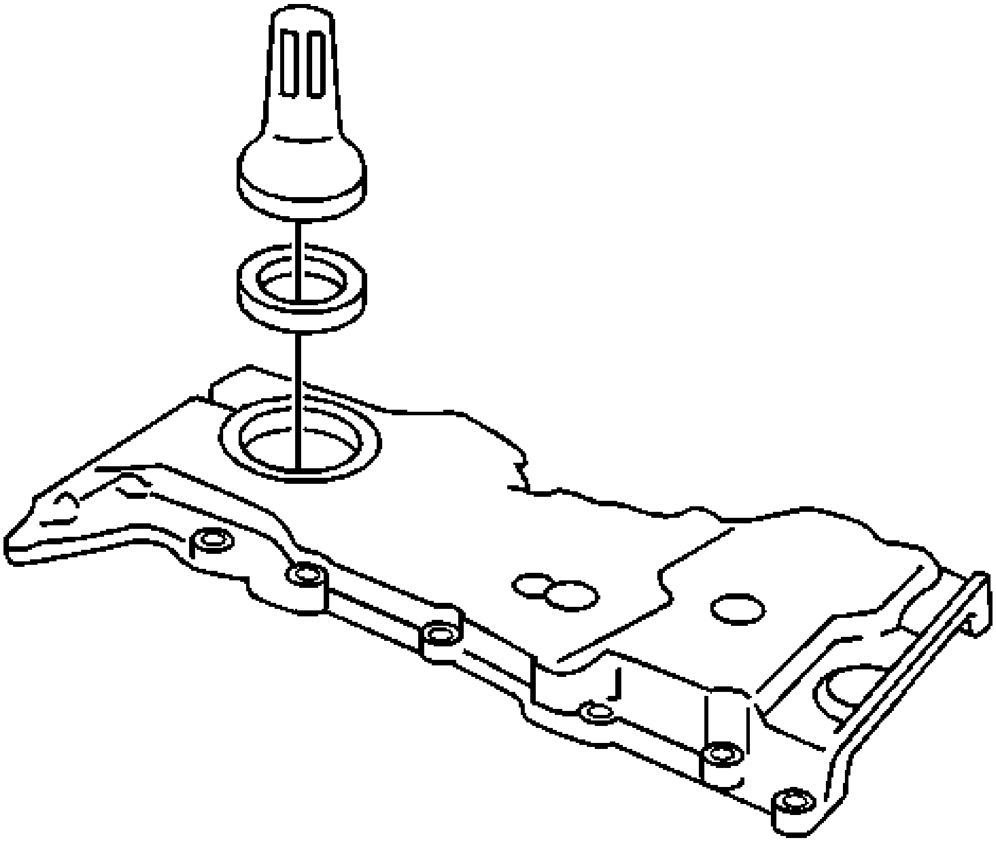
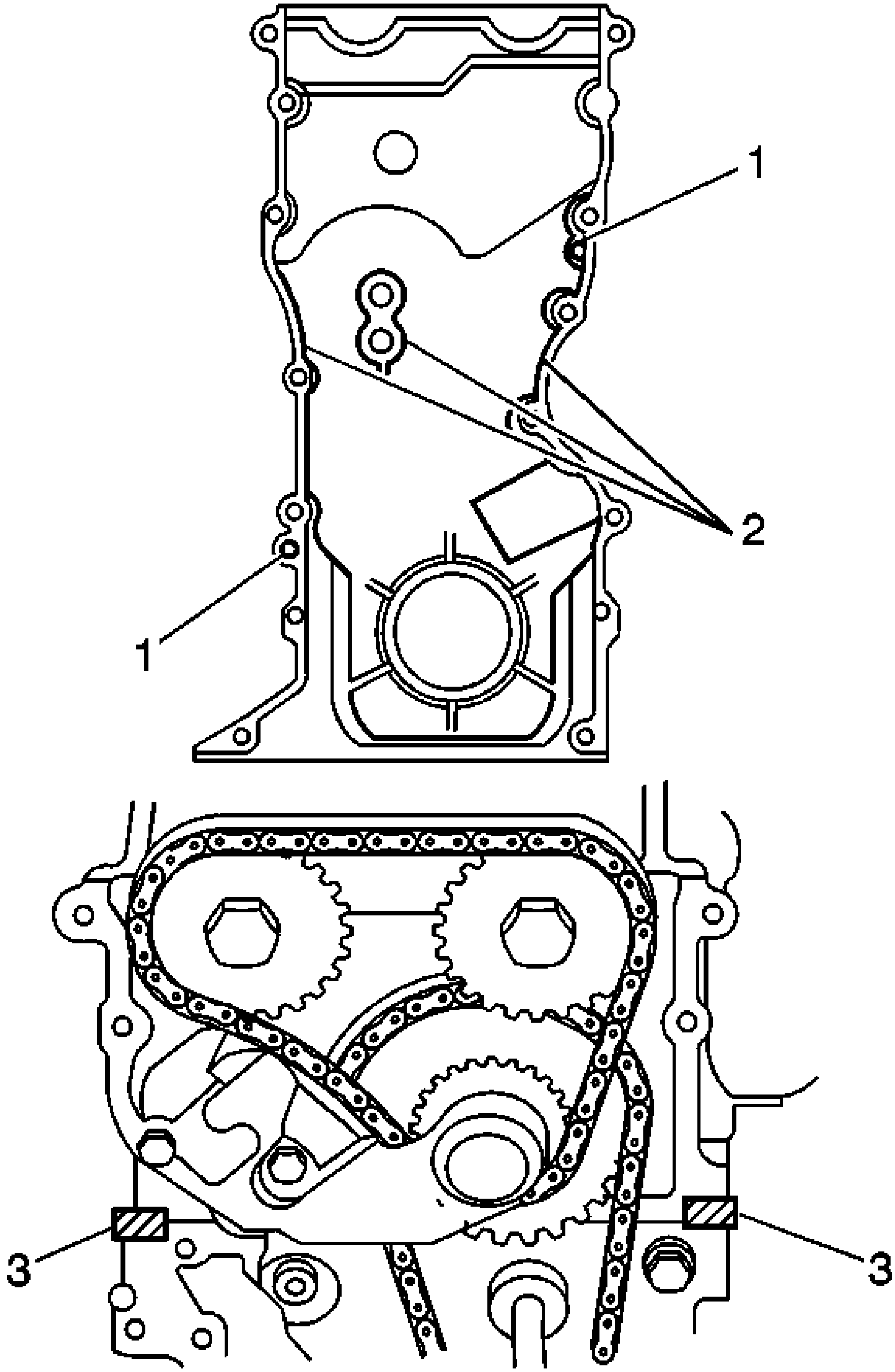


Fig. 428: Installing Dowel Pins To Timing Chain Housing
Courtesy of GENERAL MOTORS CORP.

3. Apply a continuous bead of sealant, GM P/N 12345997, Canadian P/N 12345997 or equivalent, to the following:
   - The cylinder head-engine block mating points (2).
   - The timing cover mating surface (1).
4. Lubricate the new crankshaft front oil seal with Chassis Grease, GM P/N 1051344, Canadian P/N 993037 or equivalent.
5. Install the dowel pin to the timing chain housing.



1
2
1
3
3

Fig. 429: View Of Timing Cover Mating Surface & Cylinder Head-To-Engine Block Mating Points
Courtesy of GENERAL MOTORS CORP.

6. Install the timing chain housing. Secure with the nut and 15 bolts.

   Tighten: Tighten the nut and bolts to 11 N.m (97 lb in).

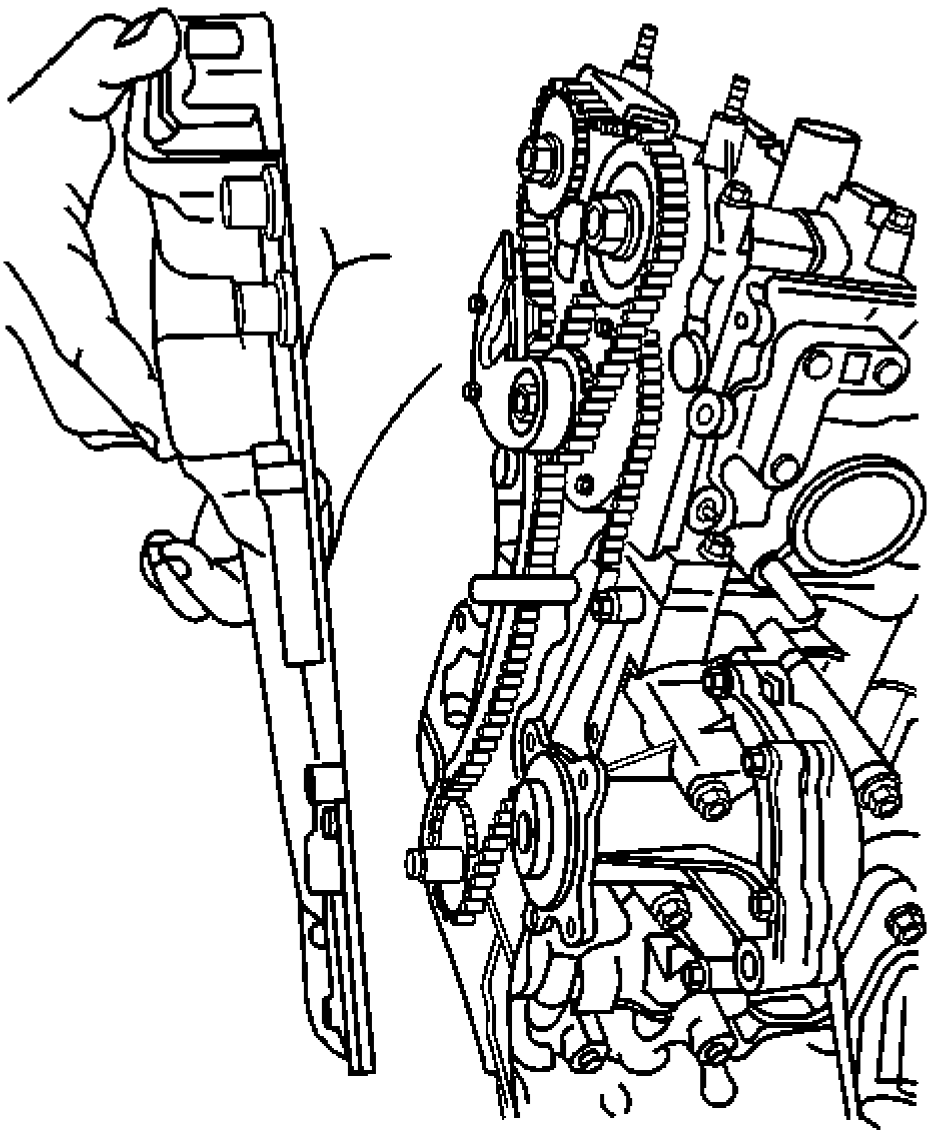


Fig. 430: Installing Timing Chain Housing

Courtesy of GENERAL MOTORS CORP.

Crankshaft Front Oil Seal Installation

Installation Procedure

1. Lubricate the new crankshaft front oil seal with Chassis Grease, GM P/N 1051344, Canadian P/N 993037 or equivalent.

IMPORTANT: Tap the oil seal in until its surface is flush with the crankshaft front oil seal retainer edge.

2. Using a hammer and an appropriate driver, lightly tap the crankshaft front oil seal into place.

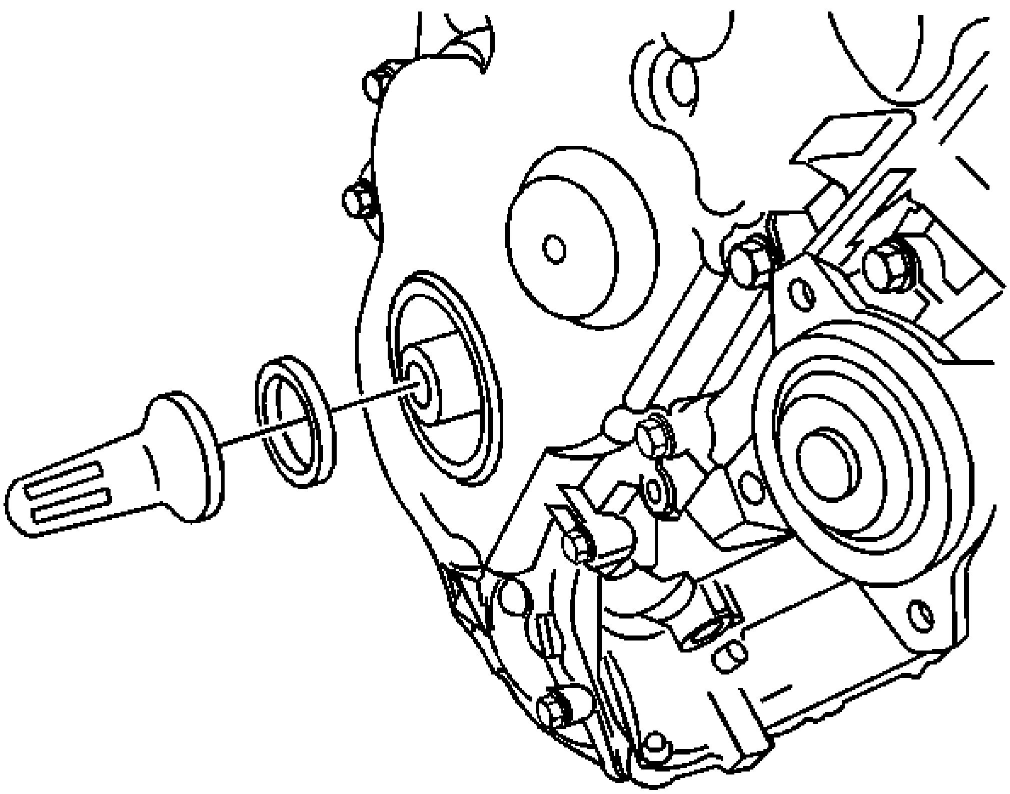


Fig. 431: Lubricating New Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

Crankshaft Pulley Installation

Tools Required

J 8614-01 Flange and Pulley Holding Tool

1. Lubricate the front seal and the sealing surface of the crankshaft pulley with Chassis Grease, GM P/N 1051344, Canadian P/N 993037 or equivalent.
2. Install the crankshaft pulley onto the crankshaft indexing the keyway.

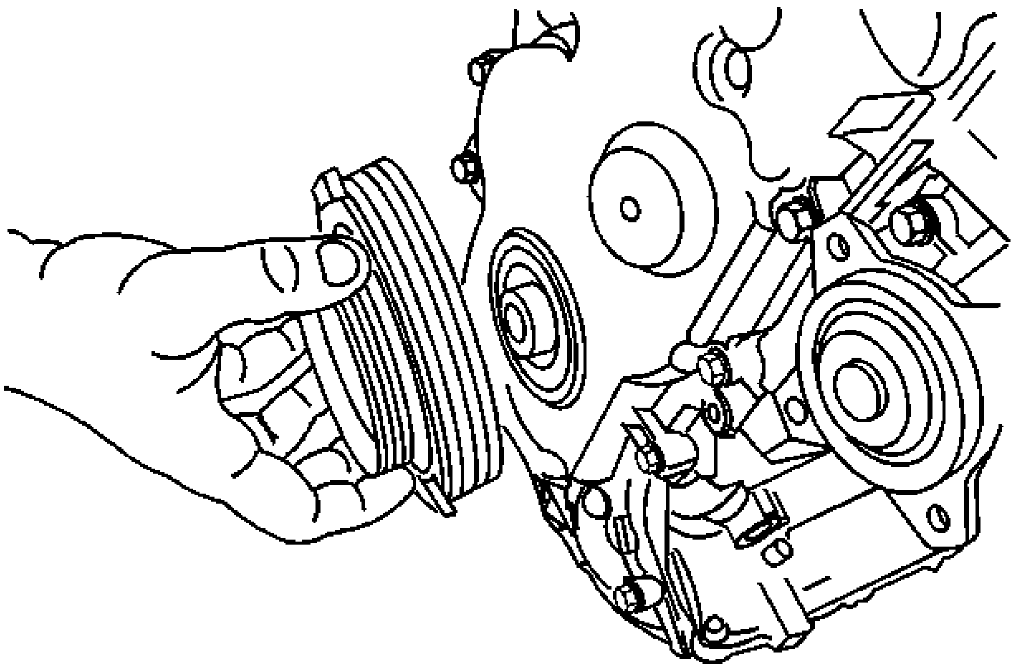


Fig. 432: Installing Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

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

3. Install the crankshaft pulley retaining bolt using the **J 8614-01** to prevent crankshaft rotation when tightening the bolt.

   Tighten: Tighten the bolt to 150 N.m (109 lb ft).

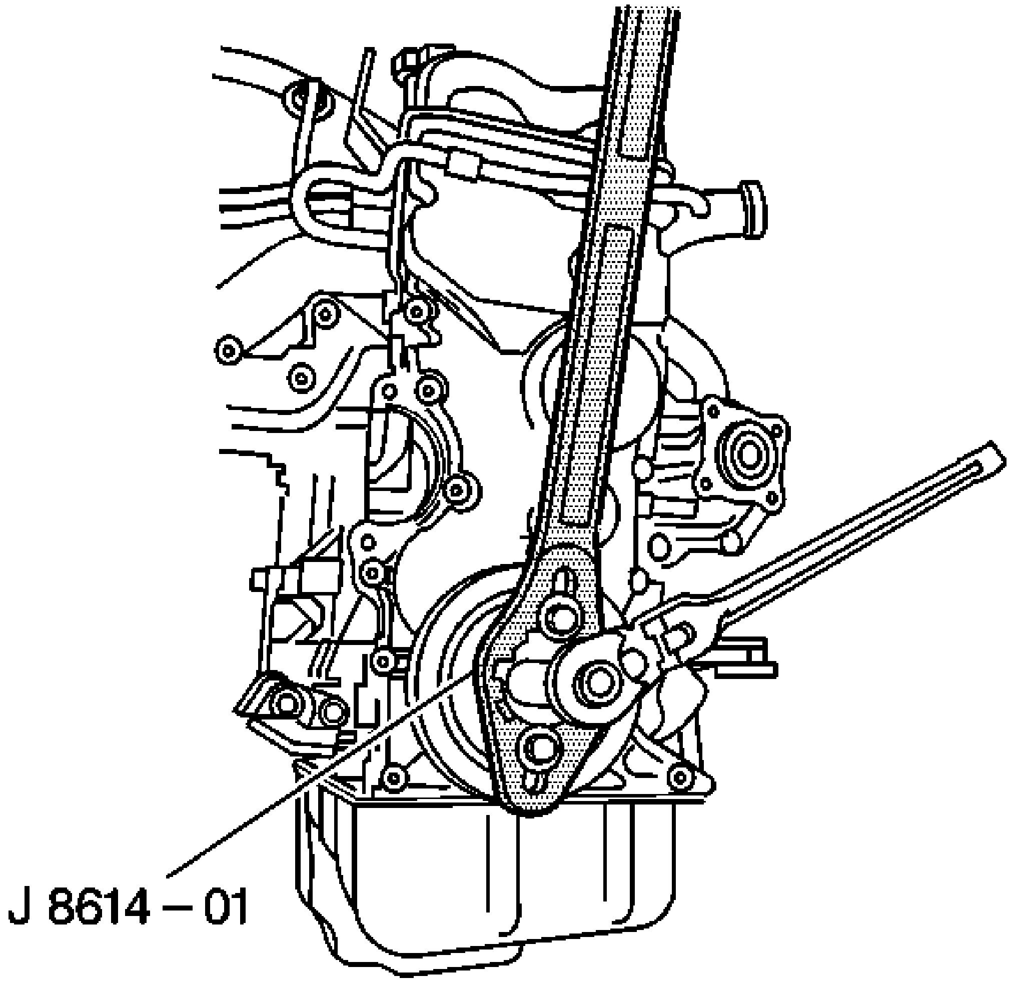


Fig. 433: View Of J 8614-01
Courtesy of GENERAL MOTORS CORP.

Water Pump Installation

1. Install the dowel pins to the water pump.
2. Install a new O-ring to the water pump and to the heater outlet line.

IMPORTANT: Use new bolts when installing the water pump. Failure to do so may result in leakage.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water pump using 4 new bolts (2).

   Tighten: Tighten the bolts to 27 N.m (20 lb ft).

4. Install the heater outlet line to the rear of the water pump housing. Secure with the 1 bolt.

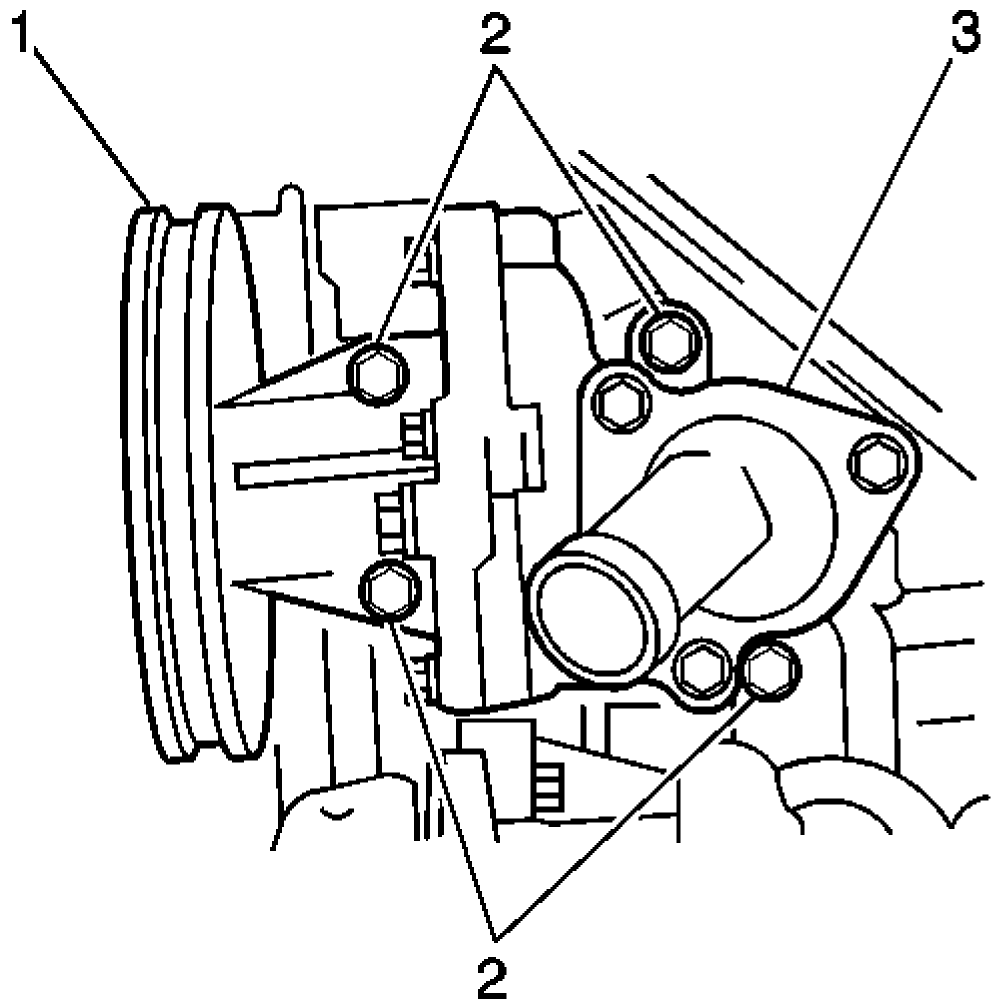


Fig. 434: View Of Water Pump Bolts
Courtesy of GENERAL MOTORS CORP.

Cylinder Head Cover Installation

IMPORTANT: Use a new cylinder head cover gasket, new O-rings and a new side seal whenever the cylinder head cover replacement procedure is performed.

1. Ensure that the new gasket, the new O-rings and the new side seal are correctly positioned during the cylinder head cover installation.
2. Clean the sealing surfaces on the cylinder head cover and the cylinder head.
3. Apply sealant, GM P/N 12345997, Canadian P/N 12345997 or equivalent, to the cylinder head at the points indicated (1).

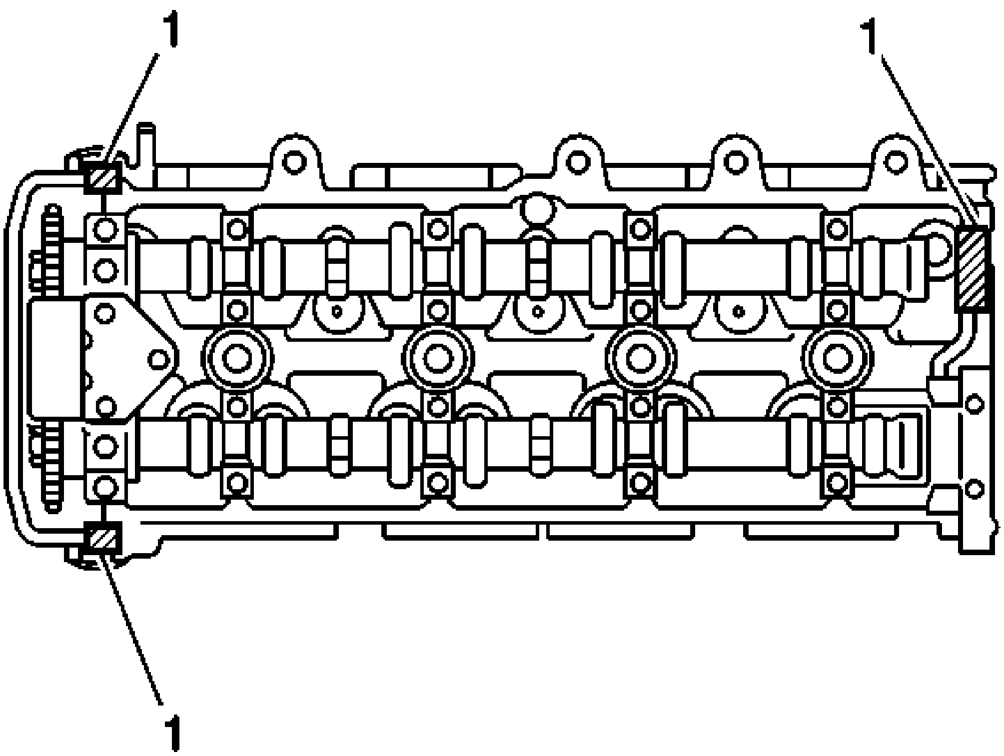


Fig. 435: Applying Sealant To Indicated Points
Courtesy of GENERAL MOTORS CORP.

4. Install the 4 new O-rings (3) to the cylinder head cover (1).
5. Install the new cylinder head cover gasket (2) to the cylinder head cover.
6. Install the new cylinder head side seal (4) to the cylinder head.
7. Install the cylinder head cover to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install new washers to the cylinder head cover and install the cap nuts.

   Tighten: Starting in the center, cross-tighten the cylinder head cover nuts evenly to 11 N.m (97 lb in).

9. Install the 4 ignition coils.
10. Install the oil level gauge.
11. Install the positive crankcase ventilation (PCV) hose.
12. Install the PCV breather hose.

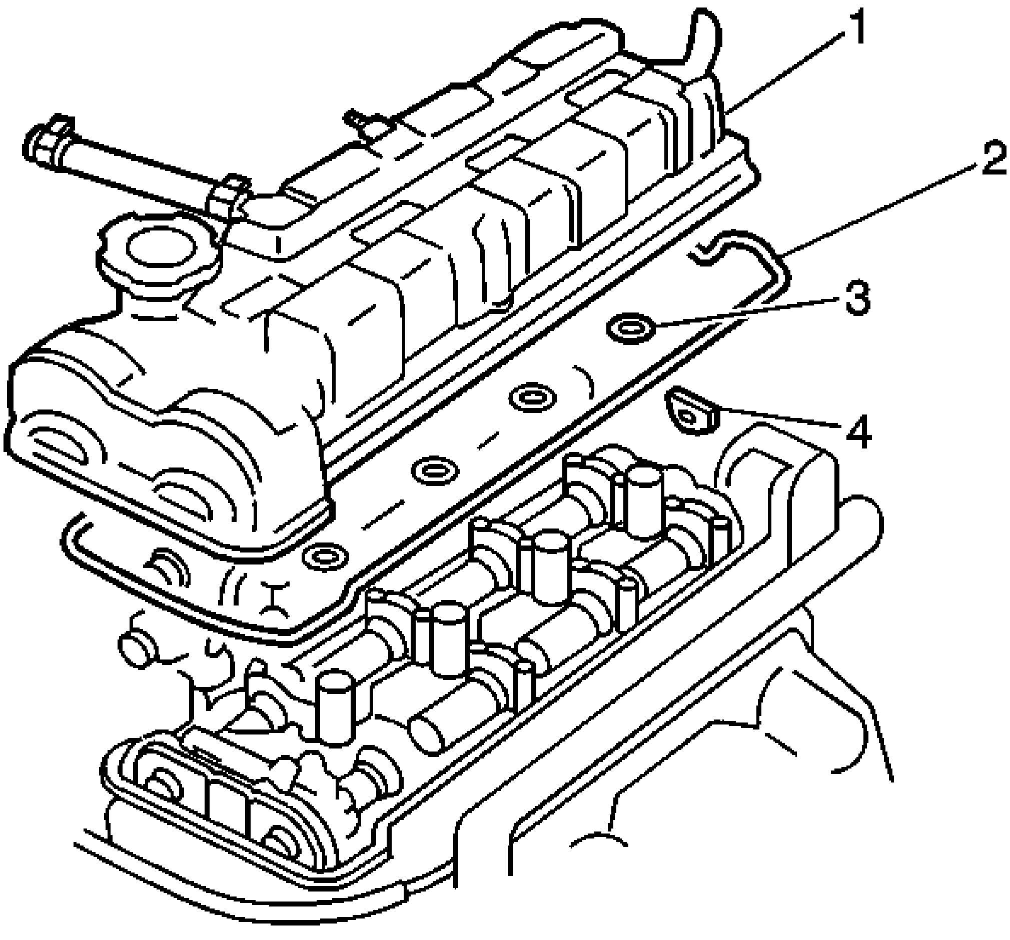


Fig. 436: View Of Cylinder Head Cover, Gasket & O-Rings
Courtesy of GENERAL MOTORS CORP.

Intake Manifold Installation

1. Install the new intake manifold gasket to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the intake manifold with the throttle body to the cylinder head. Secure the intake manifold with the 9 nuts and the 4 bolts.

   Tighten: Tighten the nuts and bolts to 25 N.m (19 lb ft).

3. Install the intake manifold front support bracket (8).
4. Install the intake manifold top support bracket (5).

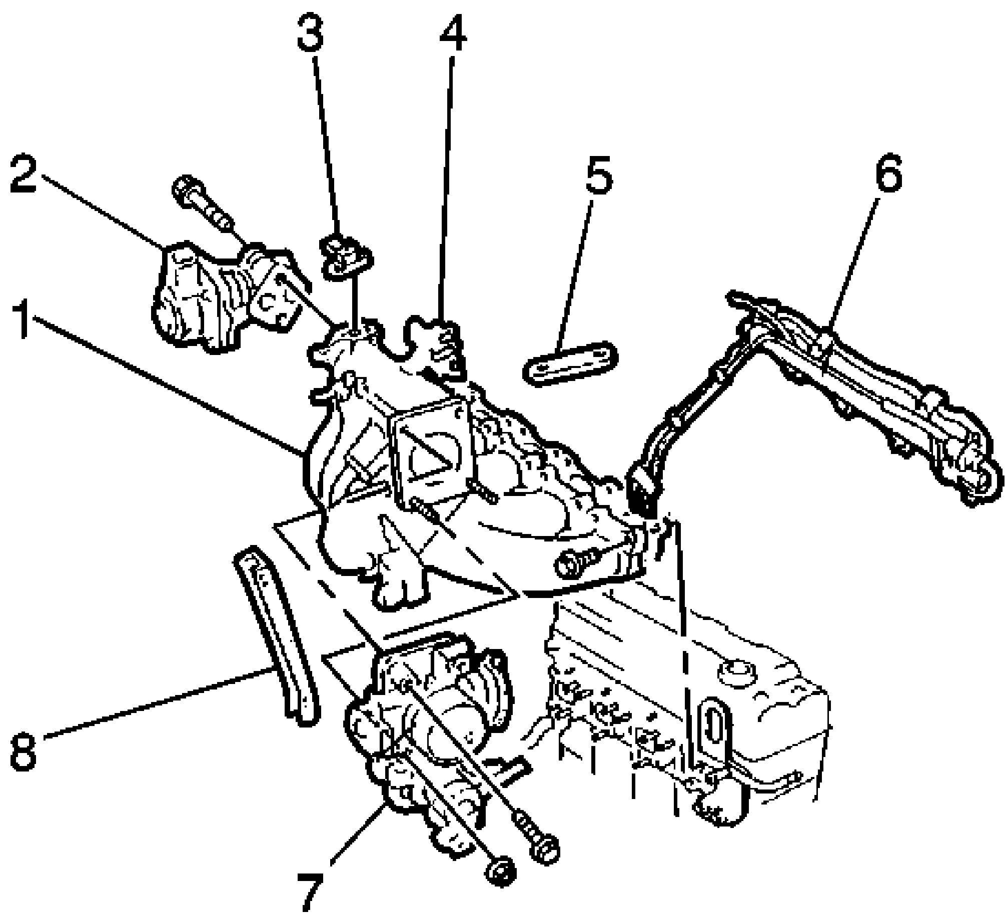


Fig. 437: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

5. Install the coolant line to the underside of the intake manifold. Secure with the 2 bolts (5).
6. Connect the coolant hoses (3,4) to the throttle body and intake manifold.
7. Connect the PCV hose (1) to the intake manifold.
8. Connect the breather hose (2) to the intake manifold.
9. Install the fuel line bracket (6) to the intake manifold. Secure with 1 bolt.
10. Connect the fuel pressure regulator vacuum hose to the intake manifold.
11. Install the fuel lines to the fuel rail. Secure with the 2 bolts.
12. Install the washer and the banjo fitting to the rear end of the fuel rail.

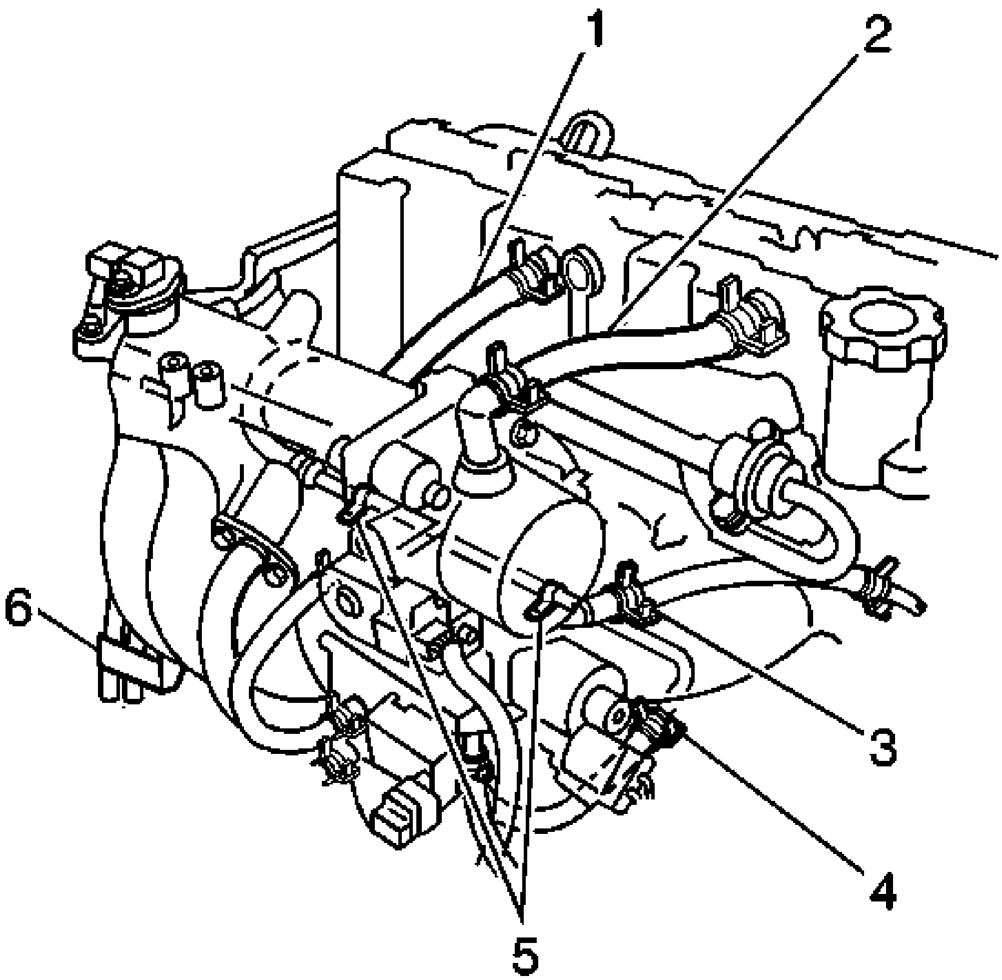


Fig. 438: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

Exhaust Manifold Installation

IMPORTANT: California emissions vehicles are equipped with an additional (PUP) catalytic converter and a different exhaust manifold from federal emissions vehicles.

1. Perform the following if the vehicle is equipped with the PUP catalytic converter:
    1. Install the new exhaust manifold gasket to the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the exhaust manifold. Secure the exhaust manifold with the 8 nuts and 1 bolt.

   Tighten: Tighten the 8 nuts and 1 bolt to 50 N.m (37 lb ft).

3. Install the exhaust manifold-to-engine block bracket.
4. Apply anti-seize compound to the threads of the oxygen sensor.
5. Install the oxygen sensor.

   Tighten: Tighten the oxygen sensor to 45 N.m (33 lb ft).

6. Install the exhaust manifold heat shield. Secure with the 3 bolts and 2 nuts.

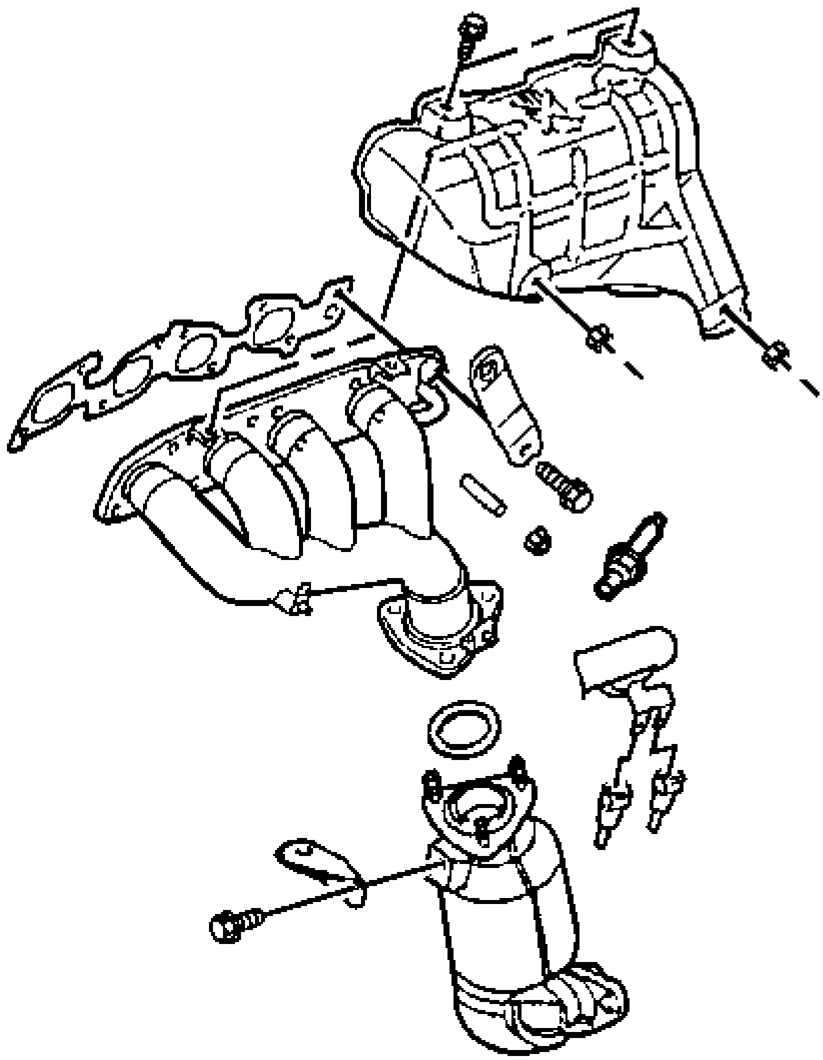


Fig. 439: View Of Exhaust Manifold & Components
Courtesy of GENERAL MOTORS CORP.

2. Perform the following if the vehicle is not equipped with the PUP catalytic converter:
    1. Install the new exhaust manifold gasket to the cylinder head.

    NOTE: Refer to Fastener Notice in Cautions and Notices.

    2. Install the exhaust manifold. Secure the exhaust manifold with the 1 bolt and the 8 nuts.

Tighten: Tighten the 8 nuts and 1 bolt to 50 N.m (37 lb ft).

3. Install the exhaust manifold-to-engine block bracket.
4. Apply anti-seize compound to the threads of the oxygen sensor.
5. Install the oxygen sensor.

   Tighten: Tighten the oxygen sensor to 45 N.m (33 lb ft).

6. Install the exhaust manifold heat shield to the exhaust manifold. Secure the exhaust manifold heat shield with the 4 bolts and 1 nut.

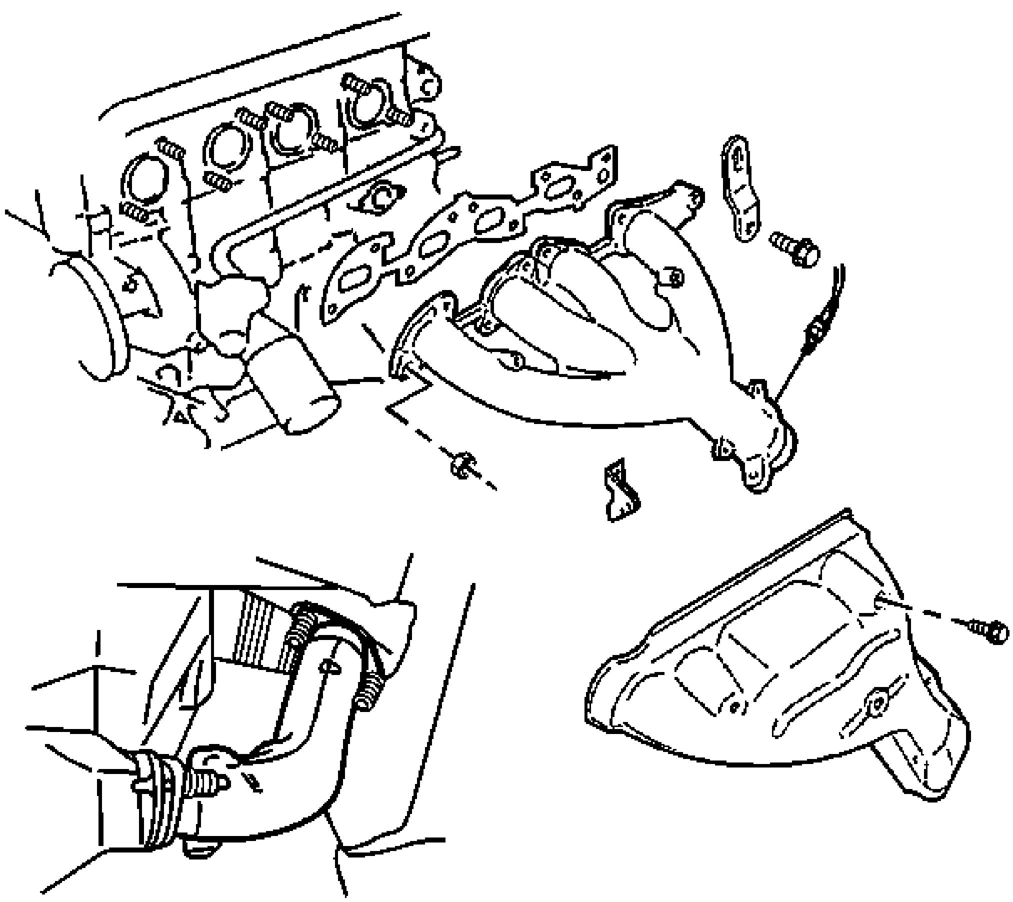


Fig. 440: Exhaust System Components
Courtesy of GENERAL MOTORS CORP.

Engine Flywheel Installation

Tool Required

J 35271 Flywheel Holder. See **Special Tools and Equipment**.

1. Align the flywheel-to-engine marks and install the flywheel (3) to the crankshaft (1).

NOTE: Apply the proper amount of the sealant to the fastener when assembling this component. Excessive use of the sealant can prohibit the component from being assembled properly or allow the fastener to loosen. A component or fastener that is not assembled properly can loosen or fall off leading to extensive engine damage.

2. Apply adhesive, GM P/N 12345493, Canadian P/N 10953488 or the equivalent, to the flywheel retaining bolt threads.

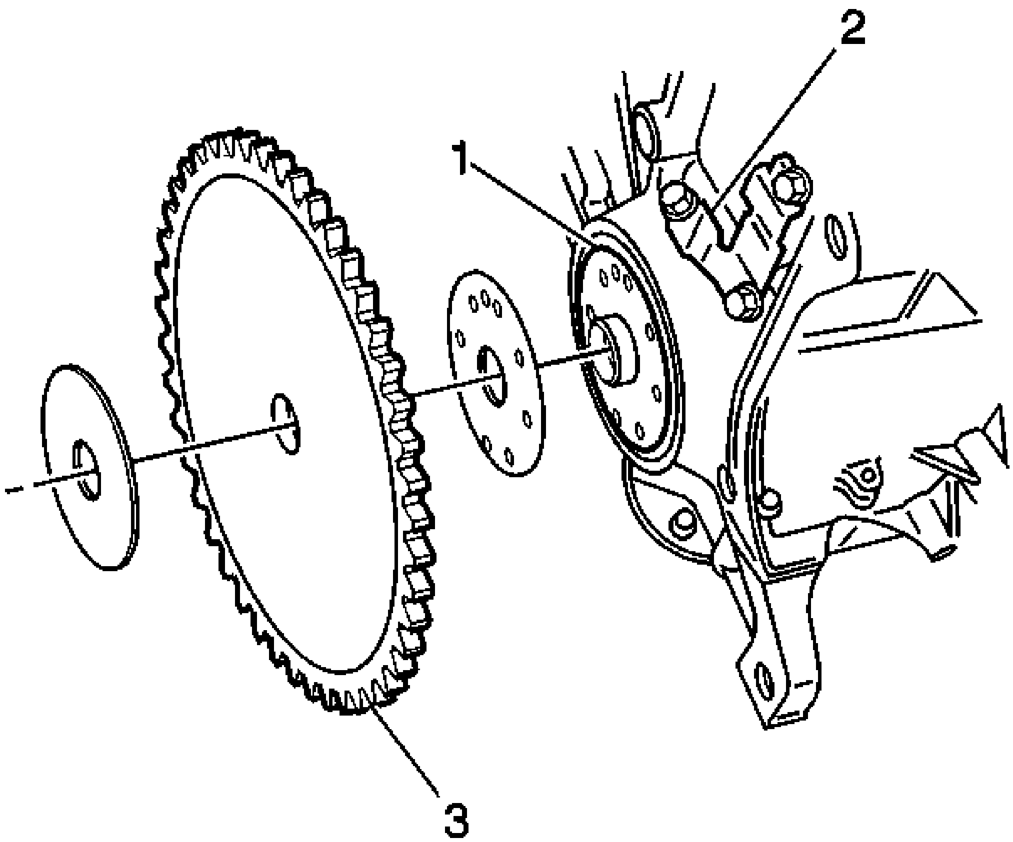


Fig. 441: View Of Crankshaft & Flywheel
Courtesy of GENERAL MOTORS CORP.

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

3. Install the flywheel retaining bolts to the crankshaft. Use the **J 35271** to lock the flywheel. See **Special Tools and Equipment**.

   Tighten: Cross tighten the 8 flywheel retaining bolts to 70 N.m (51 lb ft).

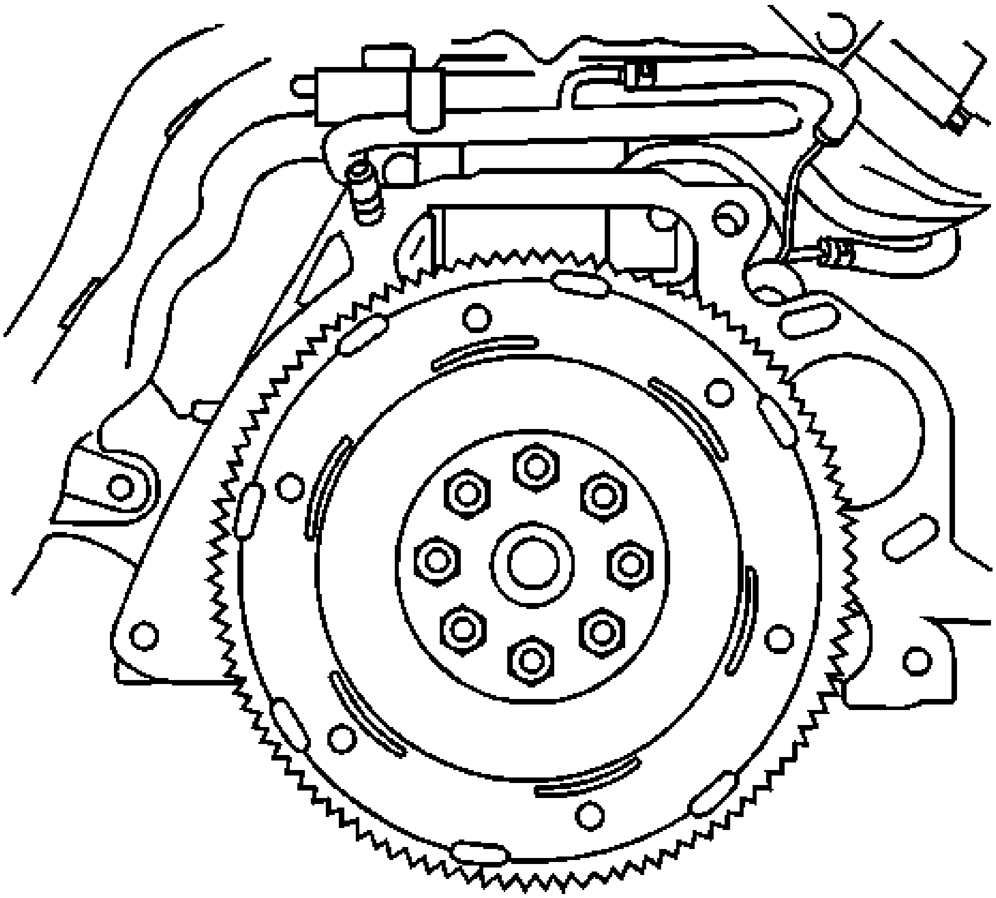


Fig. 442: Installing Flywheel
Courtesy of GENERAL MOTORS CORP.

DESCRIPTION AND OPERATION

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
    - The power steering pump, if belt driven
    - The generator
    - The A/C compressor, if equipped
    - The engine cooling fan, if belt driven
    - The water pump, if belt driven
    - The vacuum pump, if equipped
    - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers - chloroprene or EPDM - and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Construction

The engine is a four cylinder in-line, four stroke gasoline unit with a Double Overhead Cam (DOHC) valve mechanism arranged for V-type valve configuration.

The DOHC is mounted over the cylinder head and is driven by the crankshaft through two timing chains. In this configuration there are no push rods and no rocker arms provided in the valve train system.

Cylinder Block

The cylinder block is an aluminum casting with four cast iron cylinder sleeves. The cylinder block has four in-line cylinders which are numbered 1 through 4 starting from the crankshaft pulley. The cylinder block contains coolant jackets through which coolant flows around the cylinders, to cool the cylinder block and maintain a constant operating temperature. The lower crankcase of the cylinder block is also an aluminum casting with cast iron inserts at the main bearing locations. The lower crankcase runs the entire perimeter of the cylinder block.

Crankshaft

The crankshaft is nodular cast iron and is supported by five main bearings. The crankpins of cylinders 1 and 4 are 180 degrees from the crankpins of cylinders 2 and 3. The crankshaft is counterbalanced by the flywheel, the crankshaft balancer and eight counterweights cast into the crankshaft. Oil holes run through the center of the crankshaft to supply oil to the connecting rods, bearings, pistons and other components. The end thrust load is taken by the thrust washers installed at the center number three bearing journal. The main bearings are of the precision insert type. The front of the crankshaft incorporates a sprocket which drives the oil pump through a sprocket and chain.

Connecting Rod and Piston

Each piston is cast aluminum alloy and has two compression rings and one oil ring. The piston rings are of a low tension type to reduce friction. The top compression ring is plated with chromium for abrasion resistance. The second compression ring is gray iron. The oil ring is a 3-piece spring construction, consisting of two rails and one spacer.

The piston pin is offset 0.5 mm (0.02 in) toward the thrust side. This allows a gradual change in thrust pressure against the cylinder wall as the piston travels through the bore. The connecting rods are forged steel, heat treated and shot peened. Piston pins are chromium steel and have a full floating fit in the pistons and in the connecting rods. The connecting rod bearings are of the precision insert type.

Oil Pump

The oil pump is bolted to the bottom of the lower crankcase. A sprocket on the front of the oil pump is driven by a chain from the sprocket on the front of the crankshaft. The tension on the oil pump drive chain is accomplished by an adjustable guide.

Oil Pan

The oil pan is constructed of stamped steel and is mounted to the lower crankcase. The oil pan includes a baffle that helps prevent the oil from shifting away from the oil pump suction pipe during hard turns, acceleration or stopping.

Cylinder Head

The cylinder head is an aluminum alloy casting with pressed-in valve guides and valve seat inserts. The fuel injection nozzles are located in the intake ports.

The cylinder head has four in-line combustion chambers. Each combustion chamber has two intake valves and two exhaust valves.

A fuel injector is positioned near each set of intake valves. During each intake stroke of the engine, a fuel injector sprays or atomizes fuel into a fine mist. This mist mixes with air drawn in through the intake manifold as the piston reaches the bottom of the cylinder during the intake stroke.

Valves

The valve train is driven by a double overhead camshaft. Each camshaft has eight cam lobes. Each cam lobe operates an intake or exhaust valve. Valve lash is not adjustable. Valve Lash is provided for by Hydraulic Valve Lash (HVL) Adjusters.

There are two intake and two exhaust valves per cylinder. There are two valve springs per valve. The valve springs are conical-shaped to fit inside the valve lifter body. Positive valve stem seals are used on all valves.

Valve Lifters

Direct acting hydraulic valve lifters are used. The valve lifter body includes a hardened iron contact foot bonded to a steel shell. These lifters are not repairable.

Valve Lifter (Hydraulic Valve Lash Adjuster) Operation

The Hydraulic Valve Lash (HVL) Adjuster located between the camshaft and the valve stem is a direct acting type.

With the engine oil delivered into it from the oil pump, the HVL adjuster operates as follows to adjust the valve lash (clearance) to 0 automatically at all times.

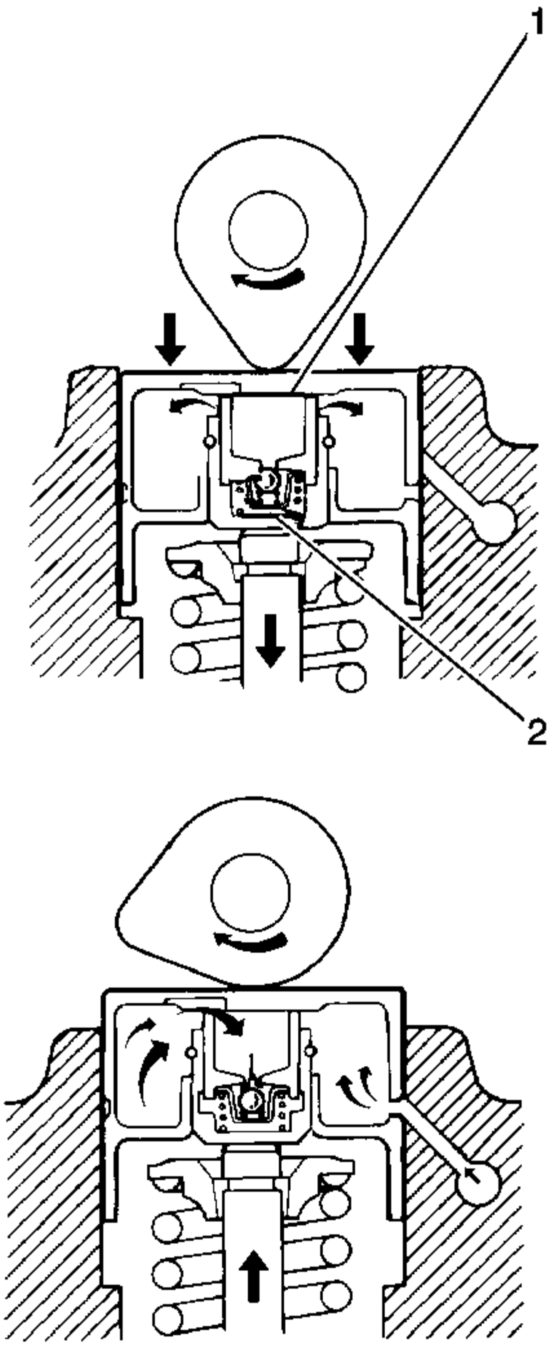


Fig. 443: View Of Hydraulic Valve Lash Adjuster
Courtesy of GENERAL MOTORS CORP.

1. When the camshaft is not depressing the HVL adjuster, the adjuster is held against the camshaft and the valve stem by the plunger spring. In this state, the valve lash is kept at 0. (At 0 valve lash, the oil pressure

becomes equal in the A (1) and B (2) chambers, and the check ball closes the passage between these two chambers.

2. When the lobe of the camshaft starts pressing the HVL adjuster, the adjuster and plunger are pushed downward at the same time the body is pushed upward by the counterforce from the valve stem. As a result, the B (2) chamber is compressed and the pressure rises inside the HVL adjuster. The engine oil in the B (2) chamber will leak through the slight clearance between the body and the plunger. However, since the compression time is very short, the volume of engine oil in the B (2) chamber will only change slightly and the HVL adjuster (plunger and body as one unit) push down the valve stem to open the valve.
3. When the pushing of the camshaft against the HVL adjuster is over, the operation starts again as described in step 1. As the oil pressure in the B (2) chamber is lower than that in A (1) (the oil in the B (2) chamber under high pressure has leaked gradually - refer to step 2), the oil pressure in the A (1) chamber pushes the check ball open to allow the engine oil to flow from the A (1) chamber to the B (2) chamber until the oil pressure becomes equal between the two chambers.

Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron. The exhaust camshaft rear end is slotted to mate with, and drive the camshaft position sensor.

Camshaft Housings and Caps

The camshaft housings and caps are cast aluminum. The camshafts run directly on the housings and caps without bearing inserts.

Camshaft Drive

Two roller timing chains are used. One chain is driven from the crankshaft and drives an idler gear. A second chain is driven from the idler gear and drives the camshafts.

A mechanical, ratcheting tensioner applies tension to an adjustable guide on the slack side of the crankshaft timing chain. A fixed guide controls crankshaft chain motion on the tension side of the chain.

An hydraulic tensioner and an upper guide control camshaft chain motion. The hydraulic tensioner incorporates a guide which applies tension to the slack side of the camshaft timing chain.

Timing Chain Housing and Cover

The timing chain housing is die cast aluminum and retains the crankshaft front seal.

Cylinder Head Cover

The cylinder head cover is die cast aluminum and houses the ignition coils.

Intake and Exhaust Manifold

The intake manifold is made of aluminum. The exhaust manifold is cast iron.

LUBRICATION DESCRIPTION

The oil pump is of a trochoid type, and is mounted under the crankshaft. Oil is drawn up through the oil pump strainer and passed through the pump to the oil filter. The filtered oil flows into 2 paths in the cylinder block. In one path, the oil reaches the crankshaft journal bearings. Oil from the crankshaft journal bearings is supplied to the connecting rod bearings by means of intersecting passages drilled in the crankshaft, and then injected from the big end of the connecting rod to lubricate the piston, rings, and cylinder wall.

In other paths oil goes up to the cylinder head and lubricates valves and camshafts after passing through he internal oilway of camshafts.

An oil relief valve is provided on the oil pump. This valve starts relieving oil pressure when the pressure exceeds about 420 kPa (59.7 psi).

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in 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 during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

IMPORTANT: Many internal engine components will develop specific wear patterns on their friction surfaces. When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure reinstallation to their original location and position.

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies

- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Tools Required

J 28410 Gasket Remover (Aluminum)

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use the proper prying points to separate components.
- Use caution when separating all RTV sealed components.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** .
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
  - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

The following 2 types of sealer are commonly used in engines:

- The RTV sealer
- The anaerobic gasket eliminator sealer

Follow the service procedure instructions. Use the correct sealer in the proper place in order to prevent oil leaks. Do not interchange the 2 types of sealers. Use the sealer recommended in the service procedure.

Applying RTV Sealer

- Do not use the room temperature vulcanizing (RTV) sealant in areas where extreme temperatures are expected. These areas include the following locations:
  - The exhaust manifold
  - The head gasket
  - The other surfaces where gasket eliminator is specified
- Use a rubber mallet in order to separate the components sealed with RTV sealant. Bump the part sideways in order to shear the RTV sealer. Perform the bumping at the bends or the reinforced areas in order to prevent distortion of the components. The RTV sealant is weaker in shear (lateral) strength than in tensile (vertical) strength.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a component.

- Do not use the following items in order to clean the gasket surfaces:
  - Abrasive pads
  - Sand Paper
  - Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.

IMPORTANT: Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:

  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt

- Apply the RTV sealant to a clean surface. Use a bead size as specified in the procedure. Apply the bead to the inside of any bolt holes.
- Assemble the components while the RTV sealant is still wet (within 3 minutes). Do not wait for the RTV sealant to skin over.

IMPORTANT: Do not overtighten the bolts.

- Tighten the bolts to specifications.

Applying Anaerobic Sealer

The anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.

IMPORTANT: Do not use any other method or technique in order to remove the gasket material from a component.

Do not use the following items in order to clean the gasket surfaces:

- Abrasive pads
- Sand paper
- Power tools

These methods of cleaning may damage the part.

Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil. This grit is abrasive and may cause internal engine damage.

- Remove all of the gasket material from the component using a plastic or a wood scraper. Use Loctite® brand gasket remover P/N 4MA or the equivalent. Follow all of the safety recommendations and the directions that are on the container.
- Apply a continuous bead of the gasket eliminator to 1 flange. Clean and dry any surfaces that you will reseal.

IMPORTANT: Anaerobic sealed joints that are partially torqued and allowed to cure more than 5 minutes may result in incorrect shimming and sealing of the joint.

- Do not allow the sealer to enter the blind threaded holes. The sealer may cause the following conditions:
  - Prevent you from properly seating the bolt
  - Cause damage when you tighten the bolt
- Spread the sealer evenly in order to get a uniform coating on the sealing surface.
- Tighten the bolts to the specifications.

- Remove the excess sealer from the outside of the joint.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

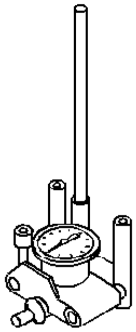
To properly service the engine assembly, the following items should be readily available:

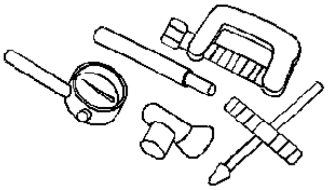
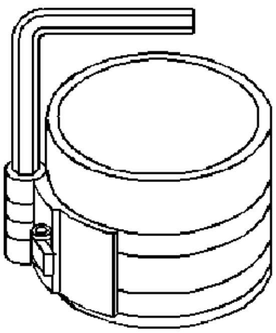
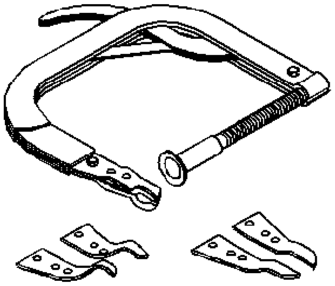
- Approved eye protection and safety gloves
- A clean, well-lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

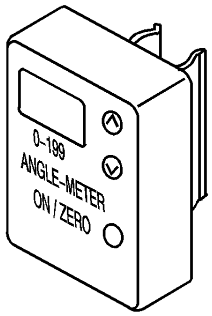
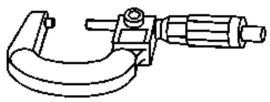
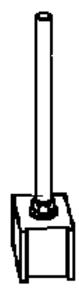
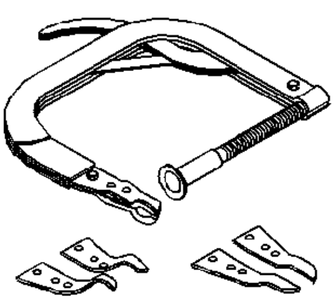
SPECIAL TOOLS AND EQUIPMENT

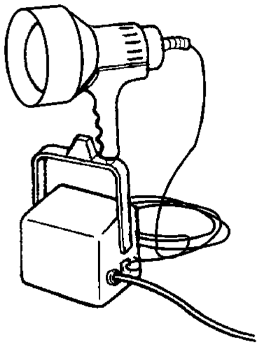
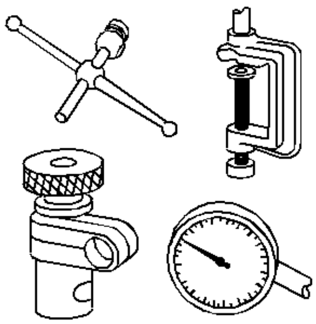
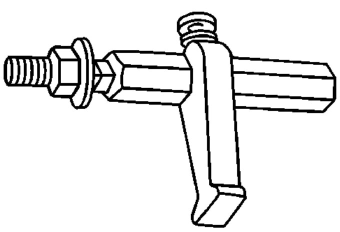
SPECIAL TOOLS

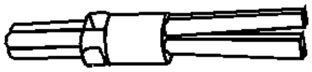
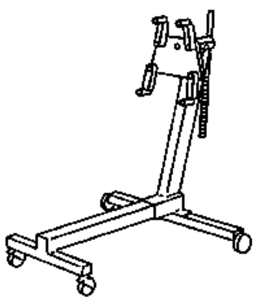
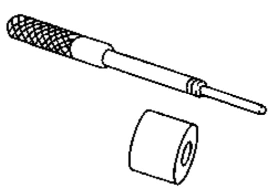
Special Tools

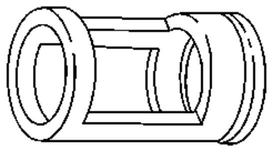
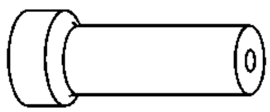
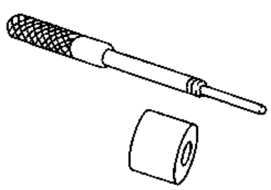
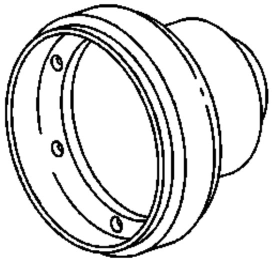
Illustration	Tool Number/ Description
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set

	
	J 8037 Ring Compressor
	J 8062 Valve Spring Compressor
	J 8087 Cylinder Bore Gage
	J 8614-O1 Flange and Pulley Holding Tool

	
	J 26900-2 Combimike Micrometer
	J 26900-13 Magnetic Indicator Base
	J 28410 Gasket Remover (Aluminum)
	J 28428-E High-Intensity Black Light Kit

	
	J 28431-6 Florescent Oil Dye
	J 35271 Flywheel Holder
	J 35667-A Cylinder Head Leakdown Tester
	J 36017

	Valve Guide Seal Remover
	J 36854 Heavy Duty Automotive Engine Stand
	J 37968 Valve Guide Seal Installer Kit
	J 37972 Reamer
	J 37979 Valve Spring Compressor Adaptor

	
	J 38232 Valve Guide Seal Installer
	J 38342 Reamer 6 mm
	J 43842 Valve Guide Installer
	J 41172 Oil Seal Installer

