2005 ENGINE

Engine Mechanical - 5.3L Ascender, Envoy, Rainier & TrailBlazer

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Cleaner Outlet Duct Bolt	10 N.m	89 lb in
Air Cleaner Outlet Duct Clamp	7 N.m	62 lb in
Air Conditioning Belt Tensioner Bolt	50 N.m	37 lb ft
Air Conditioning Bracket Bolt	50 N.m	37 lb ft
Battery Cable Channel Bolt	12 N.m	106 lb in
Brake Hose Retaining Bolt	25 N.m	18 lb ft
Camshaft Position (CMP) Sensor Bolt	12 N.m	106 lb in
Camshaft Position (CMP) Sensor Wire Harness Bolt	12 N.m	106 lb in
Camshaft Retainer Bolt	25 N.m	18 lb ft
Camshaft Sprocket Bolt	25 N.m	18 lb ft
Connecting Rod Bolt - First Pass	20 N.m	15 lb ft
Connecting Rod Bolt - Final Pass	75 degrees	
Coolant Air Bleed Pipe and Cover Bolt	12 N.m	106 lb in
Coolant Temperature Sensor	20 N.m	15 lb ft
Crankshaft Balancer Bolt - Installation Pass to Ensure the Balancer is Completely Installed	330 N.m	240 lb ft
Crankshaft Balancer Bolt - First Pass - Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	50 N.m	37 lb ft
Crankshaft Balancer Bolt - Final Pass	140 degrees	
Crankshaft Bearing Cap M10 Bolt - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Bolt - Final Pass in Sequence	80 degrees	
Crankshaft Bearing Cap M10 Studs - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Studs - Final Pass in Sequence	51 degrees	
Crankshaft Bearing Cap M8 Bolt	25 N.m	18 lb ft
Crankshaft Oil Deflector Nuts	25 N.m	18 lb ft
Crankshaft Position (CKP) Sensor Bolt	25 N.m	18 lb ft
Crankshaft Rear Oil Seal Housing Bolts	25 N.m	18 lb ft
Cylinder Head M11 Bolt - First Pass in Sequence	30 N.m	22 lb ft
Cylinder Head M11 Bolt - Second Pass in Sequence	90 degrees	
Cylinder Head M11 Bolt - Final Pass in Sequence	70 degrees	

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Cylinder Head M8 Bolt - in Sequence	30 N.m	22 lb ft
Cylinder Head Plug	20 N.m	15 lb ft
Differential Bolt	85 N.m	63 lb ft
Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Coolant Drain Hole Plug	60 N.m	44 lb ft
Engine Block Coolant Heater	50 N.m	37 lb ft
Engine Block Oil Gallery Plug	60 N.m	44 lb ft
Engine Harness Bracket Nut	10 N.m	89 lb in
Engine Mount Bracket Spacer	50 N.m	37 lb ft
Engine Mount Frame Bracket	100 N.m	74 lb ft
Engine Mount Nuts	50 N.m	37 lb ft
Engine Mount-to-Engine Bolts	50 N.m	37 lb ft
Engine Service Lift Bracket M10 Bolts	50 N.m	37 lb ft
Engine Service Lift Bracket M8 Bolt	25 N.m	18 lb ft
Engine Shield Bolt	20 N.m	15 lb ft
Engine Sight Shield Bolt	10 N.m	89 lb in
Engine Sight Shield Retainer Bolt	5 N.m	44 lb in
Engine Valley Cover Bolts	25 N.m	18 lb ft
Evaporative Emission (EVAP) Purge Solenoid Bolt	10 N.m	89 lb in
Exhaust Manifold Bolt - First Pass	15 N.m	11 lb ft
Exhaust Manifold Bolt - Final Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolt	9 N.m	80 lb in
Exhaust Manifold Studs	20 N.m	15 lb ft
Flywheel Bolt - First Pass	20 N.m	15 lb ft
Flywheel Bolt - Second Pass	50 N.m	37 lb ft
Flywheel Bolt - Final Pass	100 N.m	74 lb ft
Front Cover Bolt	25 N.m	18 lb ft
Front Shock Upper Retaining Nut	100 N.m	74 lb ft
Fuel Rail Bolt	10 N.m	89 lb in
Fuel Rail Crossover Tube Bolt	3.8 N.m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N.m	37 lb ft
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolt	12 N.m	106 lb in
Ignition Coil-to-Bracket Bolt	10 N.m	89 lb in
Intake Manifold Bolt - First Pass in Sequence	5 N.m	44 lb in
Intake Manifold Bolt - Final Pass in Sequence	10 N.m	89 lb in
Intake Manifold Wiring Harness Stud	10 N.m	89 lb in
Knock Sensor Bolt	20 N.m	15 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Fitting	55 N.m	40 lb ft
Oil Filter Tube-to-Bottom of Oil Pan Bolt	12 N.m	106 lb in
Oil Filter Tube-to-Side of Oil Pan Bolt		

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	12 N.m	106 lb in
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Pan Baffle Bolt	12 N.m	106 lb in
Oil Pan Closeout Cover Bolt - Left Side	9 N.m	80 lb in
Oil Pan Closeout Cover Bolt - Right Side	9 N.m	80 lb in
Oil Pan Cover Bolt	12 N.m	106 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan M6 Bolt - Oil Pan-to-Rear Cover	12 N.m	106 lb in
Oil Pan M8 Bolt - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pan Oil Gallery Plugs	25 N.m	18 lb ft
Oil Pressure Sensor	20 N.m	15 lb ft
Oil Pump Cover Bolt	12 N.m	106 lb in
Oil Pump Relief Valve Plug	12 N.m	106 lb in
Oil Pump Screen Nuts	25 N.m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N.m	106 lb in
Oil Pump-to-Engine Block Bolt	25 N.m	18 lb ft
Propeller Shaft Yoke Retainer Bolt	20 N.m	15 lb ft
Service Lift Bracket M8 Bolt	25 N.m	18 lb ft
Service Lift Bracket M10 Bolt	50 N.m	37 lb ft
Spark Plugs - New Cylinder Heads	20 N.m	15 lb ft
Spark Plugs - All Subsequent Installations	15 N.m	11 lb ft
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Nuts	10 N.m	89 lb in
Throttle Body Studs	6 N.m	53 lb in
Timing Chain Dampener Bolt	25 N.m	15 lb ft
Torque Converter Bolts	60 N.m	44 lb ft
Transmission Bell Housing Bolt	50 N.m	37 lb ft
Transmission Oil Cooler Line Bracket Bolt	9 N.m	80 lb in
Upper Ball Joint Pinch Bolt	40 N.m	30 lb ft
Upper Engine Mount Bracket	50 N.m	37 lb ft
Valve Lifter Guide Bolt	10 N.m	89 lb in
Valve Lifter Oil Manifold (VLOM) Bolt	25 N.m	18 lb ft
Valve Rocker Arm Bolt	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolt	12 N.m	106 lb in
Water Inlet Housing Bolt	15 N.m	11 lb ft
Water Pump Bolt - First Pass	15 N.m	11 lb ft
Water Pump Bolt - Final Pass	30 N.m	22 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

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Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	5.3L	325 CID
• RPO	LH6	
• VIN	M	
• Bore	96.0-96.018 mm	3.779-3.78 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	9.95:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Displacement-on-Demand Cylinders	1-4-6-7	
• Spark Plug Gap	1.02 mm	0.04 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.58-59.63 mm	2.345-2.347 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 3 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.871-69.889 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	96.0-96.018 mm	3.779-3.78 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.57-234.82 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.99-55.04 mm	2.164-2.166 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Intake - Non Displacement-on-Demand Cylinders	7.20 mm	0.283 in
• Camshaft Lobe Lift - Intake - Displacement-on-Demand Cylinders	7.33 mm	0.289 in
• Camshaft Lobe Lift - Exhaust - Non Displacement-		

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on-Demand Cylinders	7.20 mm	0.283 in
• Camshaft Lobe Lift - Exhaust - Displacement-on-Demand Cylinders	7.33 mm	0.289 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.023-0.065 mm	0.0009-0.0025 in
• Connecting Rod Bearing Clearance - Service	0.023-0.076 mm	0.0009-0.003 in
• Connecting Rod Bore Diameter - Bearing End	56.505-56.525 mm	2.224-2.225 in
• Connecting Rod Bore Out-of-Round - Bearing End - Production	0.004-0.008 mm	0.00015-0.0003 in
• Connecting Rod Bore Out-of-Round - Bearing End - Service	0.004-0.008 mm	0.00015-0.0003 in
• Connecting Rod Side Clearance	0.11-0.51 mm	0.00433-0.02 in
Crankshaft		
• Connecting Rod Journal Diameter - Production	53.318-53.338 mm	2.0991-2.0999 in
• Connecting Rod Journal Diameter - Service	53.308 mm	2.0987 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service	0.02 mm	0.00078 in
• Crankshaft End Play	0.04-0.2 mm	0.0015-0.0078 in
• Crankshaft Main Bearing Clearance - Production	0.02-0.052 mm	0.0008-0.0021 in
• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in
• Crankshaft Main Journal Diameter - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.003 mm	0.000118 in
• Crankshaft Main Journal Out-of-Round - Service	0.008 mm	0.0003 in
• Crankshaft Main Journal Taper - Production	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Service	0.02 mm	0.00078 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in

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• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in
• Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
• Surface Flatness - Block Deck - Measured Within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.13 mm	0.005 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.0031 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured Within a 200 mm (7.87 in) Area that Includes Two Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Capacity - with Filter	5.68 liters	6.0 quarts
• Oil Capacity - without Filter	5.20 liters	5.5 quarts
• Oil Pressure - Minimum - Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM
• Displacement-on-Demand Relief Valve Oil Pressure - as Measured at Oil Pressure Sensor Location	379-517 kPa Maximum	55-75 psig Maximum
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Crankshaft Rear Oil Seal Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.25 mm	0.0-0.01 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.23-0.44 mm	0.009-0.017 in
• Piston Ring End Gap - First Compression Ring -	0.23-0.5 mm	0.009-0.0196 in

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Measured in Cylinder Bore - Service		
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.44-0.7 mm	0.017-0.027 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.44-0.76 mm	0.0173-0.03 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.18-0.75 mm	0.007-0.029 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.18-0.81 mm	0.007-0.032 in
• Piston Ring-to-Groove Clearance - First Compression Ring - Production	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring-to-Groove Clearance - First Compression Ring - Service	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Production	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Service	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring-to-Groove Clearance - Oil Control Ring - Production	0.012-0.2 mm	0.0005-0.0078 in
• Piston Ring-to-Groove Clearance - Oil Control Ring - Service	0.012-0.2 mm	0.0005-0.0078 in
Pistons and Pins		
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.0004 in
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.943-0.943 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	96.002-96.036 mm	3.779-3.78 in
• Piston - Piston-to-Bore Clearance - Production	-0.036 to +0.016 mm	-0.0014 to +0.0006 in
• Piston - Piston-to-Bore Clearance - Service Limit with Skirt Coating Worn Off	0.071 mm	0.0028 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in

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• Valves - Valve Lash	Net Lash - No Adjustment	
• Valve Lift - Intake - Non Displacement on Demand	12.24 mm	0.482 in
• Valve Lift - Intake - Displacement on Demand	12.41 mm	0.489 in
• Valve Lift - Exhaust - Non Displacement on Demand	12.24 mm	0.482 in
• Valve Lift - Exhaust - Displacement on Demand	12.41 mm	0.489 in
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
• Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Valve Spring Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Cylinder Head Expansion Plug	Threadlock	12345382	10953489
Cylinder Head Plug Threads	Threadlock	12345382	10953489
Engine Block Coolant Drain Hole Plug Sealing Washer	Sealant	12346004	10953480
Engine Block Front Oil Gallery Plug	Threadlock	12345382	10953489
Engine Block Oil Gallery Plug Sealing Washers	Sealant	12346004	10953480

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Engine Flywheel Bolts	Threadlock	12345382	10953489
Engine Oil	5W-30 Oil	12345610	993193
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolt Threads	Threadlock	12345493	10953488
Fuel Rail Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket-to-Valve Cover Bolts	Threadlock	12345382	10953489
Ignition Coil-to-Bracket Bolts	Threadlock	12345382	10953489
Intake Manifold Bolts	Threadlock	12345382	10953489
Oil Pan Oil Gallery Plug Threads	Sealant	12346004	10953480
Oil Pan Surface at Front Cover and Rear Housing	Sealant	12378190	-
Oil Pressure Sensor Threads	Sealant	12346004	10953480
Thread Repair Component Cleaner	Cleaner	12346139	10953463
Thread Repair Component Cleaner	Cleaner	12377981	10953463
Thread Repair Cutting Oil	Lubricant	1052864	992881

THREAD REPAIR SPECIFICATIONS

Engine Block - Front/Rear Views

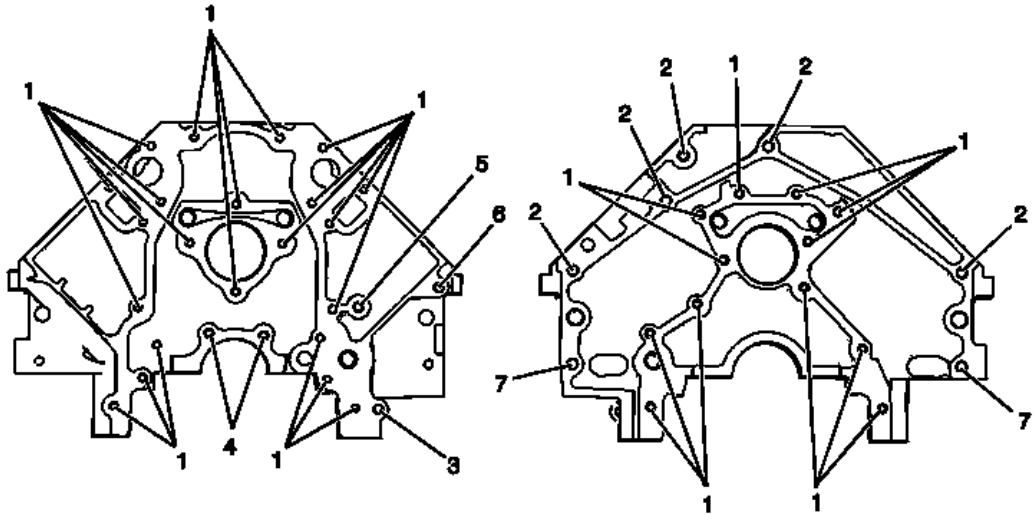

Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front/Rear Views

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Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M10 x 1.5	215	211	212	213	214	27.5 (1.08)	22.0 (0.866)
3	M10 x 1.5	215	211	212	213	214	Thru	Thru
4	M8 x 1.25	210	206	207	208	209	Thru	Thru
5	M10 x 1.5	215	211	212	213	214	25.0 (0.984)	19.5 (0.767)
6	M10 x 1.5	215	211	212	213	214	32.5 (1.279)	25.0 (0.984)
7	M10 x 1.5	215	211	212	213	214	Thru	Thru
Bolt hole 6 is drilled and tapped for aluminum block applications only.								

Engine Block - Left/Right Side Views

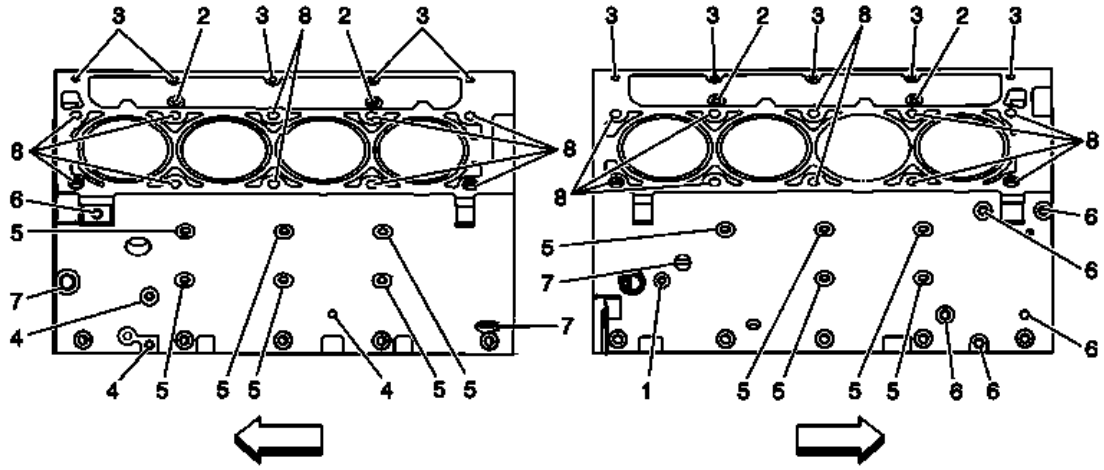

Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left/Right Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)

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2	M8 x 1.25	210	206	207	208	209	28.5 (1.122)	23.0 (0.905)
3	M8 x 1.25	210	206	207	208	209	21.5 (0.846)	16.0 (0.629)
4	M10 x 1.25	215	211	212	213	214	29.0 (1.141)	23.0 (0.905)
5	M10 x 1.5	215	211	212	213	214	27.0 (1.062)	21.5 (0.846)
6	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	M11 x 2.0	108	105	N/A	106	107	69.0 (2.72)	60.0 (2.36)
8	M28 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bolt hole 7 has a 30 mm (1.18 in) counterbore included in the 69.0 mm (2.72 in) drill depth. Use sleeve J 42385-315 with the drill and tap.								

Engine Block - Top/Bottom Views

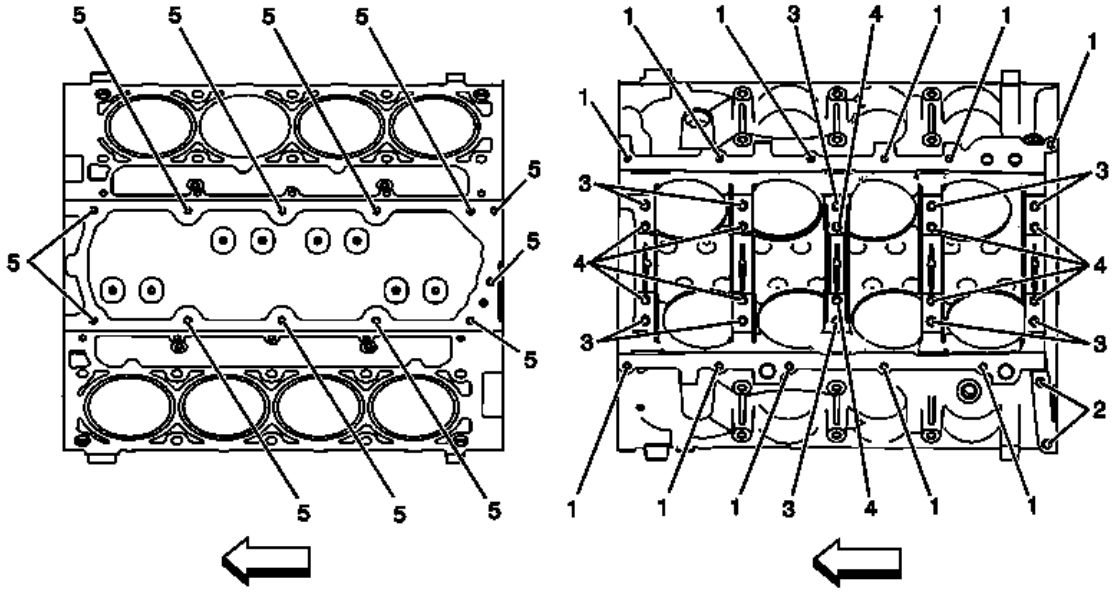

Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top/Bottom Views

	Thread			Counterbore			Drill Depth - Maximum	Tap Depth - Maximum

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Hole	Size	Insert	Drill	Tool	Tap	Driver	mm (in)	mm (in)
J 42385-								
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M10 x 1.5	215	211	212	213	214	42.5 (1.67)	37.0 (1.45)
3	M10 x 2.0	104	101	N/A	102	103	31.0 (1.22)	25.5 (1.0)
4	M10 x 2.0	104	101	N/A	102	103	53.5 (2.10)	44.0 (1.73)
5	M8 x 1.25	210	206	207	208	209	26.5 (1.043)	19.0 (0.748)

- Bolt hole 2 has an 11.5 mm (0.452 in) counterbore included in the 42.5 mm (1.67 in) drill depth. Use sleeve J 42385-311 with the drill and tap.
- Bolt hole 3 has a 1.5 mm (0.059 in) counterbore included in the 31.0 mm (1.22 in) drill depth. Use sleeve J 42385-316 with the drill and tap.
- Bolt hole 4 has a 20.5 mm (0.807 in) counterbore included in the 53.5 mm (2.10 in) drill depth.

Cylinder Head - Top/End Views

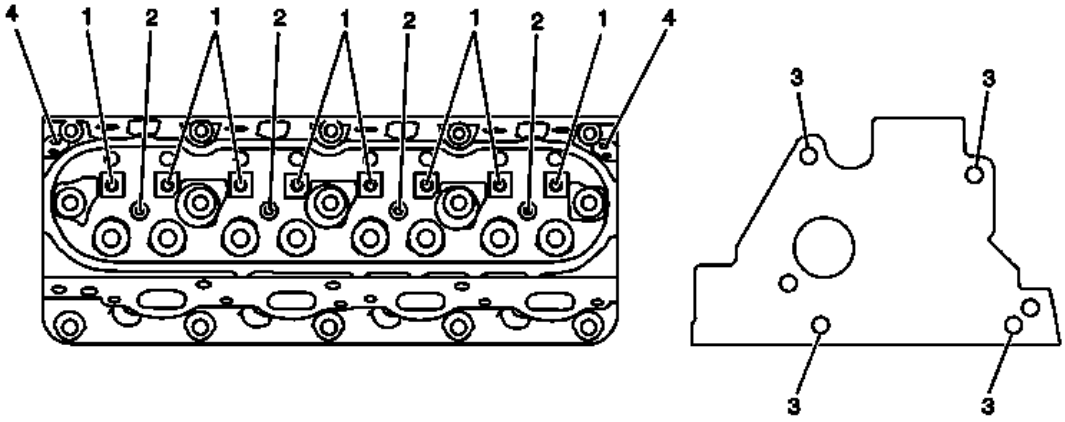

Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top/End Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M8 x 1.25	210	206	207	208	209	26.5 (1.04)	19.0 (0.784)
2	M6 x 1.0	205	201	202	203	204	20.05	16.05

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							(0.789)	(0.632)
3	M10 x 1.5	215	211	212	213	214	28.0 (1.10)	20.0 (0.787)
4	M6 x 1.0	205	201	202	203	204	22.5 (0.885)	15.0 (0.688)

Cylinder Head - Intake/Exhaust Side Views

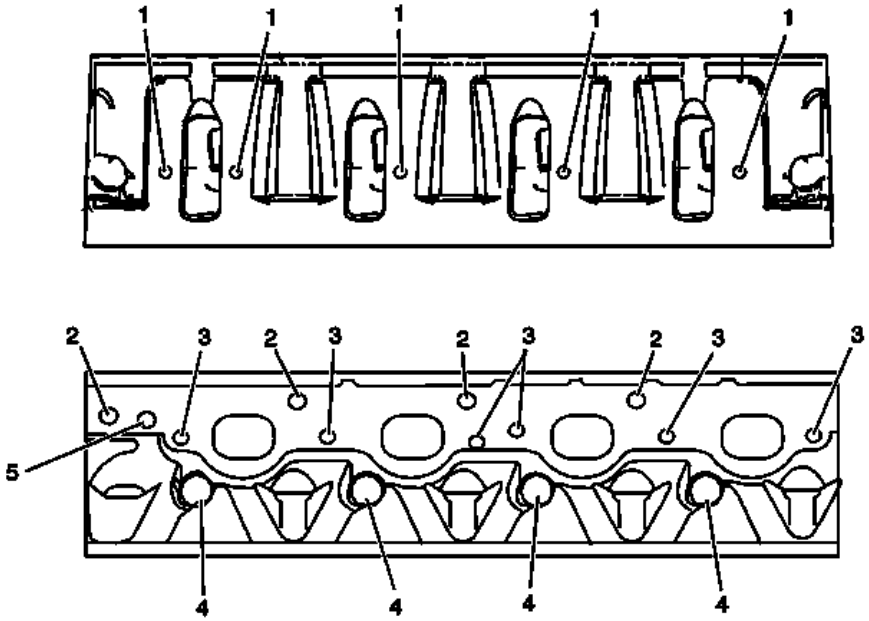

Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake/Exhaust Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				
1	M6 x 1.0	205	201	202	203	204	Thru	Thru
2	M10 x 1.5	215	211	212	213	214	28.0 (1.10)	20.0 (0.787)
3	M8 x 1.25	210	206	207	208	209	21.0 (0.826)	16.0 (0.629)
4	M14 x 1.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	M12 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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COMPONENT LOCATOR

DISASSEMBLED VIEWS

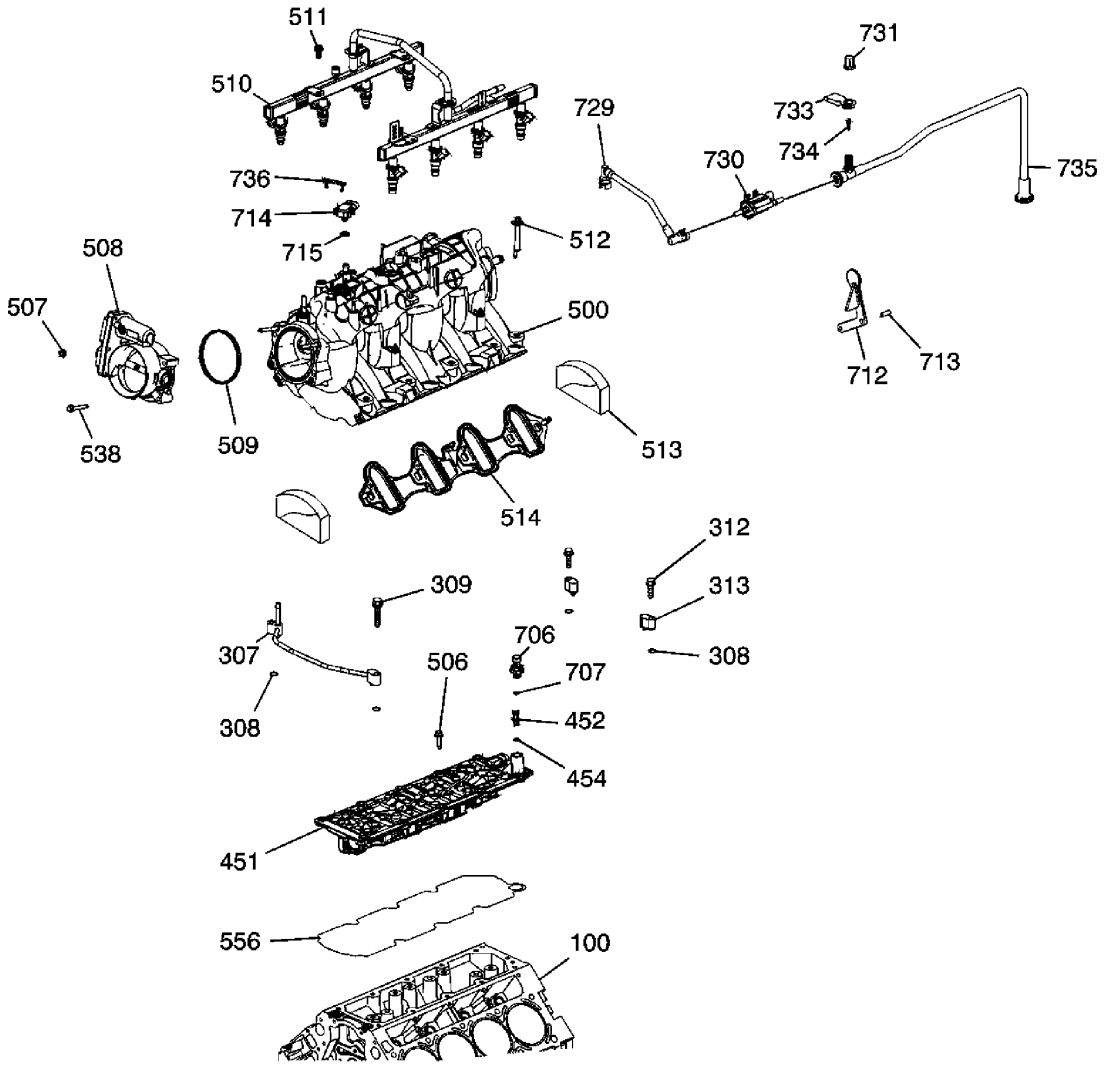

Fig. 6: Intake Manifold/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
307	Engine Coolant Air Bleed Pipe
308	Seal
308	Seal
309	Bolt
312	Bolt

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313	Engine Coolant Air Bleed Cover
451	Valve Lifter Oil Manifold (VLOM)
452	Valve Lifter Oil Filter
454	O-Ring
500	Intake Manifold
506	Bolt
507	Nut
508	Throttle Body
509	Gasket
510	Fuel Rail with Injectors
511	Bolt
512	Bolt
513	Seal
514	Gasket
538	Bolt
556	Gasket
706	Oil Pressure Sensor
707	Washer
712	Fuel Rail Stop Bracket
713	Bolt
714	Manifold Absolute Pressure (MAP) Sensor
715	O-Ring
729	Evaporative Emission (EVAP) Canister Purge Tube
730	EVAP Canister Purge Valve
731	Cap
733	Label
734	Service Valve
735	EVAP Canister Purge Tube
736	MAP Sensor Retainer

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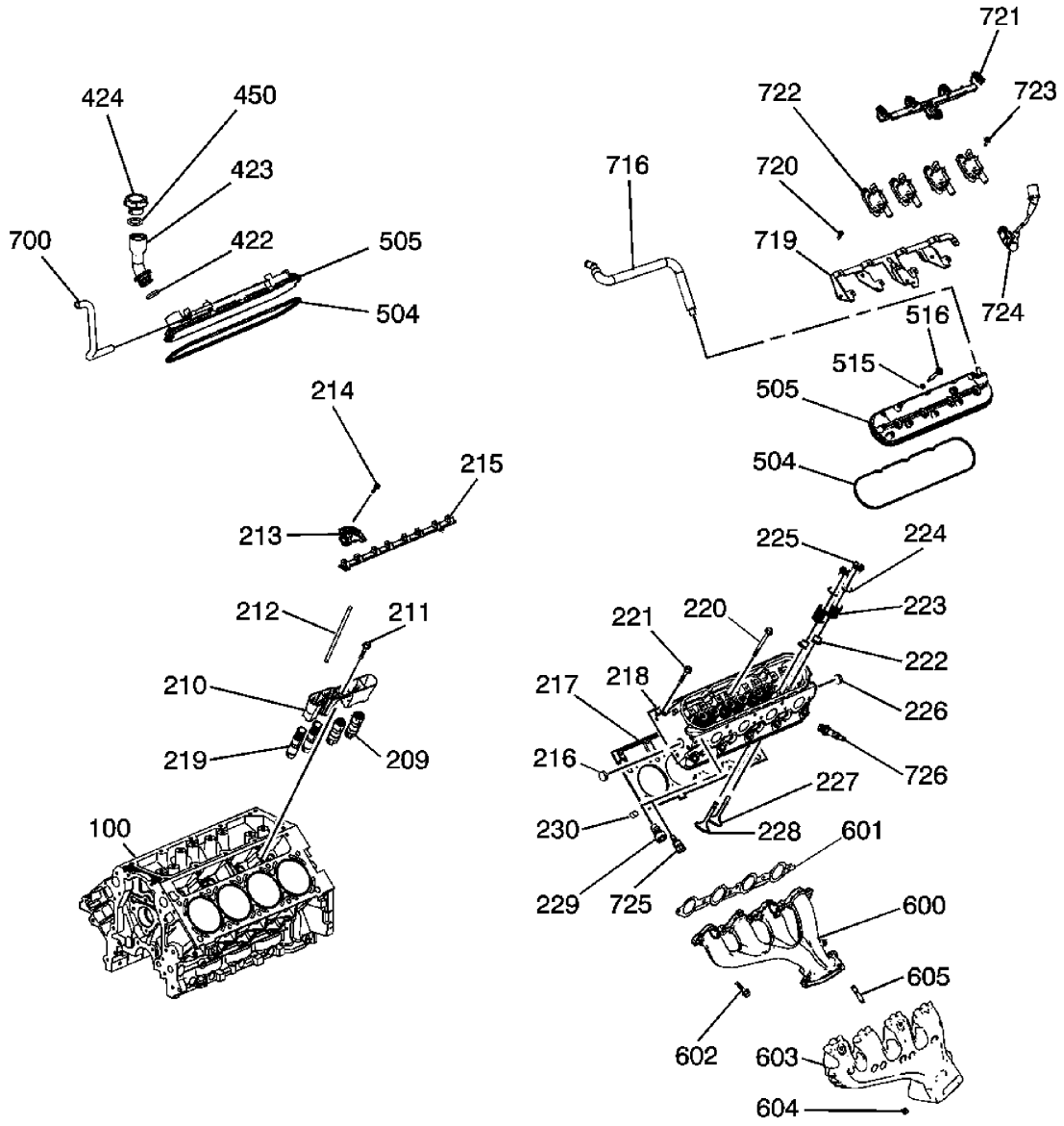

Fig. 7: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
209	Valve Lifter - Non Displacement-on-Demand
210	Valve Lifter Guide
211	Bolt
212	Pushrod
213	Rocker Arm
214	Bolt

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215	Rocker Arm Pedestal
216	Core Hole Plug
217	Gasket
218	Cylinder Head
219	Valve Lifter - Displacement-on-Demand
220	Bolt - M11
221	Bolt - M8
222	Valve Stem Oil Seal and Shim Assembly
223	Valve Spring
224	Valve Spring Cap
225	Valve Stem Key
226	Core Hole Plug
227	Intake Valve
228	Exhaust Valve
229	Cylinder Head Plug
230	Cylinder Head Locating Pin
422	Oil Fill Tube O-Ring
423	Oil Fill Tube
424	Oil Fill Cap
450	Oil Fill Cap O-Ring
504	Gasket
504	Gasket
505	Valve Cover
505	Valve Cover
515	Valve Cover Bolt Grommet
516	Bolt
600	Exhaust Manifold
601	Gasket
602	Bolt
603	Exhaust Manifold Heat Shield
604	Bolt
605	Stud
700	Positive Crankcase Ventilation (PCV) Hose - Fresh Air
716	PCV Hose - Dirty Air
719	Ignition Coil Bracket
720	Bolt
721	Ignition Coil Wire Harness
722	Ignition Coil
723	Bolt
724	Spark Plug Wire
725	Coolant Temperature Sensor

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	Spark Plug

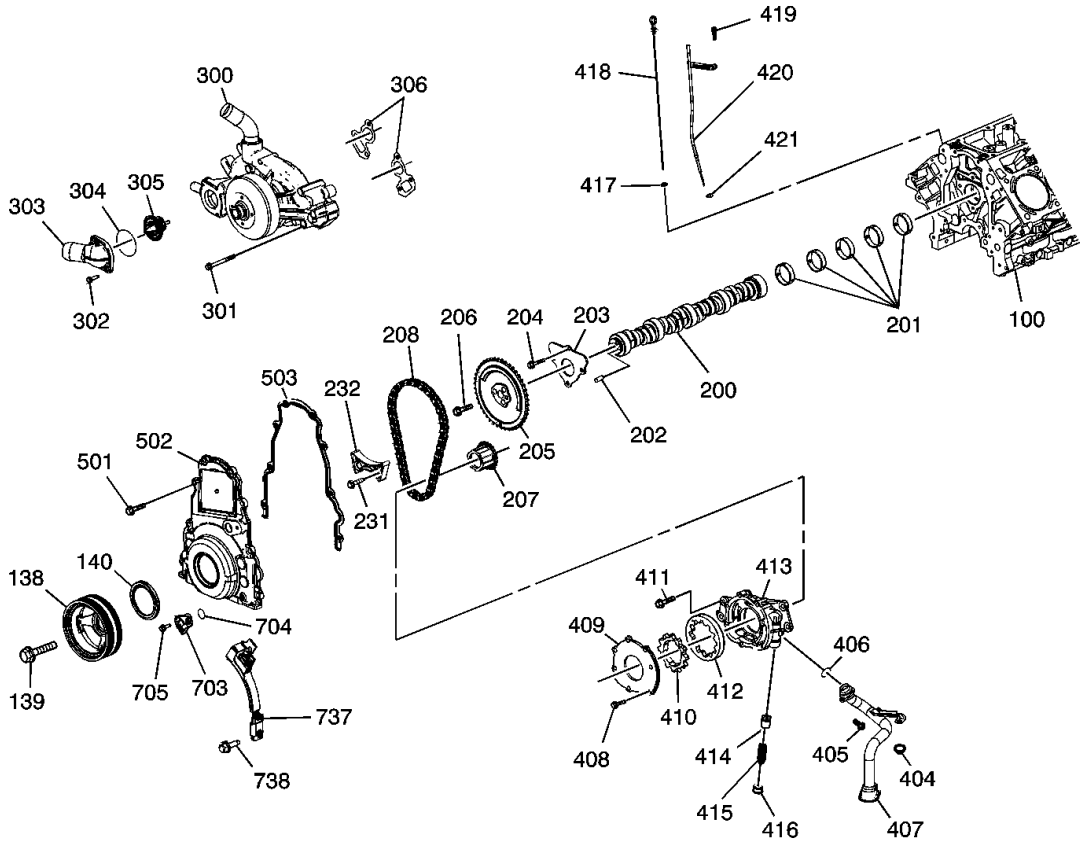

Fig. 8: Front of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
138	Crankshaft Balancer
139	Bolt
140	Crankshaft Front Oil Seal
200	Camshaft
201	Camshaft Bearings
202	Camshaft Sprocket Locating Pin
203	Camshaft Retainer Plate
204	Bolt
205	Camshaft Sprocket
206	Bolt
207	Crankshaft Sprocket

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208	Timing Chain
231	Bolt
232	Timing Chain Dampener
300	Water Pump
301	Bolt
302	Bolt
303	Water Inlet Housing
304	O-Ring
305	Thermostat
306	Gasket
404	Nut
405	Bolt
406	O-Ring
407	Oil Pump Screen
408	Bolt
409	Oil Pump Cover
410	Drive Gear
411	Bolt
412	Driven Gear
413	Oil Pump Assembly
414	Pressure Relief Valve
415	Pressure Relief Valve Spring
416	Plug
417	O-Ring
418	Oil Level Indicator
419	Bolt
420	Oil Level Indicator Tube
421	O-Ring
501	Bolt
502	Front Cover
503	Gasket
703	Camshaft Position (CMP) Sensor
704	O-Ring
705	Bolt
737	CMP Sensor Wire Harness
738	Bolt

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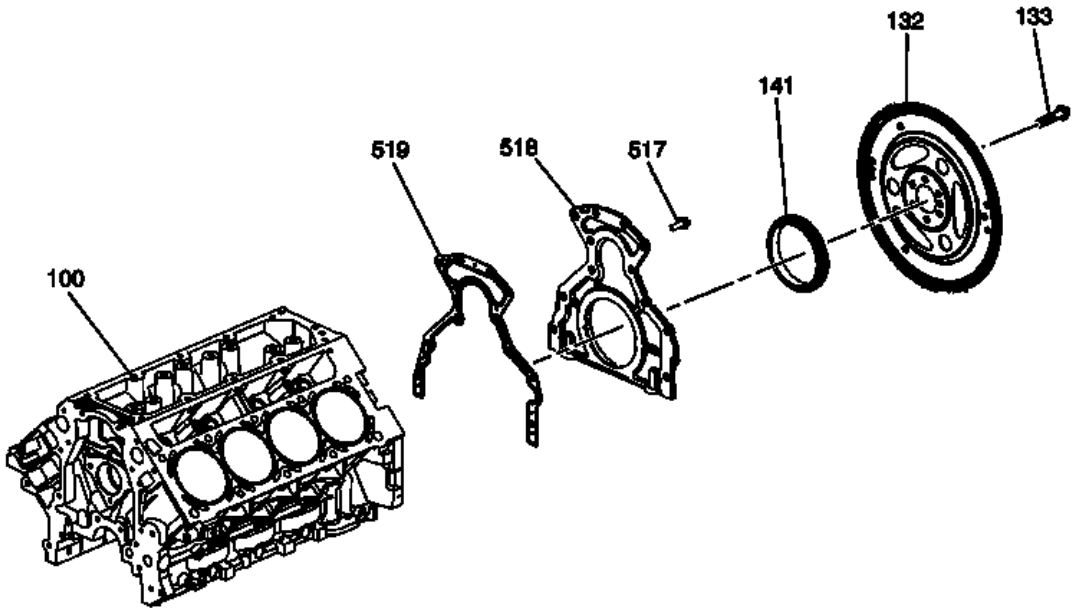

Fig. 9: Rear of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
132	Flywheel
133	Bolt
141	Crankshaft Rear Oil Seal
517	Bolt
518	Crankshaft Rear Oil Seal Housing
519	Gasket

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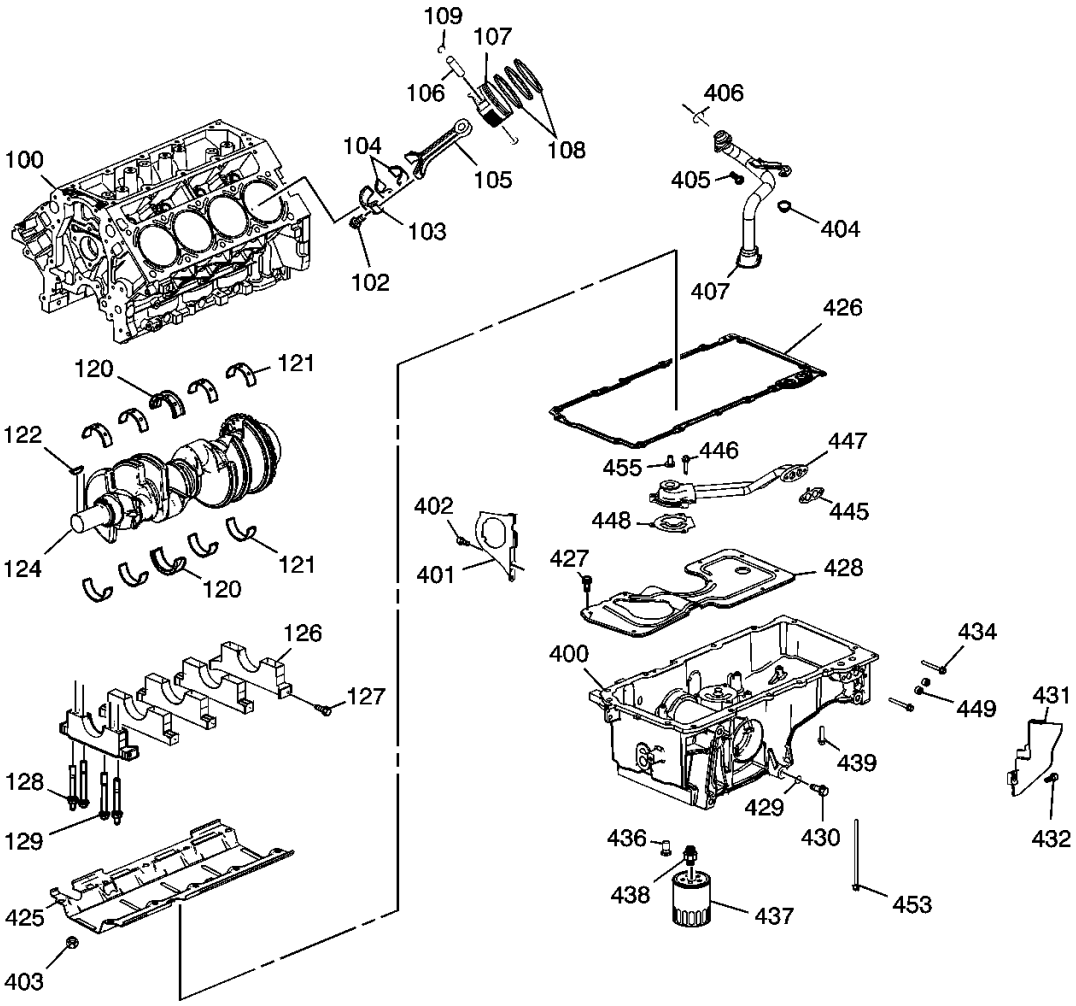

Fig. 10: Lower Engine Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
102	Bolt
103	Connecting Rod Cap
104	Connecting Rod Bearings
105	Connecting Rod
106	Piston Pin
107	Piston
108	Piston Rings
109	Retainer
120	Crankshaft Thrust Bearing

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120	Crankshaft Thrust Bearing
121	Crankshaft Main Bearing
121	Crankshaft Main Bearing
122	Crankshaft Sprocket Key
124	Crankshaft
126	Bearing Cap
127	Bolt - M8
128	Stud - M10
129	Bolt - M10
400	Oil Pan
401	Cover - Right
402	Bolt
403	Nut
404	Nut
405	Bolt
406	O-Ring
407	Oil Pump Screen
425	Crankshaft Oil Deflector
426	Gasket
427	Bolt
428	Oil Pan Baffle
429	O-Ring
430	Oil Pan Drain Plug
431	Cover - Left
432	Bolt
434	Bolt
436	Oil Filter Bypass Valve
437	Oil Filter
438	Oil Filter Fitting
439	Bolt
445	Gasket
446	Bolt
447	Oil Filter Tube
448	Gasket
449	Plug
453	Bolt
455	Oil Pressure Relief Valve

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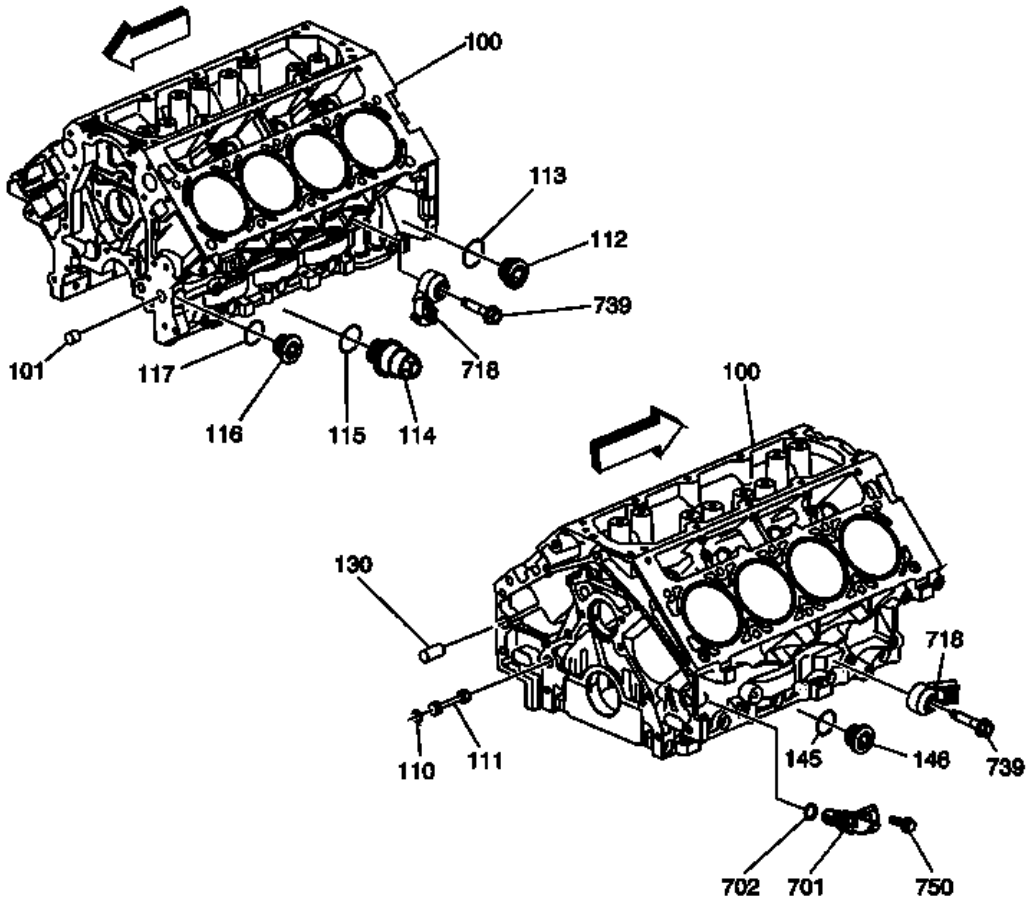

Fig. 11: Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
100	Engine Block
101	Oil Gallery Plug - Front
110	O-Ring
111	Oil Gallery Plug - Rear
112	Oil Gallery Plug - Side
113	Washer
114	Coolant Heater
115	Washer
116	Oil Gallery Plug - Side
117	Washer
130	Transmission Housing Locating Pin
145	Washer

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146	Engine Block Coolant Drain Hole Plug
701	Crankshaft Position (CKP) Sensor
702	O-Ring
718	Knock Sensor
718	Knock Sensor
739	Bolt
739	Bolt
750	Bolt

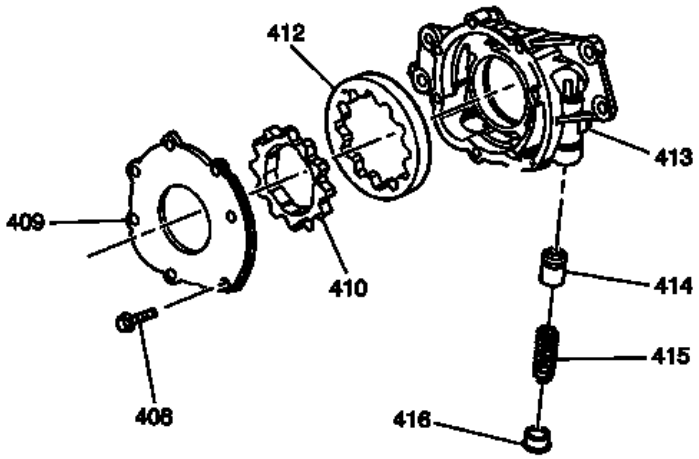

Fig. 12: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
408	Bolt
409	Cover
410	Drive Gear
412	Driven Gear
413	Oil Pump
414	Pressure Relief Valve
415	Pressure Relief Valve Spring
416	Plug

ENGINE IDENTIFICATION

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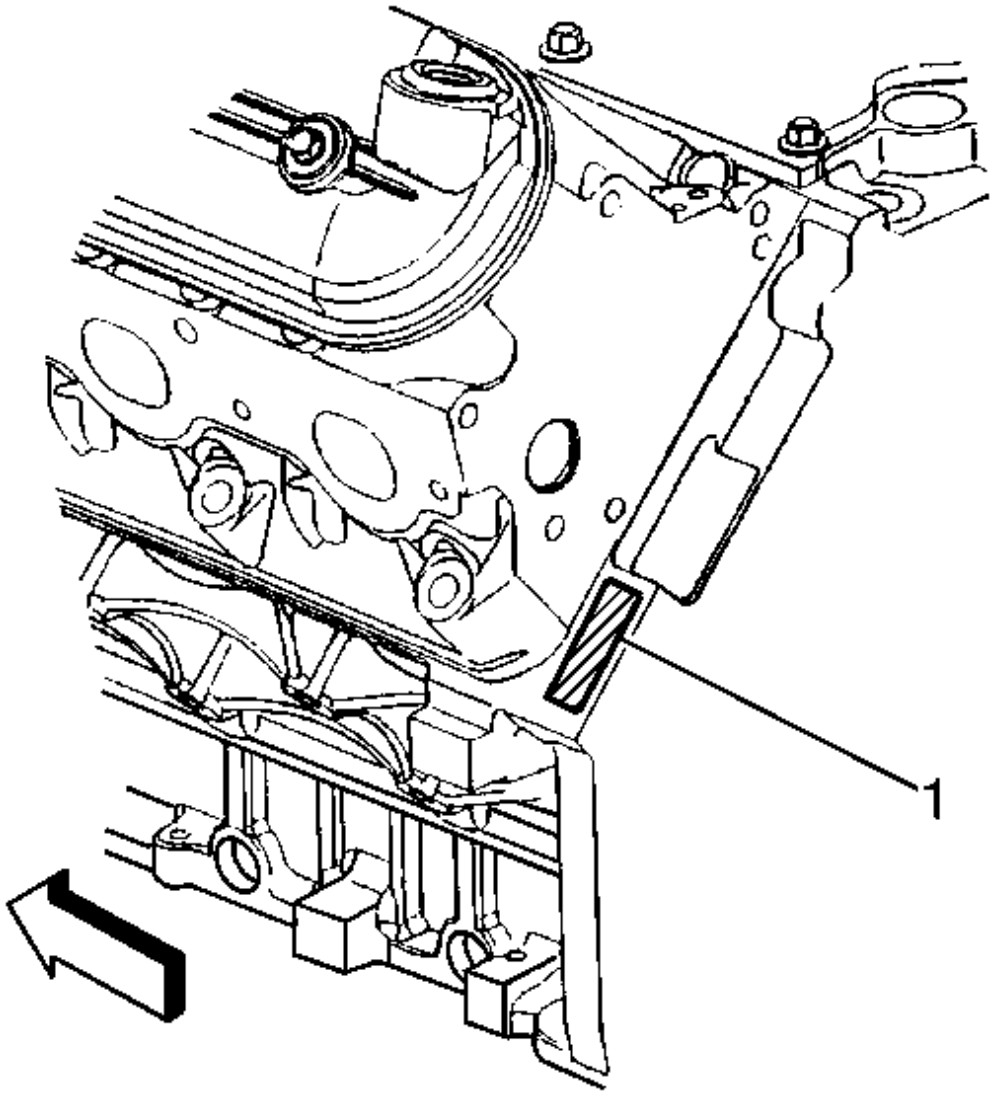

Fig. 13: Locating Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a nine digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.

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- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the VIN.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, **Lubrication Description (Main Pressure Below 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Above 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Below 55 psi - DOD On)** or **Lubrication Description (Main Pressure Above 55 psi - DOD On)** and **Displacement on Demand (DOD) System Description** in Engine Controls. 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 - Vehicle** in Vehicle DTC Information before using the symptom tables.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**,**Engine Component Description**, **Lubrication Description (Main Pressure Below 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Above 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Below 55 psi - DOD On)** or **Lubrication Description (Main Pressure Above 55 psi - DOD On)**, **Displacement on Demand (DOD) System Description** in Engine Controls and **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 condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Strategy Based Diagnosis** 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.

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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 Will Not Crank - Crankshaft Will Not Rotate**
- **Coolant in Combustion Chamber**
- **Coolant in Engine Oil**
- **Displacement on Demand (DOD) System Diagnosis**
- **Engine Compression Test**
- **Displacement on Demand (DOD) System Compression Test**
- **Cylinder Leakage Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Displacement on Demand (DOD) Oil Pressure Relief Valve Diagnosis and Testing**
- **Displacement on Demand (DOD) Valve Lifter Oil Manifold Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Drive Belt Chirping Diagnosis**
- **Drive Belt Squeal Diagnosis**
- **Drive Belt Whine Diagnosis**
- **Drive Belt Rumbling Diagnosis**
- **Drive Belt Vibration Diagnosis**
- **Drive Belt Falls Off Diagnosis**
- **Drive Belt Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

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Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, such as 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 - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout - 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 misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
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 manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
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	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.

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of compression.	
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages 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 - 5.3L. • Inspect the cylinder heads, engine block, and/or head gaskets. Refer to **Coolant in Combustion Chamber**. • 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 - 5.3L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to identify the cause. Refer to **Cylinder Leakage Test**. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then sync the crankshaft position. • 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. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.
Improper operation of the Displacement-on-Demand (DOD) system	Repair as required. Refer to **Displacement on Demand (DOD) System Diagnosis**.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

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Cause	Correction
Abnormalities, such as 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 - Accessory**.
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 and 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 Balancer 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 - 5.3L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. • 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
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.

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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 lifters	Replace as required.
Improper operation of the Displacement-on-Demand (DOD) system	Repair as required. Refer to **Displacement on Demand (DOD) System Diagnosis**.
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair as required. Refer to **Oil Pressure Diagnosis and Testing**.

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 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 - 5.3L. • Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to **Coolant in Combustion Chamber**. • 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 - 5.3L. • 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 - 5.3L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**.

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	• 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	1. Check the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace as required.
Damaged or faulty oil filter bypass valve	1. Inspect the oil filter bypass valve for proper operation. 2. 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.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm, bolt, and pedestal. • Repair or replace as required.
Worn or damaged valve rocker arm	• Inspect the rocker arm for wear or missing needle bearings • Replace the valve rocker arms as required.
Bent or damaged push rod	Inspect the following components and replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The valve lifter guide • The piston

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	Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • Improper operation of the Displacement-on-Demand (DOD) oil pressure relief valve • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
DOD valve lifter with a broken spring	Replace as required.
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
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair as required. Refer to **Oil Pressure Diagnosis and Testing**.

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

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	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 - 5.3L.
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, pin, and connecting rod. • Replace the piston and pin as an assembly, 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. Refer to **Piston, Connecting Rod, and Bearing Installation**. • Repair as required.

ENGINE NOISE UNDER LOAD

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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 - 5.3L.
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 WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flywheel bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components as required.

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Broken timing chain	• Inspect the timing chain and gears. • Repair or replace the components as required.
Seized timing chain or timing gears	• Inspect the timing chain and gears for foreign material or a seized chain. • Repair or replace the components as required.
Seized or broken camshaft	• Inspect the camshaft and the camshaft bearings. • Repair or replace the components as required.
Bent valve in the cylinder head	• Inspect the valves and the cylinder heads. • Repair or replace the components as required.
Seized oil pump	• Inspect the oil pump assembly. • Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in the cylinder • Oil in the cylinder • Fuel in the cylinder	1. Remove spark plugs and check for fluid in the cylinder. When rotating the engine with the spark plugs removed, the piston, on compression stroke, will push fluid from the combustion chamber. Refer to **Coolant in Combustion Chamber**. 2. Inspect for failed/broken head gaskets. 3. Inspect for a cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace the components as required.
Material in the cylinder • Broken valve • Broken piston rings • Piston material • Foreign material	• Inspect the cylinder for damaged components and/or foreign materials. • Repair or replace the components as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair or replace the components as required.
Bent or broken connecting rod	• Inspect the connecting rods. • Replace the piston, pin and connecting rod as an assembly, as required.
Broken crankshaft	• Inspect the crankshaft. • Repair or replace the components as required.

COOLANT IN COMBUSTION CHAMBER

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Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left** or **Cylinder Head Replacement - Right**.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	

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Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left** or **Cylinder Head Replacement - Right**.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

DISPLACEMENT ON DEMAND (DOD) SYSTEM DIAGNOSIS

1. Check the engine oil level. Fill as required.
2. Using the scan tool, check for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** in Vehicle DTC Information. Repair as required.
3. Verify proper engine oil pressure and operation of the Displacement-on-Demand (DOD) oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Verify proper operation of the DOD system components. Refer to **Displacement on Demand (DOD) System Compression Test**.
5. Remove the valve lifter oil manifold (VLOM). Refer to **Valve Lifter Oil Manifold Replacement**.
6. Verify proper operation of the VLOM. Refer to **Displacement on Demand (DOD) Valve Lifter Oil Manifold Diagnosis and Testing**.
7. Replace the DOD valve lifters as required. Both intake and exhaust lifters should be replaced in pairs. Refer to **Valve Lifter Replacement**.

ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gage at zero and crank the engine through four compression strokes, four puffs.
8. Check the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Check the compression again and record the reading.
10. The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa

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(105 psi). (1 035 x 70% = 725) (150 x 70% = 105).

- Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
- Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
- 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 you add oil.
- 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 cylinders.

DISPLACEMENT ON DEMAND (DOD) SYSTEM COMPRESSION TEST

The Displacement-on-Demand (DOD) system compression test is a functional test of the valve lifter oil manifold (VLOM) and valve lifters. Using a compression gage, the technician can monitor the specific cylinders ability to go into and out of DOD as commanded by the scan tool. The actual pressure values on the compression gage are not as critical as is observing the on-off switching action of the solenoid and valve lifters.

1. Check the engine oil level. Fill as required.
2. Perform the Diagnostic System Check. Refer to **Diagnostic System Check - Vehicle** in Vehicle DTC Information.
3. Disable the ignition system for the cylinder to be tested, by disconnecting the electrical wire harness to the ignition coil.
4. Disable the fuel injection system for the cylinder to be tested, by disconnecting the electrical wire harness to the fuel injector.
5. Remove the spark plug and wire for the cylinder to be tested.
6. Install a 0-1378 kPa (0-200 psi) compression gage.
7. Start the engine.
8. Using the scan tool output controls, command the solenoid ON, for the cylinder to be deactivated.
9. Depress the Schrader valve on the compression gage in order to release the pressure and zero the gage. With the engine running and the cylinder in DOD mode, the compression reading should be less than 172 kPa (25 psi).
10. Using the scan tool, de-energize the solenoid while observing the reading on the compression gage. With the engine running and the cylinder NOT in DOD mode, the compression gage reading should increase quickly to greater than 345 kPa (50 psi).

IMPORTANT: Only one cylinder can be tested at a time. When testing has been completed on a specific cylinder, the wire harness electrical connectors, spark plug, and spark plug wire must be installed prior to testing of each additional cylinder.

11. Test each of the four DOD cylinders one at a time. If the readings are not within specifications, remove and test the VLOM as required. Refer to **Valve Lifter Oil Manifold Replacement** and **Displacement on Demand (DOD) Valve Lifter Oil Manifold Diagnosis and Testing**.
12. If the compression test has been performed and all DOD cylinders are operating within specifications, the

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DOD system is performing as designed and no repairs are required.

13. Clear the DTCs with a scan tool.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

IMPORTANT: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate one or more of the following conditions:

- **Worn or burnt valves**
- **Broken valve springs**
- **Stuck valve lifters**
- **Incorrect valve lash**
- **Damaged piston**
- **Worn piston rings**
- **Worn or scored cylinder bore**
- **Damaged cylinder head gasket**
- **Cracked or damaged cylinder head**
- **Cracked or damaged engine block**

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

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 5.3L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **J 35667-A** or equivalent.

IMPORTANT: It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.

5. Apply shop air pressure to the **J 35667-A** and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or

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a broken valve spring.

- Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
- Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Oil Consumption Diagnosis

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or more of engine oil within 3 200 kilometers (2,000 miles).	
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time, 2-3 minutes, and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or not fitted to the cylinder bore

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OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **J 21867** Pressure Gage
- **J 42907** Oil Pressure Tester

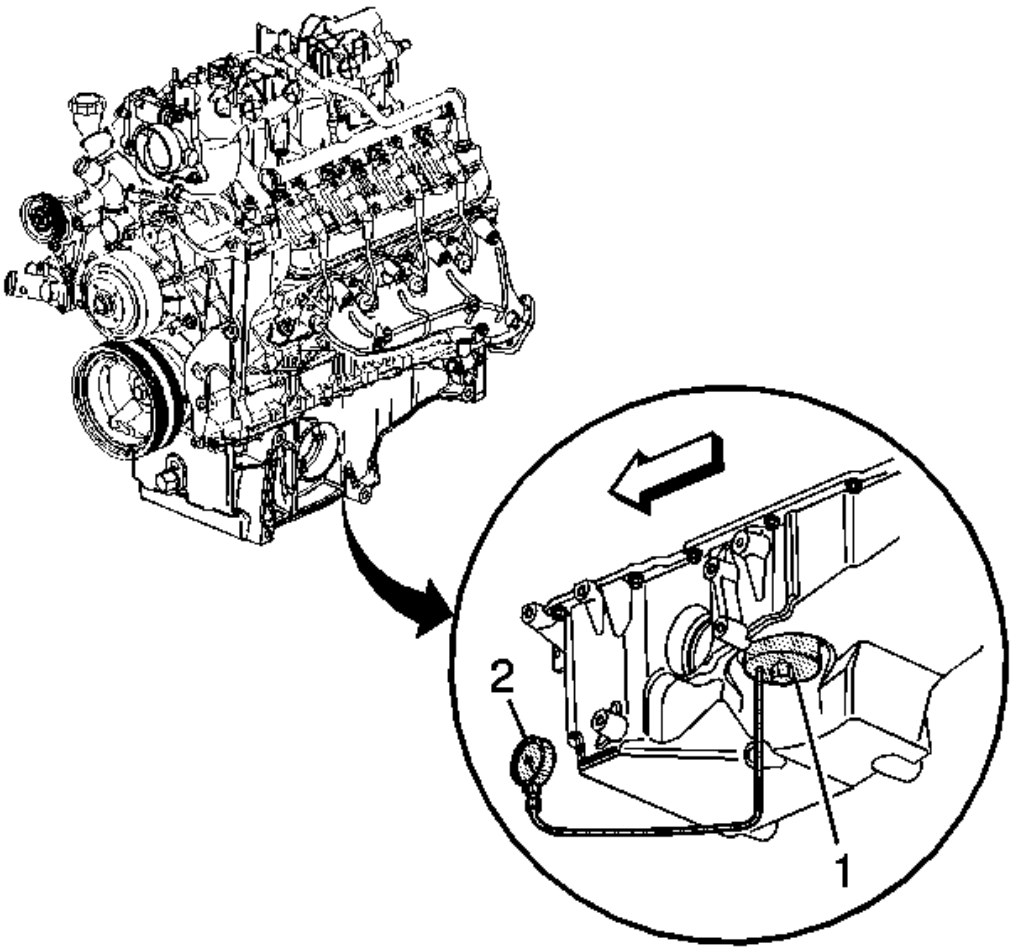

Fig. 14: View Of J 21867 & J 42907
Courtesy of GENERAL MOTORS CORP.

1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2-3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.

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3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
    - Oil diluted by water or glycol anti freeze

      Refer to **Coolant in Engine Oil** .

    - Foamy oil, which may be caused by a cut or damaged oil pump screen O-ring seal
6. Remove the oil filter and install the **J 42907** .
7. Install **J 21867** or equivalent to the **J 42907** .
8. Run the engine and measure the engine oil pressure.
9. Compare the readings to **Engine Mechanical Specifications**.
10. If the engine oil pressure is below specifications, inspect the engine for one or more of the following conditions:
    - Oil pump worn or dirty

      Refer to **Oil Pump Cleaning and Inspection** .

    - Oil pump-to-engine block bolts loose

      Refer to**Oil Pump, Pump Screen and Deflector Installation** .

    - Oil pump screen loose, plugged, or damaged
    - Oil pump screen O-ring seal missing or damaged
    - Oil filter tube loose or a leaking or damaged gasket
    - Malfunctioning oil pump pressure relief valve
    - Excessive bearing clearance
    - Cracked, porous, or restricted oil galleries
    - Oil gallery plugs missing or incorrectly installed

      Refer to**Engine Block Plug Installation** .

    - Improper operation of the Displacement on Demand (DOD) oil pressure relief valve

      Refer to **Displacement on Demand (DOD) Oil Pressure Relief Valve Diagnosis and Testing** .

DISPLACEMENT ON DEMAND (DOD) OIL PRESSURE RELIEF VALVE DIAGNOSIS AND TESTING

Tools Required

- **J 21867** Pressure Gage
- **J-21867-16** Oil Pressure Adapter. See **Special Tools**.

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- **J 42907** Oil Pressure Tester

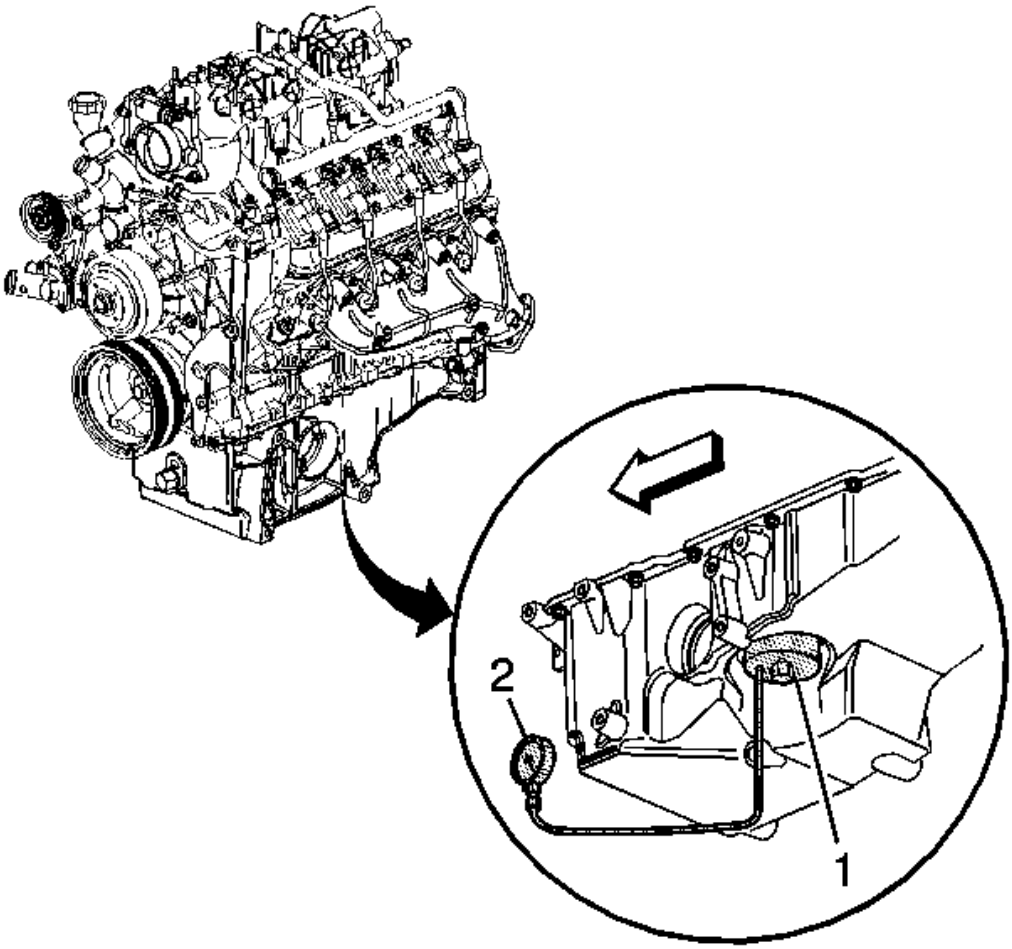

Fig. 15: View Of J 21867 & J 42907
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This test is performed to verify the operation of the displacement on demand (DOD) oil pressure relief valve. Refer to Displacement on Demand (DOD) System Description andLubrication Description (Main Pressure Below 55 psi - DOD Off) or Lubrication Description (Main Pressure Above 55 psi - DOD Off) or Lubrication Description (Main Pressure Below 55 psi - DOD On) or Lubrication Description (Main Pressure Above 55 psi - DOD On).

1. Remove the oil filter and install the **J 42907** .

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2. Install the **J 21867** or equivalent to the **J 42907** .

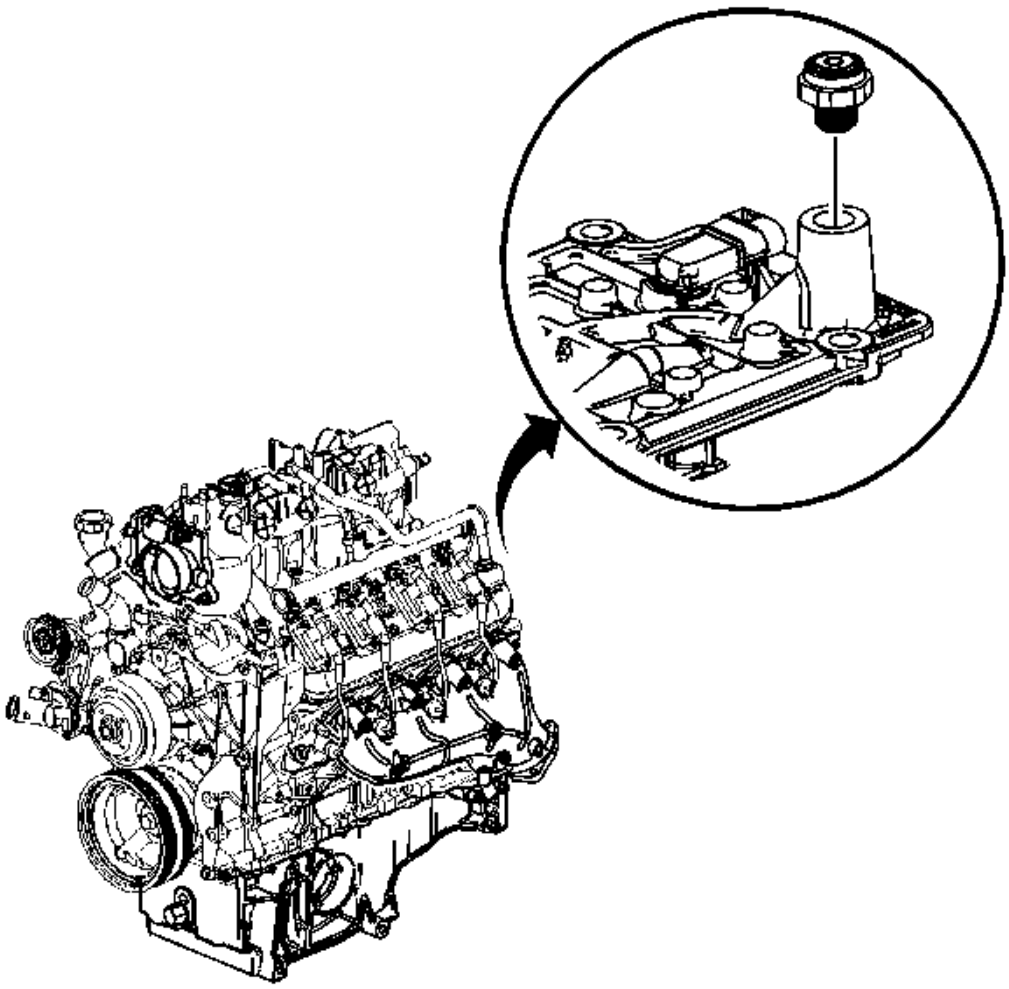

Fig. 16: Locating Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pressure sensor and install the **J-21867-16** . See **Special Tools**.

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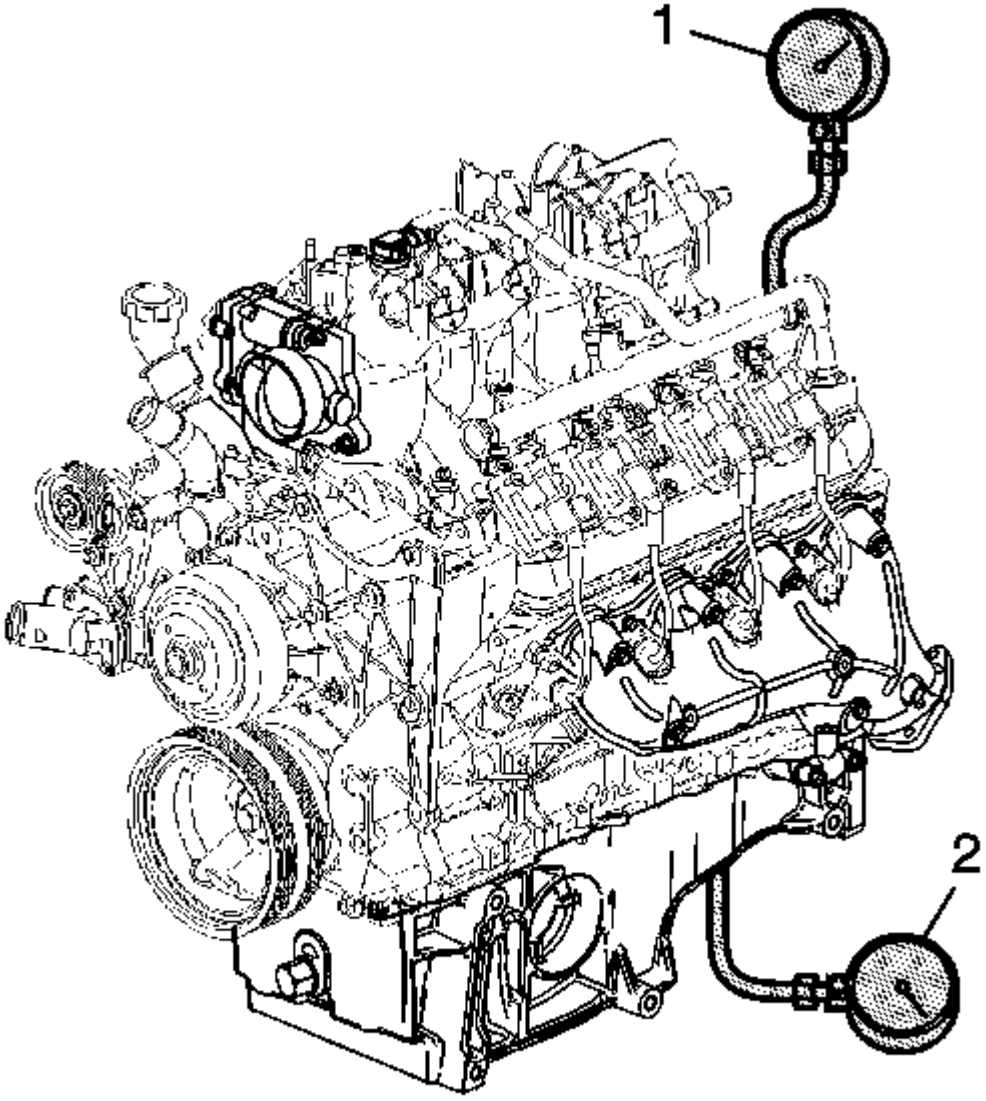

Fig. 17: Installing J 21867 To J-21867-16
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 21867** (1), or equivalent, to the **J-21867-16** (2). See **Special Tools**.
5. Run the engine and measure the engine oil pressure while observing both gages.

   Operate the throttle as required to increase and decrease the engine oil pressure.

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- With the engine running and the lower pressure gage (2) measuring below 379 kPa (55 psi), both gages should display the same pressure reading. If the readings are not the same and the lower gage (2) has a higher reading, the DOD oil pressure relief valve is stuck in the open position or the valve lifter oil manifold filter is plugged.
- With the engine running and the lower pressure gage (2) measuring above 379 kPa (55 psi), the upper gage (1) should display no greater than 379-517 kPa (55-75 psi). If the reading on the upper gage (1) is greater than 517 kPa (75 psi), the DOD oil pressure relief valve is stuck in the closed position.

6. Repair as required.

DISPLACEMENT ON DEMAND (DOD) VALVE LIFTER OIL MANIFOLD DIAGNOSIS AND TESTING

Tools Required

- **EN-46999** Displacement-on-Demand Tester. See **Special Tools**.
- **EN-46999-1** Displacement-on-Demand Tester Air Adapter. See **Special Tools**.
- **EN-46999-5** Displacement-on-Demand Tester Harness - Small Block V8. See **Special Tools**.

IMPORTANT:

- **This component test applies only to vehicles with functional Displacement-on-Demand.**
- **A minimum shop air source of 206 kPa (30 psi) is required for manifold testing.**
- **A water bleed is located on the side of the EN-46999 . See Special Tools. Occasionally, depress the valve in order to remove excess water from the tool.**

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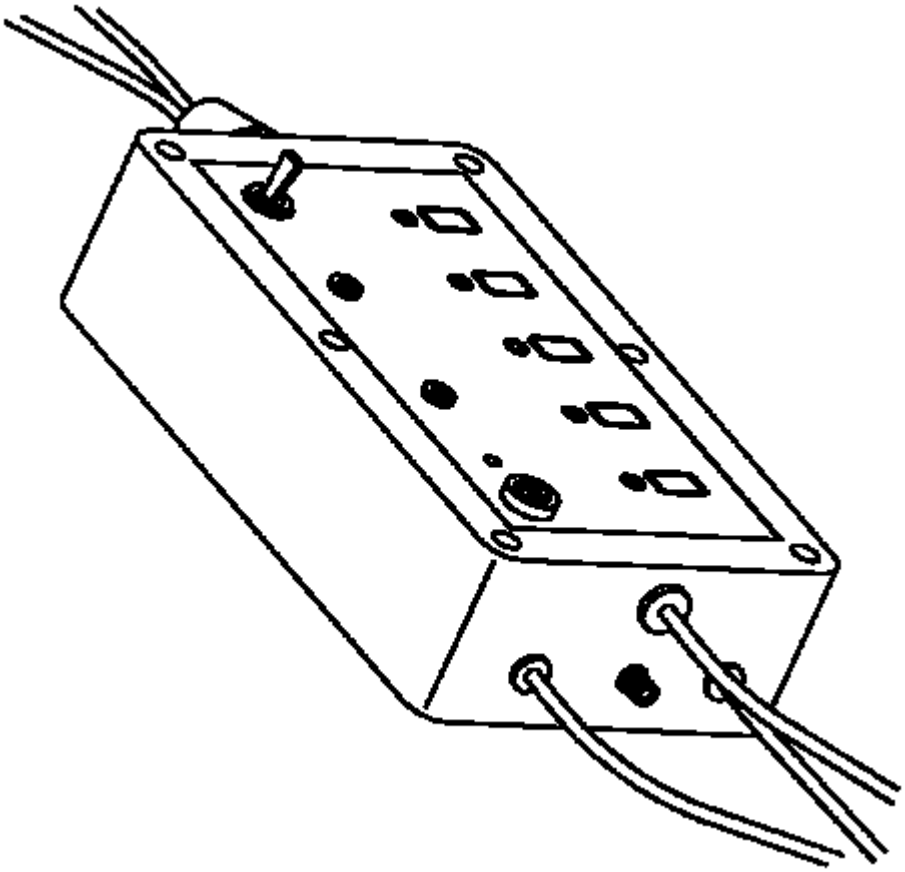

Fig. 18: Displacement-On-Demand Tester
Courtesy of GENERAL MOTORS CORP.

The manifold bench test provides a maximum 206 kPa (30 psi) of filtered shop air to the manifold and will test each solenoid/valve for the following conditions:

- Proper operation
- A stuck open condition - constant air flow
- A stuck closed condition - no air flow
- A flow restriction within the manifold

1. Individually depress each of the buttons 1-4 on the **EN-46999** in order to activate each of the solenoid/valves. See **Special Tools**. When activating each solenoid/valve, a loud click should be heard from the solenoid and an increased amount of air will exit the outlet ports.
    - Button 1 will energize the solenoid/valve 1 for engine cylinder number 1.
    - Button 2 will energize the solenoid/valve 2 for engine cylinder number 4.
    - Button 3 will energize the solenoid/valve 3 for engine cylinder number 6.
    - Button 4 will energize the solenoid/valve 4 for engine cylinder number 7.

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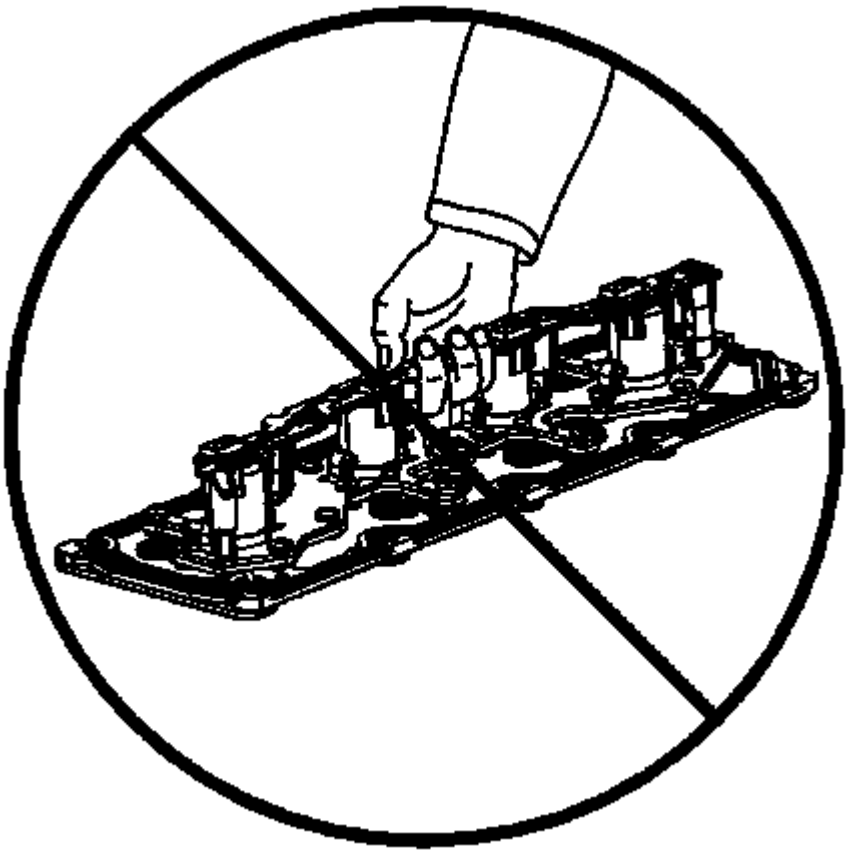

Fig. 19: Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

2. Do not lift the manifold assembly by the electrical lead frame.

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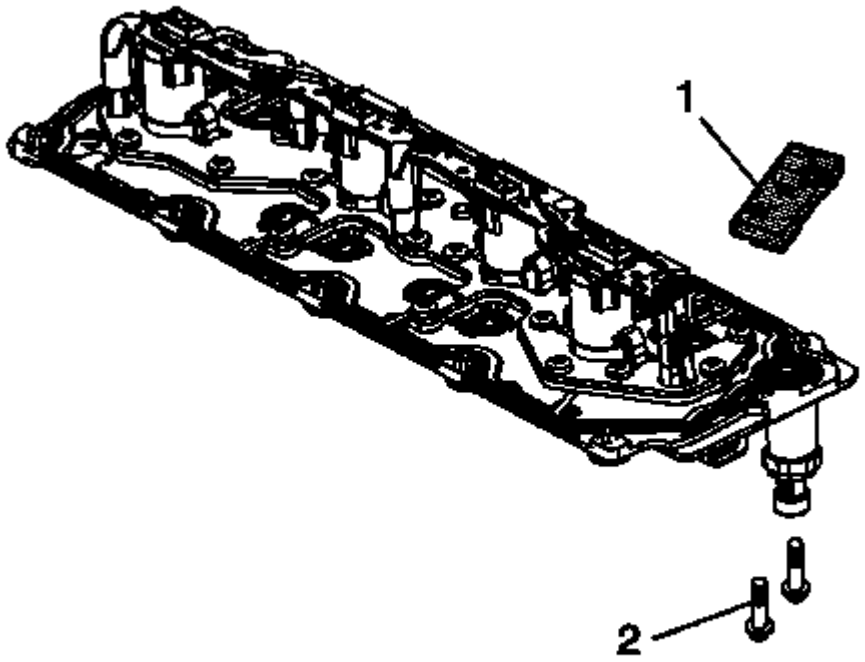

Fig. 20: Displacement-on-Demand Tester Air Adapter (EN-46999-1)
Courtesy of GENERAL MOTORS CORP.

3. Install the **EN-46999-1** (1) to the manifold. See **Special Tools**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install 2 of the manifold bolts (2) to the **EN-46999-1** . See **Special Tools**.

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

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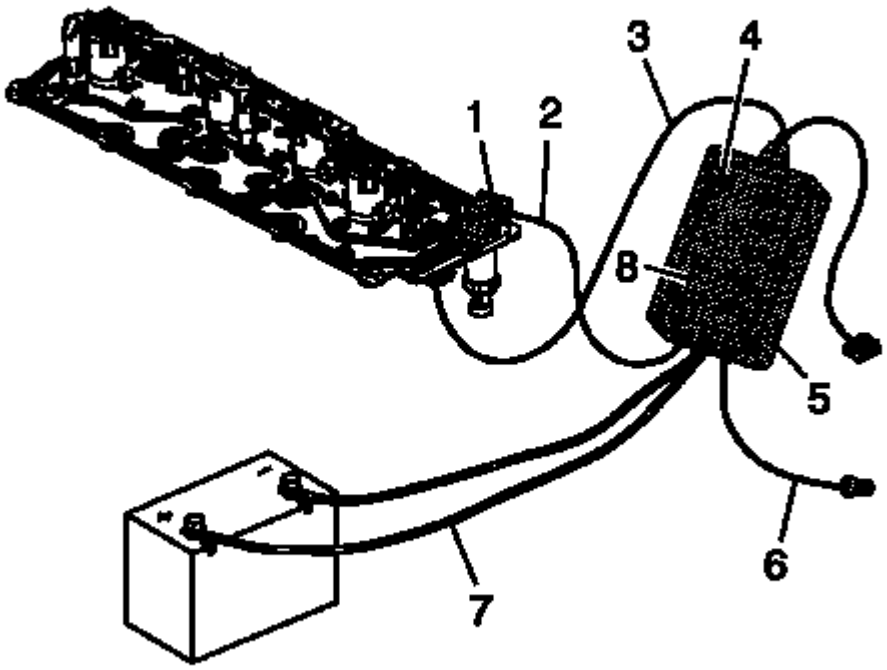

Fig. 21: Connecting Air Out Hose
Courtesy of GENERAL MOTORS CORP.

5. Connect the air out hose (2) of the **EN-46999** (5) to the **EN-46999-1** (1). See **Special Tools**. Verify the air supply switch (4) is in the off position.
6. Connect the air in hose (6) of the **EN-46999** (5) to a shop air source. See **Special Tools**.
7. Connect the 12 volt power supply connectors (7) of the **EN-46999** (5) to a 12 volt power supply. See **Special Tools**. Verify the Power light (8) on the tool is illuminated. If the light on the tool is not illuminated when connected to a 12 volt power supply, test and/or replace the 3 amp fuse.
8. Connect the **EN-46999-5** power cable (3) to the electrical connector of the manifold. See **Special Tools**.

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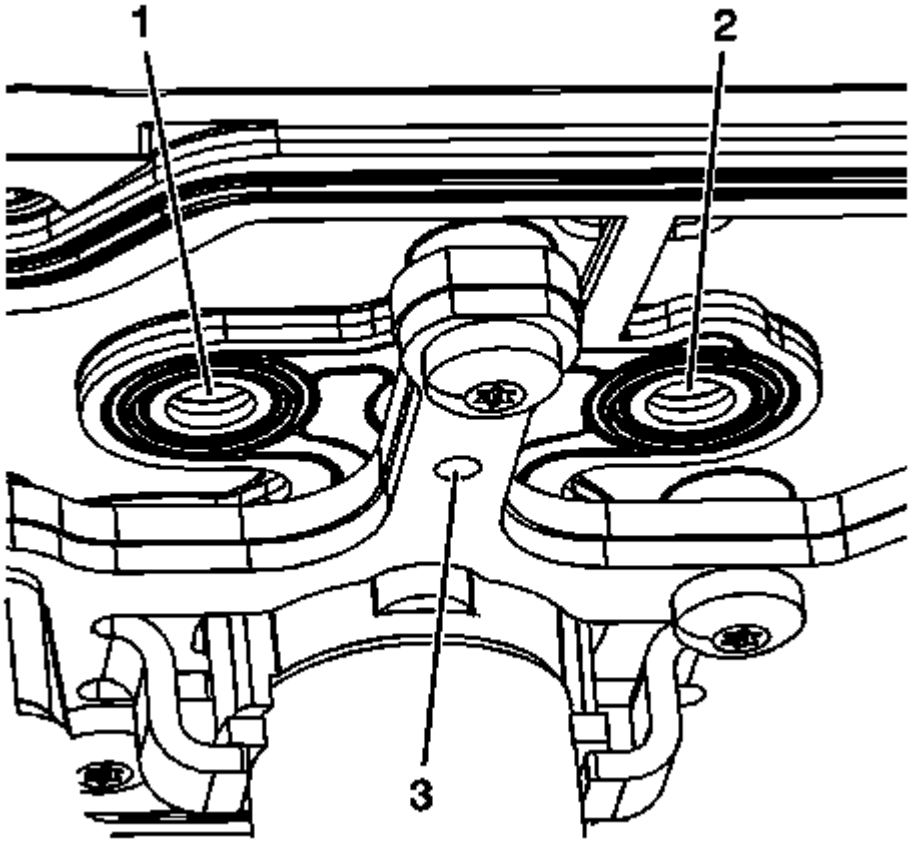

Fig. 22: Bleed Holes & Outlet Ports
Courtesy of GENERAL MOTORS CORP.

9. Turn the air supply switch of the **EN-46999** to the ON position. See **Special Tools**. With the air supply connected to the manifold assembly and the solenoid/valves in the closed position, a limited amount of air will exit each of the bleed holes (3) and outlet ports (1, 2) of the manifold.

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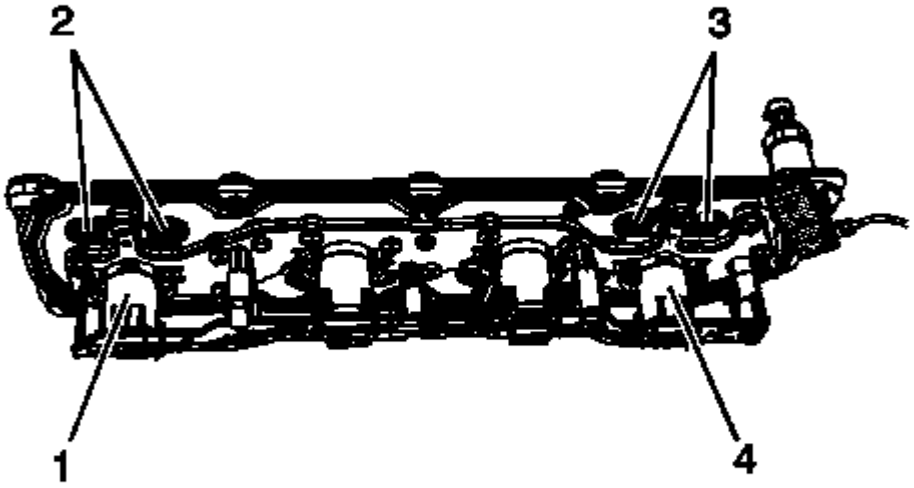

Fig. 23: Testing Solenoid/Valves
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The manifold must be tested in the proper position to ensure the solenoid/valves operate as designed.

10. Position the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 1 and 4.
11. Depress button number 1 on the tool to activate solenoid/valve 1. With button 1 depressed, the solenoid/valve (1) should open, allowing an increased amount of air to exit the outlet ports (2) of the manifold.
12. Depress button number 4 on the tool to activate solenoid/valve 4. With button 4 depressed, the solenoid/valve (4) should open, allowing an increased amount of air to exit the outlet ports (3) of the manifold.

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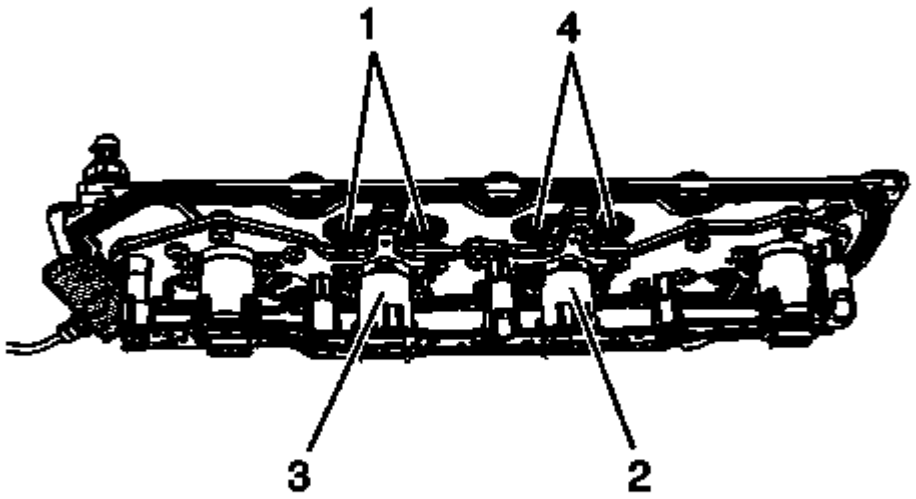

Fig. 24: Testing Solenoid/Valves
Courtesy of GENERAL MOTORS CORP.

13. Reposition the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 2 and 3.
14. Depress button number 2 on the tool to activate solenoid/valve 2. With button 2 depressed, the solenoid/valve (2) should open, allowing an increased amount of air to exit the outlet ports (4) of the manifold.
15. Depress button number 3 on the tool to activate solenoid/valve 3. With button 3 depressed, the solenoid/valve (3) should open, allowing an increased amount of air to exit the outlet ports (1) of the manifold.
16. When the test is completed, turn the air source switch on the **EN-46999** to the off position and disconnect the tool from the 12 volt power supply, shop air source and manifold assembly. See **Special Tools**.
17. If after testing, it has been determined that one or more of the solenoid/valves is not functioning properly, replace the manifold as an assembly.
18. If after testing, it has been determined that the solenoid/valves are functioning properly, replace the valve lifters as required. Both intake and exhaust lifters should be replaced in pairs.

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

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Step	Action	Yes	No
IMPORTANT: **You can repair most fluid leaks 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.**			
1	1. Operate the vehicle 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. 4. Check for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings		

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	• Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 6**
6	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 kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use the **J 28428-E** High-Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	System OK
	1. Inspect the engine for mechanical damage.		

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10	Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Crankcase Ventilation System Inspection/Diagnosis

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted positive crankcase ventilation (PCV) orifice • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted PCV orifice • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted PCV orifice • Restricted or kinked PCV hose or engine vent hose

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	• Leaking (damaged) PCV hose
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for any of the following conditions: • Restricted PCV orifice • Restricted or kinked PCV hose or engine vent hose

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

The chirping noise may be intermittent due to moisture on the drive belts or the accessory drive pulleys. In order to duplicate the customer's concern, it may be necessary to spray a small amount of water onto the drive belts. If spraying water onto the drive belts duplicates the symptom, cleaning the accessory drive pulleys may be the most probable solution.

A loose or improper installation of a body or suspension component, or other items on the vehicle may also cause the chirping noise.

Test Description

The numbers below refer to the steps in the diagnostic table.

2: The chirping 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 any further in this table.

3: The noise may be an internal engine noise. Remove the drive belts and operate the engine for a few seconds, this will verify if the chirping noise is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: Inspect the drive belts for signs of pilling. Pilling is the small balls, pills, or strings in the drive belt grooves caused by the accumulation of rubber dust.

6: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of an accessory drive component, or the pulley may be bent inward or outward from a previous repair. Test for a misaligned accessory drive 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 removal and installation procedure for that pulley.

10: Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed.

12: Inspection of the accessory drive pulleys should include inspecting for bends, dents, or other damage to the pulleys that would prevent the drive belts from seating properly in the pulley grooves or on the smooth surface of the pulley when the back side of the drive belt is used to drive the pulley.

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

Drive Belt Chirping Diagnosis

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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 belts or a accessory drive pulley. • Chirping may occur on cold damp start-up conditions and will subside once the vehicle reaches normal operating temperature.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, 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 belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect for severe drive belt pilling exceeding 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the accessory drive pulleys with a suitable wire brush. Were the accessory drive pulleys cleaned?	Go to **Step 15**	-
6	Inspect for a misaligned accessory drive pulleys. Is there a misaligned accessory drive pulleys?	Go to **Step 7**	Go to **Step 8**
7	Replace and/or repair the misaligned accessory drive pulleys. Were the misaligned accessory drive pulleys replaced and/or repaired?	Go to **Step 15**	-
8	Inspect for a bent or cracked accessory drive brackets. Did you find any bent or cracked accessory drive brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace the bent and/or cracked accessory drive brackets. Was the bent and/or cracked accessory drive brackets replaced?	Go to **Step 15**	-
10	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose, and/or missing fasteners found?	Go to **Step 11**	Go to **Step 12**
	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose fasteners. Refer to **Fastener**		

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11	**Tightening Specifications**. Were the fasteners replaced and/or tightened?	Go to **Step 15**	-
12	Inspect for a bent accessory drive pulleys. Was a bent accessory drive pulleys found?	Go to **Step 13**	Go to **Step 14**
13	Replace the bent accessory drive pulleys. Was the bent accessory drive pulleys replaced?	Go to **Step 15**	-
14	Replace the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Was the drive belts replaced?	Go to **Step 15**	-
15	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the chirping noise still exist?	-	System OK

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

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

If the squeal is intermittent, verify that it is not the accessory drive components by varying their loads, making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The numbers below refer to the steps in the diagnostic table.

2: The squeal 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 in this table

3: The squeal may be an internal engine noise. Remove the drive belts and operate the engine for a few seconds, this will verify if the squealing noise is related to the drive belts or an accessory drive component. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: This test is to verify that an accessory drive components does not have a seized bearing. With the belts removed, test the bearings in the accessory drive components for smooth operation. Also test the accessory drive components with the engine operating by varying the load on the accessory drive components to verify that the components is operating properly.

5: This test is to verify that the drive belts tensioners are not operating properly. If the drive belt tensioners are not operating properly, proper belt tension may not be achieved to keep the drive belts from slipping which could cause a squealing noise.

6: This test is to verify that the drive belts is not too long, which would prevent the drive belt tensioners

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from operating properly. Also if the incorrect length drive belts was installed, it may not be routed correctly and may be turning an accessory drive component in the incorrect direction.

7: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley may be bent inward or outward from a previous repair. 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 removal and installation procedure for that pulley.

8: Inspect the accessory drive pulleys to verify that they are the correct diameter or width. Using a known good vehicle, compare the accessory drive pulleys.

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 belts (this is unusual for a drive belt with multiple ribs) • The squeal occurs when a heavy load is applied to the drive belts, such as an A/C compressor engagement, snapping the throttle, slipping on a seized pulley, or a faulty accessory drive component.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a squealing noise. Does the engine make the squeal noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the squealing noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect for a seized accessory drive component bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 5**
5	Inspect the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 6**
6	Check for the correct length drive belts. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 7**
7	Inspect for a misaligned pulley. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 8**

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8	Inspect for an incorrect size pulley. Did you find and correct the condition?	Go to **Step 9**	-
9	1. Install the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Clear any codes. 3. Run the engine in order to verify the repair. Does the squealing noise still exist?	-	System OK

DRIVE BELT WHINE DIAGNOSIS

Diagnostic Aids

The drive belts will not cause the whine.

If the whine is intermittent, verify that it is not the accessory drive components by varying their loads, making sure they are operating to their maximum capacity. An overcharged air conditioning (A/C) system, a power steering system restriction or the incorrect fluid, or a failing generator are suggested items to inspect.

Test Description

The numbers below refer to the steps in the diagnostic table.

3: This test is to verify that the whine is being caused by the accessory drive components. Remove the drive belts and operate the engine for a few seconds, this will verify if the whining noise is related to the accessory drive component. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: This inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings. The drive belts may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper removal and installation procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a whining noise.		Go to Diagnostic

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	Does the engine make the whining noise?	Go to **Step 3**	Aids
3	1. Remove the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the whining noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	1. Inspect for a failed accessory drive component bearing. 2. Install the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Did you find and correct the condition?	Go to **Step 5**	-
5	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the whining still exist?	-	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 belts may have a condition that can not be seen or felt. Sometimes replacing the drive belts may be the only repair for the symptom.

If after replacing the drive belts and completing the diagnostic table, the rumbling is only heard with the drive belts installed, there might be an accessory drive component failure. Varying the load on the accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the steps in 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 the drive belts is causing the rumbling. Rumbling 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. Operate the engine for a few seconds, this will verify if the rumbling noise is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with

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the drive belts removed.

4: Inspect the drive belts to ensure that the drive belts is not the cause of the noise. Small cracks across the ribs of the drive belts will not cause the noise. Belt separation is identified by the plies of the belt separating, this may be seen at the edge of the belt or felt as a lump in the belt.

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

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 belts or pulleys. • Rumbling may be caused from: o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belts pulley groove o The separation of the drive belts o A damaged drive belts			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, 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 belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect the drive belts for damage, separation, or sections of missing ribs. Were any of these conditions found?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt groove depth. Do the drive belt grooves have 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 belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt**		

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	Replacement - Air Conditioning. Did you complete the repair?	Go to **Step 8**	-
7	Install a new drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Did you complete the replacement?	Go to **Step 8**	-
8	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the rumbling noise still exist?	-	System OK

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components may have an affect on engine vibration. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or an extra load placed on the generator are suggested items to inspect. 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 steps in the diagnostic table.

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

3: This test is to verify that the drive belts or accessory drive components may be causing the vibration. Remove the drive belts and operate the engine for a few seconds, this will verify if the vibration is related to the drive belts or not. With the drive belts removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belts removed.

4: The drive belts may cause a vibration. While the drive belts is removed this is the best time to inspect the condition of the drive belts.

6: Inspection of the fasteners can eliminate the possibility that a incorrect 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 smooth operation. Inspect for a bent fan shaft or bent mounting flange.

9: Inspect the water pump drive shaft for being bent. Also inspect the water pump bearings for smooth operation 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 an extra strain on that accessory drive component causing it to vibrate.

Drive Belt Vibration Diagnosis

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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 Symptoms - Engine Mechanical diagnostic information, 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 belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to **Diagnostic Starting Point - Vibration Diagnosis and Correction** in Vibration Diagnosis and Correction	Go to **Step 4**
4	Inspect the drive belts for wear, damage, debris build-up and missing drive belt ribs. Were any of these conditions found?	Go to **Step 5**	Go to **Step 6**
5	Install a new drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Did you complete the replacement?	Go to **Step 11**	-
6	Inspect for incorrect, loose, or missing fasteners. Were any of these conditions found?	Go to **Step 7**	Go to **Step 8**
7	Replace any incorrect and/or missing fastener. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. Were the fasteners replaced and/or tightened?	Go to **Step 11**	-
8	Inspect for damaged fan blades or a bent fan clutch shaft. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
9	Inspect for a bent water pump drive shaft. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
10	Inspect for a bent or cracked accessory drive brackets. Did you find and correct the condition?	Go to **Step 11**	-
11	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the vibration still exist?	-	System OK

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DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

If the drive belts repeatedly falls off the accessory drive pulleys, this may be caused by a pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may also cause the drive belts to fall off. Verify that the accessory drive components are operating properly.

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

Test Description

The numbers below refer to the steps in the diagnostic table.

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

4: Misalignment of the accessory drive pulleys may be caused from improper mounting or incorrect installation of a accessory drive component, or the pulley may be bent inward or outward from a previous repair. 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 removal and installation procedure of that pulley.

5: Inspection of the accessory drive pulleys should include inspecting for bends, dents, or other damage that would prevent the drive belt from seating properly in the pulley grooves or on the smooth surface of a pulley when the back side of the drive belts is used to drive the pulley.

6: Accessory drive component brackets that are bent or cracked will also cause the drive belts to fall off.

7: Inspection of the fasteners can eliminate the possibility that a incorrect bolt, nut, spacer, or washer was installed. Missing, loose, or incorrect fasteners may cause pulley misalignment from the accessory drive brackets moving under load. Over tightening the fasteners may cause misalignment of the accessory component brackets.

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The drive belts falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect for a damaged drive belts. Was a damaged drive belts found?	Go to **Step 3**	Go to **Step 4**
	Install a new drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement**		

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3	**- Air Conditioning**. Does the drive belts continue to fall off?	Go to **Step 4**	System OK
4	Inspect for a misaligned accessory drive pulleys. Did you find and correct the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented accessory drive pulleys. Did you find and correct the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked accessory drive brackets. Did you find and correct the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose and/or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	1. Replace any incorrect and/or missing fasteners. 2. Tighten any loose 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 correct operation. Refer to **Drive Belt Tensioner Diagnosis**. 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 Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for a failed drive belt idler and/or tensioner pulley bearing. Did you find and repair the condition?	Go to **Step 12**	-
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	-	System OK

DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

Minor misalignment of the accessory drive pulleys will not cause excessive wear, but will probably cause the drive belts to make a noise or fall off.

Excessive misalignment of the accessory drive pulleys will cause excessive wear and may also make the drive belts fall off.

Test Description

The numbers below refer to the steps in the diagnostic table.

2: This inspection is to verify that the drive belts is correctly installed on all of the accessory drive

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pulleys. Wear on the drive belts may be caused by incorrect positioning of the drive belts by one or more grooves on a pulley.

3: The installation of a drive belts that is too wide or too narrow will cause wear on the drive belts. The drive belts ribs should match all of the grooves on the pulleys.

4: This inspection is to verify that the drive belts is not contacting any part of the engine or body while the engine is operating. Provide sufficient clearance when the accessory drive components load varies. The drive belts 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 belts due to incorrect installation of the drive belts.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect the drive belts for proper installation. Is the drive belts installed properly?	Go to **Step 5**	Go to **Step 3**
3	Inspect for the correct drive belts. Is the correct drive belt installed?	Go to **Step 5**	Go to **Step 4**
4	Inspect the drive belts for signs of rubbing against a bracket, hose, or wiring harness. Was the drive belts rubbing against anything?	Go to **Step 5**	Go to Diagnostic Aids
5	Replace the drive belts. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**. Did you complete the replacement?	Go to **Step 6**	-
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	-	System OK

DRIVE BELT TENSIONER DIAGNOSIS

Inspection Procedure

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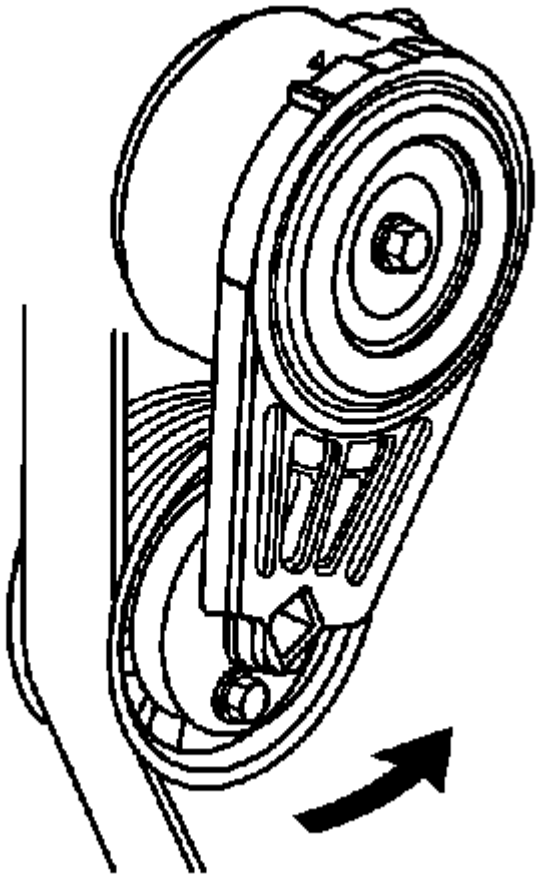

Fig. 25: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

NOTE: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

IMPORTANT: When the engine is operating the drive belt tensioner arm will move. Do not replace the drive belt tensioner because of movement in the drive belt tensioner arm.

1. Remove the drive belt. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**.
2. Move the drive belt tensioner through its full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
3. If any binding is observed, replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** or to **Drive Belt Tensioner Replacement - Air Conditioning**.

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4. Install the drive belt. Refer to **Drive Belt Replacement - Accessory** or to **Drive Belt Replacement - Air Conditioning**.

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement - Accessory

Removal Procedure

1. Remove the air cleaner resonator outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.

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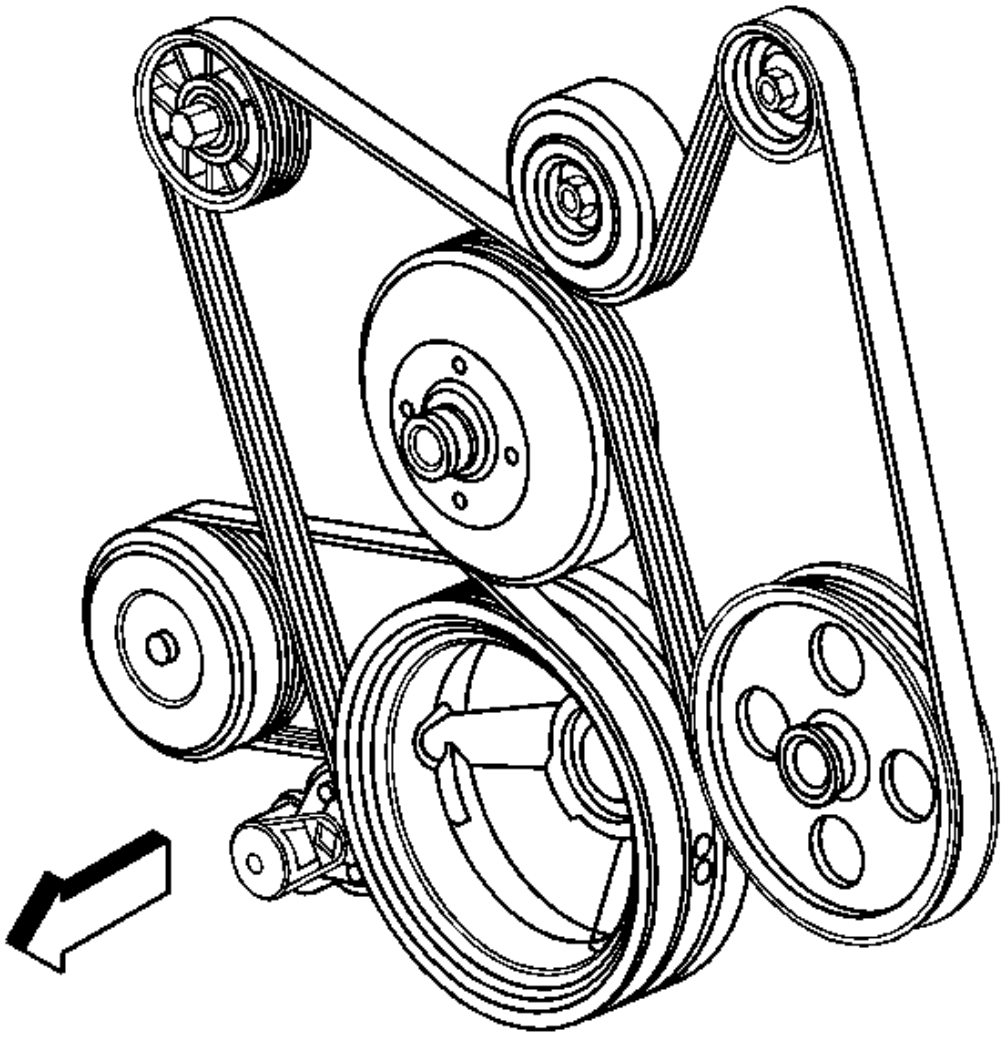

Fig. 26: View Of Accessory Drive Belt Routing & Pulley
Courtesy of GENERAL MOTORS CORP.

2. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.
3. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt.
4. Remove the belt from the generator pulley.
5. Slowly release the tension on the drive belt tensioner.
6. Remove the breaker bar and socket and from the drive belt tensioner bolt.
7. Remove the belt from the remaining pulleys.
8. Clean and inspect the belt surfaces of all the pulleys.

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Installation Procedure

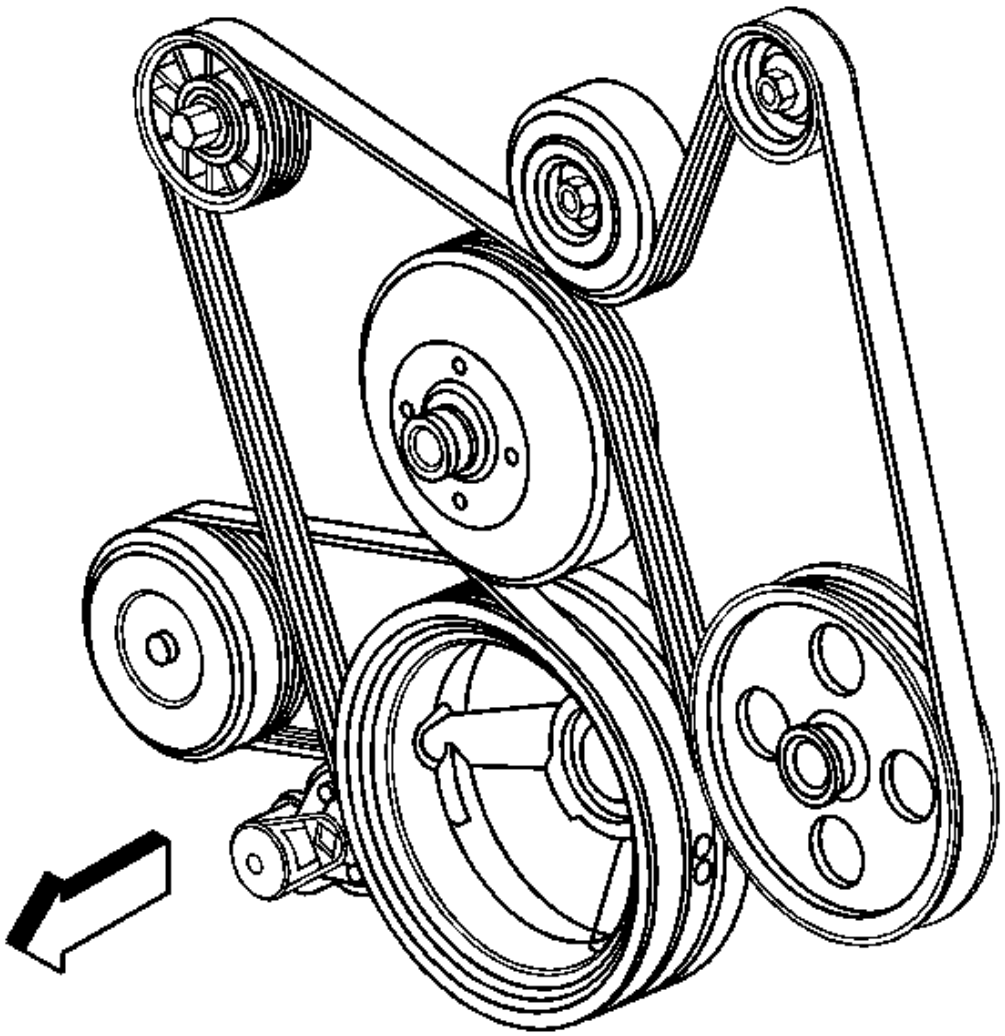

Fig. 27: View Of Accessory Drive Belt Routing & Pulley
Courtesy of GENERAL MOTORS CORP.

1. Route the drive belt around all the pulleys except the generator pulley.
2. Install the breaker bar with hex-head socket to the belt tensioner bolt.
3. Rotate the belt tensioner clockwise in order to relieve the tension on the belt.
4. Install the drive belt on the generator pulley.
5. Slowly release the tension on the belt tensioner.

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6. Remove the breaker bar and socket from the belt tensioner bolt.
7. Inspect the drive belt for proper installation and alignment.
8. Install the air cleaner resonator outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.

Drive Belt Replacement - Air Conditioning

Removal Procedure

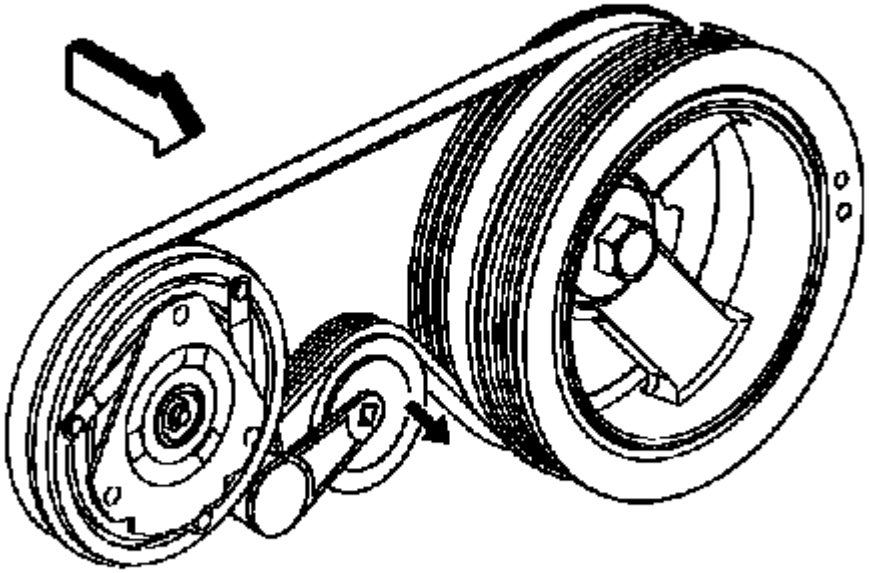

Fig. 28: A/C Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Install a ratchet into the square opening of the air conditioning (A/C) belt tensioner.
4. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
5. Remove the A/C belt from the pulleys.
6. Slowly release the tension on the A/C belt tensioner.
7. Remove the ratchet from the A/C belt tensioner.

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8. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

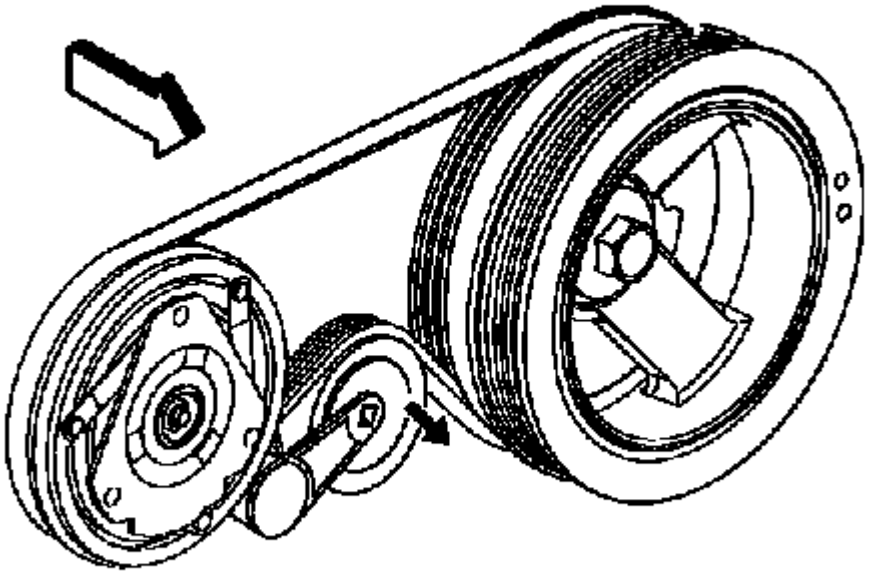

Fig. 29: A/C Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Install the A/C belt around the crankshaft balancer.
2. Install a ratchet into the square opening of the A/C drive belt tensioner.
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
4. Install the A/C belt over the idler pulley.
5. Install the A/C belt around the A/C compressor pulley.
6. Slowly release the tension on the A/C belt tensioner.
7. Remove the ratchet from the A/C belt tensioner.
8. Inspect the A/C belt for proper installation and alignment.
9. Lower the vehicle.
10. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.

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Drive Belt Idler Pulley Replacement

Removal Procedure

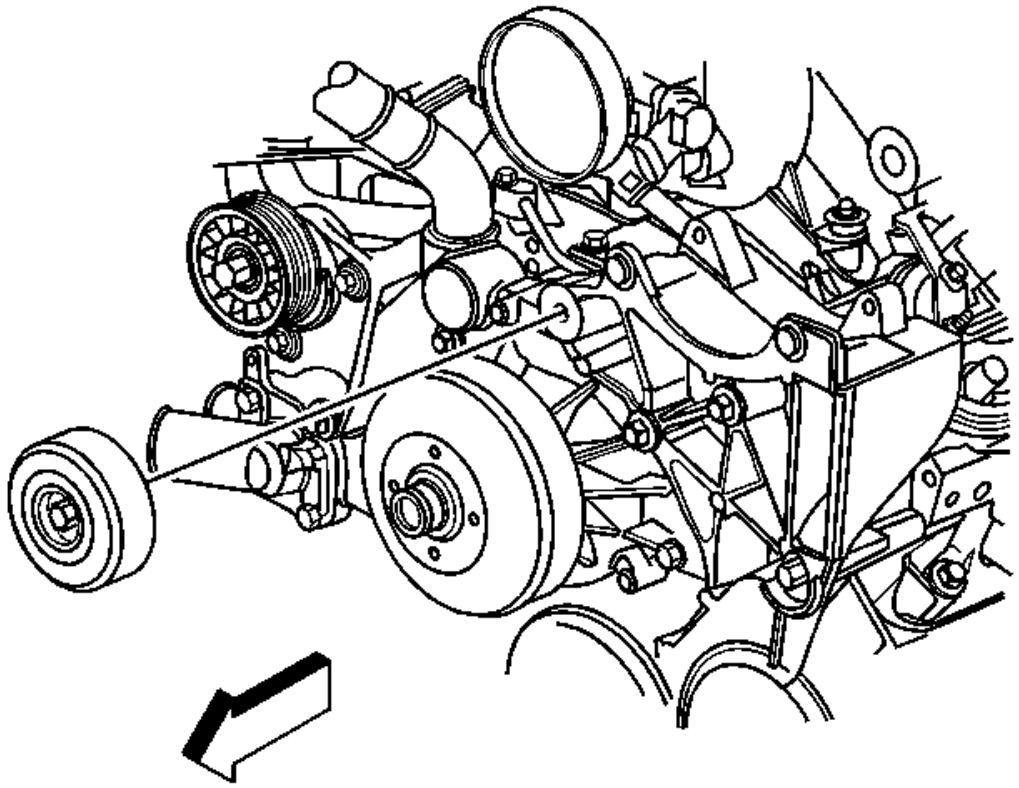

Fig. 30: View Of Accessory Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Fastener Notice** **Drive Belt Replacement - Accessory**.
2. Remove the drive belt idler pulley and bolt.

Installation Procedure

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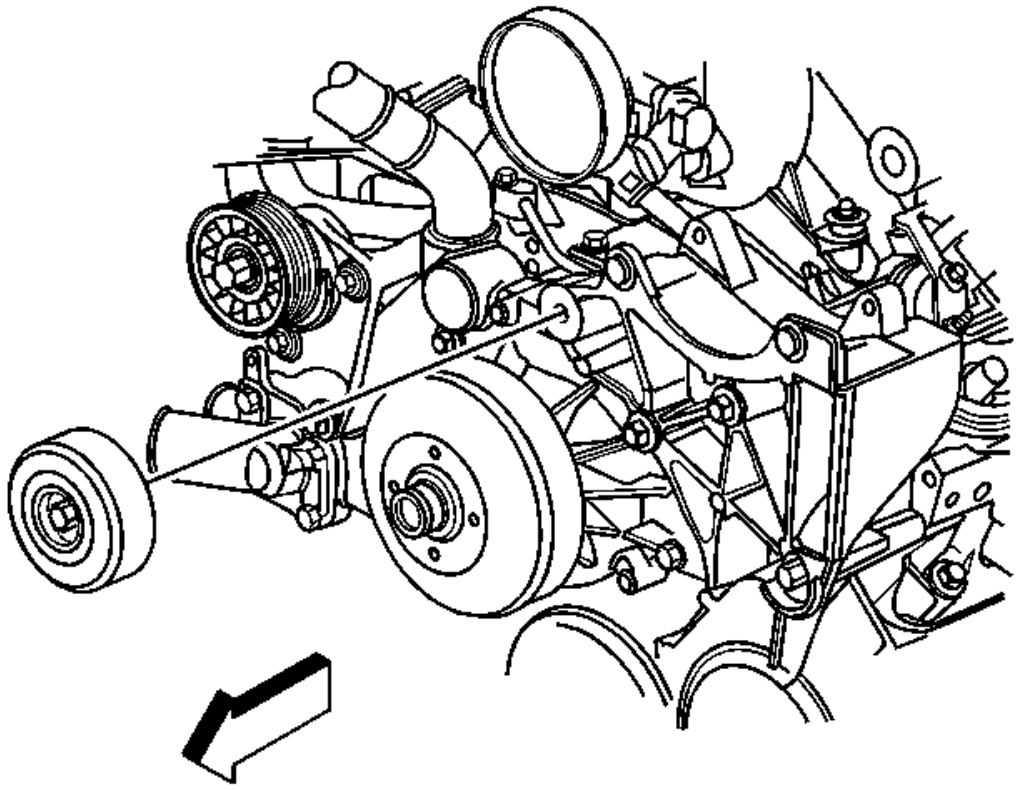

Fig. 31: View Of Accessory Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the drive belt idler pulley and bolt to the generator bracket.

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

2. Install the drive belt. Refer to **Drive Belt Replacement - Accessory**.

Drive Belt Tensioner Replacement - Accessory

Removal Procedure

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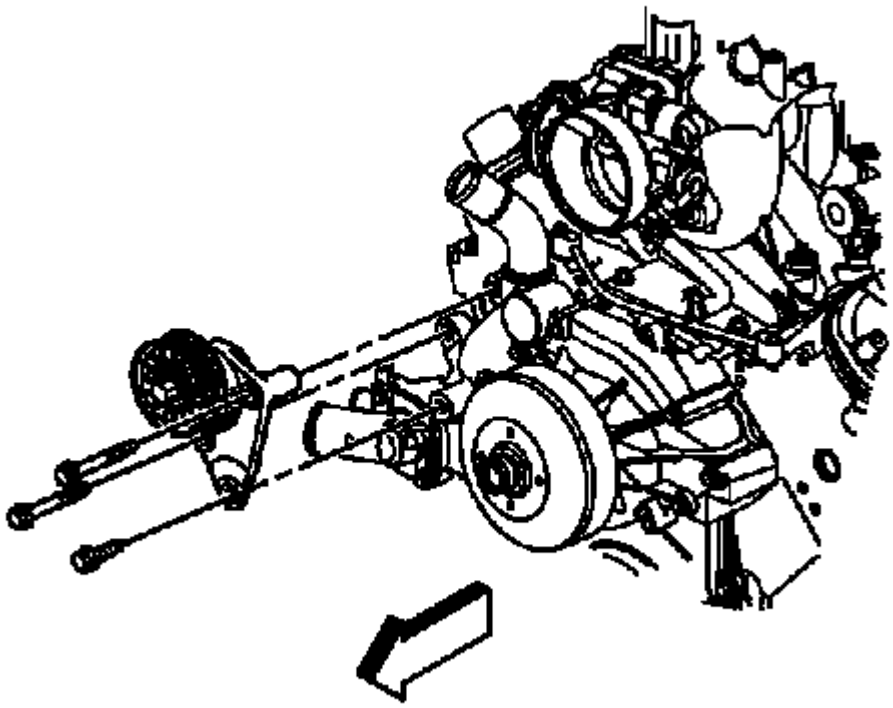

Fig. 32: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Remove the drive belt tensioner bolts.
3. Remove the drive belt tensioner.

Installation Procedure

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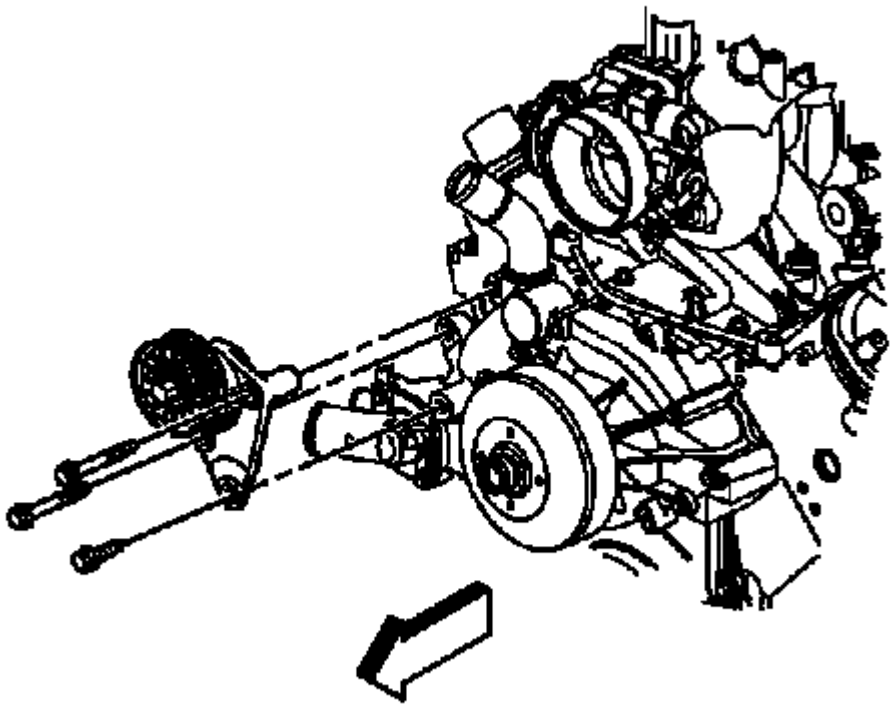

Fig. 33: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Install the drive belt tensioner.
2. Install the drive belt tensioner bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the drive belt tensioner bolts.

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

4. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.

Drive Belt Tensioner Replacement - Air Conditioning

Removal Procedure

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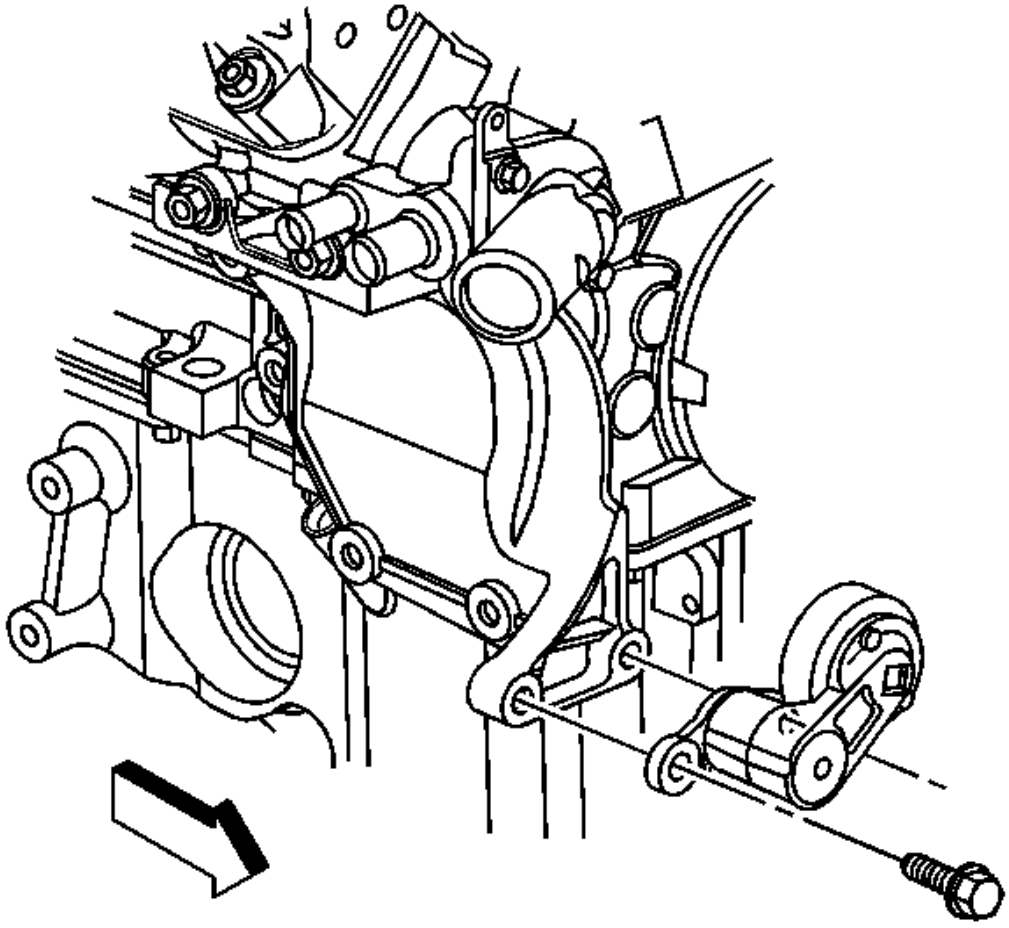

Fig. 34: View Of A/C Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
3. Remove the A/C belt tensioner bolts.
4. Remove the A/C belt tensioner.

Installation Procedure

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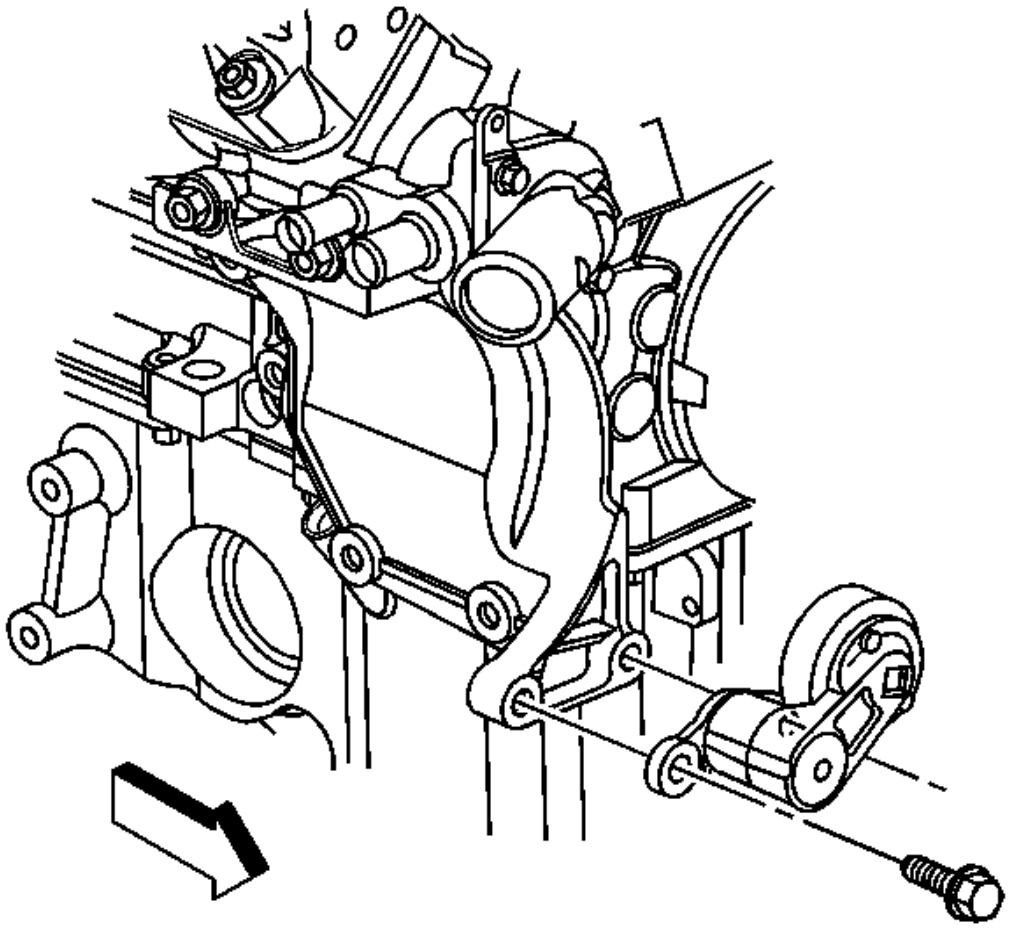

Fig. 35: View Of A/C Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the A/C belt tensioner.
2. Install the A/C belt tensioner bolts.

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

3. Lower the vehicle.
4. Install the A/C drive belt. Refer to **Drive Belt Replacement - Air Conditioning**.

Engine Mount Inspection

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Front Engine Mount

NOTE: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

1. Install a pole jack underneath the oil pan.

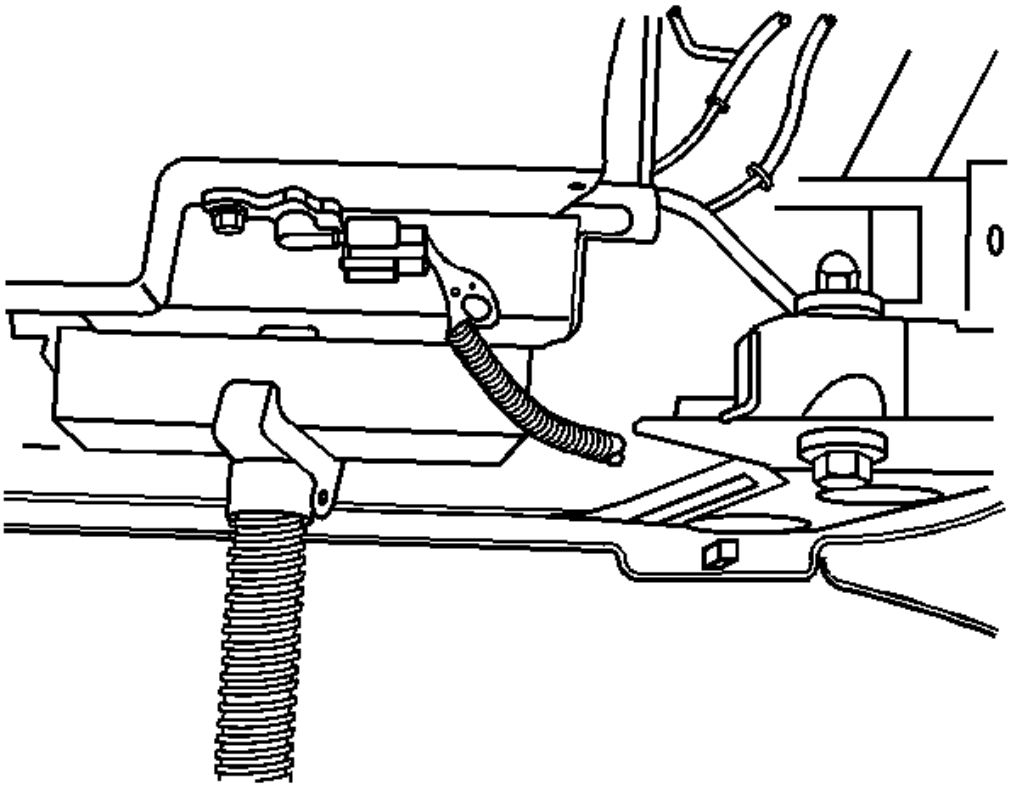

Fig. 36: Block Of Wood Between Engine Oil Pan And Pole Jack
Courtesy of GENERAL MOTORS CORP.

2. Insert a block of wood between the engine oil pan and the pole jack.
3. Raise the jack until the wooden block contacts the engine oil pan.
4. Raise the engine in order to place a slight tension on the rubber cushion. Observe both mounts while raising the engine.
5. Replace the mounts if any of the following conditions exist:
   - Hard rubber surface covered with heat check cracks

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- The rubber cushion separated from the metal plate of the mount
- The rubber cushion is split through the center
- The mount is leaking

6. If there is movement between a metal plate of the mount and its attaching points, lower the engine and tighten the bolts or nuts attaching the mount to the engine, the frame or the bracket.

Engine Mount Replacement - Left (Four-Wheel Drive)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
4. Remove the shock module. Refer to **Shock Module Replacement** in Front Suspension.
5. Remove the left side wheel drive shaft. Refer to **Wheel Drive Shaft Replacement** in Wheel Drive Shafts.
6. Remove the front differential carrier. Refer to **Differential Carrier Assembly Replacement (V8)** in Front Drive Axle.

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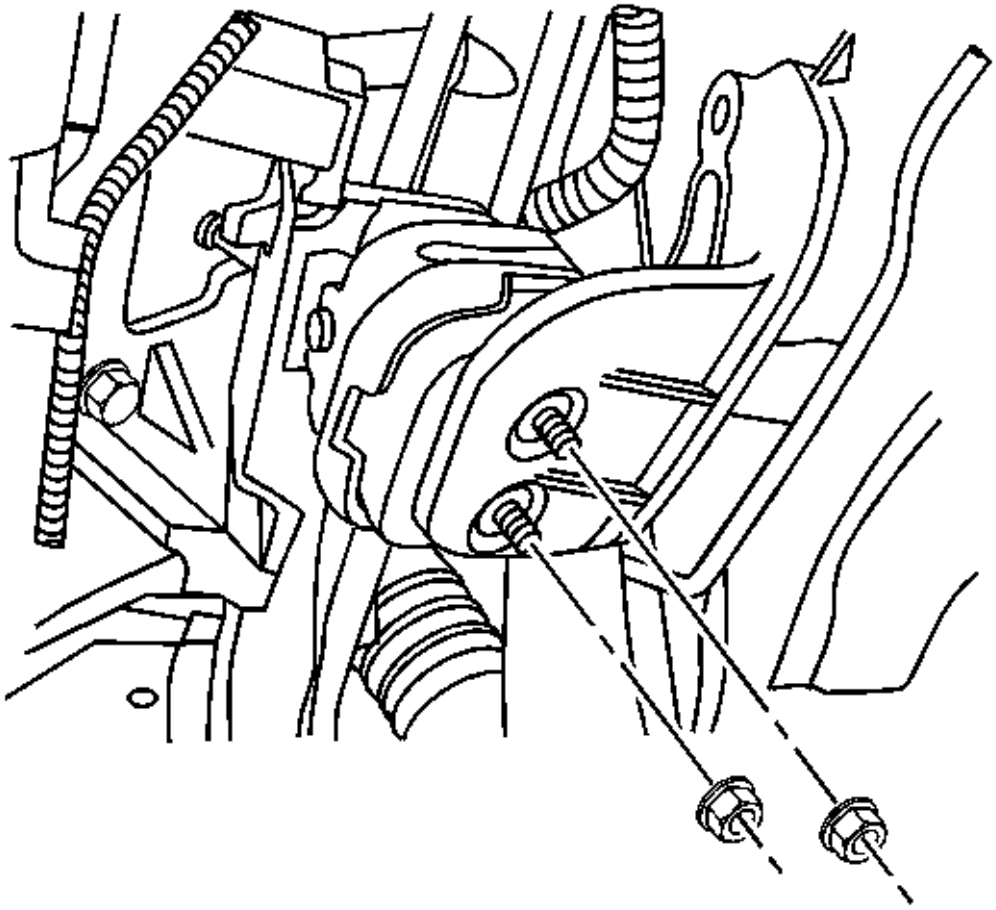

Fig. 37: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

7. Remove the lower engine mount retaining nuts from the engine mount frame bracket.

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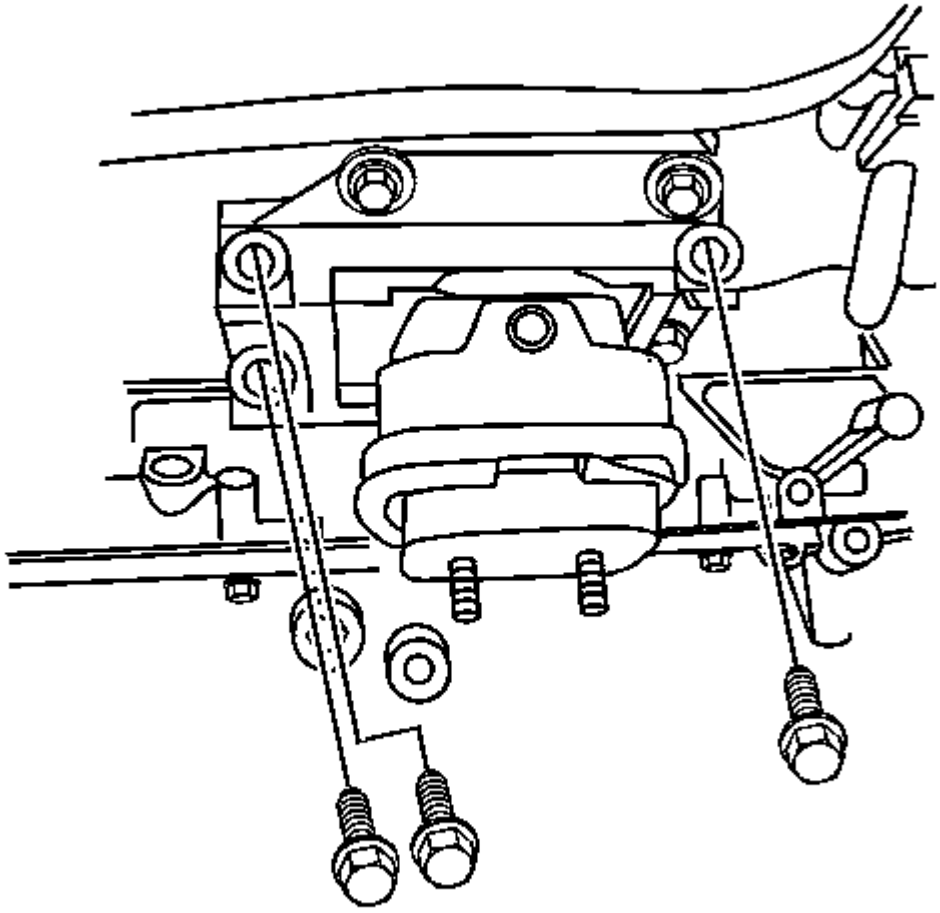

Fig. 38: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the 3 mounting bolts that secure the upper engine mount bracket to the engine block bracket.

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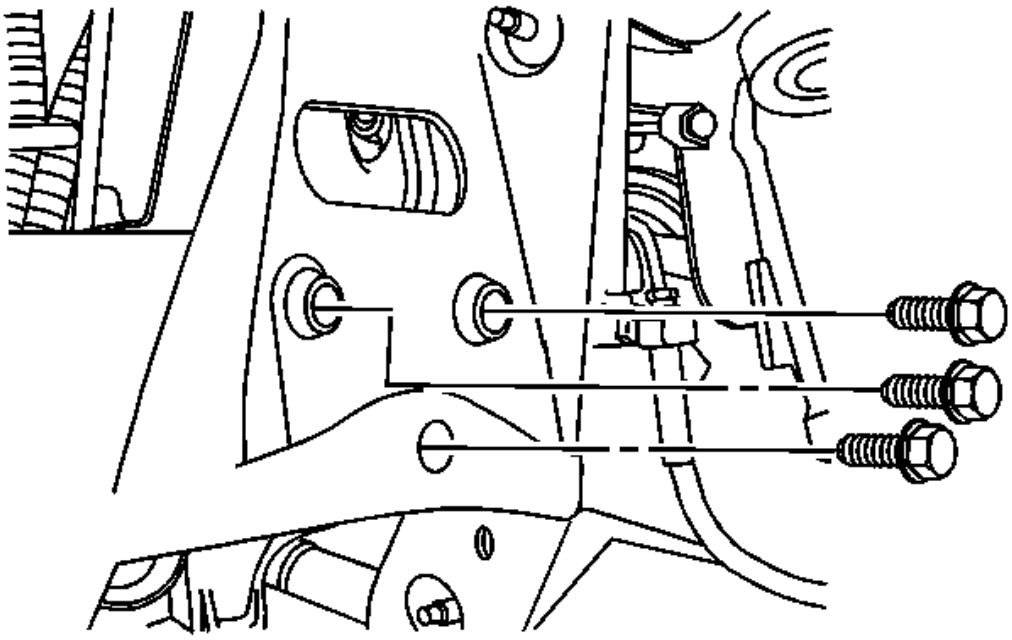

Fig. 39: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

9. Remove the 3 retaining bolts to the frame engine mount bracket.

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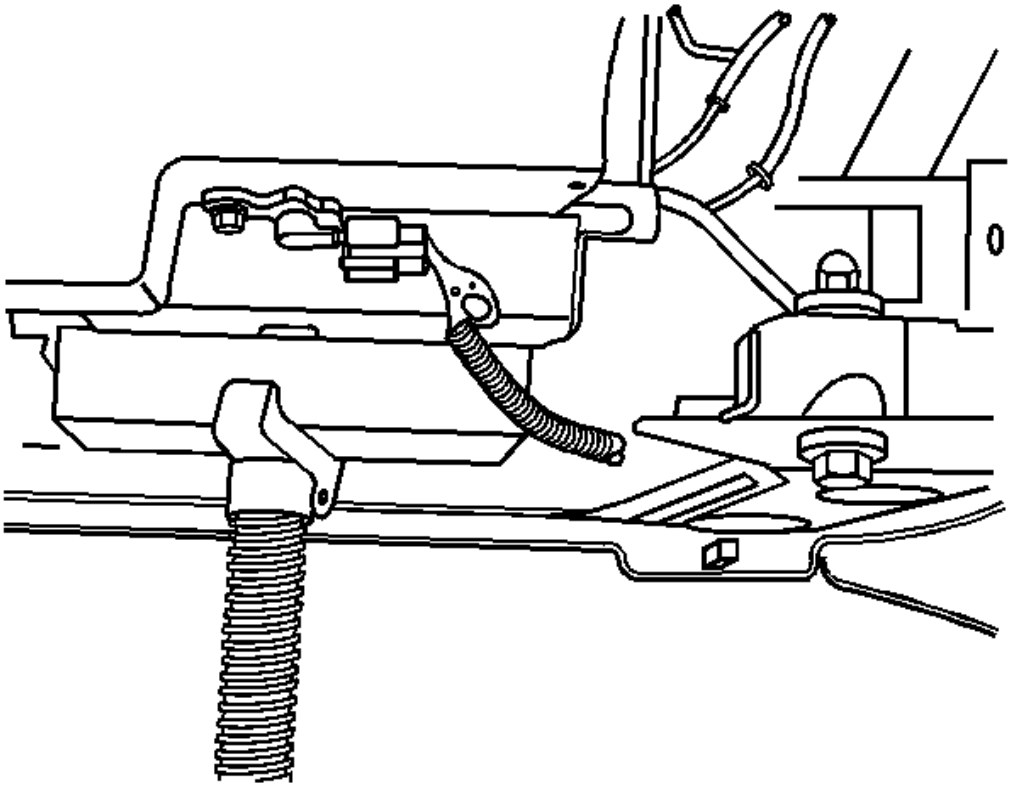

Fig. 40: Block Of Wood Between Engine Oil Pan And Pole Jack
Courtesy of GENERAL MOTORS CORP.

10. Install a pole jack underneath the oil pan.
11. Insert a block of wood between the oil pan and the pole jack.

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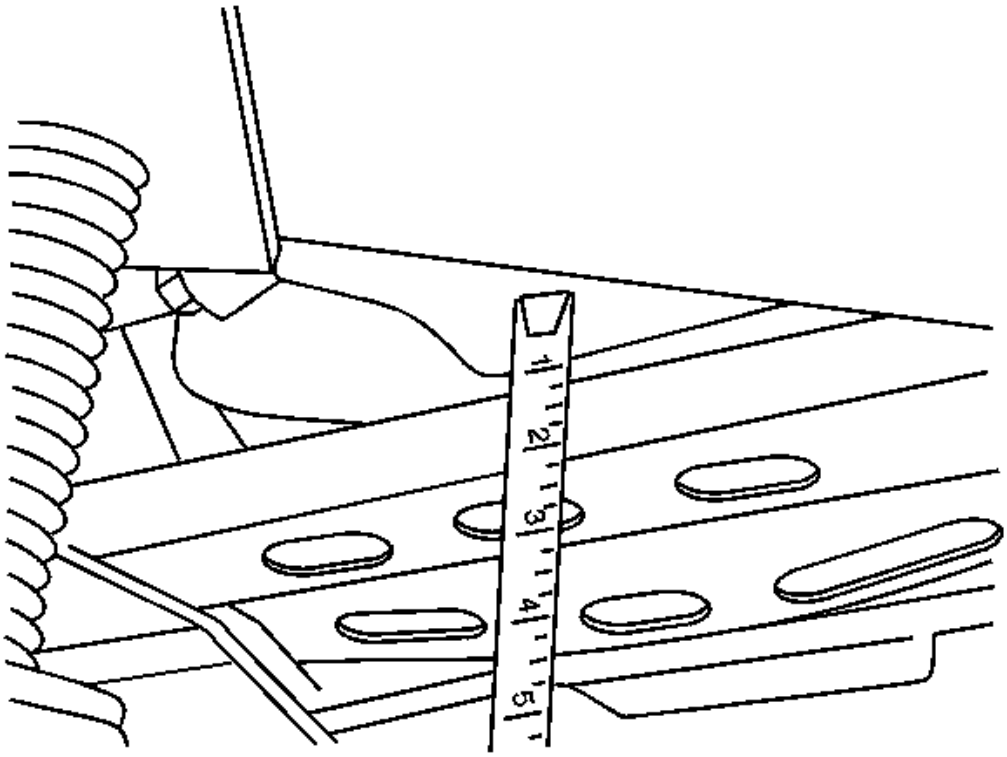

Fig. 41: Measuring Engine Elevation
Courtesy of GENERAL MOTORS CORP.

12. Raise the engine 21/4 inches measuring from the bottom of the oil pan to the front edge of the transmission support crossmember.

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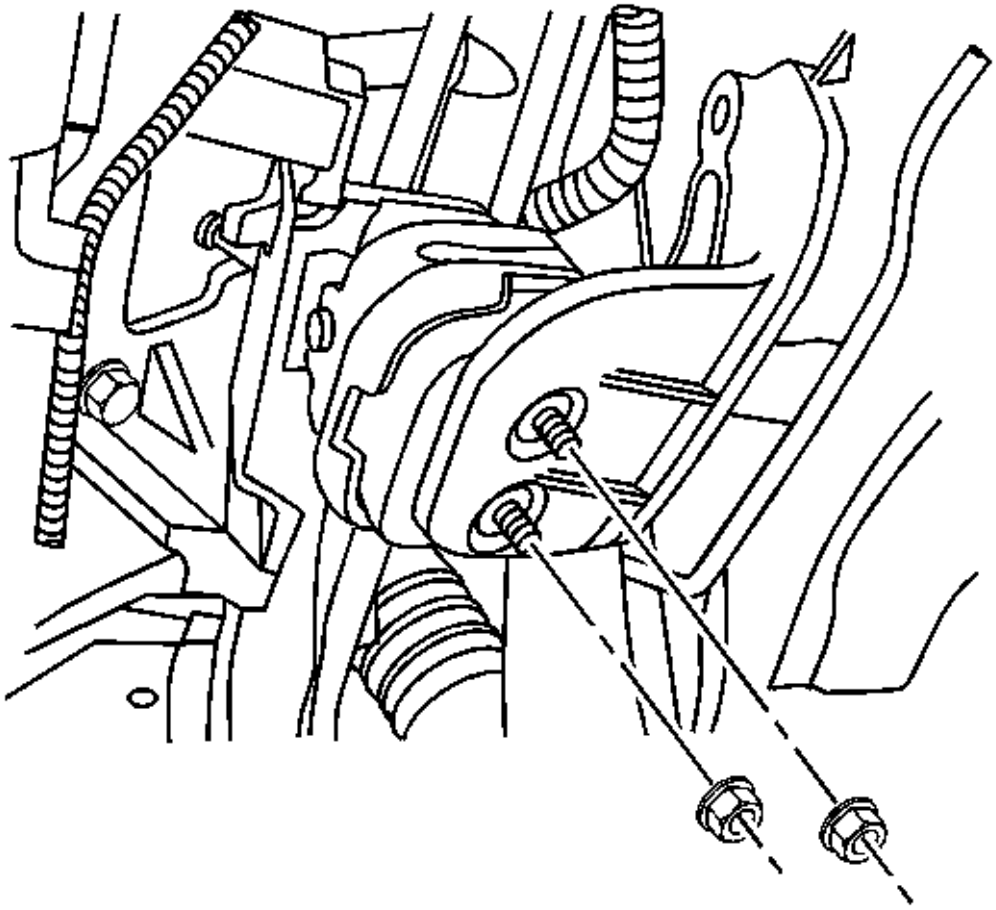

Fig. 42: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine mount frame bracket from the frame.

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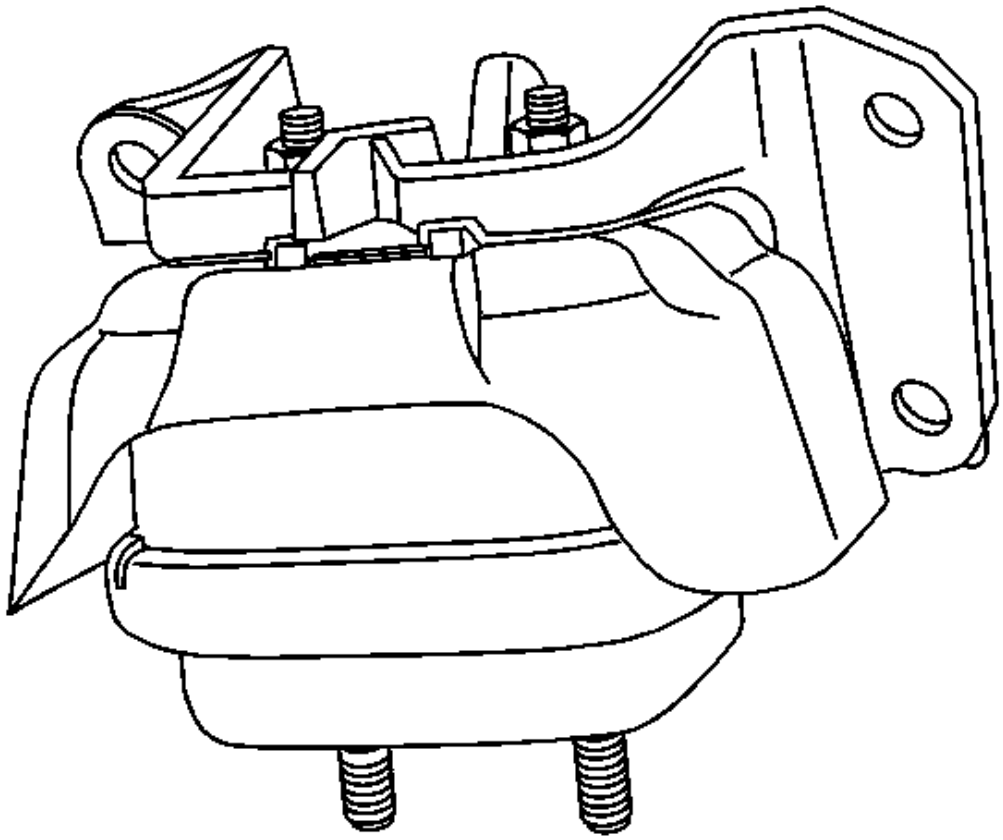

Fig. 43: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine mount with the upper engine mount bracket as an assembly.
15. Separate the engine mount from the upper engine mount bracket.

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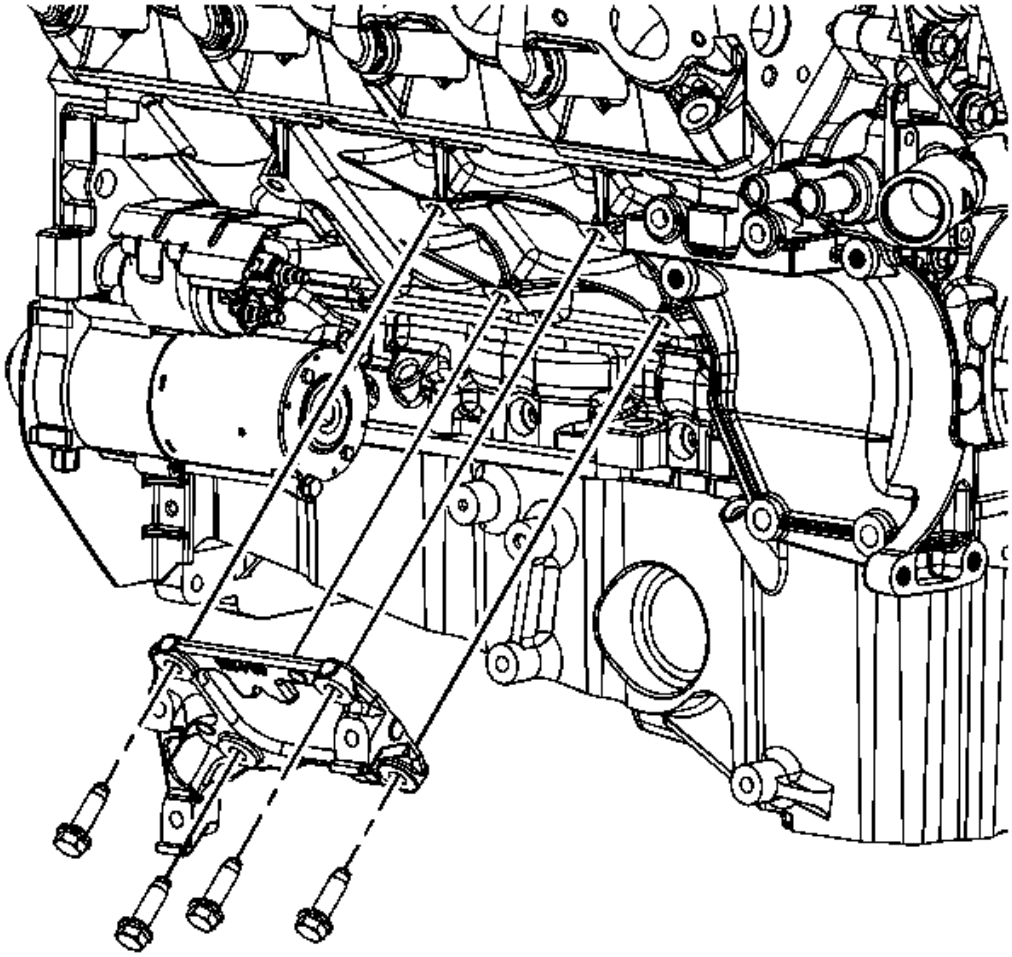

Fig. 44: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

16. Remove the engine mount bracket spacer if damaged.

Installation Procedure

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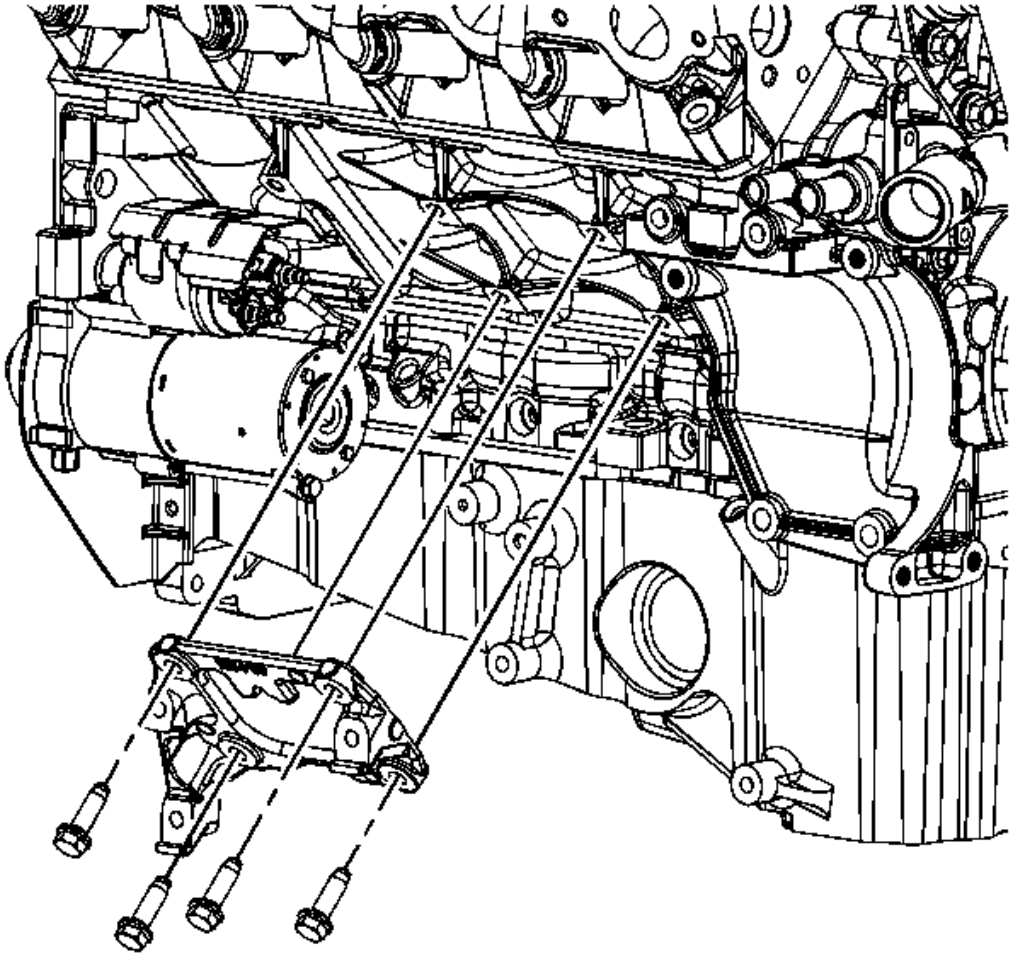

Fig. 45: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine mount bracket spacer if necessary.

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

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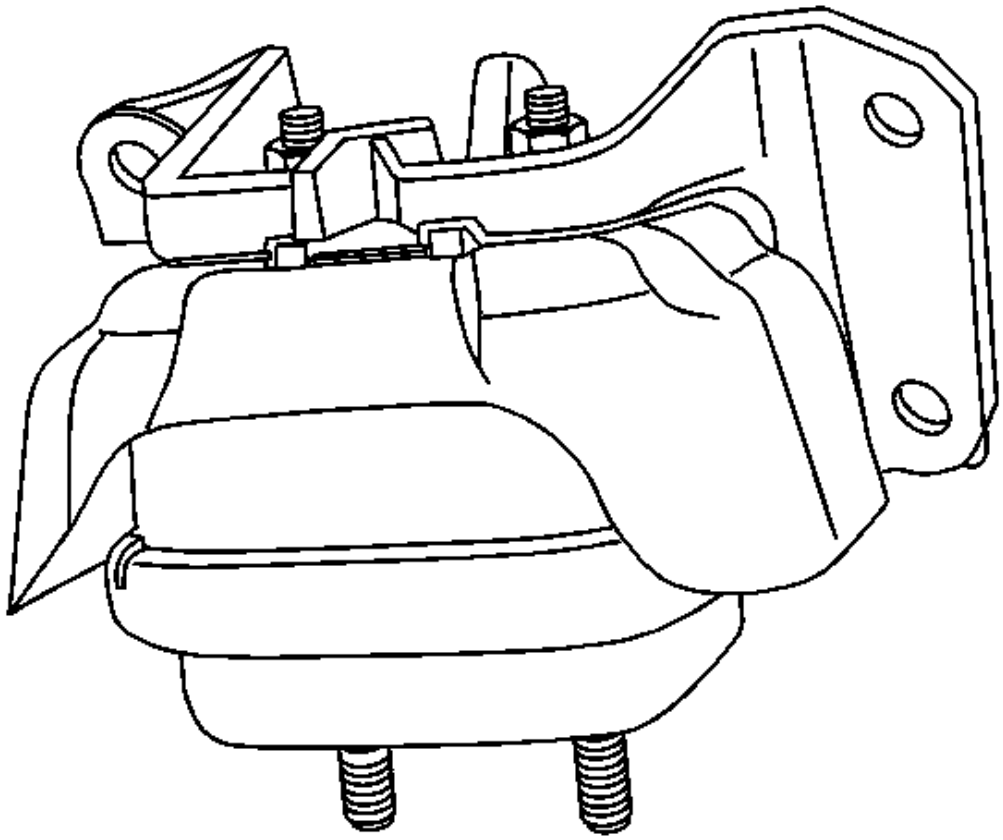

Fig. 46: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Verify that the cut out side of the engine mount shield is positioned away from the engine.

2. Install the engine mount to the upper engine mount bracket.

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

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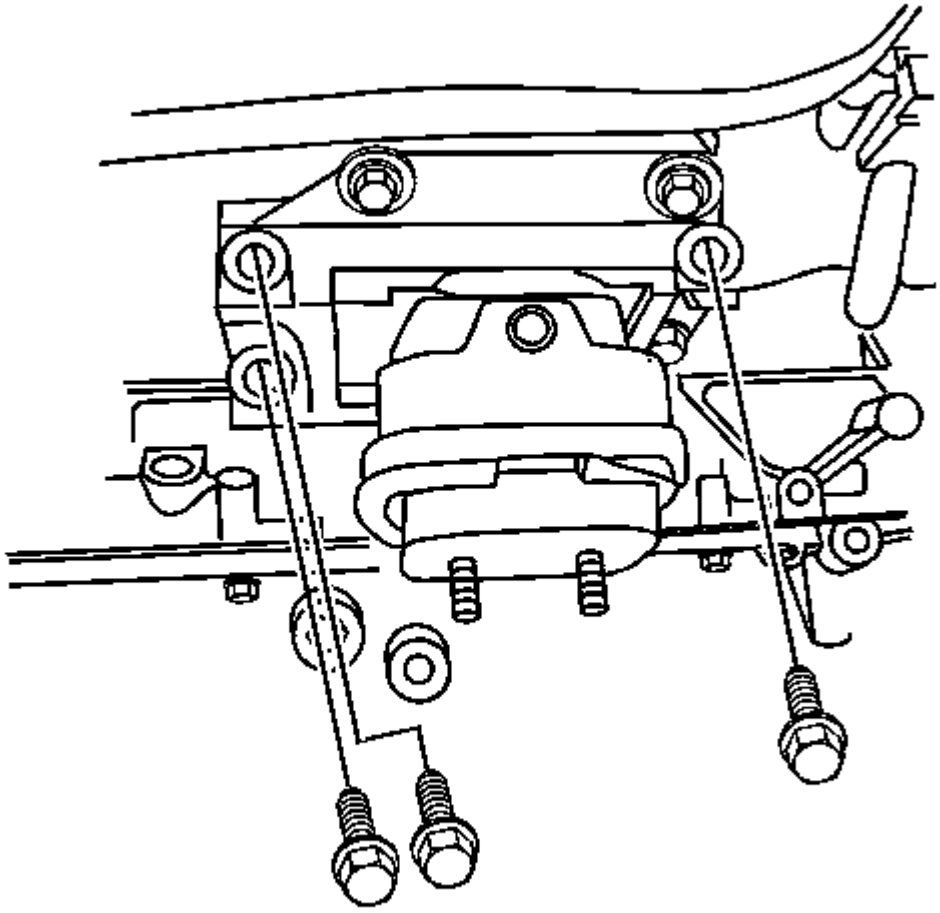

Fig. 47: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to engine.

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

4. Install the engine mount frame bracket to the frame.
5. Install the engine mount frame bracket retaining bolts.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

6. Install the left side engine mount frame bracket.

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7. Install the left side engine mount frame bracket retaining bolts.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

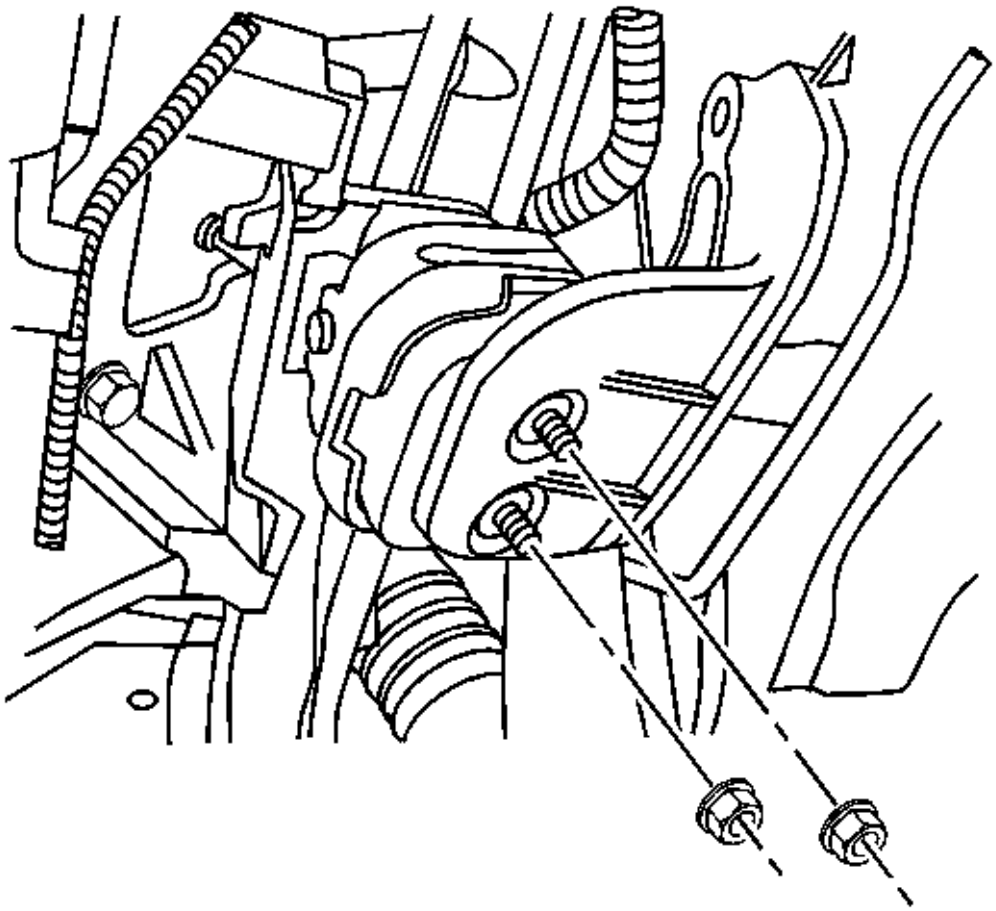

Fig. 48: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

8. Lower the engine, aligning the engine mount studs with the holes in the frame bracket.
9. Remove the pole jack and block of wood.
10. Tighten the engine mount nuts.

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

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11. Install the shock module. Refer to **Shock Module Replacement** in Front Suspension.
12. Install the front differential carrier. Refer to **Differential Carrier Assembly Replacement (V8)** in Front Drive Axle.
13. Install the left side wheel drive shaft. Refer to **Wheel Drive Shaft Replacement** in Wheel Drive Shafts.
14. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
15. Install the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
16. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

Engine Mount Replacement - Left (Two-Wheel Drive)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
4. Remove the shock module. Refer to **Shock Module Replacement** in Front Suspension.

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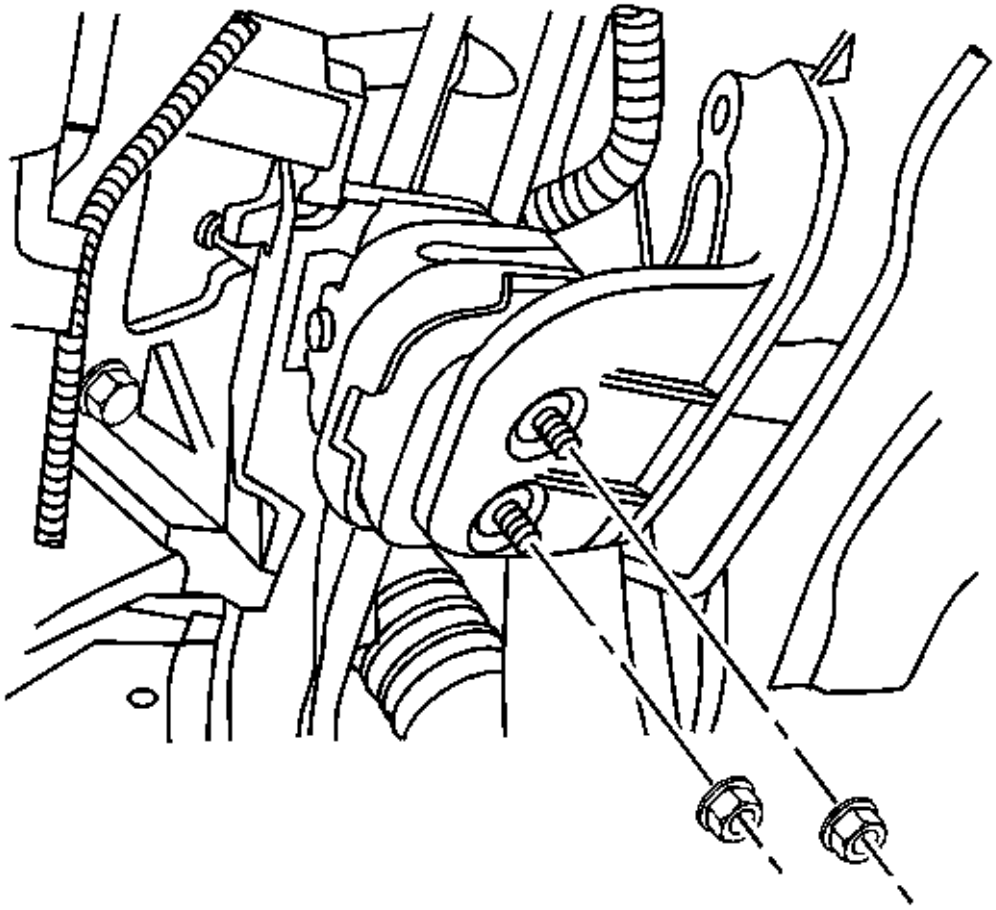

Fig. 49: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

5. Remove the lower engine mount retaining nuts from the engine mount frame bracket.

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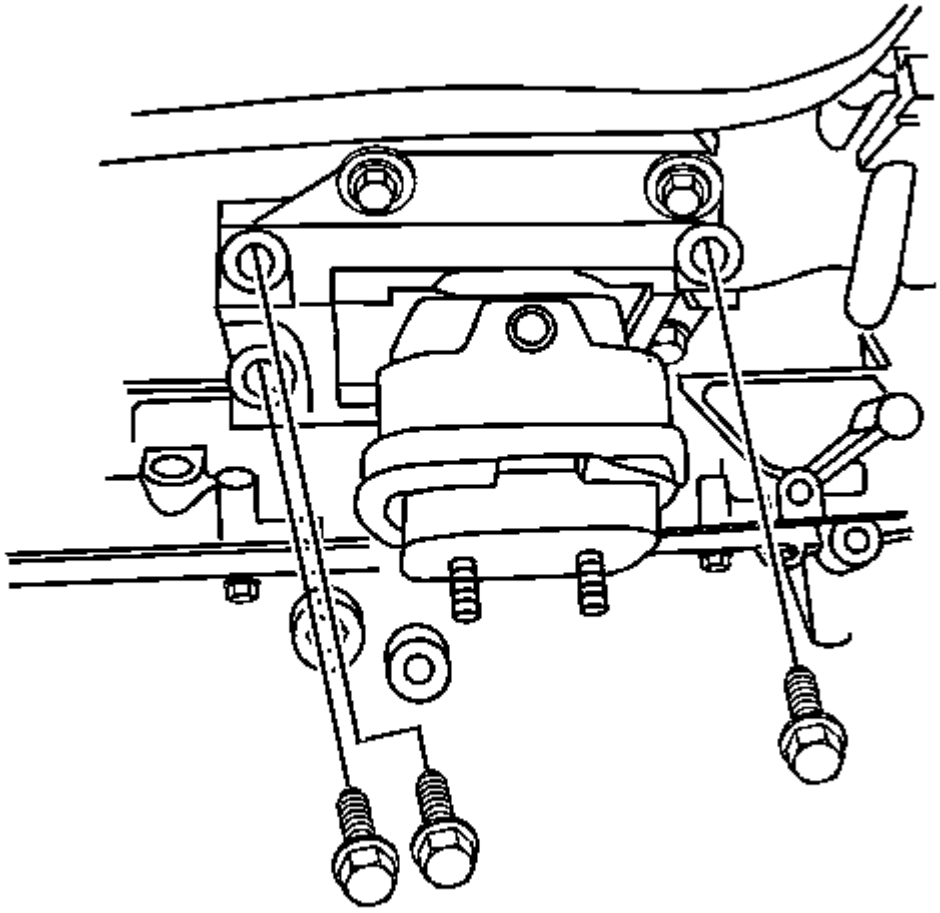

Fig. 50: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

6. Remove the 3 mounting bolts that secure the upper engine mount bracket to the engine block bracket.

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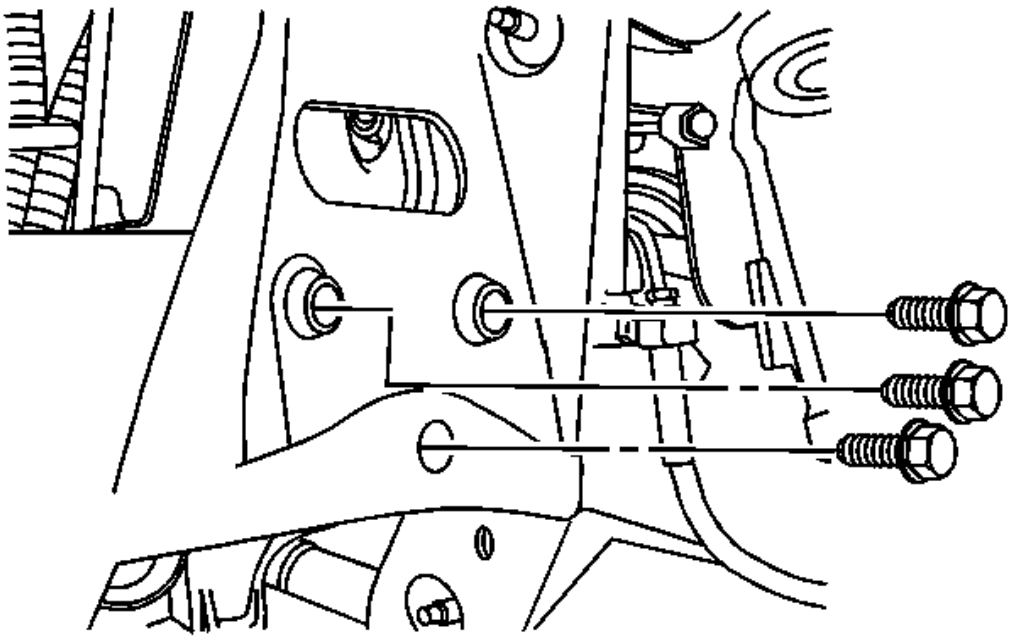

Fig. 51: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

7. Remove the 3 frame engine mount bracket retaining bolts.

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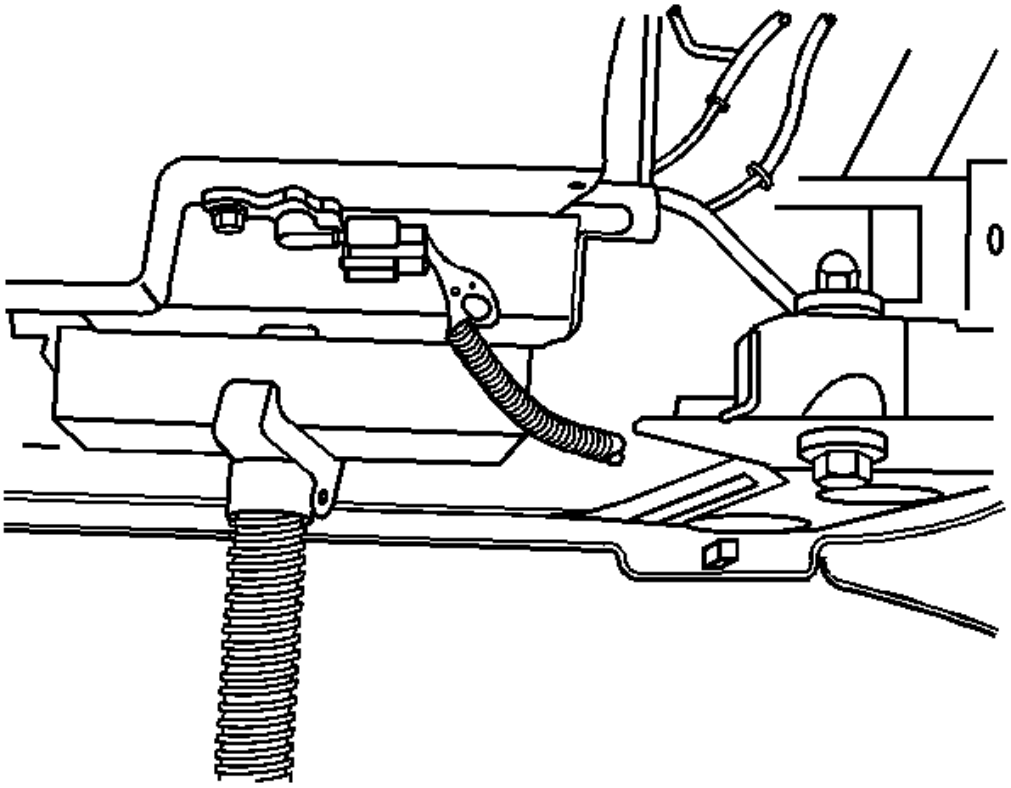

Fig. 52: Block Of Wood Between Engine Oil Pan And Pole Jack
Courtesy of GENERAL MOTORS CORP.

8. Install a pole jack underneath the oil pan.
9. Insert a block of wood between the oil pan and the pole jack.

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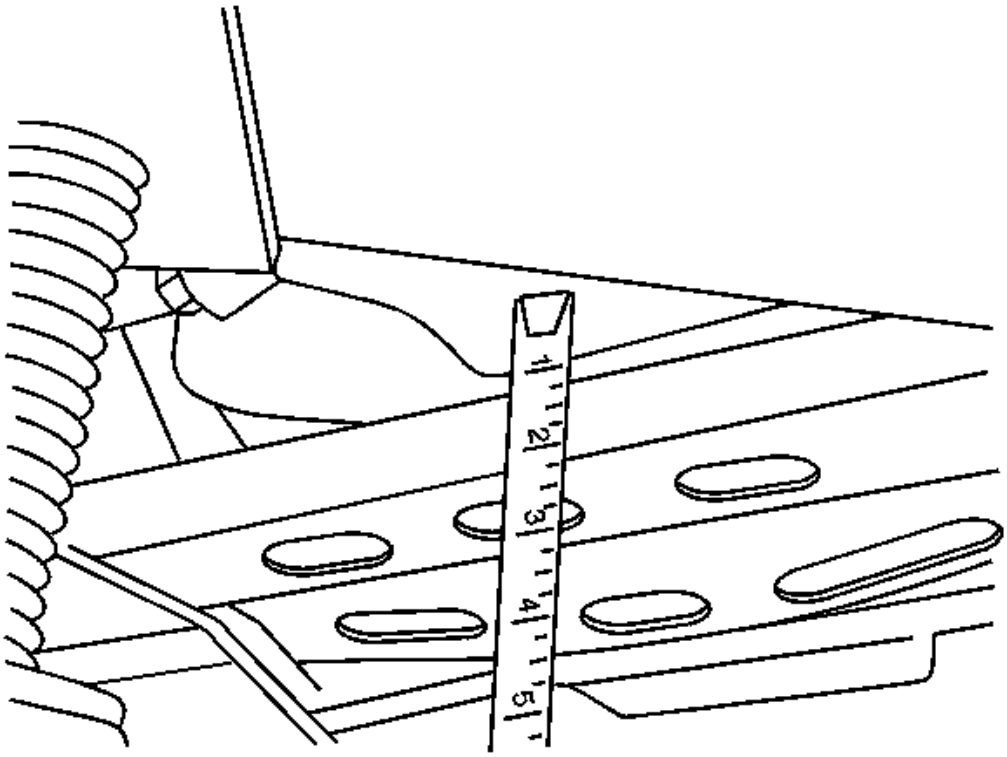

Fig. 53: Measuring Engine Elevation
Courtesy of GENERAL MOTORS CORP.

10. Raise the engine 21/4 inches measuring from the bottom of the oil pan to the front edge of the transmission support crossmember.

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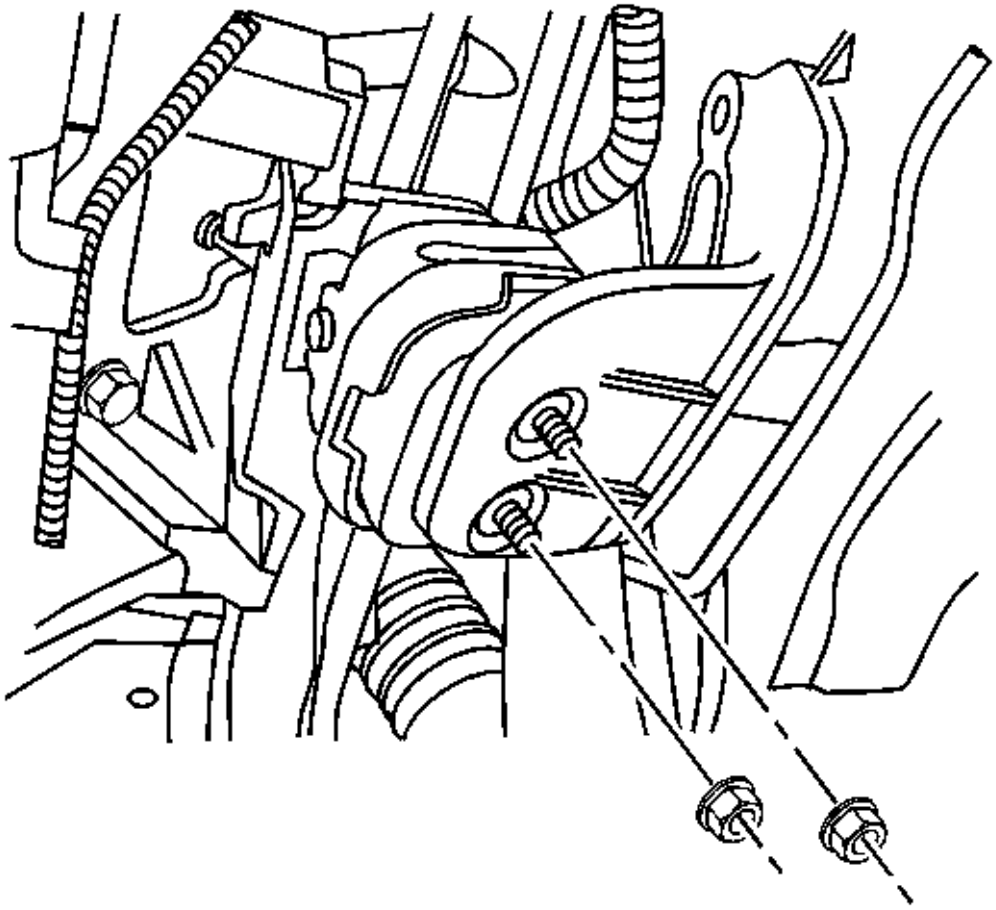

Fig. 54: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine mount frame bracket from the frame.

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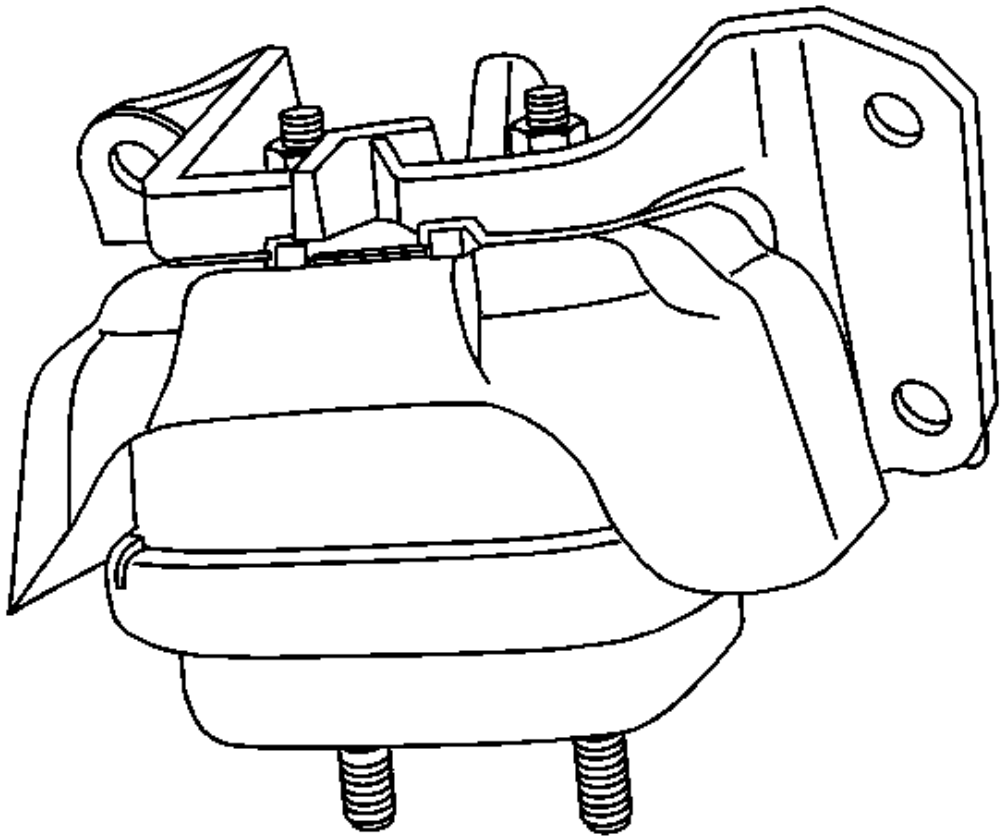

Fig. 55: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine mount with the upper engine mount bracket as an assembly.
13. Separate the engine mount from the upper engine mount bracket.

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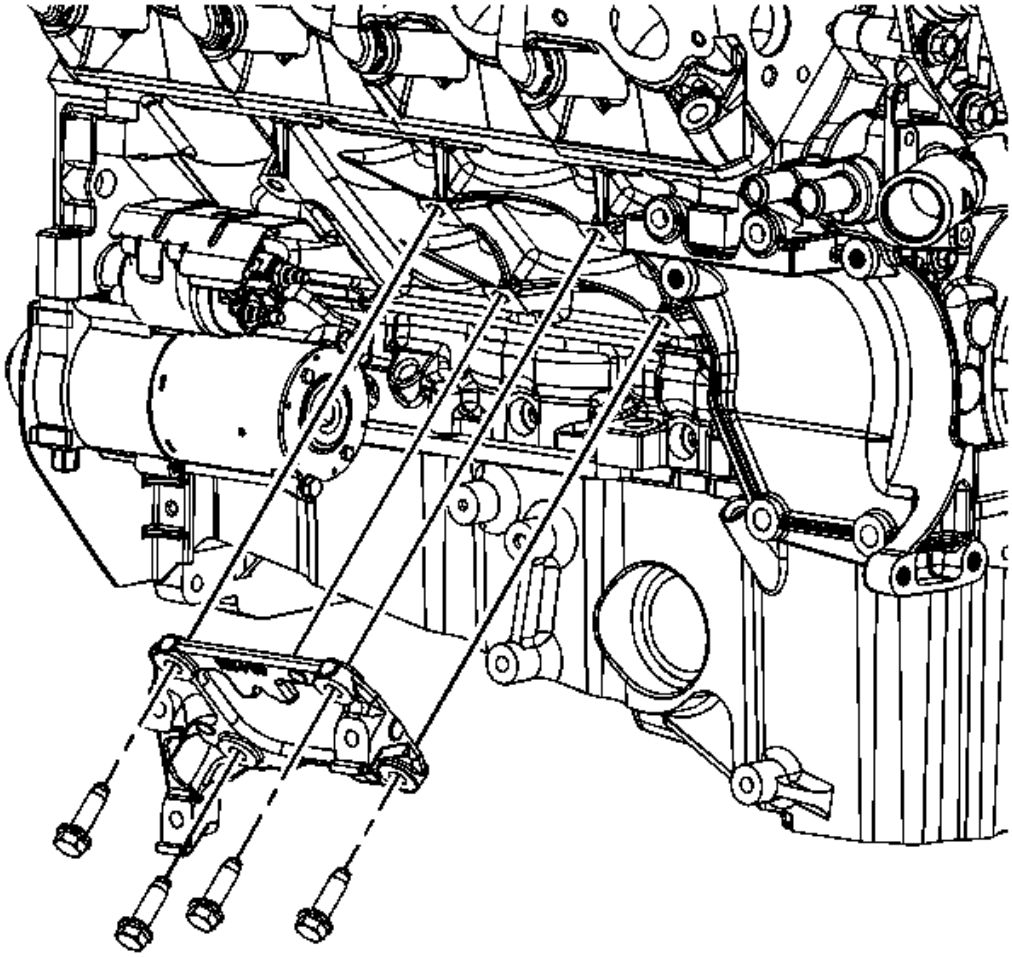

Fig. 56: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine mount bracket spacer if damaged.

Installation Procedure

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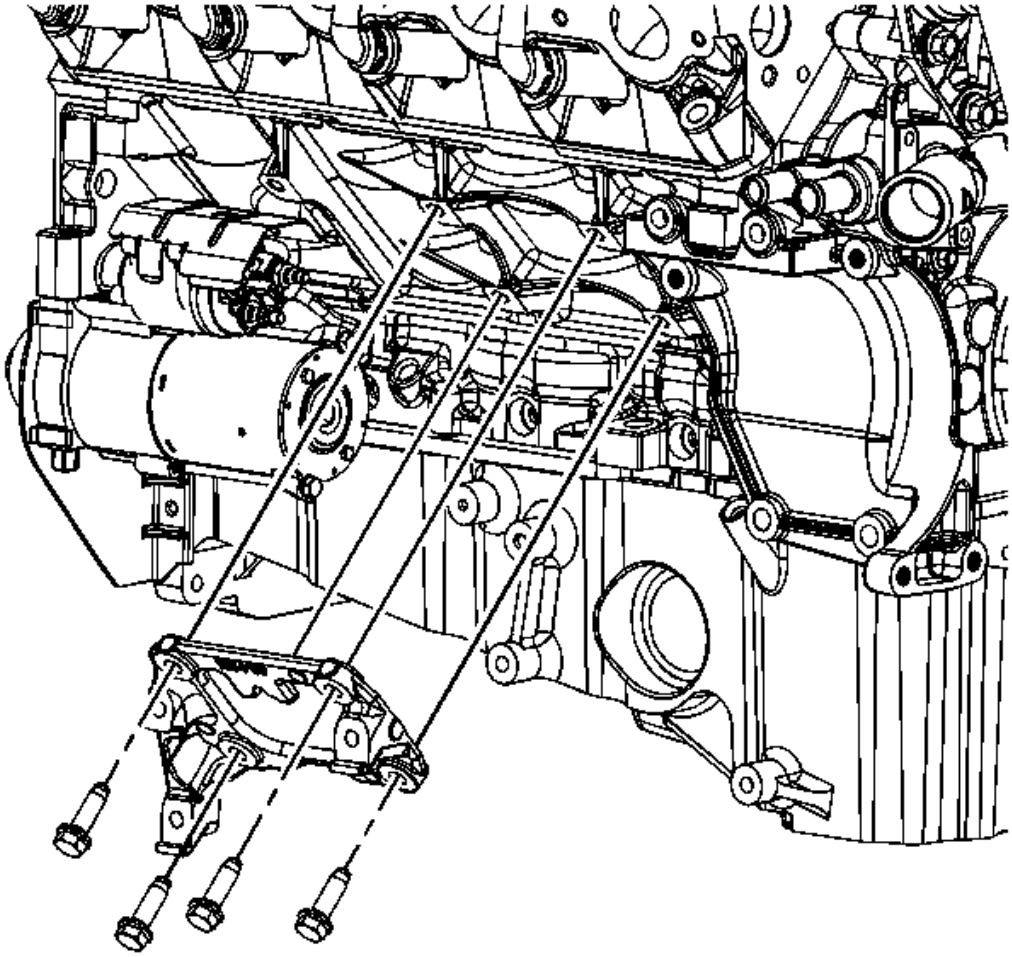

Fig. 57: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine mount bracket spacer if necessary.

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

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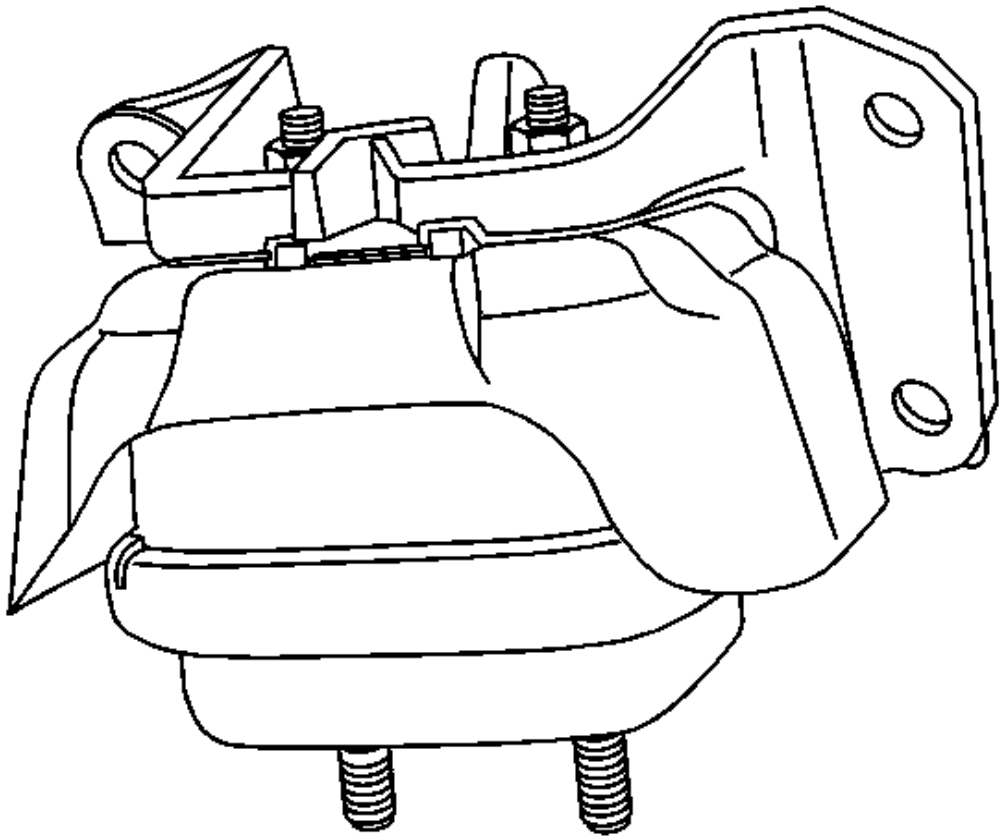

Fig. 58: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Verify that the cut out side of the engine mount shield is positioned away from the engine.

2. Install the engine mount to the upper engine mount bracket.

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

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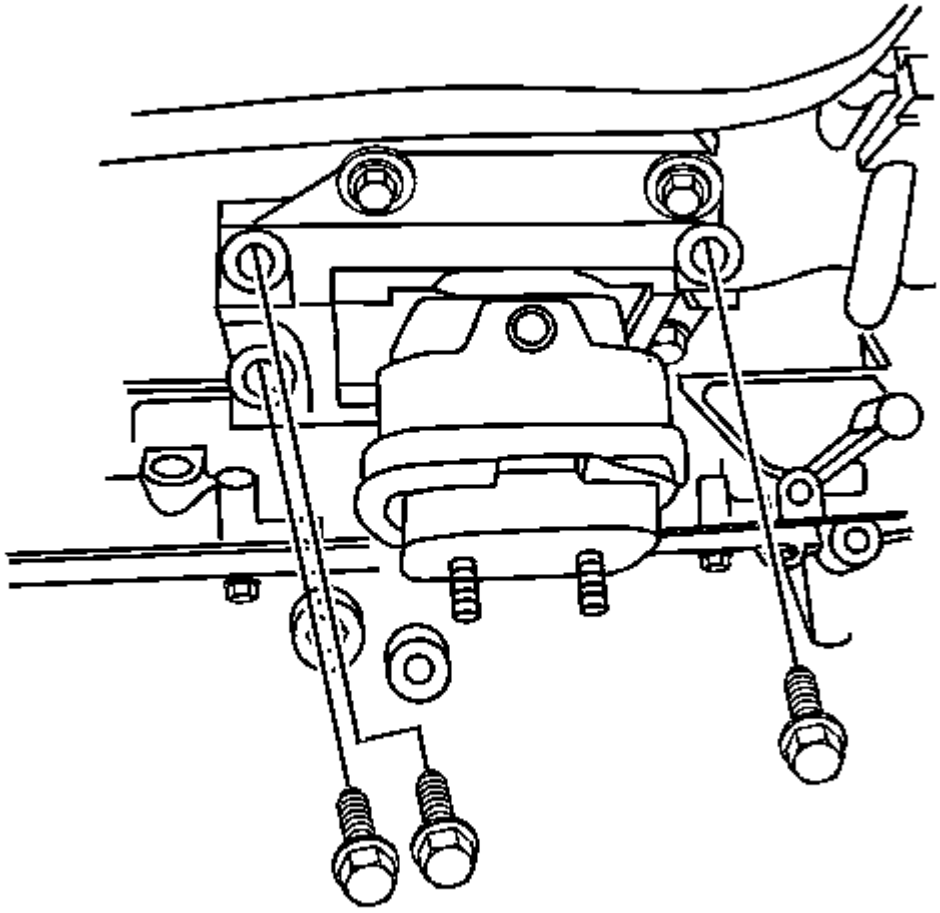

Fig. 59: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to the engine.

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

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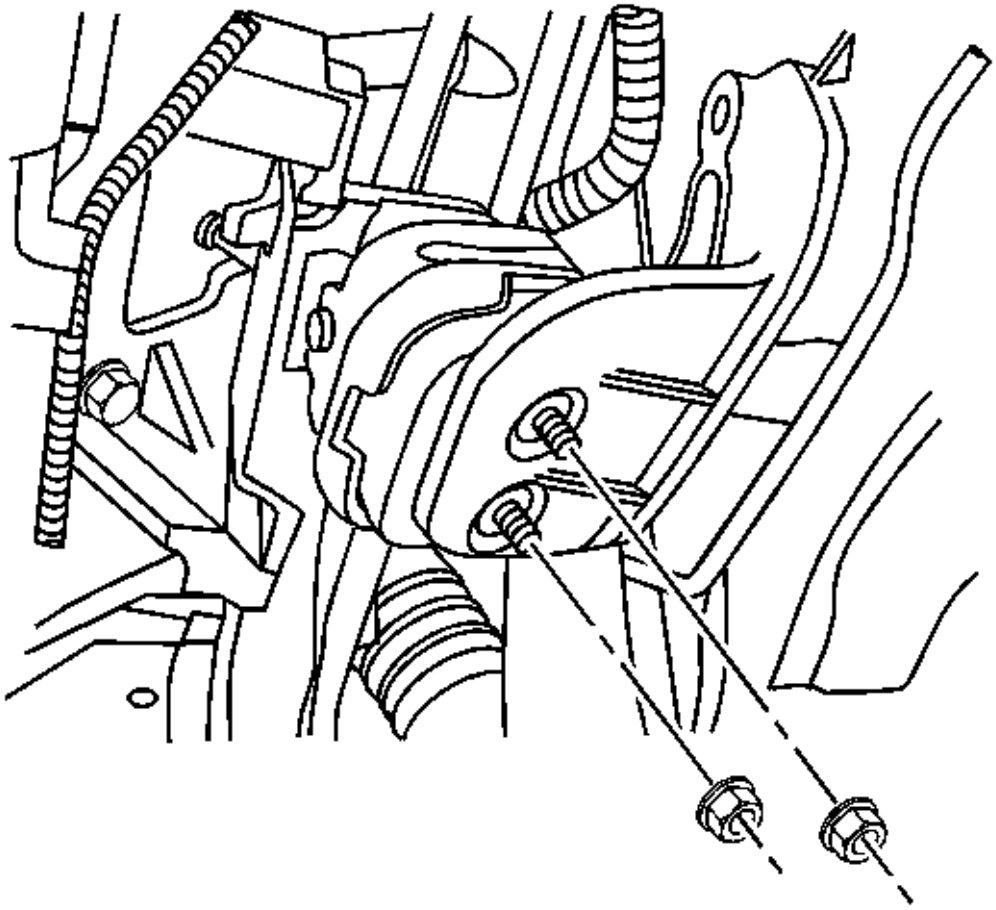

Fig. 60: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Install the engine mount frame bracket to the frame.
5. Install the retaining bolts to the engine mount frame bracket.
6. Install the left side engine mount frame bracket.
7. Install the retaining bolts to the left side engine mount frame bracket.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

8. Lower the engine, aligning the engine mount studs with the holes in the frame bracket.
9. Remove the pole jack and block of wood.
10. Tighten the engine mount nuts.

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

11. Install the shock module. Refer to **Shock Module Replacement** in Front Suspension.
12. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
13. Install the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
14. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

Engine Mount Replacement - Right (Four-Wheel Drive)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
4. Remove the shock module. Refer to **Shock Module Replacement** in Front Suspension.
5. Remove the left side wheel drive shaft. Refer to **Wheel Drive Shaft Replacement** in Wheel Drive Shafts.
6. Remove the front differential carrier. Refer to **Differential Carrier Assembly Replacement (V8)** in Front Drive Axle.

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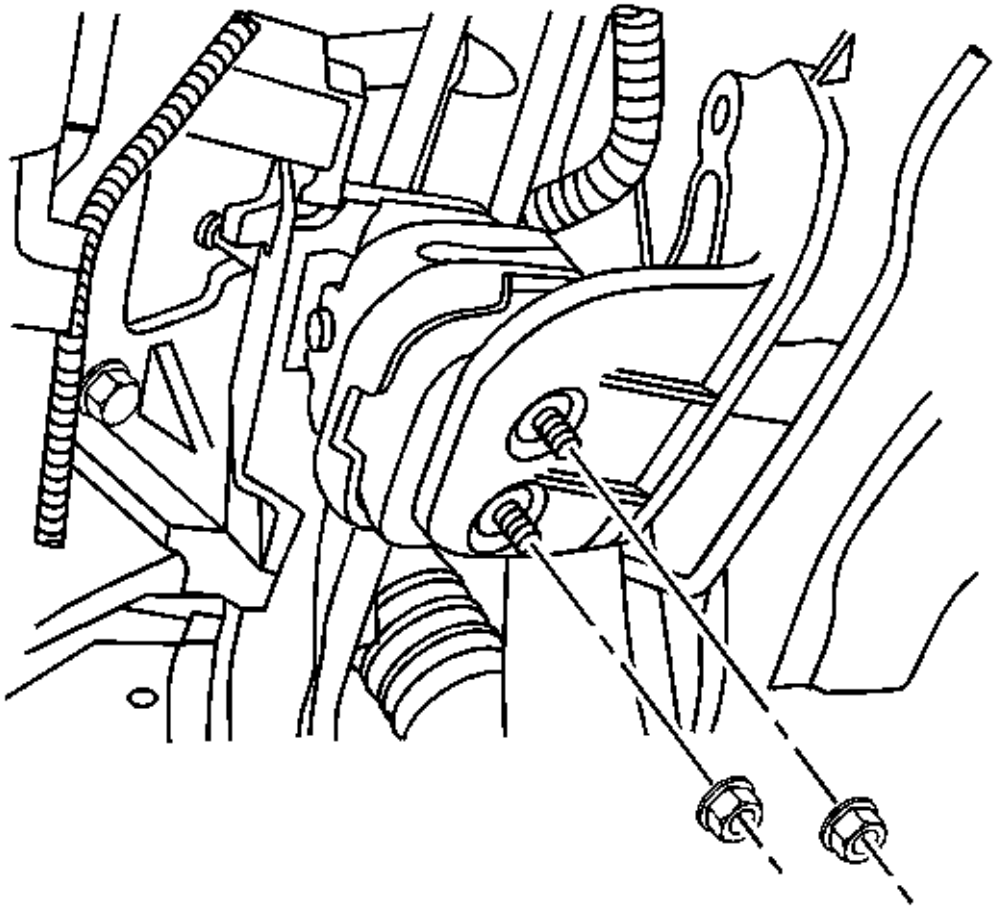

Fig. 61: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

7. Remove the lower engine mount retaining nuts from the engine mount frame bracket.

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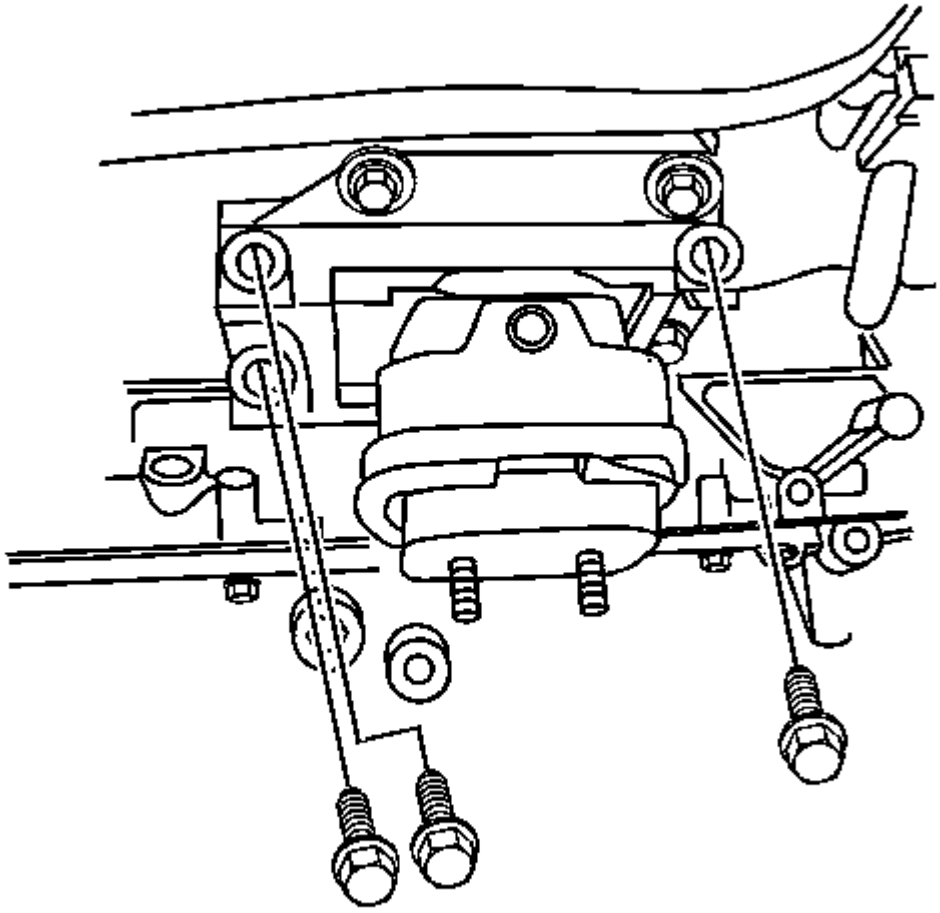

Fig. 62: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the 3 mounting bolts that secure the upper engine mount bracket to the engine block bracket.

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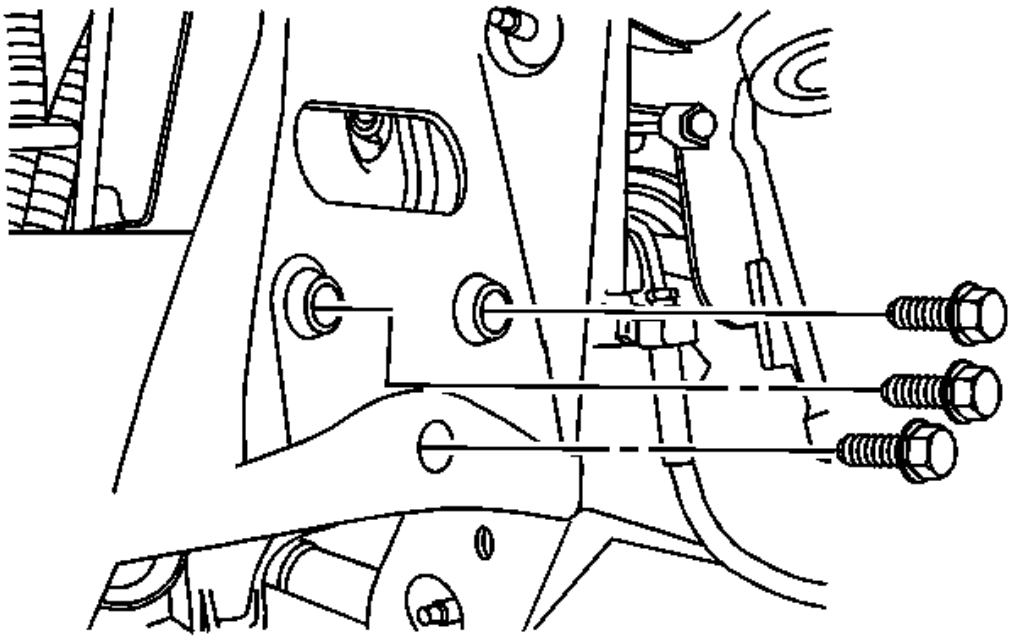

Fig. 63: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

9. Remove the 3 retaining bolts from the frame engine mount bracket.

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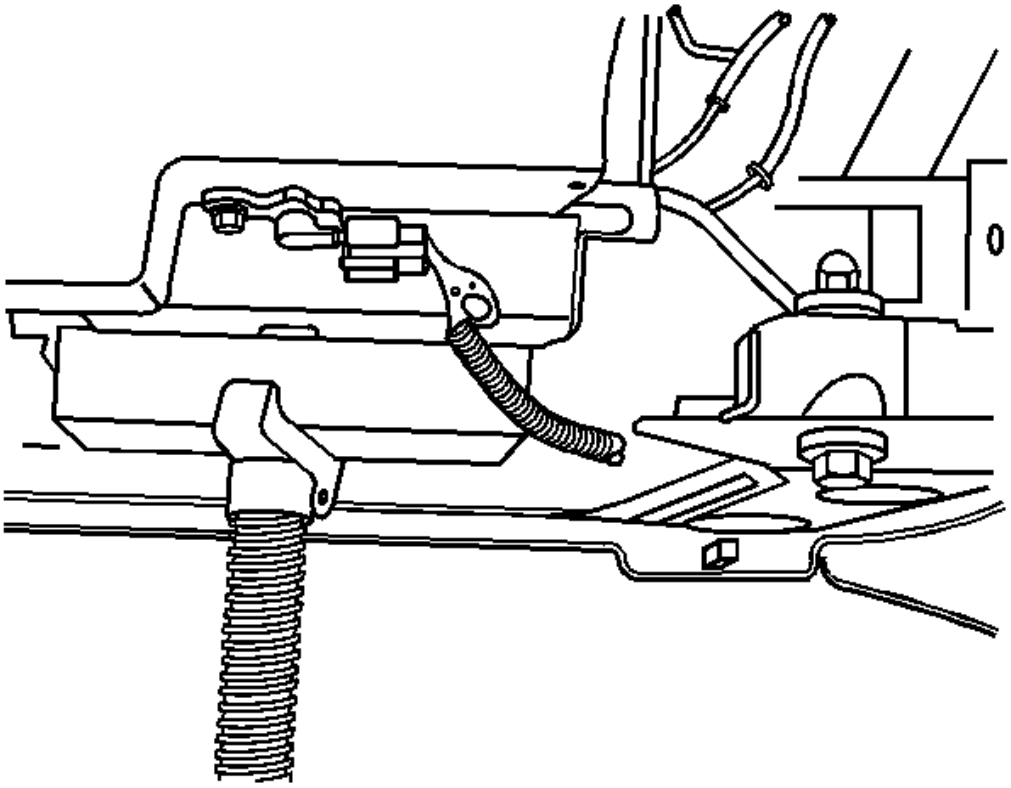

Fig. 64: Block Of Wood Between Engine Oil Pan And Pole Jack
Courtesy of GENERAL MOTORS CORP.

10. Install a pole jack underneath the oil pan.
11. Insert a block of wood between the oil pan and the pole jack.

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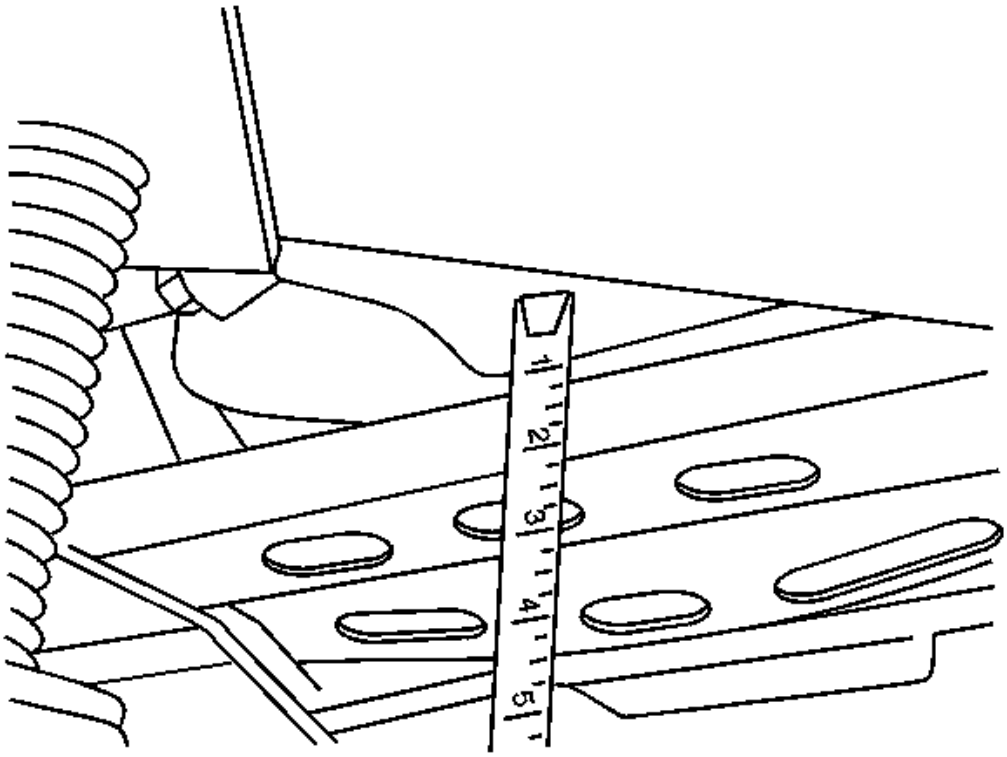

Fig. 65: Measuring Engine Elevation
Courtesy of GENERAL MOTORS CORP.

12. Raise the engine 21/4 inches measuring from the bottom of the oil pan to the front edge of the transmission support crossmember.
13. Shift the engine towards the left side of the frame.

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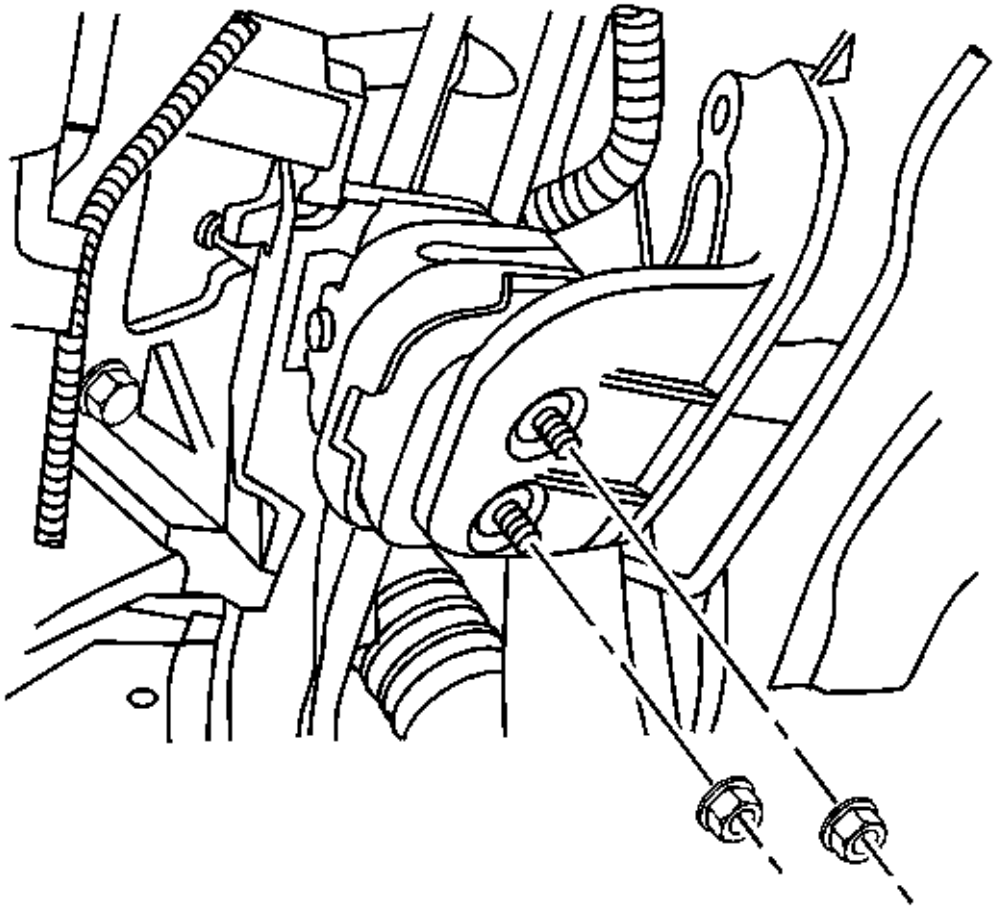

Fig. 66: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine mount frame bracket from the frame.

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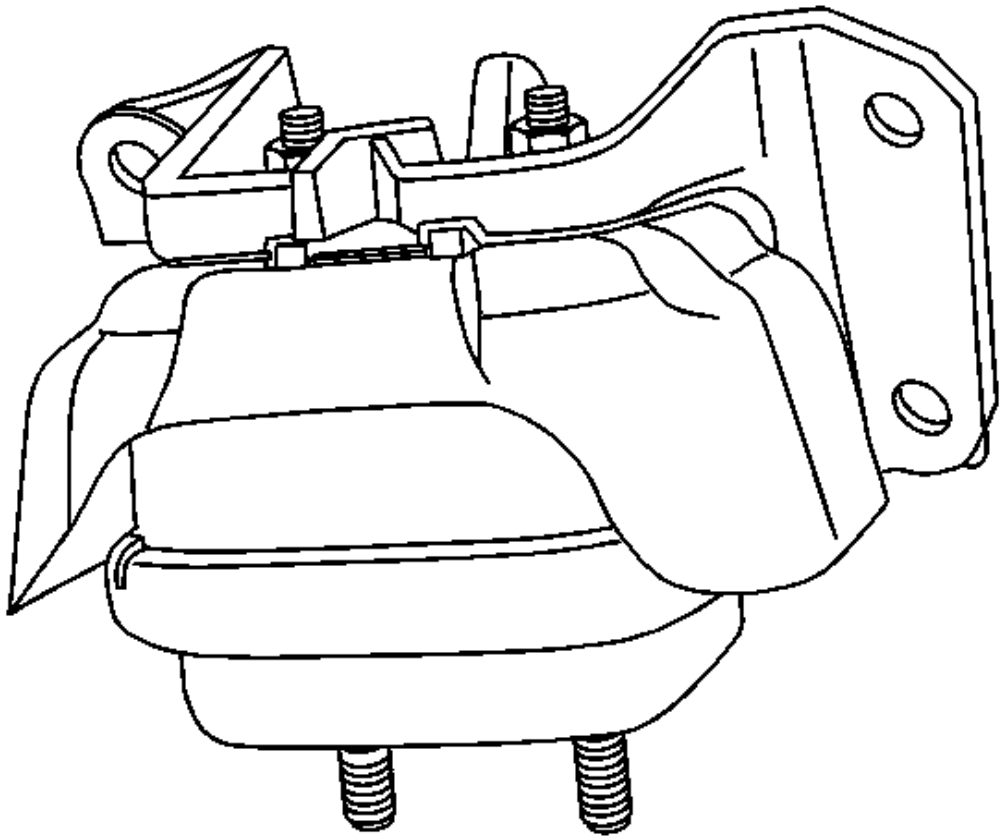

Fig. 67: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

15. Remove the engine mount with the upper engine mount bracket as an assembly.
16. Separate the engine mount from the upper engine mount bracket.

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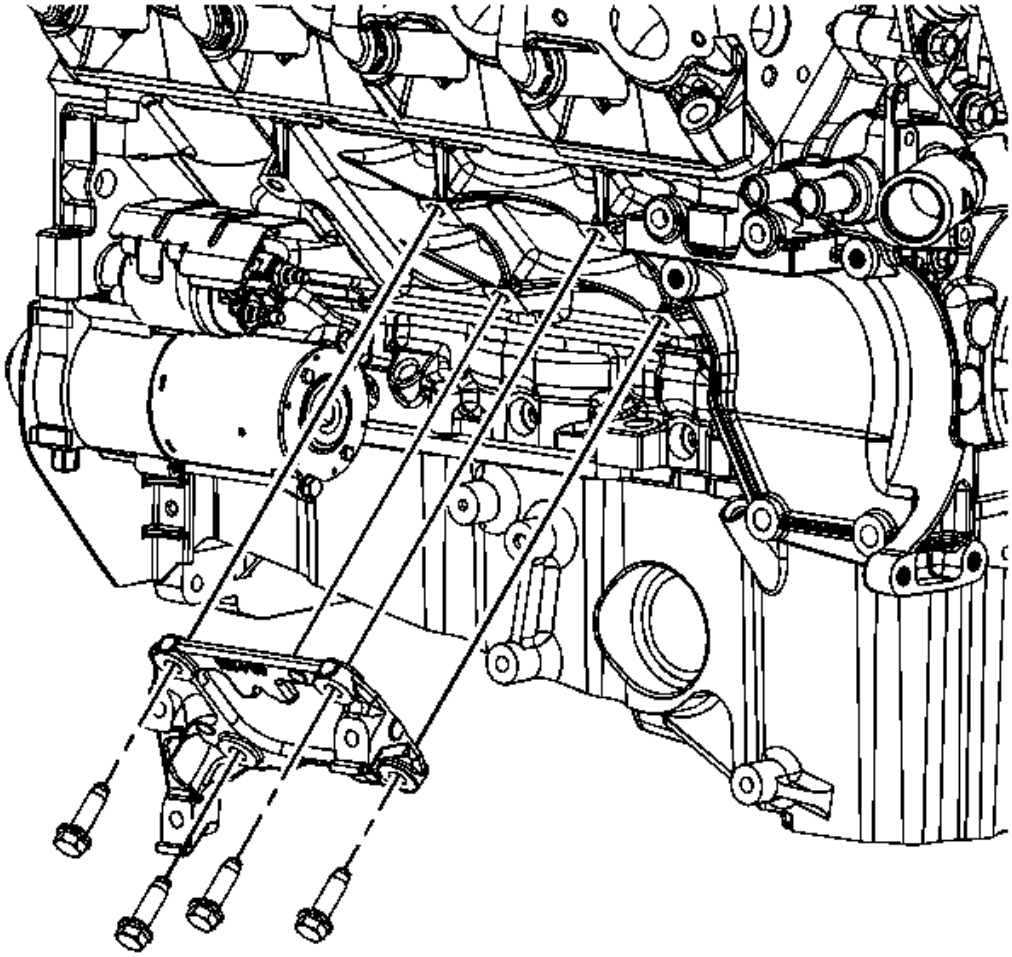

Fig. 68: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

17. Remove the engine mount bracket spacer if damaged.

Installation Procedure

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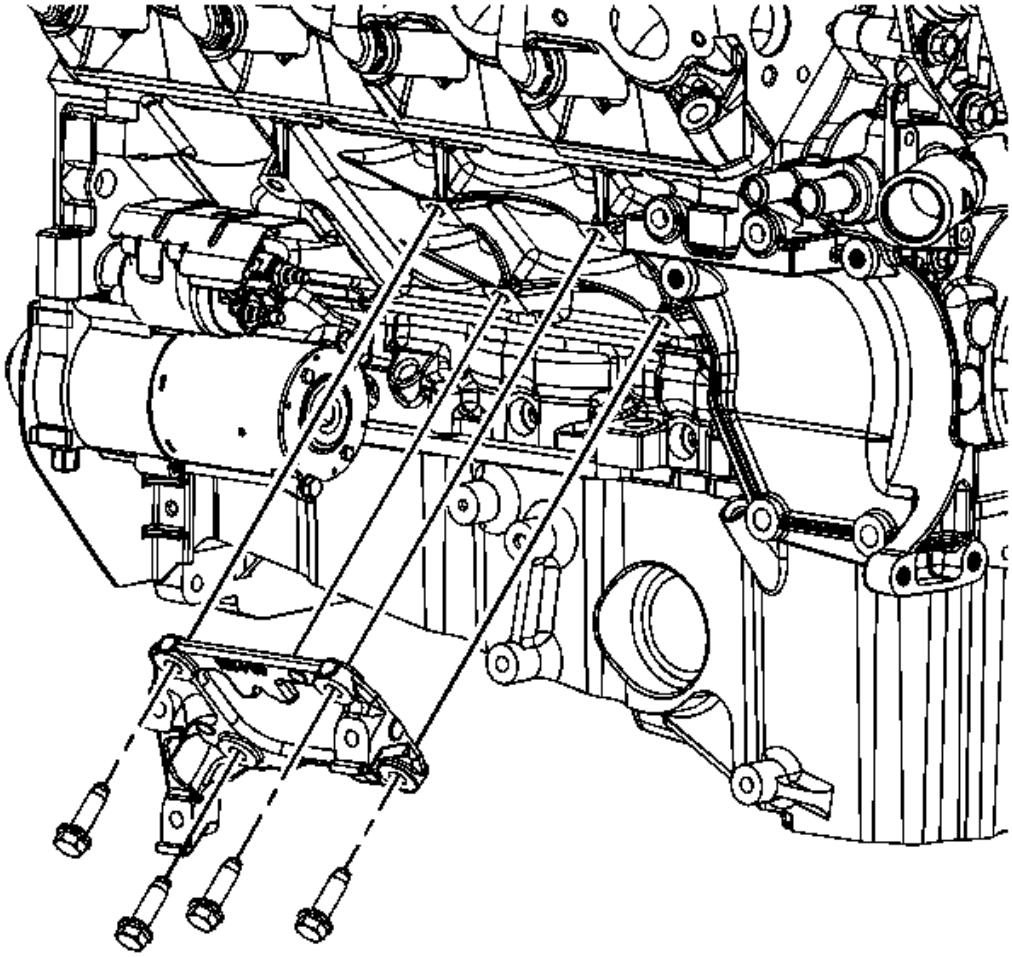

Fig. 69: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine mount bracket spacer if necessary.

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

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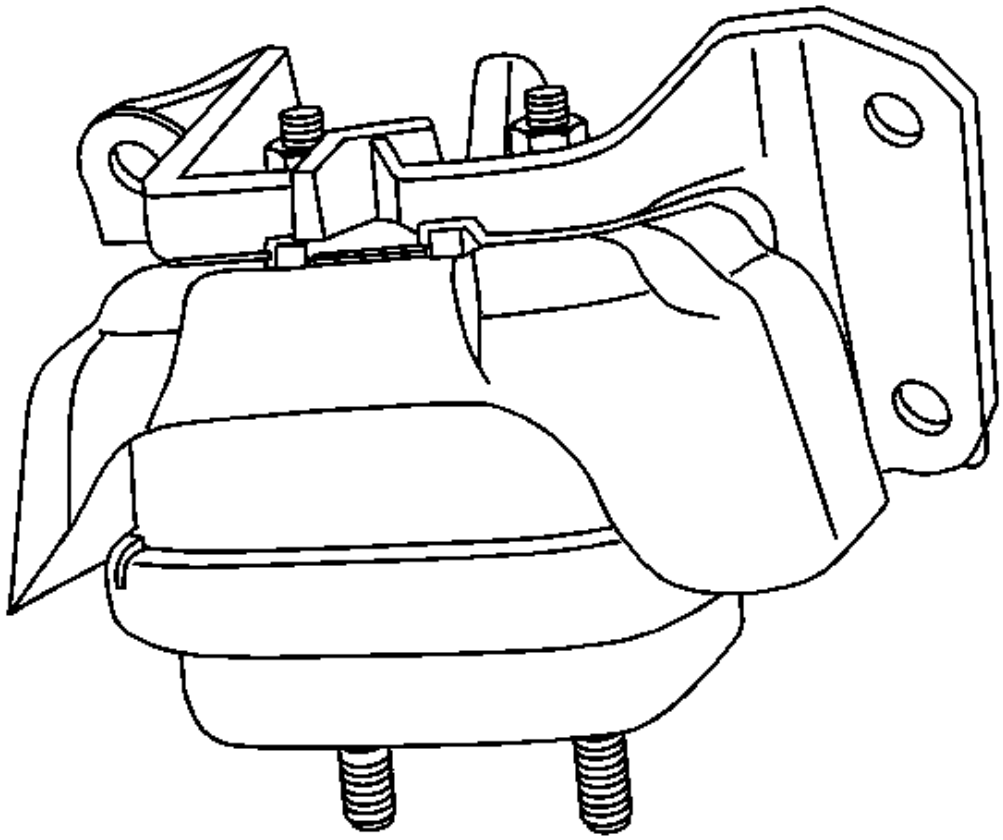

Fig. 70: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Verify that the cut out side of the engine mount shield is positioned away from the engine.

2. Install the engine mount to the upper engine mount bracket.

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

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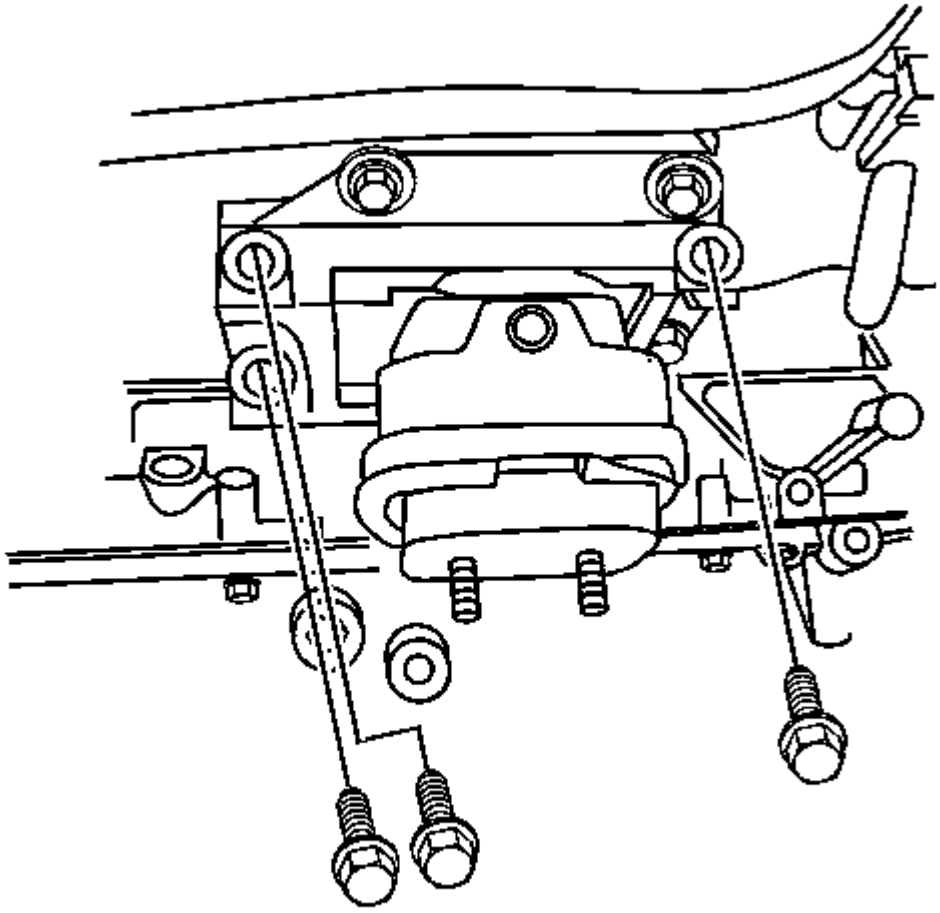

Fig. 71: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to engine.

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

4. Install the engine mount frame bracket to the frame.
5. Install the engine mount frame bracket retaining bolts.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

6. Shift the engine back towards the right side of the frame.

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7. Install the left side engine mount frame bracket.
8. Install the left side engine mount frame bracket retaining bolts.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

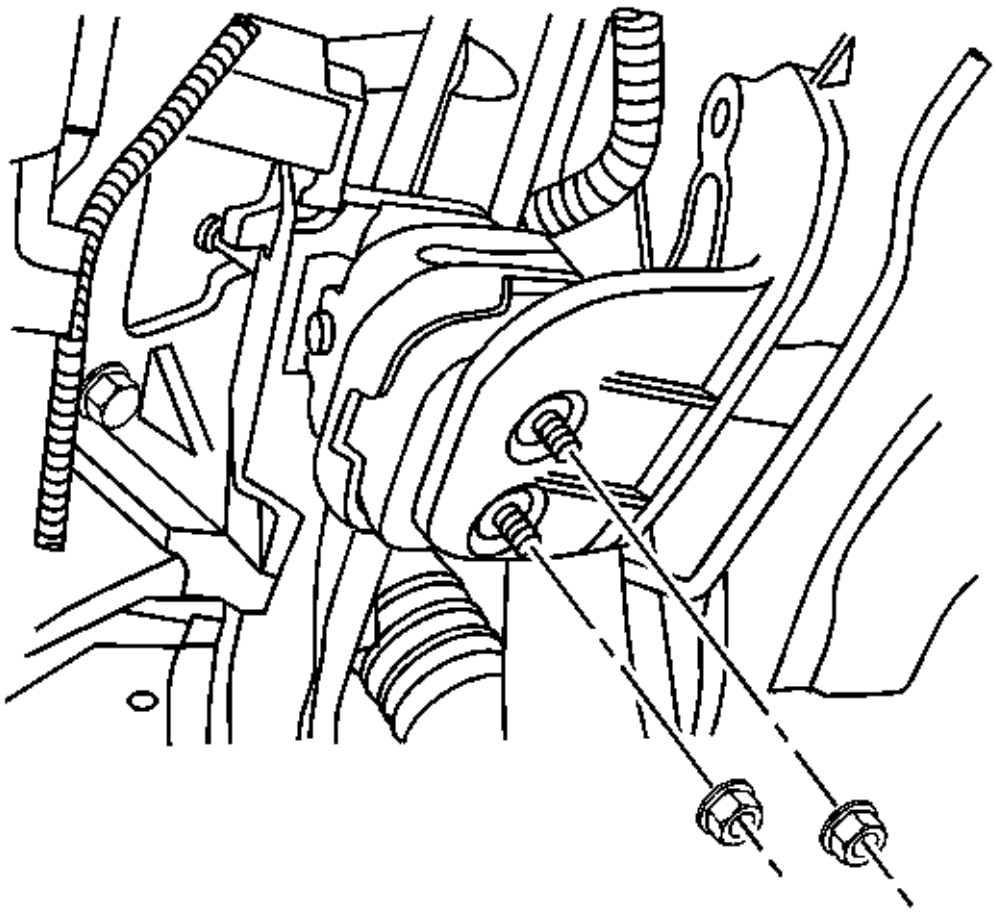

Fig. 72: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Lower the engine, aligning the engine mount studs with the holes in the frame bracket.
10. Remove the pole jack and block of wood.
11. Tighten the engine mount nuts.

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

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12. Install the shock module. Refer to **Shock Module Replacement** in Front Suspension.
13. Install the front differential carrier. Refer to **Differential Carrier Assembly Replacement (V8)** in Front Drive Axle.
14. Install the left side wheel drive shaft. Refer to **Wheel Drive Shaft Replacement** in Wheel Drive Shafts.
15. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
16. Install the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
17. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

Engine Mount Replacement - Right (Two-Wheel Drive)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
3. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
4. Remove the shock module. Refer to **Shock Module Replacement** in Front Suspension.

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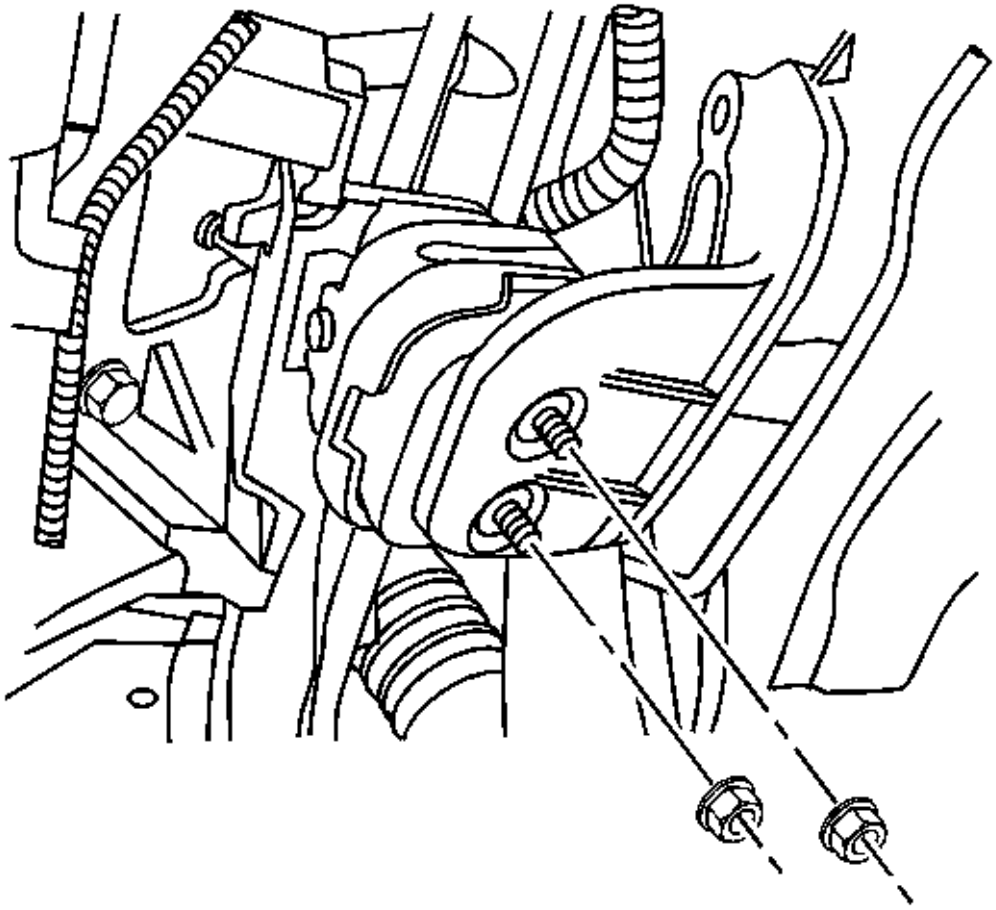

Fig. 73: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

5. Remove the lower engine mount retaining nuts from the engine mount frame bracket.

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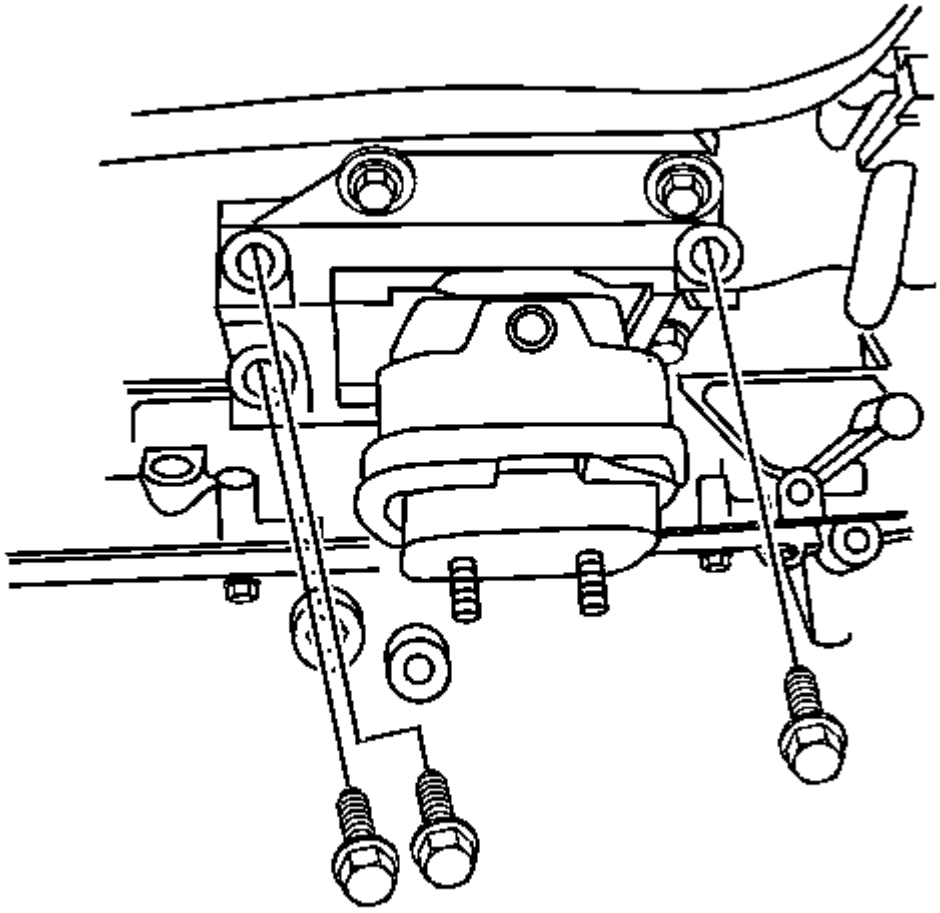

Fig. 74: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

6. Remove the 3 mounting bolts that secure the upper engine mount bracket to the engine block bracket.

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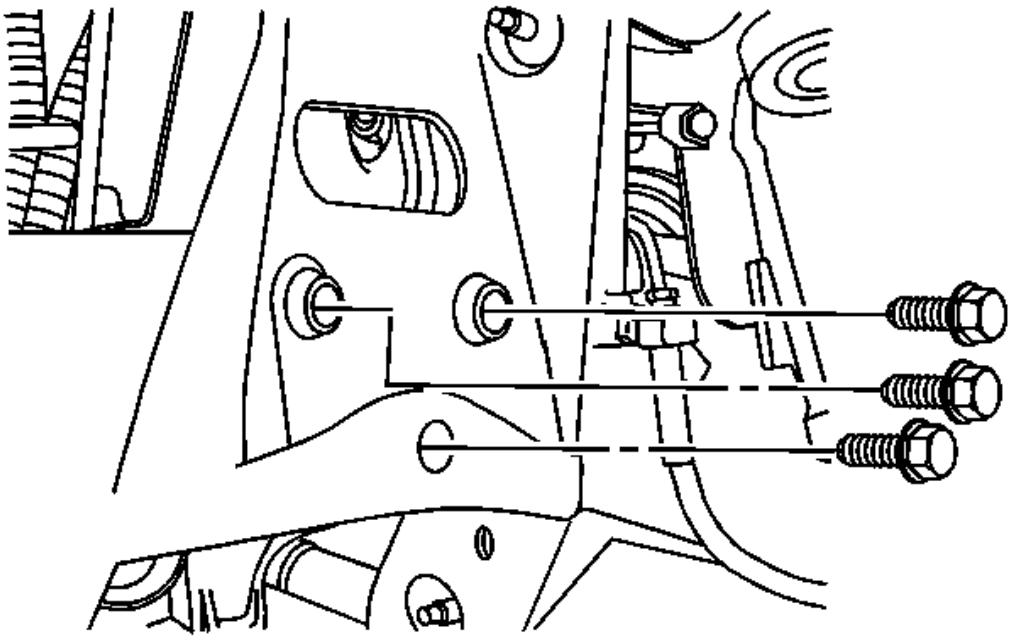

Fig. 75: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

7. Remove the 3 bracket retaining bolts from the frame engine mount.

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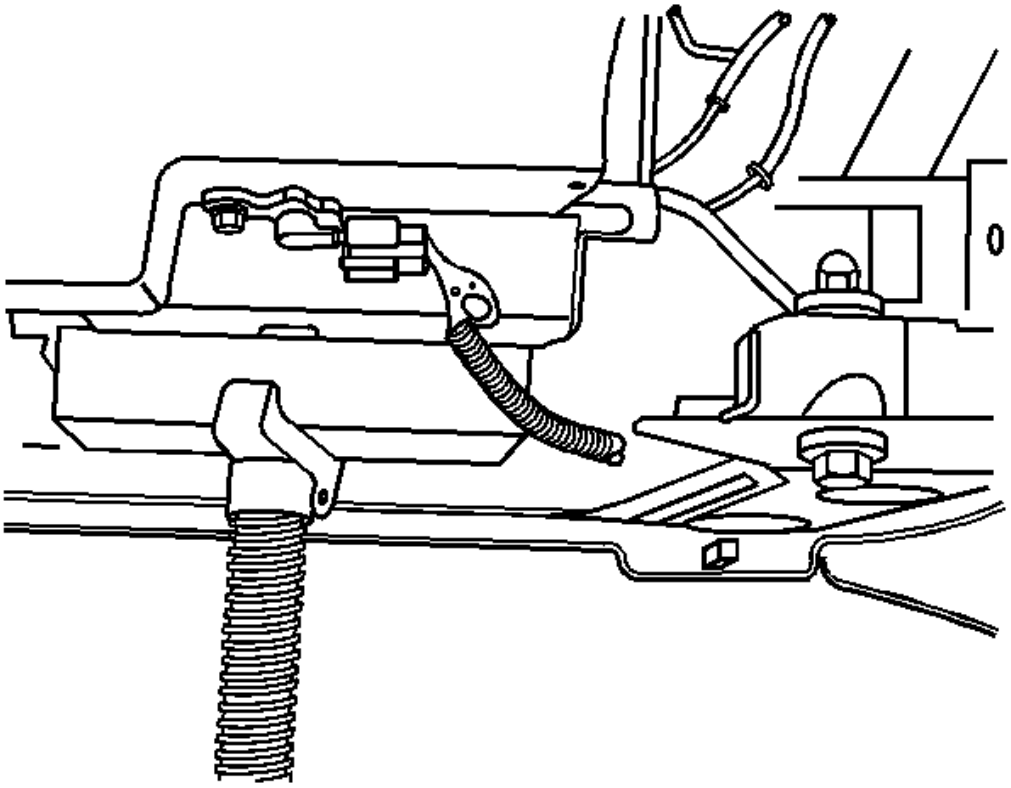

Fig. 76: Block Of Wood Between Engine Oil Pan And Pole Jack
Courtesy of GENERAL MOTORS CORP.

8. Install a pole jack underneath the oil pan.
9. Insert a block of wood between the oil pan and the pole jack.

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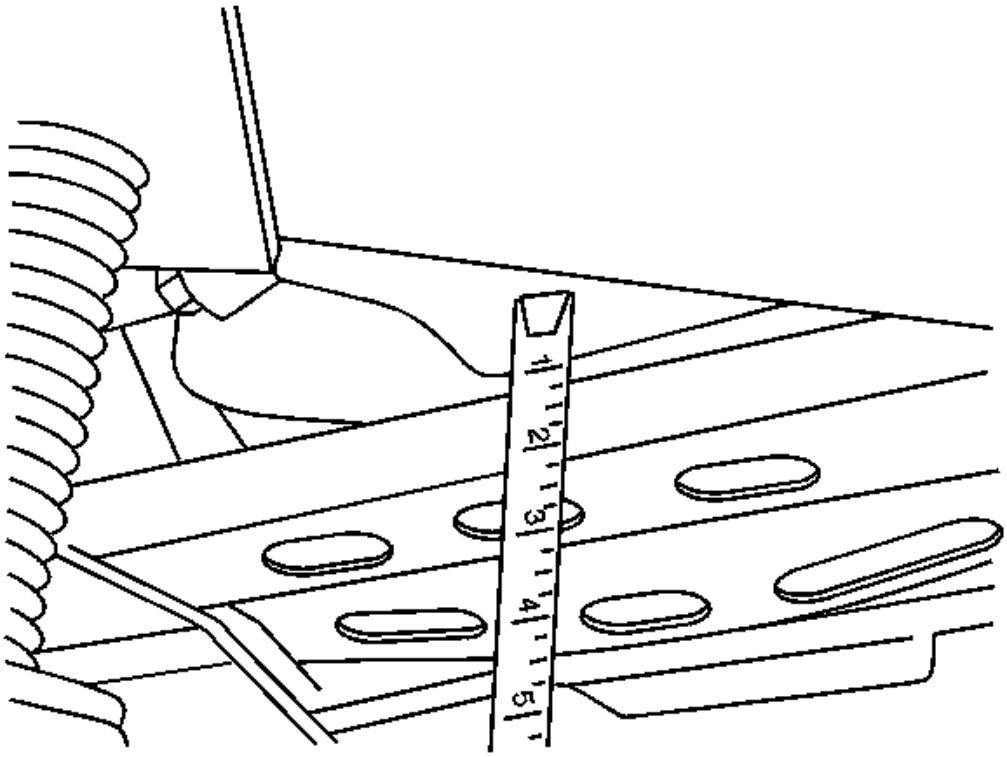

Fig. 77: Measuring Engine Elevation
Courtesy of GENERAL MOTORS CORP.

10. Raise the engine 21/4 inches measuring from the bottom of the oil pan to the front edge of the transmission support crossmember.
11. Shift the engine towards the left side of the frame.

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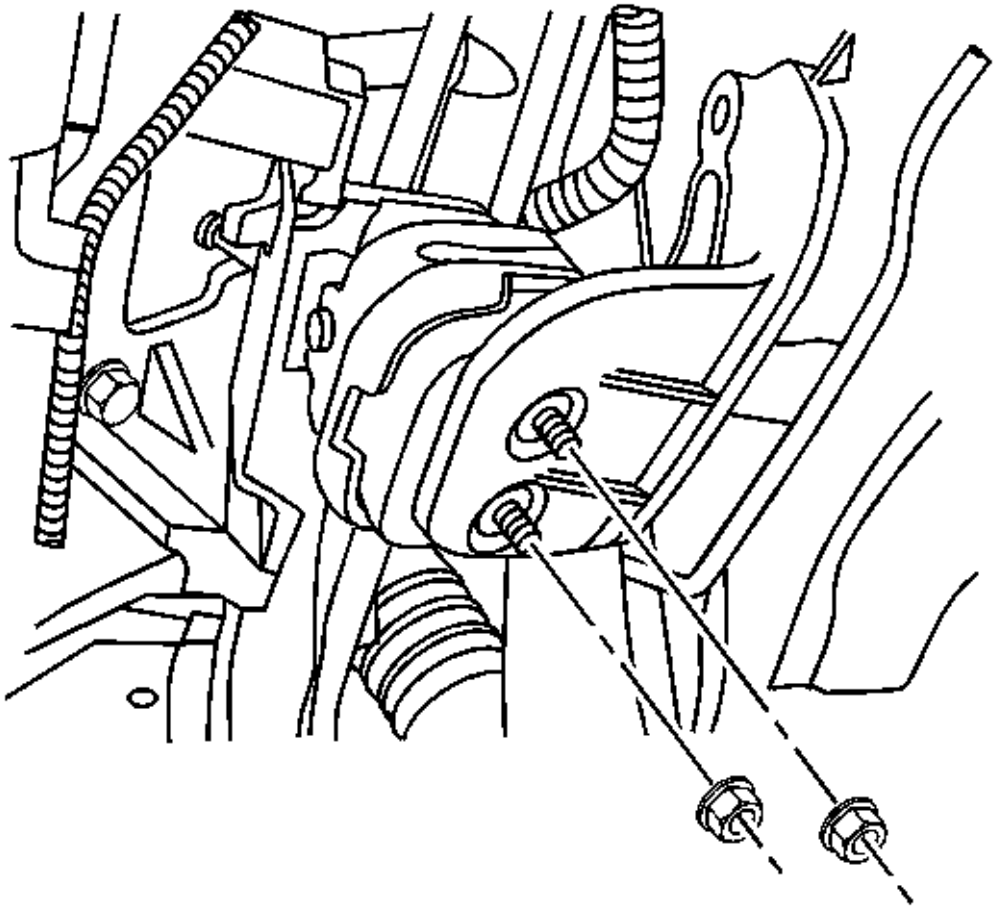

Fig. 78: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine mount frame bracket from the frame.

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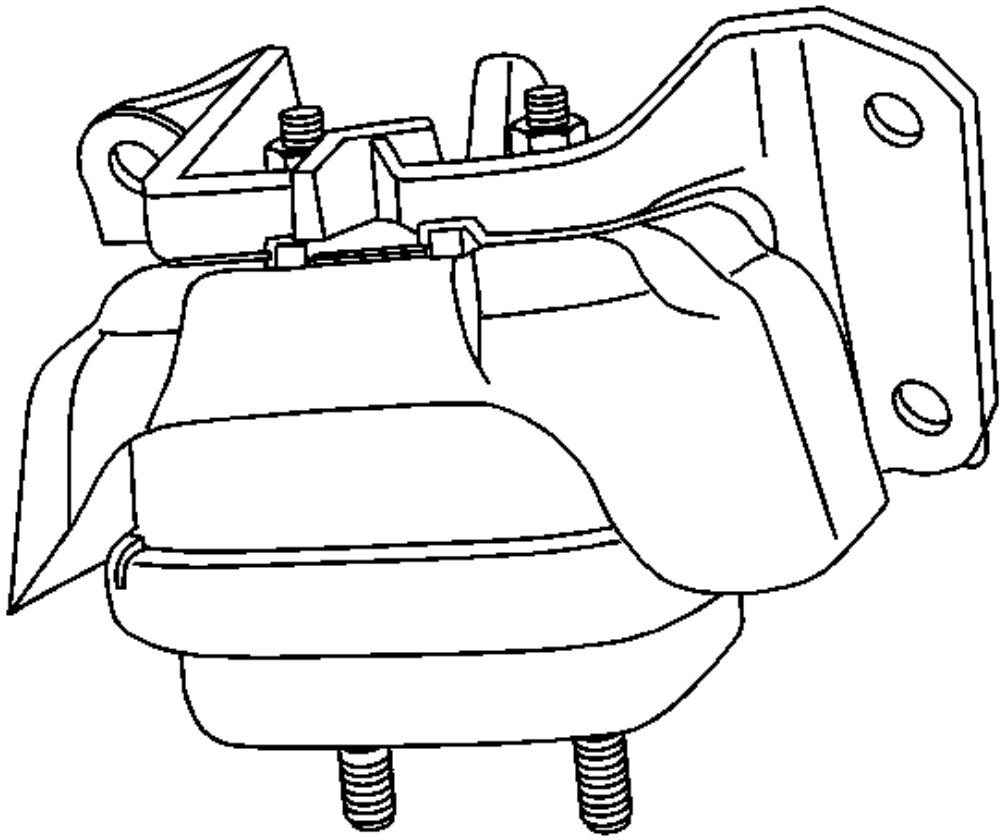

Fig. 79: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine mount with the upper engine mount bracket as an assembly.
14. Separate the engine mount from the upper engine mount bracket.

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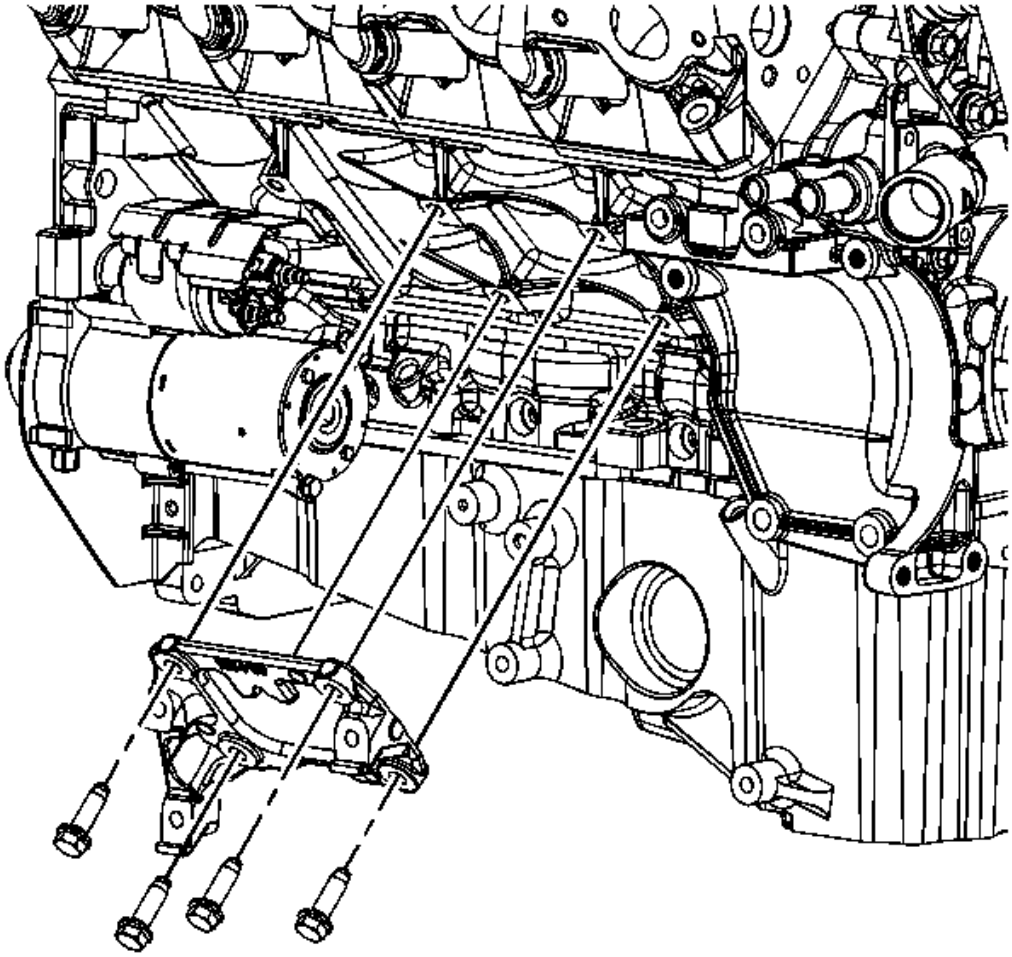

Fig. 80: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

15. Remove the engine mount bracket spacer if damaged.

Installation Procedure

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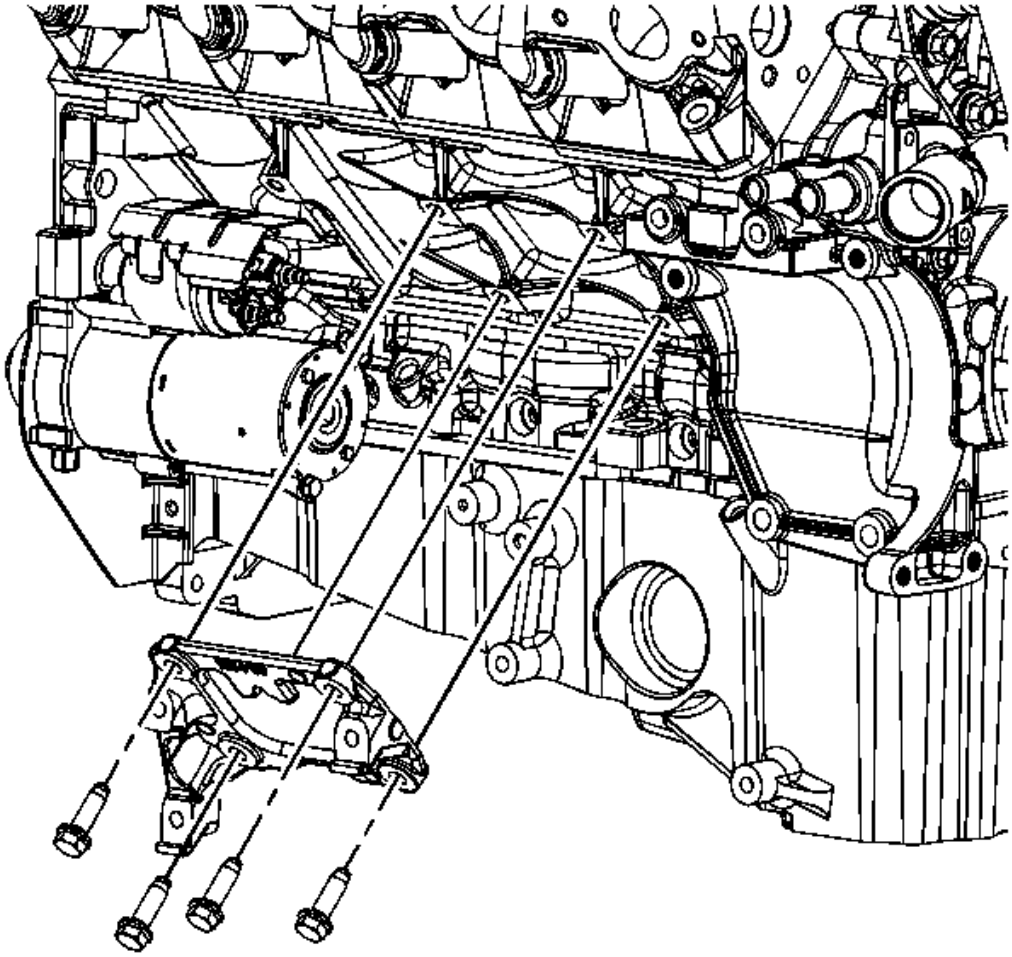

Fig. 81: Removing/Installing Engine Mounting Bracket
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the engine mount bracket spacer if it has been replaced.

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

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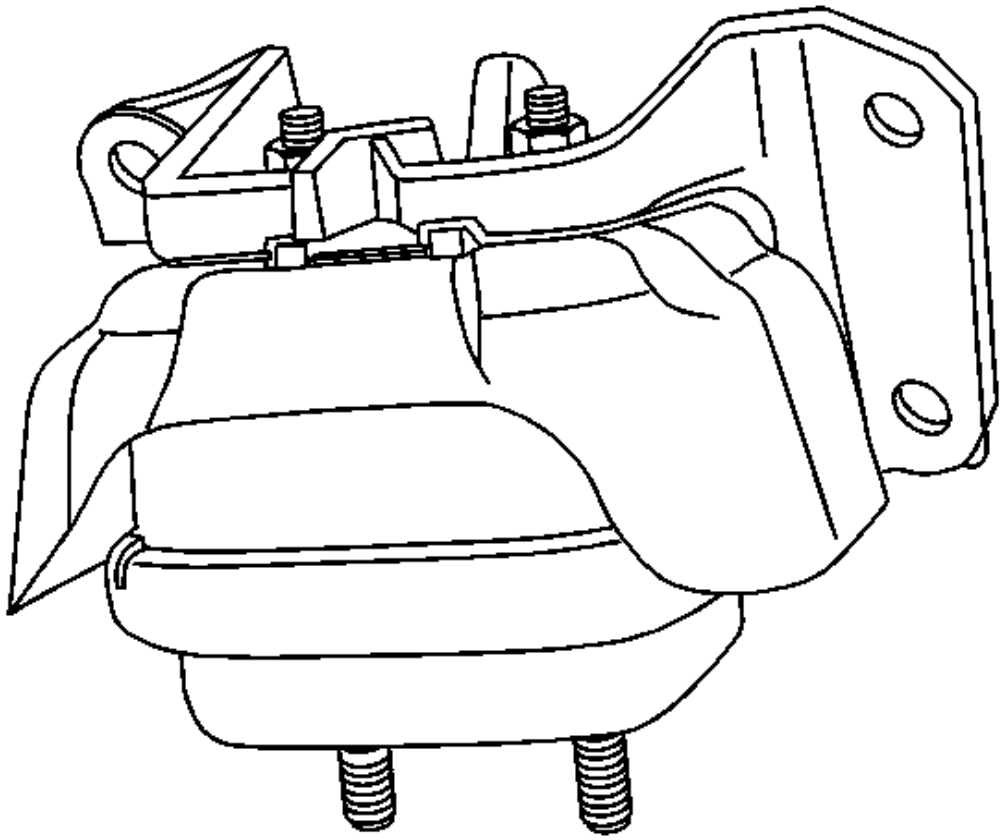

Fig. 82: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that the cut out side of the engine mount shield is positioned away from the engine.

2. Install the engine mount to the upper engine mount bracket.

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

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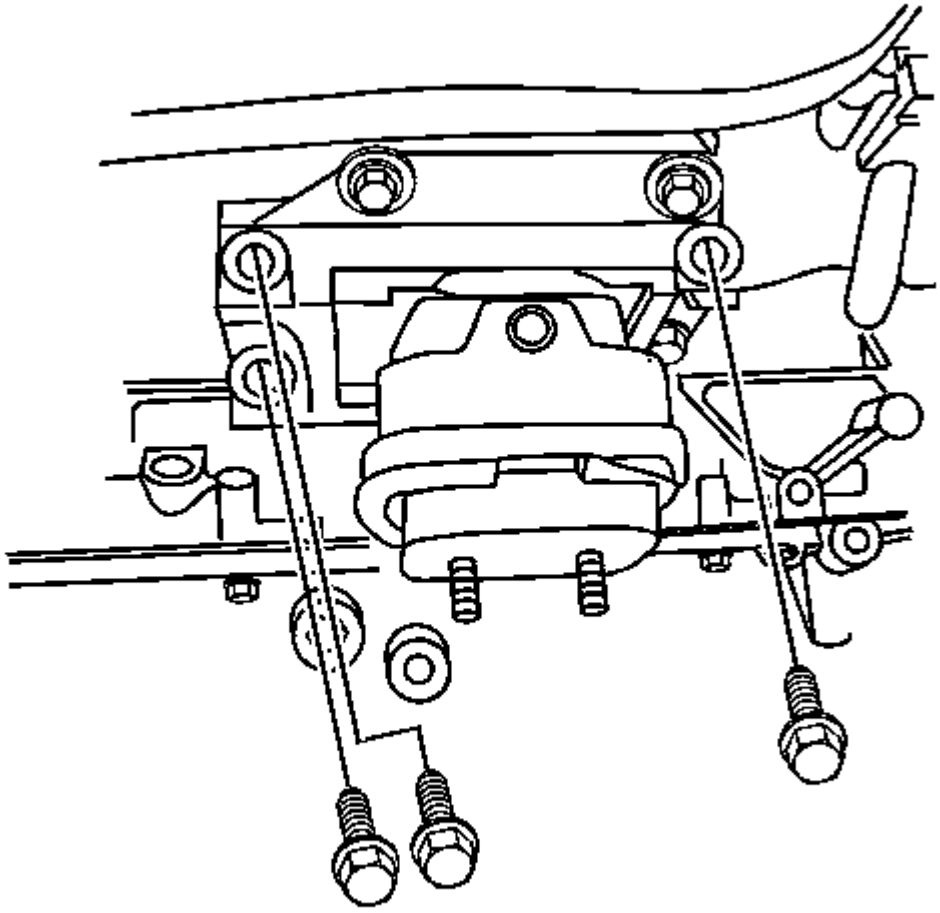

Fig. 83: Identifying Upper Engine Mount Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the engine mount to engine.

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

4. Install the engine mount frame bracket to the frame.
5. Install the engine mount frame bracket retaining bolts.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

6. Shift engine back to the right side of the frame.

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7. Install the left side engine mount frame bracket.
8. Install the retaining bolts to the left side of the engine mount frame bracket.

   Tighten: Tighten the bolts to 100 N.m (74 lb ft).

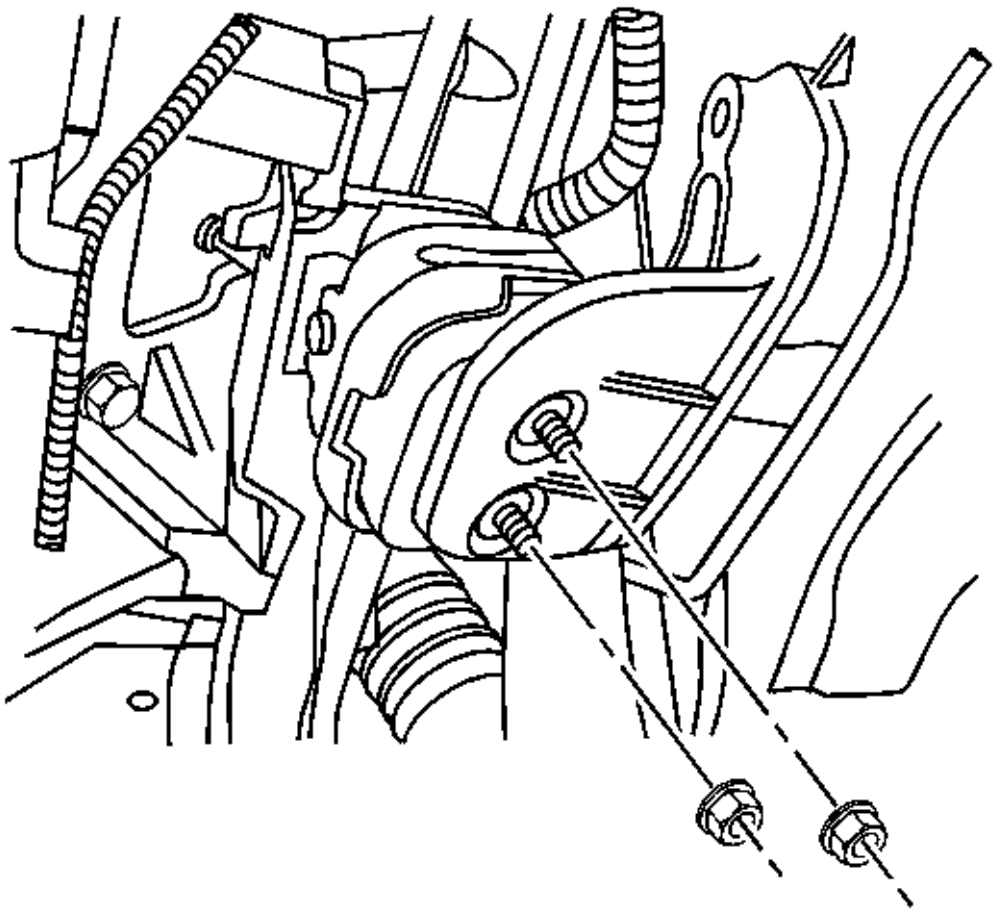

Fig. 84: View Of Left Lower Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Lower the engine, aligning the engine mount studs with the holes in the frame bracket.
10. Remove the pole jack and the block of wood.
11. Tighten the engine mount nuts.

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

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12. Install the shock module. Refer to **Shock Module Replacement** in Front Suspension.
13. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** in Frame and Underbody.
14. Install the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
15. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.

Crankcase Ventilation Hoses/Pipes Replacement

Removal Procedure

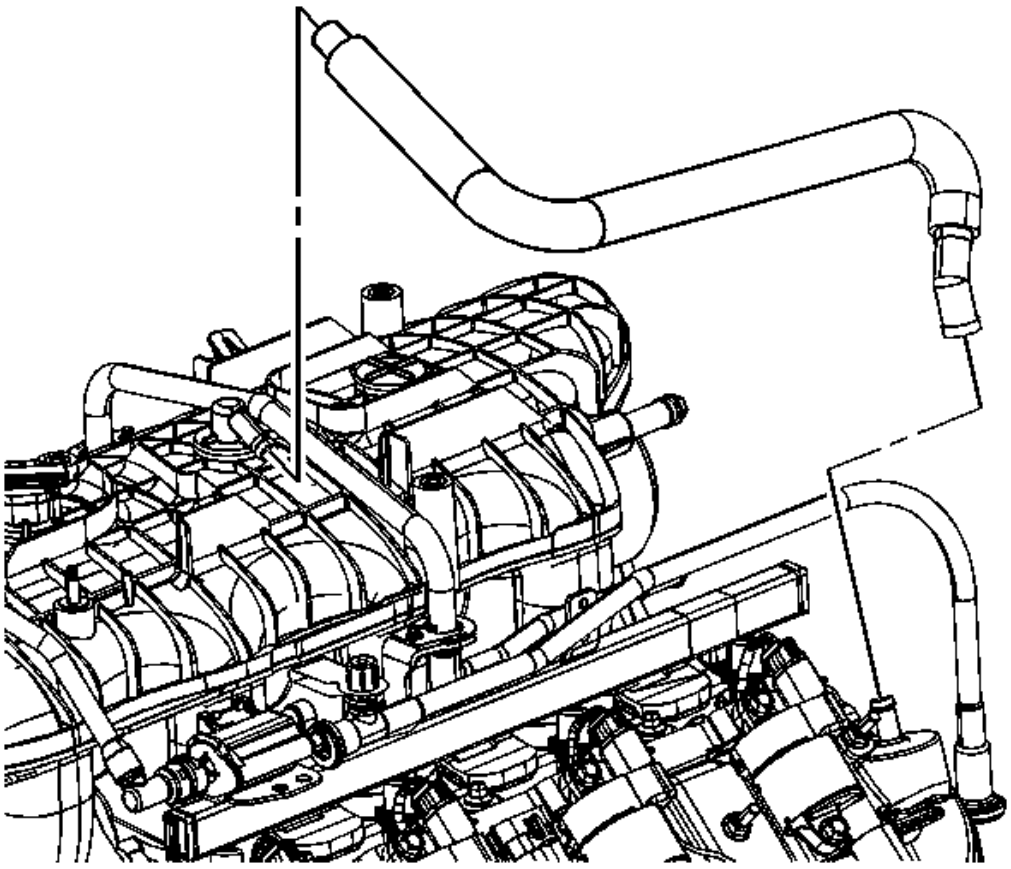

Fig. 85: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

1. Remove the positive crankcase ventilation (PCV) foul air hose from the intake manifold and valve rocker arm cover.

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2. Remove the air cleaner resonator outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.

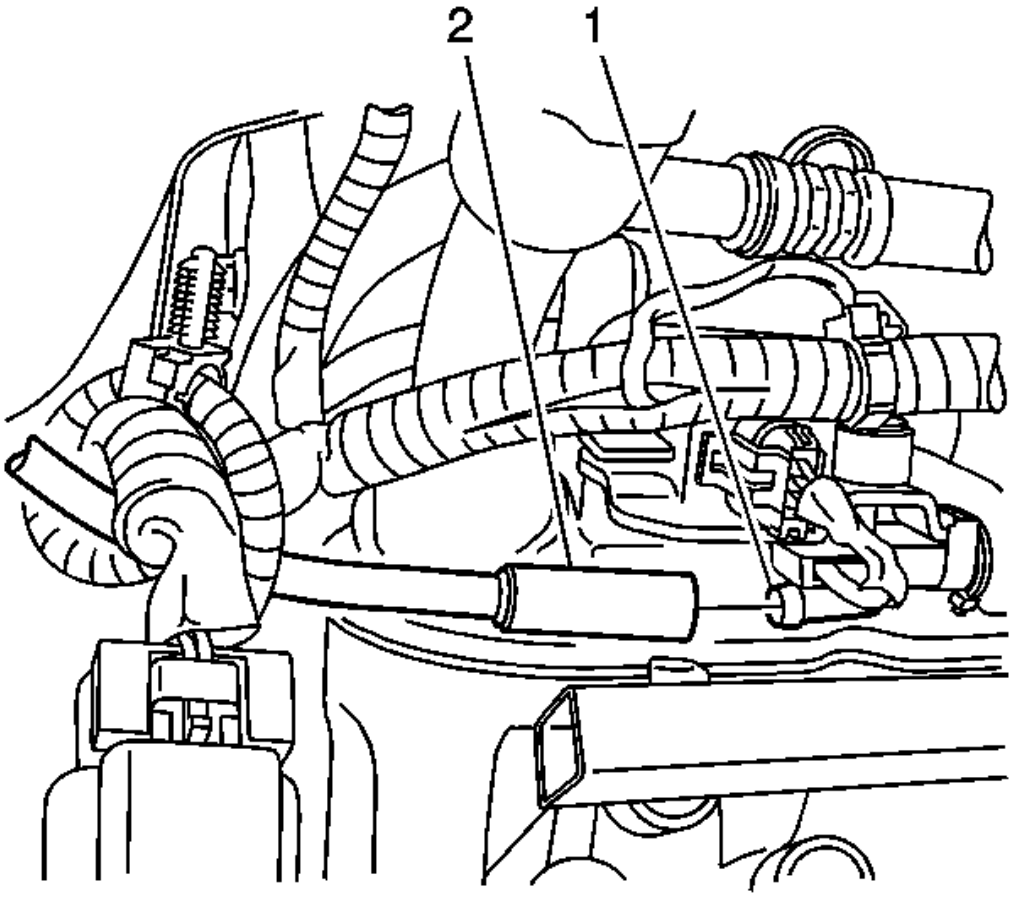

Fig. 86: PCV Fresh Air Hose
Courtesy of GENERAL MOTORS CORP.

3. Remove the PCV fresh air hose (2) from the valve rocker arm cover (1).

Installation Procedure

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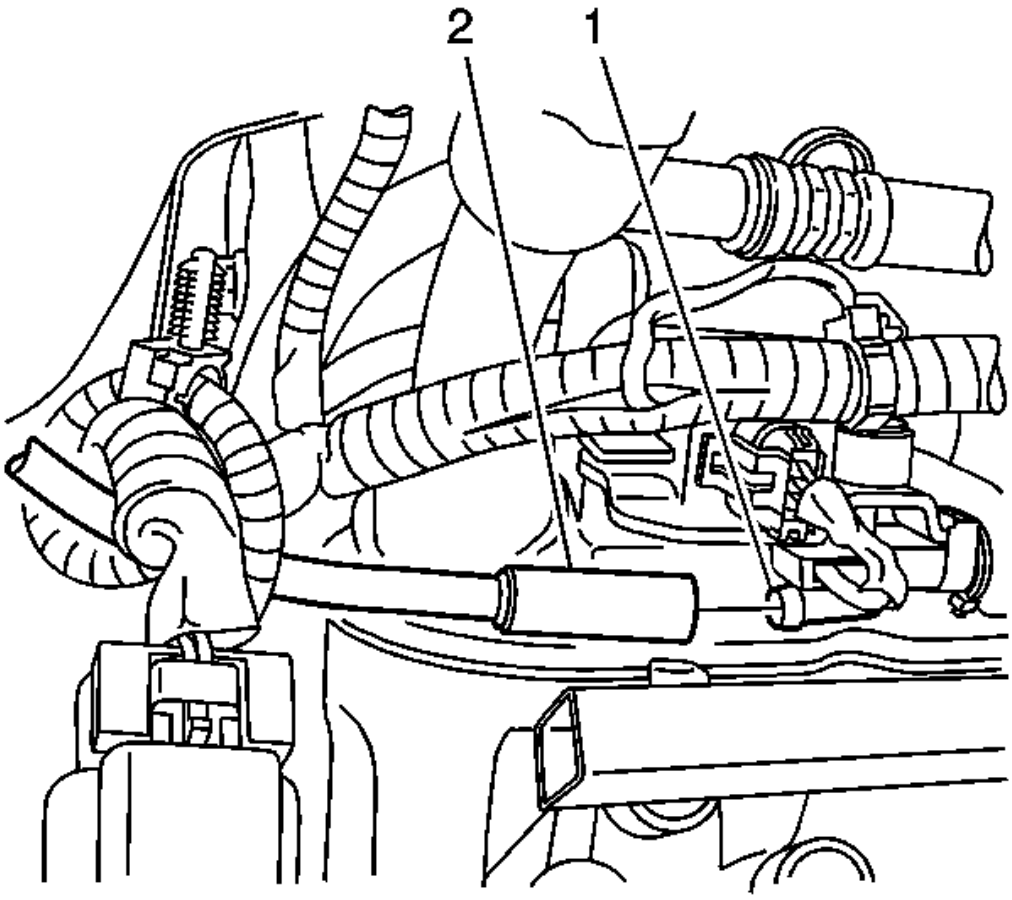

Fig. 87: PCV Fresh Air Hose
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV fresh air hose (2) to the valve rocker arm cover (1).
2. Install the air cleaner resonator outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.

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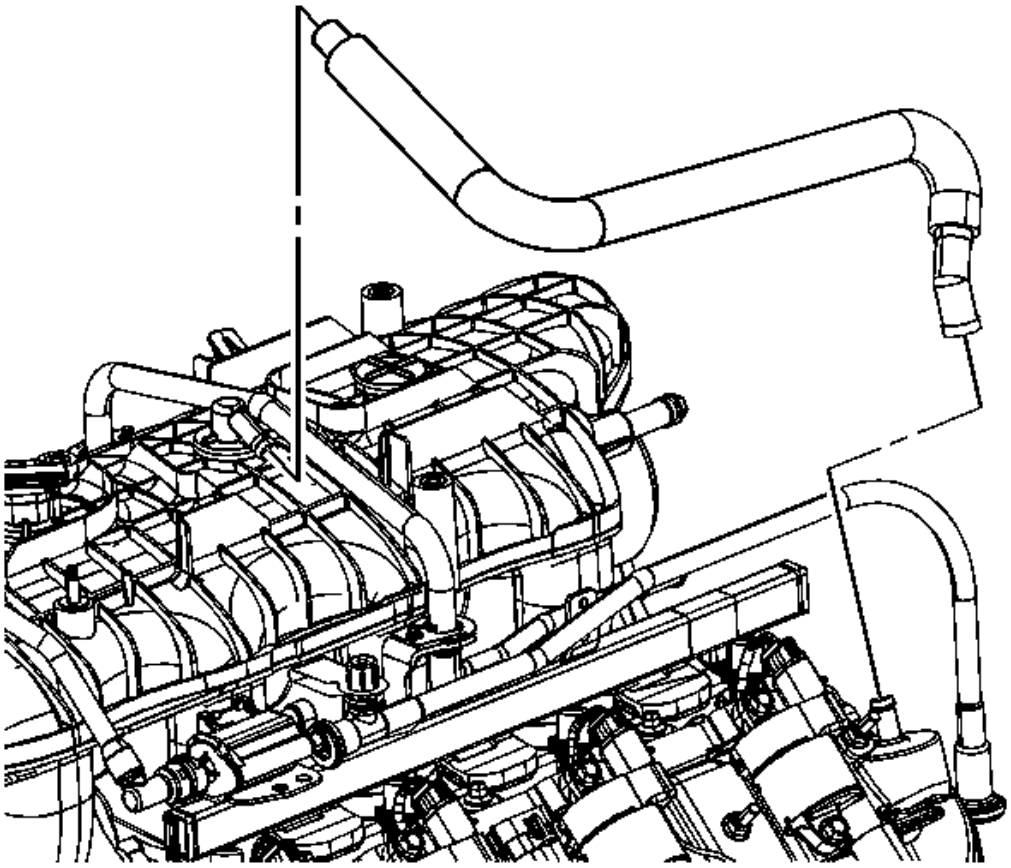

Fig. 88: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

3. Install the PCV foul air hose to the intake manifold and valve rocker arm cover.

Valve Lifter Oil Filter Replacement

Removal Procedure

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Disconnect the electrical connector from the oil pressure sensor.

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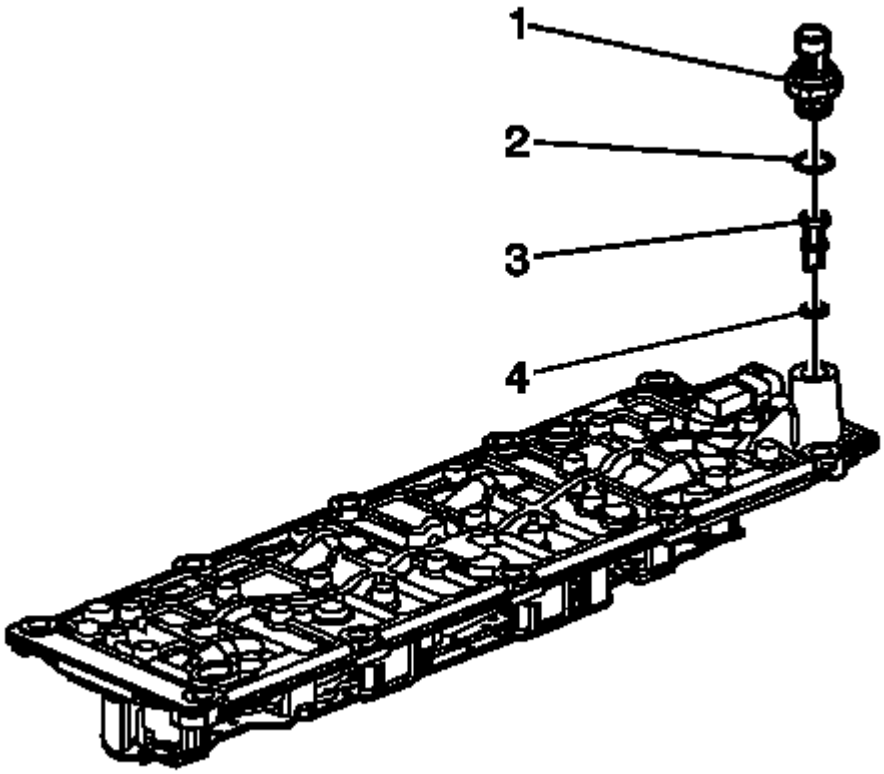

Fig. 89: Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the passages of the manifold. Plug as required.

3. Remove the oil pressure sensor (1) and washer (2).
4. Remove the oil filter (3).
5. Inspect the O-ring (4) for cuts or damage. If the filter is plugged or the O-ring is cut or damaged, replace the filter and O-ring as an assembly.

Installation Procedure

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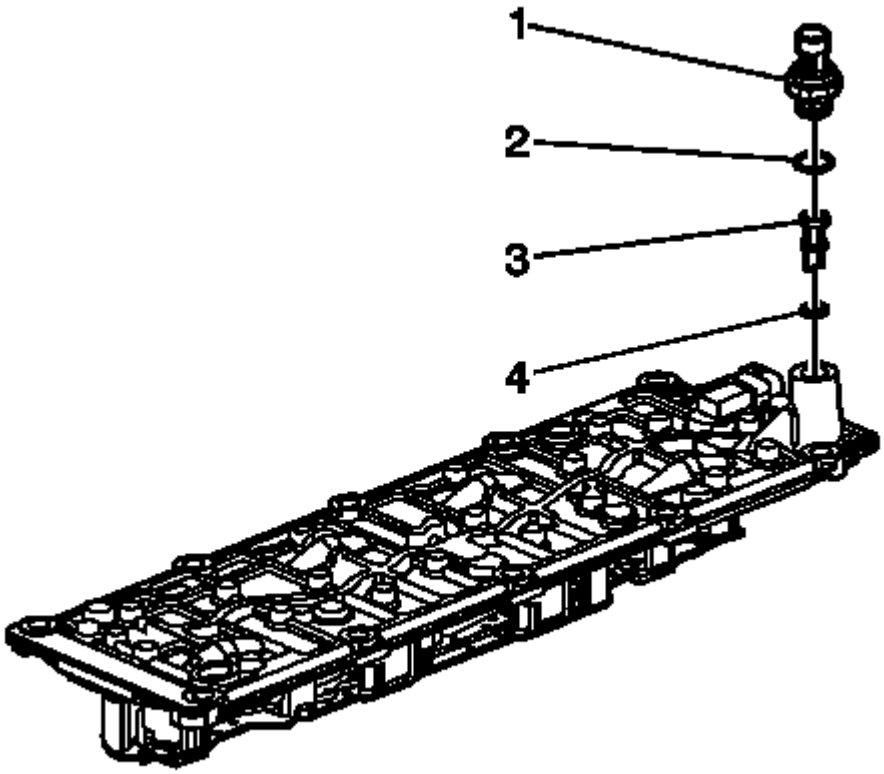

Fig. 90: Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the passages of the manifold. Plug as required.

1. Install a NEW oil filter (3) and O-ring (4) assembly.
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pressure sensor (1) and washer (2).

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

4. Connect the electrical connector to the oil pressure sensor.
5. Install the intake manifold. Refer to **Intake Manifold Replacement**.

Intake Manifold Replacement

Removal Procedure

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1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

IMPORTANT: The intake manifold, throttle body, fuel rail, and injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.
3. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 5.3L.

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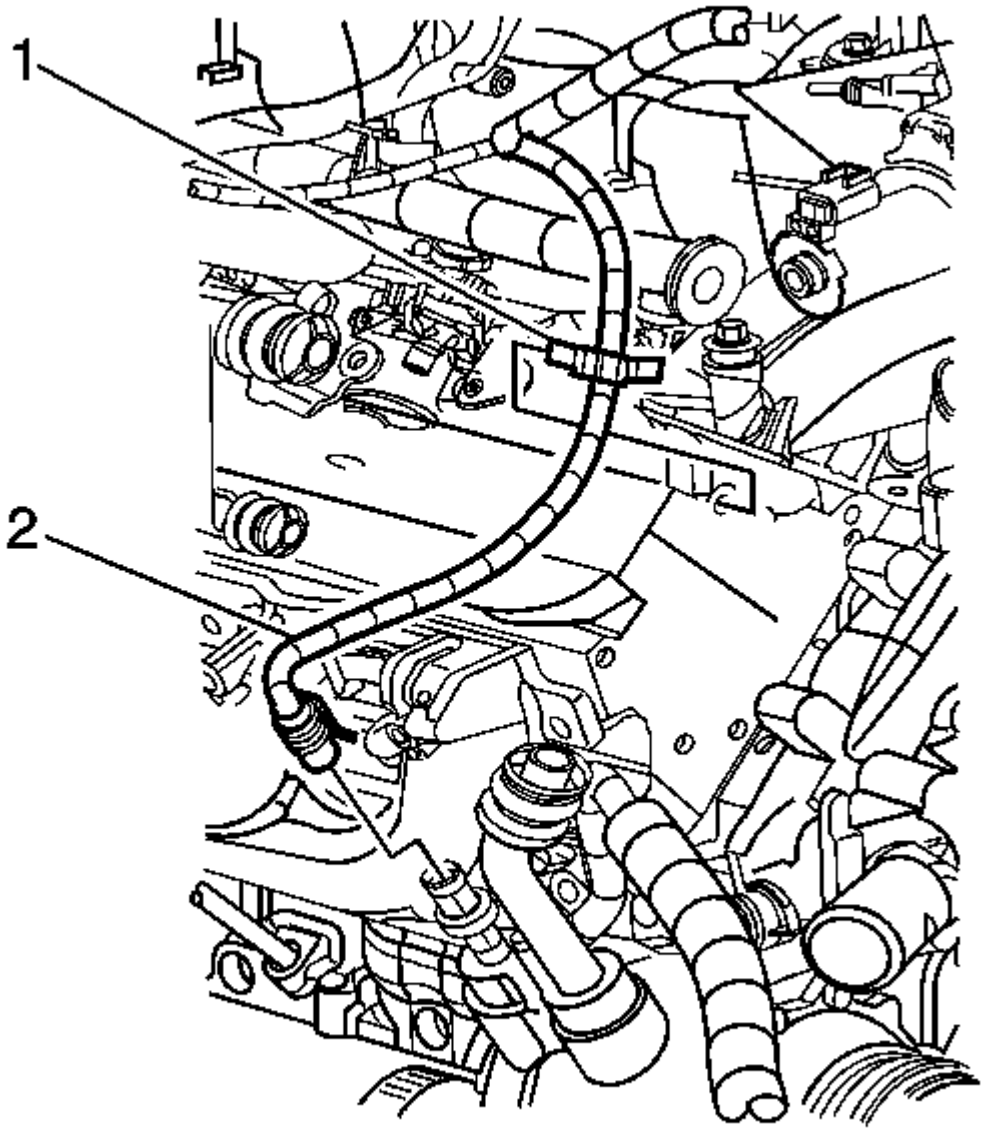

Fig. 91: View Of A/C Compressor Pressure Switch Electrical Connector & Retaining Clip
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the air conditioning (A/C) compressor pressure switch electrical connector (2).
5. Remove the harness clip (1) from the cylinder head.

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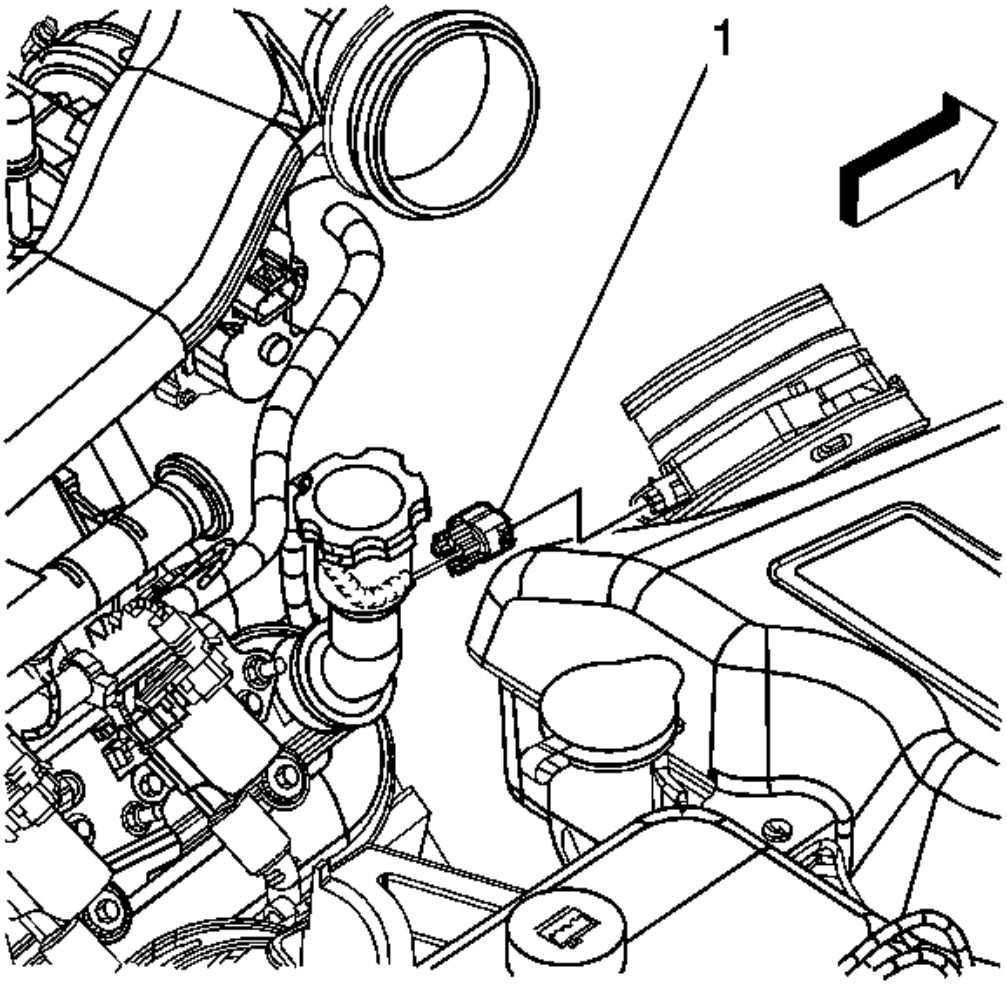

Fig. 92: View Of MAF/IAT Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the electrical connector (1) from the mass air flow (MAF) intake air temperature (IAT) sensor.
7. Remove the harness clips from the fuel rail.

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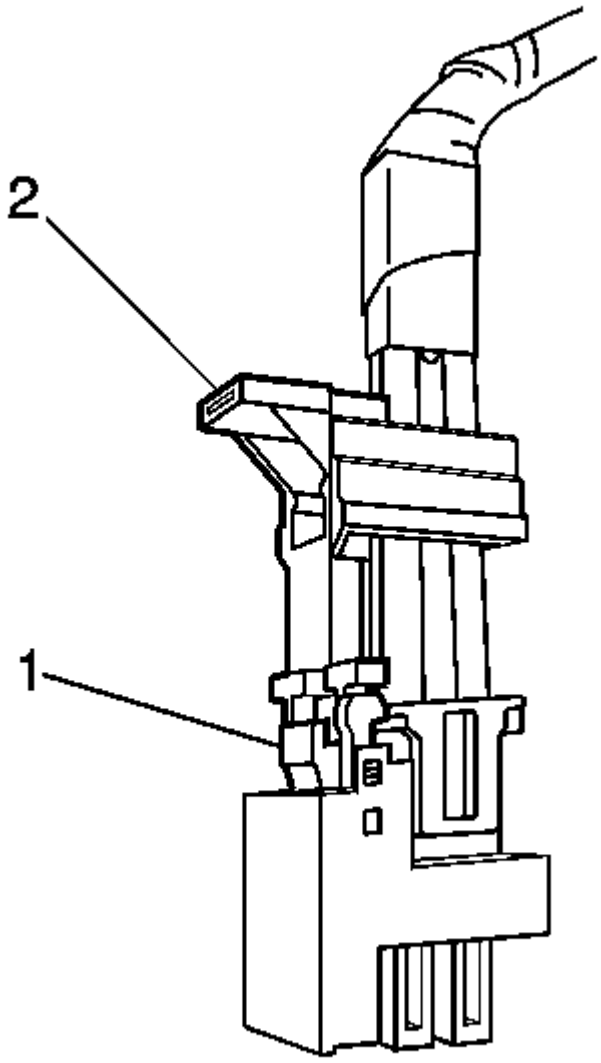

Fig. 93: View Of CPA Retainer & Tab
Courtesy of GENERAL MOTORS CORP.

8. Perform the following steps in order to disconnect the fuel injector electrical connectors.
    1. Mark the connectors to their corresponding injectors to ensure correct reassembly.
    2. Pull the connector position assurance (CPA) retainer (2) on the connector up one click.
    3. Push the tab (1) on the connector in.
    4. Disconnect the fuel injector electrical connector.

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5. Repeat the steps for each injector electrical connector.

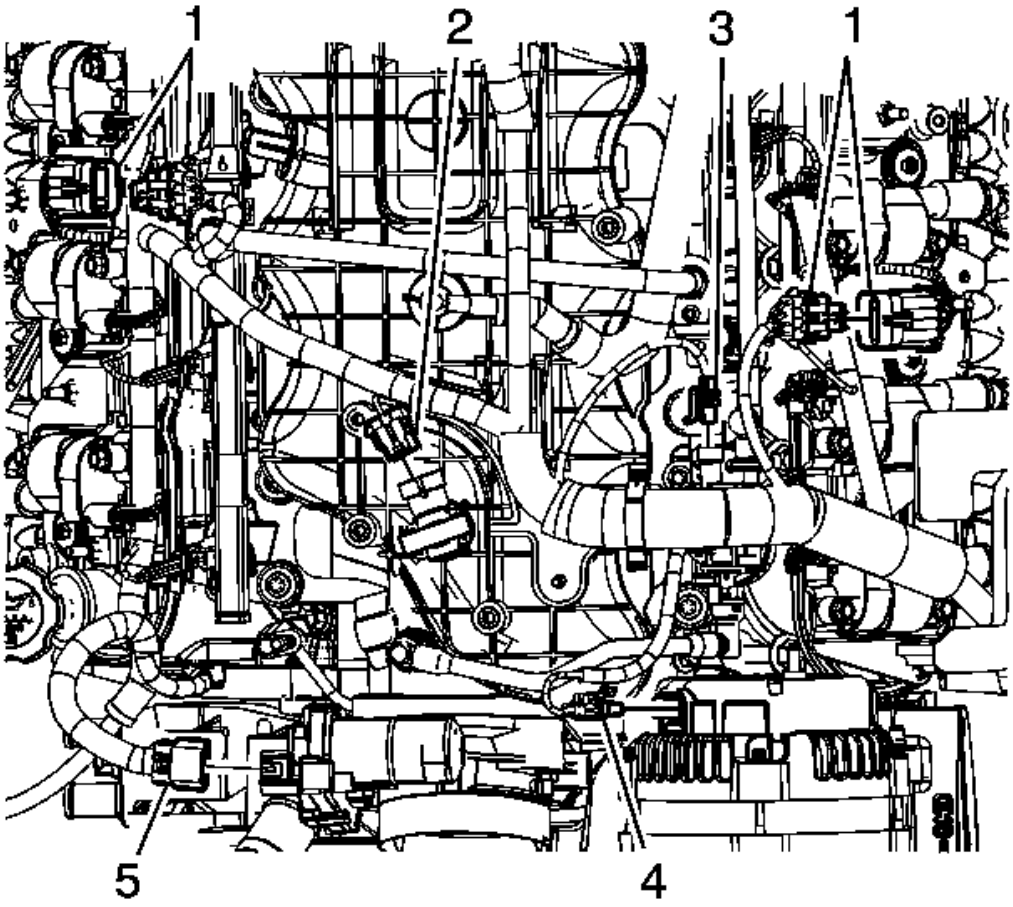

Fig. 94: EVAP Purge Solenoid, MAP Sensor, Main Coil & Throttle Body Harness Connectors
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the following electrical connectors:
   - Evaporative emission (EVAP) purge solenoid (3)
   - Throttle body harness (5)
   - Manifold absolute pressure (MAP) sensor (2)
   - Main coil (1)
   - Generator (4)
10. Remove the electrical harness clips from the fuel rail.

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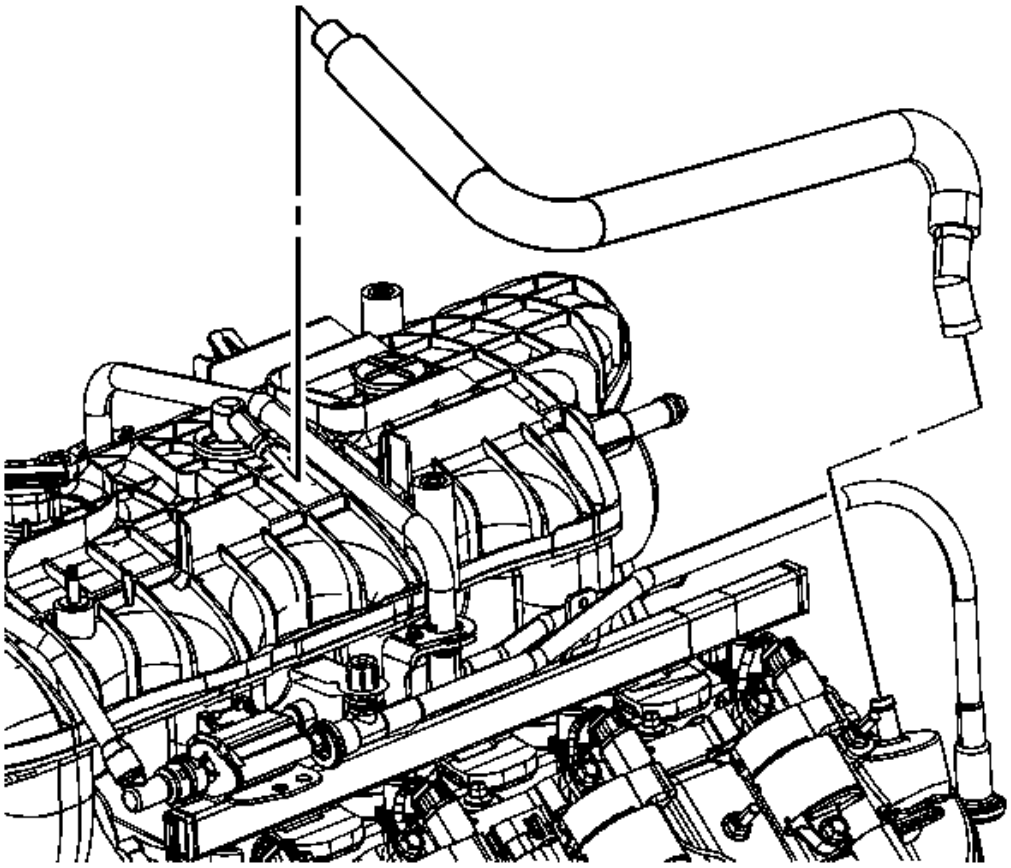

Fig. 95: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

11. Remove the positive crankcase ventilation (PCV) hose.

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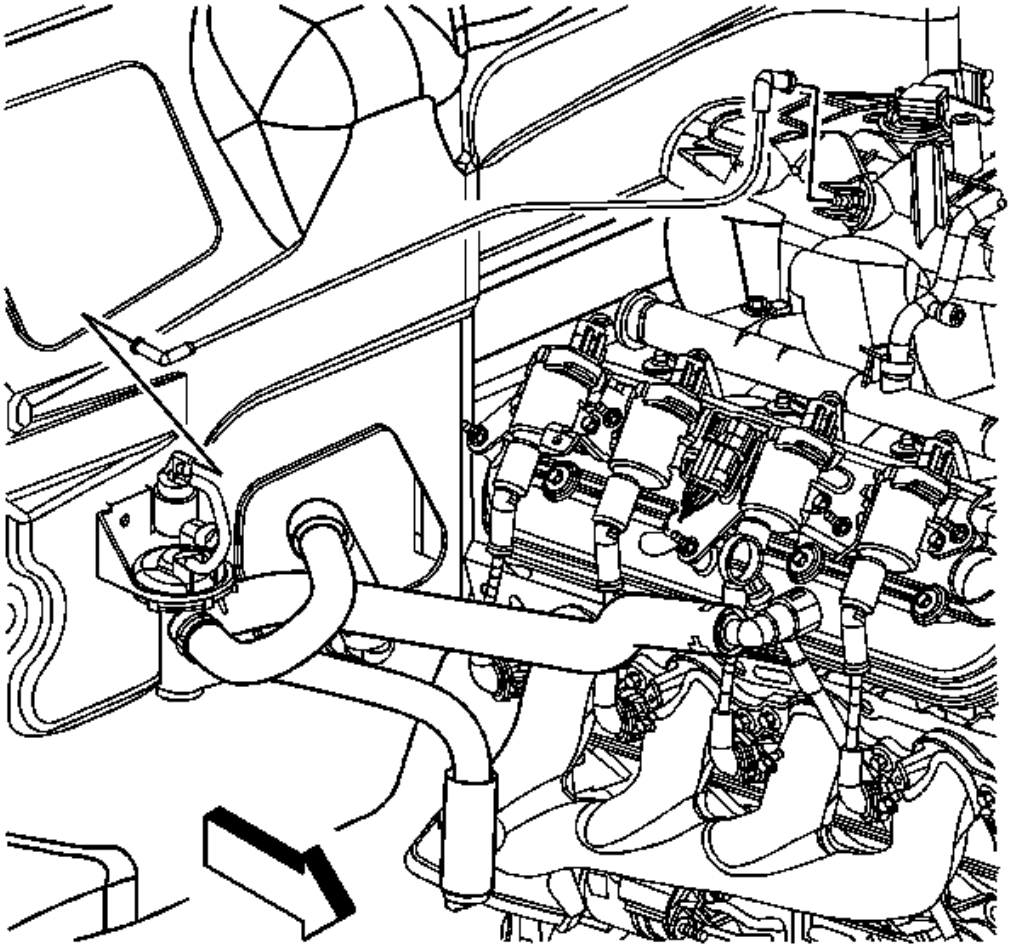

Fig. 96: View Of Heater Water Shutoff Valve Actuator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

12. Remove the heater water shutoff valve actuator inlet hose from the intake manifold.

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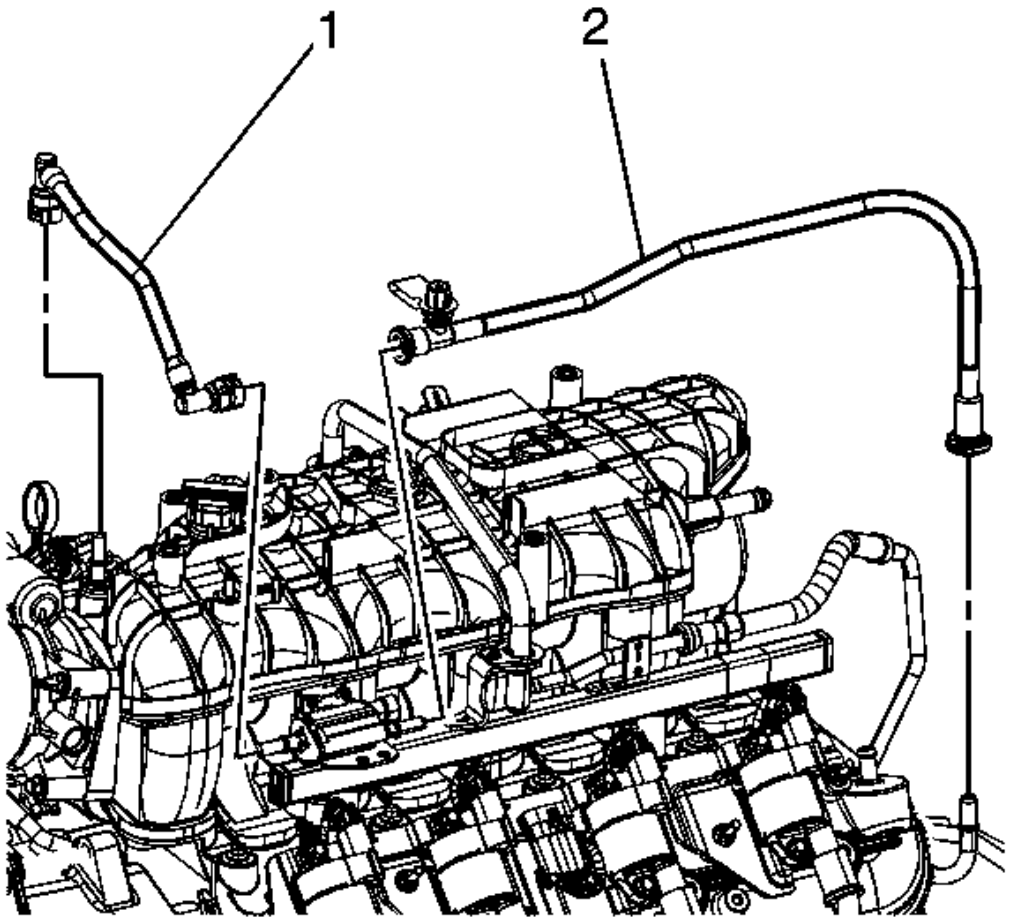

Fig. 97: EVAP Purge Solenoid Vent Tubes
Courtesy of GENERAL MOTORS CORP.

13. Remove the EVAP purge solenoid vent tubes (1, 2). Refer to **Quick Connect Fitting(s) Service (Plastic Collar)** .

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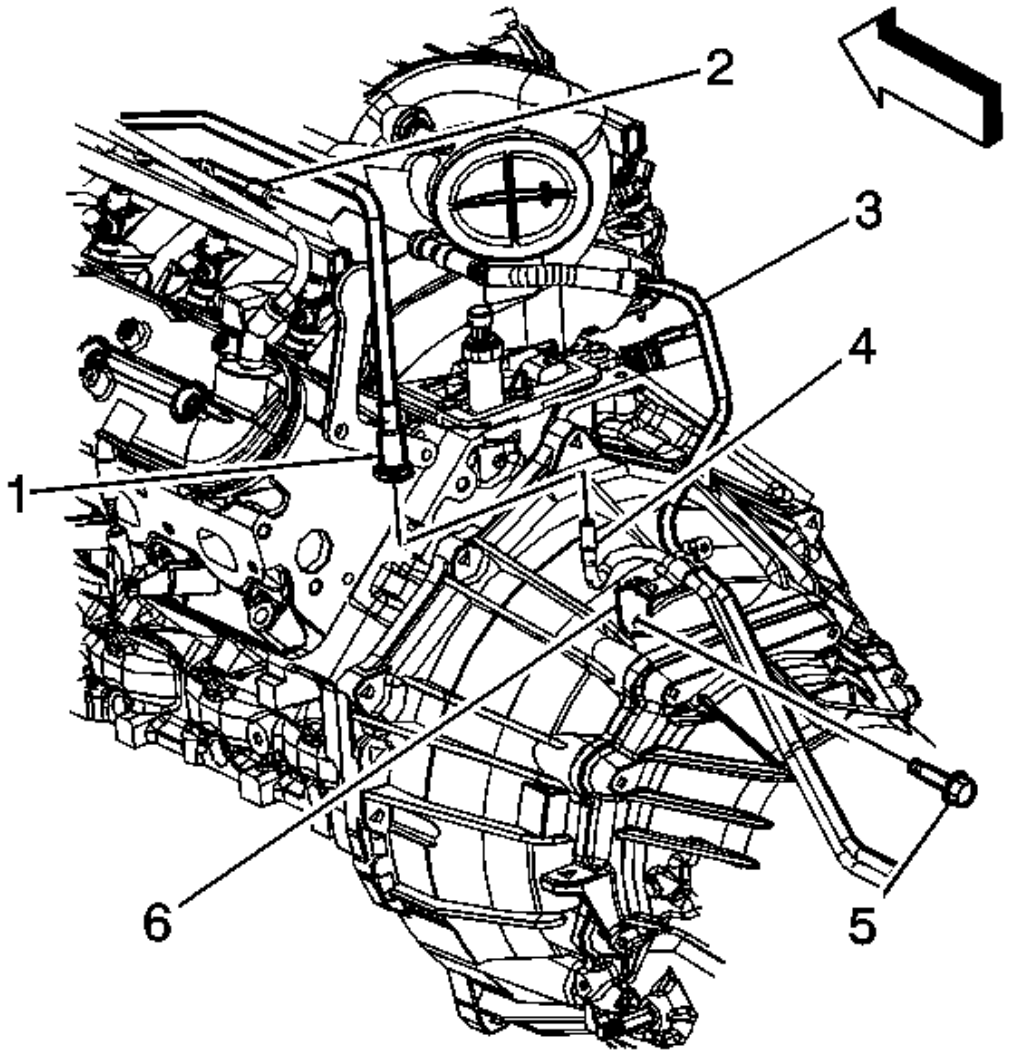

Fig. 98: Fuel Feed Pipe From Fuel Rail
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the fuel feed pipe (3) from the fuel rail (2). Refer to **Quick Connect Fitting(s) Service (Metal Collar)** in Engine Controls - 5.3L.

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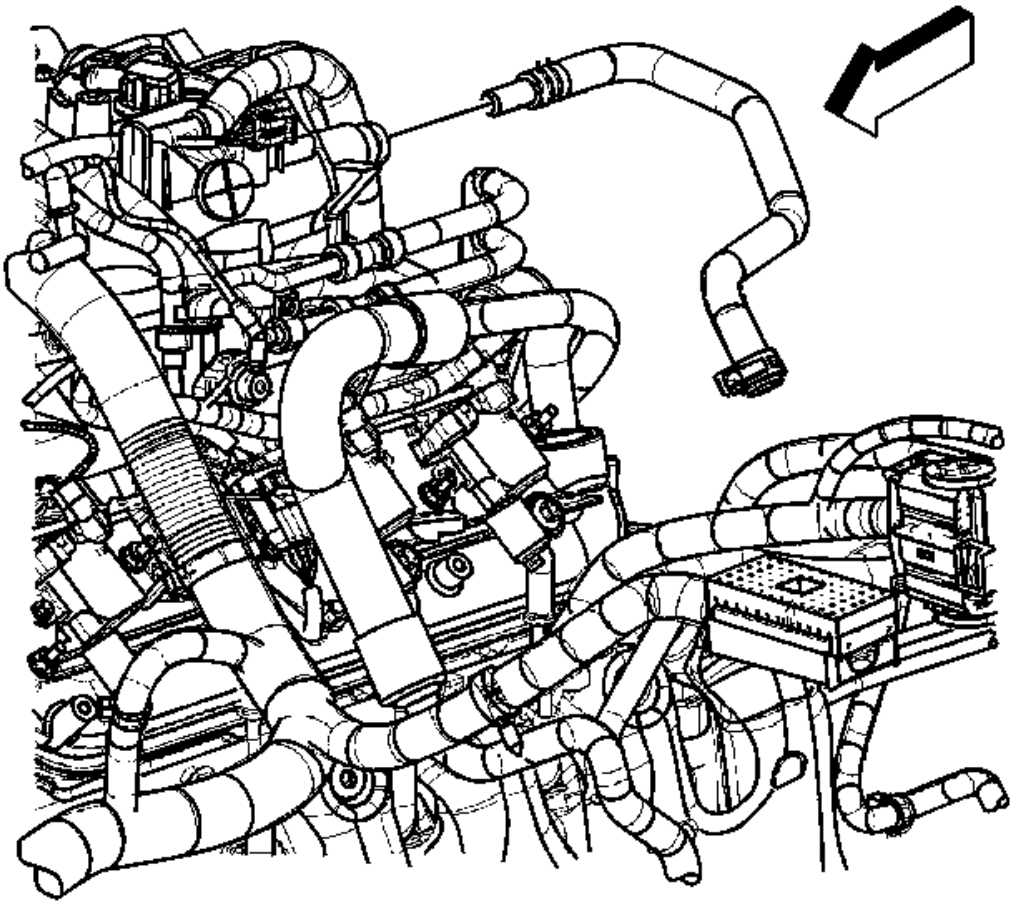

Fig. 99: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

15. Remove the vacuum brake booster hose from the rear of the intake manifold.

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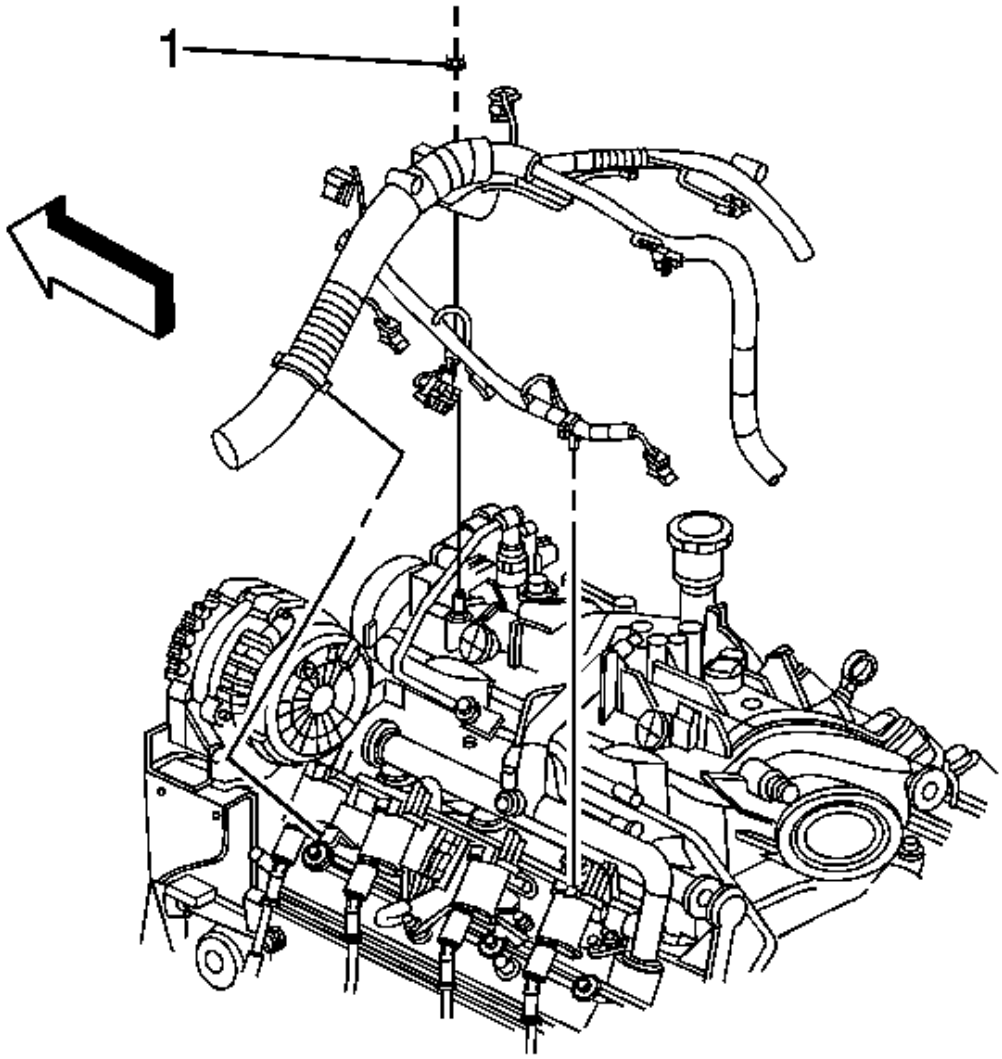

Fig. 100: View Of Upper Engine Wire Harness Retainer Nut
Courtesy of GENERAL MOTORS CORP.

16. Remove the upper engine wire harness retainer nut (1).
17. Reposition the upper engine wire harness aside.

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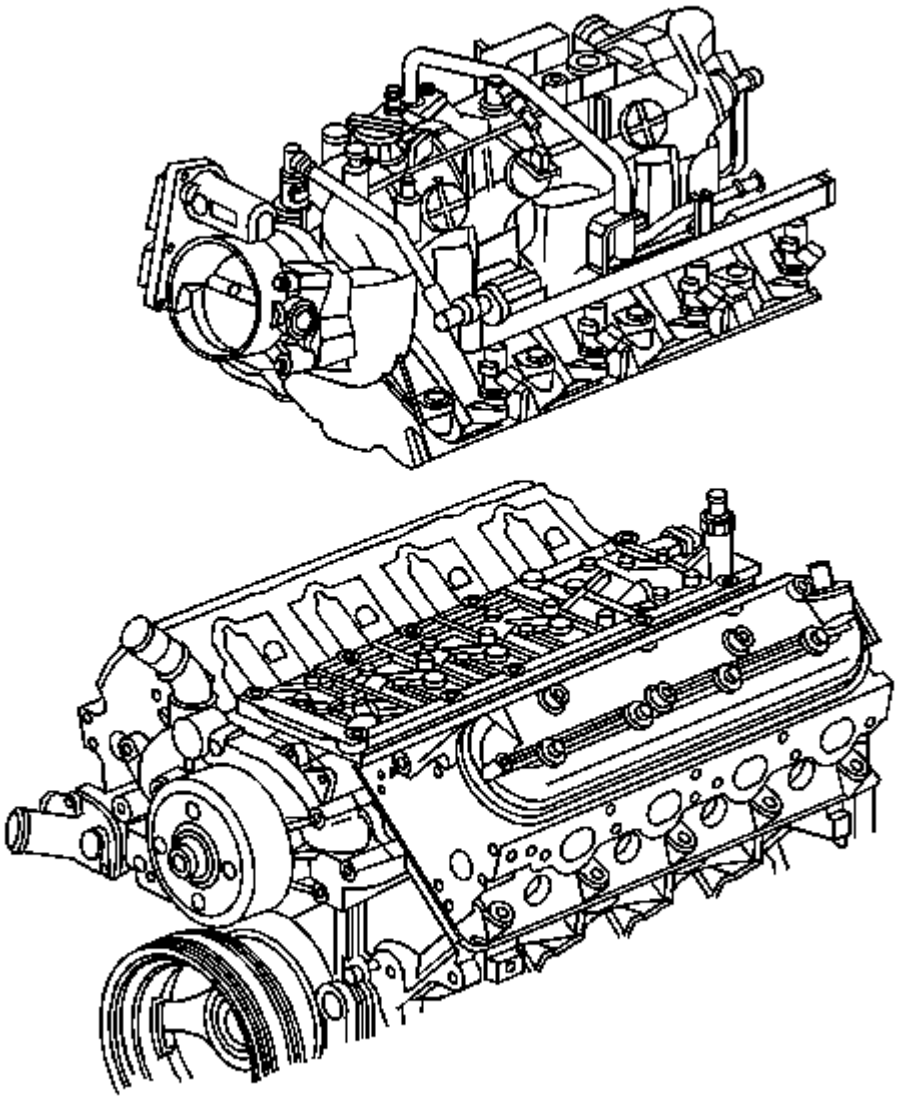

Fig. 101: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

18. Remove the intake manifold bolts.
19. Remove the intake manifold.

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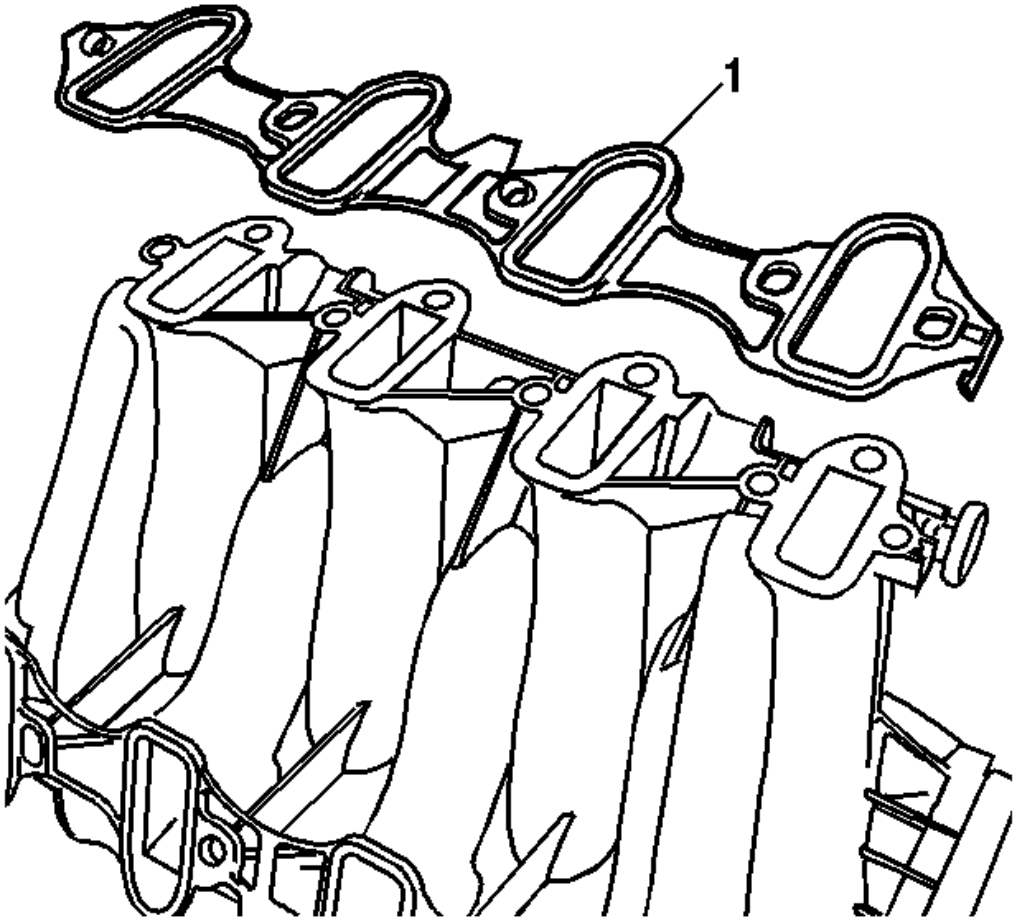

Fig. 102: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

20. Remove the intake manifold gaskets (1) from the intake manifold.
21. Discard the old intake manifold gaskets.
22. If necessary, clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

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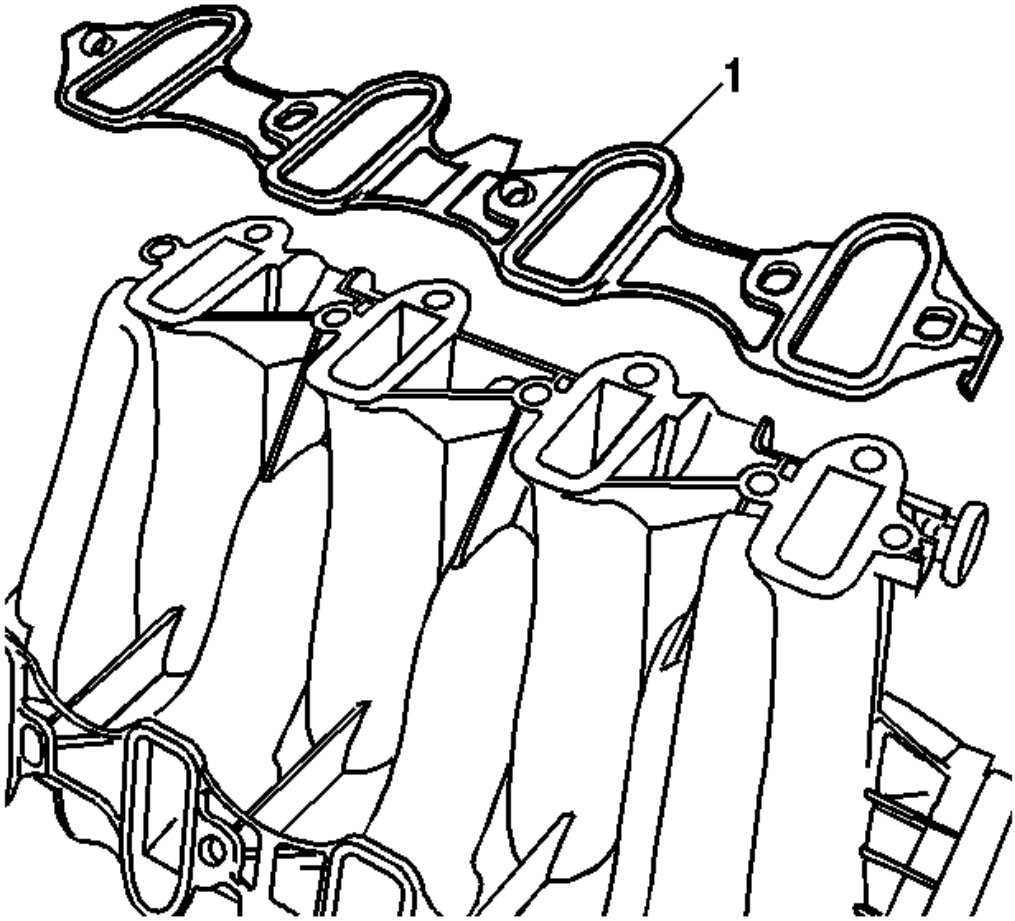

Fig. 103: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install NEW intake manifold gaskets (1) to the intake manifold.

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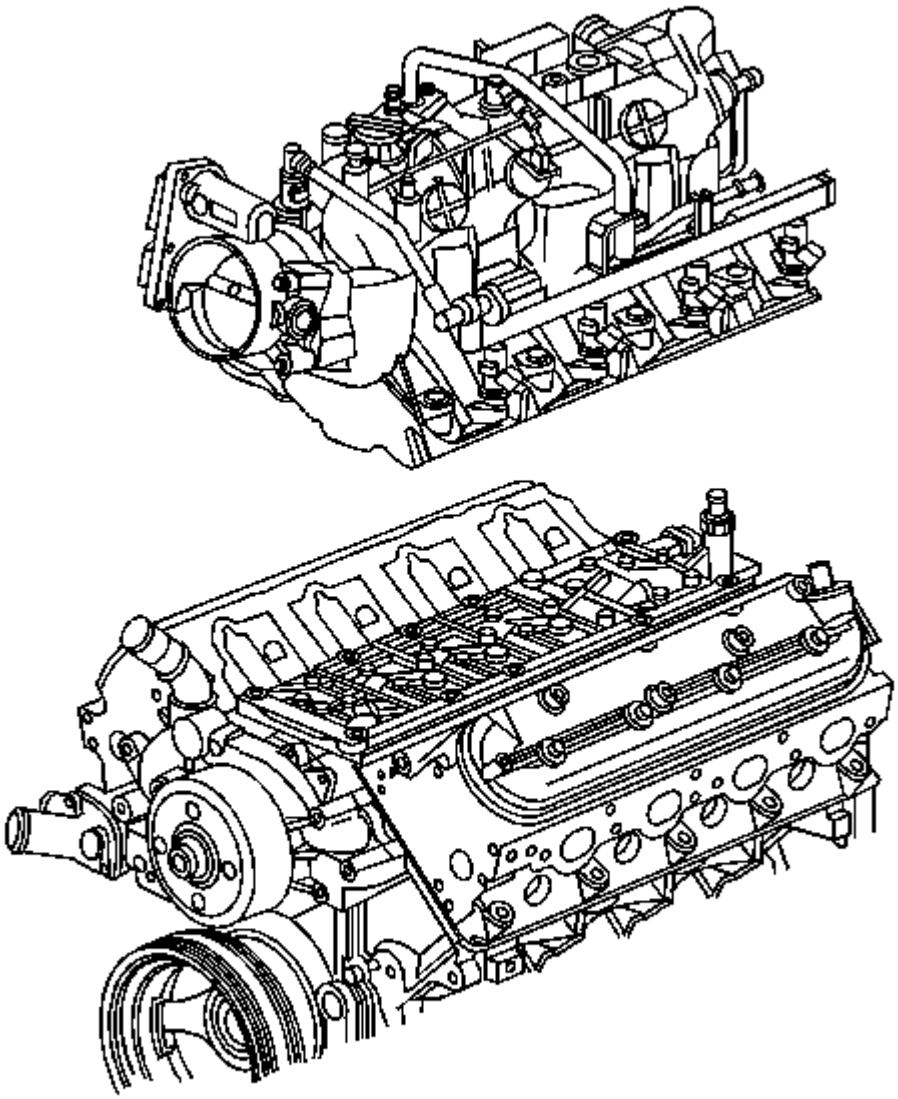

Fig. 104: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) bead of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the intake manifold bolts.

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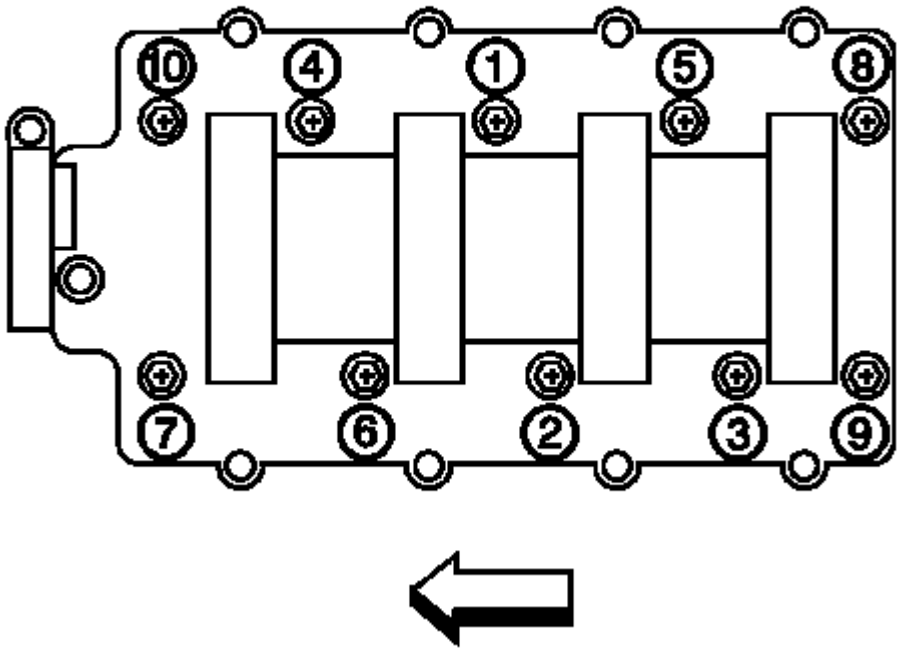

Fig. 105: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the intake manifold bolts.

Tighten:

1. Tighten the bolts a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the bolts a final pass in sequence to 10 N.m (89 lb in).

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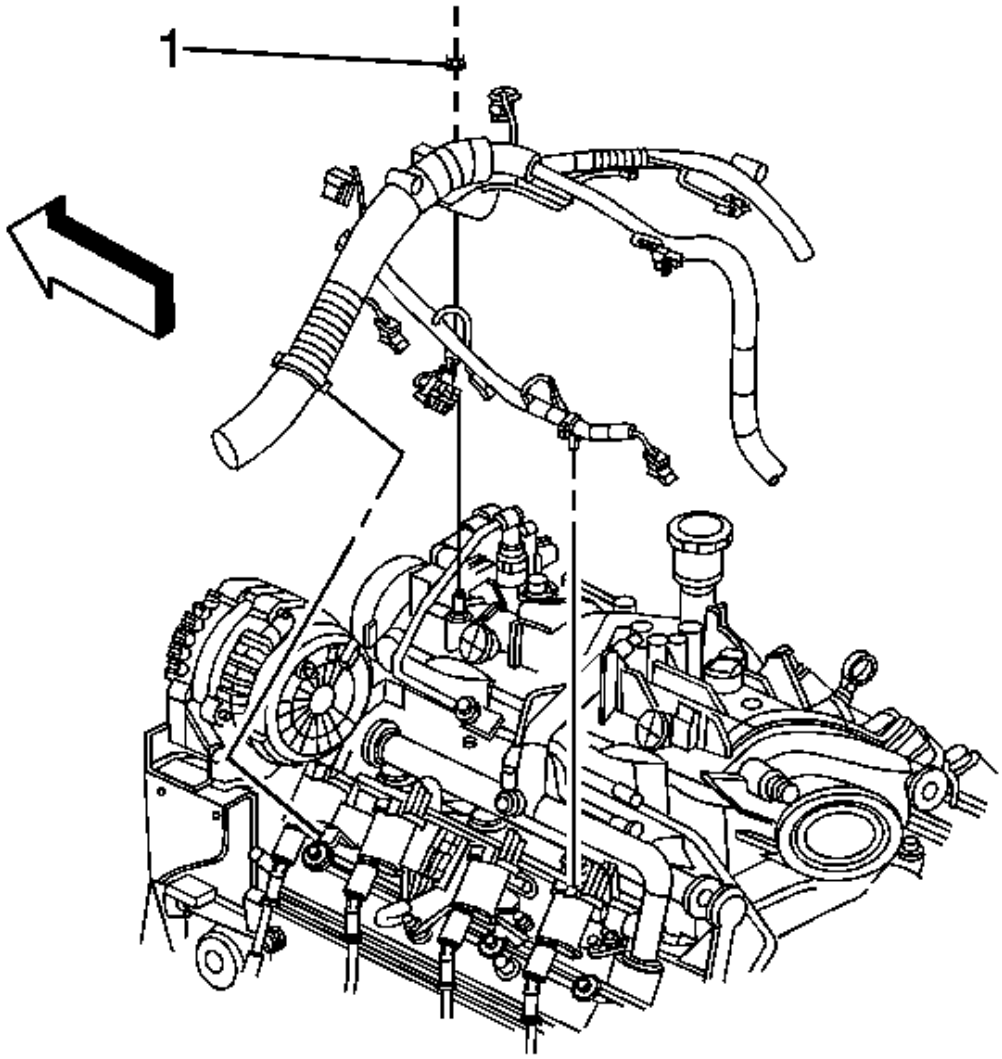

Fig. 106: View Of Upper Engine Wire Harness Retainer Nut
Courtesy of GENERAL MOTORS CORP.

5. Route the electrical harness into position over the engine.
6. Install the engine harness bracket nut (1).

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

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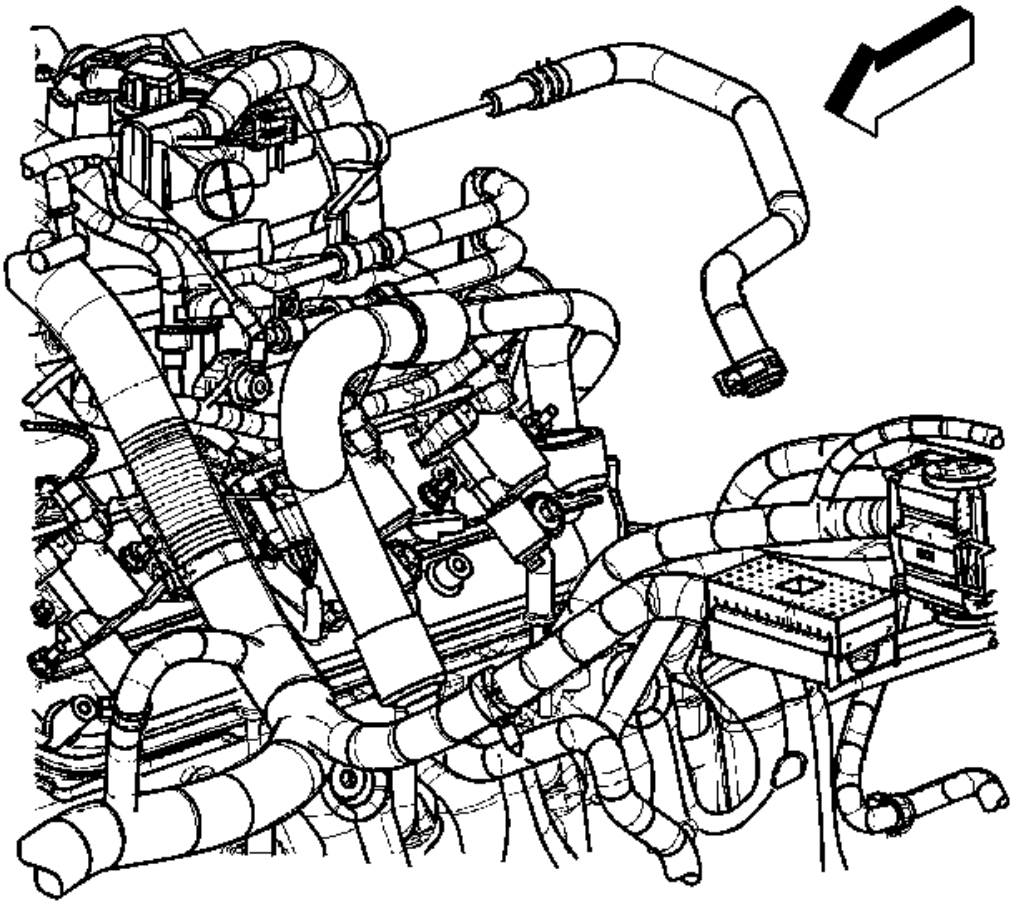

Fig. 107: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

7. Install the vacuum brake booster hose to the rear of the intake manifold.

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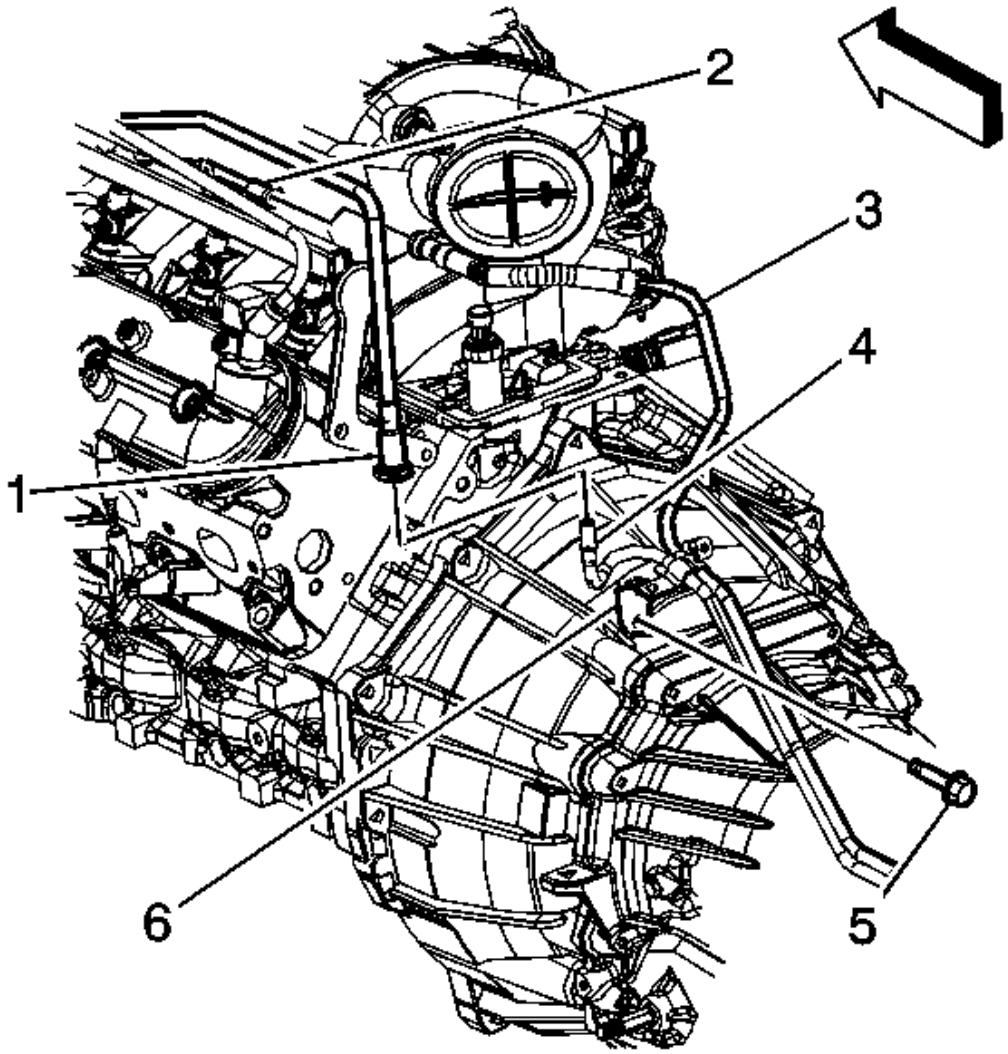

Fig. 108: Fuel Feed Pipe To Fuel Rail
Courtesy of GENERAL MOTORS CORP.

8. Connect the fuel feed pipe (3) to the fuel rail (2). Refer to **Quick Connect Fitting(s) Service (Metal Collar)** in Engine Controls - 5.3L.

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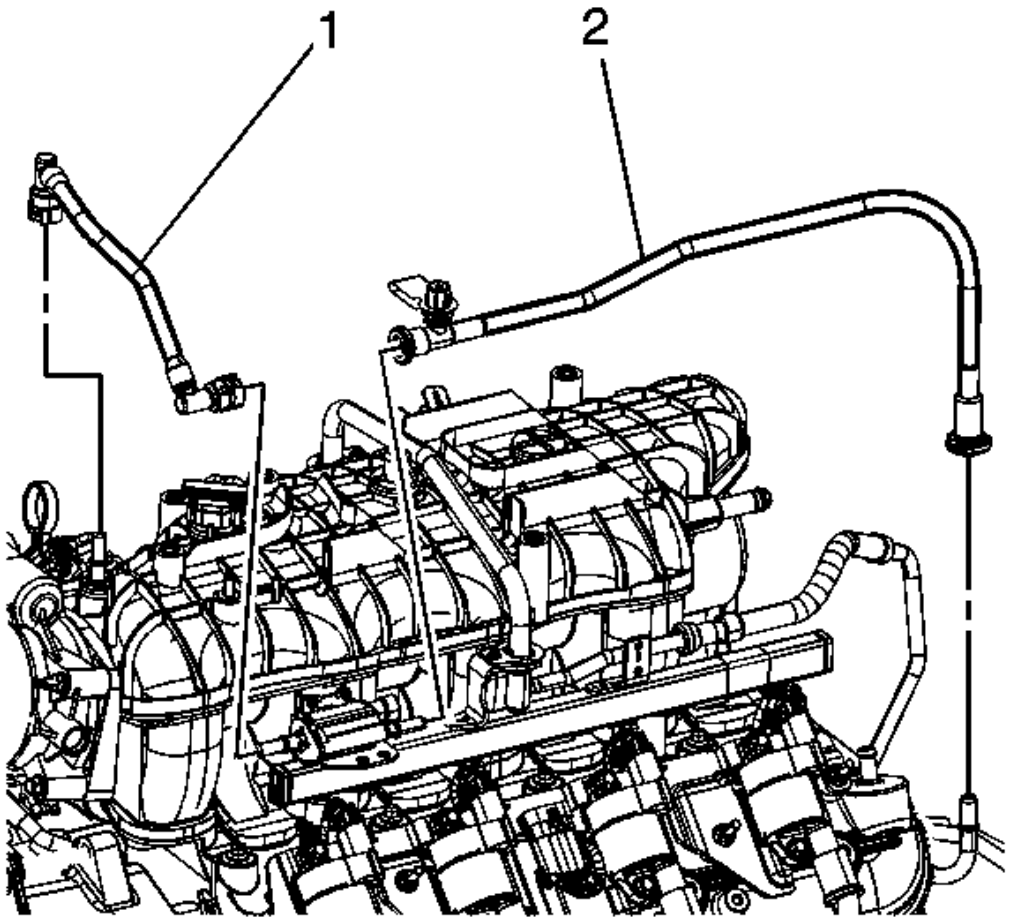

Fig. 109: EVAP Purge Solenoid Vent Tubes
Courtesy of GENERAL MOTORS CORP.

9. Install the EVAP purge solenoid vent tubes (1, 2). Refer to **Quick Connect Fitting(s) Service (Plastic Collar)** .

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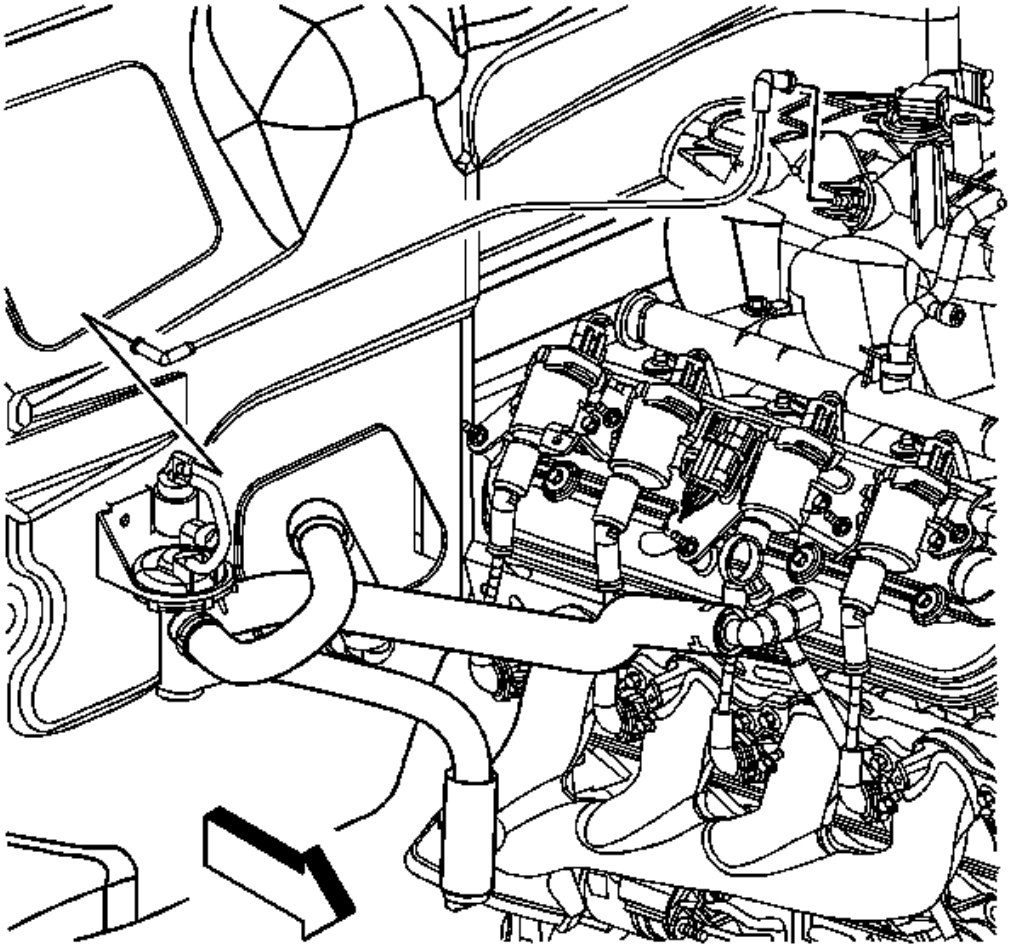

Fig. 110: View Of Heater Water Shutoff Valve Actuator Inlet Hose
Courtesy of GENERAL MOTORS CORP.

10. Install the heater water shutoff valve actuator inlet hose to the intake manifold.

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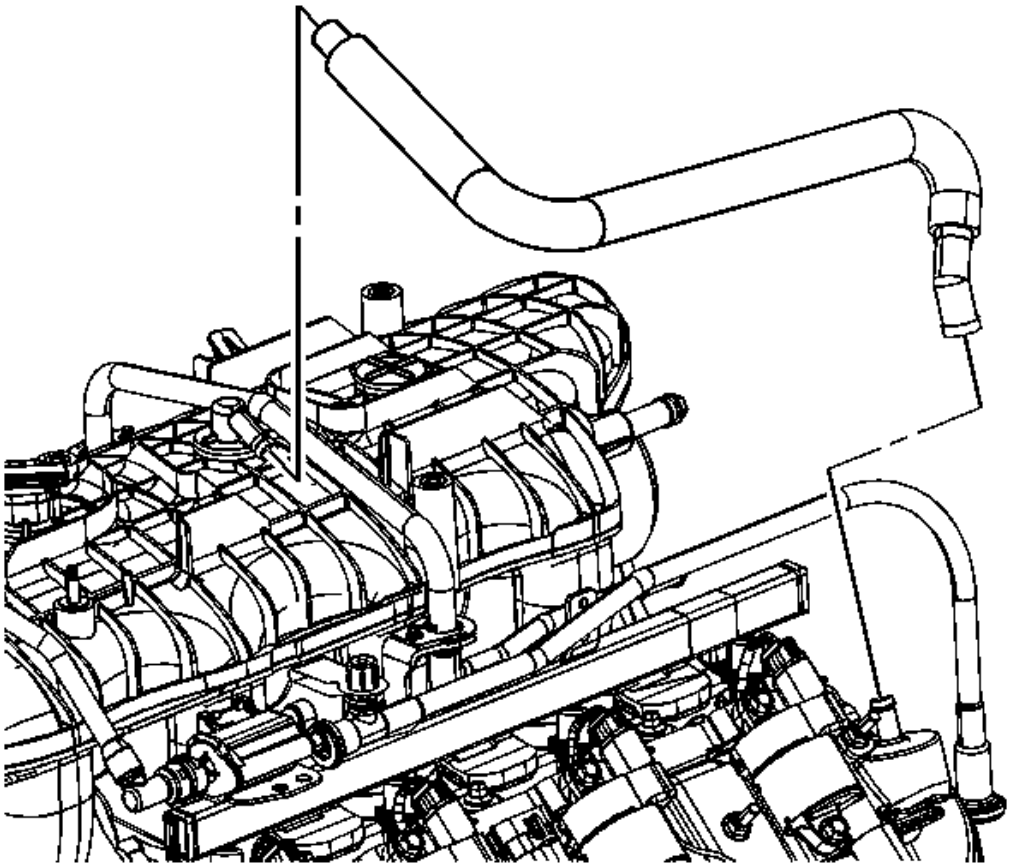

Fig. 111: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

11. Install the PCV hose.
12. Connect the electrical harness clips to the fuel rail.

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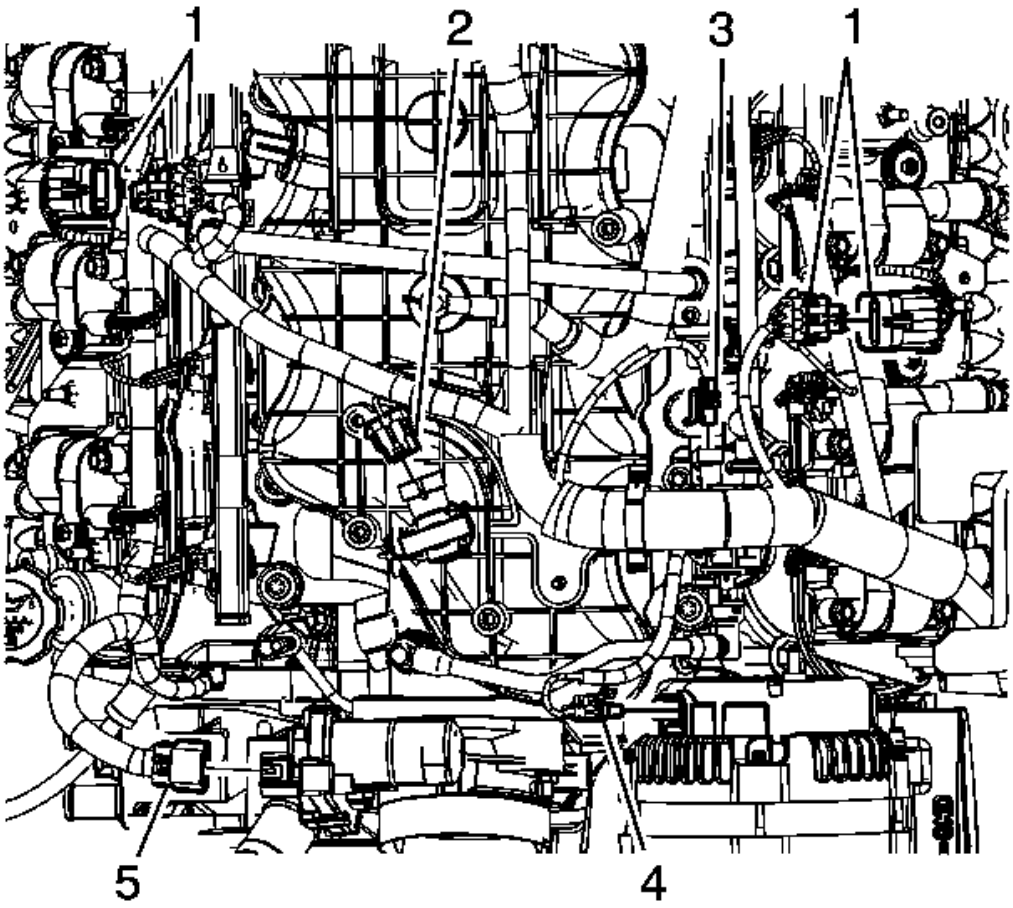

Fig. 112: EVAP Purge Solenoid, MAP Sensor, Main Coil & Throttle Body Harness Connectors
Courtesy of GENERAL MOTORS CORP.

13. Connect the following electrical connectors:
    - EVAP purge solenoid (3)
    - Throttle body harness (5)
    - MAP sensor (2)
    - Main coil (1)
    - Generator (4)

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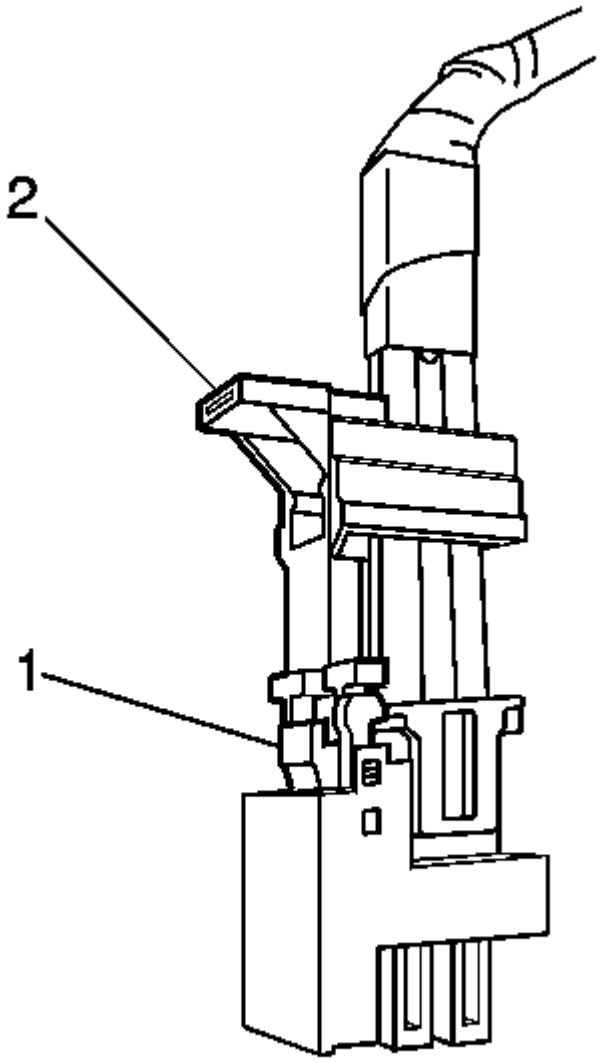

Fig. 113: View Of CPA Retainer & Tab
Courtesy of GENERAL MOTORS CORP.

14. Perform the following steps in order to connect the fuel injector electrical connectors.
    1. Install the connectors to their corresponding injectors to ensure correct reassembly.
    2. Connect the fuel injector electrical connector.
    3. Push the CPA retainer (2) on the connector in one click.
    4. Repeat the steps for each injector electrical connector.

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15. Install the electrical harness clips to the fuel rail.

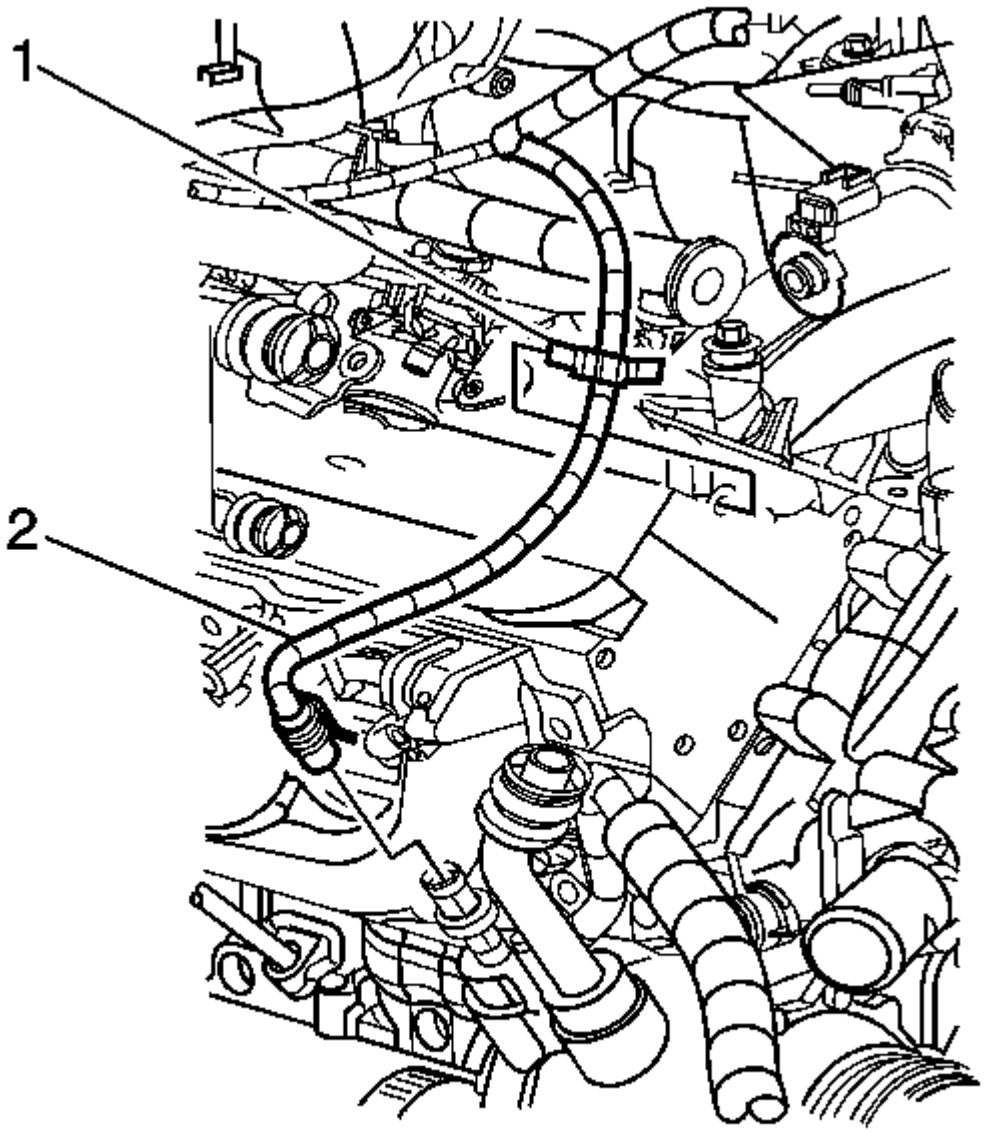

Fig. 114: View Of A/C Compressor Pressure Switch Electrical Connector & Retaining Clip
Courtesy of GENERAL MOTORS CORP.

16. Connect the A/C compressor pressure switch electrical connector (2).
17. Install the harness clip (1) to the cylinder head.

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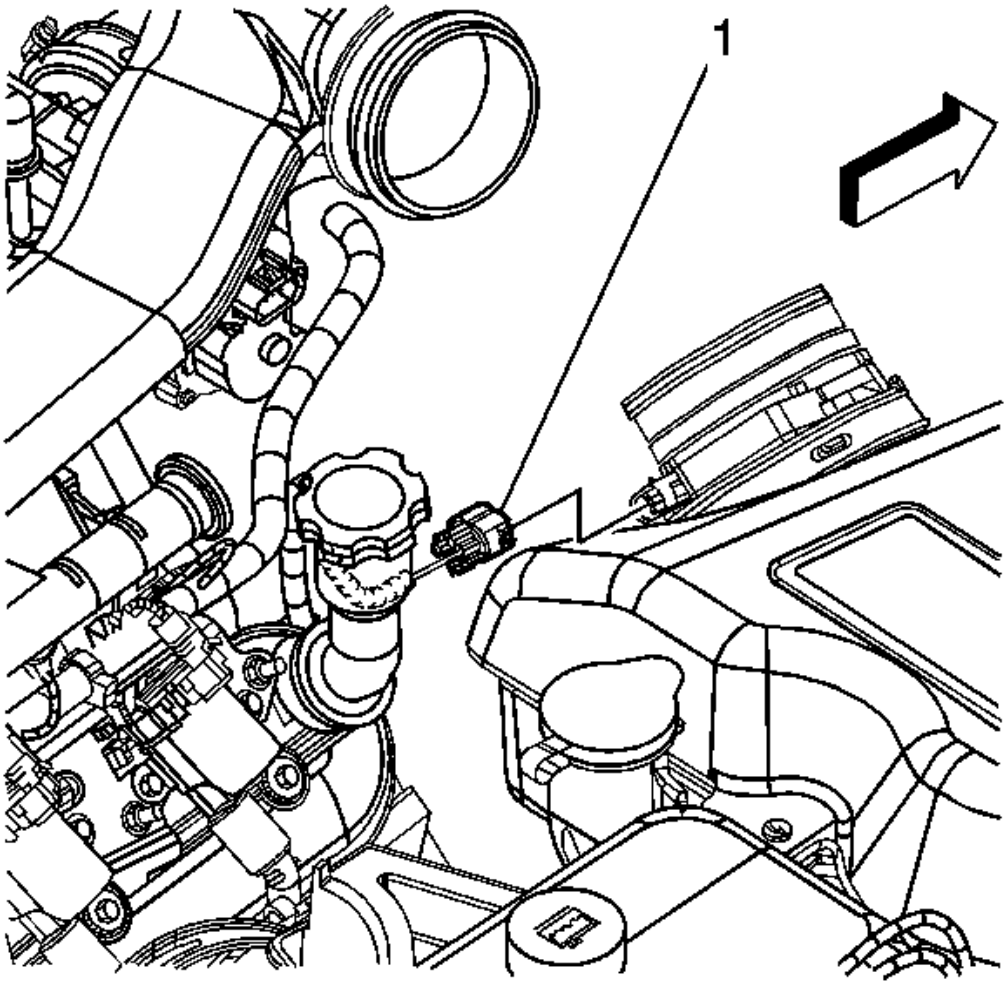

Fig. 115: View Of MAF/IAT Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

18. Connect the MAF/IAT sensor electrical connector (1).
19. Install the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** in Engine Controls - 5.3L.
20. Install the fuel fill cap.
21. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
22. Use the following procedure in order to inspect for leaks:
    1. Turn the ignition ON, with the engine OFF, for 2 seconds.

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2. Turn the ignition OFF for 10 seconds.
3. Turn the ignition ON, with the engine OFF.
4. Inspect for fuel leaks.

Valve Lifter Oil Manifold Replacement

Removal Procedure

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Disconnect the electrical connector from the oil pressure sensor.

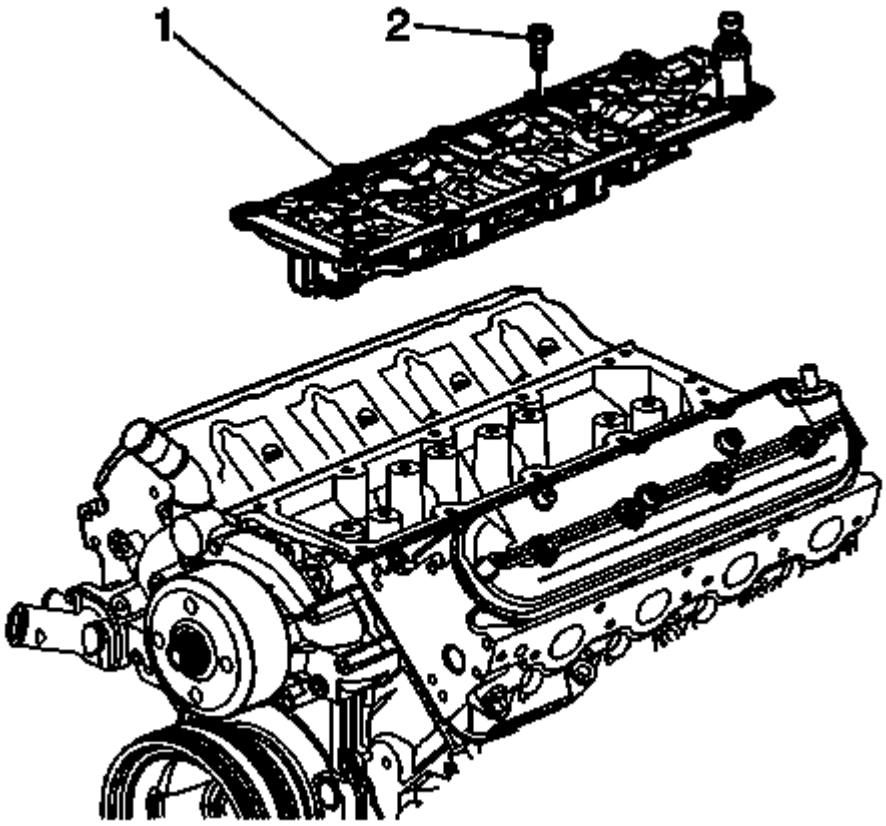

Fig. 116: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifter oil manifold bolts (2).

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.

4. Remove the valve lifter oil manifold (1).

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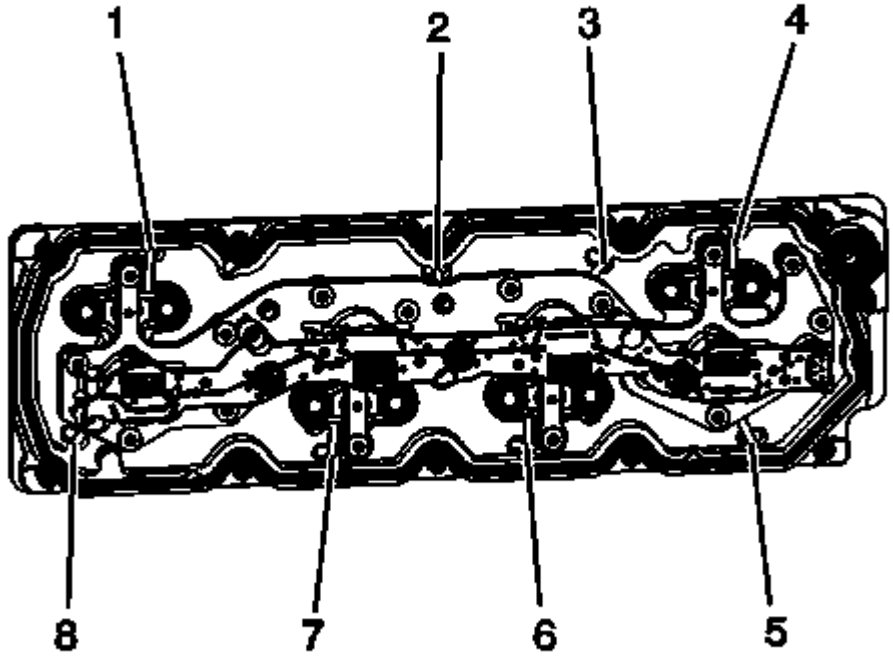

Fig. 117: Gasket Retaining Strap Locations
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove only the outer gasket from the manifold. Do not disassemble any of the internal components of the manifold in an attempt to remove the 8 inner sealing gaskets. If the inner gaskets are cut or damaged, replace the manifold as an assembly. Only use a wire-cutter type tool in order to minimize the amount of debris. Do not use a rotary-type cutting tool on the retaining straps.

5. Identify the 8 gasket retaining strap locations (1-8).

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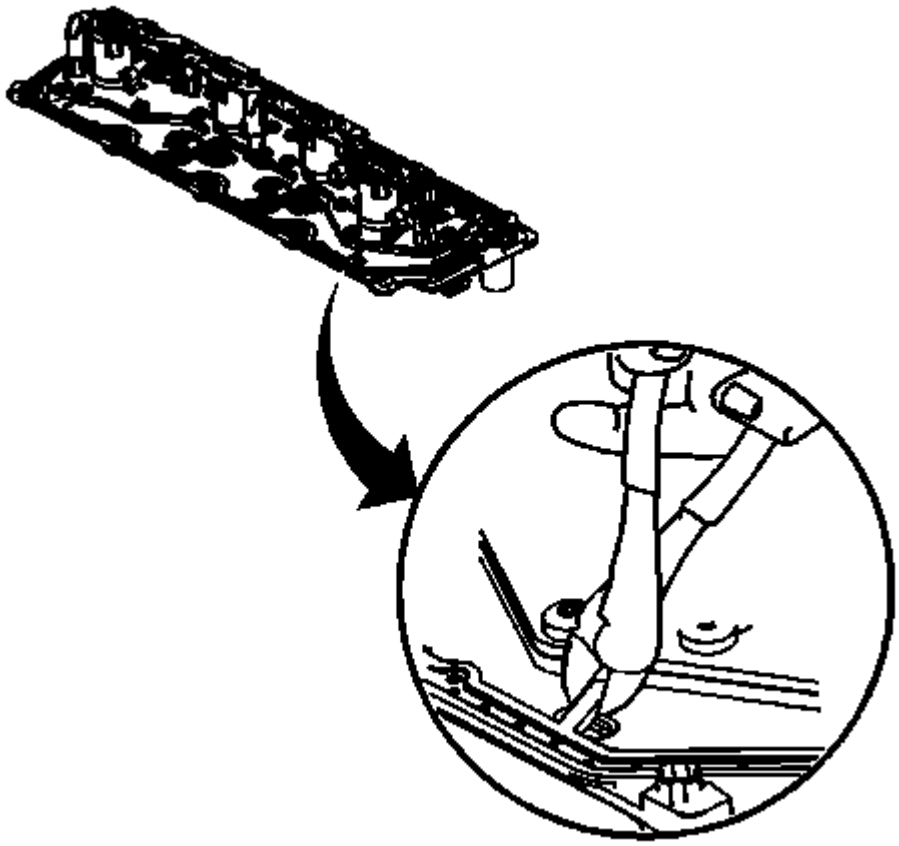

Fig. 118: Cutting Retaining Straps On Outer Gasket
Courtesy of GENERAL MOTORS CORP.

6. Using a wire-cutter type tool, cut the 8 retaining straps of the outer gasket.

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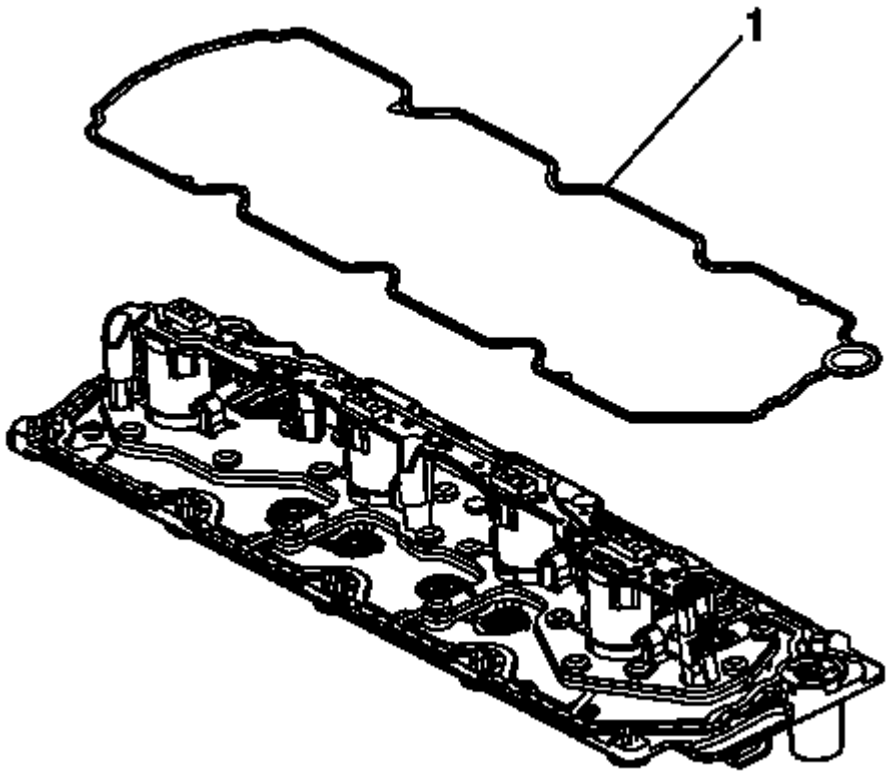

Fig. 119: Outer Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the outer gasket (1) from the manifold.

Installation Procedure

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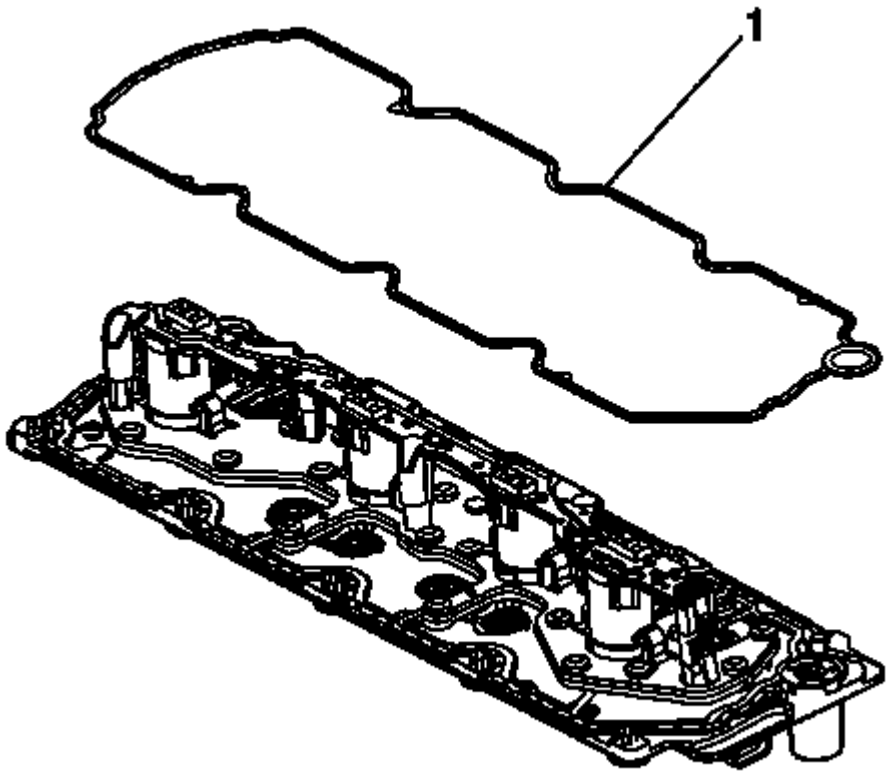

Fig. 120: Outer Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **Do not allow dirt or debris to enter the manifold. Plug as required.**

1. Install the service gasket (1) onto the manifold.

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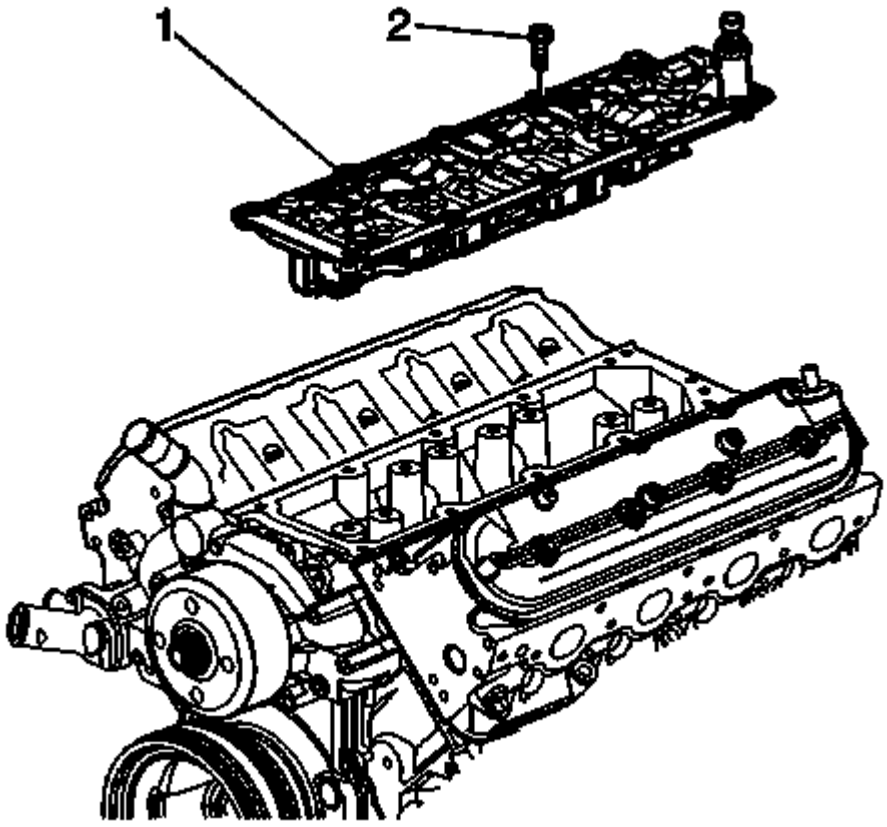

Fig. 121: Service Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the manifold (2) with gasket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the manifold bolts (1).

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

4. Connect the electrical connector to the oil pressure sensor.
5. Install the intake manifold. Refer to **Intake Manifold Replacement**.

Valve Rocker Arm Cover Replacement - Left

Removal Procedure

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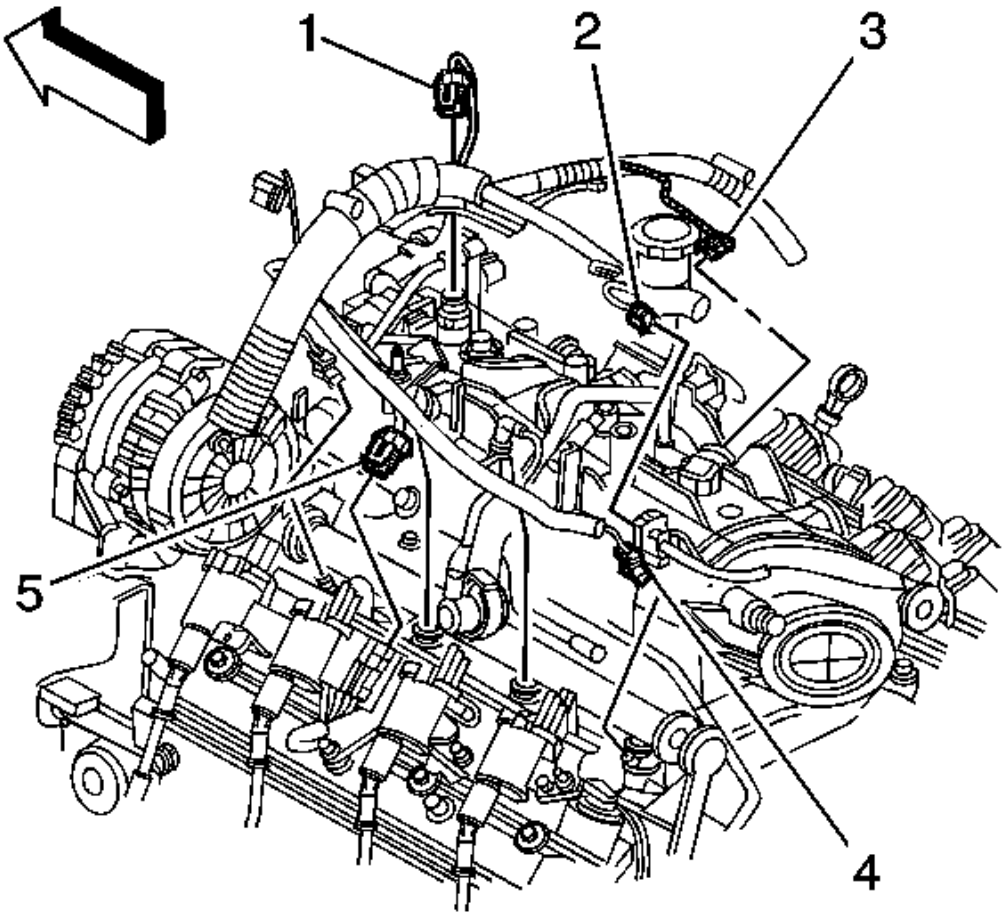

Fig. 122: Top Of Engine Wiring Harness View
Courtesy of GENERAL MOTORS CORP.

1. Remove the connector position assurance (CPA) lock.
2. Disconnect the main electrical connector (5) to the ignition coil wire harness.
3. Remove the harness clips.
4. Reposition the engine harness, if necessary.
5. Remove the spark plug wires from the ignition coils.
    - Twist each plug wire 1/2 turn.
    - Pull only on the boot in order to remove the wire from the ignition coil.

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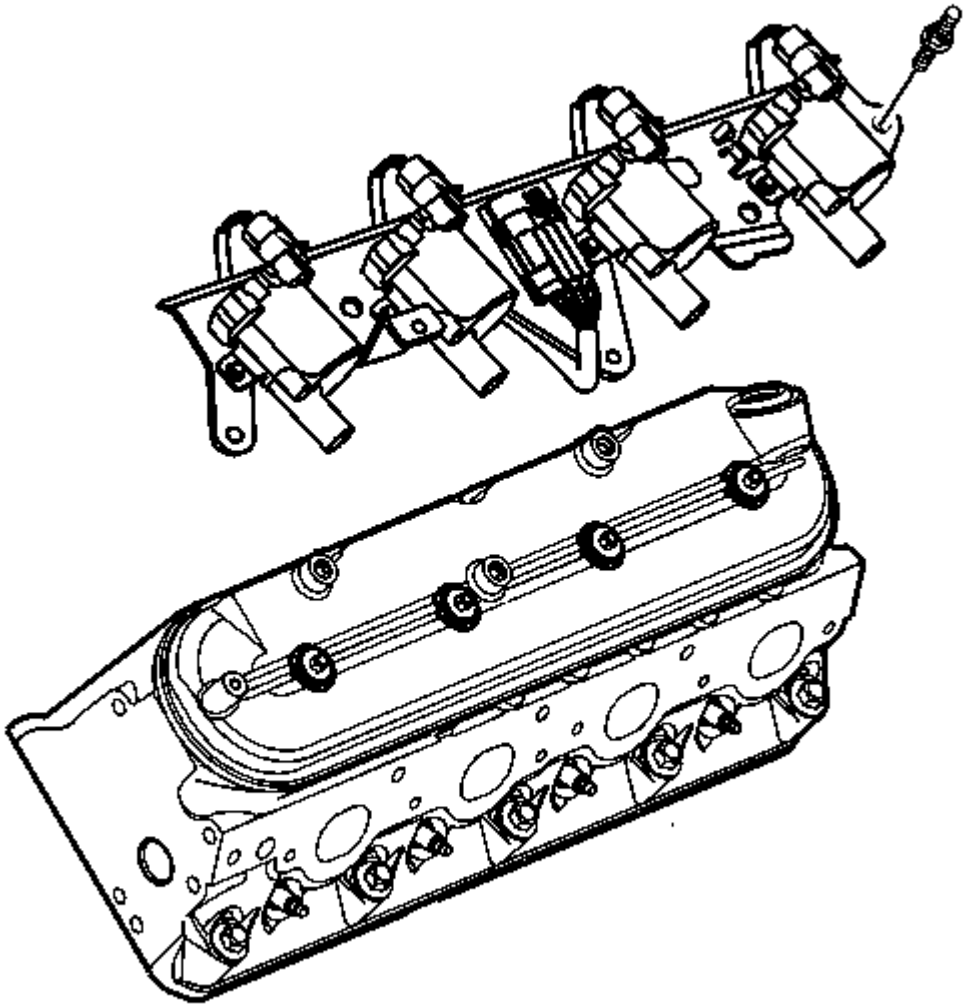

Fig. 123: Identifying Ignition Coils
Courtesy of GENERAL MOTORS CORP.

6. If necessary, remove the ignition coil bracket studs from the rocker arm cover.
7. If necessary, remove the ignition coils and bracket from the rocker arm cover.

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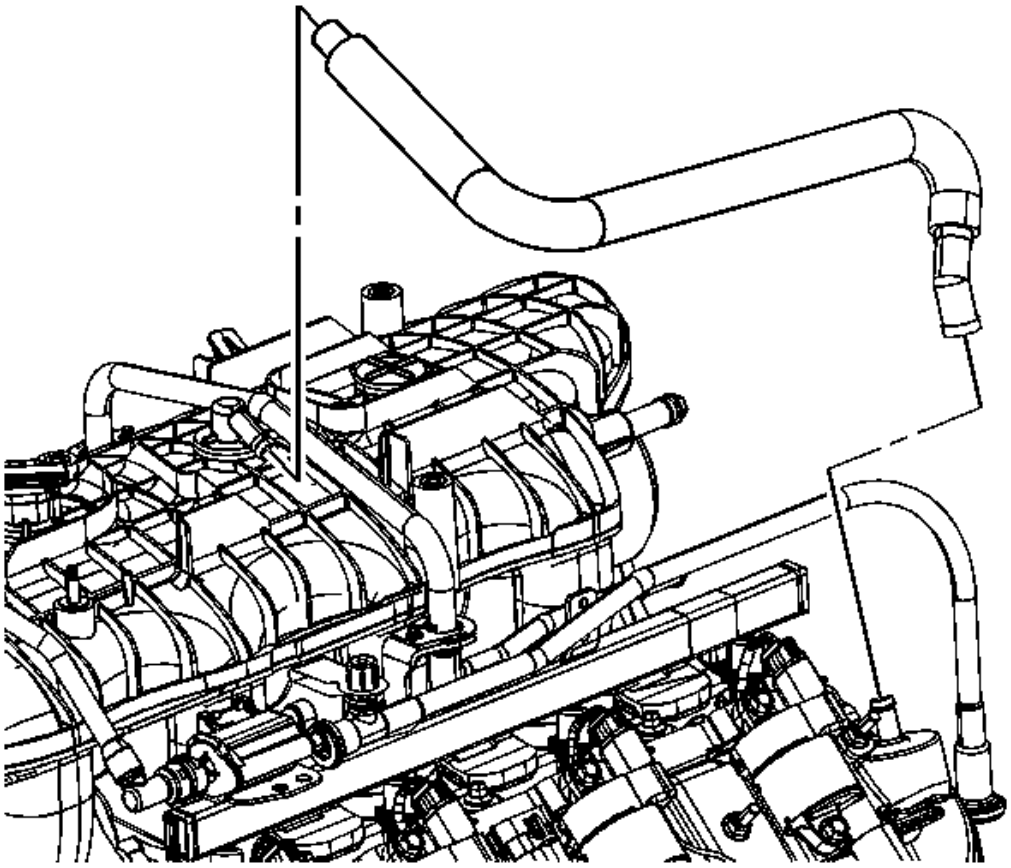

Fig. 124: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

8. Remove the positive crankcase ventilation (PCV) hose from the rocker arm cover.

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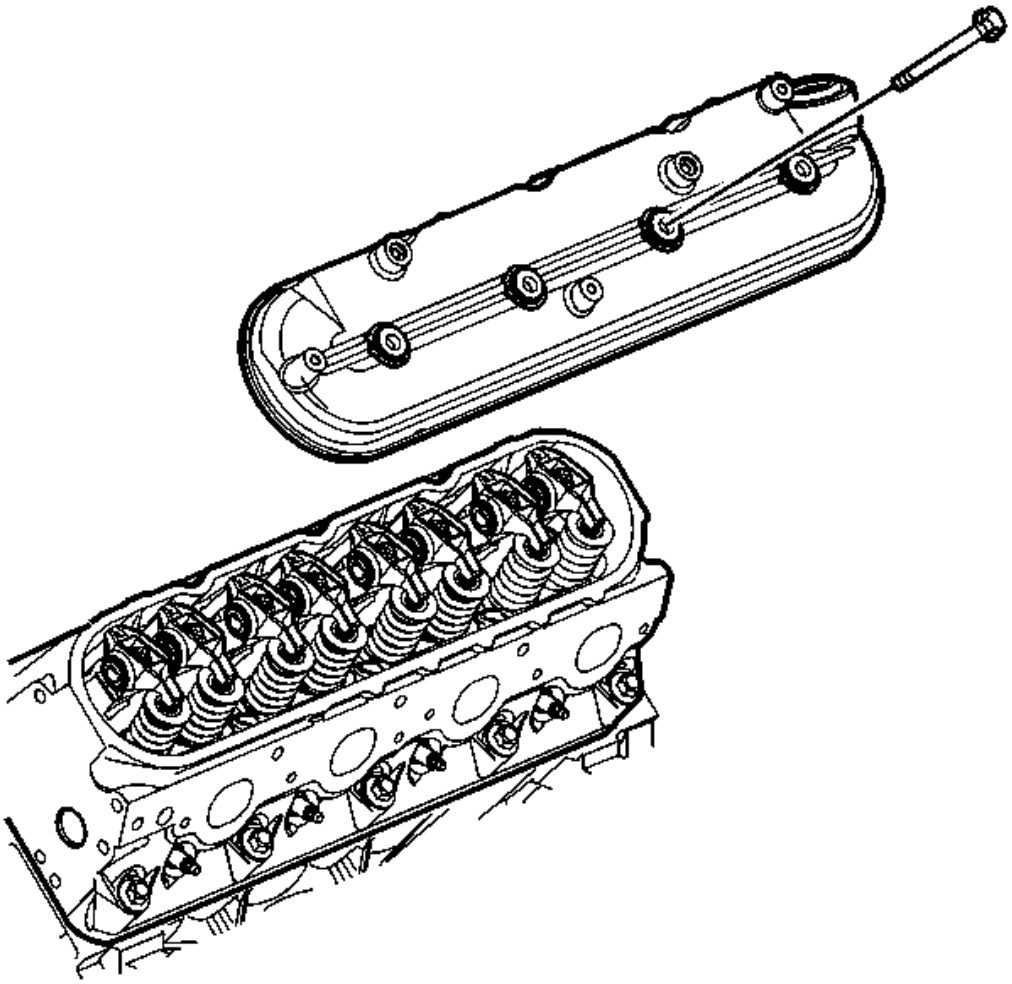

Fig. 125: Valve Cover To Cylinder Head View
Courtesy of GENERAL MOTORS CORP.

9. Remove the valve rocker arm cover bolts.
10. Remove the valve rocker arm cover.

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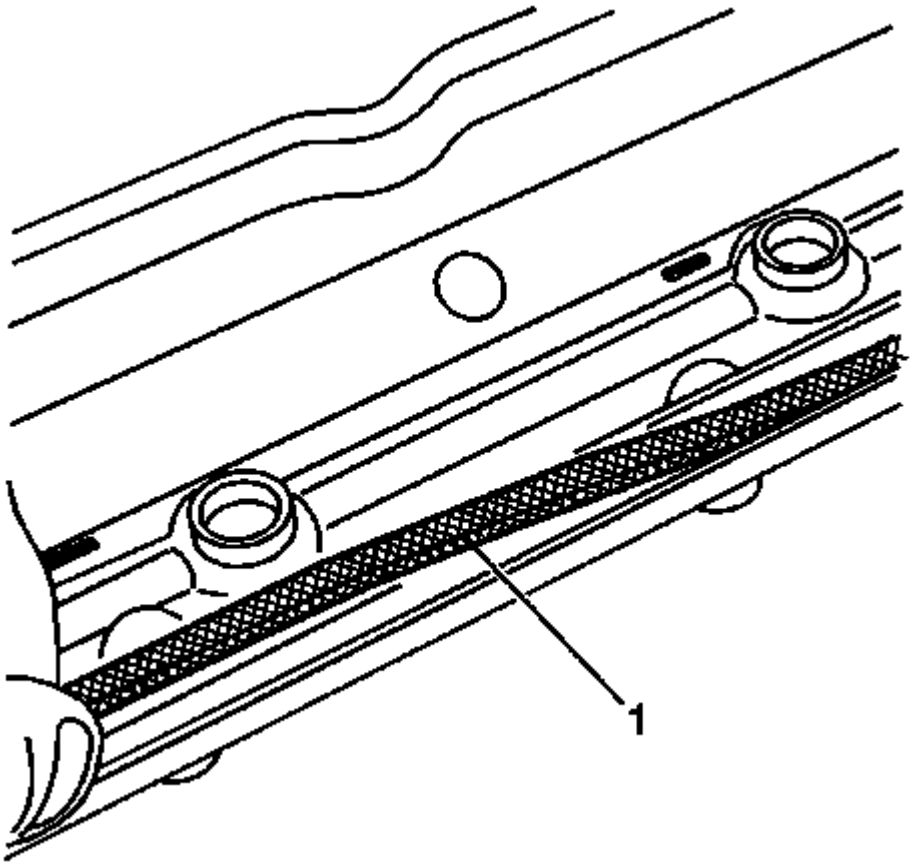

Fig. 126: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove the gasket (1) from the rocker cover.
12. Discard the OLD gasket.

Installation Procedure

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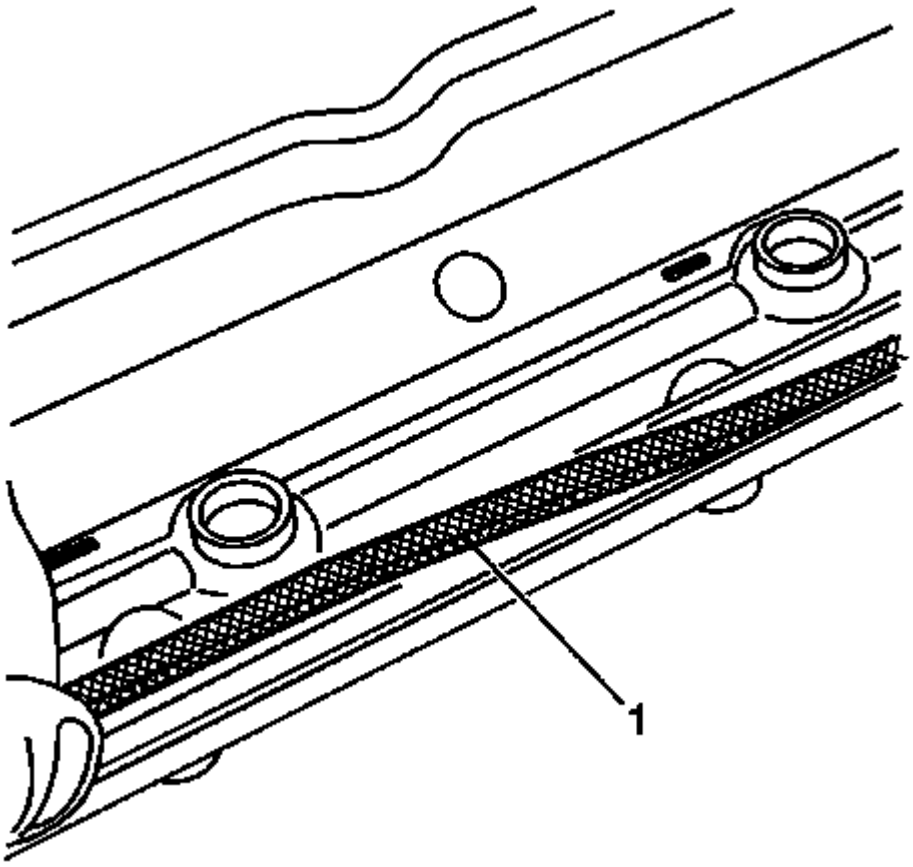

Fig. 127: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil an/or other foreign material during assembly.**
- **DO NOT reuse the valve rocker arm cover gasket.**
- **The valve rocker arm cover bolt grommets may be reused.**
- **If the PCV valve grommet has been removed from the rocker cover, install a NEW grommet during assembly.**

1. Install a NEW rocker cover gasket (1) into the groove of the valve rocker arm cover.

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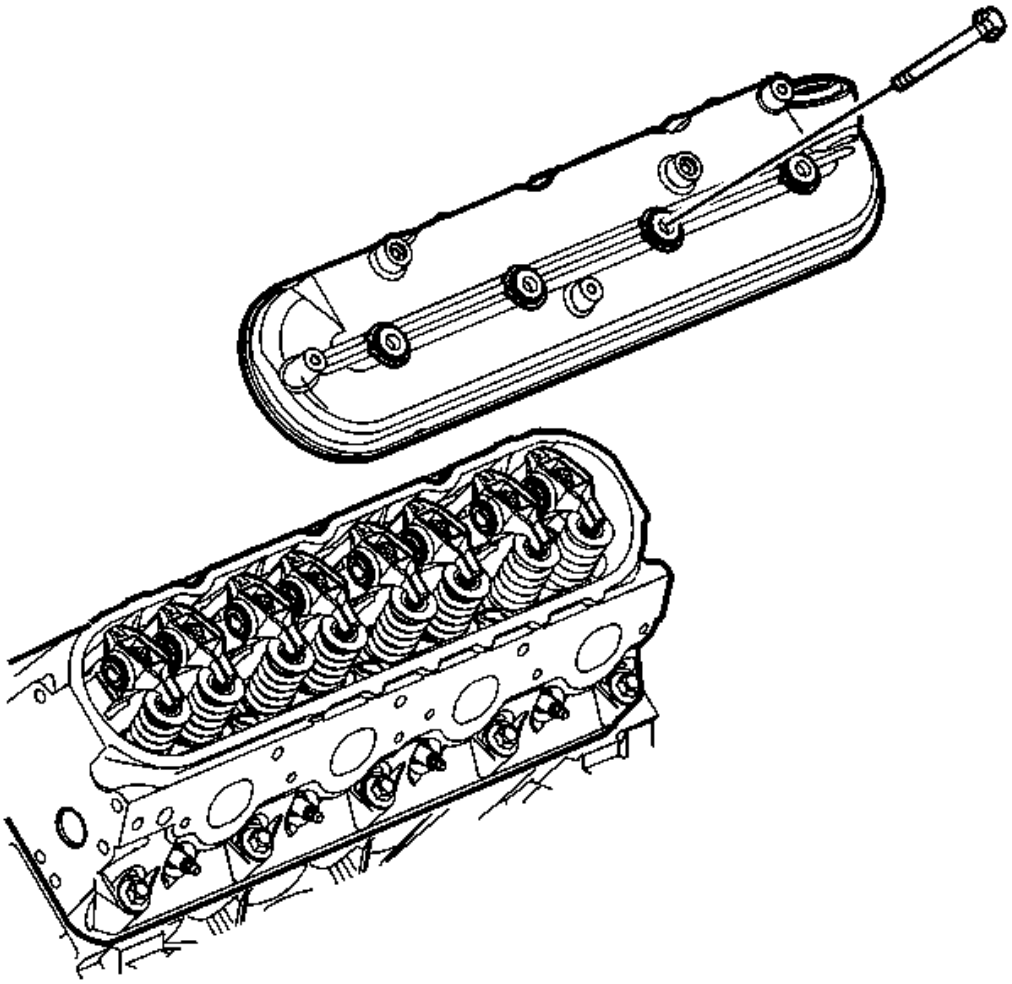

Fig. 128: Valve Cover To Cylinder Head View
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.
3. Install new rocker arm cover grommets, if necessary.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the rocker arm cover bolts.

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

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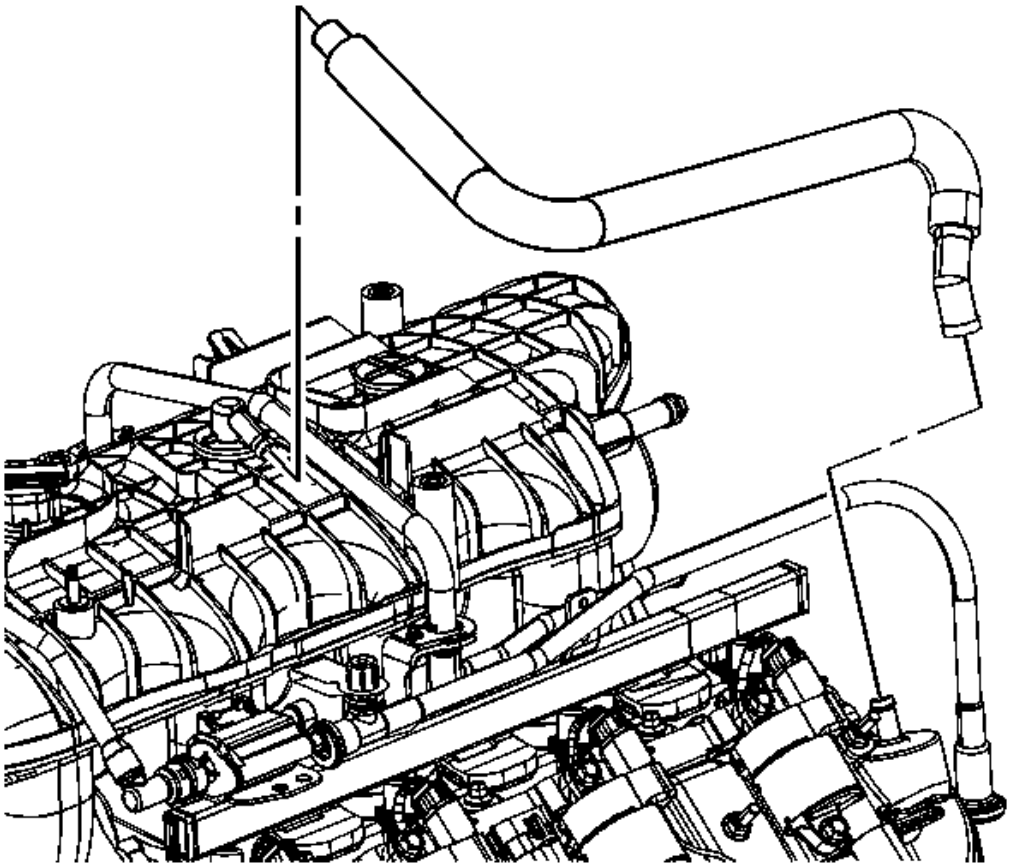

Fig. 129: Identifying Positive Crankcase Ventilation (PCV) Foul Air Hose
Courtesy of GENERAL MOTORS CORP.

5. Install the PCV hose to the rocker arm cover.

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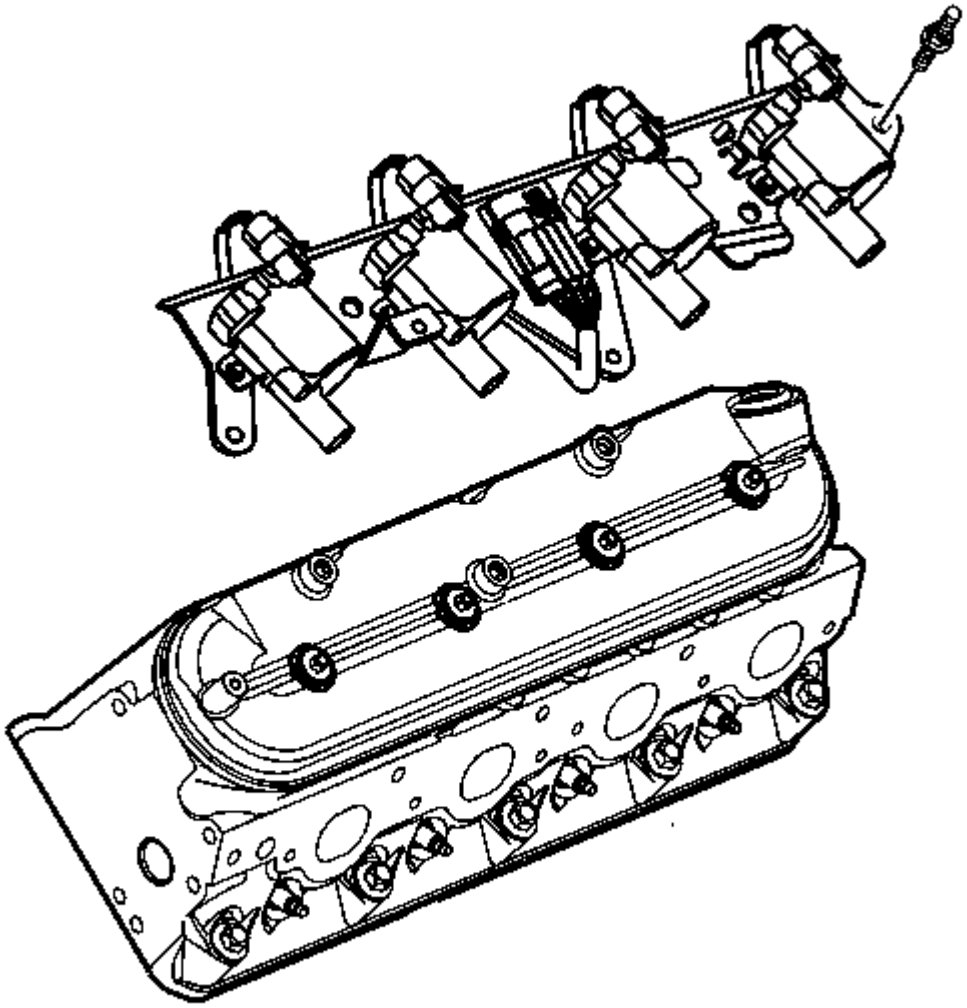

Fig. 130: Identifying Ignition Coils
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
7. If necessary, install the ignition coils and bracket to the rocker arm cover.
8. If necessary, install the ignition coil bracket studs to the rocker arm cover.

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

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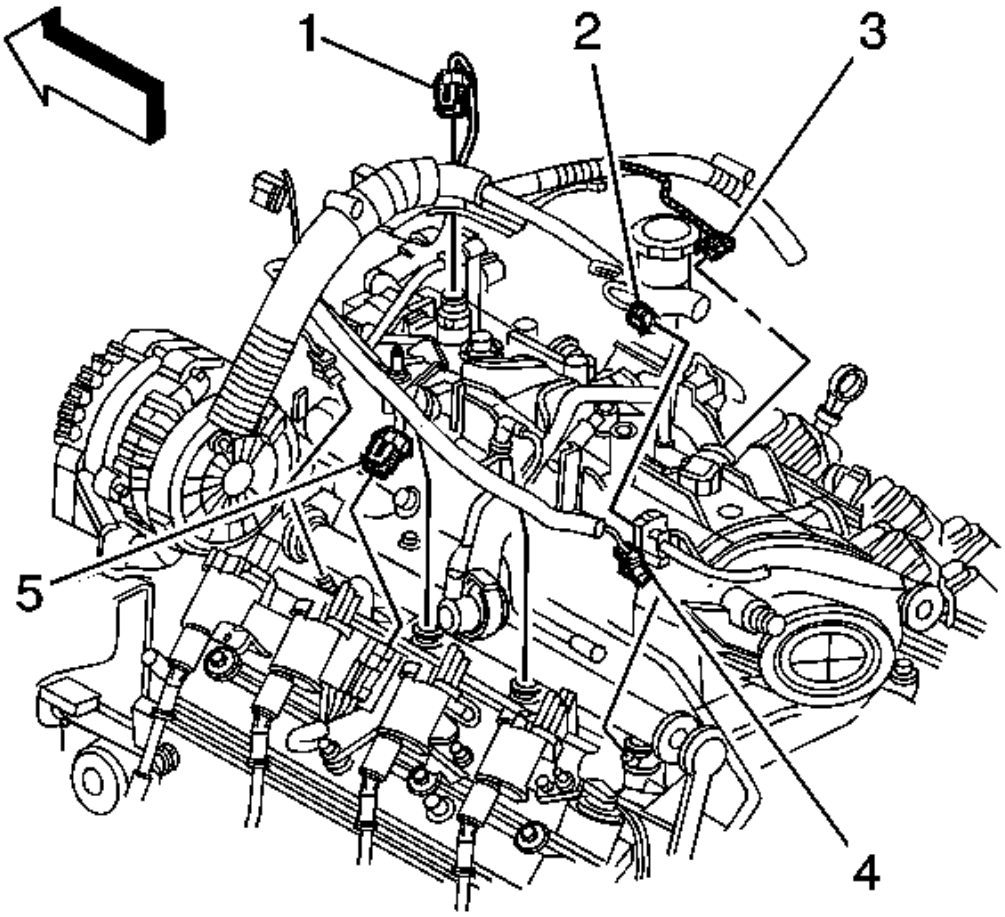

Fig. 131: Top Of Engine Wiring Harness View
Courtesy of GENERAL MOTORS CORP.

9. Install the spark plug wires to the ignition coils.
10. Position the engine harness, if necessary.
11. Install the harness clips.
12. Connect the main electrical connector (5) to the ignition coil wire harness.
13. Install the CPA lock.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

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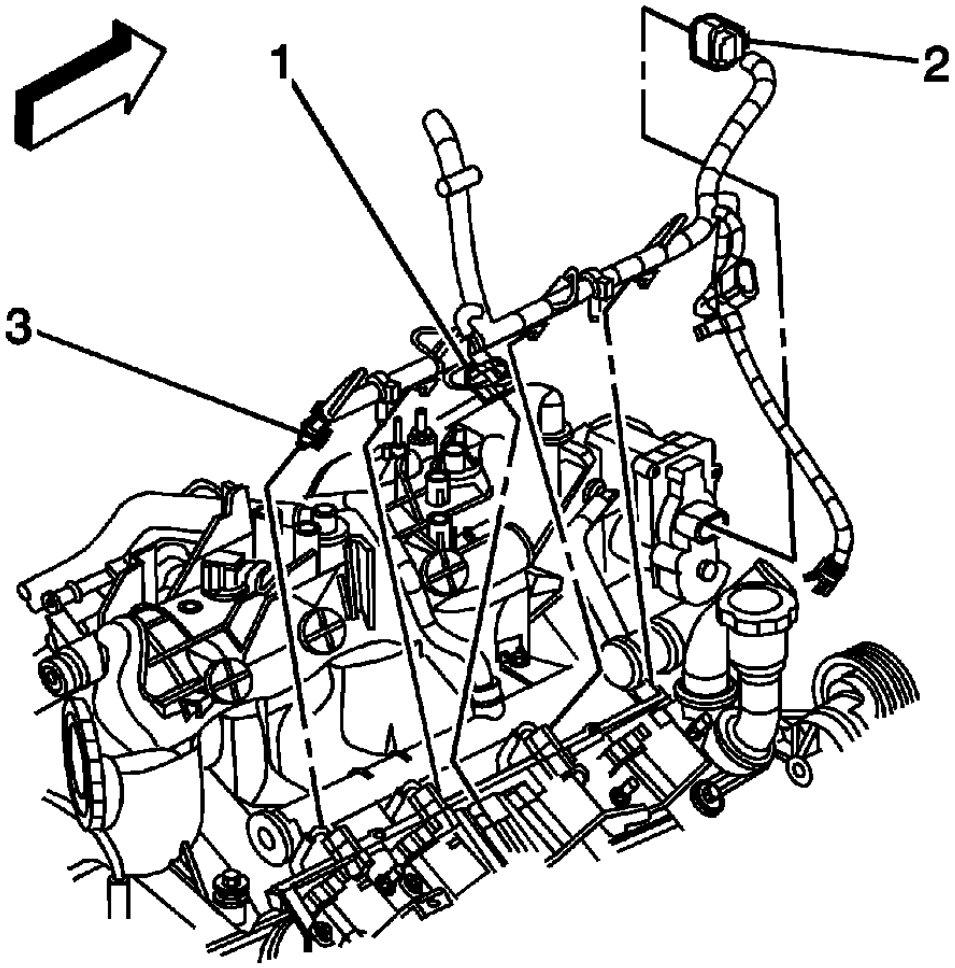

Fig. 132: Locating Electrical Components At Top Of Engine
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) compressor hose. Refer to **Compressor Hose Assembly Replacement (LM4)** in Heating, Ventilation, and Air Conditioning.
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (1) to the ignition coil wire harness.
4. Remove the harness clips.
5. Reposition the engine harness, if necessary.
6. Remove the spark plug wires from the ignition coils.
   - Twist each plug wire 1/2 turn.
   - Pull only on the boot in order to remove the wire from the ignition coil.

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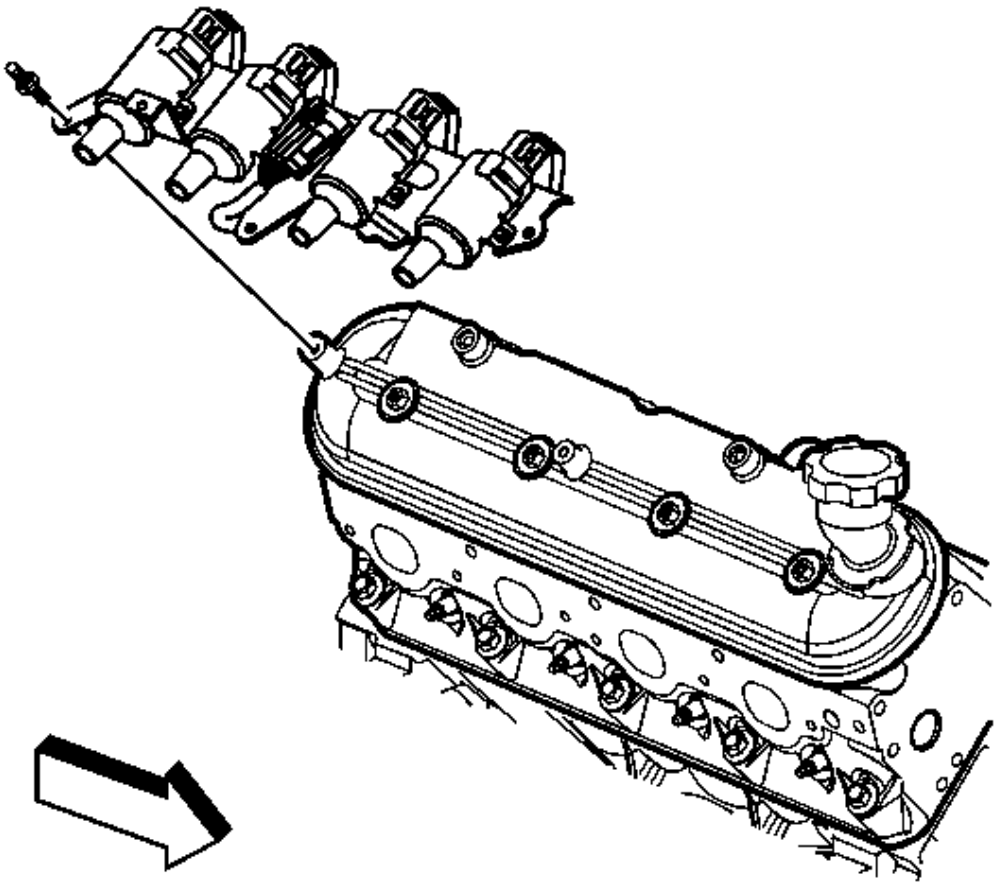

Fig. 133: Ignition Coil View
Courtesy of GENERAL MOTORS CORP.

7. If necessary, remove the ignition coil bracket studs from the rocker arm cover.
8. If necessary, remove the ignition coils and bracket from the rocker cover.

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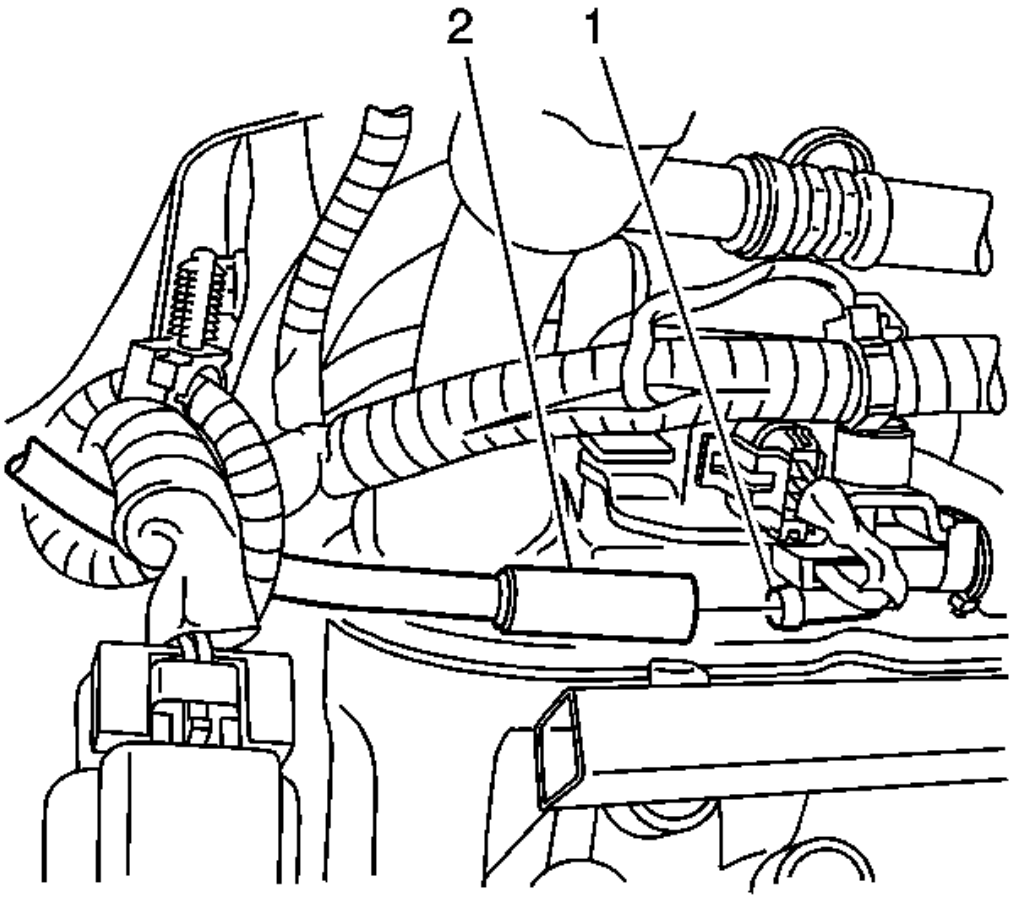

Fig. 134: Vent Hose
Courtesy of GENERAL MOTORS CORP.

9. Remove the vent hose (2) from the valve rocker arm cover (1).

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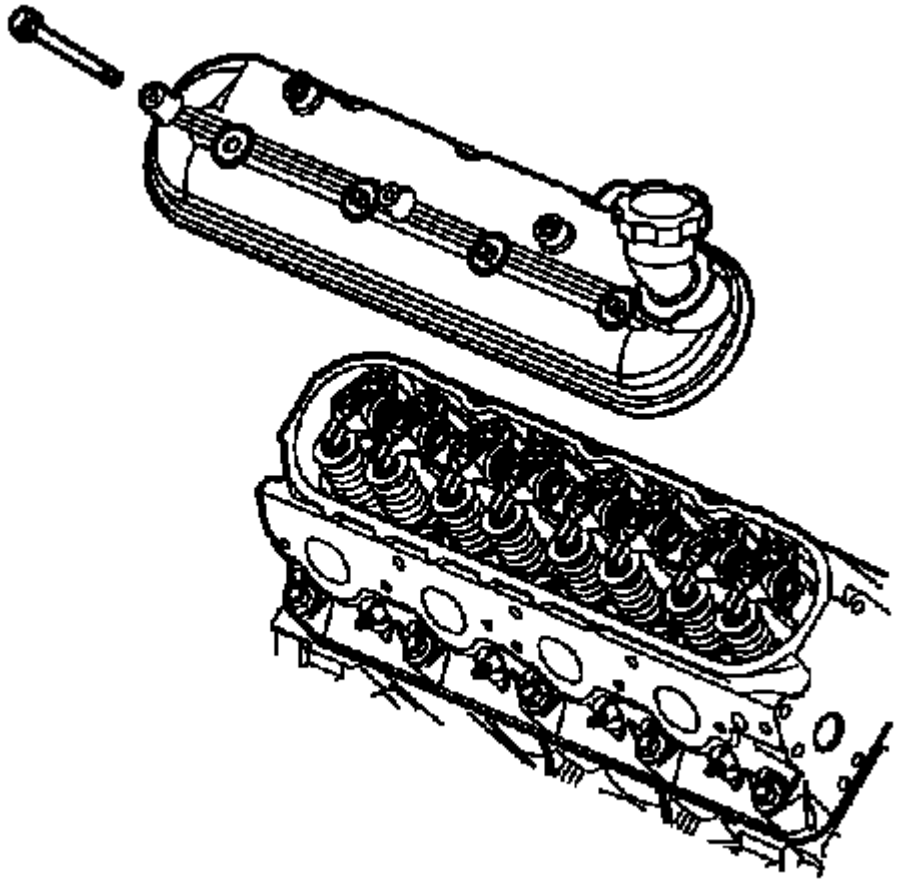

Fig. 135: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve rocker arm cover bolts.
11. Remove the valve rocker arm cover.

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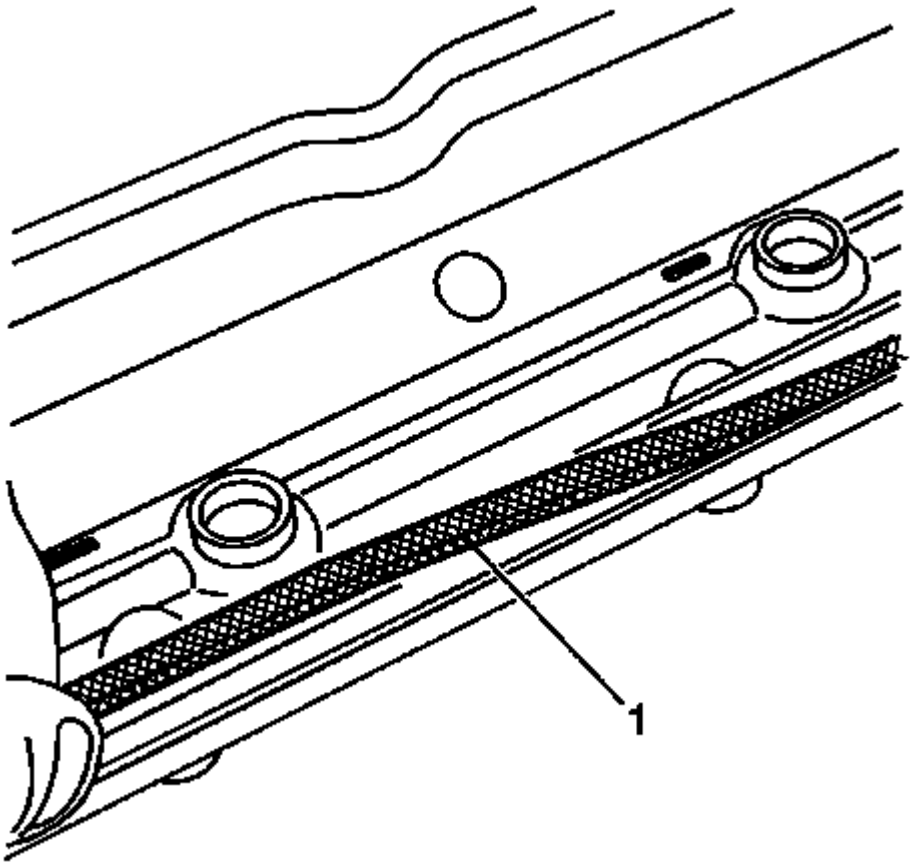

Fig. 136: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

12. Remove the gasket (1) from the rocker cover.
13. Discard the OLD gasket.

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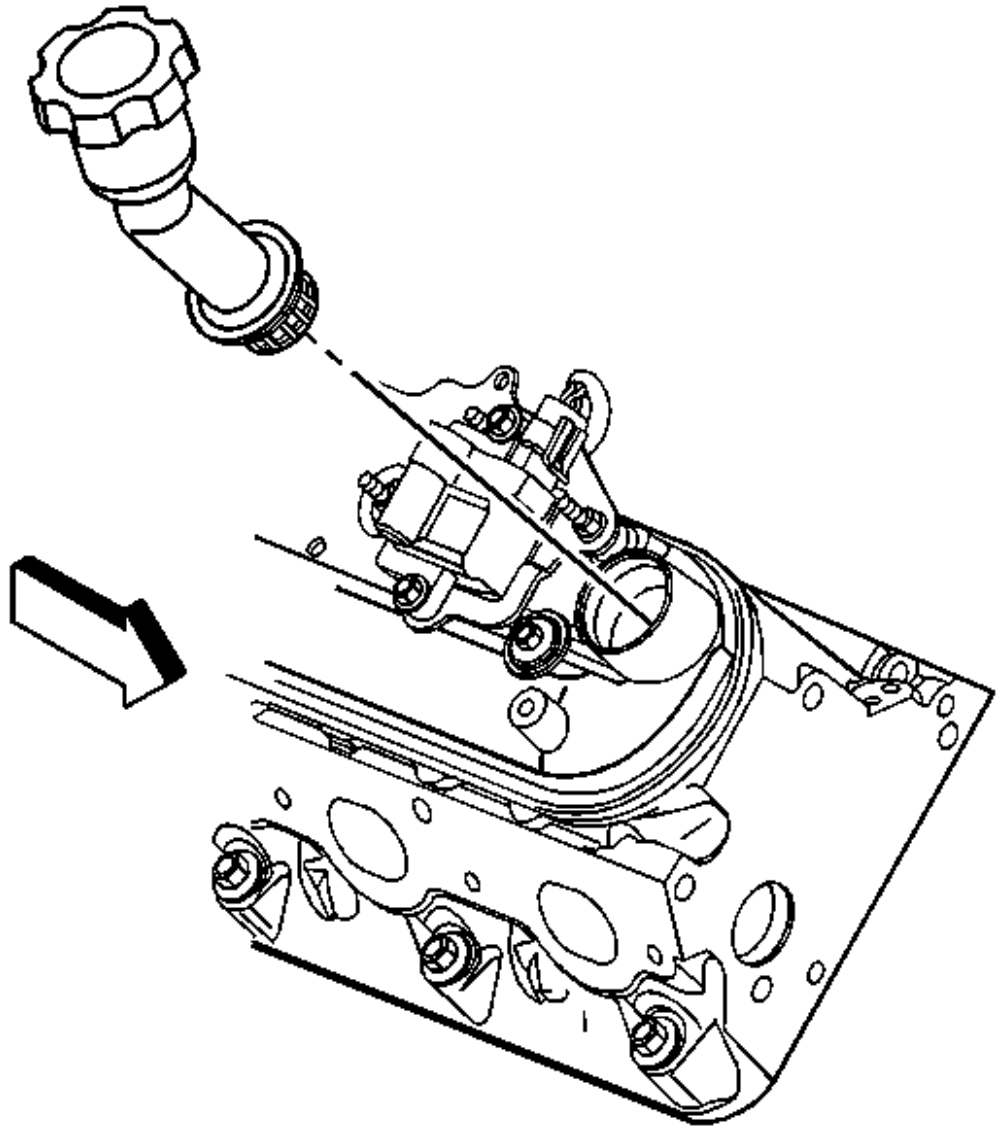

Fig. 137: View Of Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

14. Remove the oil fill cap from the oil fill tube.
15. Remove the oil fill tube from the rocker cover, if required.
16. Discard the oil fill tube.

Installation Procedure

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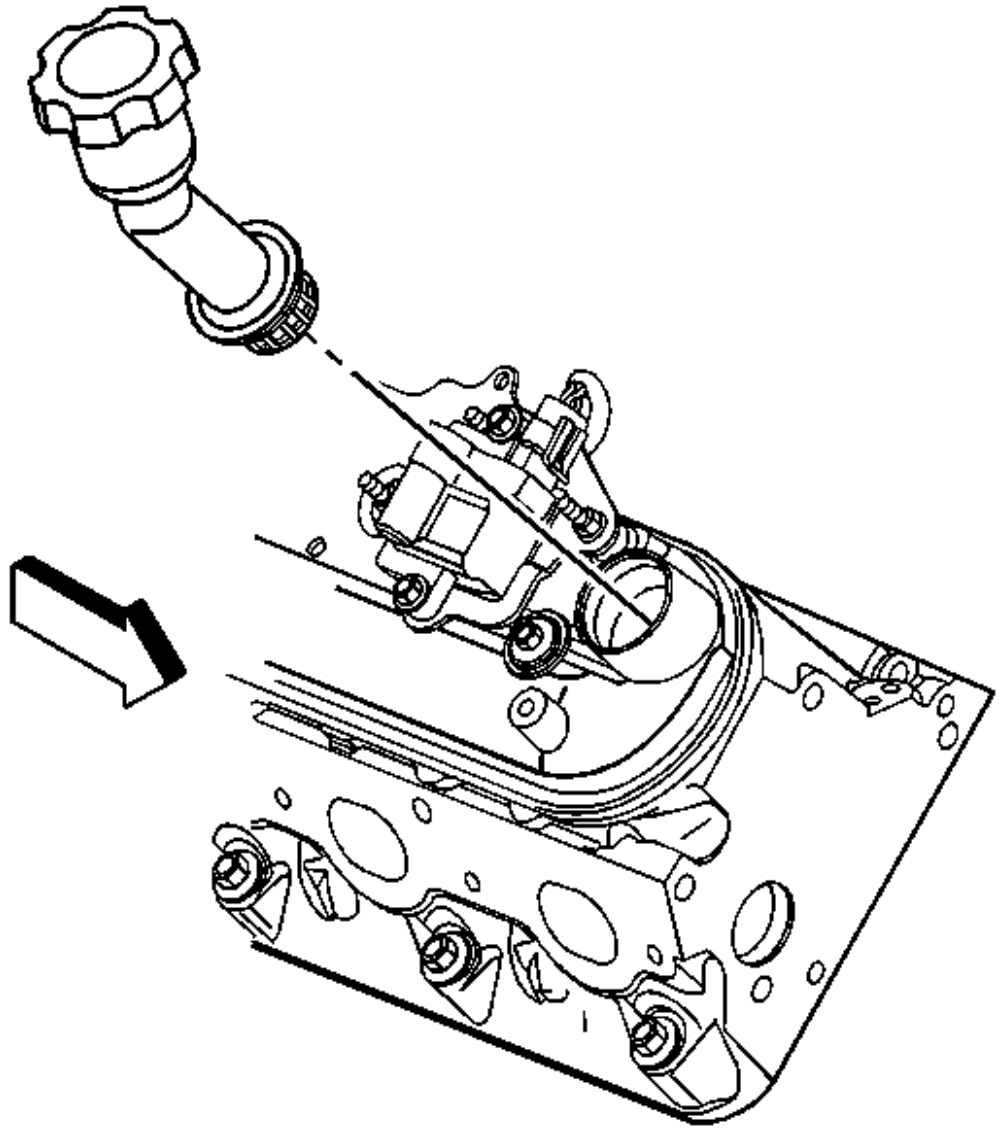

Fig. 138: View Of Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT reuse the valve rocker arm cover gasket.**
- **The valve rocker arm cover bolt grommets may be reused.**

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- **If the oil fill tube has been removed from the rocker arm cover, install a NEW fill tube during assembly.**

1. Lubricate the O-ring seal of the NEW oil fill tube with clean engine oil.
2. Insert the NEW oil fill tube into the rocker arm cover.

   Rotate the tube clockwise until locked in the proper position.

3. Install the oil fill cap into the tube.

   Rotate the cap clockwise until locked in the proper position.

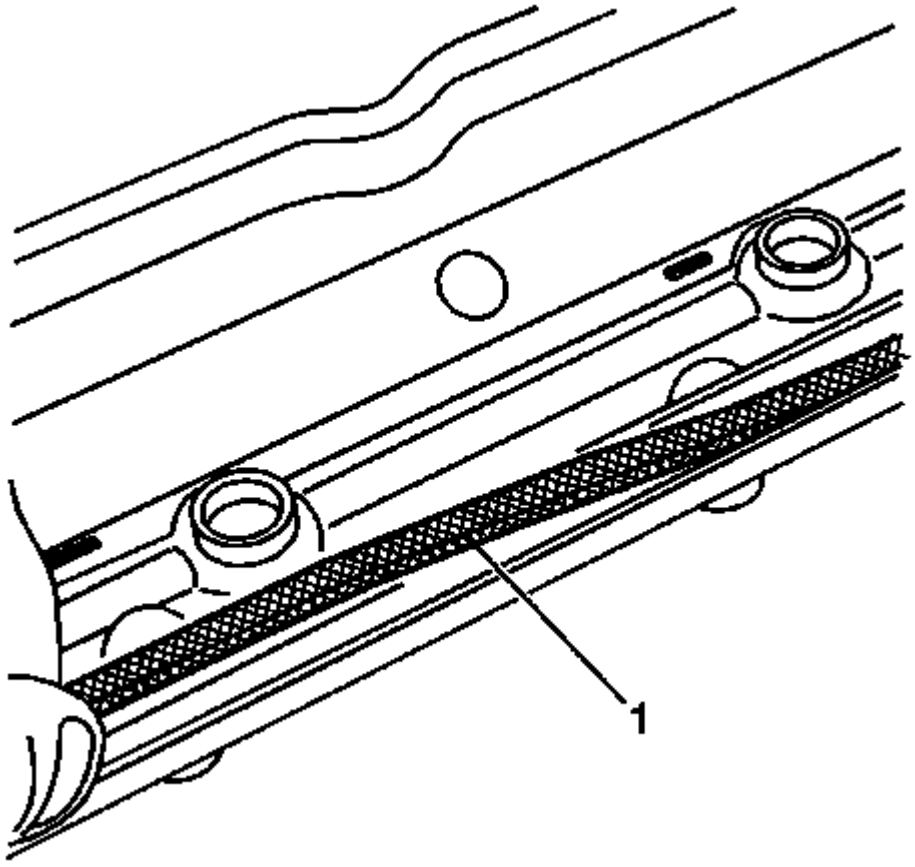

Fig. 139: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

4. Install a NEW rocker cover gasket (1) into the valve rocker arm cover.

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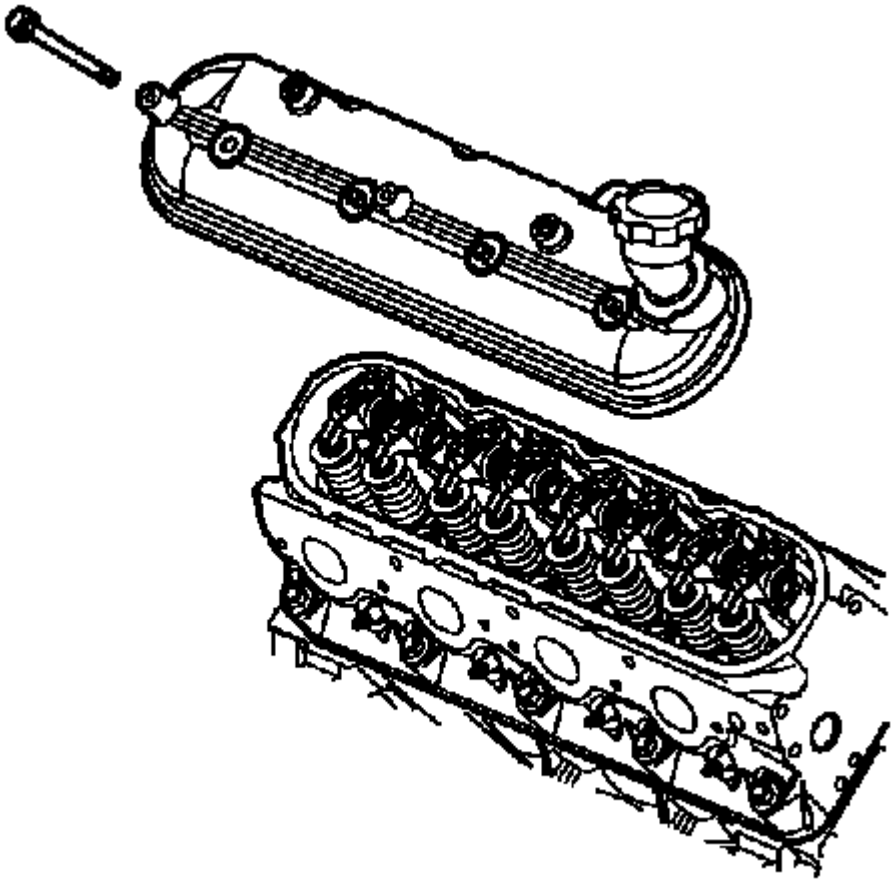

Fig. 140: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

5. Install the valve rocker arm cover onto the cylinder head.
6. Install new rocker arm cover grommets, if necessary.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the rocker arm cover bolts and grommets.

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

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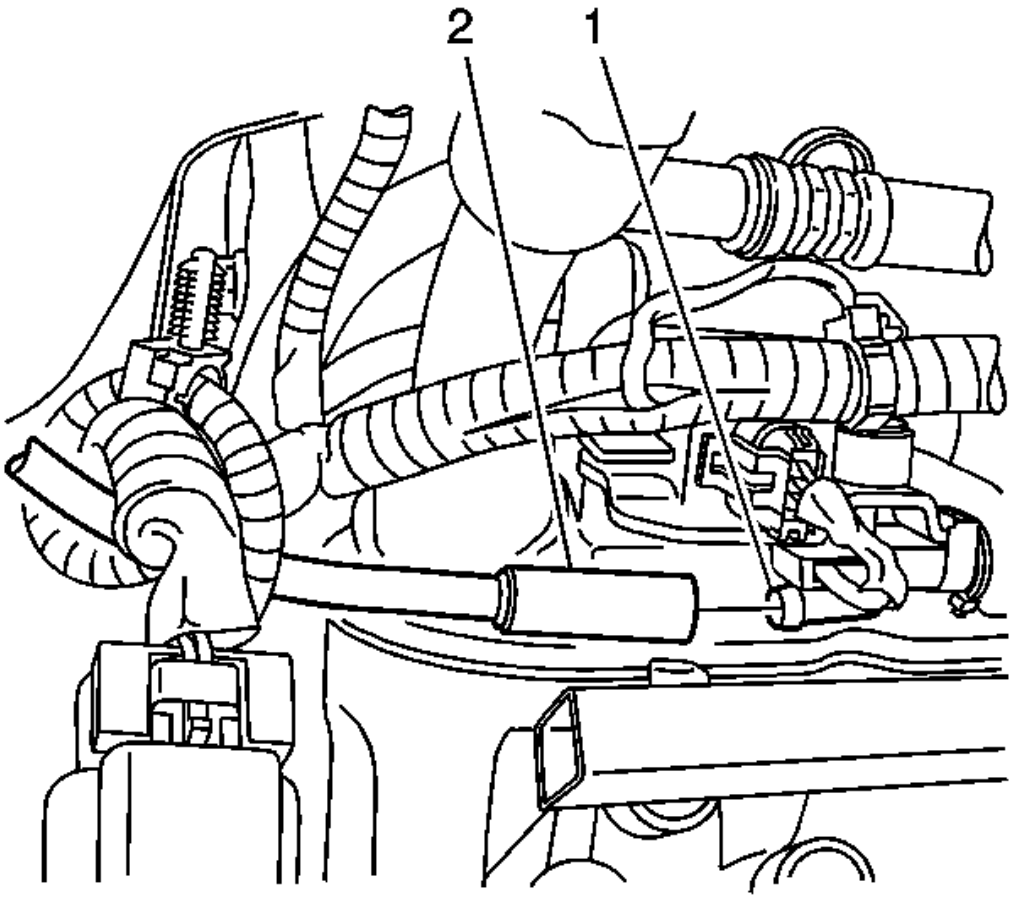

Fig. 141: Vent Hose
Courtesy of GENERAL MOTORS CORP.

8. Install the vent hose (2) to the valve rocker arm cover (1).

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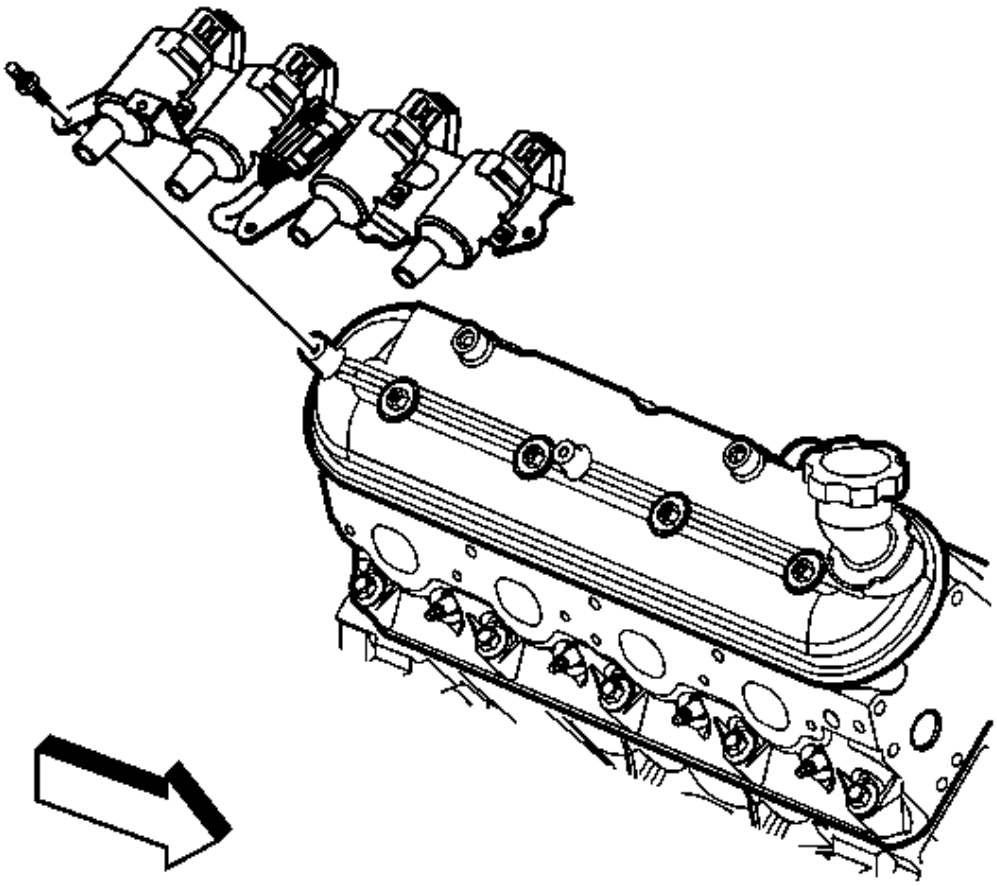

Fig. 142: Ignition Coil View
Courtesy of GENERAL MOTORS CORP.

9. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the bracket bolts.
10. If necessary, install the ignition coils and bracket to the rocker arm cover.
11. If necessary, install the ignition coil bracket studs to the rocker cover.

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

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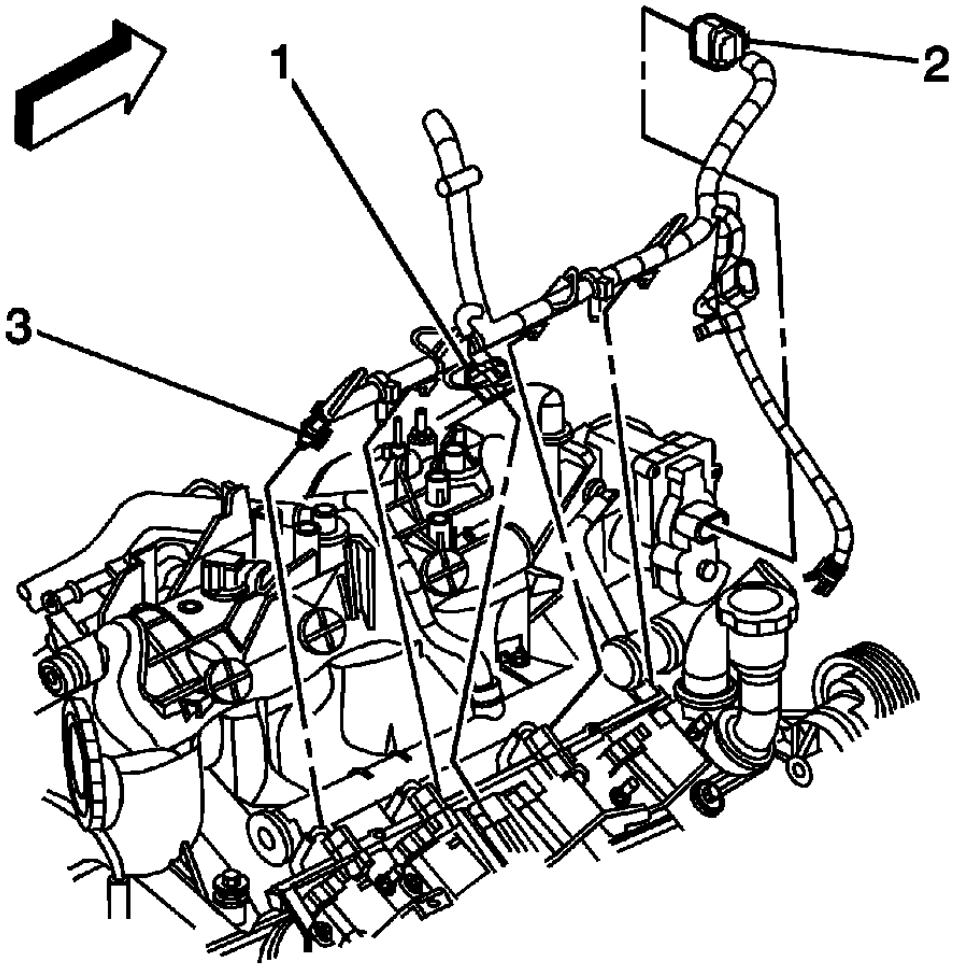

Fig. 143: Locating Electrical Components At Top Of Engine
Courtesy of GENERAL MOTORS CORP.

12. Install the spark plug wires to the ignition coils.
13. Position the engine harness, if necessary.
14. Install the harness clips.
15. Connect the main electrical connector (1) feeding the ignition coils.
16. Install the CPA lock.
17. Install the A/C compressor hose. Refer to **Compressor Hose Assembly Replacement (LM4)** in Heating, Ventilation, and Air Conditioning.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

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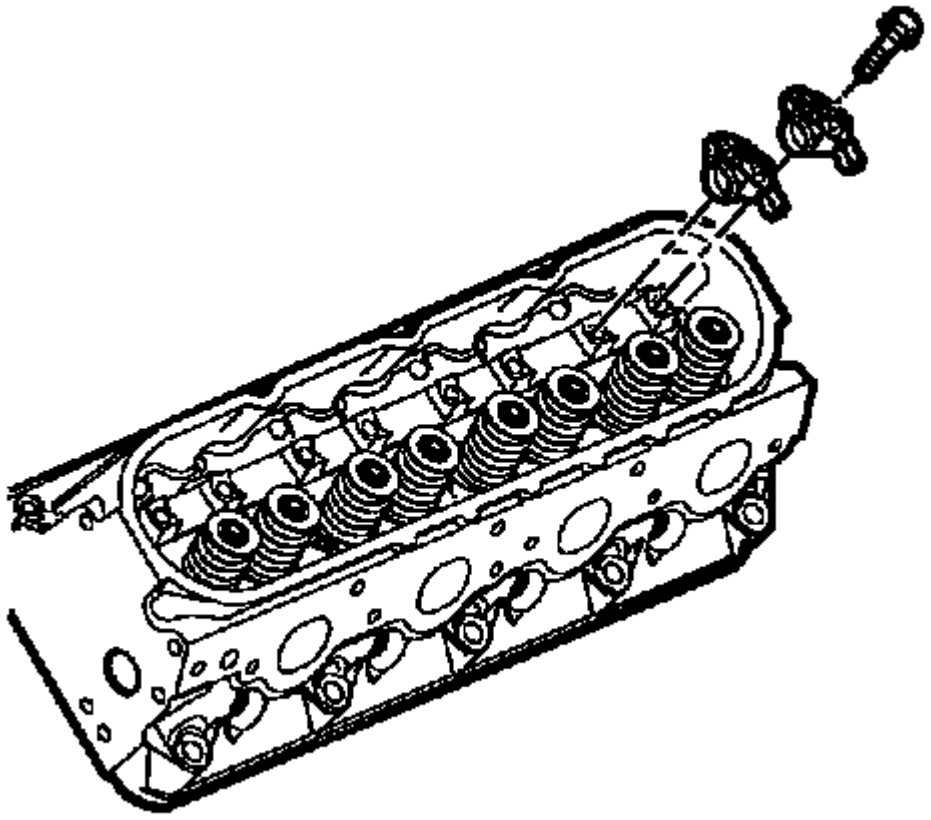

Fig. 144: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve rocker arms, pushrods, and pivot support, in a rack so that the can be installed in the same location from which they were removed.

1. Remove the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** or to **Valve Rocker Arm Cover Replacement - Right**.
2. Remove the valve rocker arm bolts.
3. Remove the valve rocker arms.

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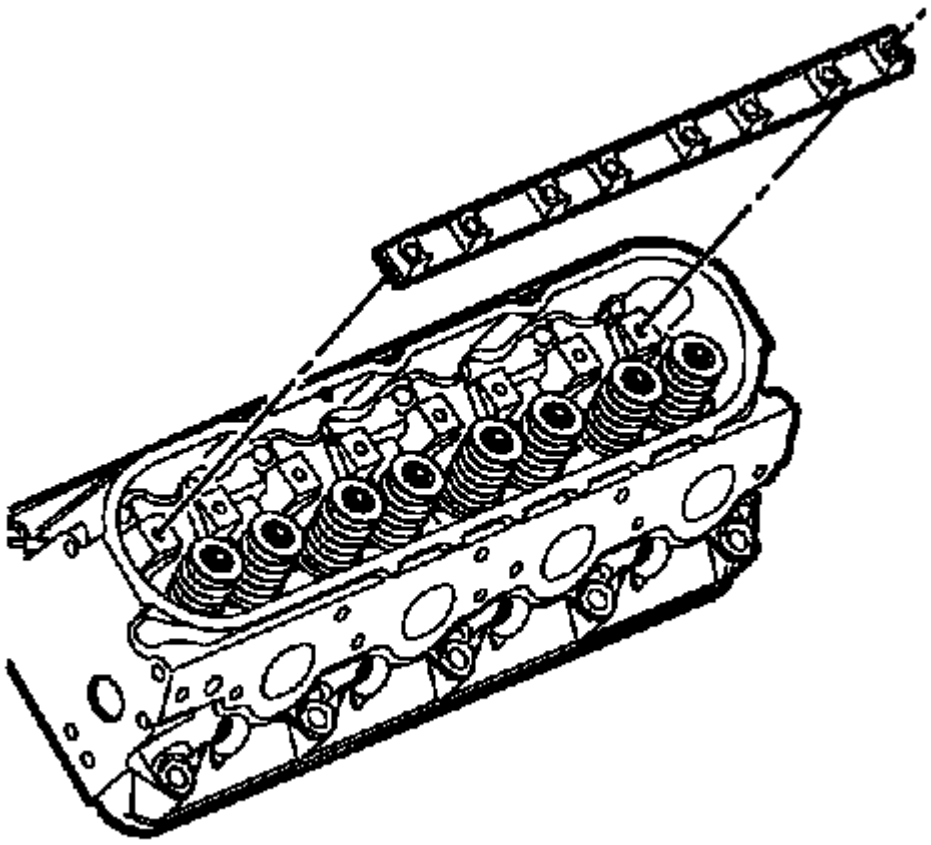

Fig. 145: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm pivot support.

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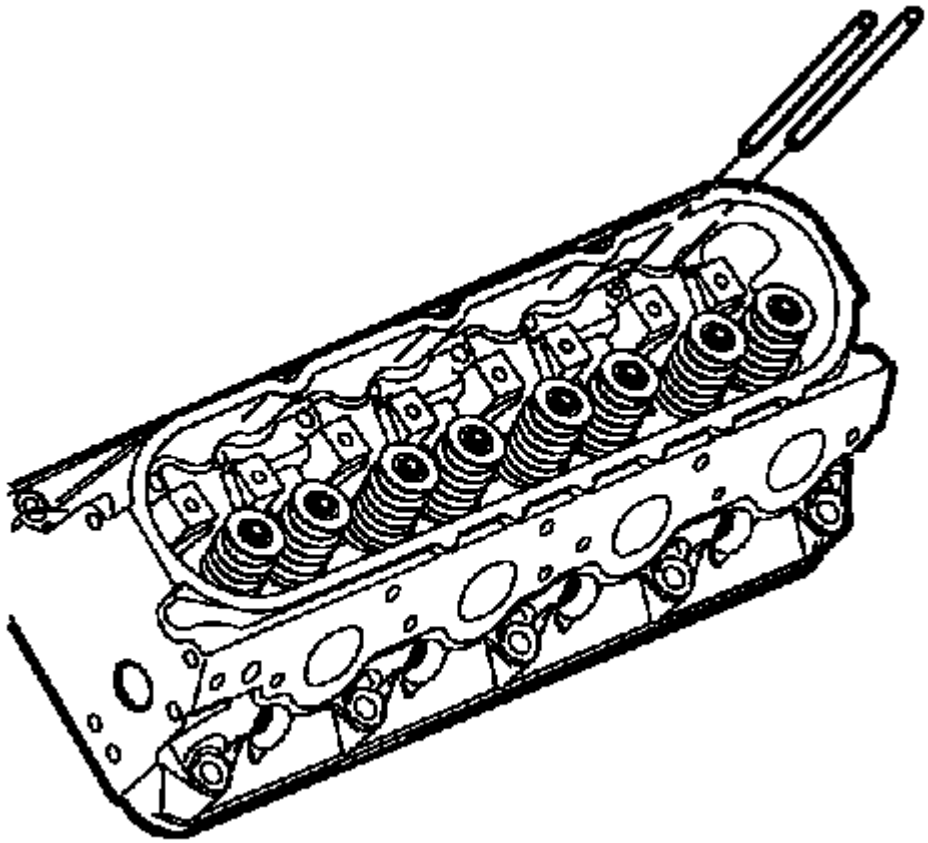

Fig. 146: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

5. Remove the pushrods.
6. Clean and inspect the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection**.

Installation Procedure

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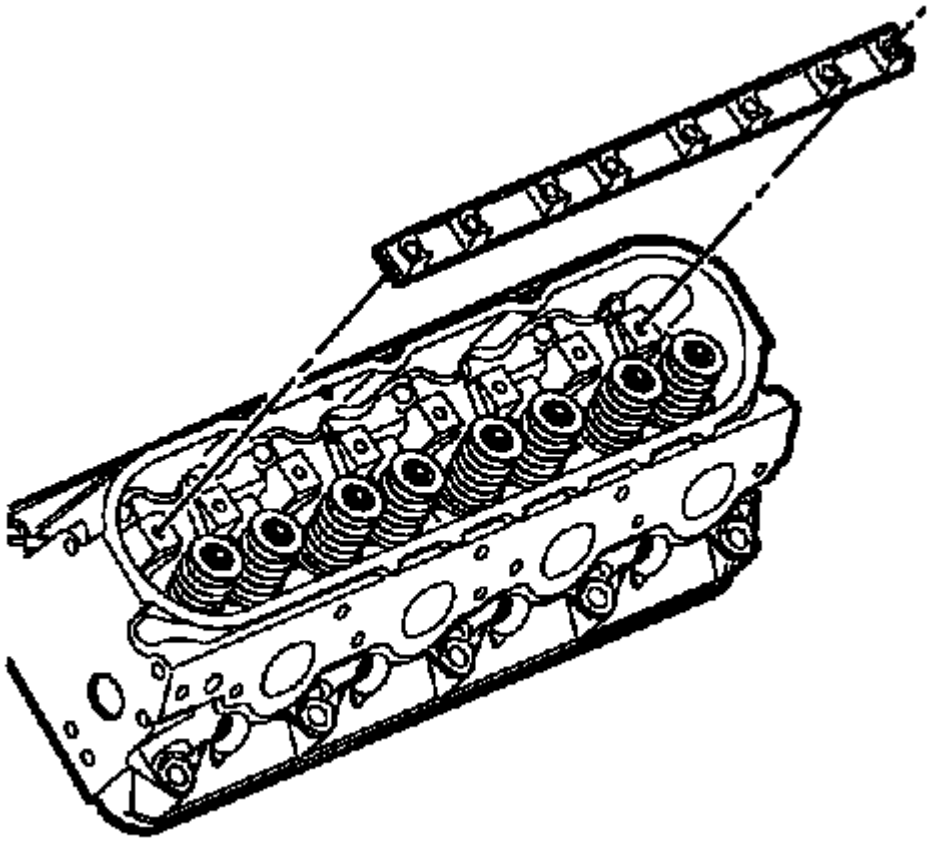

Fig. 147: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When reusing the valve train components, always install the components to the original location and position.
The valve lash is net build, no valve adjustment is required.

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.
3. Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.
4. Install the valve rocker arm pivot support.

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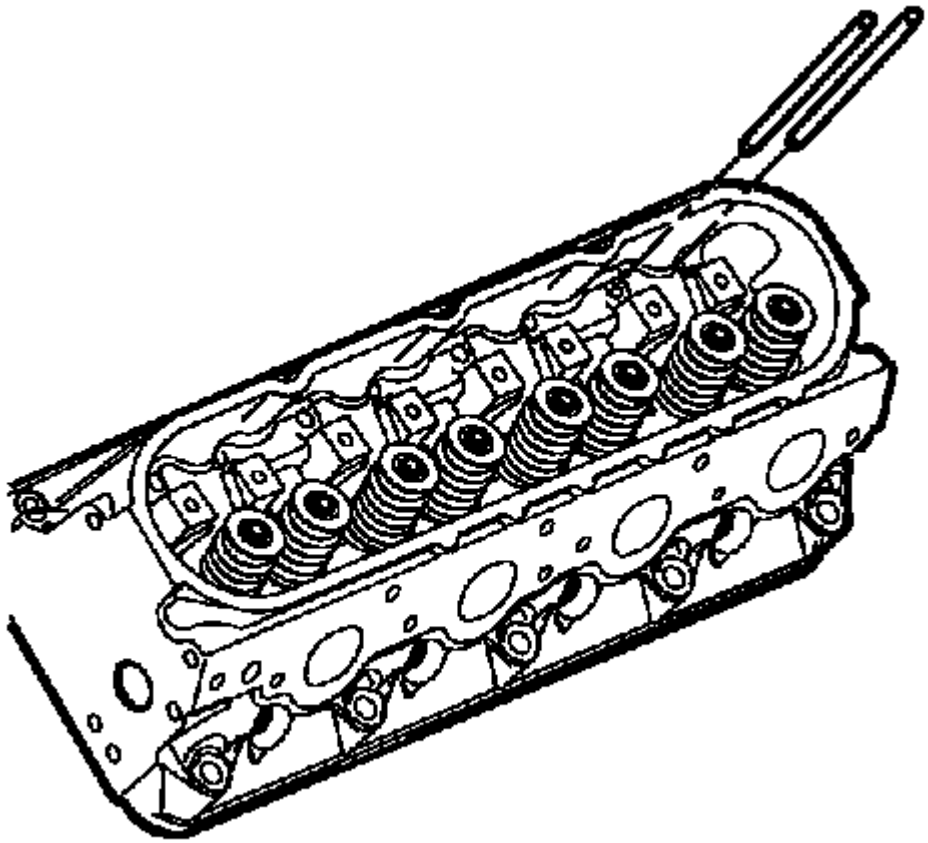

Fig. 148: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that the pushrods seat properly to the valve lifter sockets.

5. Install the pushrods.

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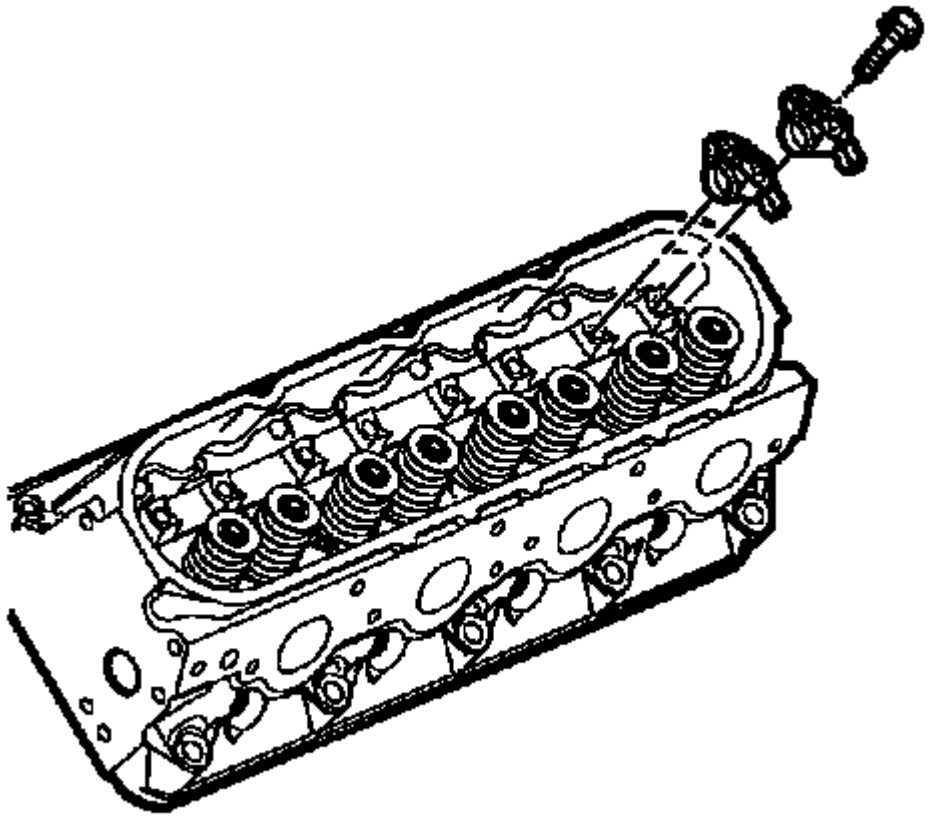

Fig. 149: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Verify that the pushrods seat properly to the ends of the rocker arms. DO NOT tighten the rocker arm bolts at this time.

6. Install the rocker arms and bolts.

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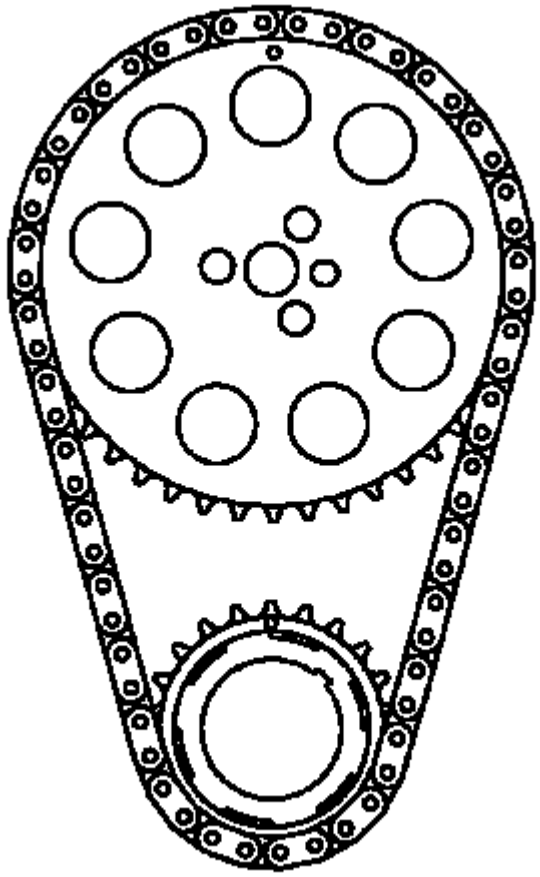

Fig. 150: View of Crankshaft/Camshaft In Position For Number 1 Piston At TDC
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Rotate the crankshaft until the number one piston is at top dead center (TDC) of the compression stroke.

   In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position.

   The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

   Cylinders 1, 3, 5 and 7 are the left bank.

   Cylinder 2, 4, 6 and 8 are the right bank.

8. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

   Tighten:

   - Tighten cylinders 1, 2, 7 and 8 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).

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- Tighten cylinders 1, 3, 4 and 5 intake valve rocker arm bolts to 30 N.m (22 lb ft).

9. Rotate the crankshaft 360 degrees.
10. Tighten the following valve rocker arm bolts:

    Tighten:
    - Tighten cylinders 3, 4, 5 and 6 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
    - Tighten cylinders 2, 6, 7 and 8 intake valve rocker arm bolts to 30 N.m (22 lb ft).

11. Install the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** or to **Valve Rocker Arm Cover Replacement - Right**.

Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- **J 22794** Spark Plug Port Adapter. See **Special Tools**.
- **J 38606** Valve Spring Compressor. See **Special Tools**.

Removal Procedure

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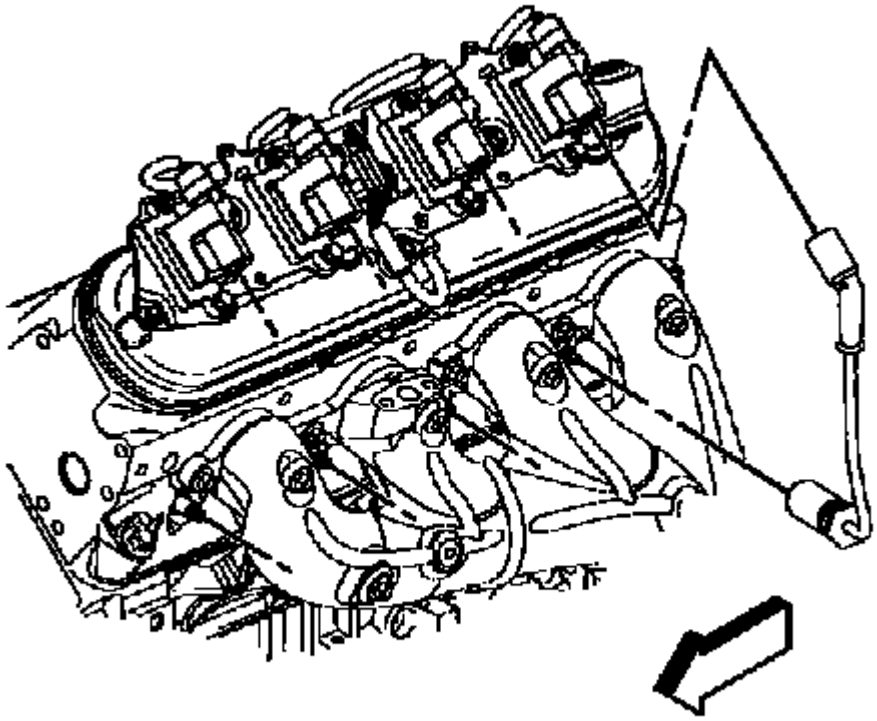

Fig. 151: View Of Spark Plug Wire & Boot
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Disconnect the spark plug wire at the spark plug.
   - Twist each plug wire boot 1/2 turn.
   - Pull only on the boot in order to remove the wire from the spark plug.

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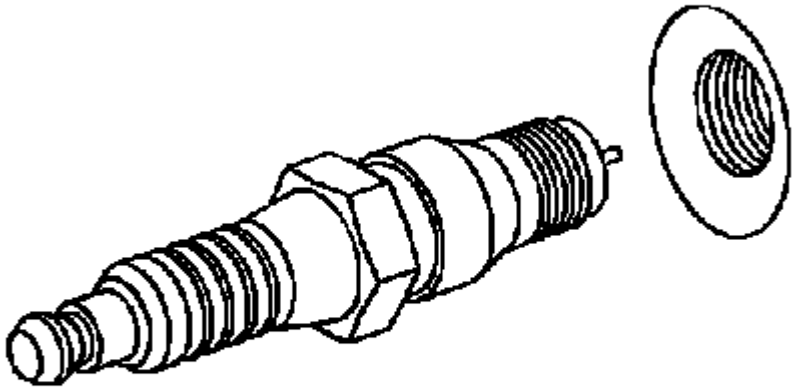

Fig. 152: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the spark plugs from the cylinder head with the engine at room temperature.

3. Loosen the spark plug 1-2 turns.
4. Brush or air blast away any dirt or debris from around the spark plug.
5. Remove the spark plug.

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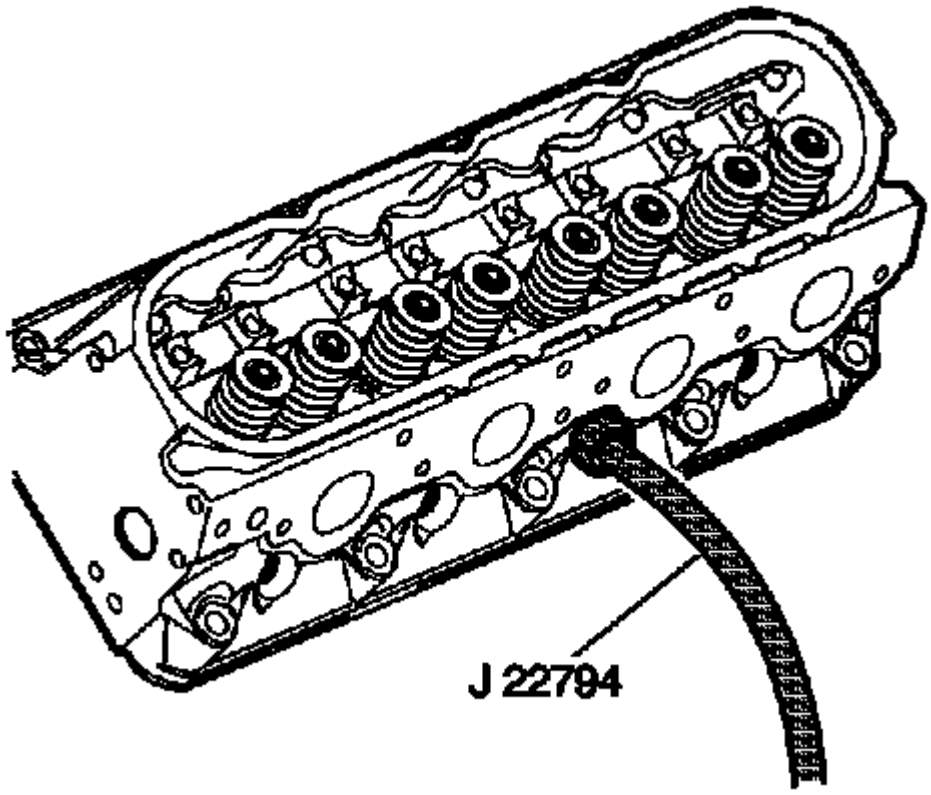

Fig. 153: Applying Compressed Air To J 22794
Courtesy of GENERAL MOTORS CORP.

6. Install**J 22794** into the spark plug hole. See **Special Tools**.
7. Attach an air hose to **J 22794** . See **Special Tools**.
8. Apply compressed air to **J 22794** in order to hold the valves in place. See **Special Tools**.

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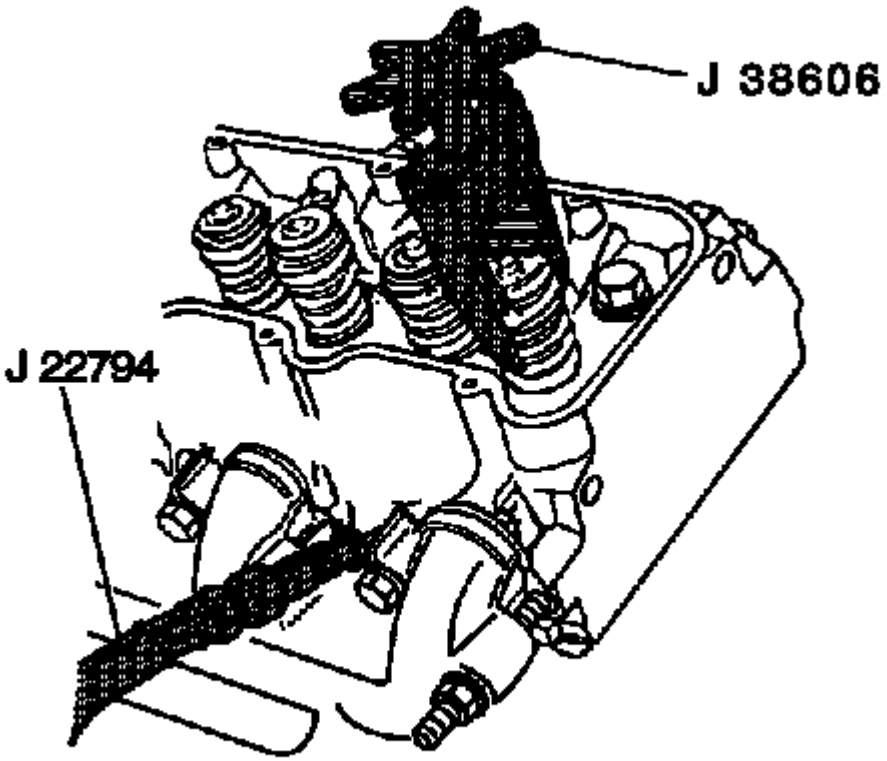

Fig. 154: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

9. Use **J 38606** in order to compress the valve spring. See **Special Tools**.

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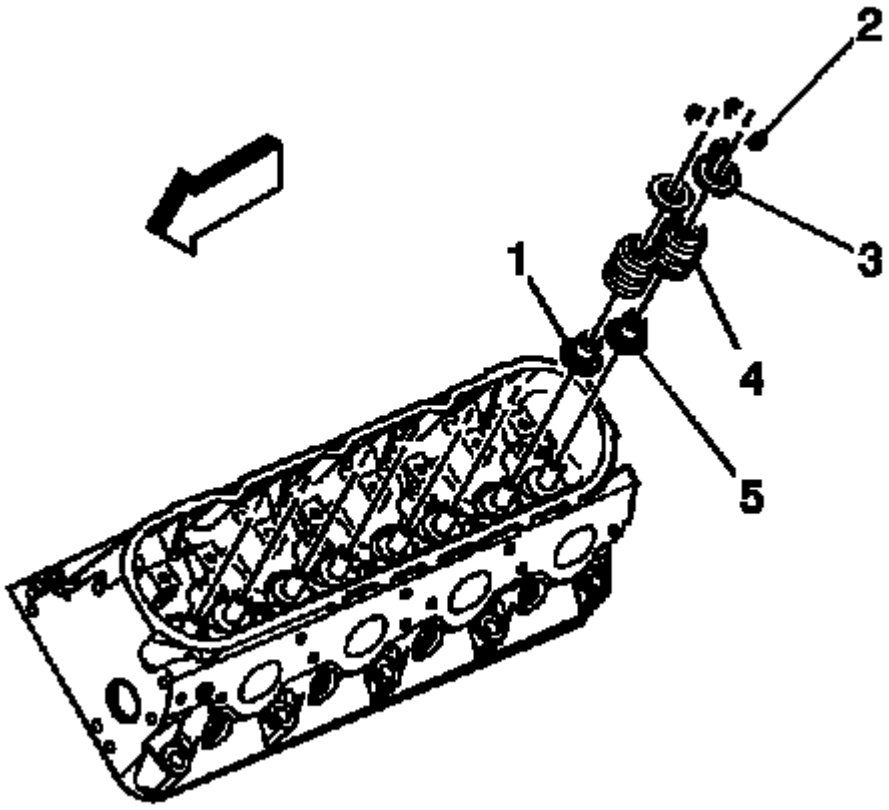

Fig. 155: View Of Valve Stem & Valve Spring Components
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve stem keys (2).
11. Carefully release the valve spring tension.
12. Remove **J 38606** . See **Special Tools**.
13. Remove the valve spring cap (3).
14. Remove the valve spring (4).
15. Remove the valve stem oil seal/shim assembly (1, 5).

Installation Procedure

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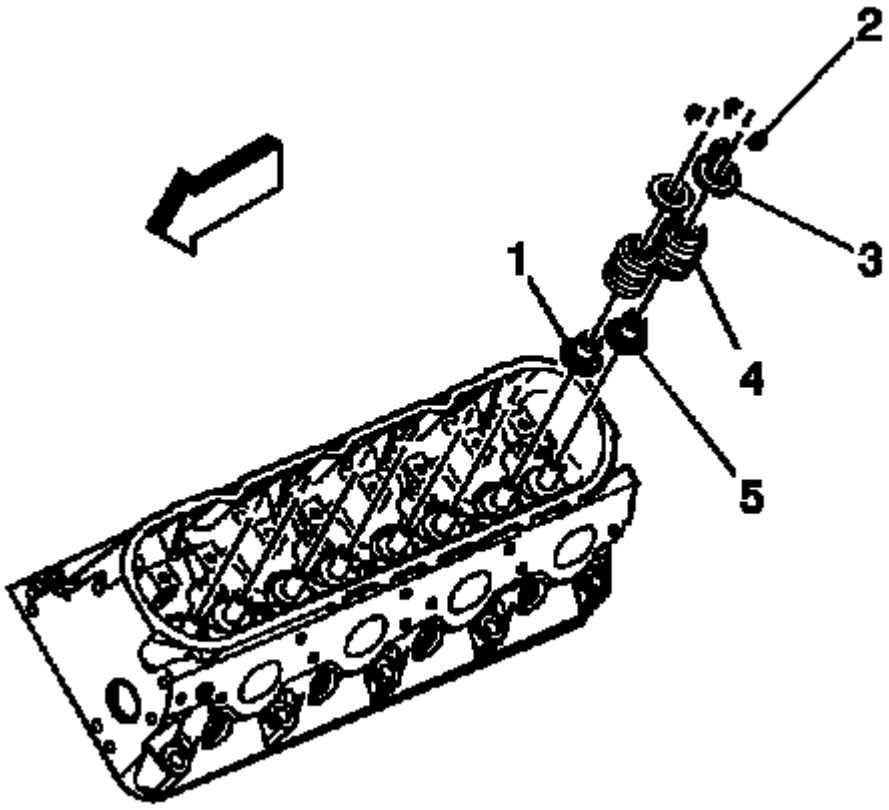

Fig. 156: View Of Valve Stem & Valve Spring Components
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring seat and/or shim area.
2. Lubricate the valve guide and valve stem oil seal with clean engine oil.
3. Install the valve stem oil seal/shim assembly (1, 5).
4. Install the valve spring (4).
5. Install the valve spring cap (3).

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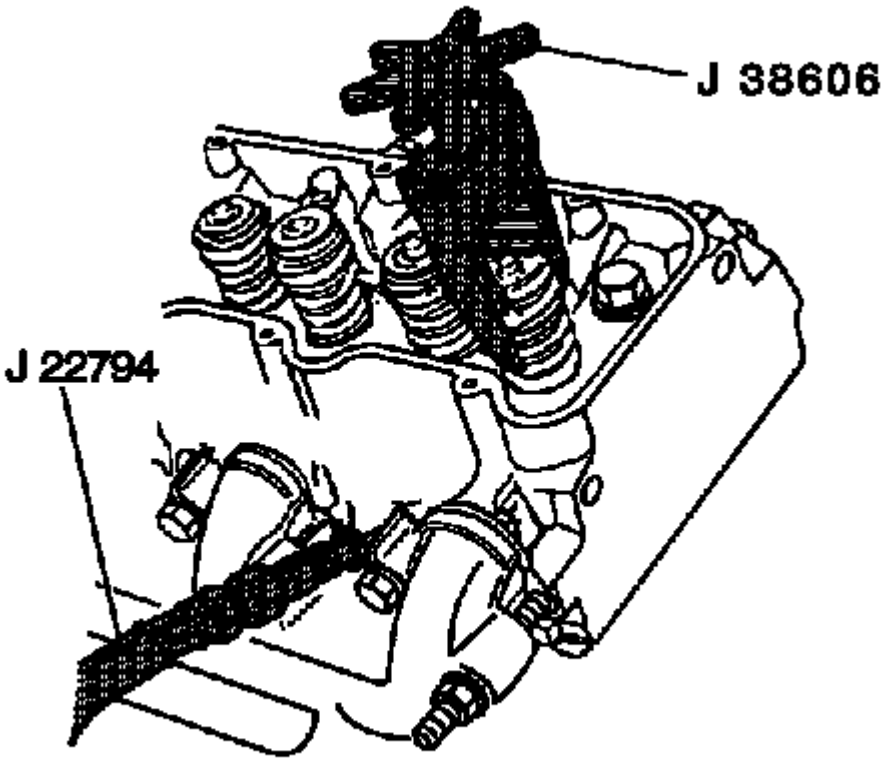

Fig. 157: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve spring using the **J 38606** . See **Special Tools**.
7. Install the valve keys.
    1. Use grease in order to hold the valve keys in place.
    2. Make sure the keys seat properly in the groove of the valve stem.
    3. Carefully release the valve spring pressure, making sure the valve keys stay in place.
    4. Remove **J 38606** . See **Special Tools**.
    5. Tap the end of the valve stem with a plastic faced hammer to seat the keys (if necessary).

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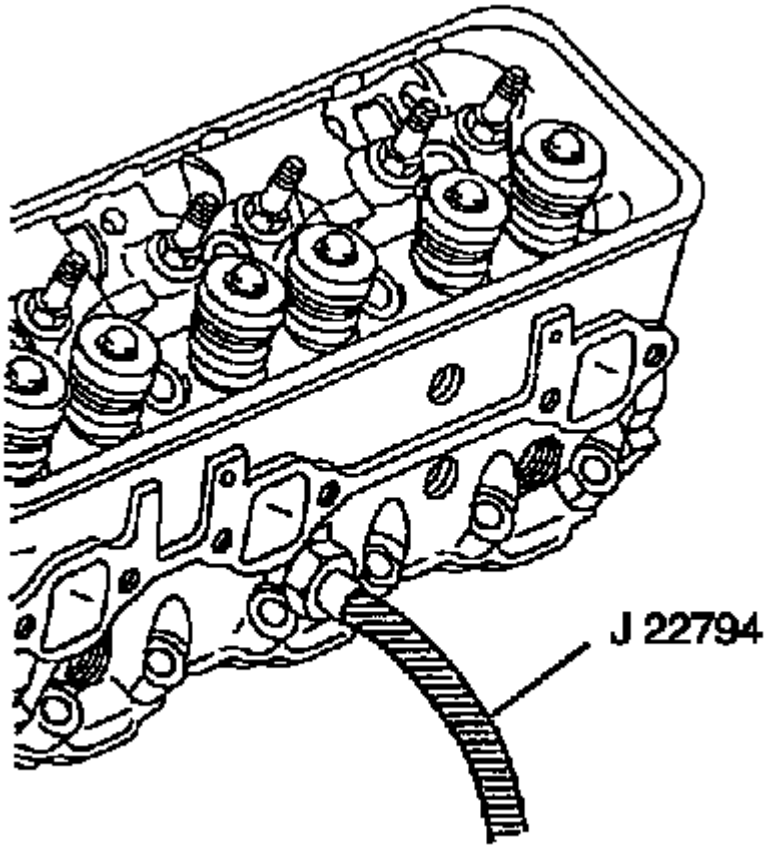

Fig. 158: View Of J 22794
Courtesy of GENERAL MOTORS CORP.

8. Remove**J 22794** from the spark plug port. See **Special Tools**.

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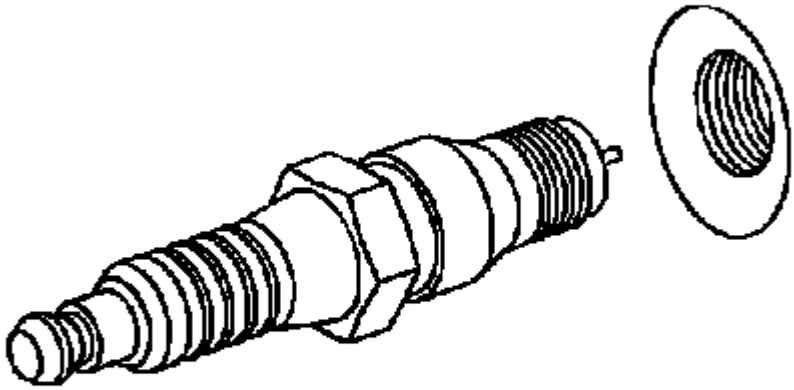

Fig. 159: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

9. Hand start the spark plug.

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

10. Install the spark plug wires at the ignition coil.
11. Install the spark plug wire to the spark plug.
12. Inspect the wires for proper installation:
    - Push sideways on each boot in order to check for proper installation.
    - Reinstall any loose boot.
13. Install the valve rocker arm. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Oil Level Indicator and Tube Replacement

Removal Procedure

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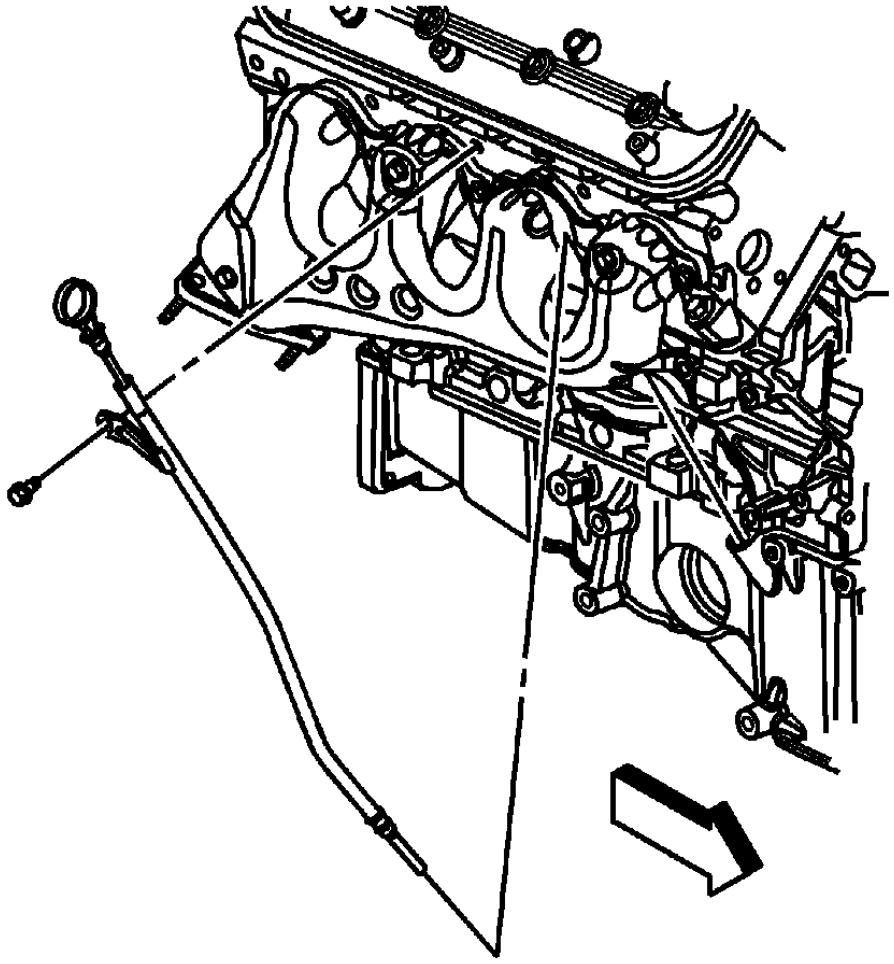

Fig. 160: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder number 2 spark plug and wire. Refer to **Spark Plug Replacement** in Engine Controls - 5.3L.
2. Remove the oil level indicator from the tube.
3. Remove the oil level indicator tube bolt.
4. Remove the oil level indicator tube from the engine block.

IMPORTANT: The O-ring seal may be reused if not cut or damaged.

5. Inspect the O-ring seal for cuts or damage.
6. Remove the O-ring seal from the tube, if required.

Installation Procedure

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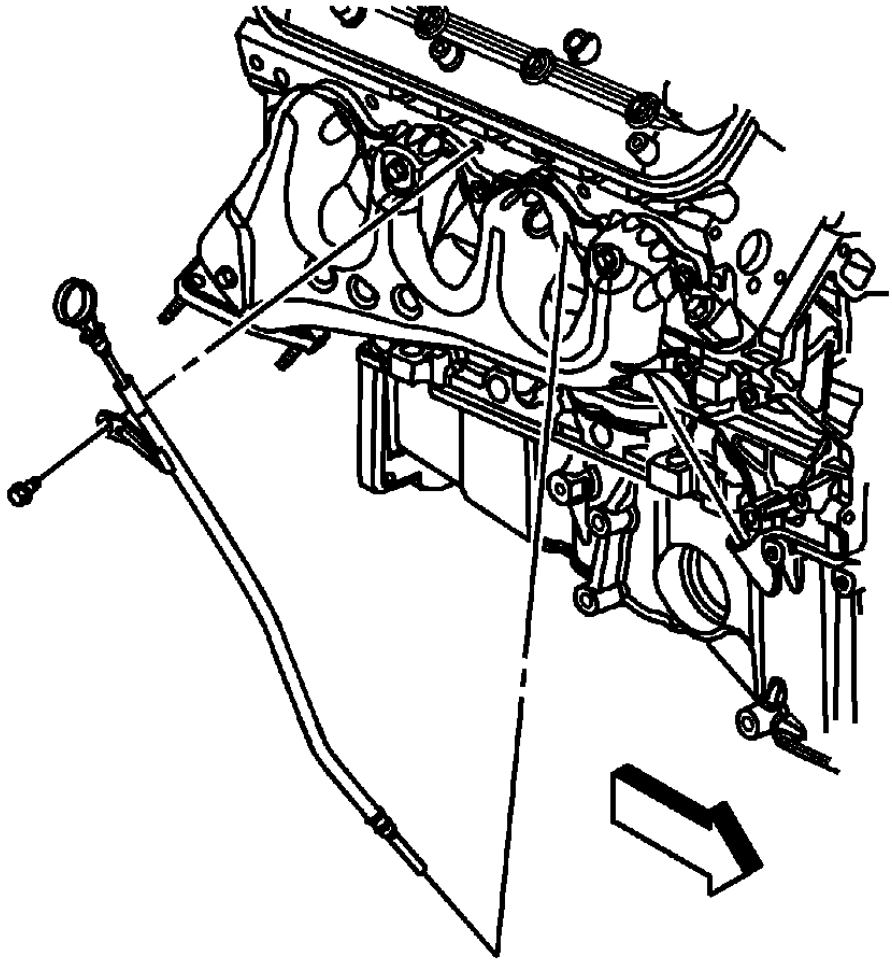

Fig. 161: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the O-ring seal with clean engine oil.
2. Install the O-ring seal onto the oil level indicator tube.
3. Install the oil level indicator tube behind the exhaust manifold.
4. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
5. Install the oil level indicator tube into the block. Install the tube with the collar flush to the block.
6. Lower the vehicle.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the oil level indicator tube bolt

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

8. Install the oil level indicator to the tube.

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9. Install the cylinder number 2 spark plug and wire. Refer to **Spark Plug Replacement** in Engine Controls - 5.3L.

Cylinder Head Replacement - Left

Tools Required

J 45059 Angle Meter

Removal Procedure

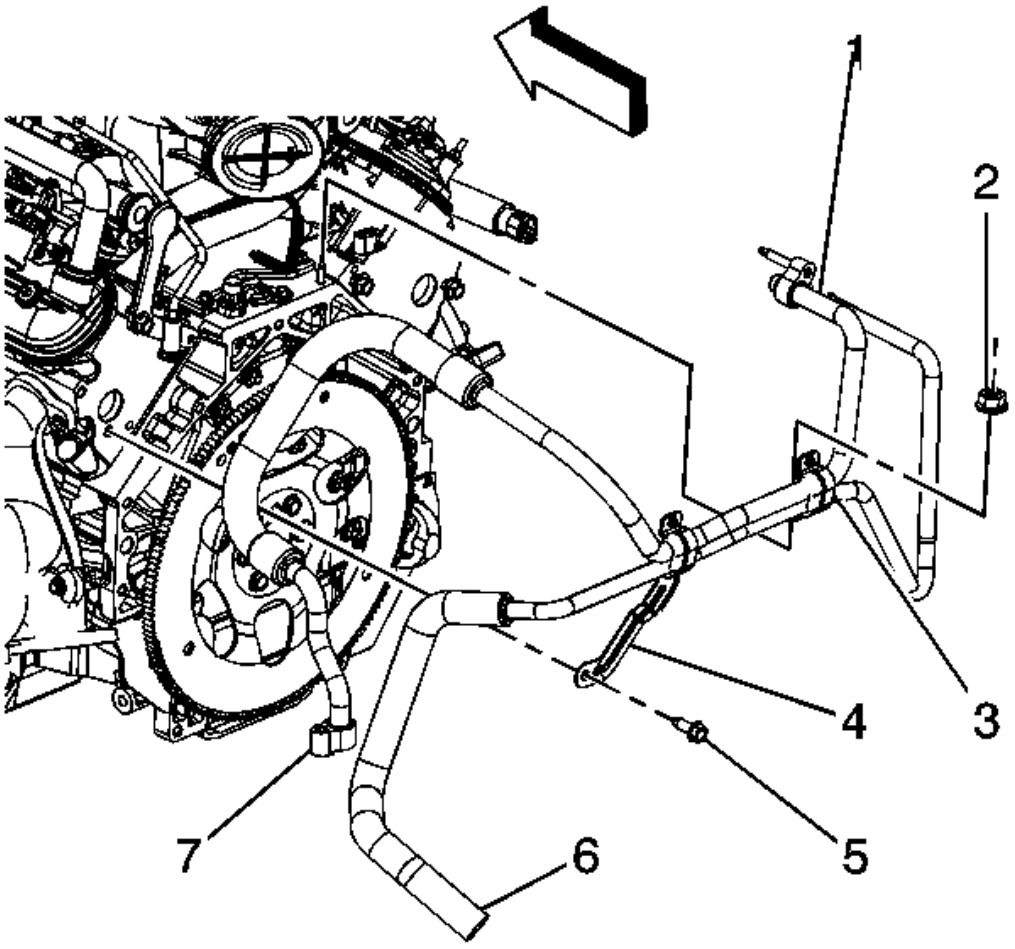

Fig. 162: View Of Rear A/C Lines
Courtesy of GENERAL MOTORS CORP.

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1. Remove the generator bracket. Refer to **Generator Bracket Replacement (5.3L Engine)** in Engine Electrical.
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement (5.3L Engine)** in Engine Cooling.
3. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. If equipped, remove the auxiliary air conditioning (A/C) bracket bolt (5).
6. Remove the cylinder head. Refer to **Cylinder Head Removal - Left**.
7. Clean and inspect the cylinder head. Refer to **Fastener Notice** **Cylinder Head Cleaning and Inspection**.

Installation Procedure

1. Install the cylinder head. Refer to **Cylinder Head Installation - Left**.

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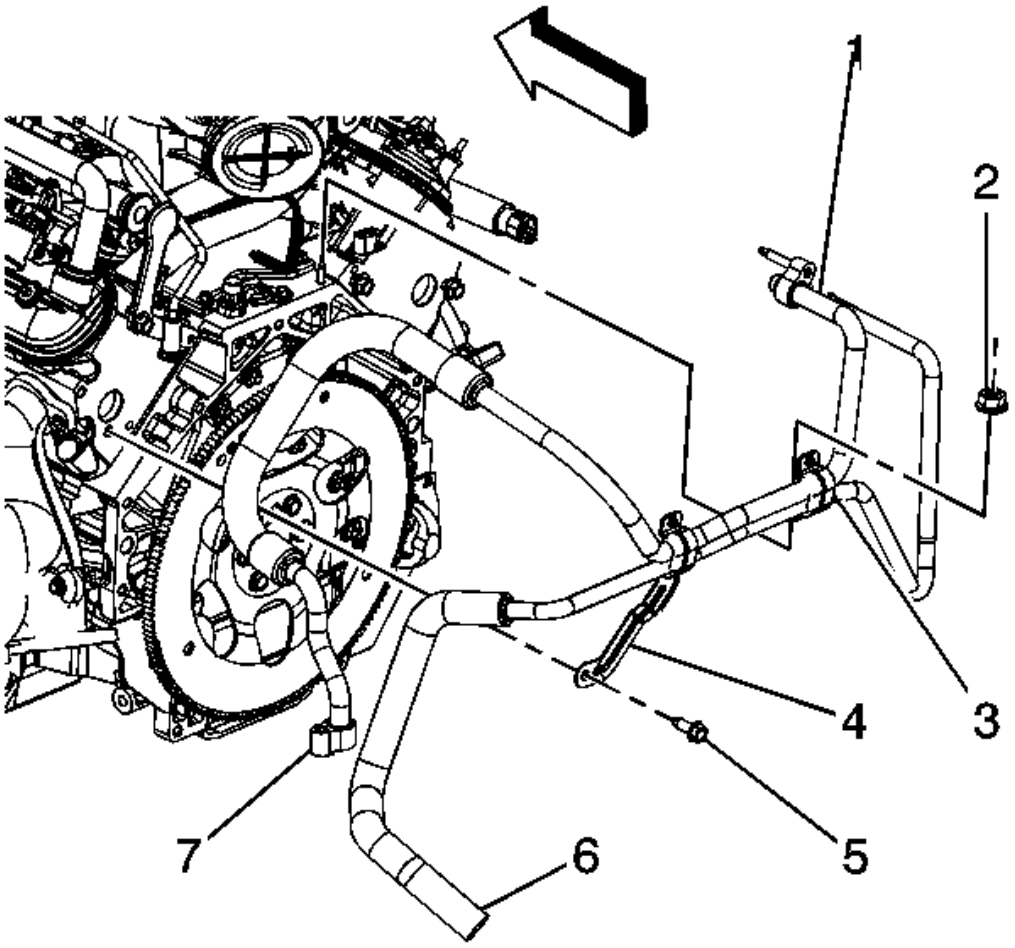

Fig. 163: View Of Rear A/C Lines
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. If equipped, install the auxiliary A/C bracket bolt (5).

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

3. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
4. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left** in Engine Exhaust.
5. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement (5.3L Engine)** in Engine Cooling.

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6. Install the generator bracket. Refer to **Generator Bracket Replacement (5.3L Engine)** in Engine Electrical.

Cylinder Head Replacement - Right

Tools Required

J 45059 Angle Meter

Removal Procedure

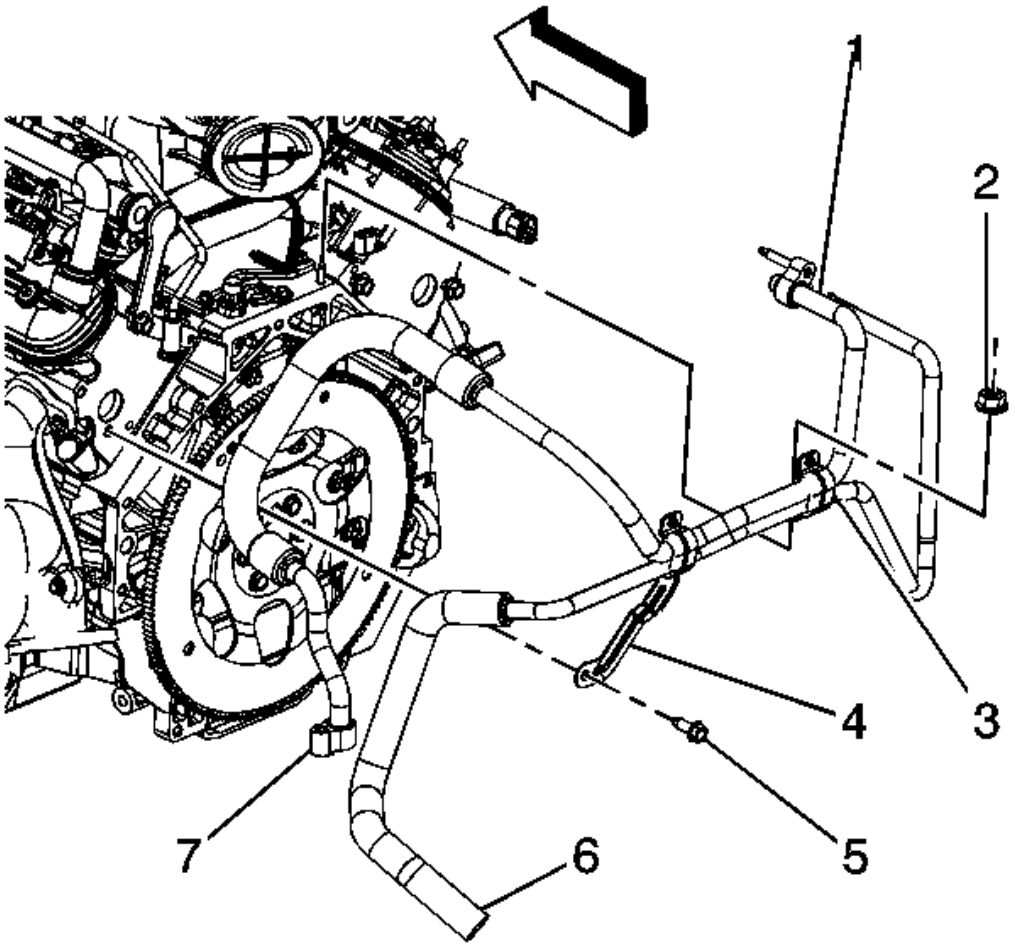

Fig. 164: View Of Rear A/C Lines
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement**.
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement (5.3L Engine)** in Engine Cooling.
3. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
5. If equipped, remove the auxiliary air conditioning (A/C) bracket nut (2).
6. Remove the cylinder head. Refer to **Cylinder Head Removal - Right**.
7. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

1. Install the cylinder head. Refer to **Cylinder Head Installation - Right**.

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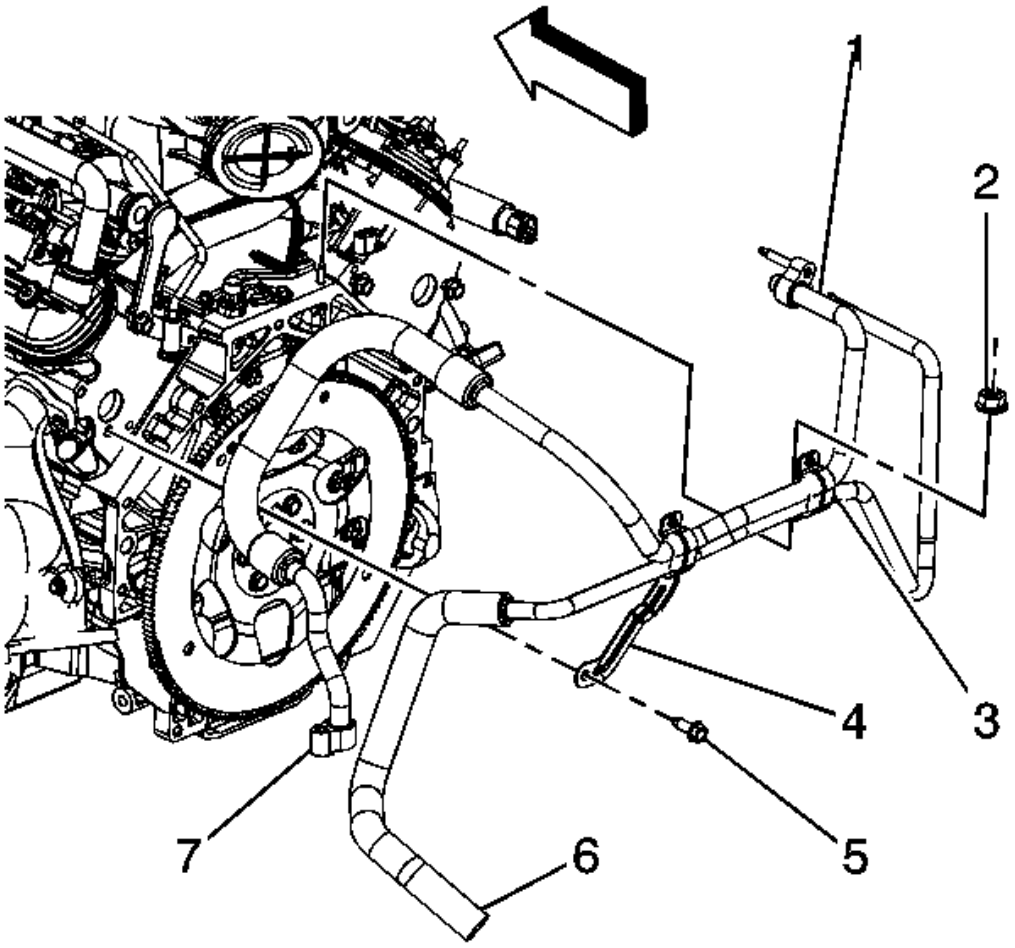

Fig. 165: View Of Rear A/C Lines
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. If equipped, install the auxiliary air conditioning (A/C) bracket nut (2).

   Tighten: Tighten the nut to 20 N.m (15 lb ft).

3. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
4. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right** in Engine Exhaust.
5. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement (5.3L Engine)** in Engine Cooling.

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6. Install the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement**.

Valve Lifter Replacement

Tools Required

J 3049-A Valve Lifter Remover. See **Special Tools**.

Removal Procedure

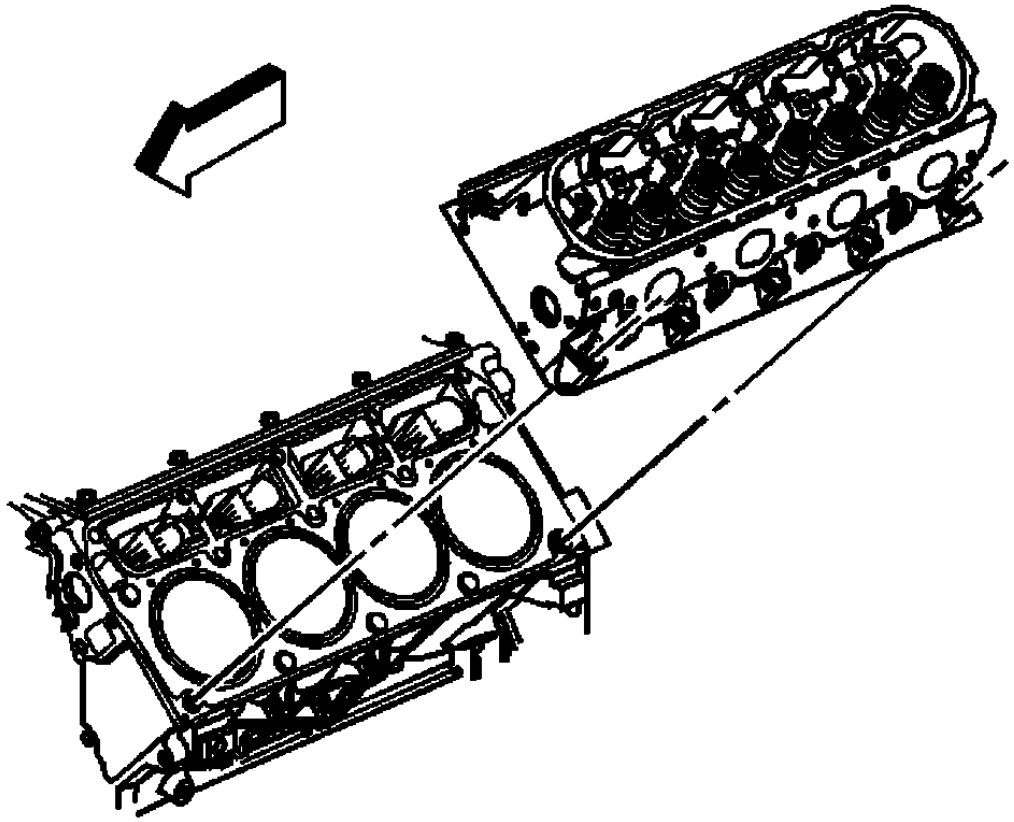

Fig. 166: View Of Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head and gasket. Refer to **Cylinder Head Replacement - Left** or to **Cylinder Head Replacement - Right**.

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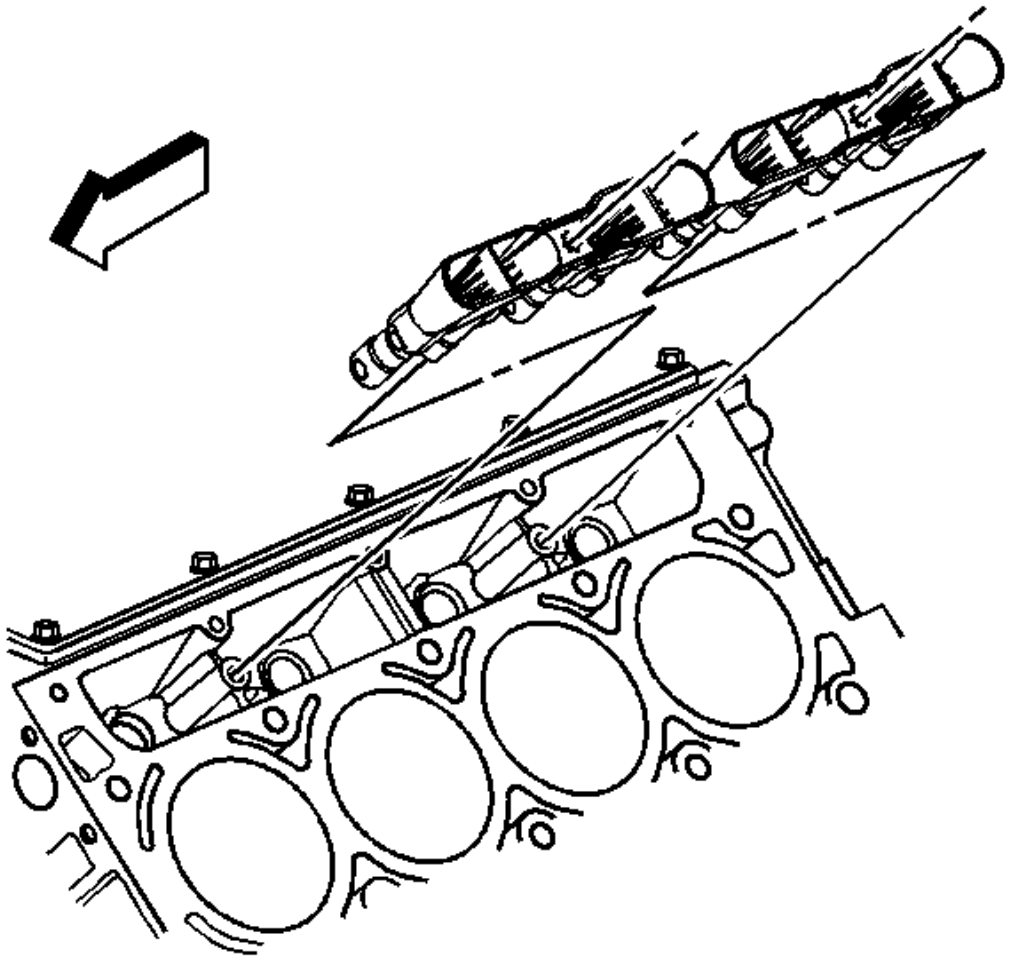

Fig. 167: View Of Valve Lifters & Guide
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve lifter. Refer to **Valve Lifter Removal**.
3. Clean and inspect the valve lifters. Refer to **Valve Lifters and Guides Cleaning and Inspection**.

Installation Procedure

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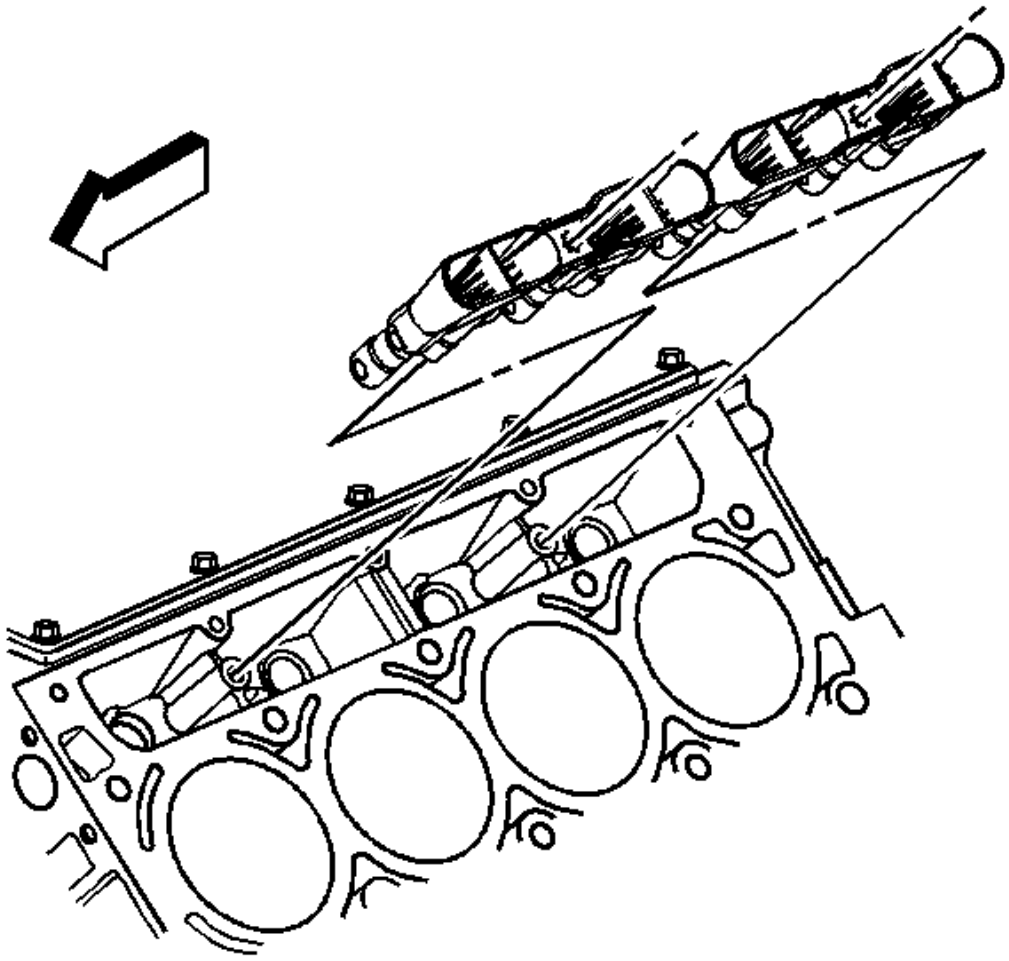

Fig. 168: View Of Valve Lifters & Guide
Courtesy of GENERAL MOTORS CORP.

1. Install the valve lifter. Refer to **Valve Lifter Installation**.

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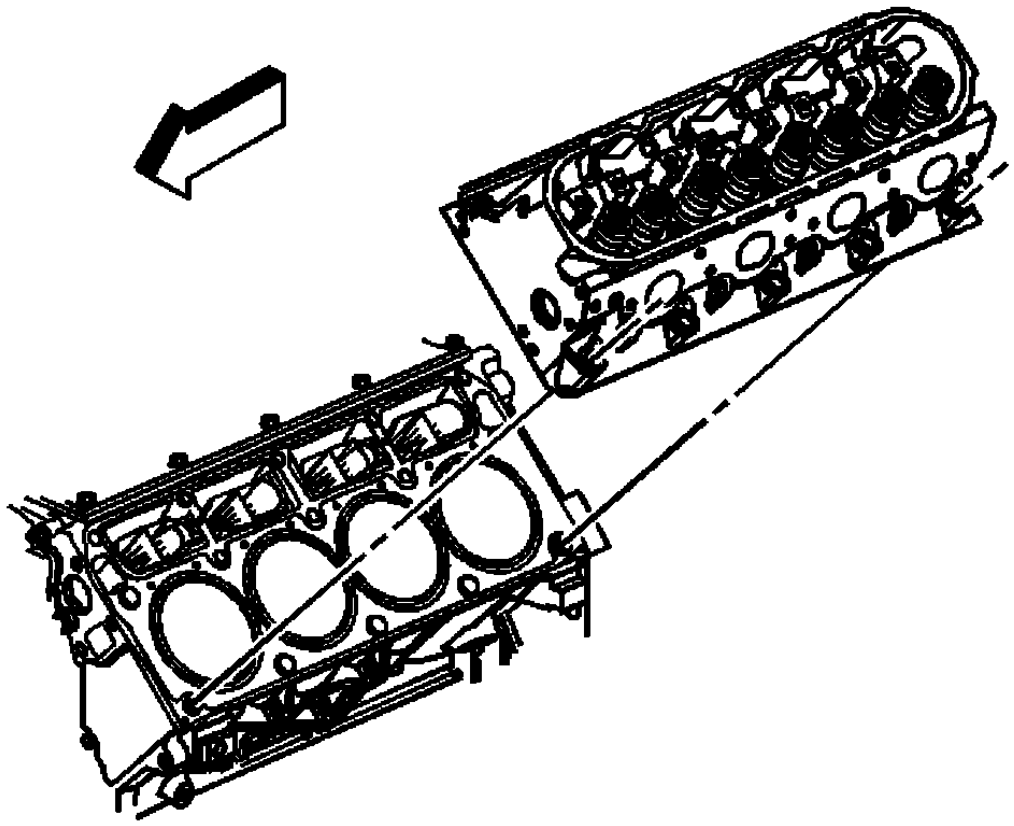

Fig. 169: View Of Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

2. Install the cylinder head and gasket. Refer to **Cylinder Head Replacement - Left** or to **Cylinder Head Replacement - Right**.

Crankshaft Balancer Replacement

Tools Required

- **J 41816** Crankshaft Balancer Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

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1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Remove the air conditioning (A/C) drive belt, if equipped. Refer to **Drive Belt Replacement - Air Conditioning**.
3. Remove the fan shroud. Refer to **Cooling Fan and Shroud Replacement** in Engine Cooling.
4. Remove the starter motor. Refer to **Starter Motor Replacement (5.3L Engine)** in Engine Electrical.

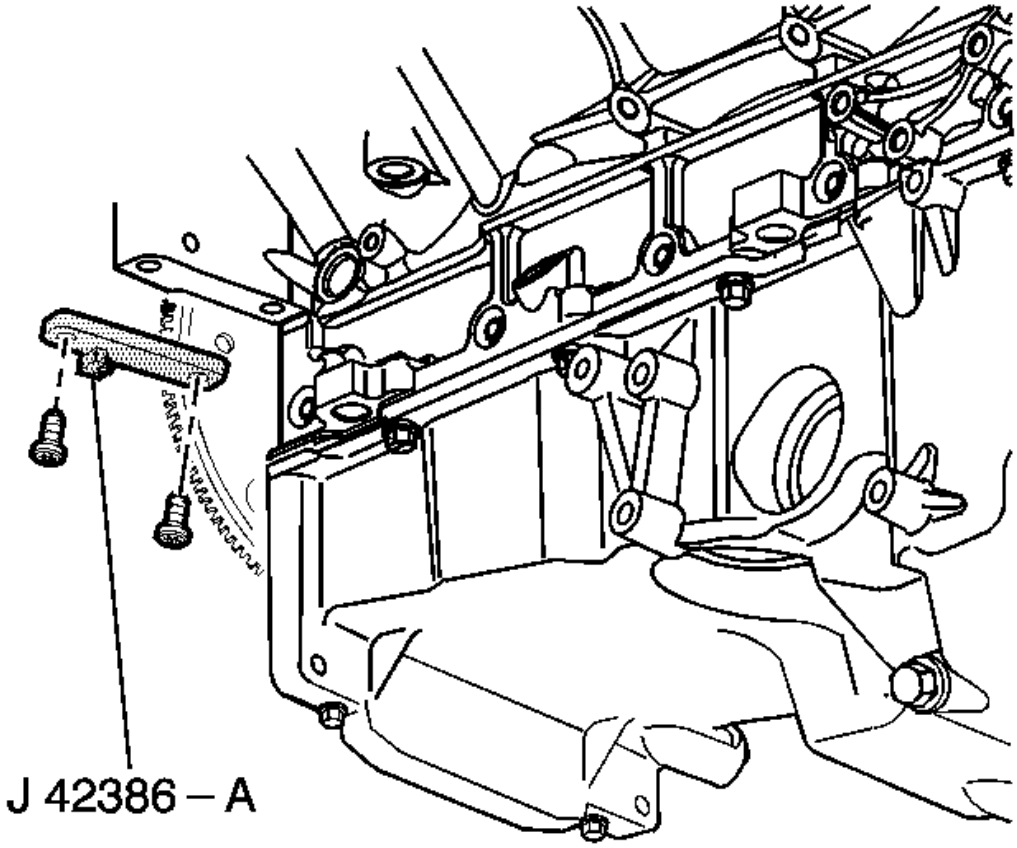

Fig. 170: View Of J 42386-A Flywheel Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure that the teeth of J 42386-A mesh with the teeth of the engine flywheel. See Special Tools.**
- **The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.**

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NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install **J 42386-A** and bolts. See **Special Tools**.

   Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool operation.

   Tighten: Tighten **J 42386-A** bolts to 50 N.m (37 lb ft).

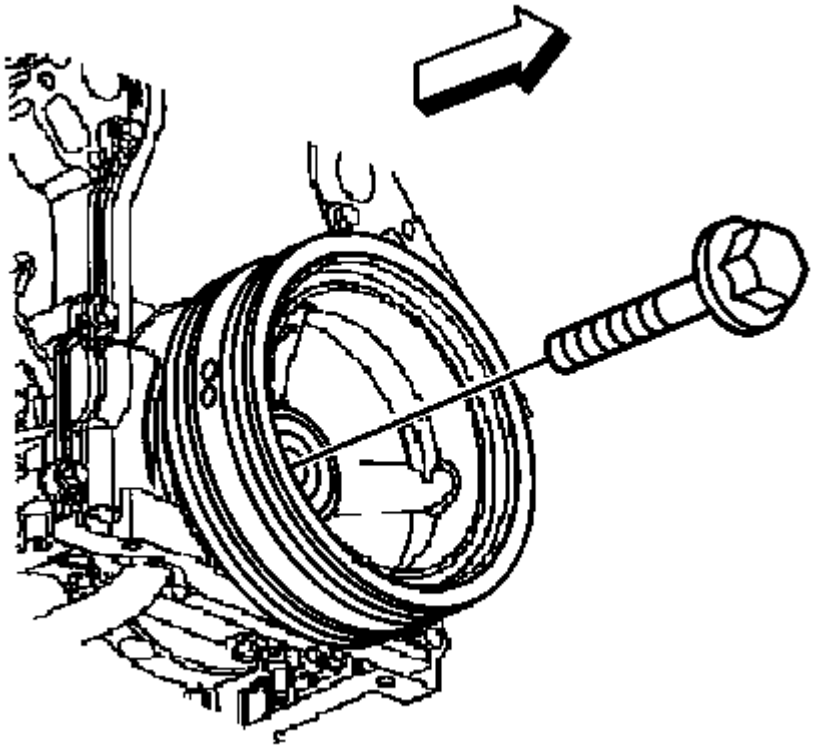

Fig. 171: Crankshaft Balancer And Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft balancer bolt.

   Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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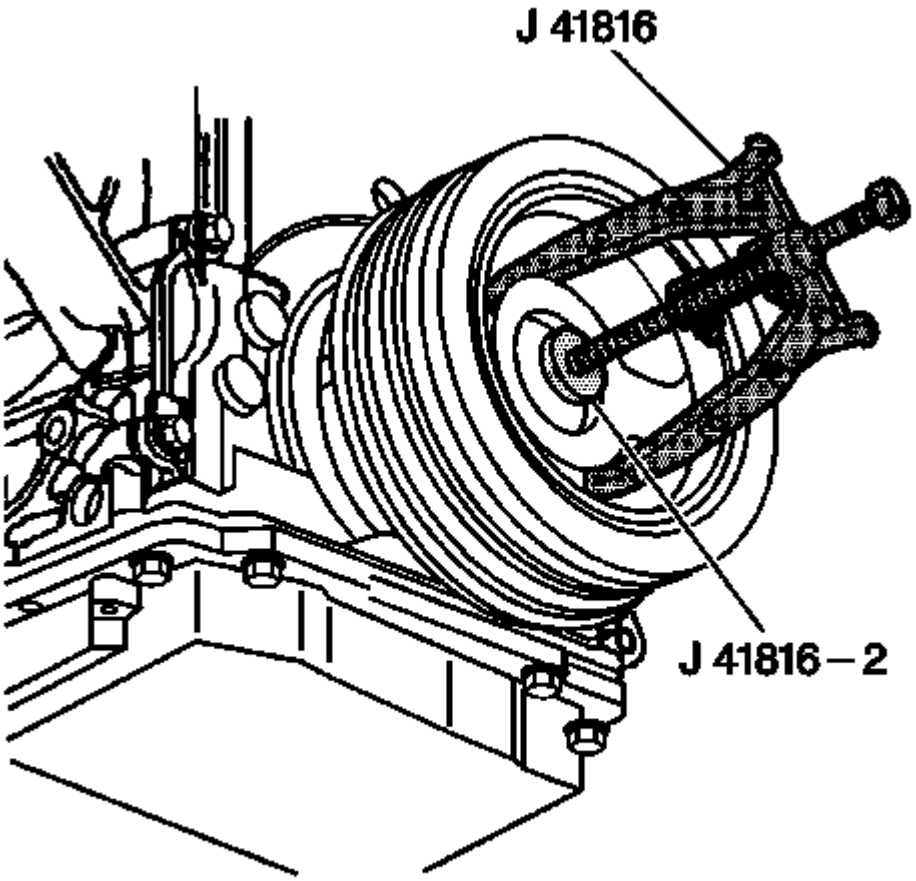

Fig. 172: Removing The Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

7. Use **J 41816** and **J 41816-2** in order to remove the crankshaft balancer.
8. Remove **J 41816** and. See **Special Tools**.**J 41816-2** from the crankshaft balancer.
9. Clean and inspect the crankshaft balancer. Refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

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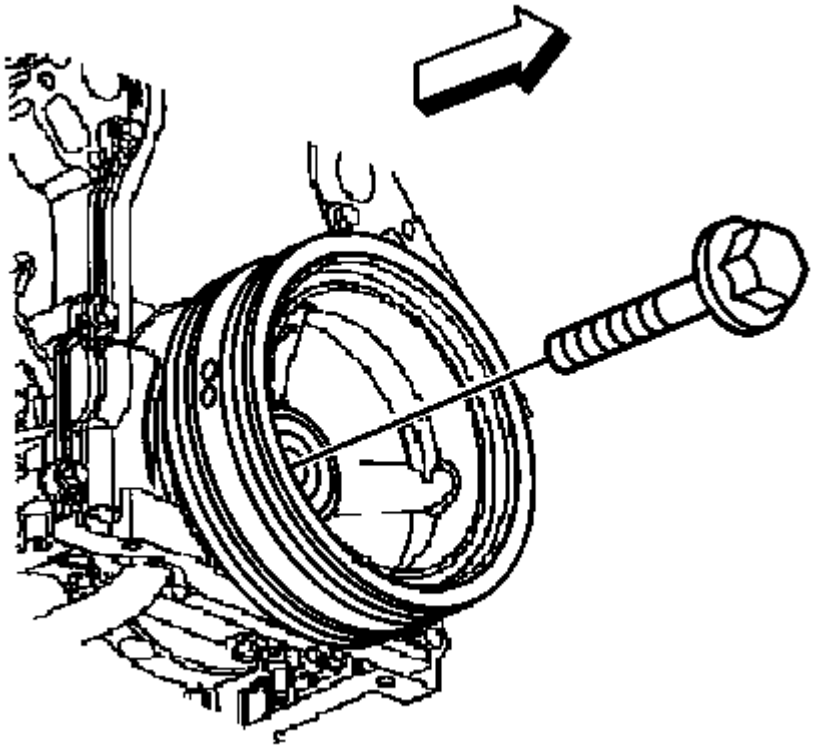

Fig. 173: Crankshaft Balancer And Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure that the teeth of J 42386-A mesh with the teeth of the engine flywheel. See Special Tools.**
- **The used crankshaft balancer bolt will be used only during the first pass of the balancer installation procedure. Install a NEW bolt and tighten as described in the second pass of the balancer bolt tightening procedure.**
- **The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and forth passes tighten the new bolt to the proper torque.**

IMPORTANT: Position the balancer onto the end of the crankshaft as straight as possible prior to tool installation.

1. Install the crankshaft balancer onto the end of the crankshaft.

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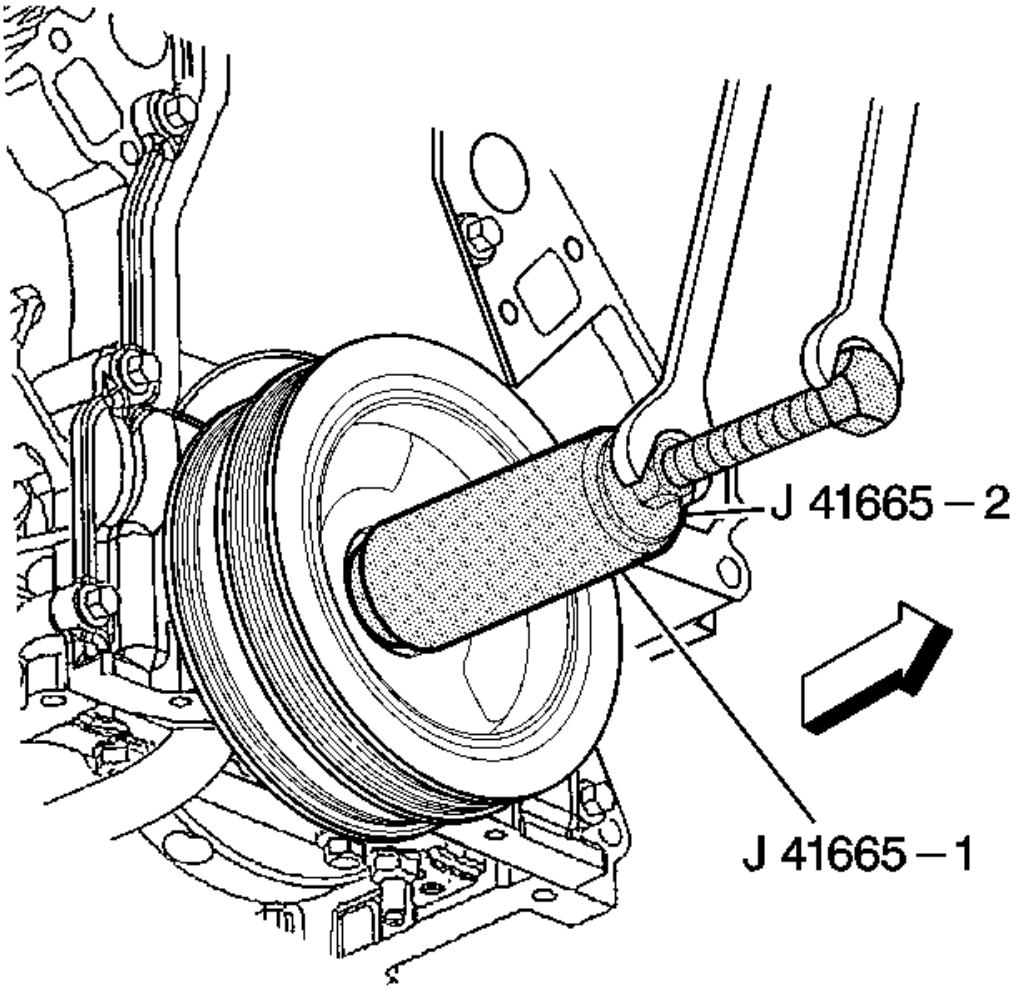

Fig. 174: Installing Balancer Using J 41665
Courtesy of GENERAL MOTORS CORP.

2. Use **J 41665** in order to install the crankshaft balancer. See **Special Tools**.
    1. Assemble the threaded rod, nut, washer and installer.

       Insert the smaller end of the installer into the front of the balancer.

    2. Use a wrench and hold the hex end of the threaded rod.
    3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
    4. Remove the tool and reverse the installation tool.

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Position the larger end of the installer against the front of the balancer.

5. Use a wrench and hold the hex end of the threaded rod.
6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
7. Remove the balancer installation tool.

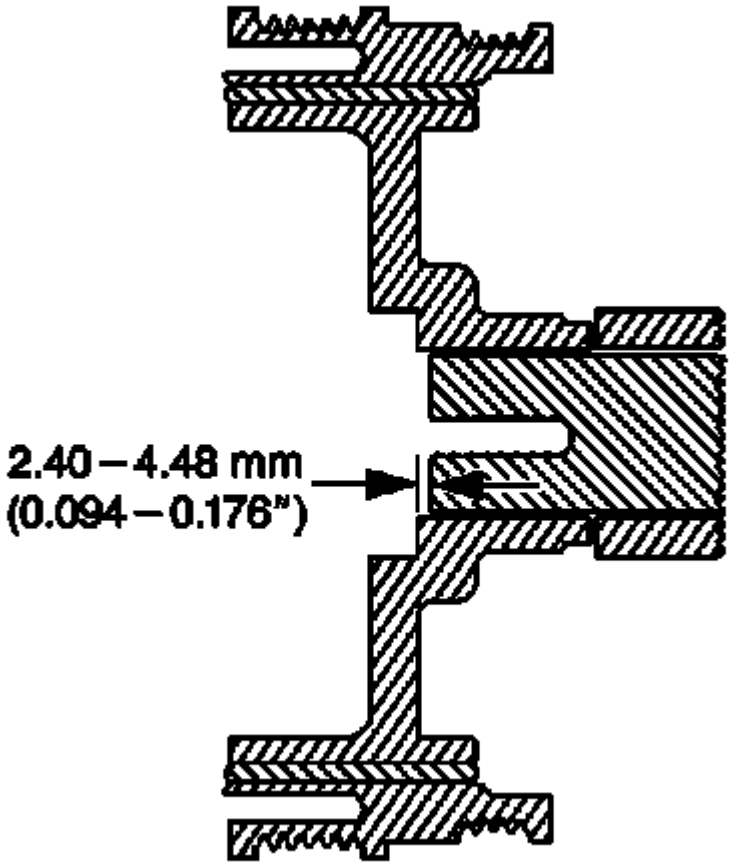

Fig. 175: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the used crankshaft balancer bolt.

   Tighten: Tighten the USED bolt to 330 N.m (240 lb ft).

4. Remove the used crankshaft balancer bolt.

IMPORTANT: Recess the nose of the crankshaft 2.4-4.48 mm (0.094-0.176 in) into the

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balancer bore.

5. Measure for a correctly installed balancer.

   If the balancer is not installed to the proper dimensions, install **J 41665** and repeat the installation procedure. See **Special Tools**.

6. Install a NEW crankshaft balancer bolt.

   Tighten:
   1. Tighten the bolt a first pass to 50 N.m (37 lb ft).
   2. Tighten the bolt a final pass to 140 degrees using **J 45059** .

7. Remove **J 42386-A** and bolts. See **Special Tools**.
8. Install the starter motor. Refer to **Starter Motor Replacement (5.3L Engine)** in Engine Electrical.
9. Install the fan shroud. Refer to **Cooling Fan and Shroud Replacement** in Engine Cooling.
10. Install the A/C drive belt, if equipped. Refer to **Drive Belt Replacement - Air Conditioning**.
11. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
12. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 5.3L.

Crankshaft Front Oil Seal Replacement

Tools Required

J 41478 Crankshaft Front Oil Seal Installer

Removal Procedure

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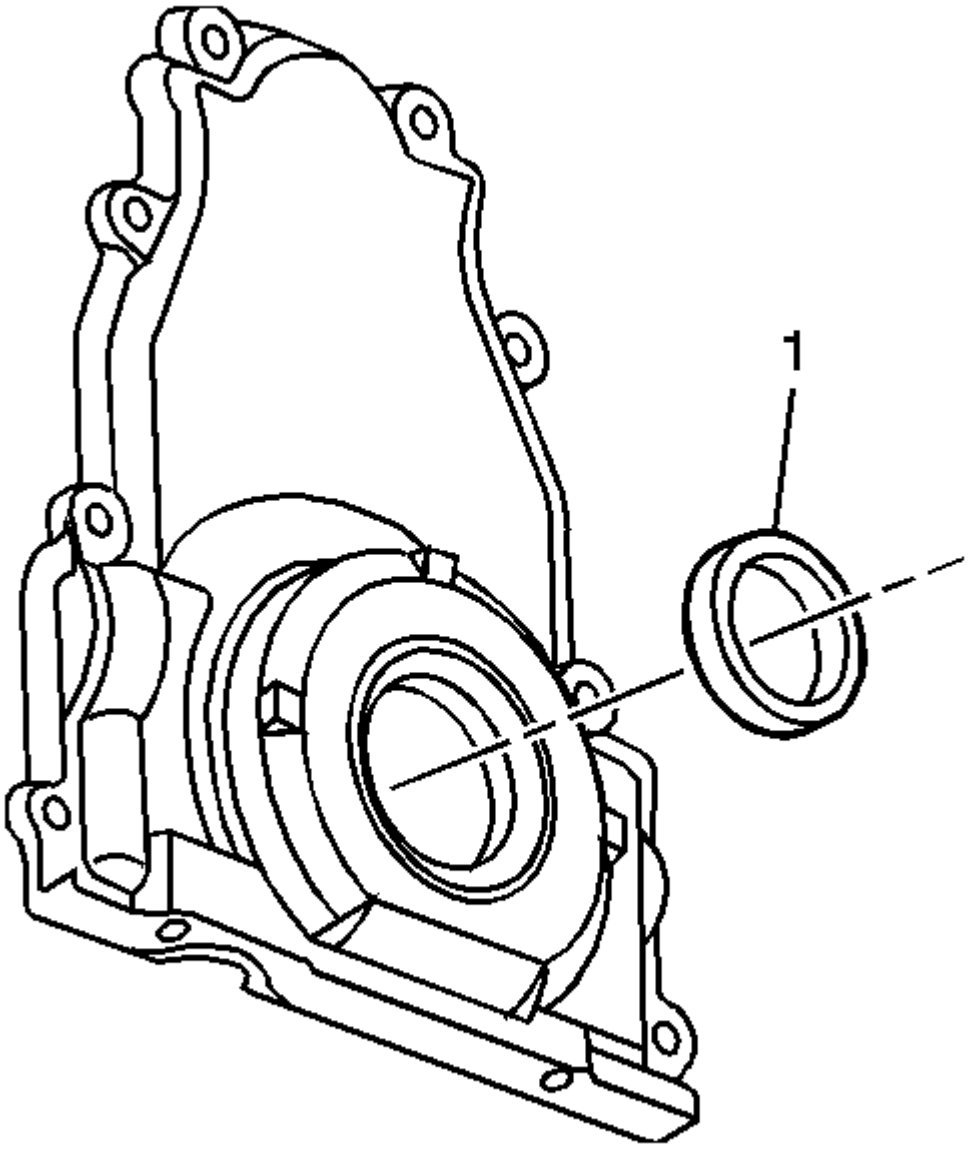

Fig. 176: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the radiator. Refer to **Radiator Replacement (LM4)** in Engine Cooling.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the crankshaft oil seal (1) from the front cover.

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Installation Procedure

IMPORTANT:

- **Do not lubricate the oil seal sealing surface.**
- **Do not reuse the crankshaft oil seal.**

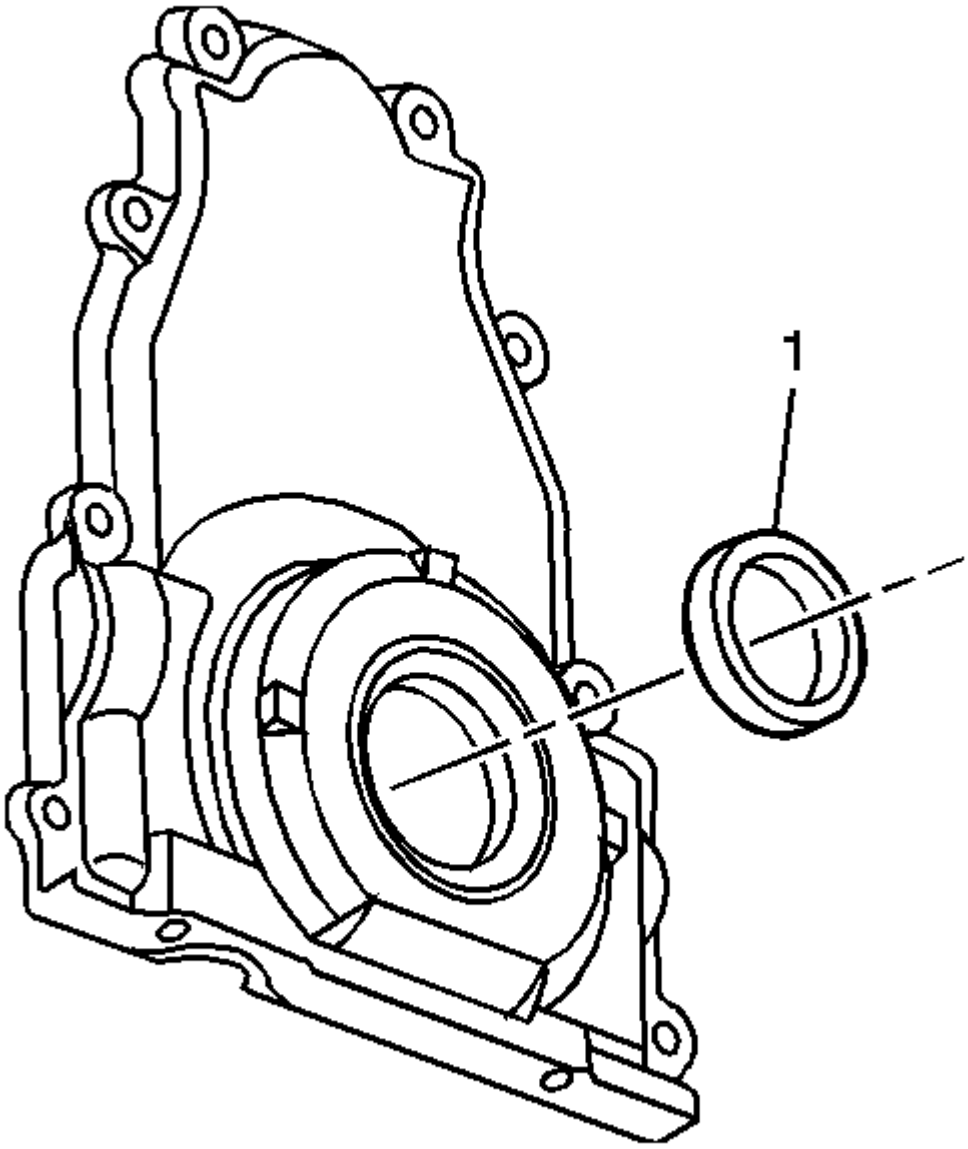

Fig. 177: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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1. Lubricate the outer edge of the oil seal (1) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

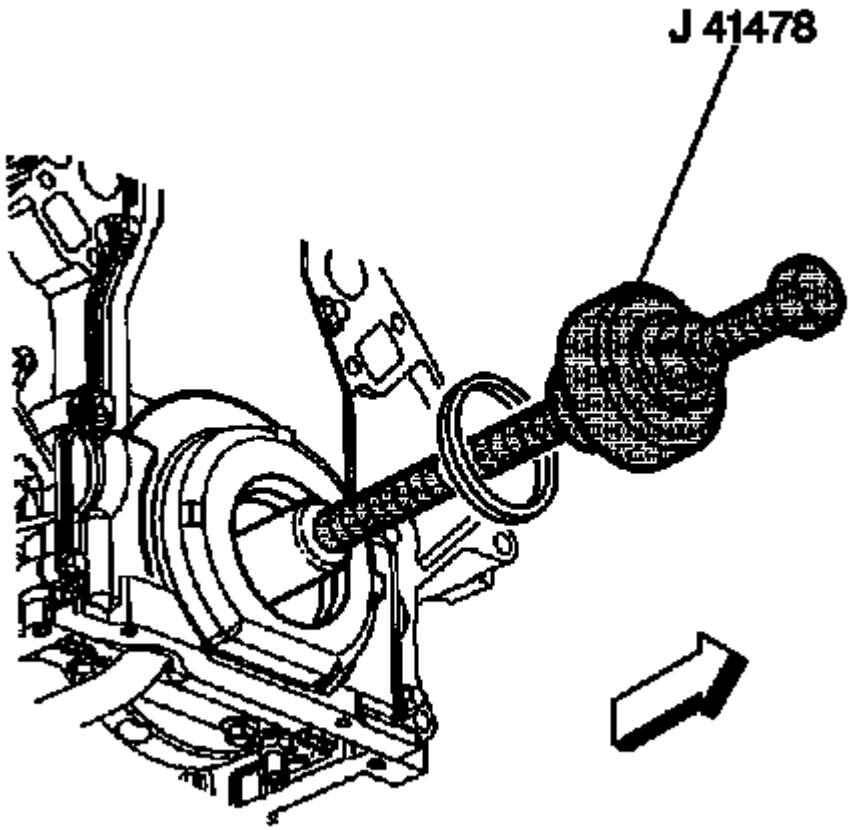

Fig. 178: Installing The Crankshaft Front Oil Seal Using J 41478
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal onto the **J 41478** guide.
4. Install **J 41478** threaded rod with nut, washer, guide, and oil seal into the end of the crankshaft.
5. Use **J 41478** in order to install the oil seal into the cover bore.
    1. Use a wrench and hold the hex on the installer bolt.
    2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
    3. Remove **J 41478** .
    4. Inspect the oil seal for proper installation.

        The oil seal should be installed evenly and completely into the front cover bore.

6. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
7. Install the radiator. Refer to **Radiator Replacement (LM4)** in Engine Cooling.

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Engine Front Cover Replacement

Tools Required

J 41476 Front and Rear Cover Alignment Tool (at crankshaft seal area). See **Special Tools**.

Removal Procedure

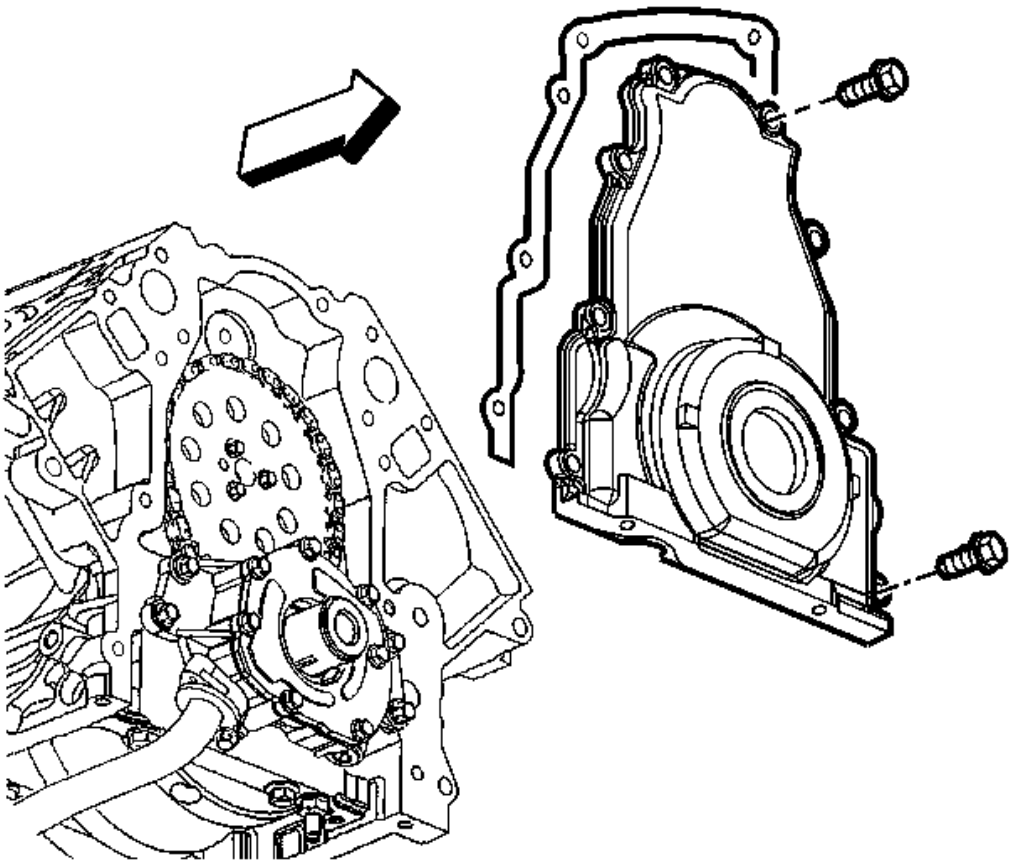

Fig. 179: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) compressor and bracket. Refer to **Compressor Replacement (LM4)** in Heating, Ventilation and Air Conditioning.
2. Remove the water pump. Refer to **Water Pump Replacement (LM4)** in Engine Cooling.
3. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
4. Remove the oil pan-to-front cover bolts.

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5. Remove the front cover bolts.
6. Remove the front cover and gasket.
7. Discard the front cover gasket.
8. Clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

Installation Procedure

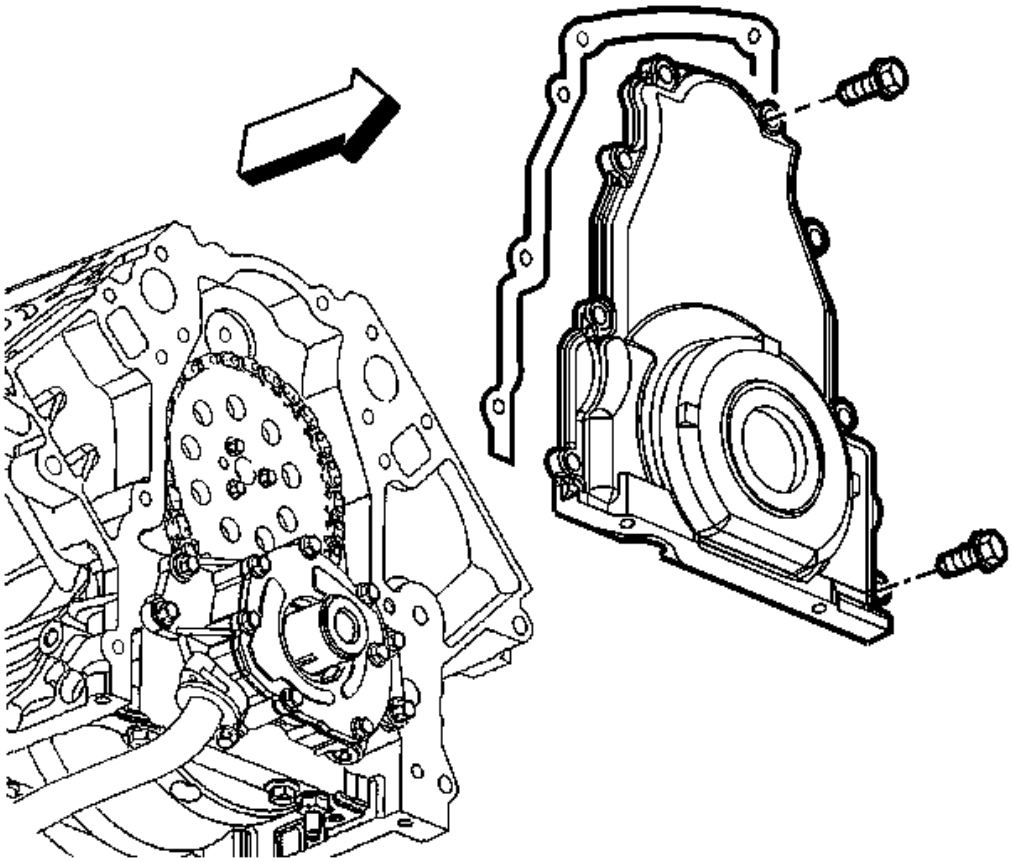

Fig. 180: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not reuse the crankshaft oil seal or front cover gasket.**
- **Do not apply any type of sealant to the front cover gasket, unless specified.**
- **The special tool in this procedure is used to properly center the front crankshaft front oil seal.**

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- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **The crankshaft front oil seal MUST be centered in relation to the crankshaft.**
- **An improperly aligned front cover may cause premature front oil seal wear and/or engine oil leaks.**

1. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.8 in) long to the junction of the oil pan and the engine block.
2. Install the front cover gasket and cover.
3. Install the front cover bolts until snug. Do not over tighten.
4. Install the oil pan-to-front cover bolts until snug. Do not over tighten.

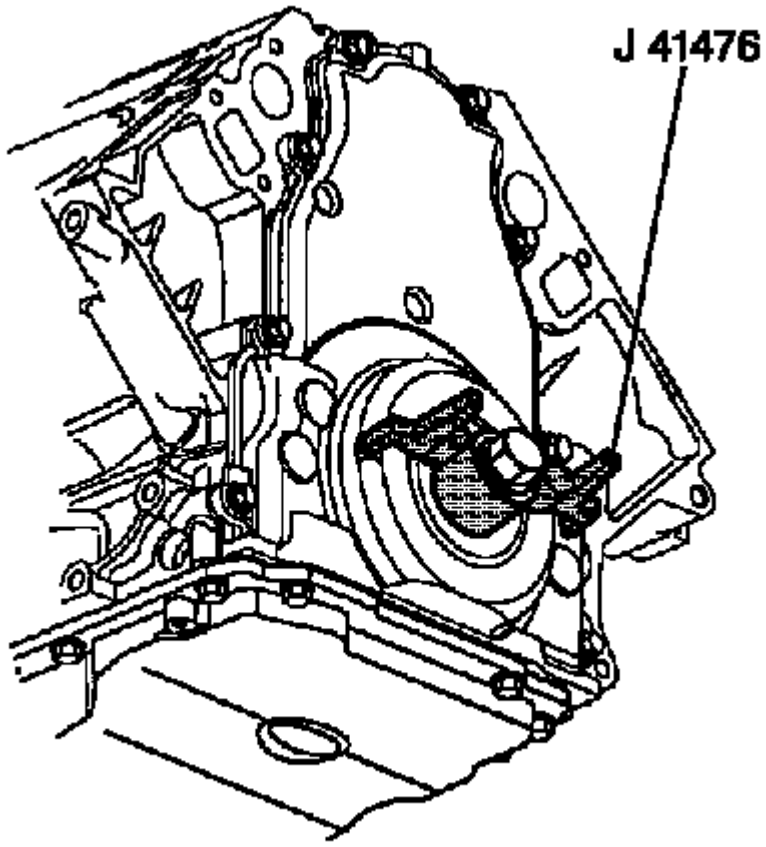

Fig. 181: View of J 41476 Installed To Front Cover
Courtesy of GENERAL MOTORS CORP.

5. Install **J 41476** to the front cover. See **Special Tools**.
6. Align the tapered legs of **J 41476** with the machined alignment surfaces on the front cover. See **Special Tools**.

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NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Install the crankshaft balancer bolt until snug. Do NOT over tighten.

   Tighten:
   1. Tighten the oil pan to front cover bolts to 25 N.m (18 lb ft).
   2. Tighten the engine front cover bolts to 25 N.m (18 lb ft).

8. Remove **J 41476** . See **Special Tools**.
9. Install a NEW crankshaft front oil seal. Refer to **Crankshaft Front Oil Seal Replacement**.
10. Install the water pump. Refer to **Water Pump Replacement (LM4)** in Engine Cooling.
11. Install the A/C compressor and bracket. Refer to **Compressor Replacement (LM4)** in Heating, Ventilation and Air Conditioning.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer. See **Special Tools**.

Removal Procedure

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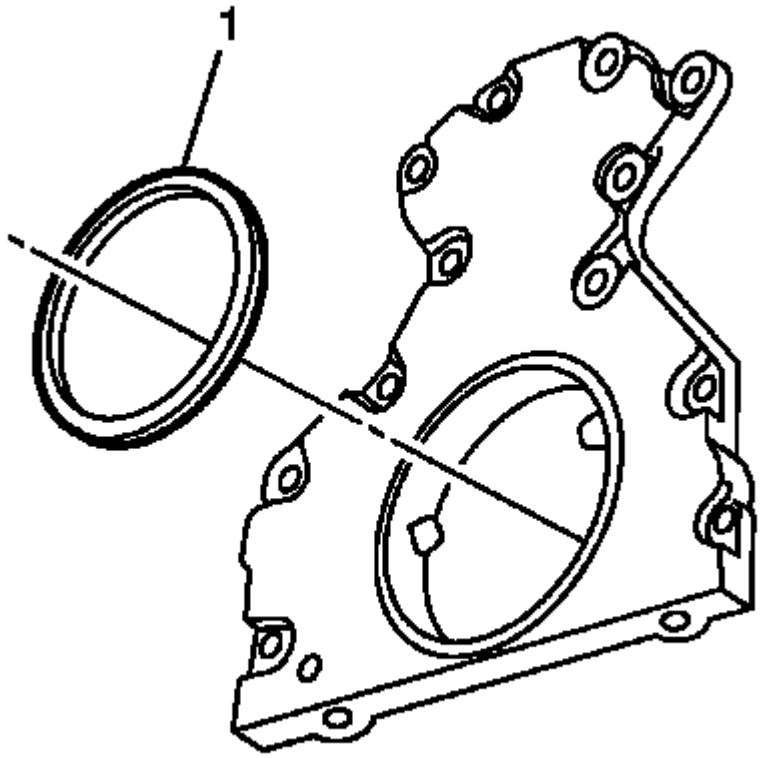

Fig. 182: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the crankshaft rear oil seal (1) from the rear cover.

Installation Procedure

IMPORTANT:

- **Remove the flywheel spacer, if applicable, prior to oil seal installation.**
- **Do not lubricate the oil seal inside diameter or the crankshaft surface.**
- **Do not reuse the crankshaft rear oil seal.**

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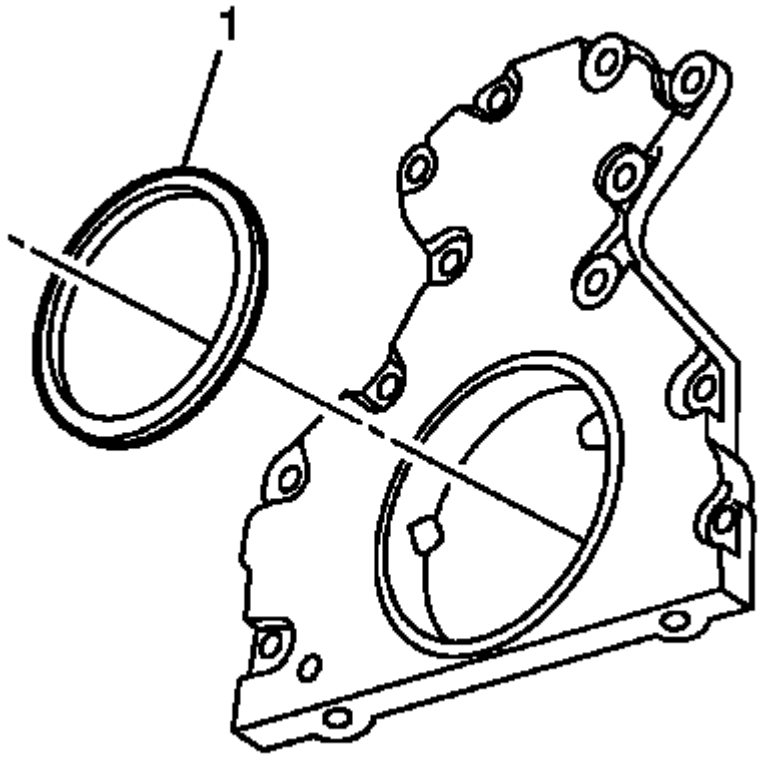

Fig. 183: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outside diameter of the oil seal (1) with clean engine oil.

   DO NOT allow oil or other lubricants to contact the seal surface.

2. Lubricate the rear cover oil seal bore with clean engine oil.

   DO NOT allow oil or other lubricants to contact the crankshaft surface.

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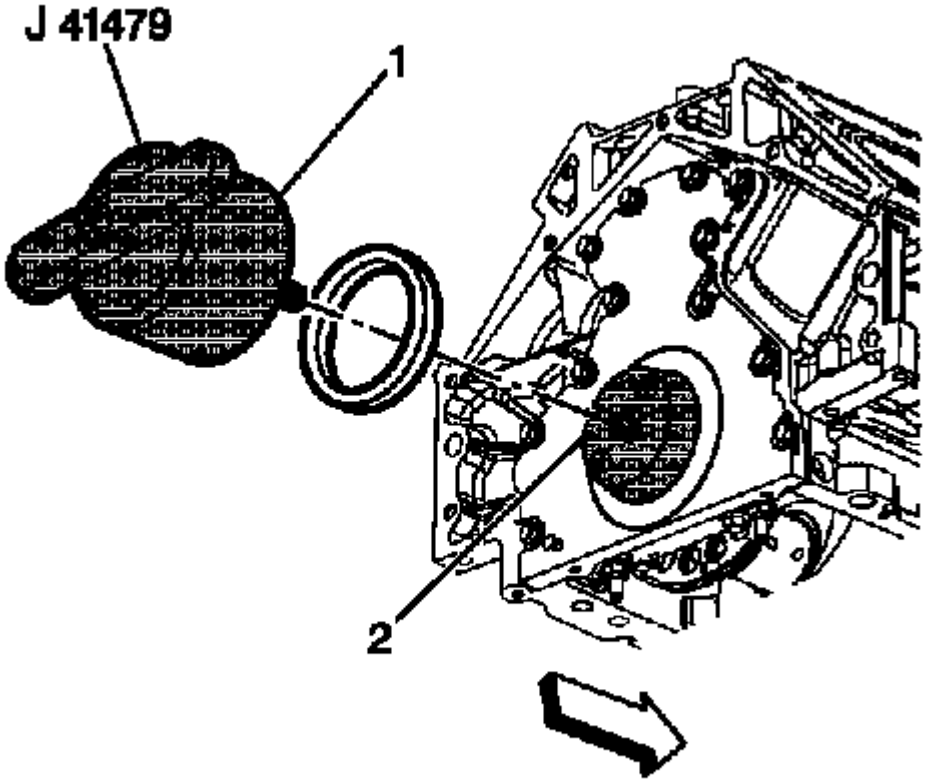

Fig. 184: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

3. Install **J 41479** tapered cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear cover bore.
6. Thread **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.
7. Align the oil seal into the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
9. Remove **J 41479** . See **Special Tools**.
10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

Engine Rear Cover Replacement

Tools Required

J 41476 Front and Rear Cover Alignment Tool at crankshaft seal area. See **Special Tools**.

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Removal Procedure

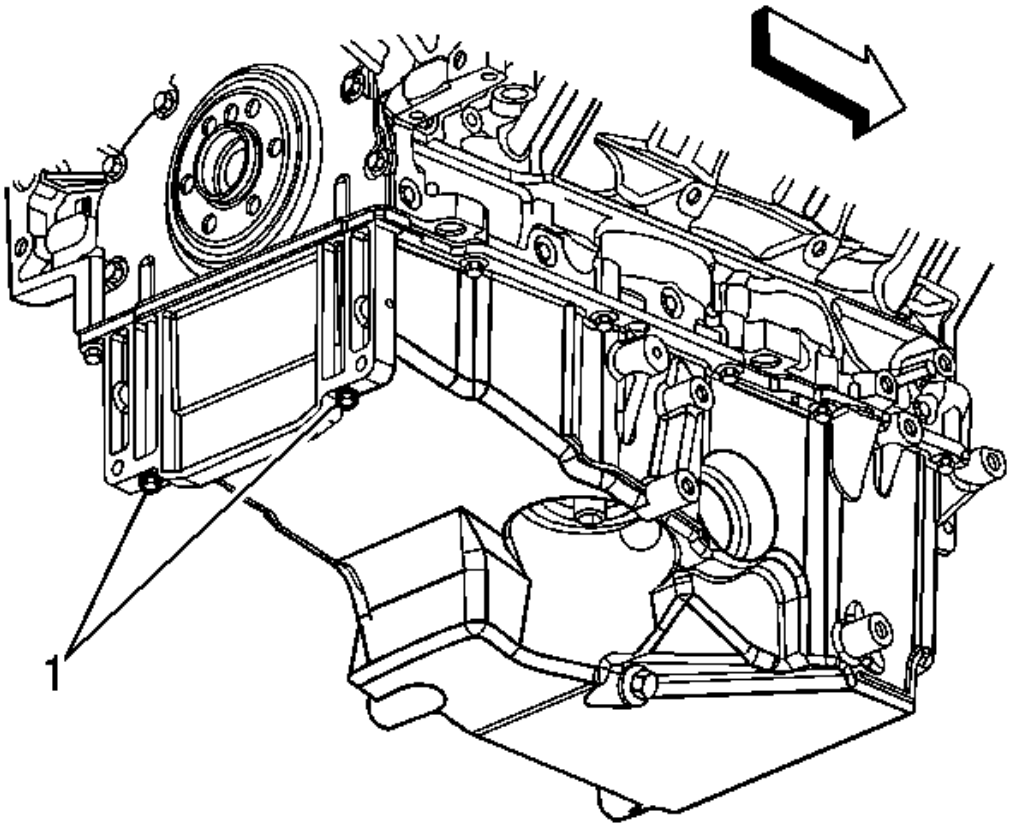

Fig. 185: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Engine Flywheel Replacement**.
2. Remove the oil pan-to-rear cover bolts (1).

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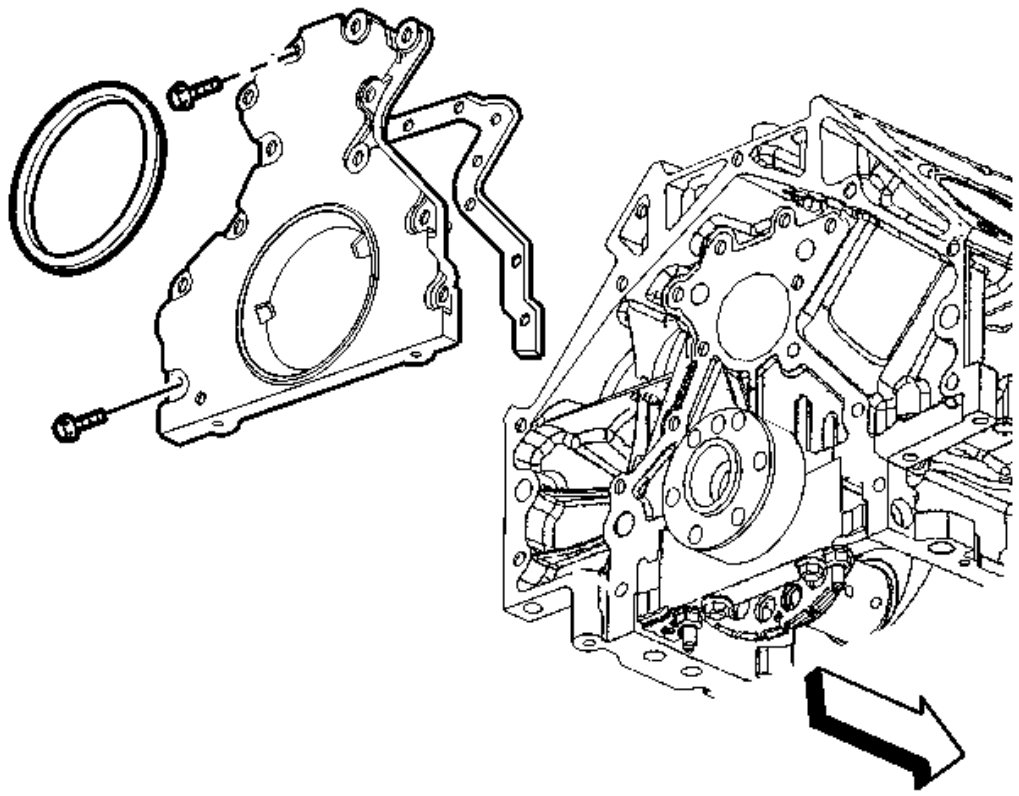

Fig. 186: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the rear cover bolts.
4. Remove the rear cover and gasket.
5. Discard the rear cover gasket.
6. Clean and inspect the rear cover. Refer to **Engine Rear Cover Cleaning and Inspection**.

Installation Procedure

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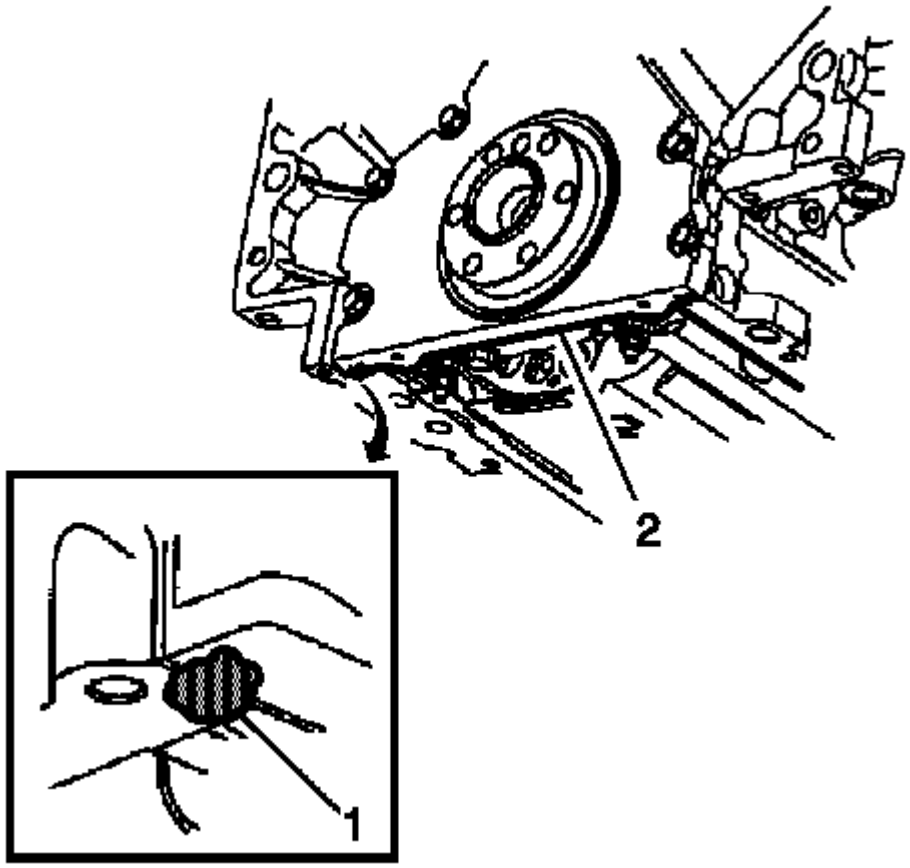

Fig. 187: View Of Sealant Applied To Rear Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not reuse the crankshaft oil seal or rear cover gasket.**
- **Do not apply any type of sealant to the rear cover gasket unless specified.**
- **The special tool in this procedure is used to properly center the crankshaft rear oil seal.**
- **Install the crankshaft rear oil seal after the rear cover has been installed and aligned.**

Install the rear cover without the crankshaft oil seal.

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **Center the crankshaft rear oil seal in relation to the crankshaft.**
- **An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.**

1. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.8 in) long to the oil

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pan to engine block junction.

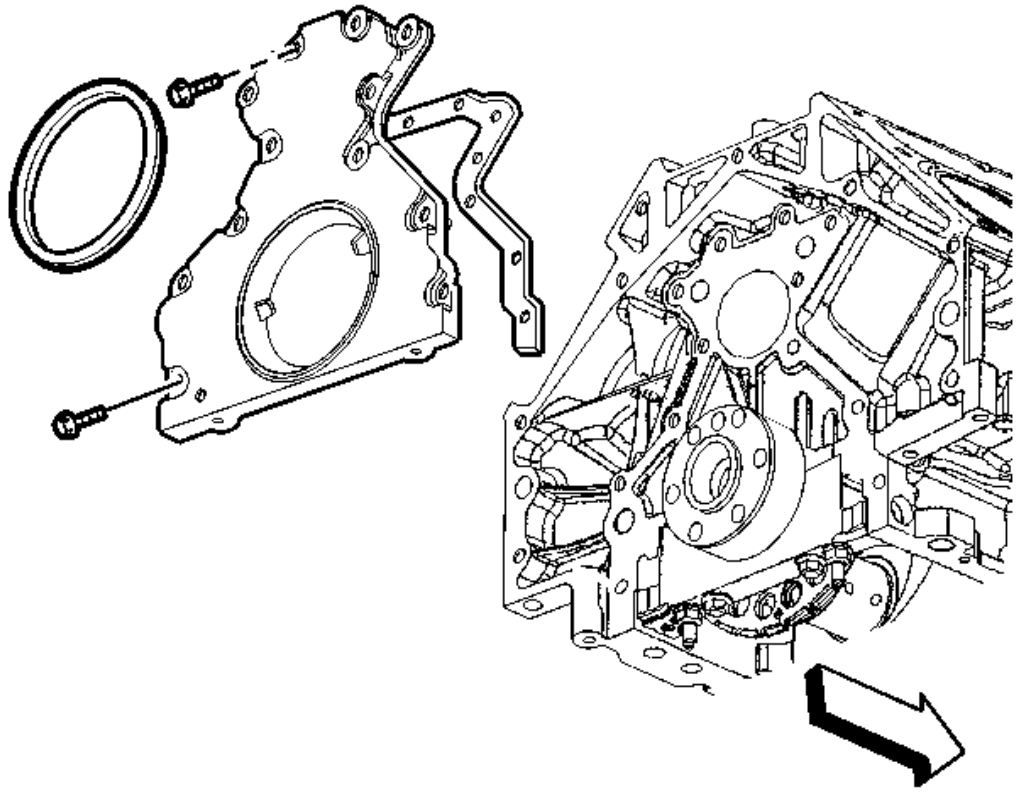

Fig. 188: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket and cover.
3. Install the rear cover bolts until snug. Do NOT over tighten.

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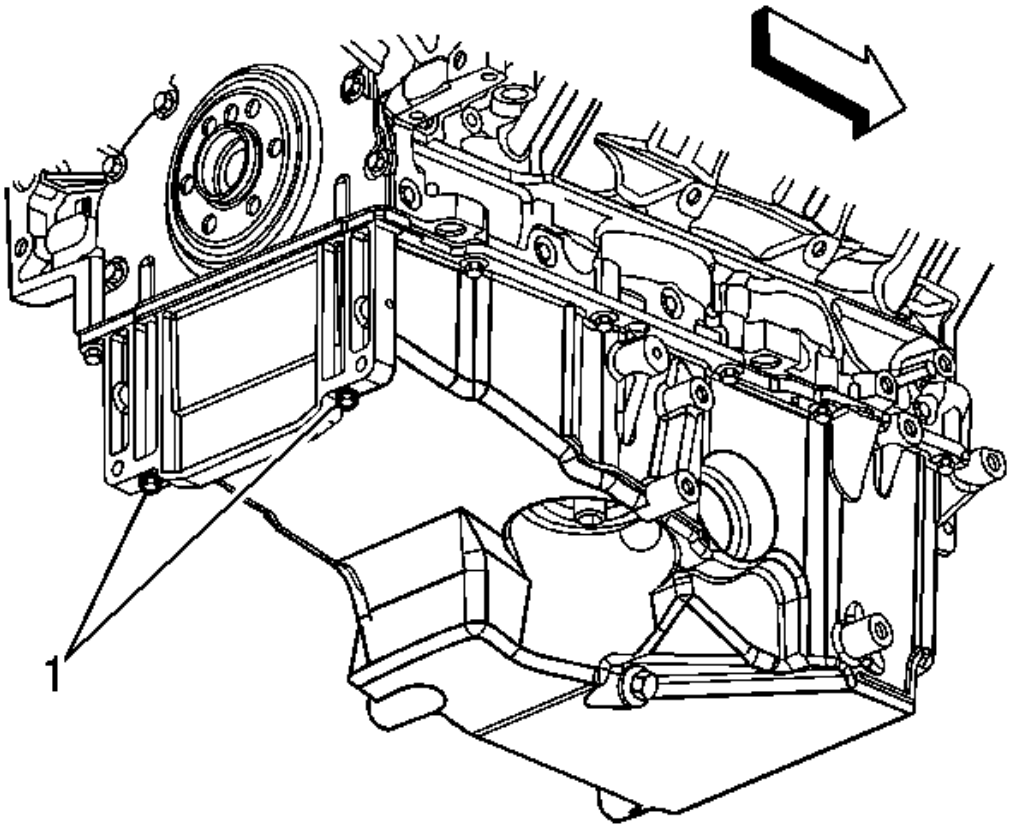

Fig. 189: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan-to-rear cover bolts (1) until snug. Do not over tighten.

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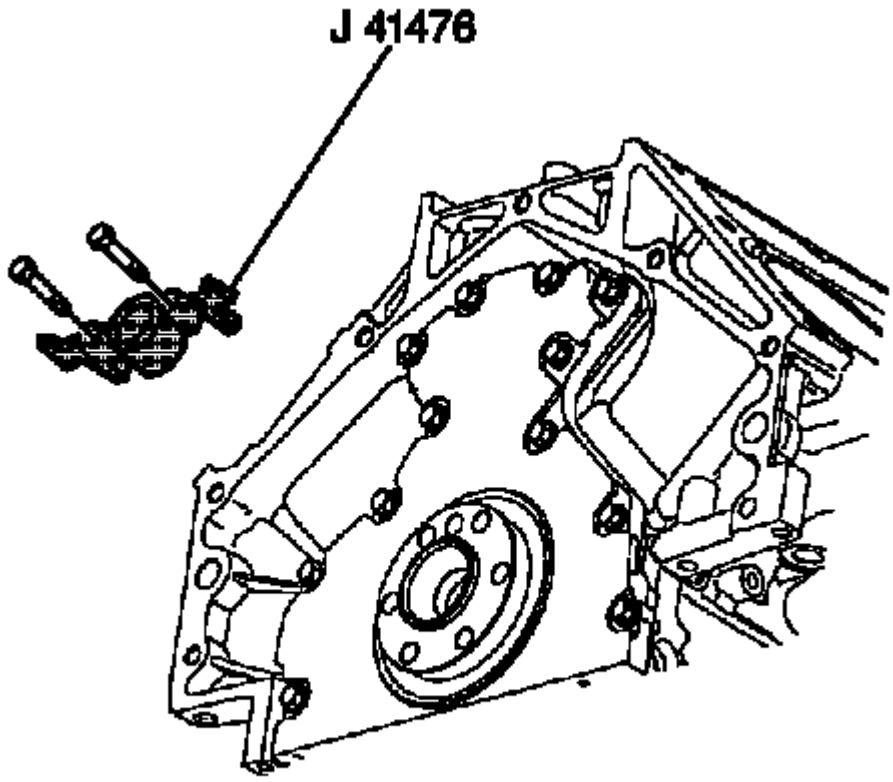

Fig. 190: View Of J 41476
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The tapered legs of the alignment tool must enter the rear cover oil seal bore.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.
6. Install **J 41476** and bolts onto the rear of the crankshaft. See **Special Tools**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. Tighten **J 41476** mounting bolts until snug. See **Special Tools**. Do not overtighten.

Tighten:

1. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
2. Tighten the engine rear cover bolts to 25 N.m (18 lb ft).

8. Remove **J 41476** . See **Special Tools**.
9. Install a NEW crankshaft rear oil seal. Refer to **Crankshaft Rear Oil Seal Replacement**.

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10. Install the engine flywheel. Refer to **Engine Flywheel Replacement**.

Oil Filter Adapter Replacement

Removal Procedure

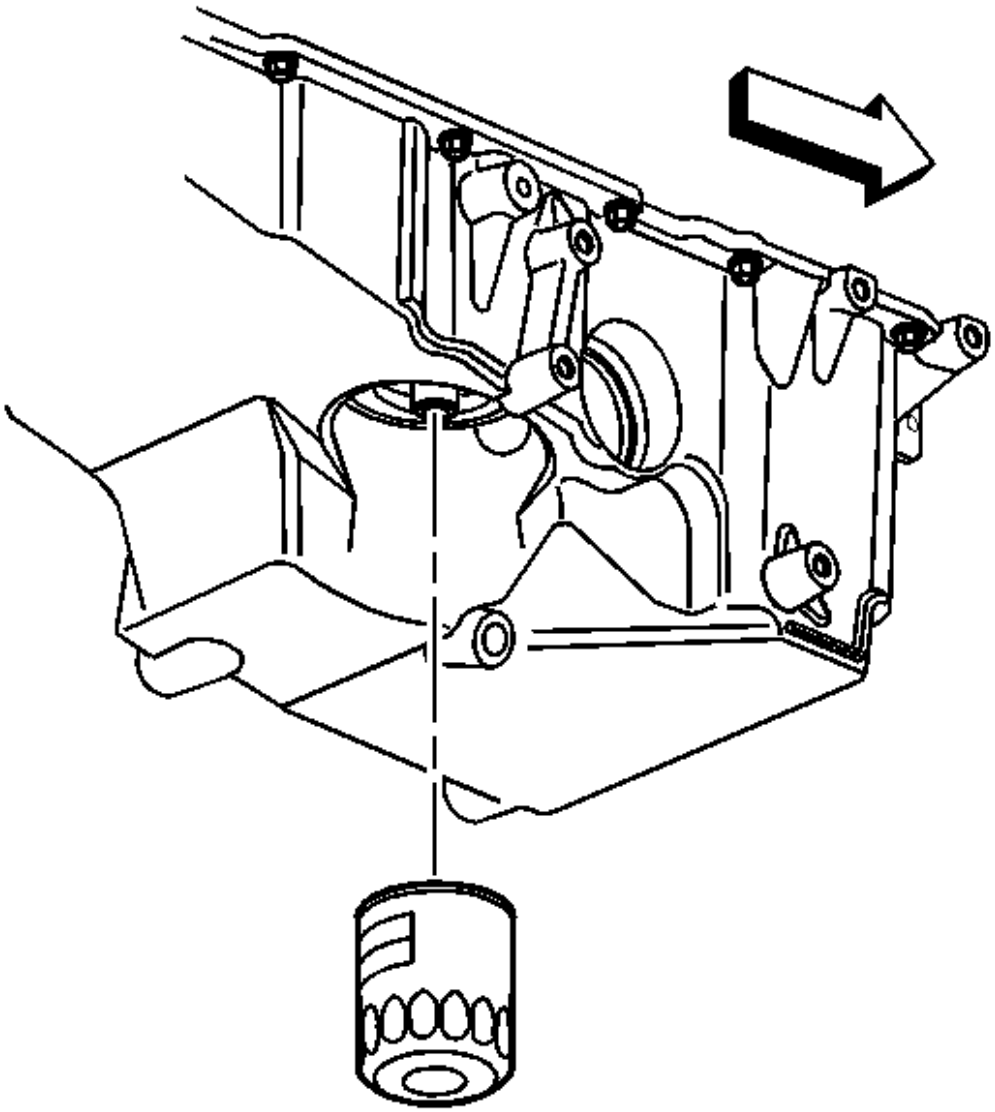

Fig. 191: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

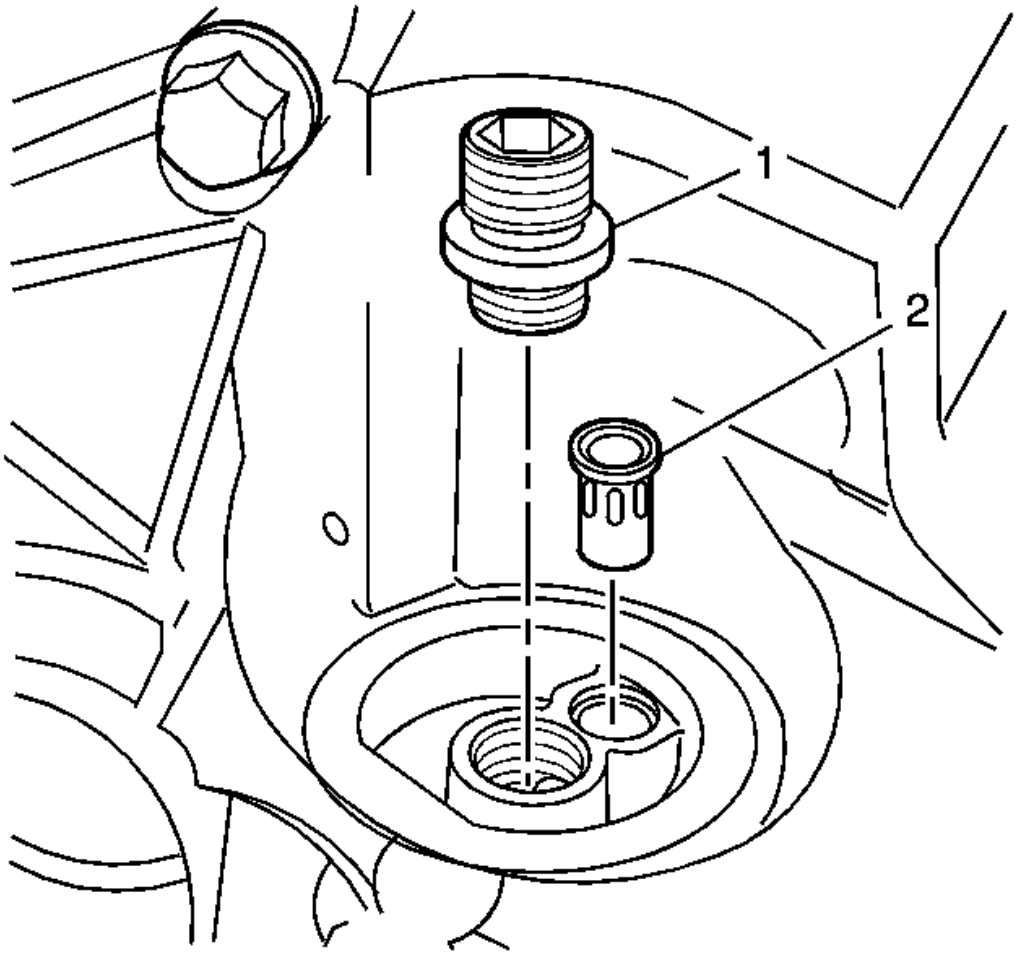

Fig. 192: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter adapter (1).

Installation Procedure

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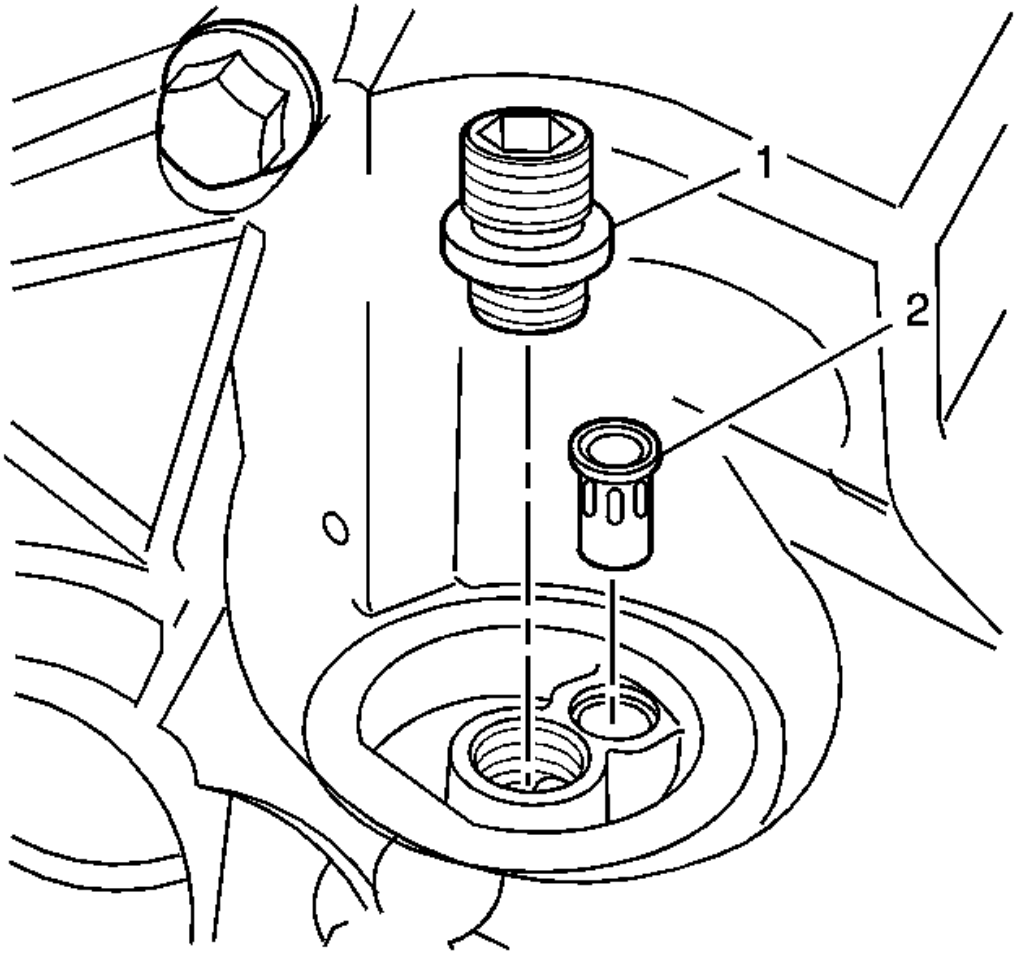

Fig. 193: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil filter adapter (1).

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

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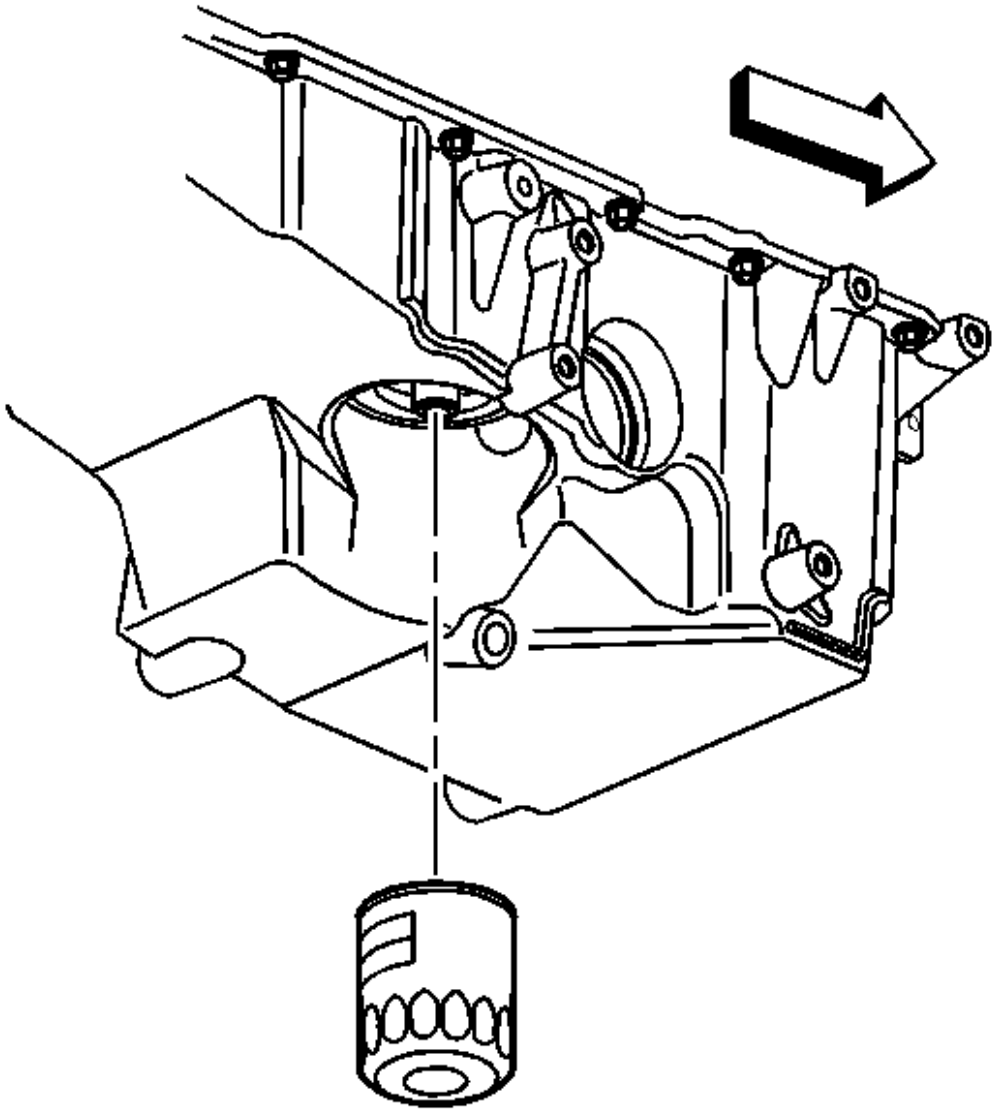

Fig. 194: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

Oil Filter Bypass Valve Replacement

Removal Procedure

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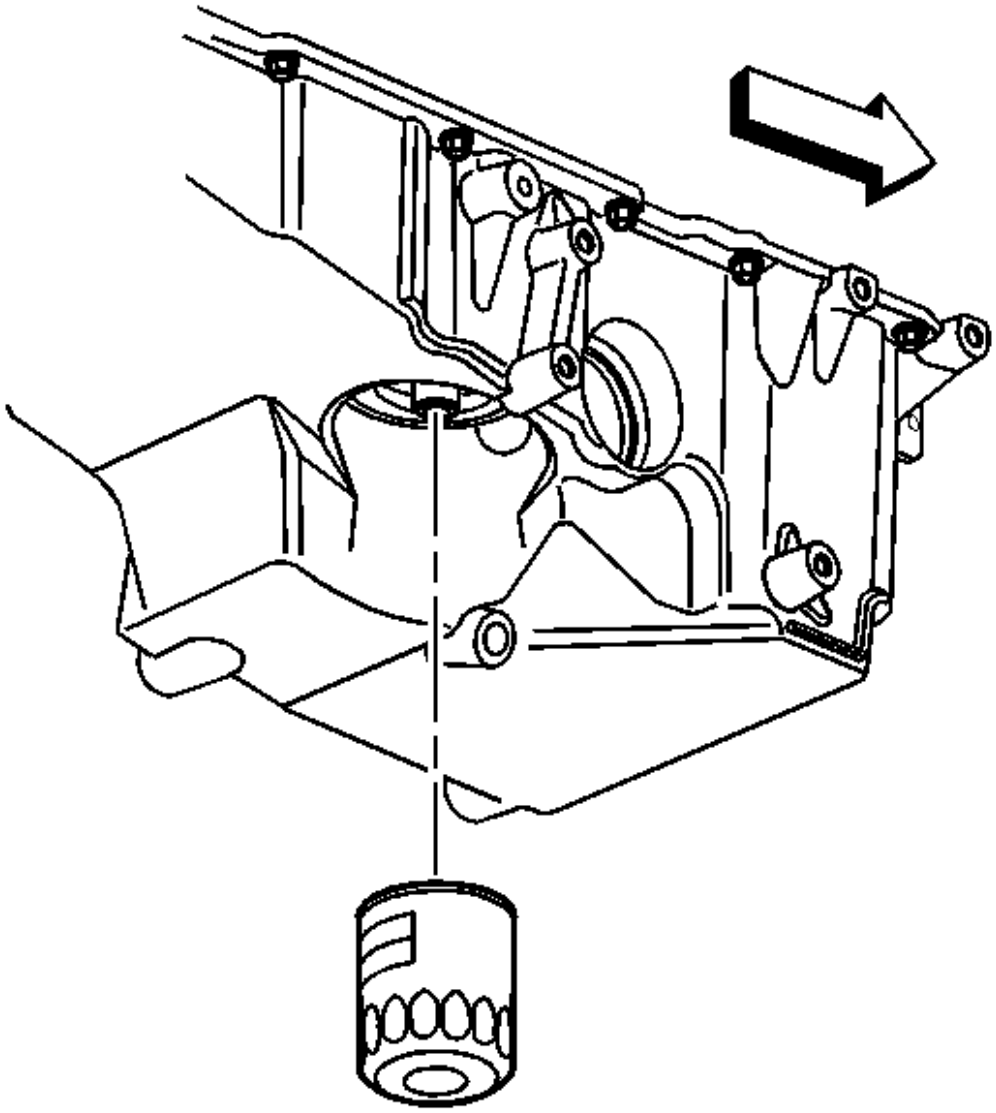

Fig. 195: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil.
2. Remove the oil filter.

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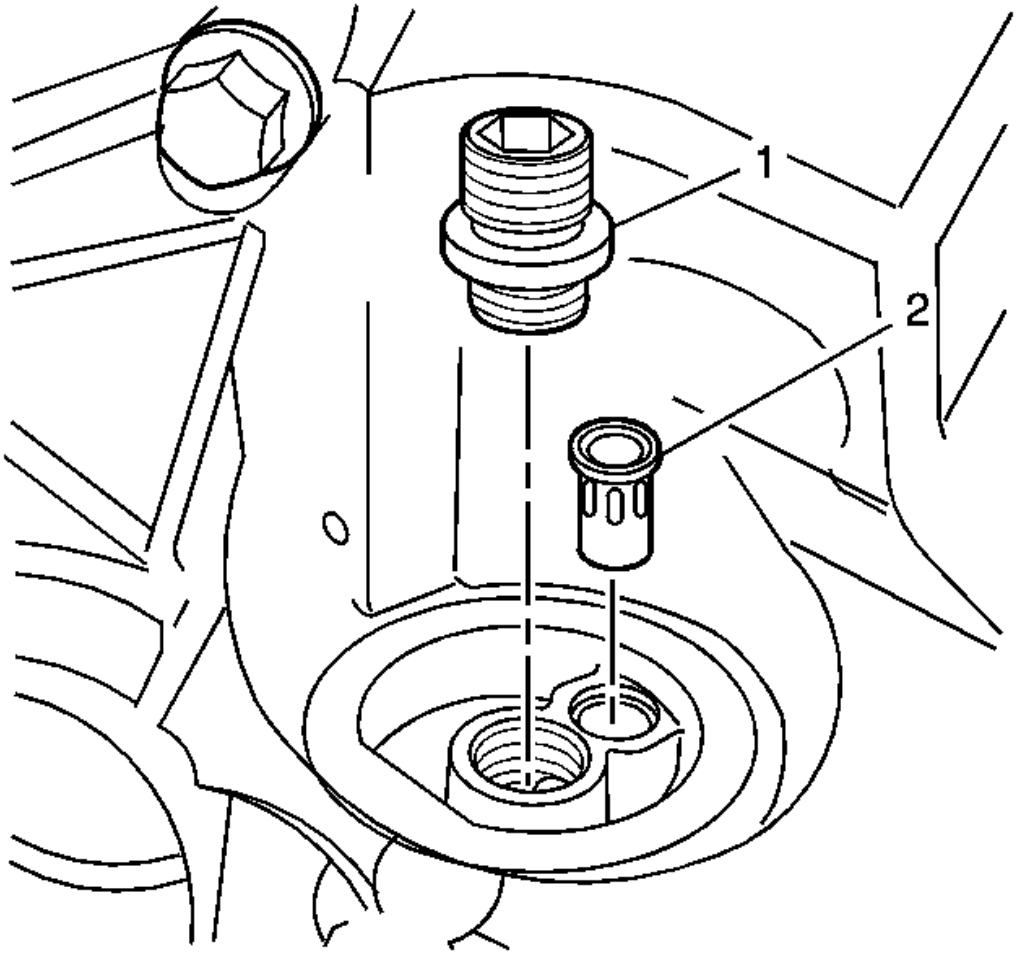

Fig. 196: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).
4. Remove the oil filter bypass valve (2).

Installation Procedure

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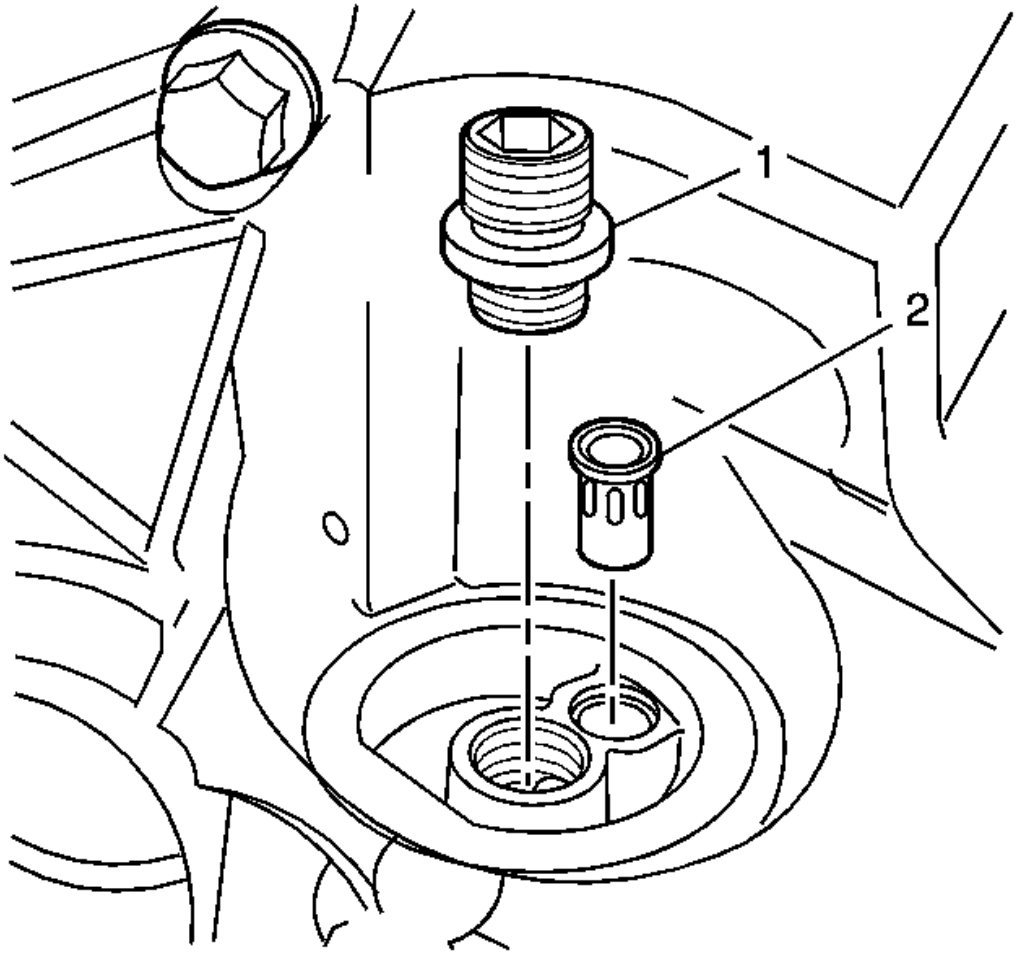

Fig. 197: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the oil filter bypass valve (2).
2. Install the oil filter adapter (1).

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

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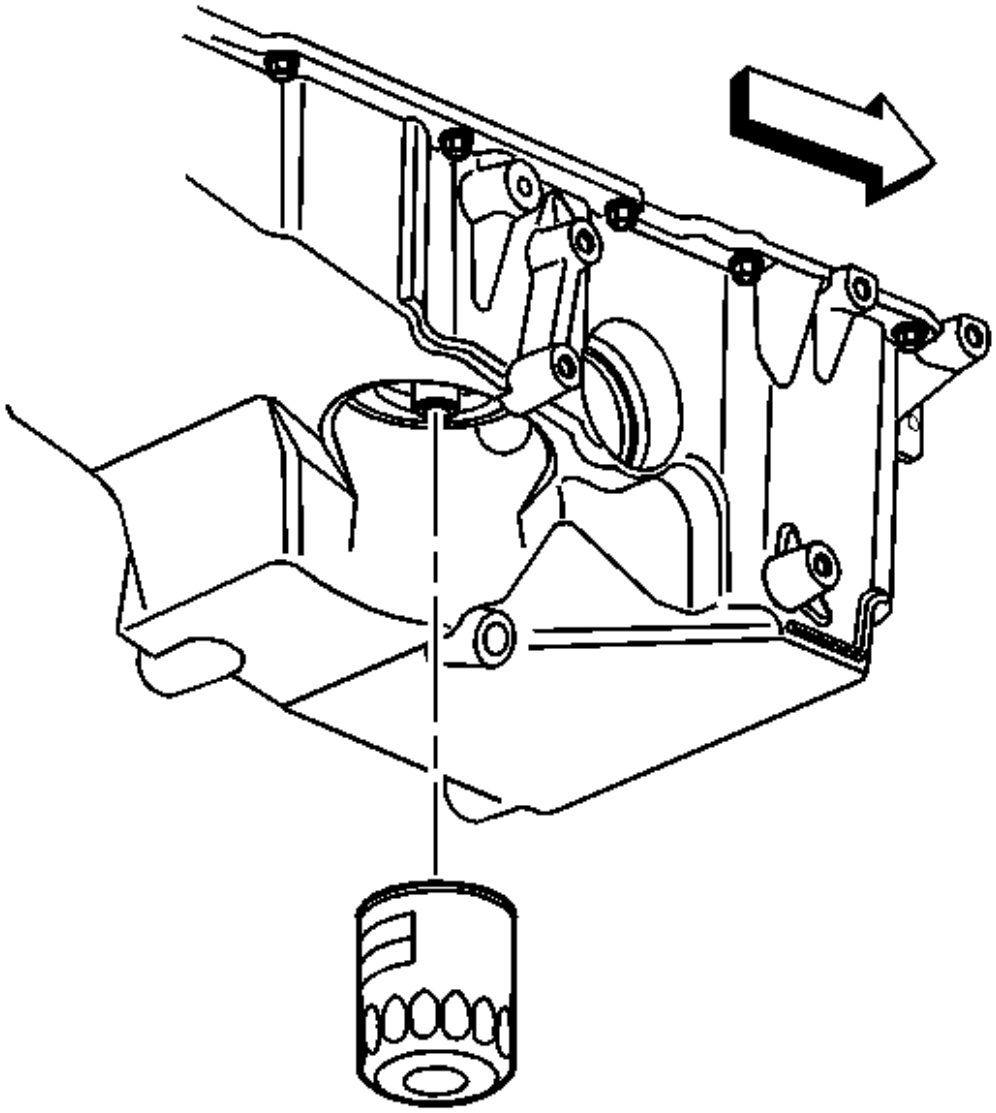

Fig. 198: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter.

   Tighten: Tighten the filter to 30 N.m (22 lb ft).

4. Refill the engine oil. Refer to **Capacities - Approximate Fluid** or to **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.

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Oil Pan Replacement

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
2. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.

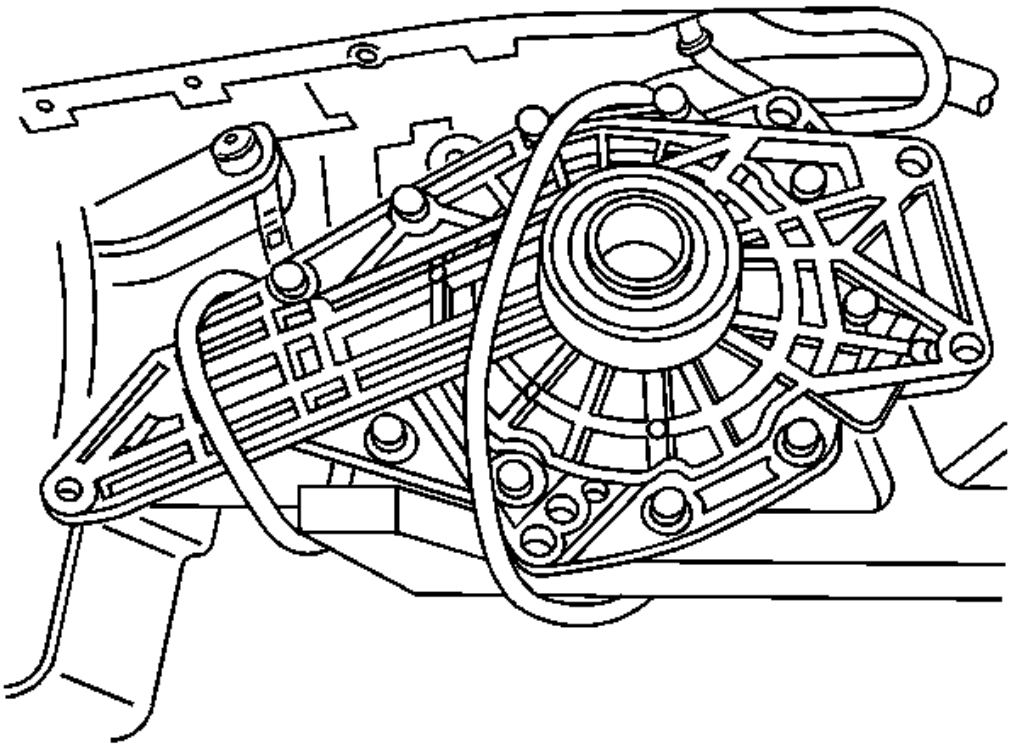

Fig. 199: Securing Front Differential To Frame
Courtesy of GENERAL MOTORS CORP.

3. Remove the front differential and secure to the frame. Refer to **Differential Carrier Assembly Replacement (V8)** In Front Drive Axle.
4. If equipped with two wheel drive (2WD), remove the steering gear. See **POWER STEERING GEAR REPLACEMENT**
5. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

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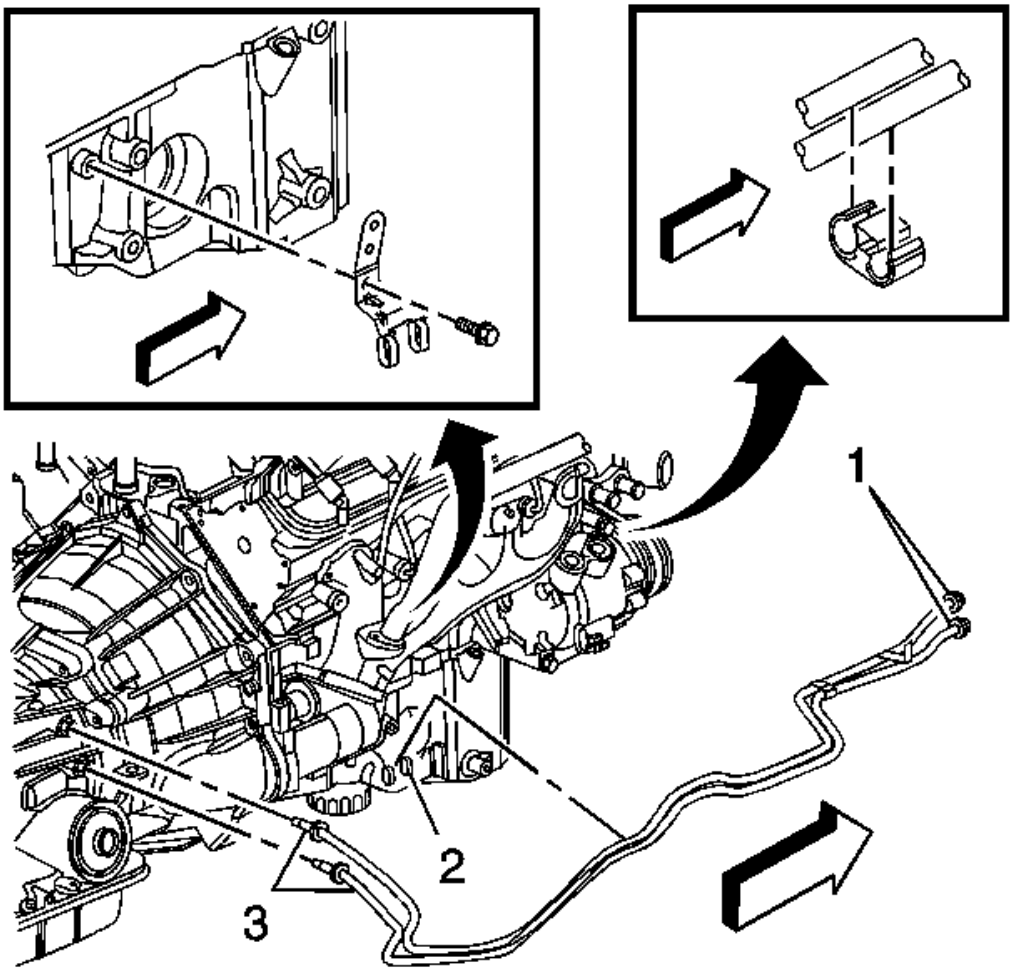

Fig. 200: View Of Transmission Oil Cooler Lines
Courtesy of GENERAL MOTORS CORP.

6. Remove the transmission oil cooler lines (1) from the retainer (2).

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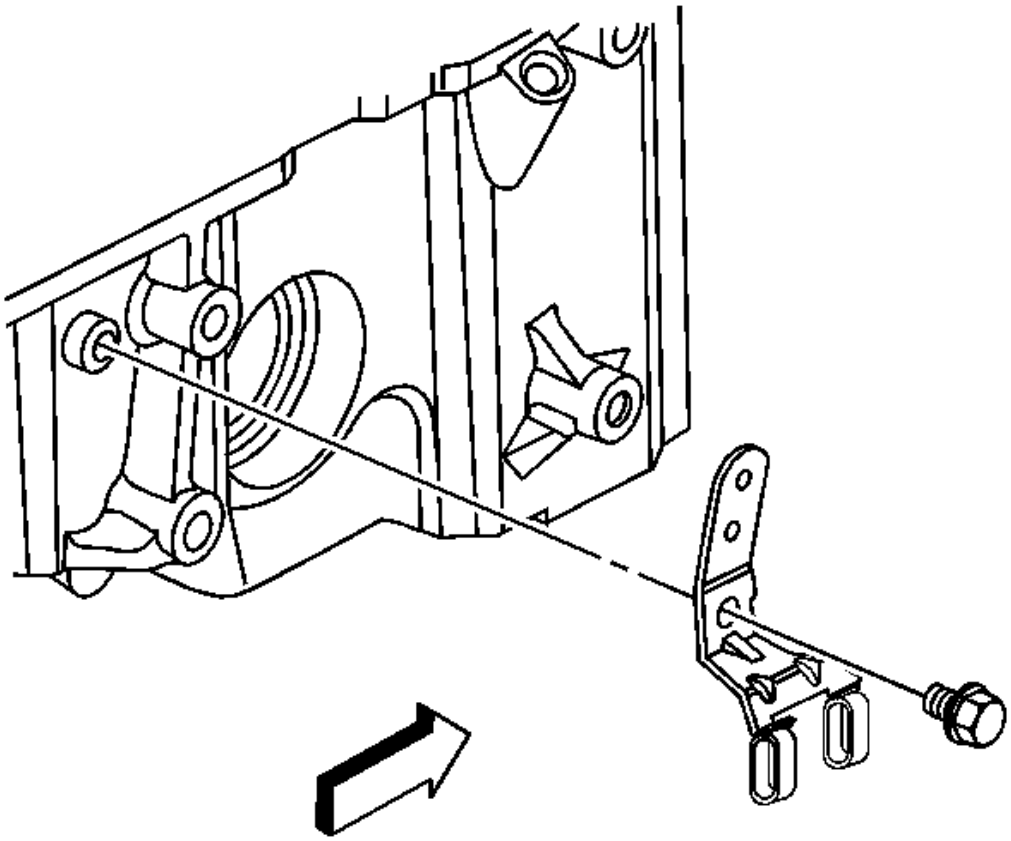

Fig. 201: View Of Transmission Oil Cooler Line Retaining Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the transmission oil cooler line retaining bracket bolt and bracket.
8. Remove the starter. Refer to **Starter Motor Replacement (5.3L Engine)** in Engine Electrical.
9. Remove the flywheel inspection cover from the left side of the transmission.

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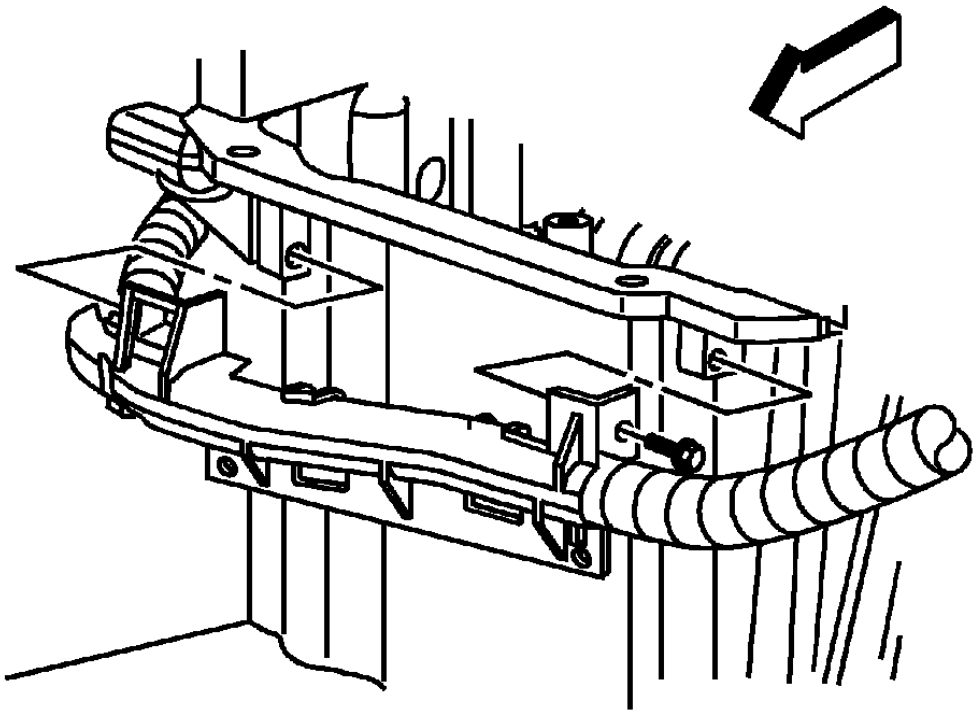

Fig. 202: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

10. Remove the battery cable channel bolt from the front of the oil pan.
11. Remove the battery cable channel from the oil pan.

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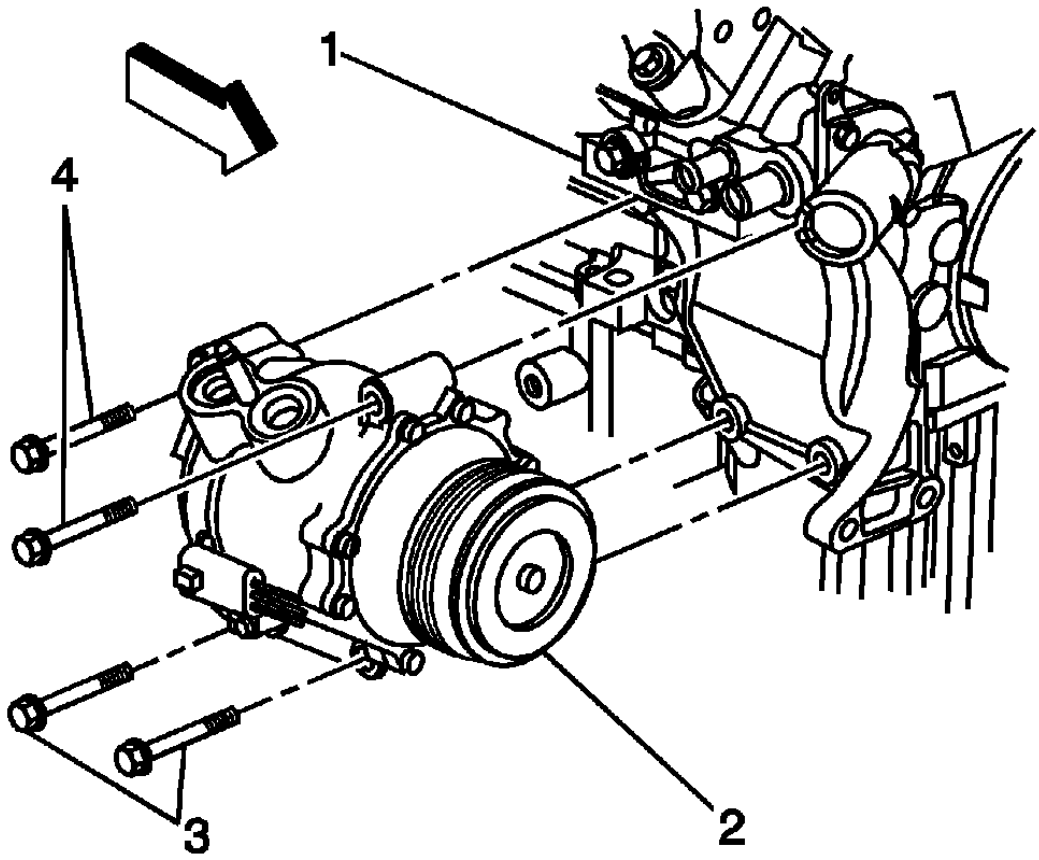

Fig. 203: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

12. Loosen the 2 upper air conditioning (A/C) compressor bracket bolts (4).
13. Remove the 2 lower A/C compressor bracket bolts (3).

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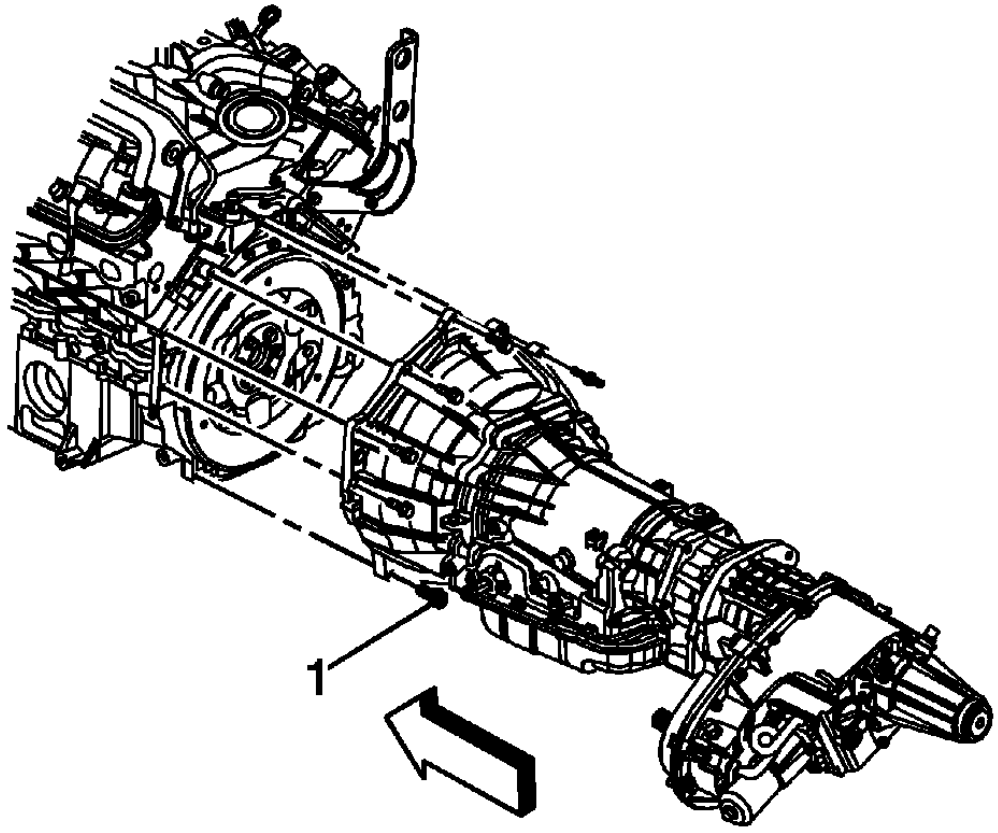

Fig. 204: View Of Lower Bellhousing Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 2 lower bellhousing bolts.

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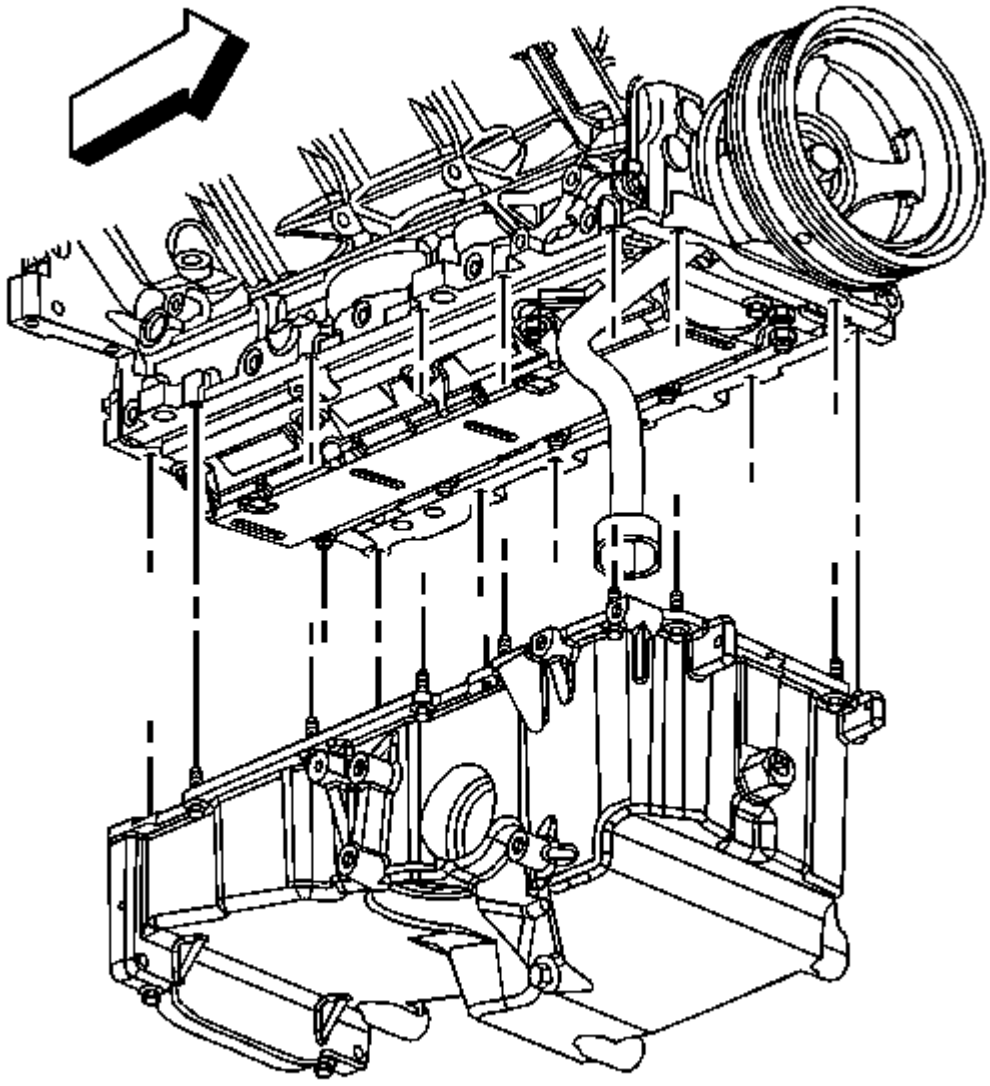

Fig. 205: Oil Pan Assembly Removed
Courtesy of GENERAL MOTORS CORP.

15. Remove the oil pan bolts.
16. Remove the oil pan by tilting the rear of the oil pan down to clear the transmission, pull the oil pan rearward past the front wire harness, then lower the oil pan clear of the vehicle.

IMPORTANT:
- **The oil pan gasket is reusable. It is NOT necessary to remove the oil**

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pan gasket unless damaged.

- **DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.**

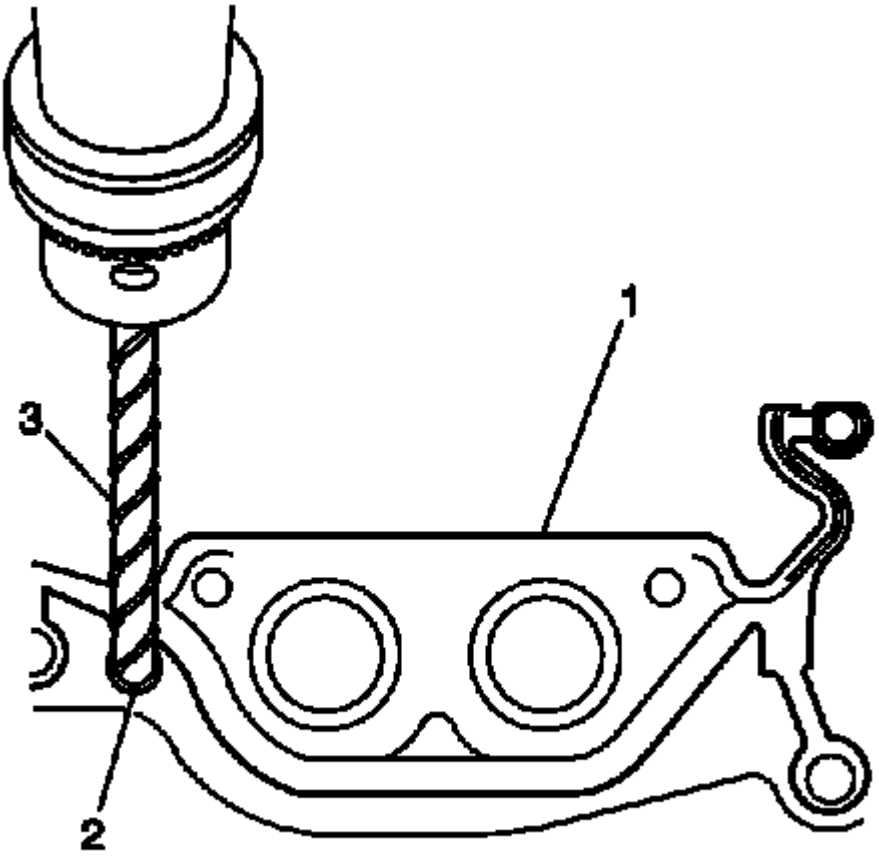

Fig. 206: Drilling Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

17. Drill out the oil pan gasket retaining rivets (2), if required.
18. Remove the gasket (1) from the pan.
19. Discard the gasket and rivets.
20. Clean and inspect the oil pan. Refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

IMPORTANT:

- **The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission bellhousing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan must NEVER protrude beyond the engine block and**

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transmission bellhousing plane.

- **If replacing the oil pan gasket it is not necessary to rivet the NEW gasket to the oil pan.**

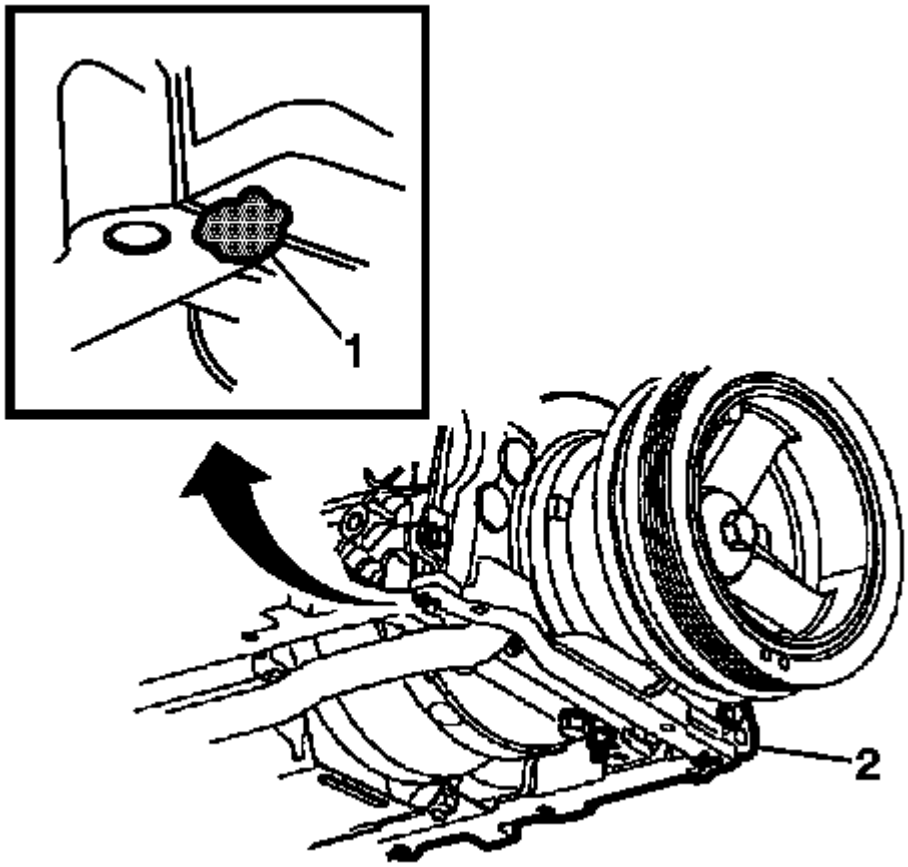

Fig. 207: View Of Sealant Applied To Front Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrudes into the oil pan surface.

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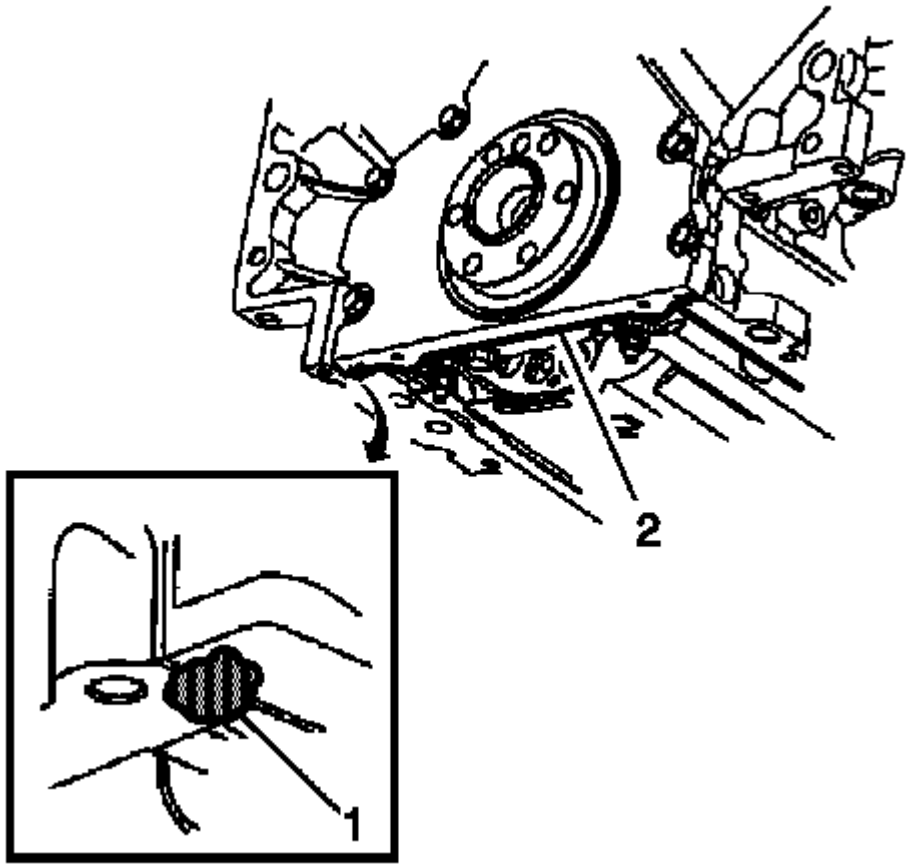

Fig. 208: View Of Sealant Applied To Rear Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.20 in) bead of sealant GM P/N 12378190, or equivalent 20 mm (0.80 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrudes into the oil pan surface.

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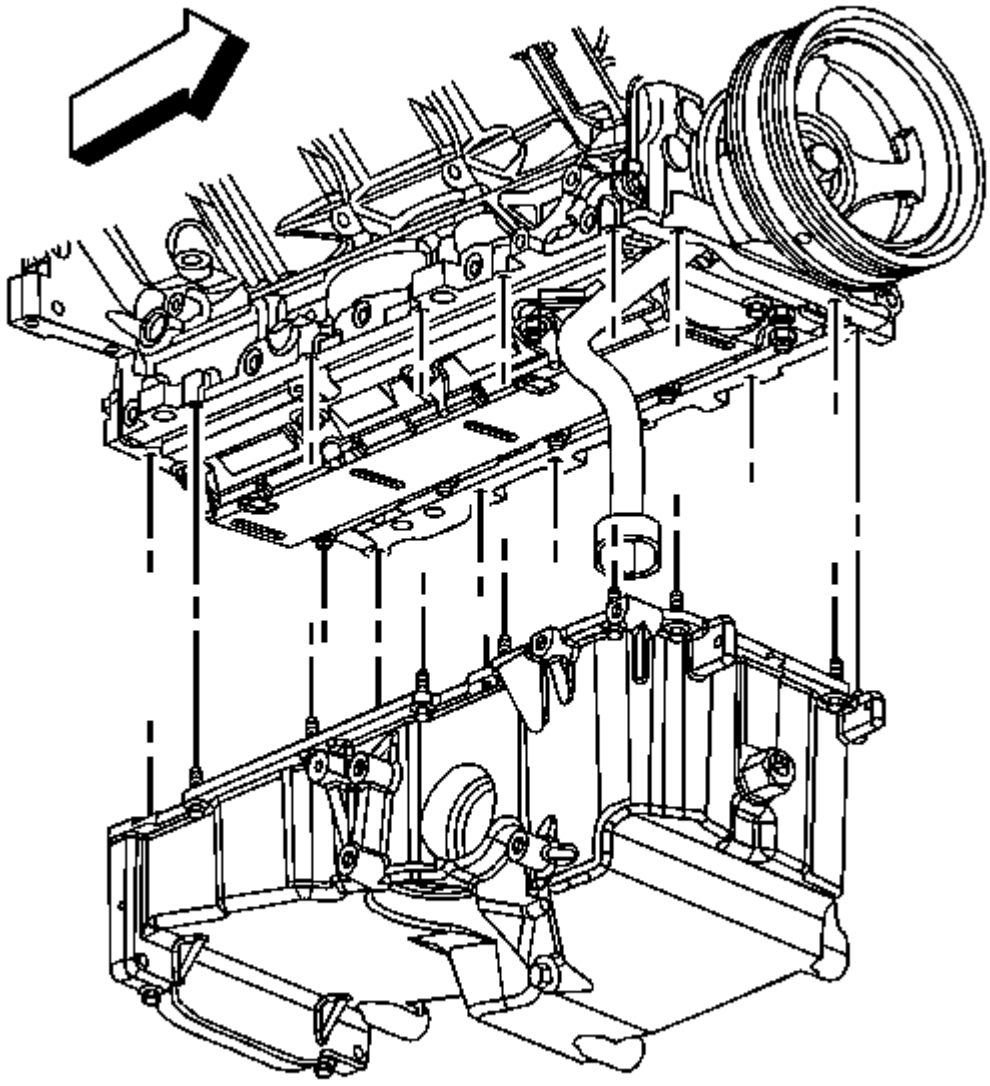

Fig. 209: Oil Pan Assembly Removed
Courtesy of GENERAL MOTORS CORP.

3. Pre-assemble the oil pan gasket and bolts to the pan.
    - Install the gasket onto the pan.
    - Install the oil pan bolts to the pan and through the gasket.
4. Install the oil pan, oil pan gasket, and bolts to the engine block as an assembly.
5. Hand thread the oil pan bolts into the engine block until snug. Do not tighten at this time.

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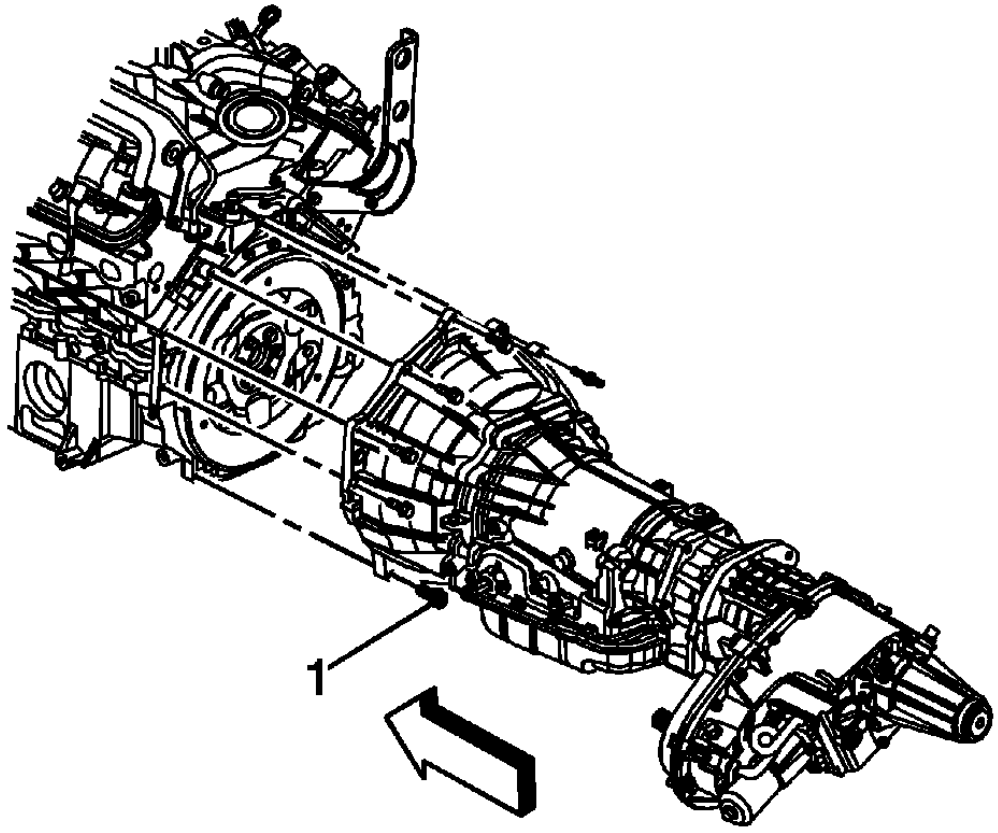

Fig. 210: View Of Lower Bellhousing Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the 2 lower bellhousing bolts.

Tighten:

1. Tighten the lower bellhousing bolts to 50 N.m (37 lb ft).
2. Tighten the 2 rear oil pan to rear cover bolts to 12 N.m (106 lb in).
3. Tighten the remaining oil pan bolts to 25 N.m (18 lb ft).

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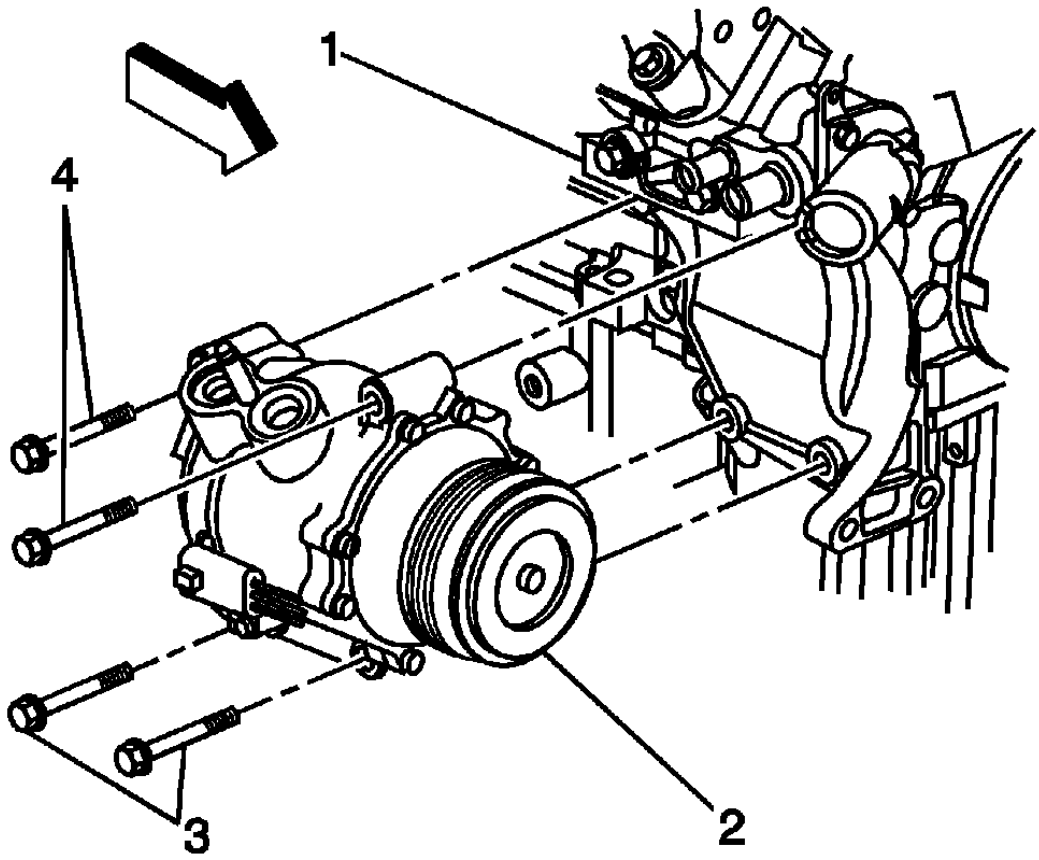

Fig. 211: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the 2 lower A/C compressor bracket bolts (3).

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

8. Tighten the 2 upper A/C compressor bracket bolts (4).

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

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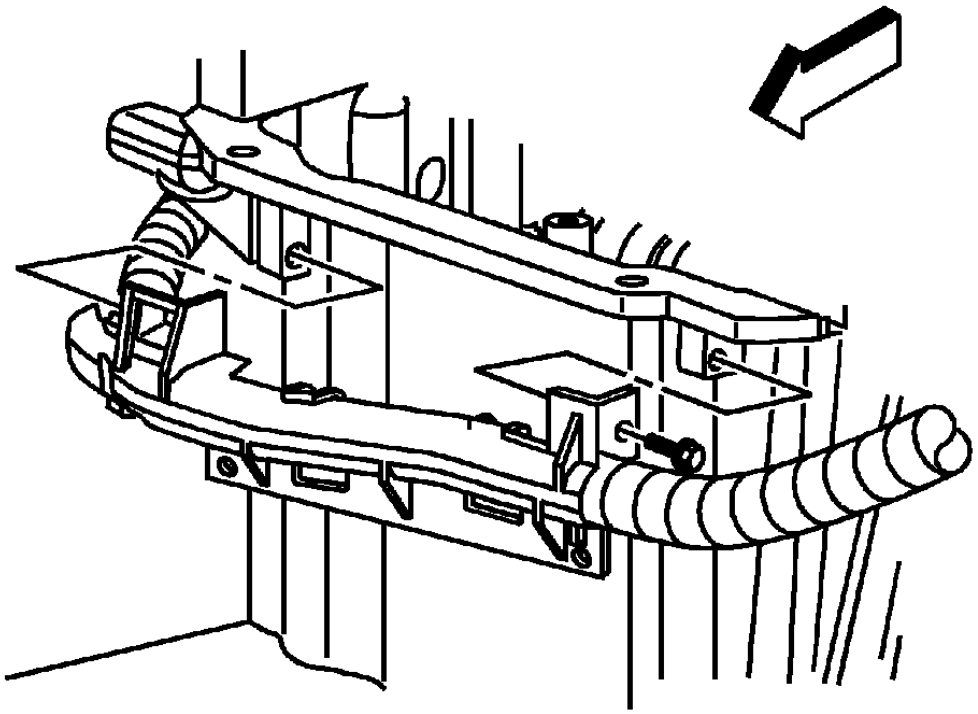

Fig. 212: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the battery cable channel to the oil pan.
10. Install the battery cable channel bolt to the oil pan.

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

11. Install the flywheel inspection cover to the left side of the transmission.

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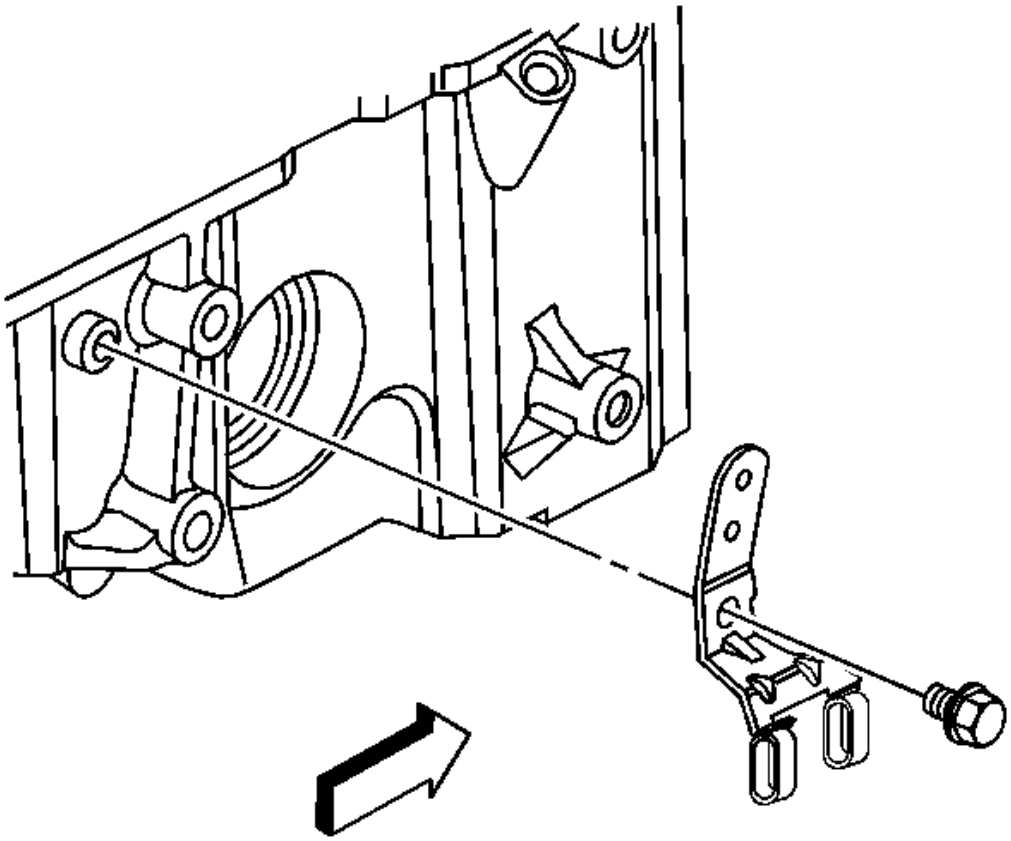

Fig. 213: View Of Transmission Oil Cooler Line Retaining Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

12. Install the starter. Refer to **Starter Motor Replacement (5.3L Engine)** in Engine Electrical.
13. Install the inner axle shaft. Refer to **Inner Axle Shaft Replacement - Front Drive Axle** in Front Drive Axle.
14. If equipped with two-wheel drive (2WD), install the steering gear. See **POWER STEERING GEAR REPLACEMENT** .
15. Install the transmission oil cooler line retaining bracket and bolt.

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

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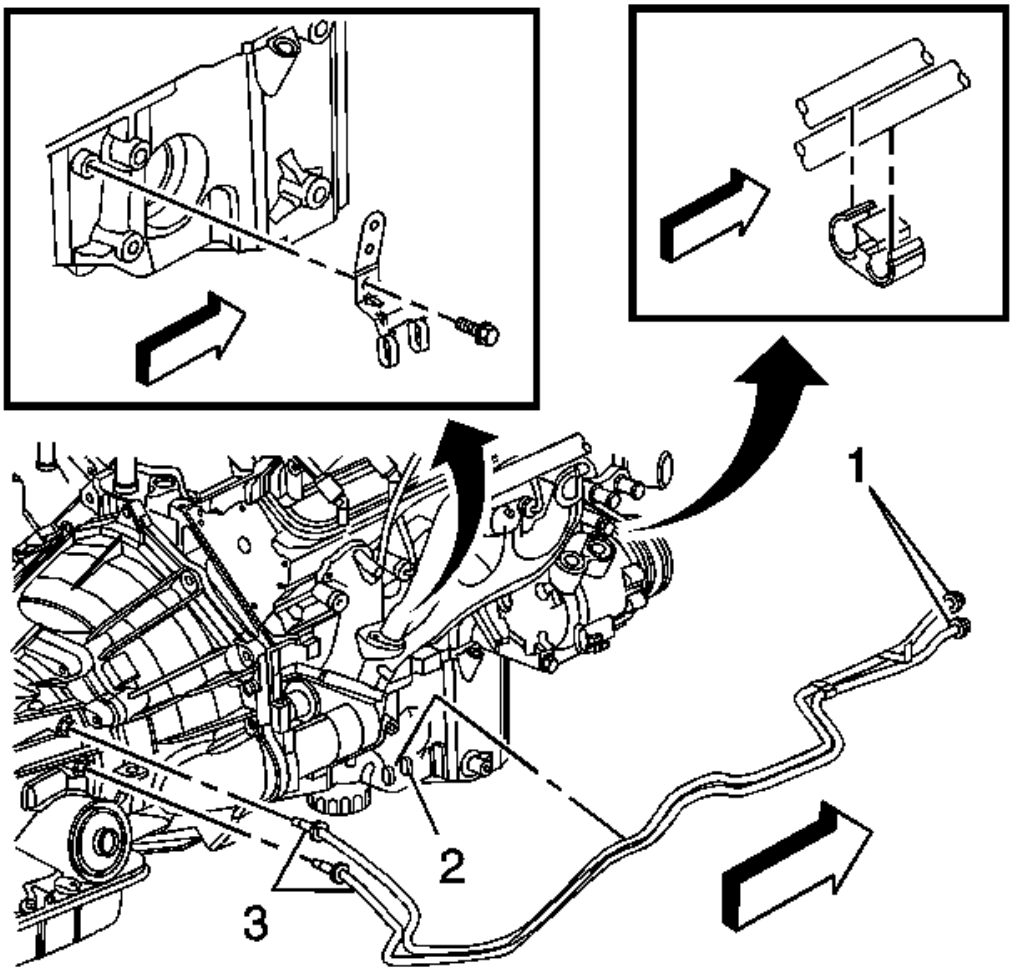

Fig. 214: View Of Transmission Oil Cooler Lines
Courtesy of GENERAL MOTORS CORP.

16. Install the transmission oil cooler lines (1) to the retainer (2).
17. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
18. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.

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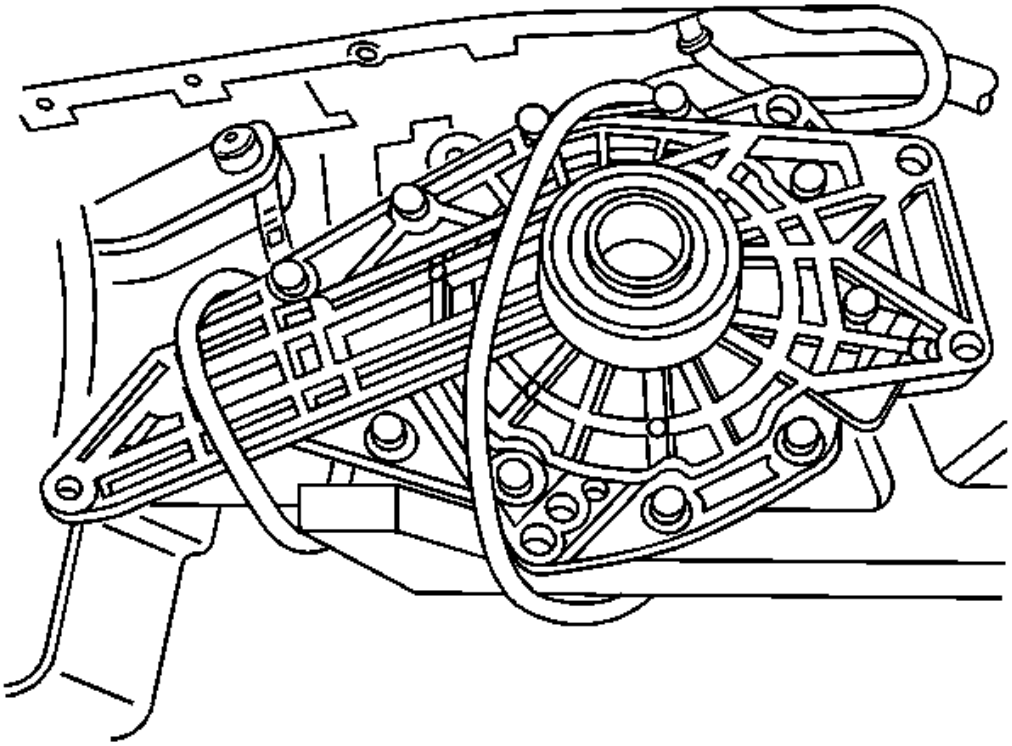

Fig. 215: Securing Front Differential To Frame
Courtesy of GENERAL MOTORS CORP.

19. Install the front differential. Refer to **Differential Carrier Assembly Replacement (V8)** in Front Drive Axle.
20. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.

Valve Lifter Oil Pressure Relief Valve Replacement

Removal Procedure

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

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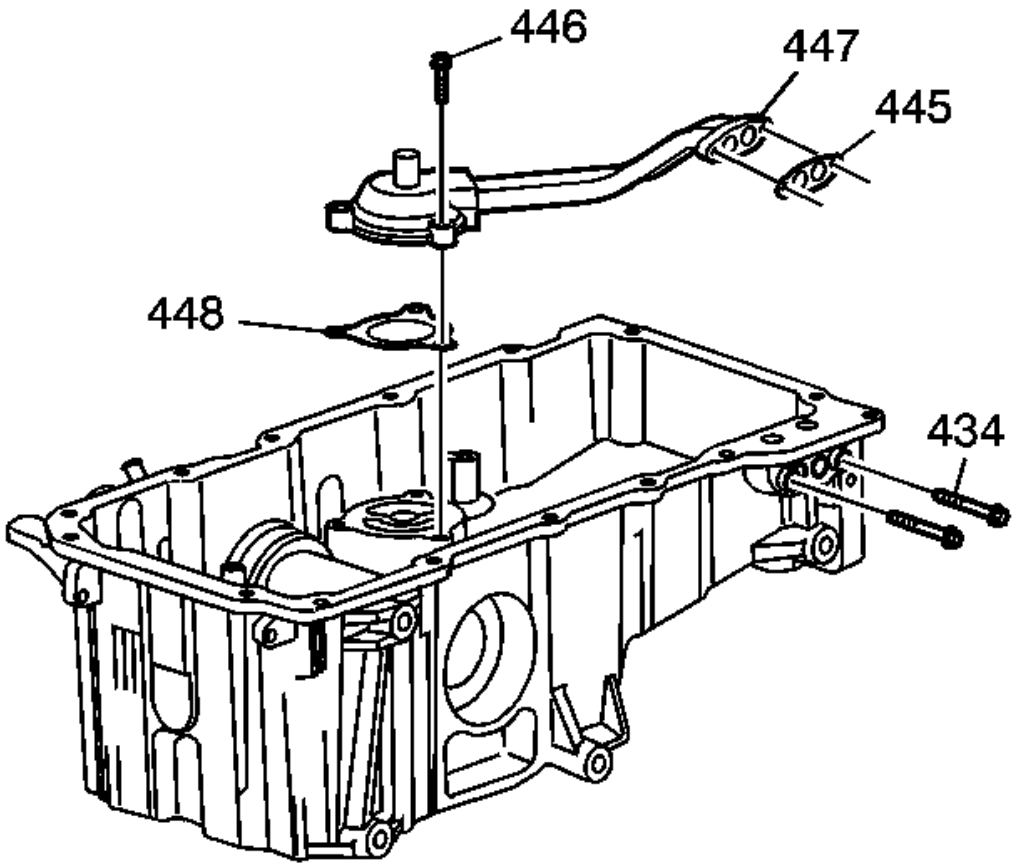

Fig. 216: Oil Transfer Tube
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil transfer tube bolts (435, 446) and gaskets (445, 448).
3. Remove the oil transfer tube (447).

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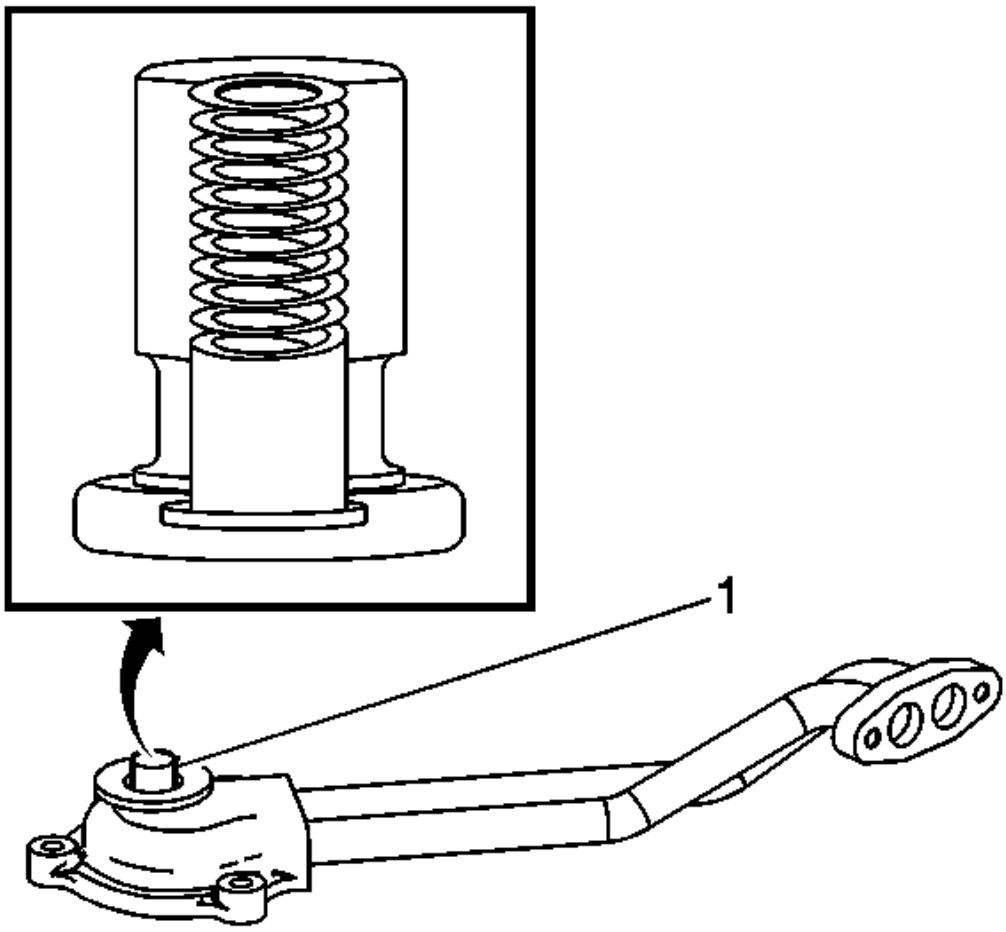

Fig. 217: Oil Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove the displacement on demand oil pressure regulator valve (1) by pushing downward.

Installation Procedure

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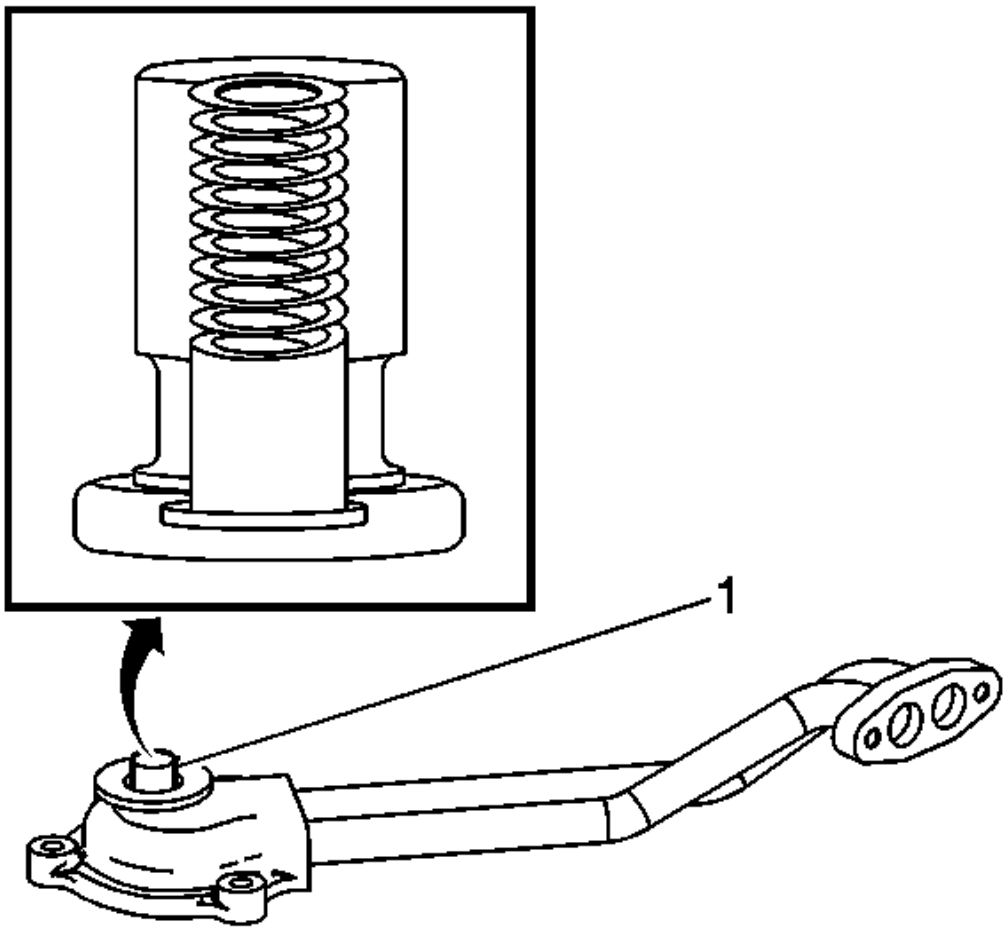

Fig. 218: Oil Pressure Regulator Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the displacement on demand oil pressure regulator valve (1) by pushing upward until fully seated.

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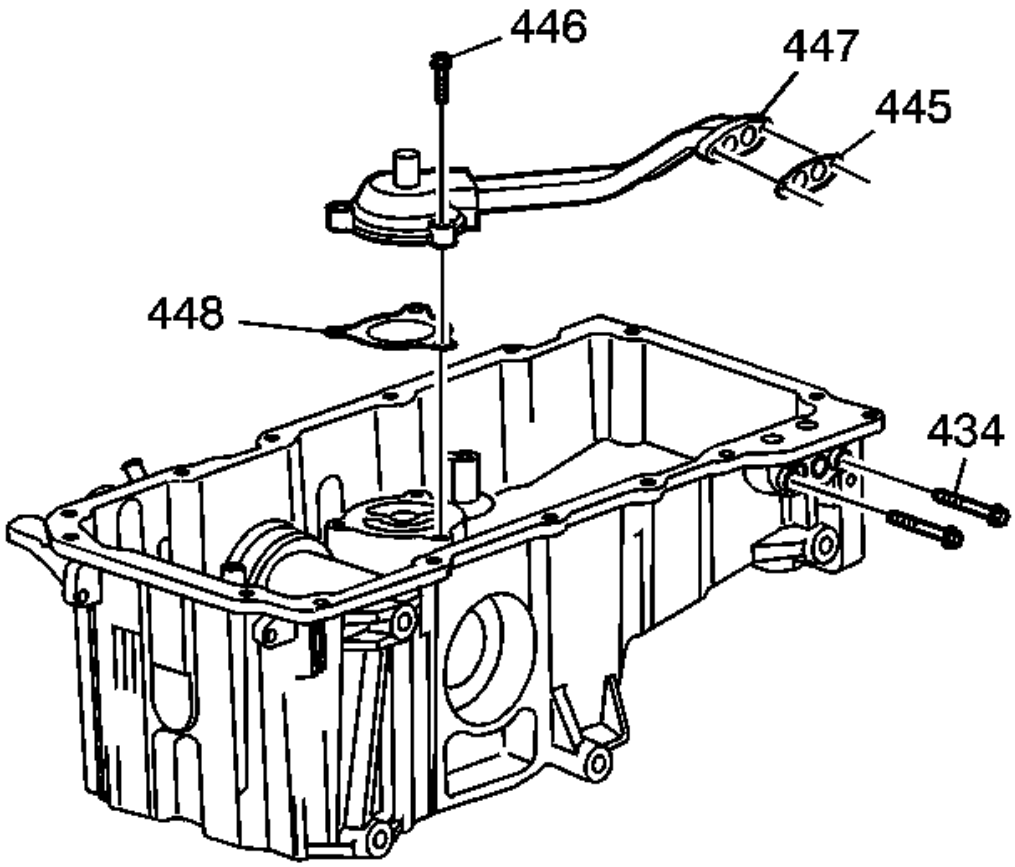

Fig. 219: Oil Transfer Tube
Courtesy of GENERAL MOTORS CORP.

2. Install the oil transfer tube (447).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil transfer tube bolts (435, 446) and gaskets (445, 448).

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

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

Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

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J 41712 Oil Pressure Switch Socket. See **Special Tools**.

Removal Procedure

1. Disconnect the oil pressure sensor electrical connector (1).

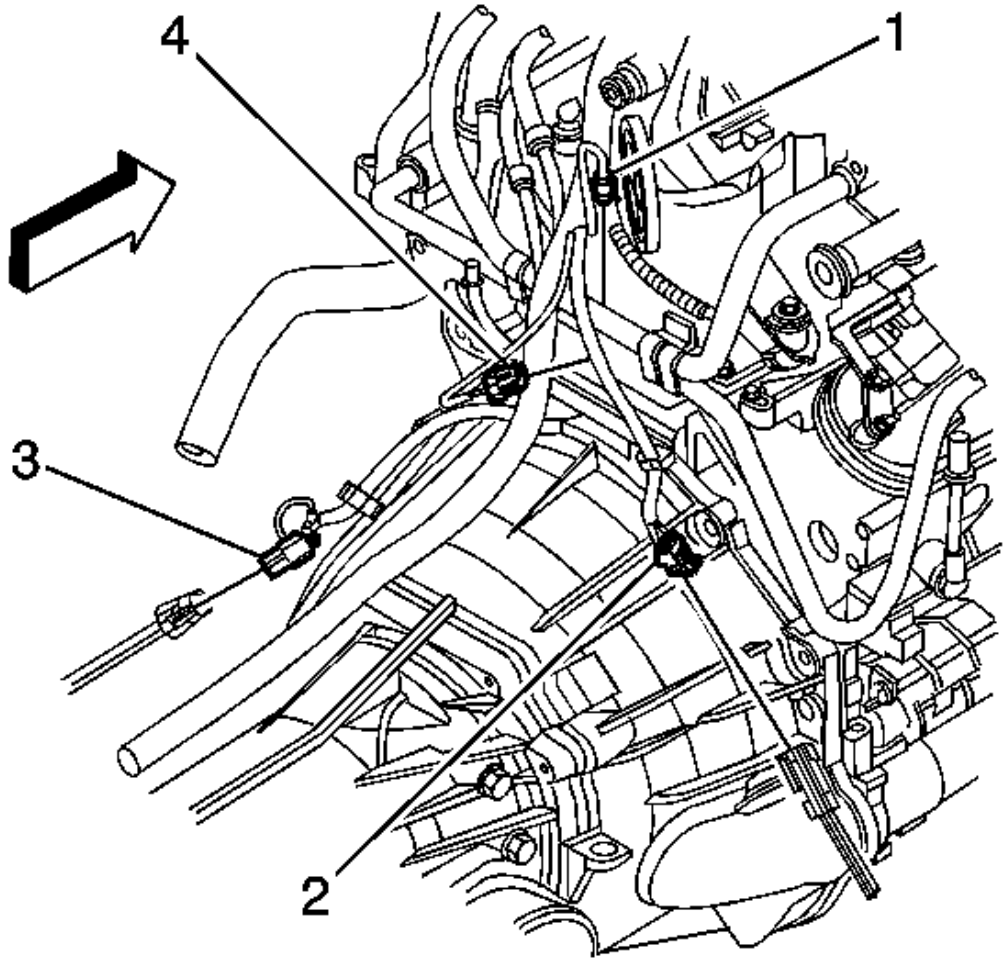

Fig. 220: Locating Components Connectors At Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

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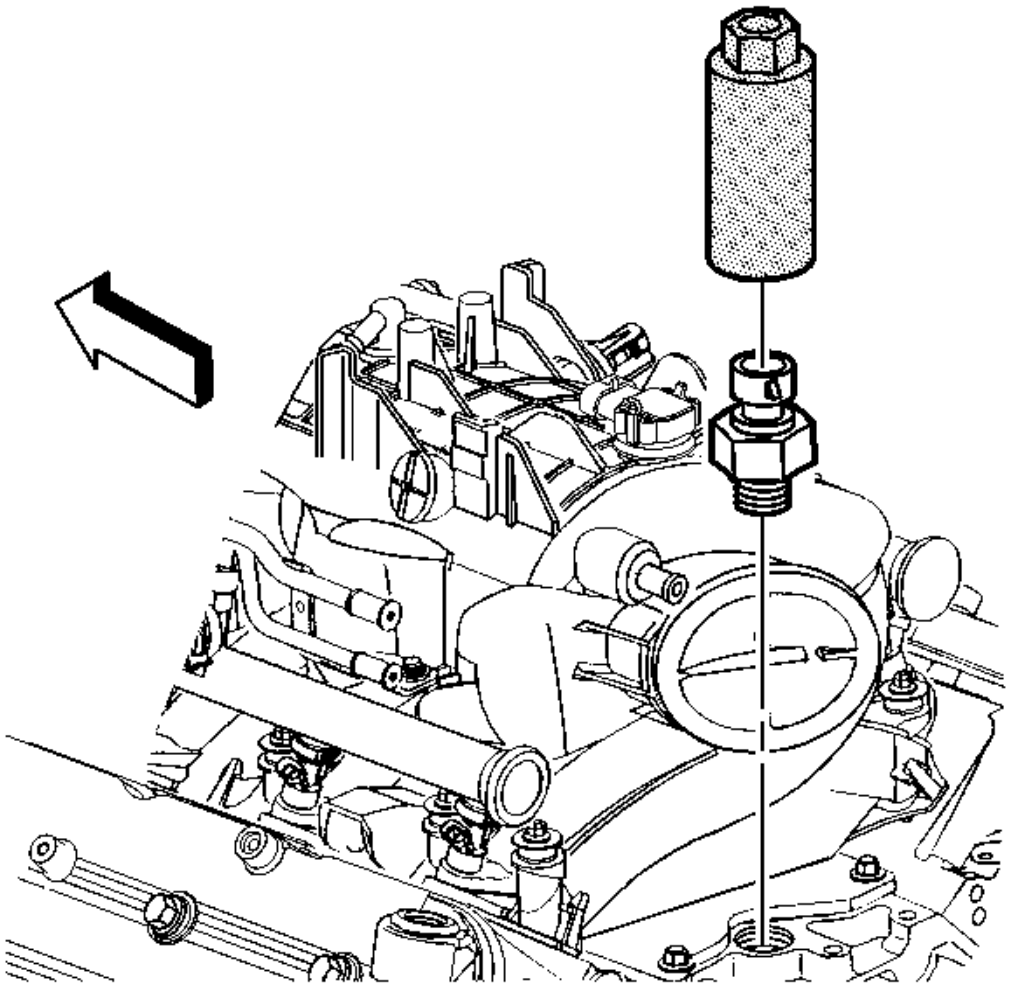

Fig. 221: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

2. Using **J 41712** or equivalent, remove the oil pressure sensor. See **Special Tools**.

Installation Procedure

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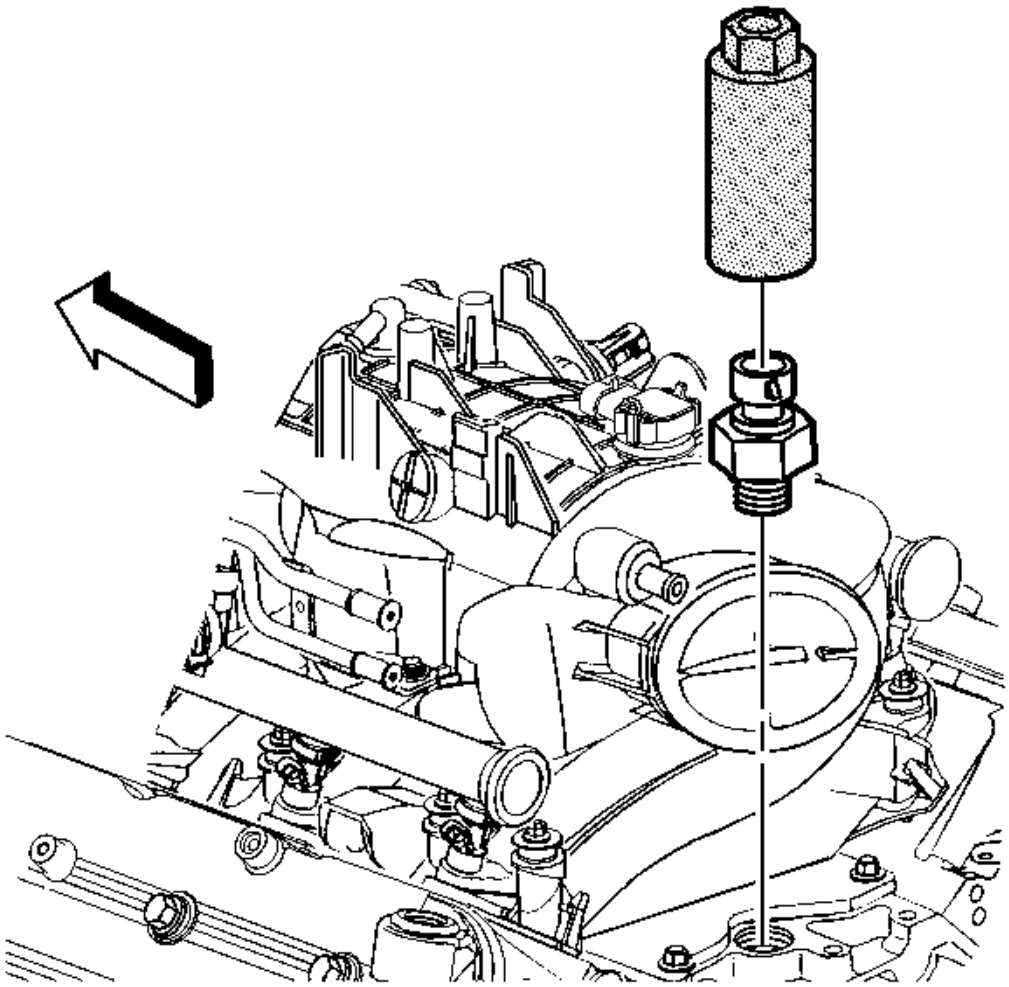

Fig. 222: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent, to the threads of the oil pressure sensor.
2. Using **J 41712** or equivalent, install the oil pressure sensor. See **Special Tools**.

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

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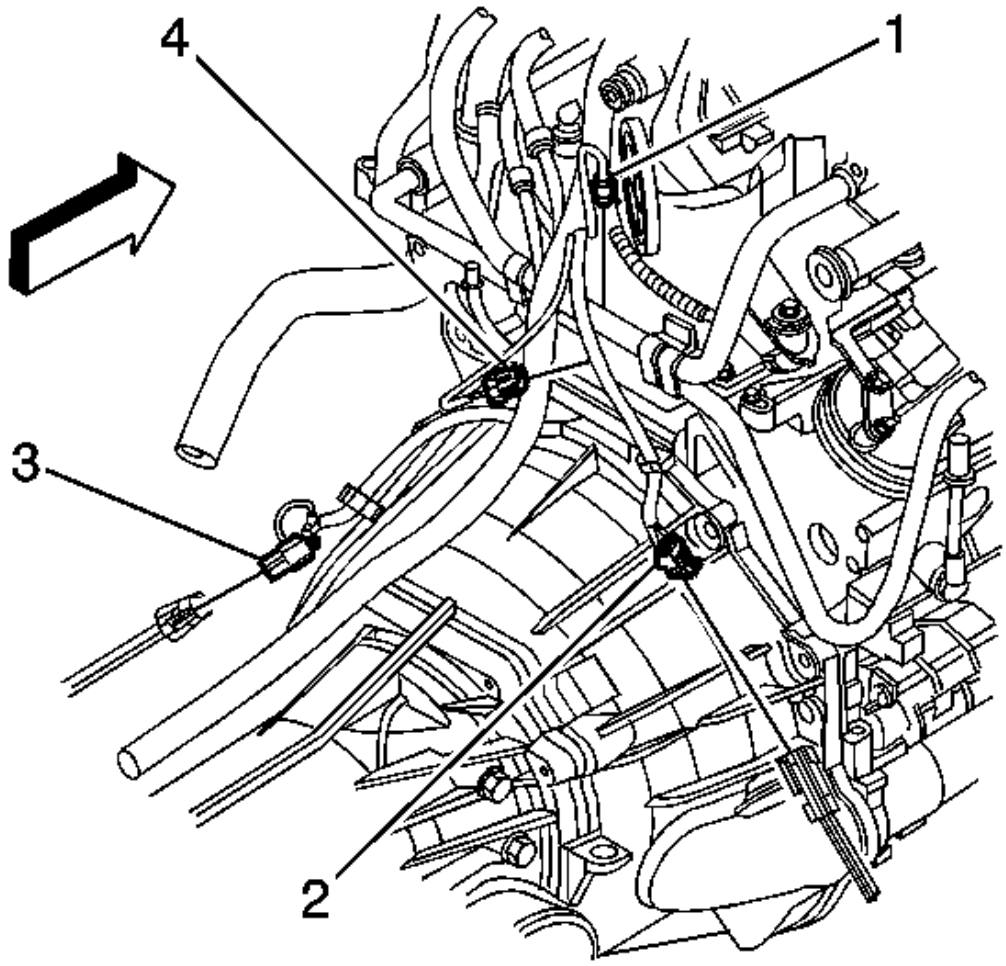

Fig. 223: Locating Components Connectors At Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (1).

Oil Pump, Pump Screen and Deflector Replacement

Removal Procedure

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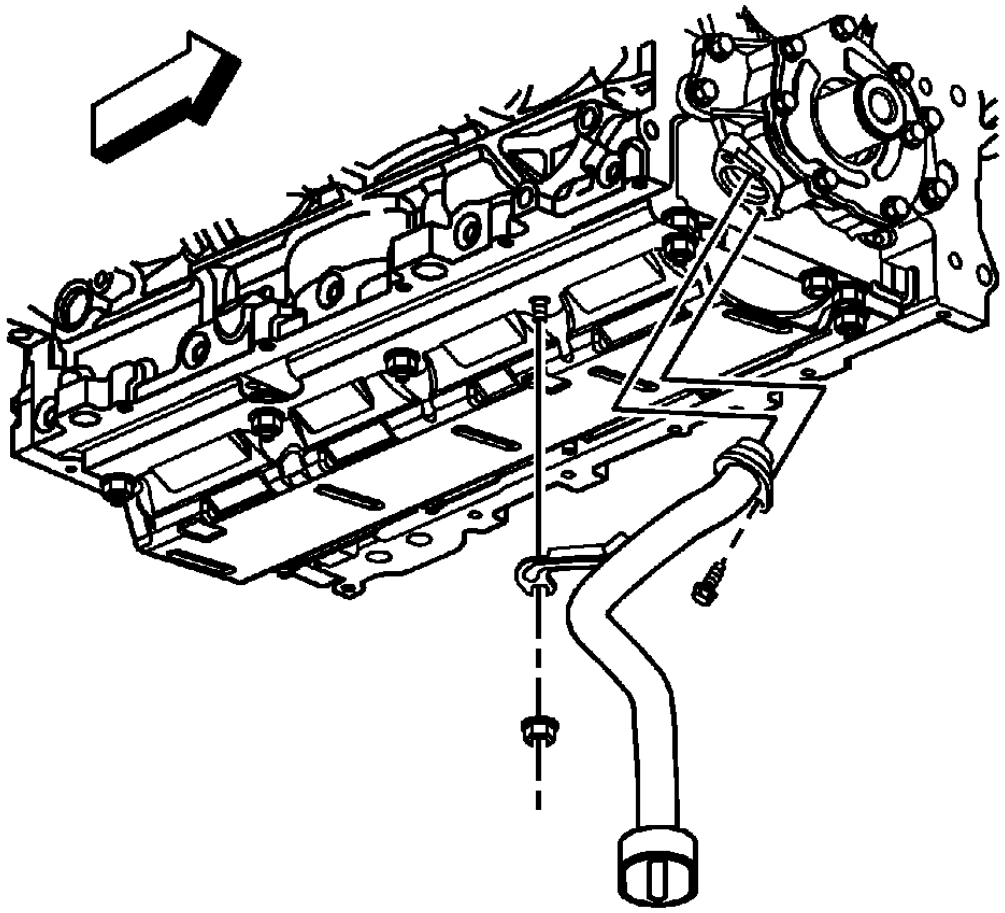

Fig. 224: View Of Oil Pump, Screen & Components
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
3. Remove the oil pump screen bolt and nuts.
4. Remove the oil pump screen with O-ring seal.
5. Remove the O-ring seal from the pump screen.
6. Discard the O-ring seal.

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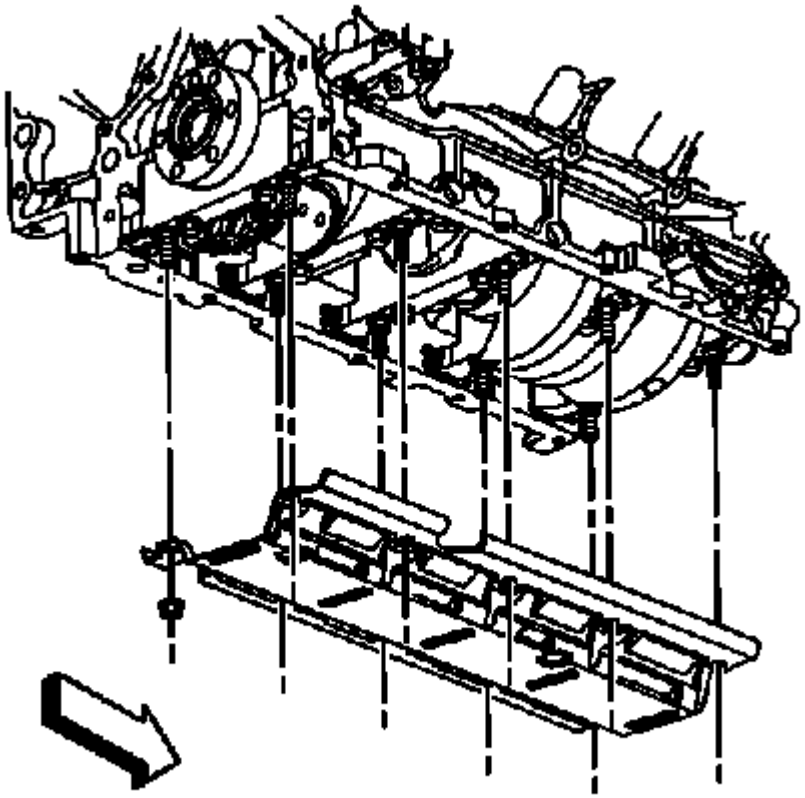

Fig. 225: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

7. Remove the remaining crankshaft oil deflector nuts.
8. Remove the crankshaft oil deflector.

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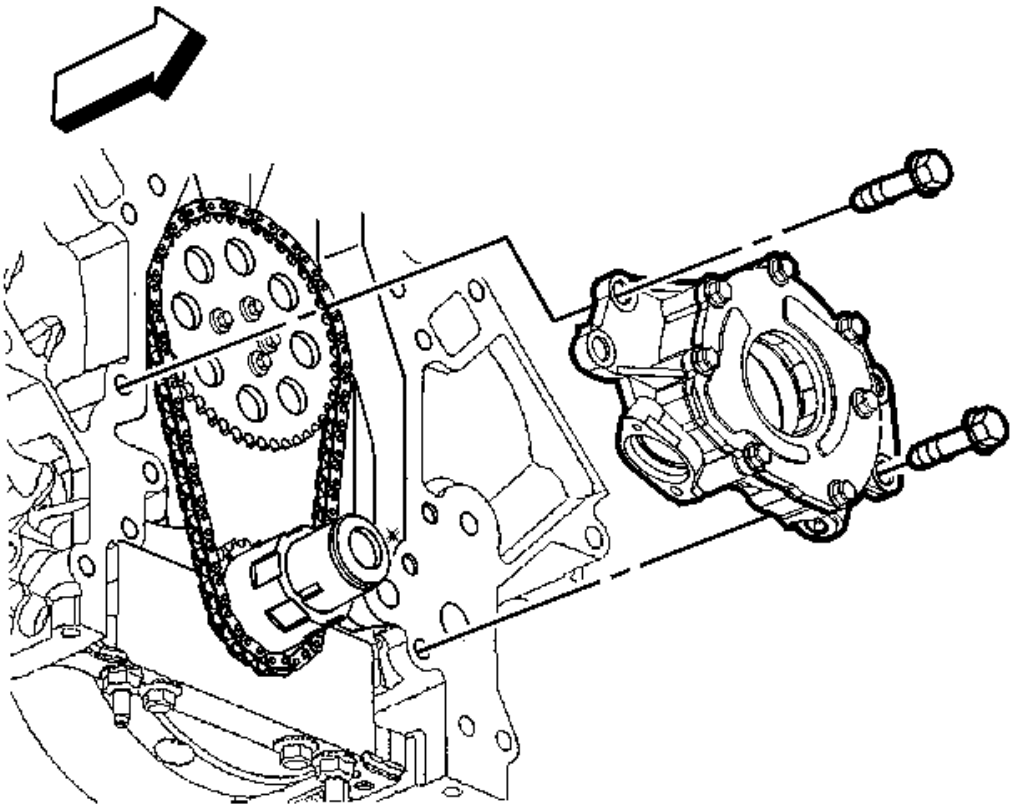

Fig. 226: View Of Oil Pump & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pump bolts.

IMPORTANT: Do not allow dirt or debris to enter the oil pump assembly, cap end as necessary.

10. Remove the oil pump.
11. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

Installation Procedure

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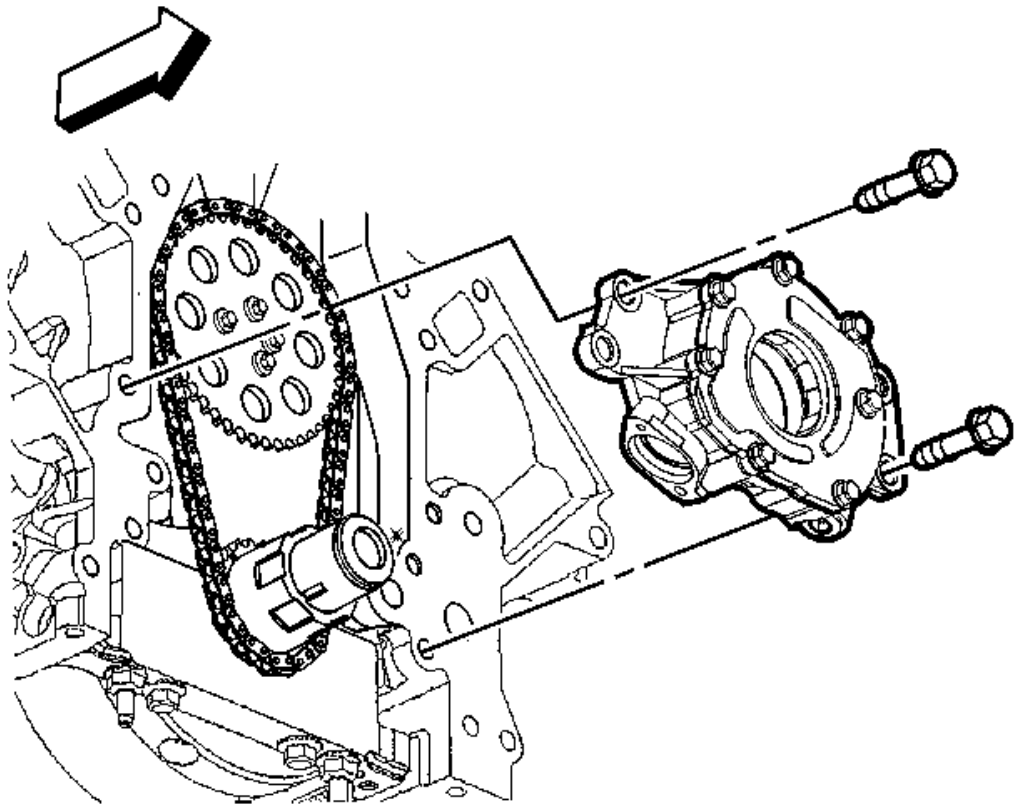

Fig. 227: View Of Oil Pump & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump.
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump bolts.

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

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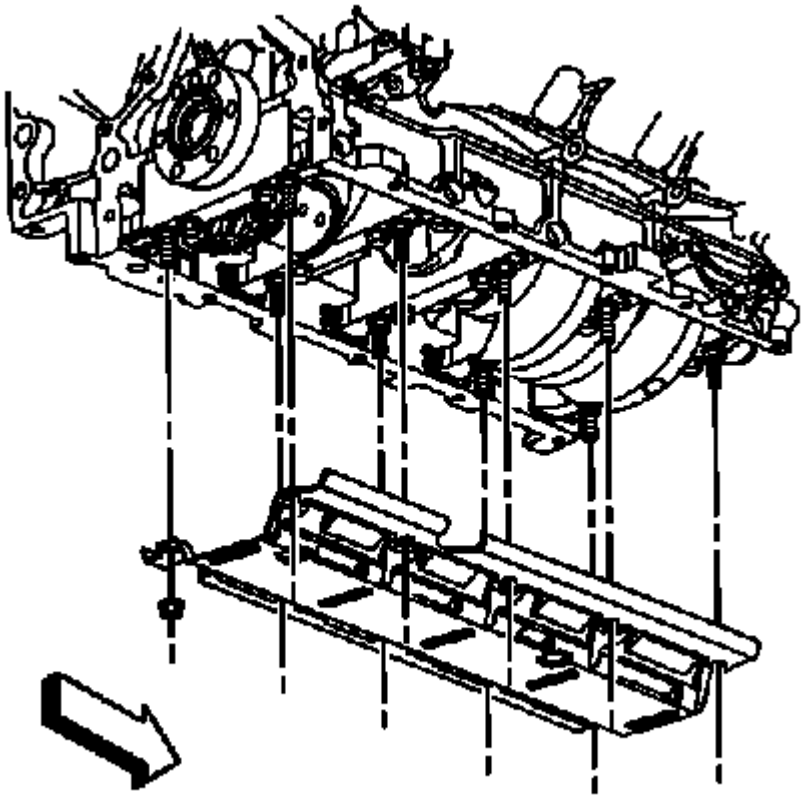

Fig. 228: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector and nuts until snug.

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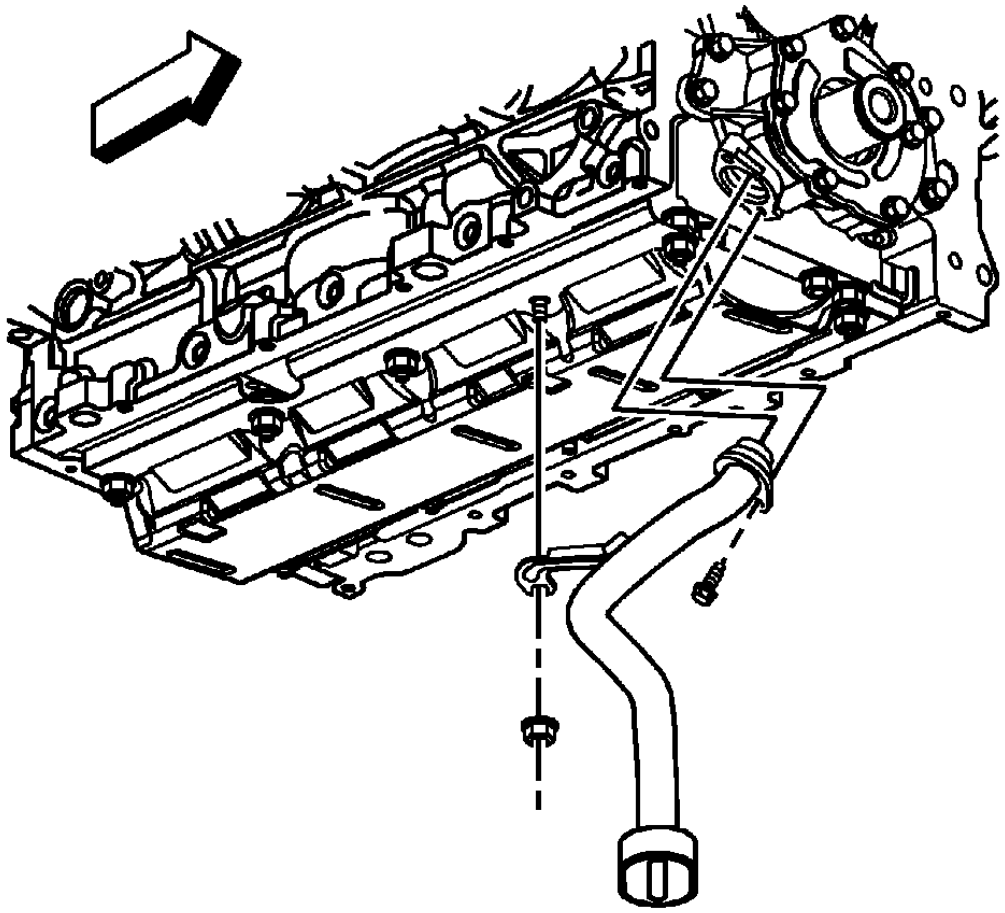

Fig. 229: View Of Oil Pump, Screen & Components
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

IMPORTANT: Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.

7. Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.
8. Install the oil pump screen.
9. Install the oil pump screen bolt and nuts.

Tighten:

- Tighten the bolt to 12 N.m (106 lb in).
- Tighten the nuts to 25 N.m (18 lb ft).

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10. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
11. Install the oil pan. Refer to **Oil Pan Replacement**.

Timing Chain and Sprockets Replacement

Tools Required

- **J 8433-1** Puller Bar. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector

Removal Procedure

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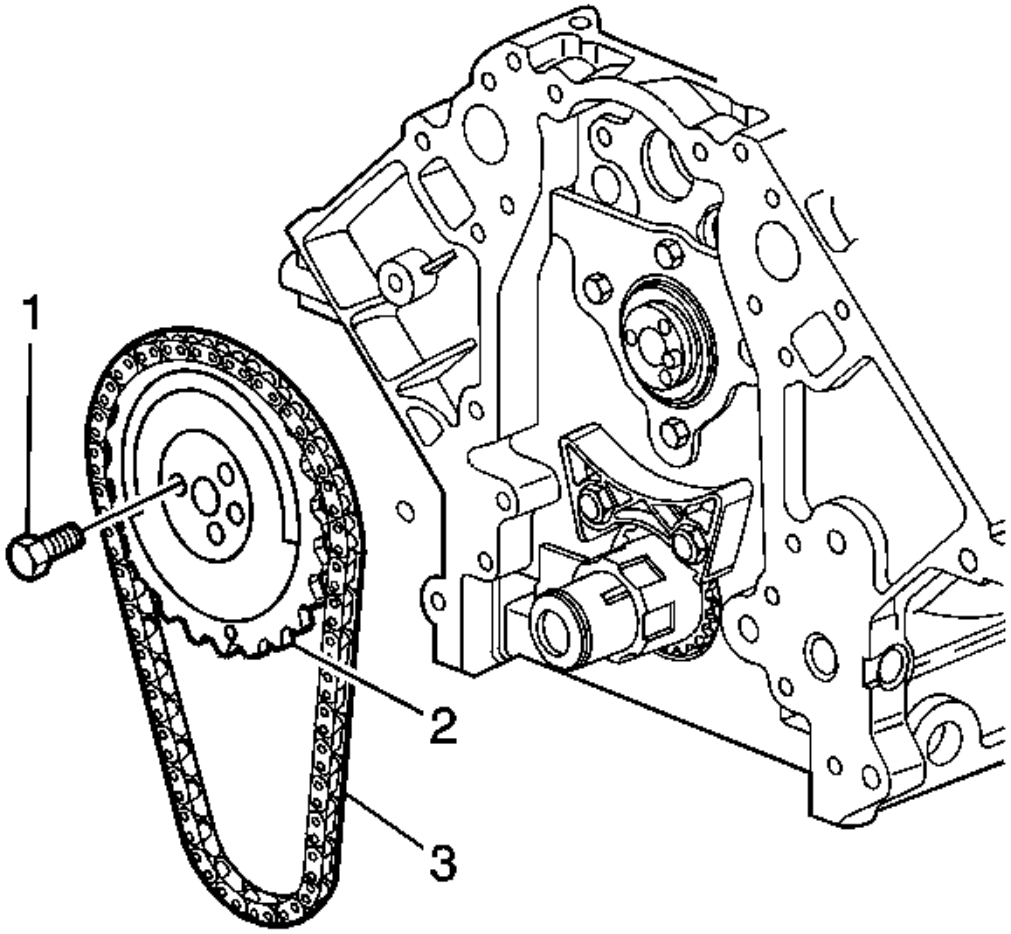

Fig. 230: Timing Chain & Sprocket Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump, Pump Screen and Deflector Replacement**.

NOTE: **Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.**

2. Rotate the crankshaft until the timing marks on the crankshaft and the camshaft sprockets are aligned.
3. Remove the camshaft sprocket bolts (1).
4. Remove the camshaft sprocket (2) and timing chain (3).

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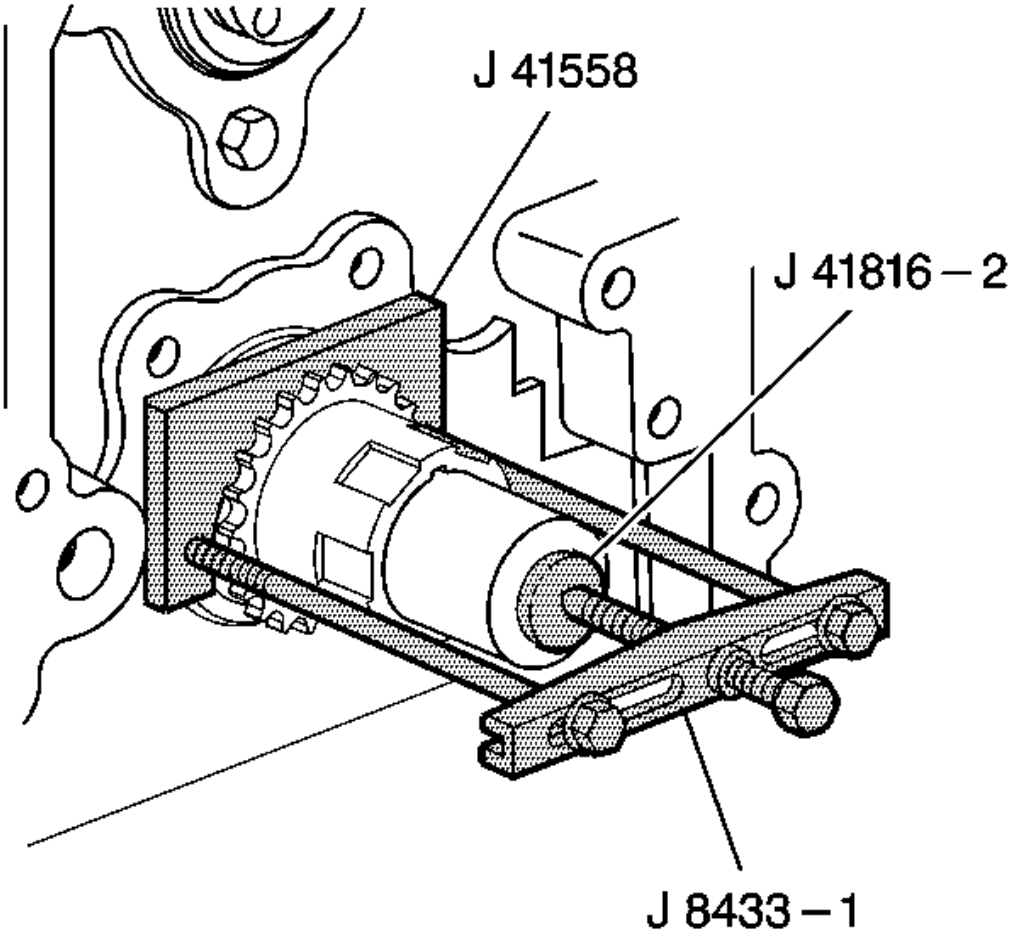

Fig. 231: Removing The Crankshaft Sprocket Using J 8433-1, J 41816-2 & J 41558
Courtesy of GENERAL MOTORS CORP.

5. Use **J 8433-1** , **J 41816-2** and **J 41558** in order to remove the crankshaft sprocket. See **Special Tools**.

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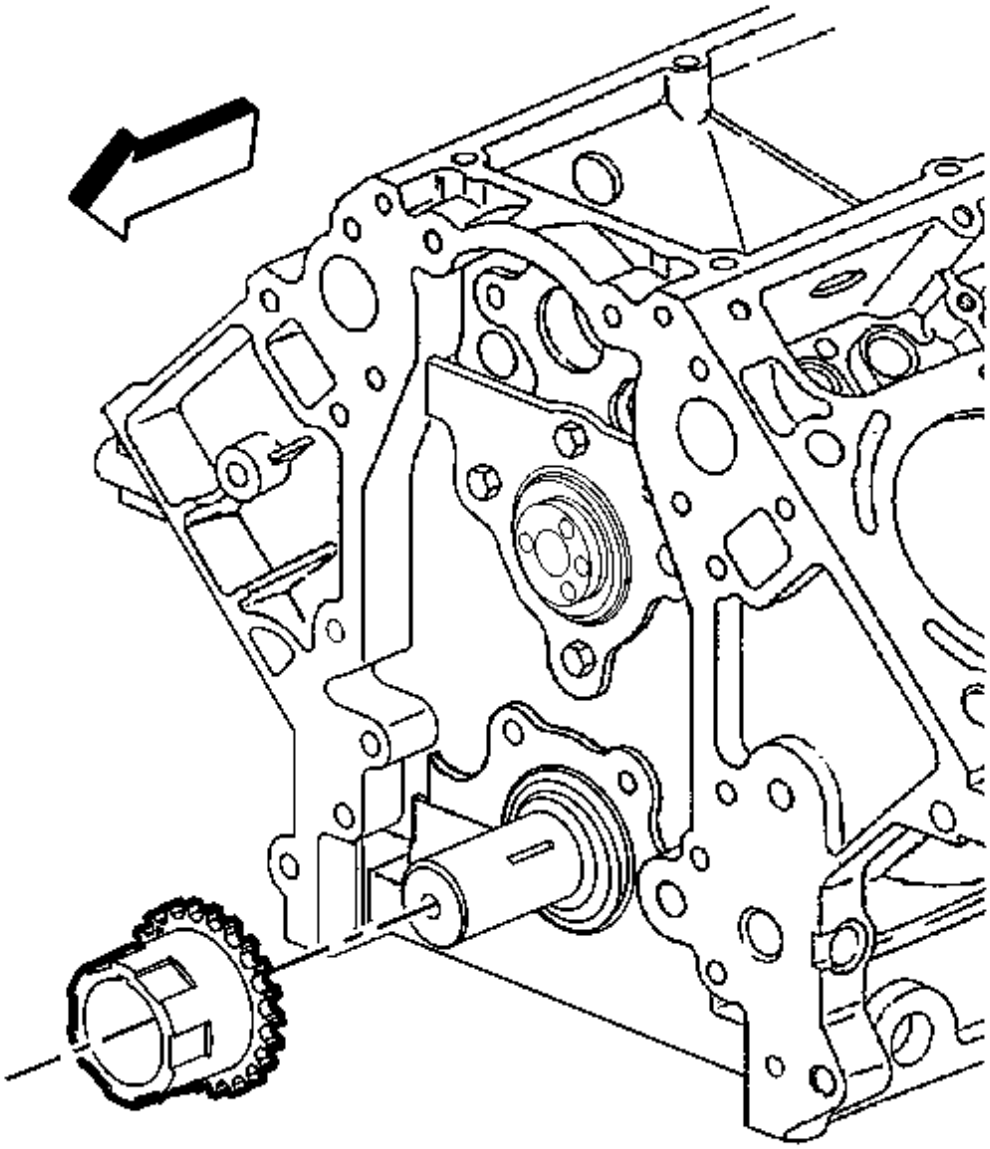

Fig. 232: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket.

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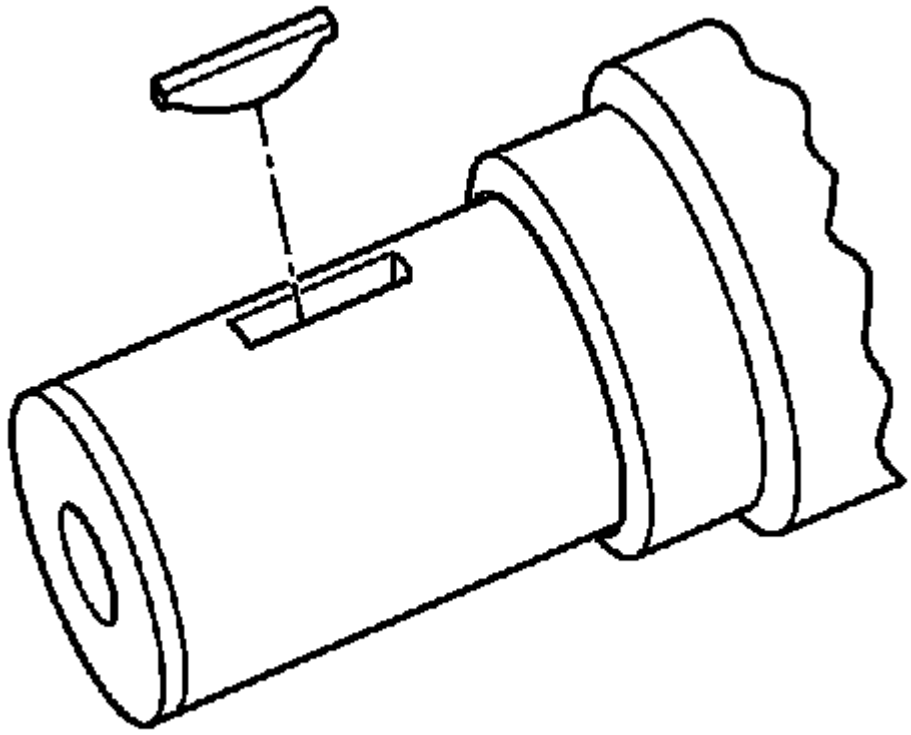

Fig. 233: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket key, if required.
8. Clean and inspect the timing chain and sprockets. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

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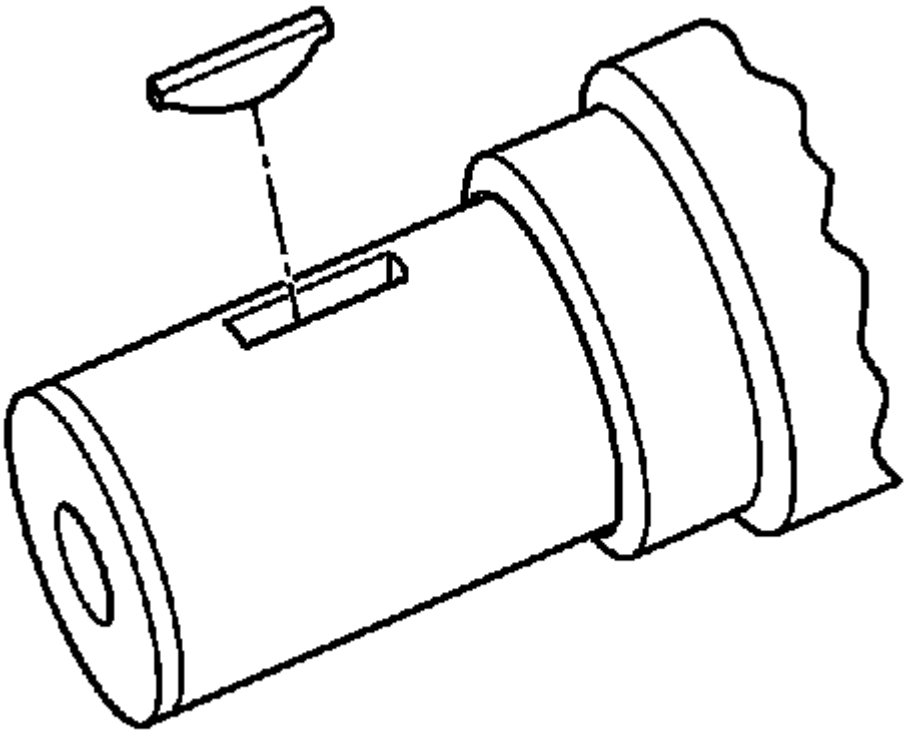

Fig. 234: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.

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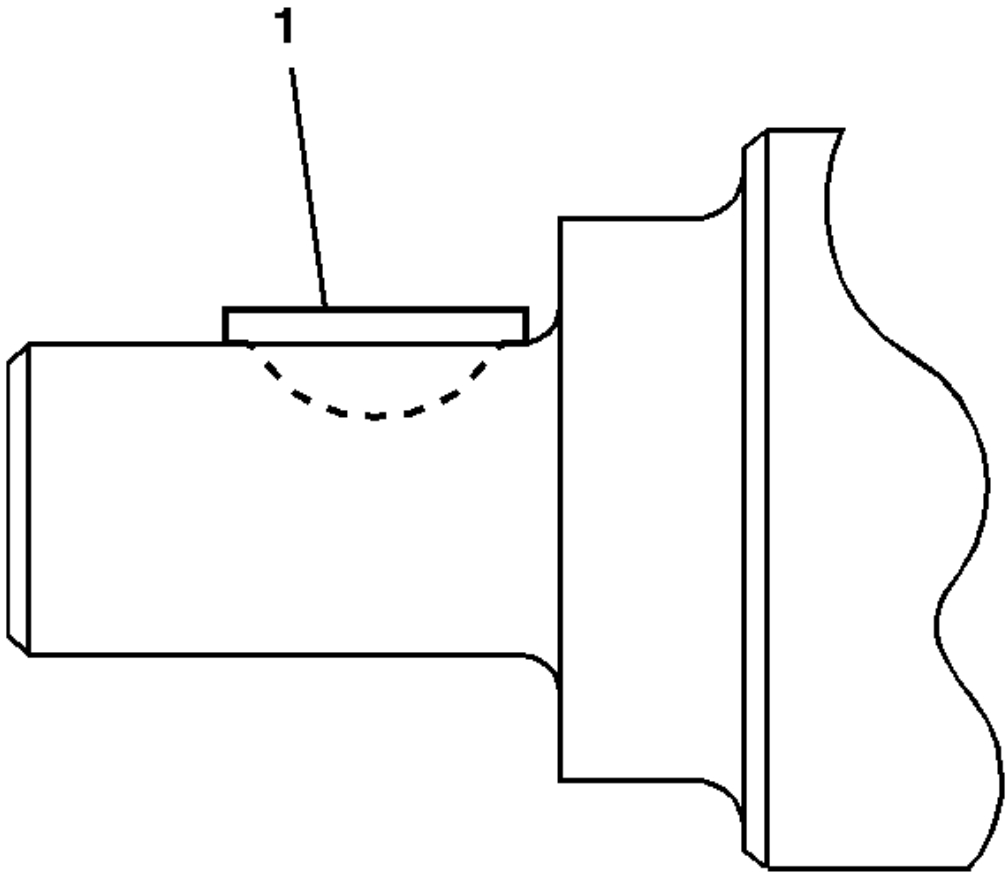

Fig. 235: View Of Crankshaft Sprocket Key Installation Position
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.

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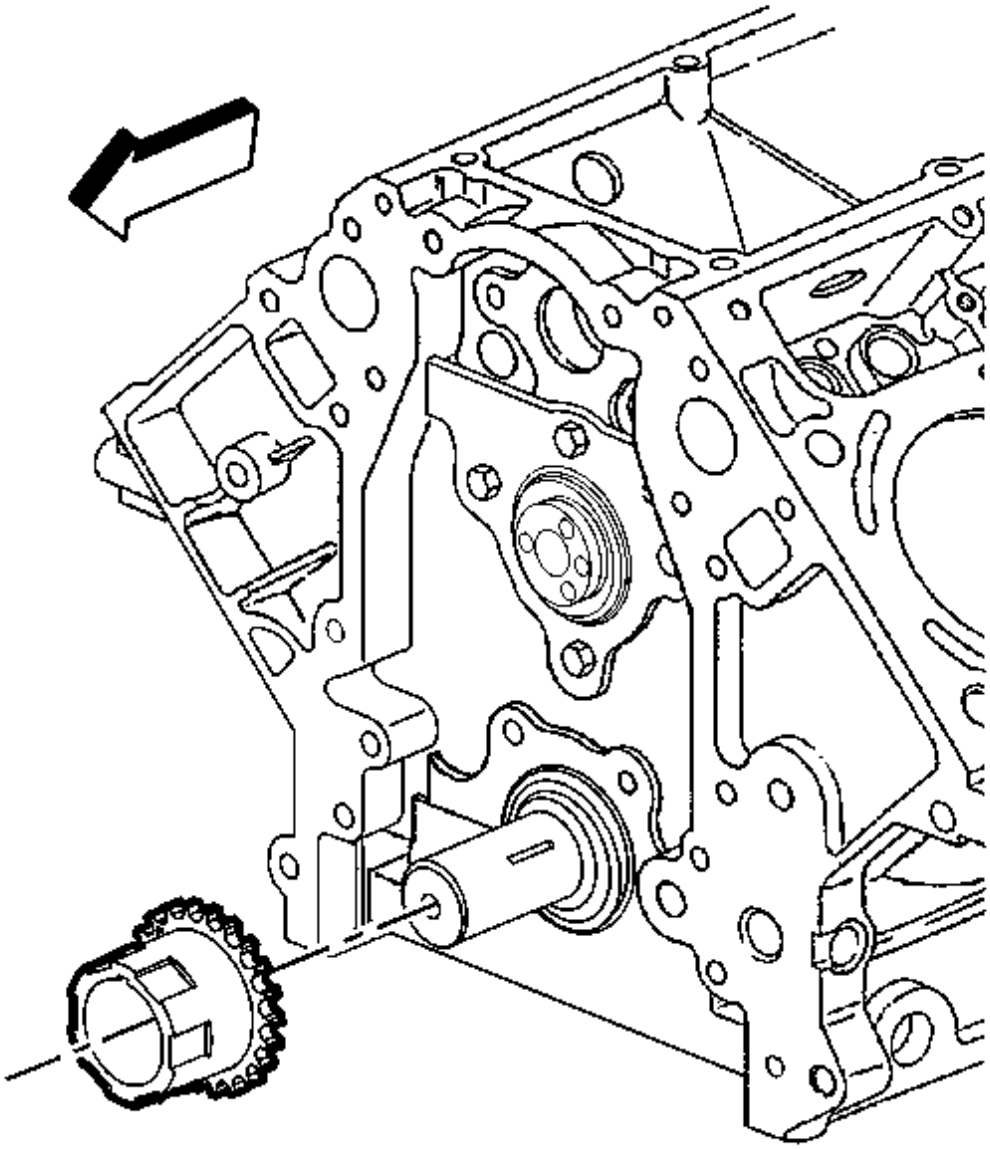

Fig. 236: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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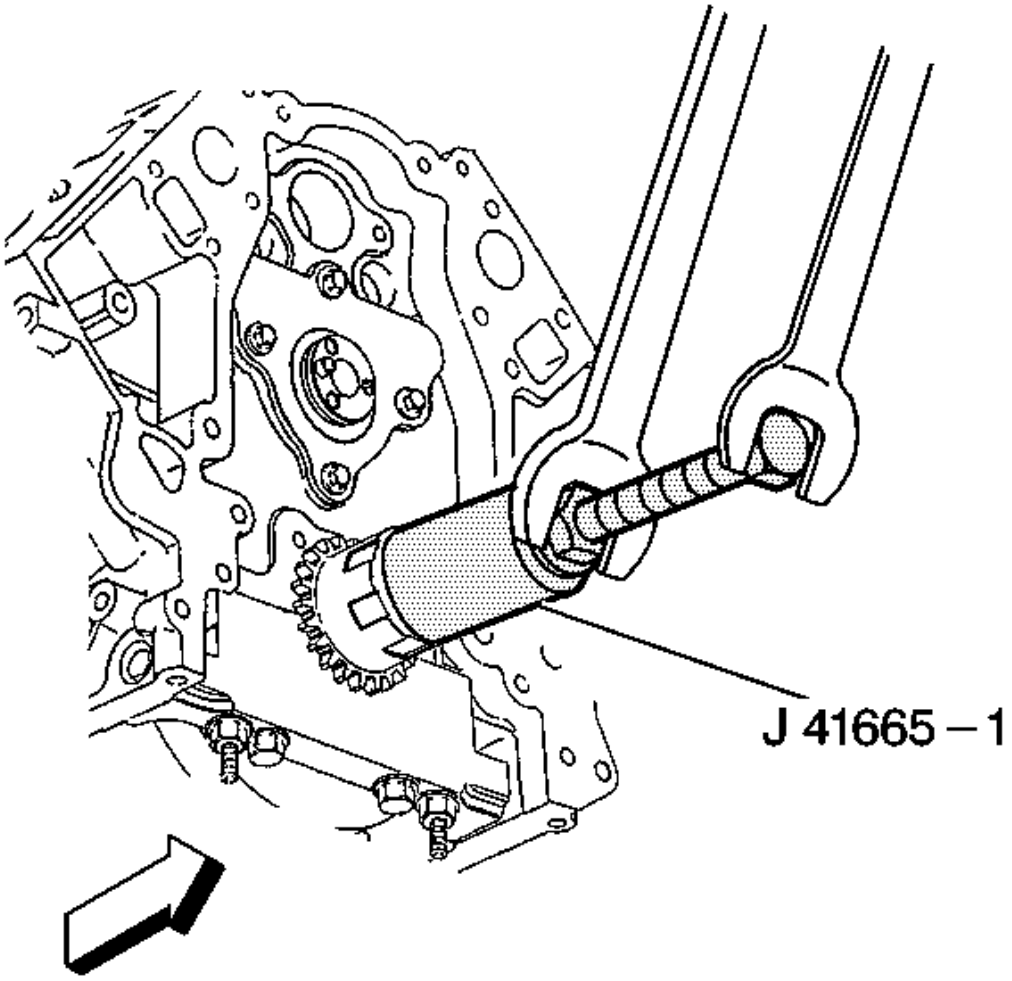

Fig. 237: Using J 41665 To Install Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use **J 41665** in order to install the crankshaft sprocket. See **Special Tools**.

   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.

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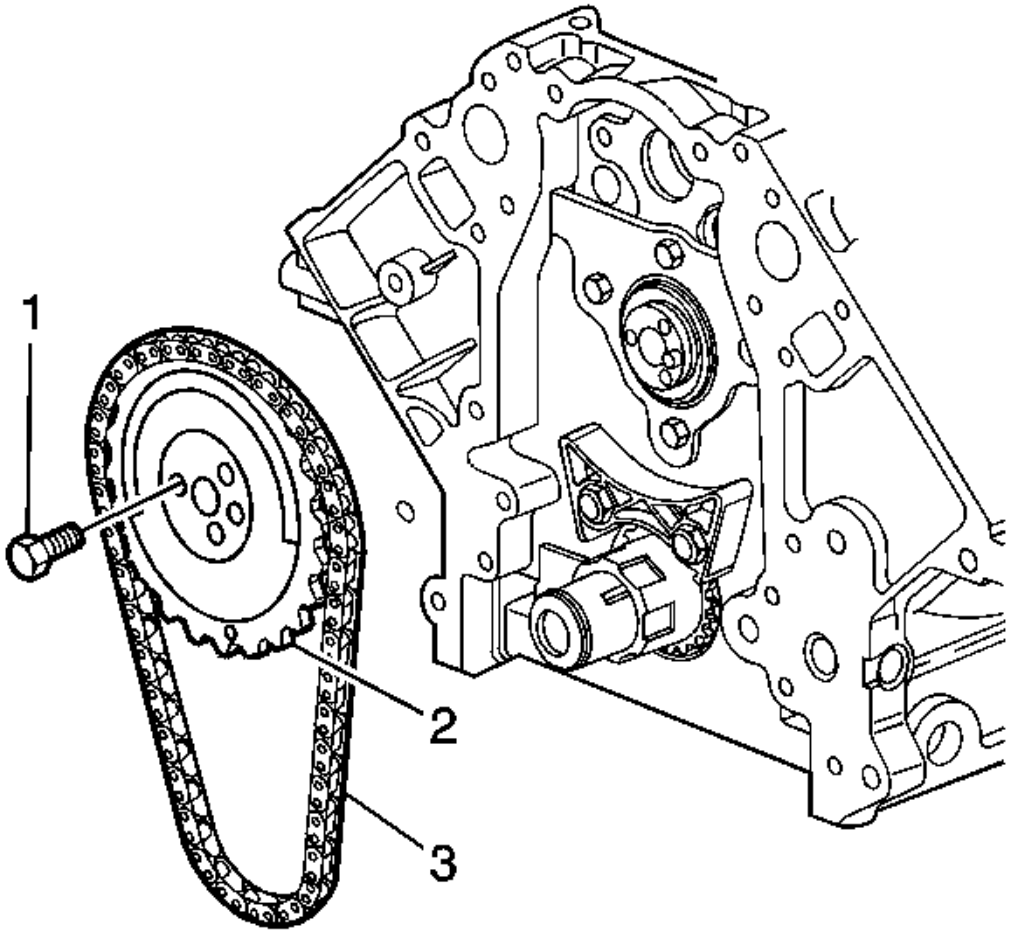

Fig. 238: Timing Chain & Sprocket Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**

  Locate the camshaft sprocket alignment mark in the 6 o'clock position.

6. Install the camshaft sprocket (2) and timing chain (3).

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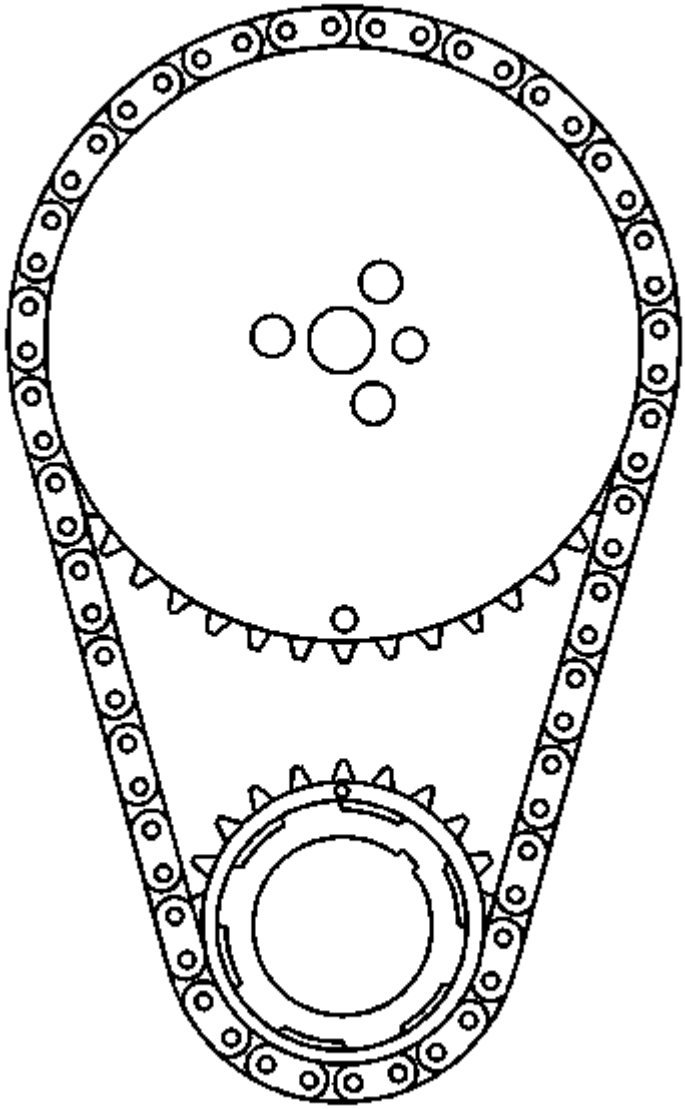

Fig. 239: Aligning Timing Marks
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

7. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.
8. Install the camshaft sprocket bolts.

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

9. Install the oil pump. Refer to **Oil Pump, Pump Screen and Deflector Replacement**.

Camshaft Replacement

Removal Procedure

1. Remove the condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.
2. Remove the valve lifters from both cylinder heads. Refer to **Valve Lifter Replacement**.

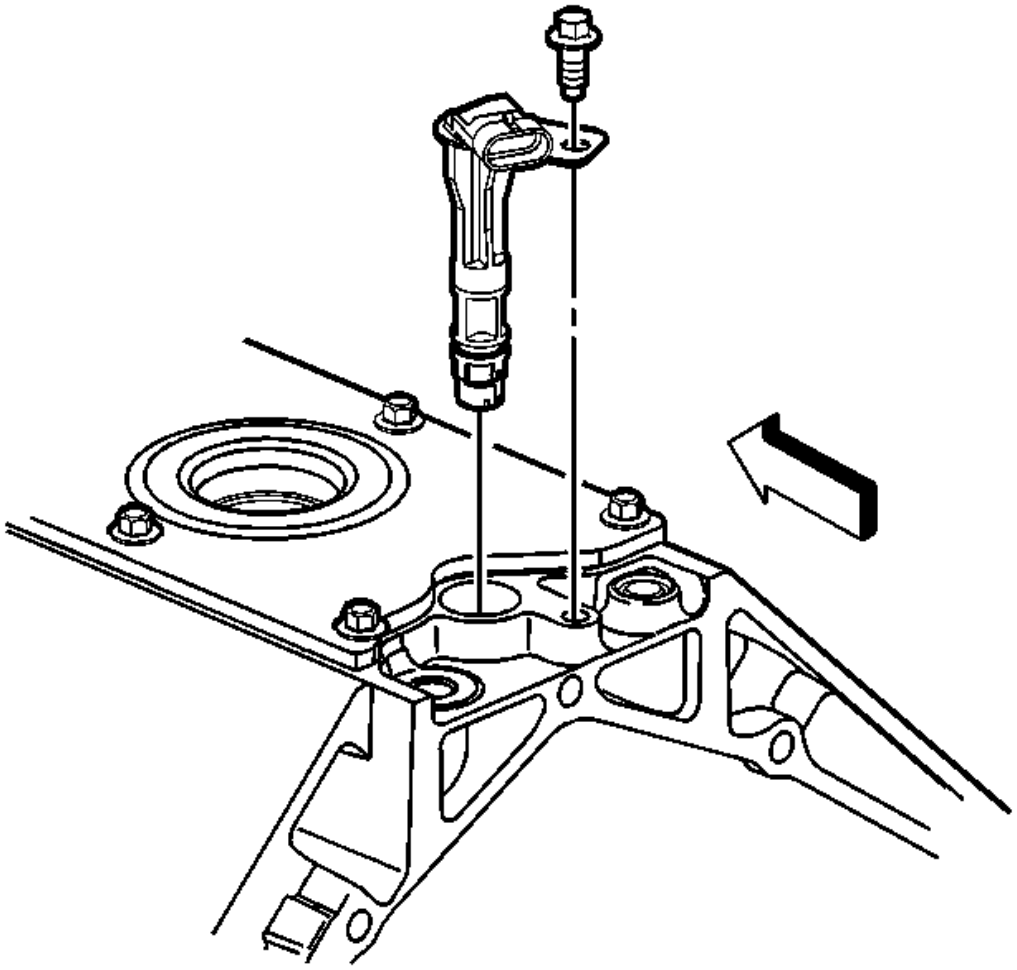

Fig. 240: View Of Camshaft Position (CMP) Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

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3. Remove the camshaft sensor bolt and sensor.

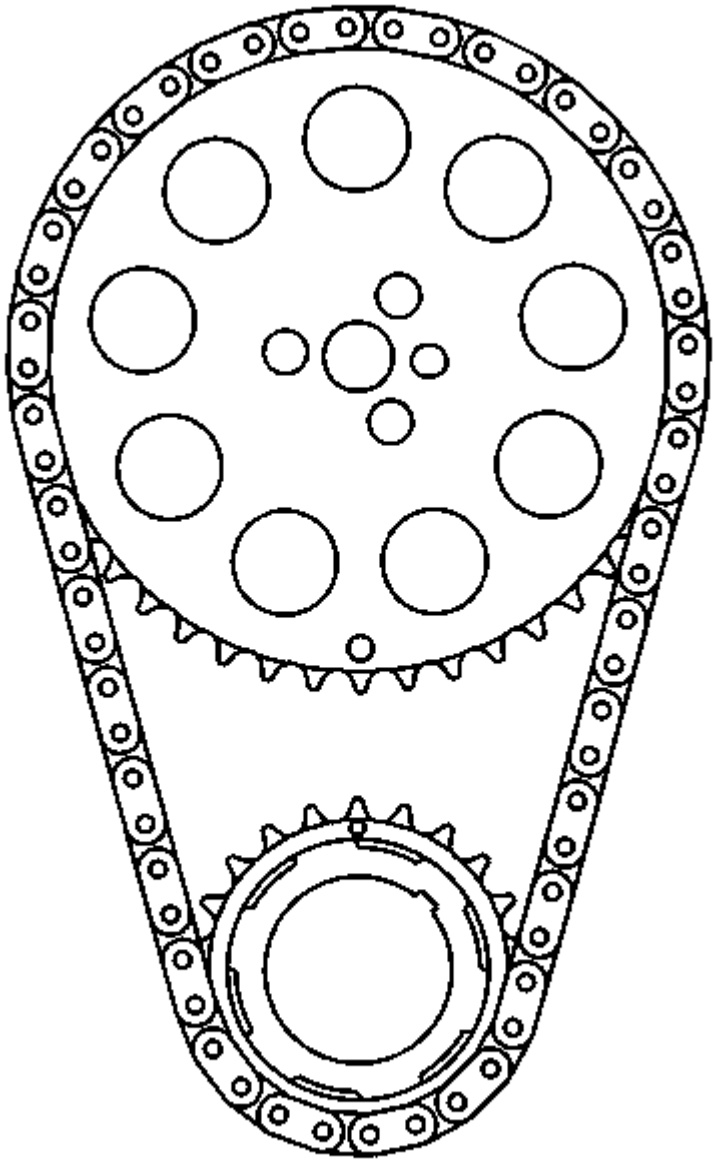

Fig. 241: View Of Camshaft & Crankshaft Sprockets Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

4. Rotate the crankshaft until the timing marks on the crankshaft and camshaft sprockets are aligned.

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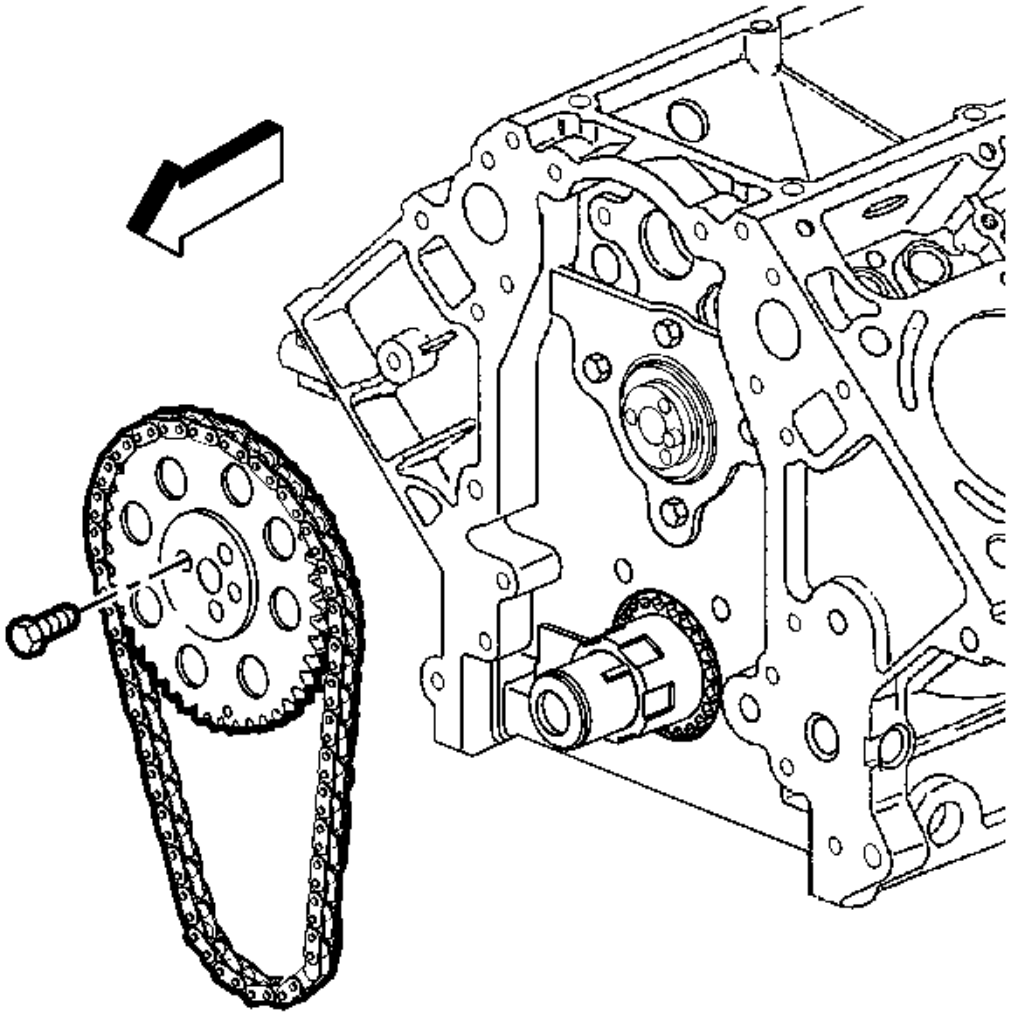

Fig. 242: Camshaft Sprocket, Bolt & Timing Chain
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft sprocket bolts.

NOTE: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

6. Remove the camshaft sprocket and reposition the timing chain.

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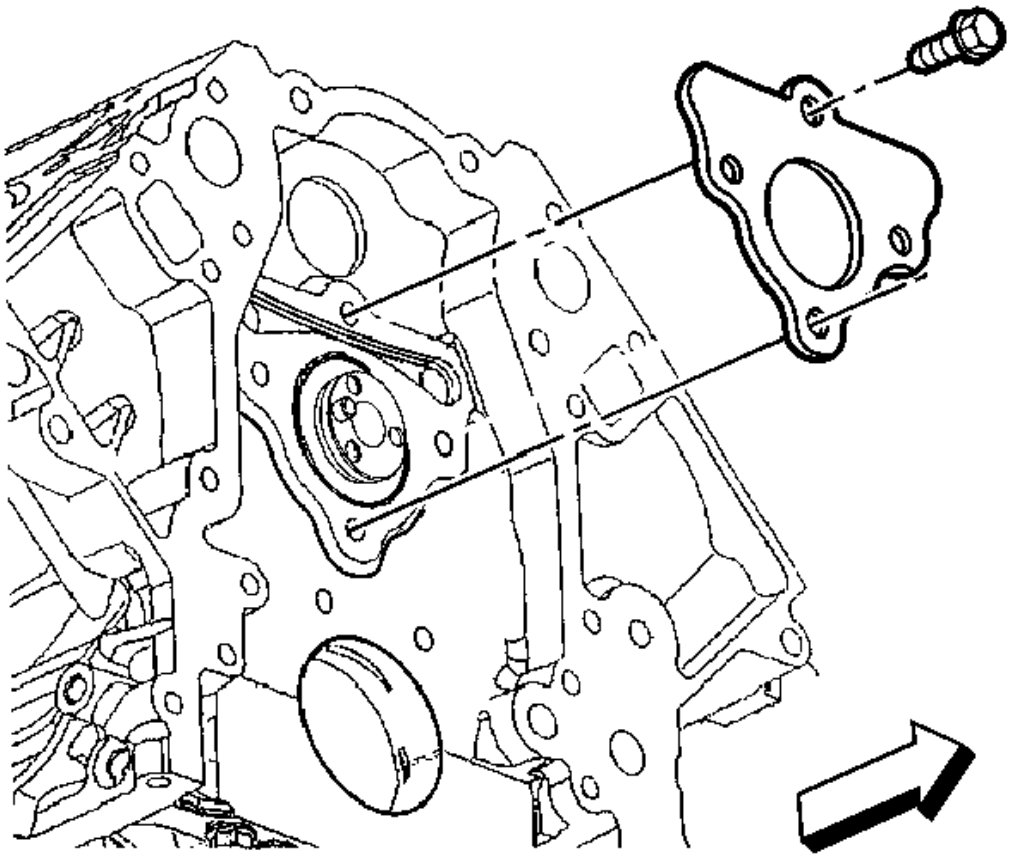

Fig. 243: View Of Camshaft Retainer Plate
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft retainer bolts and retainer.

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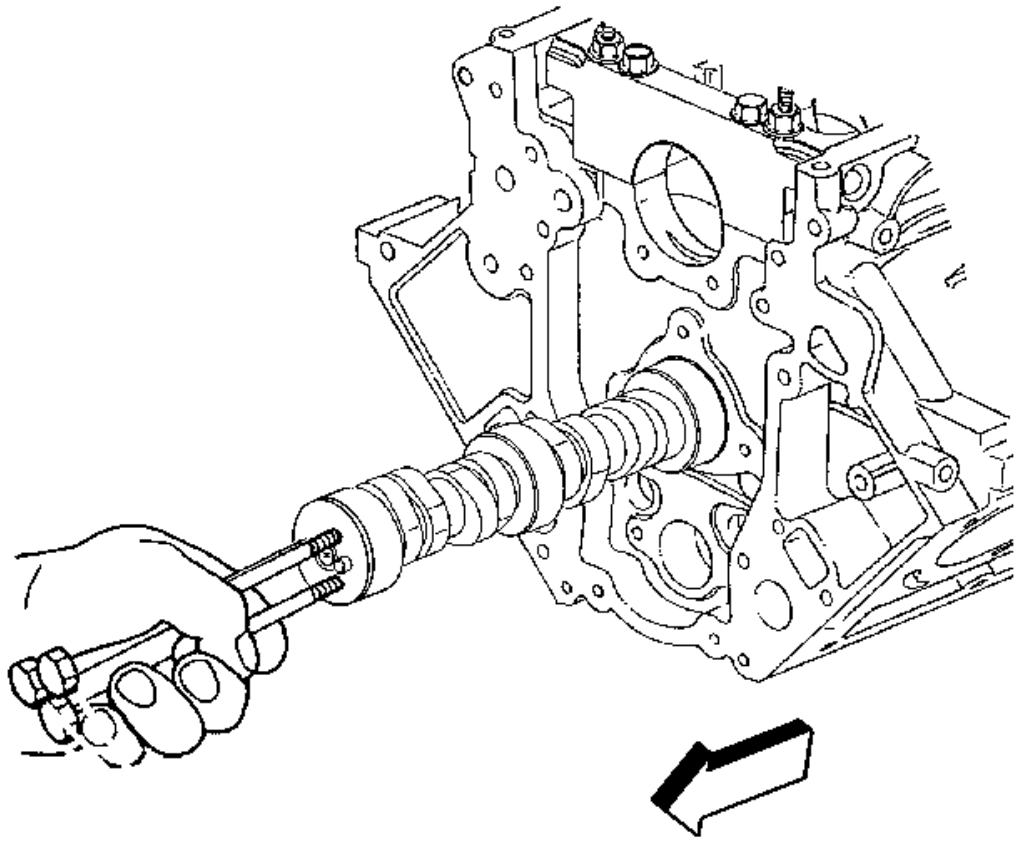

Fig. 244: View Of Bolts installed In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

NOTE: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

8. Remove the camshaft.
    1. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.
    2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the three bolts from the camshaft.
9. Clean and inspect the camshaft and bearings. Refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

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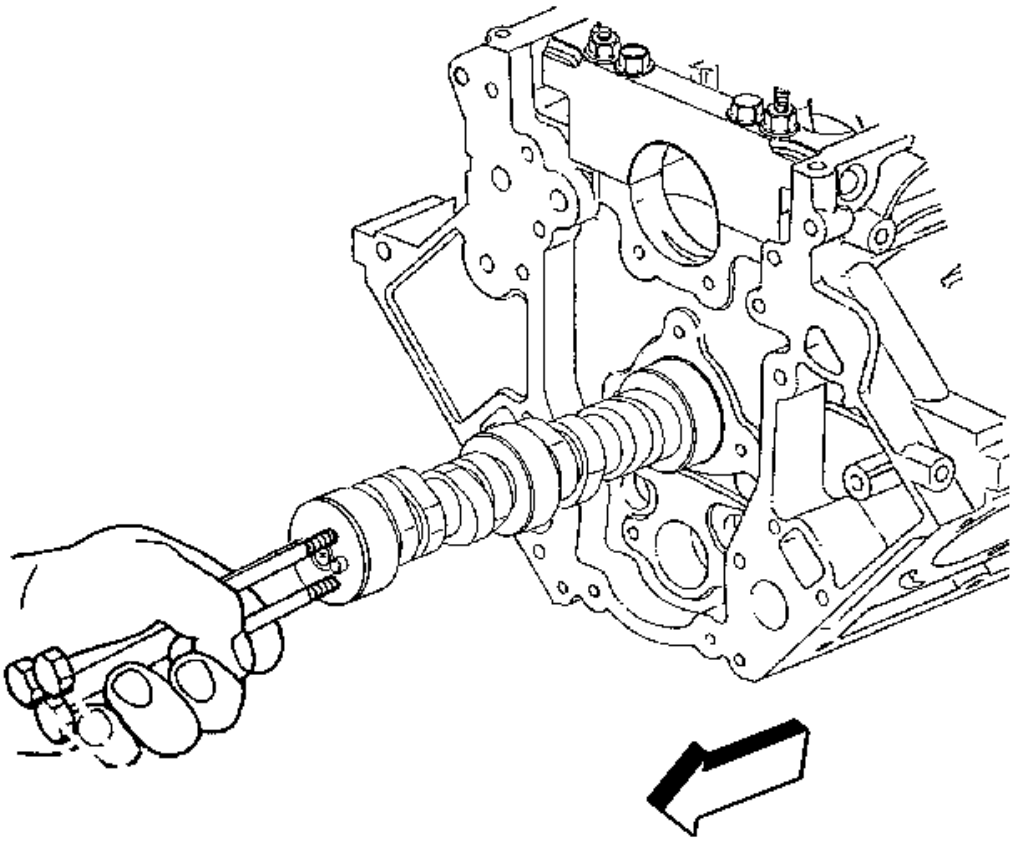

Fig. 245: View Of Bolts installed In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.

NOTE: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

2. Install three M8-1.25 x 100 mm (M8-1.25 x 4.0 in) bolts to the bolt holes in the front of the camshaft.
3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the three bolts from the front of the camshaft.

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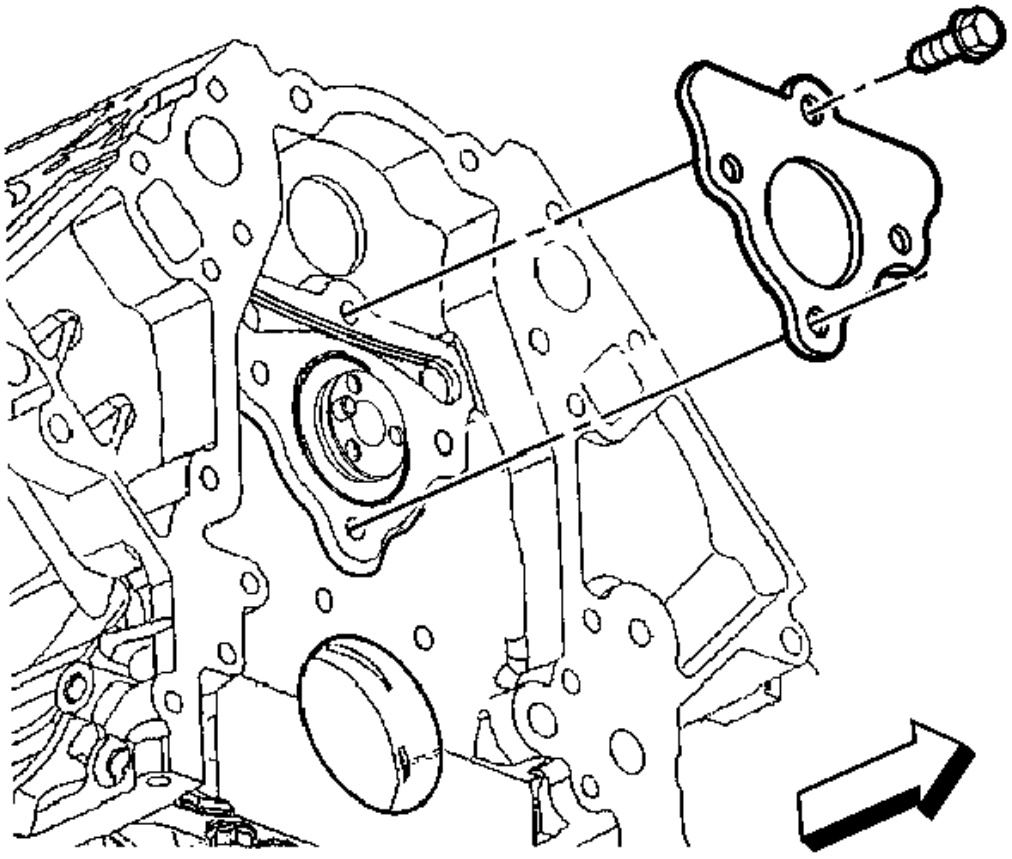

Fig. 246: View Of Camshaft Retainer Plate
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the retainer plate with the sealing gasket facing the engine block. The gasket surface on the engine block should be clean and free of dirt and/or debris.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the camshaft retainer and bolts.

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

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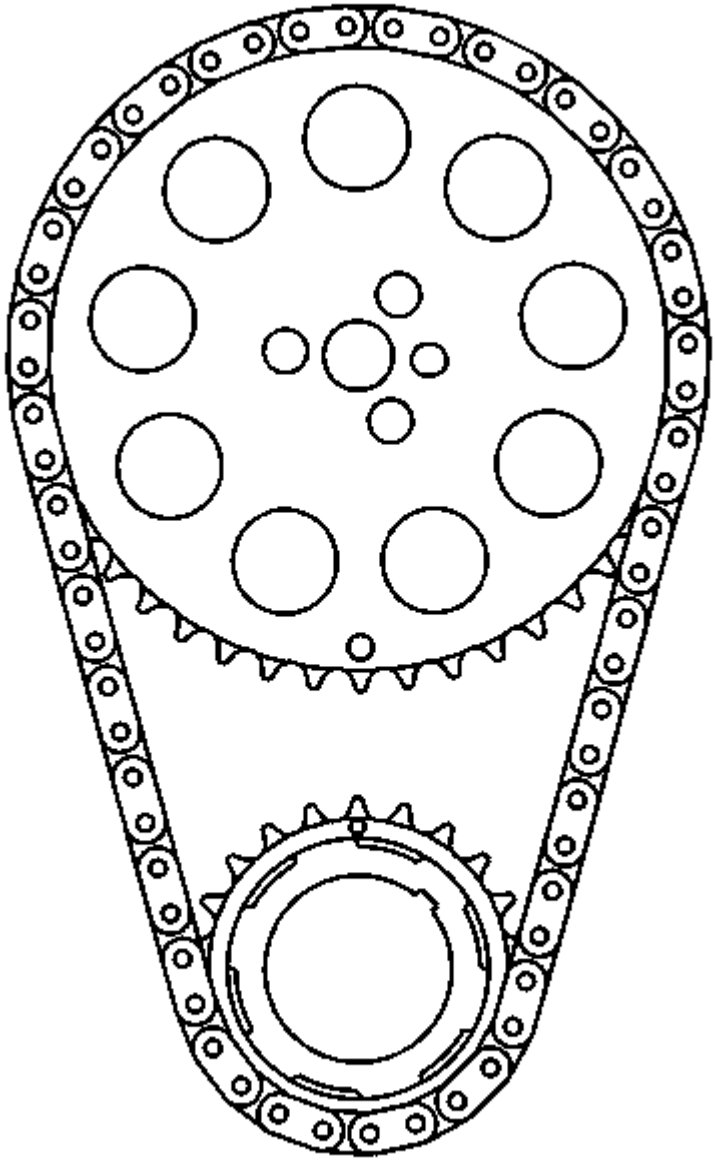

Fig. 247: View Of Camshaft & Crankshaft Sprockets Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Properly locate the camshaft sprocket locating pin with the camshaft sprocket alignment hole.**
- **The sprocket teeth and timing chain must mesh.**

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- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly. Locate the camshaft sprocket alignment mark in the 6 o'clock position.**

6. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

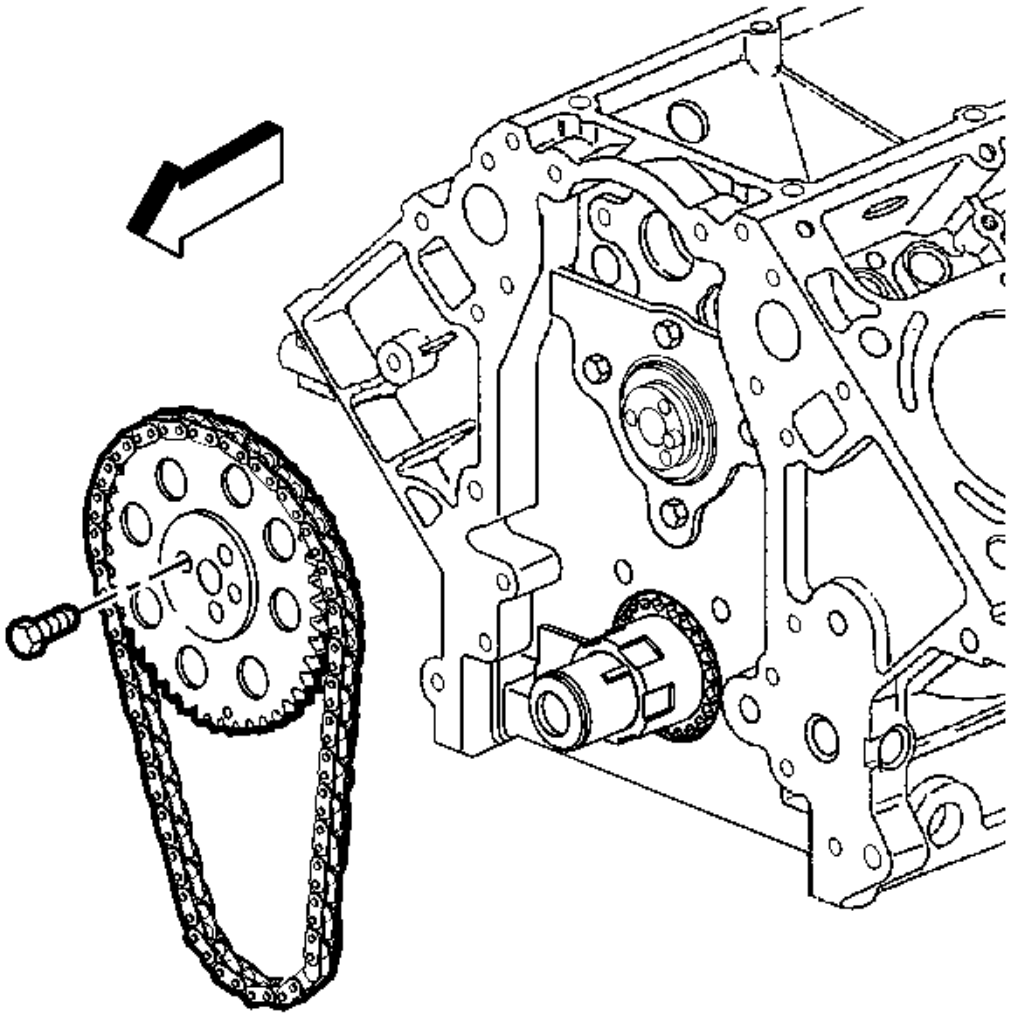

Fig. 248: Camshaft Sprocket, Bolt & Timing Chain
Courtesy of GENERAL MOTORS CORP.

7. Install the camshaft sprocket and the timing chain.
8. Install the camshaft sprocket bolts.

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

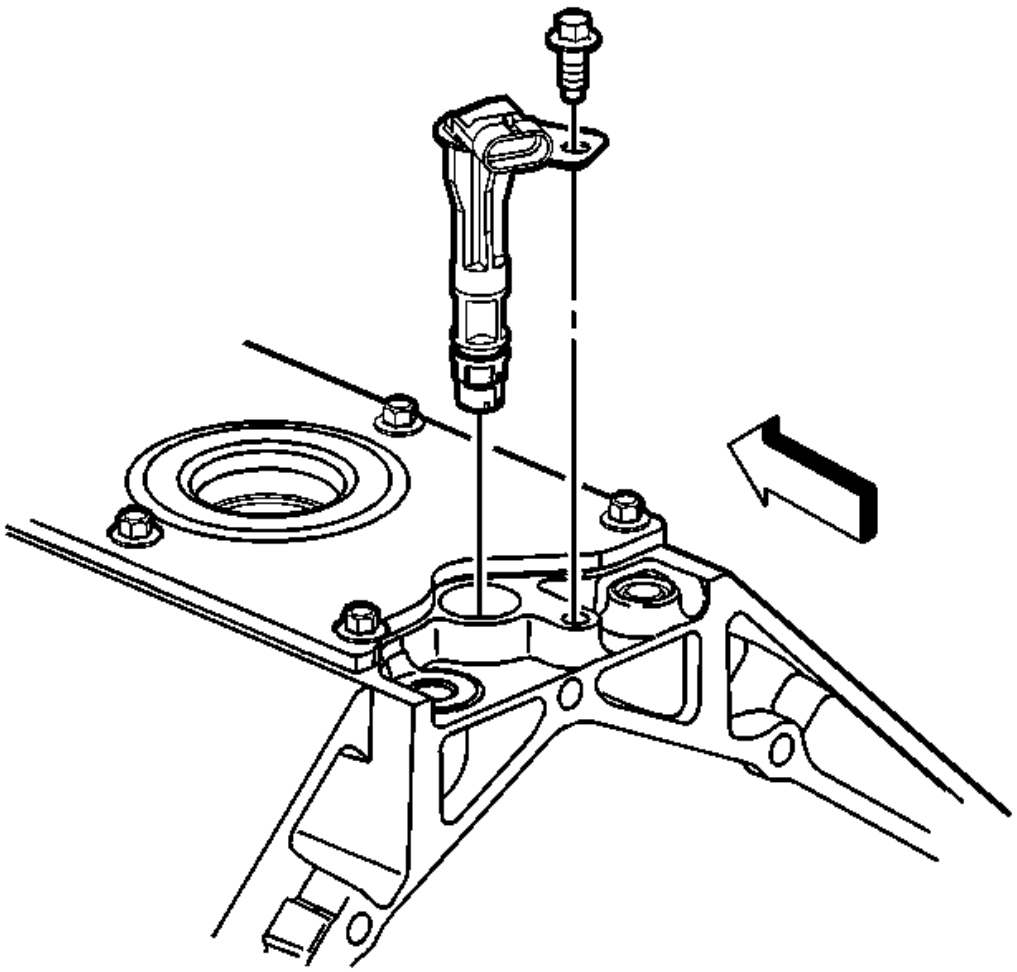

Fig. 249: View Of Camshaft Position (CMP) Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be reused.
10. Lubricate the O-ring seal with clean engine oil.
11. Install the camshaft sensor and bolt.

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

12. Install the valve lifters. Refer to **Valve Lifter Replacement**.
13. Install the condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.

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Engine Flywheel Replacement

Removal Procedure

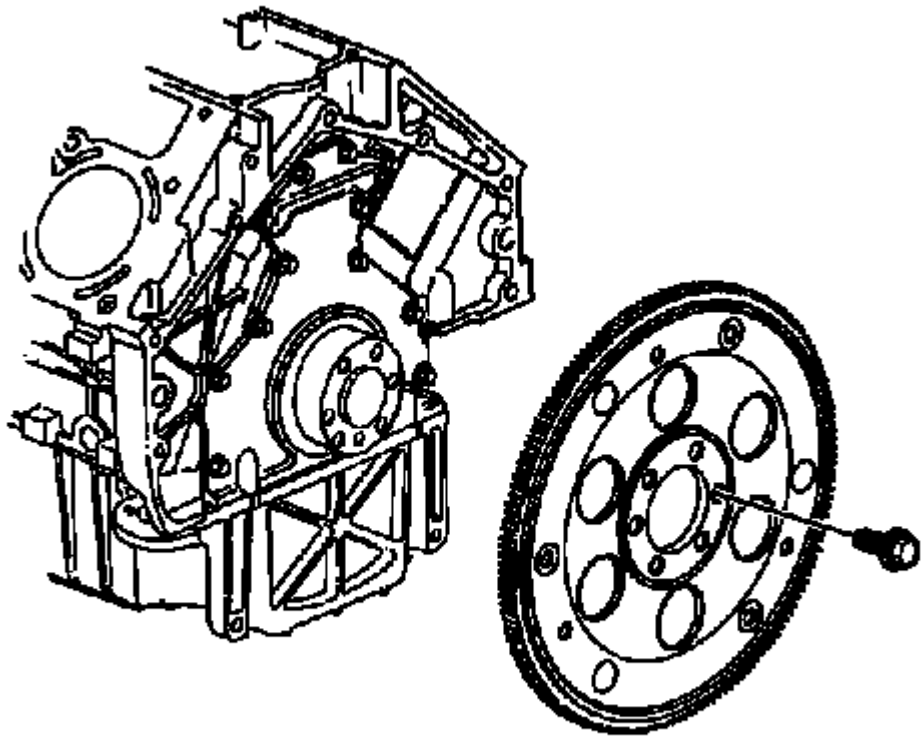

Fig. 250: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the position and direction of the engine flywheel before removal.

1. Remove the transmission. Refer to **Transmission Replacement (LM4)** in Automatic Transmission - 4L60-E.
2. Remove the engine flywheel bolts.
3. Remove the engine flywheel.
4. Clean and inspect the engine flywheel. Refer to **Engine Flywheel Cleaning and Inspection**.

Installation Procedure

IMPORTANT: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage

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tightening process.

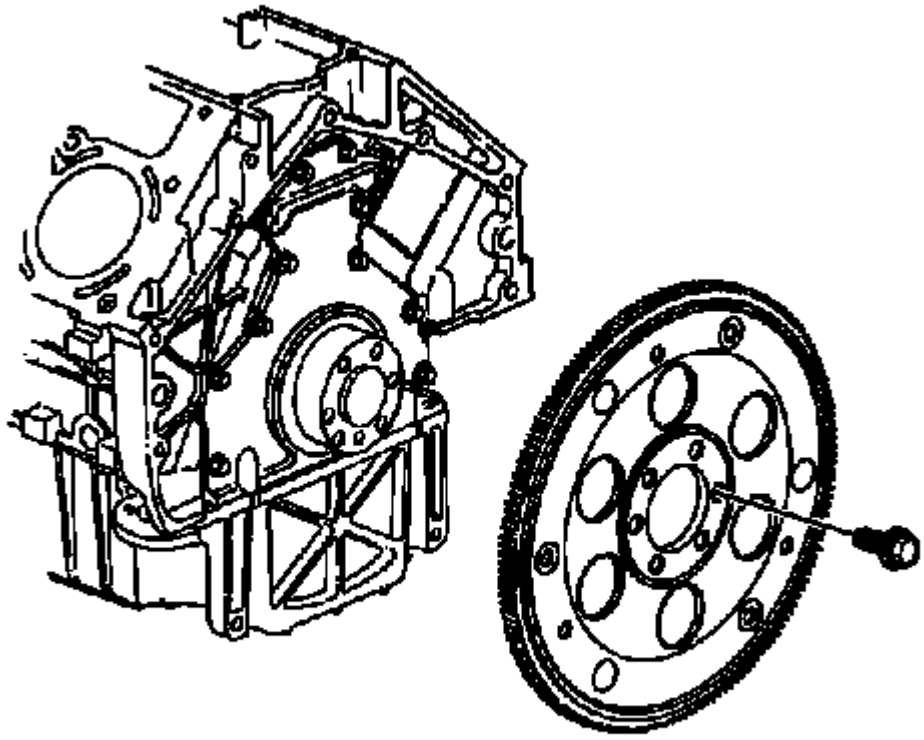

Fig. 251: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Install the engine flywheel to the crankshaft.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.

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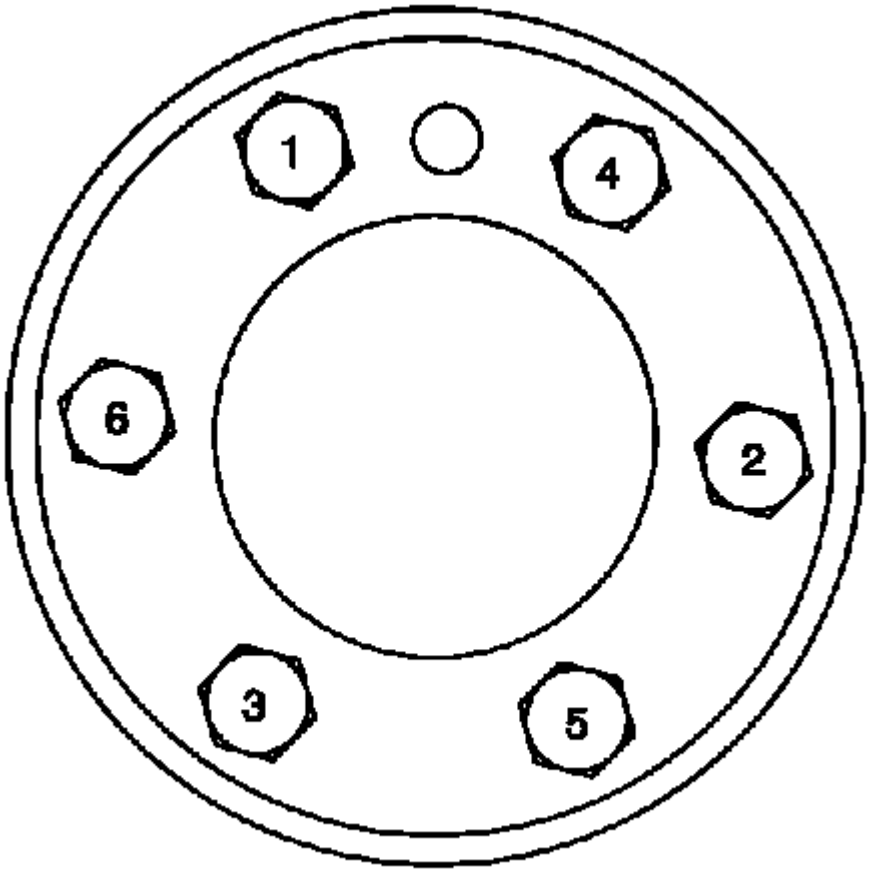

Fig. 252: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine flywheel bolts.

   Tighten:
   1. Tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
   2. Tighten the bolts a second pass in sequence to 50 N.m (37 lb ft).
   3. Tighten the bolts a final pass in sequence to 100 N.m (74 lb ft).

4. Install the transmission. Refer to **Transmission Replacement (LM4)** in Automatic Transmission - 4L60-E.

Engine Replacement

Tools Required

- **J 41798** . See **Special Tools**.

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- **J 21366** . See **Special Tools**.
- **J 38185** . See **Special Tools**.

Removal Procedure

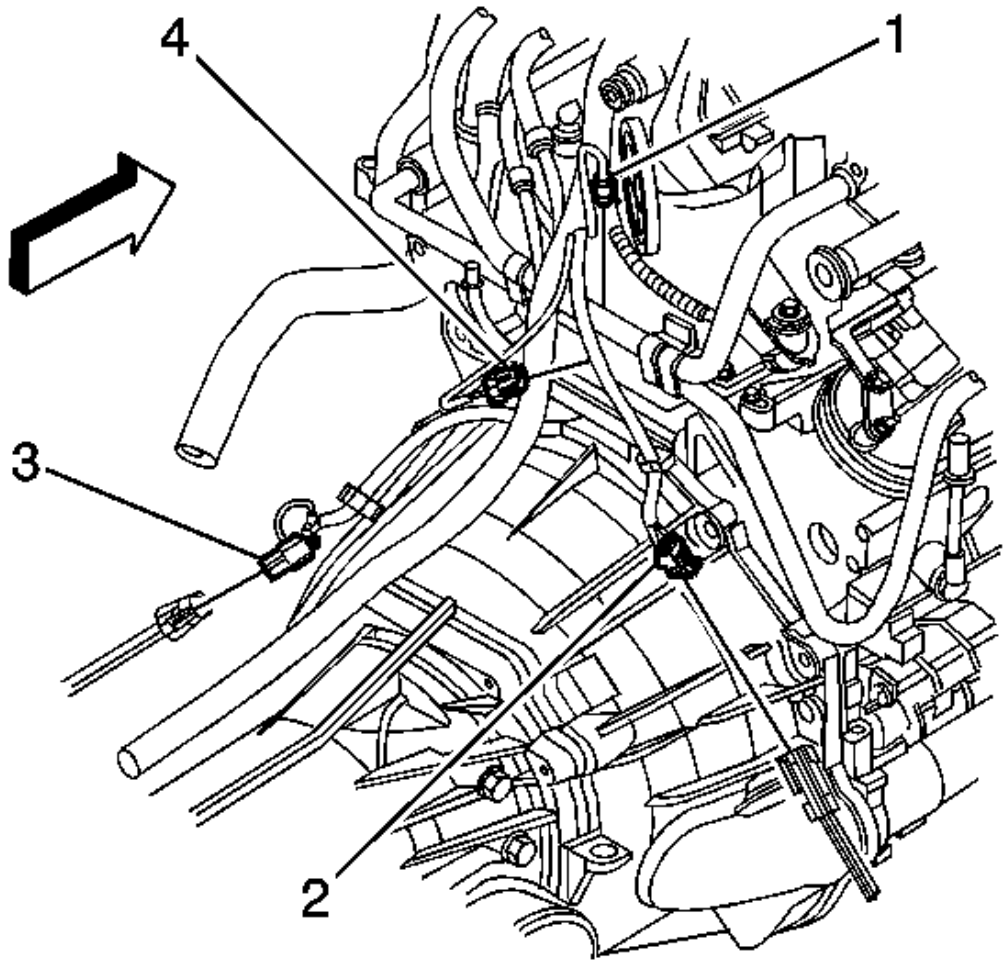

Fig. 253: Locating Components Connectors At Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

1. Remove the hood. Refer to **Hood Replacement**
2. Place fender covers over both fenders.
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure**
4. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging**

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5. Remove the radiator. Refer to **Radiator Replacement (LM4)**
6. Remove the radiator support brace. Refer to **Brace Replacement - Radiator Support Diagonal**
7. Remove the front differential drive axle, if equipped with 4-wheel drive (4WD). Refer to **Differential Carrier Assembly Replacement (V8)**
8. Remove the wheel drive shafts. Refer to **Wheel Drive Shaft Replacement**
9. Remove the intake manifold. Refer to **Intake Manifold Replacement**
10. Disconnect the following electrical connectors:
    - Oil pressure sensor (1)
    - Oxygen sensors (2, 3)
    - Camshaft position (CMP) sensor (4)

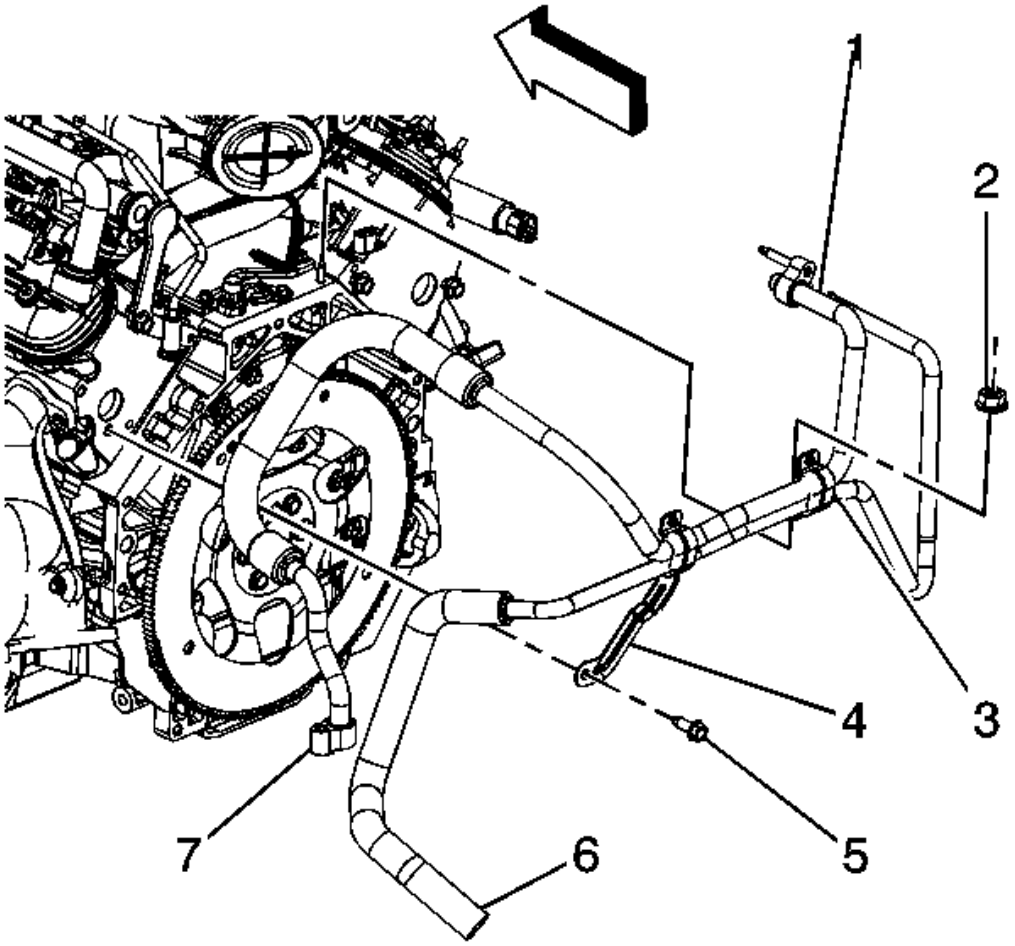

Fig. 254: View Of Rear A/C Lines

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Courtesy of GENERAL MOTORS CORP.

11. Remove the air conditioning (A/C) compressor hose. Refer to **Compressor Hose Assembly Replacement (LM4)**
12. Disconnect the rear auxiliary A/C compressor pipe fitting (7).
13. Remove the rear auxiliary A/C compressor pipe nut and bolt (2, 5).
14. Tie the pipe assembly out of the way.

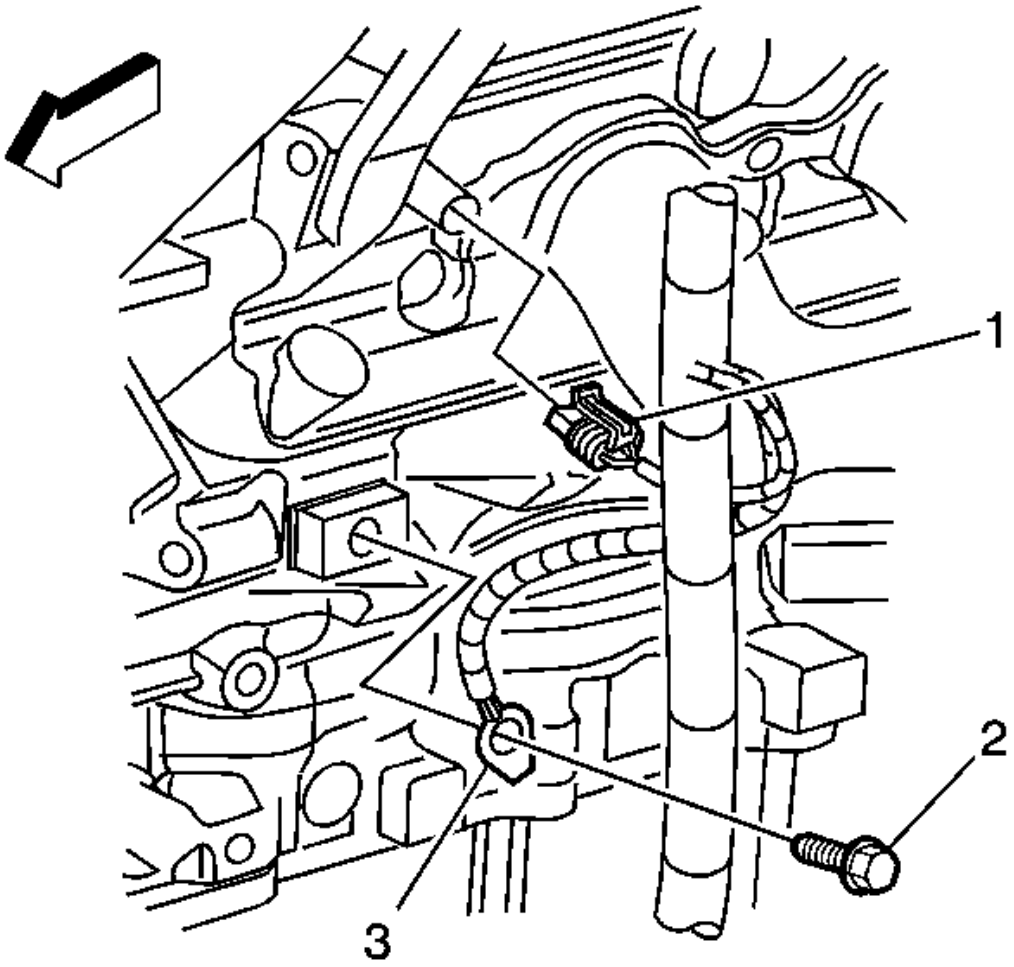

Fig. 255: View Of ECT Sensor Electrical Connector And Ground
Courtesy of GENERAL MOTORS CORP.

15. Disconnect the engine coolant temperature (ECT) sensor (1).
16. Remove the ground terminal bolt (2).

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17. Remove the retaining clips from the brackets.

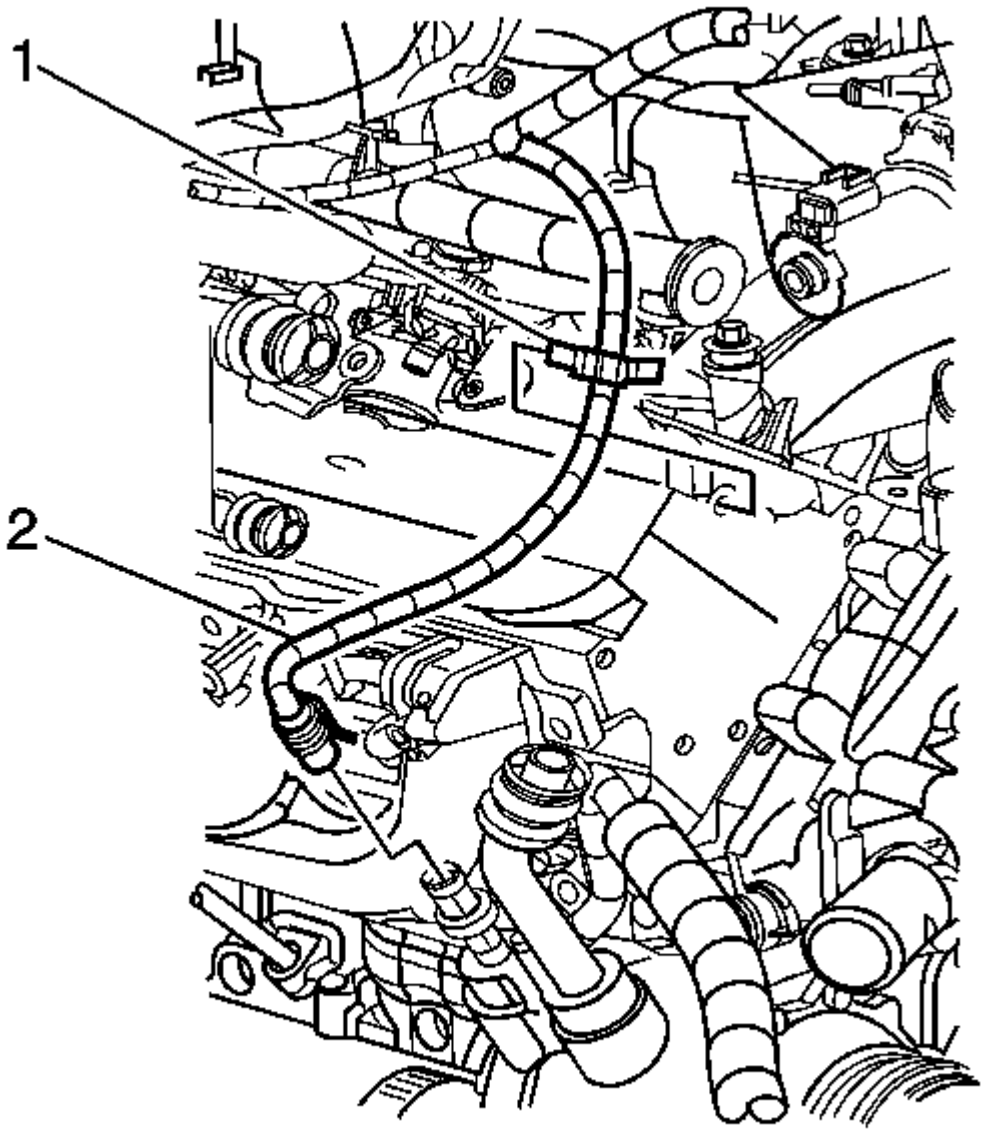

Fig. 256: View Of A/C Compressor Pressure Switch Electrical Connector & Retaining Clip
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the A/C pressure switch electrical connector (2).
19. Remove the retaining clip (1) from the cylinder head.

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20. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle**

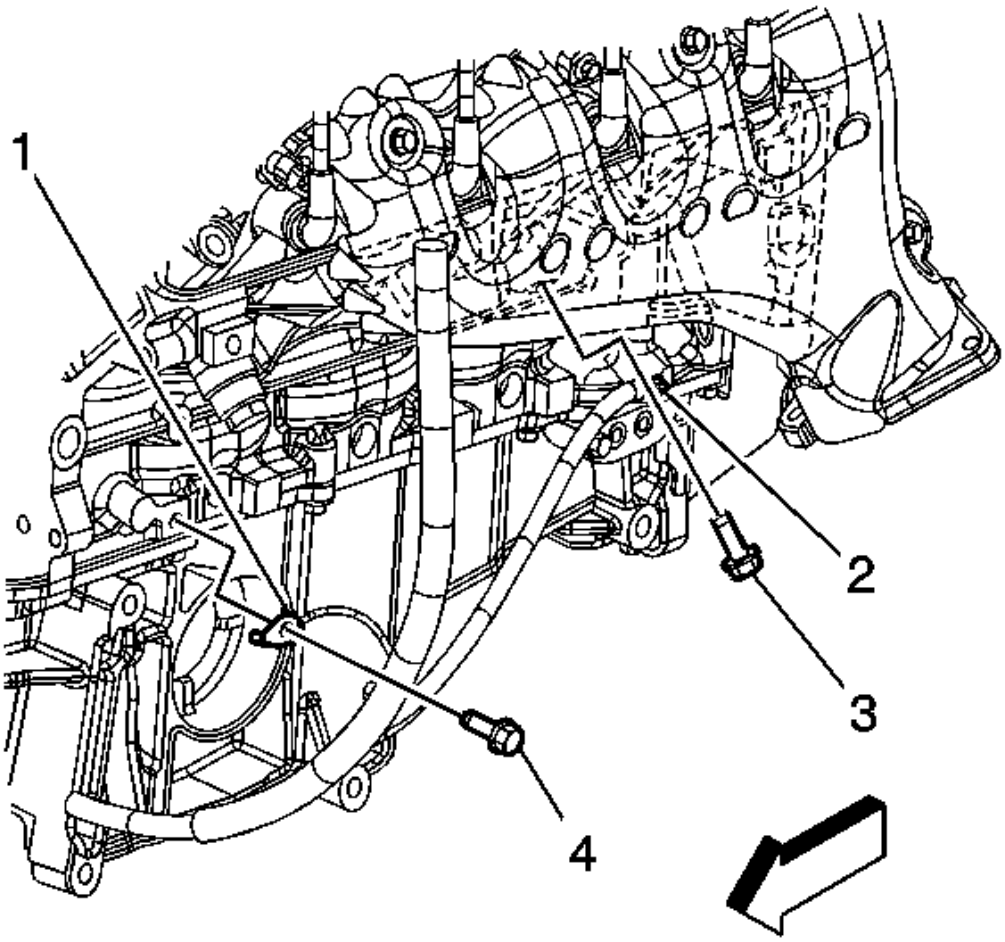

Fig. 257: View Of Ground Terminal Bolts
Courtesy of GENERAL MOTORS CORP.

21. Remove the ground terminal bolts (2, 4).
22. Remove the starter. Refer to **Starter Motor Replacement (5.3L Engine)**

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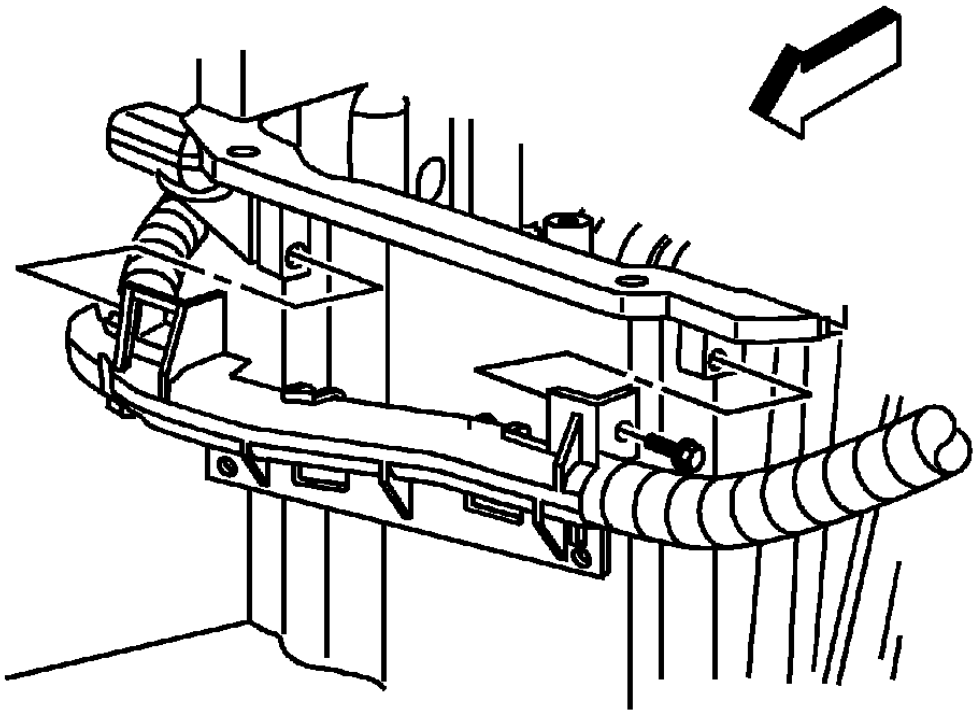

Fig. 258: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

23. Remove the battery cable channel bolt.
24. Remove the battery cable channel from the oil pan.

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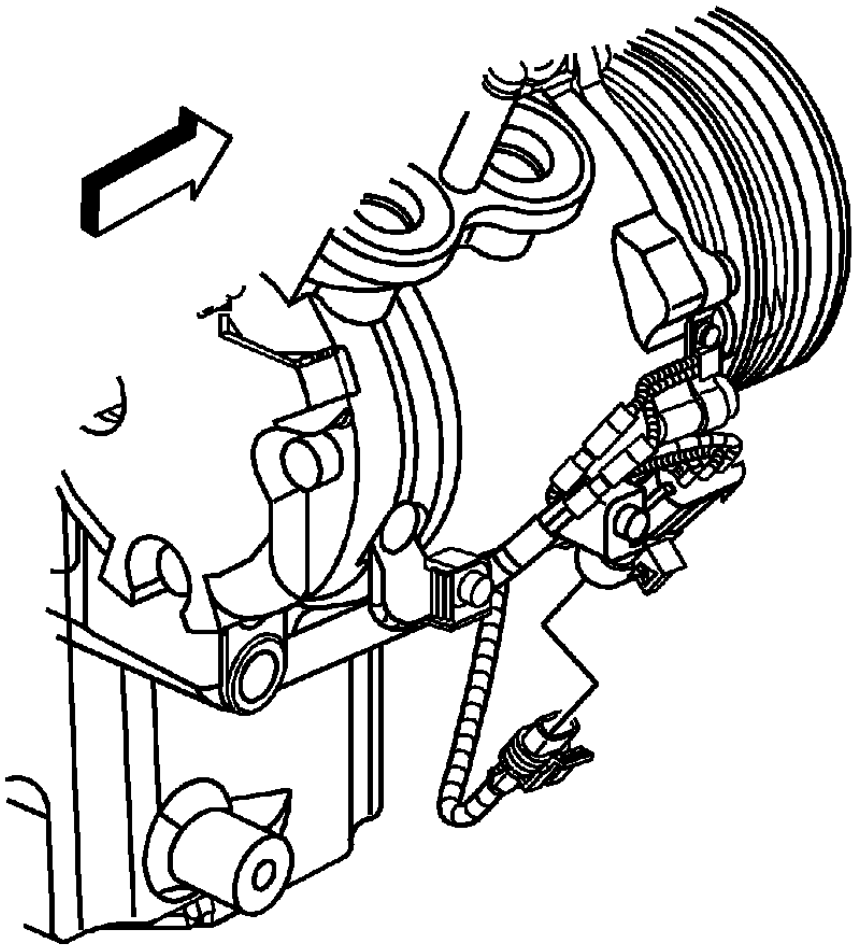

Fig. 259: View Of A/C Compressor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

25. Disconnect the A/C compressor electrical connector.
26. Lower the vehicle.
27. Gather all branches of the engine wiring harness and reposition the harness off to the side.

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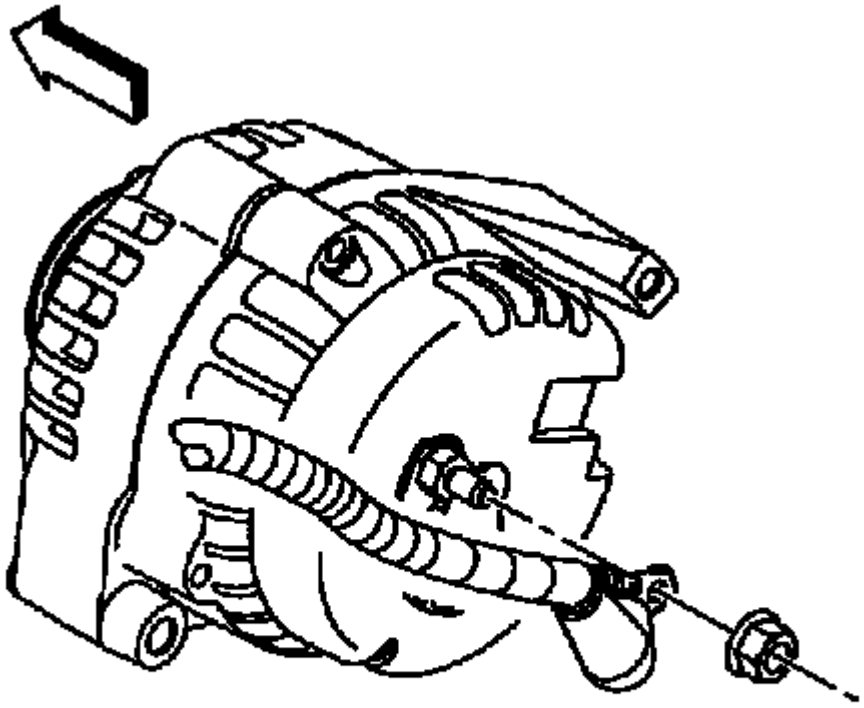

Fig. 260: View Of Generator Cable & Nut
Courtesy of GENERAL MOTORS CORP.

28. Remove the generator cable from the generator. Perform the following:
    1. Slide the boot down revealing the terminal stud.
    2. Remove the generator cable nut from the terminal stud.
    3. Remove the generator cable.

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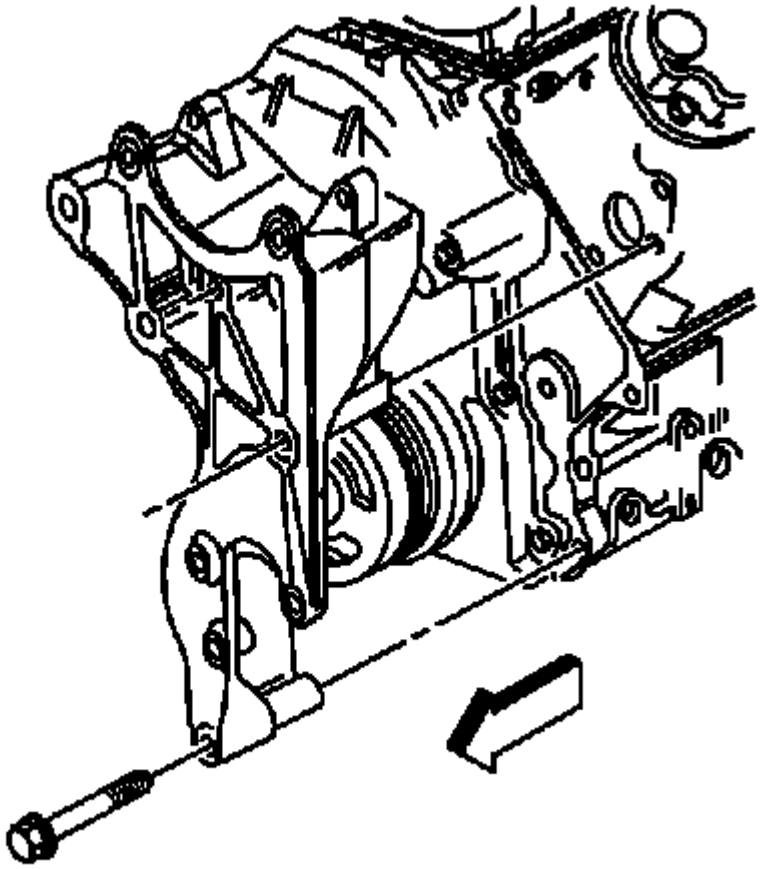

Fig. 261: View Of Generator Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

29. Remove the generator bracket bolts.
30. Position the bracket with generator aside.

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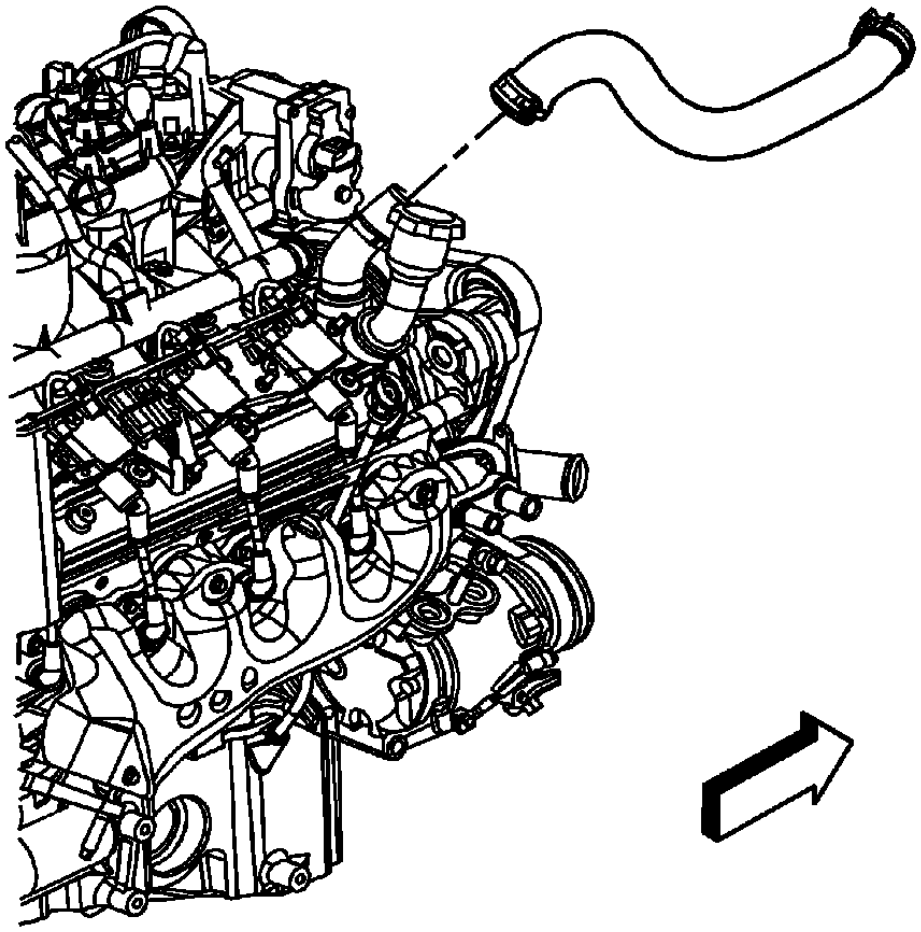

Fig. 262: View Of Inlet Hose
Courtesy of GENERAL MOTORS CORP.

31. Using **J 38185** . See **Special Tools**.
32. Remove the inlet hose from the water outlet.

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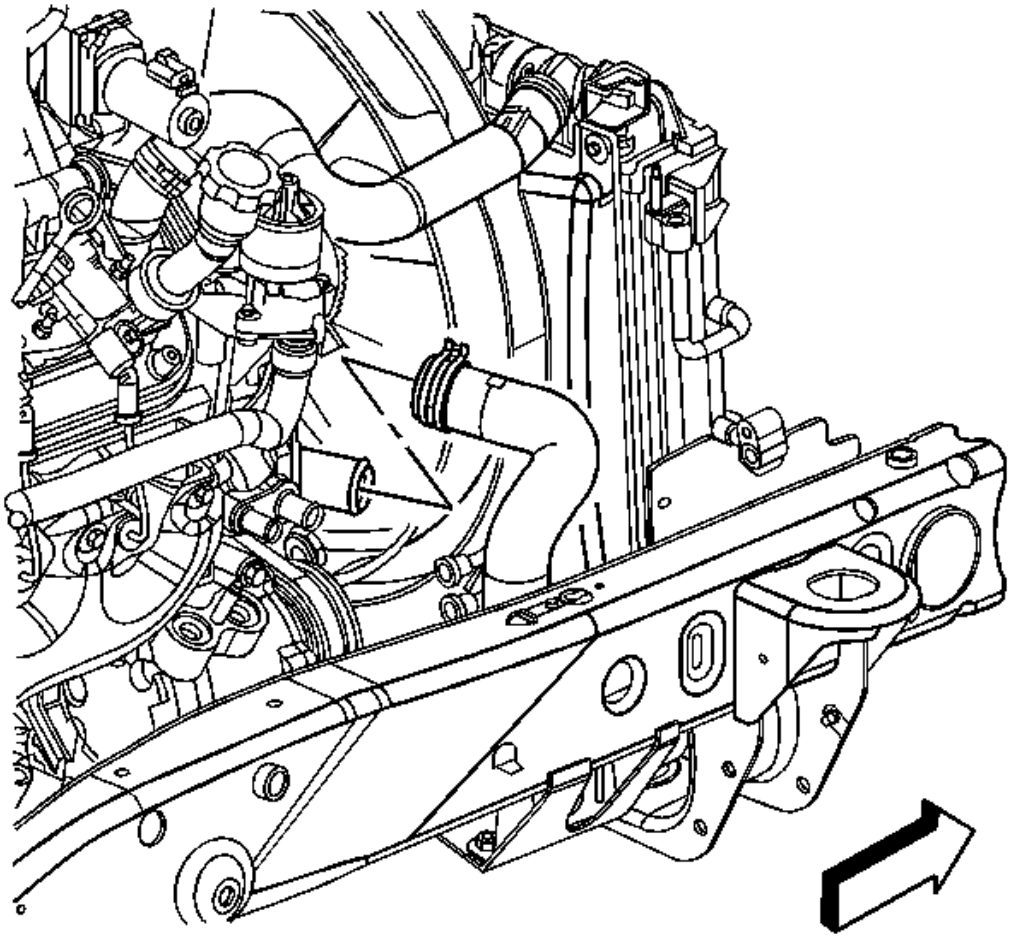

Fig. 263: View Of Outlet Hose
Courtesy of GENERAL MOTORS CORP.

33. Using **J 38185** . See **Special Tools**.
34. Remove the outlet hose from the water outlet.

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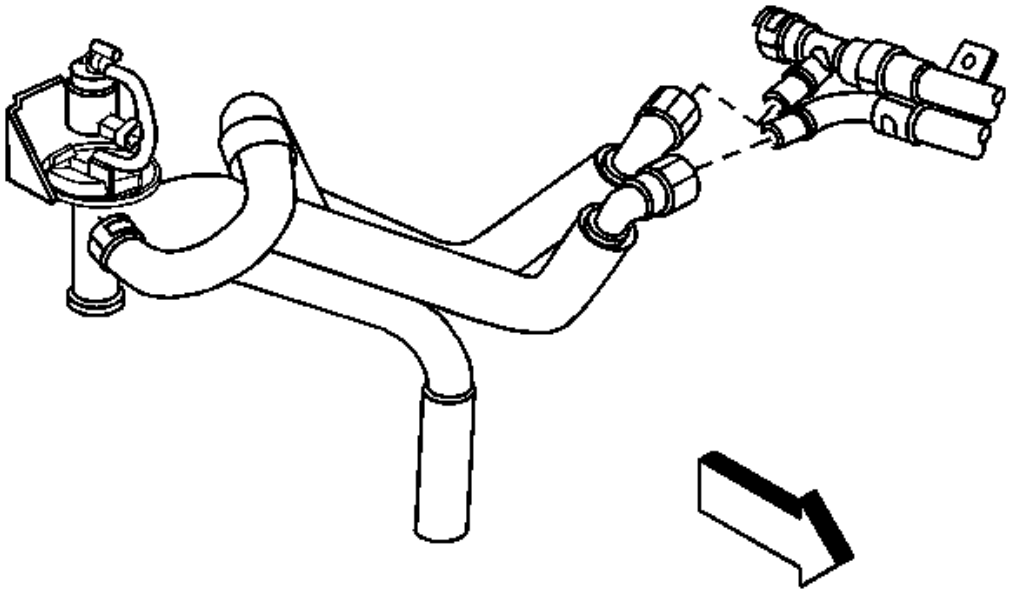

Fig. 264: View Of Auxiliary Heater Inlet & Outlet Hose/Pipe Assembly
Courtesy of GENERAL MOTORS CORP.

35. Disconnect the auxiliary heater inlet and outlet hose/pipe assembly from the heater water shutoff valve pipes.

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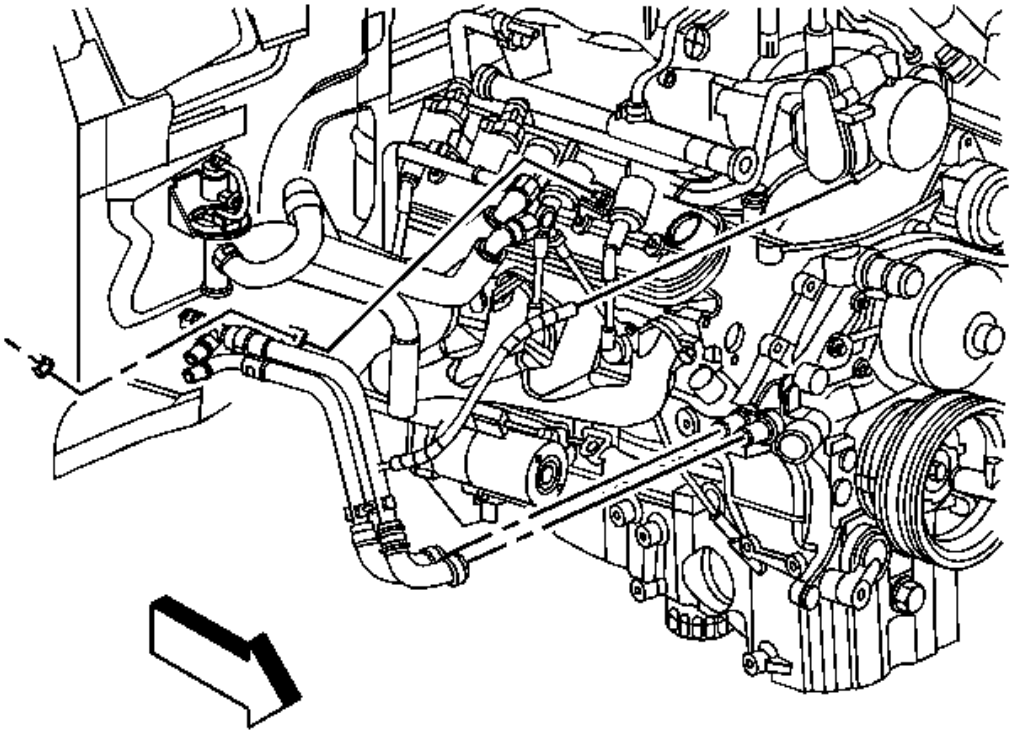

Fig. 265: View Of Auxiliary Heater Inlet & Outlet Hoses/Pipes
Courtesy of GENERAL MOTORS CORP.

36. Using **J 38185** . See **Special Tools**.
37. Remove the auxiliary heater inlet and outlet hoses/pipes from the water pump.

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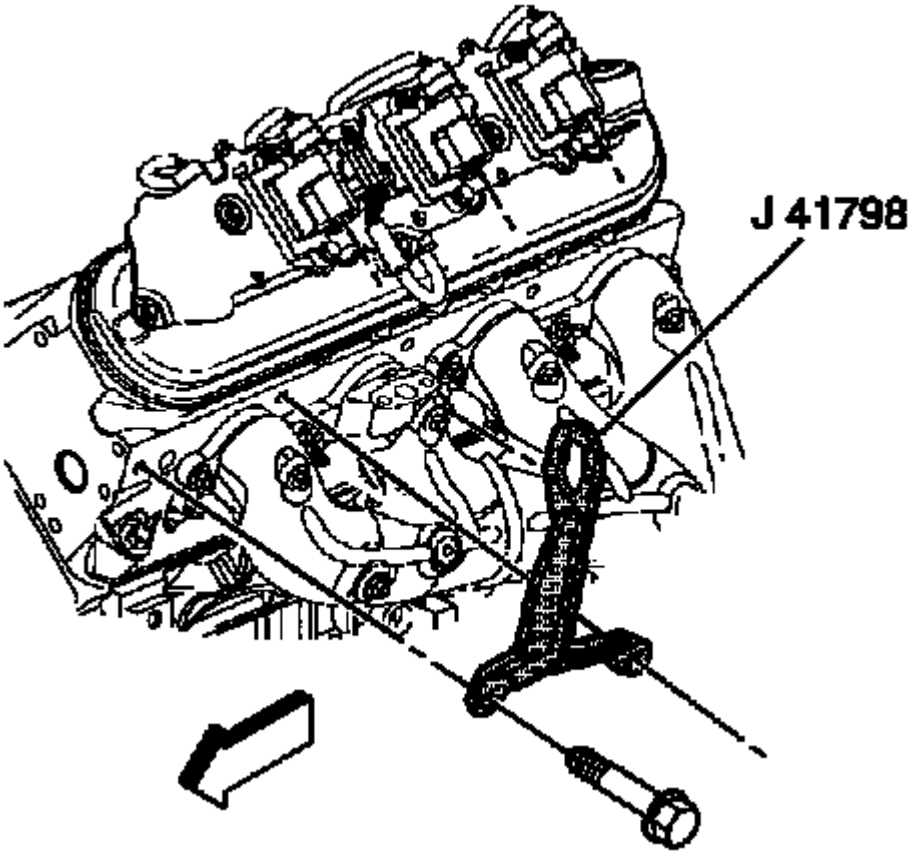

Fig. 266: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

38. Remove the ignition coils as required for the proper fit of **J 41798** . See **Special Tools**.

    Refer to **Ignition Coil(s) Replacement**

    NOTE: Refer to Fastener Notice

39. Install **J 41798** . See **Special Tools**.

    Tighten:
    - Tighten the M8 bolts to 25 N.m (18 lb ft).
    - Tighten the M10 bolts to 50 N.m (37 lb ft).

40. Raise the vehicle.
41. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (5.3L Engine)**

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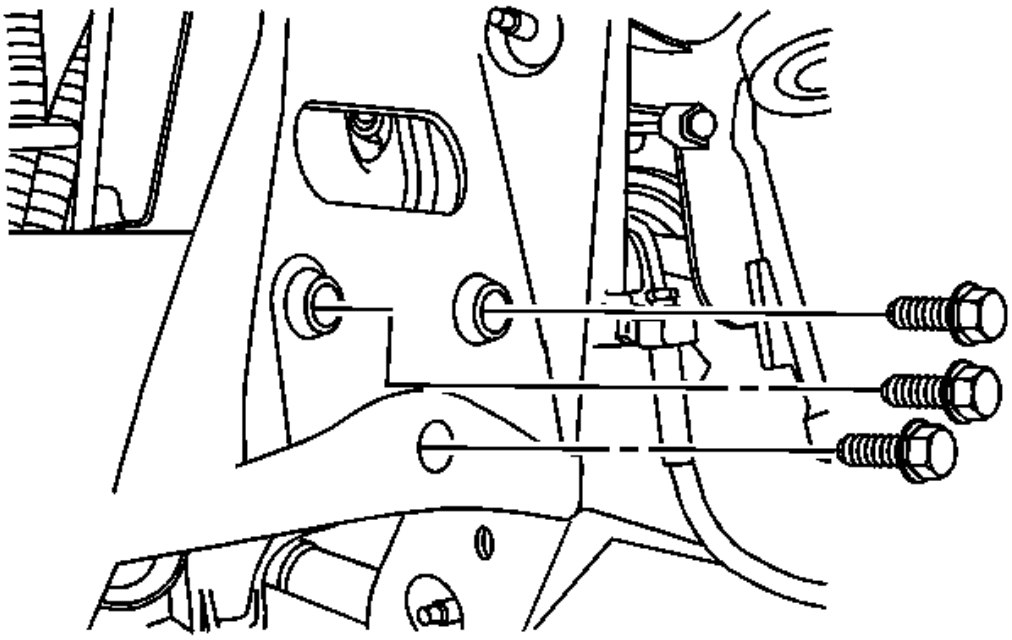

Fig. 267: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

42. Remove the 3 bracket bolts from both the right and the left sides of the frame engine mount.

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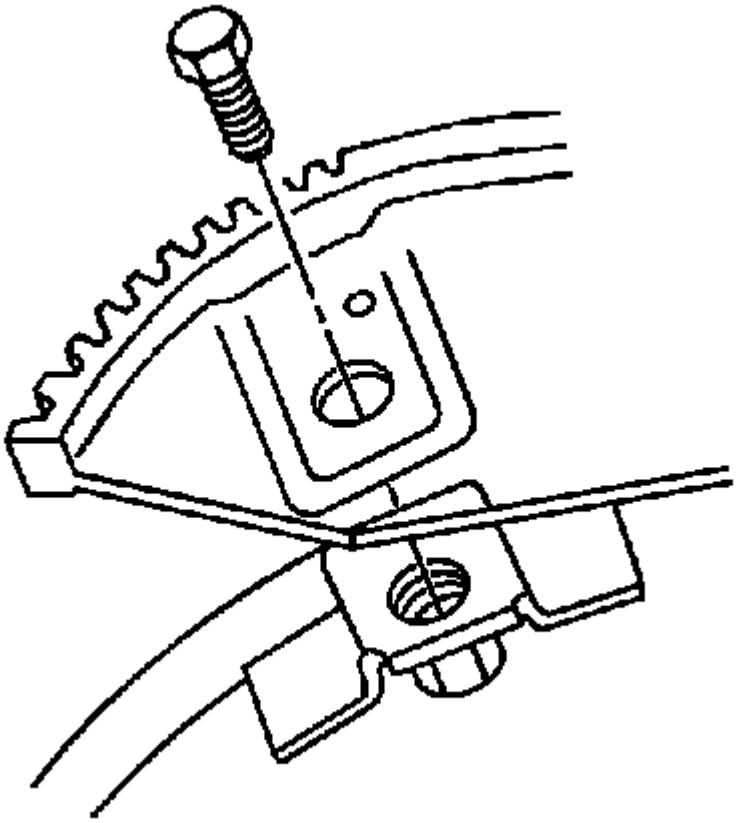

Fig. 268: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

43. Remove the torque converter bolts.

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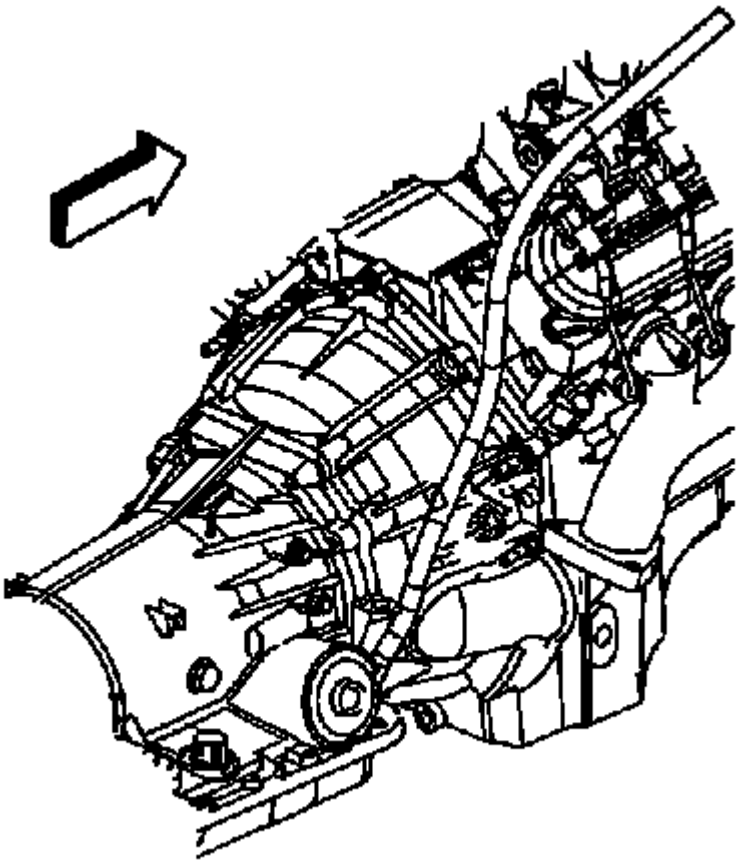

Fig. 269: View Of Oil Level Indicator Tube Nut
Courtesy of GENERAL MOTORS CORP.

44. Remove the transmission oil level indicator tube nut.

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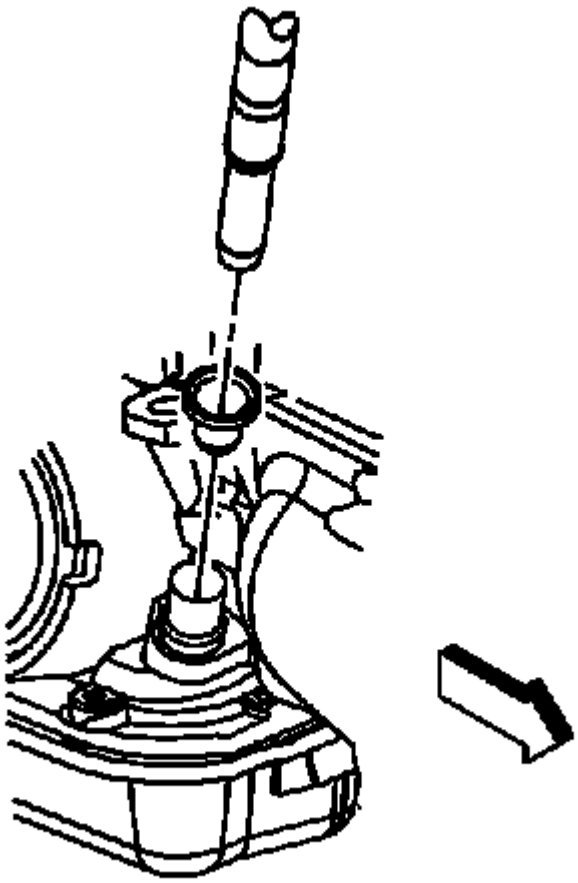

Fig. 270: View Of Oil Level Indicator Tube & Seal
Courtesy of GENERAL MOTORS CORP.

45. Remove the transmission oil level indicator tube.

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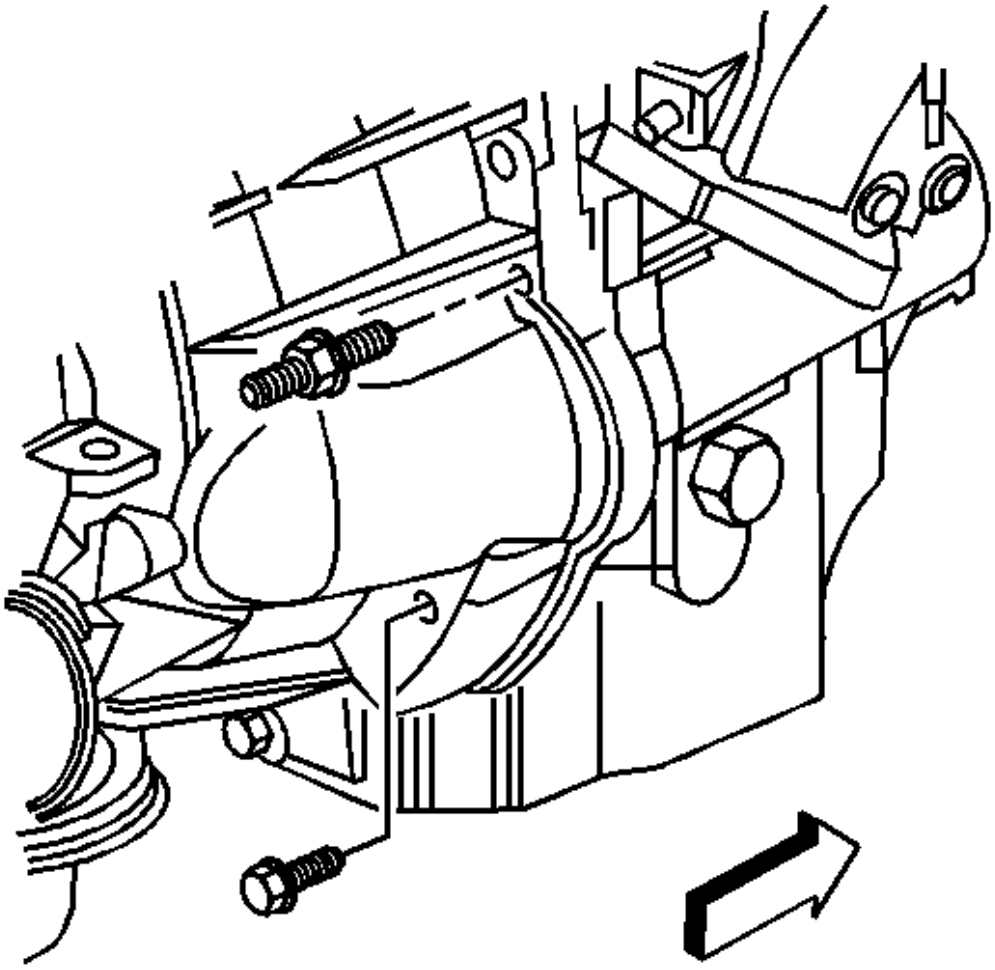

Fig. 271: View of Transmission Bolt & Stud (4L60-E)
Courtesy of GENERAL MOTORS CORP.

46. Remove the transmission bolt and stud on the right side.

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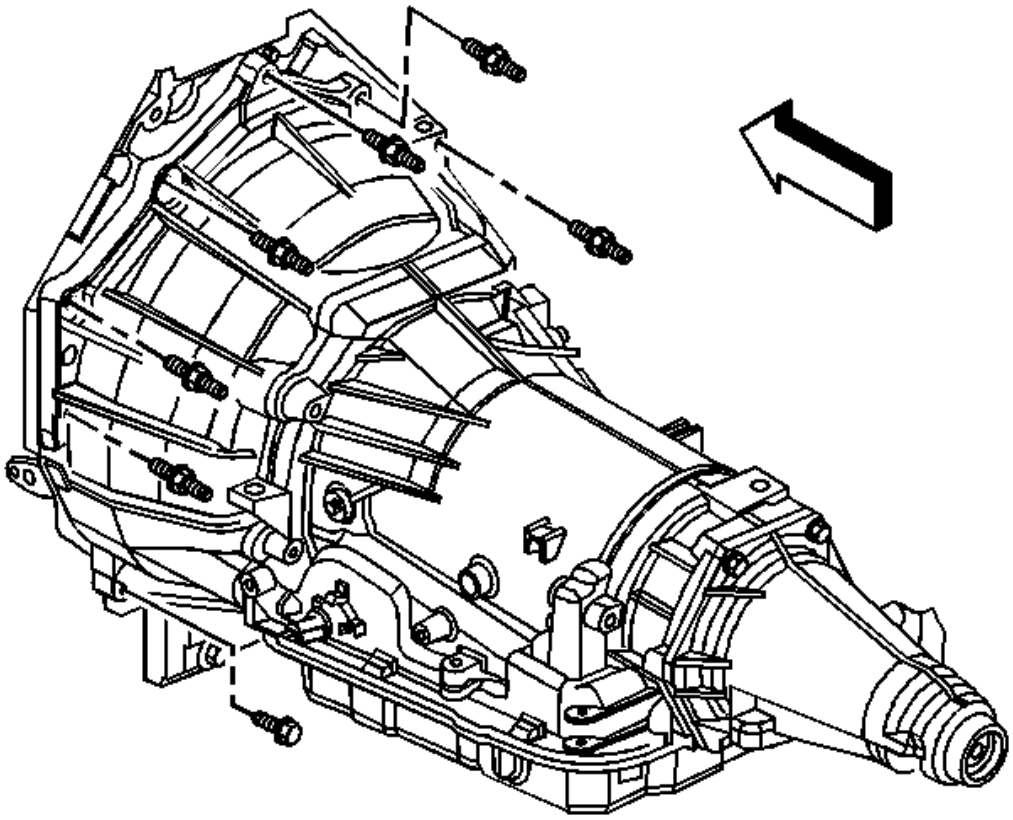

Fig. 272: View Of Automatic Transmission Bolt/Studs (4.8L, 5.3L & 6.0L Engines)
Courtesy of GENERAL MOTORS CORP.

47. Remove the lower transmission bolt/studs.
48. Lower the vehicle.
49. Remove the 3 upper transmission bolts/studs.
50. Install an engine hoist to **J 41798** . See **Special Tools**.
51. Install a floor jack under the transmission for support.
52. Separate the engine from the transmission.
53. Remove the engine.
54. Install the engine to an engine stand.
55. Install **J 21366** . See **Special Tools**.

Installation Procedure

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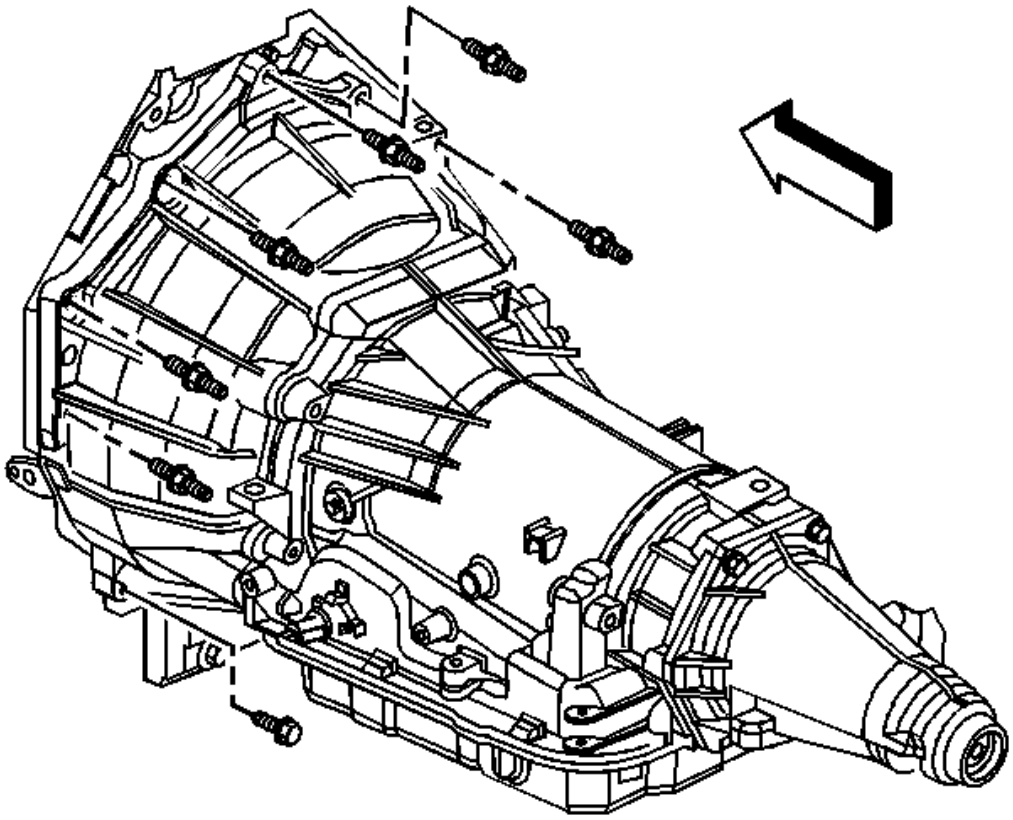

Fig. 273: View Of Automatic Transmission Bolt/Studs (4.8L, 5.3L & 6.0L Engines)
Courtesy of GENERAL MOTORS CORP.

1. Remove **J 21366** . See **Special Tools**.
2. Install an engine hoist to **J 41798** . See **Special Tools**.
3. Remove the engine from the engine stand.
4. Install the engine.
5. Mate the engine to the transmission.
6. Remove the floor jack from under the transmission for support.
7. Install the 3 upper transmission bolts/studs.

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

8. Raise the vehicle.
9. Install the lower transmission bolt/studs.

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

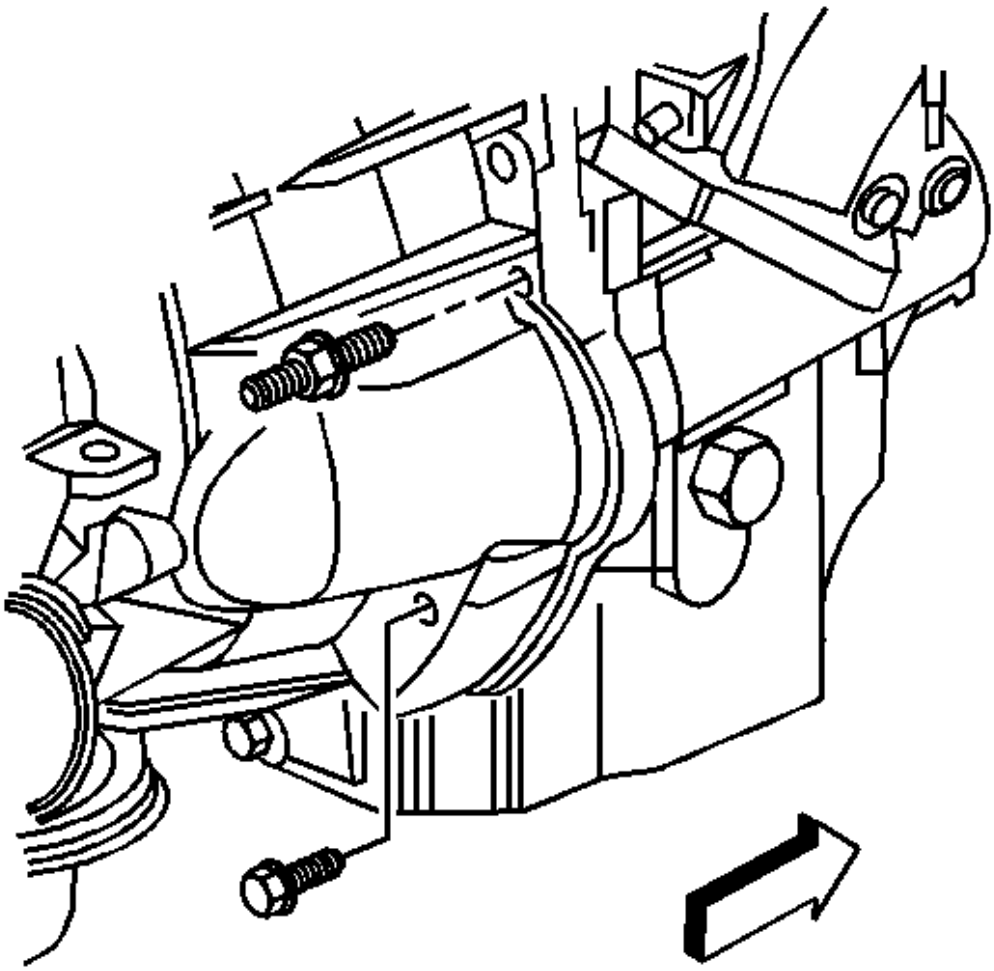

Fig. 274: View of Transmission Bolt & Stud (4L60-E)
Courtesy of GENERAL MOTORS CORP.

10. Install the transmission bolt and stud on the right side.

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

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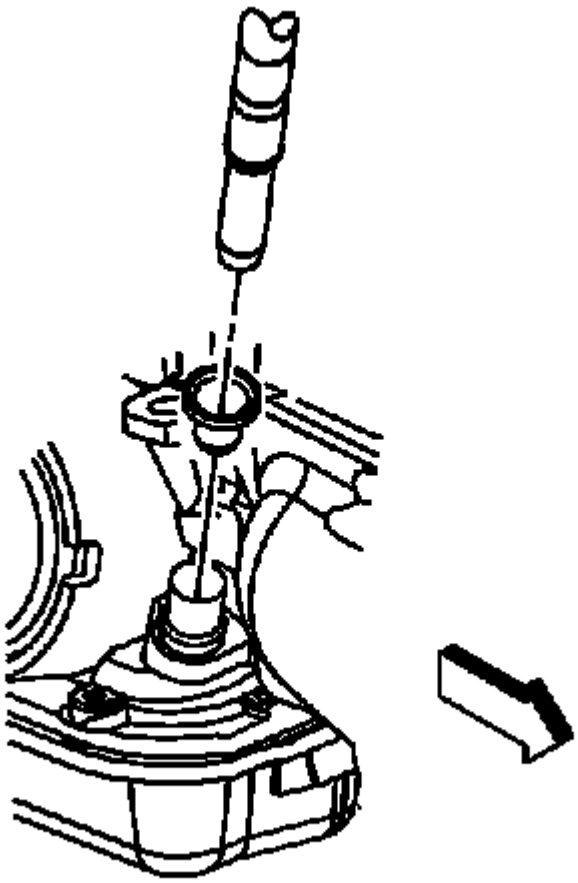

Fig. 275: View Of Oil Level Indicator Tube & Seal
Courtesy of GENERAL MOTORS CORP.

11. Install the transmission oil level indicator tube.

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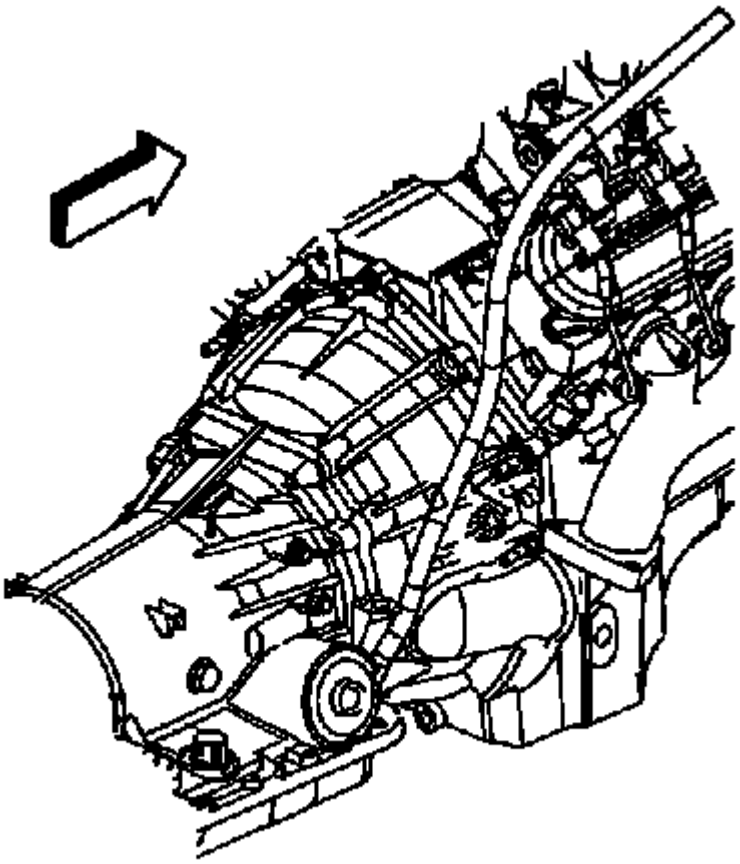

Fig. 276: View Of Oil Level Indicator Tube Nut
Courtesy of GENERAL MOTORS CORP.

12. Install the transmission oil level indicator tube nut.

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

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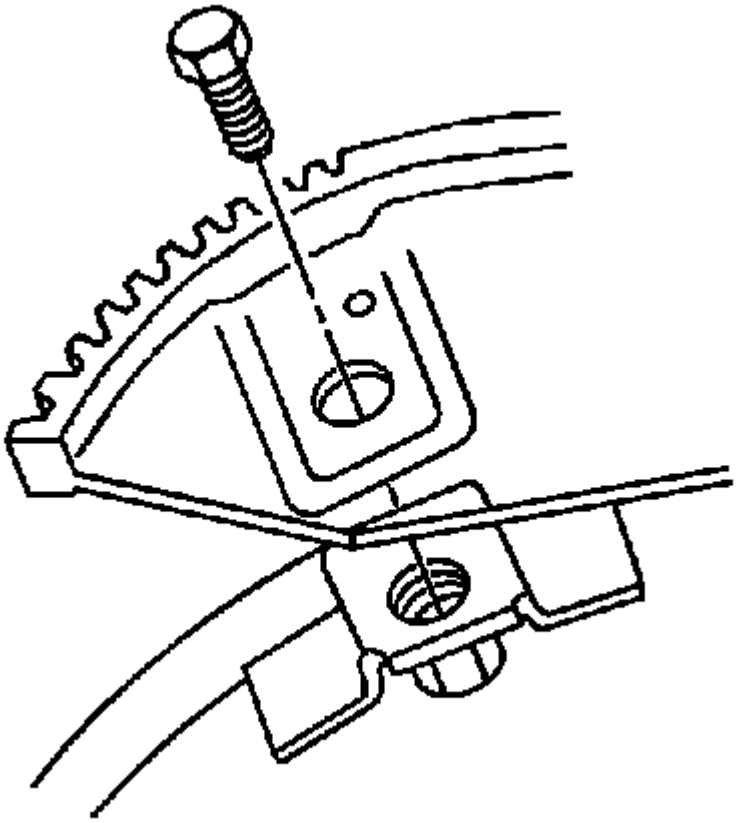

Fig. 277: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the torque converter bolts.

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

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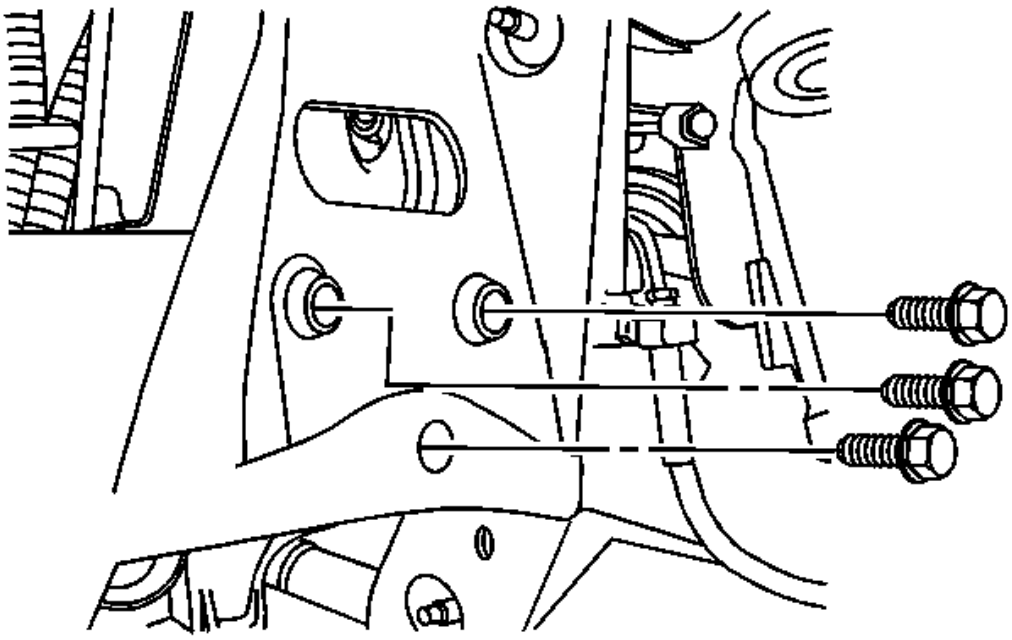

Fig. 278: View Of Frame Engine Mount Bracket Bolt Locations
Courtesy of GENERAL MOTORS CORP.

14. Install the 3 bracket bolts to both the right and the left sides of the frame engine mount.

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

15. Install the catalytic converter. Refer to **Catalytic Converter Replacement (5.3L Engine)**
16. Lower the vehicle.

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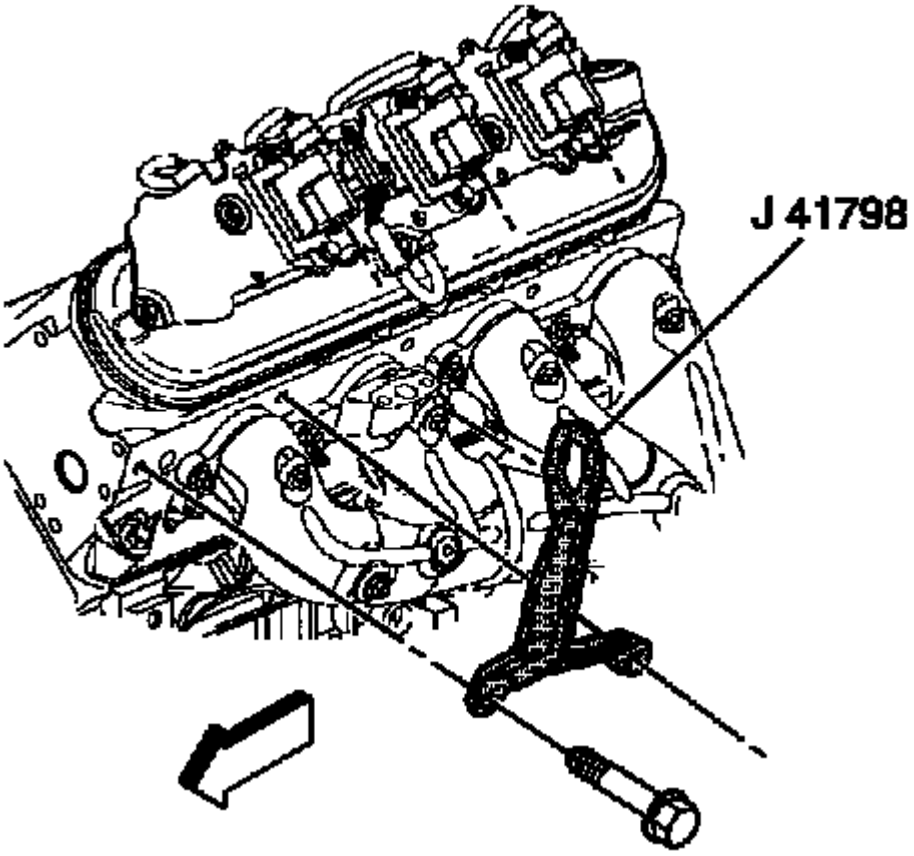

Fig. 279: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

17. Remove **J 41798** . See **Special Tools**.
18. Install the ignition coil(s) (as required).

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

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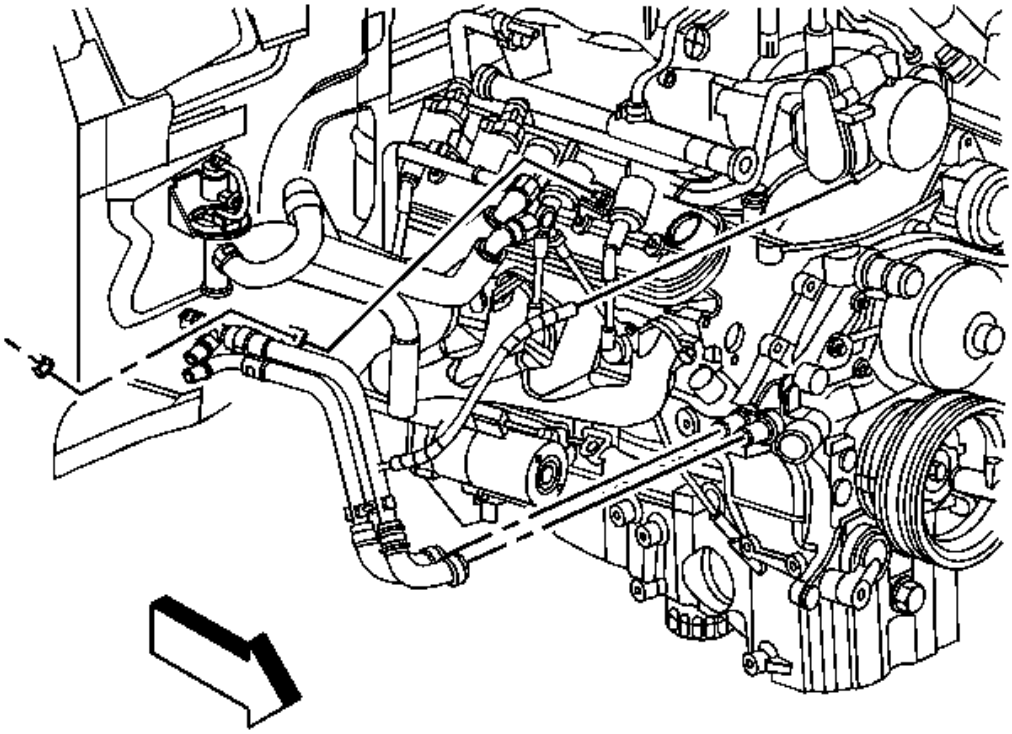

Fig. 280: View Of Auxiliary Heater Inlet & Outlet Hoses/Pipes
Courtesy of GENERAL MOTORS CORP.

19. Install the auxiliary heater inlet and outlet hoses/pipes to the water pump.
20. Using **J 38185** . See **Special Tools**.

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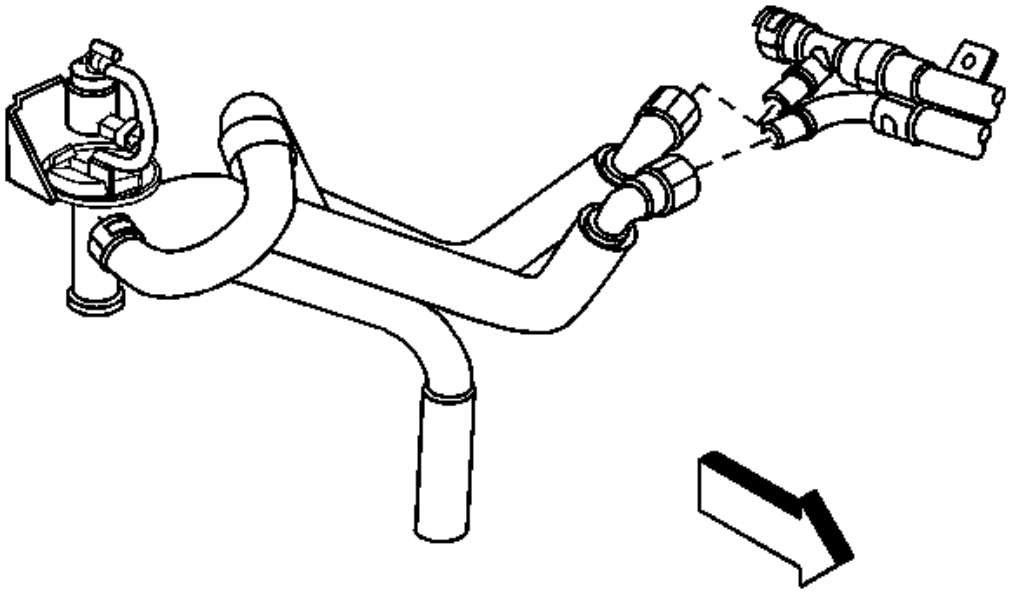

Fig. 281: View Of Auxiliary Heater Inlet & Outlet Hose/Pipe Assembly
Courtesy of GENERAL MOTORS CORP.

21. Connect the auxiliary heater inlet and outlet hose/pipe assembly to the heater water shutoff valve pipes.

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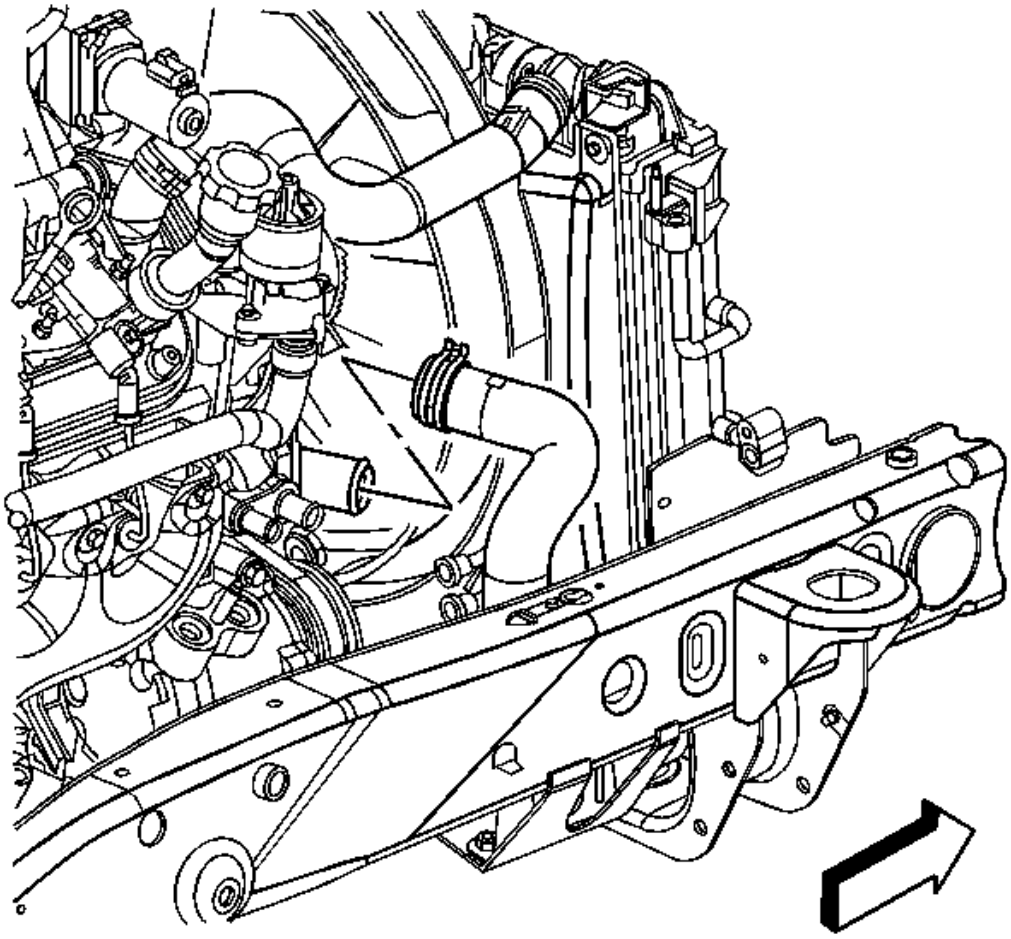

Fig. 282: View Of Outlet Hose
Courtesy of GENERAL MOTORS CORP.

22. Install the outlet hose to the water outlet.
23. Using **J 38185** . See **Special Tools**.

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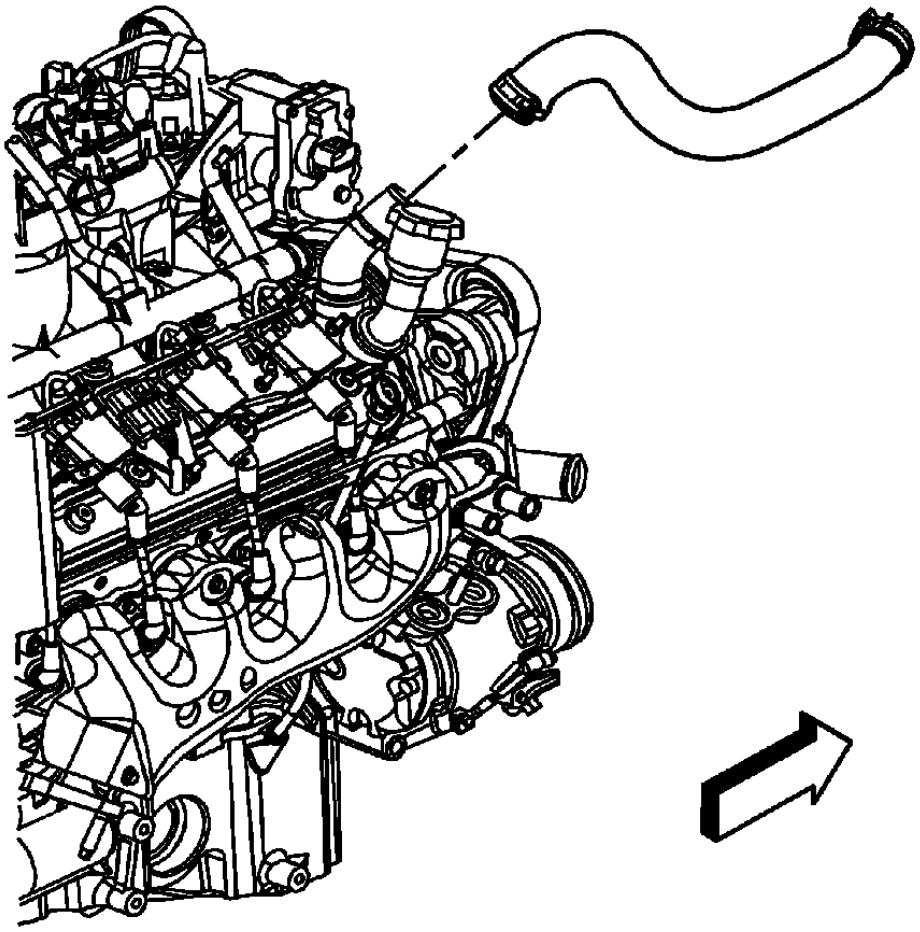

Fig. 283: View Of Inlet Hose
Courtesy of GENERAL MOTORS CORP.

24. Install the inlet hose to the water outlet.
25. Using **J 38185** . See **Special Tools**.

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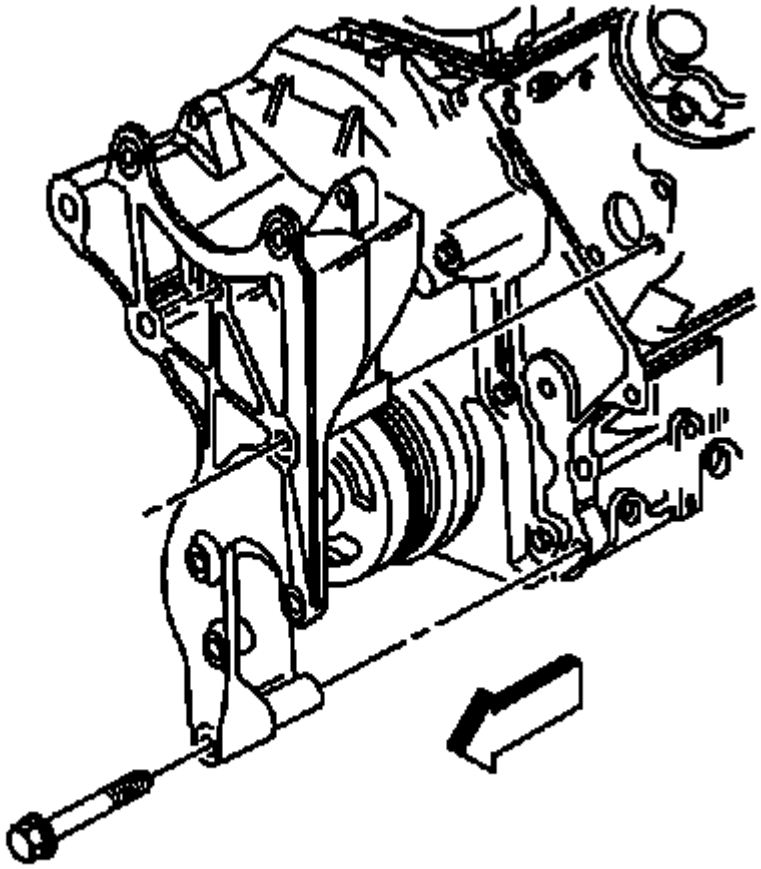

Fig. 284: View Of Generator Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

26. Position the bracket with generator to the engine.
27. Install the generator bracket bolts.

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

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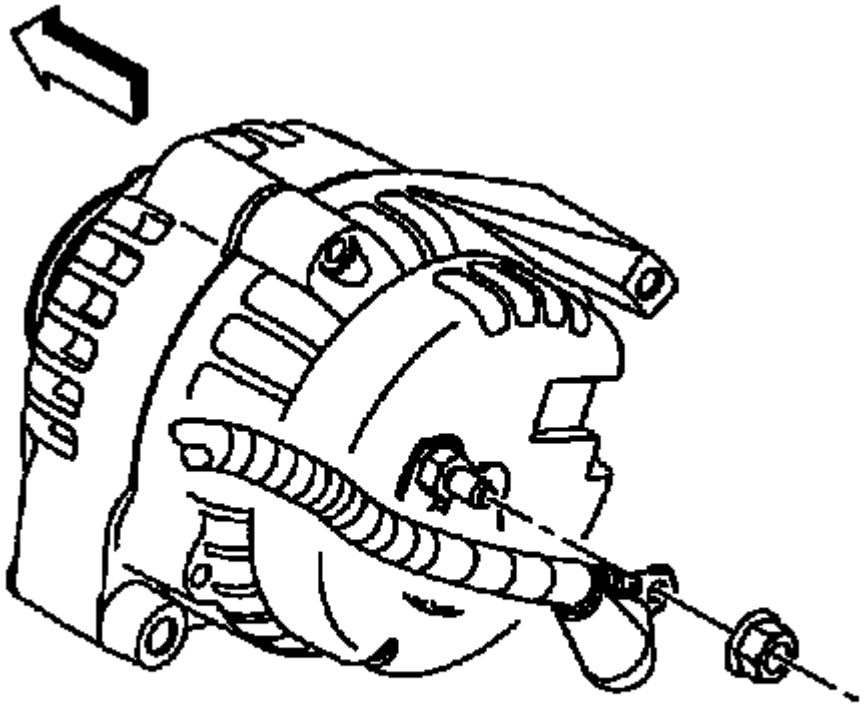

Fig. 285: View Of Generator Cable & Nut
Courtesy of GENERAL MOTORS CORP.

28. Install the generator cable to the generator, perform the following procedure:
    1. Install the generator cable.
    2. Install the generator cable nut to the terminal stud.

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

    3. Slide the boot down covering the terminal stud.

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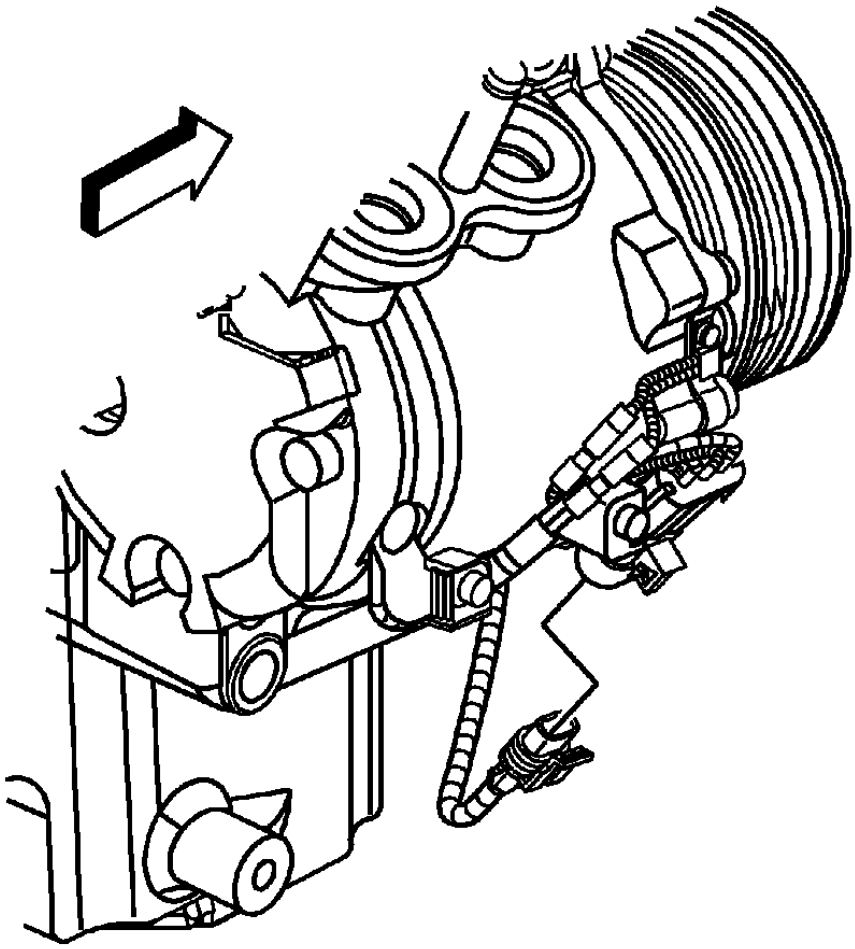

Fig. 286: View Of A/C Compressor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

29. Gather all branches of the engine wiring harness and position the harness over the engine.
30. Raise the vehicle.
31. Connect the A/C compressor electrical connector.

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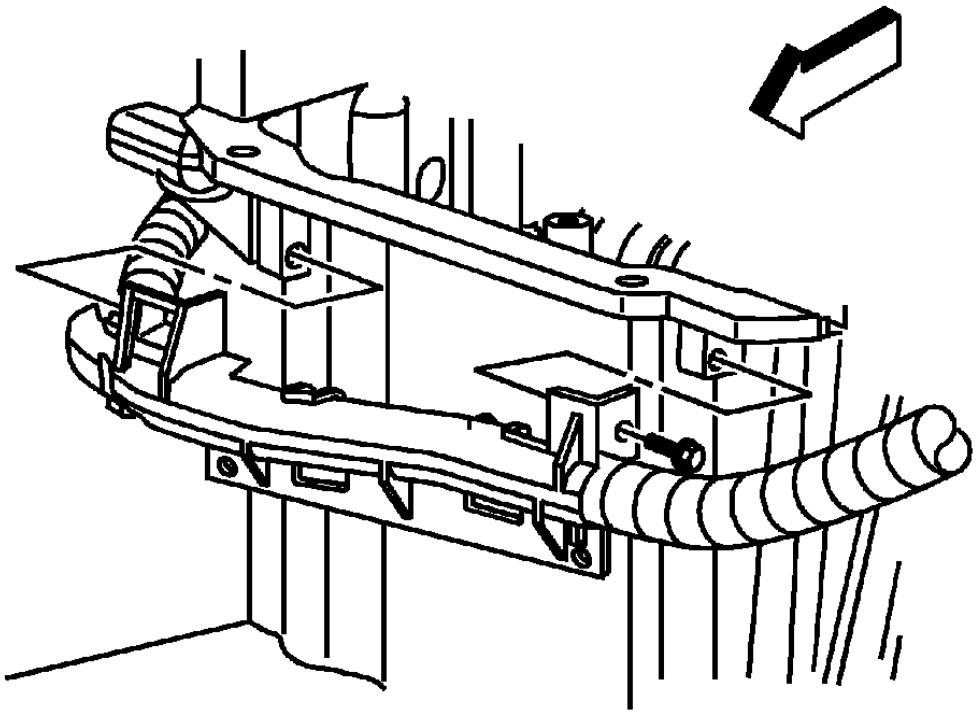

Fig. 287: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

32. Install the battery cable channel to the oil pan.
33. Install the battery cable channel bolt.

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

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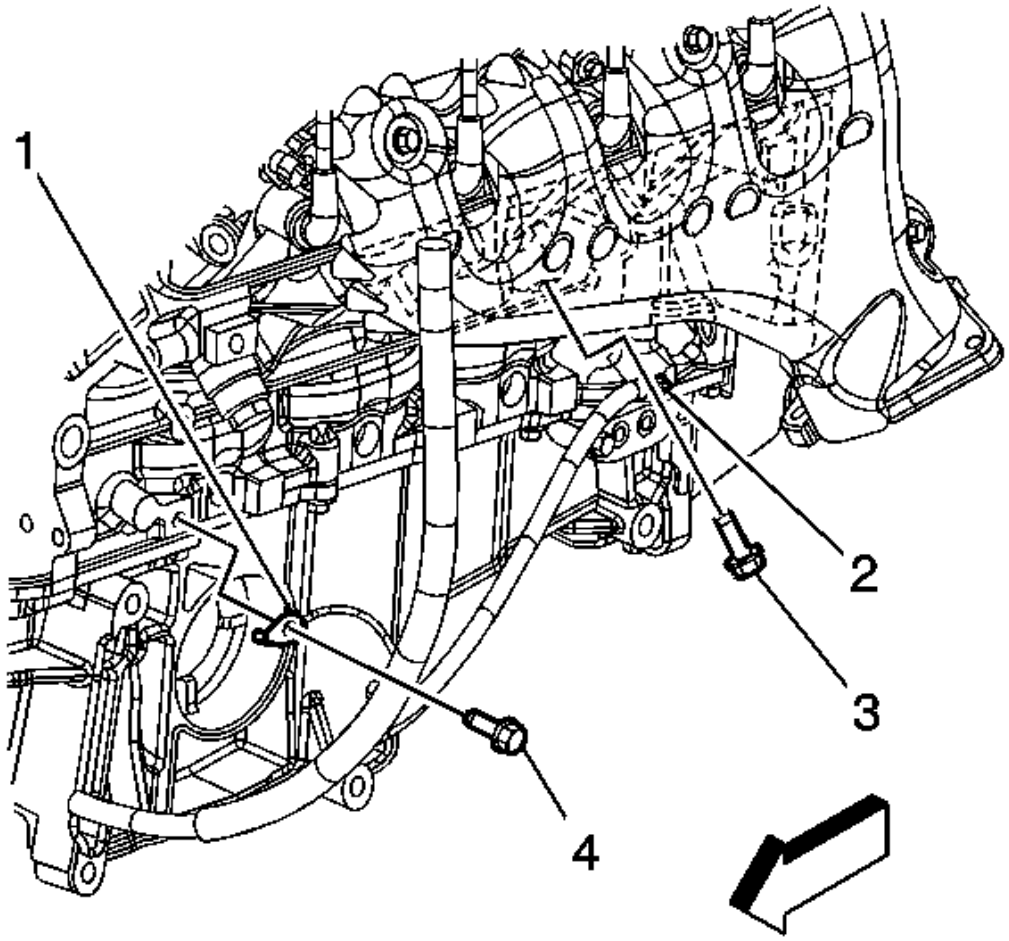

Fig. 288: View Of Ground Terminal Bolts
Courtesy of GENERAL MOTORS CORP.

34. Install the starter. Refer to **Starter Motor Replacement (5.3L Engine)**
35. Install the ground terminal bolts (2, 4).

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

36. Lower the vehicle.

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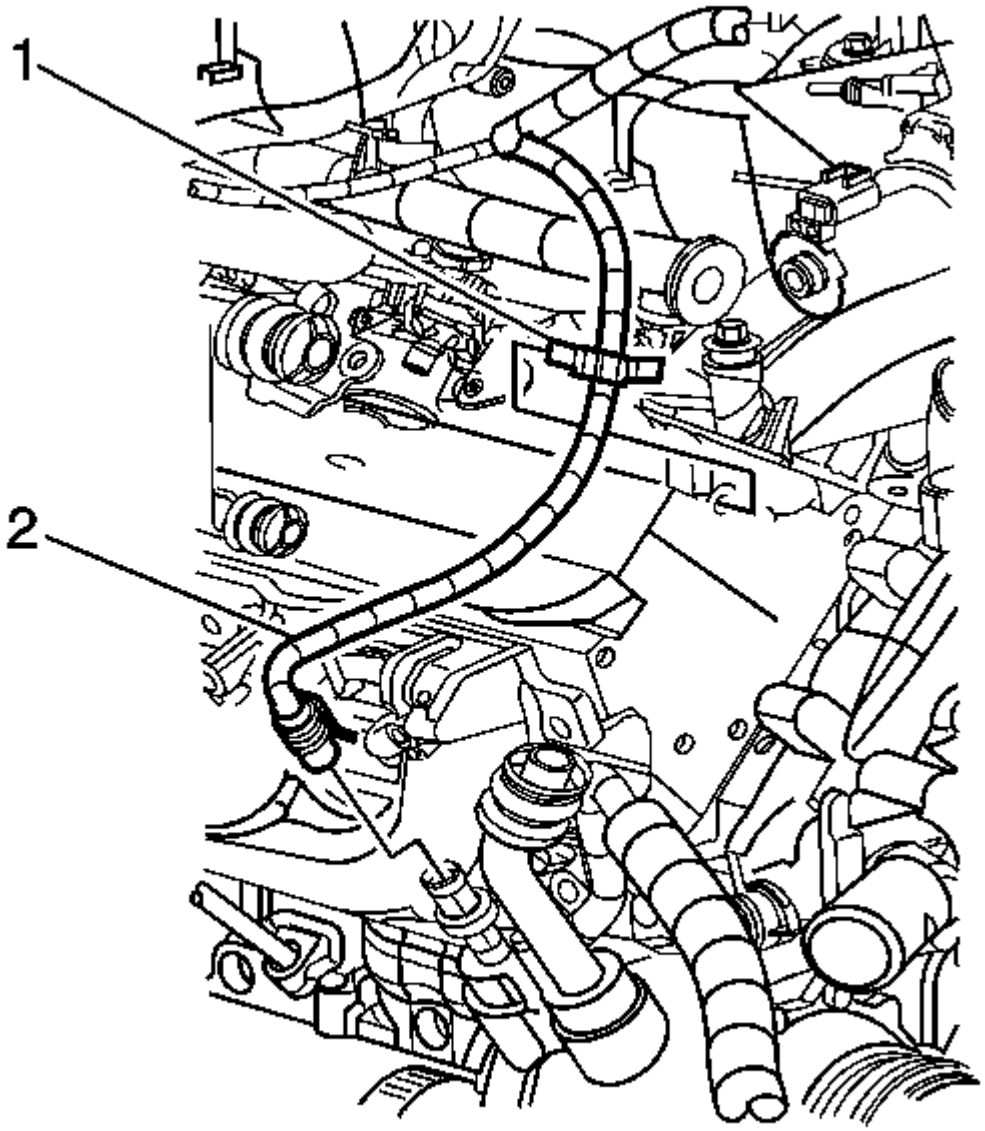

Fig. 289: View Of A/C Compressor Pressure Switch Electrical Connector & Retaining Clip
Courtesy of GENERAL MOTORS CORP.

37. Install the retaining clip (1) to the cylinder head.
38. Connect the A/C pressure switch electrical connector (2).

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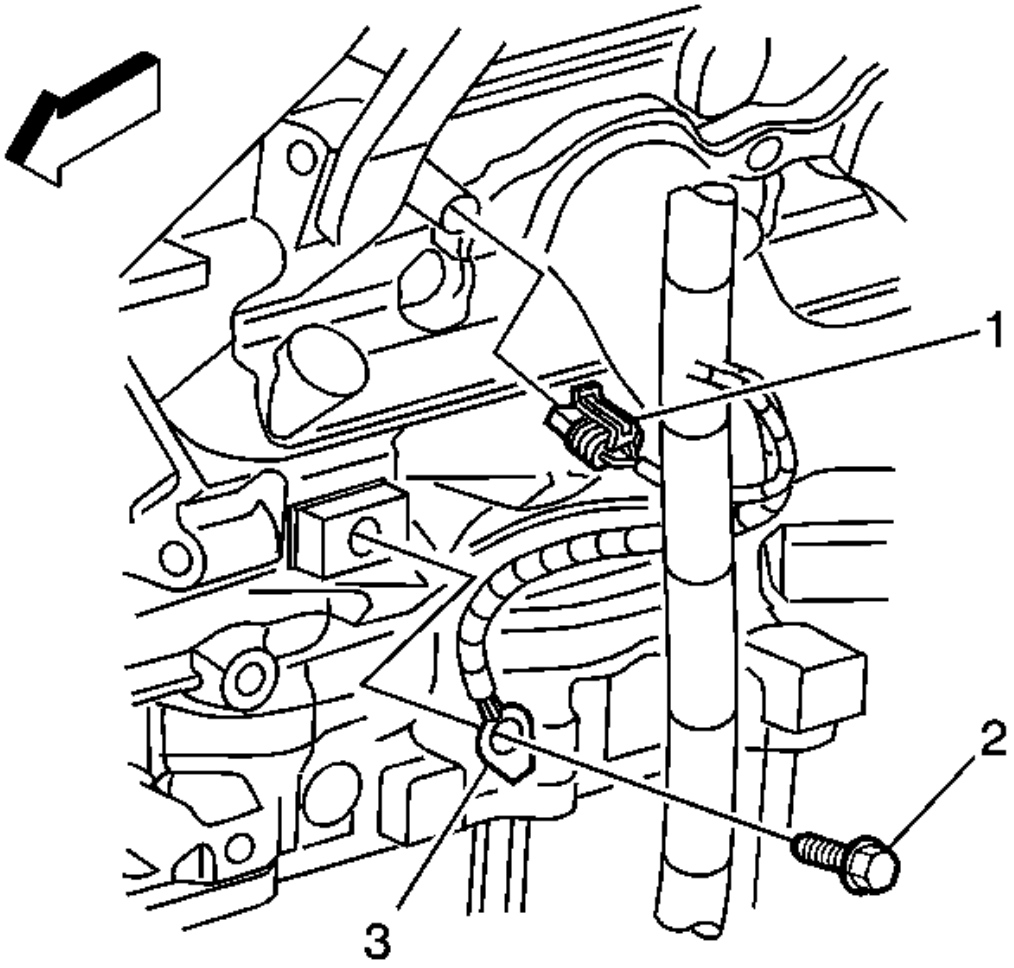

Fig. 290: View Of ECT Sensor Electrical Connector And Ground
Courtesy of GENERAL MOTORS CORP.

39. Install the retaining clips to the brackets.
40. Install the ground terminal bolt (2).

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

41. Connect the ECT sensor (1).

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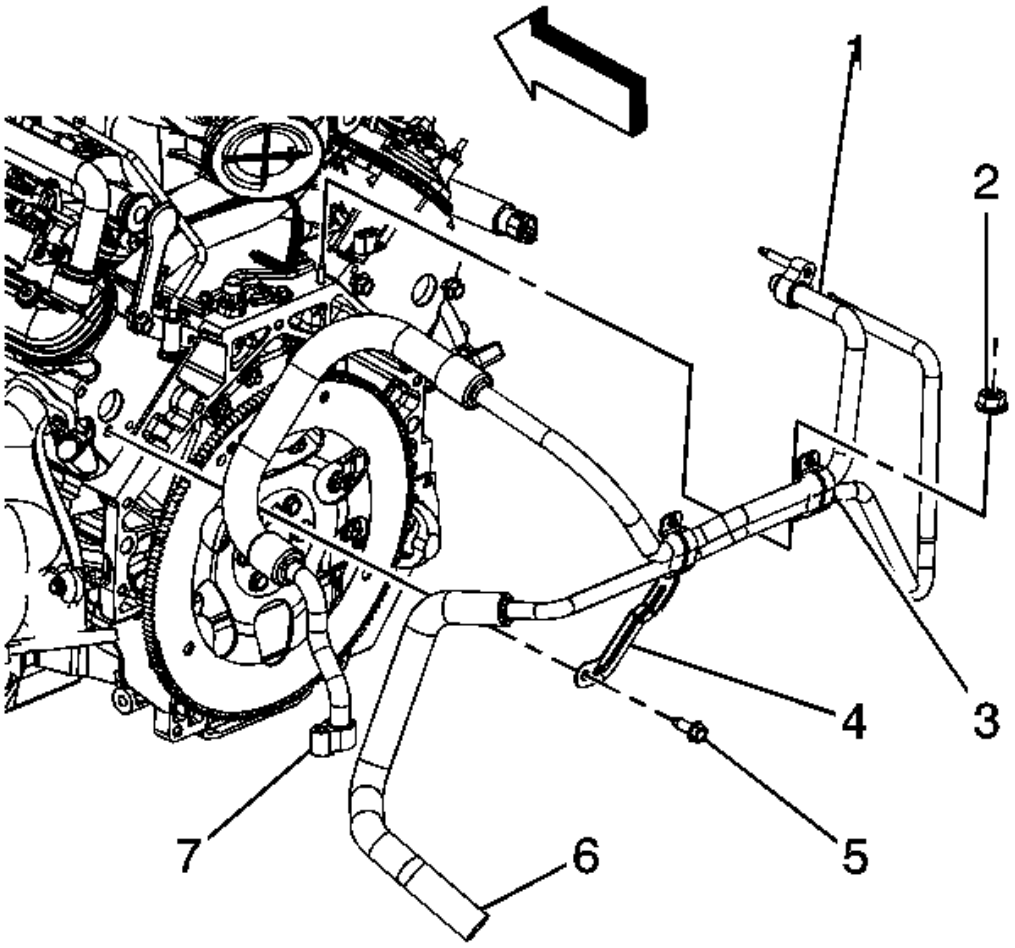

Fig. 291: View Of Rear A/C Lines
Courtesy of GENERAL MOTORS CORP.

42. Install the rear auxiliary A/C compressor pipe nut and bolt (2, 5).

    Tighten: Tighten the nut/bolt to 20 N.m (15 lb ft).

43. Connect the rear auxiliary A/C compressor pipe fitting (7).

    Tighten: Tighten the nut to 16 N.m (12 lb ft).

44. Install the A/C compressor hose. Refer to **Compressor Hose Assembly Replacement (LM4)**

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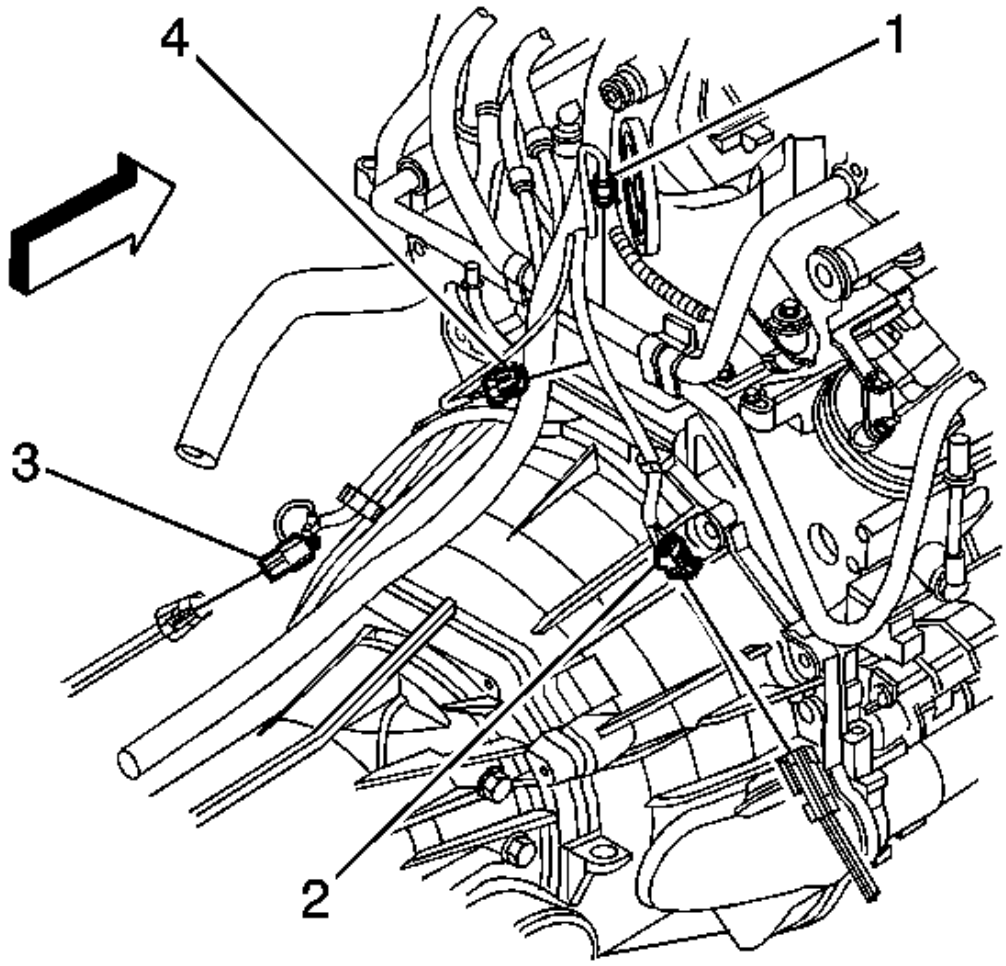

Fig. 292: Locating Components Connectors At Rear Of Engine
Courtesy of GENERAL MOTORS CORP.

45. Connect the following electrical connectors:
    - Oil pressure sensor (1)
    - Oxygen sensors (2, 3)
    - Camshaft position (CMP) sensor (4)
46. Install the intake manifold. Refer to **Intake Manifold Replacement**
47. Install the wheel drive shafts. Refer to **Wheel Drive Shaft Replacement**
48. Install the front differential drive axle, if equipped with 4WD. Refer to **Differential Carrier Assembly Replacement (V8)**

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49. Install the radiator support brace. Refer to **Brace Replacement - Radiator Support Diagonal**
50. Install the radiator. Refer to **Radiator Replacement**
51. Recharge the refrigerant. Refer to **Refrigerant Recovery and Recharging**
52. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure**
53. Remove the fender covers from both fenders.
54. Prelube the engine. Refer to **Engine Prelubing**
55. Perform the CKP system variation learn procedure. Refer to **CKP System Variation Learn Procedure**
56. Install the hood. Refer to **Hood Replacement**

IMPORTANT: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.

57. Test the vehicle using the following procedure:
    1. Disable the ignition system.
    2. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
    3. Enable the ignition system.
    4. Start the engine and listen for unusual noises.
    5. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
    6. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
    7. Listen for sticking lifter and other unusual noises.
    8. Inspect for fuel, oil and/or coolant leaks while the engine is running.
    9. Close the hood.

Engine Oil and Oil Filter Replacement

Removal Procedure

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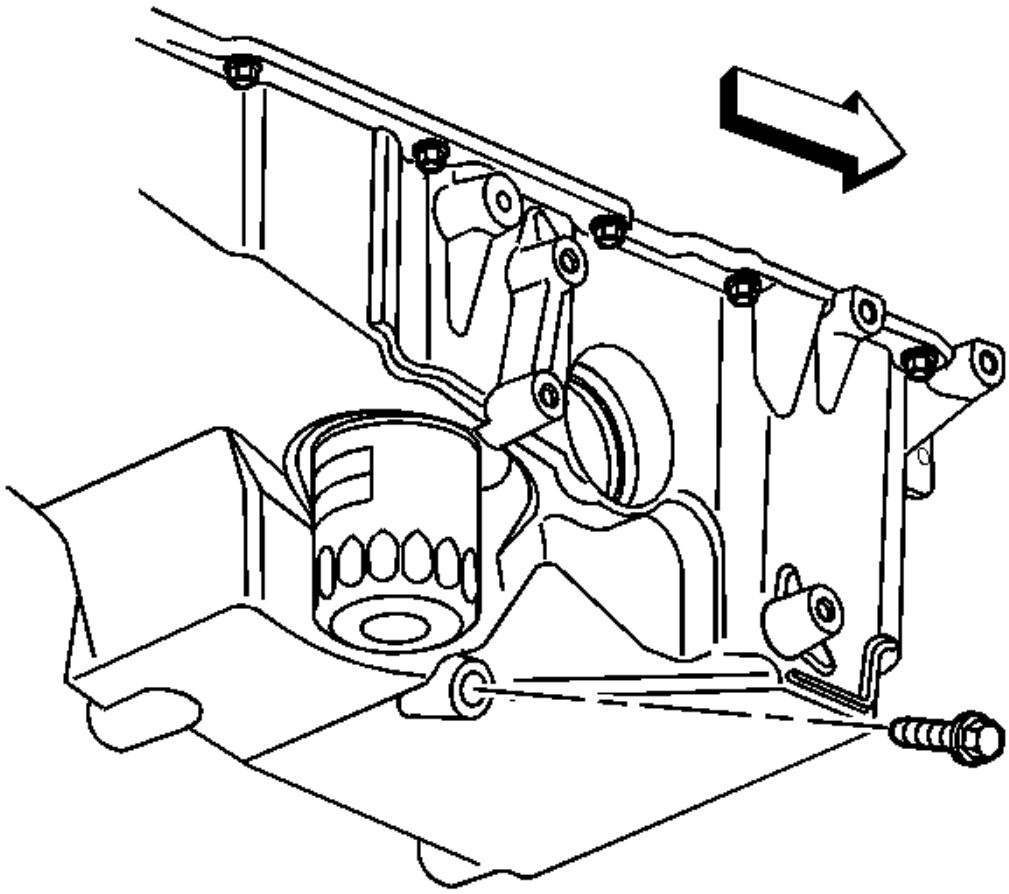

Fig. 293: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to completely drain the oil from the oil pan internal baffling, the bottom of the oil pan must be level during the oil drain procedure.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
4. Place a oil drain pan under the oil pan drain plug.
5. Remove the oil pan drain plug.
6. Drain the engine oil.

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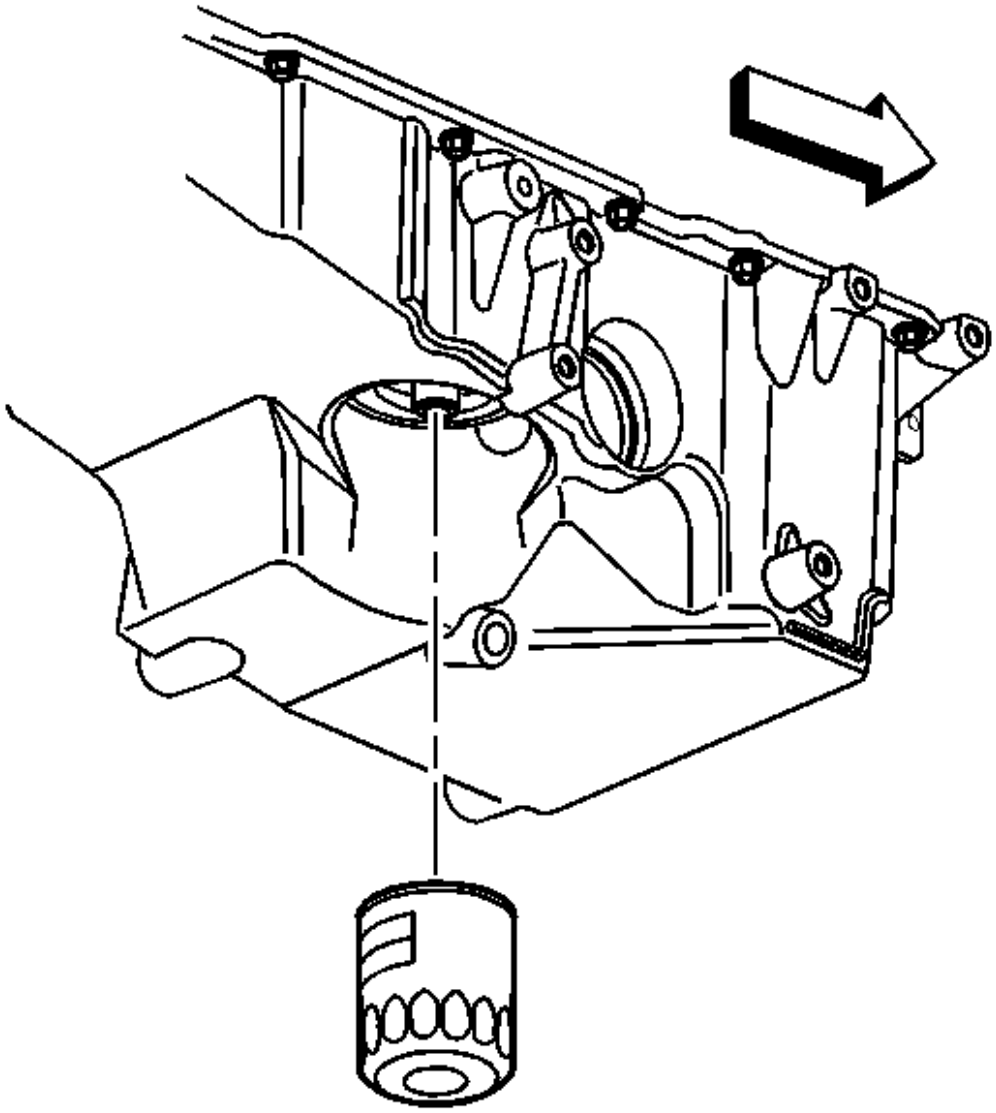

Fig. 294: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil filter from the oil pan.
8. Inspect the old oil filter to ensure that the filter seal is not left on the oil pan.

Installation Procedure

1. Wipe the excess oil from the oil filter mounting.

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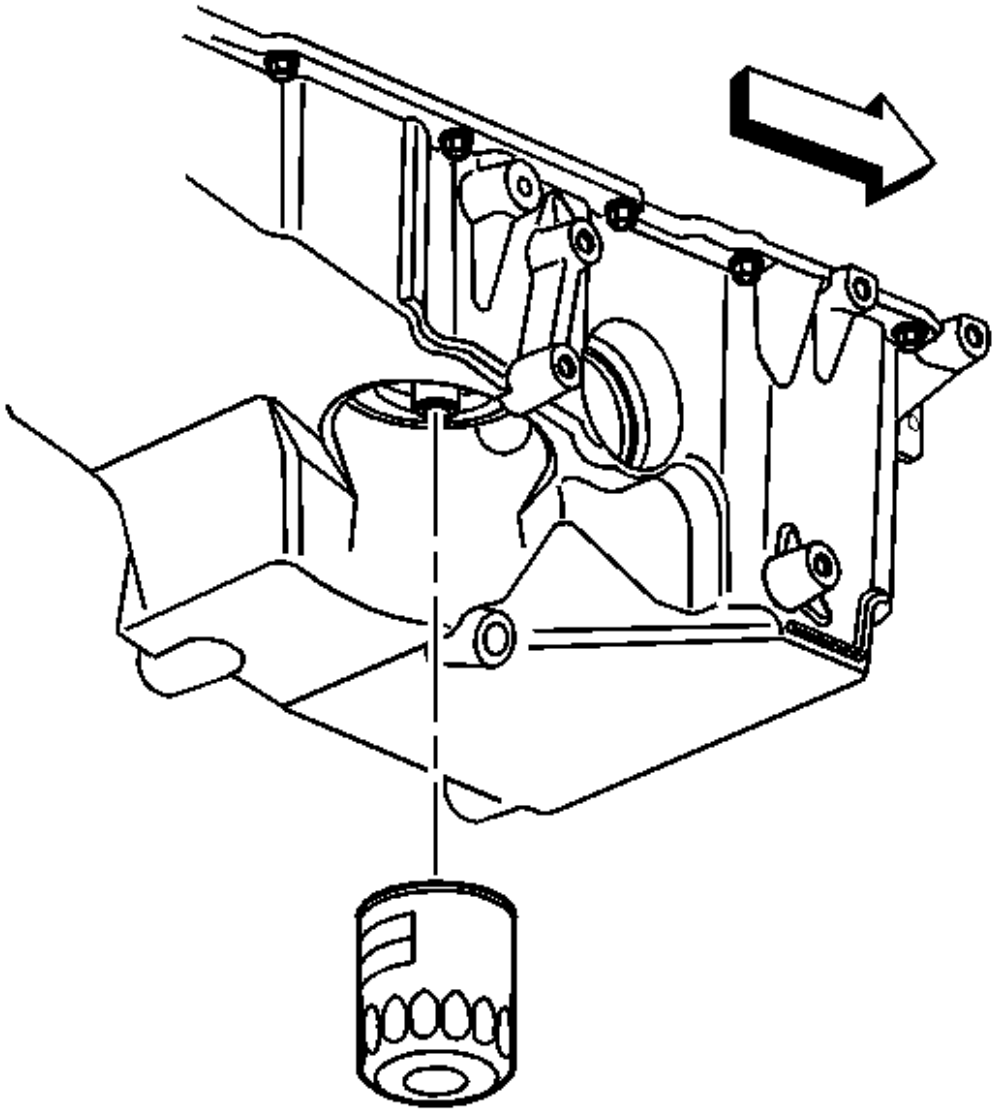

Fig. 295: Locating Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the oil filter seal with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil filter to the oil pan.

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Tighten: Tighten the filter to 30 N.m (22 lb ft).

4. Wipe the excess oil from the drain plug hole.

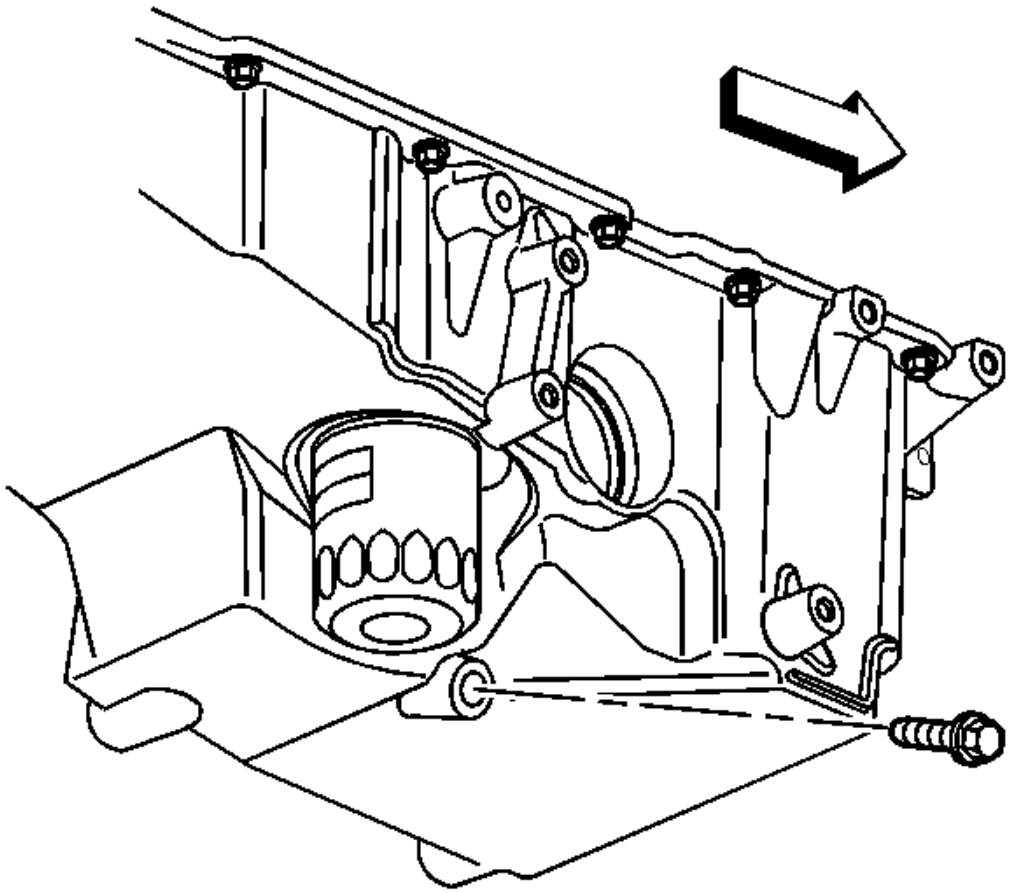

Fig. 296: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Install the oil drain plug to the oil pan.

   Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

6. Lower the vehicle.
7. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Capacities - Approximate Fluid** and to **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.
8. Remove the oil level indicator.

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9. Wipe the indicator with a clean cloth.
10. Install the oil level indicator.
11. Remove the oil level indicator in order to check the level.
12. Add oil if necessary.
13. Close the hood.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

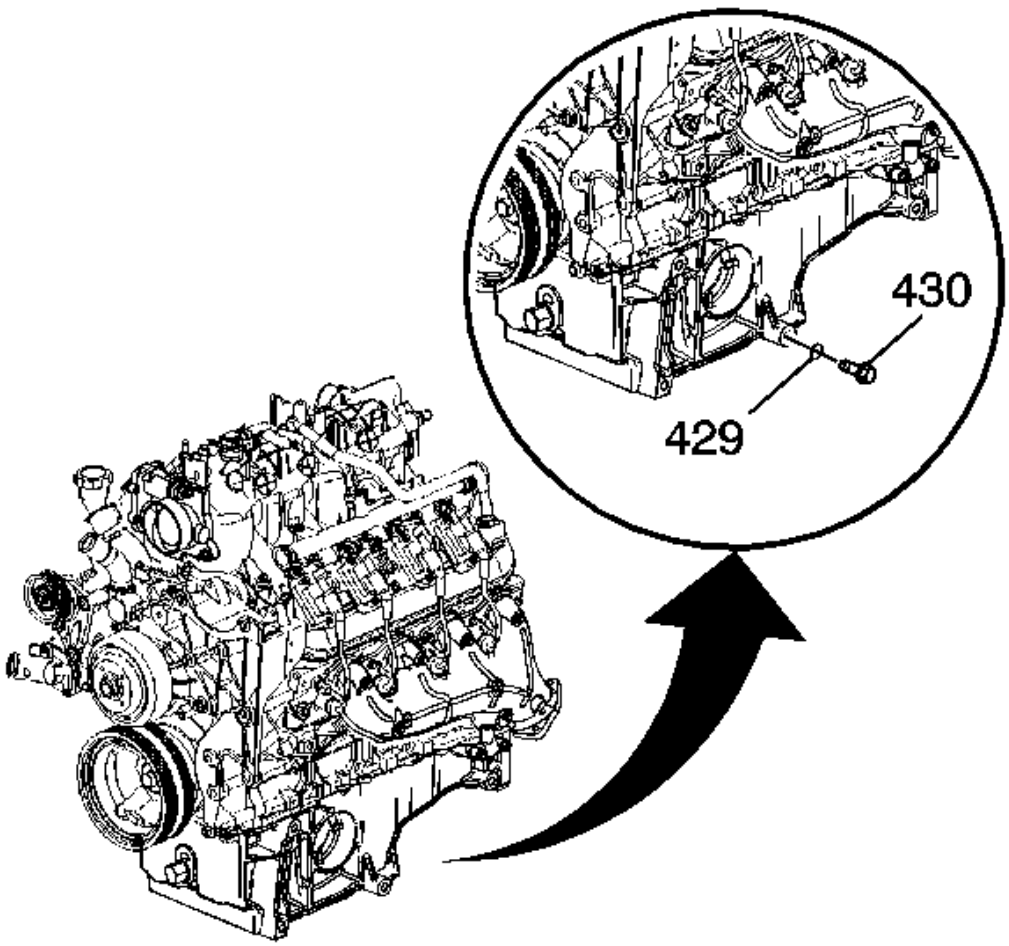

Fig. 297: Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil pan drain plug (430) and O-ring (429).

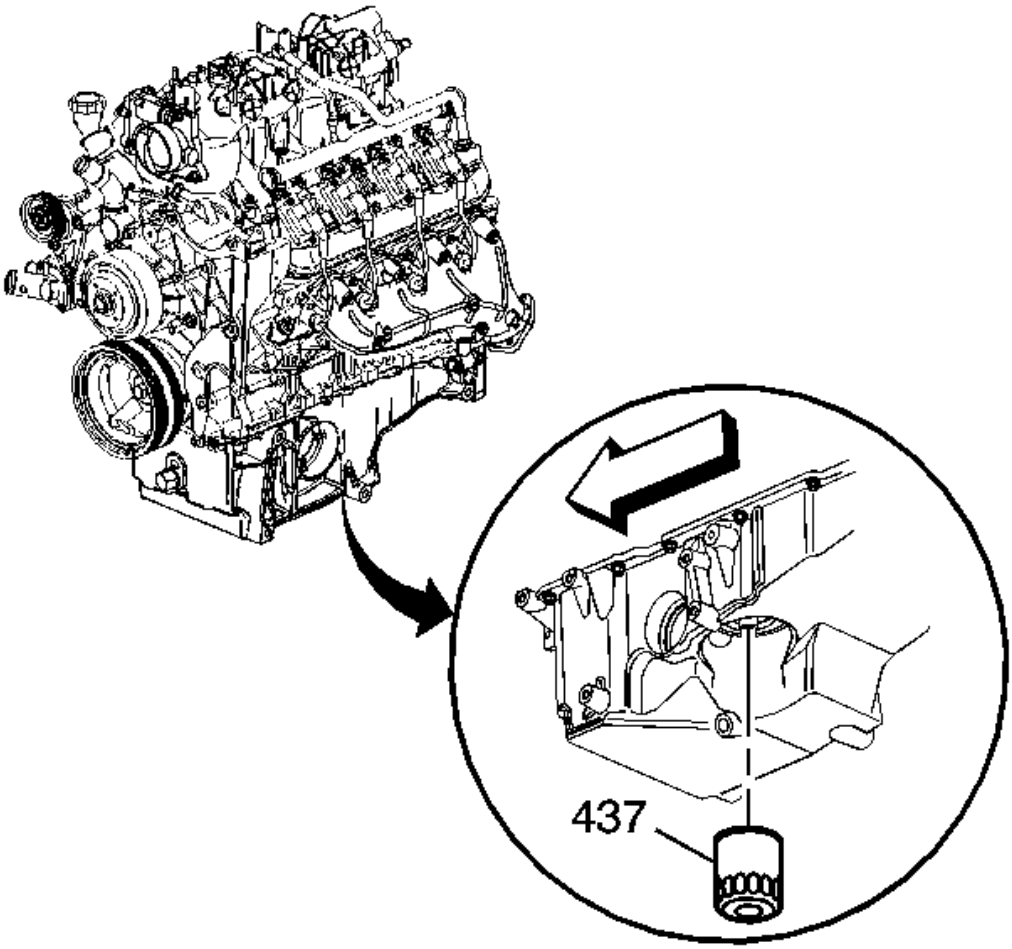

Fig. 298: Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter (437).

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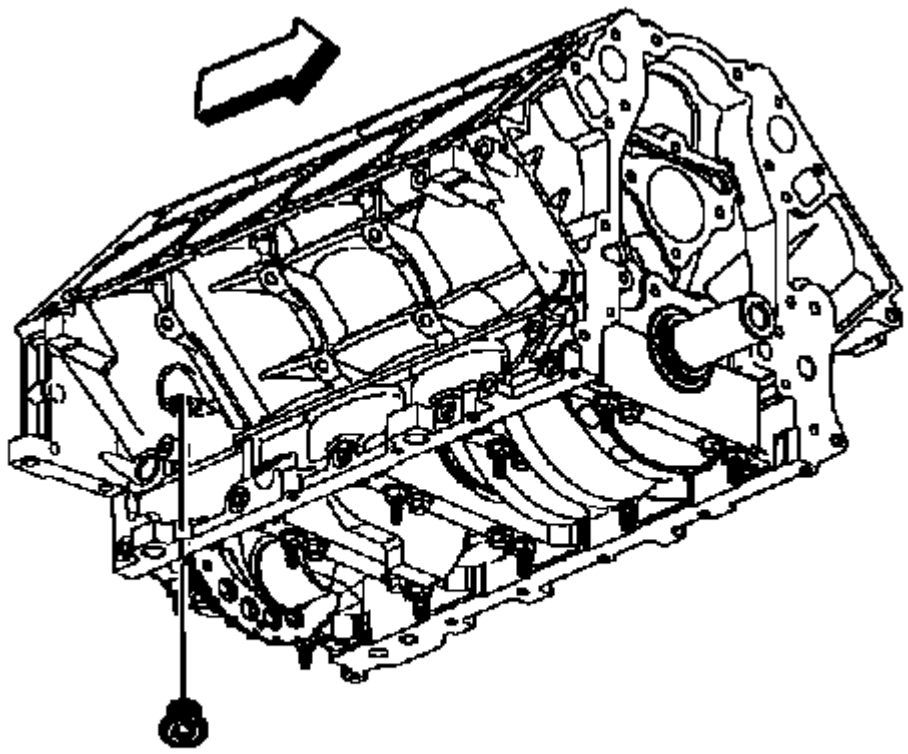

Fig. 299: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block coolant drain hole plug and washer.

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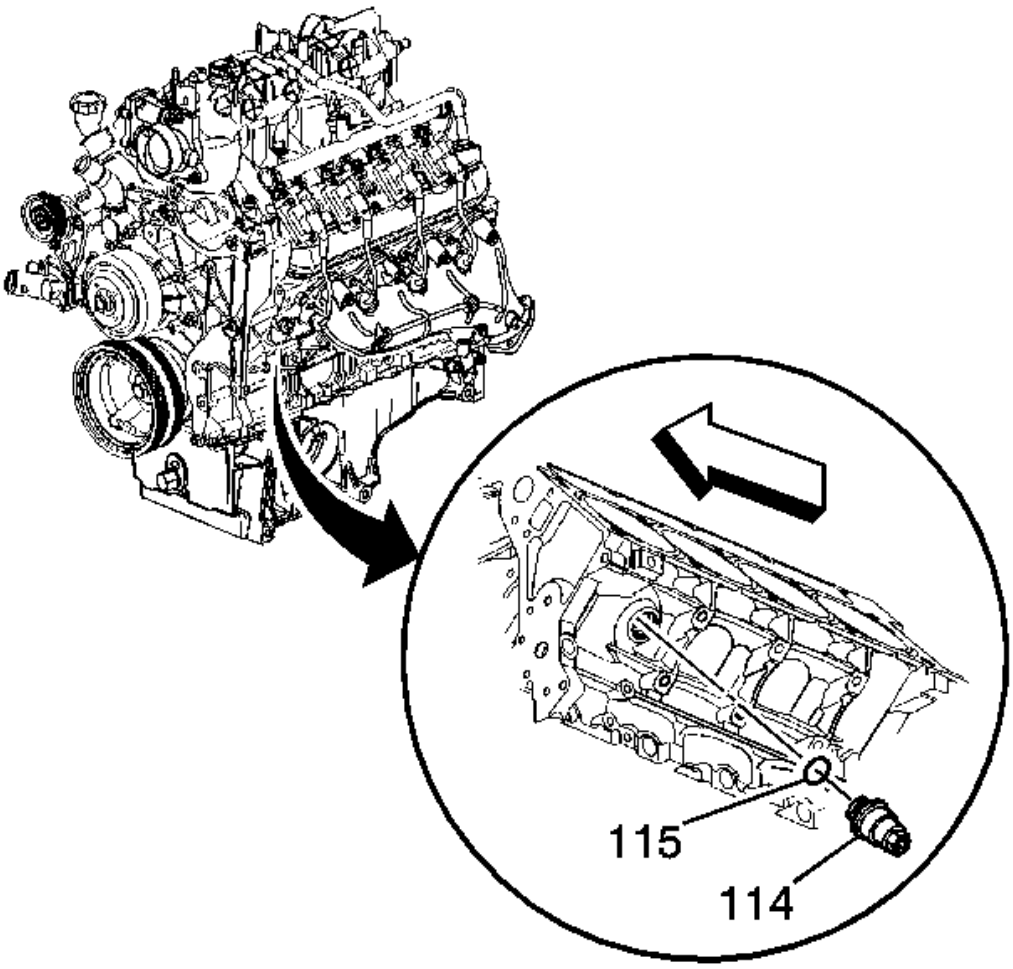

Fig. 300: Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block coolant heater (114) and washer (115).

Crankshaft Balancer Removal

Tools Required

- **J 41816** Crankshaft Balancer Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.

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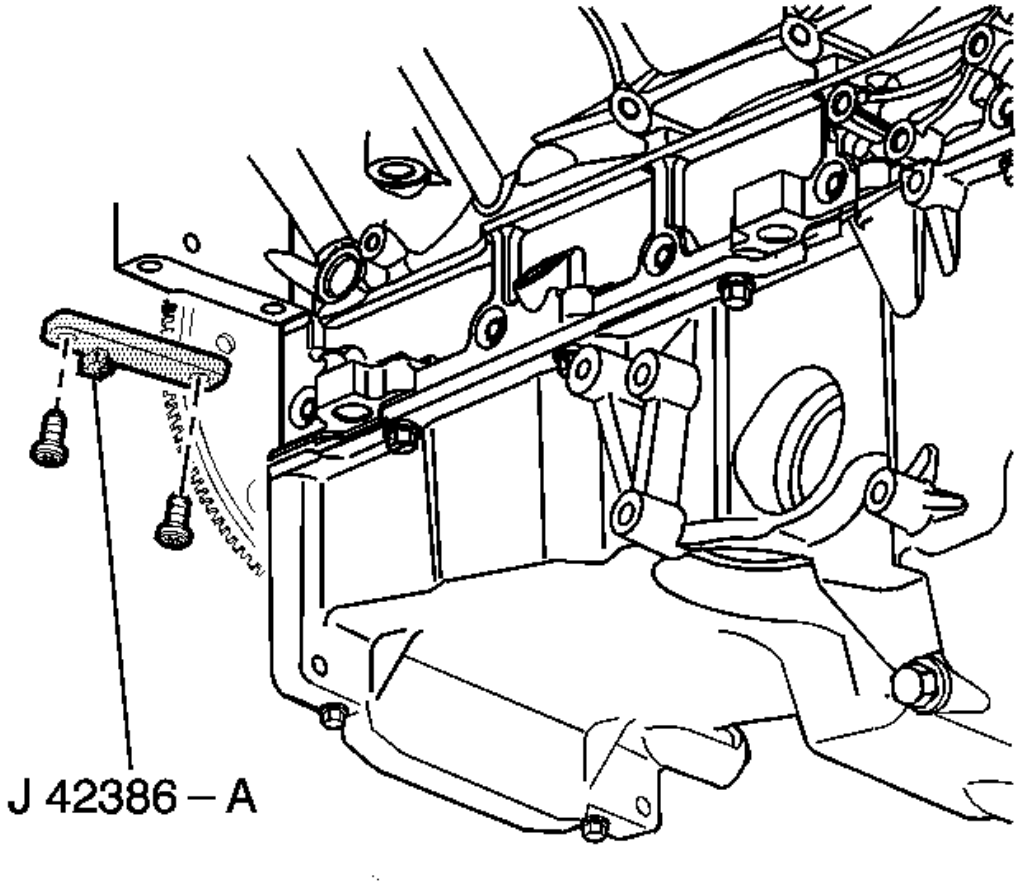

Fig. 301: View Of J 42386-A Flywheel Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

1. Install the **J 42386-A** and bolts. See **Special Tools**.

   Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

   Tighten: Tighten the **J 42386-A** bolts to 50 N.m (37 lb ft).

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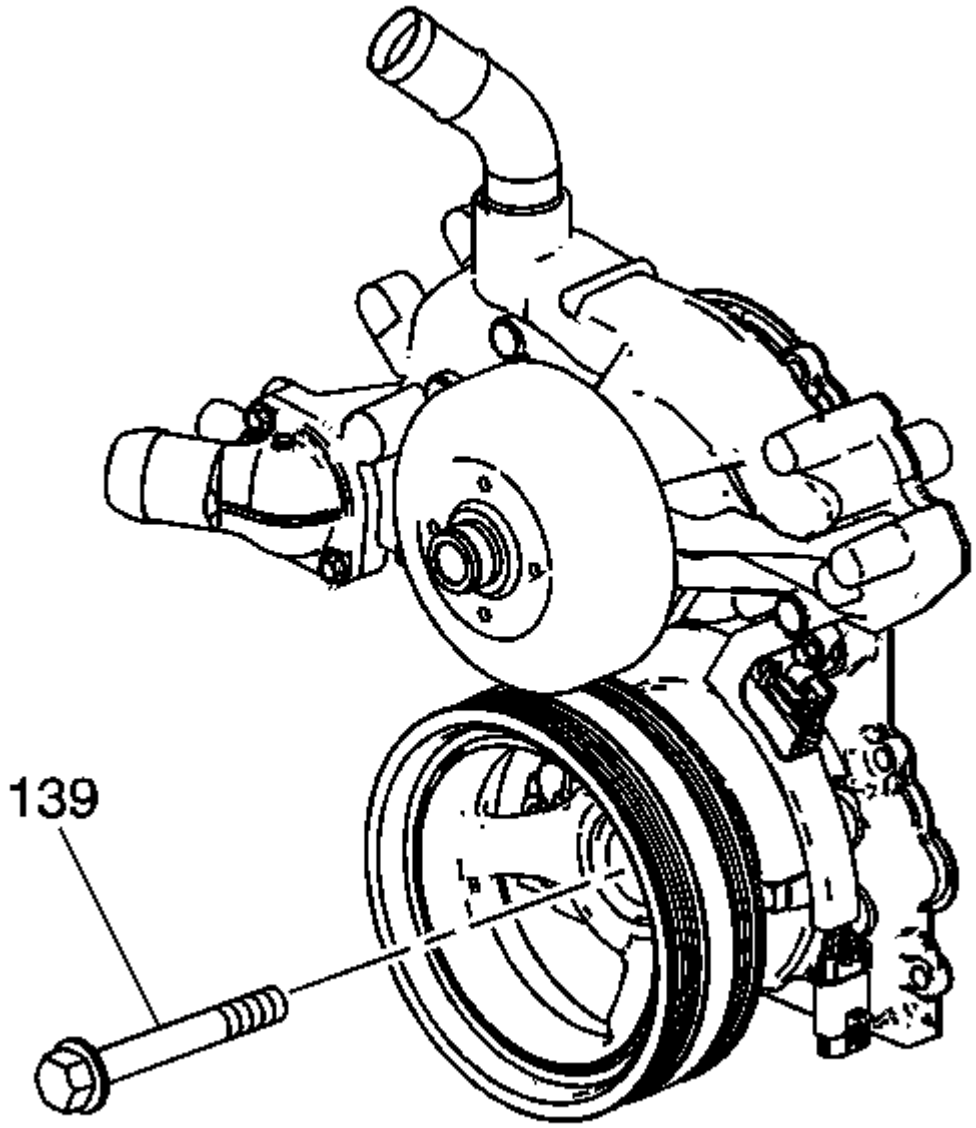

Fig. 302: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt (139).

   Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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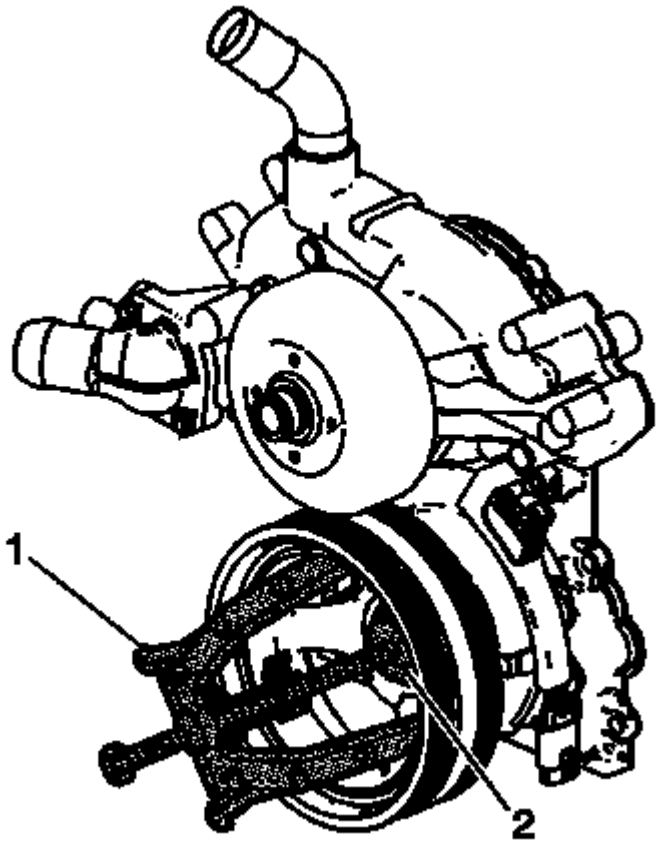

Fig. 303: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41816** (1) and the **J 41816-2** (2) in order to remove the crankshaft balancer.

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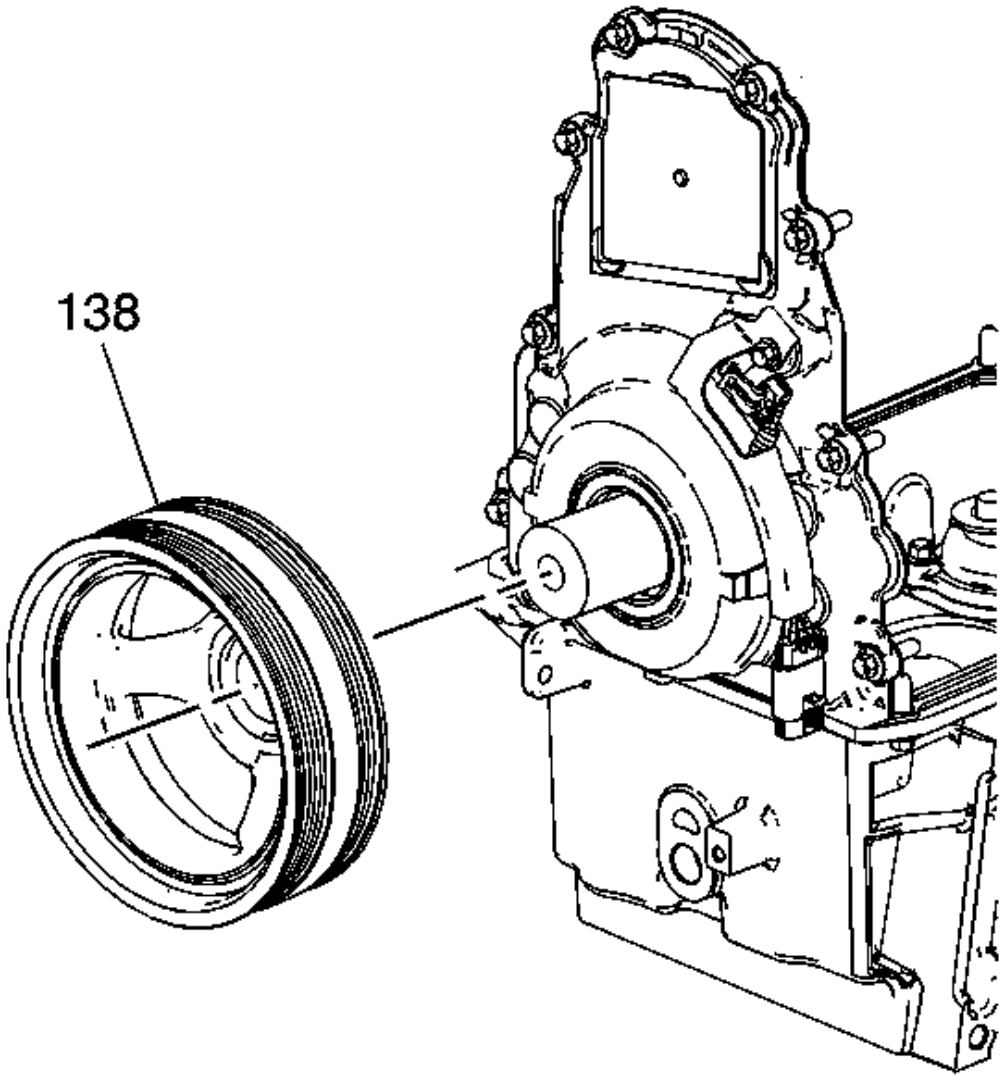

Fig. 304: Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the balancer (138).

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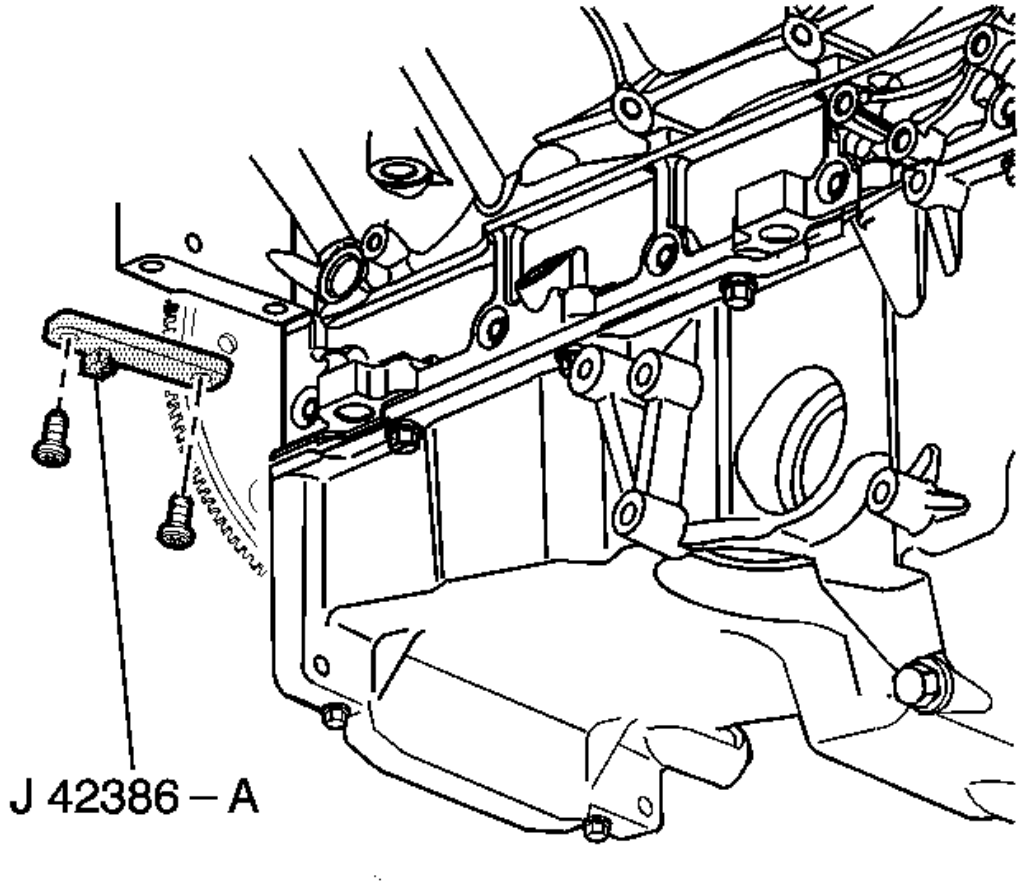

Fig. 305: View Of J 42386-A Flywheel Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 42386-A** and bolts. See **Special Tools**.

Engine Flywheel Removal

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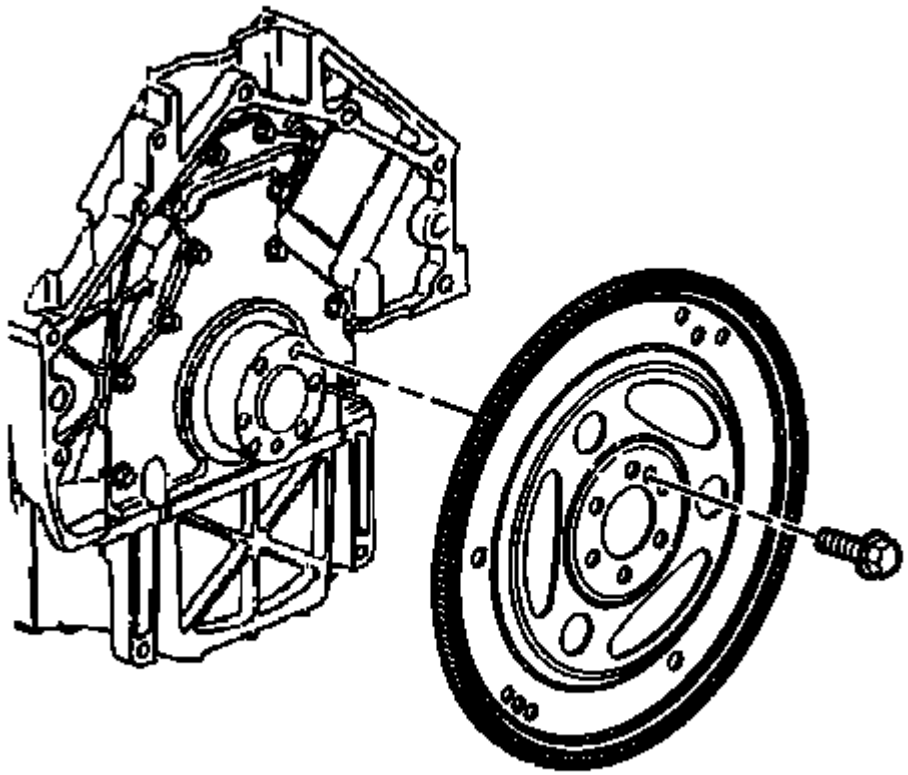

Fig. 306: Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.

1. Remove the engine flywheel bolts.
2. Remove the flywheel.

Oil Level Indicator and Tube Removal

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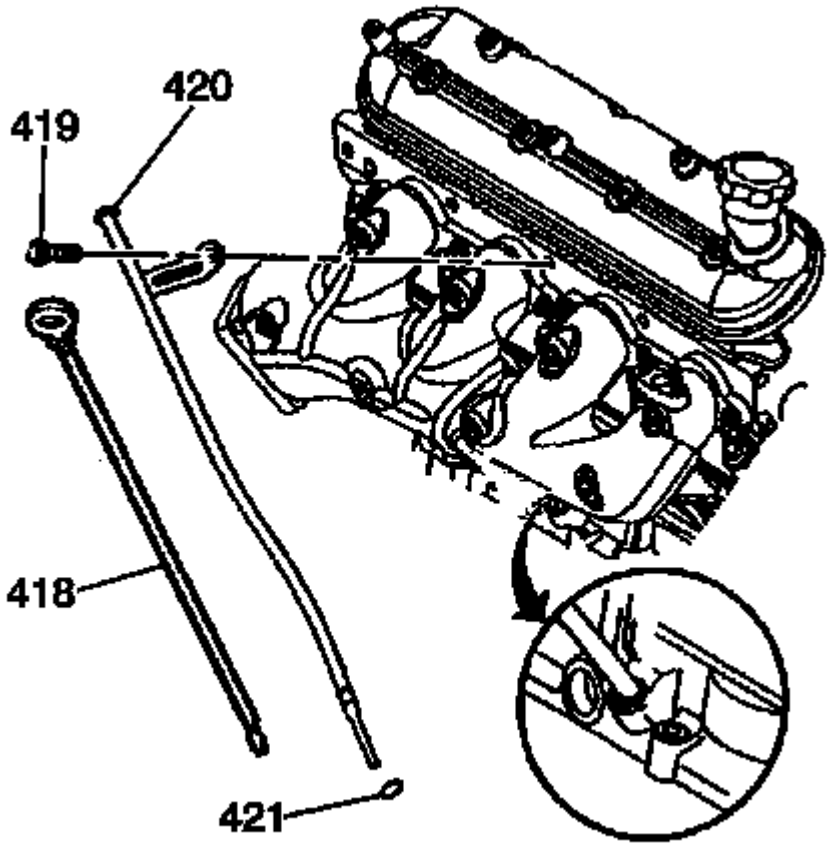

Fig. 307: Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator (418) from the tube.
2. Remove the oil level indicator tube bolt (419).
3. Remove the oil level indicator tube (420) from the engine block.

IMPORTANT: Inspect the O-ring for cuts or damage. The O-ring seal may be used again if it is not cut or damaged.

4. Remove the O-ring (421) from the tube as required.

Exhaust Manifold Removal - Left

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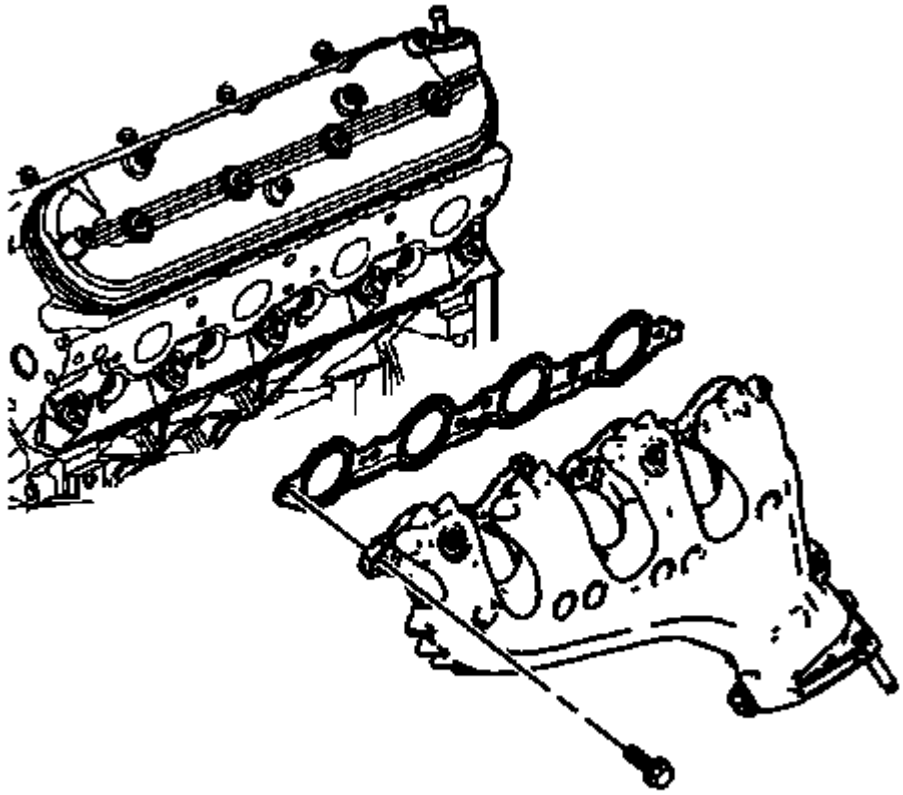

Fig. 308: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

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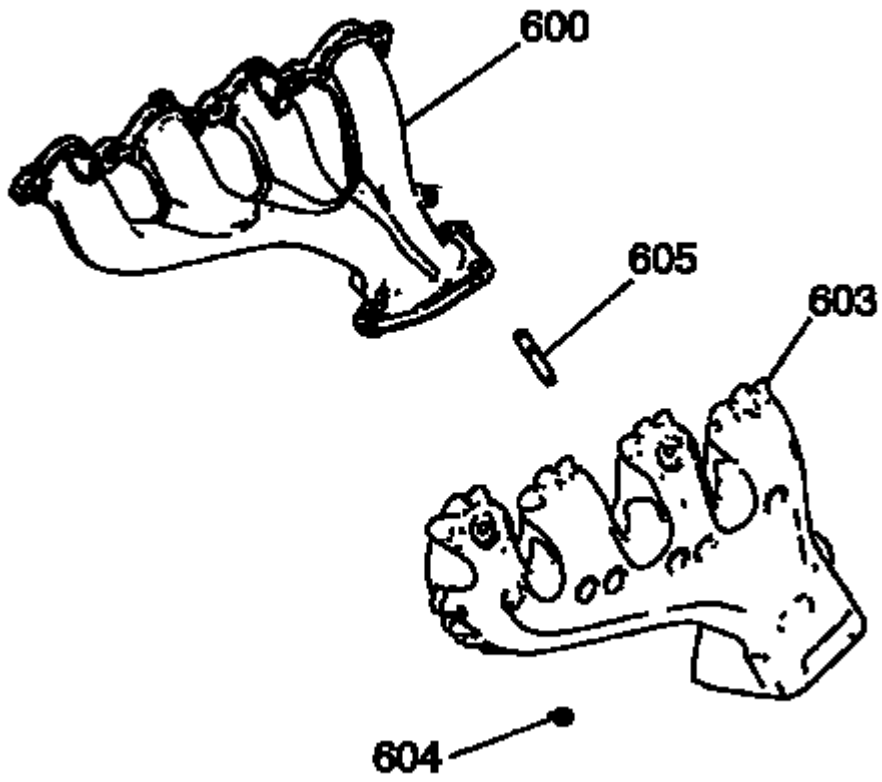

Fig. 309: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600) as required.
5. Remove the studs (605) as required.

Exhaust Manifold Removal - Right

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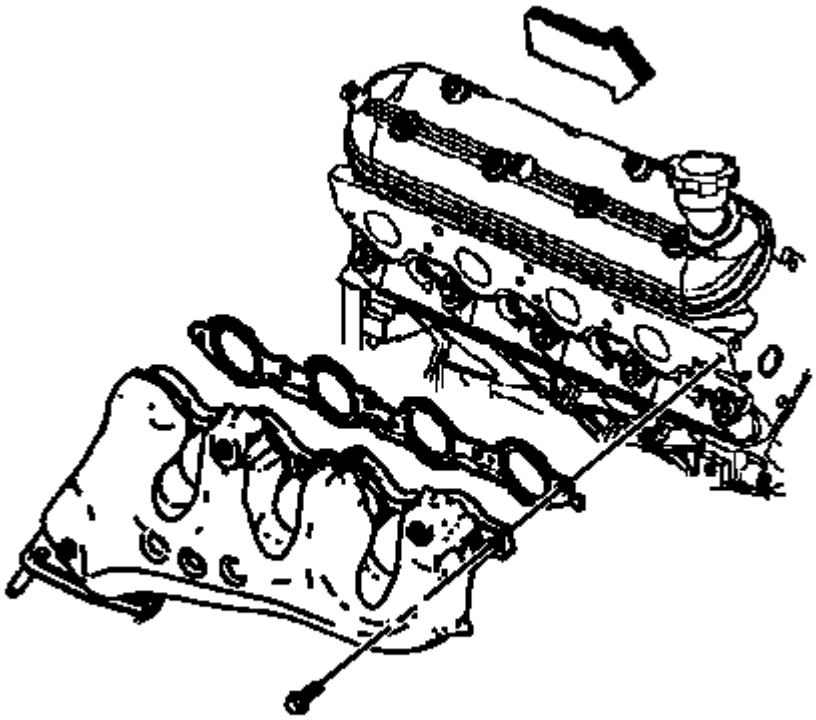

Fig. 310: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

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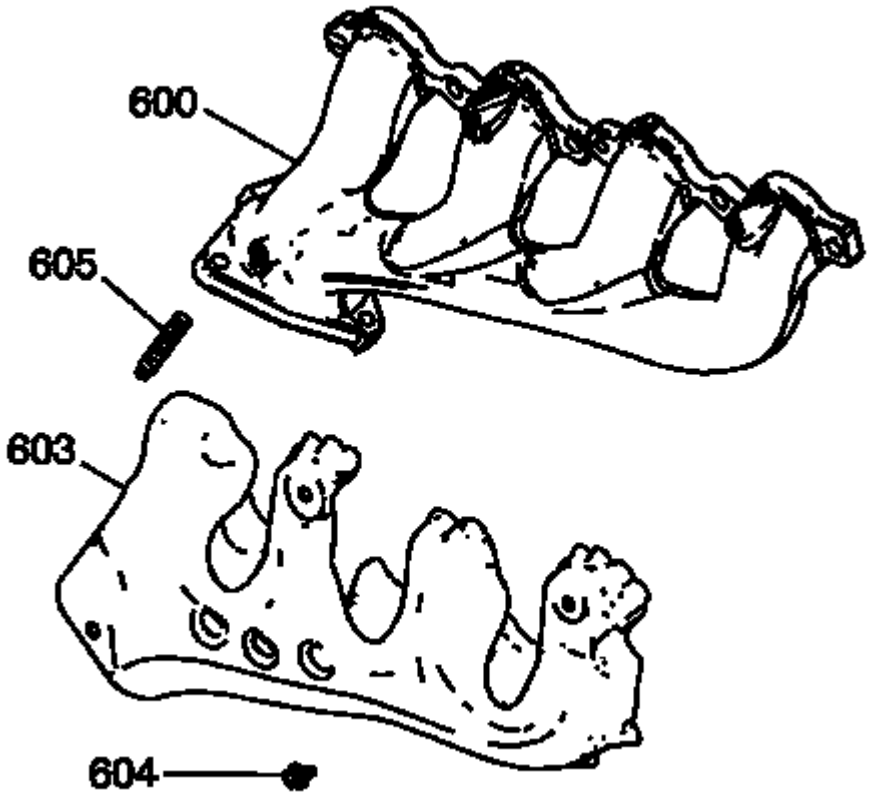

Fig. 311: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600) as required.
5. Remove the studs (605) as required.

Water Pump Removal

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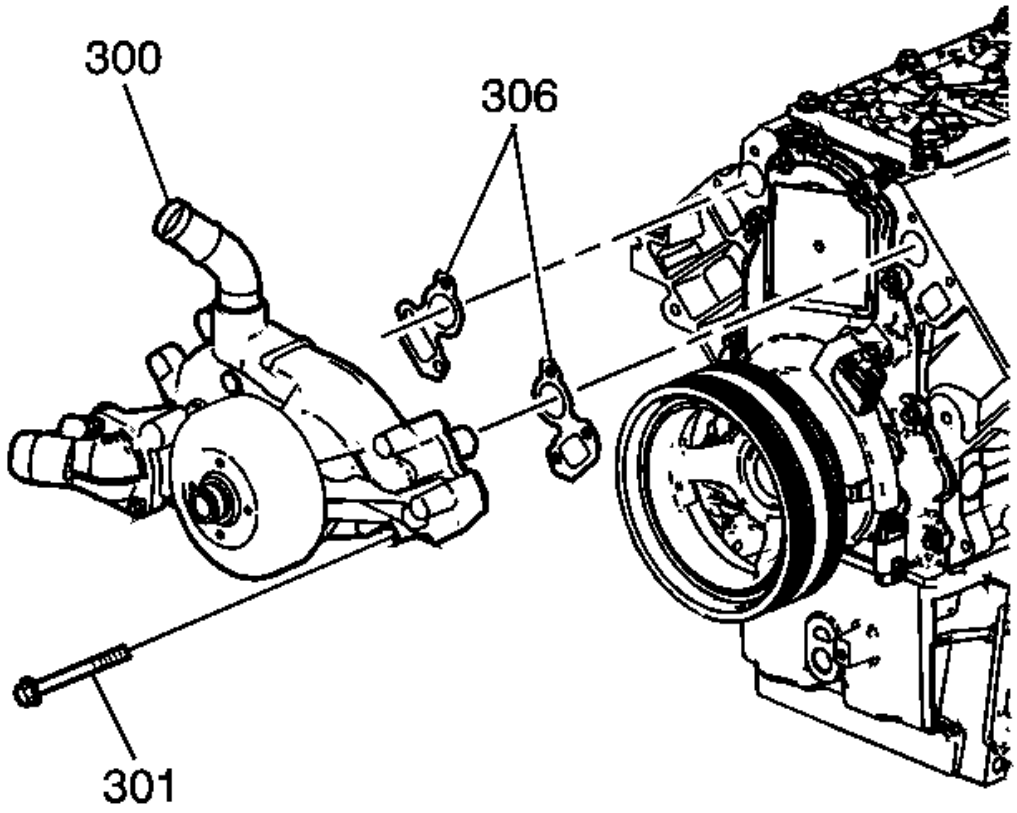

Fig. 312: Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump bolts (301).
2. Remove the water pump (300) and gaskets (306).
3. Discard the water pump gaskets.

Throttle Body Removal

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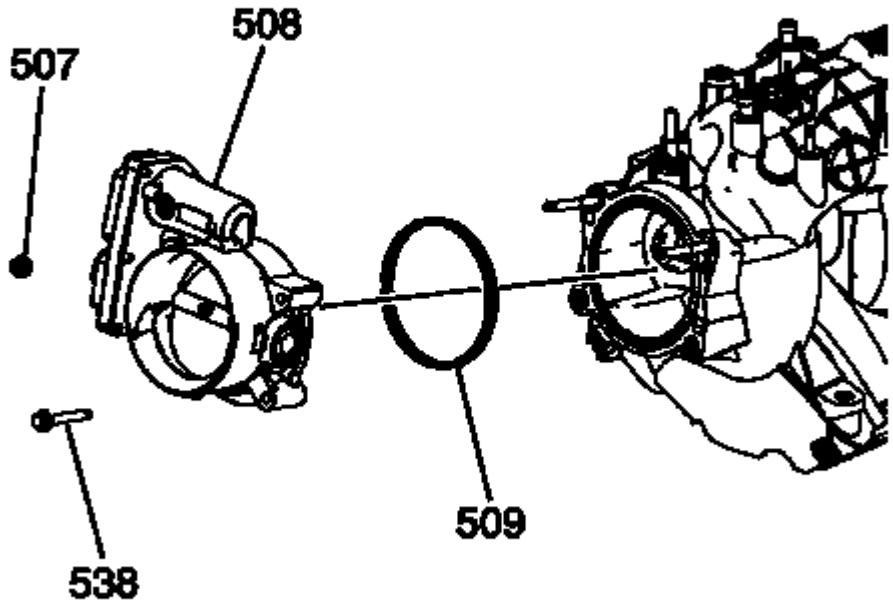

Fig. 313: Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.

1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the throttle body nuts (507) and bolts (538).
3. Remove the throttle body (508).
4. Remove the throttle body gasket (509).
5. Discard the gasket.

Fuel Rail and Injectors Removal

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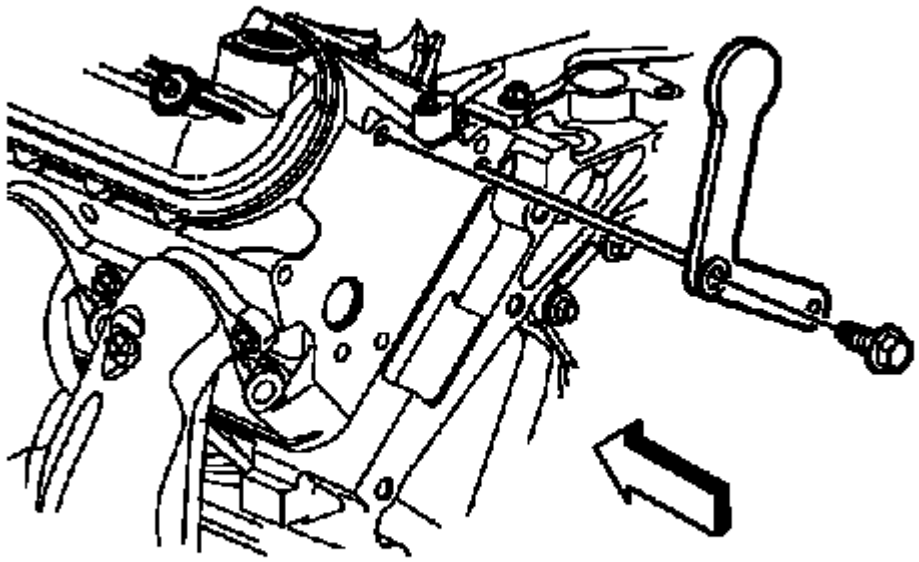

Fig. 314: View Of Fuel Rail Stop Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

IMPORTANT: The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the intake manifold as a complete assembly.

1. Remove the fuel rail stop bracket and bolt as required.

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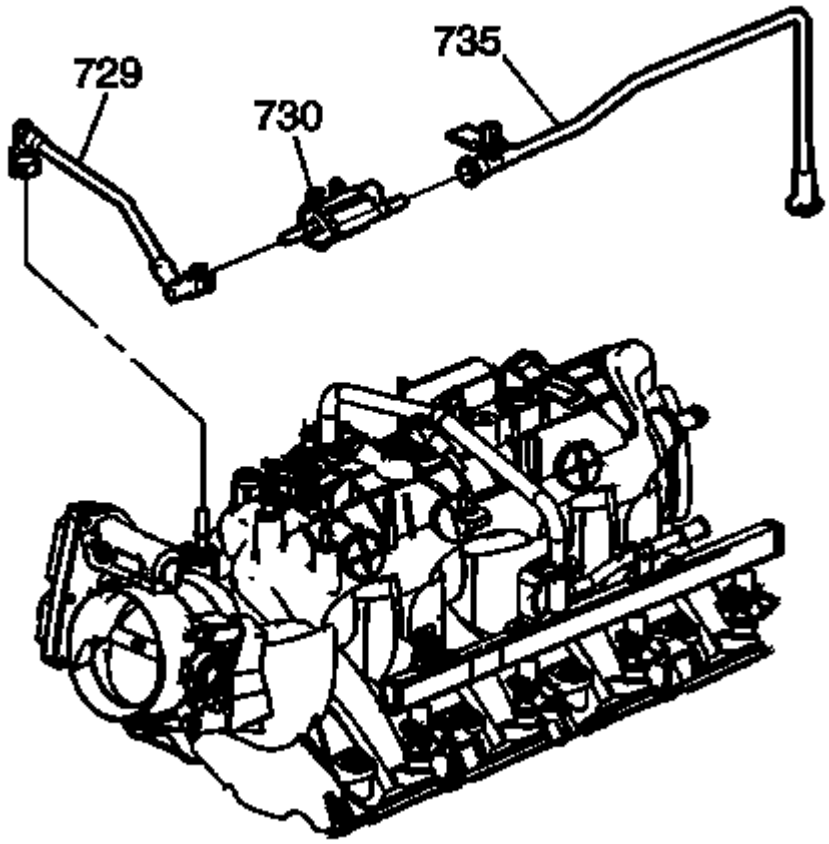

Fig. 315: EVAP Purge Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

2. Remove the evaporative emission (EVAP) purge valve (730) and tubes (729, 735).

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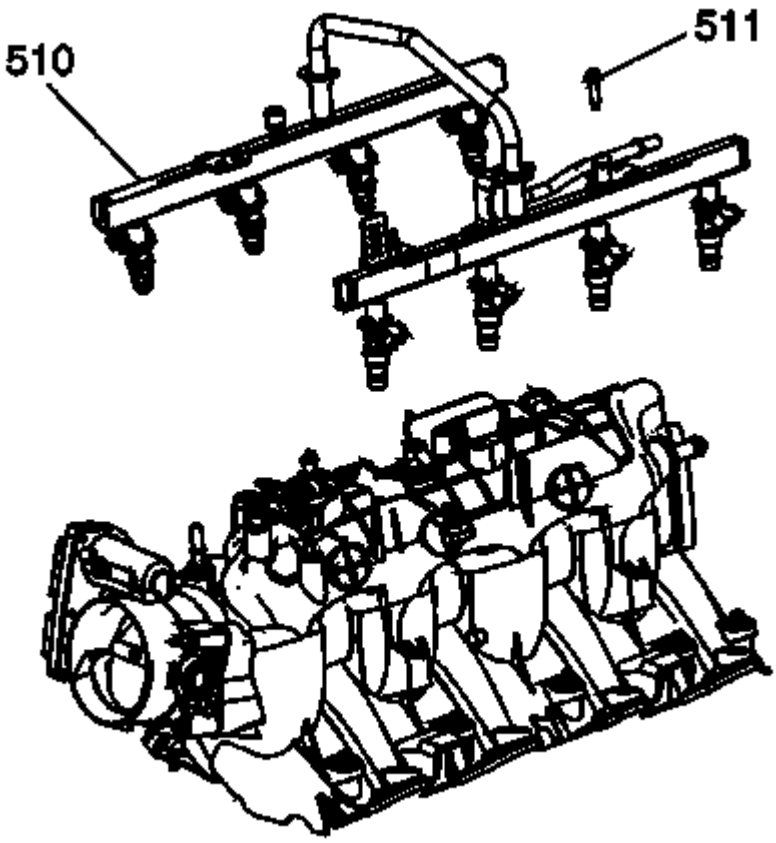

Fig. 316: Fuel Rail
Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel rail bolts (511).

IMPORTANT:
- **Do not separate the fuel injectors from the fuel rail unless component service is required.**
- **Use cleanliness and care when handling the fuel system components.**
- **Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends as necessary.**

4. Remove the fuel rail (510) with injectors. Lift evenly on both sides of the fuel rail until all the injectors have left their bores.

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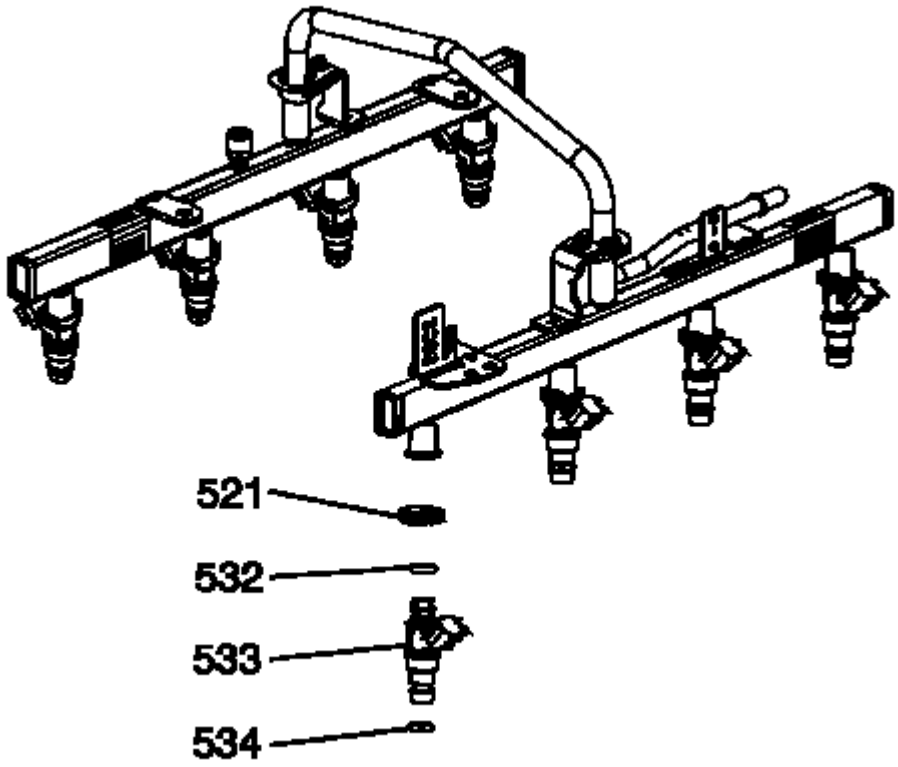

Fig. 317: Fuel Injector Retaining Clips
Courtesy of GENERAL MOTORS CORP.

5. Remove the fuel injector retaining clips (521) and fuel injectors (533) as required.
6. Remove the O-rings (532, 534) from the injectors as required.

Intake Manifold Removal

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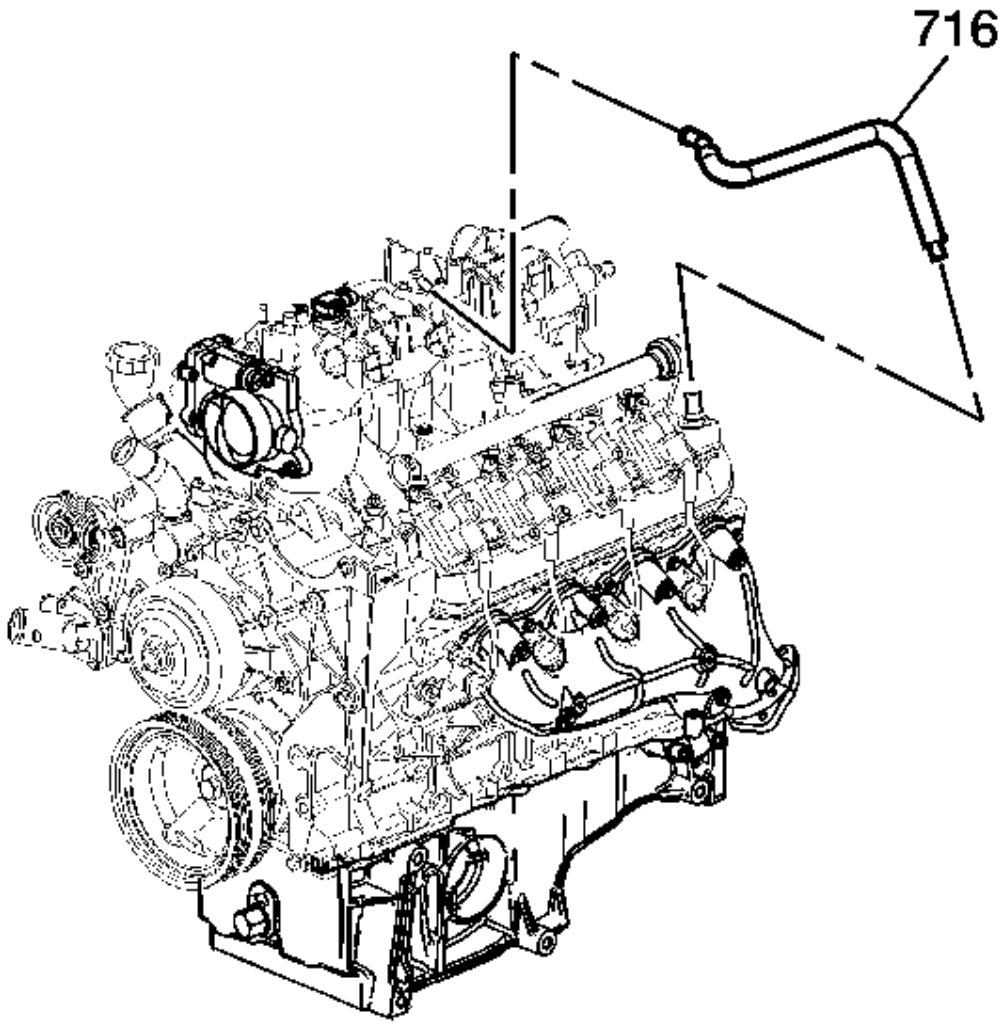

Fig. 318: PCV Hose
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, remove the manifold as a complete assembly.**
- **DO NOT use the intake manifold-to-cylinder head gaskets again.**

1. Remove the positive crankcase ventilation (PCV) hose - dirty air (716).

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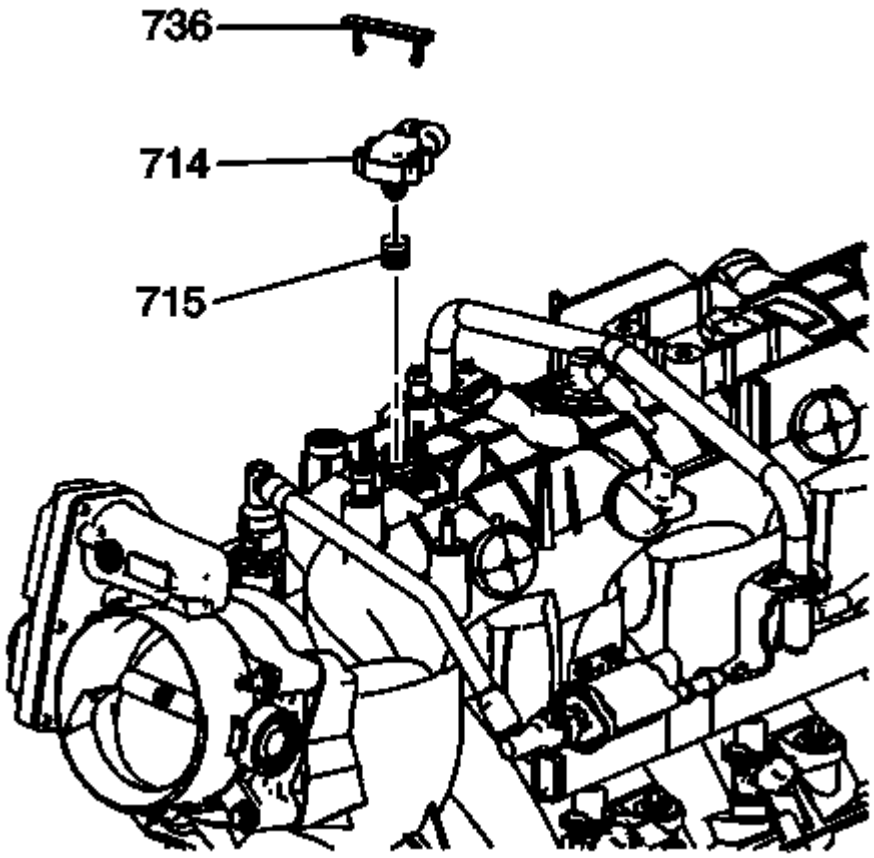

Fig. 319: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714) and retainer (736) as required.
3. Remove the O-ring (715) from the sensor as required.

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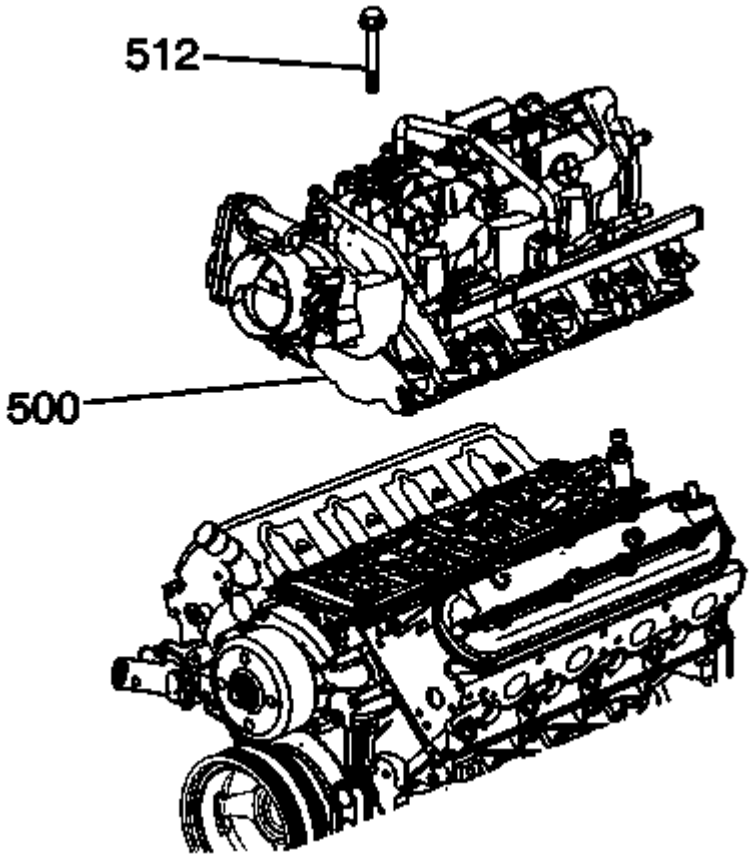

Fig. 320: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold bolts (512).
5. Remove the intake manifold (500) with gaskets.

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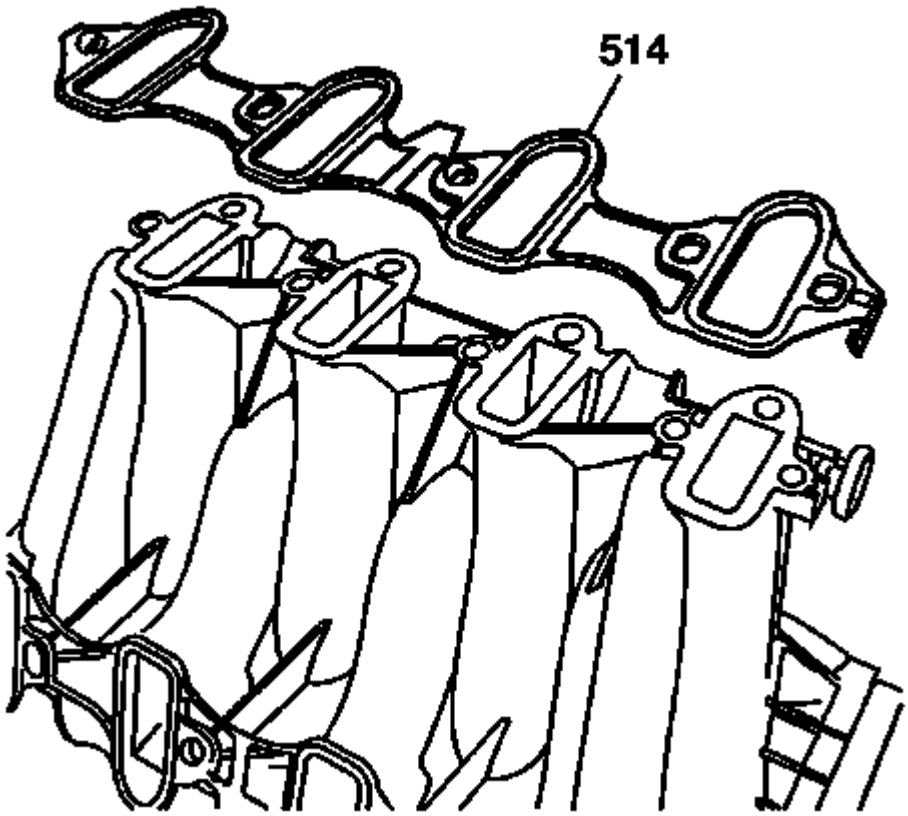

Fig. 321: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake manifold gaskets (514).
7. Discard the intake manifold gaskets.

Coolant Air Bleed Pipe Removal

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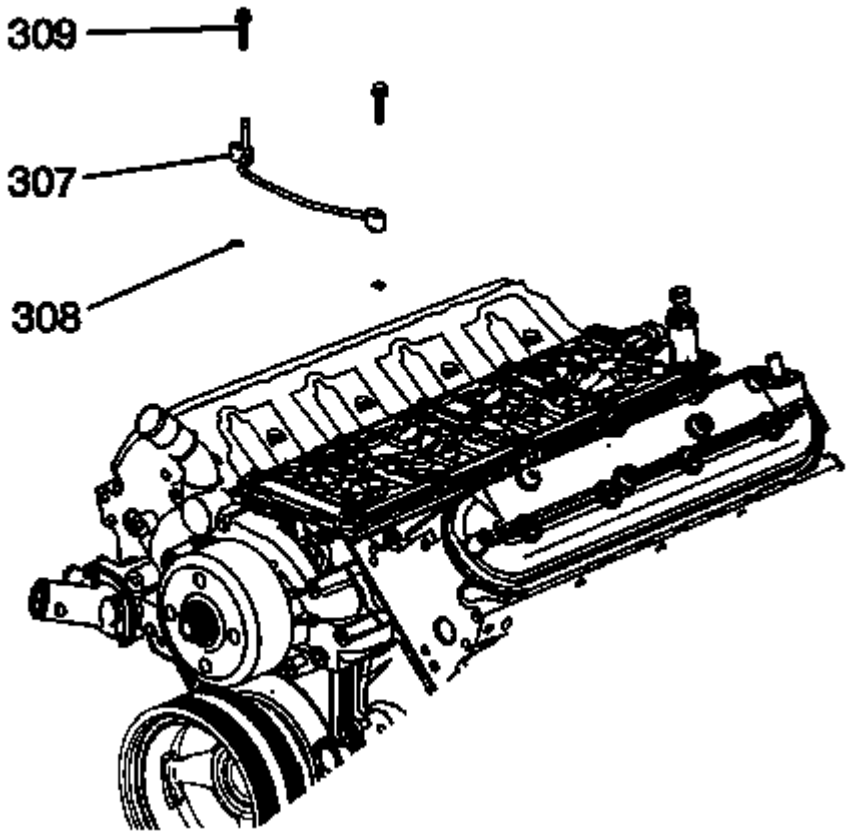

Fig. 322: Engine Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with seals (308).

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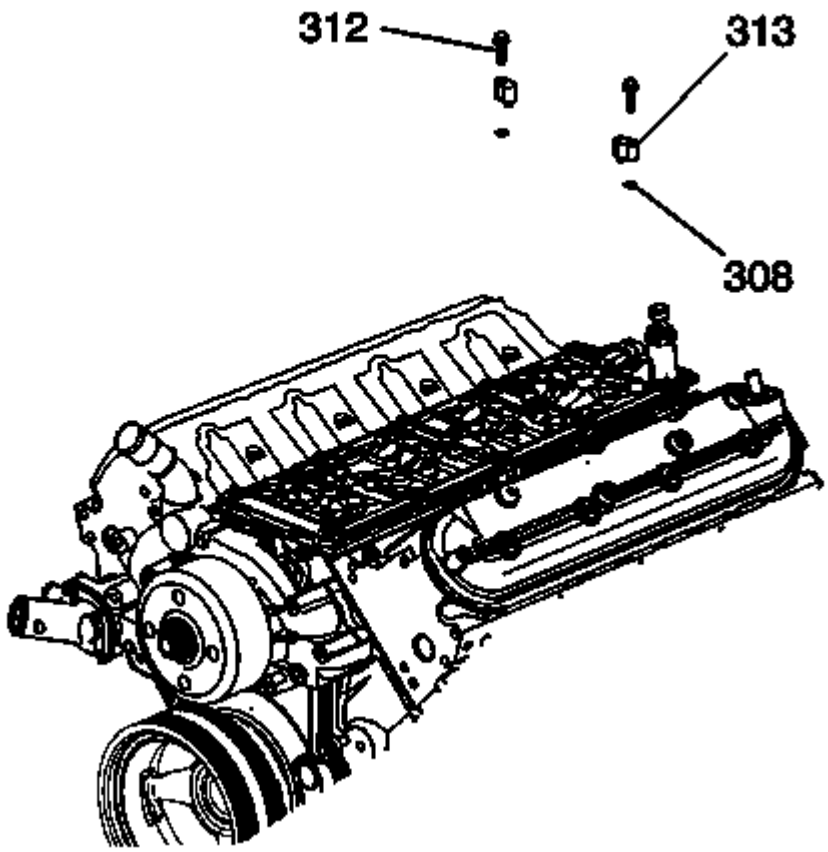

Fig. 323: Engine Coolant Air Bleed Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine coolant air bleed cover bolts (312).
4. Remove the covers (313) with seals (308).

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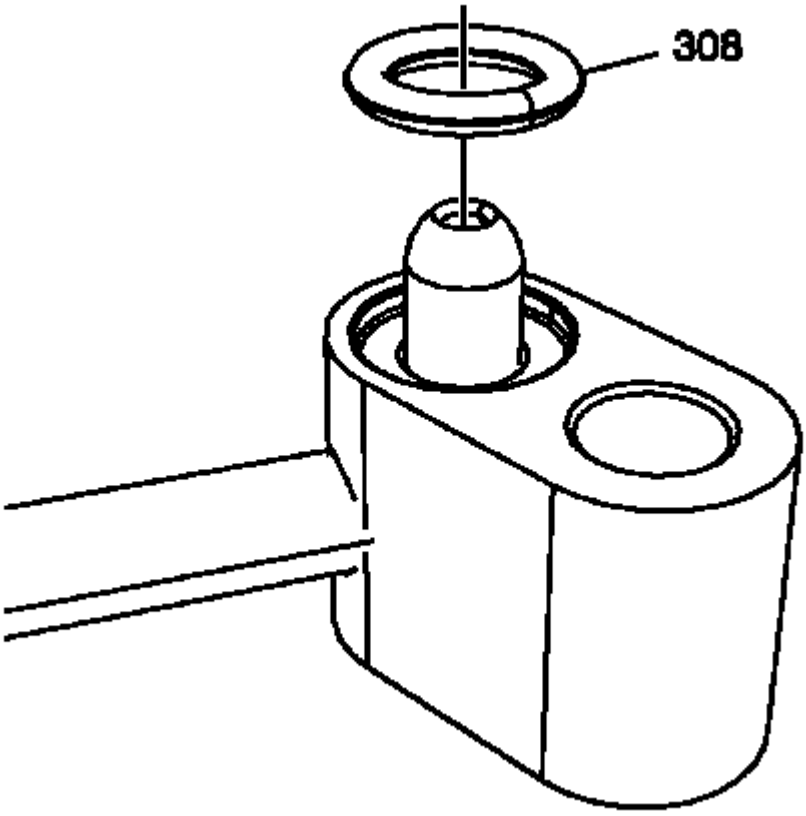

Fig. 324: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove the seals (308) from the pipe and covers.
6. Discard the seals.

Valve Lifter Oil Manifold Removal

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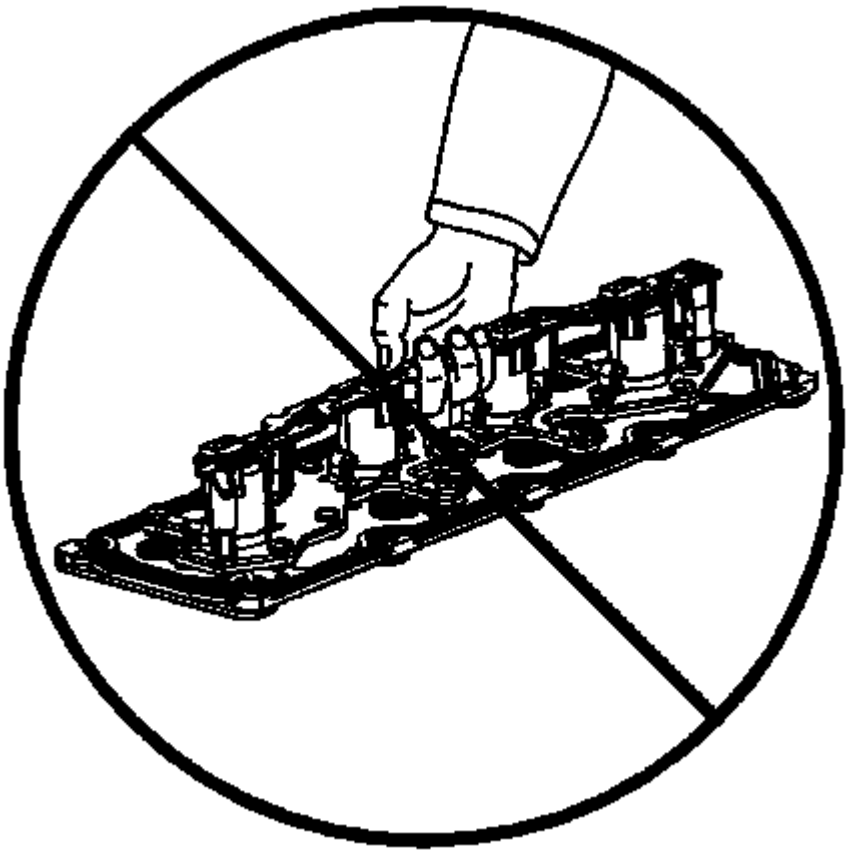

Fig. 325: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

1. Do not lift the manifold by the electrical lead frame.

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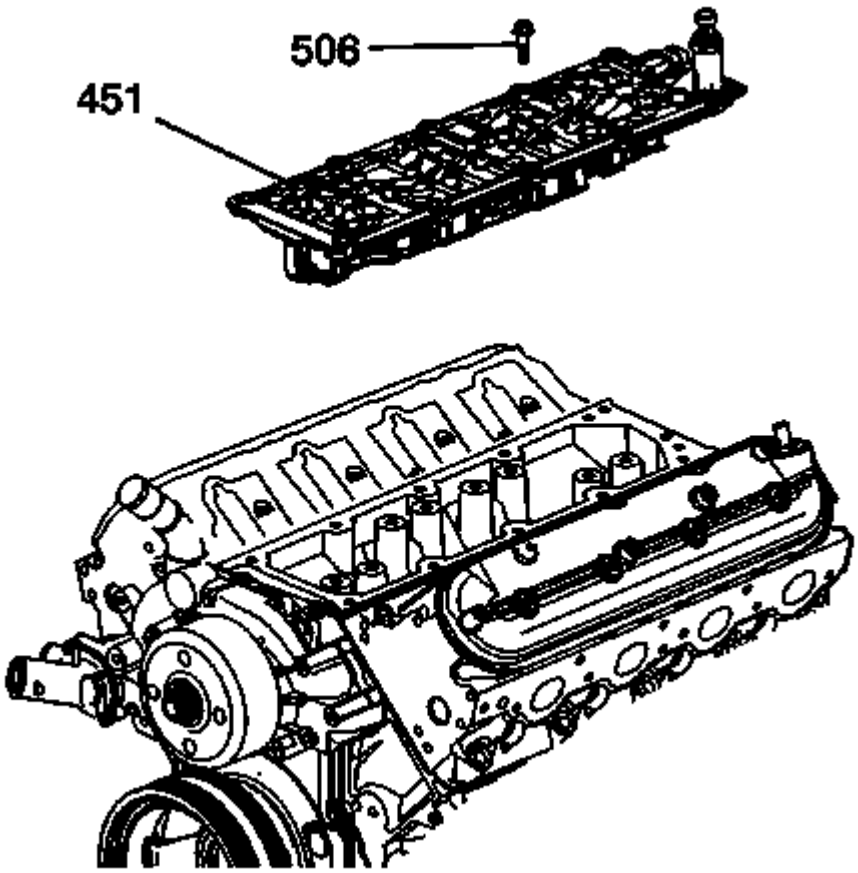

Fig. 326: Valve Lifter Oil Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve lifter oil manifold (VLOM) bolts (506).

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.

3. Remove the VLOM (451).

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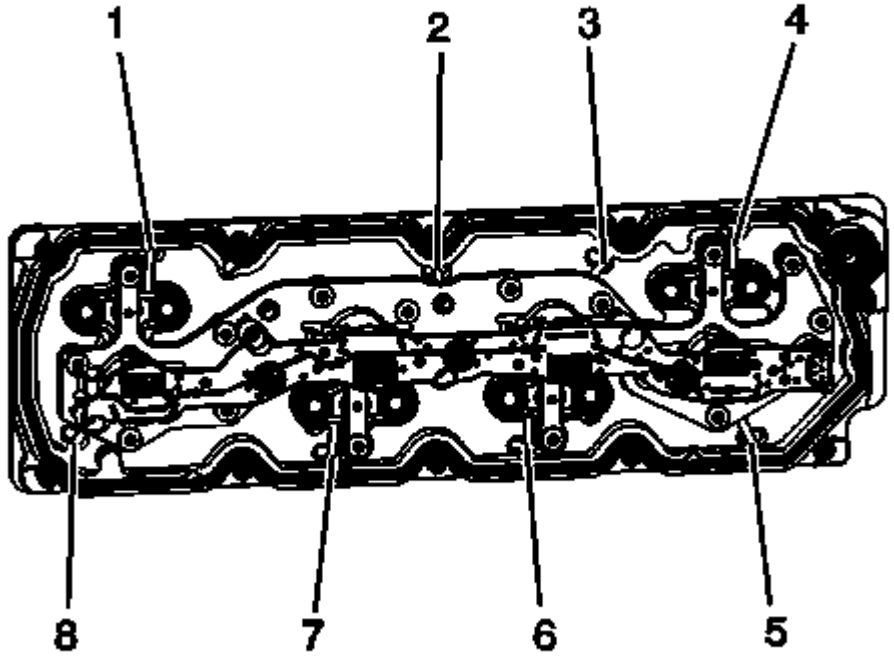

Fig. 327: Gasket Retaining Strap Locations
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove only the outer gasket from the manifold. Do not disassemble any of the internal components of the manifold in an attempt to remove the eight inner sealing gaskets. If the inner gaskets are cut or damaged, replace the manifold as an assembly. Only use a wire-cutter type tool in order to minimize the amount of debris. Do not use a rotary-type cutting tool on the retaining straps.

4. Identify the eight gasket retaining strap locations (1-8).

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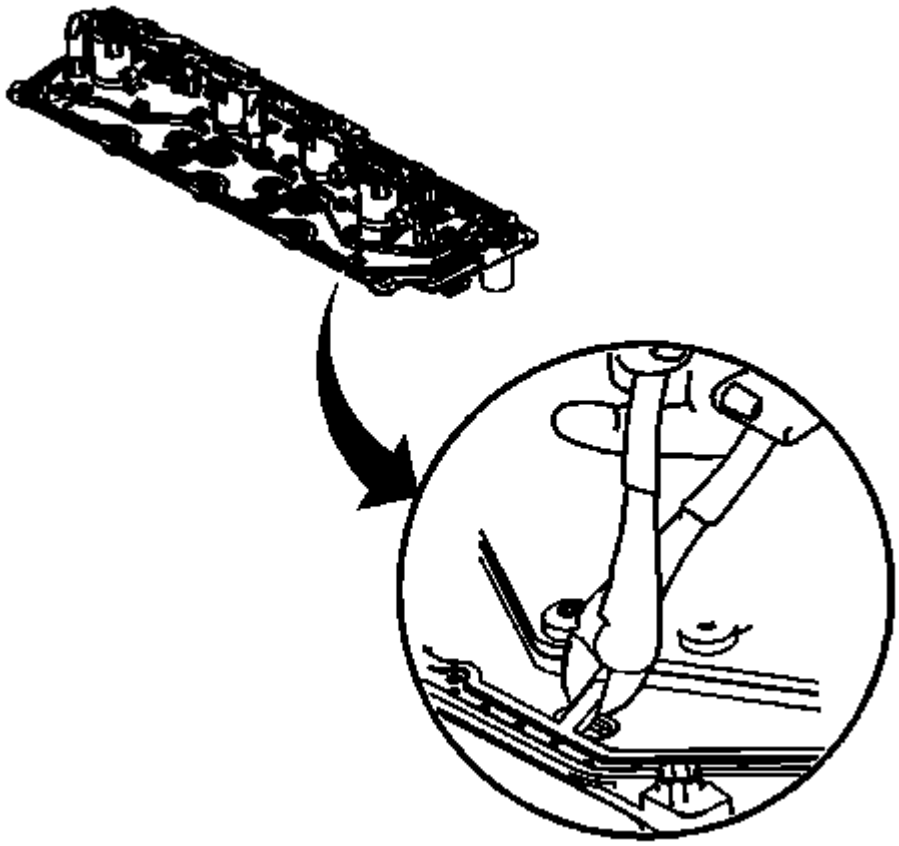

Fig. 328: Retaining Strap
Courtesy of GENERAL MOTORS CORP.

5. Using a wire-cutter type tool, snip the eight retaining straps.

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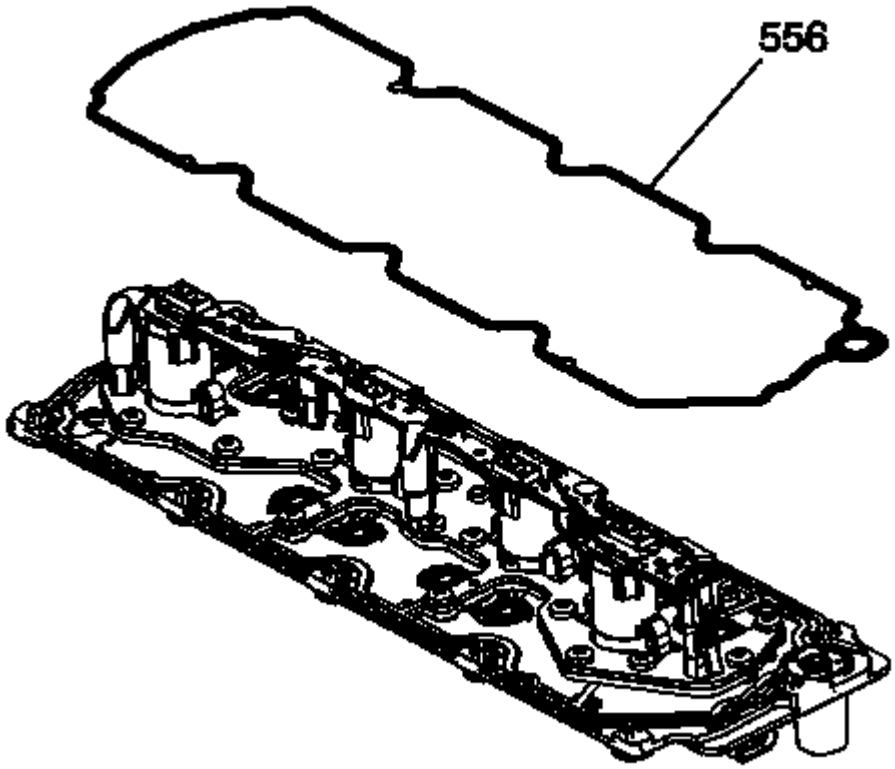

Fig. 329: Outer Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the outer gasket (556) from the manifold.

Valve Lifter Oil Filter Removal

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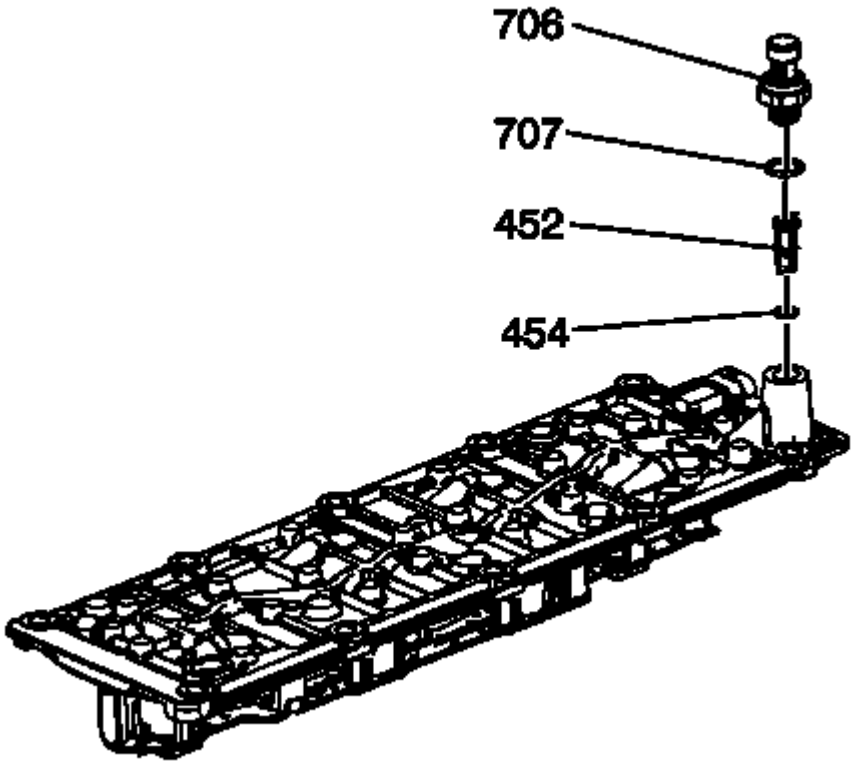

Fig. 330: Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.

1. Remove the oil pressure sensor (706).
2. Remove the oil filter (452).
3. Inspect the O-ring (454) for cuts or damage. If the filter is plugged or the O-ring is cut or damaged, replace the filter and O-ring as an assembly.

Valve Rocker Arm Cover Removal - Left

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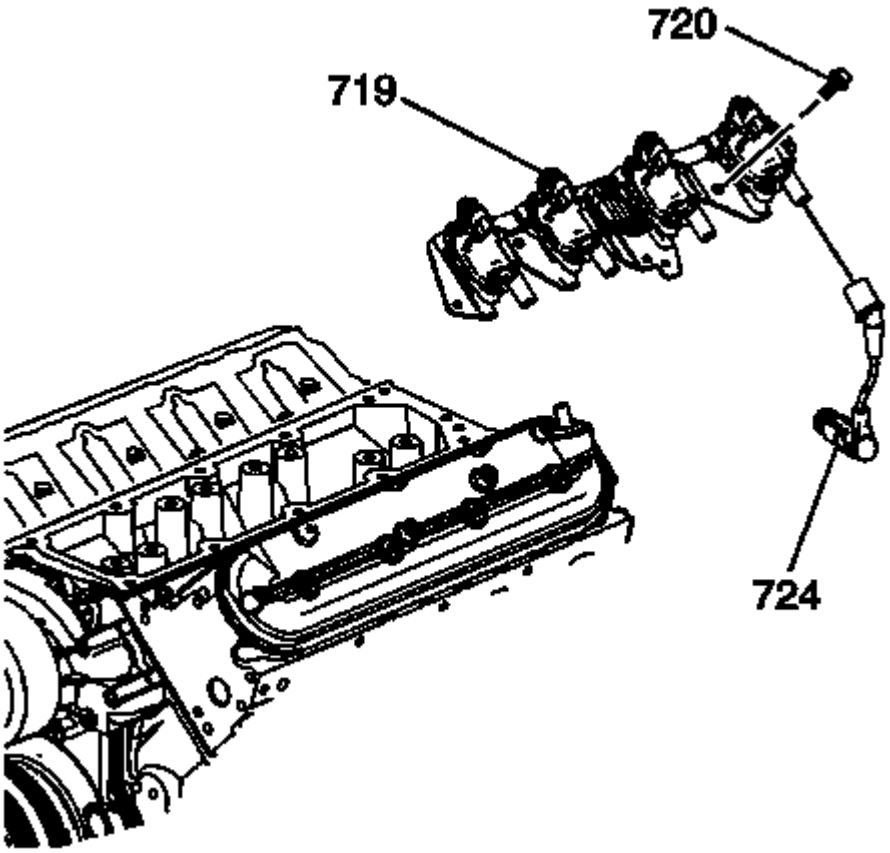

Fig. 331: Ignition Coil & Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket bolts (720).
3. Remove the ignition coil and bracket assembly (719).

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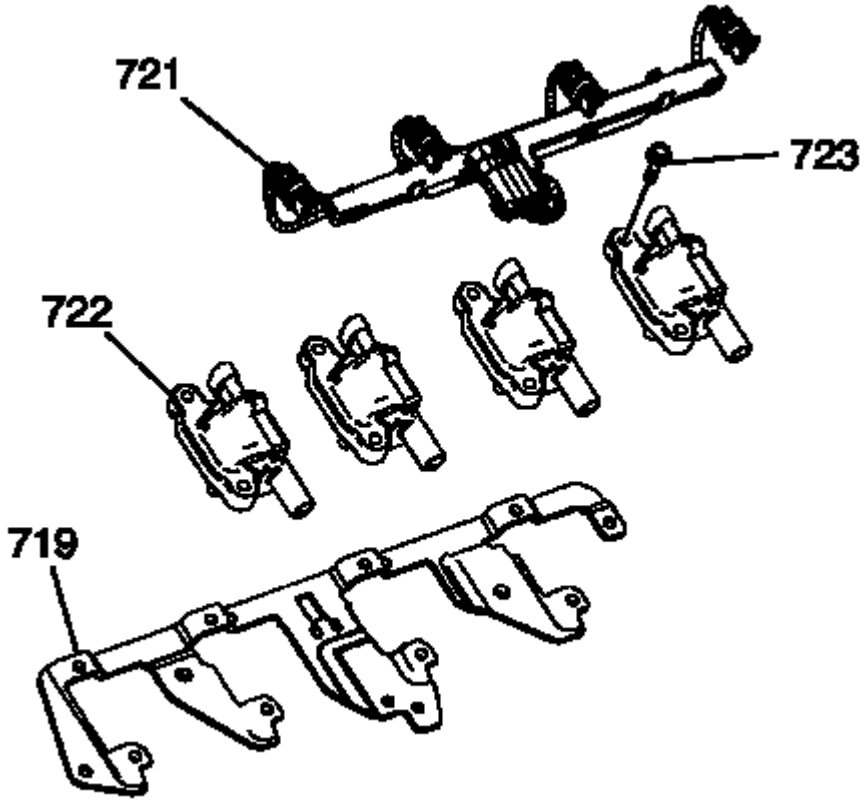

Fig. 332: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719) as required.

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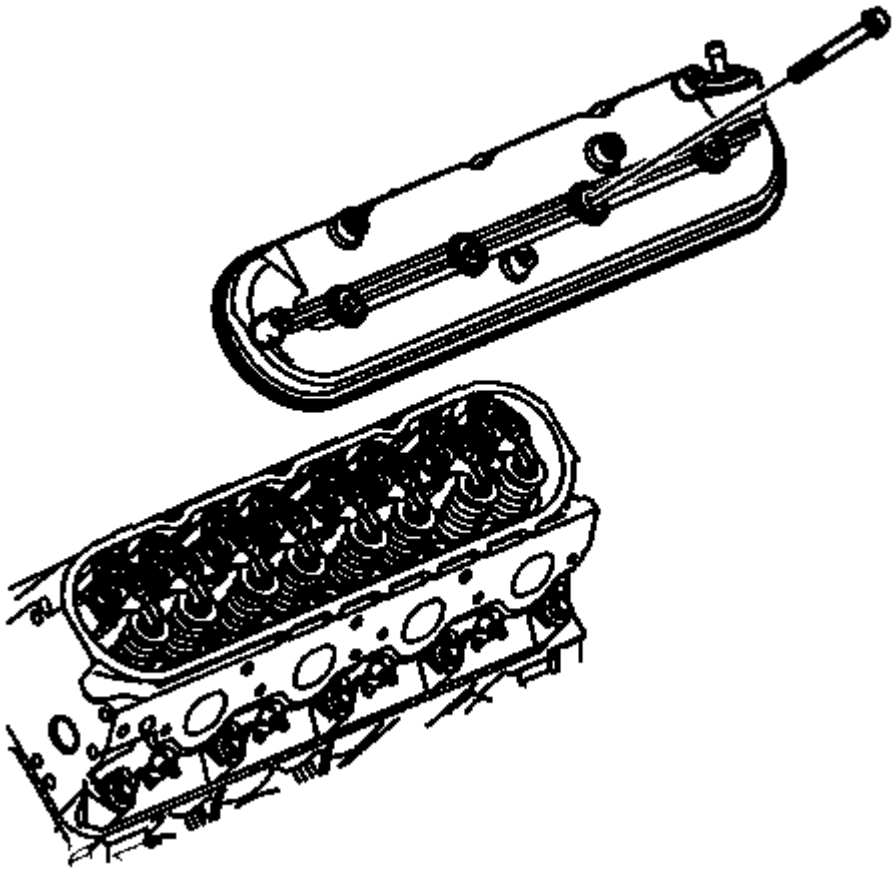

Fig. 333: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

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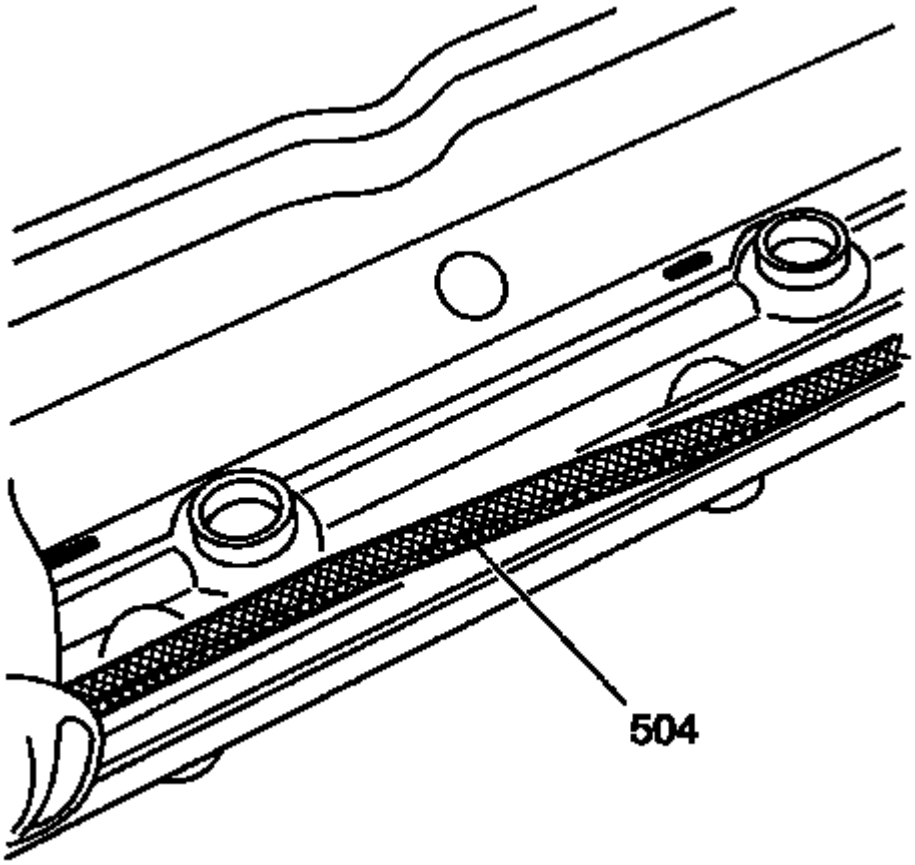

Fig. 334: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

Valve Rocker Arm Cover Removal - Right

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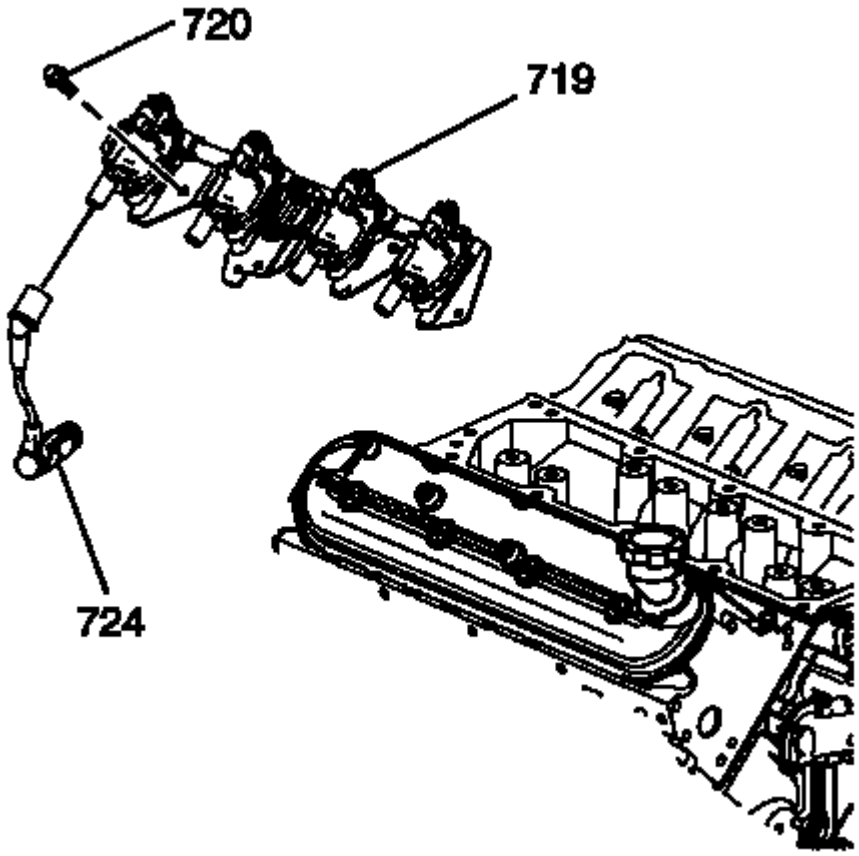

Fig. 335: Ignition Coil & Bracket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the oil fill tube from the cover unless service is required. If the oil fill tube has been removed from the cover, install a NEW tube during assembly.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket bolts (720).
3. Remove the ignition coil and bracket assembly (719).

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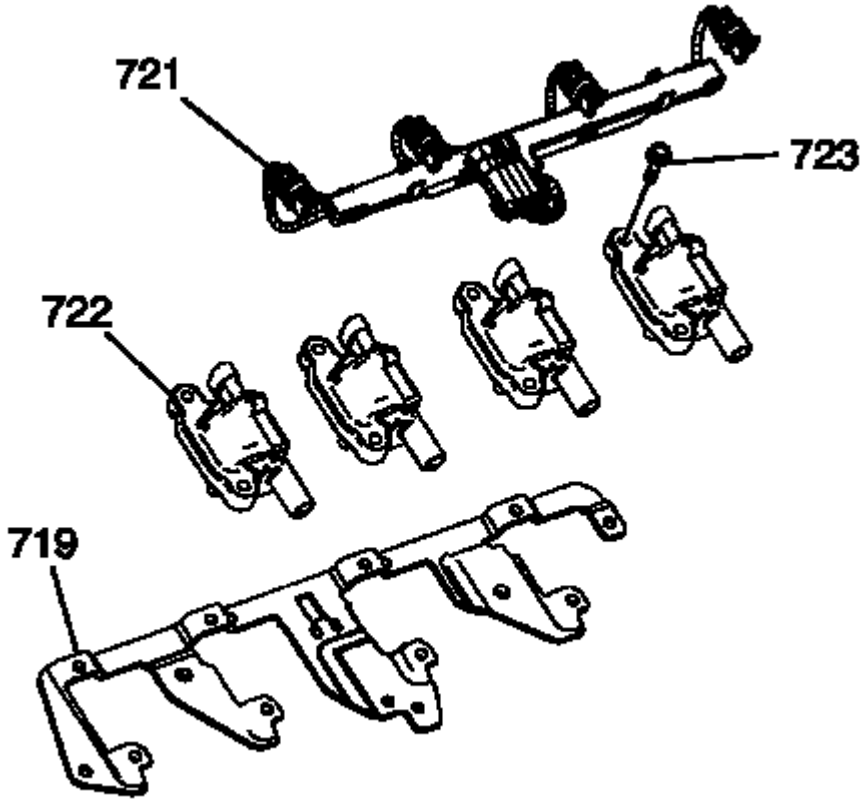

Fig. 336: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719) as required.

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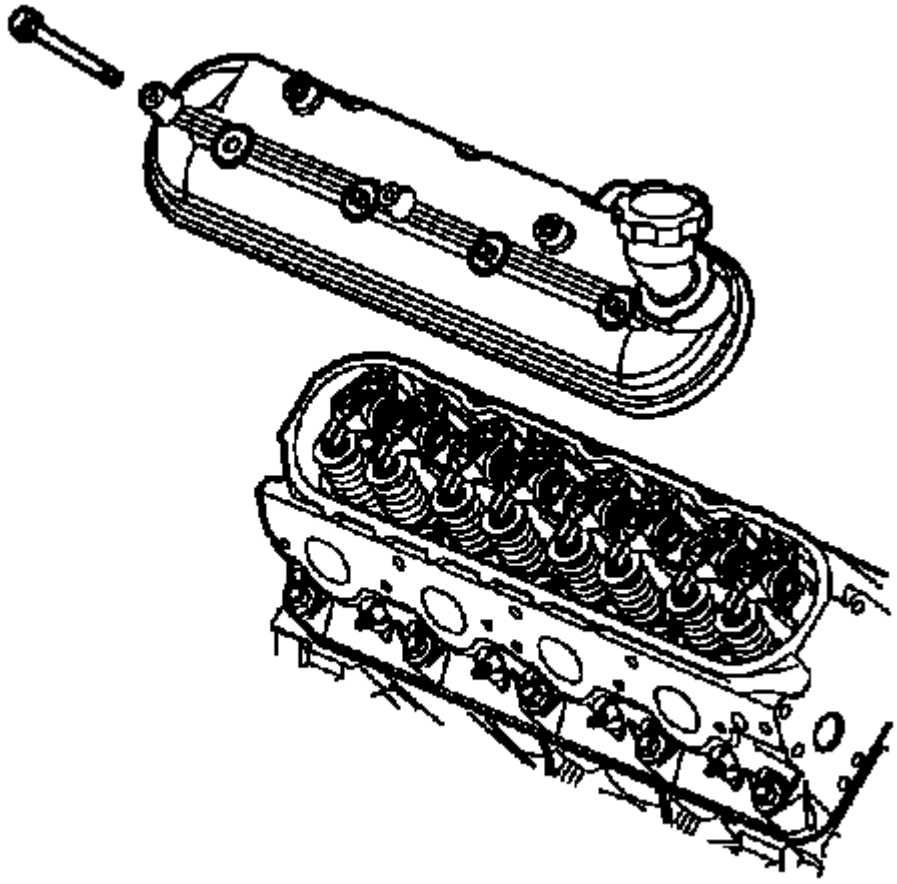

Fig. 337: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

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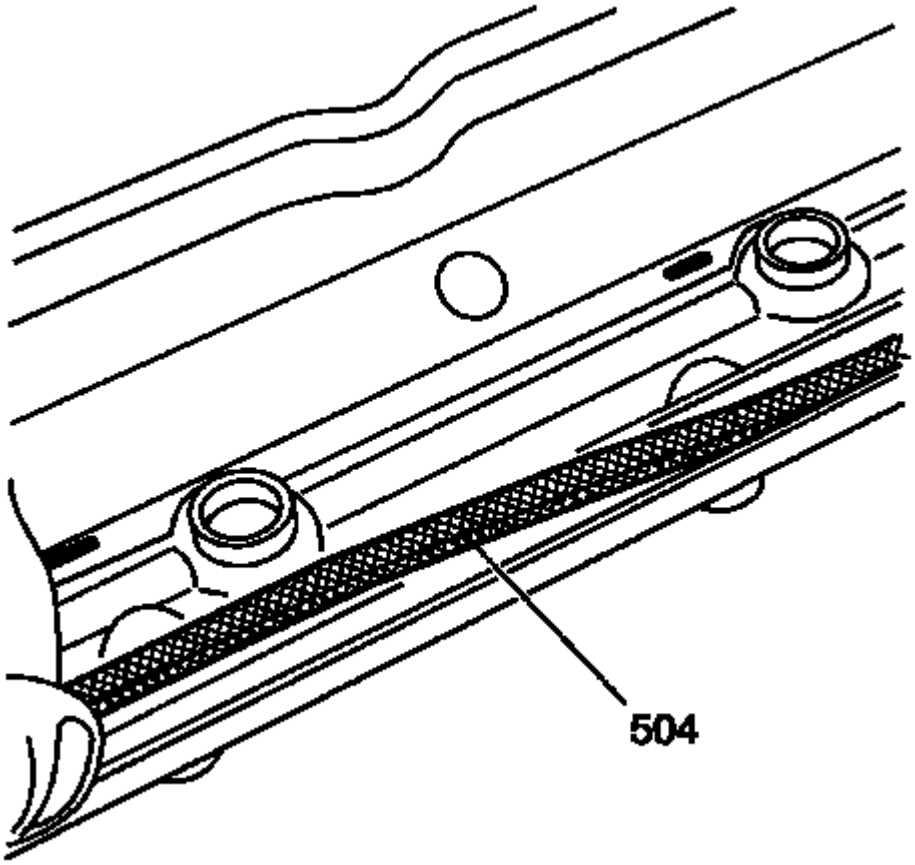

Fig. 338: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

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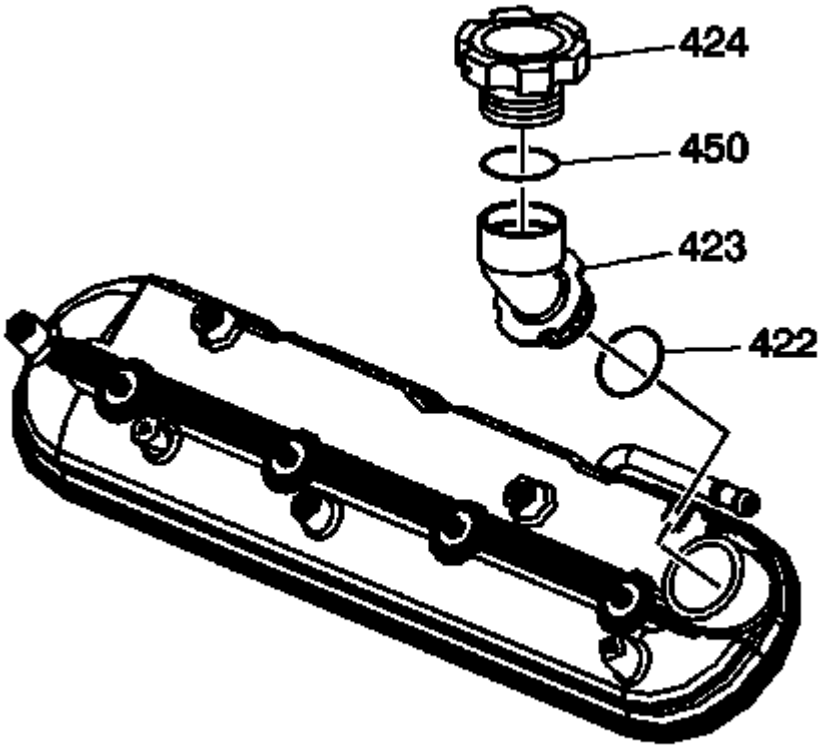

Fig. 339: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil fill cap (424) from the oil fill tube (423).
9. Remove the oil fill tube as required.
10. Discard the oil fill tube.

Valve Rocker Arm and Push Rod Removal

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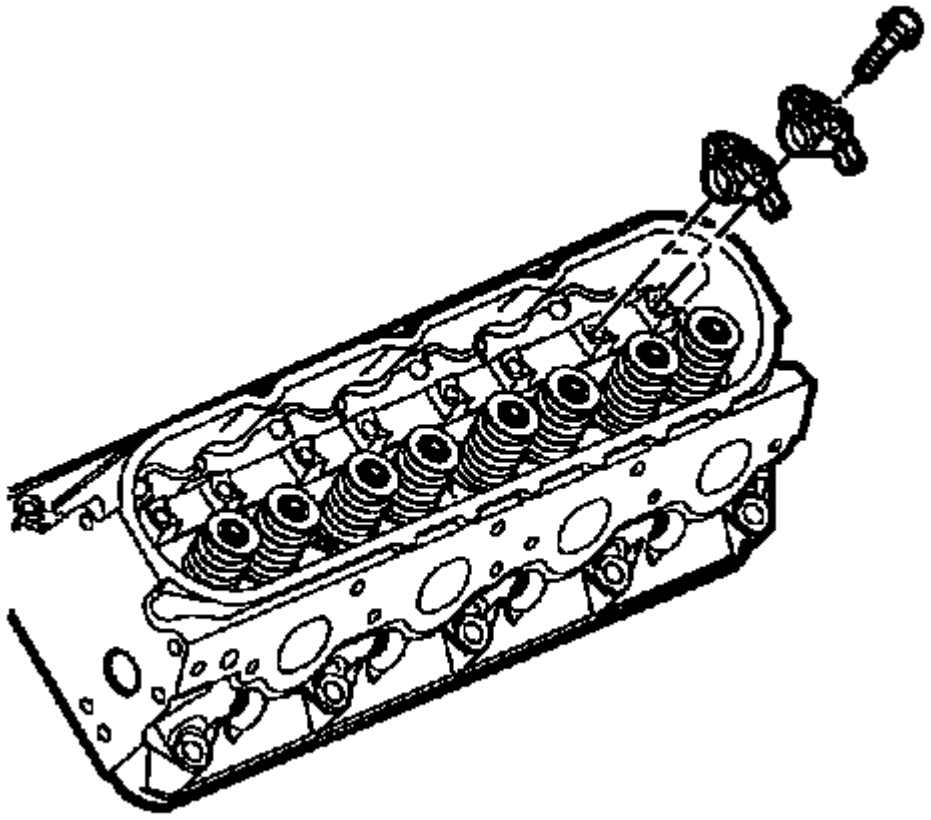

Fig. 340: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the valve rocker arms, valve pushrods, and pivot support, in a rack so they can be installed in the same location from which they were removed.

1. Remove the valve rocker arm bolts.
2. Remove the valve rocker arms.

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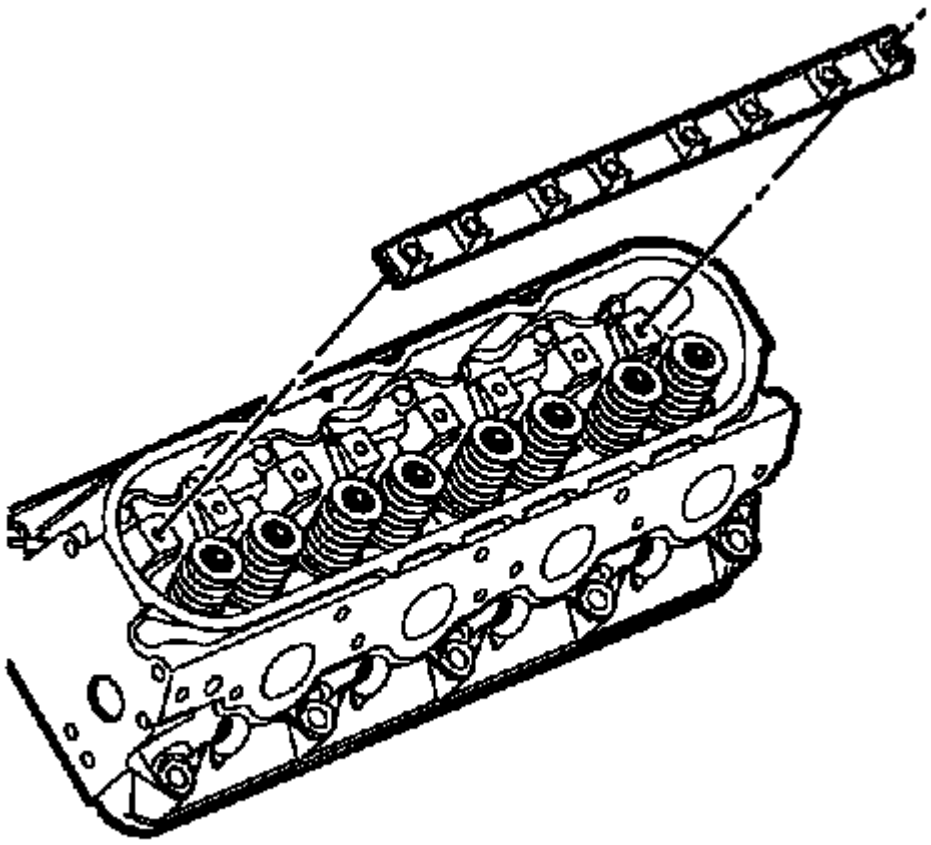

Fig. 341: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

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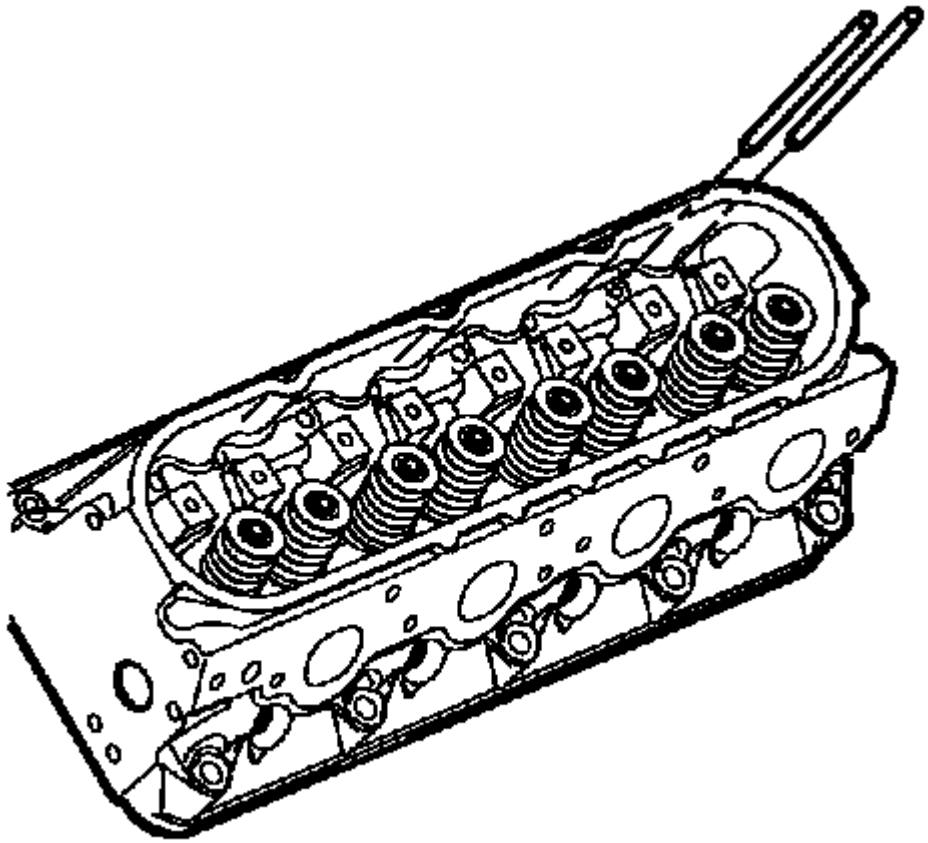

Fig. 342: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

Cylinder Head Removal - Left

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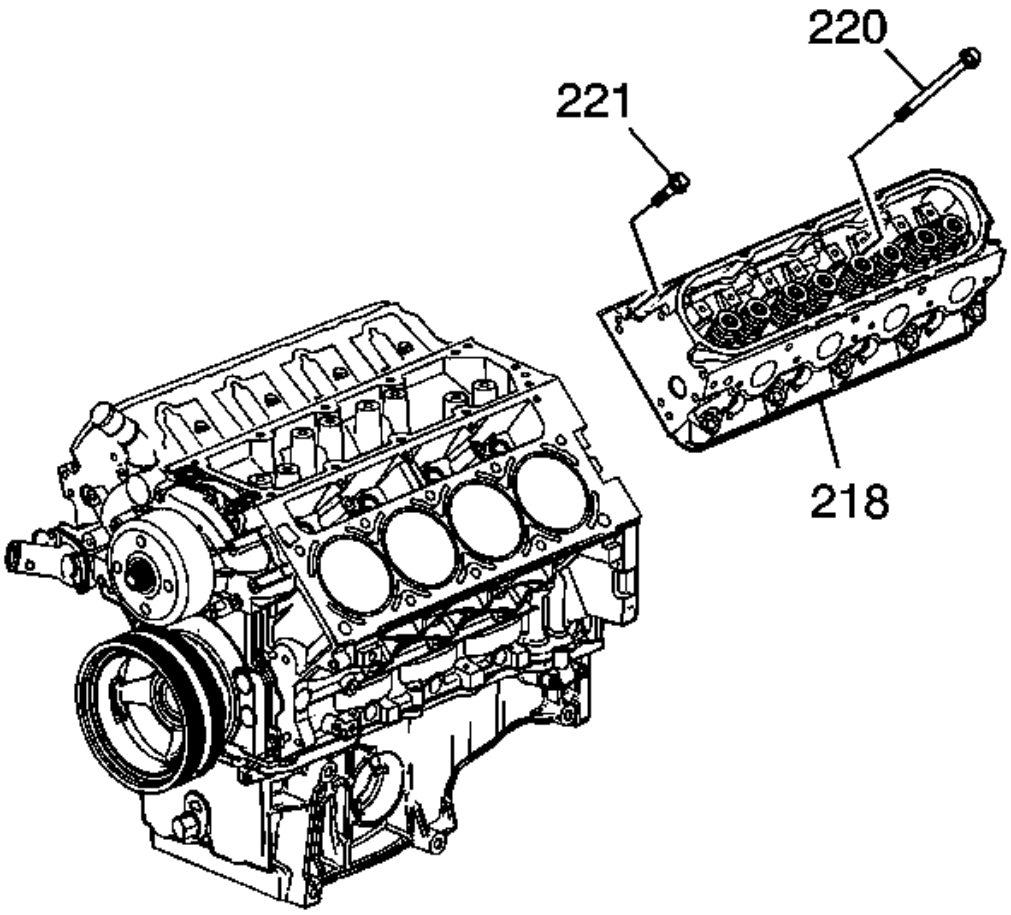

Fig. 343: Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

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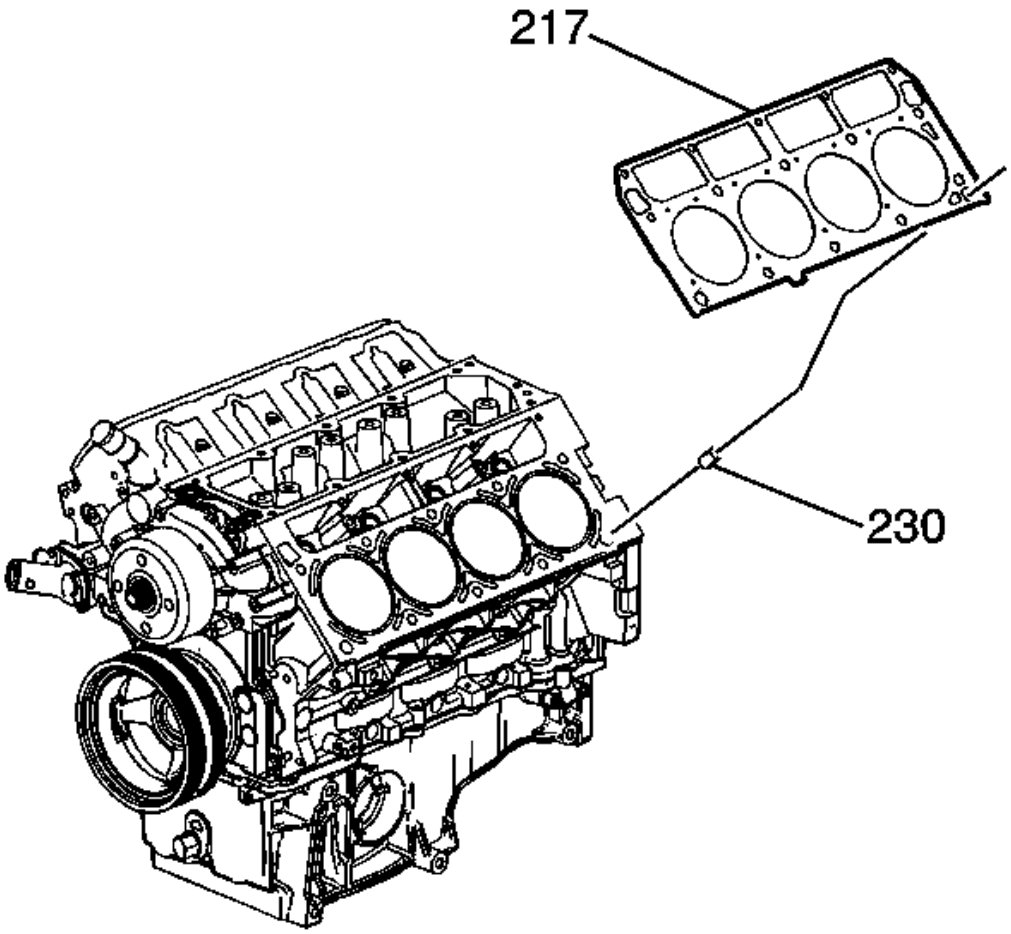

Fig. 344: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

Cylinder Head Removal - Right

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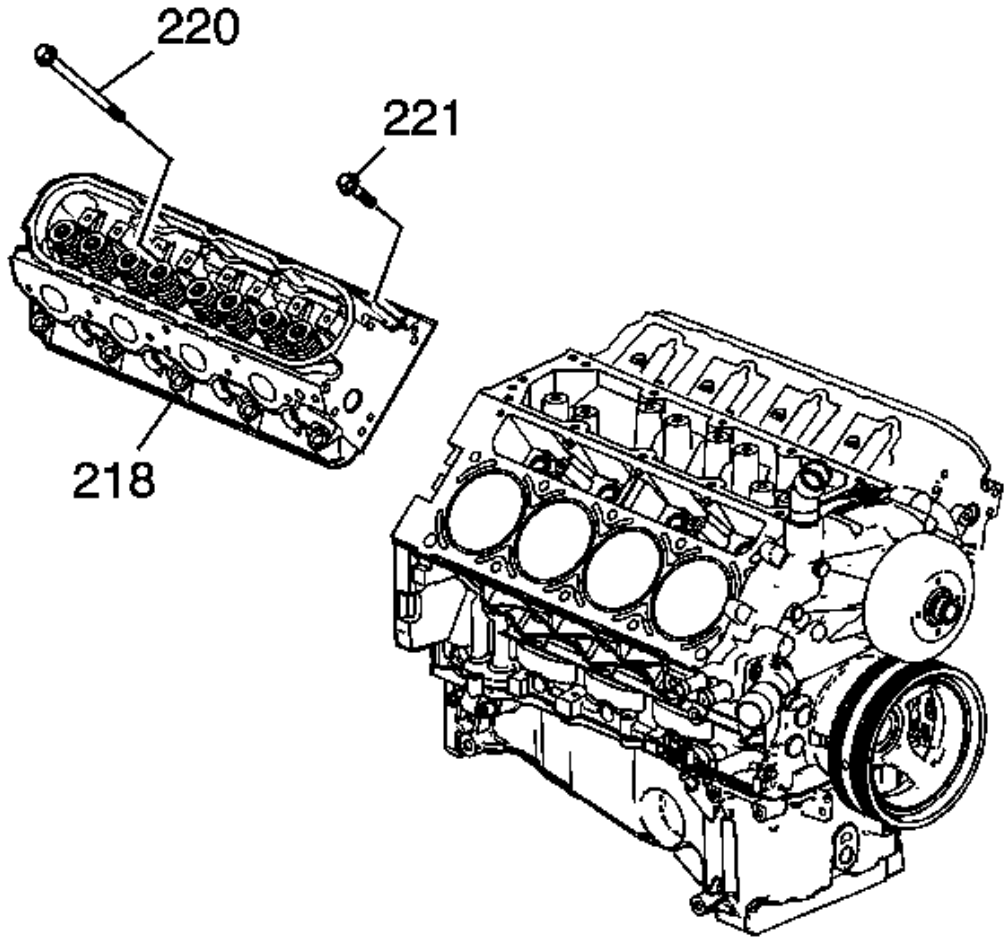

Fig. 345: Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are of a torque-to-yield design and are NOT to be used again. Install NEW cylinder head bolts during assembly.

1. Remove the cylinder head bolts (220, 221).

NOTE: After removal, place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

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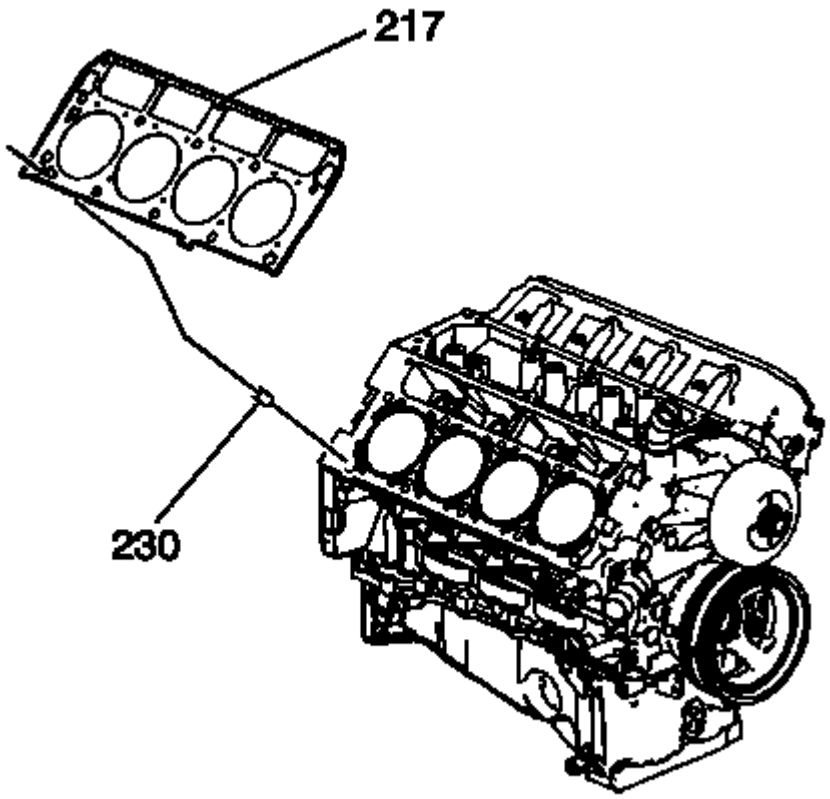

Fig. 346: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

Valve Lifter Removal

Tools Required

J 3049-A Valve Lifter Remover. See **Special Tools**.

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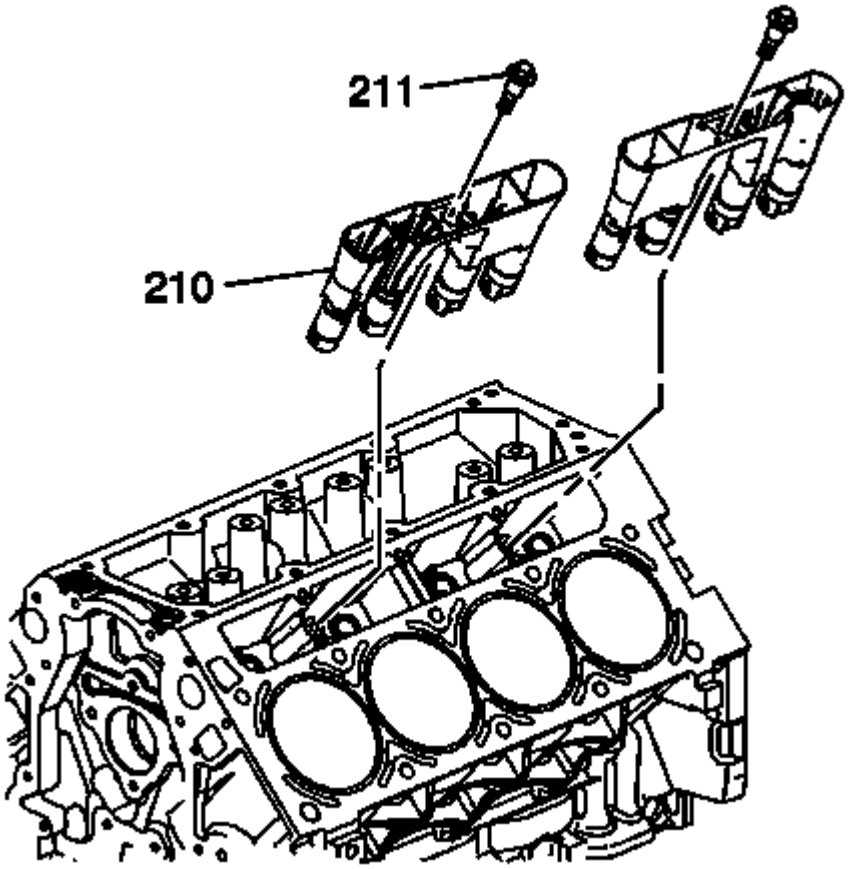

Fig. 347: Lifter Guides
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolts (211).
2. Remove the guides (210) with lifters.

   Note the installed position of the guides. The notched area of the guide is to align with the locating tab of the block.

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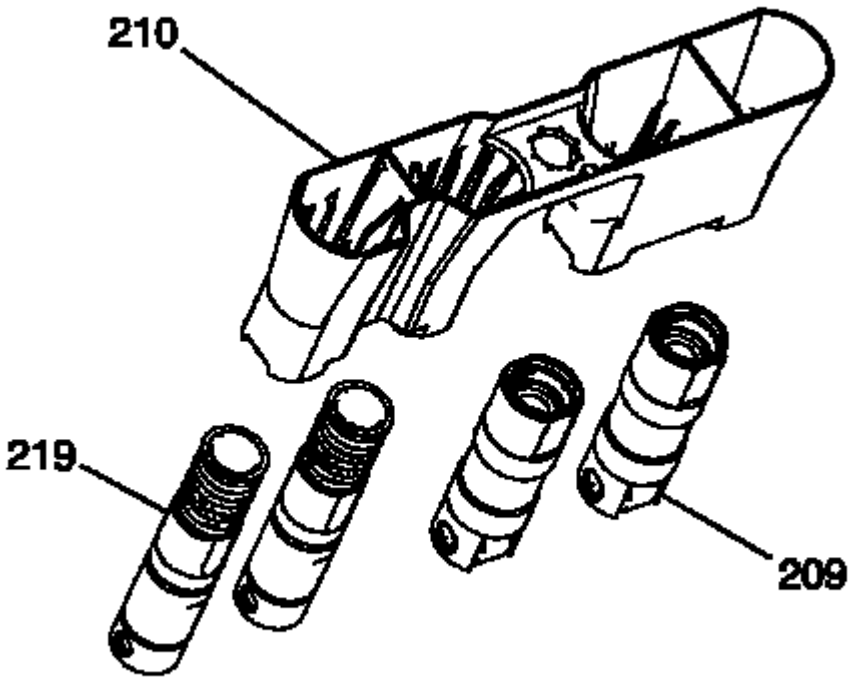

Fig. 348: Valve Lifters & Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifters (209, 219) from the guide (210).

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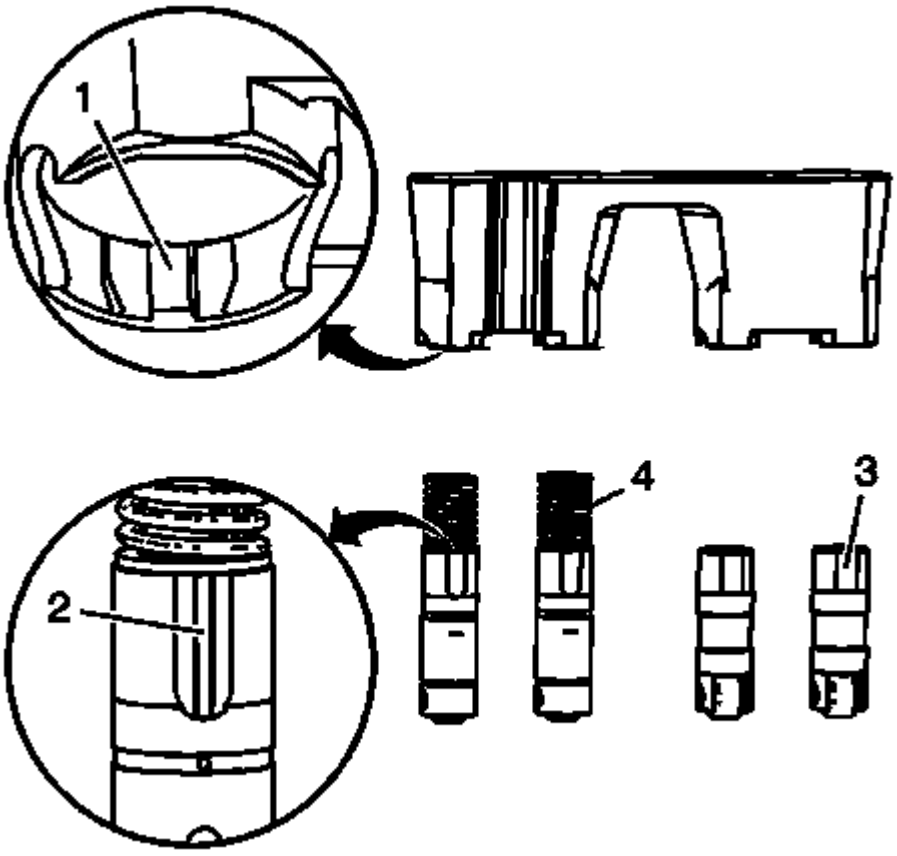

Fig. 349: Aligning Notched Area Of Guide With Raised Surface On Side Of Lifter
Courtesy of GENERAL MOTORS CORP.

4. Organize or mark the components so they can be installed in the same location from which they were removed. The displacement on demand lifters are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to **Separating Parts**.

Oil Filter and Adapter Removal

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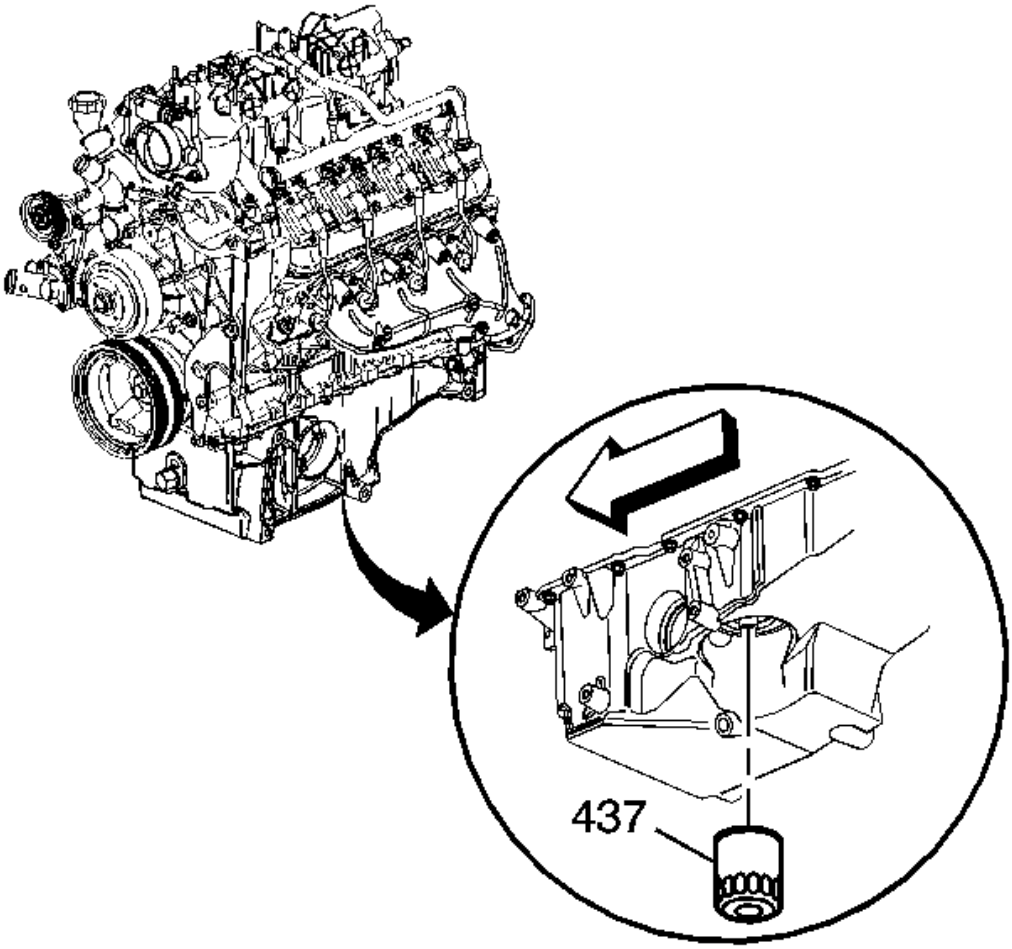

Fig. 350: Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (437).

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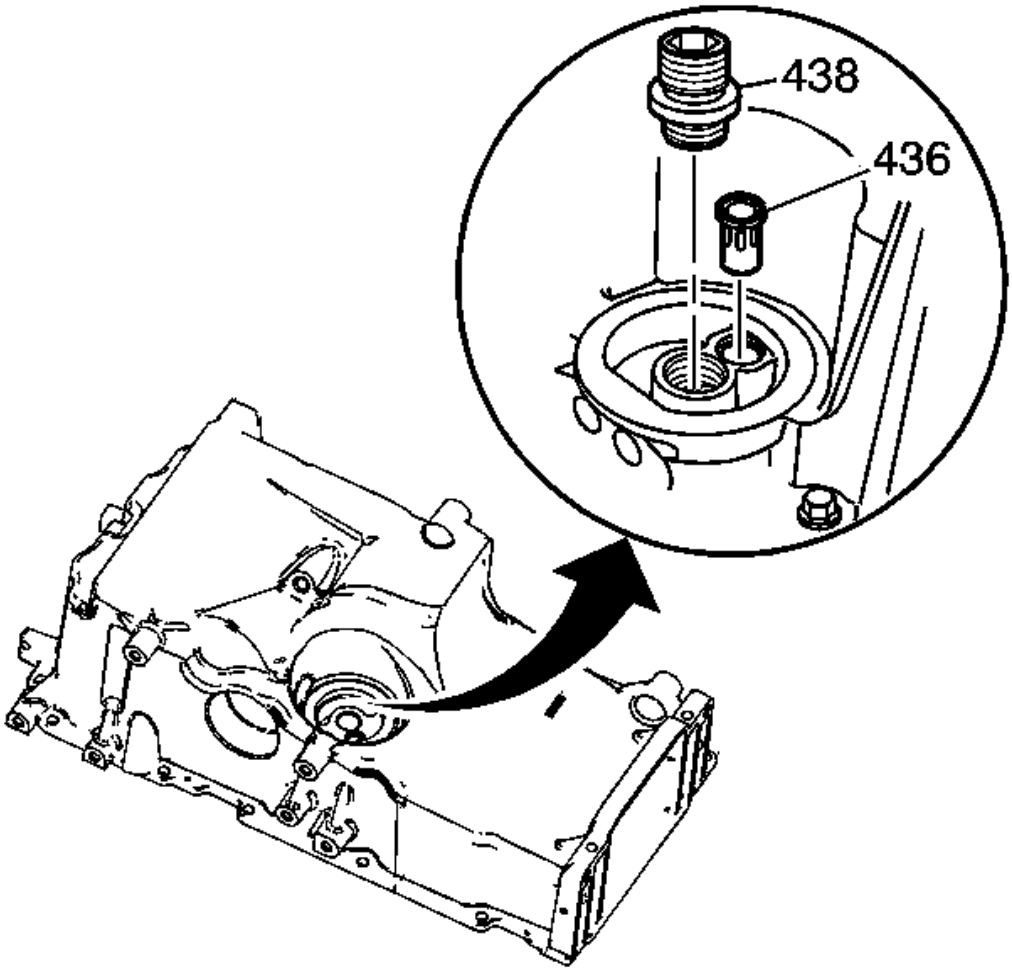

Fig. 351: Oil Filter Fitting & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting (438) and bypass valve (436) as required.

Oil Pan Removal

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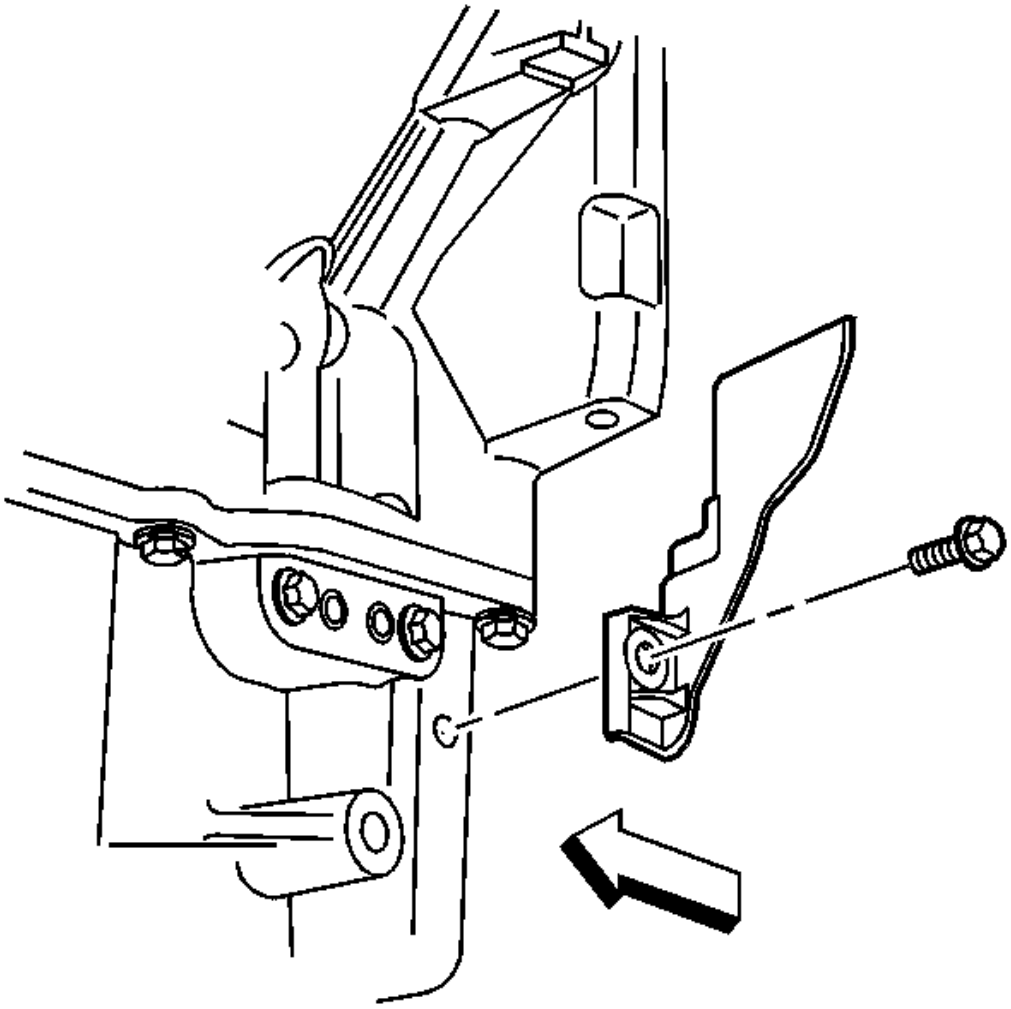

Fig. 352: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The original oil pan gasket is retained and aligned to the oil pan by rivets. When installing a new gasket, it is not necessary to install new oil pan gasket rivets.**
- **DO NOT use the oil pan gasket again. When installing the oil pan, install a NEW oil pan gasket.**

1. Remove the left closeout cover and bolt.

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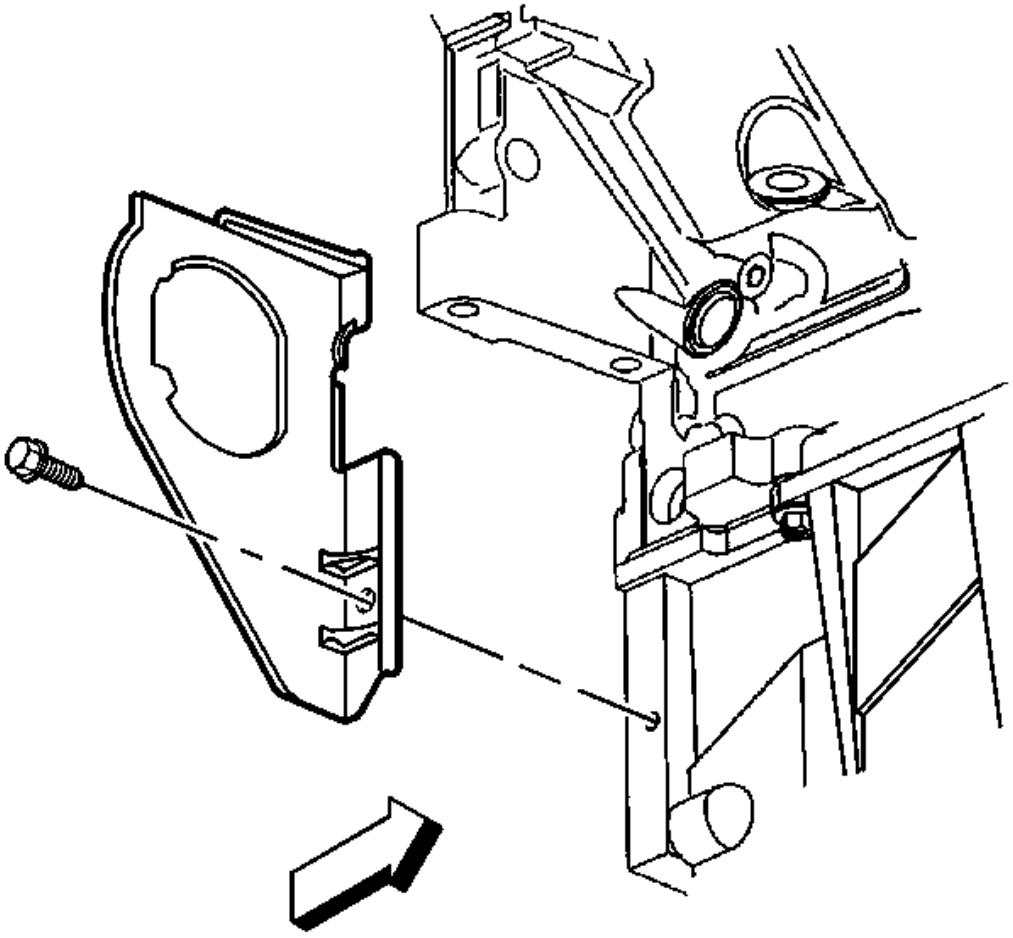

Fig. 353: View Of Right Transmission Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the right closeout cover and bolt.

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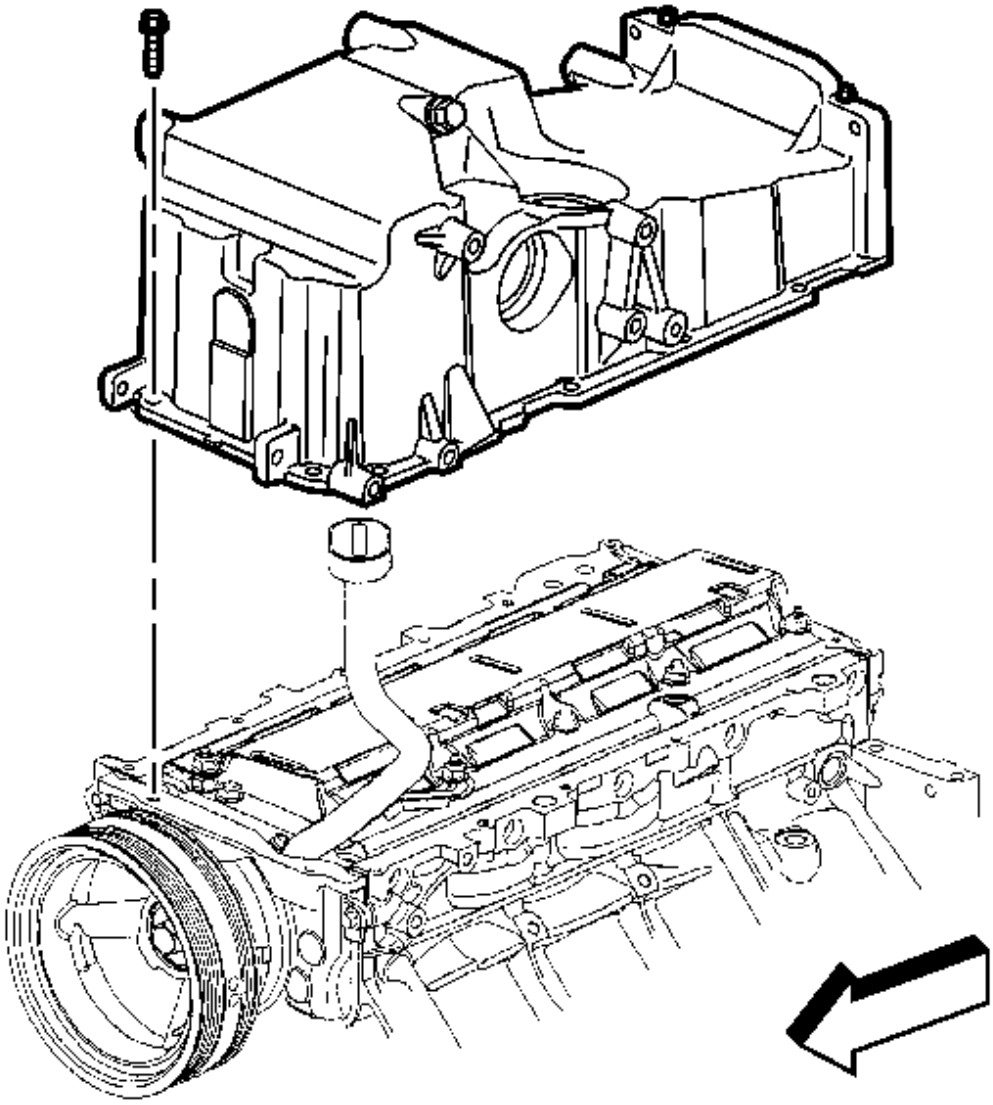

Fig. 354: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan bolts.
4. Remove the oil pan.

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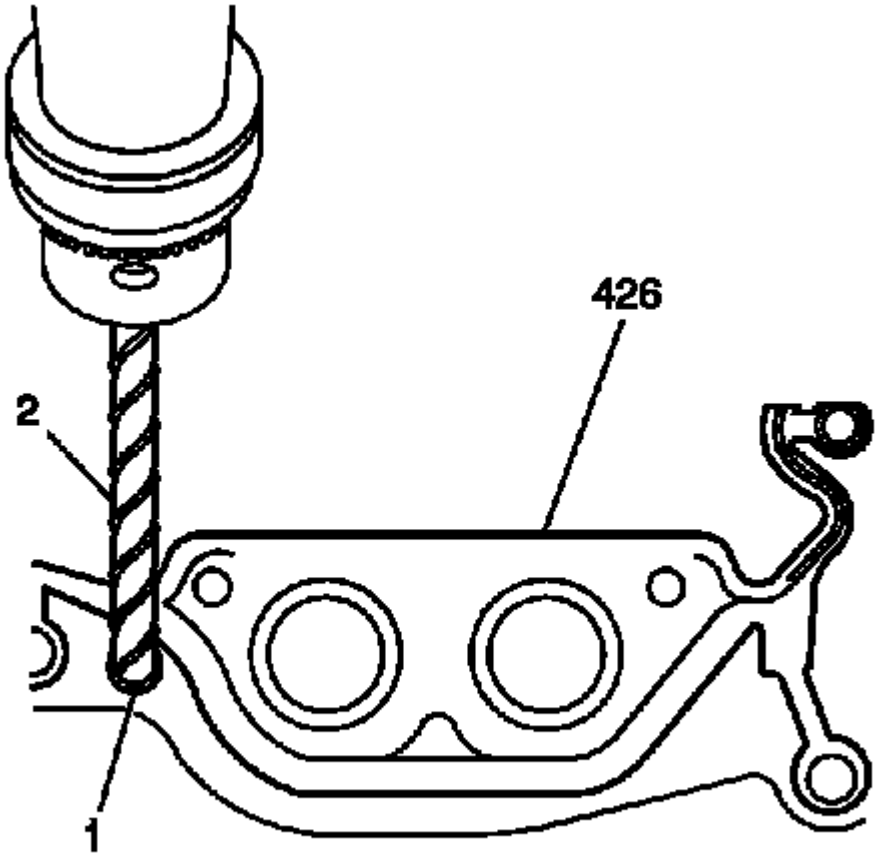

Fig. 355: Drilling Out Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **DO NOT allow foreign material to enter the oil passages of the oil pan. Cap or cover the openings as required.**
- **Use care not to gouge, score, or damage the oil pan sealing surface.**

5. Drill (2) out the oil pan gasket retaining rivets (1), if required.
6. Remove the gasket (426) from the pan.
7. Discard the gasket and rivets.
8. Remove the oil filter tube, baffle, and other internal components, as required. Refer to **Oil Pan Cleaning and Inspection**.

Engine Front Cover Removal

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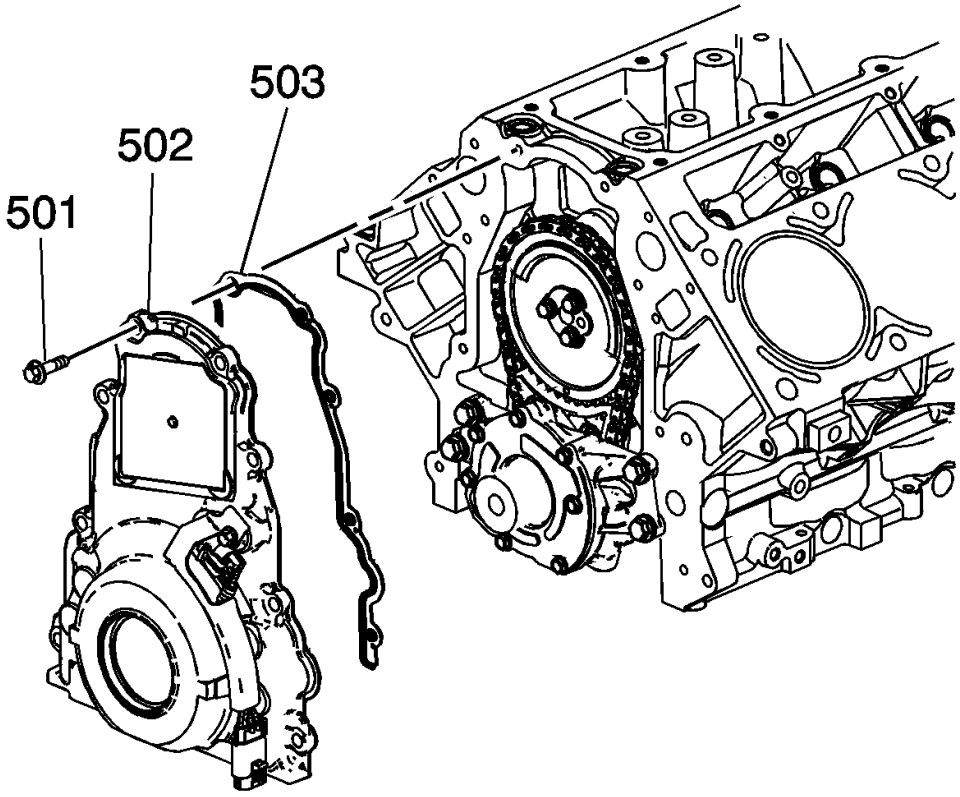

Fig. 356: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the front cover bolts (501).
2. Remove the front cover (502) and gasket (503).
3. Discard the front cover gasket.

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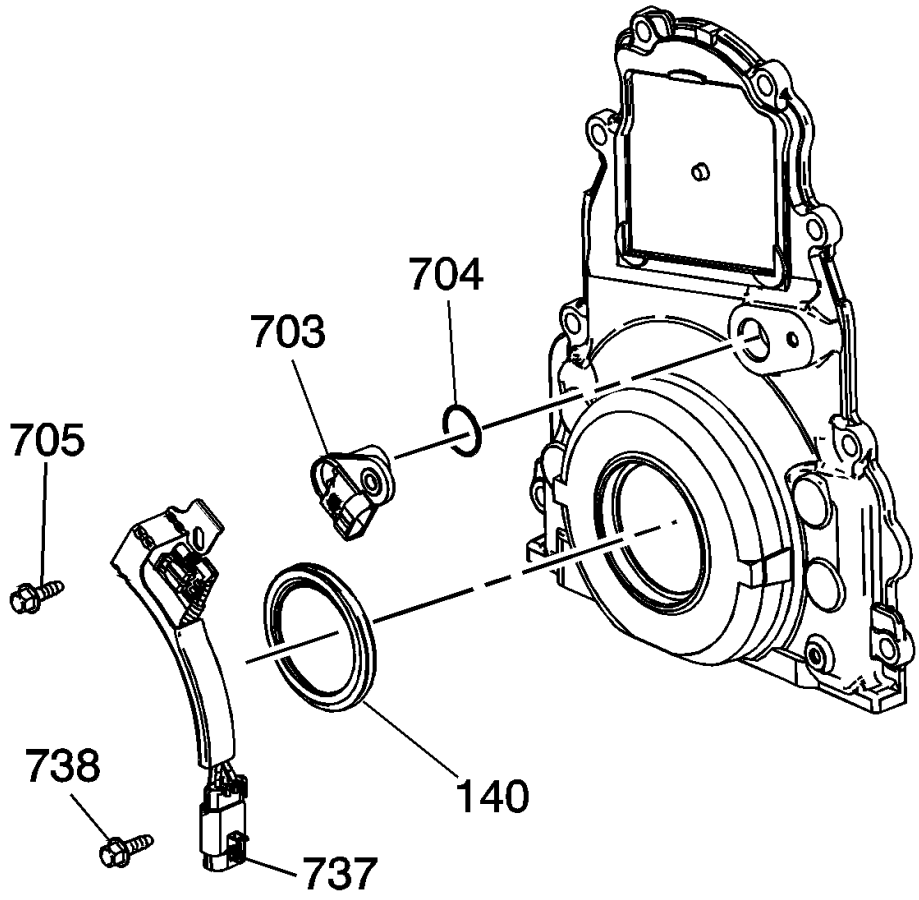

Fig. 357: Front Cover Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil seal (140).
5. Remove the bolts (705, 738), camshaft position (CMP) sensor (703), and wire harness (737).
6. Remove the O-ring (704) from the sensor as required.

Engine Rear Cover Removal

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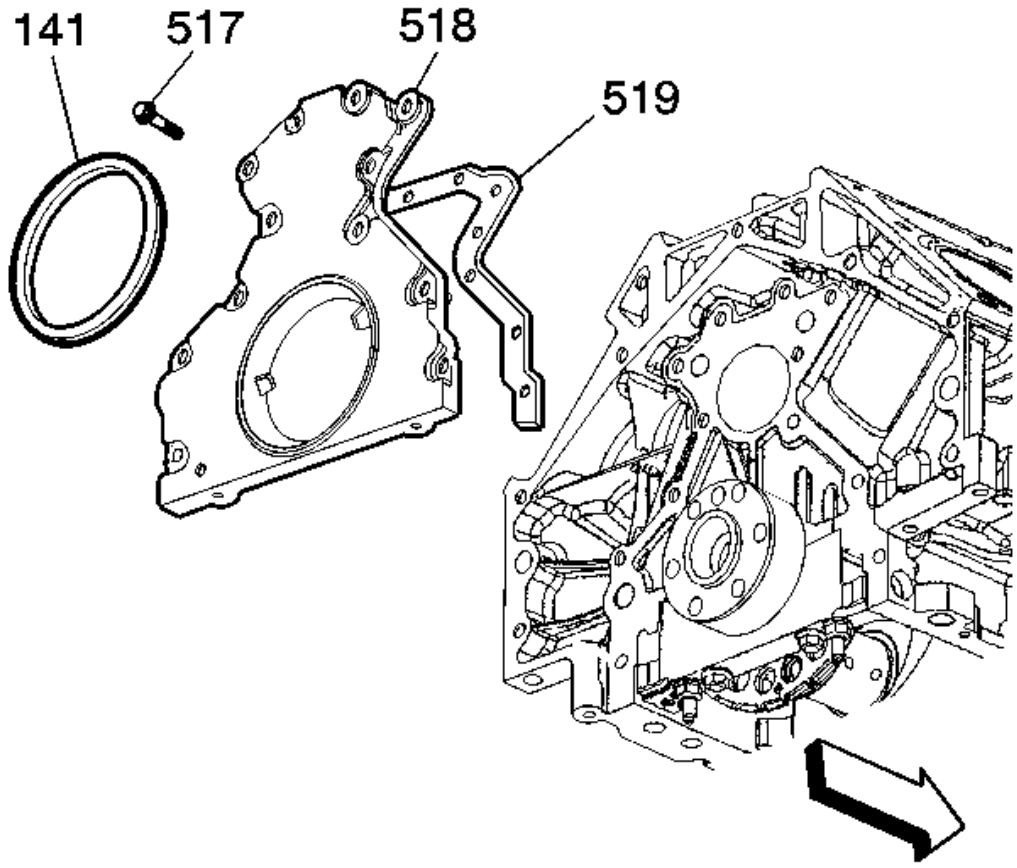

Fig. 358: Engine Rear Cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the rear cover bolts (517).
2. Remove the rear cover (518) and gasket (519).
3. Discard the rear cover gasket.
4. Remove the rear oil seal (141).

Oil Pump, Pump Screen and Deflector Removal

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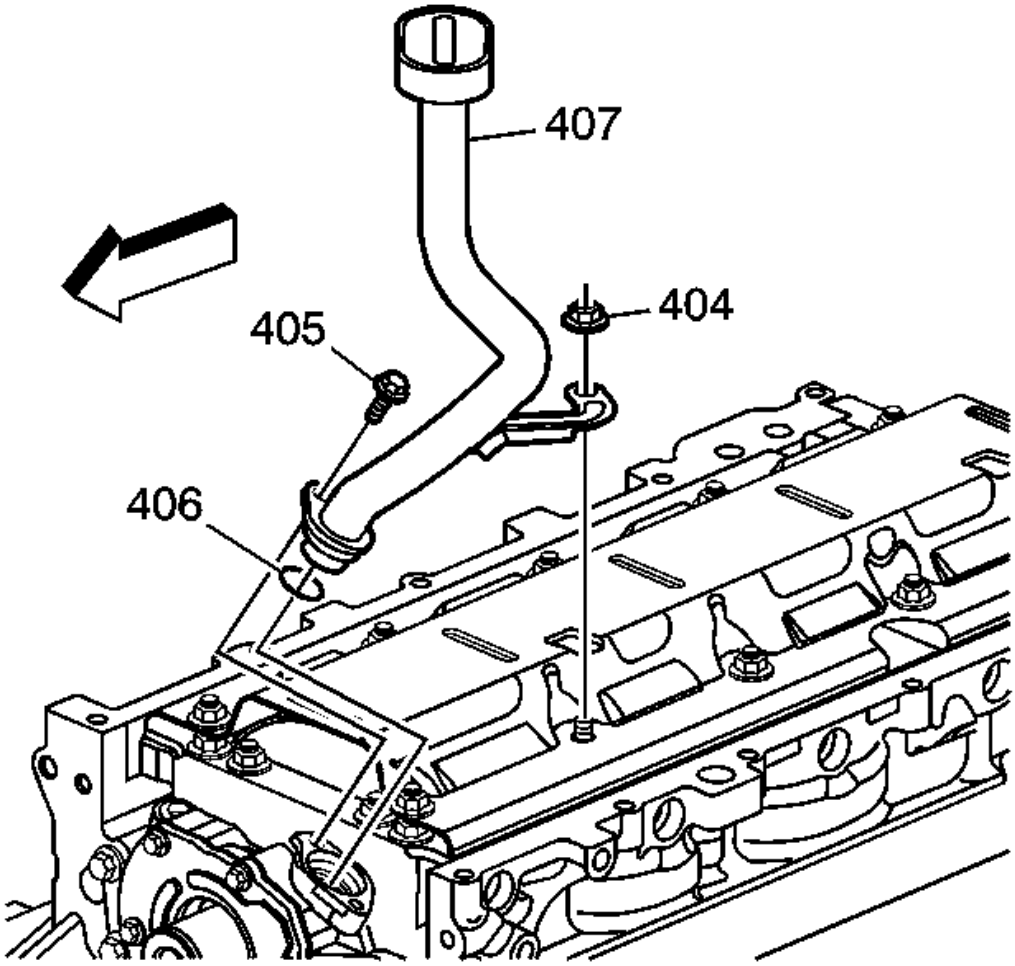

Fig. 359: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump screen bolt (405) and nut (404).
2. Remove the oil pump screen (407) with O-ring seal.
3. Remove the O-ring seal (406) from the pump screen.
4. Discard the O-ring seal.

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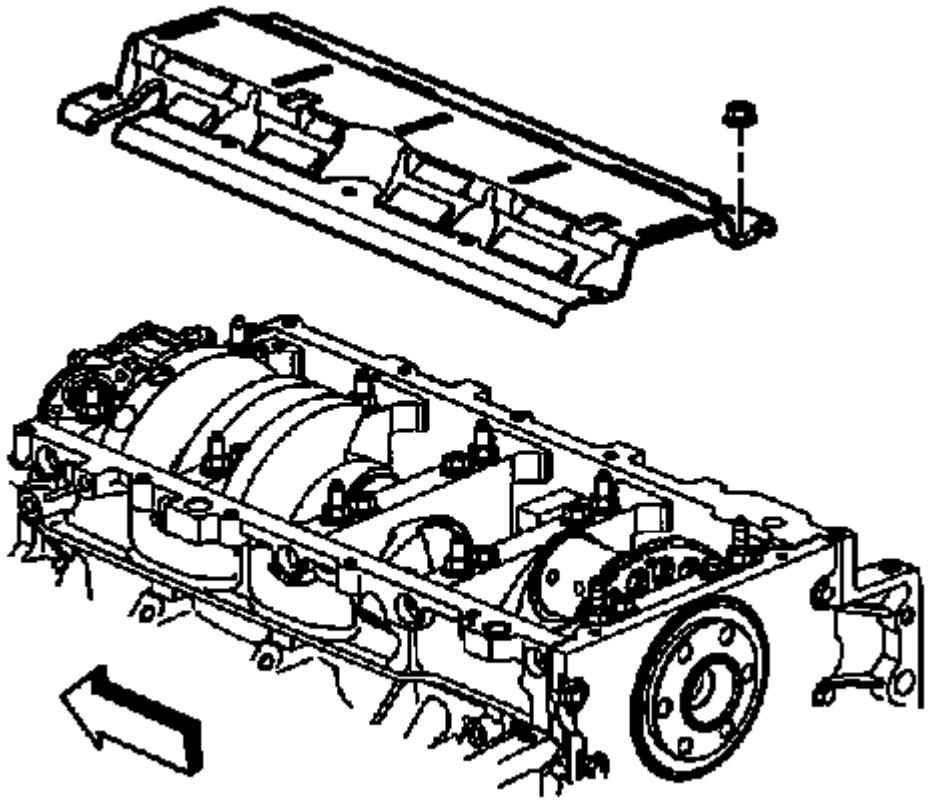

Fig. 360: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

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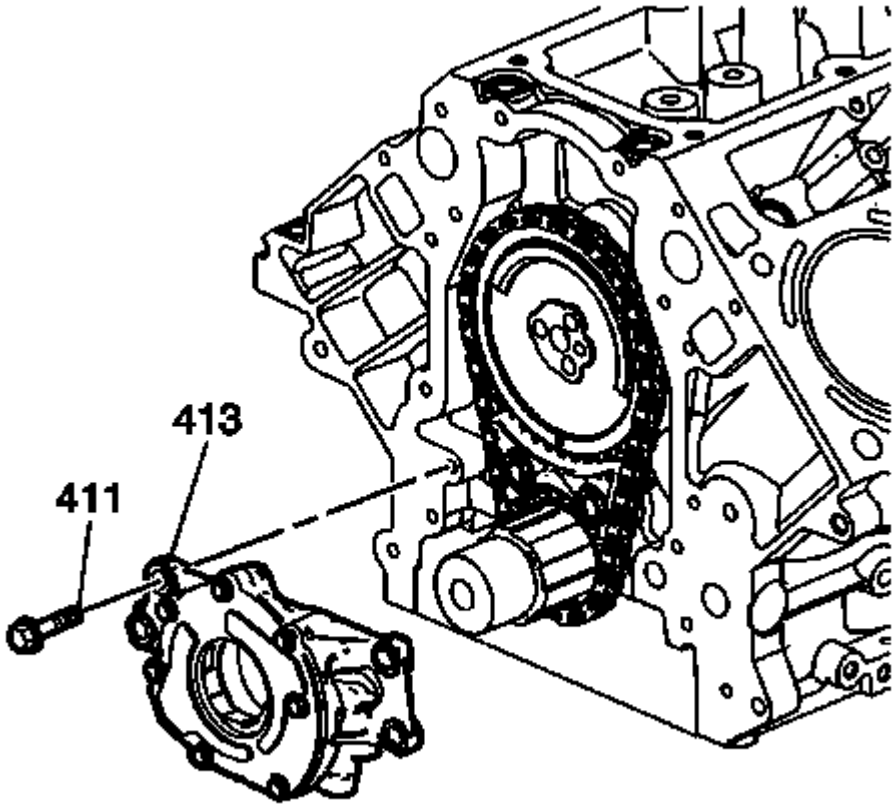

Fig. 361: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pump bolts (411).

IMPORTANT: Do not allow dirt or debris to enter the oil pump assembly. Cap ends as necessary.

8. Remove the oil pump (413).

Timing Chain and Sprockets Removal

Tools Required

- **J 8433-1** Puller Bar. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector

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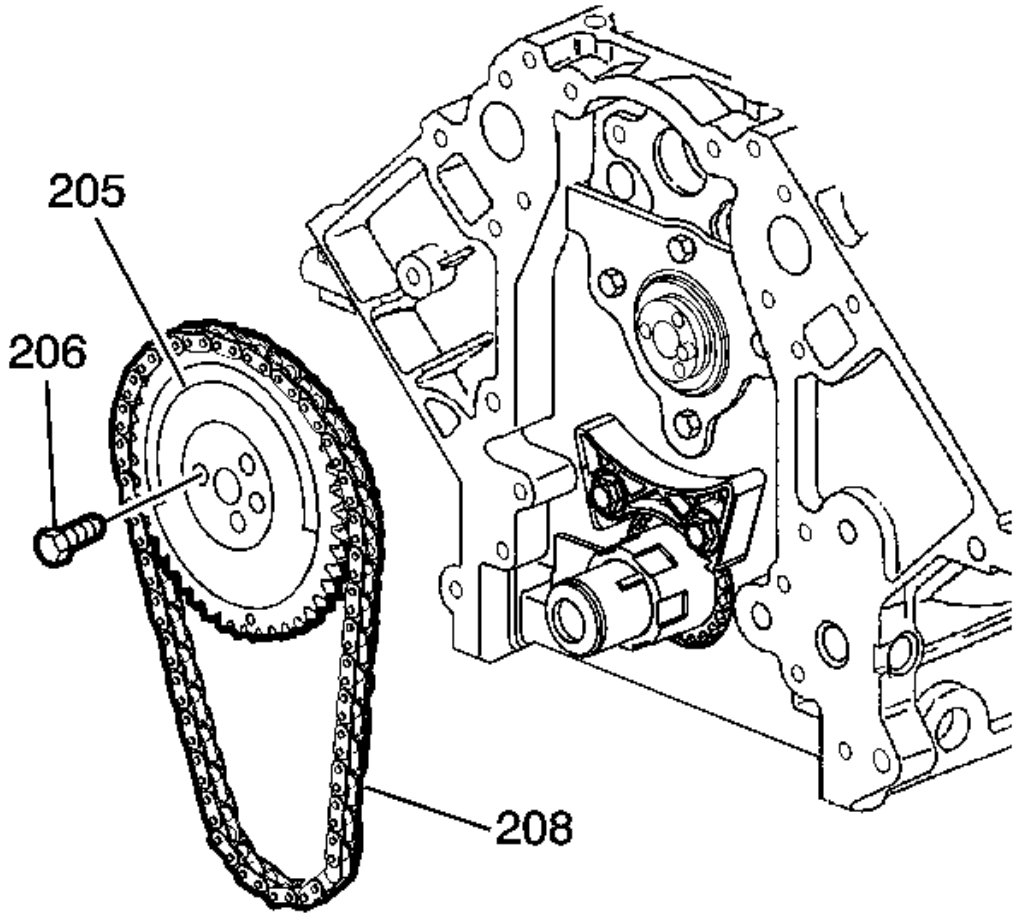

Fig. 362: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not turn the crankshaft assembly after the timing chain has been removed in order to prevent damage to the piston assemblies or the valves.

1. Remove the camshaft sprocket bolts (206).
2. Remove the camshaft sprocket (205) and timing chain (208).

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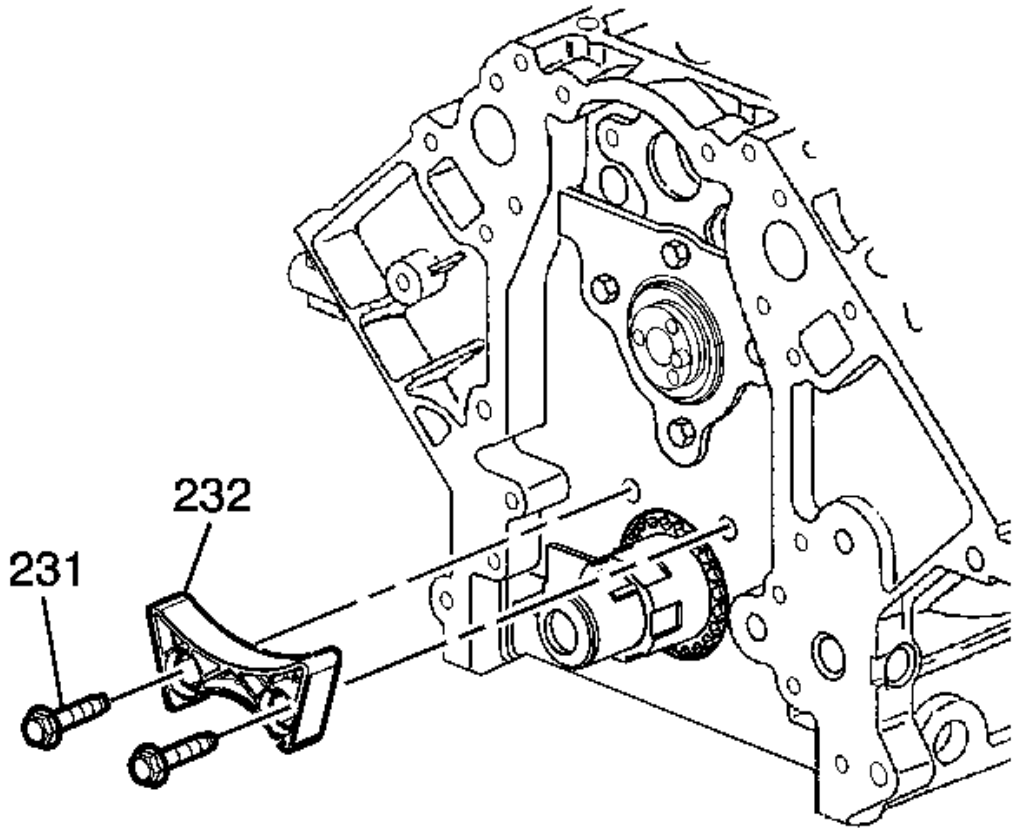

Fig. 363: Chain Dampener
Courtesy of GENERAL MOTORS CORP.

3. Remove the bolts (231) and chain dampener (232).

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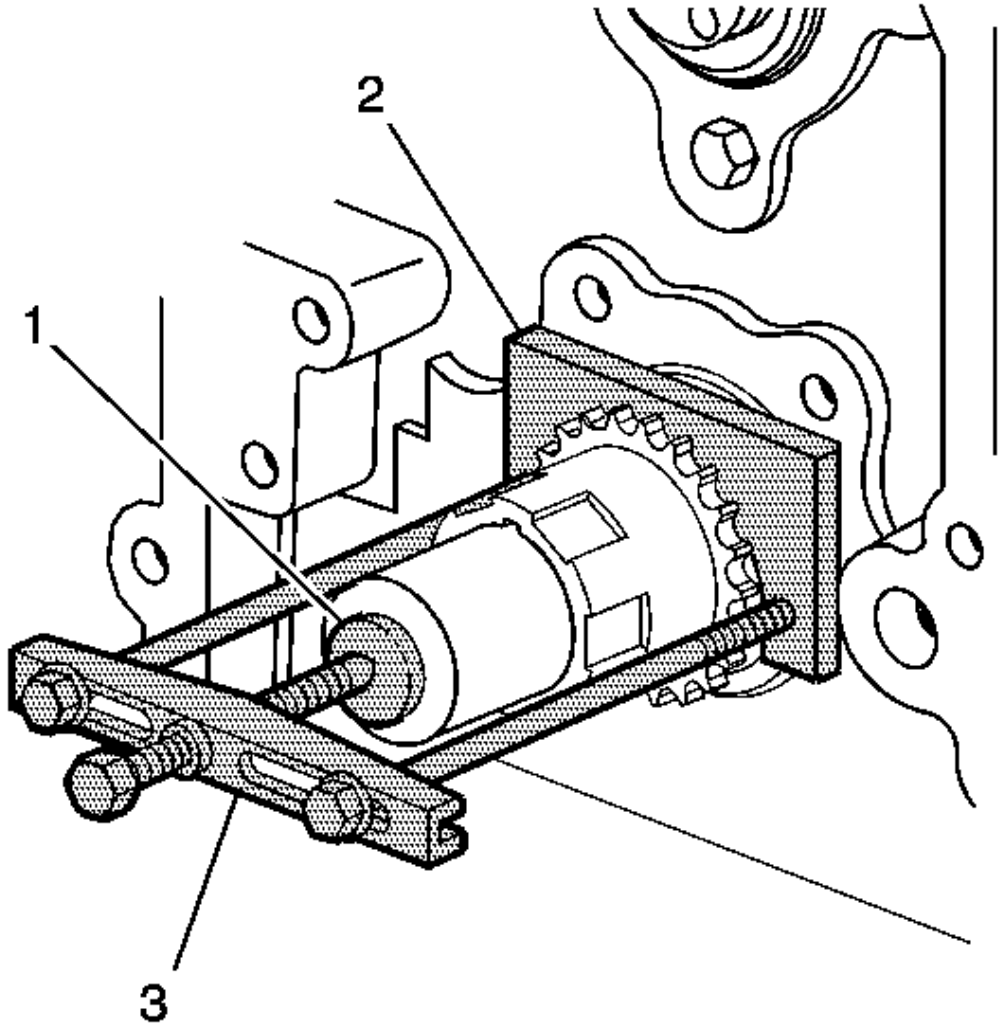

Fig. 364: Removing Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41816-2** (1), the **J 41558** (2), and the **J 8433-1** (3) in order to remove the crankshaft sprocket. See **Special Tools**.

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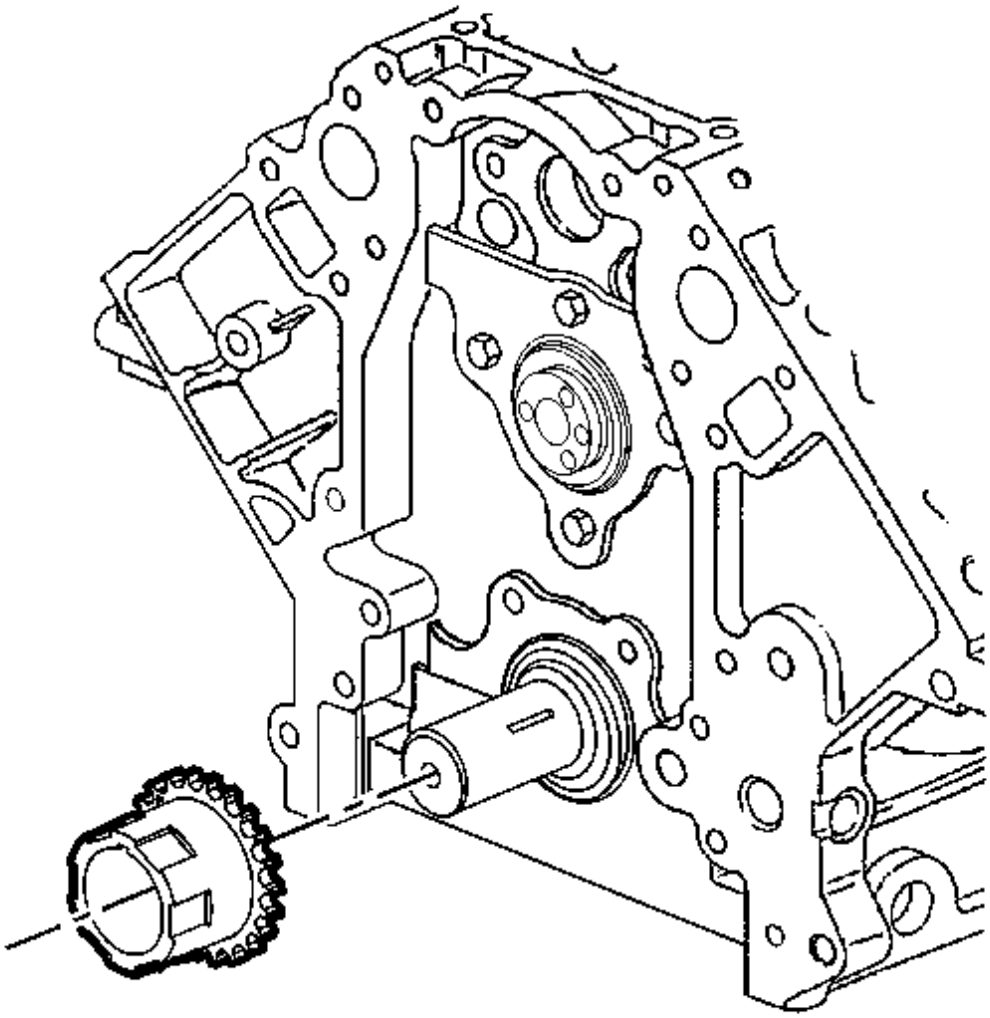

Fig. 365: Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft sprocket.

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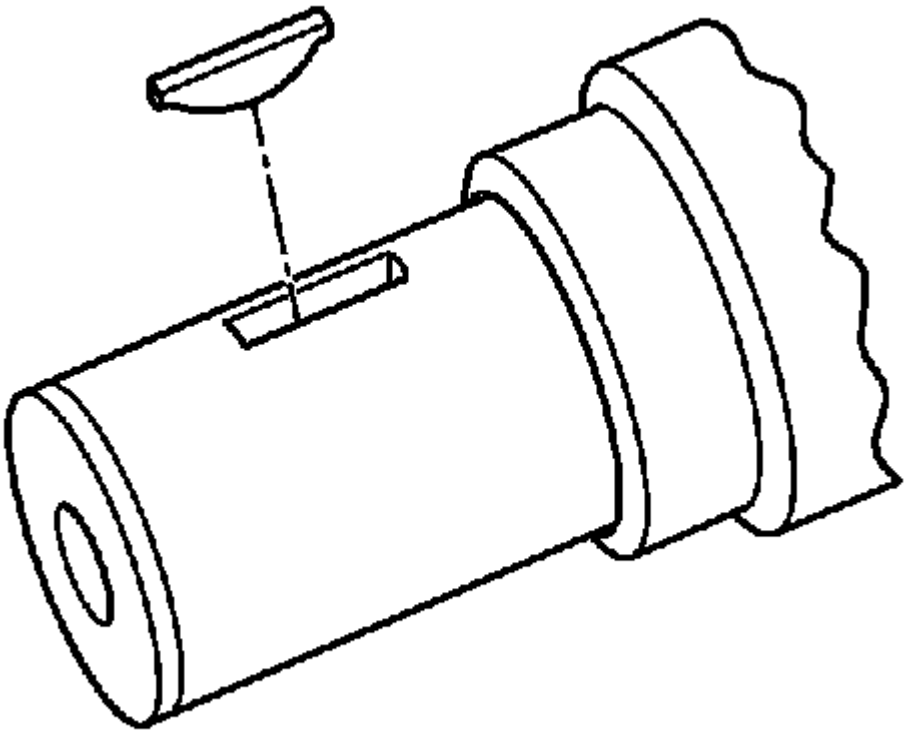

Fig. 366: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket key as required.

Camshaft Removal

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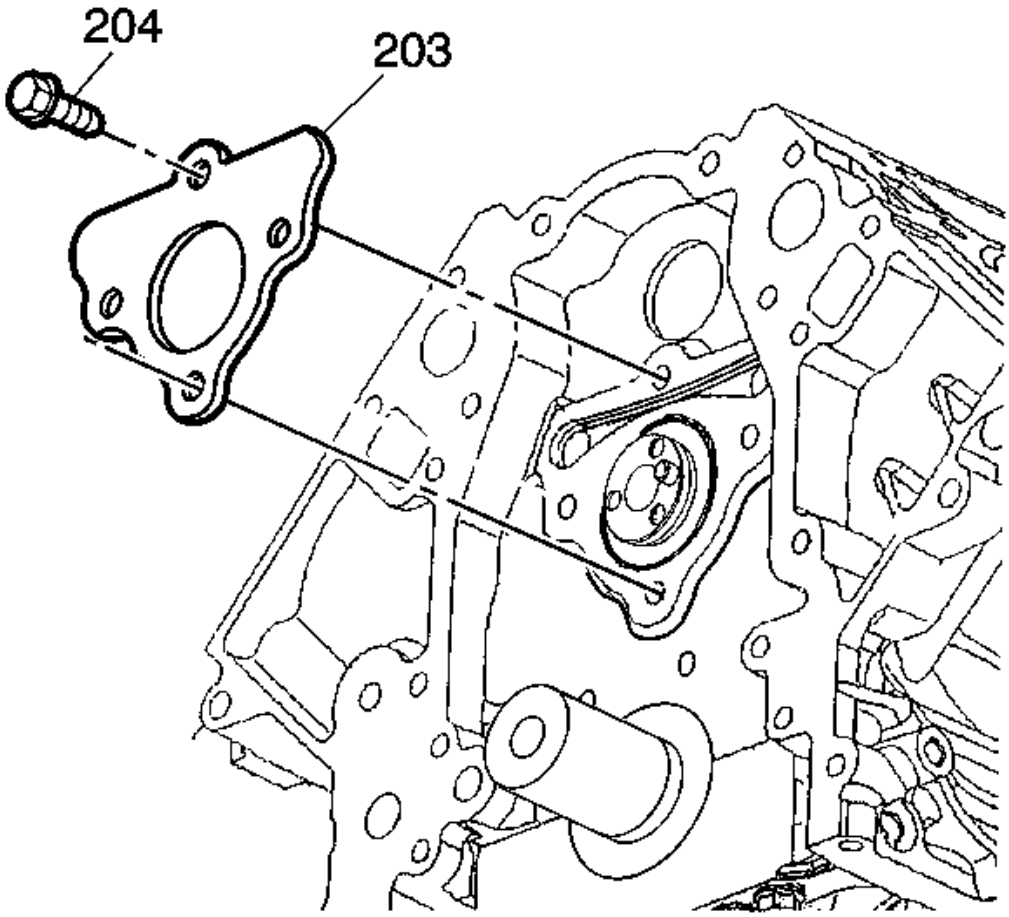

Fig. 367: Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts (204) and retainer (203).

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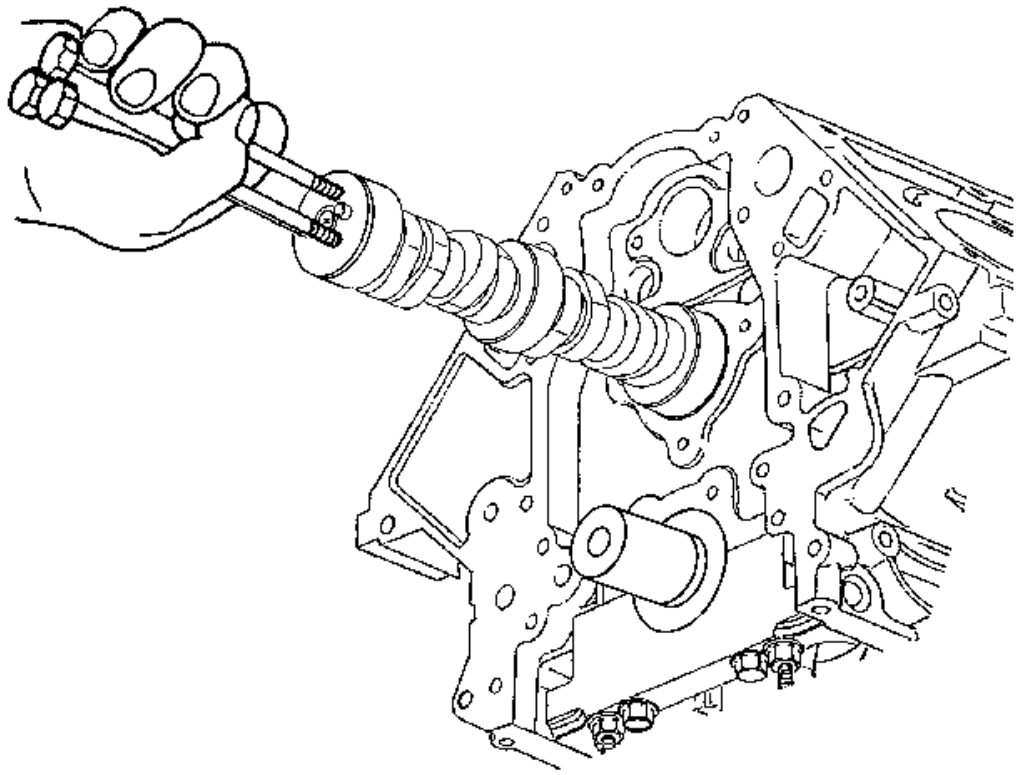

Fig. 368: Removing Camshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

2. Remove the camshaft.
    1. Install the 3 M8-1.25 x 100 mm bolts in the camshaft front bolt holes.
    2. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the bolts from the front of the camshaft.

Piston, Connecting Rod, and Bearing Removal

Tools Required

- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools**.
- **J 41556** Connecting Rod Guide

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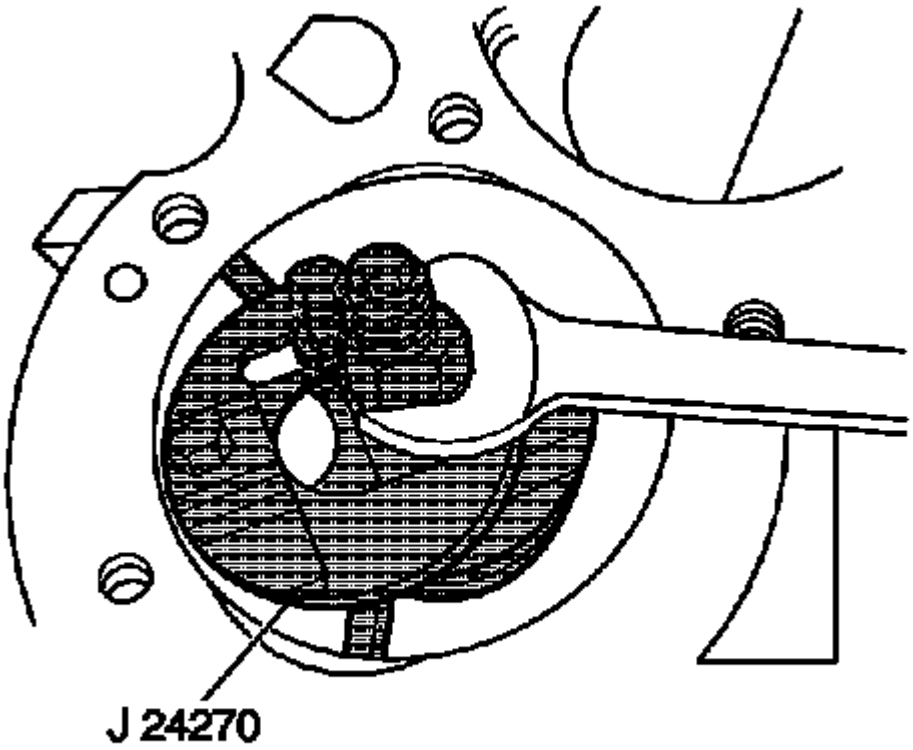

Fig. 369: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 24270** in order to remove the cylinder bore ring ridge, if required. See **Special Tools**.
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Place a cloth on top of the piston.
    3. Use the **J 24270** , or equivalent, in order to remove a cylinder ring ridge. See **Special Tools**.
    4. Turn the crankshaft so the piston is at the top of the stroke.
    5. Remove the cloth.
    6. Remove the cutting debris from the cylinder and piston.

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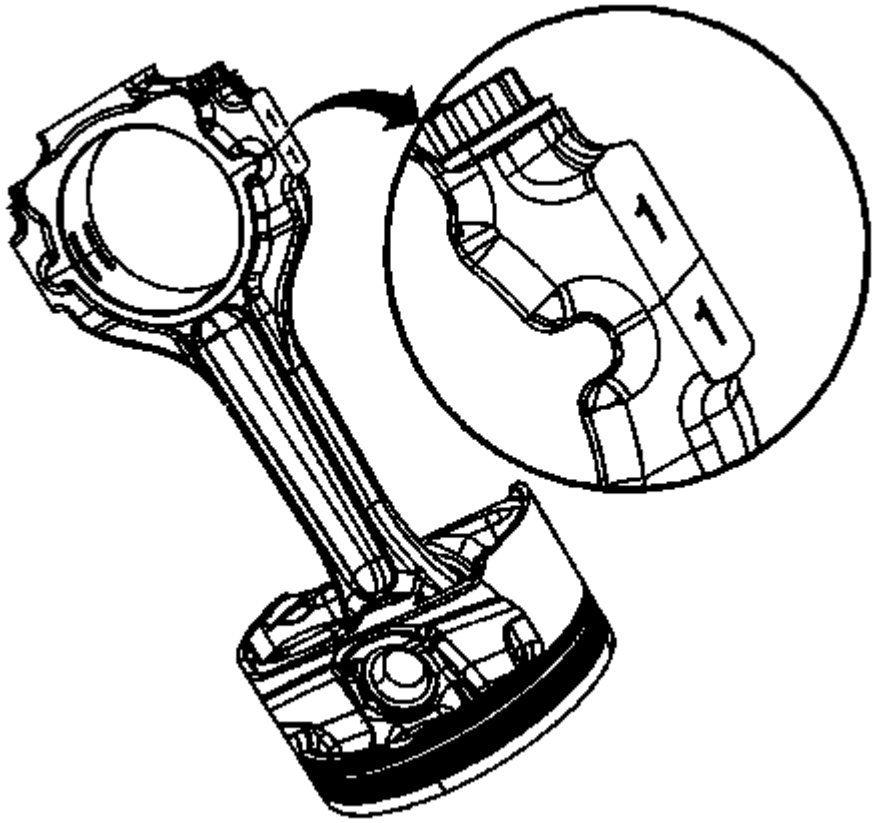

Fig. 370: Stamping Mark On Side Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

2. Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
    - A stamping mark on the side of the connecting rod, at the crankshaft journal, may affect component geometry.
    - Mark the top of the piston to the specific cylinder bore.

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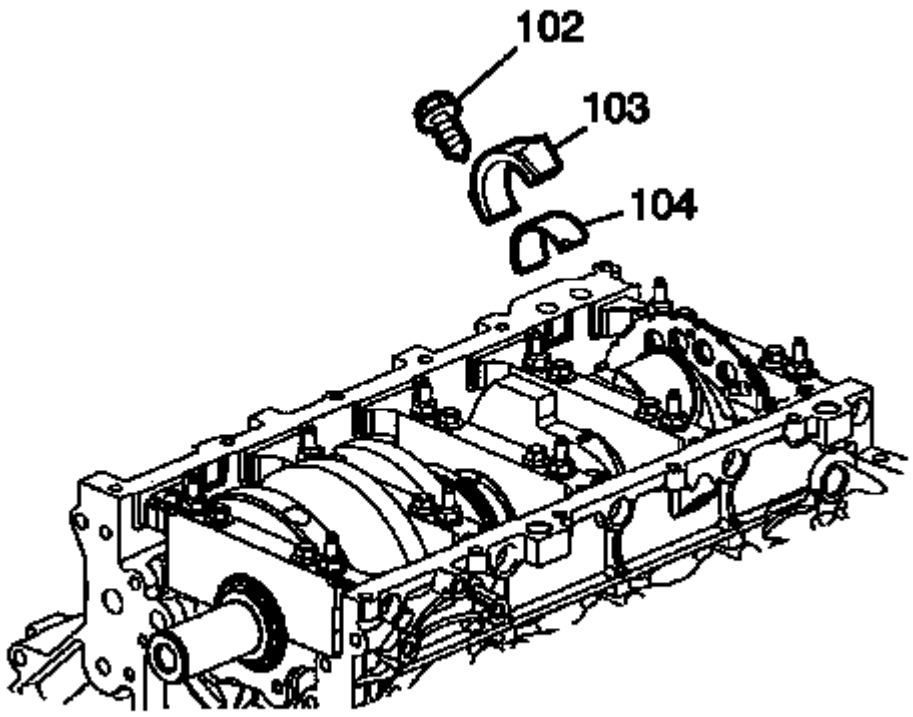

Fig. 371: Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location. The connecting rods and the bearing caps are NOT interchangeable. Refer to Separating Parts.

3. Remove the connecting rod bolt (102), cap (103) and bearing (104).

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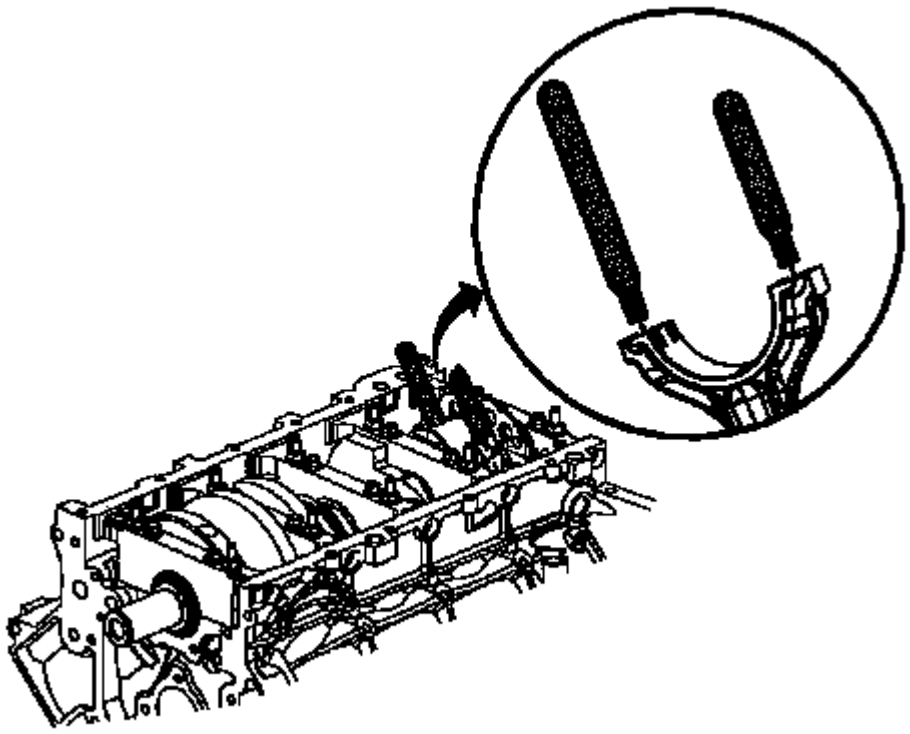

Fig. 372: Installing J 41556 To Connecting Rod
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod.

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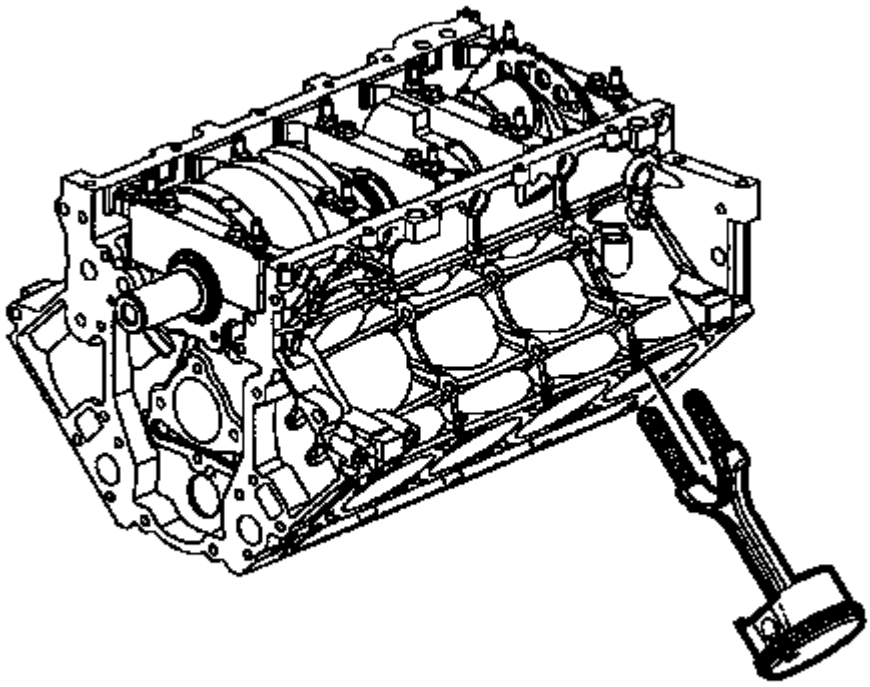

Fig. 373: Removing Piston & Connecting Rod Assembly From Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

5. Using a hammer, tap lightly on the end of the **J 41556** in order to remove the piston and connecting rod assembly from the cylinder bore.

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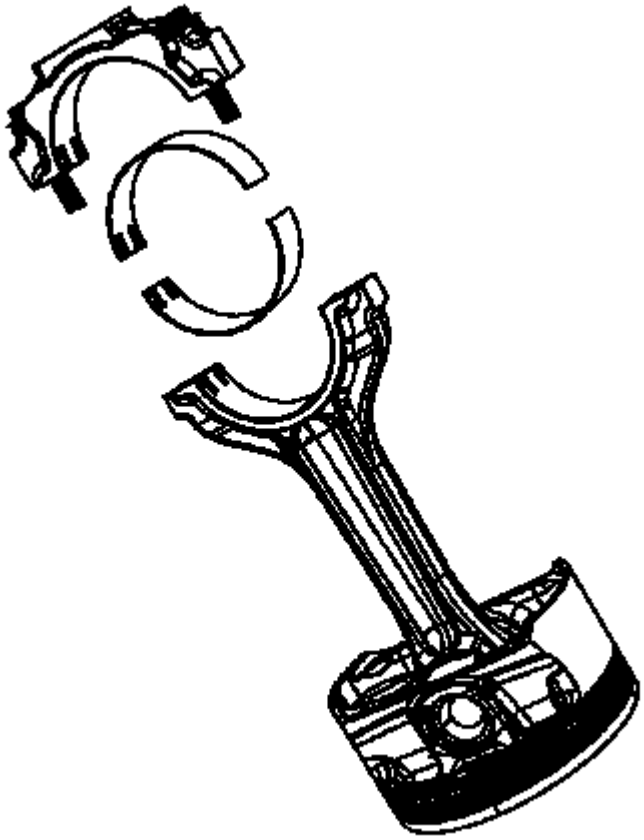

Fig. 374: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

6. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolt onto the matching connecting rod.

Crankshaft and Bearings Removal

Tools Required

- J 6125-1B Slide Hammer with Adapter
- **J 41818** Crankshaft Bearing Cap Remover. See **Special Tools**.

IMPORTANT:
- **The crankshaft bearing caps are machined with the engine block for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps MUST be installed to their original position and direction.**
- **Do not use the bearing cap M8 side bolts again.**

1. Remove the crankshaft position (CKP) sensor bolt (702).

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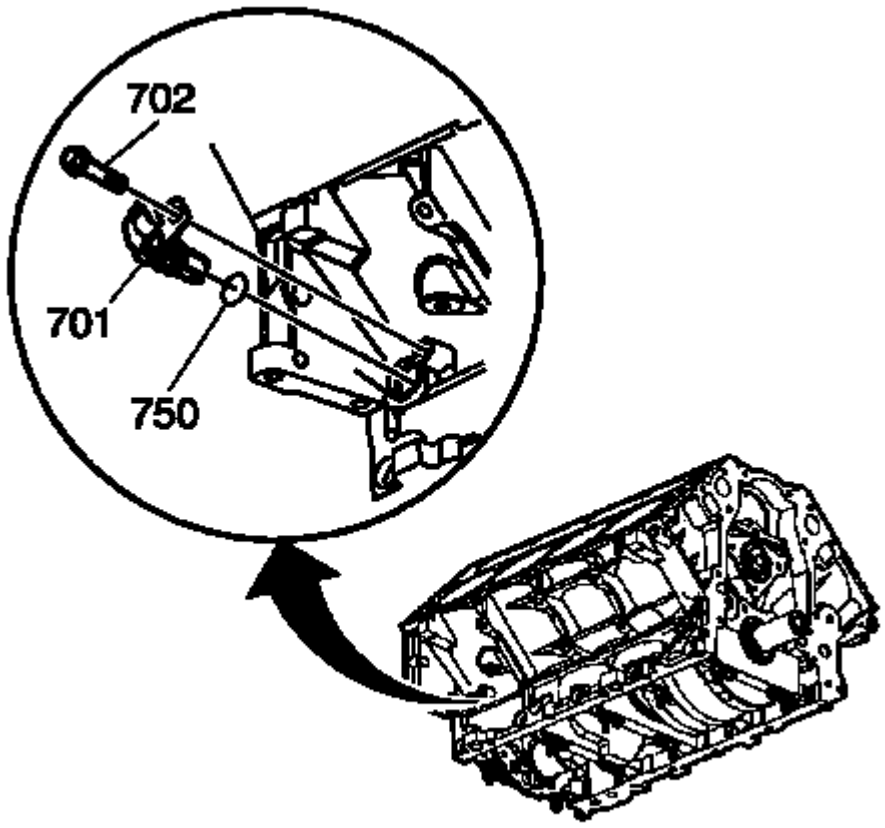

Fig. 375: CKP Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the CKP sensor (701).
3. Remove the O-ring (750) from the sensor as required.

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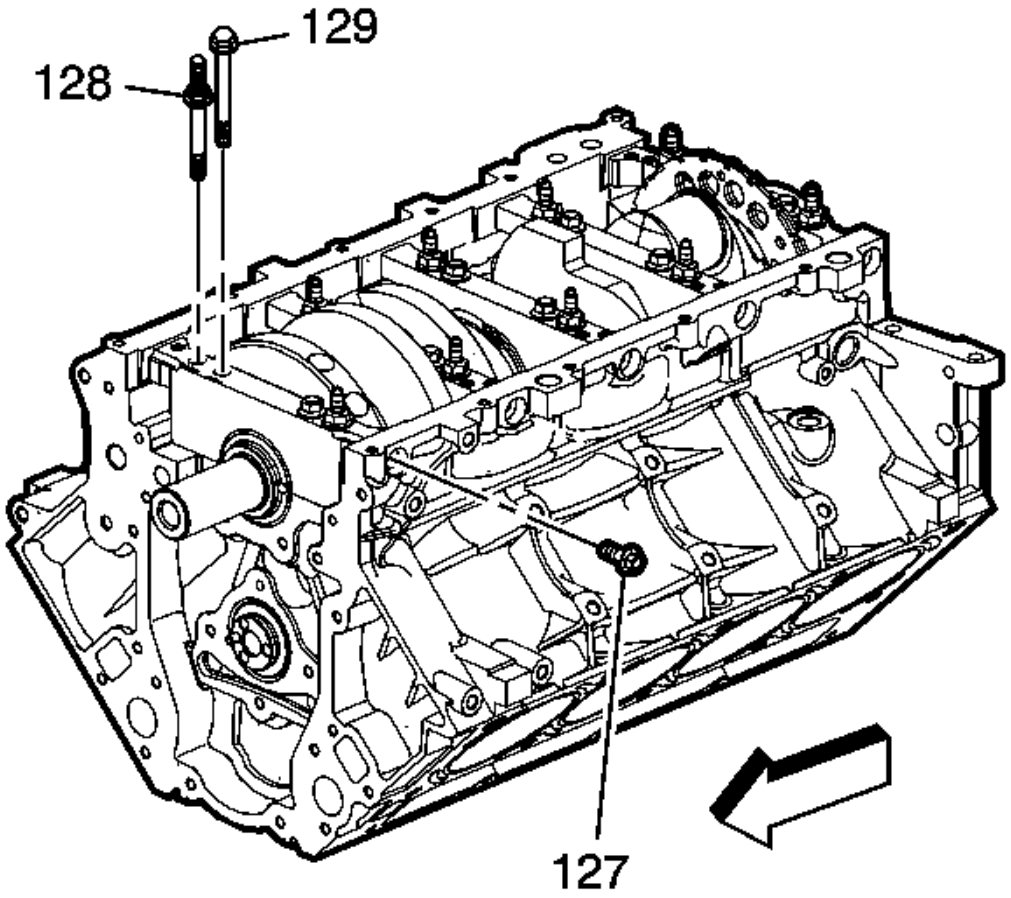

Fig. 376: Crankshaft Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft bearing cap M8 bolts (127).
5. Remove the crankshaft bearing cap M10 bolts (129) and studs (128).

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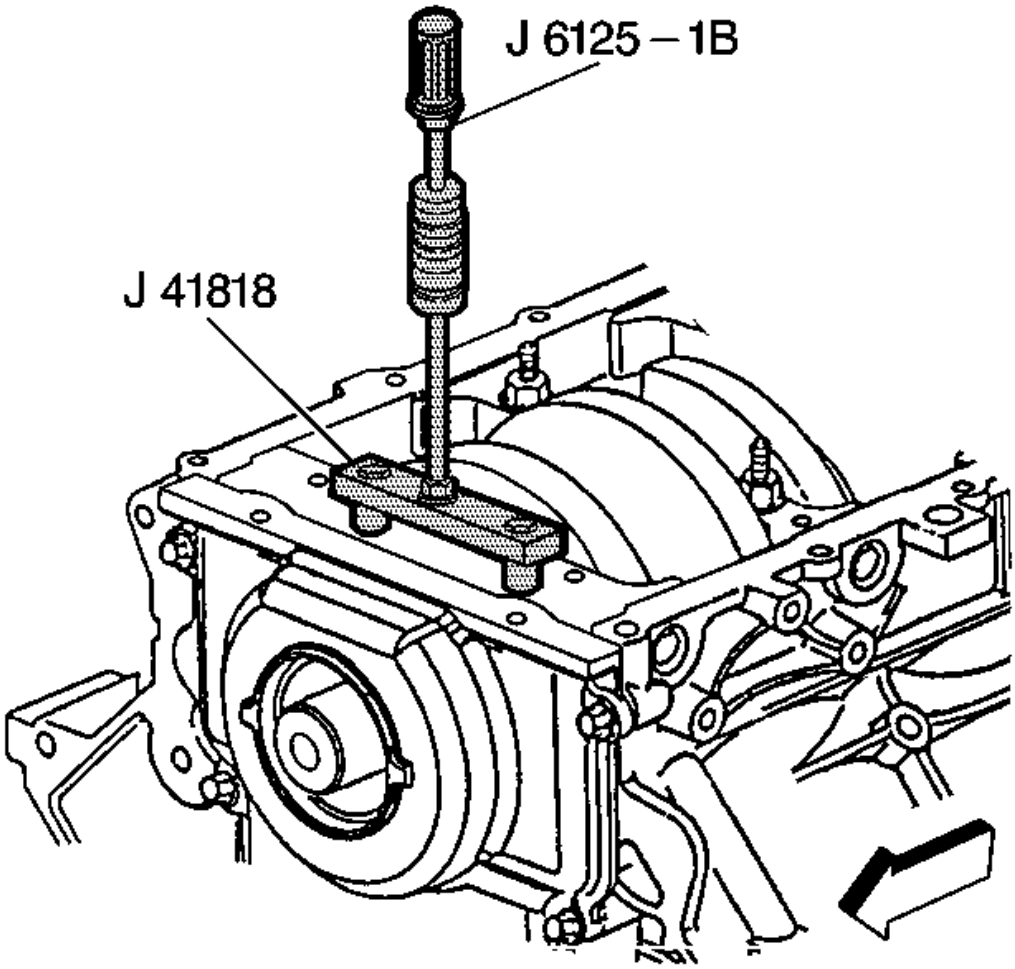

Fig. 377: View Of J 6125-1B & J 41818 Removing Main Bearing Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the **J 41818** . See **Special Tools**.

   Tighten: Tighten the **J 41818** bolts to 11 N.m (100 lb in).

7. Install the J 6125-1B to the **J 41818** in order to remove the crankshaft bearing caps. See **Special Tools**.

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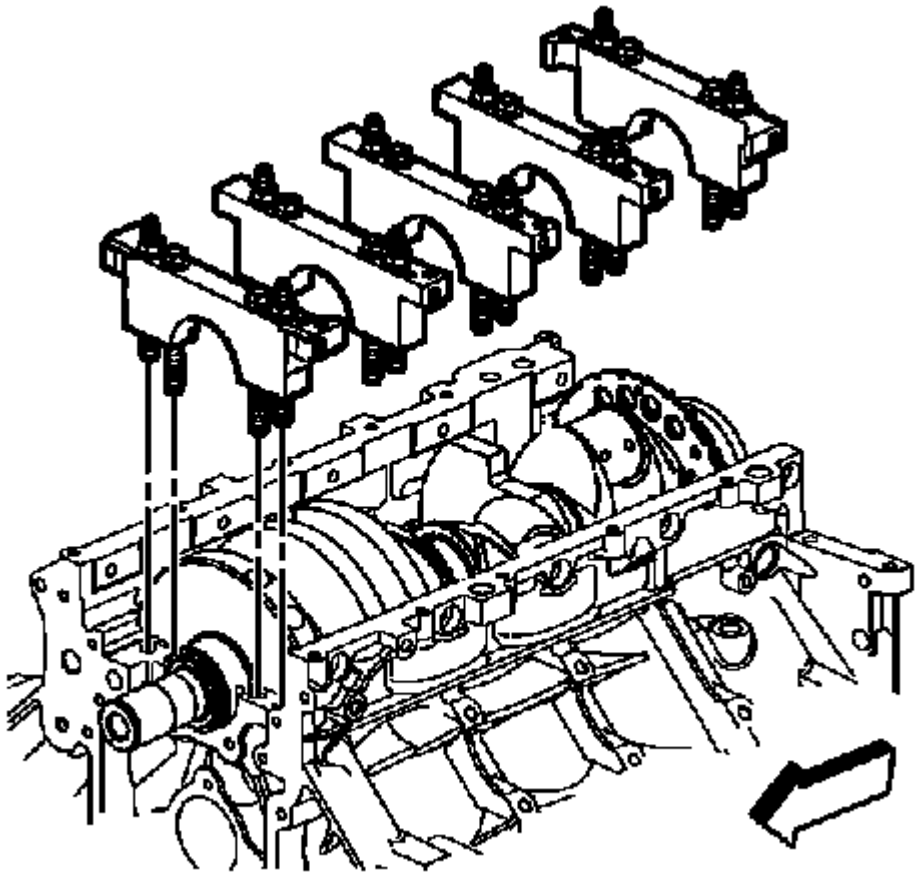

Fig. 378: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Remove the bearing caps.

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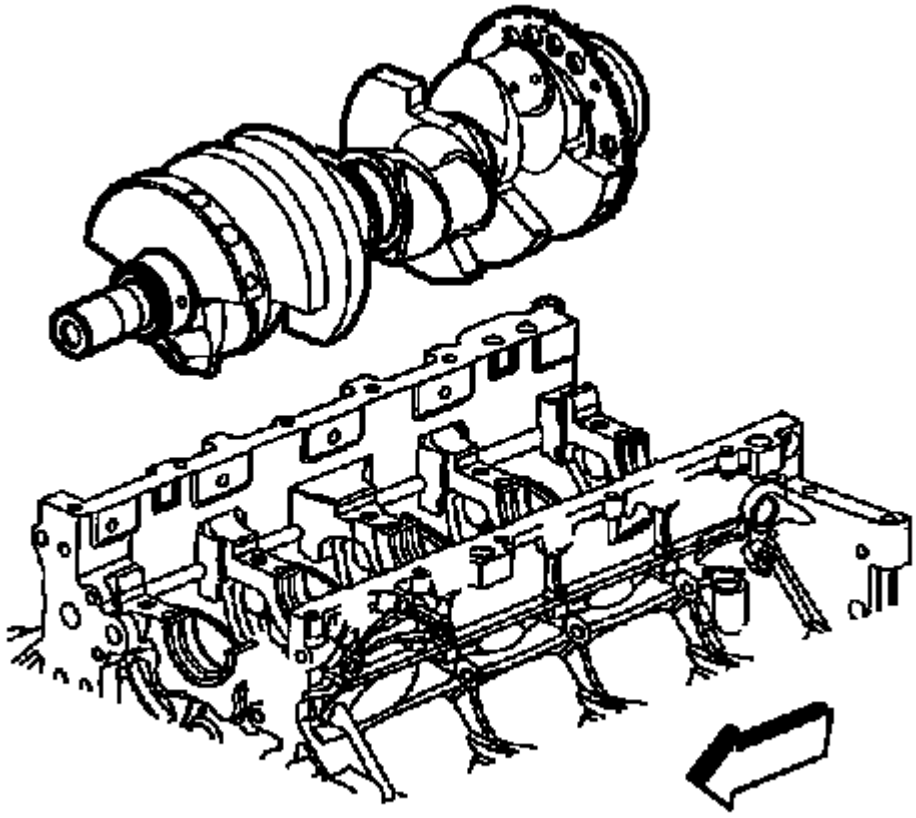

Fig. 379: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs, or other damage to the teeth may effect on-board diagnostics (OBD) II system performance.

9. Remove the crankshaft.

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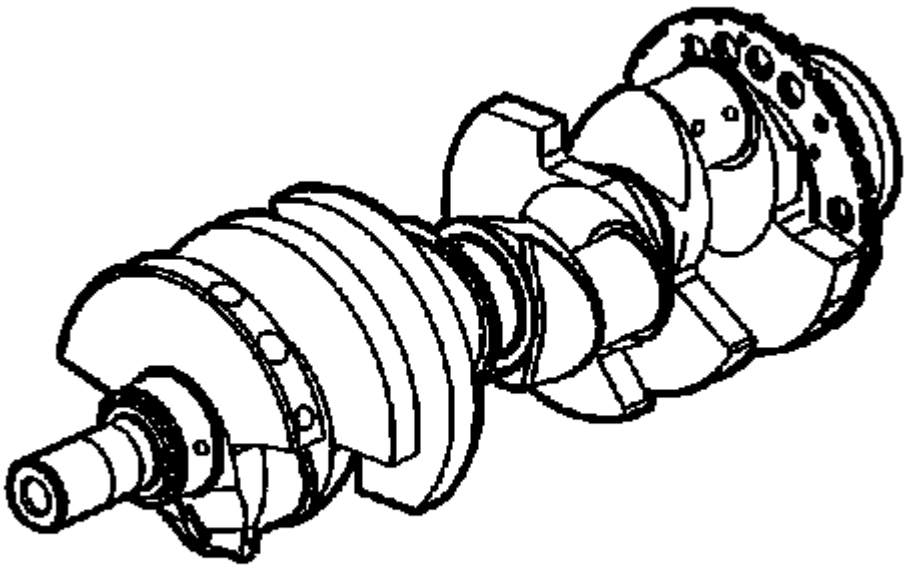

Fig. 380: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

10. Lay the crankshaft onto wooden V blocks or other protective surface.

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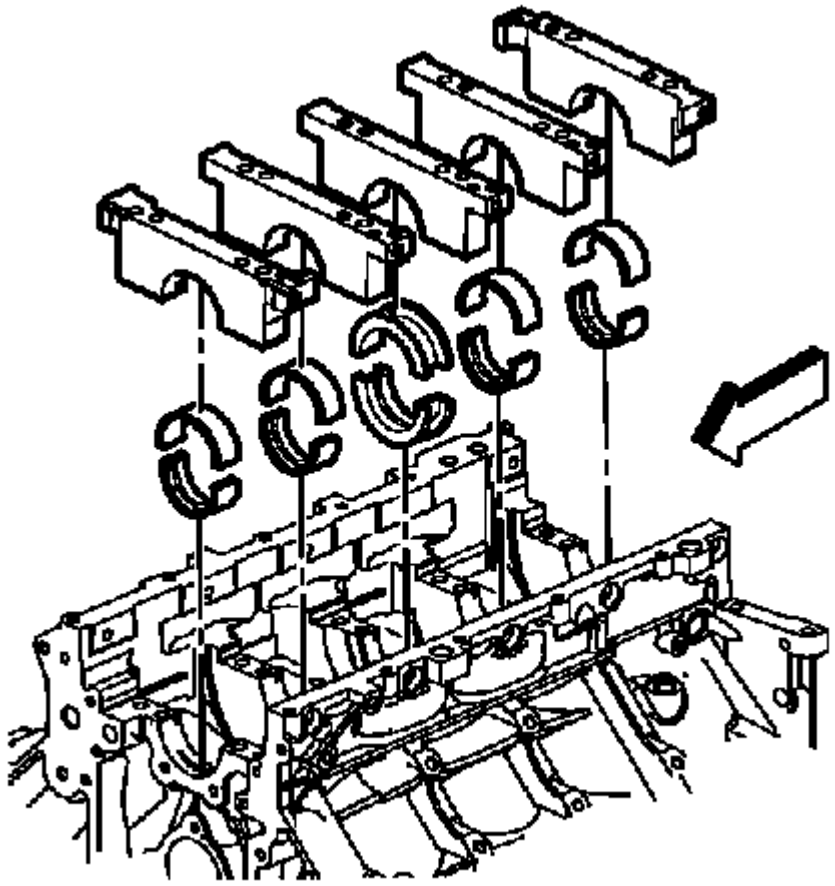

Fig. 381: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft bearings from the bearing caps and the engine block.
12. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to **Separating Parts**.

Engine Block Plug Removal

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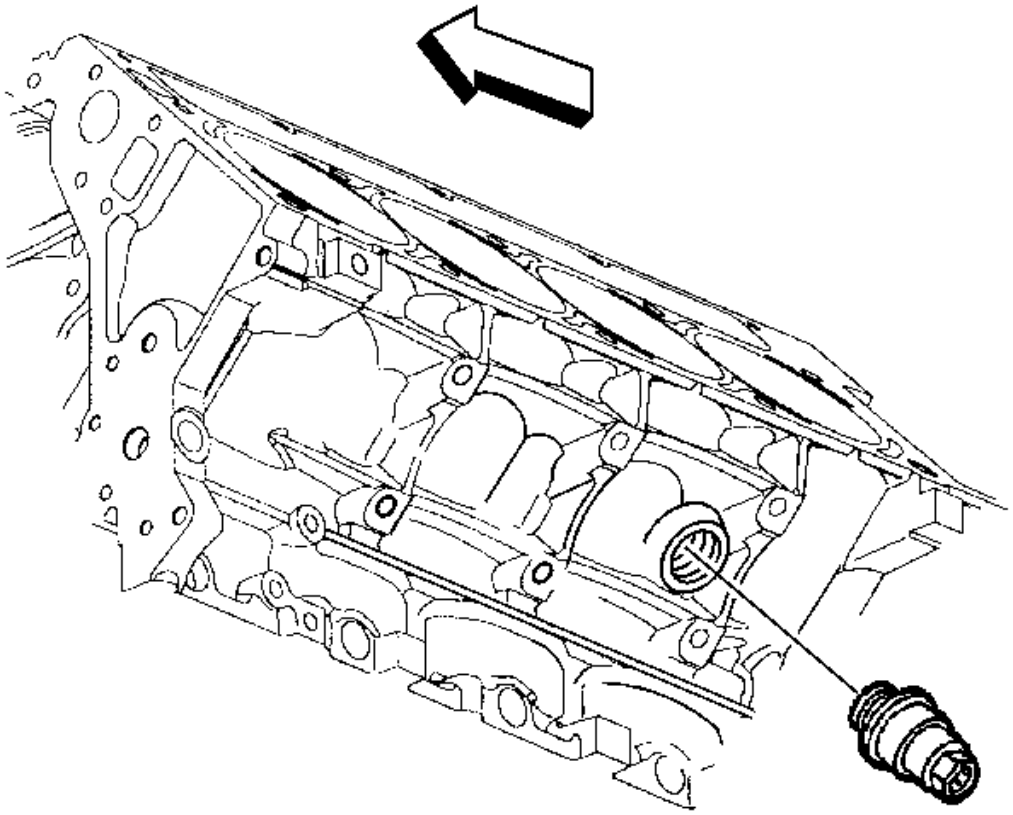

Fig. 382: Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the engine block front oil gallery plug unless service is required. If the front oil gallery plug is removed for service, a NEW oil gallery plug must be installed.

1. Remove the engine block coolant heater.

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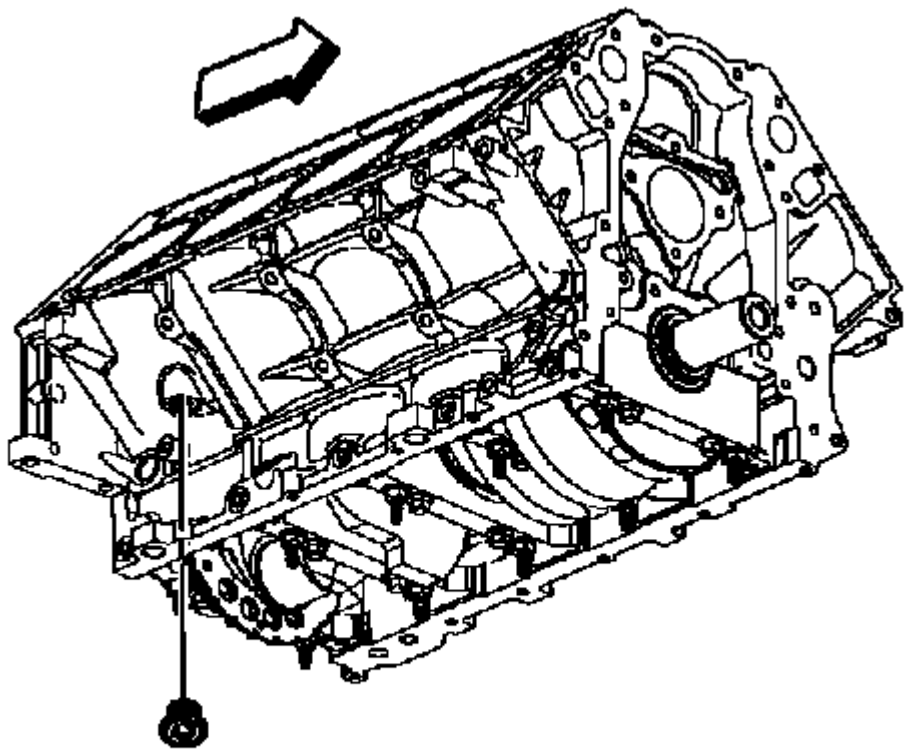

Fig. 383: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block coolant drain hole plug.

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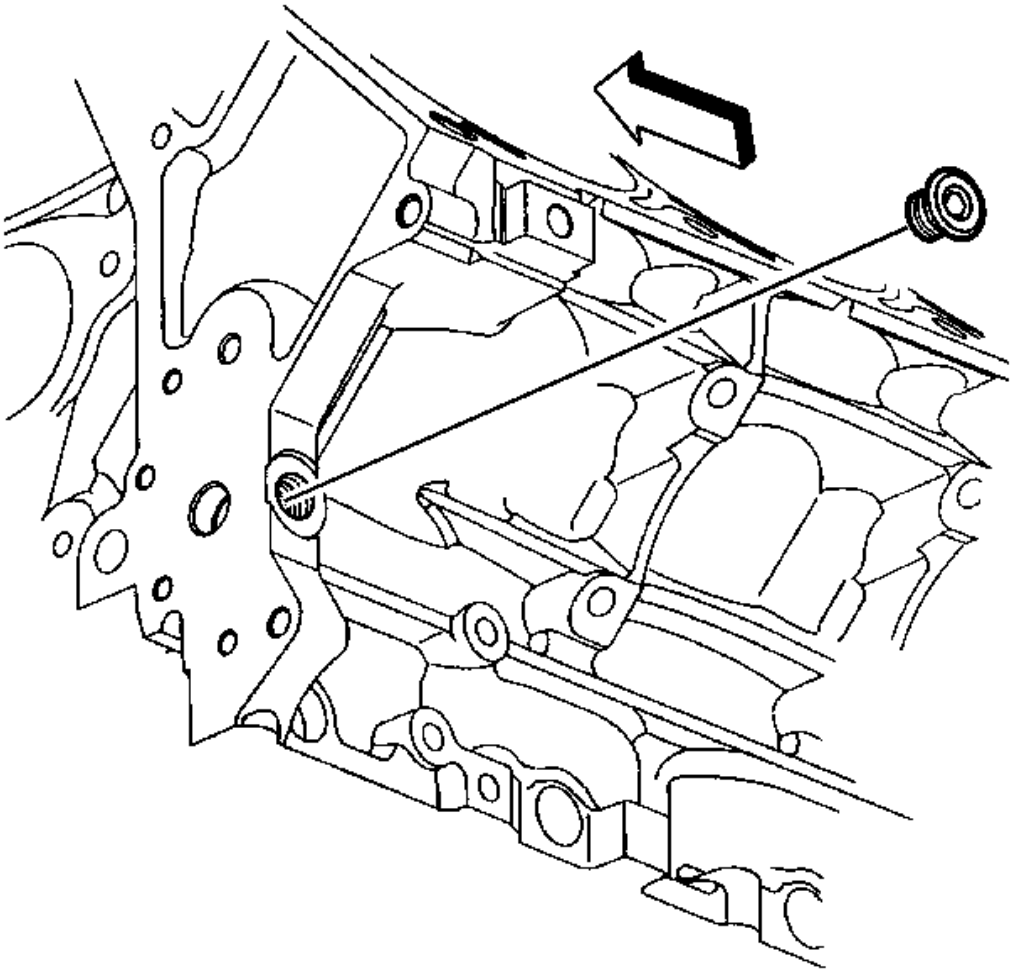

Fig. 384: Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block left front oil gallery plug.

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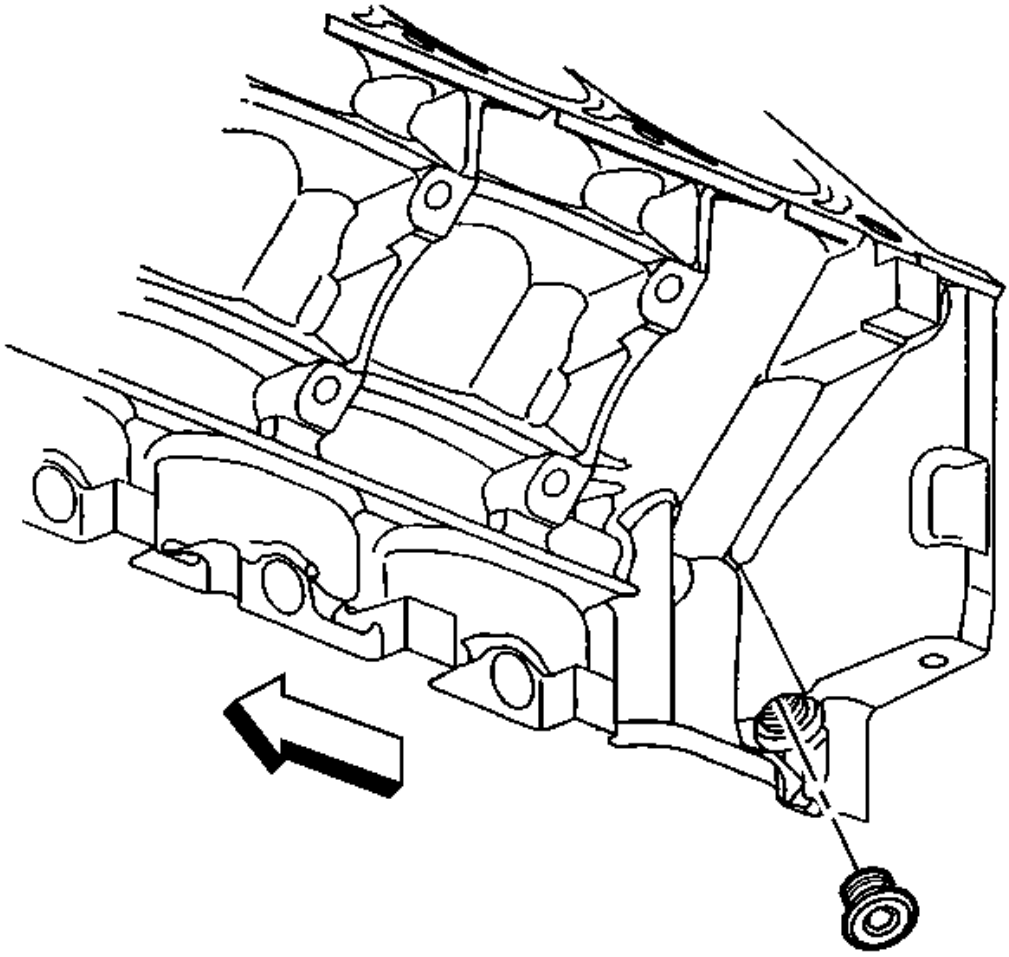

Fig. 385: View Of Engine Block Left Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block left rear oil gallery plug.
5. Inspect the block plug sealing washers.

If the block plug and heater sealing washers are not damaged, they may be used during assembly.

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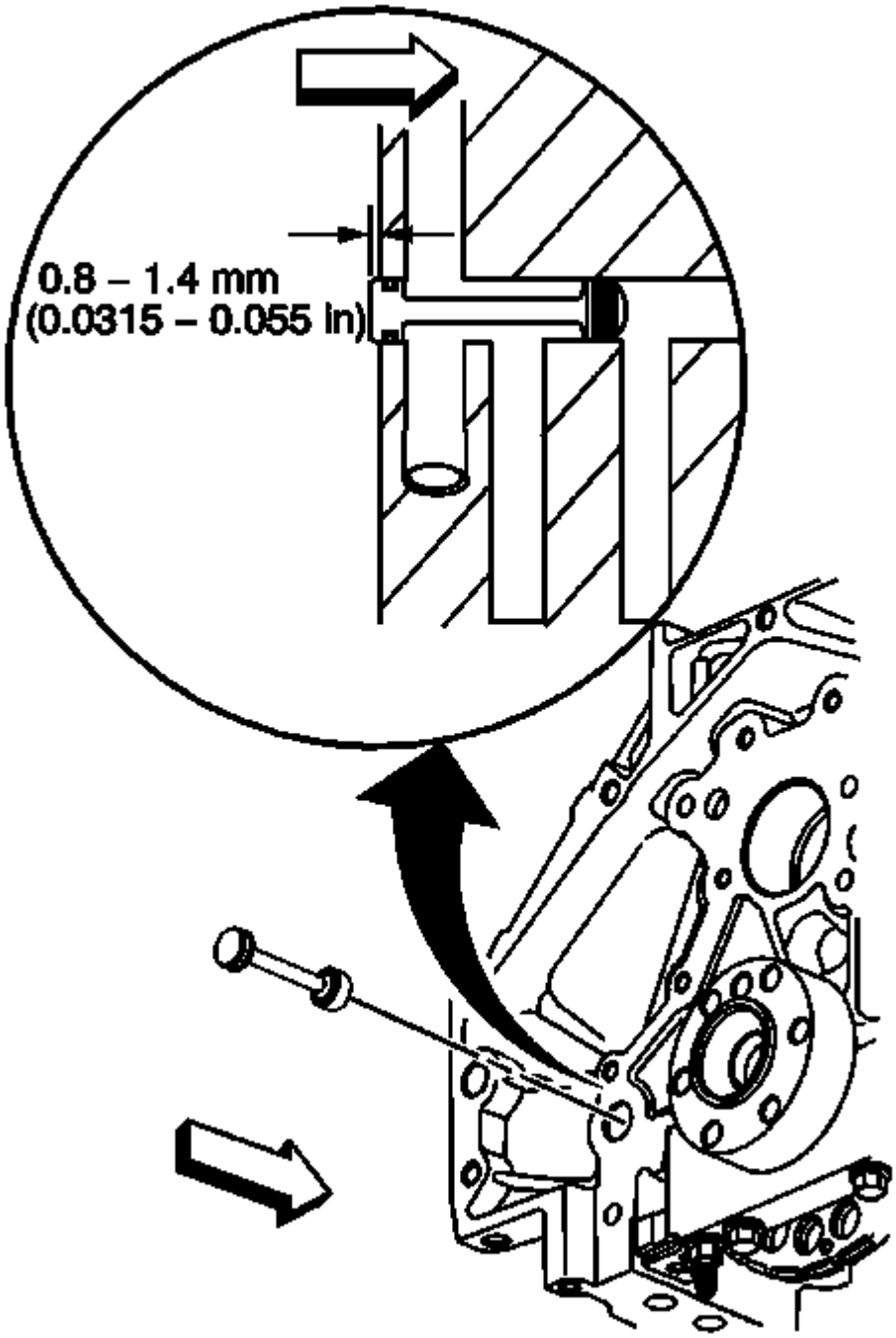

Fig. 386: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine block rear oil gallery plug.
7. Inspect the O-ring seal of the rear oil gallery plug.

   If the O-ring seal is not cut or damaged, the plug and O-ring seal may be used during assembly.

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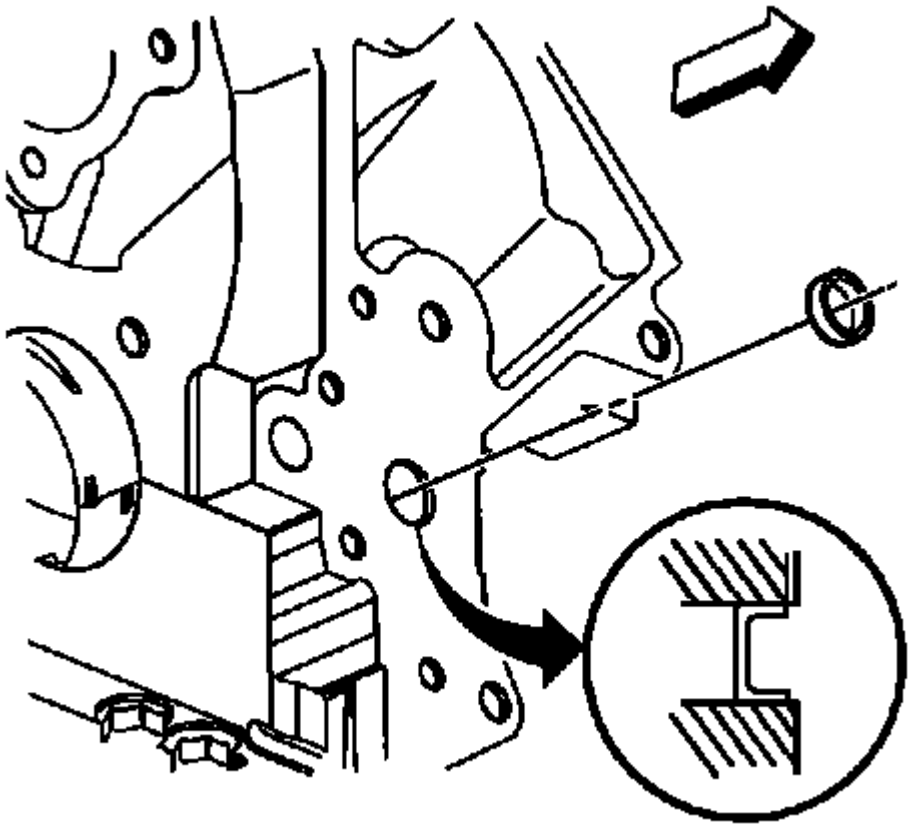

Fig. 387: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the front oil gallery plug only if service is required. If the front oil gallery plug is removed, a NEW oil gallery plug must be installed.

8. Remove the engine block front oil gallery plug.

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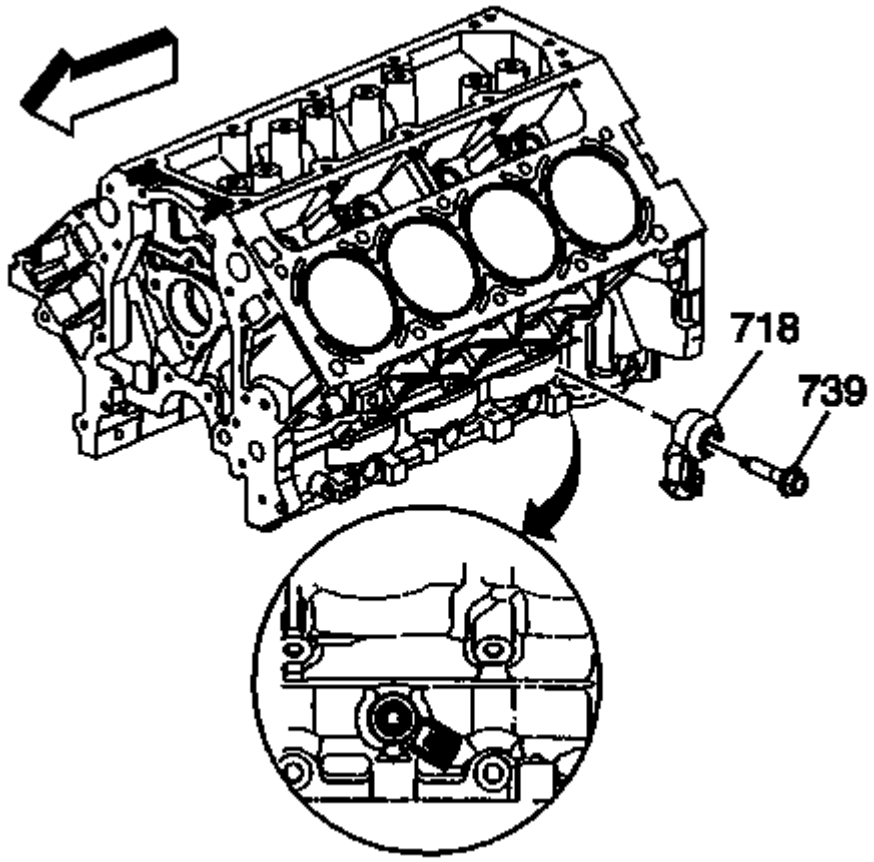

Fig. 388: Left Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

9. Remove the left side knock sensor (718) and bolt (739).

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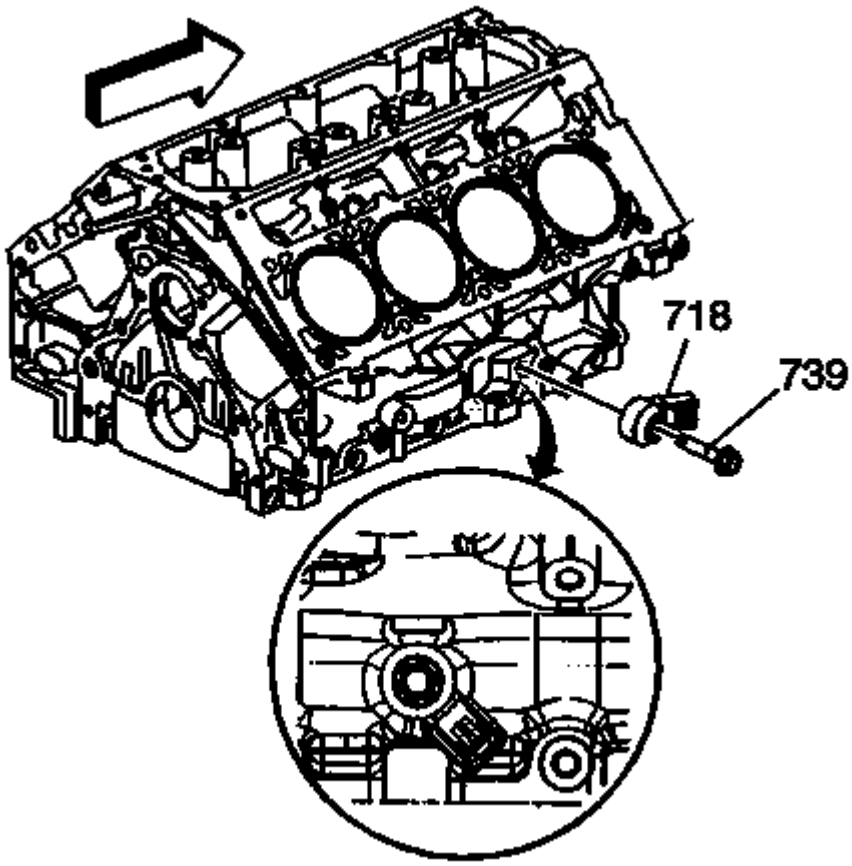

Fig. 389: Right Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

10. Remove the right side knock sensor (718) and bolt (739).

Engine Block Cleaning and Inspection

Tools Required

- **J 8087** Cylinder Bore Gage
- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.

Cleaning Procedure

NOTE: Do not use a caustic solution to clean the aluminum engine block.

IMPORTANT: When cleaning the engine block in a thermal type oven, do not exceed 450°F (232°C).

Clean the following components:

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- Remove all sludge, dirt, or debris using a cleaning solvent or thermal type oven. Refer to **Cleanliness and Care**.
- Gasket surfaces

  Refer to **Replacing Engine Gaskets**.

- Coolant passages
- Oil galleries
- Main bearing caps
- Cylinder head bolt holes to remove threadlocking material

  Thread repair driver tool J 42385-107 may be used to clean the threads of old threadlocking material.

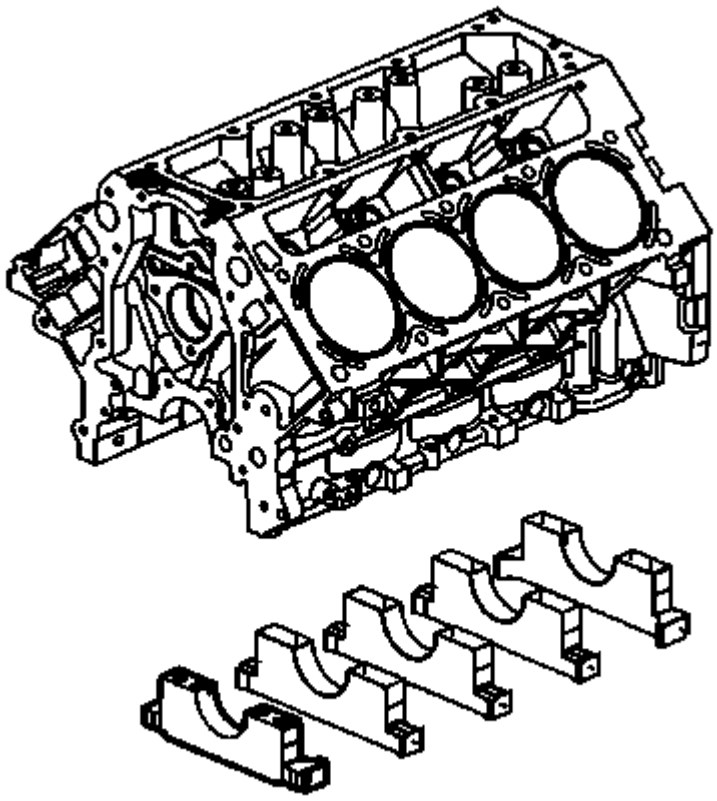

Fig. 390: Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

Inspection Procedure

1. Inspect the following components:
   - Cylinder walls for excessive scratches, gouging, or ring ridge

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- Cylinder bores for excessive ring ridge at the top of the cylinder
- Coolant jacket for cracks
- Valve lifter bores for excessive scoring or wear
- Crankshaft bearing webs for cracks
- Gasket sealing surfaces for excessive scratches or gouging

  Refer to **Replacing Engine Gaskets**.

- Oil galleries for restrictions
- Threaded bolt holes for damaged threads
- Scoring or damage to the displacement on demand oil passages or sealing surfaces

2. Measure the cylinder bores for excessive ring ridge at the top of the cylinder.

Measuring the Cylinder for Oversize

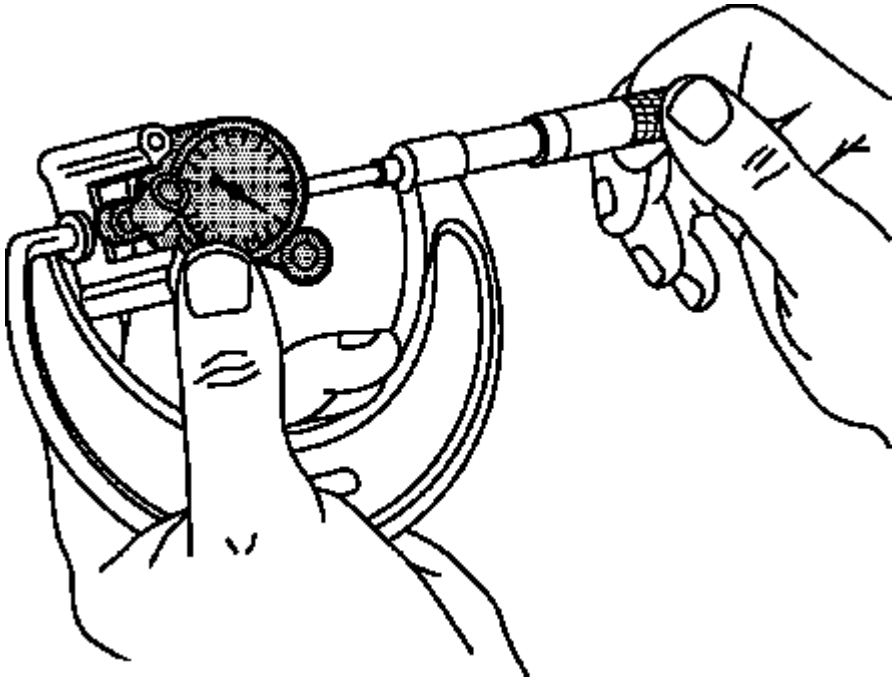

Fig. 391: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical Specifications**.
2. Insert the **J 8087** bore gage into the micrometer and zero the bore gage dial.

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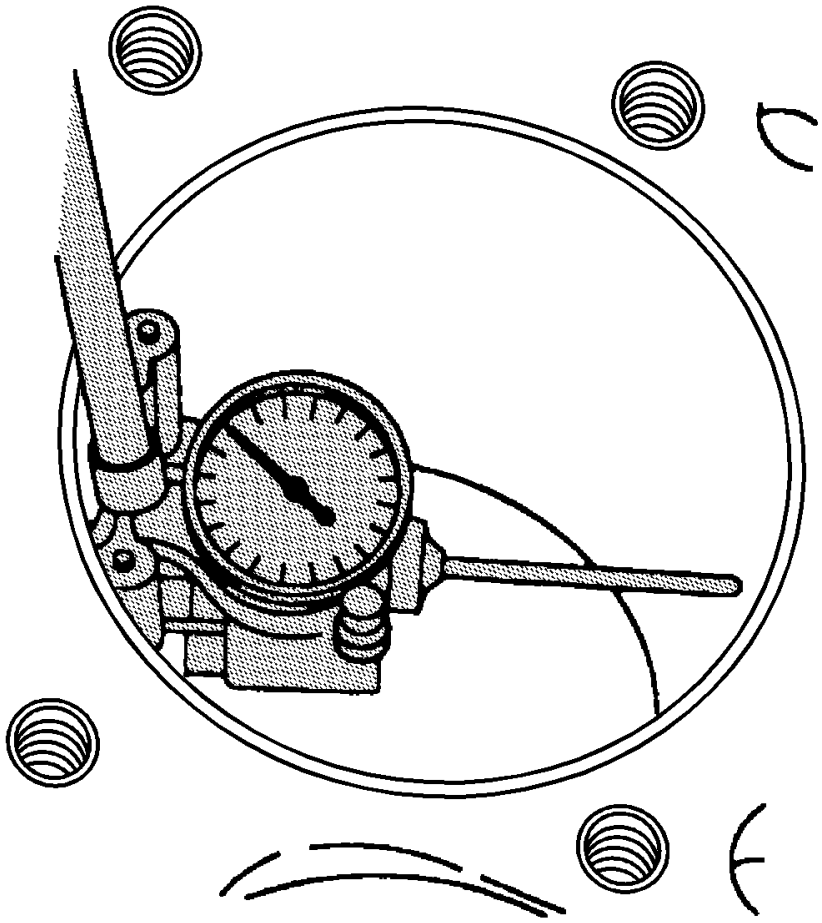

Fig. 392: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Using the **J 8087** , measure the cylinder bore for oversize.

   Slide the bore gage up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center, and bottom of the bore. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston. Refer to **Engine Mechanical Specifications**.

Cylinder Boring and Honing

Boring Procedure

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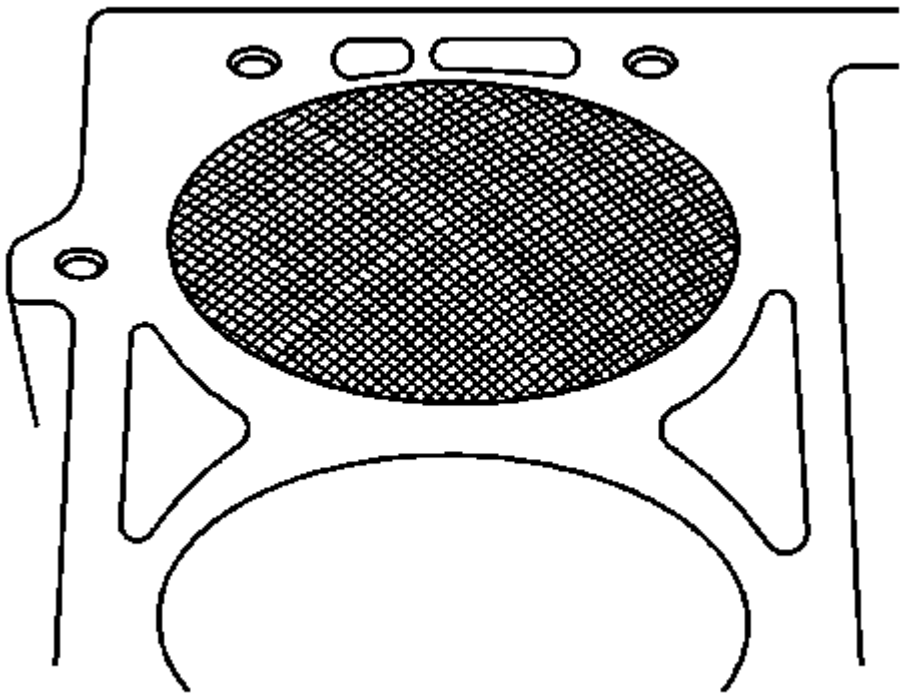

Fig. 393: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A 0.5 mm (0.02 in) oversize service piston and a piston ring set are available.

1. Measure all pistons with a micrometer to determine the cylinder bore diameter.
2. Before you use any type of boring bar, use a fine file and clean the top of the cylinder block removing any dirt or burrs. If you do not check the cylinder block, the boring bar may be improperly positioned or tilted and the cylinder bore could be bored at an incorrect angle.
3. Carefully follow the instructions furnished by the manufacturer regarding use of the equipment.
4. When you bore the cylinders, ensure all the crankshaft bearing caps are in place. Tighten the crankshaft bearing caps to the proper torque in order to avoid distortion of the cylinder bores during final assembly.
5. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for the finish honing and fit of the piston.

Honing Procedure

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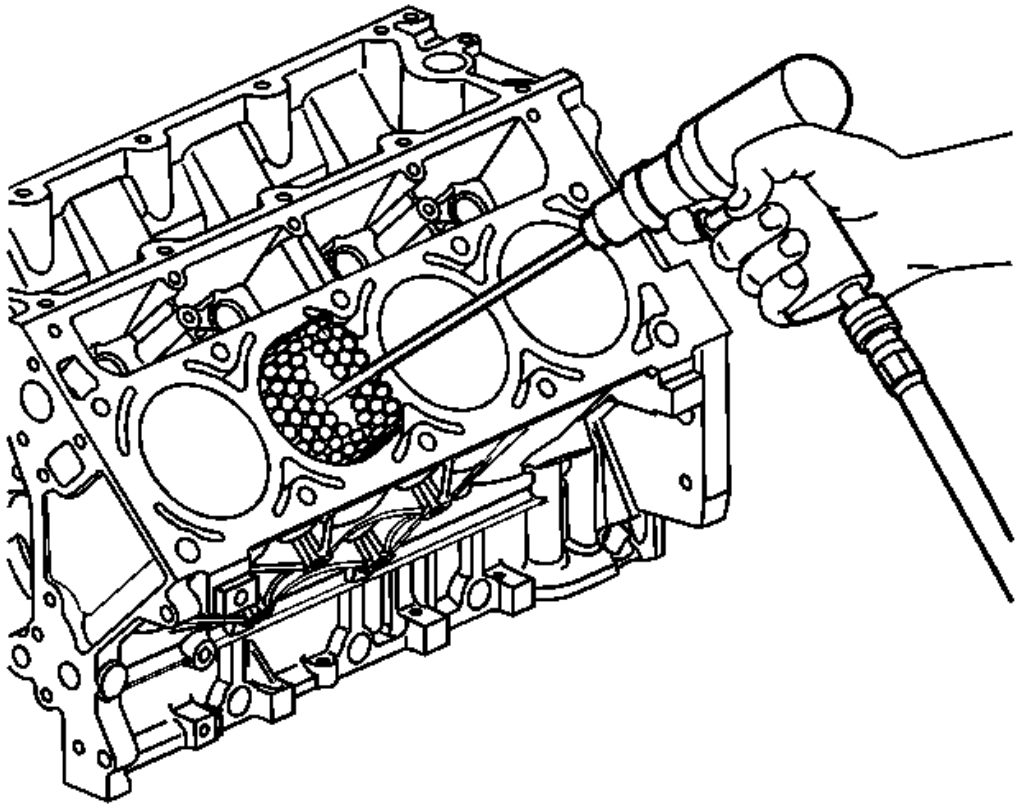

Fig. 394: Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. When honing the cylinders, 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 you remove. Dull, dirty stones cut unevenly and generate excessive heat. Do not hone to final clearance with a coarse or medium-grade stone. Leave sufficient metal so that all stone marks may be removed with fine-grade stones. Perform final honing with a fine-grade stone, honing the cylinder to the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore. Repeatedly inspect the cylinder bore for fit with the selected piston.

   All measurements of the piston or the cylinder bore should be made with the components at normal room temperature.

3. When honing a cylinder for fit to an oversize piston, first perform the preliminary honing with a 100 grit stone.
4. Perform final cylinder honing with a 240 grit stone and obtain a 45 degree cross hatch pattern.

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Repeatedly check the measurement at the top, the middle, and the bottom of the bore.

A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.

5. The finish marks should be clean but not sharp. The finish marks should also be free from imbedded particles and torn or folded metal.
6. By measuring the selected piston at the sizing point and by adding the average of the clearance specification, you can determine the final cylinder honing dimension required.
7. After final honing and before the piston is checked for fit, clean the cylinder bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material may cause premature wear of the new piston rings and the cylinder bores. Abrasive material will also contaminate the engine oil and may cause premature wear of the bearings. After washing the cylinder bore, dry the bore with a clean rag.
8. Perform final measurements of the piston and the cylinder bore.
9. Permanently mark the top of the piston for the specific cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Deglazing Procedure

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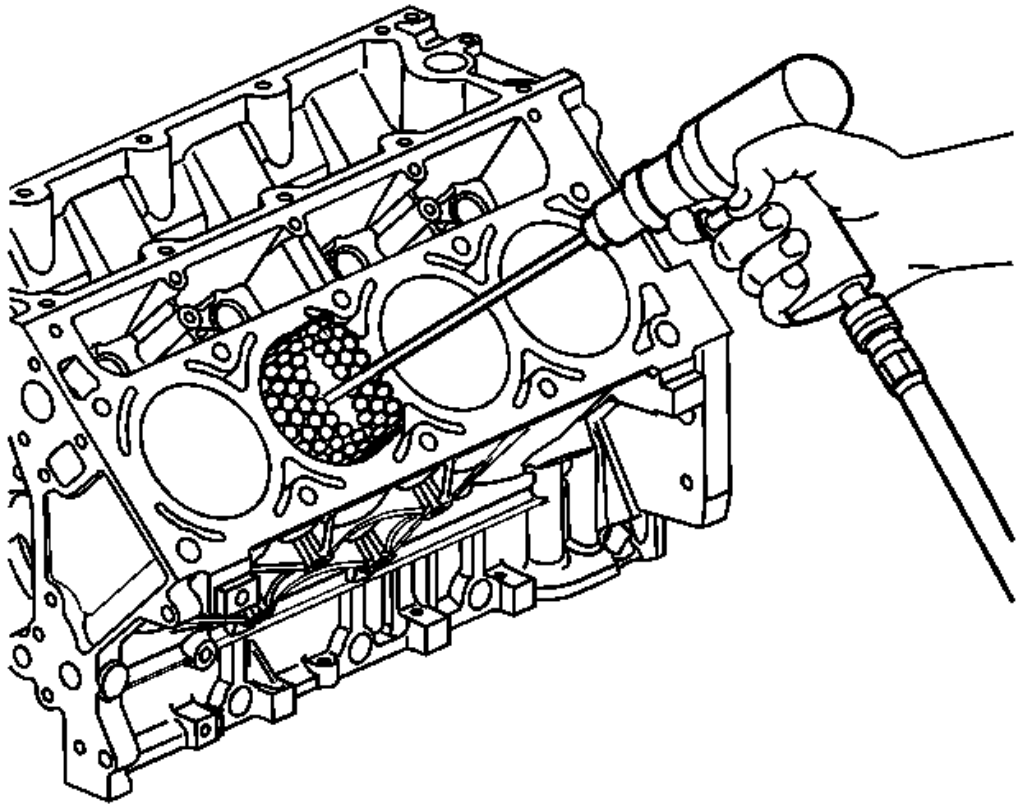

Fig. 395: Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

Using a ball type or self centering honing tool, deglaze the cylinder bore lightly. Deglazing should be done only to remove any deposits that may have formed. Use a 240 grit stone of silicone carbide or equivalent material when preforming the deglazing procedure.

A 240 grit stone is preferred for final honing. If a 240 grit stone is not available, a 220 grit stone may be used as a substitute.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator Set
- **J 43690** Rod Bearing Checking Tool. See **Special Tools**.
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit. See **Special Tools**.

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Cleaning Procedure

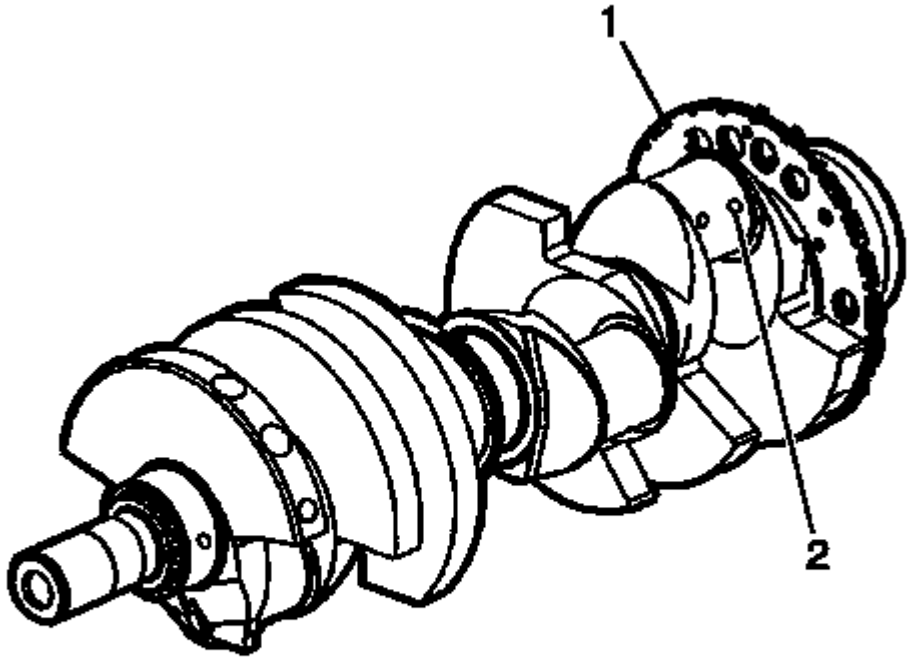

Fig. 396: Crankshaft Position Sensor Reluctor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the crankshaft position (CKP) sensor reluctor ring teeth. Nicks, burrs, or other damage to the teeth may effect on-board diagnostics (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages (2) and inspect for restrictions or burrs.

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

3. Dry the crankshaft with compressed air.

Inspection Procedure

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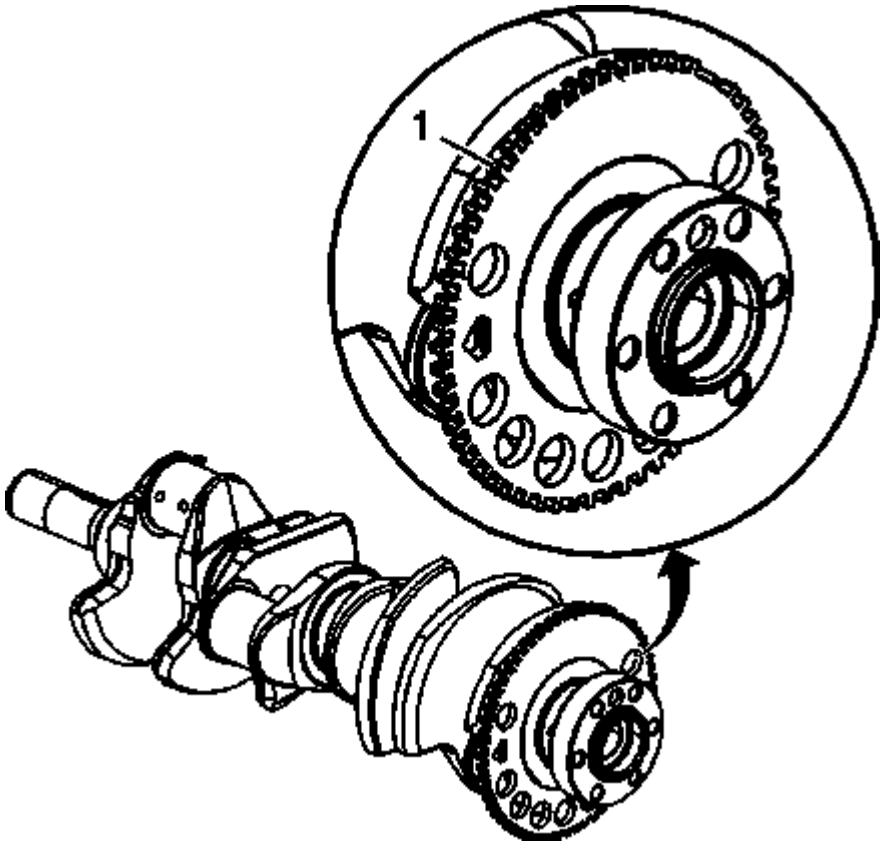

Fig. 397: CKP Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may effect OBD II system performance.

1. Perform a visual inspection of the crankshaft for damage.
2. Inspect the CKP reluctor ring teeth (1) for damage.

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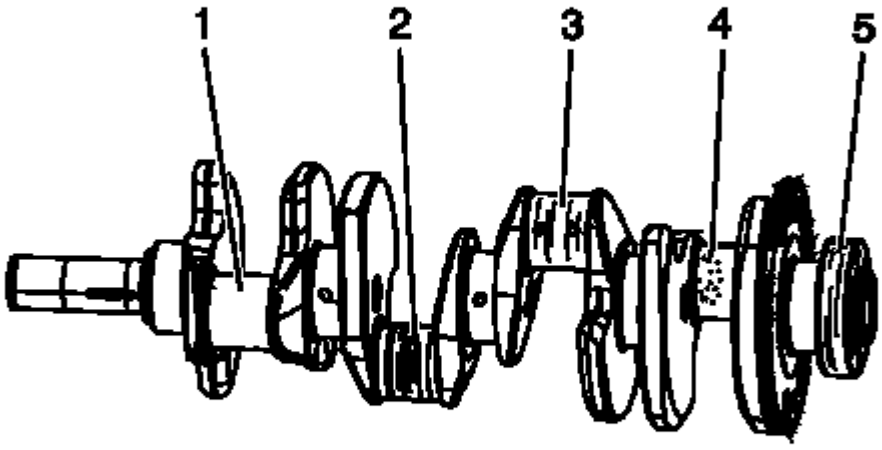

Fig. 398: Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft journals for wear (1).

   Journals should be smooth with no signs of scoring, wear, or damage.

4. Inspect the crankshaft journals for grooves or scoring (2).
5. Inspect the crankshaft journals for scratches or wear (3).
6. Inspect the crankshaft journals for pitting or imbedded bearing material (4).
7. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.

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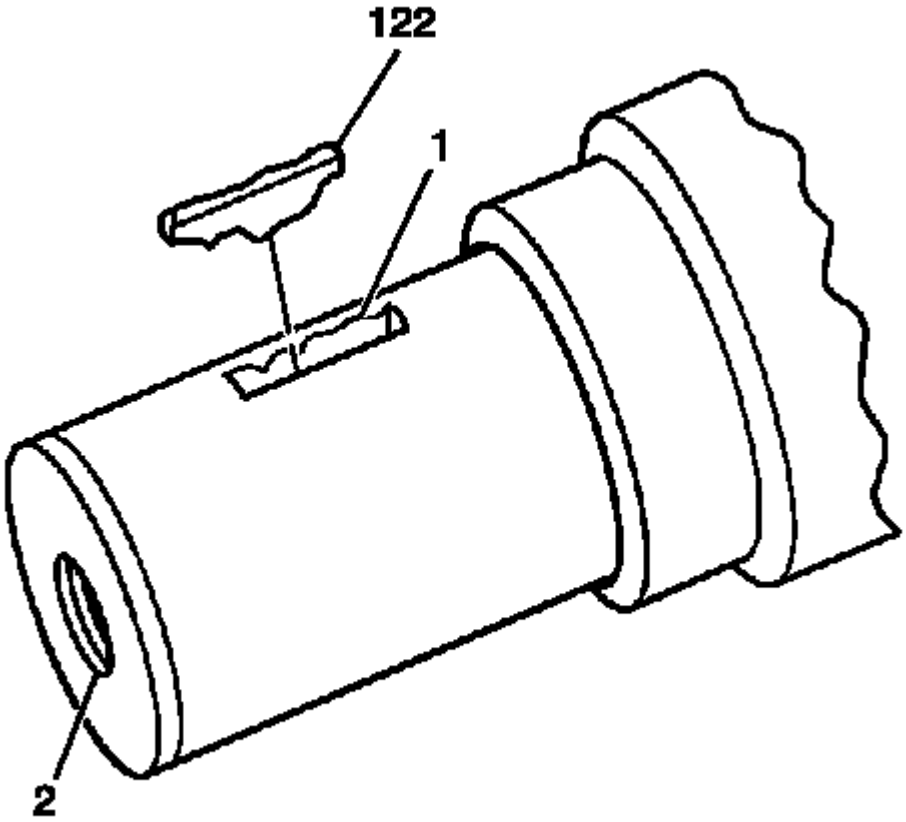

Fig. 399: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

8. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

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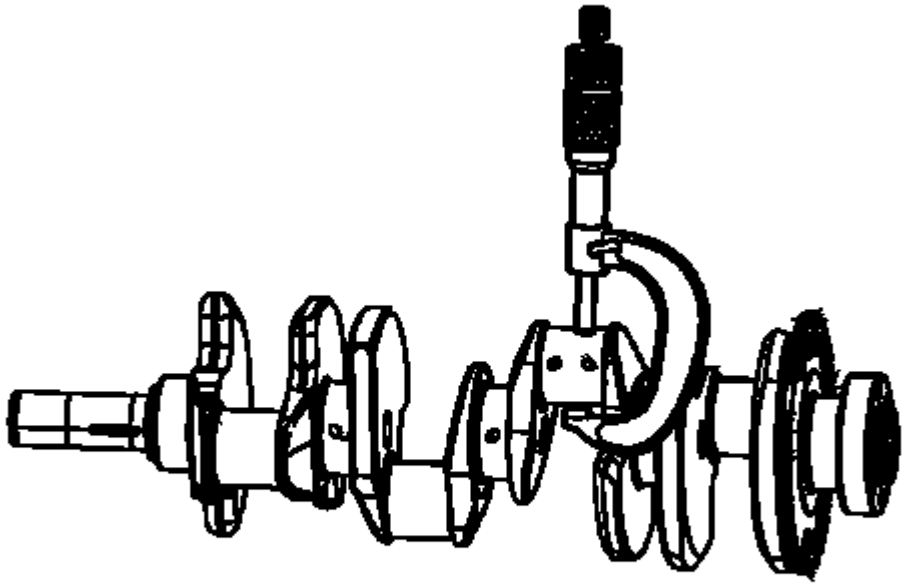

Fig. 400: Measuring Crank Pins For Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

9. Measure the crank pins for the out-of-round.
10. Measure the crank pins for taper.

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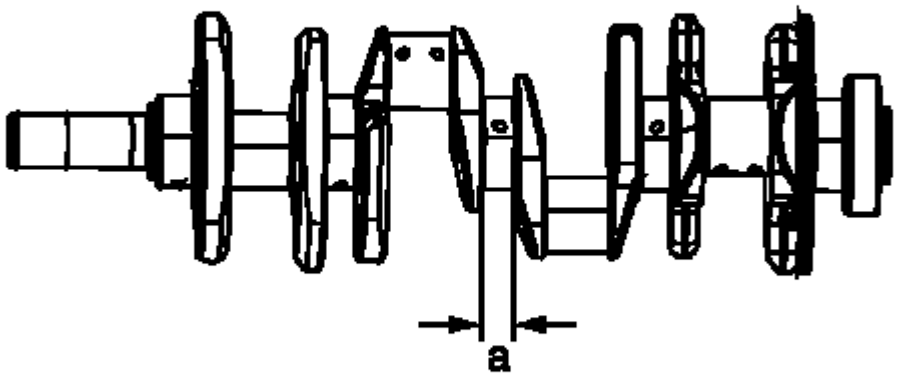

Fig. 401: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft thrust wall width.

    A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) (a) must be replaced.

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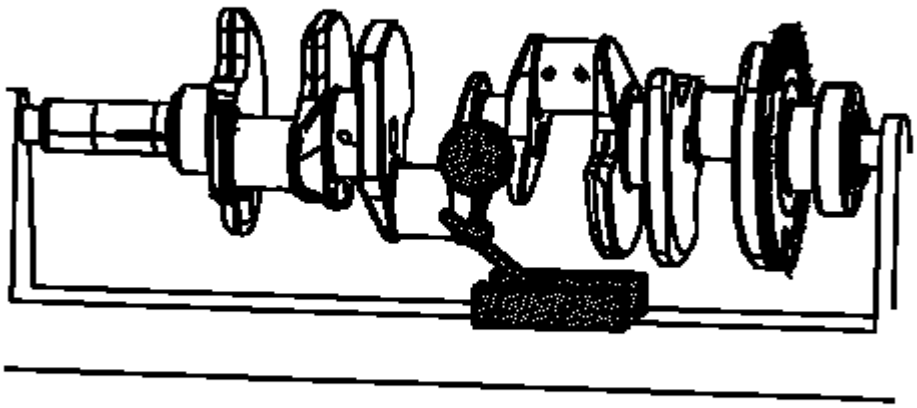

Fig. 402: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

    Use wooden V blocks or a fixture to support the crankshaft on the front and rear journals.

13. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
15. Use the **J 7872** in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

    If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.

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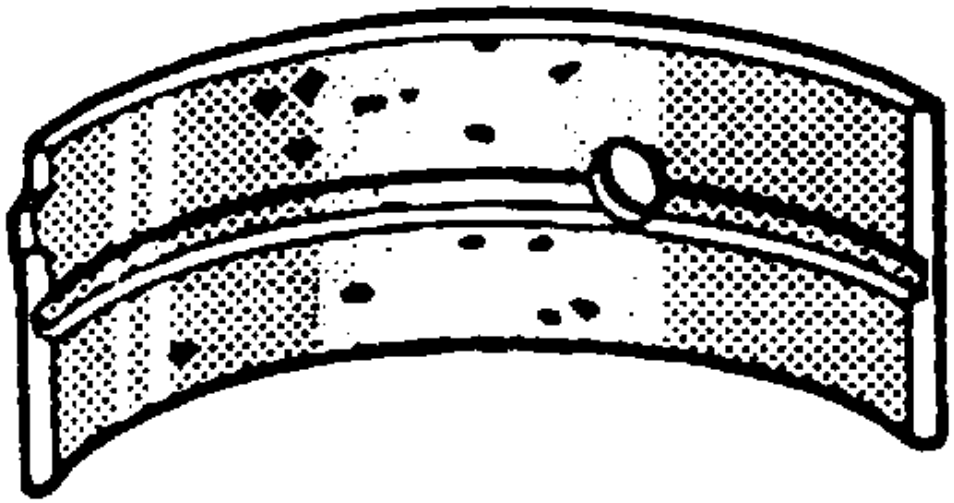

Fig. 403: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

16. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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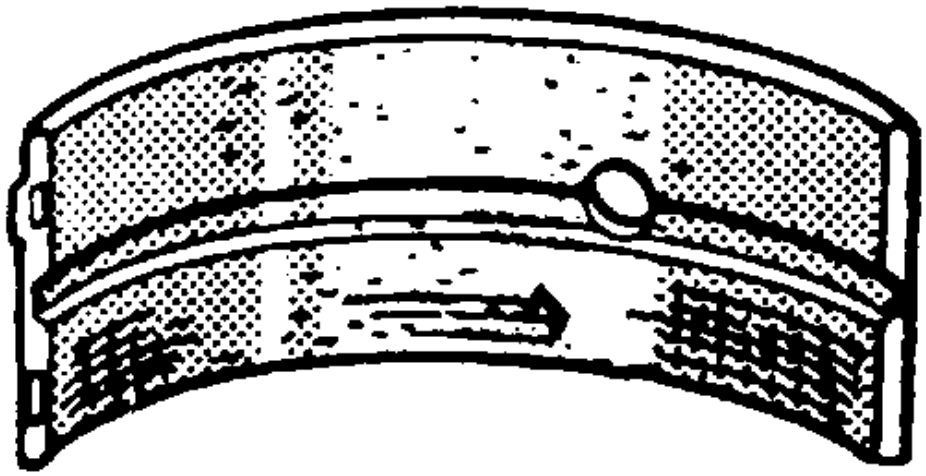

Fig. 404: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

17. Inspect the crankshaft bearings for excessive scoring or discoloration.
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

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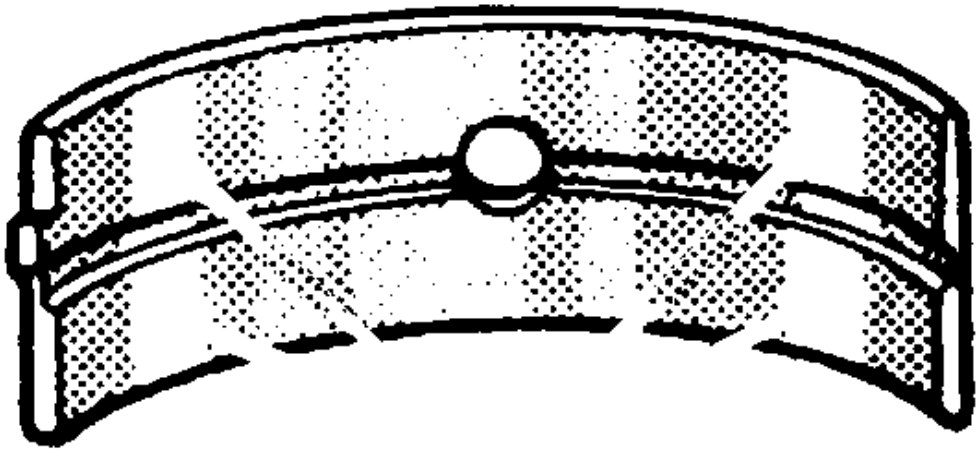

Fig. 405: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

19. 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, both upper and lower halves should be replaced.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Measuring Main Bearing Clearance - Gaging Plastic Method

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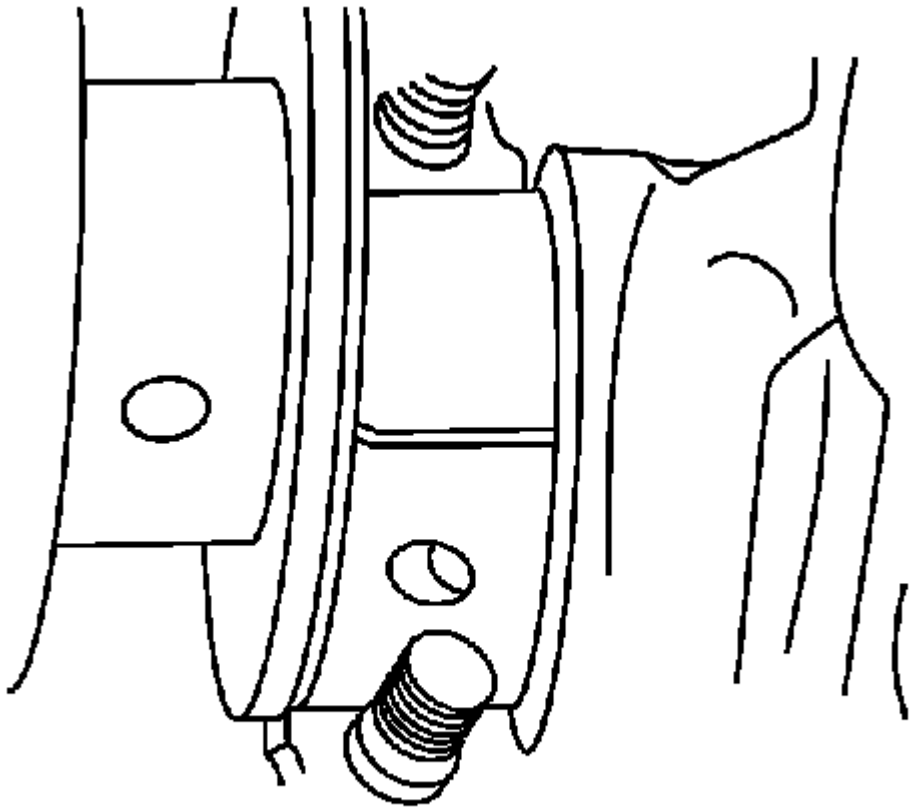

Fig. 406: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.**
- **Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.**
- **The crankshaft bearing clearances are critical. Excessive bearing clearance may effect CKP sensor signals and may effect on-board diagnostics (OBD) II system operation.**
- **Remove the bearing cap side bolts prior to cap removal.**

1. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearings Removal**.
2. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of the crankshaft bearing journal.
3. Install the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearings Installation**.

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4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearings Removal**.

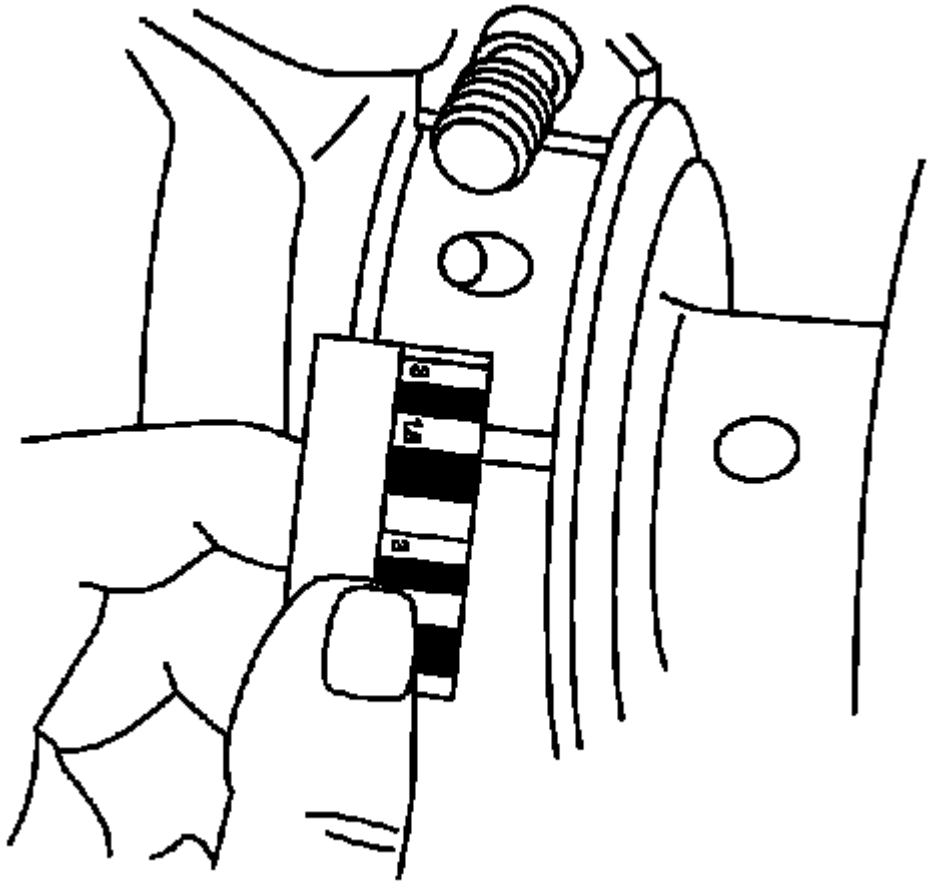

Fig. 407: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit.
   - If the gaging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
   - If clearance cannot be brought to specifications, replace the crankshaft or engine block as required. Refer to **Engine Mechanical Specifications**.

Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method

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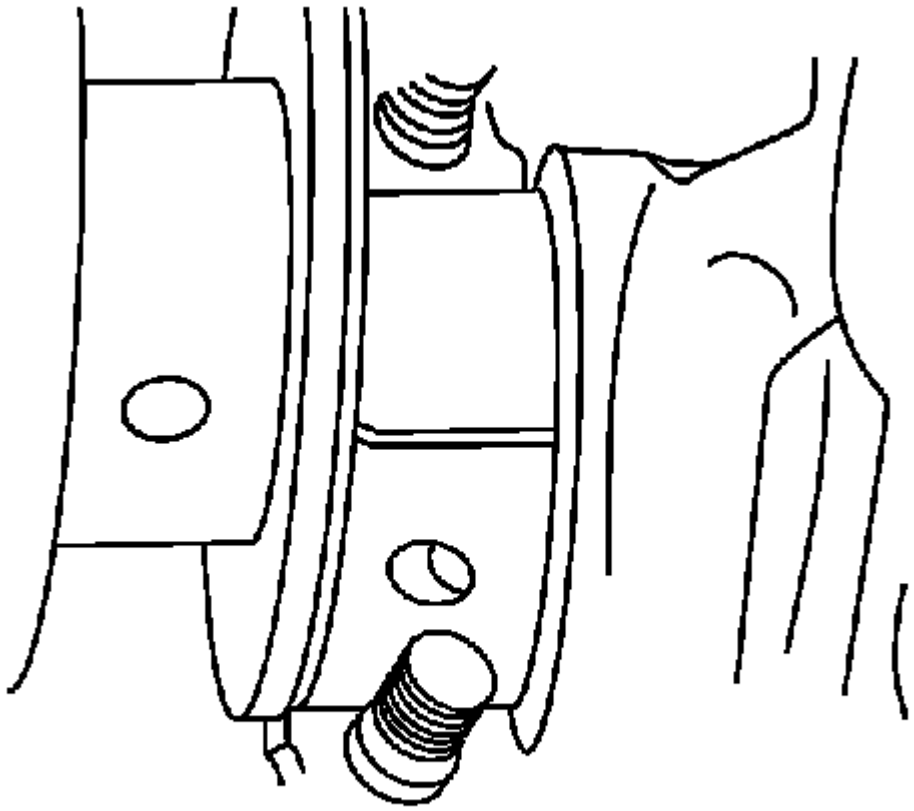

Fig. 408: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required.**
- **Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.**

1. Remove the bearing cap, bearing half and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.
2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.
3. Install the bearing cap, bearing half, and bolts. Refer to **Piston, Connecting Rod, and Bearing Installation**.
4. Remove the bearing cap, bearing half and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.

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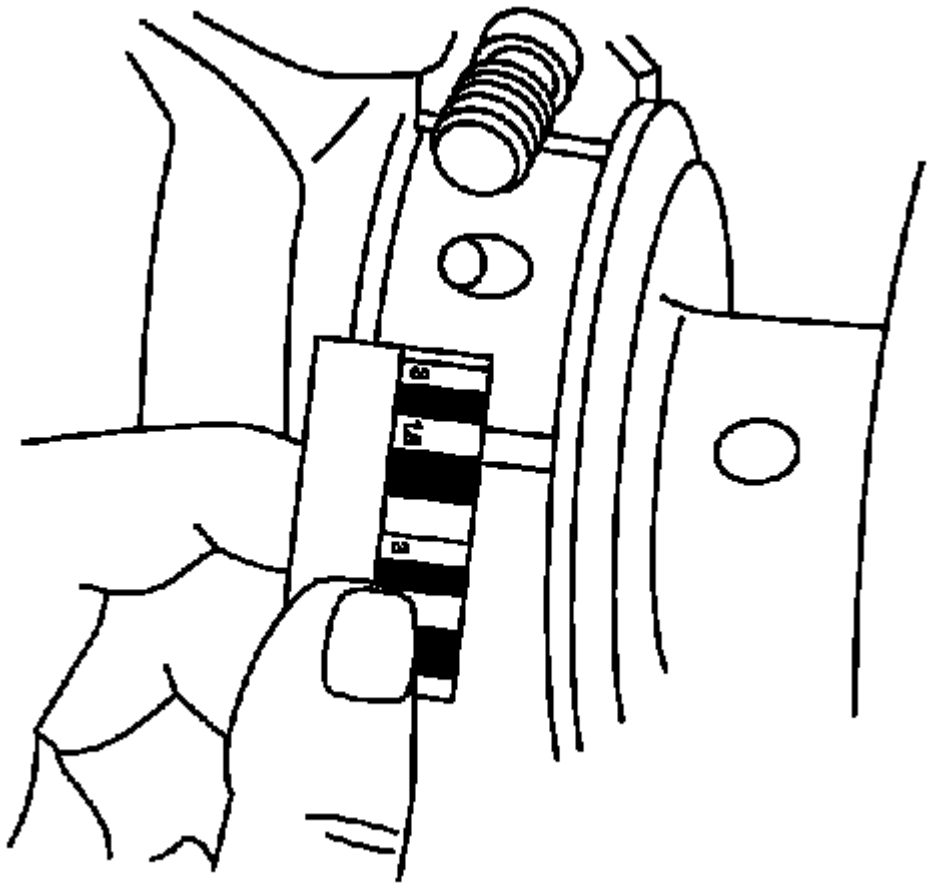

Fig. 409: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

5. Measure the gaging plastic at its widest area using the scale supplied with the plastic gaging kit. Refer to **Engine Mechanical Specifications**.

Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

J 43690 and **J 43690-100** have been developed as a more accurate method to measure connecting rod bearing clearances. See **Special Tools**. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

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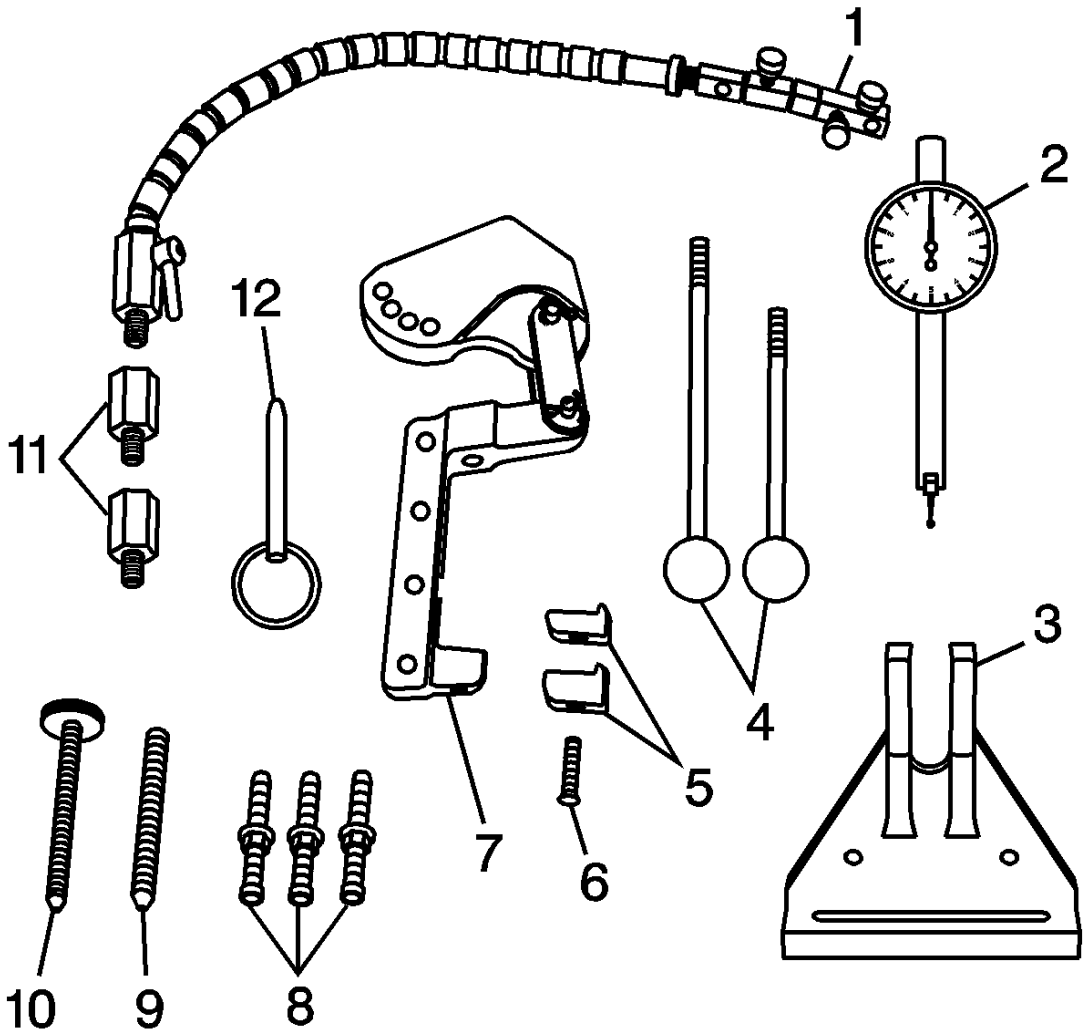

Fig. 410: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

J 43690 Rod Bearing Checking Tool. See Special Tools.

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)
- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)

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- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

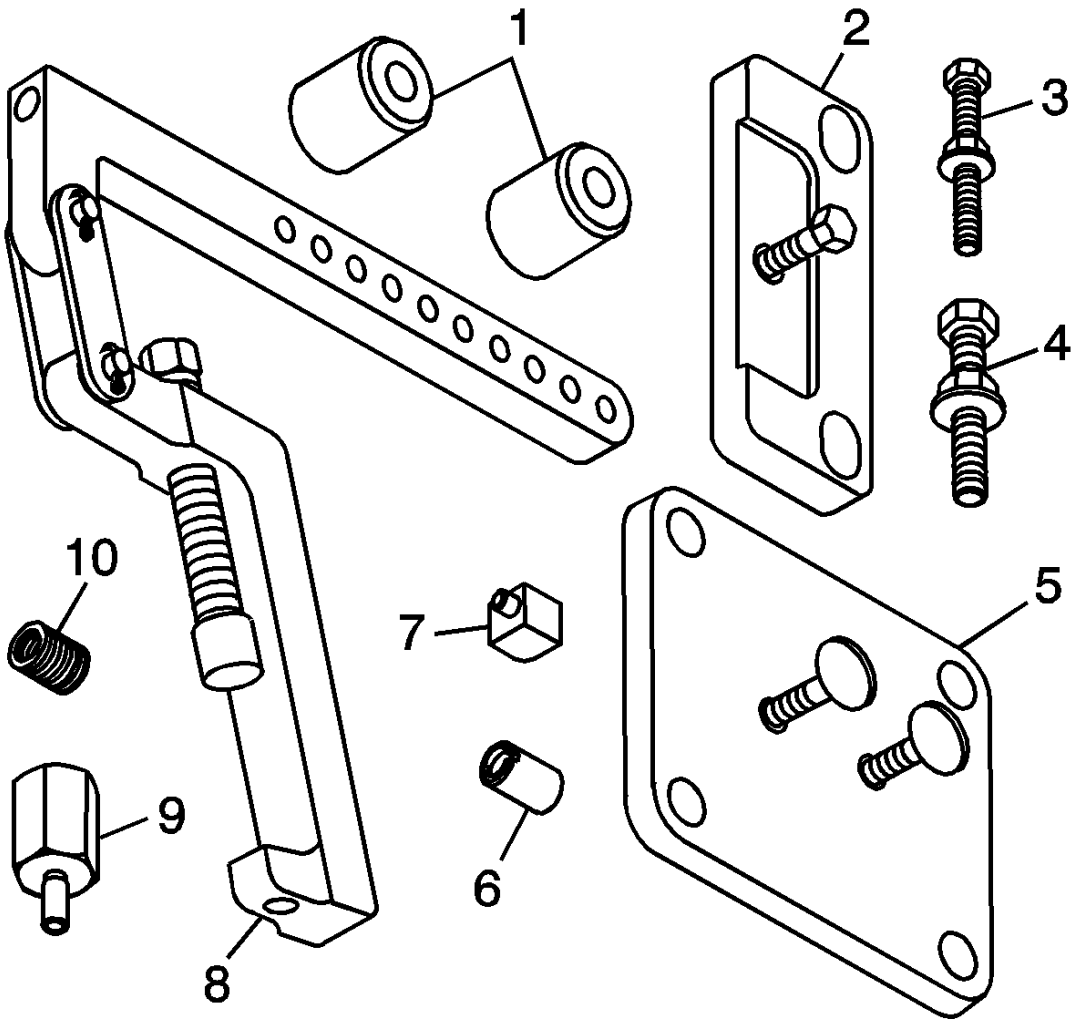

Fig. 411: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

J 43690-100 Rod Bearing Checking Tool - Adapter Kit. See Special Tools.

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)

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- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

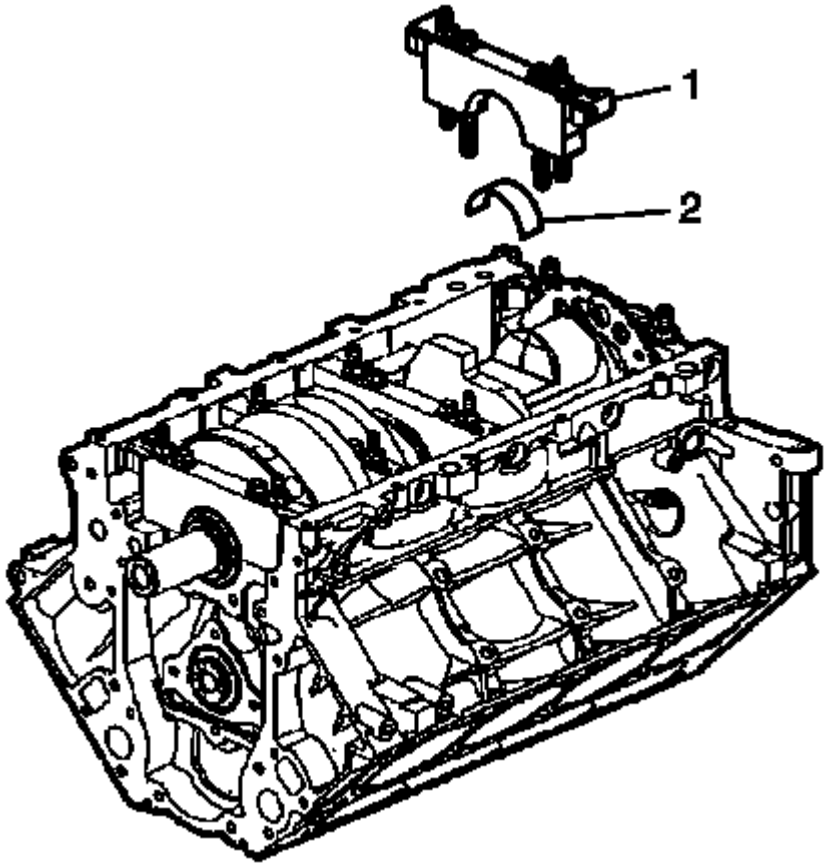

Fig. 412: View Of Bearing Cap, Bolt & Bearing Half
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to **Fastener Tightening Specifications**.

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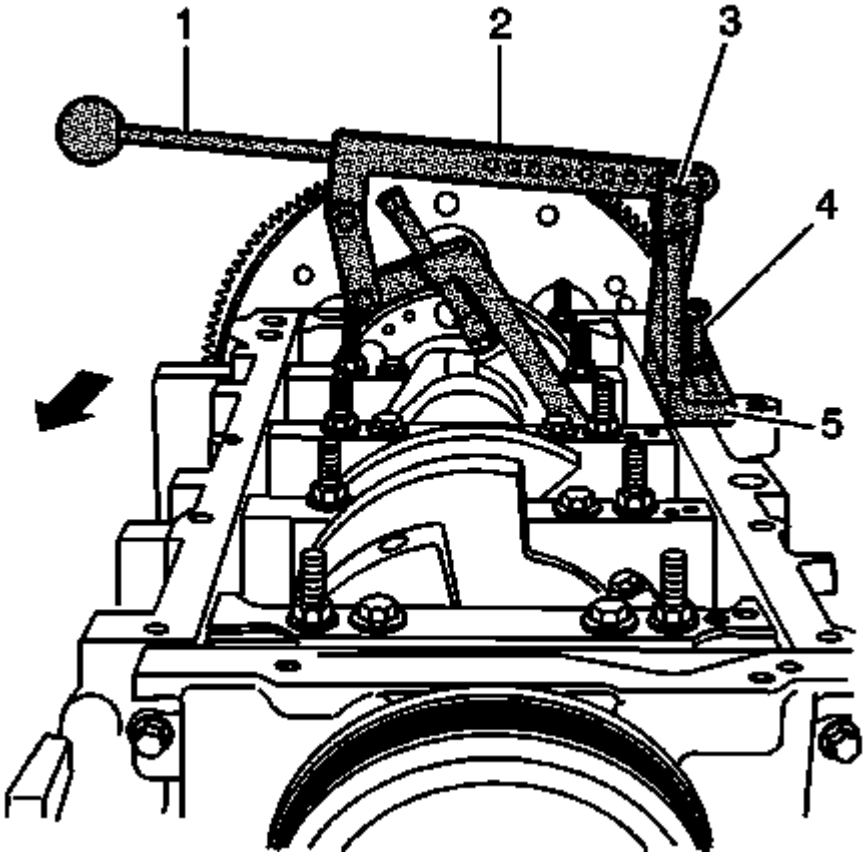

Fig. 413: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Install the following:
    1. J 43690-2 (5)
    2. J 43690-3 (4)
    3. J 43690-101 (2)
    4. 280310 (3)
    5. J 43690-5 (1)

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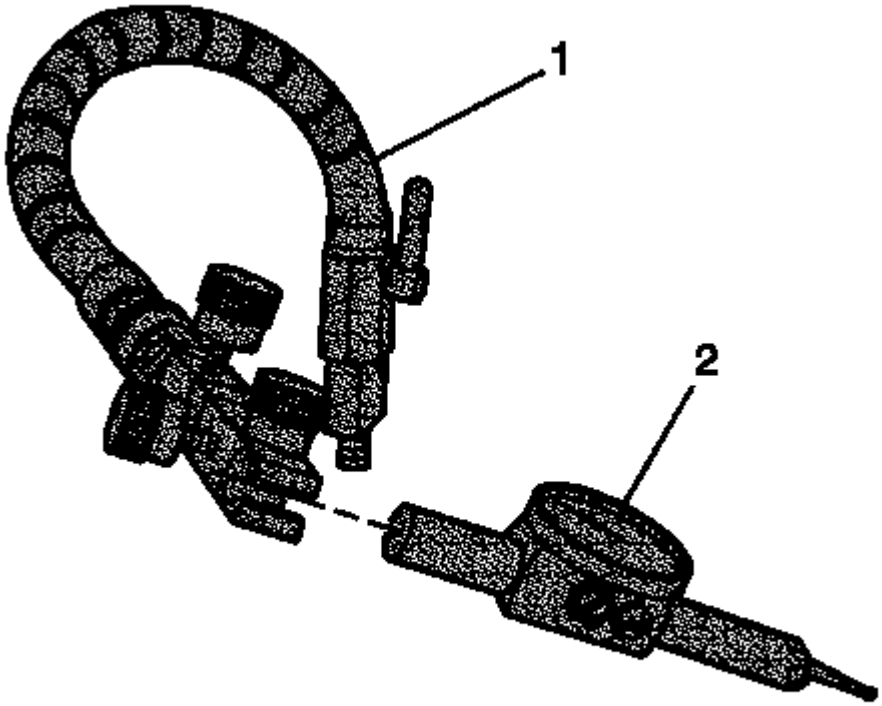

Fig. 414: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

   A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components as required.

Crankshaft Balancer Cleaning and Inspection

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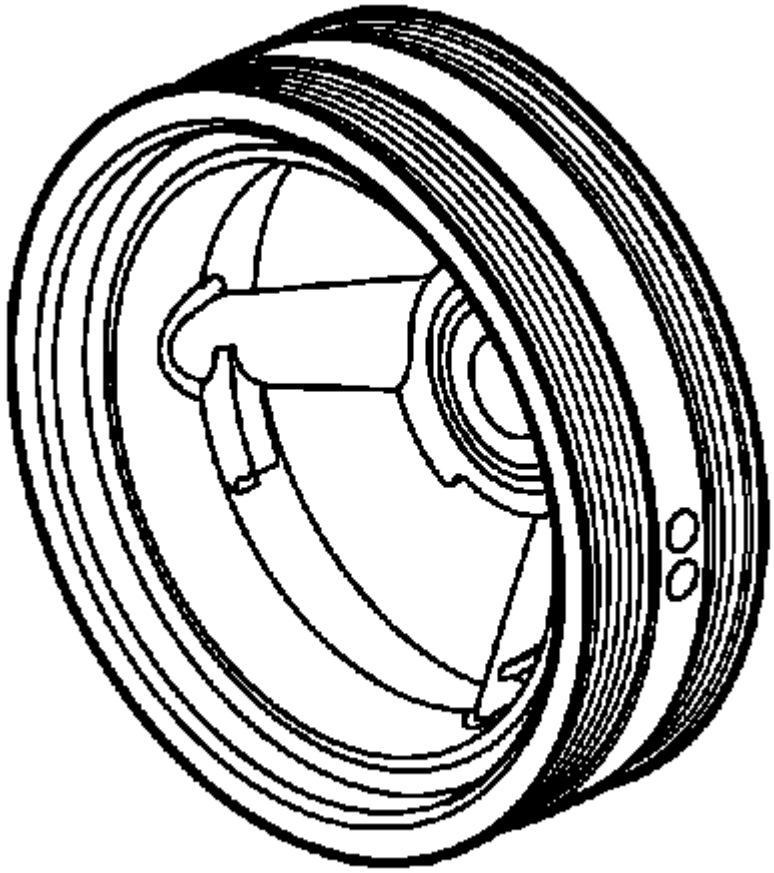

Fig. 415: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following conditions:
   - Worn, grooved, or damaged hub seal surface

     A crankshaft balancer 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

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The balancer 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

Engine Flywheel Cleaning and Inspection

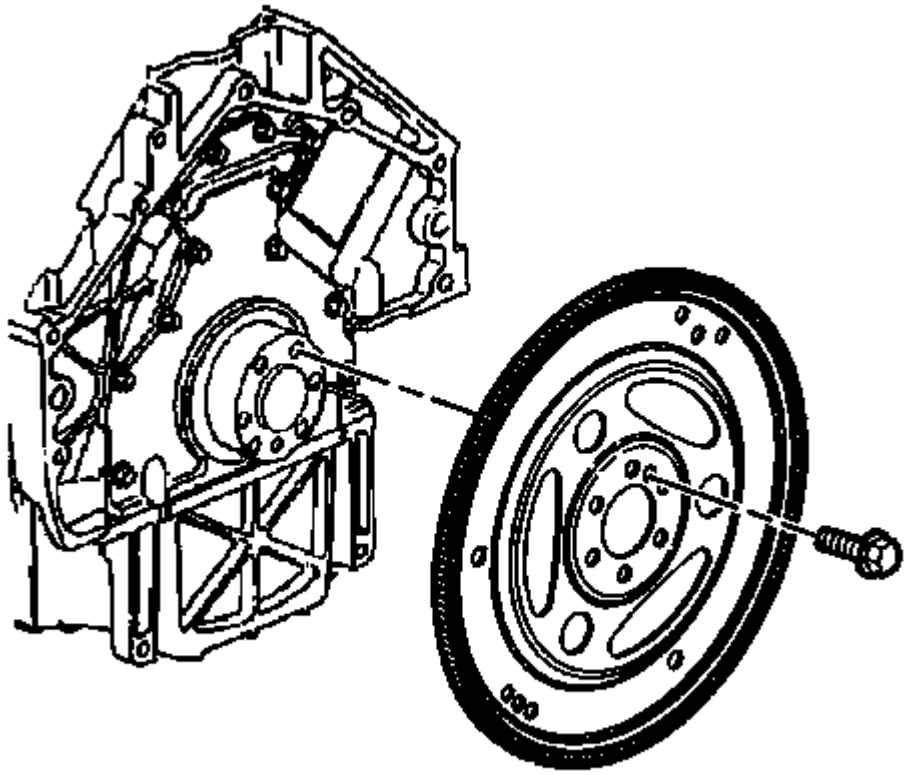

Fig. 416: Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.
2. Dry the flywheel with compressed air.
3. Inspect the flywheel for the following conditions:
   - Damaged ring gear teeth
   - 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

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the flywheel plate. Install a new flywheel.

- Welded areas that retain the ring gear onto the flywheel for cracking

Piston and Connecting Rod Disassemble

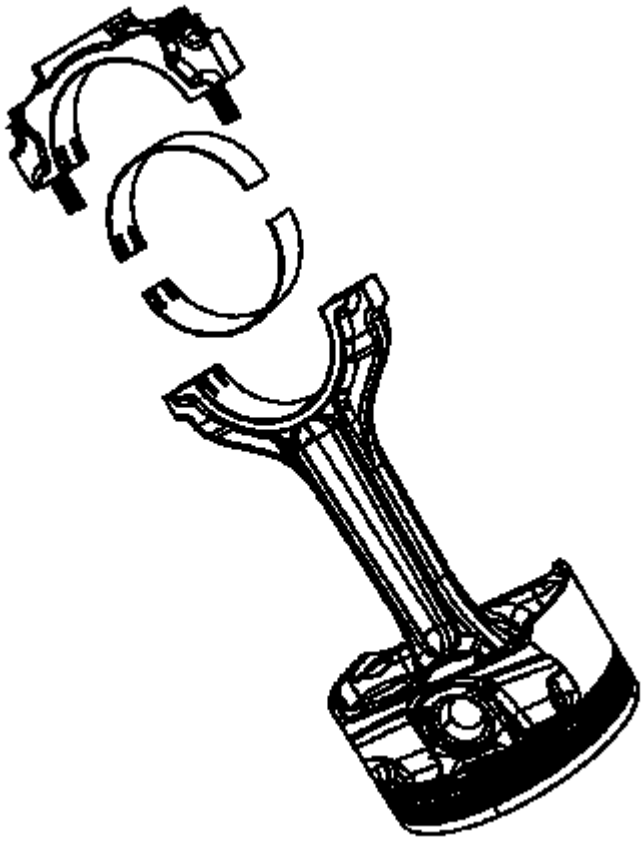

Fig. 417: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings from the rod and cap.

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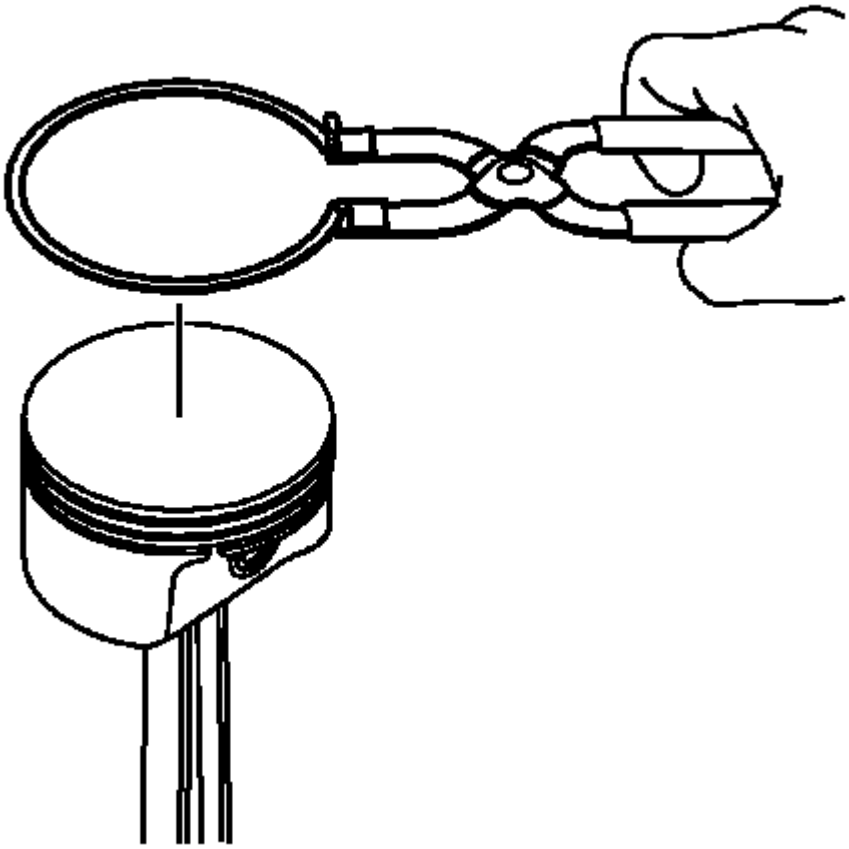

Fig. 418: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

2. Using piston ring pliers, remove the piston rings from the piston.

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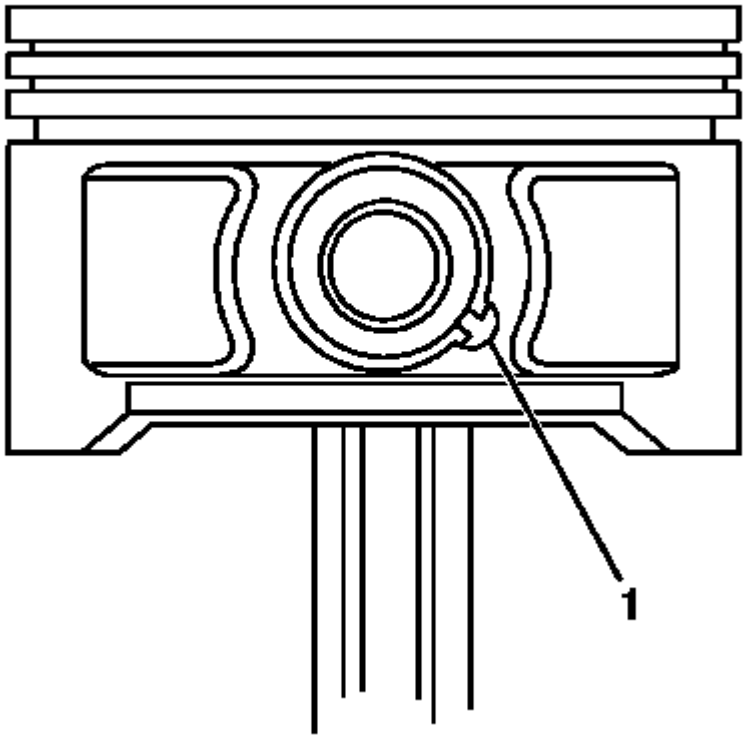

Fig. 419: View Of Piston Pin Retaining Clip & Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retainers until the ring end gap is positioned in the cutout area (1) of the pin bore.

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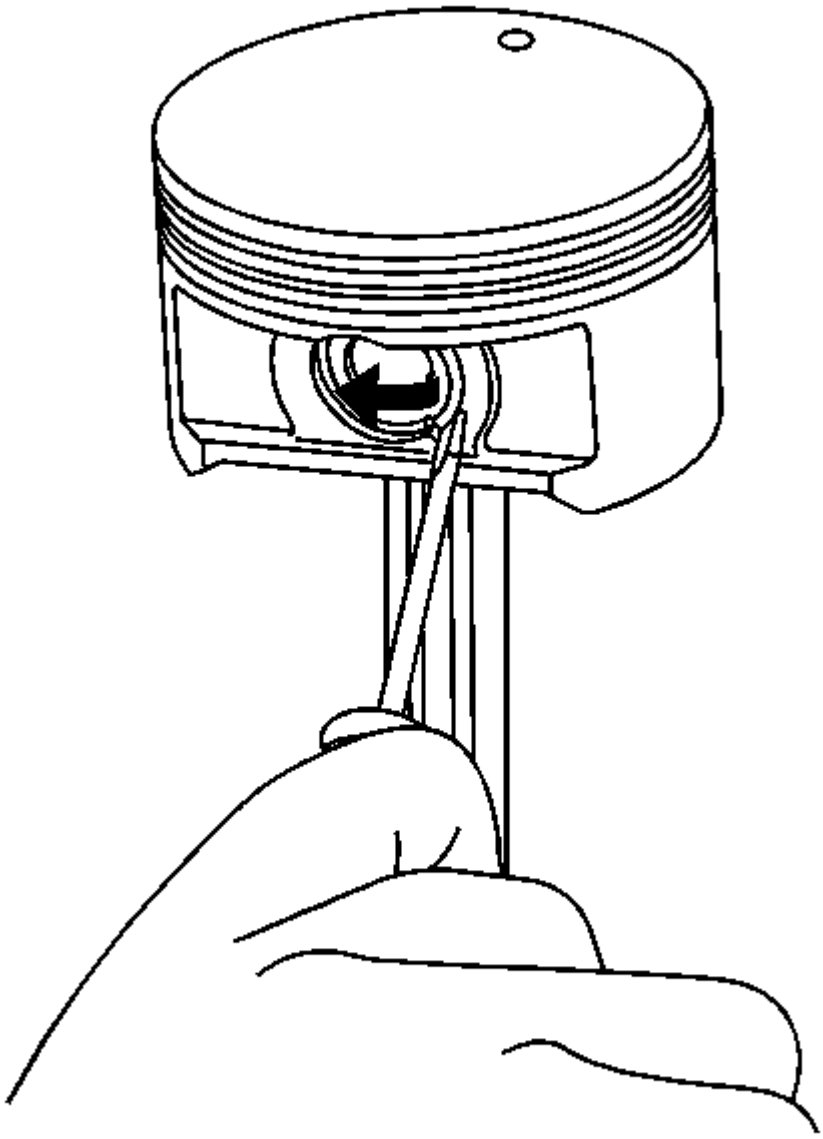

Fig. 420: Removing Piston Pin Retaining Clips
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainers starting in the cutout area of the pin bore.

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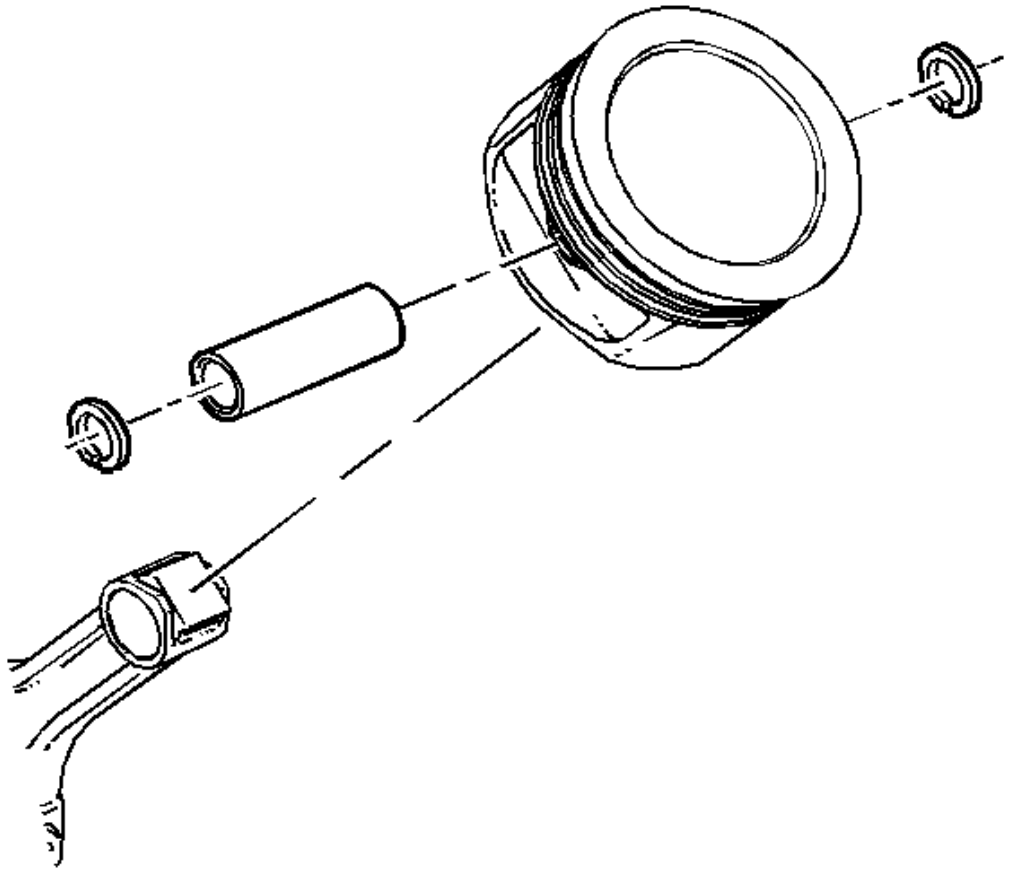

Fig. 421: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

   Mark, sort, or organize the piston and the matching piston pin.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

Piston, Pin, and Piston Rings

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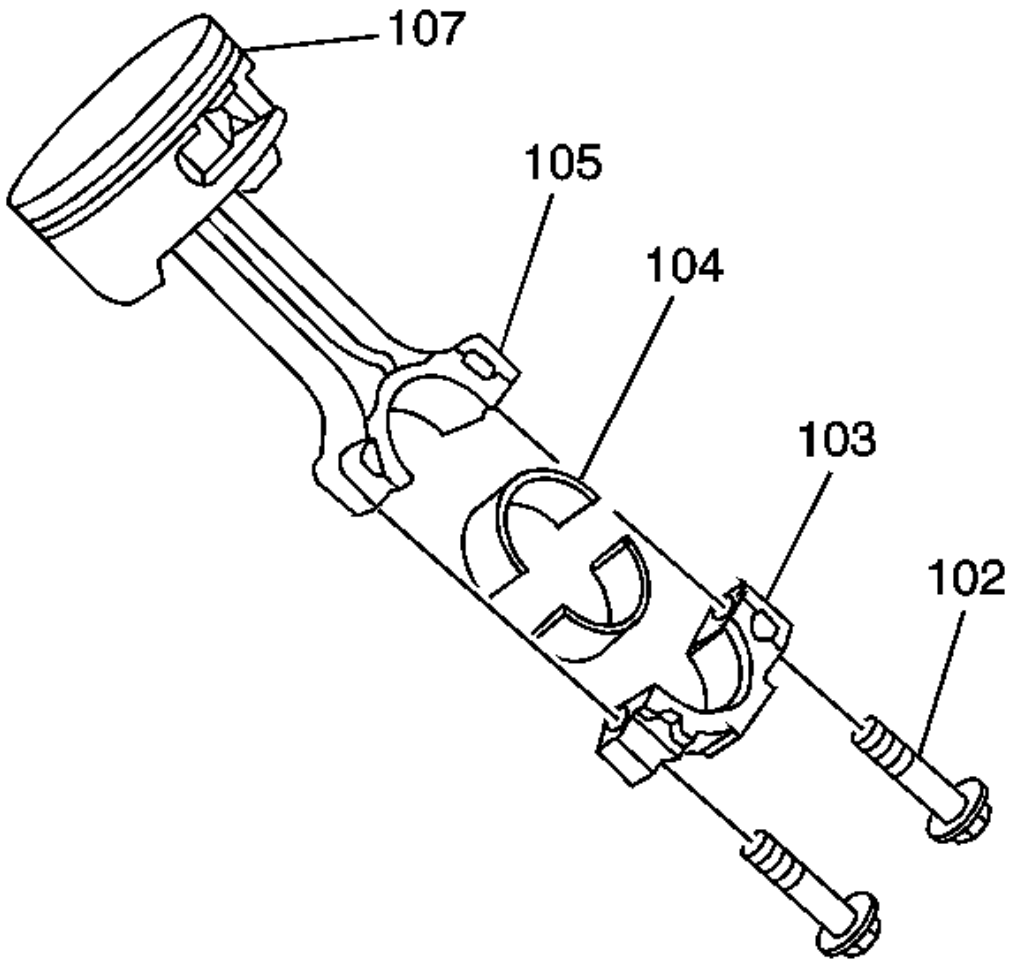

Fig. 422: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.**
- **The piston and pin are to be serviced as an assembly.**
- **Do not wire brush any part of the piston.**
- **Measurement of the components should be taken with the components at normal room temperature.**

1. Clean the varnish and carbon from the piston (107) using cleaning solvent.

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CAUTION: Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.

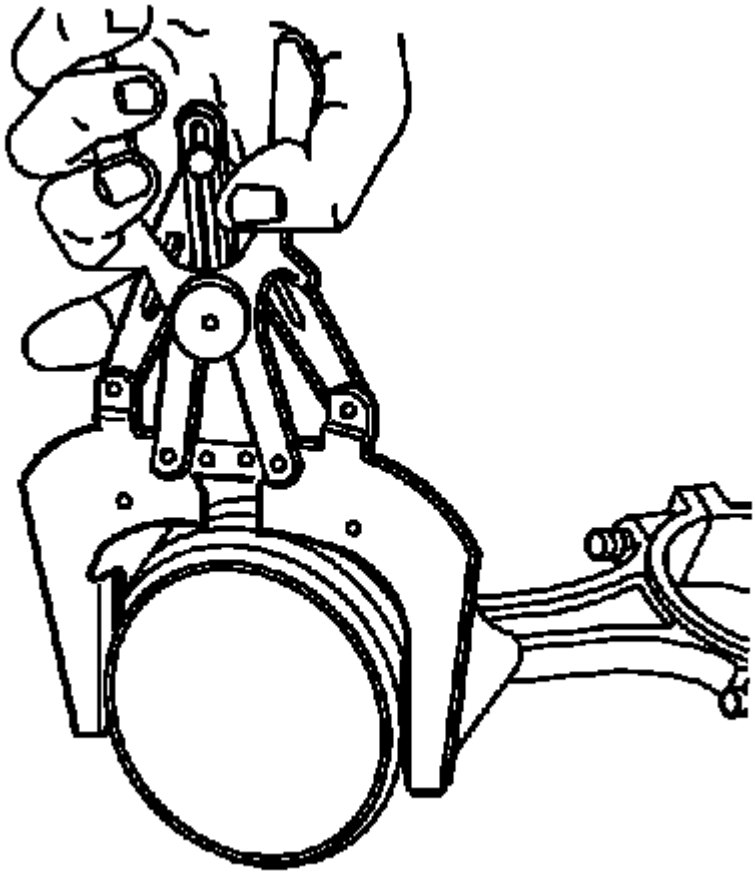

Fig. 423: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

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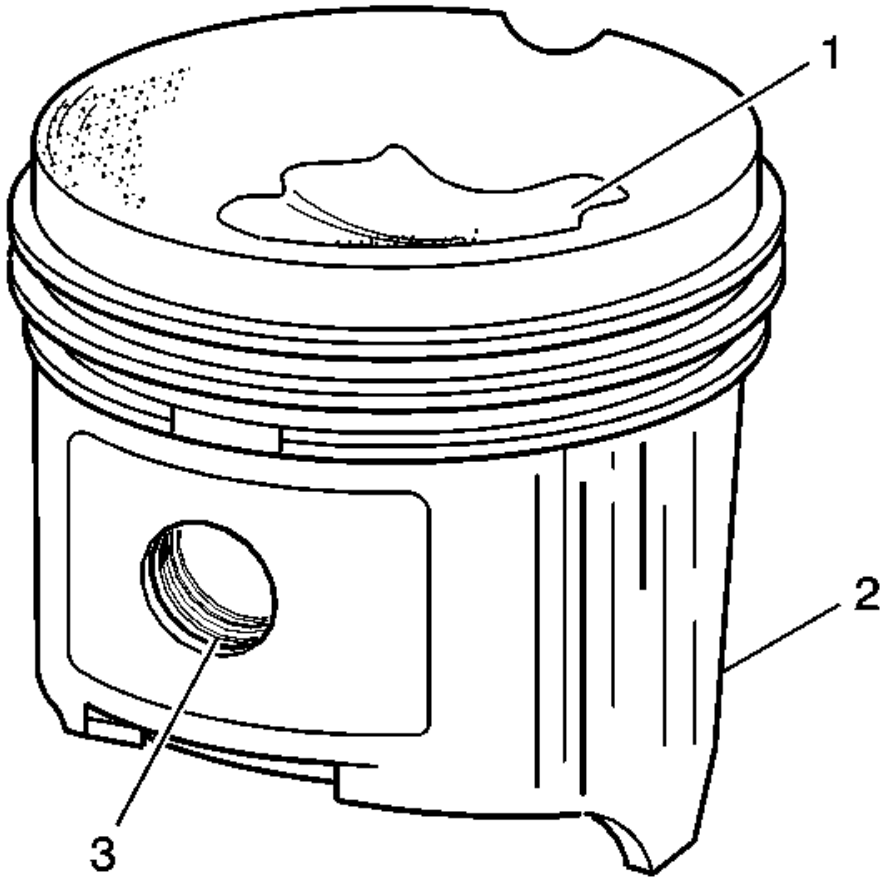

Fig. 424: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

5. Inspect the piston for the following conditions:
   - Cracks in the piston ring lands, the piston skirt, or pin bosses
   - Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind

     MINOR imperfections may be removed from the piston with a fine file.

   - Scuffed or damaged skirts (2)
   - Eroded areas at the top of the piston (1)
   - Scoring to the full-floating design piston pin bore (3) or piston pin

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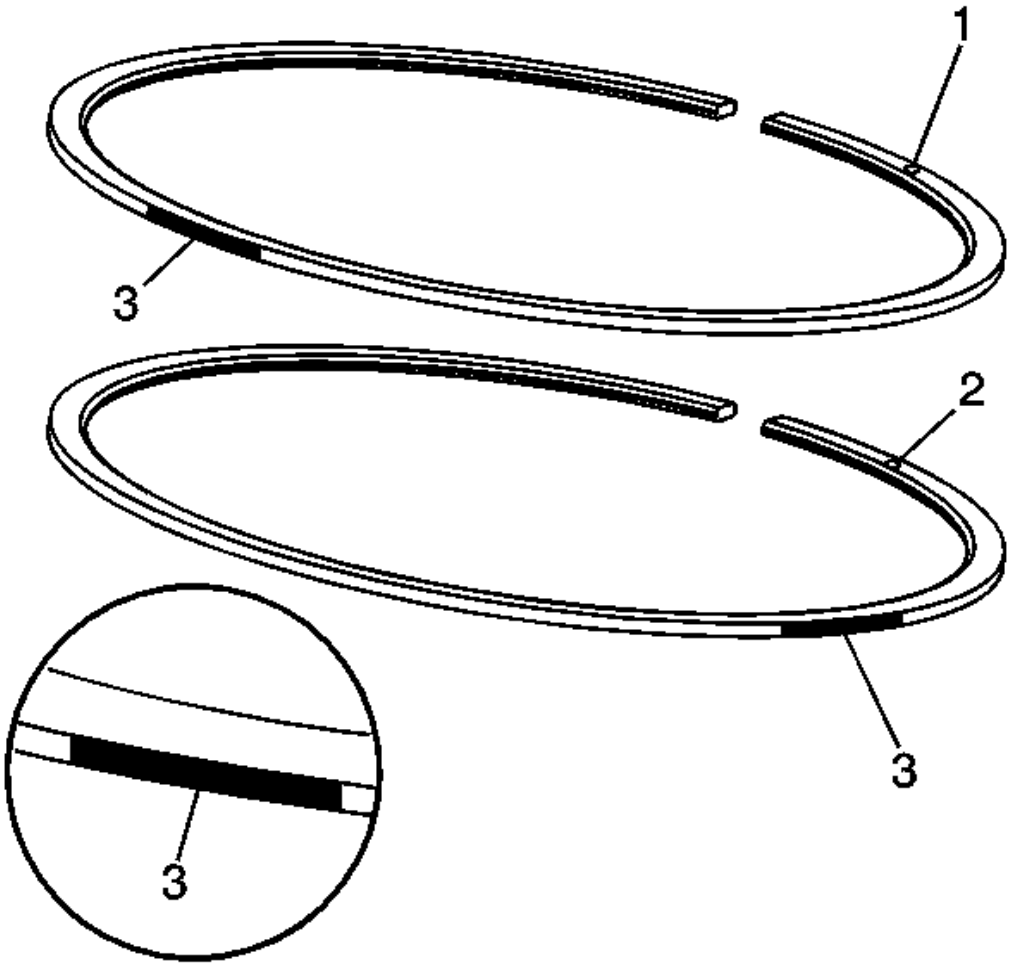

Fig. 425: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

6. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

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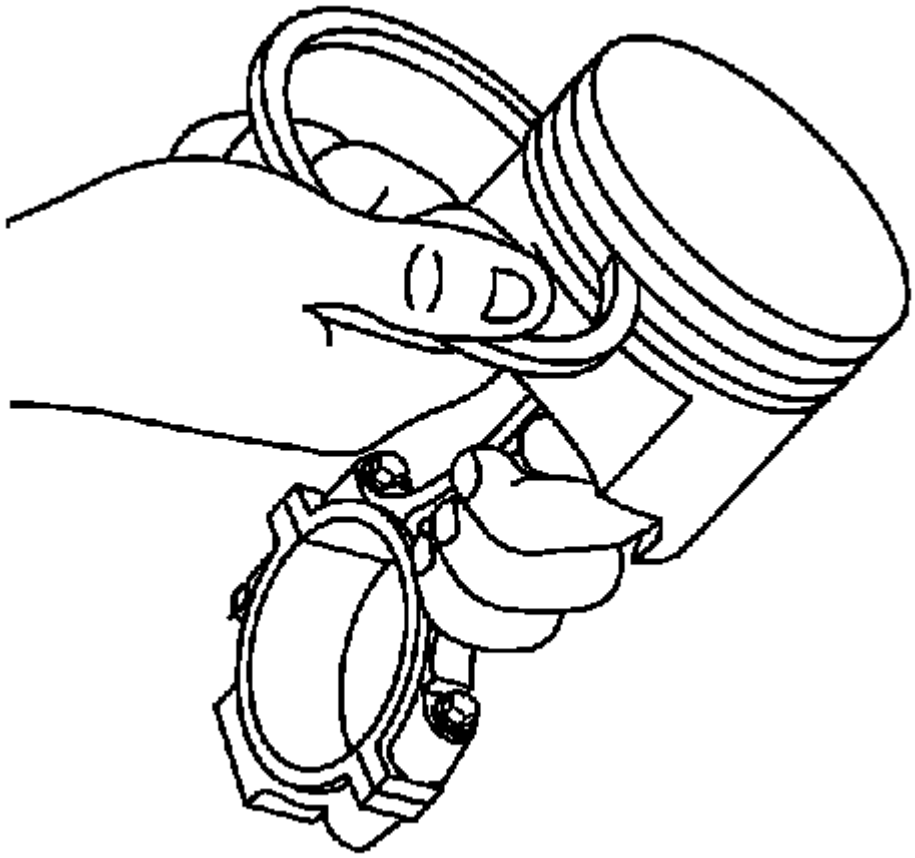

Fig. 426: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. Insert the edge of the piston ring into the piston ring groove.

   Roll the piston ring completely around the piston. If binding is caused by distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings as required.

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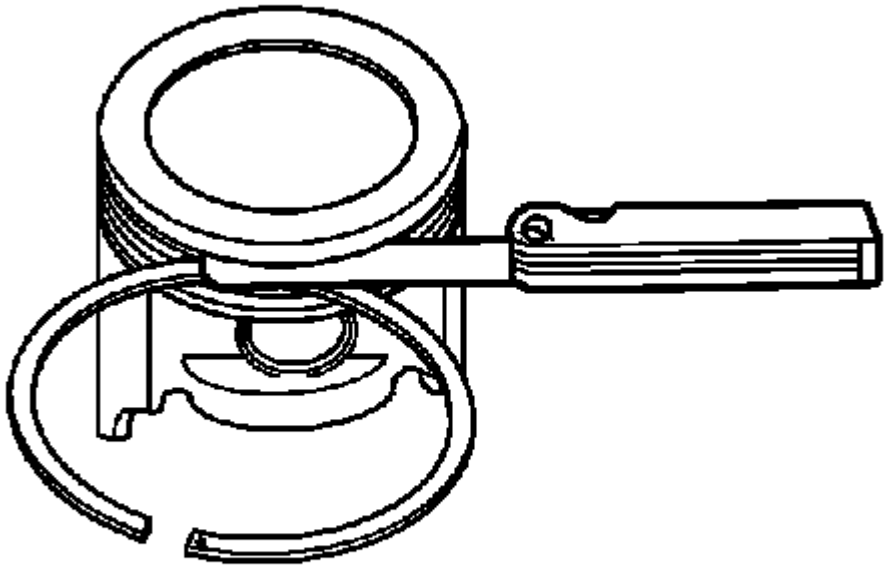

Fig. 427: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to- groove clearance cannot be obtained, replace the piston, pin, and connecting rod assembly. Refer to **Engine Mechanical Specifications**.

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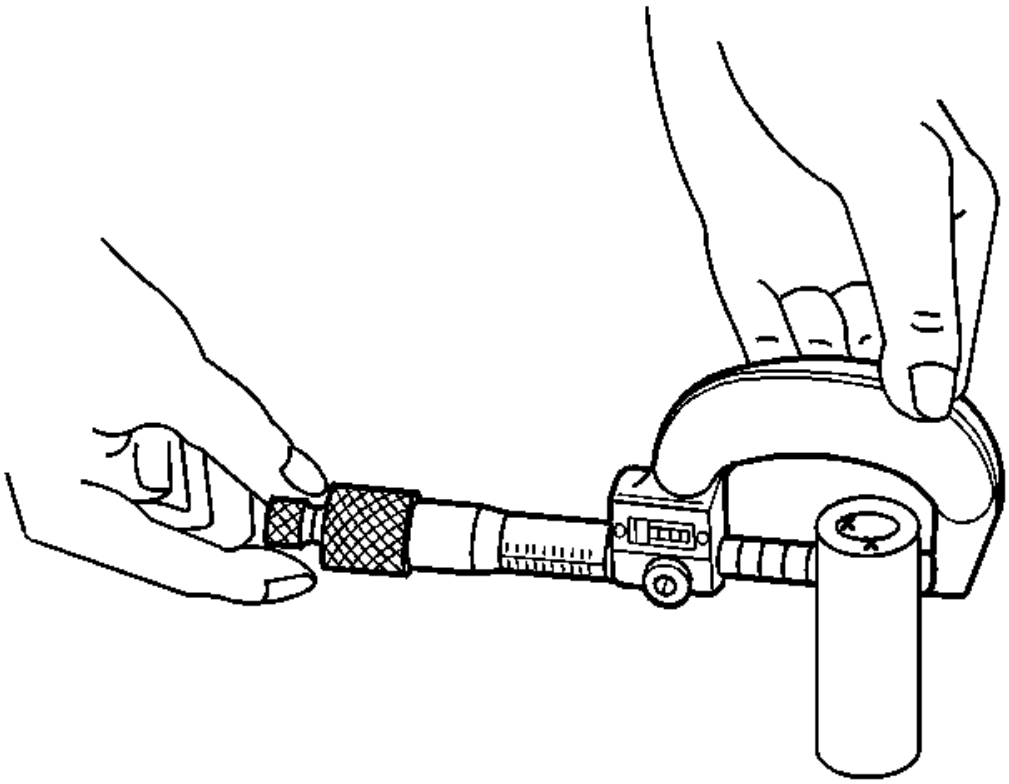

Fig. 428: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

9. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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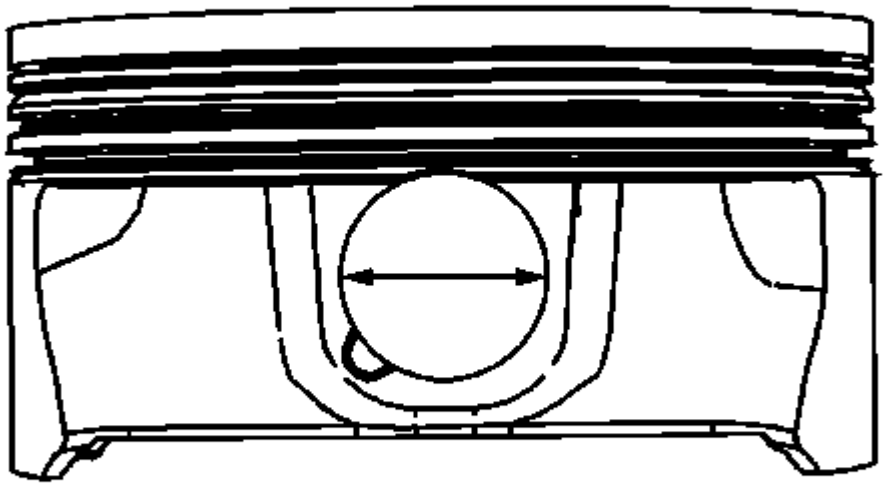

Fig. 429: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS CORP.

10. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
11. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance.

    Refer to **Engine Mechanical Specifications**.

Measuring Piston Ring End Gap

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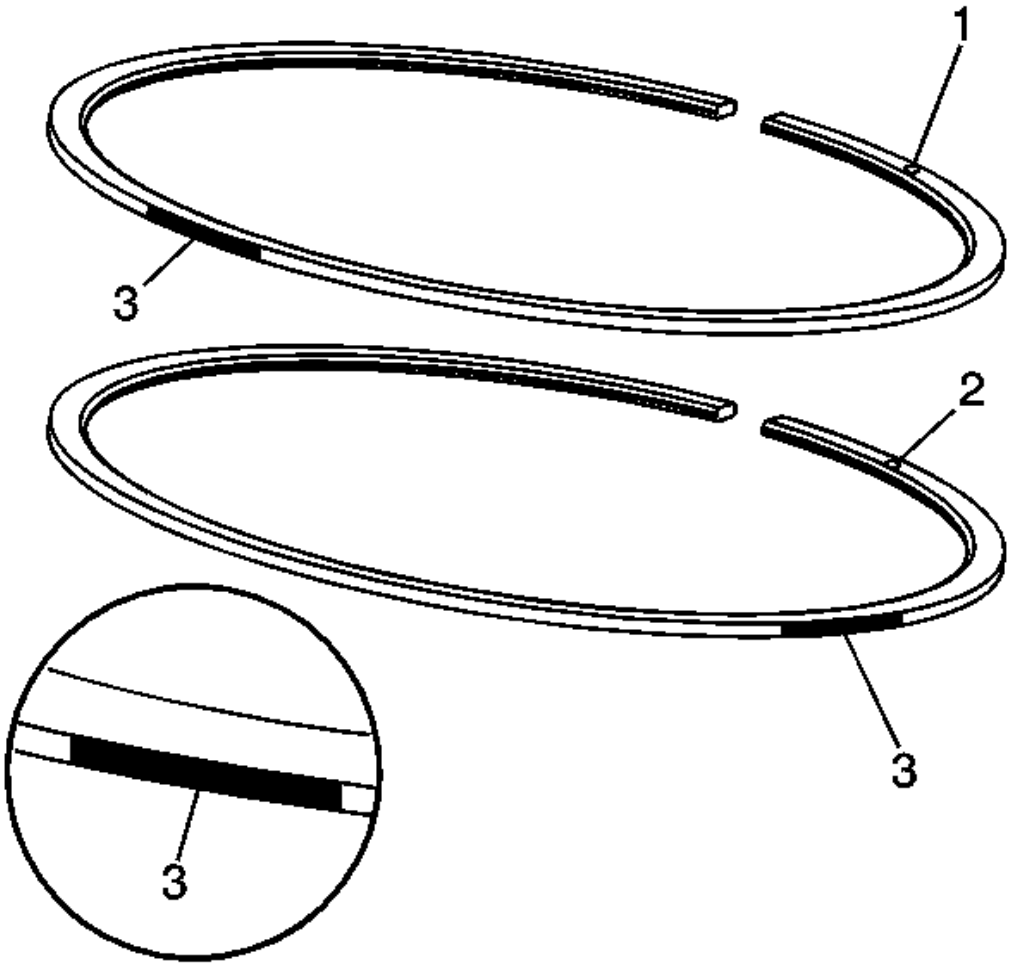

Fig. 430: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.**
- **Measure the piston ring in the cylinder in which it will be used.**

1. Identify the NEW upper and lower compression rings. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

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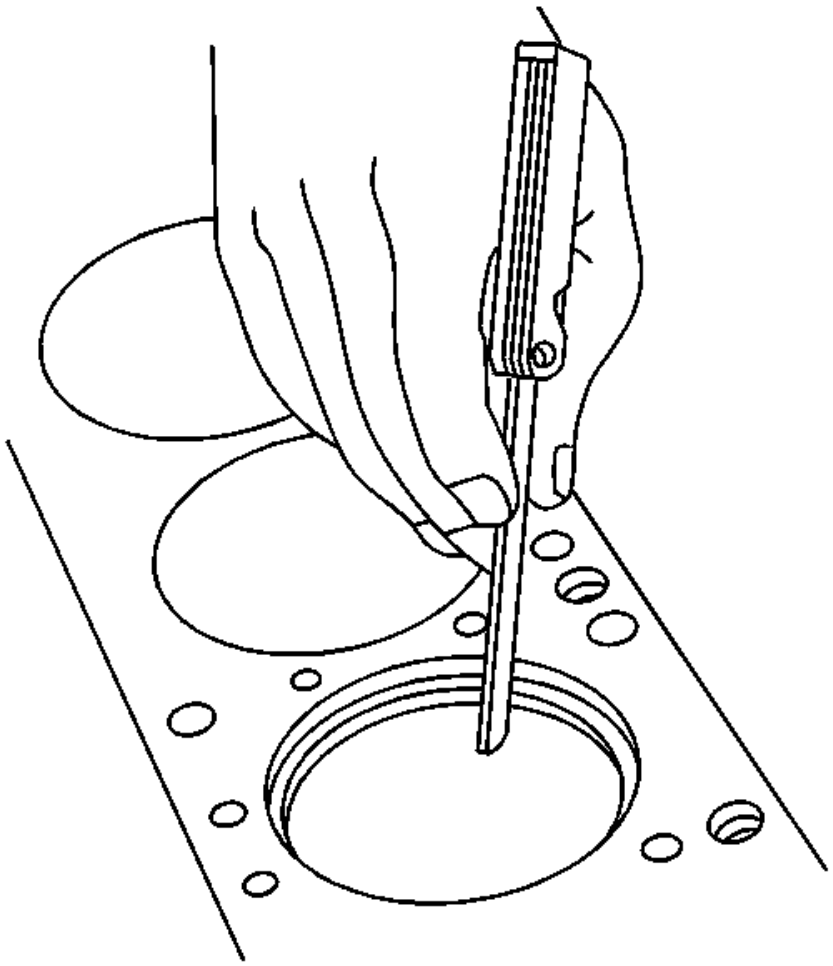

Fig. 431: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

2. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area.
3. Insert a feeler gage and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings

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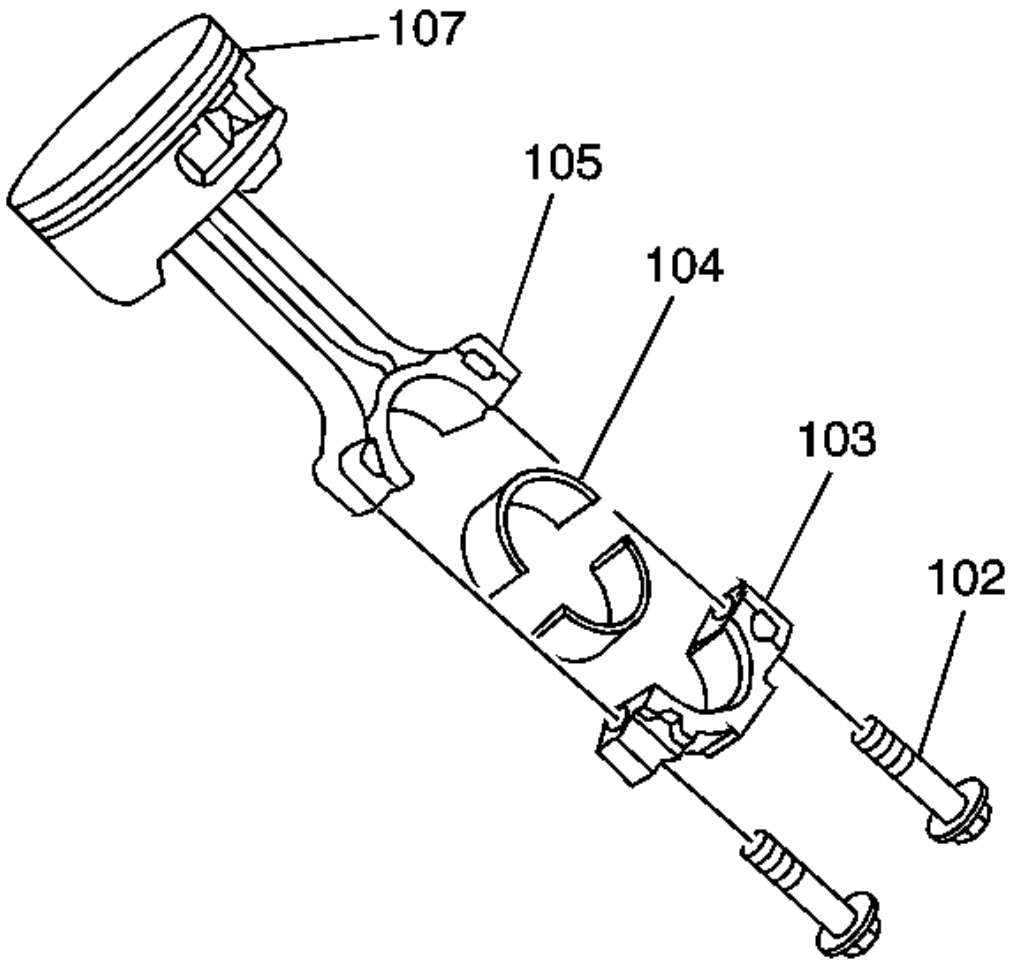

Fig. 432: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the piston, pin, and connecting rod as an assembly.**
- **Do not attempt to repair the bolt hole threads of the connecting rod.**

1. Clean the connecting rod (105) and cap (103) in solvent.

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CAUTION: Wear safety glasses in order to avoid eye damage.

2. Dry the components with compressed air.

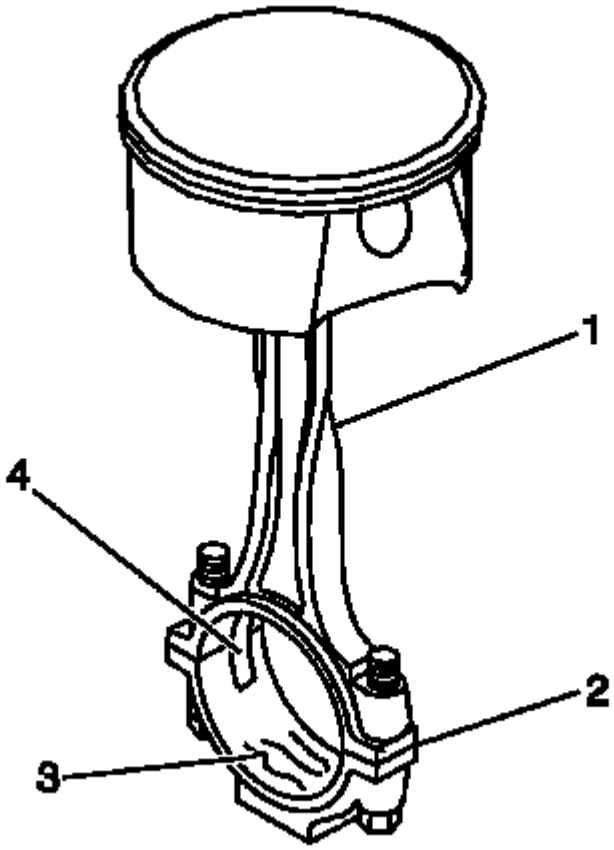

Fig. 433: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the connecting rod for the following conditions:
   - Twisting (1)
   - Proper fit of the connecting rod and cap mating surfaces (2)
   - Nicks or gouges in the bearing bore (3)
   - Damage to the bearing locating slots (4)

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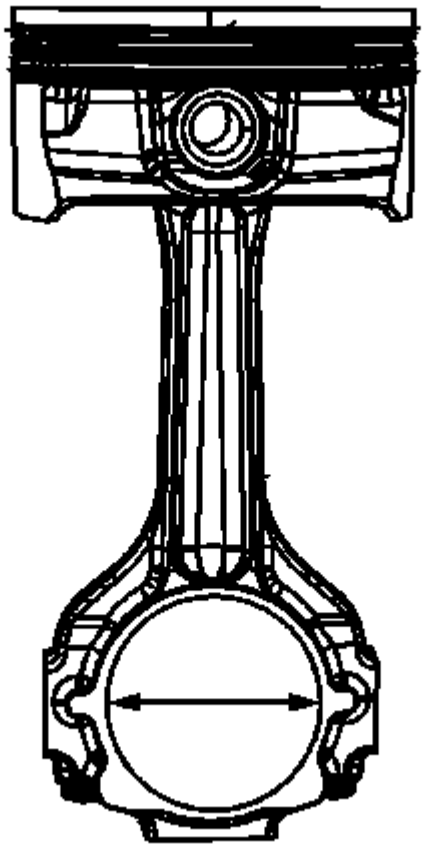

Fig. 434: Measuring Connecting Rod Bearing Bore For An Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

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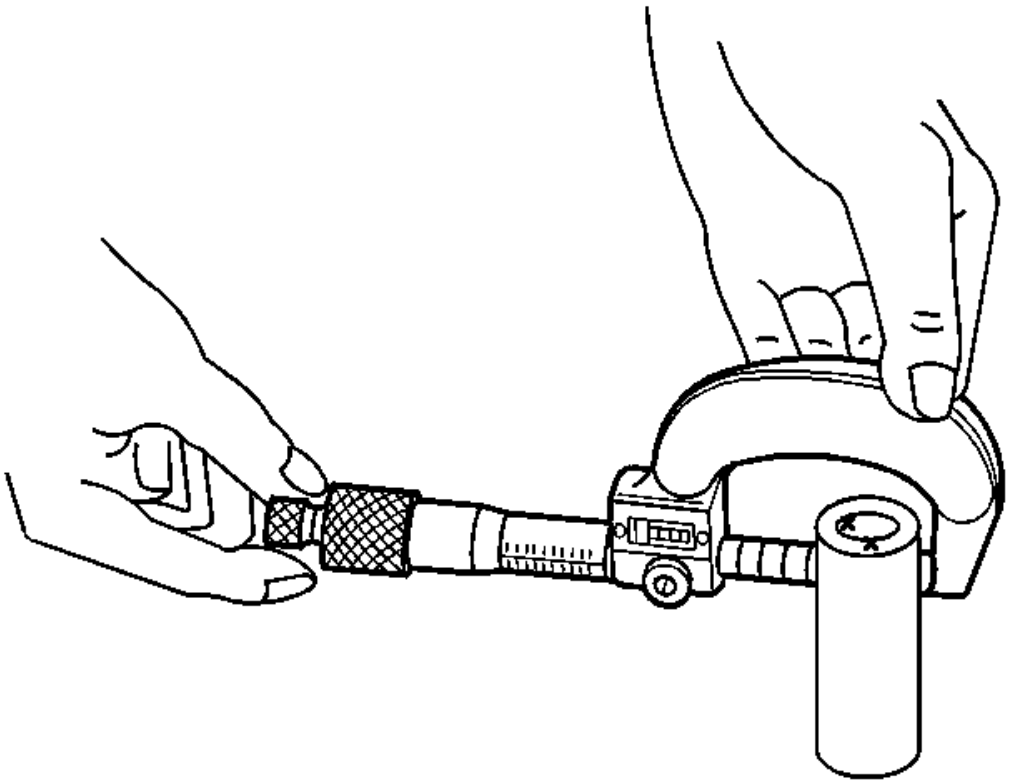

Fig. 435: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. To determine full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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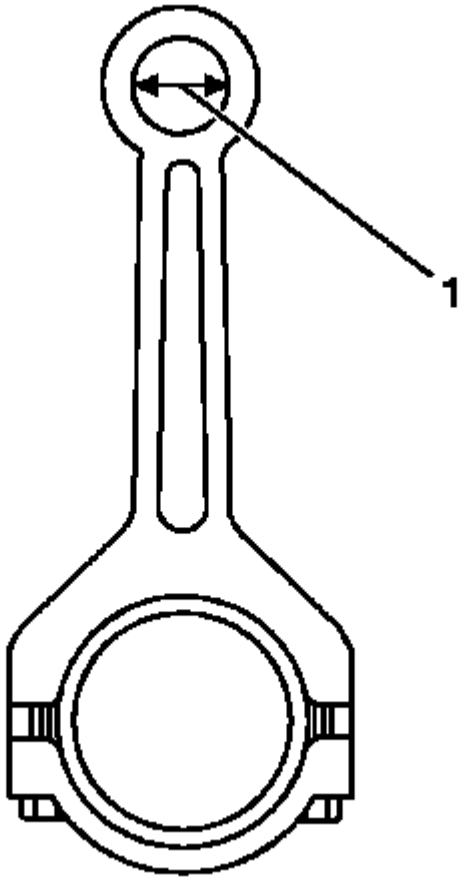

Fig. 436: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS CORP.

6. To determine the full-floating piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) inside diameter (ID).
7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications**.

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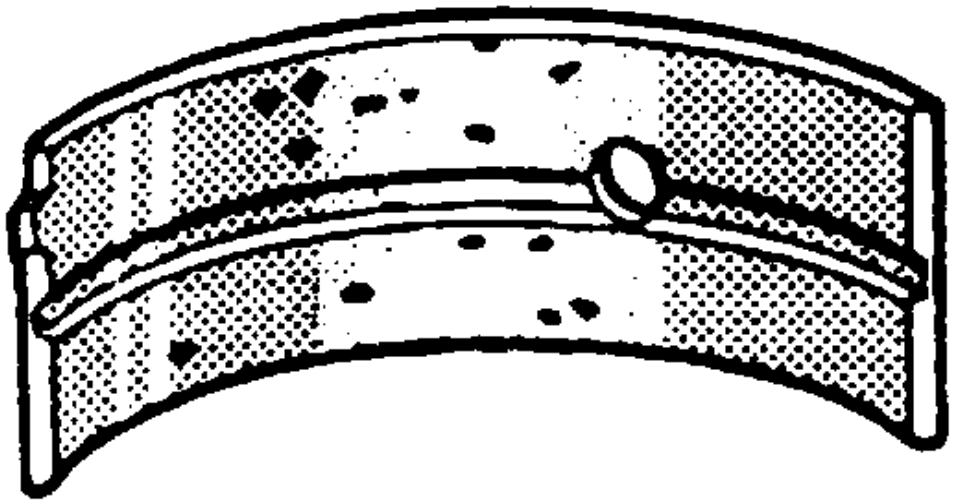

Fig. 437: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.

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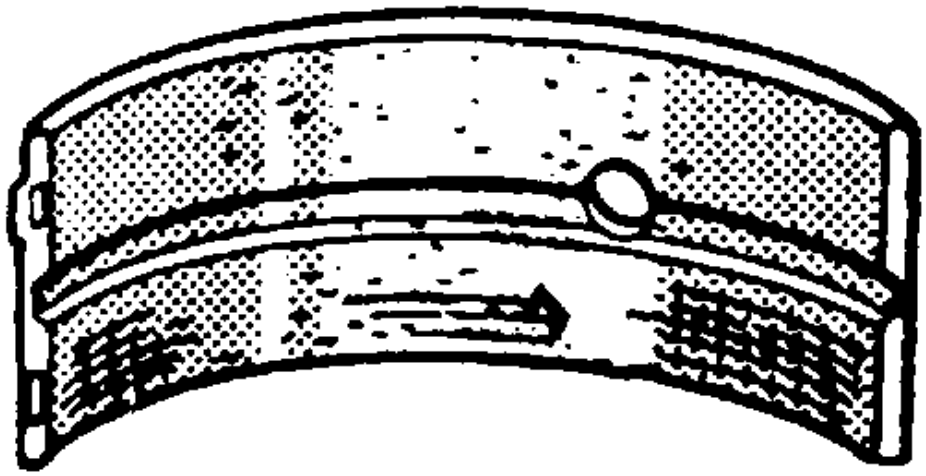

Fig. 438: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

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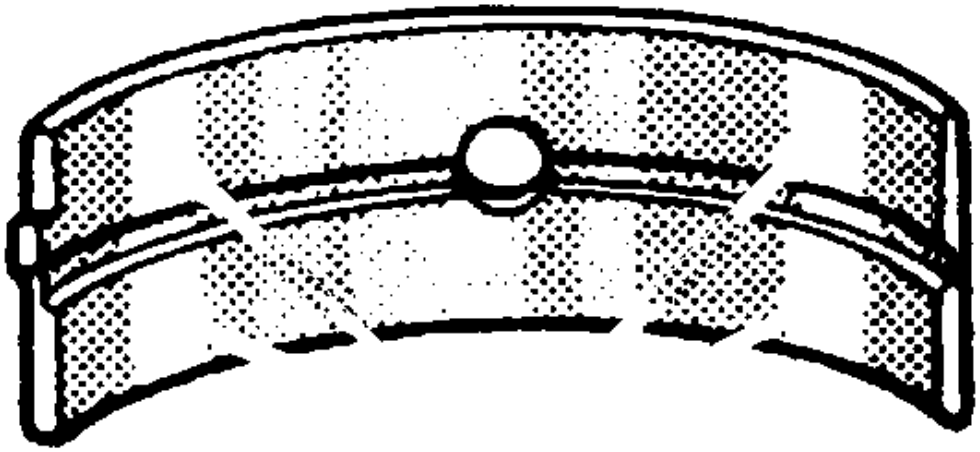

Fig. 439: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.

Piston and Connecting Rod Assemble

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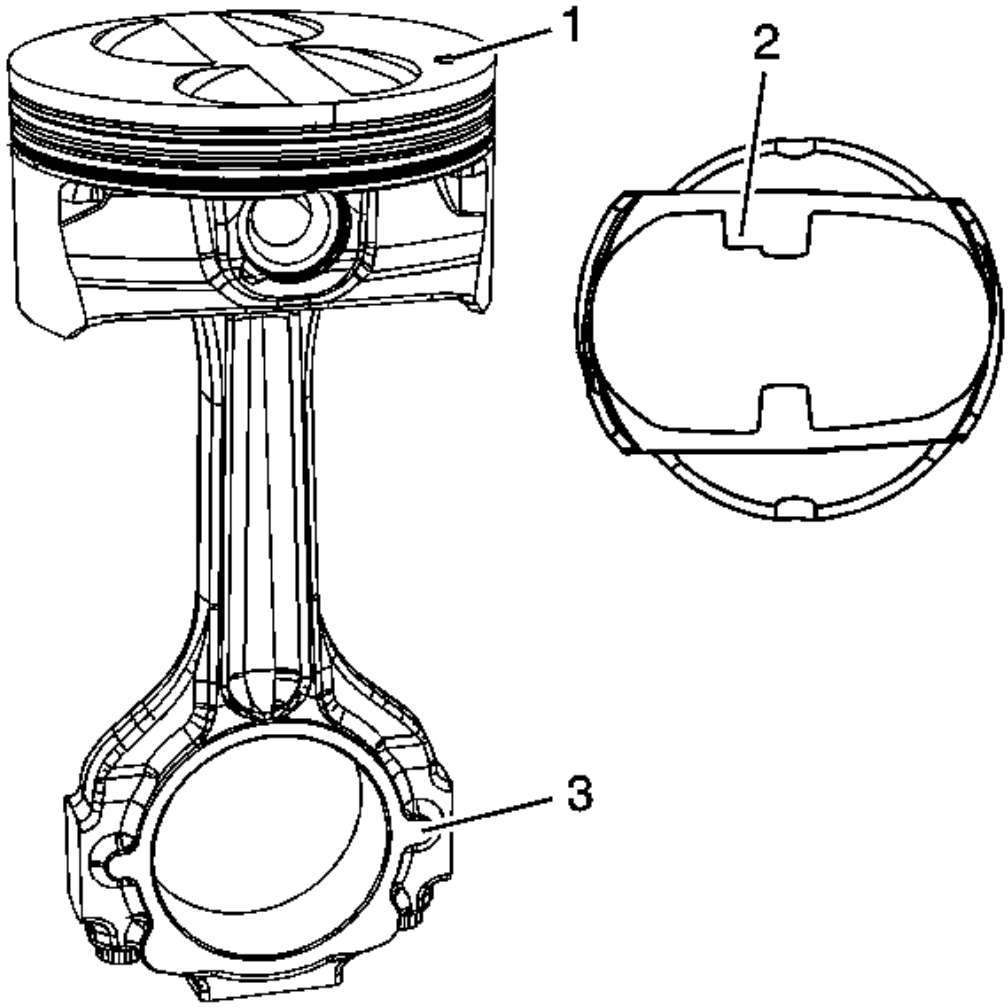

Fig. 440: Locating Piston Lug & Tab
Courtesy of GENERAL MOTORS CORP.

1. Assemble the piston and connecting rod with the lug (1) on the bottom of the piston and the tab (2) on the side of the connecting rod facing the same direction.

   When installing the piston and connecting rod assembly, the mark on the top of the piston and the tab (2) on the side of the connecting rod should face the front of the engine.

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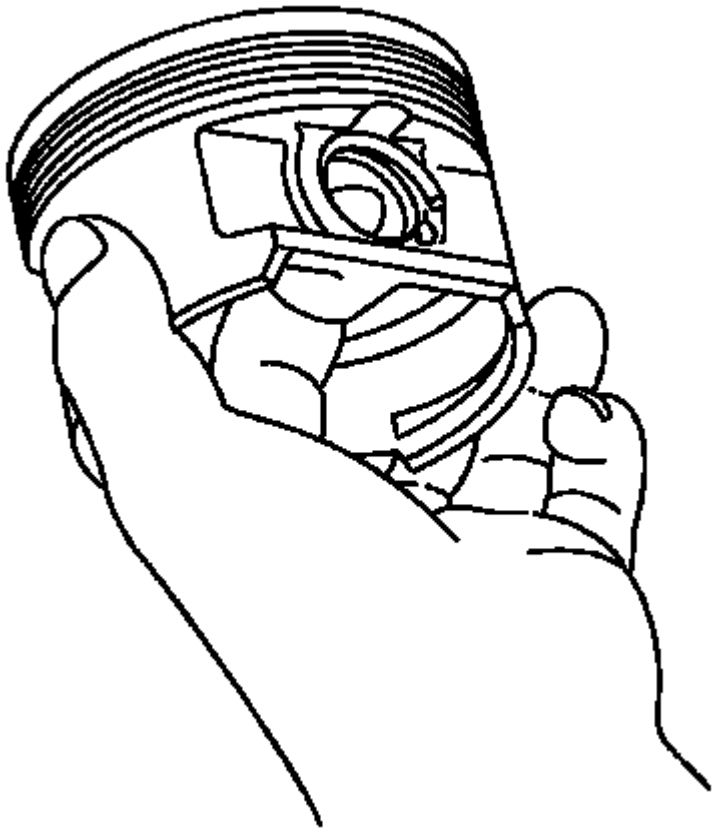

Fig. 441: View Of Retaining Clip In Pin Bore Groove
Courtesy of GENERAL MOTORS CORP.

2. Install the retainer. The retainer should be seated in the groove of the pin bore.

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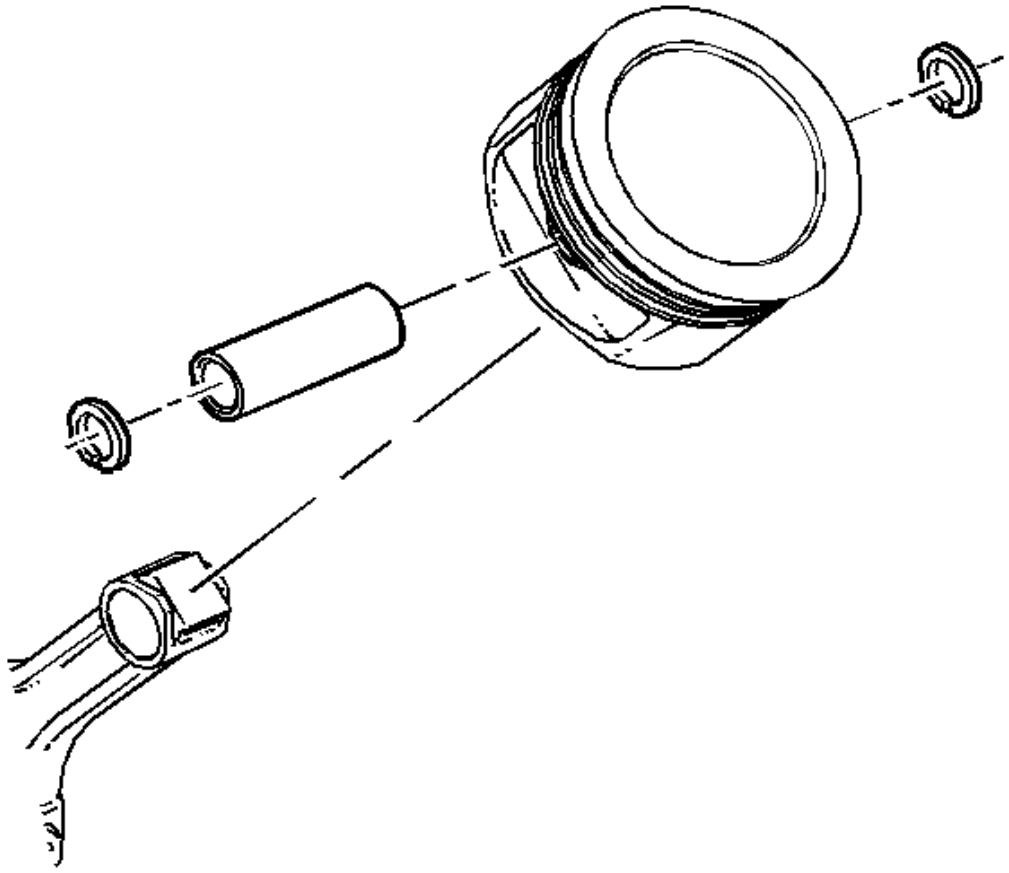

Fig. 442: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Install the piston pin to the piston and connecting rod.
4. Install the retainer. The retainer should be seated in the groove of the pin bore.

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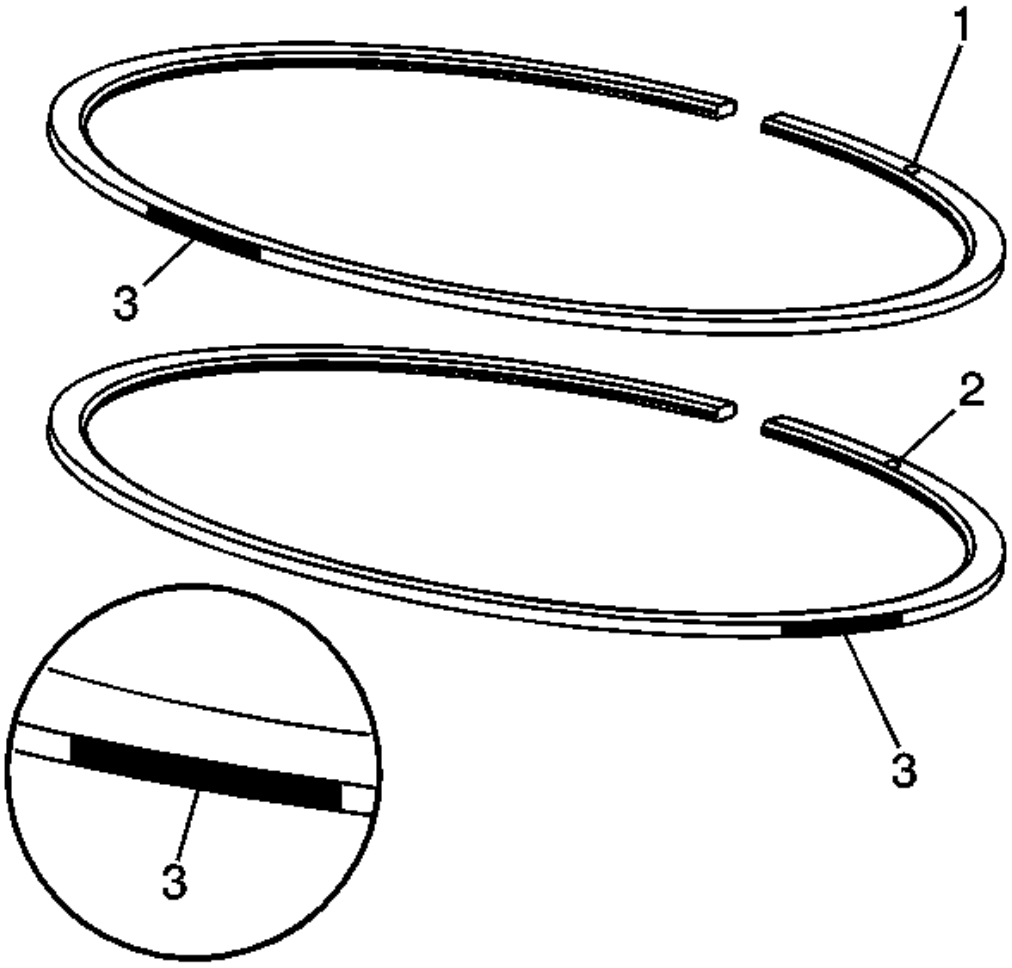

Fig. 443: View Of Upper/Lower Compression Rings & Marks
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.

5. Identify the compression and oil control rings for proper installation. The upper compression ring can be identified by a paint mark (3) located 180 degrees from the end gap. The lower compression ring can be identified by a paint mark (3) located 90 degrees from the end gap. Both rings should be installed with the orientation marks (1, 2) facing the top of the piston.

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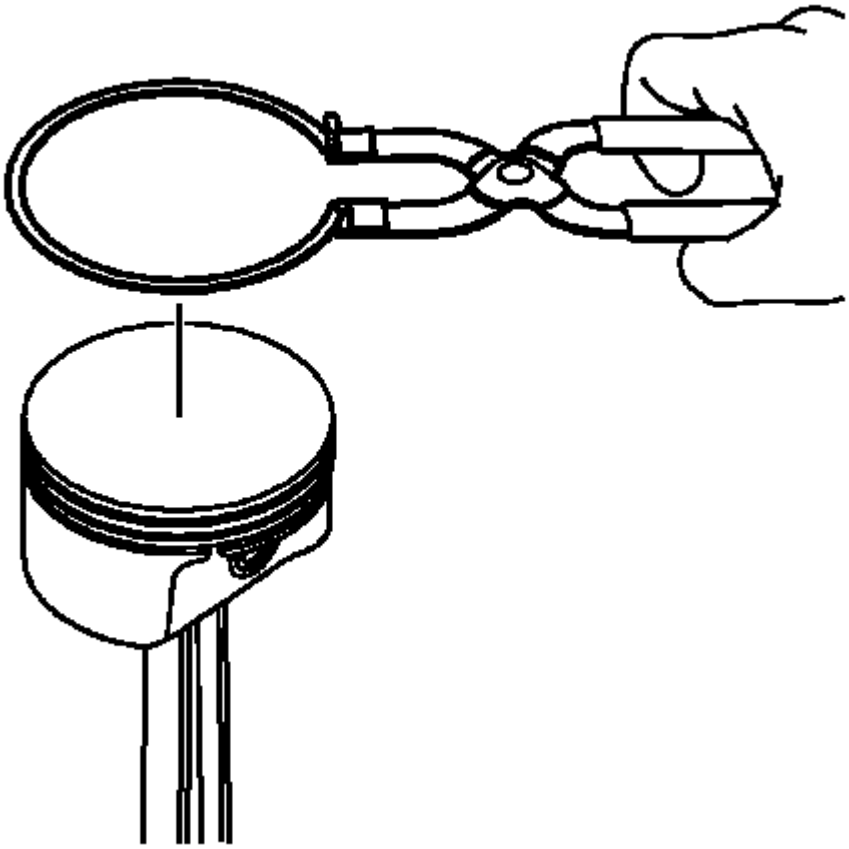

Fig. 444: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

6. Using piston ring pliers, install the piston rings onto the piston.
7. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
8. Position the compression ring end gaps 180 degrees opposite each other.

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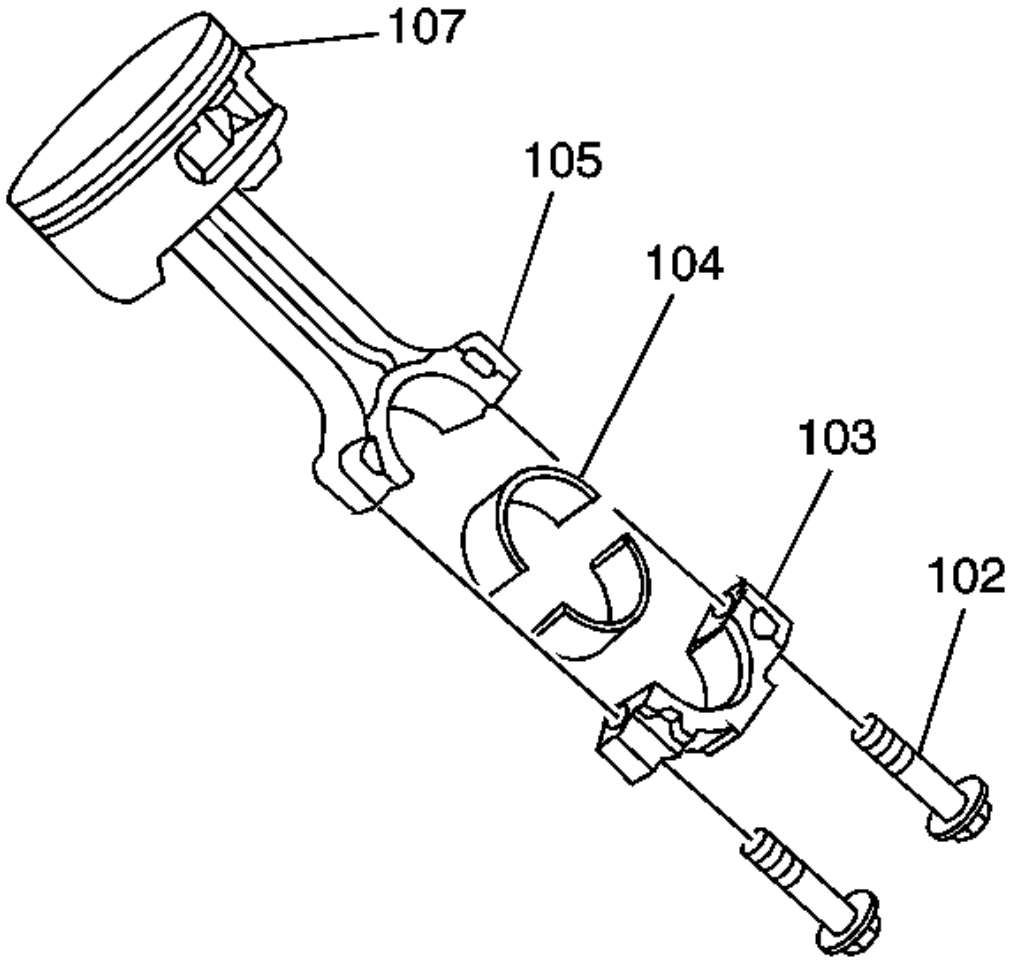

Fig. 445: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

9. Install the connecting rod bearings (104) to the rod (105) and cap (103).

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**.

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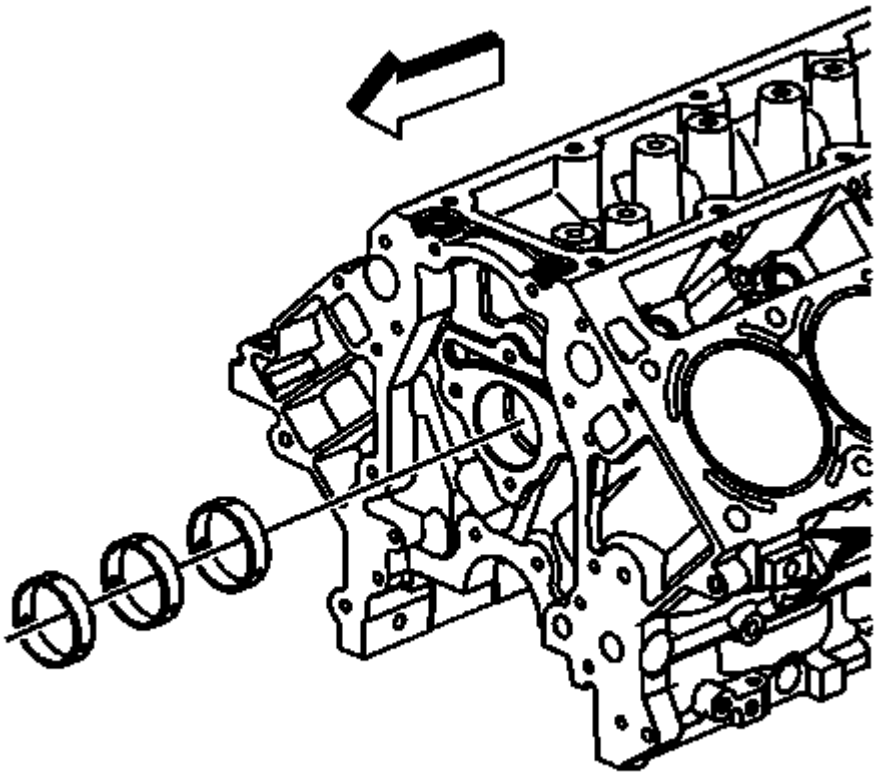

Fig. 446: Camshaft Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out of round, or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores. Refer to **Camshaft and Bearings Cleaning and Inspection**.
2. Repair or replace the components as required.

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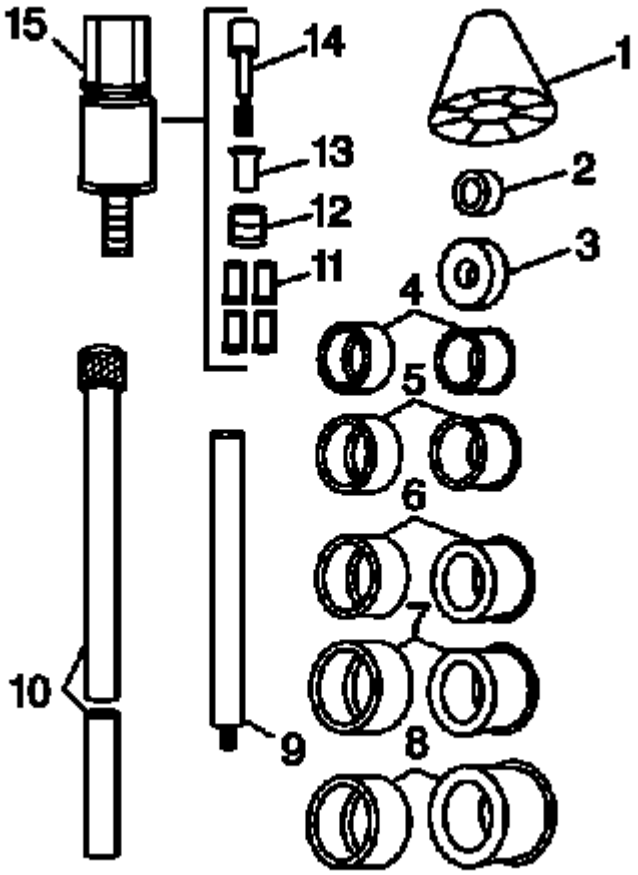

Fig. 447: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . See **Special Tools**.
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing in order to align the tool.

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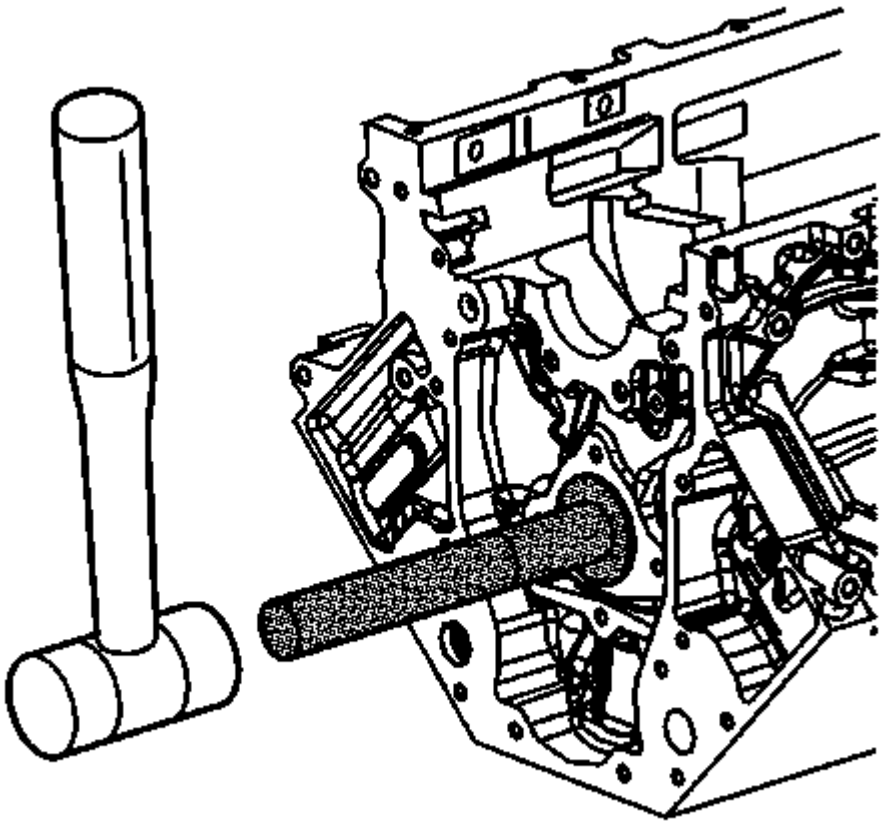

Fig. 448: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Drive the bearing from the block bore.

IMPORTANT: In order to remove the front camshaft bearing, operate the tool from the rear of the block, using the guide cone in the rear camshaft bearing bore.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

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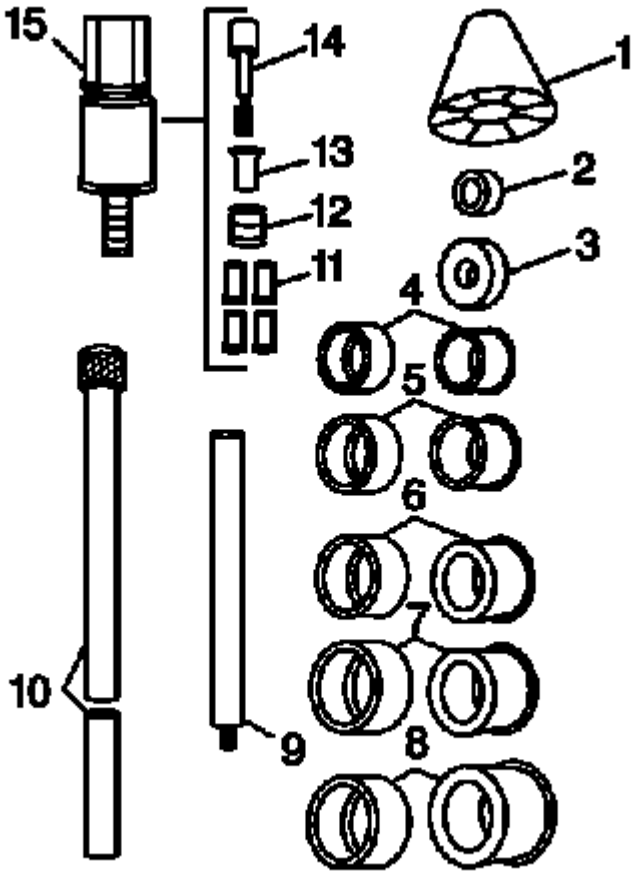

Fig. 449: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).
- Expander bearing driver number 1 inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the expander assembly and the small washer.
- Expander bearing driver number 2 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with number 1 expanding driver and the small washer.
- Expander bearing driver number 3 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with number 2 expanding driver and the large washer.
- Expander bearing driver number 4 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with number 3 expanding driver and the large washer.
- Expander bearing driver number 5 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with number 4 expanding driver and the large washer.
- Expander bearing driver number 6 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with number 5 expanding driver and the large washer.

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Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

IMPORTANT: To install or remove the expanding driver, always push on or pull from the ends.
Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Ensure the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. With the small end of the cone facing the driver assembly, place the guide cone over the driving bar.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

For removal of the inner bearings, it may be necessary to install the driver bar extension.

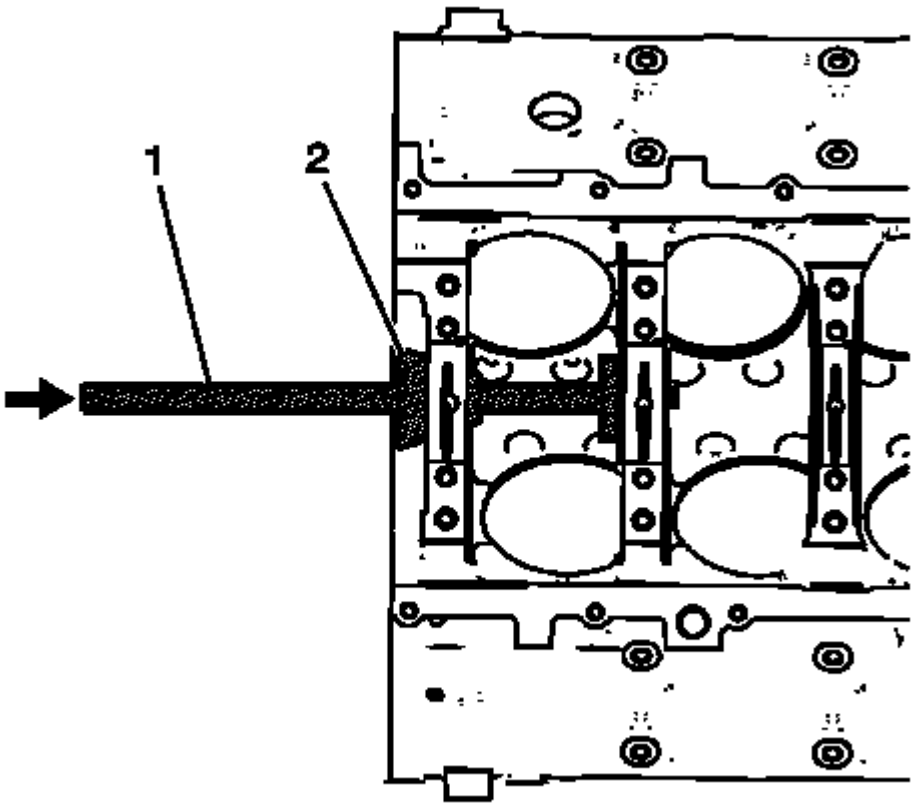

Fig. 450: Expander Assembly
Courtesy of GENERAL MOTORS CORP.

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7. Insert the tool into an inner camshaft bearing and tighten until snug.

   Operate the tool from the front or rear of the engine block.

   On some engine blocks, the nut on the expander assembly is inaccessible, except from either end. In this case, you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.

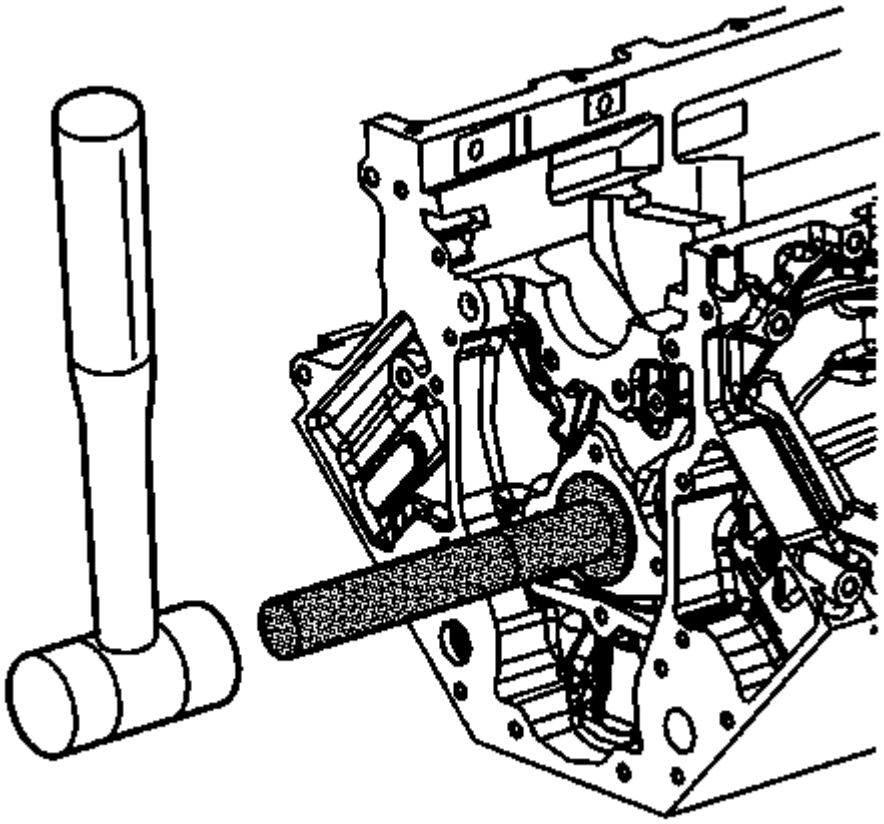

Fig. 451: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

11. For the 2 end bearings, front and rear, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

Camshaft and Bearings Cleaning and Inspection

Tools Required

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- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Camshaft Lobe Lift Indicator. See **Special Tools**.

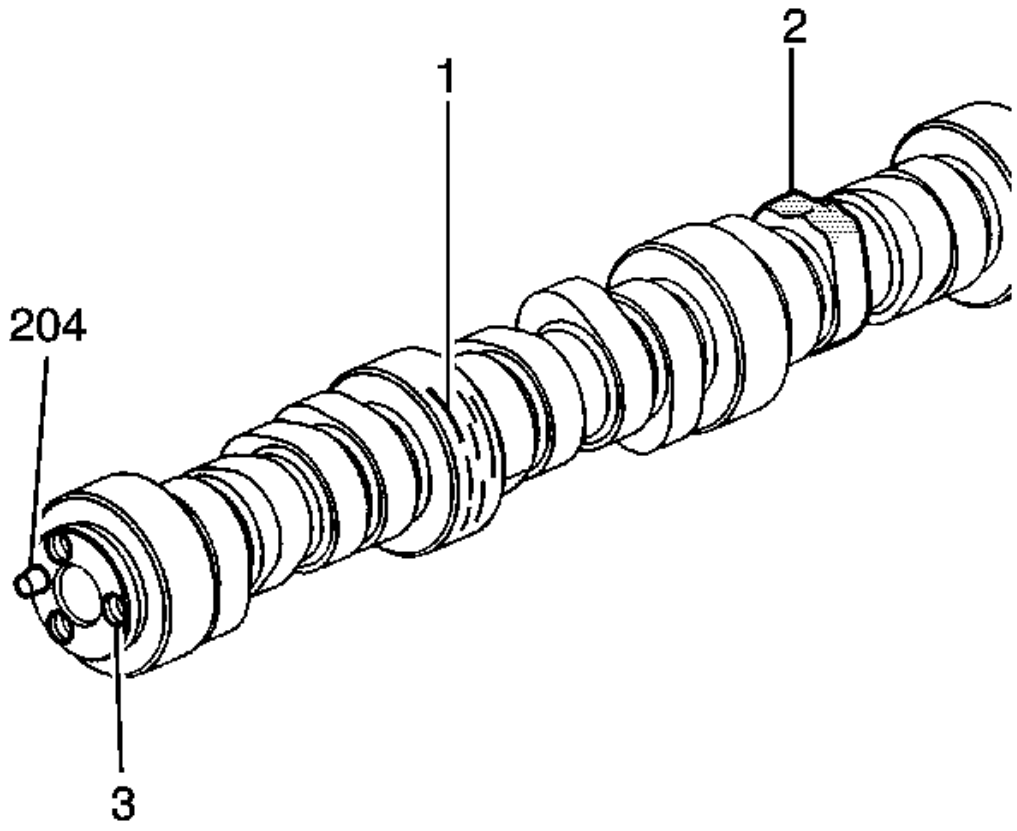

Fig. 452: Identifying Camshaft & Bearing Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Clean the components in solvent.

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

2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the threaded bolt holes (3) in the front of the camshaft for damaged threads or debris.

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6. Inspect the camshaft sprocket pin (204) for damage.

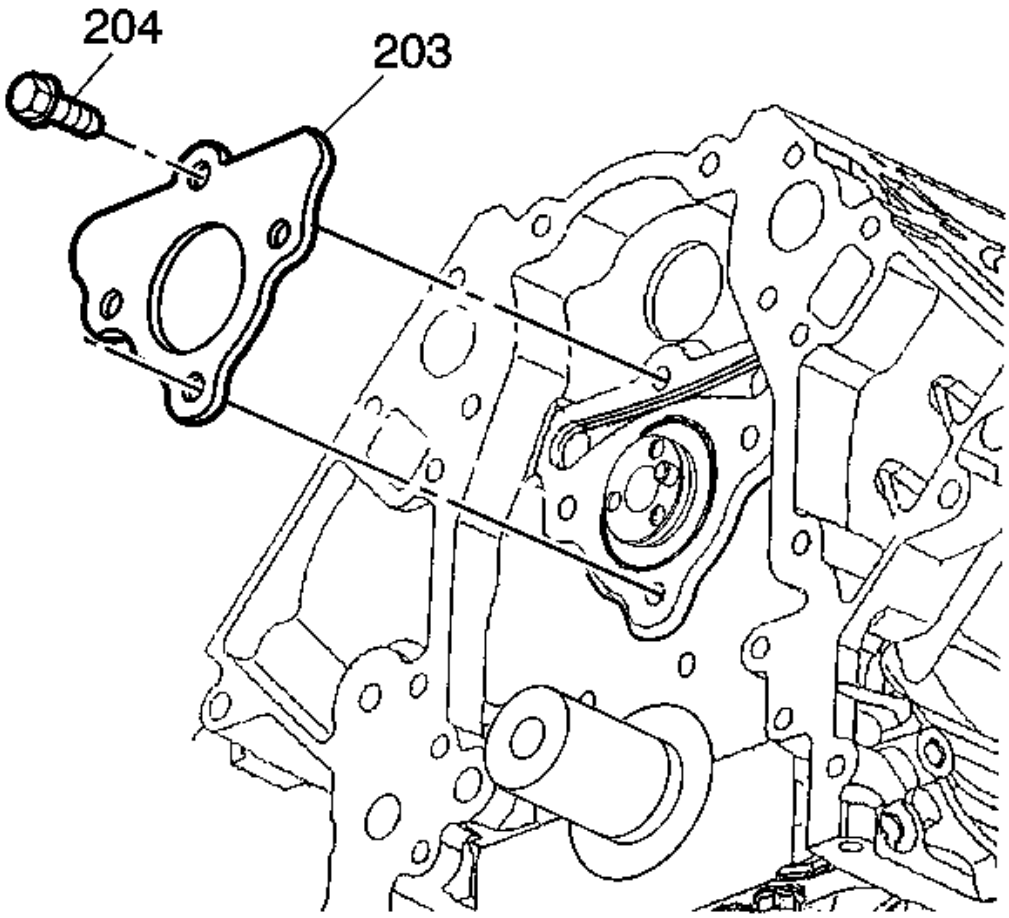

Fig. 453: Camshaft Retainer Plate
Courtesy of GENERAL MOTORS CORP.

7. Inspect the camshaft retainer plate (203) for wear or a damaged sealing gasket.

   If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

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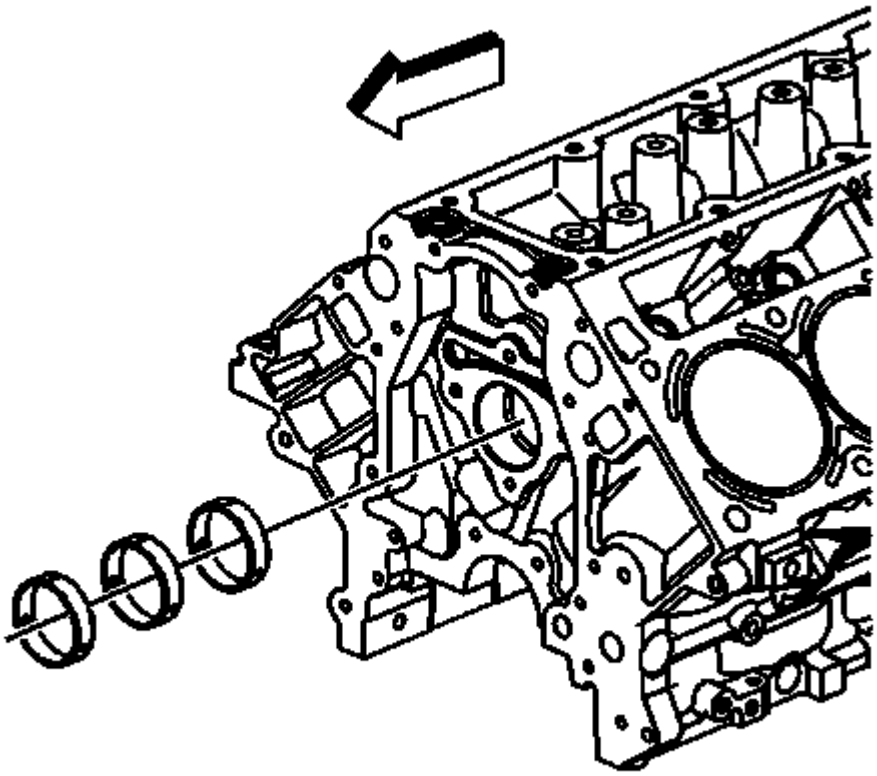

Fig. 454: Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

8. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
9. Inspect the camshaft bearings for excessive wear or scoring.

   Bearings with excessive scoring or wear must be replaced.

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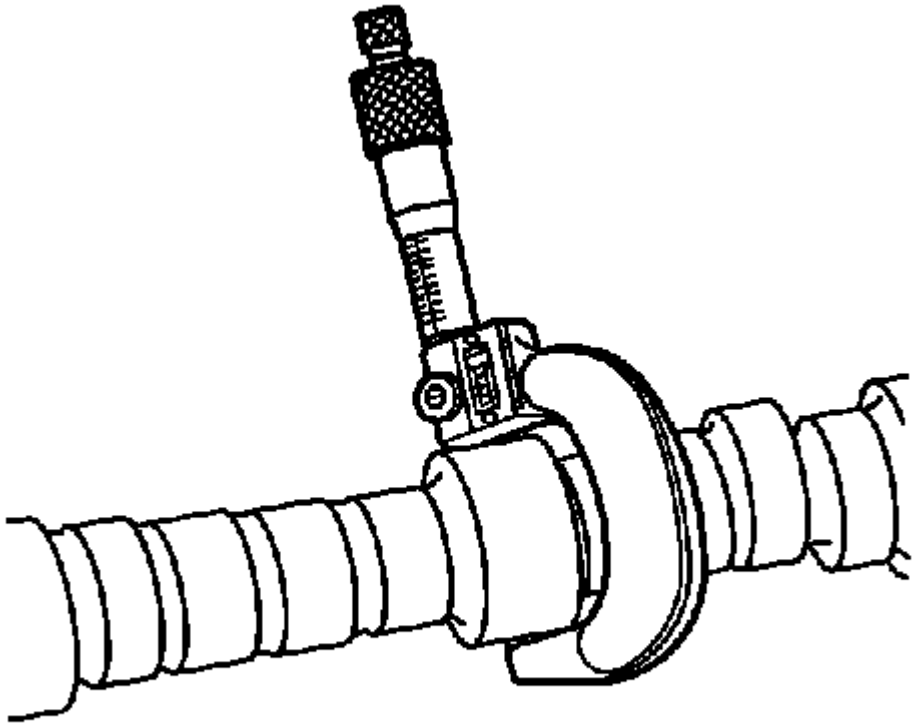

Fig. 455: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

10. Measure the camshaft journals for wear and out-of-round with a micrometer.
    - If the camshaft bearing journals measure greater than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
    - If the camshaft bearing journal diameter measures less than 54.99 mm (2.164 in), replace the camshaft.

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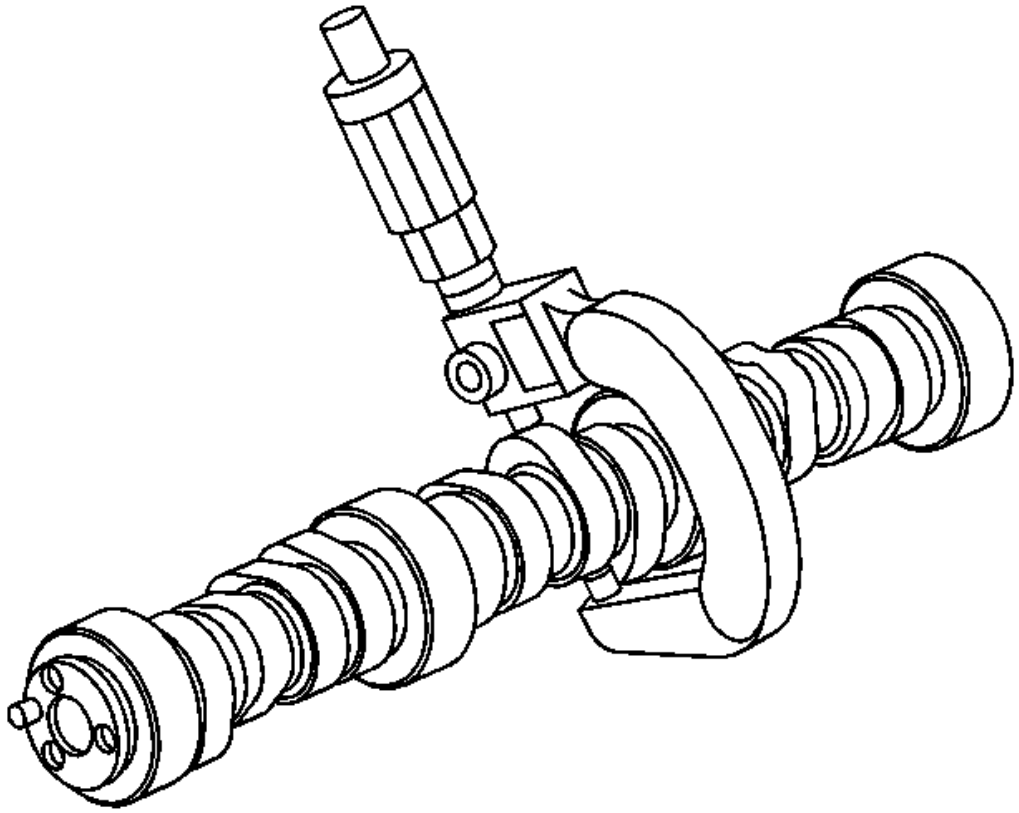

Fig. 456: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

11. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

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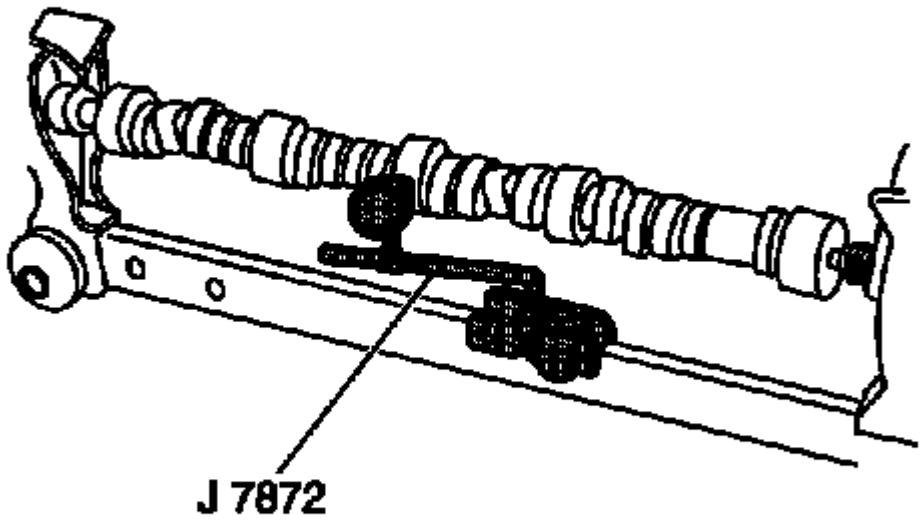

Fig. 457: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the camshaft runout.
    1. Mount the camshaft in wooden V blocks or between centers on a fixture.
    2. Using the **J 7872** , measure the runout of the intermediate camshaft bearing journals.
    3. If camshaft runout exceeds 0.05 mm (0.002 in), the camshaft is bent and should be replaced.

Measuring Camshaft Lobe Lift

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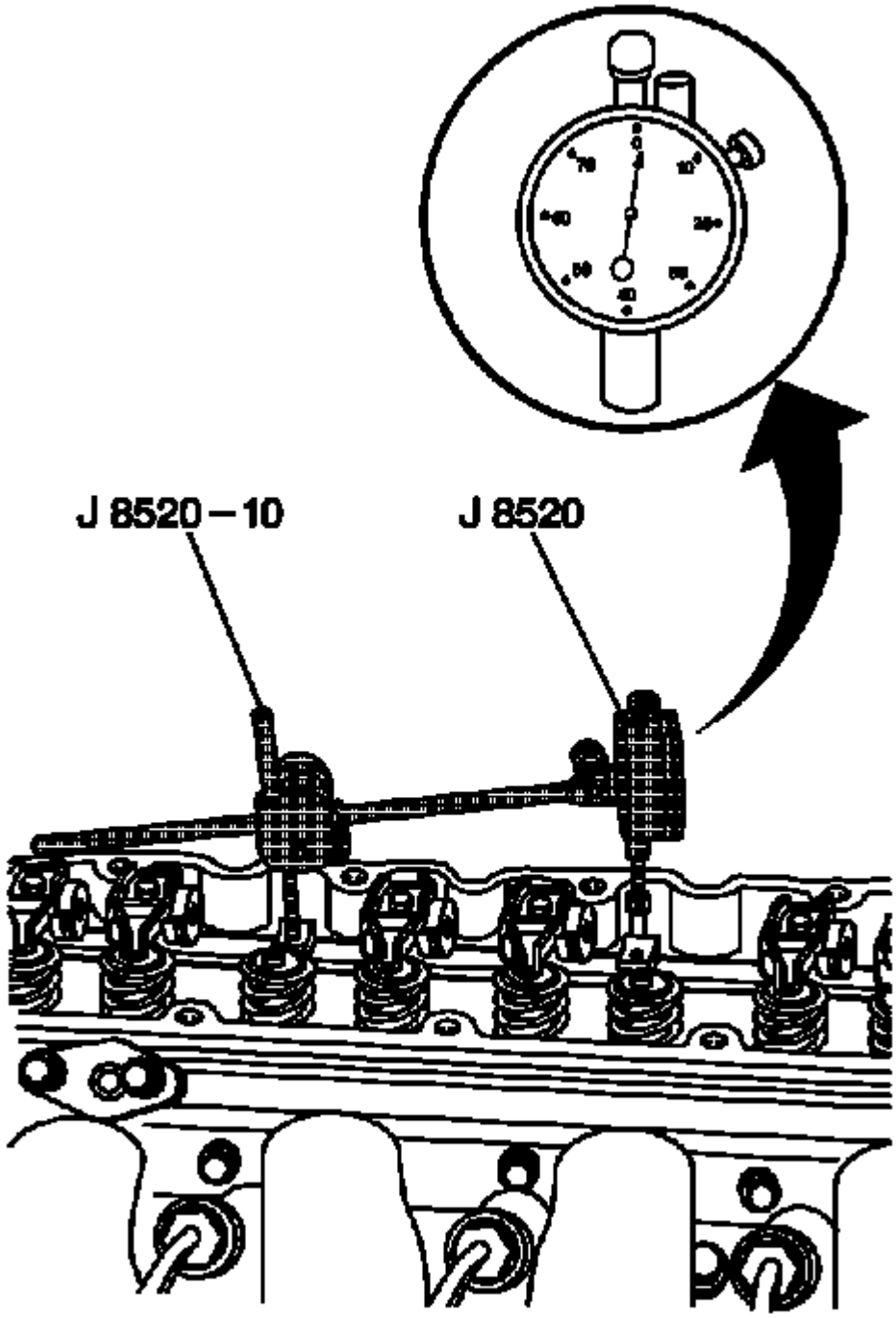

Fig. 458: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes are worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

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1. Measure camshaft lobe lift using **J 8520** . See **Special Tools**.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the **J 8520** and position onto the stud. See **Special Tools**.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise until the dial indicator obtains its highest and lowest readings.
8. Compare the total to specifications. Refer to **Engine Mechanical Specifications**.

Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**.

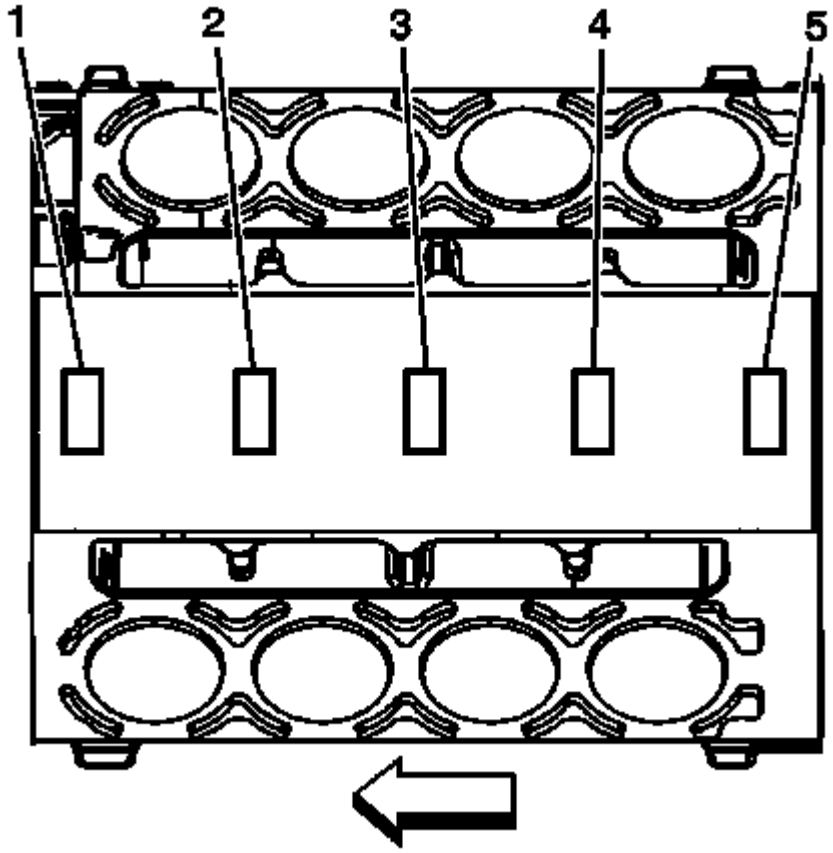

Fig. 459: Identifying Engine Block Camshaft Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Position 1 and 5 are the largest

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diameter bores. Position 3 is the smallest diameter bore. Position 2 and 4 are the intermediate size bores. The inside diameter (ID) for all camshaft bearings is the same size.

1. Measure the engine block camshaft bearing bores (1-5) in order to identify the correct OD size bearing for each position. Refer to **Engine Mechanical Specifications**.

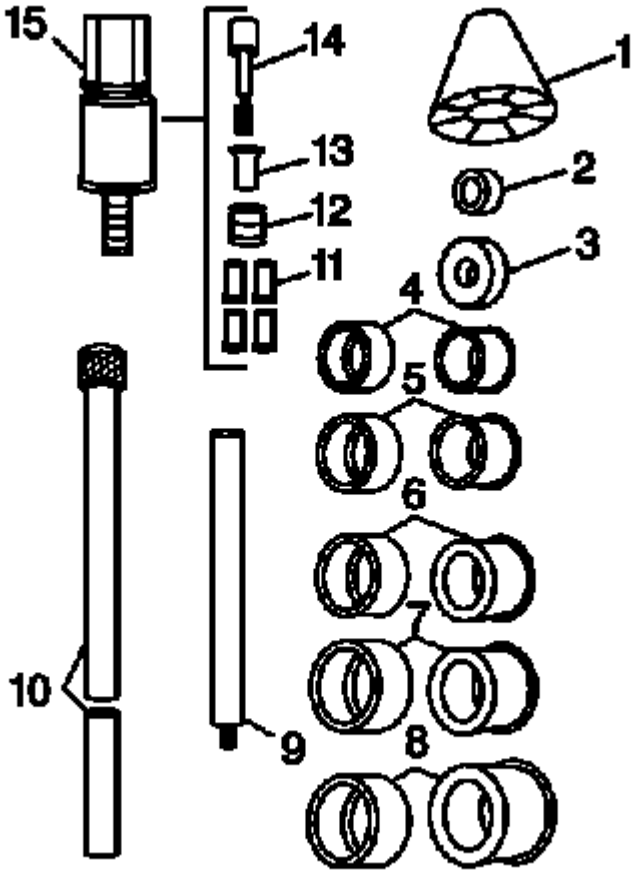

Fig. 460: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

2. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** . See **Special Tools**. Refer to **Piston and Connecting Rod Assemble**.
3. Assemble the tool.

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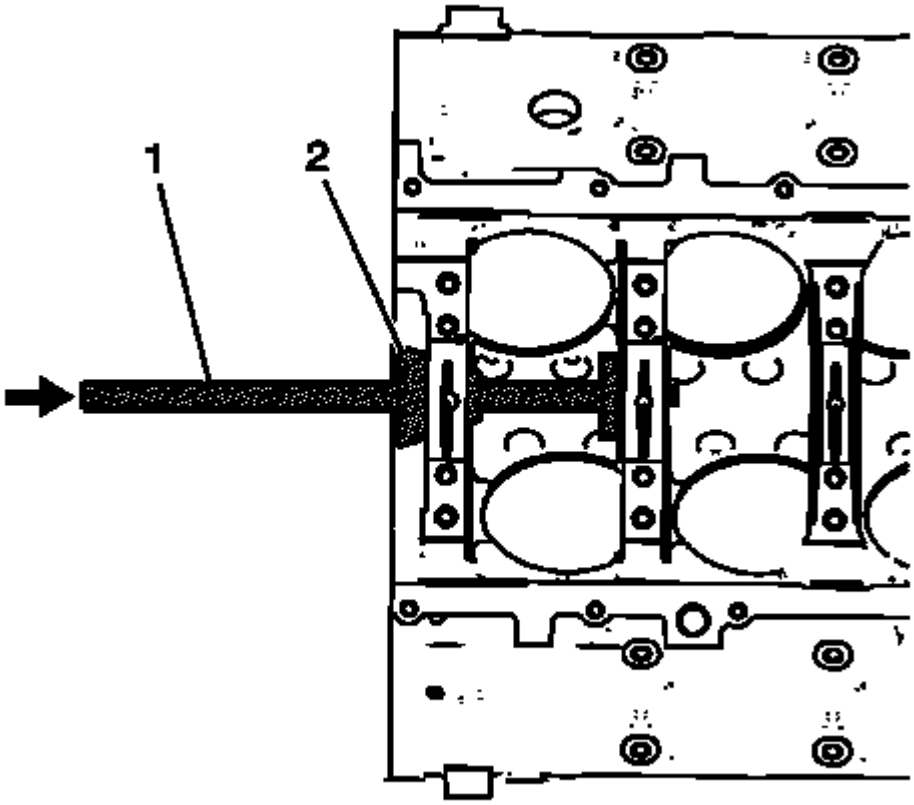

Fig. 461: Camshaft Bearing Service Kit
Courtesy of GENERAL MOTORS CORP.

4. Insert the tool through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone into the front camshaft bearing in order to align the tool.
7. Drive the bearing into the block bore.

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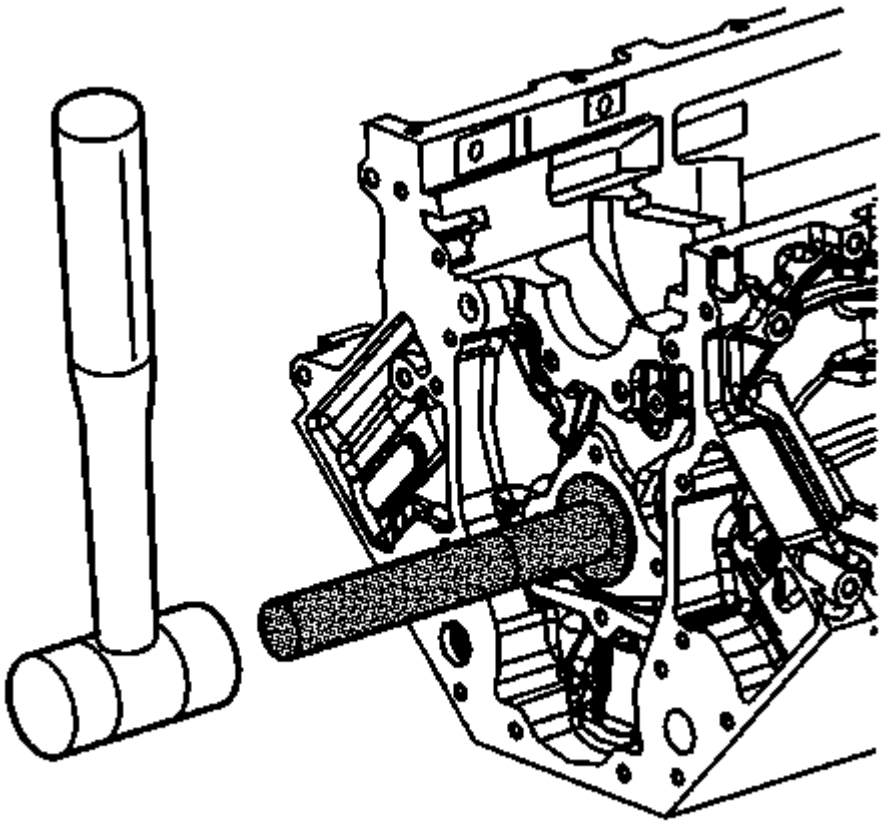

Fig. 462: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Install the front and rear bearings to the block.

Timing Chain and Sprockets Cleaning and Inspection

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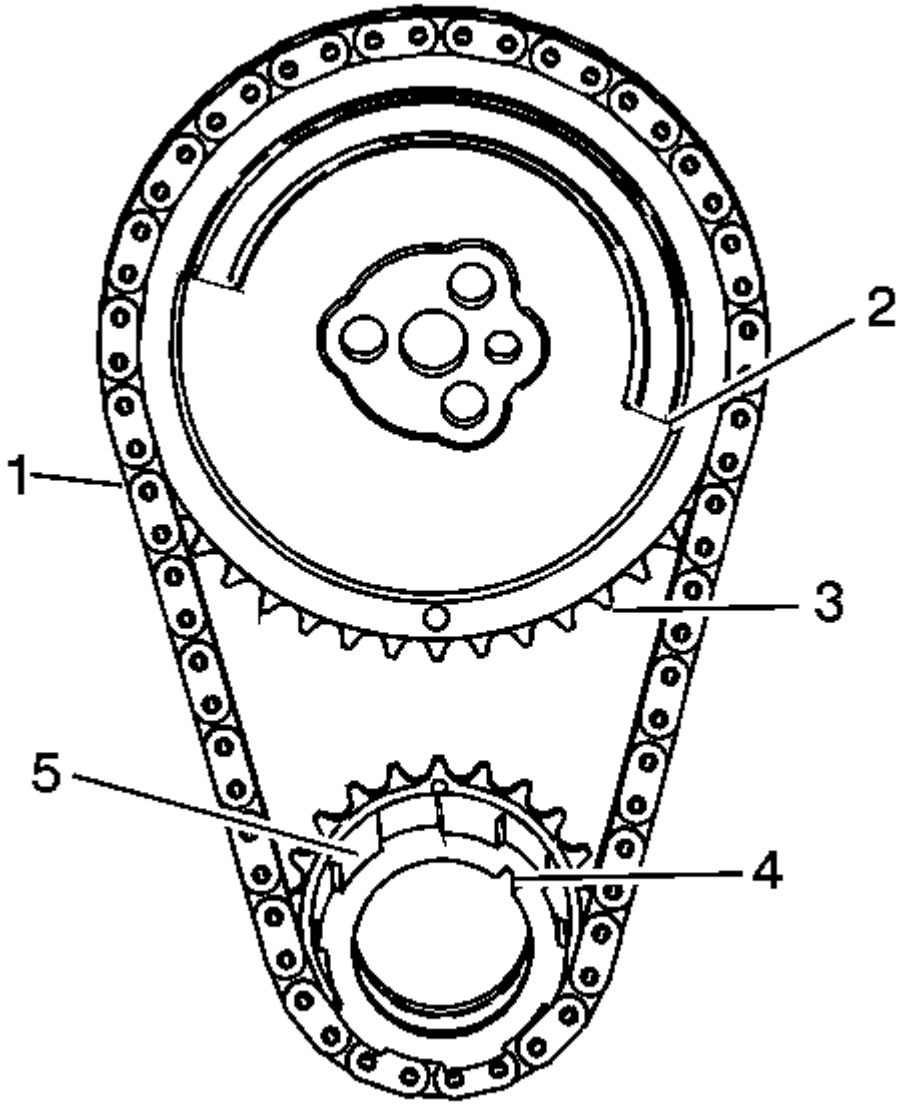

Fig. 463: Timing Chain & Sprockets Assembly
Courtesy of GENERAL MOTORS CORP.

1. Clean the components with cleaning solvent.

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

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2. Dry the components with compressed air.
3. Inspect the timing chain (1) for binding or wear.
4. Inspect the camshaft position (CMP) sensor raised area (2) for nicks or damage.
5. Inspect for worn, damaged, or chipped teeth (3).
6. Inspect for a damaged keyway (4).
7. Inspect for worn oil pump drive splines (5).

Valve Rocker Arm and Push Rods Cleaning and Inspection

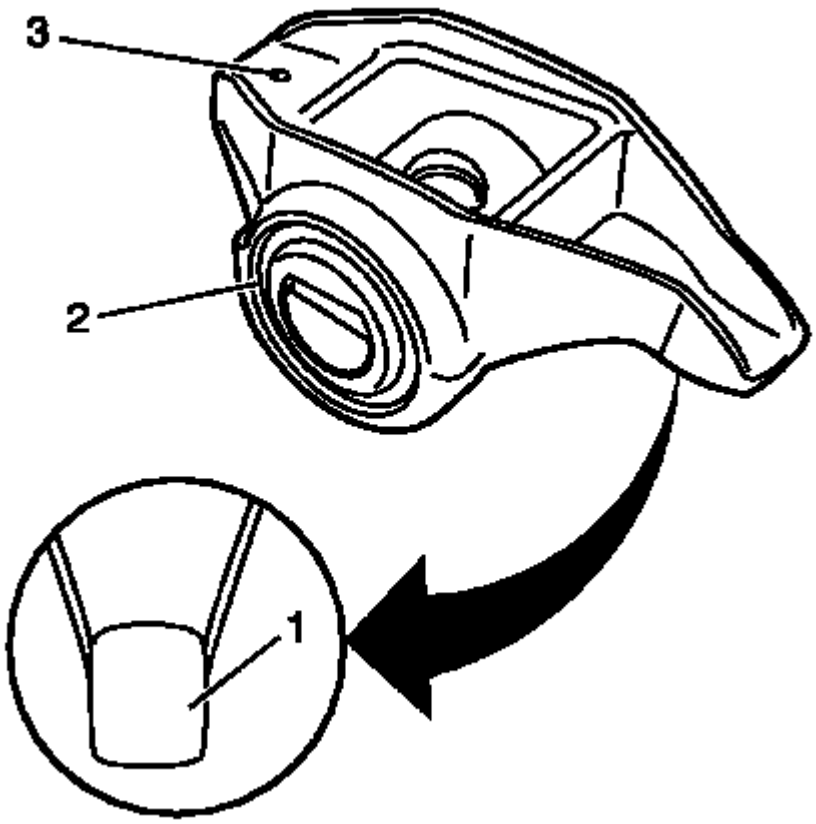

Fig. 464: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Parts that are to be used again must be marked, sorted or organized for assembly.

1. Mark, sort, or organize the components for assembly. Refer to **Separating Parts**.
2. Clean the components with cleaning solvent.

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

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3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.
6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.
9. Inspect the rocker arm pivot supports for cracks, wear, or other damage.

Valve Lifters and Guides Cleaning and Inspection

Non Displacement on Demand Valve Lifters

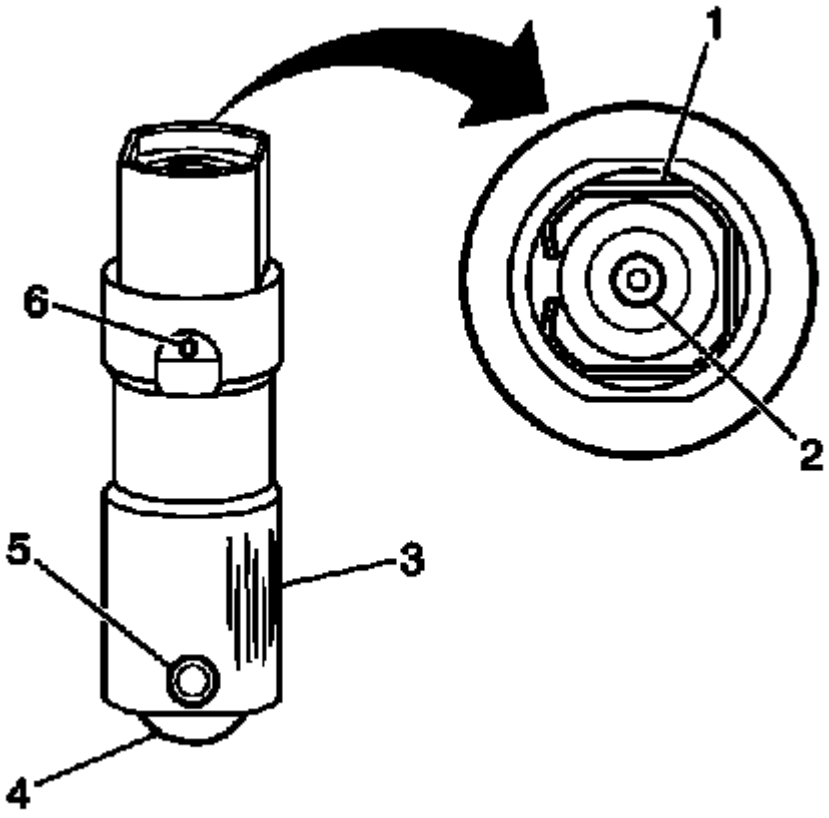

Fig. 465: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

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

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
   - Bent or broken clip (1)
   - Worn pushrod socket (2)
   - Scuffed or worn sides (3)

     If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

   - Flat spots on the roller (4)
   - Loose or damaged pin (5)
   - Plugged oil hole (6)
   - Worn or damaged roller bearing

     The roller should rotate freely with no binding or roughness.

Displacement On Demand Valve Lifters

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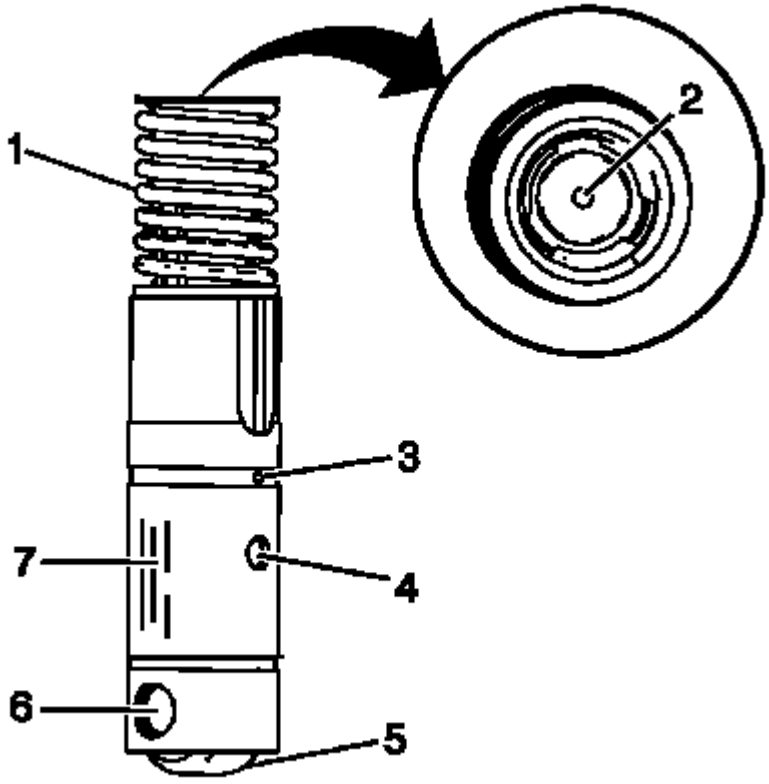

Fig. 466: Displacement On Demand Valve Lifters Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

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

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
   - Broken or collapsed spring (1)
   - Worn pushrod socket (2)
   - Plugged lubrication hole (3)
   - Plugged lifter oil-switching hole (4)
   - Flat spots on the roller (5)
   - Worn or damaged roller bearing (6)

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The roller should rotate freely with no binding or roughness.

- Scuffed or worn sides (7)

Valve Guides

Inspect the valve lifter guides for the following conditions:

- Cracks or damage
- Excessive wear in the lifter mounting bores

Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor - Head Off

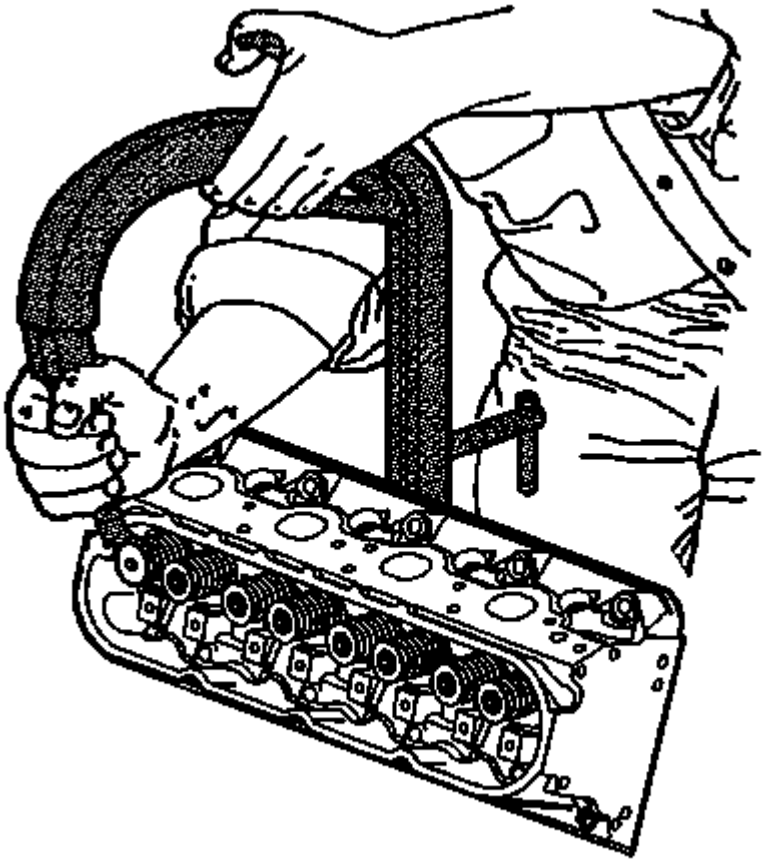

Fig. 467: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT:

- **With the components at room temperature, remove the spark plugs from the cylinder head.**
- **Mark, organize, or sort the cylinder head components for assembly. Return the components to their original location during assembly.**

1. Remove the spark plugs from the cylinder heads.
2. Use the **J 8062** in order to compress the valve spring.

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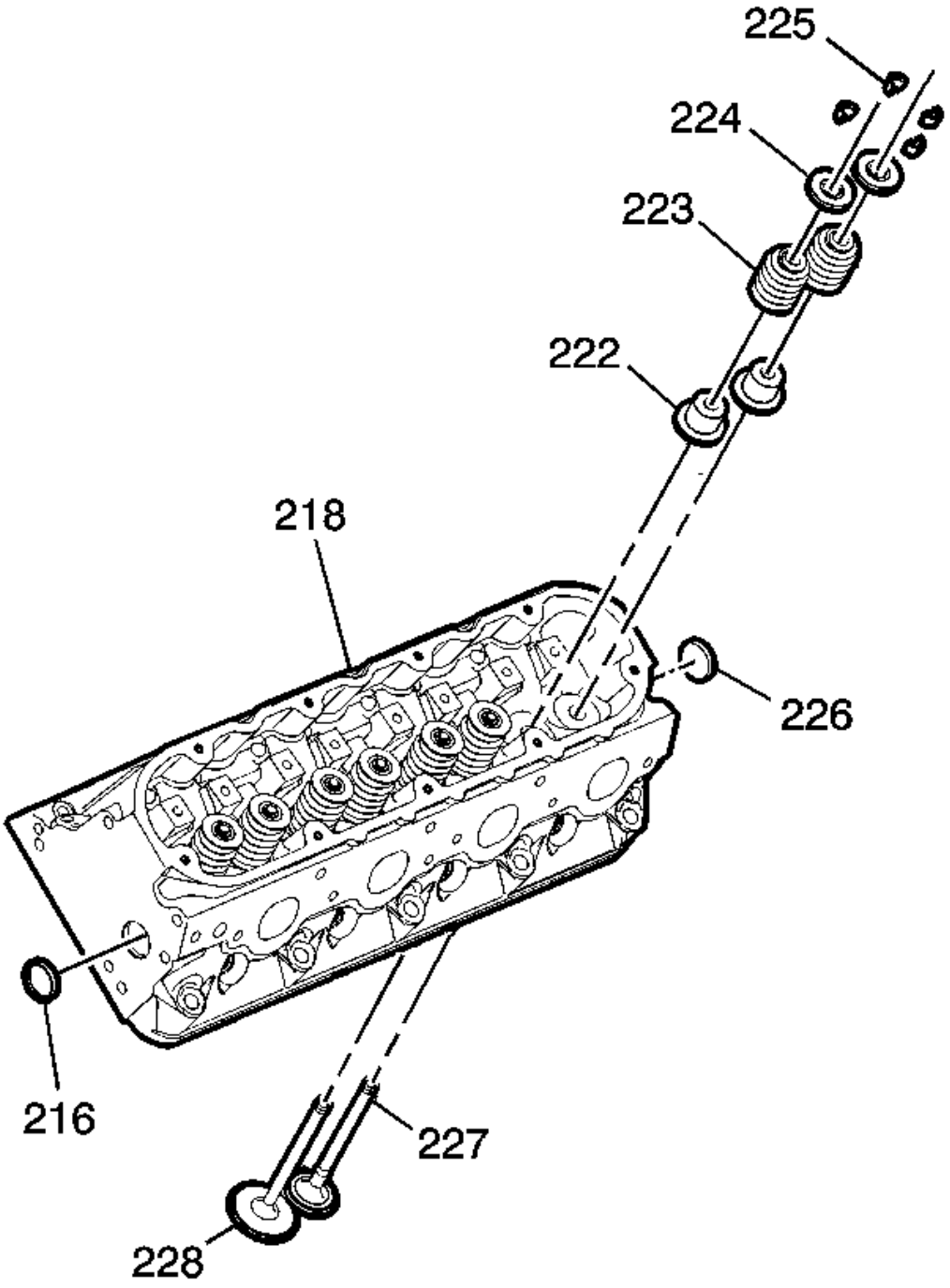

Fig. 468: View Of Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

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3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (227 and 228).
7. Remove the valve stem oil seal (222). Refer to **Separating Parts**.

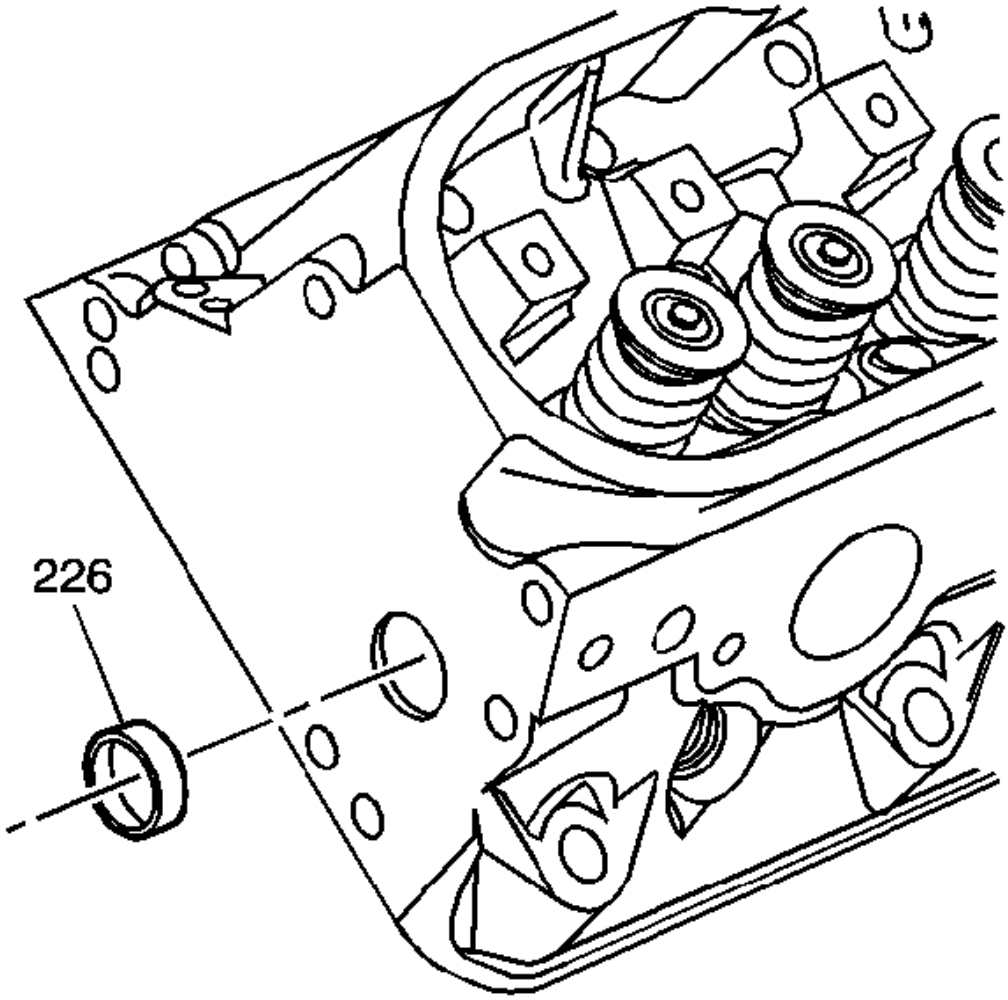

Fig. 469: View Of Cylinder Head Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head core hole plugs (226) as required.

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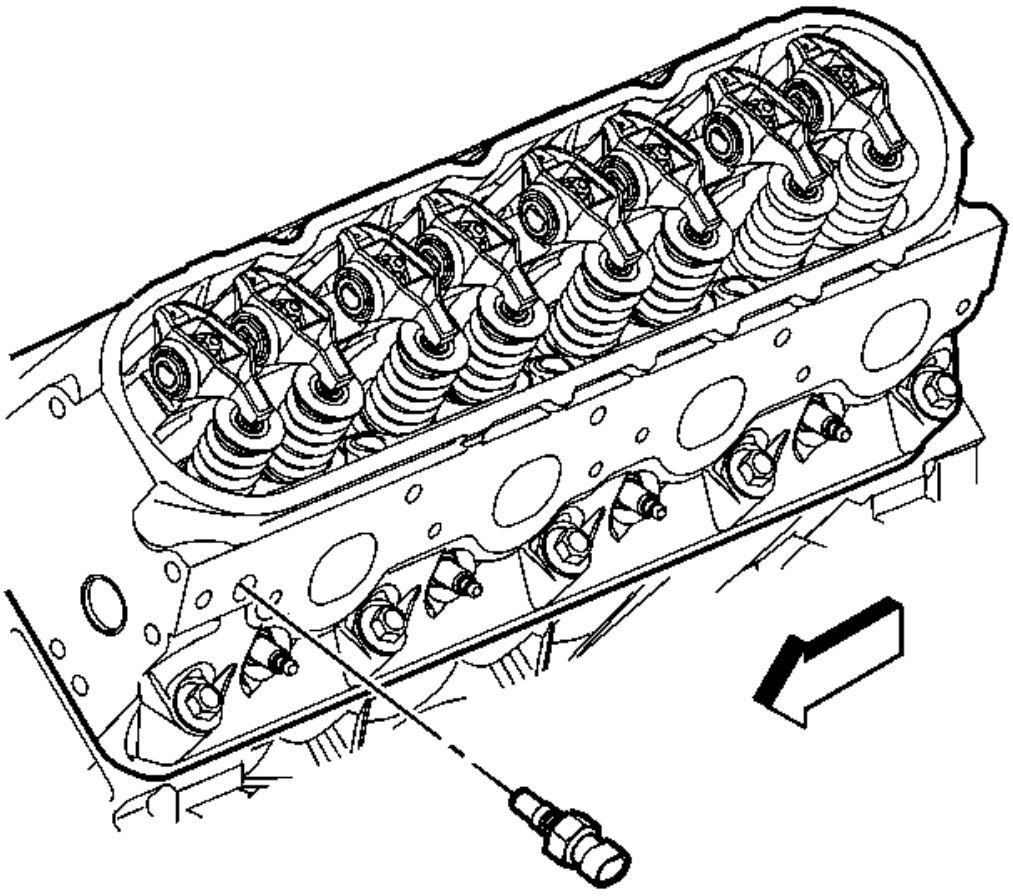

Fig. 470: View Of Coolant Temperature Sensor (Left Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor from the left cylinder head.

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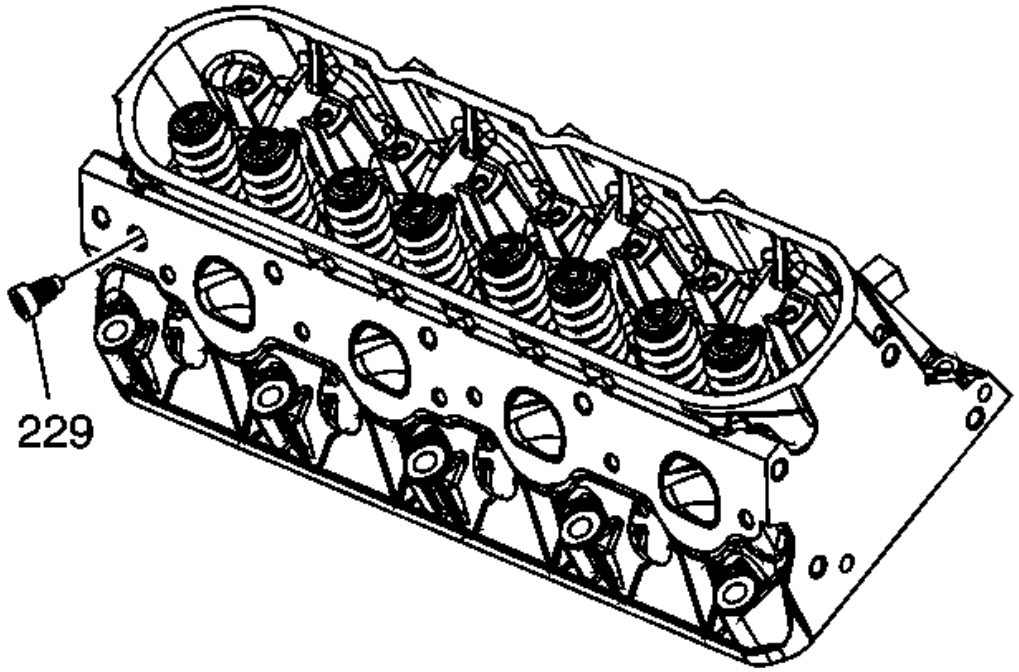

Fig. 471: Coolant Plug
Courtesy of GENERAL MOTORS CORP.

10. Remove the coolant plug from the right cylinder head.

Cylinder Head Cleaning and Inspection

Tools Required

- **J 8089** Carbon Removal Brush. See **Special Tools**.
- **J 9666** Valve Spring Tester. See **Special Tools**.

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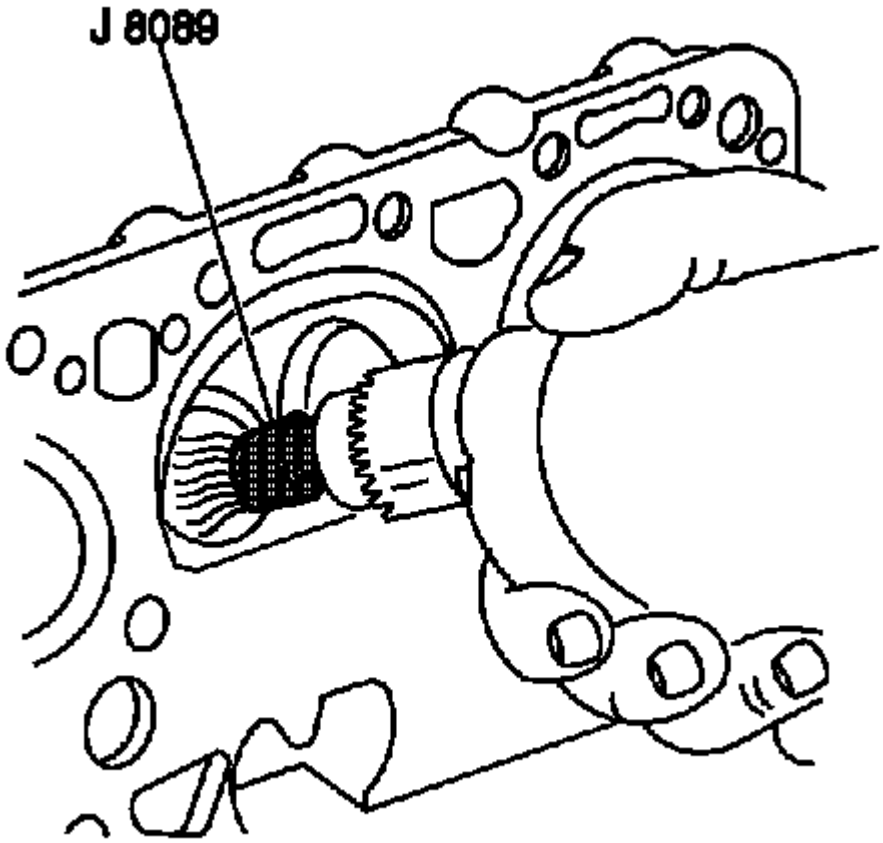

Fig. 472: Removing Carbon From Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:
- **When cleaning a cylinder head in a thermal type oven, do not exceed 204°C (400°F).**
- **Be careful not to scuff the chamber.**

1. Clean the following components:
   - Use the **J 8089** in order to remove the carbon from the combustion chambers. See **Special Tools**.
   - Gasket surfaces

     Refer to **Replacing Engine Gaskets** .

   - Valve stems and heads on a buffing wheel
   - Bolt hole threads

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Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:
    1. Cracks in the exhaust ports and combustion chambers
    2. External cracks in the water chambers
    3. Gasket surfaces for excessive scratches or gouging

    Refer to **Replacing Engine Gaskets** .

    4. Bolt hole threads for debris or damaged threads

    Refer to **Thread Repair** or **Thread Repair Specifications** .

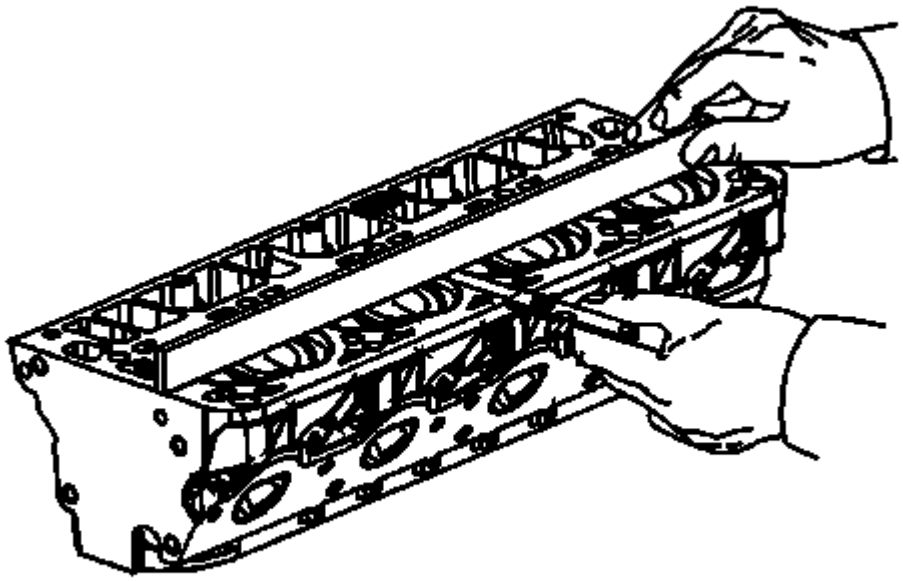

Fig. 473: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications**.

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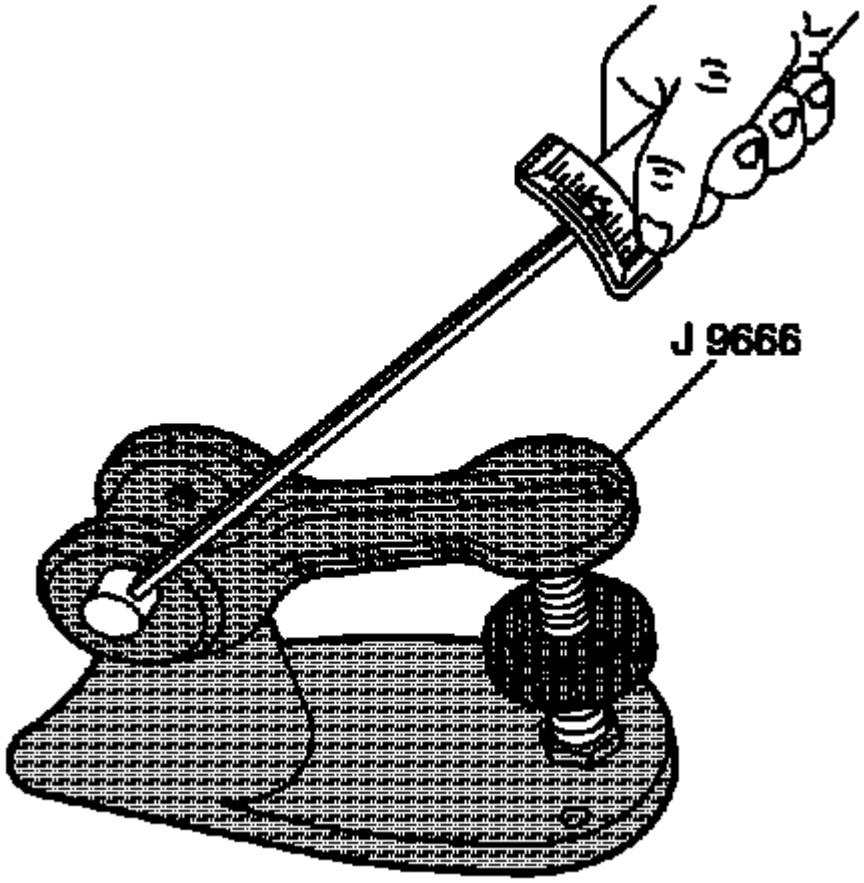

Fig. 474: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 9666** in order to measure the valve spring tension. See **Special Tools**. Refer to **Engine Mechanical Specifications**.

Valve Guide Reaming/Valve and Seat Grinding

Tools Required

J 37378-1 Valve Guide Reamer. See **Special Tools**.

Valve Guide Reaming

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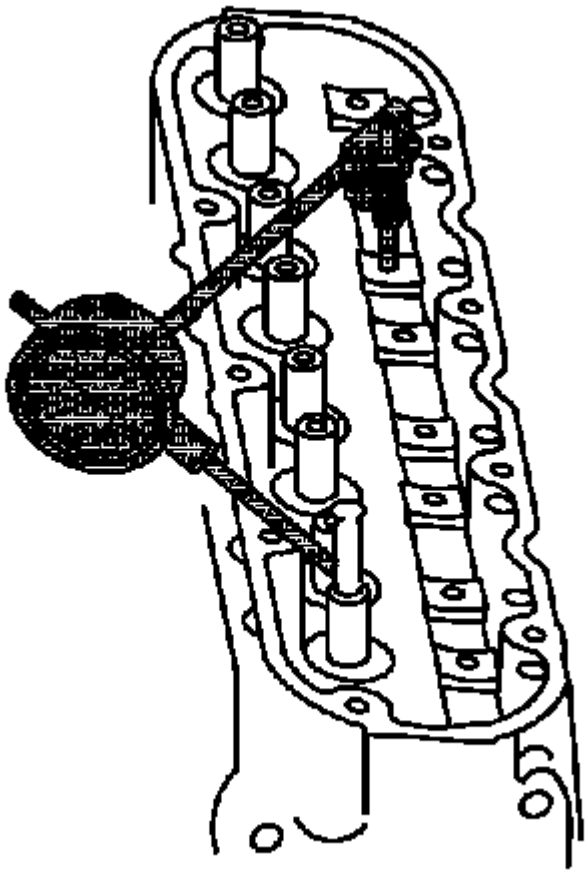

Fig. 475: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive engine 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. Measure the valve stem-to-guide clearance using a dial indicator. Position the tip of the dial indicator at the top of the valve guide.

   Valve stem-to-guide clearance may also be obtained by using a micrometer to measure the valve stem diameter and a ball type measuring gage to measure the guide bore.

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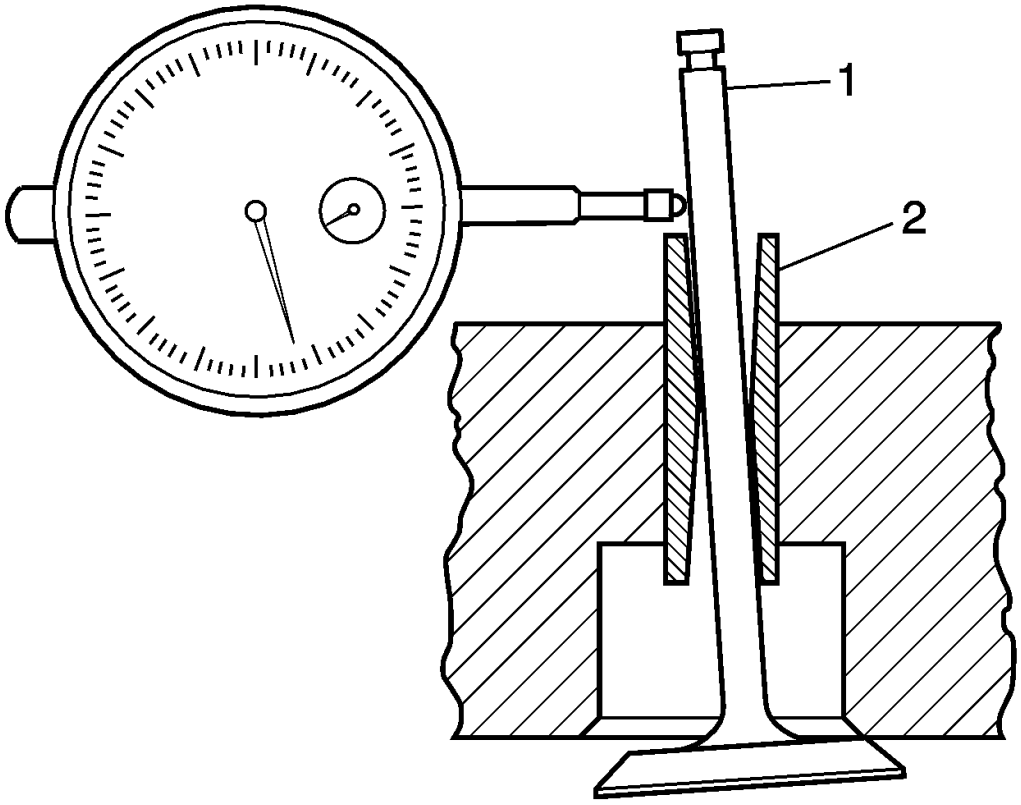

Fig. 476: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. A valve stem (1) and guide (2) with excessive clearance must be replaced or the components replaced.

   Refer to **Engine Mechanical Specifications**.

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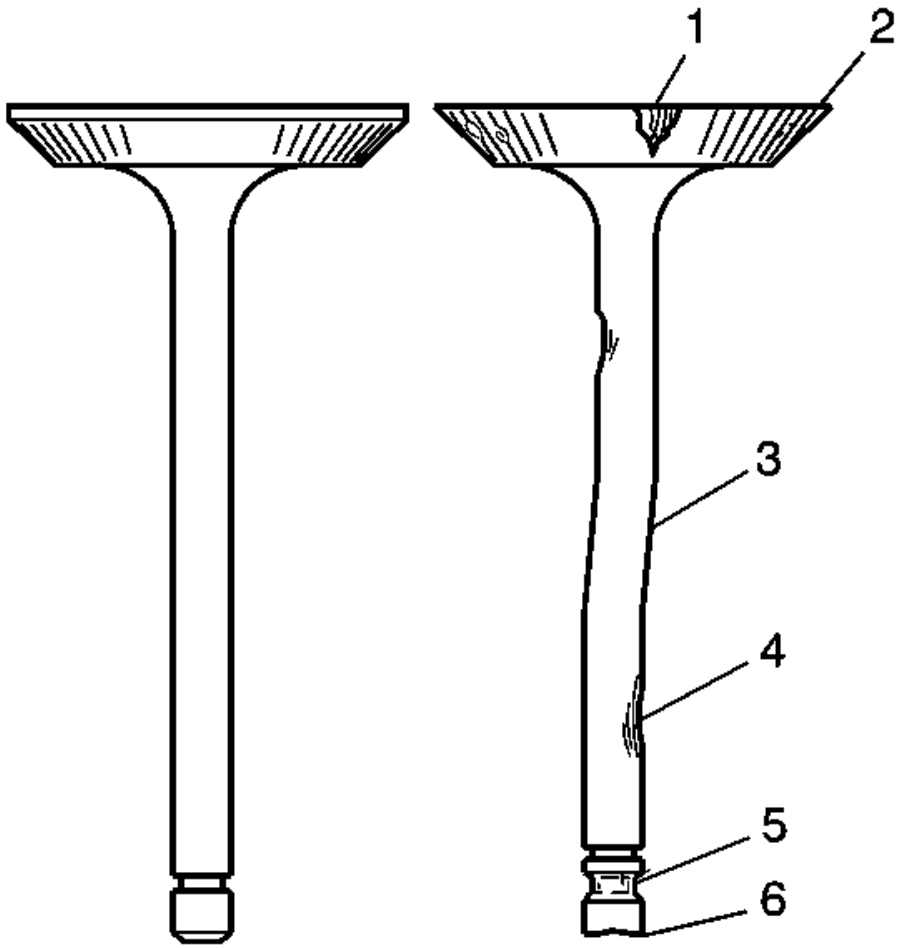

Fig. 477: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve stems for excessive scoring, wear, or warpage.
   - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
   - A valve guide that is worn and has excessive stem-to-guide clearance should be reamed and valves with oversize stems installed.
4. Measure the valve stem diameter. A valve stem with a diameter less than 7.95 mm (0.313 in) must be replaced.

   If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the valve guide must be reamed oversize and a valve with oversize stem installed.

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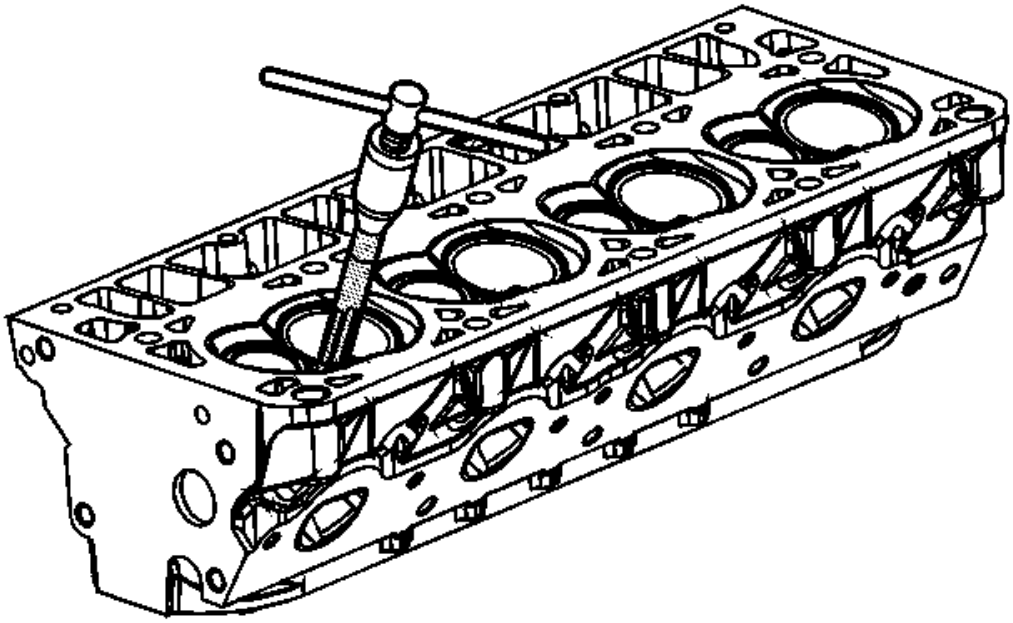

Fig. 478: Reaming Valve Guide
Courtesy of GENERAL MOTORS CORP.

5. Ream the valve guide using the **J 37378-1** . See **Special Tools**.
6. Clean the guide bore of all metal shavings and debris.

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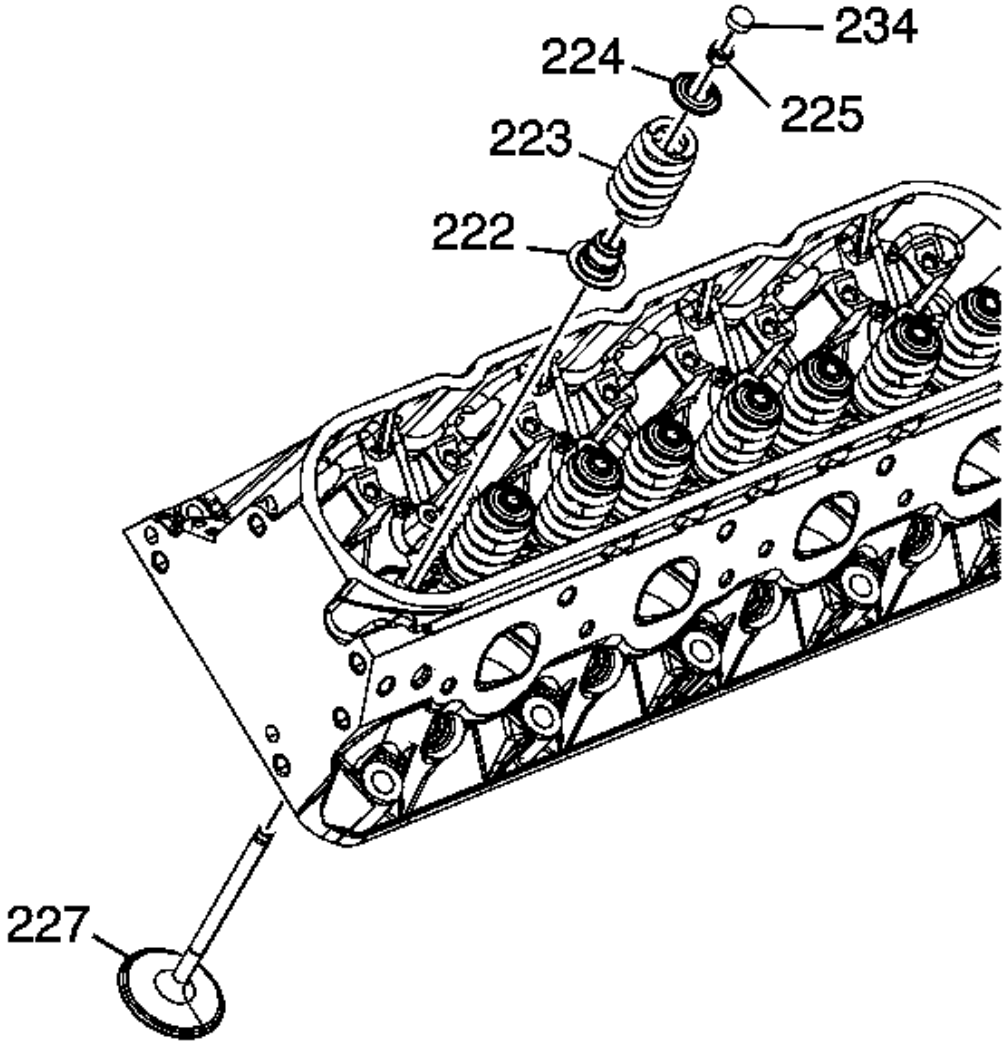

Fig. 479: Valve & Valve Spring Assembly
Courtesy of GENERAL MOTORS CORP.

7. Install the valve (228), with oversize stem, into the cylinder head.
8. Inspect the valve for the proper fit.

   Move the valve back and forth in the guide. The valve should move freely with no resistance or drag.

Valve and Seat Grinding

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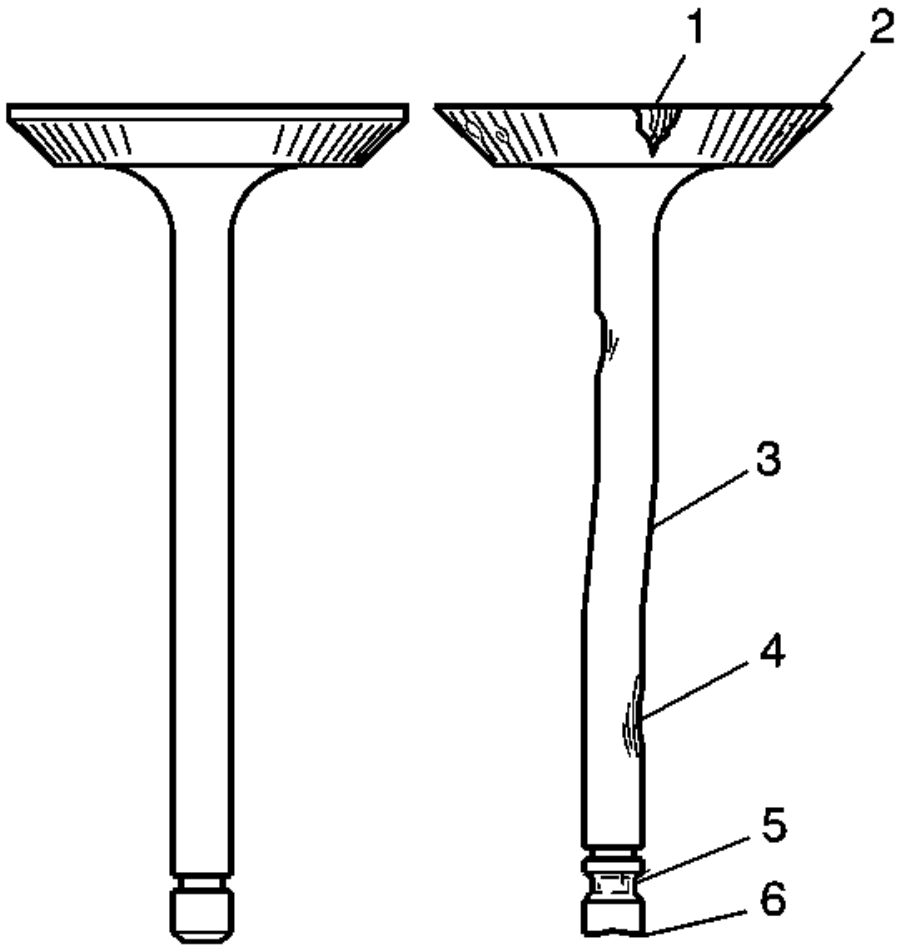

Fig. 480: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of equipment are available for grinding valve seats.**
- **Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.**
- **The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.**
- **Valves that are pitted must be refaced to the proper angle. Valve**

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stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head is less than 1.25 mm (0.05 in) after grinding, replace the valve.

- **Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment should be carefully followed to obtain the proper results.**
- **DO NOT reface intake valves. Intake valves with excessive wear or damage MUST be replaced.**

1. Inspect the valve for the following conditions:
   - Burnt or eroded areas (1)
   - A worn margin (2)
   - A bent stem (3)
   - A worn or scored stem (4)
   - A worn key groove (5)
   - A worn stem tip (6)

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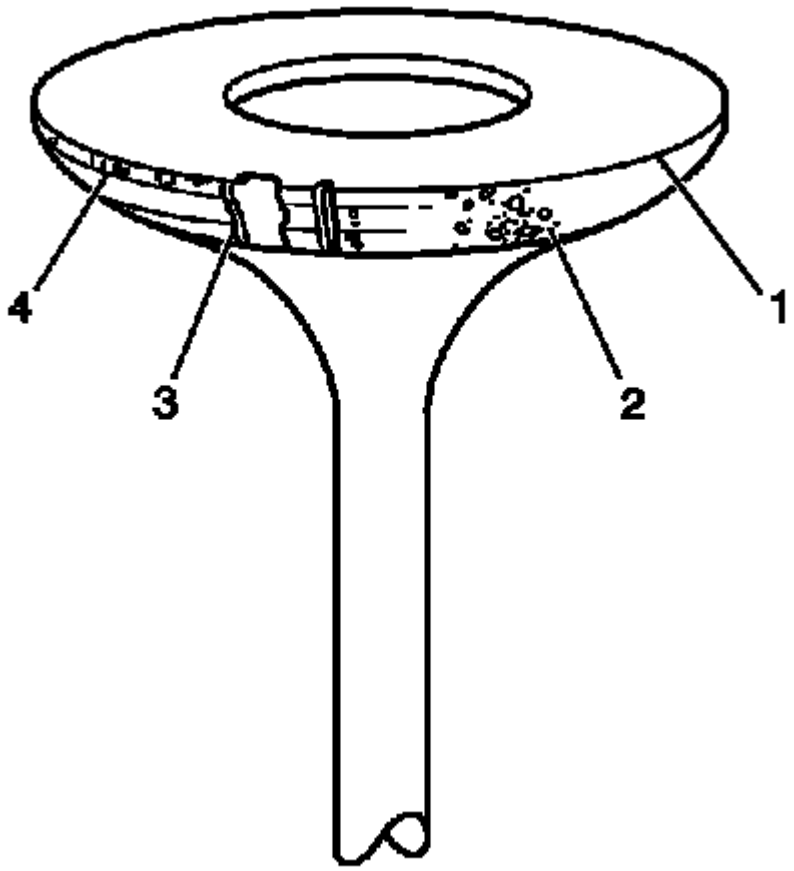

Fig. 481: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
   - Worn or no margin (1 or 4)
   - Pitted surfaces (2)
   - Burnt or eroded areas (3)

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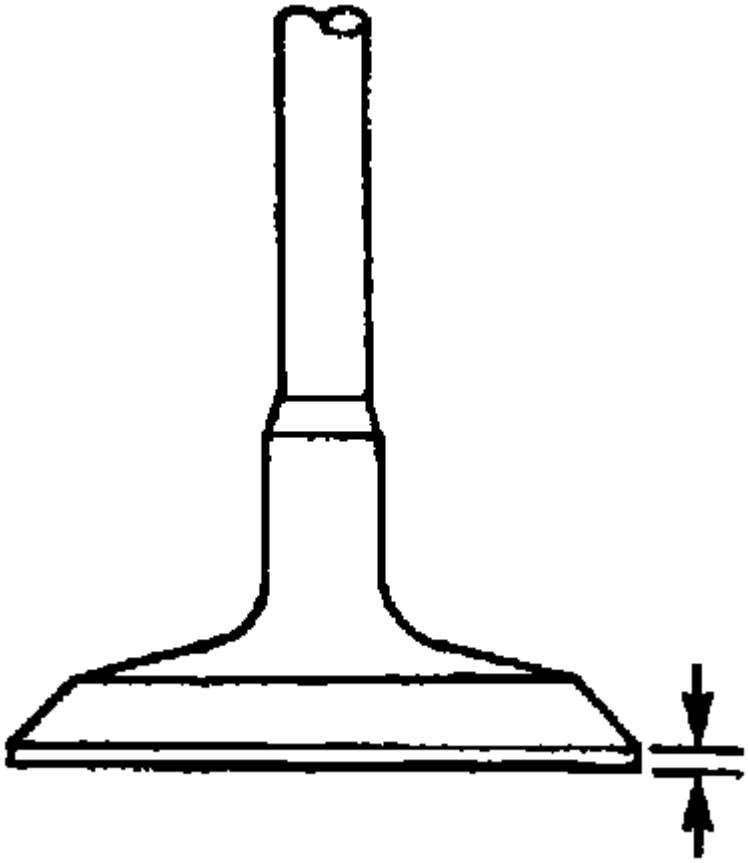

Fig. 482: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve margin.

   The exhaust valve may be refaced if the margin is greater than 1.25 mm (0.05 in) thick before grinding.

4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is less than 1.25 mm (0.05 in) thick after grinding.
6. If the valve face has been ground, it may be necessary to shim the valve spring to obtain the proper spring installed height. Refer to **Cylinder Head Disassemble**.
7. Inspect for a loose valve seat in the cylinder head. The valve seat has an interference fit to the cylinder head.
8. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

   The valve guide must be clean for the seat grinding tool to obtain proper results.

9. Grind the valve seat.

   The recommendations of the manufacturer of the equipment should be followed carefully to obtain the proper results. Regardless of what type of equipment is used, it is essential that valve guide bores be free

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from carbon or dirt to ensure proper centering of the tool pilot in the guide.

10. Inspect the valve seats.
    - The valve seats should be concentric to within 0.05 mm (0.0021 in) total indicator reading.
    - If the valve seat has been ground, it may be necessary to shim the valve spring to attain the proper spring installed height. Refer to **Cylinder Head Disassemble**.

Cylinder Head Assemble

Tools Required

J 8062 Valve Spring Compressor - Head Off

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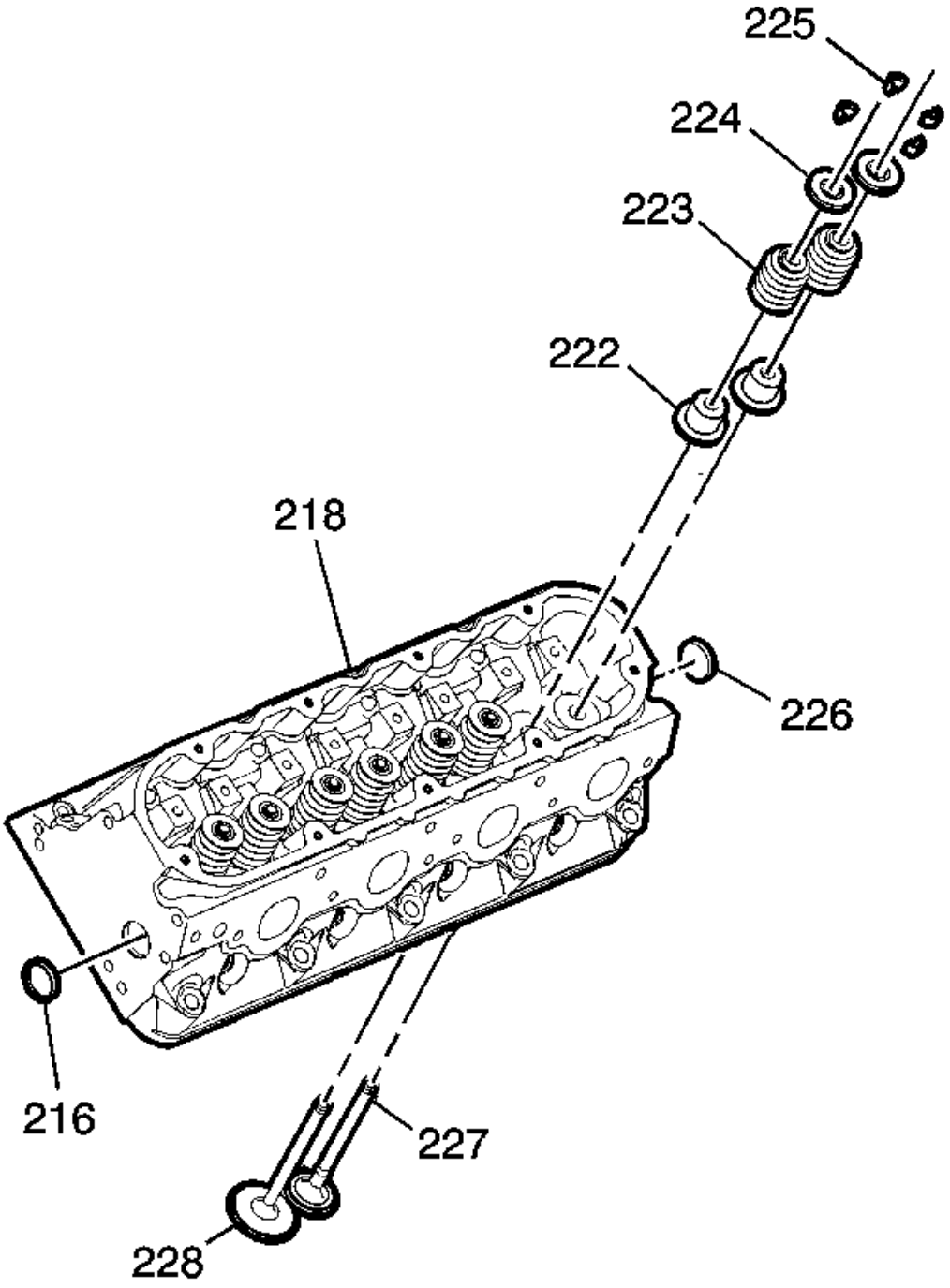

Fig. 483: View Of Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

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1. Clean the cylinder head valve spring shim area.

IMPORTANT: When using the valves and related components again, install the parts to their original location.

2. Install the valves (227 and 228) into the proper port. Refer to **Separating Parts**.

IMPORTANT: The valve stem oil seal alignment and position on the valve guide is critical.
An improperly installed valve stem oil seal may lead to excessive oil consumption, increased vehicle emissions, or component damage.

3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).

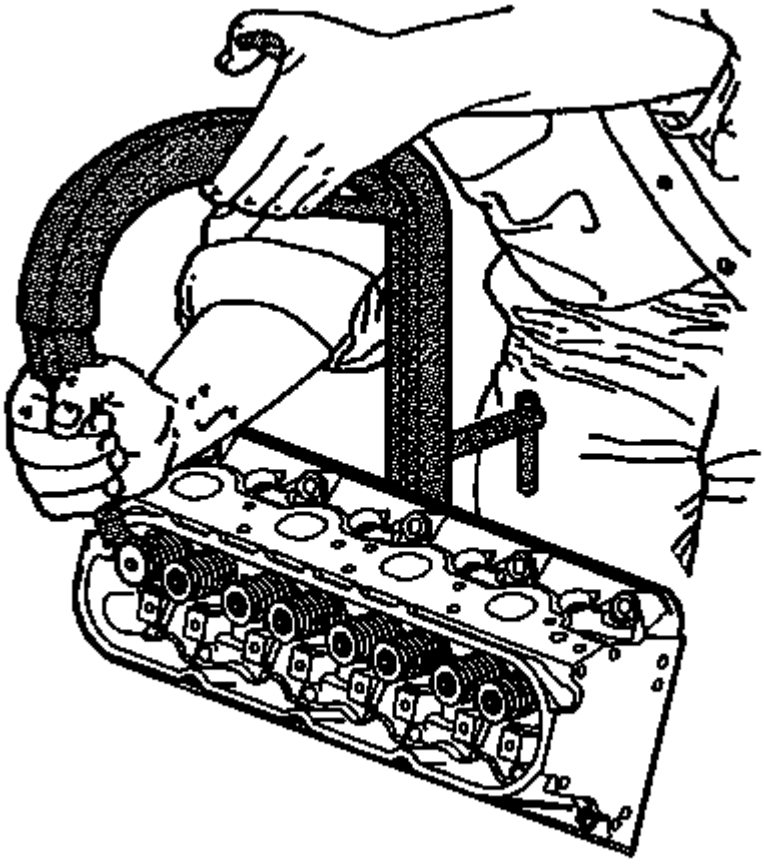

Fig. 484: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

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6. Compress the valve spring using the **J 8062** .
7. Install the valve stem keys.
    1. Use grease to hold the keys in place and remove the **J 8062** .
    2. Ensure the keys seat properly in the groove of the valve stem.
    3. Tap the end to the valve stem with a plastic faced hammer to seat the keys, if necessary.

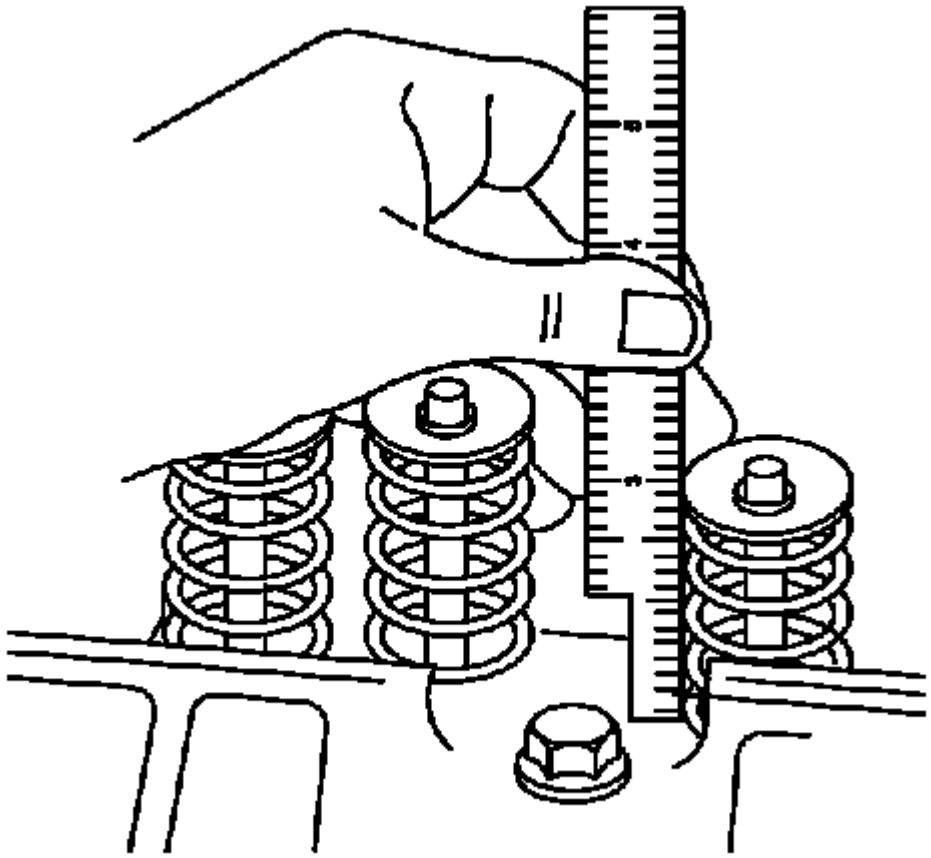

Fig. 485: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

8. Measure the valve spring installed height using a ruler.

    Measure from the base of the valve spring to the top of the valve spring.

    Specification:

    - If the installed height exceeds 46.25 mm (1.82 in), install a valve spring shim of approximately 0.5 mm (0.02 in) thick.
    - Do not shim the valve spring to obtain less than the specified height.

      Do not assemble the components without a spring shim on the cylinder head.

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9. Install the remaining valves, springs, and other components.

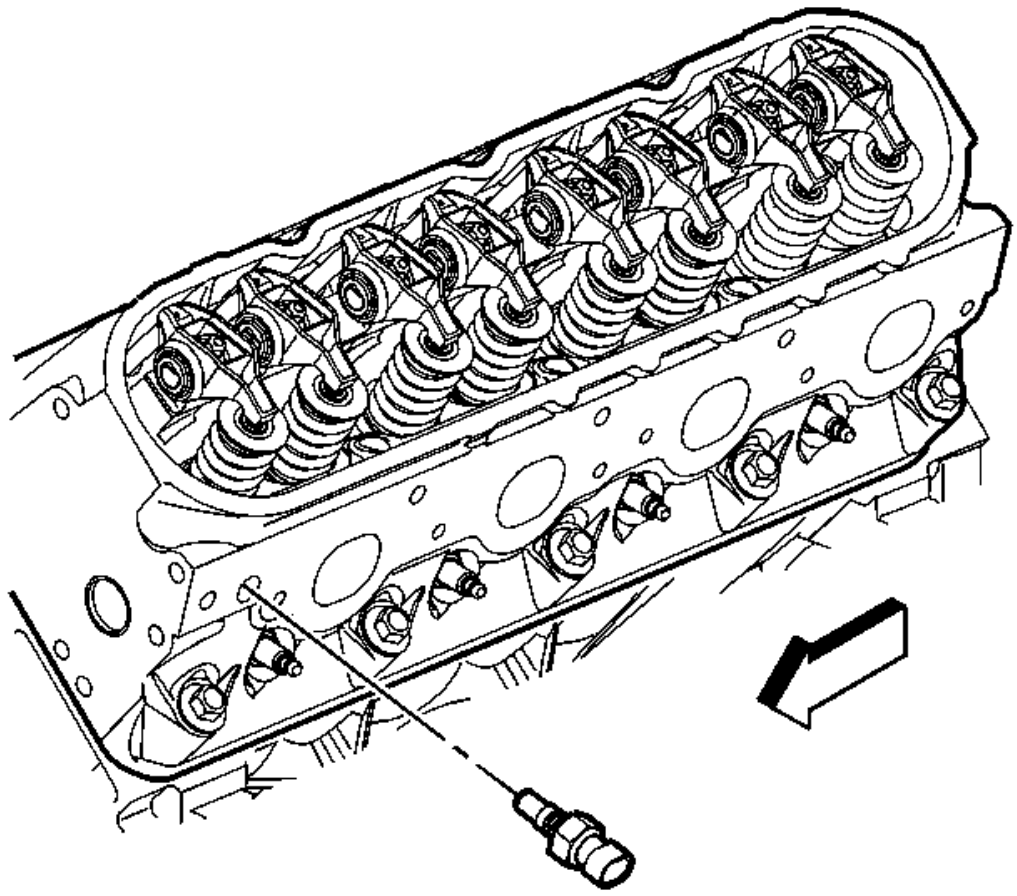

Fig. 486: View Of Coolant Temperature Sensor (Left Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

10. Install sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the coolant sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Install the coolant temperature sensor into the left cylinder head.

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

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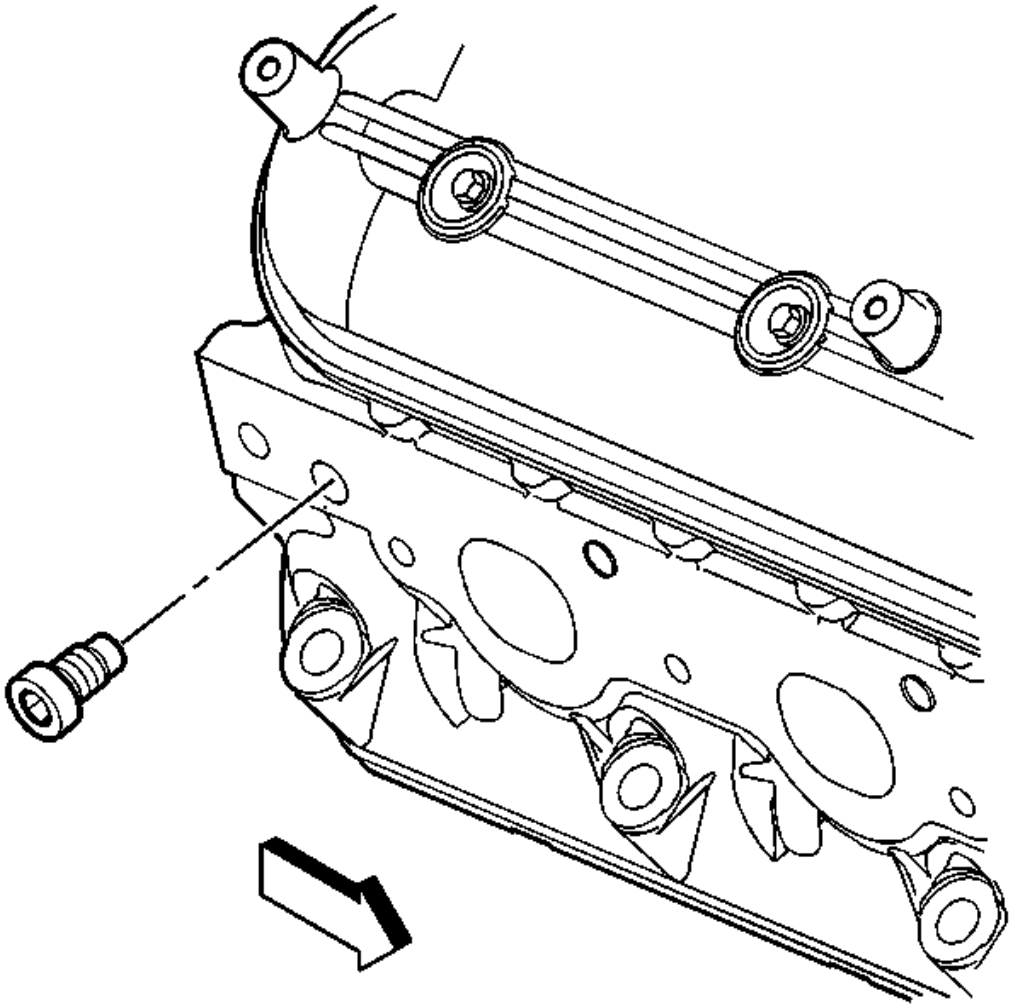

Fig. 487: View Of Coolant Plug (Right Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

12. Install threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the plug.
13. Install the coolant plug to the right cylinder head.

Tighten: Tighten the coolant plug to 20 N.m (15 lb ft).

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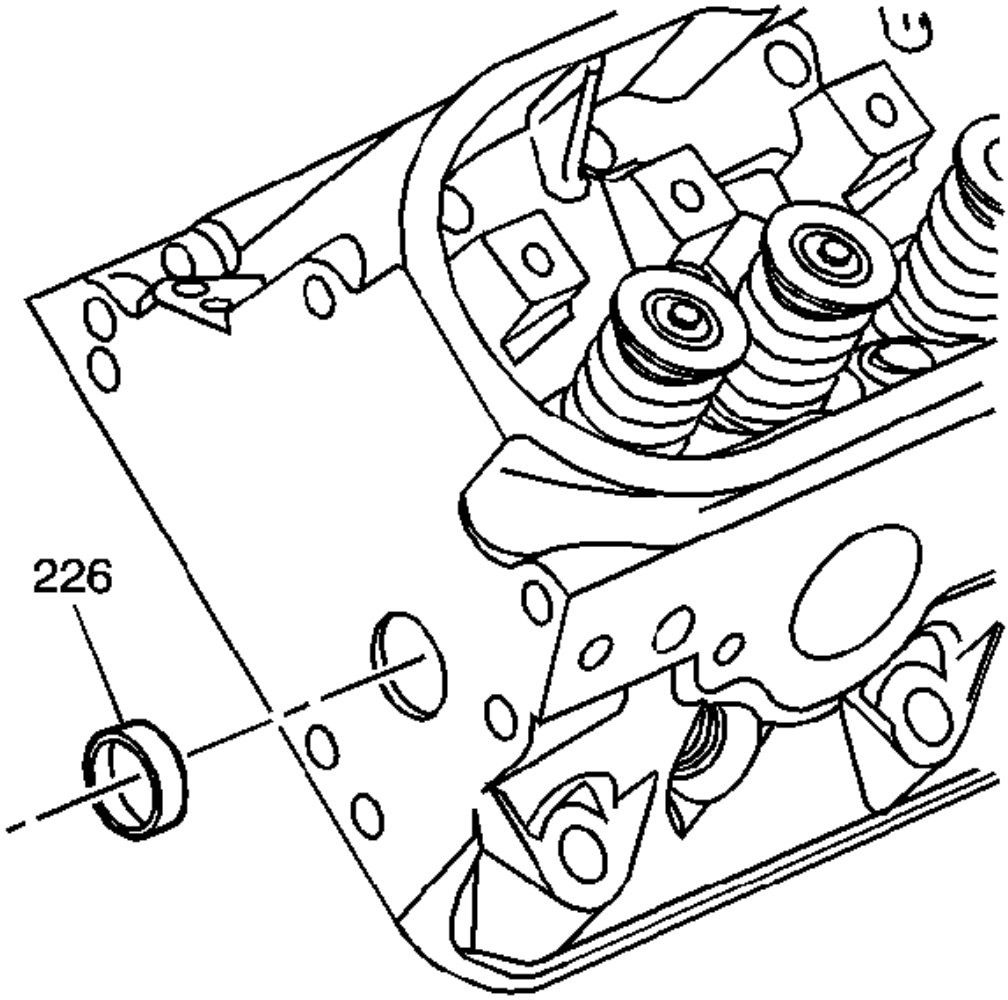

Fig. 488: View Of Cylinder Head Expansion Plugs
Courtesy of GENERAL MOTORS CORP.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the sides of the cylinder head core hole plugs (226).
15. Install the core hole plugs into the cylinder head.

    A properly installed plug should be installed 2.5 mm (0.1 in) below the end face of the head.

Oil Pump Disassemble

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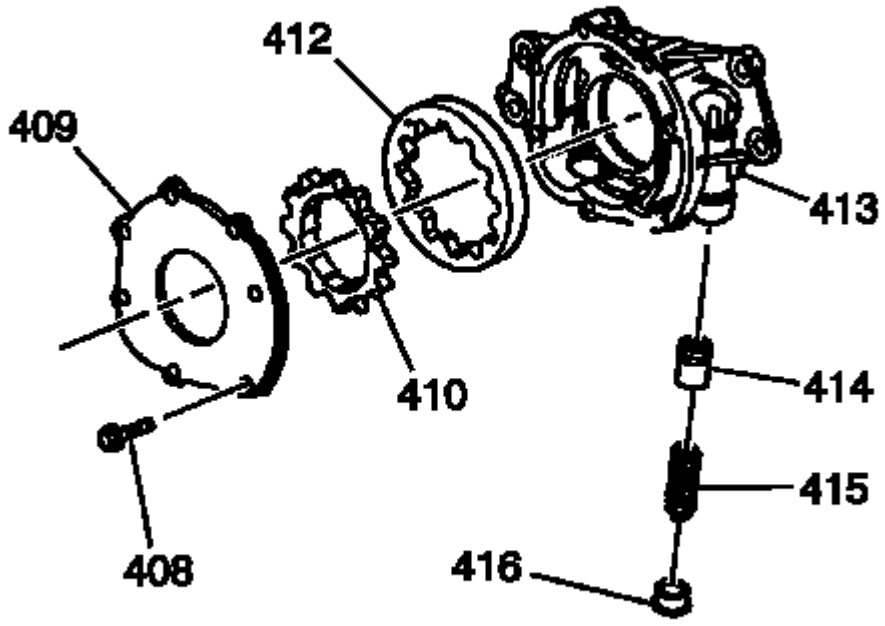

Fig. 489: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts (408).
2. Remove the oil pump cover (409).

IMPORTANT: Mark or identify the gears for assembly. Refer to Separating Parts.

3. Remove the drive gear (410).
4. Remove the driven gear (412).
5. Remove the pressure relief valve plug (416).
6. Remove the pressure relief valve spring (415).
7. Remove the pressure relief valve (414).
8. Inspect the oil pump components. Refer to **Oil Pump Cleaning and Inspection**.

Oil Pump Cleaning and Inspection

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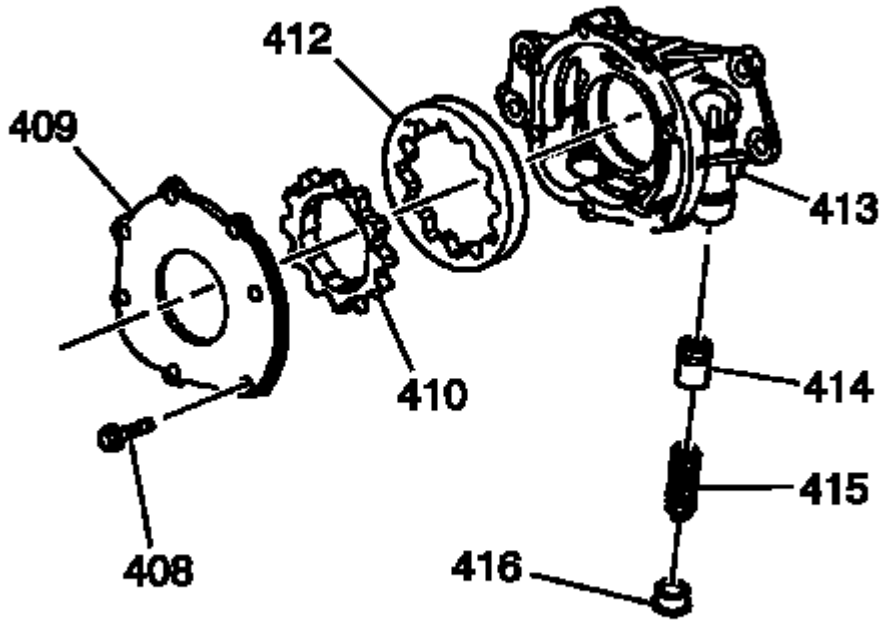

Fig. 490: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.**
- **The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pump and screen assembly.**

1. Clean the parts in solvent.

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

2. Dry the parts with compressed air.
3. Inspect the oil pump housing (413) and the cover (409) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.

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5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug (416) and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
8. Inspect the drive gear (410) and driven gear (412) for chipping, galling or wear.

   Minor burrs or imperfections on the gears may be removed with a fine oil stone.

9. Inspect the drive gear splines for excessive wear.
10. Inspect the pressure relief valve (414) and bore for scoring or wear.

    The valve must move freely in the bore with no restrictions.

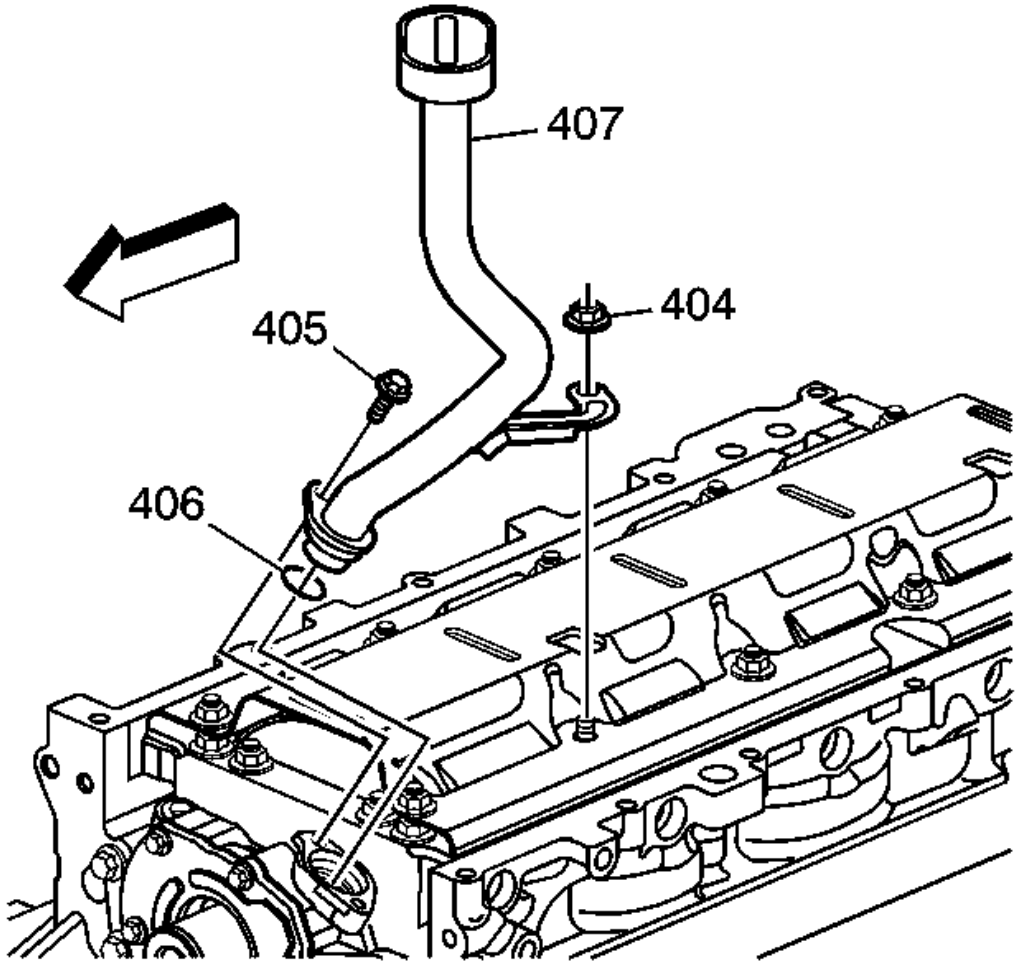

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Fig. 491: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

11. Inspect the oil pump screen (407) for debris or restrictions.
12. Inspect the oil pump screen for broken or loose wire mesh.

Oil Pump Assemble

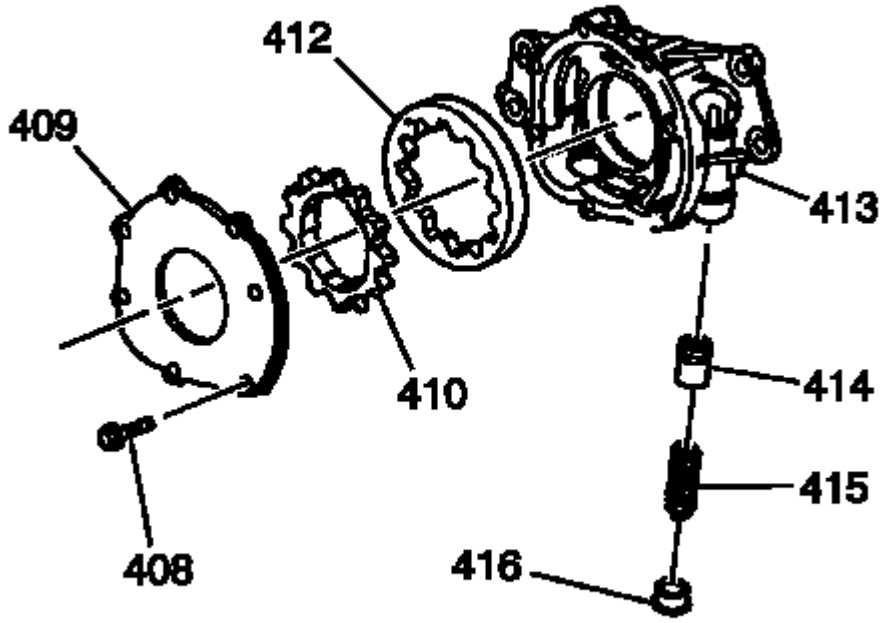

Fig. 492: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Prior to assembling the oil pump, coat all wear or internal surfaces with clean engine oil.

1. Install the driven gear (412) into the pump housing (413).

   Install the driven gear with the orientation mark facing the pump cover.

2. Install the drive gear (410) into the pump housing.
3. Install the oil pump cover (409).

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NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the pump cover bolts (408).

   Tighten: Tighten the oil pump cover bolts to 12 N.m (106 lb in).

5. Install the relief valve (414).
6. Install a NEW relief valve spring (415).
7. Install the pressure relief valve plug (416).

   Tighten: Tighten the pressure relief valve plug to 12 N.m (106 lb in).

8. Inspect the oil pump for smooth operation by rotating the drive gear.

Engine Front Cover Cleaning and Inspection

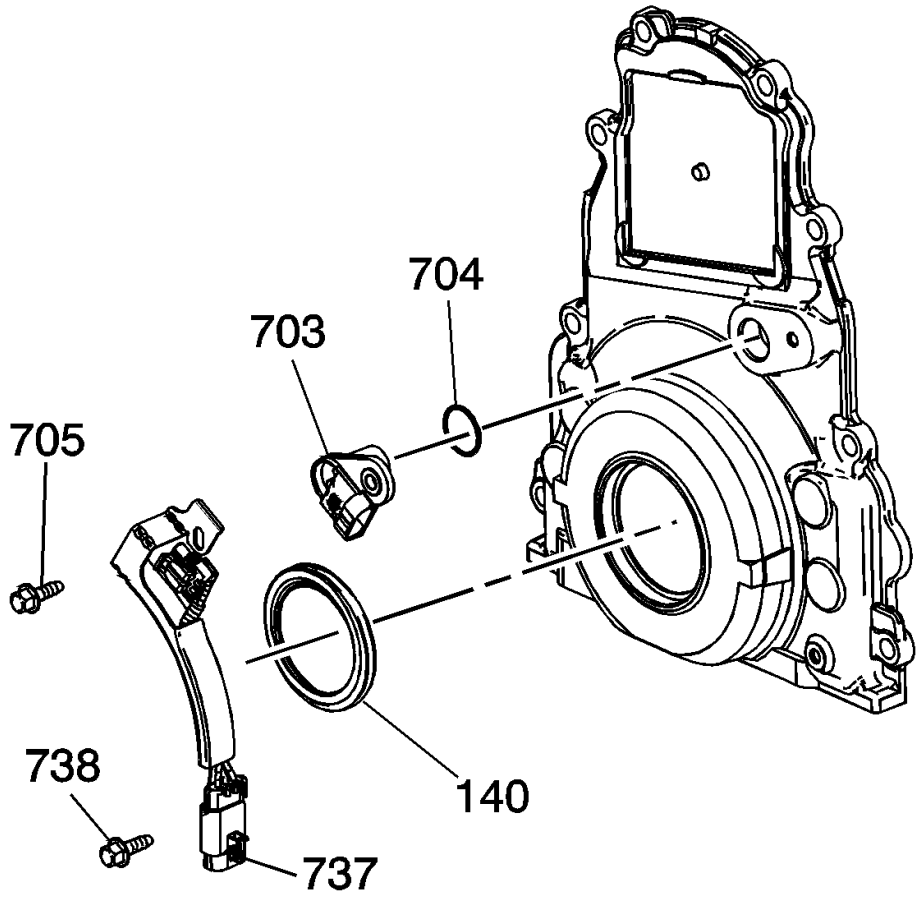

Fig. 493: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT:

- **Do not use the crankshaft oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.**

1. Remove the crankshaft oil seal (140) from the front cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets**.

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

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal and camshaft position (CMP) sensor mounting bores for damage.

Engine Rear Cover Cleaning and Inspection

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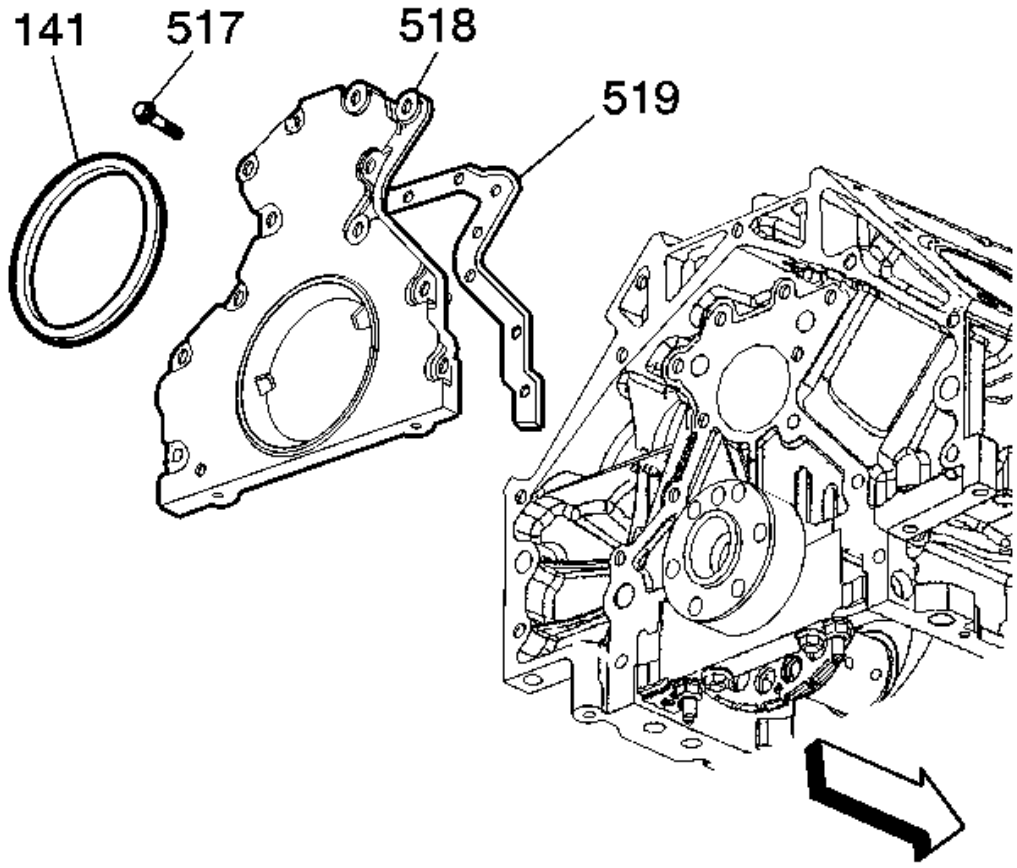

Fig. 494: Engine Rear Cover
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **Do not use the crankshaft oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the rear cover-to-engine block gasket again. Install a NEW gasket during assembly.**

1. Remove the crankshaft oil seal (141) from the rear cover.
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets**.

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

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3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the cover-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

Valve Lifter Oil Manifold Cleaning and Inspection

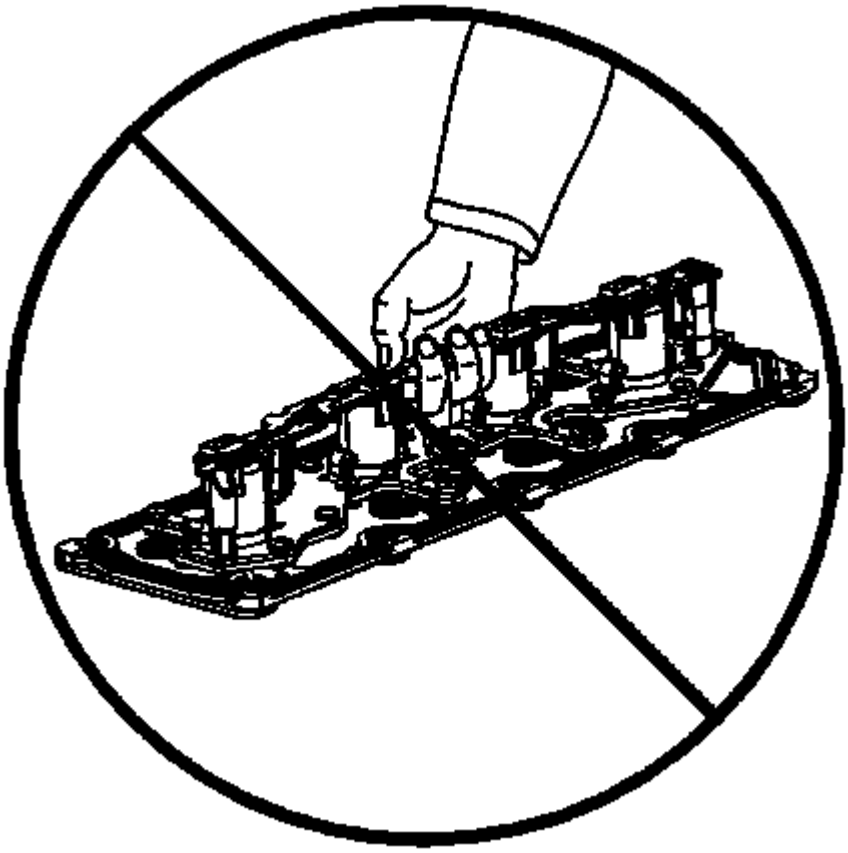

Fig. 495: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.**
- **Do not disassemble the electrical components from the manifold.**
- **Do not submerge the electrical components in cleaning solvent.**
- **Do not use the manifold exterior gasket again. Remove the exterior gasket and install a NEW service gasket during assembly.**

1. Do not lift the manifold assembly by the electrical lead frame.

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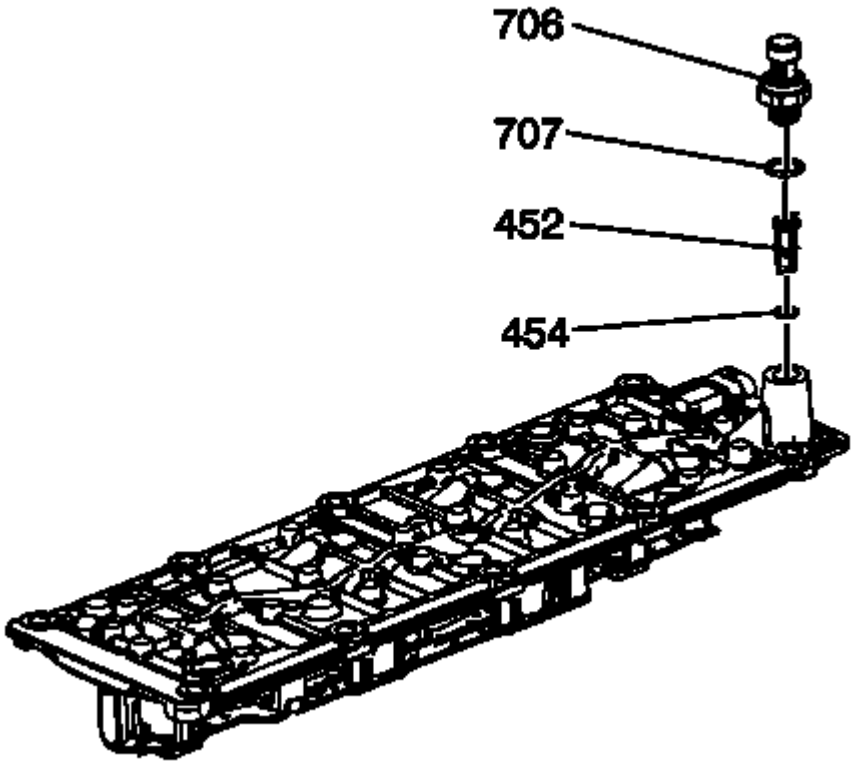

Fig. 496: Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pressure sensor (706) and washer (707).
3. Remove the oil screen (452) with O-ring (454).

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

4. Clean the manifold with compressed air.

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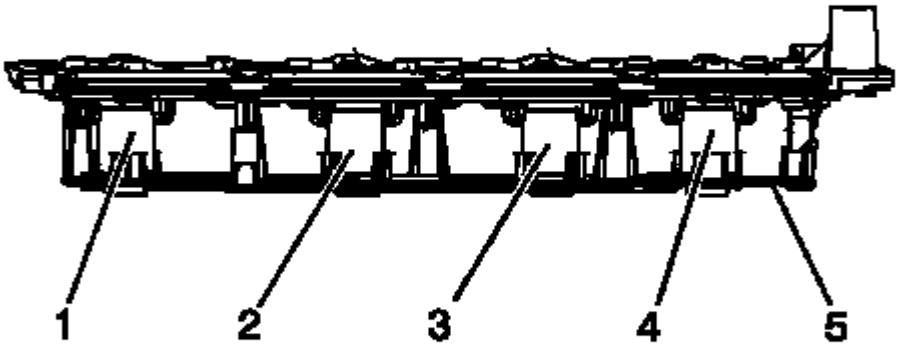

Fig. 497: Electrical Solenoids
Courtesy of GENERAL MOTORS CORP.

5. Inspect for loose electrical solenoids (1-4) or loose or missing bolts.
6. Inspect for damage to the electrical lead frame (5).
7. Inspect for a damaged electrical connector, for bent or corroded pins.

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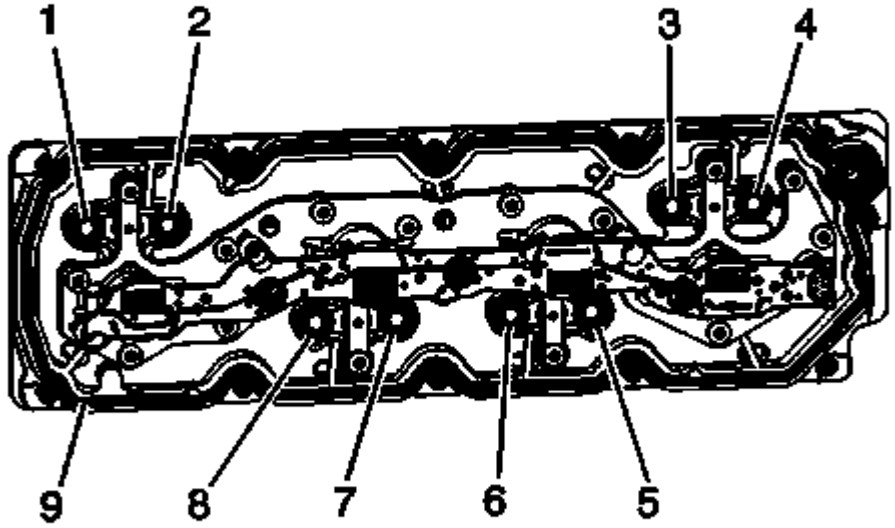

Fig. 498: Sealing Gaskets
Courtesy of GENERAL MOTORS CORP.

8. Inspect for damaged interior sealing gaskets (1-8). If the interior sealing gaskets are damaged, the manifold must be replaced as an assembly.
9. Inspect for a damaged exterior sealing gasket (9) or scored gasket surfaces.
10. Inspect for debris or restrictions within the oil passages of the manifold. Refer to **Displacement on Demand (DOD) Valve Lifter Oil Manifold Diagnosis and Testing**.

Valve Rocker Arm Cover Cleaning and Inspection

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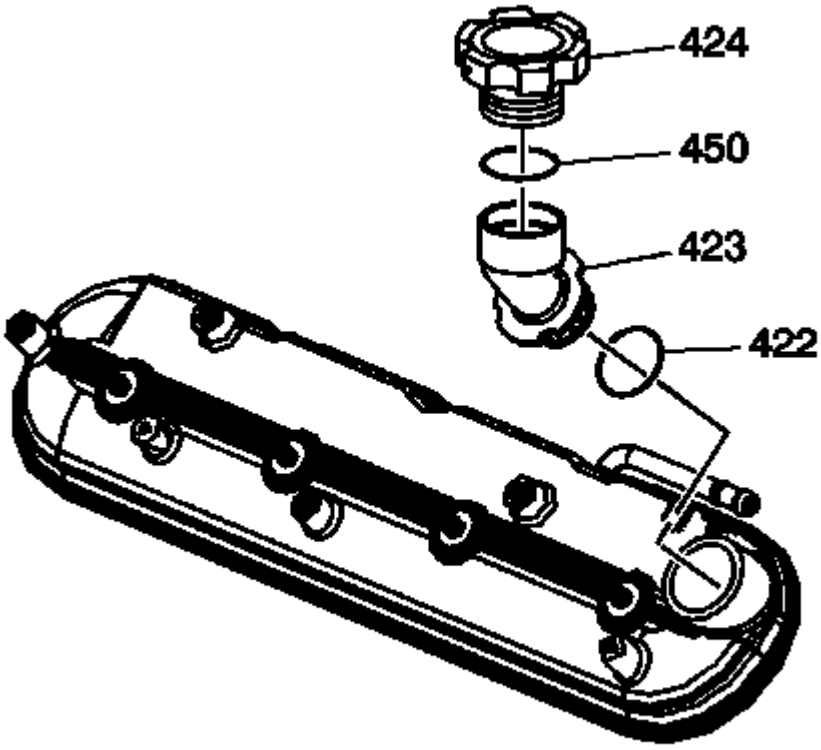

Fig. 499: Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.**
- **Remove the ignition coils before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.**
- **Do not remove the oil fill tube from the covers unless service is required.**

1. Inspect the oil fill tube (423) for a loose fit or damage.

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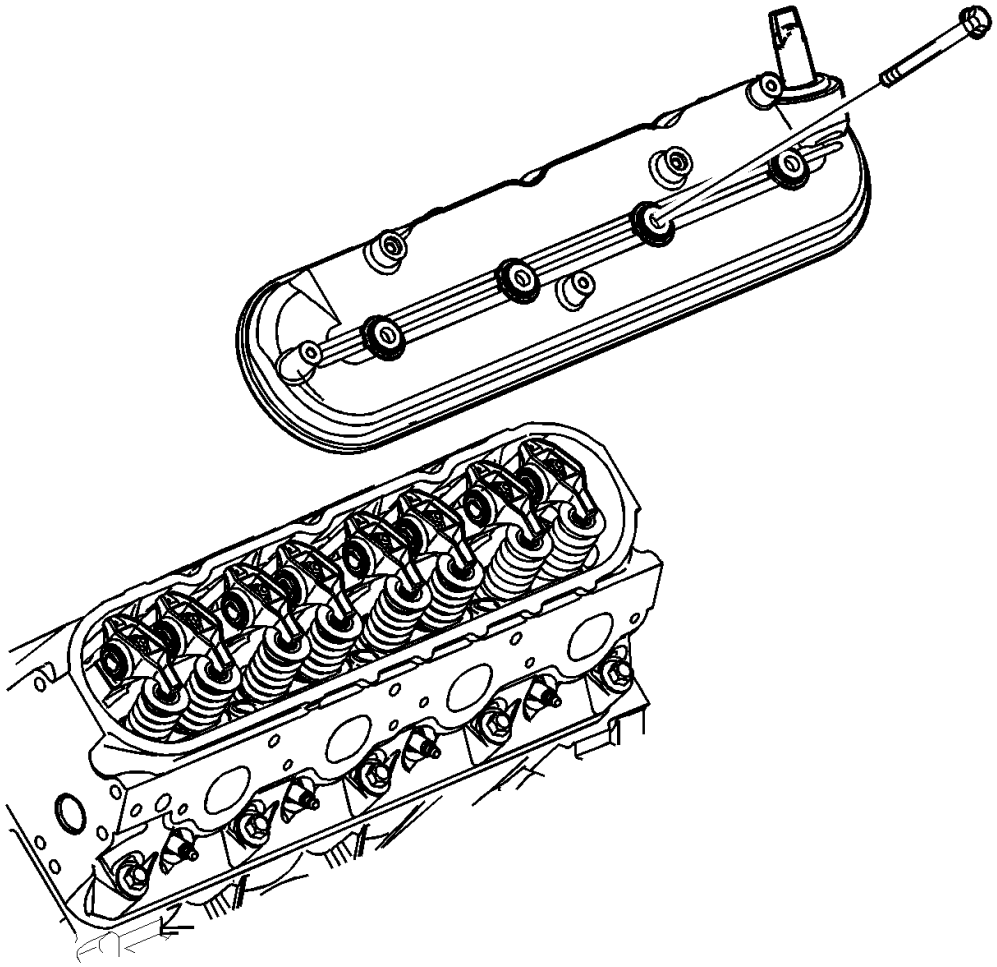

Fig. 500: Valve Cover
Courtesy of GENERAL MOTORS CORP.

2. Inspect the covers for the following conditions:
    - Scoring or damage to the gasket surfaces
    - Ventilation system passages for restrictions
    - Threaded bolt holes for damage or debris

Oil Pan Cleaning and Inspection

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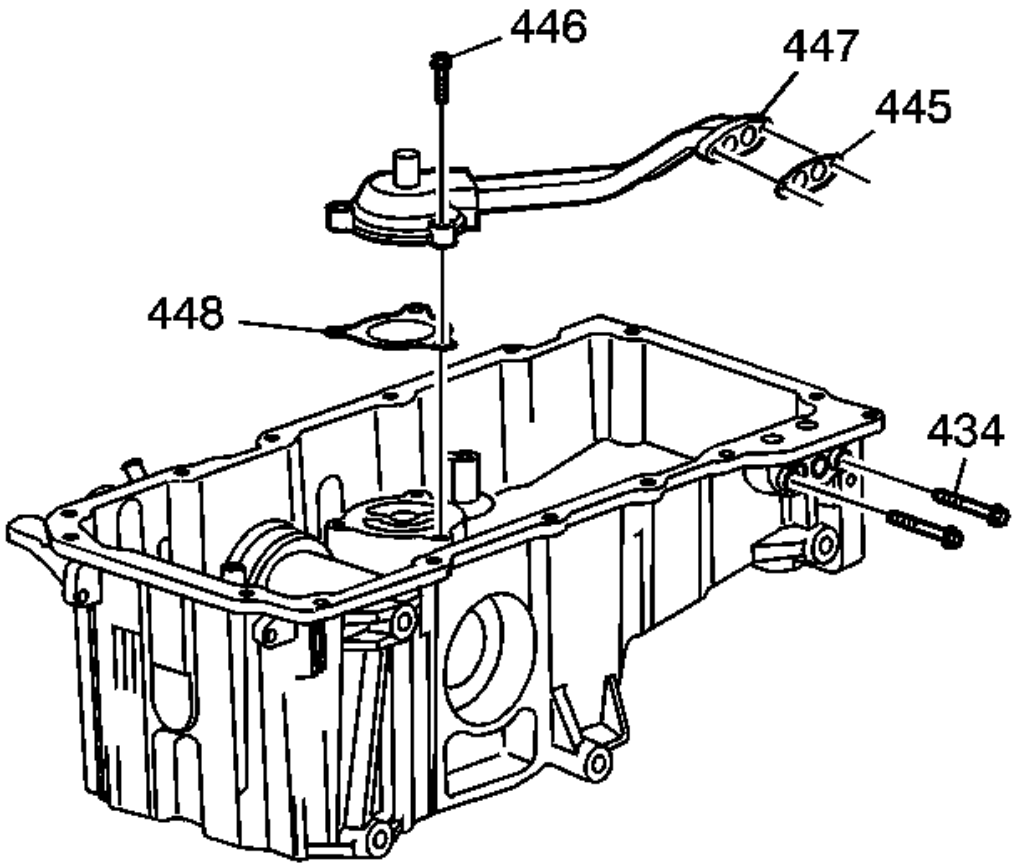

Fig. 501: Oil Filter Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing a NEW oil pan gasket, it is not necessary to install the rivets that retain the NEW gasket to the pan.

1. Remove the oil filter tube bolts (435, 446) and gaskets (445, 448).
2. Remove the oil filter tube (447).

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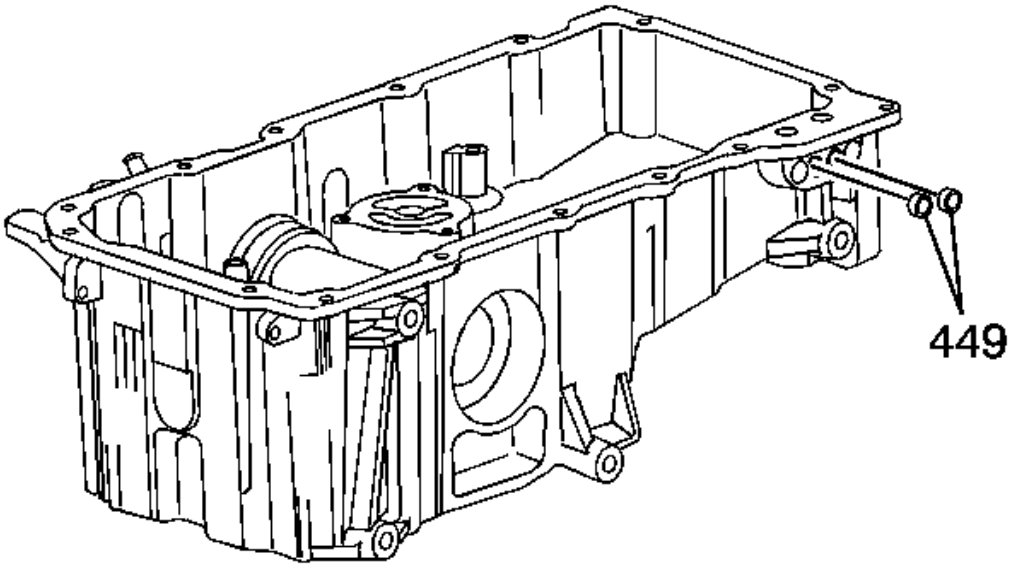

Fig. 502: View Of Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

3. Remove the plugs (449) from the oil galleries.

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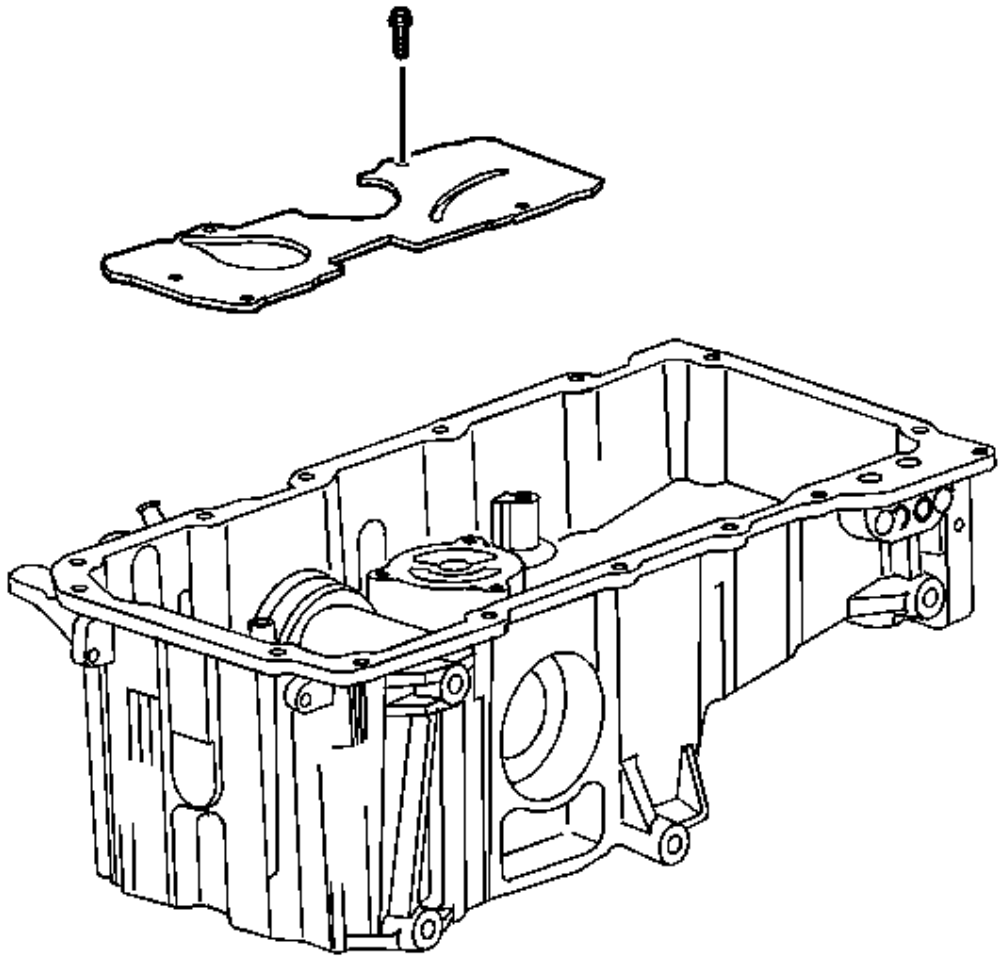

Fig. 503: View Of Oil Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan baffle and bolts.
5. Remove the oil filter fitting and oil filter bypass valve as required. Refer to **Oil Filter and Adapter Removal**.
6. Clean the oil pan in solvent. Be sure to thoroughly clean all of the oil passages and recesses of the pan.

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

7. Dry the oil pan with compressed air.

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8. Inspect the oil pan for the following conditions:
    - Damaged gasket surfaces
    - Restrictions within the oil passages of the pan
    - Threaded bolt holes for damage

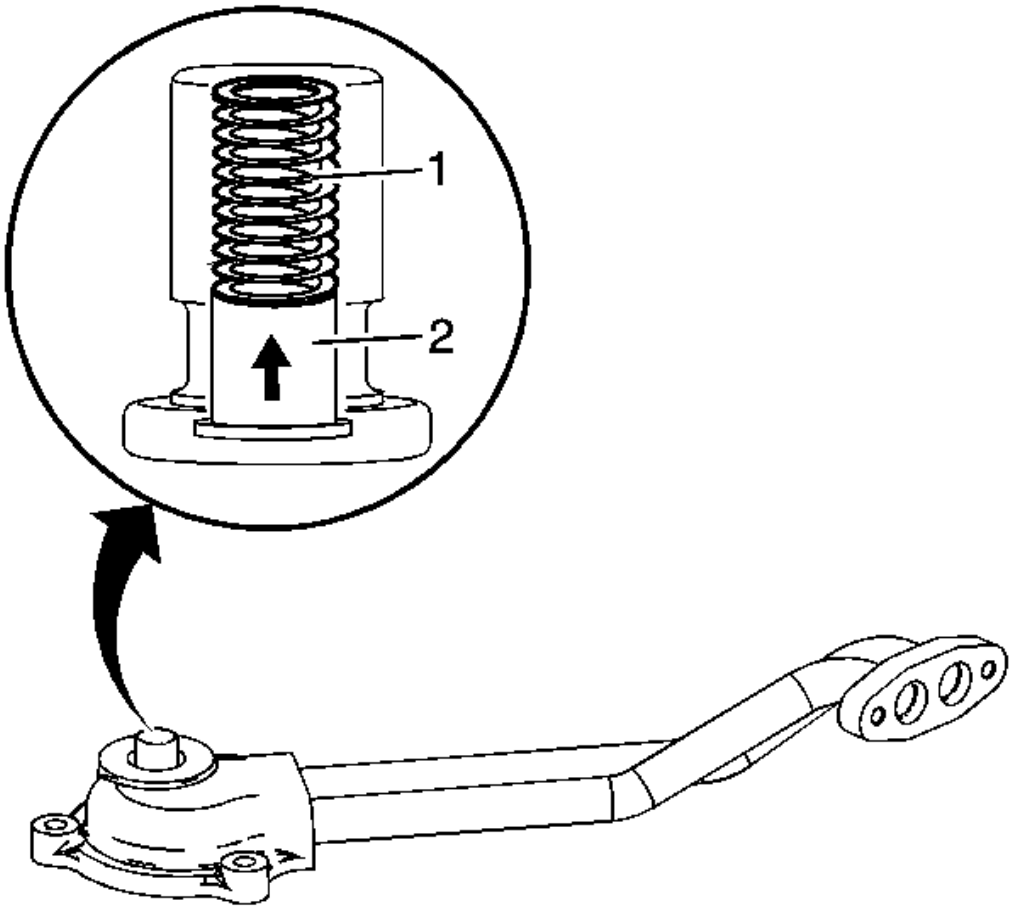

Fig. 504: Oil Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

9. Inspect the oil filter tube for restrictions or damaged gasket surfaces.
10. Inspect the displacement on demand oil pressure relief valve for proper operation.

    Lightly depress the valve (2). The valve spring (1) should seat the valve to the proper closed position.

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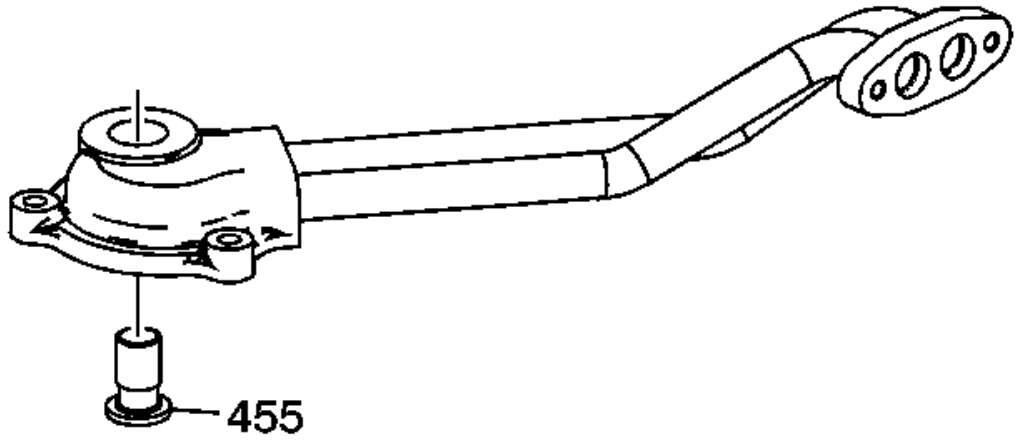

Fig. 505: Relief Valve
Courtesy of GENERAL MOTORS CORP.

11. The relief valve (455) is press-fit into the oil filter tube and is serviceable separately.

Intake Manifold Cleaning and Inspection

Cleaning Procedure

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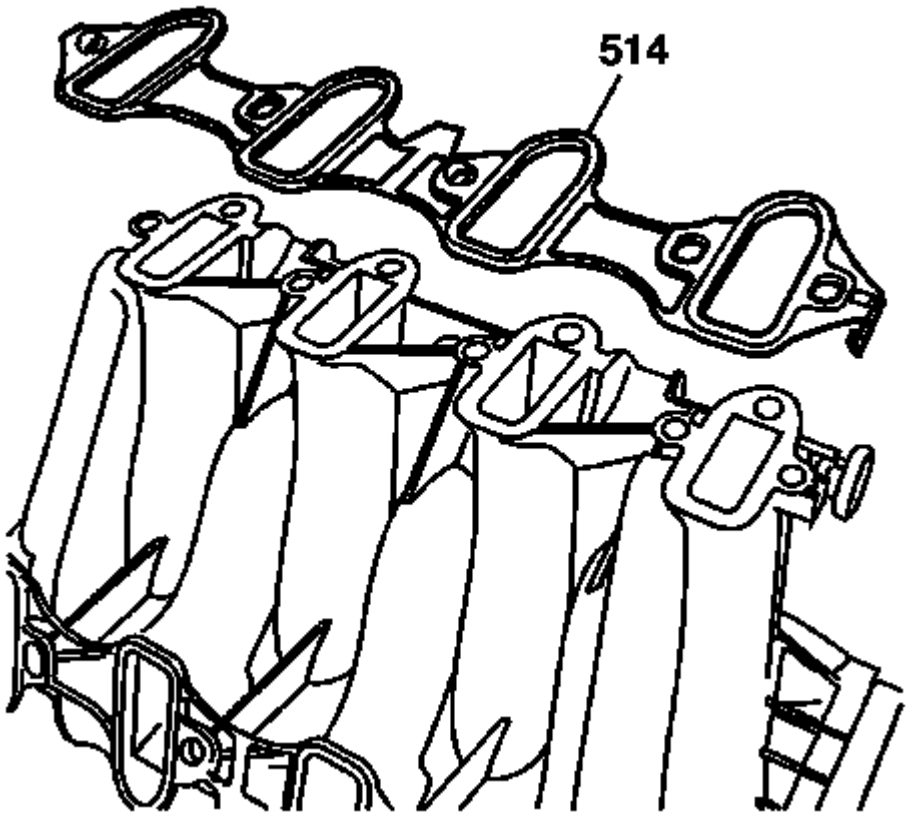

Fig. 506: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the intake manifold-to-cylinder head gaskets (514).

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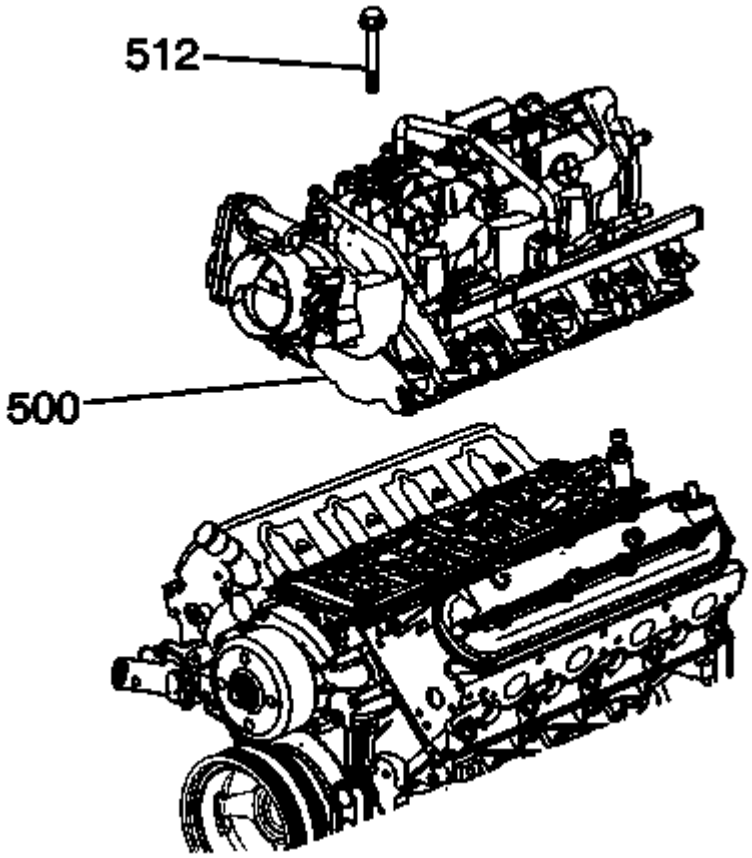

Fig. 507: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714). Refer to **Intake Manifold Removal**.
3. Remove the evaporative emission (EVAP) valve, EVAP tubes, and fuel rail with injectors. Refer to **Fuel Rail and Injectors Removal**.
4. Remove the throttle body and gasket. Refer to **Throttle Body Removal**.
5. Clean the intake manifold (500) in solvent.

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

6. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the manifold for the following conditions:
   - Damaged gasket or sealing surfaces
   - Loose threaded inserts or studs
   - Debris or restrictions within the passages of the manifold

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- Damaged or broken vacuum fittings
- Inspect the composite intake manifold assembly for cracks or other damage.

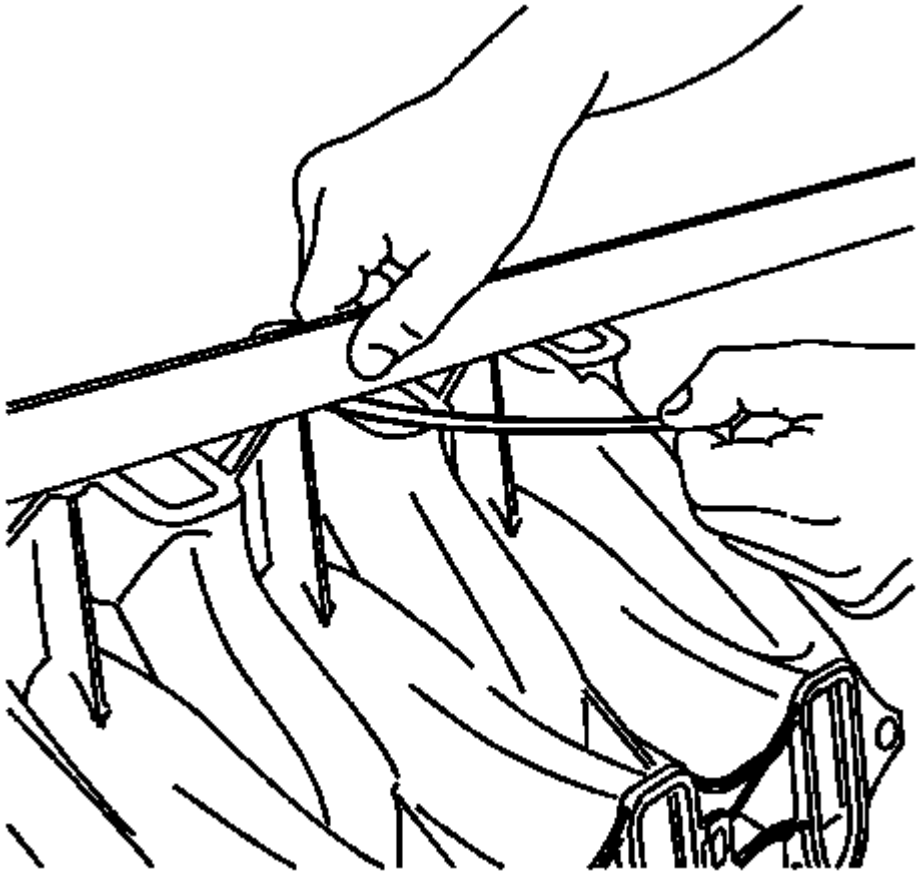

Fig. 508: Inspecting Intake Manifold Cylinder Head Deck For Warpage
Courtesy of GENERAL MOTORS CORP.

2. Inspect the intake manifold cylinder head deck for warpage.
    1. Locate a straight edge across the intake manifold cylinder head deck surface.

       Position the straight edge across a minimum of two runner port openings.

    2. Insert a feeler gage between the intake manifold and the straight edge.

       An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

Exhaust Manifold Cleaning and Inspection

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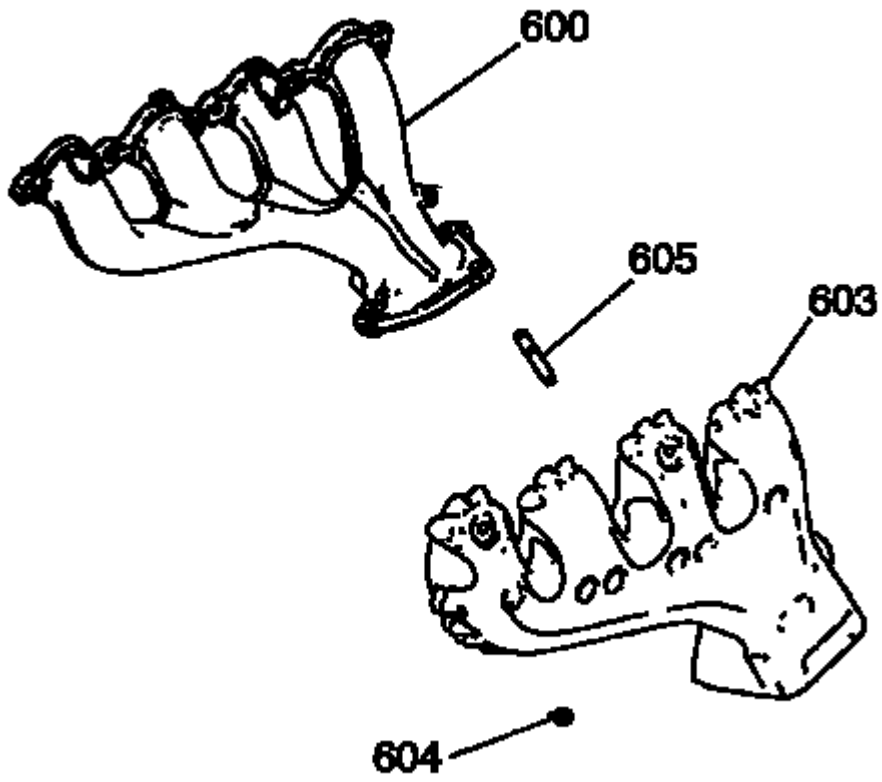

Fig. 509: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the exhaust manifold-to-cylinder head gaskets again. 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.

1. Clean the exhaust manifold (600) and heat shield (603) in solvent.

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

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose, damaged, or cracked heat shield (603).
5. Inspect the studs (605) for damaged threads.

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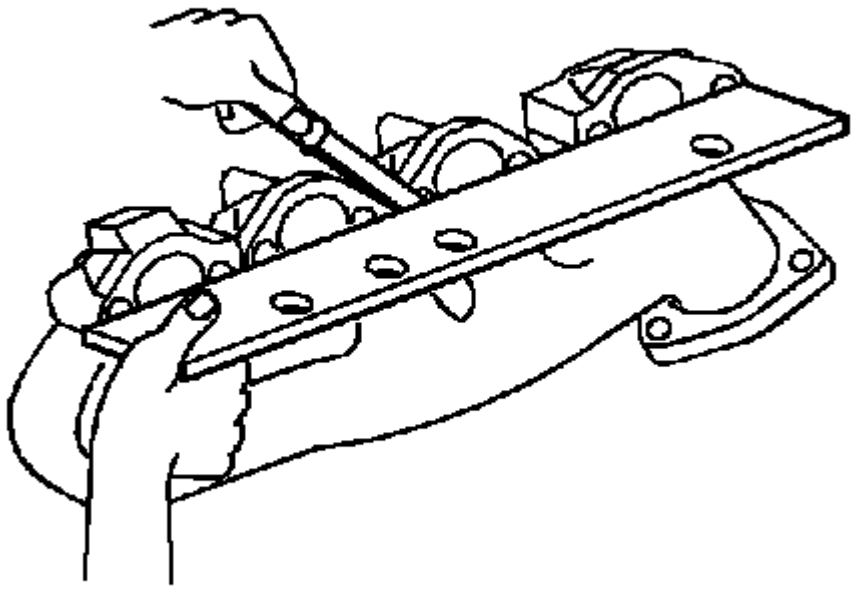

Fig. 510: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Use a straight edge and a feeler gage and measure the exhaust manifold cylinder head deck for warpage.

   An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the two front or two rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

Coolant Air Bleed Pipe Cleaning and Inspection

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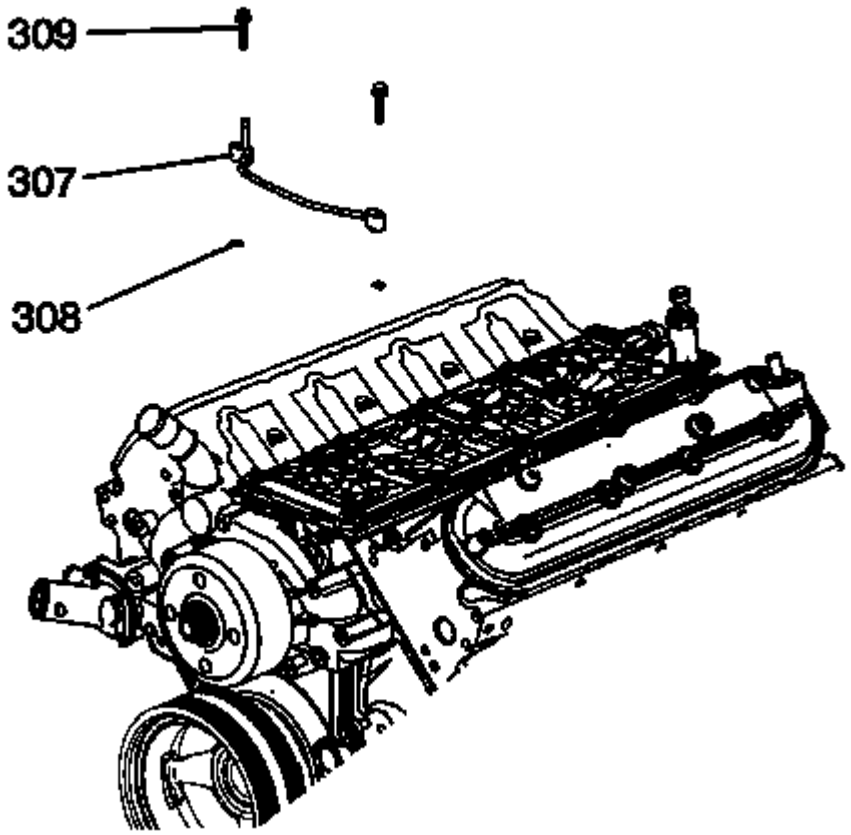

Fig. 511: Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the engine coolant air bleed pipe and cover seals again. Upon installation of the pipe and covers, install NEW seals.

1. Remove the seals (308) from the pipe (307) and covers.
2. Clean the pipe and covers in solvent.

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

3. Dry the pipe and covers with compressed air.
4. Inspect the pipe and covers for damaged sealing surfaces or restrictions within the pipe.

Water Pump Cleaning and Inspection

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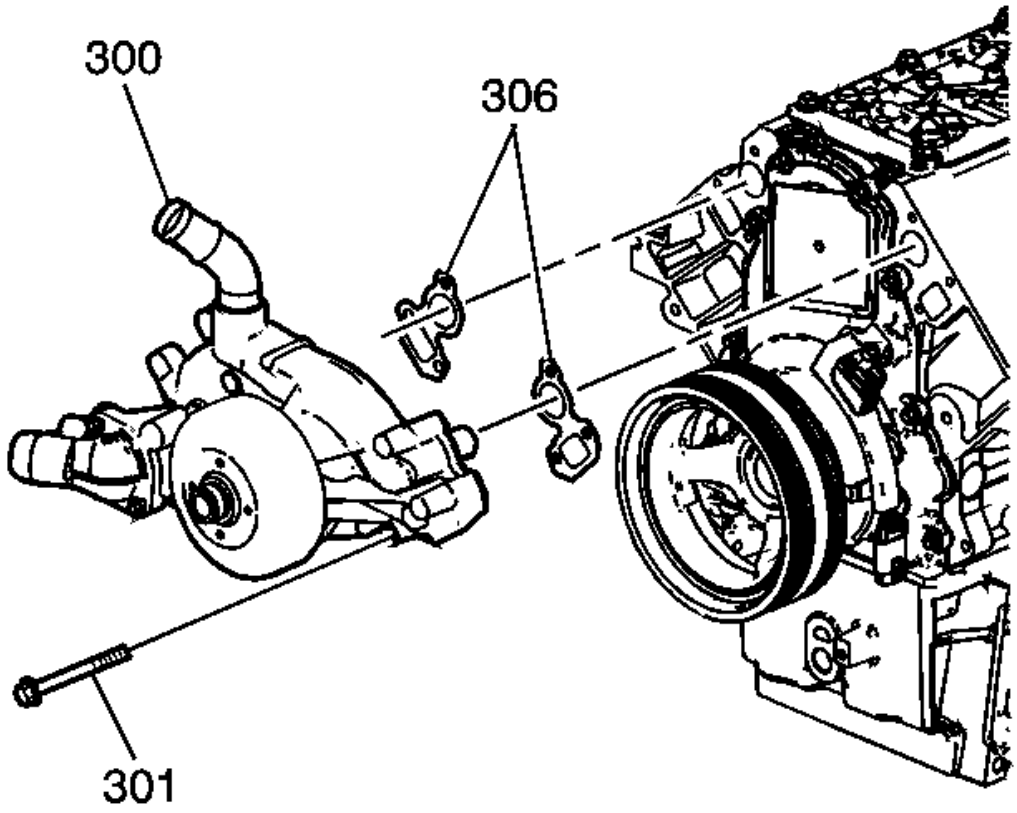

Fig. 512: Water Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the old gasket from the water pump sealing surfaces. Refer to **Replacing Engine Gaskets**.
2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump (300) for the following conditions:
   - Gasket and hose sealing surfaces for excessive scratches or gouging
   - Restrictions within the internal coolant passages
   - Excessive side-to-side play in the pulley shaft
   - Leakage at the water outlet housing or rear cover gasket
   - Leakage at the water pump vent hole

     A stain around the vent hole is acceptable. If leakage, such as dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.

   - Wear or damage in the belt tracking area of the pulley

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Thread Repair

Tools Required

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 42385-200** Common Thread Repair Kit. See **Special Tools**.
- **J 42385-300** Fixtures and Hardware Kit. See **Special Tools**.

General Thread Repair

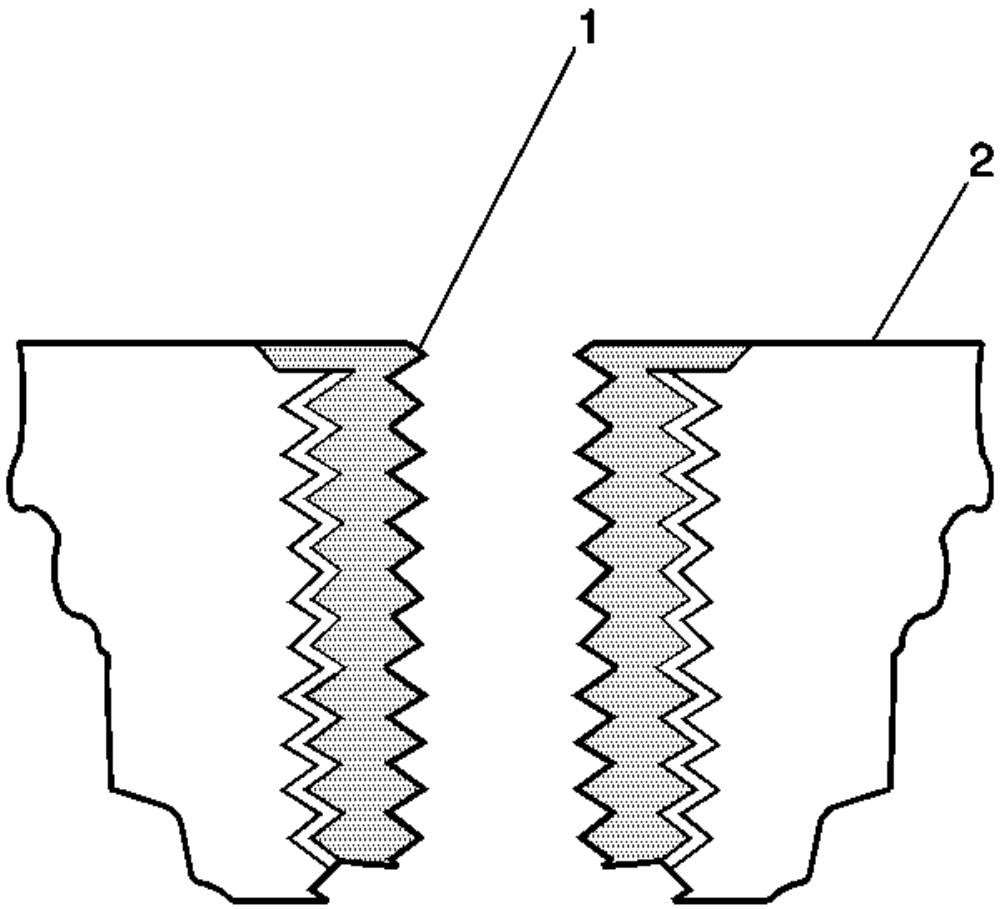

Fig. 513: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

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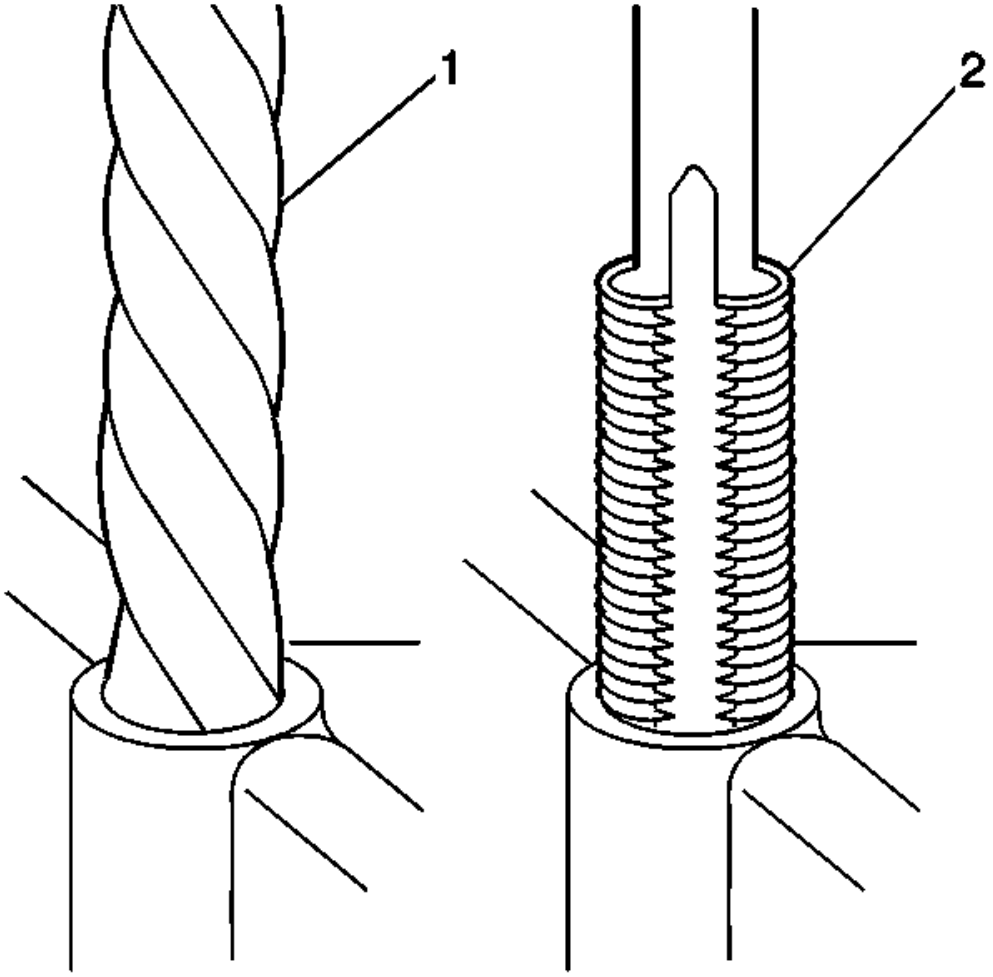

Fig. 514: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent is recommended when performing the drilling, counterboring, and tapping procedures.**
- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

1. Drill out the threads of the damaged hole (1).
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

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2. Using compressed air, clean out any chips.

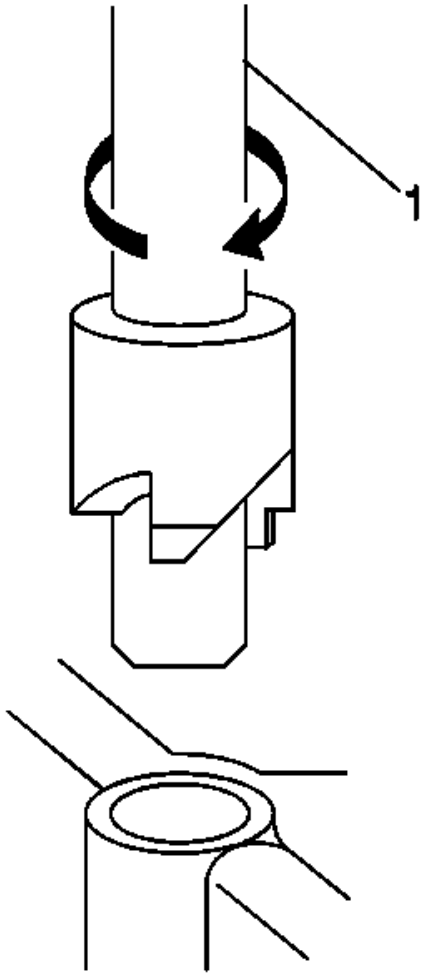

Fig. 515: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

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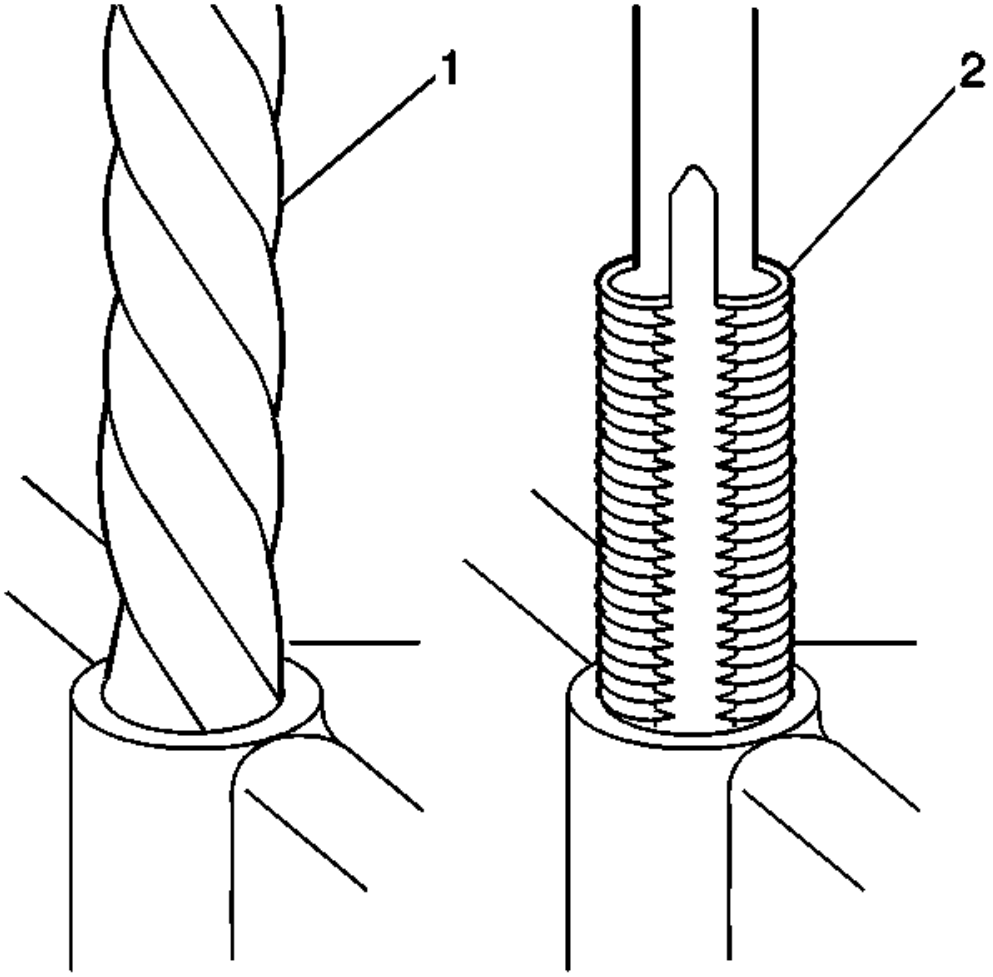

Fig. 516: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
    - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
    - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
    - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

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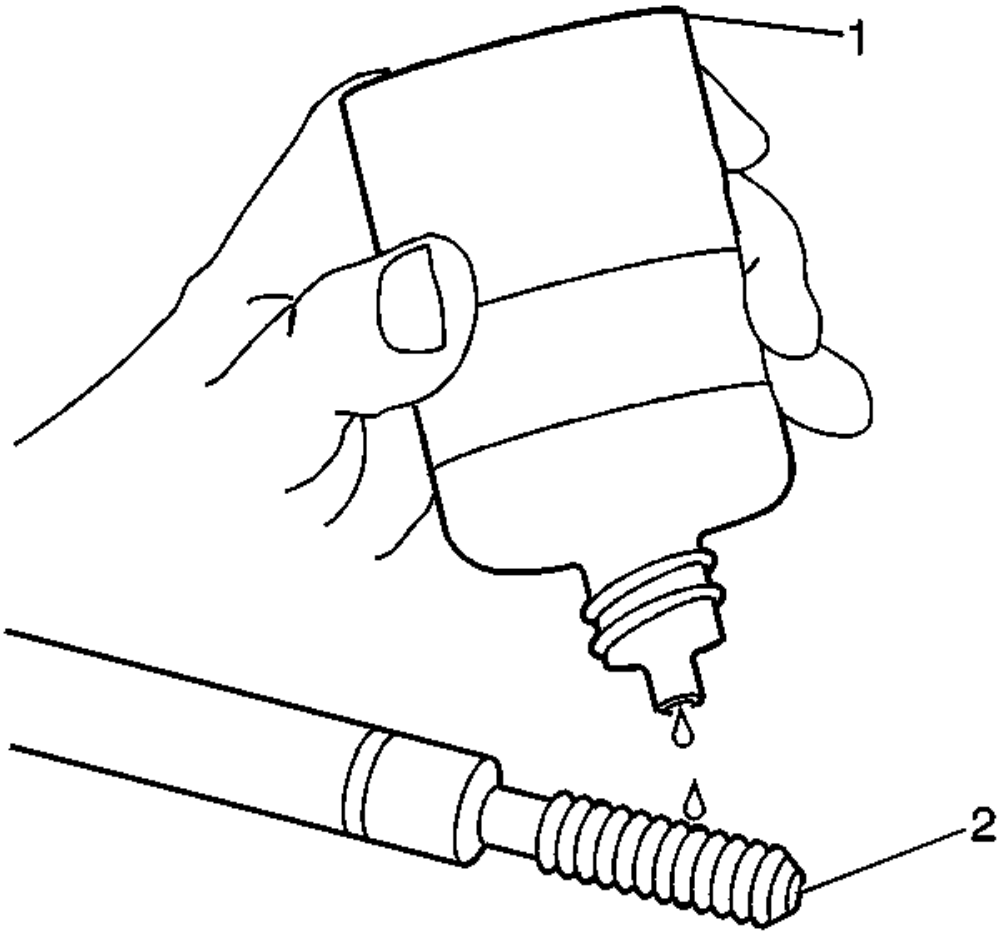

Fig. 517: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

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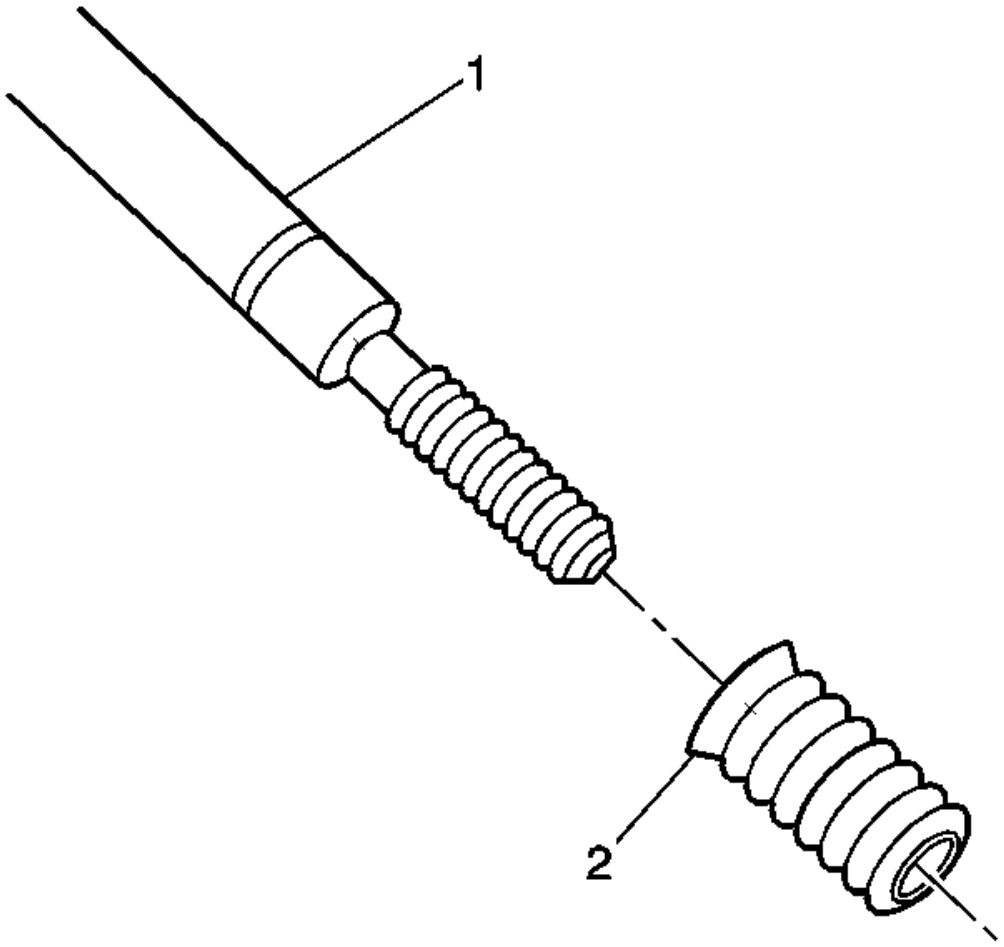

Fig. 518: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

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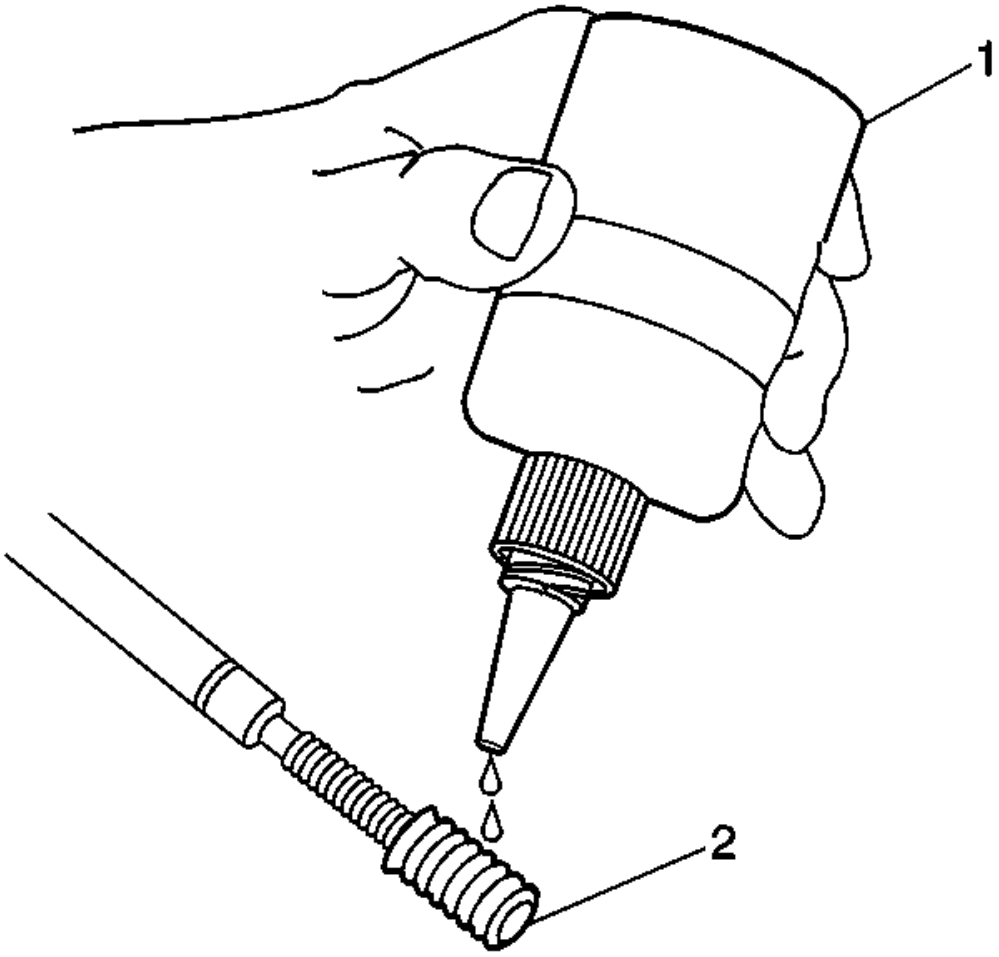

Fig. 519: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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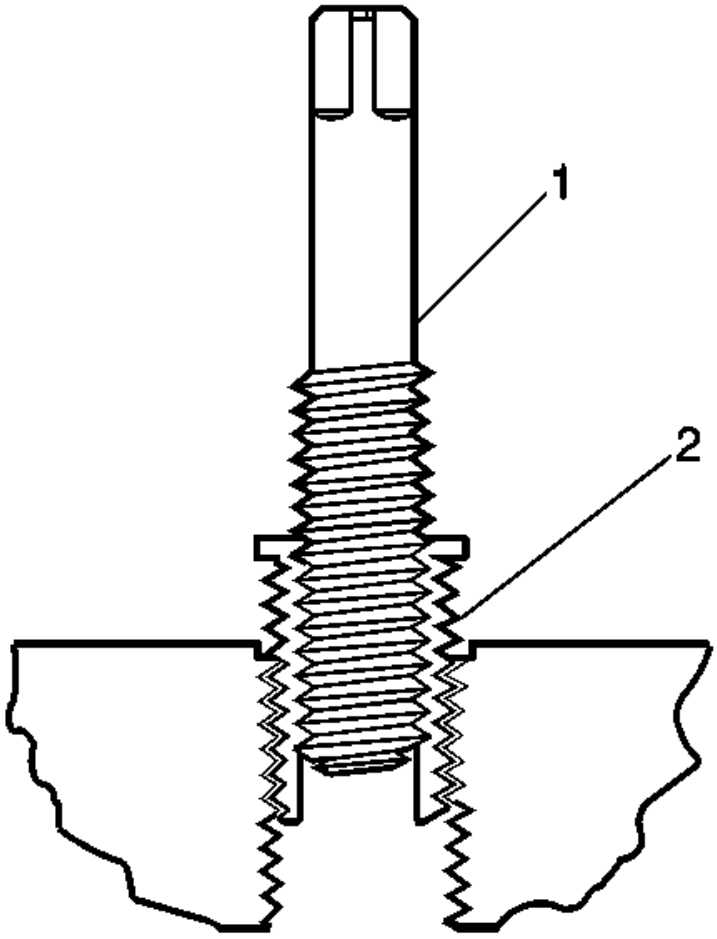

Fig. 520: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

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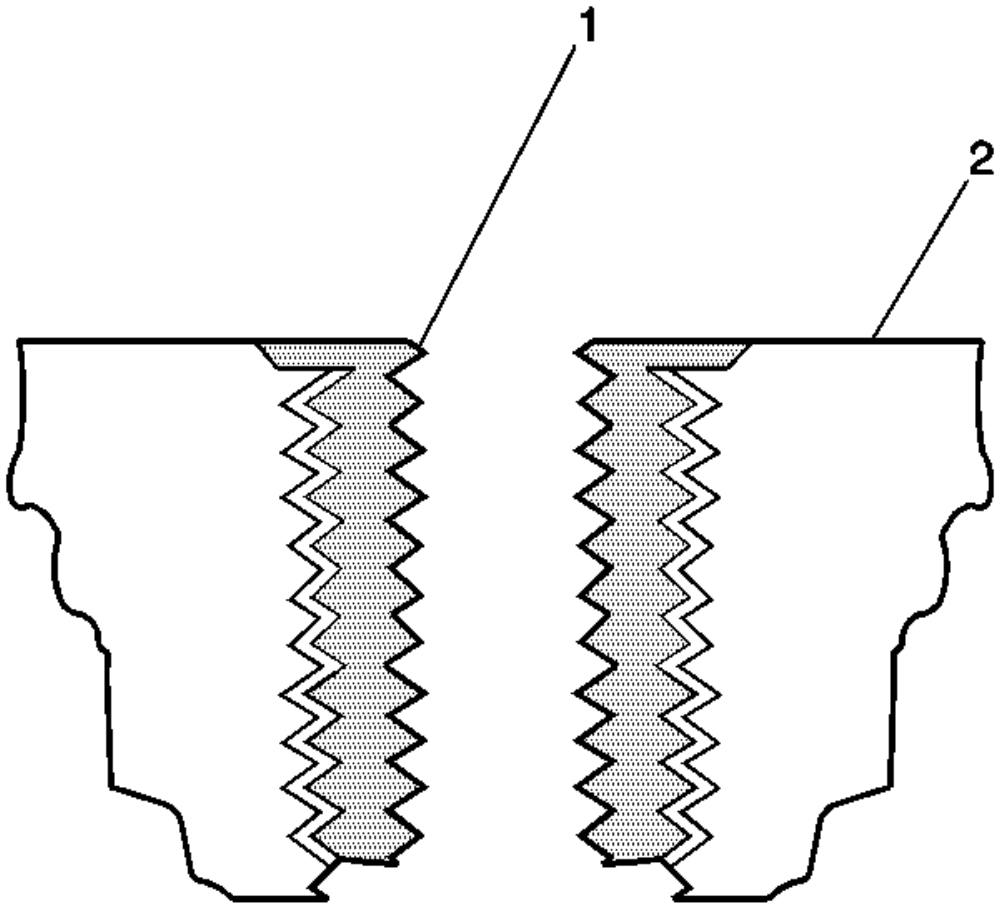

Fig. 521: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

    A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

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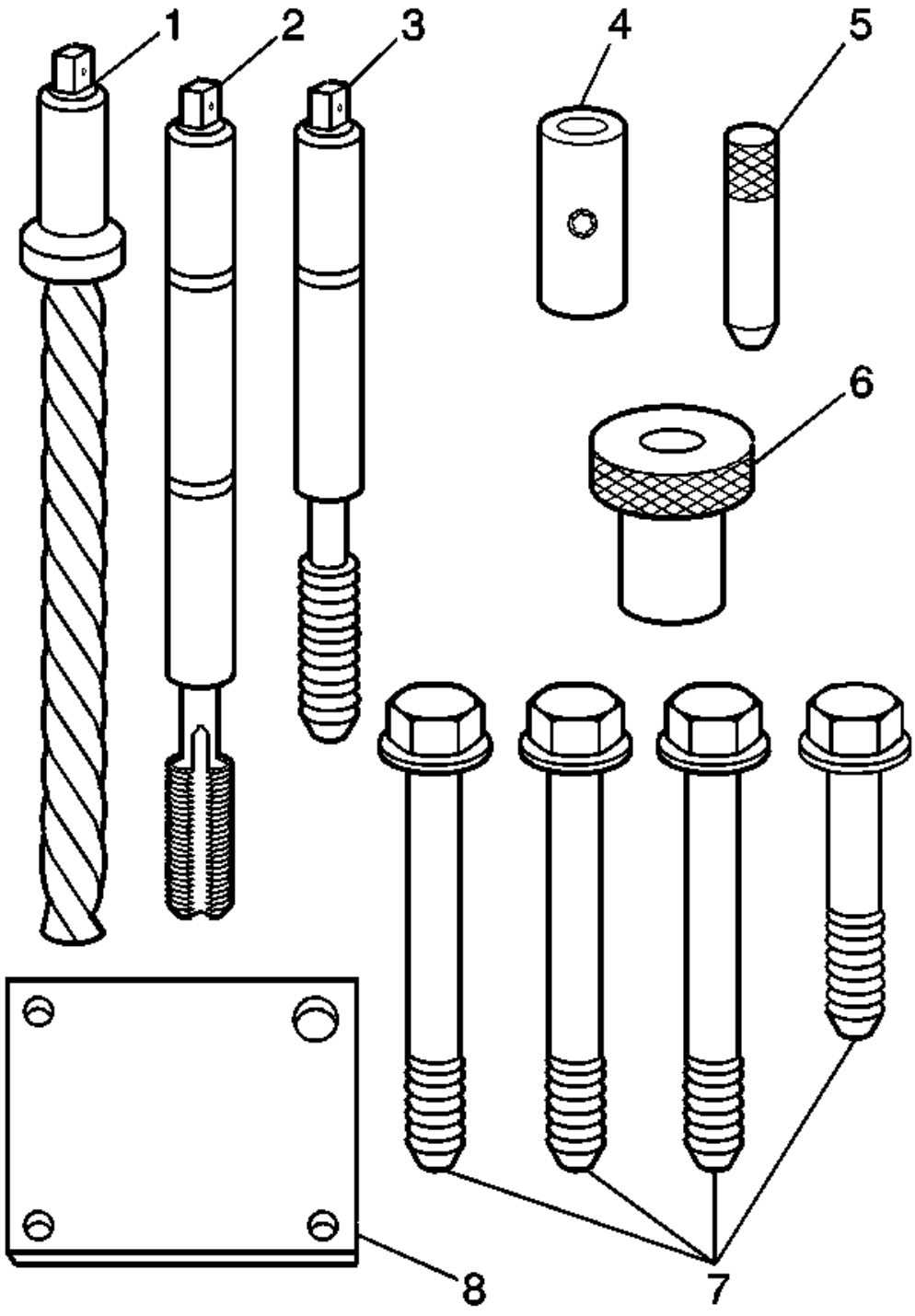

Fig. 522: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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1. The cylinder head bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The sleeve (4)
   - The alignment pin (5)
   - The bushing (6)
   - The bolts (7)
   - The fixture plate (8)

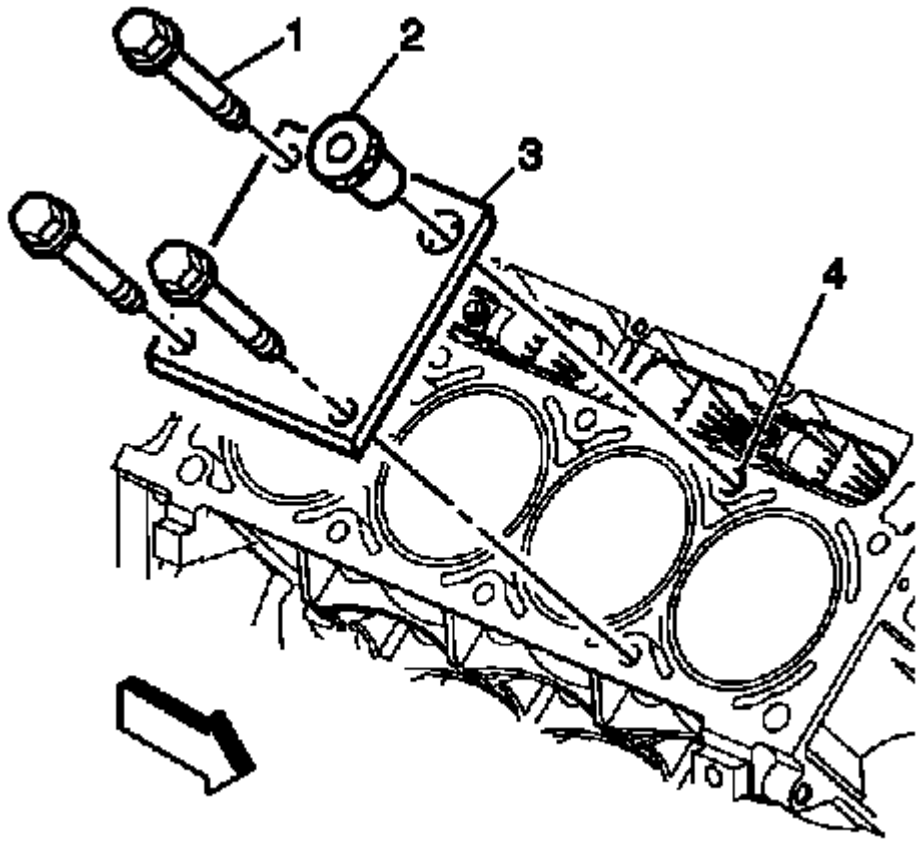

Fig. 523: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:
- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent is recommended when performing**

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the drilling and tapping procedures.

- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

   Position the fixture plate and bushing over the hole that is to be repaired (4).

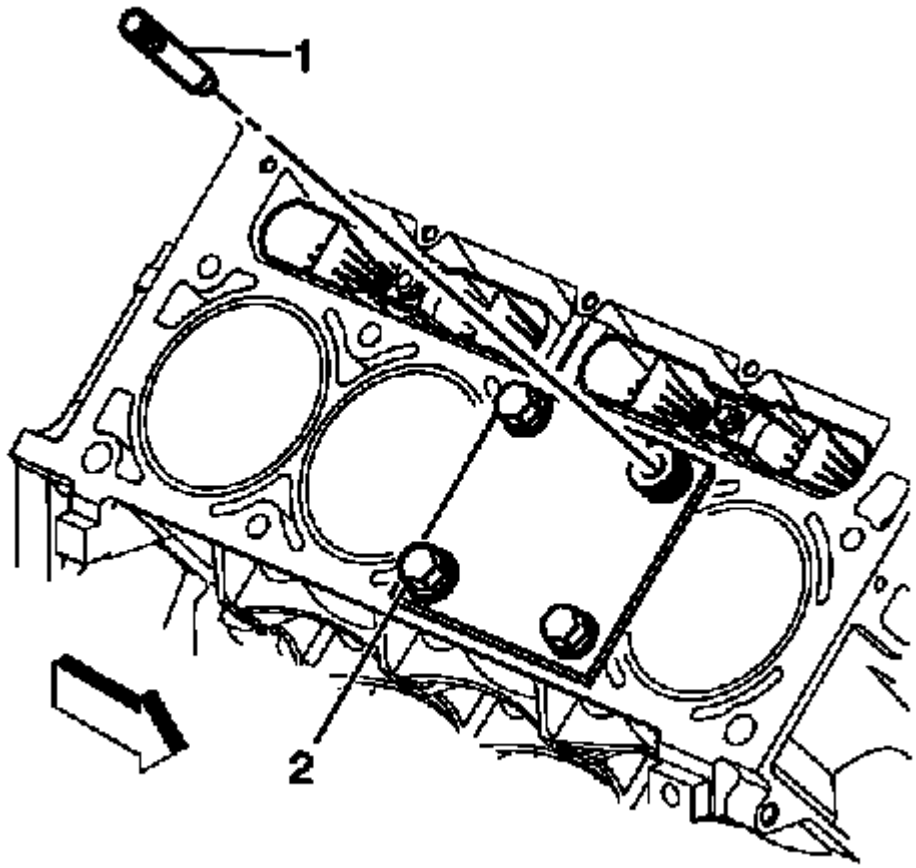

Fig. 524: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

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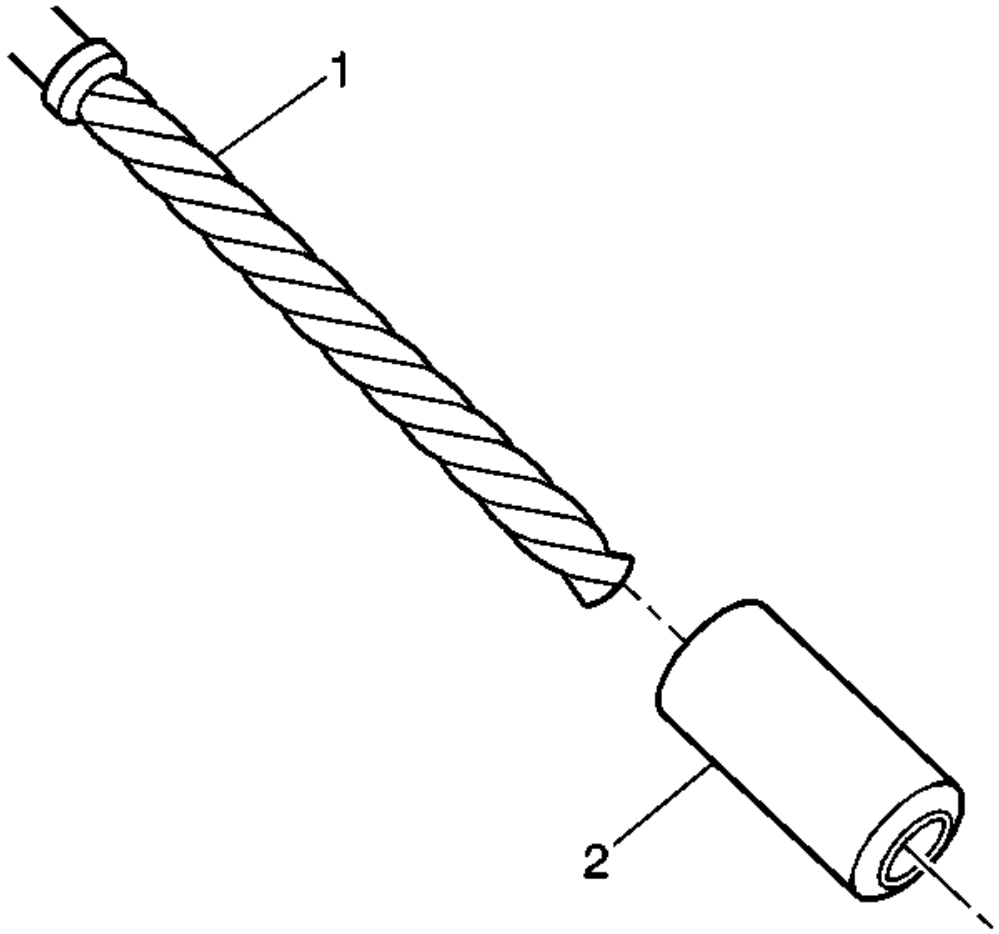

Fig. 525: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1).

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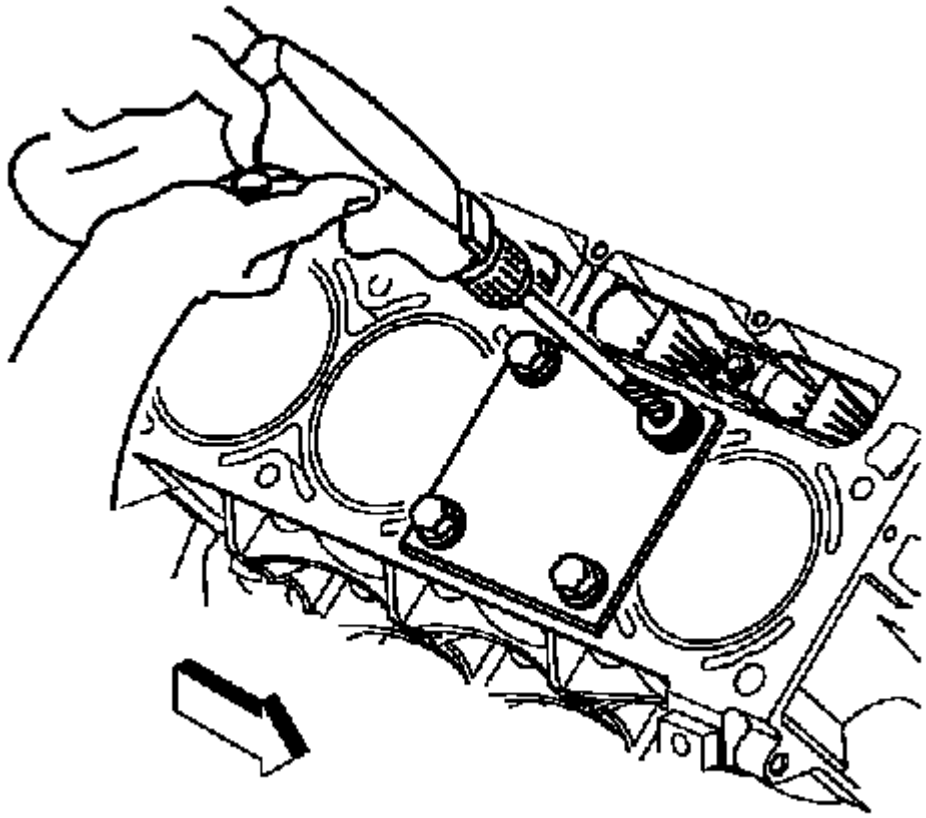

Fig. 526: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

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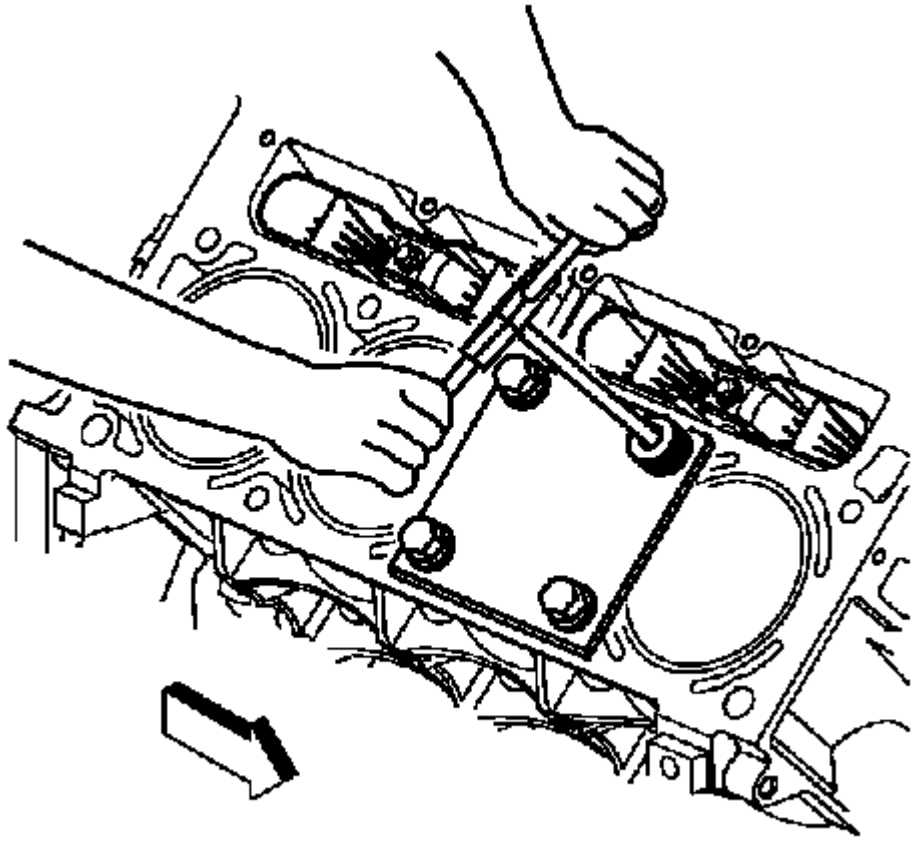

Fig. 527: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

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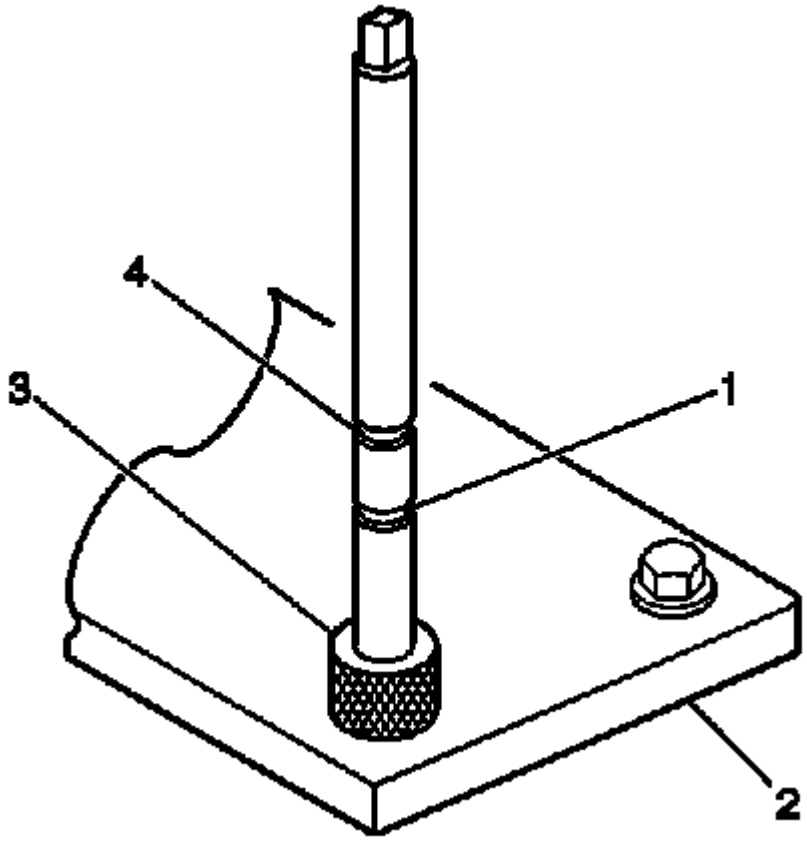

Fig. 528: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (1) on the tap aligns with the top of the drill bushing (3).
11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

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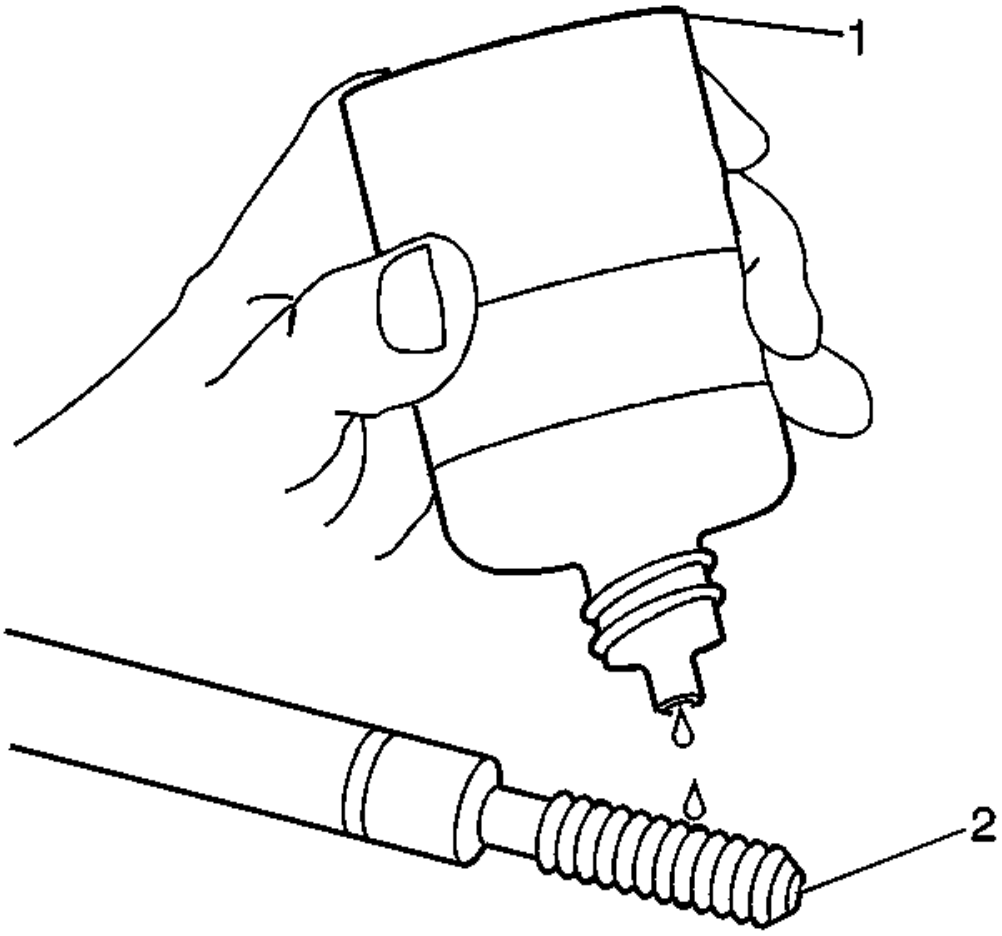

Fig. 529: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or foreign material to contact the OD of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

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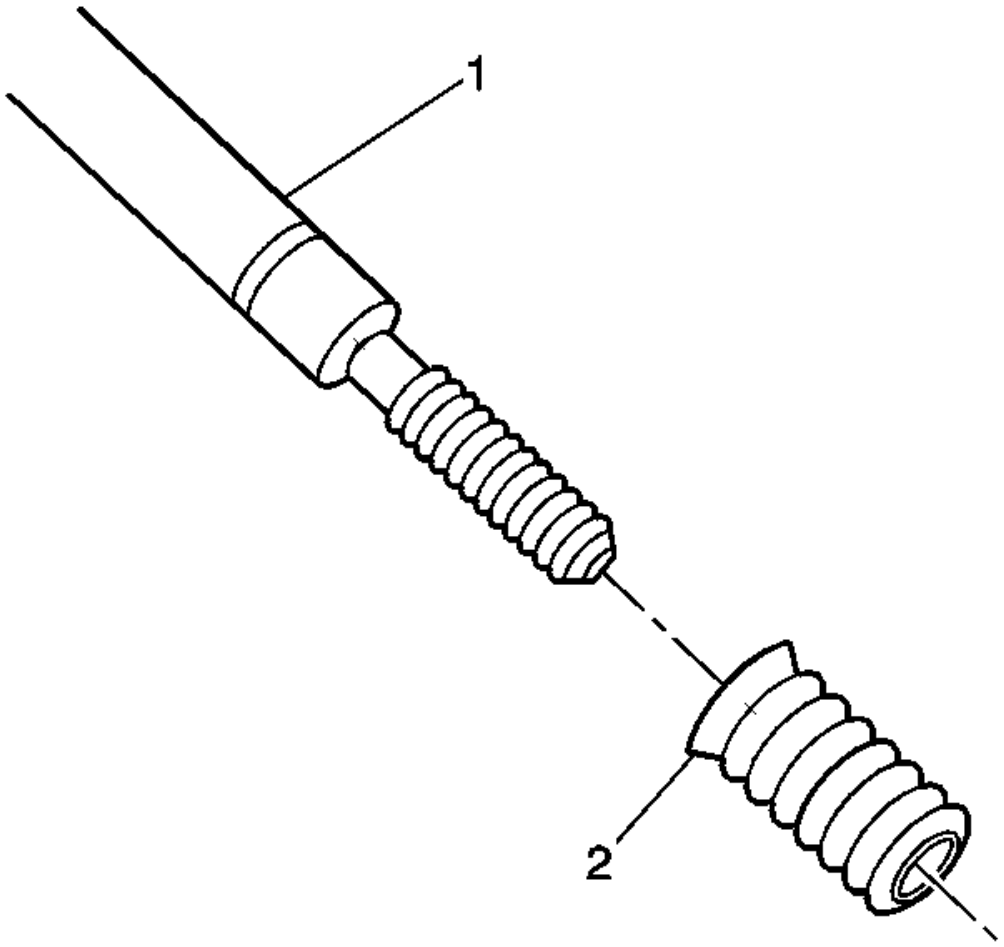

Fig. 530: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

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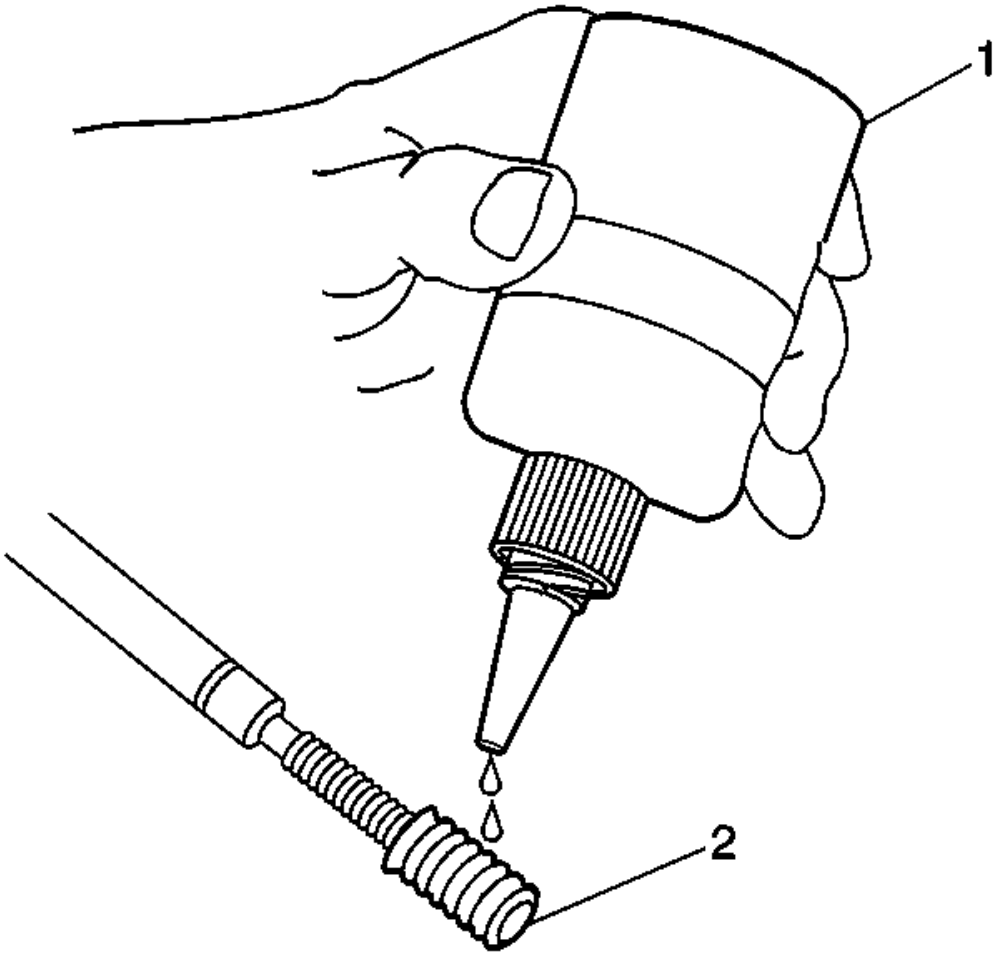

Fig. 531: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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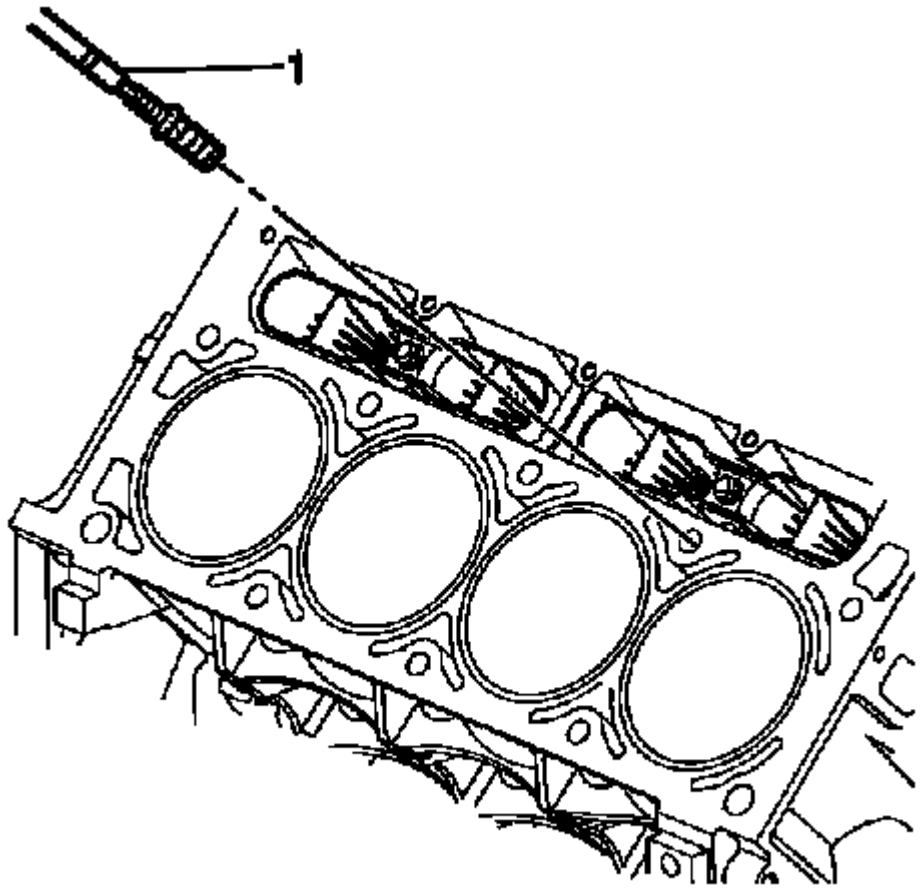

Fig. 532: Installing Insert & Driver Into Cylinder Bolt Hole
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

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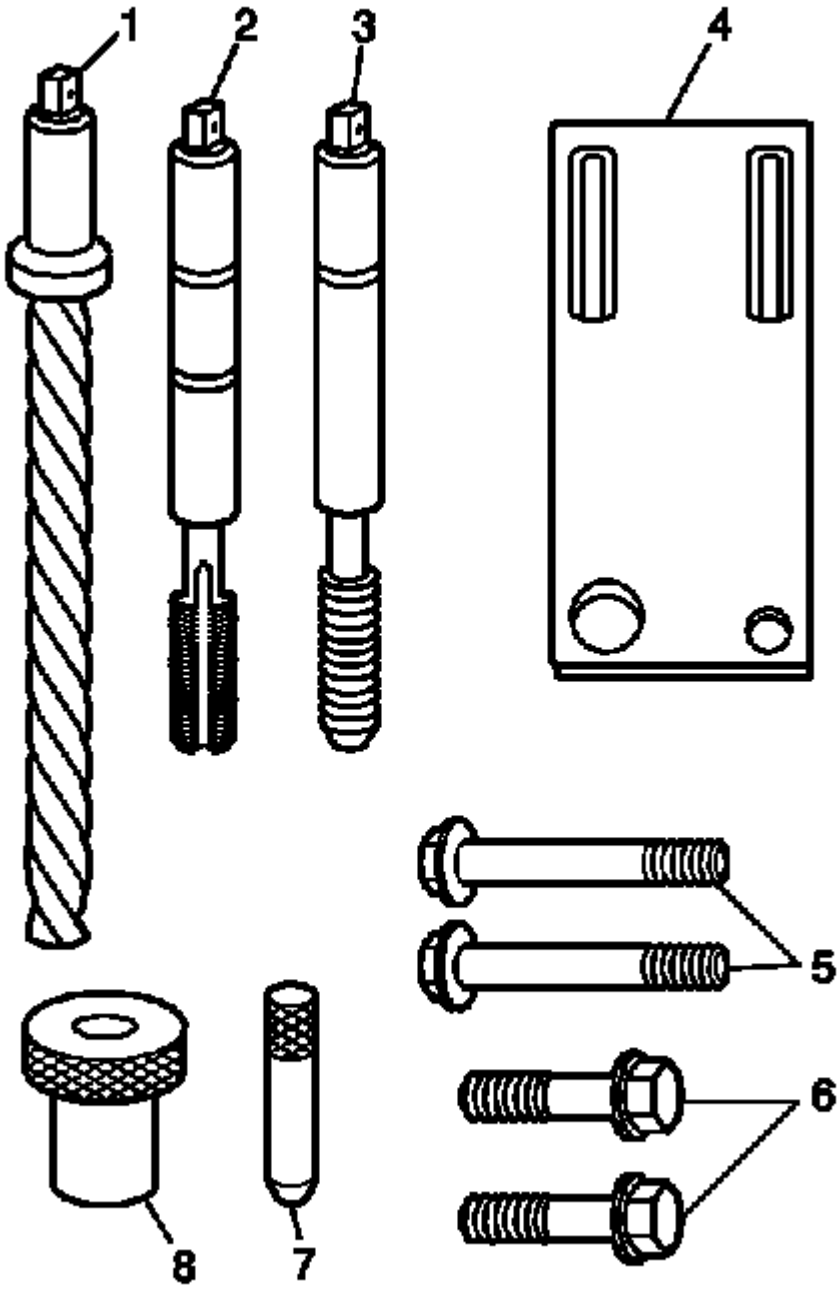

Fig. 533: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)

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- The fixture plate (4)
- The long bolts (5)
- The short bolts (6)
- The alignment pin (7)
- The bushing (8)

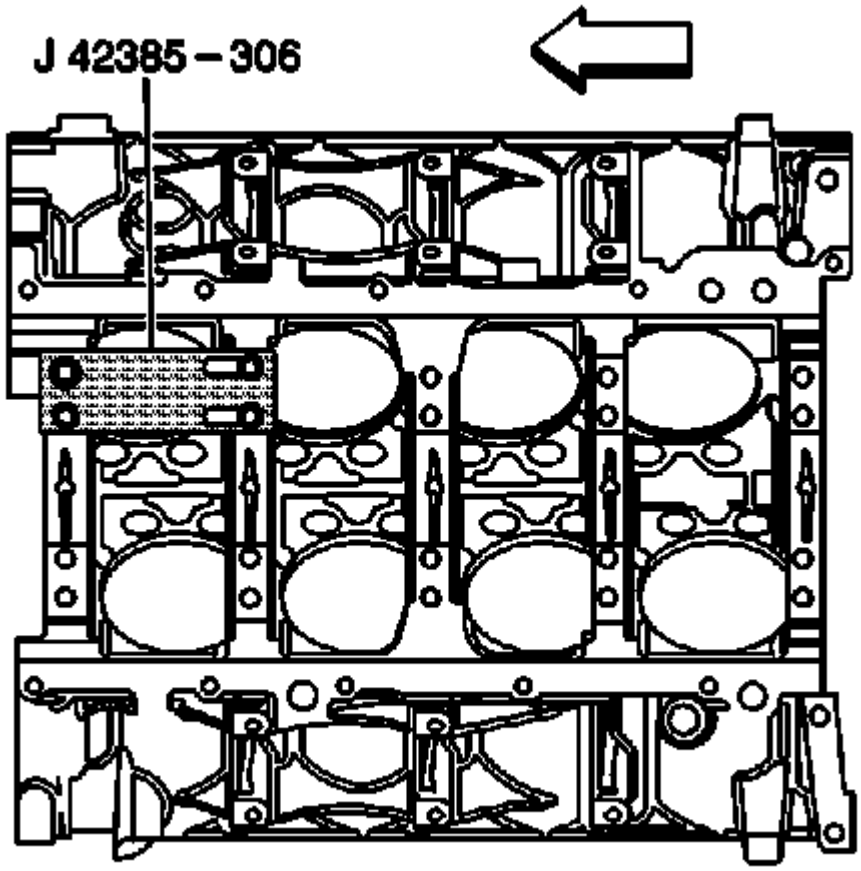

Fig. 534: View Of Fixture Plate, Bolt & Bushing
Courtesy of GENERAL MOTORS CORP.

2. Install the fixture plate, bolt, and bushing onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

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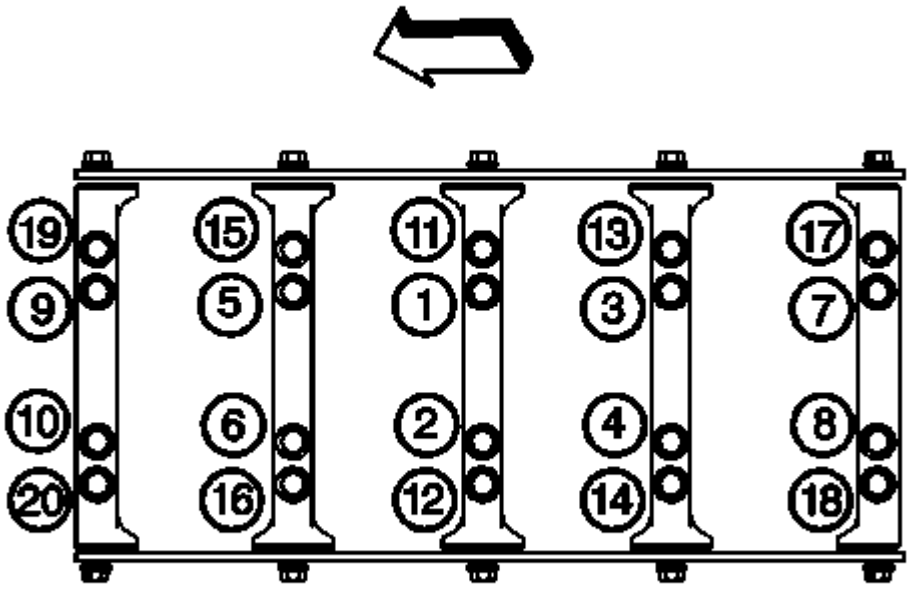

Fig. 535: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Drill out the damaged hole.

   The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

   Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.

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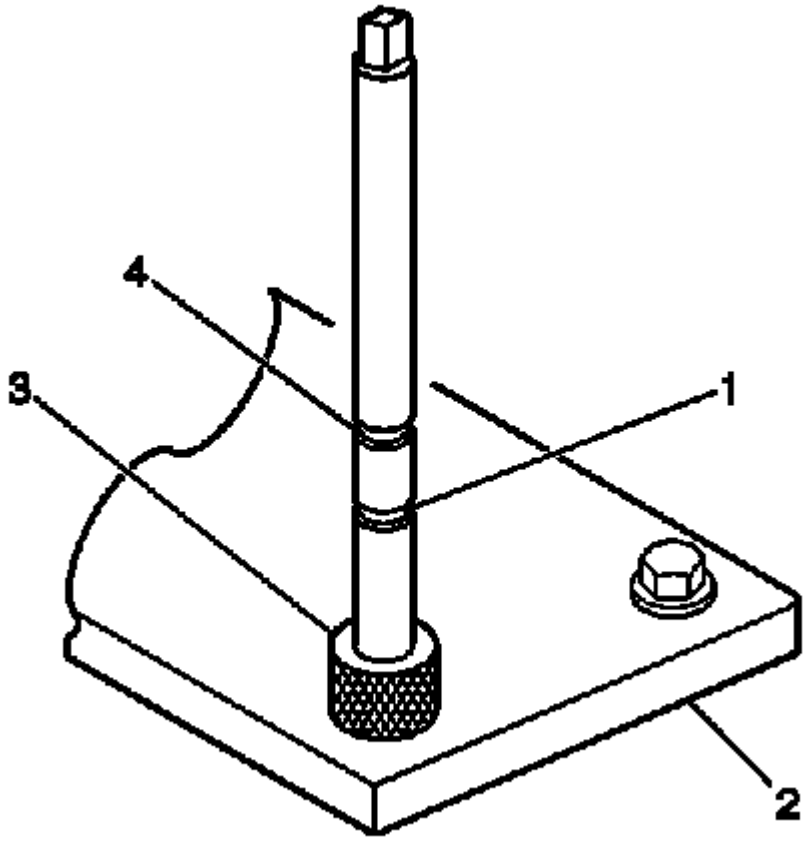

Fig. 536: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

6. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

   For the deeper main cap holes 1-10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

   For the shallower main cap holes 11-20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463) or equivalent into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.

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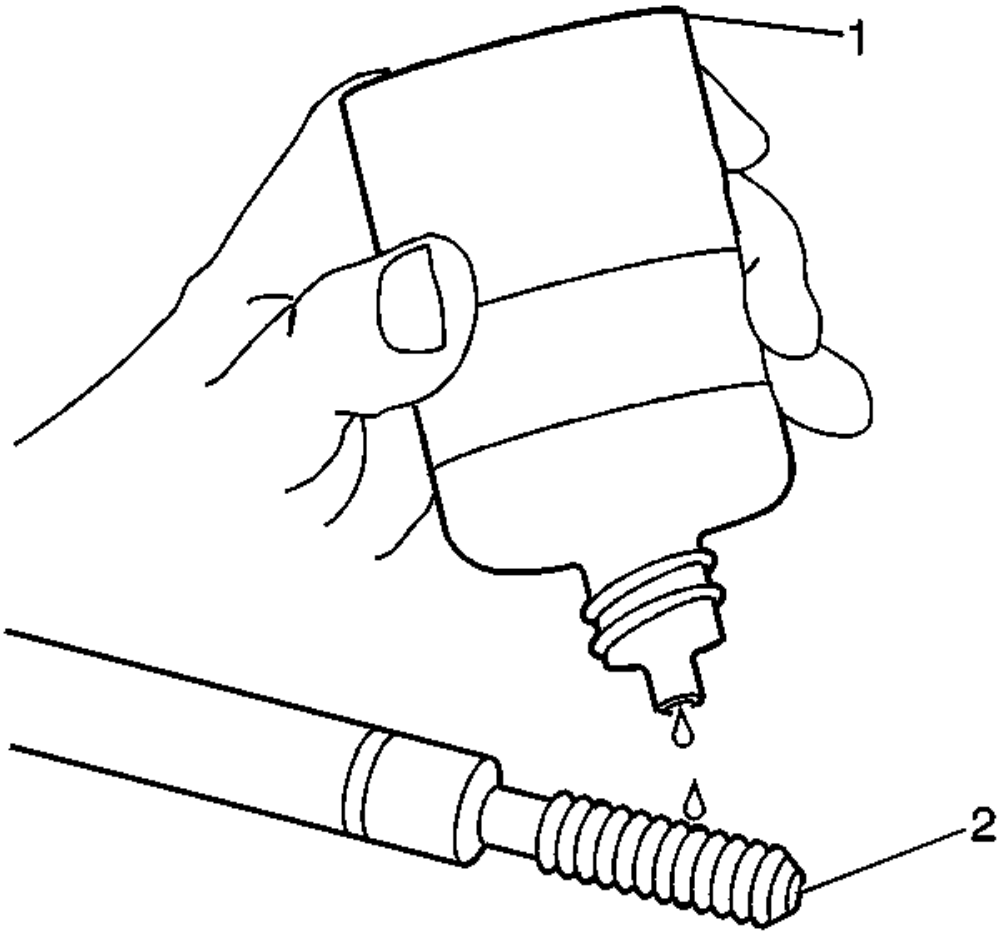

Fig. 537: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or foreign material to contact the OD of the insert.

10. Lubricate the threads of the installer tool (2) with the driver oil (1).

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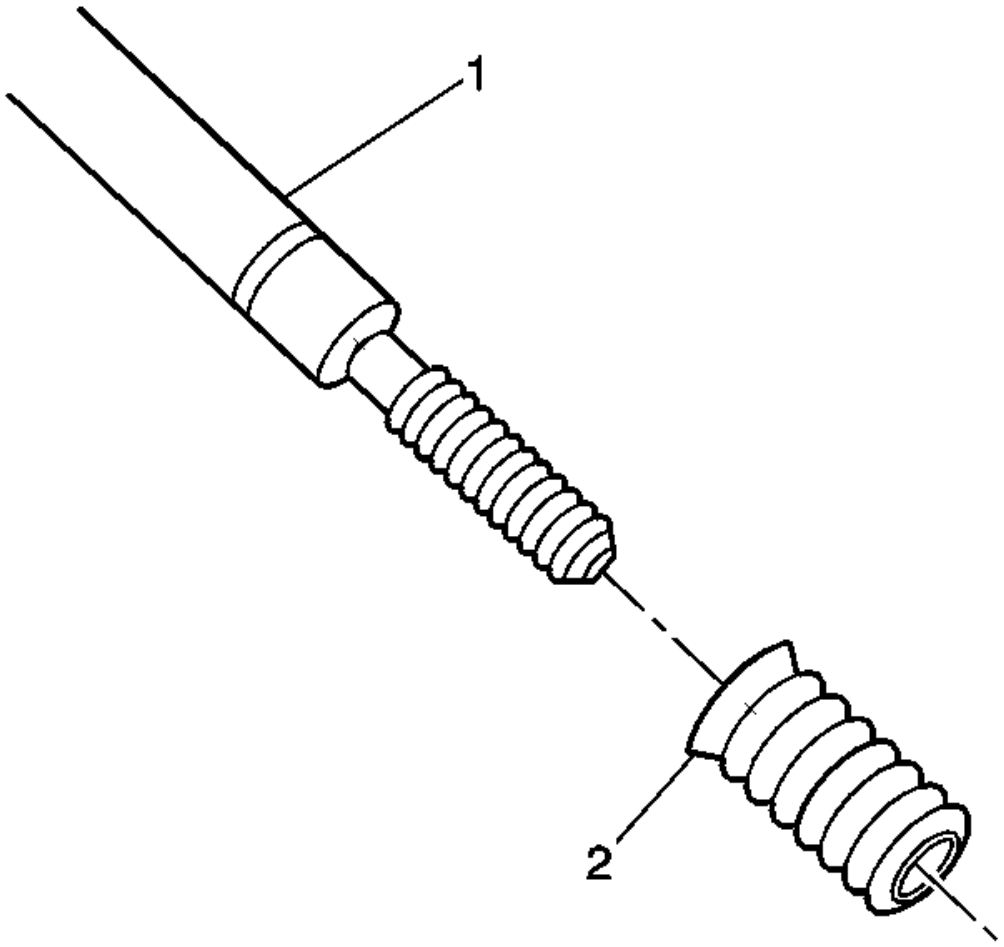

Fig. 538: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) onto the driver tool (1).

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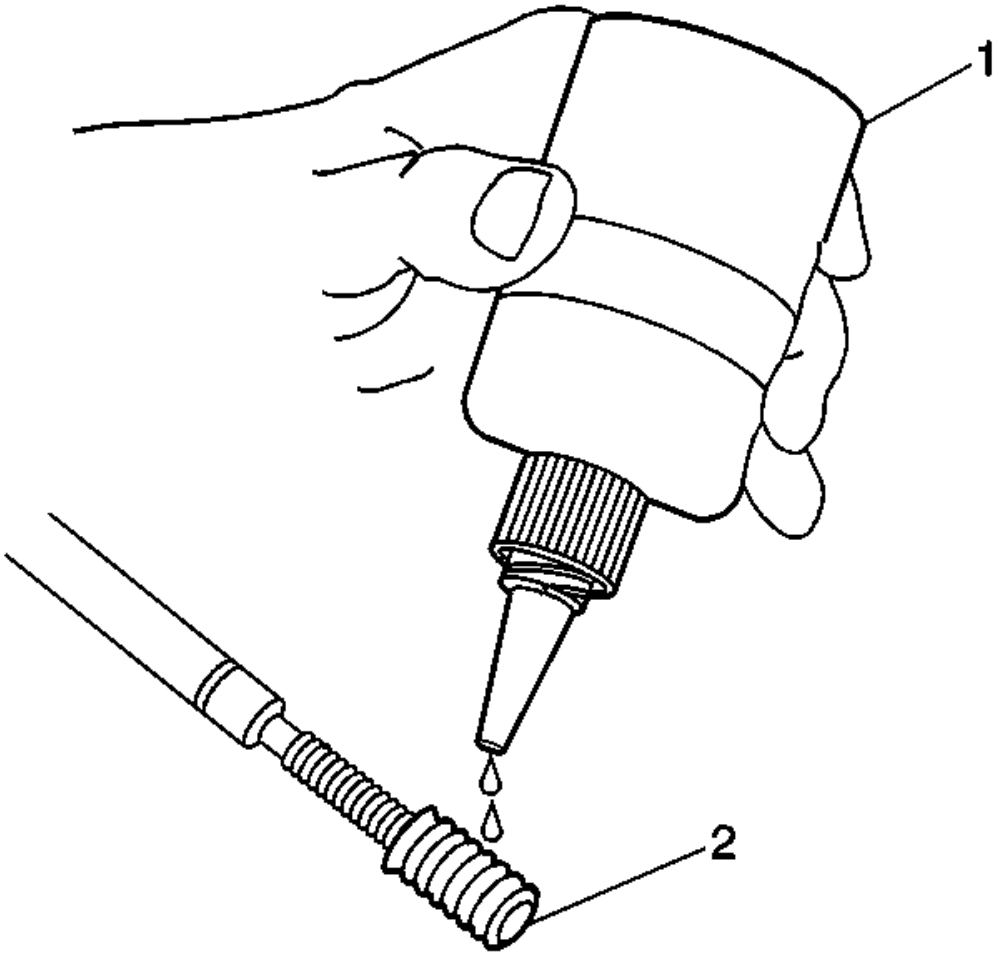

Fig. 539: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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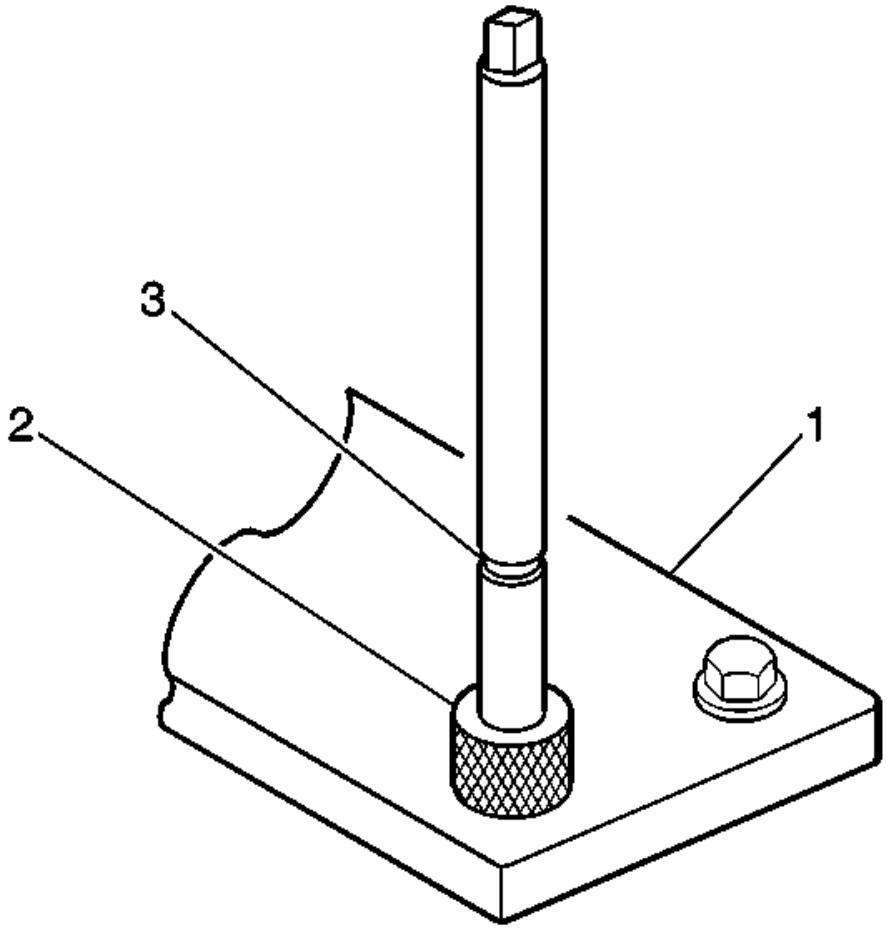

Fig. 540: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to **Cleanliness and Care**.

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- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to **Separating Parts**.
- During assembly, lubricate all moving parts with clean engine oil. This provides initial lubrication when the engine is first started.

Engine Block Plug Installation

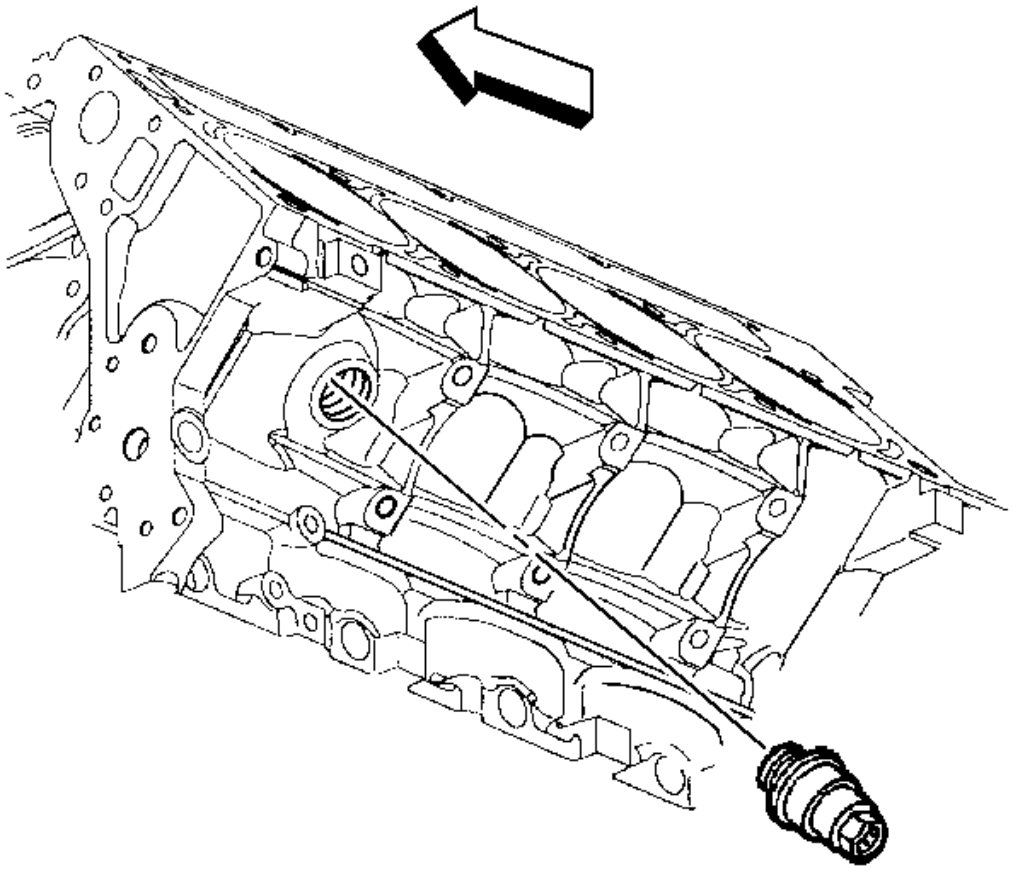

Fig. 541: View Of Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Engine block plug, oil gallery, and coolant sealing washers may be used again if not bent, scored or otherwise damaged.

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1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer, if applicable. Refer to **Sealers, Adhesives, and Lubricants**.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine block coolant heater to the engine block.

   Tighten: Tighten the block coolant heater to 50 N.m (37 lb ft).

3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant drain hole plug sealing washer.

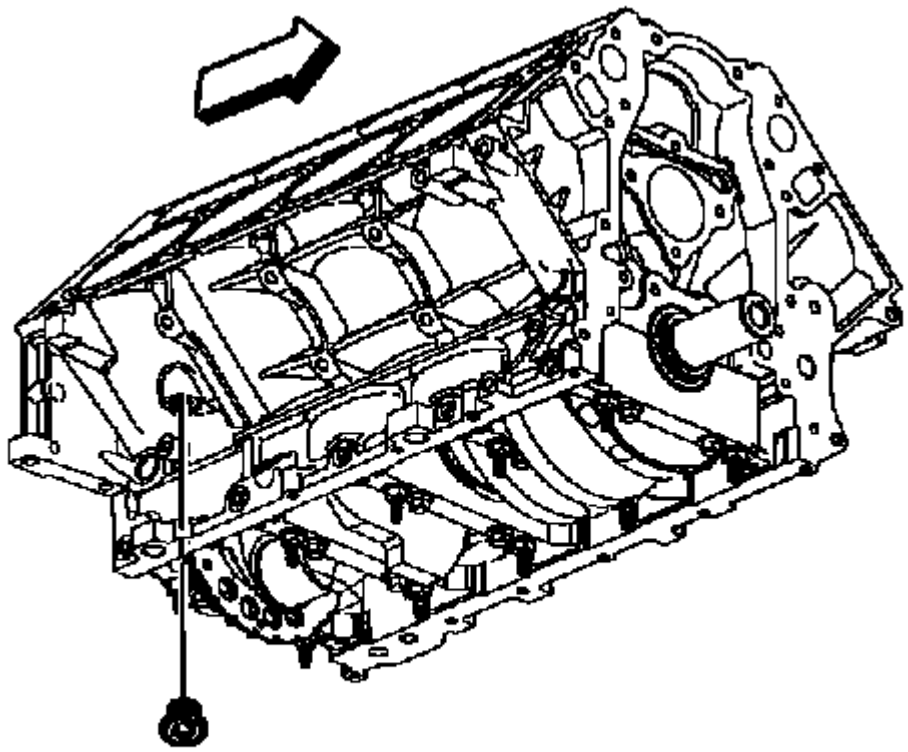

Fig. 542: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

4. Install the engine block coolant drain hole plug.

   Tighten: Tighten the coolant drain hole plug to 60 N.m (44 lb ft).

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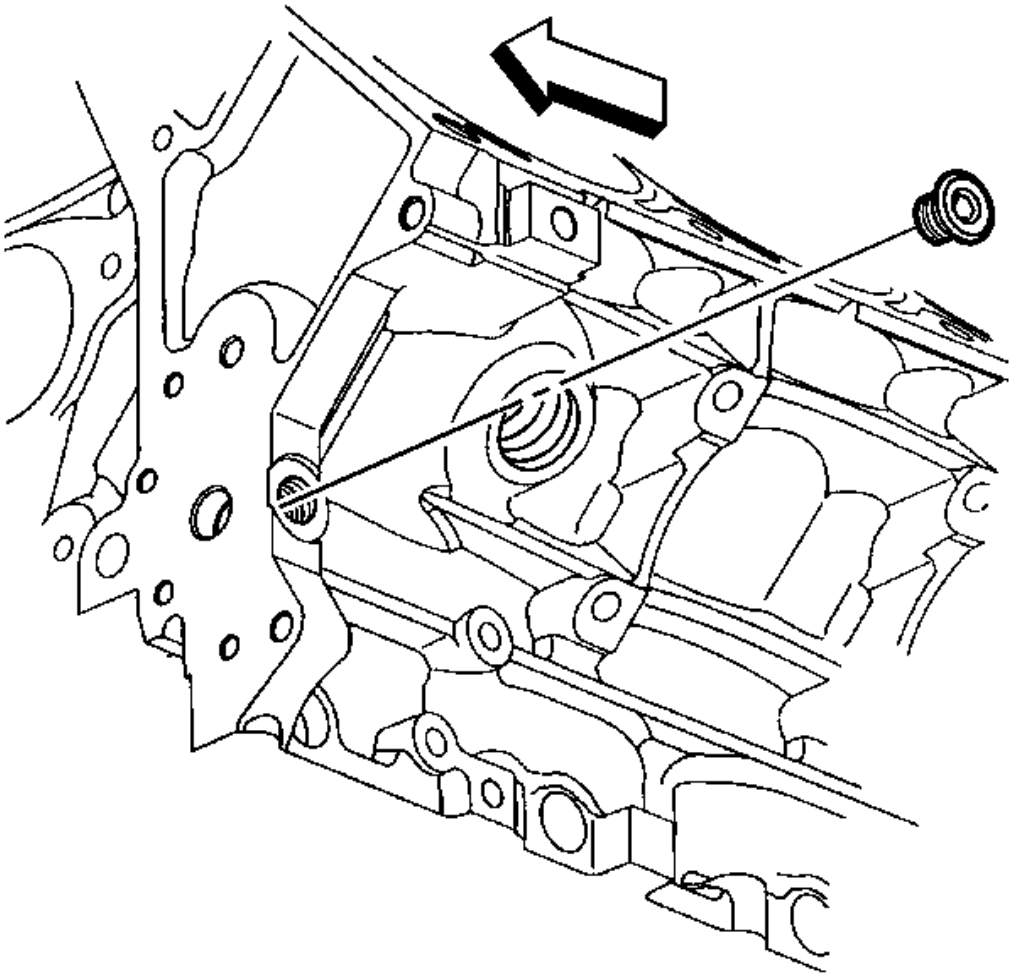

Fig. 543: View Of Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer.
6. Install the engine block left front oil gallery plug.

Tighten: Tighten the block left front oil gallery plug to 60 N.m (44 lb ft).

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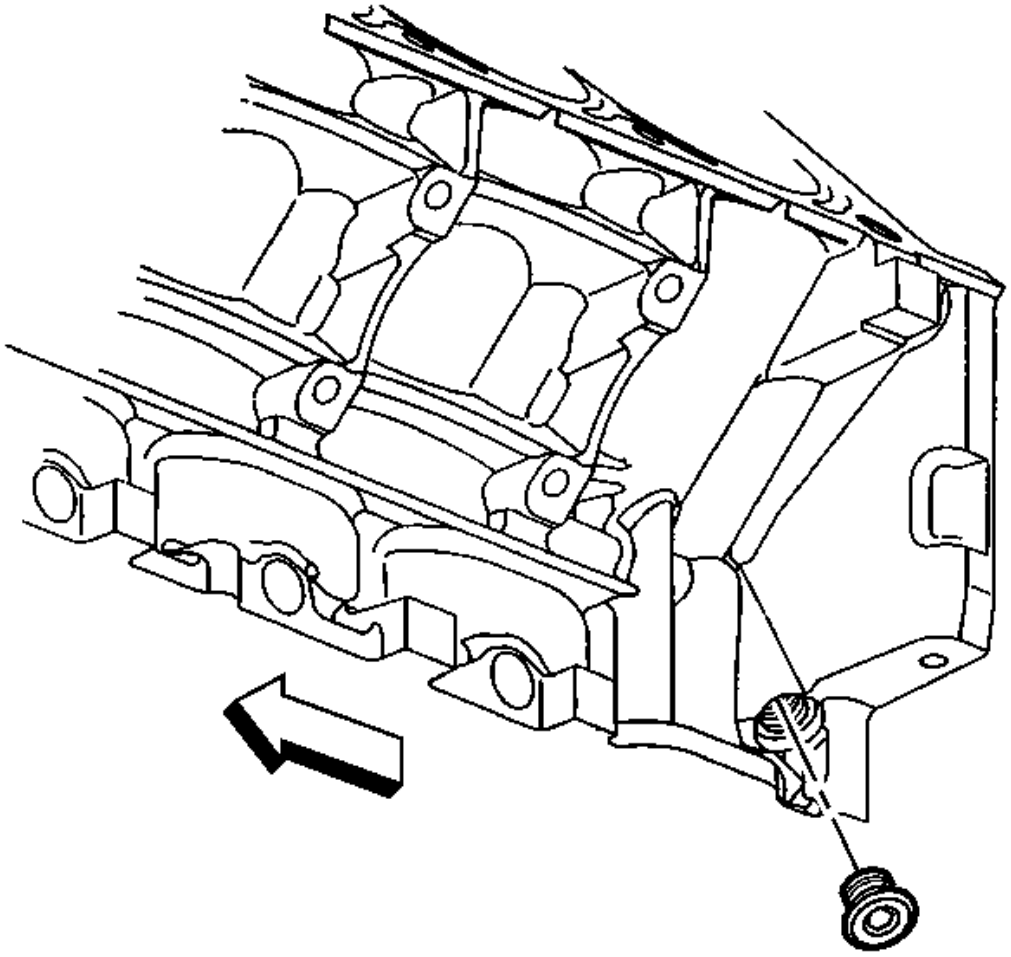

Fig. 544: View Of Engine Block Left Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer.
8. Install the engine block left rear oil gallery plug.

   Tighten: Tighten the block left rear oil gallery plug to 60 N.m (44 lb ft).

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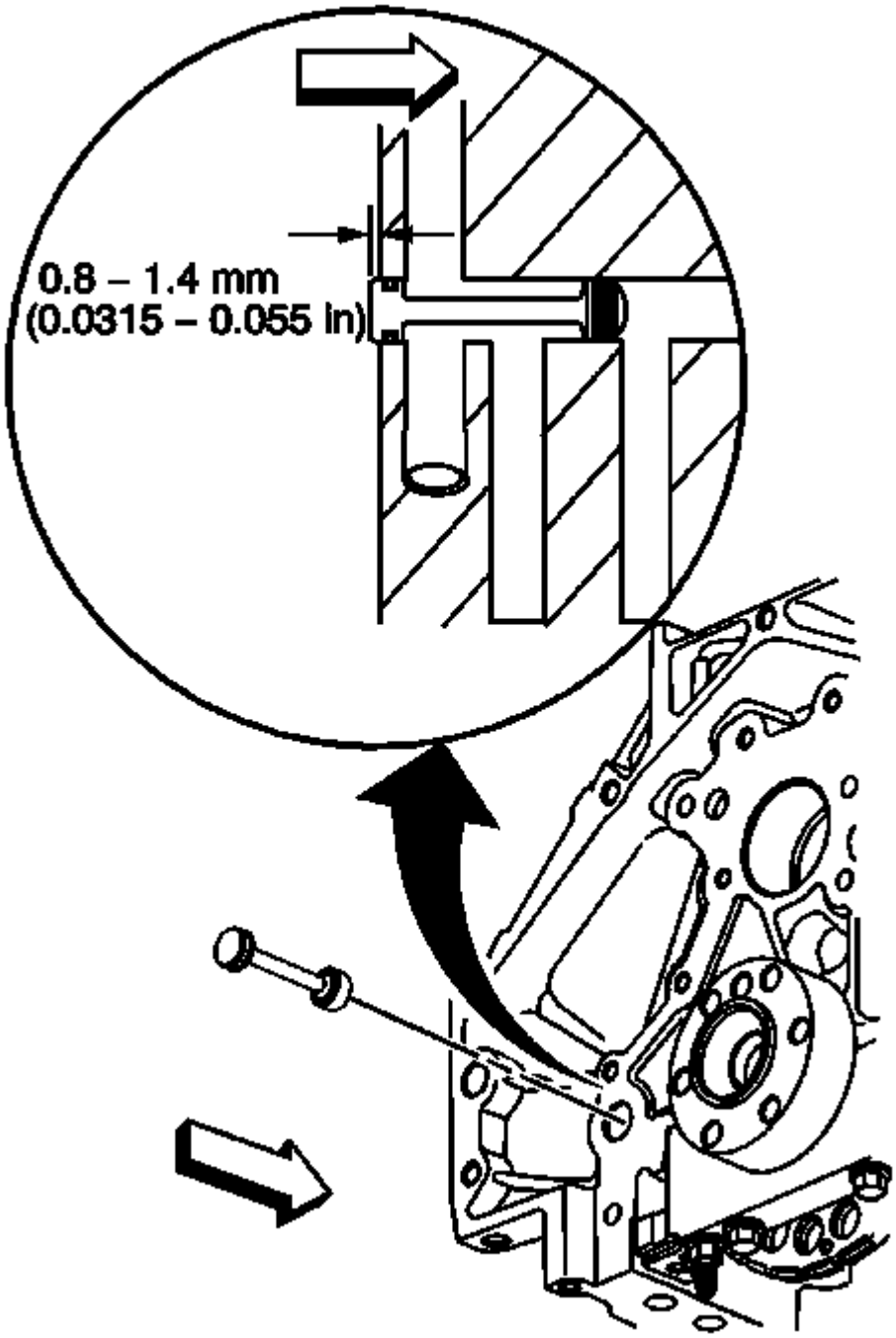

Fig. 545: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

9. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be used again.
10. Lubricate the O-ring seal with clean engine oil.
11. Install the O-ring seal onto the plug.
12. Install the engine block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.

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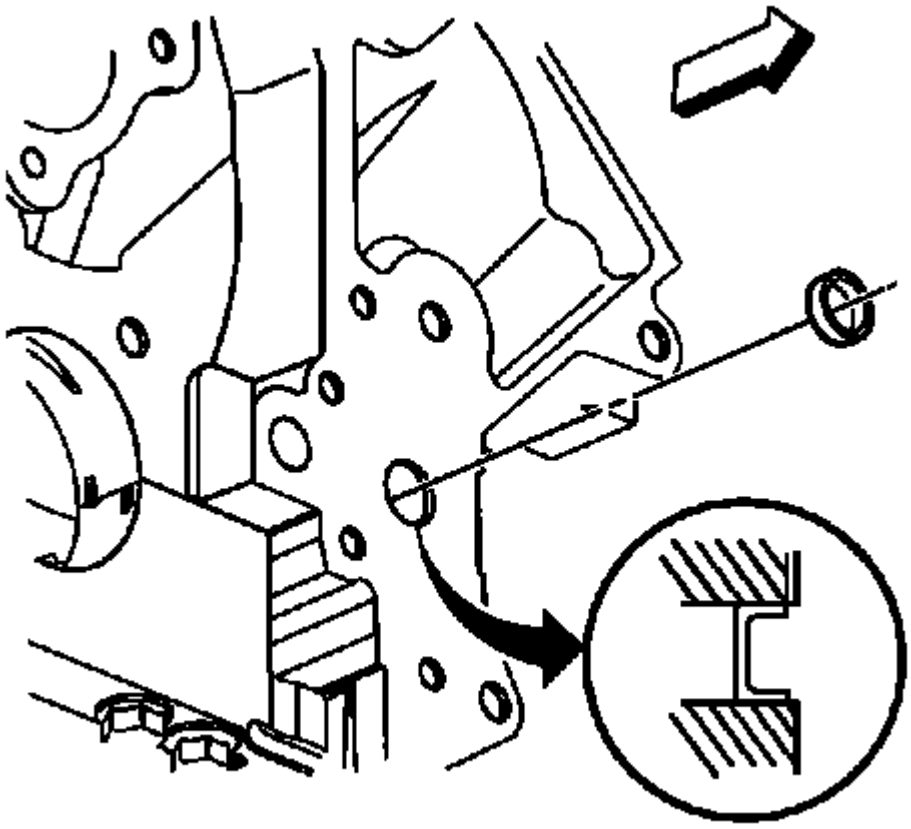

Fig. 546: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug.
14. Install a NEW engine block front oil gallery plug. Install the plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.

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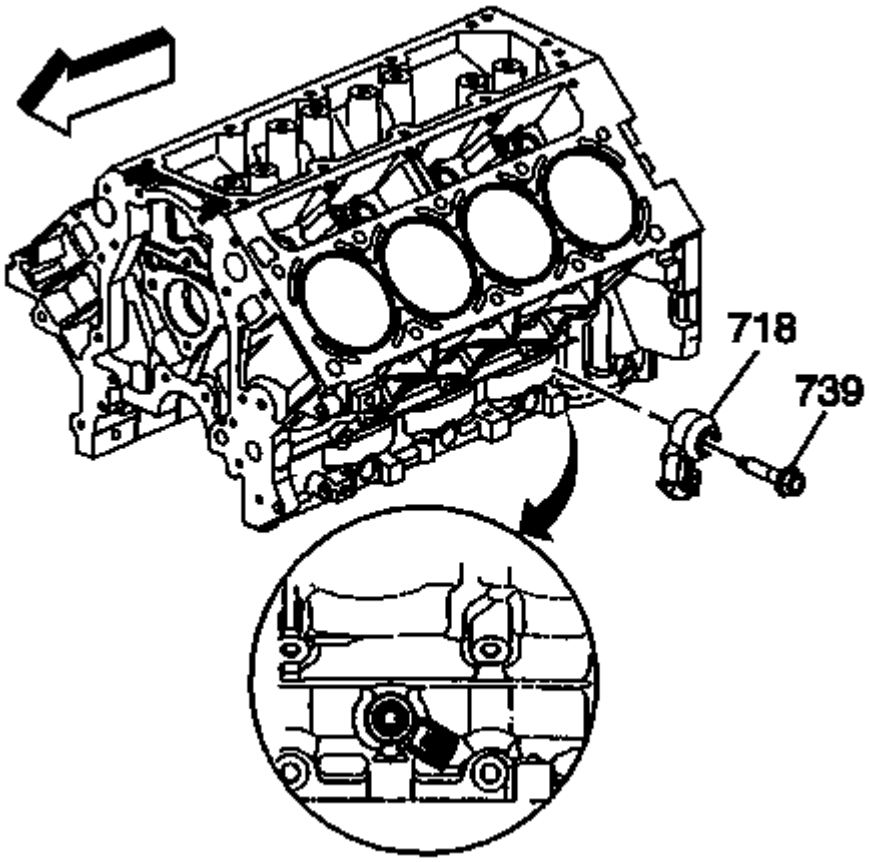

Fig. 547: Left Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

15. Install the left side knock sensor (718) and bolt (739).

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

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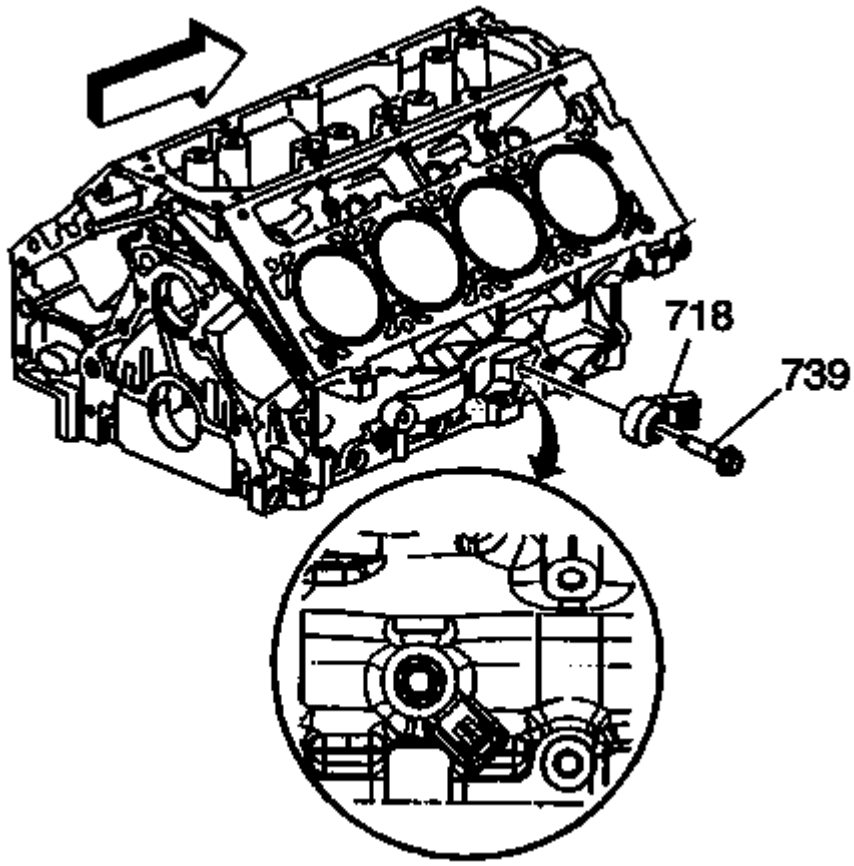

Fig. 548: Right Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

16. Install the right side knock sensor (718) and bolt (739).

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

Crankshaft and Bearings Installation

Tools Required

J 45059 Angle Meter

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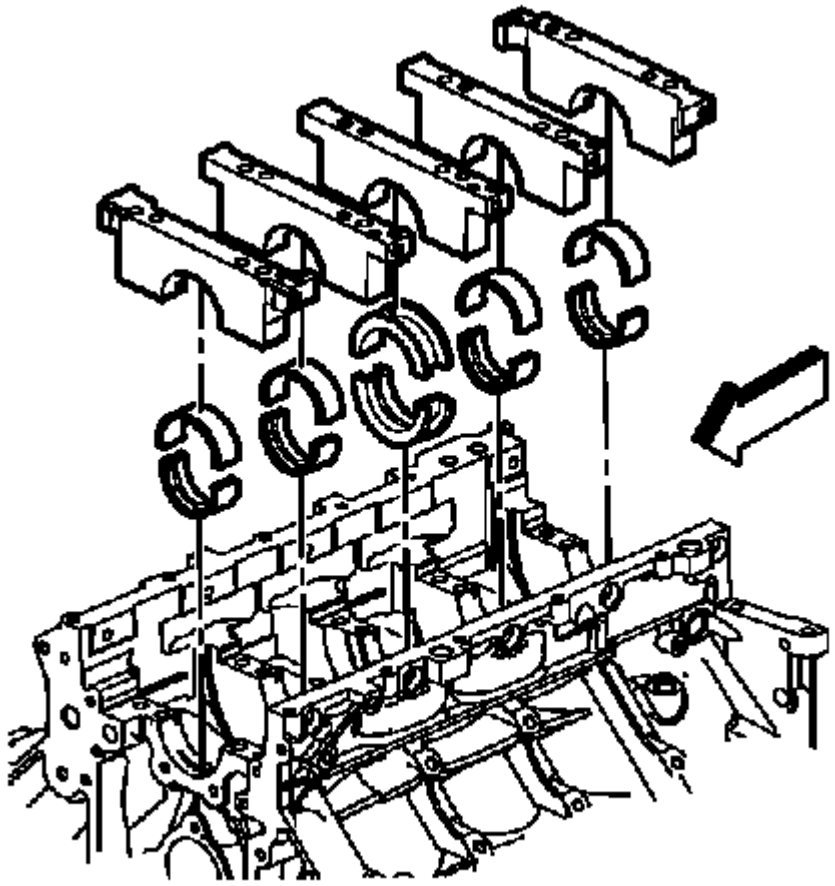

Fig. 549: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may effect crankshaft position sensor signals and/or on-board diagnostics (OBD) II system performance.**
- **Crankshaft bearing caps must be installed to the proper location and direction.**
- **When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.**
- **Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.**
- **To prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.**

  The crankshaft bearing cap M8 side bolts have a pre-applied sealant patch applied to the bolt flange.

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1. Install the crankshaft bearings to the engine block and bearing caps. The thrust bearings are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

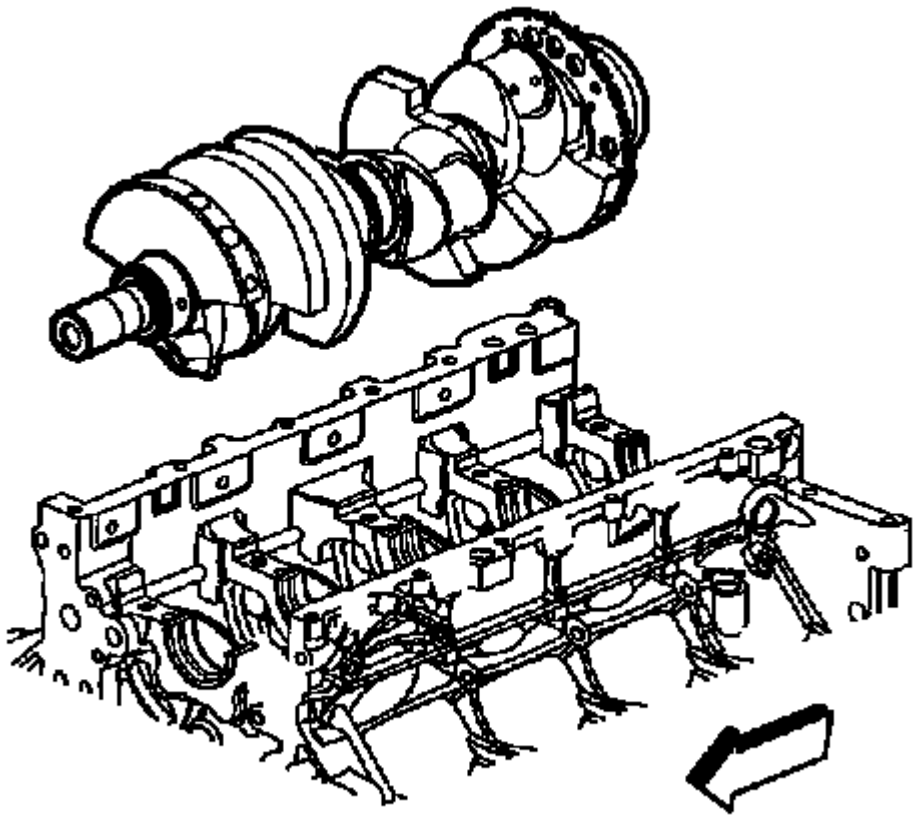

Fig. 550: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft.

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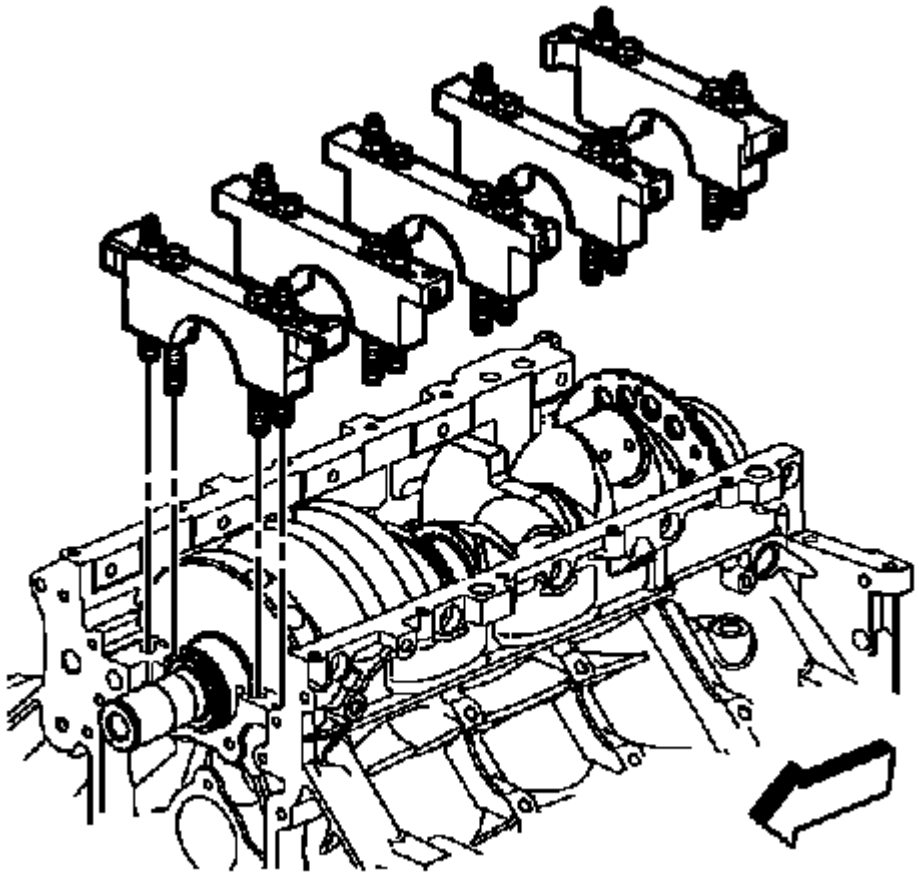

Fig. 551: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The bearing caps must be installed in the proper location and direction.

4. Install the crankshaft bearing caps, with bearings, into the engine block.

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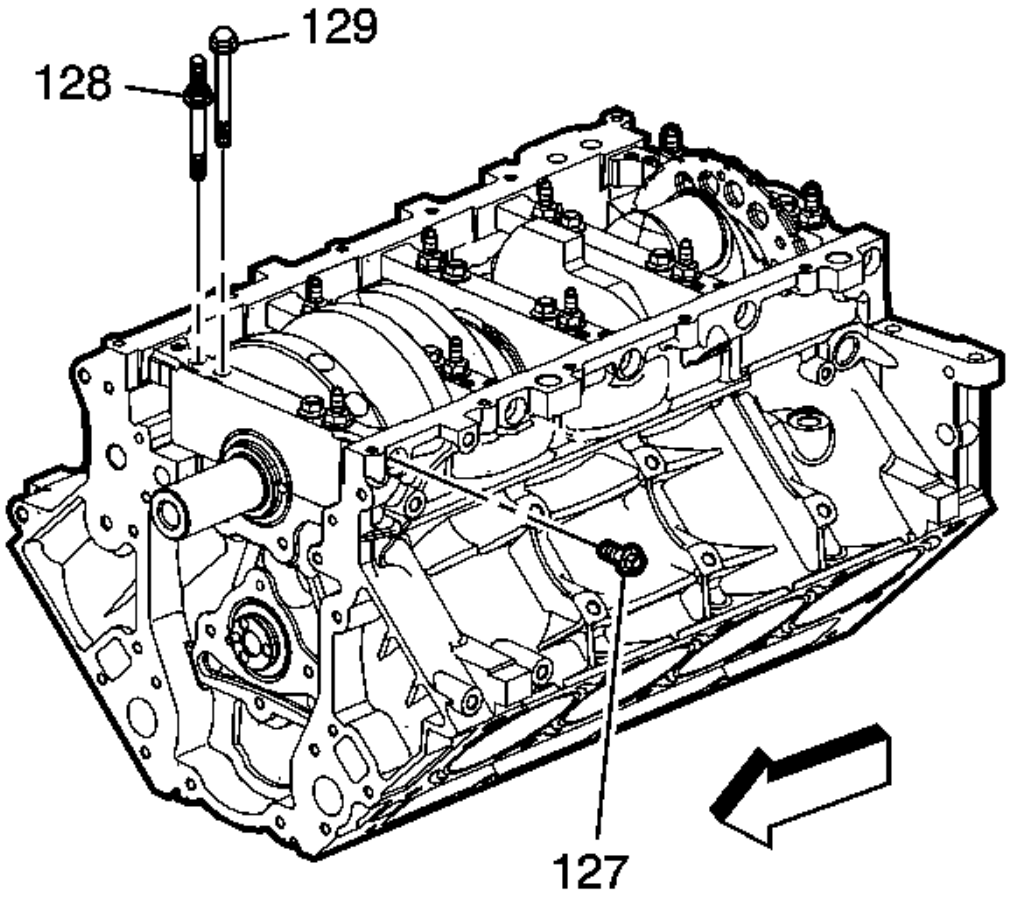

Fig. 552: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

5. Install the M10 bolts (129) and M10 studs (128).
6. Tap the bearing caps into place with a plastic-face hammer.
7. Install the NEW M8 bearing cap side bolts (127).

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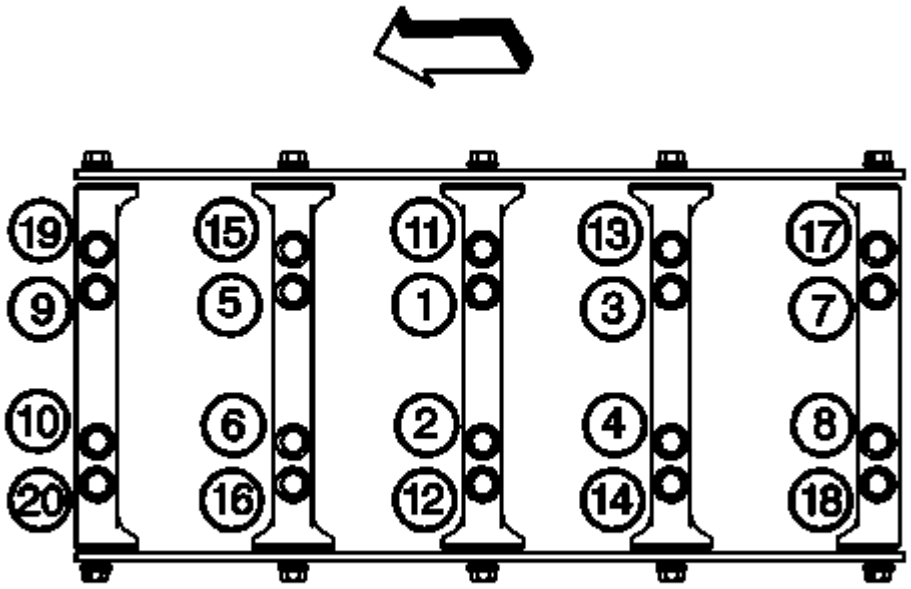

Fig. 553: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Tighten the bearing cap M10 bolts (1-10).

   Tighten: Tighten the M10 bearing cap bolts (1-10) a first pass in sequence to 20 N.m (15 lb ft).

   IMPORTANT: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward direction.

9. Using a plastic-face hammer, tap the crankshaft rearward, then forward to align the thrust bearings.

   Tighten:
   1. Tighten the M10 bolts (1-10) a final pass in sequence 80 degrees using the **J 45059** .
   2. Tighten the M10 studs (11-20) a first pass in sequence to 20 N.m (15 lb ft).
   3. Tighten the M10 studs (11-20) a final pass in sequence 51 degrees using the **J 45059** .
   4. Tighten the bearing cap M8 bolts to 25 N.m (18 lb ft).

      Tighten the bolt on one side of the bearing cap and then tighten the bolt on the opposite side of the

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same bearing cap.

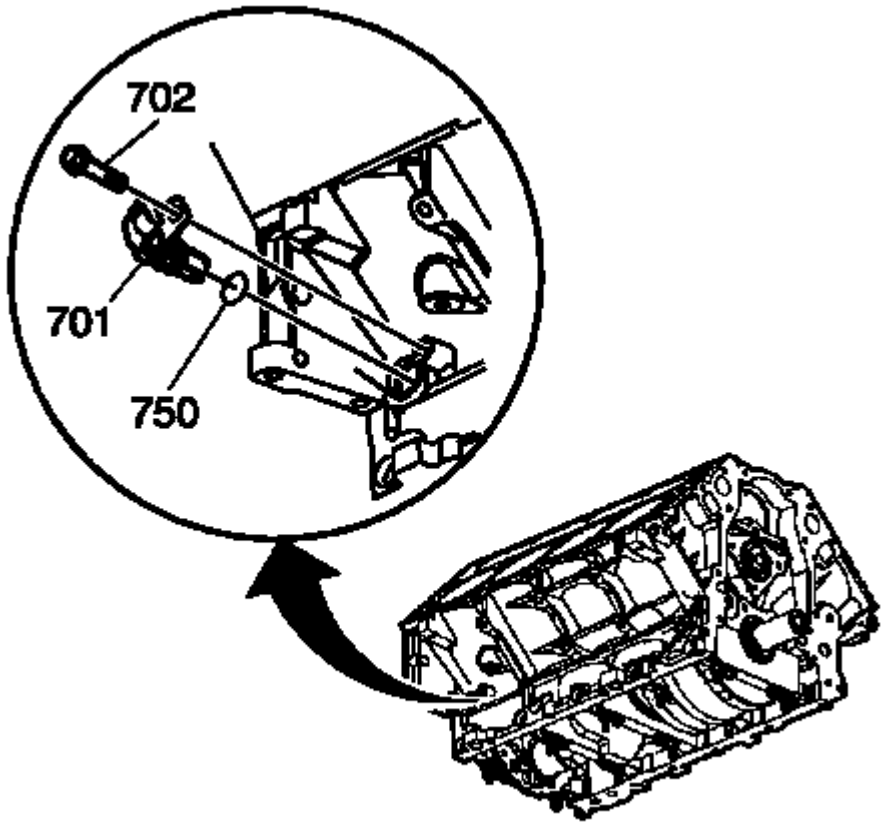

Fig. 554: CKP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the crankshaft position (CKP) sensor.
    1. Inspect the CKP sensor O-ring seal (750). If the O-ring seal is not cut or damaged, it may be used.
    2. Coat the O-ring seal with clean engine oil.
    3. Install the O-ring onto the sensor.
    4. Install the sensor (701). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.
    5. Install the sensor bolt (702).

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

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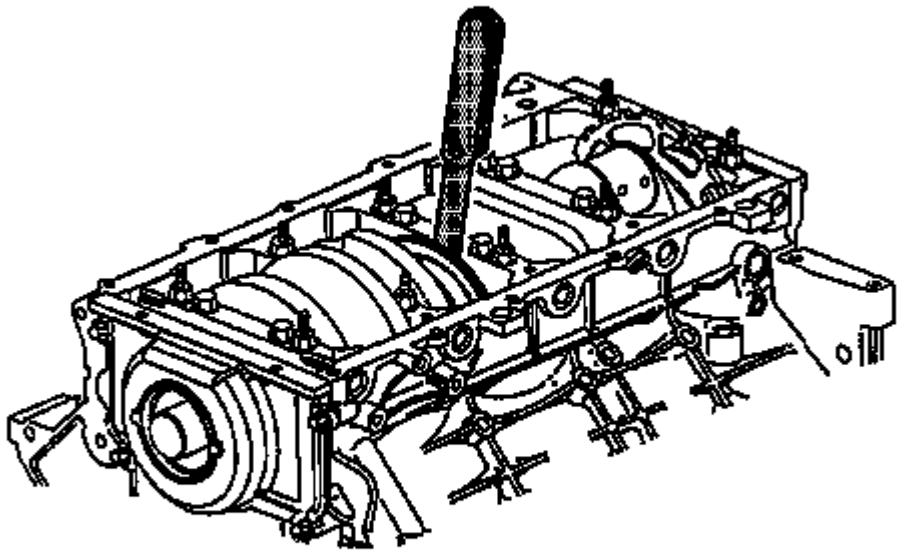

Fig. 555: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

11. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gage between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

       The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

    3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 8037** Piston Ring Compressor. See **Special Tools**.
- **J 8087** Cylinder Bore Gage
- **J 41556** Connecting Rod Guide

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- **J 45059** Angle Meter

Piston Selection

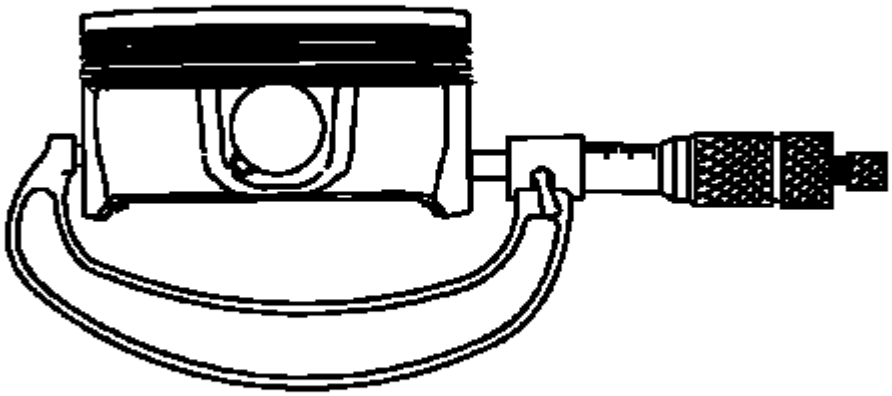

Fig. 556: Measuring Piston Outside Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.

1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to **Engine Mechanical Specifications**.
2. Record the piston OD.

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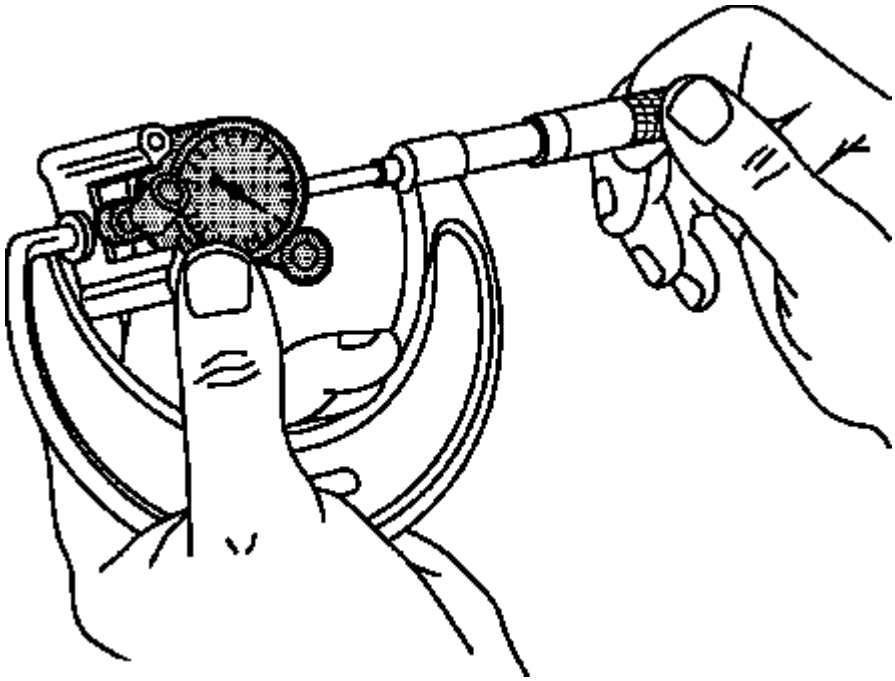

Fig. 557: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **J 8087** into the micrometer and zero the gage dial.

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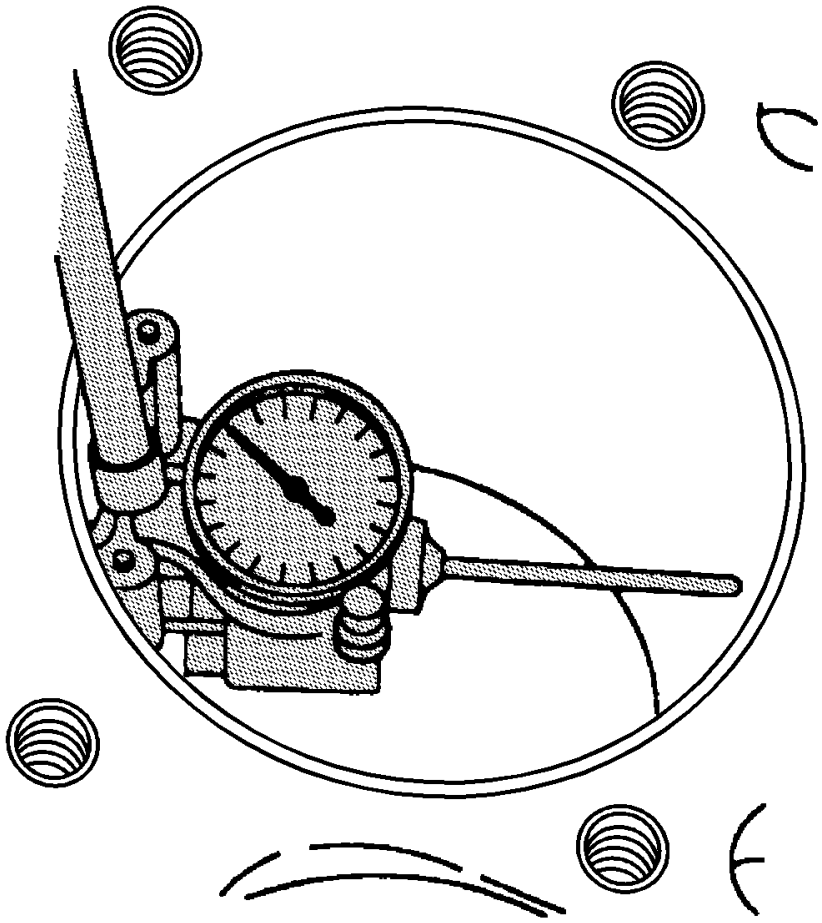

Fig. 558: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 8087** , measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston, pin, and connecting rod assembly and again measure the clearances. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

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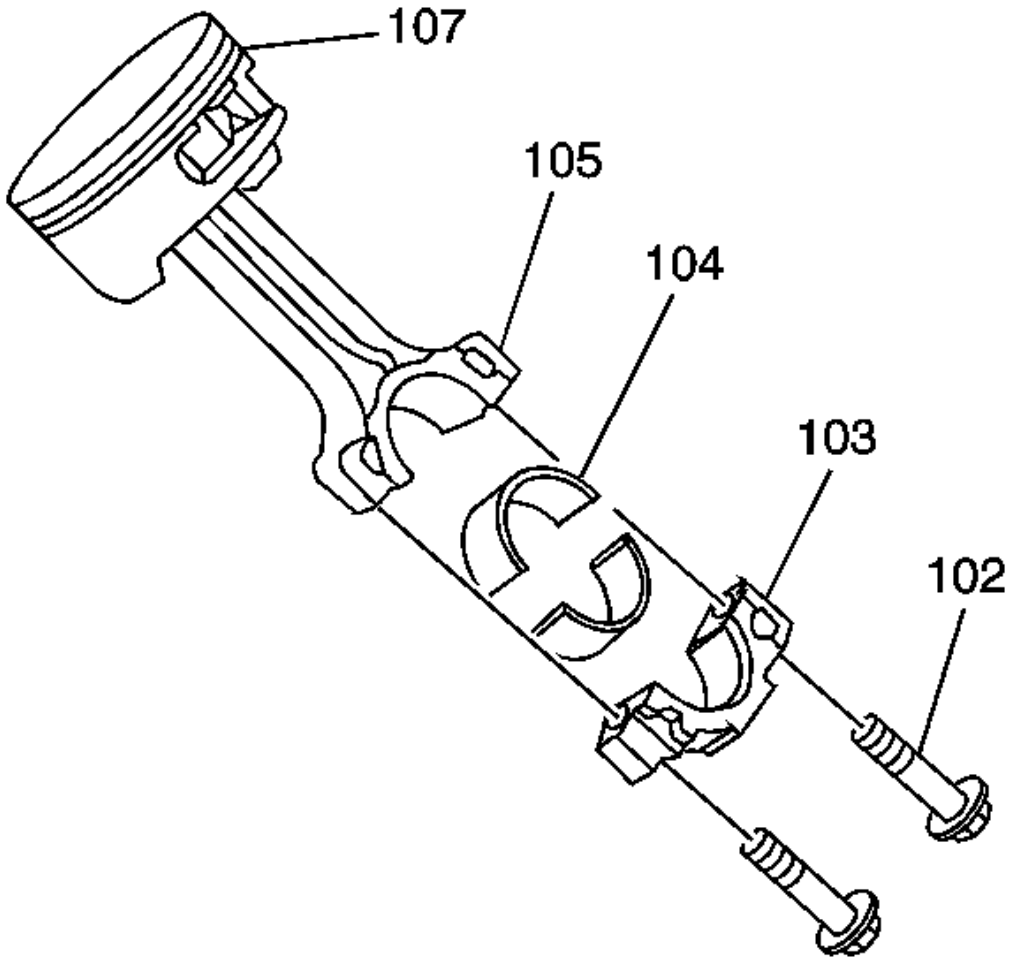

Fig. 559: Identifying Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

1. Lightly lubricate the following components with clean engine oil:
   - Piston (107)
   - Piston rings
   - Cylinder bore
   - Bearings (104) and bearing surfaces
2. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
3. Position the compression ring end gaps 180 degrees opposite each other.

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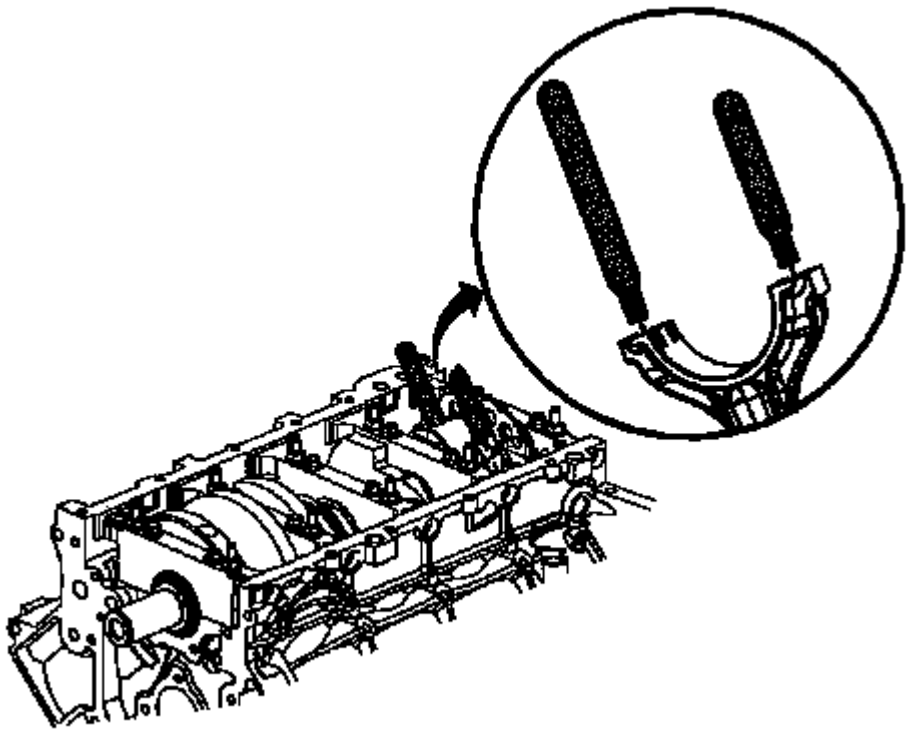

Fig. 560: Installing Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod.

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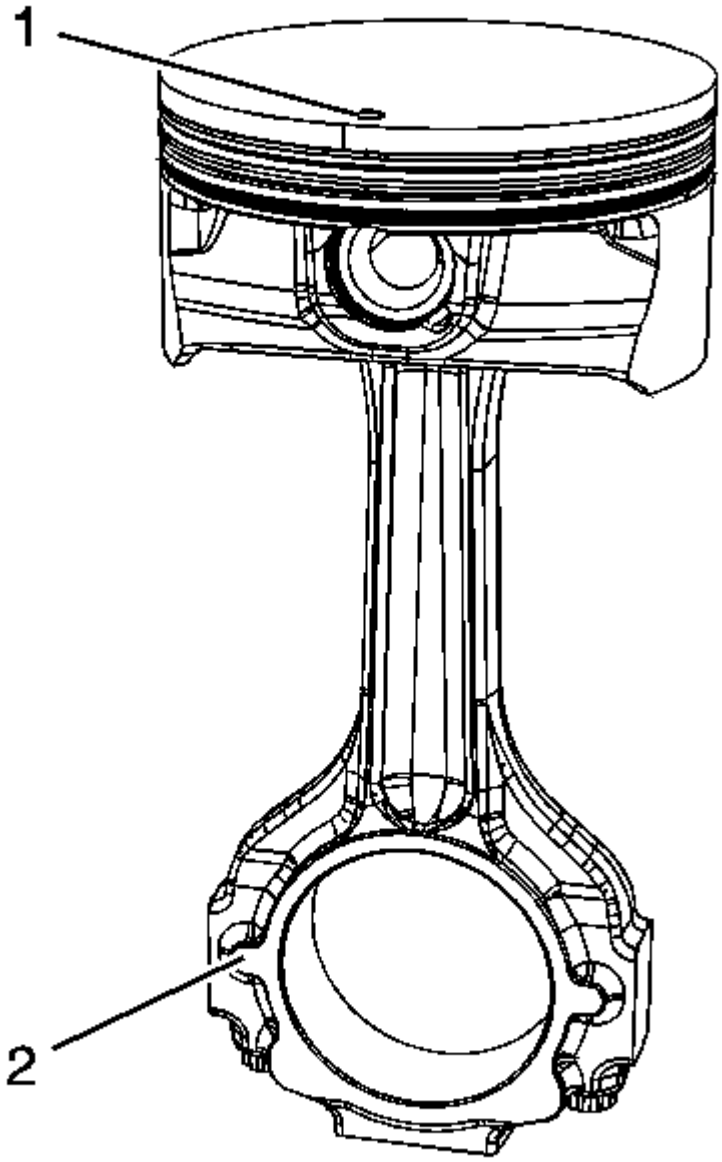

Fig. 561: Identifying Proper Installation Direction Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

5. Identify the proper installation direction of the piston and connecting rod assembly. When installing the piston and connecting rod assembly, the mark on the top of the piston (1) and the tab (2) on the side of the connecting rod should face the front of the engine.

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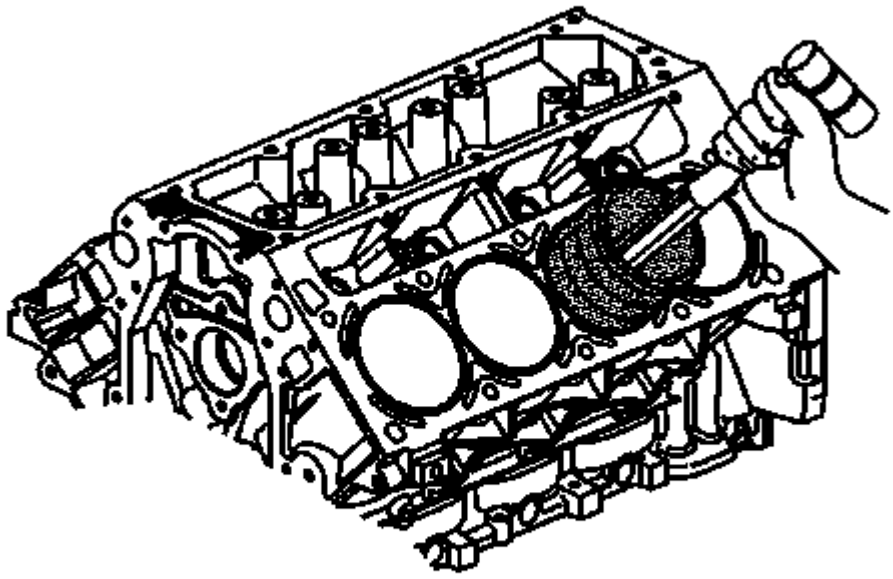

Fig. 562: Installing Piston
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 8037** onto the piston and compress the piston rings. See **Special Tools**.

IMPORTANT: The piston alignment mark MUST face the front of the engine block.

7. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all the piston rings have entered the cylinder bore.

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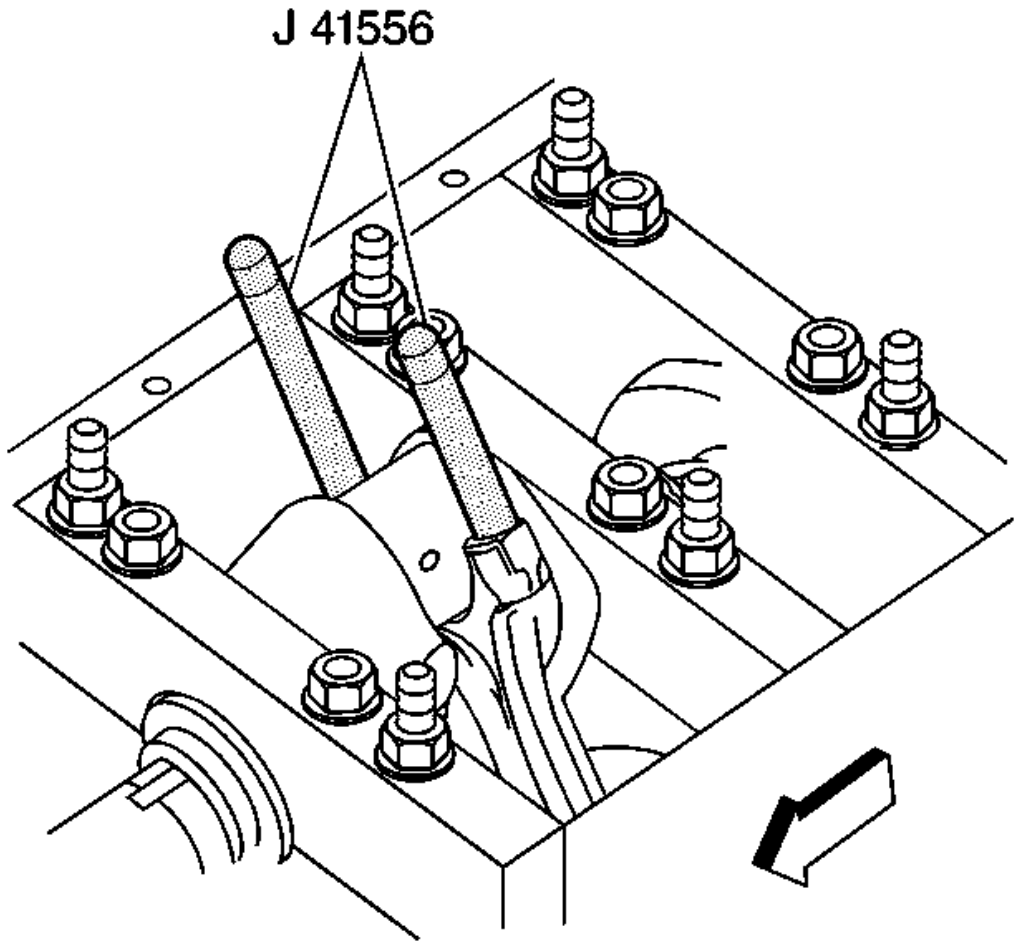

Fig. 563: View Of J 41556 & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

8. Use the **J 41556** to guide the connecting rod onto the crankshaft journal.
9. Remove the **J 41556** from the connecting rod.

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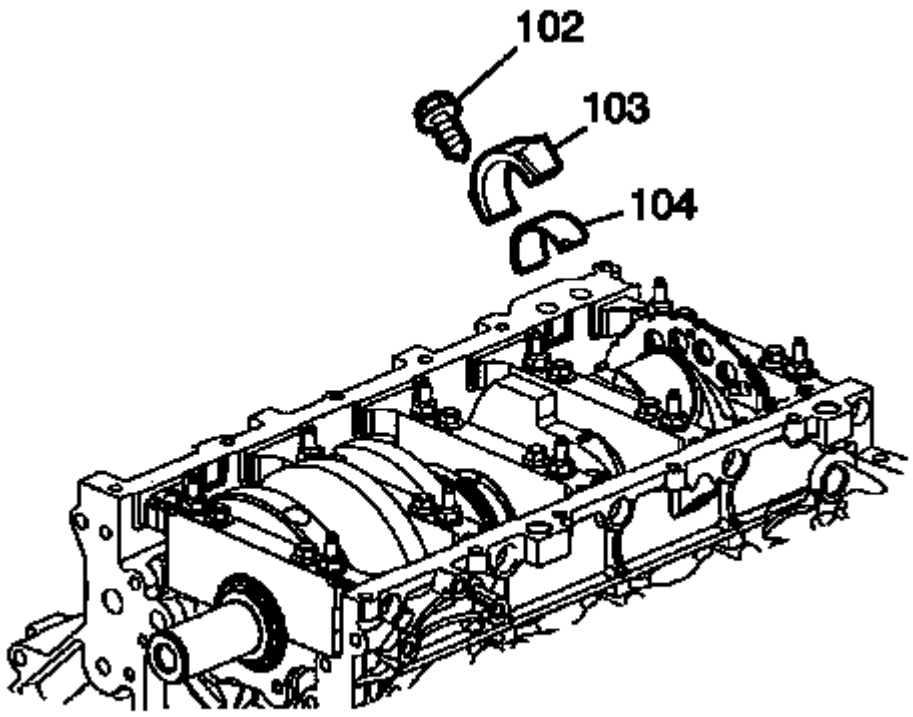

Fig. 564: Installing Bearing Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The connecting rod and cap must be assembled with the mating surfaces properly aligned.

10. Install the bearing cap (103), bearing (104), and bolts (102).

Tighten:

1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
2. Tighten the bolts a final pass to 75 degrees using the **J 45059** .

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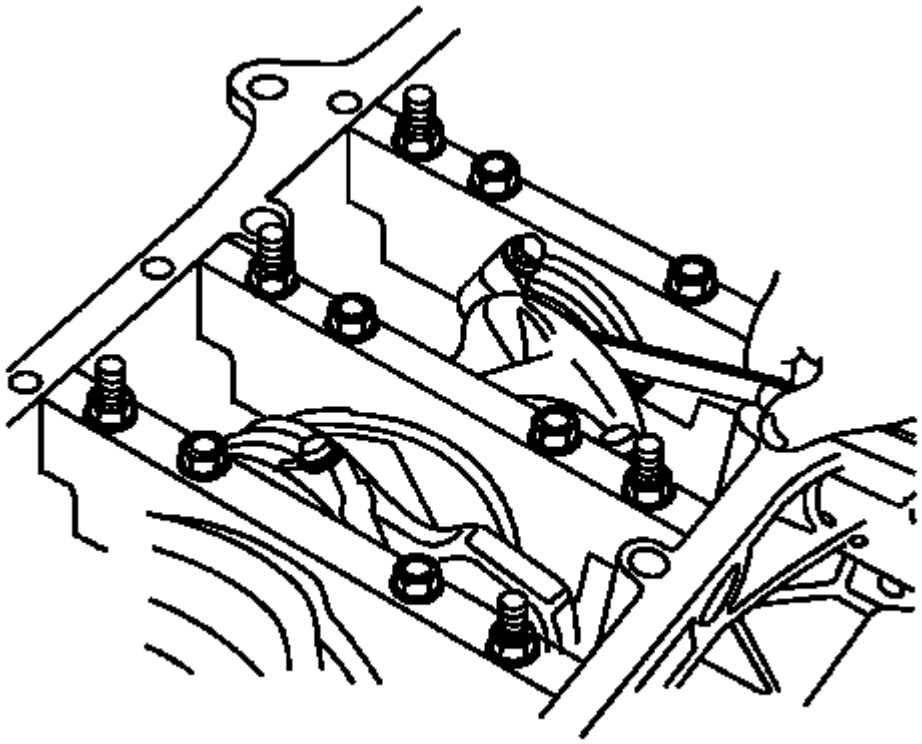

Fig. 565: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

11. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications**.

Camshaft Installation

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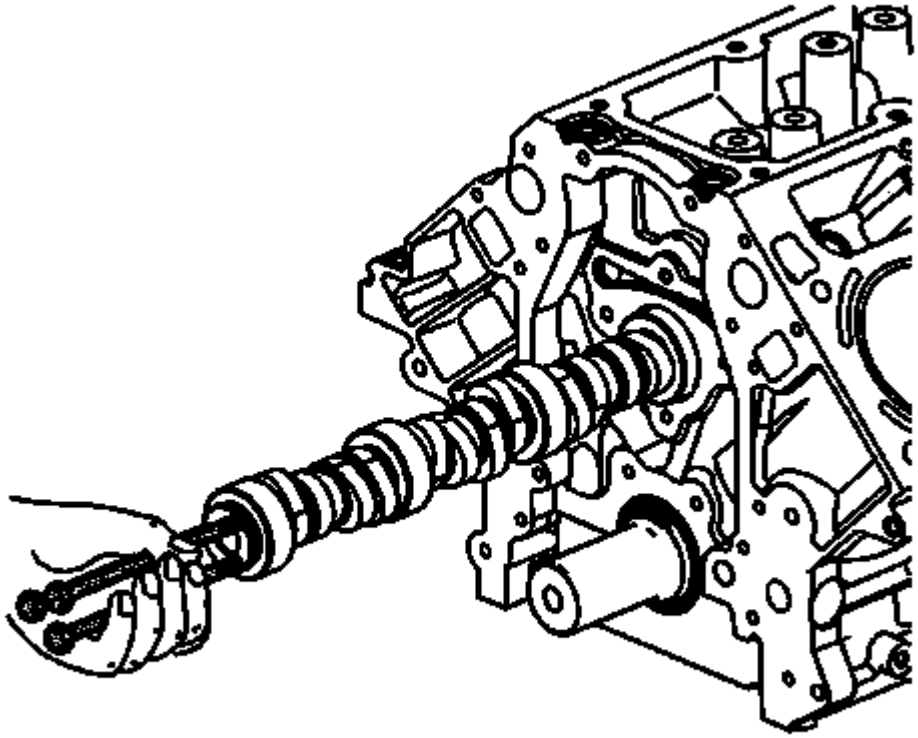

Fig. 566: Camshaft Installation
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If camshaft replacement is required, the valve lifters must also be replaced.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install 3 M8 - 1.25 x 100 mm (M8 - 1.25 x 4.0 in) bolts into the camshaft front bolt holes.

NOTE: All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Using the bolts as a handle, carefully install the camshaft into the engine block.
4. Remove the 3 bolts from the front of the camshaft.

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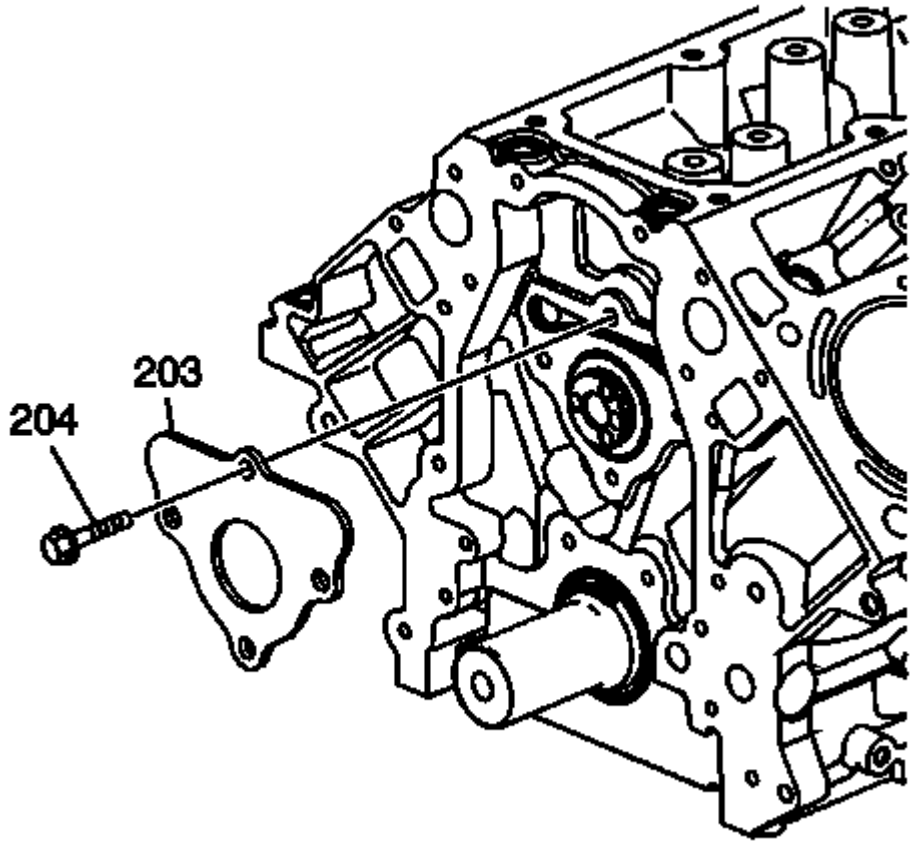

Fig. 567: Camshaft Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

IMPORTANT:
- **Install the retainer, with the sealing gasket, facing the engine block.**
- **The gasket surface on the engine block should be clean and free of dirt or debris.**

5. Install the camshaft retainer (203) and the bolts (204).

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

Timing Chain and Sprockets Installation

Tools Required

J 41665 Crankshaft Balancer and Sprocket Installer. See **Special Tools**.

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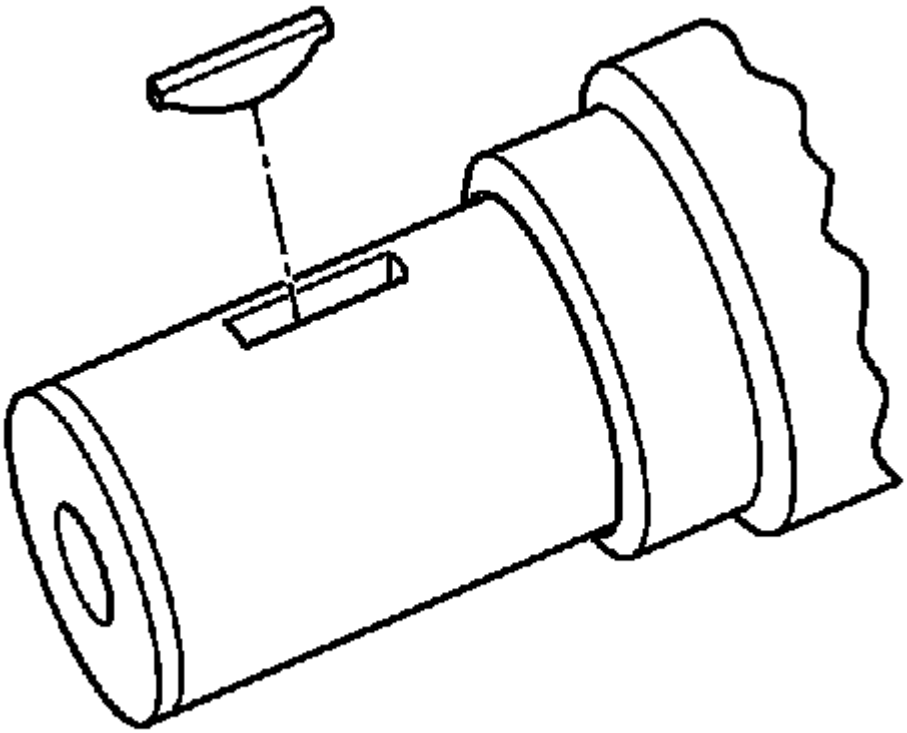

Fig. 568: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

1. Install the key into the crankshaft keyway, if previously removed.

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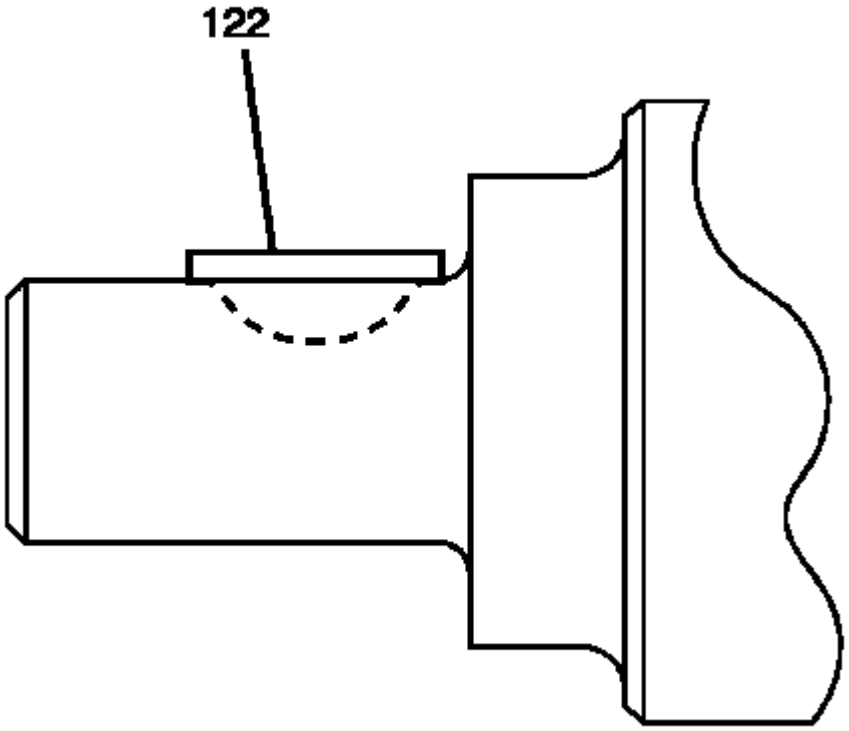

Fig. 569: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.

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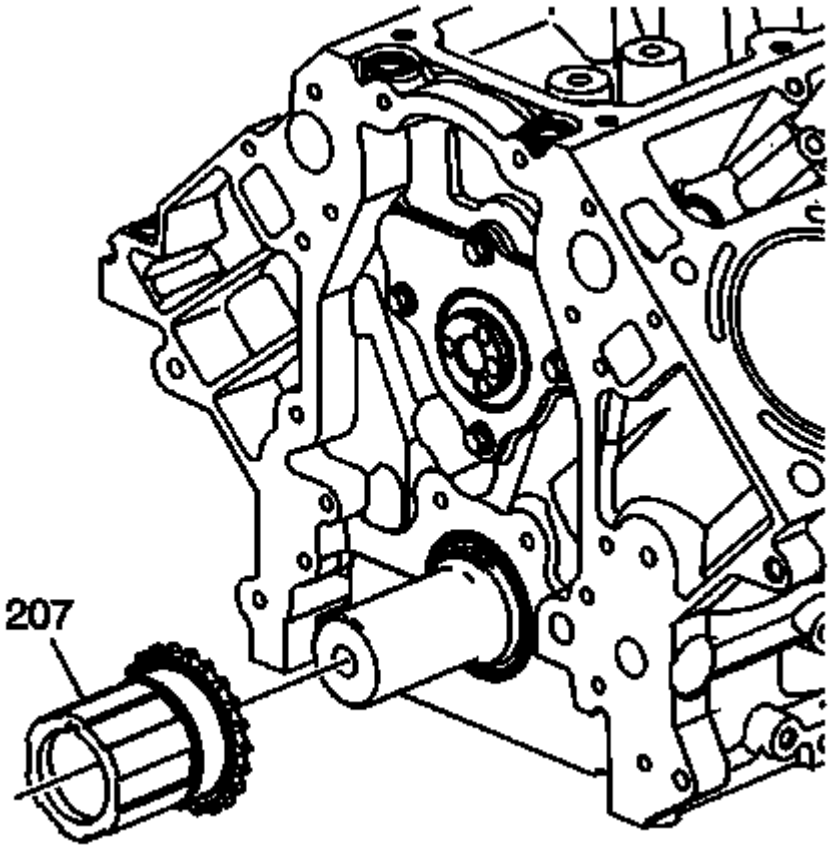

Fig. 570: Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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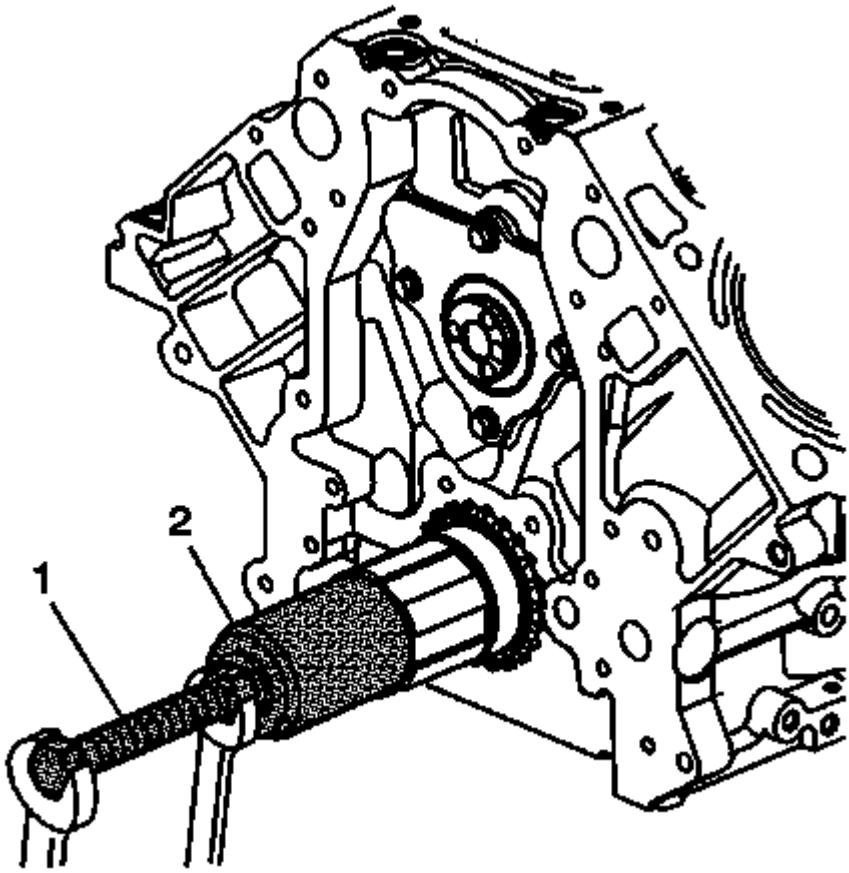

Fig. 571: Installing Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41665** (2) in order to install the crankshaft sprocket. See **Special Tools**.

   Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

5. Rotate the crankshaft sprocket until the alignment mark is in the 12 o'clock position.

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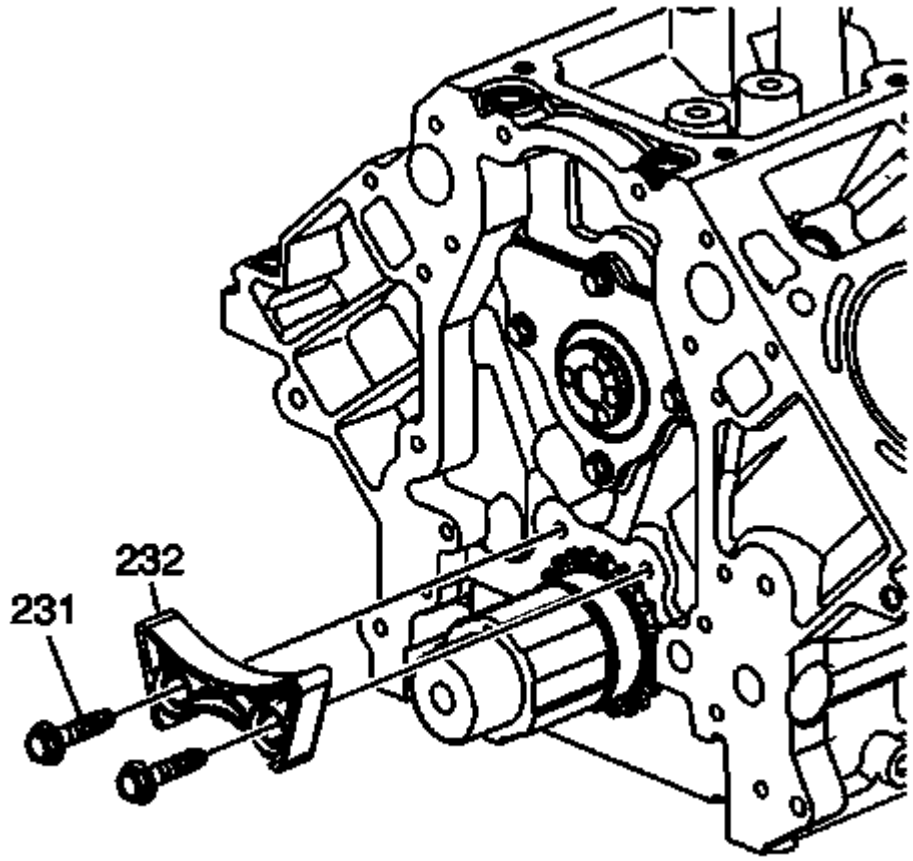

Fig. 572: Timing Chain Dampener
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the timing chain dampener (232) and bolts (231).

   Tighten: Tighten the timing chain dampener bolts to 25 N.m (18 lb ft).

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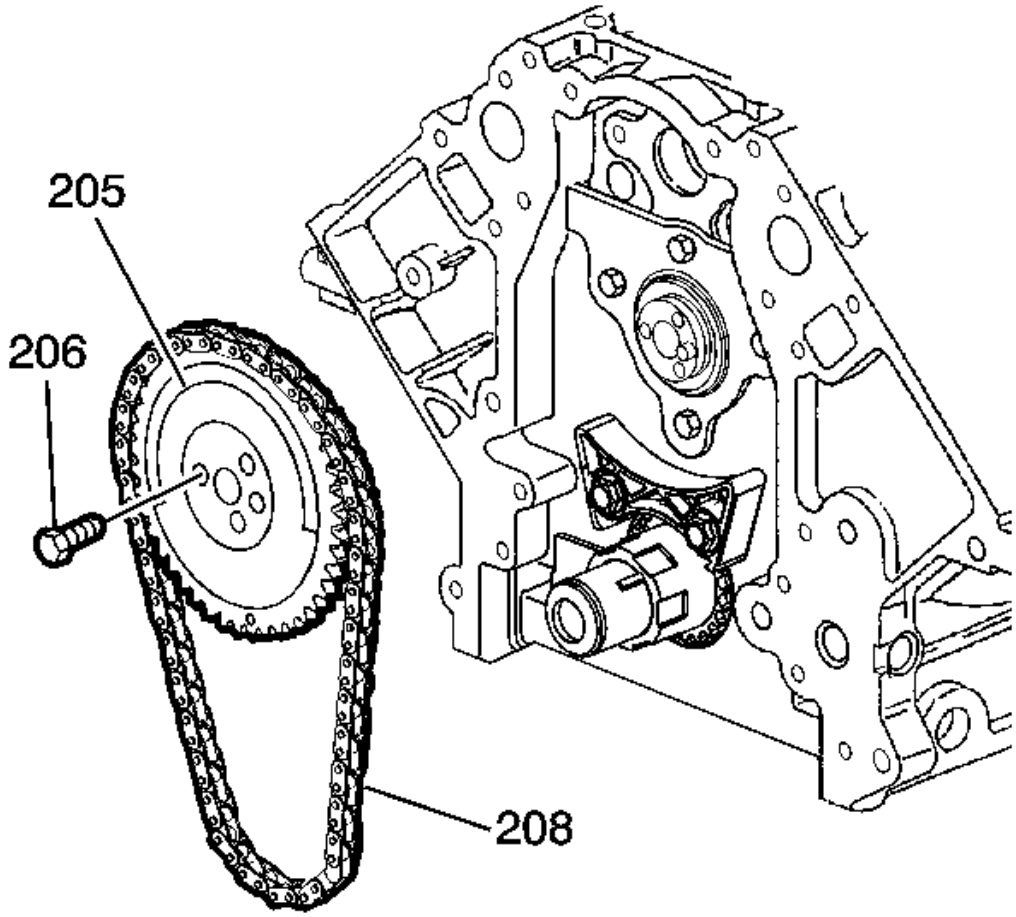

Fig. 573: View Of Camshaft Sprocket, Bolts & Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Properly locate the camshaft sprocket onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**

  Position the camshaft sprocket alignment mark in the 6 o'clock position.

7. Install the camshaft sprocket (205) and timing chain (208). If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks.

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NOTE: Refer to Fastener Notice in Cautions and Notices.

8. Install the camshaft sprocket bolts (206).

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

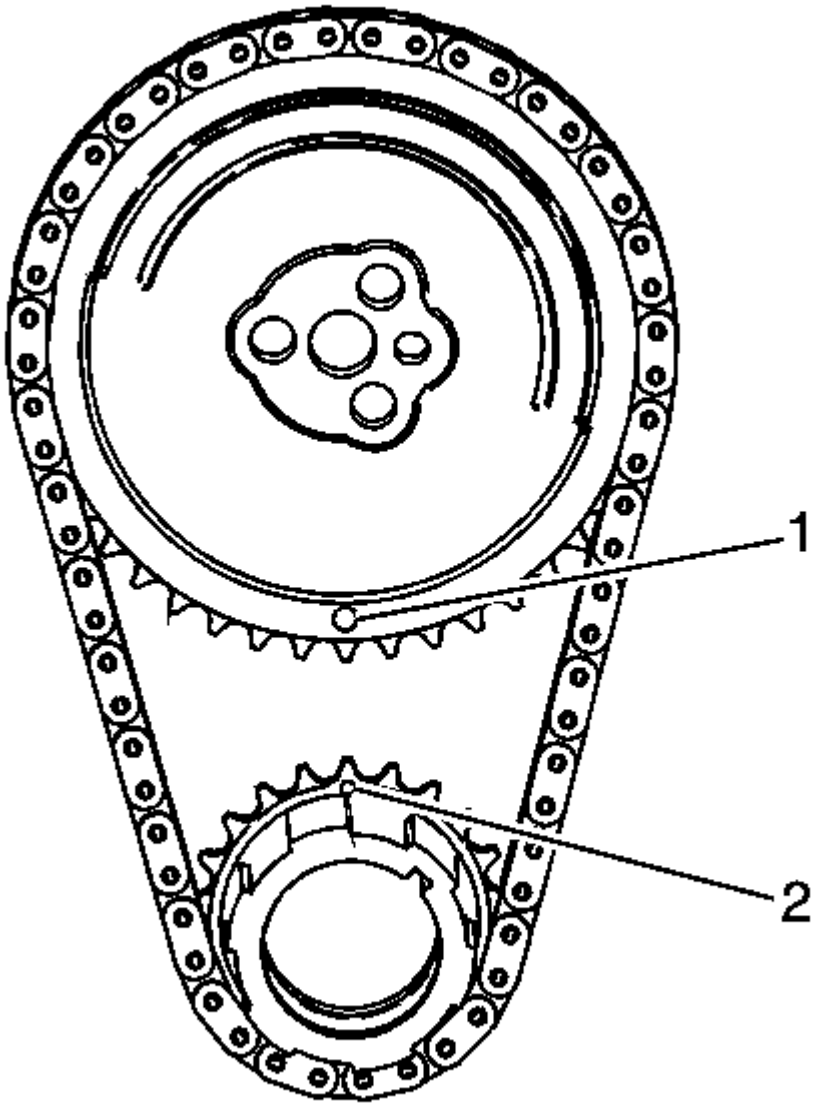

Fig. 574: View Of Camshaft And Crankshaft Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

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9. Inspect for proper alignment of the camshaft and crankshaft sprocket timing marks (1, 2).

Oil Pump, Pump Screen and Deflector Installation

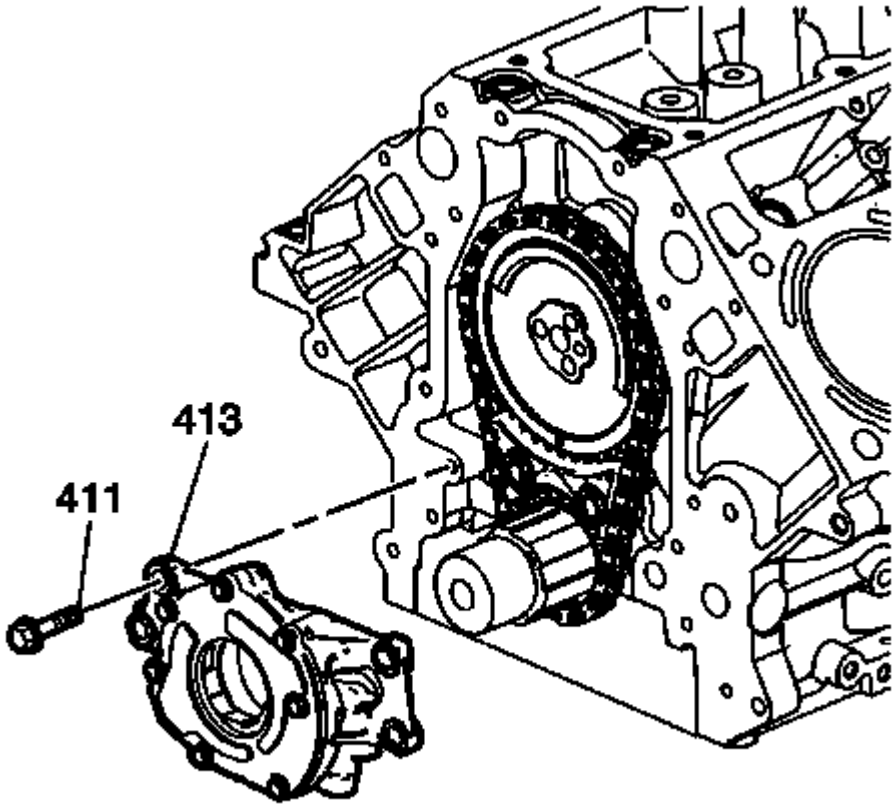

Fig. 575: Removing/Installing Oil Pump Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pump bolts (411).

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

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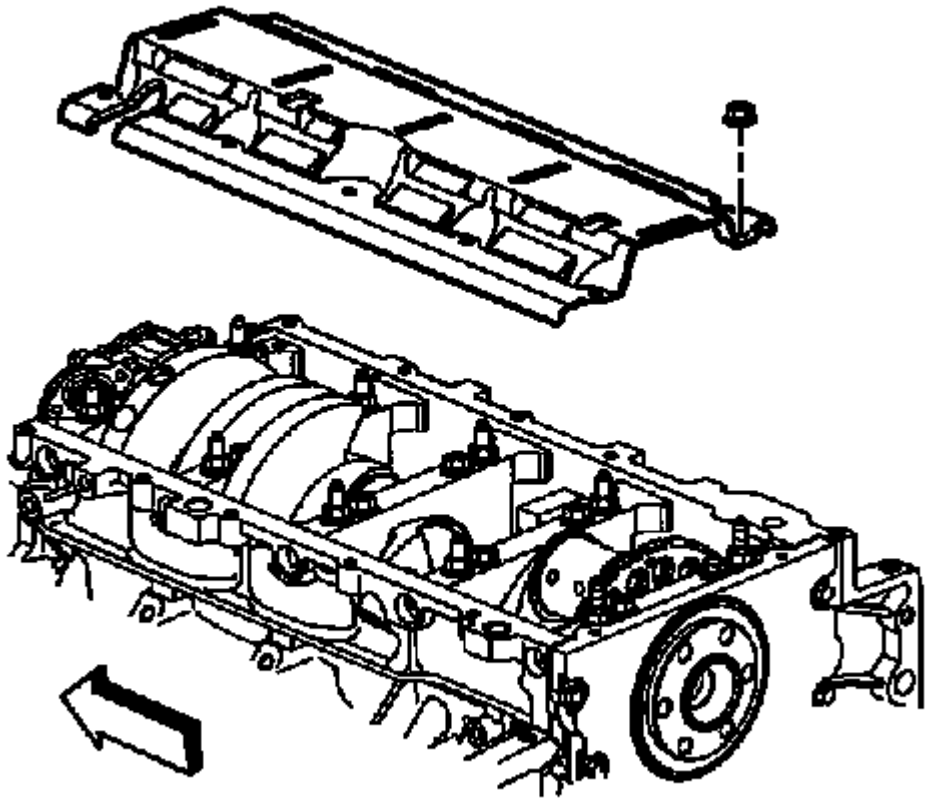

Fig. 576: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector.

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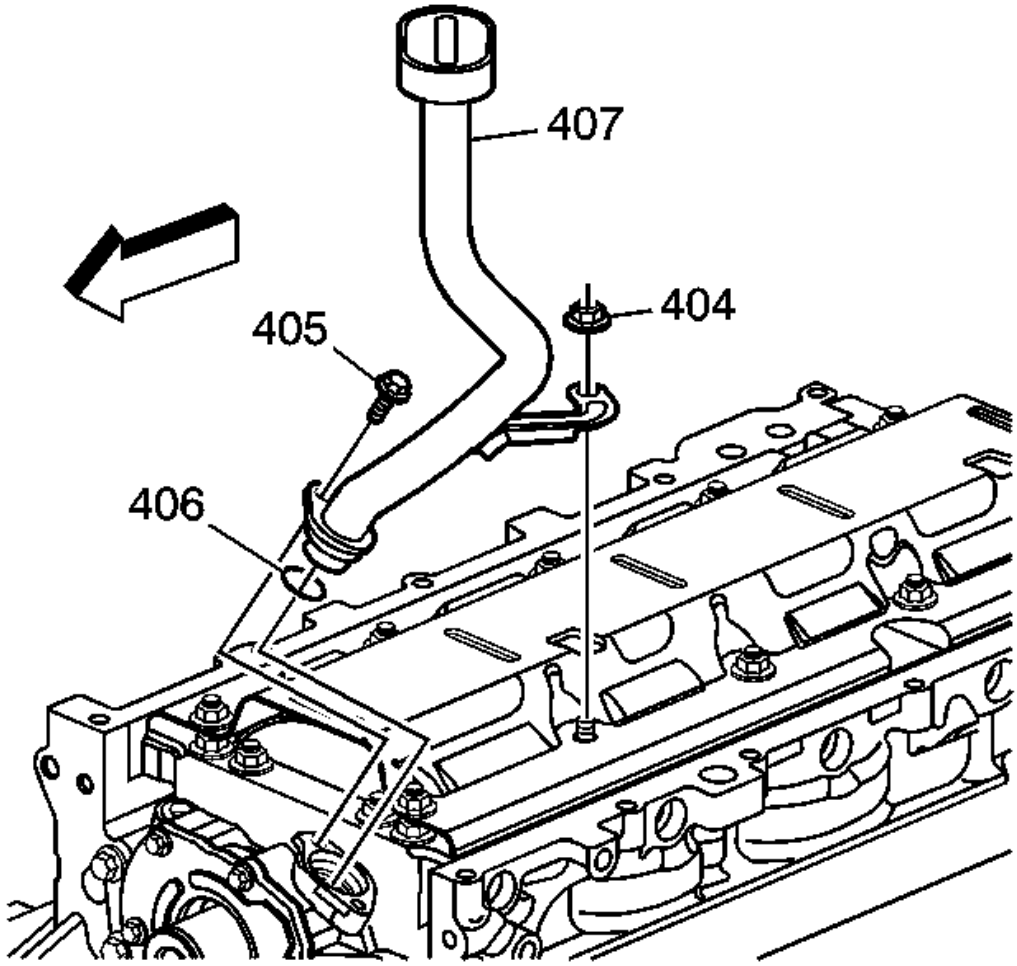

Fig. 577: View Of Oil Pump Screen, Bolt, Nuts & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

IMPORTANT:
- **Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.**
- **Align the oil pump screen mounting brackets with the correct crankshaft bearing cap bolt/studs.**

7. Install the oil pump screen (407).

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8. Install the oil pump screen bolt (405) and the deflector nut (404).

Tighten:

1. Tighten the oil pump screen bolt to 12 N.m (106 lb in).
2. Tighten the crankshaft oil deflector nut to 25 N.m (18 lb ft).

Engine Rear Cover Installation

Tools Required

- **J 41480** Front/Rear Cover Alignment - Oil Pan Surface. See **Special Tools**.
- **J 41476** Front/Rear Cover Alignment - Crankshaft Oil Seal Area. See **Special Tools**.

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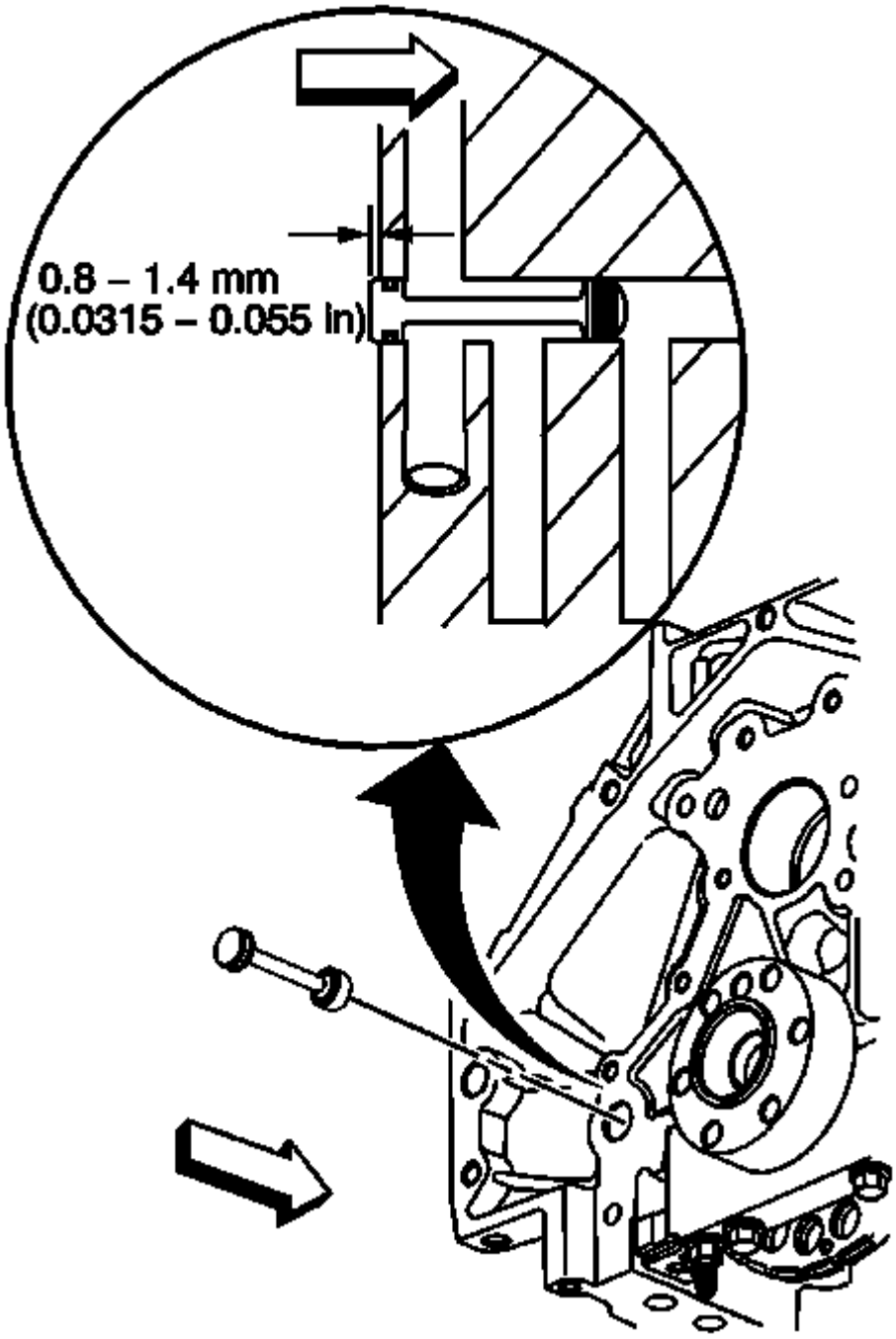

Fig. 578: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft rear oil seal or the engine rear cover gasket again.**
- **Do not apply any type of sealant to the rear cover gasket, unless specified.**
- **The special tools in this procedure are used to properly align the**

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engine rear cover at the oil pan surface and to center the crankshaft rear oil seal.

- **The crankshaft rear oil seal will be installed after the rear cover has been installed and aligned. Install the rear cover without the crankshaft oil seal.**
  - **The crankshaft rear oil seal MUST be centered in relation to the crankshaft.**
  - **The oil pan sealing surface at the rear cover and engine block MUST be aligned within specifications.**
  - **An improperly aligned rear cover may cause premature rear oil seal wear and/or engine assembly oil leaks.**

1. Inspect the rear oil gallery plug for proper installation.

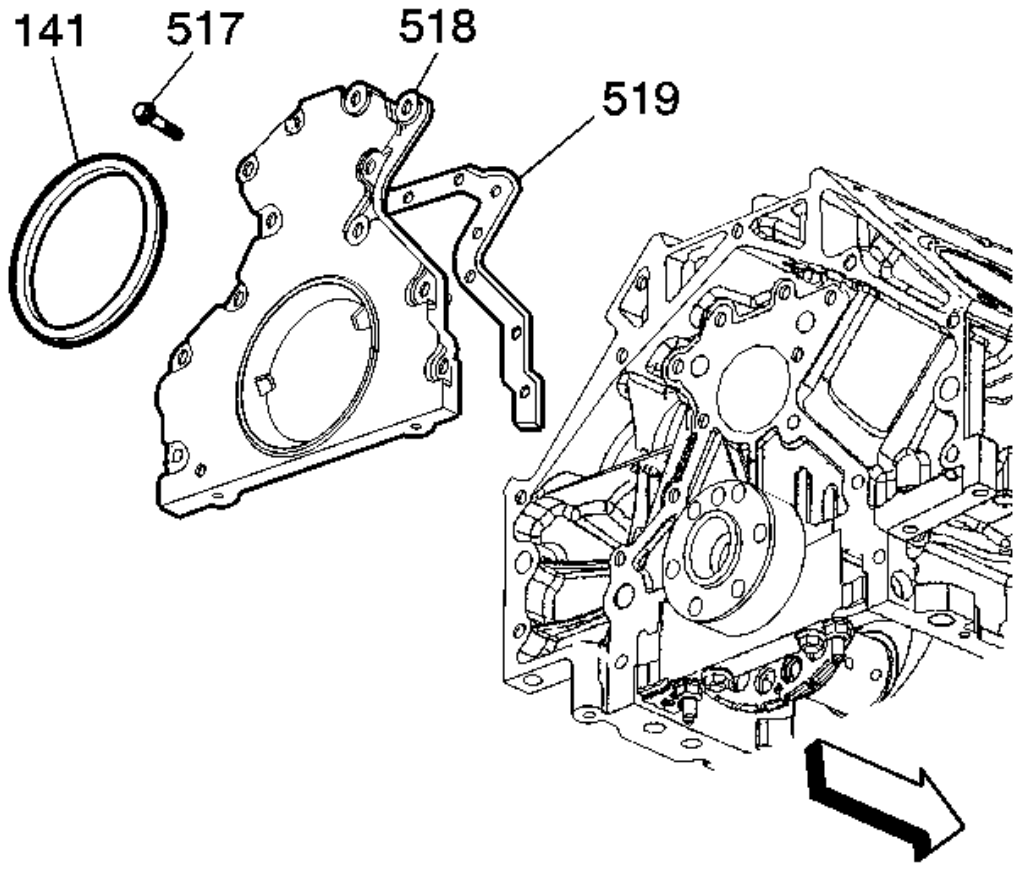

Fig. 579: Rear Cover & Gasket

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Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket (519), rear cover (518), and bolts (517).
3. Tighten the bolts finger tight. Do not overtighten.

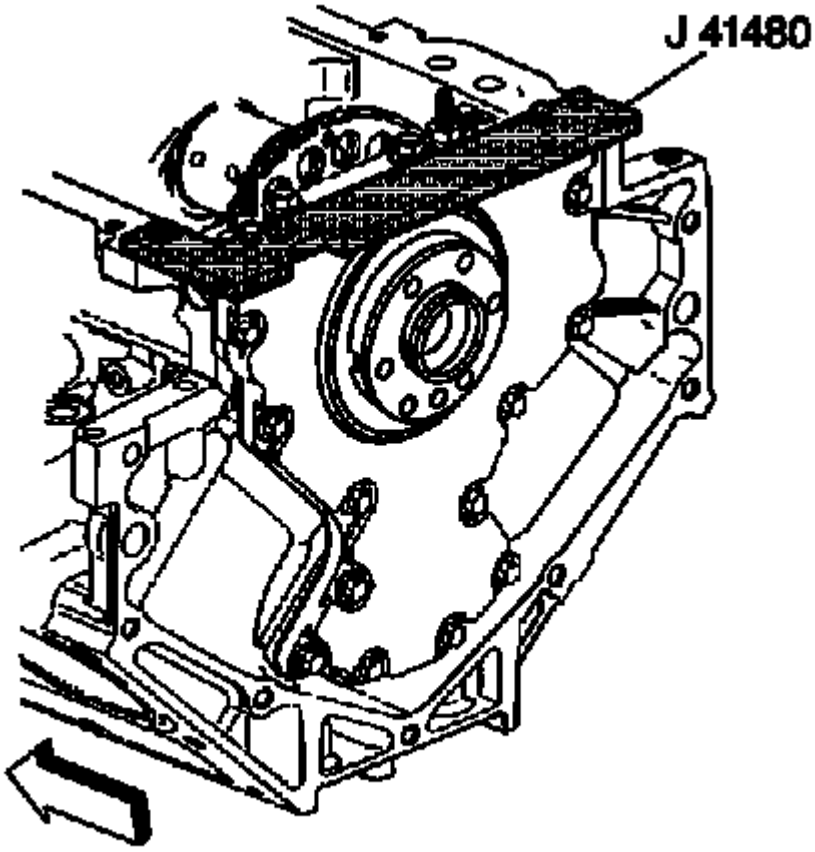

Fig. 580: View Of J 41480 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Start the J 41480 tool-to-rear cover bolts. See Special Tools. Do not tighten the bolts at this time.

4. Install the **J 41480** and bolts. See **Special Tools**.

Tighten: Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

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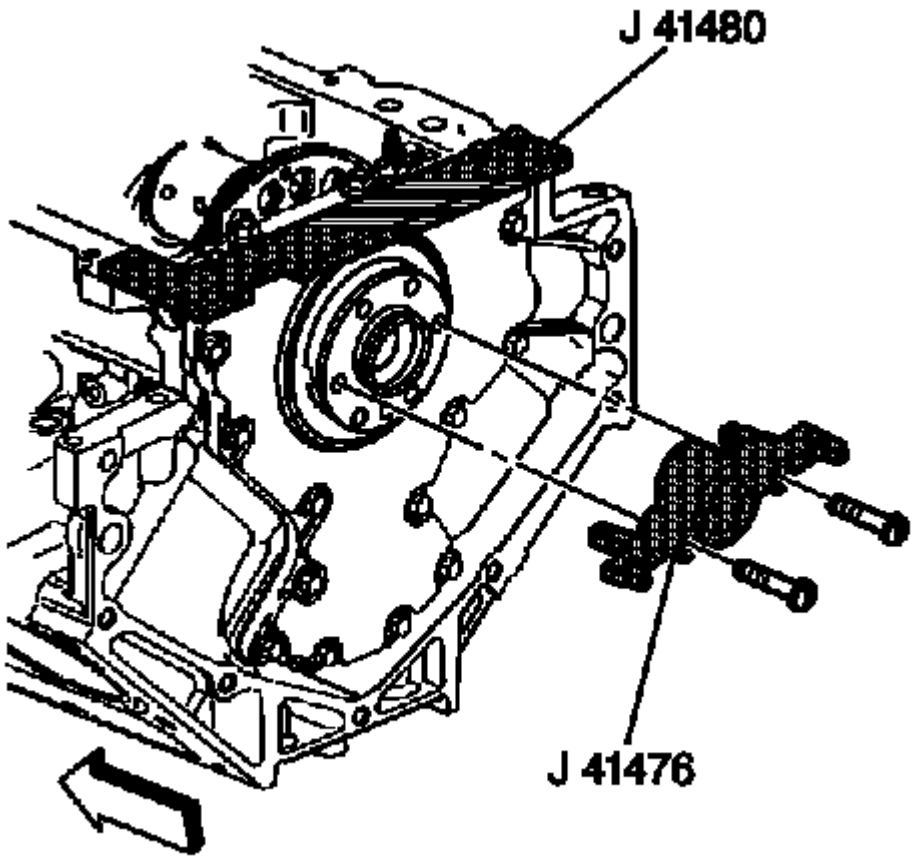

Fig. 581: View Of J 41480 & J 41476
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: To properly align the rear cover, the J 41476 must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface. See Special Tools.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.

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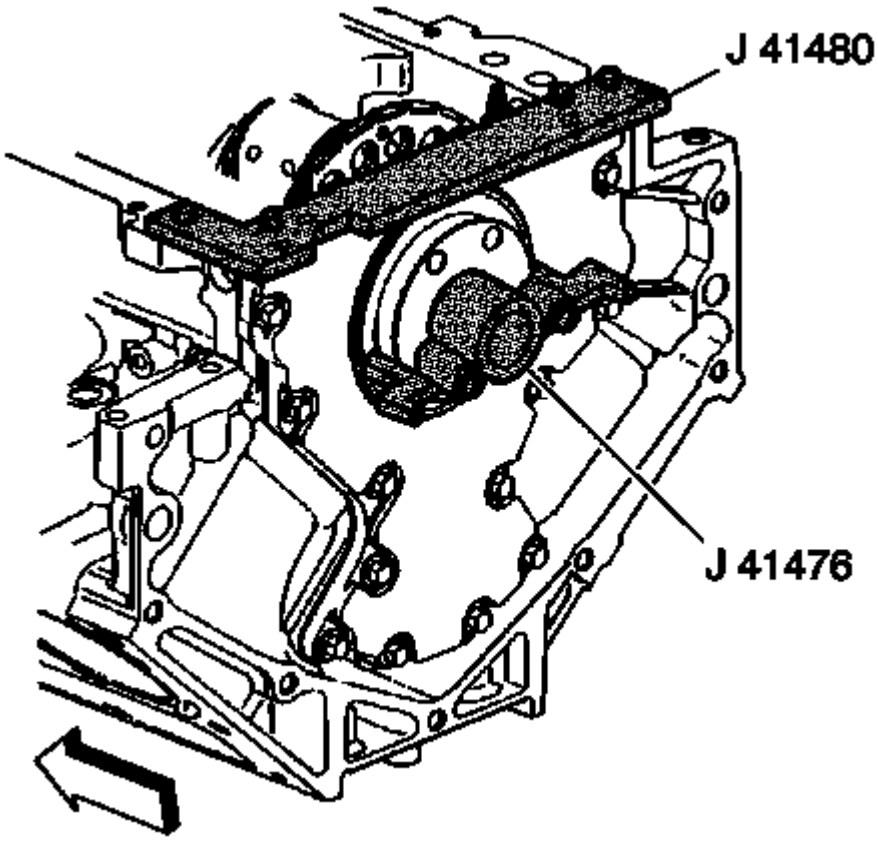

Fig. 582: View Of J 41480 & J 41476 Installed
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The tapered legs of the alignment tool must enter the rear cover oil seal bore.

6. Install the **J 41476** and bolts onto the rear of the crankshaft. See **Special Tools**.

   Tighten:
   1. Tighten the tool mounting bolts until snug. Do not overtighten.
   2. Tighten the **J 41480** tool-to-rear cover bolts evenly to 12 N.m (106 lb in).
   3. Tighten the rear cover bolts to 25 N.m (18 lb ft).

7. Remove the tools.

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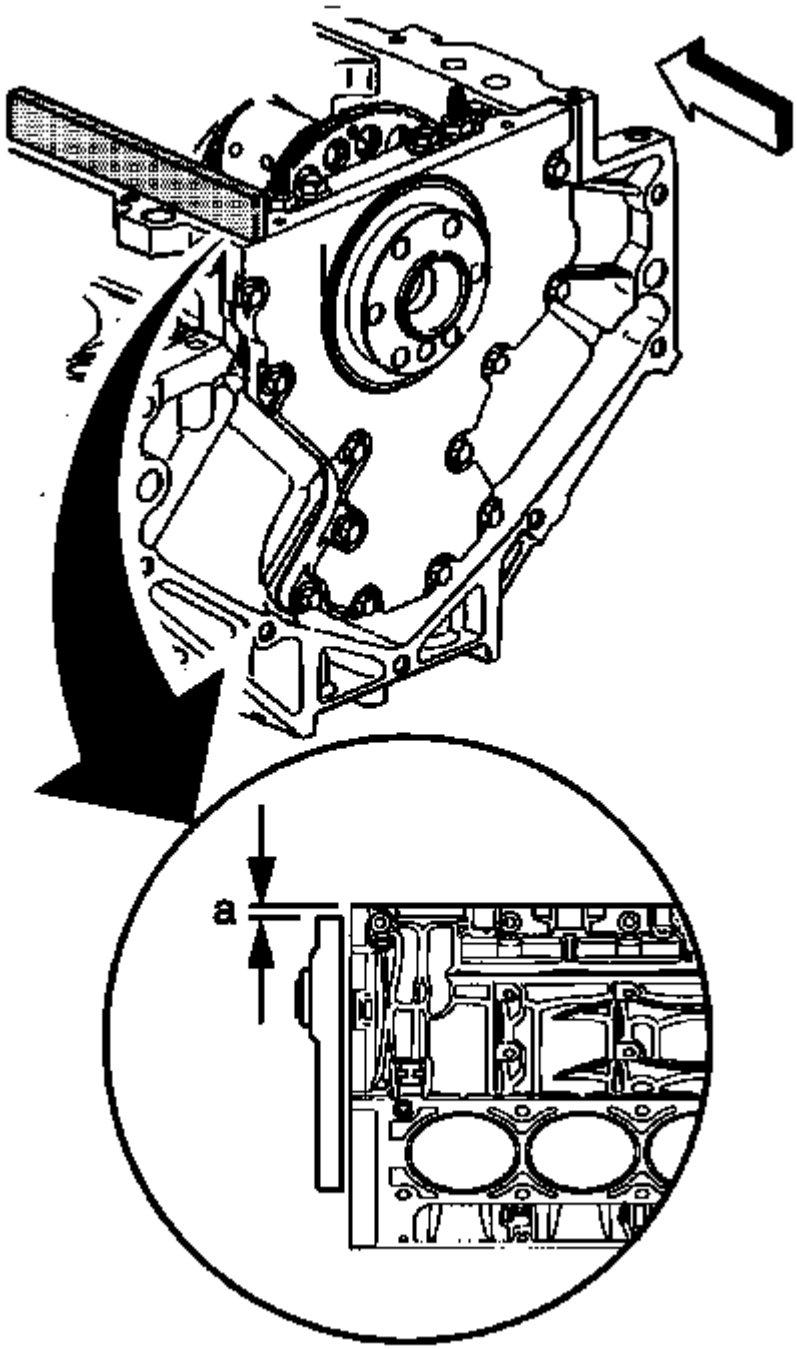

Fig. 583: Checking Rear Cover-To-Engine Block Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

8. Measure the rear cover-to-engine block oil pan surface for flatness.
    1. Place a straight edge onto the engine block and rear cover oil pan sealing surfaces.

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Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

2. Insert a feeler gage between the rear cover and the straight edge. The cover must be flush with the oil pan or no more than 0.5 mm (0.02 in) below flush.

9. If the rear cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
10. If the correct rear cover-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear cover.

Crankshaft Rear Oil Seal Installation

Tools Required

J 41479 Crankshaft Rear Oil Seal Installer. See **Special Tools**.

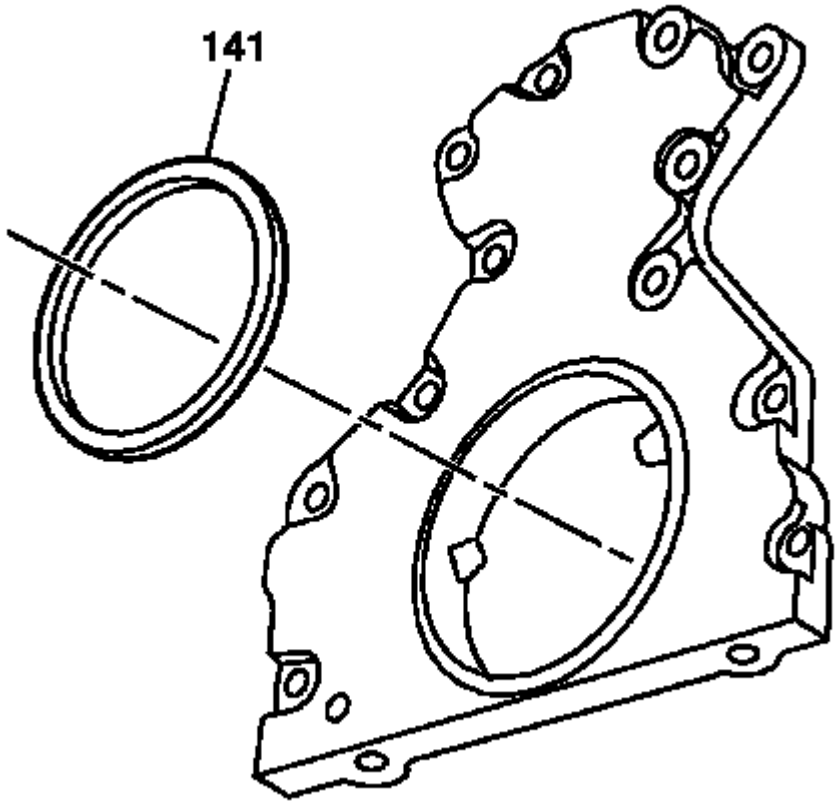

Fig. 584: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.**
- **Do not use the crankshaft rear oil seal again.**

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1. Lubricate the outside diameter (OD) of the oil seal (141) with clean engine oil.

   DO NOT allow oil or other lubricants to contact the seal surface.

2. Lubricate the rear housing oil seal bore with clean engine oil.

   DO NOT allow oil or other lubricants to contact the crankshaft surface.

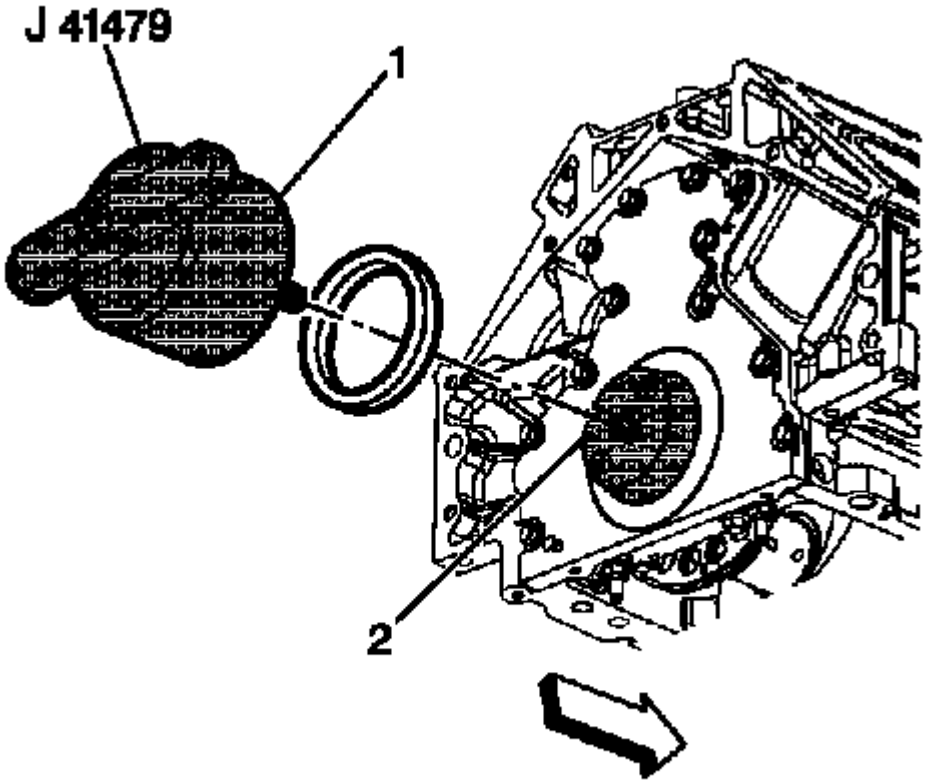

Fig. 585: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear housing bore.
6. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.
7. Align the oil seal onto the tool (1).
8. Rotate the handle of the tool (1) clockwise until the seal enters the rear housing and bottoms into the housing bore.

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9. Remove the tool.

Engine Front Cover Installation

Tools Required

- **J 41480** Front/Rear Cover Alignment - Oil Pan Surface. See **Special Tools**.
- **J 41476** Front/Rear Cover Alignment - Crankshaft Oil Seal Area. See **Special Tools**.

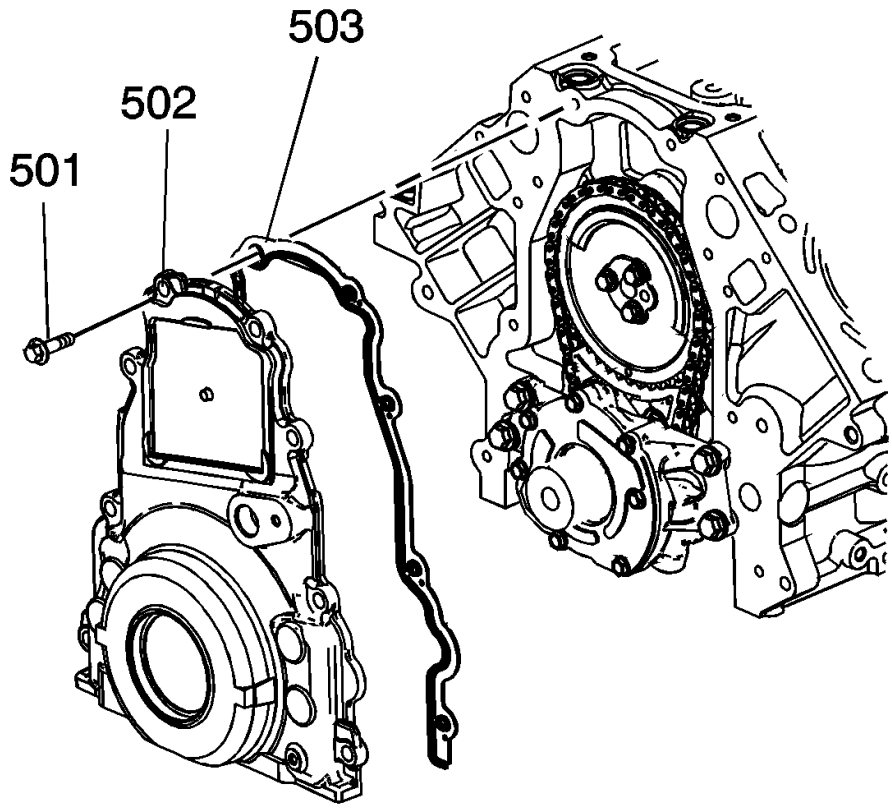

Fig. 586: Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft oil seal or the engine front cover gasket again.**
- **Do not apply any type of sealant to the front cover gasket, unless specified.**
- **The special tools in this procedure are used to properly align the**

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engine front cover at the oil pan surface and to center the crankshaft front oil seal.

- **All gasket surfaces should be free of oil or other foreign material during assembly.**

  The crankshaft front oil seal MUST be centered in relation to the crankshaft.

- **The oil pan sealing surface at the front cover and engine block MUST be aligned within specifications.**
- **An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.**

1. Install the front cover gasket (503), front cover (502), and bolts (501).
2. Tighten the cover bolts finger tight. Do not overtighten.

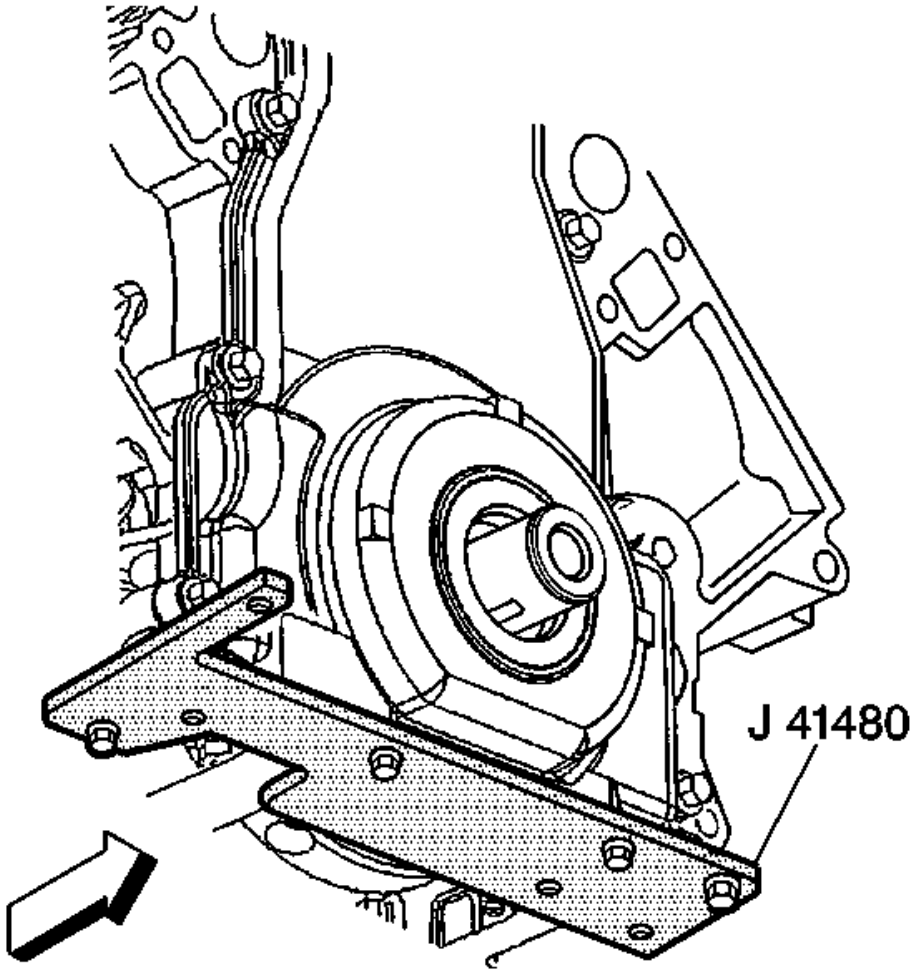

Fig. 587: View Of J 41480 Installed On Engine Block

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Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

3. Install the **J 41480** . See **Special Tools**.

   Tighten: Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

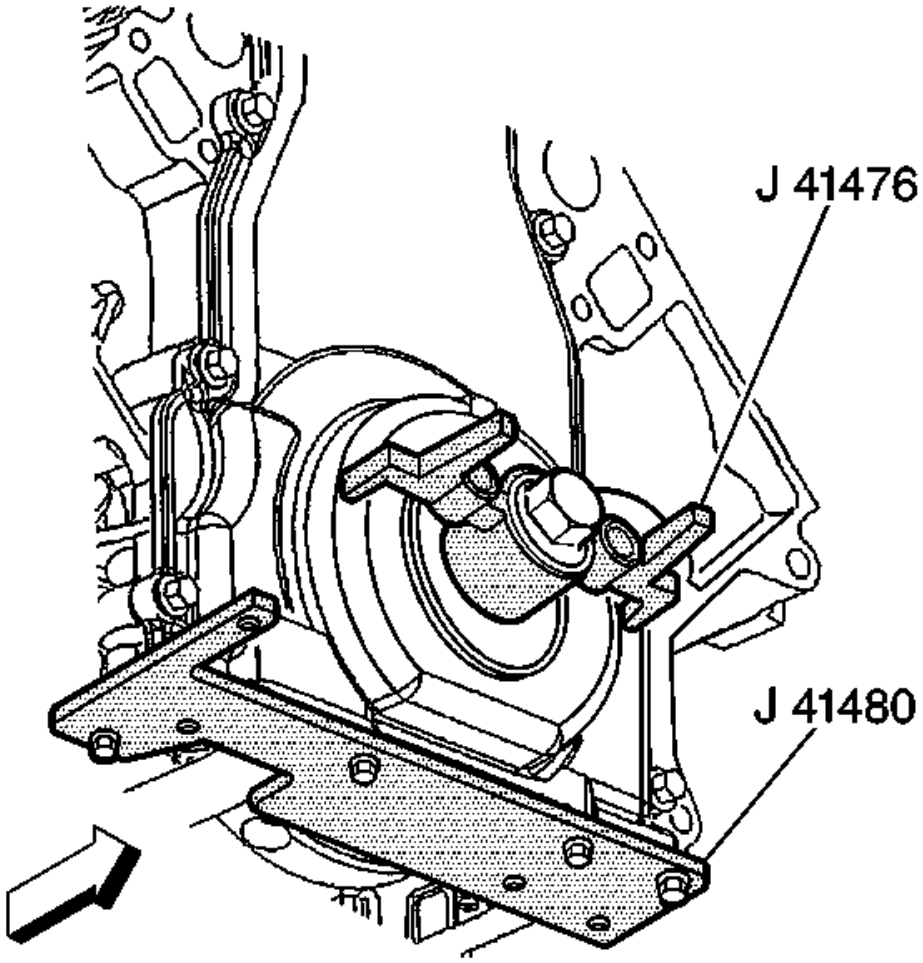

Fig. 588: View Of J 41476 & J 41480 Installed On Engine
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

4. Install the **J 41476** . See **Special Tools**.

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5. Install the crankshaft balancer bolt.

   Tighten:

   1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
   2. Tighten the **J 41480** . See **Special Tools**.
   3. Tighten the engine front cover bolts to 25 N.m (18 lb ft).

6. Remove the tools.

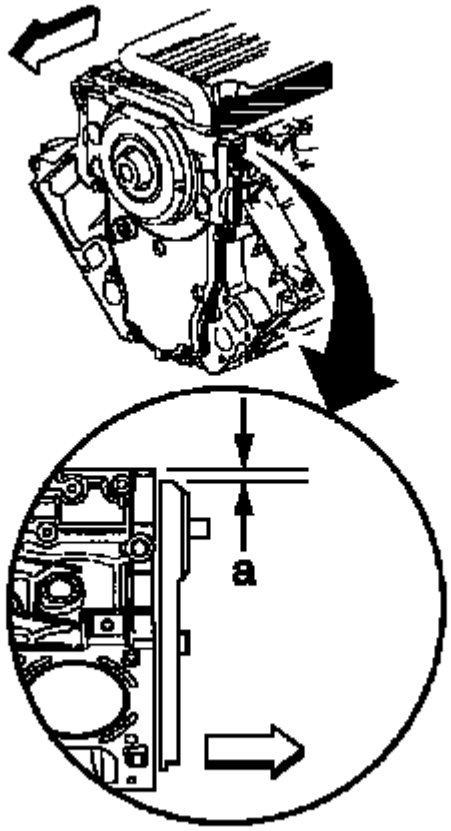

Fig. 589: Measuring Oil Pan Surface Flatness & Front Cover-To-Engine Block
Courtesy of GENERAL MOTORS CORP.

7. Measure the oil pan surface flatness, front cover-to-engine block.
   1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

      Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

   2. Insert a feeler gage between the front cover and the straight edge tool. The cover must be flush with the oil pan surface, or no greater than 0.5 mm (0.02 in) (a) below flush.

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8. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
9. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.

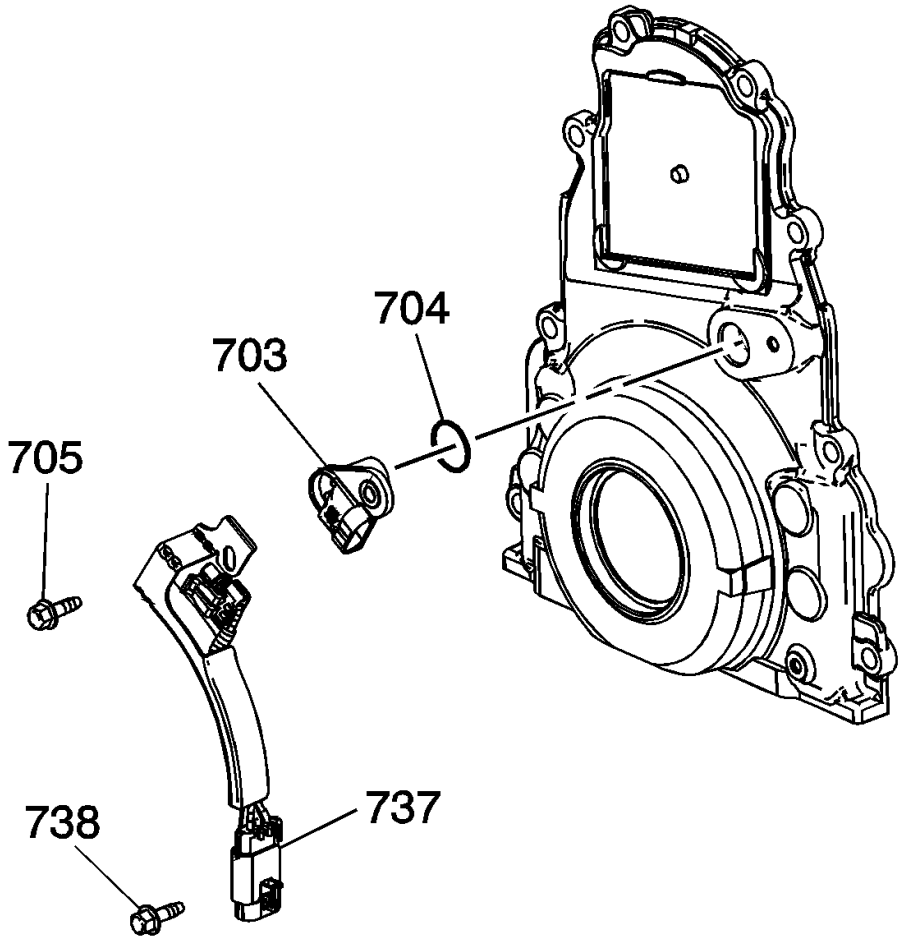

Fig. 590: CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position (CMP) sensor O-ring seal (704) for cuts or damage. If the seal is not cut or damaged, it may be used again.
11. Lubricate the O-ring seal with clean engine oil.
12. Install the O-ring seal onto the sensor (703).
13. Install the sensor to the cover.
14. Install the CMP sensor wire harness (737) and bolts (705, 738).

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

Crankshaft Front Oil Seal Installation

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Tools Required

J 41478 Crankshaft Front Oil Seal Installer

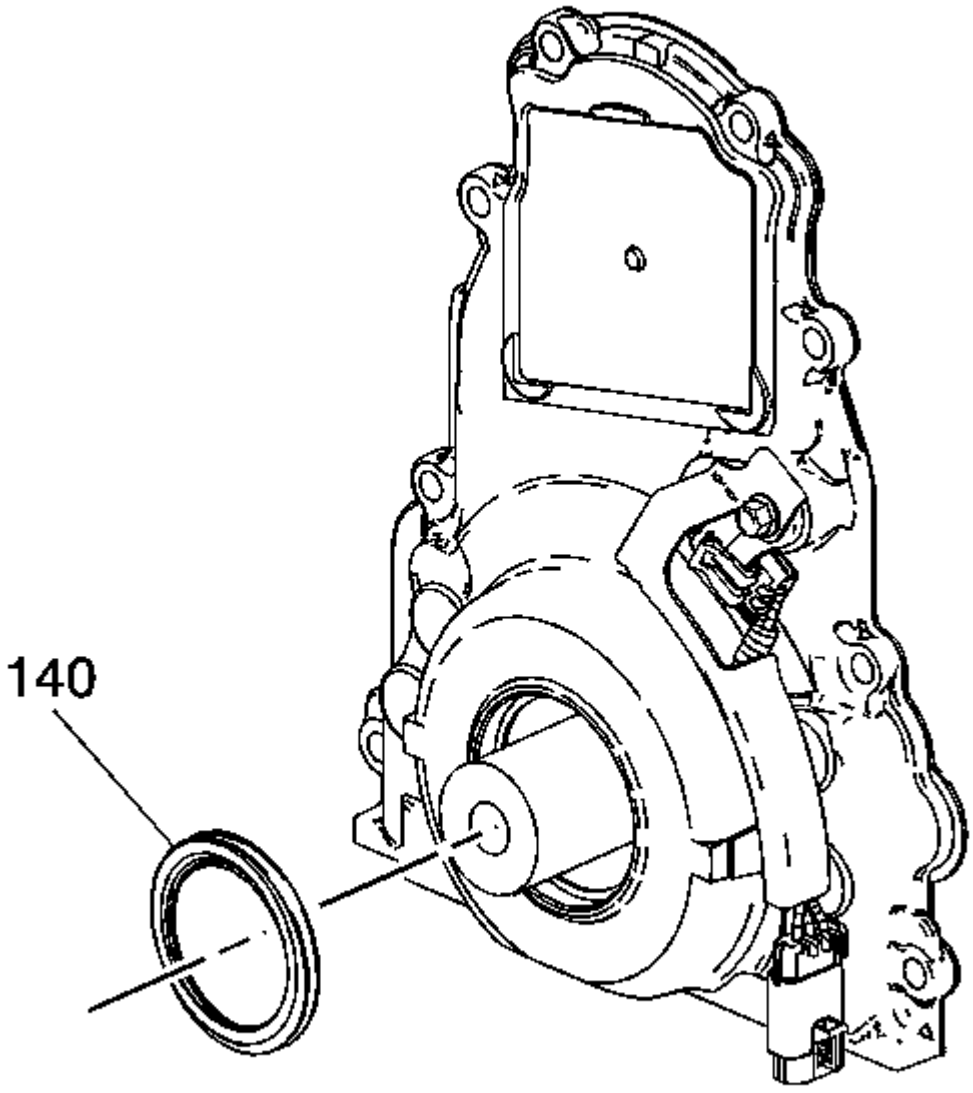

Fig. 591: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not lubricate the oil seal sealing surface.**

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- **Do not use the crankshaft front oil seal again.**

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

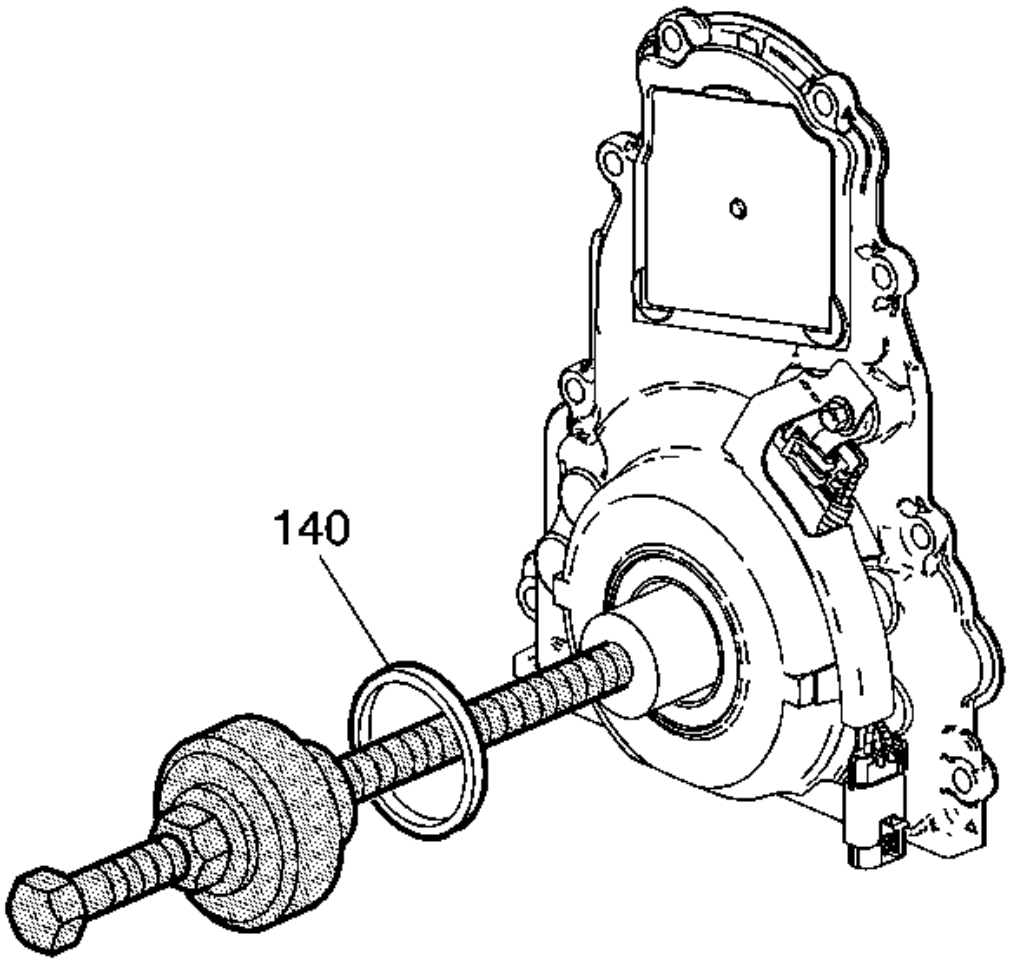

Fig. 592: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) onto the **J 41478** .
4. Install the **J 41478** threaded rod, with nut, washer, guide, and oil seal, into the end of the crankshaft.
5. Use the **J 41478** in order to install the oil seal into the cover bore.
    1. Use a wrench and hold the hex on the installer bolt.

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2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
3. Remove the tool.
4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

Oil Pan Installation

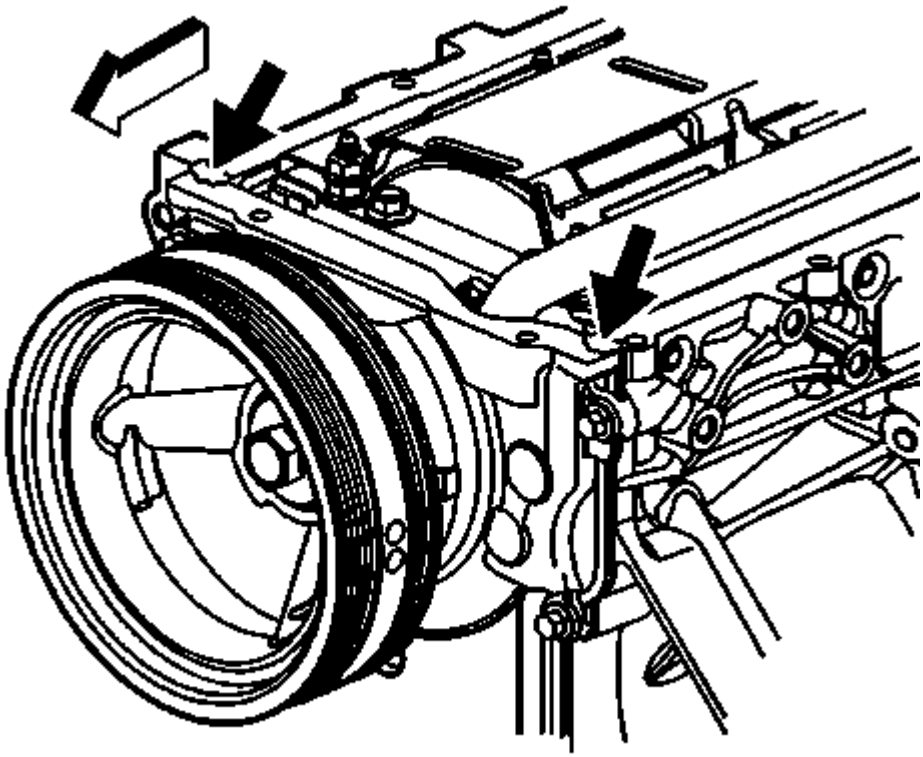

Fig. 593: View Of Sealant On Engine Front Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush, or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.**
- **Do not use the oil pan gasket again.**
- **It is not necessary to rivet the NEW gasket to the oil pan.**

1. Install the oil filter tube, baffle, and other internal components as required. Refer to **Oil Pan Cleaning**

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and Inspection.

2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to **Sealers, Adhesives, and Lubricants**.

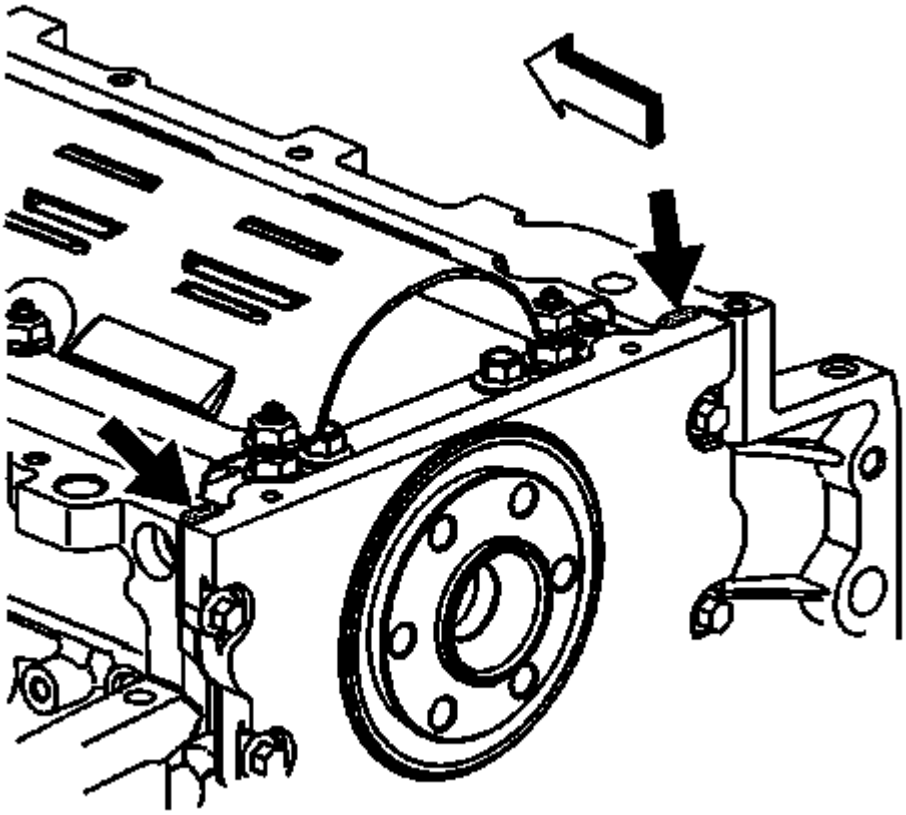

Fig. 594: View Of Sealant On Engine Rear Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378190 or equivalent 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear cover gasket that protrude into the oil pan surface.

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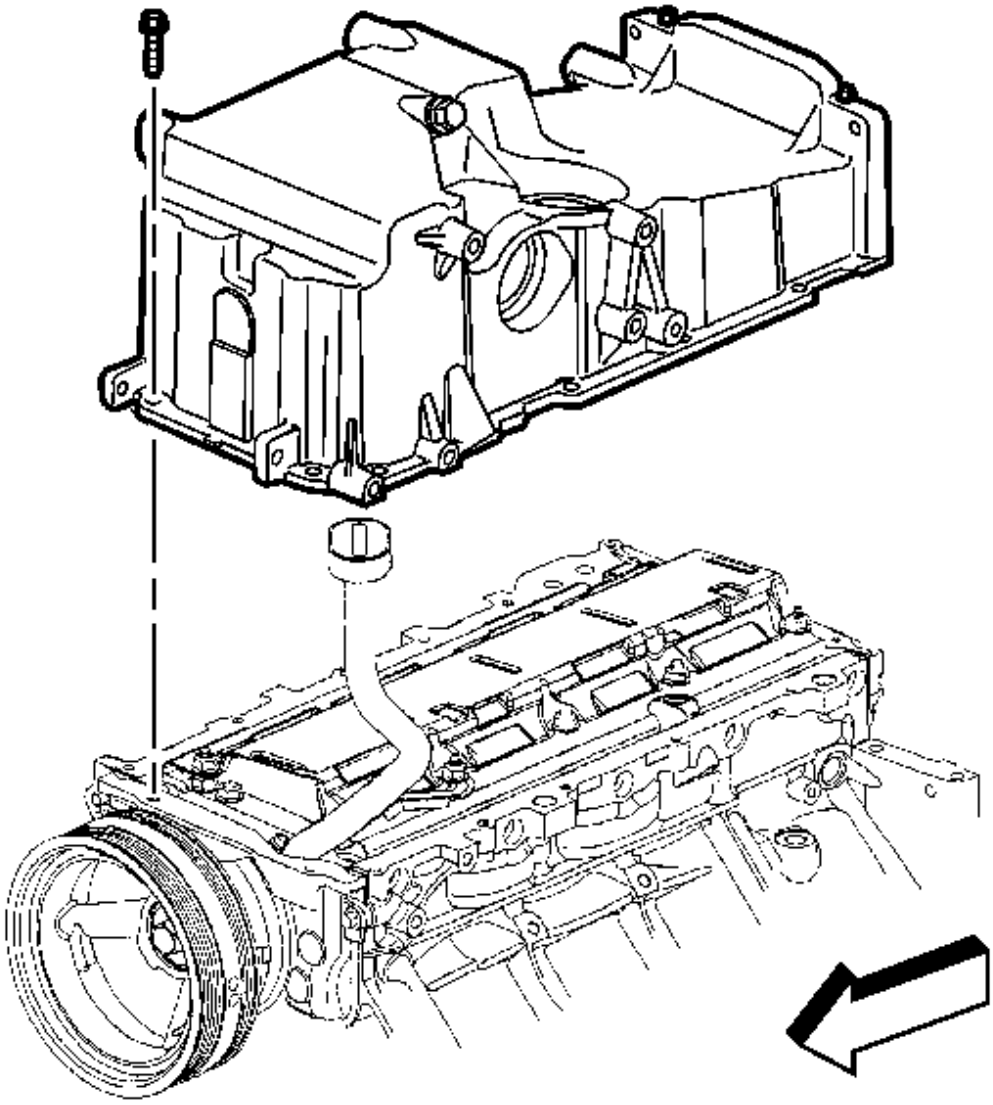

Fig. 595: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the oil gallery passages in the oil pan and engine block properly align with the oil pan gasket.

4. Pre-assemble the oil pan gasket to the pan.
    1. Install the gasket onto the oil pan.

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2. Install the oil pan bolts to the pan and through the gasket.
5. Install the oil pan, gasket and bolts to the engine block.
6. Tighten bolts finger tight. Do not overtighten.

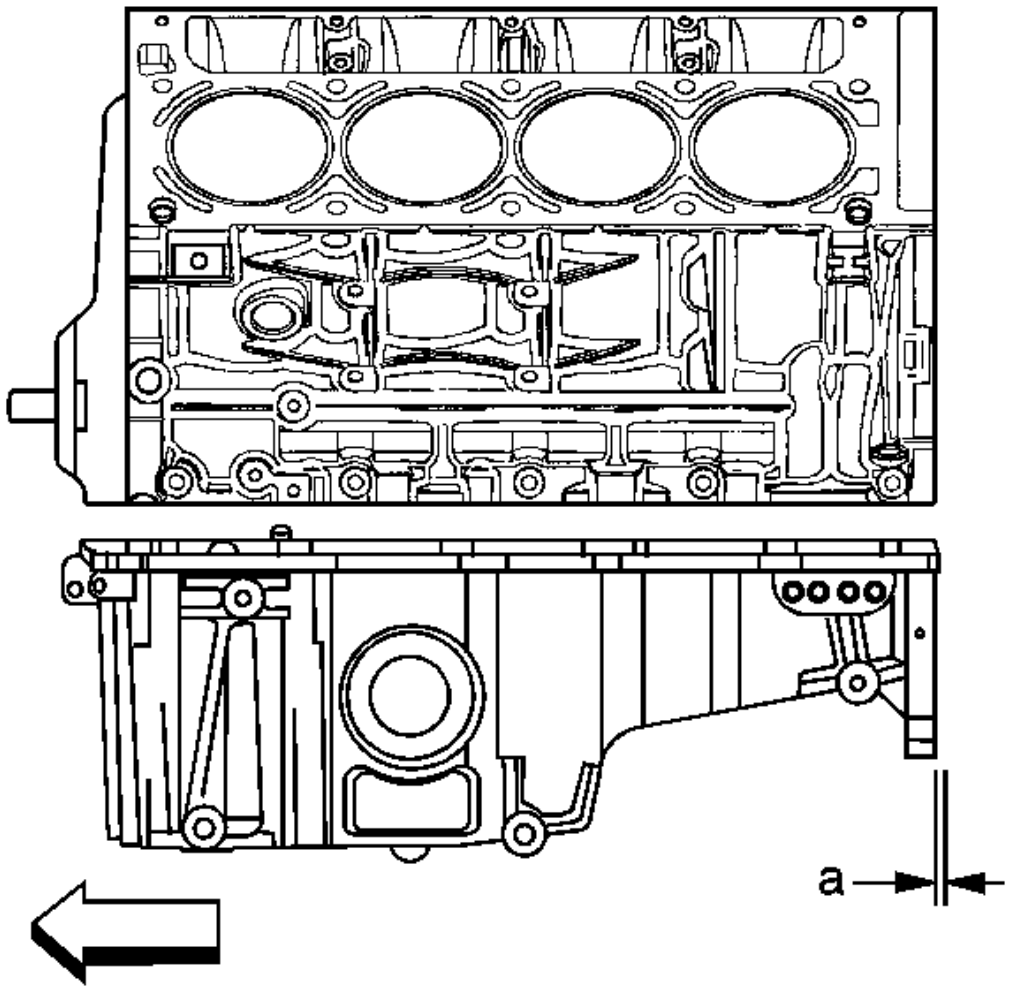

Fig. 596: Aligning Rear Of Oil Pan & Rear Of Engine Block
Courtesy of GENERAL MOTORS CORP.

7. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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8. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.

   Tighten:

   1. Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N.m (18 lb ft).
   2. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).

9. Measure the oil pan-to-engine block alignment.
   1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

      IMPORTANT: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

   2. Insert a feeler gage between the straight edge and the oil pan transmission housing mounting surface, and inspect to ensure there is no more than a 0.25 mm (0.01 in) gap (a) between the pan and straight edge.
   3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

Oil Filter and Adapter Installation

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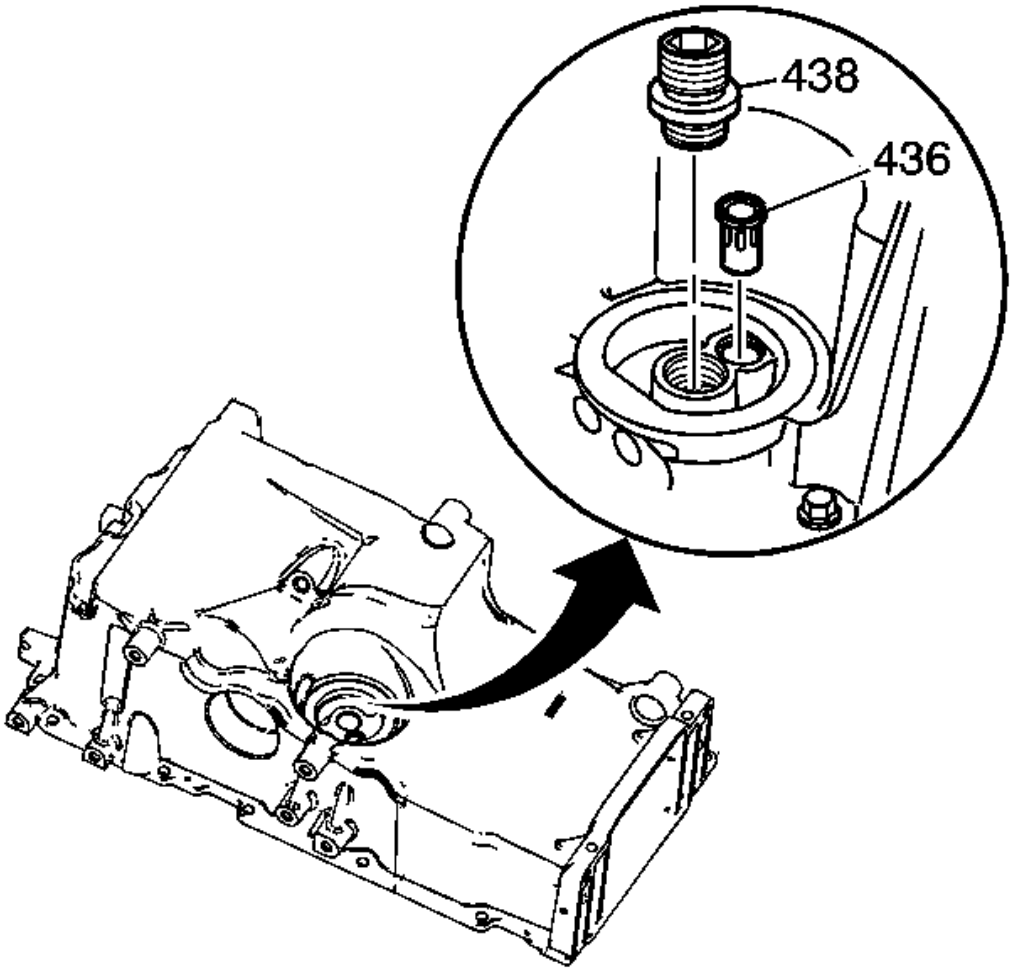

Fig. 597: Oil Filter Bypass Valve
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter bypass valve (436) into the oil pan as required.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter fitting (438).

Tighten: Tighten the oil filter fitting to 55 N.m (40 lb ft).

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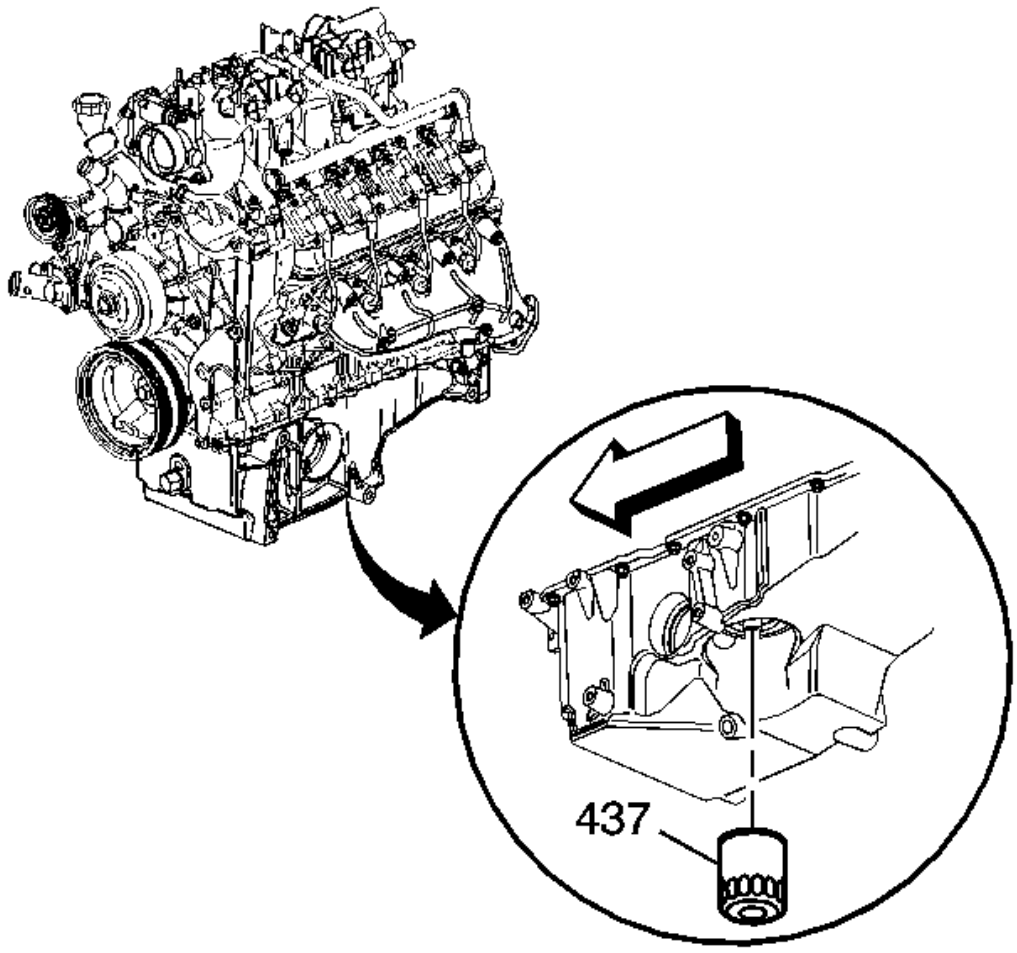

Fig. 598: Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the oil filter seal with clean engine oil.
4. Install the oil filter (437).

Tighten: Tighten the oil filter to 30 N.m (22 lb ft).

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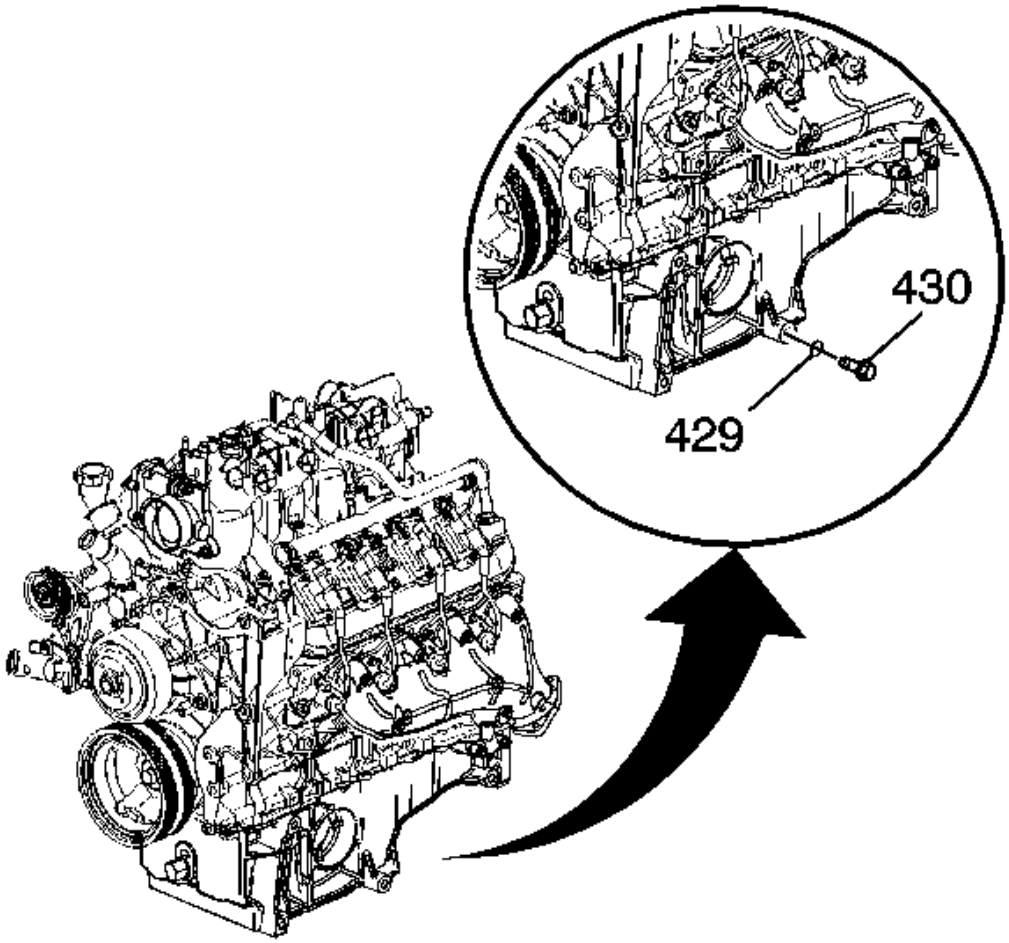

Fig. 599: Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

5. Install the oil pan drain plug (430) and O-ring (429).

   Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

Valve Lifter Installation

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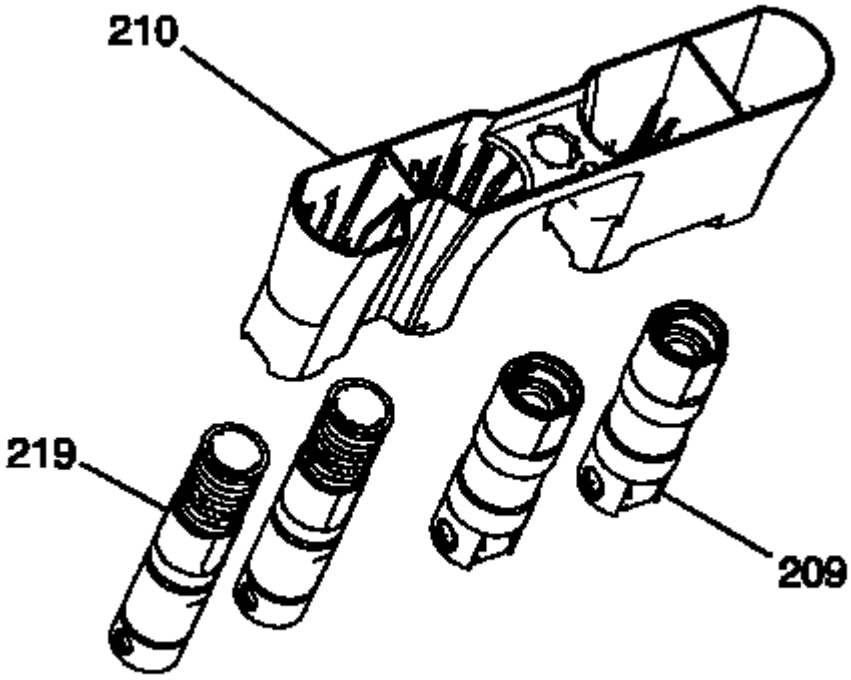

Fig. 600: Valve Lifter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the 4 valve guide assemblies will contain 2 displacement on demand valve lifters and 2 non-displacement on demand valve lifters.**
- **With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain 2 displacement on demand valve lifters.**

1. Lubricate the valve lifters (209, 219) and engine block valve lifter bores with clean engine oil.

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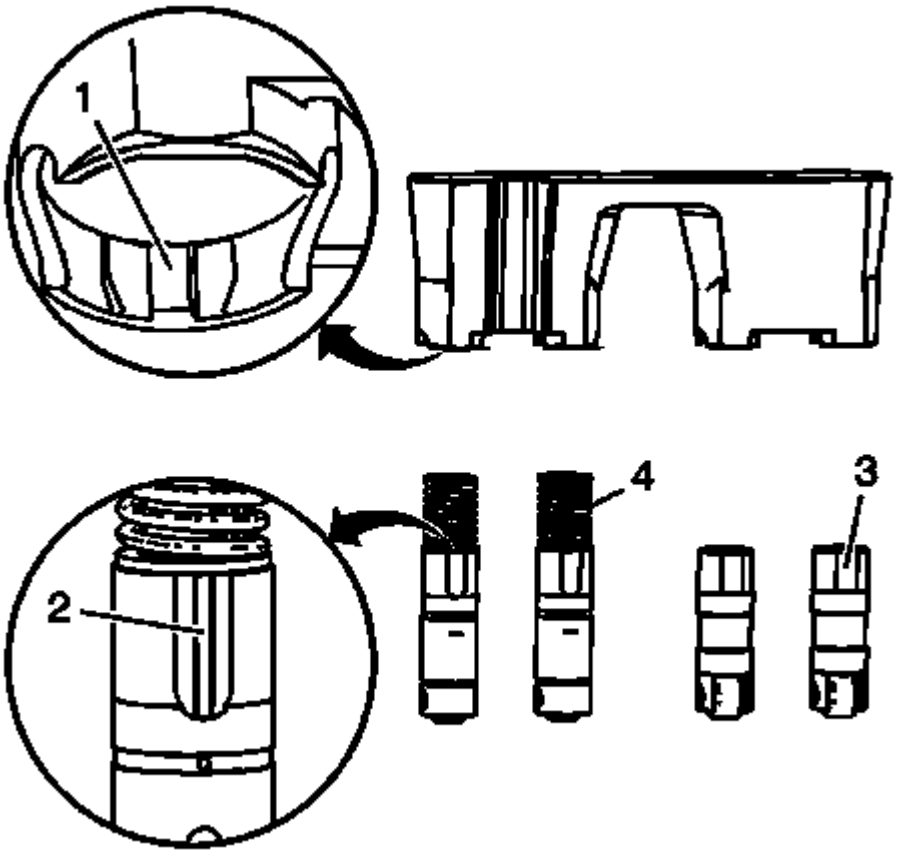

Fig. 601: Inserting Valve Lifters Into Lifter Guides
Courtesy of GENERAL MOTORS CORP.

2. Insert the valve lifters into the lifter guides.
    - Align the flat area (3) on the top of the non displacement on demand lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
    - The displacement on demand lifters are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.

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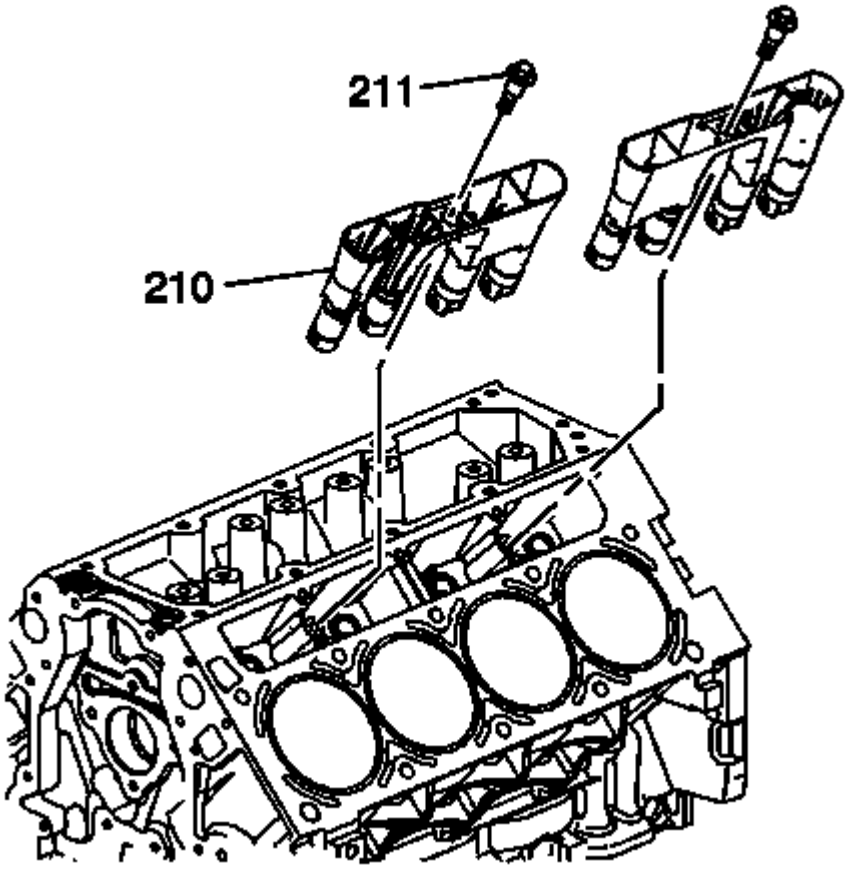

Fig. 602: Valve Lifters & Guide Assembly
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifters and guide assembly (210) to the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve lifter guide bolts (211).

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

Cylinder Head Installation - Left

Tools Required

- **J 42385-100** Thread Repair Kit. See **Special Tools**.
- **J 45059** Angle Meter

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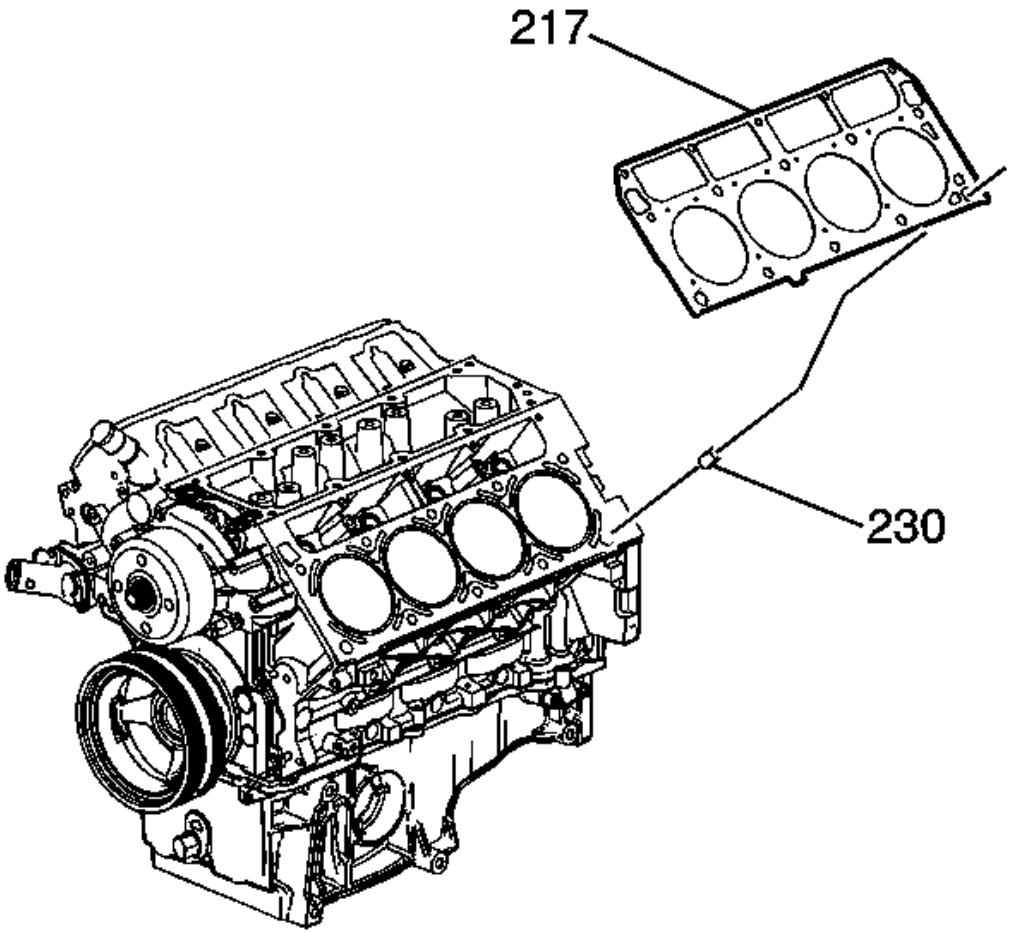

Fig. 603: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

IMPORTANT:

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless**

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specified.

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

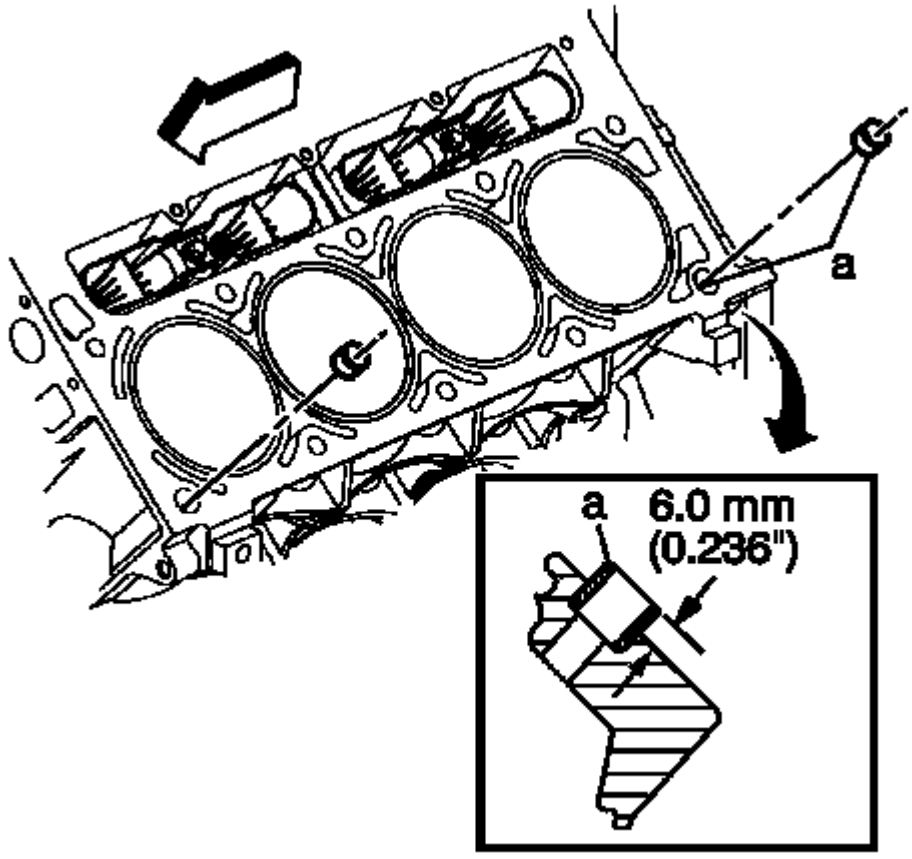

Fig. 604: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

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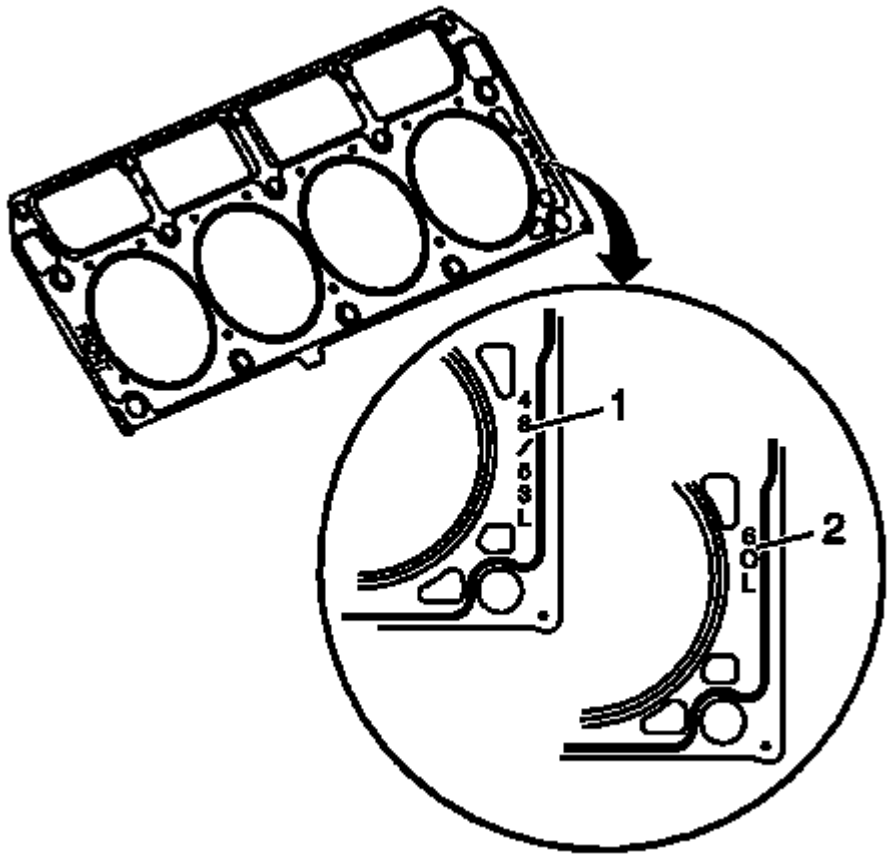

Fig. 605: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket for proper usage.

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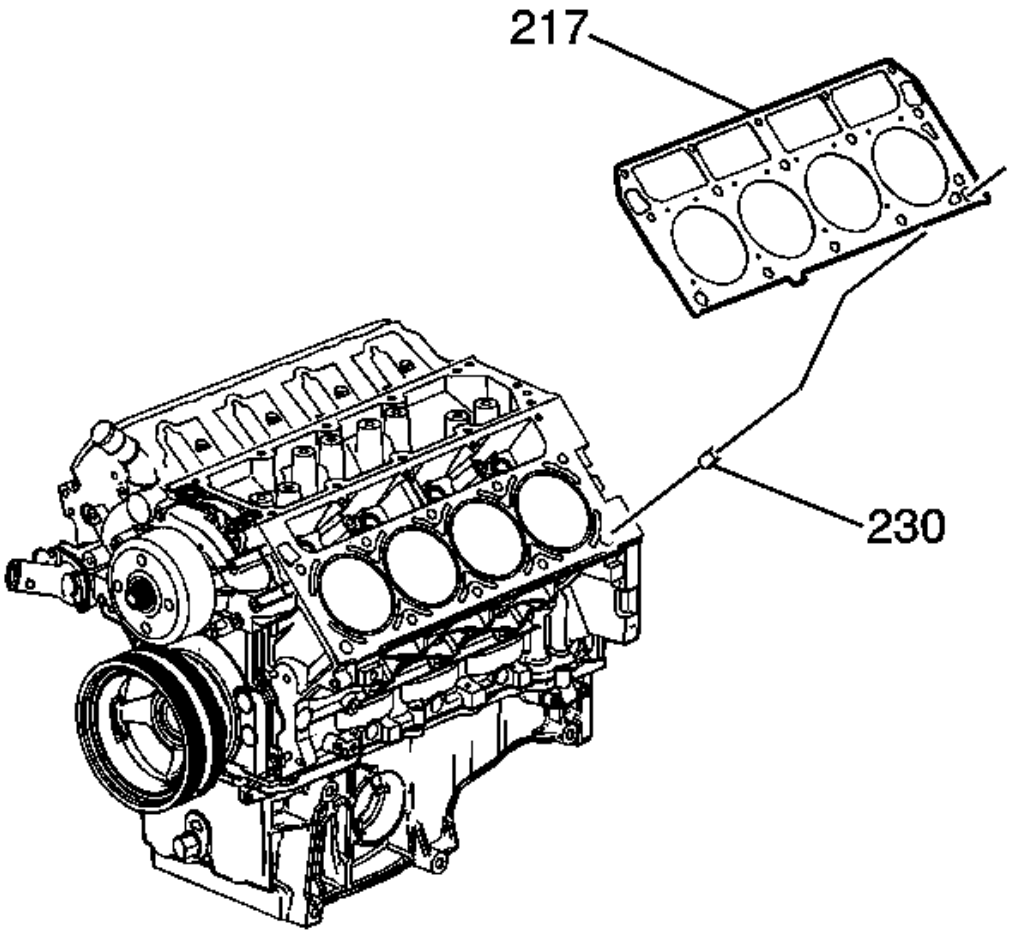

Fig. 606: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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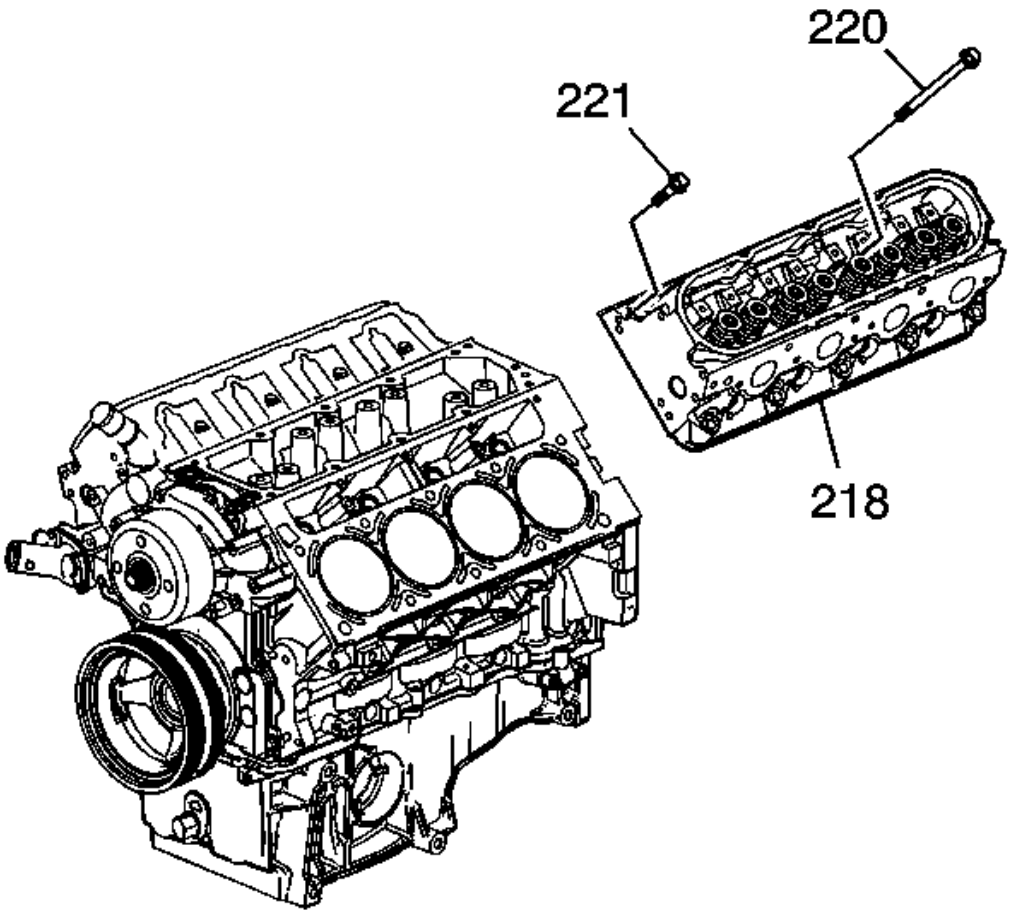

Fig. 607: Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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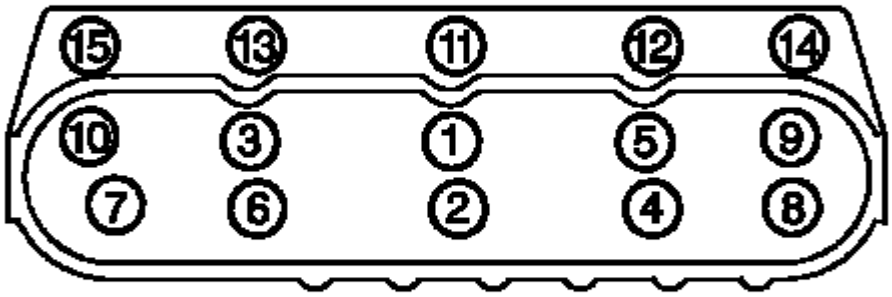

Fig. 608: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Tighten the cylinder head bolts.

    Tighten:

    1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
    2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** .
    3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** .
    4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

Cylinder Head Installation - Right

Tools Required

- **J 42385-100** Thread Repair Kit. See **Special Tools**.

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- **J 45059** Angle Meter

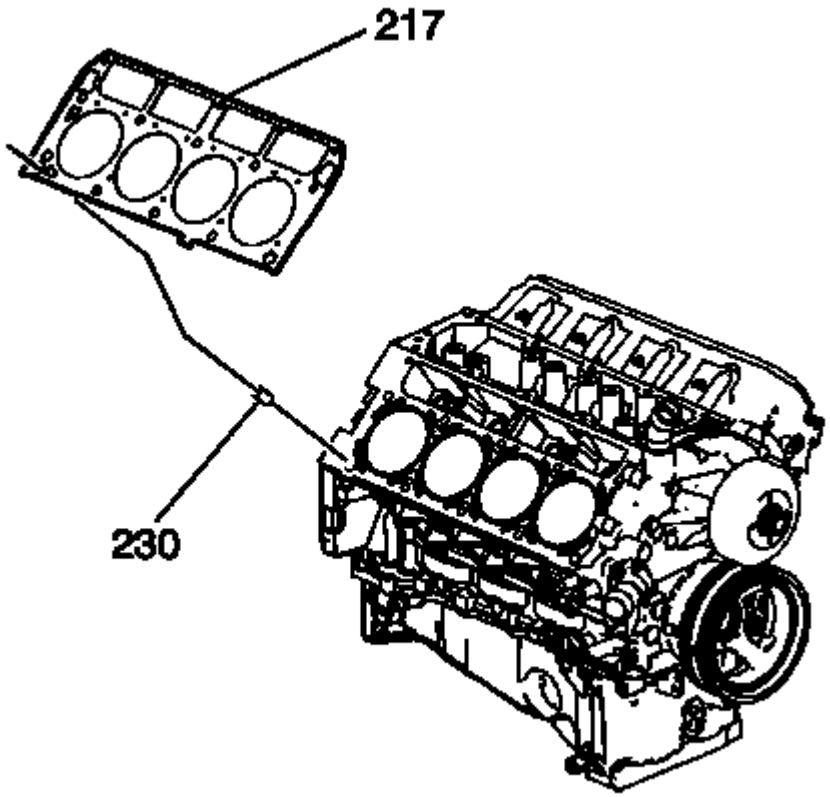

Fig. 609: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Clean all dirt, debris, and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to components.

IMPORTANT:
- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless specified.**

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

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2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463) or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

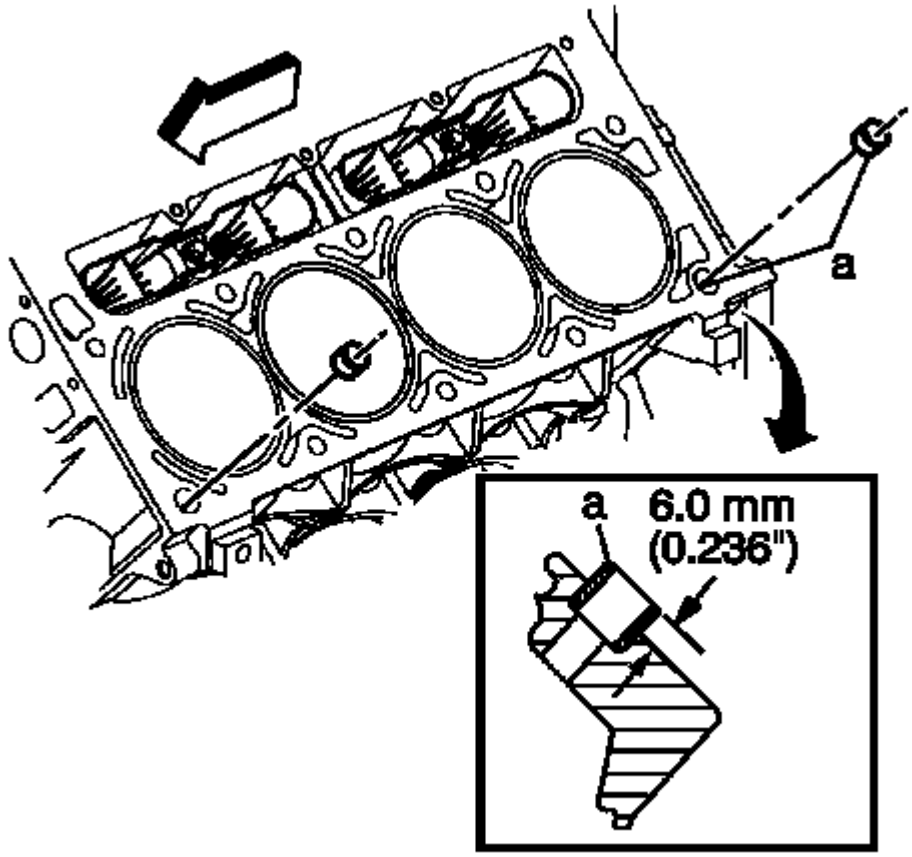

Fig. 610: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

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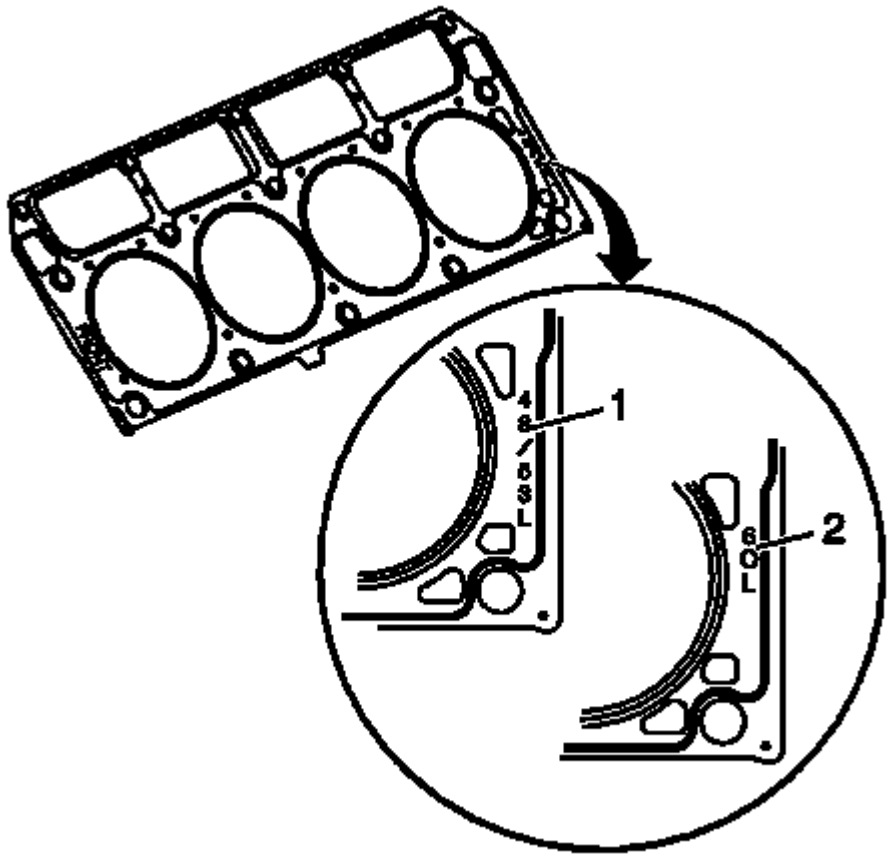

Fig. 611: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket for proper usage.

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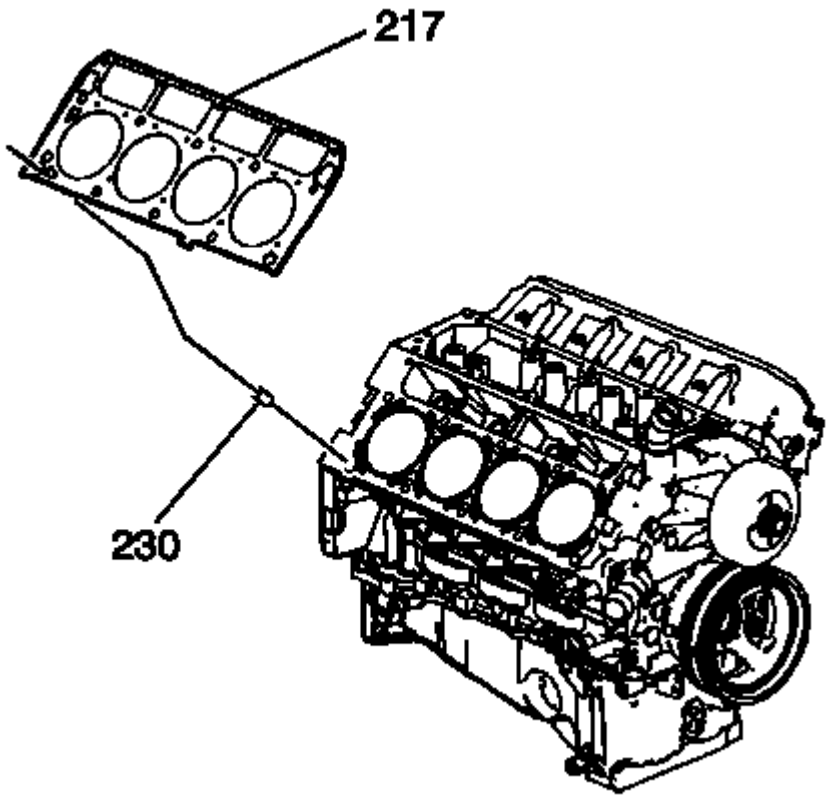

Fig. 612: Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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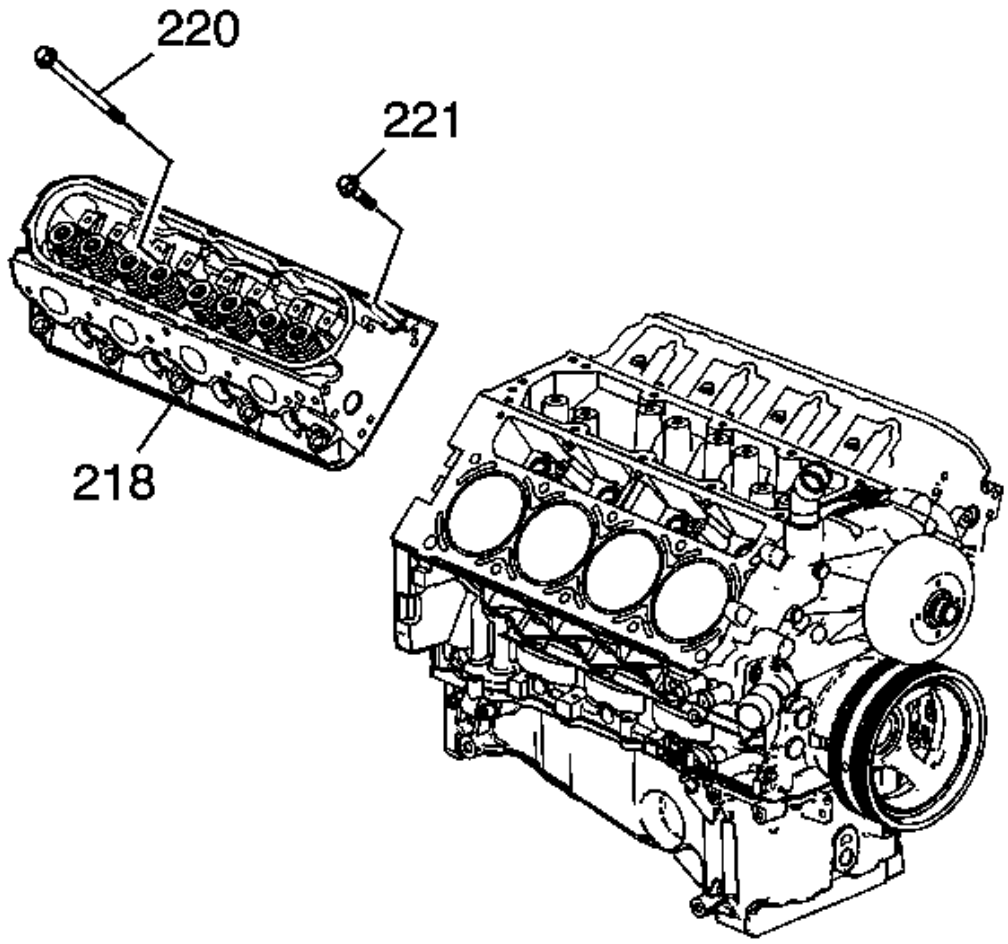

Fig. 613: Cylinder Head
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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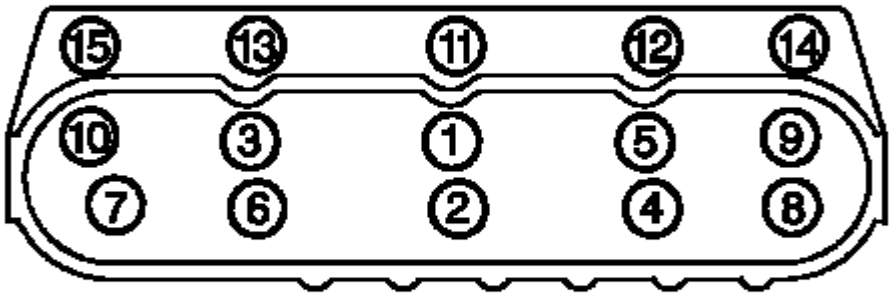

Fig. 614: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

10. Tighten the cylinder head bolts.

Tighten:

1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** .
3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** .
4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

Valve Rocker Arm and Push Rod Installation

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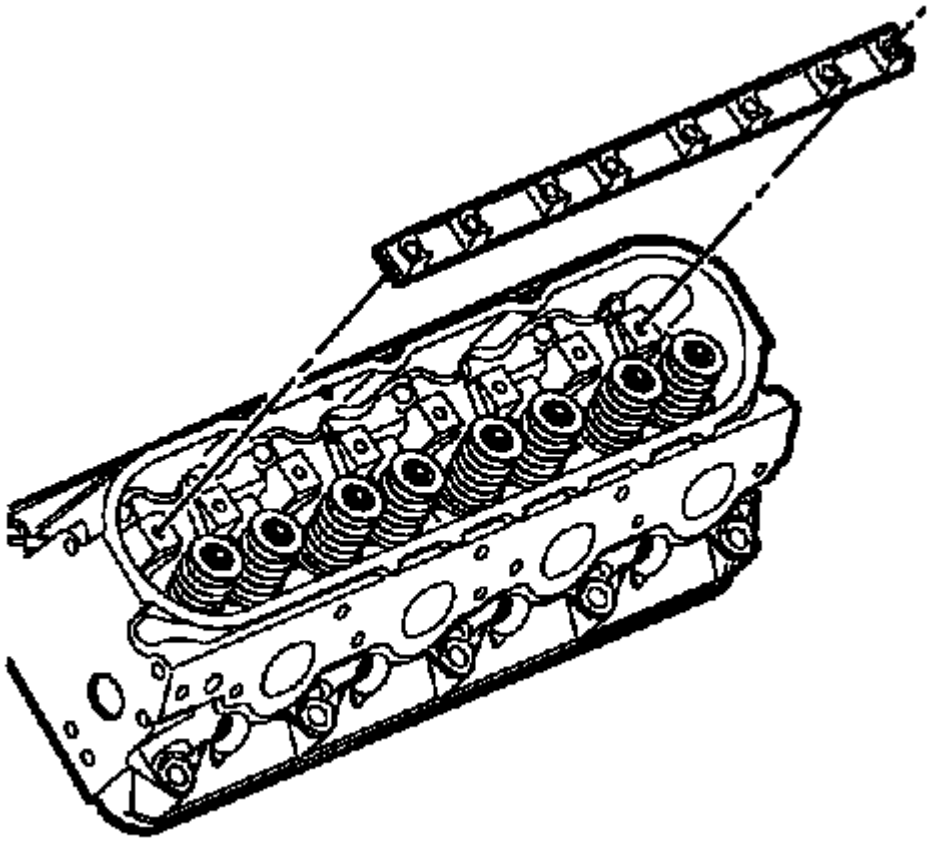

Fig. 615: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **When using the valve train components again, always install the components to the original location and position.**
- **Valve lash is net build, no valve adjustment is required.**

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.
3. Install the valve rocker arm pivot support.

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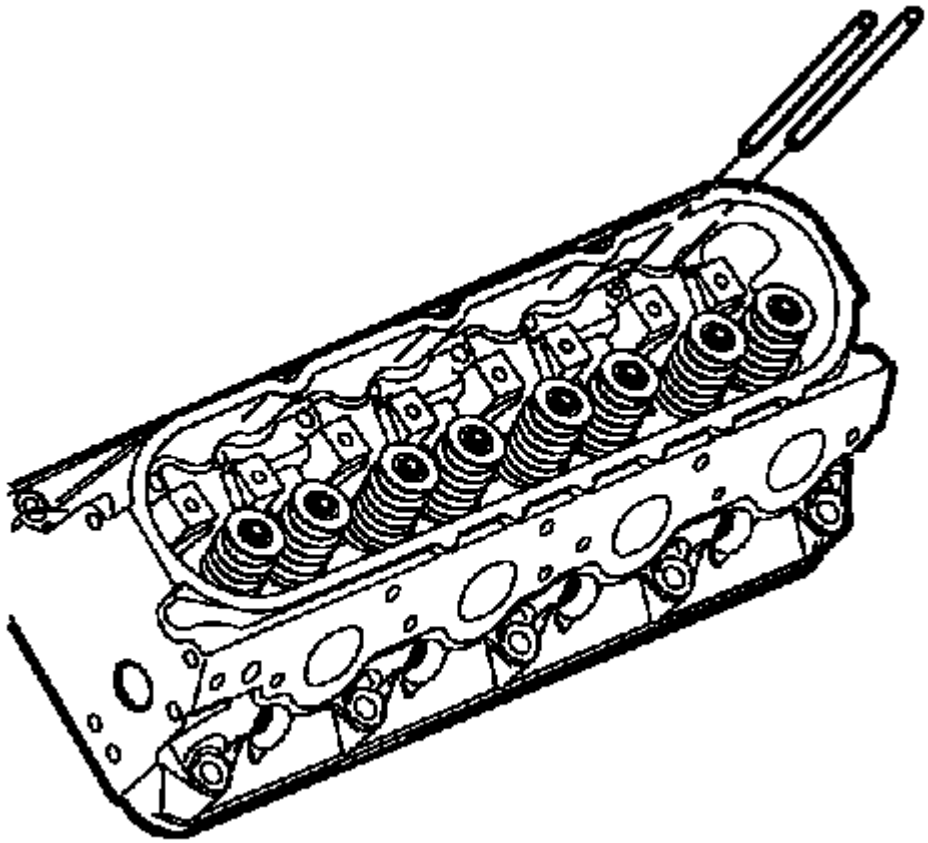

Fig. 616: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

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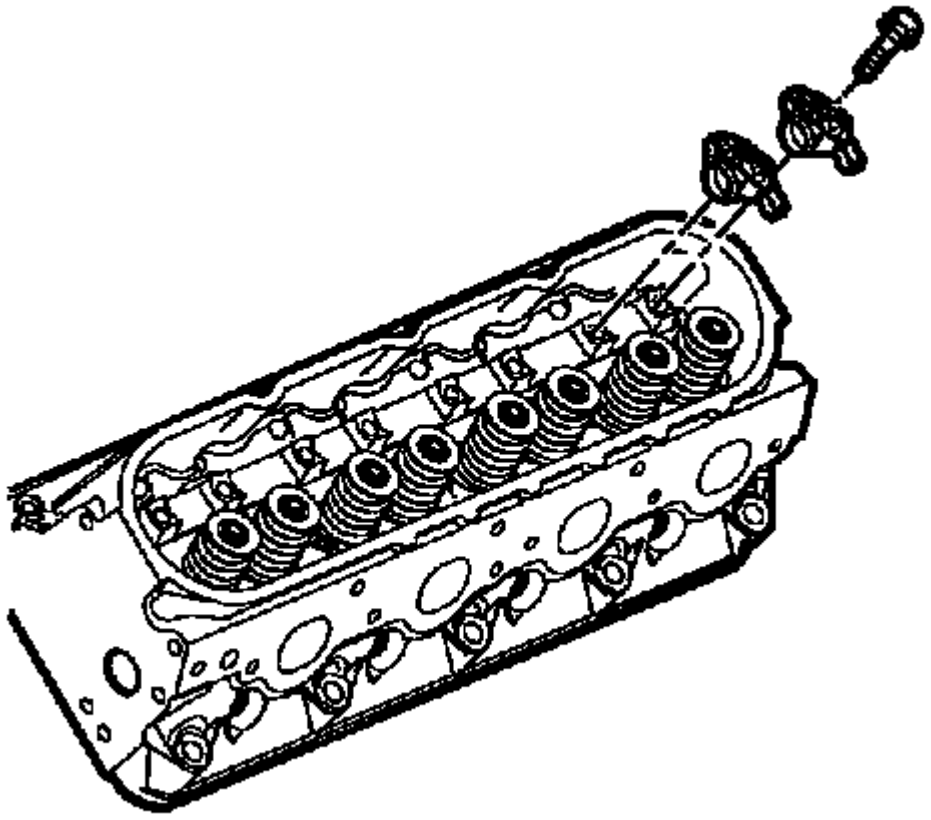

Fig. 617: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **Ensure the pushrods seat properly to the ends of the rocker arms.**
- **DO NOT tighten the rocker arm bolts at this time.**

5. Install the rocker arms and bolts.

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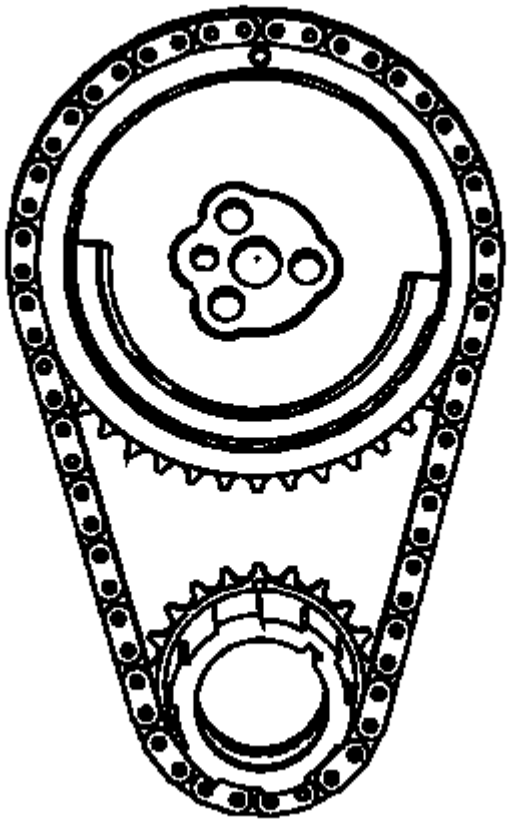

Fig. 618: Camshaft And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number one piston is at top dead center of compression stroke.

   In this position, cylinder number one rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks will be in the 12 o'clock positions. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

   The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

   Cylinders 1, 3, 5 and 7 are left bank.

   Cylinders 2, 4, 6, and 8 are right bank.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

7. With the engine in the number one firing position, tighten the following valve rocker arm bolts:

   Tighten:

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- Tighten exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N.m (22 lb ft).

8. Rotate the crankshaft 360 degrees.
9. Tighten the following valve rocker arm bolts:

Tighten:

- Tighten exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
- Tighten intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

Valve Rocker Arm Cover Installation - Left

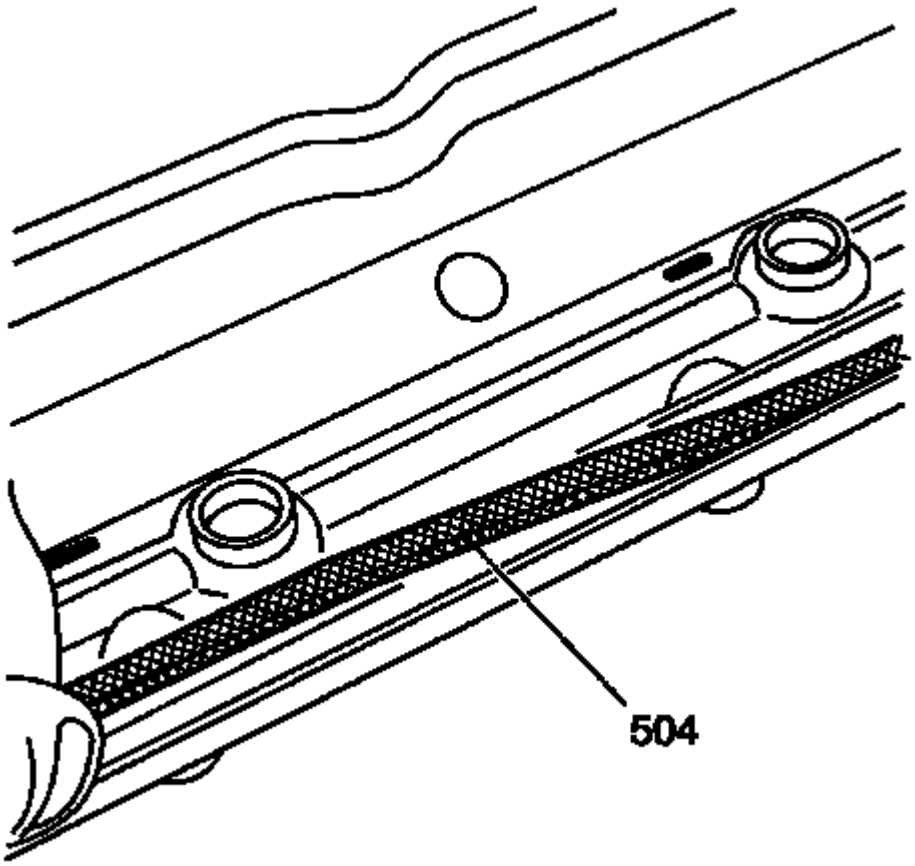

Fig. 619: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**
- **The valve rocker arm cover bolt grommets may be used again if not**

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damaged.

1. Install a NEW gasket (504) into the valve rocker arm cover.

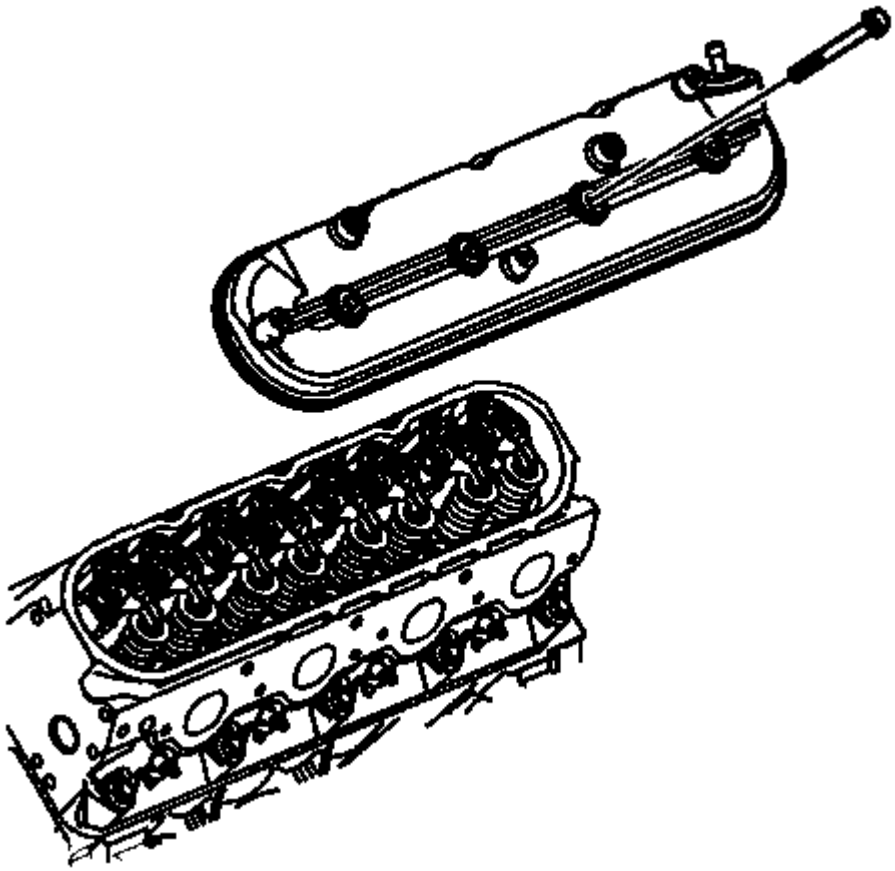

Fig. 620: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

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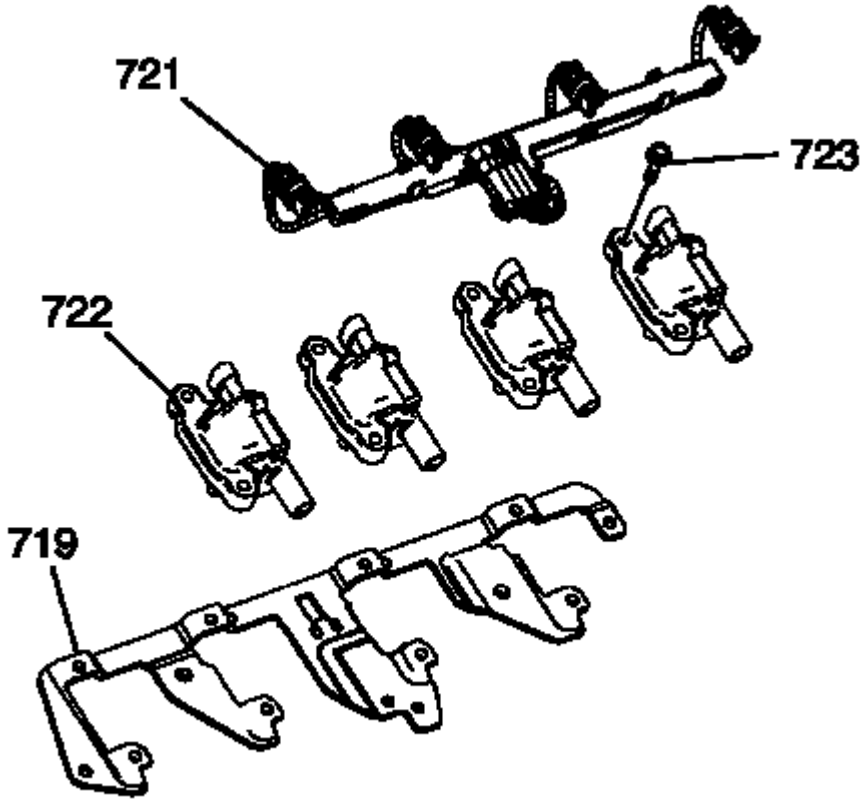

Fig. 621: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bolts (723).
5. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719).

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

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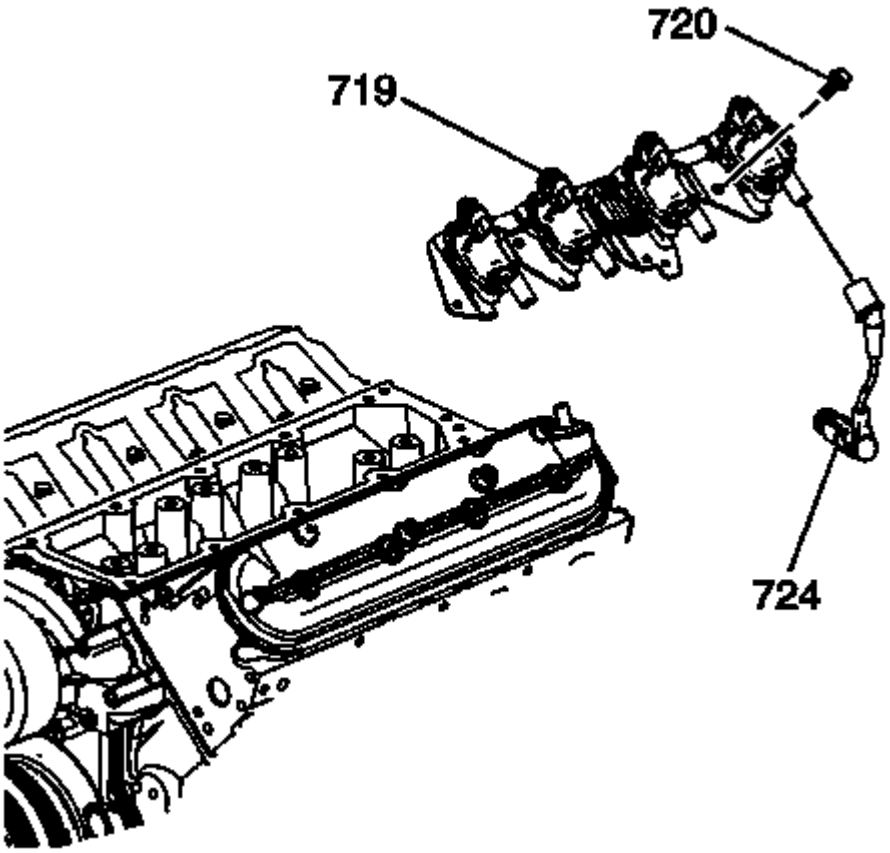

Fig. 622: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

6. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bracket bolts (723).
7. Install the ignition coil and bracket assembly (719) and bolts (720).

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

Valve Rocker Arm Cover Installation - Right

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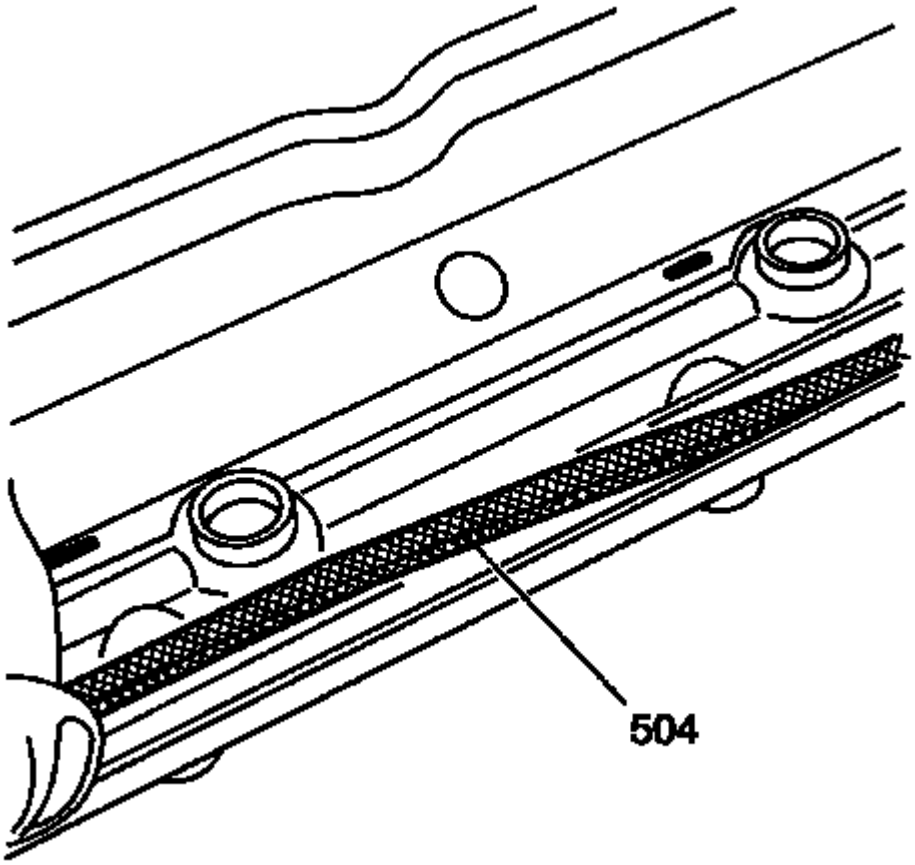

Fig. 623: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**
- **The valve rocker arm cover bolt grommets may be used again if not damaged.**

1. Install a NEW gasket (504) into the valve rocker arm cover.

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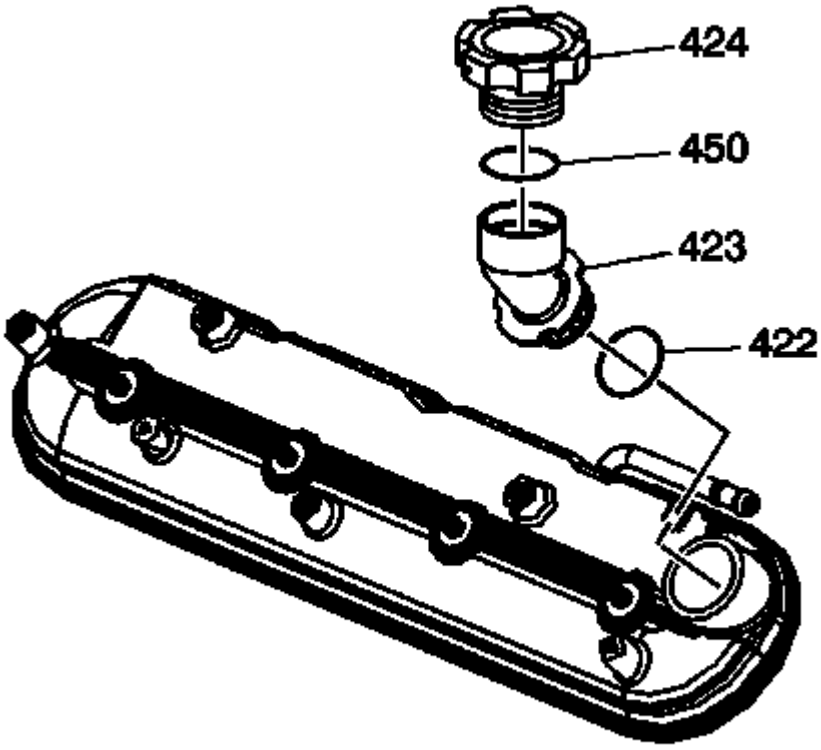

Fig. 624: Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW oil fill tube (423) to the valve rocker arm cover

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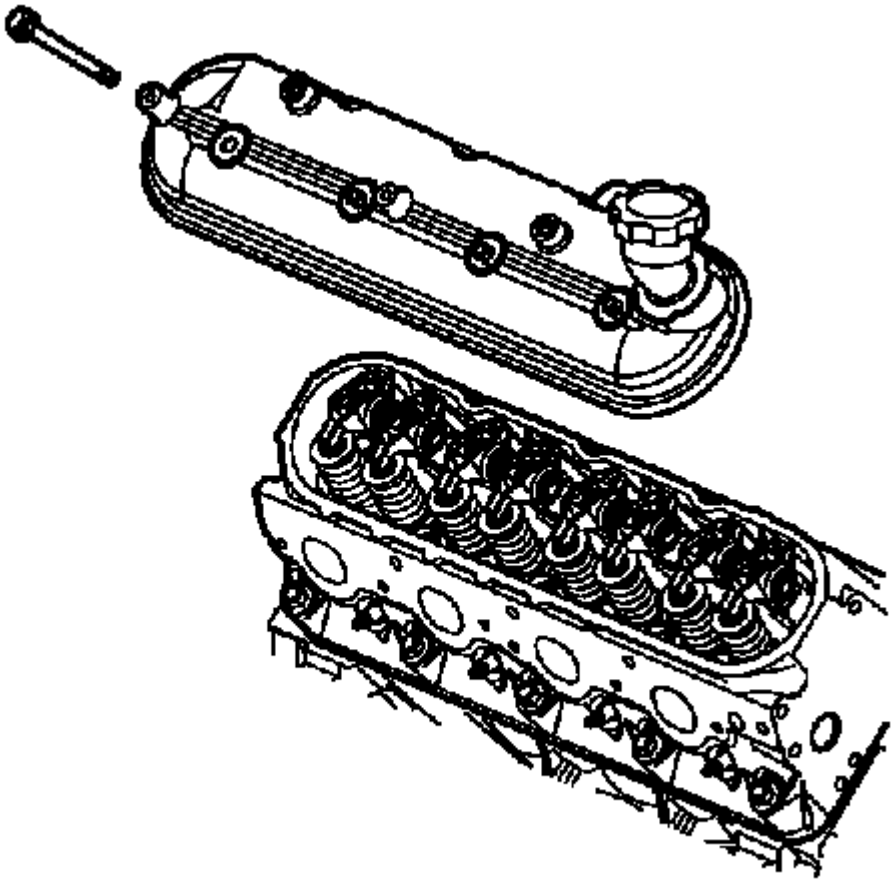

Fig. 625: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the cover bolts with grommets.

Tighten: Tighten the valve rocker arm cover bolts to 12 N.m (106 lb in).

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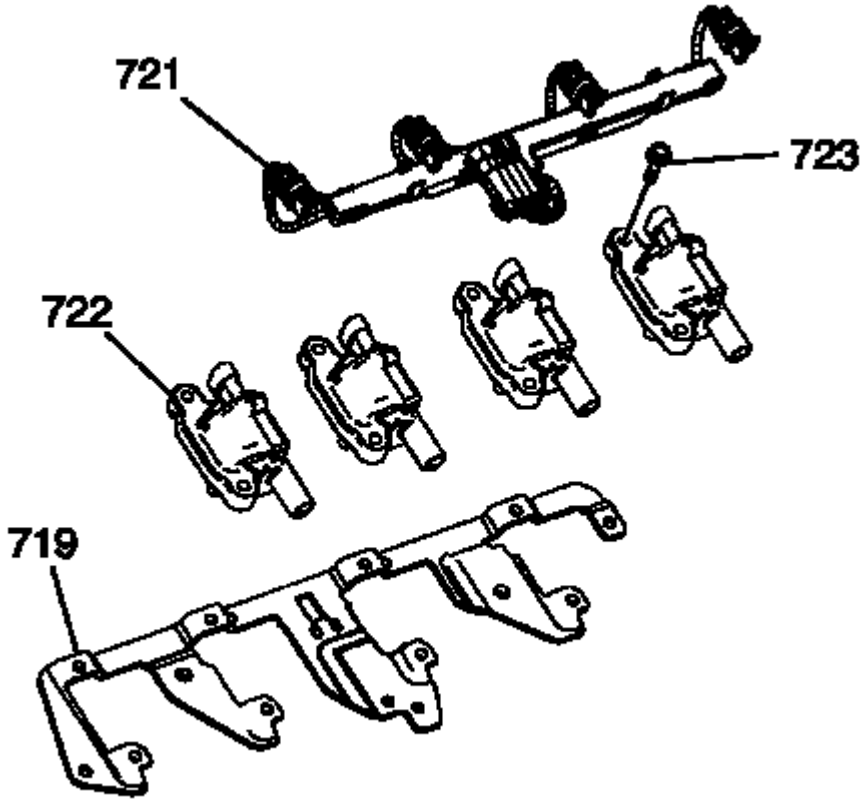

Fig. 626: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bolts (723).
6. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719).

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

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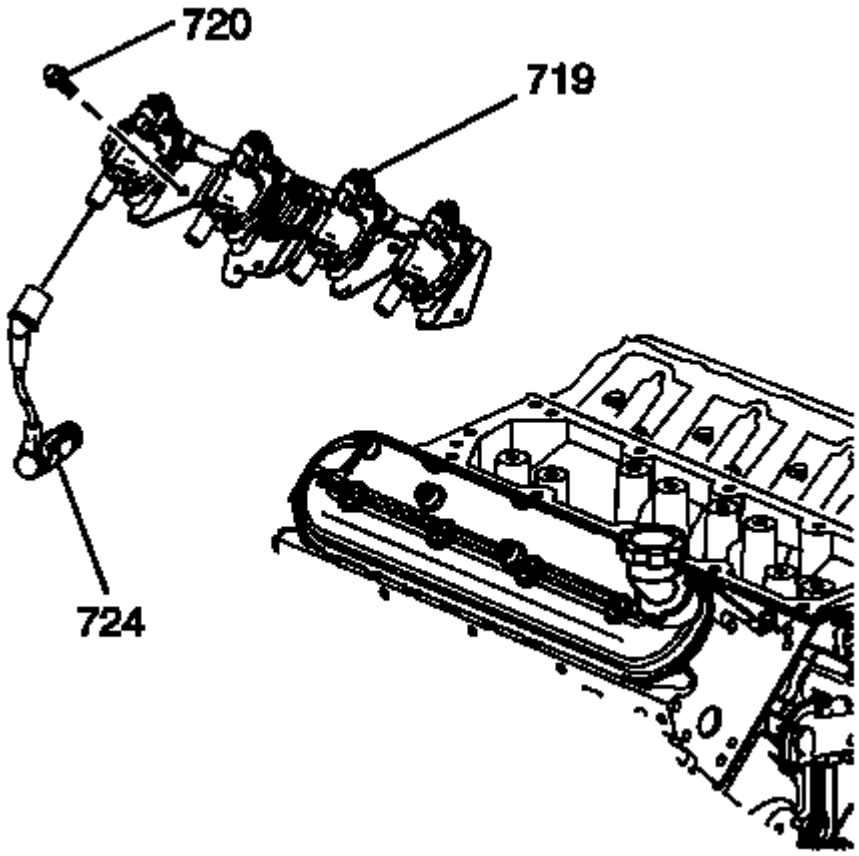

Fig. 627: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the ignition coil bracket bolts (723).
8. Install the ignition coil and bracket assembly (719) and bolts (720).

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

Valve Lifter Oil Filter Installation

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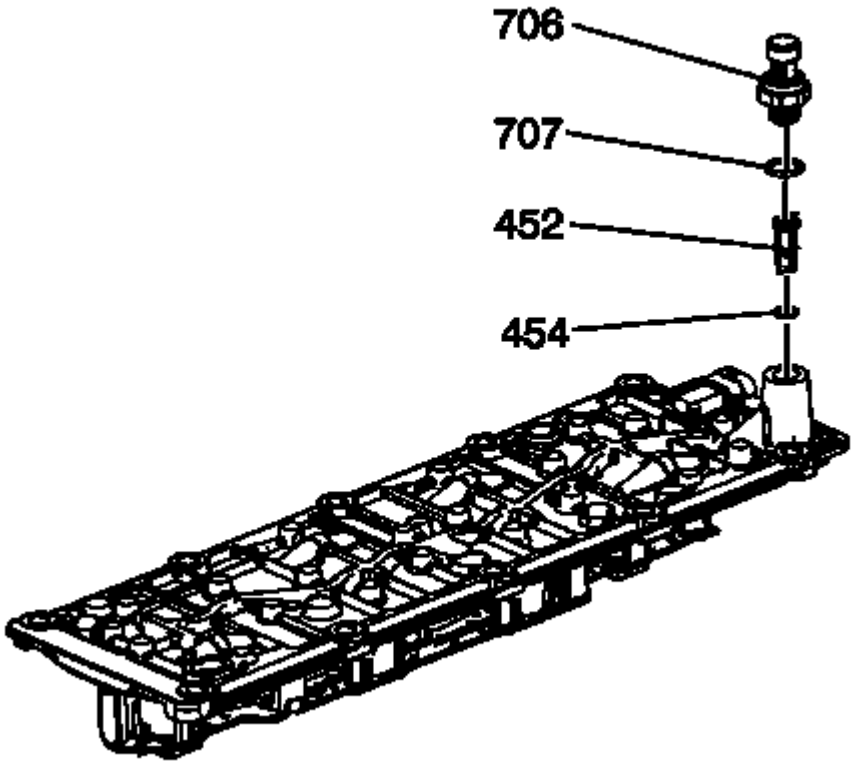

Fig. 628: Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow dirt or debris to enter the oil passages of the manifold. Plug as required.

1. Install a NEW oil filter (452) and O-ring (454) assembly.
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the oil pressure sensor (706) and washer (707).

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

Valve Lifter Oil Manifold Installation

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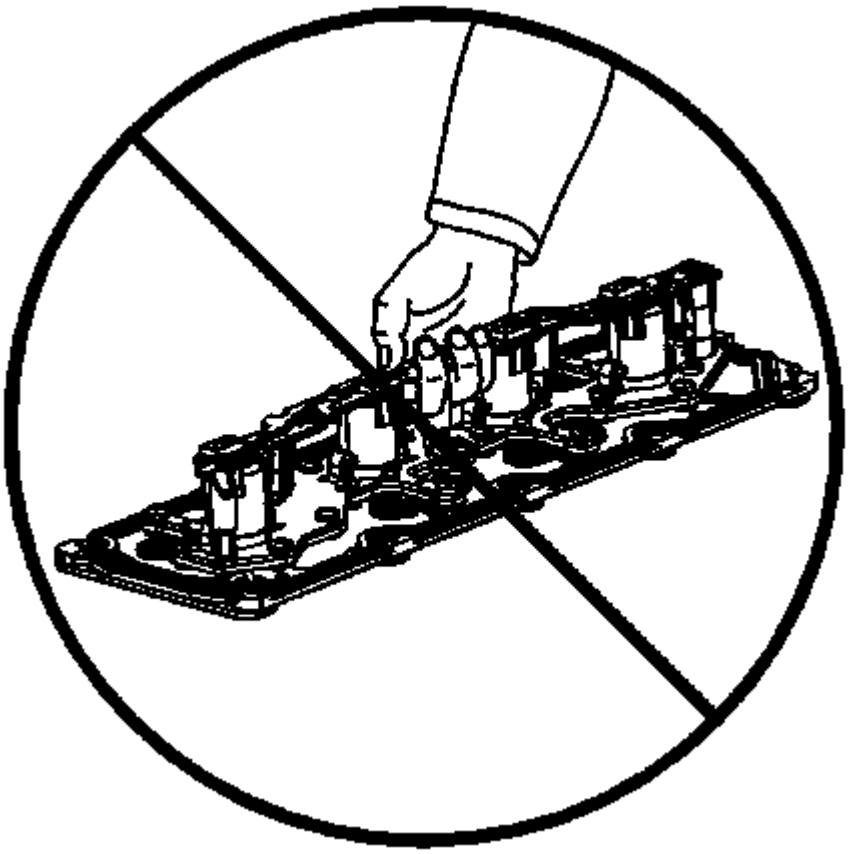

Fig. 629: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS CORP.

1. Do not lift the manifold assembly by the electrical lead frame.

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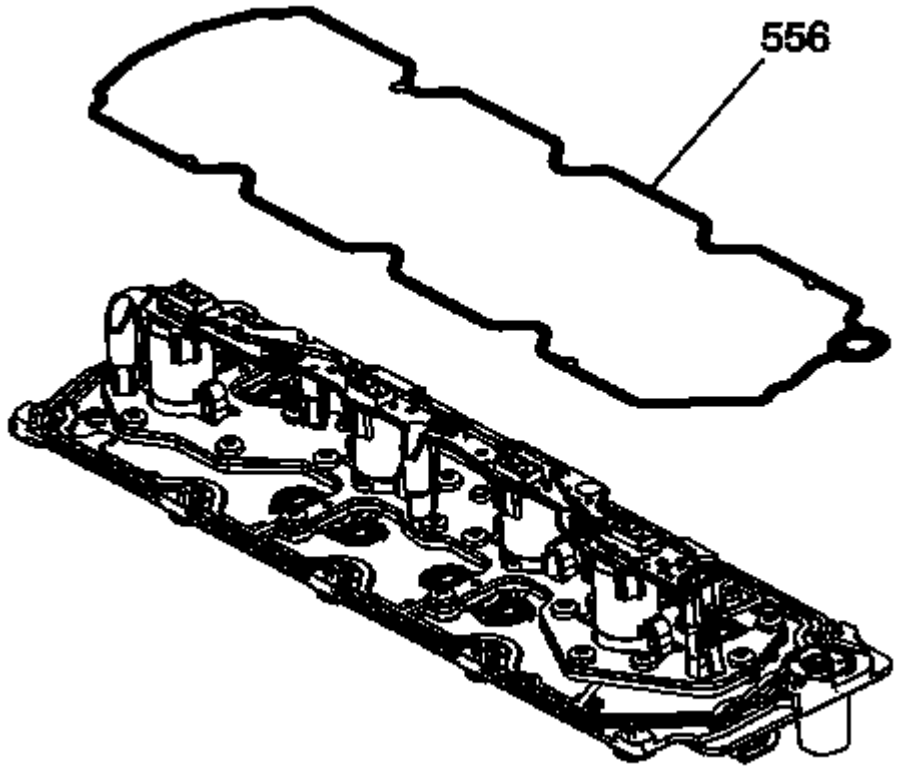

Fig. 630: Valve Lifter Oil Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **Do not allow dirt or debris to enter the manifold. Plug as required.**

2. Install the service gasket (556) onto the manifold.

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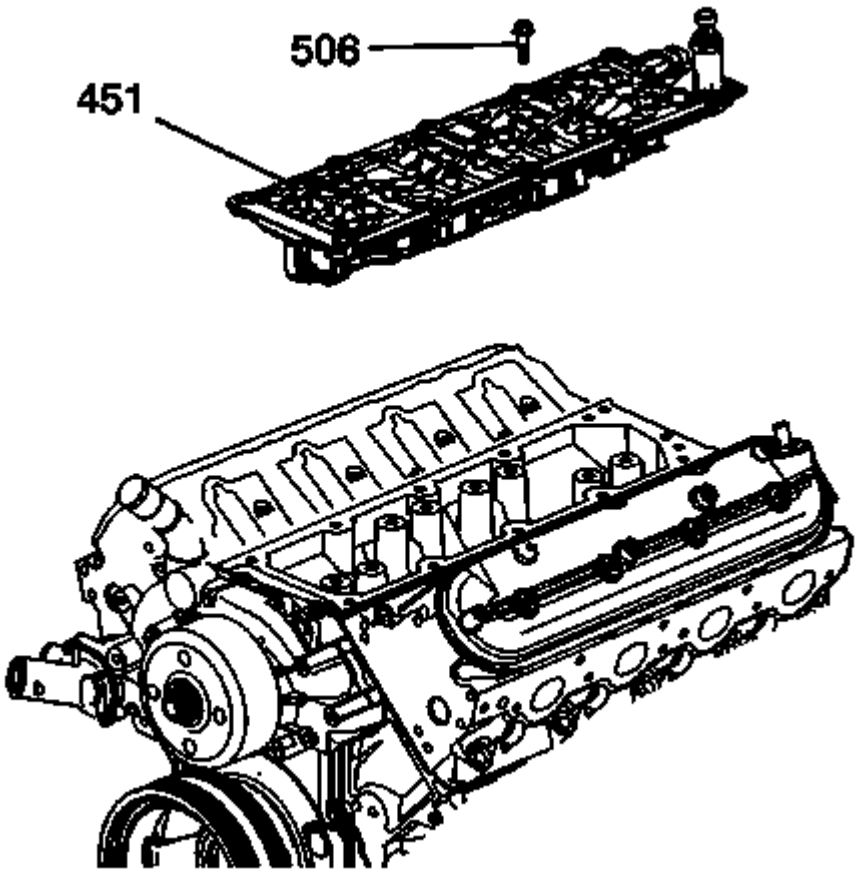

Fig. 631: Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Install the manifold (451) with gasket.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the manifold bolts (506).

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

Coolant Air Bleed Pipe Installation

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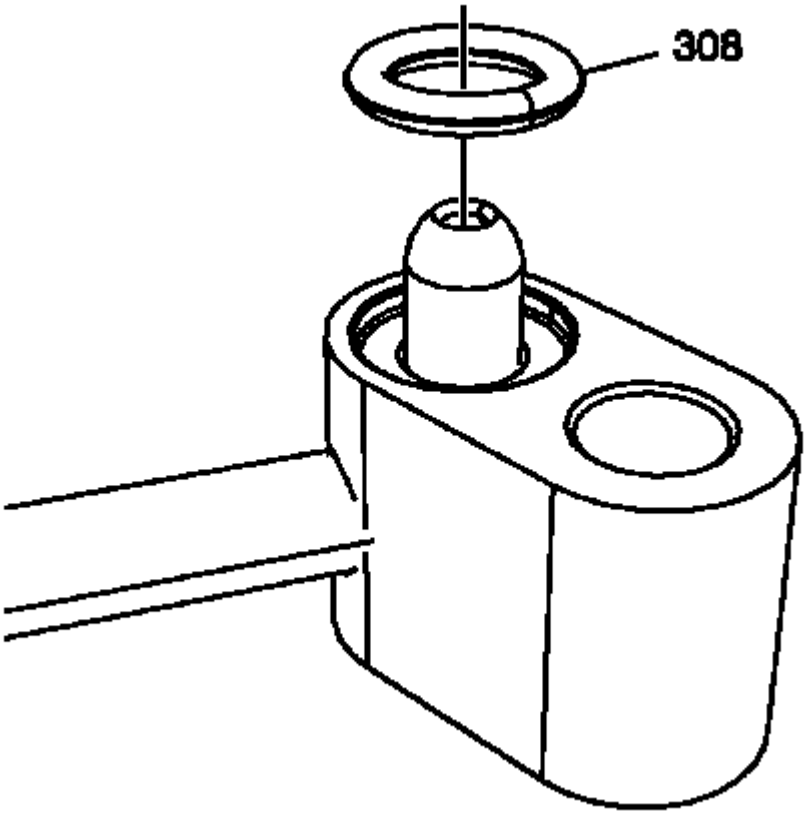

Fig. 632: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Position the O-ring seal onto the nipple portion of the pipe.

1. Install the seals (308) onto the engine coolant air bleed pipe and covers.

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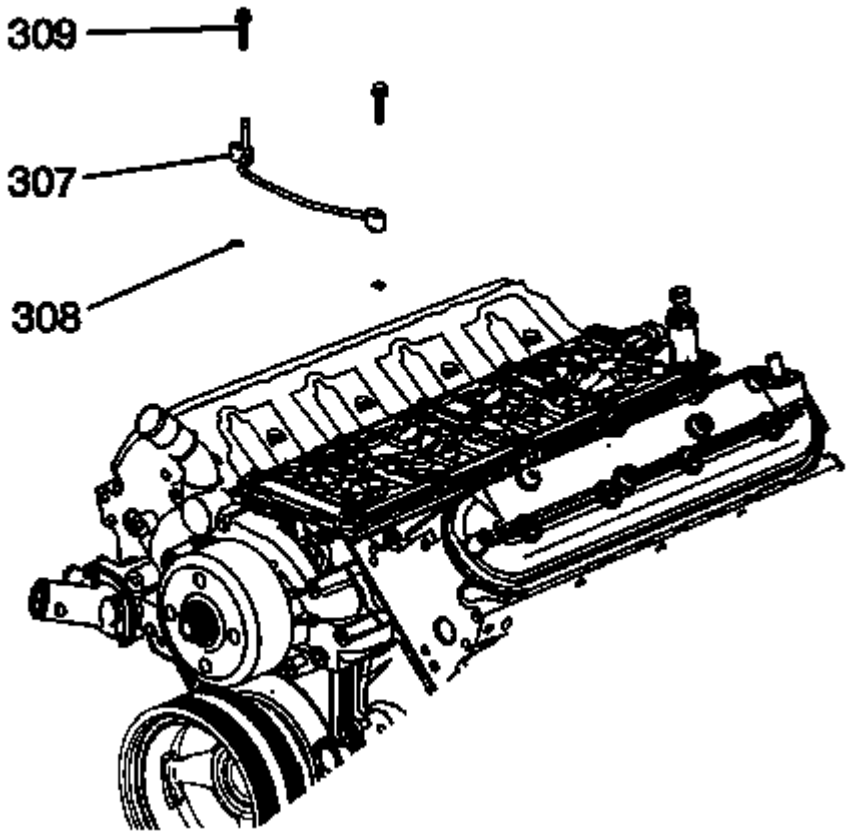

Fig. 633: Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

2. Install the pipe (307) and seals (308).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the bolts (309).

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

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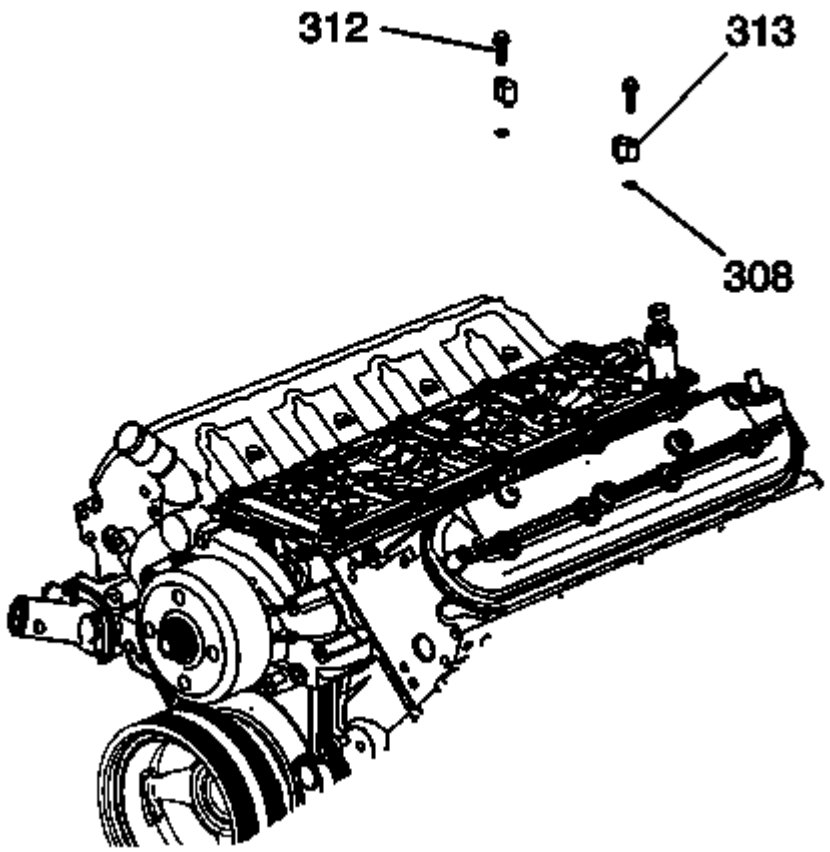

Fig. 634: Covers & Seals
Courtesy of GENERAL MOTORS CORP.

4. Install the covers (313) and seals (308).
5. Install the bolts (312).

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

Intake Manifold Installation

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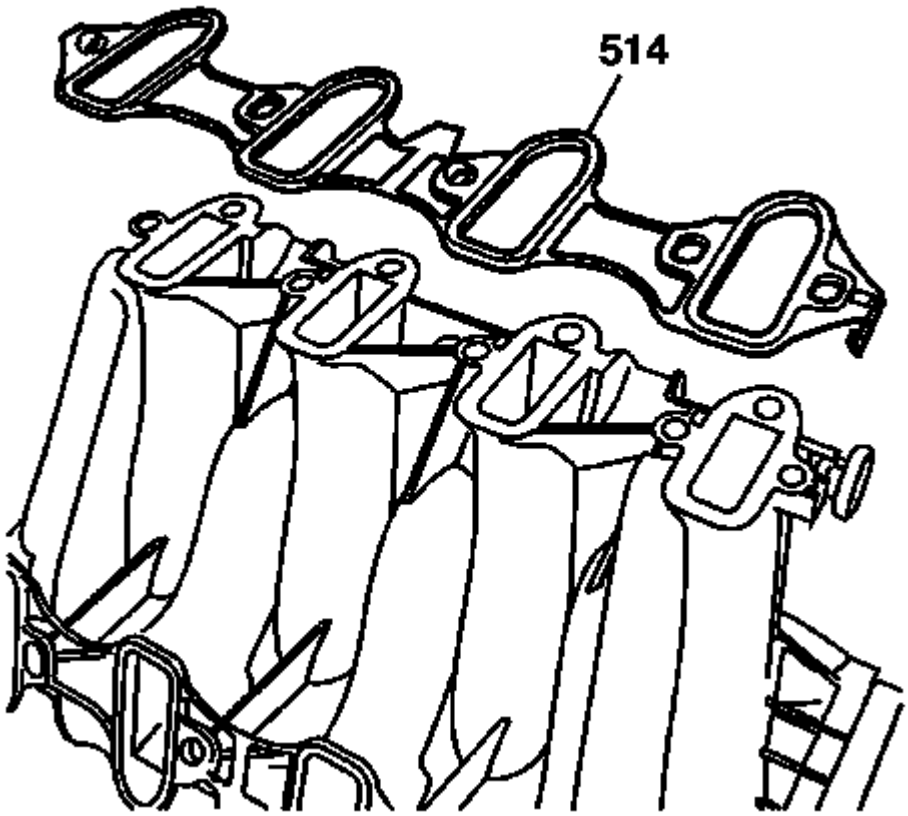

Fig. 635: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **The intake manifold, throttle body, fuel injection rail and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.**
- **DO NOT use the intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.**

1. Install NEW intake manifold-to-cylinder head gaskets (514).

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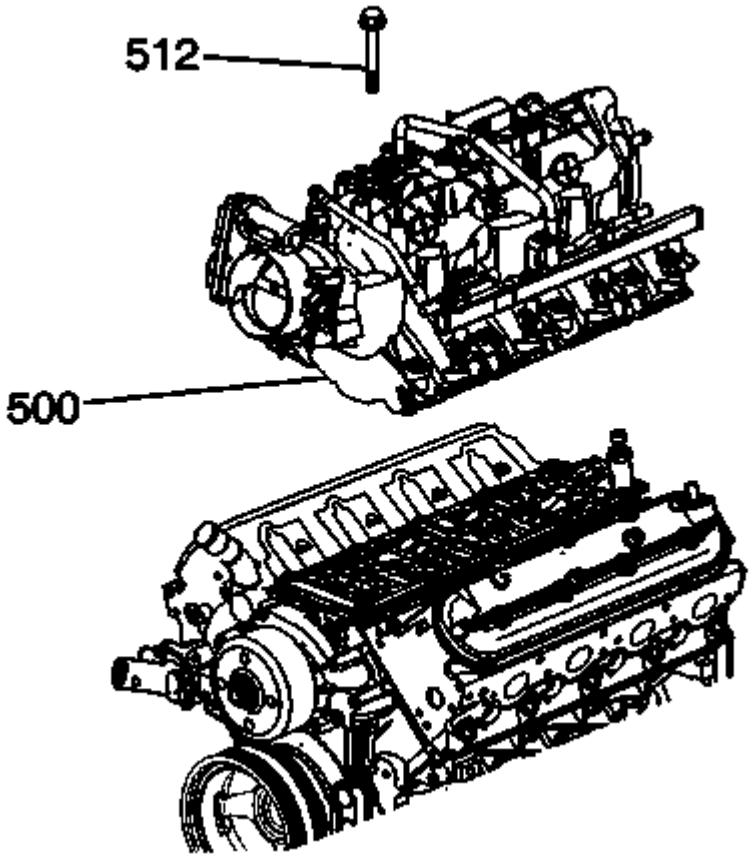

Fig. 636: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold (500).
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512). Refer to **Sealers, Adhesives, and Lubricants**.

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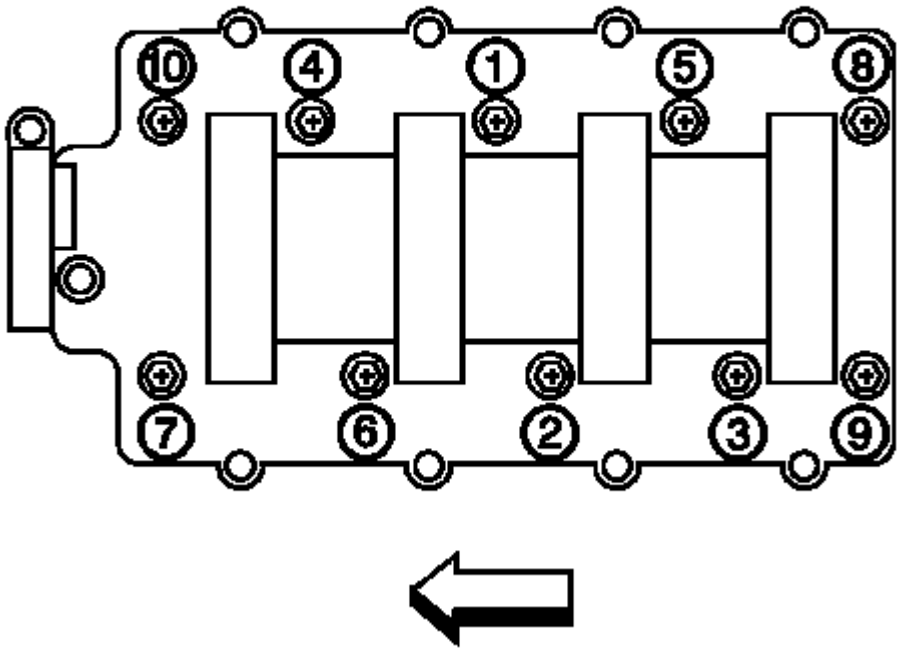

Fig. 637: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the intake manifold bolts.

Tighten:

1. Tighten the intake manifold bolts (1-10) a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts (1-10) a final pass in sequence to 10 N.m (89 lb in).

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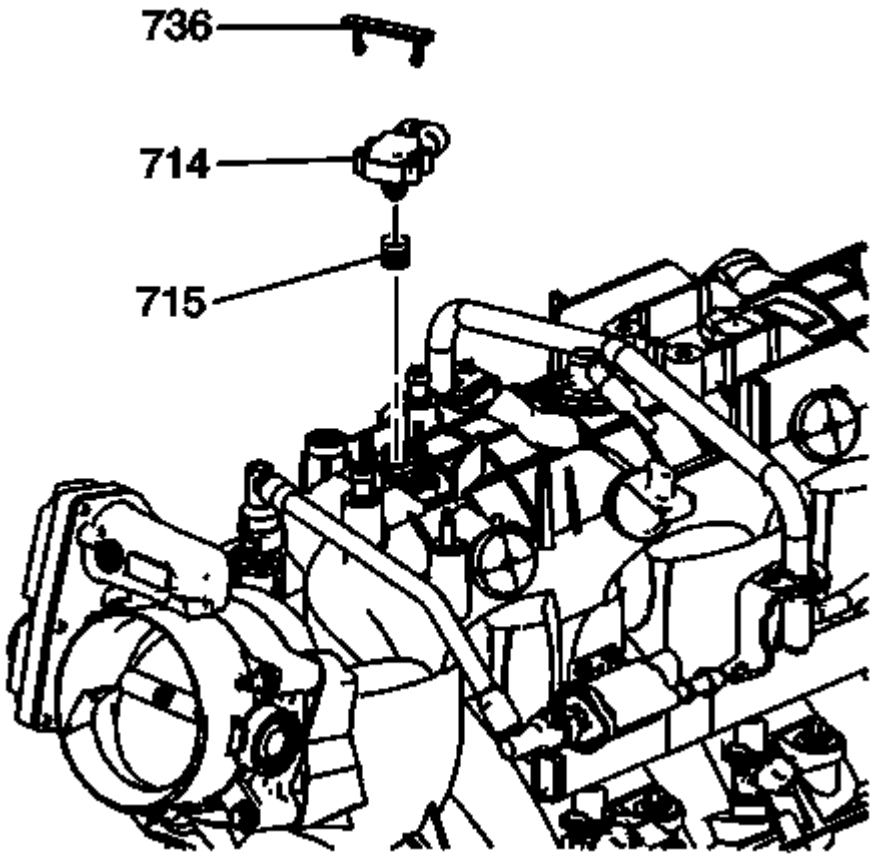

Fig. 638: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail. Refer to **Fuel Rail and Injectors Installation**.
6. Lubricate the manifold absolute pressure (MAP) sensor grommet (715) with clean engine oil.
7. Install the grommet onto the MAP sensor (714).
8. Install the MAP sensor and retainer (736).

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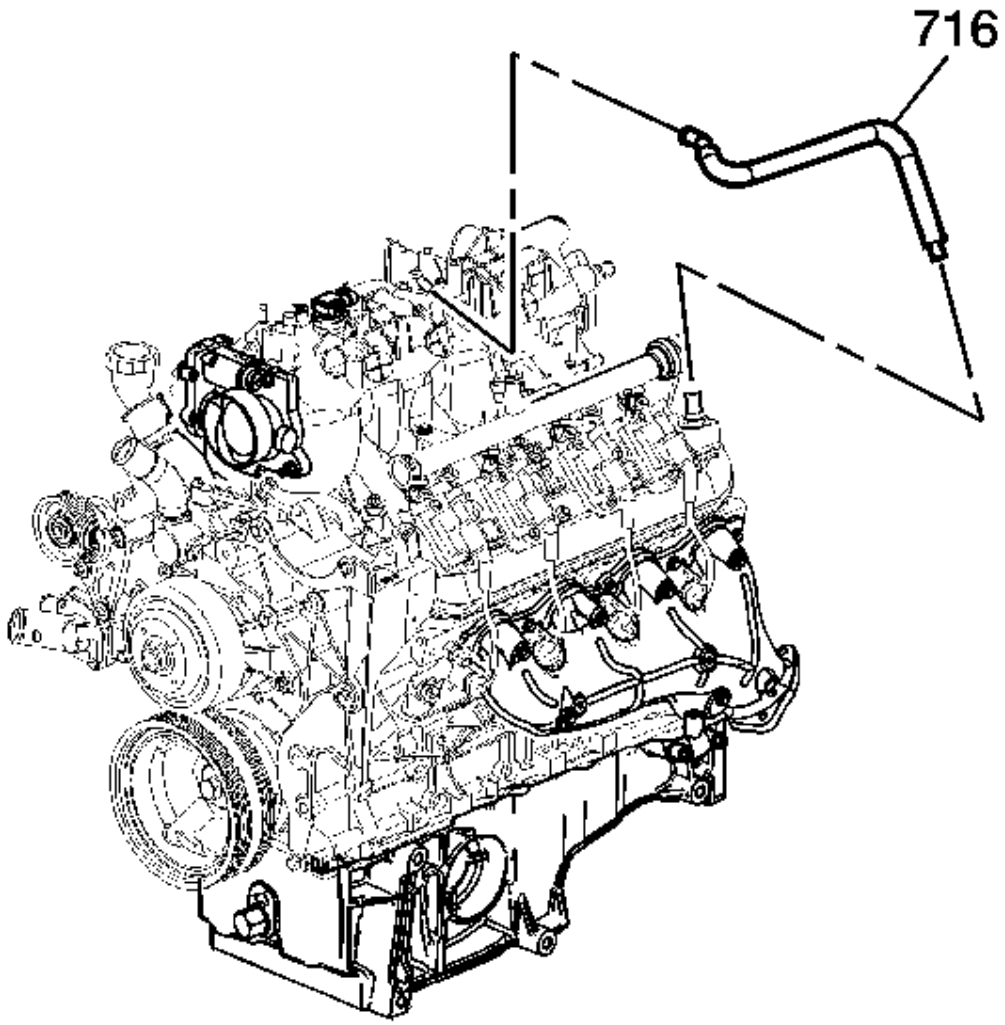

Fig. 639: PCV Hose
Courtesy of GENERAL MOTORS CORP.

9. Install the positive crankcase ventilation (PCV) hose - dirty air (716).

Fuel Rail and Injectors Installation

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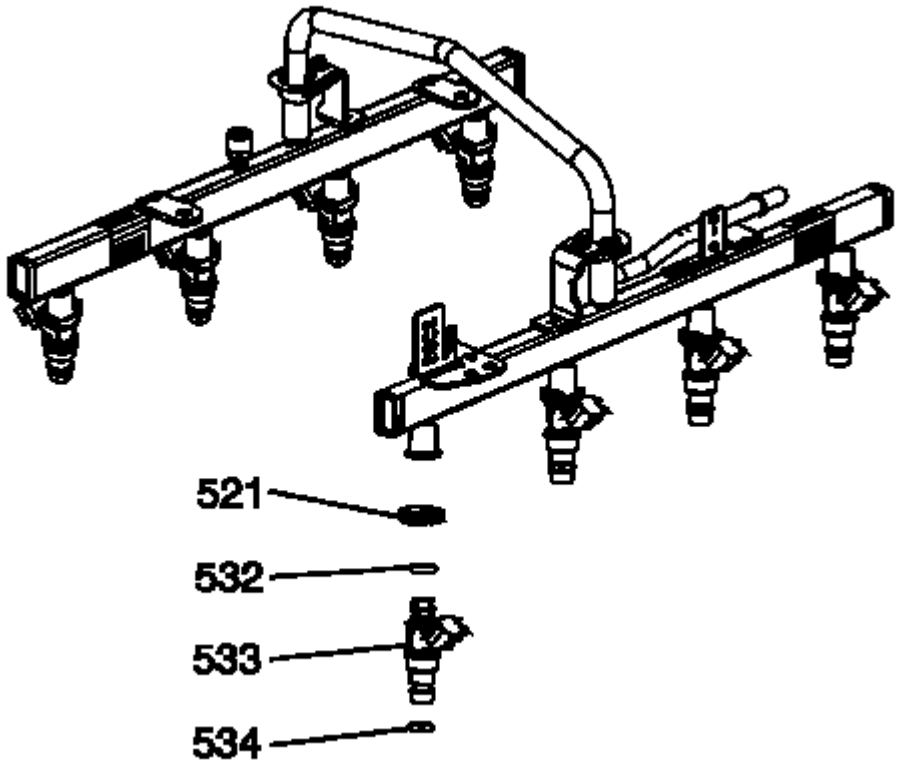

Fig. 640: Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution in Cautions and Notices.

IMPORTANT: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals (532, 534) with clean engine oil.
2. Install the O-ring seals to the fuel injectors.
3. Install the fuel injectors (533) and retaining clips (521).

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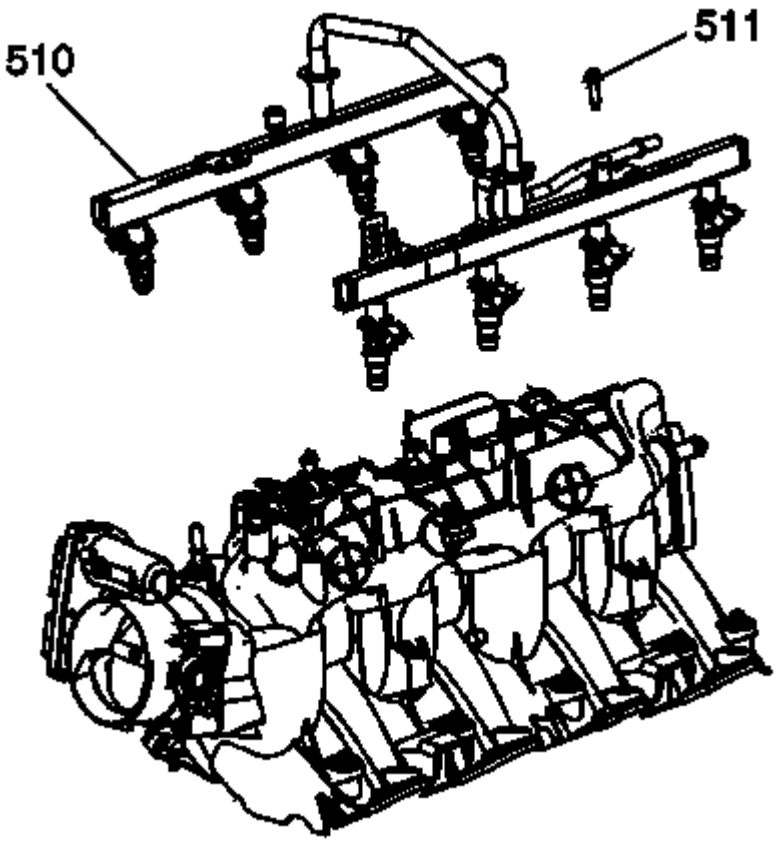

Fig. 641: Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel rail assembly (510) to the manifold. Push firmly on both sides of the rail until all the injectors have entered their bores.
5. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the fuel rail bolts. Refer to **Sealers, Adhesives, and Lubricants**.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the fuel rail bolts (511).

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

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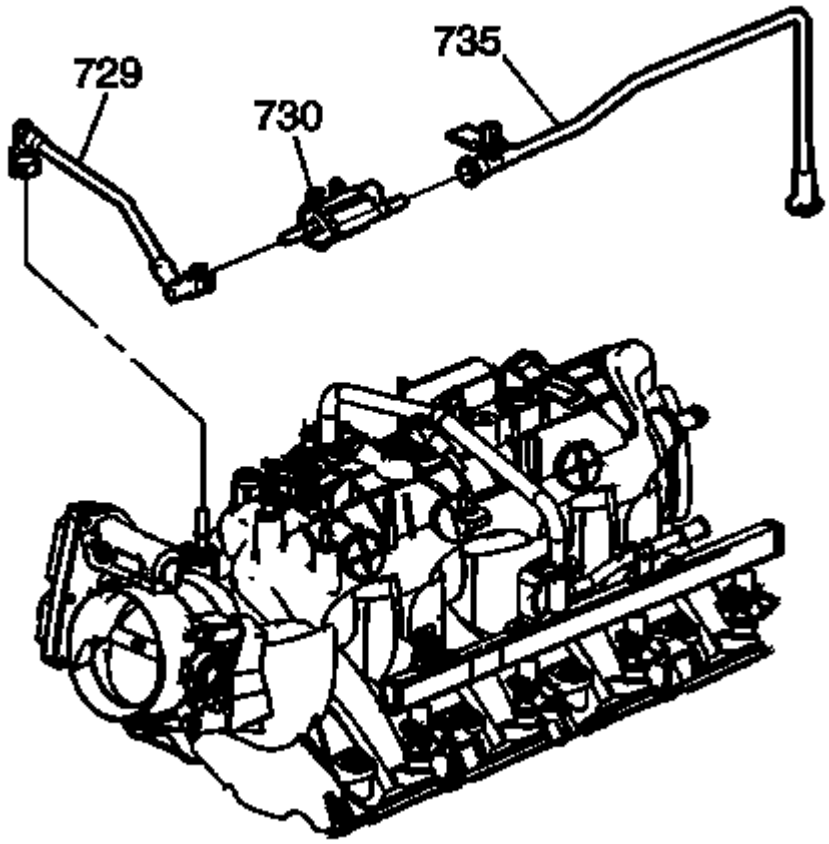

Fig. 642: EVAP Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

7. Install the evaporative emission (EVAP) valve (730) and tubes (729, 735).

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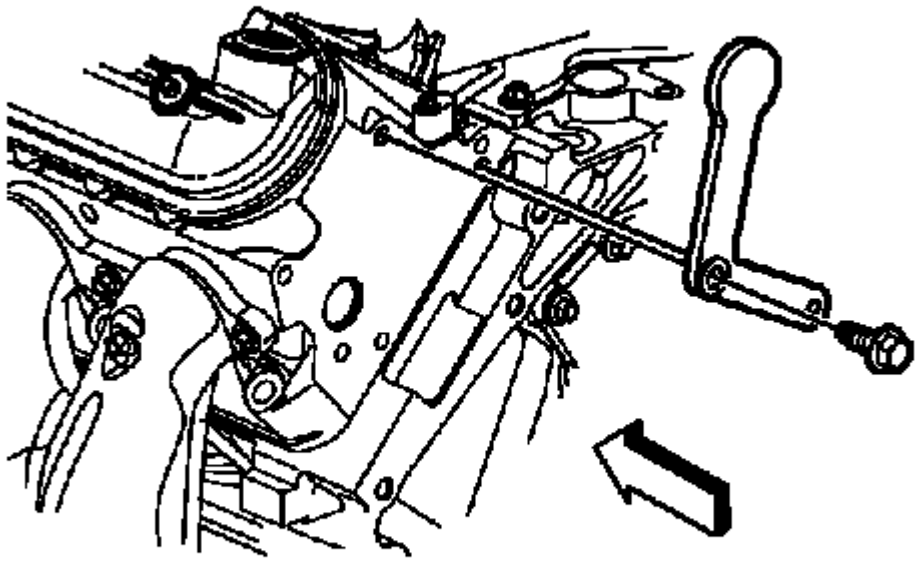

Fig. 643: View Of Fuel Rail Stop Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the fuel rail stop bracket and bolt.

   Tighten: Tighten the fuel rail stop bracket bolt to 50 N.m (37 lb ft).

Throttle Body Installation

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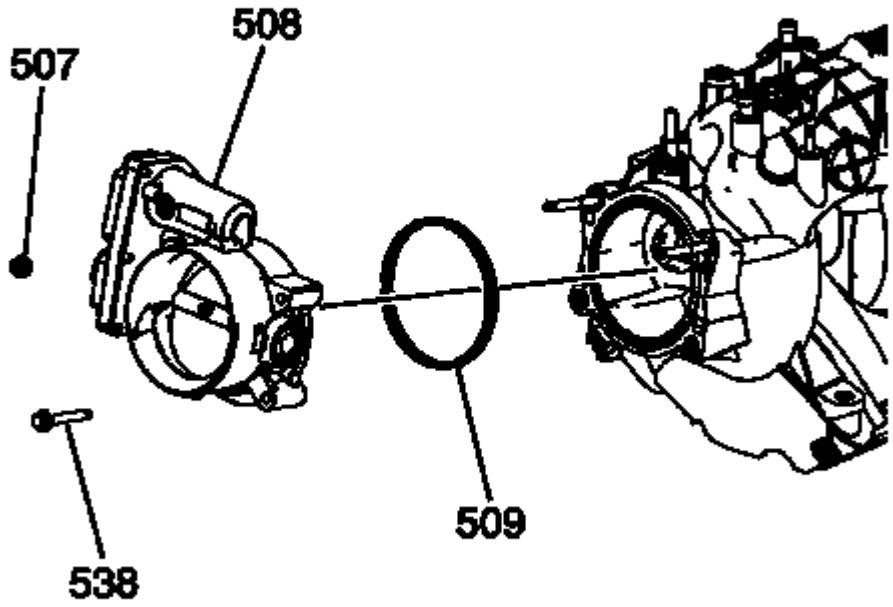

Fig. 644: Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the throttle body studs as required.

   Tighten: Tighten the throttle body studs to 6 N.m (53 lb in).

   IMPORTANT: DO NOT use the throttle body gasket again. Install a NEW gasket during assembly.

2. Install the throttle body gasket (509) to the intake manifold. Align the locating tab of the gasket with the notch in the manifold.
3. Install the throttle body (508), bolts (538), and nuts (507).

   Tighten: Tighten the throttle body nuts and bolts to 10 N.m (89 lb in).

Water Pump Installation

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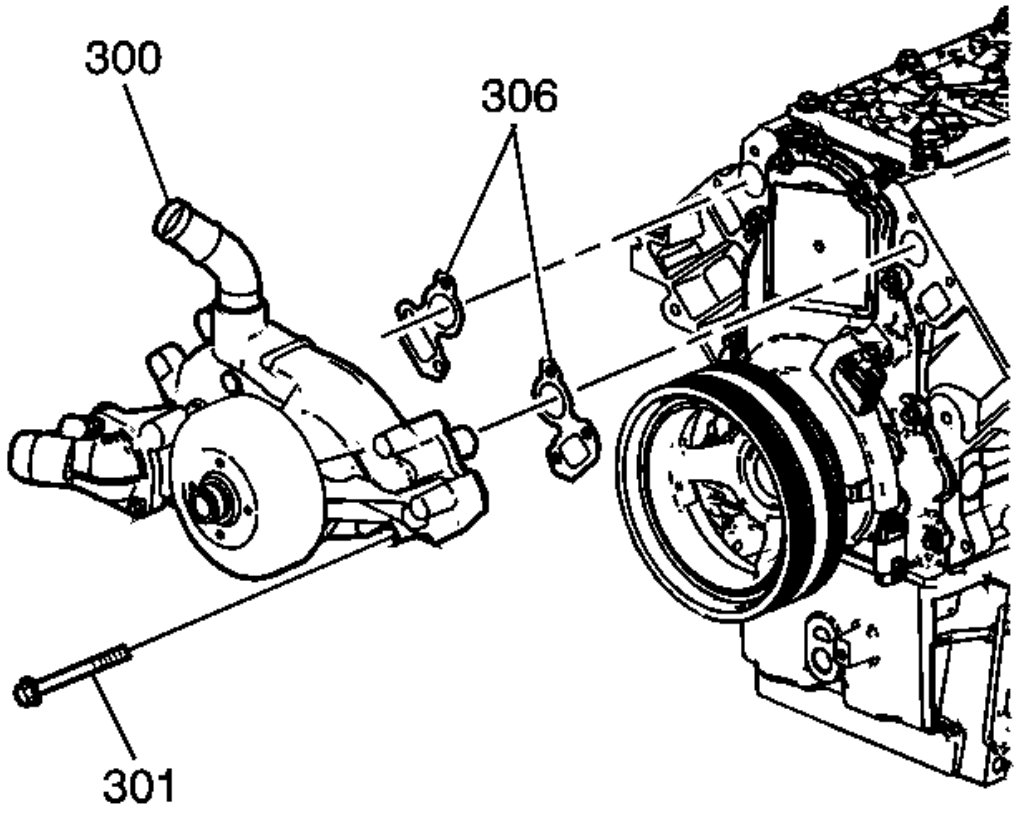

Fig. 645: Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

IMPORTANT: All gasket surfaces are to be free of oil or other foreign material during assembly.

1. Install the water pump (300) and NEW gaskets (306).

NOTE: Refer to Fastener Notice in Cautions and Notices.

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2. Install the water pump bolts (301).

Tighten:

1. Tighten the water pump bolts a first pass to 15 N.m (11 lb ft).
2. Tighten the water pump bolts a final pass to 30 N.m (22 lb ft).

Exhaust Manifold Installation - Left

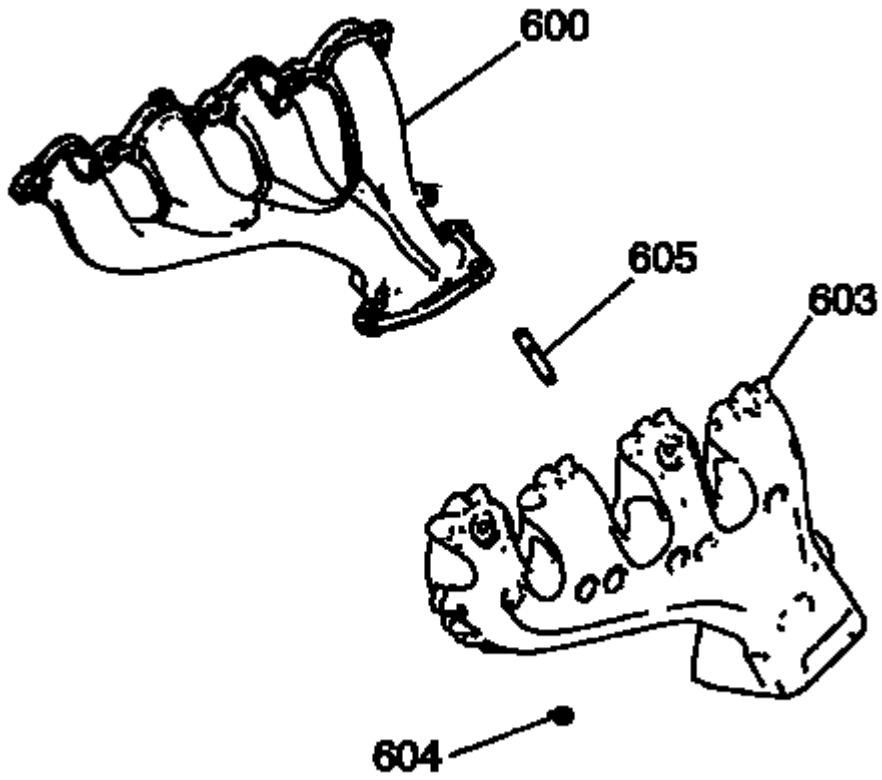

Fig. 646: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.**
- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first three threads of the bolt.**

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1. Install the heat shield (603) and bolts (604).

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

2. Install the exhaust pipe studs (605).

   Tighten: Tighten the studs to 20 N.m (15 lb ft).

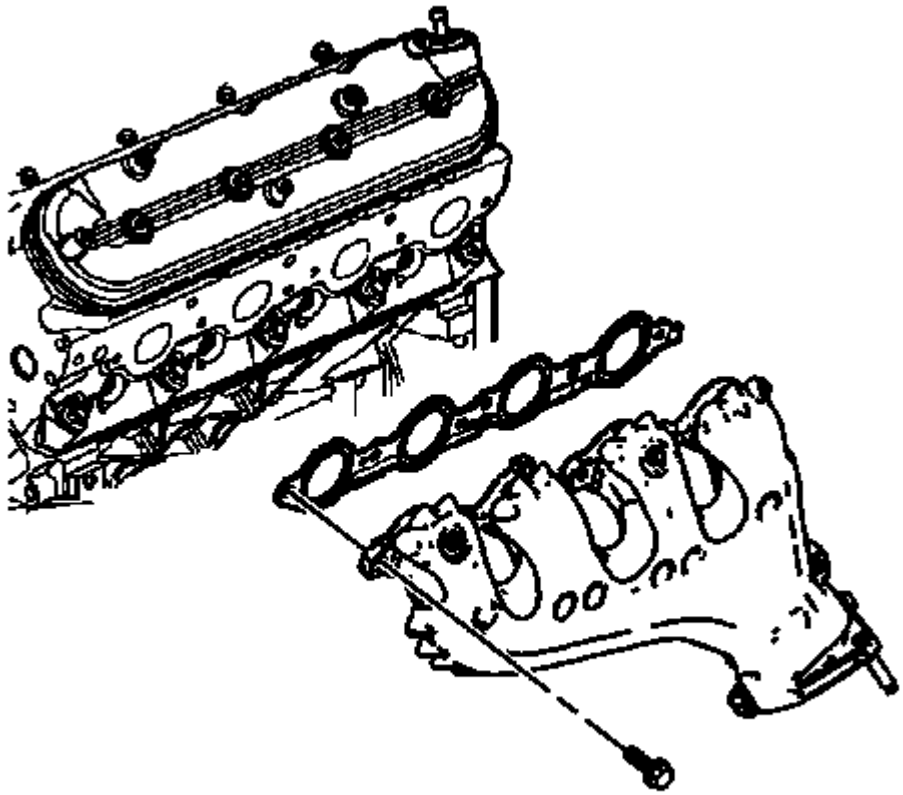

Fig. 647: Exhaust Manifold Heat Shields
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants**.
4. Install the exhaust manifold, NEW gasket, and bolts.

   Tighten:

   1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
   2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold

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bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

Exhaust Manifold Installation - Right

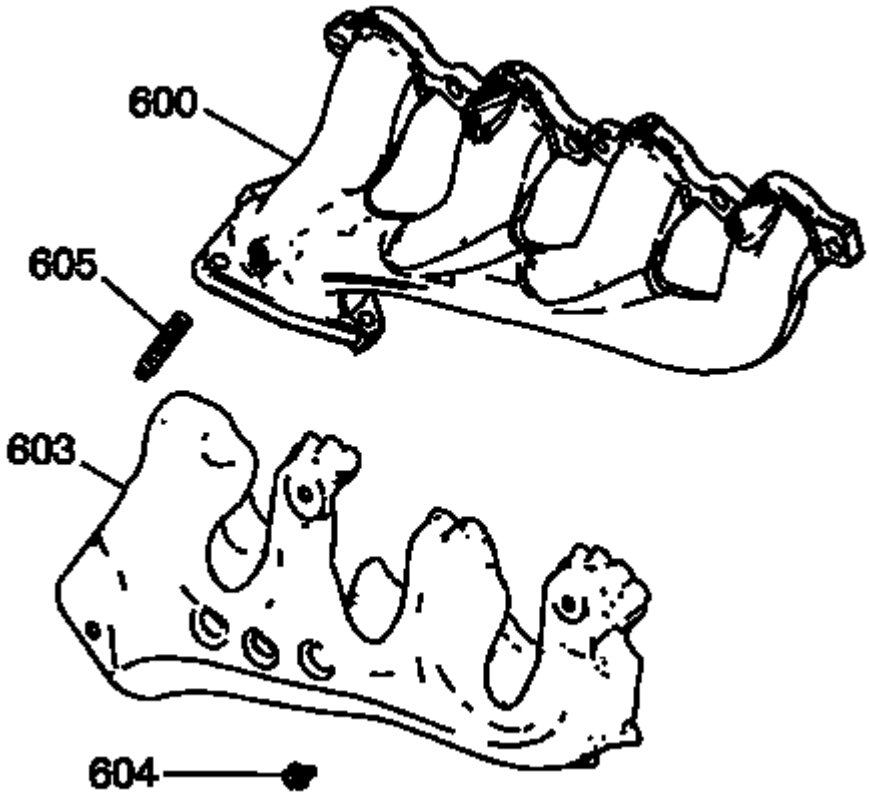

Fig. 648: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or On-Board Diagnostic (OBD) II system performance.**
- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first three threads of the bolt.**

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1. Install the heat shield (603) and bolts (604).

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

2. Install the exhaust pipe studs (605).

   Tighten: Tighten the studs to 20 N.m (15 lb ft).

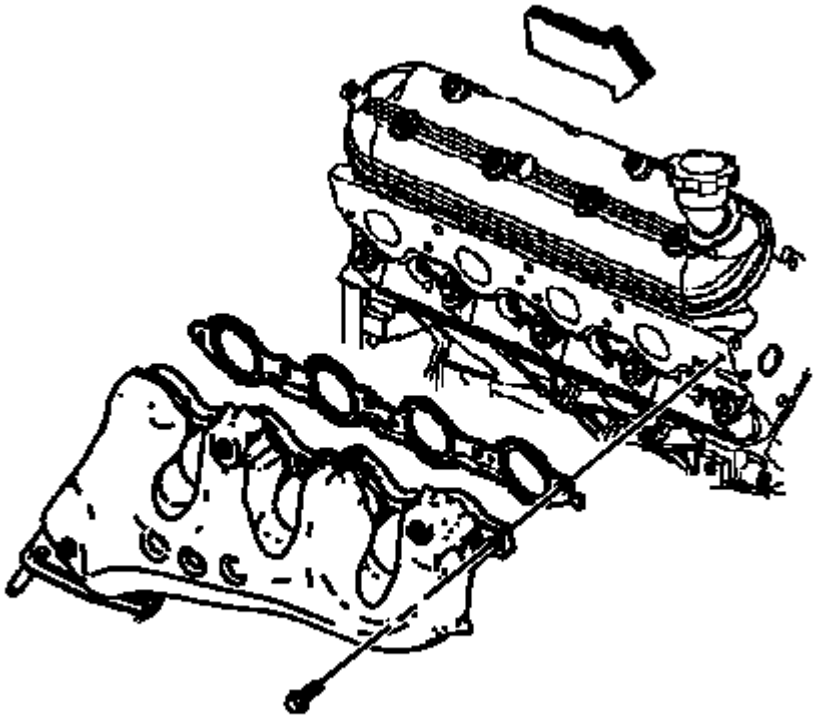

Fig. 649: Exhaust Manifold Heat Shields
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488) or equivalent to the threads of the exhaust manifold bolts. Refer to **Sealers, Adhesives, and Lubricants**.
4. Install the exhaust manifold, NEW gasket and bolts.

   Tighten:

   1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.
   2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold

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bolts beginning with the center two bolts. Alternate from side-to-side, and work toward the outside bolts.

5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

Oil Level Indicator and Tube Installation

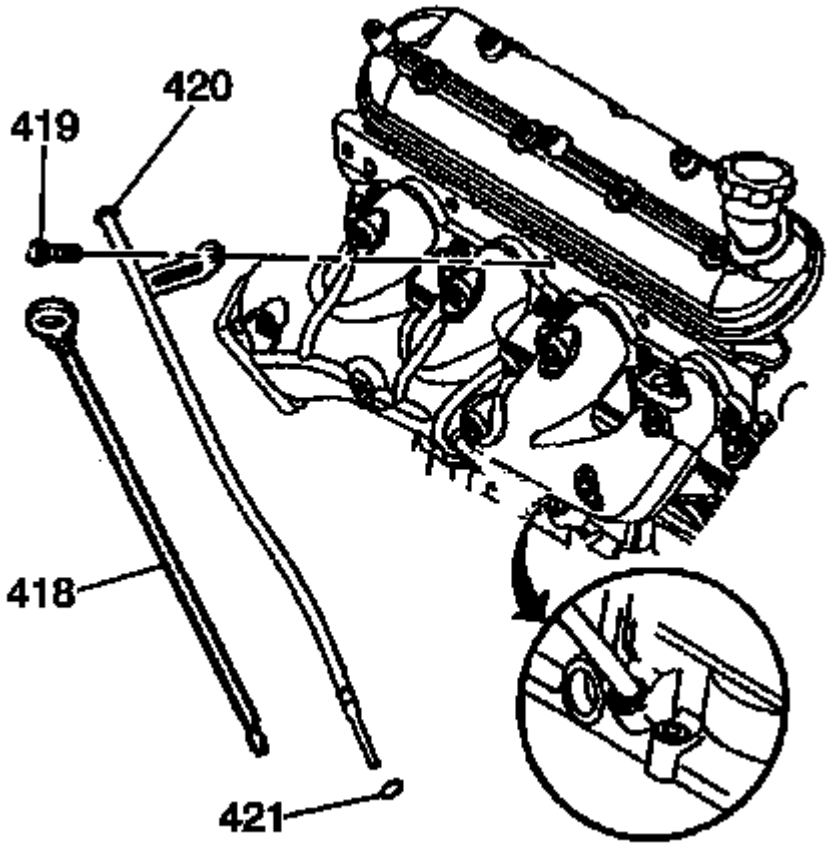

Fig. 650: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS CORP.

1. Inspect the O-ring seal (421) for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be used again.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube (420).
4. Install the oil level indicator tube into the engine block and rotate into proper position.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the tube bolt (419).

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Tighten: Tighten the oil level indicator tube bolt to 25 N.m (18 lb ft).

6. Install the oil level indicator (418) into the tube.

Engine Flywheel Installation

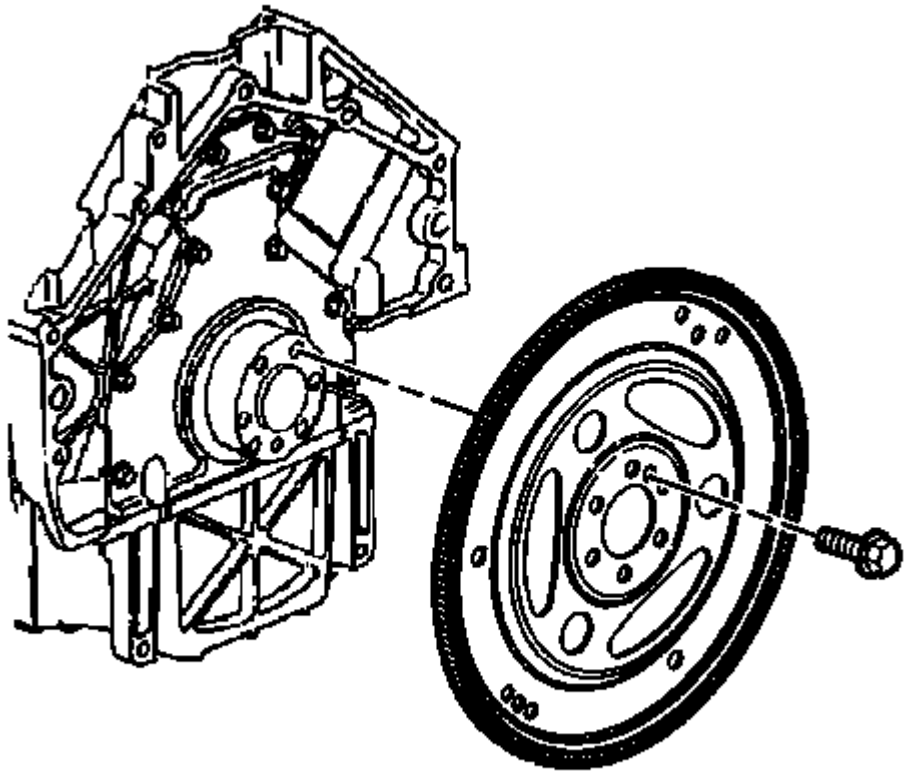

Fig. 651: Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.

1. Install the flywheel to the crankshaft.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the threads of the flywheel bolts.

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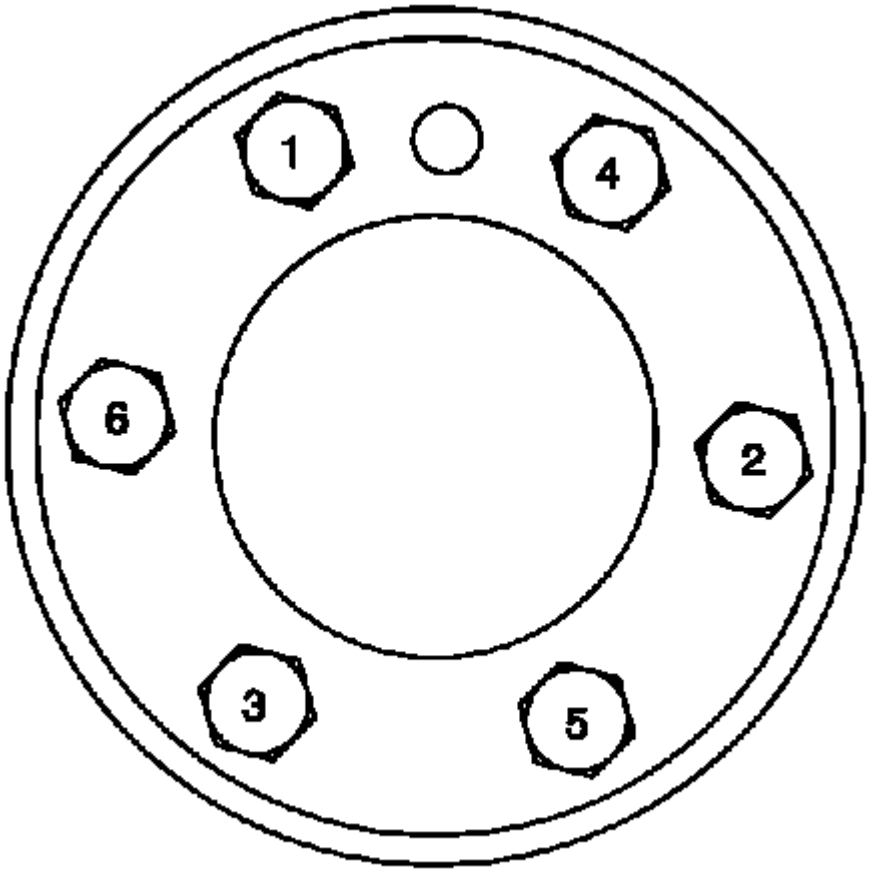

Fig. 652: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the engine flywheel bolts.

Tighten:

1. Tighten the engine flywheel bolts (1-6) a first pass in sequence to 20 N.m (15 lb ft).
2. Tighten the engine flywheel bolts (1-6) a second pass in sequence to 50 N.m (37 lb ft).
3. Tighten the engine flywheel bolts (1-6) a final pass in sequence to 100 N.m (74 lb ft).

Crankshaft Balancer Installation

Tools Required

- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.
- **J 45059** Angle Meter

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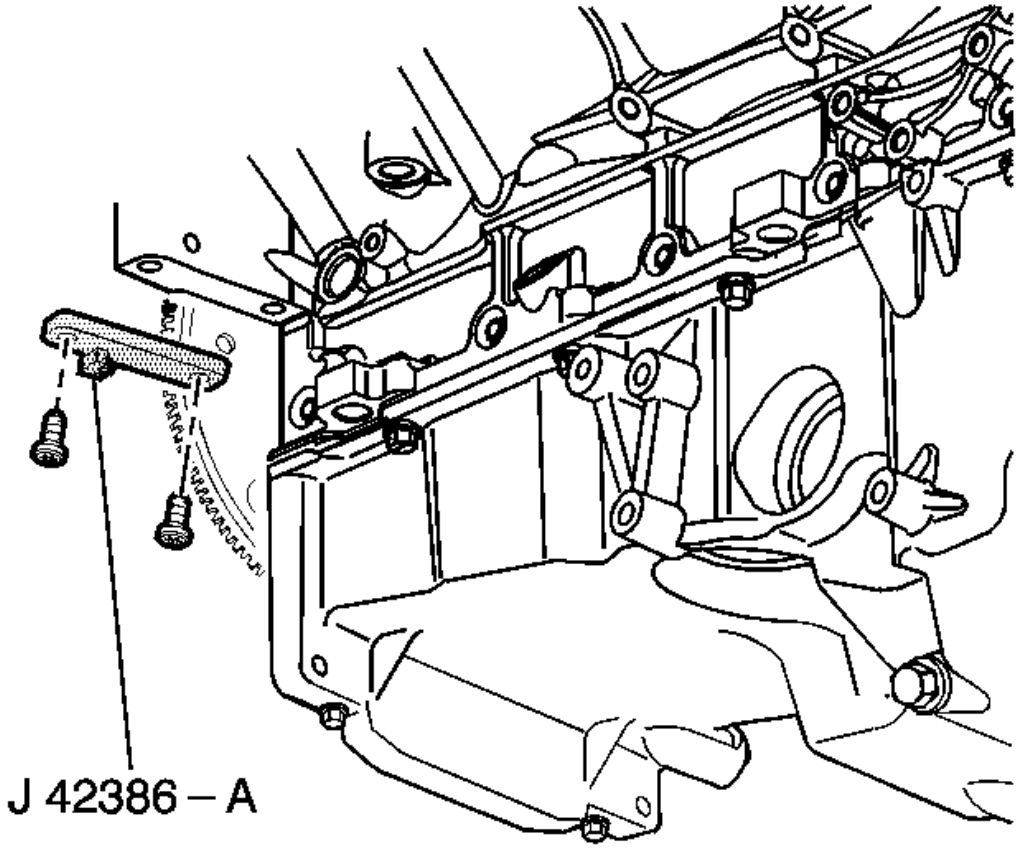

Fig. 653: View Of J 42386-A Flywheel Tool
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- **The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.**
- **The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third and fourth passes tighten the NEW bolt to the proper torque.**
- **The used crankshaft balancer bolt is used only during the first pass of the balancer installation procedure. Install a NEW crankshaft balancer bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.**

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- **Ensure the teeth of the tool engage the engine flywheel teeth.**

1. Install the **J 42386-A** and bolts. See **Special Tools**.

   Use one M10 - 1.5 x 120 mm and one M10 - 1.5 x 45 mm bolt for proper tool operation.

   Tighten: Tighten the **J 42386-A** bolts to 50 N.m (37 lb ft).

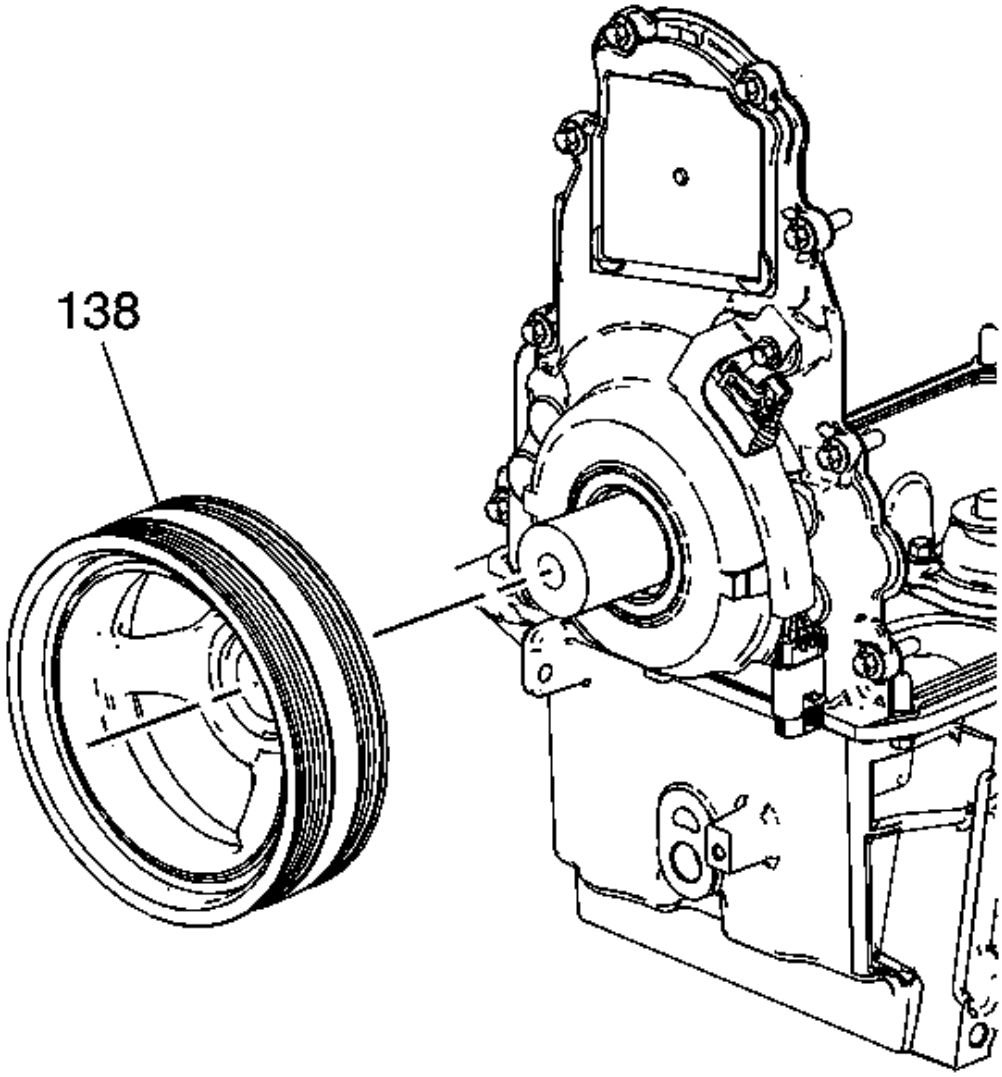

Fig. 654: Crankshaft Balancer Pulley

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Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Position the balancer (138) onto the end of the crankshaft.

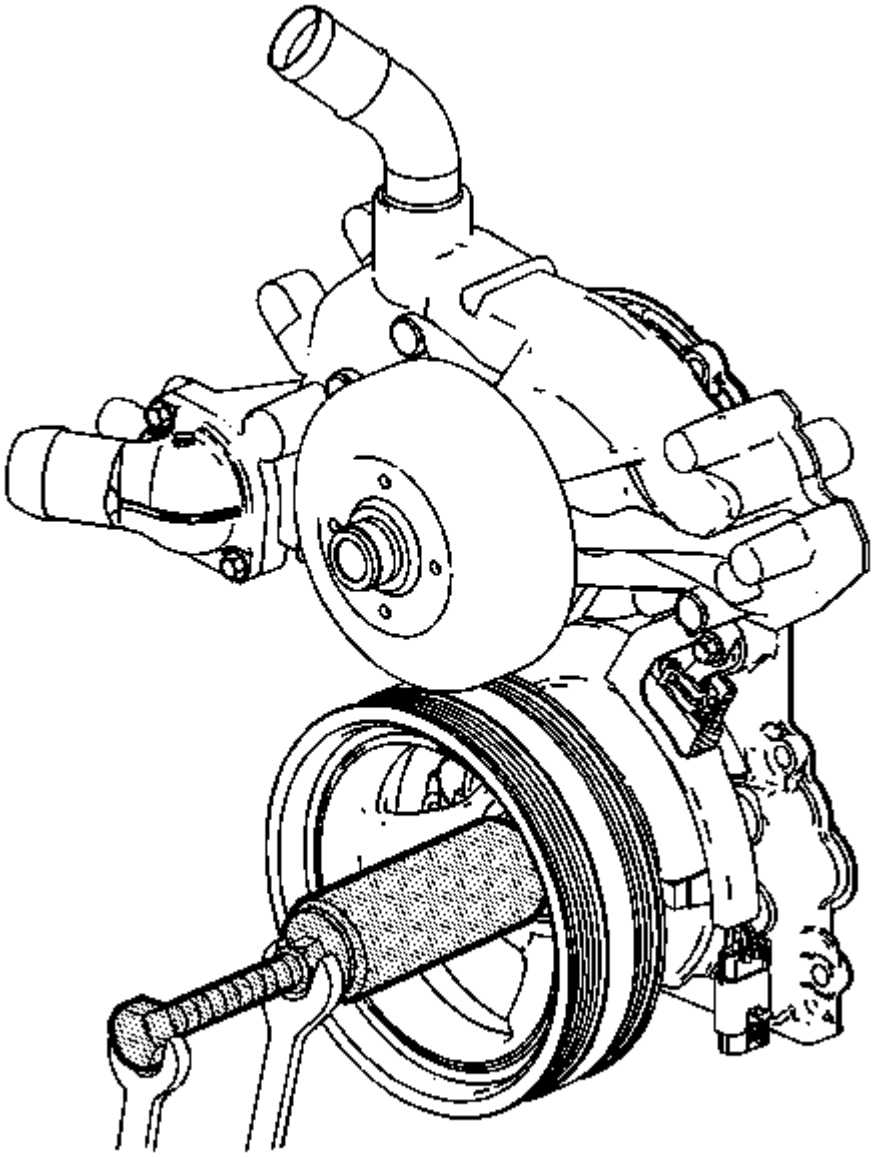

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Fig. 655: Installing Balancer
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41665** in order to install the balancer. See **Special Tools**.
    1. Assemble the threaded rod, nut, washer and installer.

       Insert the smaller end of the installer into the front of the balancer.

    2. Use a wrench and hold the hex end of the threaded rod.
    3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
    4. Remove the tool and reverse the installation tool.

       Position the larger end of the installer against the front of the balancer.

    5. Use a wrench and hold the hex end of the threaded rod.
    6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
    7. Remove the balancer installation tool.

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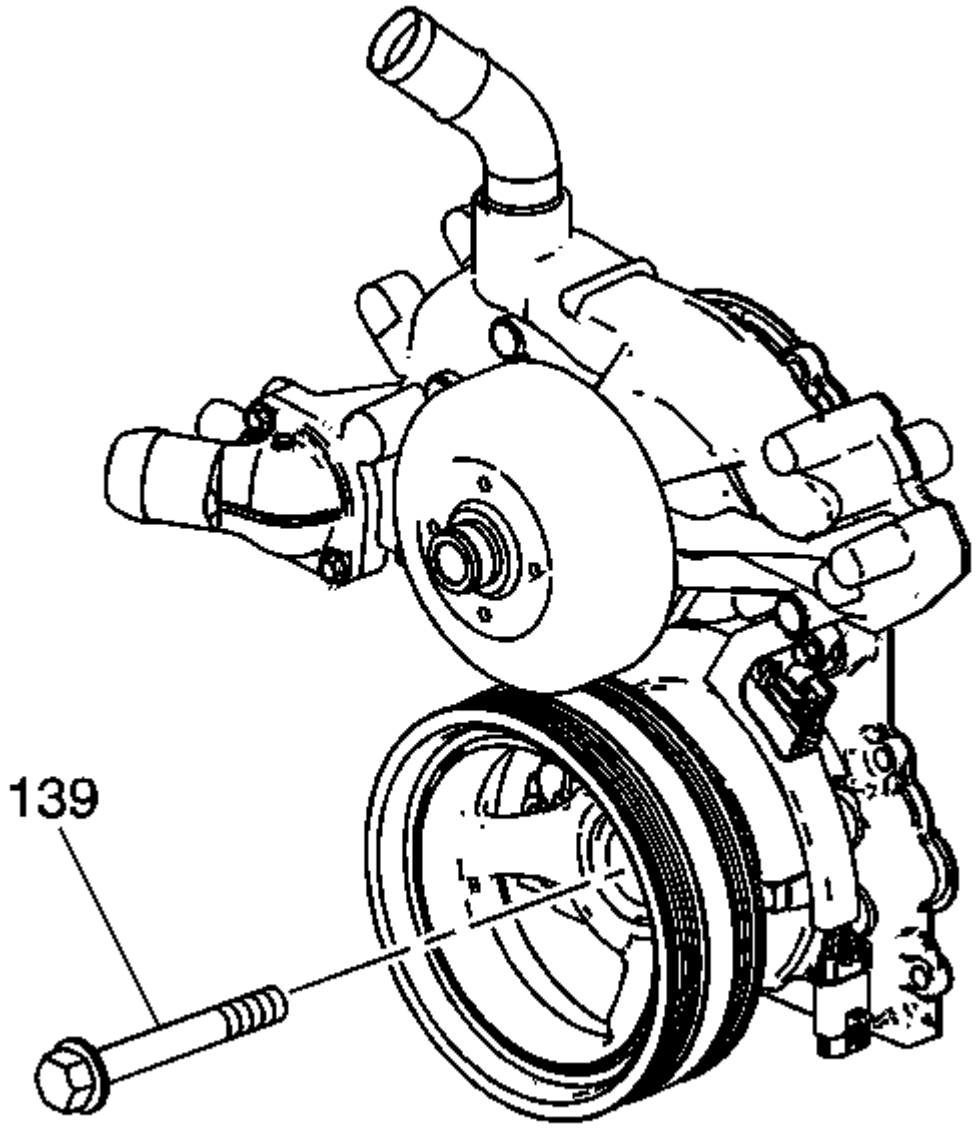

Fig. 656: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the used crankshaft balancer bolt (139).

   Tighten: Tighten the crankshaft balancer bolt to 330 N.m (240 lb ft).

5. Remove the used crankshaft balancer bolt.

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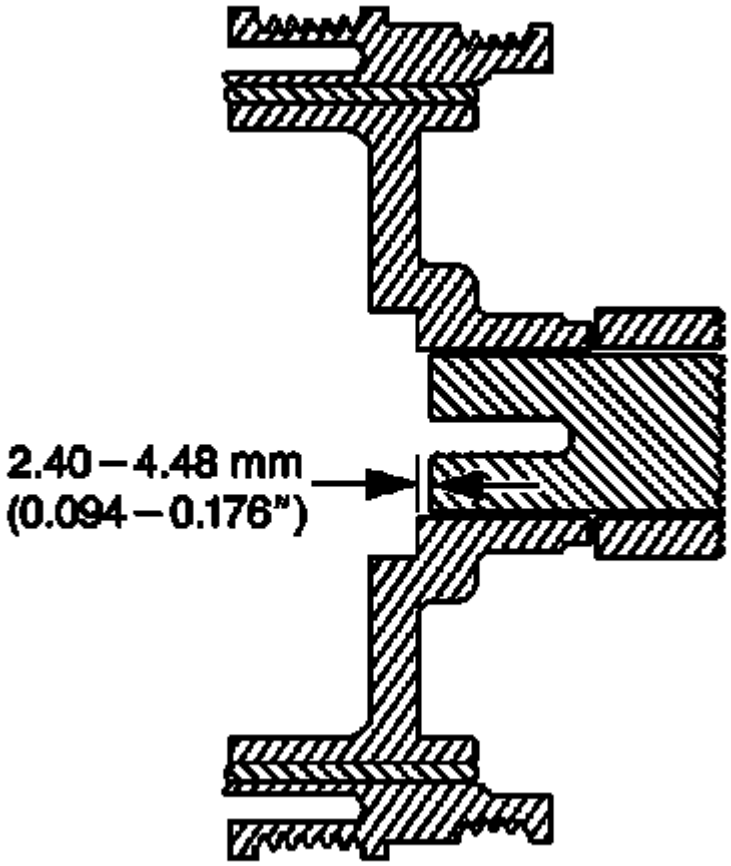

Fig. 657: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.

6. Measure for a correctly installed balancer.

   If the balancer is not installed to the proper dimensions, install the **J 41665** and repeat the installation procedure. See **Special Tools**.

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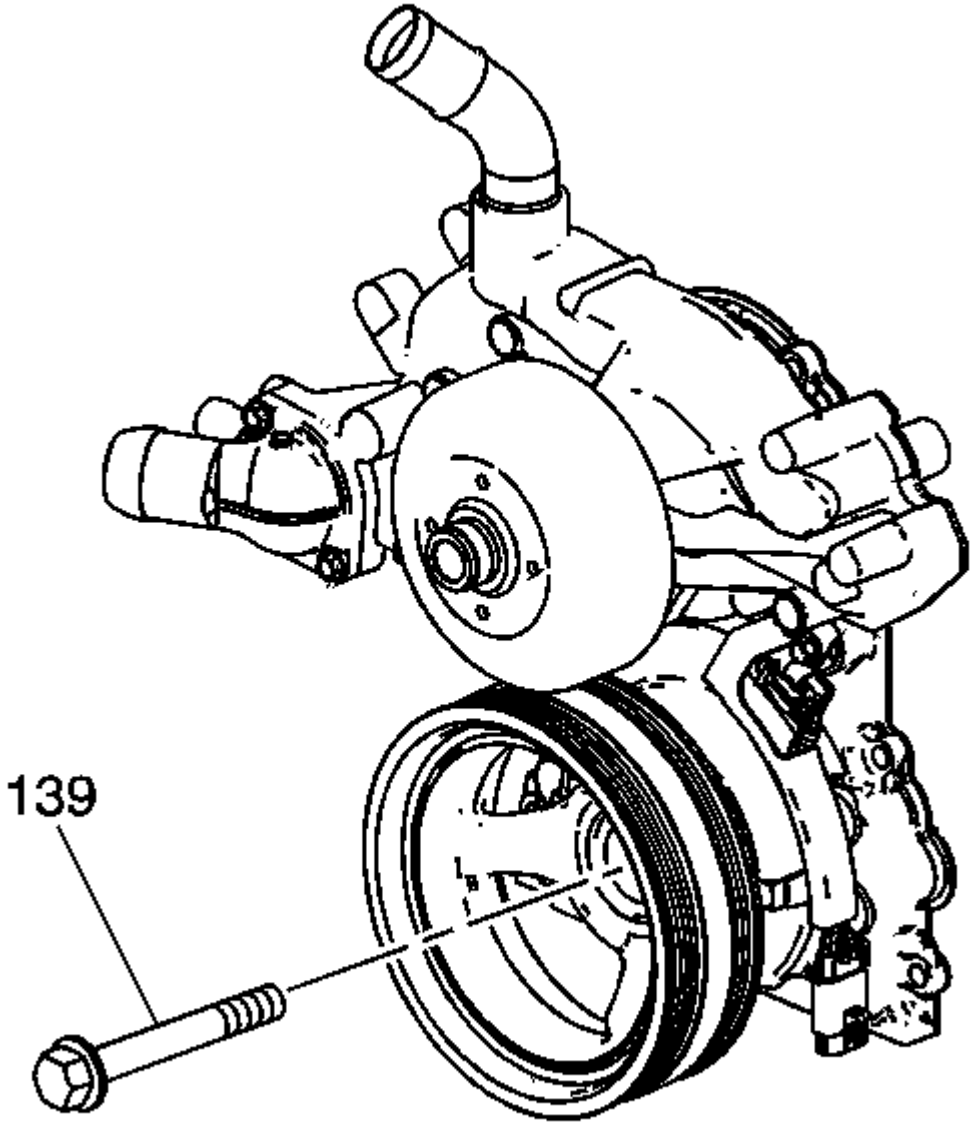

Fig. 658: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW crankshaft balancer bolt (139).

Tighten:

1. Tighten the crankshaft balancer bolt a first pass to 50 N.m (37 lb ft).

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2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the **J 45059** .

8. Remove the **J 42386-A** . See **Special Tools**.

Engine Prelubing

Tools Required

J 45299 Engine Preluber

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owner's manual.

1. Remove the engine oil filter, and fill with clean engine oil.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

Tighten: Tighten the oil filter to 30 N.m (22 lb ft).

3. Locate the engine block left front oil gallery plug (116).

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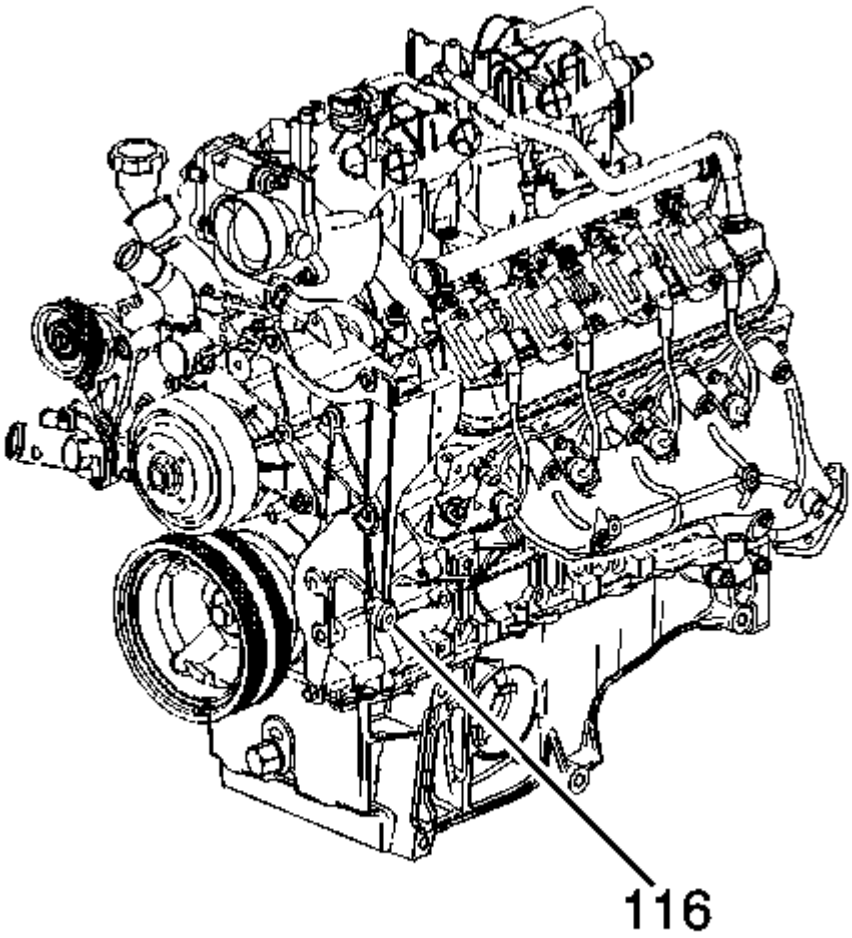

Fig. 659: Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

4. Install the M16 x 1.5 adapter P/N 509375.

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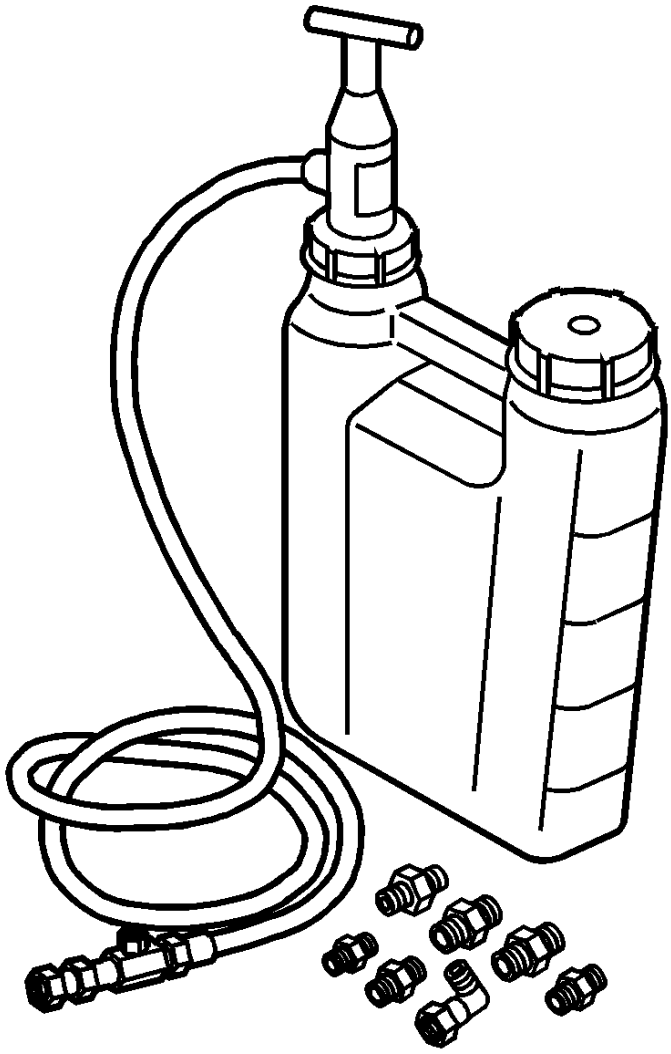

Fig. 660: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the **J 45299** in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine.

   Tighten: Tighten the oil gallery plug to 60 N.m (44 lb ft).

9. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

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A closed crankcase ventilation system provides a more complete scavenging of crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation pipe/passage into the intake manifold.

Results of Incorrect Operation

A plugged positive crankcase ventilation (PCV) pipe/passage way may cause any of the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

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 plies 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.

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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

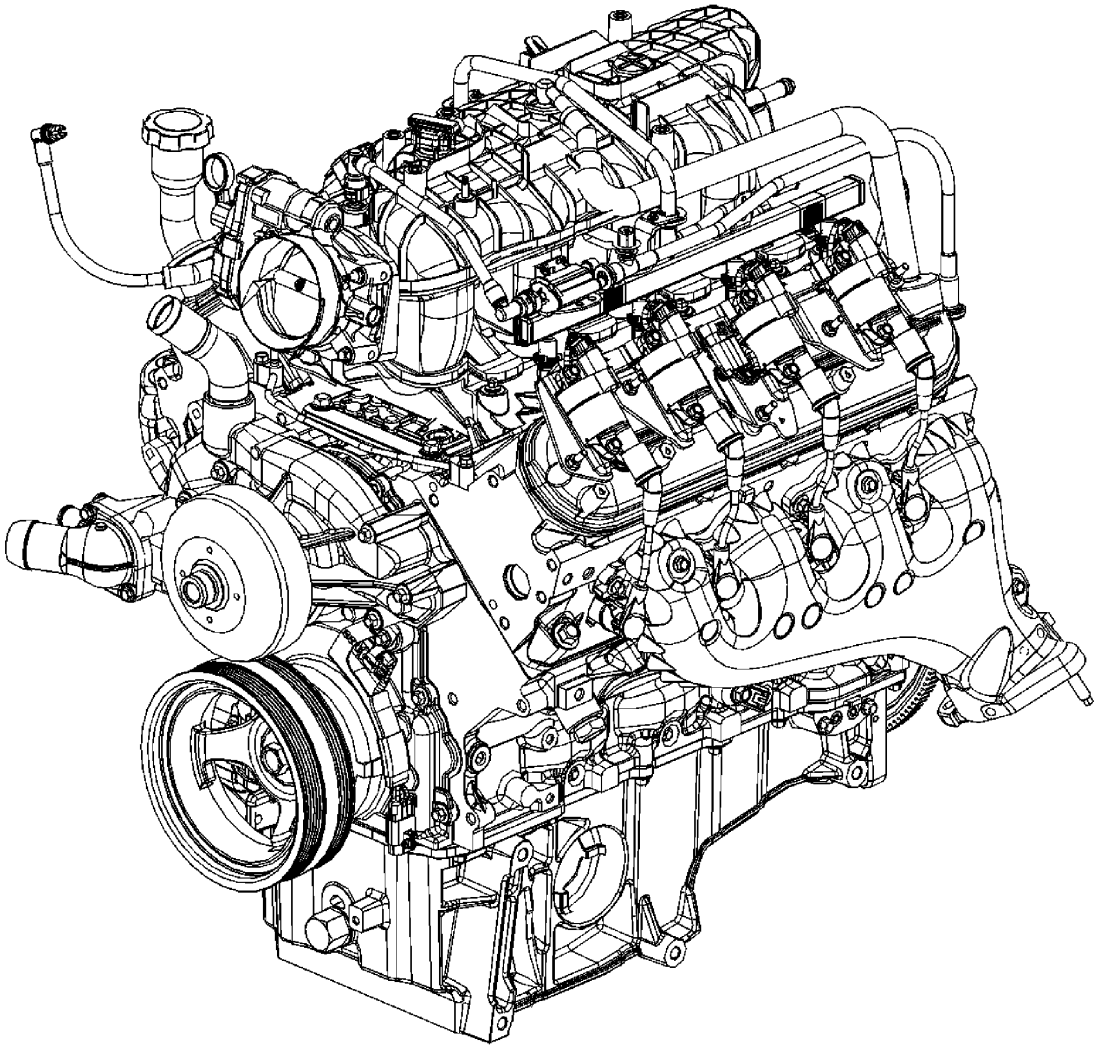

Fig. 661: 5.3L V8 Engine
Courtesy of GENERAL MOTORS CORP.

The 5.3 liter V8 engine is identified as RPO LH6 VIN M.

Camshaft and Drive System

A billet steel one piece camshaft is supported by 5 bearings pressed into the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the camshaft timing chain. The camshaft position (CMP) sensor lobes are incorporated into the front face of the camshaft

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sprocket with the CMP sensor mounted in the engine front cover. A timing chain dampener is mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location.

Crankshaft

The crankshaft is cast nodular iron. The crankshaft is supported by 5 crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A crankshaft position (CKP) reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.

Cylinder Heads

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. Passages for the engine coolant air bleed system are at the front of each cylinder head. The valve rocker arm covers are retained to the cylinder heads by 4 center mounted rocker arm cover bolts.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V configuration with 5 crankshaft bearing caps. The engine block is cast aluminum. The 5 crankshaft bearing caps each have 4 vertical M10 and 2 horizontal M8 mounting bolts. The camshaft is supported by 5 camshaft bearings pressed into the block.

Exhaust Manifolds

The exhaust manifolds are a one-piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a one-piece composite design that incorporates brass threaded inserts for mounting the fuel rail, throttle body, and wire harness studs. Each side of the intake manifold is sealed to the cylinder head by a non-reusable silicone sealing gasket/nylon carrier assembly. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a one-piece push in place silicone gasket. The fuel rail assembly, with 8 separate fuel injectors, is retained to the intake by 4 bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. A fuel rail stop bracket is retained to the rear of the left cylinder head by a mounting bolt. The manifold absolute pressure (MAP) sensor is installed and retained to the top front of the intake manifold and sealed by an O-ring seal. The evaporative emission (EVAP) solenoid valve is mounted to the fuel rail at the left front of the intake manifold. There are no coolant passages within the intake manifold.

Oil Pan

The structural front-sump oil pan is cast aluminum. Incorporated into the design is the oil filter mounting boss, drain plug opening, oil level indicator tube opening, and oil pan baffle. An internal oil filter tube directs

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pressurized oil from the engine block to the oil filter. Filtered oil is returned to the engine block through the oil filter tube to the engine block upper oil galleries. The oil filter tube assembly, which is mounted in the center area of the pan, includes the press-fit oil pressure relief valve. The alignment of the structural oil pan to the rear of the engine block and transmission bell housing is critical.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a flat or recessed top and barrel shaped skirt. The piston pins are chromium steel and are a full-floating design. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance. All applications use a piston with a graphite coated skirt. The piston and pin are to be serviced as an assembly.

Valve Rocker Arm Cover Assemblies

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the coil and bracket assemblies. Incorporated into the left cover is the positive crankcase ventilation (PCV) system dirty air passage. Incorporated into the right cover are the oil fill tube and the PCV fresh air passage.

Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve lifter guides position and retain the valve lifters. The valve rocker arms for each bank of cylinders are mounted on pedestals or pivot supports. Each rocker arm is retained on the pivot support and cylinder head by a bolt. Valve lash is net build. Cylinders 1, 4, 6, and 7 are displacement on demand. Refer to **Displacement on Demand (DOD) System Description**.

DISPLACEMENT ON DEMAND (DOD) SYSTEM DESCRIPTION

System Operation

General Motors Displacement on Demand® (DOD) engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy by deactivating 4 of the engines 8 cylinders. The engine will normally operate on 8 cylinders in V8 mode during, starting, idling, and medium or heavy throttle conditions. When commanded ON, the engine control module (ECM) will direct the DOD system and deactivate cylinders 1 and 7 on the left bank and cylinders 4 and 6 on the right bank, forcing V4 mode. Refer to **Lubrication Description (Main Pressure Below 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Above 55 psi - DOD Off)** or **Lubrication Description (Main Pressure Below 55 psi - DOD On)** or **Lubrication Description (Main Pressure Above 55 psi - DOD On)** and **Displacement on Demand (DOD) System Description** in Engine Controls.

Valve Lifter Oil Manifold Assembly

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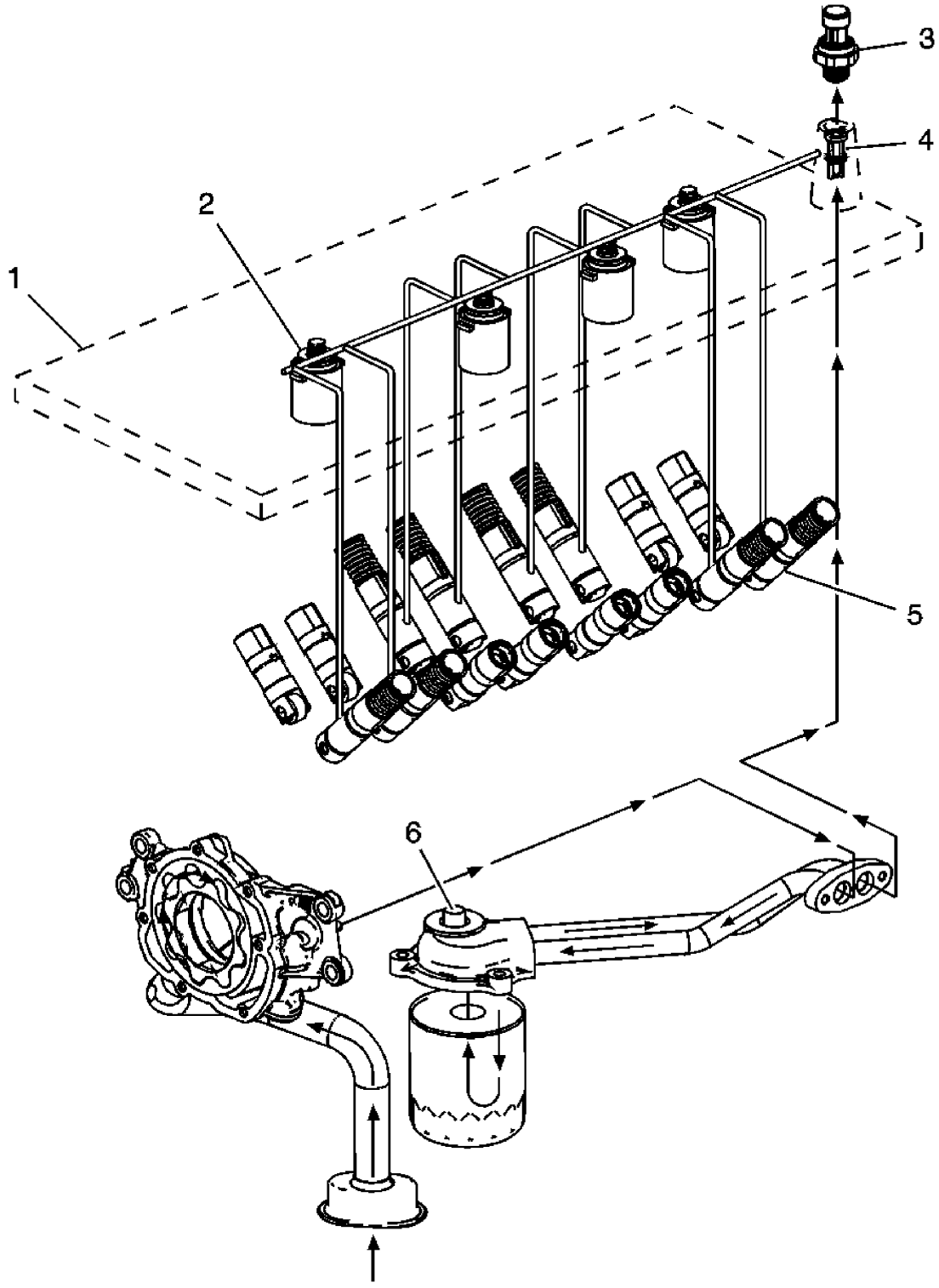

Fig. 662: Valve Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS CORP.

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The valve lifter oil manifold (VLOM) assembly (1) is bolted to the top of the engine block beneath the intake manifold assembly. The oil manifold consists of 4 electrically operated and normally-closed solenoids (2). Each solenoid directs the flow of pressurized engine oil to the DOD intake and exhaust valve lifters (5). The oil pressure relief valve (6), located in the oil pan, regulates engine oil pressure to the lubrication system and the oil manifold.

When enabling conditions are met for DOD operation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the windings energized, the solenoid valves open and direct pressurized engine oil through the VLOM into 8 vertical passages in the engine block lifter valley. The 8 vertical passages, 2 per cylinder, direct pressurized oil to the valve lifter bores of the cylinders to be deactivated. When vehicle operating conditions require a return to V8 mode, the ECM will turn OFF the ground circuit for the solenoids, allowing the solenoid valves to close. When the solenoid valves are closed, remaining oil pressure is exhausted through the bleed passages of the VLOM into the engine block lifter valley. The housing of the oil manifold incorporates several oil bleed passages that continually purge trapped air from the manifold and engine block.

To help control contamination within the DOD hydraulic system, a small replaceable oil filter (4) is located in the VLOM oil inlet passage. The oil pressure sensor (3) monitors engine oil pressure and provides information to the ECM.

Displacement On Demand Valve Lifters

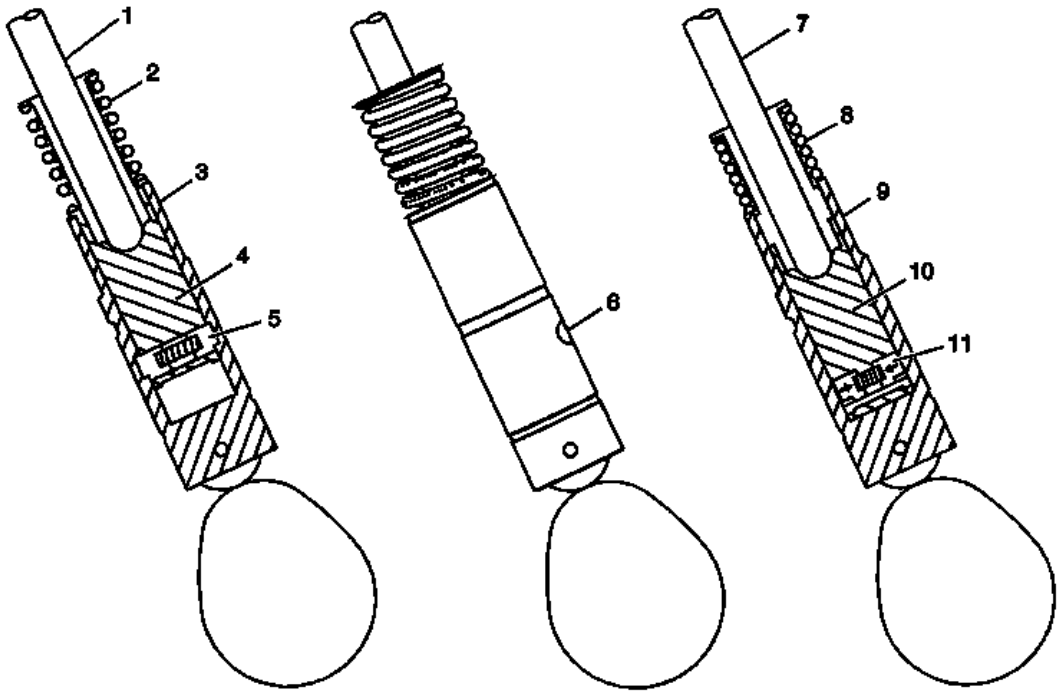

Fig. 663: Displacement On Demand Valve Lifters
Courtesy of GENERAL MOTORS CORP.

When operating in V8 mode, the DOD valve lifters function similar to the non-DOD valve lifters. The DOD oil manifold solenoids are in the closed position, with no pressurized oil directed to the valve lifters. The pushrod

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(1) travels upward and downward to actuate the rocker arm and valve. The spring loaded locking pins (5) of the lifter are extended outward and mechanically lock the pin housing (4) to the outer body of the valve lifter (3).

When the DOD system is commanded ON, the ECM will direct the solenoids of the oil manifold to open and direct pressurized oil to the valve lifters. Oil travels through the VLOM and engine block oil galleries and enters the inlet port (6) of the valve lifter.

When operating in V4 mode, pressurized oil forces the locking pins (11) inward. The pushrod (7) remains in a constant position and does not travel upward and downward. The outer body of the lifter (9) moves upward and downward independently from the pin housing (10). The valve lifter spring (8) retains tension on the valve train components to eliminate valve train noise.

When the DOD system is commanded OFF, the ECM directs the solenoids of the oil manifold to close, stopping the flow of pressurized oil to the valve lifters. The oil pressure within the lifter will decrease and the locking pins will move outward to mechanically lock the pin housing and outer body.

Engine Block

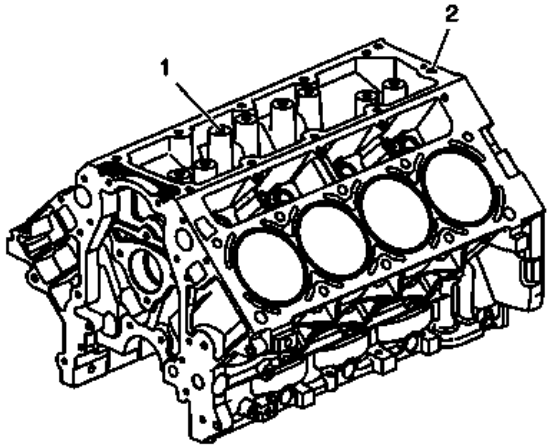

Fig. 664: DOD Engine Block
Courtesy of GENERAL MOTORS CORP.

The DOD engine block incorporates additional features to support DOD system operation. Engine oil pressure is routed to the VLOM assembly from an oil gallery (2) in the rear of the cylinder block. Cylinders 1, 4, 6, and 7 each have 2 vertical, cast-in-block oil passages (1). The vertical oil passages permit oil flow from the manifold assembly to the valve lifter bores.

Engine Control Module (ECM)

Refer to **Displacement on Demand (DOD) System Description** in Engine Controls - 5.3L.

LUBRICATION DESCRIPTION (MAIN PRESSURE BELOW 55 PSI - DOD OFF)

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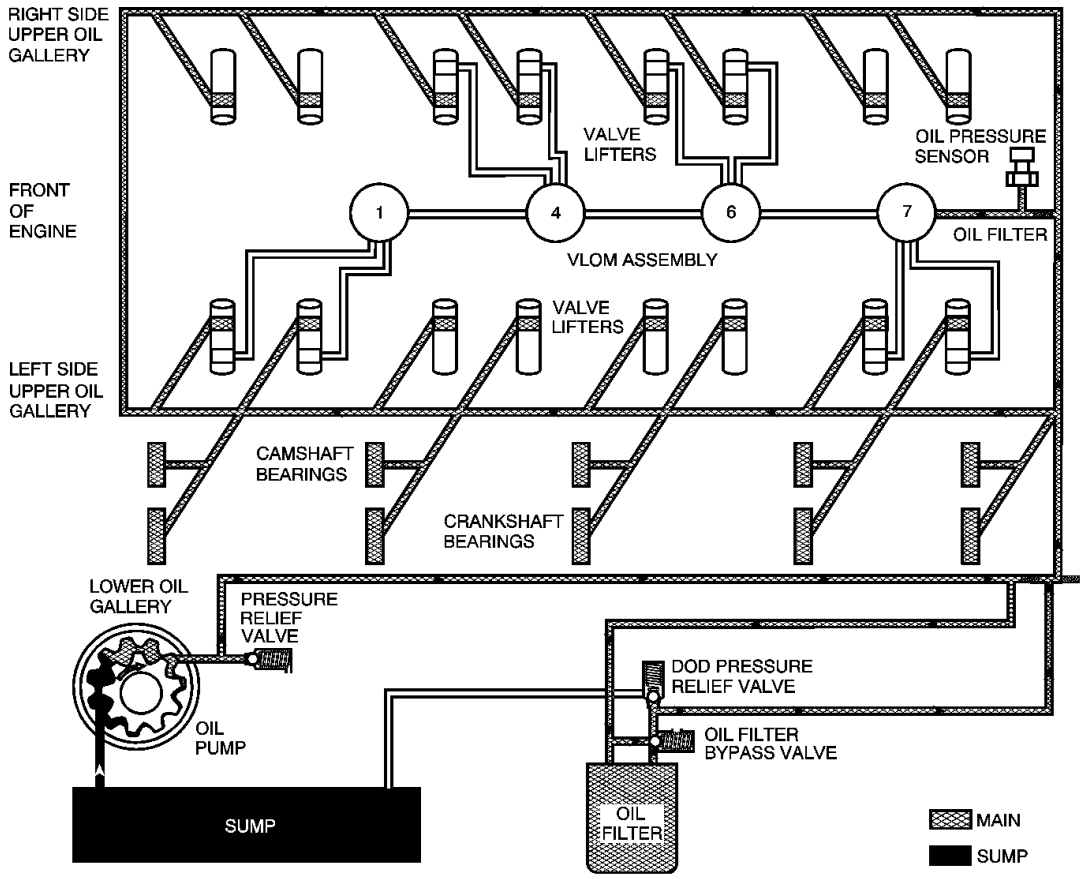

Fig. 665: Lubrication Flow
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery and through the oil filter tube to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan at the oil filter boss, which permits oil flow in the event the filter becomes restricted. A second valve, the displacement on demand (DOD) oil pressure relief valve is incorporated into the oil filter tube. The DOD oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 379-517 kPa (55-75 psi) maximum.

Oil is then directed from the filter to the upper main oil galleries and the valve lifter oil manifold (VLOM) assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the

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crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine. Refer to **Displacement on Demand (DOD) System Description**.

LUBRICATION DESCRIPTION (MAIN PRESSURE ABOVE 55 PSI - DOD OFF)

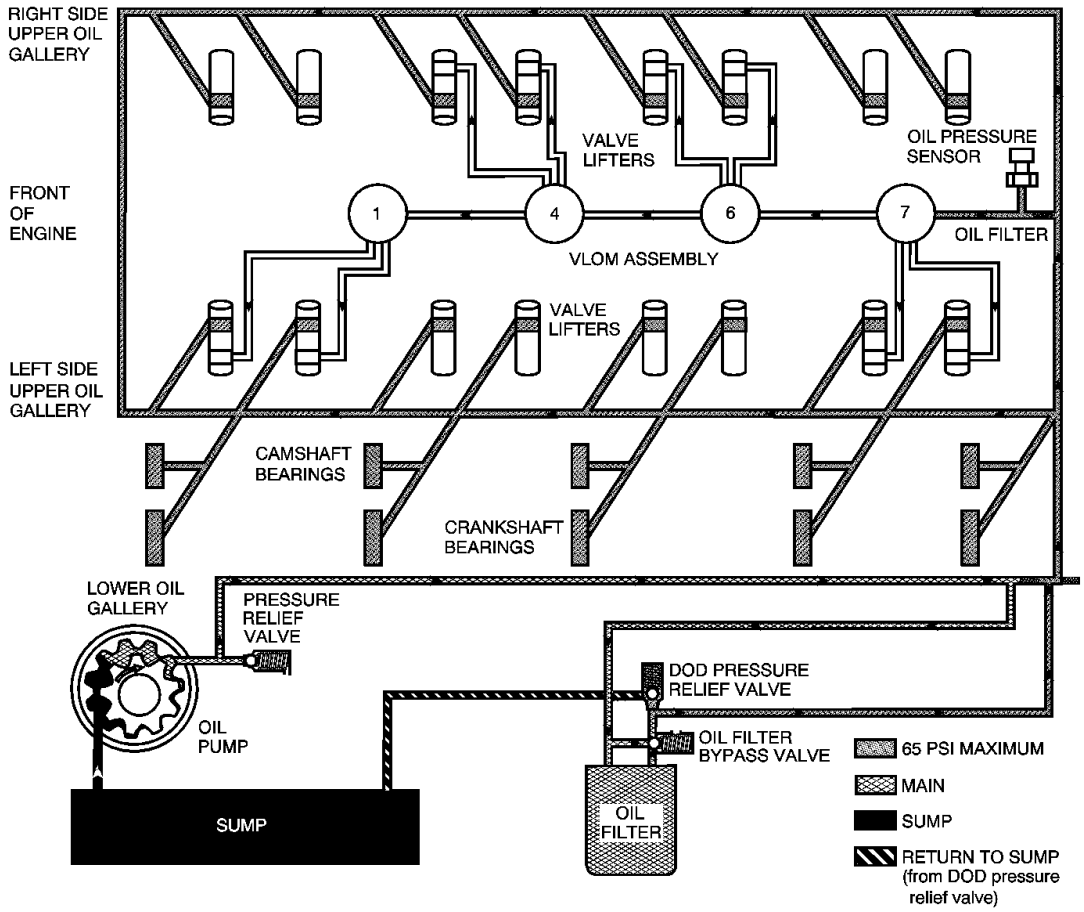

Fig. 666: Lubrication Flow
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery and through the oil filter tube to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan at the oil filter boss, which permits oil flow in the event the filter becomes restricted. A second valve, the displacement on demand (DOD) oil pressure relief valve is incorporated into the oil filter tube. The DOD oil pressure relief valve limits oil pressure directed to the upper oil galleries and valve lifter oil manifold (VLOM)

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assembly to 379-517 kPa (55-75 psi) maximum. When main oil pressure exceeds 379 kPa (55 psi), the DOD oil pressure relief valve exhausts excess oil to the sump.

Oil is then directed from the filter to the upper main oil galleries and the VLOM assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine. Refer to **Displacement on Demand (DOD) System Description**.

LUBRICATION DESCRIPTION (MAIN PRESSURE BELOW 55 PSI - DOD ON)

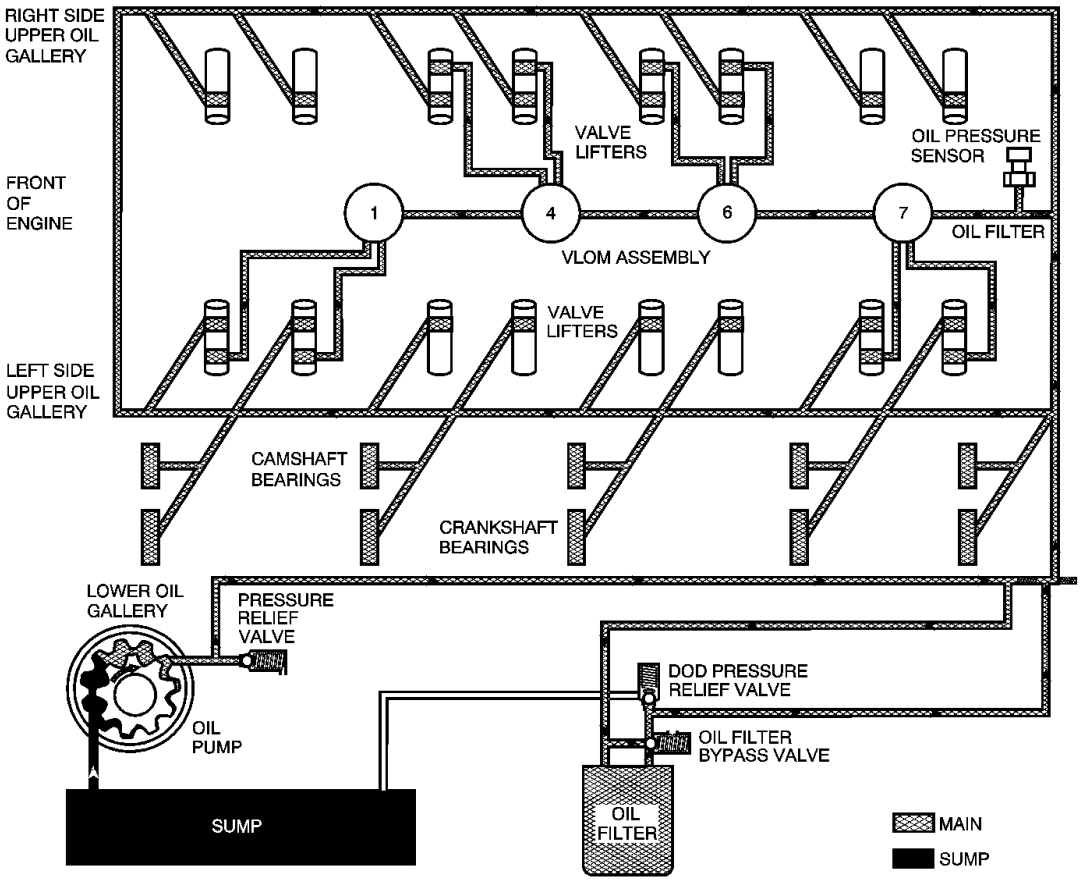

Fig. 667: Lubrication Flow
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

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Pressurized oil is directed through the engine block lower oil gallery and through the oil filter tube to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan at the oil filter boss, which permits oil flow in the event the filter becomes restricted. A second valve, the displacement on demand (DOD) oil pressure relief valve is incorporated into the oil filter tube. The DOD oil pressure relief valve limits oil pressure directed to the upper oil galleries and oil manifold assembly to 379-517 kPa (55-75 psi) maximum.

Oil is then directed from the filter to the upper main oil galleries and the valve lifter oil manifold (VLOM) assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine.

With DOD activated, the engine control module (ECM) commands the 4 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 1, 4, 6, and 7. Refer to **Displacement on Demand (DOD) System Description**.

LUBRICATION DESCRIPTION (MAIN PRESSURE ABOVE 55 PSI - DOD ON)

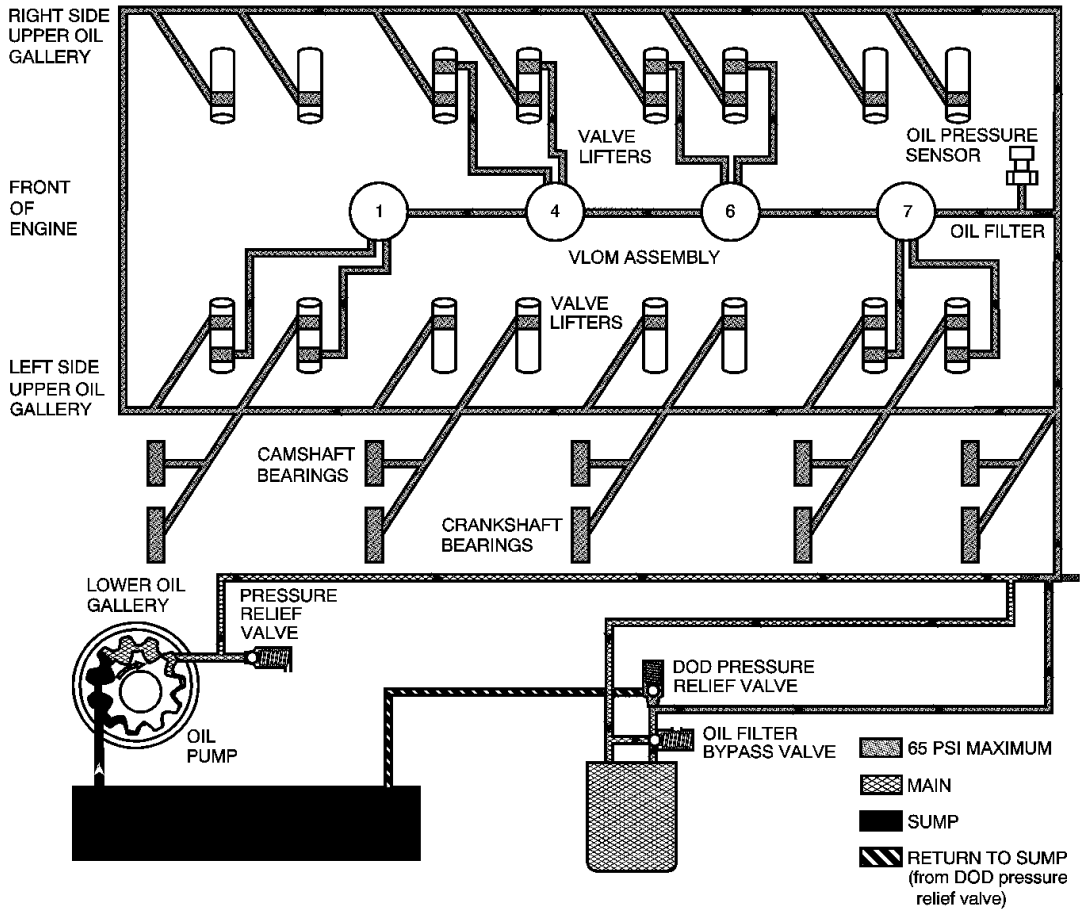

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Fig. 668: Lubrication Flow
Courtesy of GENERAL MOTORS CORP.

Engine lubrication is supplied by a gerotor type oil pump assembly. The pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery and through the oil filter tube to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil pan at the oil filter boss, which permits oil flow in the event the filter becomes restricted. A second valve, the displacement on demand (DOD) oil pressure relief valve is incorporated into the oil filter tube. The DOD oil pressure relief valve limits oil pressure directed to the upper oil galleries and valve lifter oil manifold (VLOM) assembly to 379-517 kPa (55-75 psi) maximum. When main oil pressure exceeds 379 kPa (55 psi), the DOD oil pressure relief valve exhausts excess oil to the sump.

Oil is then directed from the filter to the upper main oil galleries and the VLOM assembly. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine.

With DOD activated, the engine control module (ECM) commands the 4 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 1, 4, 6, and 7. Refer to **Displacement on Demand (DOD) System Description**.

CLEANLINESS AND CARE

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for assembly. Refer to **Separating Parts**.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

SEPARATING PARTS

IMPORTANT:
- **Many internal engine components will develop specific wear patterns on**

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their friction surfaces.

- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation 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 location and orientation 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 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

Gasket Use and Applying Sealants

- Do not use any gasket again unless specified.
- Gaskets that can be used again 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 a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

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- Remove all gasket and sealing material from the part using the J 28410 or equivalent.
- 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

NOTE: Refer to Sealant Notice in Cautions and Notices.

- 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.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Pipe Joint Compound

IMPORTANT: Three types of sealer are commonly used in engines. These are room temperature vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type of sealer is used where two non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

NOTE: Refer to Sealant Notice in Cautions and Notices.

- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.

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- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- RTV sealant hardens when exposed to air. This type of sealer is used where two non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

  NOTE: Refer to Sealant Notice in Cautions and Notices.

- Apply RTV sealant to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes.
- Assemble components while the RTV sealant is still wet, within 3 minutes. Do not wait for the RTV sealant to skin over.
- Tighten bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be sealed must be clean and dry.

  NOTE: Refer to Sealant Notice in Cautions and Notices.

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

  IMPORTANT: Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

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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 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.

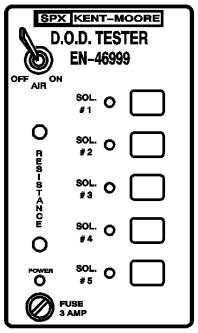
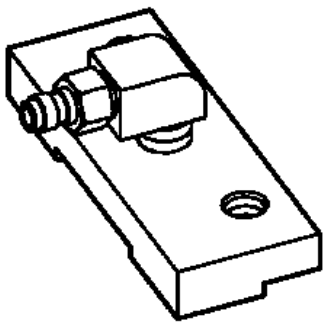
To properly service the engine assembly, the following items should be readily available:

- 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
	EN-46999 Displacement on Demand Tester
	EN-46999-1 Displacement on Demand Tester Air Adapter

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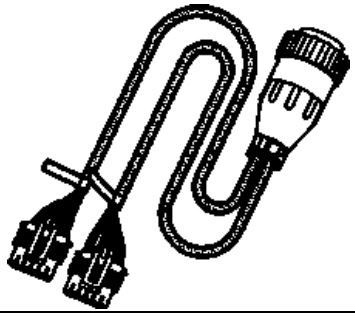
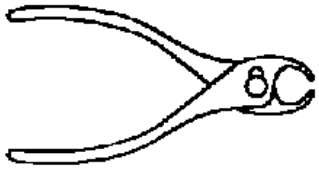
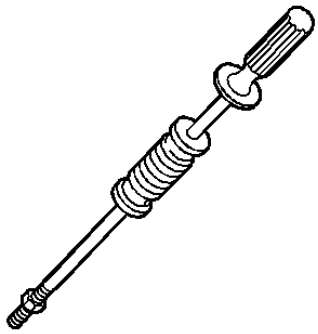
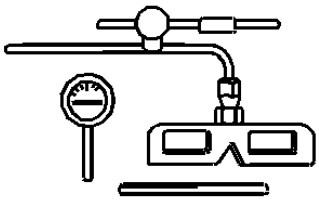
	EN-46999-5 Displacement on Demand Tester Harness - Small Block V8
	J 3049-A Valve Lifter Remover
	J 6125-1B Slide Hammer with Adapter
	J 7872 Magnetic Base Dial Indicator Set
	J 8001 Dial Indicator Set

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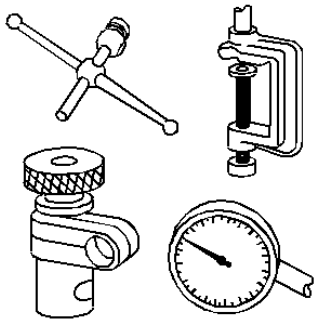
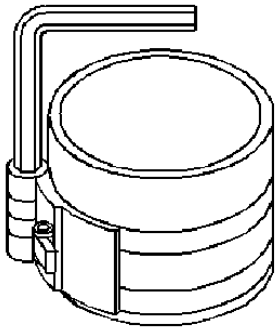
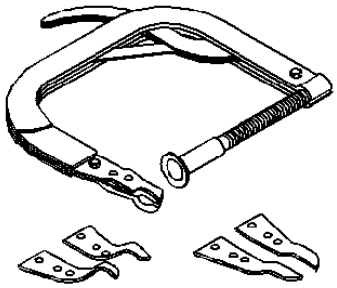
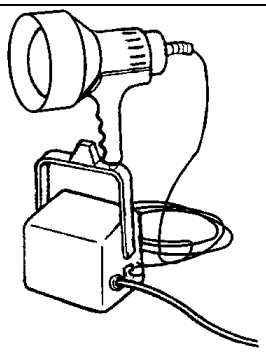
	
	J 8037 Ring Compressor
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage
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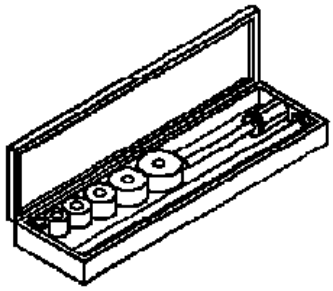
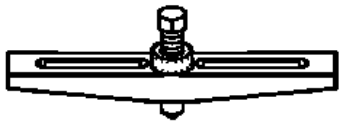
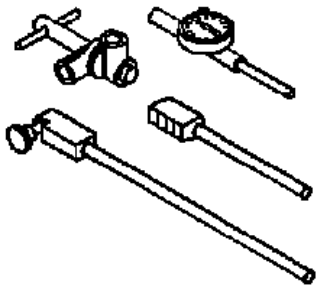
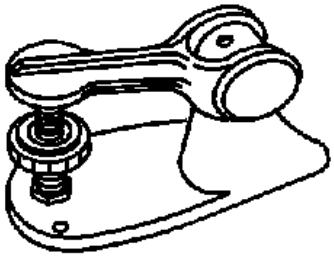
	Carbon Removal Brush
	J 8433-1 Puller Bar
	J 8520 Cam Lobe Lift Indicator
	J 9666 Valve Spring Tester
	J 21366 Converter Holding Strap

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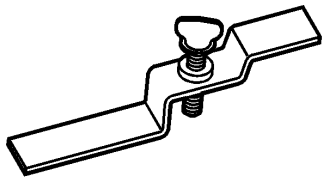
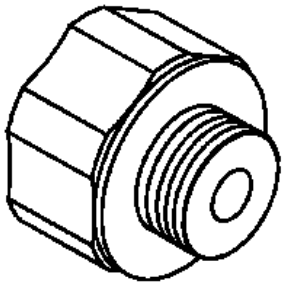
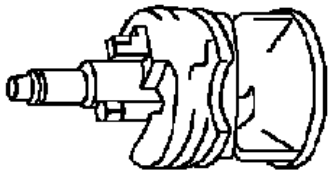
	
	J-21867-16 Oil Pressure Adapter
	J 22794 Spark Plug Port Adapter
	J 24270 Cylinder Bore Ridge Reamer
	J 28410 Gasket Remover

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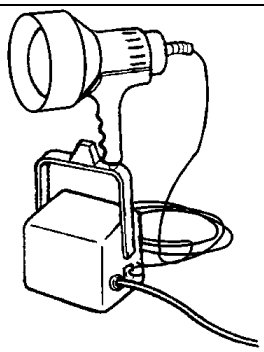
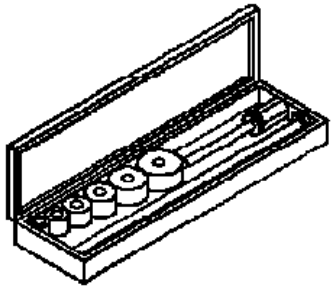
	J 28428-E High-Intensity Black Light Kit
	J 33049 Camshaft Bearing Service Set
	J 35667-A Cylinder Head Leakdown Tester
	J 37378-1 Valve Guide Reamer

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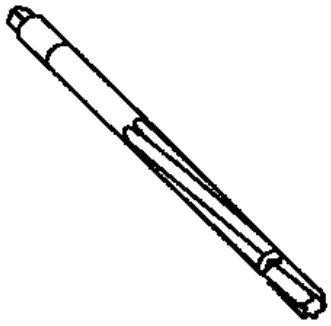
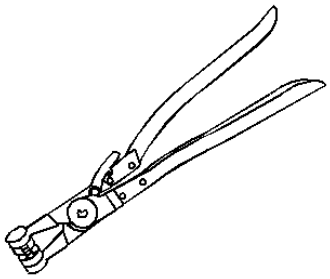
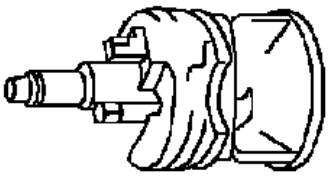
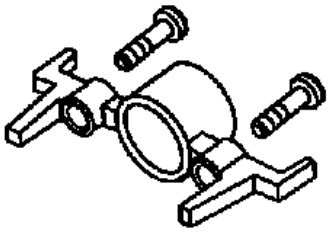
	
	J 38185 Hose Clamp Pliers
	J 38606 Valve Spring Compressor
	J 41476 Front and Rear Cover Alignment Tool
	J 41478 Crankshaft Front Oil Seal Installer

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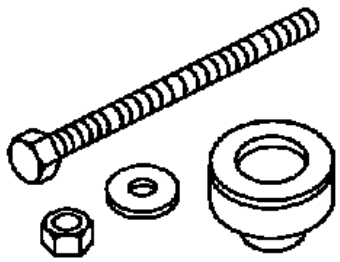
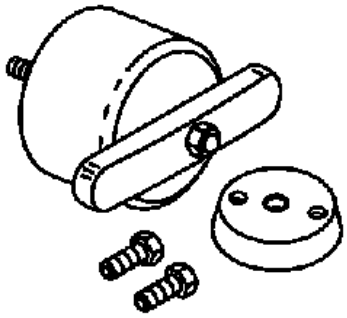
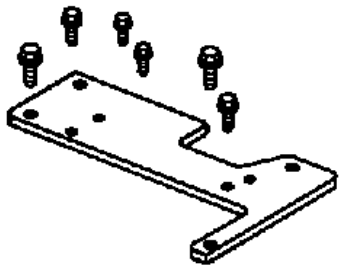
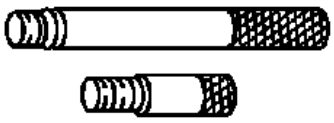
	
	J 41479 Crankshaft Rear Oil Seal Installer
	J 41480 Front and Rear Cover Alignment
	J 41556 Connecting Rod Guide
	J 41558

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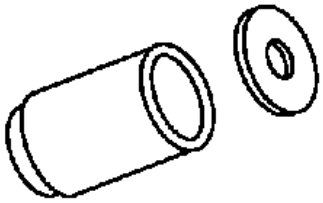
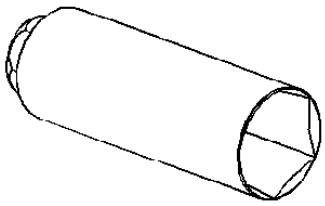
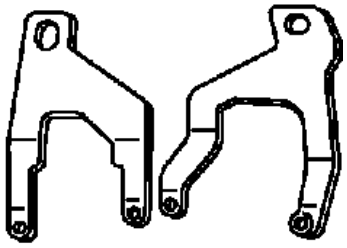
	Crankshaft Sprocket Remover
	J 41665 Crankshaft Balancer and Sprocket Installer
	J 41712 Oil Pressure Switch Socket
	J 41798 Engine Lift Bracket
	J 41816 Crankshaft Balancer Remover

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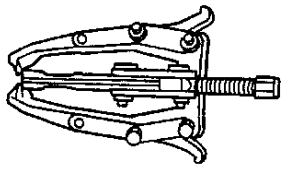
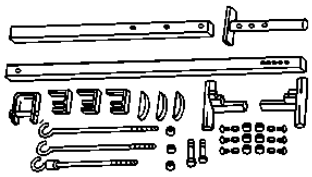
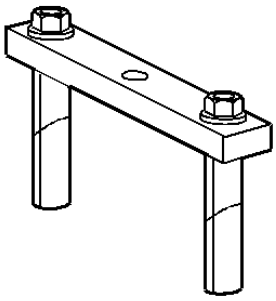
	
	J 41816-2 Crankshaft End Protector
	J 41818 Crankshaft Bearing Cap Remover
	J 42385-100 Head/Main Bolt Thread Repair Kit
	J 42385-200 Common Thread Repair Kit

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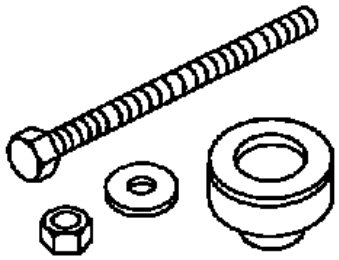
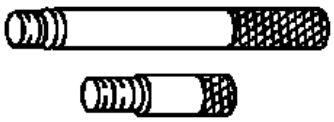
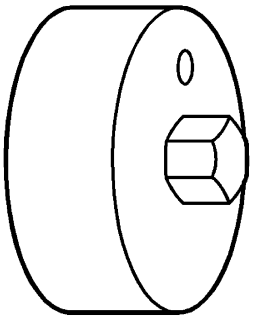
	
	J 42385-300 Fixtures and Hardware Kit
	J 42386-A Flywheel Holding Tool
	J 42907 Oil Pressure Tester
	J 43690 Rod Bearing Checking Tool

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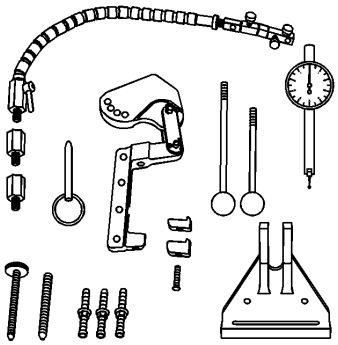
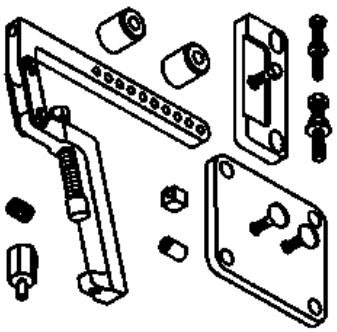
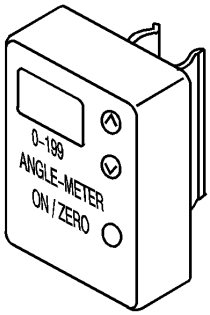
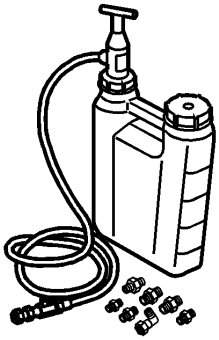
	
	J 43690-100 Rod Bearing Checking Tool - Adapter Kit
	J 45059 Angle Meter
	J 45299 Engine Preluber

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