SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
Accessory Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Accessory Drive Belt Tensioner Bolts	50 N.m	37 lb ft
Active Fuel Management Oil Pressure Relief Valve	27 N.m	20 lb ft
Air Conditioning Drive Belt Tensioner Bolts	50 N.m	37 lb ft
Automatic Transmission Flex Plate Bolts - First Pass	20 N.m	15 lb ft
Automatic Transmission Flex Plate Bolts - Second Pass	50 N.m	37 lb ft
Automatic Transmission Flex Plate Bolts - Final Pass	100 N.m	74 lb ft
Battery Cable Channel Bolt	12 N.m	106 lb in
Camshaft Position (CMP) Actuator Magnet Bolts	12 N.m	106 lb in
Camshaft Position (CMP) Actuator Solenoid Valve - First Pass	65 N.m	48 lb ft
Camshaft Position (CMP) Actuator Solenoid Valve - Final Pass	90 degrees	
Camshaft Position (CMP) Sensor Bolt	12 N.m	106 lb in
Camshaft Position (CMP) Sensor Wire Harness Bolt	12 N.m	106 lb ft
Camshaft Retainer Bolts - Hex Head Bolts	25 N.m	18 lb ft
Camshaft Retainer Bolts - TORX Head Bolts	15 N.m	11 lb ft
Camshaft Sprocket Bolt - First Pass	75 N.m	55 lb ft
Camshaft Sprocket Bolt - Final Pass	50 degrees	
Connecting Rod Bolts - First Pass	20 N.m	15 lb ft
Connecting Rod Bolts - Final Pass	85 degrees	
Coolant Air Bleed Pipe and Cover Bolts	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 M8 Bolts	25 N.m	18 lb ft
Crankshaft Bearing Cap M10 Bolts - First Pass in Sequence	20 N.m	15 lb ft
Crankshaft Bearing Cap M10 Bolts - 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 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	30 N.m	22 lb ft
Cylinder Head M8 Bolts - in Sequence	30 N.m	22 lb ft
Cylinder Head M11 Bolts - First Pass in Sequence	30 N.m	22 lb ft
Cylinder Head M11 Bolts - Second Pass in Sequence	90 degrees	
Cylinder Head M11 Bolts - Final Pass in Sequence	70 degrees	
Cylinder Head Plug	20 N.m	15 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 Plugs	60 N.m	44 lb ft
Exhaust Manifold Bolts - First Pass	15 N.m	11 lb ft
Exhaust Manifold Bolts - Final Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolts	9 N.m	80 lb in
Exhaust Manifold Studs	20 N.m	15 lb ft
Front Cover Bolts	25 N.m	18 lb ft
Fuel Injection Fuel Rail Bolts	10 N.m	89 lb in
Fuel Injection Fuel Rail Crossover Tube Bolts	3.8 N.m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N.m	37 lb ft
Generator Bracket Bolts	50 N.m	37 lb ft
Ignition Coil Bracket-to-Valve Rocker Arm Cover Studs	12 N.m	106 lb in

Ignition Coil-to-Bracket Bolts	10 N.m	89 lb in
Intake Manifold Bolts - First Pass in Sequence	5 N.m	44 lb in
Intake Manifold Bolts - Final Pass in Sequence	10 N.m	89 lb in
Intake Manifold Sight Shield Retainer Bolts	5 N.m	44 lb in
J 41798 M8 Bolt	25 N.m	18 lb ft
J 41798 M10 Bolts	50 N.m	37 lb ft
Knock Sensor Bolts	25 N.m	18 lb ft
Oil Filter	30 N.m	22 lb ft
Oil Filter Fitting	55 N.m	40 lb ft
Oil Level Indicator Switch	20 N.m	15 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Pan Baffle Bolts	9 N.m	80 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 Bolts	9 N.m	80 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan M6 Bolts - Oil Pan-to-Rear Housing	12 N.m	106 lb in
Oil Pan M8 Bolts - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pressure Sensor	35 N.m	26 lb ft
Oil Pump Cover Bolts	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 Bolts	12 N.m	106 lb in
Oil Pump-to-Engine Block Bolts	25 N.m	18 lb ft
Power Steering Pump-to-Engine Block Bolts	50 N.m	37 lb ft
Spark Plugs	15 N.m	11 lb ft
Throttle Body Bolts	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 Tensioner Bolts	25 N.m	18 lb ft
Valley Cover Bolts	25 N.m	18 lb ft
Valve Lifter Guide Bolts	12 N.m	106 lb in
Valve Rocker Arm Bolts	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolts	12 N.m	106 lb in

Water Inlet Housing Bolts	15 N.m	11 lb ft
Water Pump Bolts - First Pass	15 N.m	11 lb ft
Water Pump Bolts - Final Pass	30 N.m	22 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	6.2L	376 CID
• RPO	L92	
• VIN	8	
• Bore	103.241-103.259 mm	4.065-4.065 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	10.5:1	
• Firing Order	1-8-7-2-6-5-4-3	
• 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	103.241-103.259 mm	4.065-4.065 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	0.22 mm	0.008 in

Deck		
• 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 - Exhaust	7.48 mm	0.294 in
• Camshaft Lobe Lift - Intake	7.48 mm	0.294 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
• 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 2 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
• Active Fuel Management 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	0.0-0.1 mm	0.0-0.004 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 - Measured in Cylinder Bore - Service	0.23-0.5 mm	0.009-0.0196 in
• 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 -	0.18-0.81 mm	0.007-0.032 in

Measured in Cylinder Bore - Service		
• 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 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
• Valves - Valve Lash	Net Lash - No Adjustment	

• Valve Lift - Exhaust	12.72 mm	0.501 in
• Valve Lift - Intake	12.72 mm	0.501 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 - Valve 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 - 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
• 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
• 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

Application	Type of Material	GM Part Number	
		United States	Canada
Coolant Temperature Sensor Threads	Sealant	12346004	10953480
Cylinder Head Core Hole Plug	Threadlock	12345382	10953489
Cylinder Head Plug	Threadlock	12345382	10953489
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480

Sealing Washer			
Engine Block Front Oil Gallery Plug	Threadlock	12345382	10953489
Engine Block Oil Gallery Plug Sealing Washers	Sealant	12346004	10953480
Engine Oil Pressure Sensor Threads	Sealant	12346004	10953480
Engine Oil Supplement	Fluorescent Dye	12345795	10953470
Exhaust Manifold Bolts	Threadlock	12345493	10953488
Flywheel/Flex Plate Bolts	Threadlock	12345382	10953489
Fuel Injection Fuel Rail Bolts	Threadlock	12345382	10953489
Ignition Coil Bracket-to-Valve Cover Studs	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	12378521	88901148
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

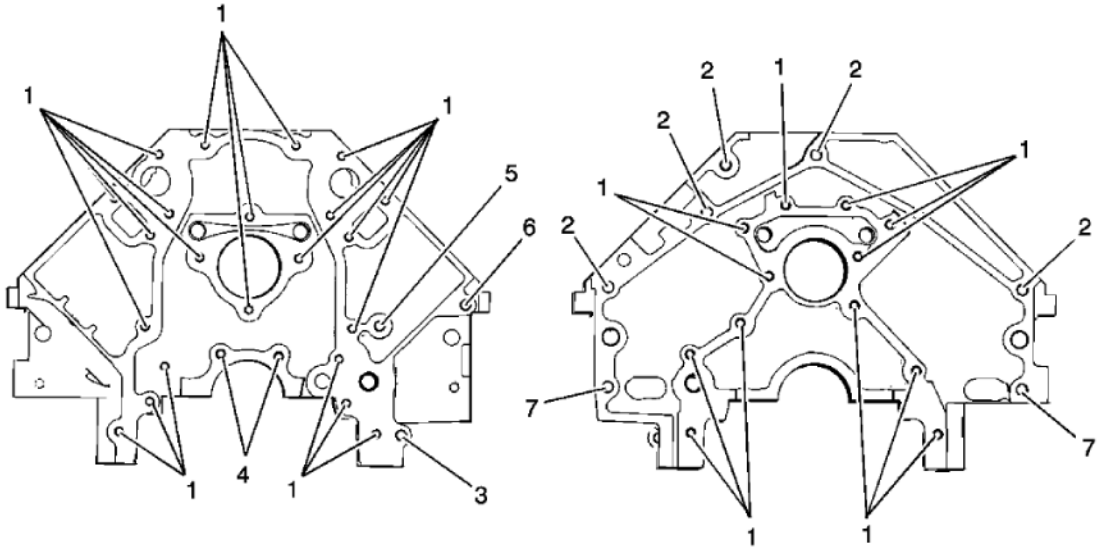

Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS CORP.

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

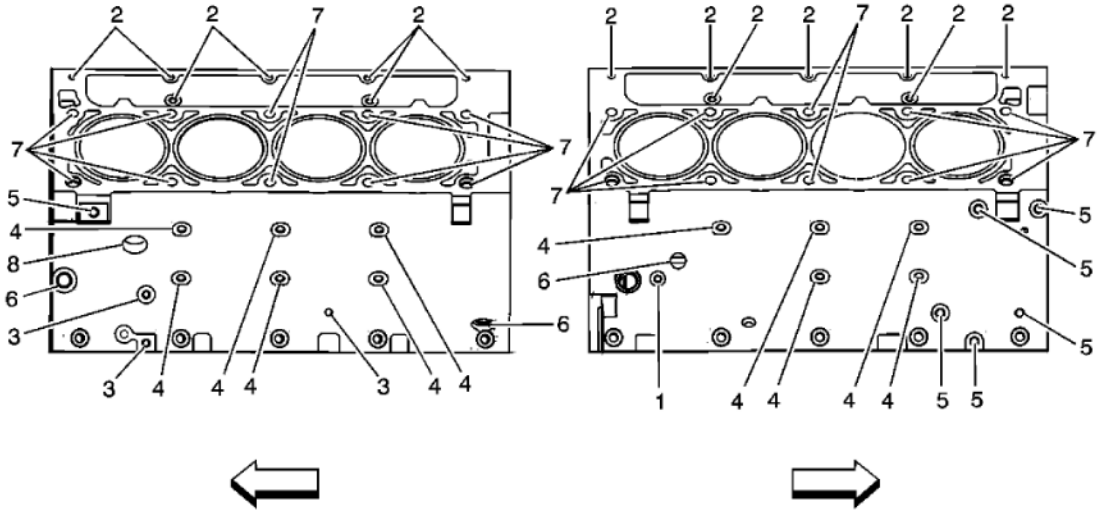

Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS CORP.

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	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

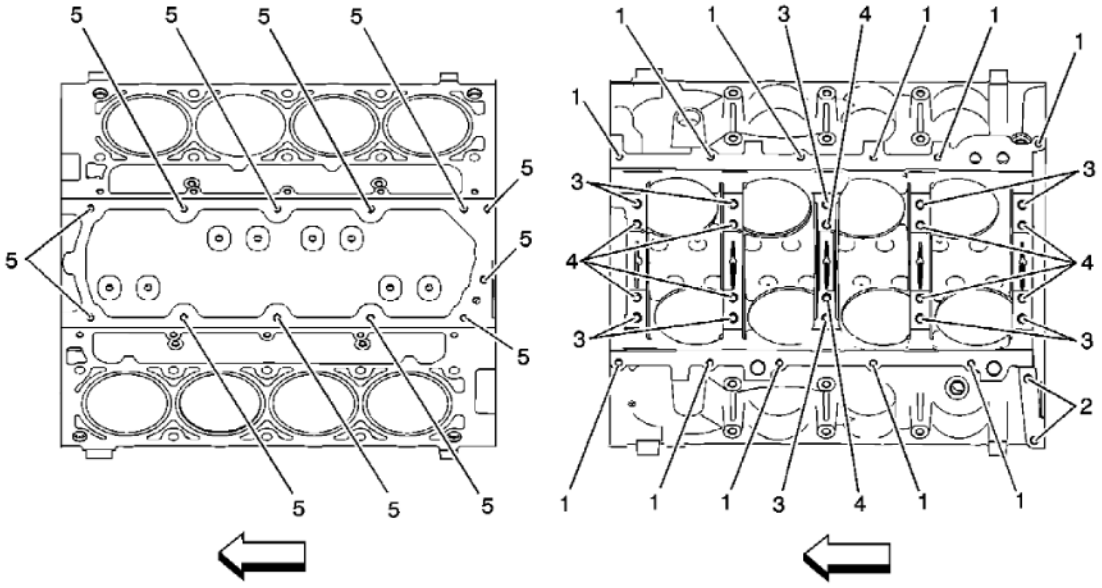

Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS CORP.

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	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

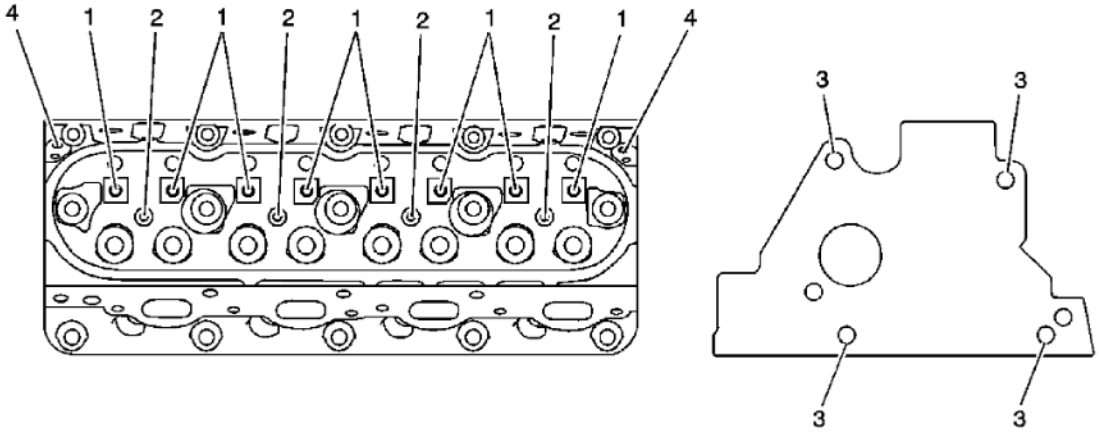

Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS CORP.

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 (0.789)	16.05 (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

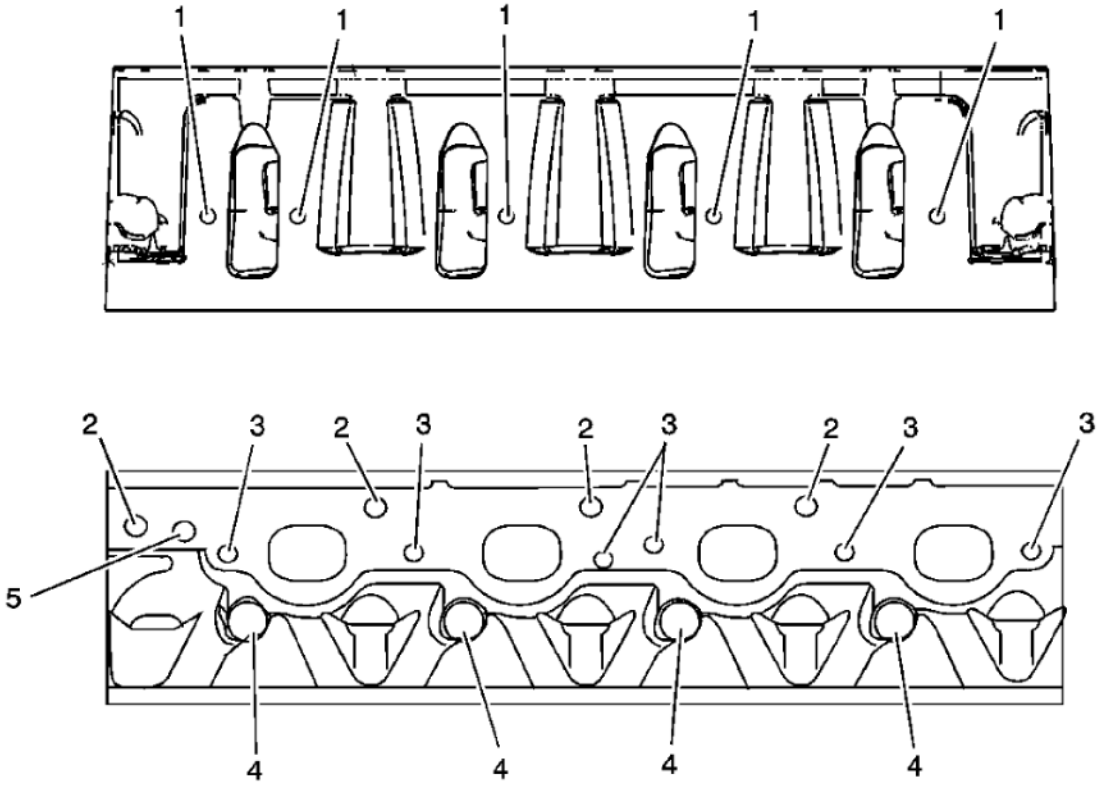

Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS CORP.

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

SCHEMATIC AND ROUTING DIAGRAMS

ENGINE MECHANICAL SCHEMATICS

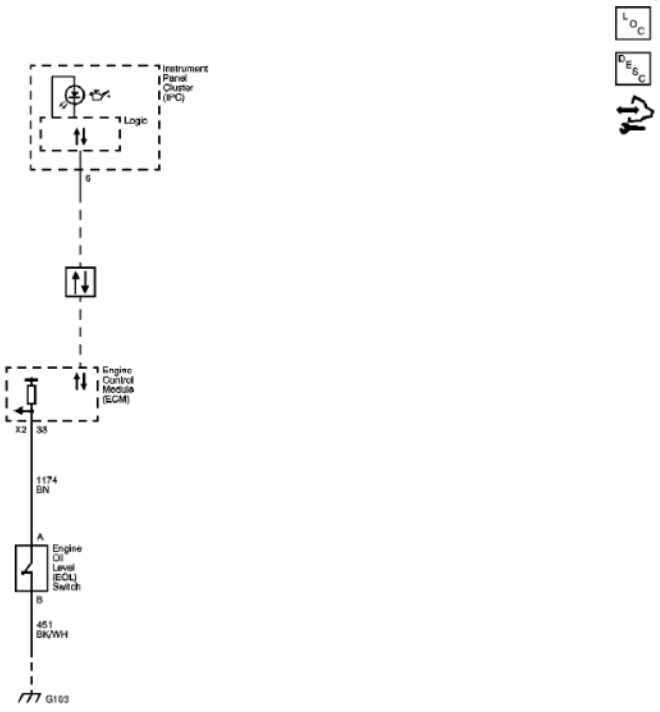

Fig. 6: Engine Mechanical
Courtesy of GENERAL MOTORS CORP.

COMPONENT LOCATOR

DISASSEMBLED VIEWS

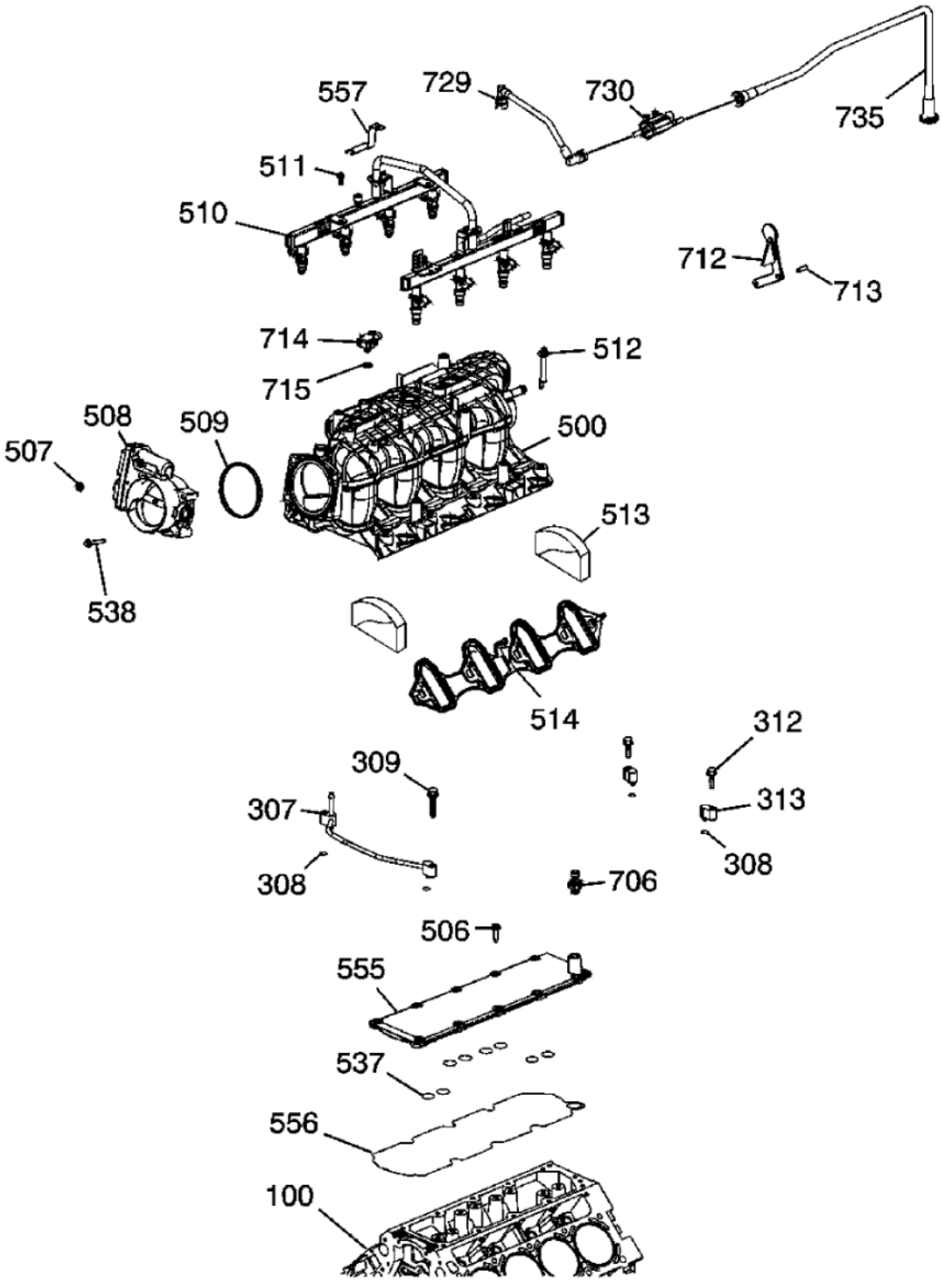

Fig. 7: Intake Manifold/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
307	Engine Coolant Air Bleed Pipe
308	Engine Coolant Air Bleed Pipe O-Ring Seal
308	Engine Coolant Air Bleed Pipe O-Ring Seal
309	Bolt
312	Bolt
313	Engine Coolant Air Bleed Pipe Hole Cover
500	Intake Manifold
506	Bolt
507	Nut
508	Throttle Body
509	Throttle Body Seal
510	Sequential Multi-Port Fuel Injector Assembly with Fuel Rail
511	Bolt
512	Bolt
513	Intake Manifold Seal
514	Intake Manifold Gasket
537	O-Ring Seal
538	Bolt
555	Engine Valley Cover
556	Gasket
557	Fuel Injection Fuel Rail Bracket
706	Engine Oil Pressure Sensor
712	Fuel Injection Fuel Rail Stop
713	Bolt
714	Manifold Absolute Pressure (MAP) Sensor
715	MAP Sensor O-Ring Seal
729	Evaporative (EVAP) Emission Canister Purge Tube
730	EVAP Emission Canister Purge Solenoid Valve
731	EVAP Emission Canister Port Cap
734	EVAP Emission Service Valve
735	EVAP Emission Canister Purge Tube

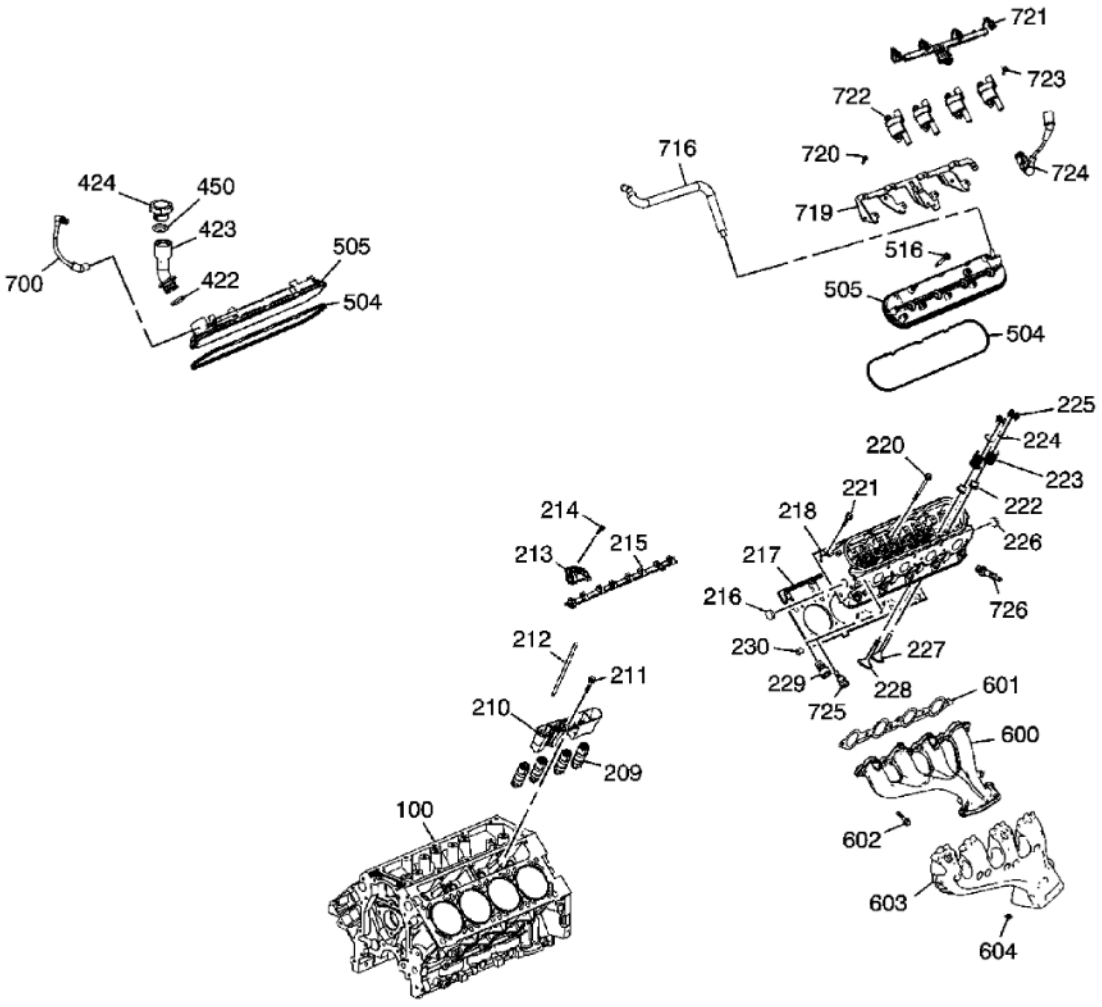

Fig. 8: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
209	Valve Lifter
210	Valve Lifter Guide
211	Valve Lifter Guide Bolt
212	Valve Push Rod
213	Valve Rocker Arm
214	Valve Rocker Arm Pivot Support Bolt
215	Valve Rocker Arm Pivot Support
216	Cylinder Head Core Hole Plug

217	Cylinder Head Gasket
218	Cylinder Head
220	Cylinder Head Bolt - M10
221	Cylinder Head Bolt - M8
222	Valve Stem Oil Seal
223	Valve Spring
224	Valve Spring Cap
225	Valve Stem Key
226	Cylinder Head Core Hole Plug
227	Intake Valve
228	Exhaust Valve
229	Cylinder Head Plug
230	Cylinder Head Locating Pin
422	Oil Fill Tube O-Ring Seal
423	Oil Fill Tube
424	Oil Fill Cap
450	Oil Fill Cap O-Ring Seal
504	Valve Rocker Arm Cover Gasket
504	Valve Rocker Arm Cover Gasket
505	Valve Rocker Arm Cover
505	Valve Rocker Arm Cover
516	Valve Rocker Arm Cover Bolt
600	Exhaust Manifold
601	Exhaust Manifold Gasket
602	Exhaust Manifold Flange Bolt
603	Exhaust Manifold Heat Shield
604	Exhaust Manifold Heat Shield Bolt
700	Positive Crankcase Ventilation (PCV) Hose - Fresh Air
716	PCV Hose - Dirty Air
719	Ignition Coil Bracket
720	Ignition Coil Bracket Stud
721	Ignition Coil Wire Harness Assembly
722	Ignition Coil
723	Ignition Coil Bolt
724	Spark Plug Wire

	Engine Coolant Temperature Sensor
726	Spark Plug

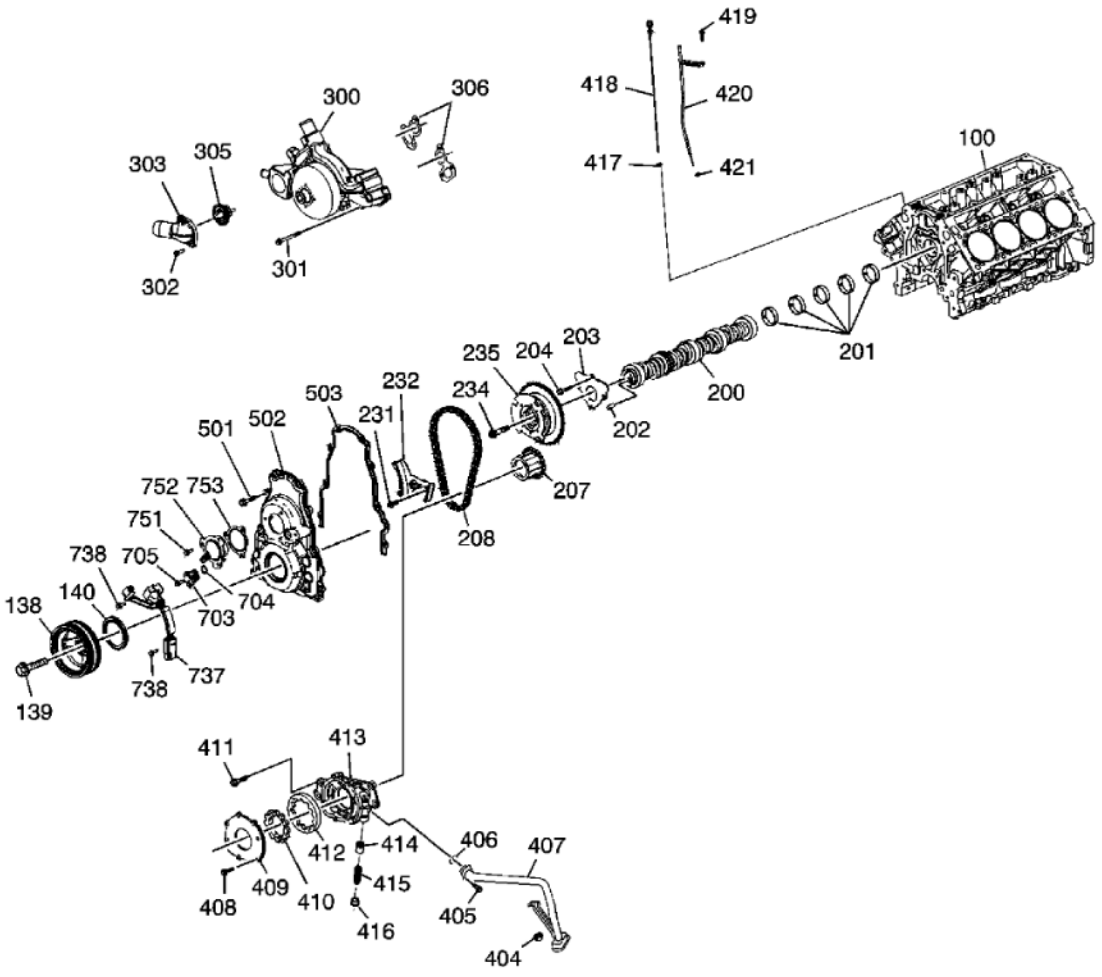

Fig. 9: Front of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
138	Crankshaft Balancer
139	Crankshaft Balancer Bolt
140	Crankshaft Front Oil Seal
200	Camshaft
201	Camshaft Bearing
202	Camshaft Sprocket Locating Pin

203	Camshaft Retainer
204	Camshaft Retainer Bolt
207	Crankshaft Sprocket
208	Timing Chain
231	Timing Chain Tensioner Bolt
232	Timing Chain Tensioner
234	Camshaft Position (CMP) Actuator Solenoid Valve
235	CMP Actuator
300	Water Pump
301	Water Pump Bolt
302	Water Pump Inlet Bolt
303	Water Pump Inlet
305	Engine Coolant Thermostat
306	Water Pump Gasket
404	Oil Pump Suction Pipe Nut
405	Oil Pump Suction Pipe Bolt
406	Oil Pump O-Ring Seal
407	Oil Pump Suction Pipe
408	Oil Pump Cover Bolt
409	Oil Pump Cover
410	Oil Pump Drive Gear
411	Oil Pump Bolt
412	Oil Pump Driven Gear
413	Oil Pump
414	Oil Pressure Relief Valve
415	Oil Pressure Relief Valve Spring
416	Oil Pressure Relief Valve Bore Plug
417	Oil Level Indicator O-Ring Seal
418	Oil Level Indicator
419	Oil Level Indicator Tube Bolt
420	Oil Level Indicator Tube
421	O-Ring
501	Engine Front Cover Bolt
502	Engine Front Cover
503	Engine Front Cover Gasket

	CMP Sensor
704	CMP Sensor O-Ring Seal
705	CMP Sensor Bolt
737	CMP Sensor Wire Harness Assembly
738	CMP Sensor Wire Harness Assembly Bolt
738	CMP Sensor Wire Harness Assembly Bolt
751	CMP Actuator Hub Cover Bolt
752	CMP Actuator Magnet
753	CMP Actuator Magnet Gasket

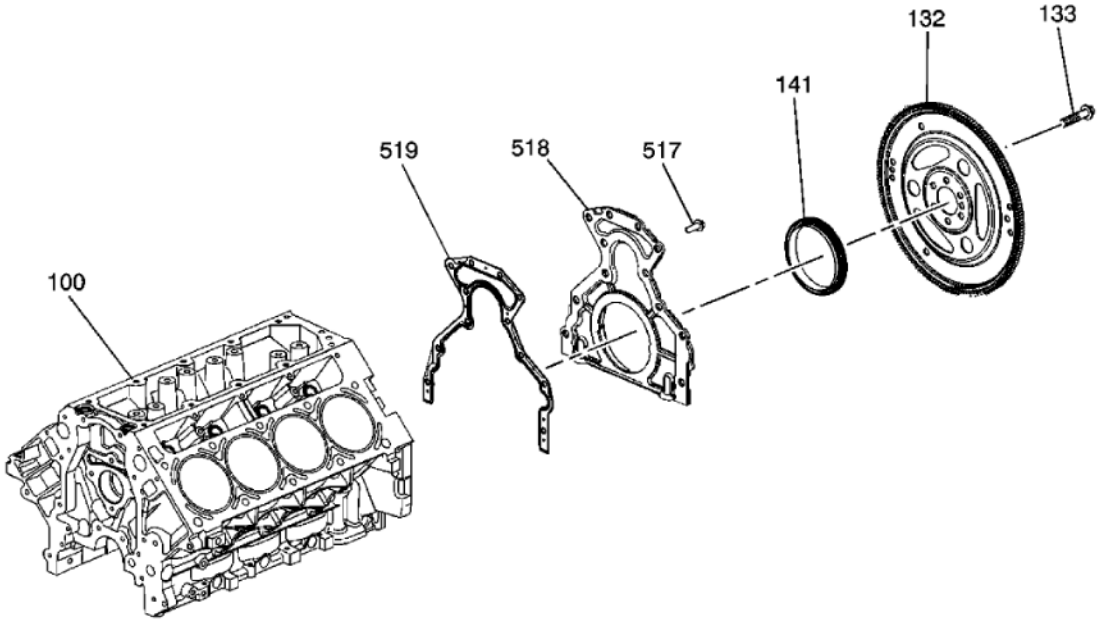

Fig. 10: Rear of Engine
Courtesy of GENERAL MOTORS CORP.

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

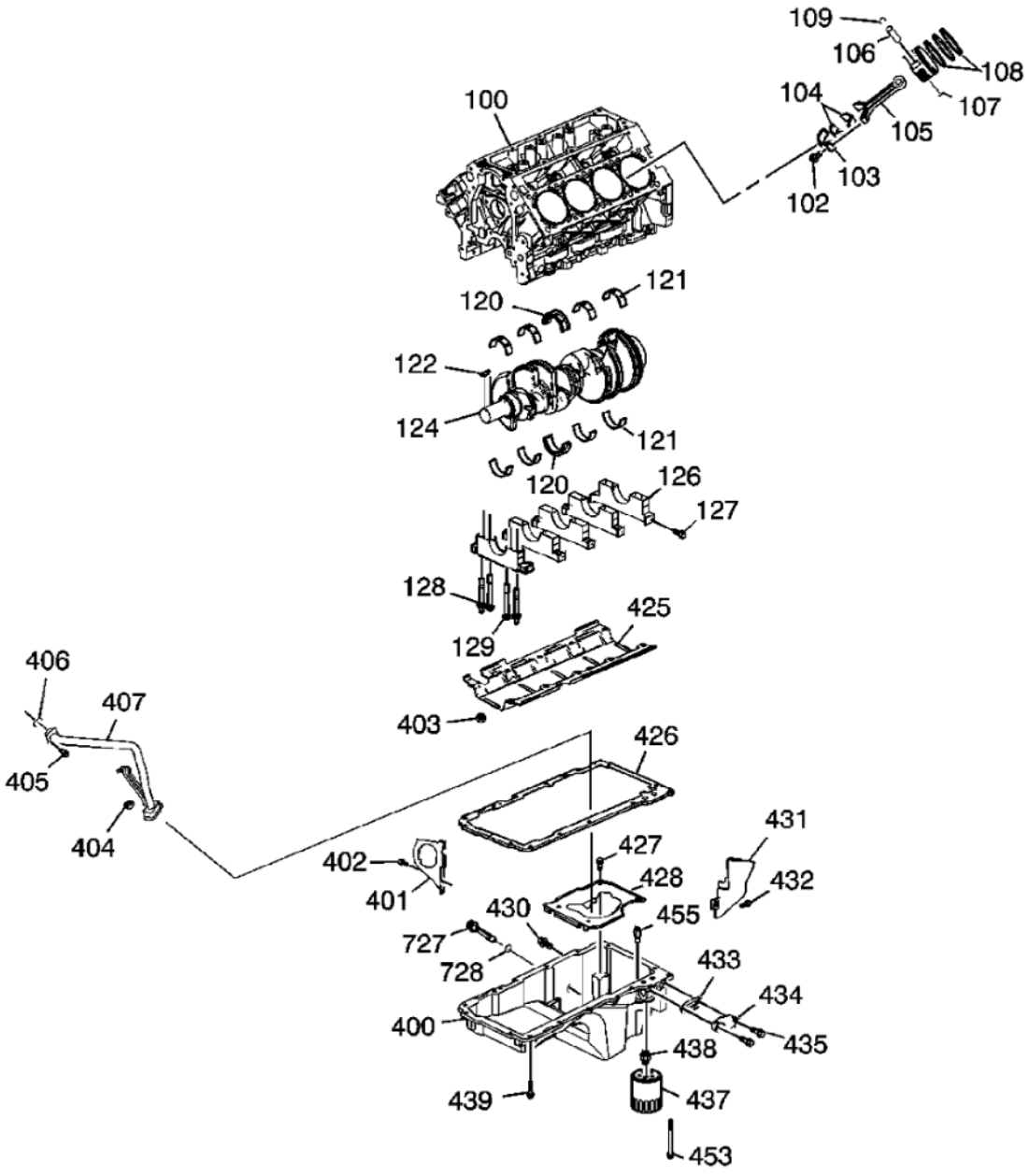

Fig. 11: Lower Engine Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
102	Connecting Rod Bolt
103	Connecting Rod Cap
104	Connecting Rod Bearing

105	Connecting Rod
106	Piston Pin
107	Piston
108	Piston Ring Set
109	Piston Pin Retainer
120	Crankshaft Thrust Bearing
120	Crankshaft Thrust Bearing
121	Crankshaft Bearing
121	Crankshaft Bearing
122	Crankshaft Balancer Key
124	Crankshaft
126	Crankshaft Bearing Cap
127	Crankshaft Bearing Cap Bolt - M8
128	Crankshaft Bearing Cap Stud - M10
129	Crankshaft Bearing Cap Bolt - M10
400	Oil Pan
401	Oil Pan Closeout Cover
402	Oil Pan Closeout Cover Bolt
403	Crankshaft Oil Deflector Nut
404	Oil Pump Suction Pipe Nut
405	Oil Pump Suction Pipe Bolt
406	Oil Pump O-Ring Seal
407	Oil Pump Suction Pipe
425	Crankshaft Oil Deflector
426	Oil Pan Gasket
427	Oil Pan Baffle Bolt
428	Oil Pan Baffle
430	Oil Pan Drain Plug
431	Oil Pan Closeout Cover
432	Oil Pan Closeout Cover Bolt
433	Oil Pan Cover Gasket
434	Oil Pan Cover
435	Oil Pan Cover Bolt
437	Oil Filter
438	Oil Filter Fitting

	Oil Pan Bolt
453	Oil Pan Bolt
455	Active Fuel Management Oil Pressure Relief Valve
727	Engine Oil Level Indicator Switch
728	O-Ring

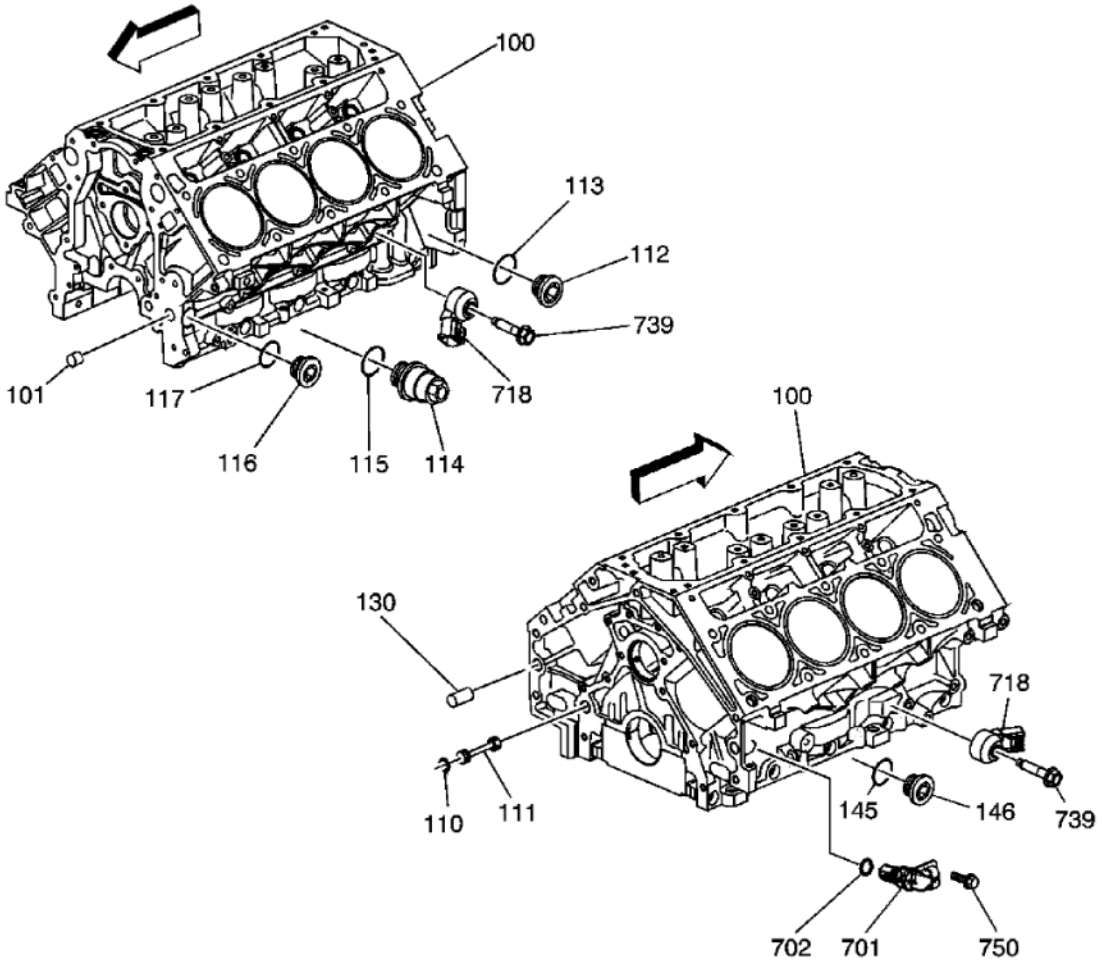

Fig. 12: Exploded View Of Engine Block Plugs/Sensors Components
Courtesy of GENERAL MOTORS CORP.

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	Engine Coolant Heater
115	Washer
116	Oil Gallery Plug - Side
117	Washer
130	Transmission Housing Locating Pin
145	Washer
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	CKP Sensor Bolt

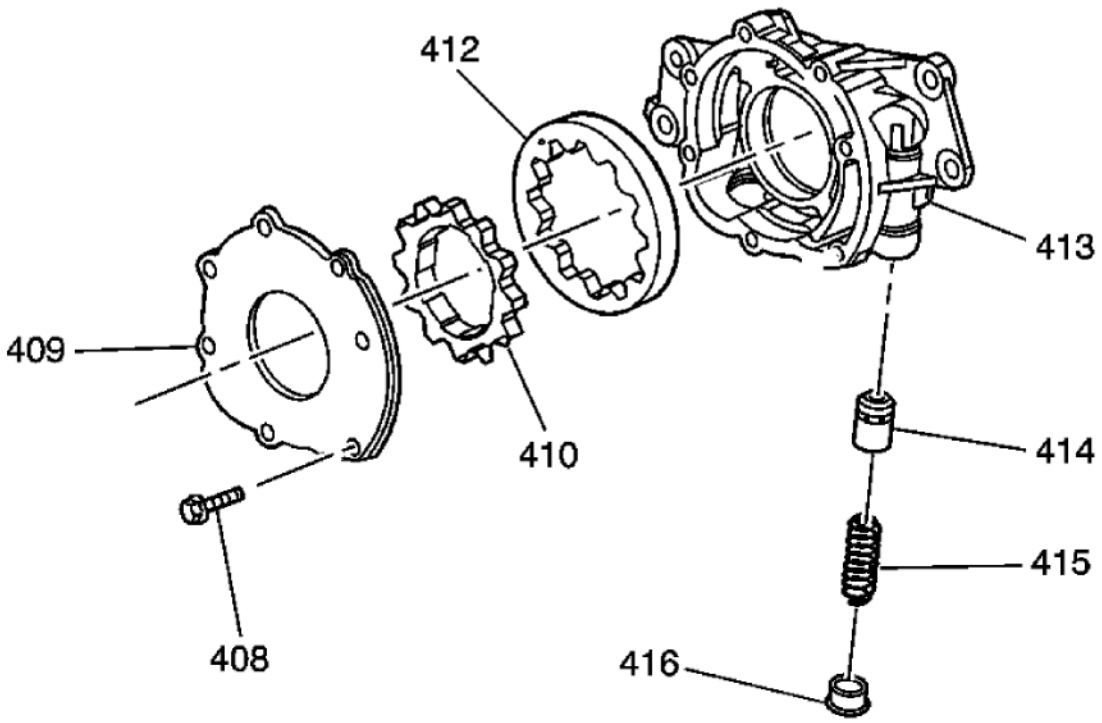

Fig. 13: Exploded View Of Oil Pump Assembly

Courtesy of GENERAL MOTORS CORP.

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

ENGINE IDENTIFICATION

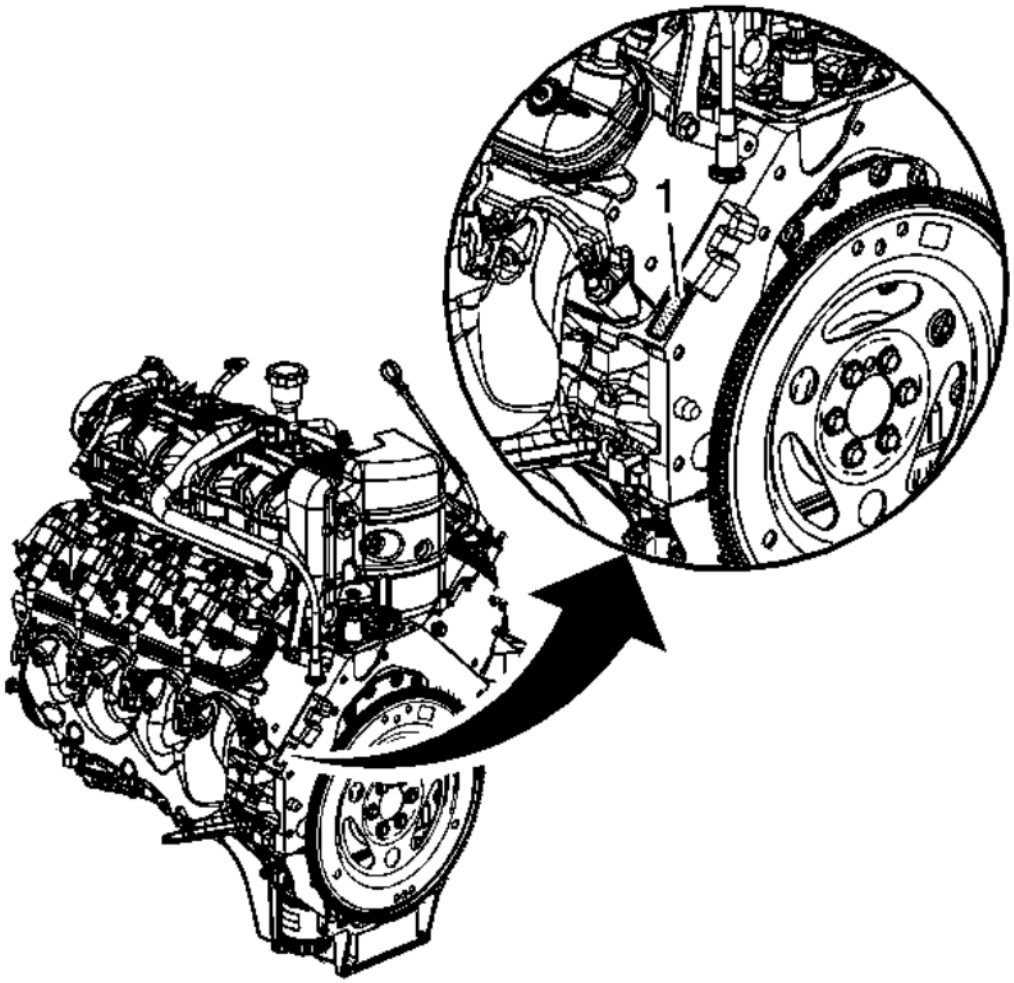

Fig. 14: Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS CORP.

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a 9 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.
- The third digit identifies the assembly plant.

- The fourth through ninth digits are the last 6 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**, and **Camshaft Position Actuator and Solenoid Valve Description**. Reviewing the description and operation information helps you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information also helps 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 the **Diagnostic System Check - Vehicle** 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**, and **Camshaft Position Actuator and Solenoid Valve 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** .

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **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**
- **Engine Compression Test**
- **Cylinder Leakage Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Cylinder Deactivation (Active Fuel Management) Oil Pressure Relief Valve Diagnosis and Testing**
- **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Crankcase Ventilation System Inspection/Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Fuel injector harness connectors are connected to the incorrect fuel injectors/cylinders	Relocate the fuel injector harness connectors, as necessary.
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 diagnostic trouble code (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 flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flex plate and/or balancer, as required. Refer to **Automatic Transmission Flex Plate 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 to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets, as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Inspect the cylinder heads, engine block, and/or head gaskets. Refer to **Coolant in Combustion Chamber**. 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to identify the cause. Refer to **Cylinder Leakage Test**. 4. 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 camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER 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, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.

actual misfire condition.	
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 flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flex plate and/or balancer, as required. Refer to **Automatic Transmission Flex Plate Replacement**, or **Crankshaft Balancer Replacement**.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. 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

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.
Stuck valves Carbon buildup on the valve stem can cause the valve to not 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.
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**.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

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.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. 3. 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**. 4. Repair or replace, as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** .

engine to misfire.	2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.

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. Inspect the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace, as required.
Damaged or faulty oil filter bypass valve The bypass valve is now internal to the oil filter.	1. Inspect the oil filter bypass valve for proper operation. 2. Repair or replace, as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm, bolt, and pedestal. 2. Repair or replace, as required.
Worn or damaged valve rocker arm	1. Inspect the rocker arm for wear or missing needle bearings

	2. 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 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 • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters, as required.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. 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

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components, as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace, as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair or replace, as required.
Loose or damaged flywheel or flex plate	Repair or replace the flywheel or flex plate.
Oil pump screen loose, damaged, or restricted	1. Inspect the oil pump screen. 2. Repair or replace, as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair, as required.

Excessive piston pin-to-bore clearance	1. Inspect the piston, pin, and connecting rod. 2. 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.	1. Verify the pistons, piston pins and connecting rods are installed correctly. Refer to **Piston, Connecting Rod, and Bearing Installation**. 2. Repair, as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair, as required.
Cracked flex plate - automatic transmission	1. Inspect the flex plate bolts and flex

	plate. 2. 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

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 flex plate location. 3. Repair or replace the components, as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flex plate bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flex plate location. 3. Repair or replace the components, as required.
Broken timing chain	1. Inspect the timing chain and sprockets. 2. Repair or replace the components, as

	required.
Seized timing chain or timing sprockets	1. Inspect the timing chain and sprockets for foreign material or a seized chain. 2. Repair or replace the components, as required.
Seized or broken camshaft	1. Inspect the camshaft and the camshaft bearings. 2. Repair or replace the components, as required.
Bent valve in the cylinder head	1. Inspect the valves and the cylinder heads. 2. Repair or replace the components, as required.
Seized oil pump	1. Inspect the oil pump assembly. 2. Repair or replace, as required.
Hydraulically locked cylinder • Coolant/antifreeze in the cylinder • Oil in the cylinder • Fuel in the cylinder	1. Remove the spark plugs and inspect 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	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace the components, as required.
Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod

	bearings. 2. Repair or replace the components, as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Replace the piston and pin as an assembly, as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair or replace the components, as required.

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. 2 cylinders side-by-side on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
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

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. 2 cylinders side-by-side on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
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 Side** or **Cylinder Head Replacement - Right Side**.
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.

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 4 compression strokes, 4 puffs.
8. Measure 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. Measure the compression again and record the reading.
10. The minimum compression in any 1 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 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (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 2 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.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester, or equivalent. See **Special Tools**.

Test

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 .

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .
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. See **Special Tools**.

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. See **Special Tools**.
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 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

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 measure 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

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **J 21867** Pressure Gage. See **Special Tools**.

Test

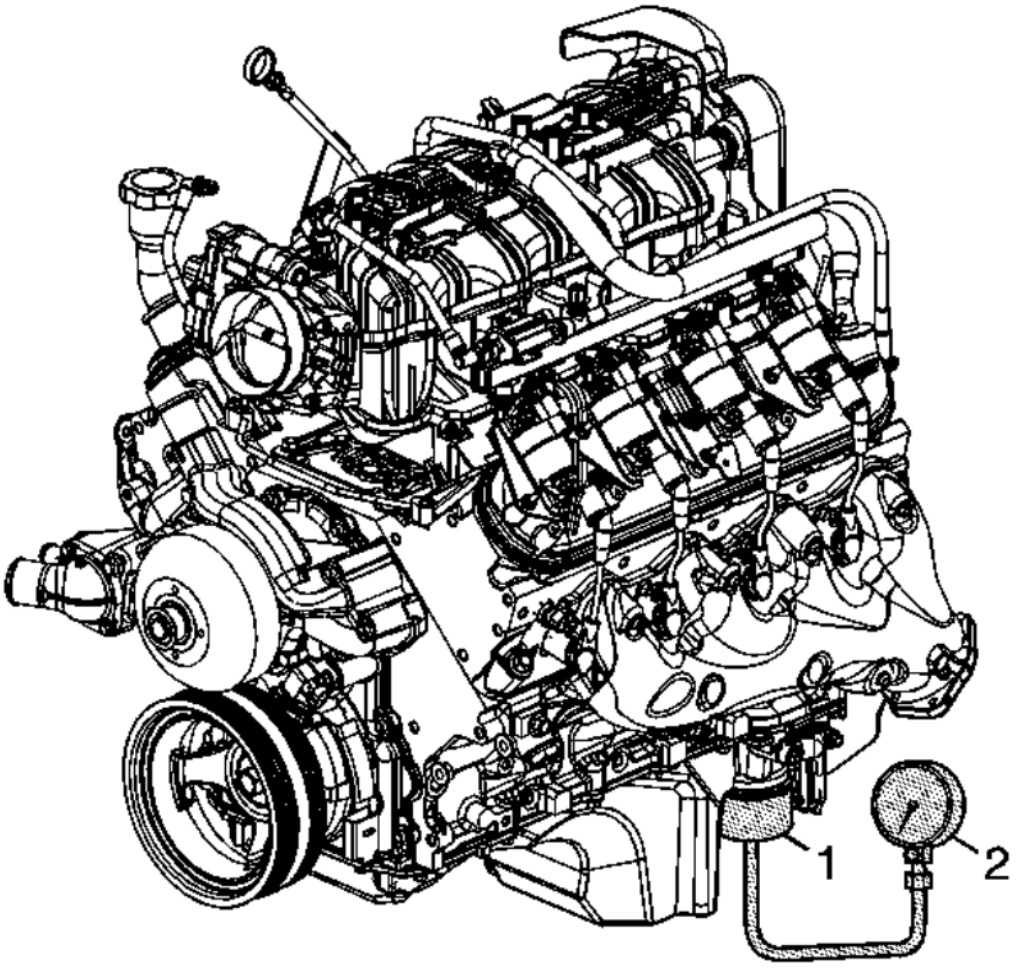

Fig. 15: View Of Special Tools Oil Pressure Gage & Adapter
Courtesy of GENERAL MOTORS CORP.

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.
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 antifreeze

      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 **EN-47971** (1). See **Special Tools**.
7. Install the **J 21867** (2), or equivalent to the **EN-47971** (1). See **Special Tools**.
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 1 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, Screen and Crankshaft Oil Deflector Installation** .

    - Oil pump screen loose, plugged, or damaged
    - Oil pump screen O-ring seal missing or damaged
    - 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 active fuel management oil pressure relief valve

      Refer to **Cylinder Deactivation (Active Fuel Management) Oil Pressure Relief Valve Diagnosis and Testing** .

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) OIL PRESSURE RELIEF VALVE VALVE DIAGNOSIS AND TESTING

Tools Required

- **EN-47971** Oil Pressure Gage Adapter. See **Special Tools**.
- **J 21867** Pressure Gage. See **Special Tools**.
- **J-21867-16** Oil Pressure Adapter. See **Special Tools**.

Diagnosis and Testing

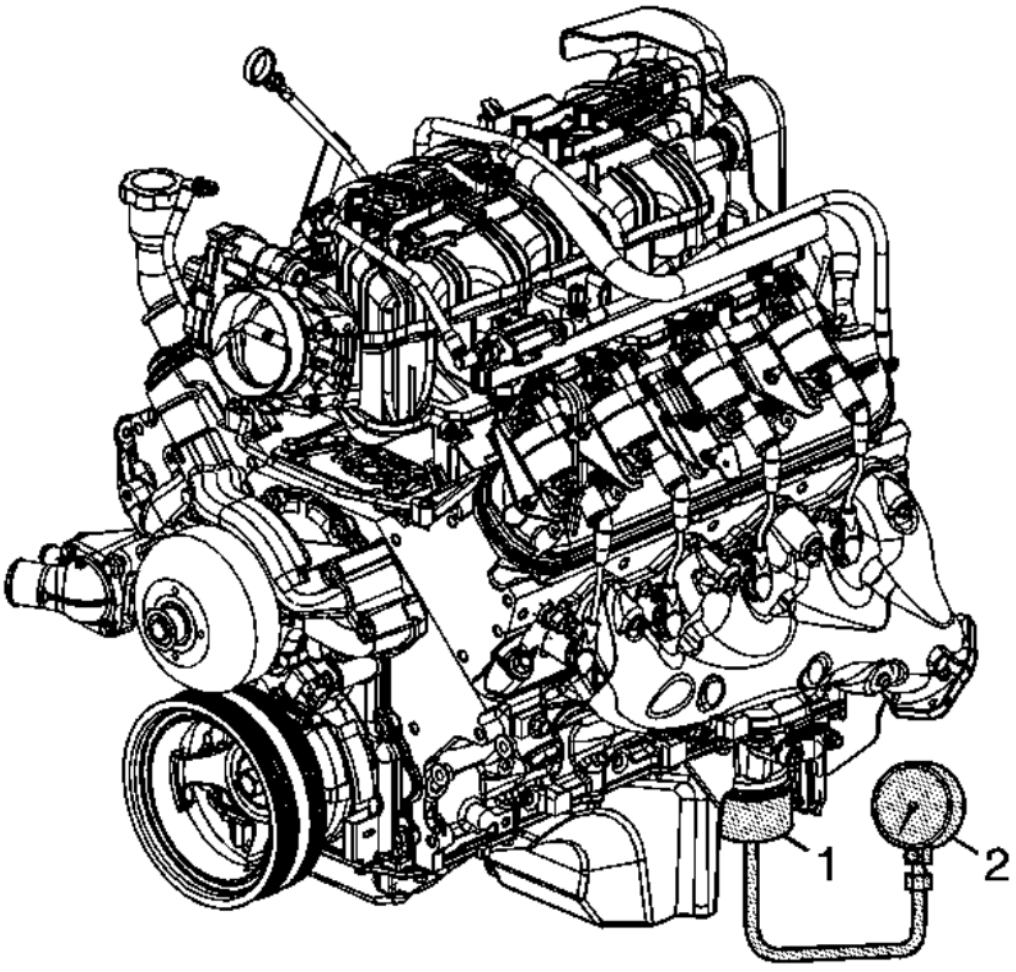

Fig. 16: View Of Special Tools Oil Pressure Gage & Adapter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: This test is performed to verify the operation of the active fuel management oil pressure relief valve located in the oil

pan. Refer to Lubrication Description.

1. Remove the oil filter and install the **EN-47971** (1). See **Special Tools**.
2. Install the **J 21867** (2), or equivalent, to the **EN-47971** (1). See **Special Tools**.

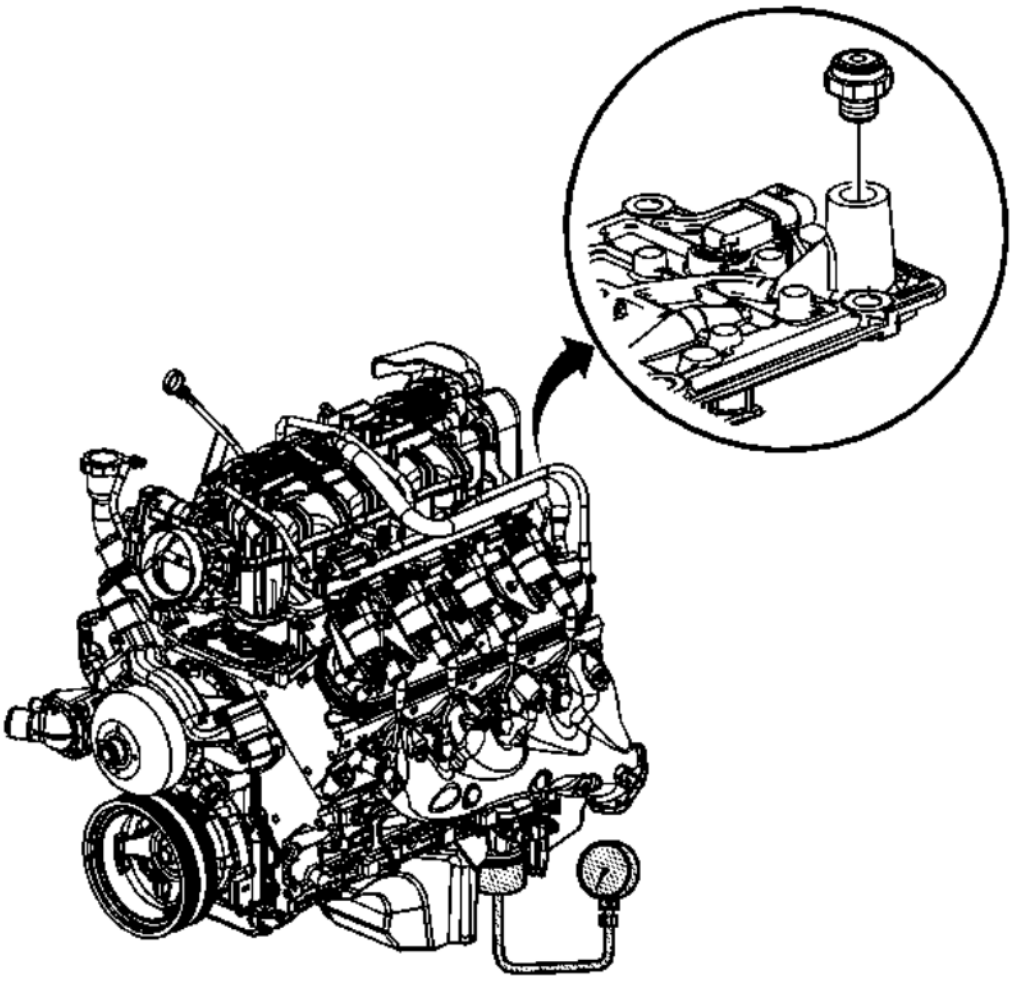

Fig. 17: Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

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

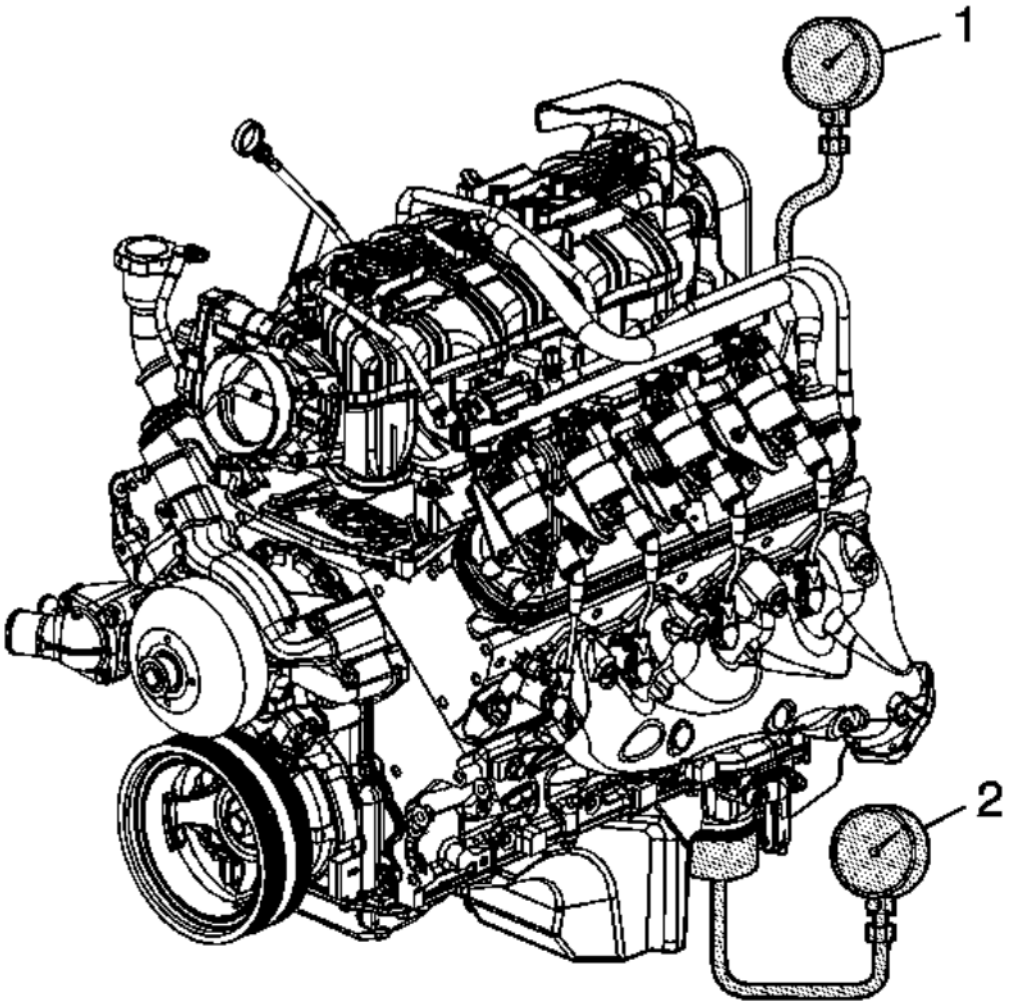

Fig. 18: Measure Engine Oil Pressure
Courtesy of GENERAL MOTORS CORP.

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.

   - 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 active fuel management 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 active fuel management oil pressure relief valve is stuck in the closed position.

6. Repair, as required.

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DIAGNOSIS AND TESTING

1. Measure the engine oil level. Fill, as required.
2. Using the scan tool, inspect for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** . Repair, as required.
3. Verify proper engine oil pressure and operation of the active fuel management oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Inspect the camshaft position (CMP) actuator solenoid valve for proper operation. Refer to **Camshaft Position Actuator Solenoid Valve Inspection (On-Vehicle)** or **Camshaft Position Actuator Solenoid Valve Inspection (Off-Vehicle)**.
   - If valve inspection confirms proper movement of the spool, replace the CMP actuator and CMP valve.
   - If valve inspection confirms improper movement of the spool, replace only the CMP valve.
5. Verify proper operation of the CMP actuator control system. Refer to **Diagnostic Starting Point - Engine Controls** .

OIL LEAK DIAGNOSIS

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. Inspect 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. Inspect 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. Inspect 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 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. Inspect 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. See **Special Tools**. 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**
	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations:		

9	• 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
10	1. Inspect the engine for mechanical damage. 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

Symptom	Correction

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

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

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

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

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

4: Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.

6: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

12: Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

14: This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.

15: This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

16: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across 2 or 3 pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .**		

DEFINITION: The following items are indications of chirping:

- A high pitched noise that is heard once per revolution of the drive belt or a pulley.
- Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp.

DEFINITION: The following items are indications of drive belt squeal:

- A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs.
- The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component.

DEFINITION: The following items are indications of drive belt whine:

- A high pitched continuous noise.
- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belts. Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**

4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 19**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 14**
	Test the drive belt tensioner for proper		

14	operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Did you complete the repair?	Go to **Step 20**	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

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

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

Test Description

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

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

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

4: Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.

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

9: Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.

11: This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump 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.

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

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: ○ Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove ○ The separation of the drive belt ○ A damaged drive belt		

DEFINITION: The following items are indications of drive belt vibration:

- The vibration is engine-speed related.
- The vibration may be sensitive to accessory load.

1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	**IMPORTANT:** **If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed.** 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to **Symptoms - Engine Mechanical** or Go to **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**

7	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

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

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

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

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

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

Test Description

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

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

4: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley 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 installation procedure of that pulley.

5: Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

6: Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

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

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

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

15: This inspection is to verify the drive belt is not contacting any parts of the engine or

body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.		
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**.		

	2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. 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 Tensioner Replacement - Accessory** or **Drive Belt Tensioner Replacement - Air Conditioning**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**
13	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to Diagnostic Aids
16	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory** or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Inspection Procedure

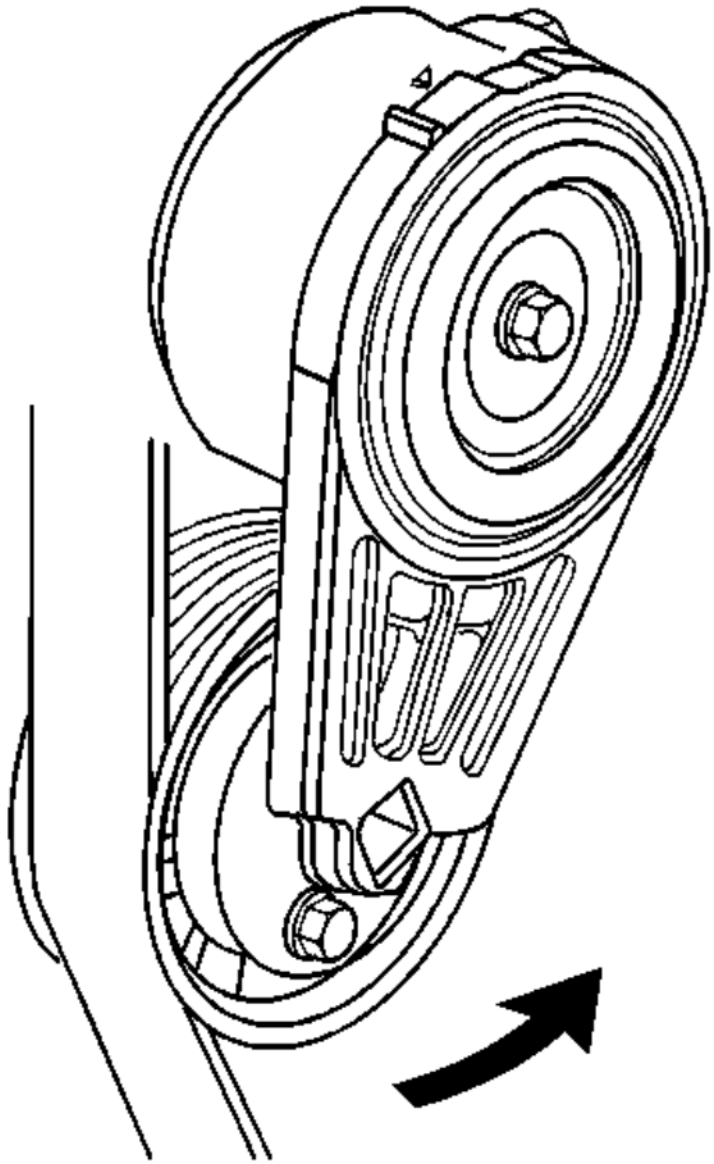

Fig. 19: Releasing Drive Belt Tension
Courtesy of GENERAL MOTORS CORP.

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

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT - ACCESSORY

Removal Procedure

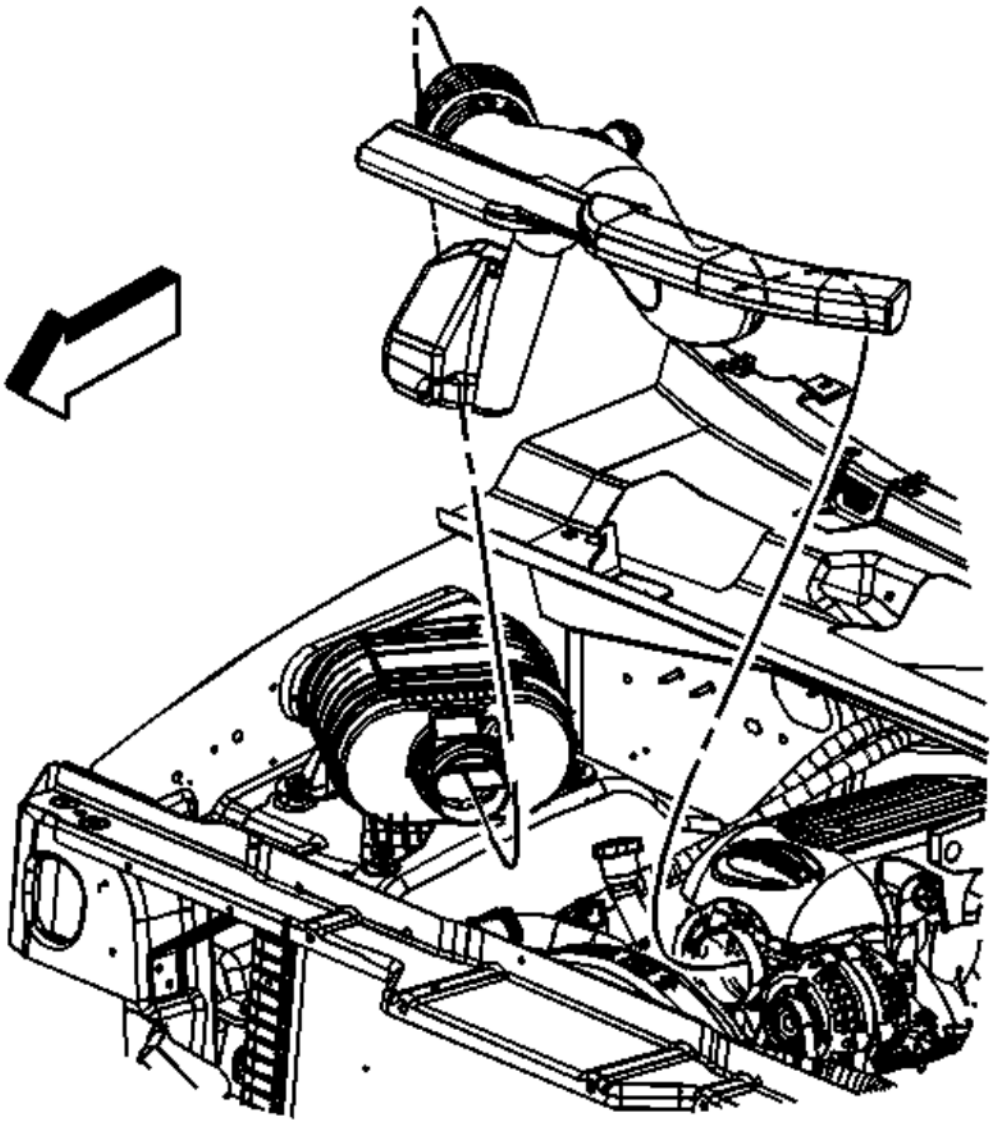

Fig. 20: MAF/IAT Sensor & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Loosen the air cleaner outlet duct clamps at the following locations:
    - Throttle body
    - Mass airflow/intake air temperature (MAF/IAT) sensor

2. Remove the air cleaner outlet duct.

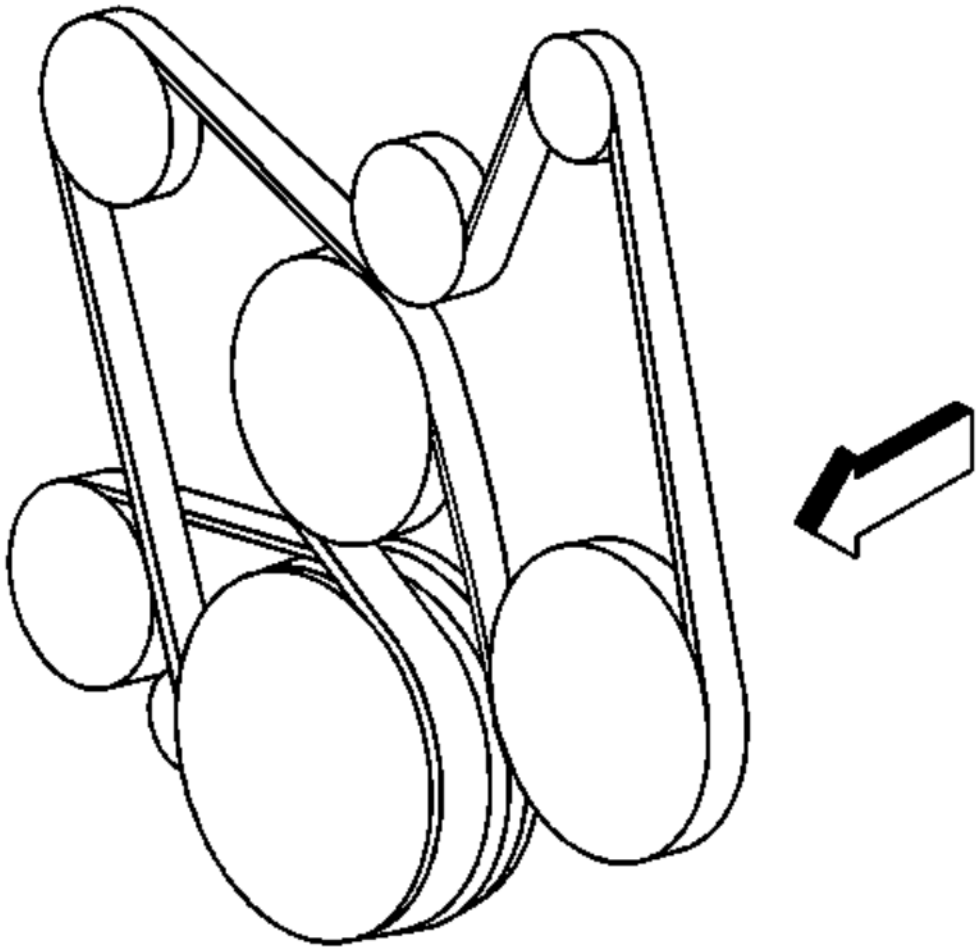

Fig. 21: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

3. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.
4. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt.
5. Remove the belt from the pulleys and the drive belt tensioner.
6. Slowly release the tension on the drive belt tensioner.

7. Remove the breaker bar and socket and from the drive belt tensioner bolt.
8. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

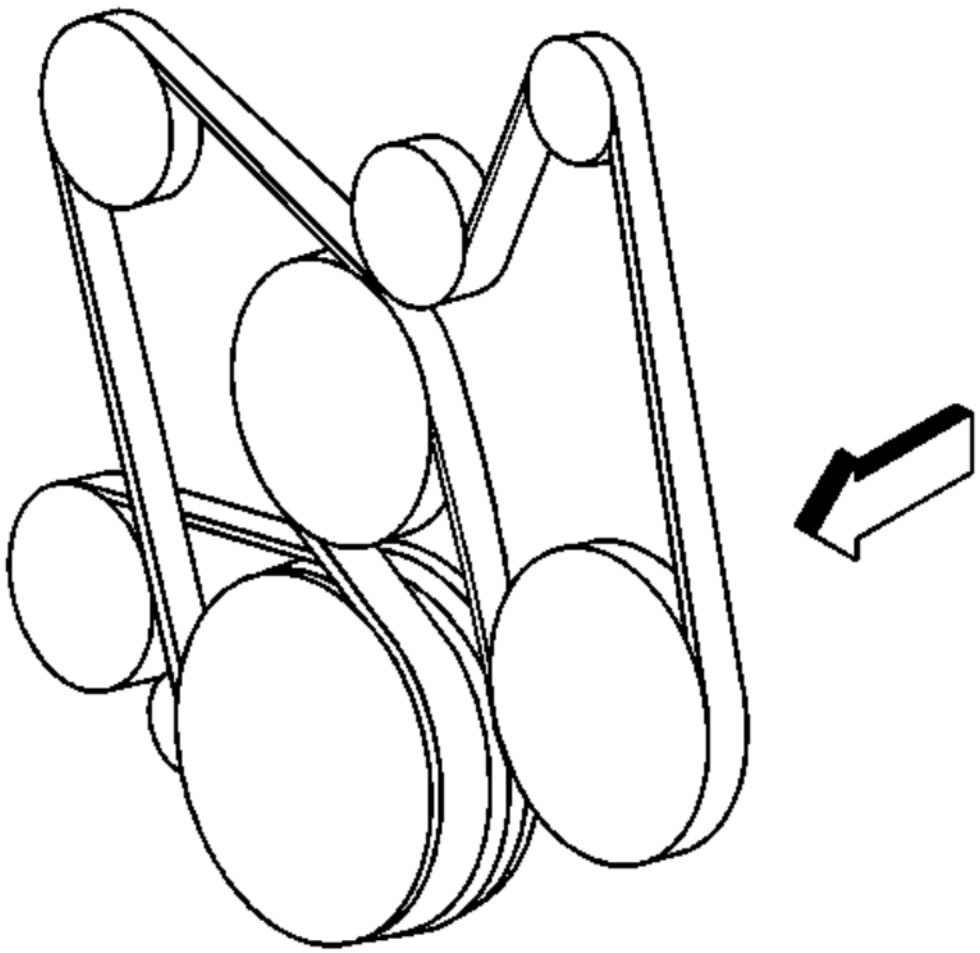

Fig. 22: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Route the drive belt around all the pulleys except the idler 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 tensioner.
4. Install the drive belt under the idler pulley.
5. Slowly release the tension on the belt tensioner.
6. Remove the breaker bar and socket from the belt tensioner bolt.
7. Inspect the drive belt for proper installation and alignment.

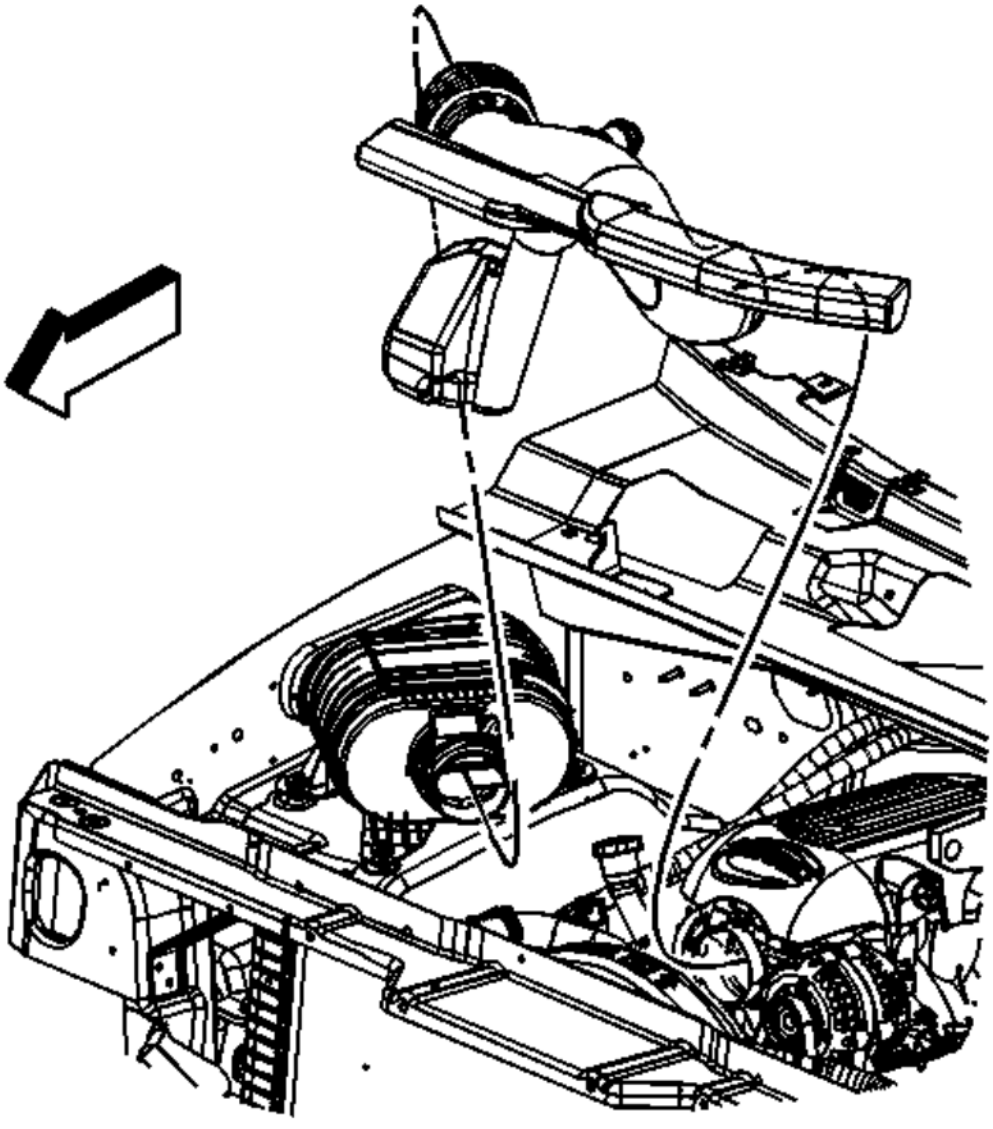

Fig. 23: MAF/IAT Sensor & Air Cleaner Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Align the arrow at the throttle body end of the duct with the throttle body attaching stud.

8. Install the air cleaner outlet duct.

NOTE: Refer to Fastener Notice .

9. Tighten the air cleaner outlet duct clamps at the following locations:
   - Throttle body
   - MAF/IAT sensor

   Tighten: Tighten the air cleaner outlet duct clamp screws to 7 N.m (62 lb in).

AIR CONDITIONING COMPRESSOR BELT REPLACEMENT

Removal Procedure

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Remove the engine protection shield. Refer to **Engine Protection Shield Replacement** .

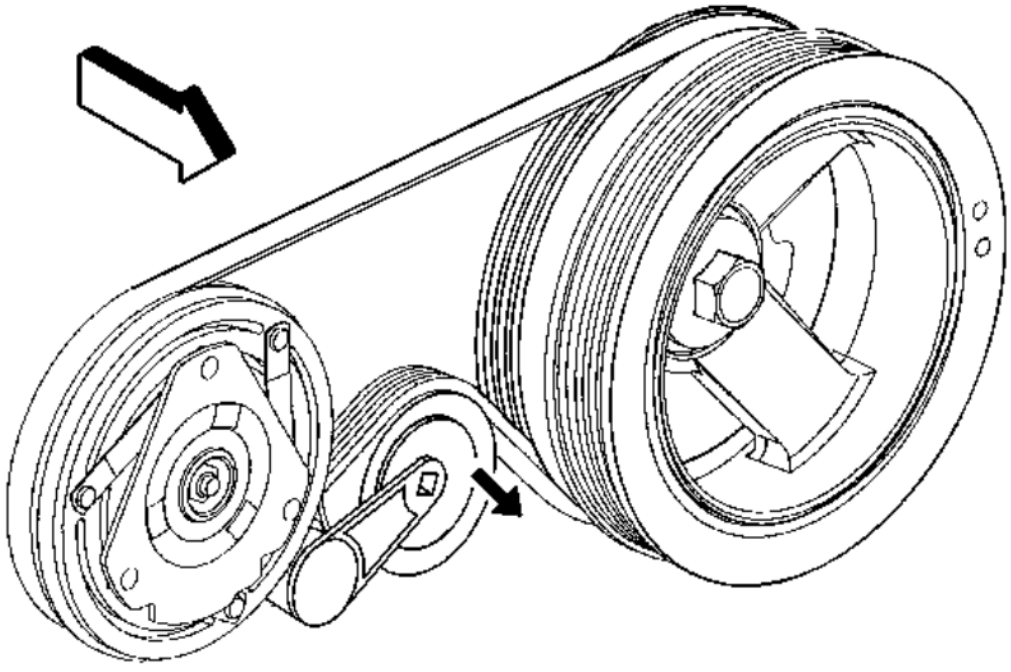

Fig. 24: A/C Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install a ratchet into the air conditioning (A/C) belt tensioner adapter opening.
5. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
6. Remove the A/C belt from the pulleys.
7. Slowly release the tension on the A/C belt tensioner.
8. Remove the ratchet from the A/C belt tensioner.
9. Clean and inspect the belt surfaces of all the pulleys.

Installation Procedure

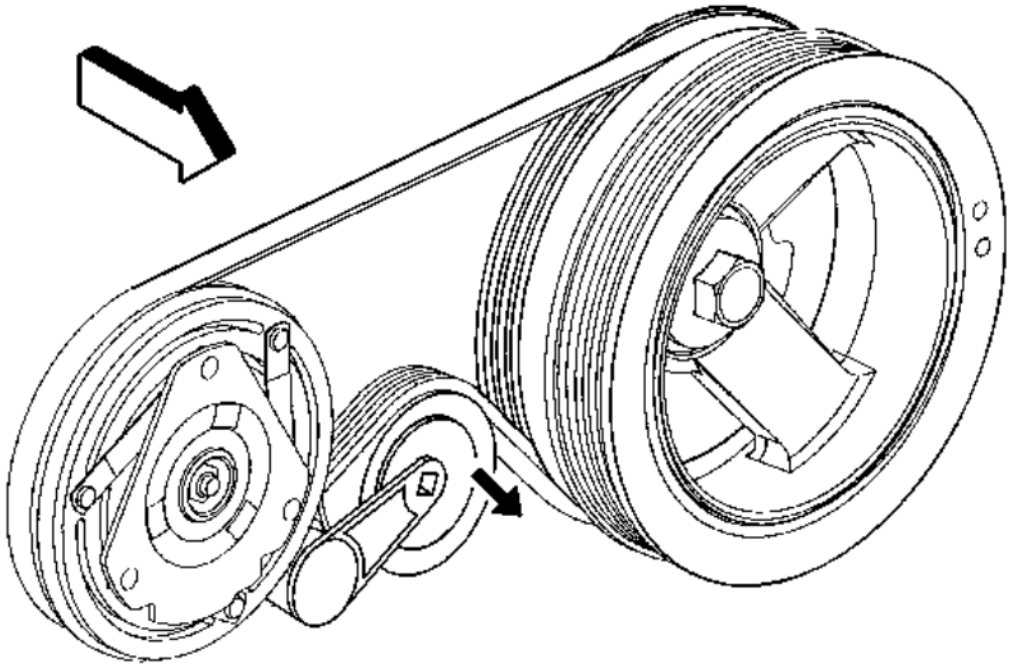

Fig. 25: A/C Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Install the A/C belt around the crankshaft balancer.
2. Install a ratchet into the A/C drive belt tensioner adapter opening.
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the tensioner.
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. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** .

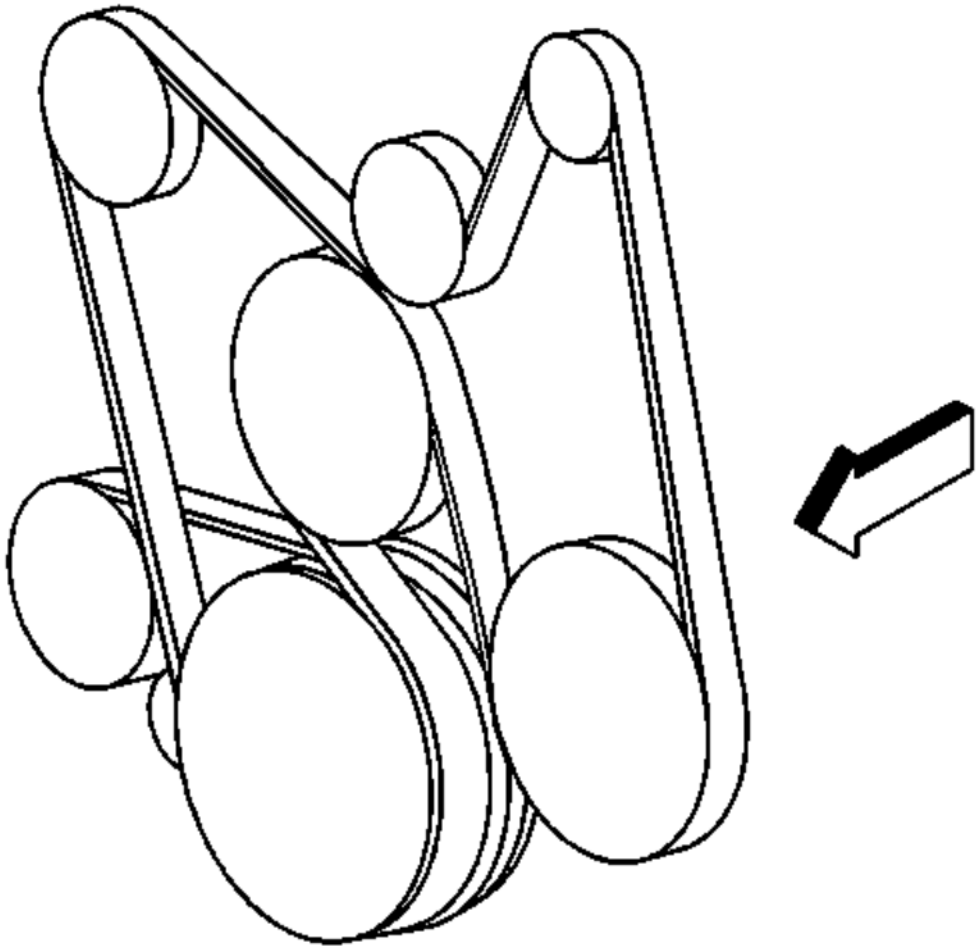

Fig. 26: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

10. Install the engine shield bolts.

    Tighten: Tighten the engine shield bolts to 20 N.m (15 lb ft).

11. Lower the vehicle.

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

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

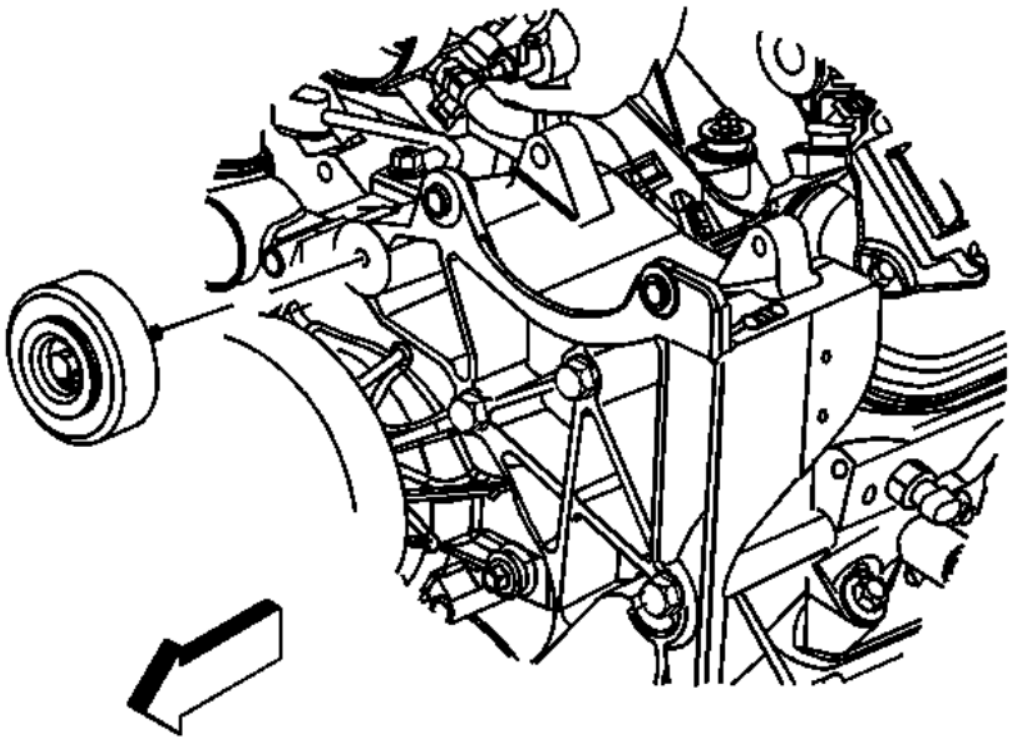

Fig. 27: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

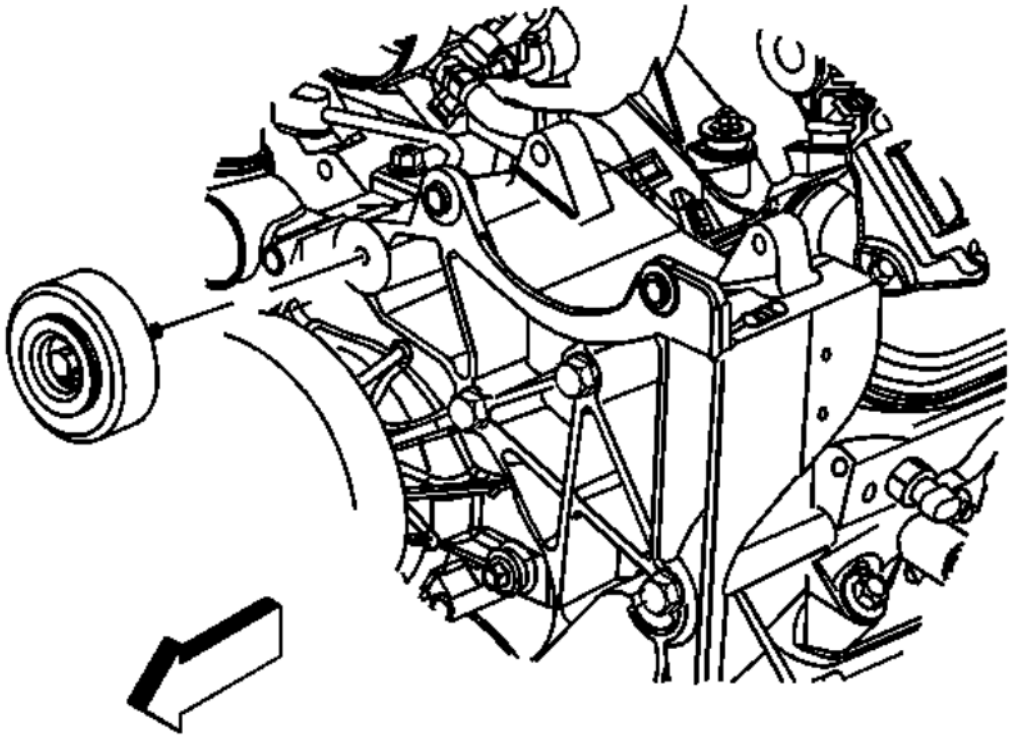

Fig. 28: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

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

   Snug the bolt finger tight.

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

   NOTE: Refer to Fastener Notice .

3. Tighten the drive belt idler pulley bolt.

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

DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY

Removal Procedure

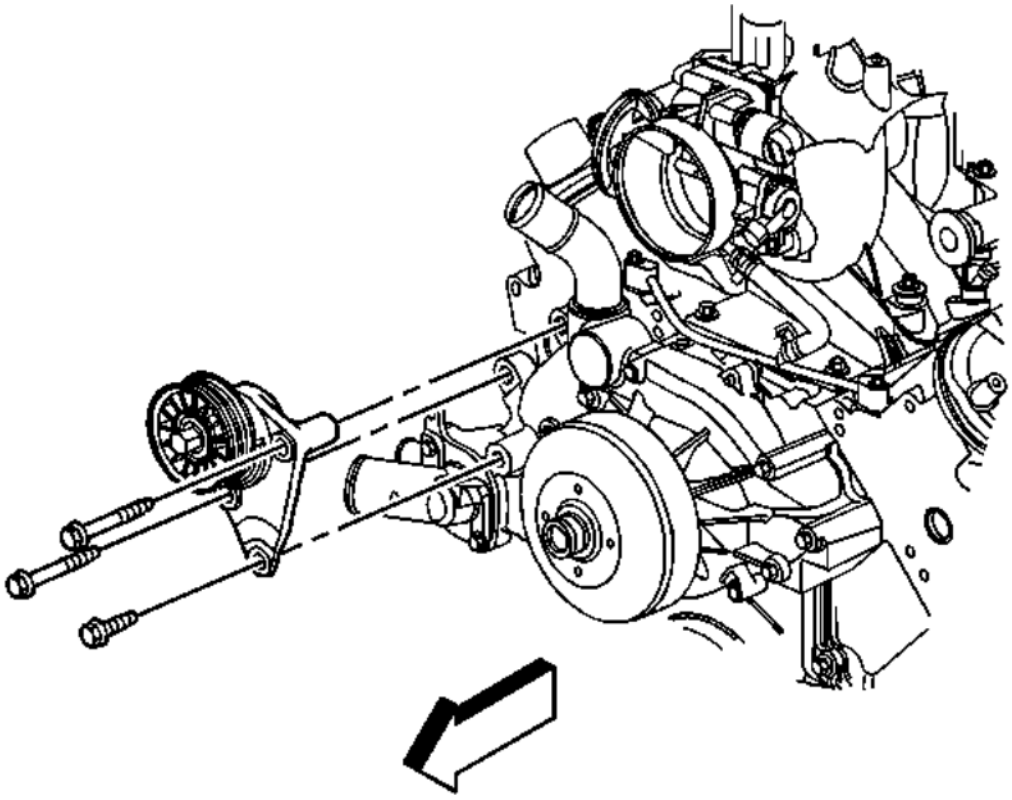

Fig. 29: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

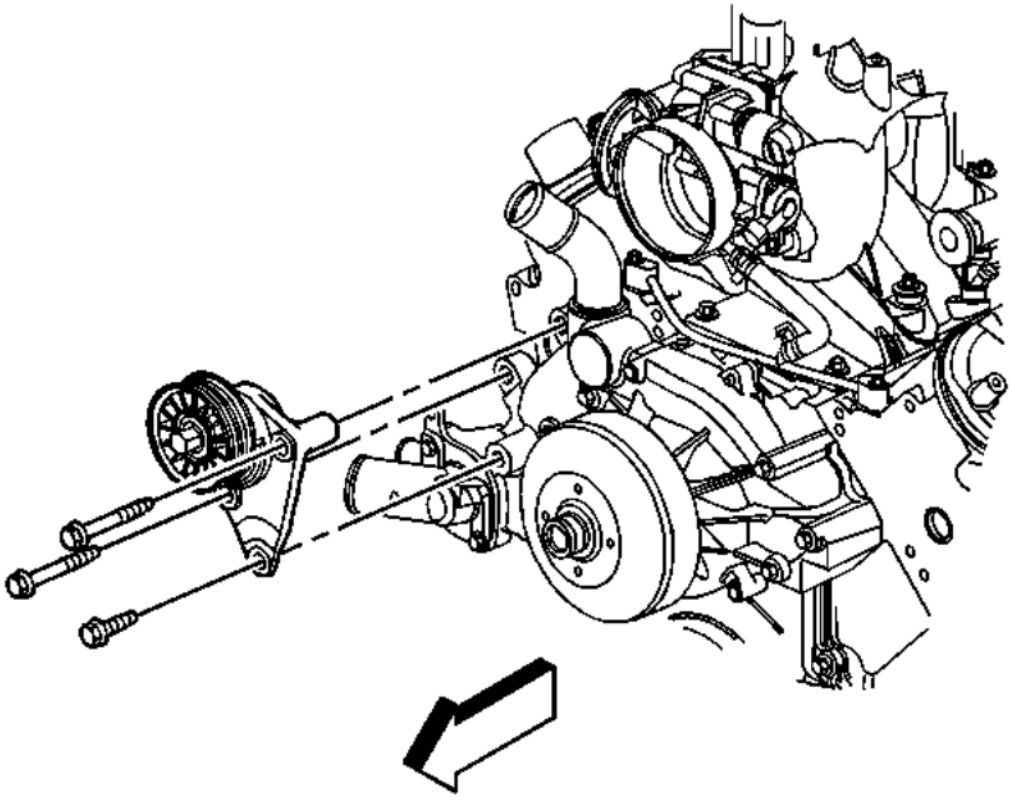

Fig. 30: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: **Refer to Fastener Notice .**

3. Tighten the drive belt tensioner bolts.

   Tighten: Tighten the accessory drive belt tensioner 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

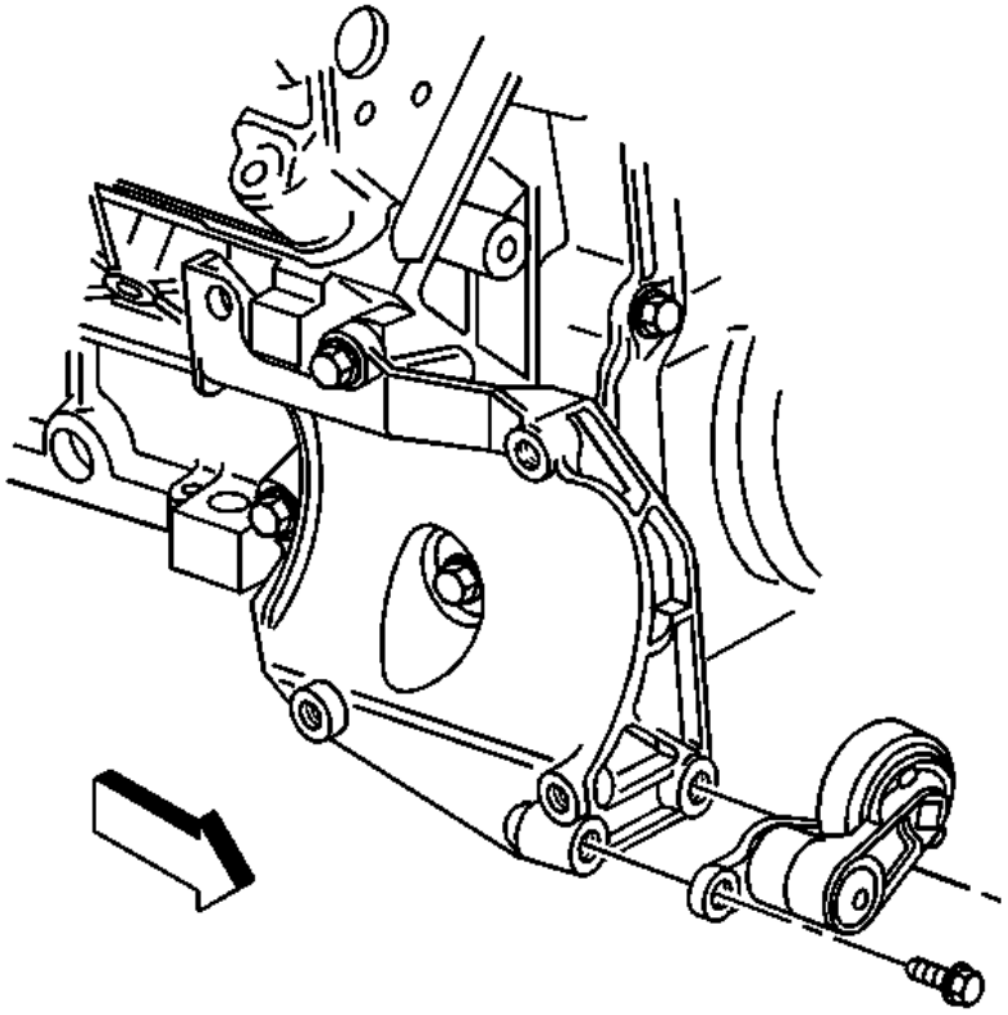

Fig. 31: View Of A/C Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Air Conditioning Compressor Belt Replacement**.
2. Remove the A/C belt tensioner bolts.
3. Remove the A/C belt tensioner.

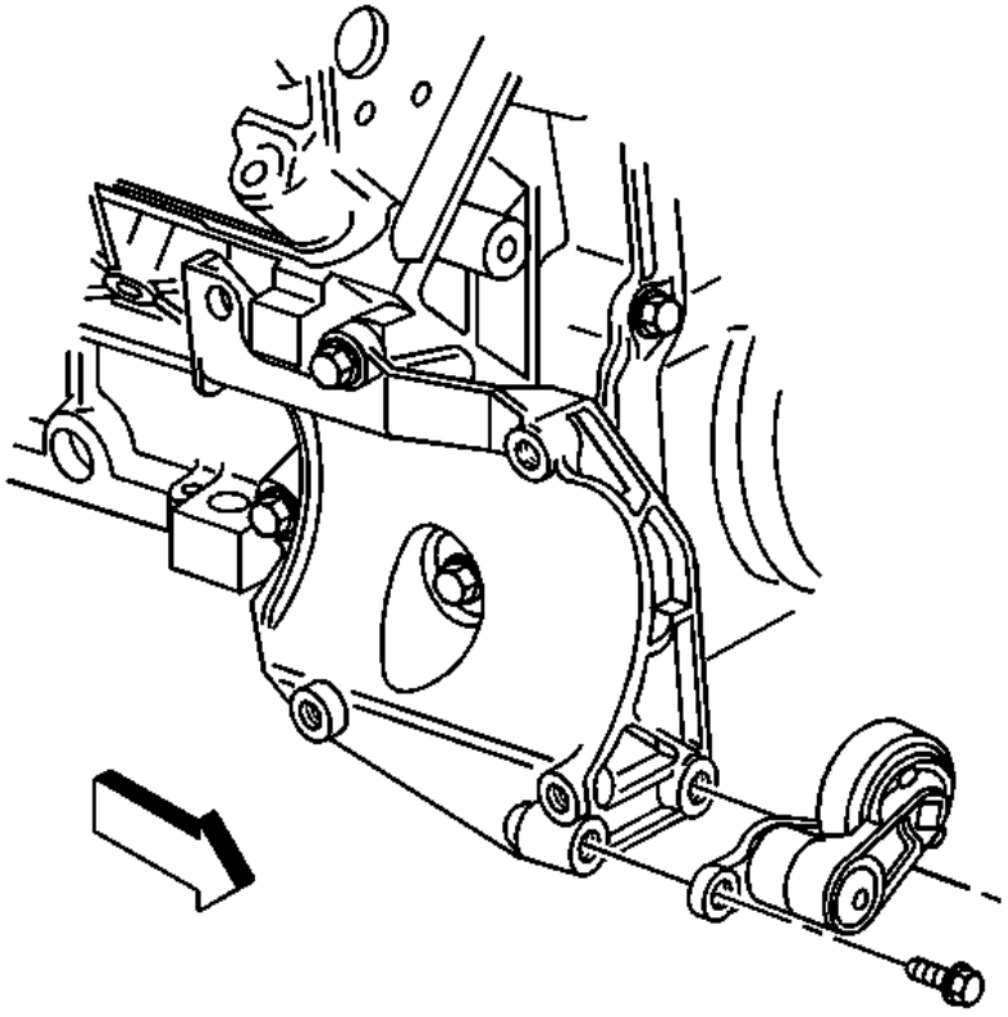

Fig. 32: View Of A/C Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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

Tighten: Tighten the A/C belt tensioner bolts to 50 N.m (37 lb ft).

3. Install the A/C drive belt. Refer to **Air Conditioning Compressor Belt Replacement**.

ENGINE MOUNT INSPECTION

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.

NOTE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Measure the engine movement at the engine mount in order to check for damage to the rubber portions of the mount.
    1. Apply the park brake.
    2. Start the engine.
    3. Firmly apply and hold the primary brakes.
    4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
    5. Slightly load the engine shifting from drive to reverse a few times.
    6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, check for loose engine mount bolts.
2. If the engine mount bolt torque is within specifications, check the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:
    - Heat check cracks cover the rubber cushion surface.
    - The rubber cushion is separated from the metal plate of the mount.
    - There is a split through the rubber cushion.

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

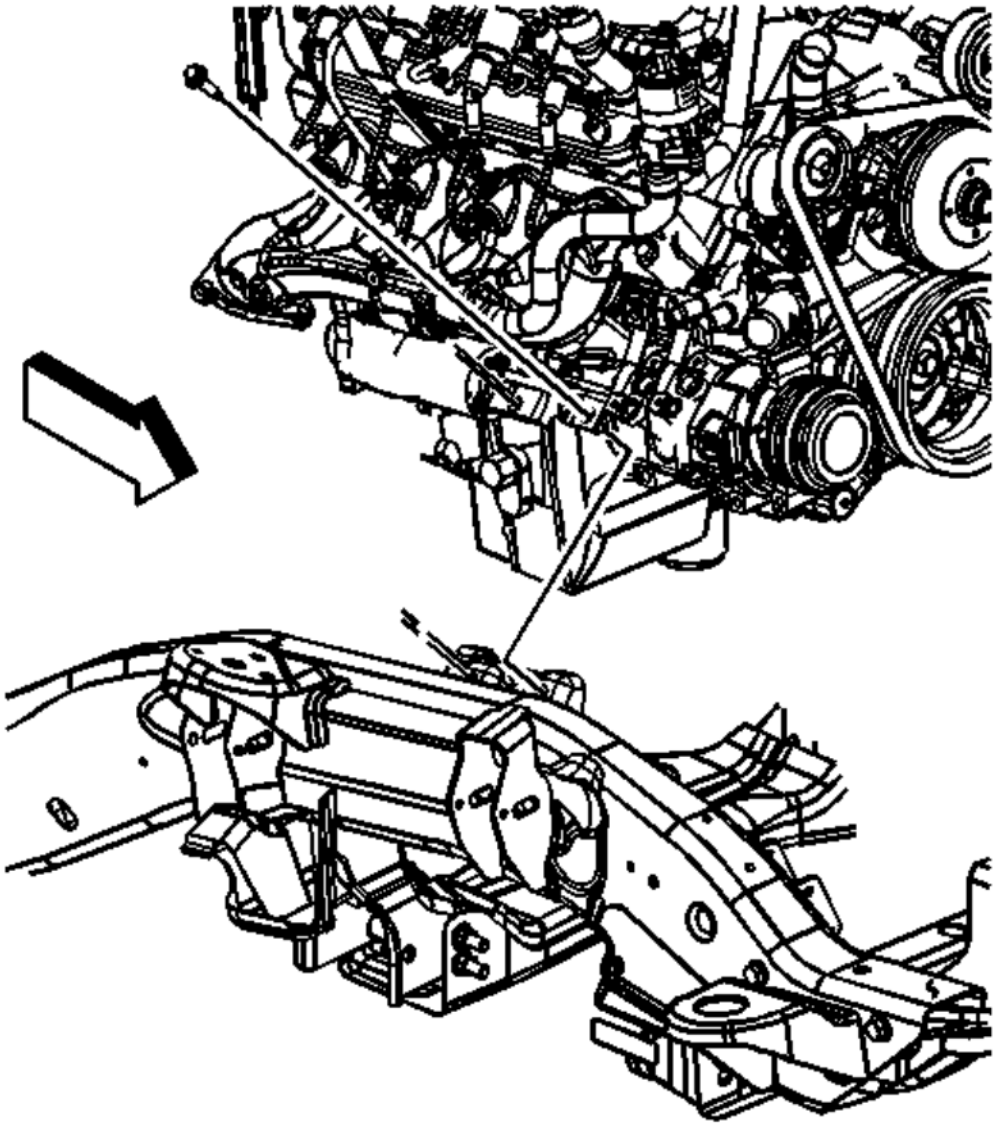

Fig. 33: Engine Mount-To-Frame Bracket Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount-to-frame bracket bolts. (Right side shown, left side similar).
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

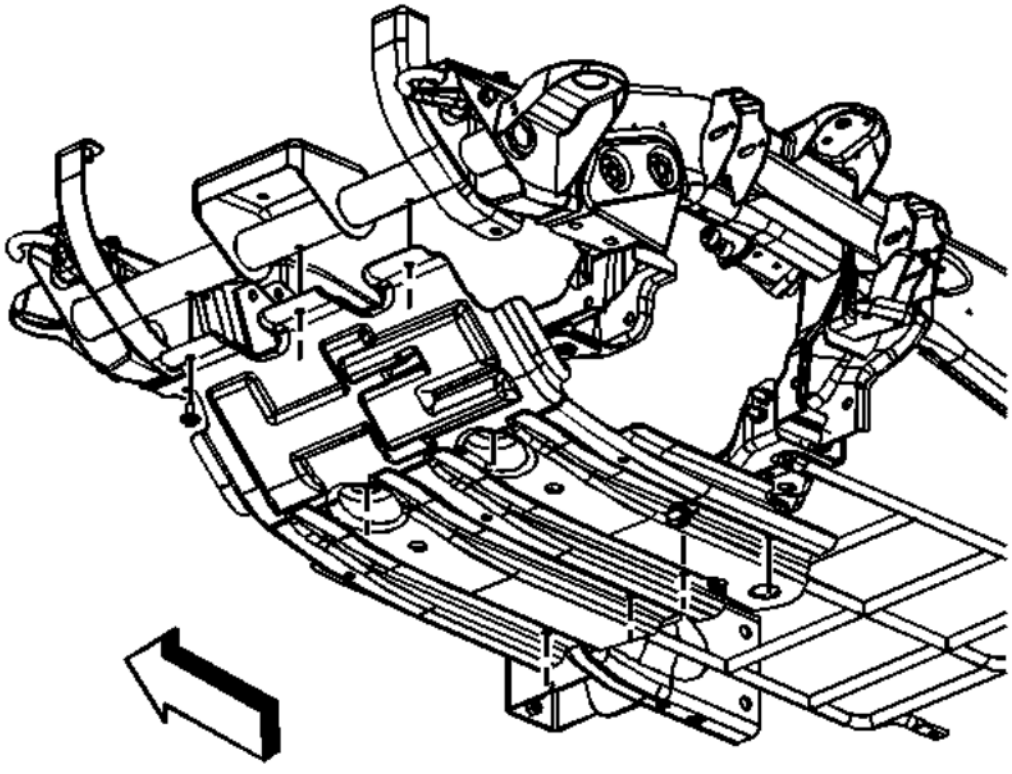

Fig. 34: Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine shield bolts.
4. Remove the engine shield.

IMPORTANT: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.

5. Raise and suitably support the engine using adjustable (screw type) jack stands.

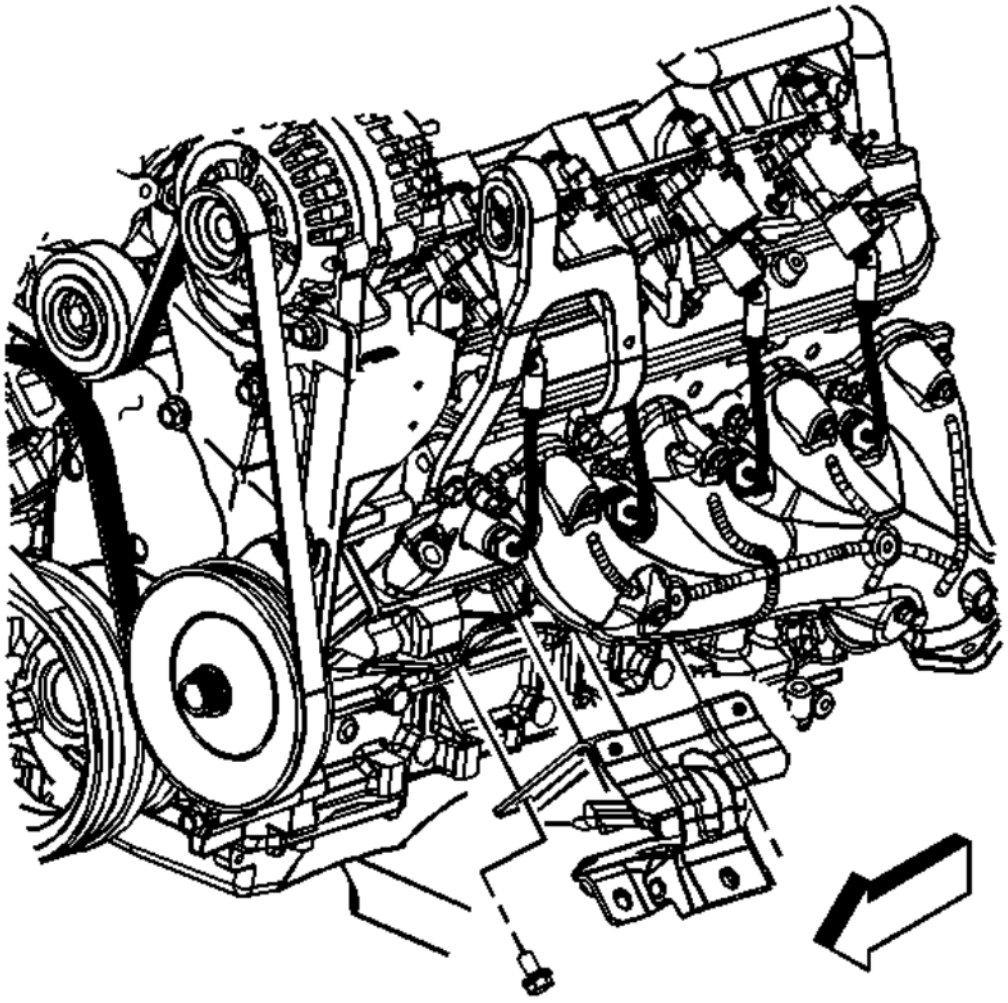

Fig. 35: Engine Mount (Left)
Courtesy of GENERAL MOTORS CORP.

6. Remove the engine mount bolts.
7. Remove the engine mount.

Installation Procedure

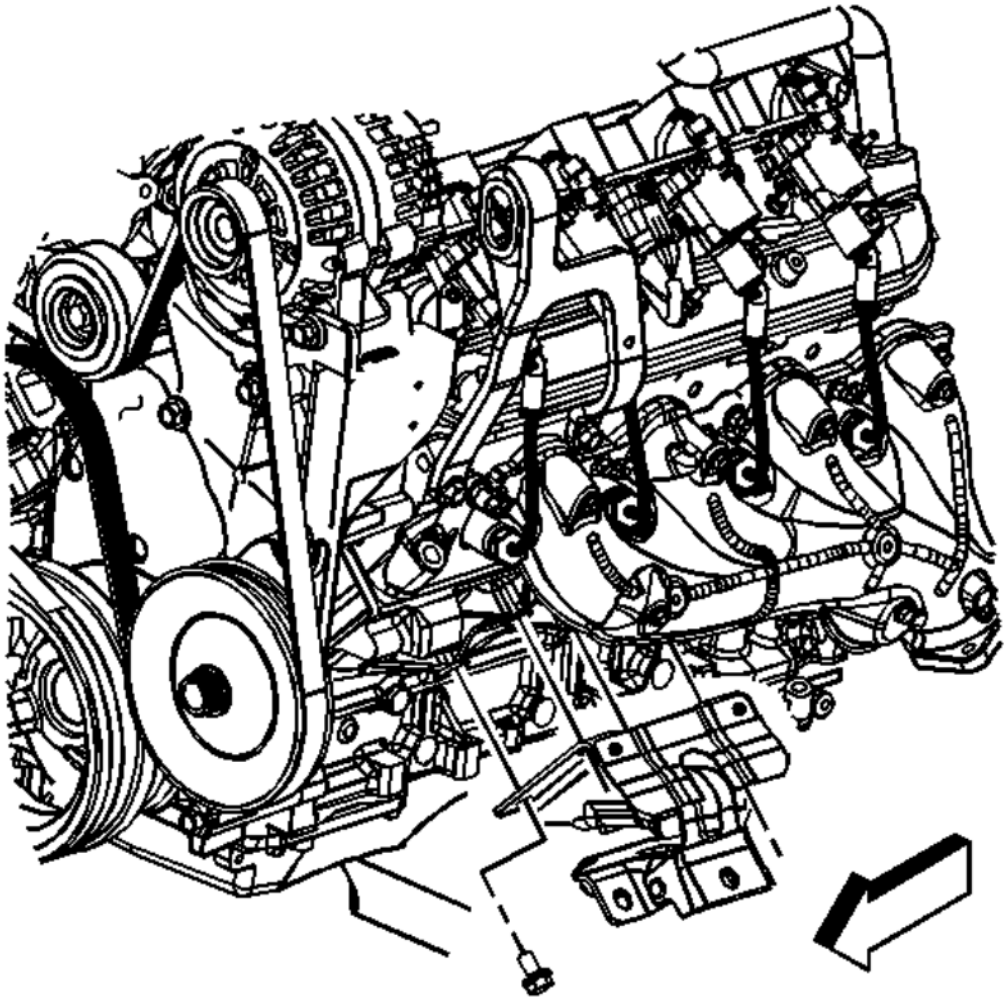

Fig. 36: Engine Mount (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

1. Position the engine mount to the engine.
2. Install the engine mount bolts.

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

3. Lower the engine.
4. Remove the adjustable jack stands.

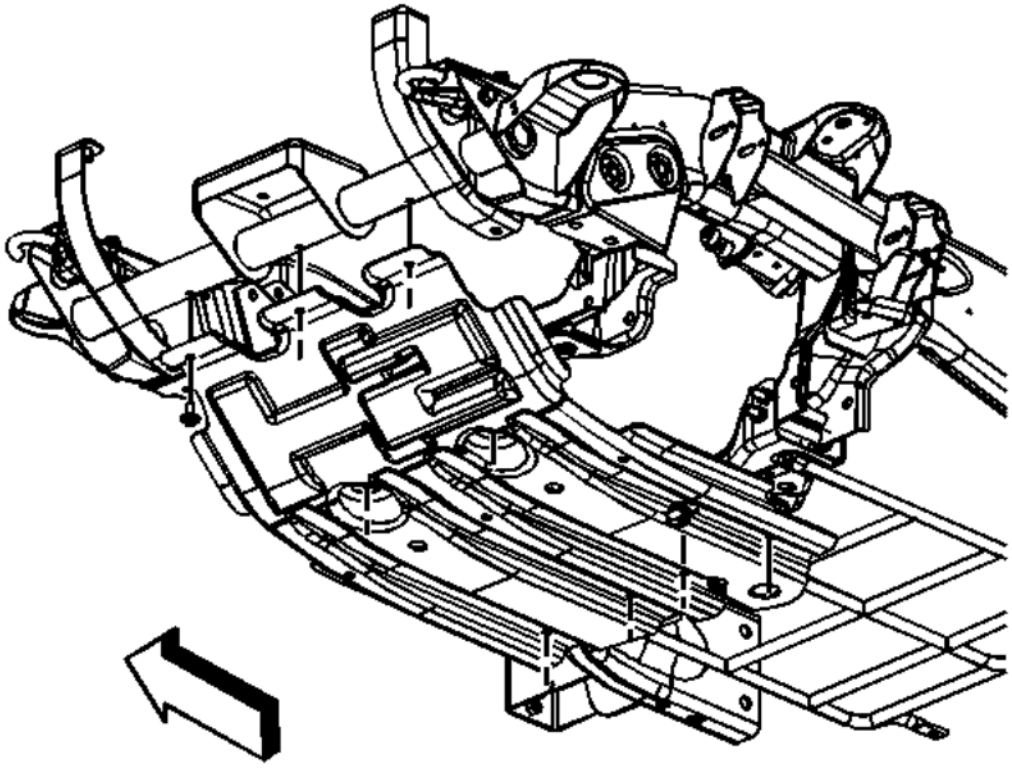

Fig. 37: Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

5. Position the engine shield to the vehicle.
6. Install the engine shield bolts.

   Tighten: Tighten the engine shield bolts to 30 N.m (22 lb ft).

7. Lower the vehicle.

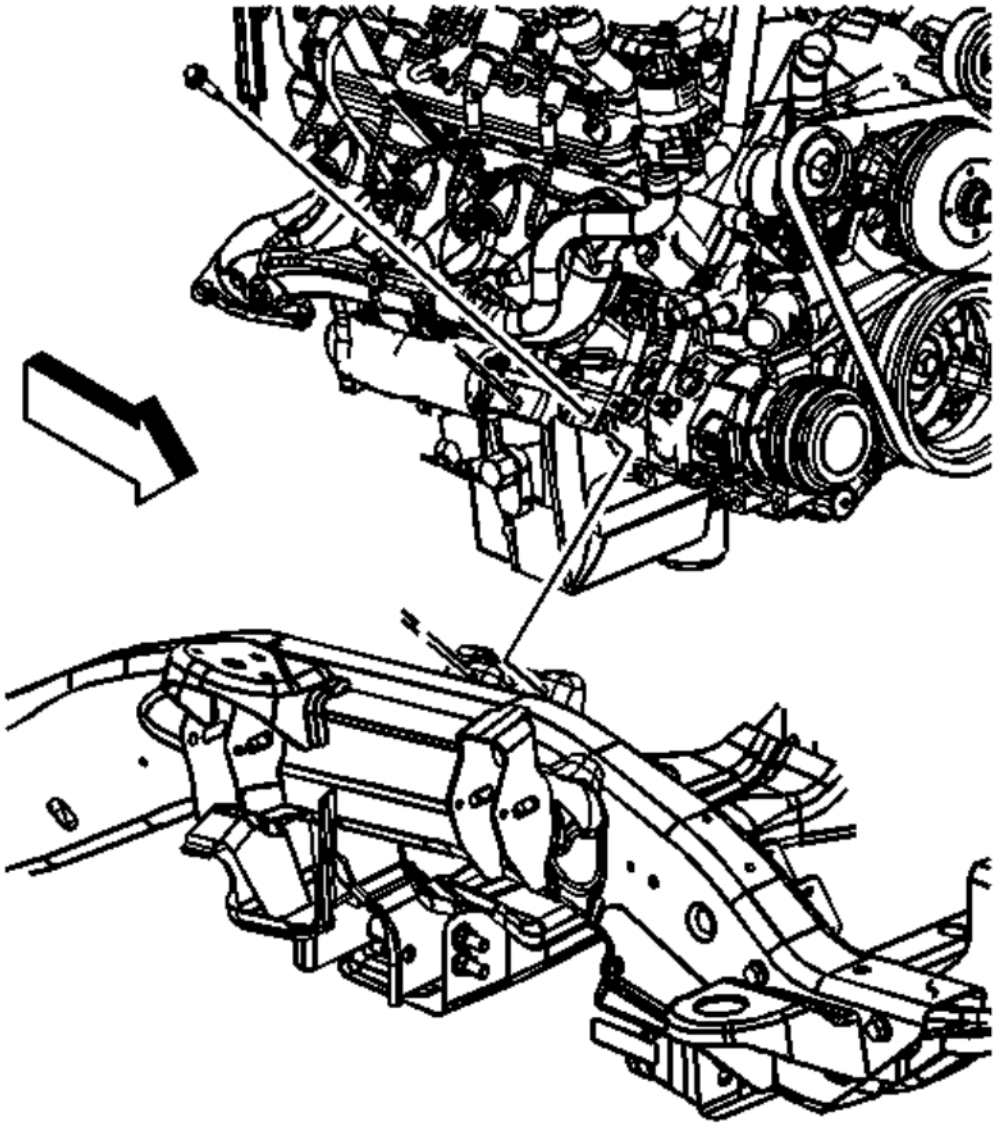

Fig. 38: Engine Mount-To-Frame Bracket Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

8. Install the engine mount-to-frame bracket bolts (right side shown, left side similar).

   Tighten: Tighten the engine mount-to-frame bracket bolts to 65 N.m (48 lb ft).

ENGINE MOUNT BRACKET REPLACEMENT - LEFT SIDE

Removal Procedure

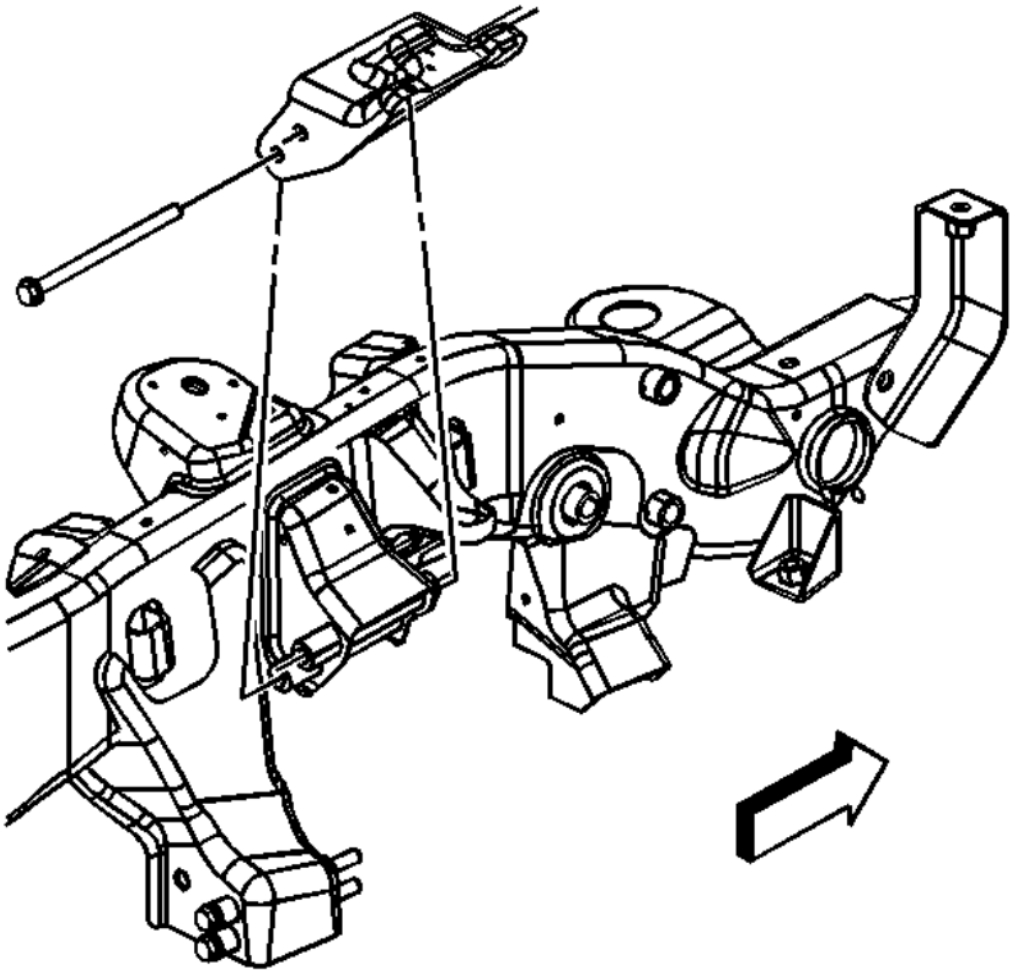

Fig. 39: Engine Mount Bracket (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to **Engine Mount Replacement - Left Side**.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

Installation Procedure

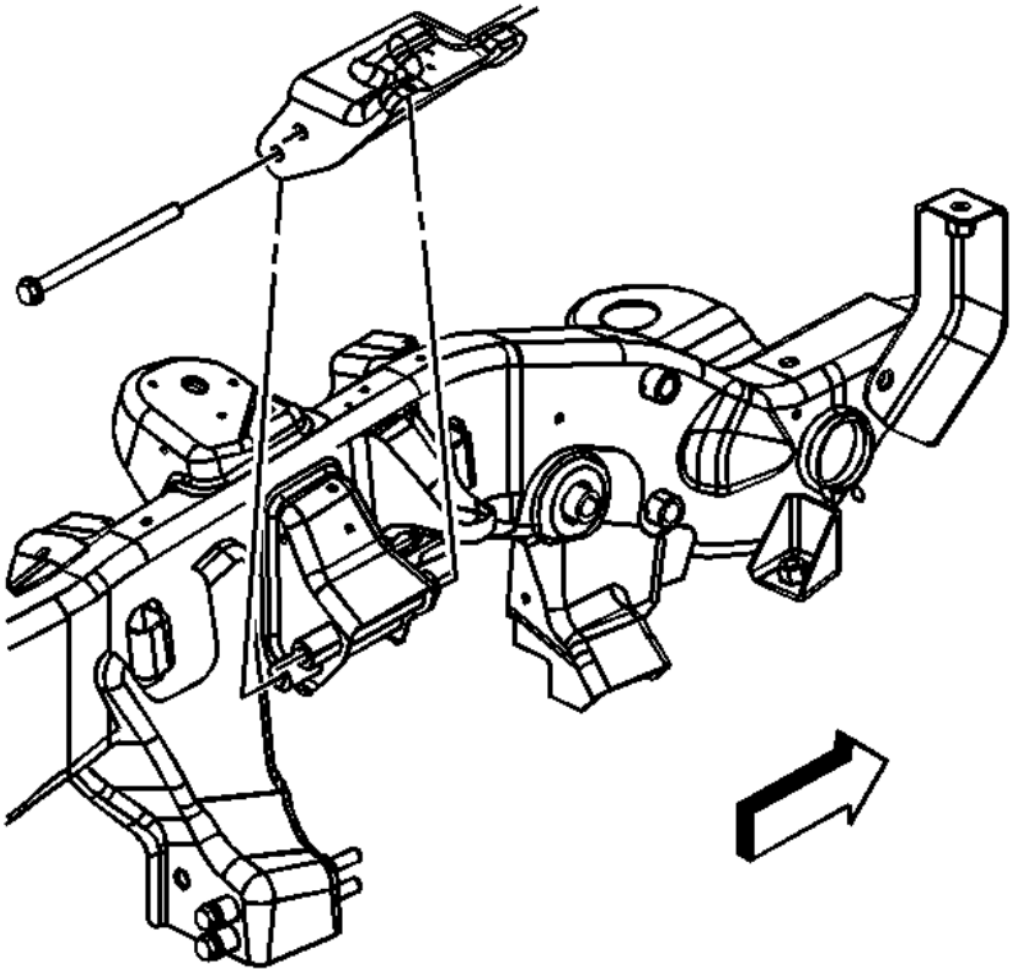

Fig. 40: Engine Mount Bracket (Left)
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.
2. Perform the following procedure prior to installing the engine mount bracket bolts:
   - Remove all traces of the original adhesive patch.
   - Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
   - Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

NOTE: **Refer to Fastener Notice .**

3. Install the engine mount bracket bolts.

   Tighten: Tighten the engine mount bracket bolts to 75 N.m (55 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement - Left Side**.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

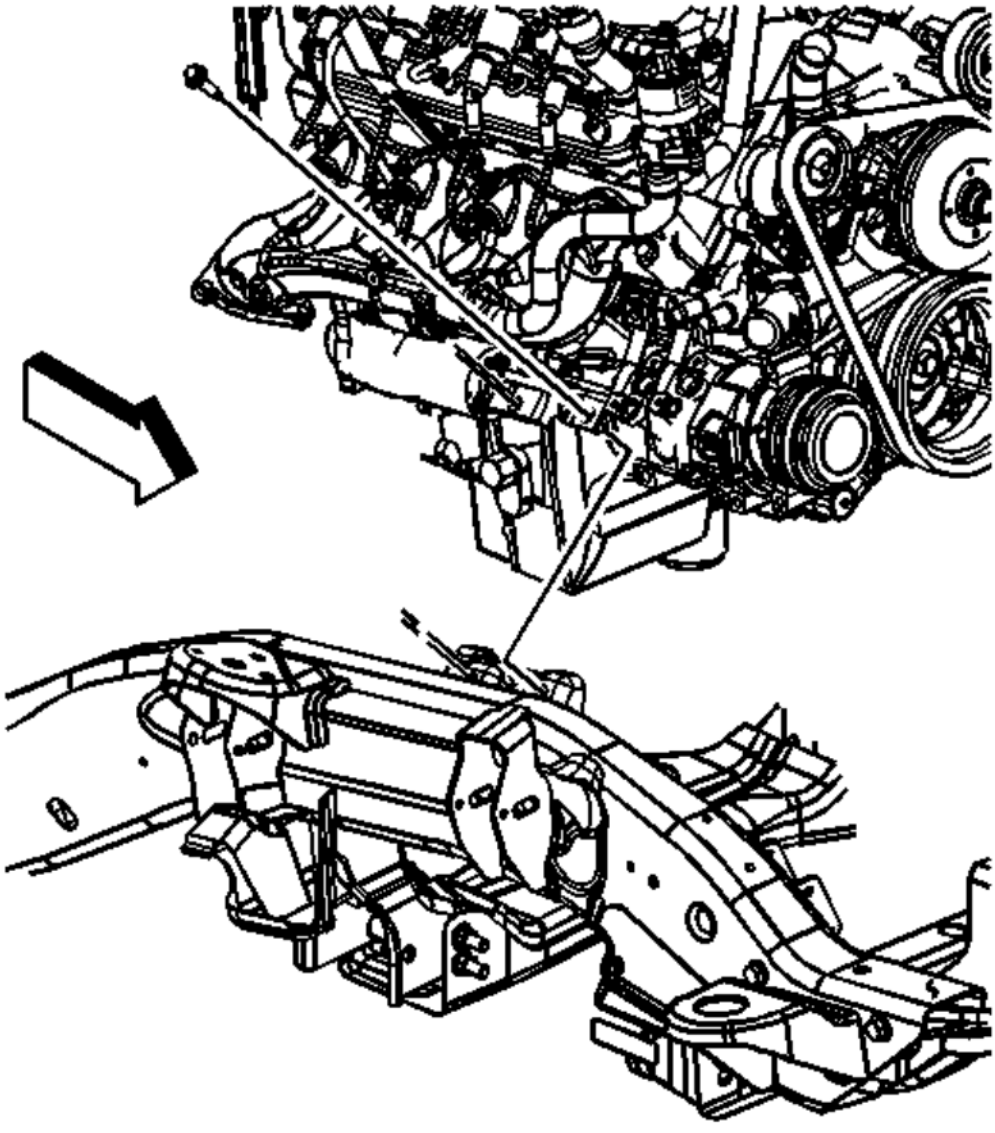

Fig. 41: Engine Mount-To-Frame Bracket Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount-to-frame bracket bolts.
2. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

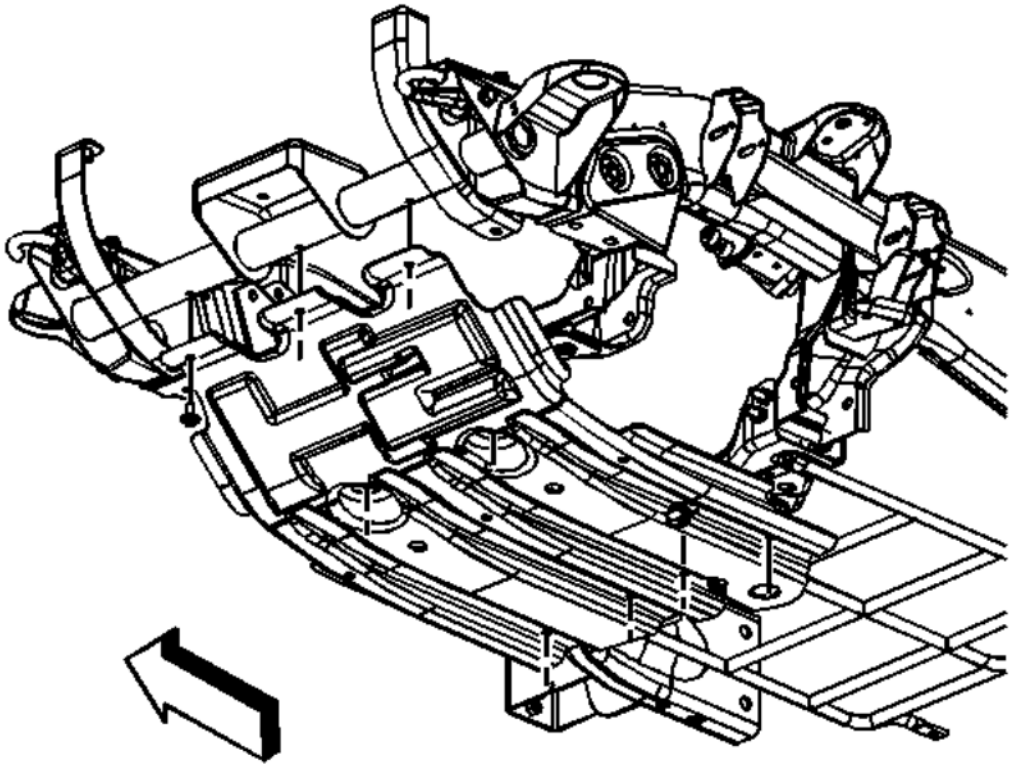

Fig. 42: Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine shield bolts.
4. Remove the engine shield.
5. Remove the air conditioning (A/C) compressor. Refer to **Compressor Replacement** .
6. Remove the starter motor. Refer to **Starter Motor Replacement** .

IMPORTANT: DO NOT raise and/or support the engine by the crankshaft balancer, or oil pan.

7. Raise and suitably support the engine using adjustable (screw type) jack stands.

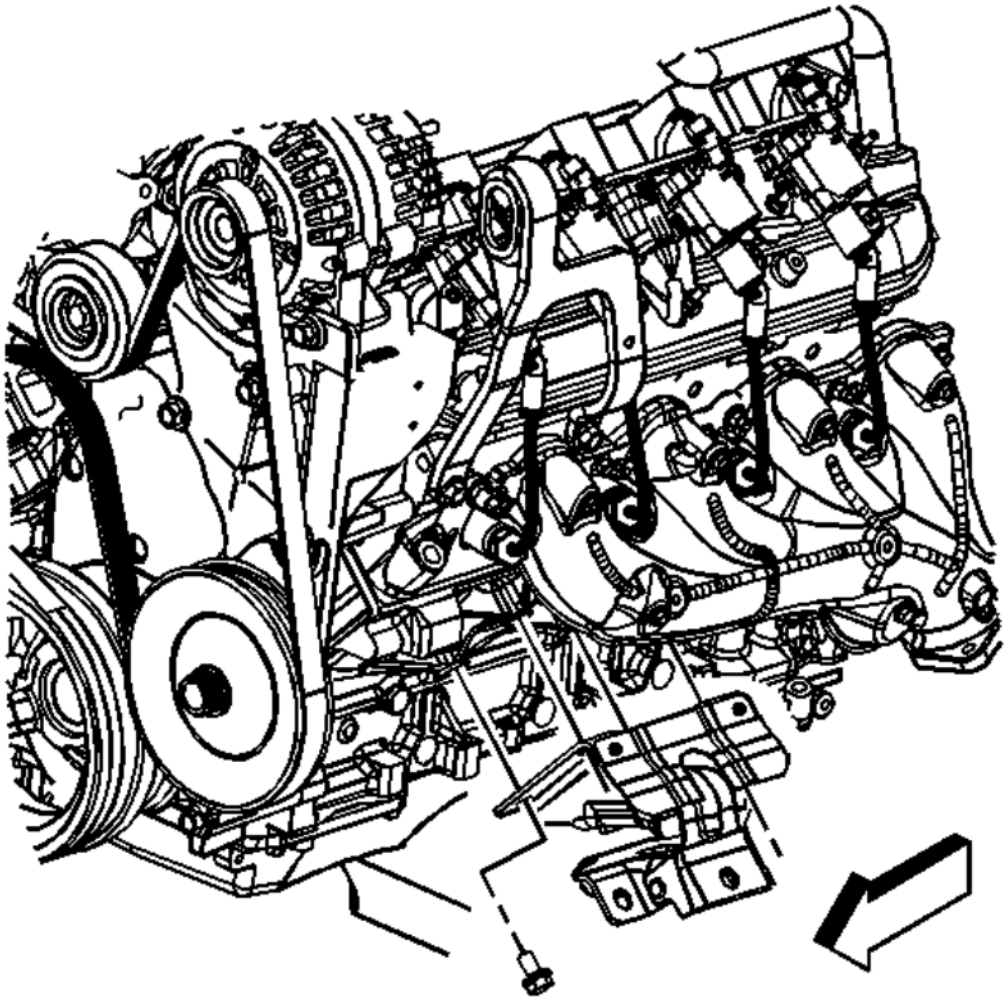

Fig. 43: Engine Mount (Left)
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount bolts (left side shown, right side similar).
9. Remove the right engine mount.

Installation Procedure

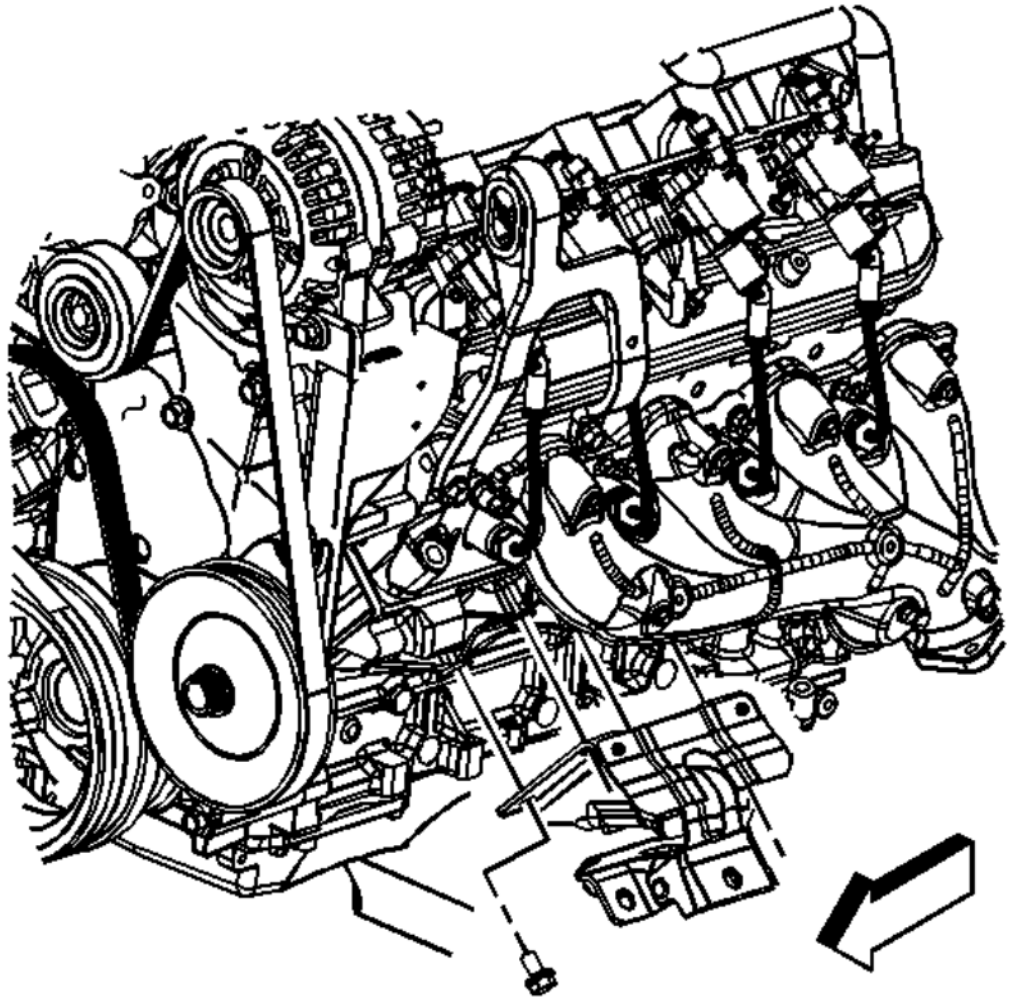

Fig. 44: Engine Mount (Left)
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

1. Position the right engine mount to the engine (left side shown, right side similar).
2. Install the engine mount bolts.

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

3. Lower the engine.
4. Remove the adjustable jack stands.
5. Install the starter motor. Refer to **Starter Motor Replacement** .
6. Install the A/C compressor. Refer to **Compressor Replacement** .

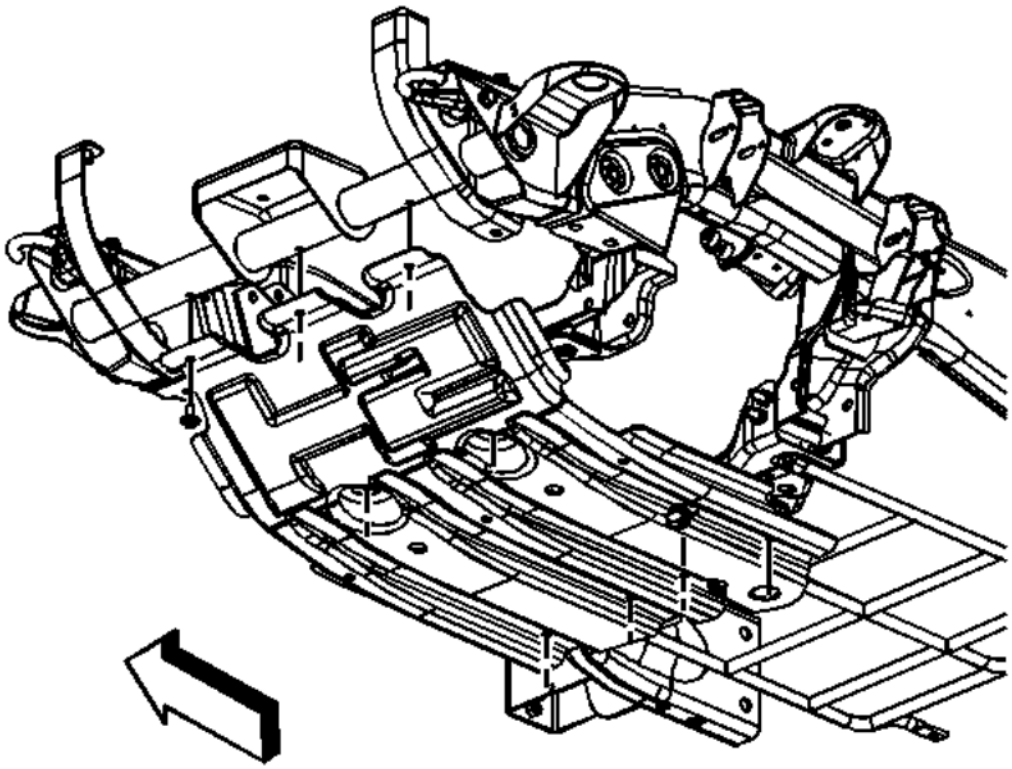

Fig. 45: Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

7. Position the engine shield to the vehicle.
8. Install the engine shield bolts.

   Tighten: Tighten the engine shield bolts to 30 N.m (22 lb ft).

9. Lower the vehicle.

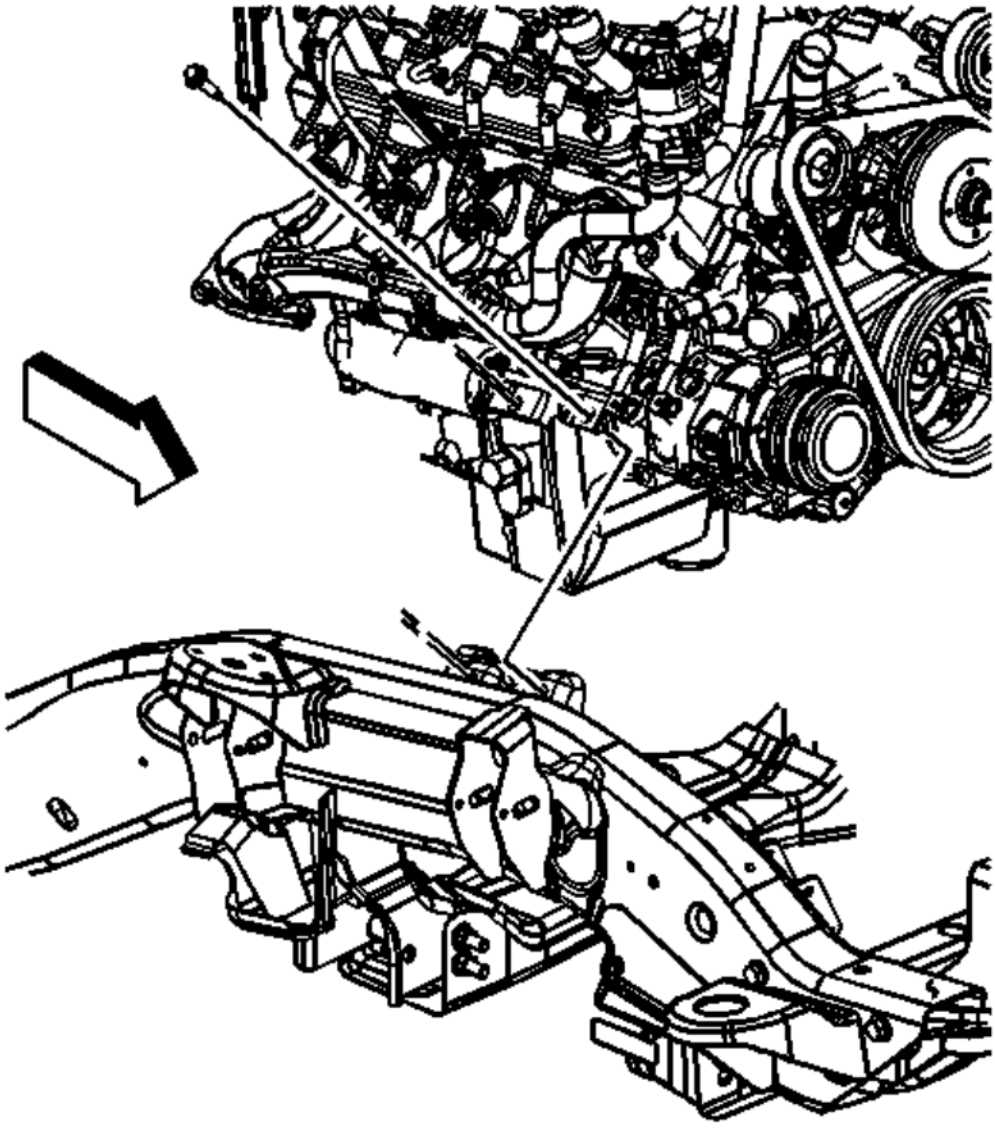

Fig. 46: Engine Mount-To-Frame Bracket Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

10. Install the engine mount-to-frame bracket bolts.

    Tighten: Tighten the engine mount-to-frame bracket bolts to 65 N.m (48 lb ft).

ENGINE MOUNT BRACKET REPLACEMENT - RIGHT SIDE

Removal Procedure

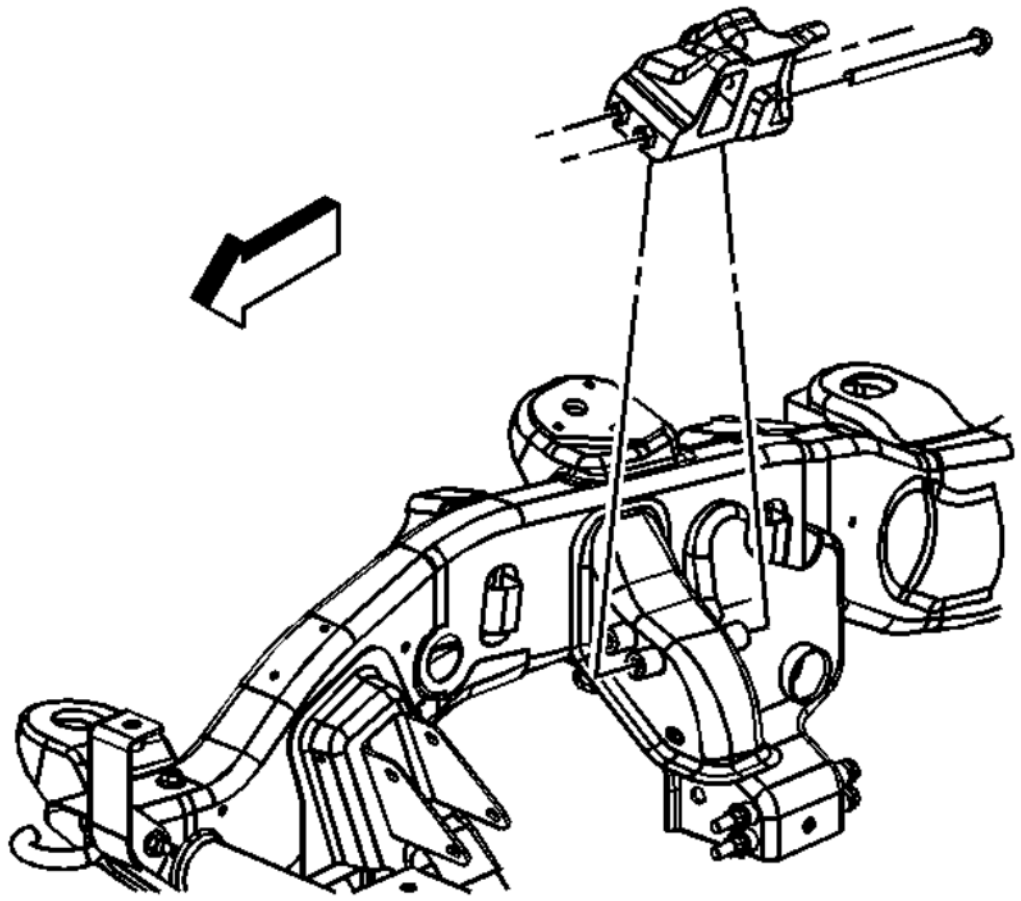

Fig. 47: Engine Mount Bracket (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine mount. Refer to **Engine Mount Replacement - Right Side**.
2. Remove the engine mount bracket bolts.
3. Remove the engine mount bracket.

Installation Procedure

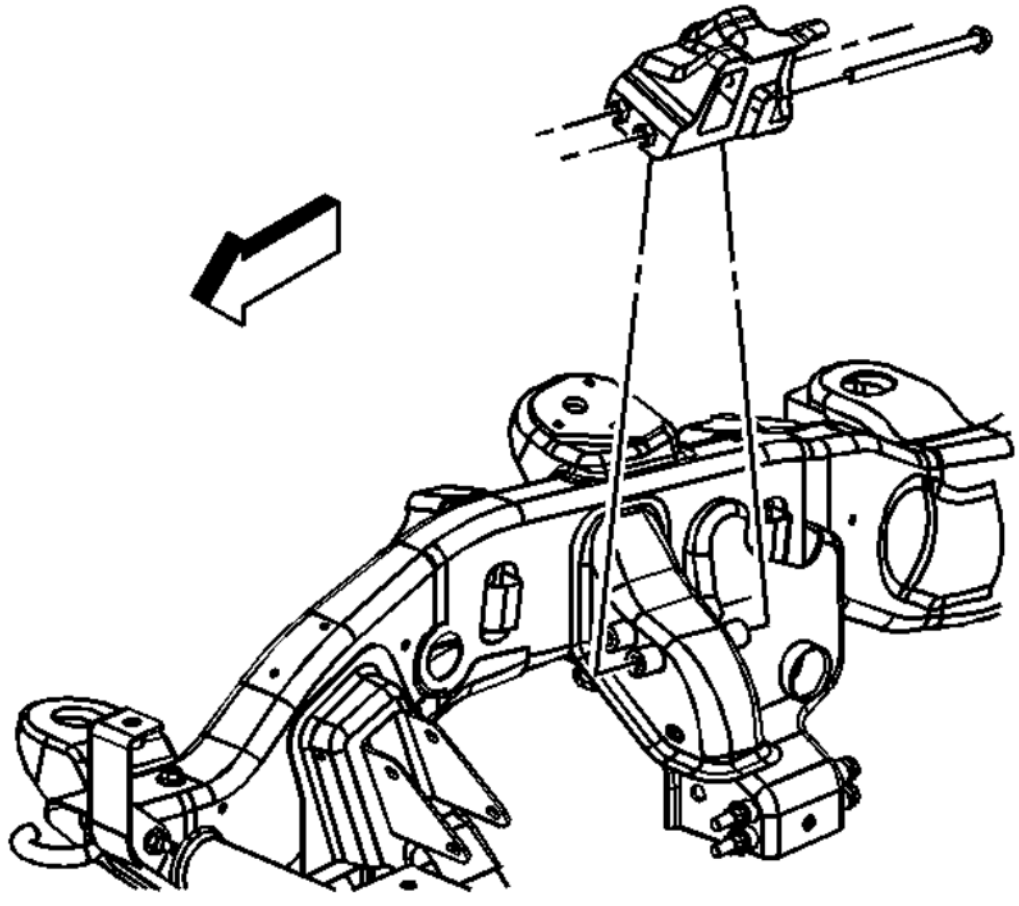

Fig. 48: Engine Mount Bracket (Right)
Courtesy of GENERAL MOTORS CORP.

1. Install the engine mount bracket.
2. Perform the following procedure prior to installing the engine mount bracket bolts:
   - Remove all traces of the original adhesive patch.
   - Clean the threads of the bolt with denatured alcohol or equivalent and allow to dry.
   - Apply threadlocker GM P/N 12345382 (Canadian P/N 10953489) or equivalent to the bolts.

NOTE: **Refer to Fastener Notice .**

3. Install the engine mount bracket bolts.

   Tighten: Tighten the engine mount bracket bolts to 75 N.m (55 lb ft).

4. Install the engine mount. Refer to **Engine Mount Replacement - Right Side**.

UPPER INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT (6.0L (LQ4))

Removal Procedure

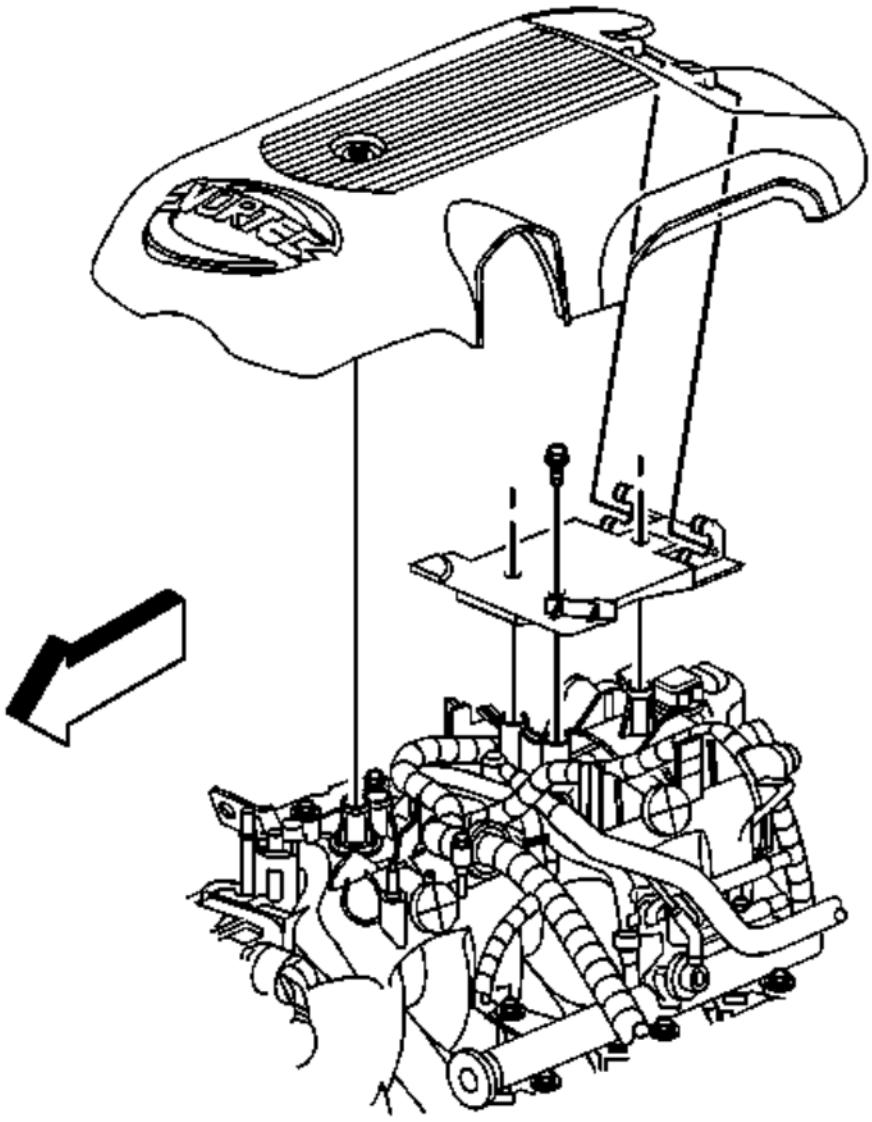

Fig. 49: View Of Top Engine Cover
Courtesy of GENERAL MOTORS CORP.

1. Loosen the intake manifold sight shield bolt.
2. Remove the sight shield from the sight shield retainer.
3. Remove the sight shield retainer bolts and the retainer, if required.

Installation Procedure

NOTE: Refer to Fastener Notice .

1. Install the sight shield retainer and the bolts, if required.

   Tighten: Tighten the retainer bolts to 5 N.m (44 lb in).

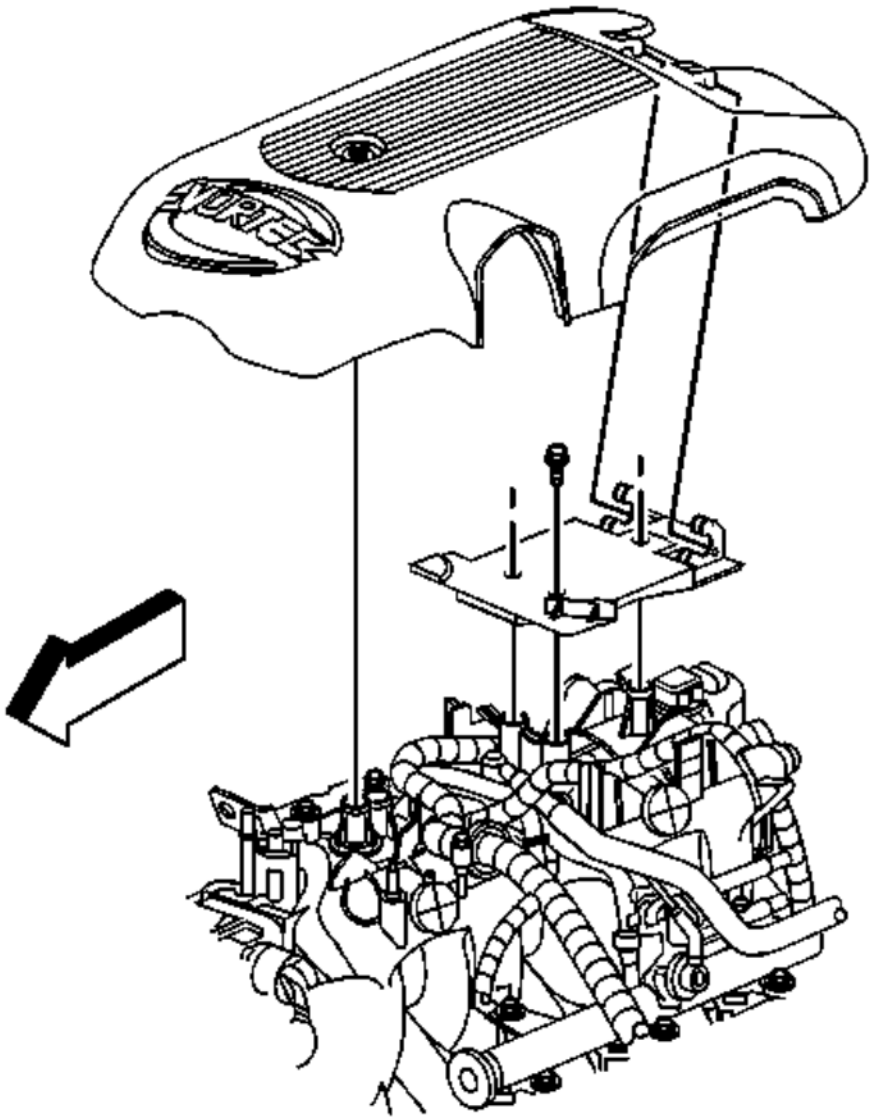

Fig. 50: View Of Top Engine Cover
Courtesy of GENERAL MOTORS CORP.

NOTE: **Use care when installing the engine sight shield to avoid contacting the manifold absolute pressure (MAP) sensor wire harness connector. Loss of engine performance or engine**

damage may result.

2. Install the intake manifold sight shield to the retainer.

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

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

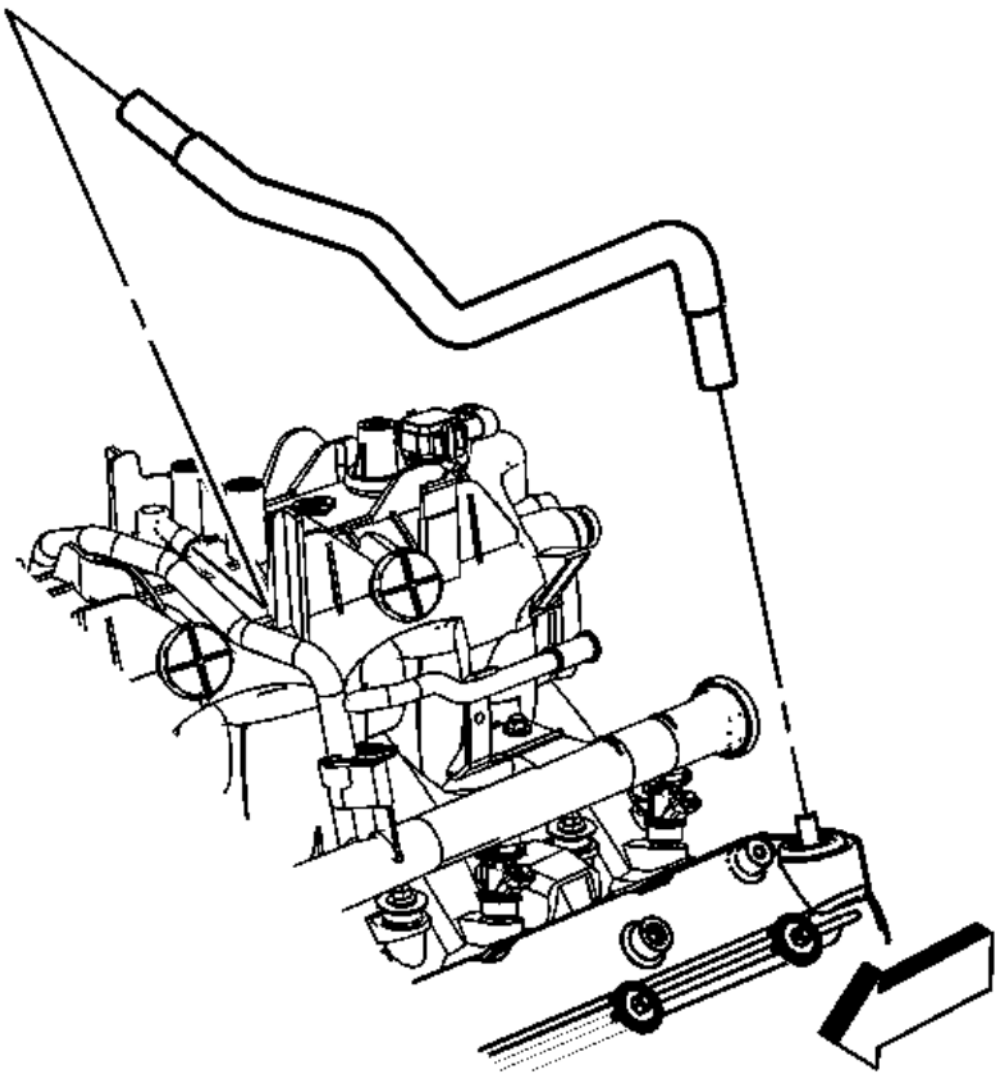

Fig. 51: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.
2. Remove the positive crankcase ventilation (PCV) hose from the intake manifold and valve rocker arm cover.

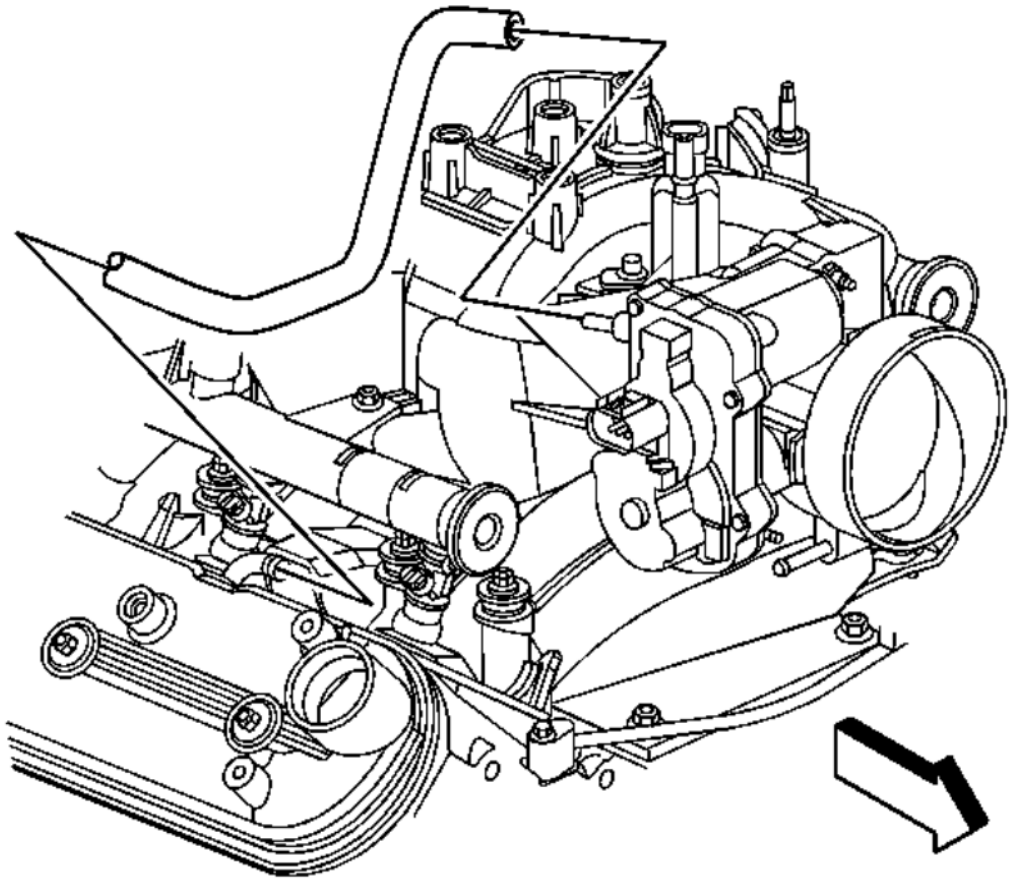

Fig. 52: View Of Throttle Body To Valve Rocker Arm Cover PCV Hose
Courtesy of GENERAL MOTORS CORP.

3. Remove the vent hose from the throttle body and the valve rocker arm cover.
4. Replace the hose as necessary.

Installation Procedure

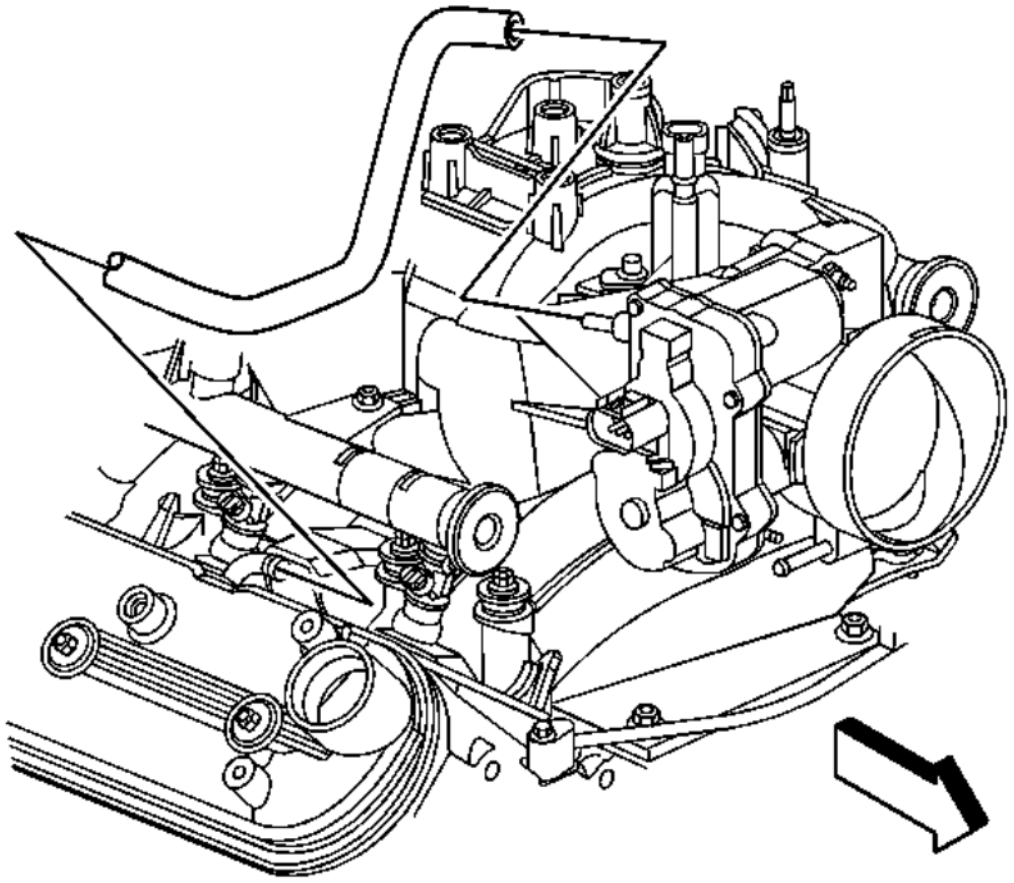

Fig. 53: View Of Throttle Body To Valve Rocker Arm Cover PCV Hose
Courtesy of GENERAL MOTORS CORP.

1. Install the hose as necessary.
2. Install the vent hose to the throttle body and the valve rocker arm cover.

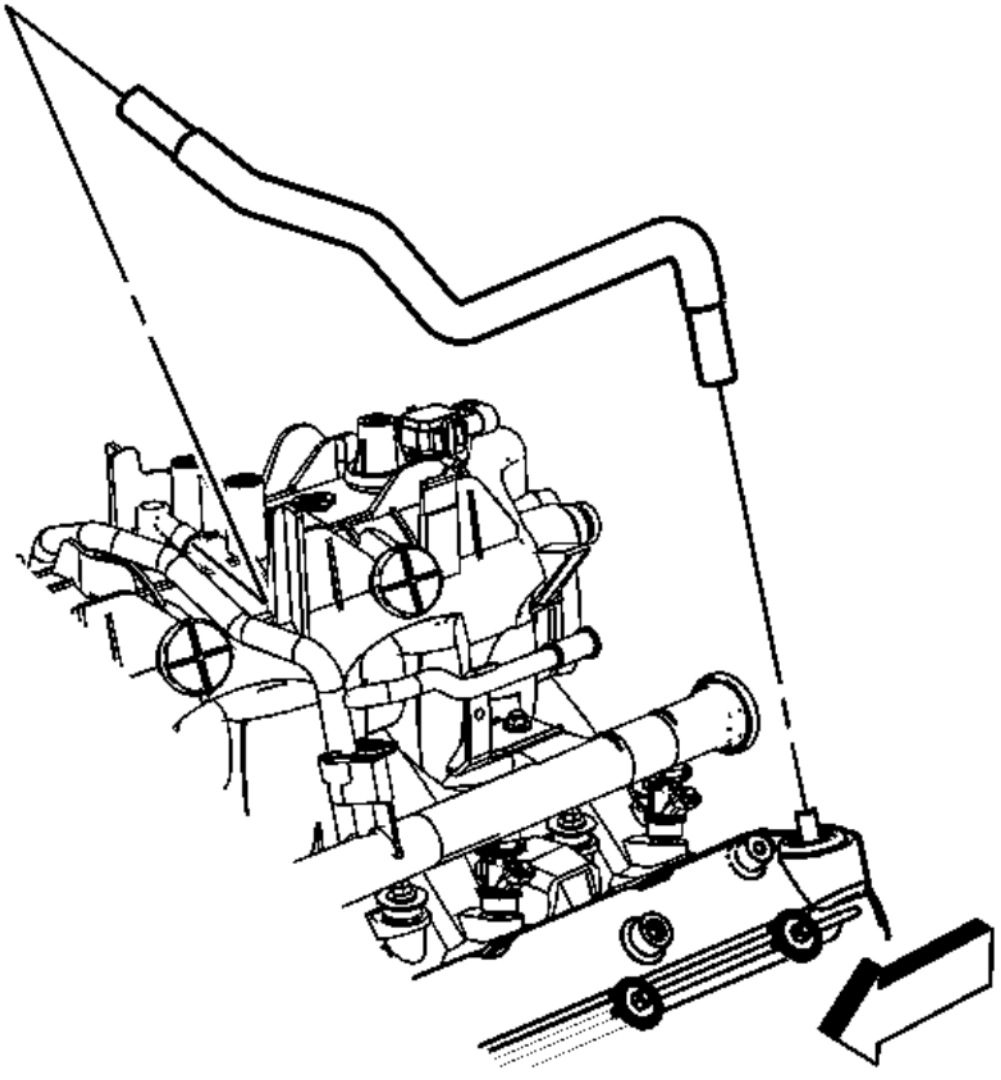

Fig. 54: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

3. Install the PCV hose to the intake manifold and valve rocker arm cover.
4. Install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

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.

1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement** .
2. Remove the fuel injectors. Refer to **Fuel Injector Replacement** .

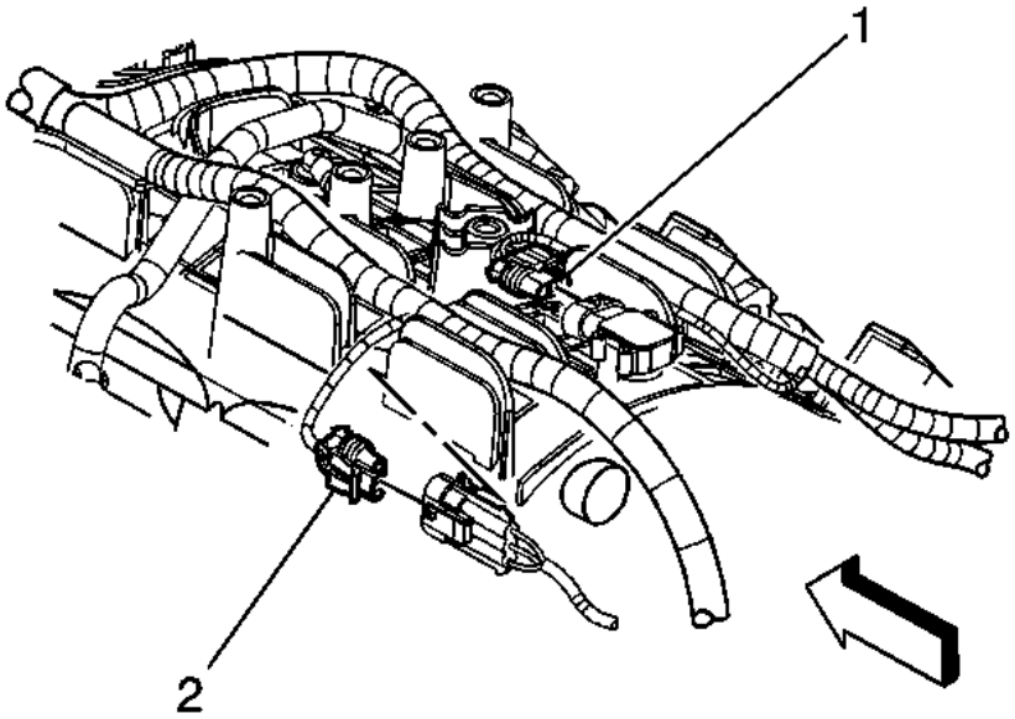

Fig. 55: View Of MAP Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Disconnect the following electrical connectors:
   - Manifold absolute pressure (MAP) sensor (1)
   - Knock sensor (2)

4. Remove the knock sensor harness electrical connector from the intake manifold.
5. Set the electrical harness aside.

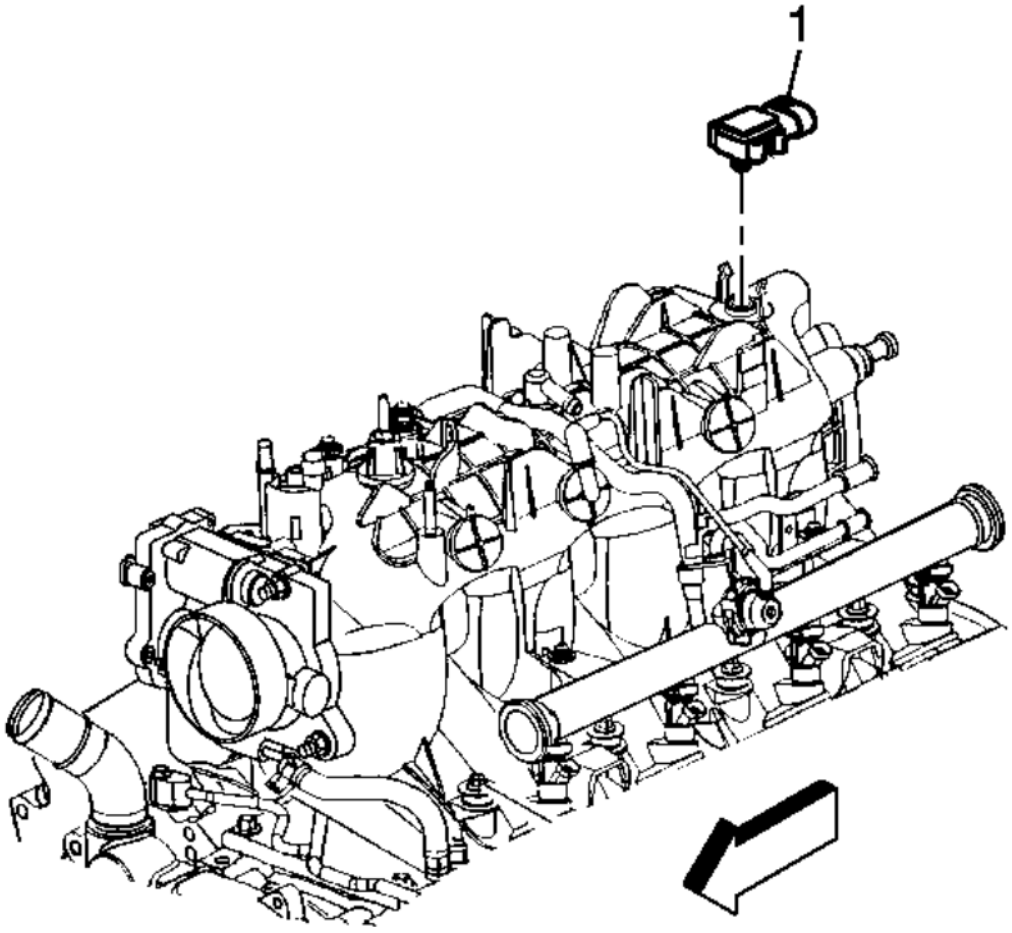

Fig. 56: View Of Manifold Absolute Pressure (MAP) Sensor
Courtesy of GENERAL MOTORS CORP.

6. Remove the MAP sensor (1) from the intake manifold.

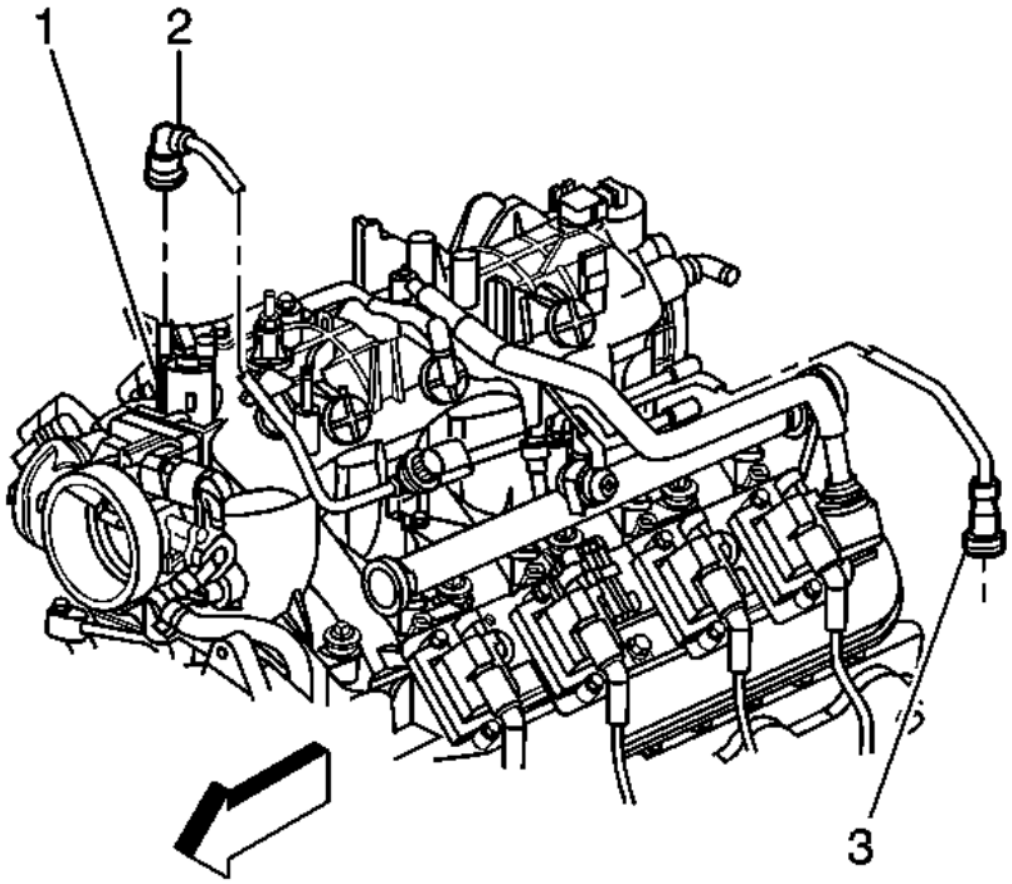

Fig. 57: View Of EVAP Purge Solenoid Vent Tube
Courtesy of GENERAL MOTORS CORP.

7. Remove the evaporative emission (EVAP) purge solenoid vent tube by performing the following:
    1. Remove the EVAP tube end (2) from the solenoid (1).
    2. Squeeze the EVAP pipe quick connect fitting (3) retainer together.
    3. Remove the EVAP tube end (3) from the vapor pipe.

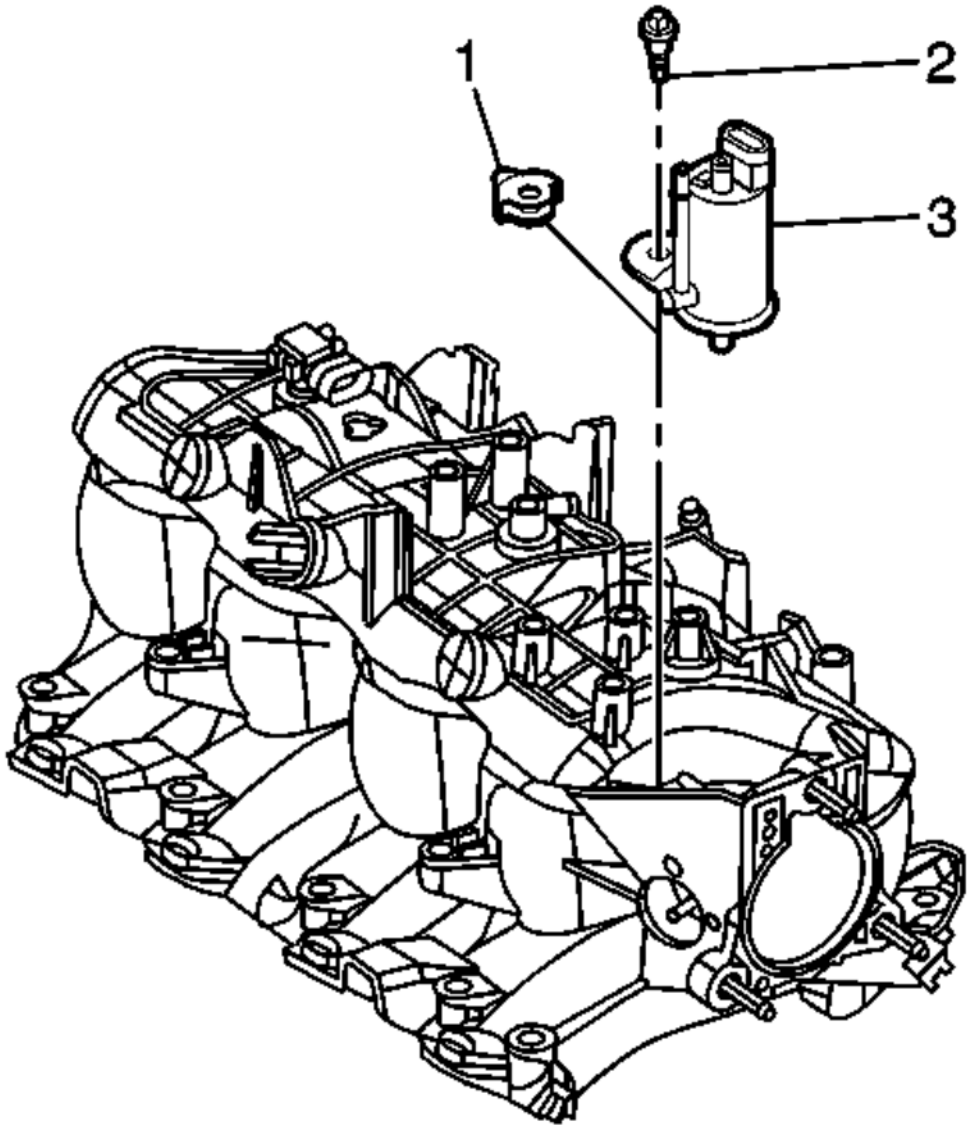

Fig. 58: View Of EVAP Purge Solenoid Bolt, Solenoid & Isolator
Courtesy of GENERAL MOTORS CORP.

8. Remove the EVAP purge solenoid bolt (2), solenoid (3), and isolator (1) from the intake manifold.

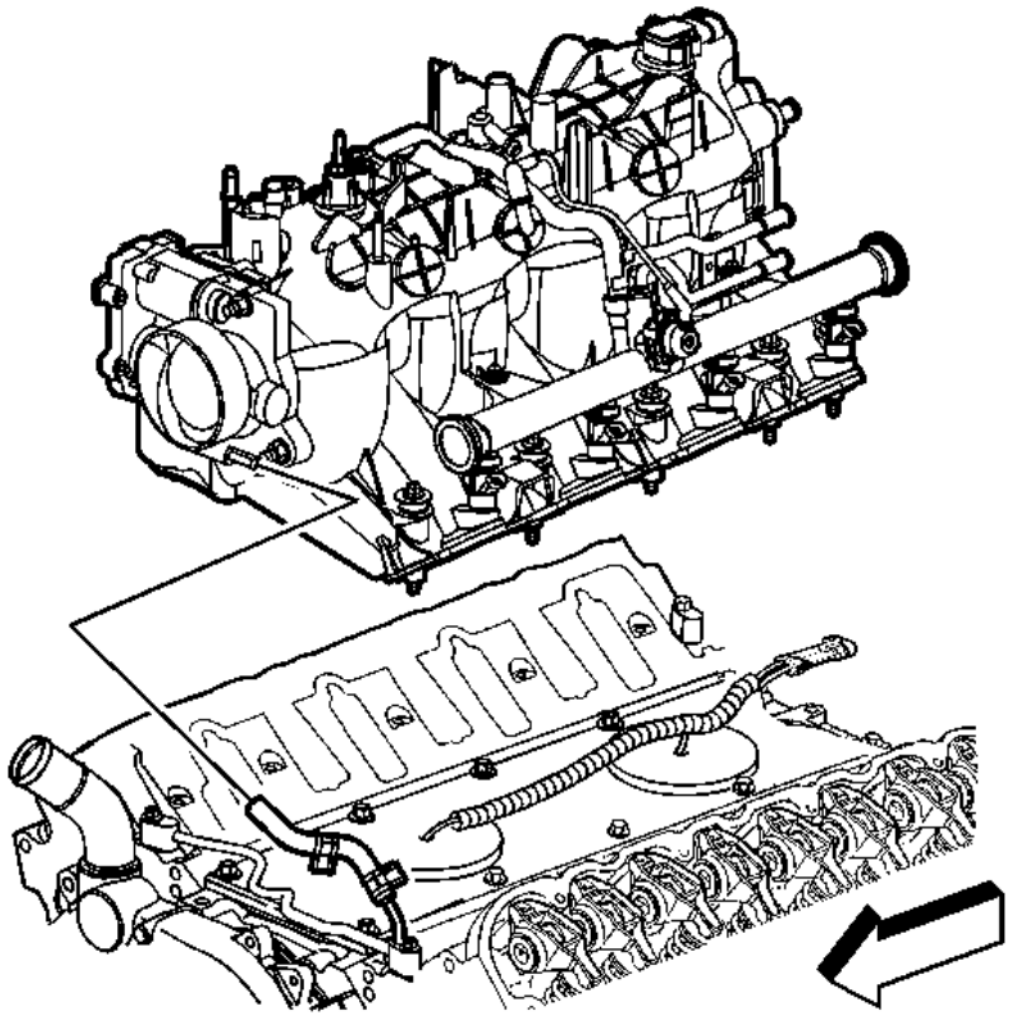

Fig. 59: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

9. Remove the intake manifold bolts.
10. Remove the intake manifold.

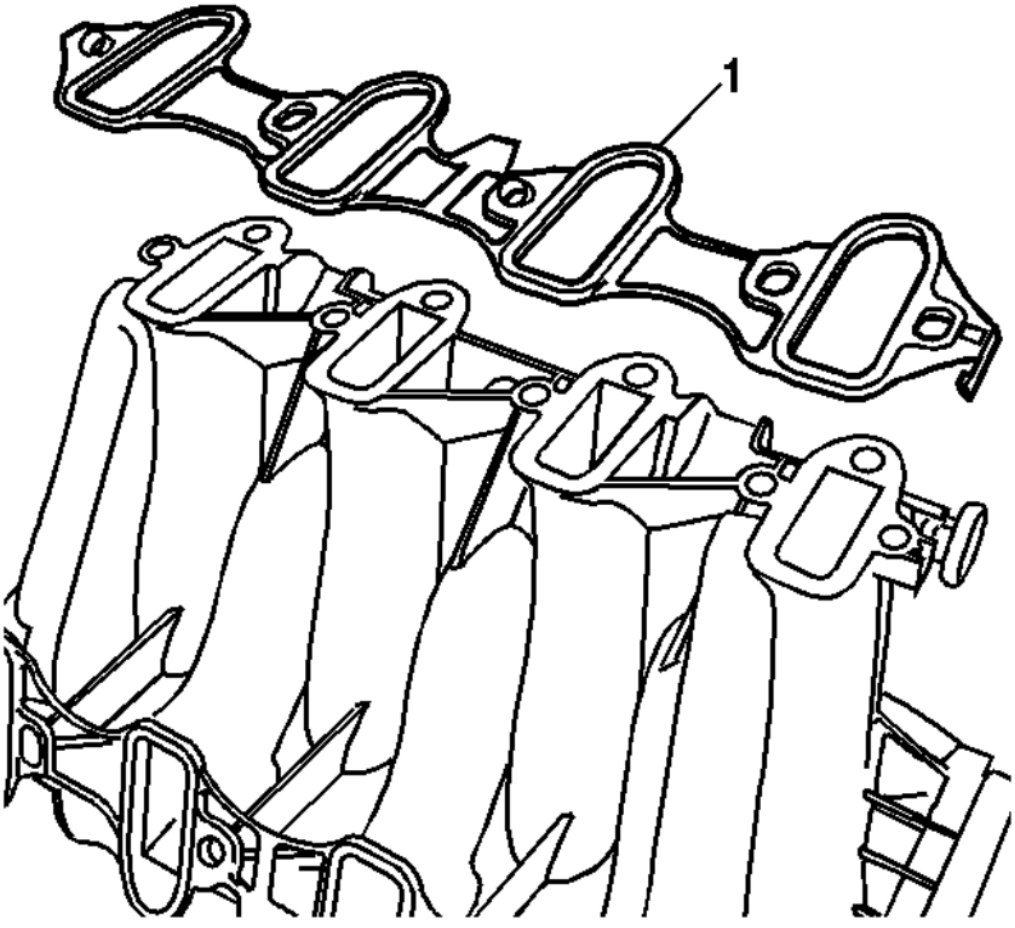

Fig. 60: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove the intake manifold gaskets (1) from the intake manifold.
12. Discard the old intake manifold gaskets.
13. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

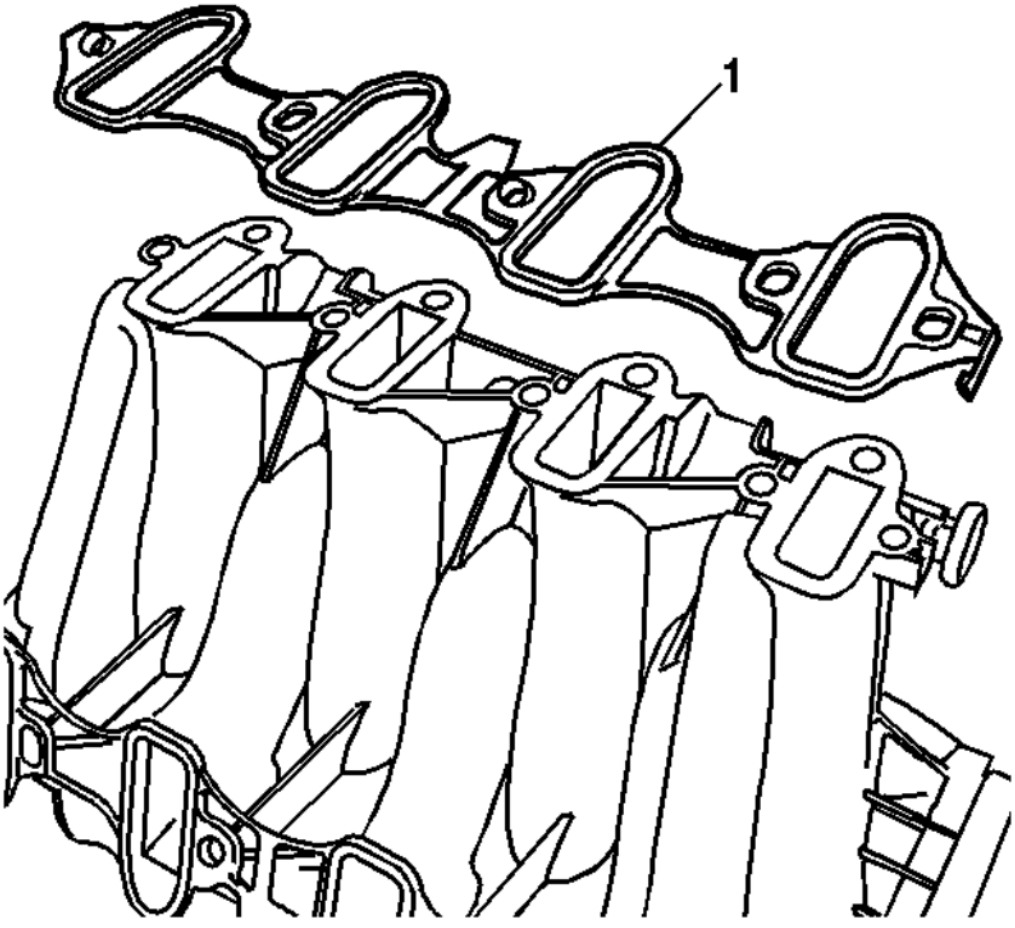

Fig. 61: View Of Intake Manifold Gasket
Courtesy of GENERAL MOTORS CORP.

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

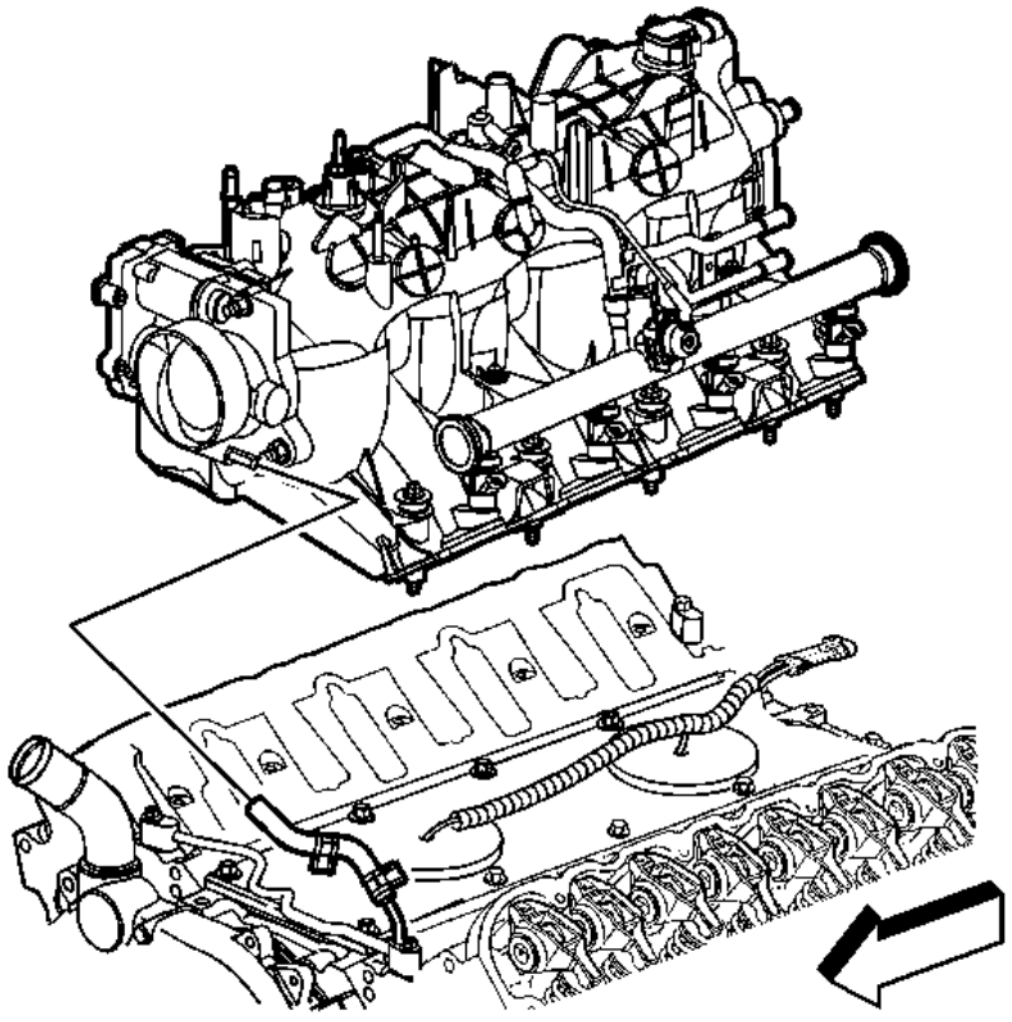

Fig. 62: Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold.
3. Apply a 5 mm (0.20 in) band of threadlock to the threads of the intake manifold bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

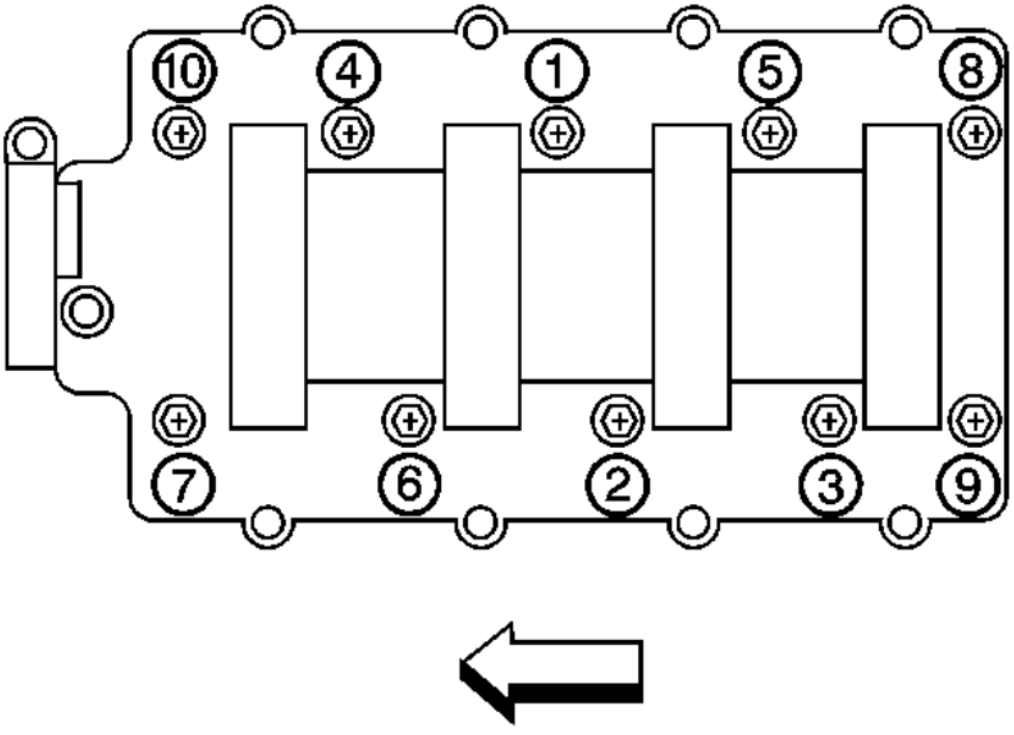

Fig. 63: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

4. Install the intake manifold bolts.

Tighten:

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

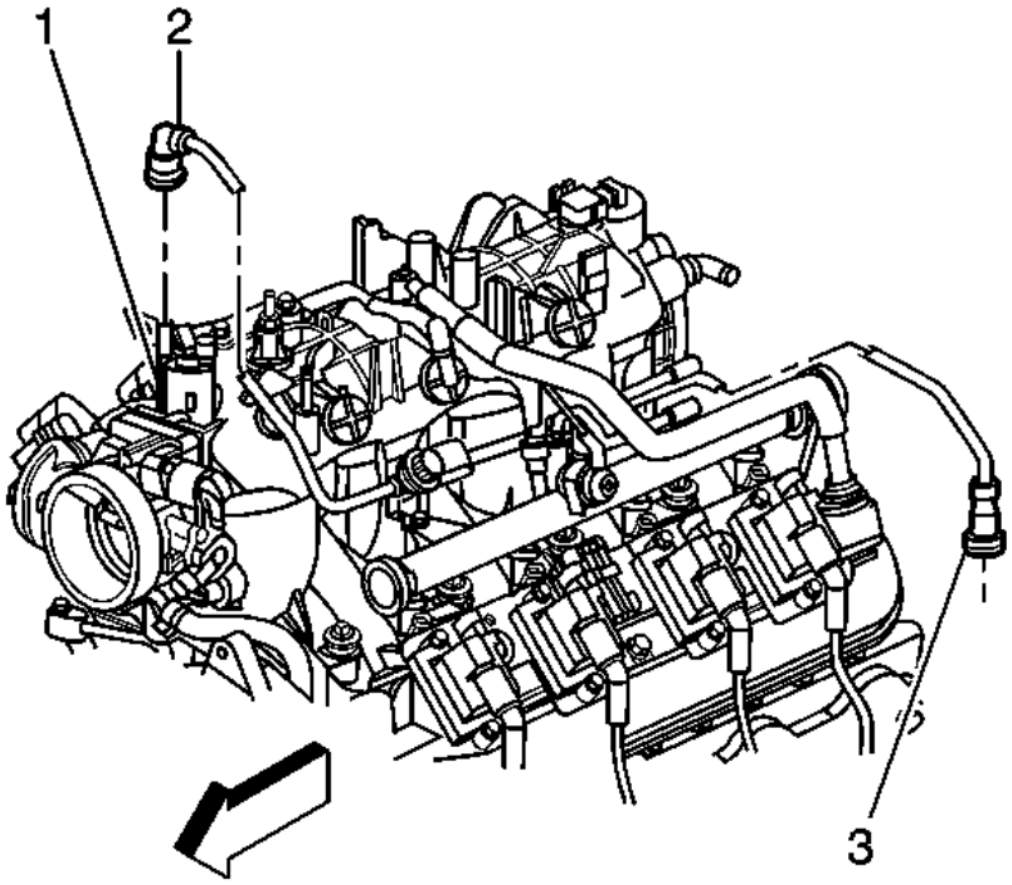

Fig. 64: View Of EVAP Purge Solenoid Vent Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the EVAP purge solenoid vent tube to the solenoid (1) and vapor pipe.

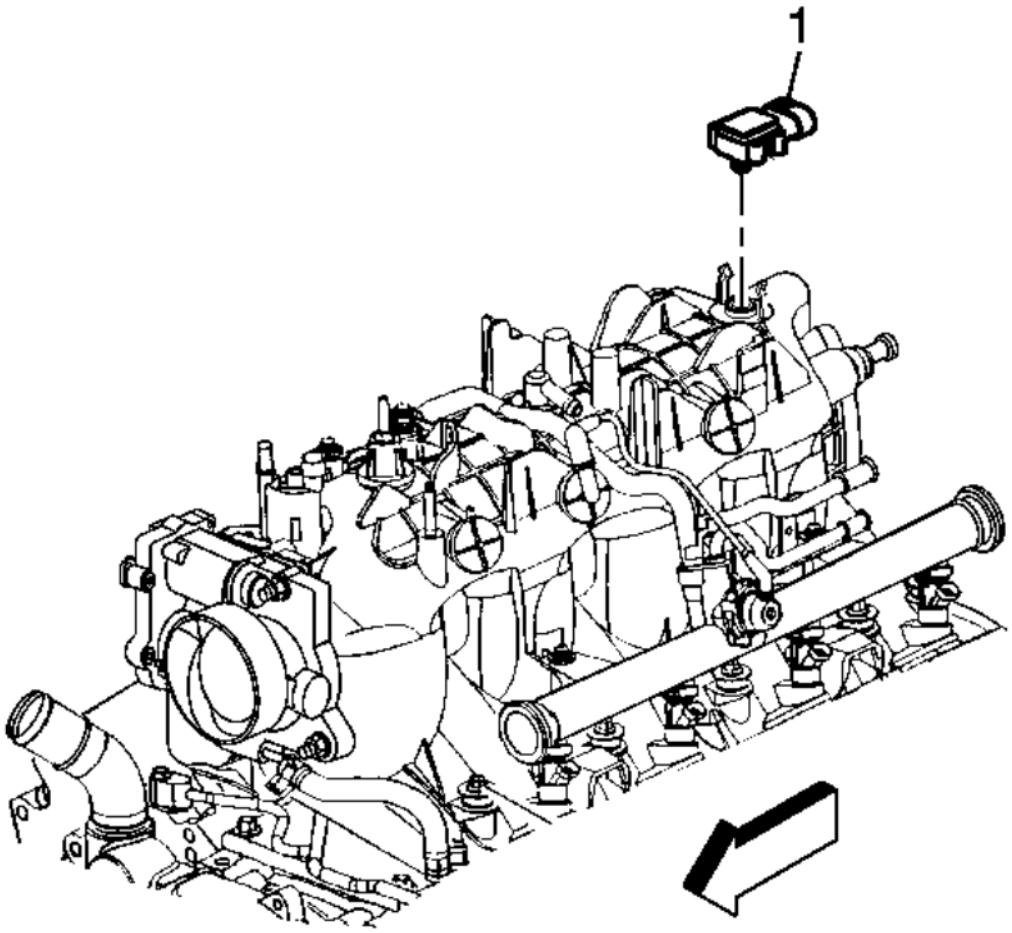

Fig. 65: View Of Manifold Absolute Pressure (MAP) Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lightly coat the MAP sensor seal with clean engine oil before installing.

6. Install the MAP sensor (1) to the intake manifold.
7. Route the electrical harness into position over the engine.

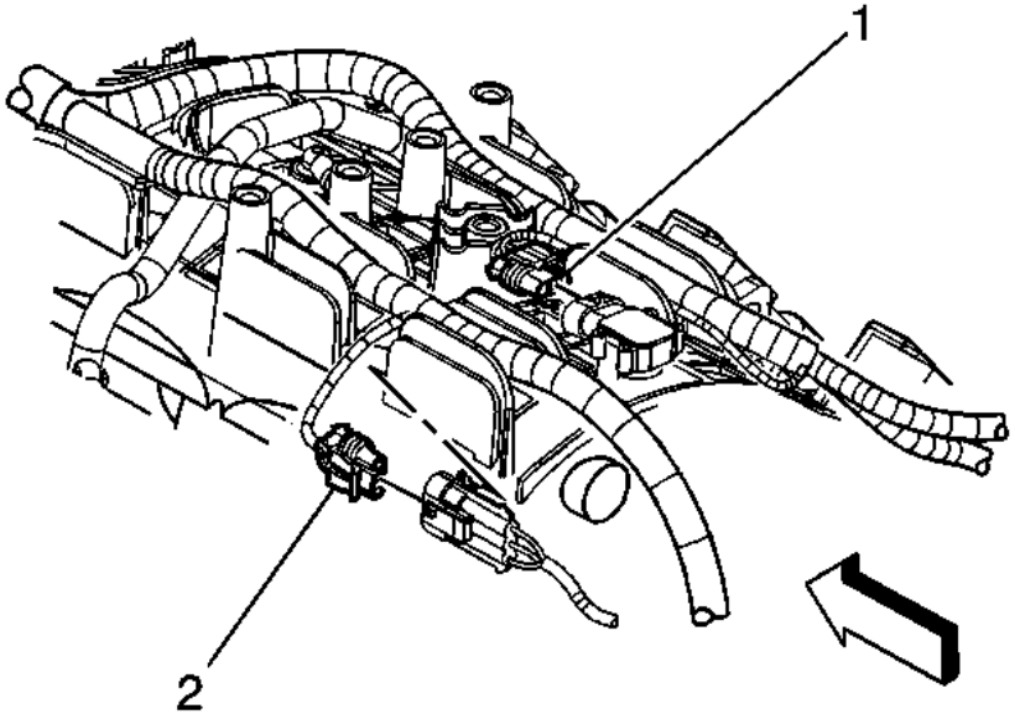

Fig. 66: View Of MAP Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

8. Connect the knock sensor harness electrical connector to the intake manifold.
9. Connect the following electrical connectors.
   - MAP sensor (1)
   - Knock sensor (2)
10. Install the fuel injectors. Refer to **Fuel Injector Replacement** .
11. Install the throttle body. Refer to **Throttle Body Assembly Replacement** .

ENGINE BLOCK VALLEY COVER REPLACEMENT

Removal Procedure

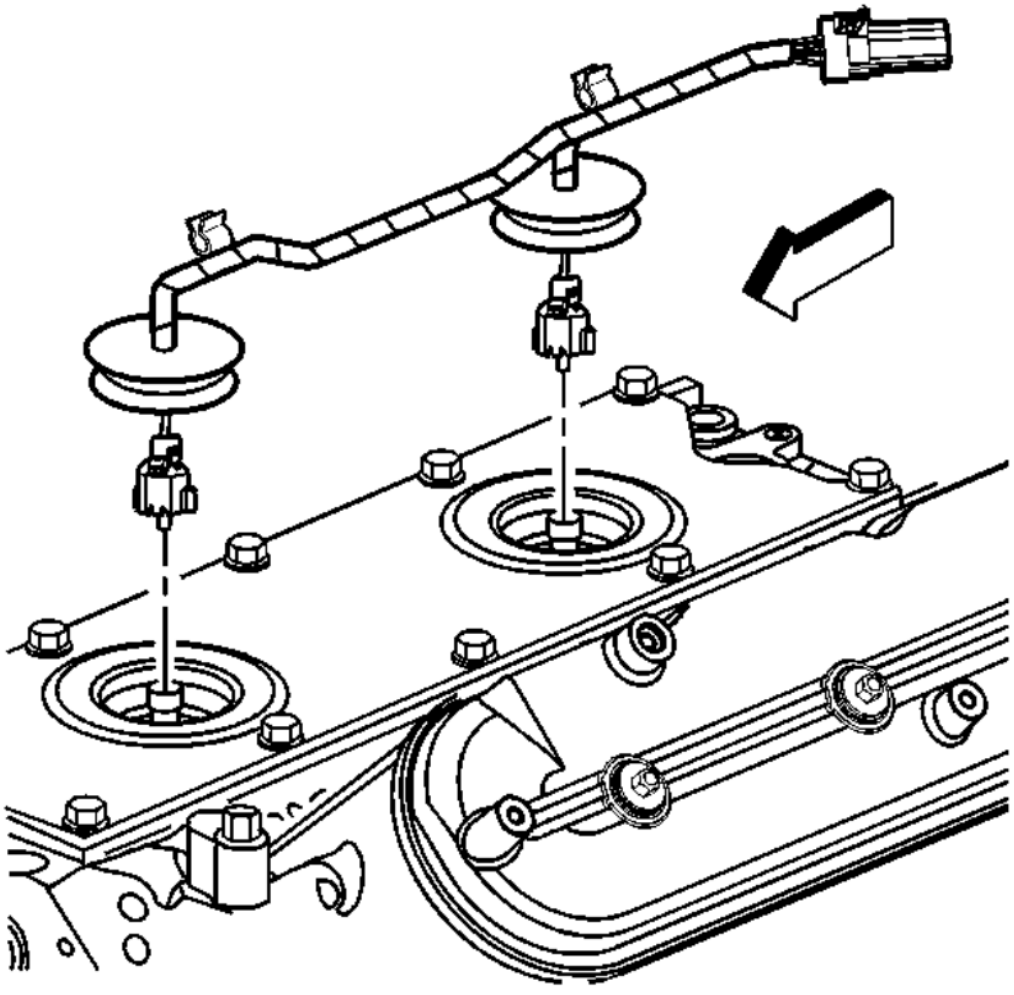

Fig. 67: View Of Knock Sensor Wire Harness
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Gently pry up the rubber covers.
3. Disconnect the knock sensor electrical connectors.

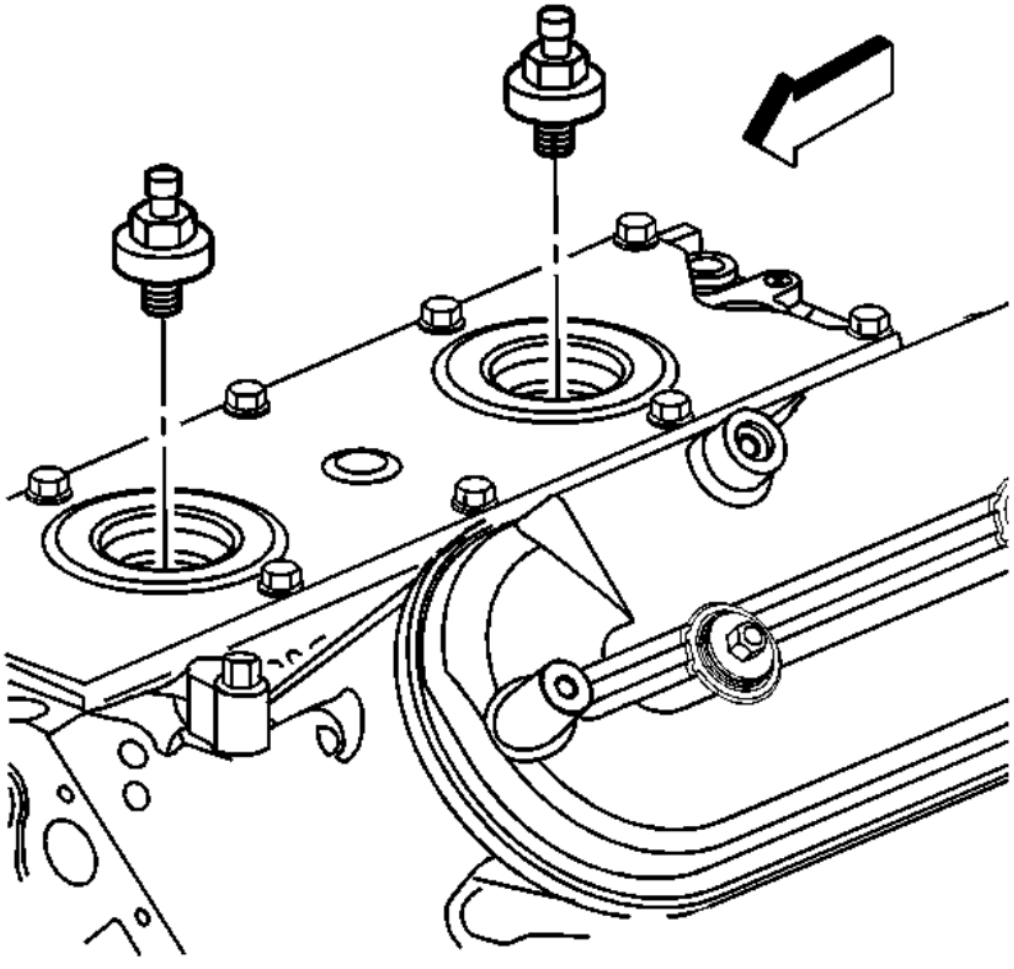

Fig. 68: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

4. Remove the knock sensors.

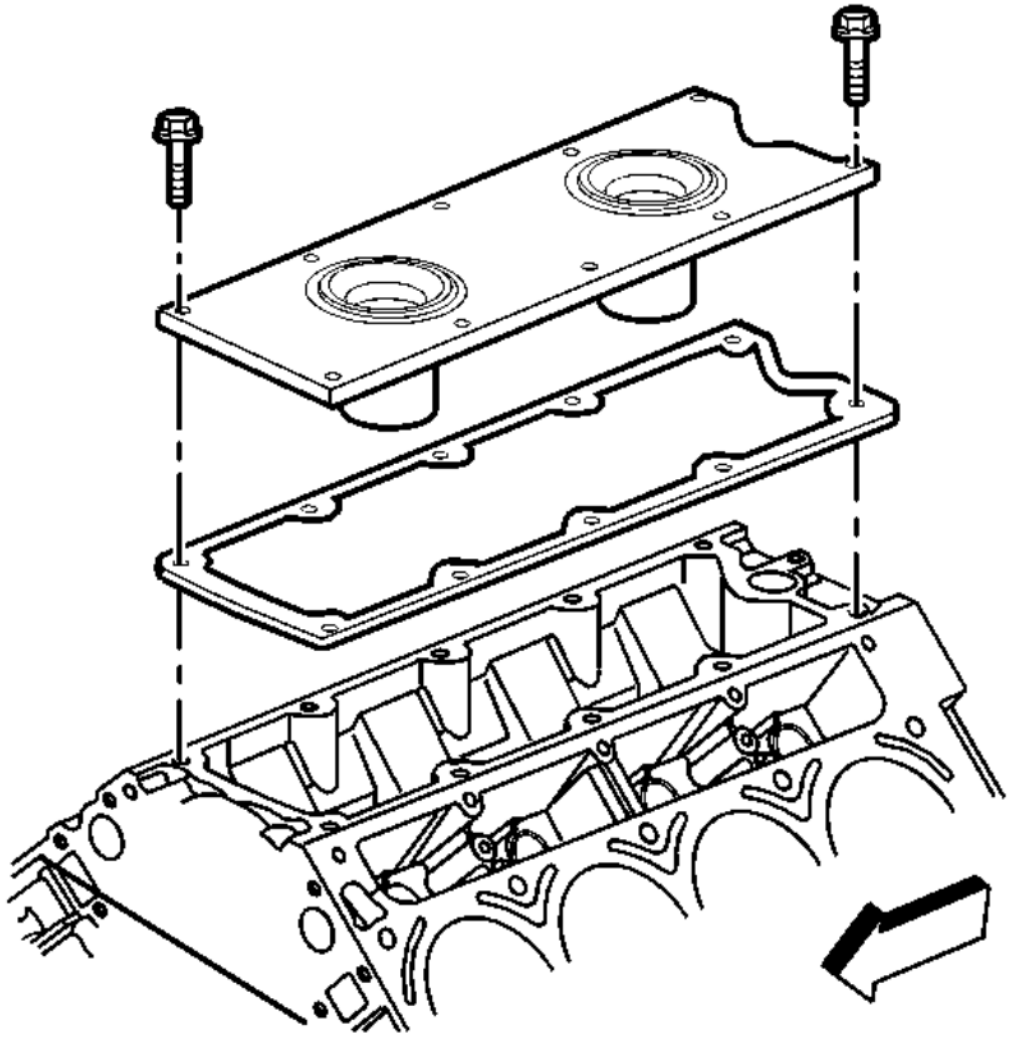

Fig. 69: View Of Engine Valley Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine valley cover bolts.
6. Remove the engine valley cover and gasket.
7. Discard the old gasket.

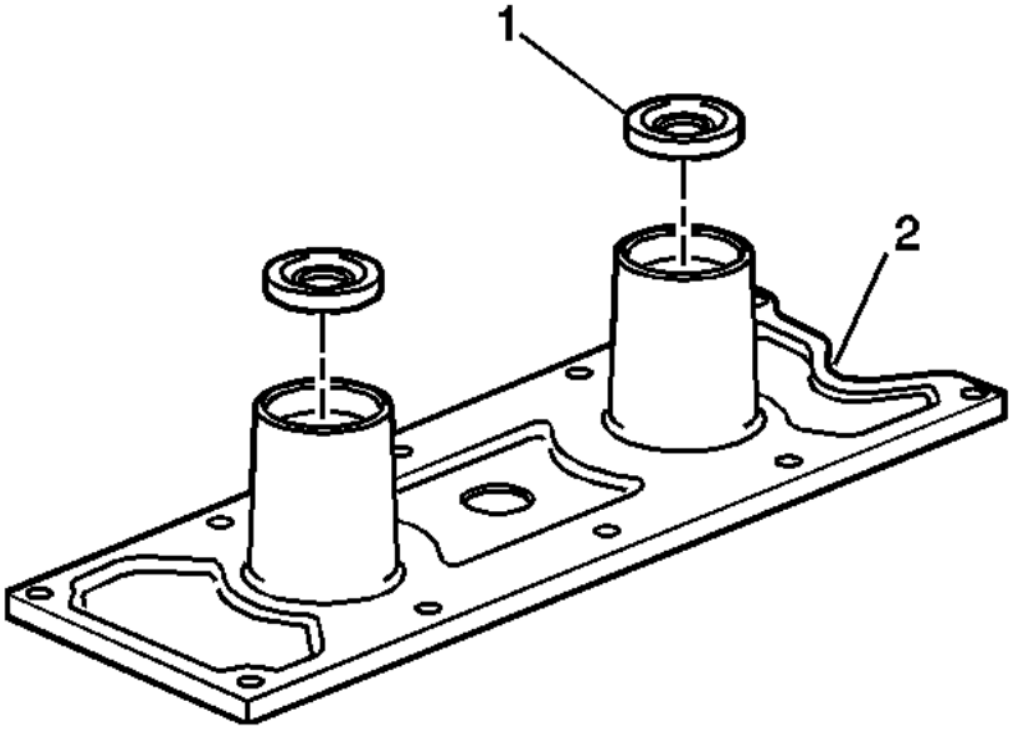

Fig. 70: View Of Knock Sensor Oil Seals & Cover
Courtesy of GENERAL MOTORS CORP.

8. Remove the knock sensor oil seals (1) from the cover (2).
9. Clean and inspect the engine valley cover. Refer to **Engine Block Valley Cover Cleaning and Inspection**.

Installation Procedure

IMPORTANT: All gasket surfaces should be free of oil or other foreign material during assembly.

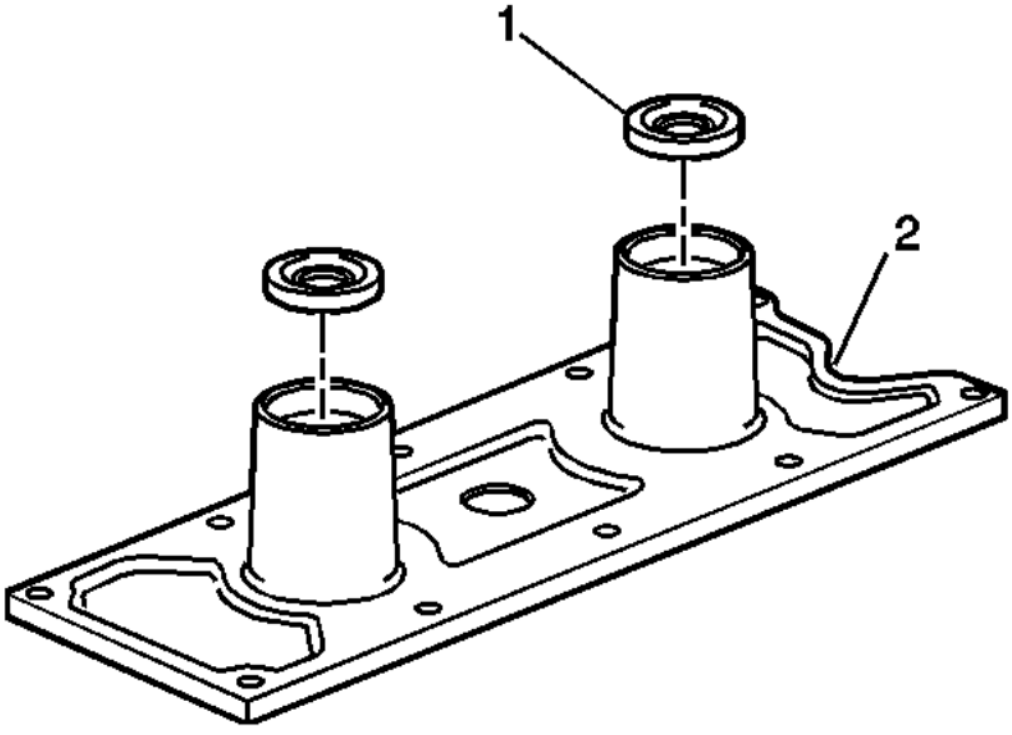

Fig. 71: View Of Knock Sensor Oil Seals & Cover
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the NEW knock sensor seals (1) with clean engine oil.
2. Install the knock sensor oil seals (1) into the engine valley cover (2).

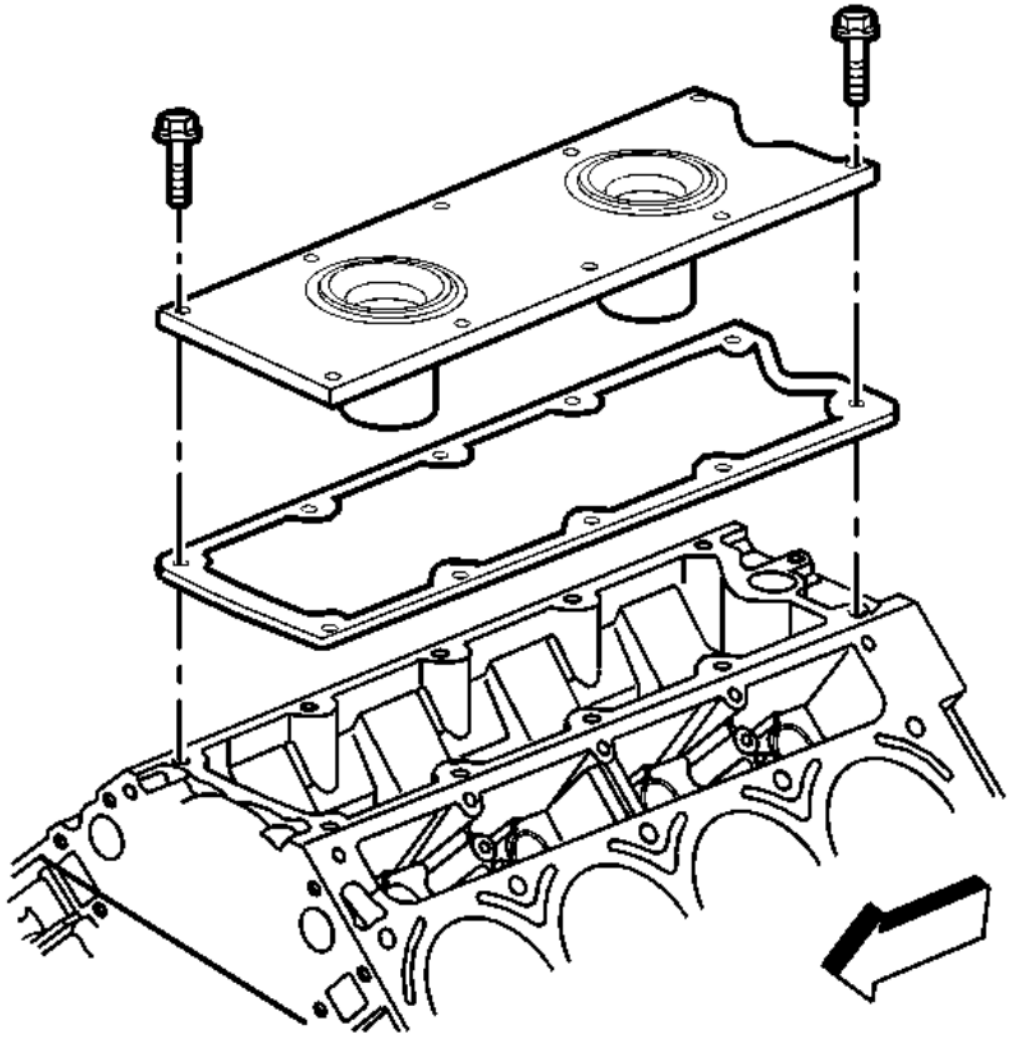

Fig. 72: View Of Engine Valley Cover, Gasket & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the engine valley cover and a NEW gasket onto the engine block.
4. Install the engine valley cover bolts.

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

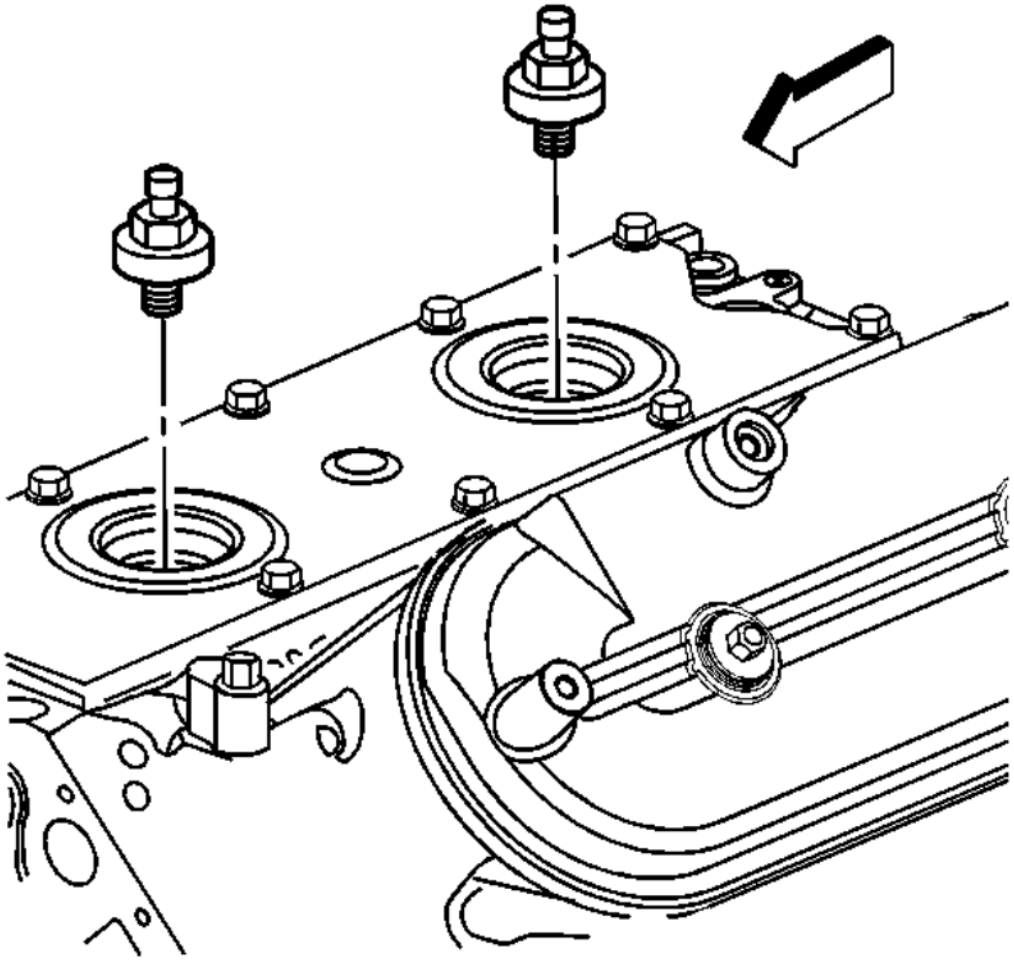

Fig. 73: View Of Knock Sensors
Courtesy of GENERAL MOTORS CORP.

5. Install the knock sensors.

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

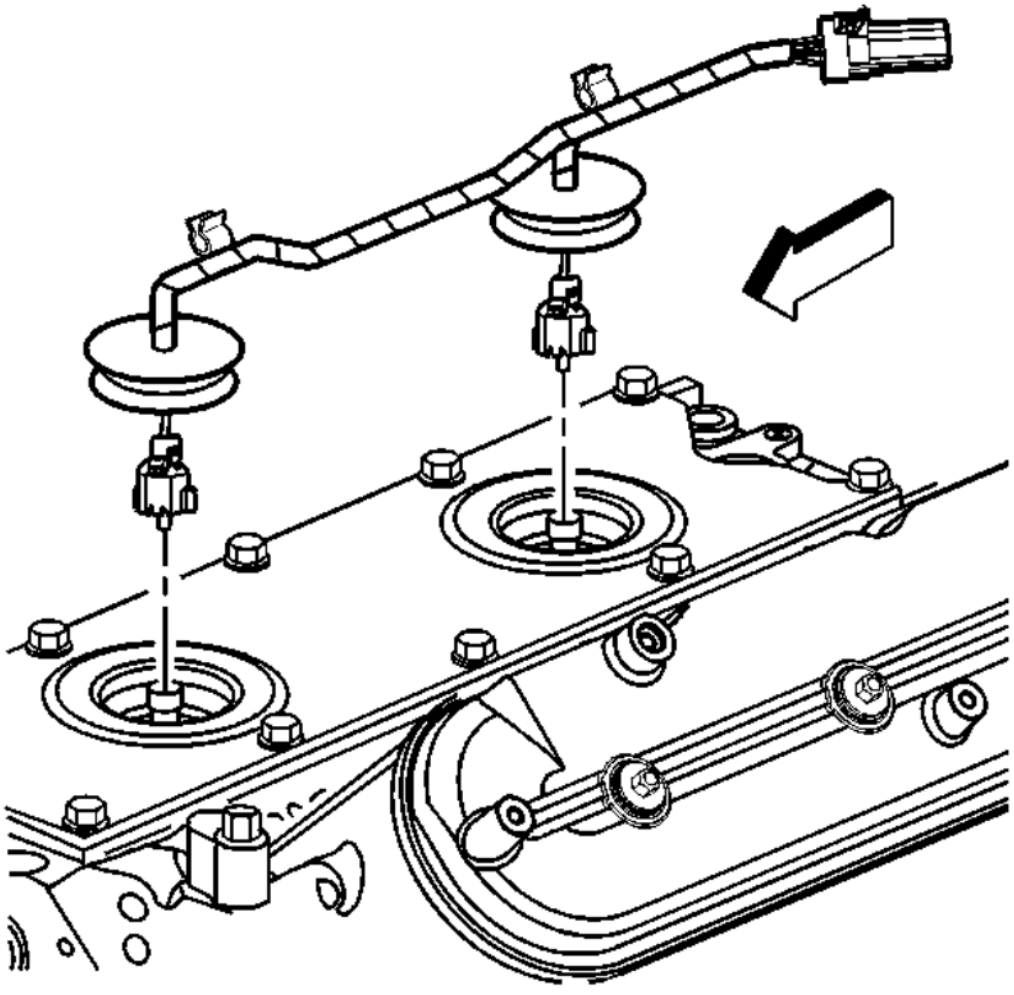

Fig. 74: View Of Knock Sensor Wire Harness
Courtesy of GENERAL MOTORS CORP.

6. Connect the knock sensor electrical connectors.
7. Push down on the rubber covers.
8. Install the intake manifold. Refer to **Intake Manifold Replacement**.

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

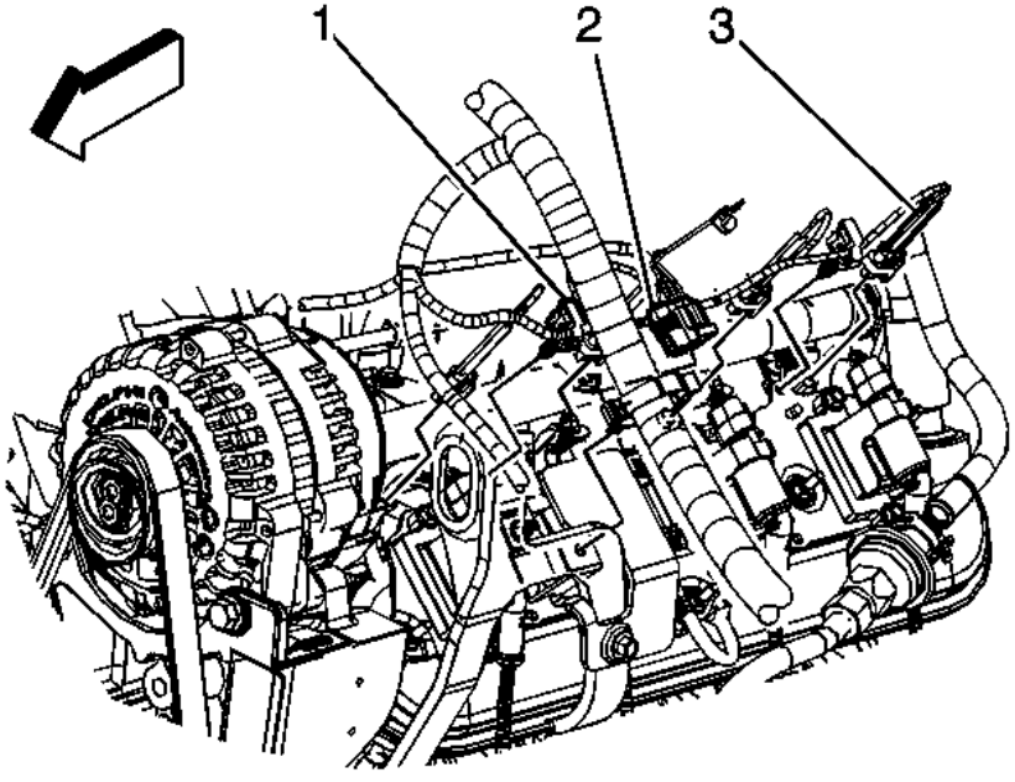

Fig. 75: View Of Main Coil Harness & Fuel Injector Electrical Connectors (Left Side)
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (2) feeding the ignition coils.
4. Remove the harness clips (1).
5. Reposition the engine harness.
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.

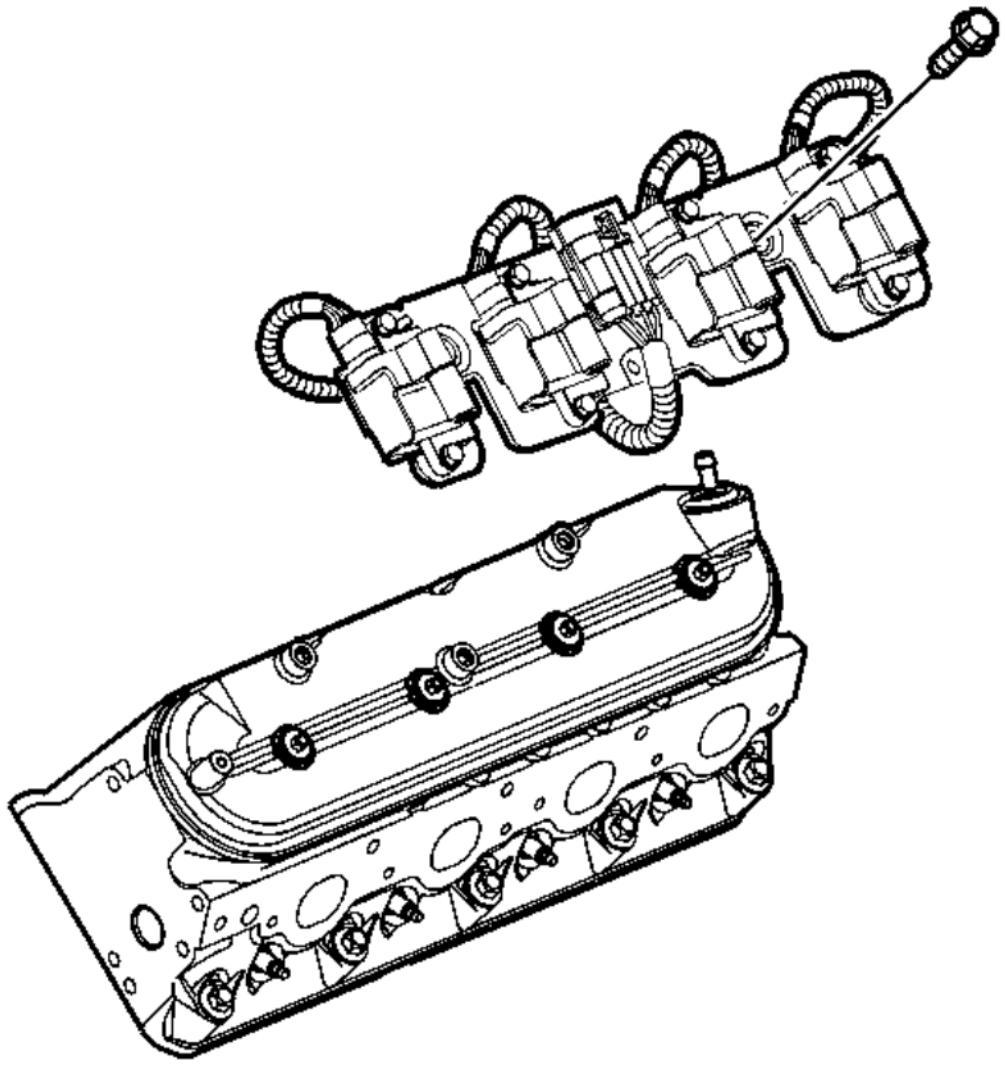

Fig. 76: View Of Ignition Coil, Bracket Assembly, Wire Harness & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

7. Remove the ignition coil bracket studs from the rocker arm cover.
8. Remove the ignition coils and bracket from the rocker arm cover.
9. Remove the valve rocker arm cover bolts.
10. Remove the valve rocker arm cover.

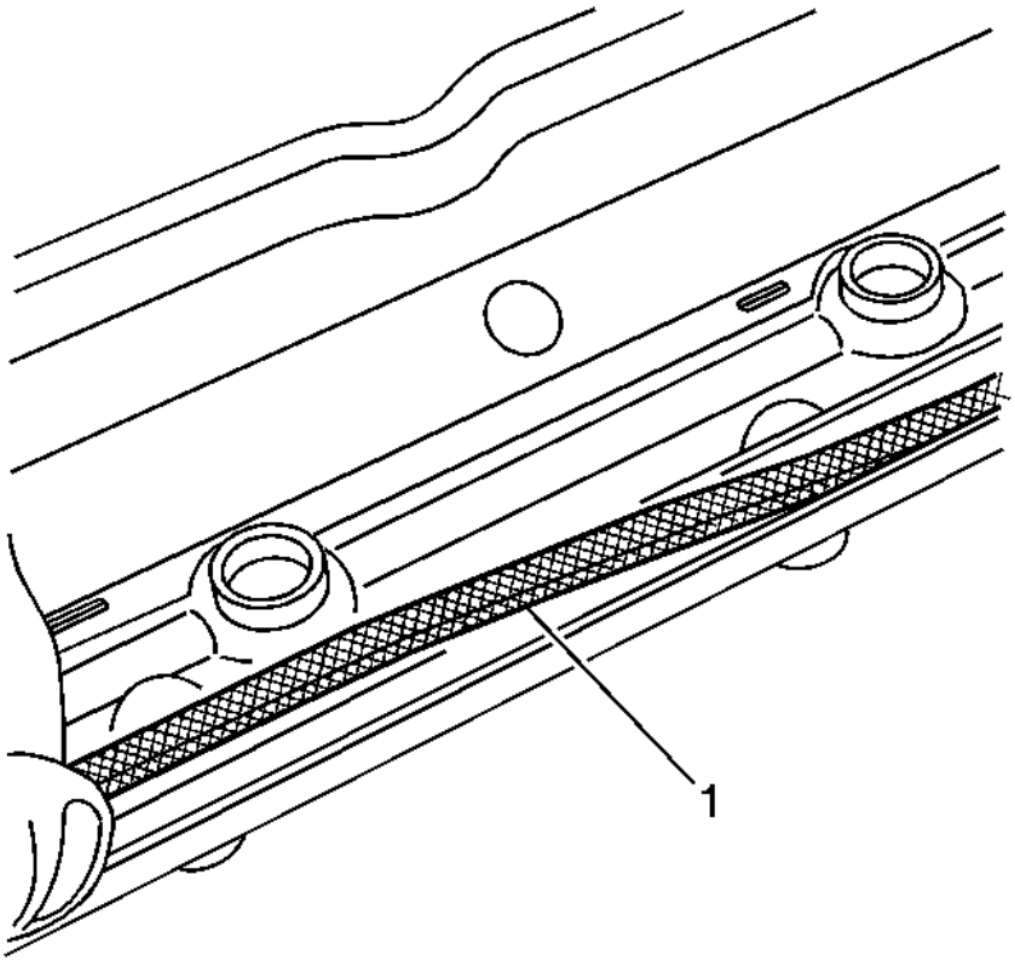

Fig. 77: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

11. Remove the gasket (1) from the rocker cover.
12. Discard the OLD gasket.
13. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

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.

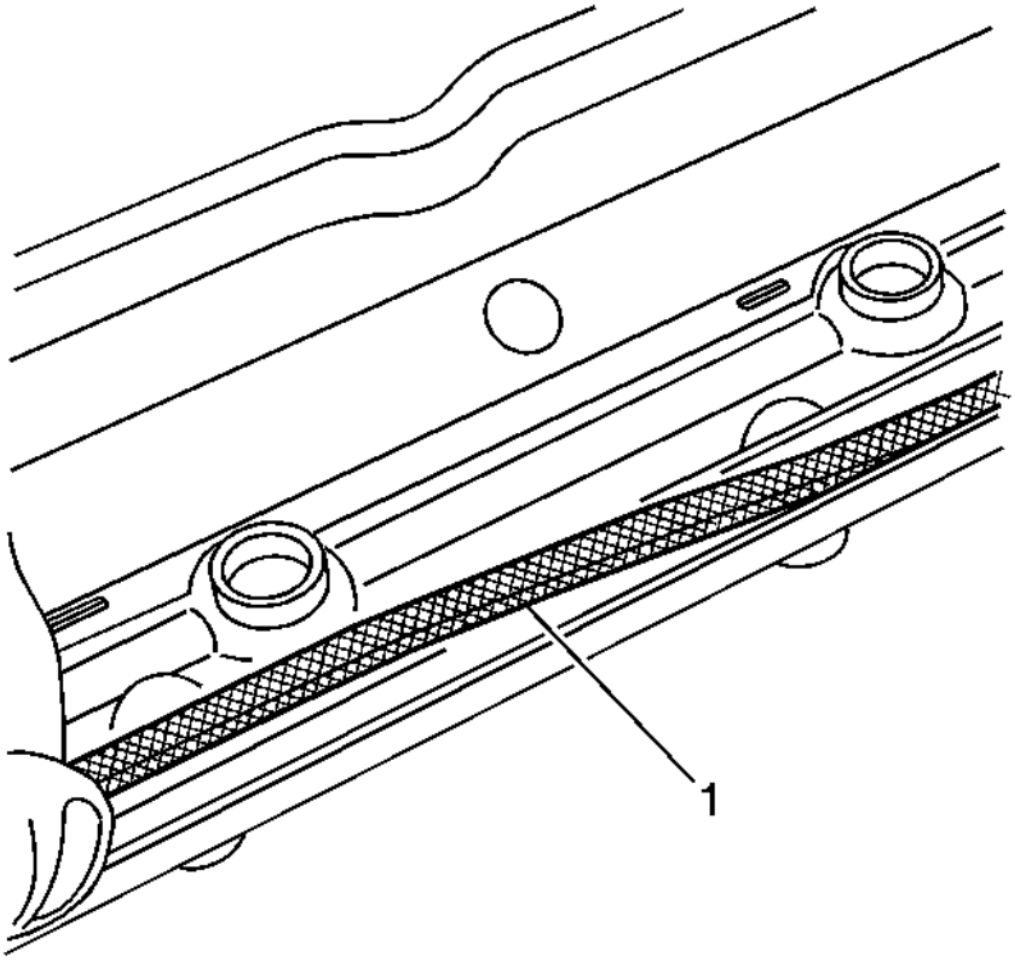

Fig. 78: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

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 .

4. Install the rocker arm cover bolts.

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

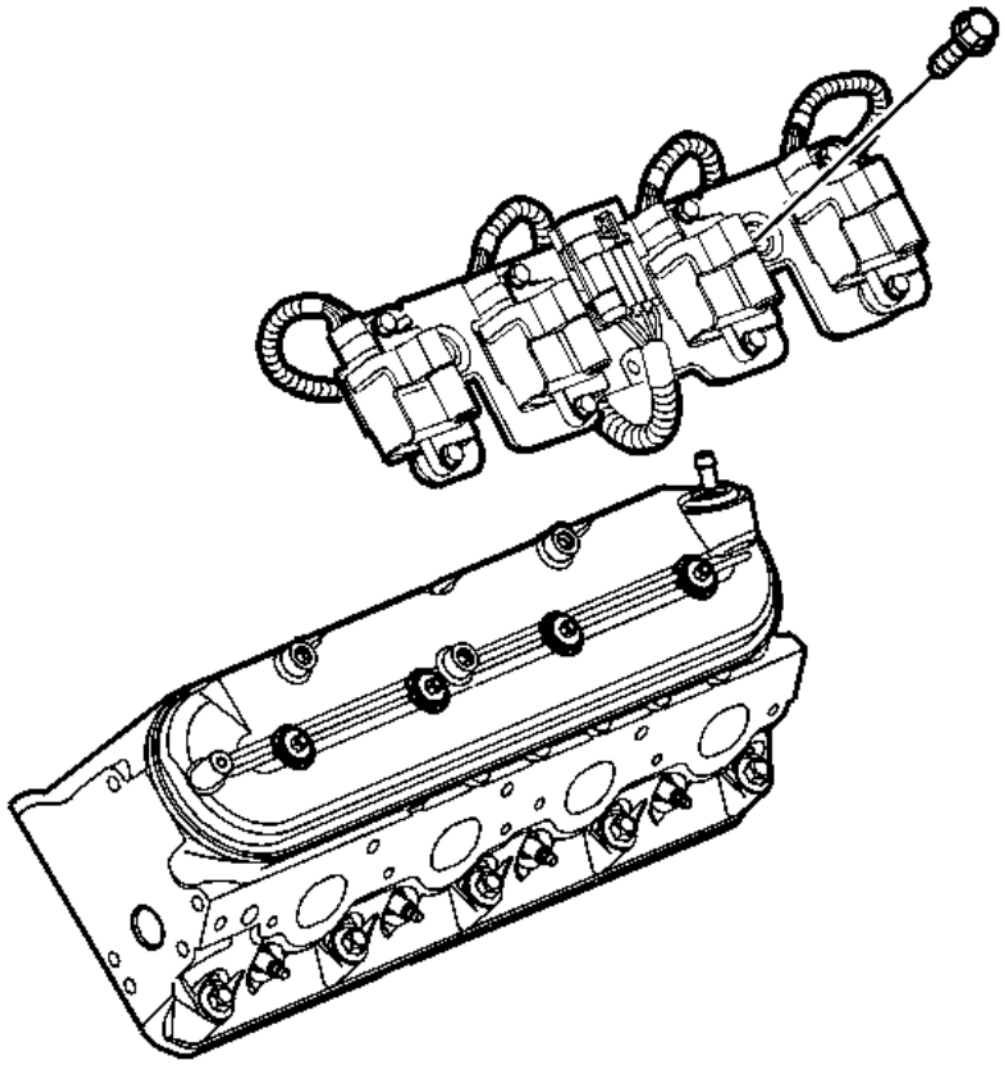

Fig. 79: View Of Ignition Coil, Bracket Assembly, Wire Harness & Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock to the threads of the bracket bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
6. Install the ignition coils and bracket to the rocker arm cover.
7. Install the ignition coil bracket studs to the rocker arm cover.

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

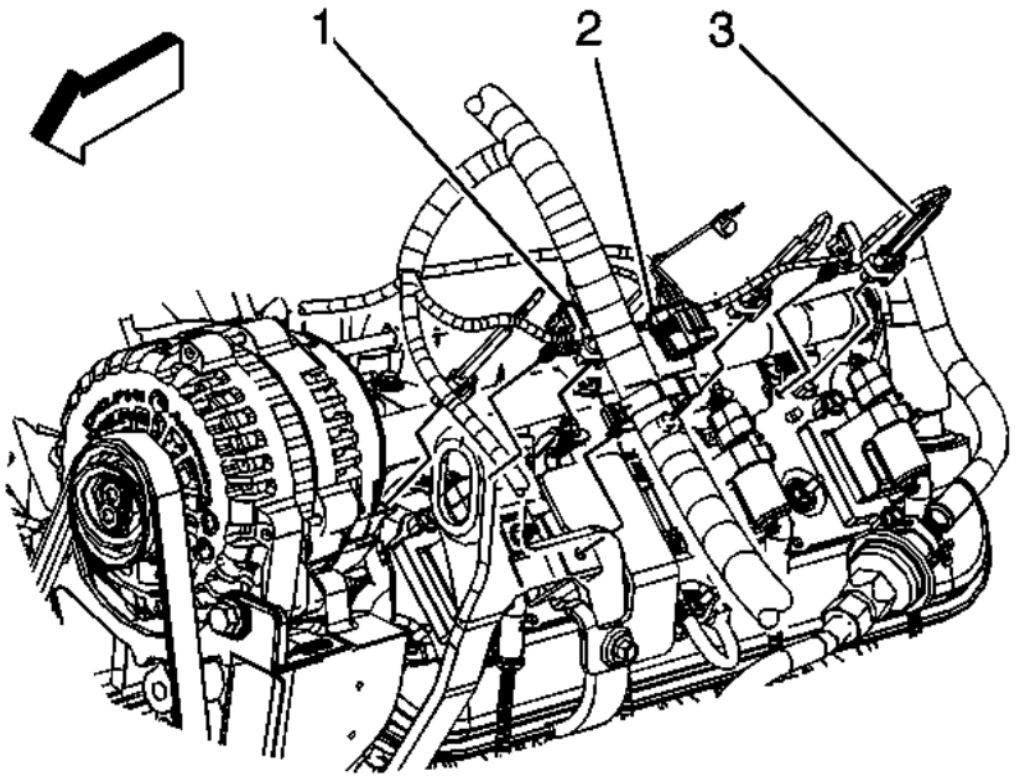

Fig. 80: View Of Main Coil Harness & Fuel Injector Electrical Connectors (Left Side)
Courtesy of GENERAL MOTORS CORP.

8. Install the spark plug wires to the ignition coils.
9. Re-position the engine harness.
10. Install the harness clips (1).
11. Connect the main electrical connector (2) feeding the ignition coils.
12. Install the CPA lock.
13. Install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

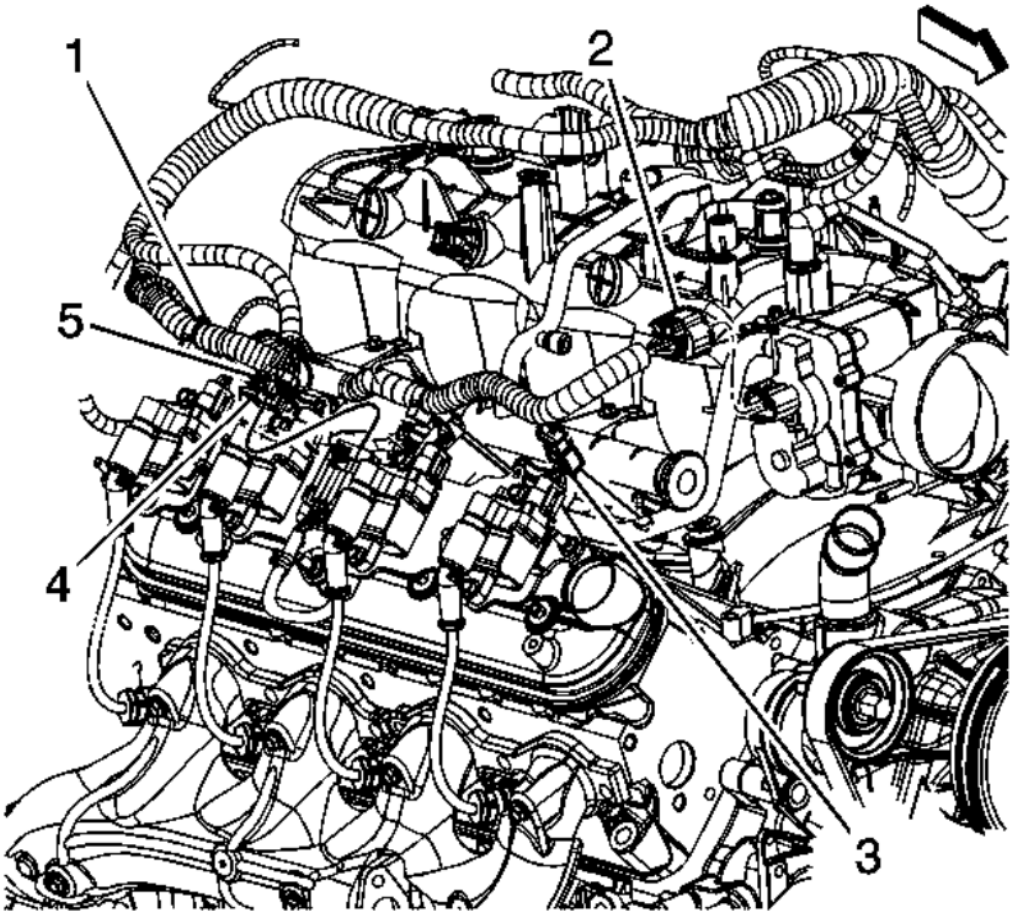

Fig. 81: Identifying Right Side Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.
2. Remove the connector position assurance (CPA) lock (5).
3. Disconnect the main electrical connector (4) feeding the ignition coils.
4. Remove the harness clips (1).
5. Reposition the engine harness.
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.

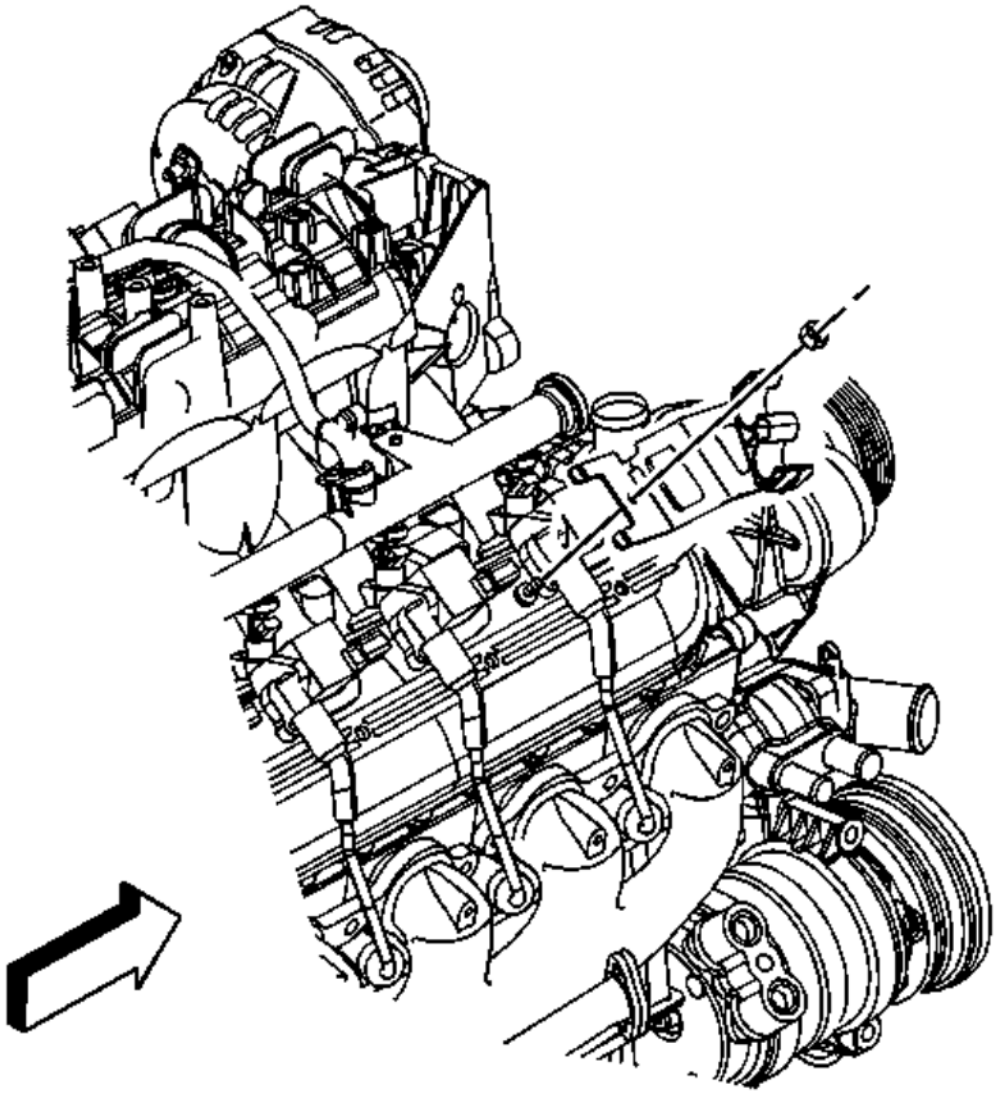

Fig. 82: View Of Heater Hose Bracket Nut
Courtesy of GENERAL MOTORS CORP.

7. Reposition the surge tank/heater hoses from the heater hose bracket.

8. Remove the heater hose bracket nut and bracket.

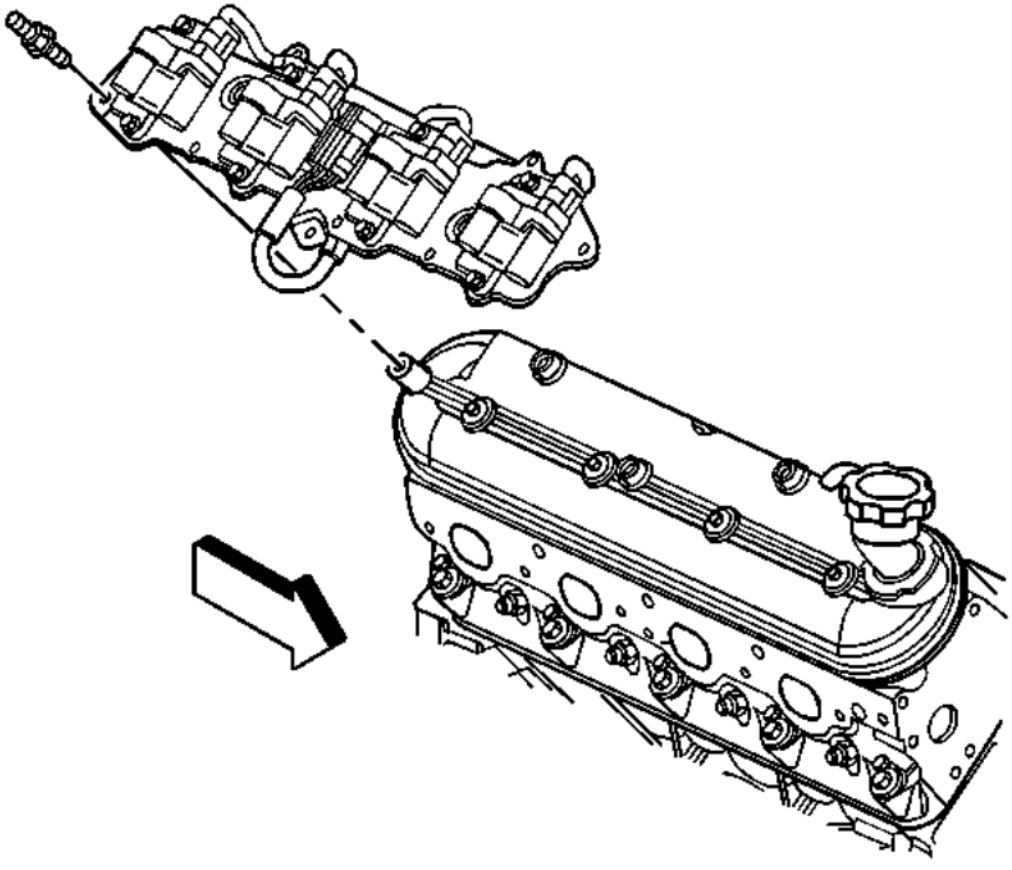

Fig. 83: Ignition Coils And Bracket
Courtesy of GENERAL MOTORS CORP.

9. Remove the ignition coil bracket studs from the rocker arm cover.
10. Remove the ignition coils and bracket from the rocker cover.
11. Remove the positive crankcase ventilation (PCV) fresh air hose.

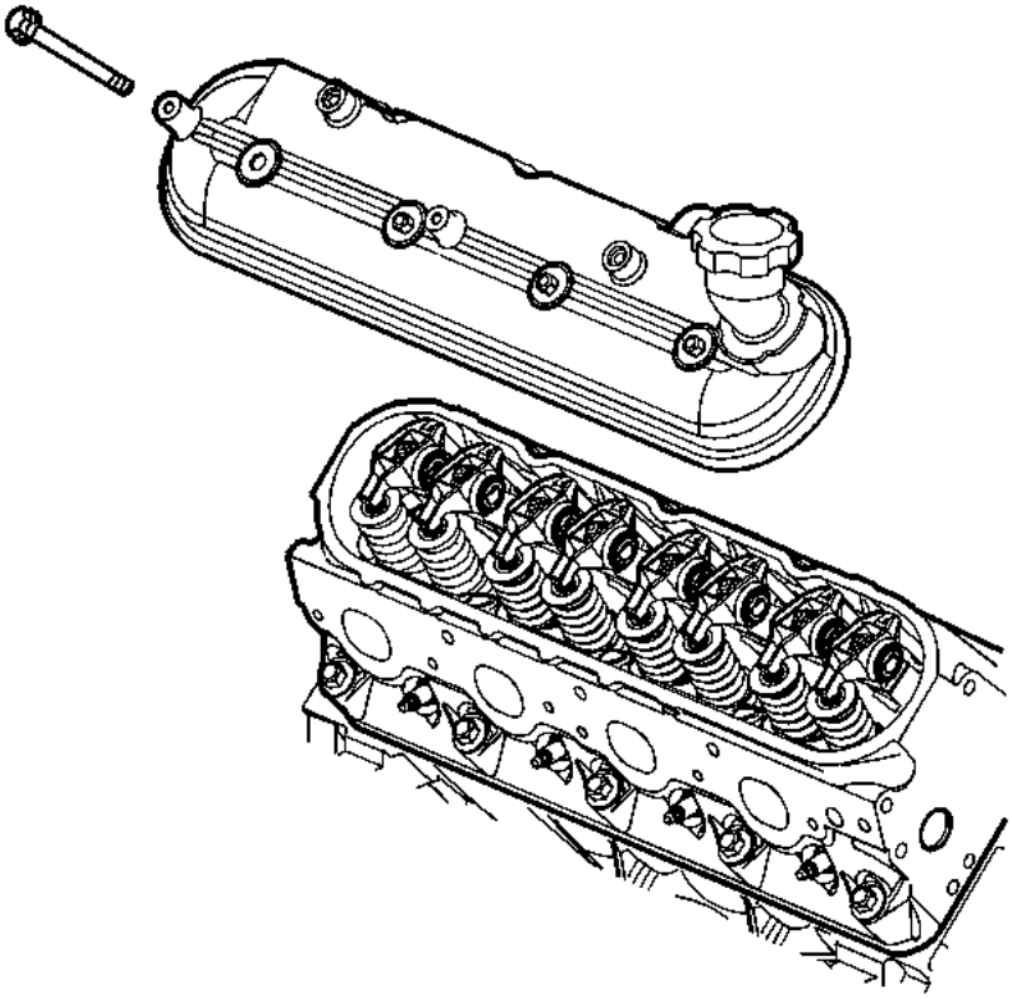

Fig. 84: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve rocker arm cover bolts.
13. Remove the valve rocker arm cover.

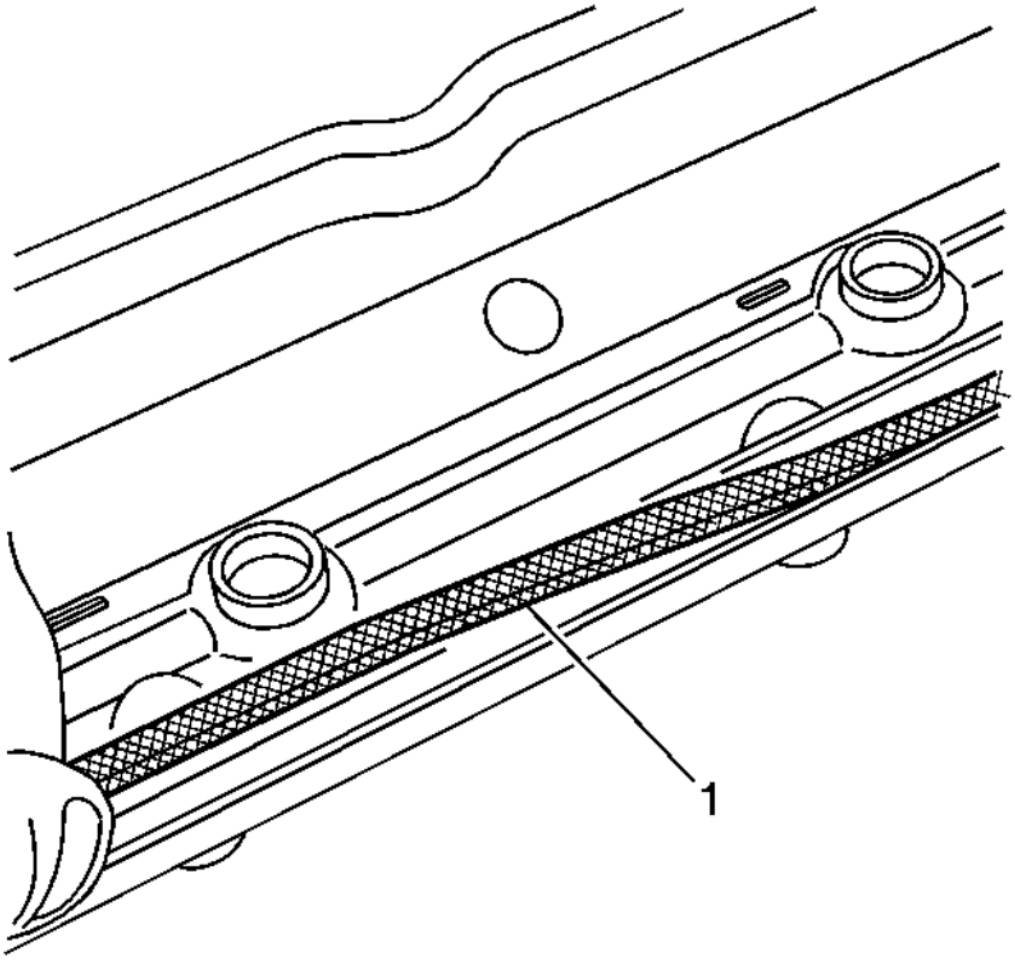

Fig. 85: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

14. Remove the gasket (1) from the rocker cover.
15. Discard the OLD gasket.

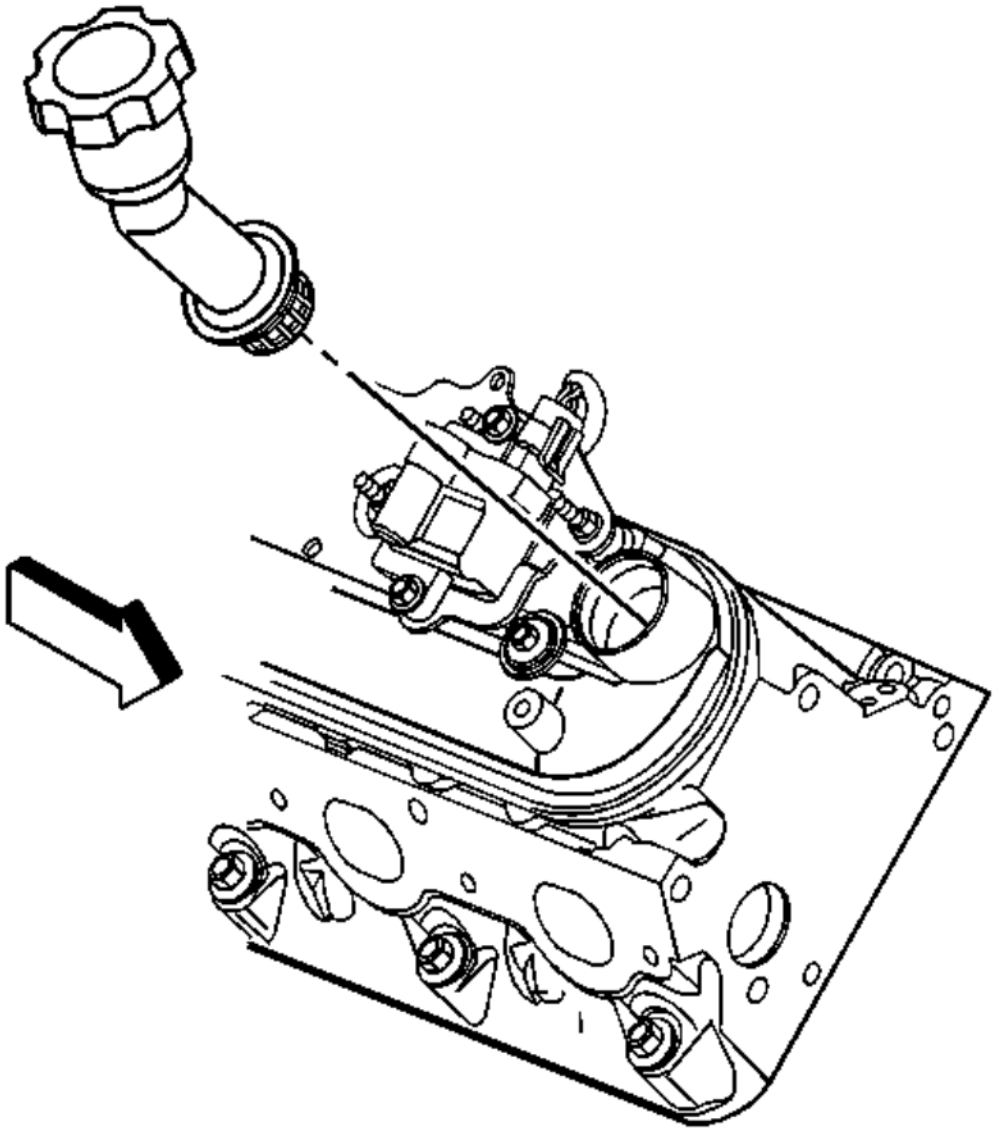

Fig. 86: View Of Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil fill cap from the oil fill tube.
17. Remove the oil fill tube from the rocker cover, if required.
18. Discard the oil fill tube.

19. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

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

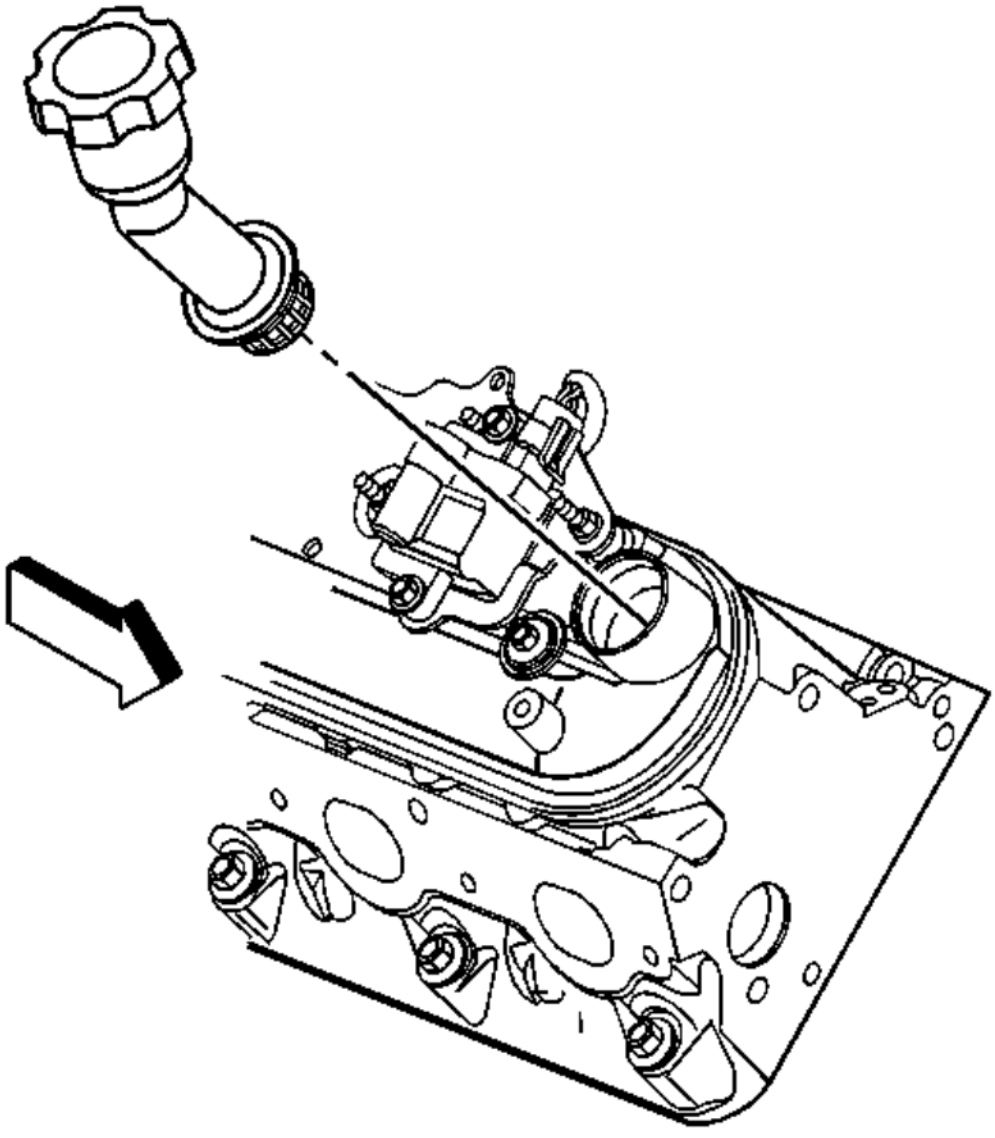

Fig. 87: View Of Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

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.

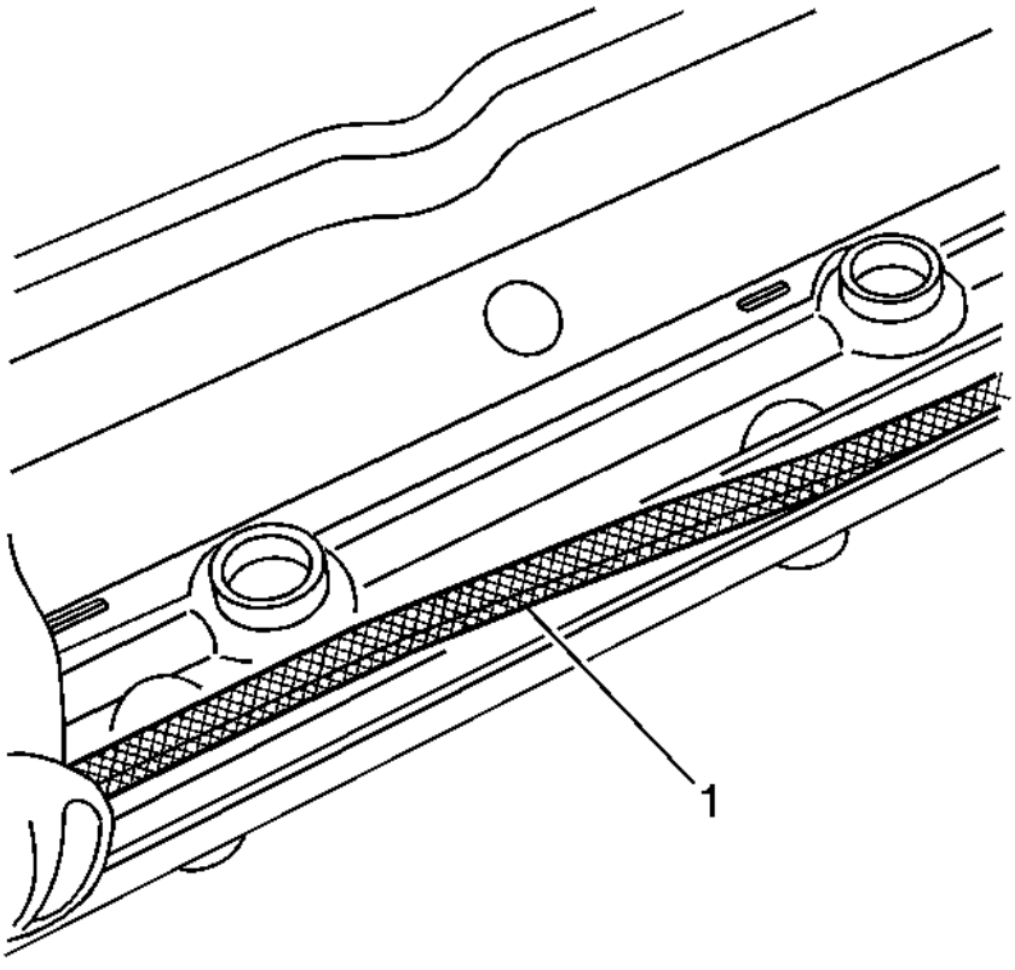

Fig. 88: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

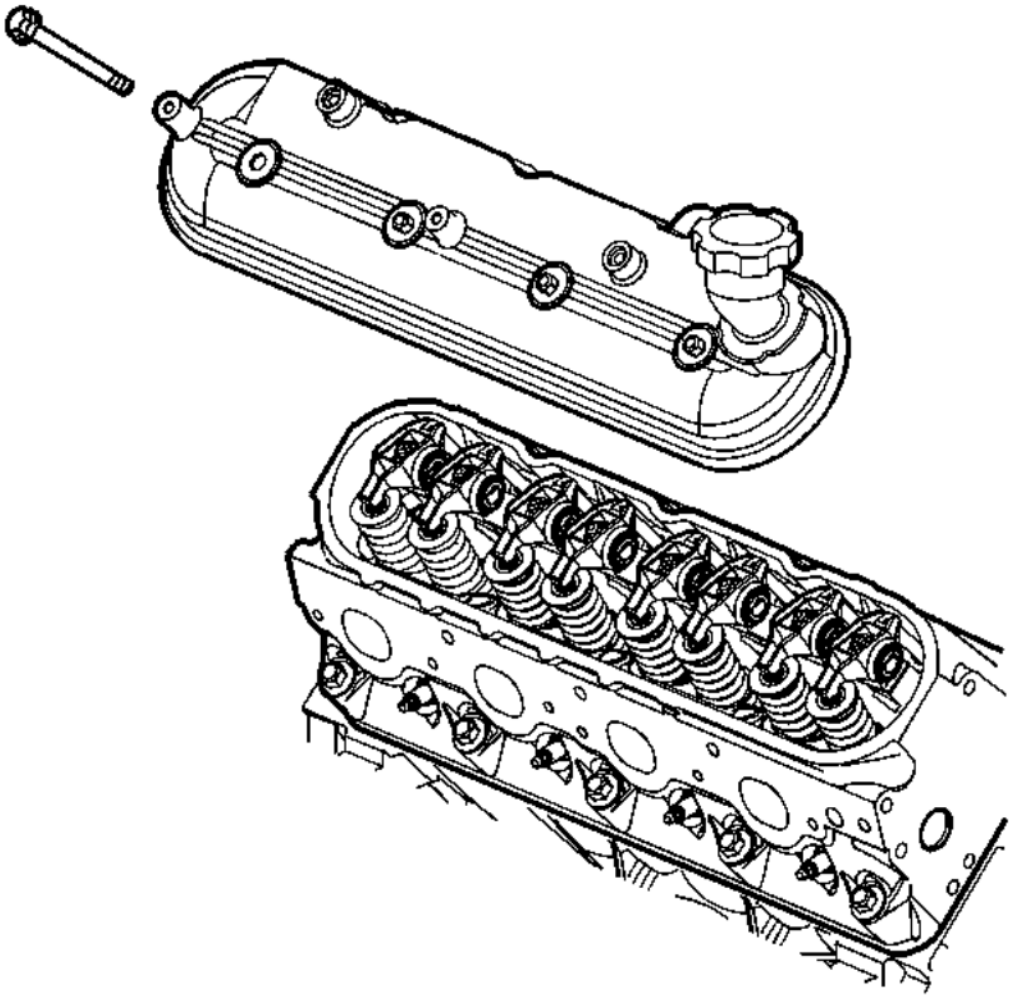

Fig. 89: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

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 .

7. Install the rocker arm cover bolts and grommets.

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

8. Install the PCV fresh air hose.

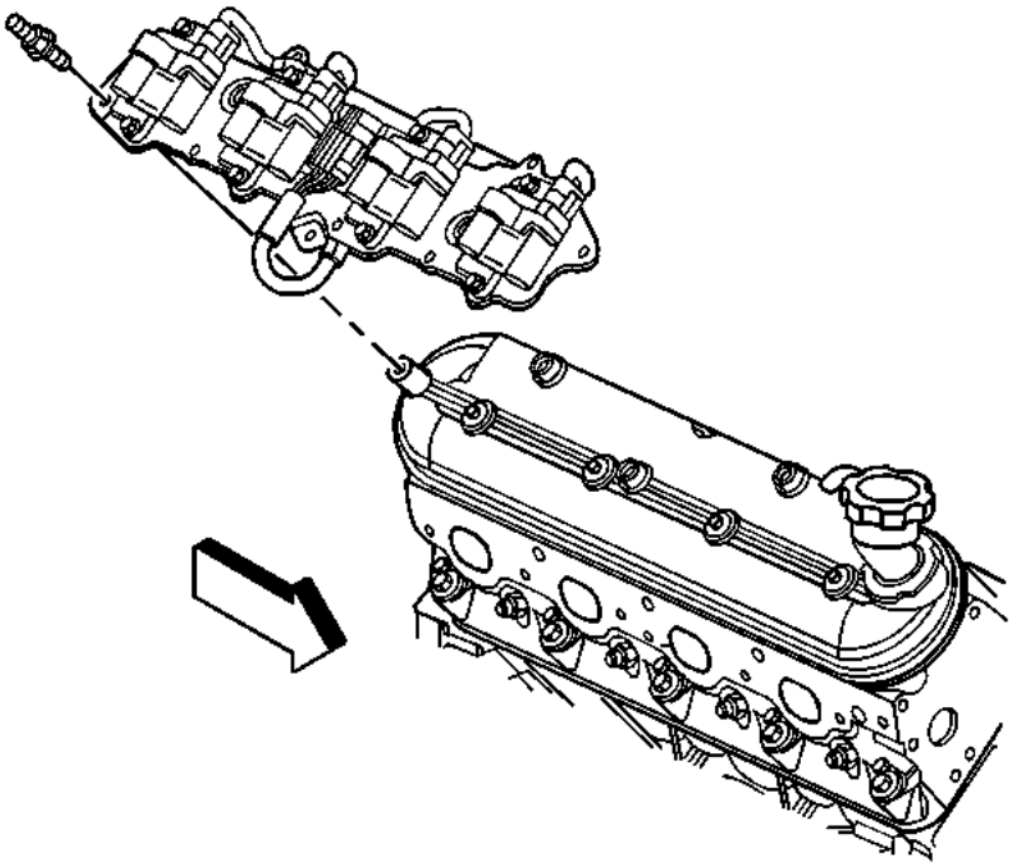

Fig. 90: Ignition Coils And Bracket
Courtesy of GENERAL MOTORS CORP.

9. Apply threadlock to the threads of the bracket bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
10. Install the ignition coils and bracket to the rocker arm cover.
11. Install the ignition coil bracket studs to the rocker cover.

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

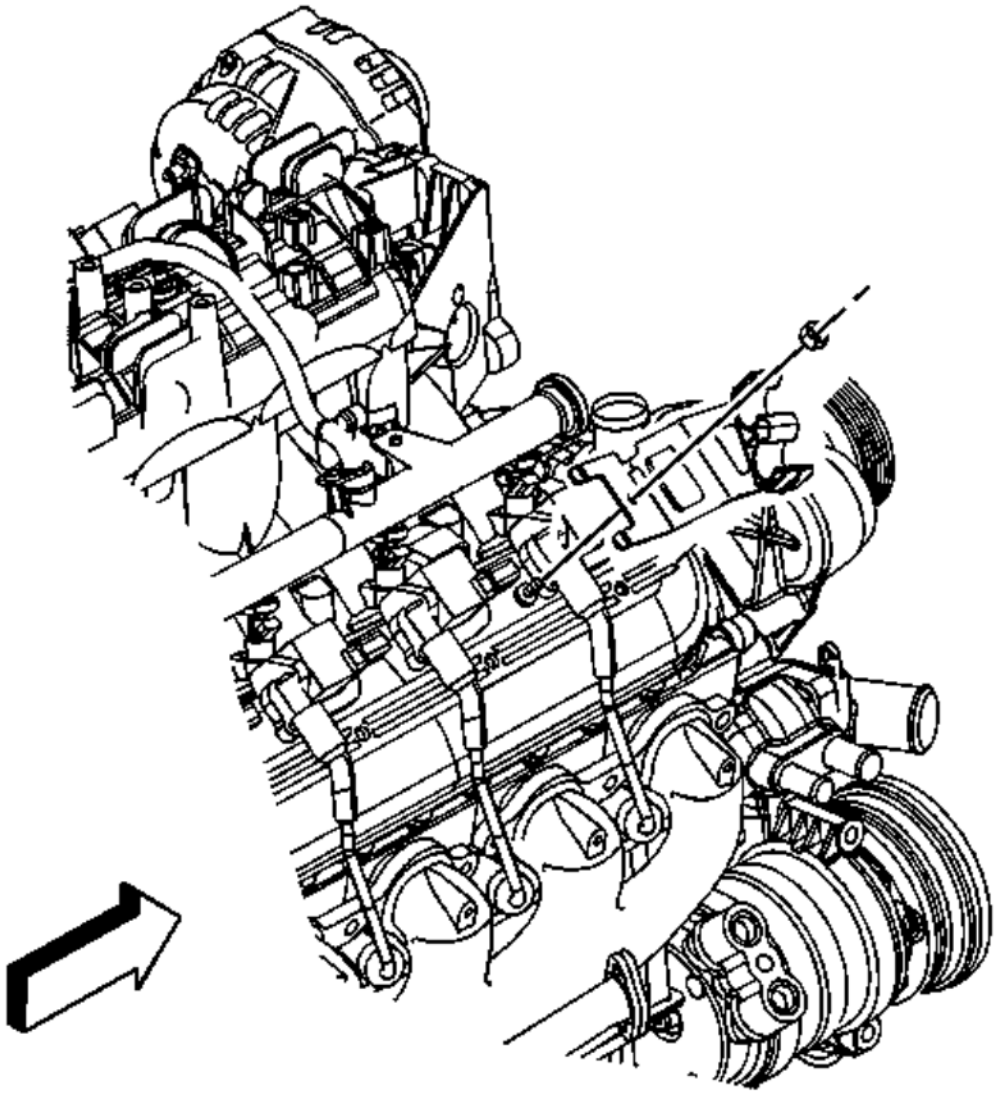

Fig. 91: View Of Heater Hose Bracket Nut
Courtesy of GENERAL MOTORS CORP.

12. Install the heater hose bracket and nut.

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

13. Position the surge tank/heater hoses to the heater hose bracket.

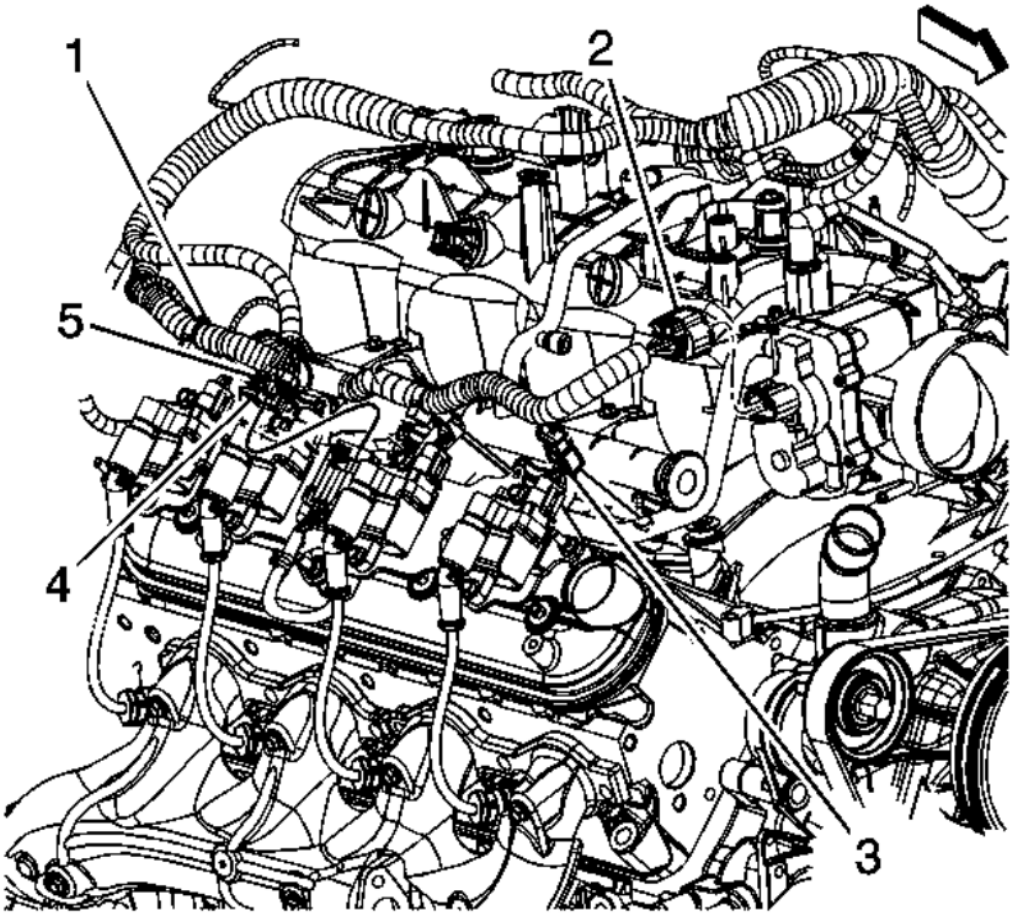

Fig. 92: Identifying Right Side Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

14. Install the spark plug wires to the ignition coils.
15. Re-position the engine harness.
16. Install the harness clips (1).
17. Connect the main electrical connector (4) feeding the ignition coils.
18. Install the CPA lock (5).
19. Install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

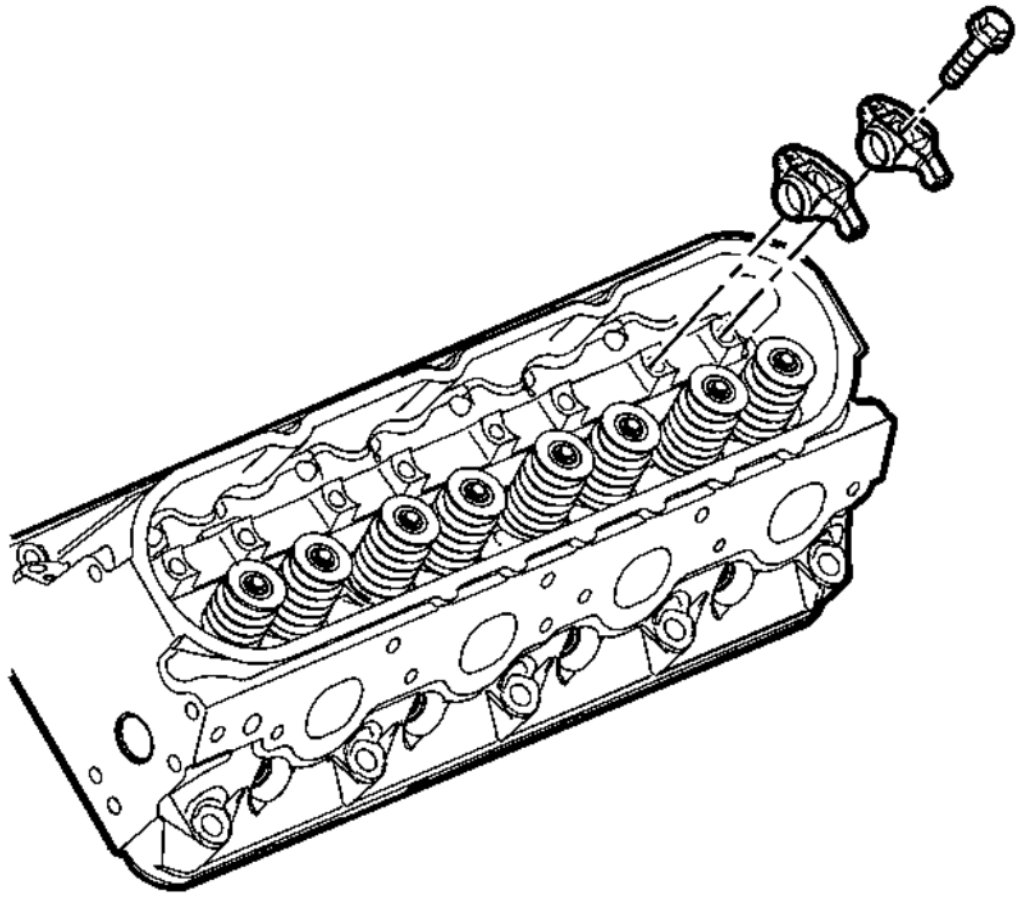

Fig. 93: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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.

2. Remove the valve rocker arm bolts.
3. Remove the valve rocker arms.

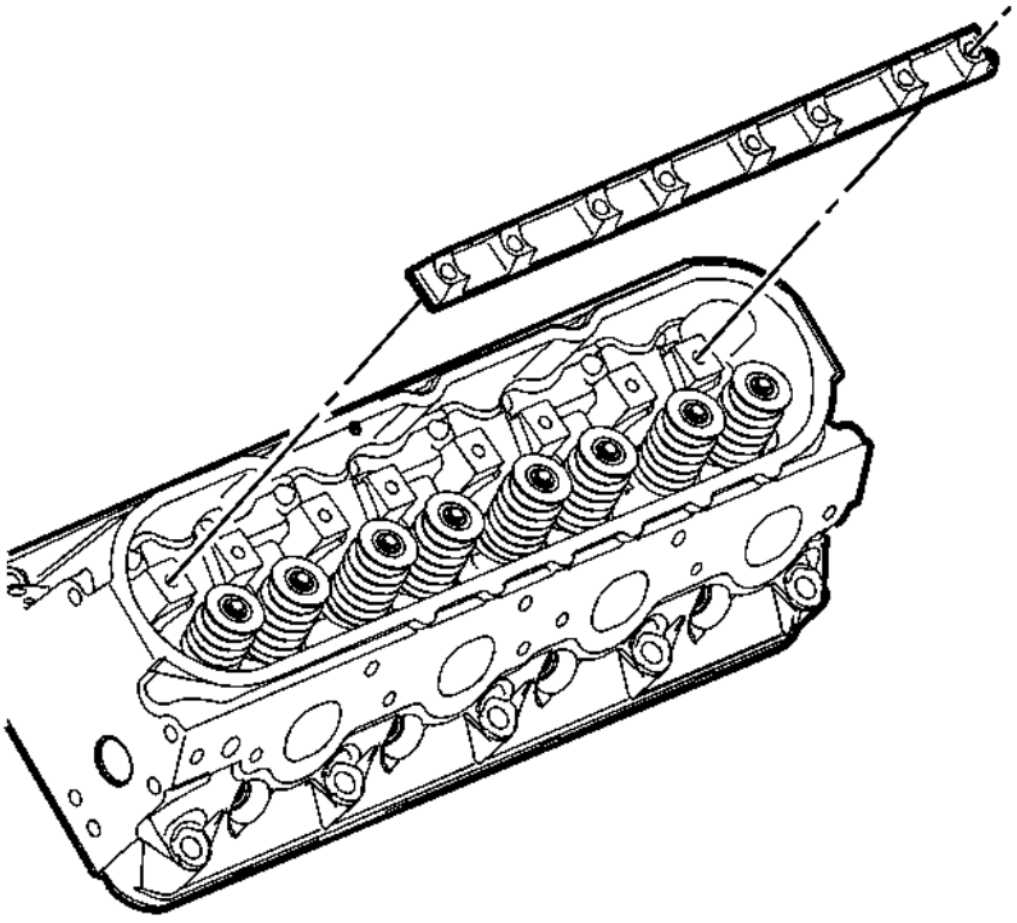

Fig. 94: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm pivot support.

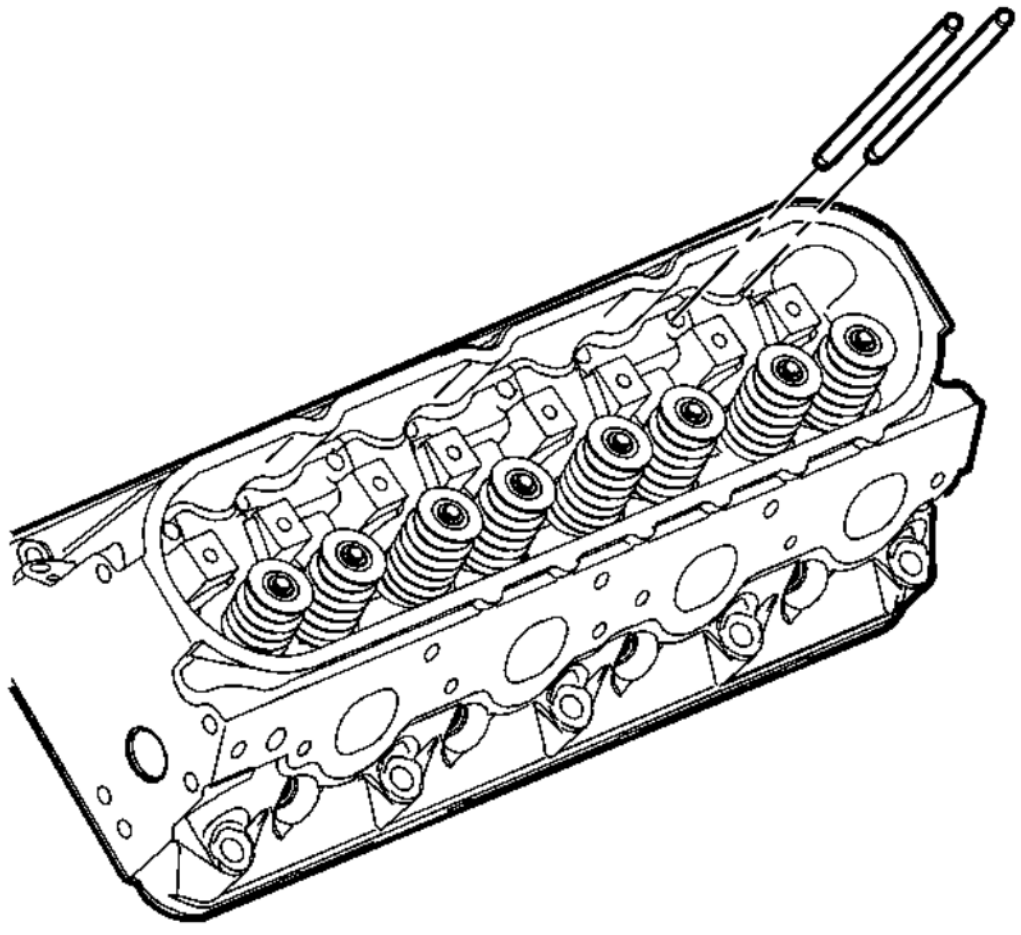

Fig. 95: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

IMPORTANT: When reusing the valve train components, always install the components to the original location and position.

Valve lash is net build, no valve adjustment is required.

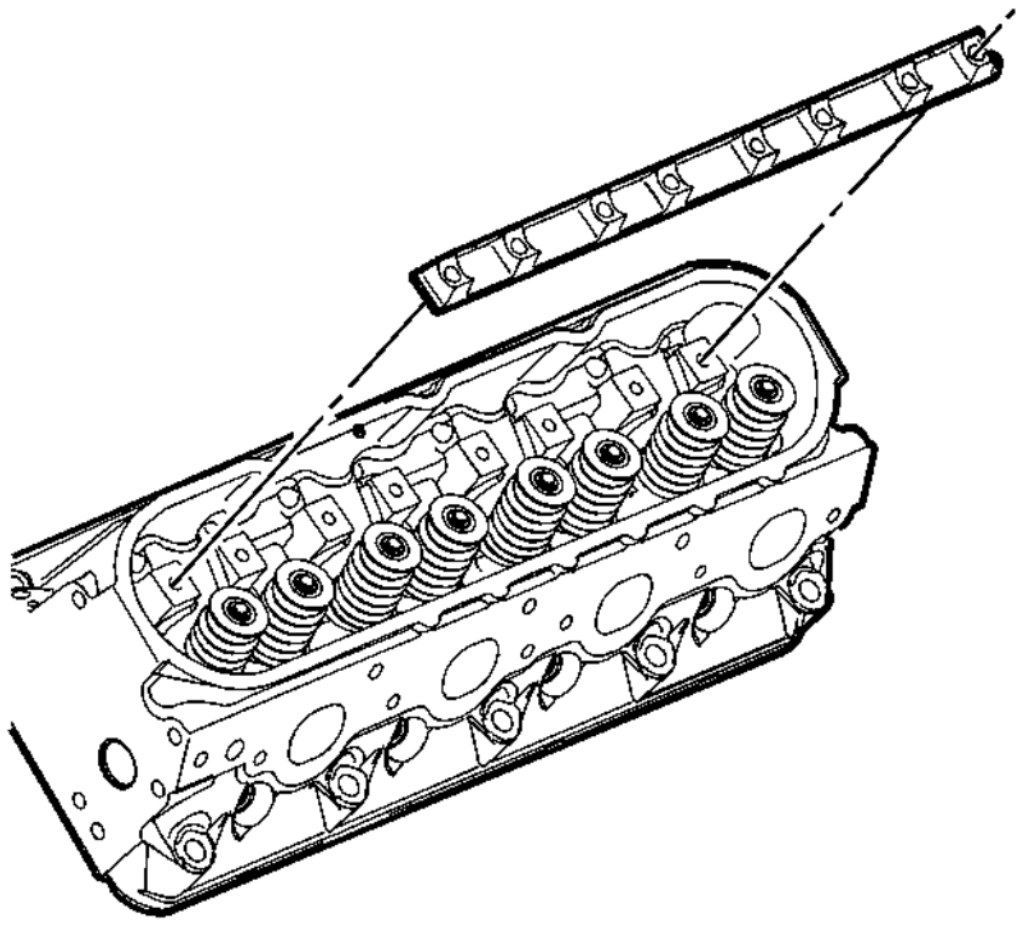

Fig. 96: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

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.

   Lubricate the flange or washer surface of the bolt that will contact the valve rocker arm.

3. Install the valve rocker arm pivot support.

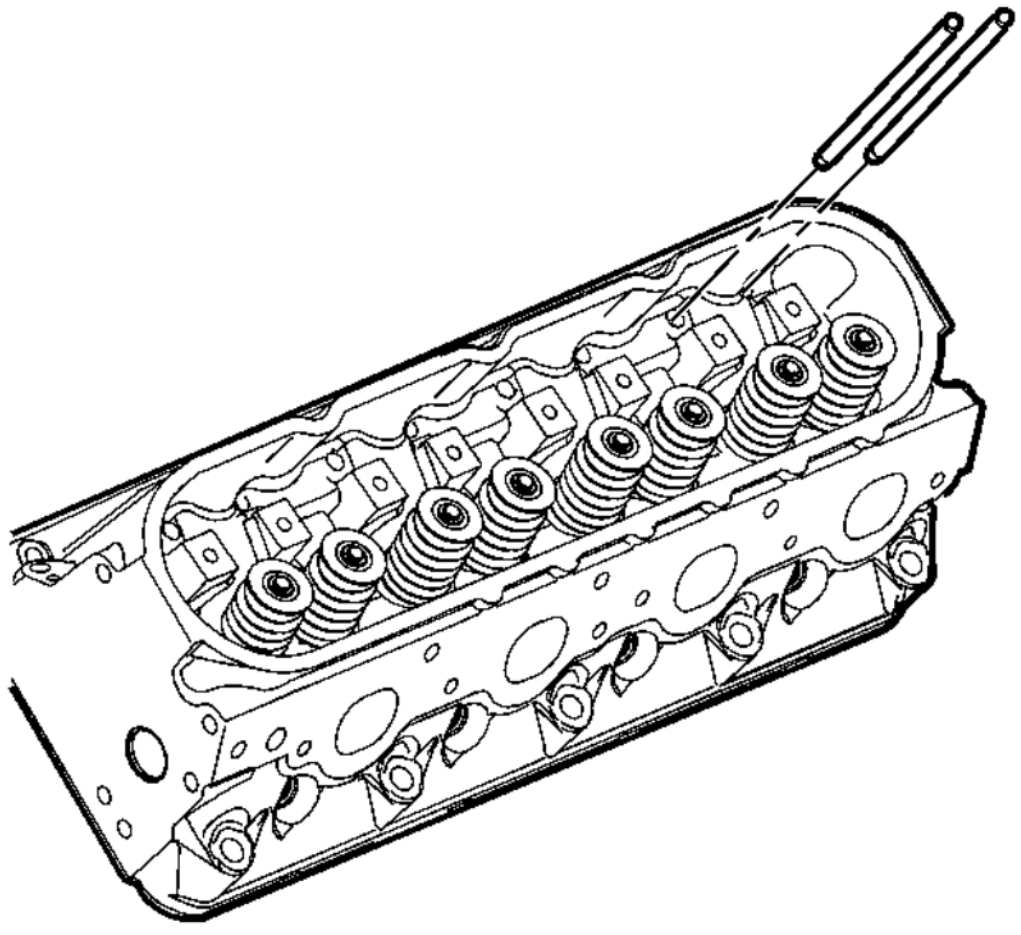

Fig. 97: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

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

4. Install the pushrods.

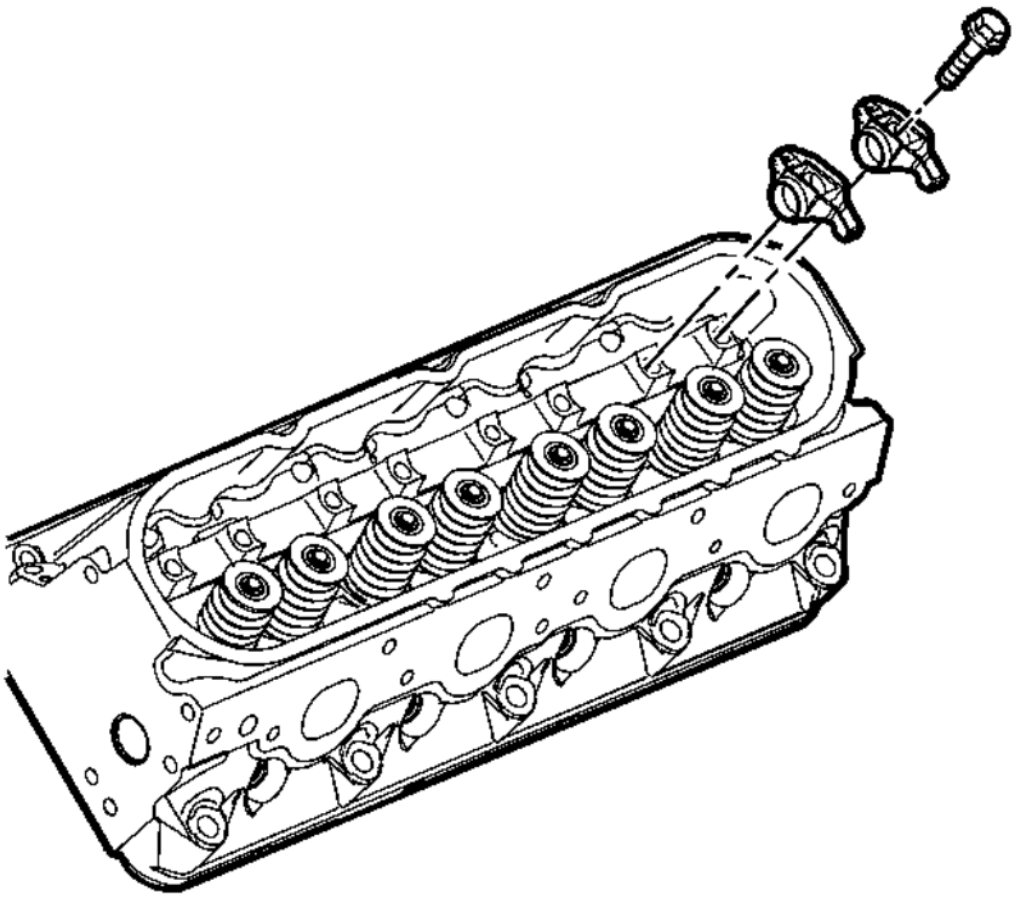

Fig. 98: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure that 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.

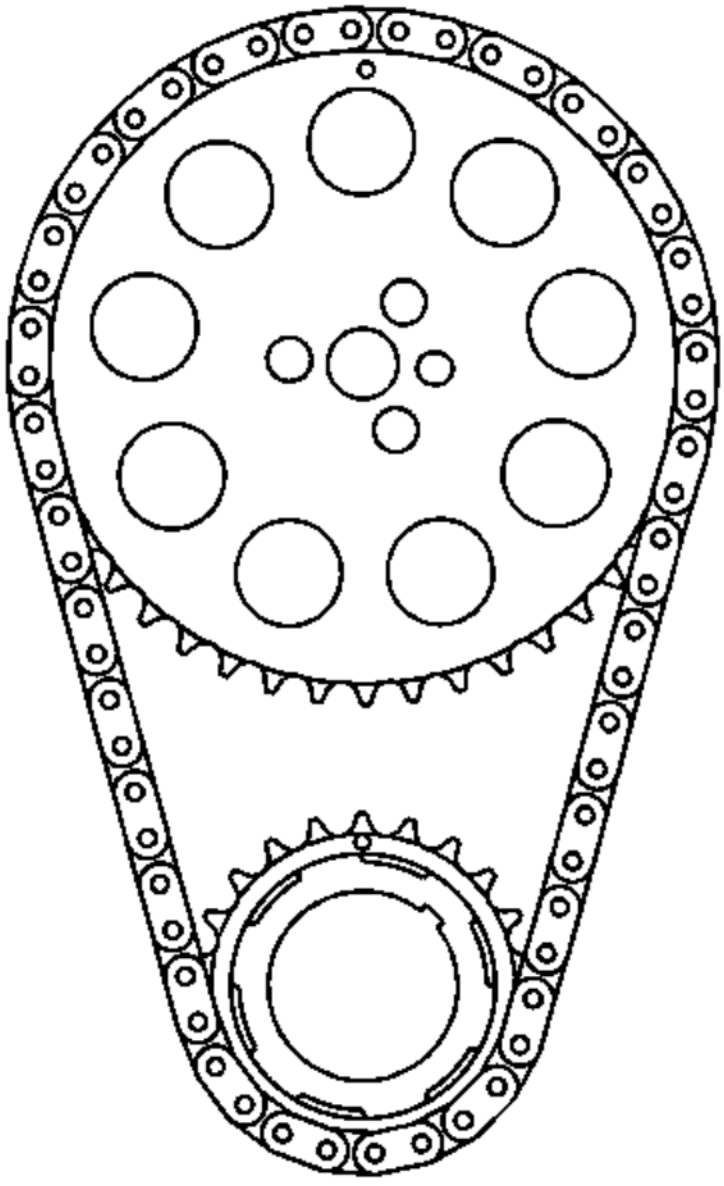

Fig. 99: View of Crankshaft/Camshaft In Position For Number 1 Piston At TDC
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

6. 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.

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

   Tighten:
   - Tighten the cylinders 1,2,7 and 8 exhaust valve rocker arm bolts to 30 N.m (22 lb ft).
   - Tighten the cylinders 1,3,4 and 5 intake valve rocker arm bolts to 30 N.m (22 lb ft).

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

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

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

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

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

Removal Procedure

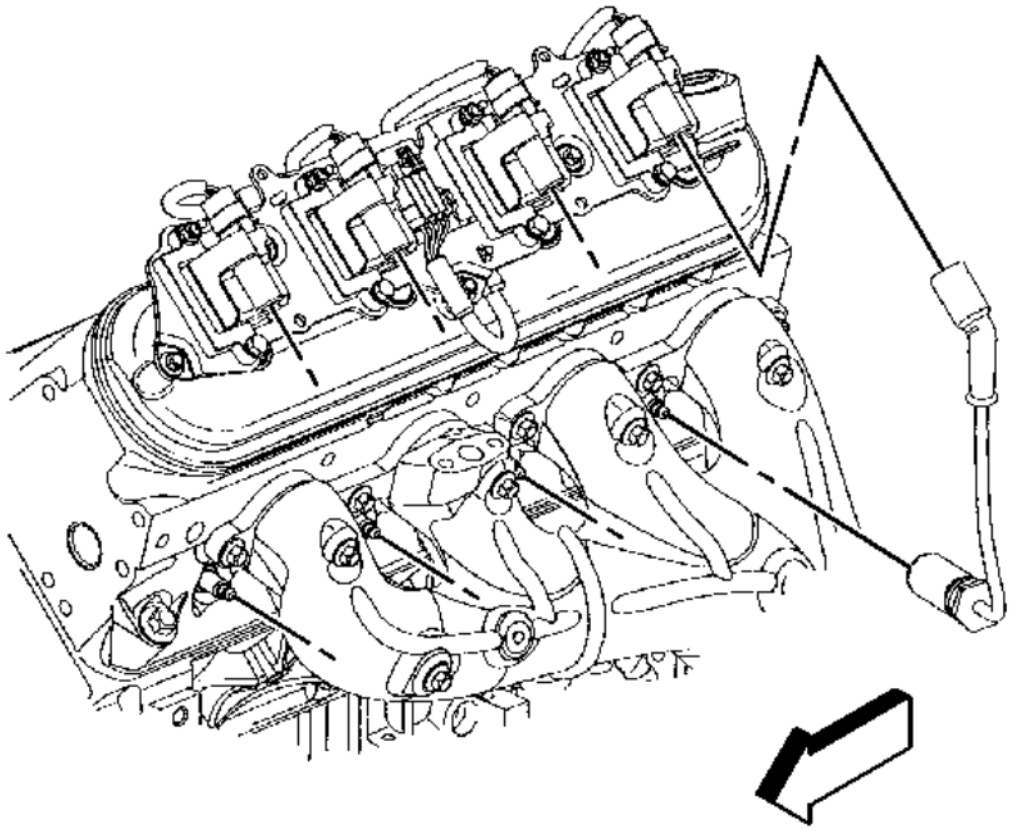

Fig. 100: View Of Spark Plug Wire & Boot
Courtesy of GENERAL MOTORS CORP.

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.

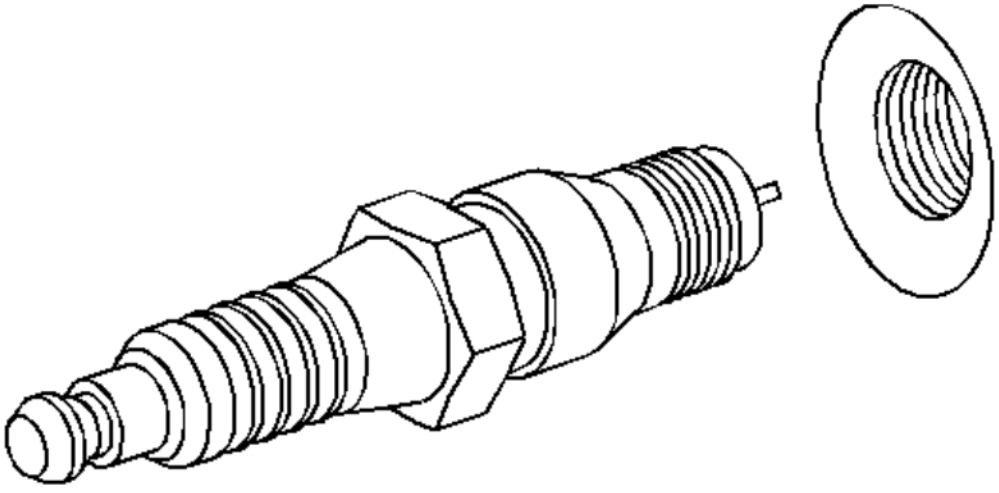

Fig. 101: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

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

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

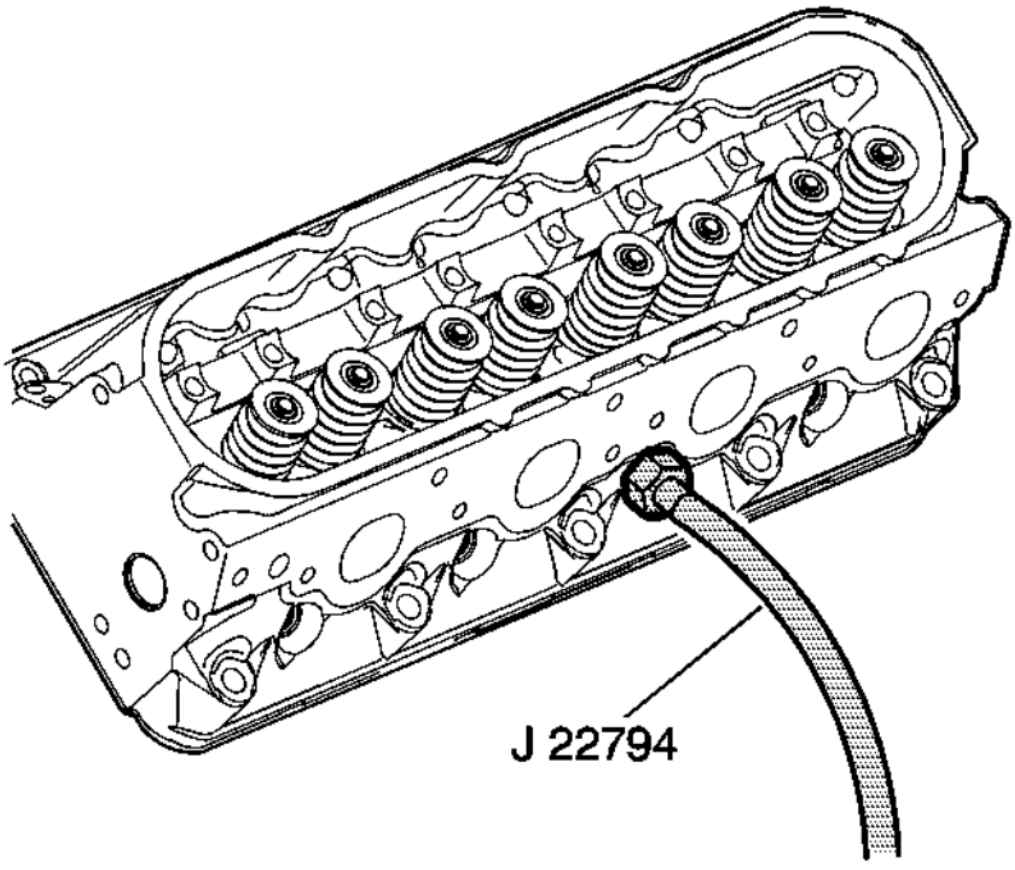

Fig. 102: Applying Compressed Air To J 22794
Courtesy of GENERAL MOTORS CORP.

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**.

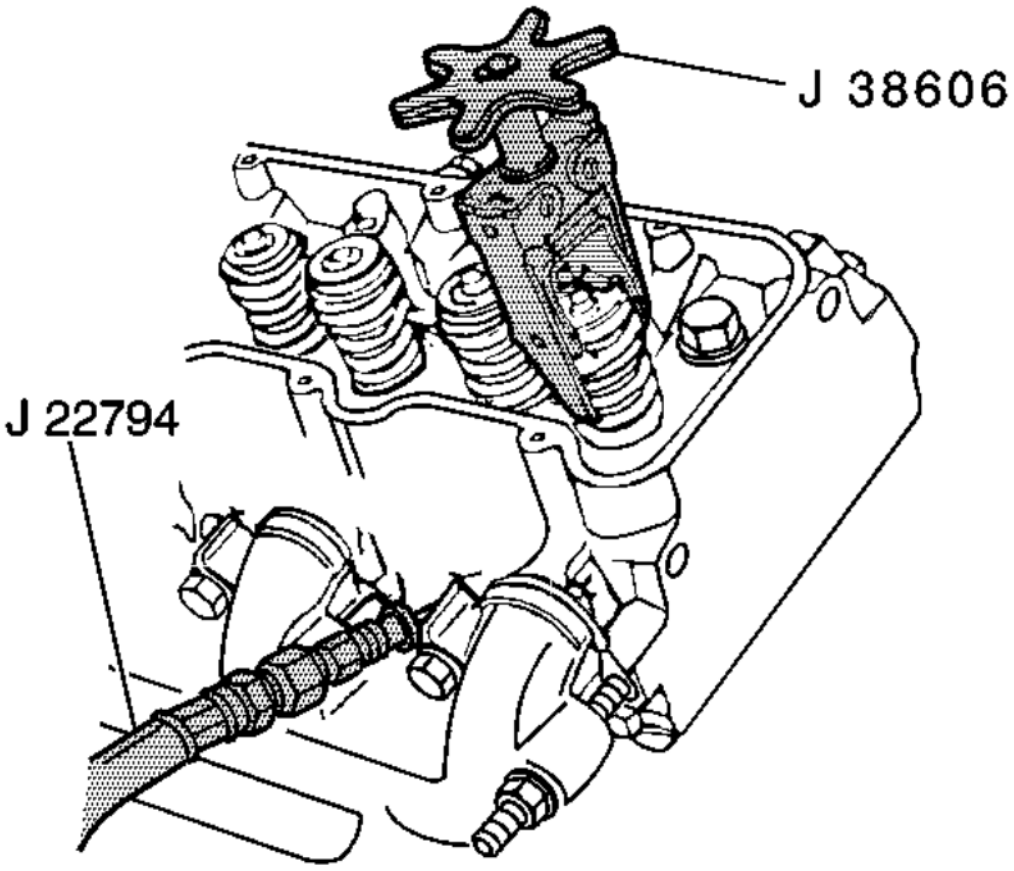

Fig. 103: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

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

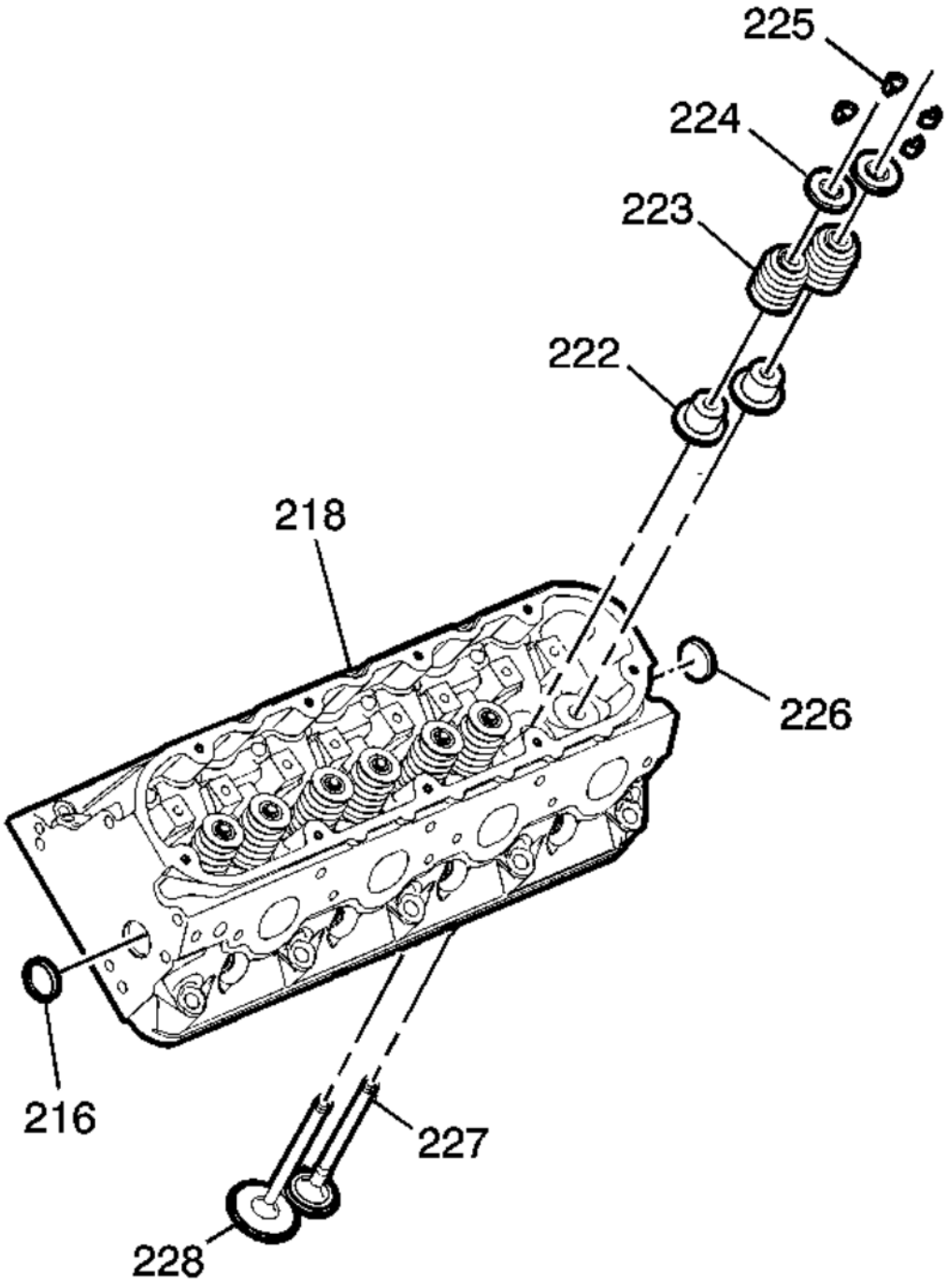

Fig. 104: View Of Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

10. Remove the valve stem keys (225).
11. Carefully release the valve spring tension.
12. Remove the **J 38606** . See **Special Tools**.
13. Remove the valve spring cap (224).
14. Remove the valve spring (223).
15. Remove the valve stem oil seal and shim (222) assembly.

Installation Procedure

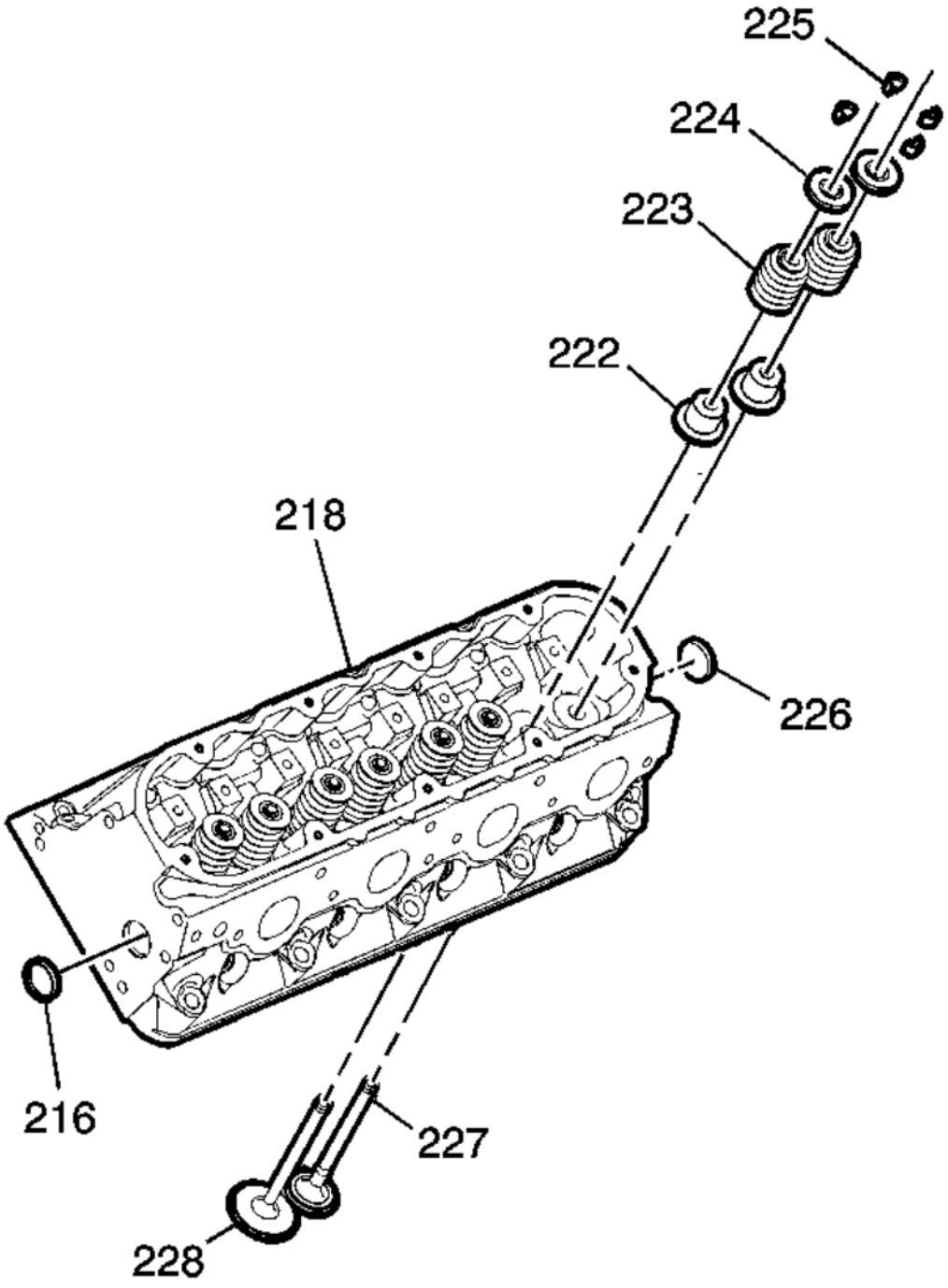

Fig. 105: View Of Cylinder Head Components
Courtesy of GENERAL MOTORS CORP.

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 and shim (222) assembly.
4. Install the valve spring (223).
5. Install the valve spring cap (224).

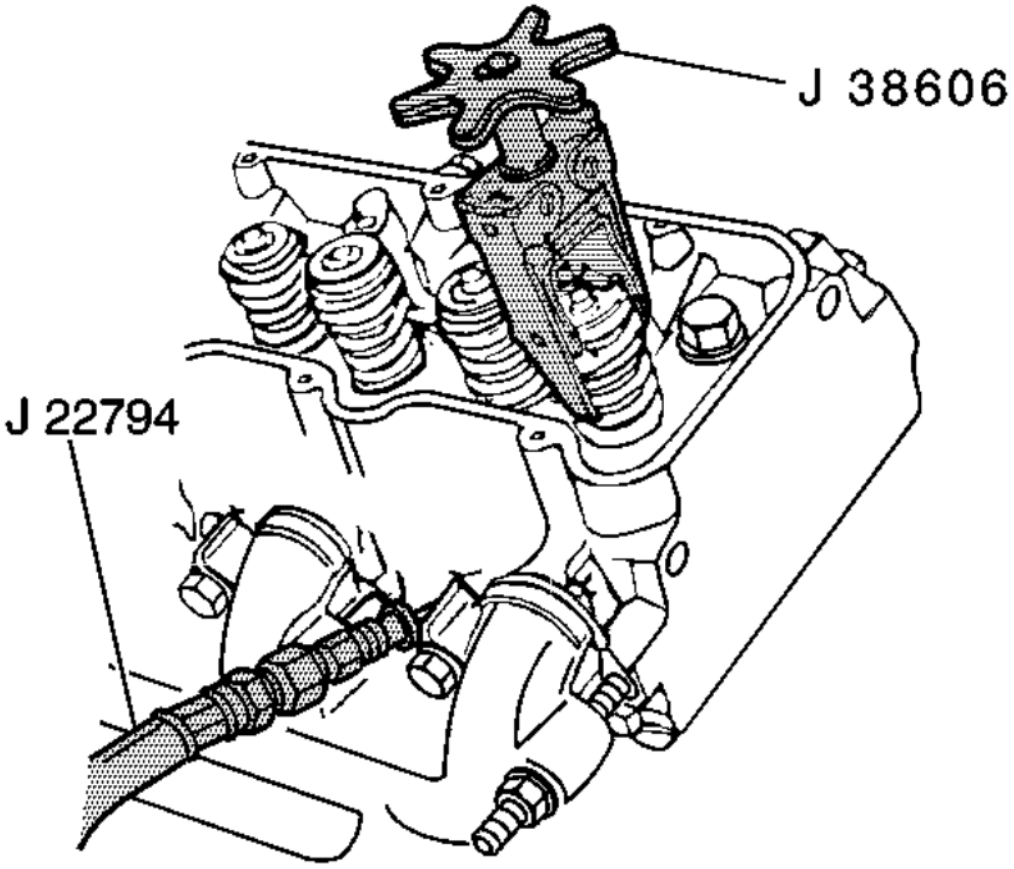

Fig. 106: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

6. Compress the valve spring using the **J 38606** . See **Special Tools**.
7. Install the valve stem keys (225).
   - Use grease in order to hold the valve keys in place.

- Make sure the keys seat properly in the groove of the valve stem.
- Carefully release the valve spring pressure, making sure the valve keys stay in place.
- Remove the **J 38606** . See **Special Tools**.
- Tap the end of the valve stem with a plastic faced hammer to seat the keys, if necessary.

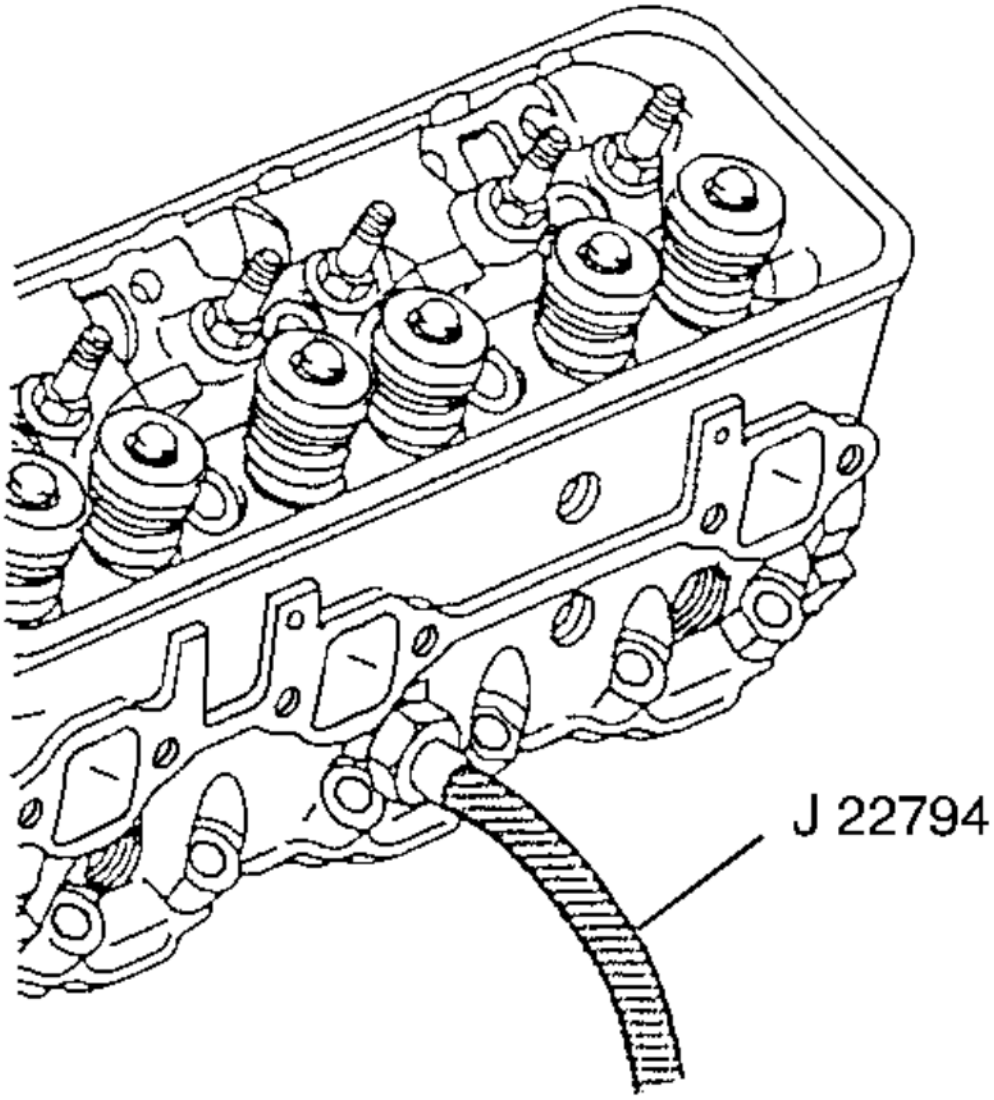

Fig. 107: View Of J 22794
Courtesy of GENERAL MOTORS CORP.

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

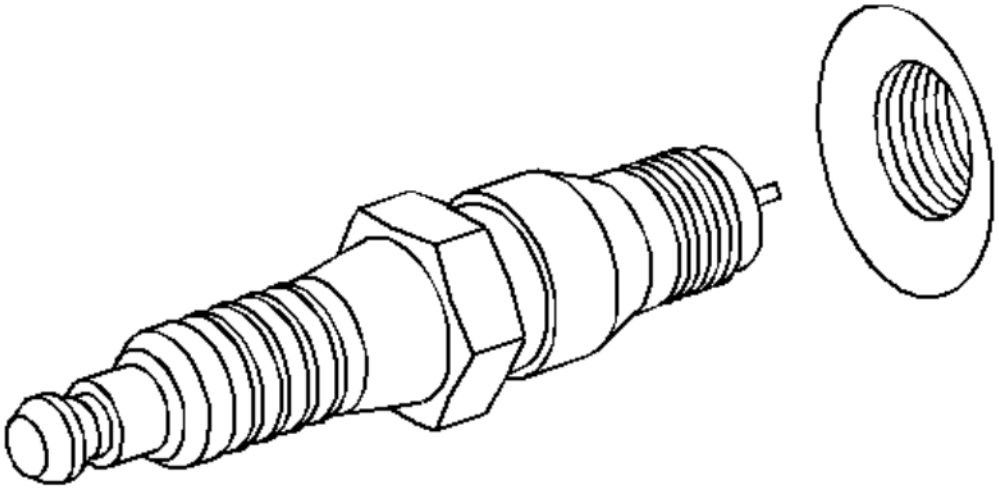

Fig. 108: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

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

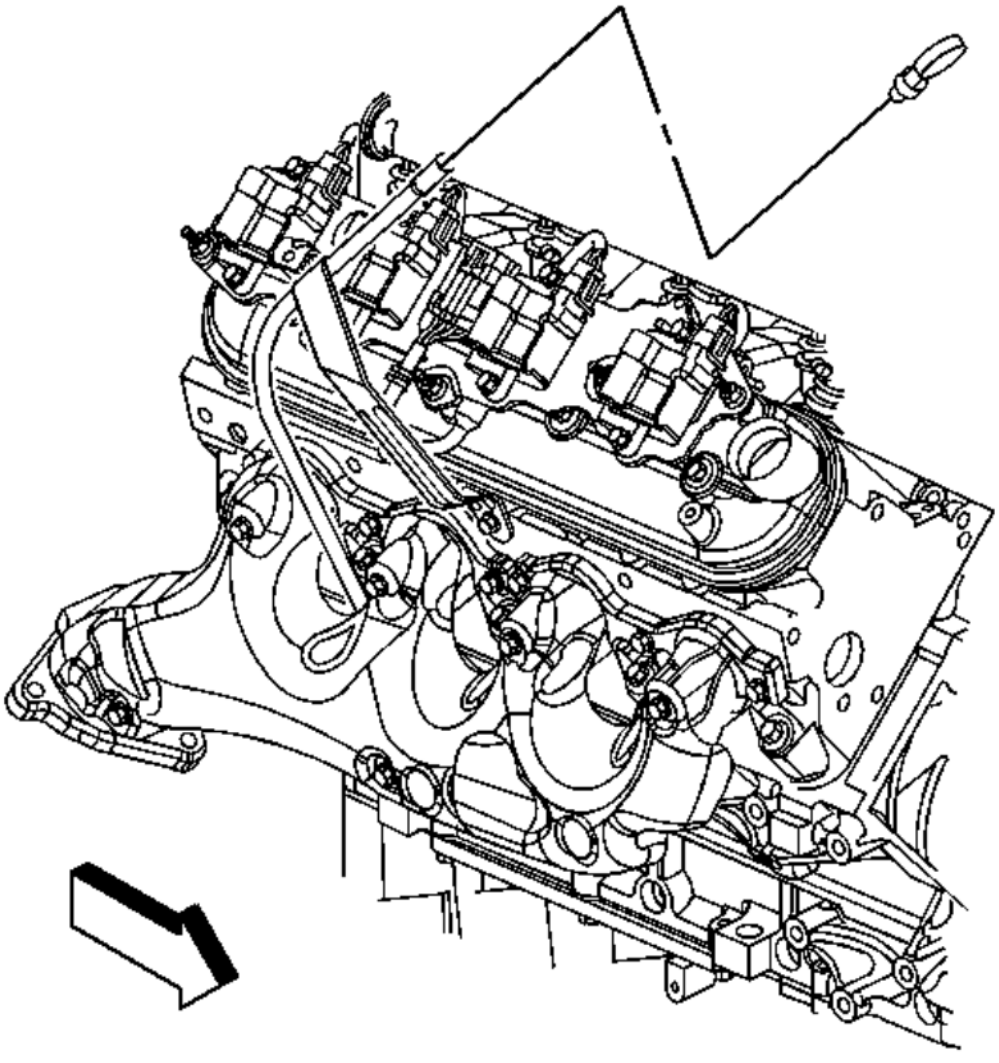

Fig. 109: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the tube.

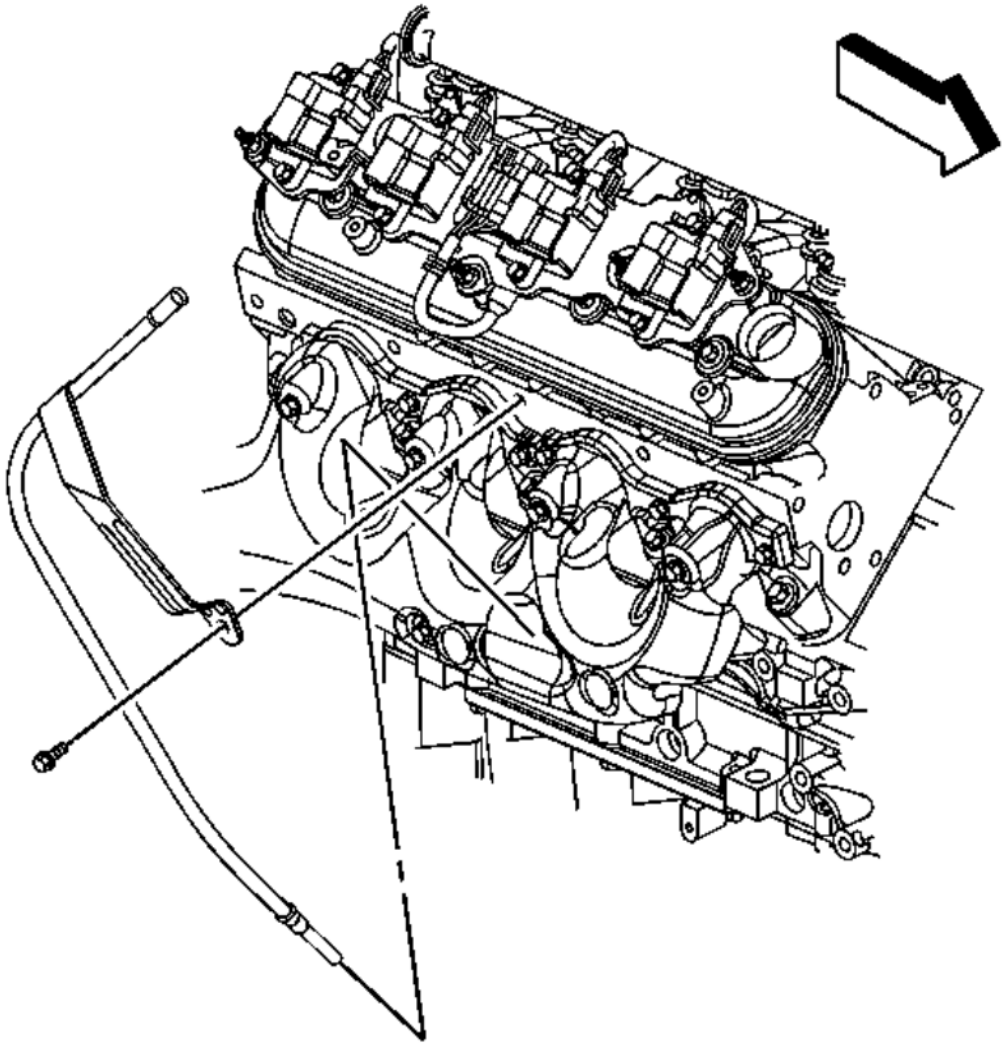

Fig. 110: View Of Oil Level Indicator Tube & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the engine block.

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

4. Inspect the O-ring seal for cuts or damage.

5. Remove the O-ring seal from the tube (if required).

Installation Procedure

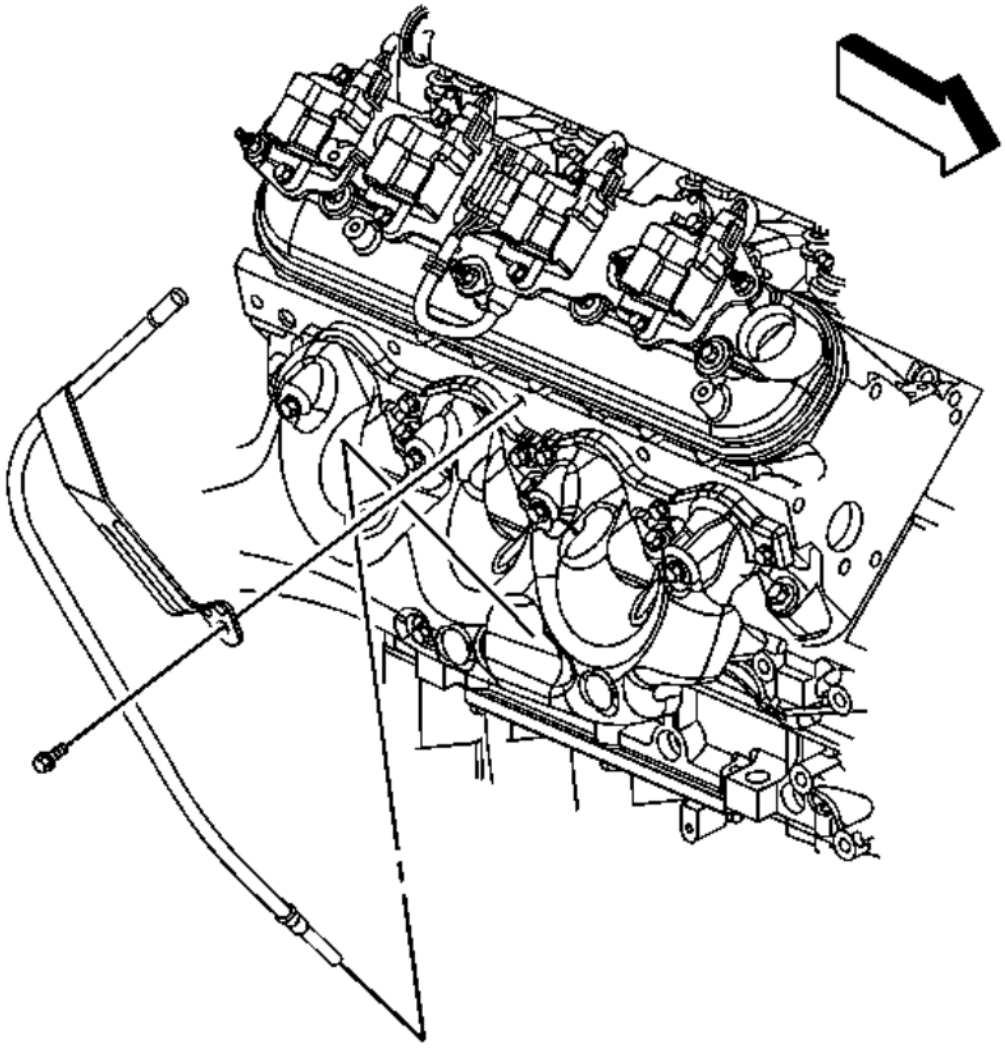

Fig. 111: View Of Oil Level Indicator Tube & Bolt
Courtesy of GENERAL MOTORS CORP.

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** .
5. Install the oil level indicator tube into the block. The tube must be installed with the collar flush to the block.
6. Lower the vehicle.

NOTE: **Refer to Fastener Notice .**

7. Install the oil level indicator tube bolt

Tighten: Tighten the oil level indicator tube bolt to 25 N.m (18 lb ft).

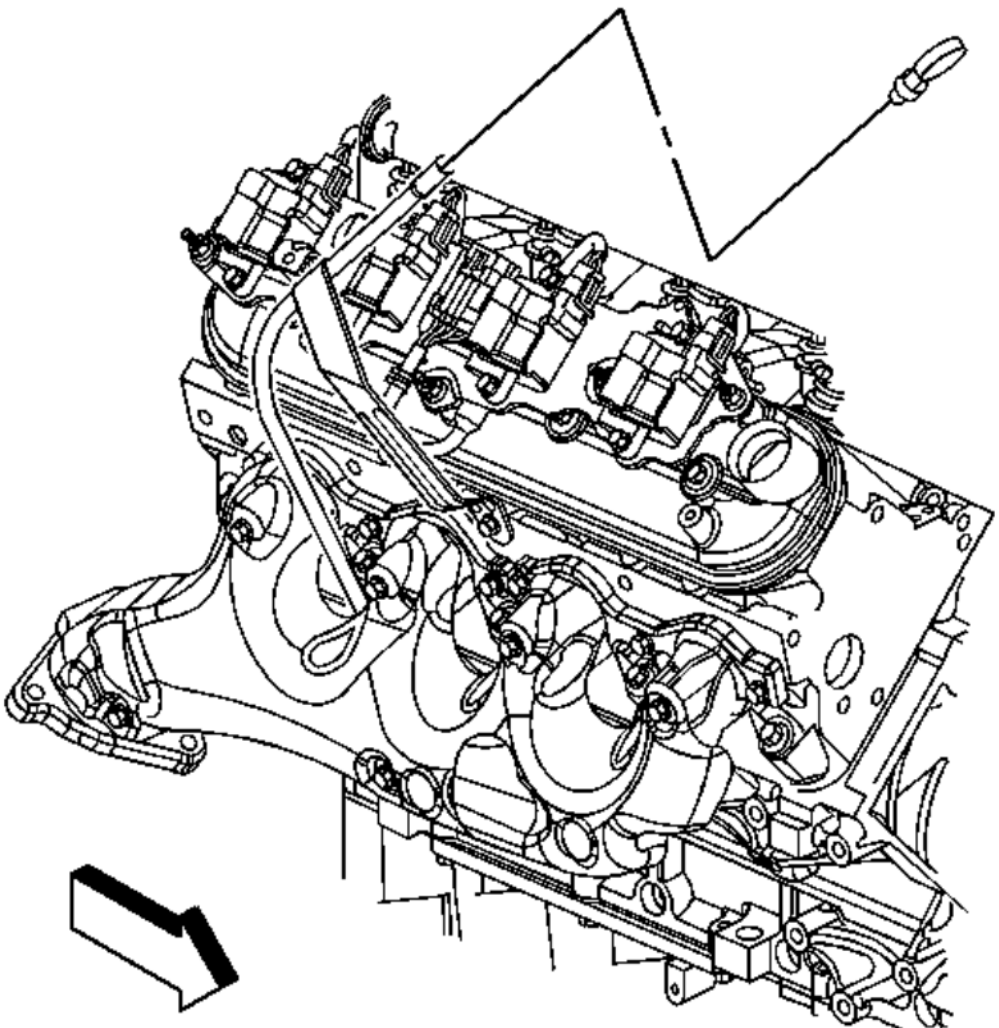

Fig. 112: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

8. Install the oil level indicator to the tube.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Special Tools

- **J 45059** Angle Meter. See **Special Tools**.
- **J 42385-200** Thread Repair Kit. See **Special Tools**.

Removal Procedure

1. Remove the generator bracket. Refer to **Generator Replacement** .
2. Remove the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
3. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side** .
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

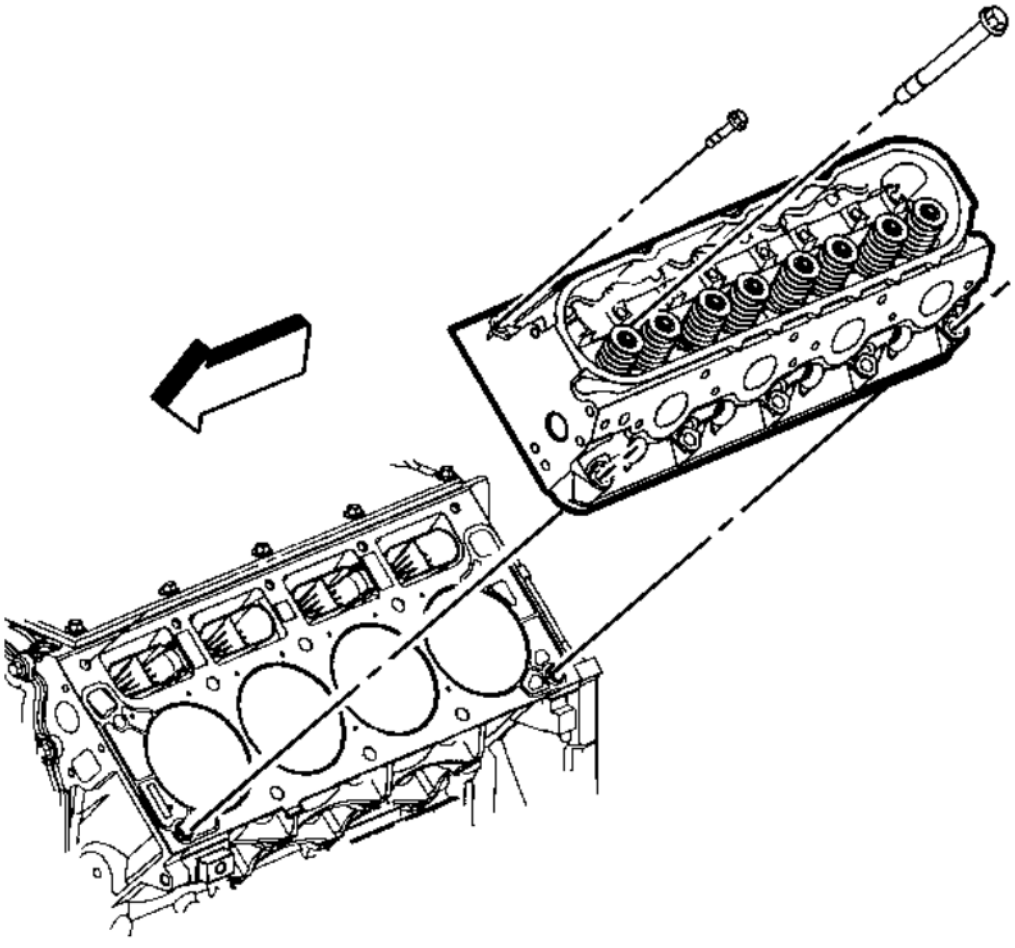

Fig. 113: View Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are NOT reusable.

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

5. Remove the cylinder head bolts.
6. Remove the cylinder head.

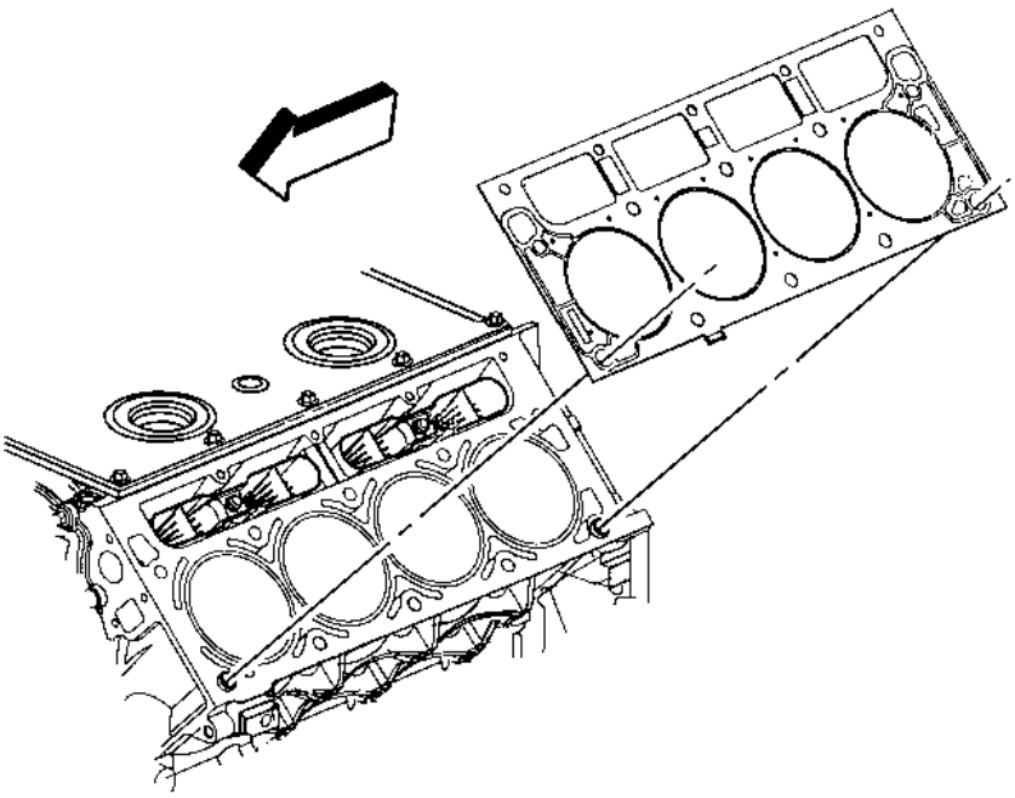

Fig. 114: View Of Left Cylinder Head Gasket & Locator Pins
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head gasket.

8. Discard the gasket.
9. Discard the cylinder head bolts.
10. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

CAUTION: Wear safety glasses in order to avoid eye damage.

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 reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless specified.**
- **The cylinder head gaskets must be installed in the proper direction and position.**

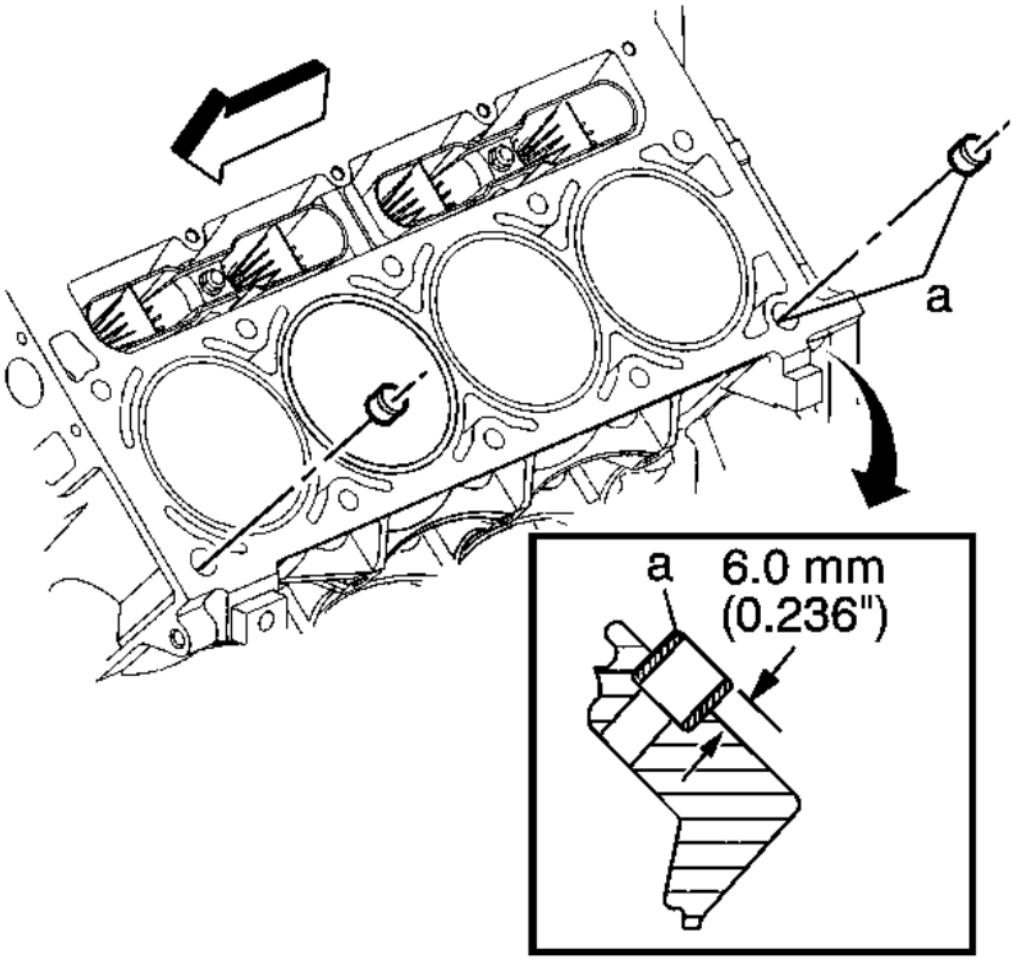

Fig. 115: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107, found in **J 42385-200** may be used to clean the threads of old threadlocking material. See **Special Tools**.

2. Use spray cleaner to clean out the hole. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
3. Clean the cylinder head bolt holes with compressed air.

4. Check the cylinder head locating pins for proper installation.

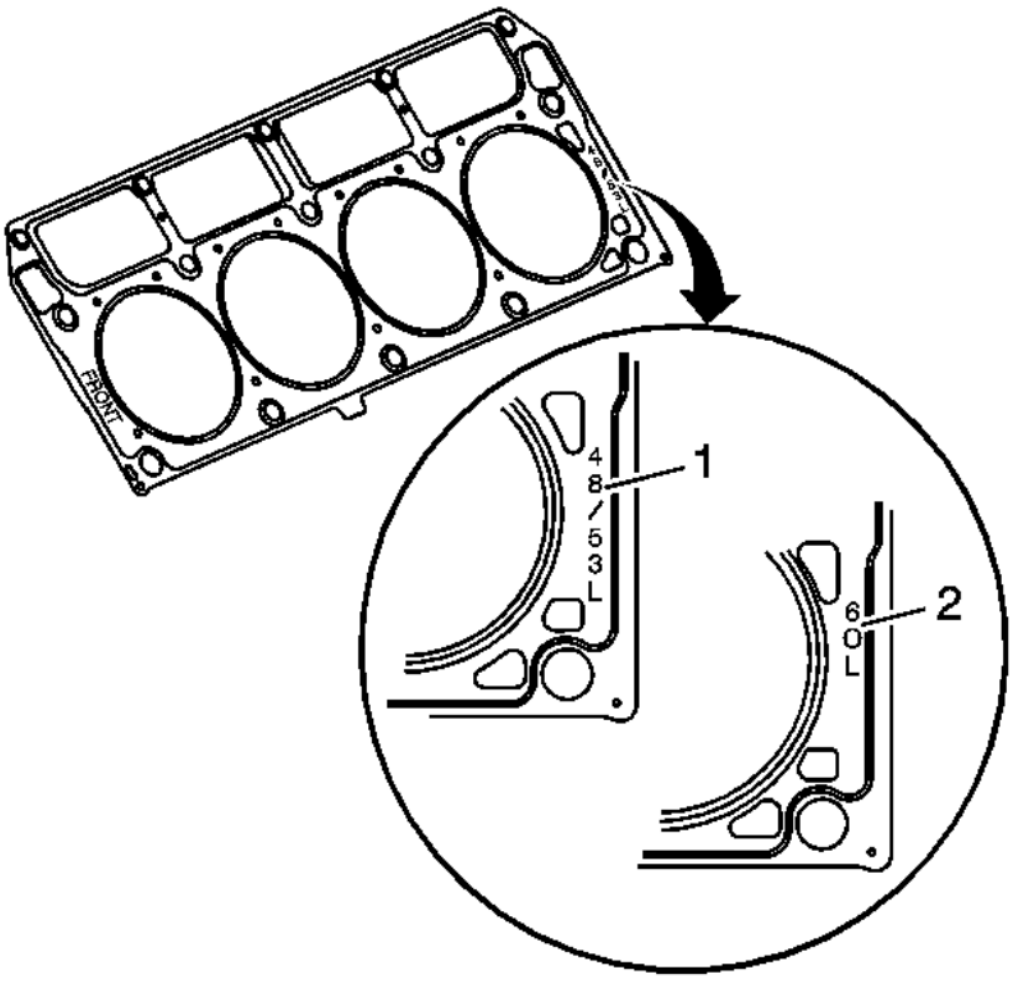

Fig. 116: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

5. Inspect the displacement markings (2) on the gasket, for proper usage.

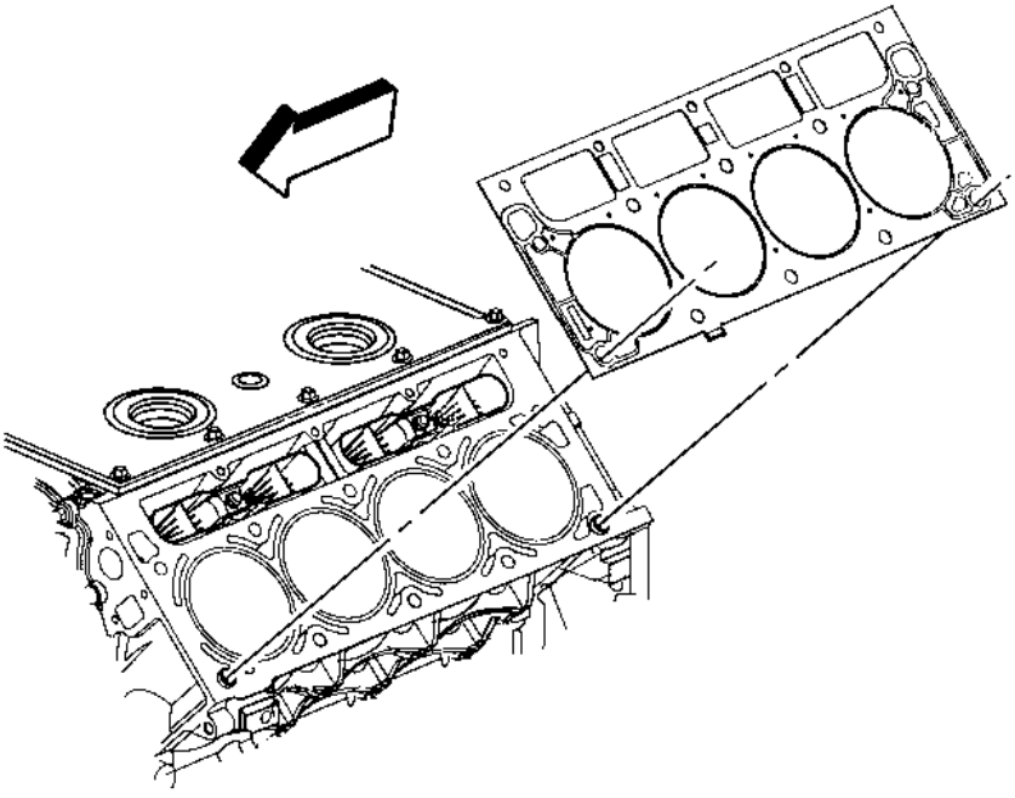

Fig. 117: View Of Left Cylinder Head Gasket & Locator Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When properly installed, the tab on the left cylinder head gasket will be located left of center or closer to the front of the engine.

6. Install the NEW left cylinder head gasket onto the locating pins.

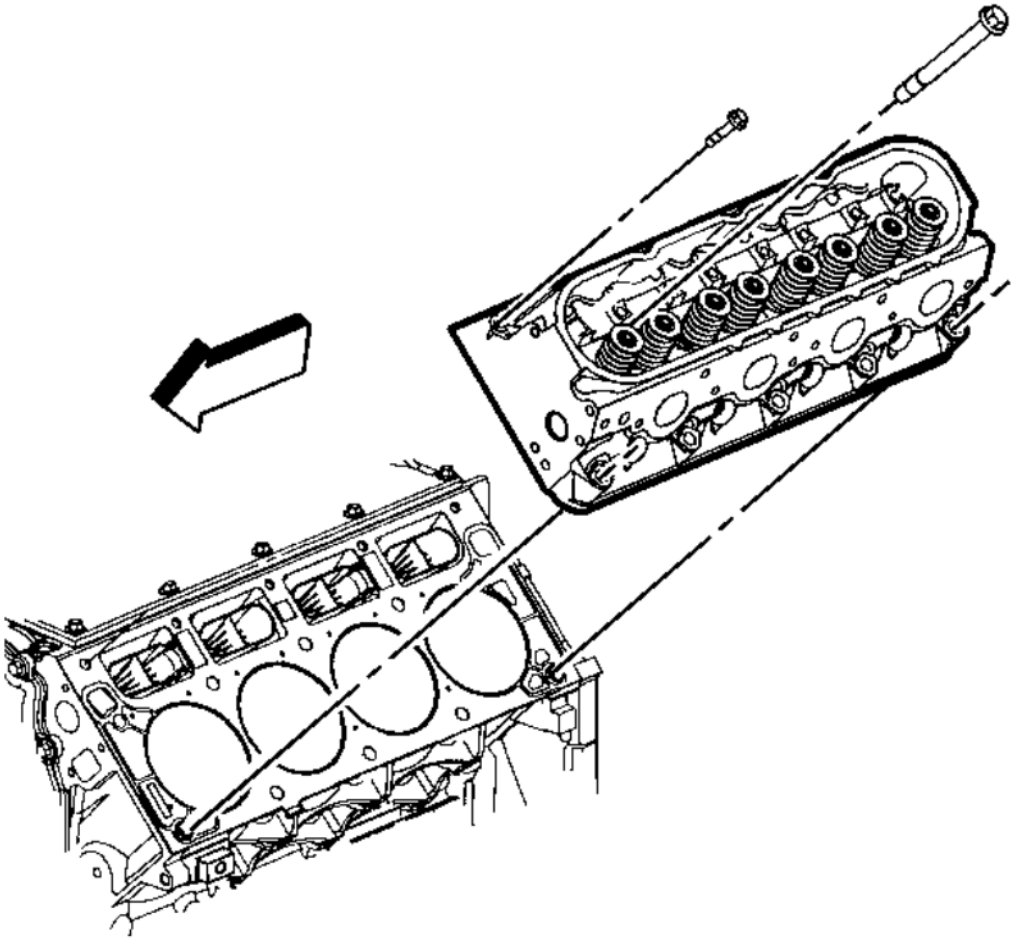

Fig. 118: View Of Left Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Install the cylinder head onto the locating pins and gasket.
8. Install the NEW cylinder head bolts.

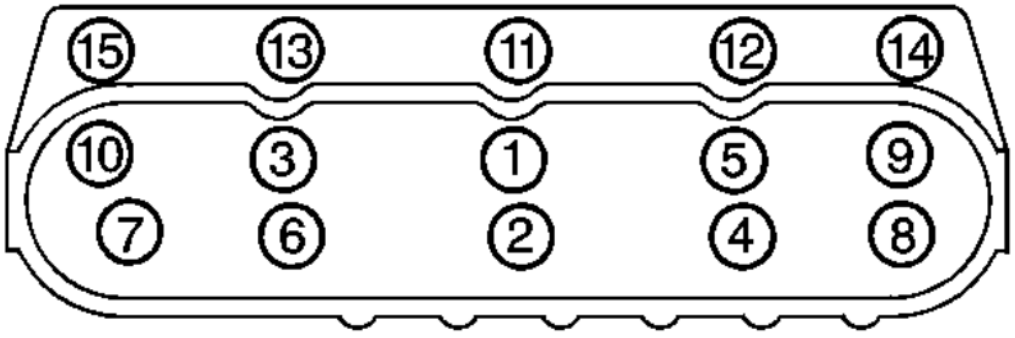

Fig. 119: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. 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 **J 45059** . See **Special Tools**.
   3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using **J 45059** . See **Special Tools**.
   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.

10. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
11. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side** .
12. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
13. Install the generator bracket. Refer to **Generator Replacement** .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Special Tools

- **J 45059** Angle Meter. See **Special Tools**.
- **J 42385-200** Thread Repair Kit. See **Special Tools**.

Removal Procedure

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** .
3. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .
4. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

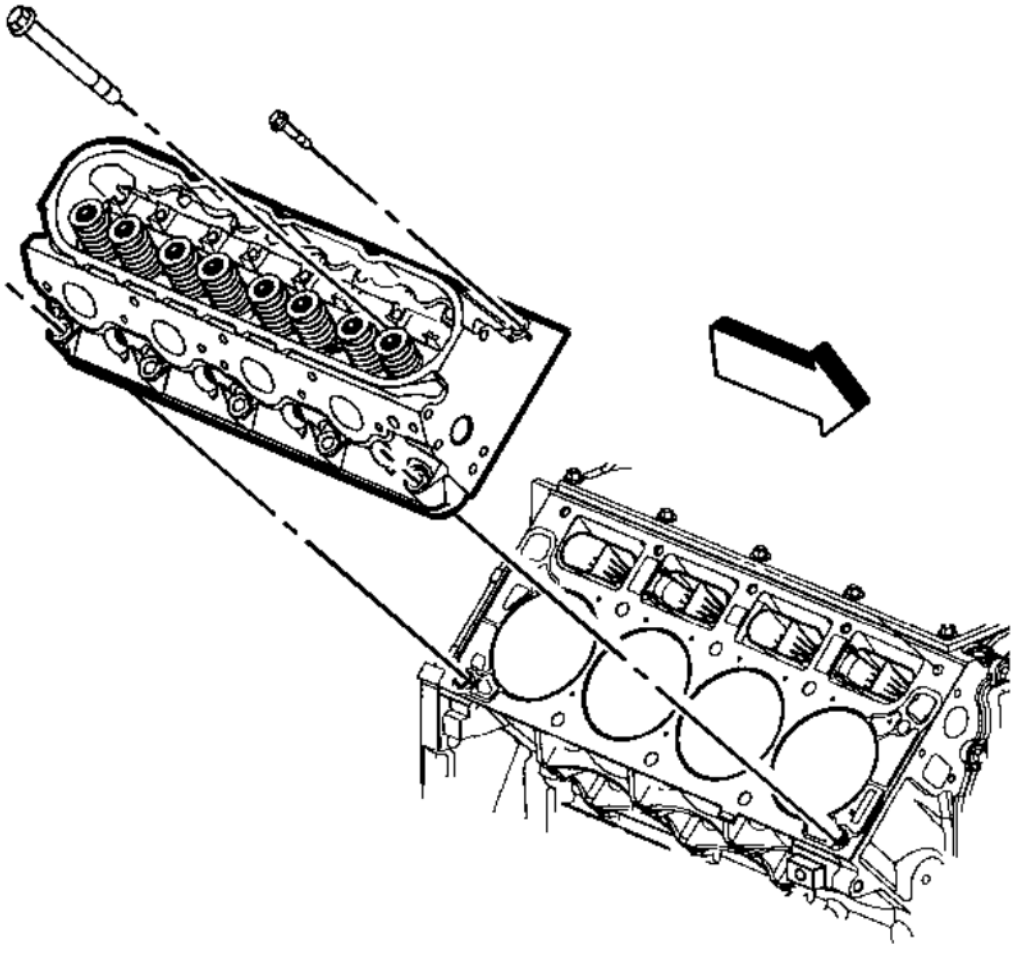

Fig. 120: View Of Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The cylinder head bolts are NOT reusable.

NOTE: After removal, place the cylinder head on 2 wood blocks in order to prevent damage to the sealing surfaces.

5. Remove the cylinder head bolts.
6. Remove the cylinder head.

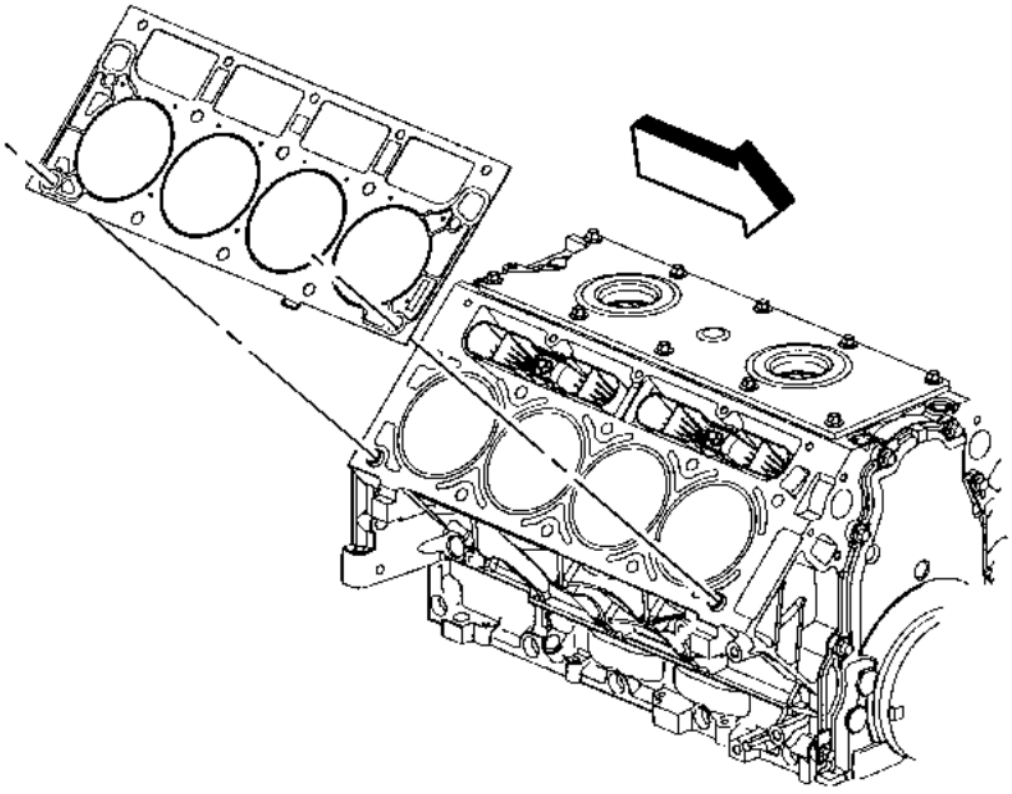

Fig. 121: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

7. Remove the cylinder head gasket.
8. Discard the gasket.
9. Discard the cylinder head bolts.
10. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

CAUTION: Wear safety glasses in order to avoid eye damage.

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 reuse the cylinder head bolts. Install NEW cylinder head bolts during assembly.
- Do not use any type of sealant on the cylinder head gasket, unless specified.
- The cylinder head gaskets must be installed in the proper direction and position.

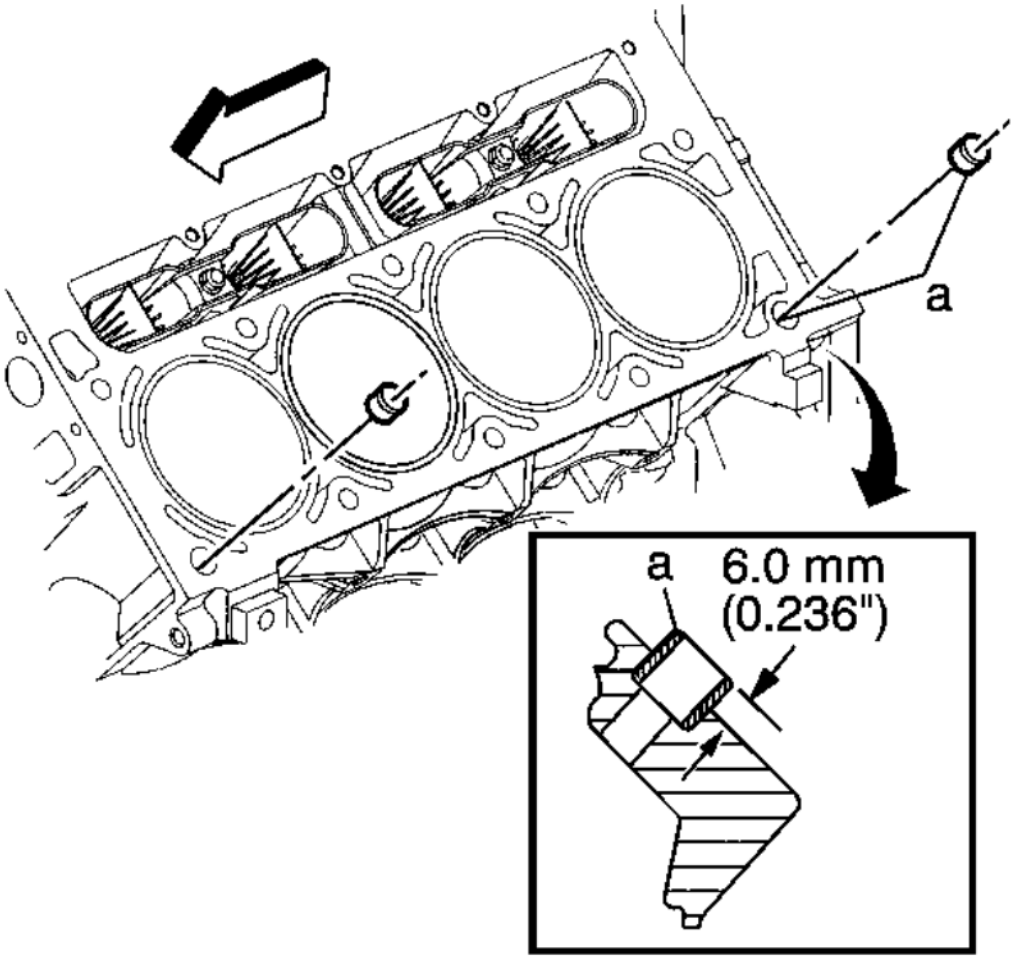

Fig. 122: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine block cylinder head bolt holes, if required.

   Thread repair tool J 42385-107, found in **J 42385-200** may be used to clean the threads of old threadlocking material. See **Special Tools**.

2. Use spray cleaner to clean out the hole. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation.

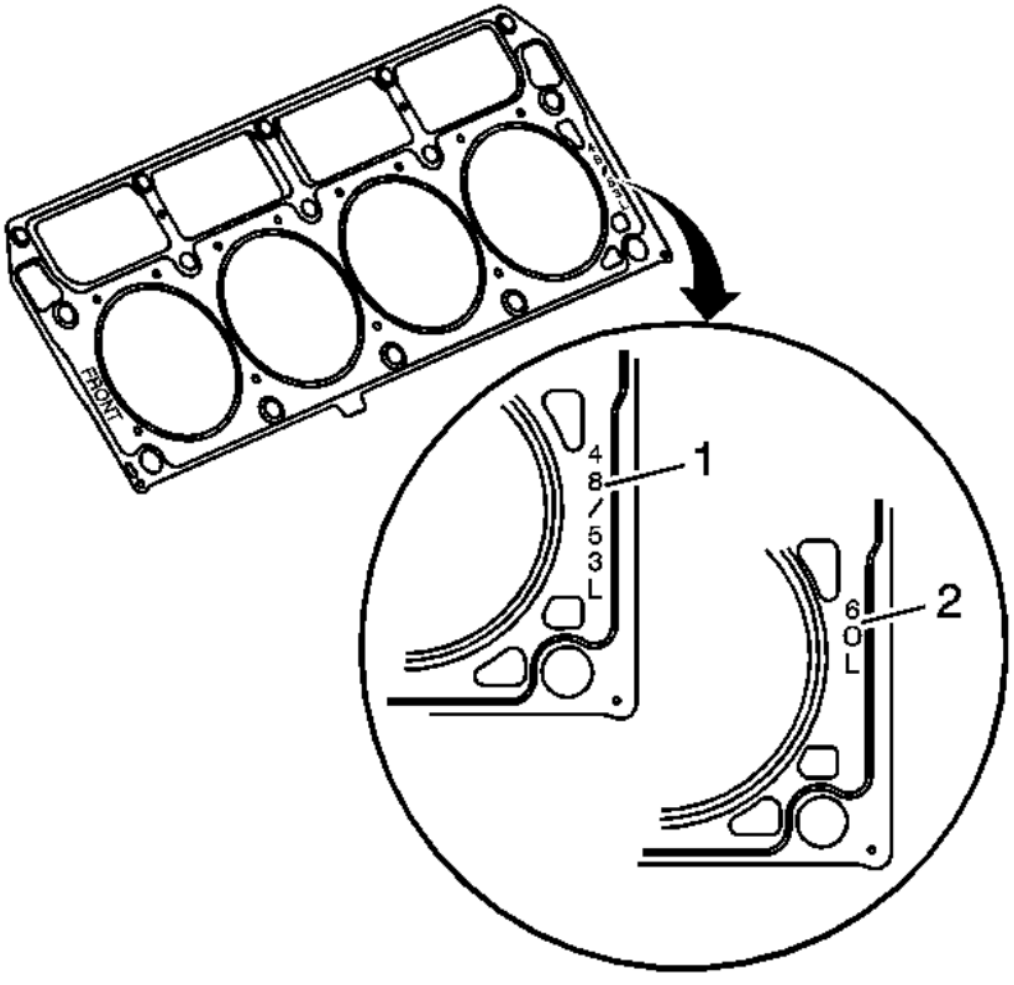

Fig. 123: View Of Cylinder Head Gasket Displacement Markings
Courtesy of GENERAL MOTORS CORP.

5. Inspect the displacement markings (2) on the gasket, for proper usage.

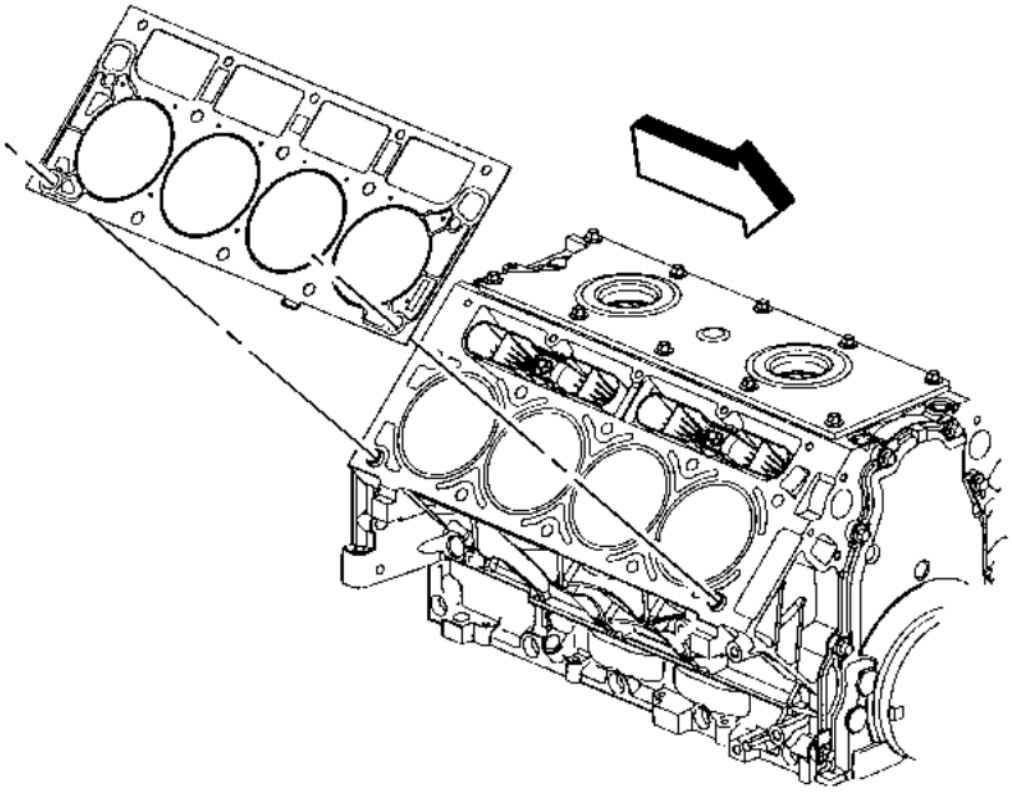

Fig. 124: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When properly installed, the tab on the right cylinder head gasket will be located right of center or closer to the front of the engine.

6. Install the NEW right cylinder head gasket onto the locating pins.

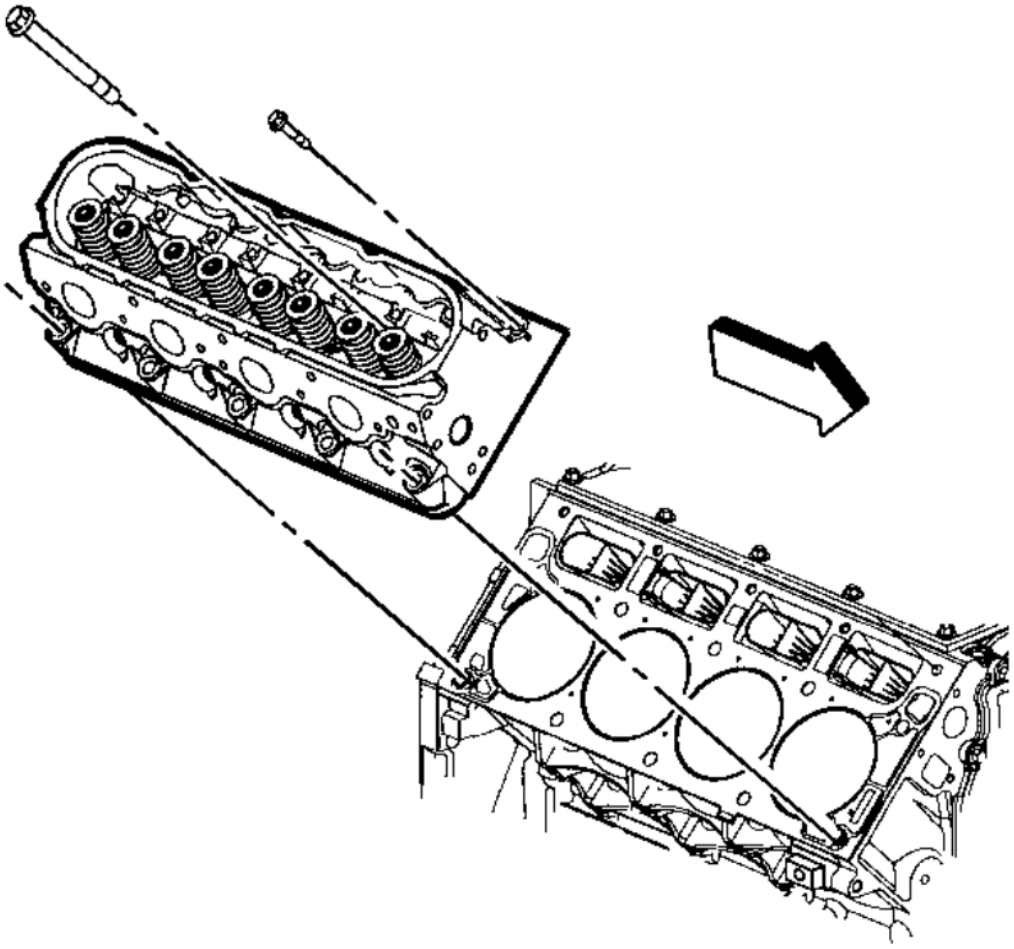

Fig. 125: View Of Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

7. Install the cylinder head onto the locating pins and gasket.
8. Install the NEW cylinder head bolts.

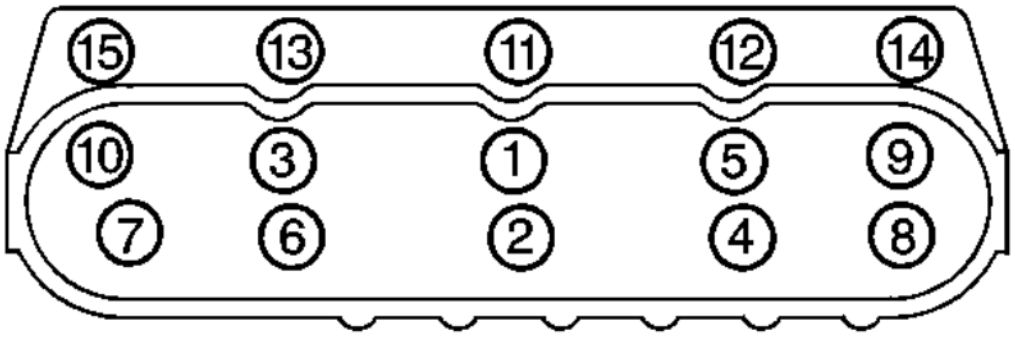

Fig. 126: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. 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 **J 45059** . See **Special Tools**.
   3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using **J 45059** . See **Special Tools**.
   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.

10. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
11. Install the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side** .
12. Install the coolant air bleed pipe. Refer to **Coolant Air Bleed Pipe Assembly Replacement** .
13. Install the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement**.

VALVE LIFTER REPLACEMENT

Special Tools

J 3049-A Valve Lifter Remover

Removal Procedure

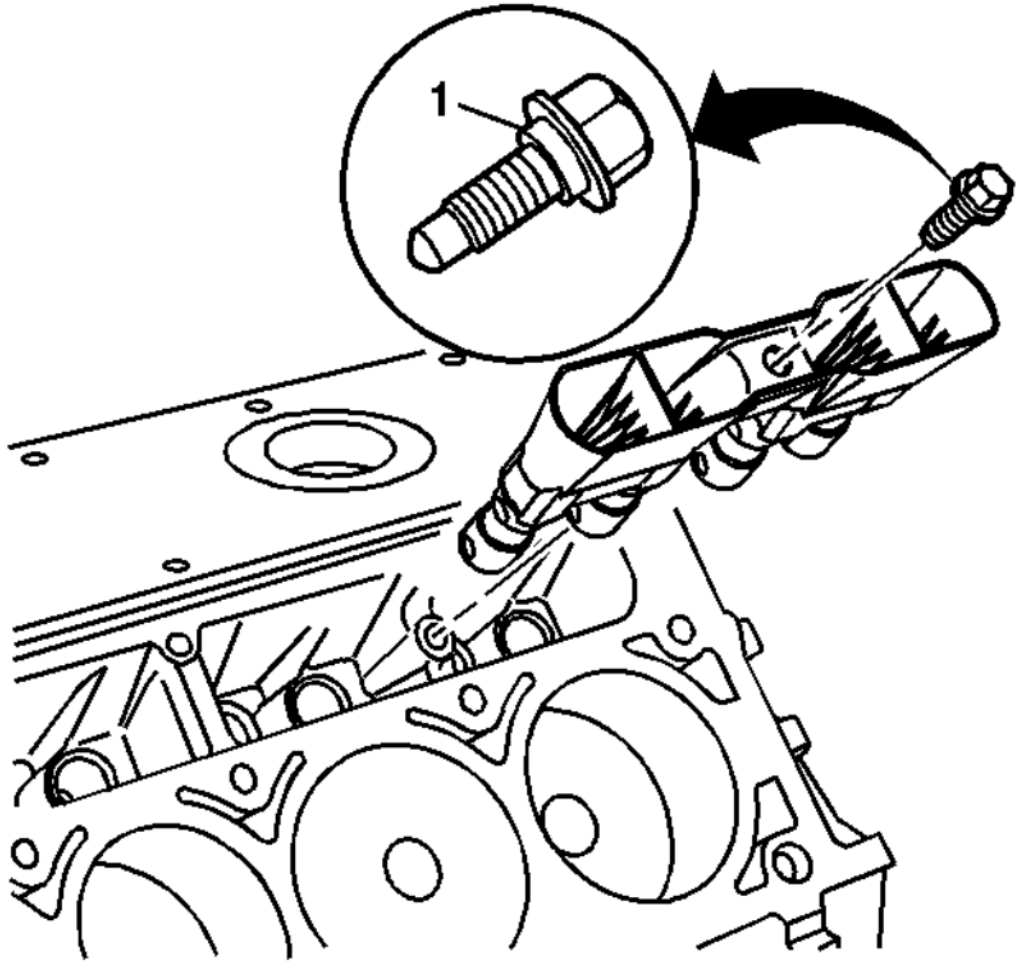

Fig. 127: View Of Valve Lifter Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head and gasket. Refer to **Cylinder Head Replacement - Left Side** or **Cylinder Head Replacement - Right Side**.
2. Remove the valve lifter guide bolts (1).

3. Remove the valve lifters and guide.

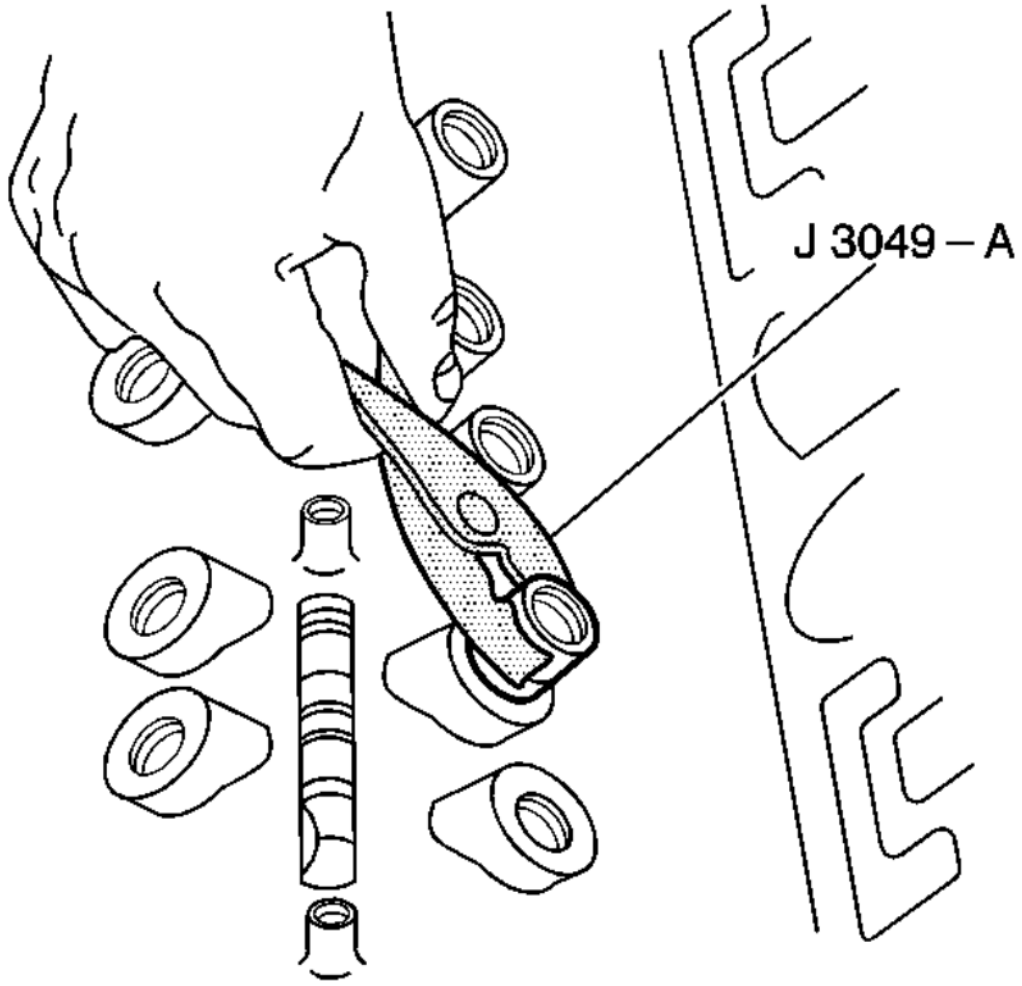

Fig. 128: Using J 3049-A To Remove Sticking Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some valve lifters may be stuck in their bores because of gum or varnish deposits.

4. Use **J 3049-A** or equivalent in order to remove the valve lifters, if required.

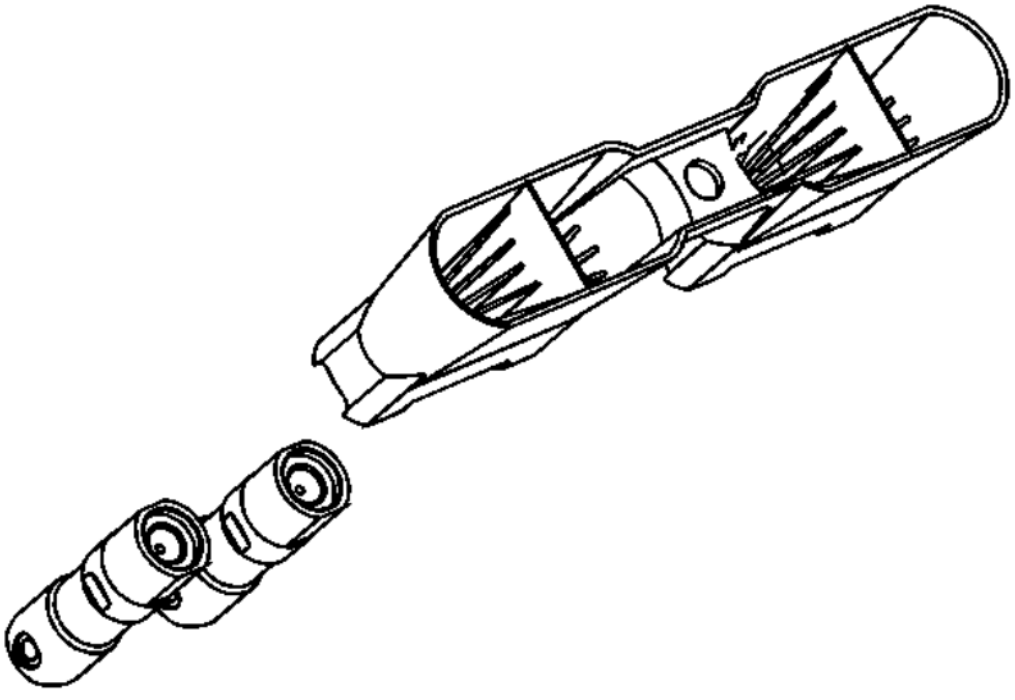

Fig. 129: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve lifters from the guide.
6. Organize or mark the components so that they can be installed in the same location from which they were removed.
7. Clean and inspect the valve lifters. Refer to **Valve Lifters and Guides Cleaning and Inspection**.

Installation Procedure

IMPORTANT: When reusing valve lifters, install the lifters to their original locations.

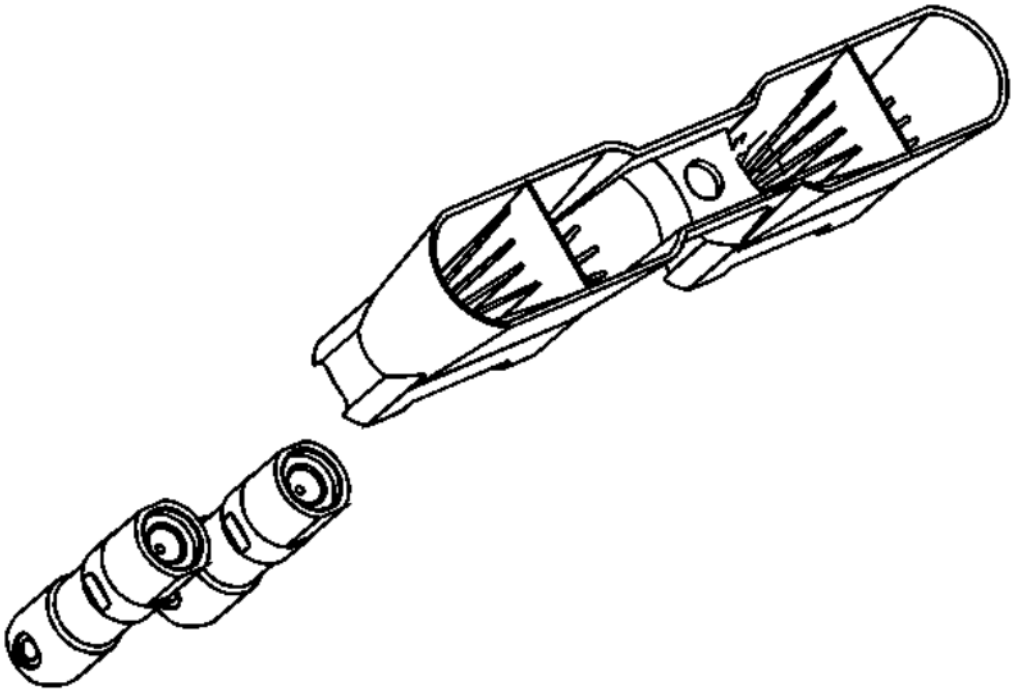

Fig. 130: View Of Valve Lifters & Lifter Guides
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve lifters and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides.

   Align the flat area on the top of the lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.

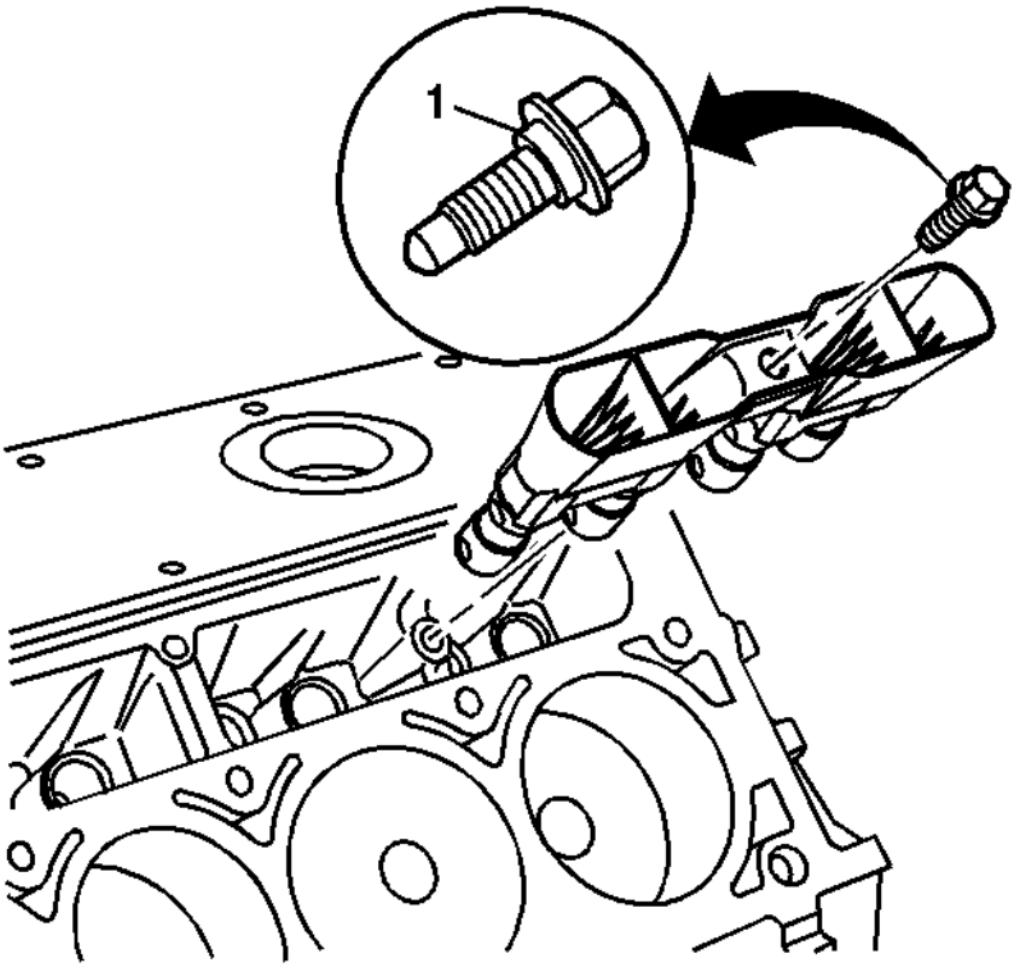

Fig. 131: View Of Valve Lifter Guide And Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the valve lifters and guide to the engine block.
4. Install the valve lifter guide bolt (1).

   Tighten: Tighten the valve lifter guide bolt (1) to 12 N.m (106 lb in).

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

Cylinder Head Replacement - Right Side.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41816** Crankshaft Balancer Remover
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

1. Remove the fan shroud. Refer to **Cooling Fan and Shroud Replacement** .
2. Remove the starter motor. Refer to **Starter Motor Replacement** .

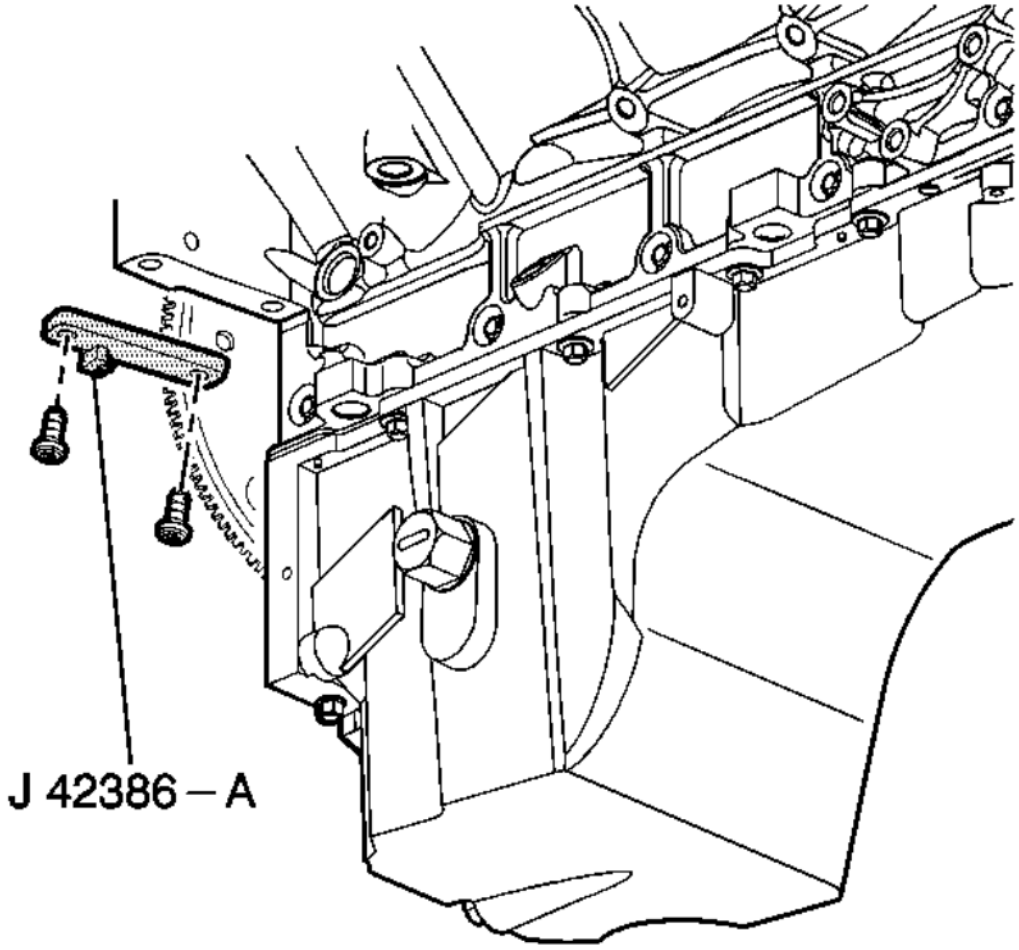

Fig. 132: Using J 42386-A To Lock Flywheel
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Make sure that the teeth of the J 42386-A are fully engaged into the flywheel ring gear teeth. See Special Tools.**
- **The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.**

NOTE: **Refer to Fastener Notice .**

3. Install the **J 42386-A** . 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** to 50 N. See **Special Tools**.m (37 lb ft).

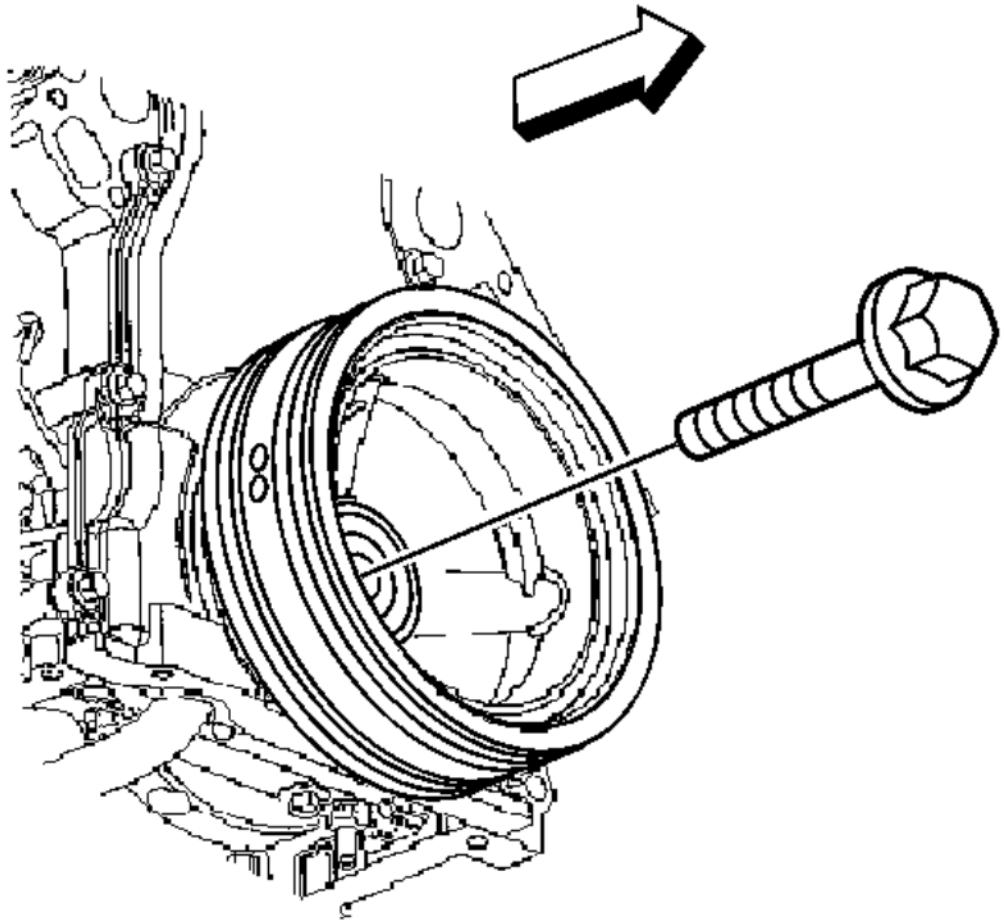

Fig. 133: Crankshaft Balancer And Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer bolt.

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

balancer installation procedure.

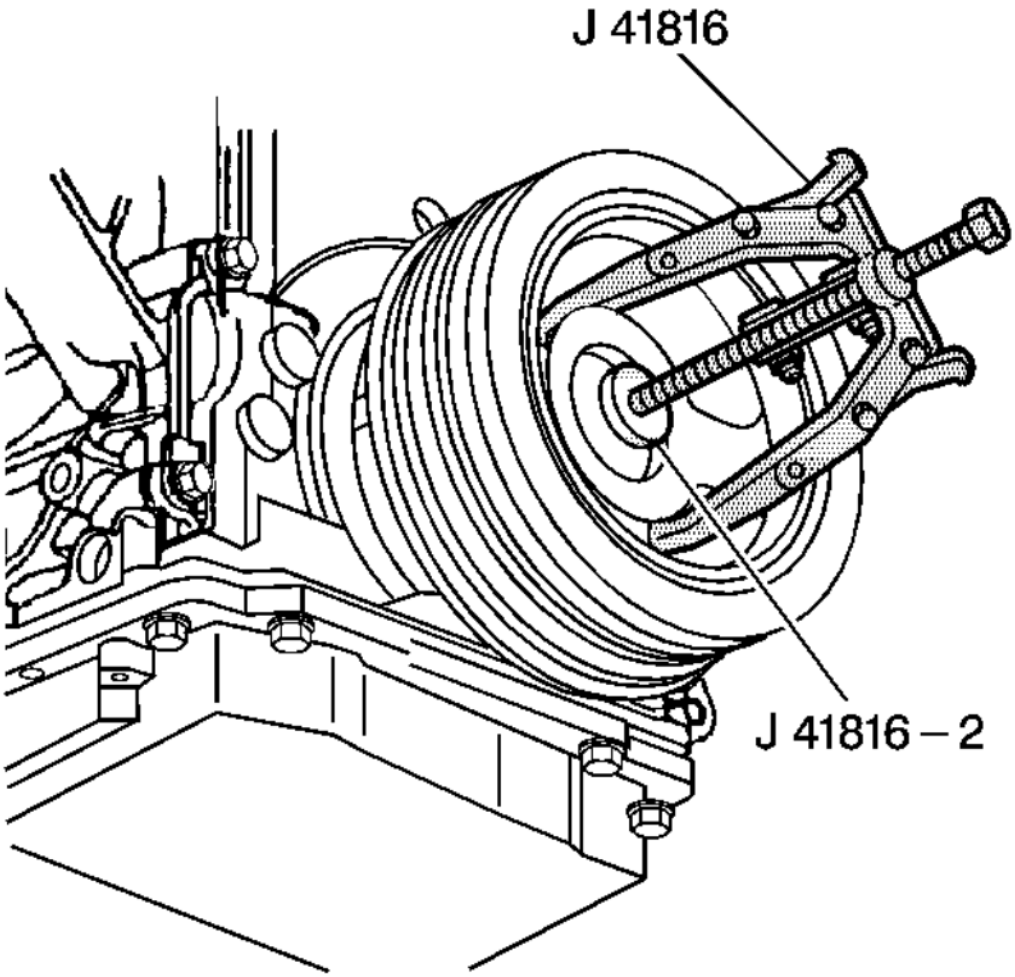

Fig. 134: Removing Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:

- **Make sure that the teeth of J 42386-A are fully engaged into the flywheel ring gear teeth. 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, third and forth passes 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.**
- **The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.**

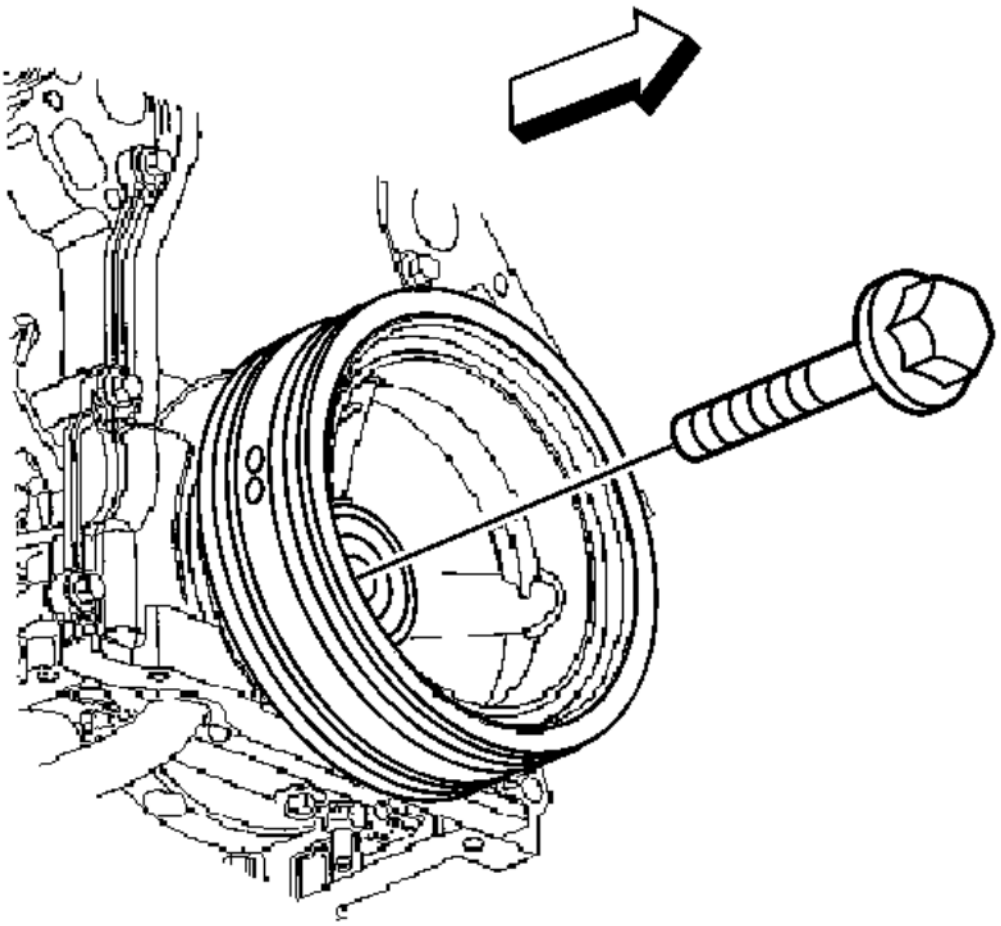

Fig. 135: Crankshaft Balancer And Retaining Bolt
Courtesy of GENERAL MOTORS CORP.

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

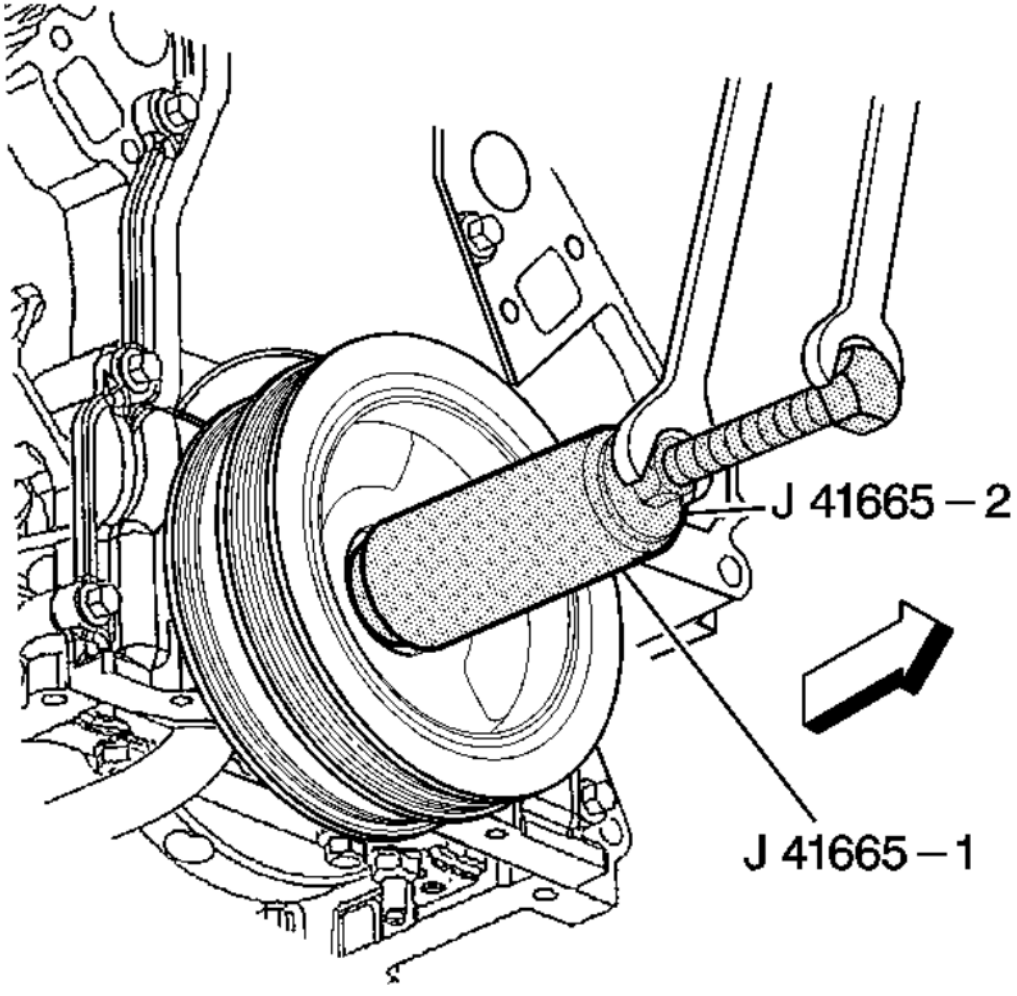

Fig. 136: Installing Balancer Using J 41665
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 41665** and **J 41478** for the following steps. See **Special Tools**.
    1. Assemble the **J 41478** threaded rod, nut, washer and **J 41665** installer. See **Special Tools**.

       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 tools.

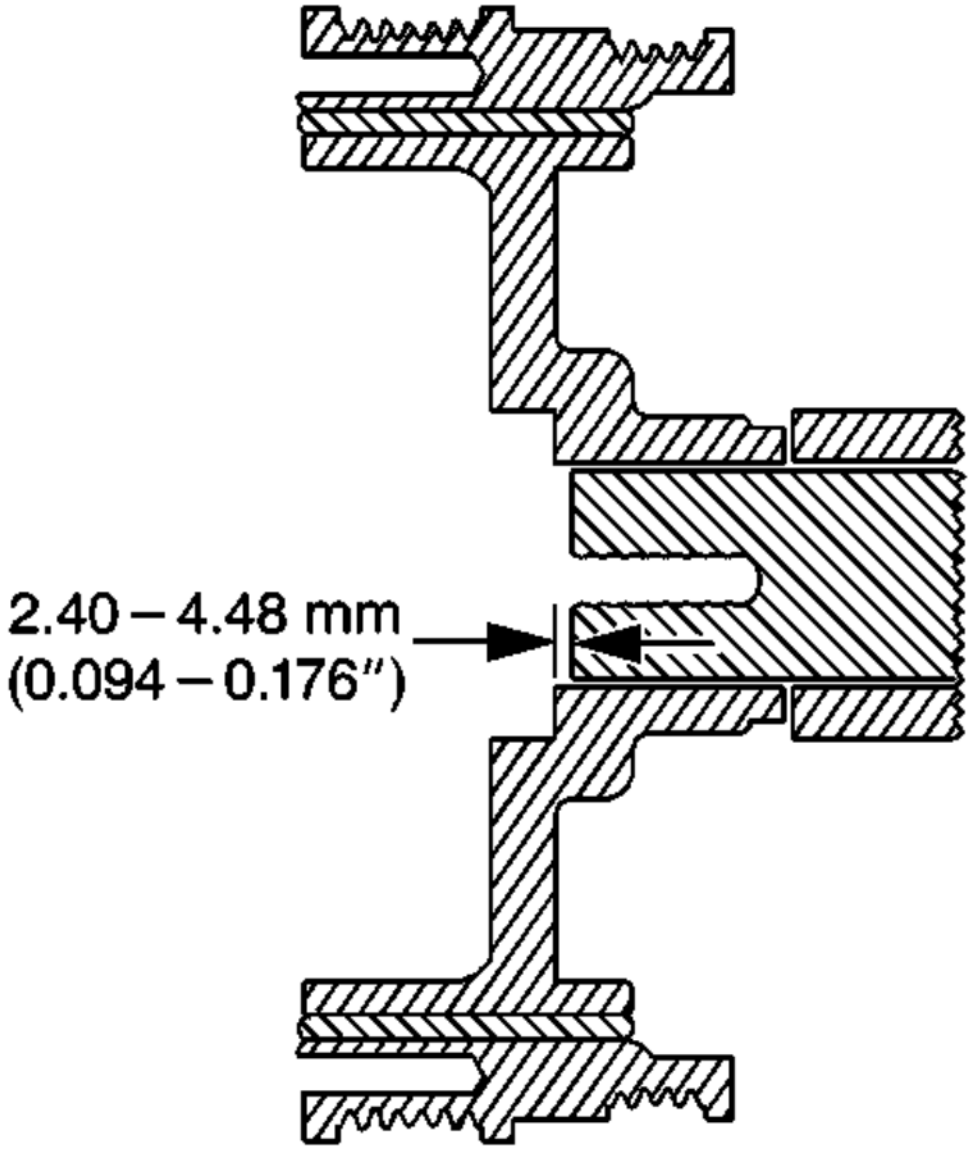

Fig. 137: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the used crankshaft balancer bolt.

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

4. Remove the used crankshaft balancer bolt.

IMPORTANT: The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.

5. Measure for a correctly installed balancer.

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

6. Install a NEW crankshaft balancer bolt.

   Tighten:

   1. Tighten the crankshaft balancer bolt a first pass to 50 N.m (37 lb ft).
   2. Tighten the crankshaft balancer bolt a second pass to 140 degrees using the **J 45059** . See **Special Tools**.

7. Remove the **J 42386-A** . See **Special Tools**.
8. Install the starter motor. Refer to **Starter Motor Replacement** .
9. Install the fan shroud. Refer to **Cooling Fan and Shroud Replacement** .
10. Install the accessory drive belt, if not equipped with A/C. Refer to **Drive Belt Replacement - Accessory**.
11. Install the A/C drive belt, if equipped. Refer to **Air Conditioning Compressor Belt Replacement**.
12. Perform the crankshaft position (CKP) system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

J 41478 Crankshaft Front Oil Seal Installer. See **Special Tools**.

Removal Procedure

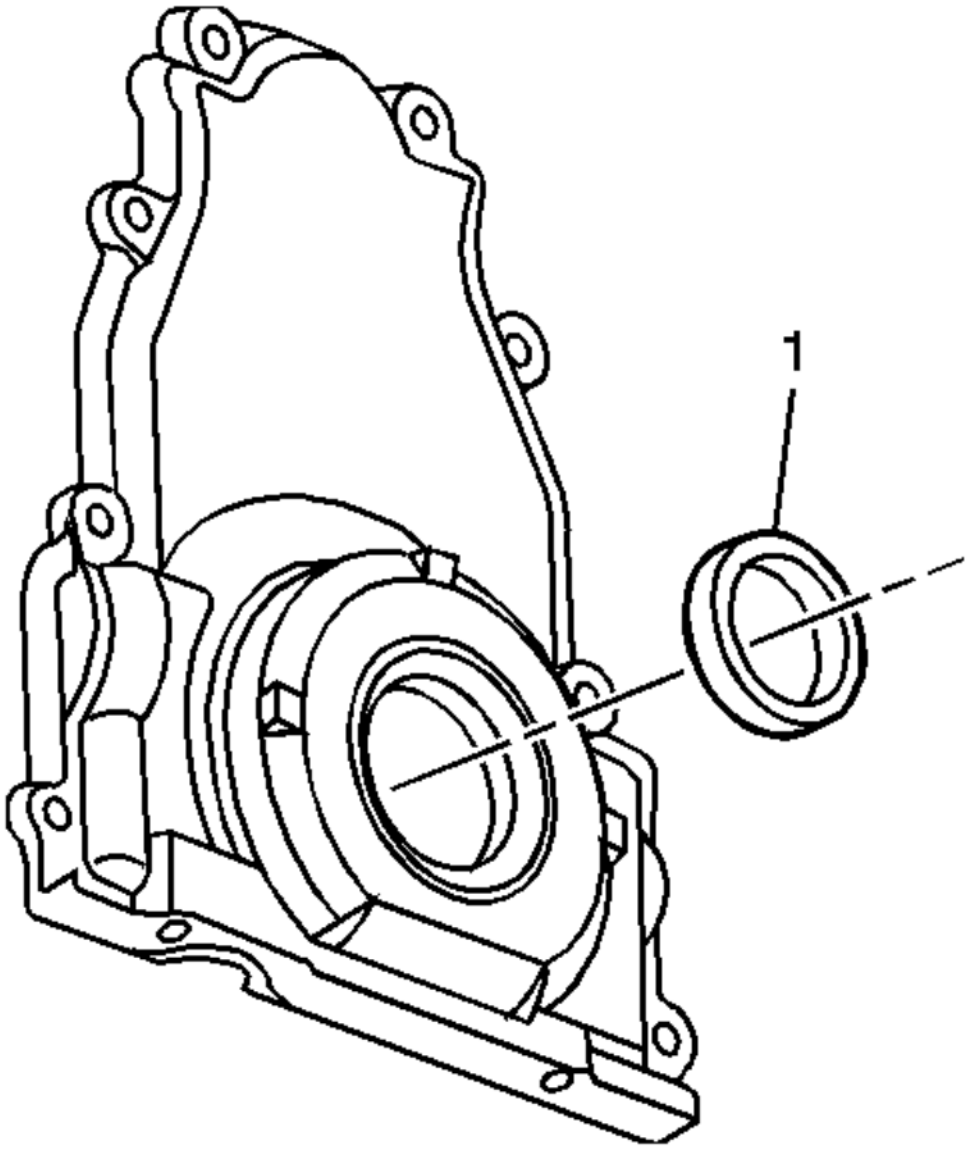

Fig. 138: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Remove the crankshaft oil seal (1) from the front cover.

Installation Procedure

IMPORTANT:

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

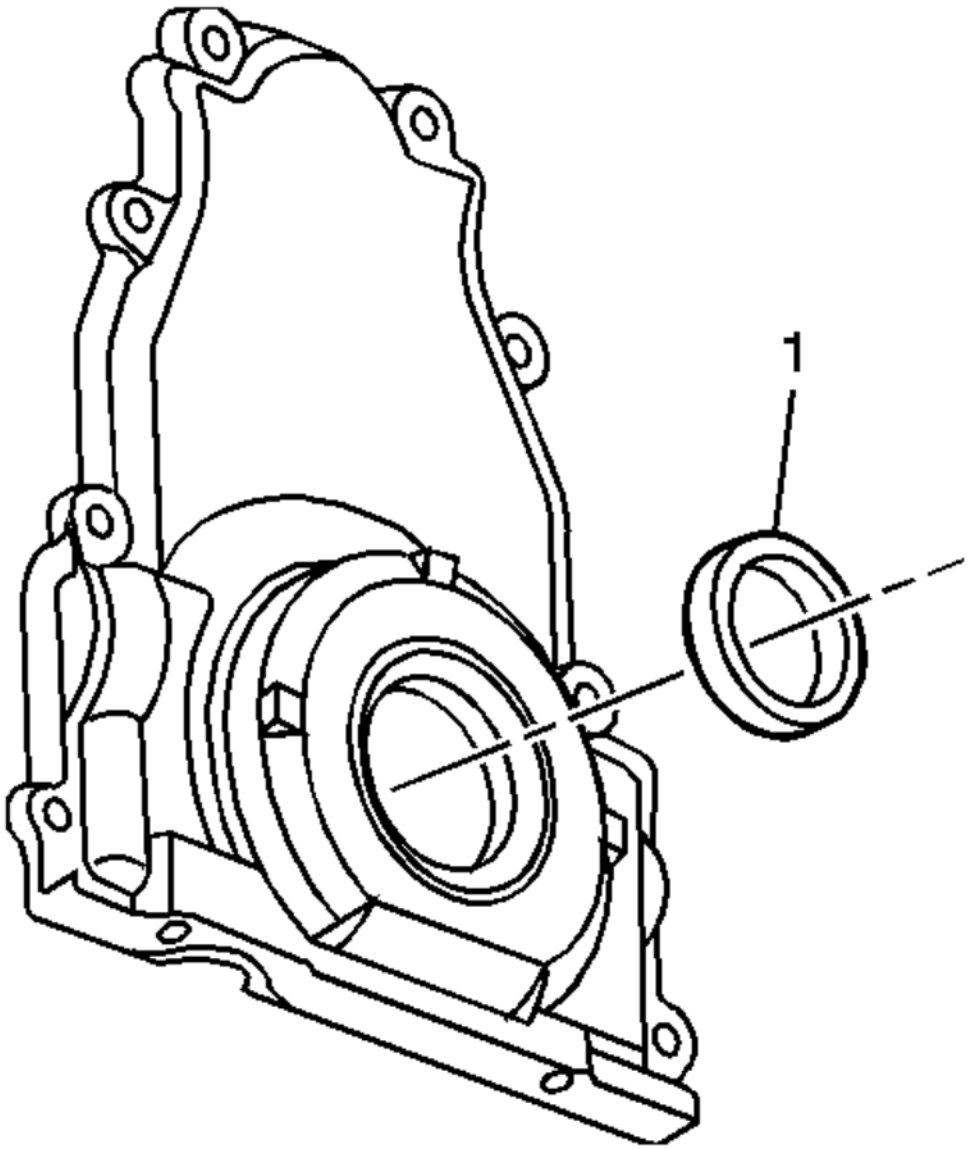

Fig. 139: View Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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.

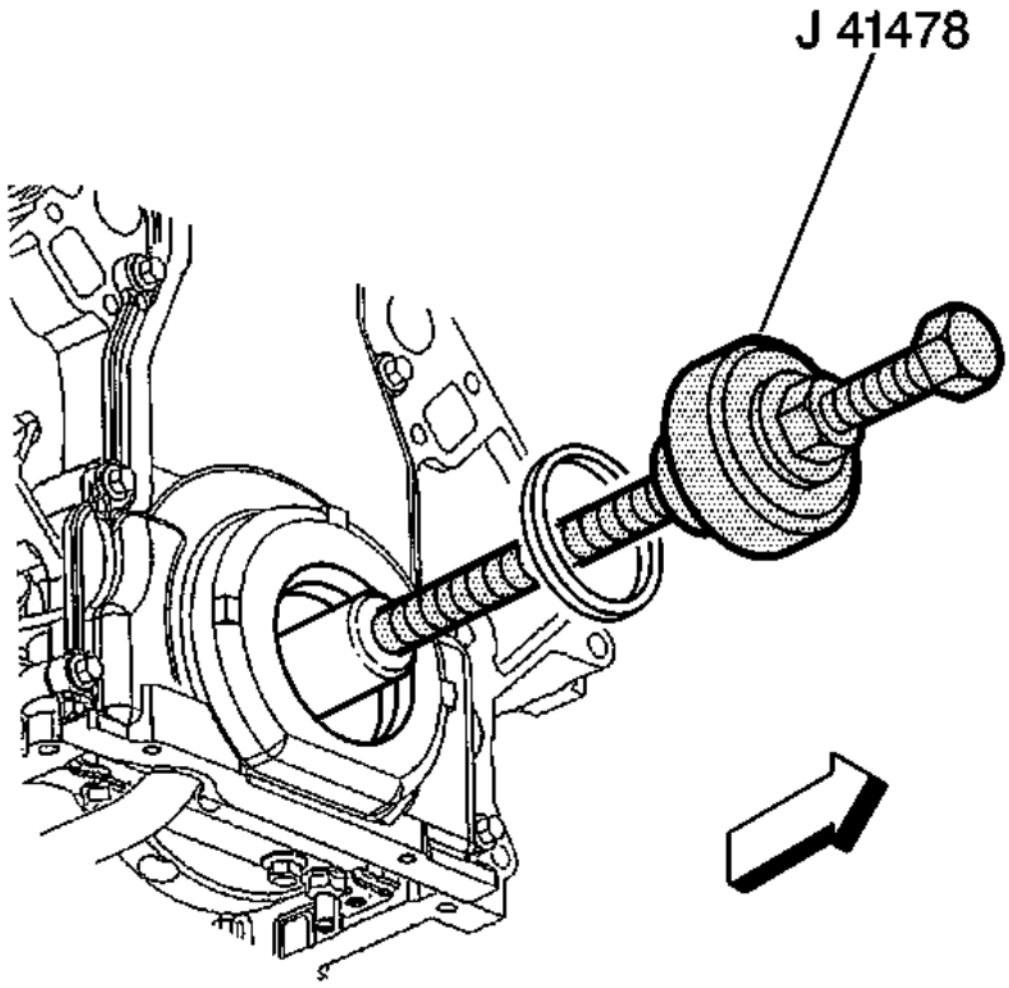

Fig. 140: Installing Crankshaft Front Oil Seal Using J 41478
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal onto the **J 41478** guide. See **Special Tools**.

4. Install the **J 41478** threaded rod (with nut, washer, guide, and oil seal) into the end of the crankshaft. See **Special Tools**.
5. Use the **J 41478** in order to install the oil seal into the cover bore. See **Special Tools**.
    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 the **J 41478** . See **Special Tools**.
    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**.

CAMSHAFT POSITION ACTUATOR MAGNET REPLACEMENT

Removal Procedure

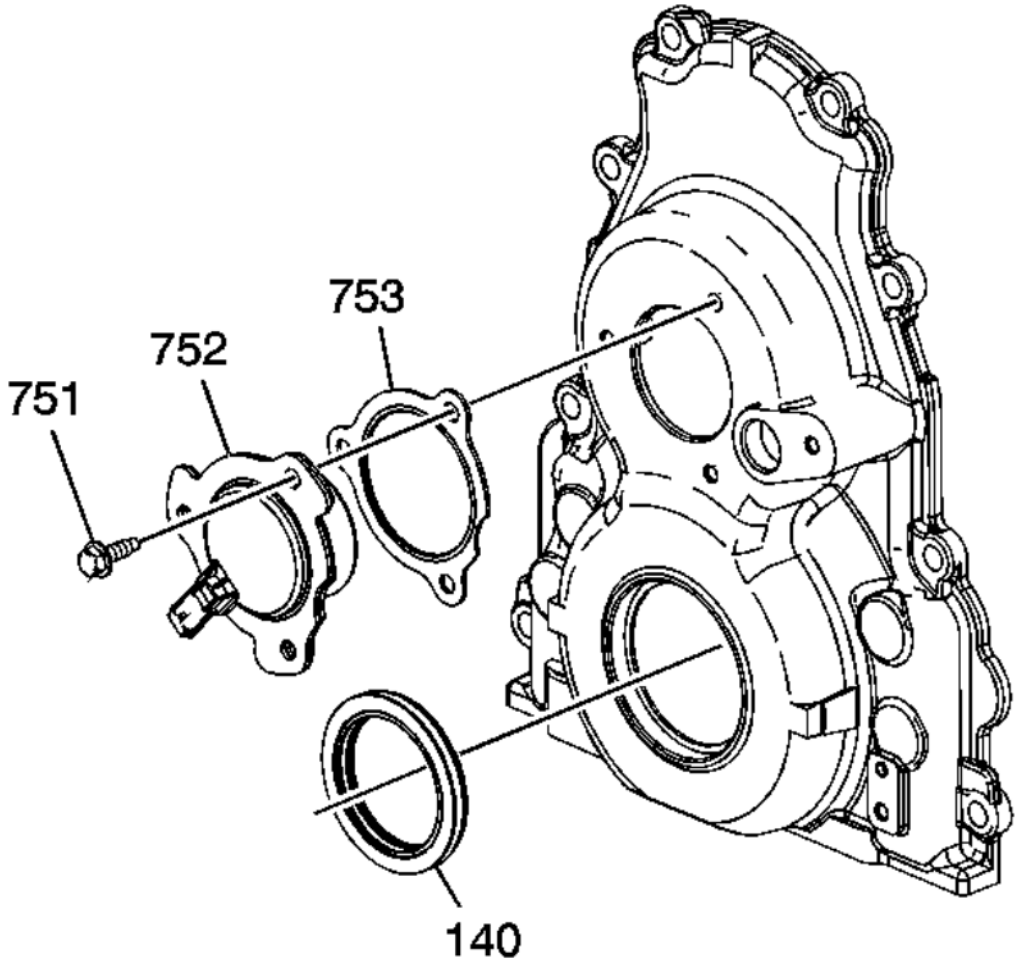

Fig. 141: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement** .
2. Disconnect the engine harness electrical connector from the camshaft position (CMP) actuator magnet.
3. Remove the CMP actuator magnet bolts (751) and magnet (752).
4. Remove and discard the CMP actuator magnet gasket (753).

Installation Procedure

IMPORTANT: The gasket surface should be free of oil or other foreign material during assembly.

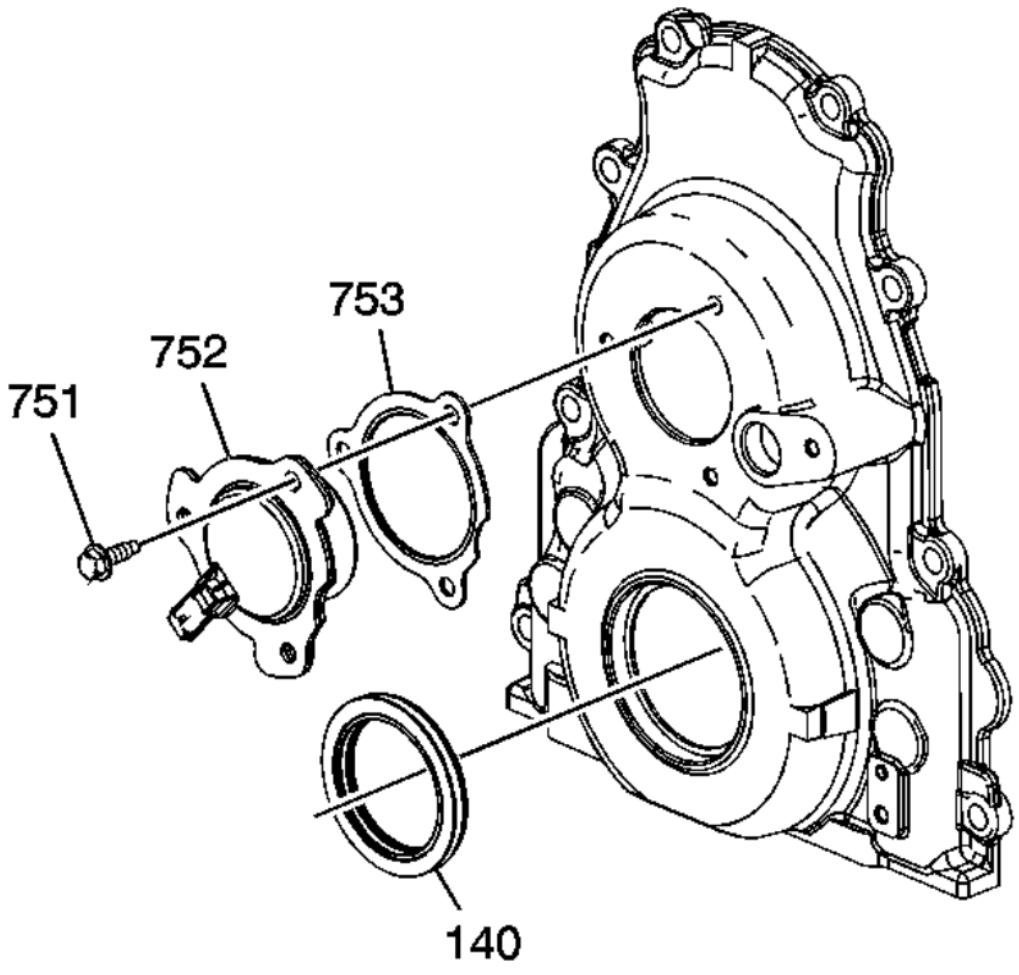

Fig. 142: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW CMP actuator magnet gasket (753) onto the CMP actuator magnet.
2. Install the CMP actuator magnet (752) to the front cover.

NOTE: Refer to Fastener Notice .

3. Install the CMP actuator magnet bolts (751).

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

4. Connect the engine harness electrical connector to the CMP actuator magnet.
5. Install the water pump. Refer to **Water Pump Replacement** .

ENGINE FRONT COVER REPLACEMENT

Special Tools

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

Removal Procedure

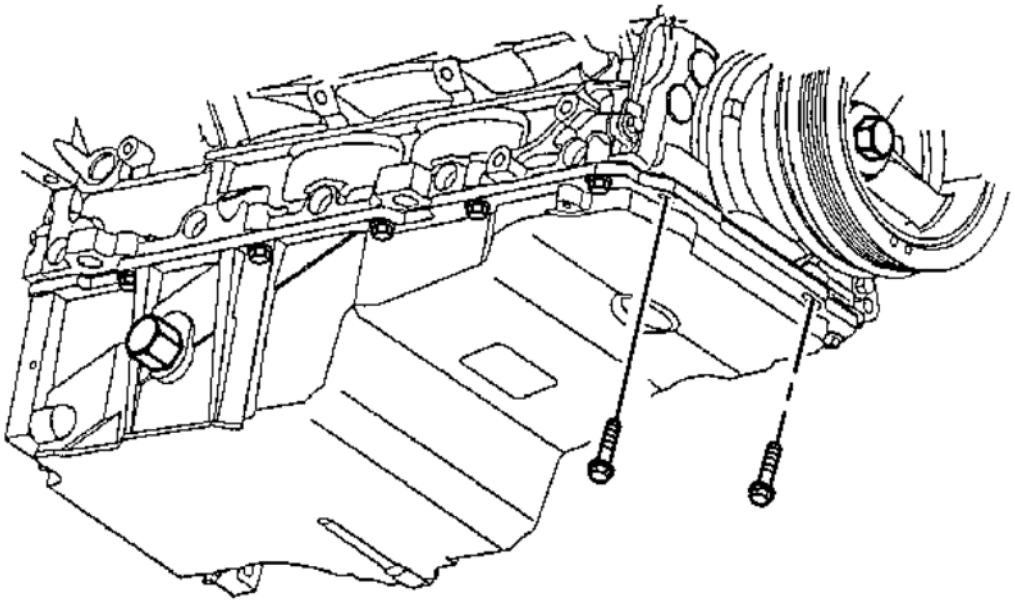

Fig. 143: View Of Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement** .
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

3. Remove the oil pan-to-front cover bolts.

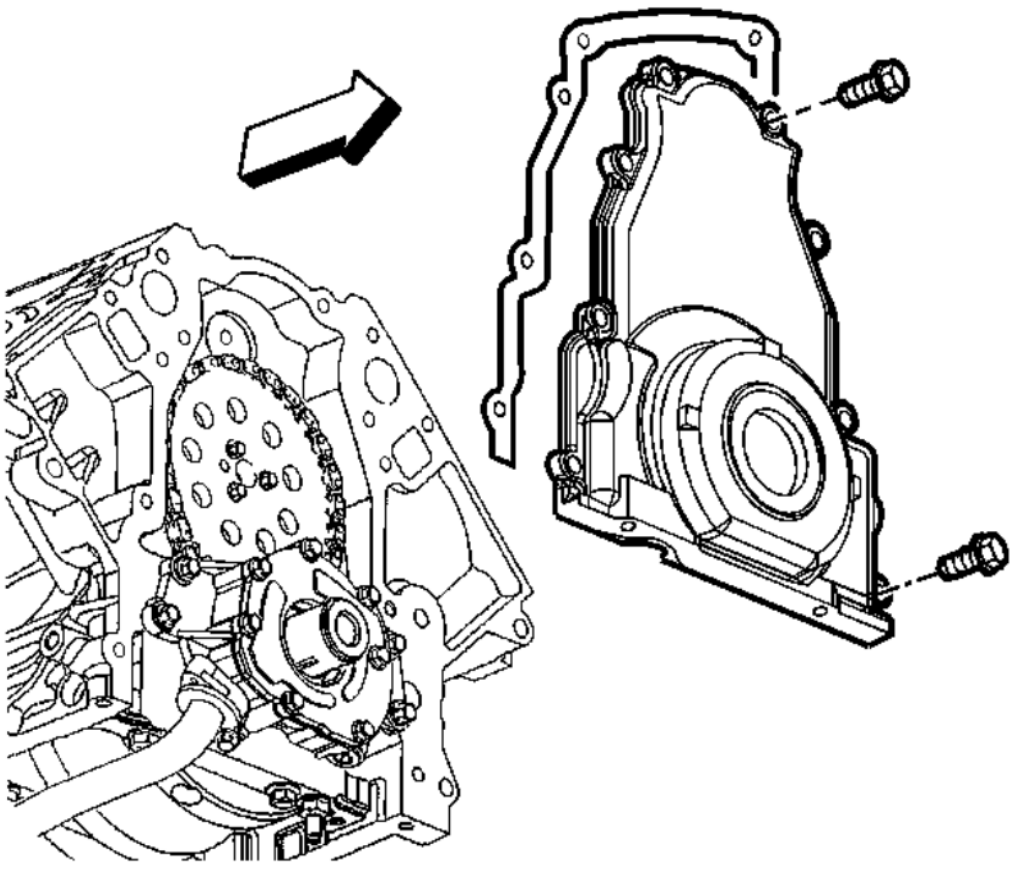

Fig. 144: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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.**
  - **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.**

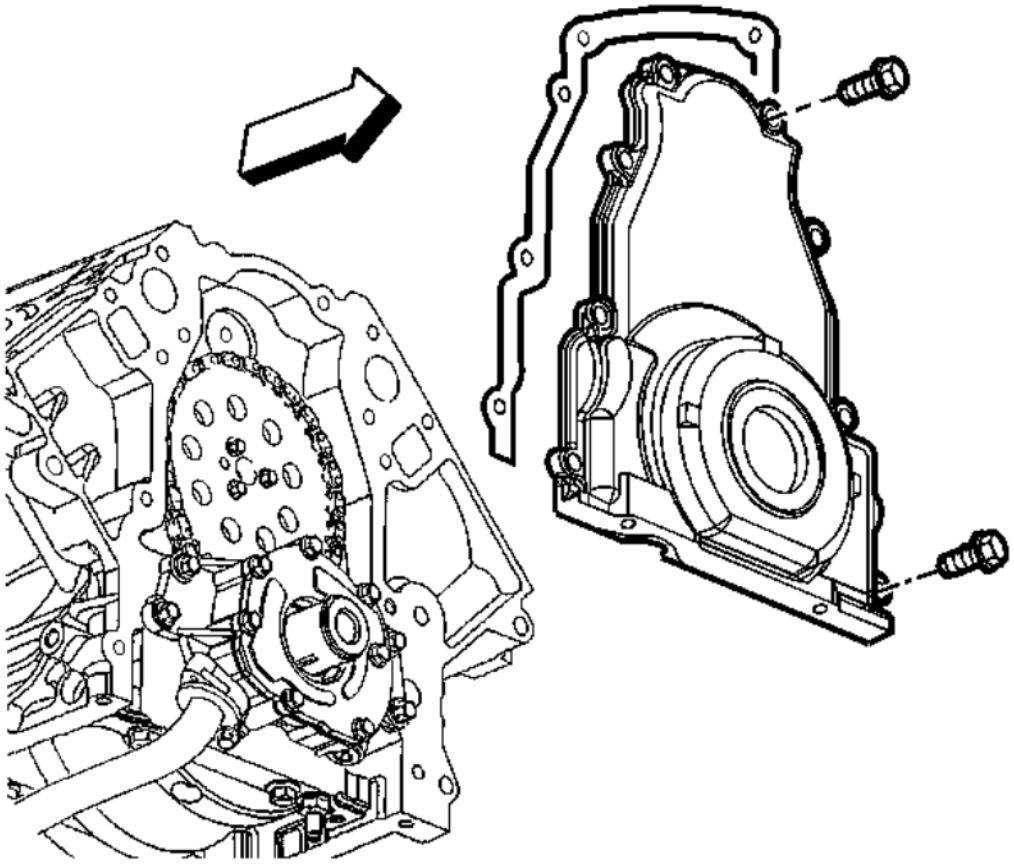

Fig. 145: View Of Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant 20 mm (0.80 in) long to the oil pan to engine block junction. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
2. Install the front cover gasket and cover.
3. Install the front cover bolts until snug. Do not overtighten.

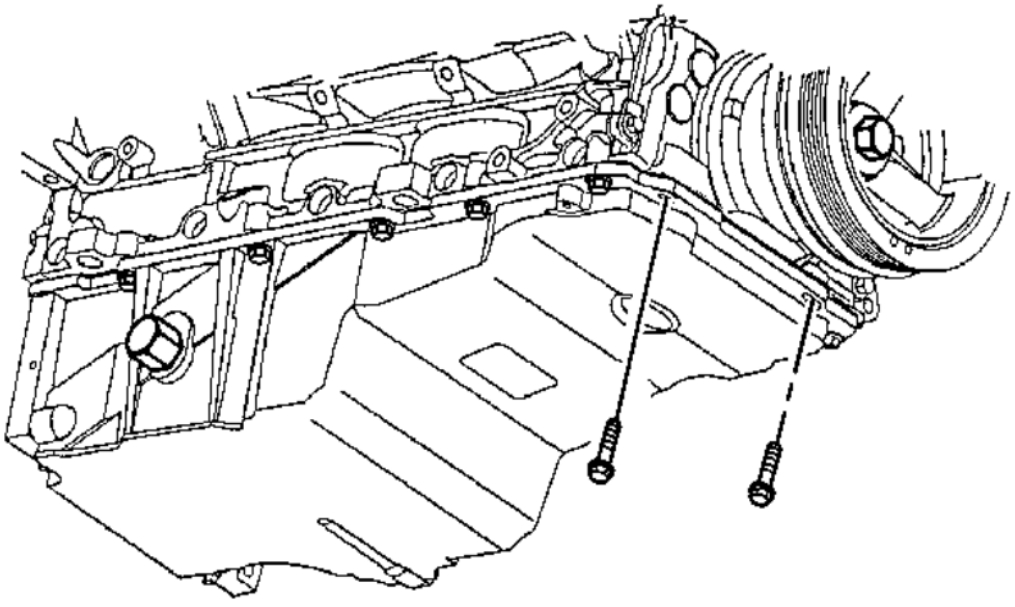

Fig. 146: View Of Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan-to-front cover bolts until snug. Do not over tighten.

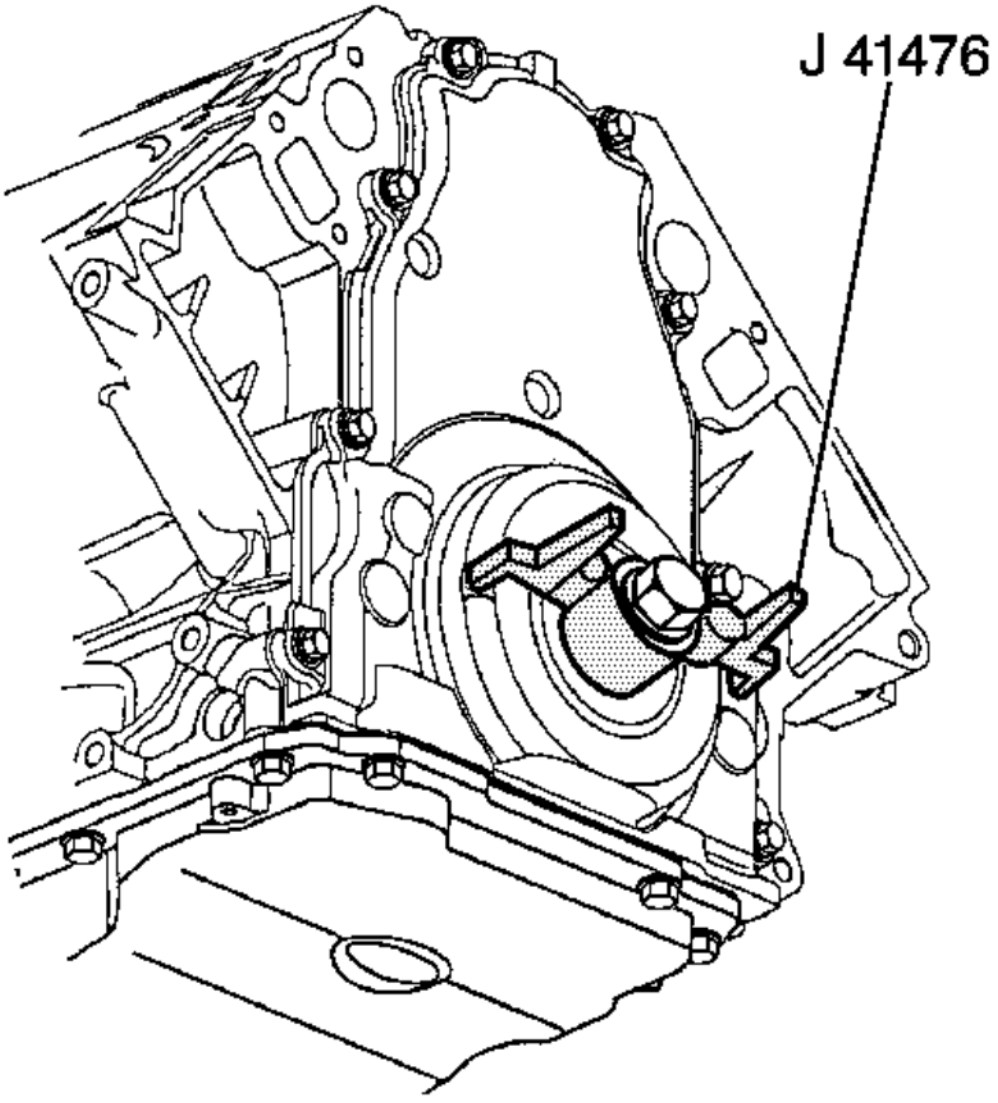

Fig. 147: View of J 41476 Installed To Front Cover
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to **Fastener Notice** .

7. Install the crankshaft balancer bolt until snug. Do not overtighten.

   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 the **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** .

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REPLACEMENT

Tools Required

J 45059 Angle Meter. See **Special Tools**.

Removal Procedure

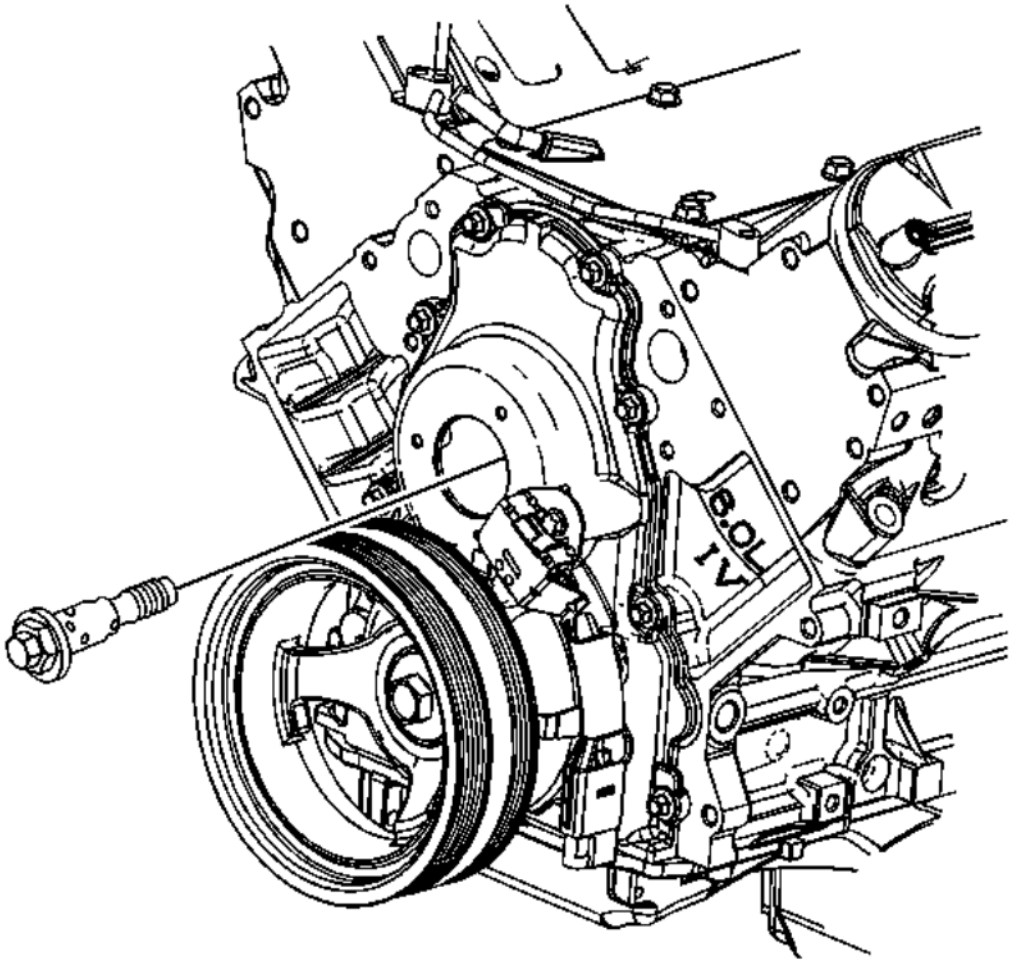

Fig. 148: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft position (CMP) actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.
2. Remove and discard the CMP actuator solenoid valve.

Installation Procedure

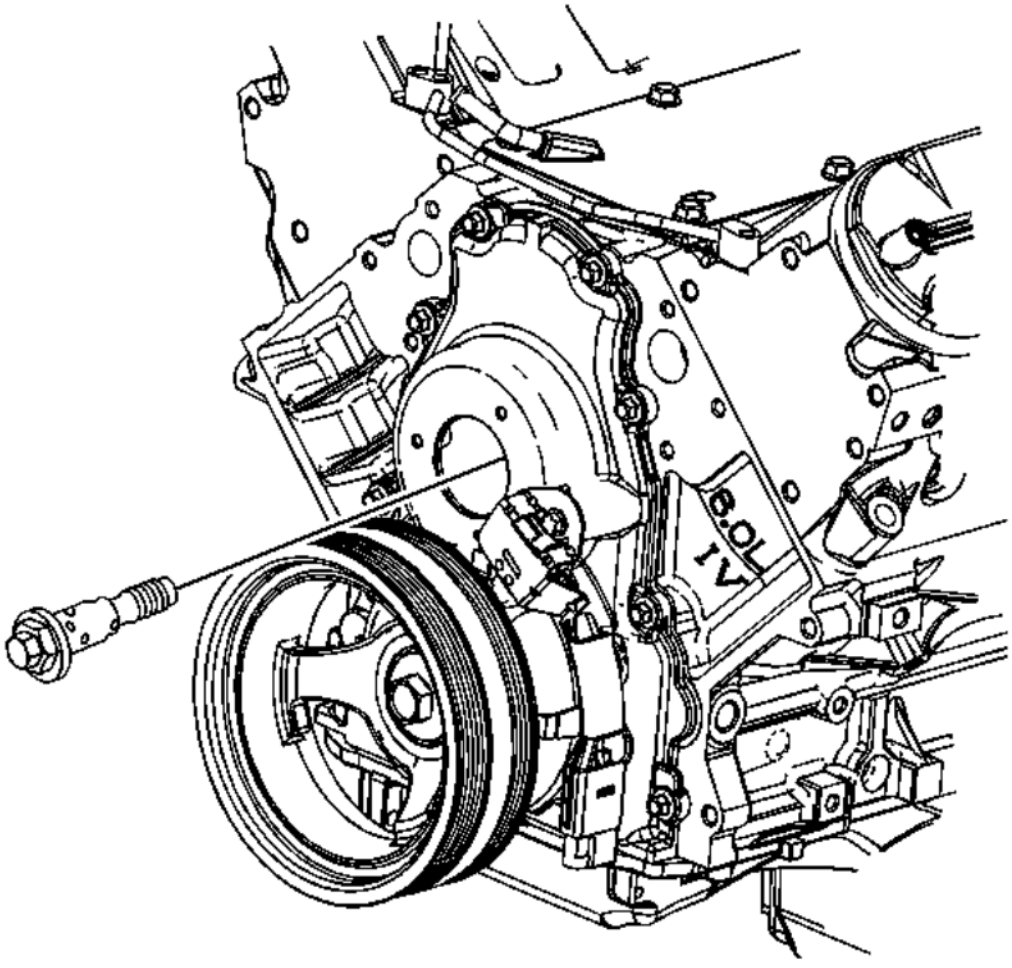

Fig. 149: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Install the a NEW CMP actuator solenoid valve until snug.

   With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.

   NOTE: Refer to Fastener Notice .

2. Tighten the CMP actuator solenoid valve.

   Tighten:

   1. Tighten the solenoid valve a first pass to 65 N.m (48 lb ft).
   2. Tighten the solenoid valve a final pass and additional 90 degrees using **J 45059** . See **Special Tools**.

3. Install the CMP actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.

CAMSHAFT POSITION ACTUATOR REPLACEMENT

Tools Required

- **EN 46330** Timing Belt Tensioner Retaining Pin. See **Special Tools**.
- **J 45059** Angle Meter. See **Special Tools**.

Removal Procedure

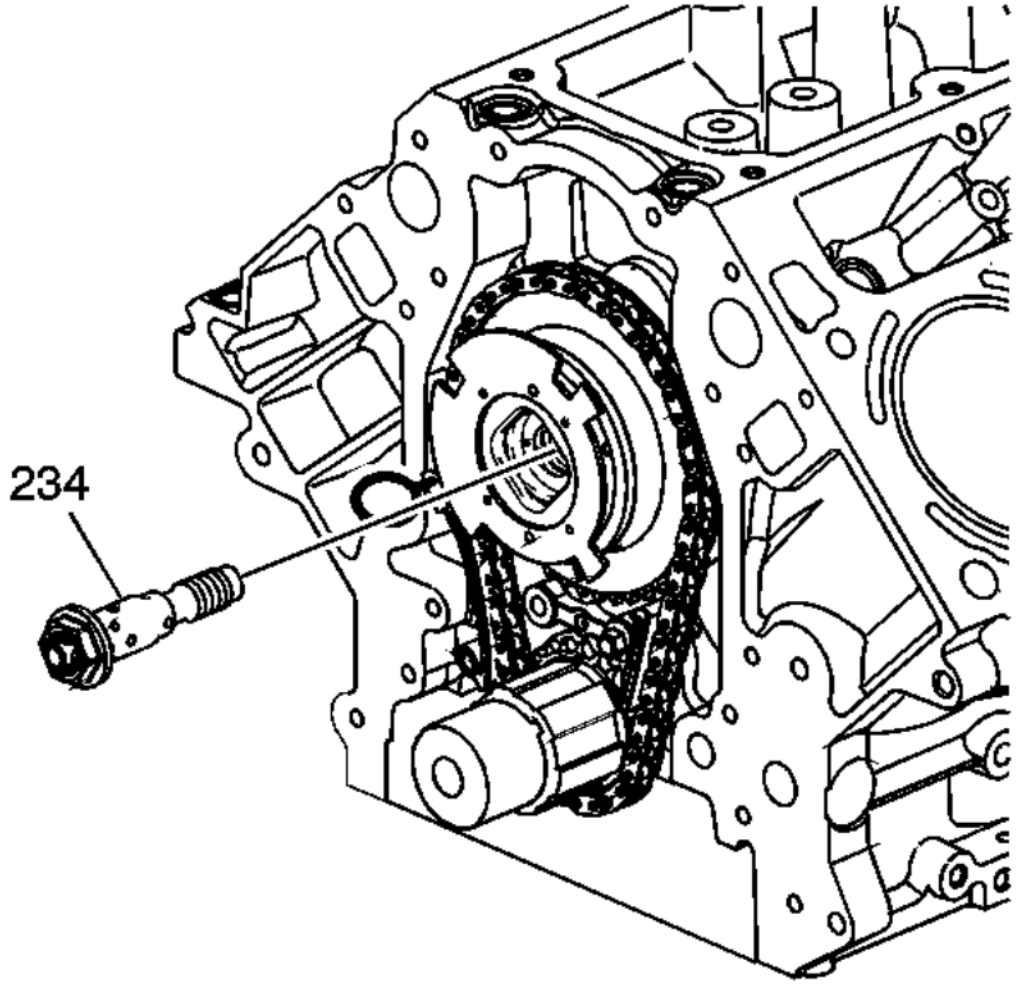

Fig. 150: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump, Screen, and Crankshaft Oil Deflector Replacement**.
2. Remove and discard the camshaft position (CMP) actuator solenoid valve (234).

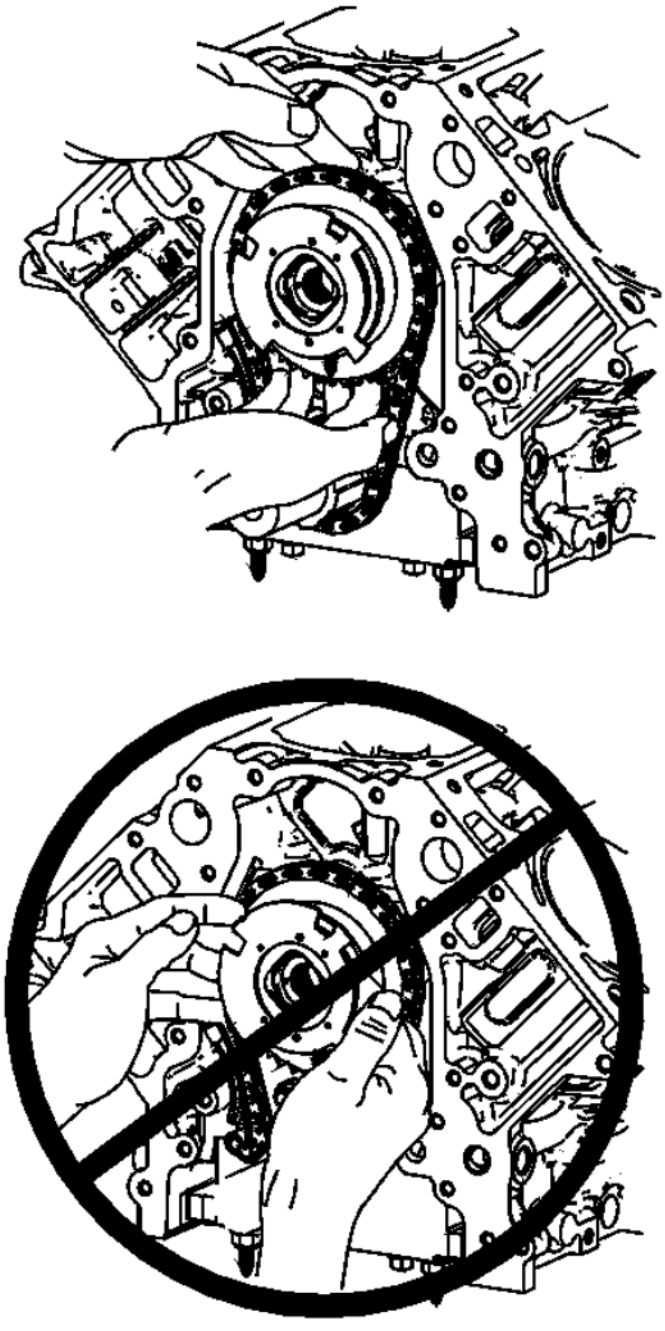

Fig. 151: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not push or pull on the reluctor wheel of the camshaft position (CMP) actuator during removal or installation. The reluctor wheel is retained to the front of the CMP actuator by 3 roll pins. Pushing or pulling on the wheel may dislodge the wheel from the front of the actuator. The actuator return spring is under tension and may rotate the dislodged reluctor wheel, causing personal injury.

3. Loosen and separate the CMP actuator and timing chain from the camshaft. Position your fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

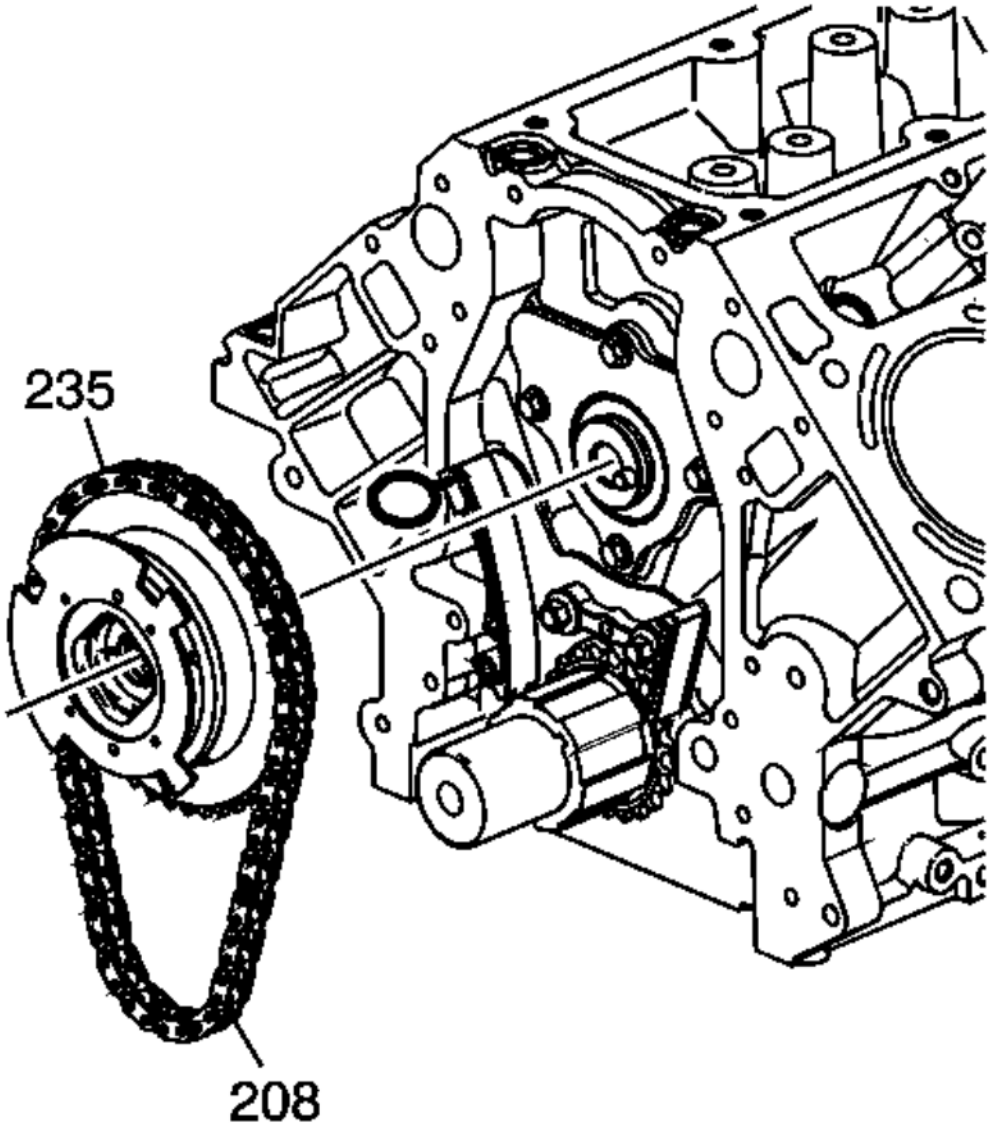

Fig. 152: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Remove the CMP actuator (235) and timing chain (208).

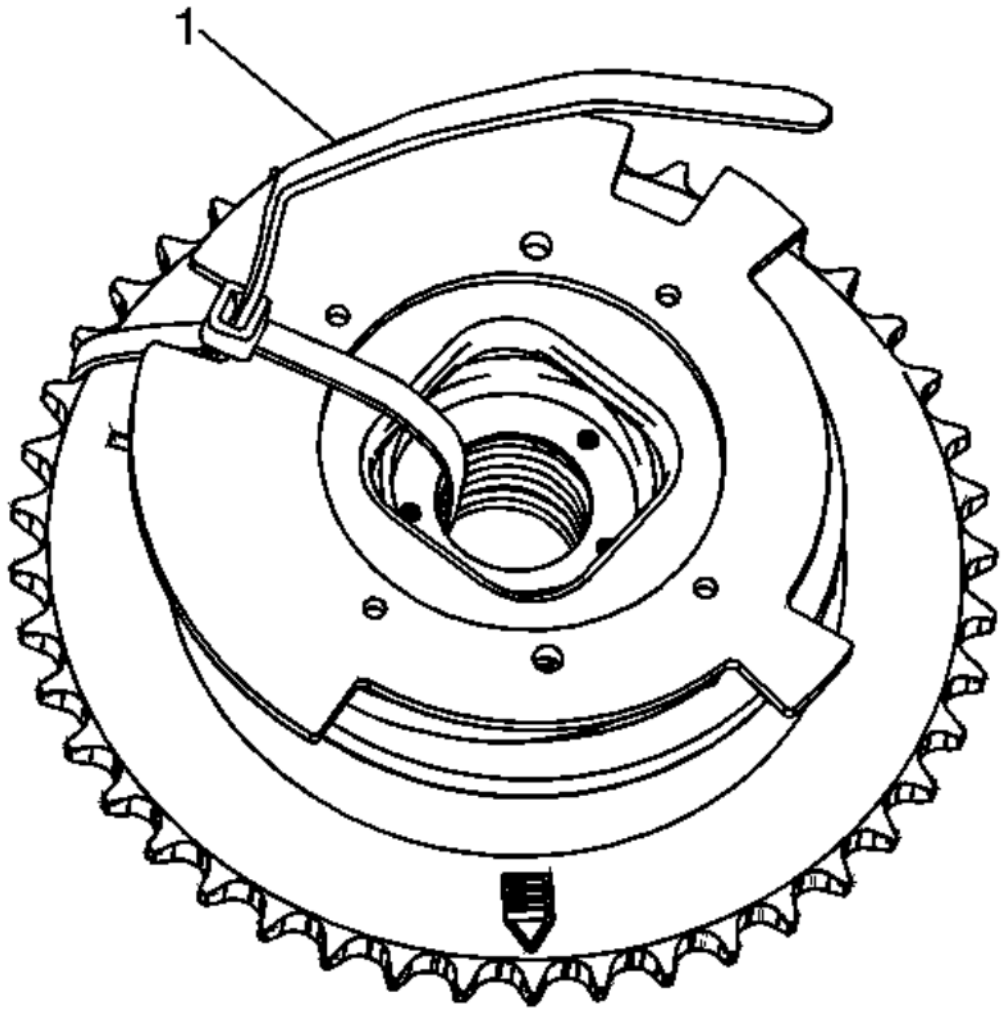

Fig. 153: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

5. Insert and secure a tie strap (1) through the center of the actuator and over the reluctor wheel.

Installation Procedure

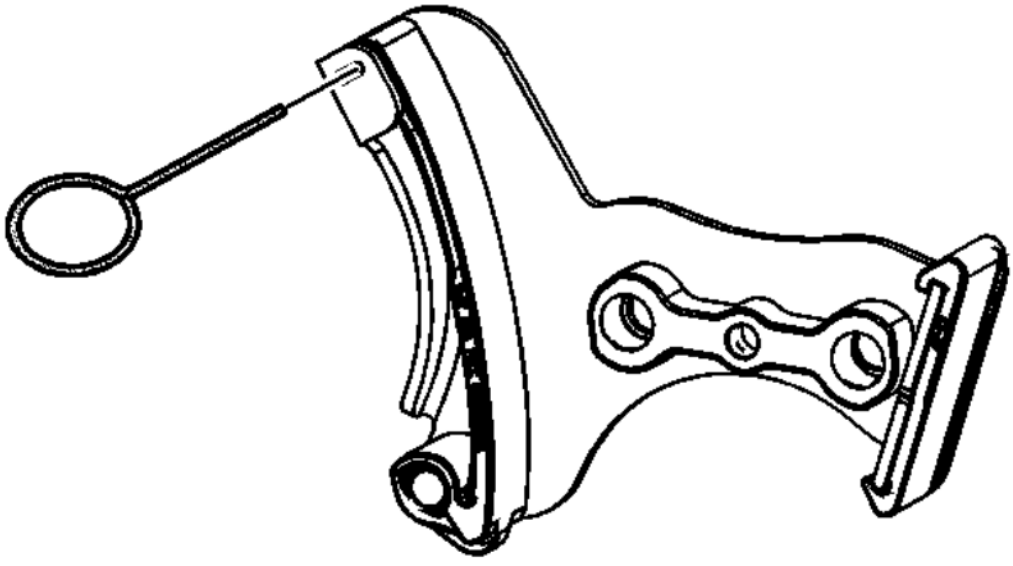

Fig. 154: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Compress the timing chain tensioner guide and install the **EN 46330** . See **Special Tools**.

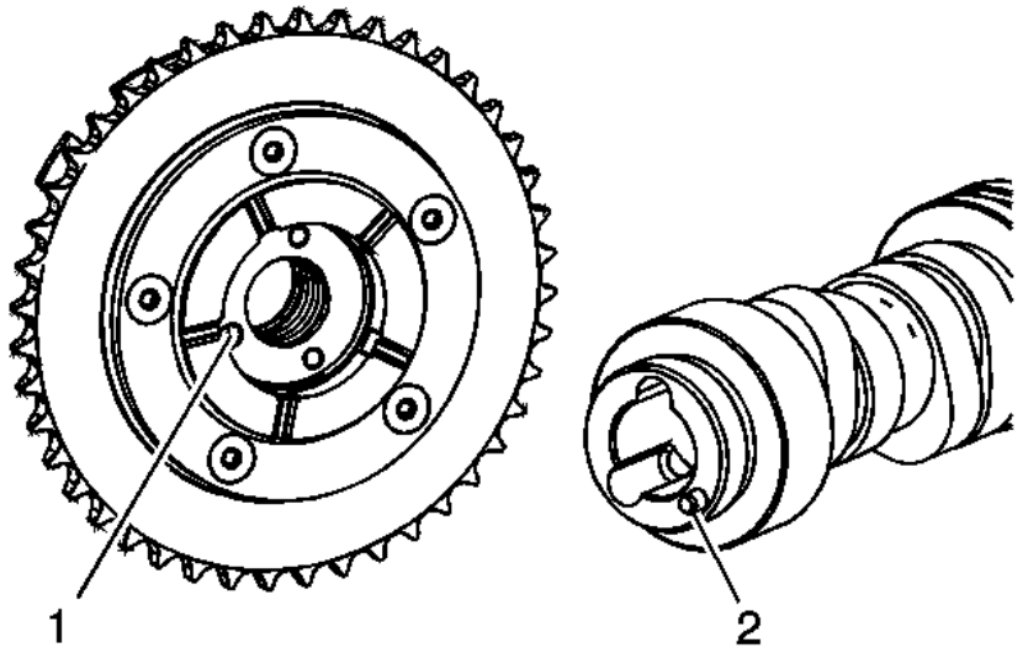

Fig. 155: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Properly locate the CMP actuator on 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.**
- **DO NOT use the CMP solenoid valve again. Install a NEW valve during assembly.**

2. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

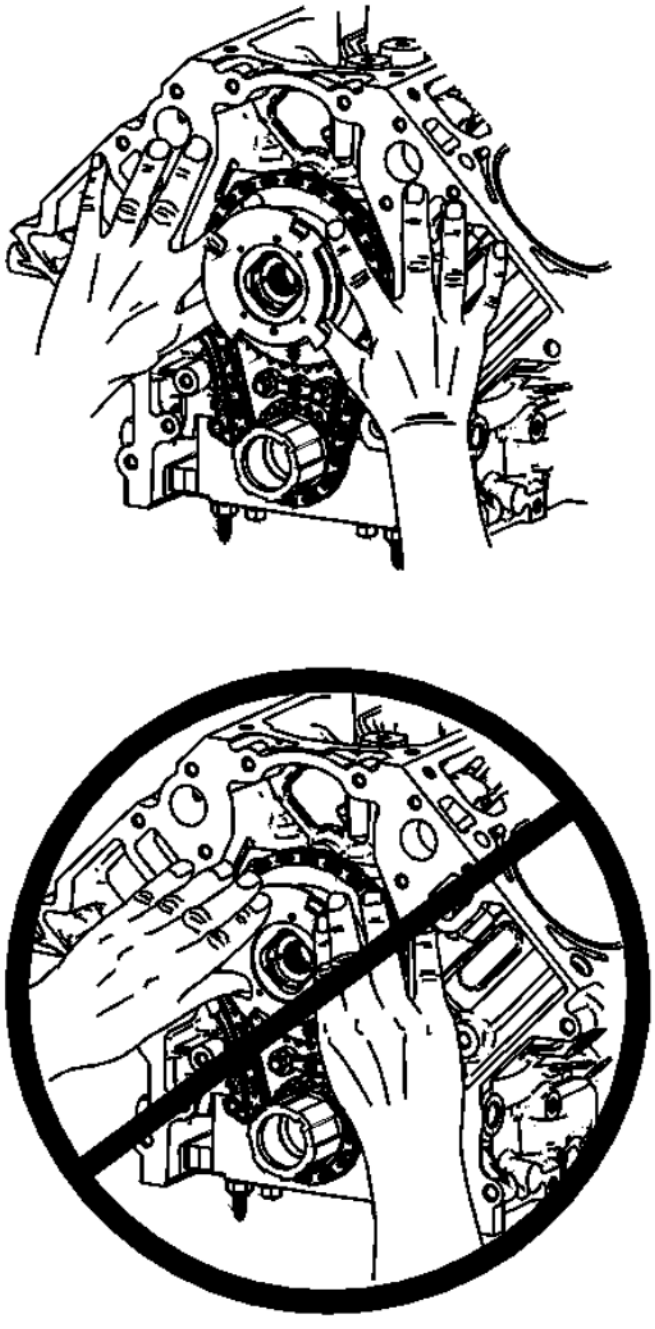

Fig. 156: Proper Installation Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not push or pull on the reluctor wheel of the camshaft position (CMP) actuator during removal or installation. The reluctor wheel is retained to the front of the CMP actuator by 3 roll pins. Pushing or pulling on the wheel may dislodge the wheel from the front of the actuator. The actuator return spring is under tension and may rotate the dislodged reluctor wheel, causing personal injury.

3. Install the CMP actuator and timing chain. Align the hole in the rear face of the CMP actuator with the locating pin on the front face of the camshaft. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks. Use care to install the actuator completely onto the front of the camshaft. Position your fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

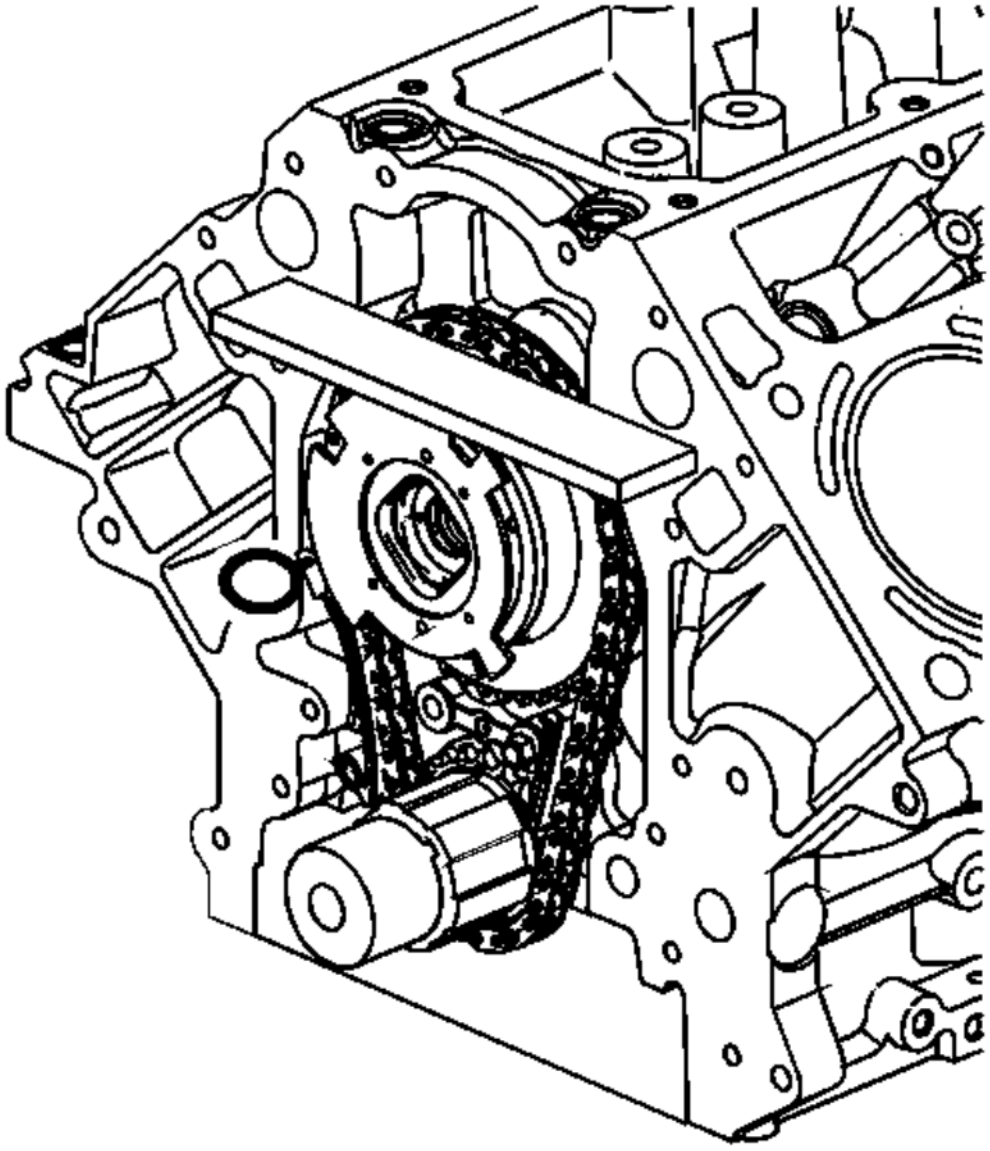

Fig. 157: Inspecting For Proper Installation Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

4. Place a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of the camshaft, the timing chain will not protrude

beyond the front face of the engine block.

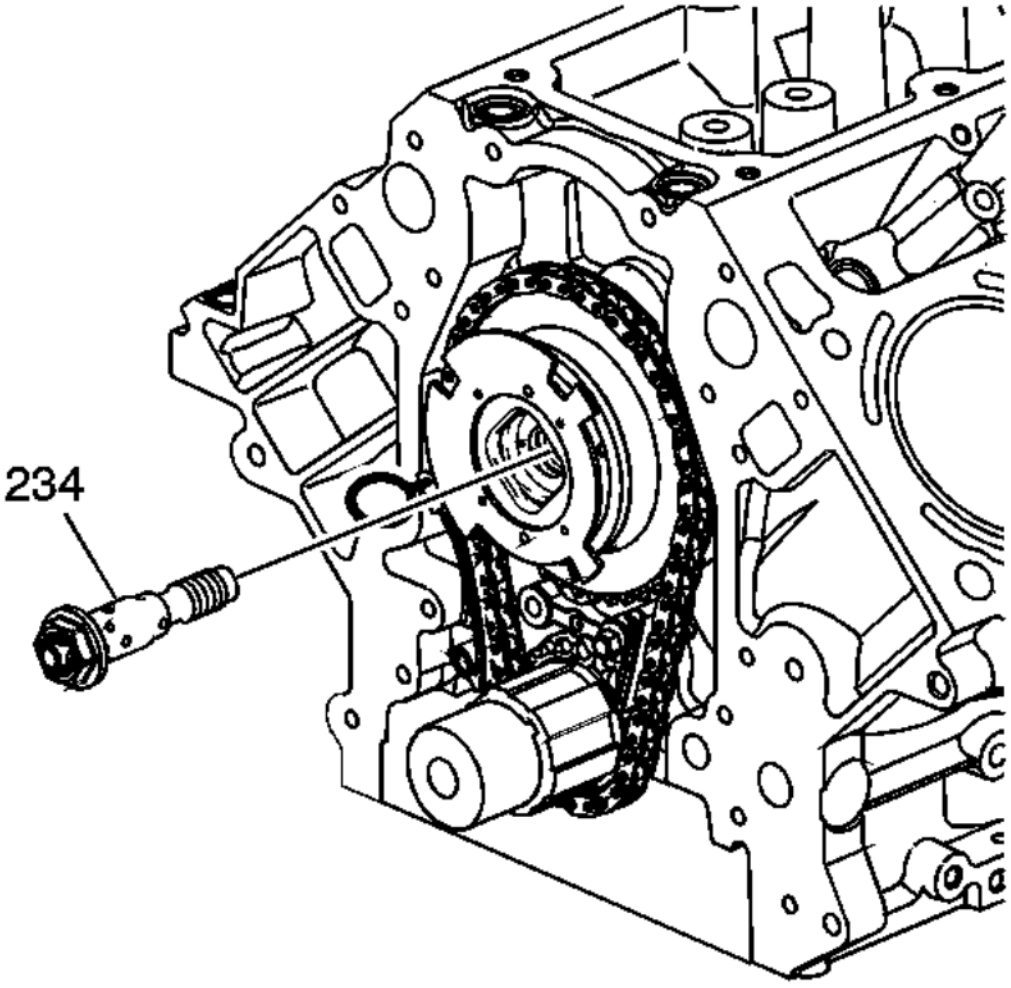

Fig. 158: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

5. Install a NEW CMP actuator solenoid valve (234). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.

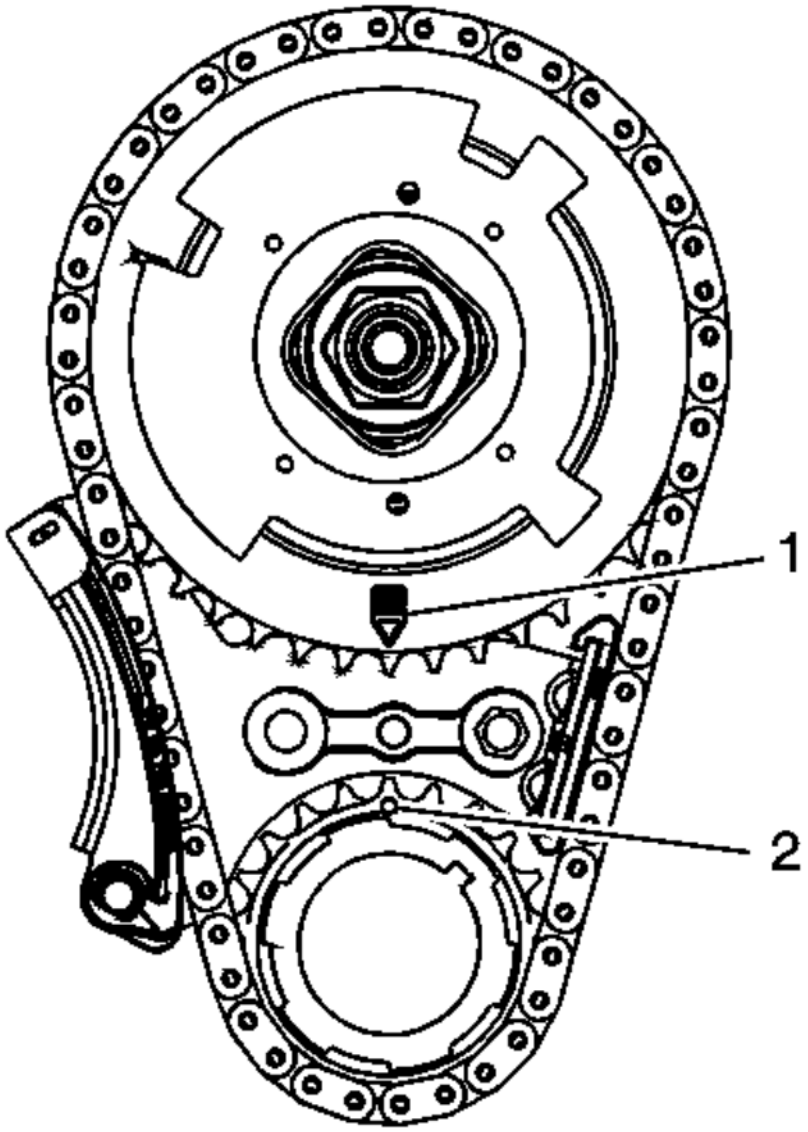

Fig. 159: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS CORP.

6. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft sprocket (2)

should be located in the 12 o'clock position.

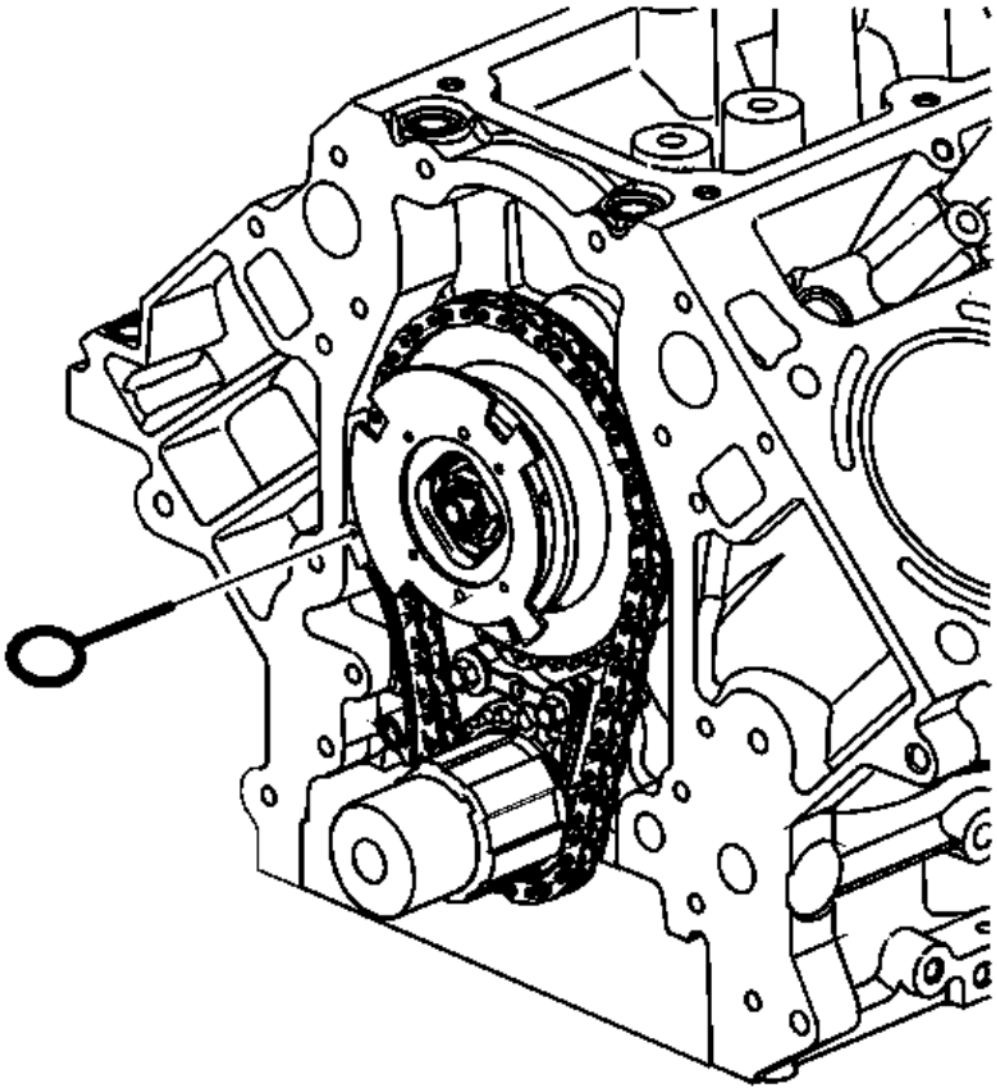

Fig. 160: View Of Special Tool EN 46330
Courtesy of GENERAL MOTORS CORP.

7. Remove the **EN 46330** . See **Special Tools**.

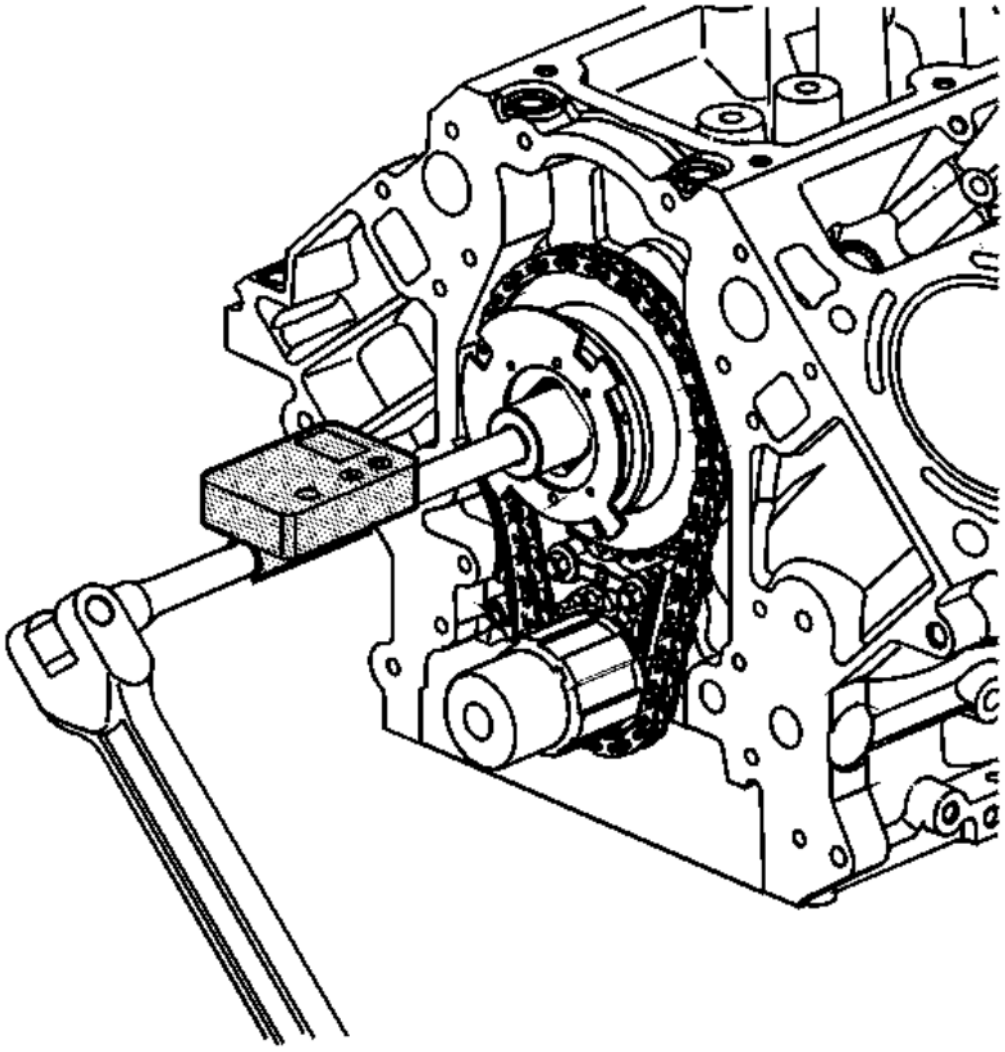

Fig. 161: Tightening The CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

8. Tighten the CMP actuator solenoid valve.

Tighten:

1. Tighten the valve a first pass to 65 N.m (48 lb ft).

2. Tighten the valve a final pass and additional 90 degrees using **J 45059** . See **Special Tools**.

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

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

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

Removal Procedure

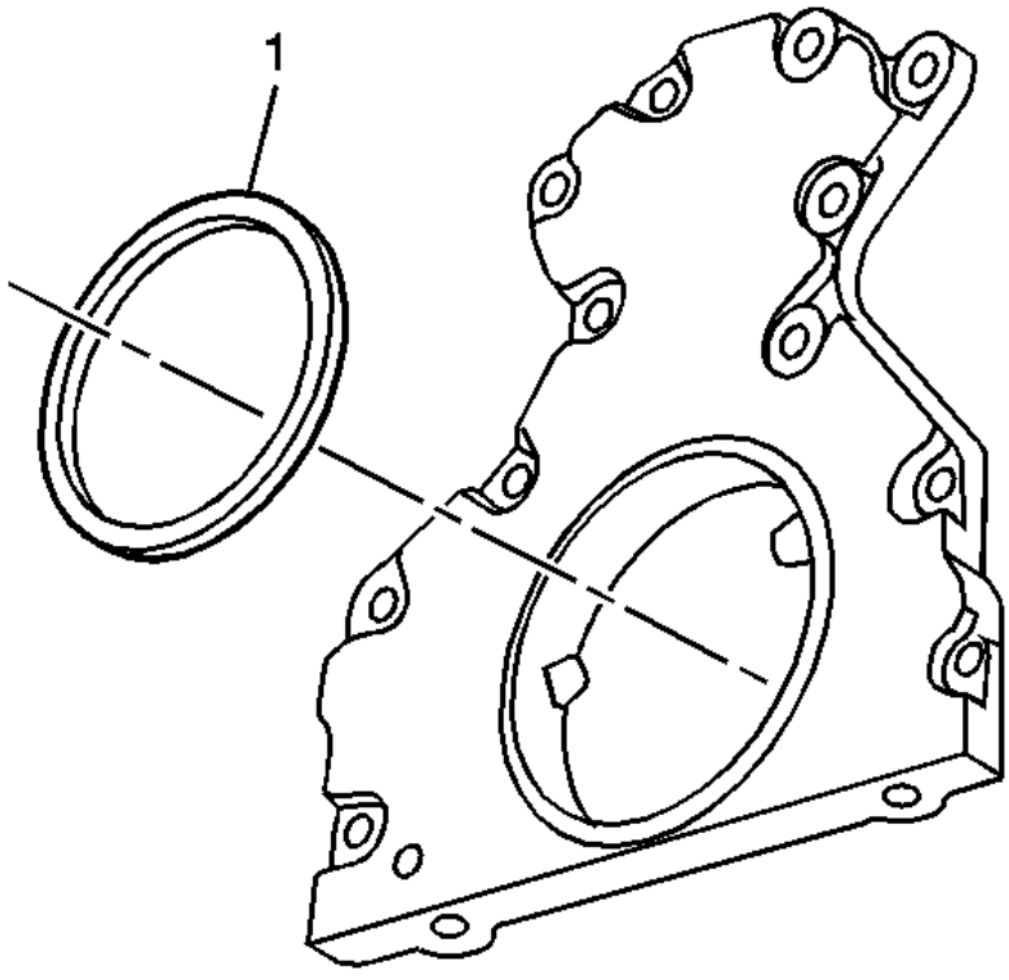

Fig. 162: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Automatic Transmission Flex Plate Replacement**.
2. Remove the crankshaft rear oil seal (1) from the rear cover.

Installation Procedure

IMPORTANT:

- **The flywheel spacer (if applicable) must be removed prior to oil seal installation.**

- **Do not lubricate the oil seal inside diameter (ID) or the crankshaft surface.**
- **Do not reuse the crankshaft rear oil seal.**

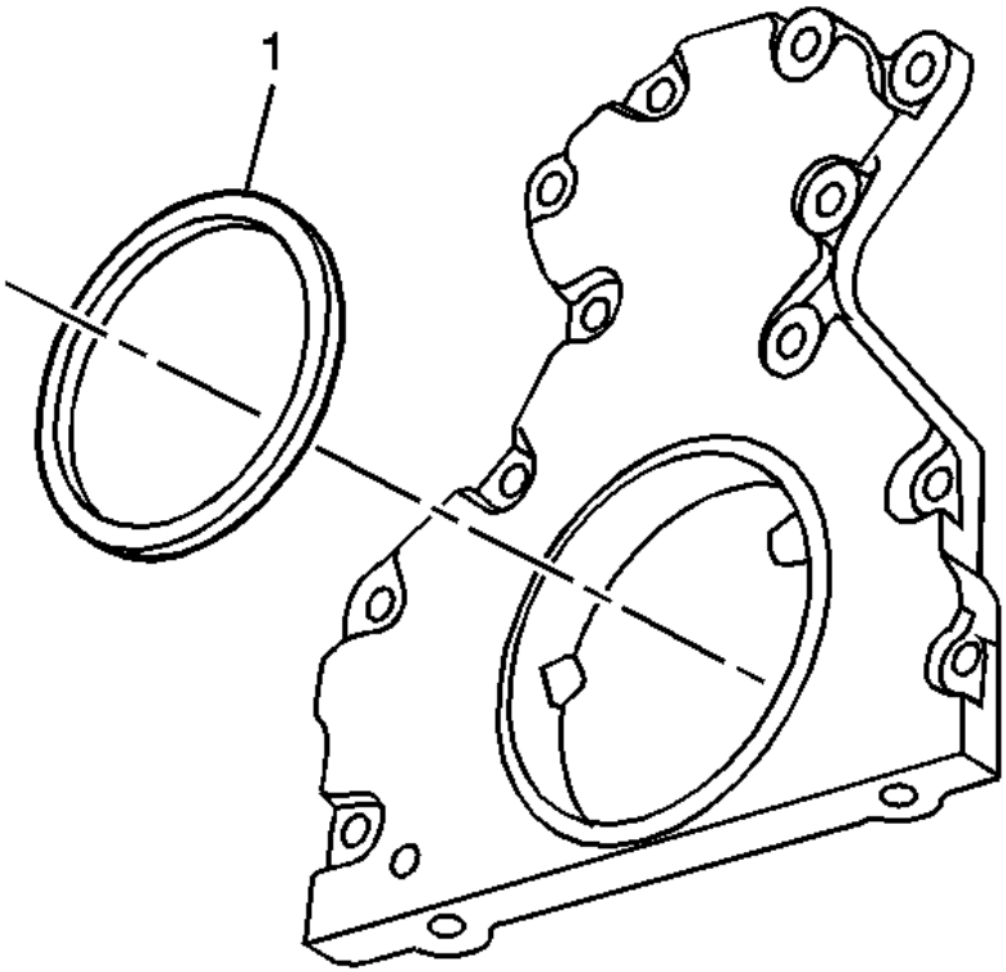

Fig. 163: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outside diameter (OD) 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.

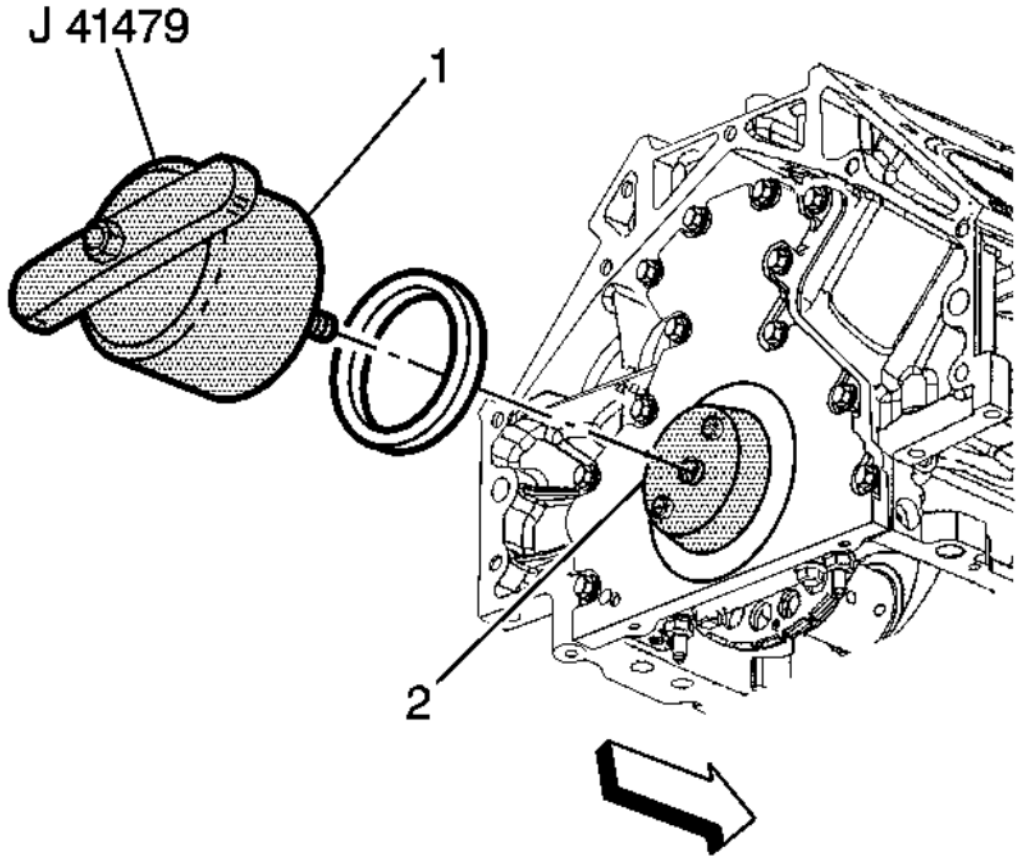

Fig. 164: Installing Crankshaft Rear Oil Seal Using J 41479
Courtesy of GENERAL MOTORS CORP.

3. Install the **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 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 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 the **J 41479** . See **Special Tools**.
10. Install the engine flywheel. Refer to **Automatic Transmission Flex Plate Replacement**.

ENGINE REAR COVER REPLACEMENT

Tools Required

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

Removal Procedure

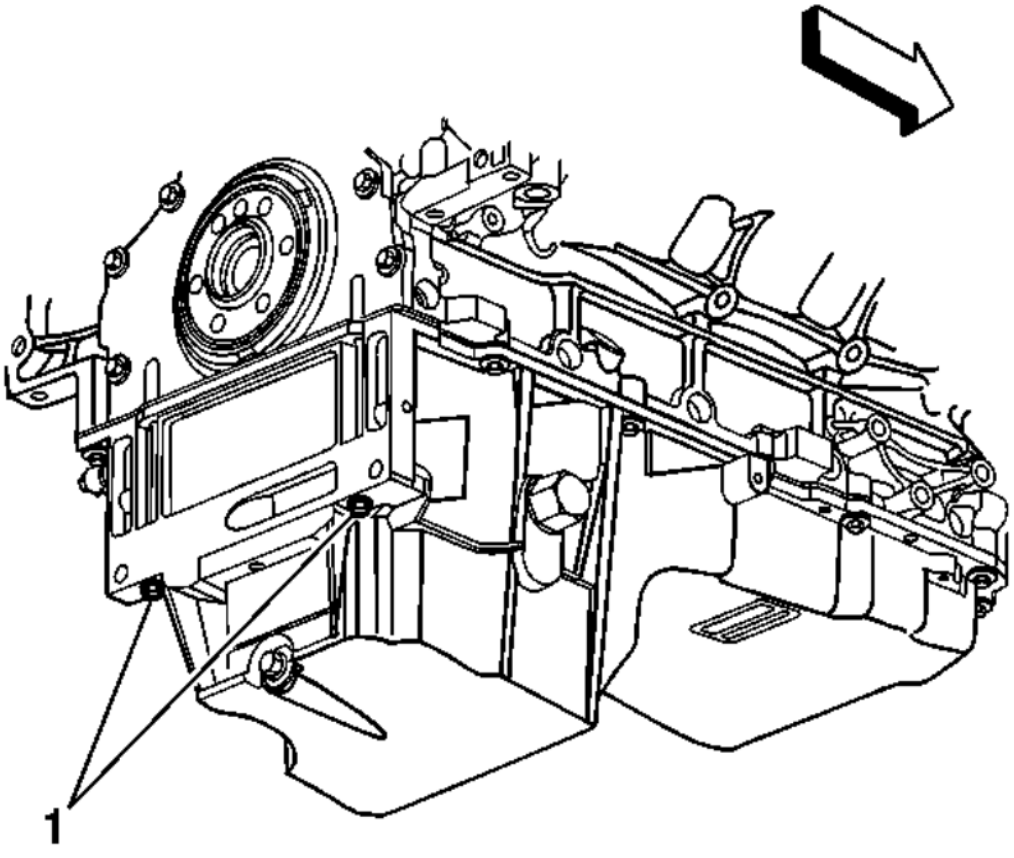

Fig. 165: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel. Refer to **Automatic Transmission Flex Plate Replacement**.
2. Remove the oil pan-to-rear cover bolts (1).

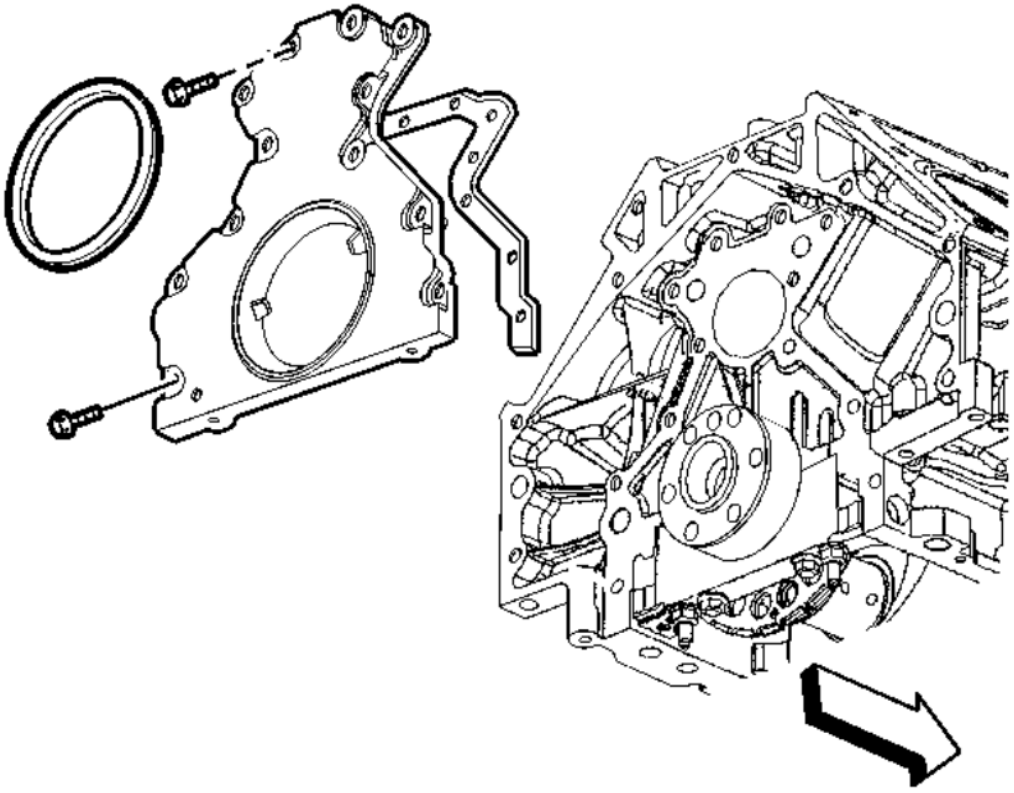

Fig. 166: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

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 **Crankshaft Rear Oil Seal Housing Cleaning and Inspection**.

Installation Procedure

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.**
- **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.

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

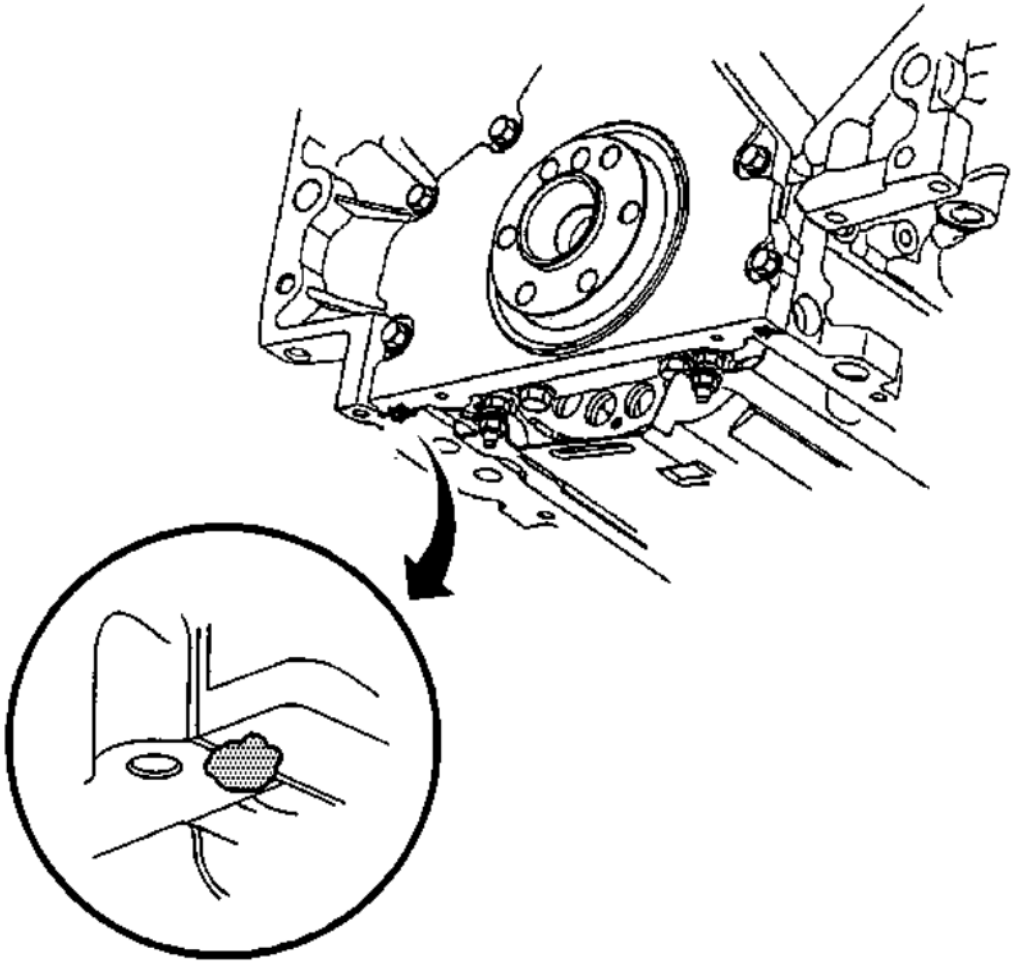

Fig. 167: View Of Sealant Applied To Rear Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant 20 mm (0.80 in) long to the oil pan to engine block junction. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

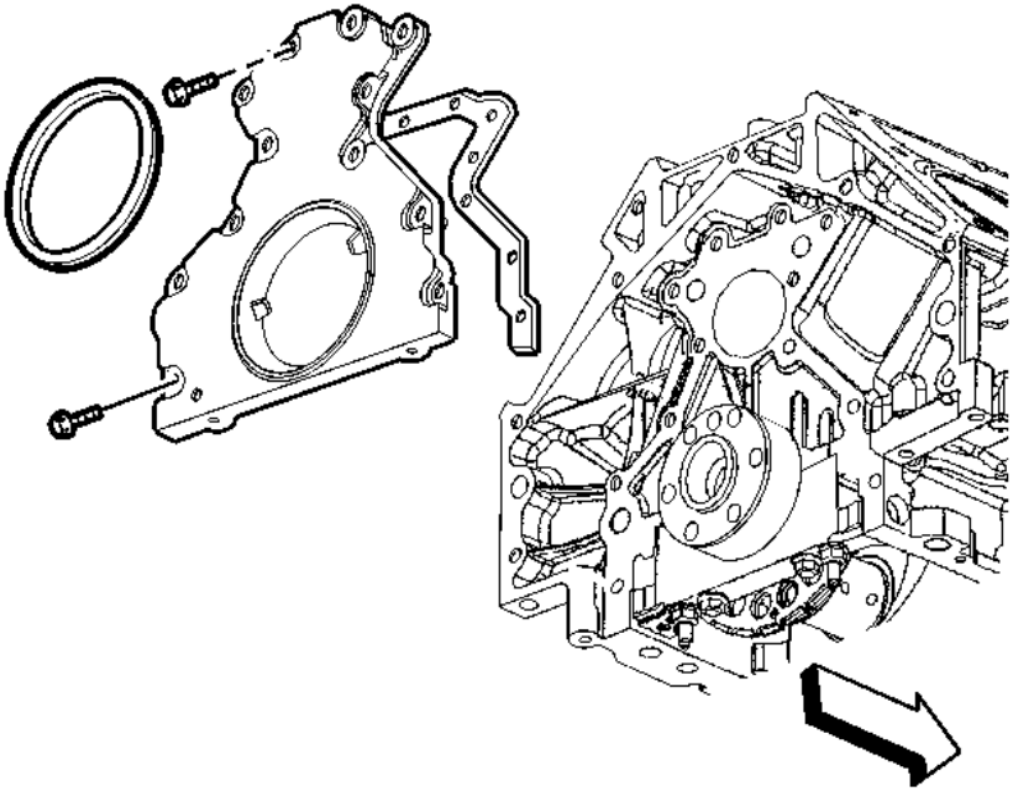

Fig. 168: View Of Rear Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the rear cover gasket and cover.
3. Install the rear cover bolts until snug. Do not overtighten.

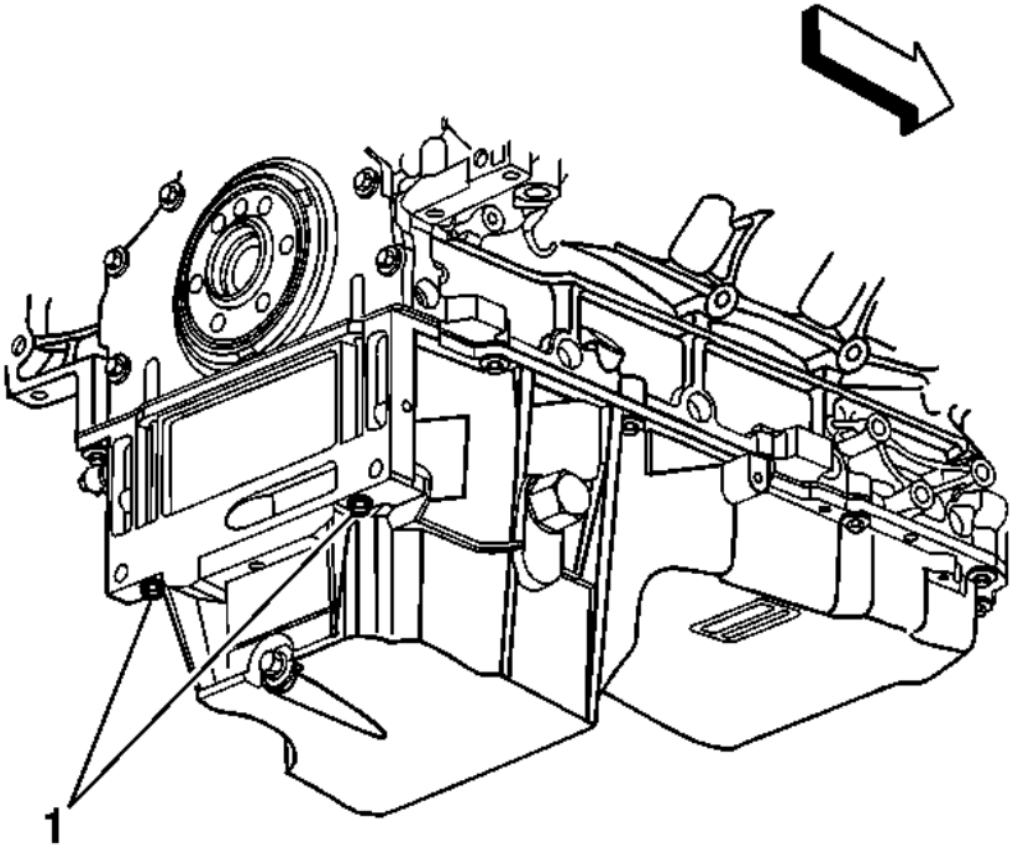

Fig. 169: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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

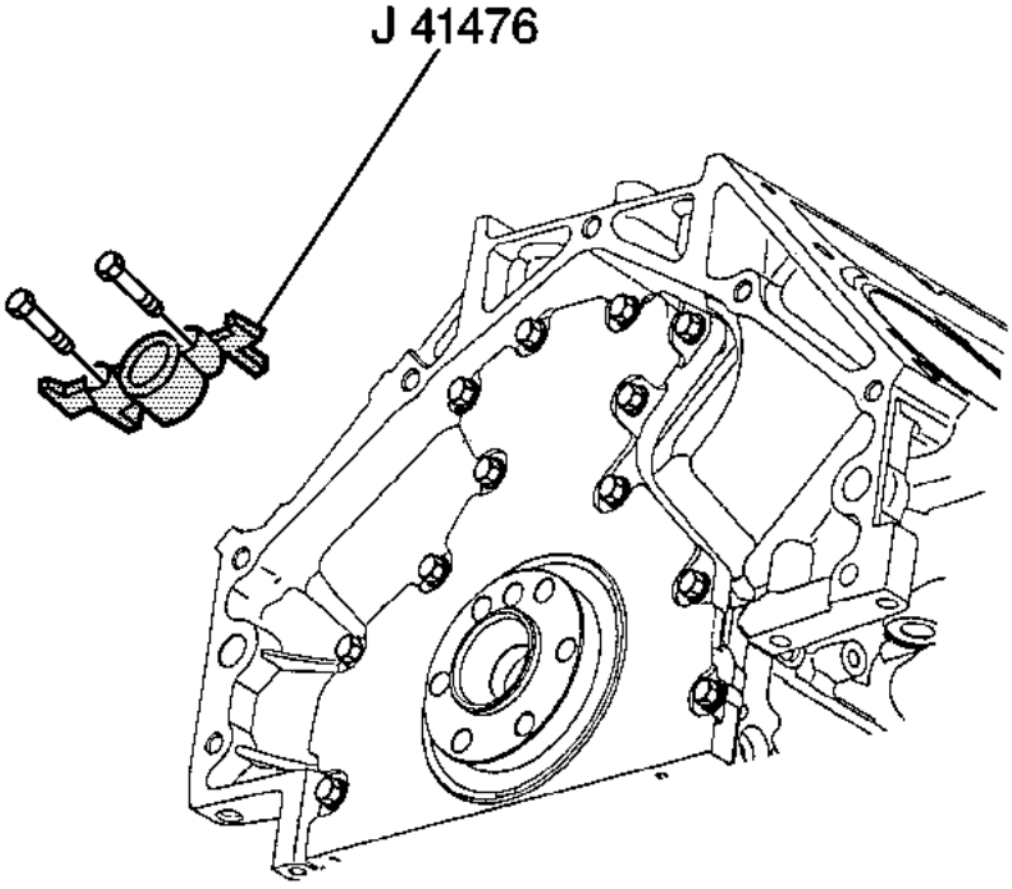

Fig. 170: View Of J 41476
Courtesy of GENERAL MOTORS CORP.

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

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

NOTE: Refer to Fastener Notice .

7. Tighten the **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 30 N.m (22 lb ft).

8. Remove the **J 41476** . See **Special Tools**.
9. Install a NEW crankshaft rear oil seal. Refer to **Crankshaft Rear Oil Seal Replacement**.
10. Install the engine flywheel. Refer to **Automatic Transmission Flex Plate Replacement**.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

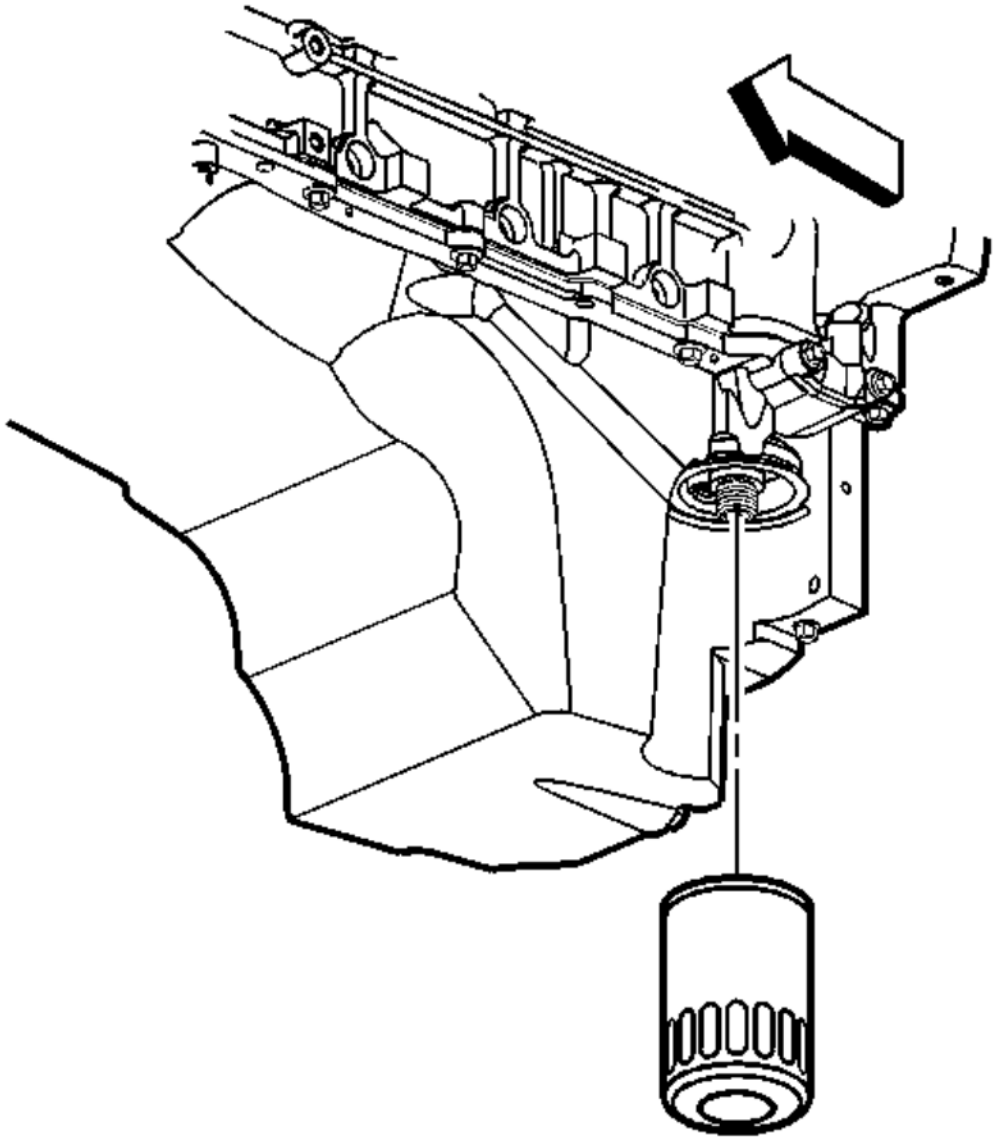

Fig. 171: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

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

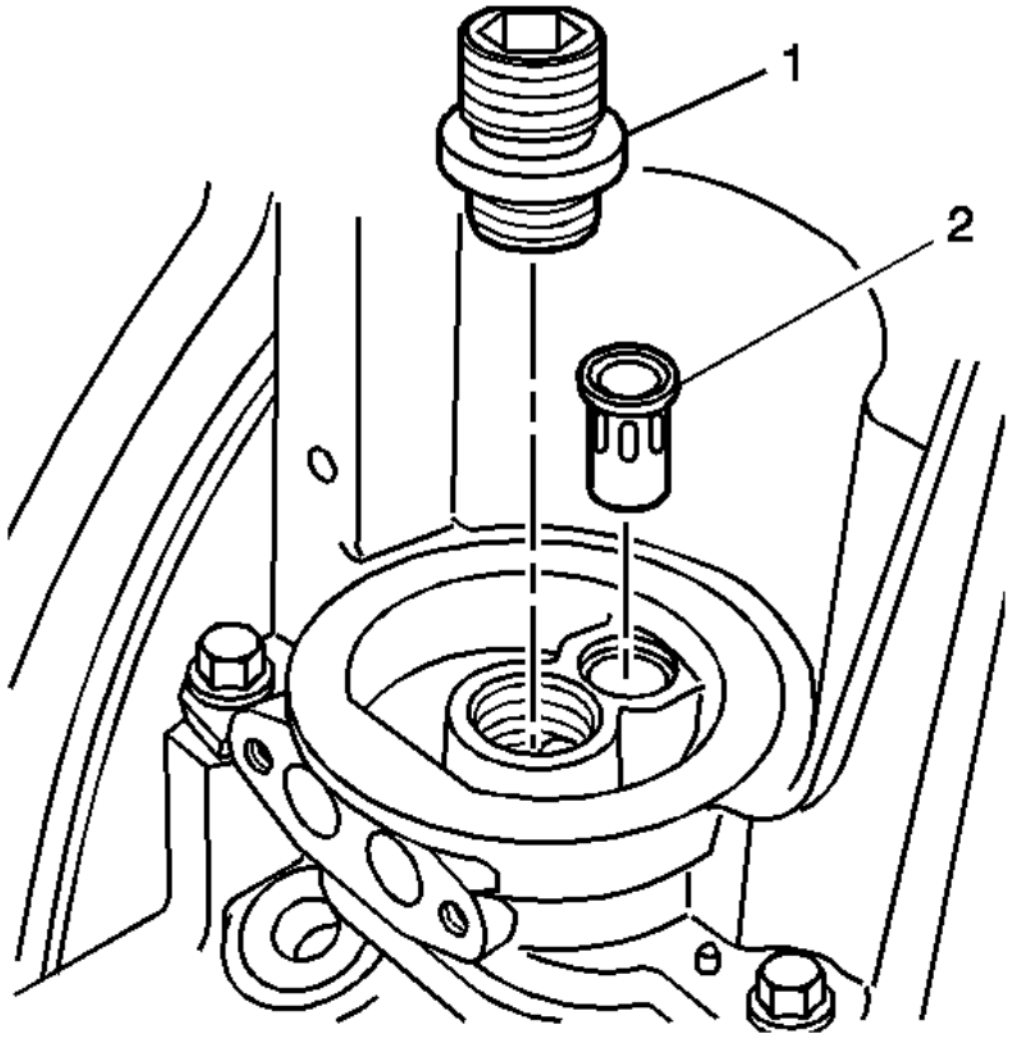

Fig. 172: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter adapter (1).

Installation Procedure

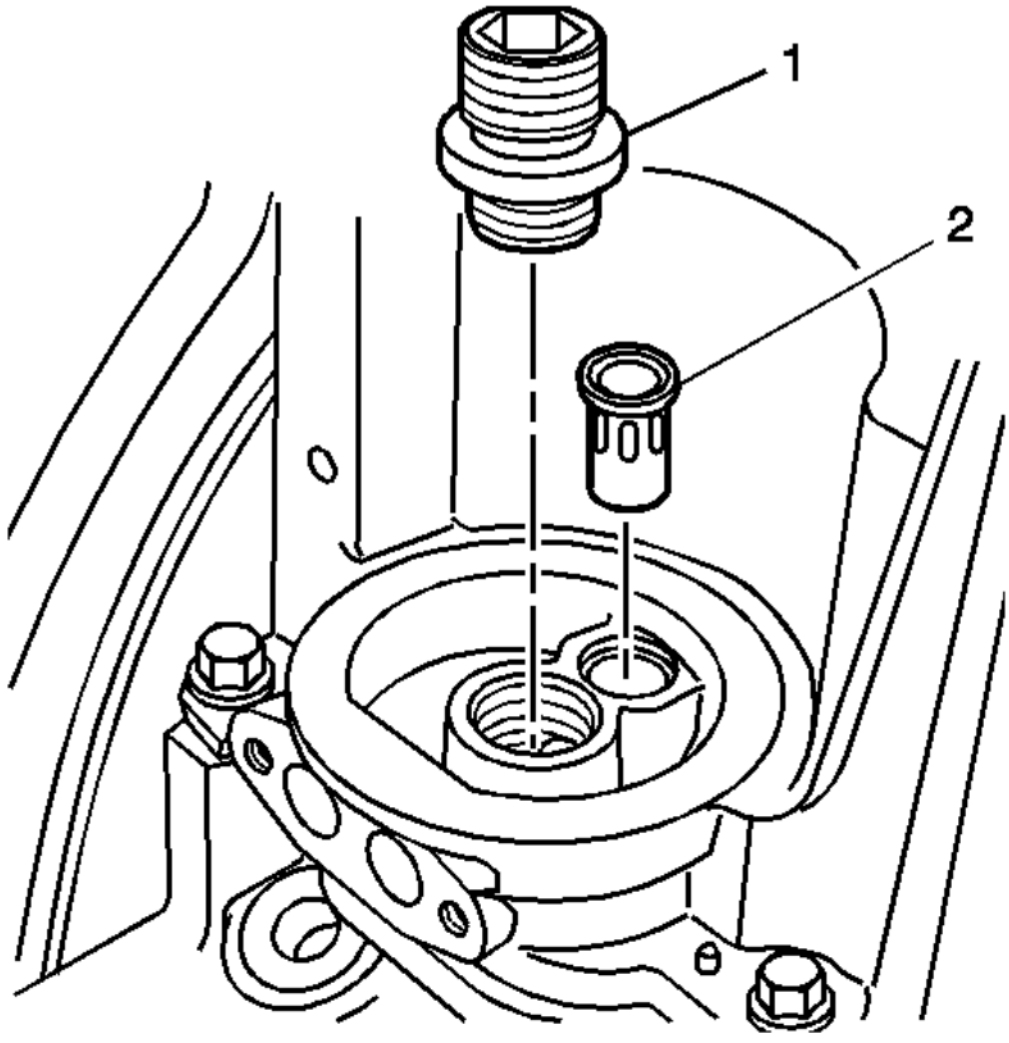

Fig. 173: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil filter adapter (1).

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

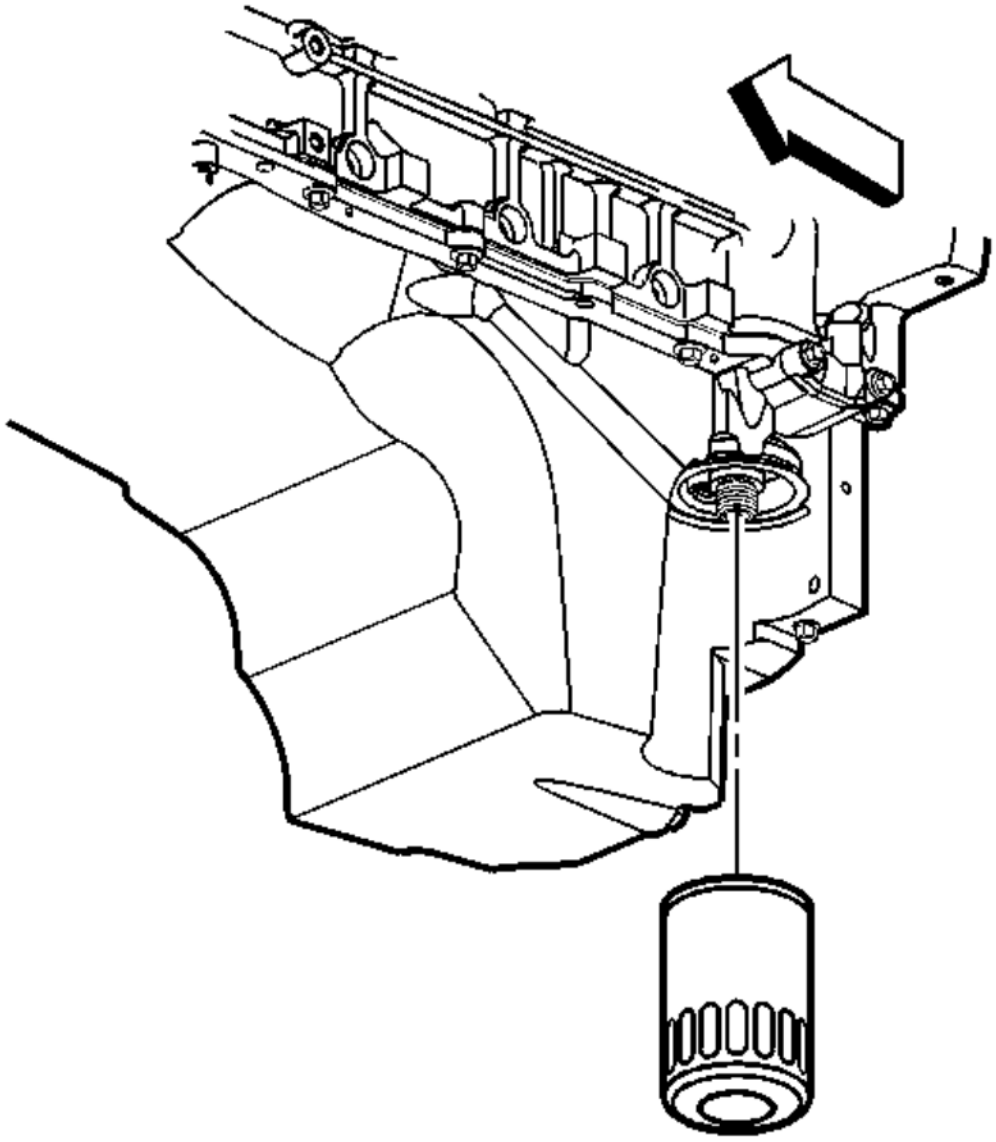

Fig. 174: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Install the oil filter.
3. Refill the engine oil. Refer to **Approximate Fluid Capacities** and/or **Fluid and Lubricant Recommendations** .

OIL FILTER BYPASS VALVE REPLACEMENT

Removal Procedure

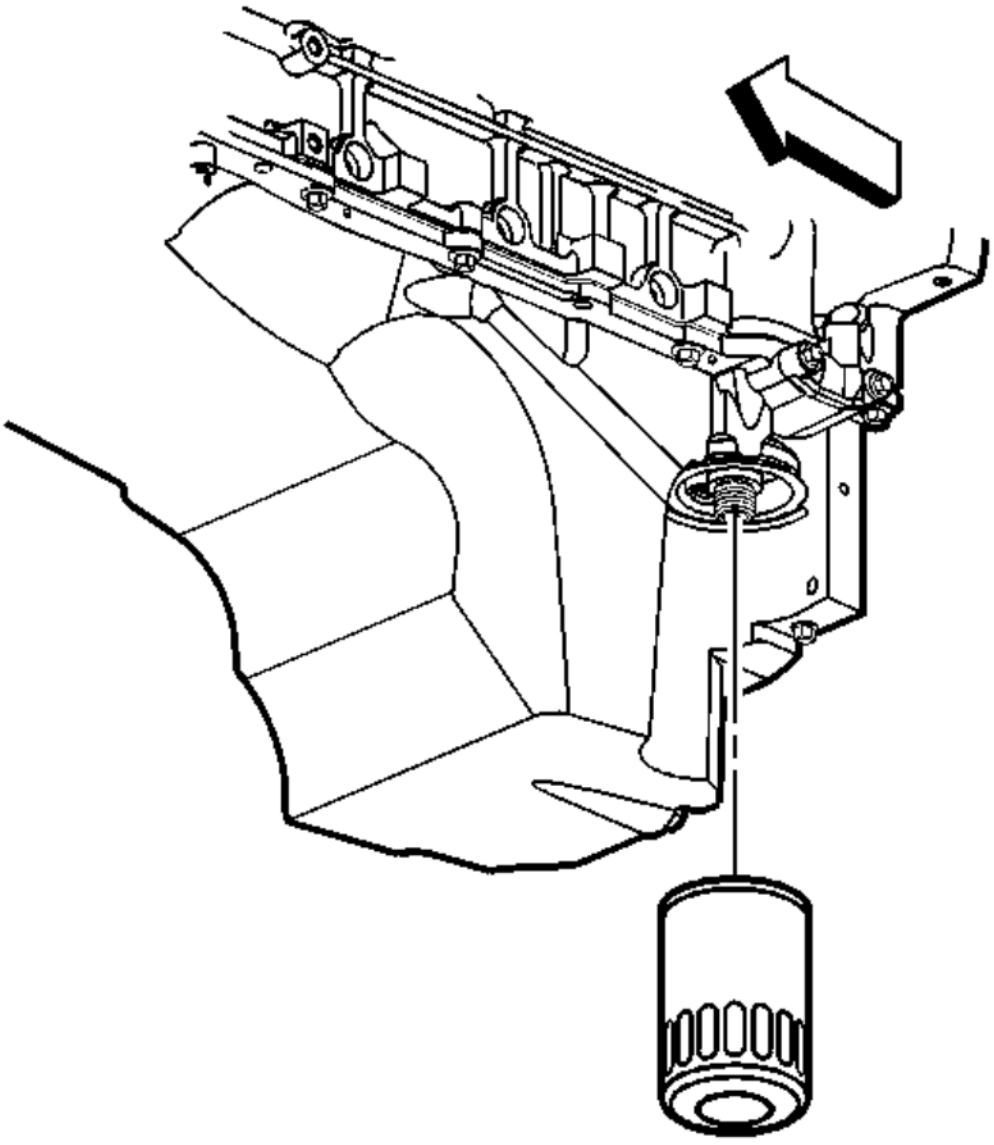

Fig. 175: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

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

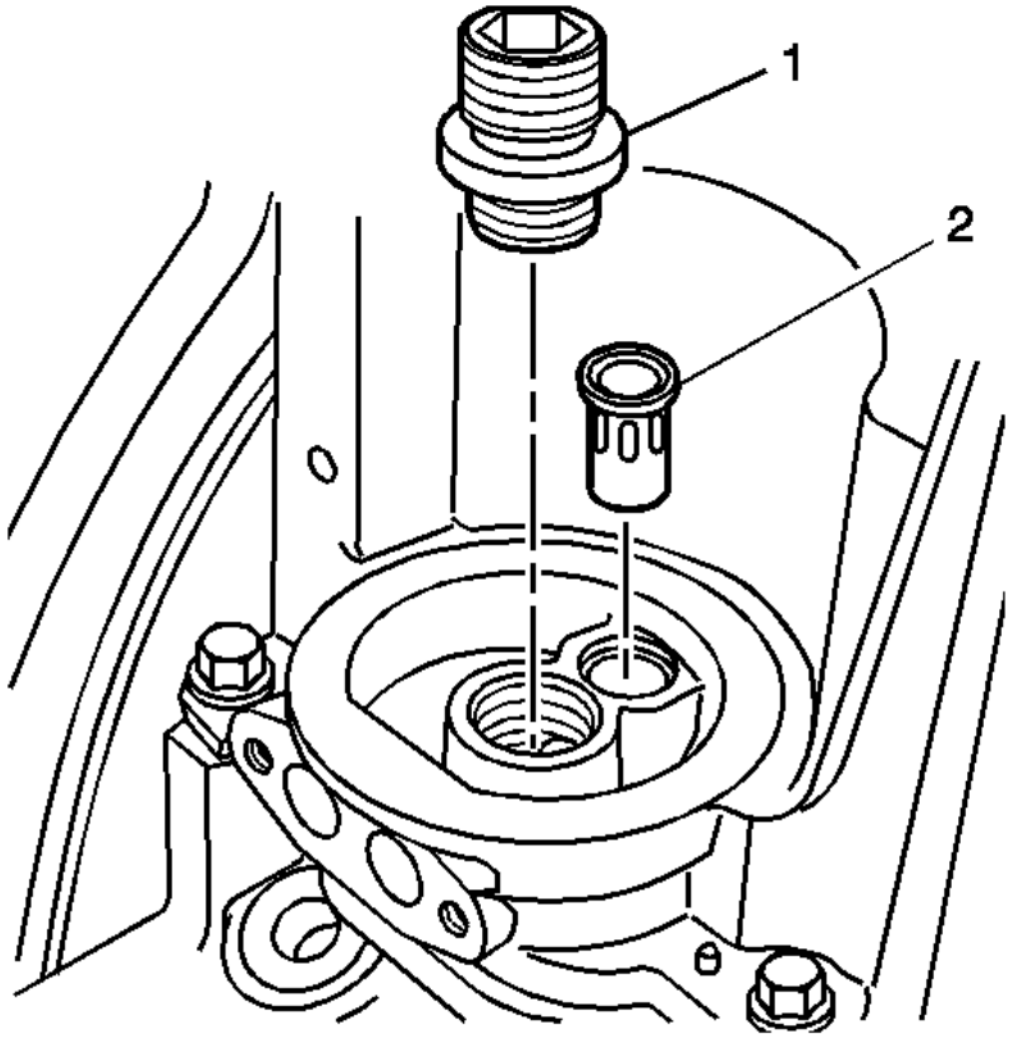

Fig. 176: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

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

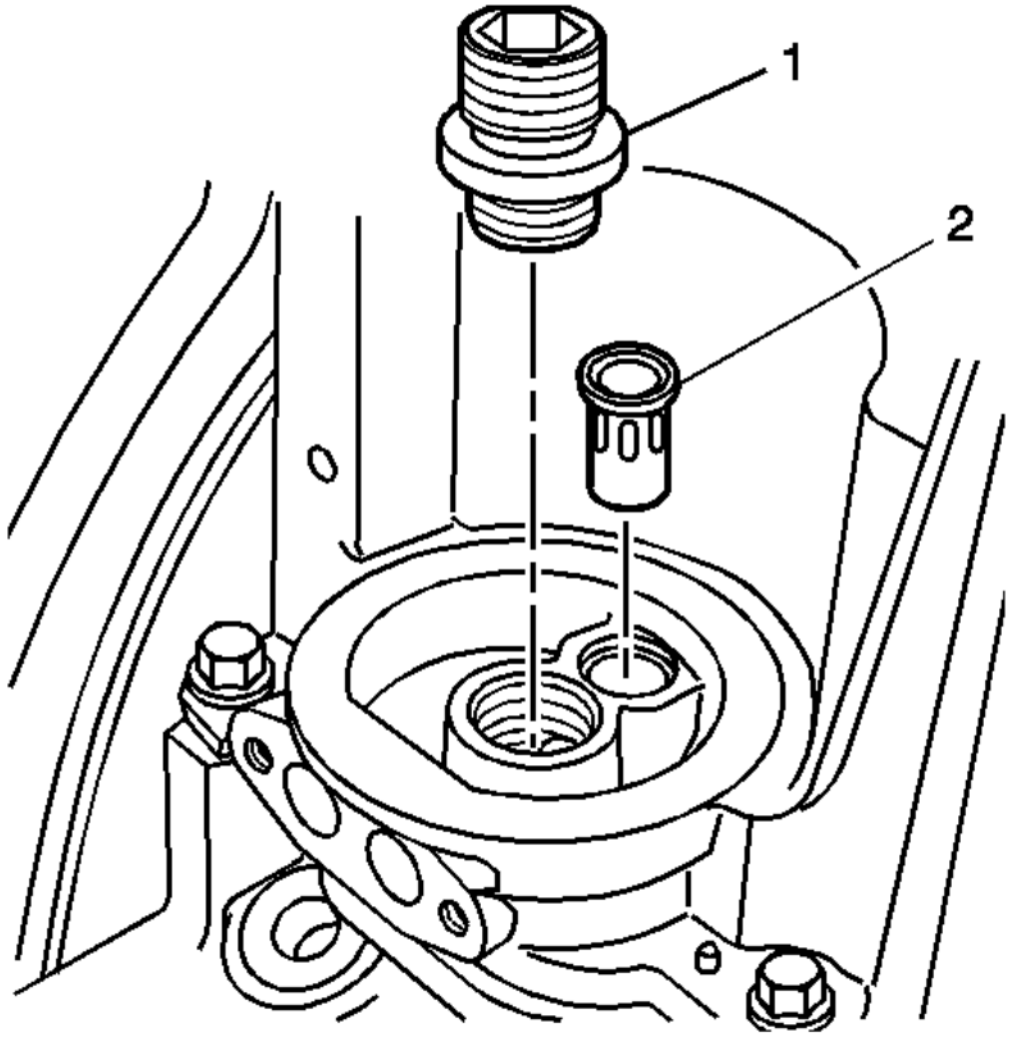

Fig. 177: View Of Oil Filter Adapter & Bypass Valve
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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

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

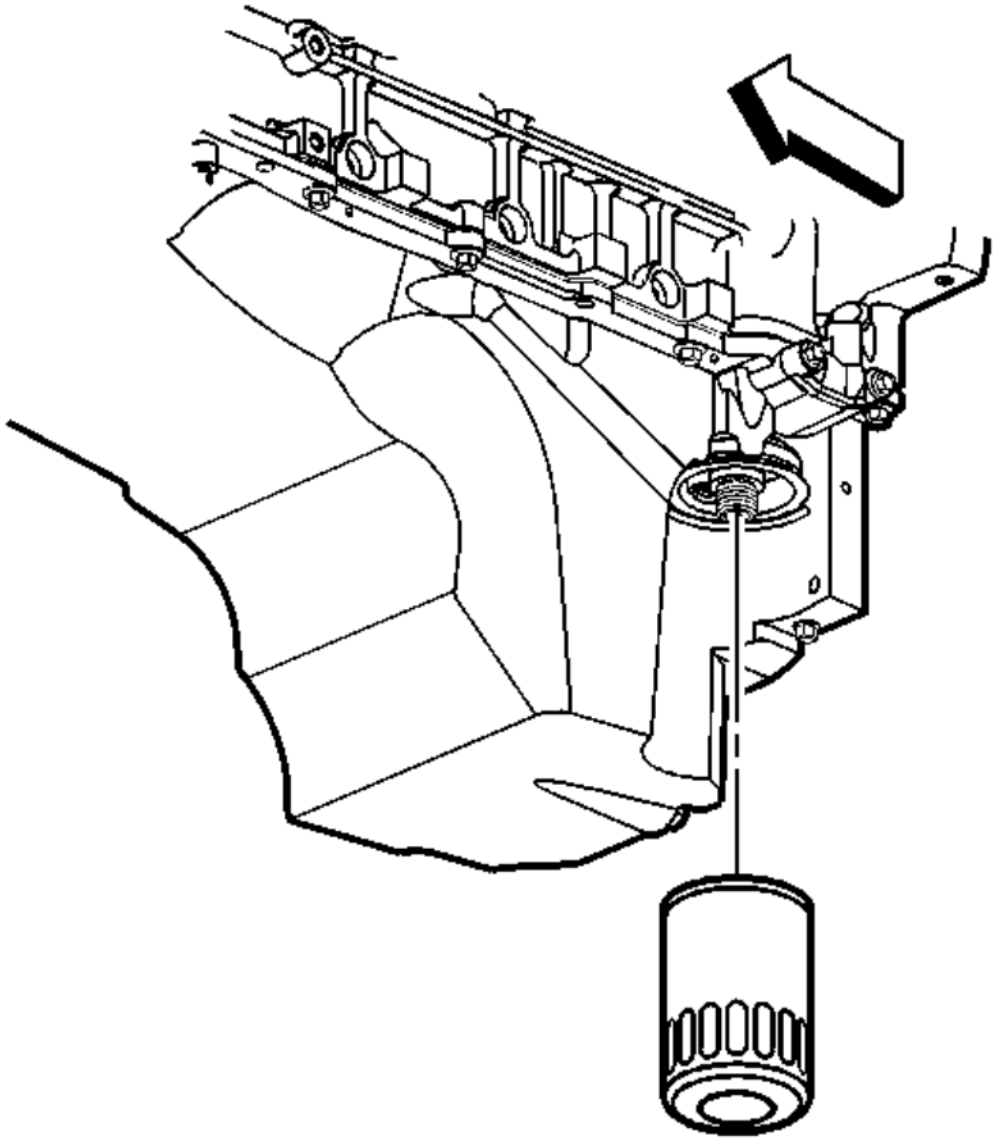

Fig. 178: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

3. Install the oil filter.

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

4. Refill the engine oil. Refer to **Approximate Fluid Capacities** and/or **Fluid and Lubricant Recommendations** .

OIL PAN REPLACEMENT

Removal Procedure

1. Remove the front differential. Refer to **Differential Carrier Assembly Replacement** .
2. Remove the starter motor. Refer to **Starter Motor Replacement** .

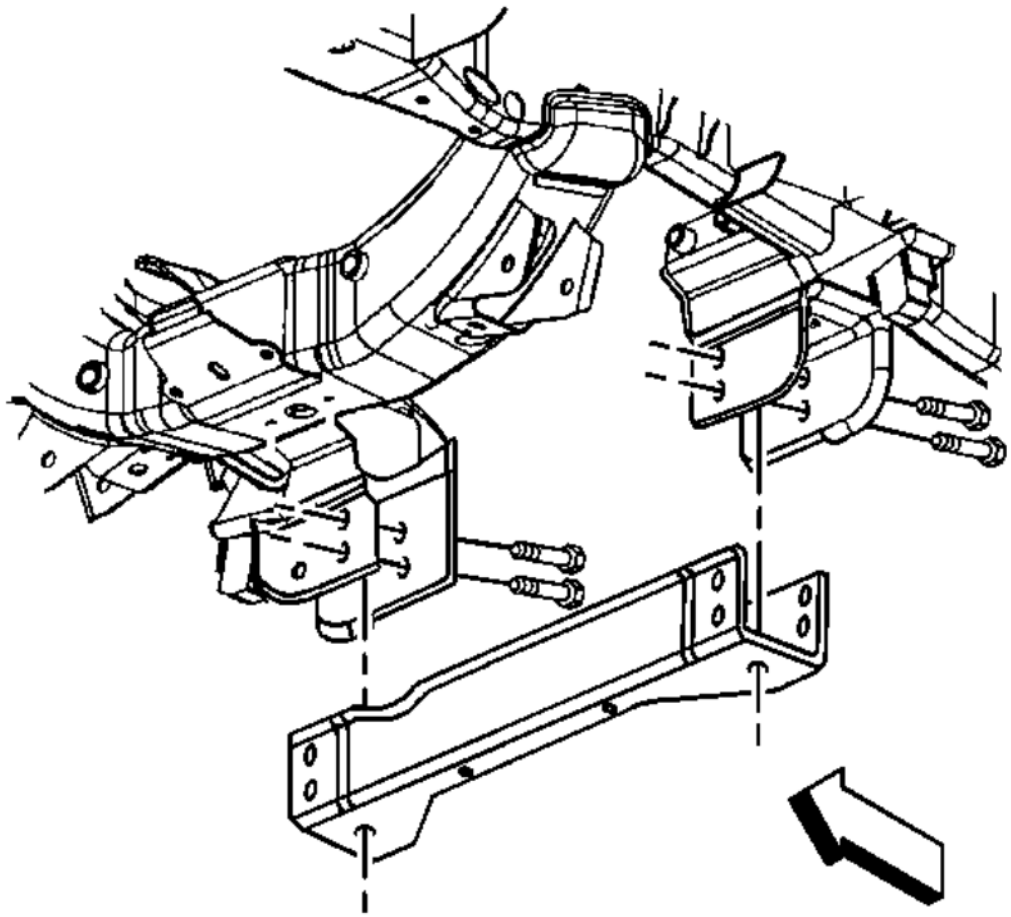

Fig. 179: View Of Crossbar Bolts & Bar (2WD)

Courtesy of GENERAL MOTORS CORP.

3. Remove the crossbar bolts.
4. Remove the crossbar.

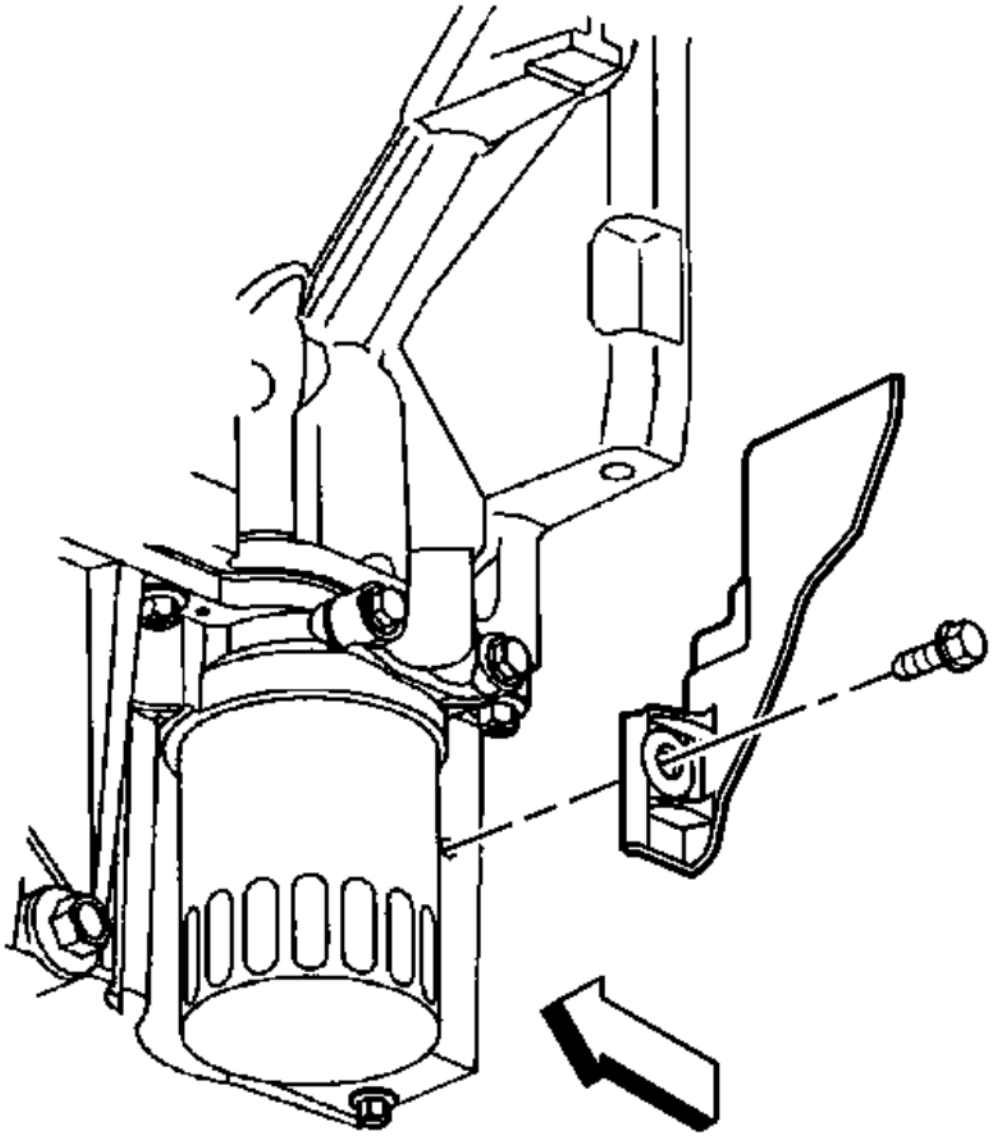

Fig. 180: View Of Left Closeout Cover & Bolt

Courtesy of GENERAL MOTORS CORP.

5. Remove the transmission cover bolt and cover.
6. Drain the engine oil and remove the engine oil filter.
7. Re-install the drain plug and oil filter until snug.

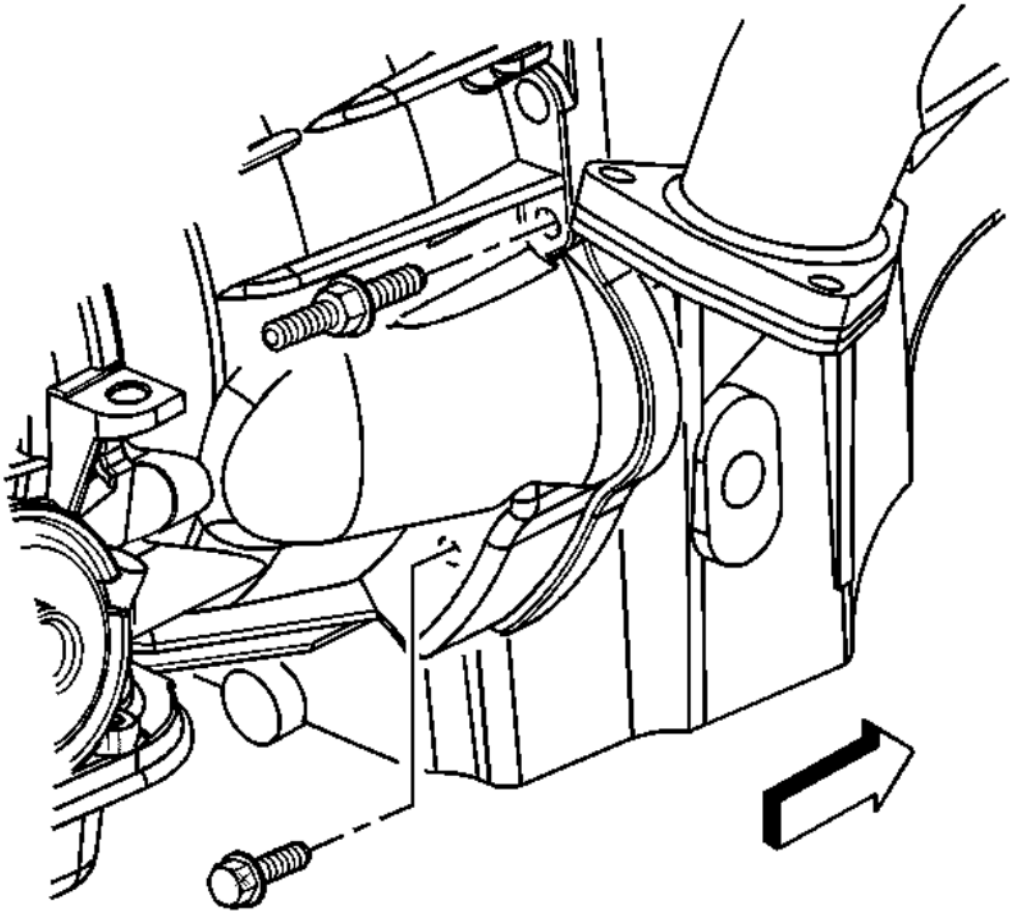

Fig. 181: Identifying Stud & Bolt Securing Transmission To Engine (Right Side)
Courtesy of GENERAL MOTORS CORP.

8. Remove the transmission bolt and stud on the right side.

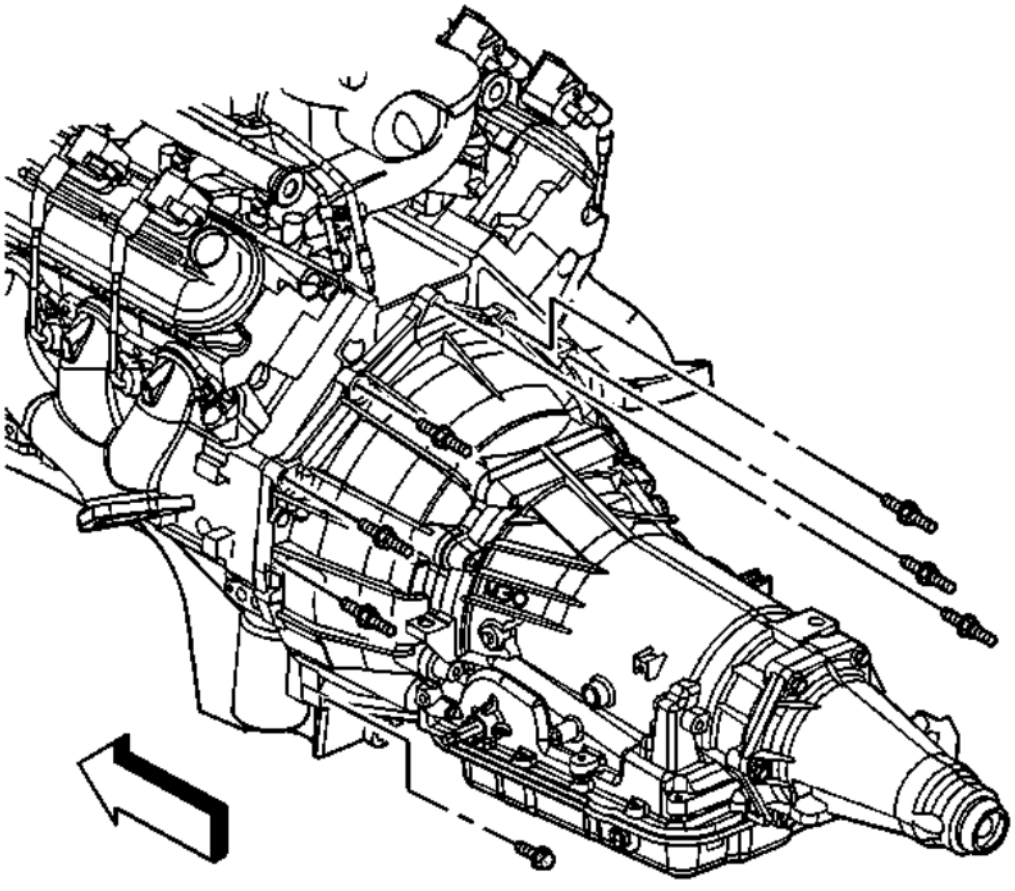

Fig. 182: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

9. Remove the bottom bolt on the left side.

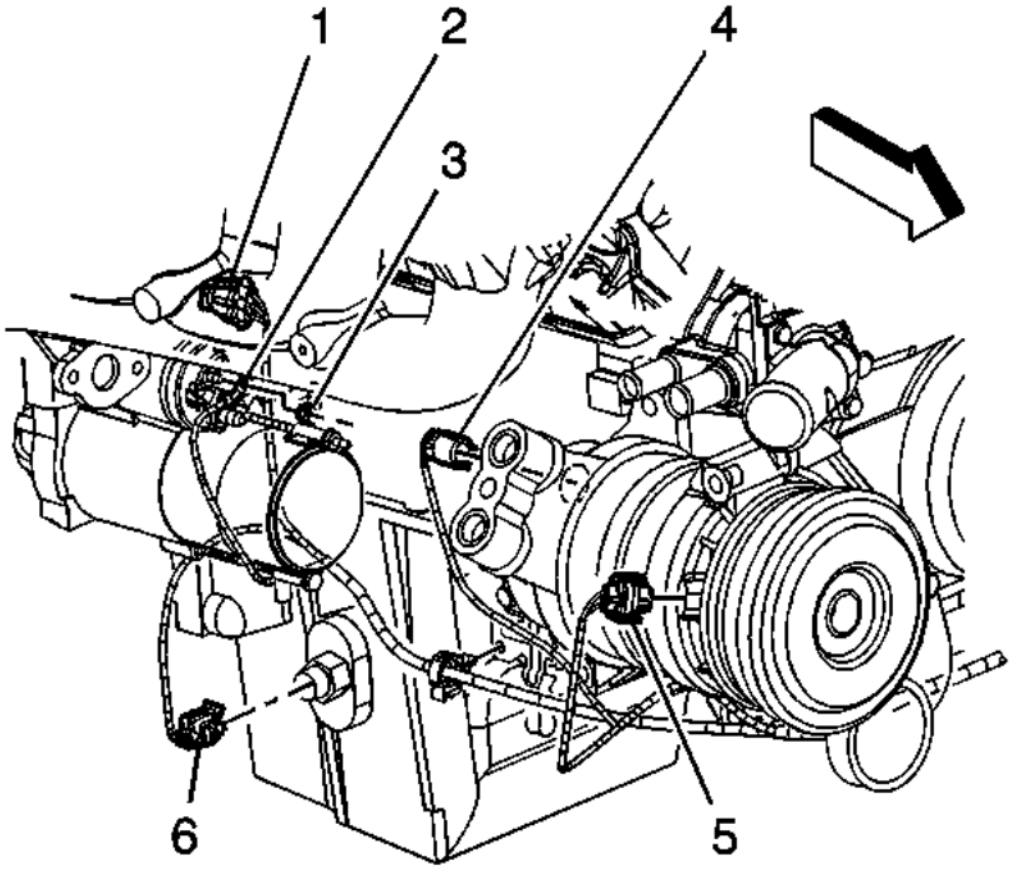

Fig. 183: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the oil level sensor electrical connector (6).

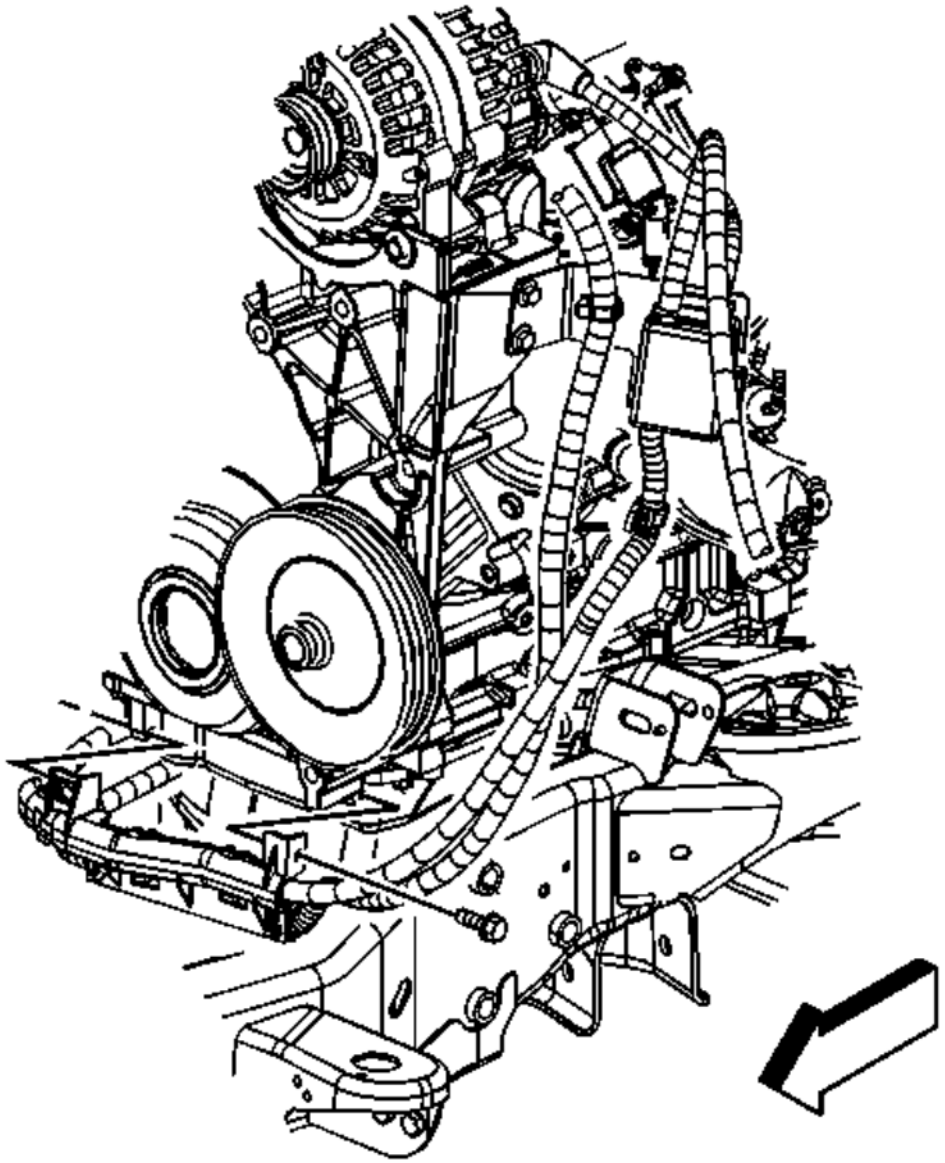

Fig. 184: View Of Positive Battery Cable, Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the battery cable channel bolt.
12. Slide the channel pin out of the oil pan tab.

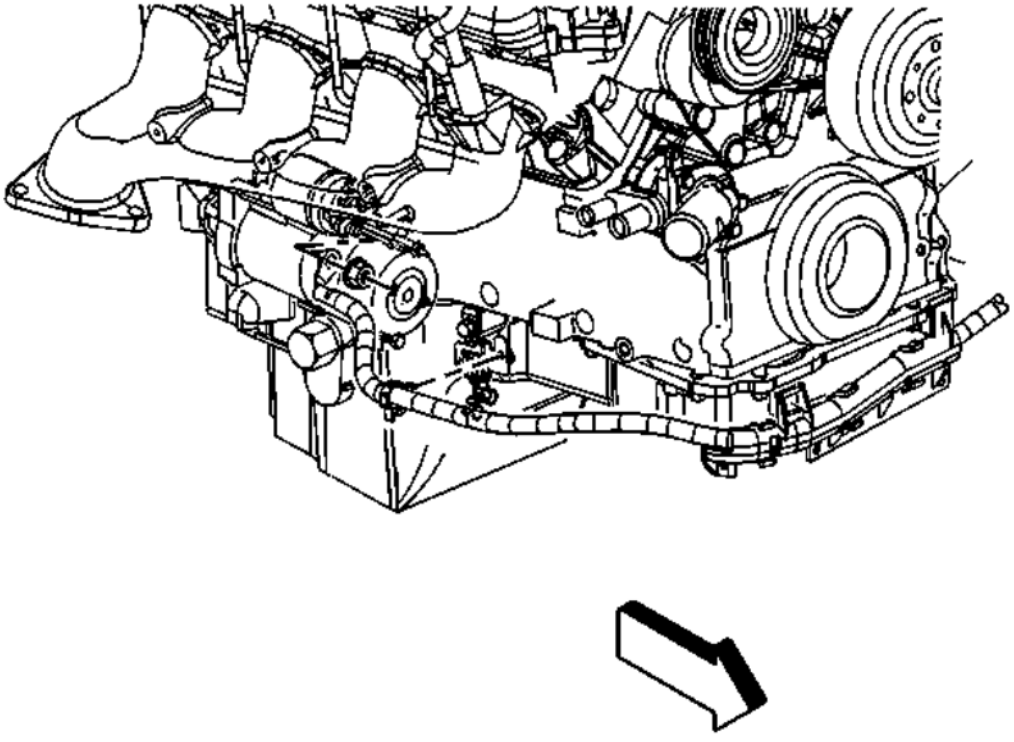

Fig. 185: View Of Positive Battery Cable Fasteners
Courtesy of GENERAL MOTORS CORP.

13. Remove the following from the positive battery cable clip:
    - Engine wiring harness clip
    - Positive battery cable clip

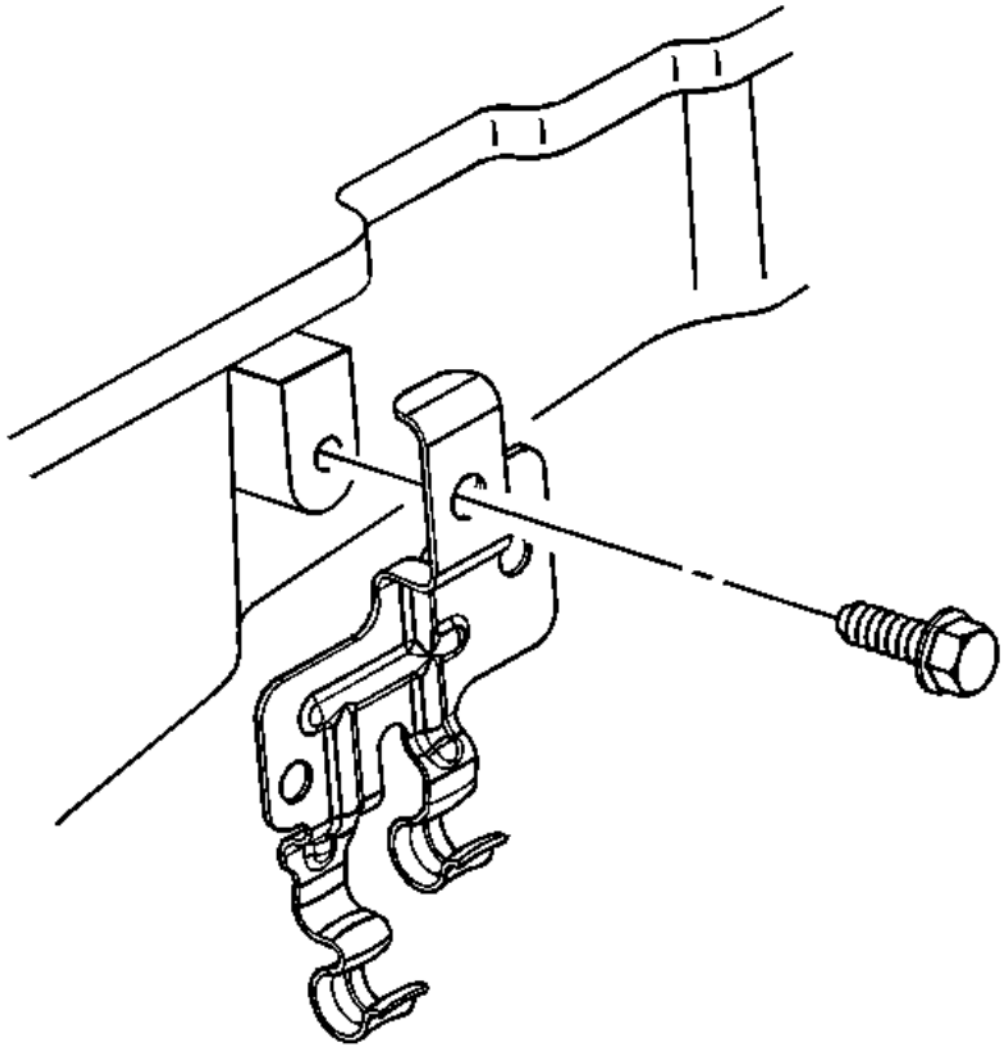

Fig. 186: View Of Positive Battery Cable Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine oil cooler lines from the positive battery cable clip.
15. Remove the positive battery cable clip bolt and clip.

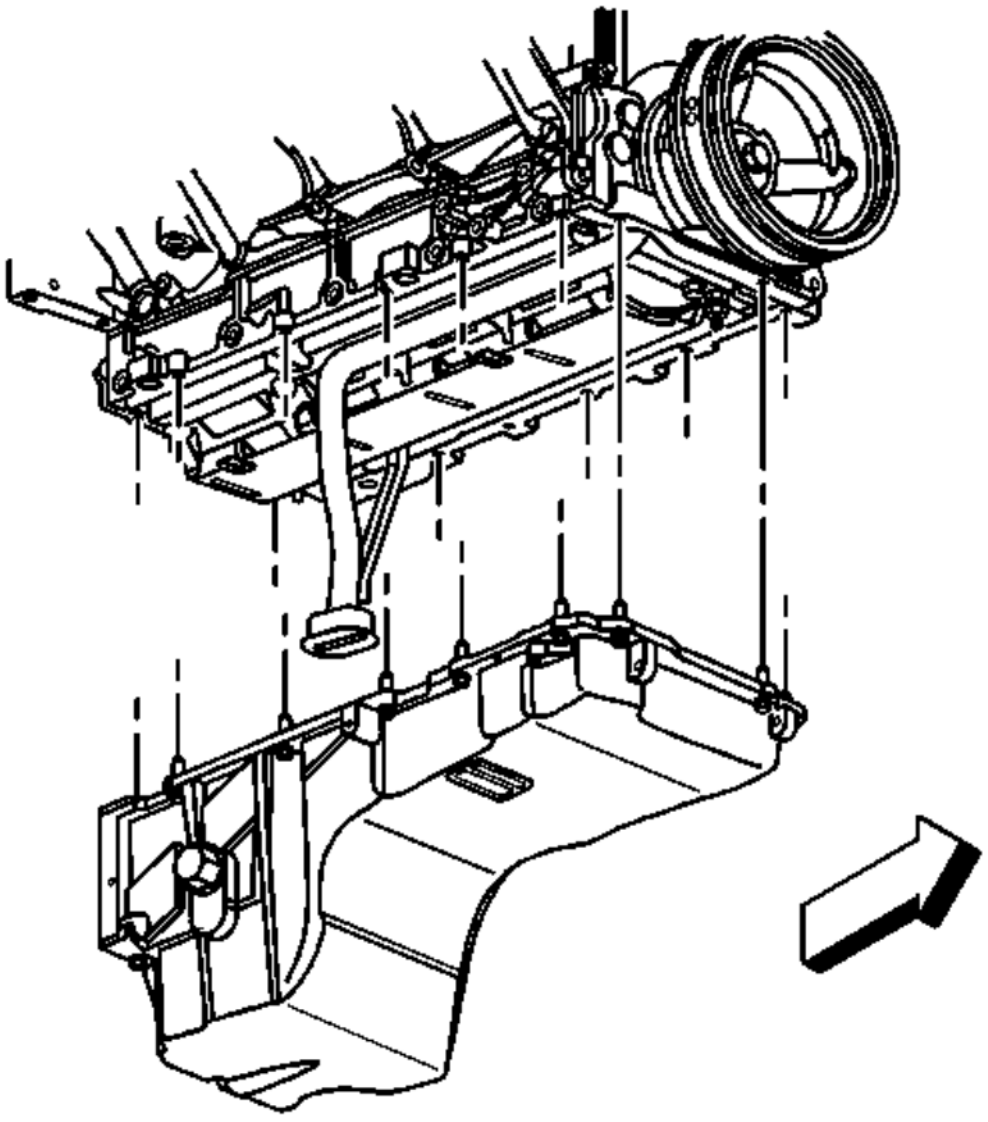

Fig. 187: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil pan bolts.
17. Remove the oil pan.

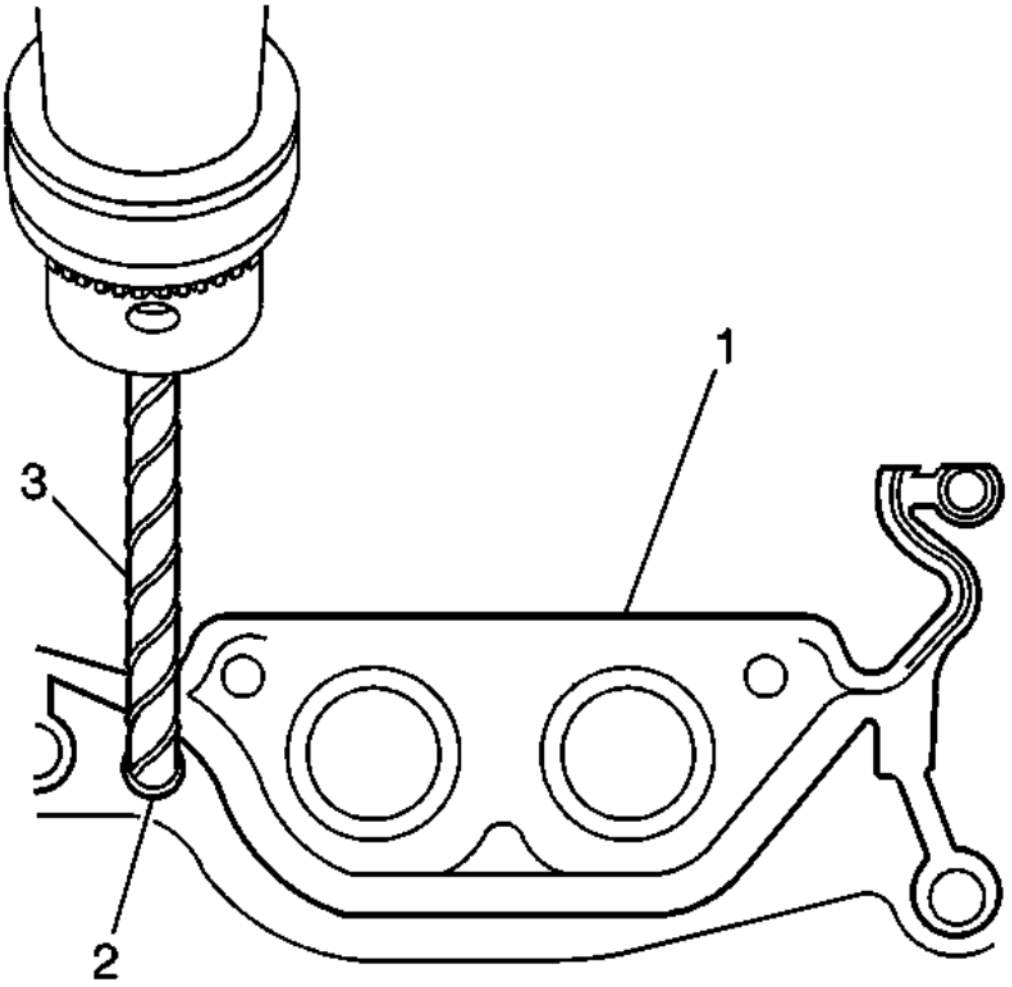

Fig. 188: Drilling Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

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

18. Drill (3) out the oil pan gasket retaining rivets (2), if required.
19. Remove the gasket (1) from the pan.
20. Discard the gasket and rivets.
21. Clean and inspect the engine oil pan. Refer to **Oil Pan Cleaning and Inspection**.

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 transmission bellhousing plane.**
- **Do not reuse the oil pan gasket.**
- **It is not necessary to rivet the NEW gasket to the oil pan.**

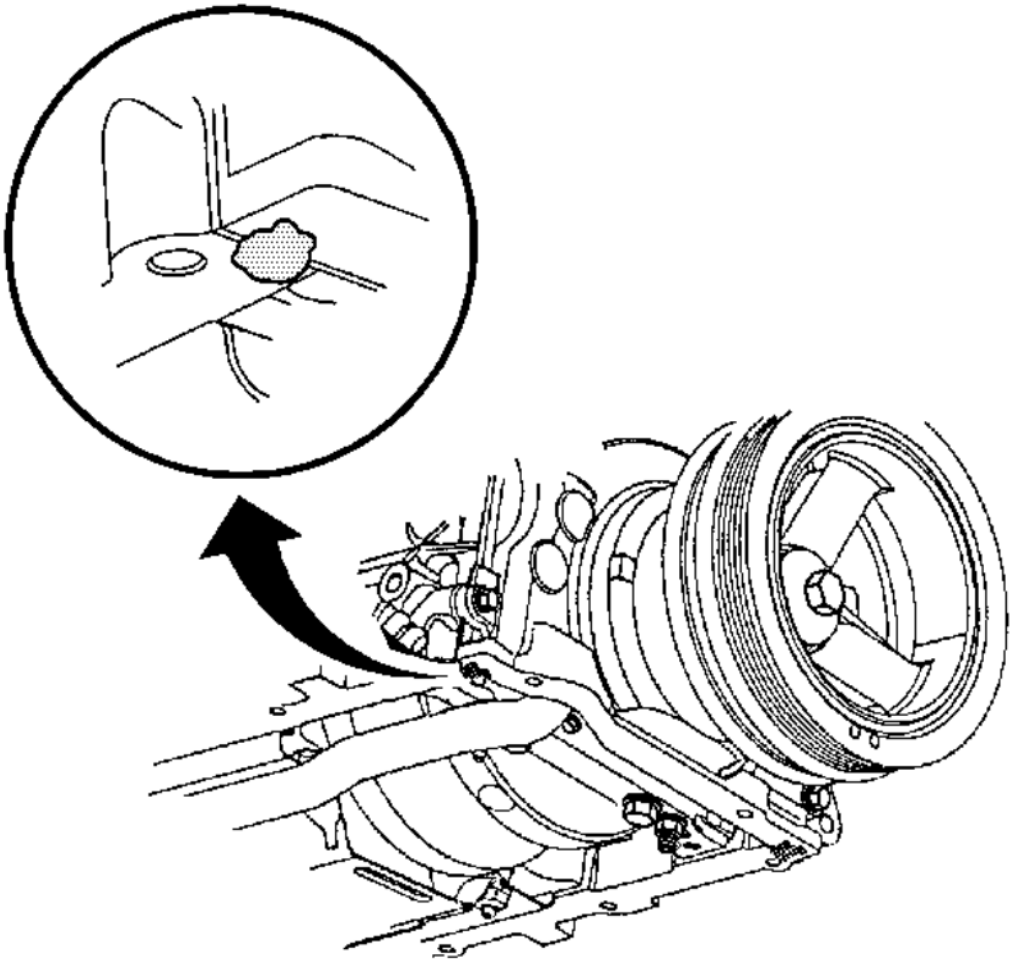

Fig. 189: View Of Sealant Applied To Front Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.20 in) bead of sealant 20 mm (0.80 in) long to the engine block. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

   Apply the sealant directly onto the tabs of the front cover gasket that protrudes into the oil pan surface.

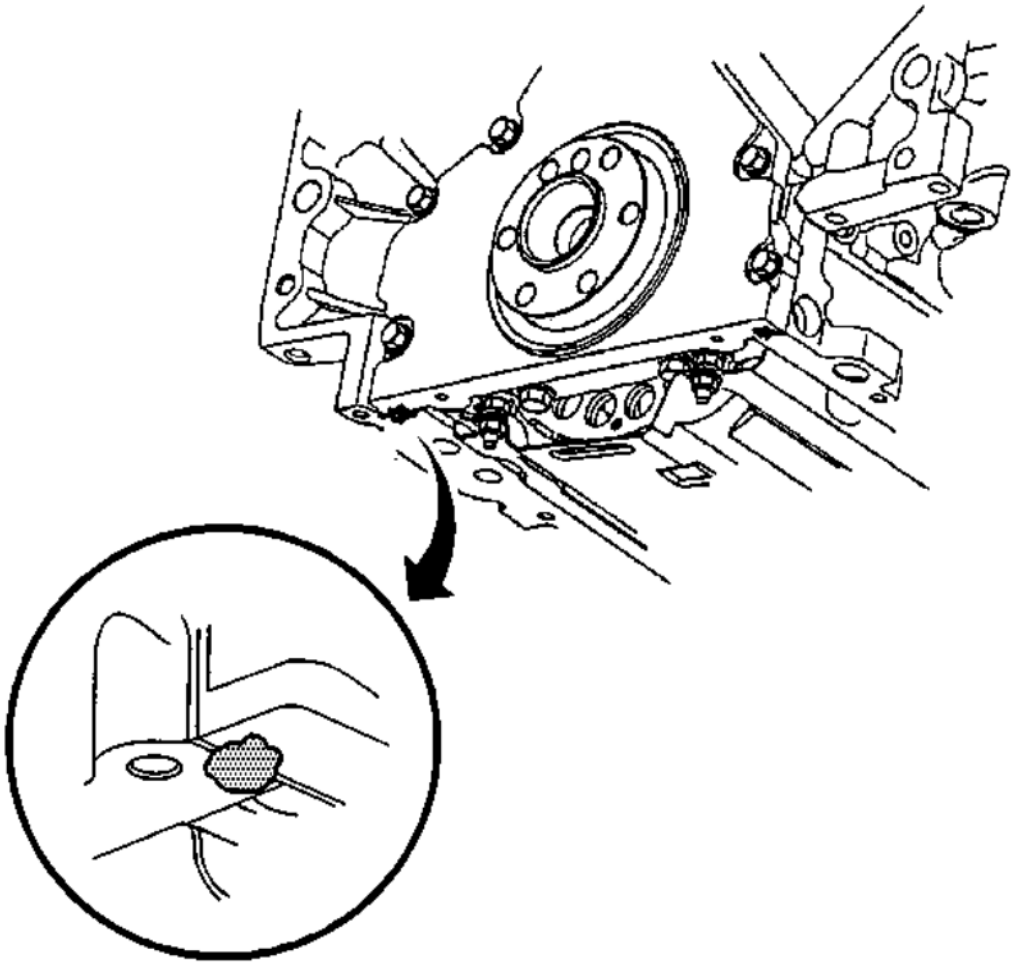

Fig. 190: View Of Sealant Applied To Rear Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.20 in) bead of sealant 20 mm (0.8 in) long to the engine block. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

   Apply the sealant directly onto the tabs of the rear cover gasket that protrudes into the oil pan surface.

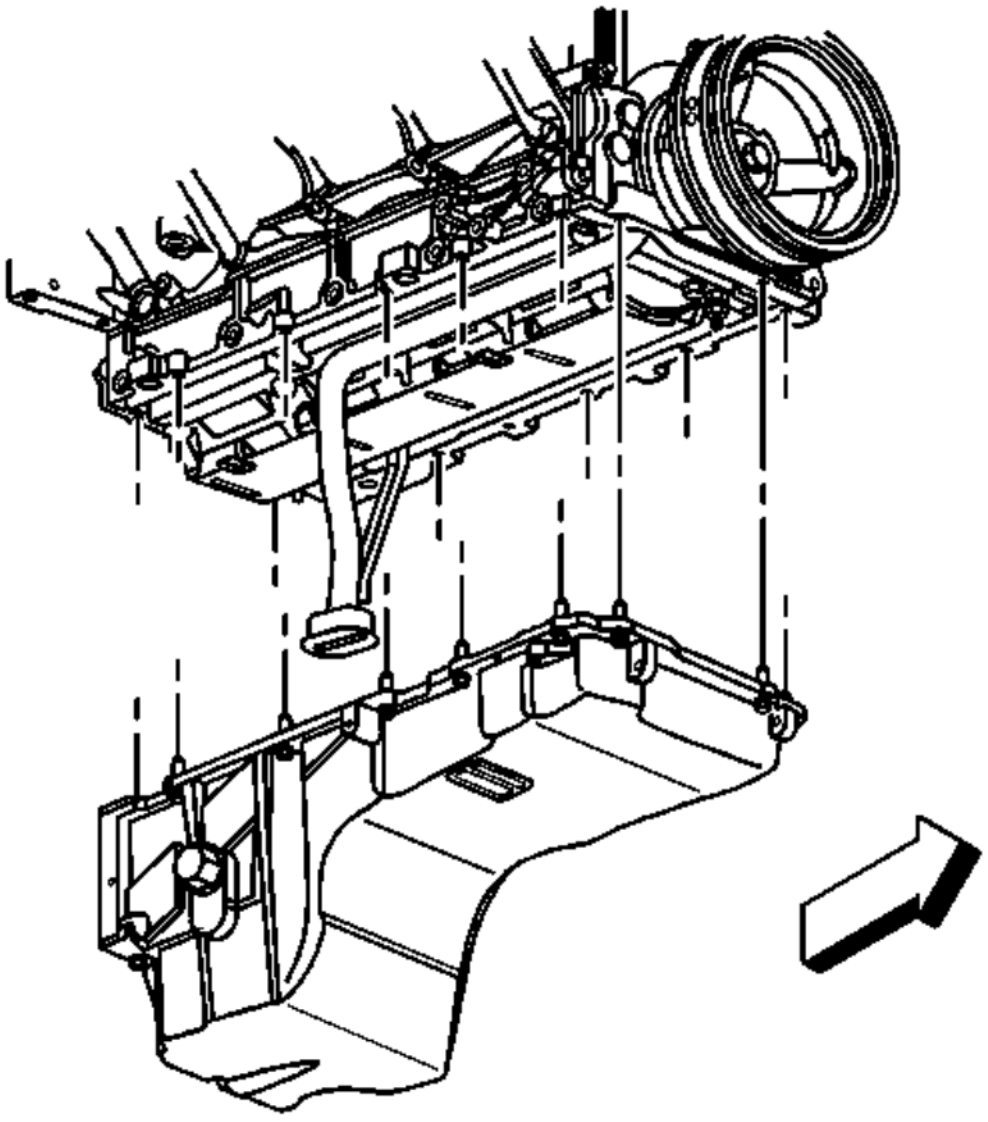

Fig. 191: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be sure to align the oil gallery passages in the oil pan and engine block properly with the oil pan gasket.

3. Pre-assemble the oil pan gasket 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, gasket and bolts to the engine block.
5. Tighten the oil pan bolts until snug. Do not overtighten.

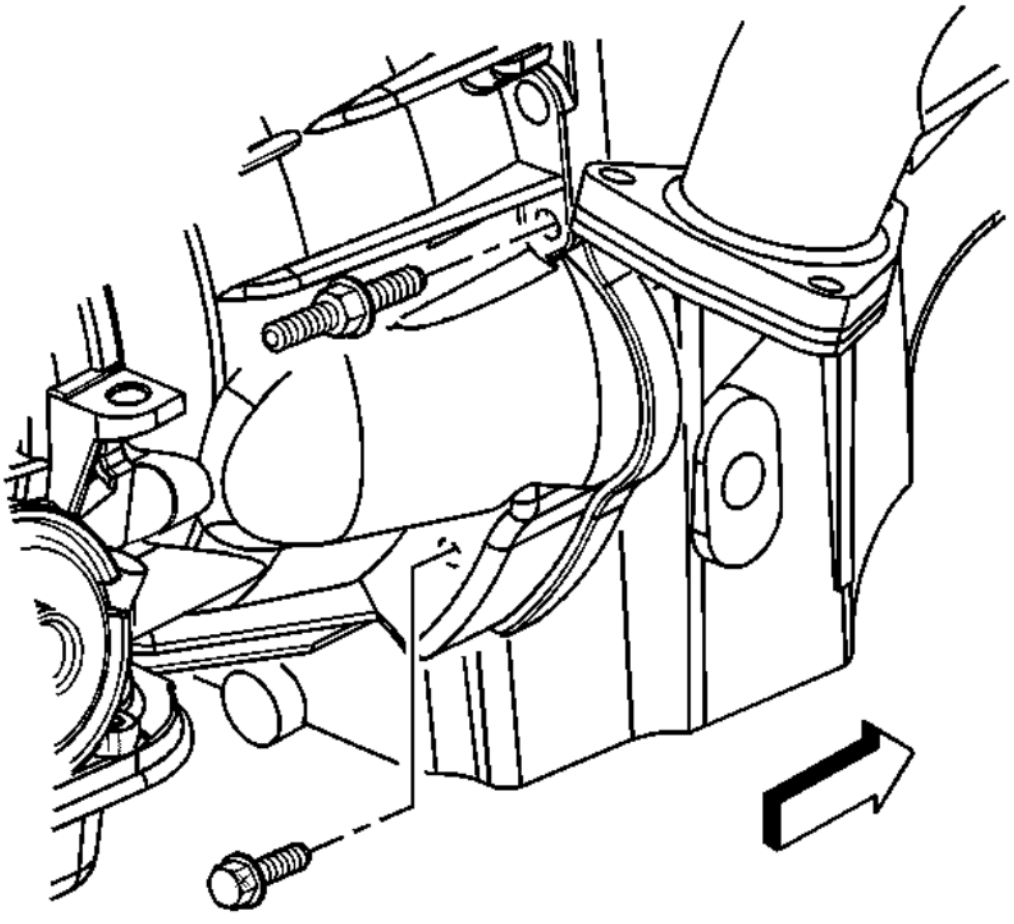

Fig. 192: Identifying Stud & Bolt Securing Transmission To Engine (Right Side)
Courtesy of GENERAL MOTORS CORP.

6. Install the transmission bolt and stud on the right side until snug.

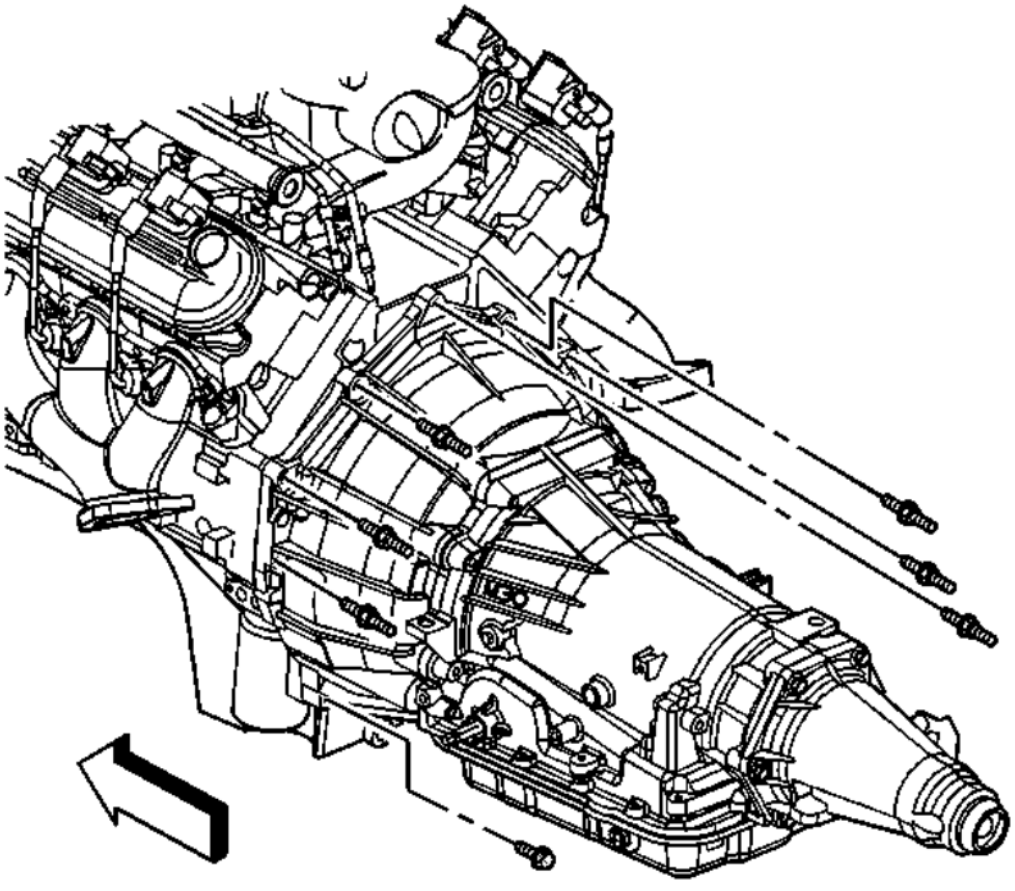

Fig. 193: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

7. Install the bottom bolt on the left side until snug.

Tighten:

1. Tighten the oil pan and oil pan-to-oil pan 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).
3. Tighten the bellhousing, converter cover, and transmission bolts/stud to 50 N.m (37 lb ft).

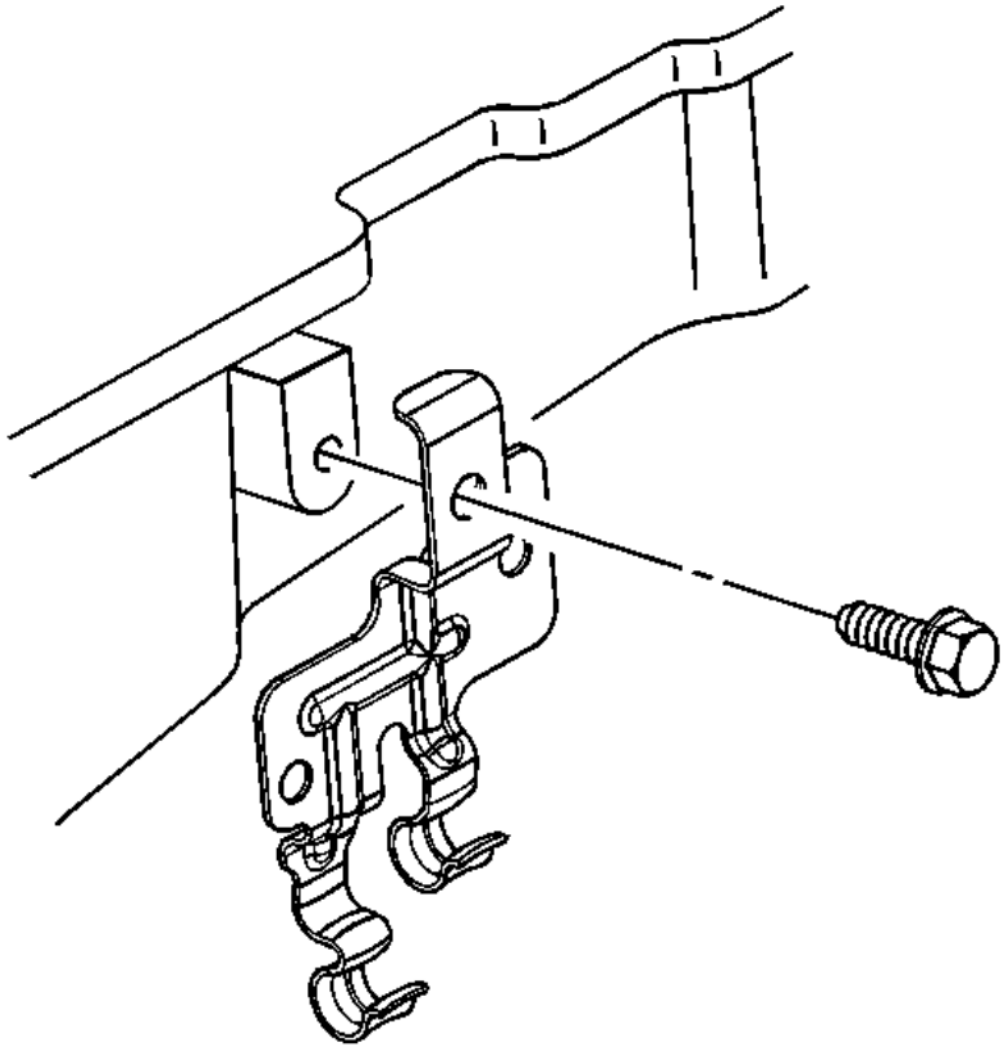

Fig. 194: View Of Positive Battery Cable Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the positive battery cable clip and bolt to the oil pan.

   Tighten: Tighten the positive battery cable clip bolt to 9 N.m (80 lb in).

9. Install the engine oil cooler lines to the positive battery cable clip.

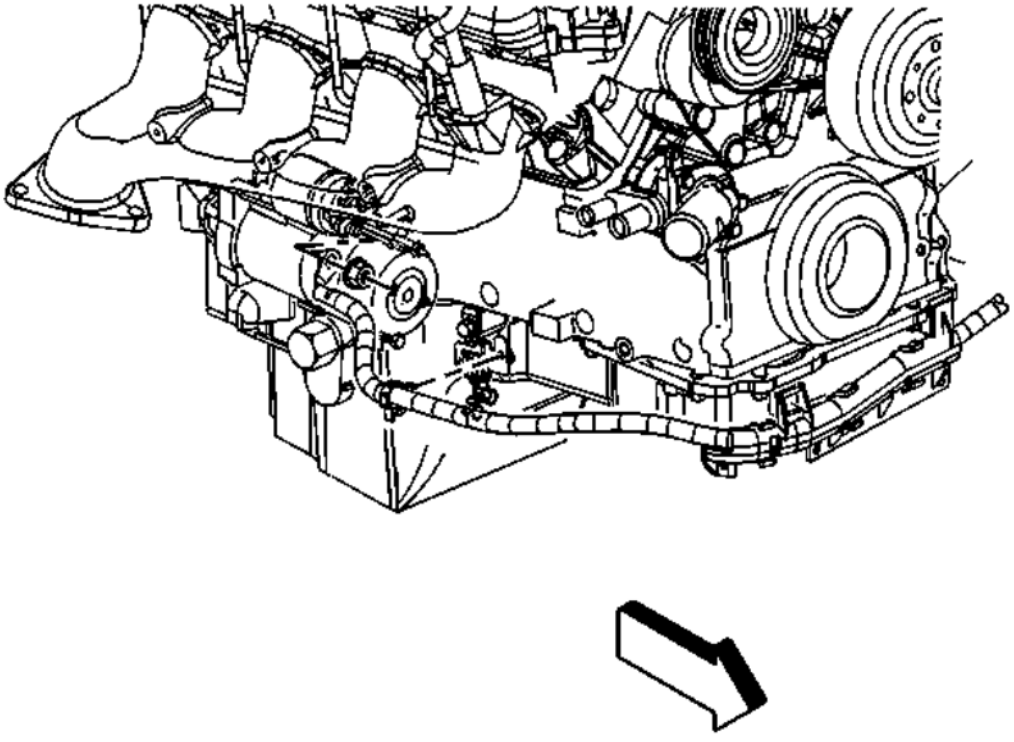

Fig. 195: View Of Positive Battery Cable Fasteners
Courtesy of GENERAL MOTORS CORP.

10. Install the following to the positive battery cable clip:
    - Engine wiring harness clip
    - Positive battery cable clip

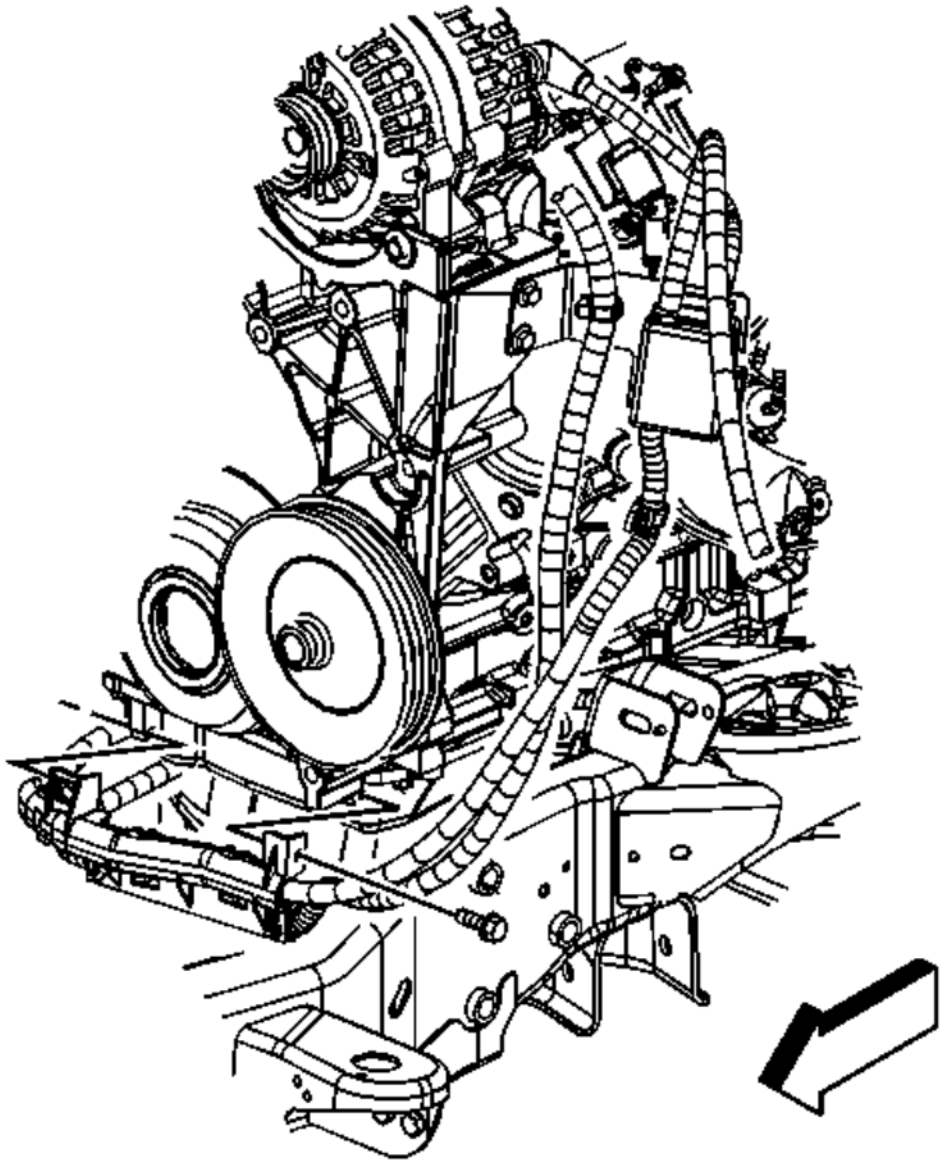

Fig. 196: View Of Positive Battery Cable, Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

11. Slide the channel pin in to the oil pan tab.
12. Install the battery cable channel bolt.

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

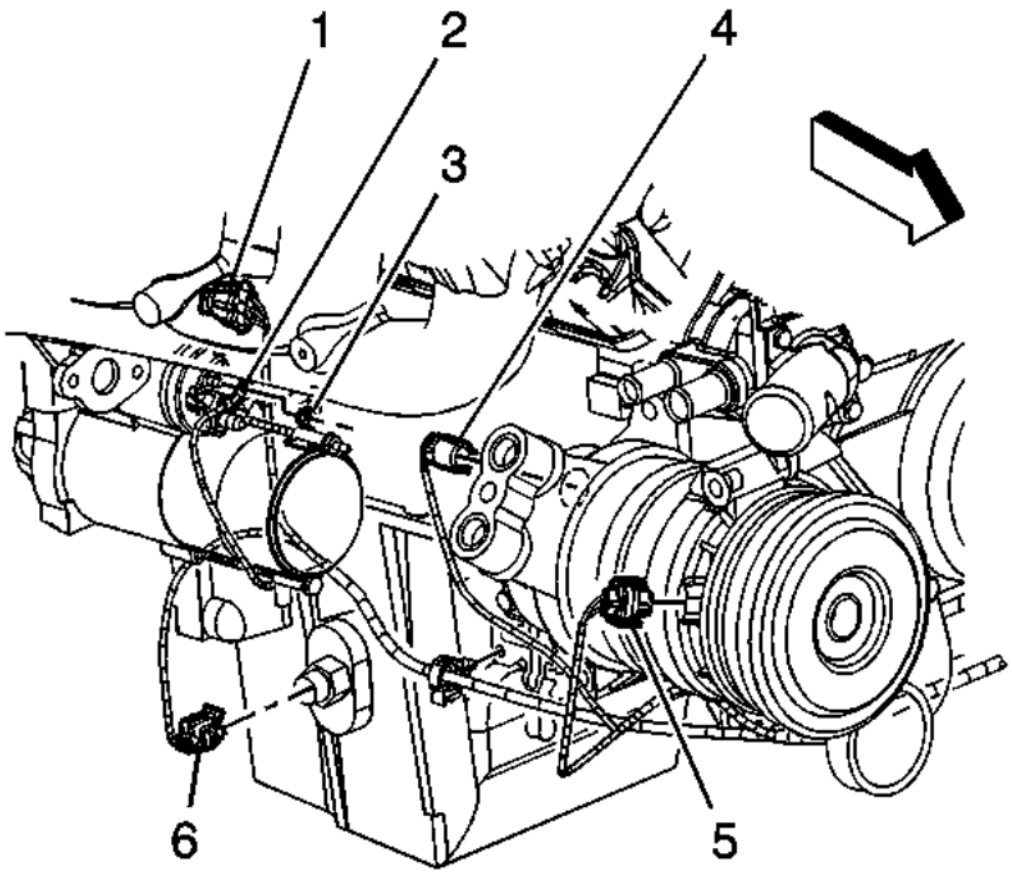

Fig. 197: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

13. Connect the oil level sensor electrical connector (6).

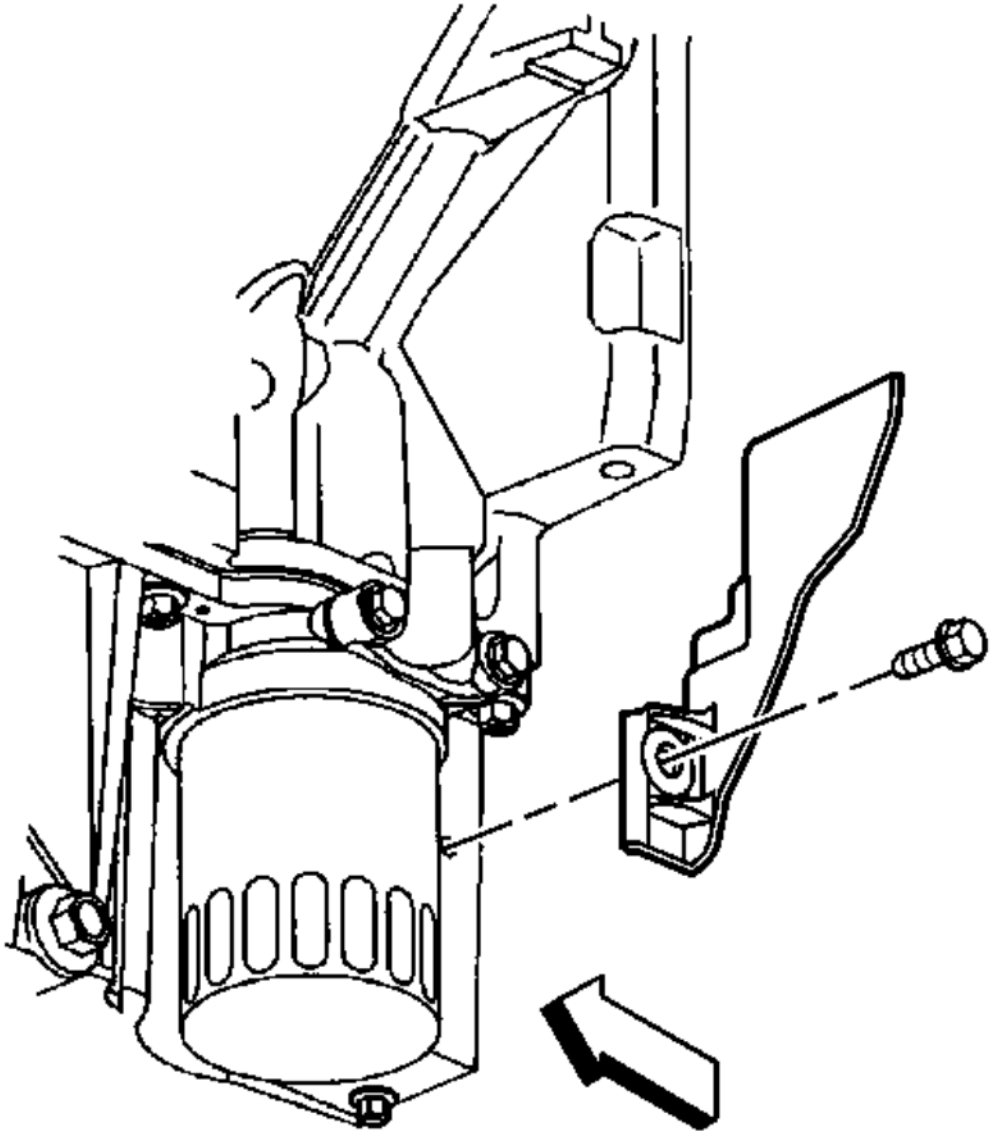

Fig. 198: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the transmission cover and bolt.

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

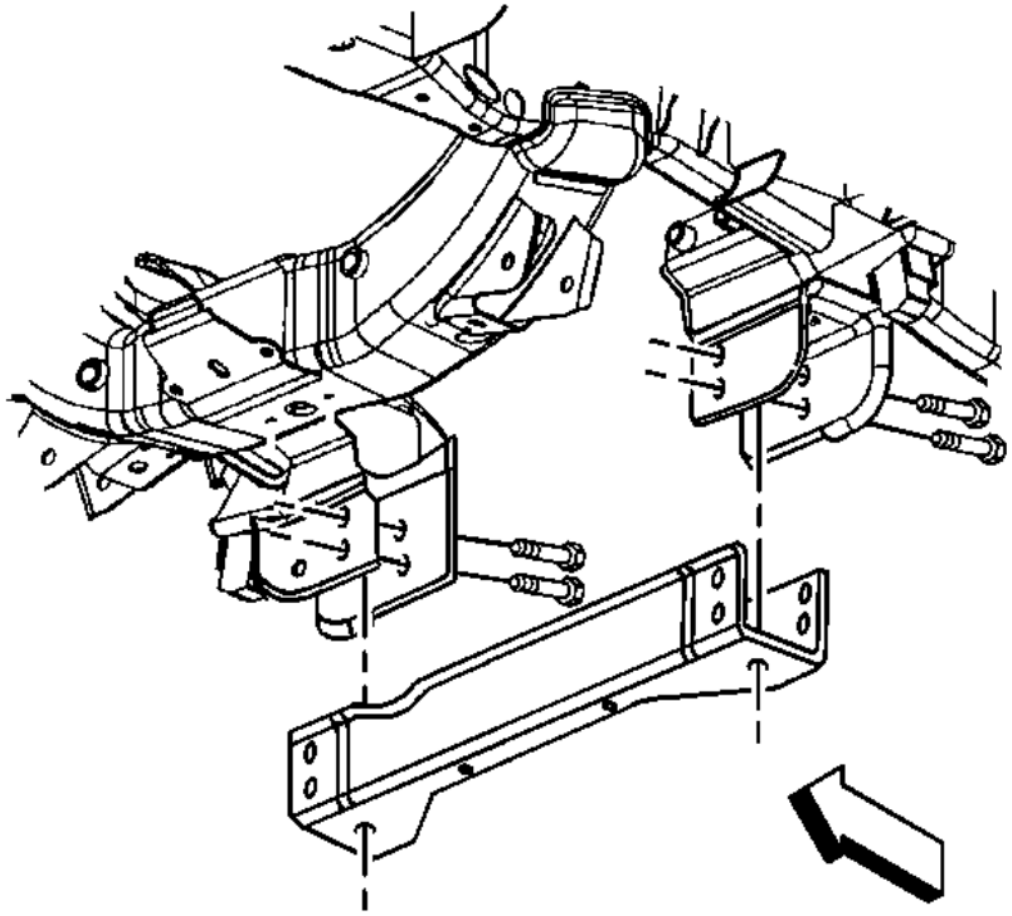

Fig. 199: View Of Crossbar Bolts & Bar (2WD)
Courtesy of GENERAL MOTORS CORP.

15. Install the crossbar.
16. Install the crossbar bolts.

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

17. Install the starter motor. Refer to **Starter Motor Replacement** .
18. Install the front differential. Refer to **Differential Carrier Assembly Replacement** .
19. Install new engine oil and a new oil filter. Refer to **Engine Oil and Oil Filter Replacement**.

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Special Tools

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

Removal Procedure

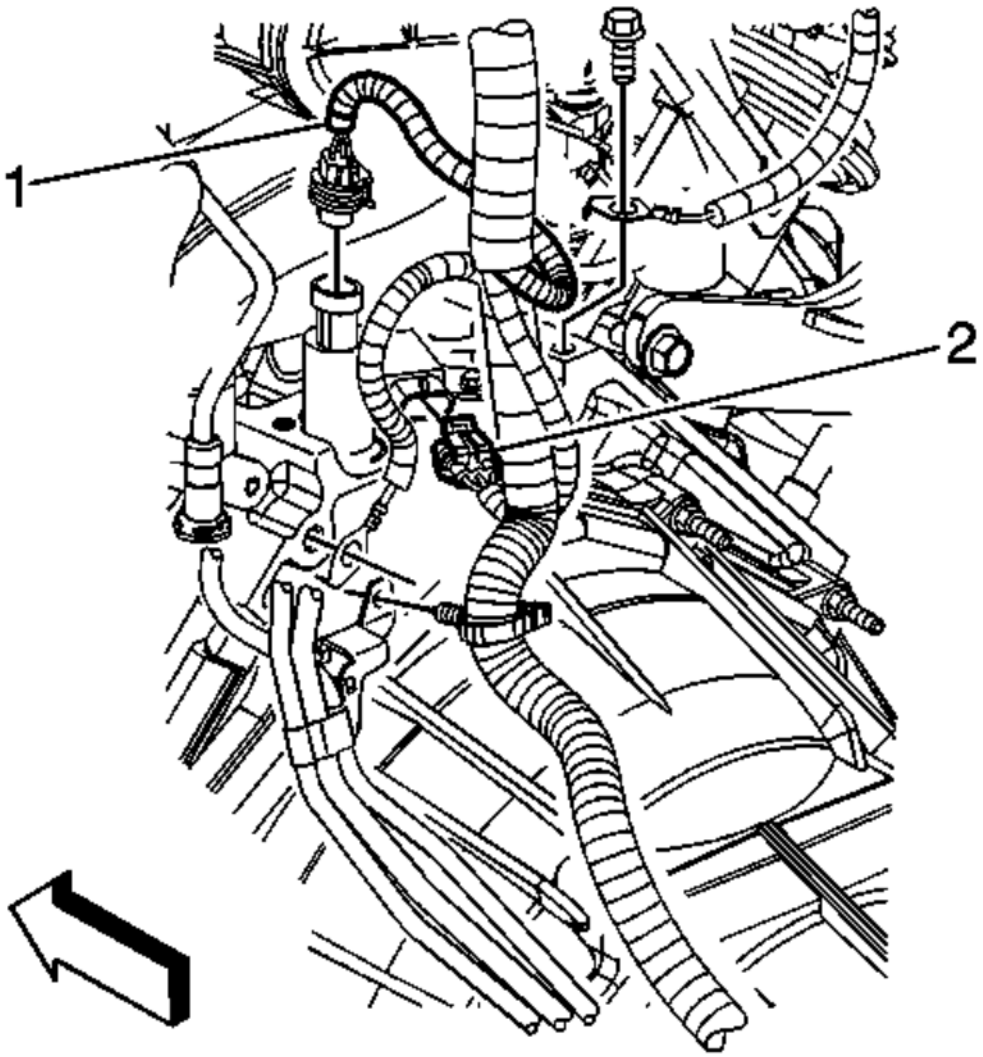

Fig. 200: View Of Oil Pressure Sensor & CMP Sensor Connectors

Courtesy of GENERAL MOTORS CORP.

1. If necessary, remove the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.
2. Disconnect the oil pressure sensor electrical connector (1).

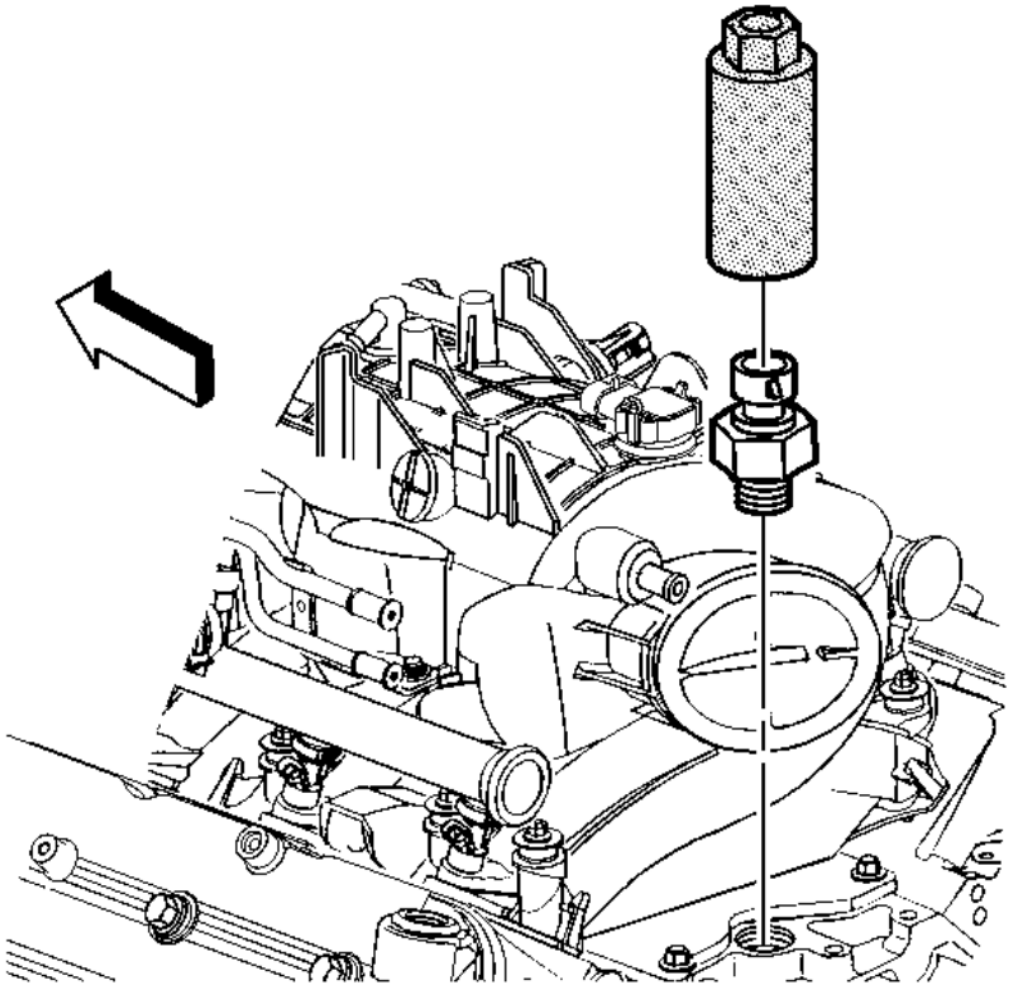

Fig. 201: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

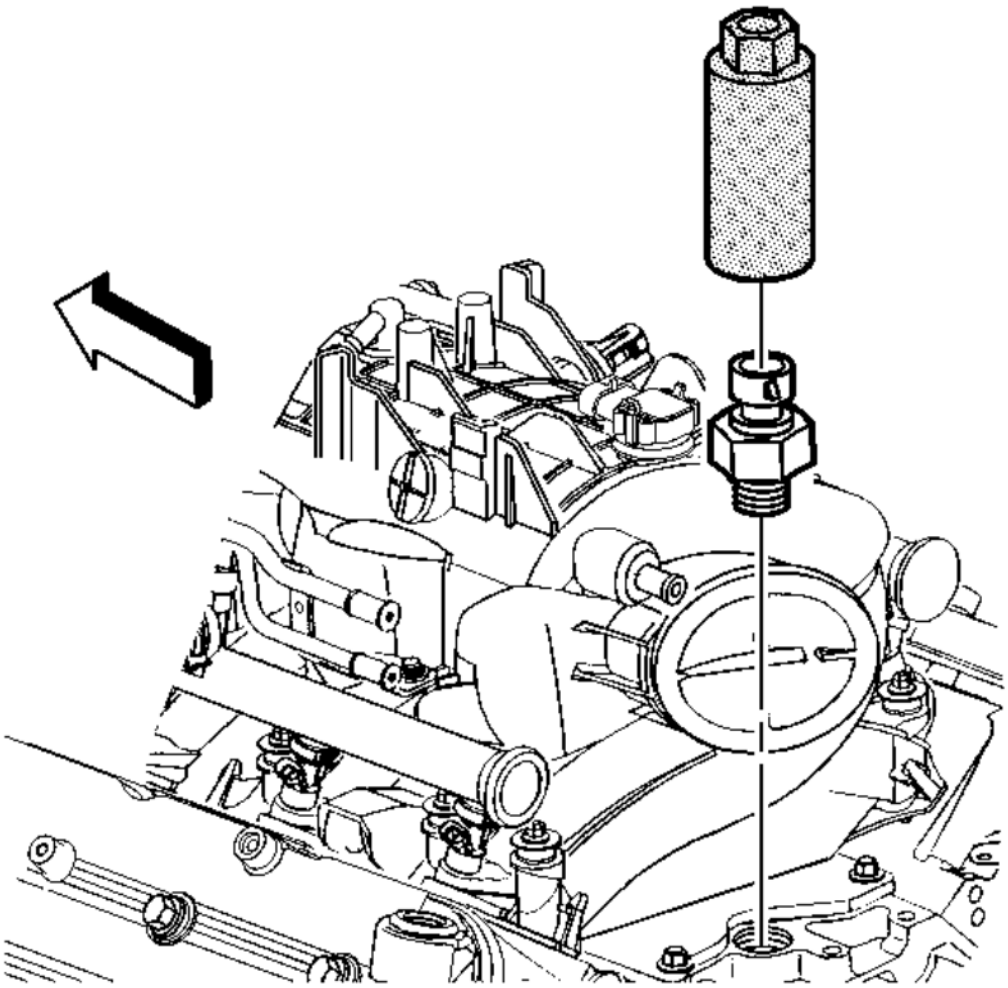

Fig. 202: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant to the threads of the oil pressure sensor. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

NOTE: Refer to Fastener Notice .

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

Tighten: Tighten the oil pressure sensor to 35 N.m (26 lb ft).

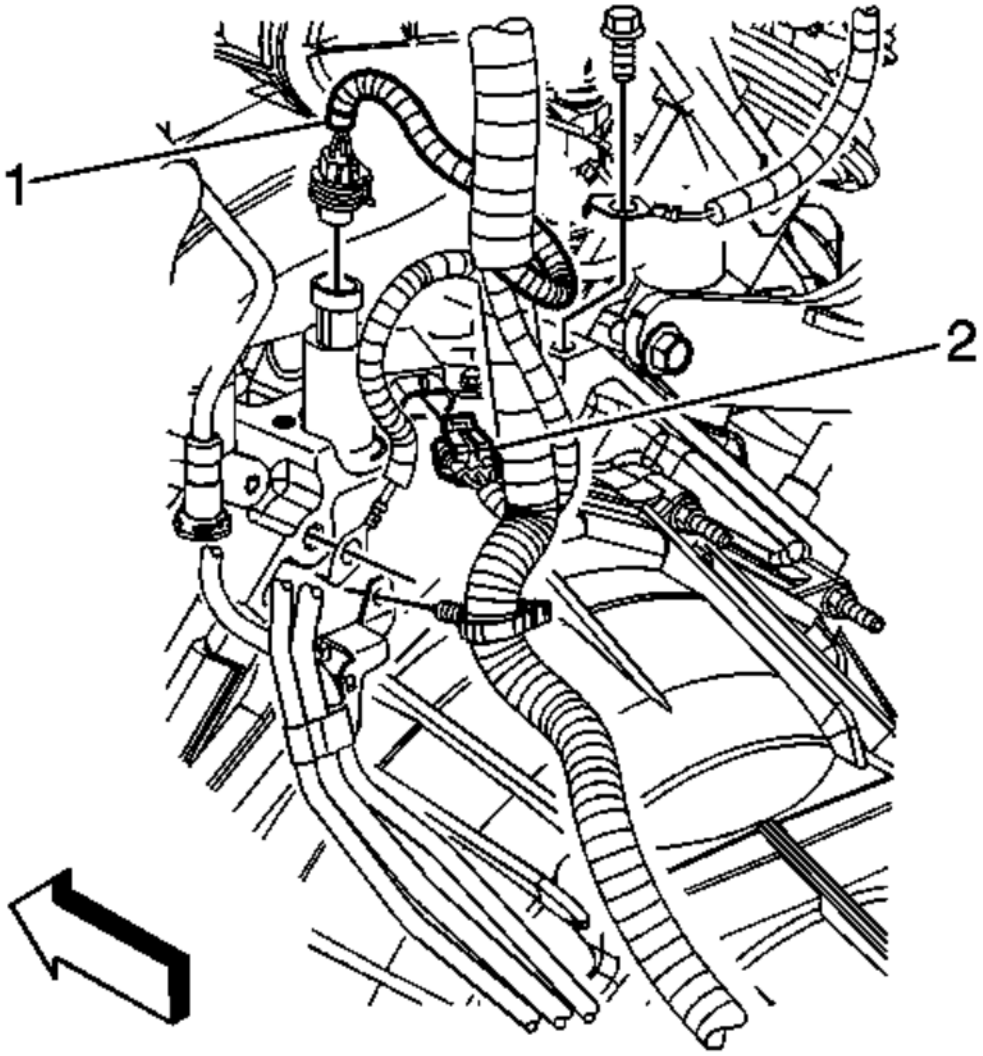

Fig. 203: View Of Oil Pressure Sensor & CMP Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (1).
4. If necessary, install the engine sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement (6.0L (LQ4))**.

ENGINE OIL LEVEL SENSOR AND/OR SWITCH REPLACEMENT

Removal Procedure

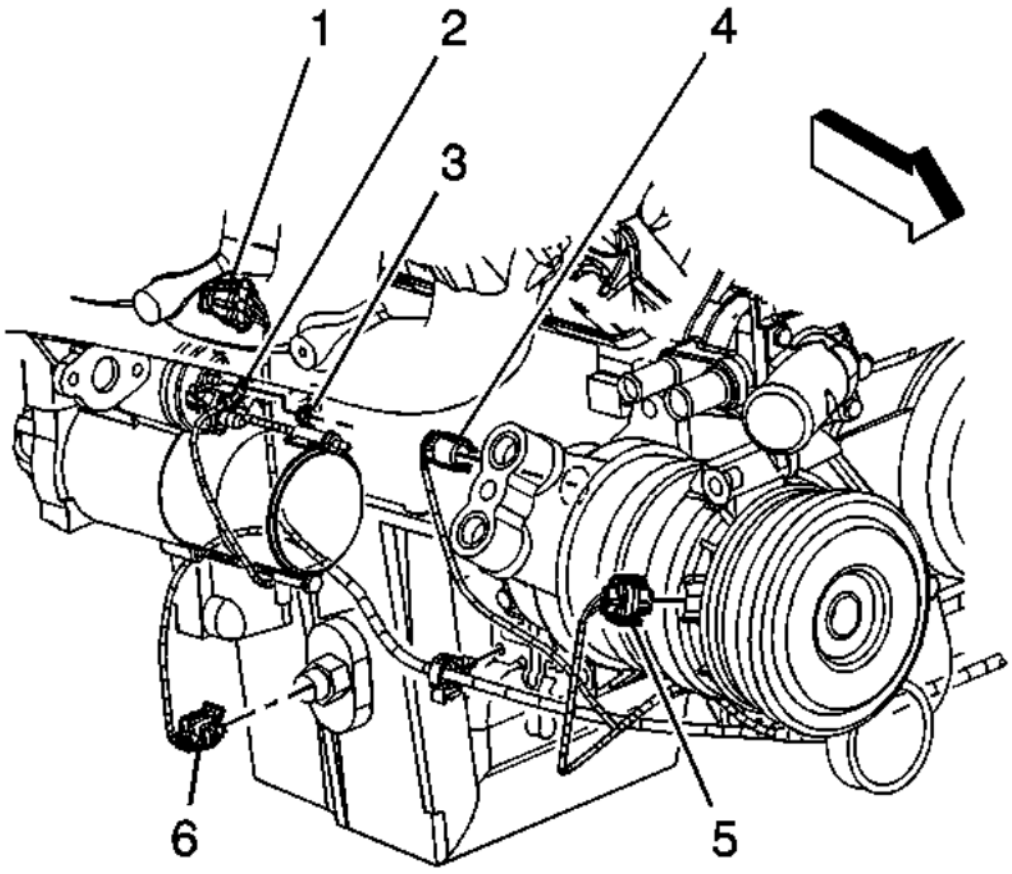

Fig. 204: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
2. Disconnect the oil level sensor electrical connector (6).

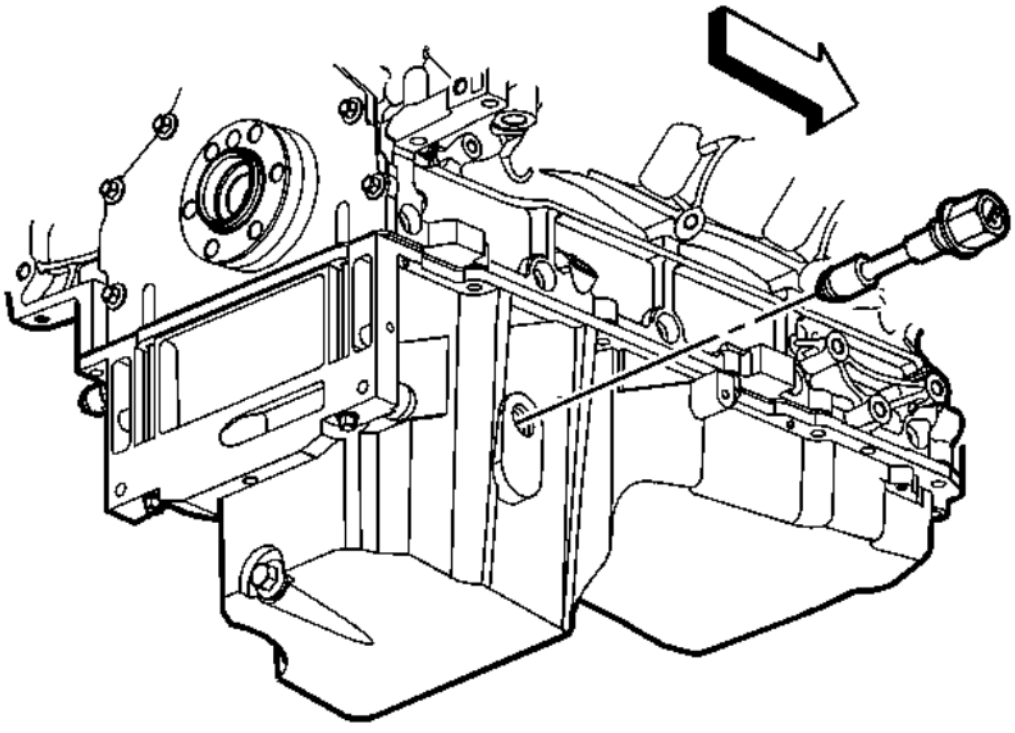

Fig. 205: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil level sensor from the oil pan.

Installation Procedure

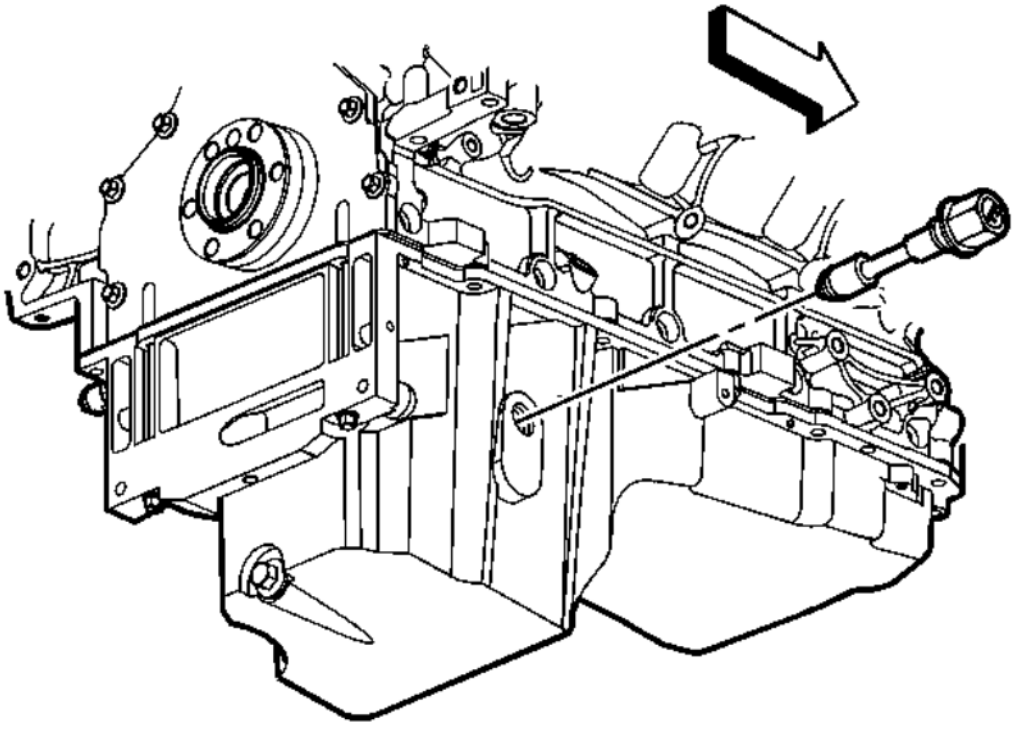

Fig. 206: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the oil level sensor to the oil pan.

   Tighten: Tighten the oil level sensor to 13 N.m (115 lb in).

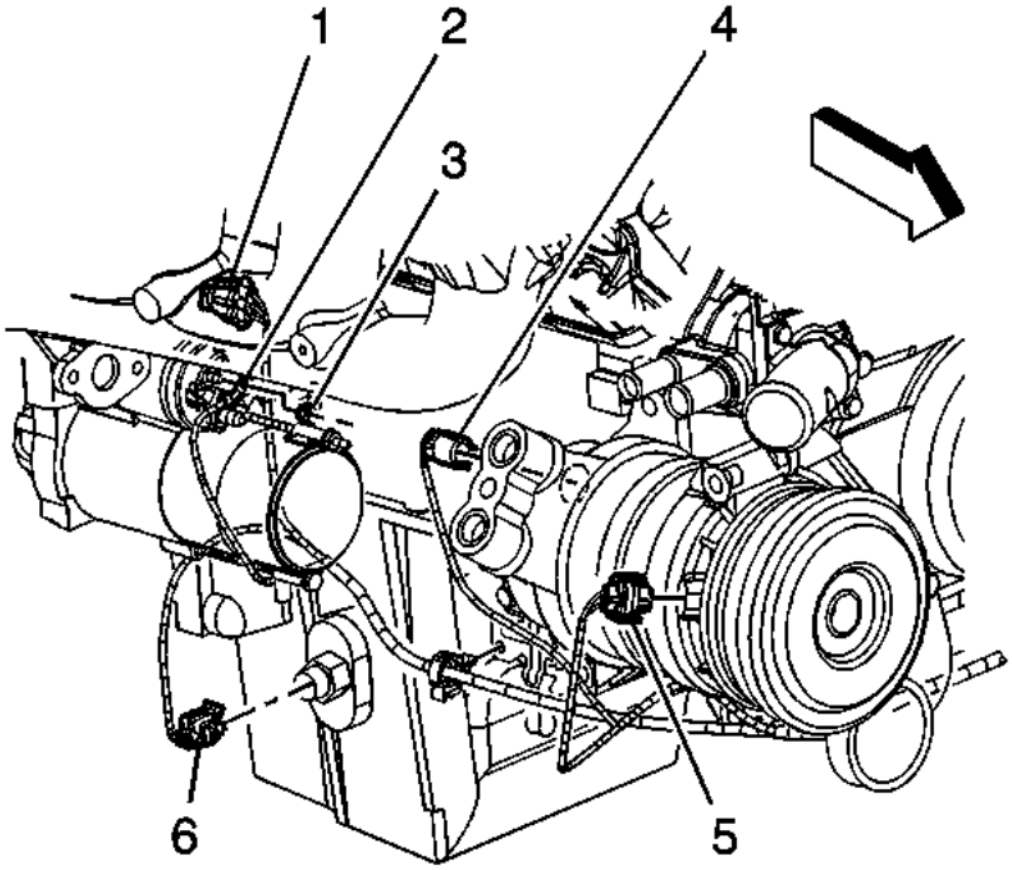

Fig. 207: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

2. Connect the oil level sensor electrical connector (6).
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

OIL PUMP, SCREEN, AND CRANKSHAFT OIL DEFLECTOR REPLACEMENT

Removal Procedure

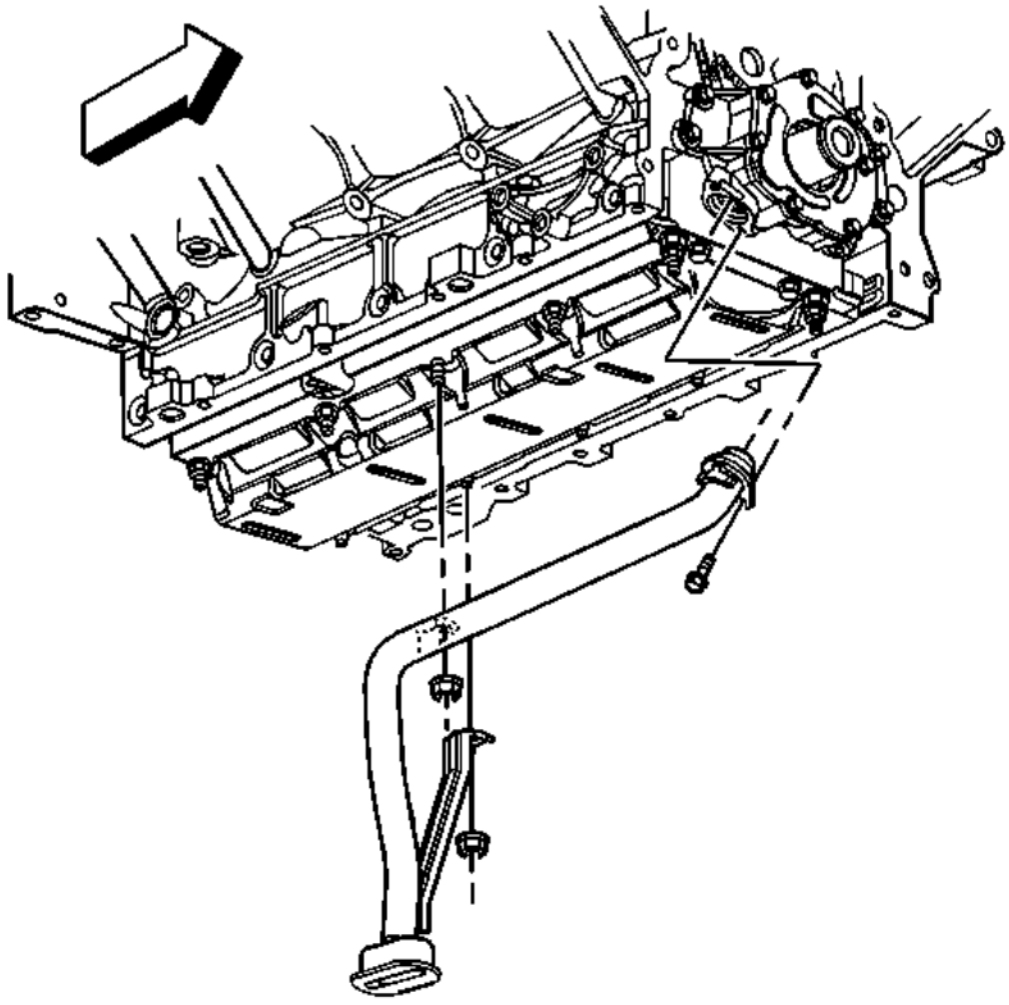

Fig. 208: View Of Oil Pump Screen & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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.

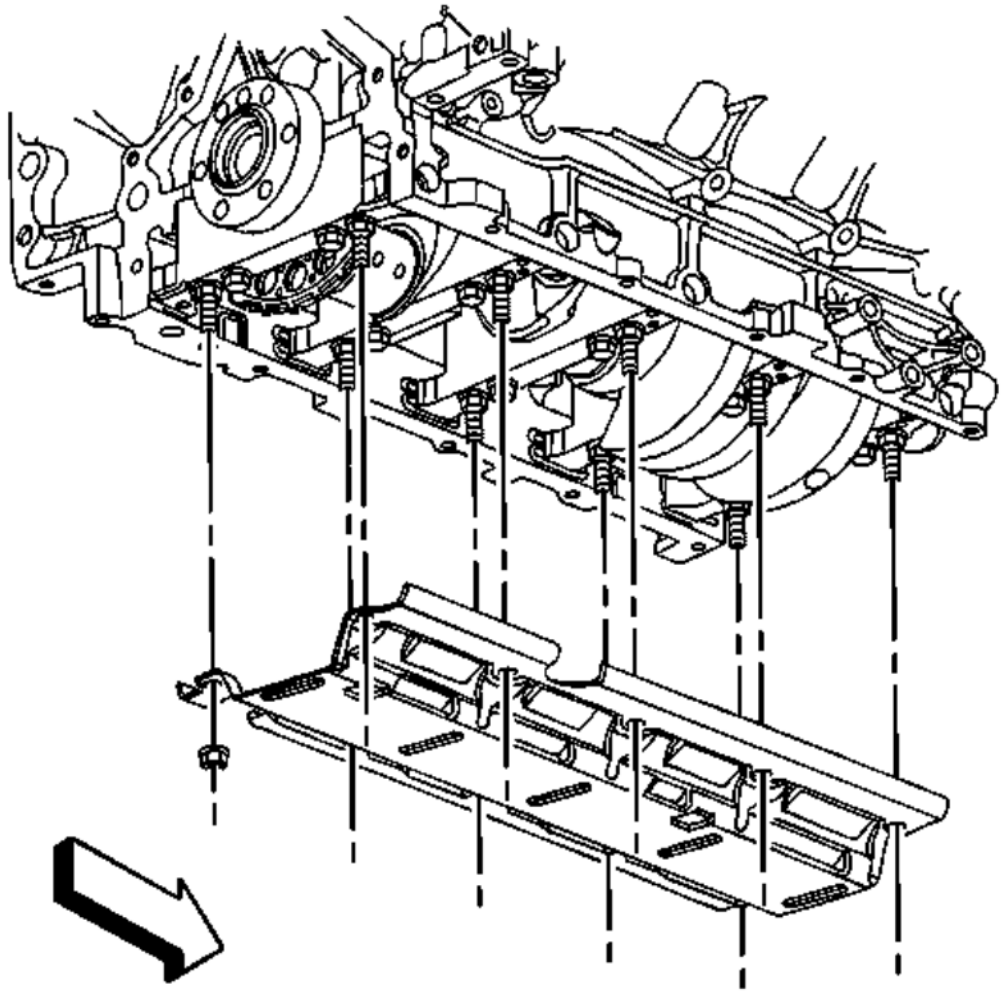

Fig. 209: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

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

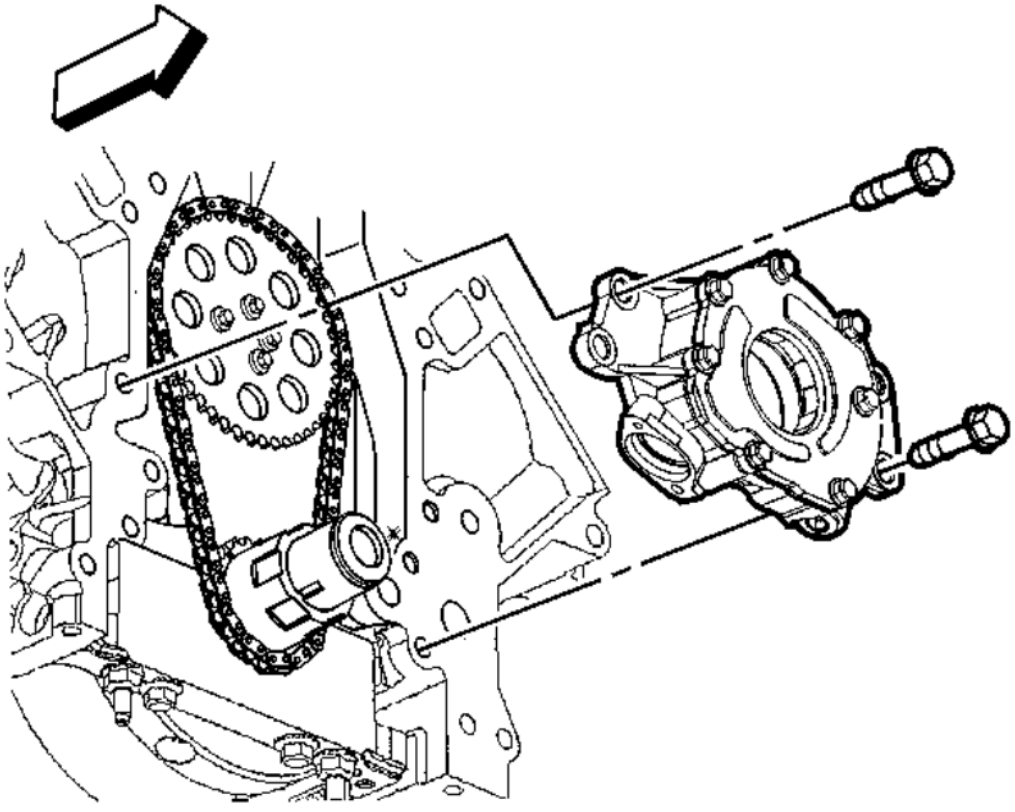

Fig. 210: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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

Installation Procedure

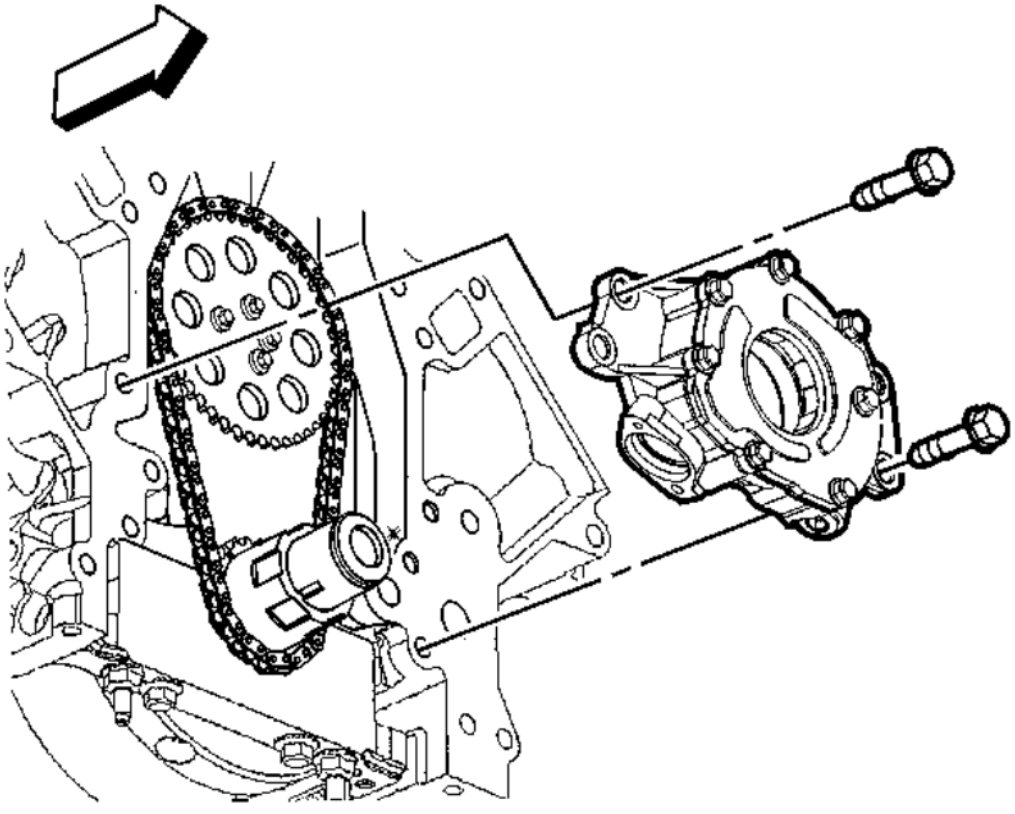

Fig. 211: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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 .

3. Install the oil pump bolts.

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

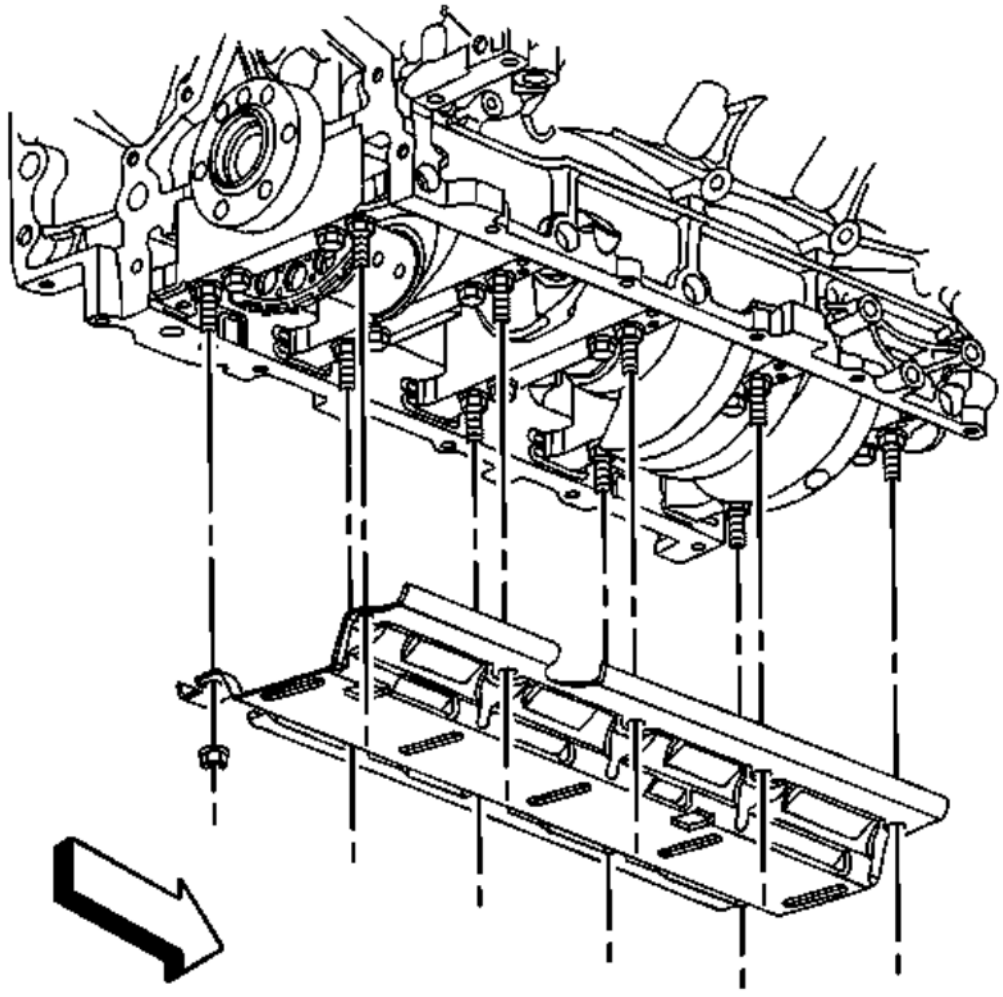

Fig. 212: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

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

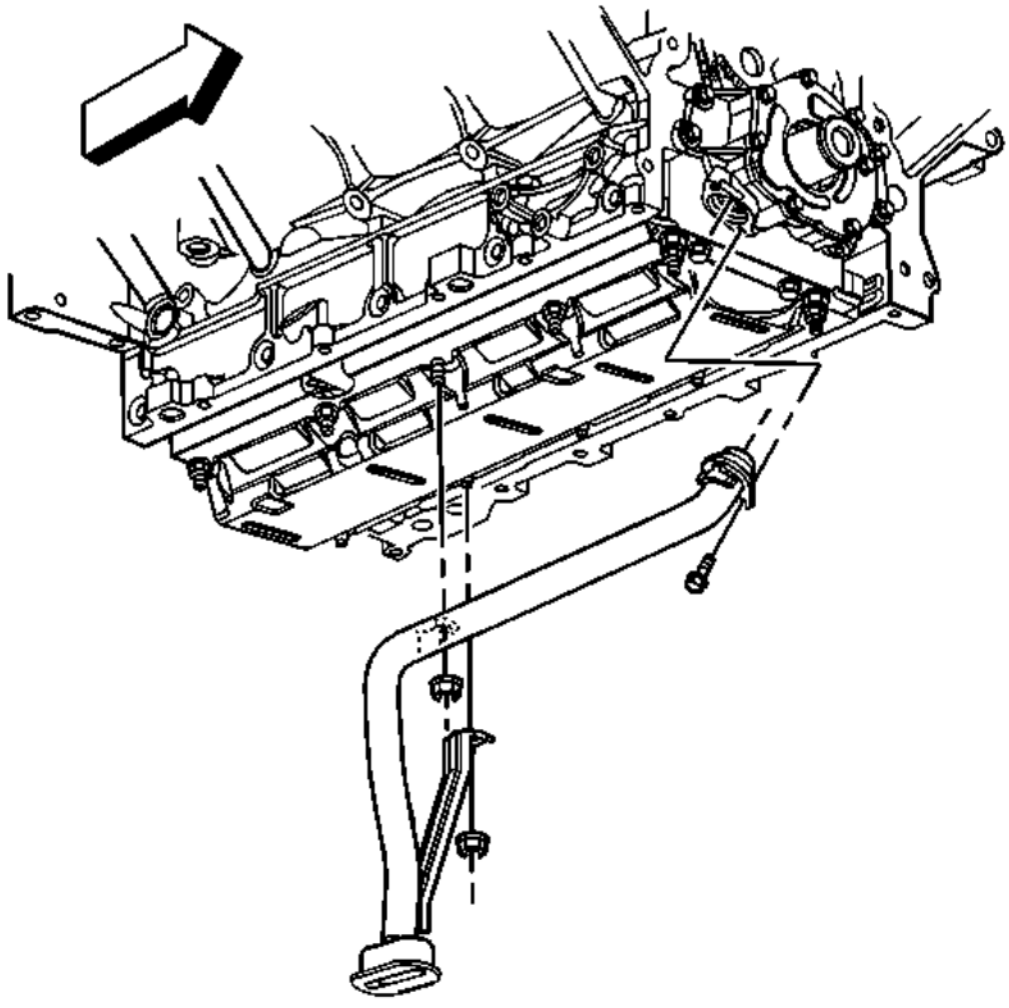

Fig. 213: View Of Oil Pump Screen & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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.

Align the oil pump screen mounting brackets with the correct crankshaft bearing cap studs.

7. Install the oil pump screen.
8. Install the oil pump screen bolt and nuts.

   Tighten:

   1. Tighten the oil pump screen bolt to 12 N.m (106 lb in).
   2. Tighten the crankshaft oil deflector/oil pump screen nuts to 25 N.m (18 lb ft).

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

TIMING CHAIN AND SPROCKET REPLACEMENT

Special Tools

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

Removal Procedure

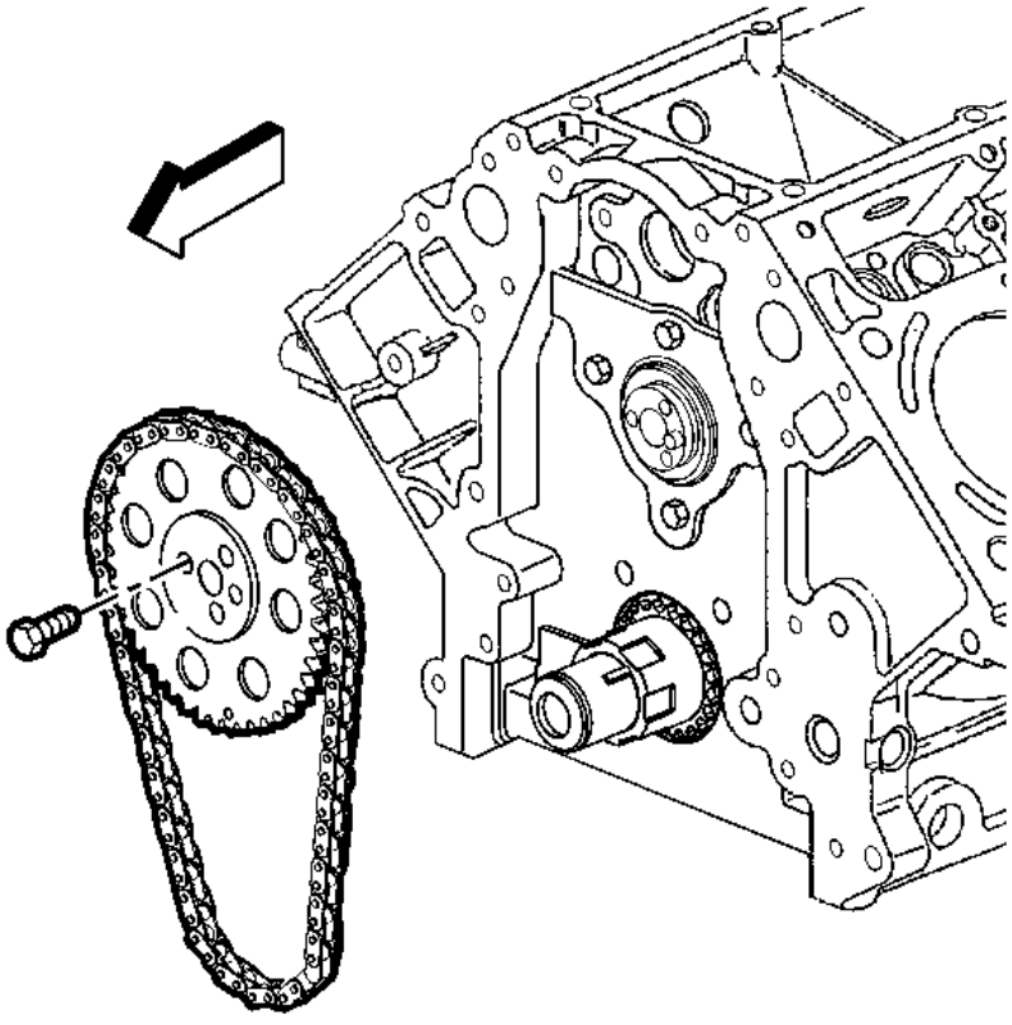

Fig. 214: Camshaft Sprocket, Bolt & Timing Chain
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump. Refer to **Oil Pump, Screen, and Crankshaft Oil Deflector Replacement**.
2. Rotate the crankshaft until the timing marks on the crankshaft and the camshaft sprockets are aligned.

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.

3. Remove the camshaft sprocket bolts.
4. Remove the camshaft sprocket and timing chain.

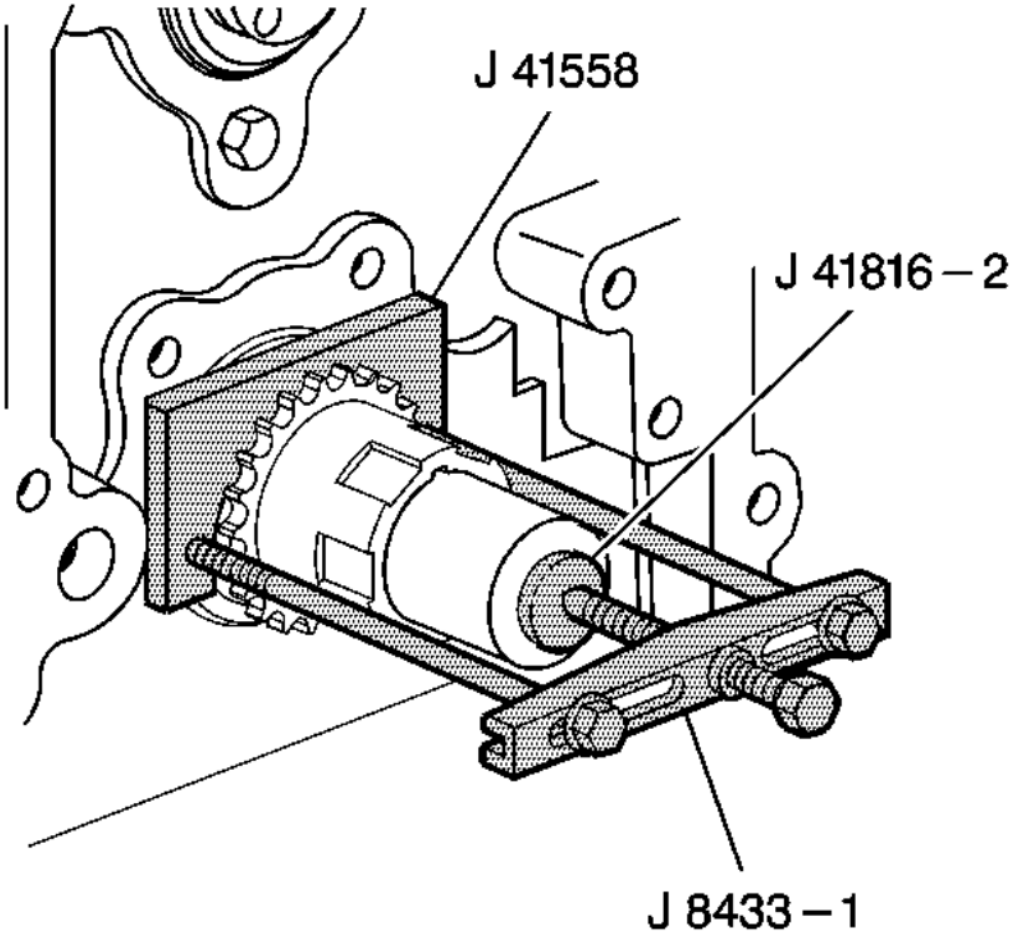

Fig. 215: Removing The Crankshaft Sprocket Using J 8433-1, J 41816-2 & J 41558
Courtesy of GENERAL MOTORS CORP.

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

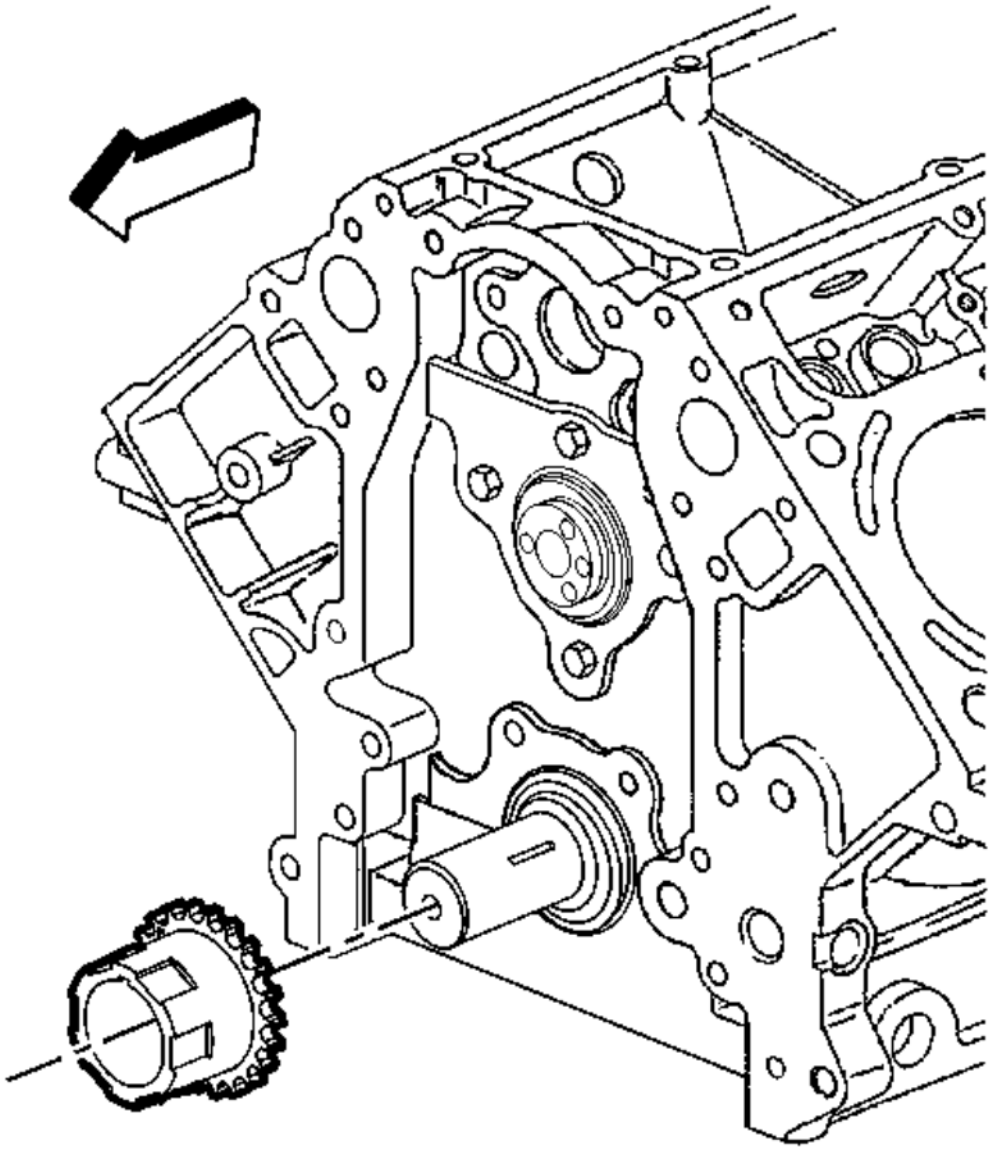

Fig. 216: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft sprocket.

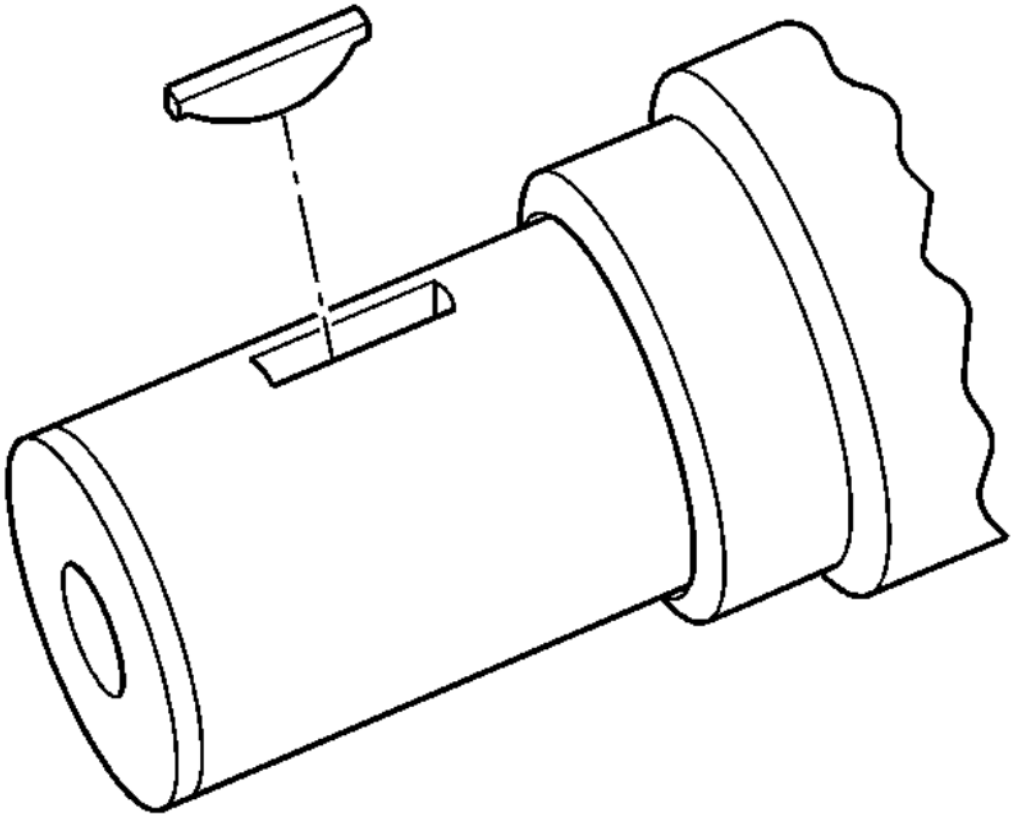

Fig. 217: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

7. Remove the crankshaft sprocket key, if required.
8. Clean and inspect the timing chain and sprockets. Refer to **Camshaft Position Actuator Cleaning and Inspection**.

Installation Procedure

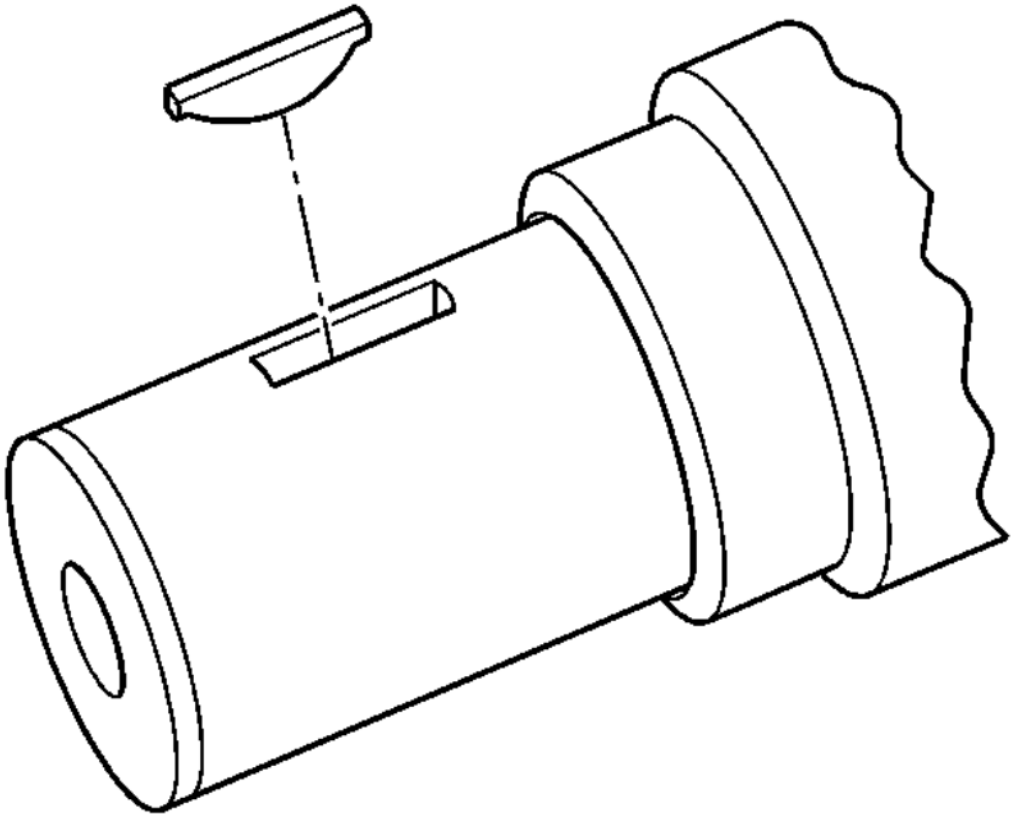

Fig. 218: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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

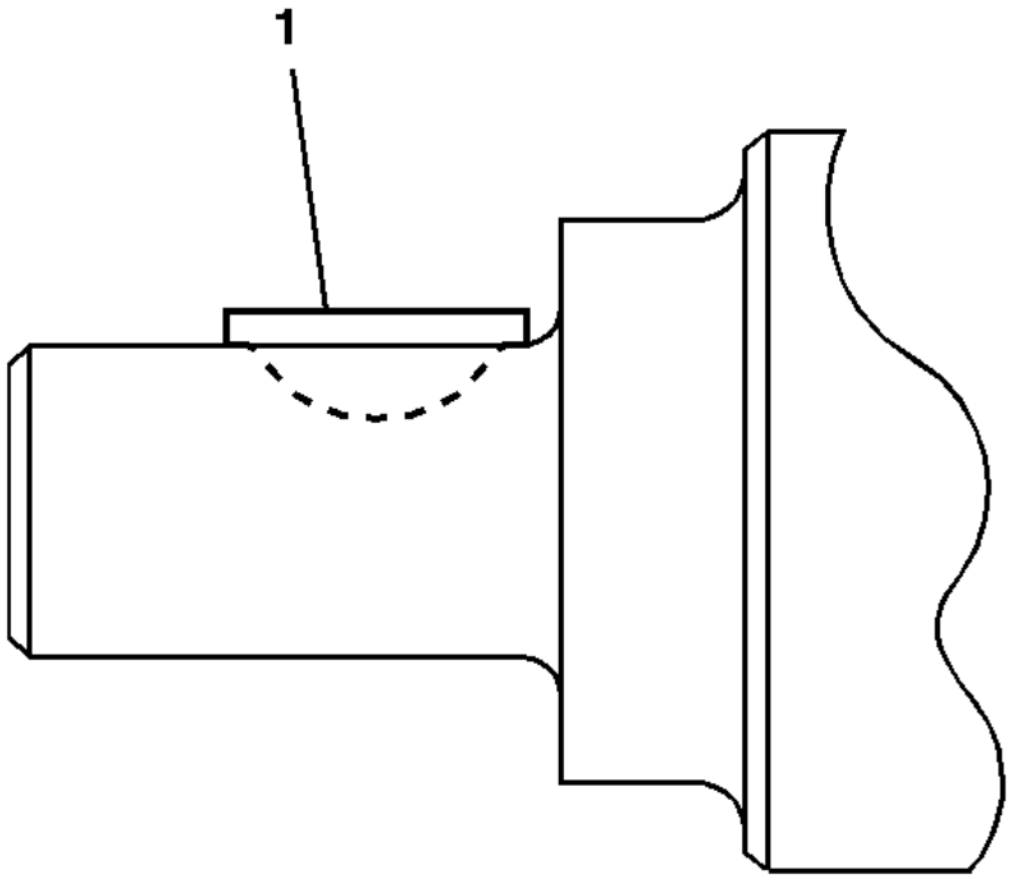

Fig. 219: View Of Crankshaft Sprocket Key Installation Position
Courtesy of GENERAL MOTORS CORP.

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

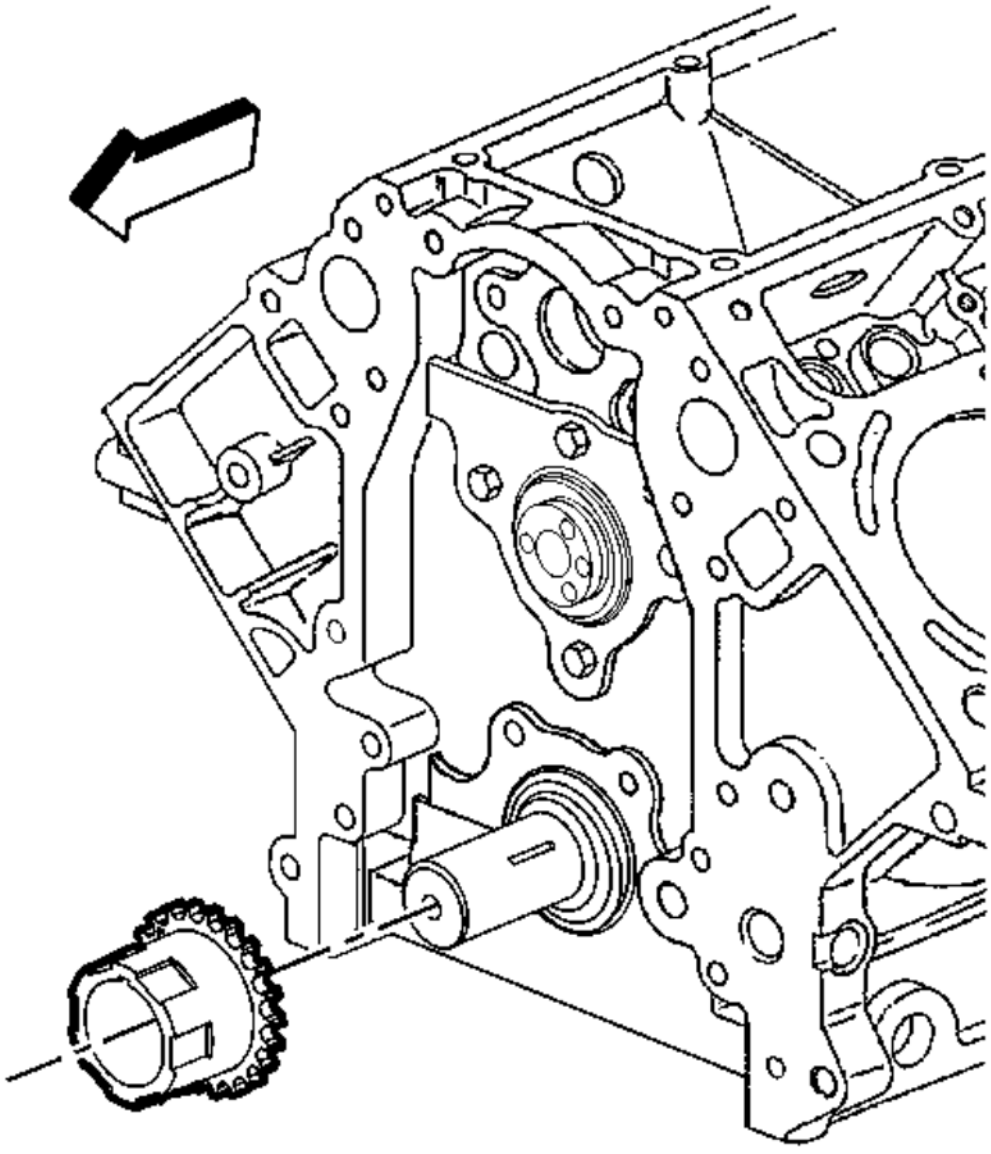

Fig. 220: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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

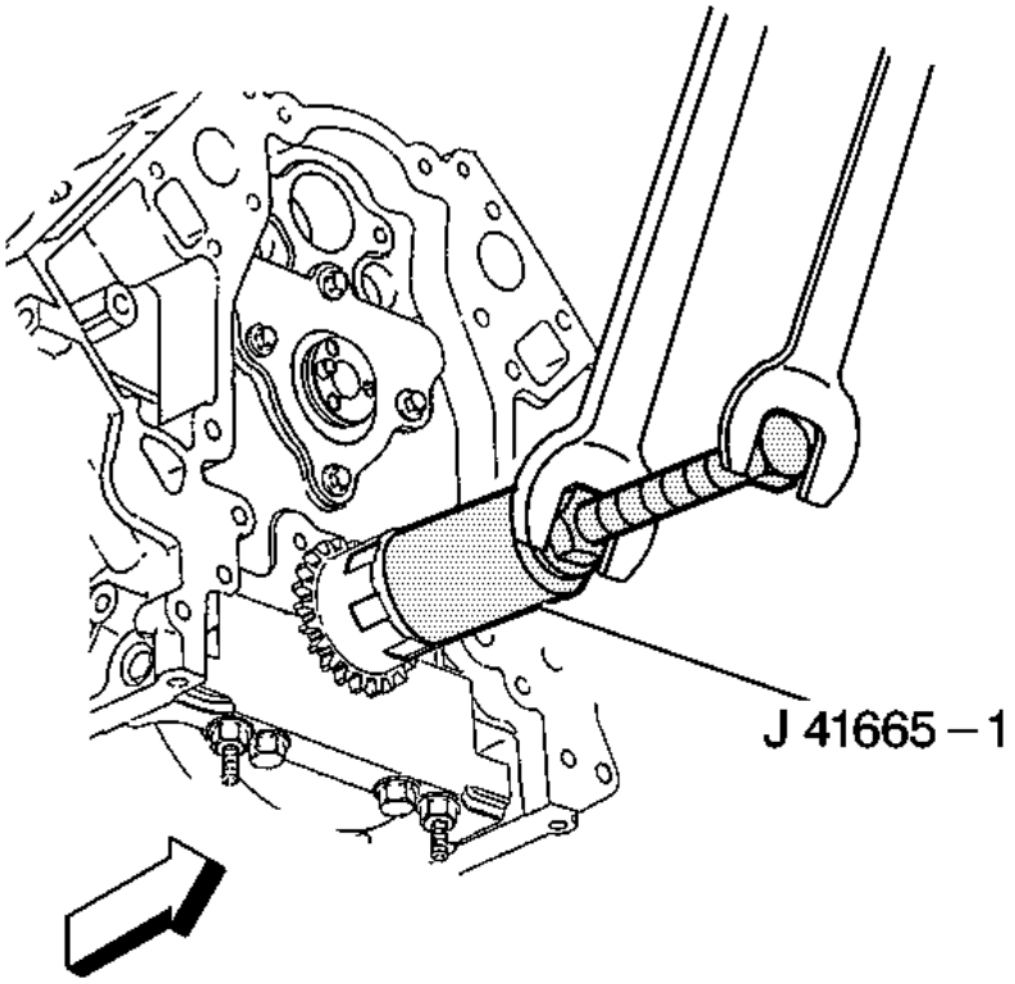

Fig. 221: Using J 41665 To Install Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Use the **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.

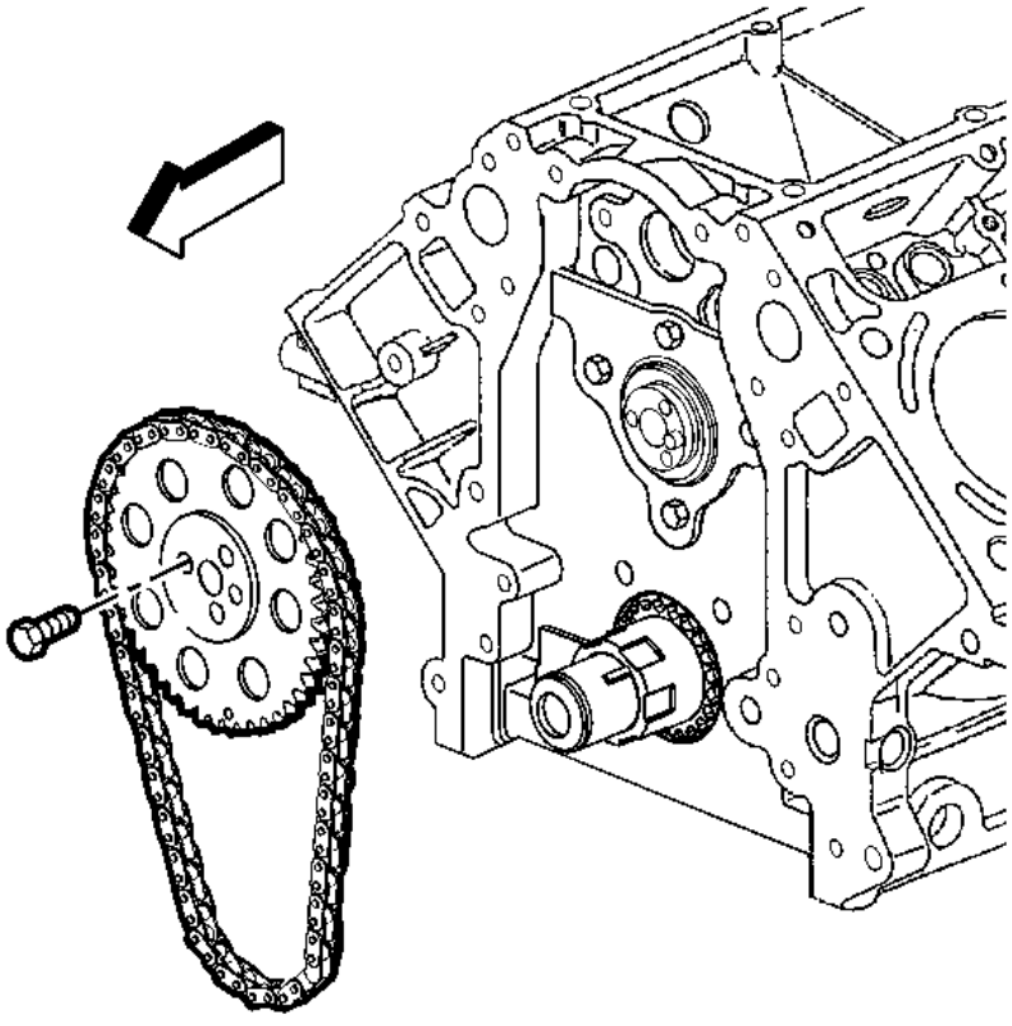

Fig. 222: Camshaft Sprocket, Bolt & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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 and timing chain.

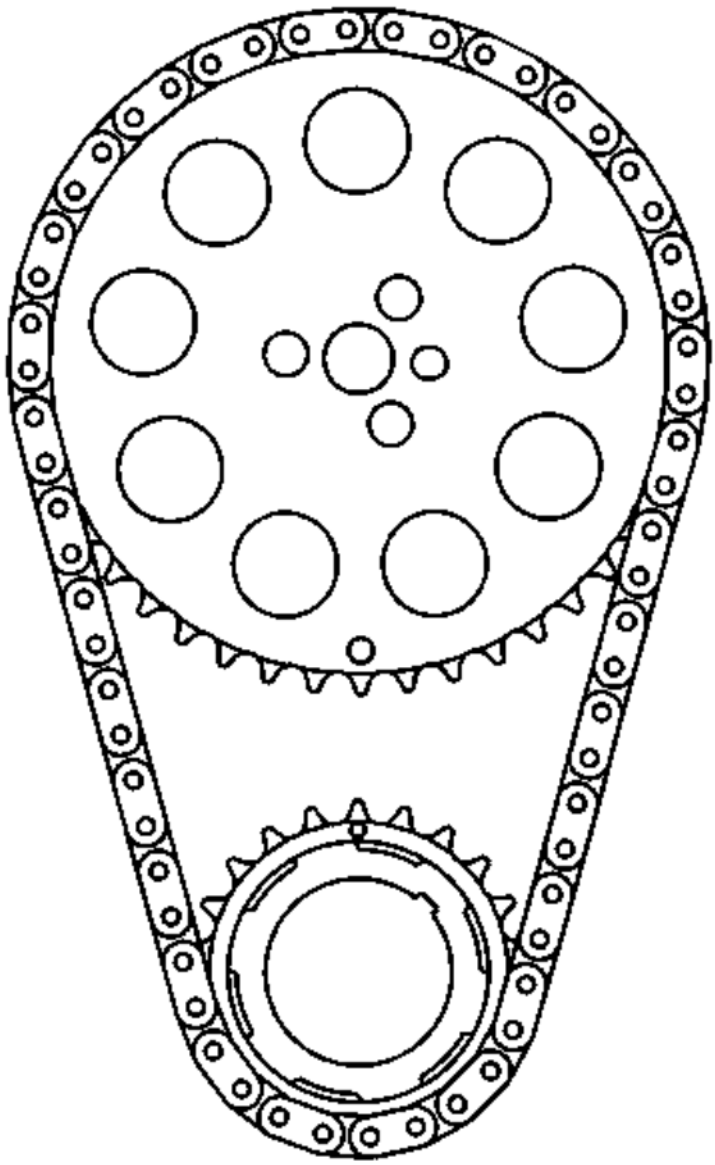

Fig. 223: View Of Camshaft & Crankshaft Sprockets Timing Marks Aligned
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

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

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

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

CAMSHAFT REPLACEMENT

Removal Procedure

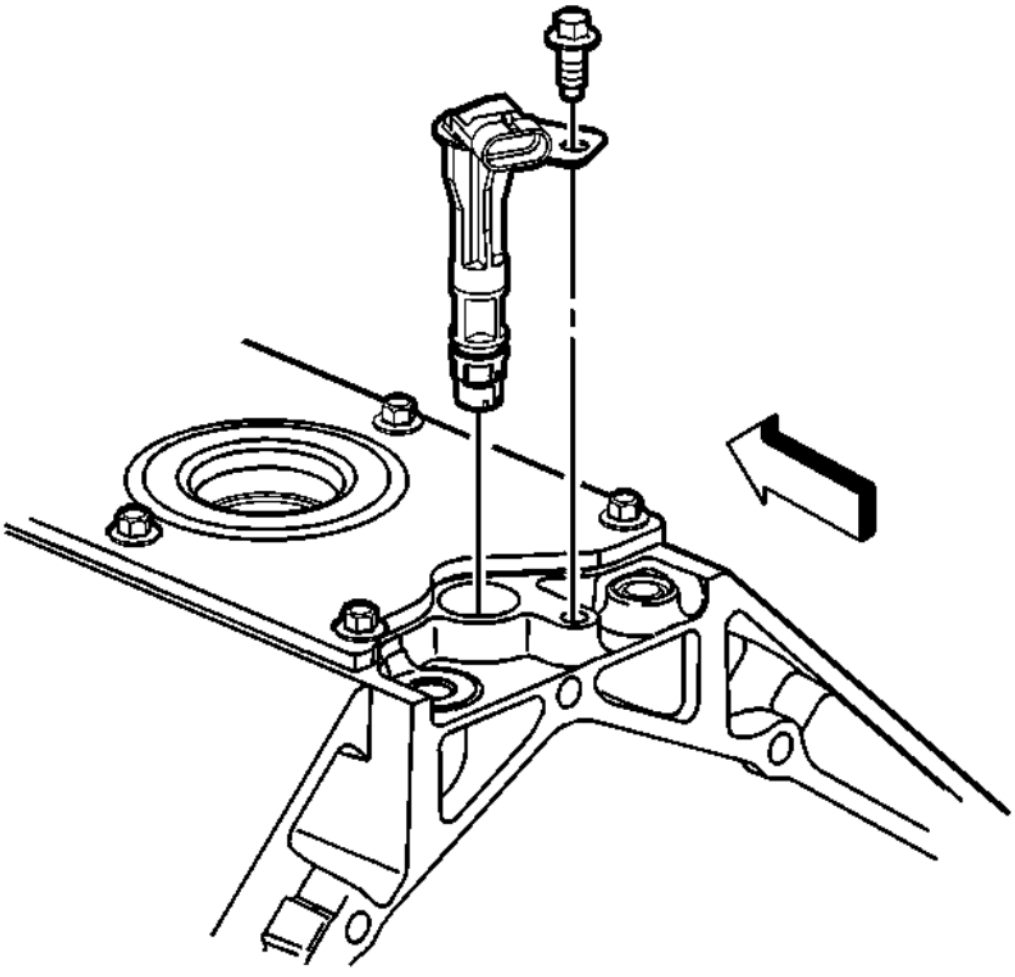

Fig. 224: View Of Camshaft Position (CMP) Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the hood. Refer to **Hood Replacement** .
2. Remove the radiator support. Refer to **Radiator Support Replacement** .
3. Remove the valve lifters from both cylinder heads. Refer to **Valve Lifter Replacement**.
4. Remove the camshaft sensor bolt and sensor.
5. Remove the engine front cover. Refer to **Engine Front Cover Removal**.
6. Rotate the engine until the timing marks are aligned.

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.

7. Remove the camshaft sprocket bolts.
8. Remove the camshaft sprocket and reposition the timing chain.

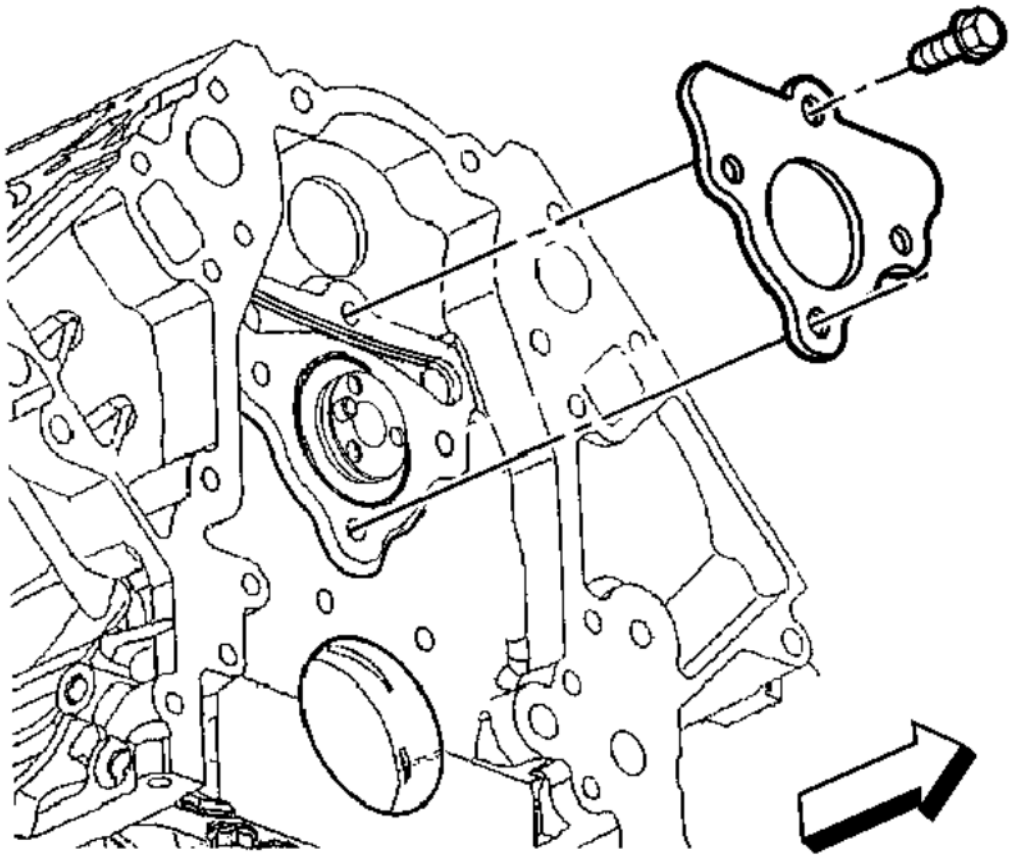

Fig. 225: View Of Camshaft Retainer Plate
Courtesy of GENERAL MOTORS CORP.

9. Remove the camshaft retainer bolts and retainer.

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.

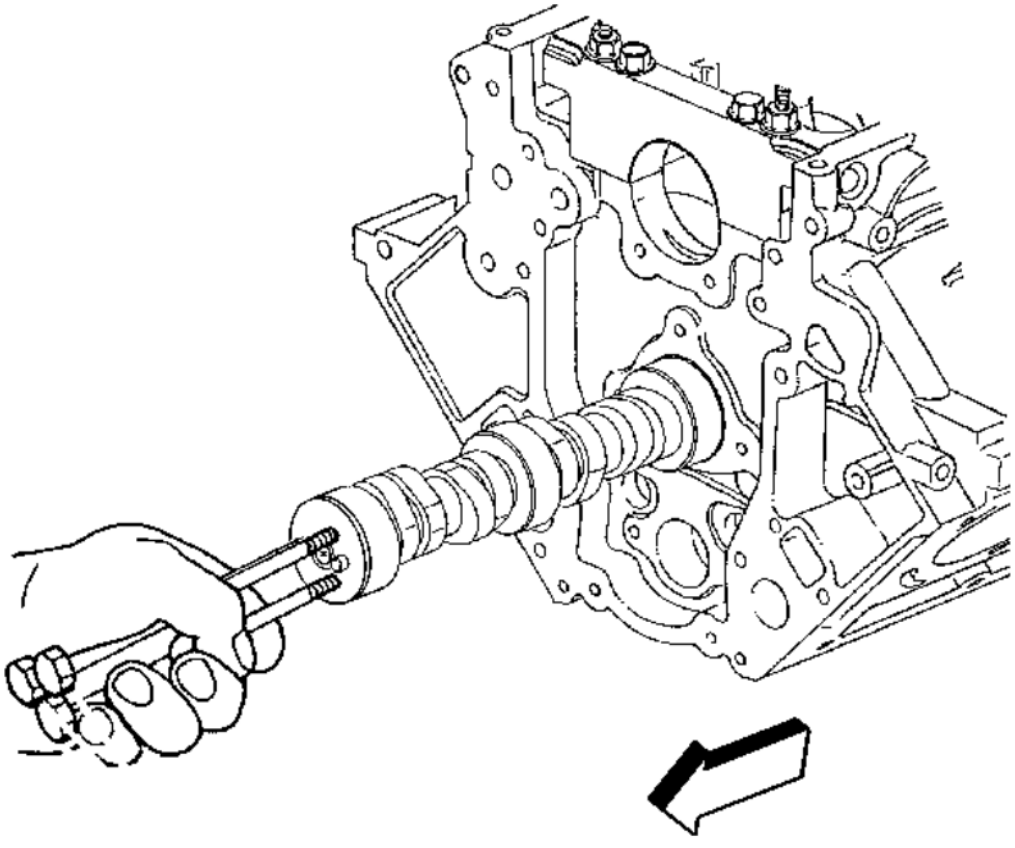

Fig. 226: View Of Bolts installed In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

10. 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.
11. Clean and inspect the camshaft and bearings. Refer to **Camshaft and Bearings Cleaning**

and Inspection.

Installation Procedure

IMPORTANT: If camshaft replacement is required, the valve lifters must also be replaced.

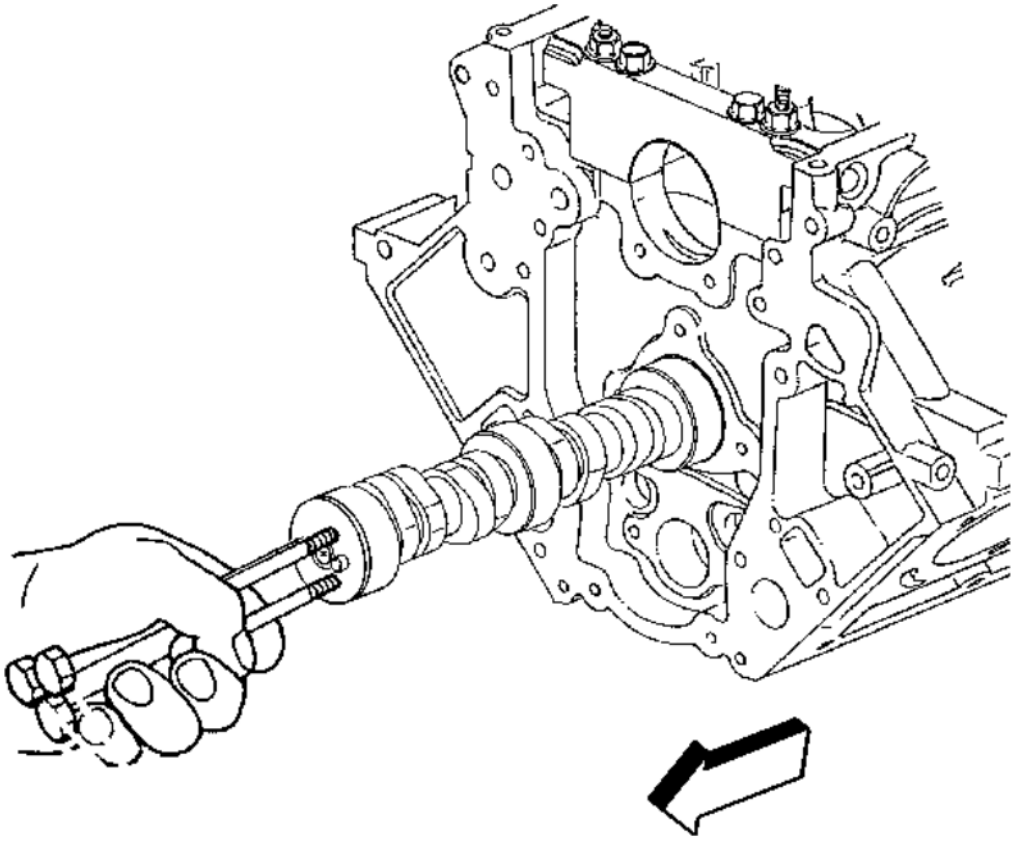

Fig. 227: View Of Bolts installed In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the camshaft journals and the bearings with clean engine oil.
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.

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 three bolts from the front of the camshaft.

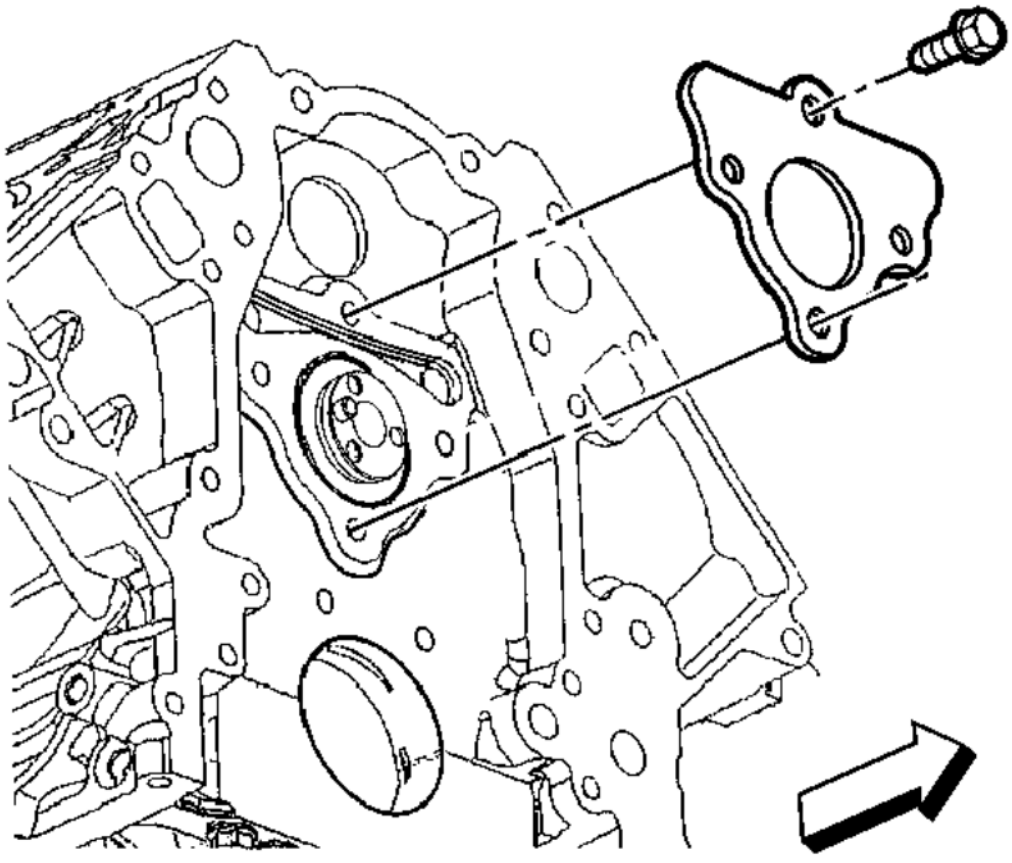

Fig. 228: View Of Camshaft Retainer Plate
Courtesy of GENERAL MOTORS CORP.

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 .

5. Install the camshaft retainer and bolts.

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

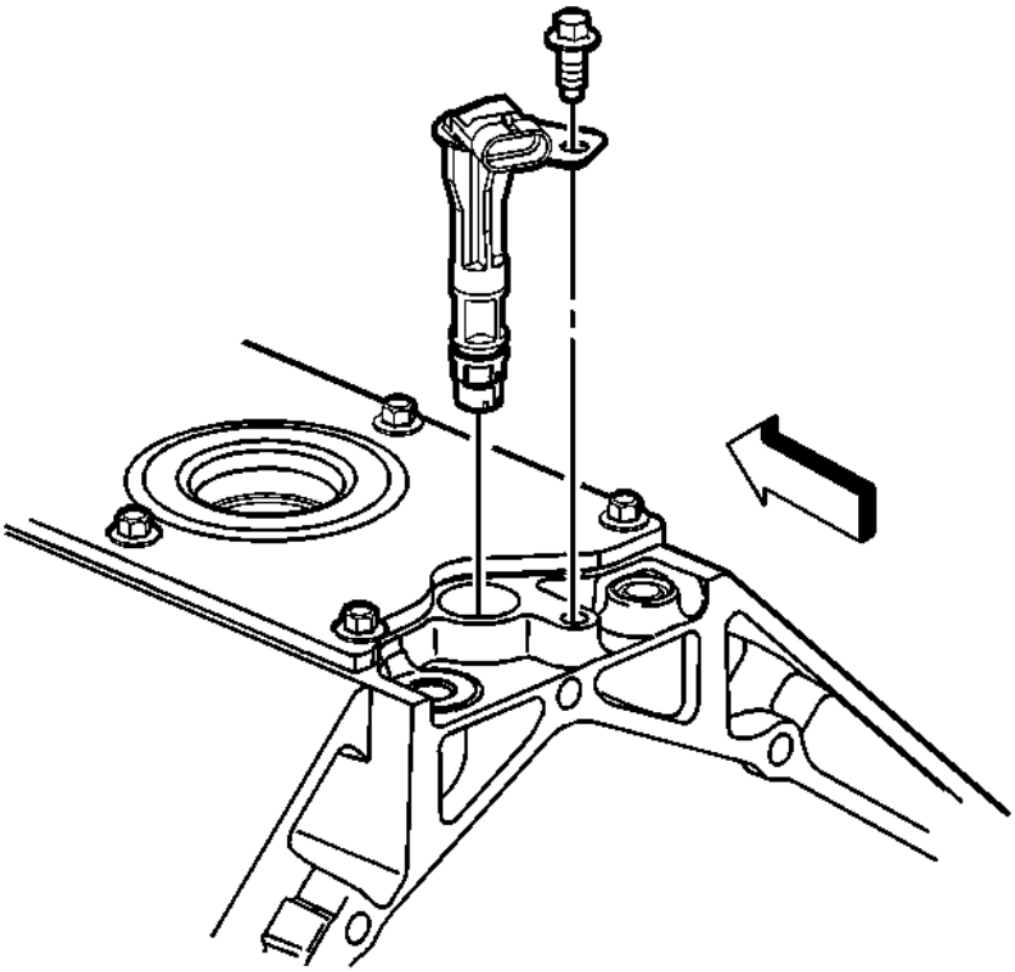

Fig. 229: View Of Camshaft Position (CMP) Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Inspect the camshaft sensor O-ring seal. If the O-ring seal is not cut or damaged, it may be reused.
7. Lubricate the O-ring seal with clean engine oil.
8. Install the camshaft sensor and bolt.

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

9. Install the camshaft sprocket and timing chain. Refer to **Timing Chain and Sprocket Replacement**.
10. Install the engine front cover. Refer to **Engine Front Cover Removal**.
11. Install the valve lifters. Refer to **Valve Lifter Replacement**.
12. Install the radiator support. Refer to **Radiator Support Replacement** .
13. Install the hood. Refer to **Hood Replacement** .
14. Lower the hood to the normal position.

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Removal Procedure

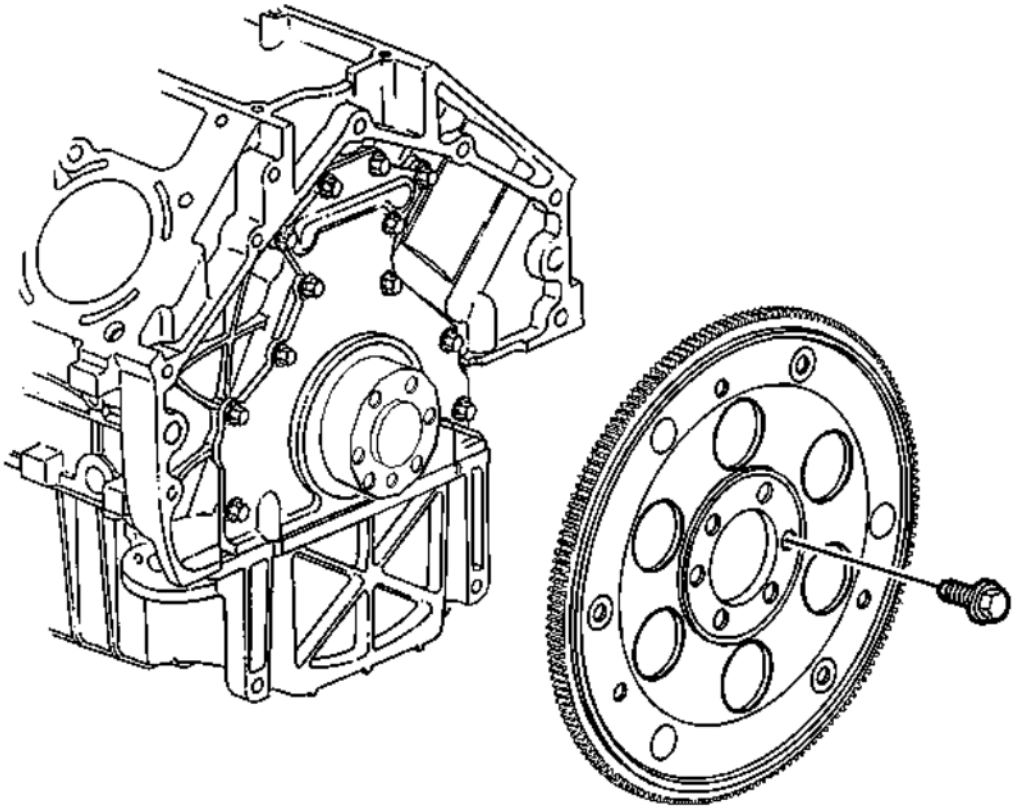

Fig. 230: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Note the position and direction of the engine flywheel before removal.

1. Remove the automatic transmission. Refer to **Transmission Replacement** .
2. Remove the engine flywheel bolts.
3. Remove the automatic transmission engine flywheel.

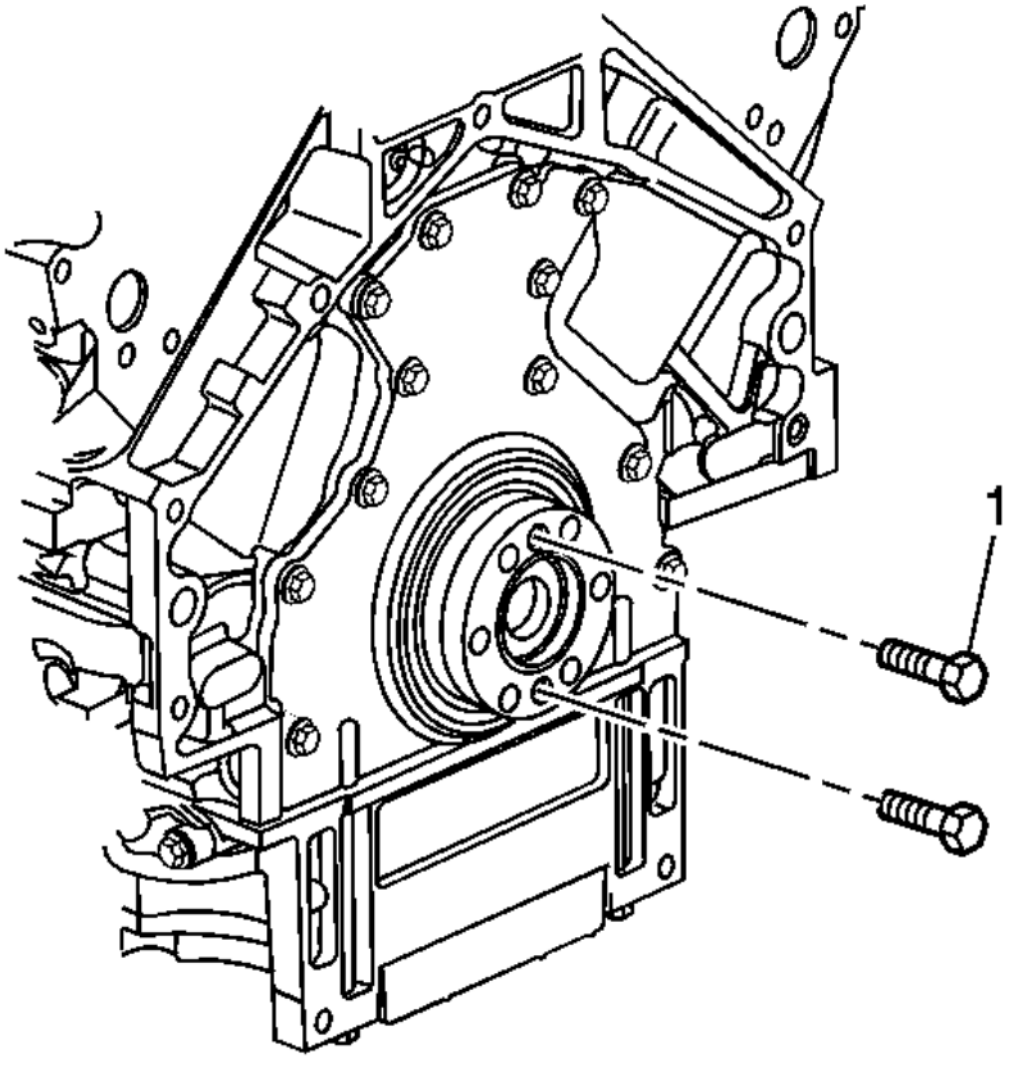

Fig. 231: View Of Bolts & Spacer
Courtesy of GENERAL MOTORS CORP.

4. Install two M11x1.5 mm bolts (1) to the threaded holes of the spacer, if applicable.
5. Rotate the bolts clockwise to remove the spacer.

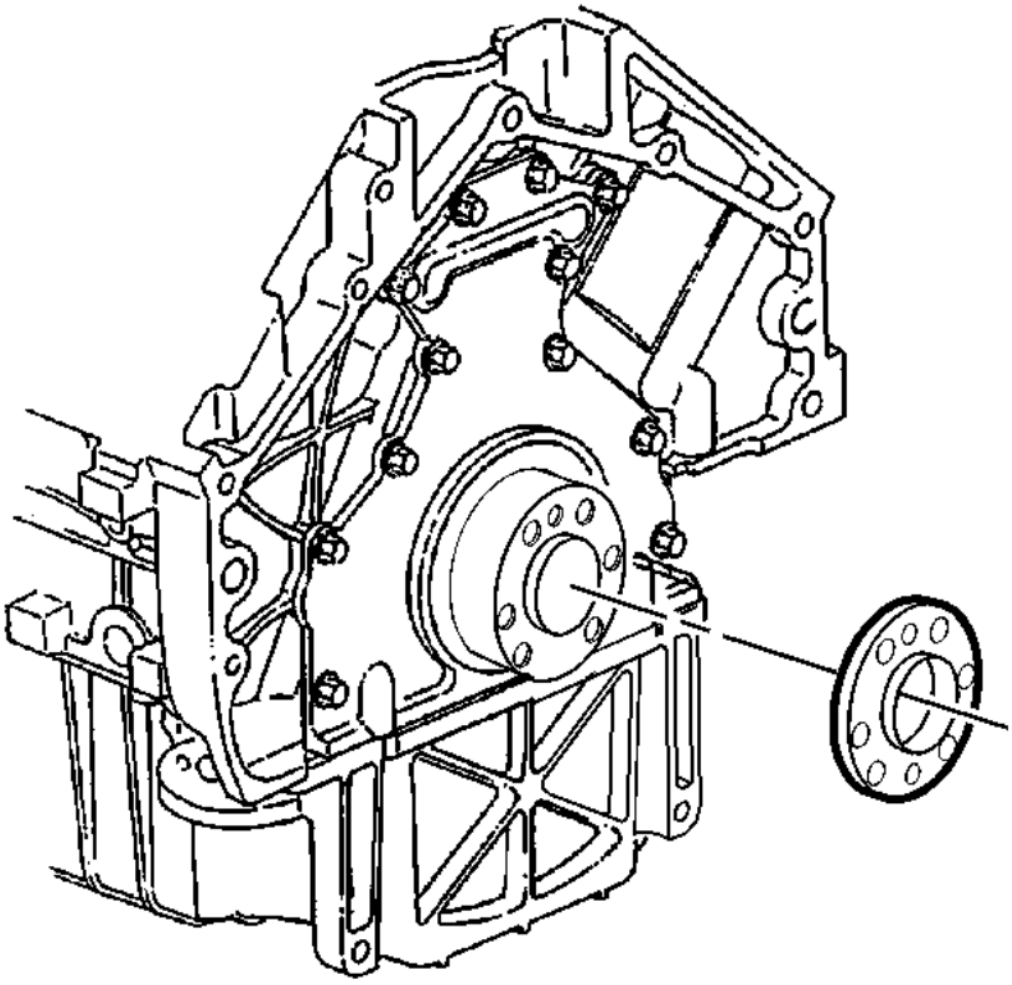

Fig. 232: View Of Spacer & Crankshaft Rear
Courtesy of GENERAL MOTORS CORP.

6. Remove the spacer from the rear of the crankshaft, if applicable.

Installation Procedure

IMPORTANT:

- **The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer (if applicable), but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage**

tightening process.

- **Certain applications (6.0L) require a spacer and longer bolts for proper flywheel position.**

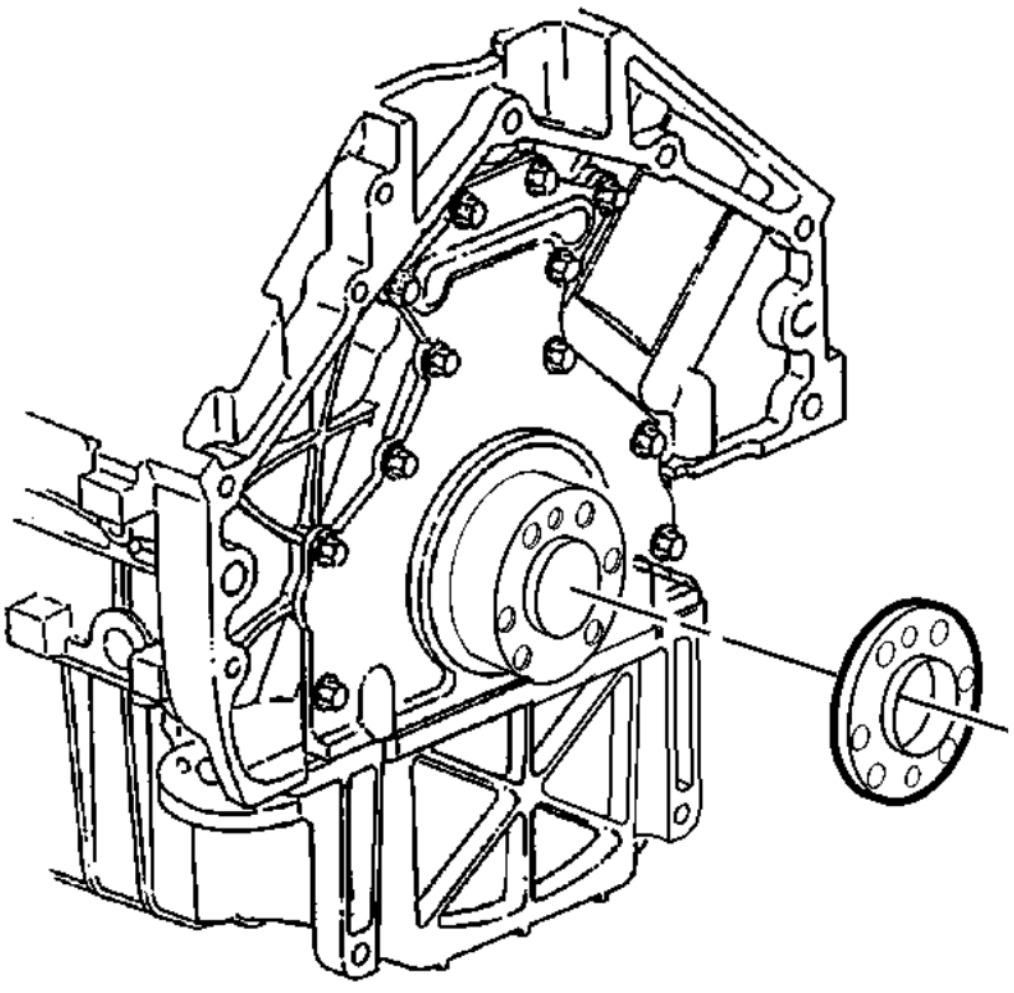

Fig. 233: View Of Spacer & Crankshaft Rear
Courtesy of GENERAL MOTORS CORP.

1. Install the spacer (if applicable) onto the rear of the crankshaft.

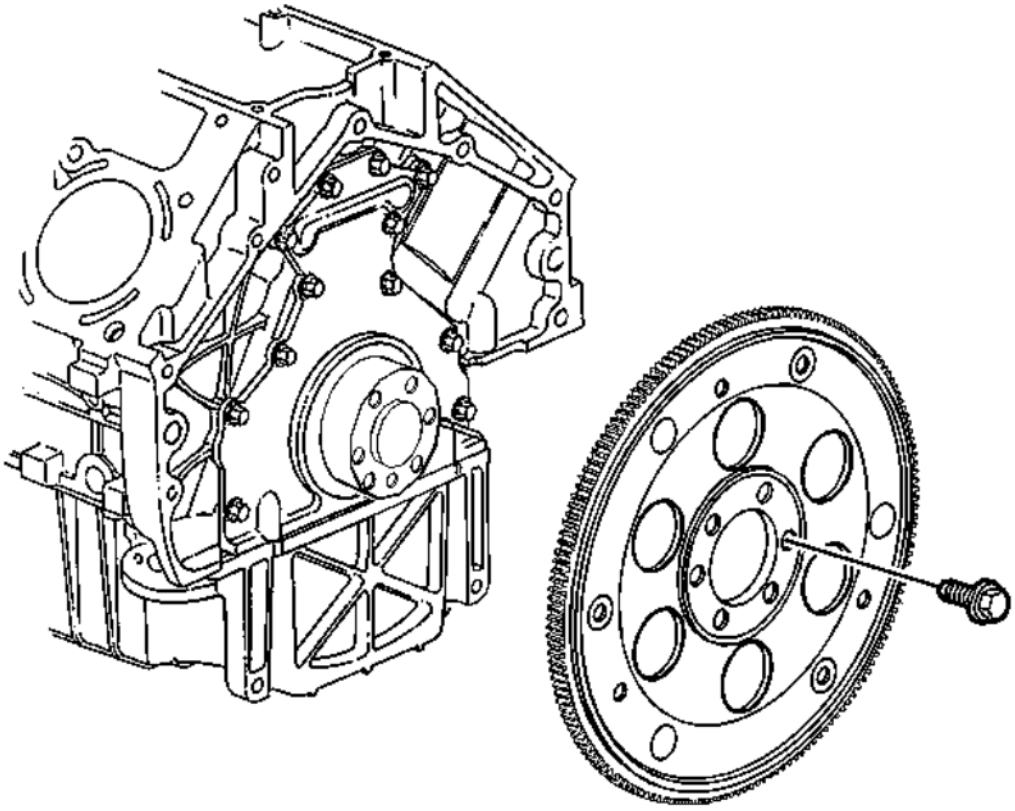

Fig. 234: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Longer flywheel bolts must be used on applications using a flywheel spacer.

2. Install the automatic transmission engine flywheel to the crankshaft.
3. Apply threadlock to the threads of the flywheel bolts. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.

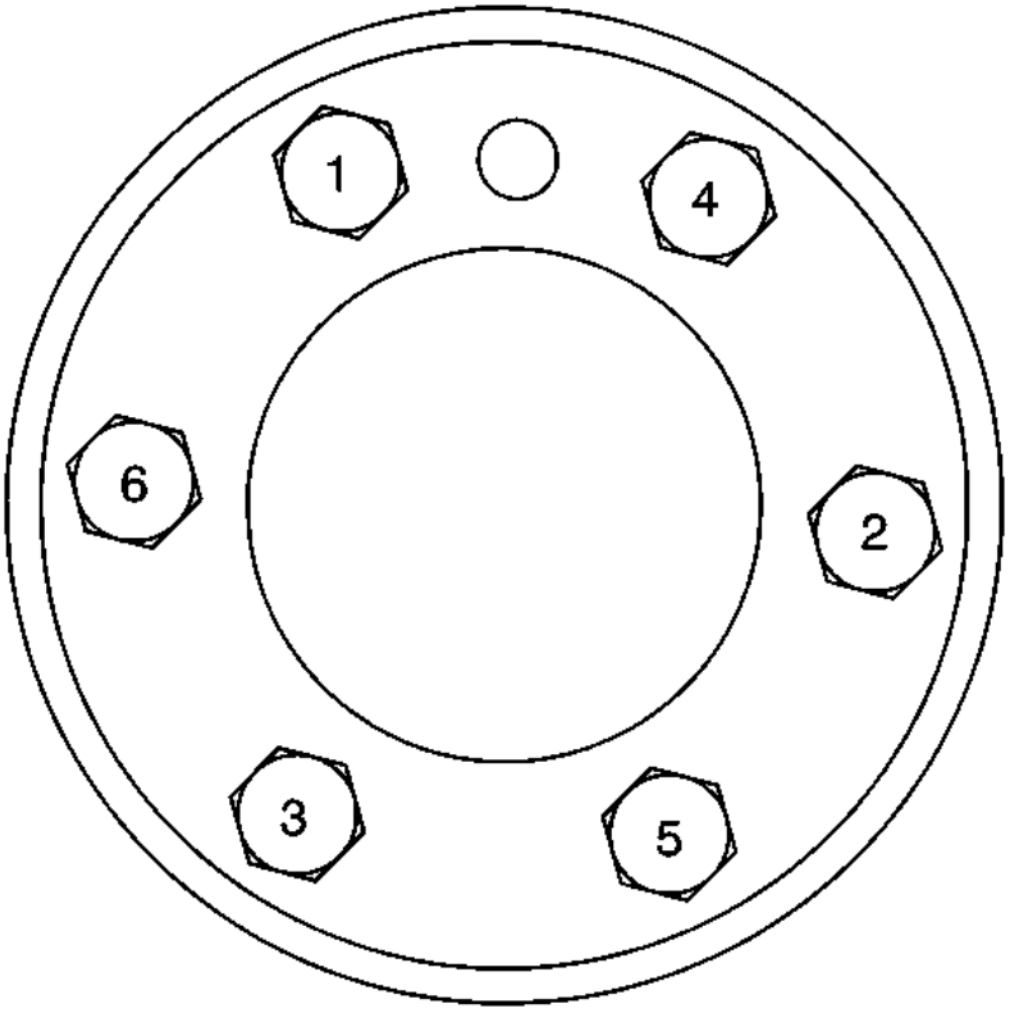

Fig. 235: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the engine flywheel bolts.

Tighten:

1. Tighten the engine flywheel bolts a first pass in sequence to 20 N.m (15 lb ft).

2. Tighten the engine flywheel bolts a second pass in sequence to 50 N.m (37 lb ft).
3. Tighten the engine flywheel bolts a final pass in sequence to 100 N.m (74 lb ft).

5. Install the automatic transmission. Refer to **Transmission Replacement** .

ENGINE REPLACEMENT

Special Tools

- **J 41798** Engine Lift Bracket. See **Special Tools**.
- **J 21366** Convert Holding Strap. See **Special Tools**.

Removal Procedure

1. Remove the hood. Refer to **Hood Replacement** .

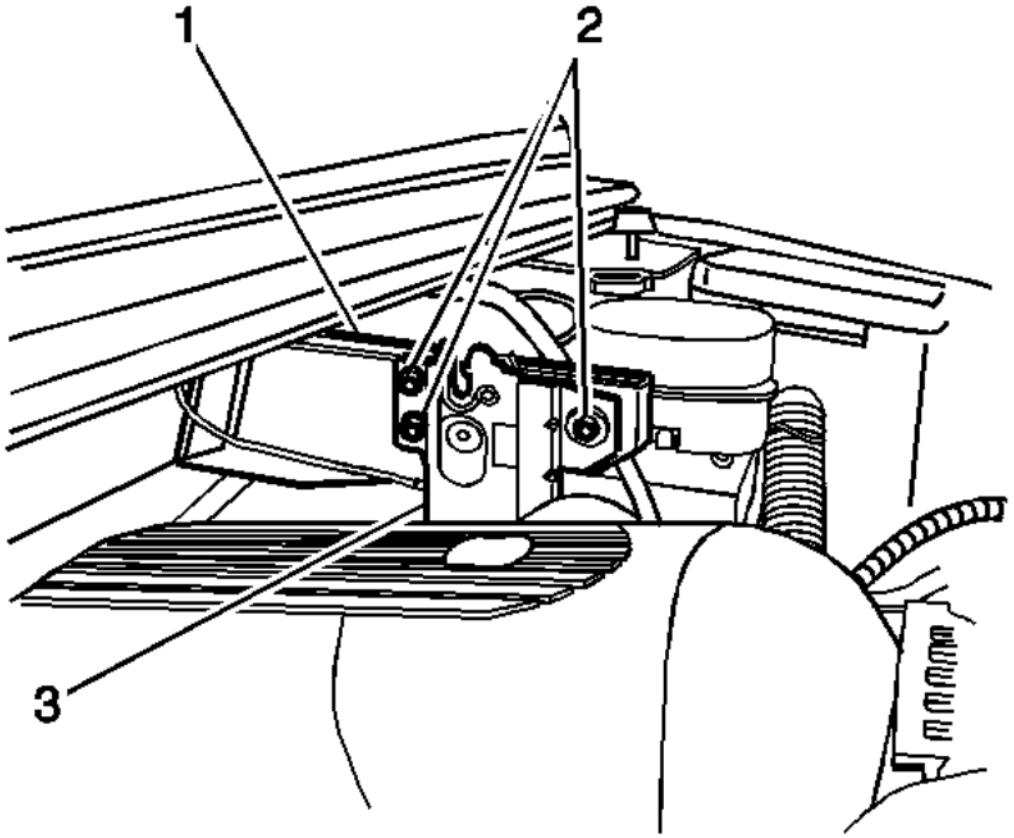

Fig. 236: Hood Latch Fasteners
Courtesy of GENERAL MOTORS CORP.

2. Remove hood latch (1) from cowl.
3. Leaving the A/C compressor lines connected remove the condenser mounting bolts and secure to frame rail.
4. Remove the upper radiator support. Refer to **Radiator Support Replacement** .

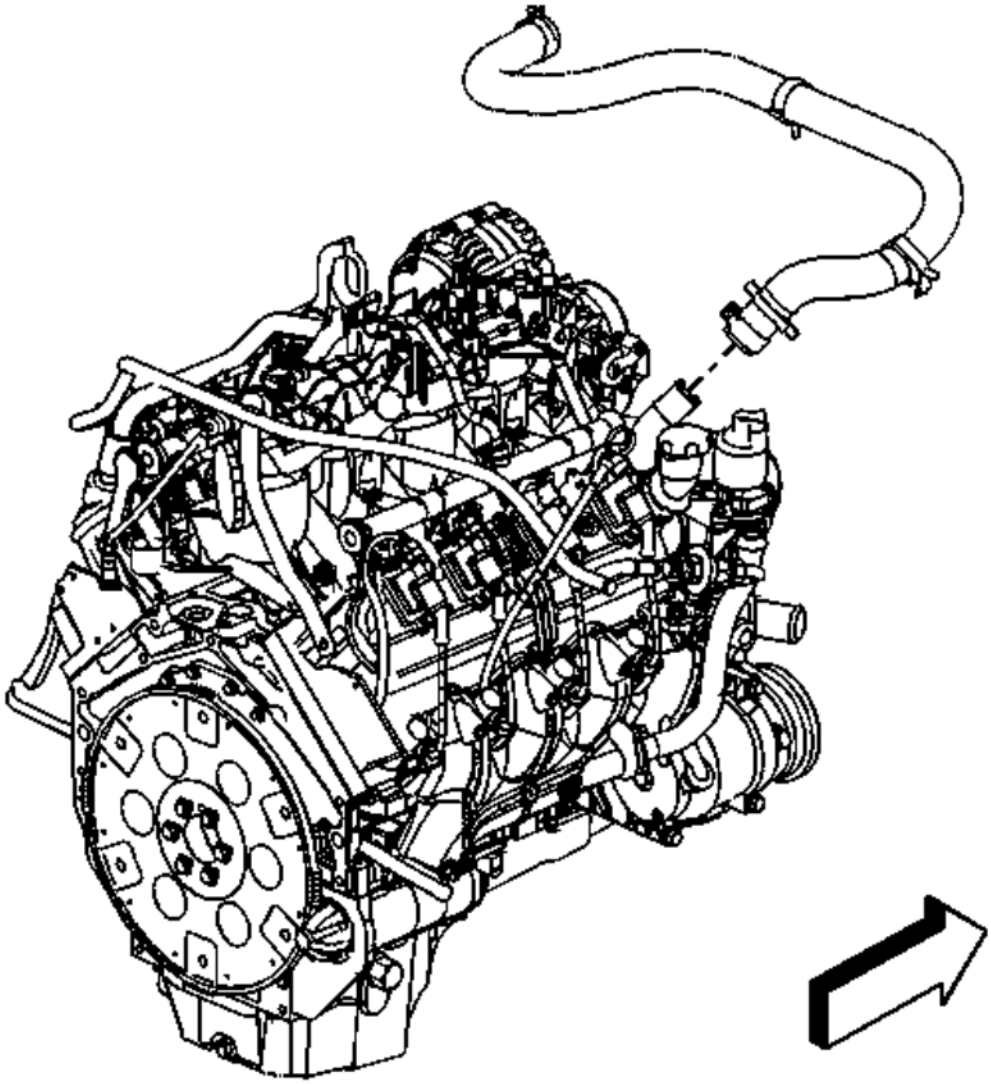

Fig. 237: View Of Inlet Hose To Water Pump
Courtesy of GENERAL MOTORS CORP.

5. Reposition the radiator inlet hose clamp at the water pump.
6. Remove the radiator inlet hose from the water pump.

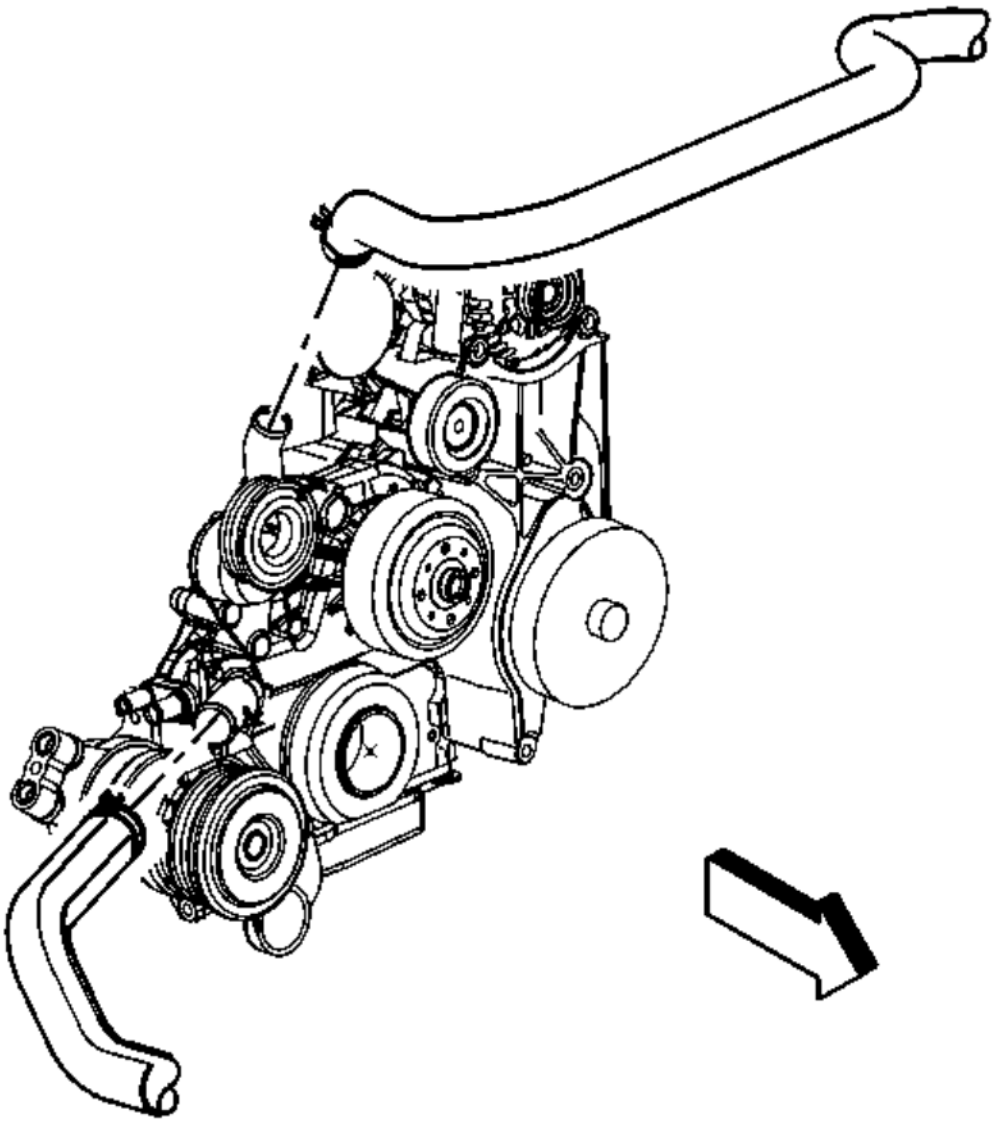

Fig. 238: View Of Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

7. Reposition the radiator outlet hose clamp at the water pump.
8. Remove the radiator outlet hose from the water pump.
9. Remove the heater hoses. Refer to **Heater Inlet Hose Replacement** and **Heater Outlet**

Hose Replacement .

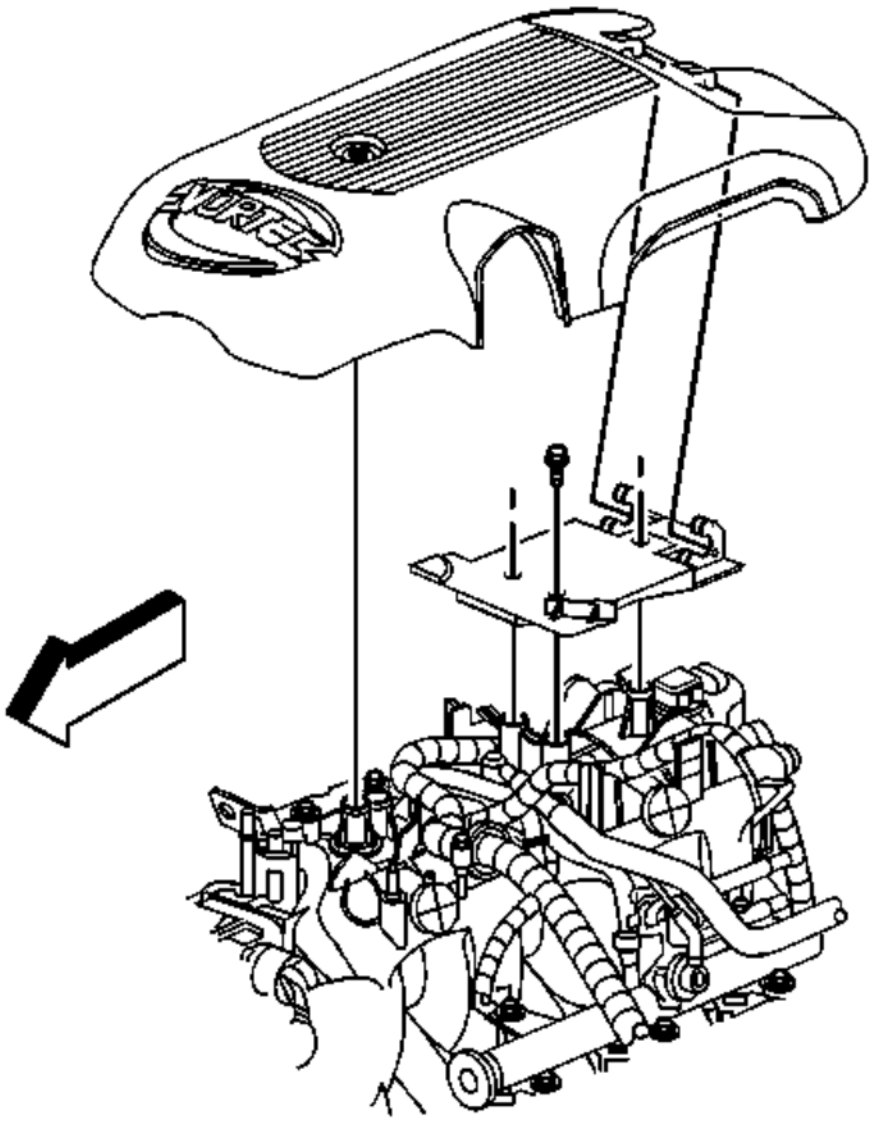

Fig. 239: View Of Top Engine Cover
Courtesy of GENERAL MOTORS CORP.

10. Loosen the intake manifold sight shield bolt.

11. Remove the sight shield from the retainer.

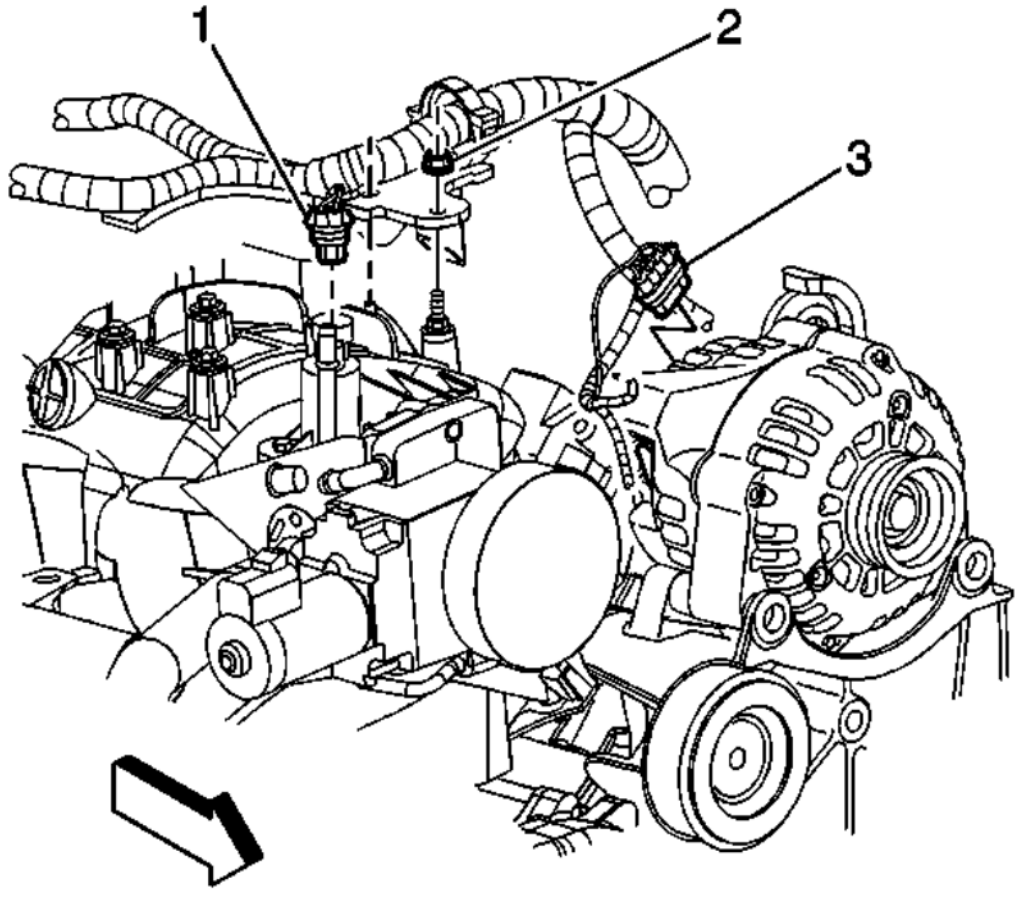

Fig. 240: Identifying Purge Solenoid Electrical Connector, Wiring Harness Nut & Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

12. Disconnect the following electrical connectors:
    - Evaporative emissions (EVAP) canister purge solenoid (1)
    - Generator (3)
13. Remove the harness bracket nut (2) in order to remove the engine harness from the intake manifold.

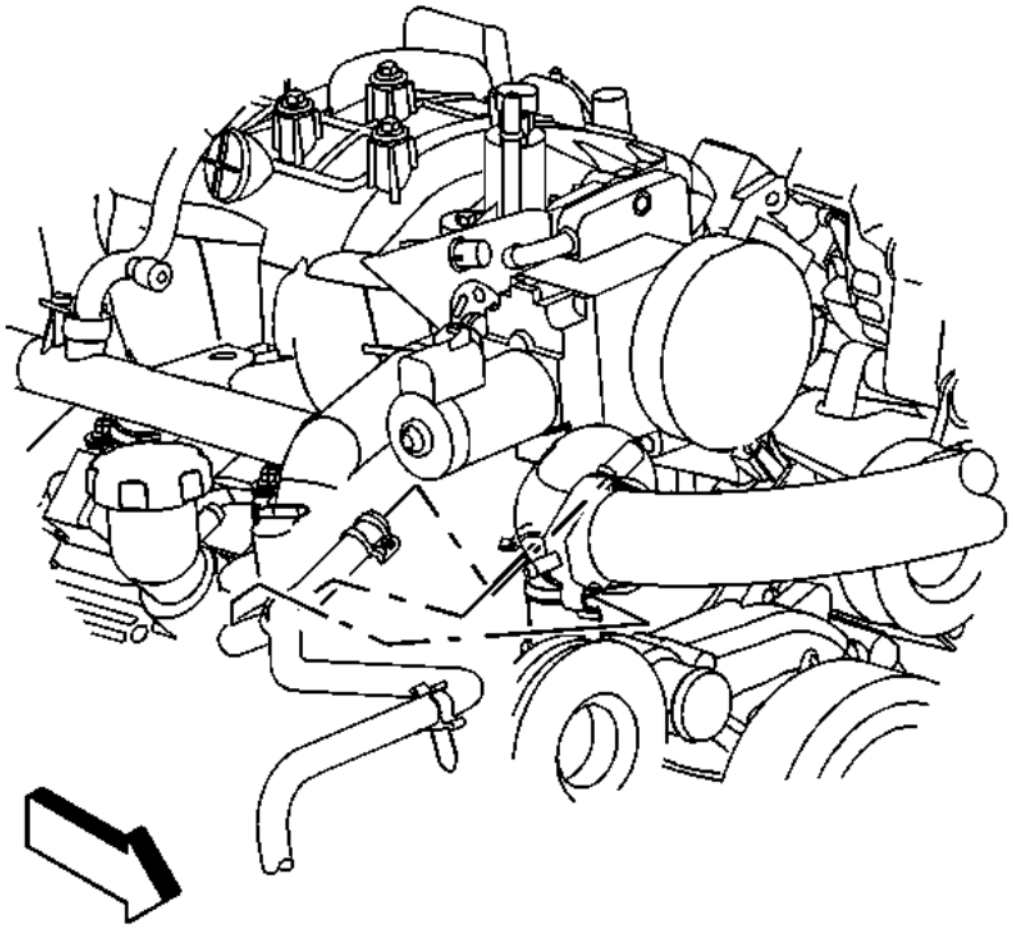

Fig. 241: View Of Vent Inlet Hose At Throttle Body
Courtesy of GENERAL MOTORS CORP.

14. Remove the radiator vent inlet hose from the throttle body.

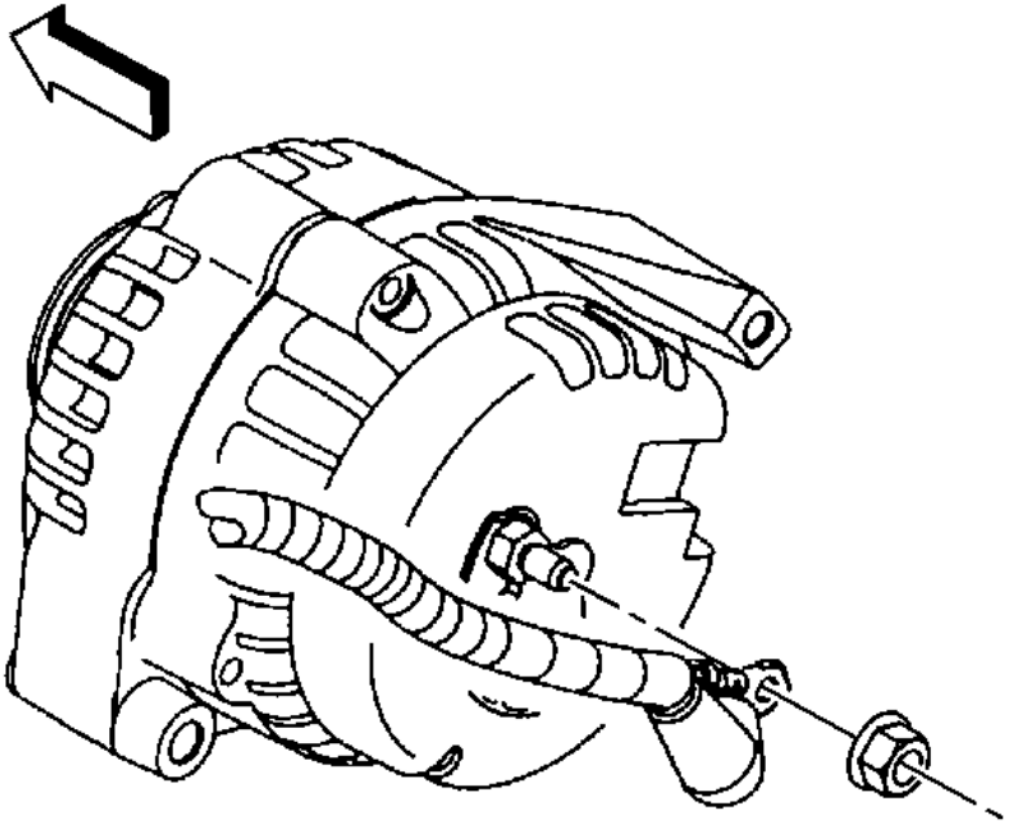

Fig. 242: View Of Generator Cable & Nut
Courtesy of GENERAL MOTORS CORP.

15. 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.

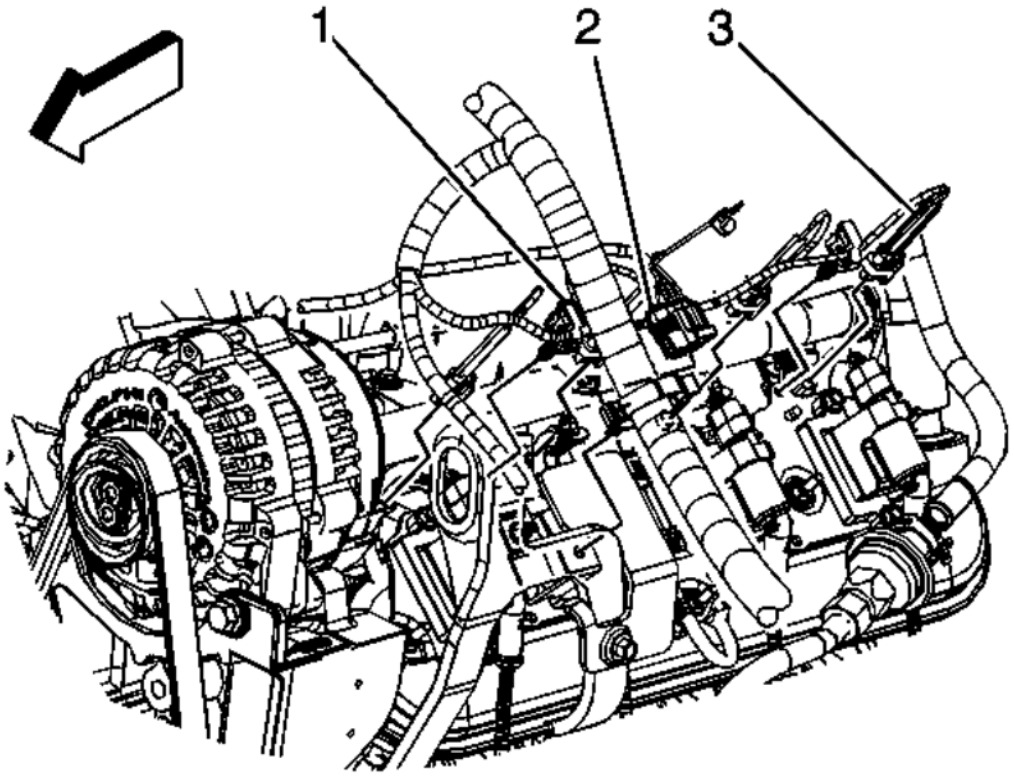

Fig. 243: View Of Main Coil Harness & Fuel Injector Electrical Connectors (Left Side)
Courtesy of GENERAL MOTORS CORP.

16. Disconnect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.

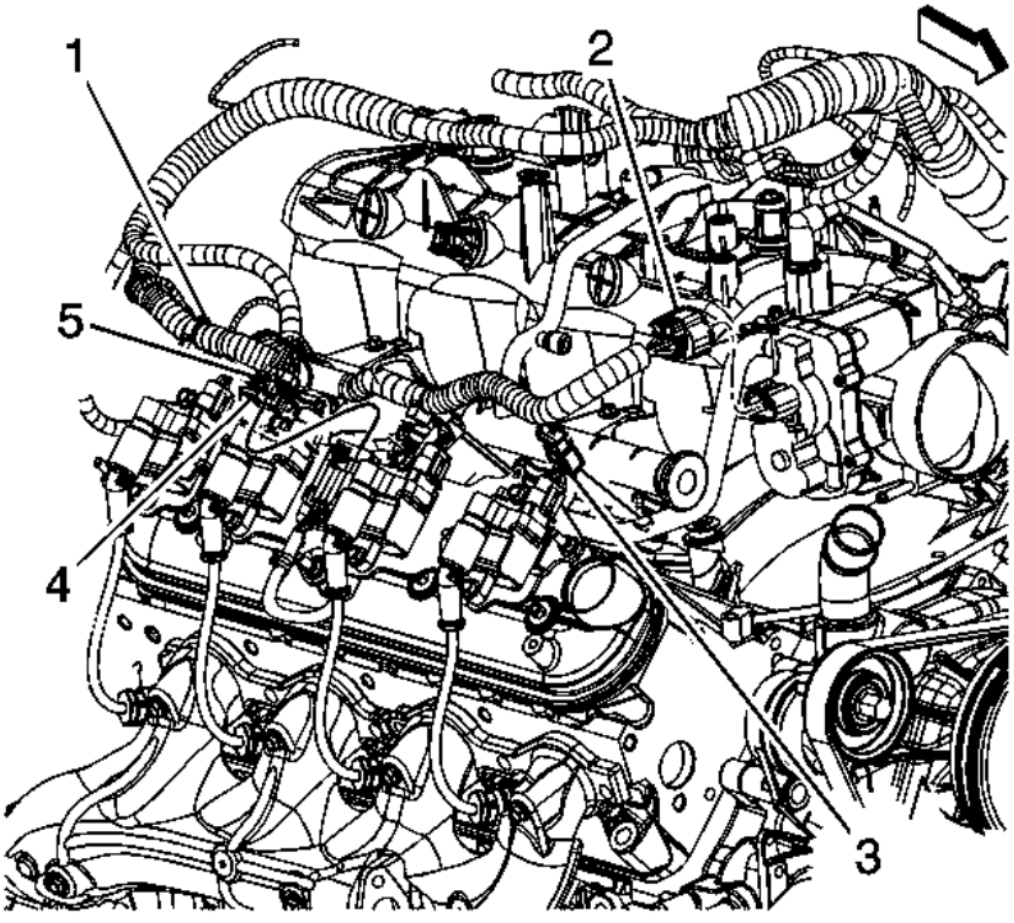

Fig. 244: Identifying Right Side Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the following electrical connectors:
    - Main coil harness (4)
    - Fuel injectors (3)
    - Electronic throttle control (ETC) (2)

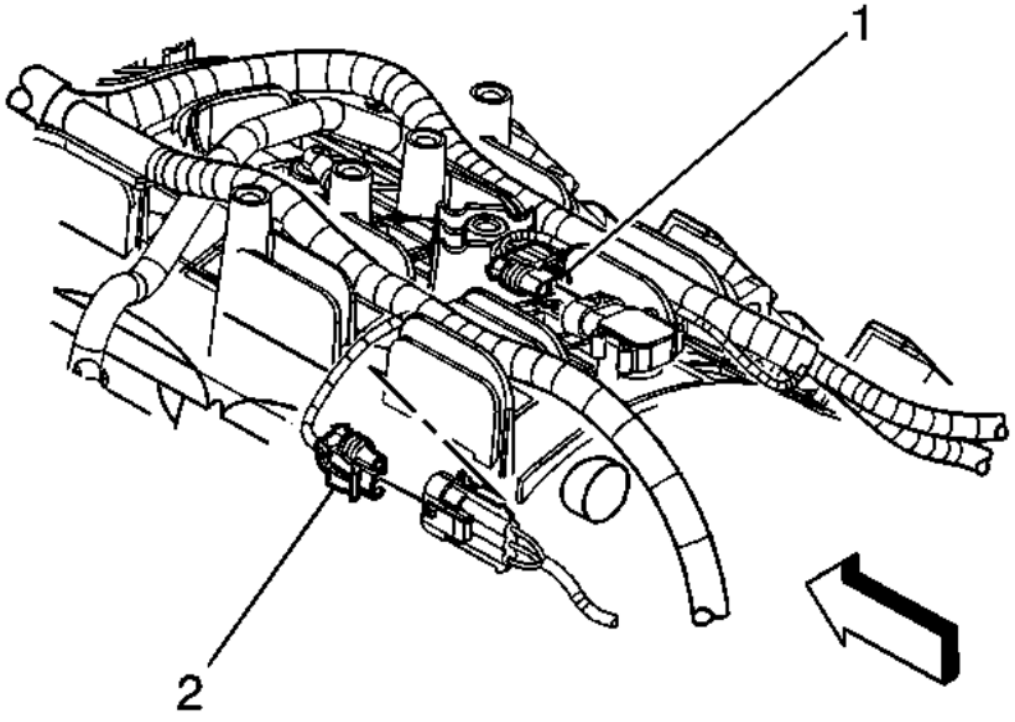

Fig. 245: View Of MAP Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

18. Disconnect the manifold absolute pressure (MAP) sensor (1) and knock sensor (2) electrical connectors.

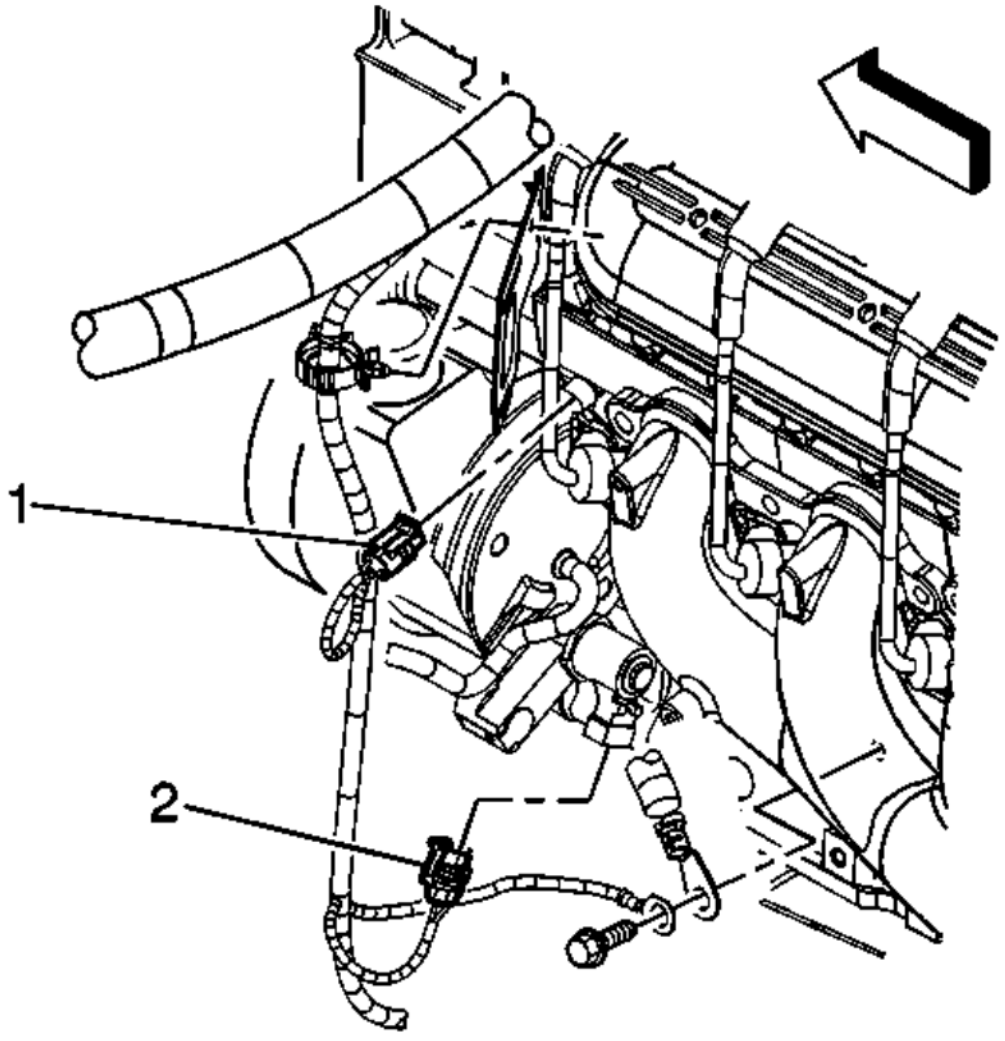

Fig. 246: Coolant Temperature Sensor & Electronic Variable Orifice Switch Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

19. Remove the harness ground bolt.
20. Reposition the harness ground and negative battery cable from the block.
21. Disconnect the following electrical connectors:
    - Coolant temperature sensor (1)

- Electronic variable orifice switch (2)

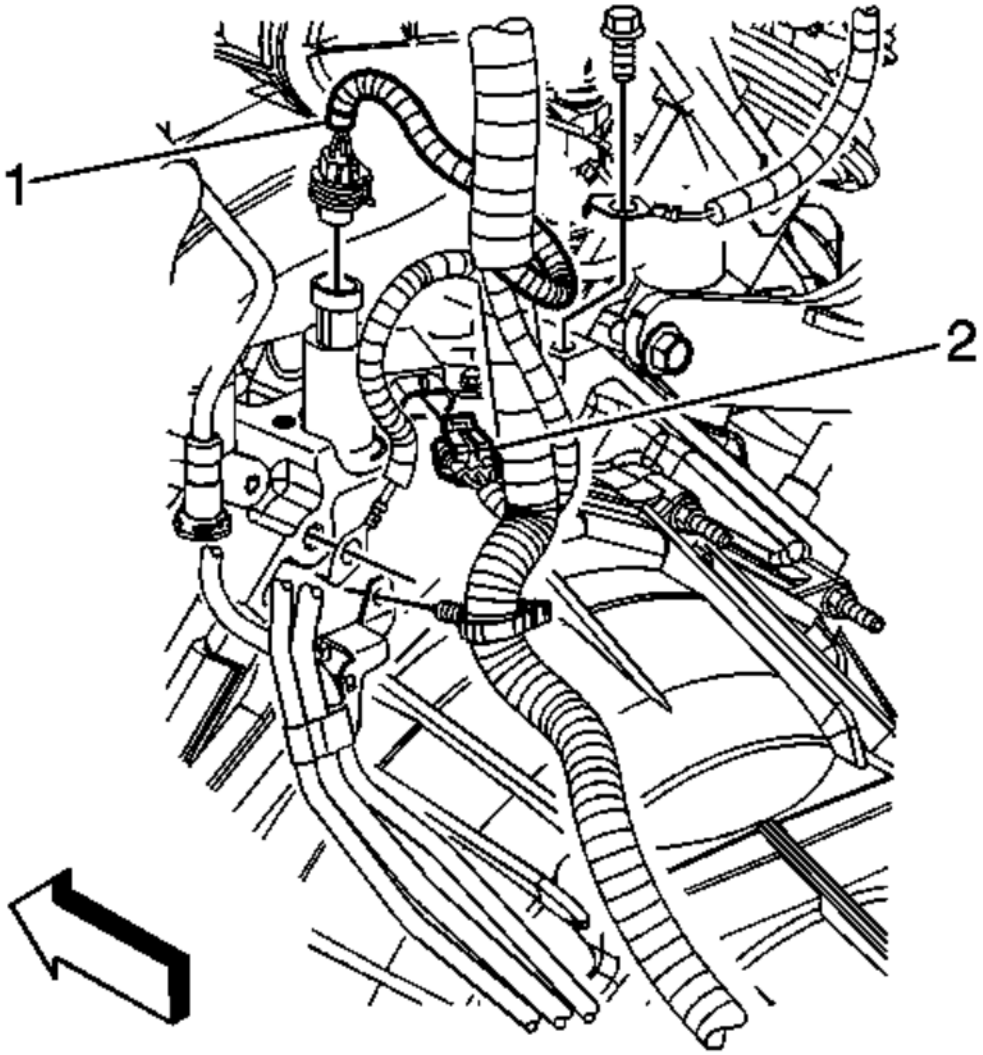

Fig. 247: View Of Oil Pressure Sensor & CMP Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

22. Remove the harness ground bolt at the right rear of the engine block.
23. Reposition the harness ground from the block.

24. Remove the harness ground bolt at the left rear of the engine block.
25. Reposition the harness ground, and engine ground strap from the block.
26. Disconnect the following electrical connectors:
    - Oil pressure sensor (1)
    - Camshaft position (CMP) sensor (2)
27. Unclip all of the engine harness clips from the engine.

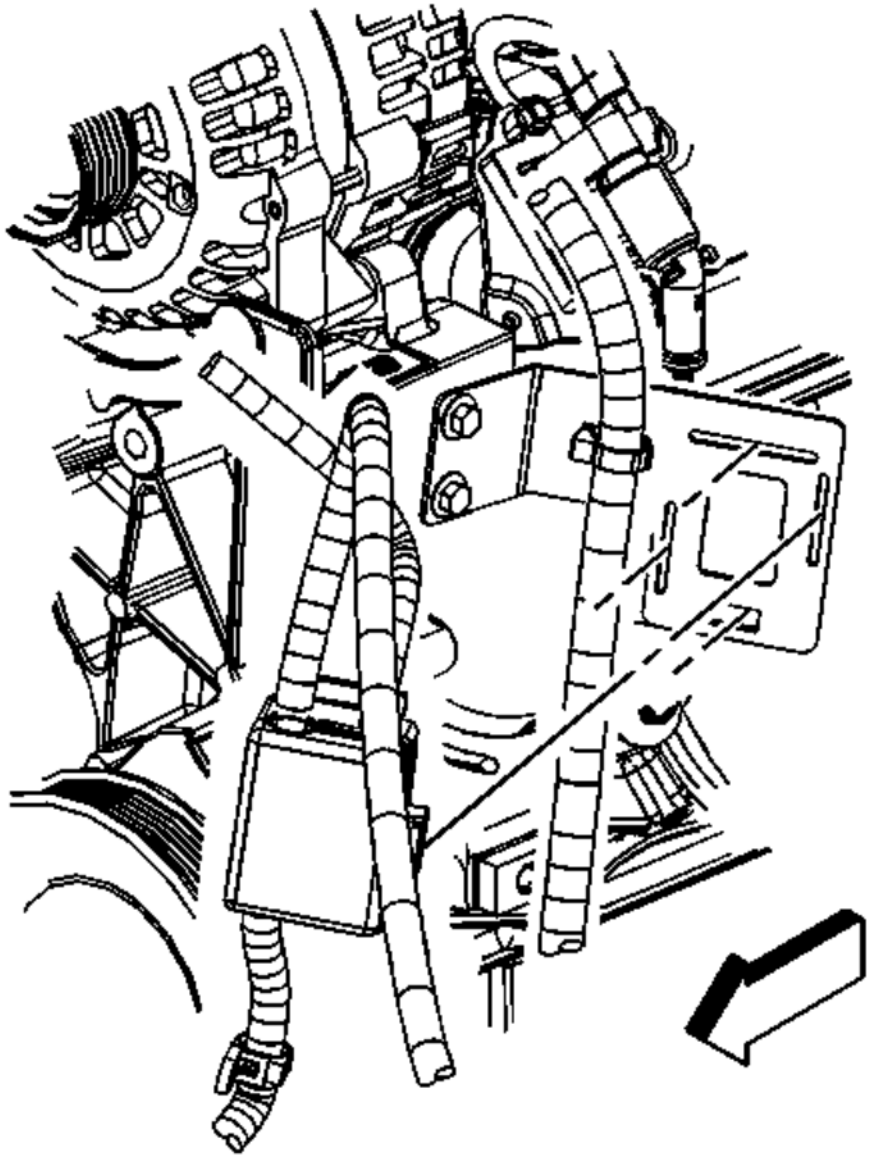

Fig. 248: View Of Battery Cable Junction Block
Courtesy of GENERAL MOTORS CORP.

28. Remove the battery cable junction block from the junction block bracket.

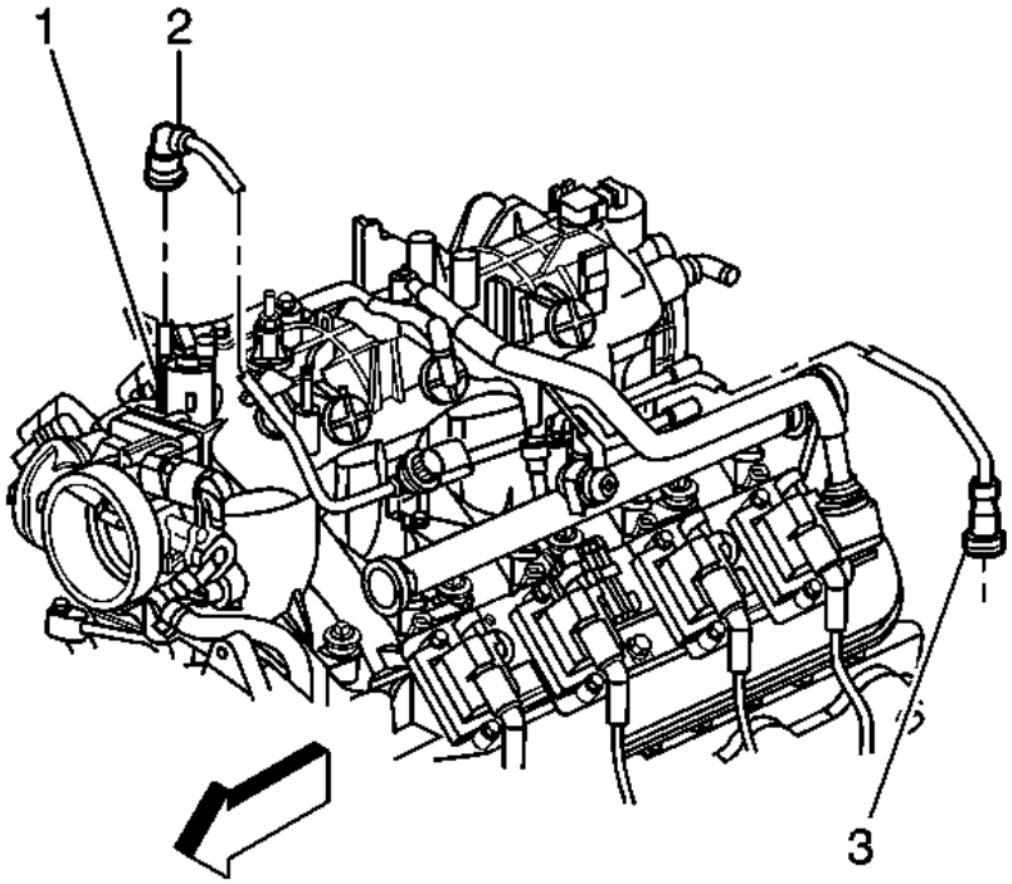

Fig. 249: View Of EVAP Purge Solenoid Vent Tube
Courtesy of GENERAL MOTORS CORP.

29. Remove the EVAP purge solenoid vent tube, perform the following:
    - Remove the EVAP tube end (2) from the solenoid (1).
    - Remove the EVAP tube end (3) from the vapor pipe.
30. Disconnect the fuel pipes. Refer to **Metal Collar Quick Connect Fitting Service** or **Plastic Collar Quick Connect Fitting Service** .
31. Raise the vehicle.

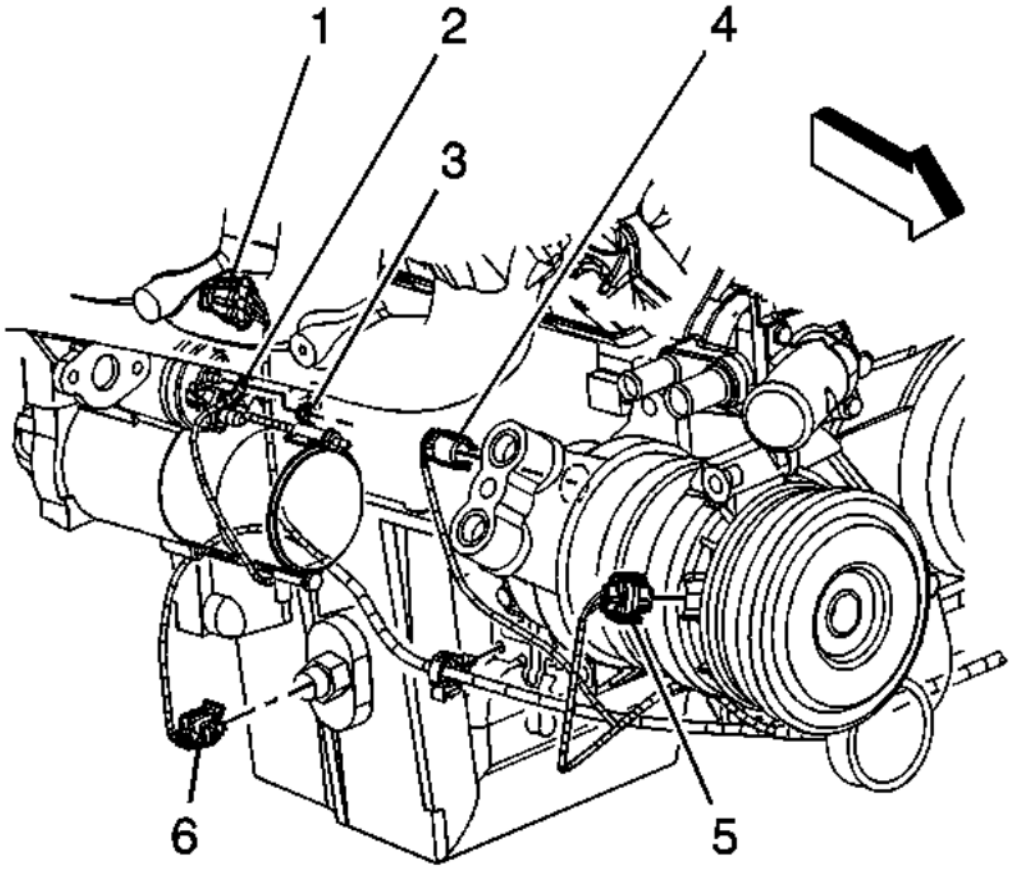

Fig. 250: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

32. Disconnect the following electrical connectors:
    - The crankshaft position (CKP) sensor (1)
    - The engine oil level sensor (6)
    - The coolant heater, if equipped

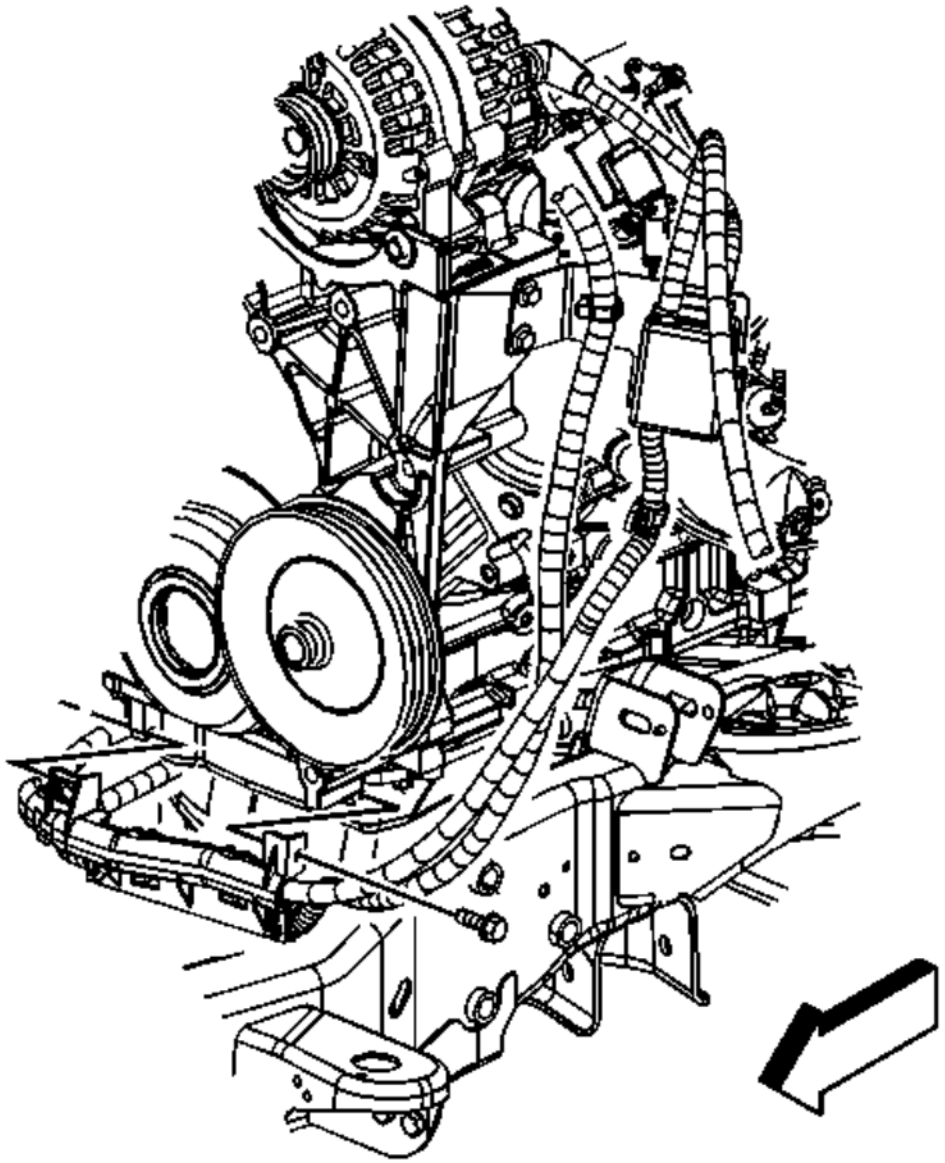

Fig. 251: View Of Positive Battery Cable, Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

33. Remove the battery cable channel bolt.
34. Slide the channel pin out of the oil pan tab.

35. Gather all branches of the engine wiring harness and reposition off to the side.
36. Lower the vehicle.

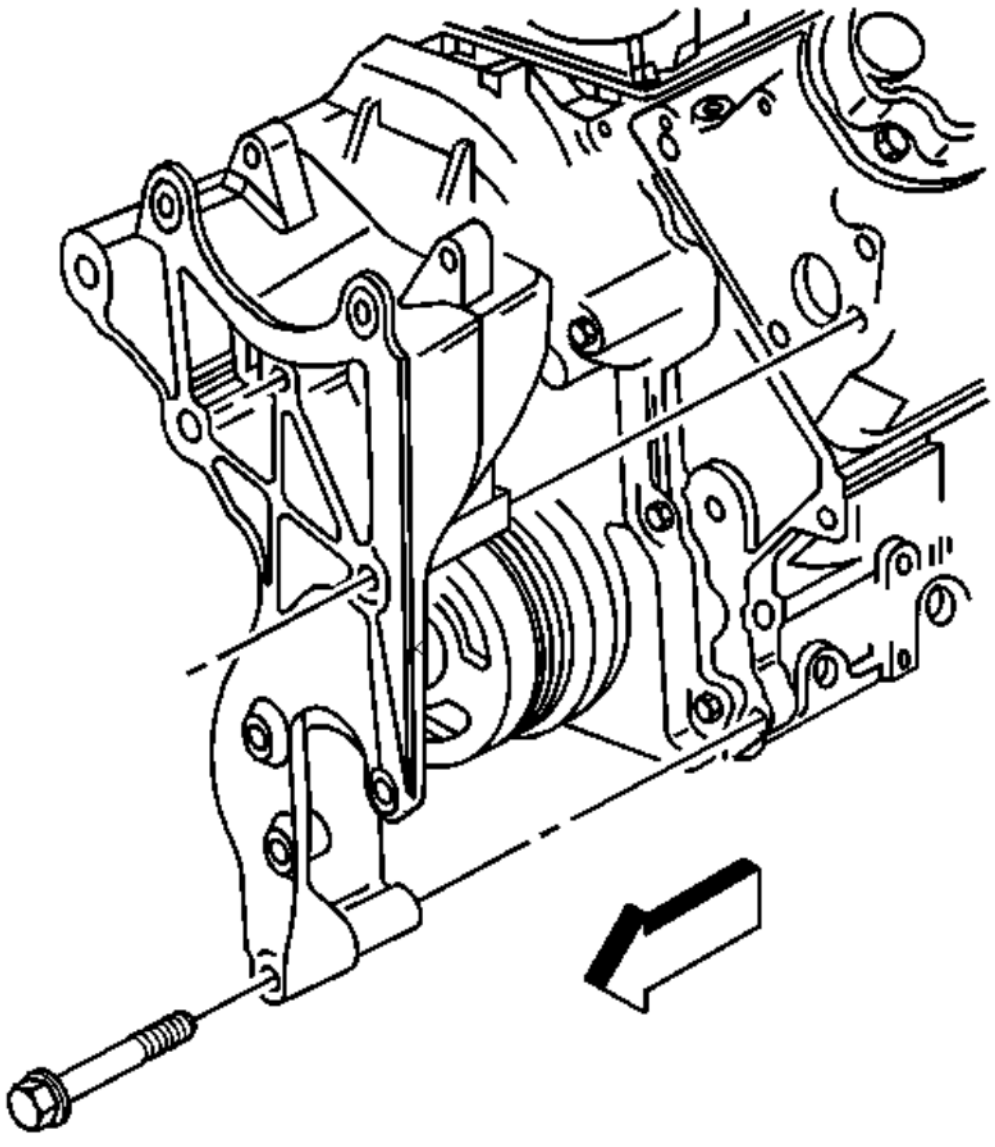

Fig. 252: View Of Generator Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

37. Remove the rear power steering pump-to-engine block bolt.
38. Remove the generator bracket mounting bolts.
39. Position the bracket aside.
40. Remove the ignition coil, as required for the proper fit of the **J 41798** before lifting the engine. See **Special Tools**. Refer to **Ignition Coil Replacement** .

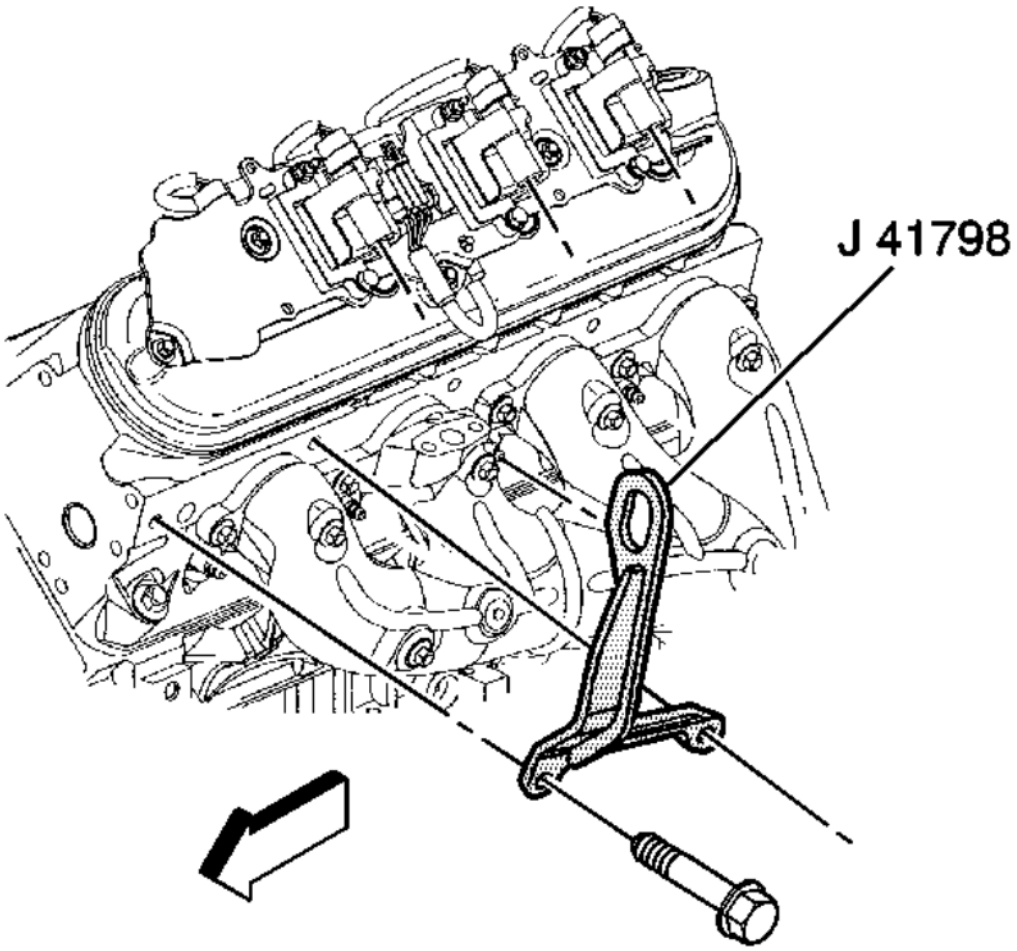

Fig. 253: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

41. Install the **J 41798** to the cylinder heads. See **Special Tools**.

Tighten:

- Tighten the M8 engine lift bracket bolts to 25 N.m (18 lb ft).
- Tighten the M10 engine lift bracket bolts to 50 N.m (37 lb ft).

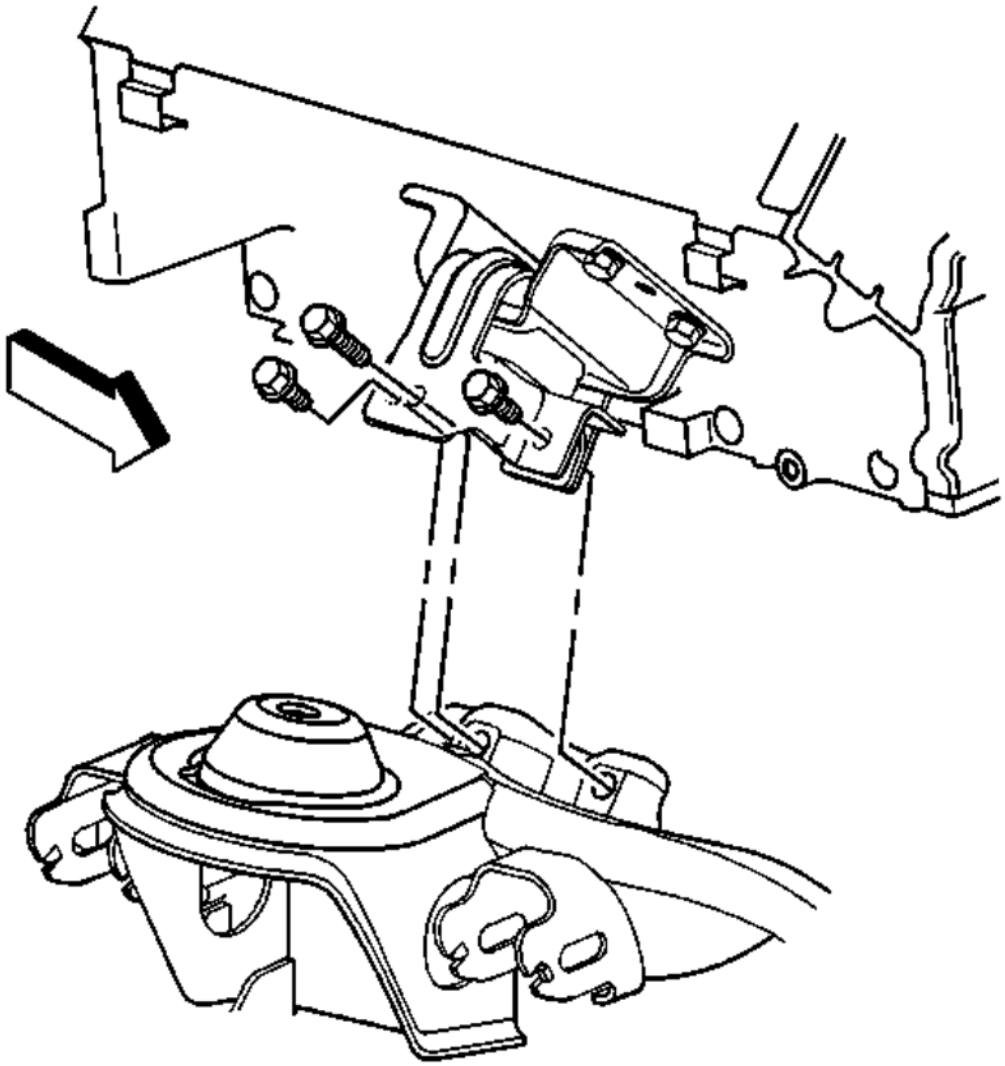

Fig. 254: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

42. Remove the left and right engine mount-to-engine mount bracket bolts.
43. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

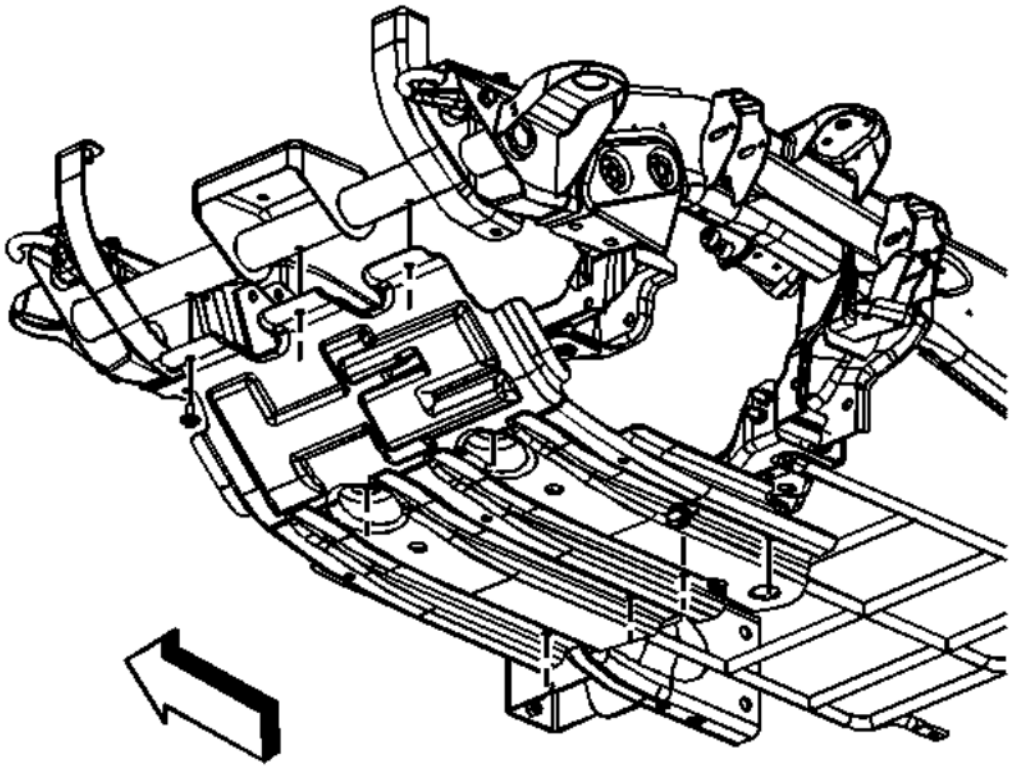

Fig. 255: Engine Protection Shield
Courtesy of GENERAL MOTORS CORP.

44. Remove the engine shield bolts and shield.

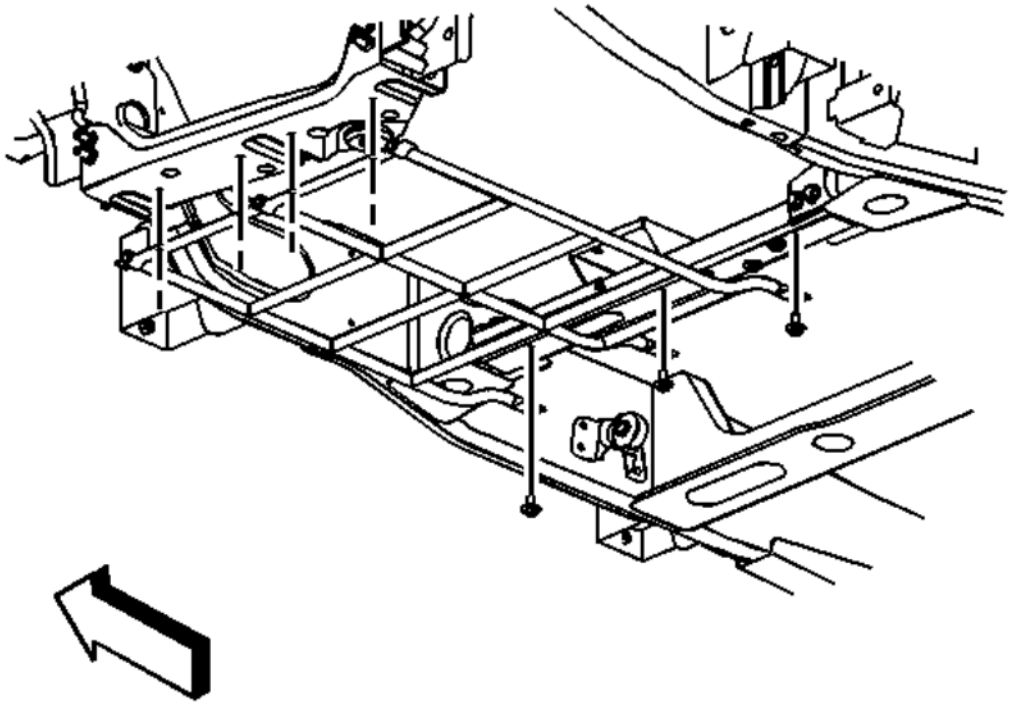

Fig. 256: Catalytic Converter Guard
Courtesy of GENERAL MOTORS CORP.

45. Remove the ladder shields bolts and plate.
46. Drain the engine oil.

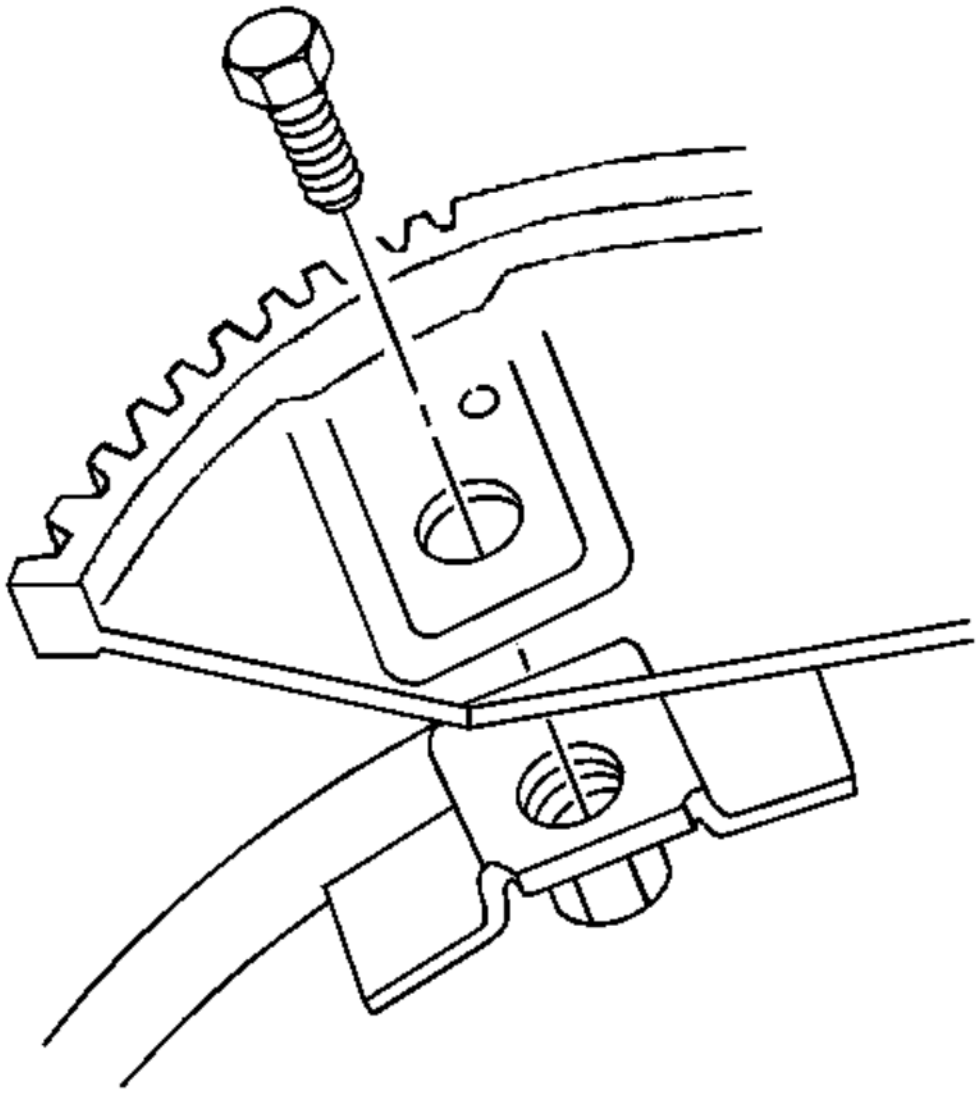

Fig. 257: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

47. Remove the flywheel to torque converter bolts.

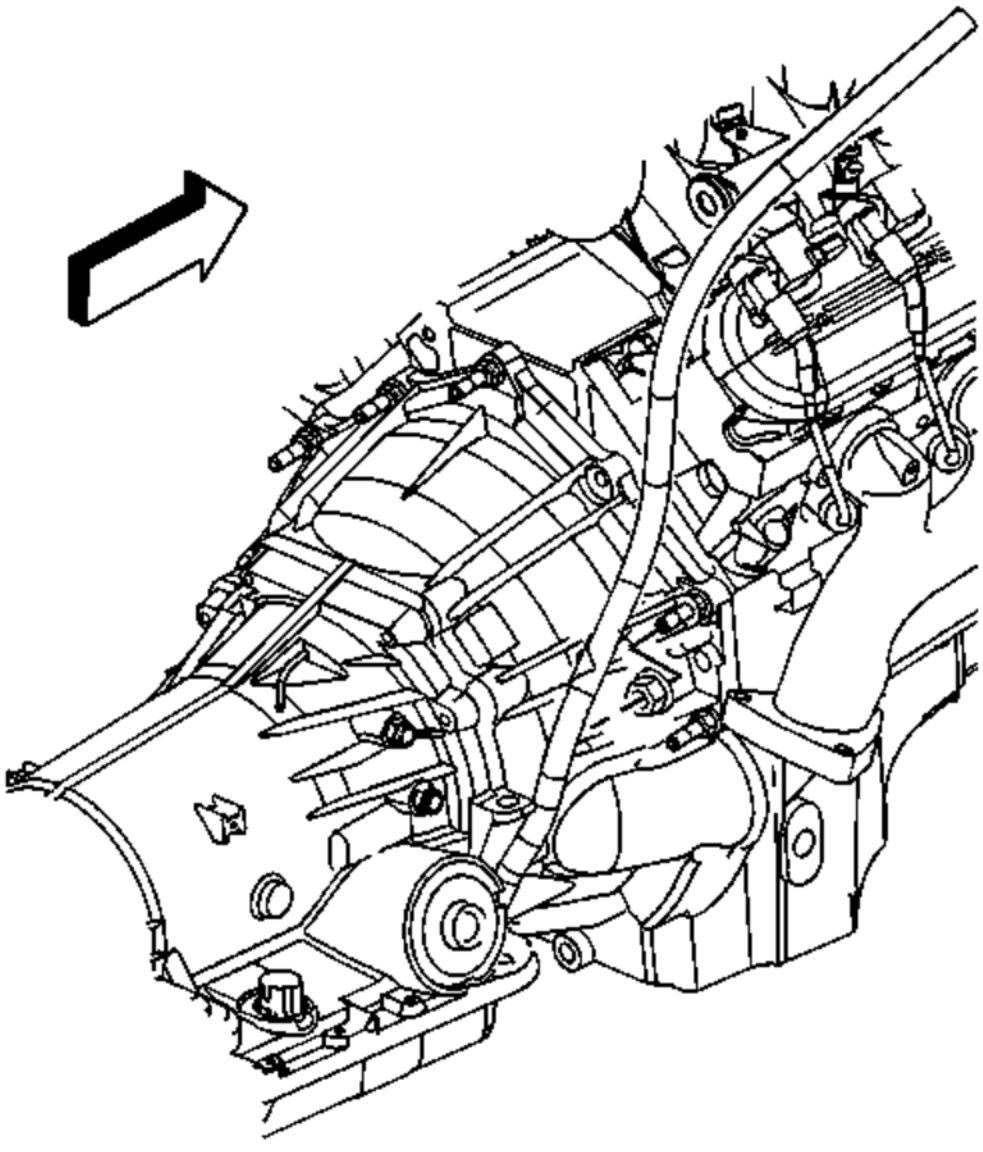

Fig. 258: View Of Oil Level Indicator Tube Nut
Courtesy of GENERAL MOTORS CORP.

48. Remove the transmission oil level indicator tube nut.

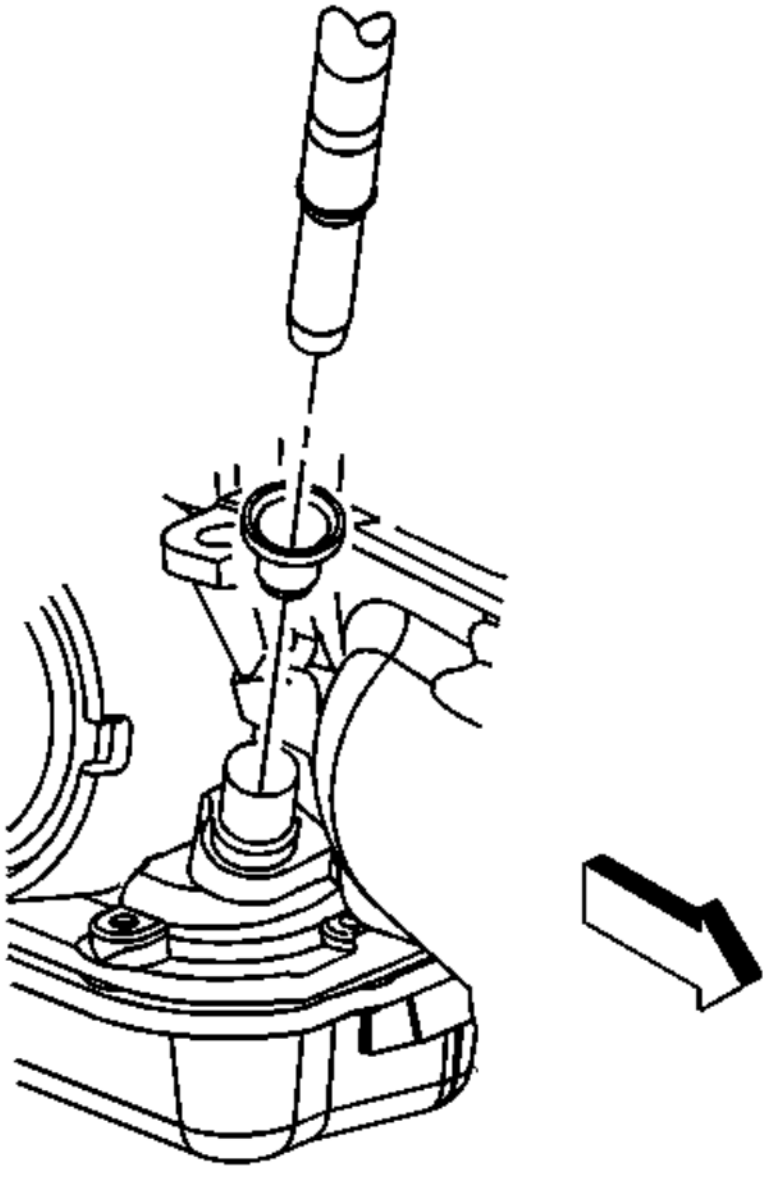

Fig. 259: View Of Oil Level Indicator Tube & Seal
Courtesy of GENERAL MOTORS CORP.

49. Remove the transmission oil level indicator tube.

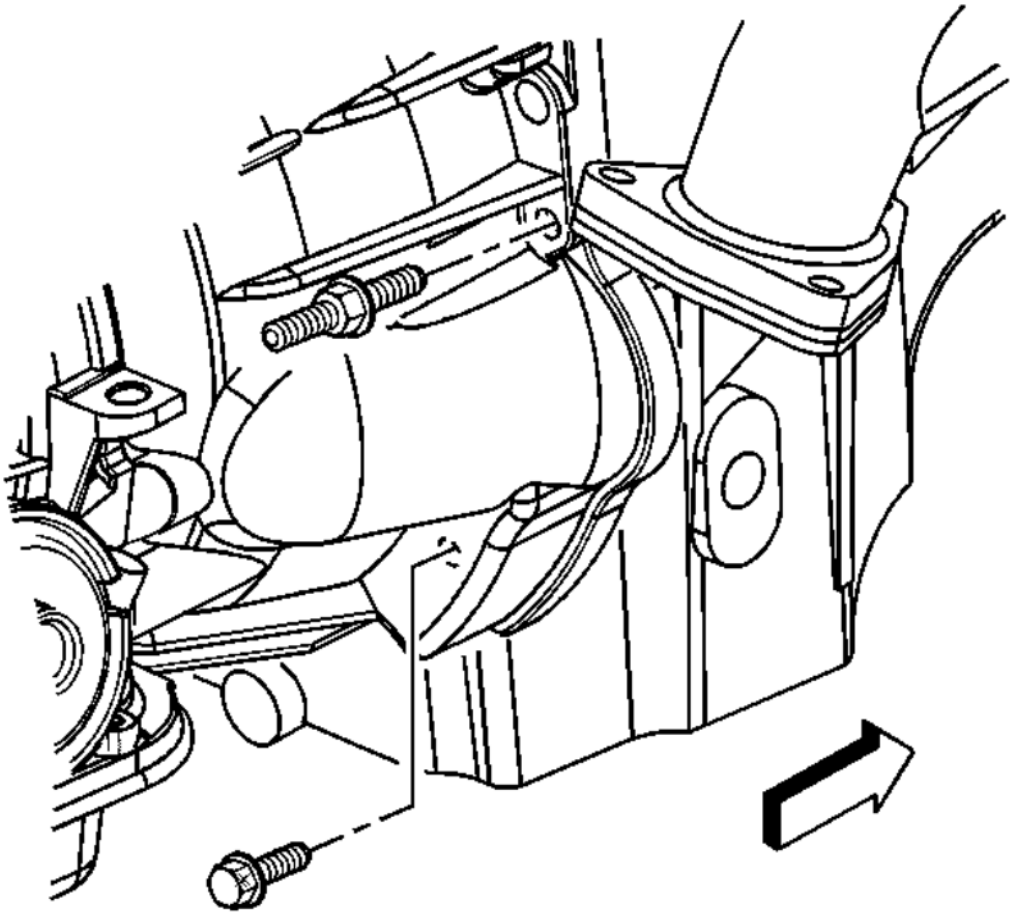

Fig. 260: Identifying Stud & Bolt Securing Transmission To Engine (Right Side)
Courtesy of GENERAL MOTORS CORP.

50. Remove the transmission bolt and stud on the right side.

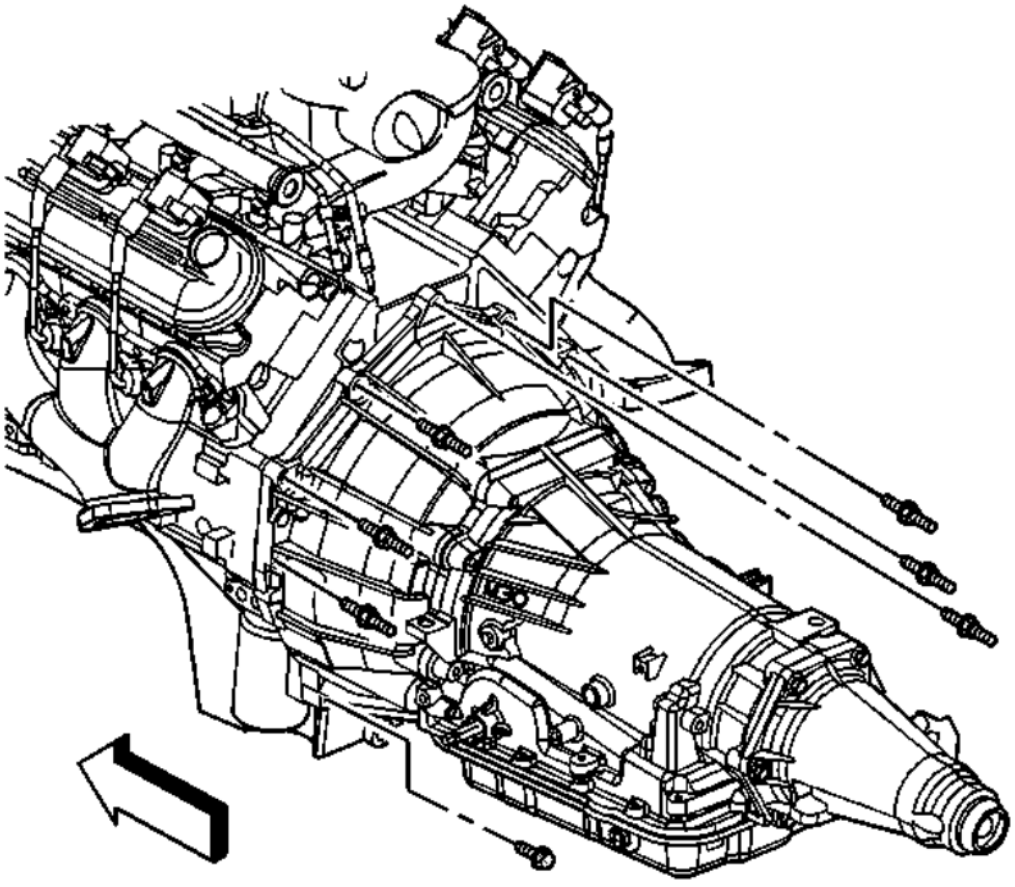

Fig. 261: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

51. Remove the automatic transmission bolt/studs.
52. Separate the engine from the automatic transmission.

    Install the **J 21366** . See **Special Tools**.

53. Lower the vehicle.
54. Install an engine hoist to the **J 41798** . See **Special Tools**.
55. Install a floor jack under the transmission for support.

NOTE: **Use care while moving the engine assembly in order to avoid**

breaking the MAP sensor locating tabs. Broken MAP sensor tabs may result in decreased engine performance.

56. Remove the engine.
57. Install the engine to an engine stand.
58. Remove the engine hoist.

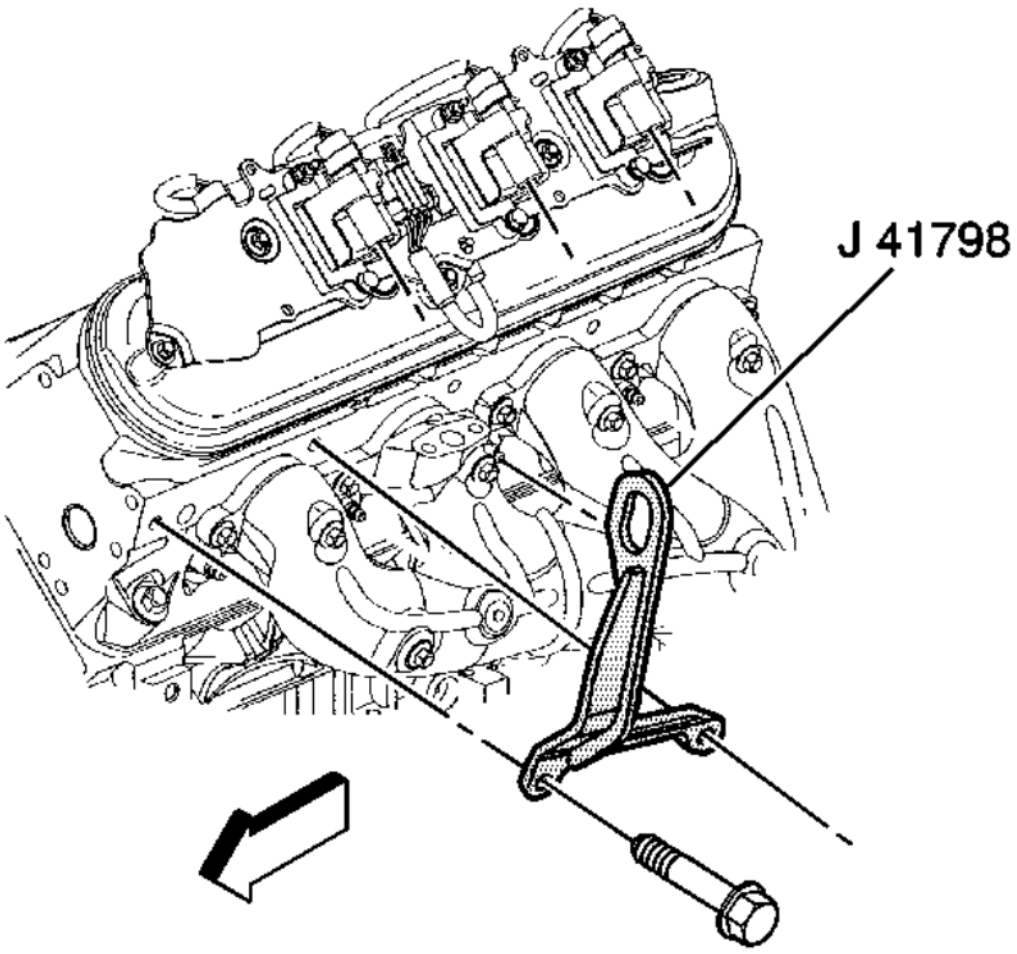

Fig. 262: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

59. Remove the **J 41798** . See **Special Tools**.

Installation Procedure

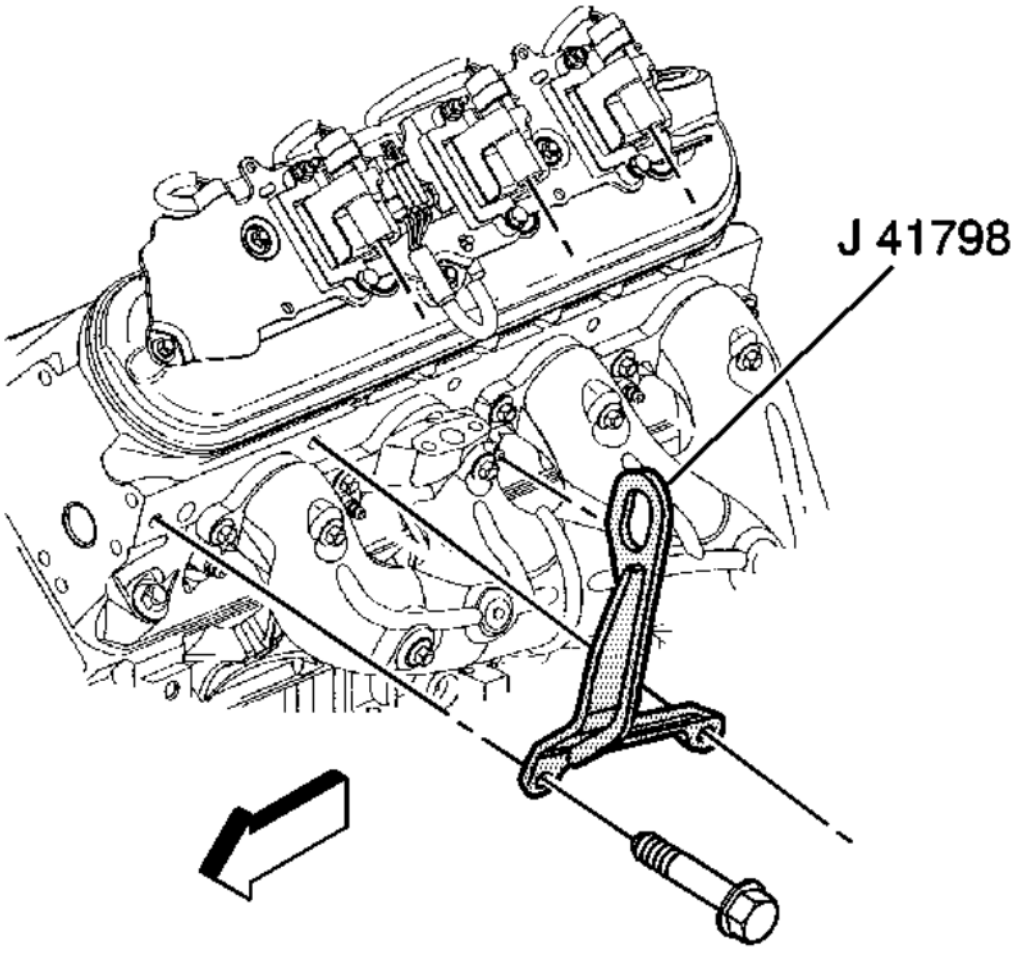

Fig. 263: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the **J 41798** to the engine. See **Special Tools**.

Tighten:

- Tighten the M8 engine lift bracket bolts to 25 N.m (18 lb ft).

- Tighten the M10 engine lift bracket bolts to 50 N.m (37 lb ft).

2. Install an engine hoist to the **J 41798** . See **Special Tools**.
3. Remove the engine from the engine stand.
4. Install the engine to the vehicle.
5. Align the engine and transmission.

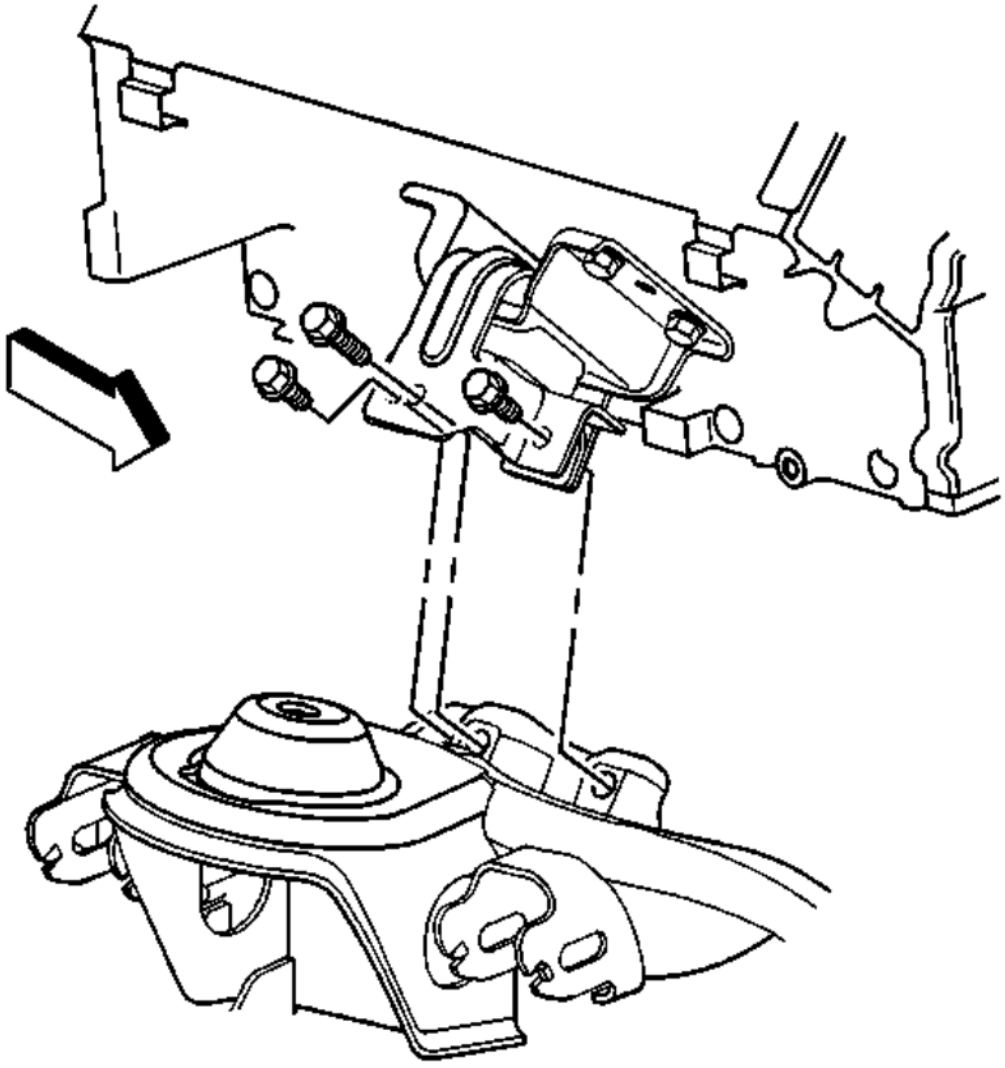

Fig. 264: View Of Engine Mount-To-Engine Mount Bracket

Courtesy of GENERAL MOTORS CORP.

6. Install the left and right engine mount-to-engine mount bracket bolts.

   Tighten: Tighten the engine mount-to-engine mount bracket bolts to 65 N.m (48 lb ft).

7. Install the upper transmission bolts until snug.
8. Remove the floor jack from under the transmission.
9. Remove the engine hoist.

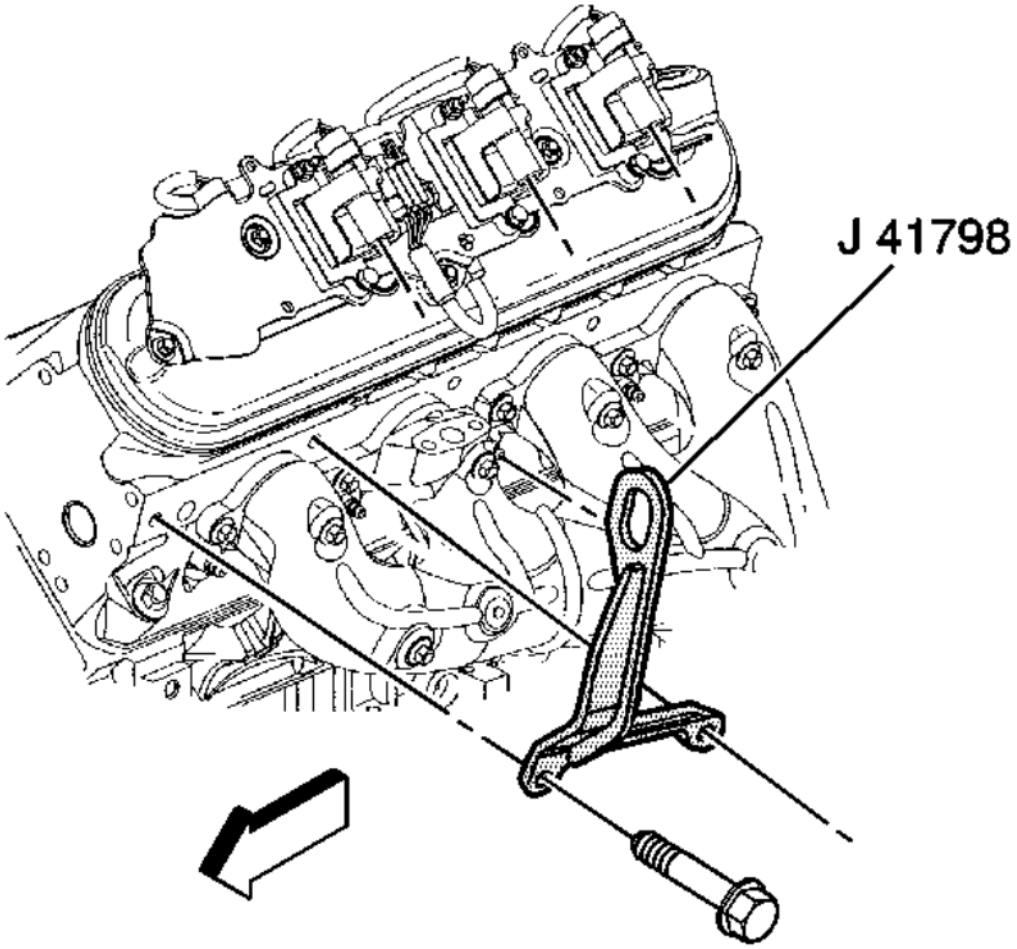

Fig. 265: View Of J 41798
Courtesy of GENERAL MOTORS CORP.

10. Remove the **J 41798** . See **Special Tools**.

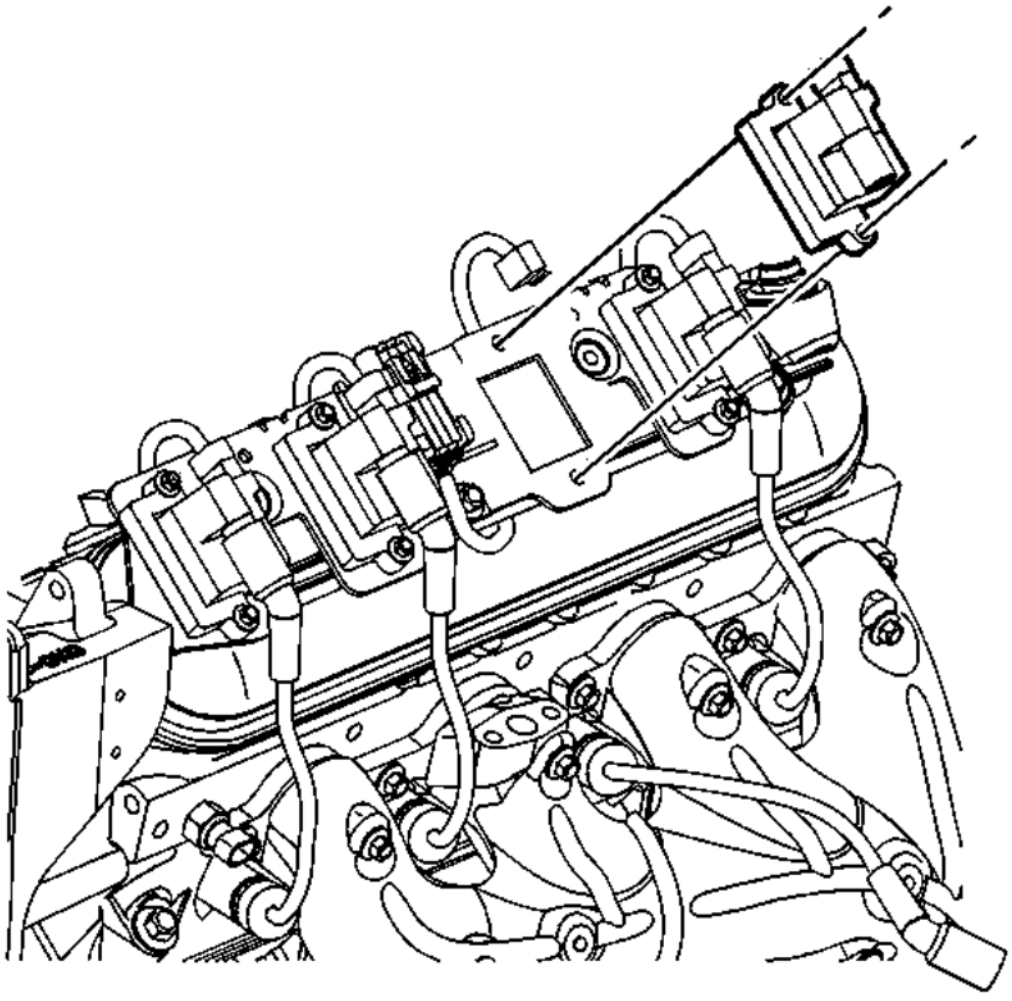

Fig. 266: View Of Ignition Coils & Spark Plug Wires
Courtesy of GENERAL MOTORS CORP.

11. Install the ignition coils and the spark plug wires. Refer to **Ignition Coil Replacement** .
12. Raise the vehicle.

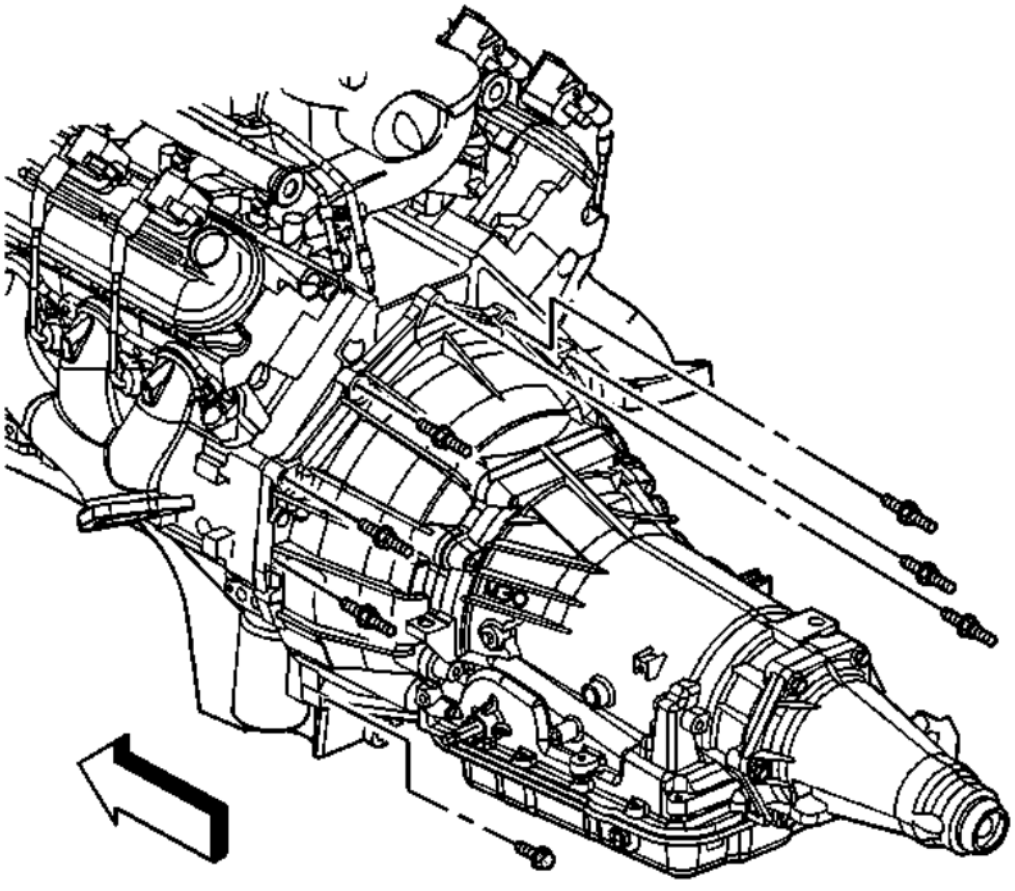

Fig. 267: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

13. Remove the **J 21366** . See **Special Tools**.
14. Install the automatic transmission bolt/studs.

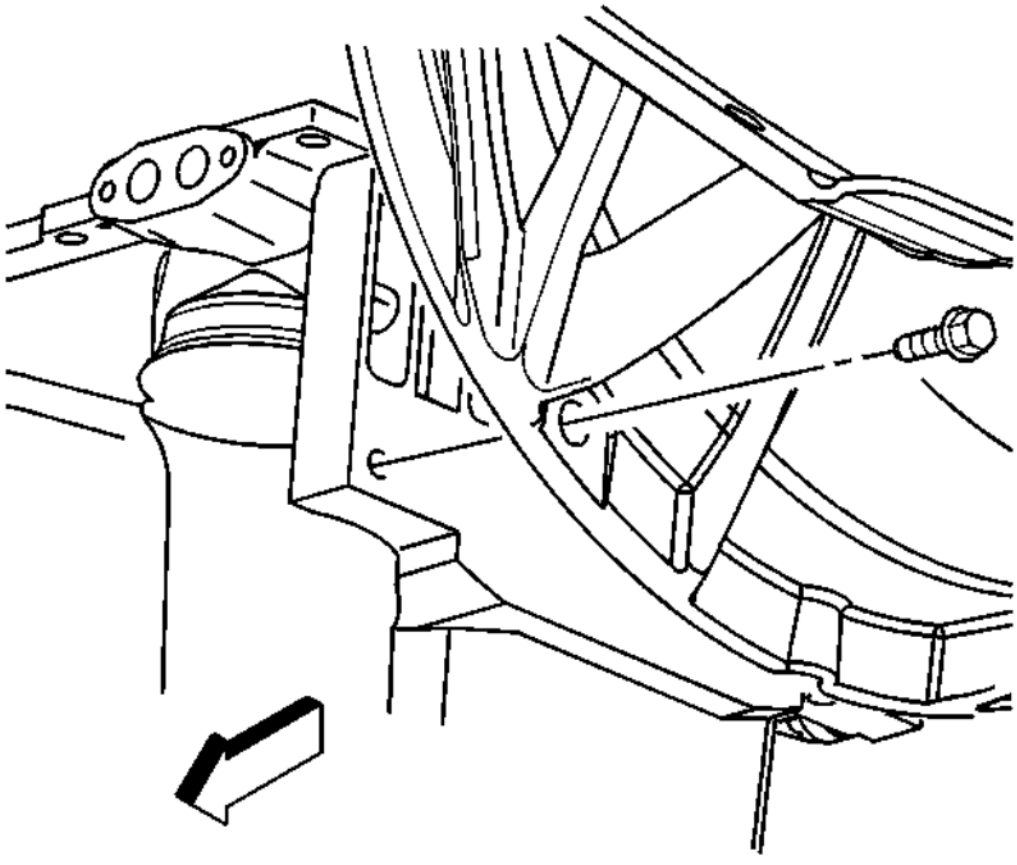

Fig. 268: View Of Transmission Converter Cover Bolt (4L80-E)
Courtesy of GENERAL MOTORS CORP.

15. Install the transmission converter cover bolts.

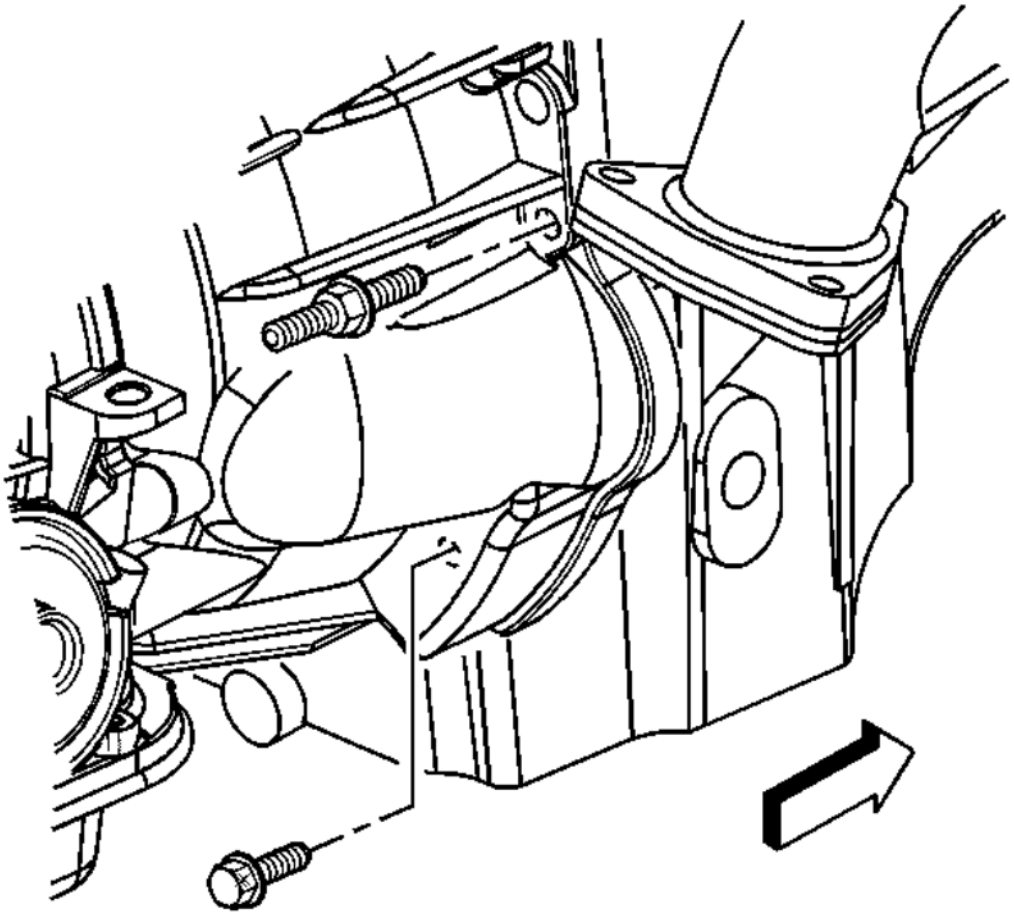

Fig. 269: Identifying Stud & Bolt Securing Transmission To Engine (Right Side)
Courtesy of GENERAL MOTORS CORP.

16. Install the transmission bolt and stud on the right side.

    Tighten: Tighten the automatic transmission bolts/studs to 50 N.m (37 lb ft).

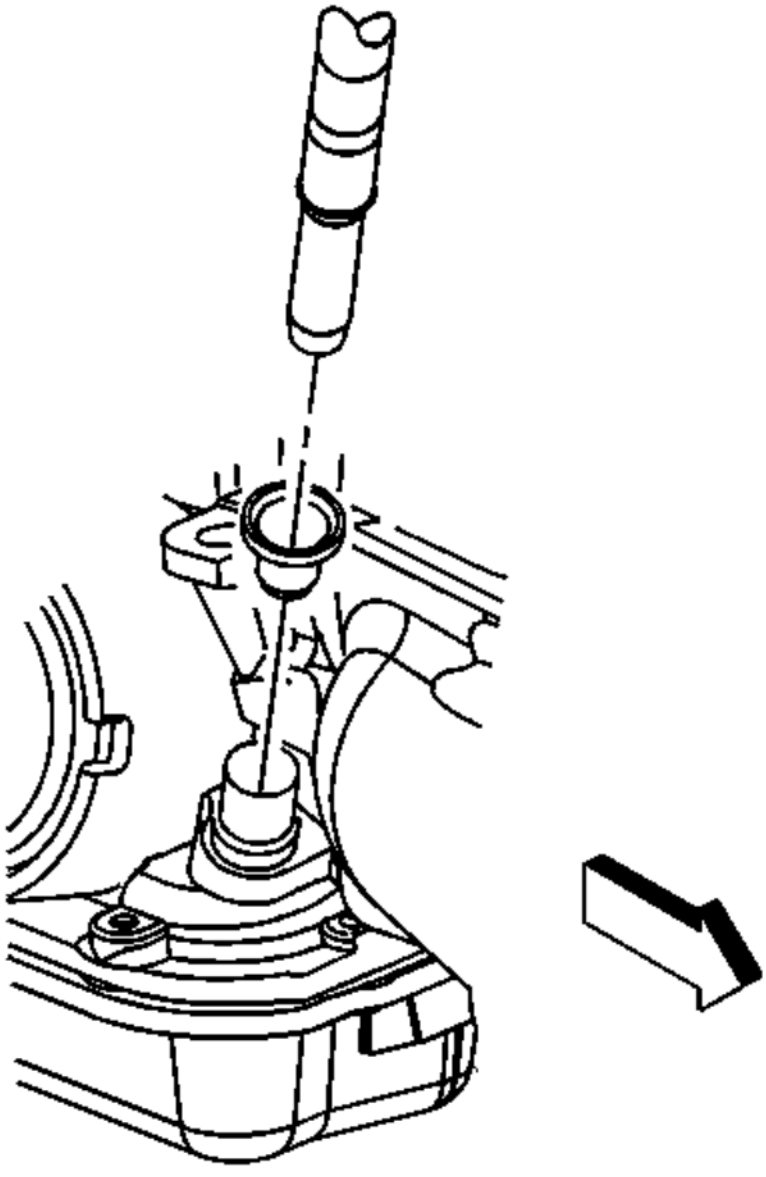

Fig. 270: View Of Oil Level Indicator Tube & Seal
Courtesy of GENERAL MOTORS CORP.

17. Install the automatic transmission oil level indicator tube.

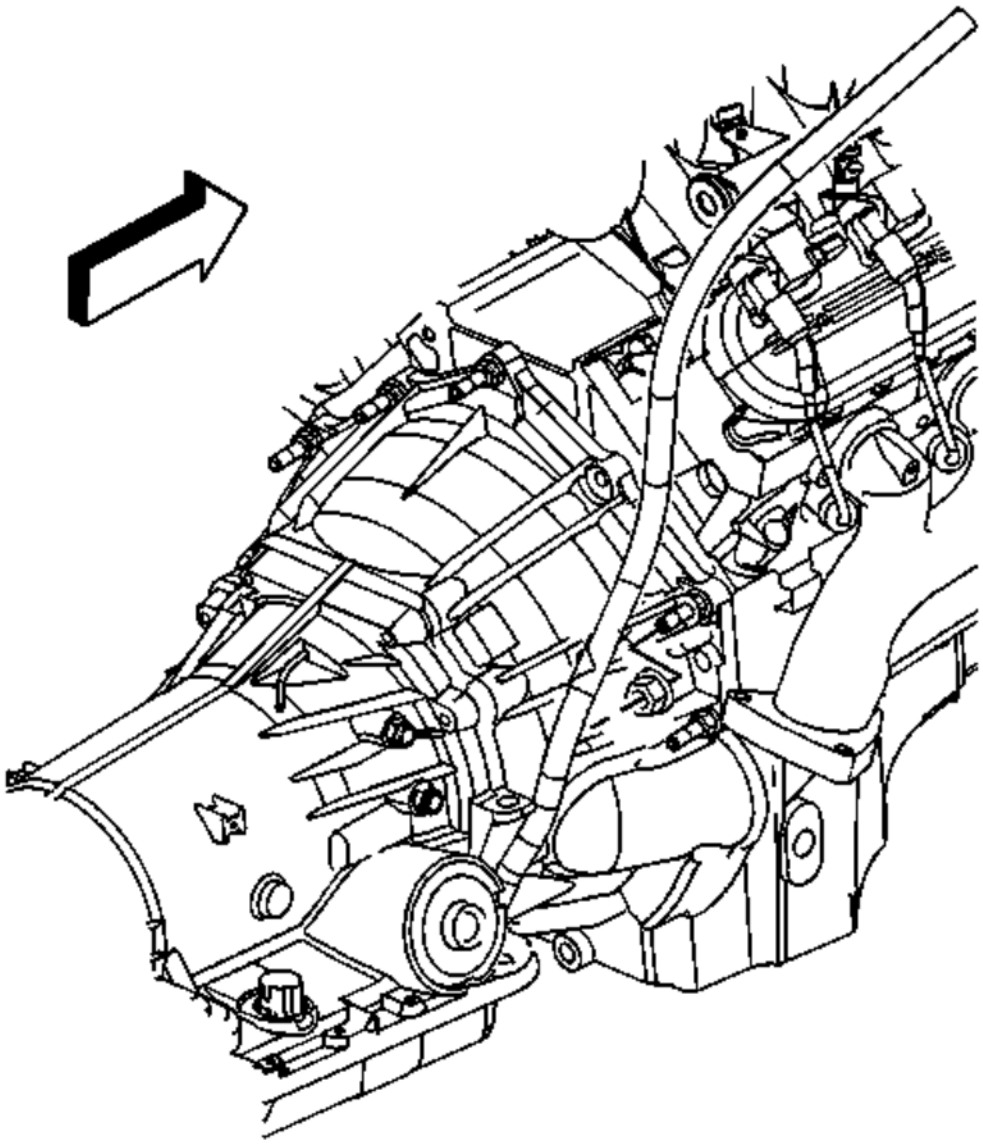

Fig. 271: View Of Oil Level Indicator Tube Nut
Courtesy of GENERAL MOTORS CORP.

18. Install the automatic transmission oil level indicator tube nut.

    Tighten: Tighten the automatic transmission oil level indicator tube nut to 18 N.m (13 lb

ft).

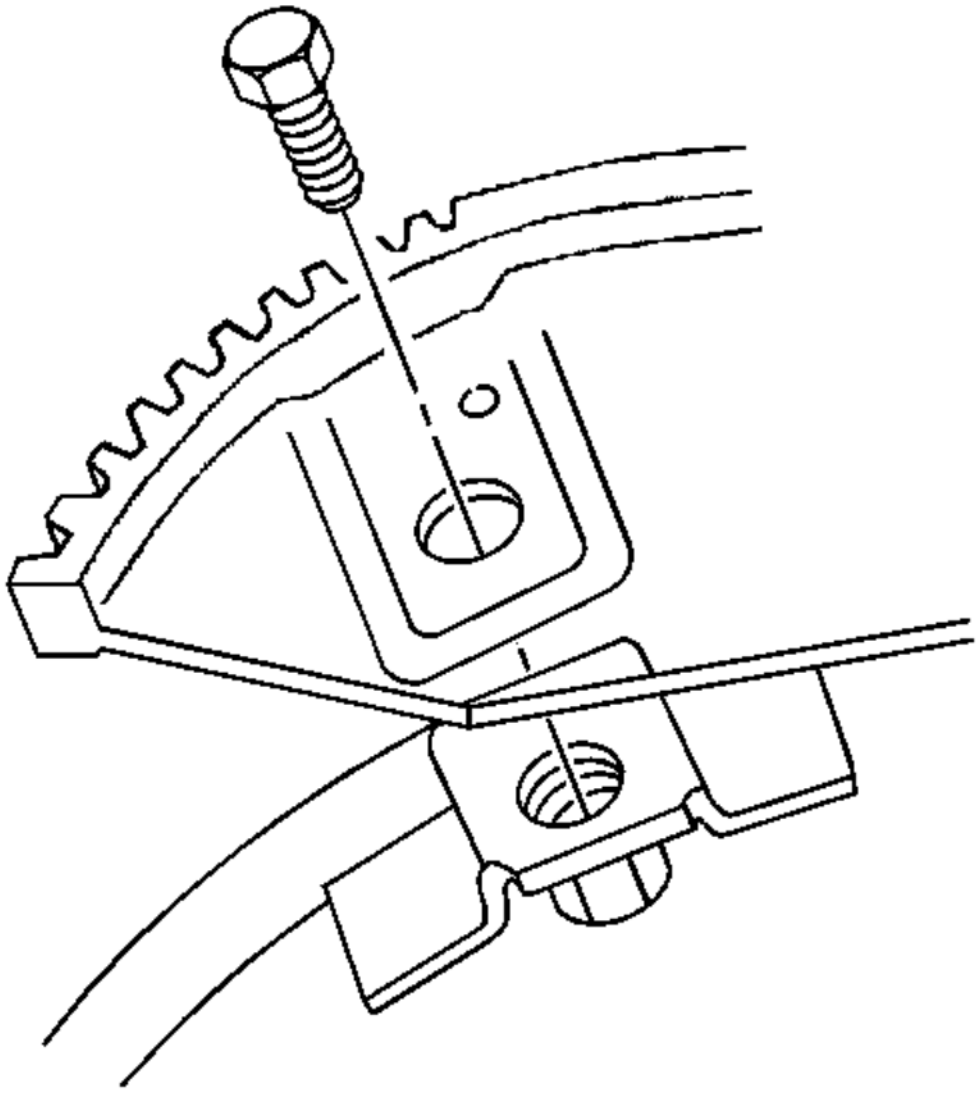

Fig. 272: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

19. Install the flywheel to torque converter bolts.

Tighten: Tighten the bolts to 63 N.m (47 lb ft).

20. Install exhaust pipes to the exhaust manifolds.

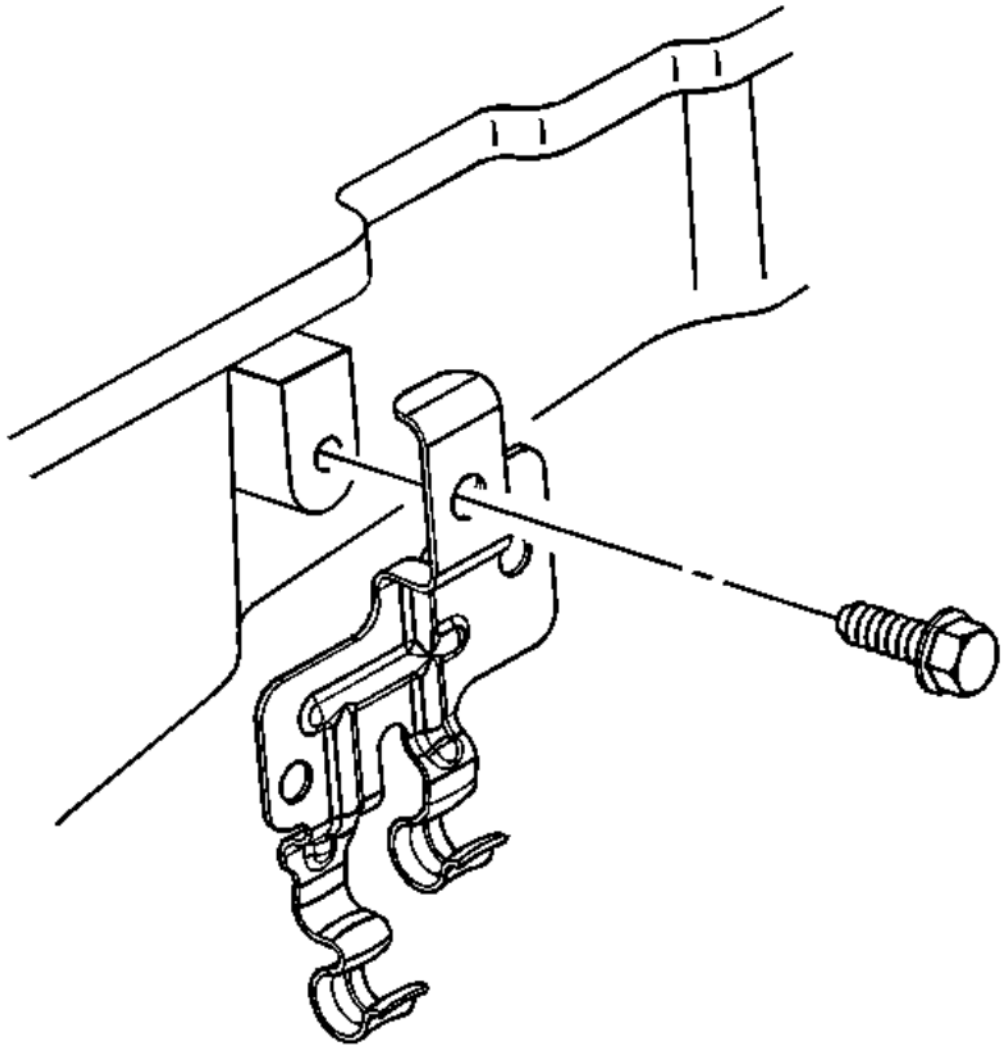

Fig. 273: View Of Positive Battery Cable Clip & Bolt
Courtesy of GENERAL MOTORS CORP.

21. Install the positive battery cable clip and bolt.

Tighten: Tighten the positive battery cable clip bolt to 9 N.m (80 lb in).

22. Install the starter motor. Refer to **Starter Motor Replacement** .
23. Install the engine protection shield. Refer to **Engine Protection Shield Replacement** .

    Tighten: Tighten the oil pan skid plate bolts to 20 N.m (15 lb ft).

24. Lower the vehicle.
25. Install the ground cable to the engine block.

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

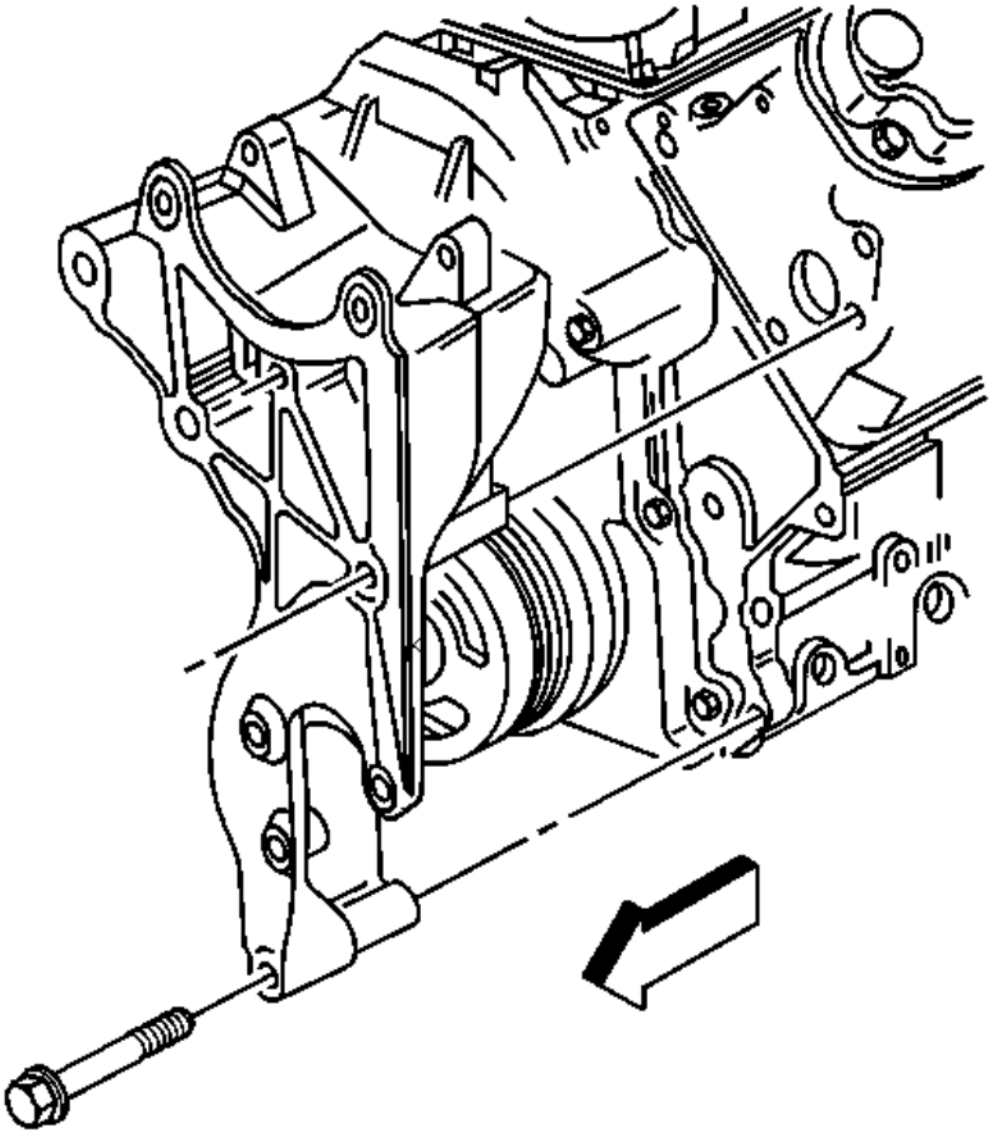

Fig. 274: View Of Generator Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

26. Position the generator bracket to the front of the engine.
27. Install the generator bracket bolts until snug.
28. Install the rear power steering pump-to-engine block bolt until snug.

Tighten:

- Tighten the rear power steering pump bolt to 50 N.m (37 lb ft).
- Tighten the generator bracket bolts to 50 N.m (37 lb ft).

29. Route the engine wiring harness to the lower engine area.
30. Raise the vehicle.

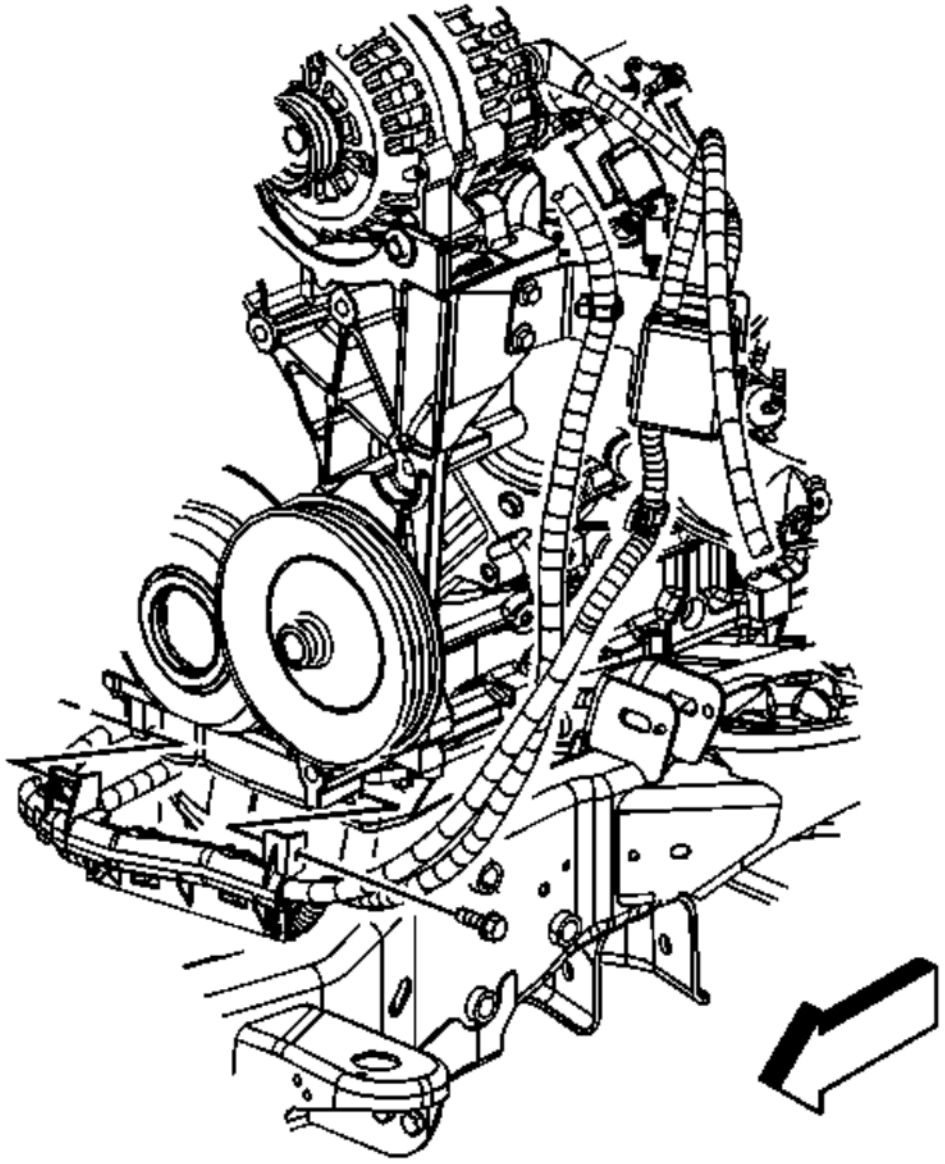

Fig. 275: View Of Positive Battery Cable, Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

31. Slide the channel pin into the oil pan tab.
32. Install the battery cable channel bolt.

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

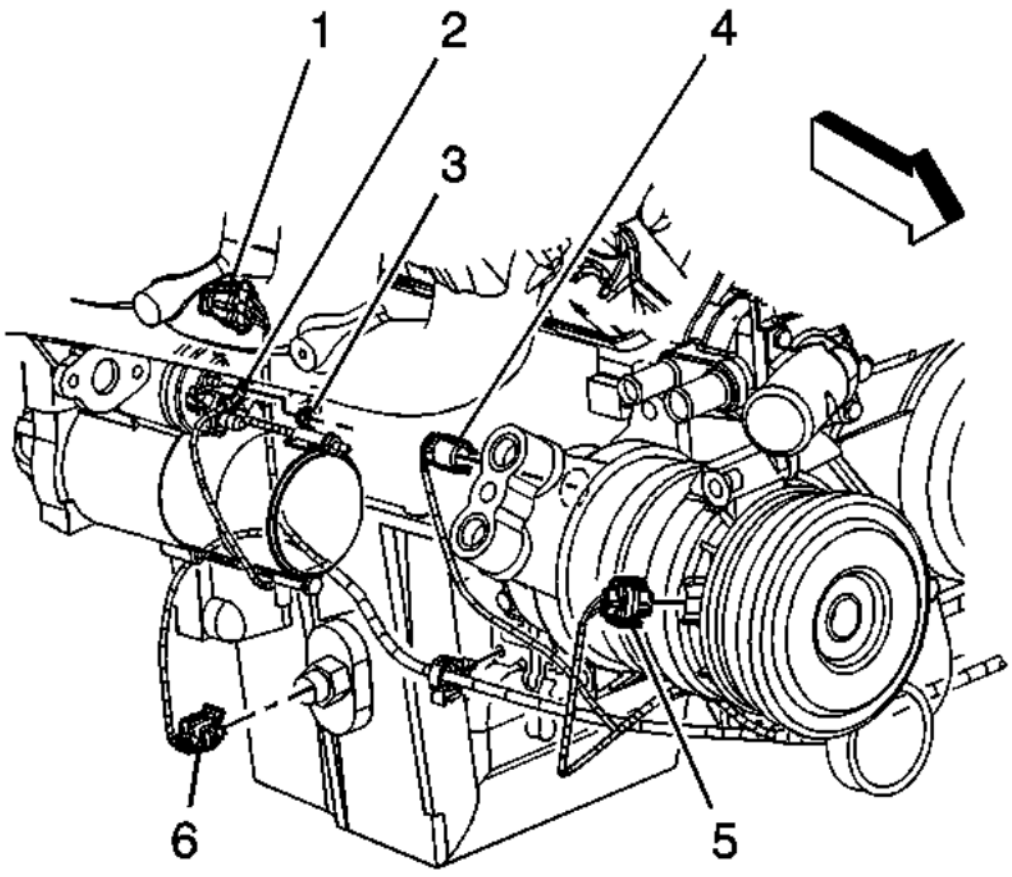

Fig. 276: Identifying Electrical Connector (Right Side Of Engine)
Courtesy of GENERAL MOTORS CORP.

33. Connect the following electrical connectors:
    - The CKP sensor (1)
    - The engine oil level sensor (6)
    - The coolant heater, if equipped
34. Lower the vehicle.
35. Connect the fuel pipes.

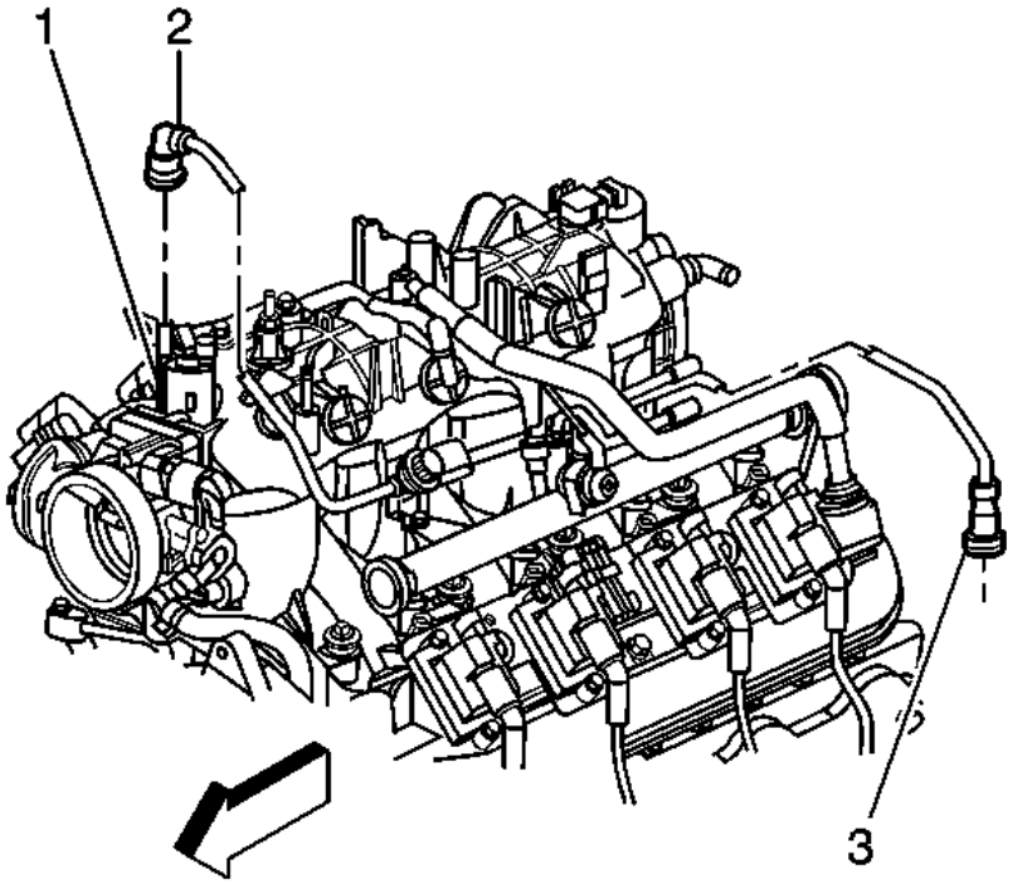

Fig. 277: View Of EVAP Purge Solenoid Vent Tube
Courtesy of GENERAL MOTORS CORP.

36. Install the EVAP purge solenoid vent tube to the solenoid (1).
37. Install the EVAP tube end (3) to the vapor pipe.

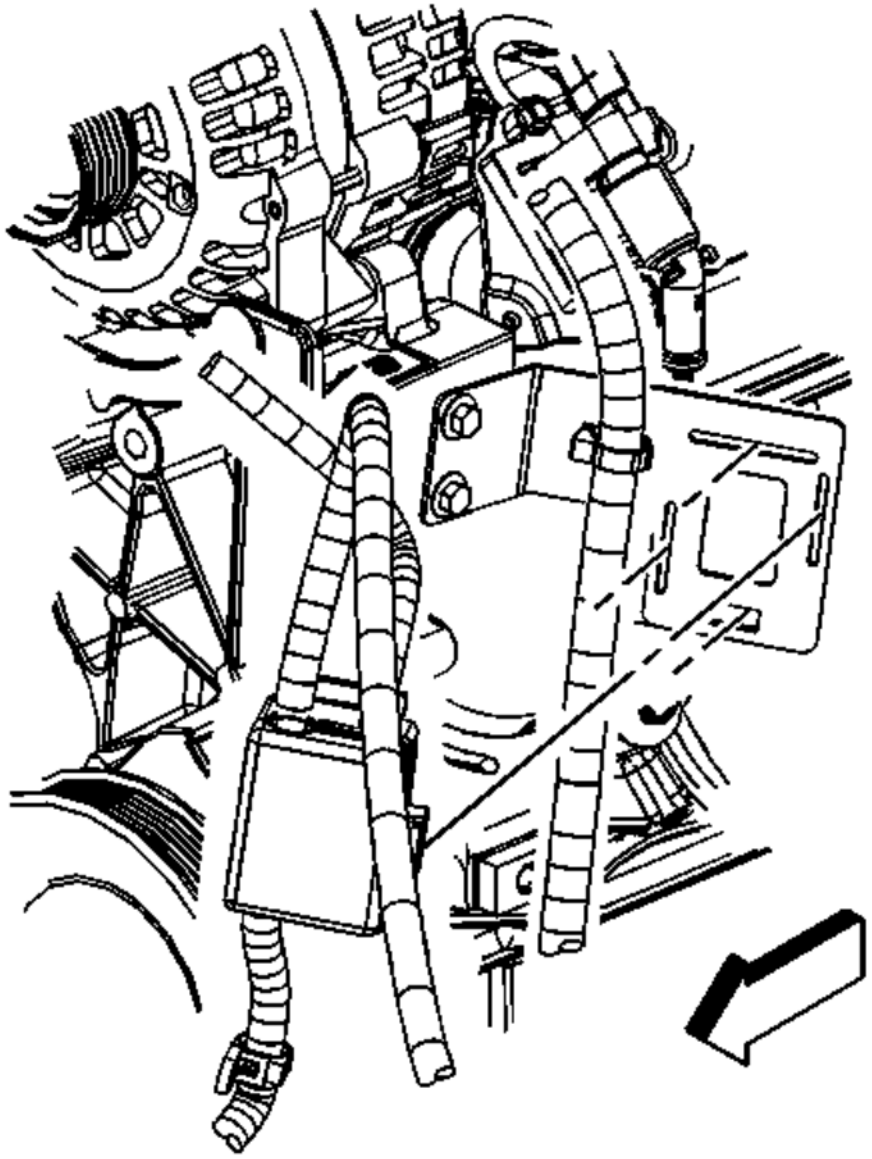

Fig. 278: View Of Battery Cable Junction Block
Courtesy of GENERAL MOTORS CORP.

38. Install the battery cable junction block to the junction block bracket.
39. Clip all of the engine wiring harness clips to their correct location.

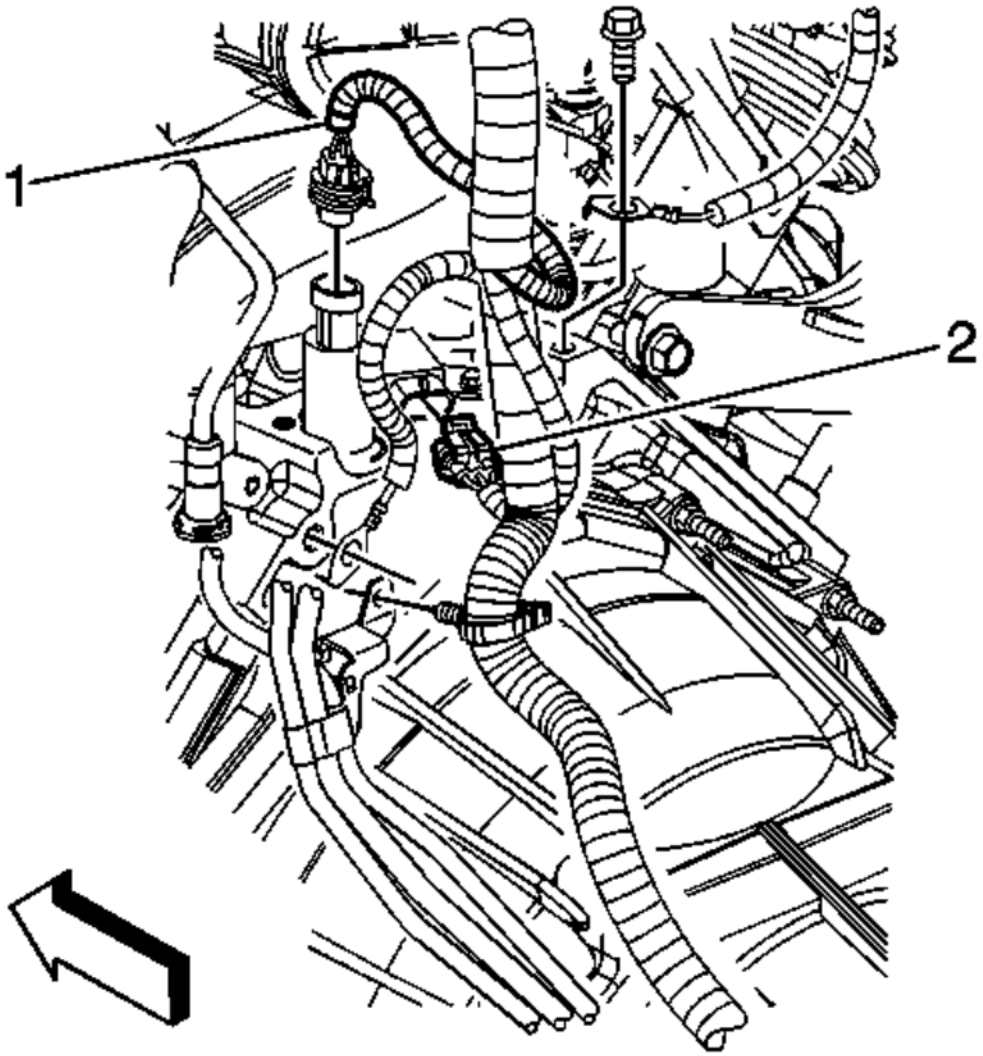

Fig. 279: View Of Oil Pressure Sensor & CMP Sensor Connectors
Courtesy of GENERAL MOTORS CORP.

40. Connect the following electrical connectors:
    - Oil pressure sensor (1)
    - CMP sensor (2)
41. Position the harness ground and the engine ground strap to the block.

42. Install the harness ground bolt at the left rear of the engine block.
43. Position the harness ground to the block.
44. Install the harness ground bolt at the right rear of the engine block.

Tighten: Tighten the harness ground bolts at the rear of the block to 16 N.m (12 lb ft).

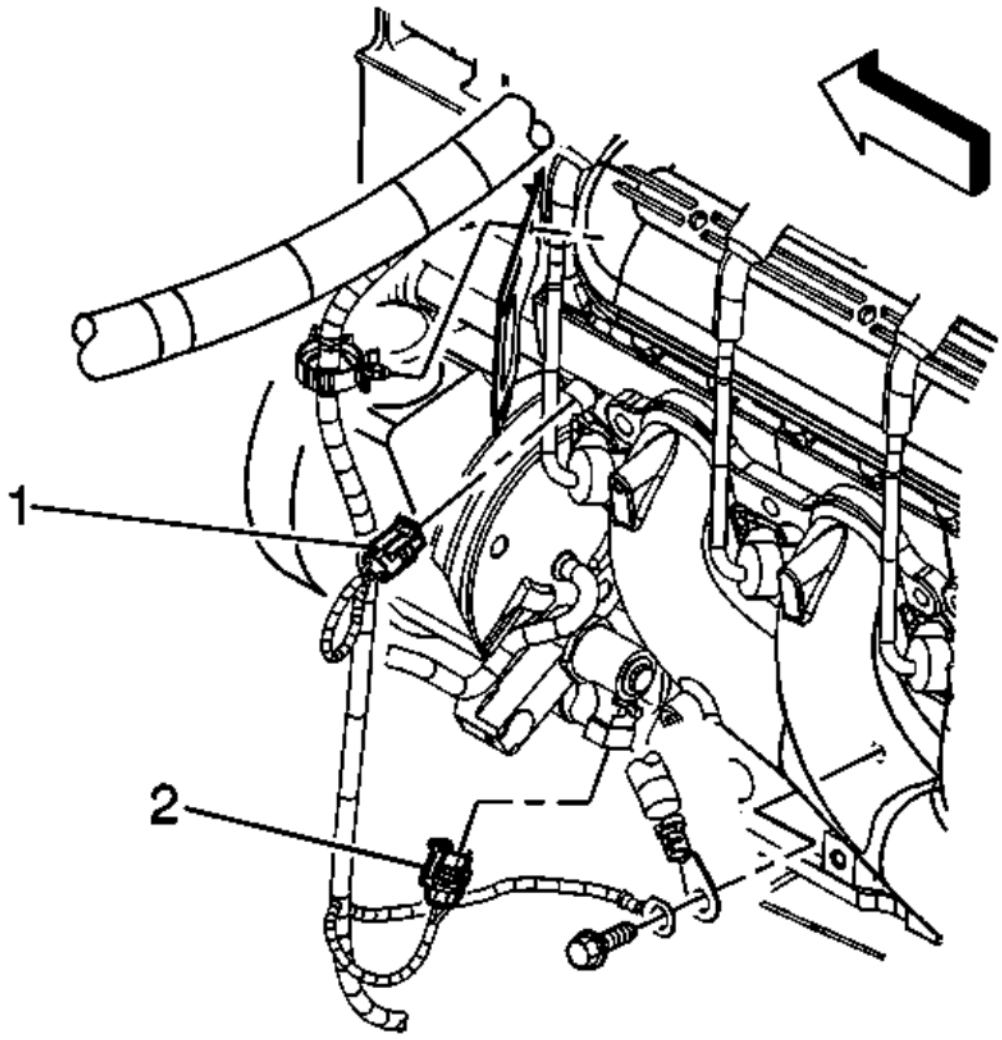

Fig. 280: Coolant Temperature Sensor & Electronic Variable Orifice Switch Electrical Connectors

Courtesy of GENERAL MOTORS CORP.

45. Connect the following electrical connectors:
    - Coolant temperature sensor (1)
    - Electronic variable orifice switch (2)
46. Position the harness ground and negative battery cable to the block.
47. Install the harness ground bolt.

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

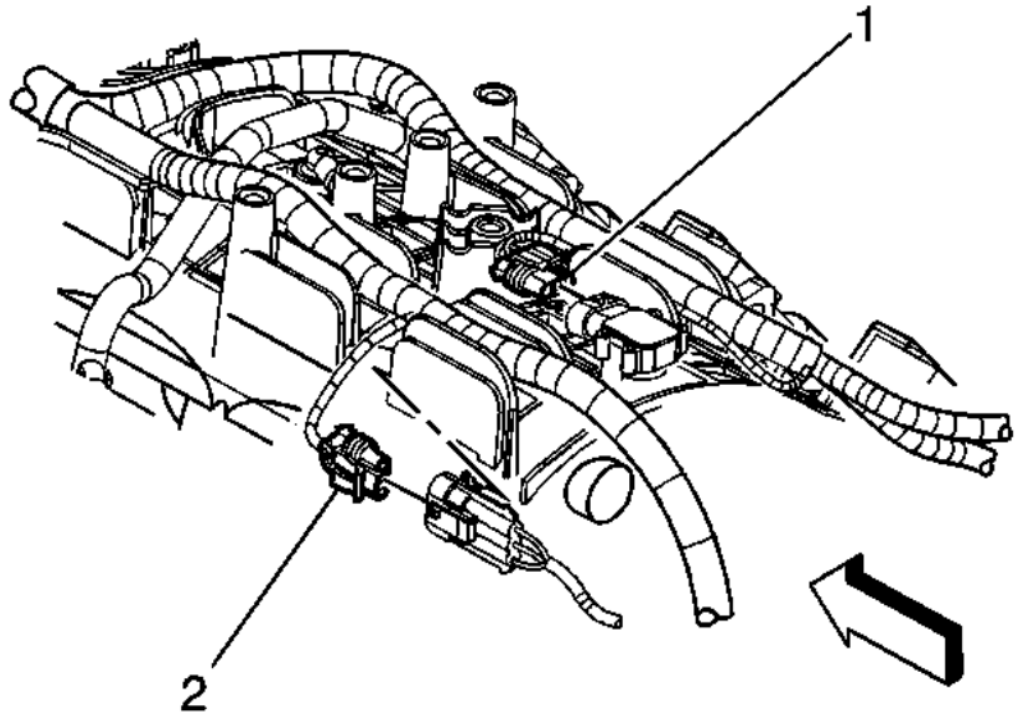

Fig. 281: View Of MAP Sensor & Knock Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

48. Connect the MAP sensor (1) and knock sensor (2) electrical connectors.

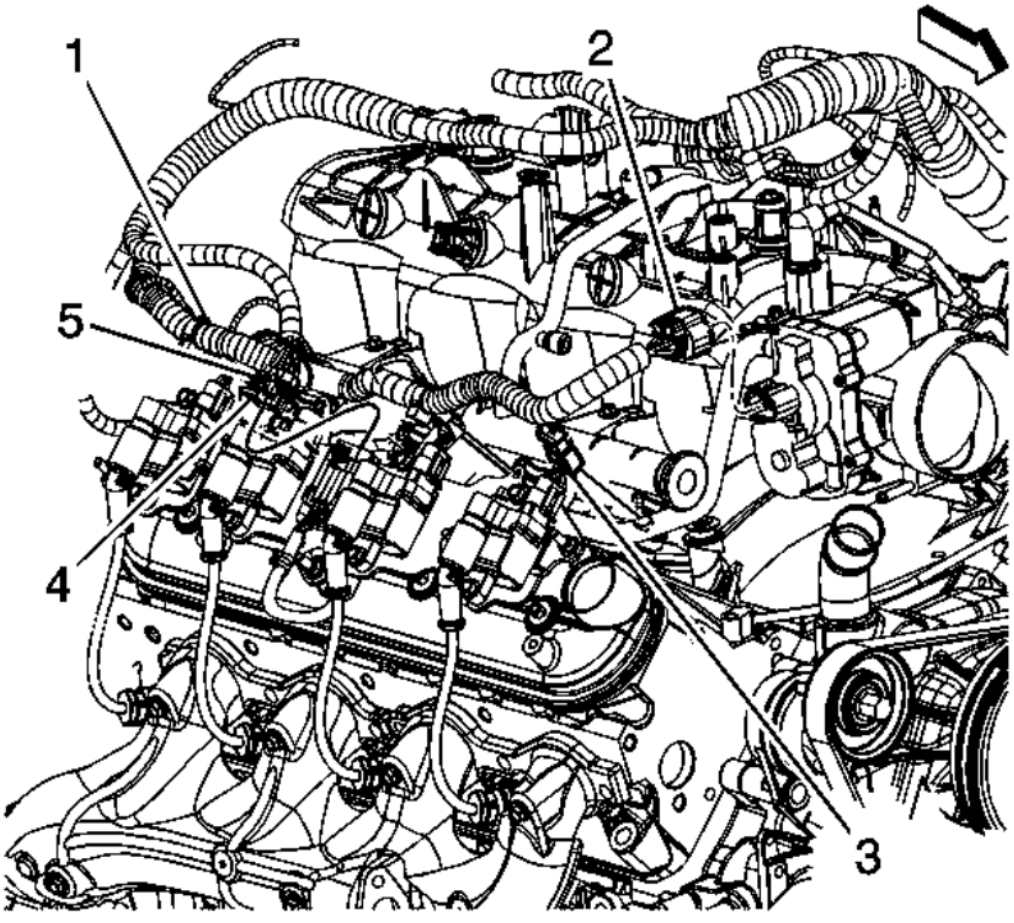

Fig. 282: Identifying Right Side Main Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

49. Connect the following electrical connectors:
    - Main coil harness (4)
    - Fuel injectors (3)
    - ETC (2)

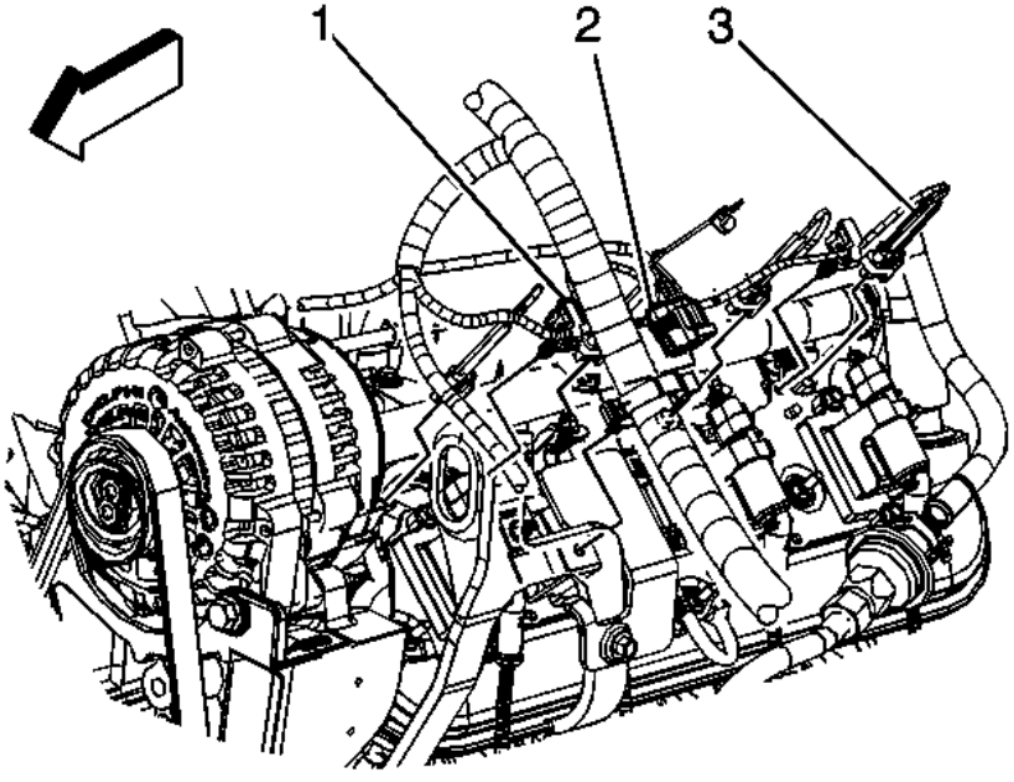

Fig. 283: View Of Main Coil Harness & Fuel Injector Electrical Connectors (Left Side)
Courtesy of GENERAL MOTORS CORP.

50. Connect the main coil harness (2) and fuel injector (3) electrical connectors on the left side.

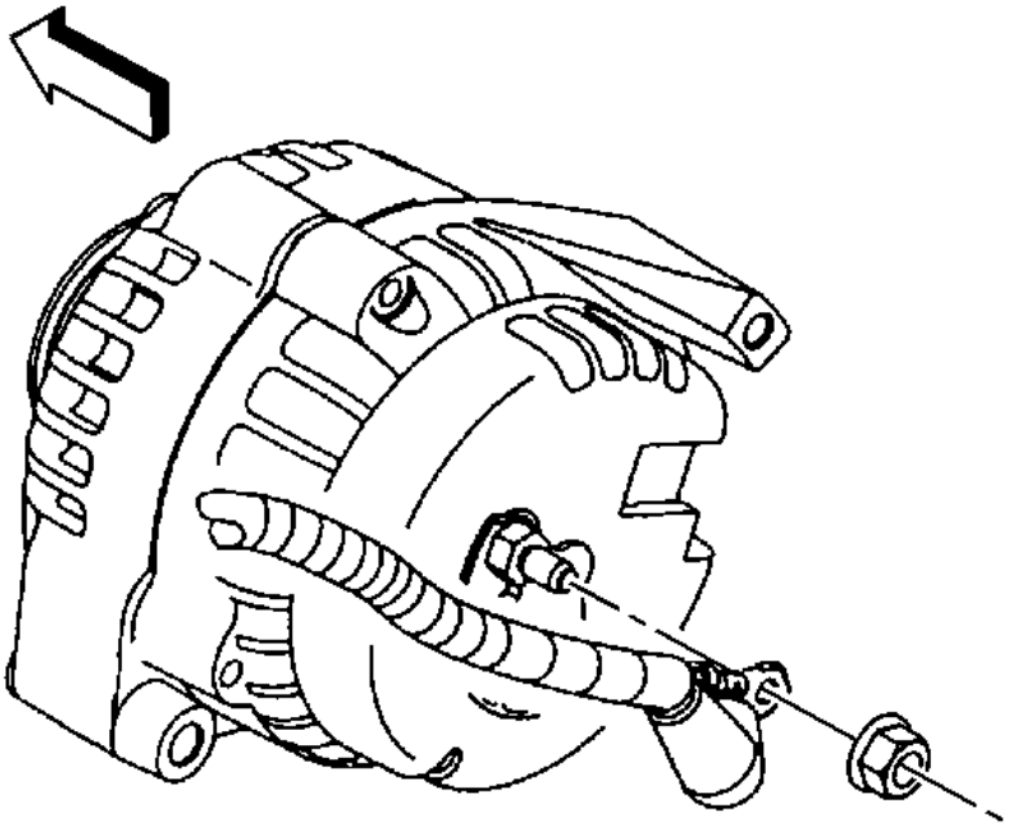

Fig. 284: View Of Generator Cable & Nut
Courtesy of GENERAL MOTORS CORP.

51. Install the generator cable to the generator, perform the following:
    1. Install the generator cable.
    2. Install the generator cable nut to the terminal stud.

       Tighten: Tighten the generator output terminal nut to 9 N.m (80 lb in).

    3. Slide the boot over the terminal stud.

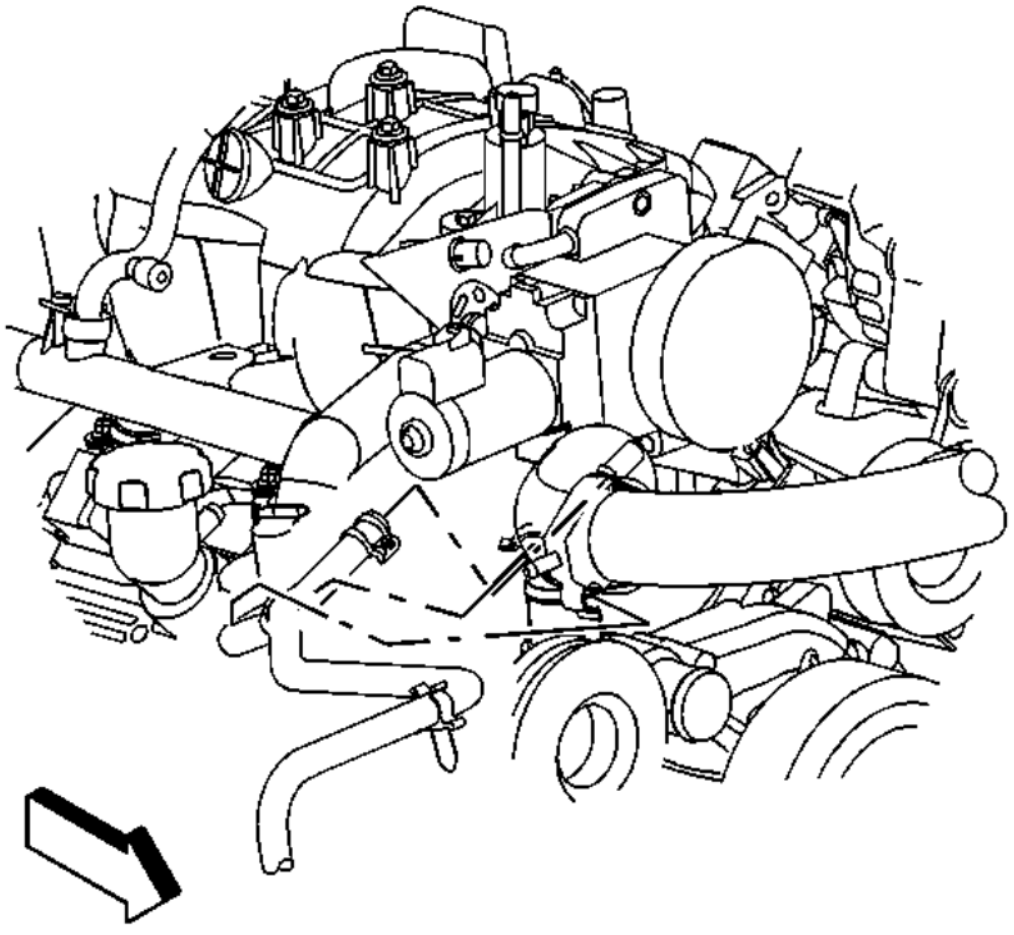

Fig. 285: View Of Vent Inlet Hose At Throttle Body
Courtesy of GENERAL MOTORS CORP.

52. Install the radiator vent inlet hose to the throttle body.
53. Position the vent inlet hose clamp at the throttle body.

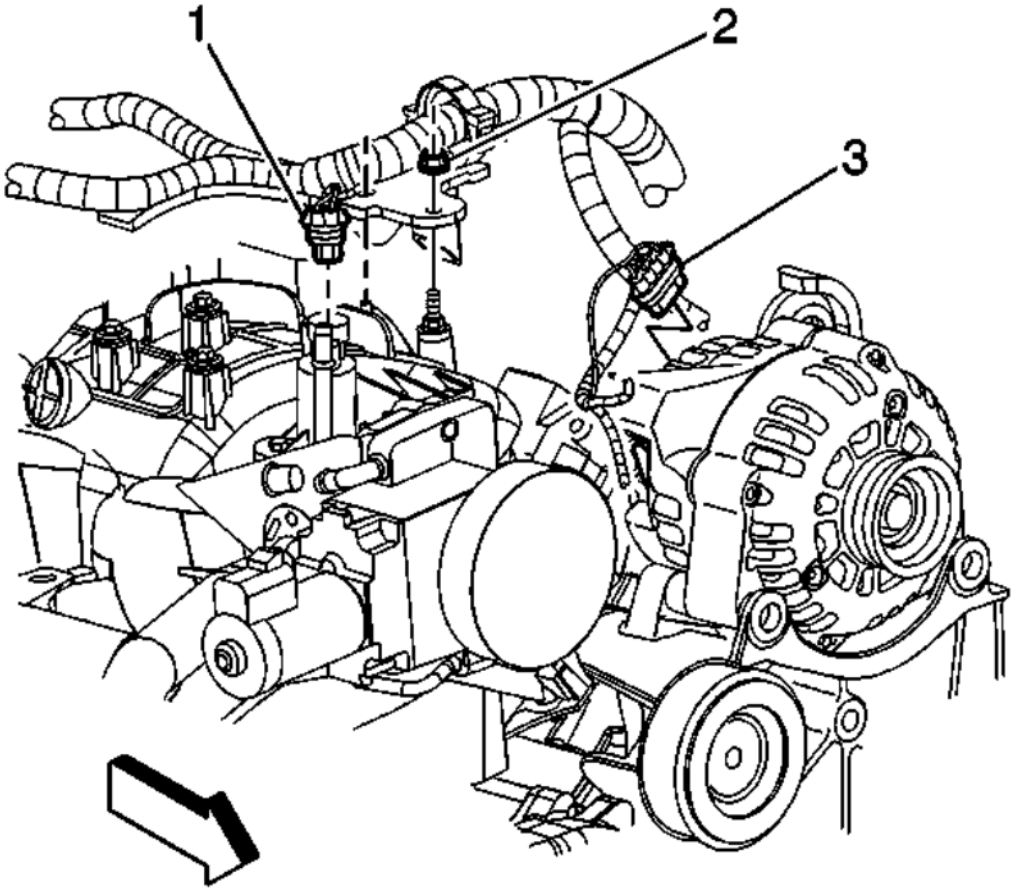

Fig. 286: Identifying Purge Solenoid Electrical Connector, Wiring Harness Nut & Generator Electrical Connector
Courtesy of GENERAL MOTORS CORP.

54. Install the engine wiring harness bracket and nut (2).

    Tighten: Tighten the engine wiring harness bracket nut to 5 N.m (44 lb in).

55. Connect the following electrical connectors:
    - EVAP canister purge solenoid (1)
    - Generator (3)
56. Install the engine sight shield retainer and bolts.

Tighten: Tighten the engine sight shield retainer bolts to 5 N.m (44 lb in).

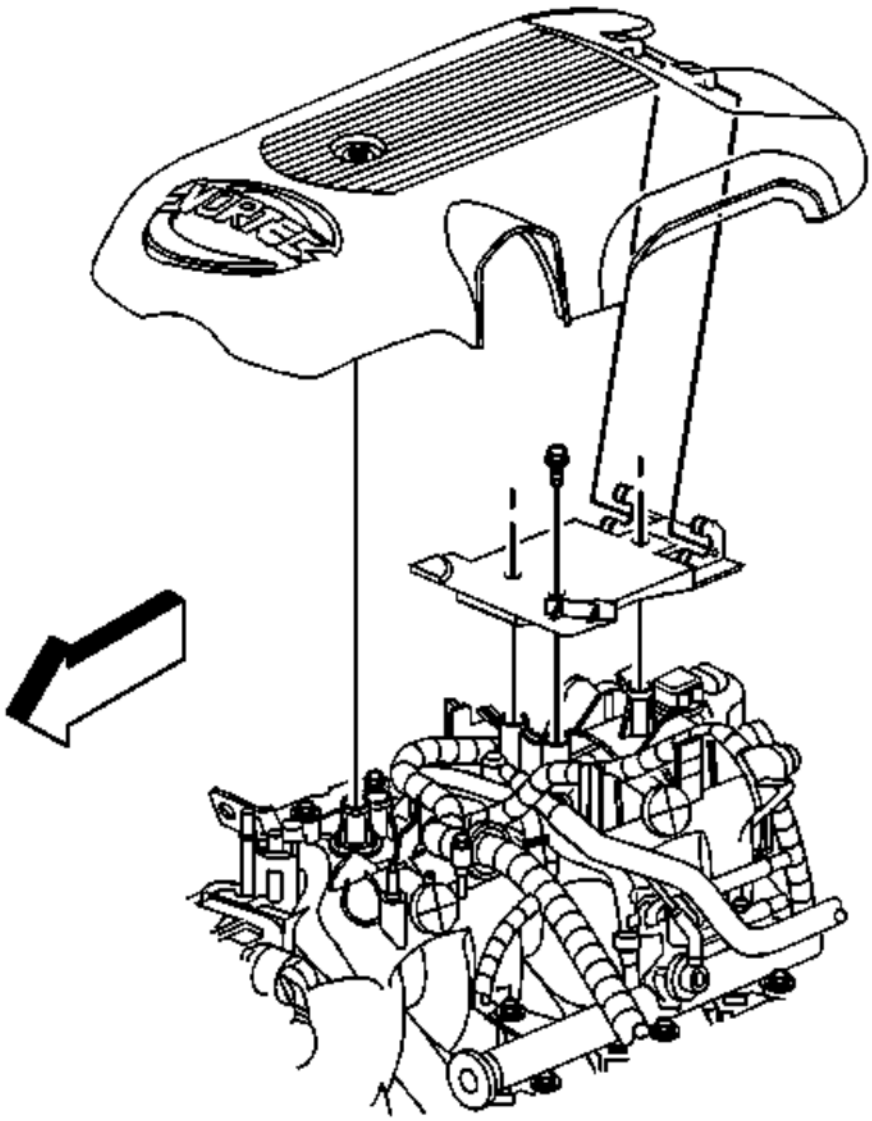

Fig. 287: View Of Top Engine Cover
Courtesy of GENERAL MOTORS CORP.

57. Install the engine sight shield to the retainer.

58. Tighten the engine sight shield bolt.

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

59. Install the heater hoses. Refer to **Heater Inlet Hose Replacement** and **Heater Outlet Hose Replacement** .

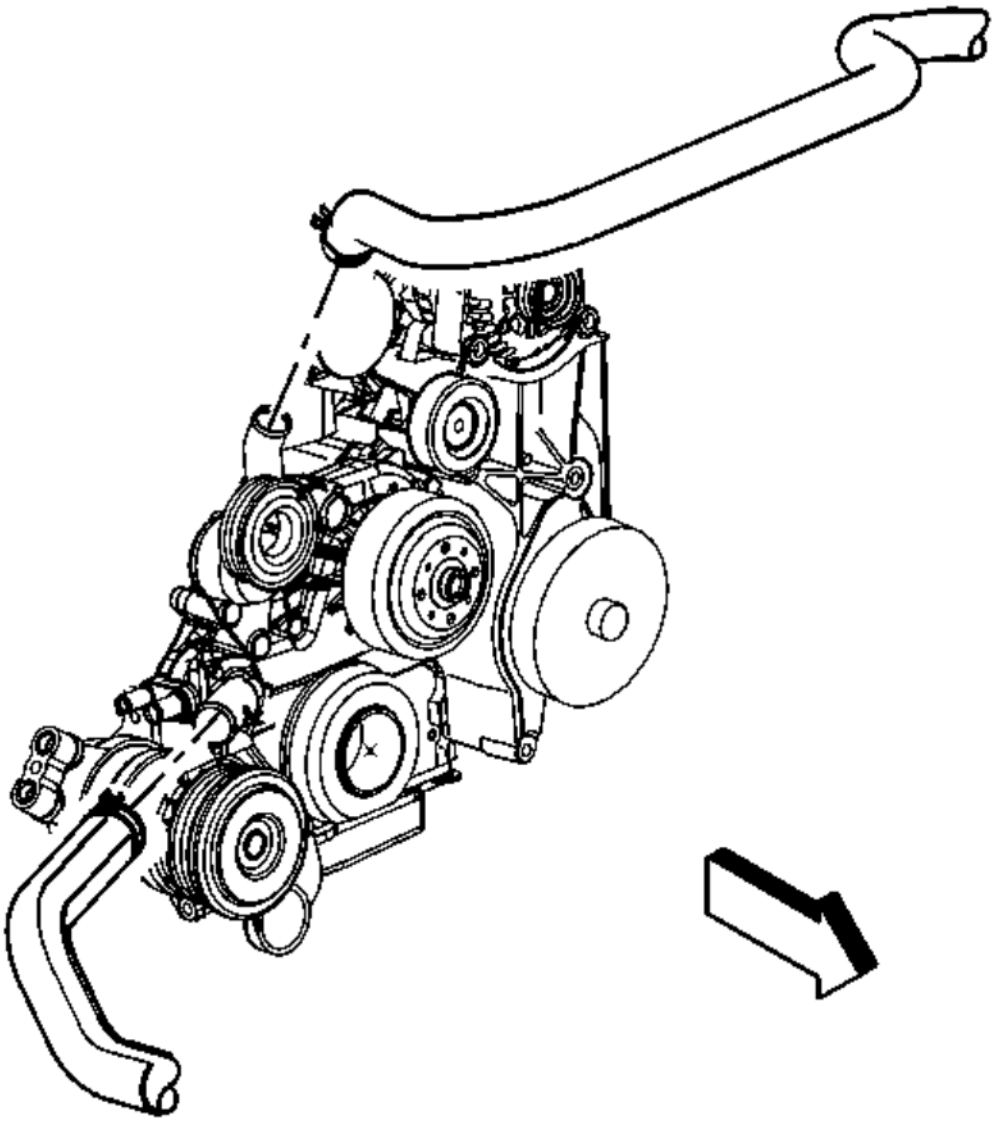

Fig. 288: View Of Radiator Inlet And Outlet Hoses
Courtesy of GENERAL MOTORS CORP.

60. Install the radiator outlet hose to the water pump.
61. Position the radiator outlet hose clamp at the water pump.

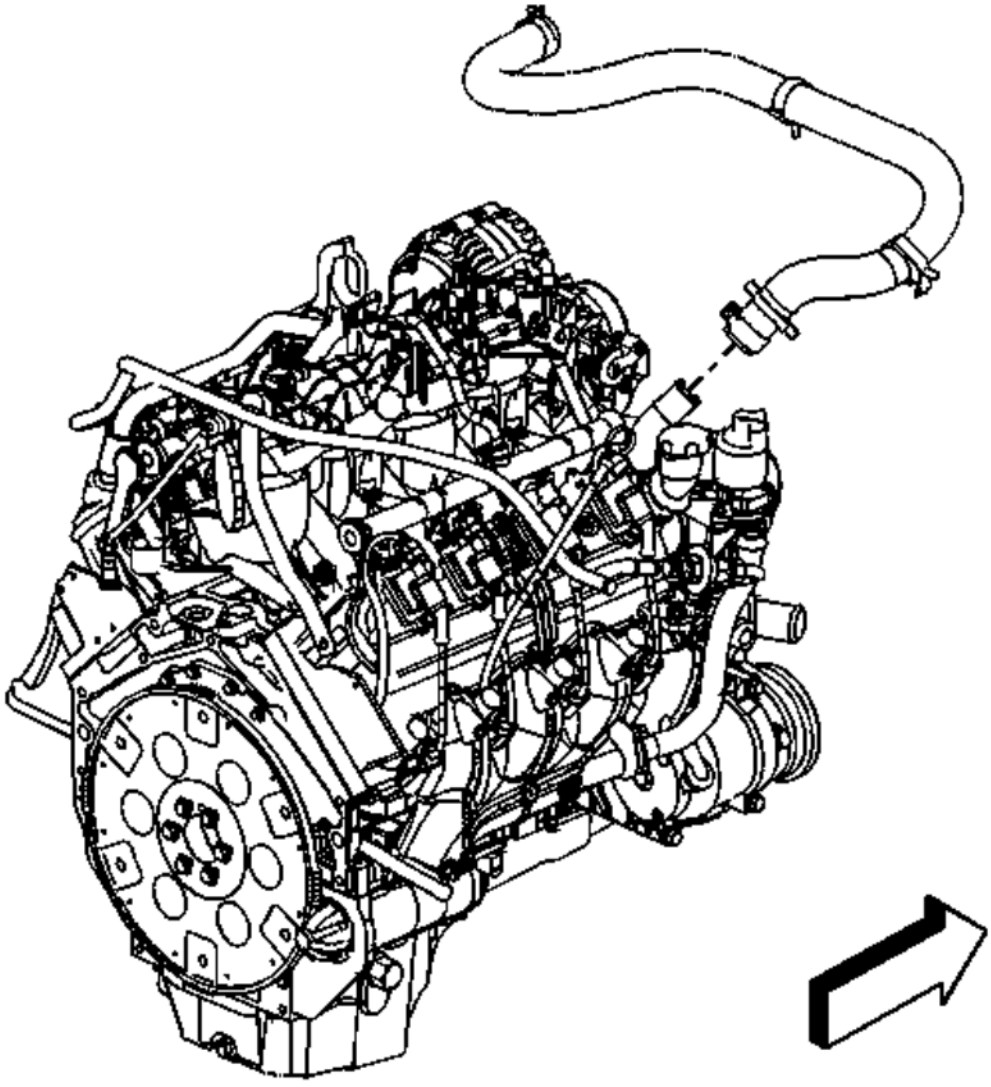

Fig. 289: View Of Inlet Hose To Water Pump

Courtesy of GENERAL MOTORS CORP.

62. Install the radiator inlet hose to the water pump.
63. Position the radiator inlet hose clamp at the water pump.
64. Install the radiator supports. Refer to **Radiator Support Replacement** .
65. Install the A/C compressor. Refer to **Compressor Replacement** .
66. Install the hood. Refer to **Hood Replacement** .
67. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Approximate Fluid Capacities** or **Fluid and Lubricant Recommendations** .
68. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

IMPORTANT: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.

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 1000 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. Perform a final inspection for the proper engine oil and coolant levels.

69. Close the hood.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

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.

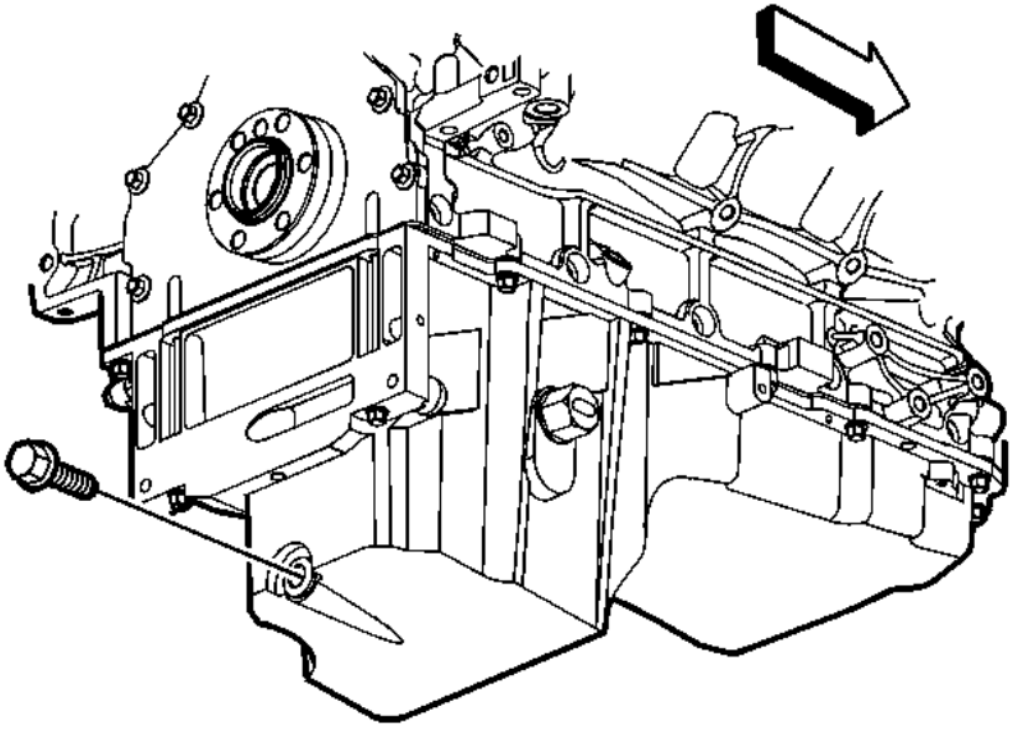

Fig. 290: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the oil fill cap.
3. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Place a oil drain pan under the oil pan drain plug.
5. Remove the oil pan drain plug.
6. Drain the engine oil.
7. Wipe the excess oil from the drain plug hole and plug.

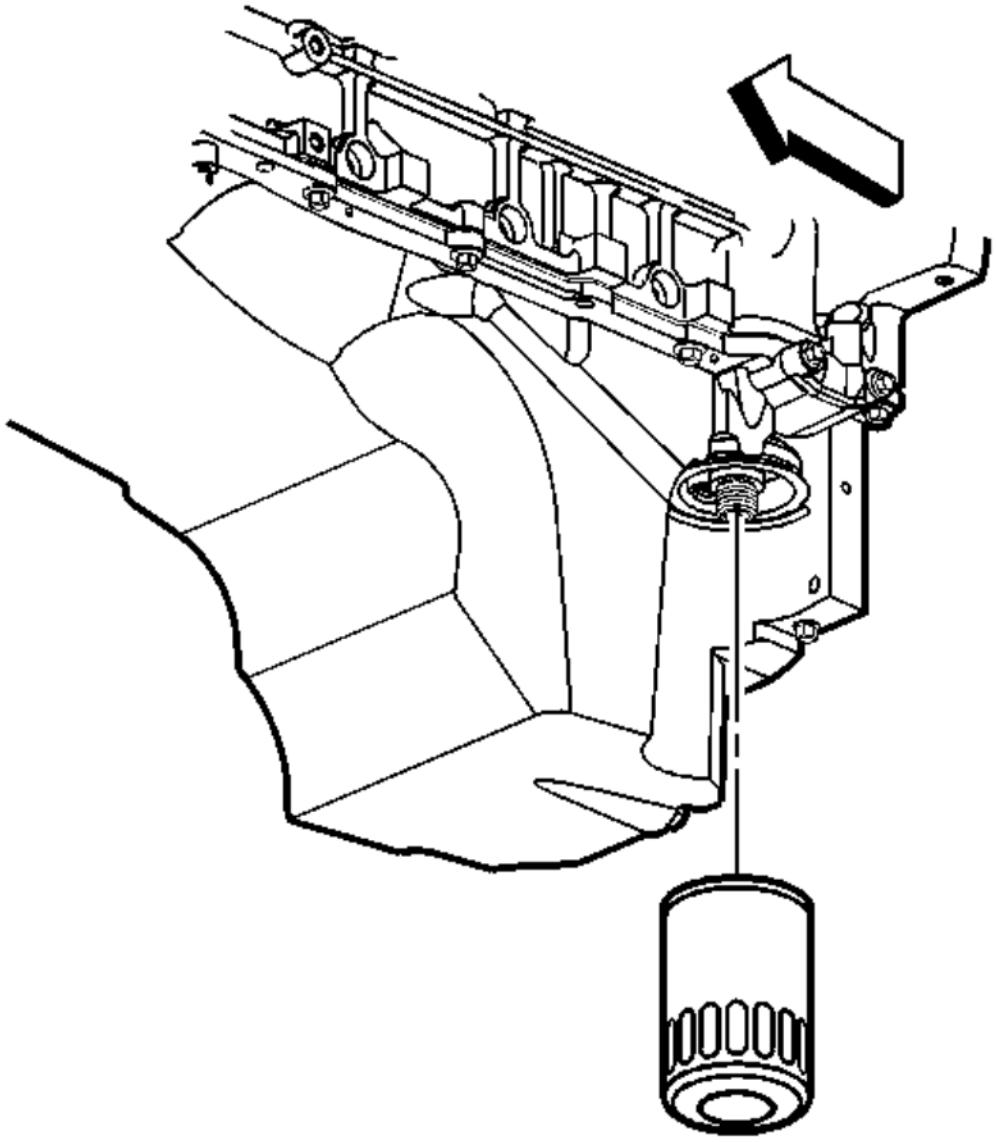

Fig. 291: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Check the old oil filter to ensure that the filter seal is not left on the engine block.

8. Remove the oil filter from the engine block.
9. Wipe the excess oil from the oil filter mounting.

Installation Procedure

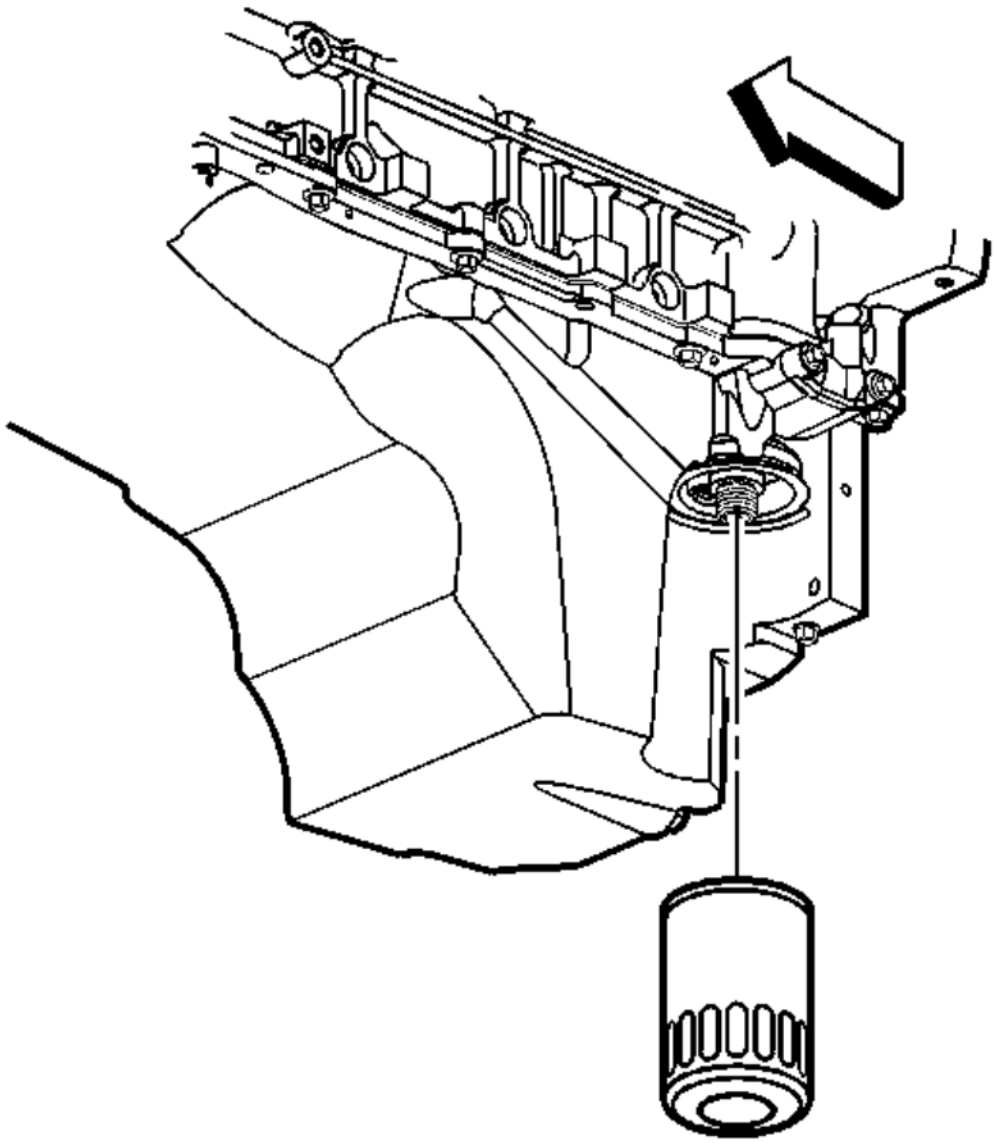

Fig. 292: View Of Engine Oil Filter

Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Lubricate the oil filter seal with clean engine oil.
2. Install the oil filter to the engine block.

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

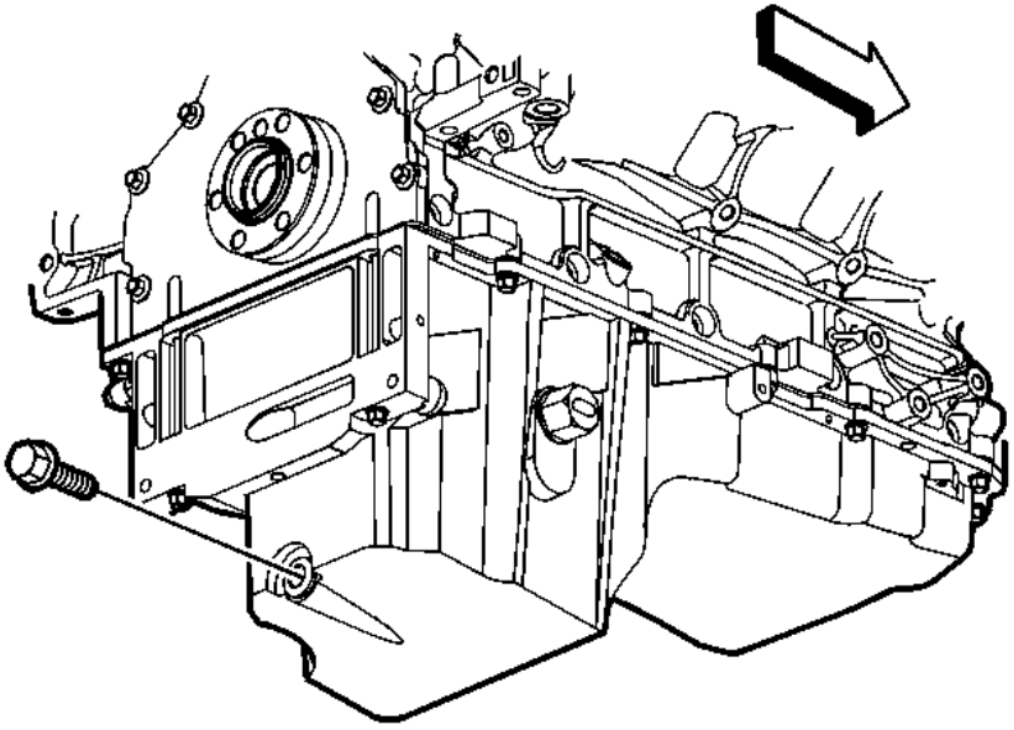

Fig. 293: View Of Oil Pan Drain Plug
Courtesy of GENERAL MOTORS CORP.

3. Install the oil drain plug to the engine block.

   Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

4. Lower the vehicle.

5. Fill the crankcase with the proper quantity and grade of engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations** .
6. Remove the oil level indicator.
7. Wipe the indicator with a clean cloth.
8. Install the oil level indicator.
9. Remove the oil level indicator in order to check the level.
10. Add oil if necessary.
11. Close the hood.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

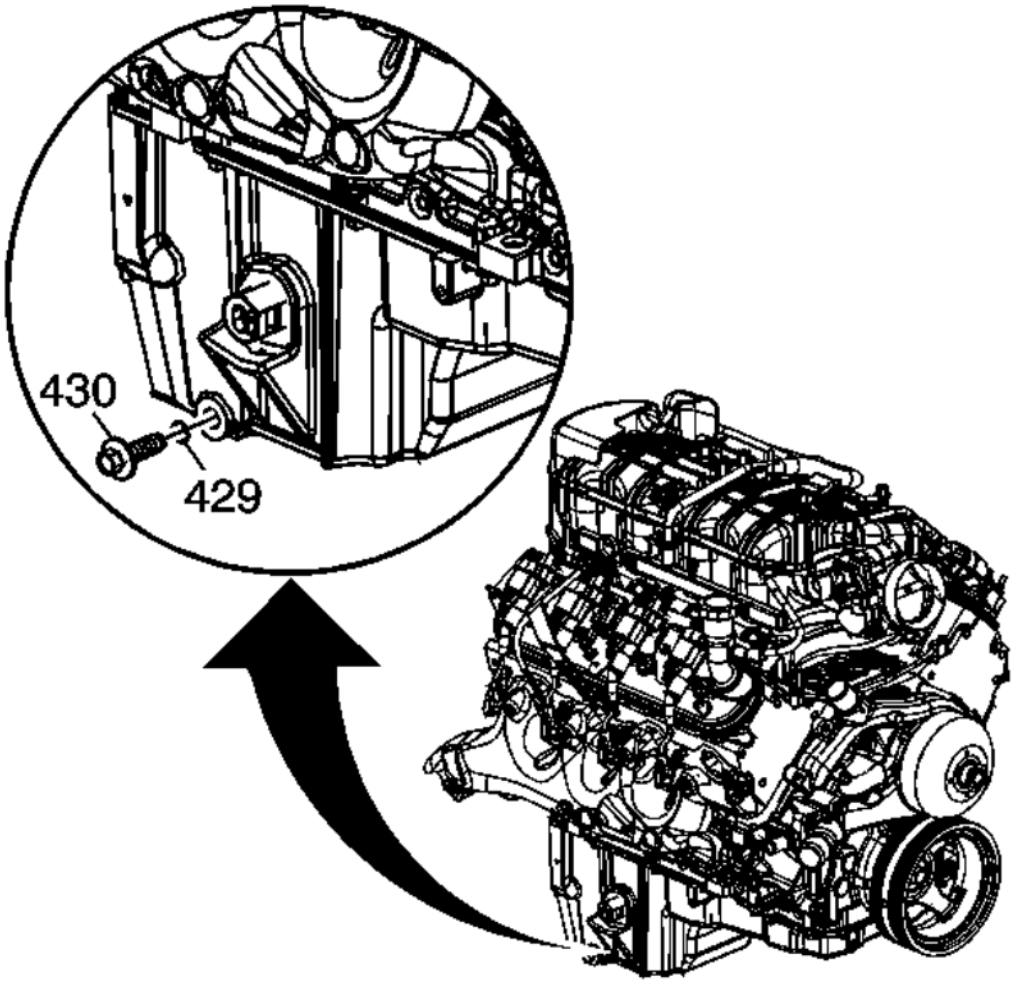

Fig. 294: View Of Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug (430) and O-ring (429).

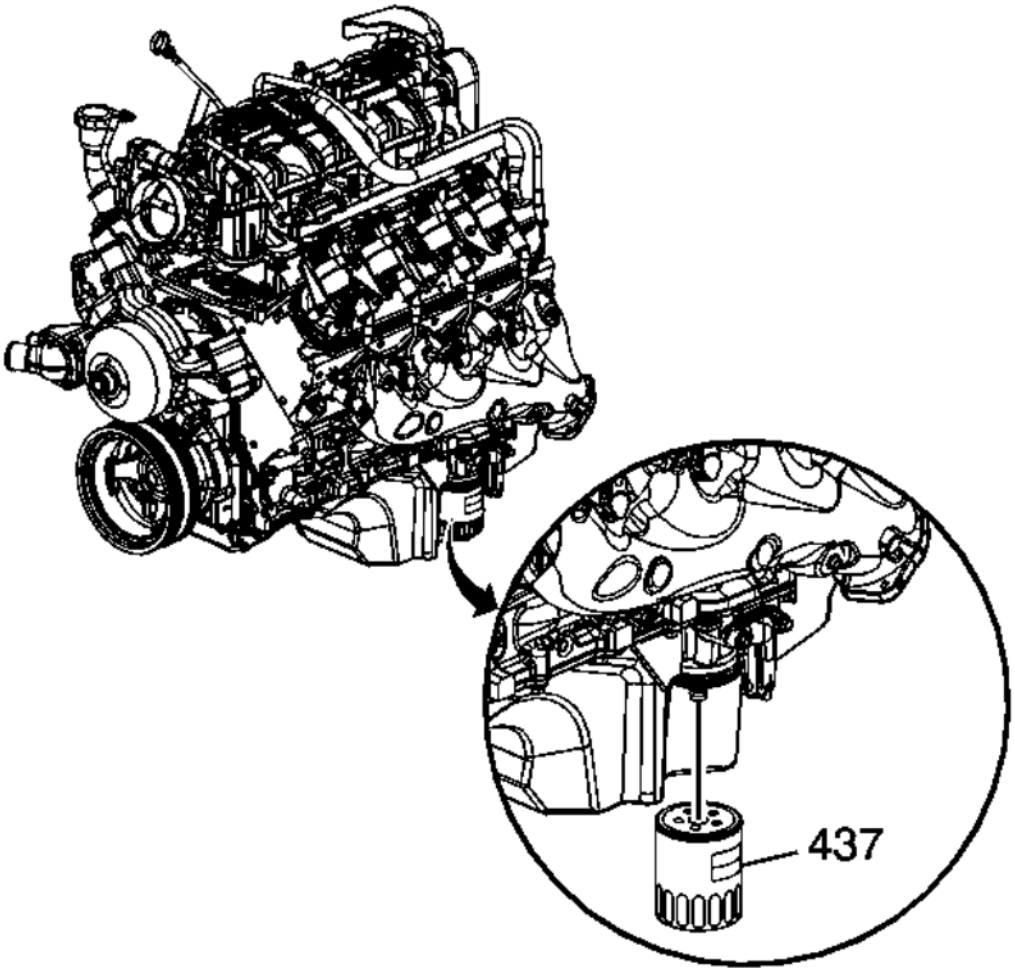

Fig. 295: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter (437).

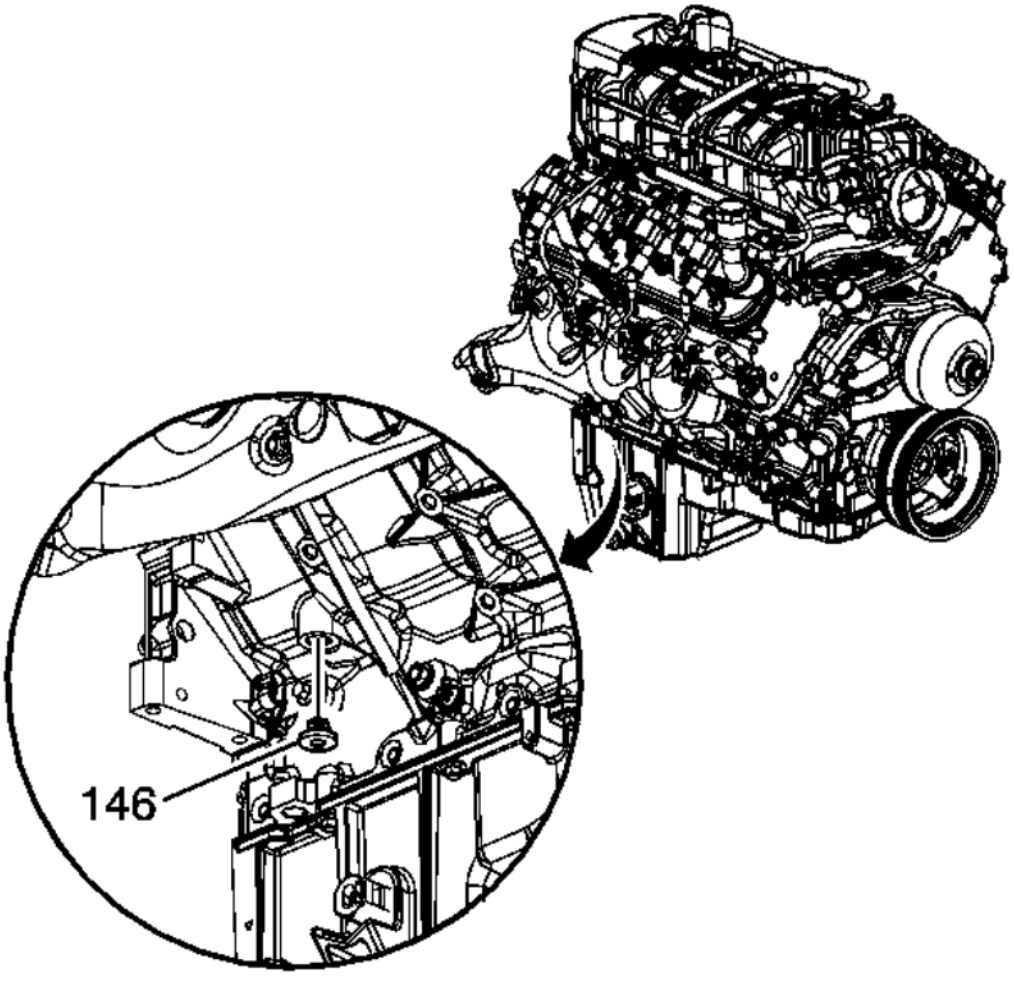

Fig. 296: View Of Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the right side engine block coolant drain hole plug (146).

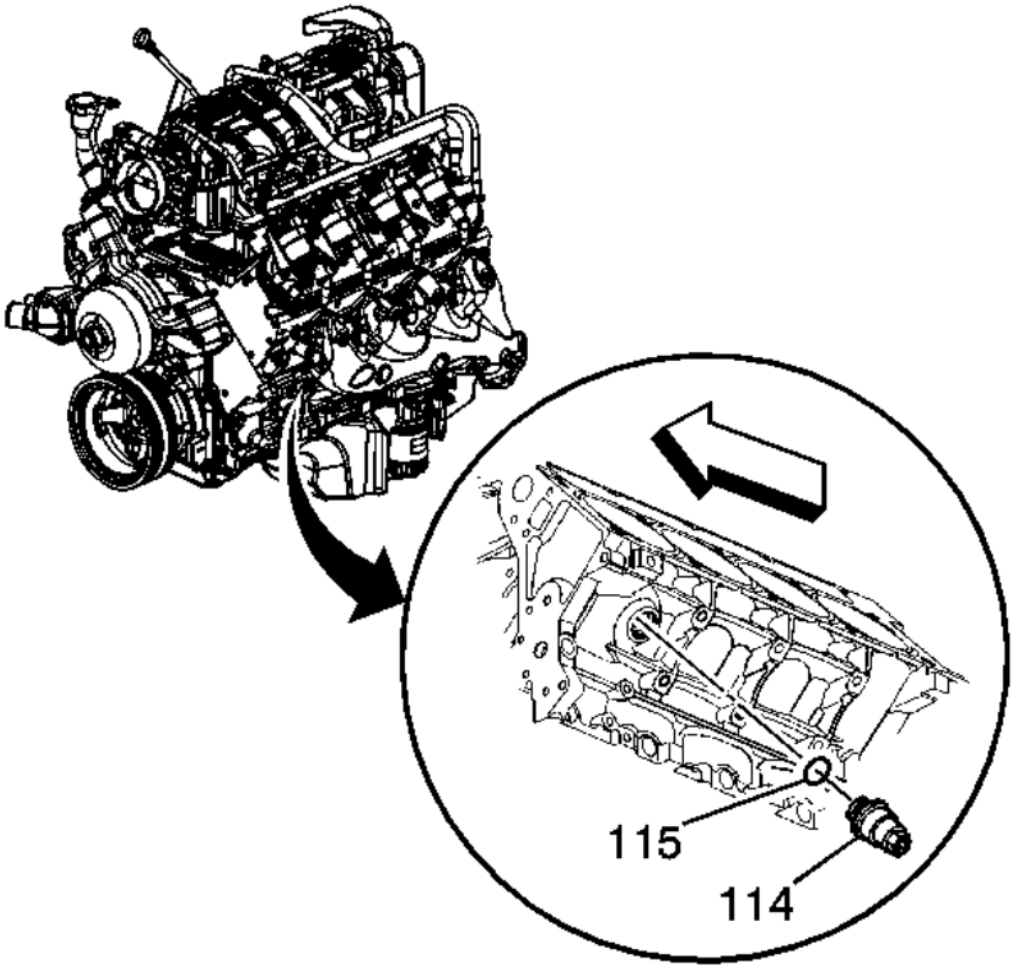

Fig. 297: View Of Engine Block Coolant Heater & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the left side engine block coolant heater (114) and washer (115).

CRANKSHAFT BALANCER REMOVAL

Tools Required

- **J 41816-A** Crankshaft Balancer Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.

- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.

Removal

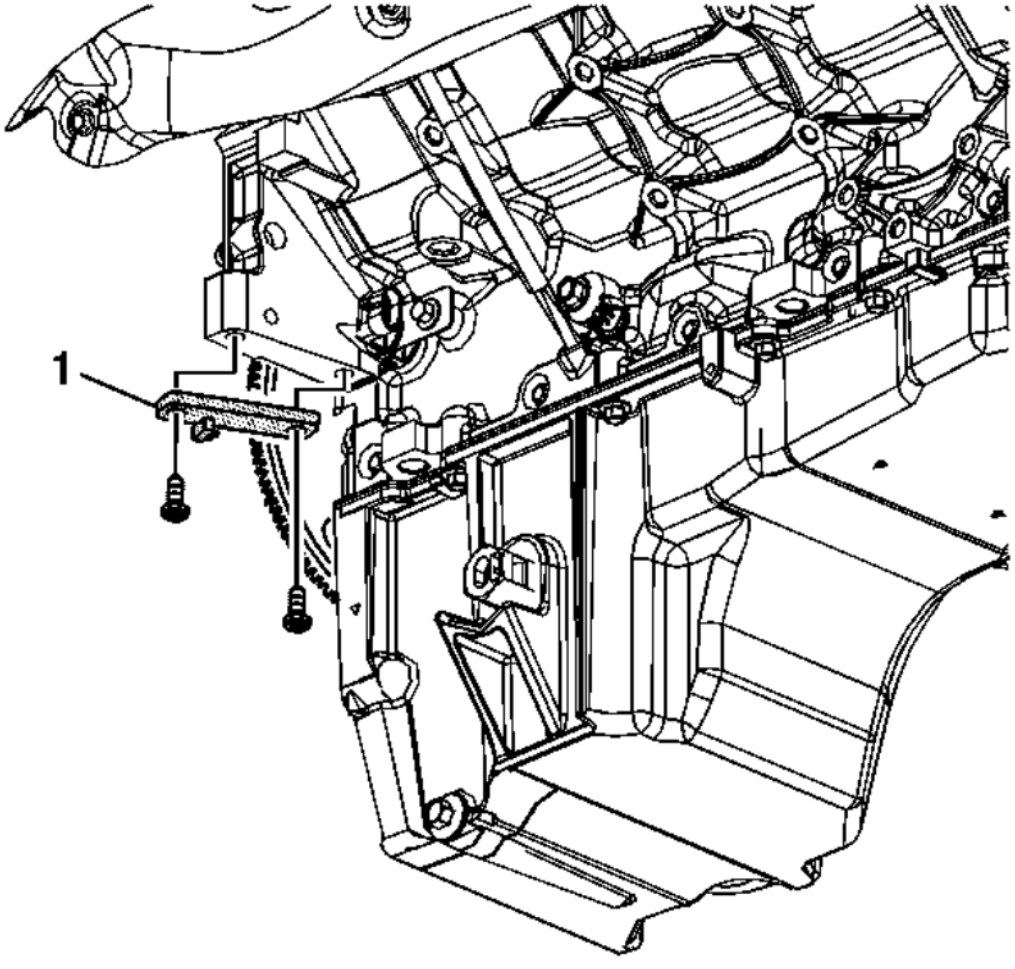

Fig. 298: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

1. Install the **J 42386-A** (1) and bolts. See **Special Tools**.

   Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation.

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

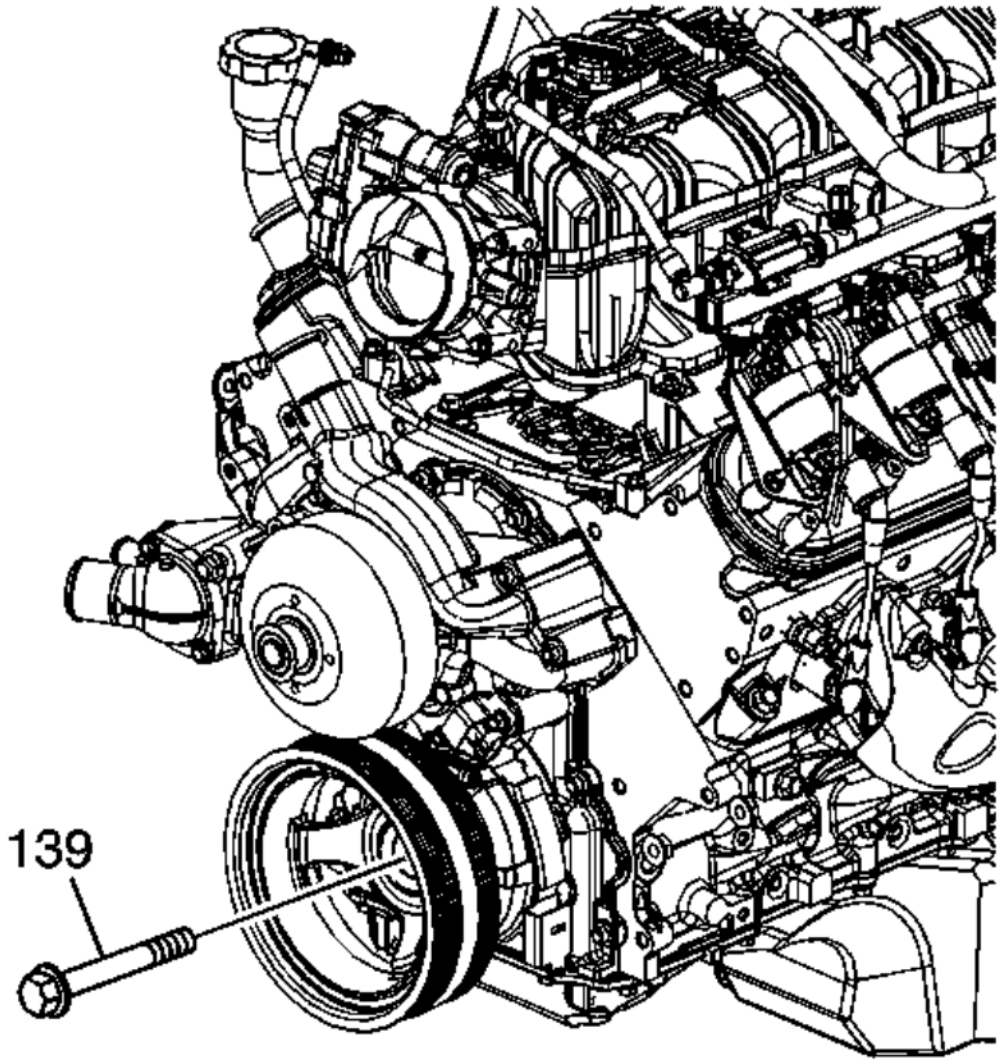

Fig. 299: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt (139).

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

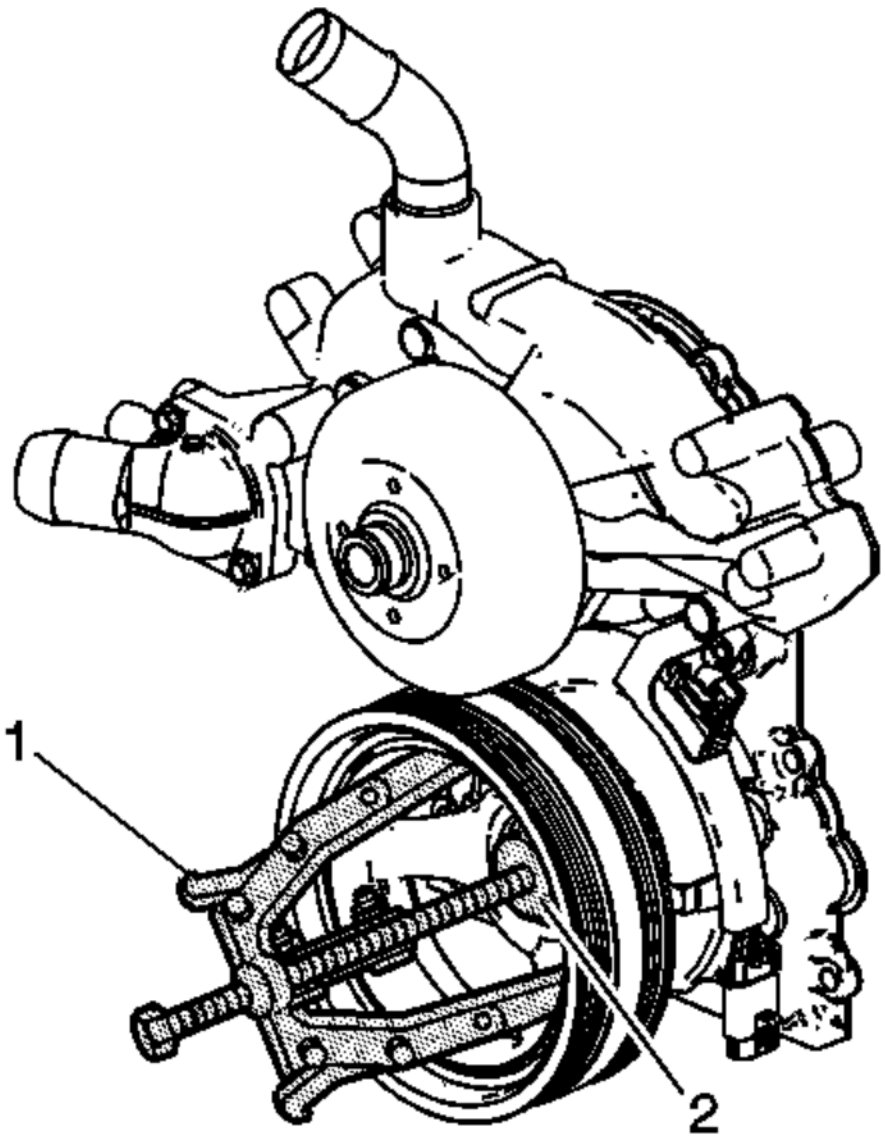

Fig. 300: Removing Crankshaft Balancer

Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41816-A** (1) and the **J 41816-2** (2) in order to remove the crankshaft balancer. See **Special Tools**.

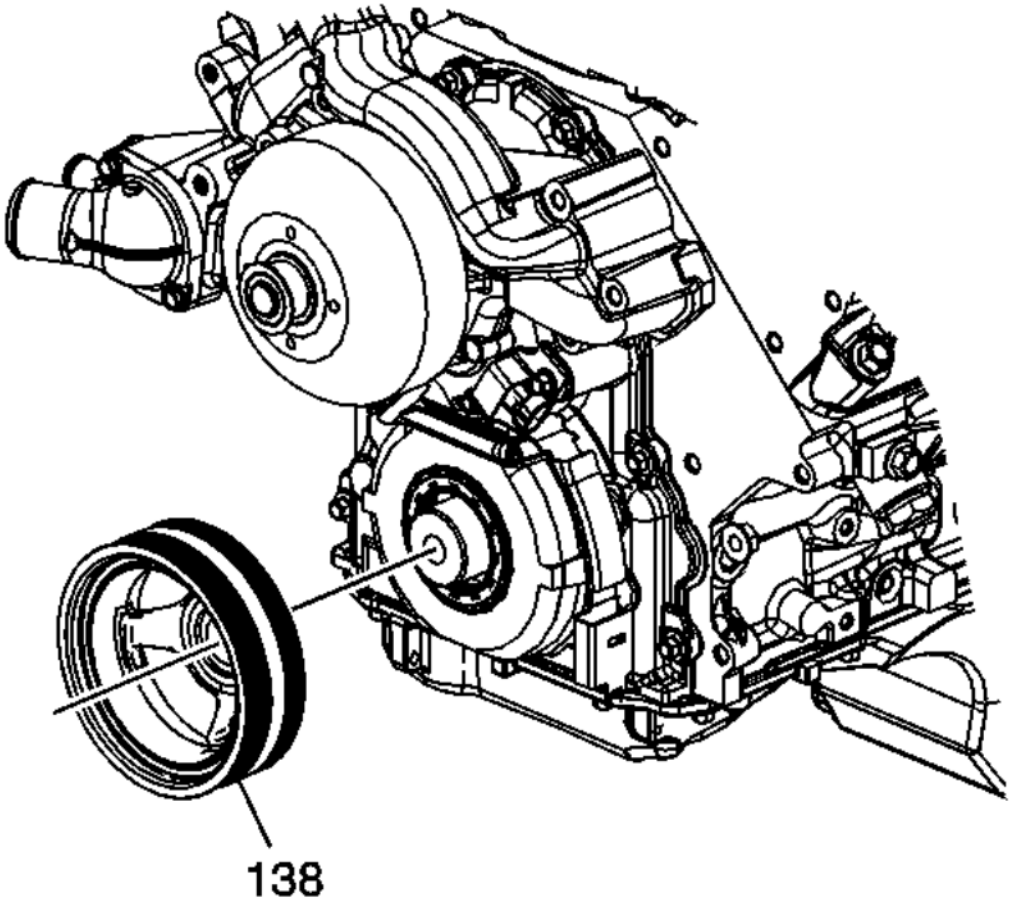

Fig. 301: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the balancer (138).

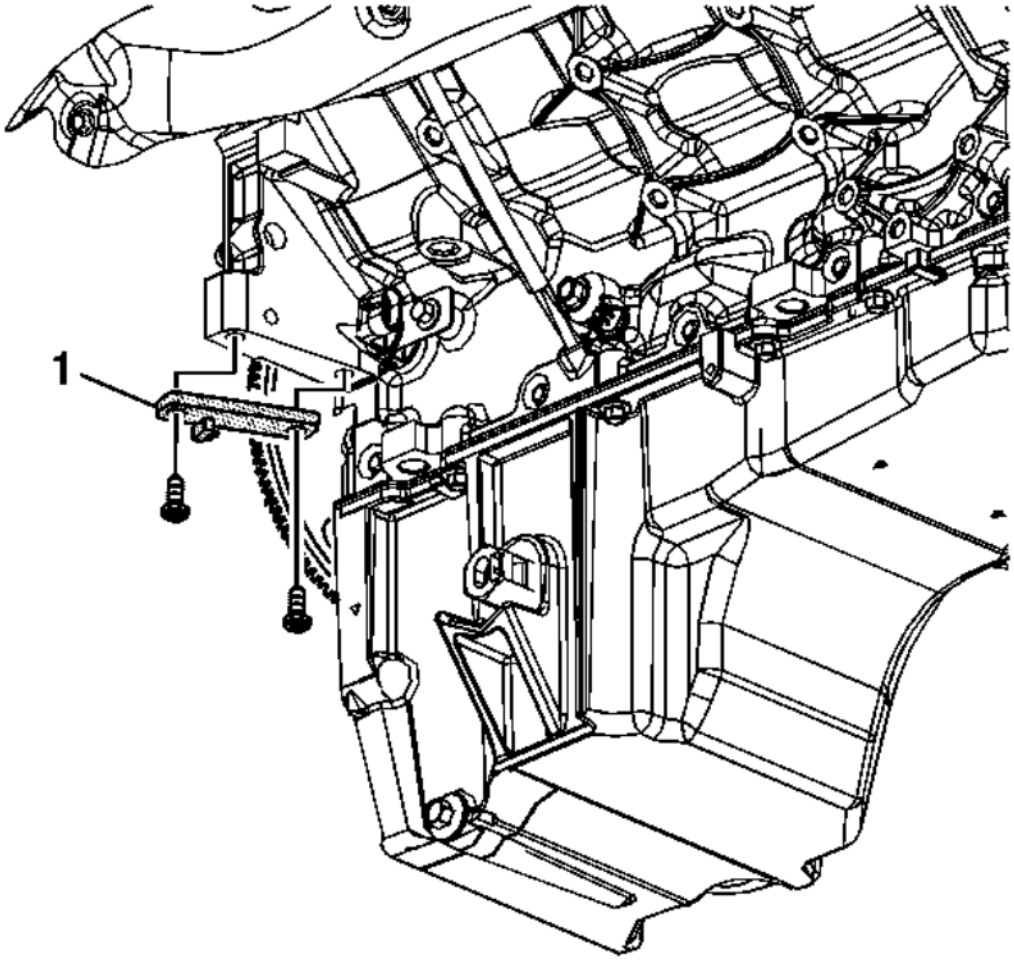

Fig. 302: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 42386-A** (1) and bolts. See **Special Tools**.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

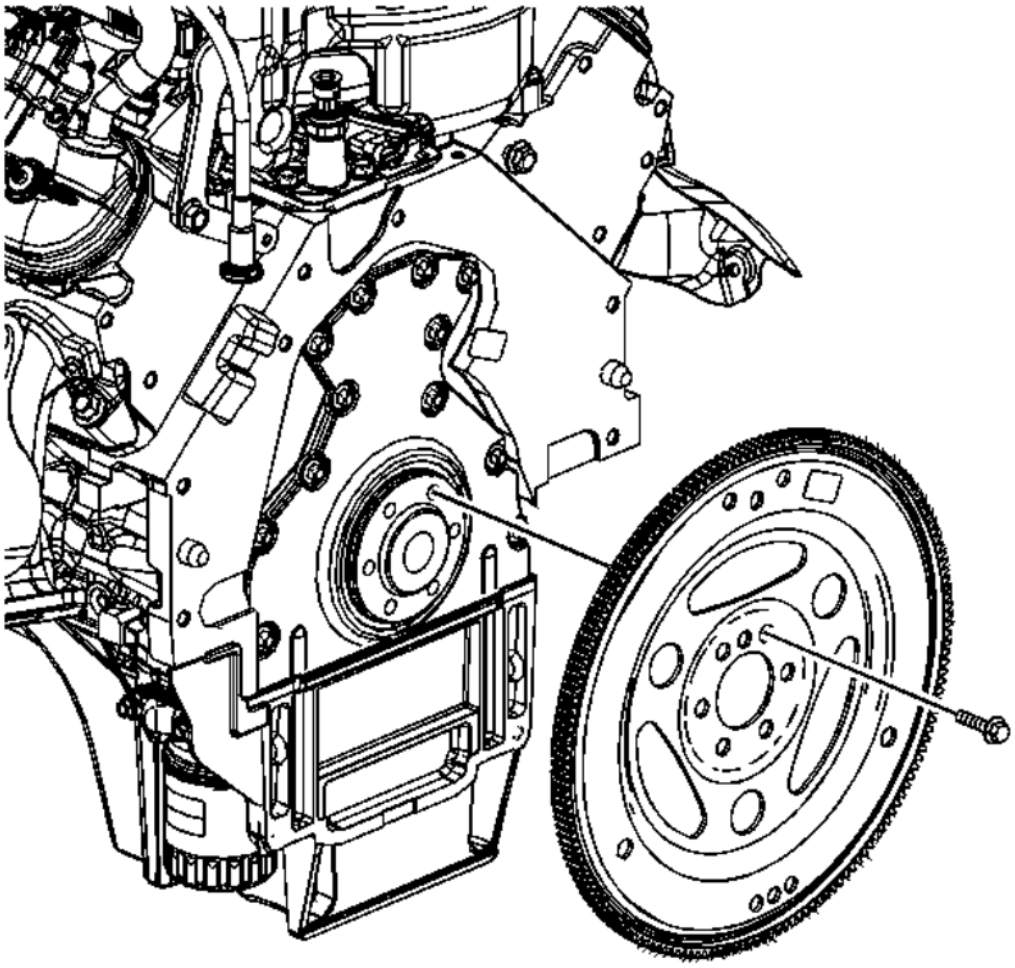

Fig. 303: View Of Flex Plate & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The flex plate 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 flex plate bolts. This procedure requires a 3 stage tightening process.

1. Remove the engine flex plate bolts.
2. Remove the flex plate.

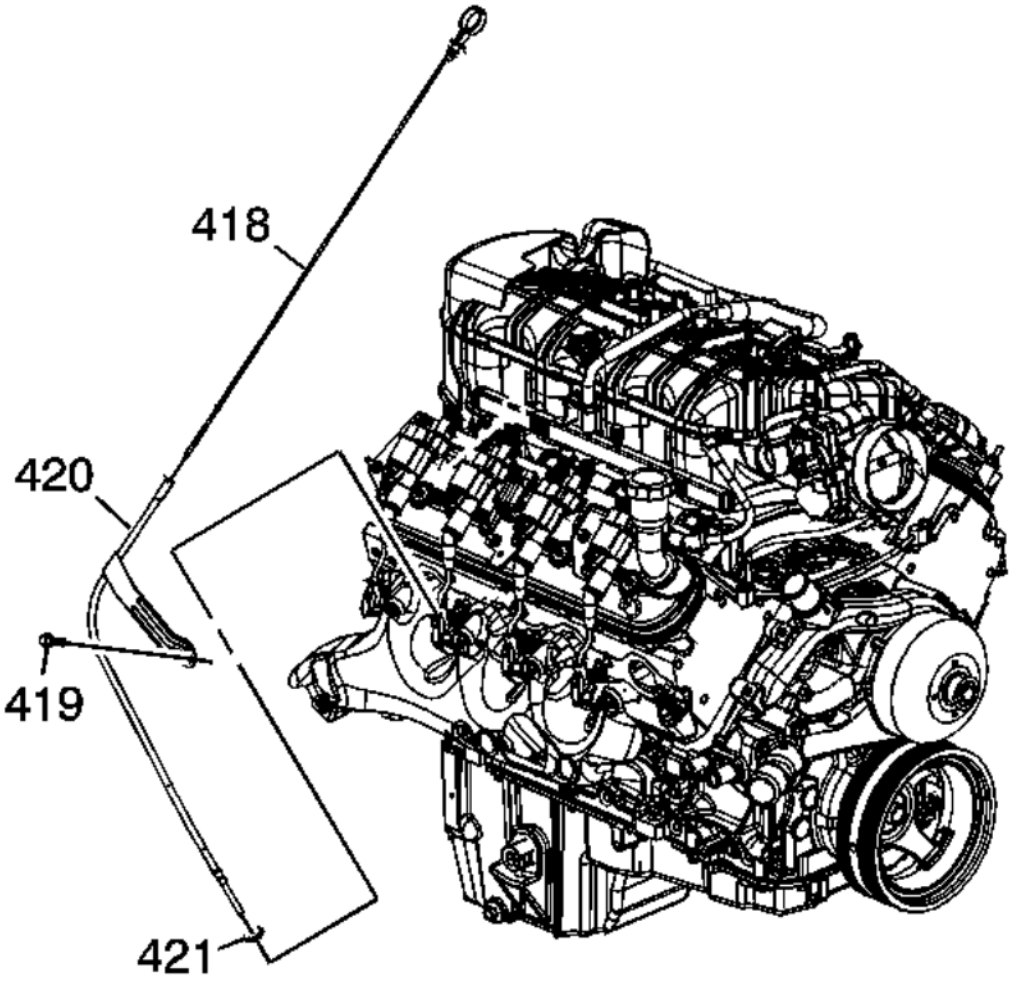

Fig. 304: View Of Oil Level Indicator, Tube Bolt, Indicator Tube & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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 SIDE

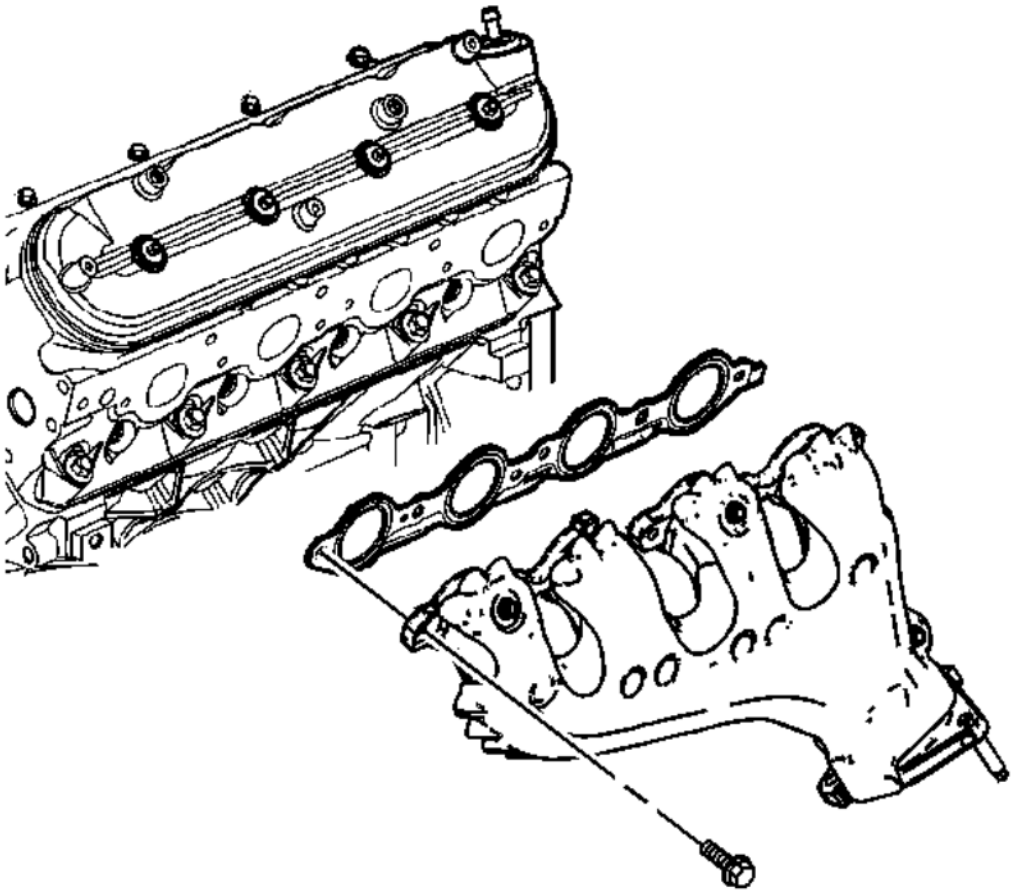

Fig. 305: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

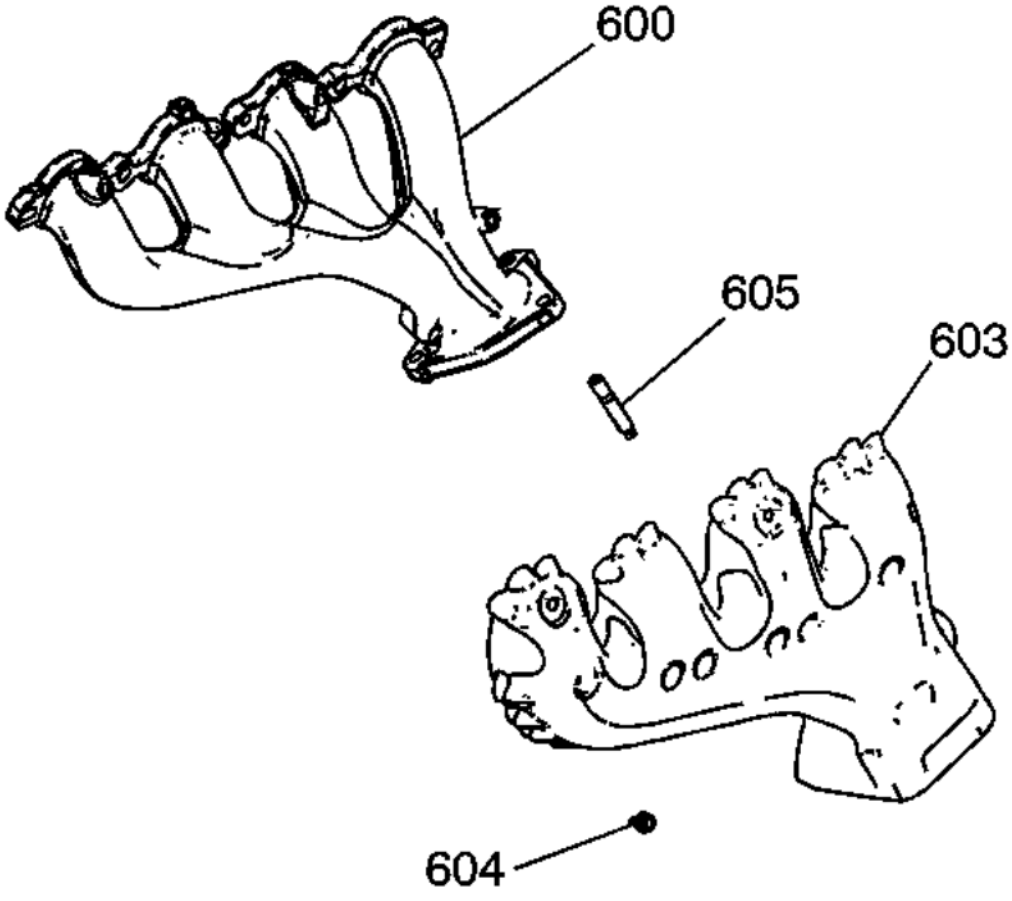

Fig. 306: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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 SIDE

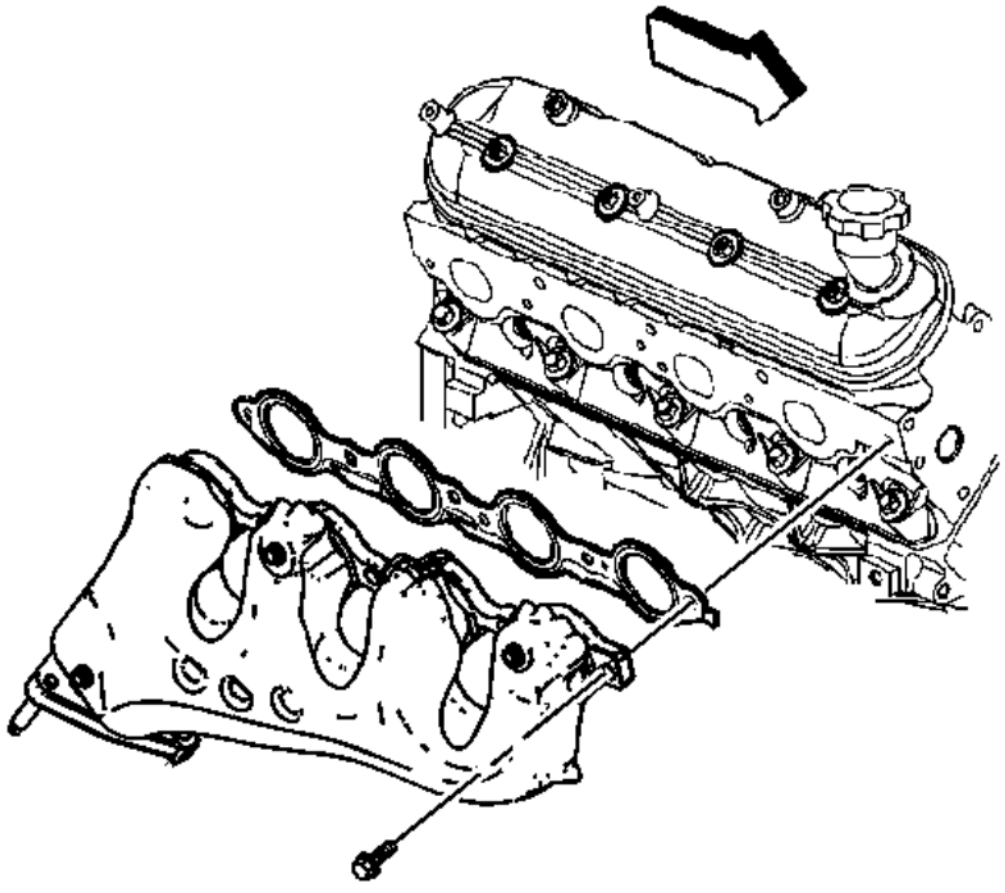

Fig. 307: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

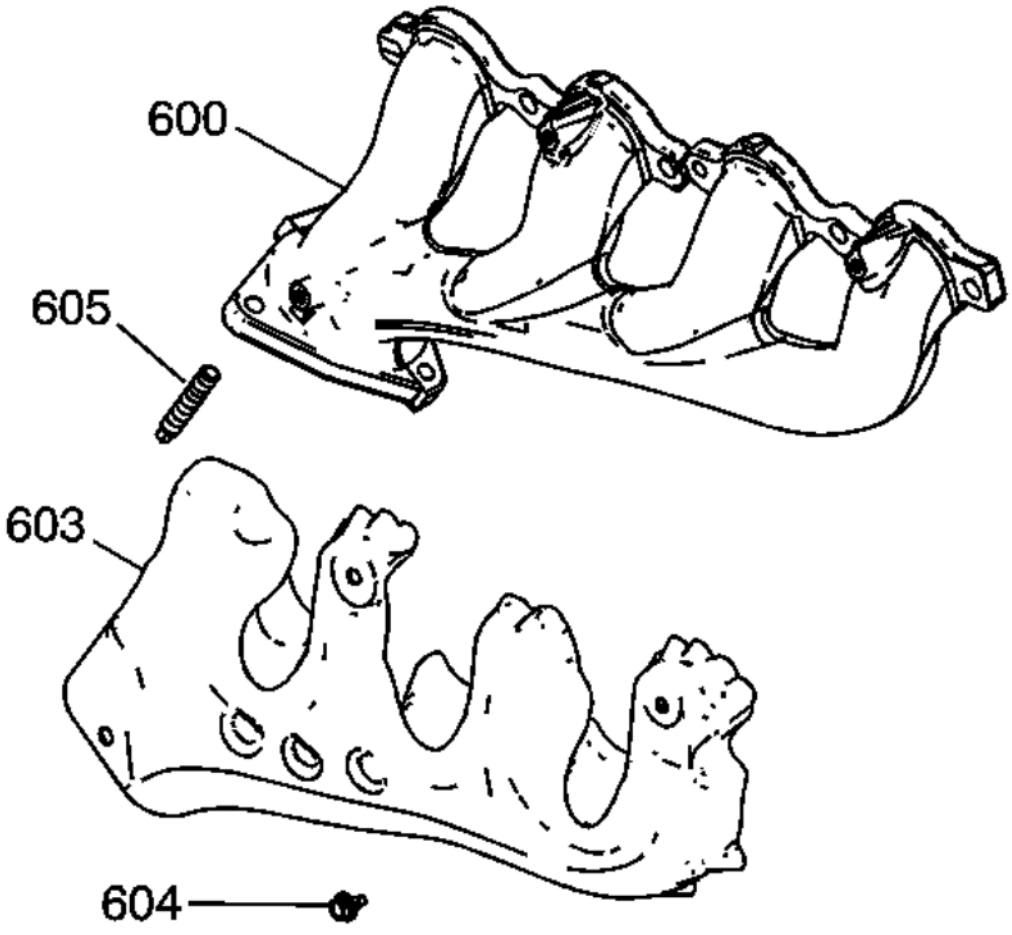

Fig. 308: View Of Right Exhaust Manifold & Heat Shield
Courtesy of GENERAL MOTORS CORP.

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

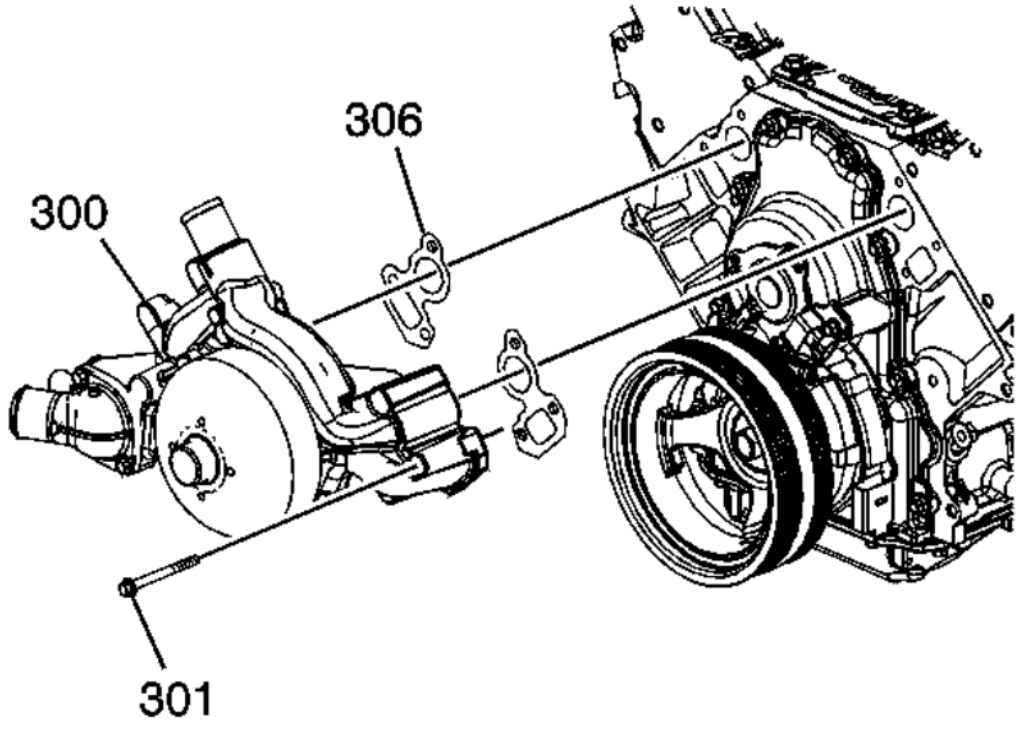

Fig. 309: View Of Water Pump, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

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

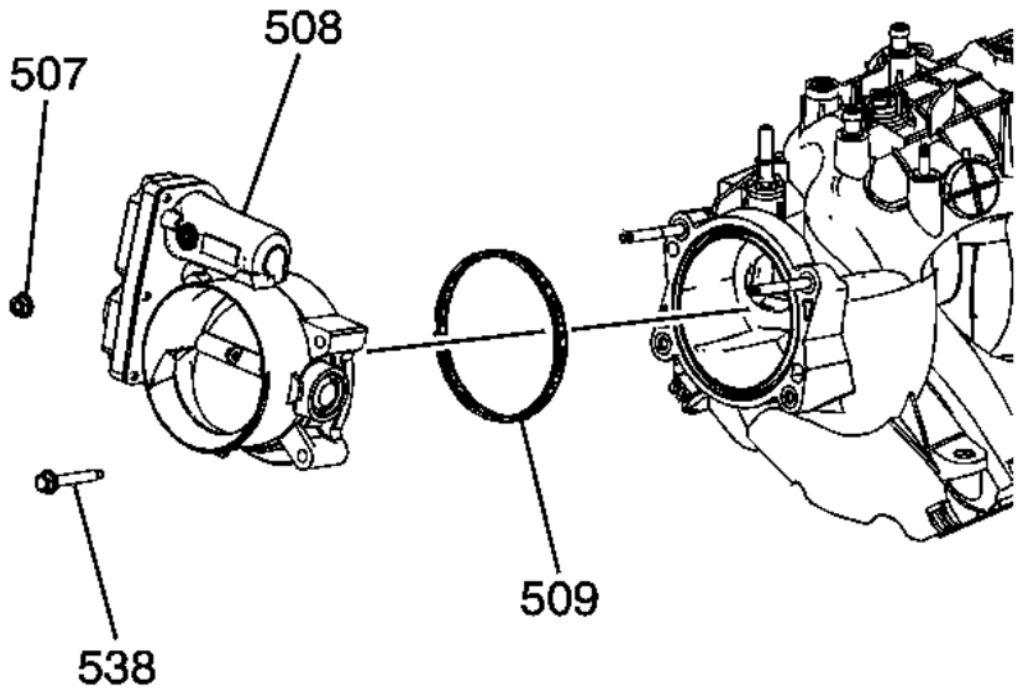

Fig. 310: Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

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

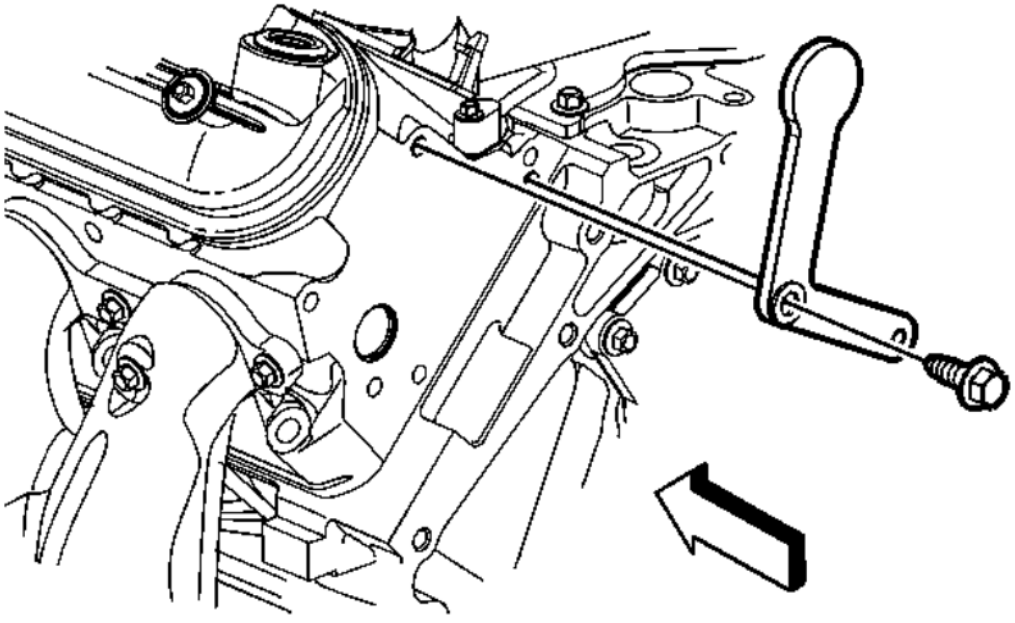

Fig. 311: View Of Fuel Rail Stop Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fuel Rail Stop Bracket Installation Caution .

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.

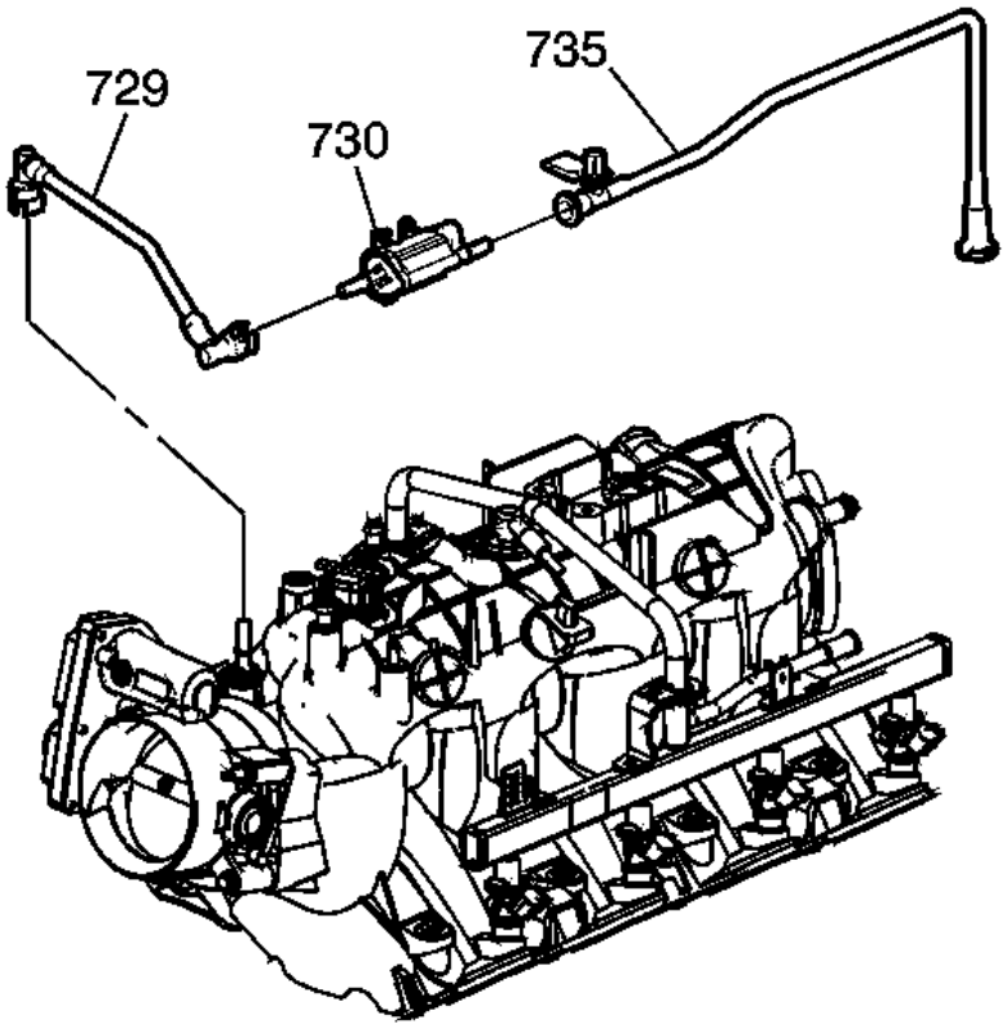

Fig. 312: EVAP Purge Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

2. Remove the evaporative emission (EVAP) canister purge solenoid valve (730) and tubes (729, 735).

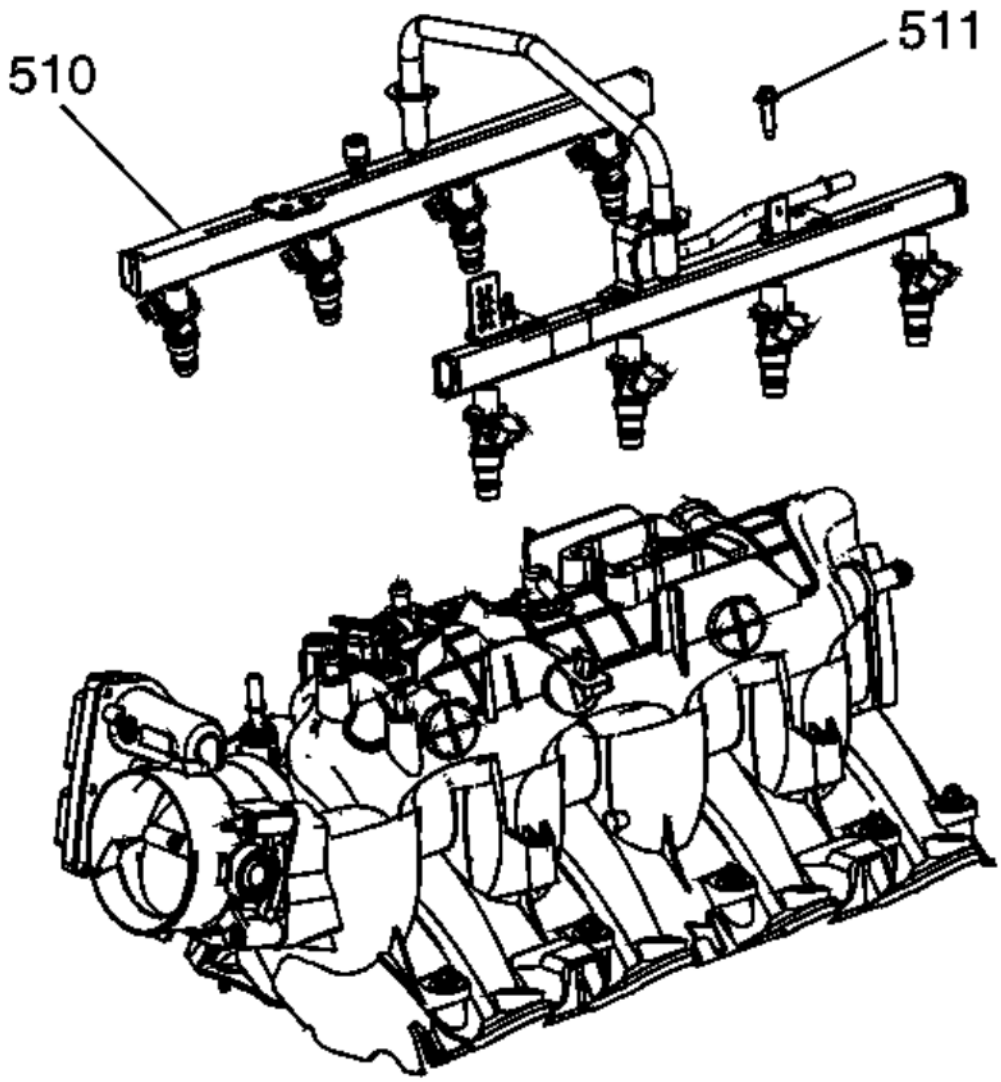

Fig. 313: Fuel Rail
Courtesy of GENERAL MOTORS CORP.

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.

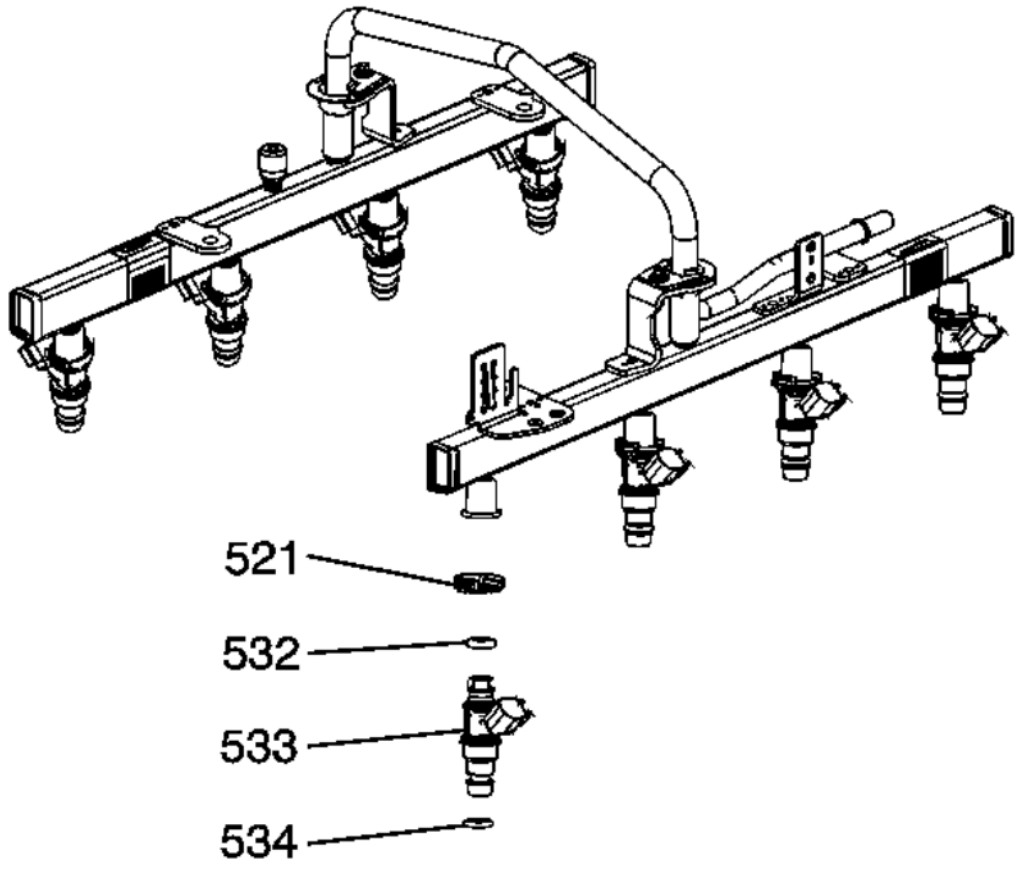

Fig. 314: Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

5. Remove the fuel injector retainers (521) and fuel injectors (533), as required.
6. Remove the O-rings (532, 534) from the injectors, as required.

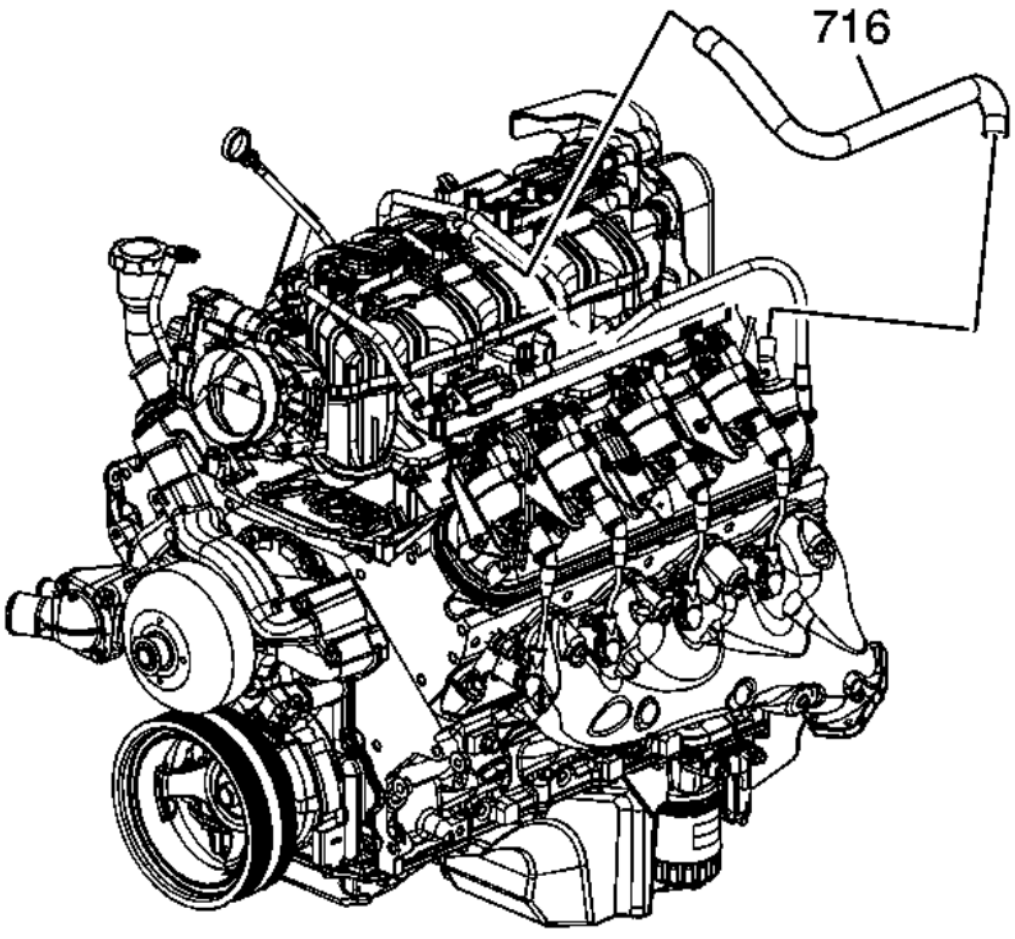

Fig. 315: View Of PCV Dirty-Air Hose
Courtesy of GENERAL MOTORS CORP.

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).

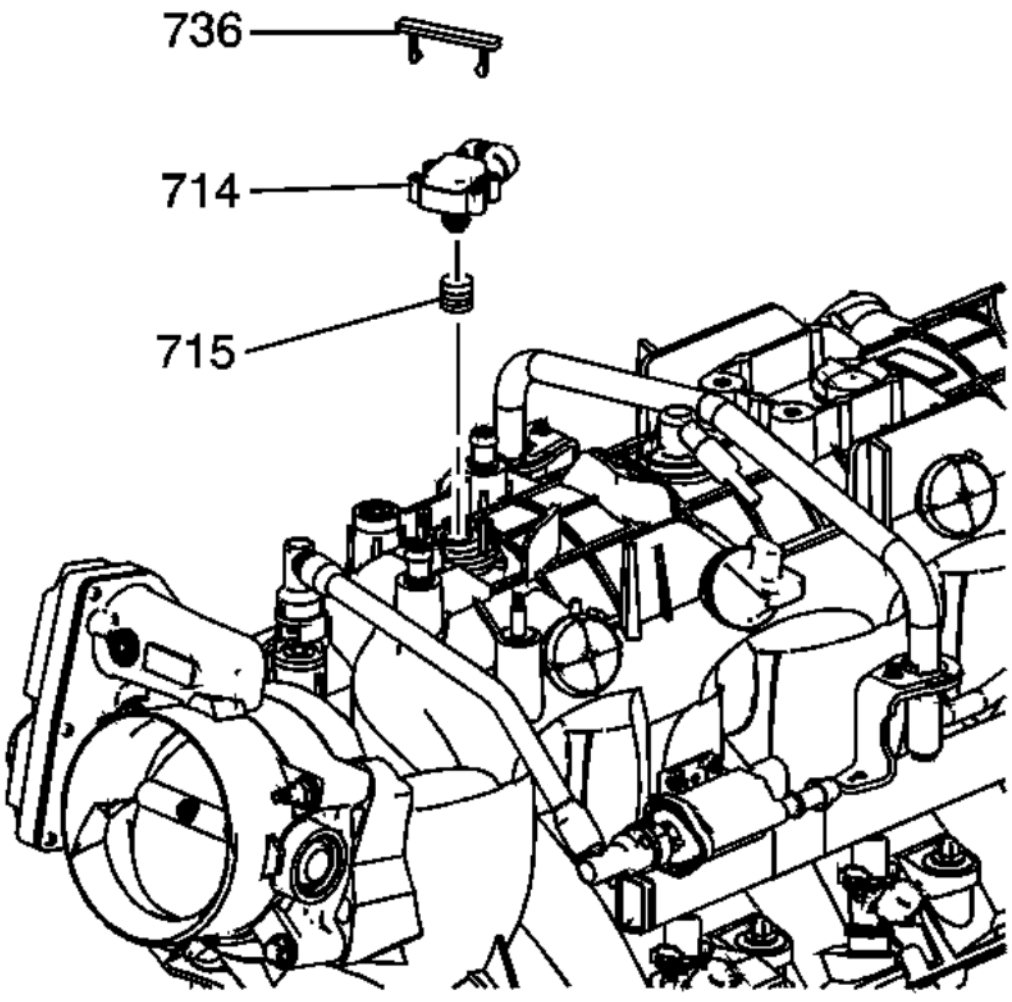

Fig. 316: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

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.

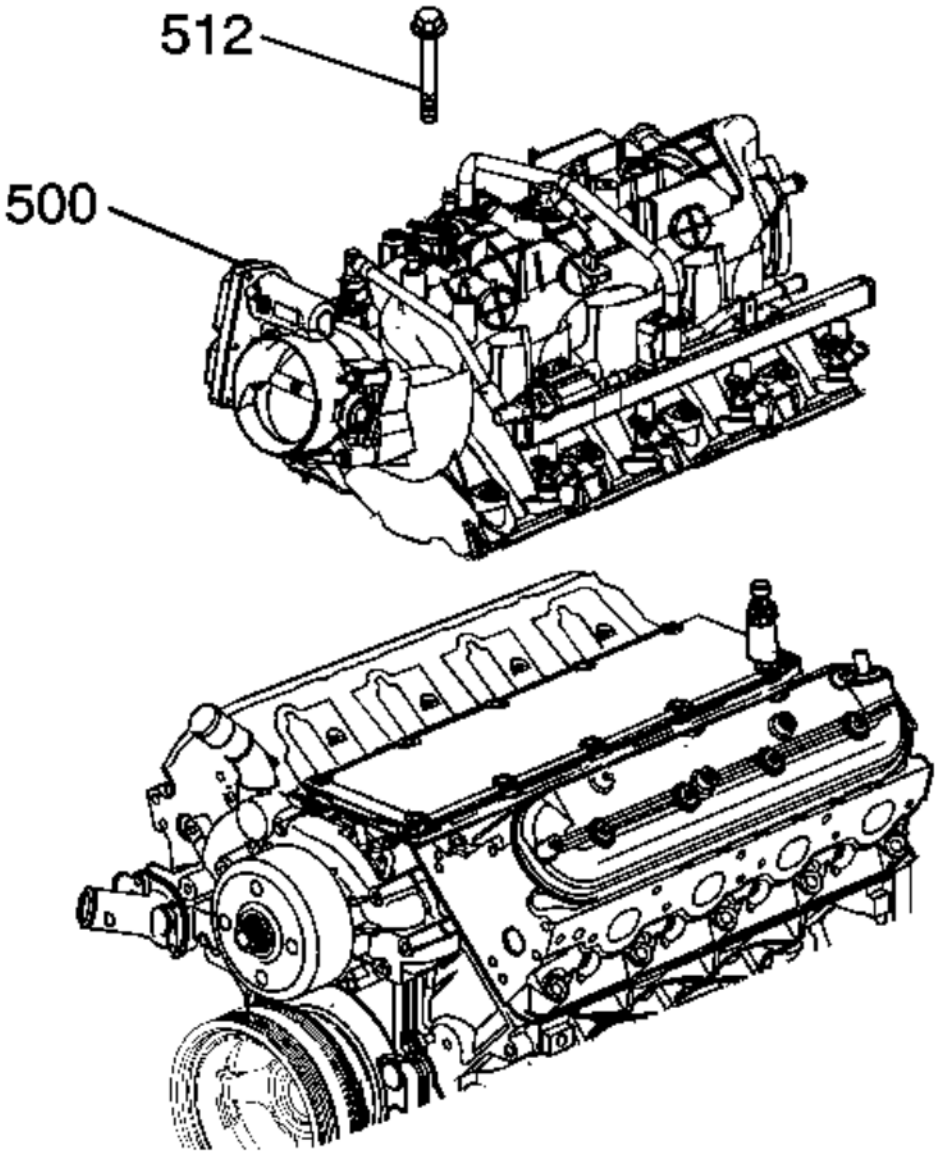

Fig. 317: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold bolts (512).
5. Remove the intake manifold (500) with gaskets.

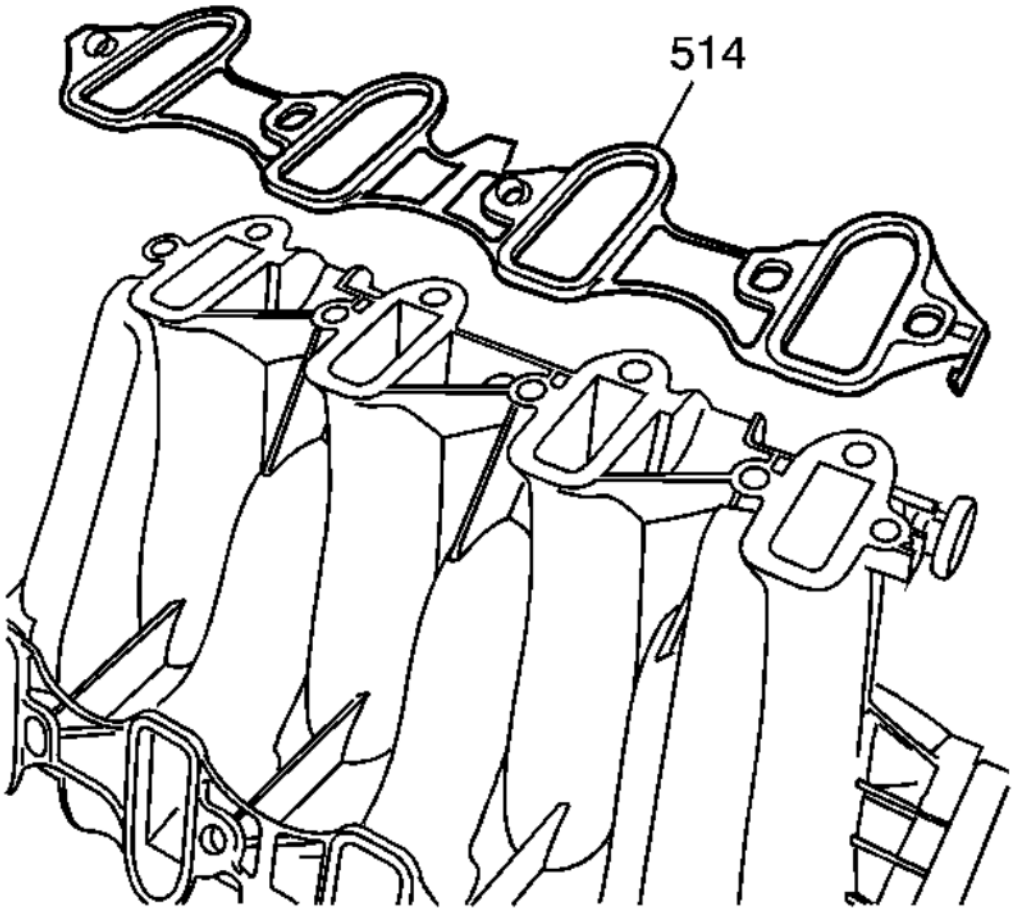

Fig. 318: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake manifold gaskets (514).
7. Discard the intake manifold gaskets.

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER REMOVAL

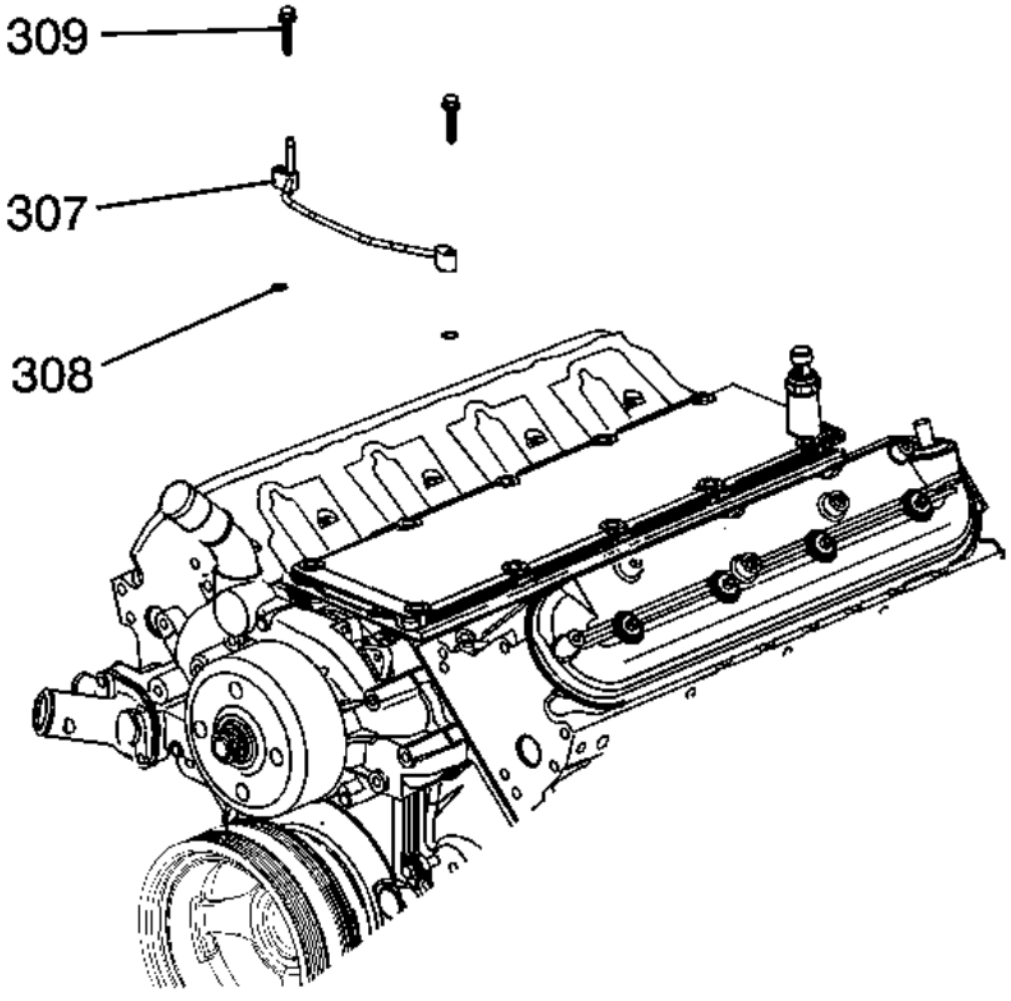

Fig. 319: Identifying Engine Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with seals (308).

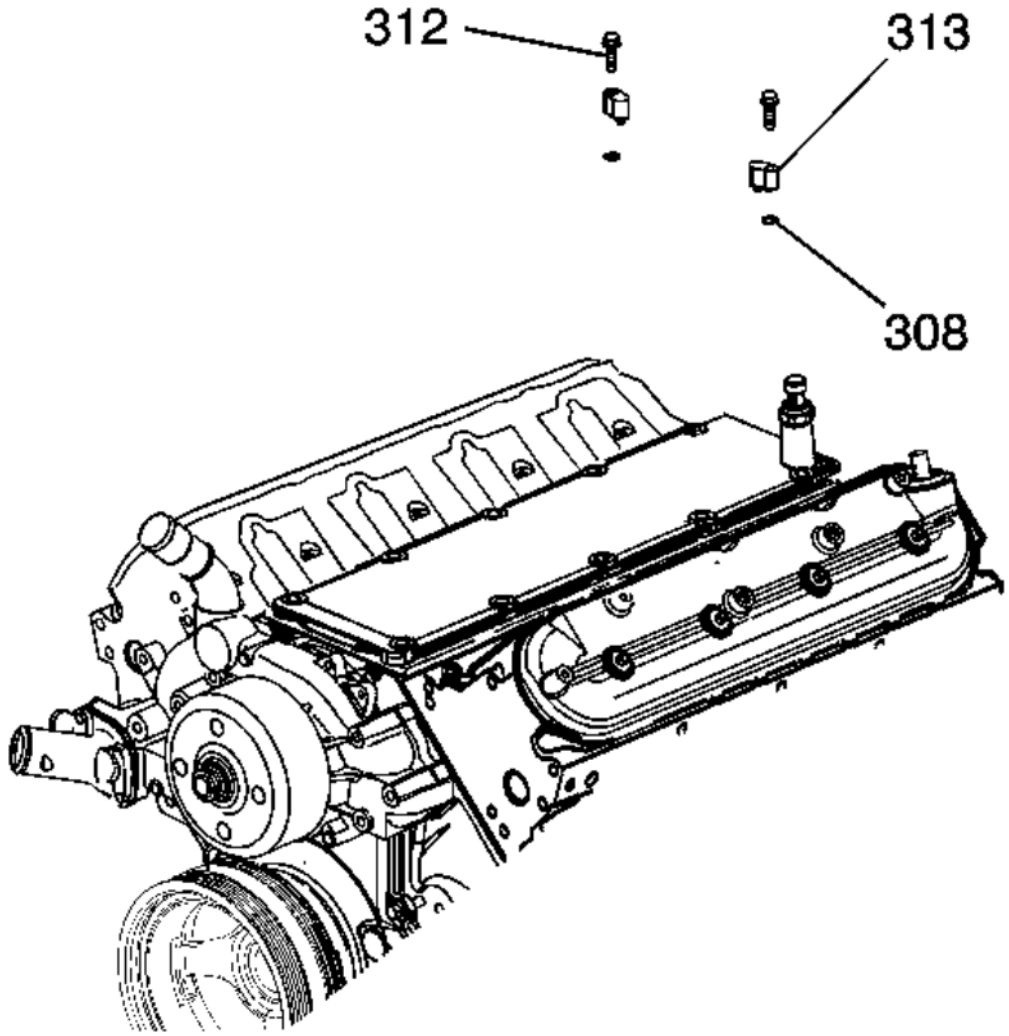

Fig. 320: Identifying Coolant Air Bleed Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine coolant air bleed cover bolts (312).
4. Remove the covers (313) with seals (308).

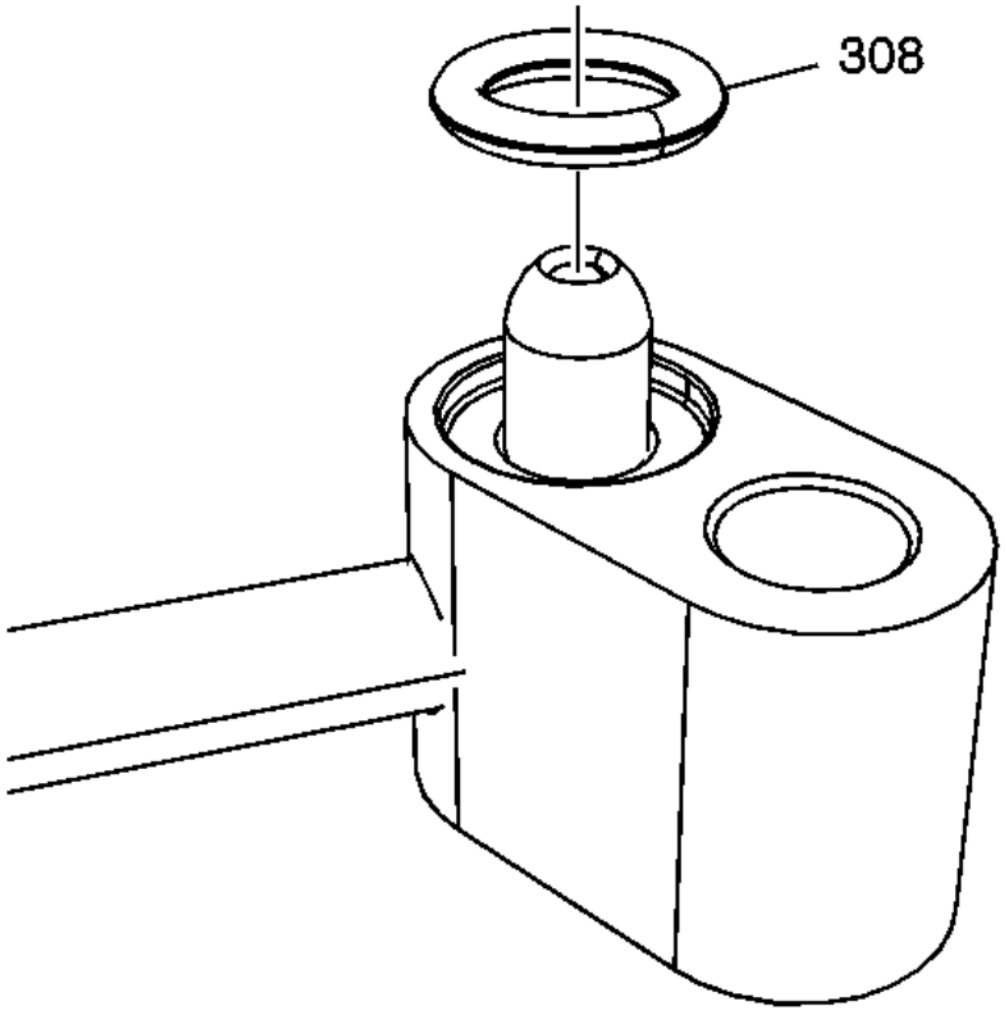

Fig. 321: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove the seals (308) from the pipe and covers.
6. Discard the seals.

ENGINE BLOCK VALLEY COVER REMOVAL

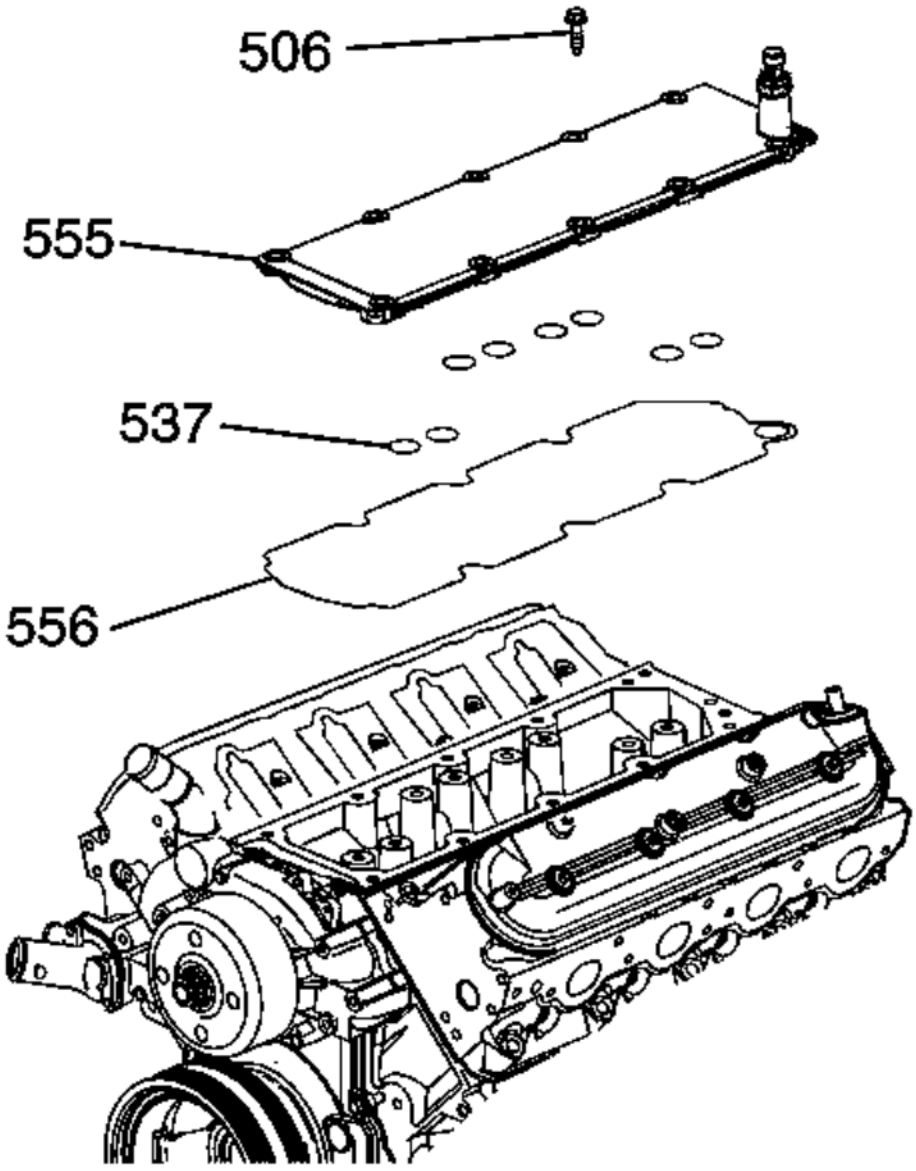

Fig. 322: View Of Engine Valley Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the valley cover bolts (506).
2. Remove the valley cover (555) and gasket (556).

3. Remove the O-ring seals (537) from the cover.

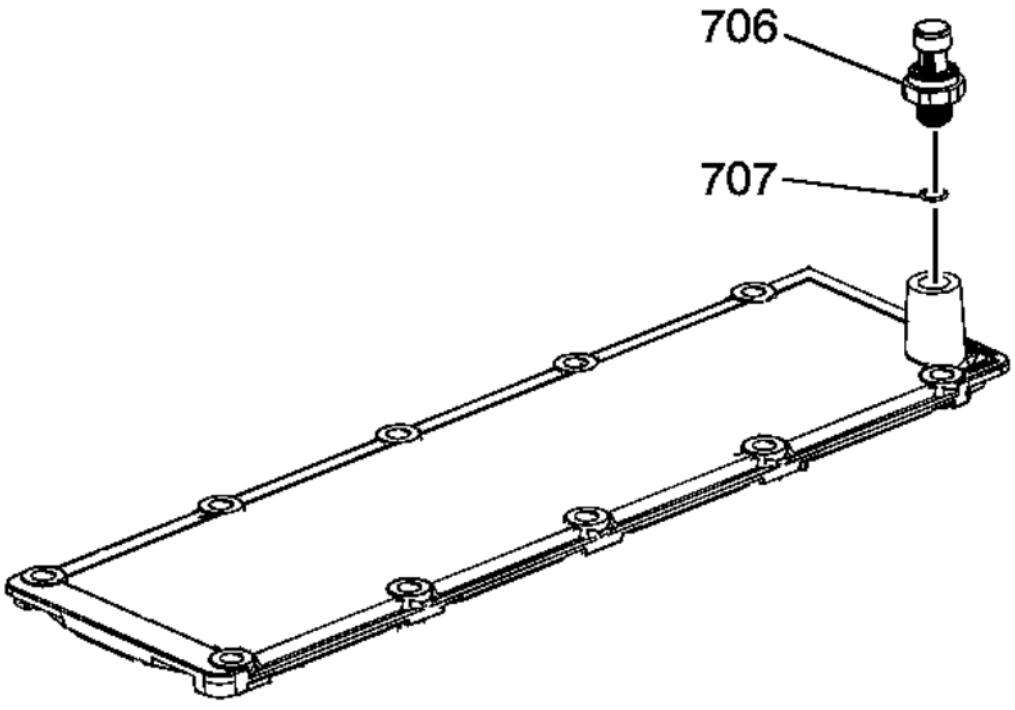

Fig. 323: Identifying Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pressure sensor (706) and washer (707), as required.

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

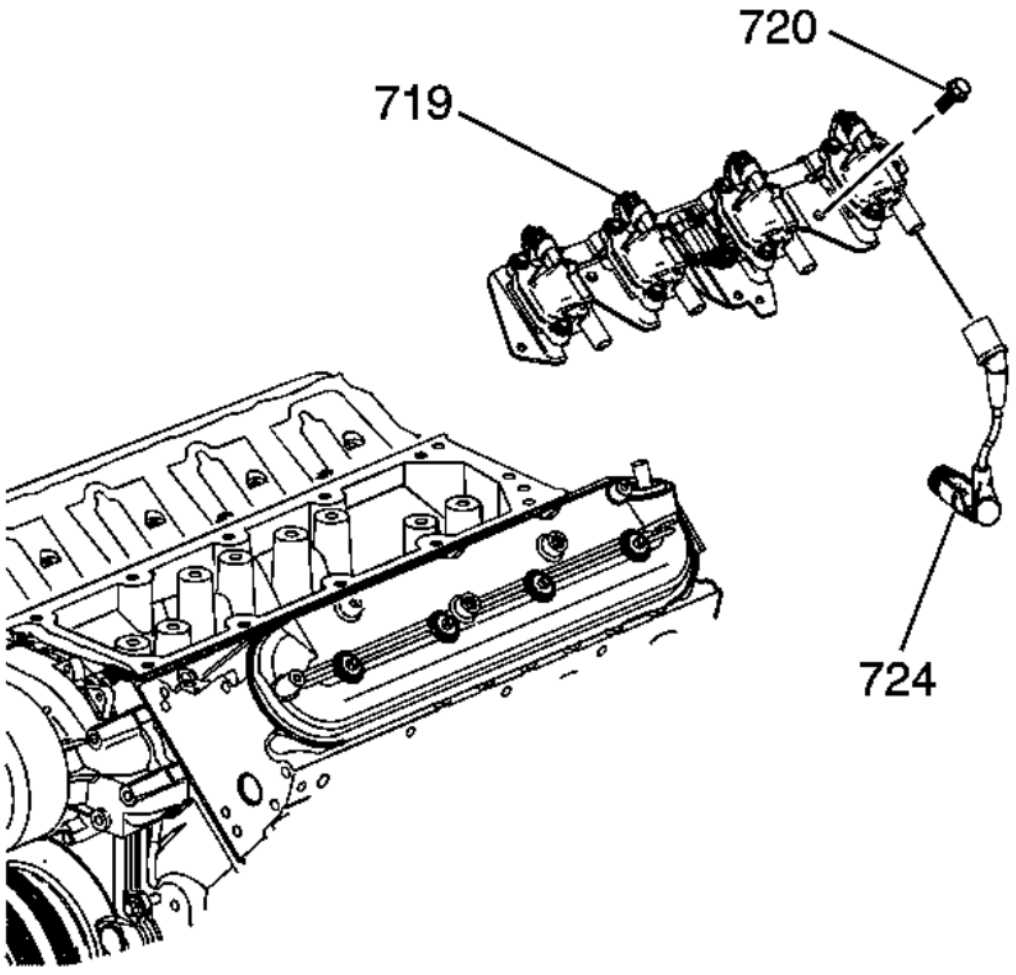

Fig. 324: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).

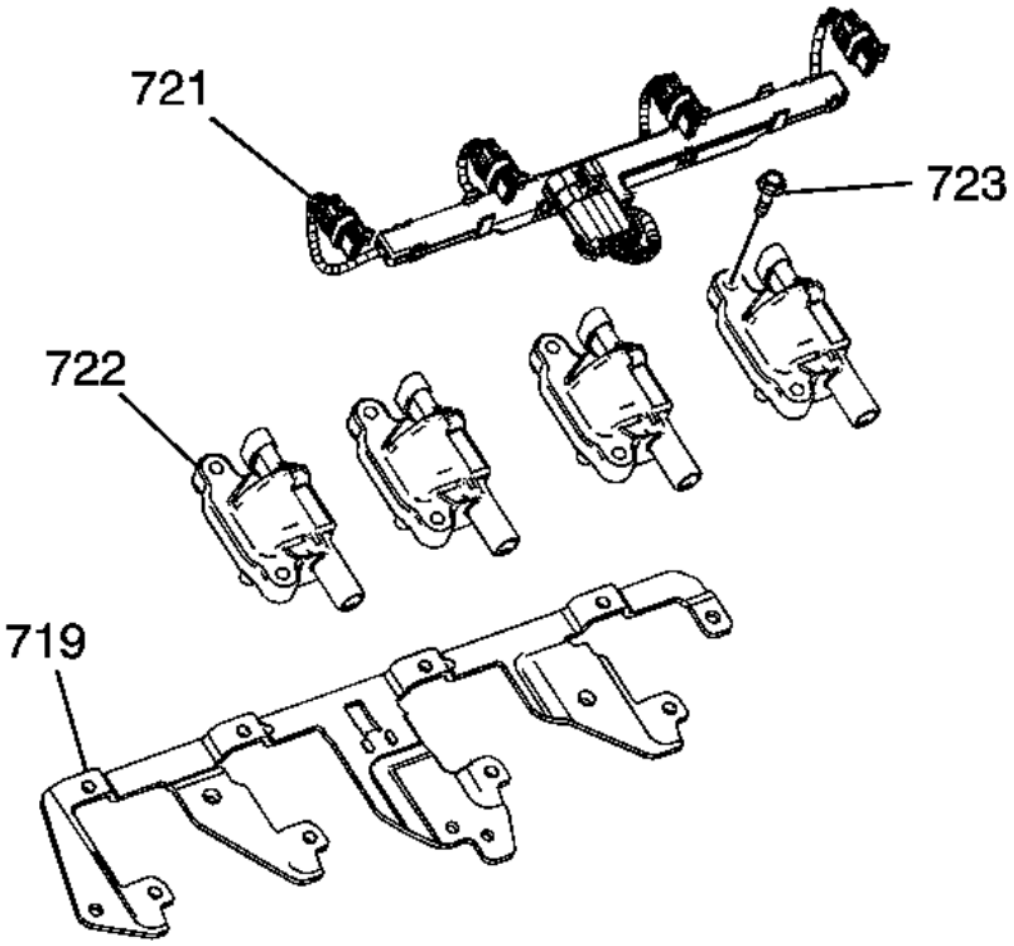

Fig. 325: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.

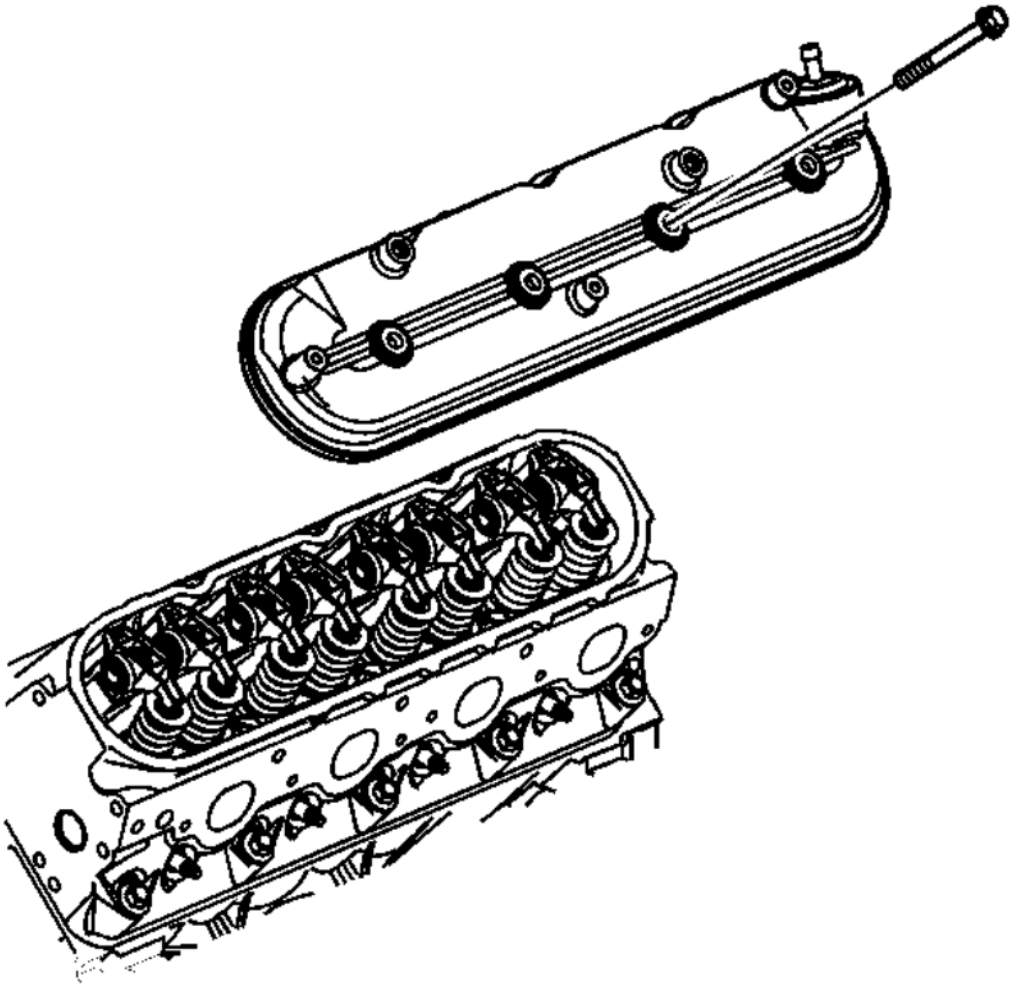

Fig. 326: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

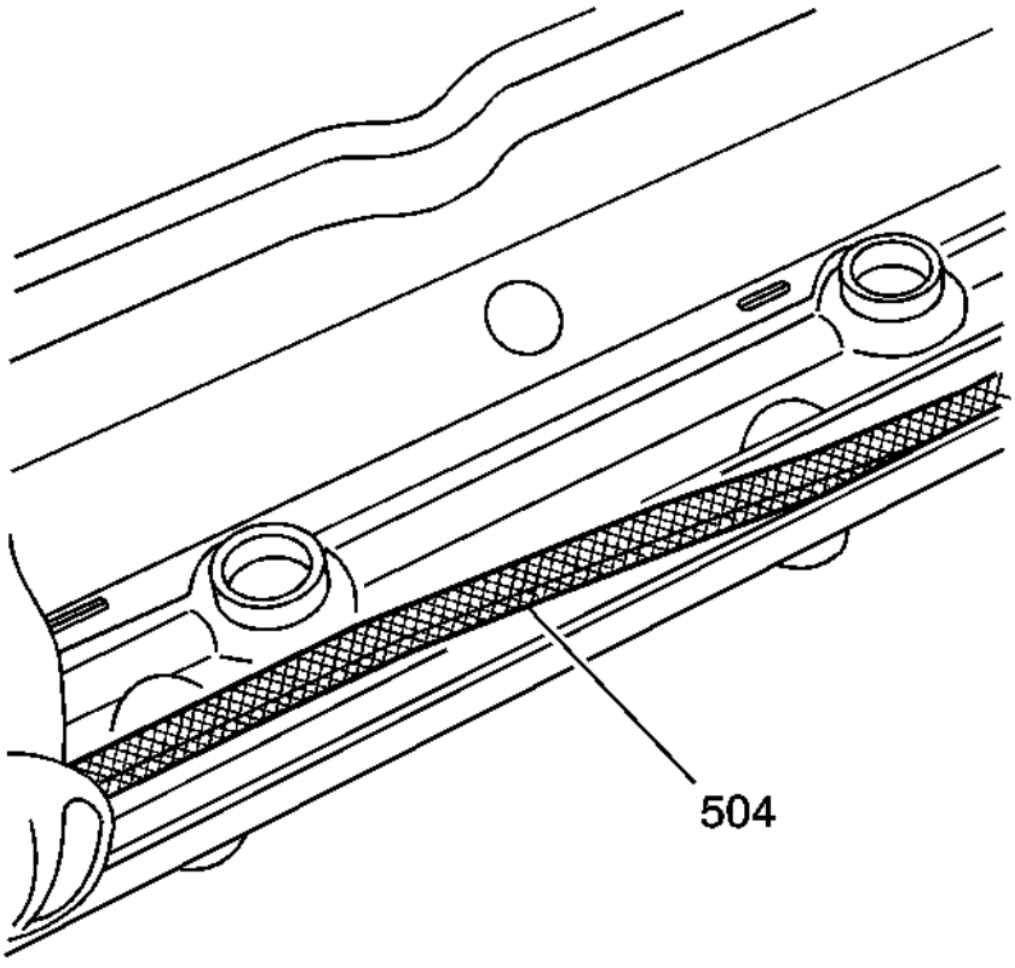

Fig. 327: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

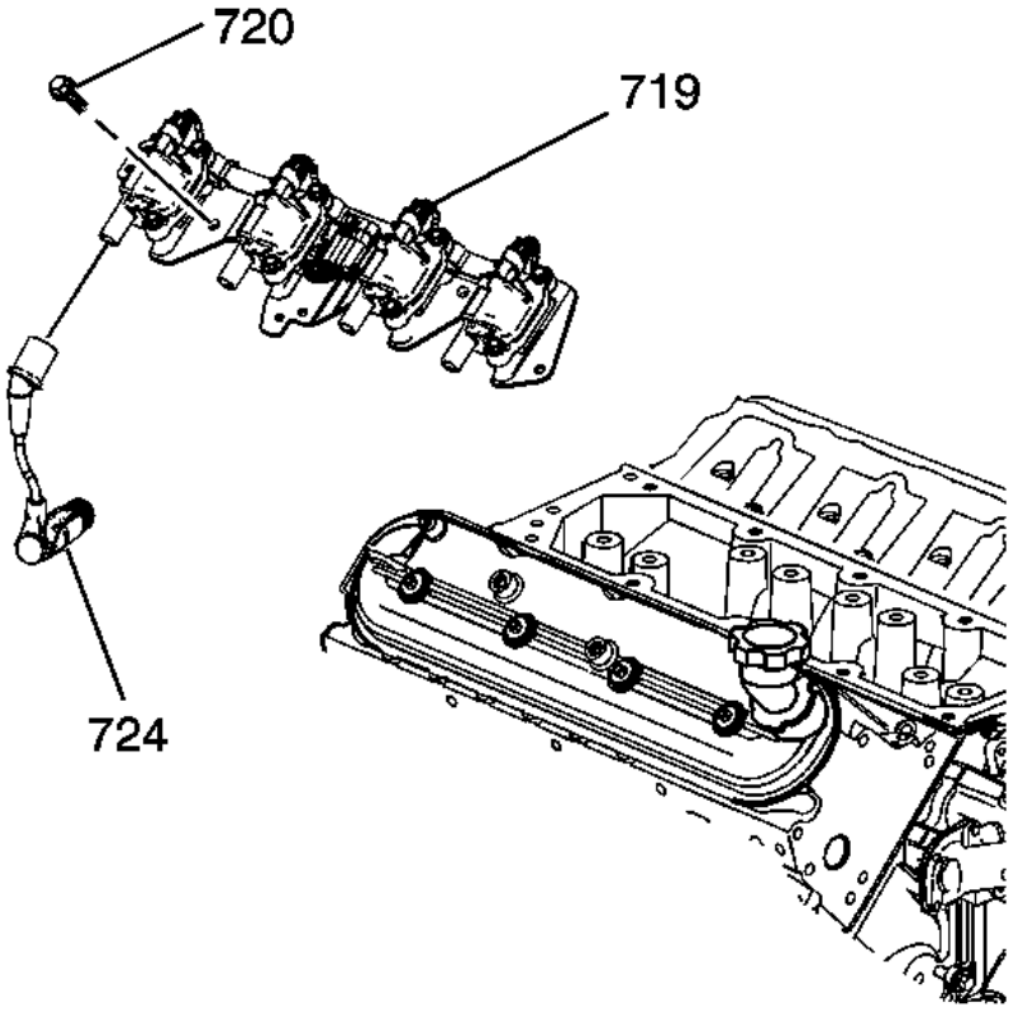

Fig. 328: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

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 studs (720).

3. Remove the ignition coil and bracket assembly (719).

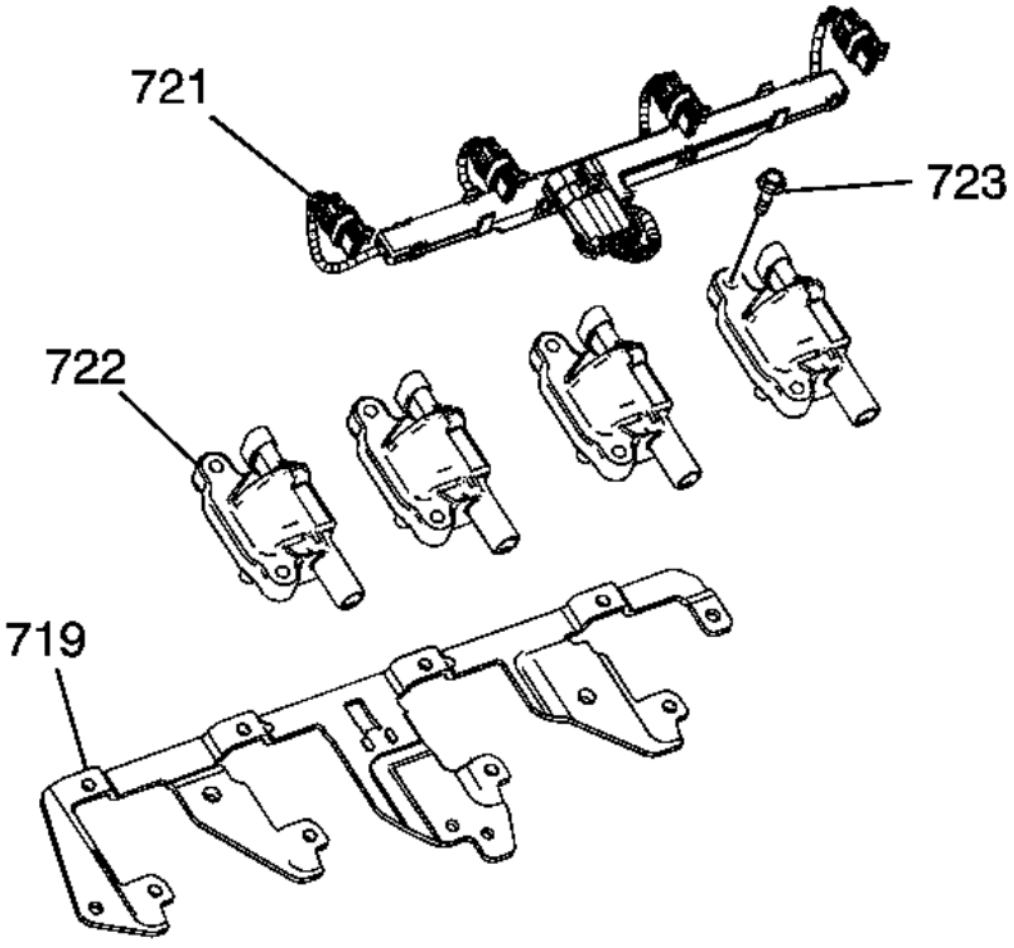

Fig. 329: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.

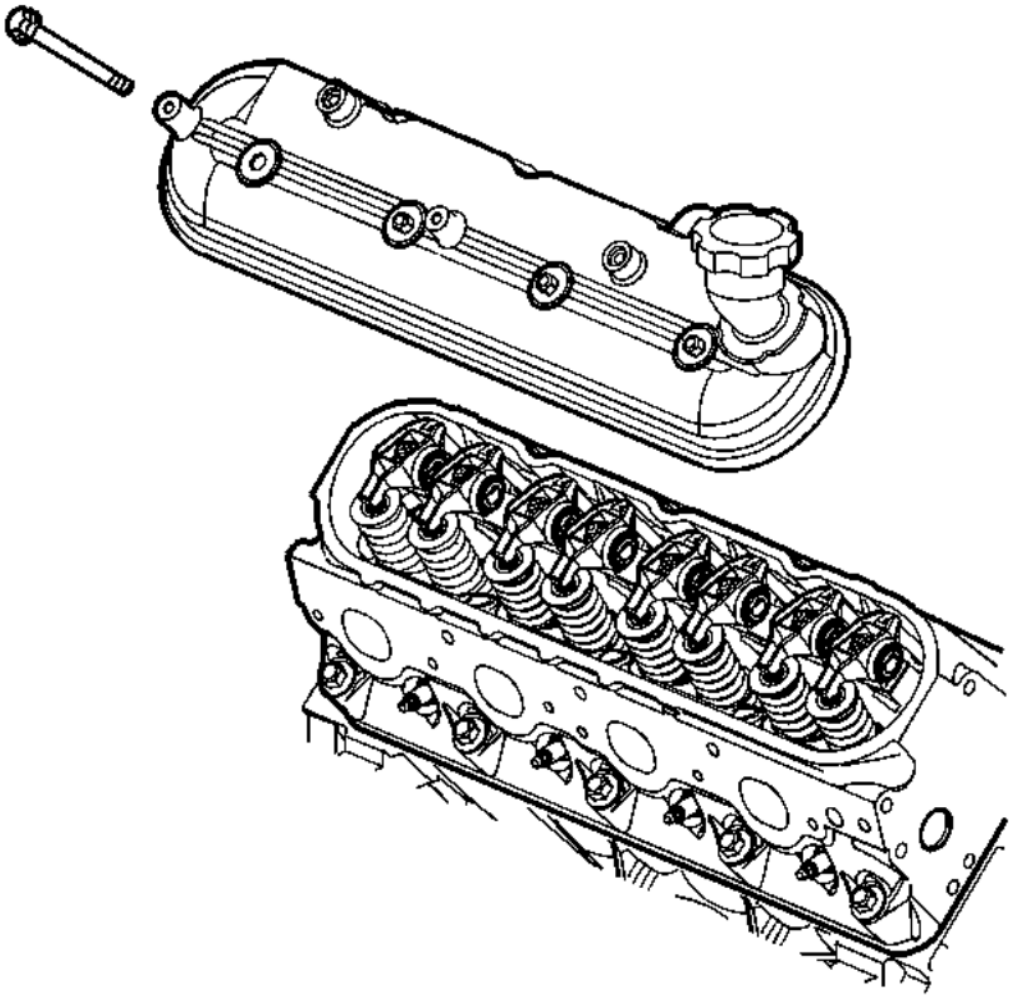

Fig. 330: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.

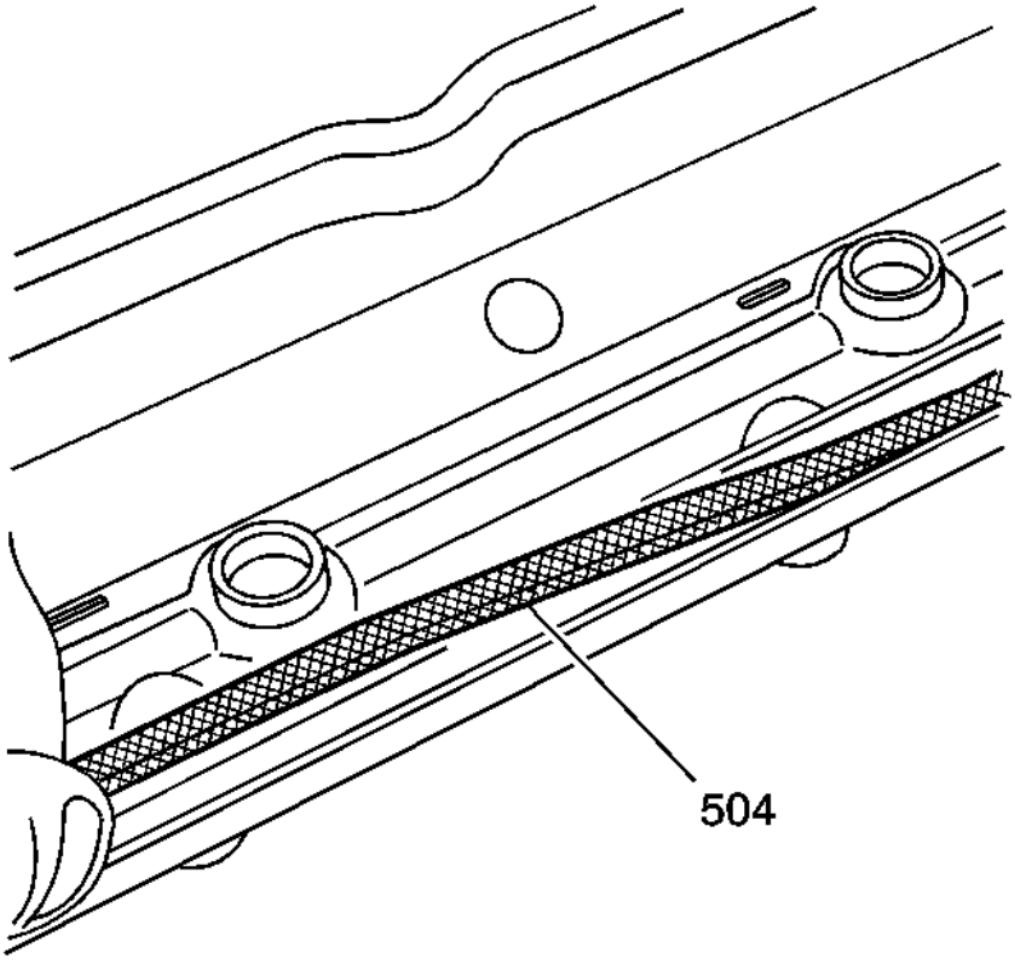

Fig. 331: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

7. Remove the gasket (504) from the cover.

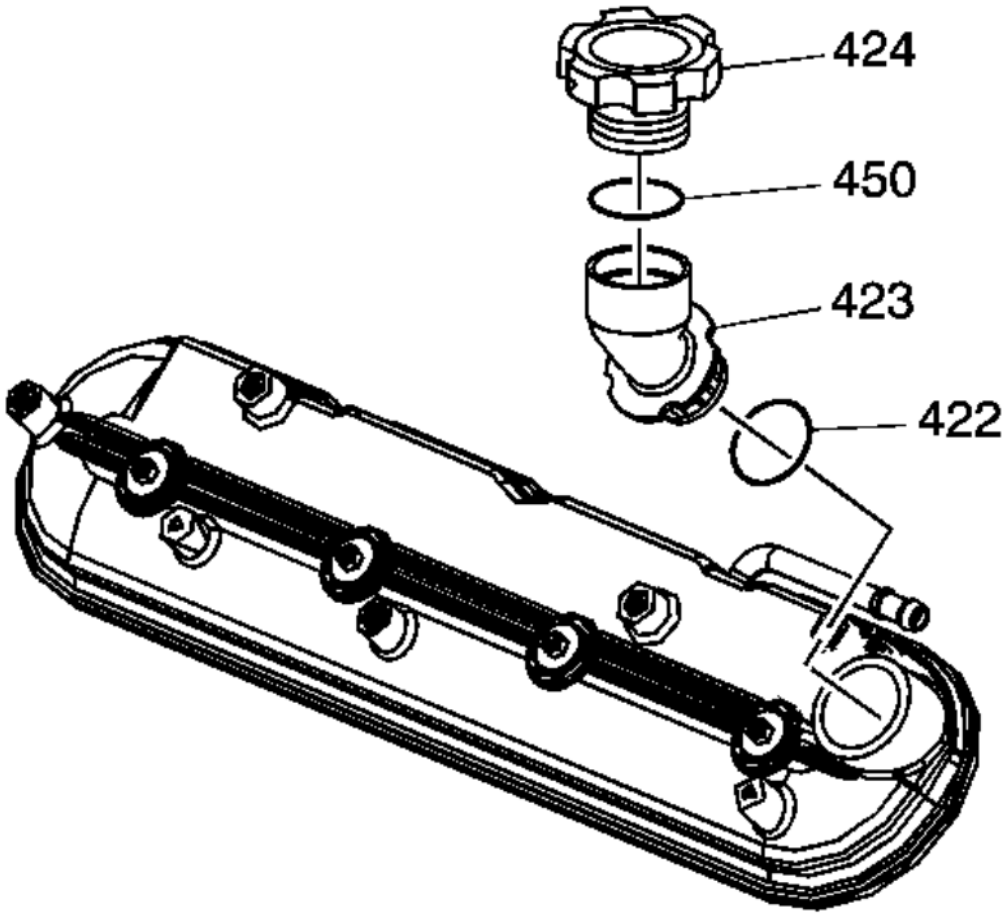

Fig. 332: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

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

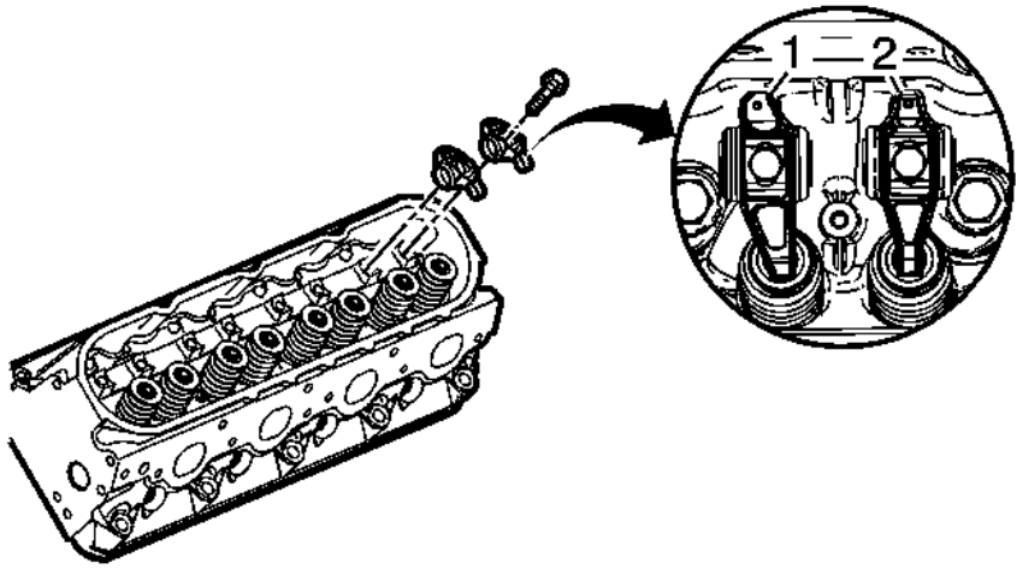

Fig. 333: Identifying Offset Intake Rocker Arm & Non-Offset Rocker Arm
Courtesy of GENERAL MOTORS CORP.

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.

The intake rocker arms (1) have an offset design.

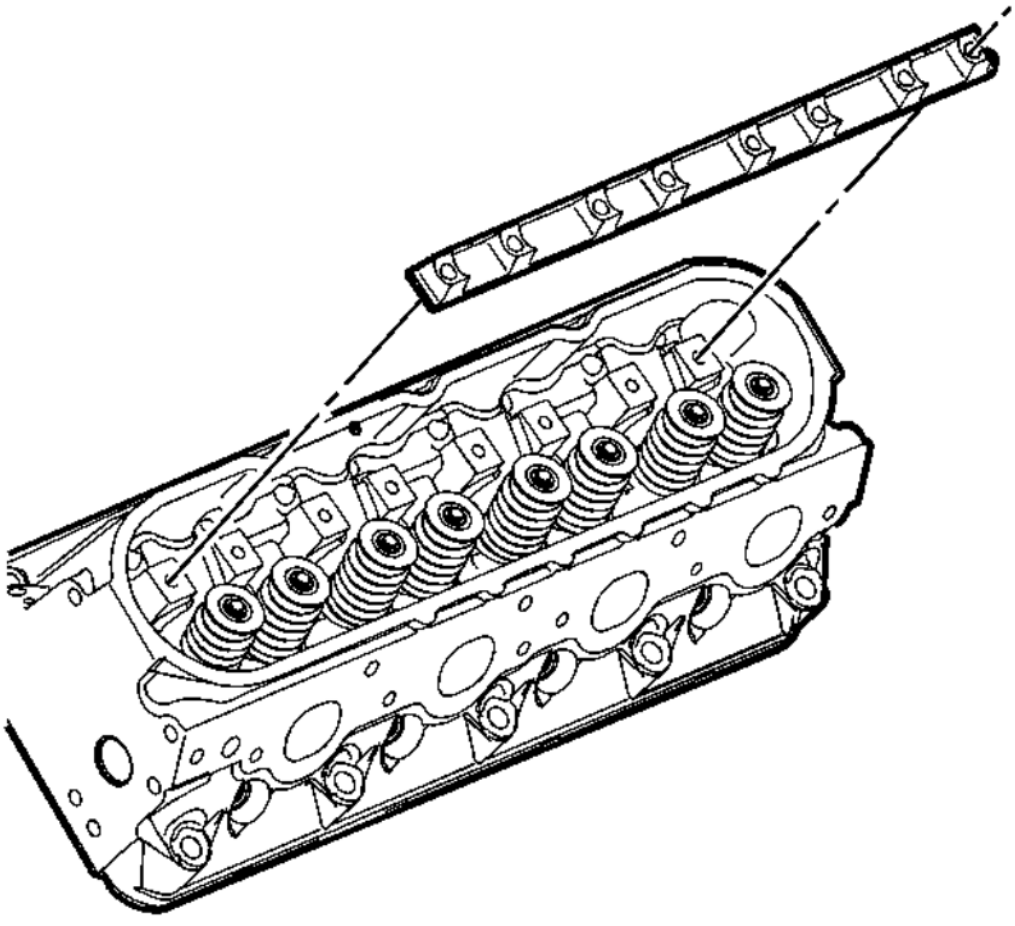

Fig. 334: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

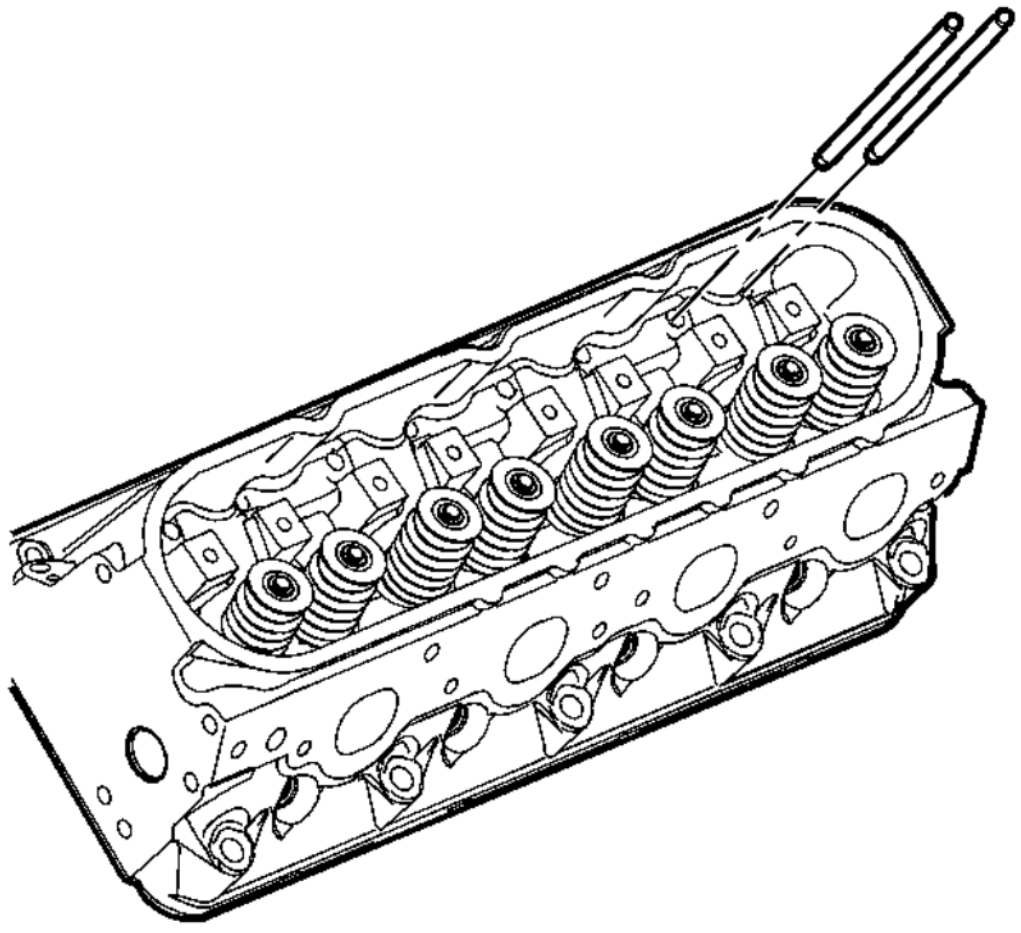

Fig. 335: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

CYLINDER HEAD REMOVAL - LEFT SIDE

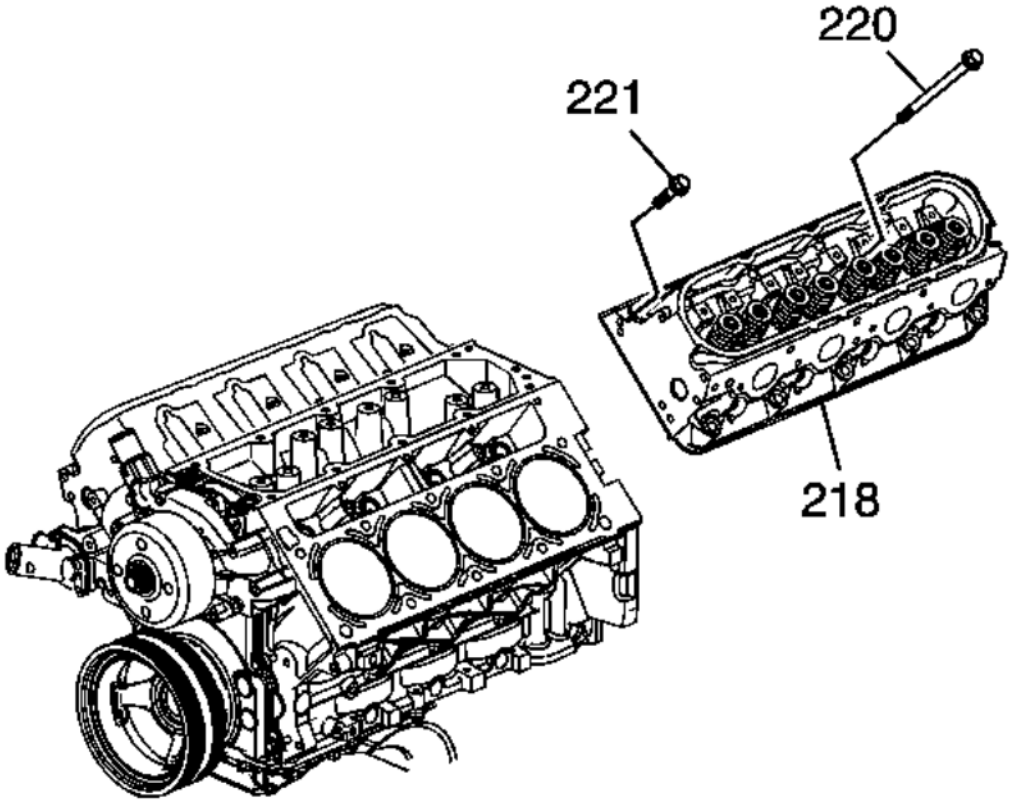

Fig. 336: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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 2 wood blocks in order to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

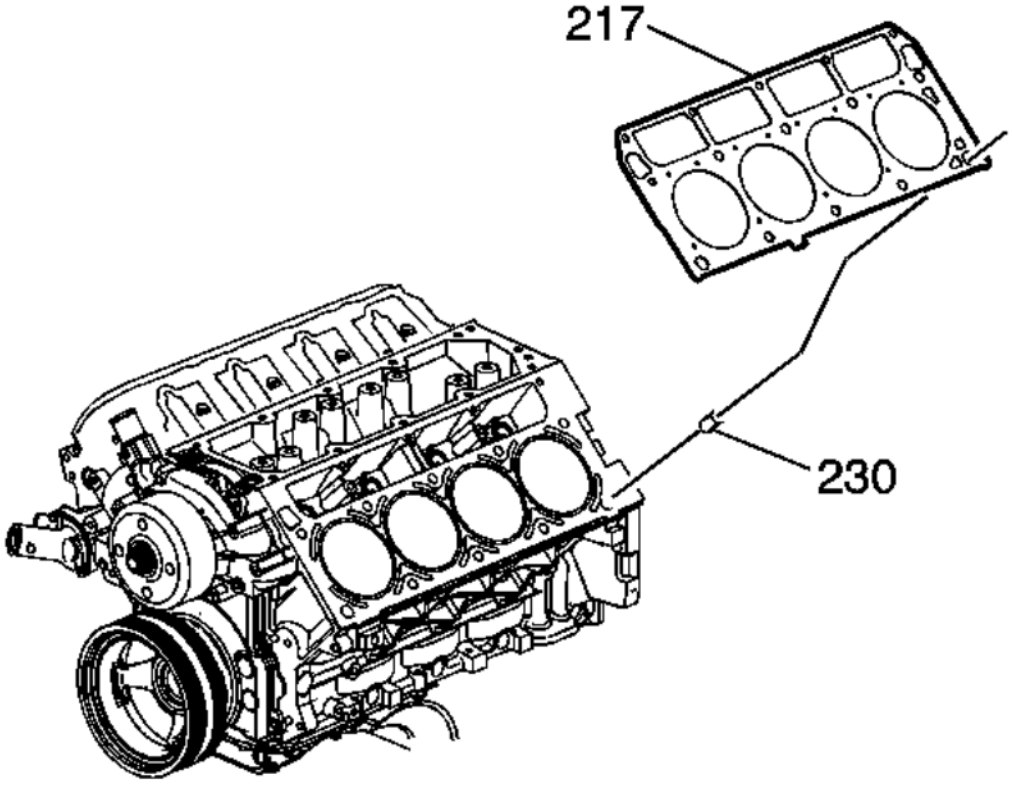

Fig. 337: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

CYLINDER HEAD REMOVAL - RIGHT SIDE

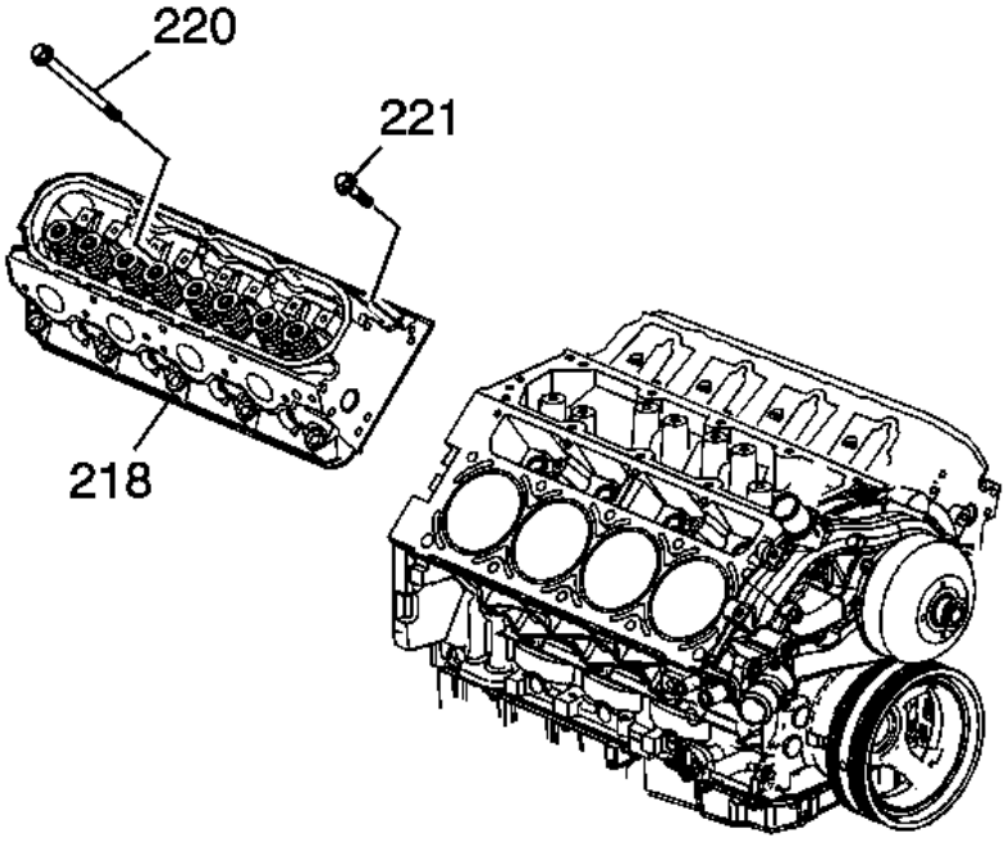

Fig. 338: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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 2 wood blocks in order to prevent damage to the sealing surfaces.

2. Remove the cylinder head (218).

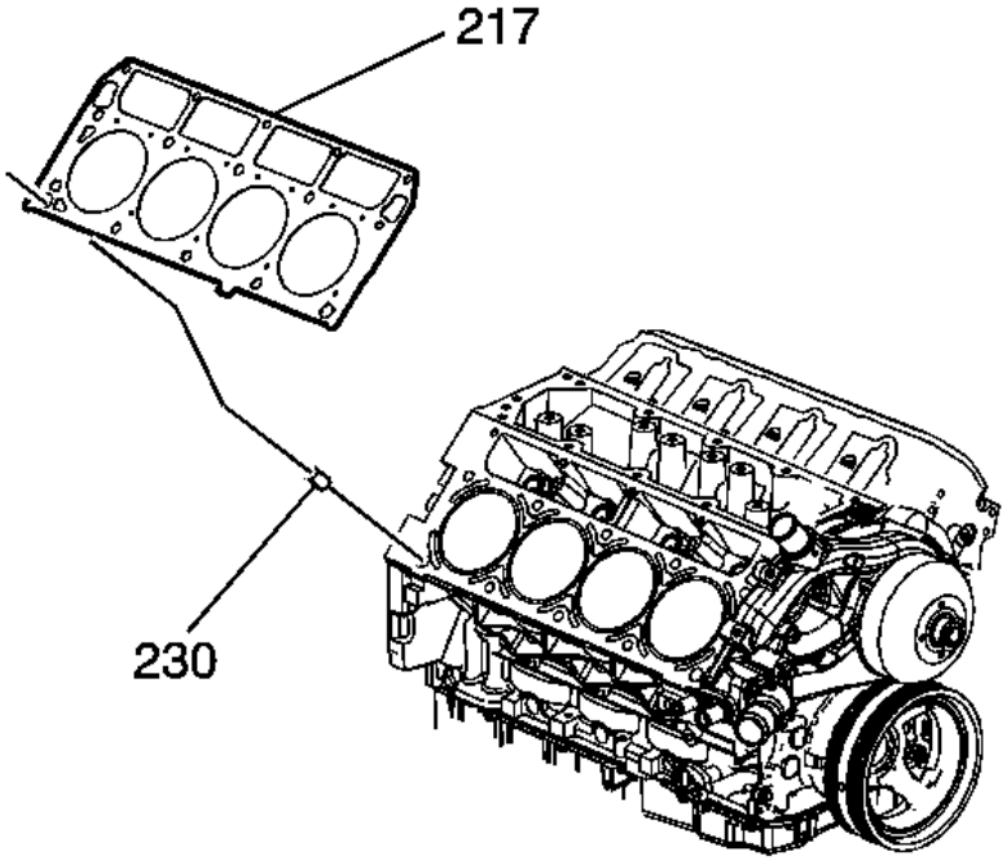

Fig. 339: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

VALVE LIFTER REMOVAL

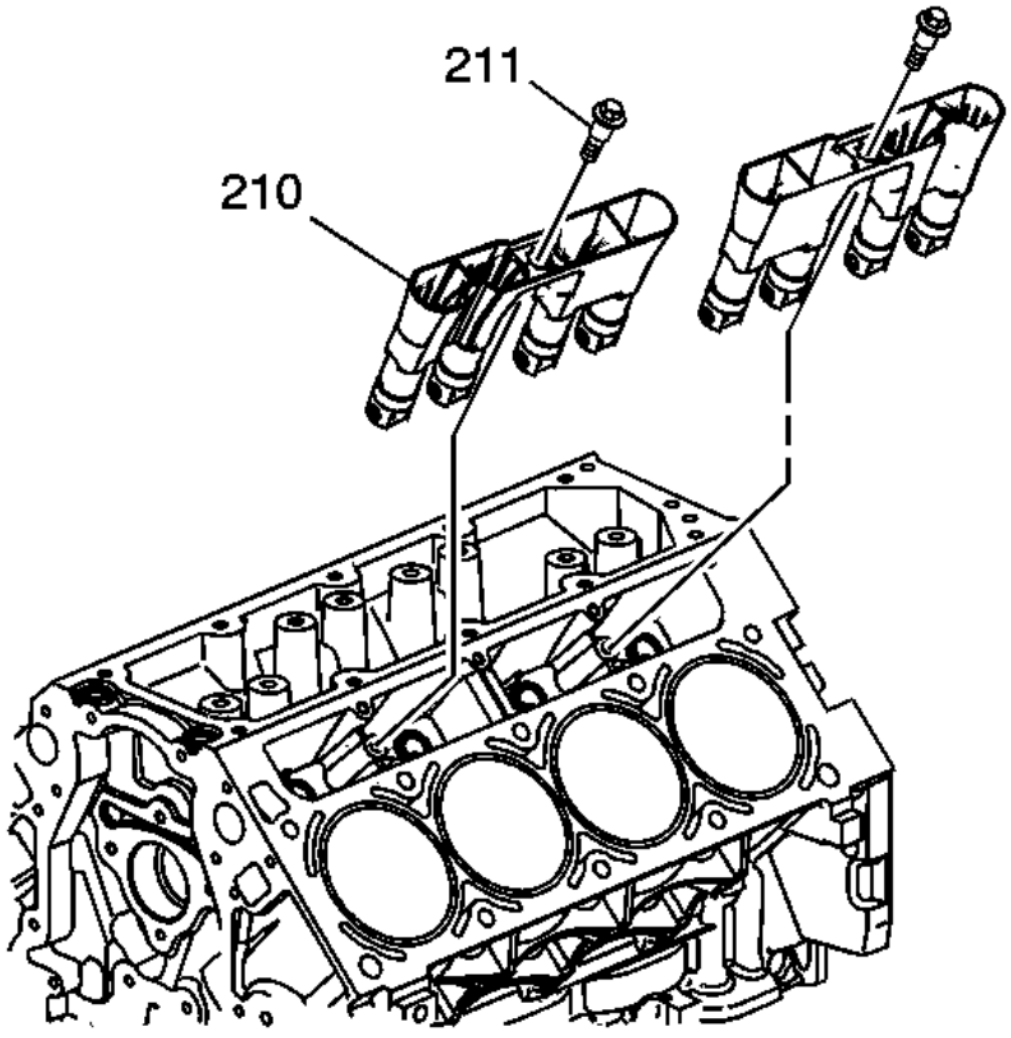

Fig. 340: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the guide 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 on the block.

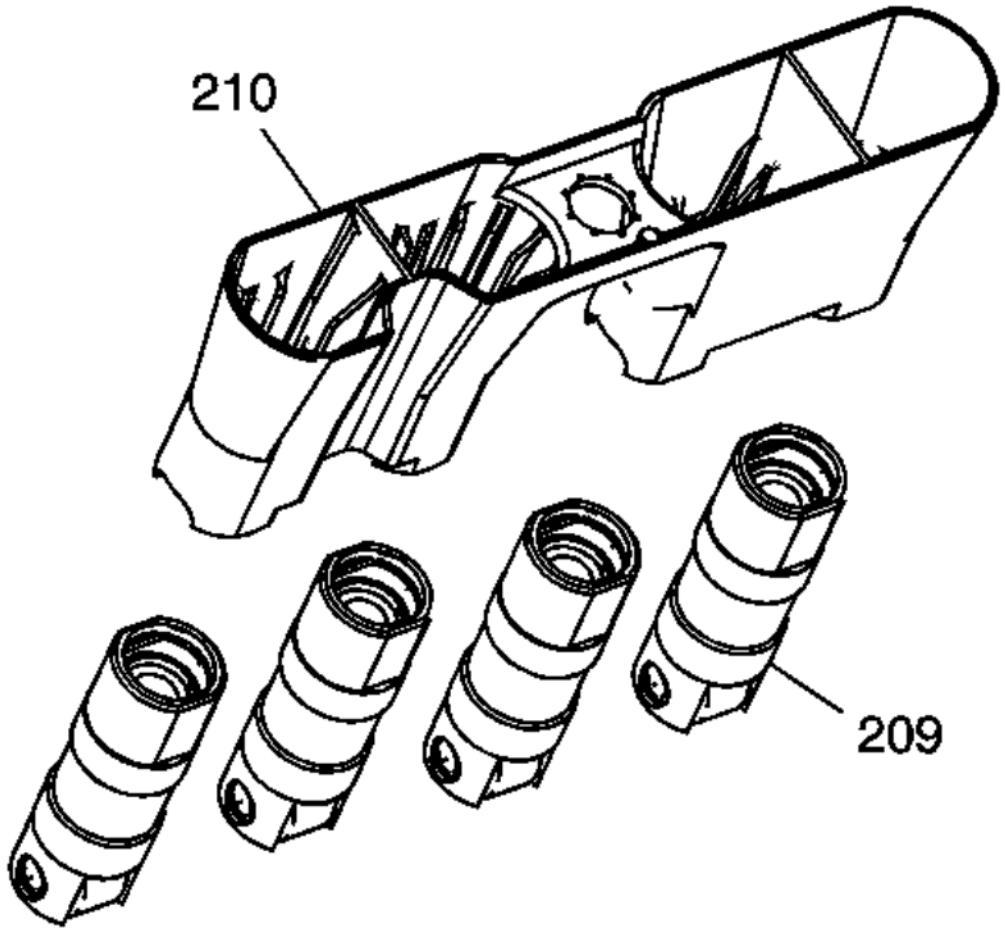

Fig. 341: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve lifters (209) from the guide (210).
4. Organize or mark the components so they can be installed in the same location from which they were removed. Refer to **Separating Parts**.

OIL FILTER REMOVAL

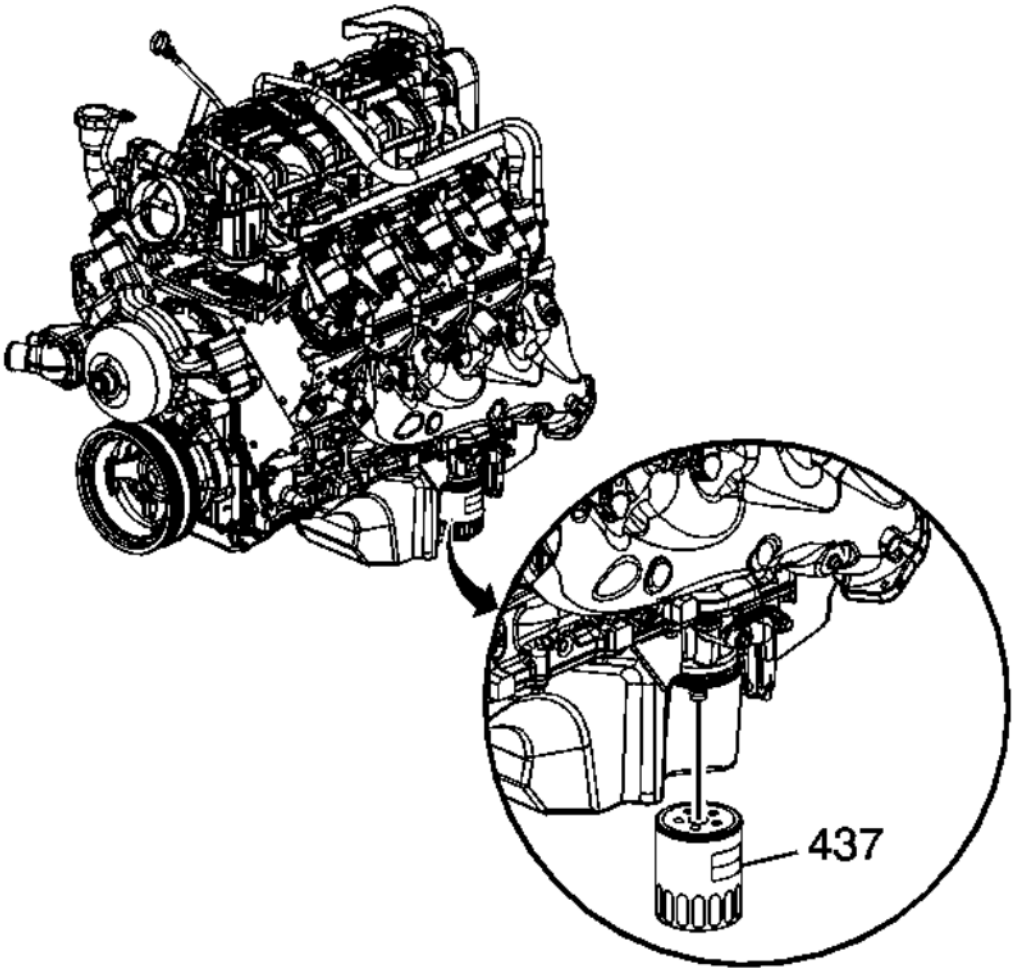

Fig. 342: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (437).

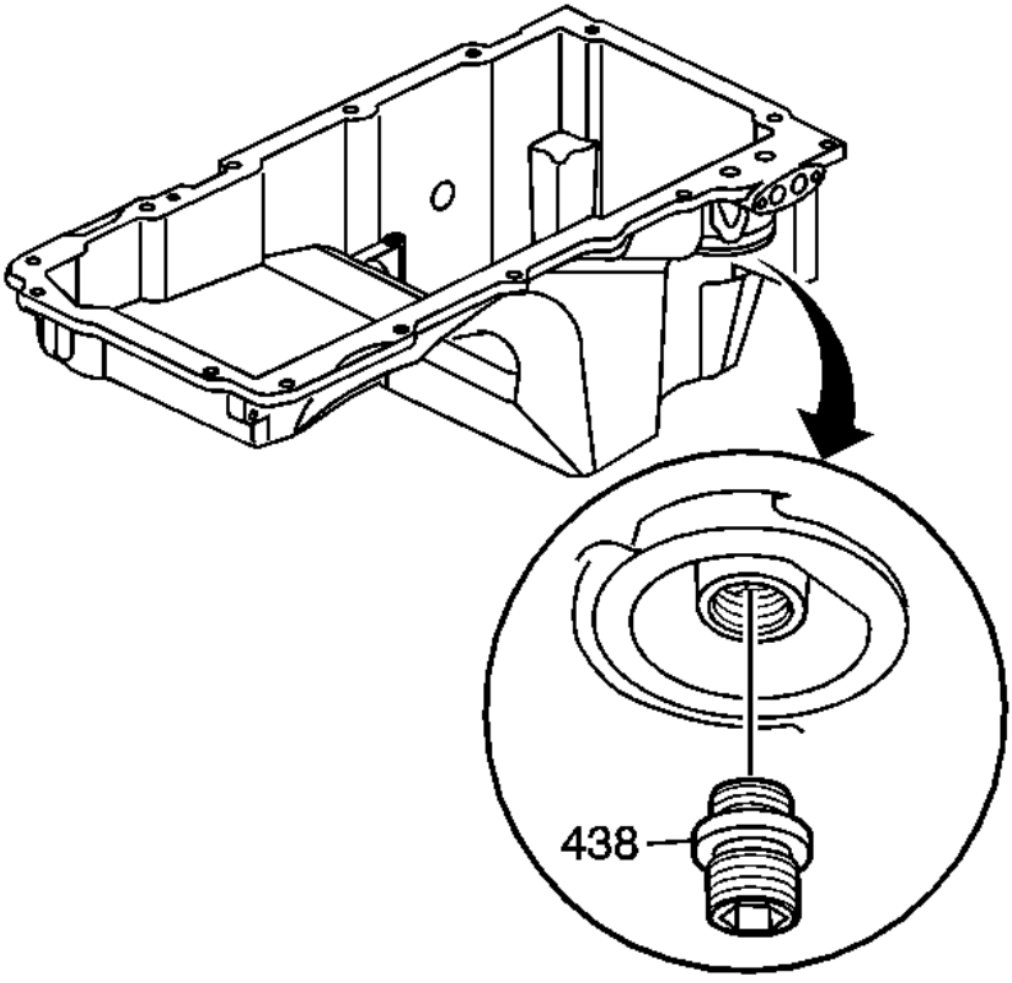

Fig. 343: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting (438).

OIL PAN REMOVAL

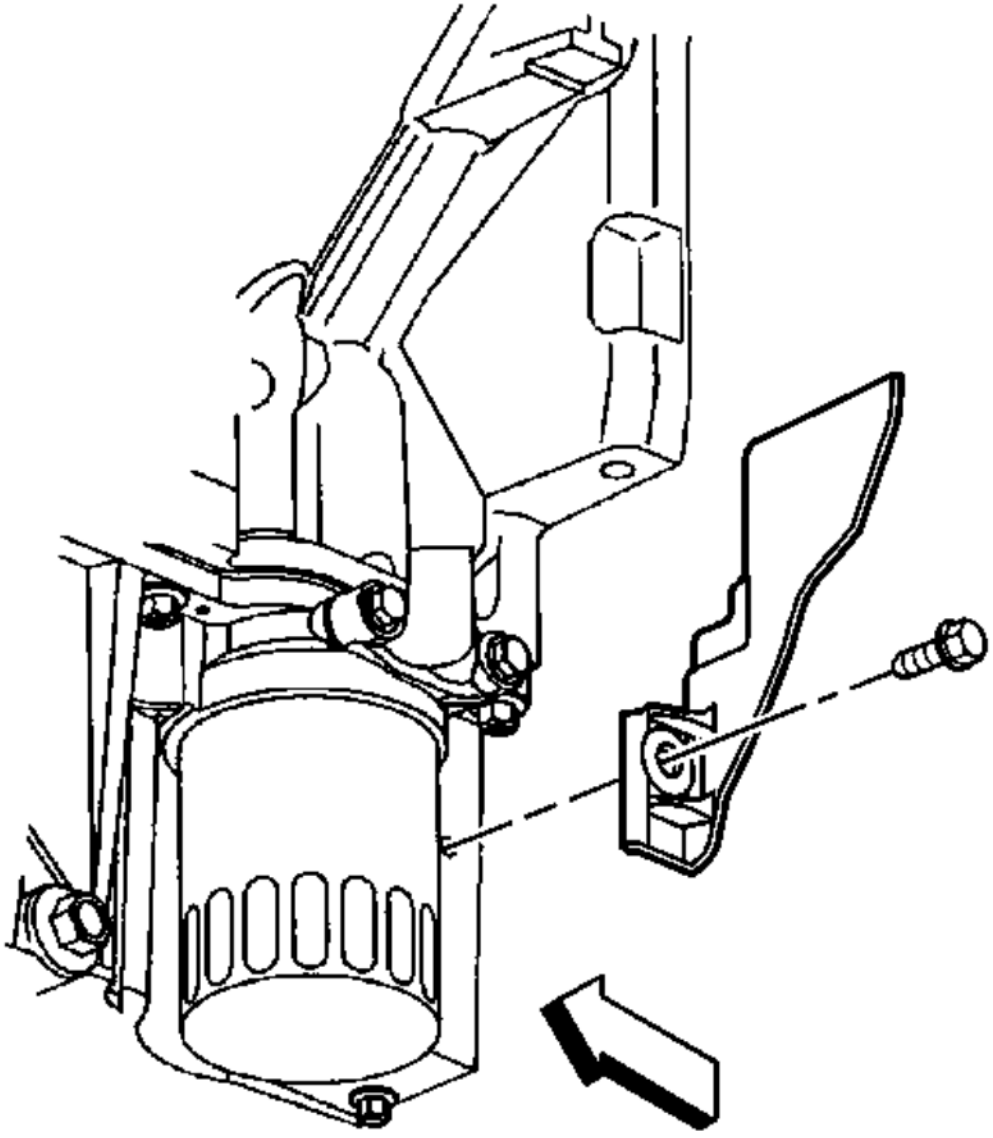

Fig. 344: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

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.**
- **It is not necessary to remove the oil level indicator switch prior to oil pan removal. Remove the oil level indicator switch, if service is required.**

1. Remove the left closeout cover and bolt.

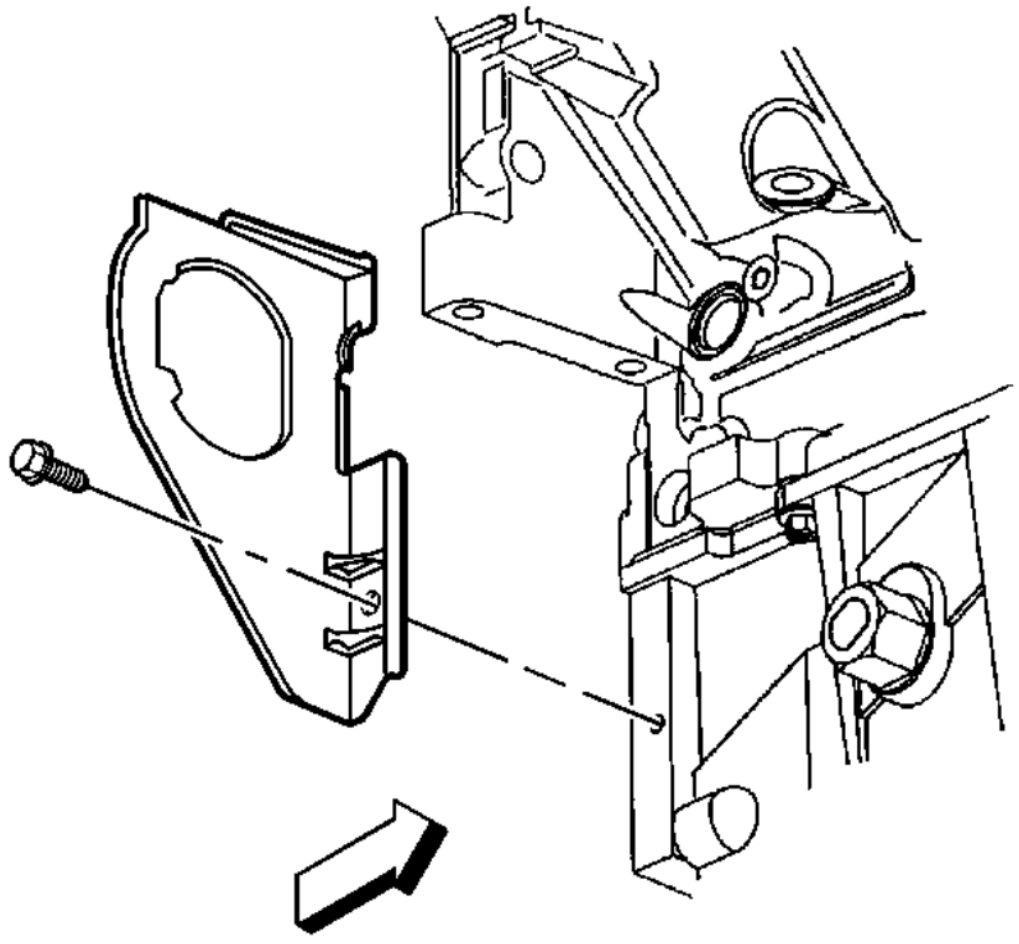

Fig. 345: View Of Right Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the right closeout cover and bolt.

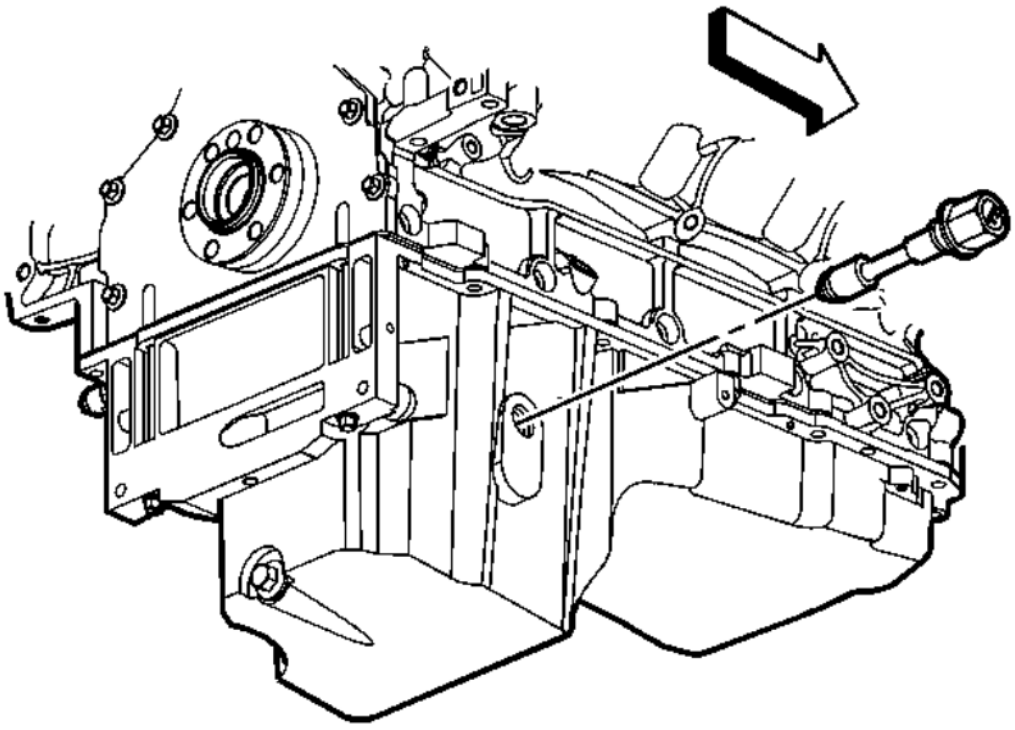

Fig. 346: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil indicator switch from the oil pan, if required.

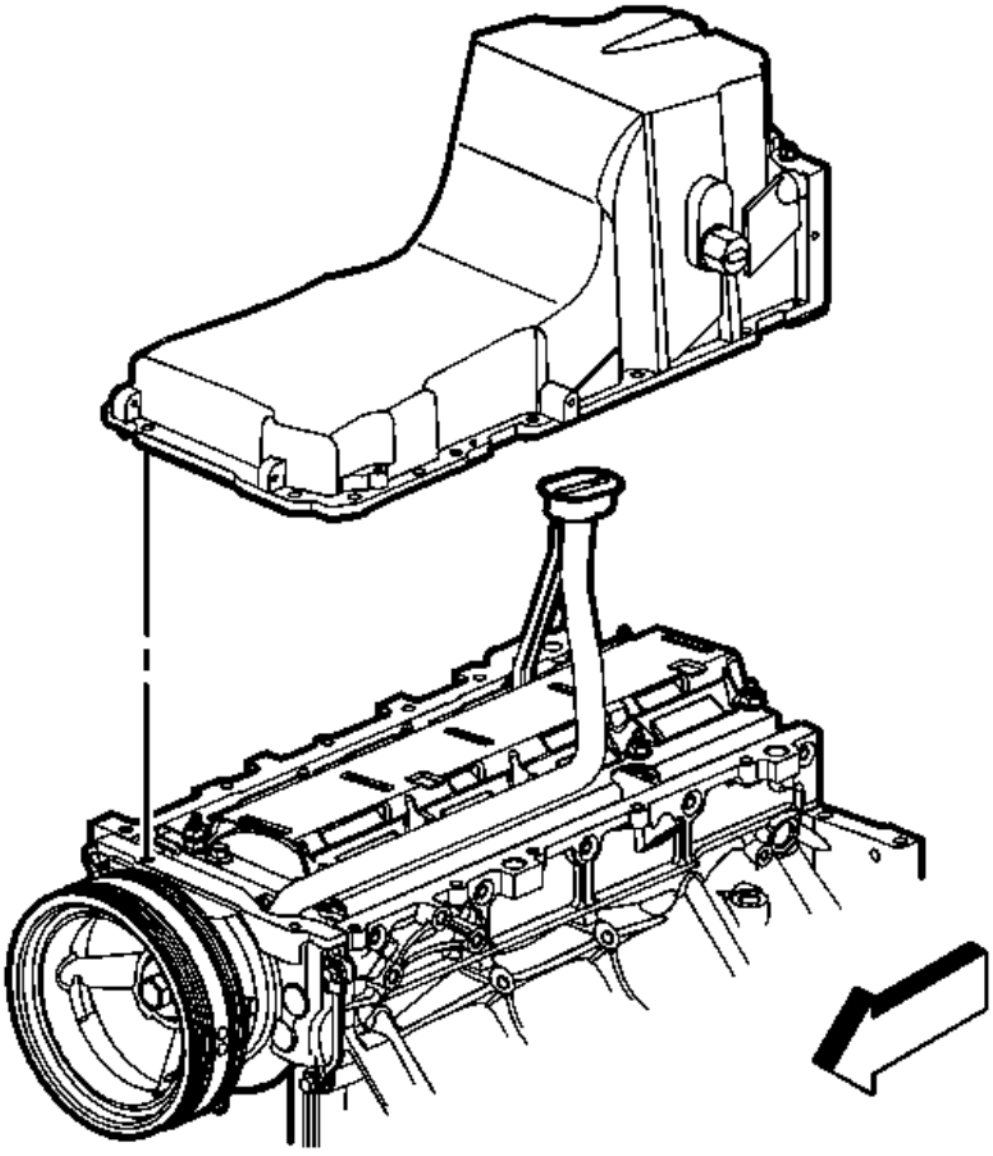

Fig. 347: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan bolts.
5. Remove the oil pan.

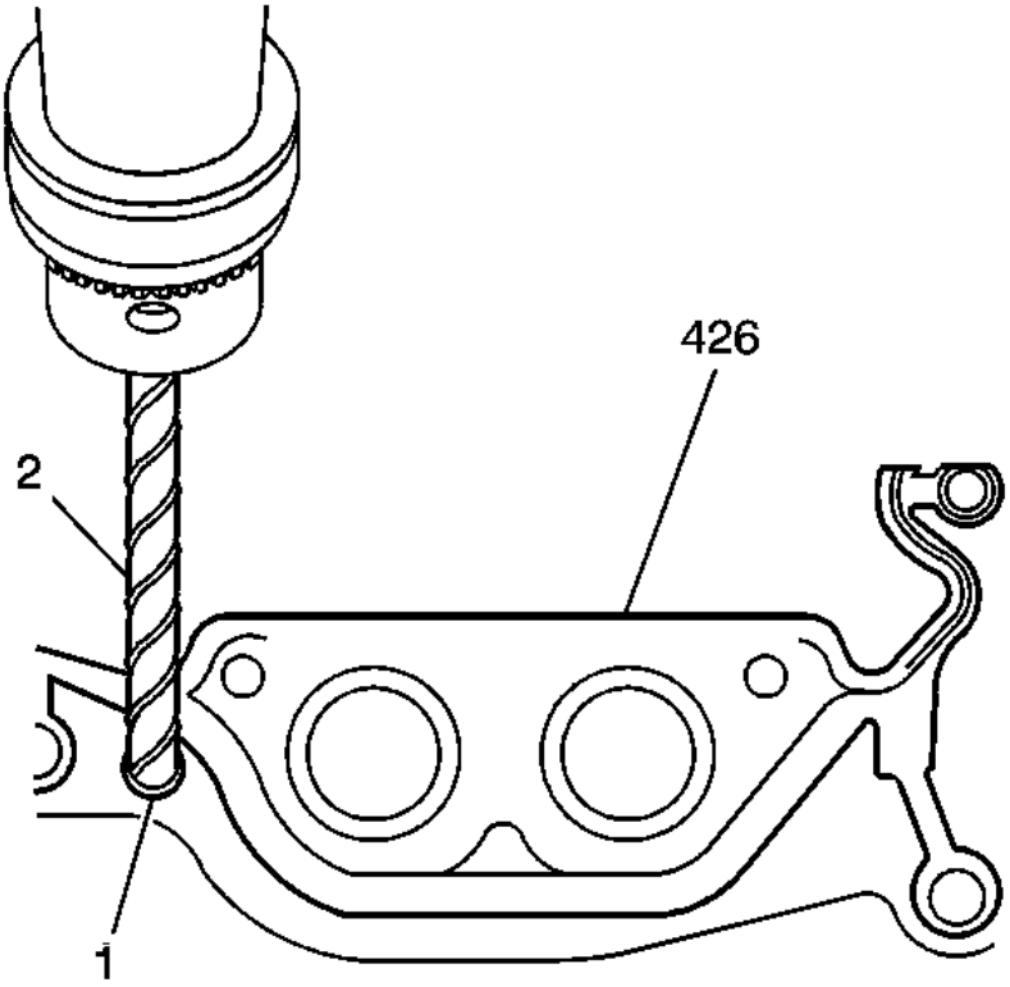

Fig. 348: Drilling Out Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

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.**

6. Drill (2) out the oil pan gasket retaining rivets (1), if required.
7. Remove the gasket (426) from the pan.

8. Discard the gasket and rivets.

ENGINE FRONT COVER REMOVAL

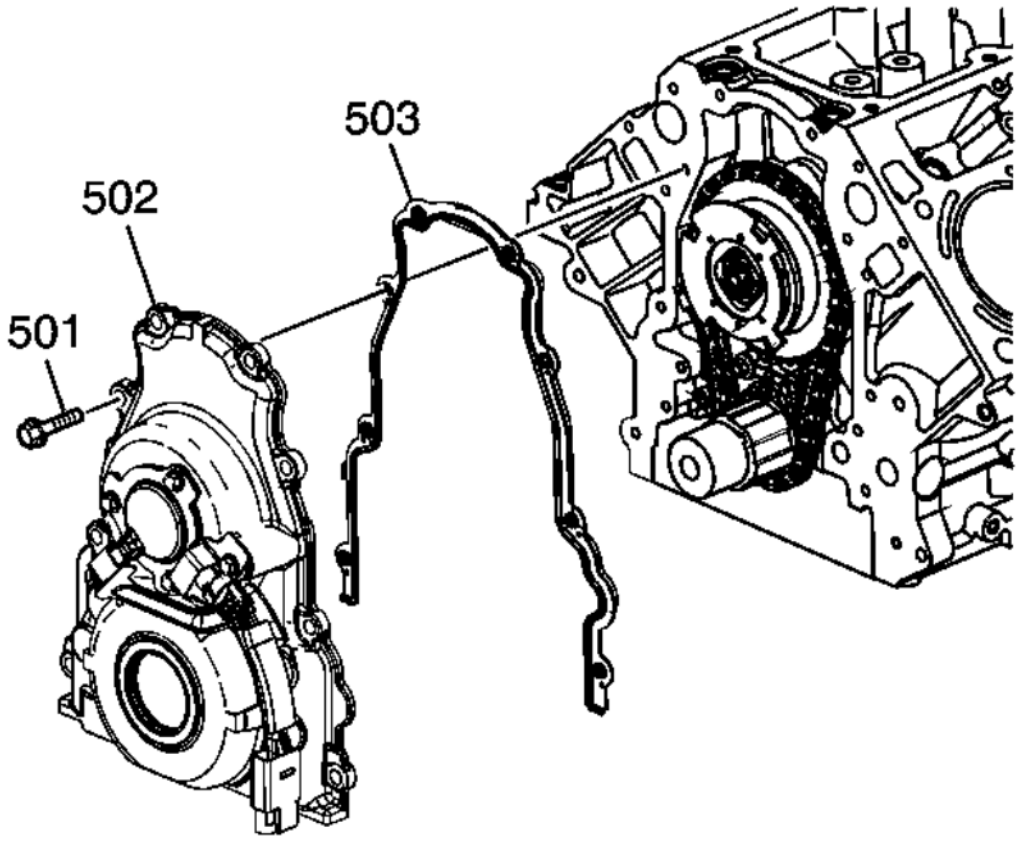

Fig. 349: View Of Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the front cover bolts (501).
2. Remove the front cover (502) and gasket (503).
3. Discard the front cover gasket.

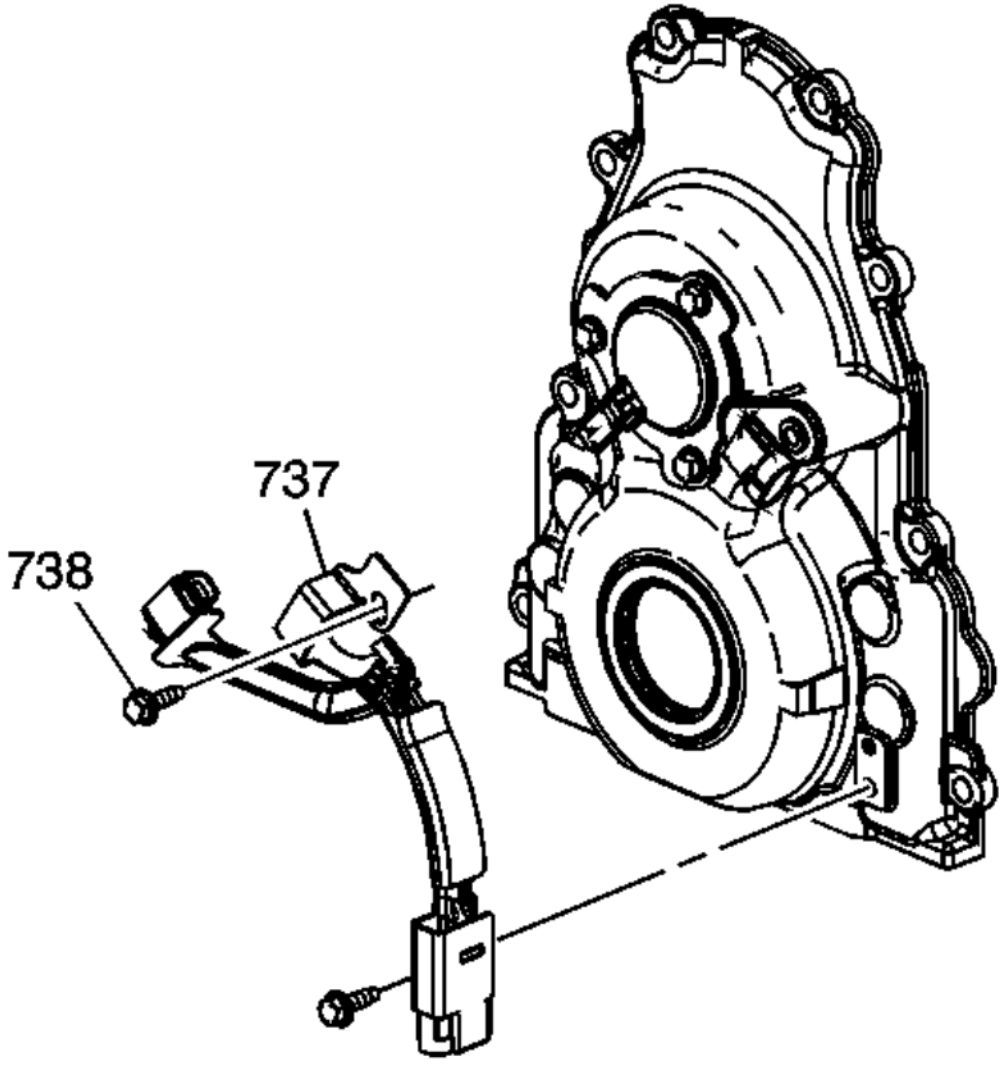

Fig. 350: View Of CMP Sensor Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft position (CMP) sensor wire harness (737) and bolts (738).

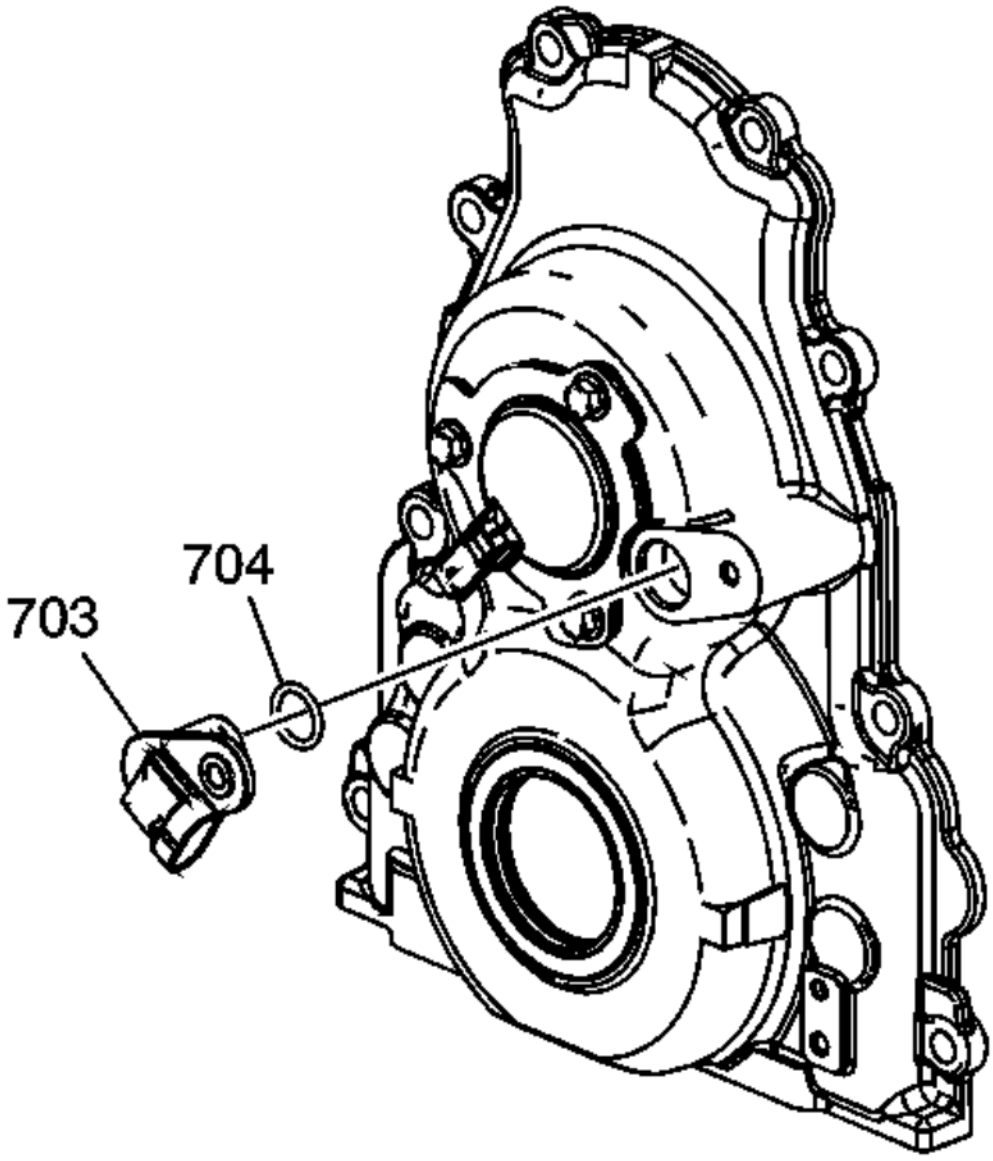

Fig. 351: View Of CMP Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Remove the CMP sensor (703).
6. Remove the O-ring (704) from the sensor, as required.

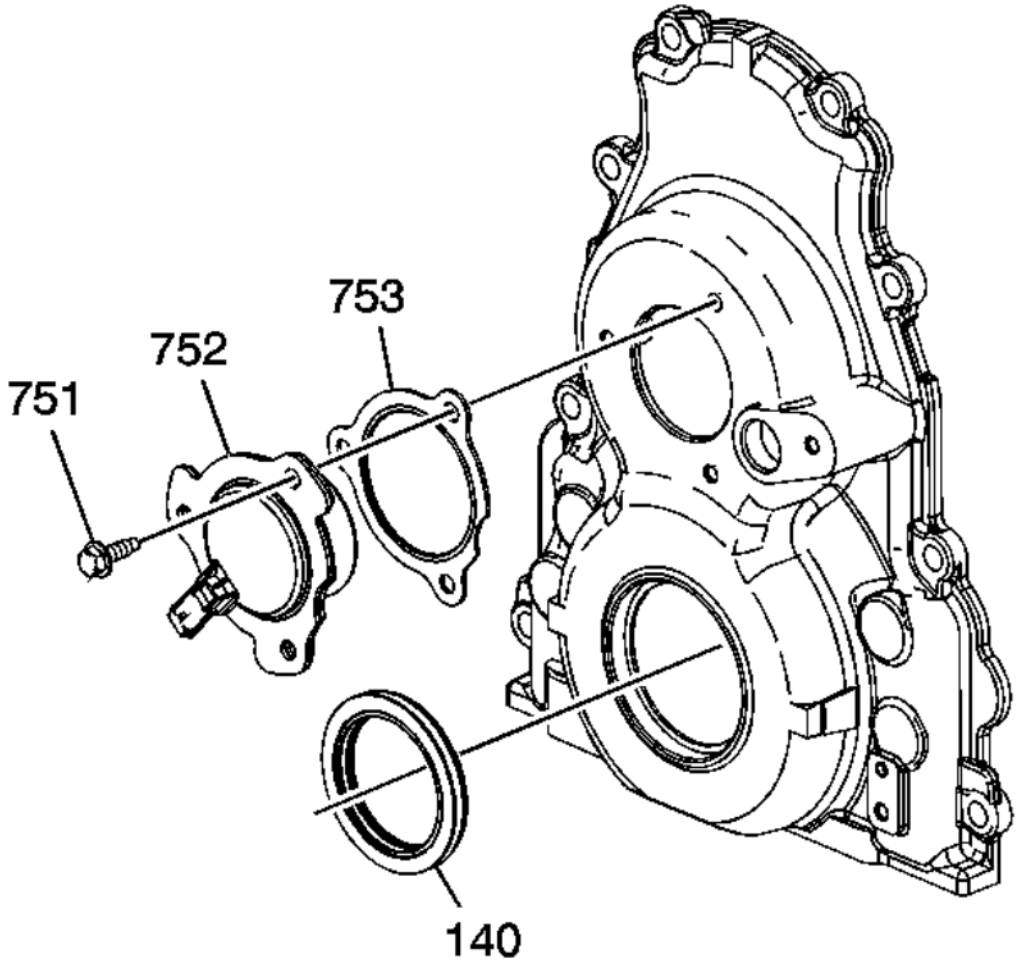

Fig. 352: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

7. Remove the CMP actuator magnet (752), bolts (751), and gasket (753).
8. Remove the oil seal (140).

CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

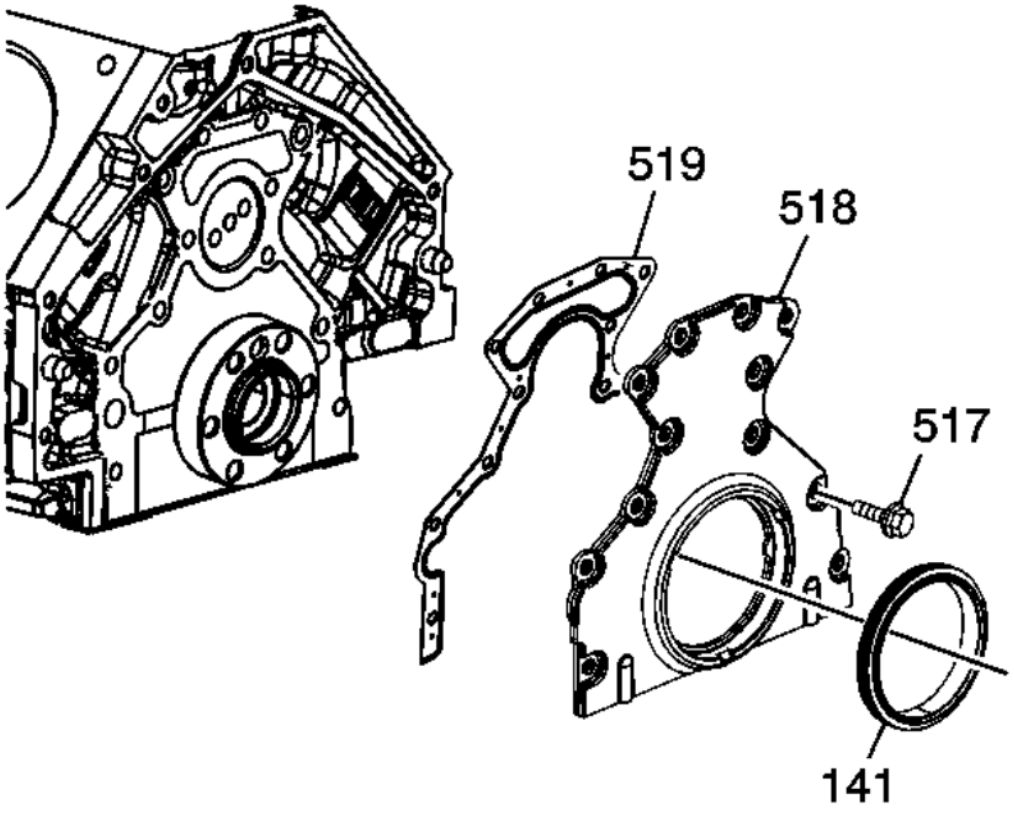

Fig. 353: View of Rear Housing, Gasket and Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the rear oil seal housing bolts (517).
2. Remove the housing (518) and gasket (519).
3. Remove the rear oil seal (141).

OIL PUMP, SCREEN AND CRANKSHAFT OIL DEFLECTOR REMOVAL

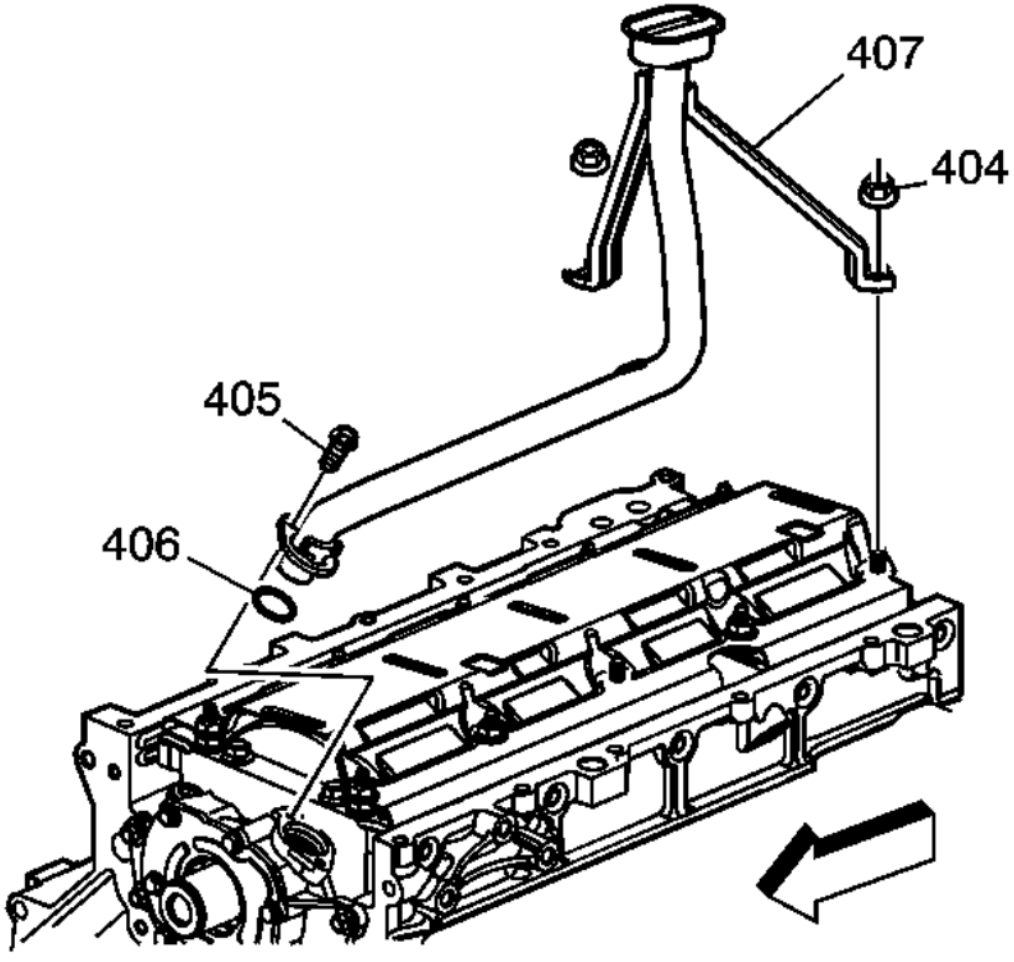

Fig. 354: View Of Oil Pump Screen, Bolt, Nuts, & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump screen bolt (405) and nuts (404).
2. Remove the oil pump screen (407) with O-ring seal (406).
3. Remove the O-ring seal from the pump screen.
4. Discard the O-ring seal.

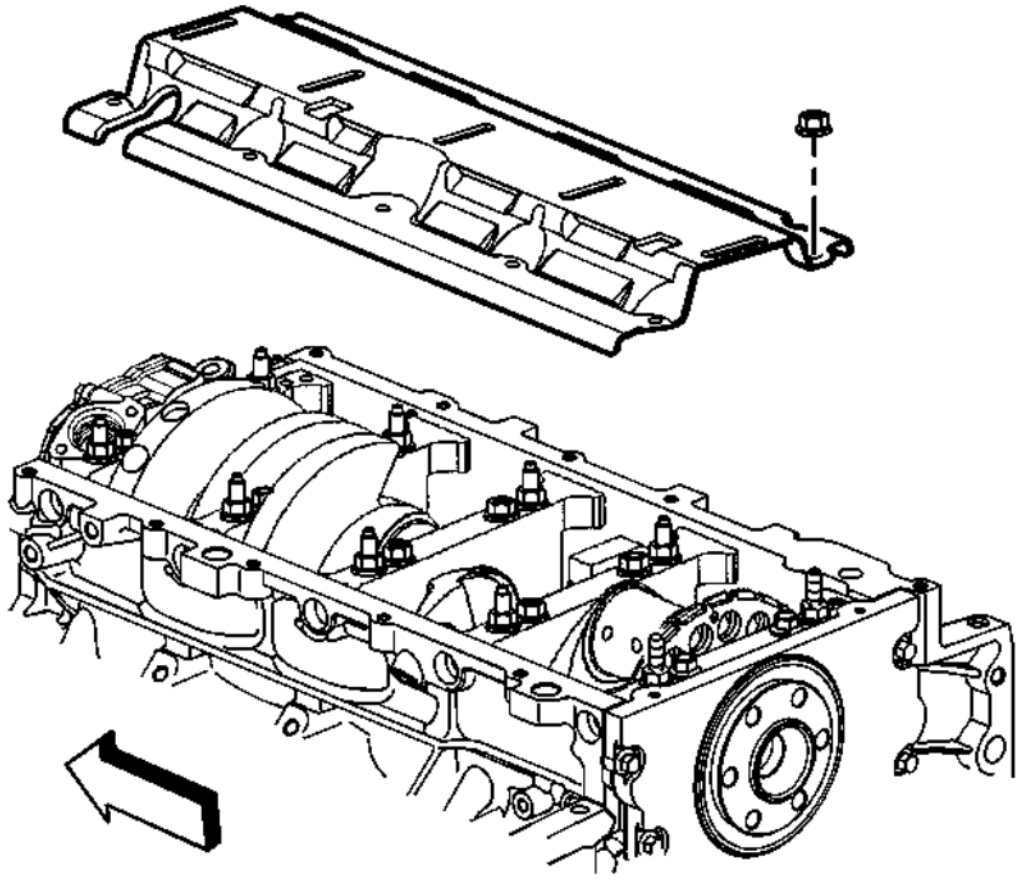

Fig. 355: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Remove the remaining crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

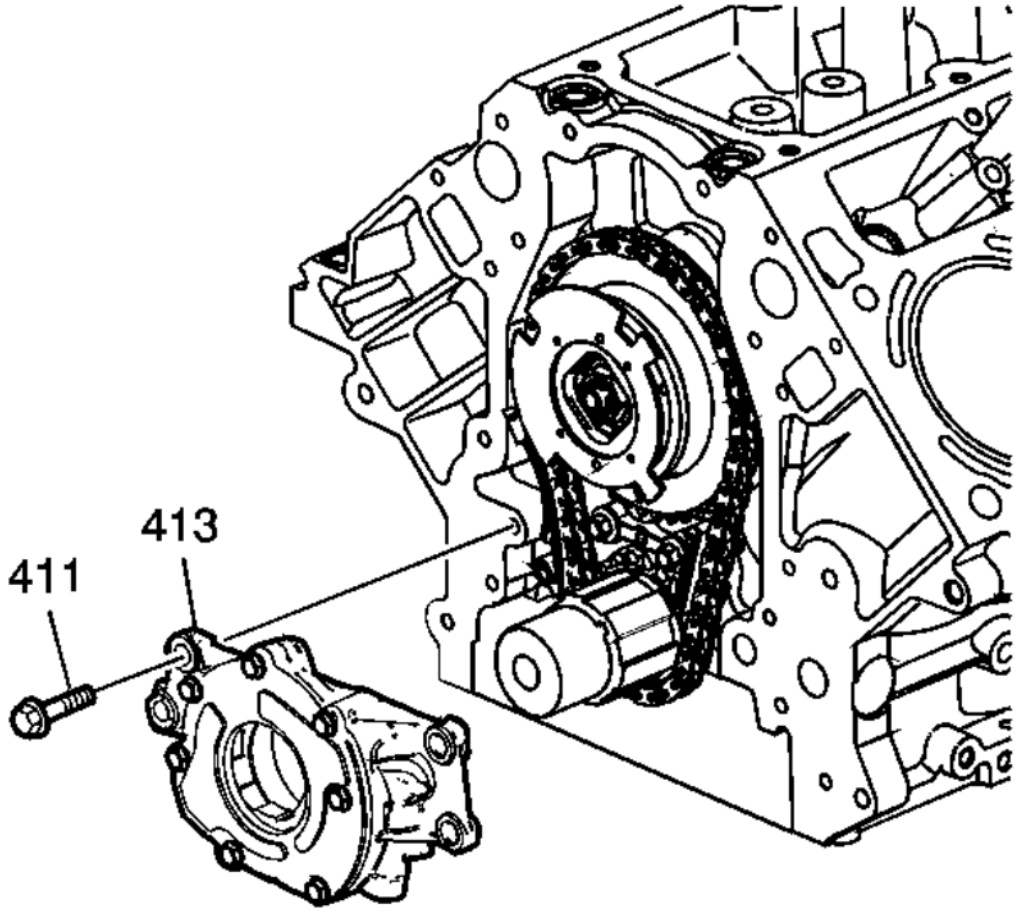

Fig. 356: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

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).

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE REMOVAL

Tools Required

- **J 8433** Two Jaw Puller
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector. See **Special Tools**.
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.

Removal

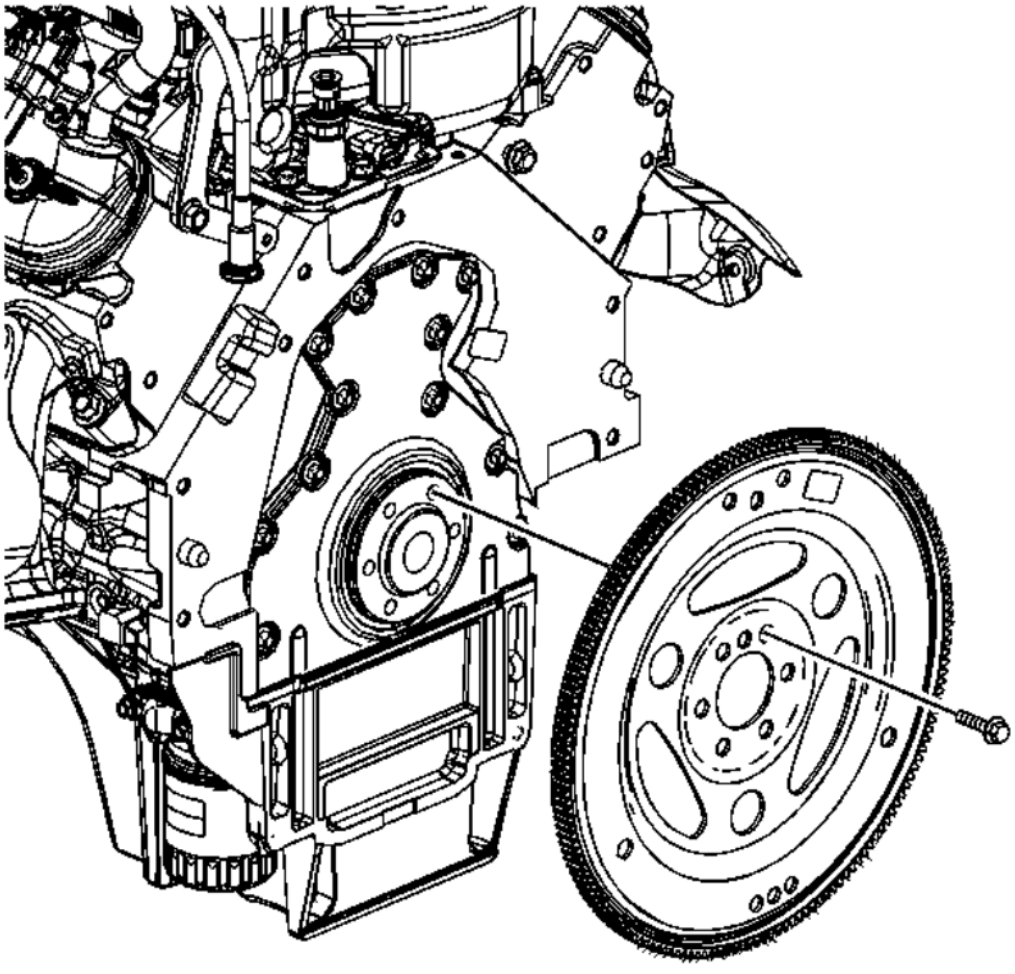

Fig. 357: View Of Flex Plate & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the camshaft position (CMP) actuator solenoid valve again. Upon installation of the CMP actuator and timing chain, install a NEW valve.**
- **Do not apply threadlock to the flex plate bolts at this time.**

1. Temporarily install the automatic transmission flex plate and bolts. Refer to **Automatic Transmission Flex Plate Installation**.

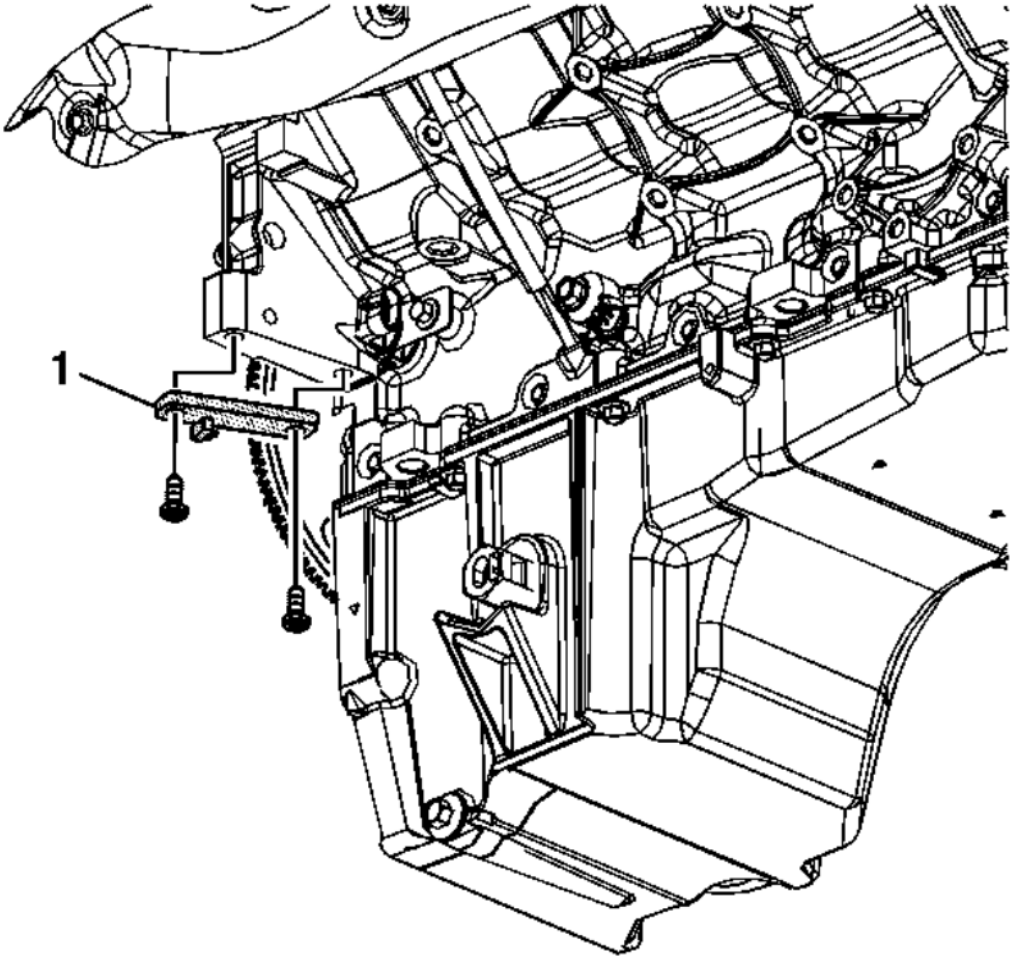

Fig. 358: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Refer to Fastener Notice .**

2. Install the **J 42386-A** (1) and bolts. See **Special Tools**. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation.

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

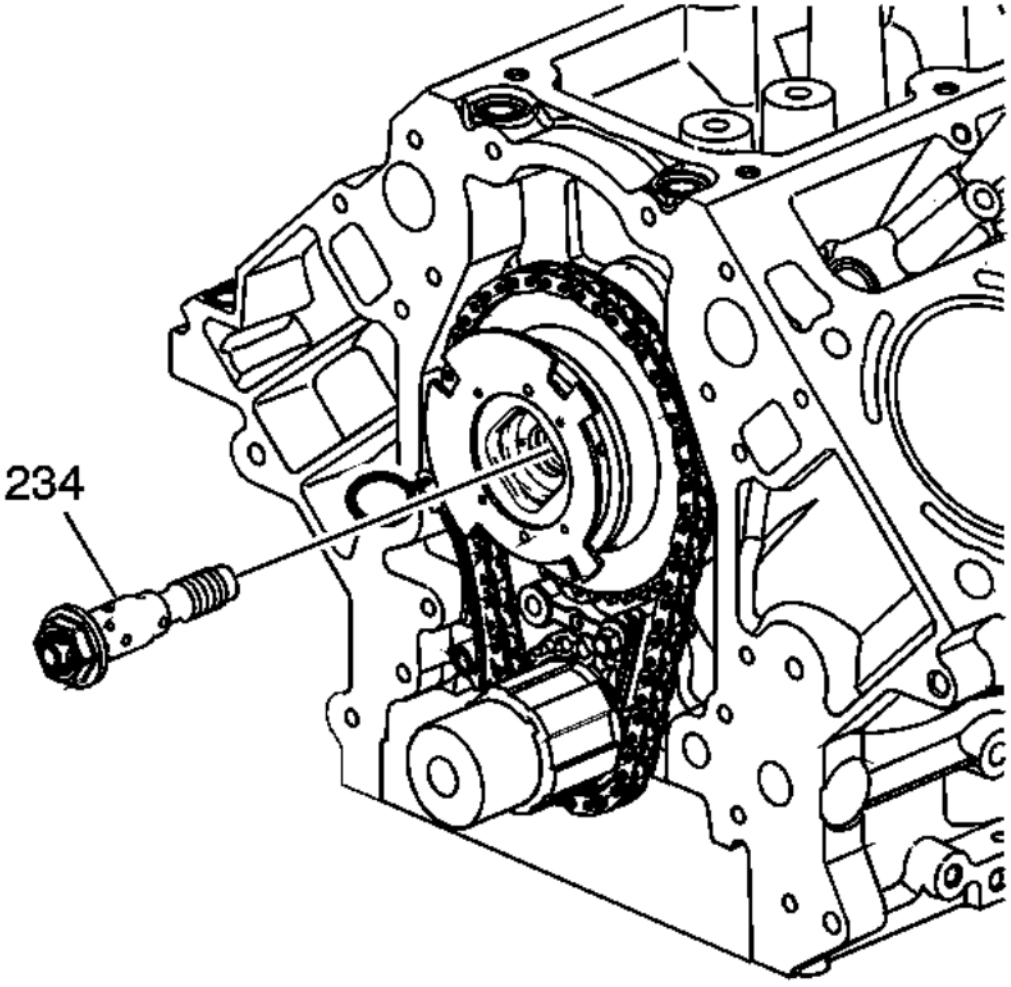

Fig. 359: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the CMP actuator solenoid valve (234).

4. Discard the solenoid valve.

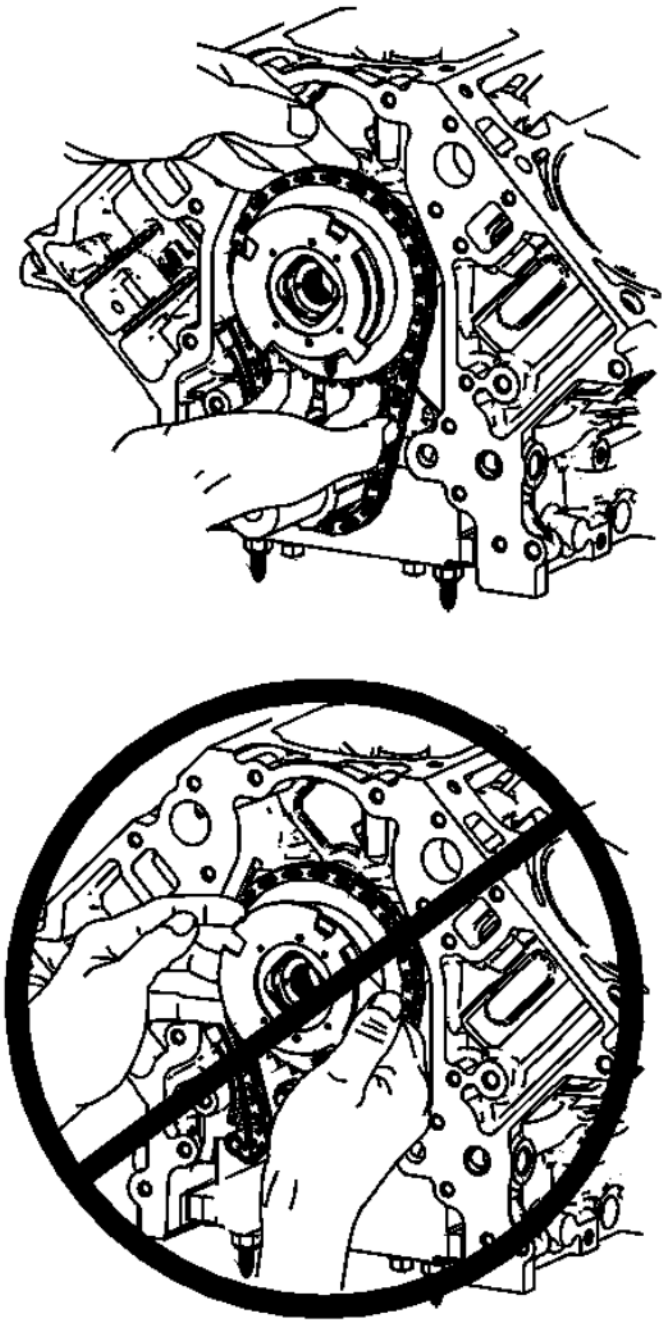

Fig. 360: View Of Proper CMP Actuator Removal

Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Camshaft Position Actuator Removal and Installation Caution .

5. Loosen and separate the CMP actuator and timing chain from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

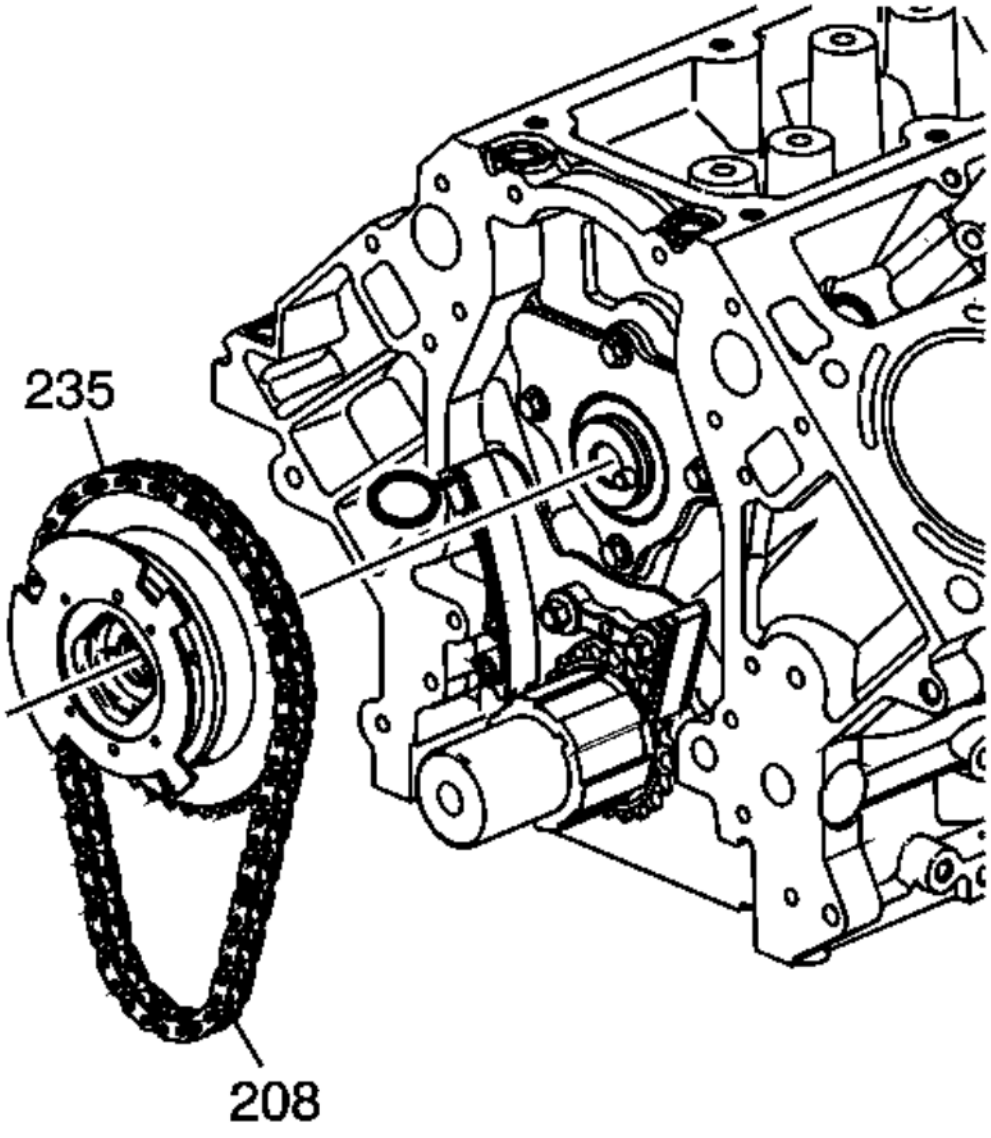

Fig. 361: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

6. Remove the CMP actuator (235) and timing chain (208).

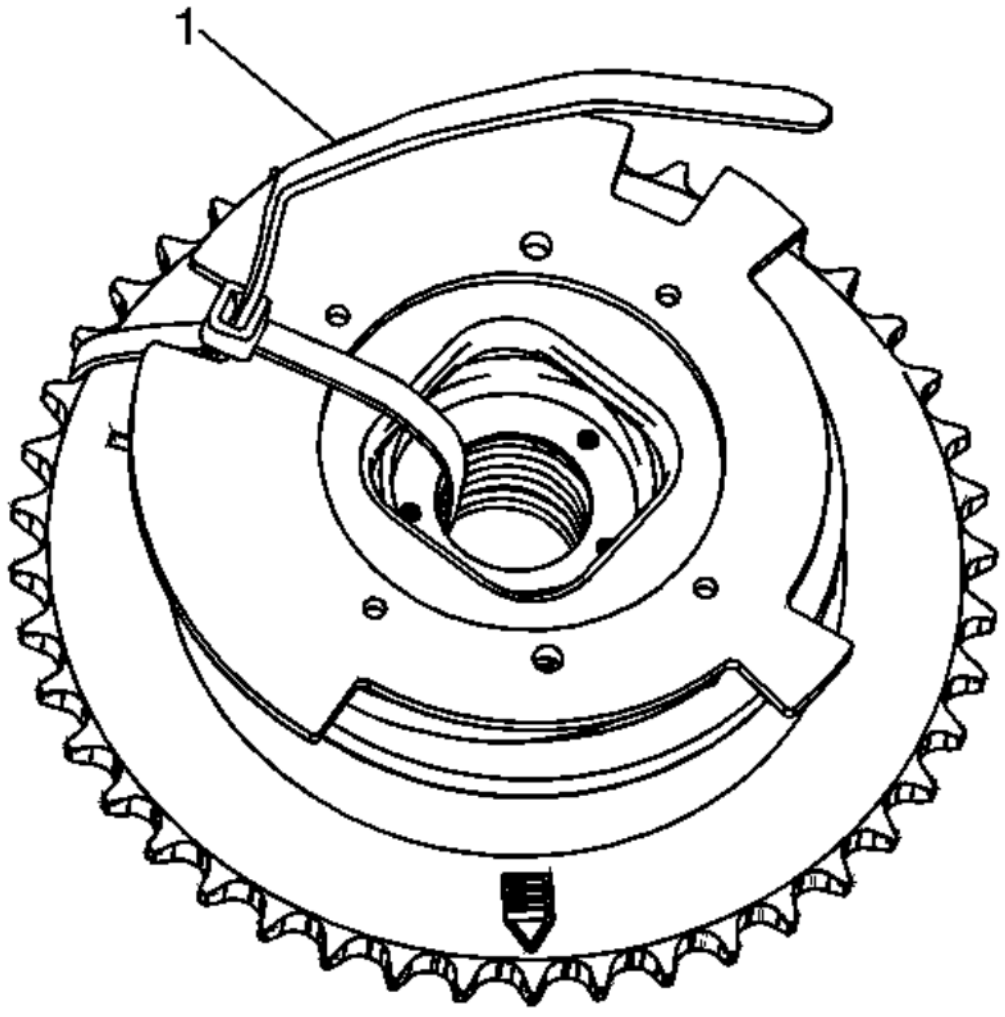

Fig. 362: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

7. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.

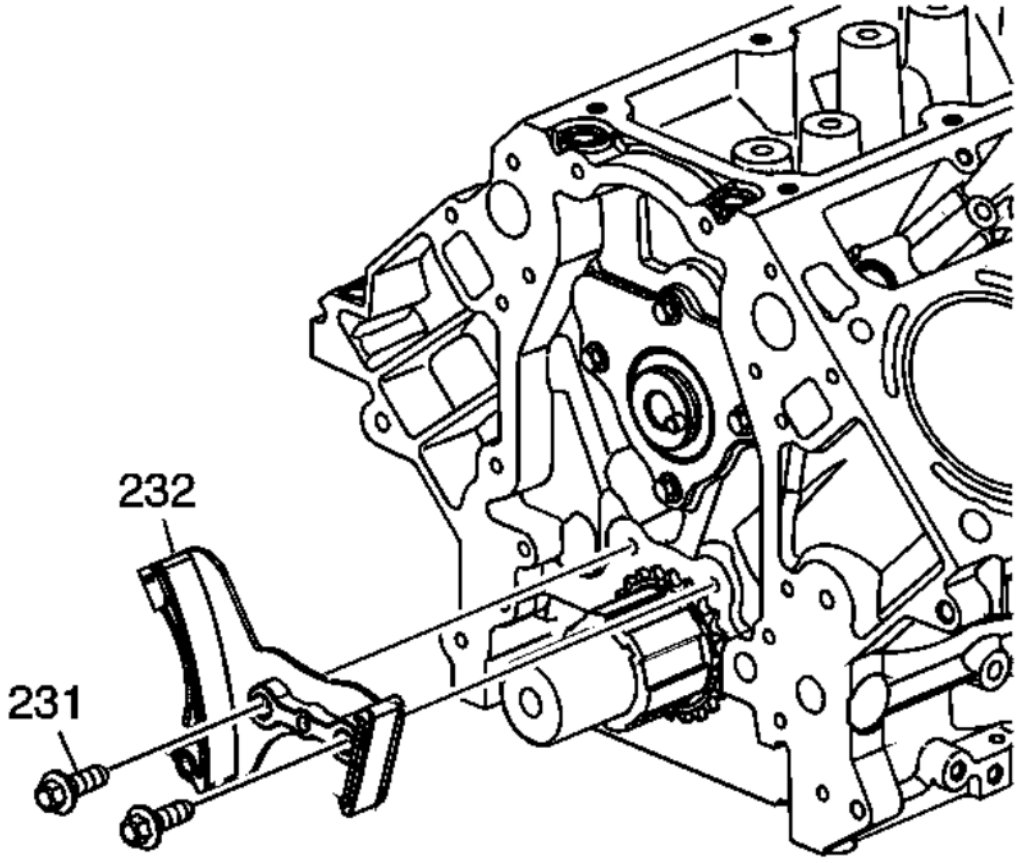

Fig. 363: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolts (231) and timing chain tensioner (232).

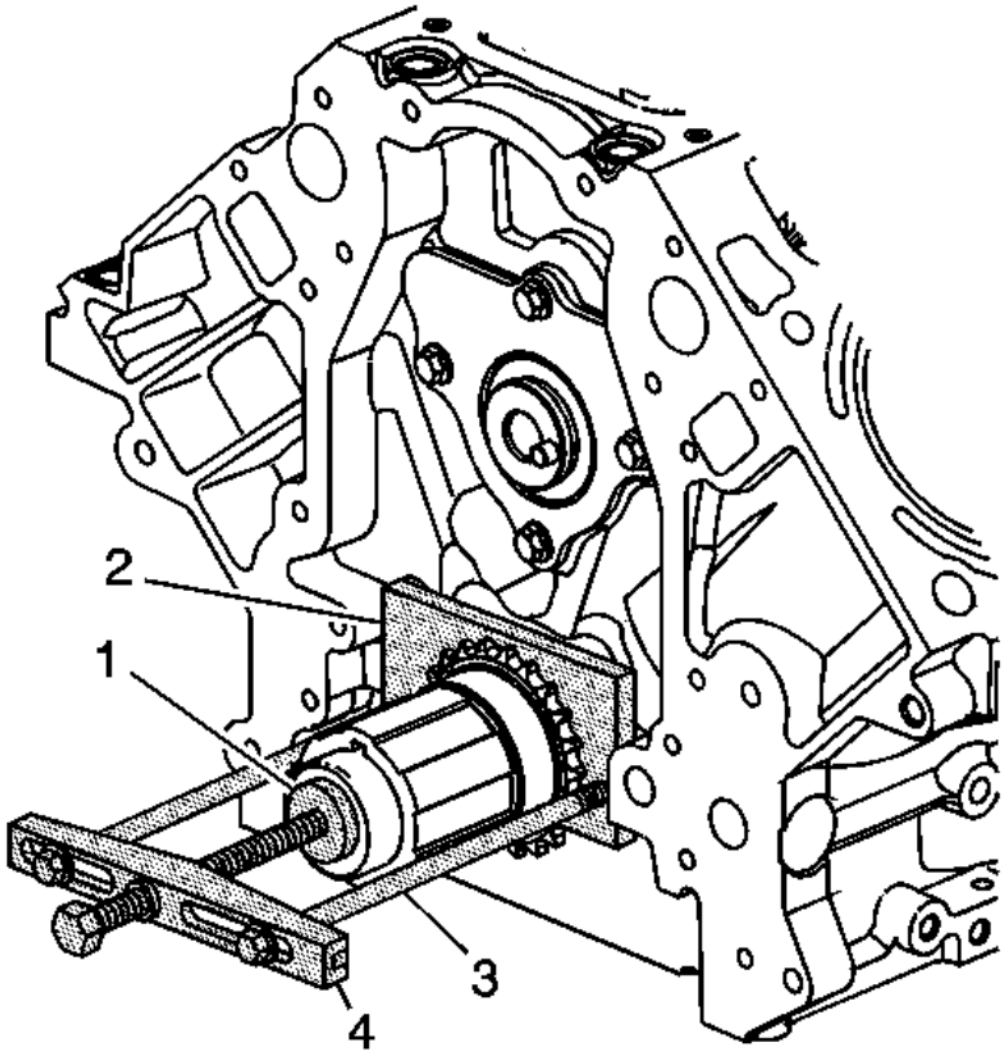

Fig. 364: View Of Crankshaft Sprocket Special Tools
Courtesy of GENERAL MOTORS CORP.

9. Use the **J 41816-2** (1), the **J 41558** (2), bolts (3), and the **J 8433** (4) in order to remove the crankshaft sprocket. See **Special Tools**.

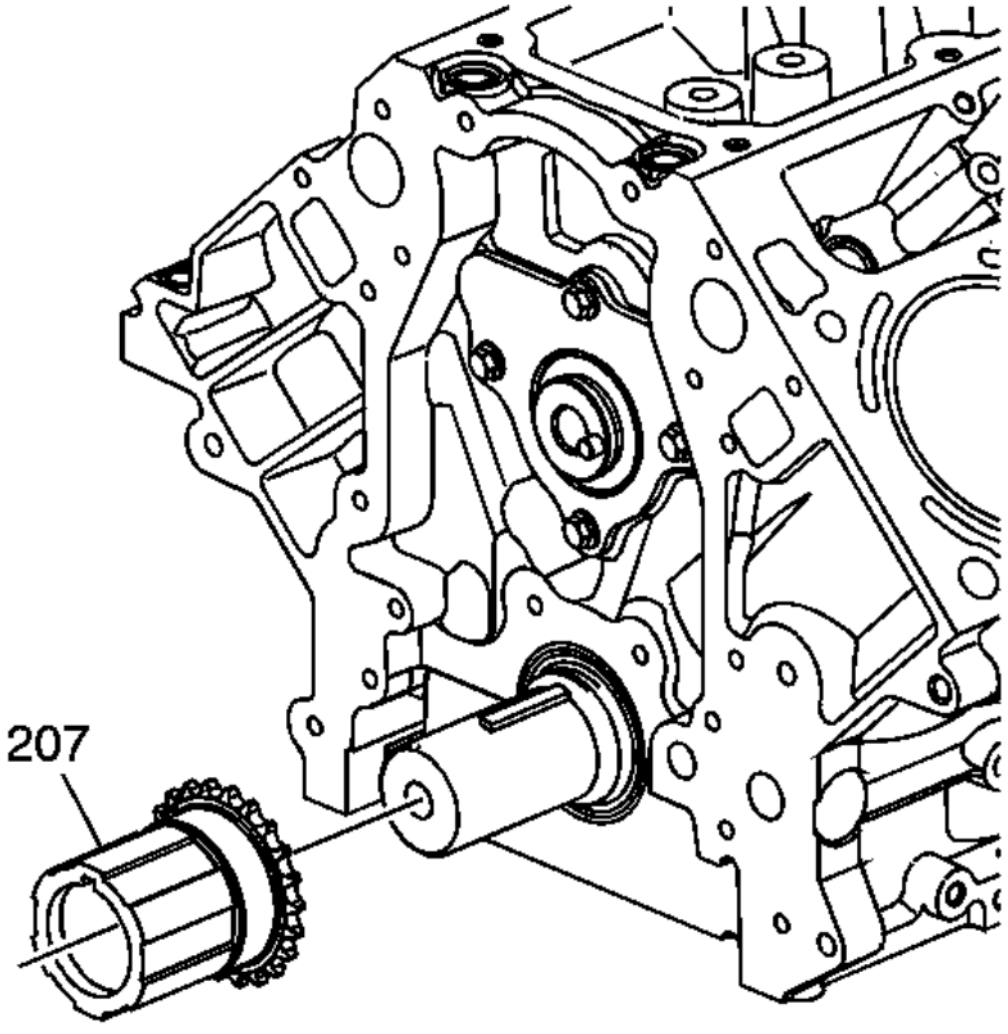

Fig. 365: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft sprocket (207).

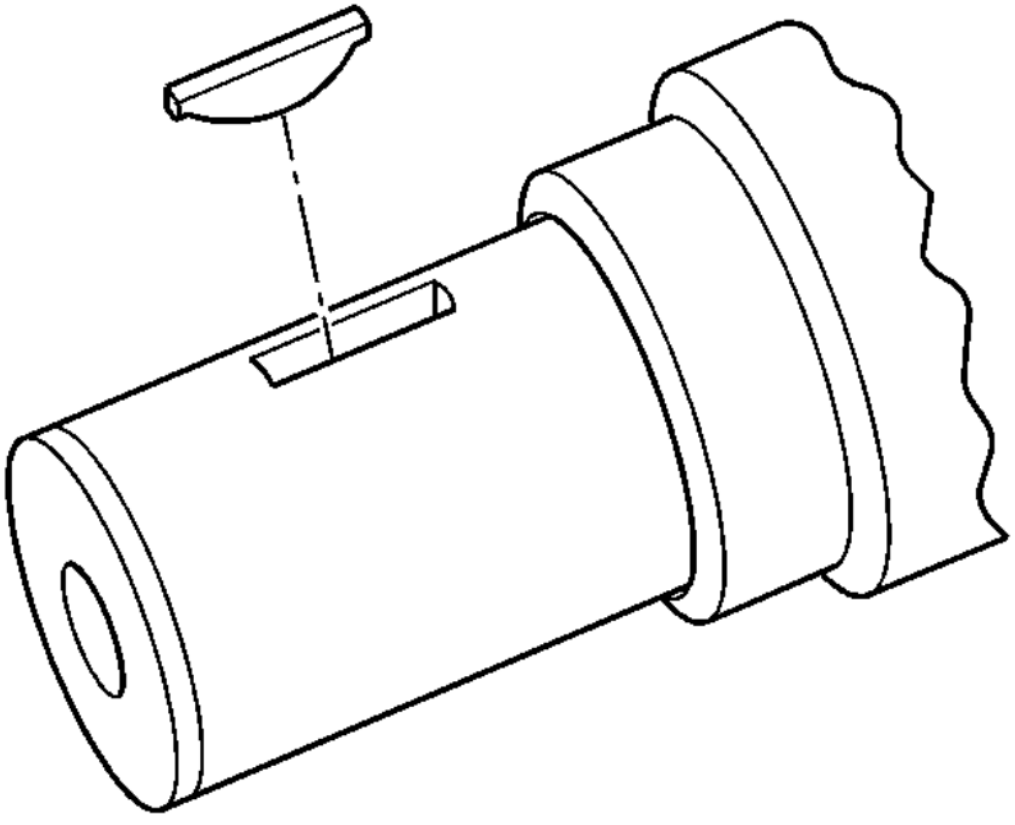

Fig. 366: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft sprocket key, as required.
12. Remove the flex plate and bolts. Refer to **Automatic Transmission Flex Plate Removal**.
13. Remove the **J 42386-A** and bolts. See **Special Tools**.

CAMSHAFT REMOVAL

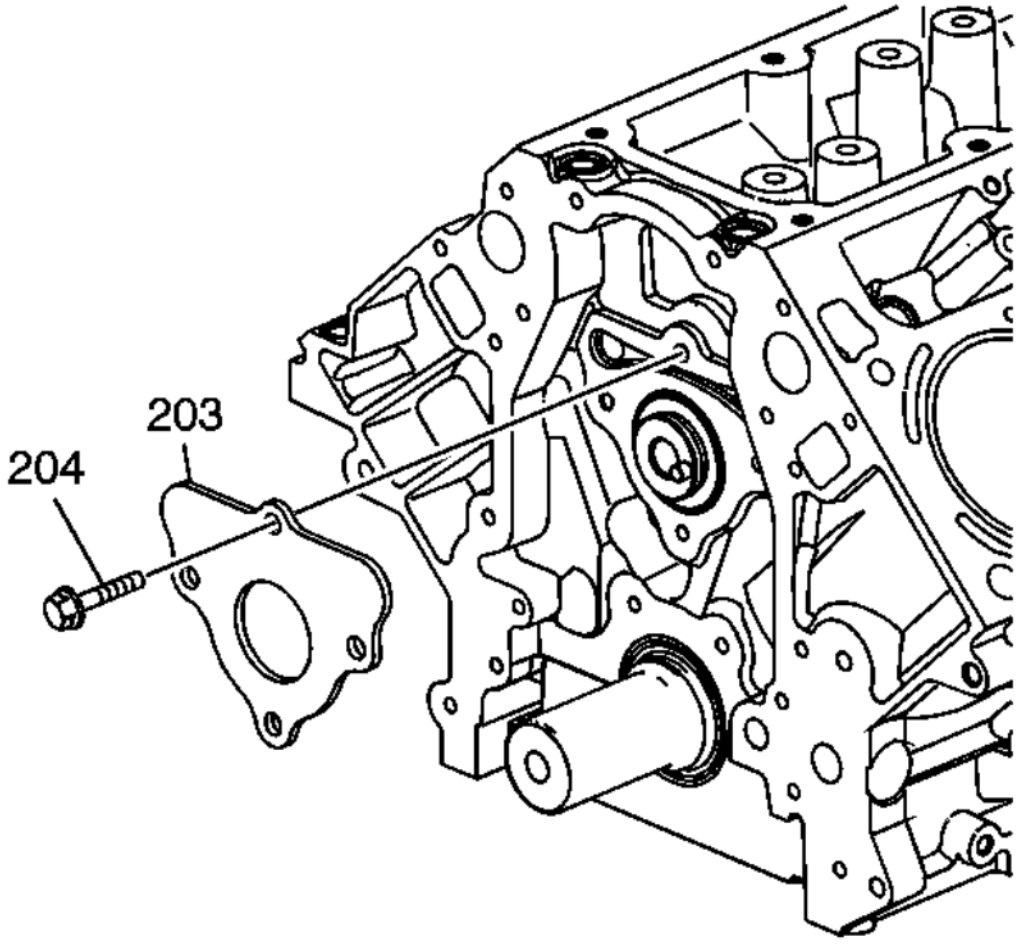

Fig. 367: Camshaft Retainer And Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts (204) and retainer (203).

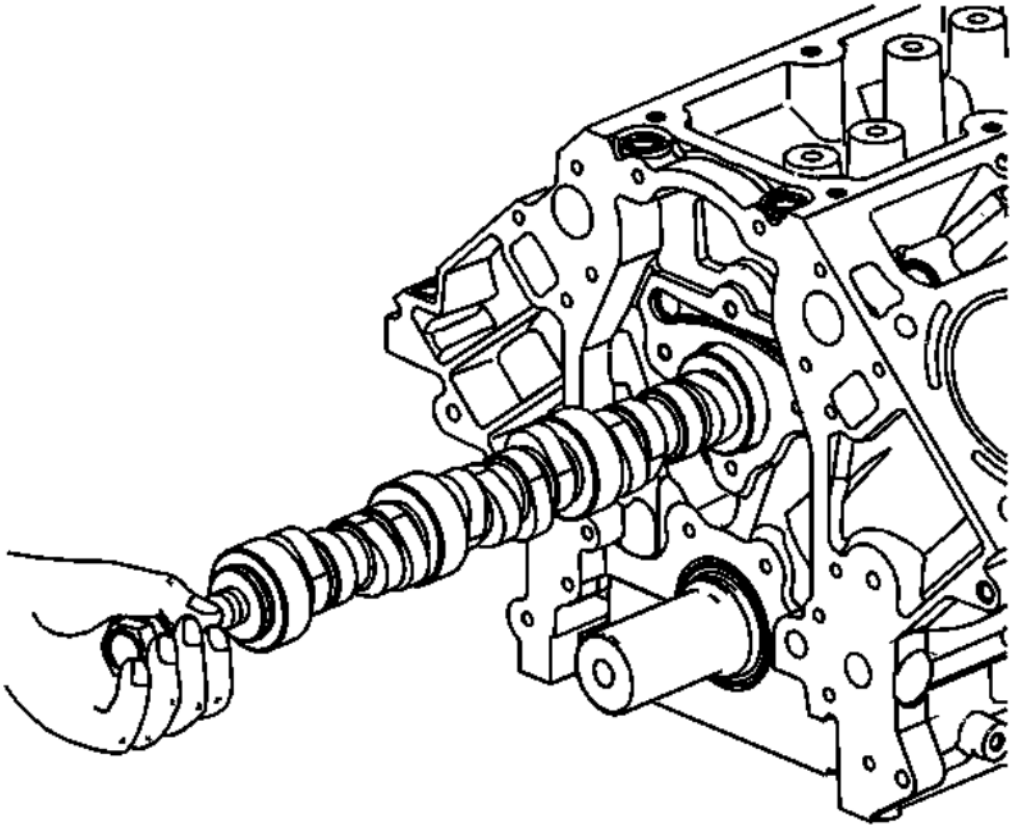

Fig. 368: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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 camshaft sprocket bolt into the camshaft front bolt hole.
    2. Using the bolt as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the bolt 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. See **Special Tools**.

Removal

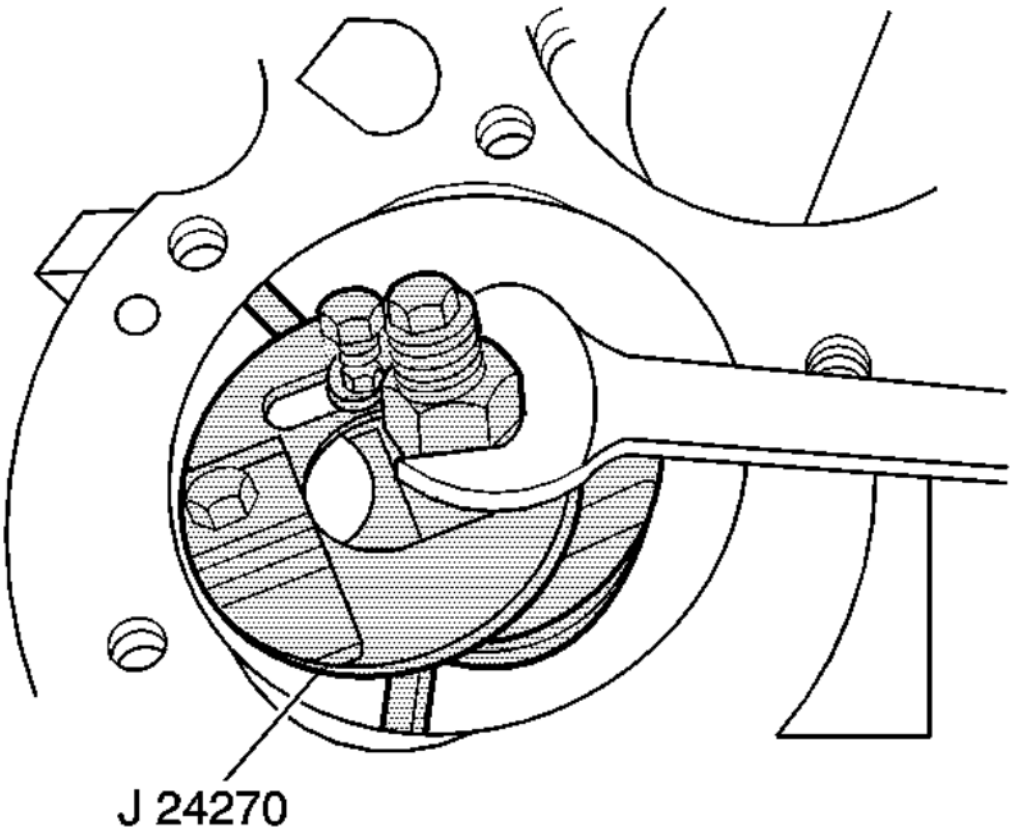

Fig. 369: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

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.

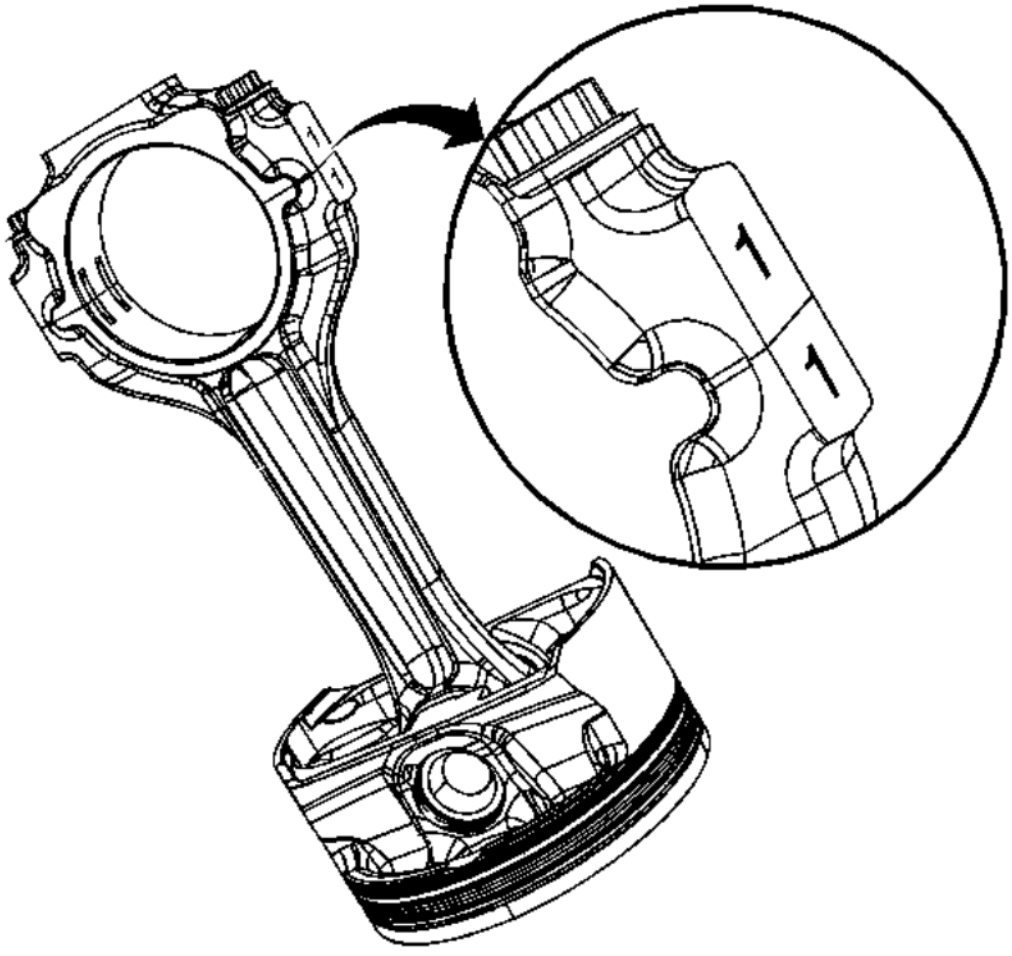

Fig. 370: Matchmarks On Connecting Rods & Caps
Courtesy of GENERAL MOTORS CORP.

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.

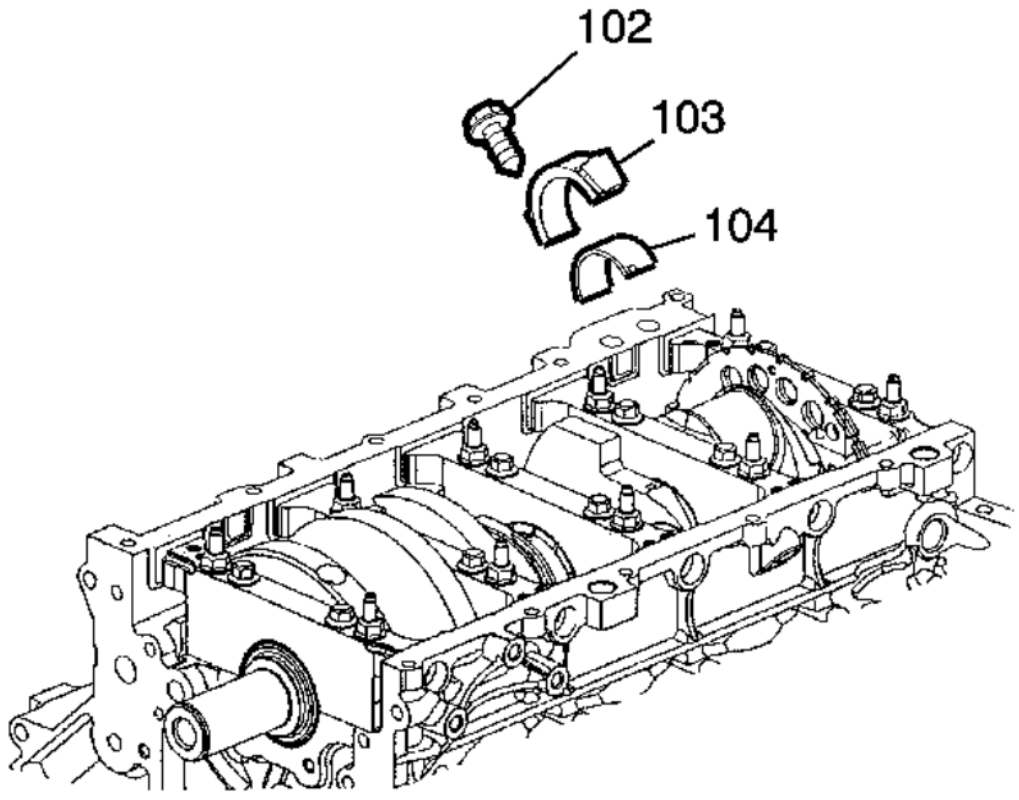

Fig. 371: Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

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 bolts (102), cap (103) and bearing (104).

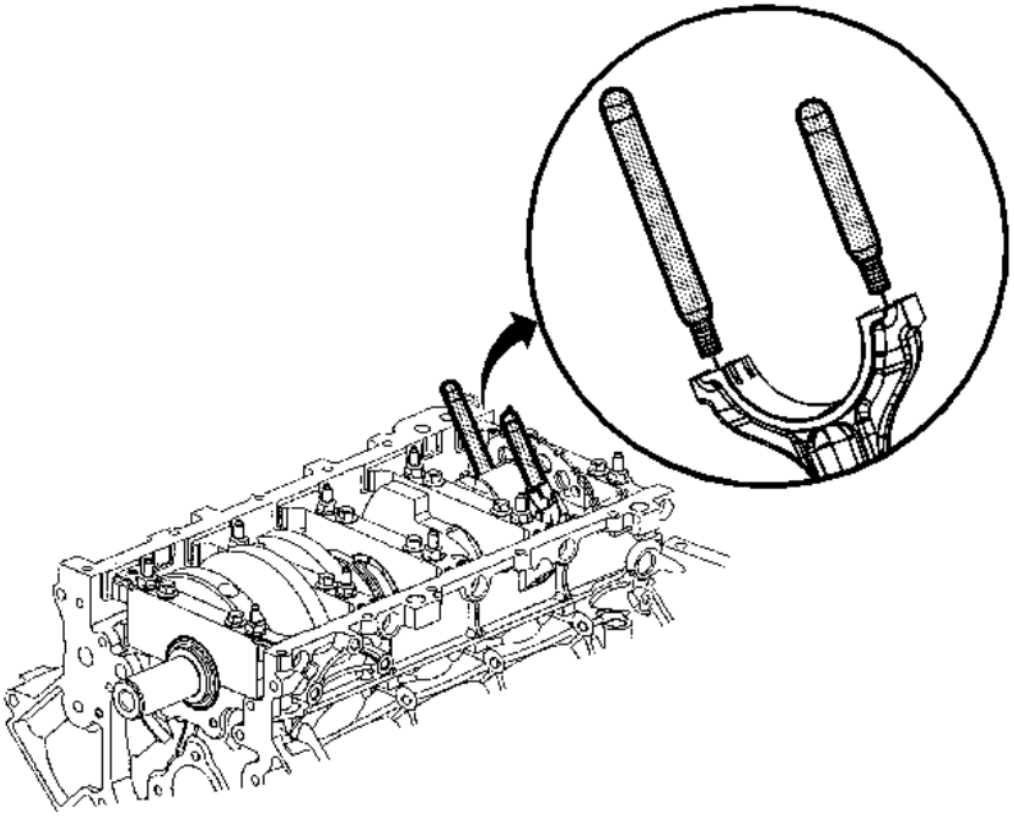

Fig. 372: Installing J 41556 To Connecting Rod
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod. See **Special Tools**.

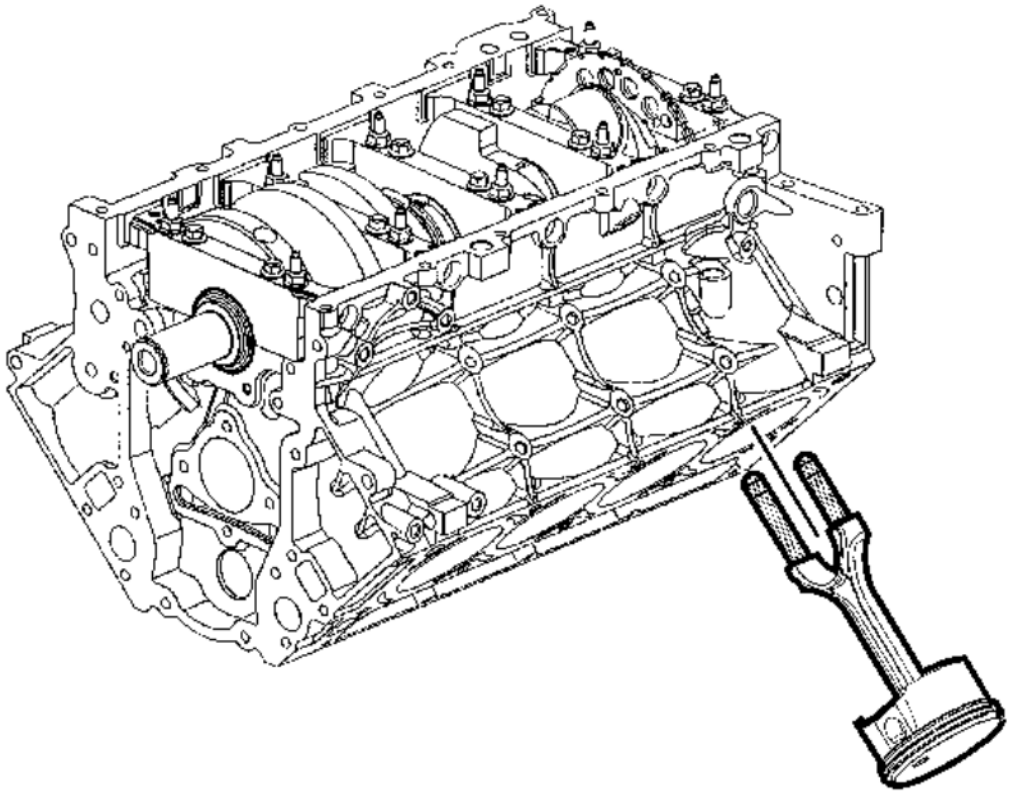

Fig. 373: Piston, Connecting Rod & Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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. See **Special Tools**.
6. Remove the **J 41556** . See **Special Tools**.

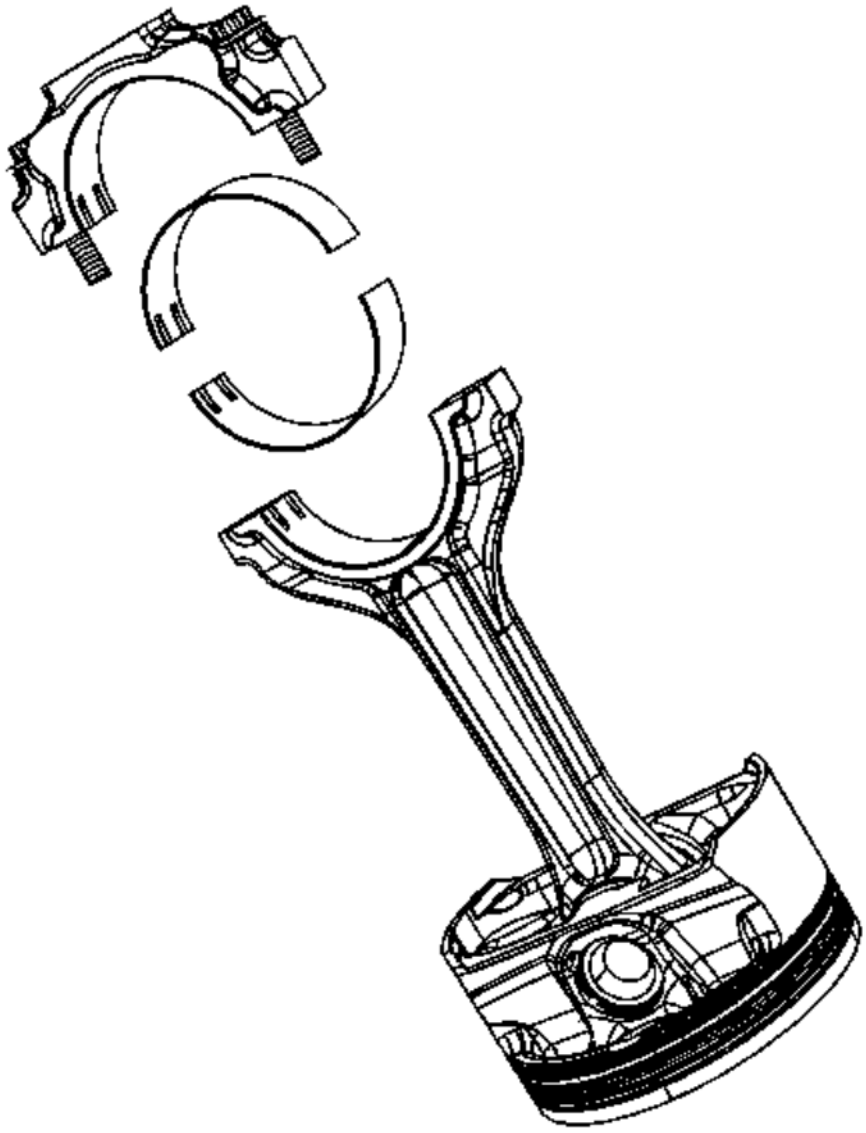

Fig. 374: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

7. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

CRANKSHAFT AND BEARING REMOVAL

Tools Required

- **J 6125-1B** Slide Hammer
- **J 41818** Crankshaft Bearing Cap Remover. See **Special Tools**.

Removal

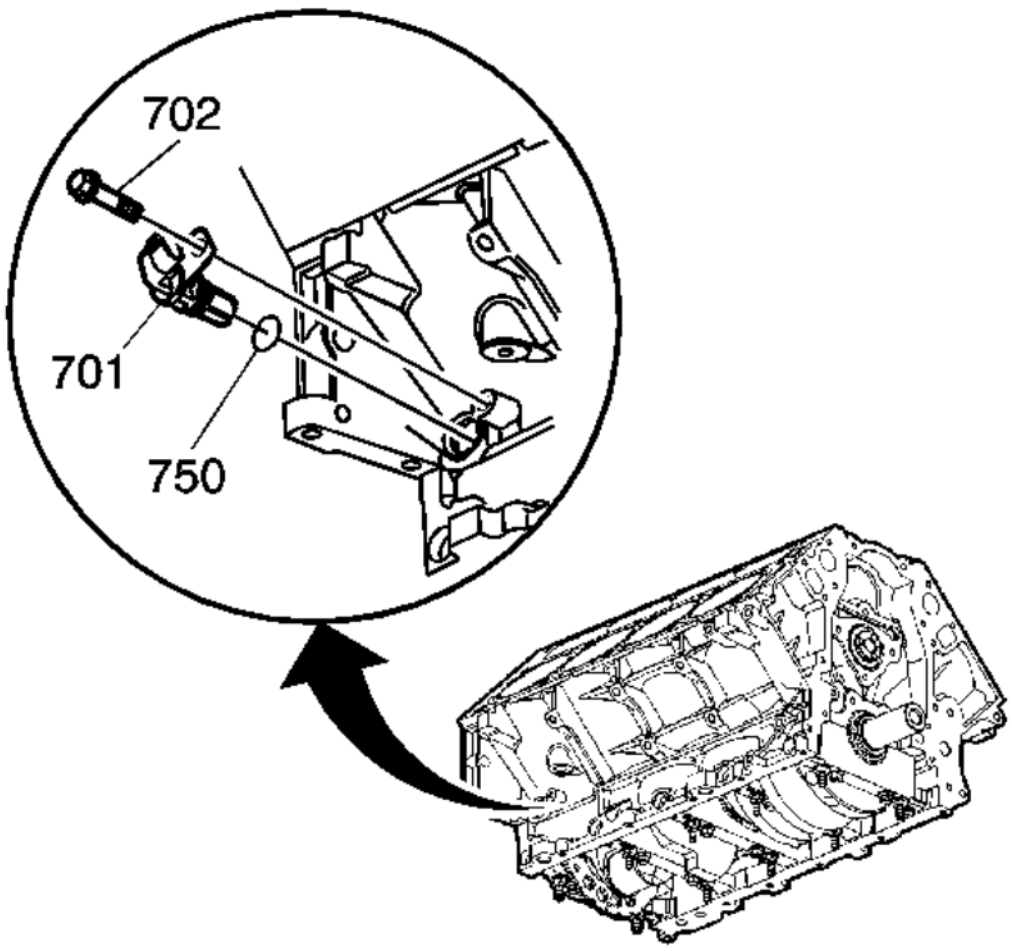

Fig. 375: CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

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).
2. Remove the CKP sensor (701).
3. Remove the O-ring (750) from the sensor, as required.

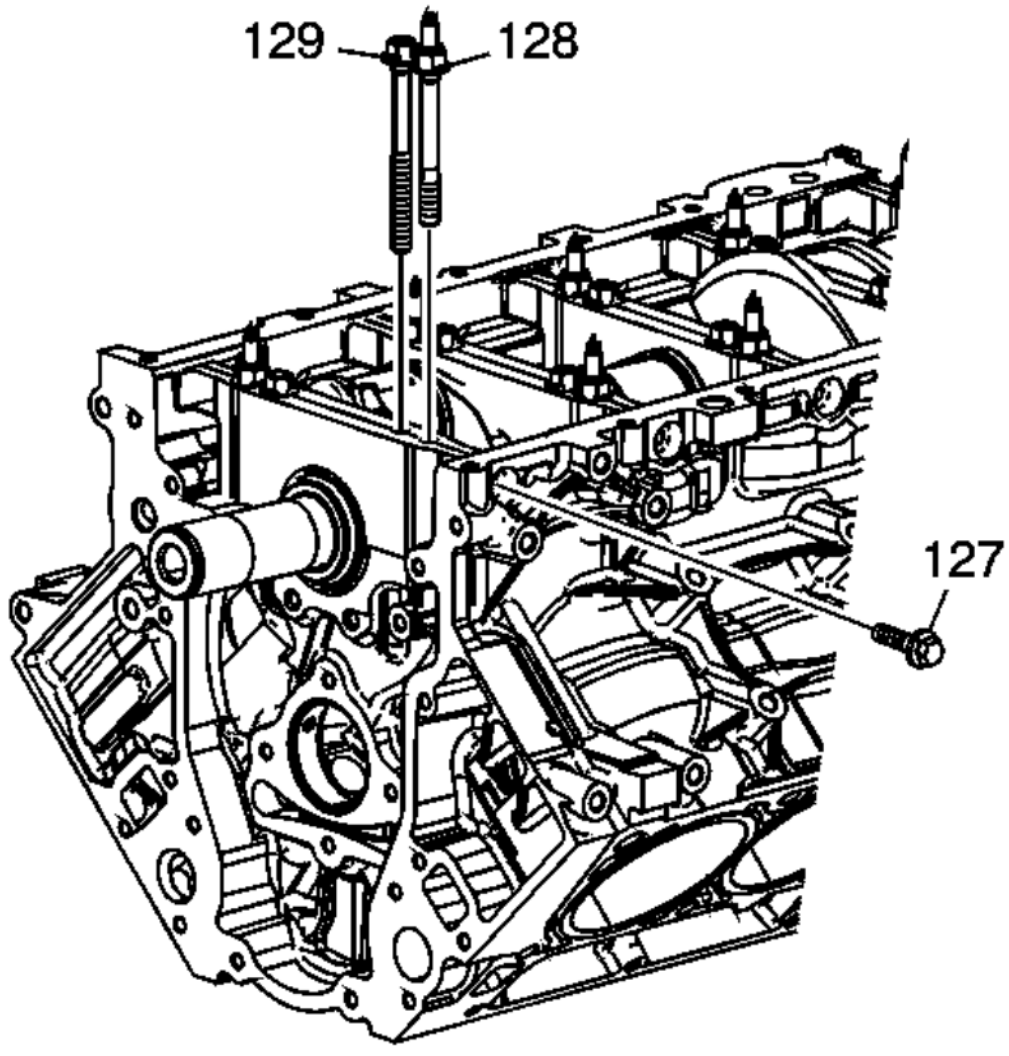

Fig. 376: Identifying Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft bearing cap M8 bolts (127).
5. Remove the bearing cap M10 bolts (129) and studs (128).

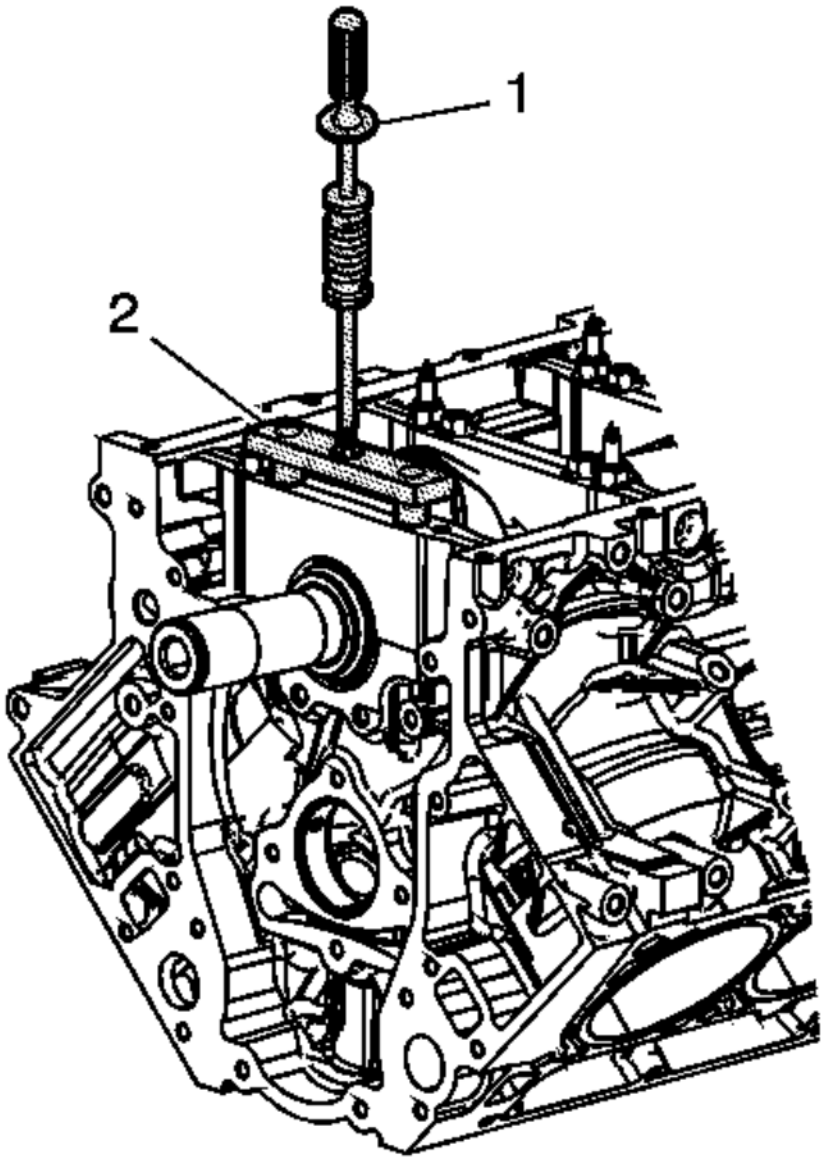

Fig. 377: Removing Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

6. Install the **J 41818** (2). See **Special Tools**.

   Tighten: Tighten the **J 41818** (2) bolts to 11 N. See **Special Tools**.m (100 lb in).

7. Install the **J 6125-1B** (1) to the **J 41818** (2) in order to remove the crankshaft bearing caps. See **Special Tools**.

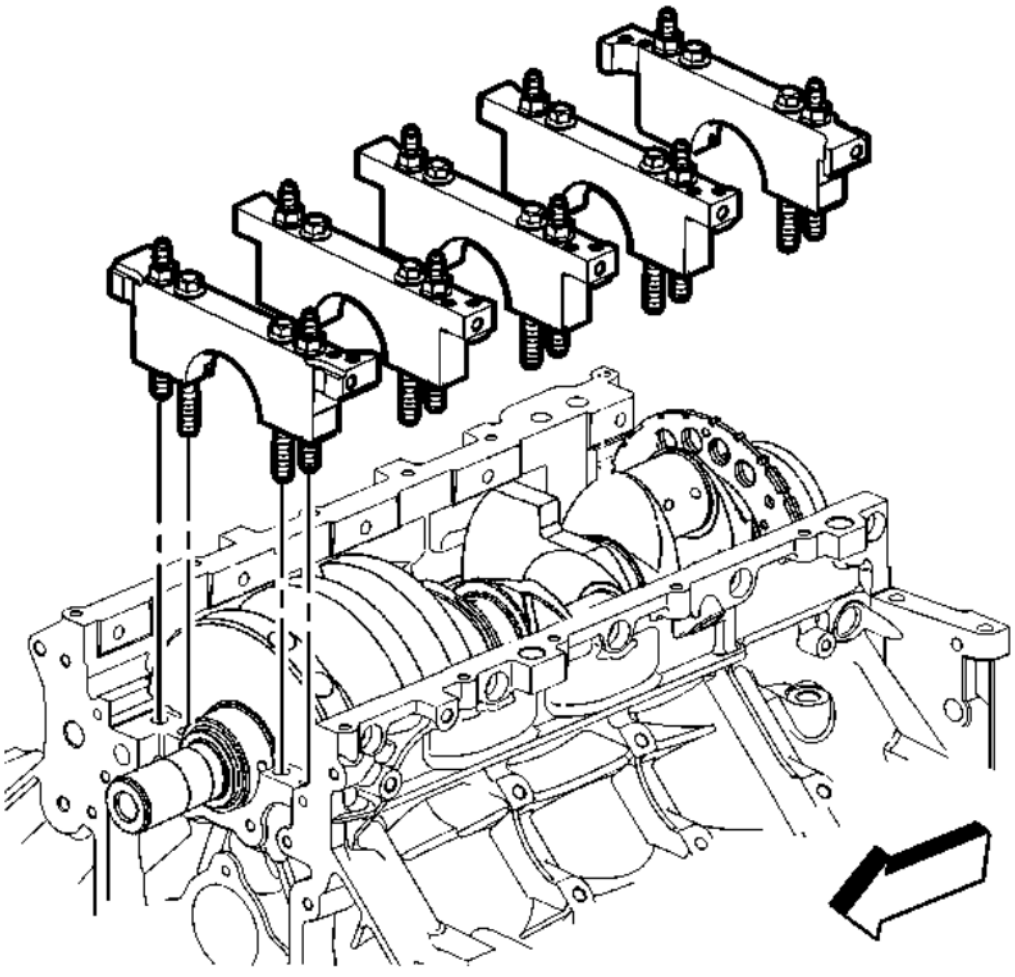

Fig. 378: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Remove the bearing caps.

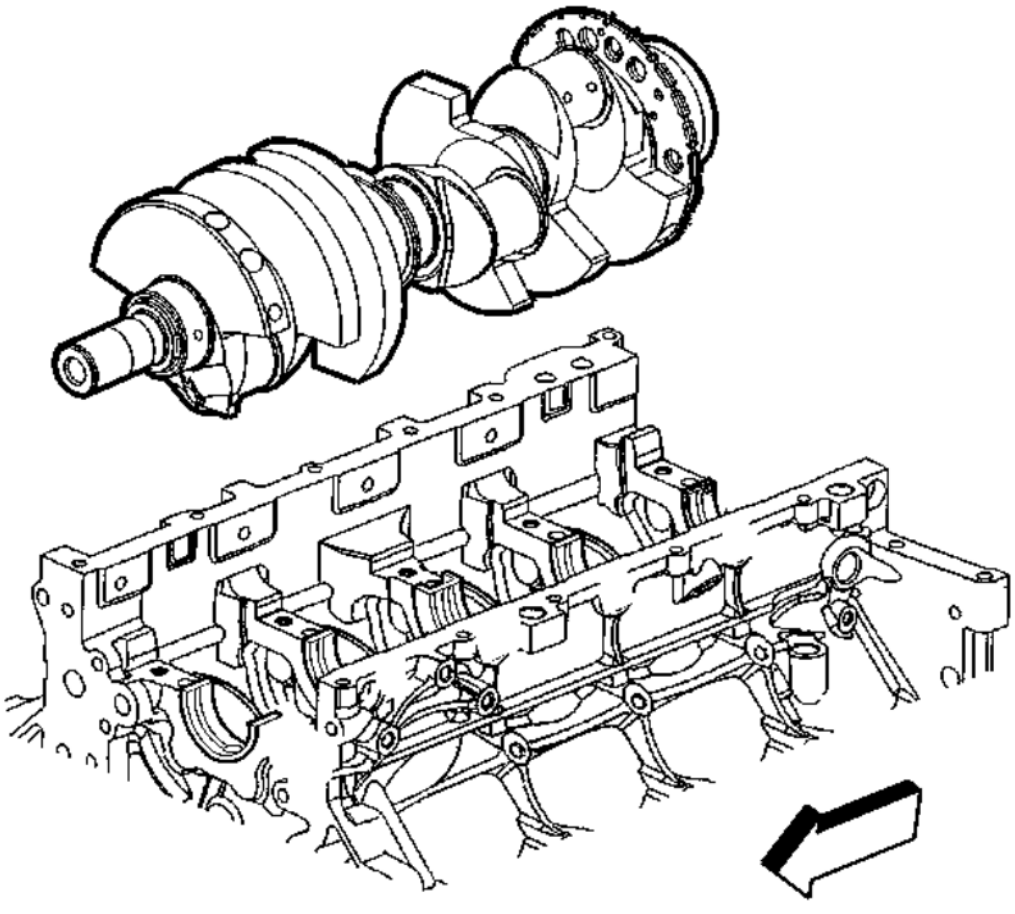

Fig. 379: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft.

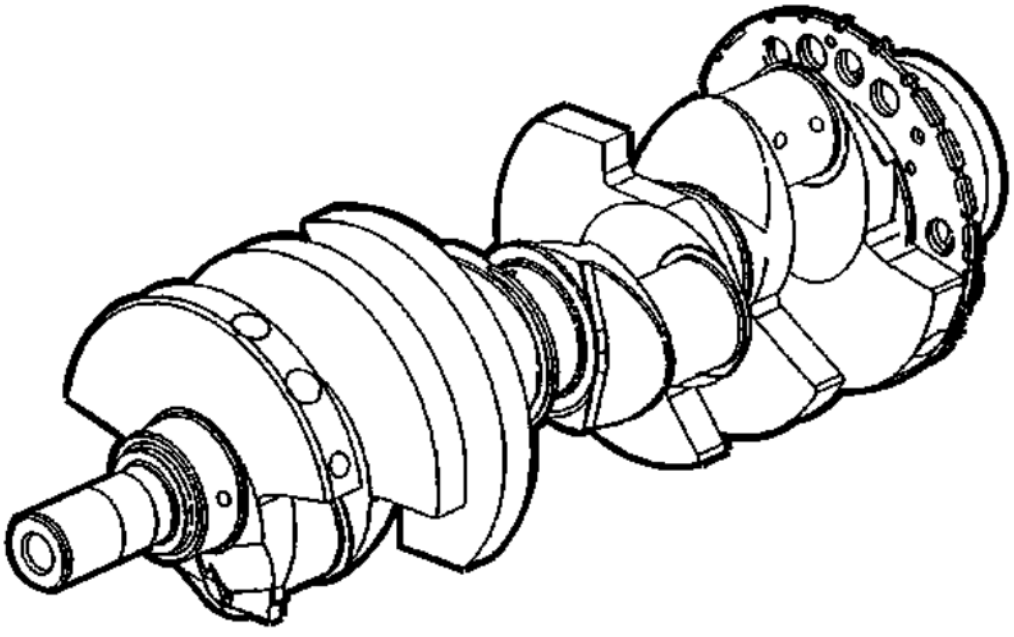

Fig. 380: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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.

10. Lay the crankshaft onto 2 wooden V-blocks or other protective surface.

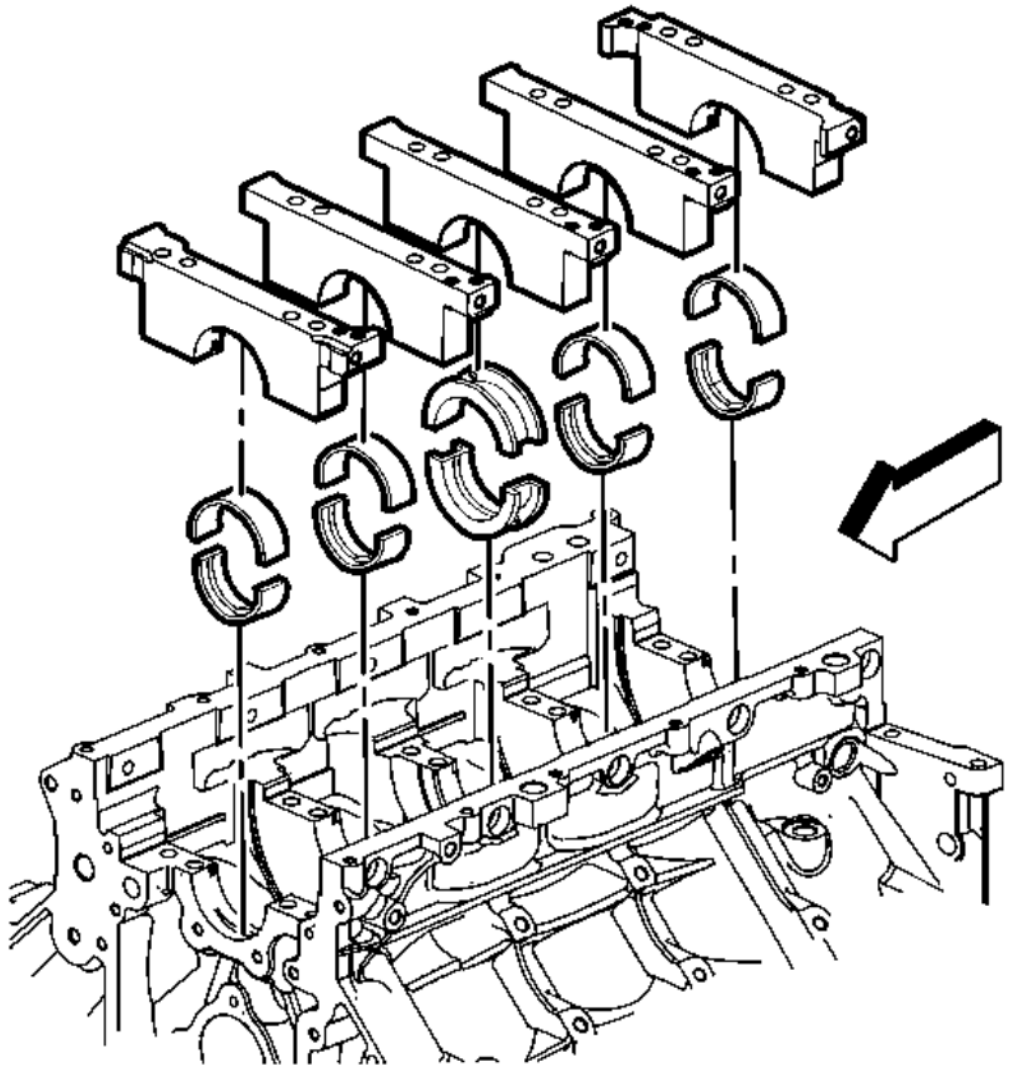

Fig. 381: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

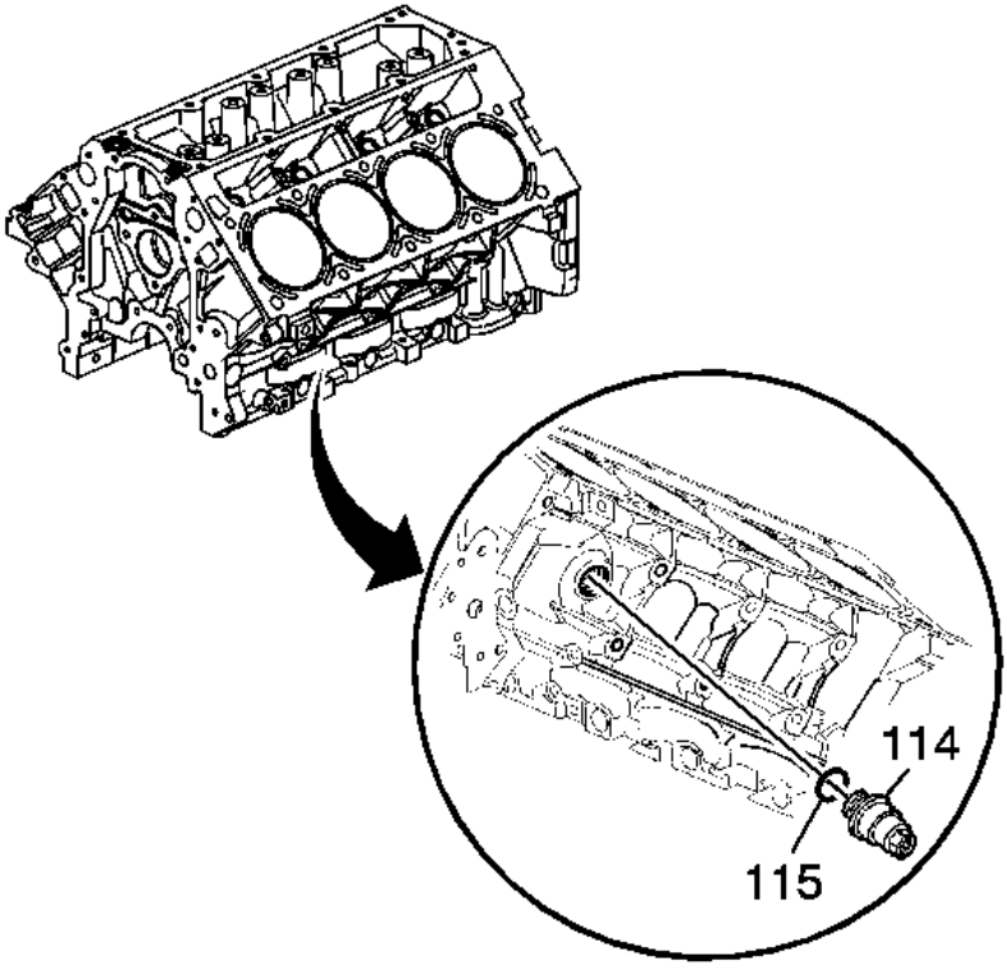

Fig. 382: Identifying Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block coolant heater (114) and seal (115).

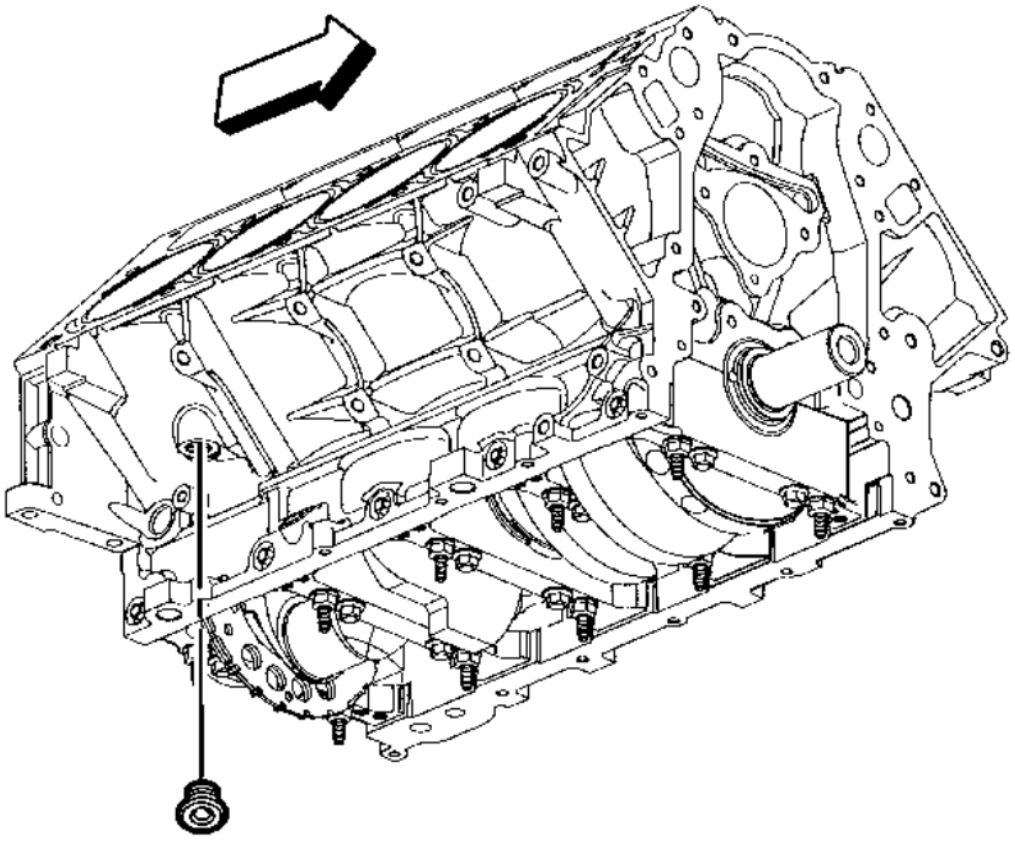

Fig. 383: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block right rear coolant drain hole plug and seal.

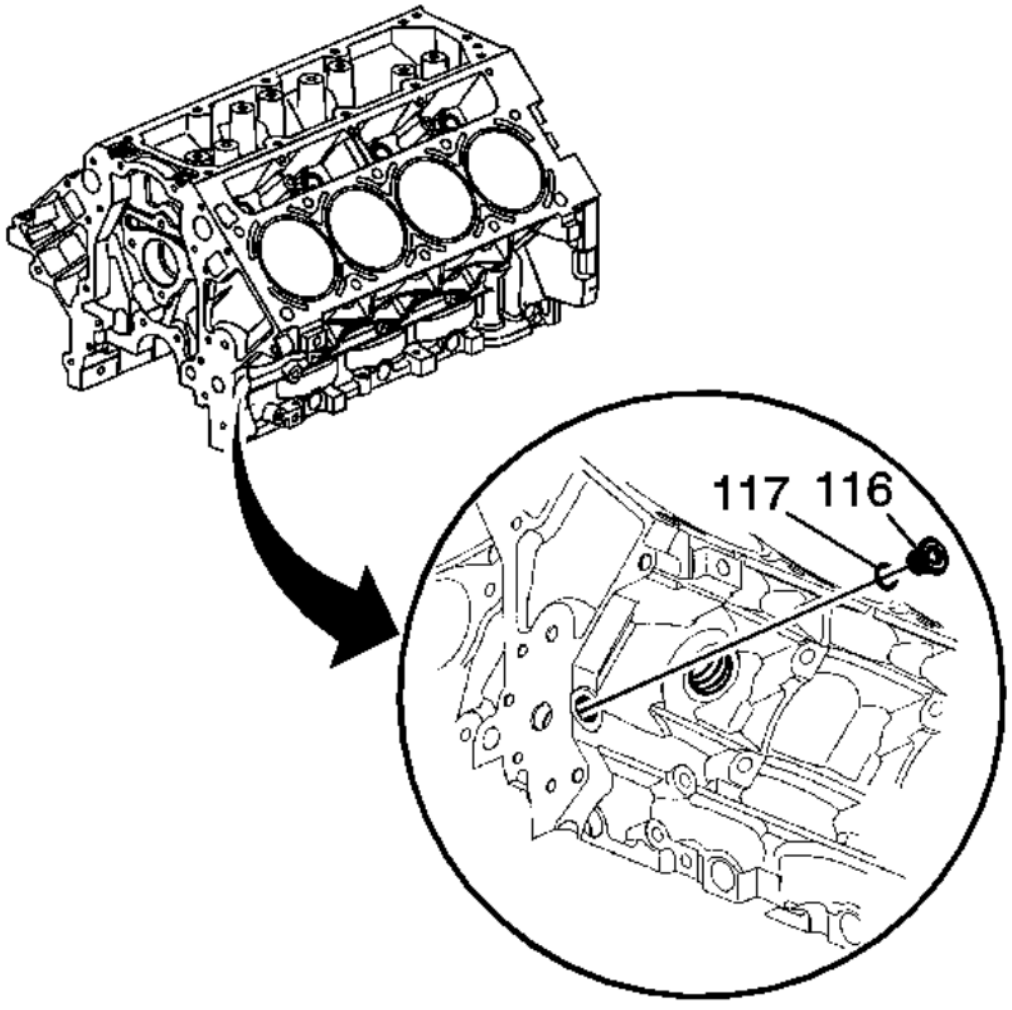

Fig. 384: Locating Engine Block Left Front Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block left front oil gallery plug (116) and seal (117).

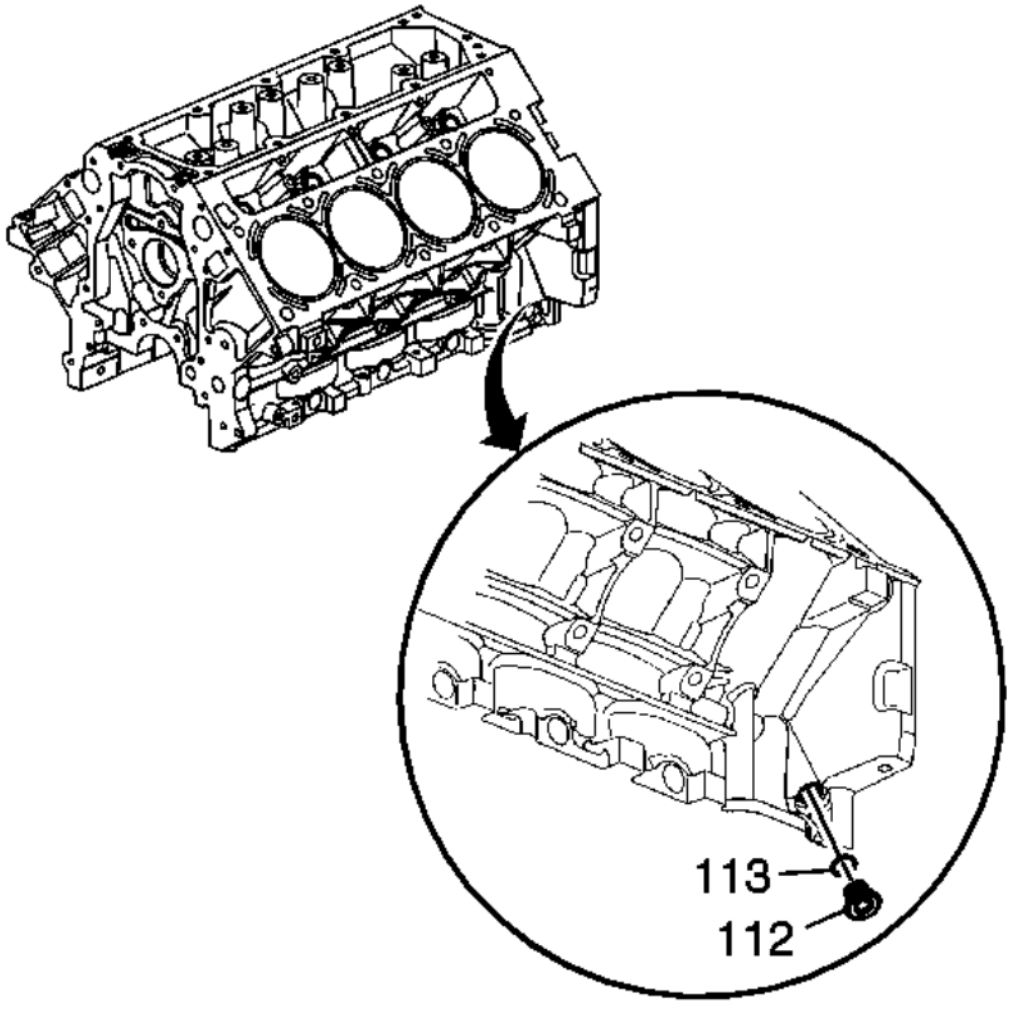

Fig. 385: Locating Engine Block Left Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine block left rear oil gallery plug (112) and seal (113).

   If the block plug and coolant heater sealing washers are not damaged, they may be used during assembly.

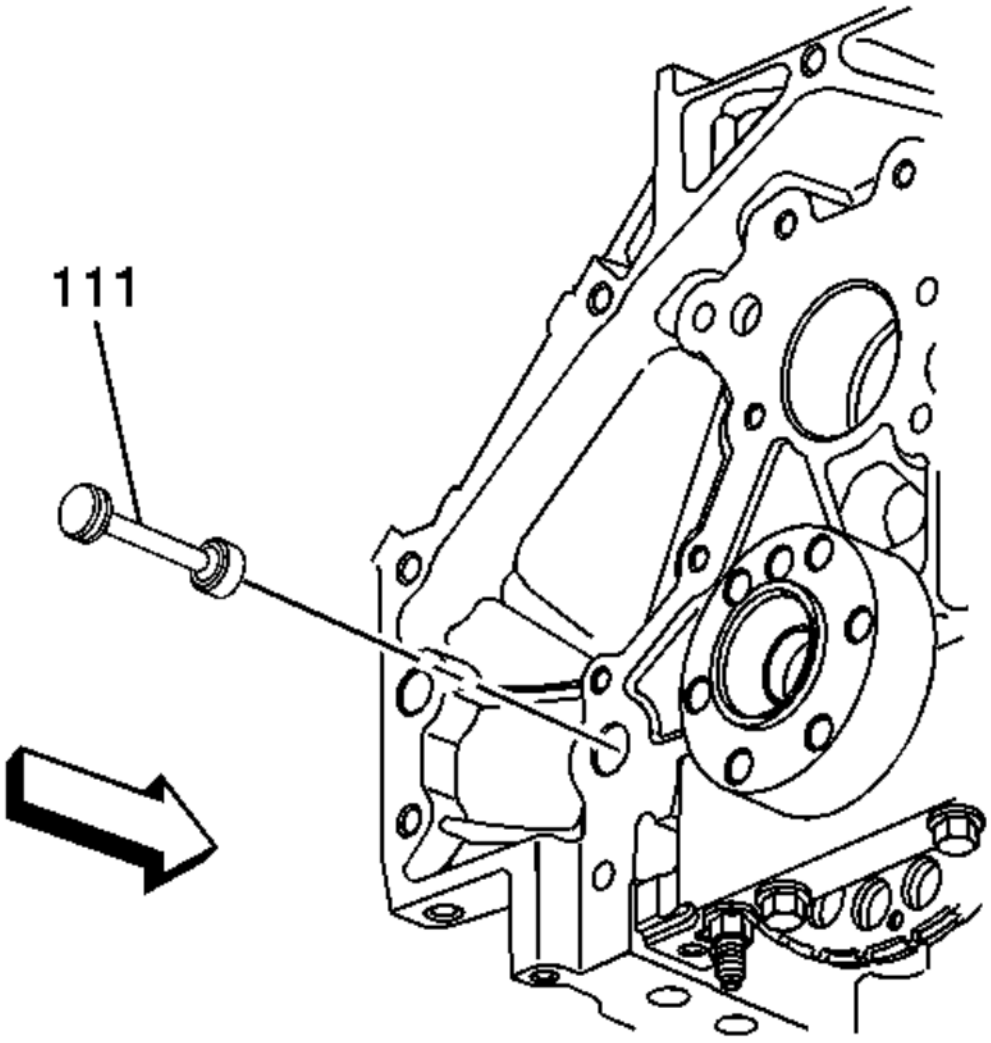

Fig. 386: Identifying Engine Block Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine block rear oil gallery plug (111) and seal.
6. 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.

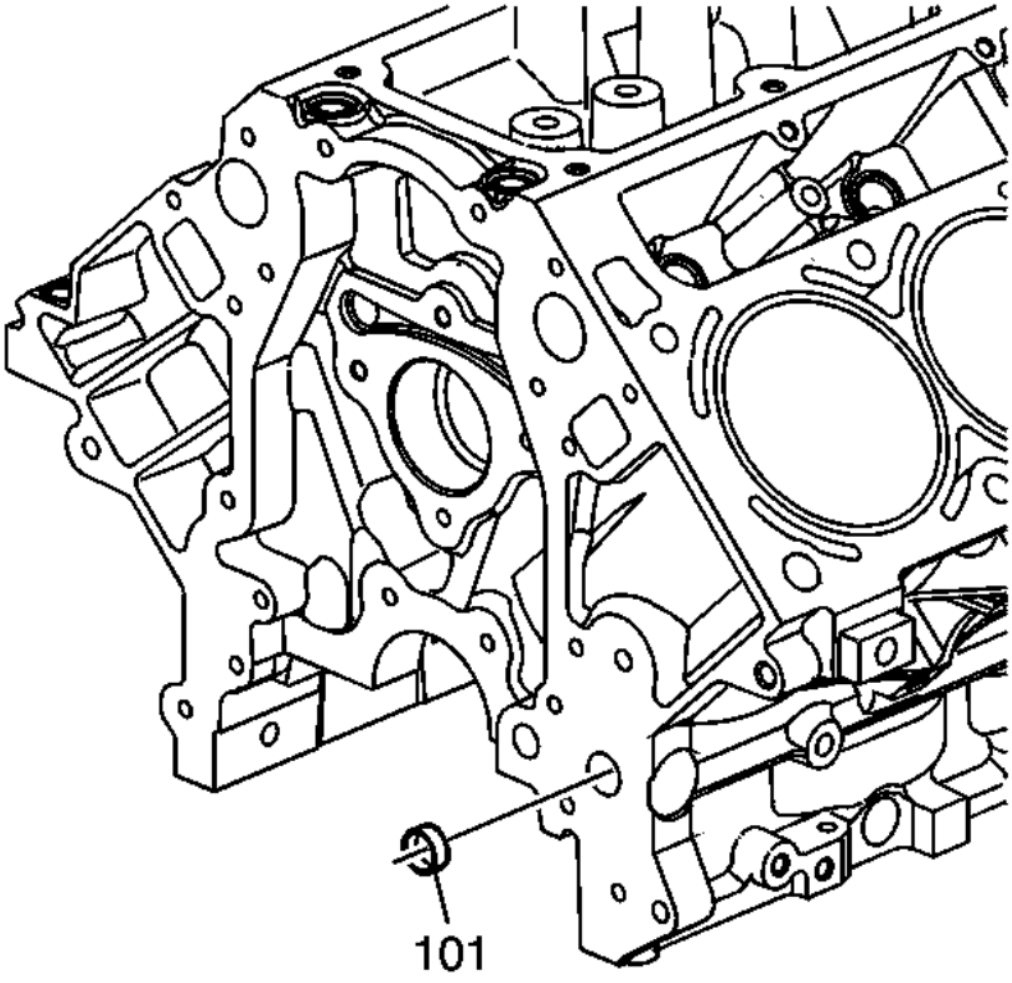

Fig. 387: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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.

7. Remove the engine block front oil gallery plug (101).

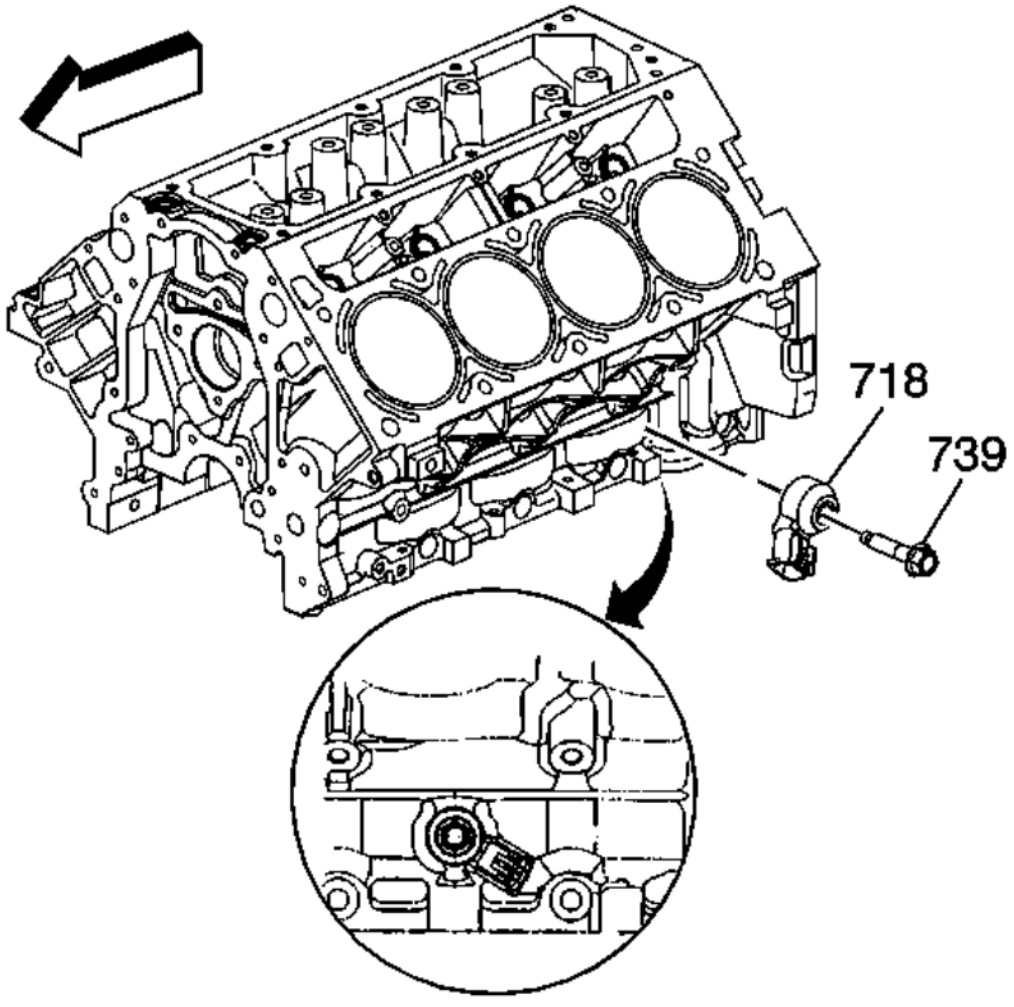

Fig. 388: Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the left side knock sensor (718) and bolt (739).

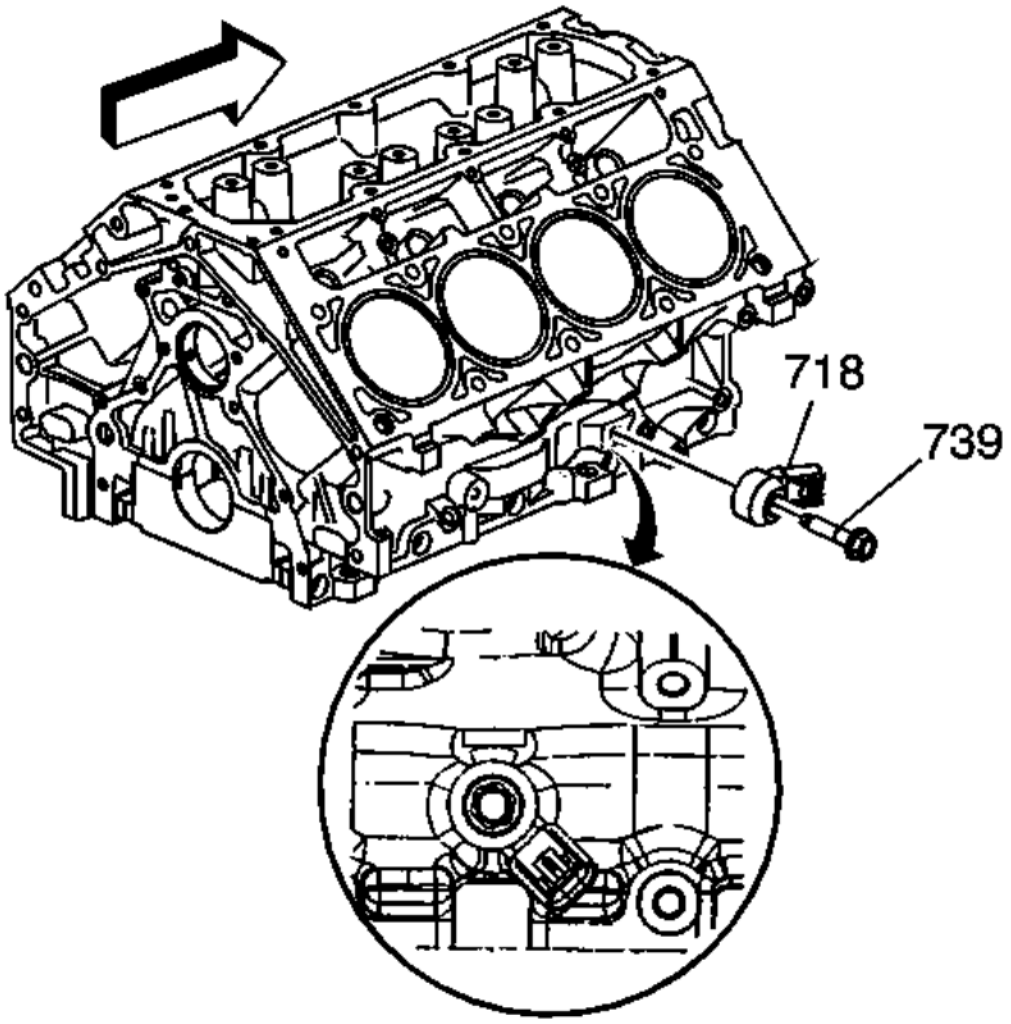

Fig. 389: Right Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the right side knock sensor (718) and bolt (739).

ENGINE BLOCK CLEANING AND INSPECTION

Tools Required

- **J 8087** Cylinder Bore Gage. See **Special Tools**.

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.

Cleaning Procedure

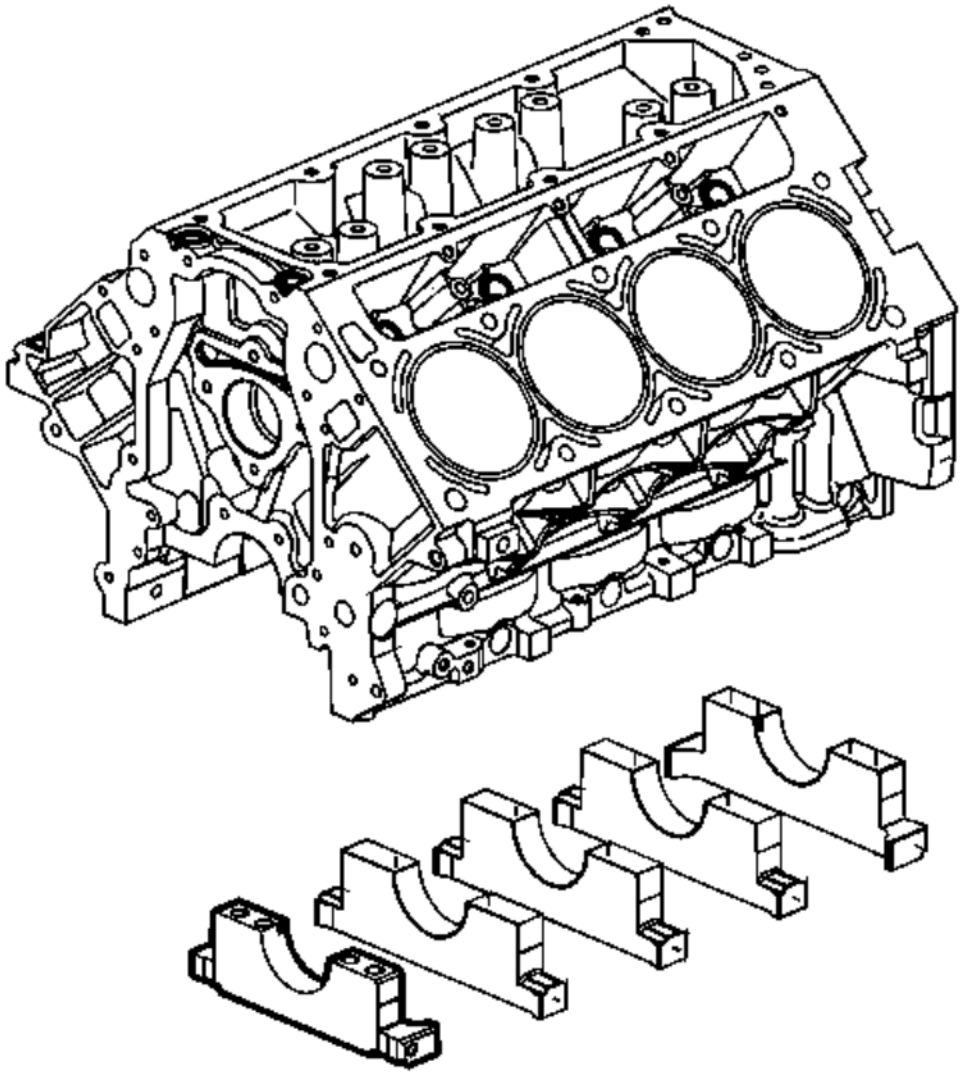

Fig. 390: Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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 232℃ (450℉).

Clean the following components:

- 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 tool J 42385-107 may be used to clean the threads of any residual threadlocking material.

Inspection Procedure

1. Inspect the following components:
   - Cylinder walls for excessive scratches, gouging, or ring ridge
   - 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
   - Cylinder bores for excessive ring ridge at the top of the cylinder
2. Measure the cylinder bores for an oversize condition:

Measuring the Cylinder for Oversize

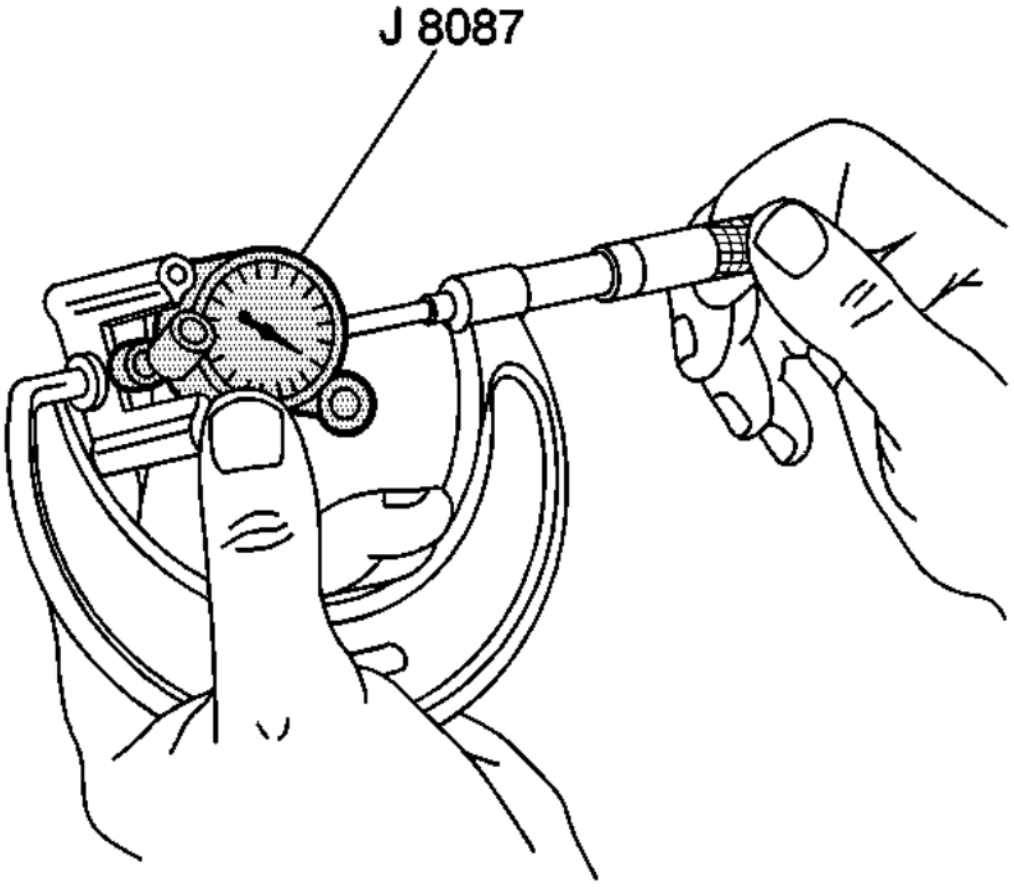

Fig. 391: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical Specifications**.
2. Insert the **J 8087** into the micrometer and zero the bore gage dial. See **Special Tools**.

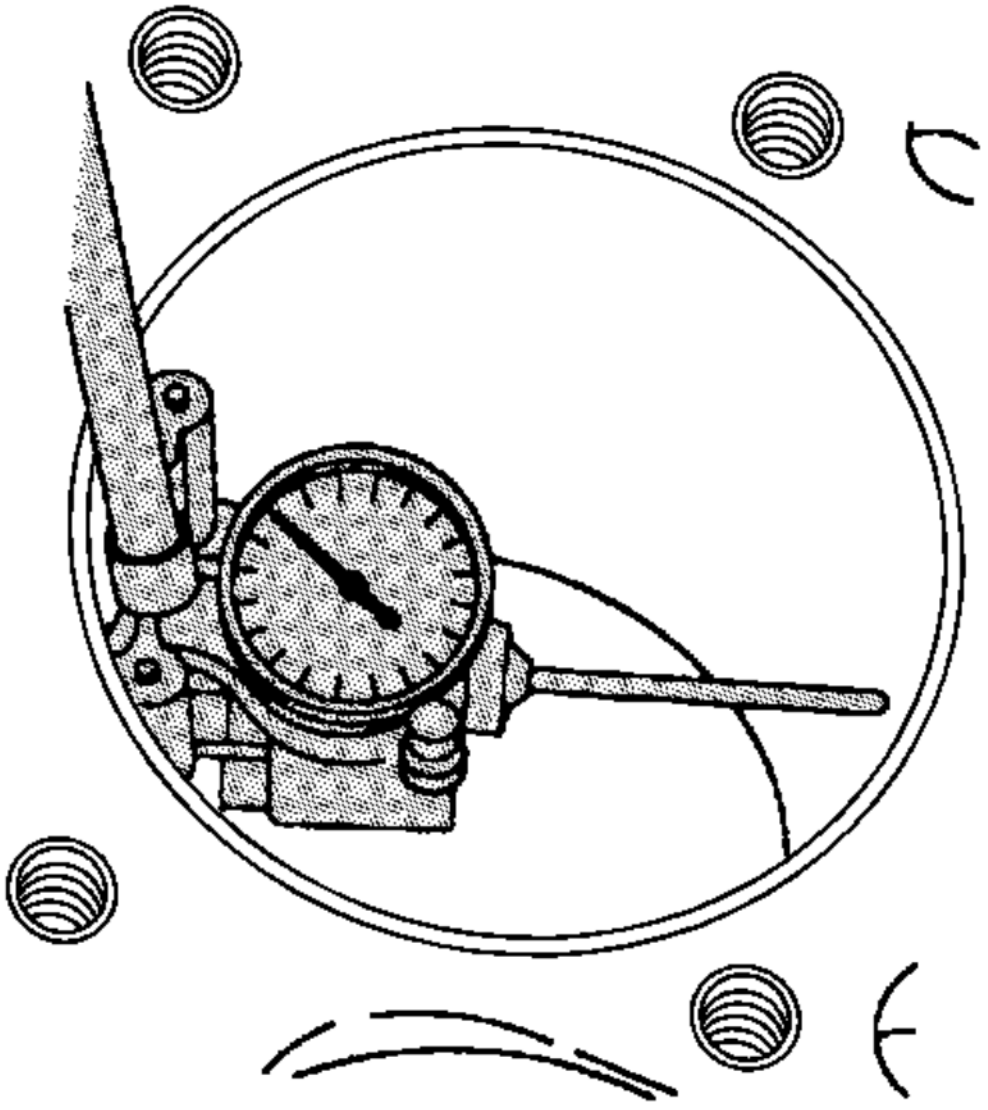

Fig. 392: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 8087** and measure the cylinder bore for oversize. See **Special Tools**.

   Slide the bore gage up and down throughout the length of the cylinder bore. Measure 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

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

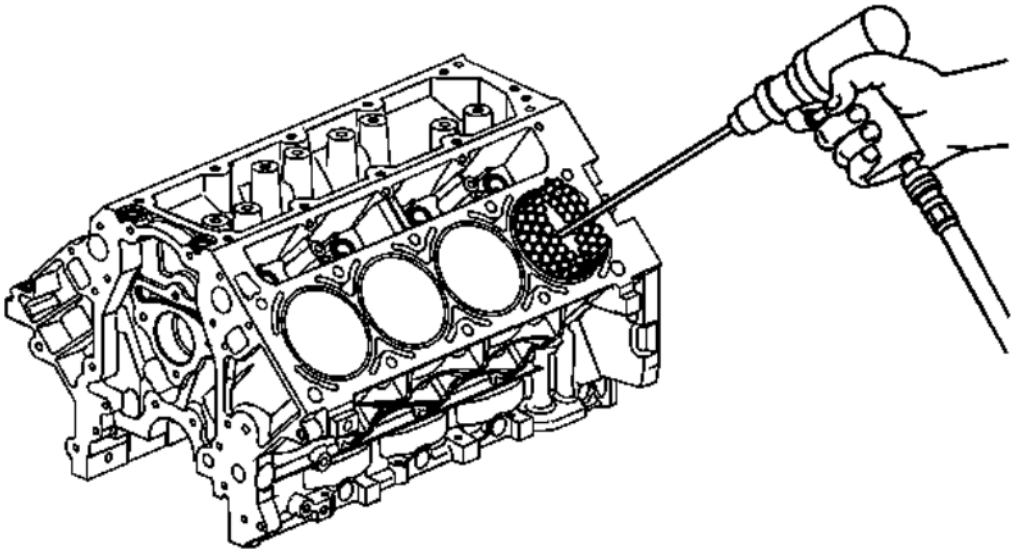

Fig. 393: View Of Honing Of Cylinders
Courtesy of GENERAL MOTORS CORP.

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 check 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.

   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

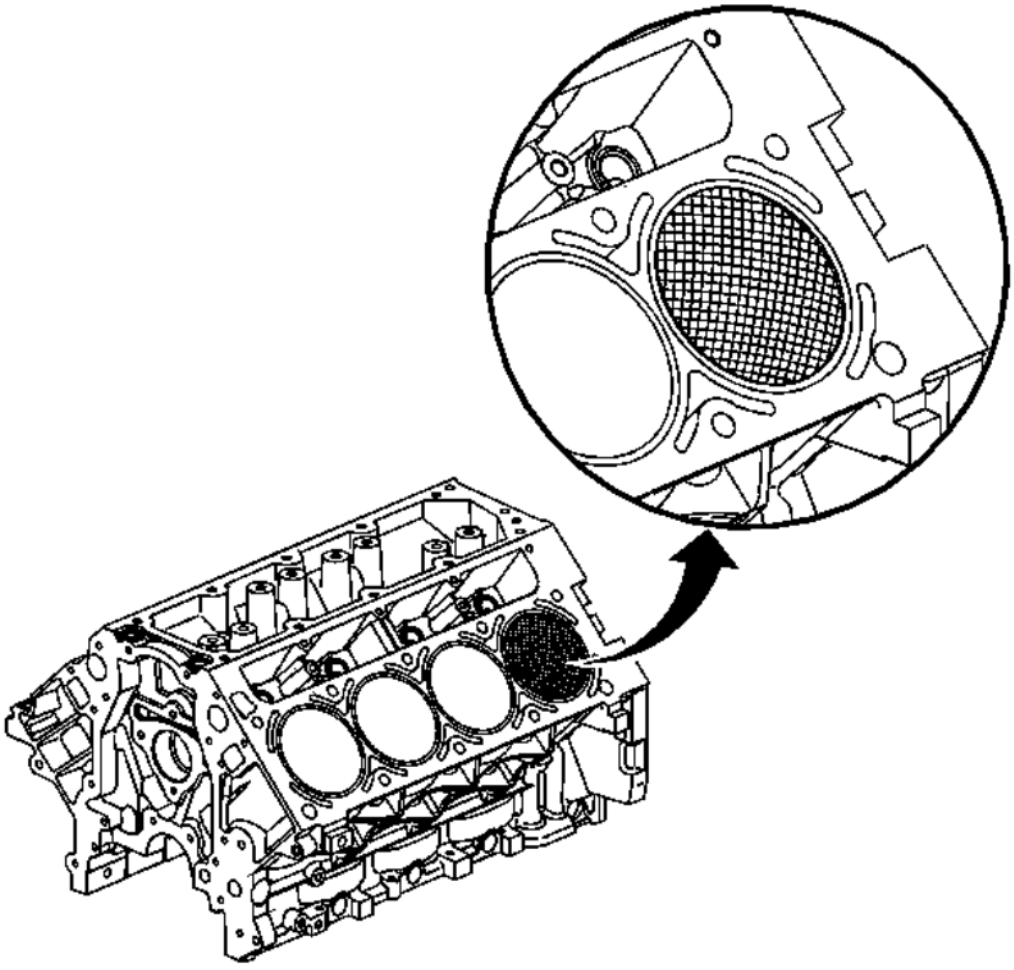

Fig. 394: Illustrating Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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 BEARING 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**.

Cleaning Procedure

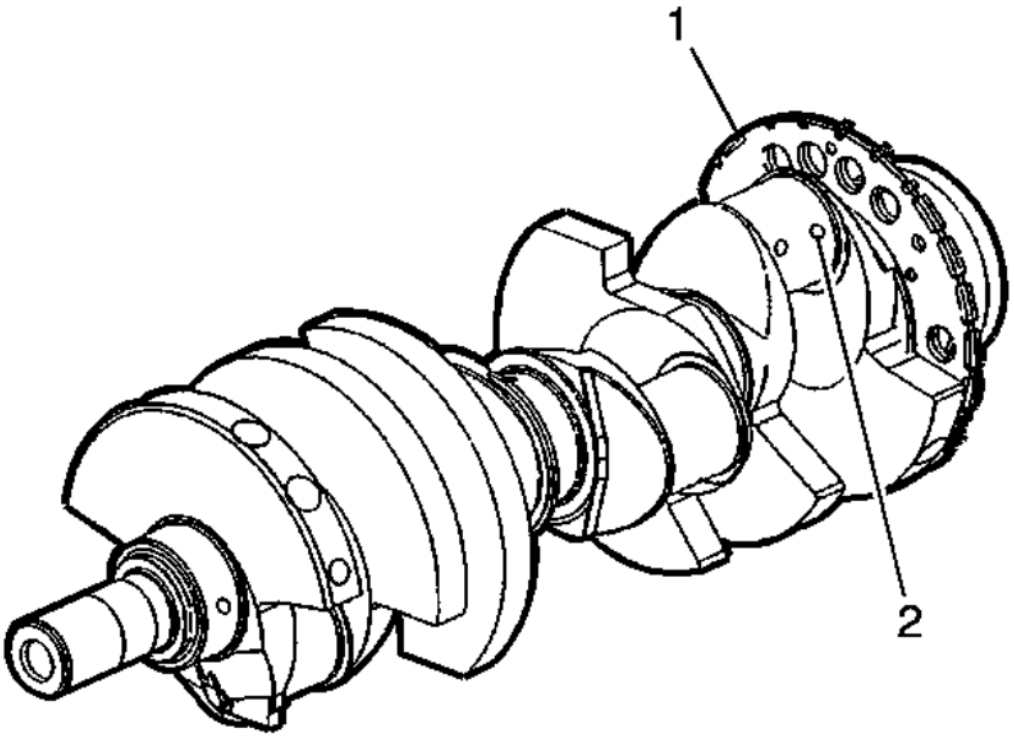

Fig. 395: Oil Passages & CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position (CKP) reluctor ring. Damage to the teeth of the CKP reluctor ring may affect 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 .

3. Dry the crankshaft with compressed air.

Inspection Procedure

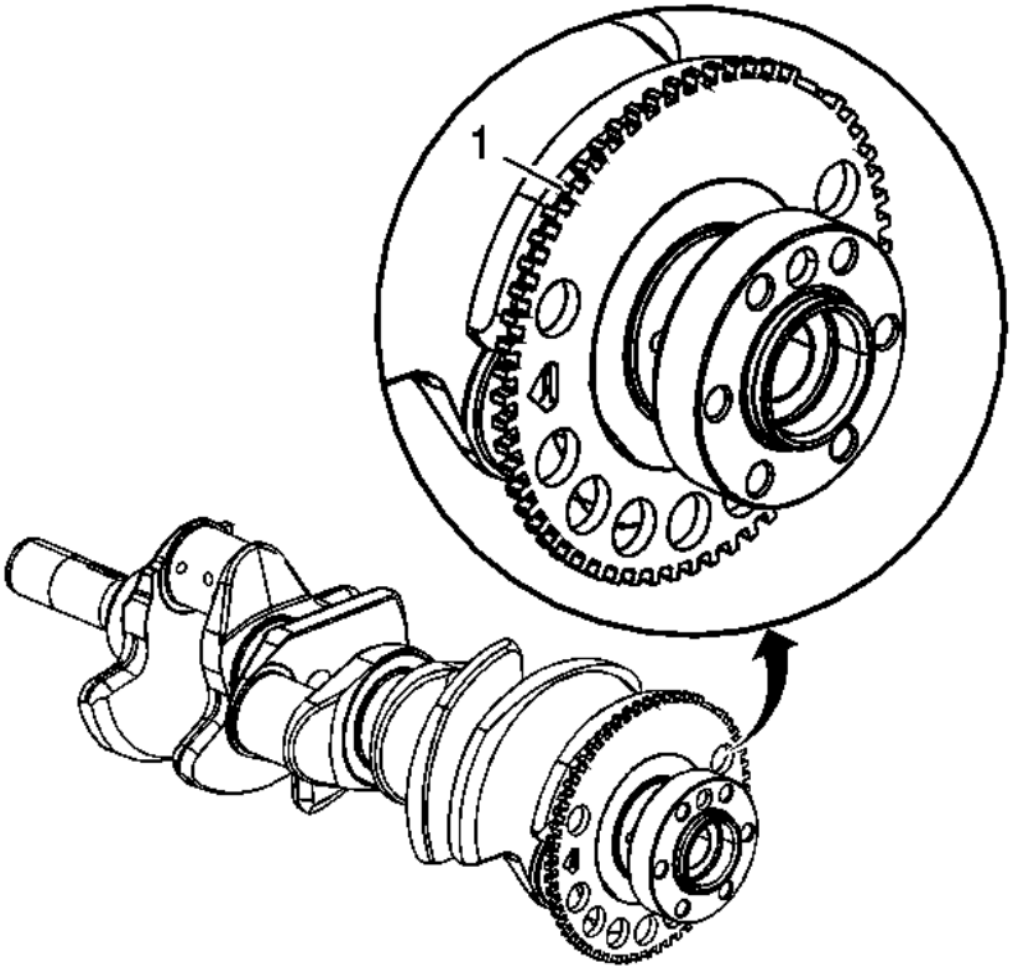

Fig. 396: View Of Reluctor Ring Teeth

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 affect OBD II system performance.

1. Inspect the CKP reluctor ring teeth (1) for damage.

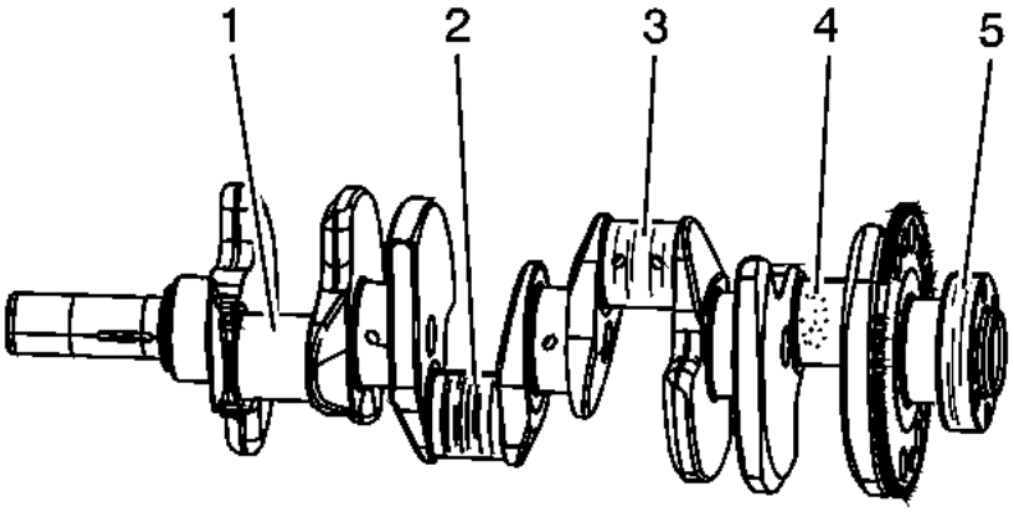

Fig. 397: Inspecting Crankshaft Journals For Wear
Courtesy of GENERAL MOTORS CORP.

2. Inspect the crankshaft journals for wear.

   Journals should be smooth (1) with no signs of scoring, wear, or damage.

3. Inspect the crankshaft journals for grooves or scoring (2).
4. Inspect the crankshaft journals for scratches or wear (3).
5. Inspect the crankshaft journals for pitting or imbedded bearing material (4).
6. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.

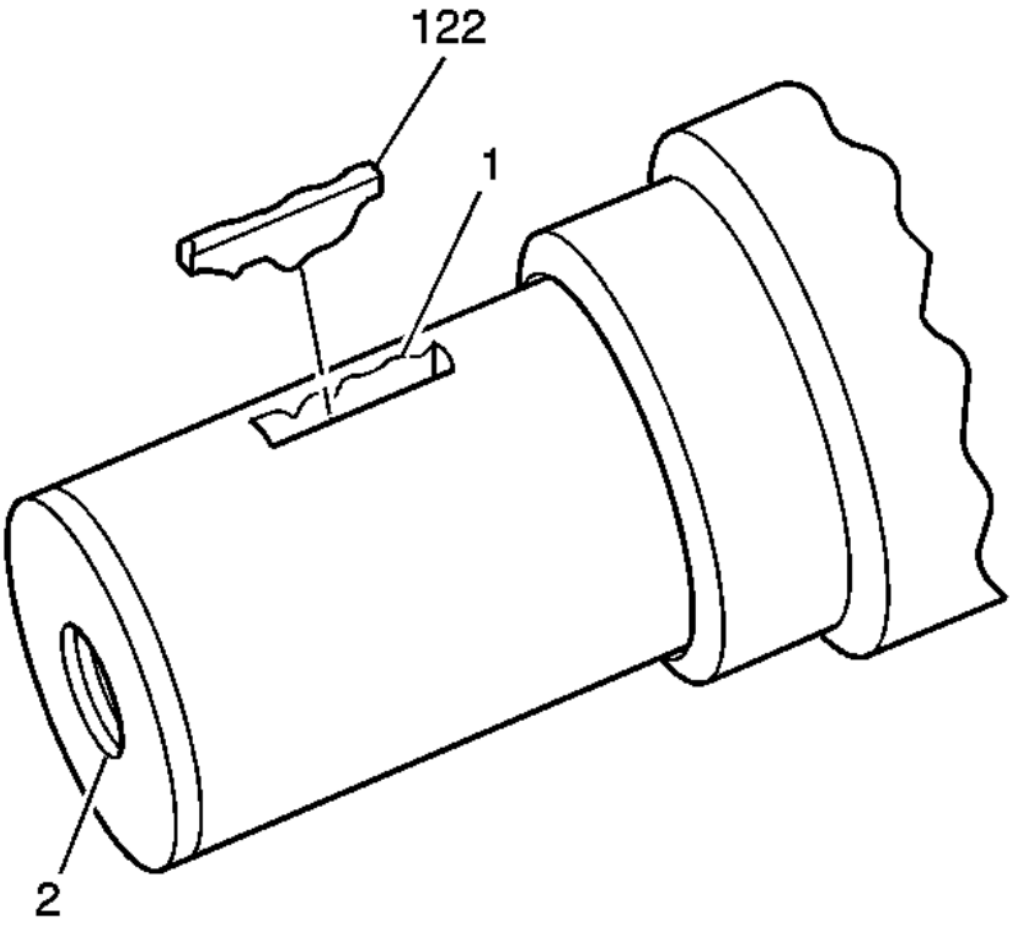

Fig. 398: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

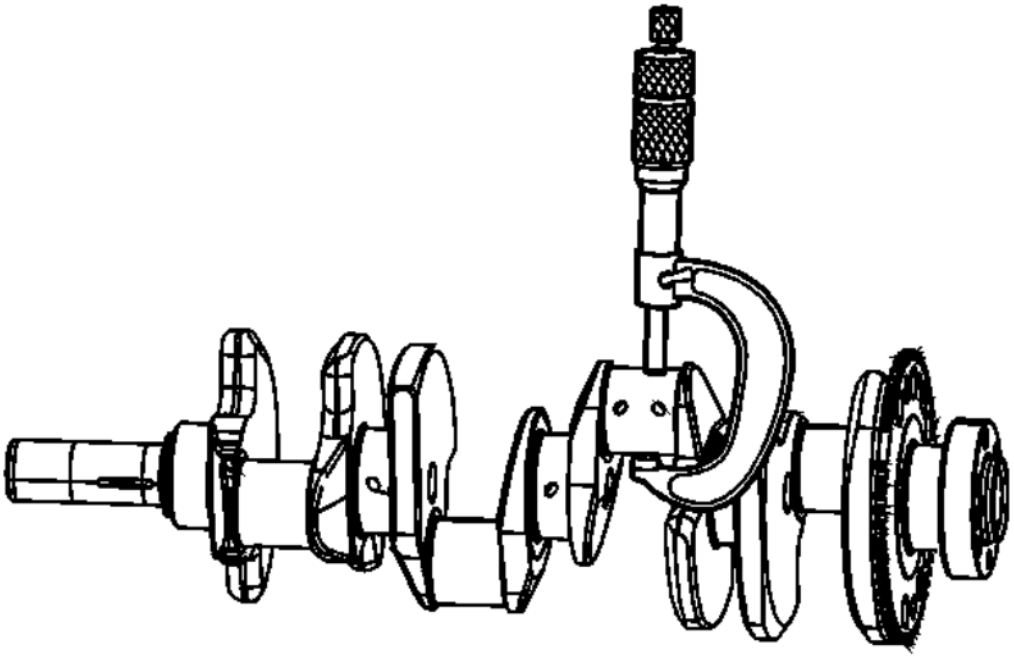

Fig. 399: Measuring Connecting Rod Journals For Out-Of-Round And Taper
Courtesy of GENERAL MOTORS CORP.

8. Measure the connecting rod journals for out-of-round and taper.

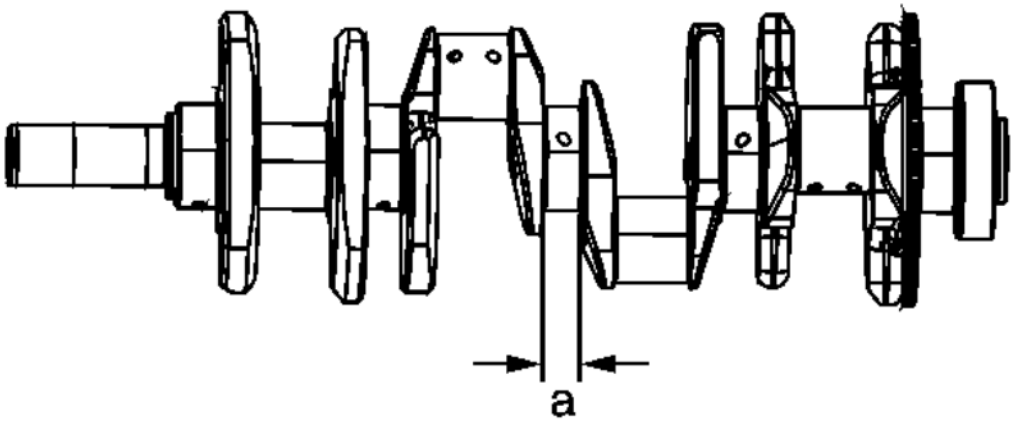

Fig. 400: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

9. 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.

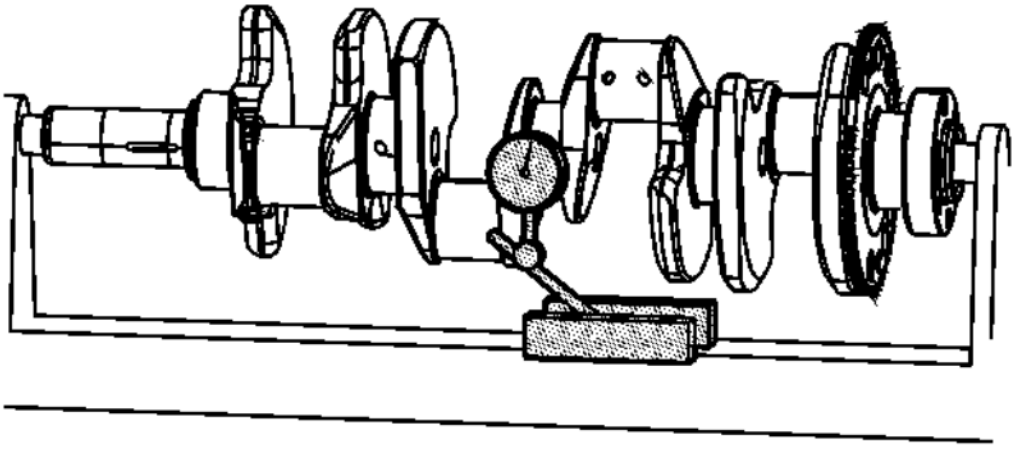

Fig. 401: Measuring Crankshaft Runout

Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft runout.

    Use wooden V-blocks or a fixture to support the crankshaft on the front and rear journals.

11. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals.
12. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
13. 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.

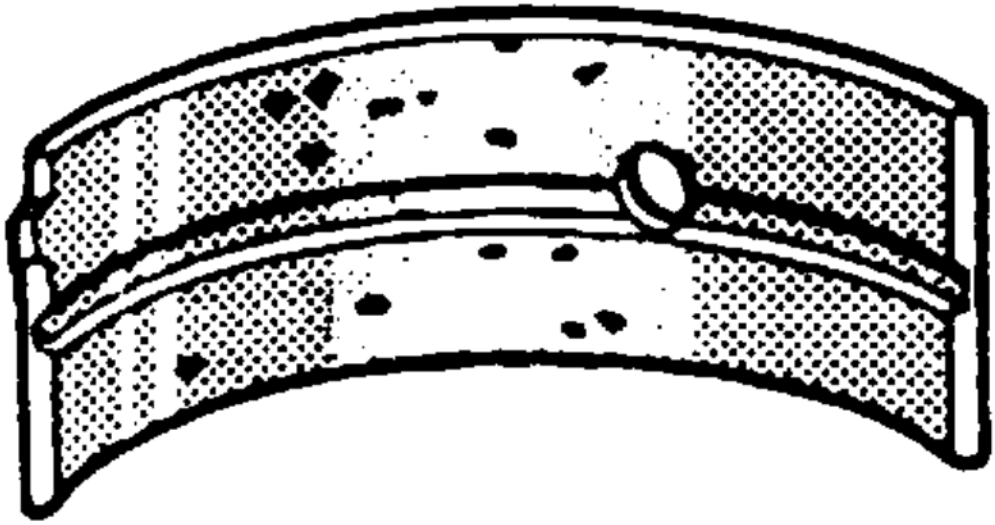

Fig. 402: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

14. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

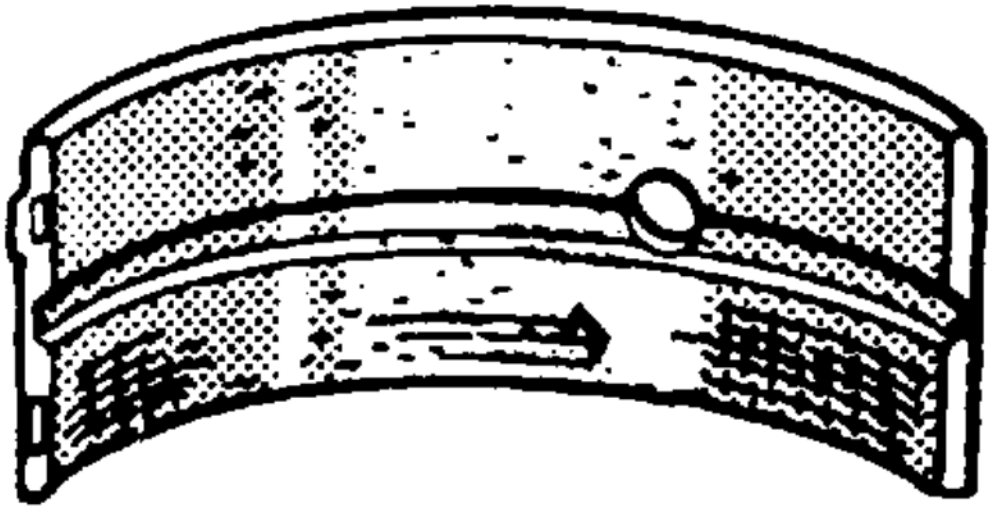

Fig. 403: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

15. Inspect the crankshaft bearings for excessive scoring or discoloration.
16. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

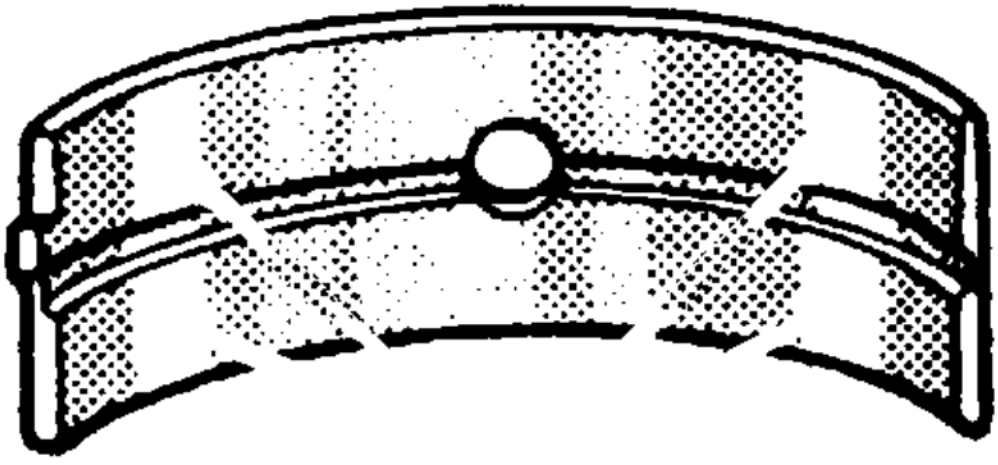

Fig. 404: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

17. 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

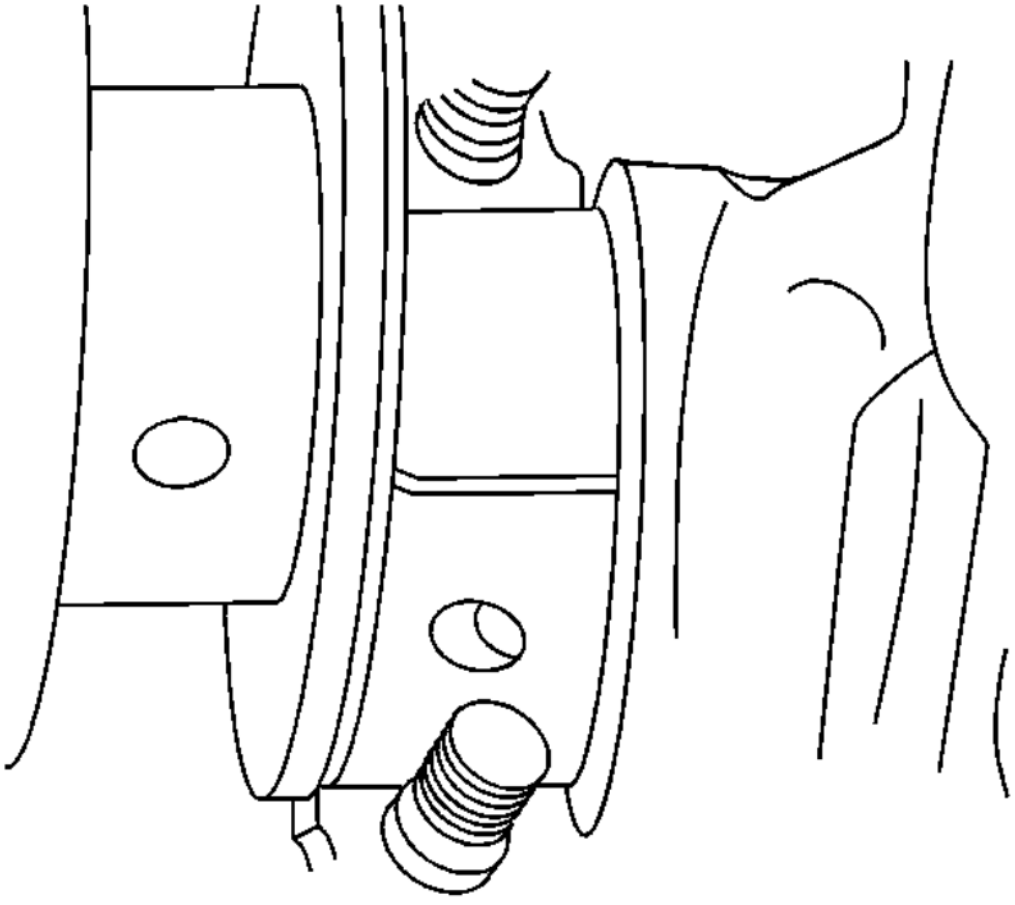

Fig. 405: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

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 affect crankshaft position sensor signals and may affect 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 Bearing 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 Bearing Installation**.
4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.

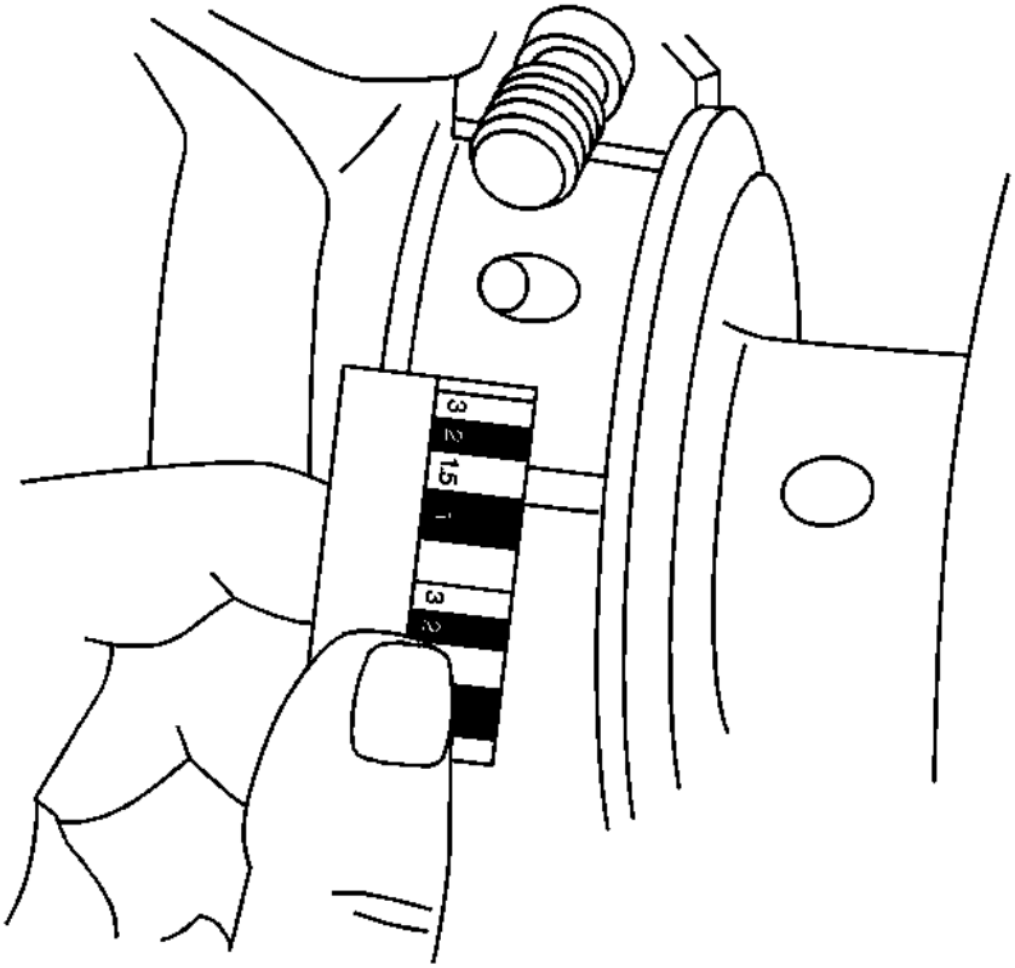

Fig. 406: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area.
    - 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

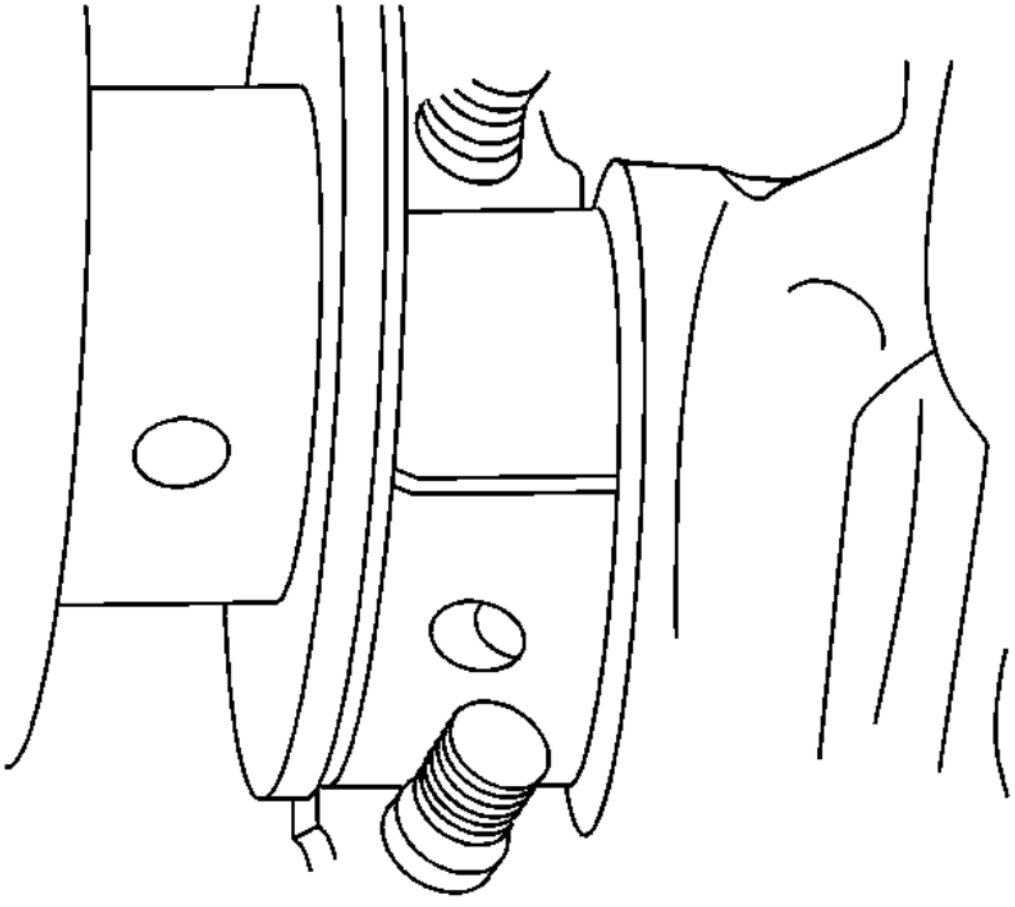

Fig. 407: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

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 is 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**.

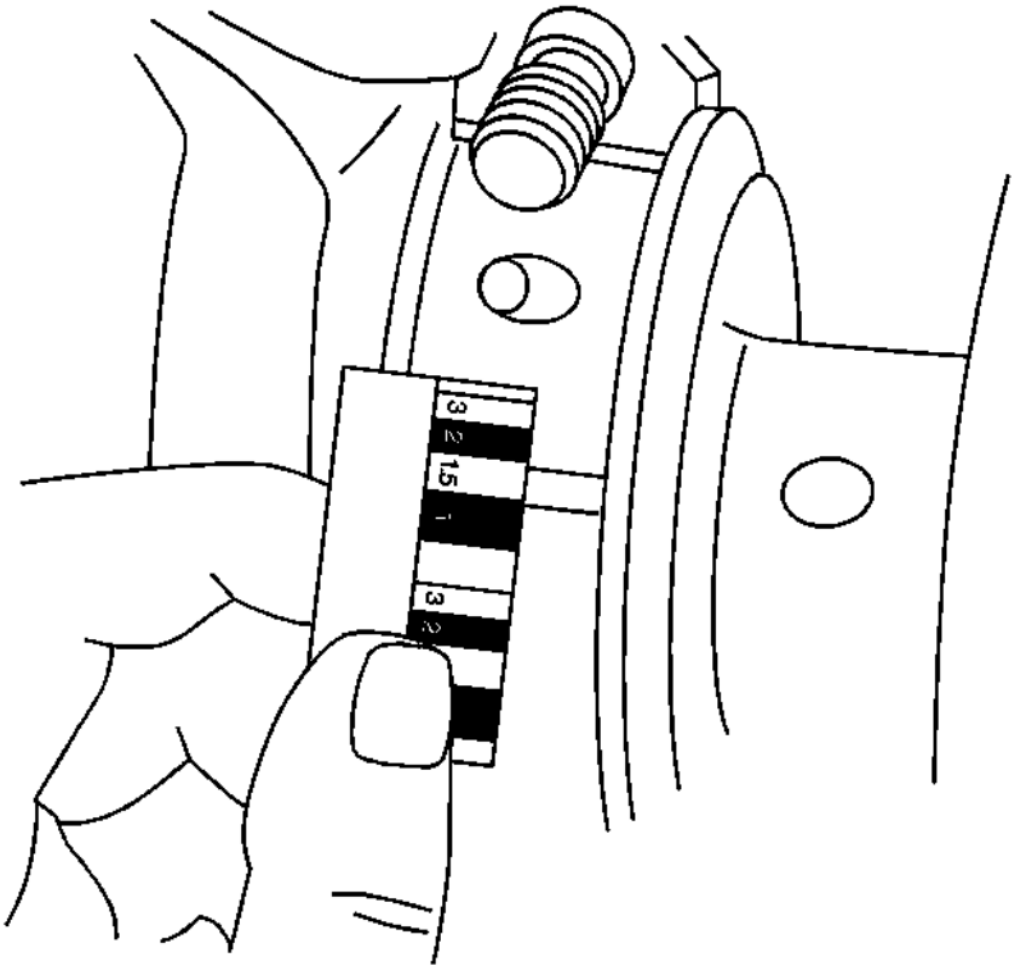

Fig. 408: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area. 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 supplied by the tool manufacturer.

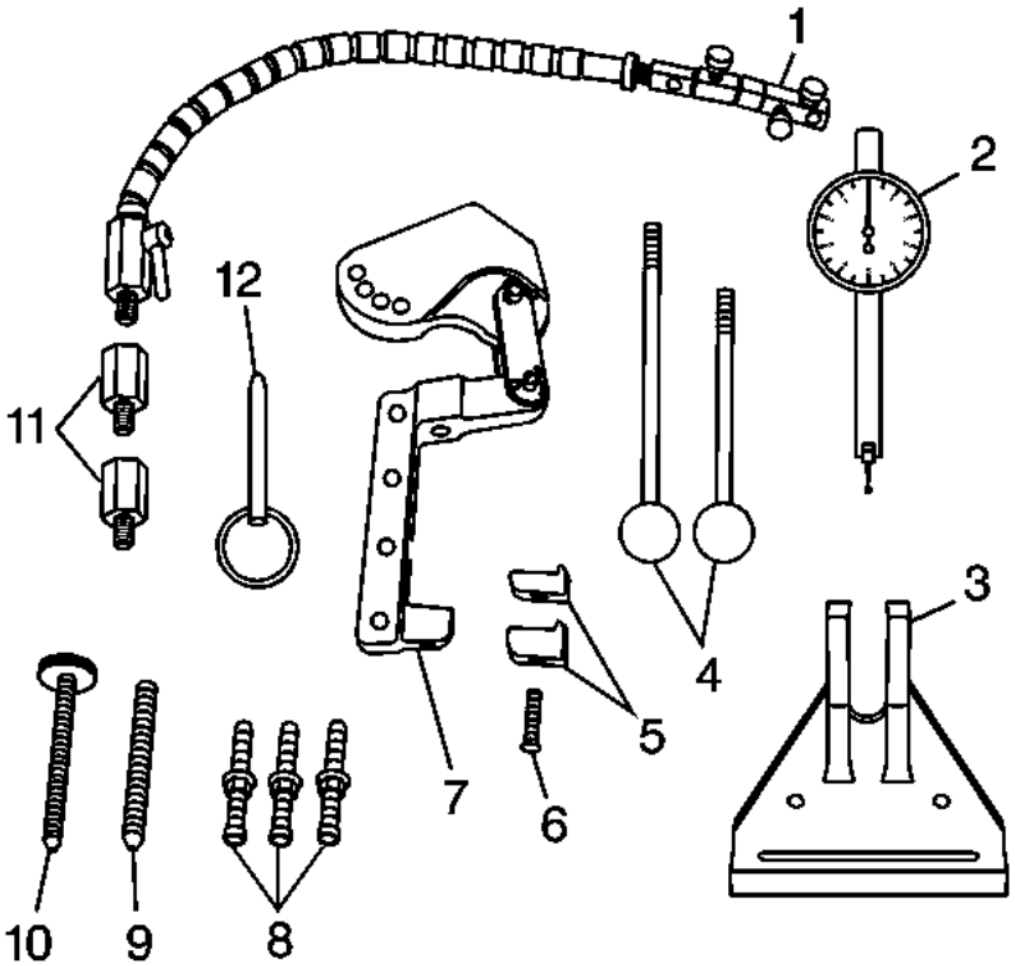

Fig. 409: Identifying Rod Bearing Clearance Checking Tool

Courtesy of GENERAL MOTORS CORP.

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, J 43690-6 Handle (4)
- J 43690-10, J 43690-11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, J 43690-7, J 43690-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

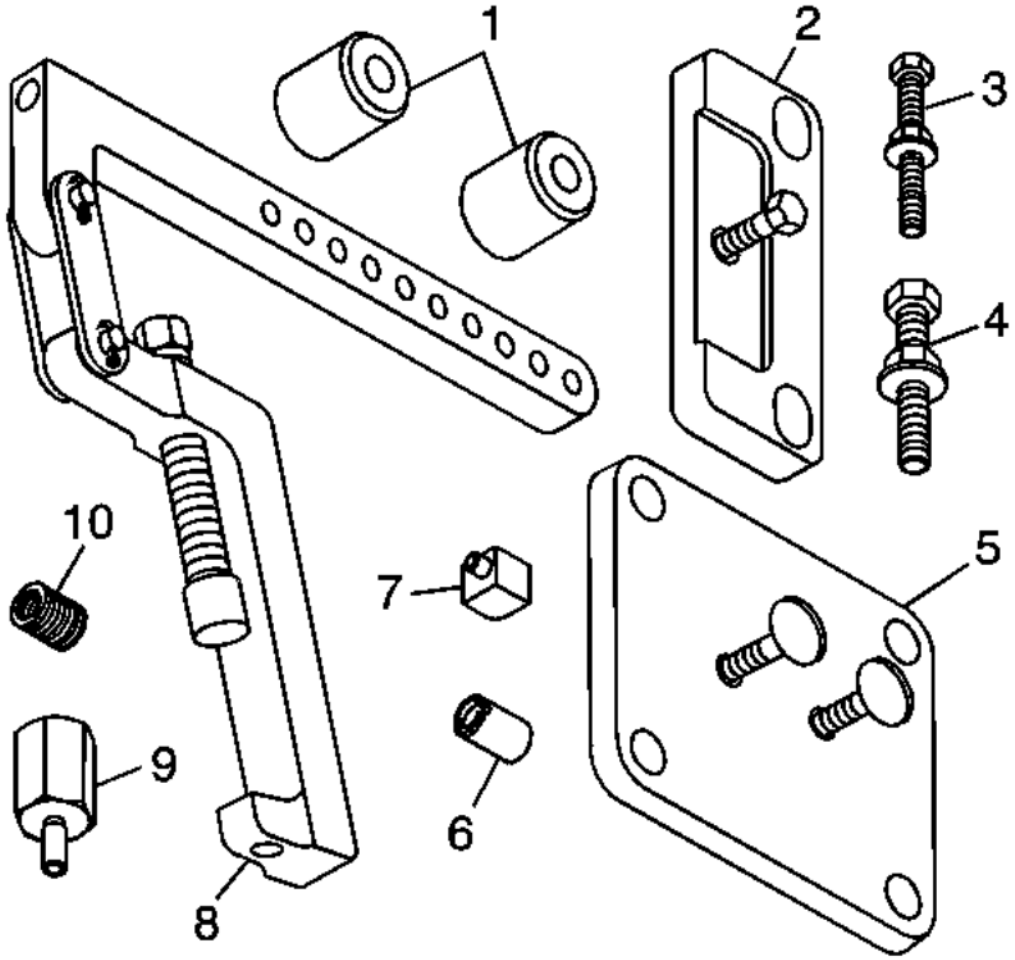

Fig. 410: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

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)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

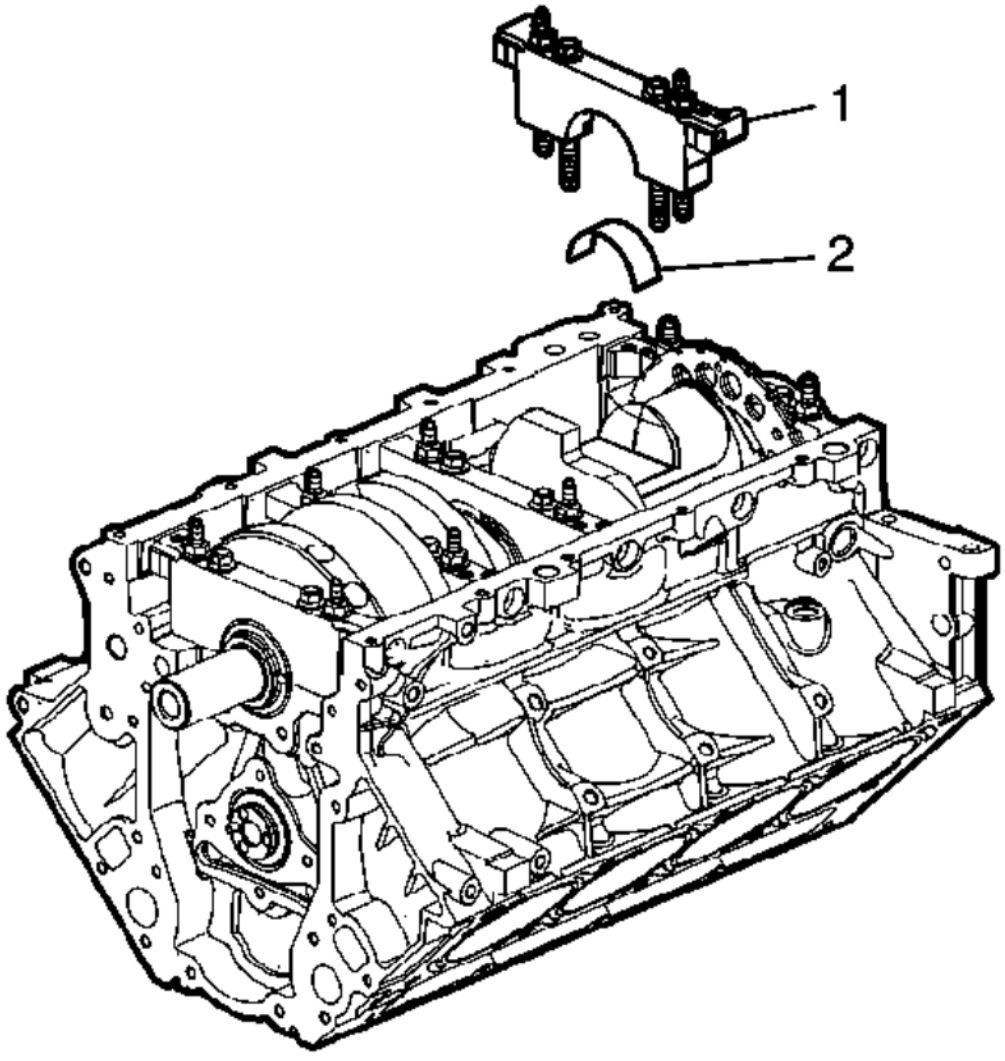

Fig. 411: View Of Bearing Cap, Bolt & Bearing Half

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**.

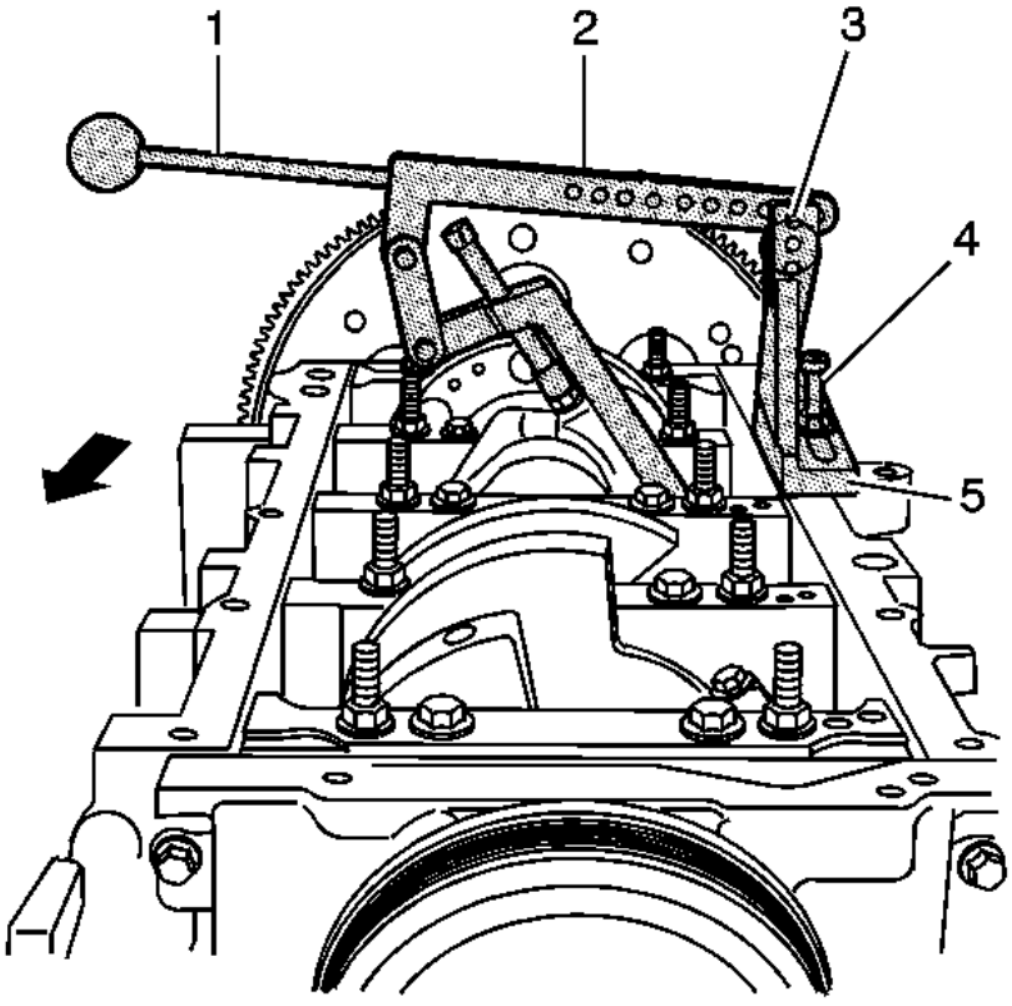

Fig. 412: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

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)

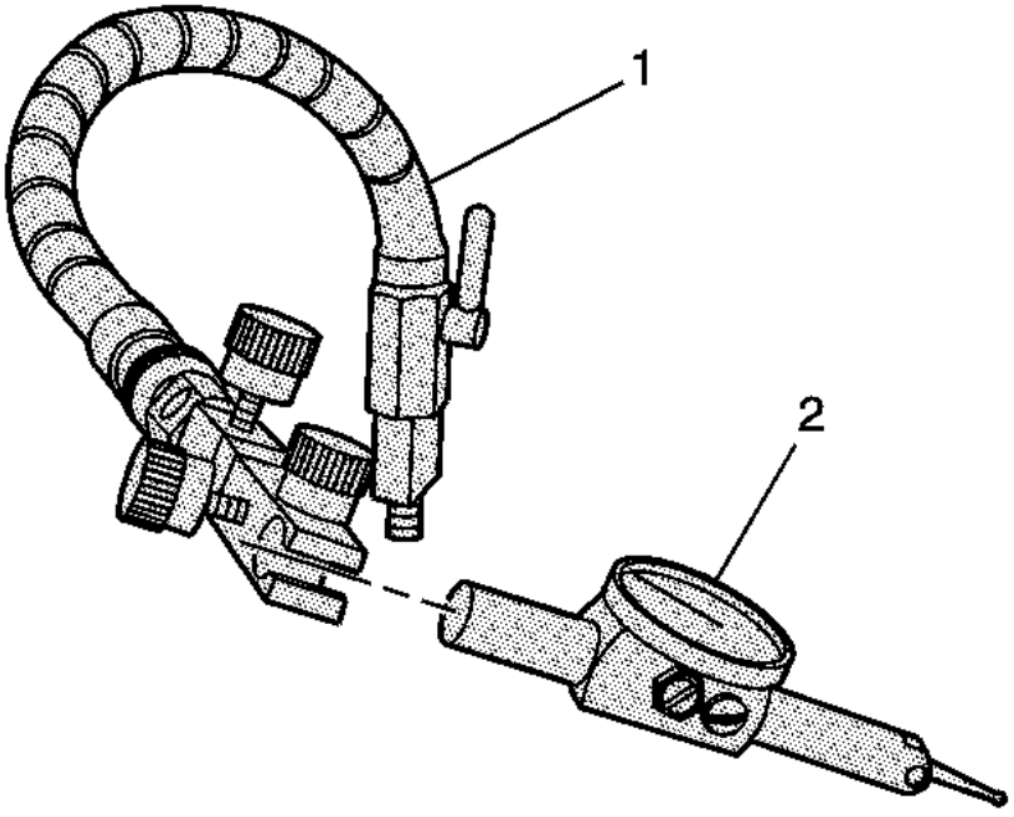

Fig. 413: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

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

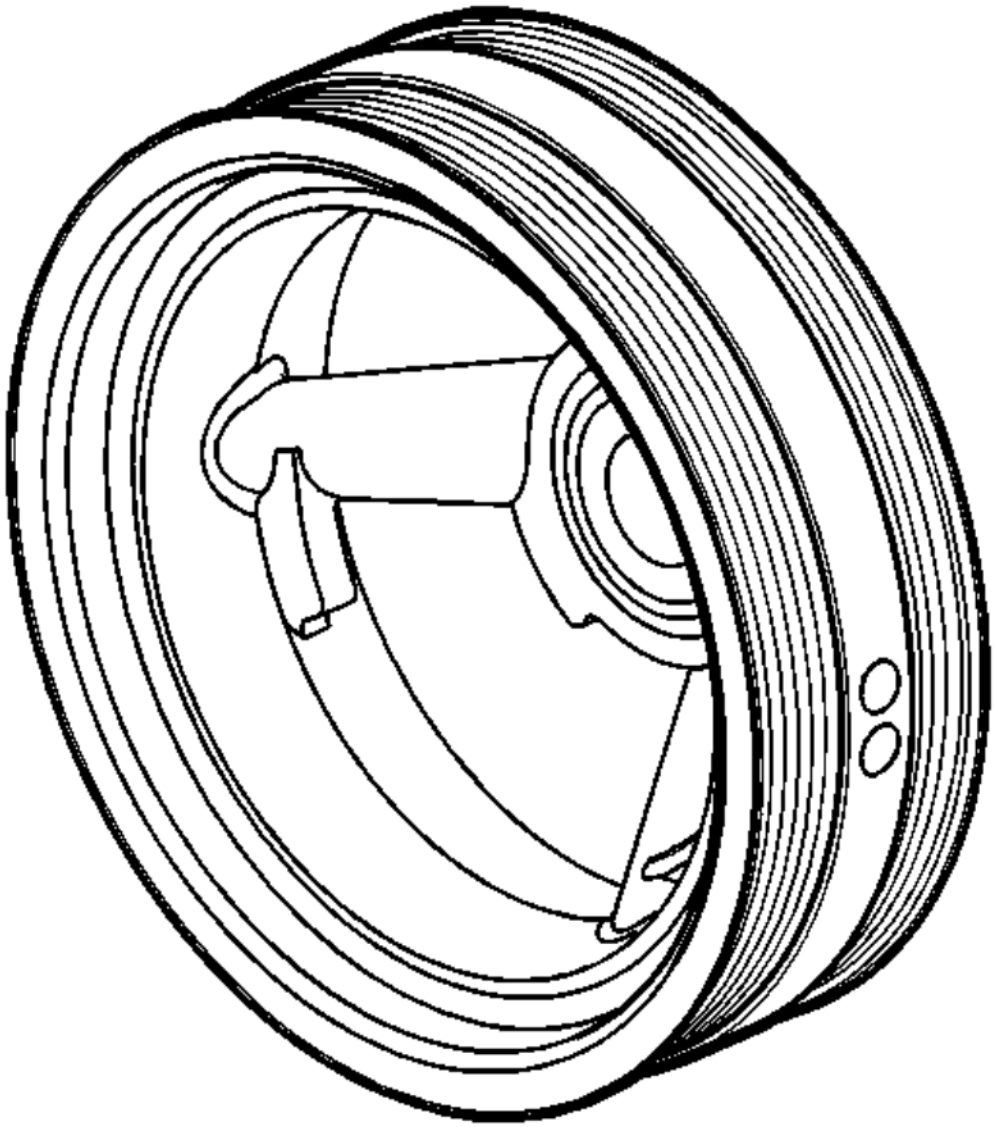

Fig. 414: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

     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

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

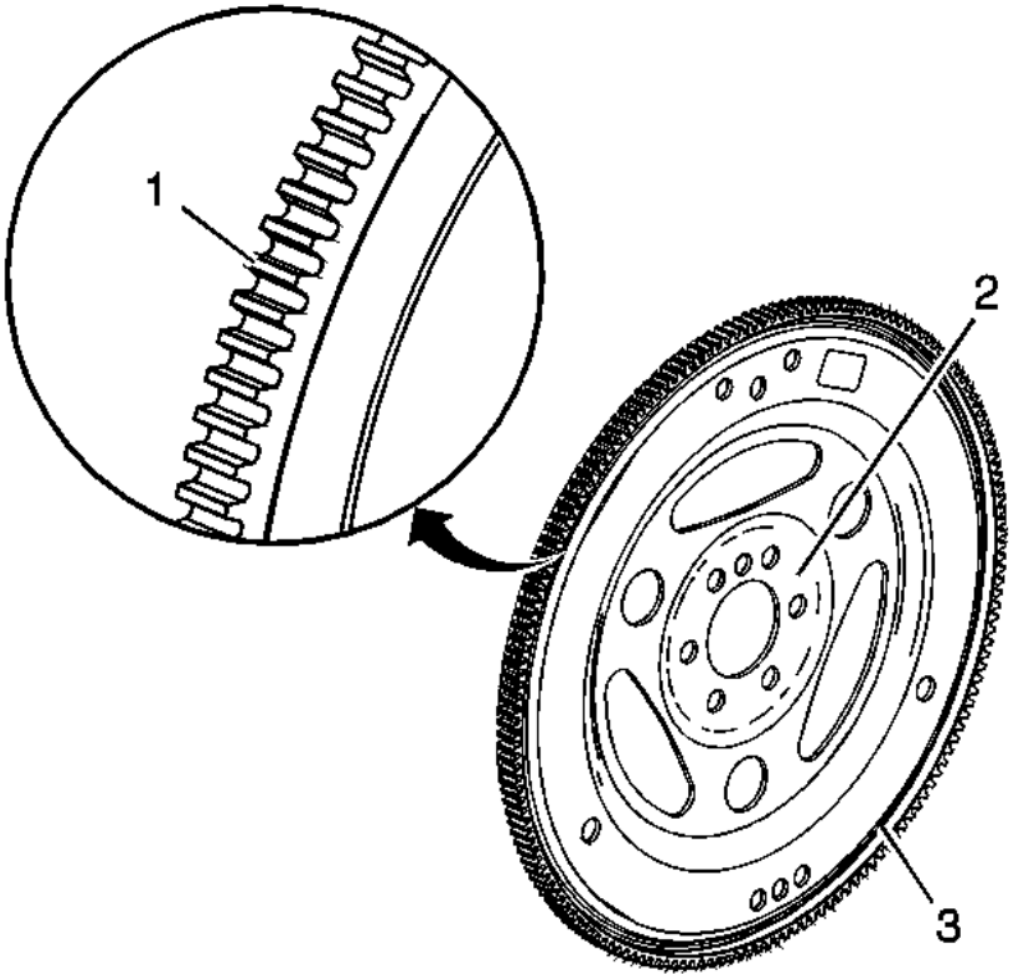

Fig. 415: View Of Ring Gear Teeth
Courtesy of GENERAL MOTORS CORP.

1. Clean the flex plate in solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

2. Dry the flex plate with compressed air.
3. Inspect the flex plate for the following conditions:

- Damaged ring gear teeth (1)
- Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a new flex plate.

- Welded areas (3) that retain the ring gear onto the flex plate for cracking

PISTON AND CONNECTING ROD DISASSEMBLE

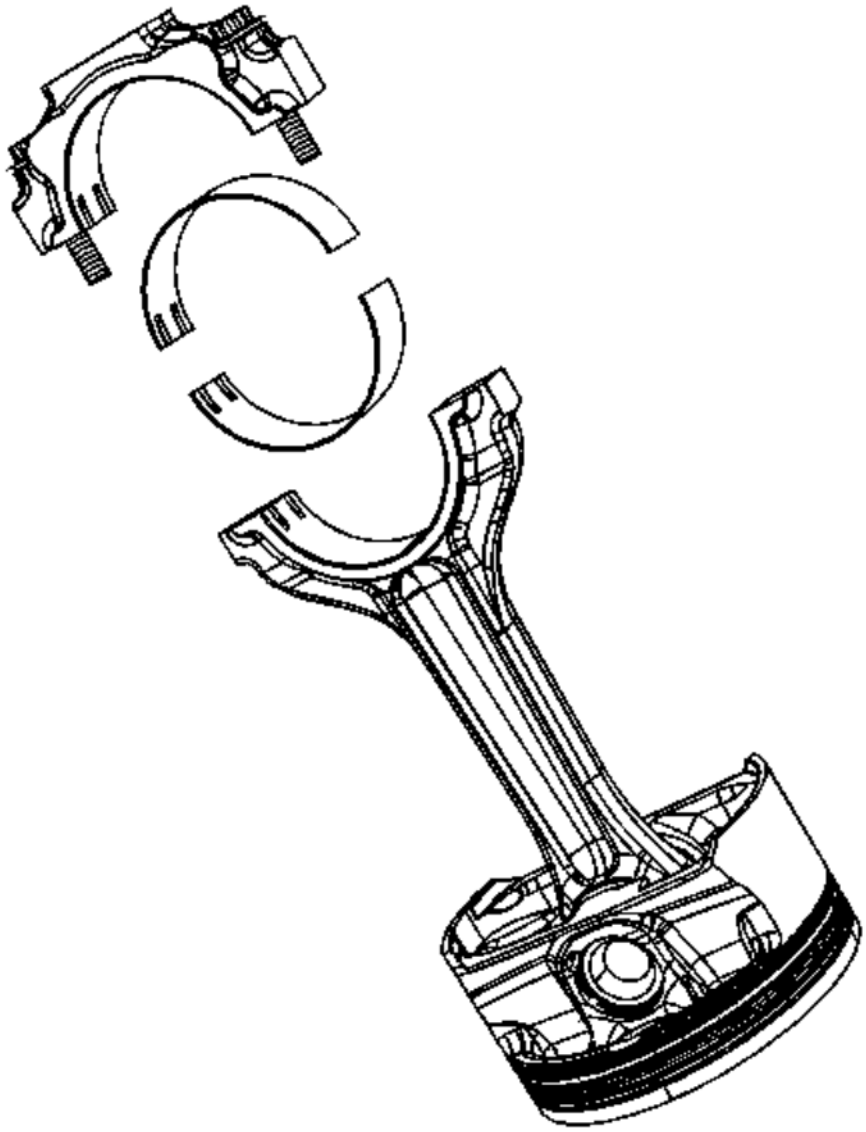

Fig. 416: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings from the rod and cap.

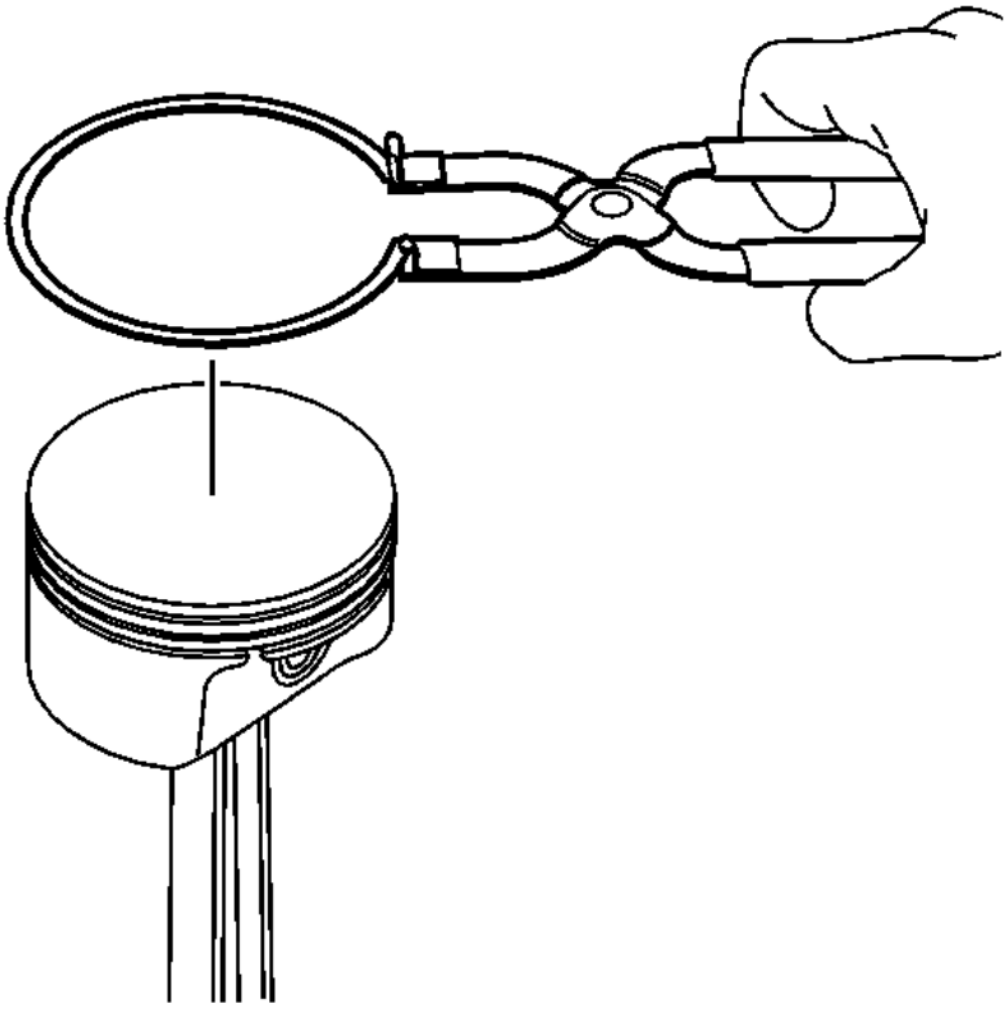

Fig. 417: View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

2. Using piston ring pliers, remove the piston rings from the piston.

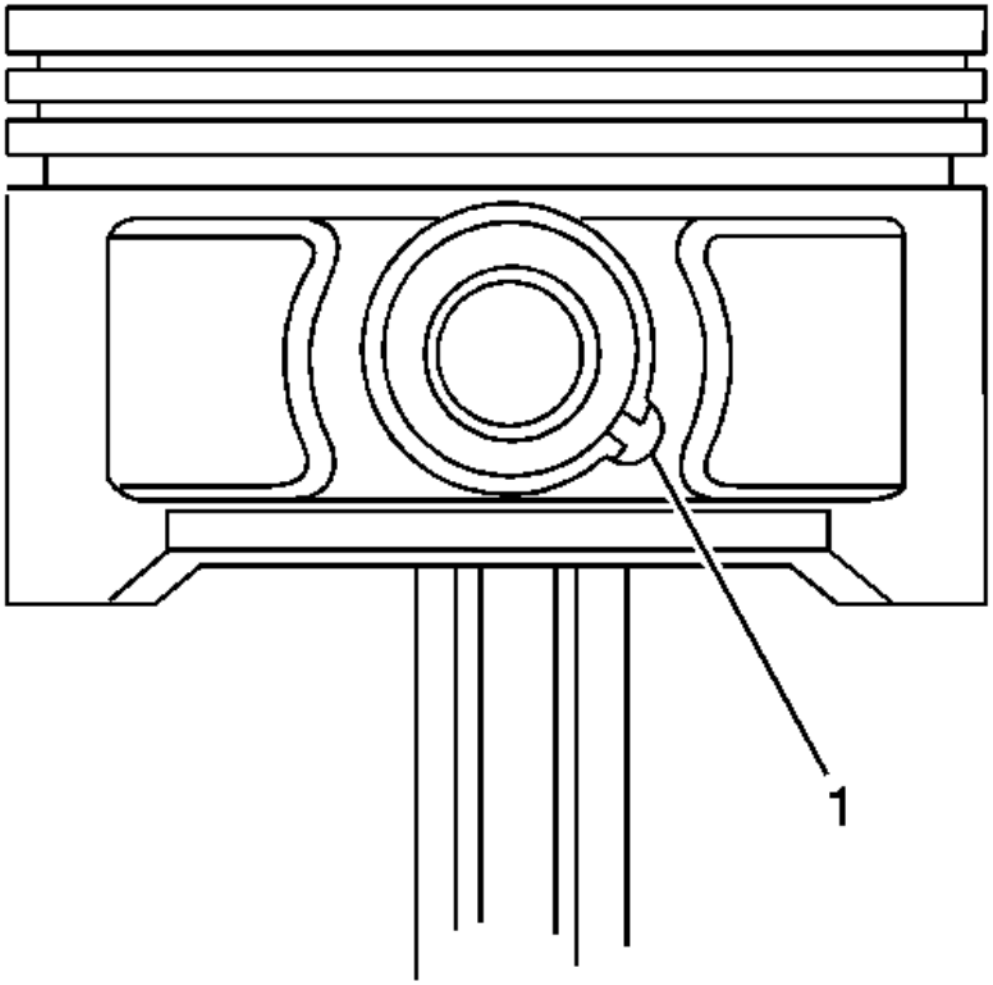

Fig. 418: View Of Piston Pin Retaining Clip & Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.

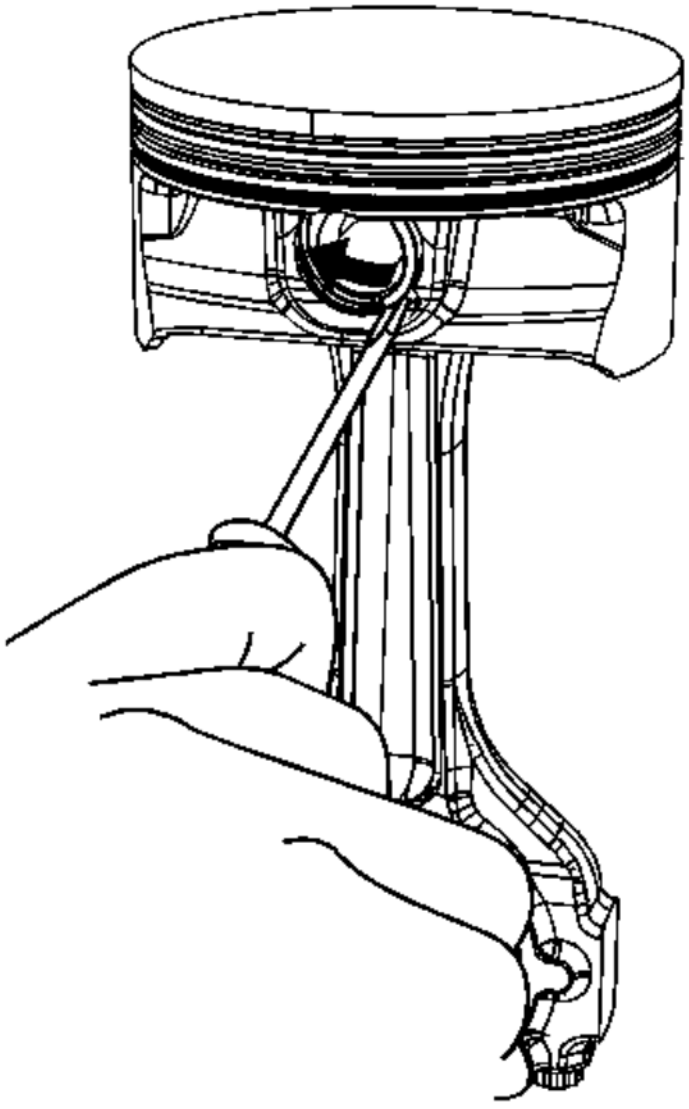

Fig. 419: Piston Pin Retainer
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainers starting in the cutout area of the pin bore.

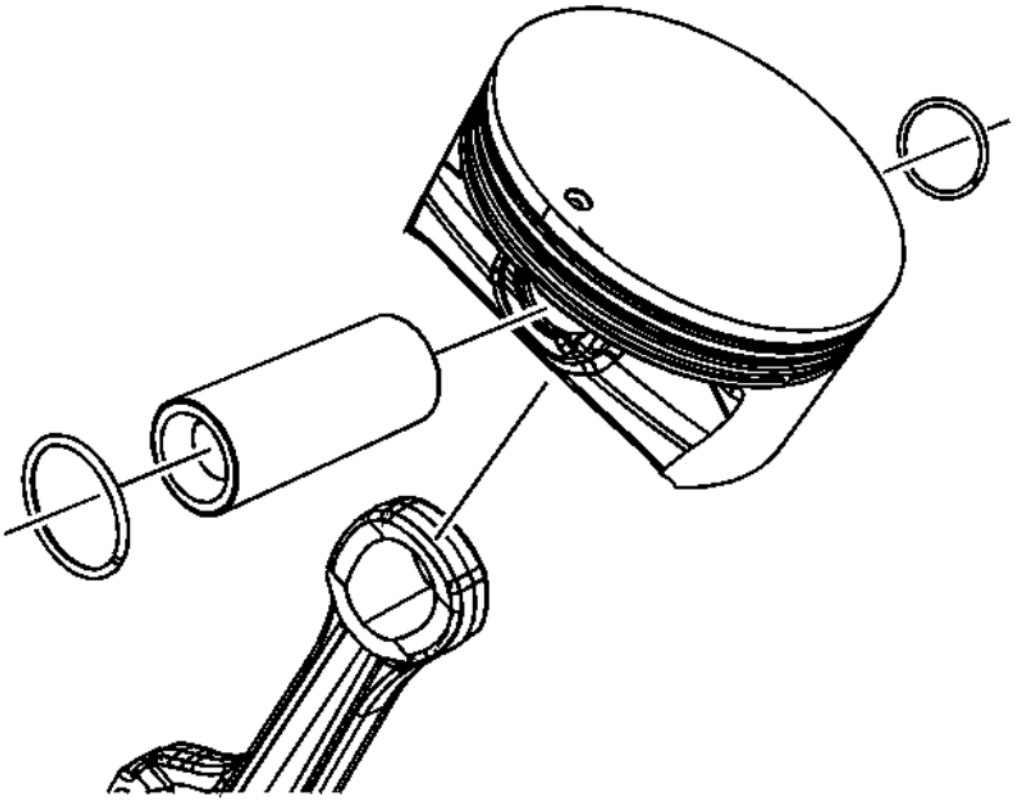

Fig. 420: Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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 BEARING CLEANING AND INSPECTION

Piston, Pin, and Piston Rings

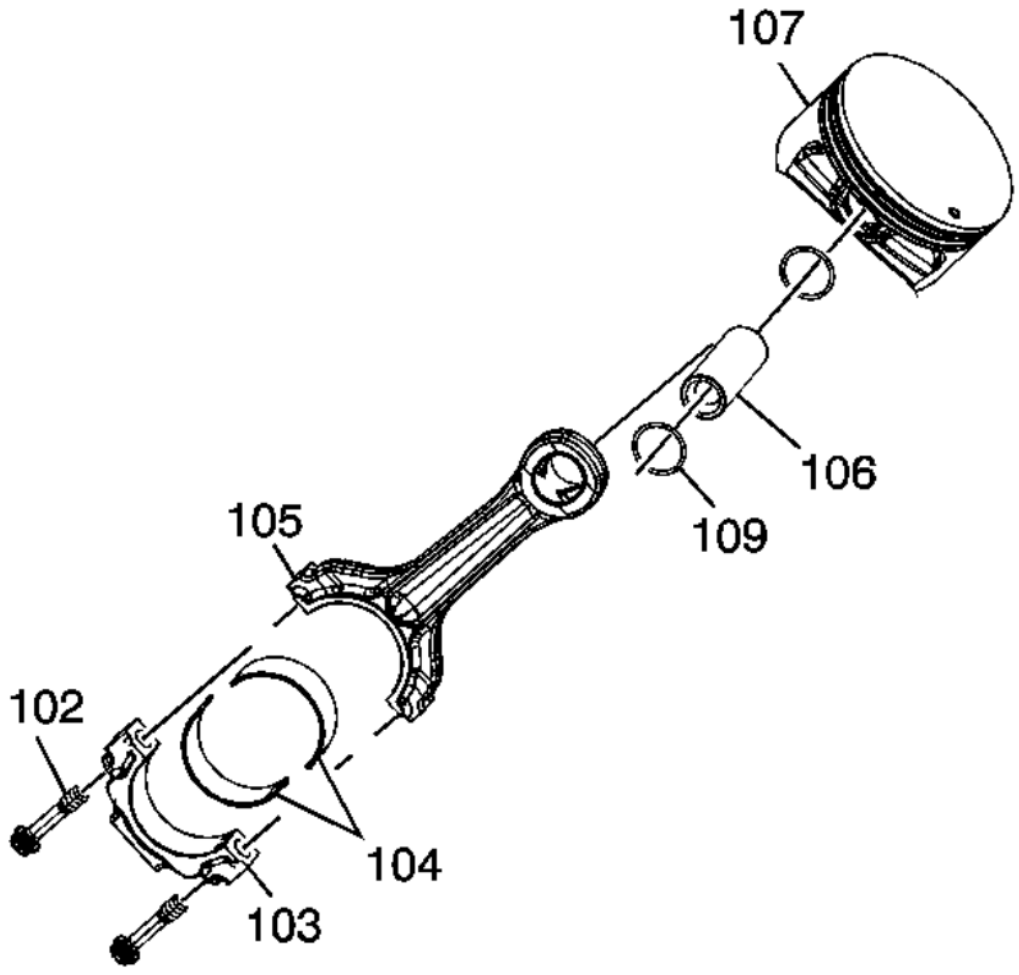

Fig. 421: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS CORP.

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.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the components with compressed air.

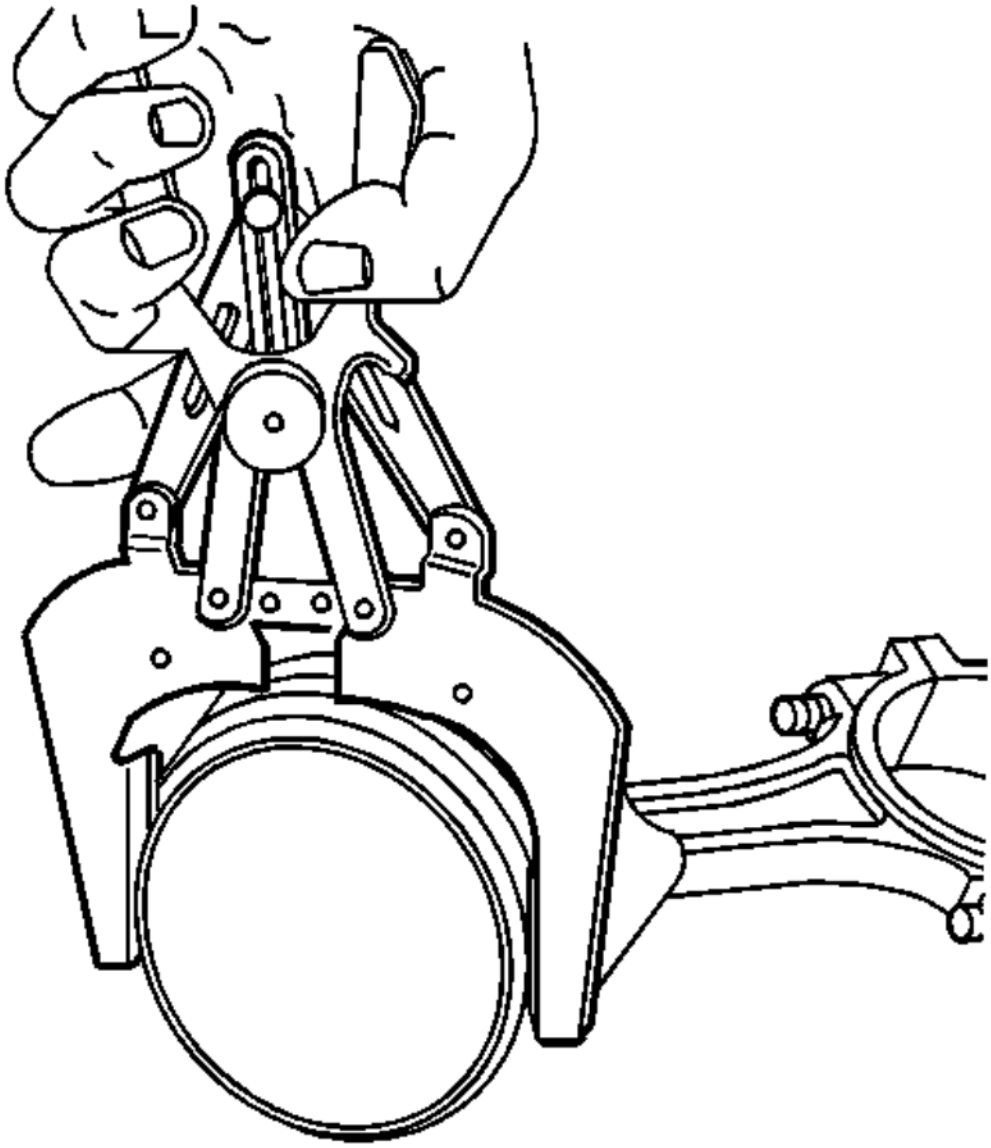

Fig. 422: Cleaning Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

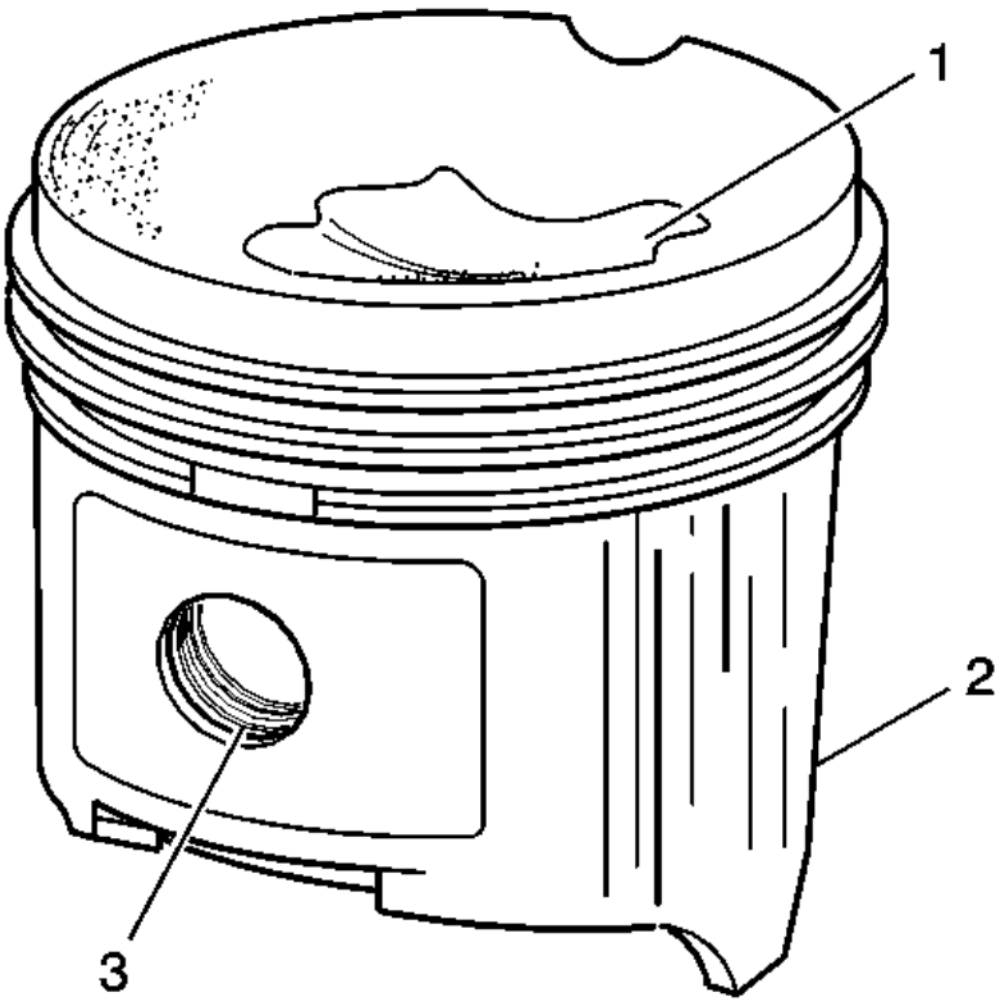

Fig. 423: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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.

- Eroded areas at the top of the piston (1)
- Scuffed or damaged skirts (2)
- Scoring to the piston pin bore (3) or piston pin

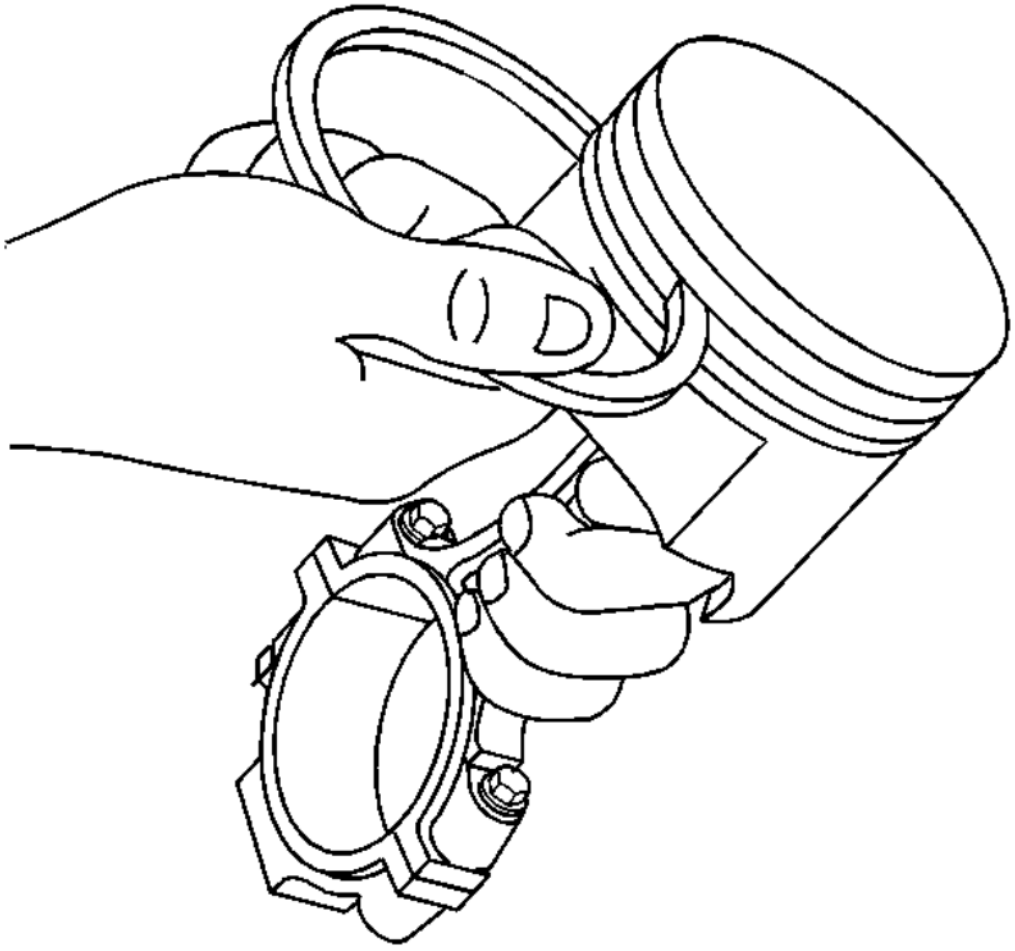

Fig. 424: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

6. 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 a 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.

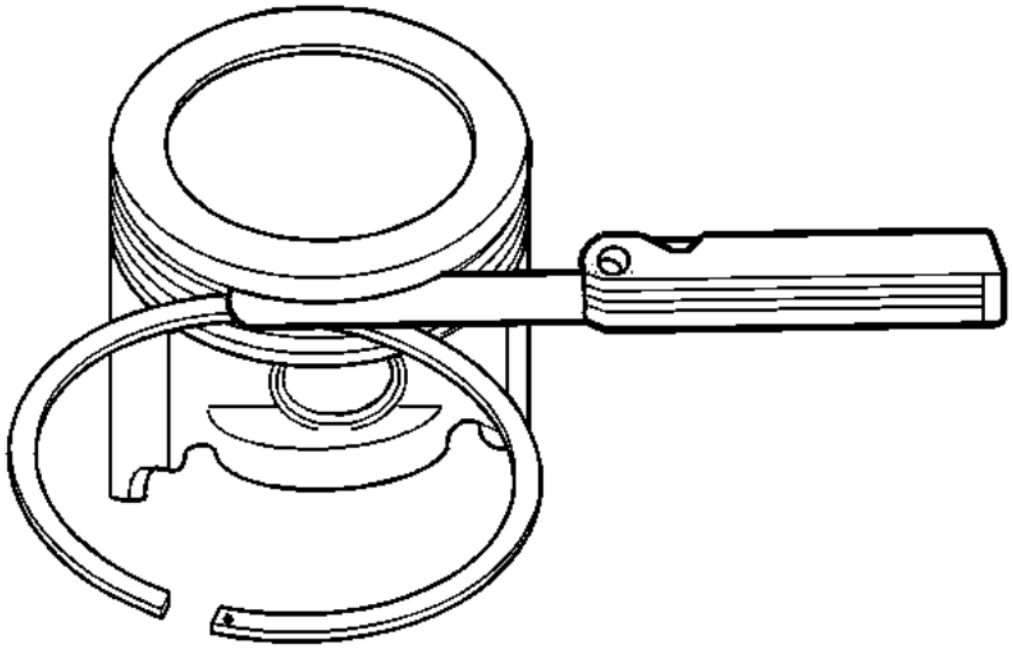

Fig. 425: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance with a feeler gage. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston and pin as an assembly. Refer to **Engine Mechanical Specifications**.

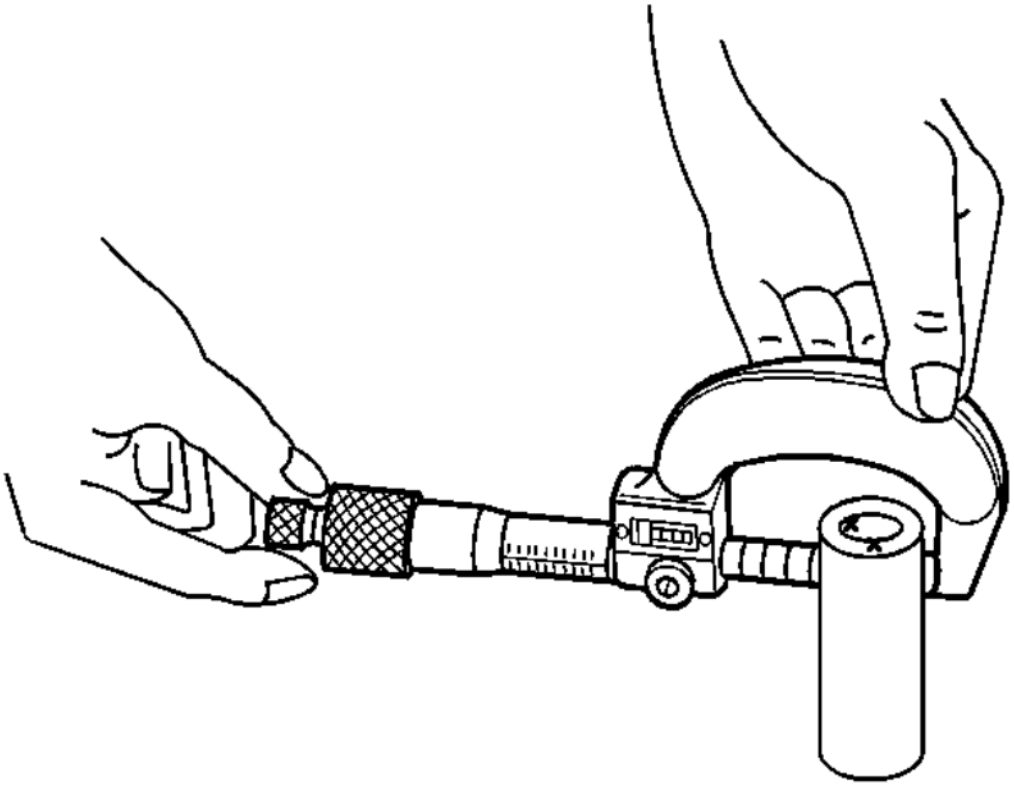

Fig. 426: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

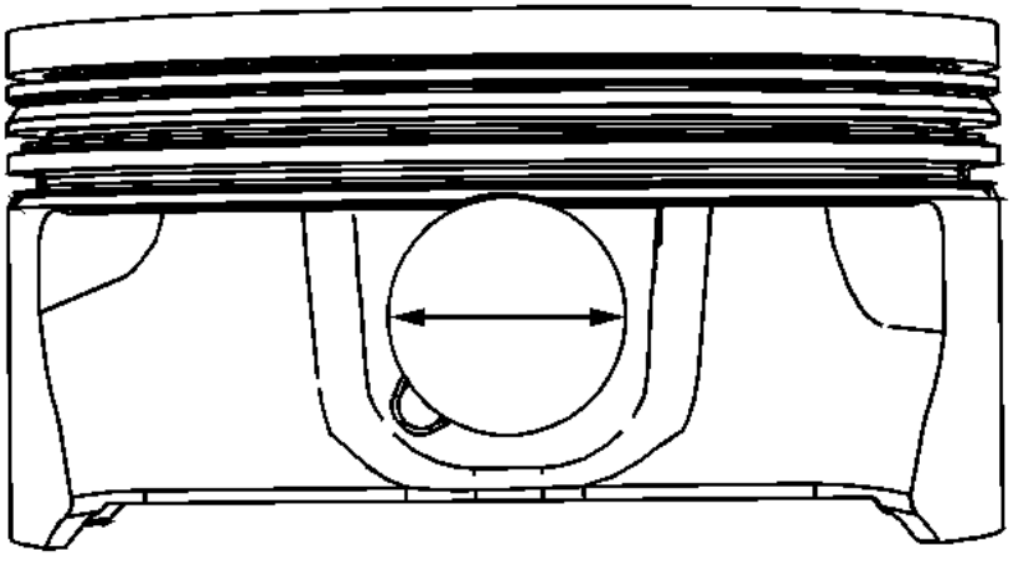

Fig. 427: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS CORP.

9. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
10. 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

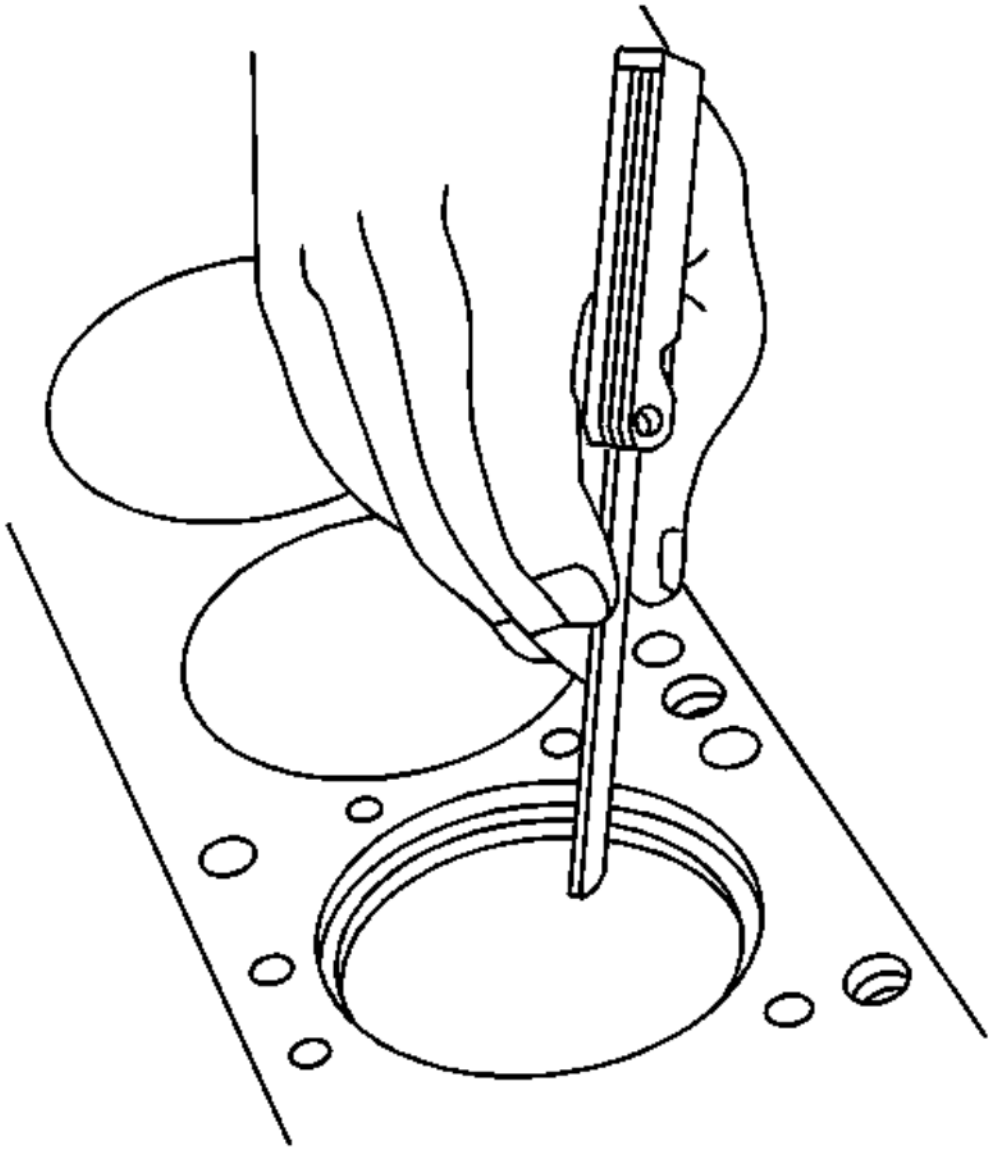

Fig. 428: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

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. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area. Both rings should be installed with the orientation marks facing the top of the piston.
2. Insert a feeler gage and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings

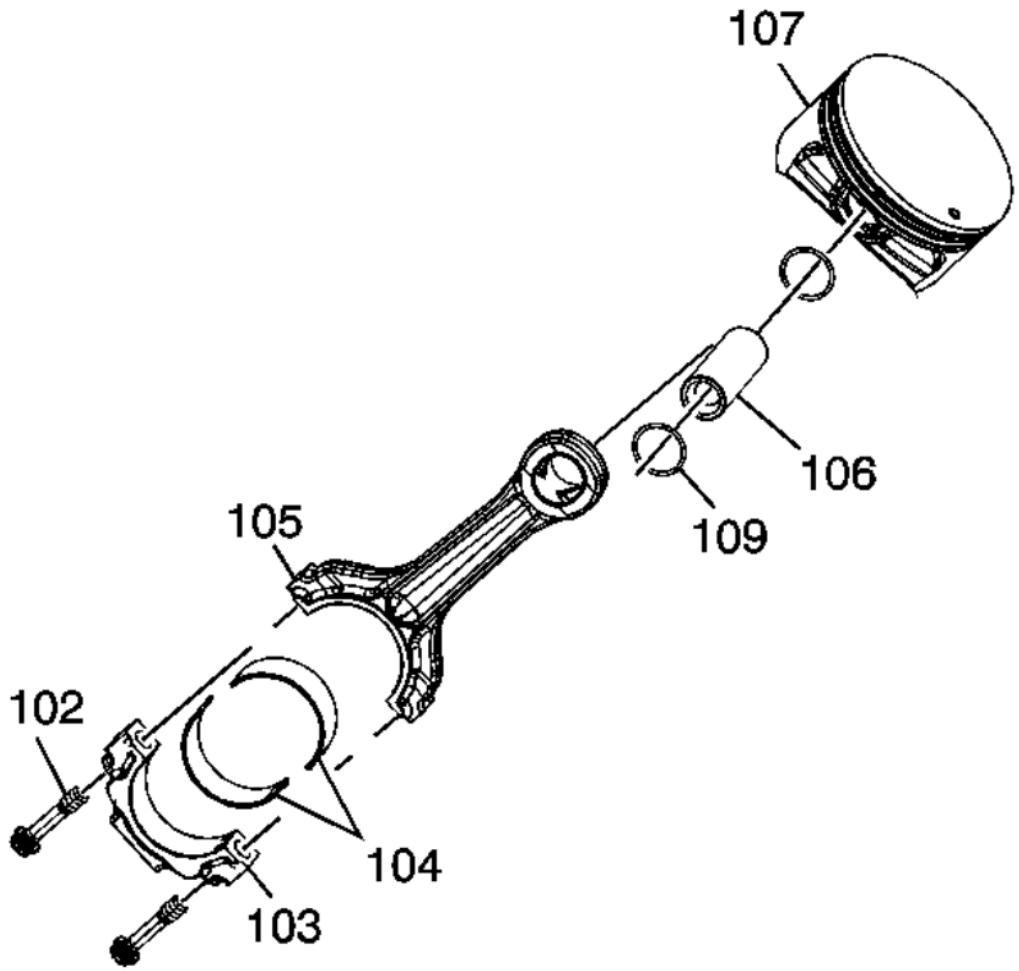

Fig. 429: View Of Piston, Pin & Piston Rings

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 rod and cap 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.

CAUTION: Refer to Safety Glasses Caution .

2. Dry the components with compressed air.

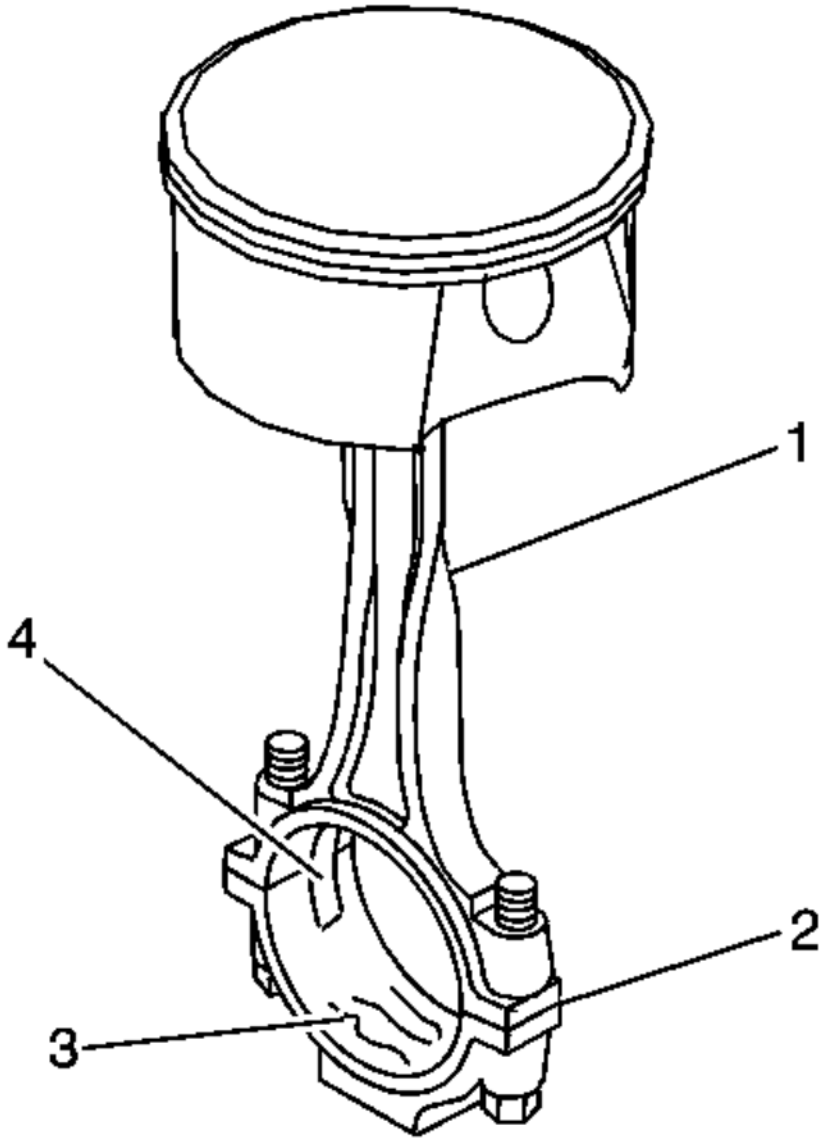

Fig. 430: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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)

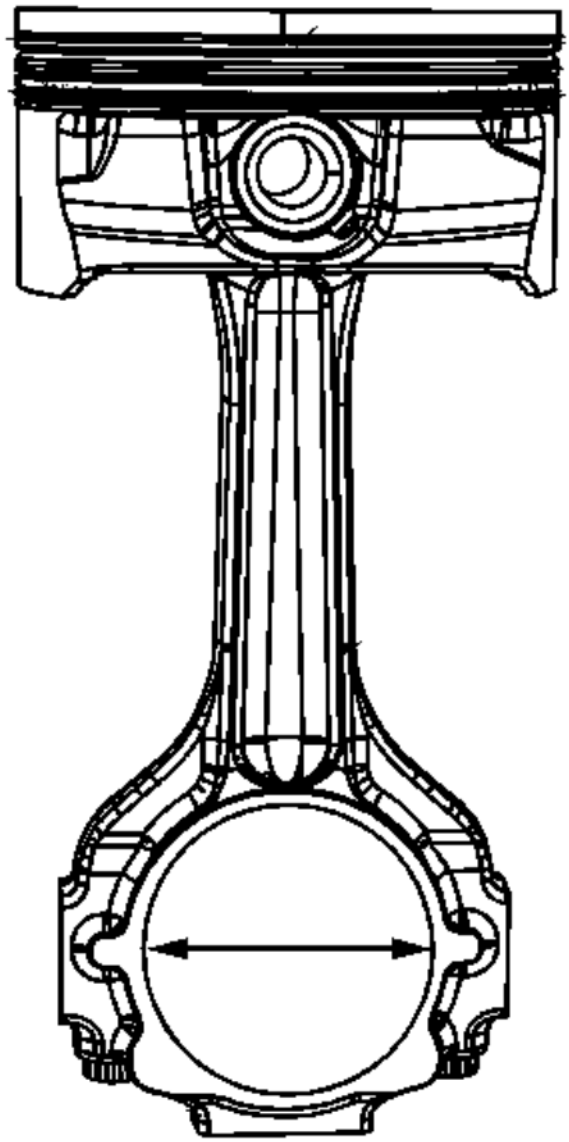

Fig. 431: Identifying Connecting Rod Bearing Bore
Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

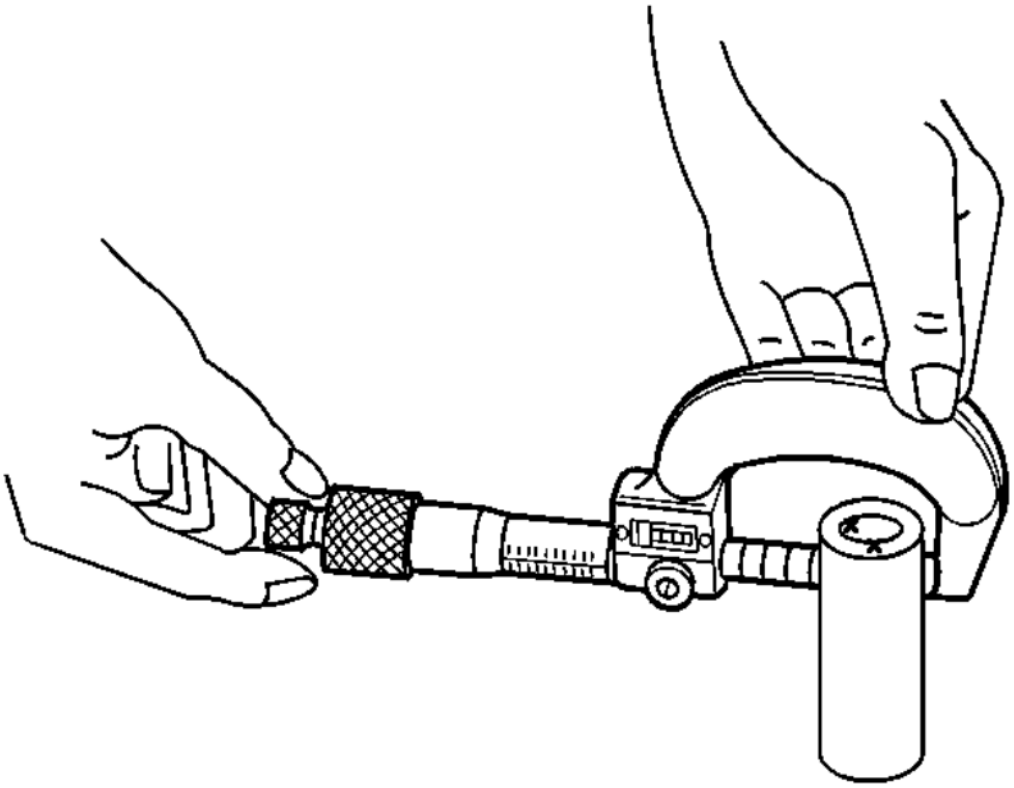

Fig. 432: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. To determine piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin OD.

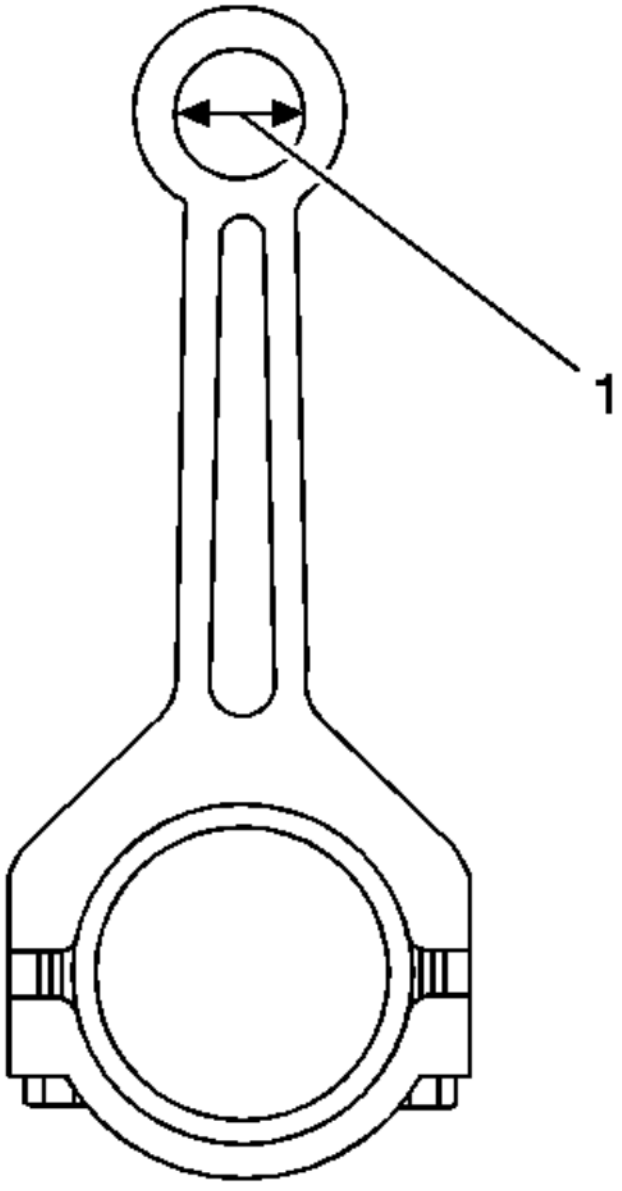

Fig. 433: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS CORP.

6. To determine the piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) 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**.

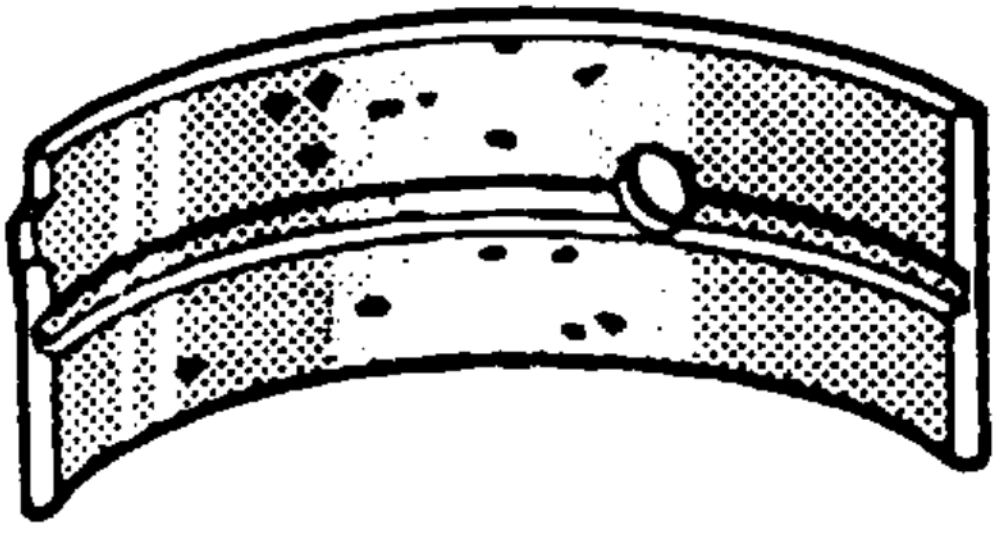

Fig. 434: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.

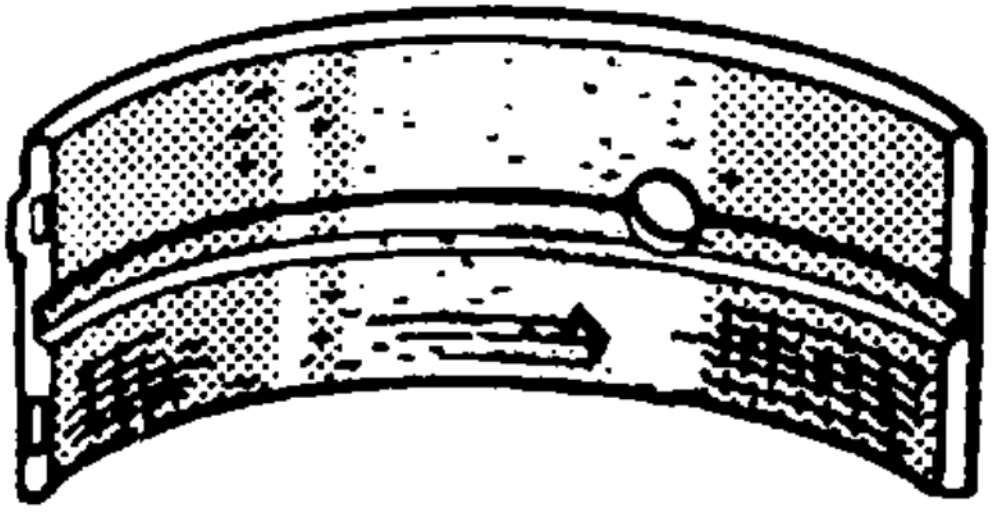

Fig. 435: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

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.

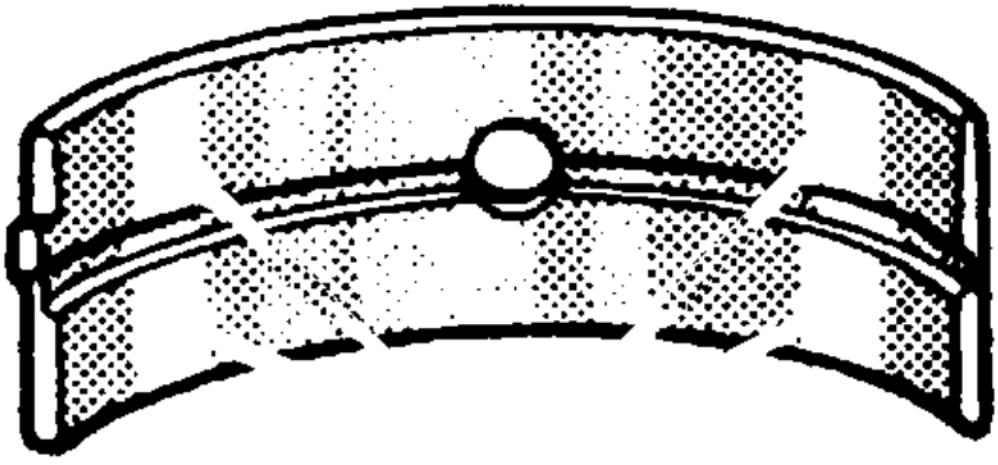

Fig. 436: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.
12. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore ID.
13. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications**.

PISTON AND CONNECTING ROD ASSEMBLE

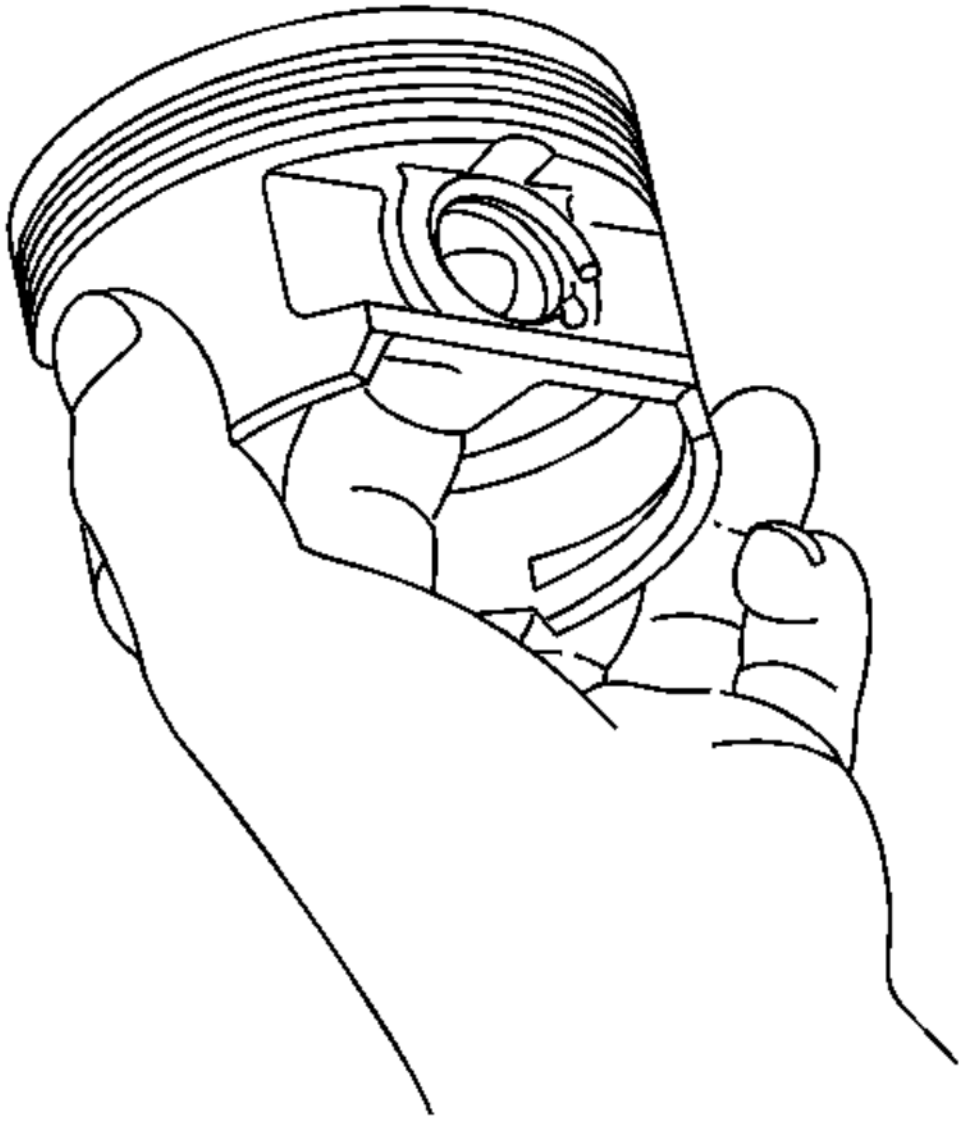

Fig. 437: View Of Retaining Clip In Pin Bore Groove
Courtesy of GENERAL MOTORS CORP.

1. Install the retainer. The retainer should be seated in the groove of the pin bore.

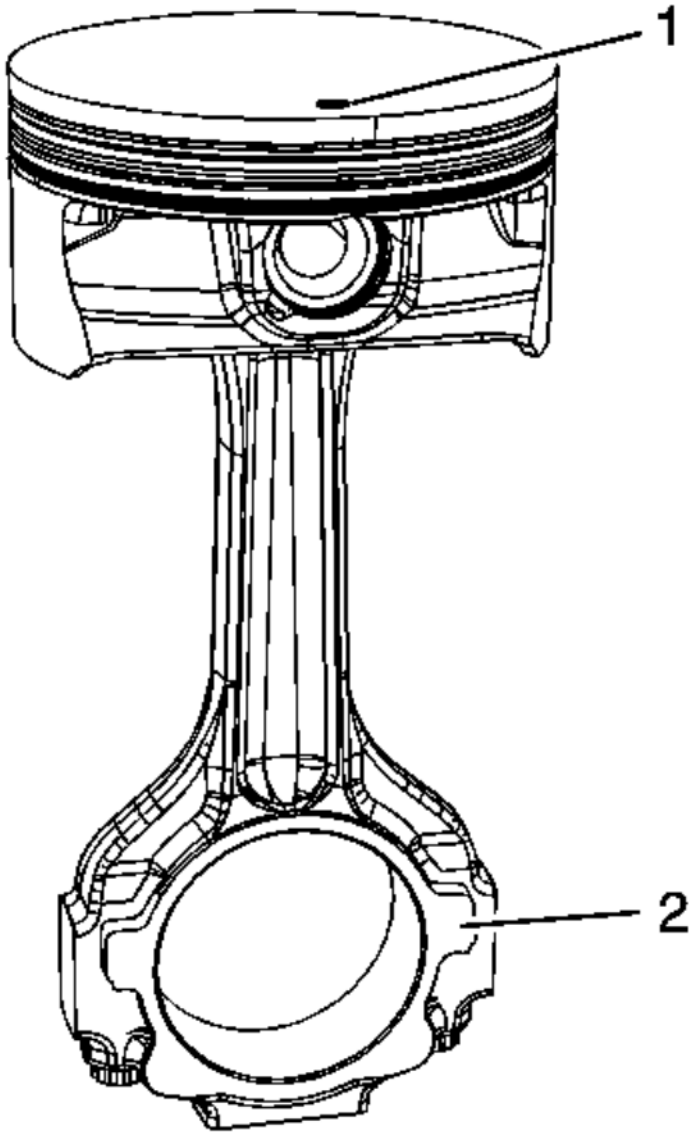

Fig. 438: Locating Mark On Top Of Piston & Connecting Rod Tab
Courtesy of GENERAL MOTORS CORP.

2. Assemble the piston and connecting rod. The mark (1) on the top of the piston and the tab (2) on the side of the connecting rod should be facing the same direction.

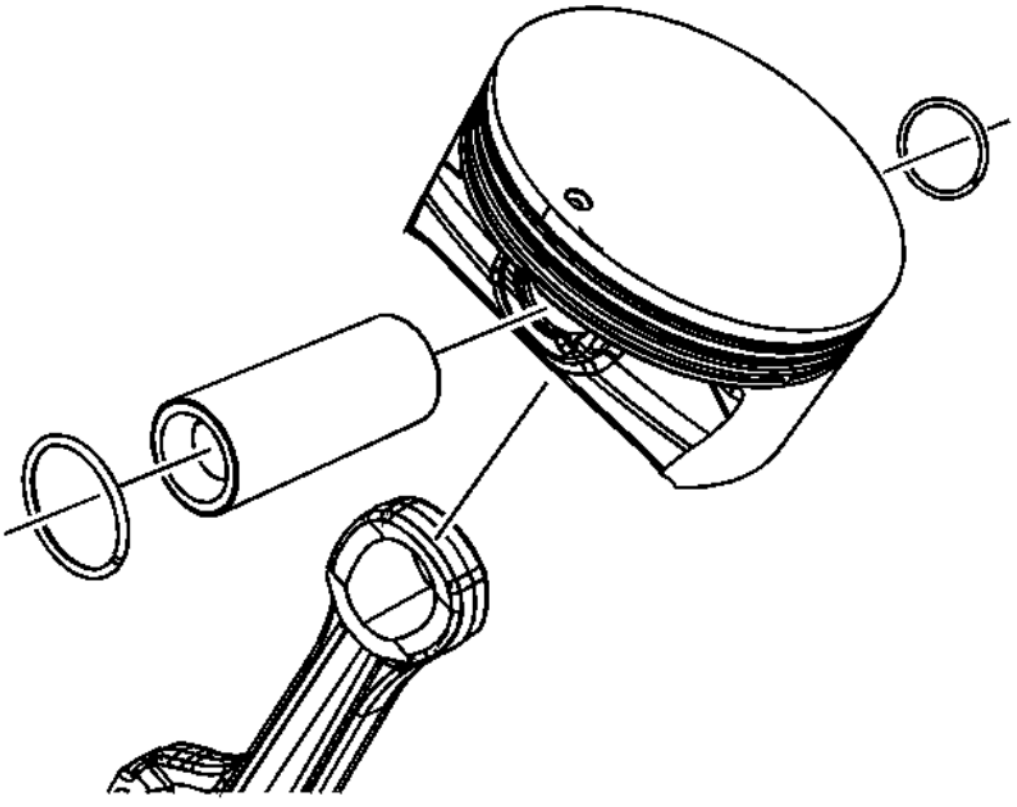

Fig. 439: Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Install the piston pin to the piston and connecting rod.
4. Install the retainers. The retainers should be seated in the groove of the pin bore.

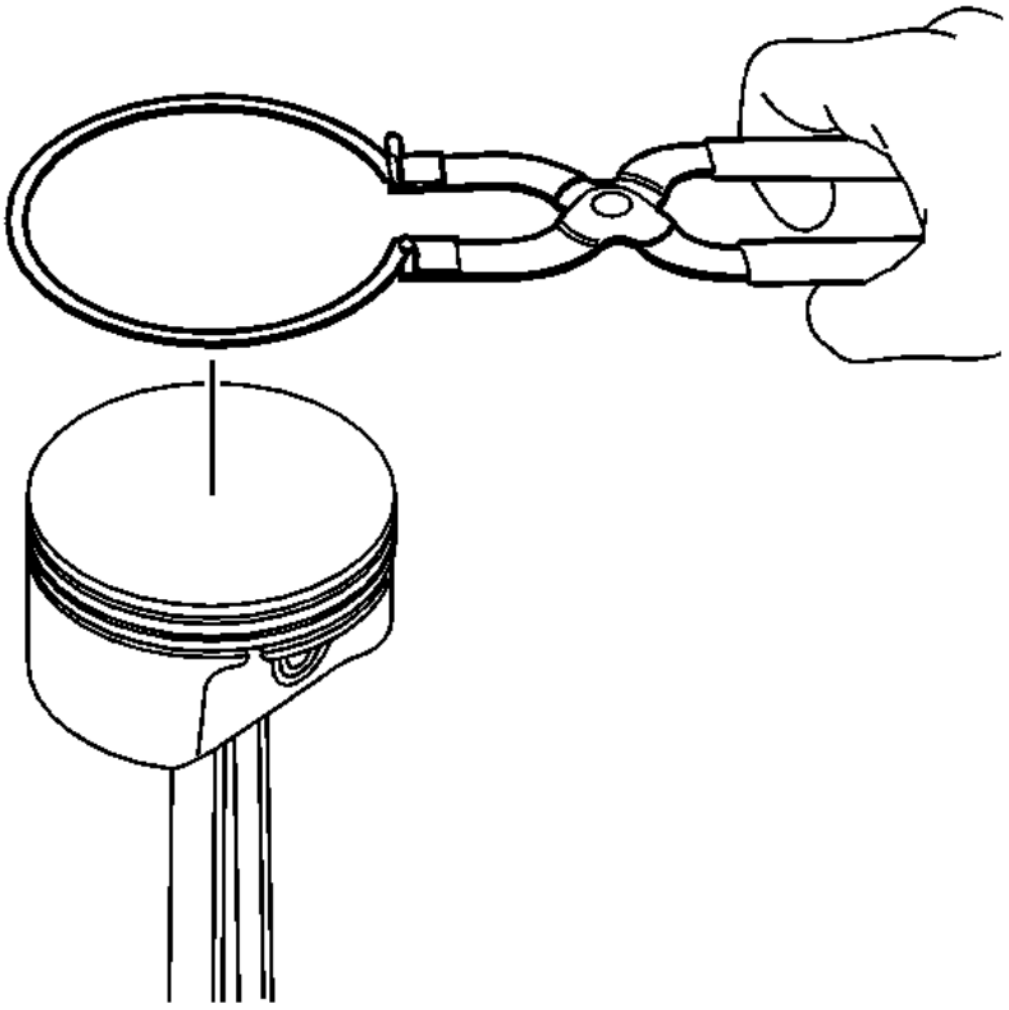

Fig. 440: View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

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. Using piston ring pliers, install the piston rings onto the piston. The dimple or mark on the piston ring should face the top of the piston. If no dimple or mark can be found on the top

compression ring, it may be installed in either direction.

6. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
7. Position the compression ring end gaps 180 degrees opposite each other.

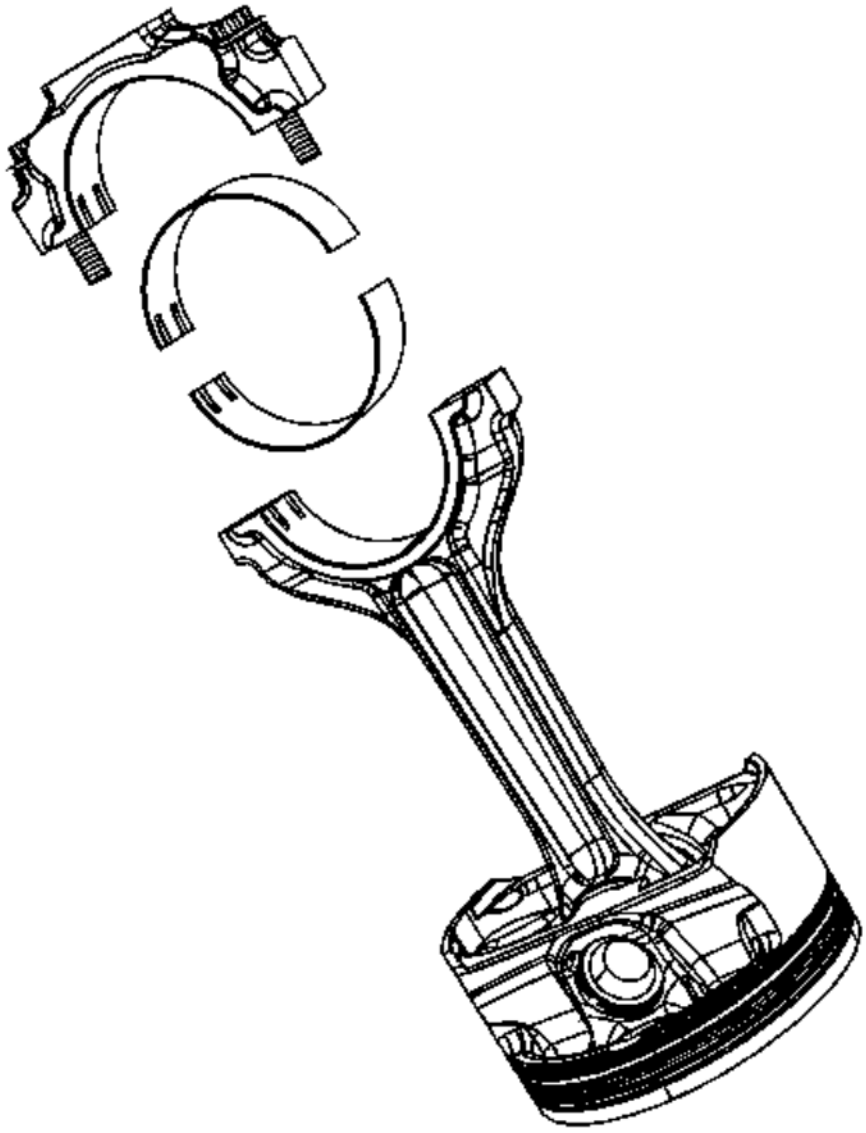

Fig. 441: View Of Piston, Connecting Rod & Bearing Assembly
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod bearings to the rod and cap.

CAMSHAFT BEARING REMOVAL

Tools Required

J 33049 Camshaft Bearing Service Set. See **Special Tools**.

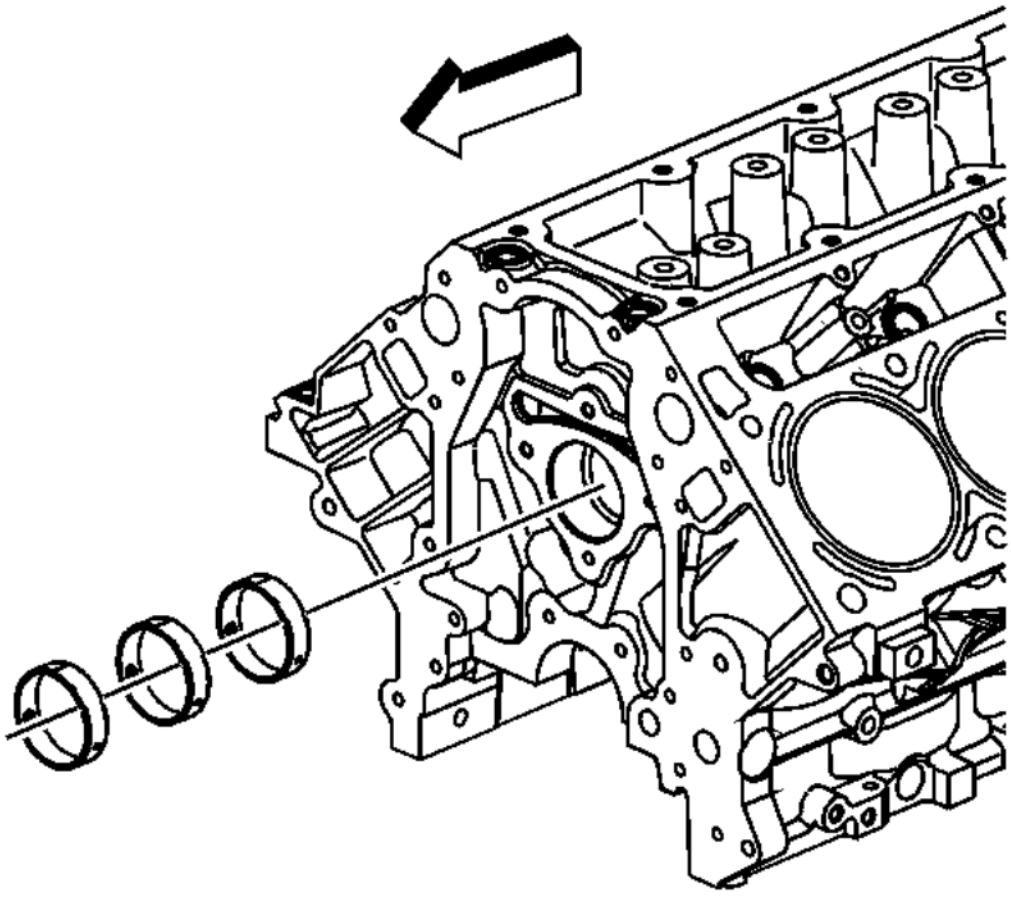

Fig. 442: Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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.

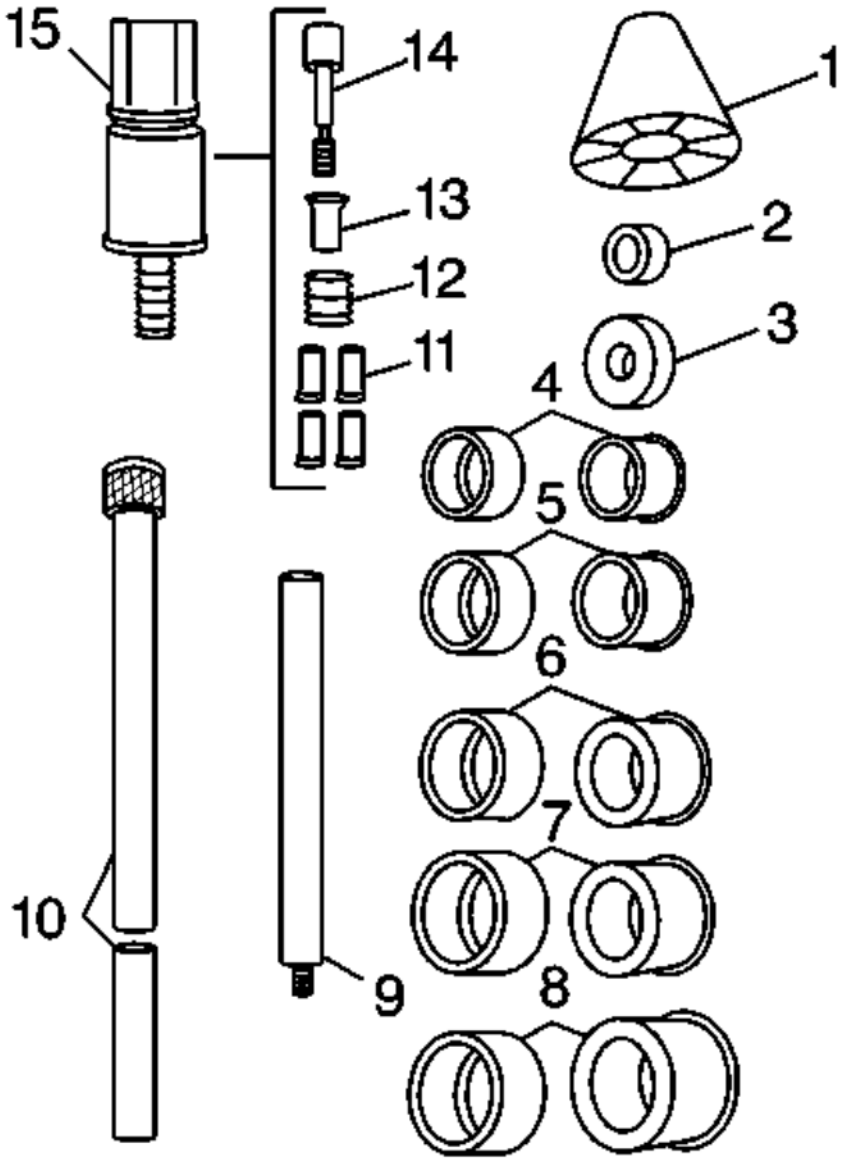

Fig. 443: View Of J 33049 Camshaft Bearing Service Kit Components

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.

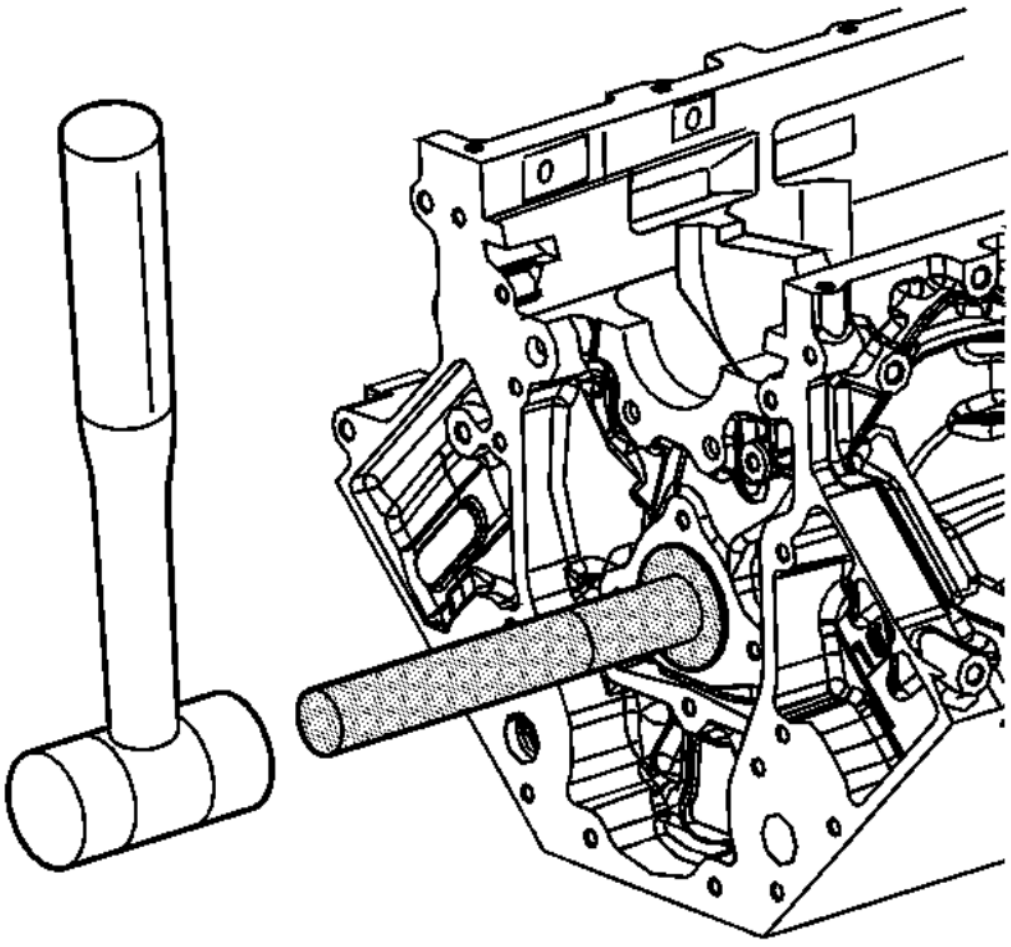

Fig. 444: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

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

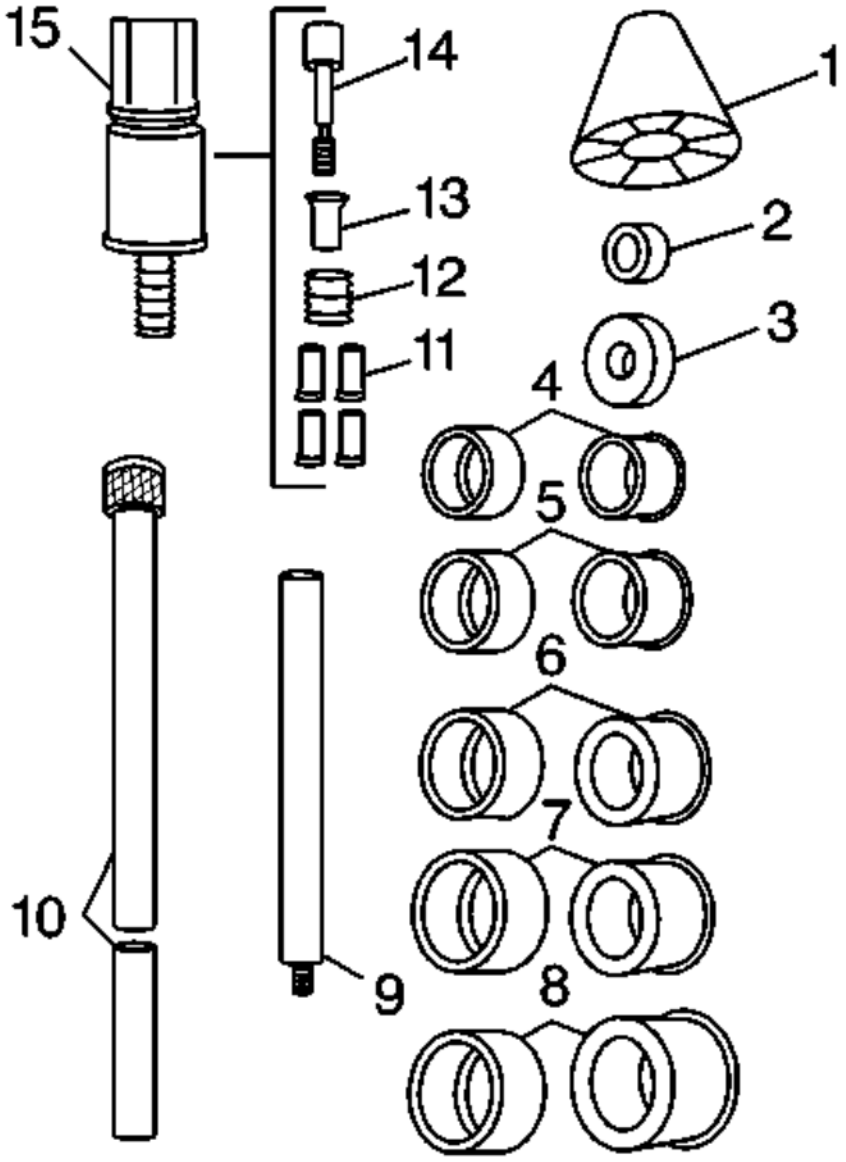

Fig. 445: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

- 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.

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.

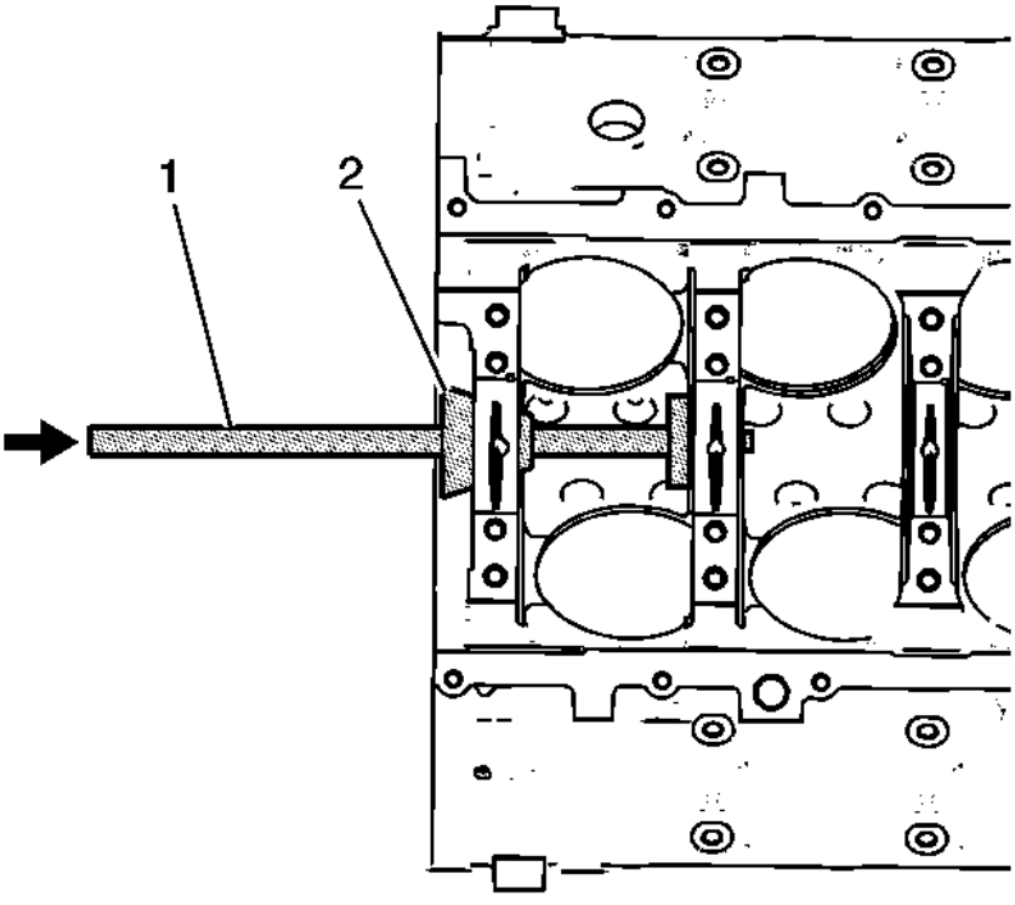

Fig. 446: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

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 (2) 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.

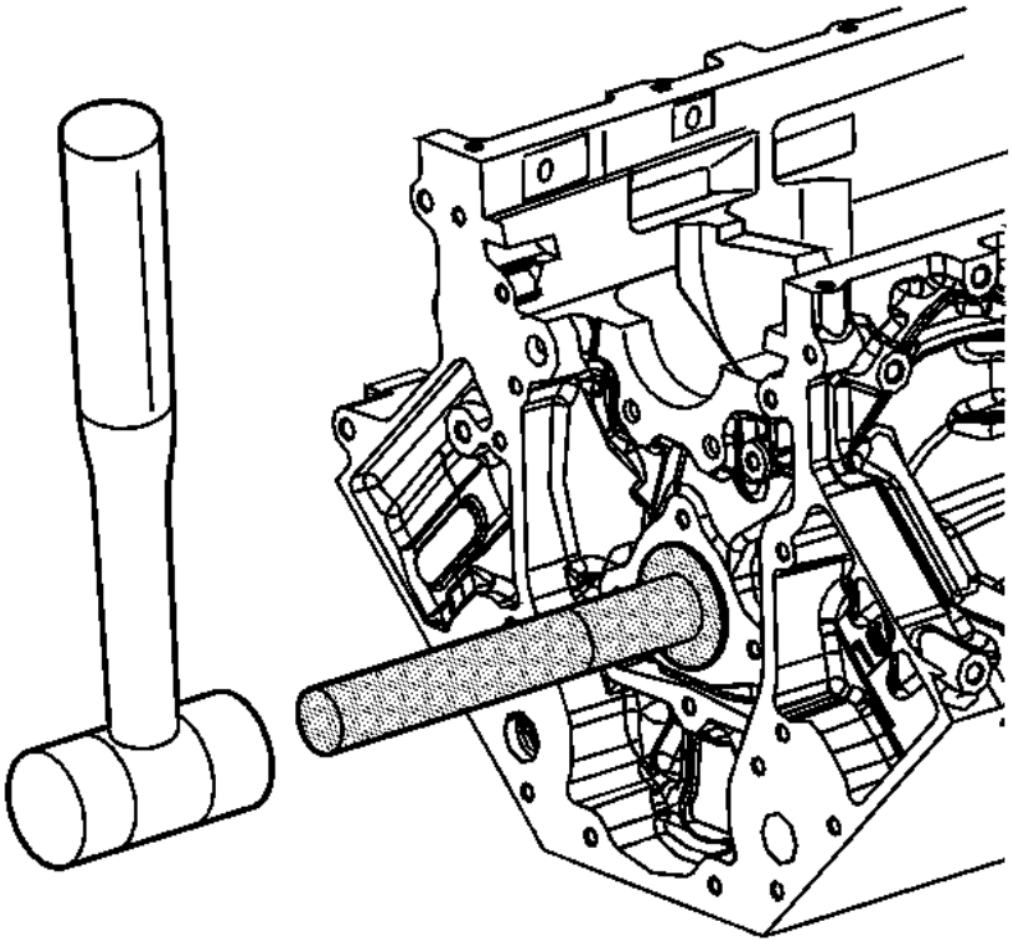

Fig. 447: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

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

- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Camshaft Lobe Lift Indicator. See **Special Tools**.

Cleaning and Inspection

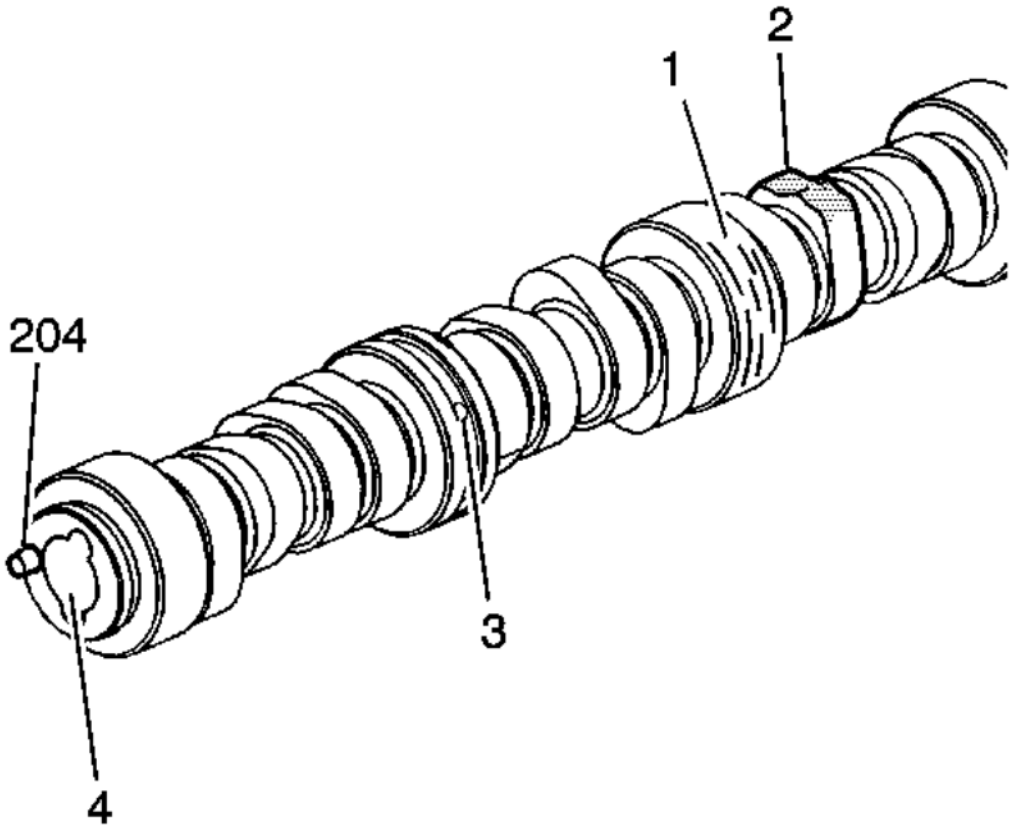

Fig. 448: View Of Camshaft Inspection Points
Courtesy of GENERAL MOTORS CORP.

1. Clean the components in solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

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 camshaft position (CMP) actuator oil passages (3) for restrictions.
6. Inspect the threaded bolt hole (4) in the front of the camshaft for damaged threads or debris.
7. Inspect the camshaft sprocket pin (204) for damage.
8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

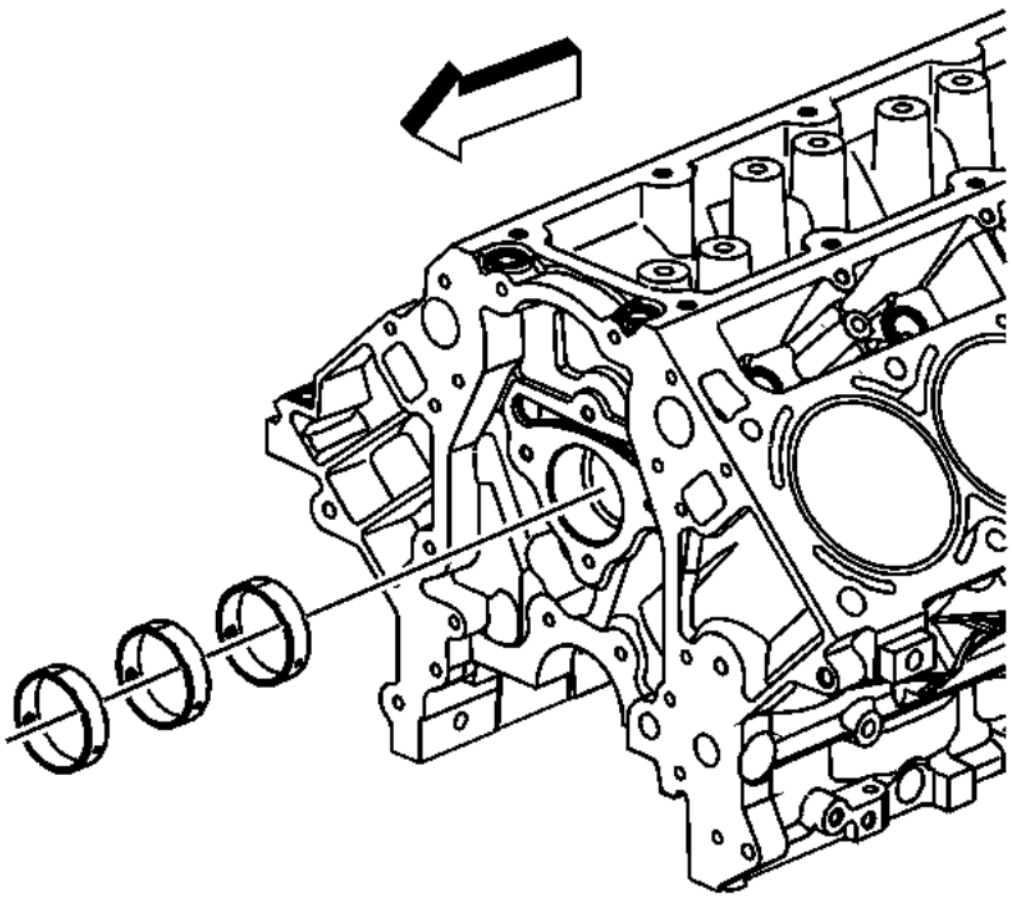

Fig. 449: Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

9. 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 the engine block bearing bores.
10. Inspect the camshaft bearings for excessive wear or scoring.

    Bearings with excessive scoring or wear must be replaced.

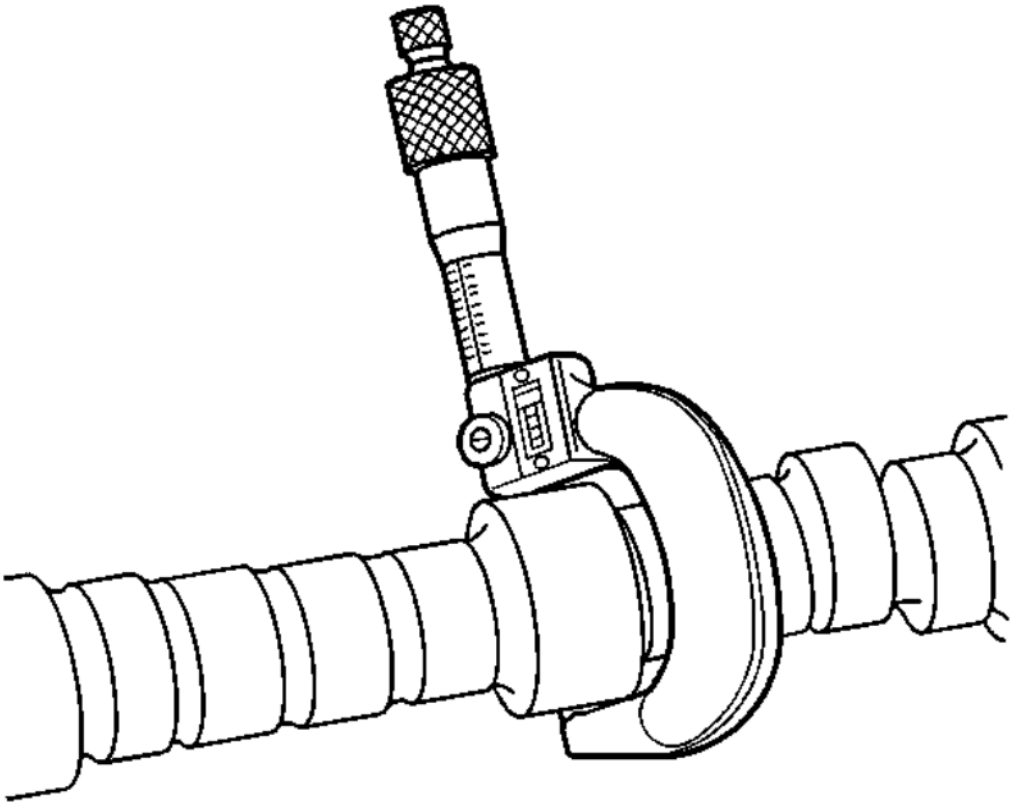

Fig. 450: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

11. Using a micrometer, measure the camshaft journals for wear and out-of-round.
    - If the camshaft bearing journals are greater than 0.025 mm (0.001 in) out-of-round, replace the camshaft.
    - If the camshaft bearing journal diameter is less than 54.99 mm (2.164 in), replace the

camshaft.

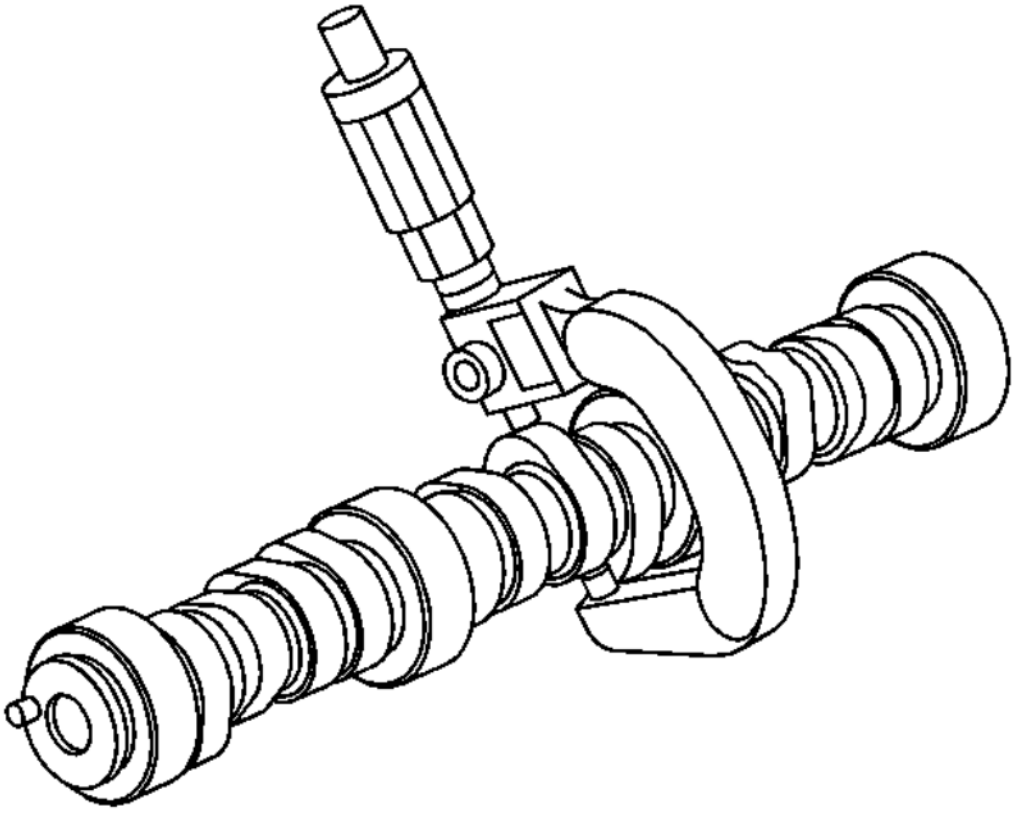

Fig. 451: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

12. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

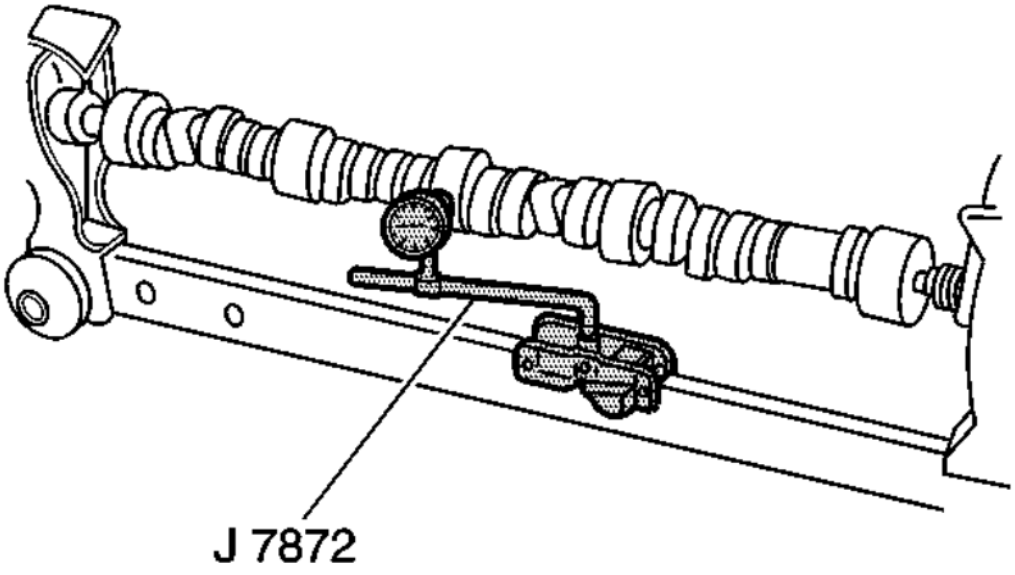

Fig. 452: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

13. 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

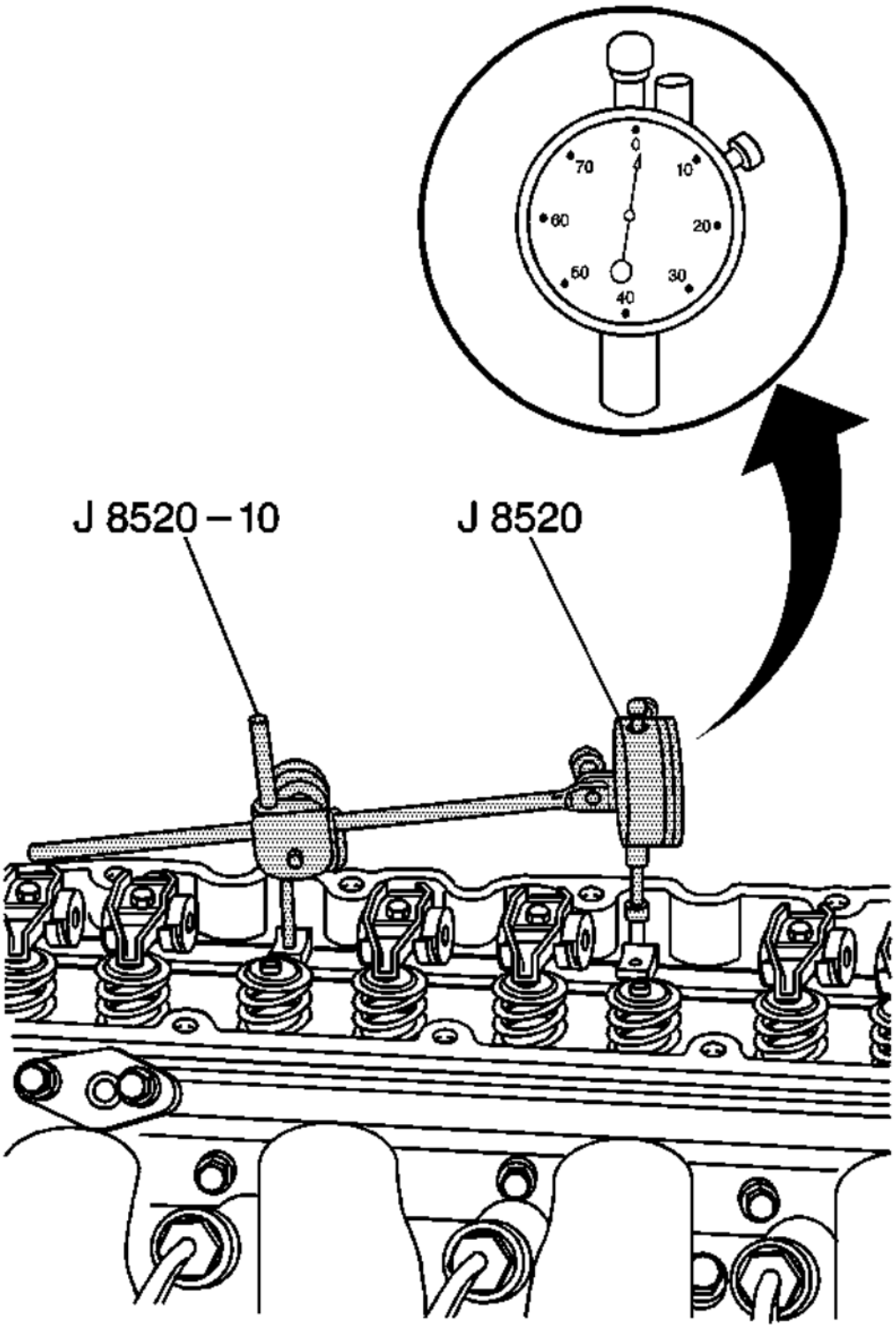
J 8520 – 10
J 8520
0
10
20
30
40
50
60
70

Fig. 453: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.

1. Using the **J 8520** , measure camshaft lobe lift. 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**.

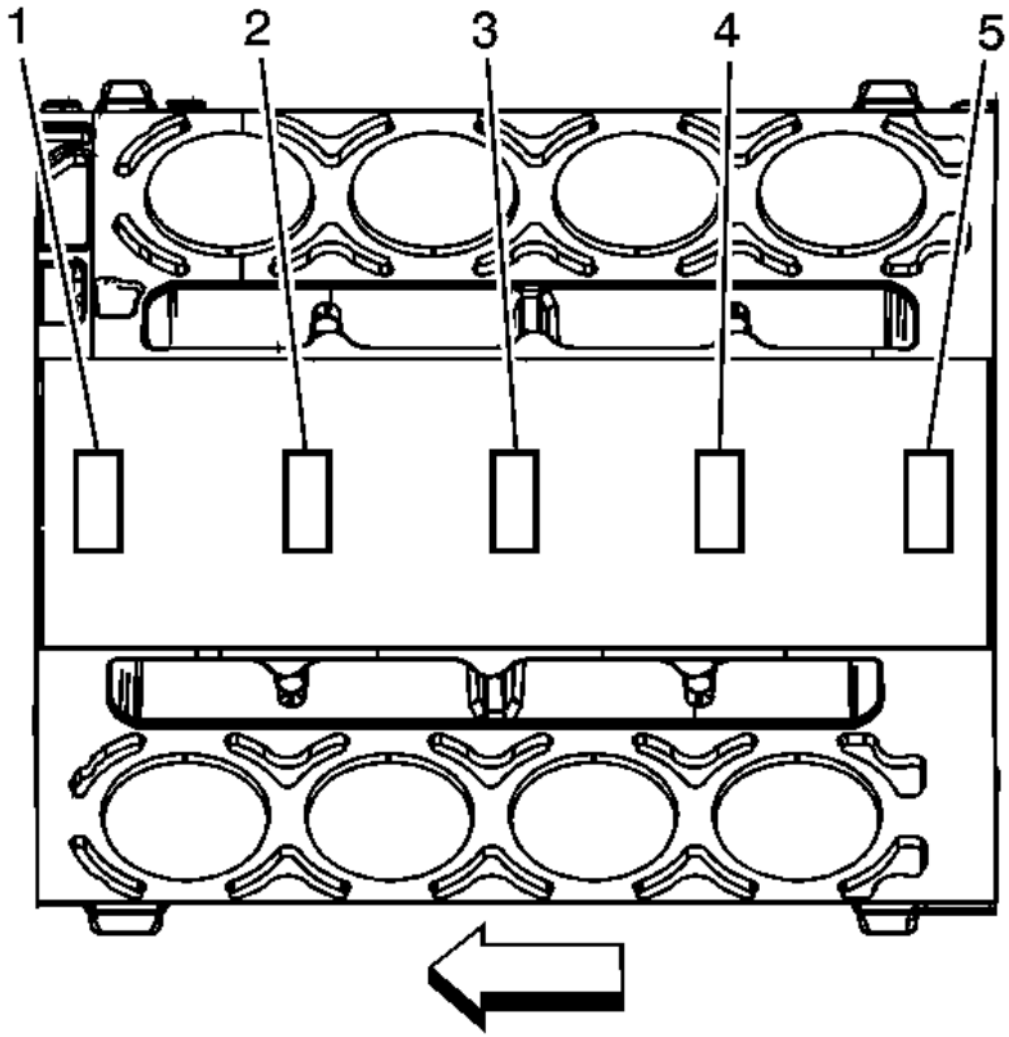

Fig. 454: Identifying Engine Block Camshaft Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine block camshaft bearing bores are machined for 3 different outside diameter (OD) size bearings. Position 1 and 5 are the largest 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**.

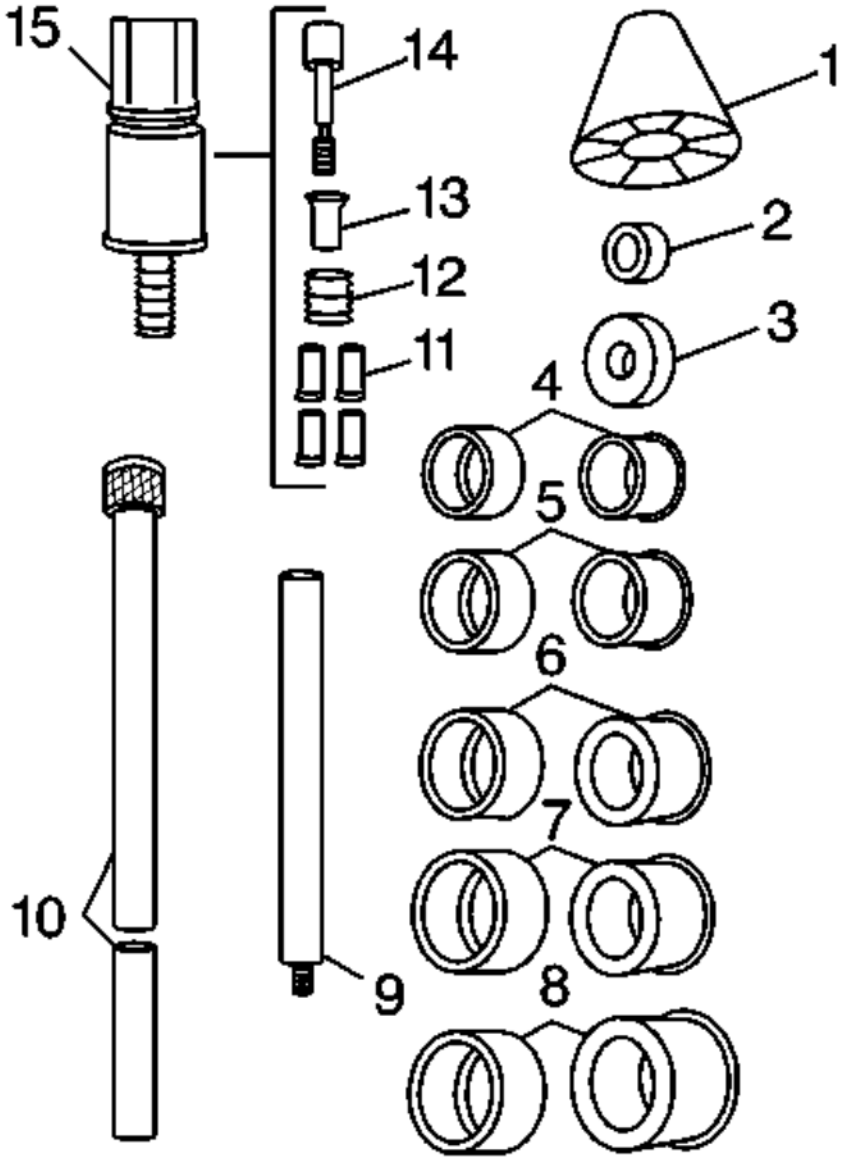

Fig. 455: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

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.

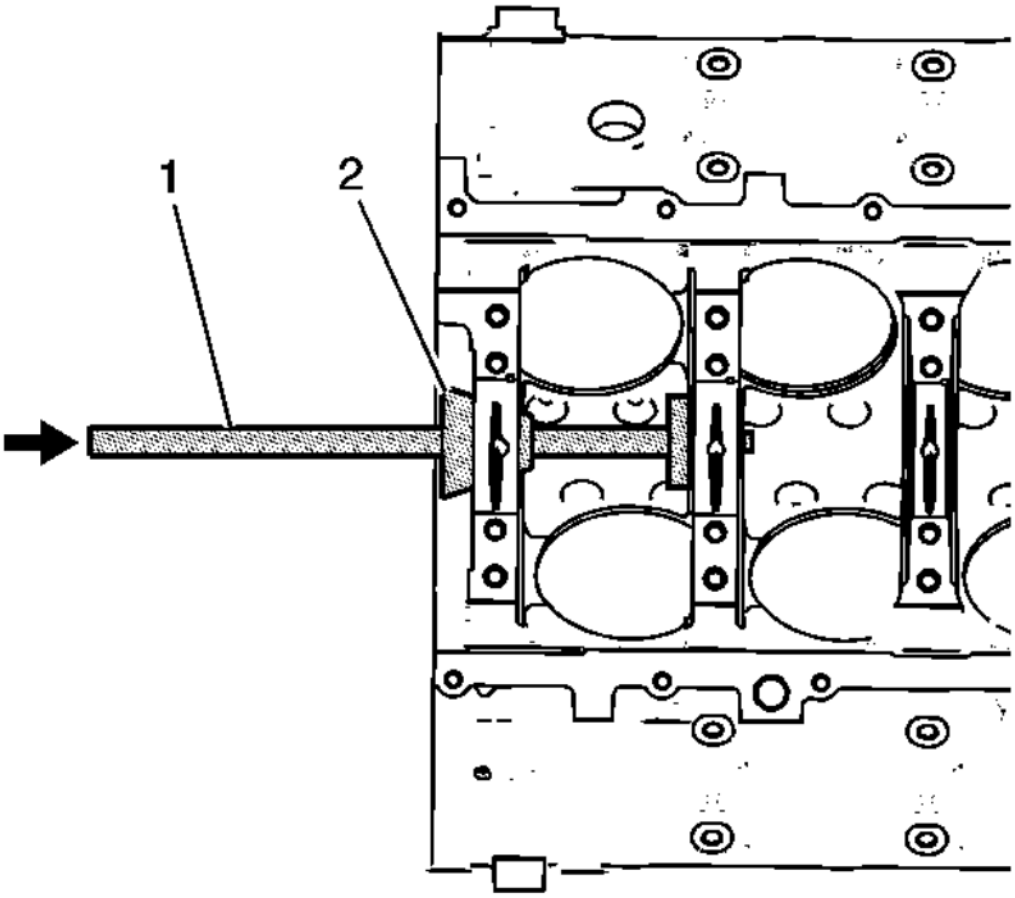

Fig. 456: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Insert the tool (1) through the front of the engine block and into the bearing.
5. Tighten the expander assembly nut until snug.
6. Push the guide cone (2) into the front camshaft bearing in order to align the tool.
7. Drive the bearing into the block bore.

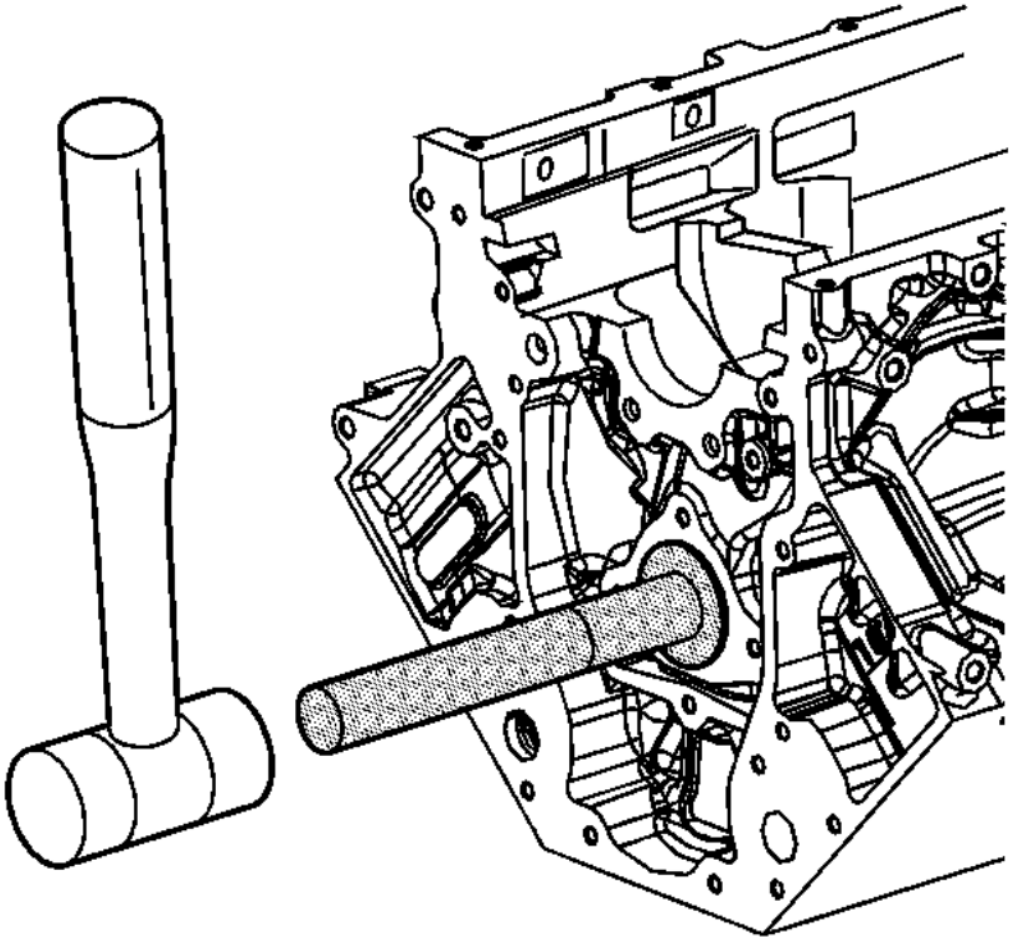

Fig. 457: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Install the front and rear bearings to the block.

Installation

CAMSHAFT POSITION ACTUATOR CLEANING AND INSPECTION

CAUTION: Refer to Camshaft Position Actuator Removal and Installation Caution .

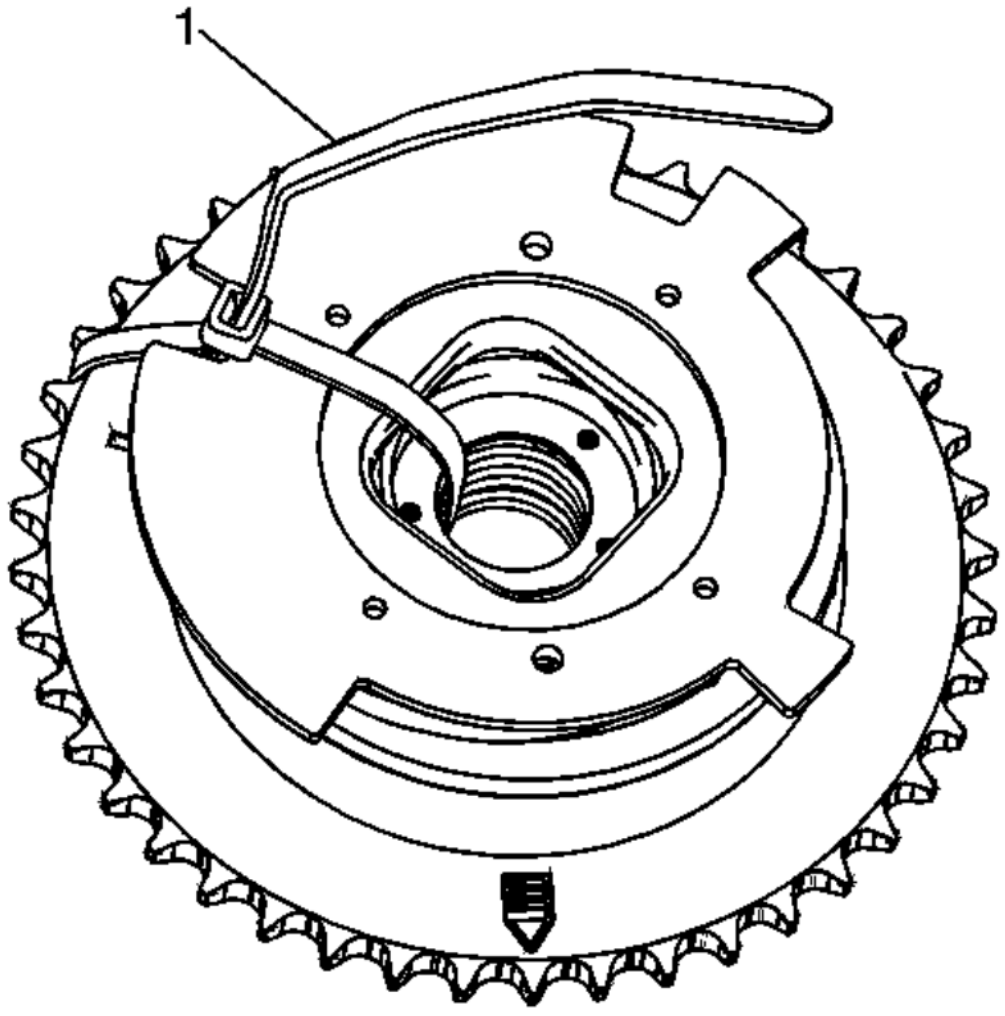

Fig. 458: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.

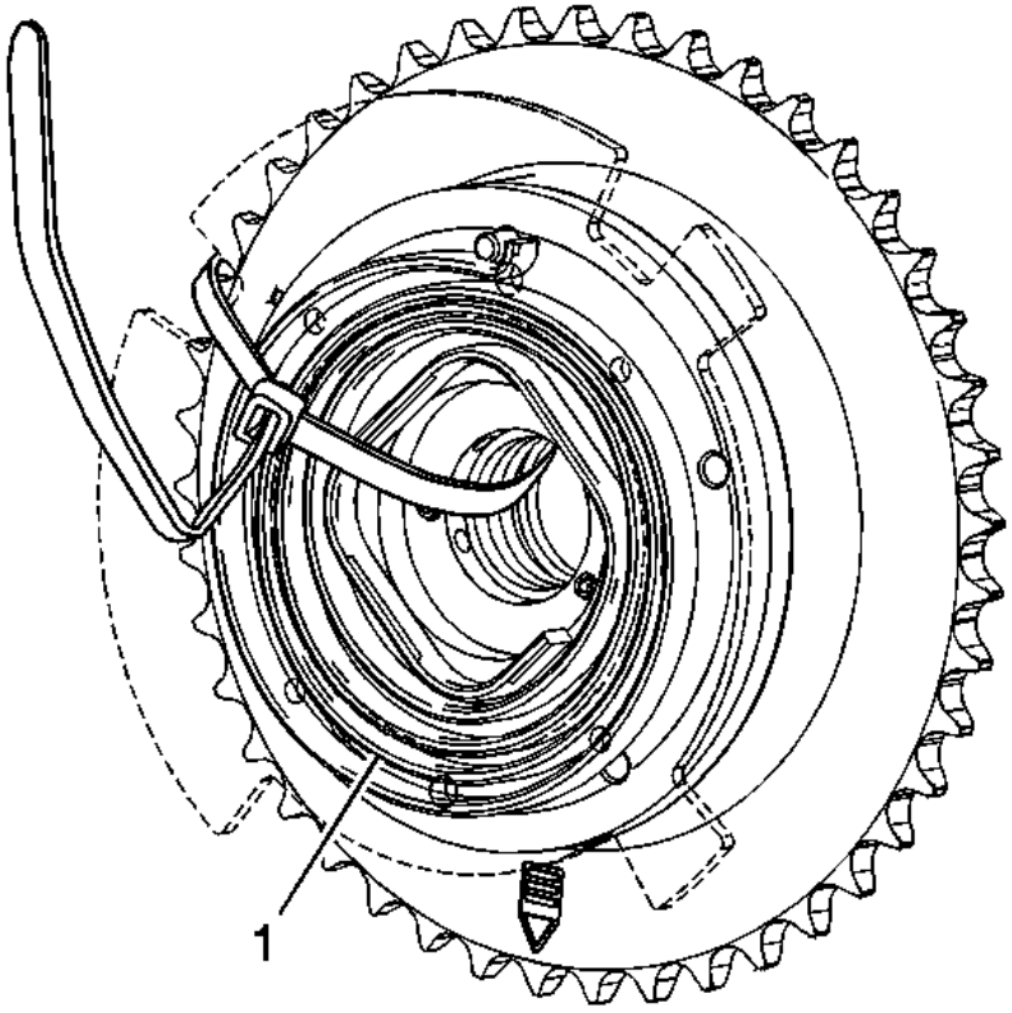

Fig. 459: Inspecting CMP Actuator For Broken Spring
Courtesy of GENERAL MOTORS CORP.

2. Clean the CMP actuator with cleaning solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).

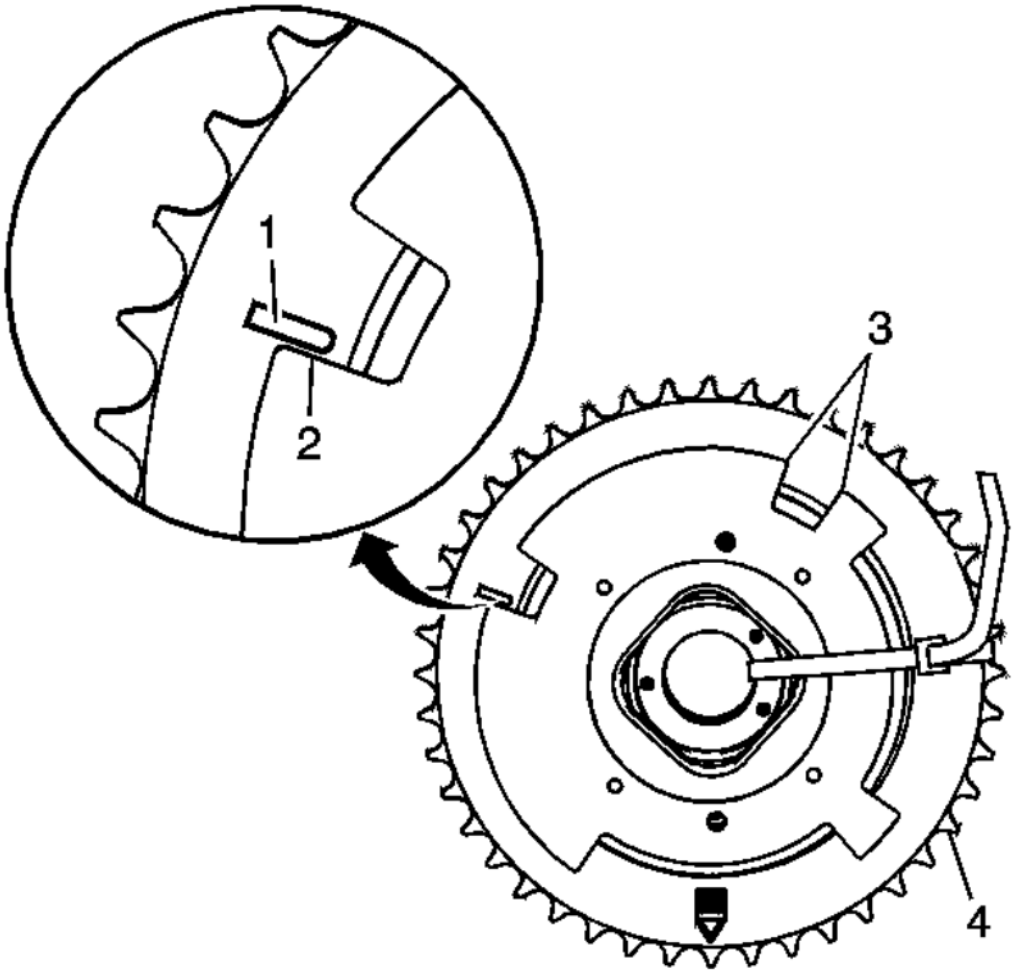

Fig. 460: CMP Actuator Inspection Points
Courtesy of GENERAL MOTORS CORP.

5. Inspect the CMP actuator for the following conditions:
    - Improper positioning of the CMP reluctor wheel. The actuator return spring should reposition the reluctor wheel to the PARK position. Inspect for proper alignment of the mark on the face of the sprocket (1) with the flat edge of the reluctor wheel (2). If the reluctor wheel is not properly positioned, the internal components of the actuator are sticking or the return spring is broken and the actuator should be replaced as an assembly.
    - Nicked or damaged edges (3) on the CMP reluctor wheel

- Damaged timing chain teeth (4)

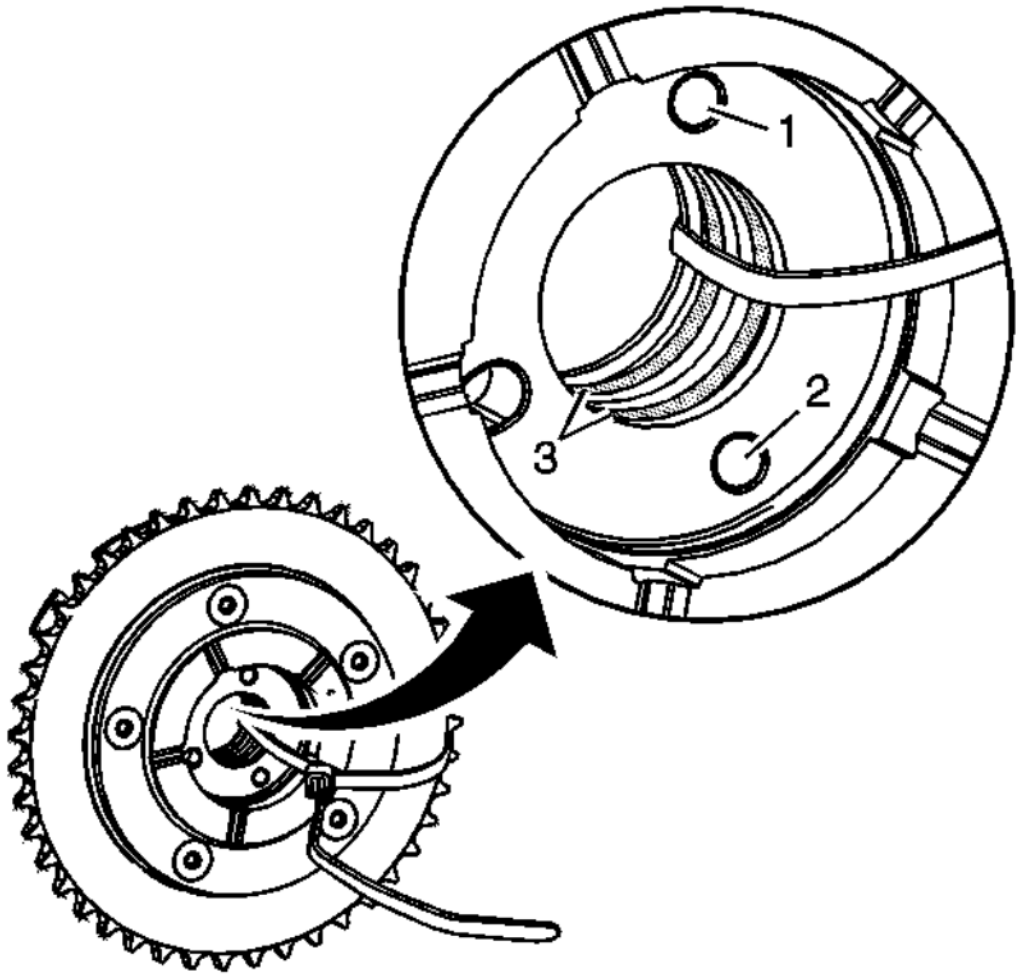

Fig. 461: View Of Oil Passages
Courtesy of GENERAL MOTORS CORP.

6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).

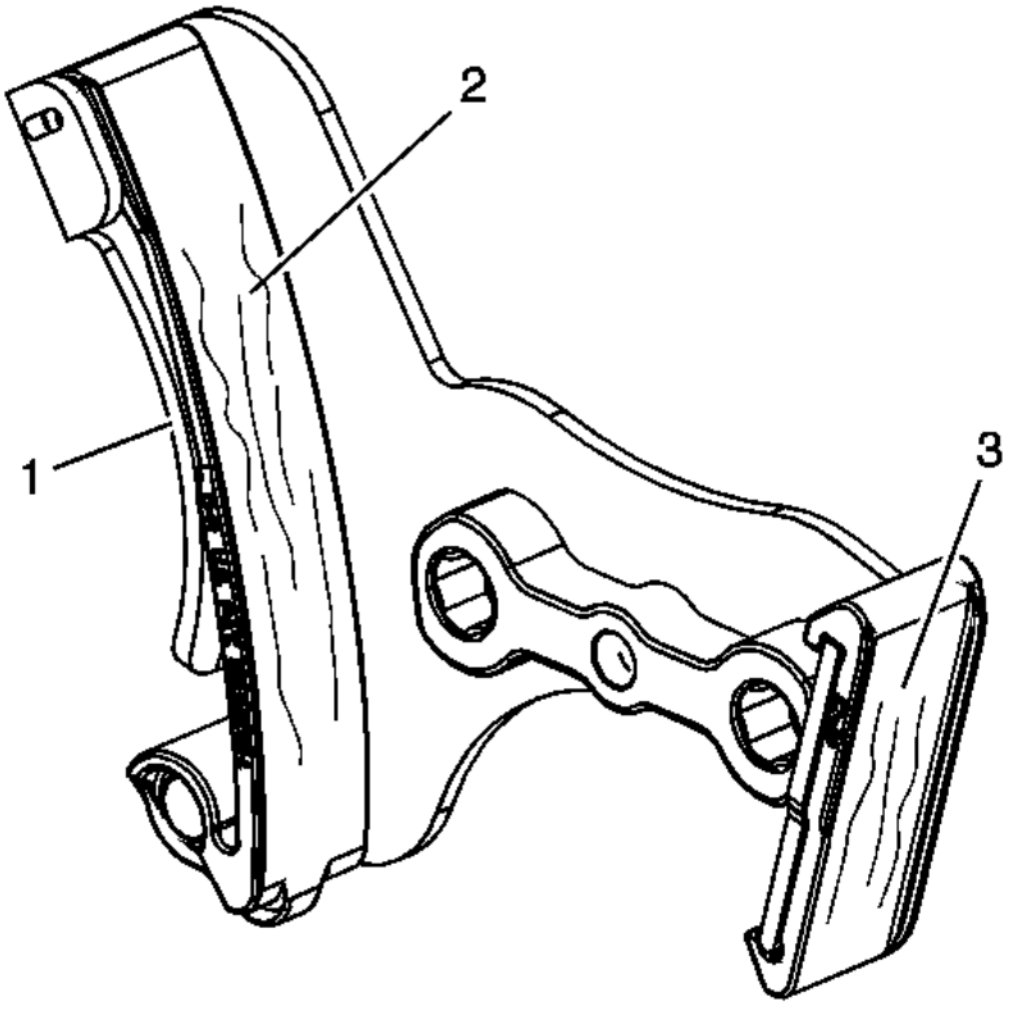

Fig. 462: Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS CORP.

7. Inspect the timing chain tensioner for the following conditions:
    - Damaged or broken tension spring (1)
    - Excessive wear or scoring on the chain guide surfaces (2, 3)

CAMSHAFT POSITION ACTUATOR MAGNET CLEANING AND INSPECTION

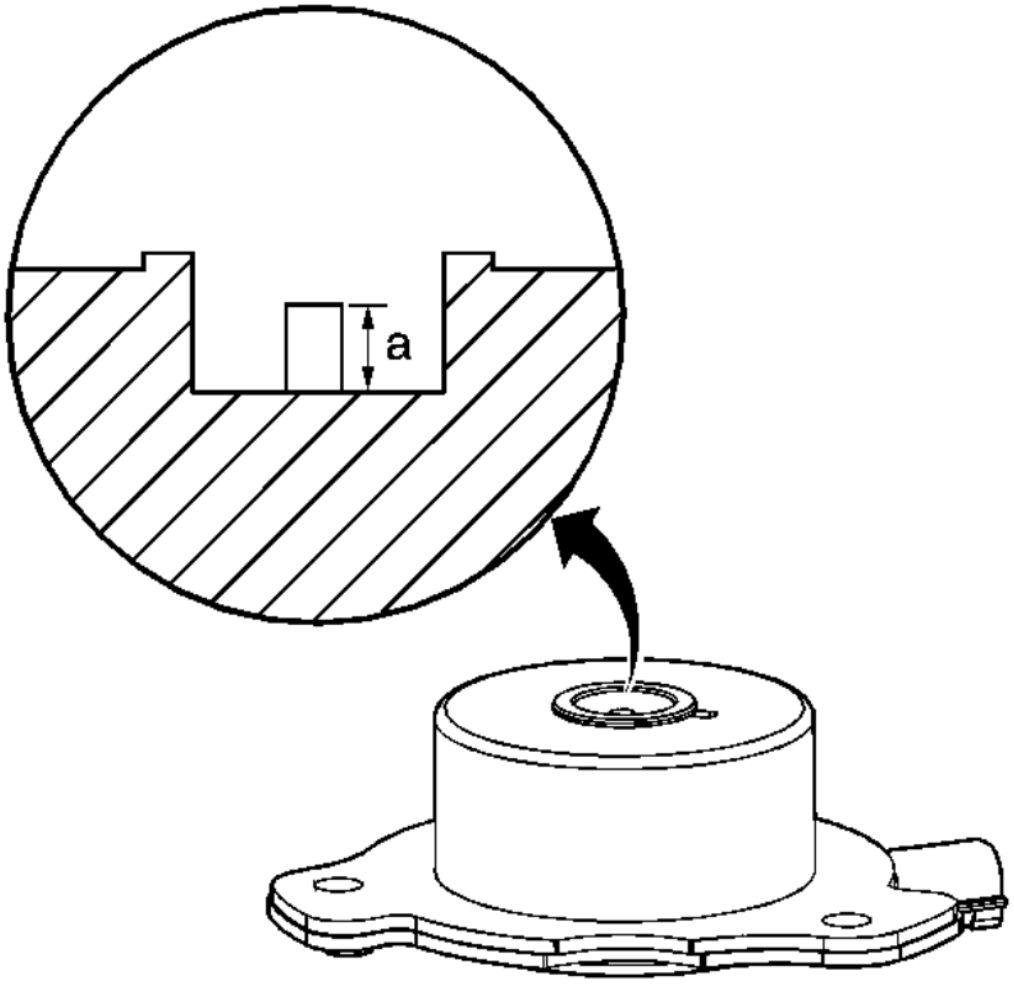

Fig. 463: Measuring The Retracted Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not energize the camshaft position (CMP) magnet using a 12-volt power supply.

1. Inspect the CMP magnet for the following conditions:
   - A damaged electrical connector
   - An accumulation of dirt or debris in the recessed area around the pintle
   - A build-up of burnt engine oil on the shaft of the pintle which may cause the pintle to

stick and not move freely within the proper range of travel

2. Holding the CMP magnet with the pintle facing upward, measure the pintle retracted position (a). Record the dimension.

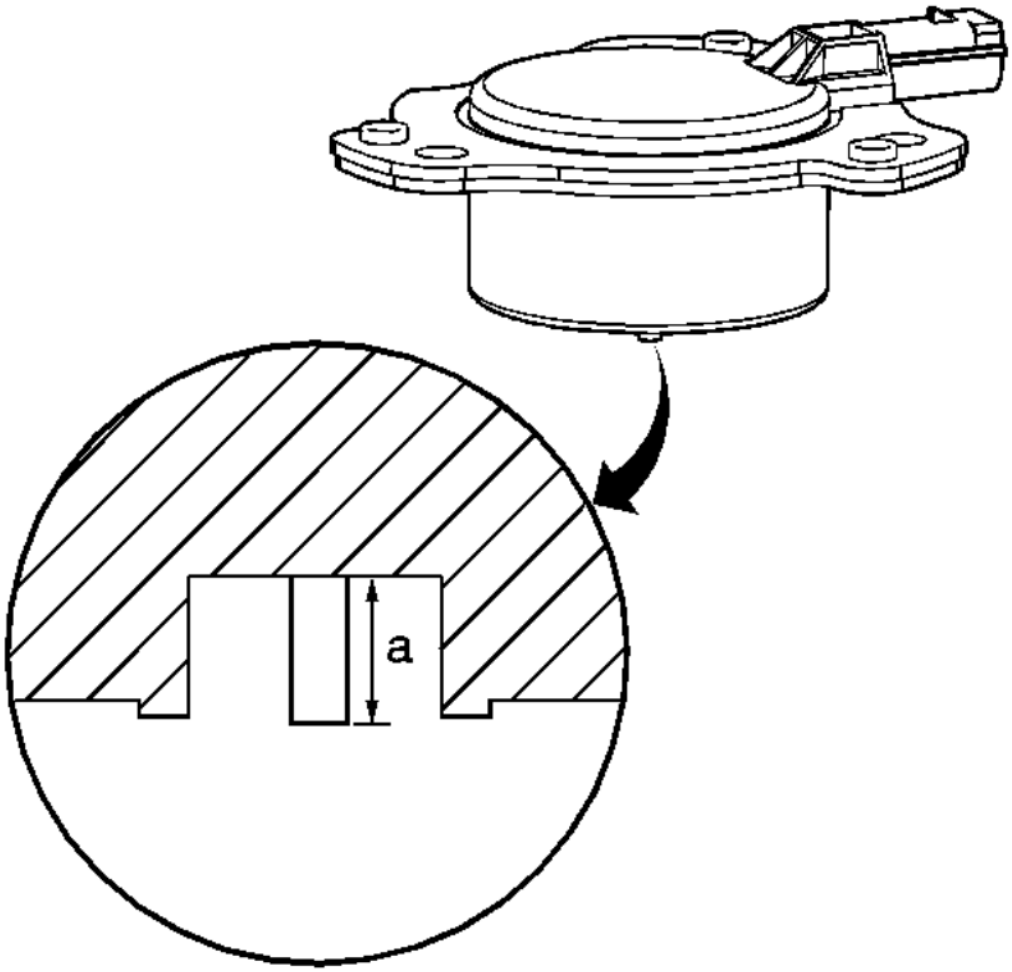

Fig. 464: Measuring The Pintle Extended Position
Courtesy of GENERAL MOTORS CORP.

3. Holding the CMP magnet with the pintle facing downward, measure the pintle extended position (a). Record the dimension.
4. Subtract the retracted dimension from the extended dimension to determine pintle travel. A properly moving pintle will travel 3.0-5.5 mm (0.12-0.22 in).

5. If the pintle of the CMP magnet is binding or does not move within the proper range of travel, replace the CMP magnet as an assembly.

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSPECTION (ON-VEHICLE)

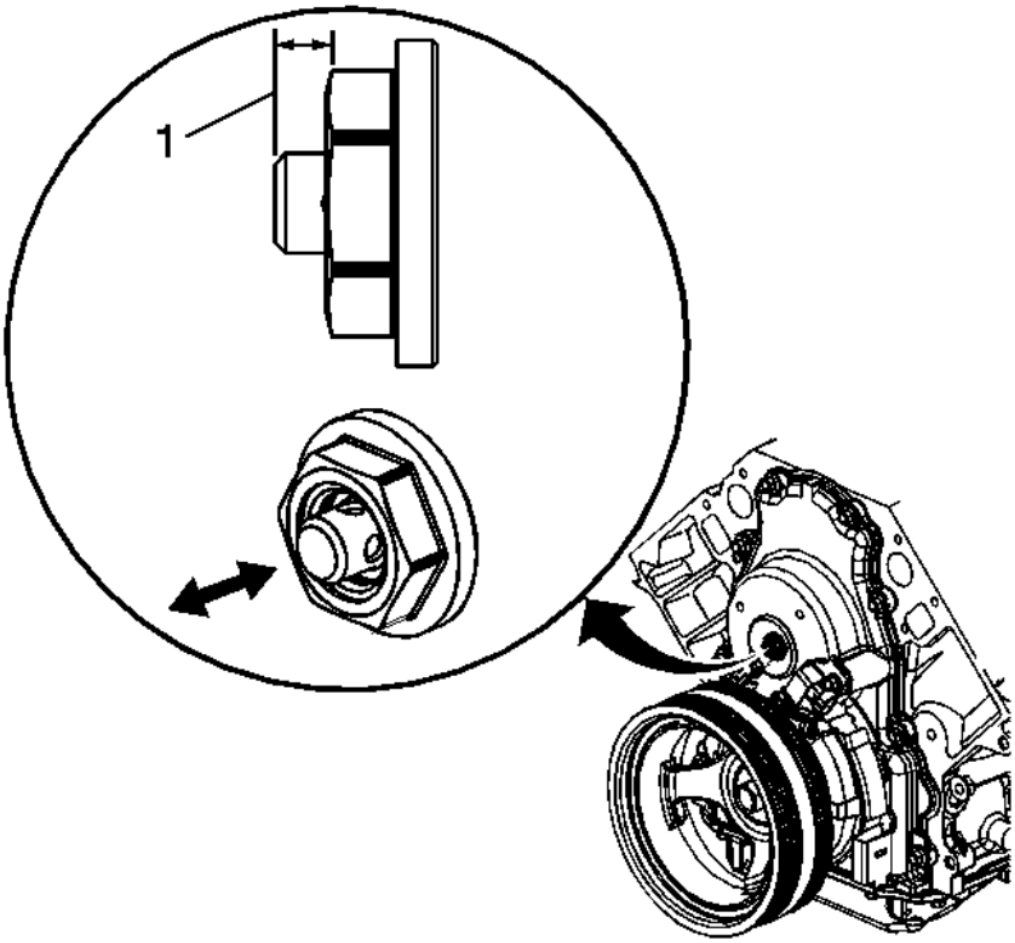

Fig. 465: View Of Proper Valve Spool Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for on-vehicle diagnostic purposes only.

1. With the CMP magnet removed, inspect for a sticking valve spool or broken valve spool spring.
2. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08-6.12 mm (0.239-0.241 in).

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSPECTION (OFF-VEHICLE)

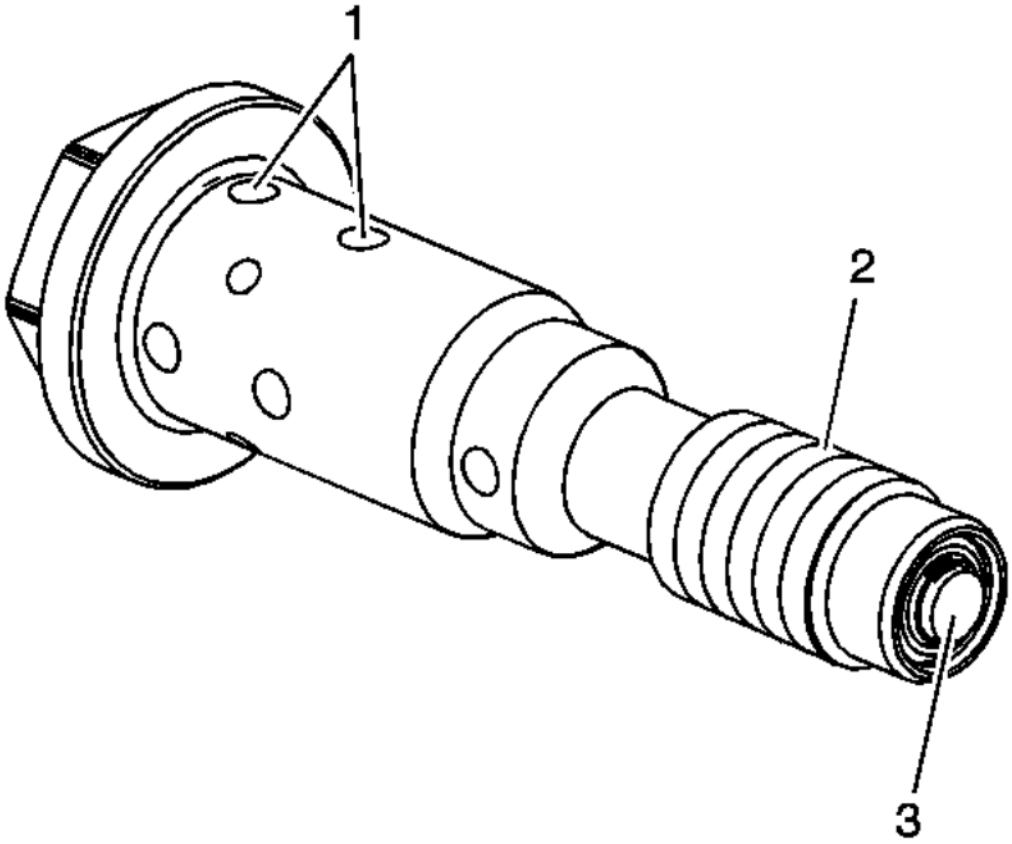

Fig. 466: View Of CMP Inspection Points
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for off-vehicle

diagnostic purposes only.

1. Inspect the CMP valve for the following conditions:
   - Dirt, debris, or restrictions within the oil passages (1)
   - Damaged threads (2)

     If the threads of the valve are damaged, also inspect the threads in the front of the camshaft for damage.

   - Dirt, debris, or restrictions within the oil inlet check valve (3)

     If debris is detected, the engine assembly should be inspected to determine the source of contamination.

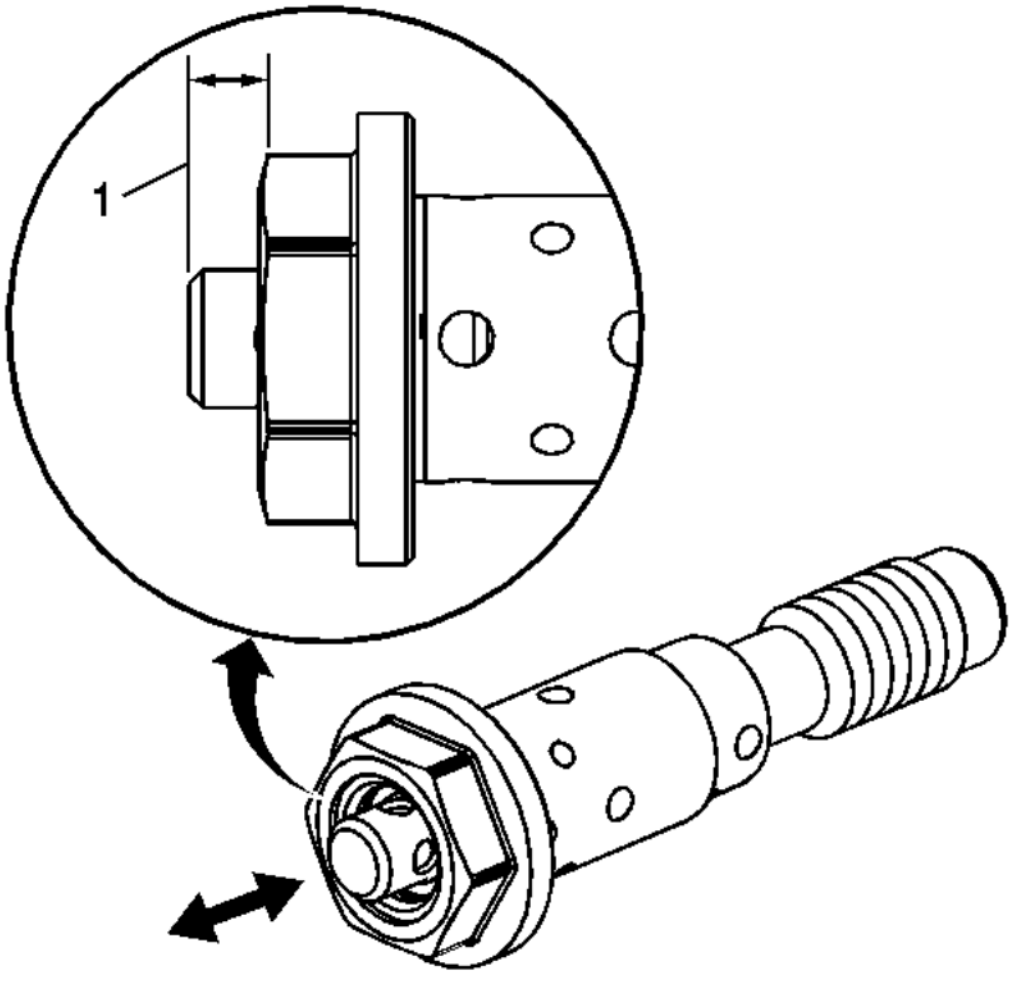

Fig. 467: View Of Proper Valve Spool Position
Courtesy of GENERAL MOTORS CORP.

2. Inspect for a sticking valve spool or broken valve spool spring.
3. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.08-6.12 mm (0.239-0.241 in).

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

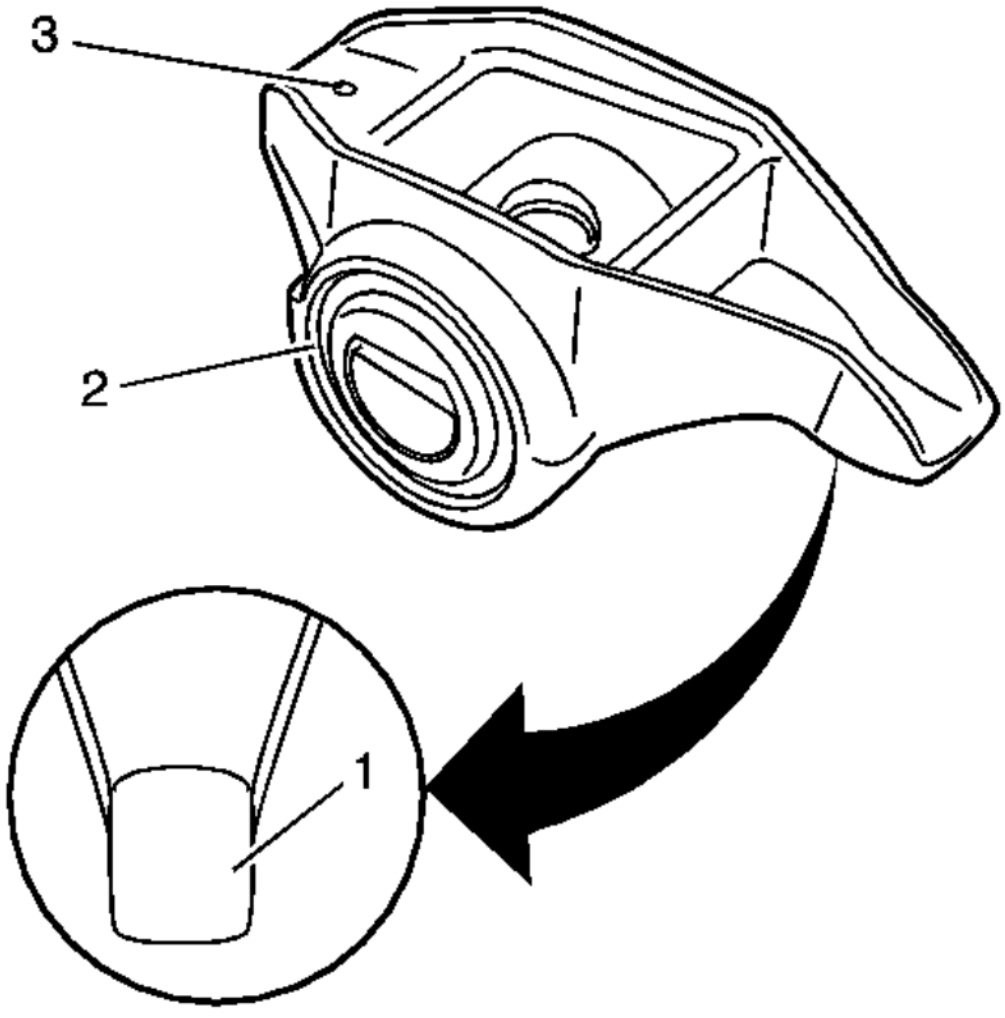

Fig. 468: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS CORP.

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 and Compressed Air Caution .

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

Valve Lifters

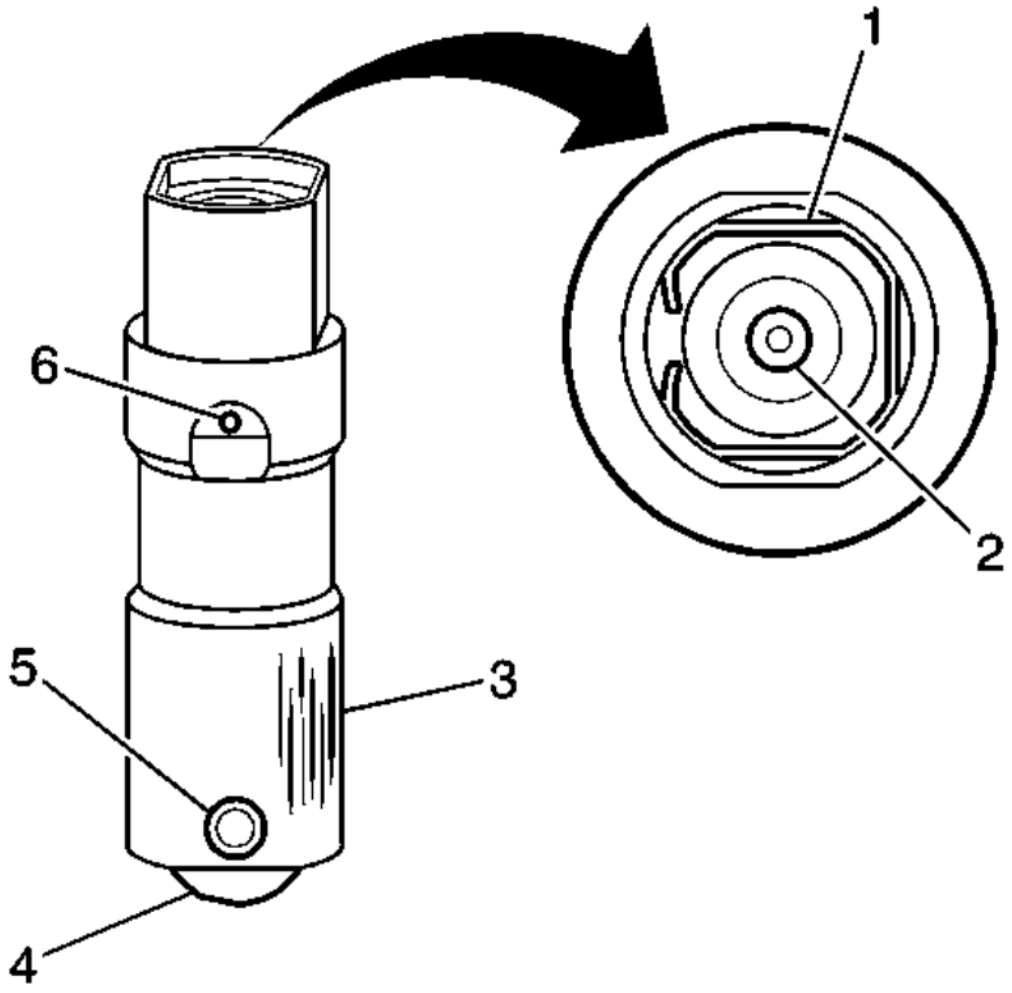

Fig. 469: Inspecting Areas Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

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 and Compressed Air Caution .

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.

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. See **Special Tools**.

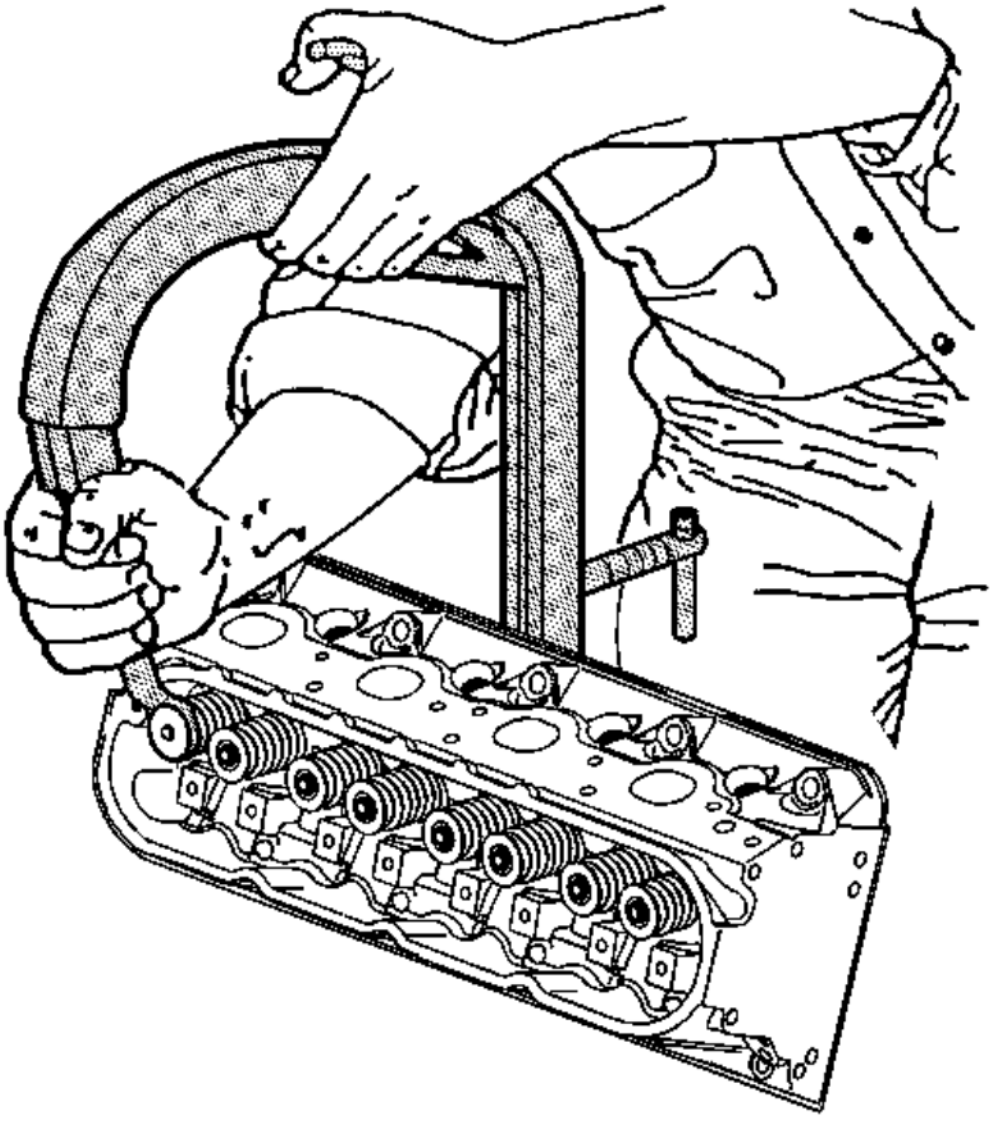

Fig. 470: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

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. See **Special Tools**.

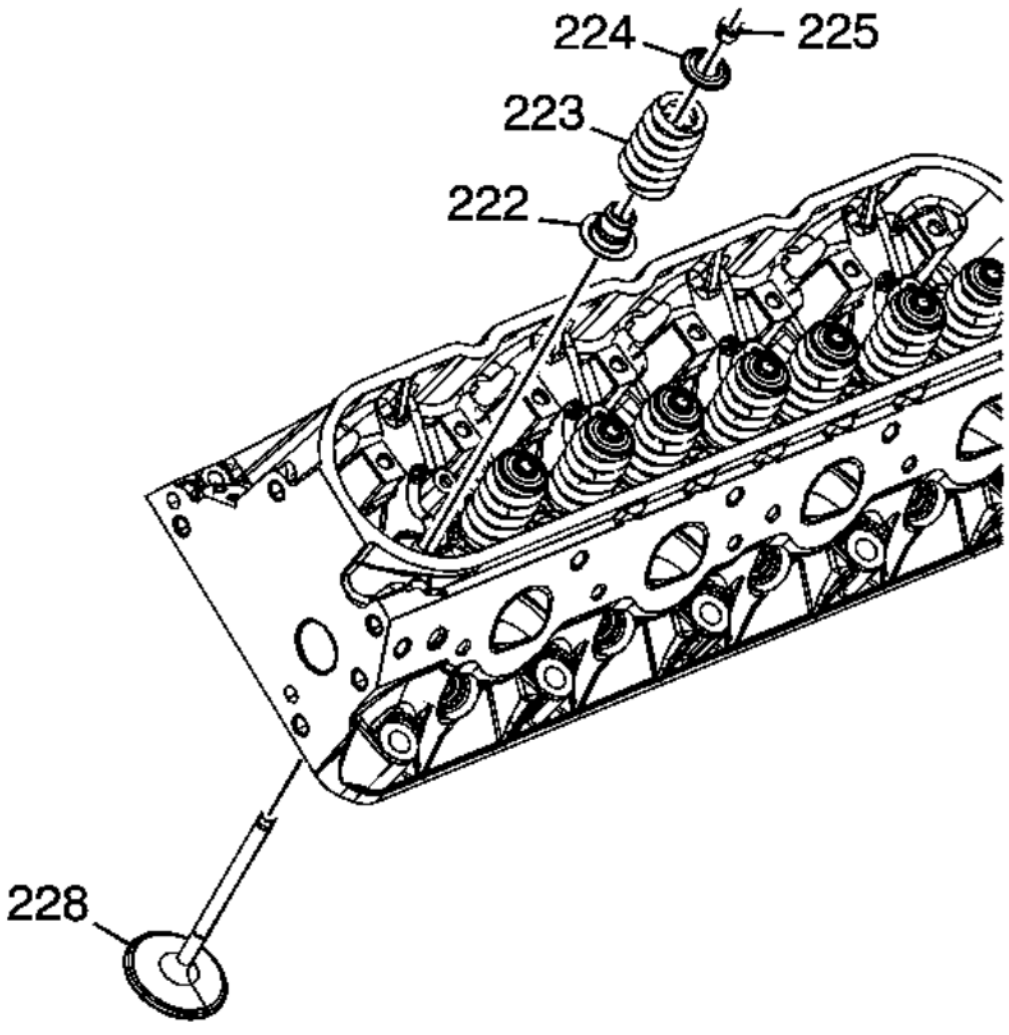

Fig. 471: Valve Stem Keys, Valve Spring Cap & Valve Spring
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve stem keys (225).
4. Remove the valve spring cap (224).
5. Remove the valve spring (223).
6. Remove the valves (228).
7. Remove the valve stem oil seal (222). Refer to **Separating Parts**.

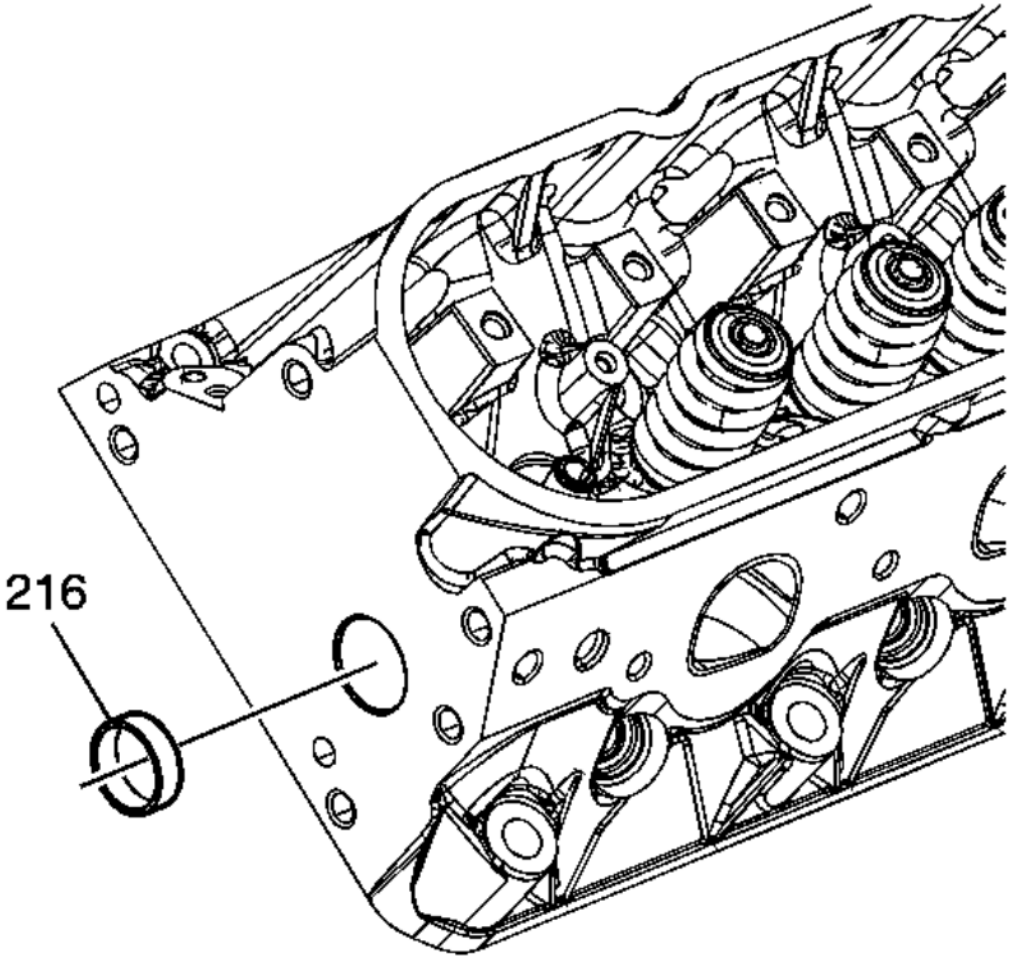

Fig. 472: Locating Cylinder Head Core Hole Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head core hole plugs (216), as required.

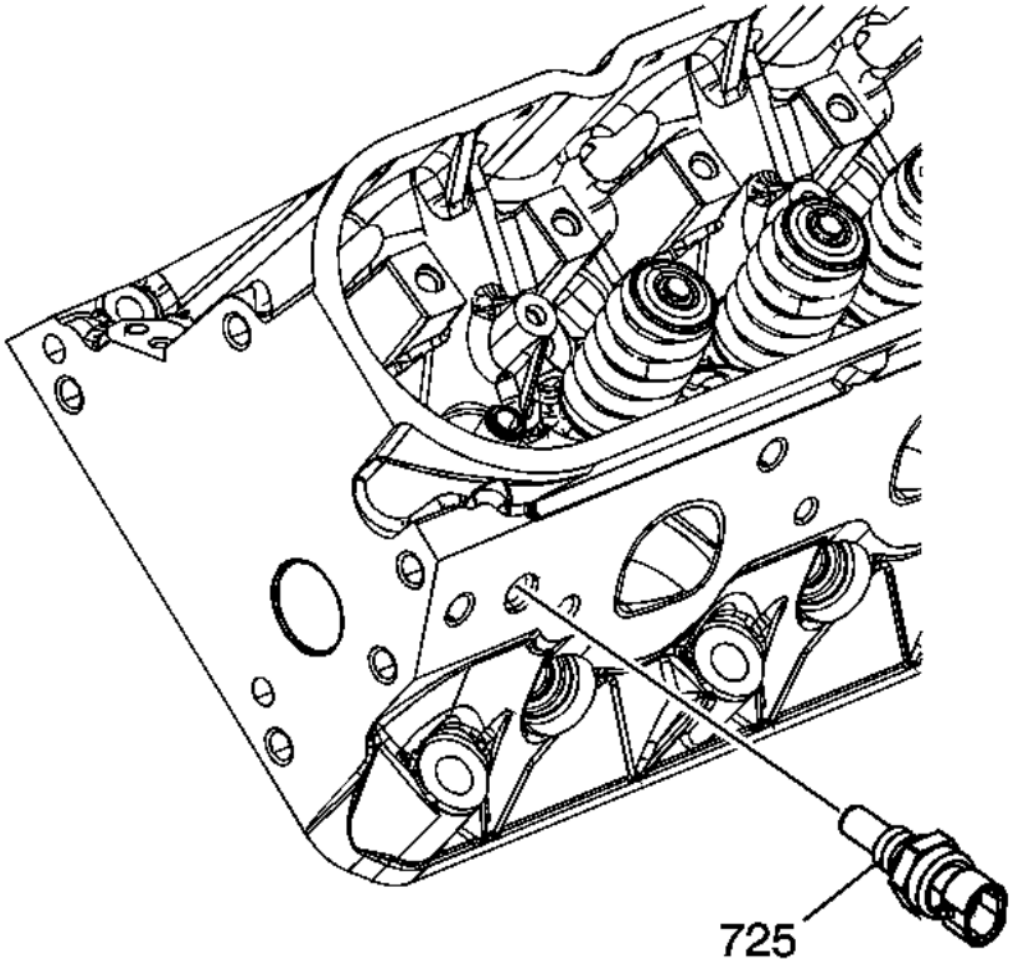

Fig. 473: Locating Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor (725) from the left cylinder head.

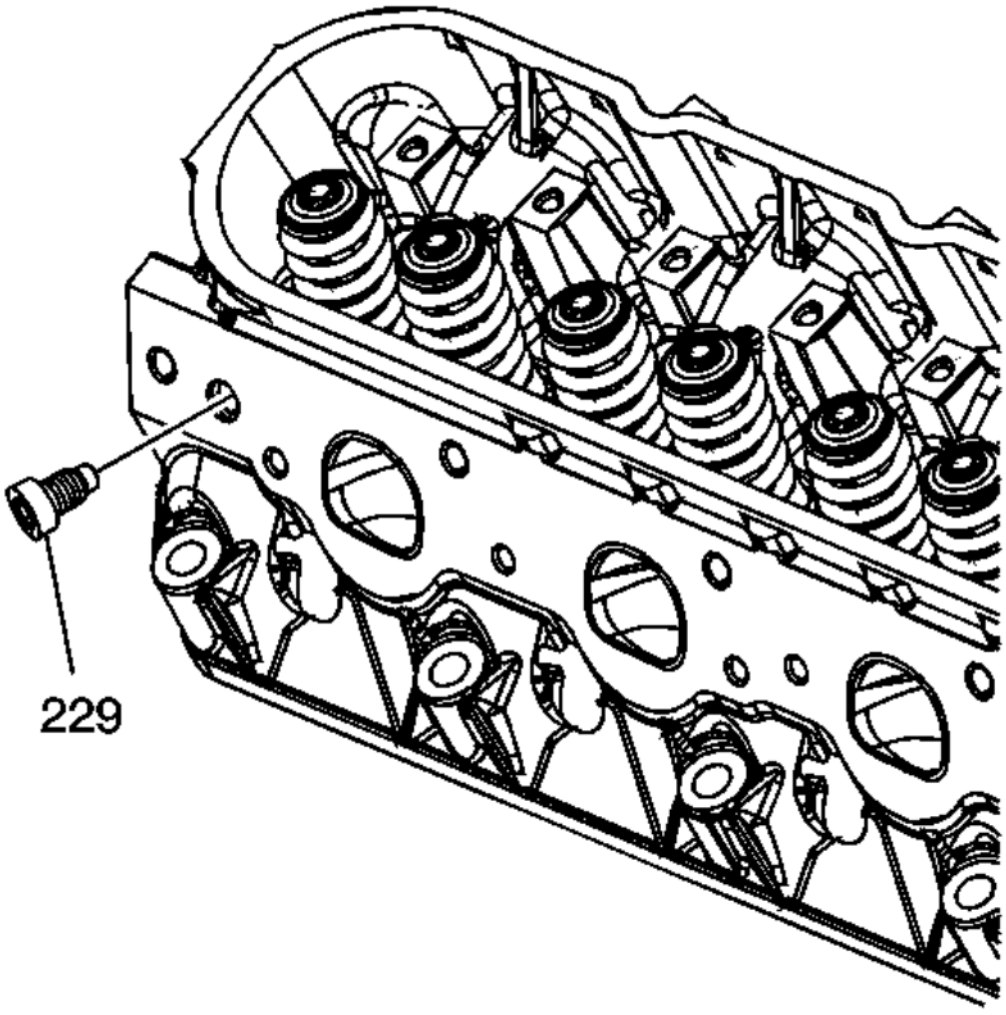

Fig. 474: Locating Coolant Plug
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plug (229) from the right cylinder head.

Disassemble

CYLINDER HEAD CLEANING AND INSPECTION

Tools Required

- **J 8089** Carbon Removal Brush. See **Special Tools**.
- **J 9666** Valve Spring Tester. See **Special Tools**.

Cleaning and Inspection

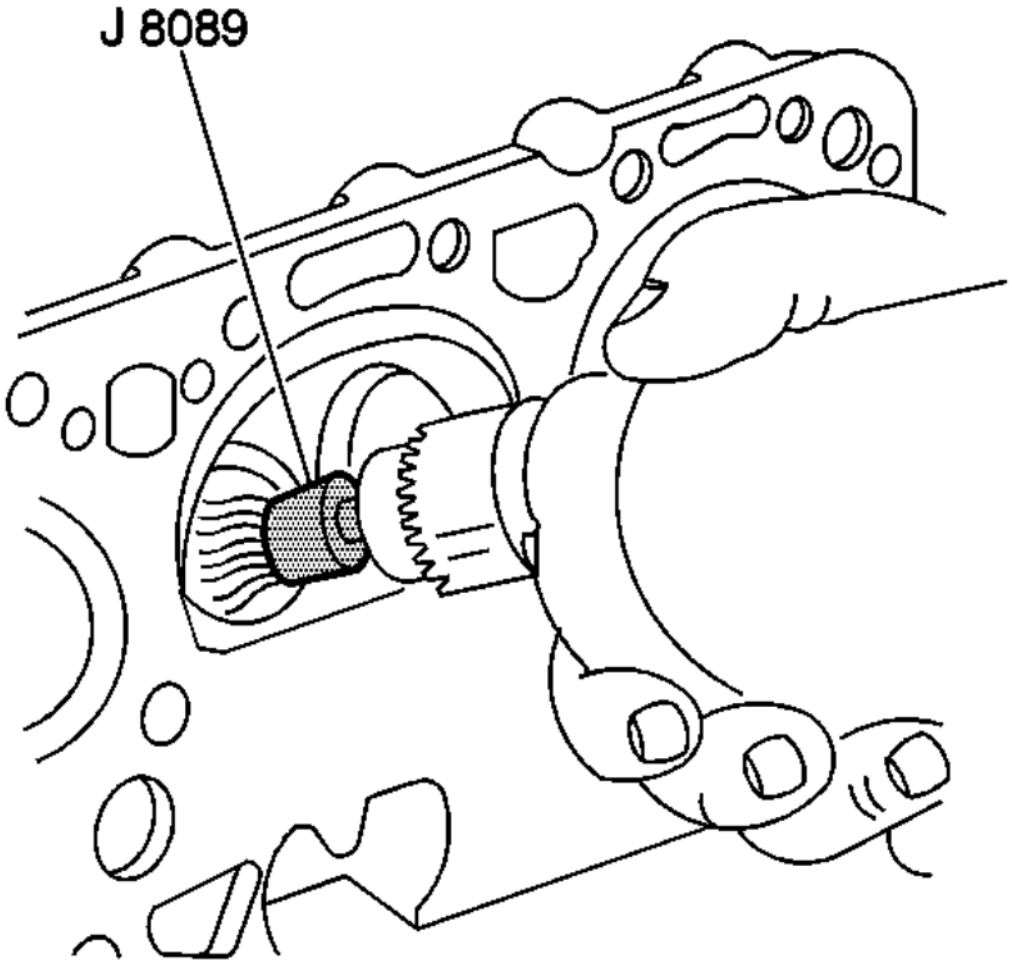

Fig. 475: Cleaning Carbon Using J 8089
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

IMPORTANT:

- **When cleaning a cylinder head in a thermal type oven, do not exceed 204℃ (400℉).**
- **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

     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** .

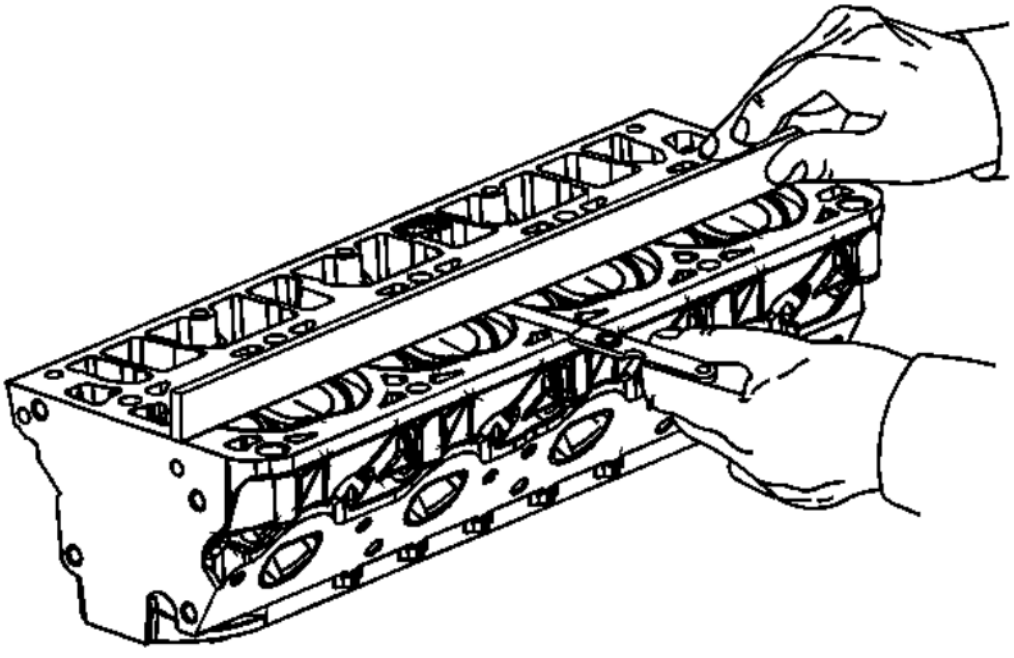

Fig. 476: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications**.

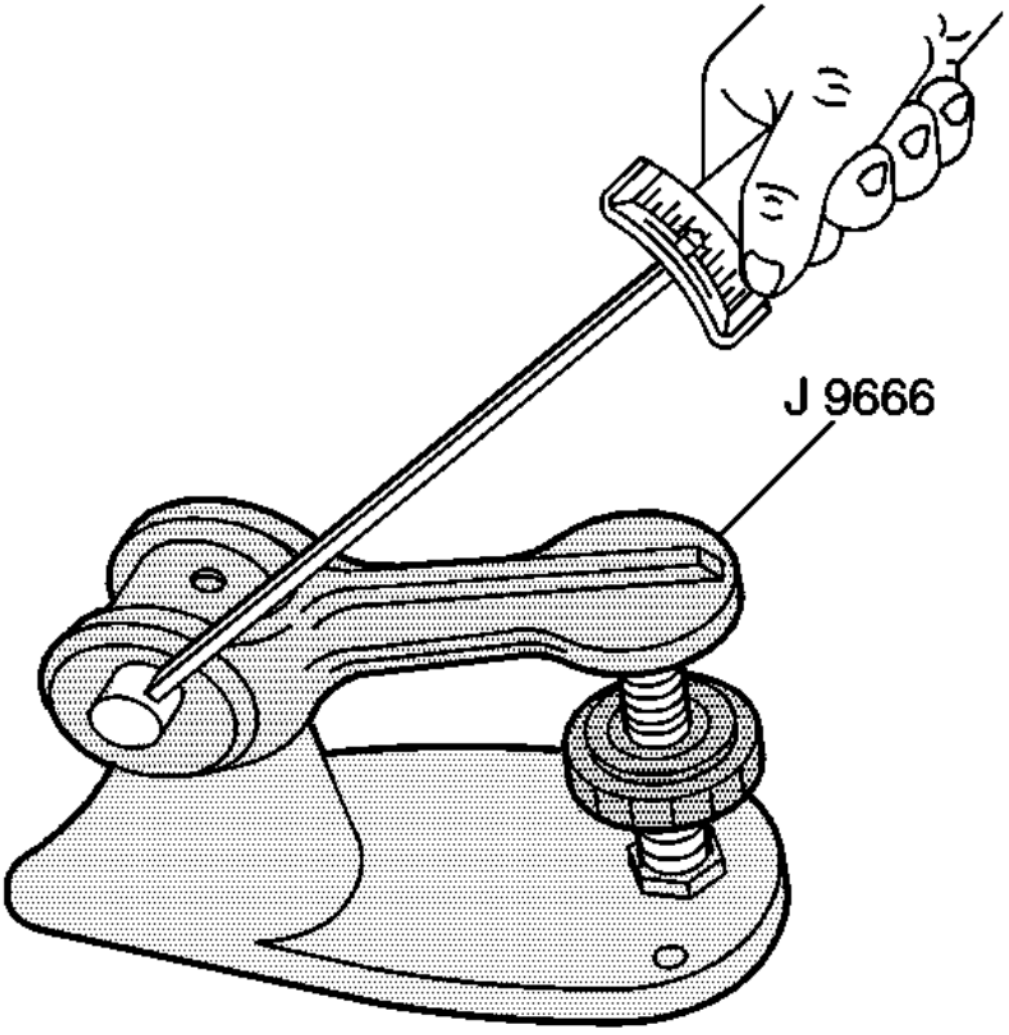

Fig. 477: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 9666** in order to measure the valve spring tension. See **Special Tools**. Refer to **Engine Mechanical Specifications**.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Tools Required

J 37378-1 Valve Guide Reamer. See **Special Tools**.

Valve Guide Reaming

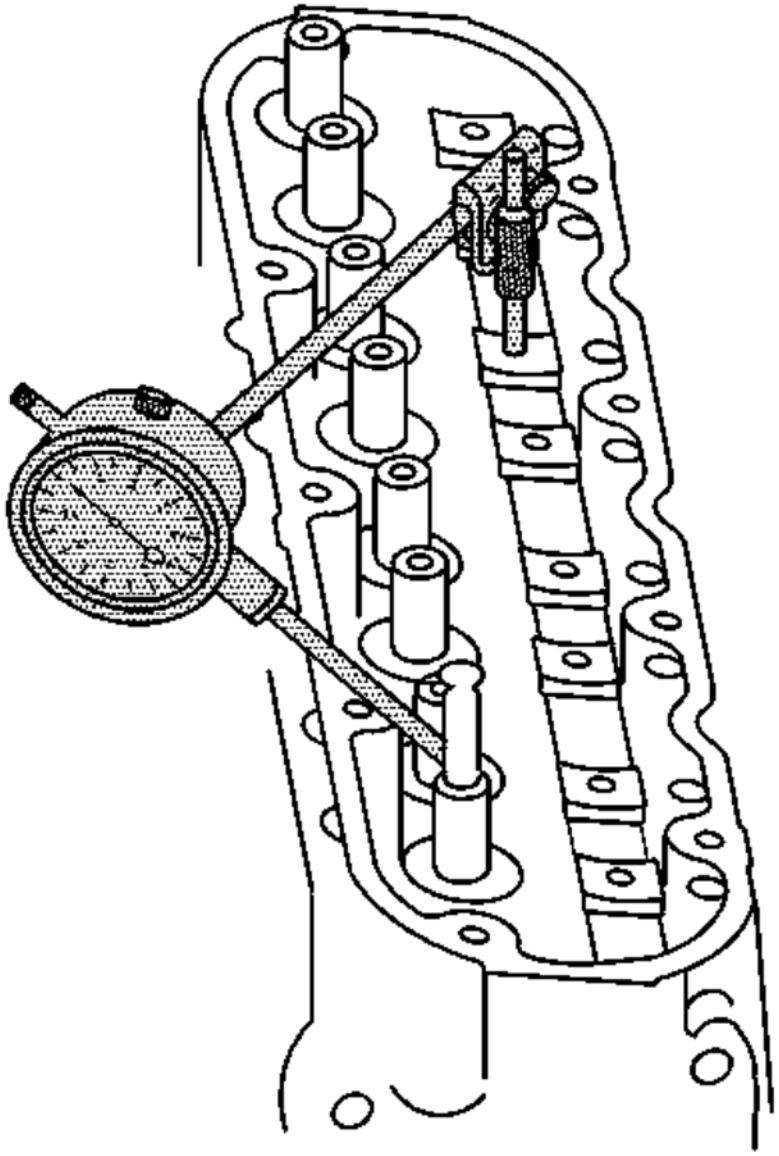

Fig. 478: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

NOTE: **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.**

NOTE: **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. Using a dial indicator, measure the valve stem-to-guide clearance. 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.

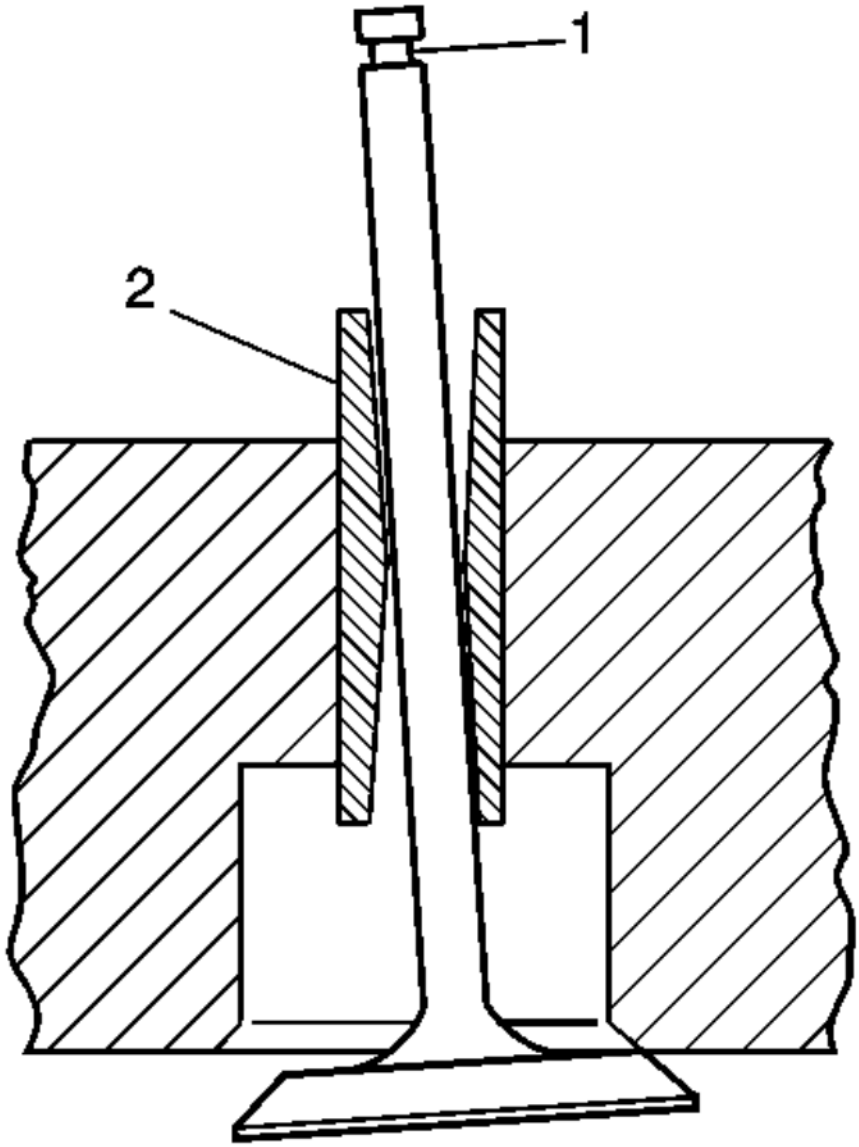

Fig. 479: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. A valve stem (1) and guide (2), with excessive clearance, must be replaced or the cylinder head replaced. Refer to **Engine Mechanical Specifications**.

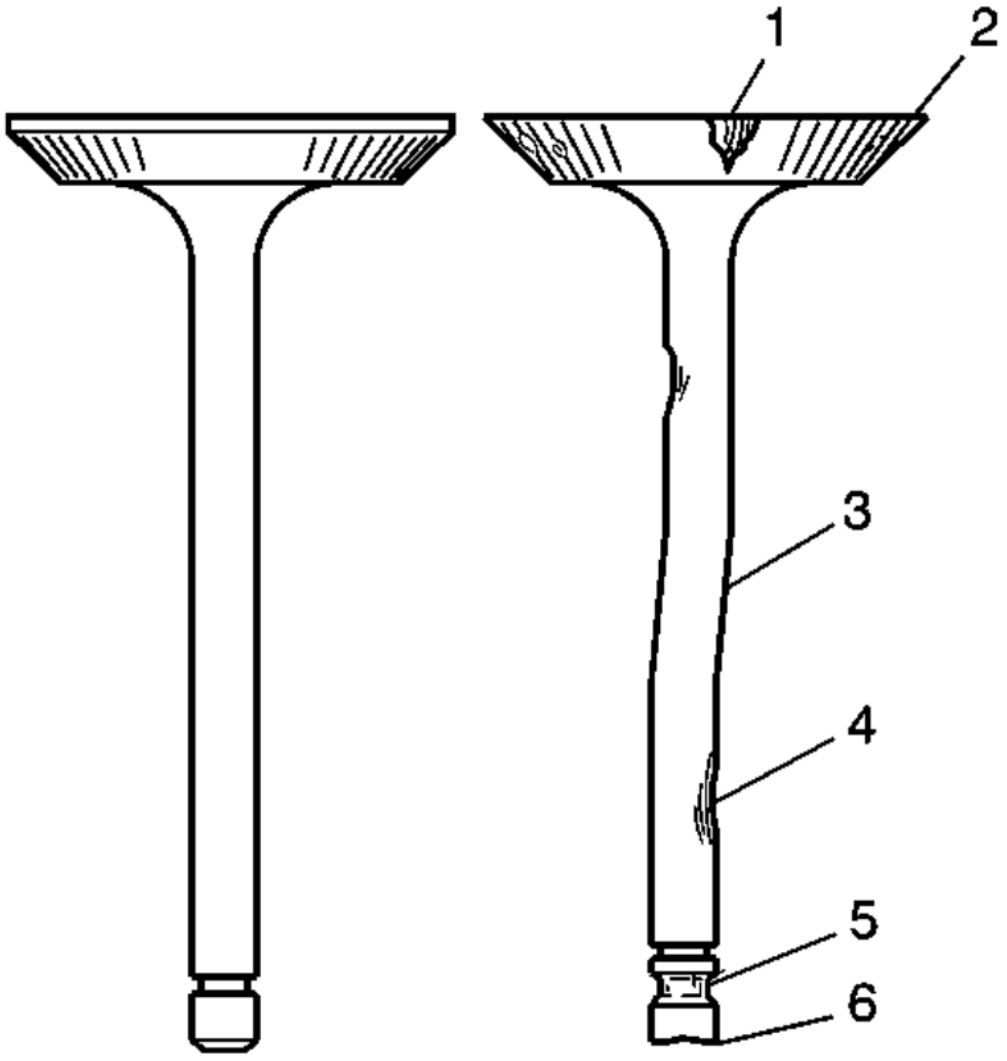

Fig. 480: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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.
   - If a valve guide is worn or has excessive stem-to-guide clearance, the cylinder head should be replaced.
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 cylinder head must be replaced.

Valve and Seat Grinding

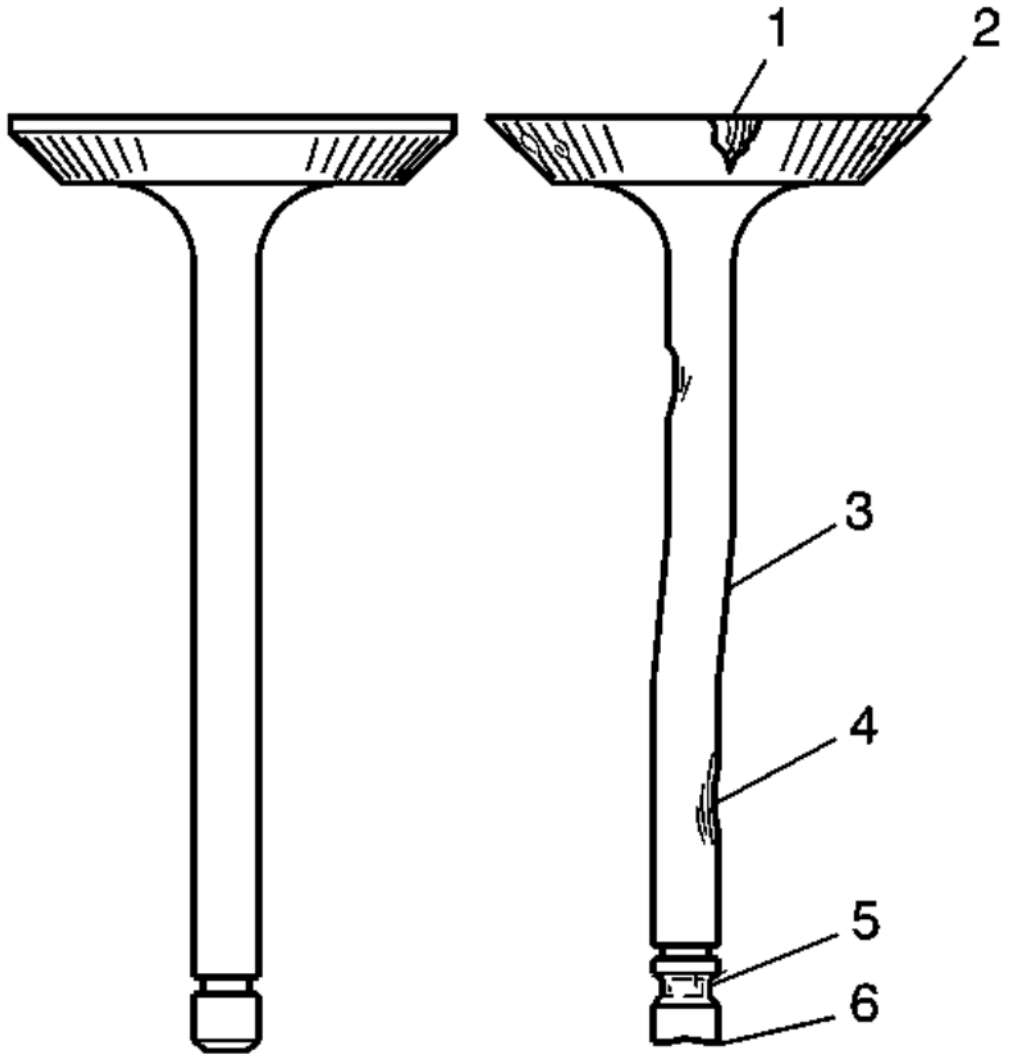

Fig. 481: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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 equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free of 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 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 equipment manufacturer 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)

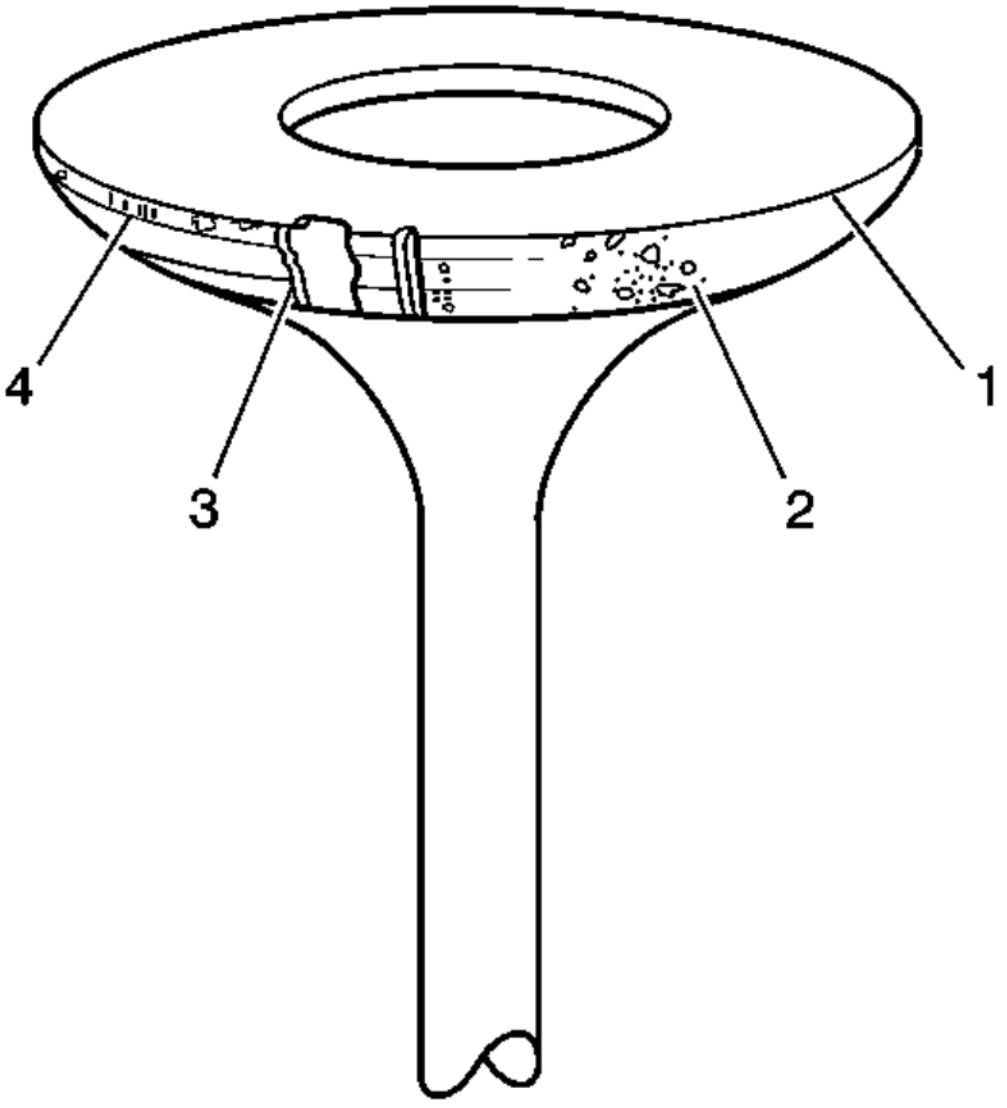

Fig. 482: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
   - Worn or no margin (1 or 4)

- Pitted surfaces (2)
- Burnt or eroded areas (3)

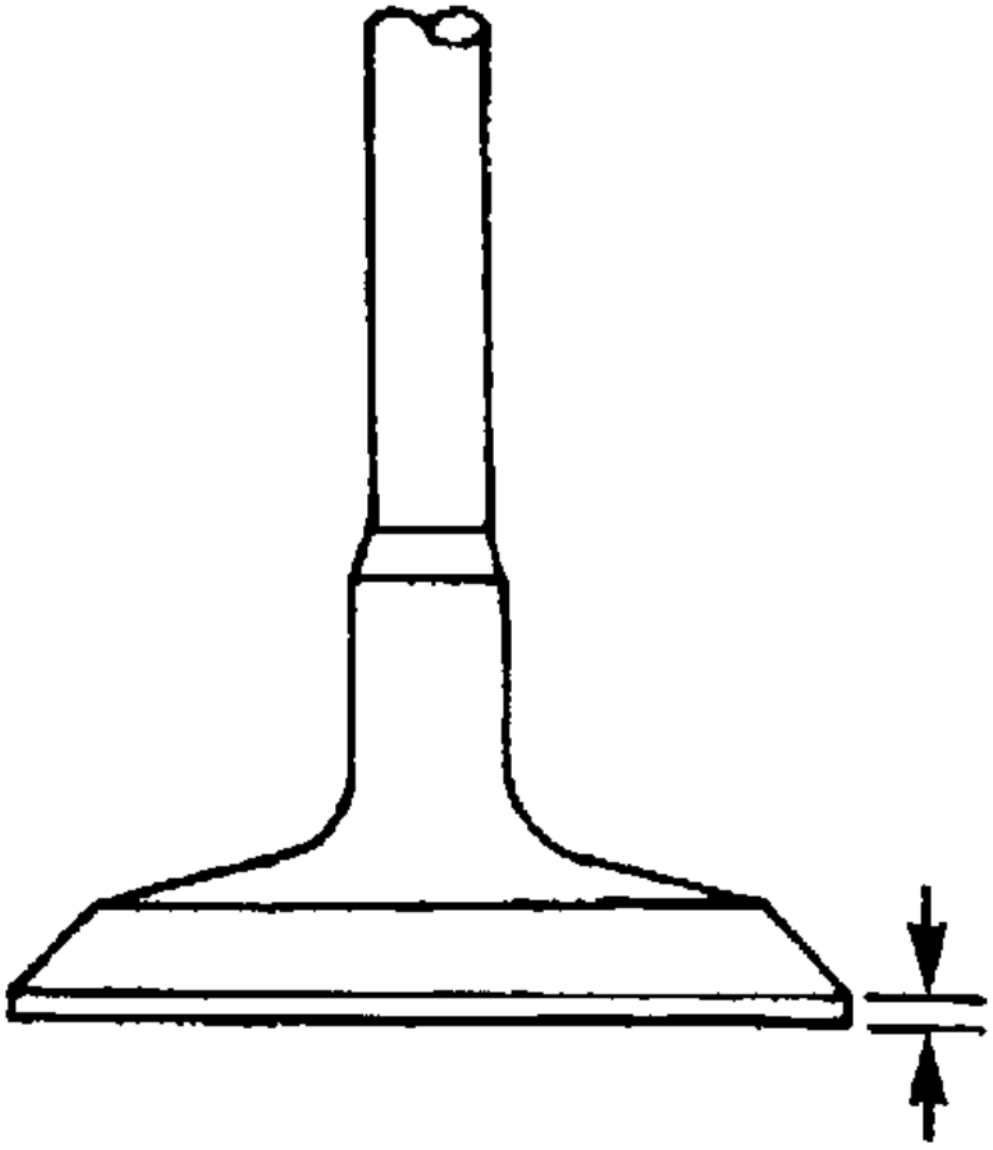

Fig. 483: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

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 in order 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 equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment 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.

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 in order to attain the proper spring installed height. Refer to **Cylinder Head Disassemble**.

CYLINDER HEAD ASSEMBLE

Tools Required

J 8062 Valve Spring Compressor - Head Off. See **Special Tools**.

Assemble

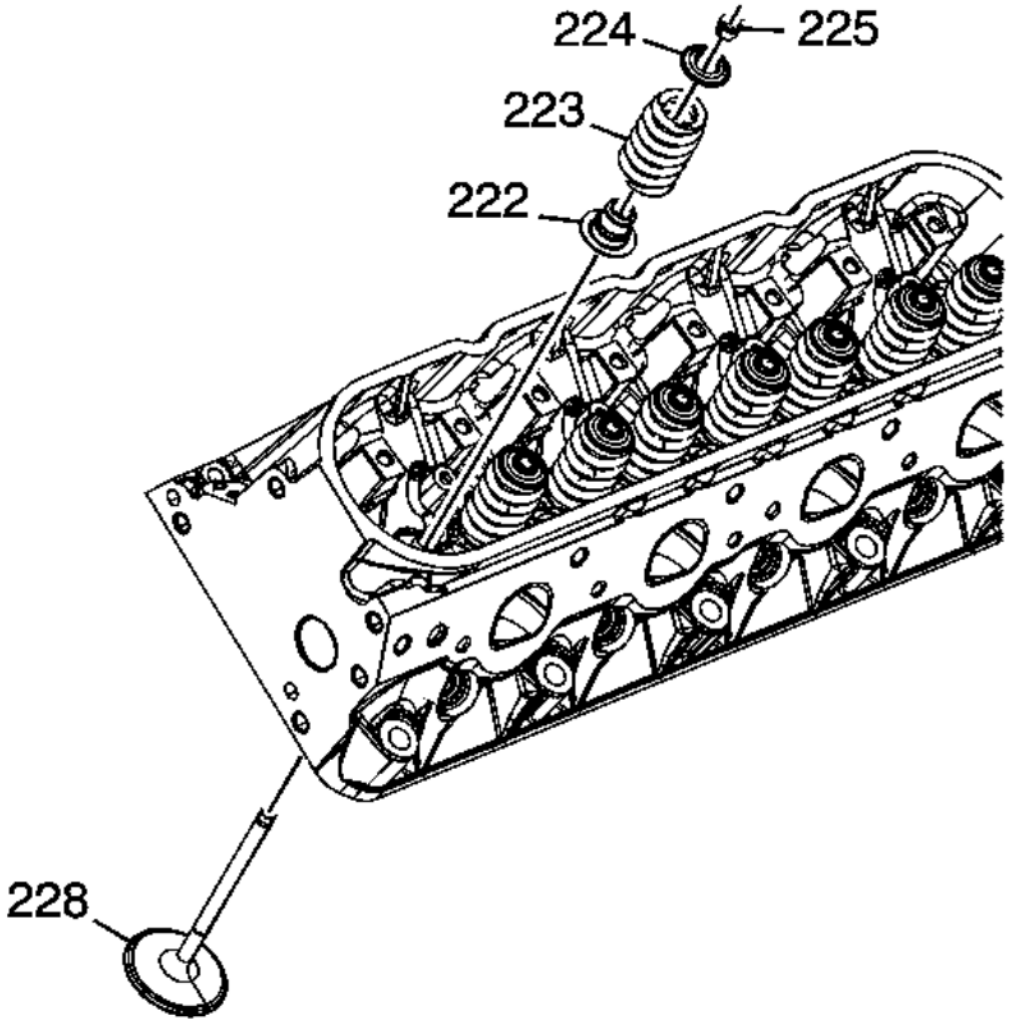

Fig. 484: Valve Stem Keys, Valve Spring Cap & Valve Spring
Courtesy of GENERAL MOTORS CORP.

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 (228) into the proper port. Refer to **Separating Parts**.

3. Install the valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).

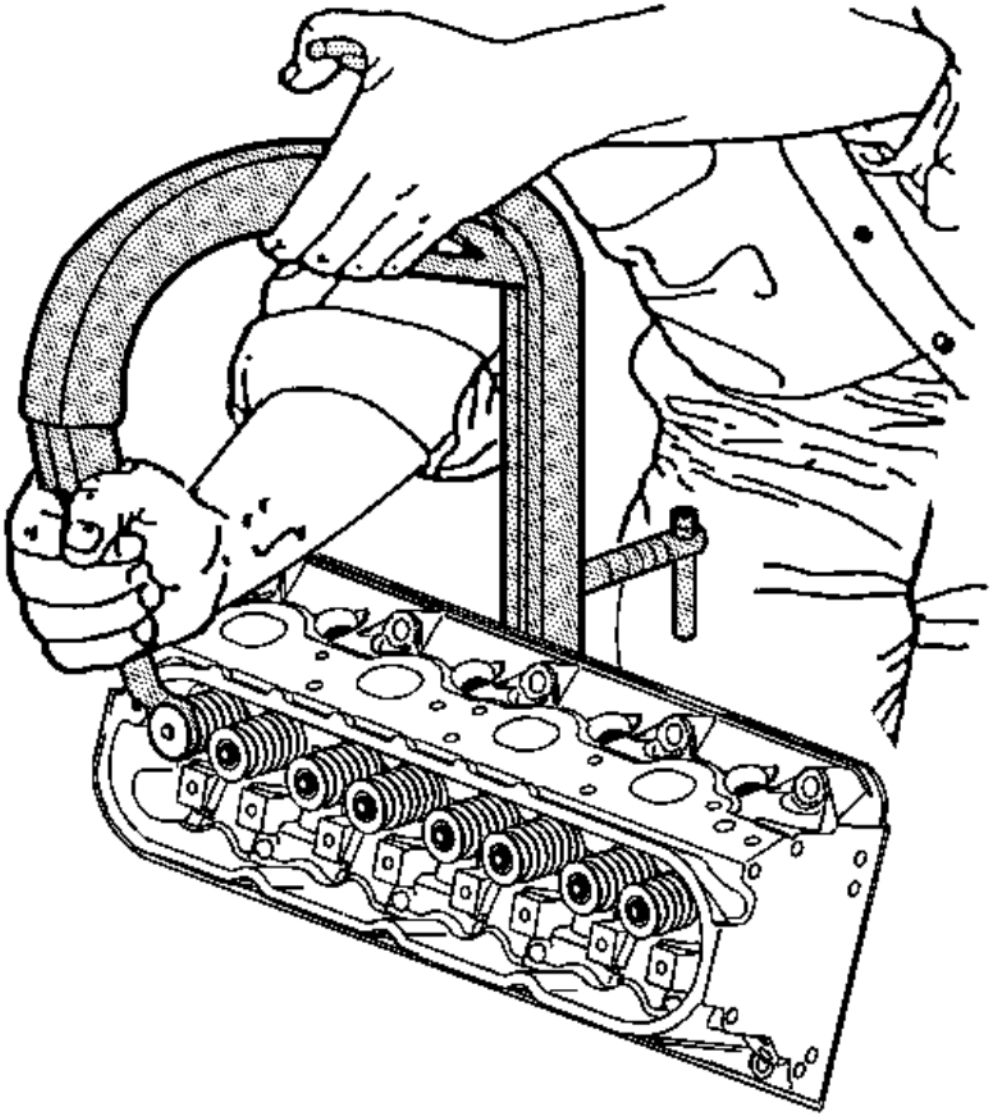

Fig. 485: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

6. Using the **J 8062** , compress the valve spring. See **Special Tools**.
7. Install the valve stem keys.
    1. Use grease in order to hold the keys in place and remove the **J 8062** . See **Special Tools**.
    2. Ensure the keys seat properly in the groove of the valve stem.
    3. Tap the end of the valve stem with a plastic face hammer to seat the keys, if necessary.

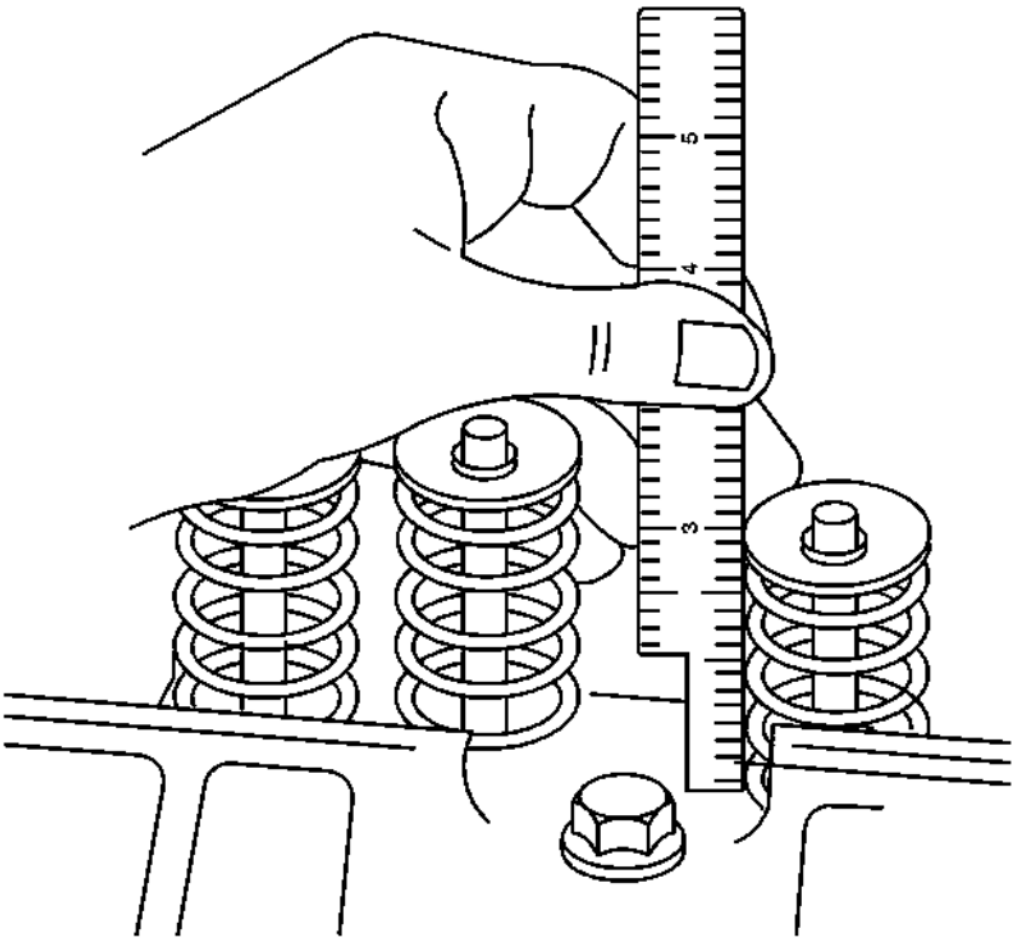

Fig. 486: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

8. Using a ruler, measure the valve spring installed height.

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.

9. Install the remaining valves, springs, and other components.

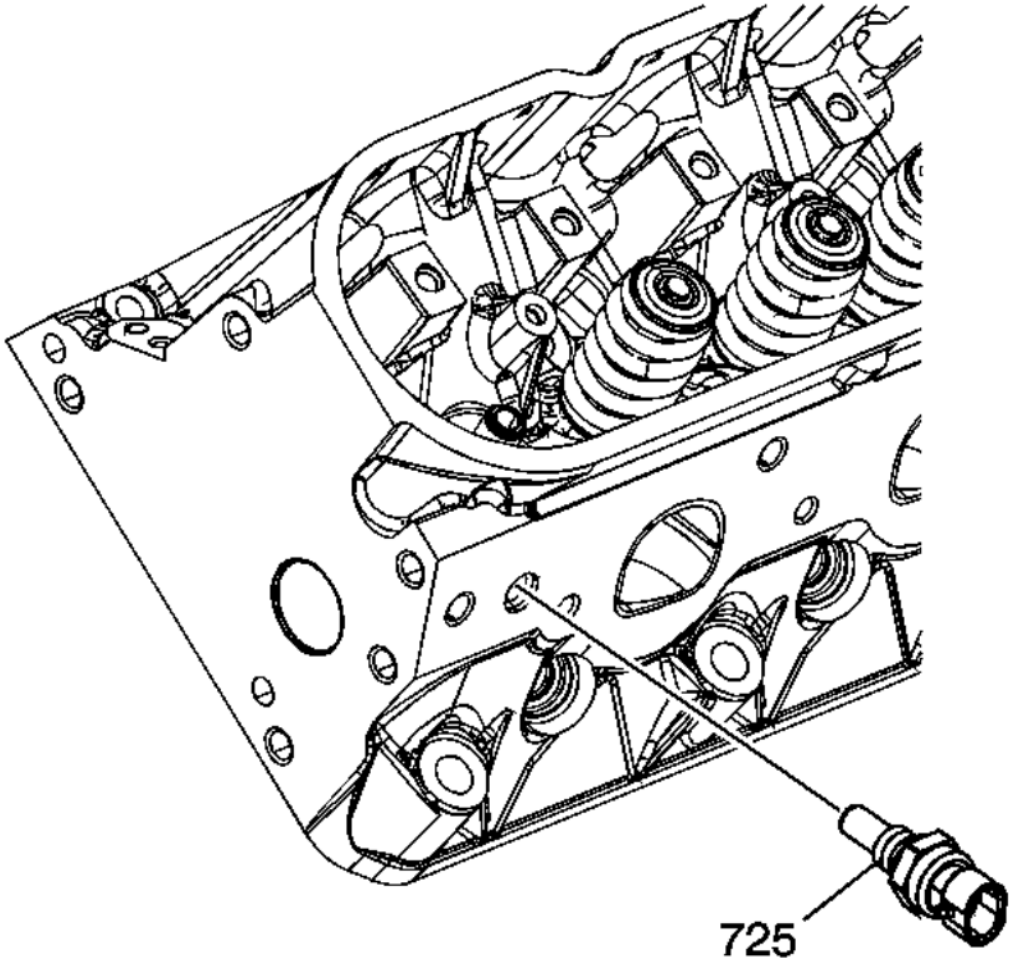

Fig. 487: Locating Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the coolant temperature sensor (725).

NOTE: **Refer to Fastener Notice .**

11. Install the coolant temperature sensor into the left cylinder head.

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

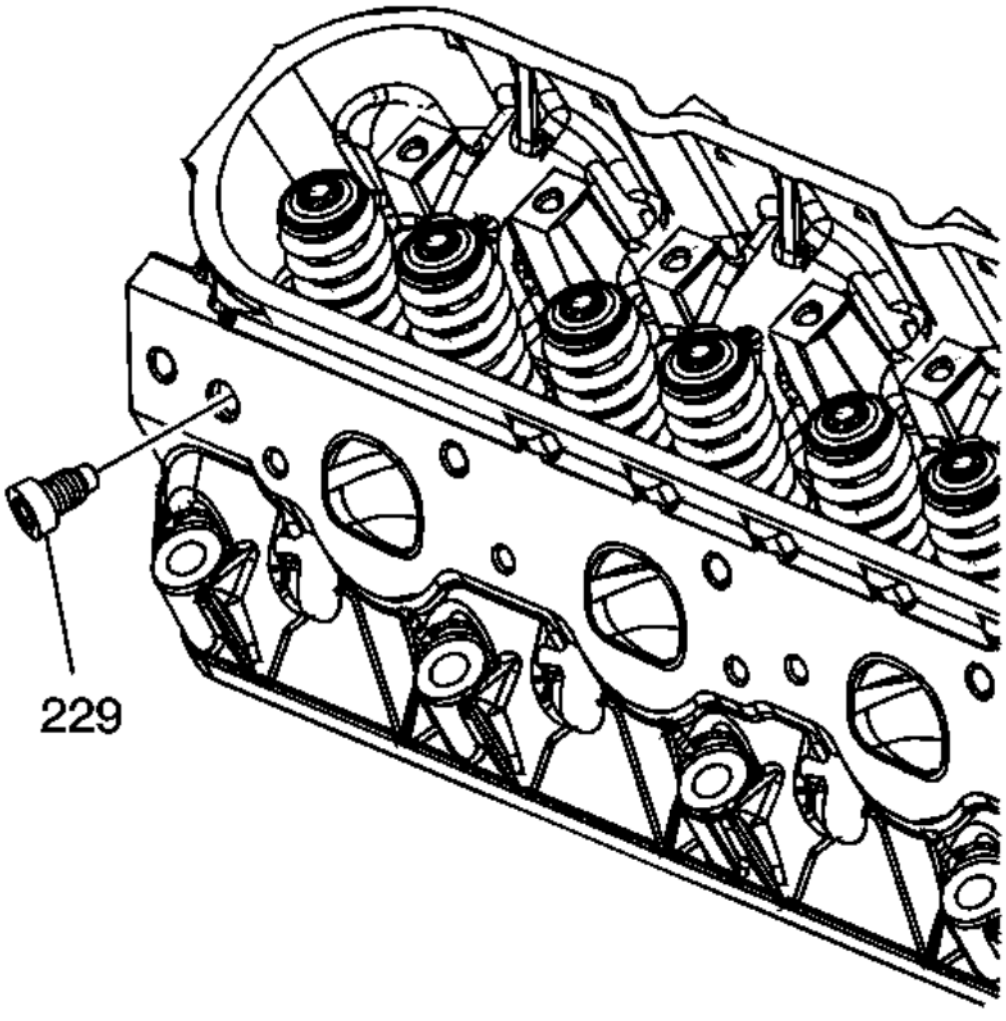

Fig. 488: Locating Coolant Plug
Courtesy of GENERAL MOTORS CORP.

12. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the cylinder head plug (229).
13. Install the cylinder head plug to the right cylinder head.

Tighten: Tighten the cylinder head plug to 20 N.m (15 lb ft).

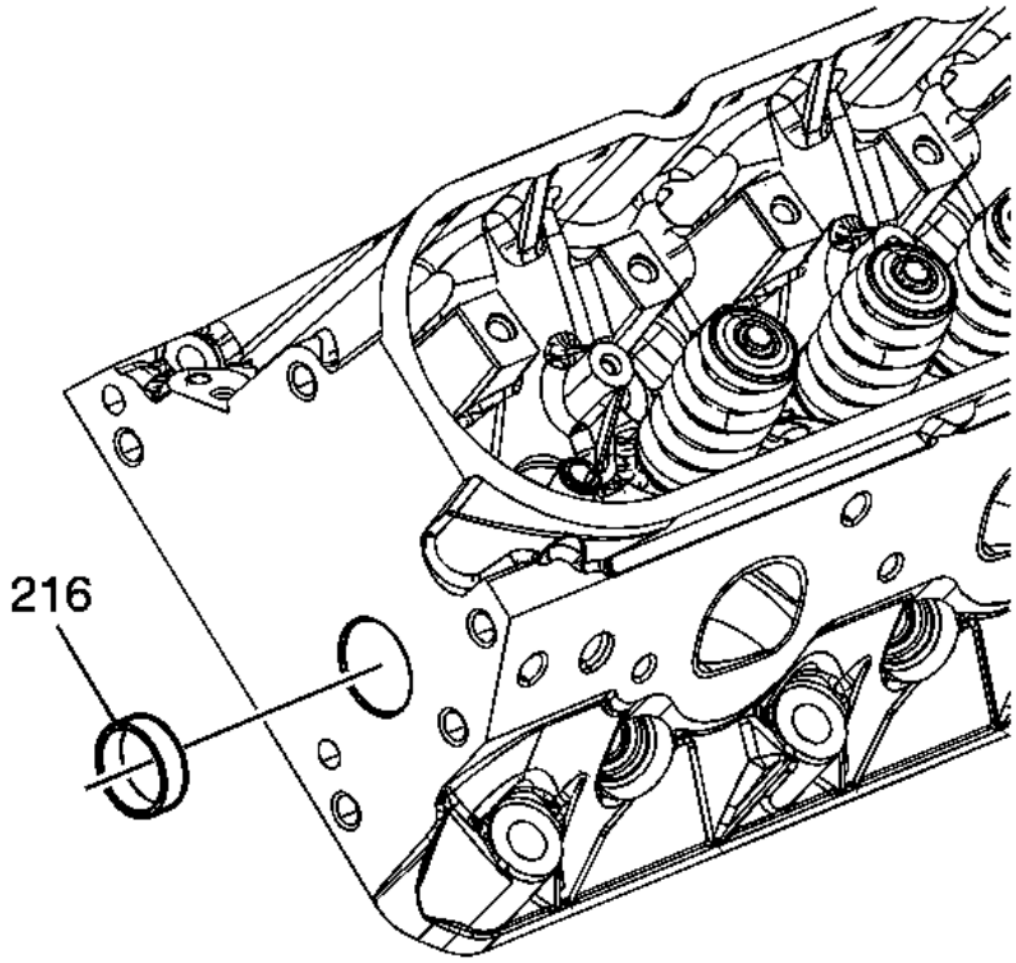

Fig. 489: Locating Cylinder Head Core Hole Plug
Courtesy of GENERAL MOTORS CORP.

14. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the sides of the cylinder head plugs (216).
15. Install the cylinder head 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

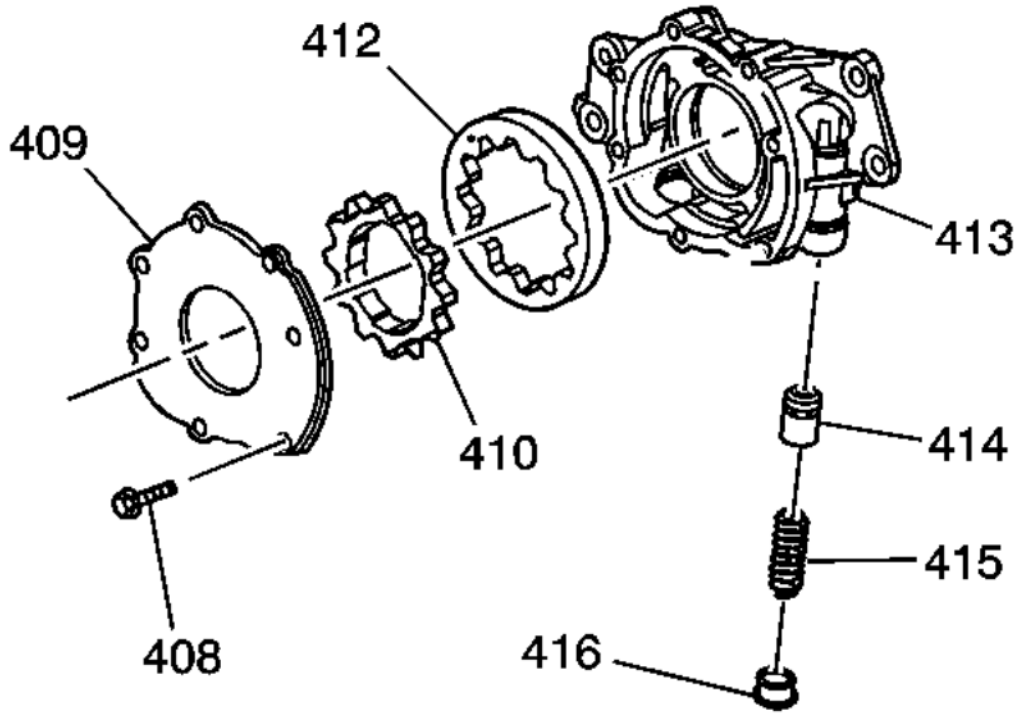

Fig. 490: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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.

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

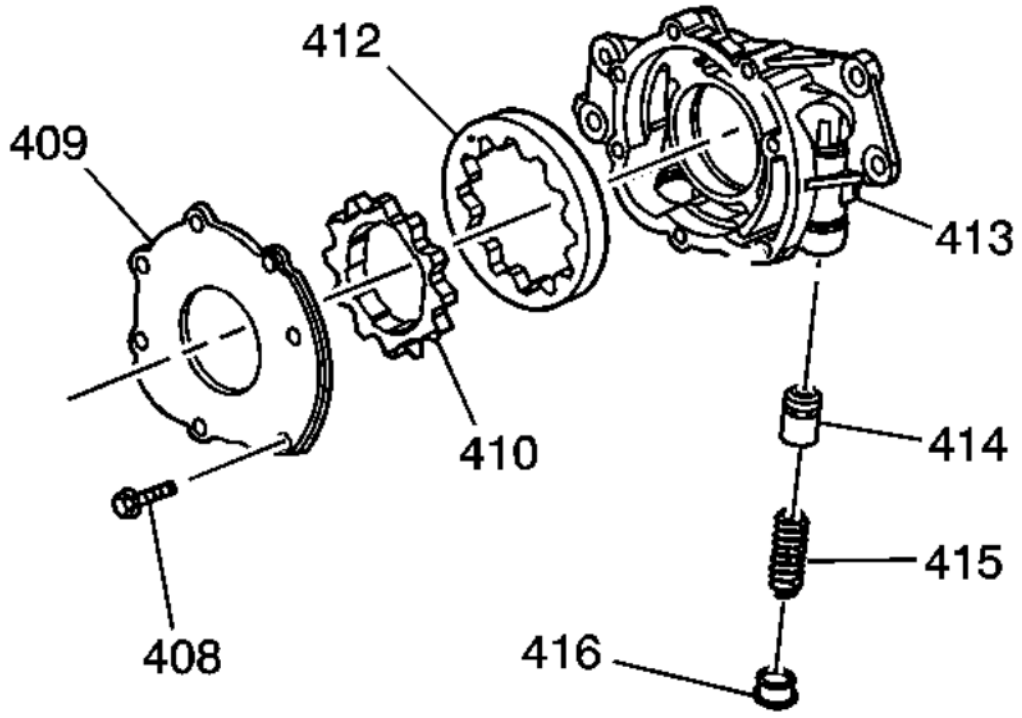

Fig. 491: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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 .

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.
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.

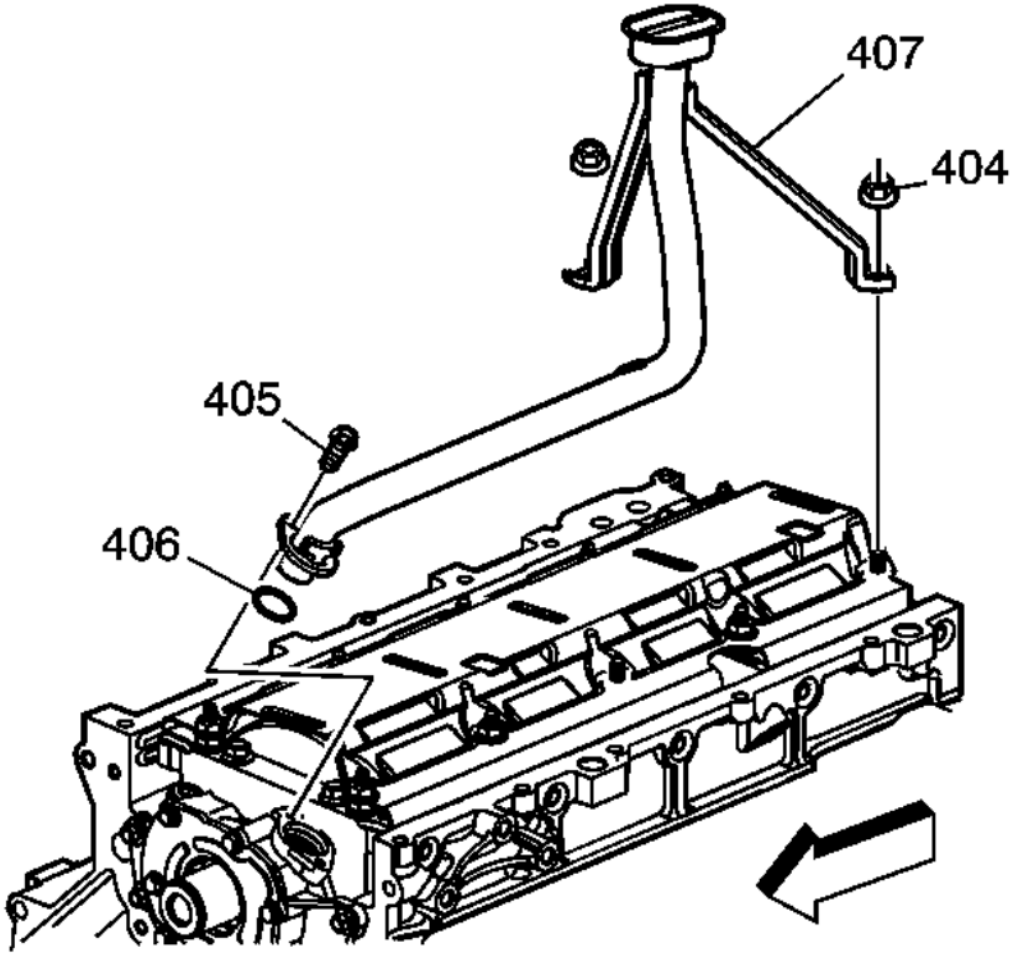

Fig. 492: View Of Oil Pump Screen, Bolt, Nuts, & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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

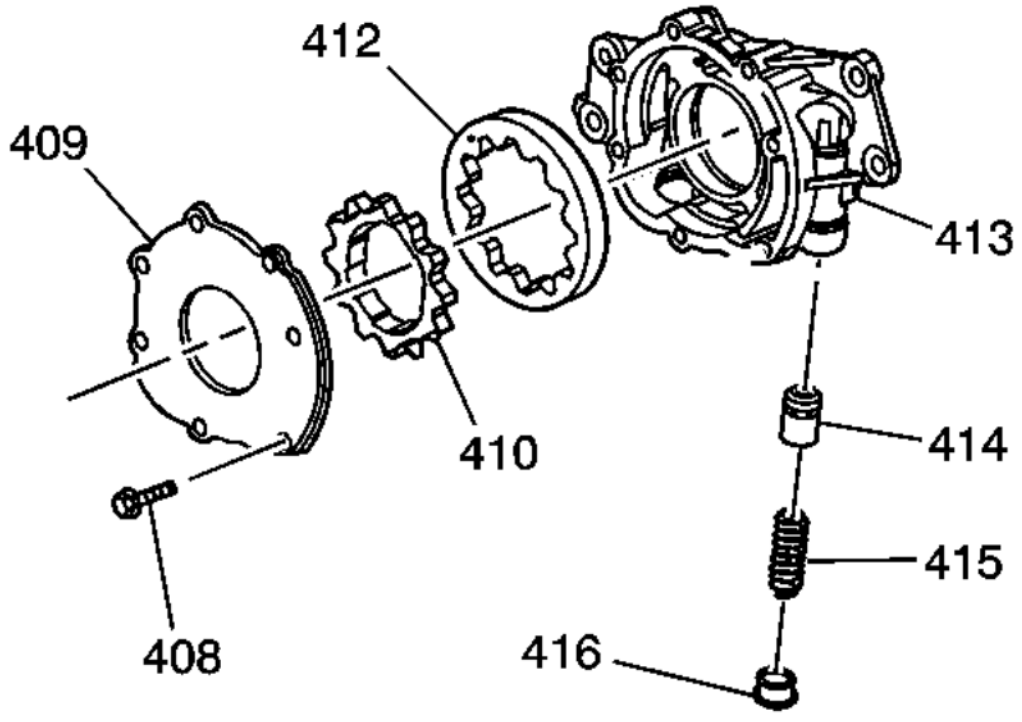

Fig. 493: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

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).

NOTE: Refer to Fastener Notice .

4. Install the oil 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 the relief valve spring (415).
7. Install the relief valve plug (416).

Tighten: Tighten the 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

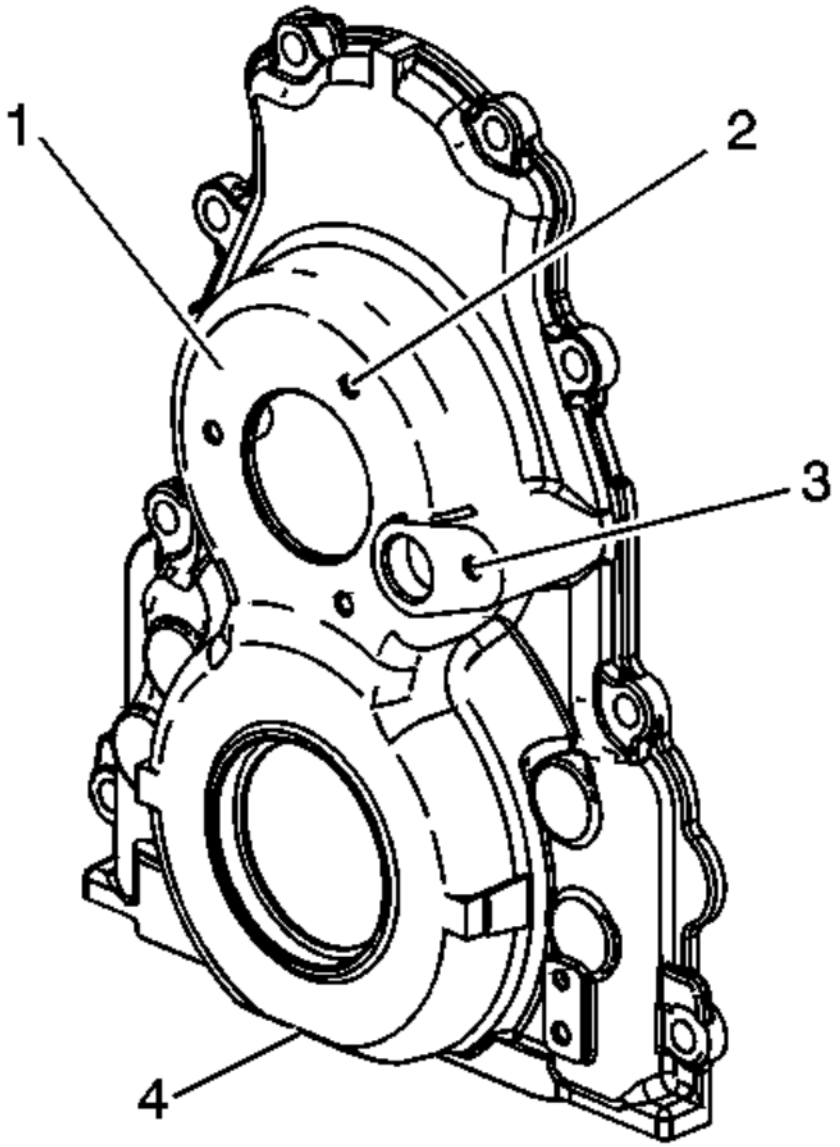

Fig. 494: View Of Gasket Sealing Surfaces & Bolt Holes
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft front oil seal again. Install a NEW crankshaft front oil seal during assembly.**

- **Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.**
- **Do not use the camshaft position (CMP) actuator magnet gasket again. Install a NEW gasket during assembly.**

1. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

2. Dry the cover with compressed air.
3. Inspect the gasket sealing surfaces (1, 4) for excessive scratches or gouging.
4. Inspect the threaded bolt holes (2, 3) for damaged threads or debris.

CRANKSHAFT REAR OIL SEAL HOUSING CLEANING AND INSPECTION

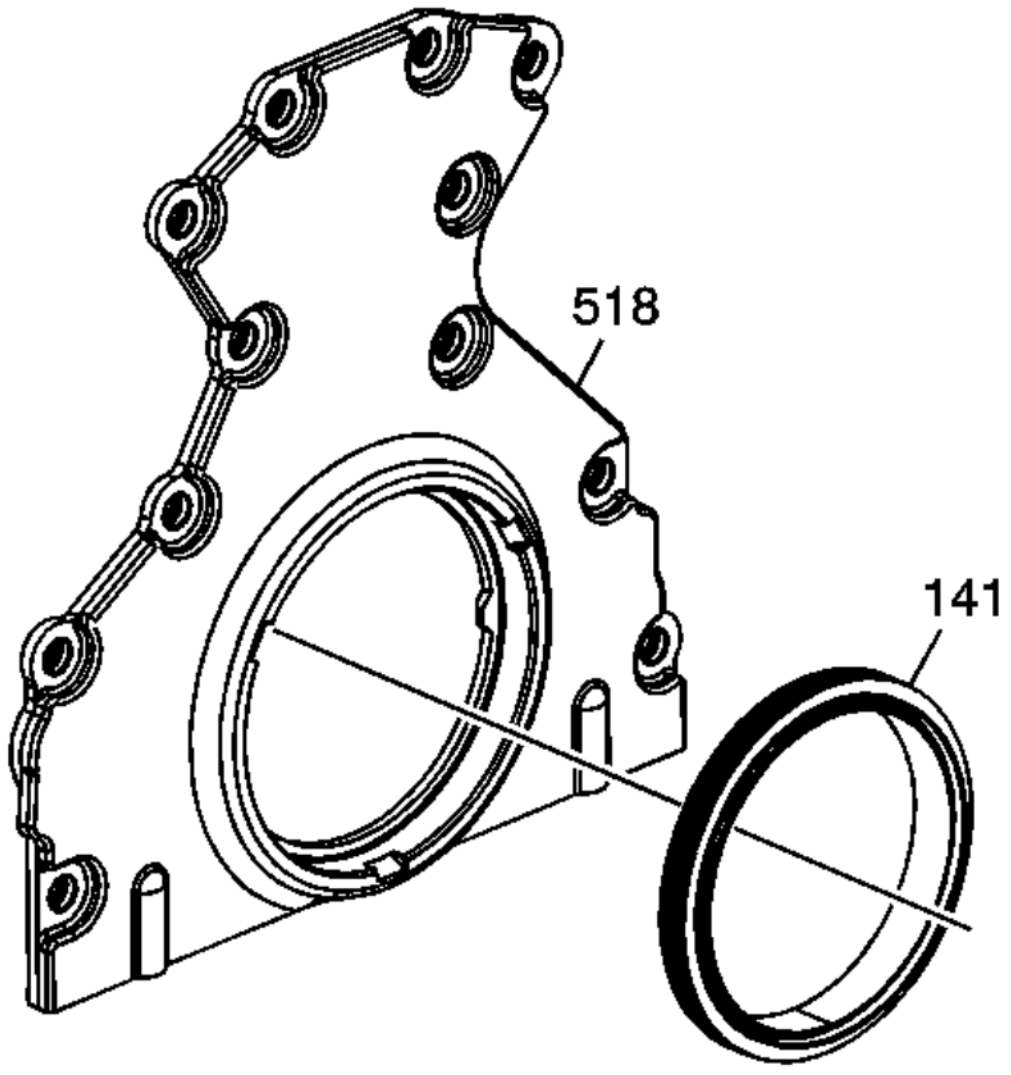

Fig. 495: Crankshaft Rear Oil Seal & Housing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not use the crankshaft rear oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the rear housing-to-engine block gasket again. Install a NEW gasket during assembly.**

1. Remove the crankshaft oil seal (141) from the rear housing.
2. Clean the housing in solvent. Remove the sealant from the housing oil pan surface. Refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the housing with compressed air.
4. Inspect the gasket sealing surfaces for excessive scratches or gouging.
5. Inspect the housing-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage.

ENGINE BLOCK VALLEY COVER CLEANING AND INSPECTION

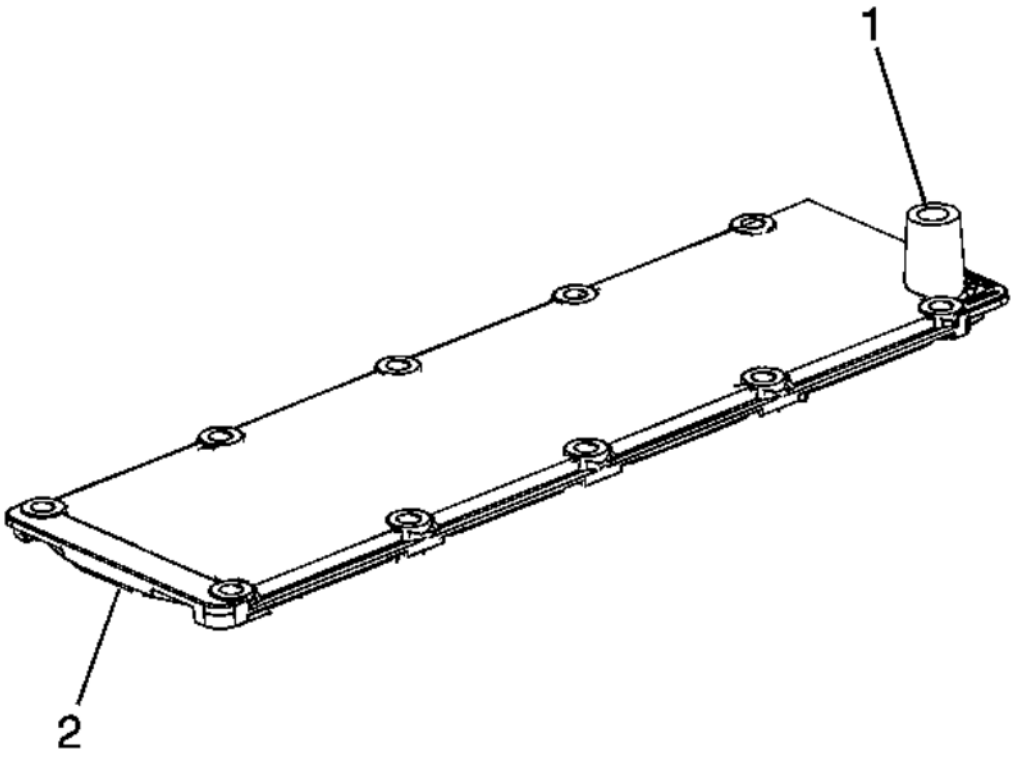

Fig. 496: View Of Engine Valley Cover

Courtesy of GENERAL MOTORS CORP.

1. Clean the valley cover in solvent.

CAUTION: Refer to Safety Glasses Caution .

2. Dry with compressed air.
3. Inspect for damaged threads (1) and damaged sealing surfaces (2).

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

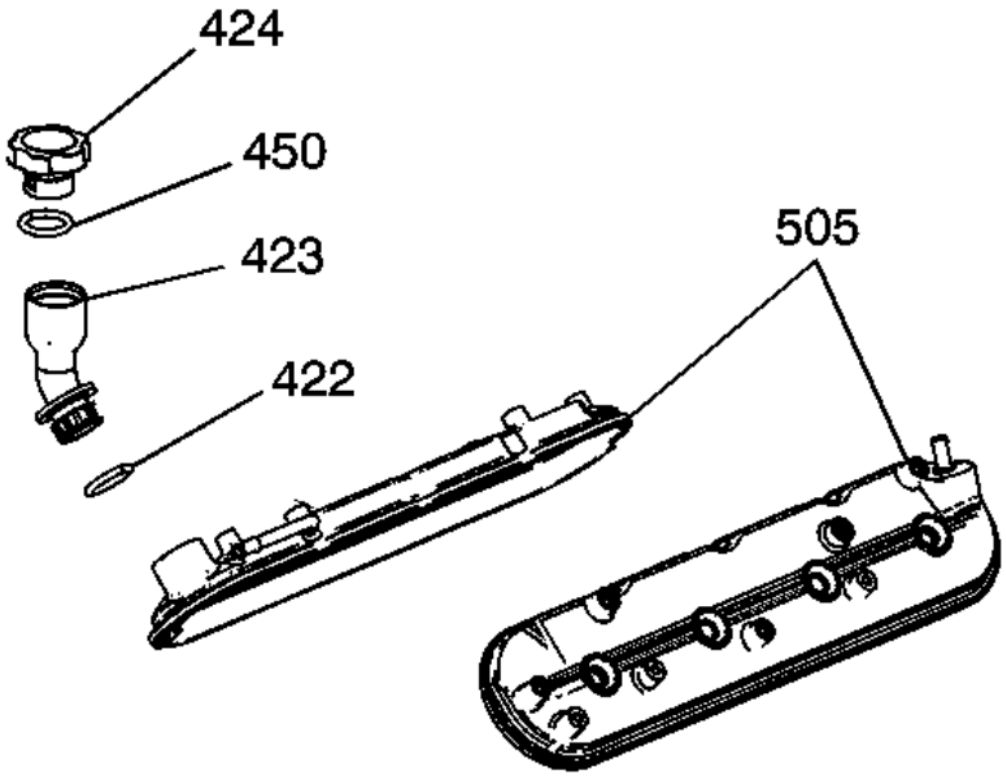

Fig. 497: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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. If the tube is removed from the cover, install a NEW tube (423) and seal (422) during assembly.**

1. Inspect the oil fill tube (423) for a loose fit or damage.
2. Inspect the covers (505) 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

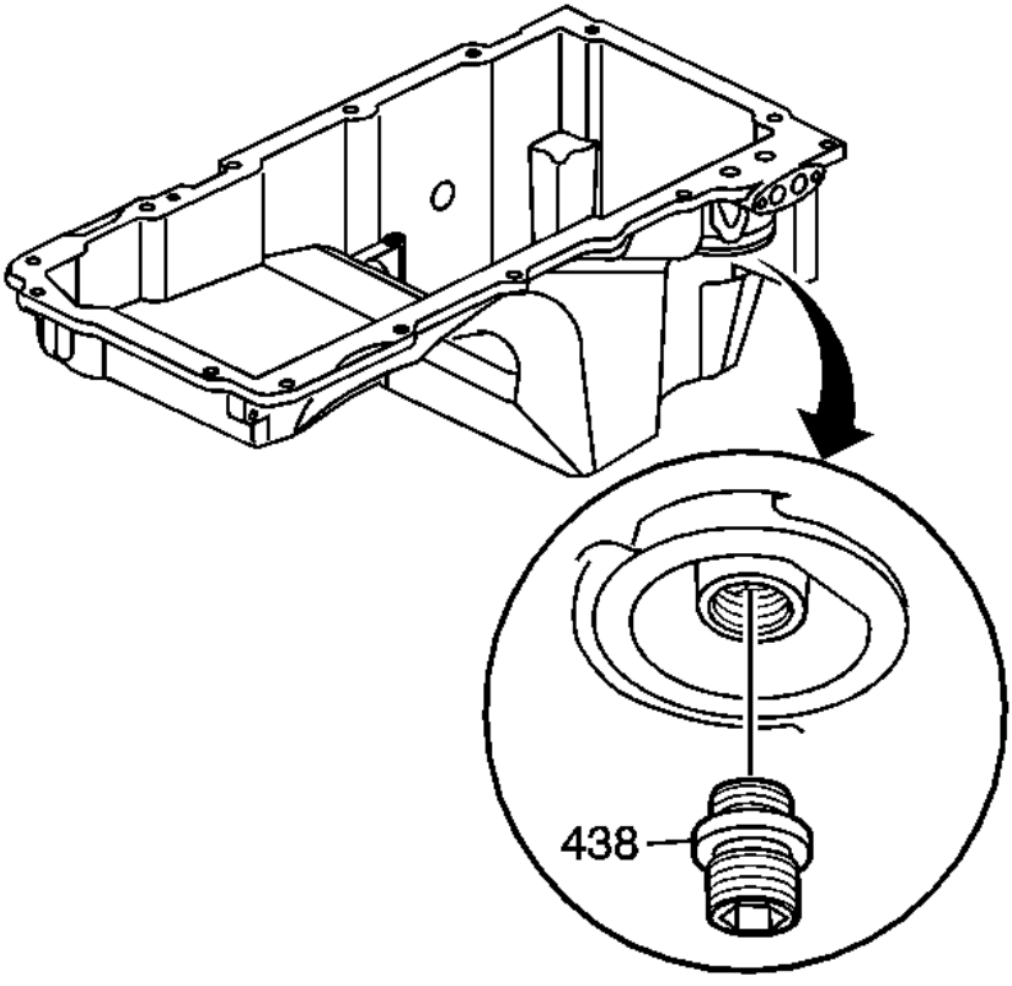

Fig. 498: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter fitting (438), as required.

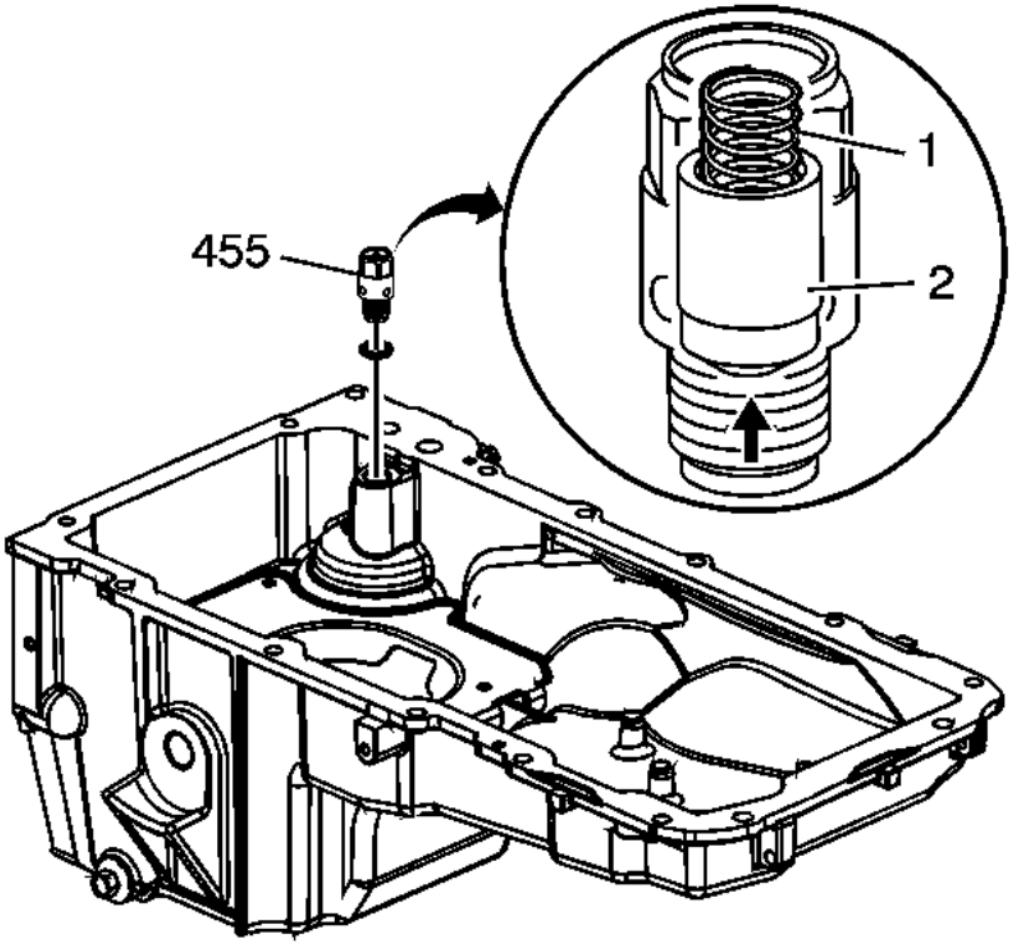

Fig. 499: View Of Oil Pressure Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the active fuel management oil pressure relief valve (455) and washer.
3. Inspect the 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.

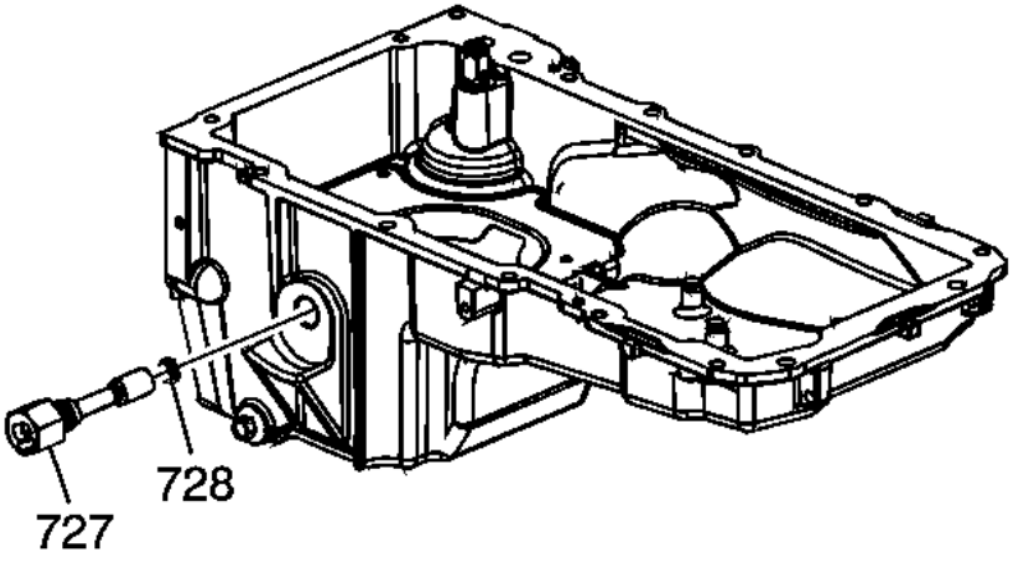

Fig. 500: View Of Oil Level Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil level sensor (727) and O-ring (728).

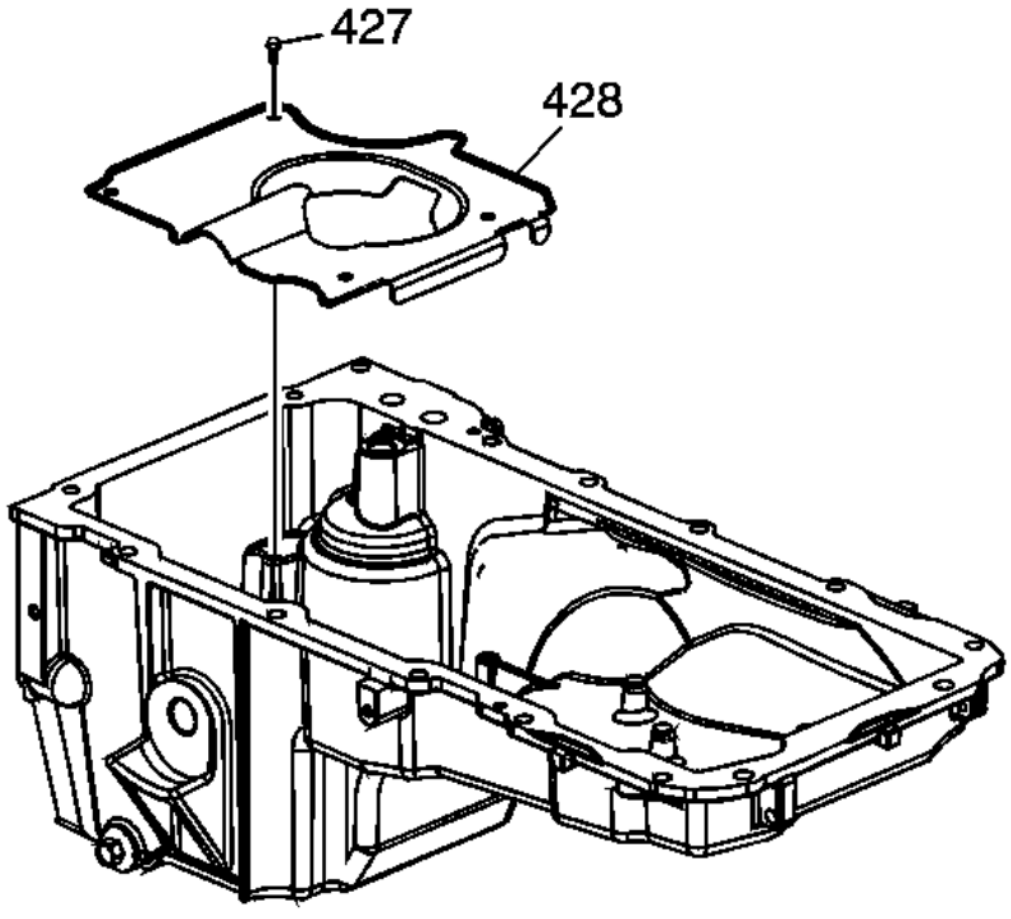

Fig. 501: View Of Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the bolts (427) and baffle (428).

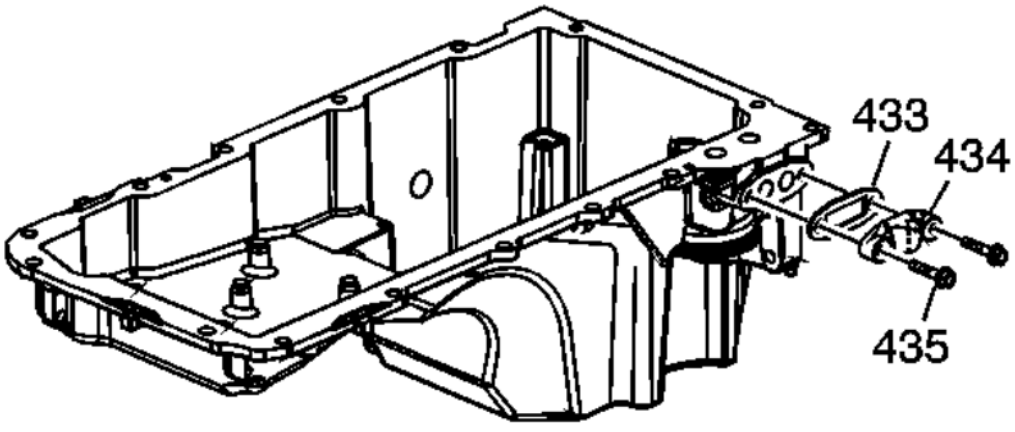

Fig. 502: View Of Oil Pan Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil pan cover (434), bolts (435), and gasket (433).
7. Clean the oil pan in solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

8. Dry the oil pan with compressed air.

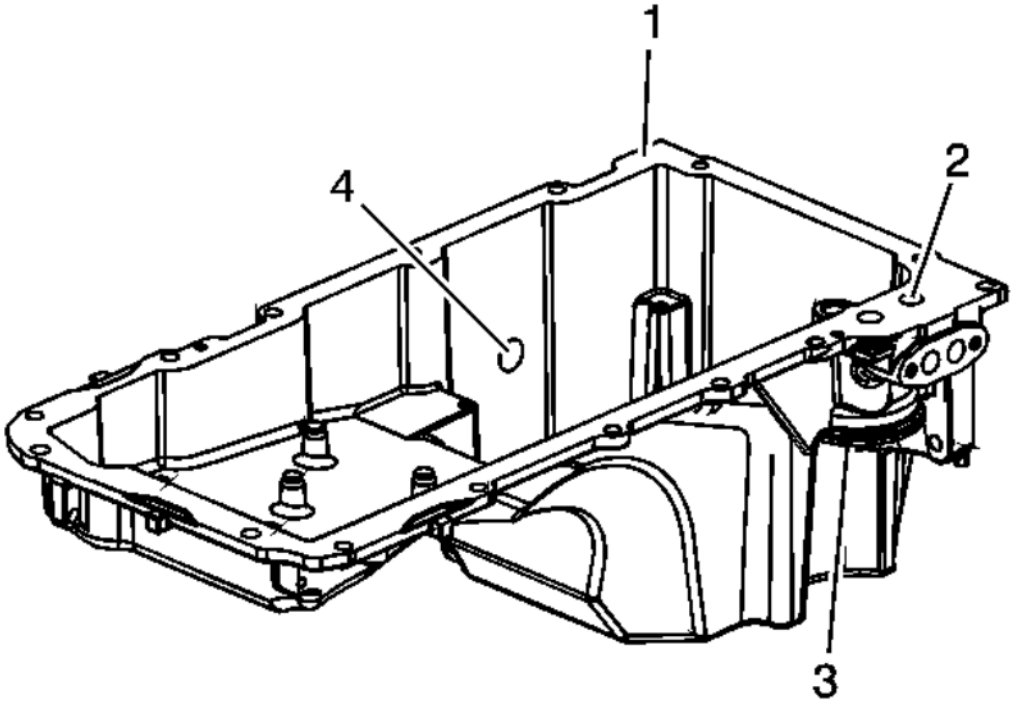

Fig. 503: View Of Oil Pan Inspection Points
Courtesy of GENERAL MOTORS CORP.

9. Inspect the oil pan for the following conditions:
    - Damaged gasket surfaces (1)
    - Restrictions within the oil passages (2) of the pan
    - Damaged oil filter seal surface (3)
    - Threaded oil level sensor hole (4) for damage

INTAKE MANIFOLD CLEANING AND INSPECTION

Cleaning Procedure

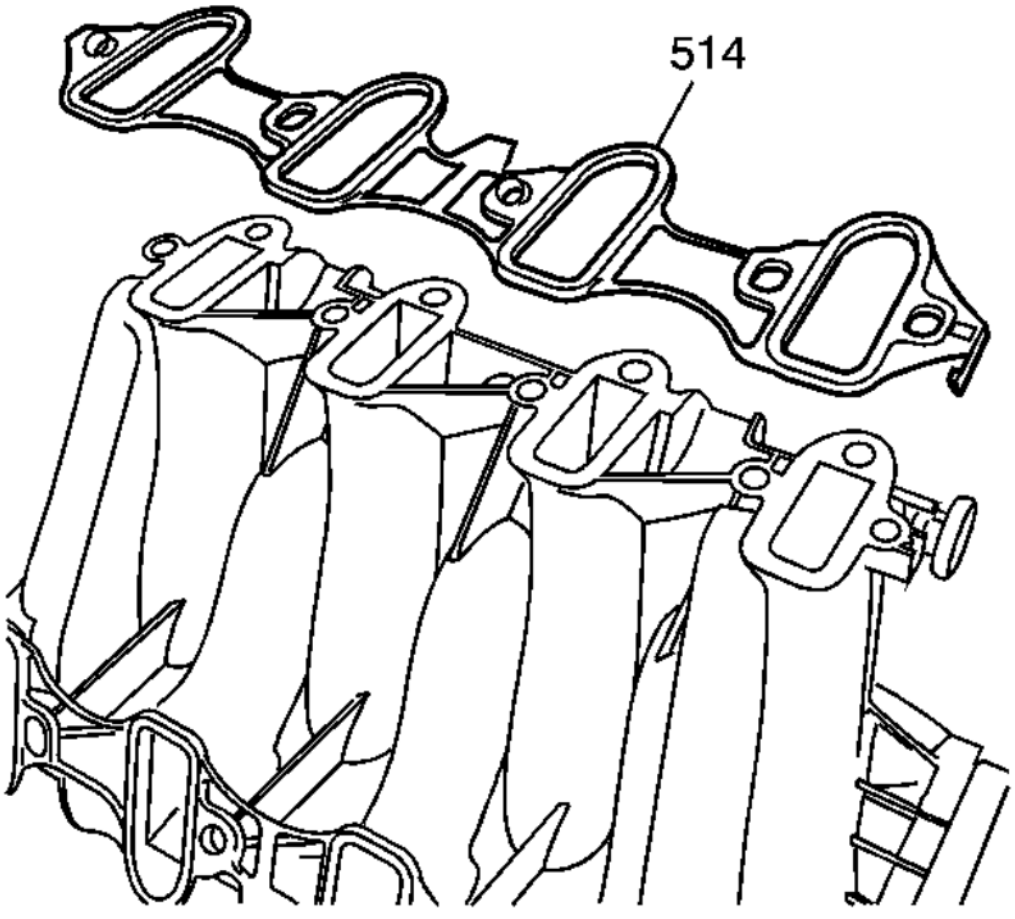

Fig. 504: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the intake manifold-to-cylinder head gaskets (514).

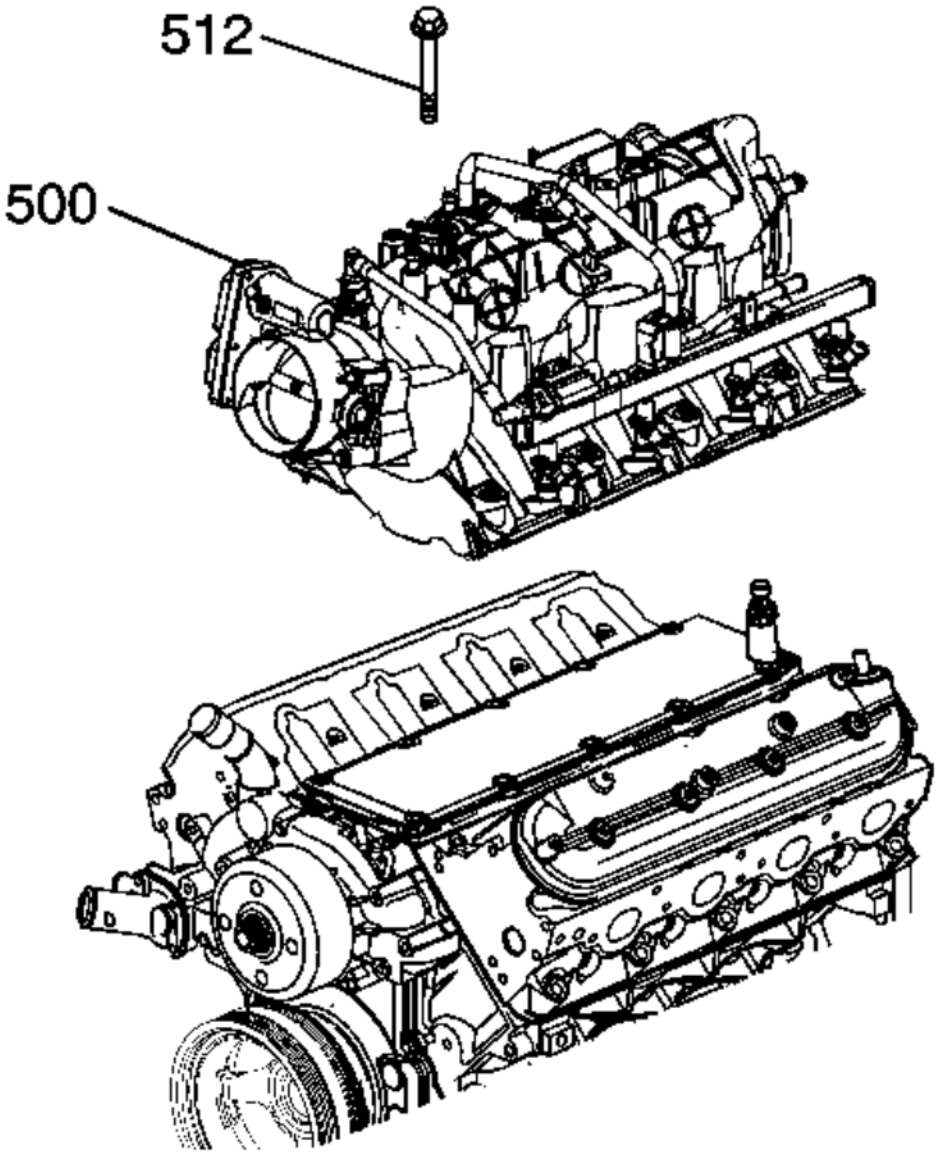

Fig. 505: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714). Refer to **Intake Manifold Removal**.

3. Remove the evaporative emission (EVAP) canister purge solenoid 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 and Compressed Air Caution .

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
   - Damaged or broken vacuum fittings
   - Inspect the composite intake manifold assembly for cracks or other damage.

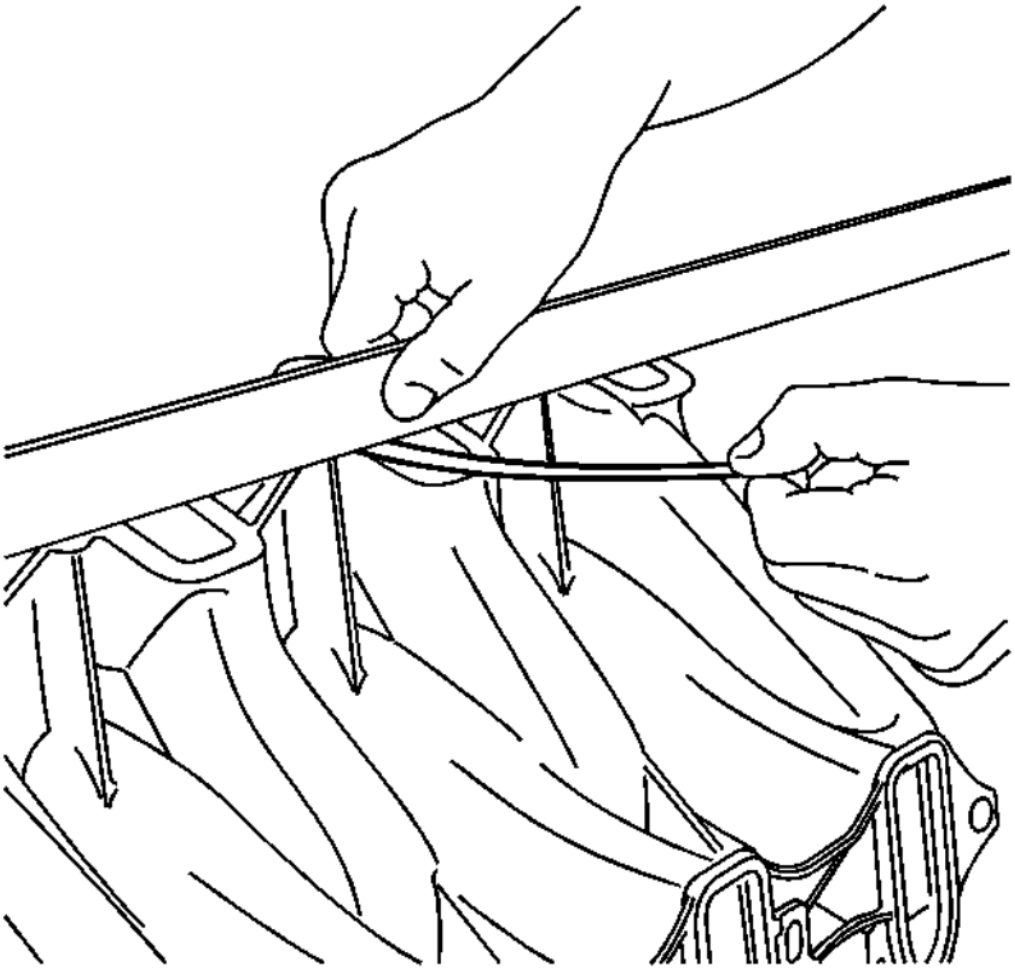

Fig. 506: Inspecting Intake Manifold Cylinder Head Deck For Warpage
Courtesy of GENERAL MOTORS CORP.

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

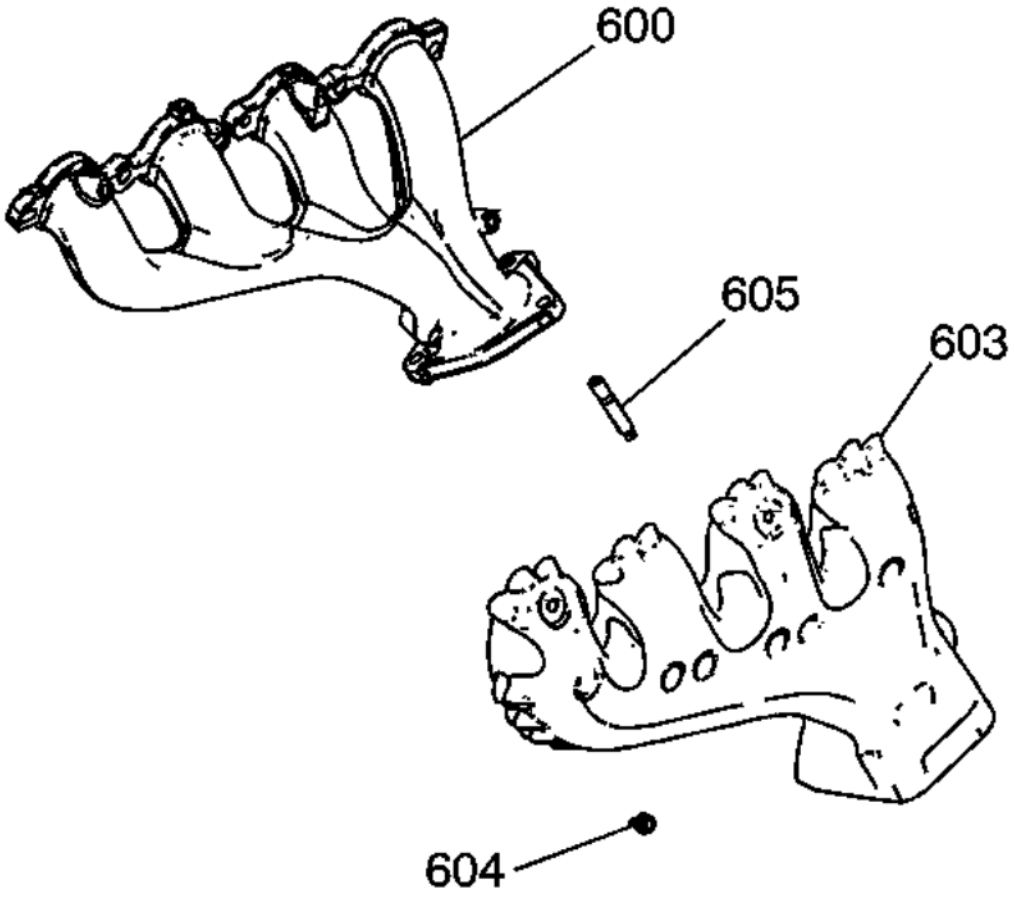

Fig. 507: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

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 affect 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 .

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.

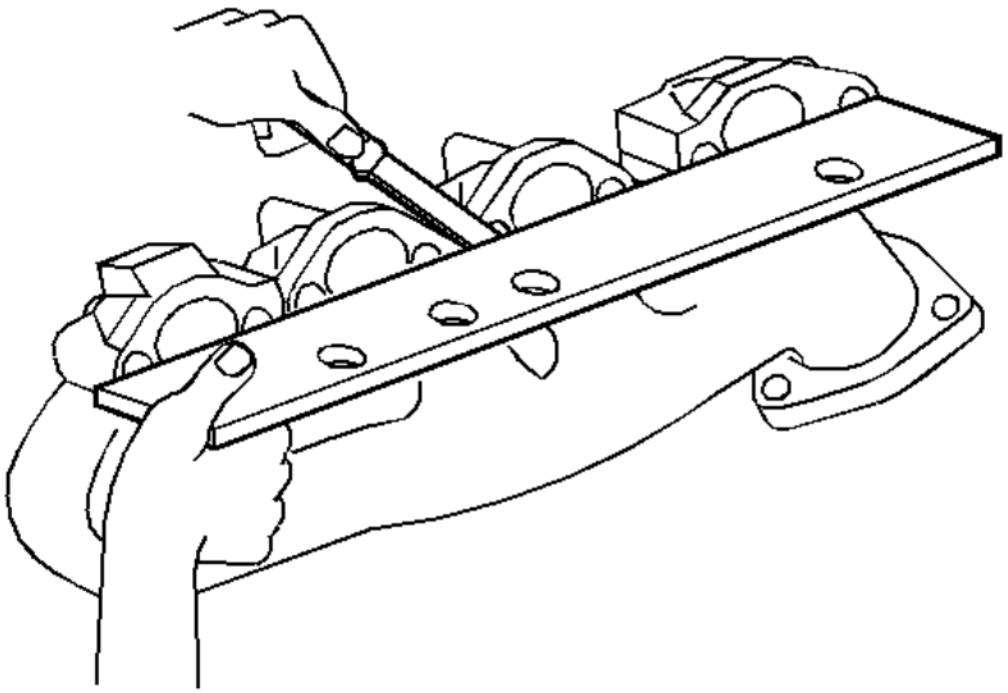

Fig. 508: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

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 2 front or 2 rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER CLEANING AND INSPECTION

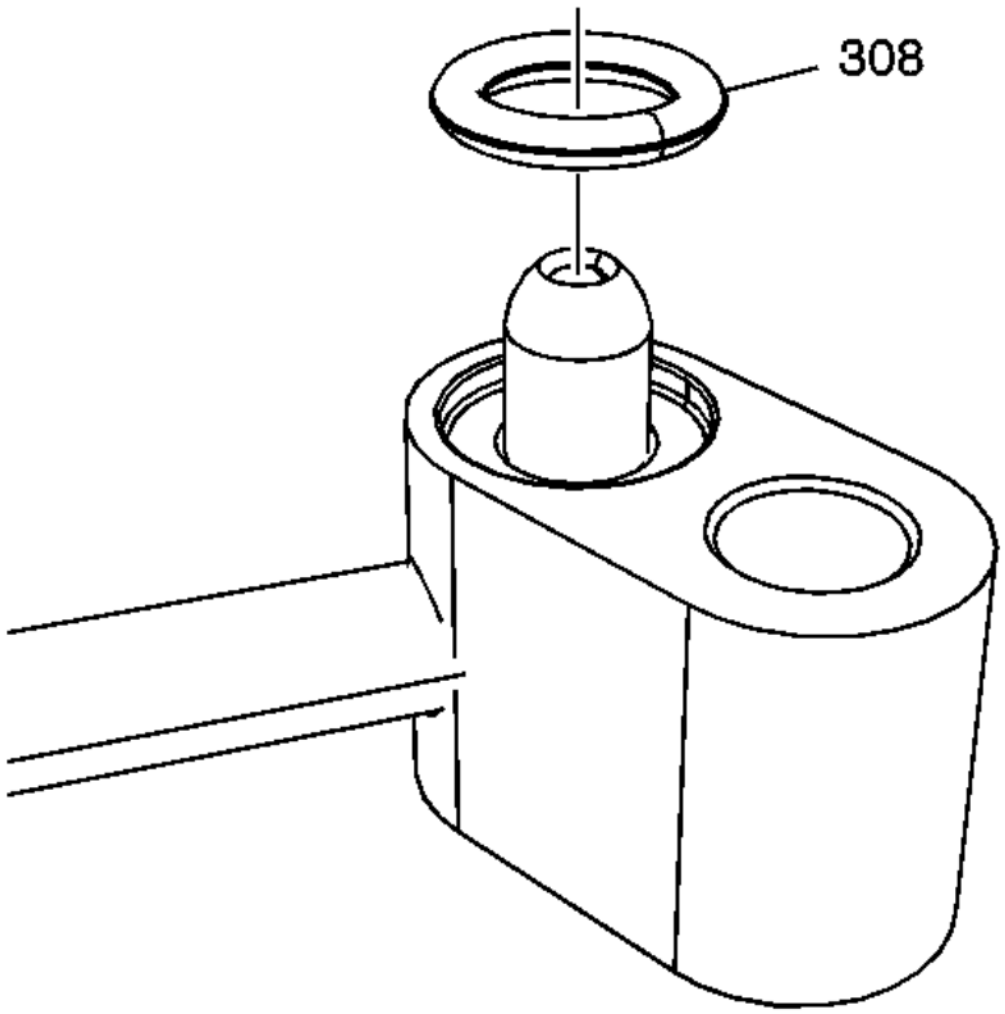

Fig. 509: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

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 and covers.

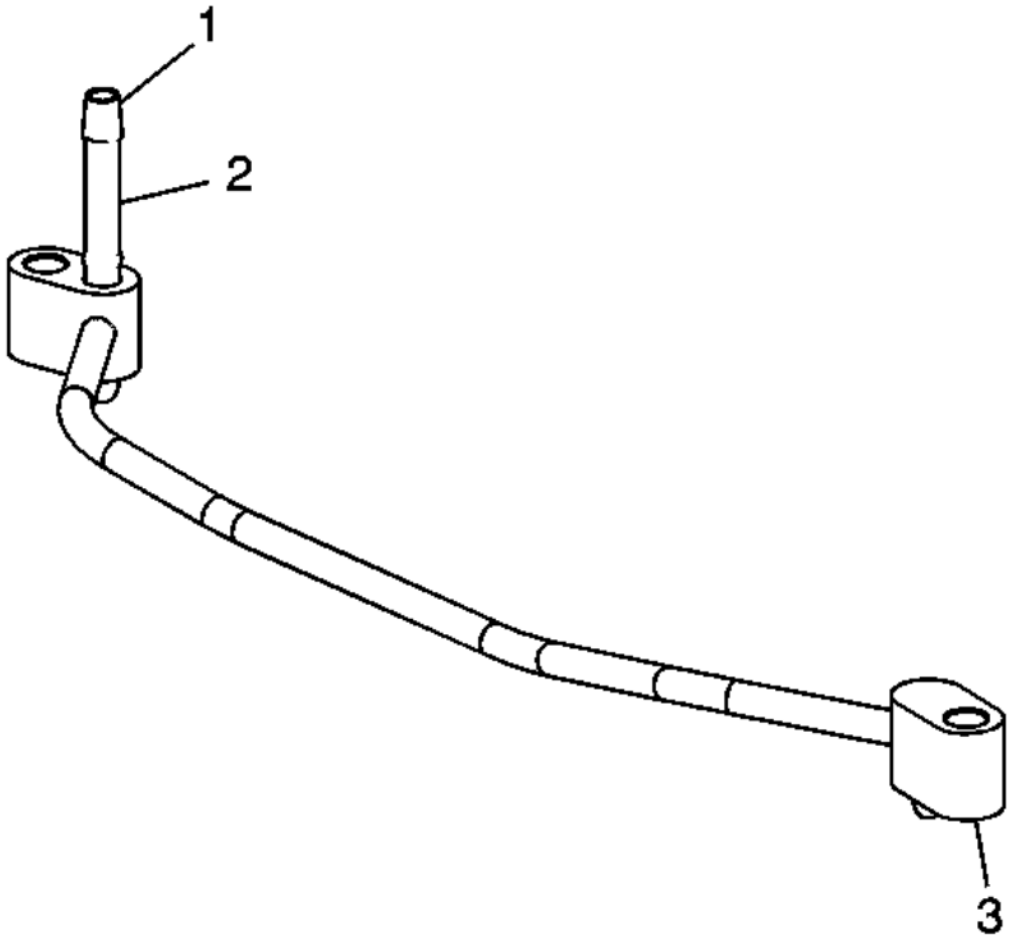

Fig. 510: View Of Coolant Air Bleed Pipe Components
Courtesy of GENERAL MOTORS CORP.

2. Clean the pipe and covers in solvent.

CAUTION: Refer to Safety Glasses and Compressed Air Caution .

3. Dry the pipe and covers with compressed air.
4. Inspect the pipe and covers for restrictions within the pipe (1) or damaged sealing surfaces (2, 3).

WATER PUMP CLEANING AND INSPECTION

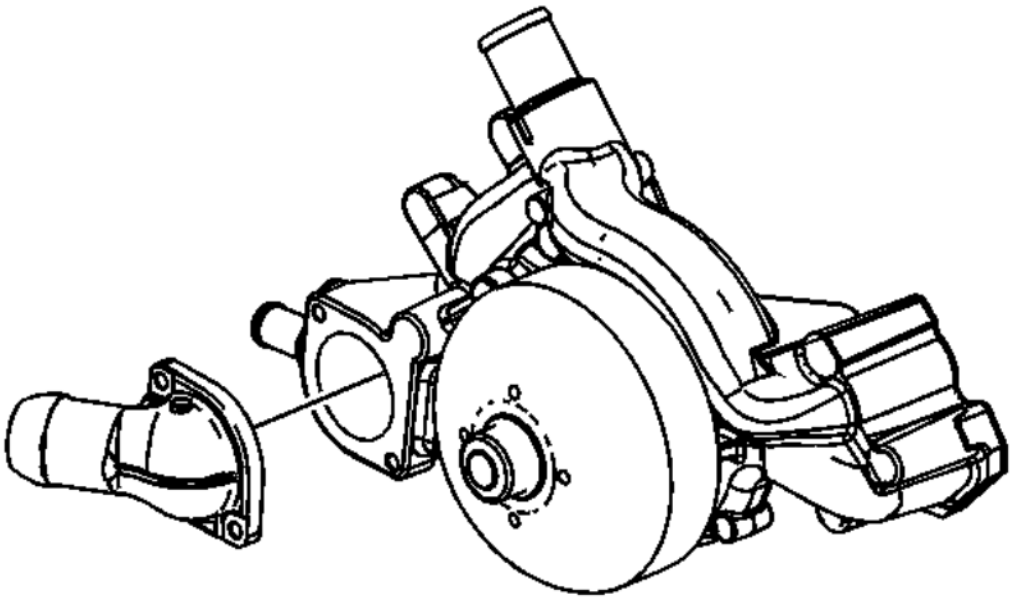

Fig. 511: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

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 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 inlet housing or rear cover

- Leakage at the water pump vent hole

  A stain around the vent hole is acceptable. If leakage, 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

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

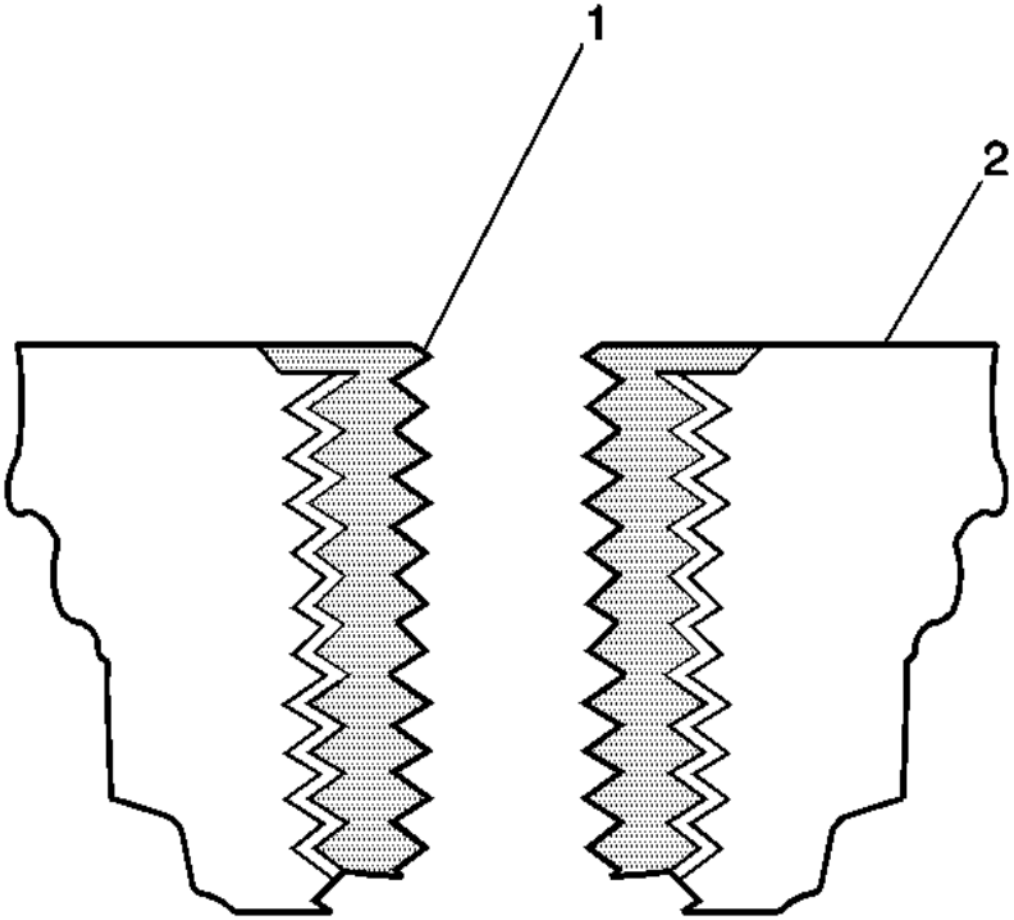

Fig. 512: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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.

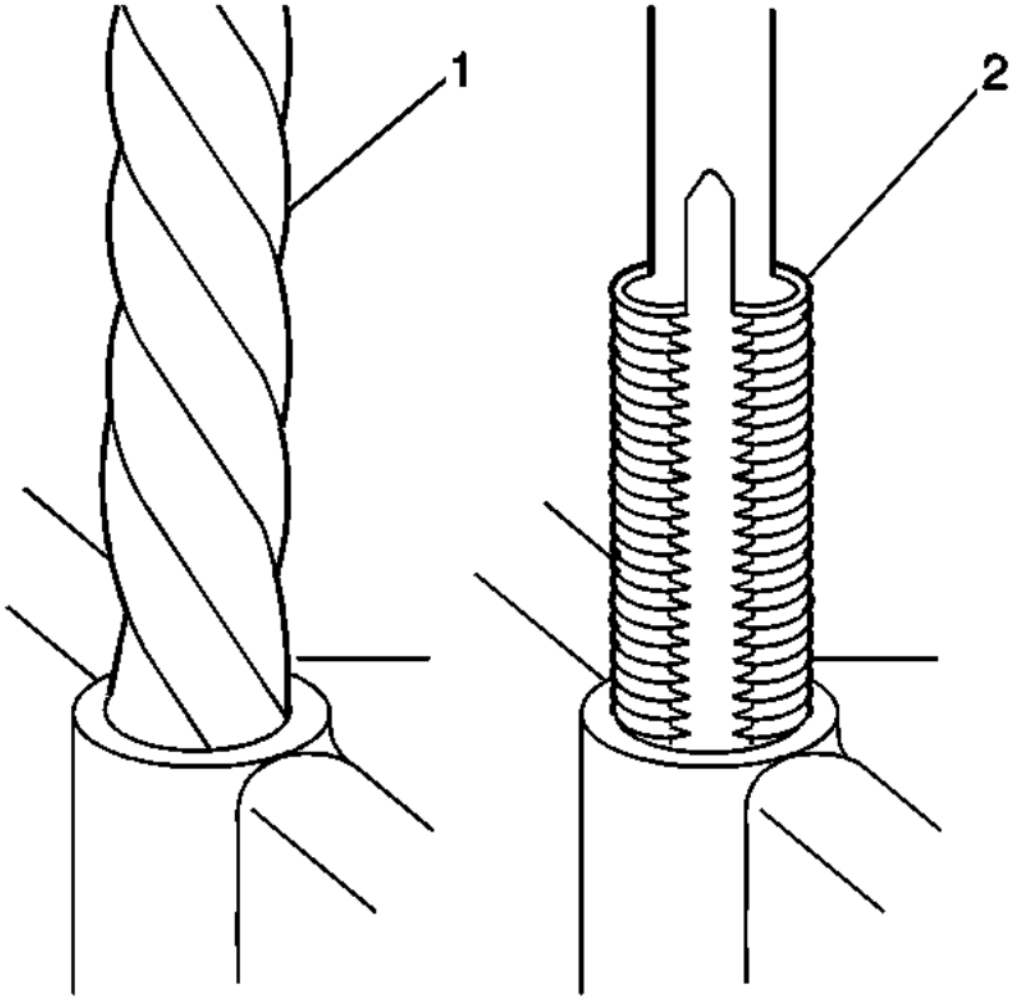

Fig. 513: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

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).
2. Using compressed air, clean out any chips.

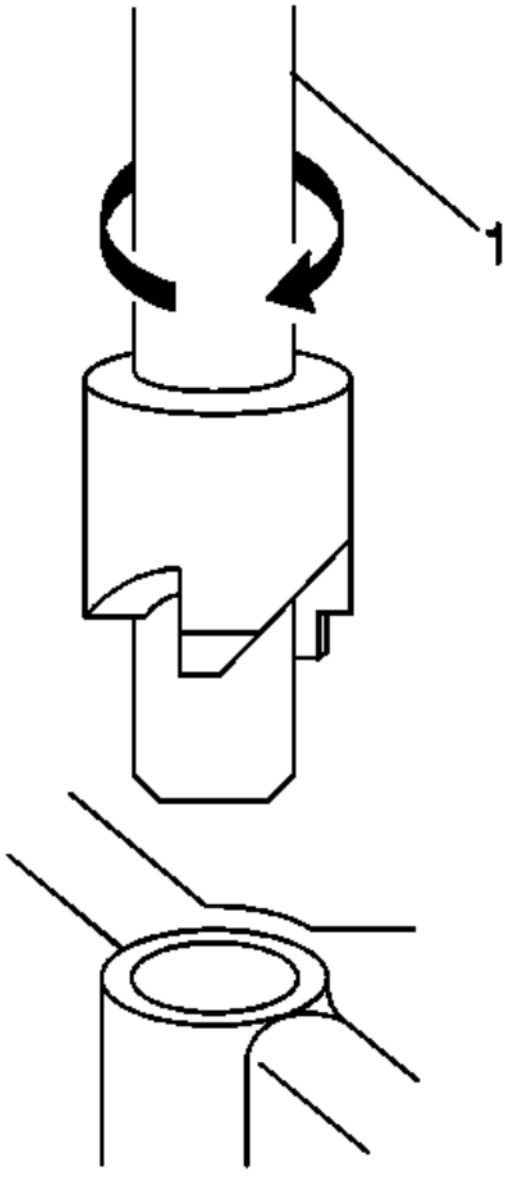

Fig. 514: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

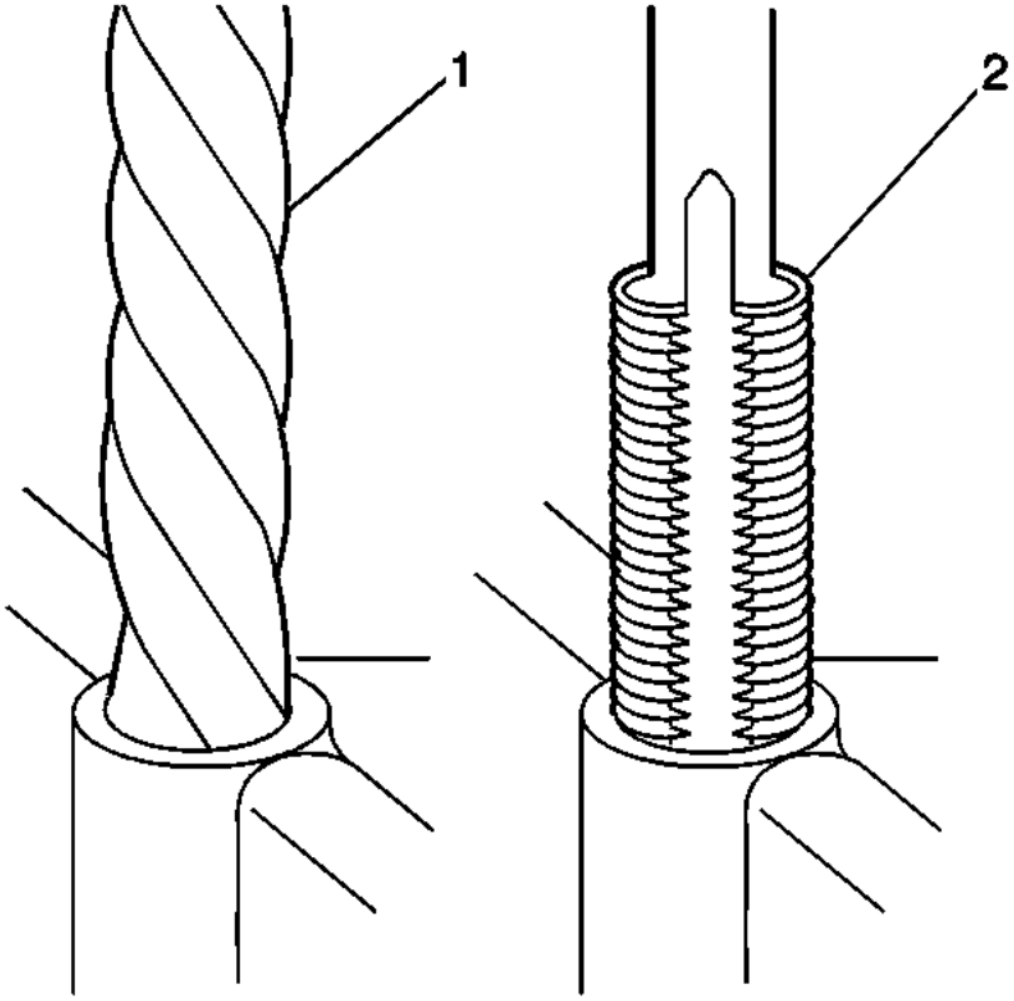

Fig. 515: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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.

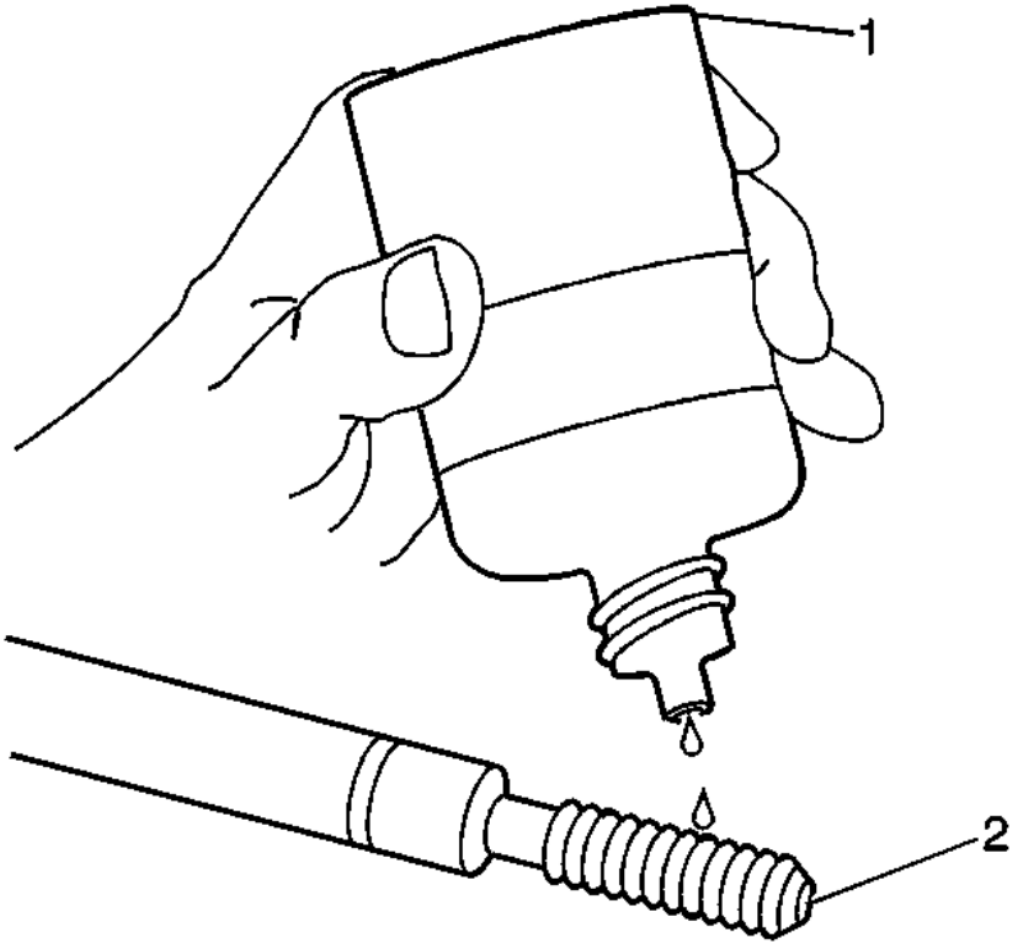

Fig. 516: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

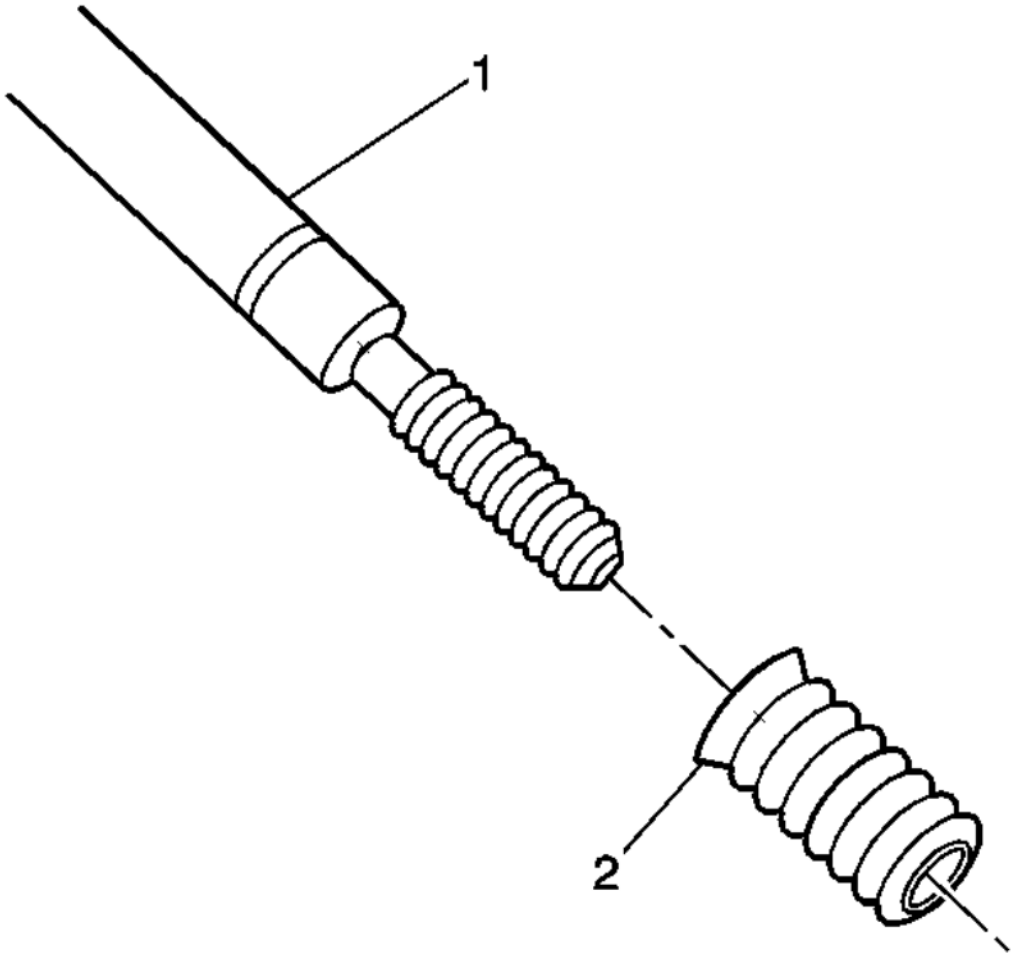

Fig. 517: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

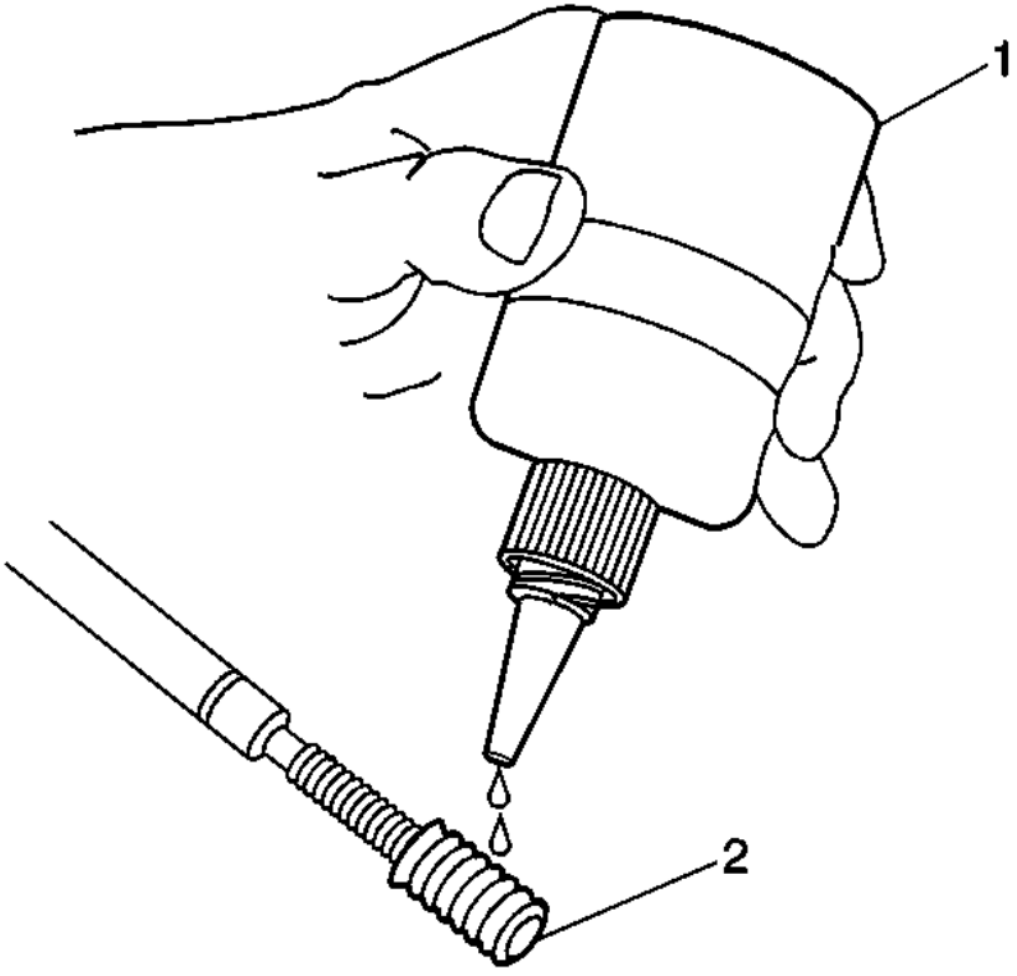

Fig. 518: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

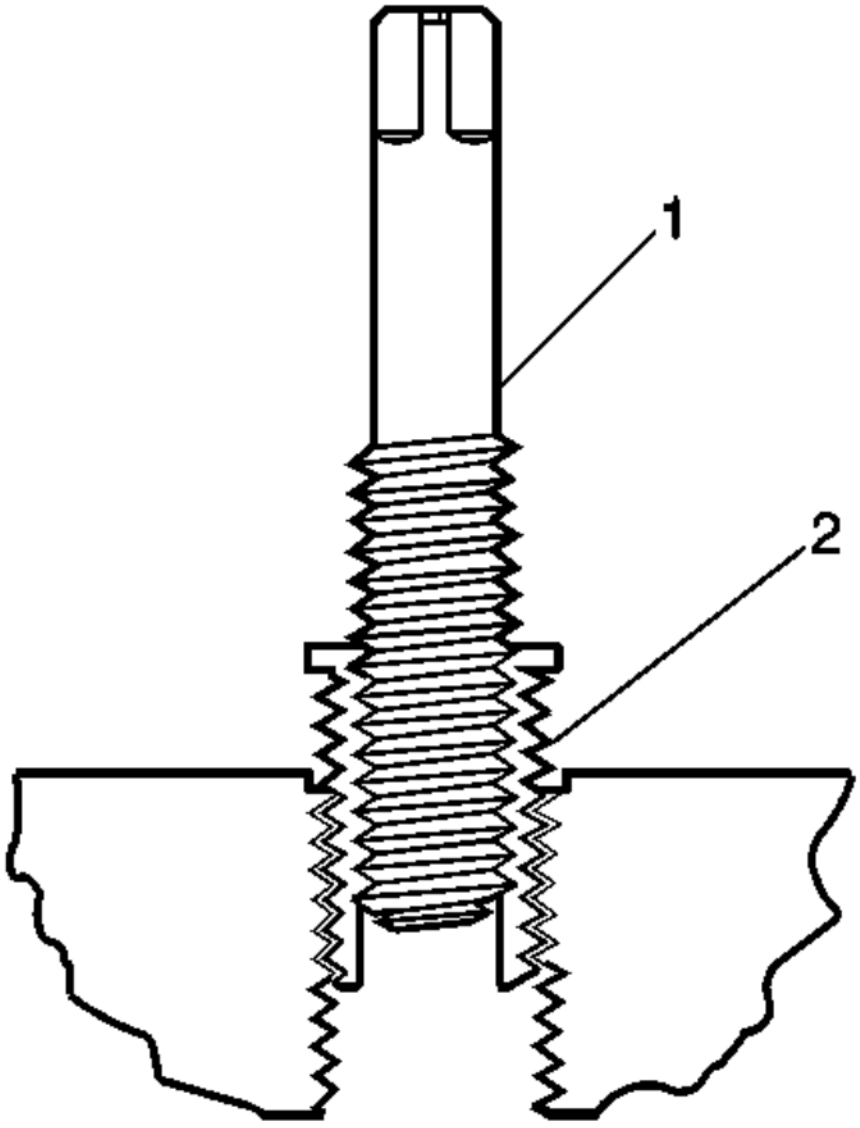

Fig. 519: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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.

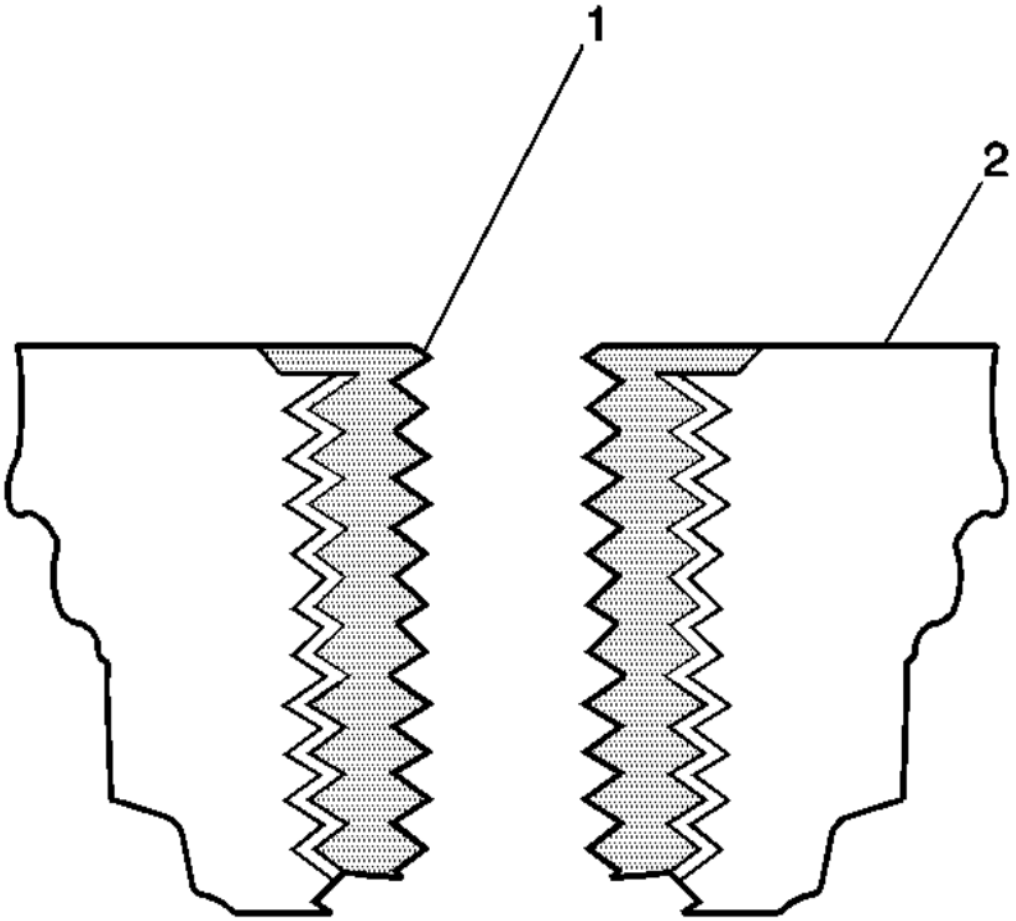

Fig. 520: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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).

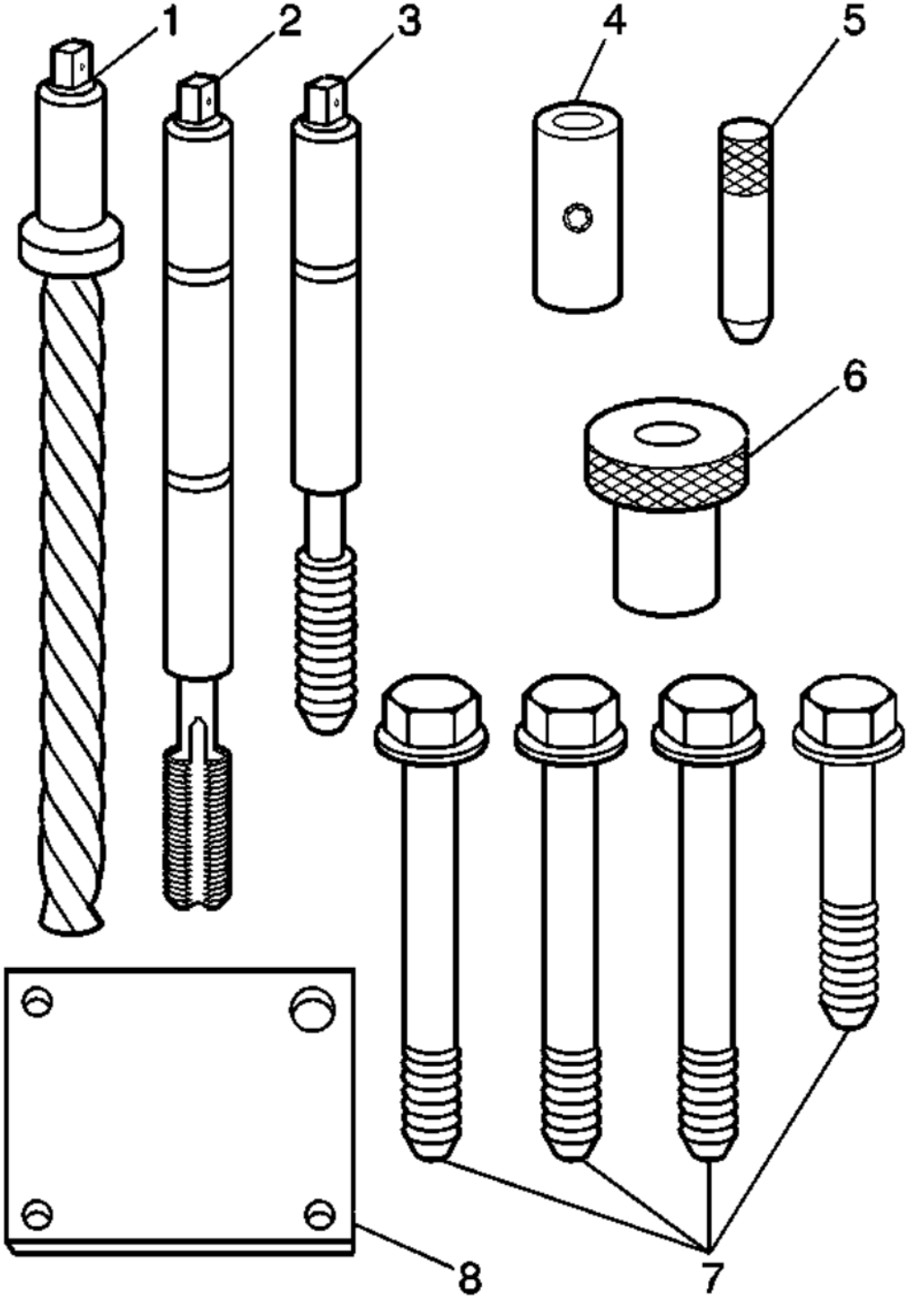
1
2
3
4
5
6
7
8

Fig. 521: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

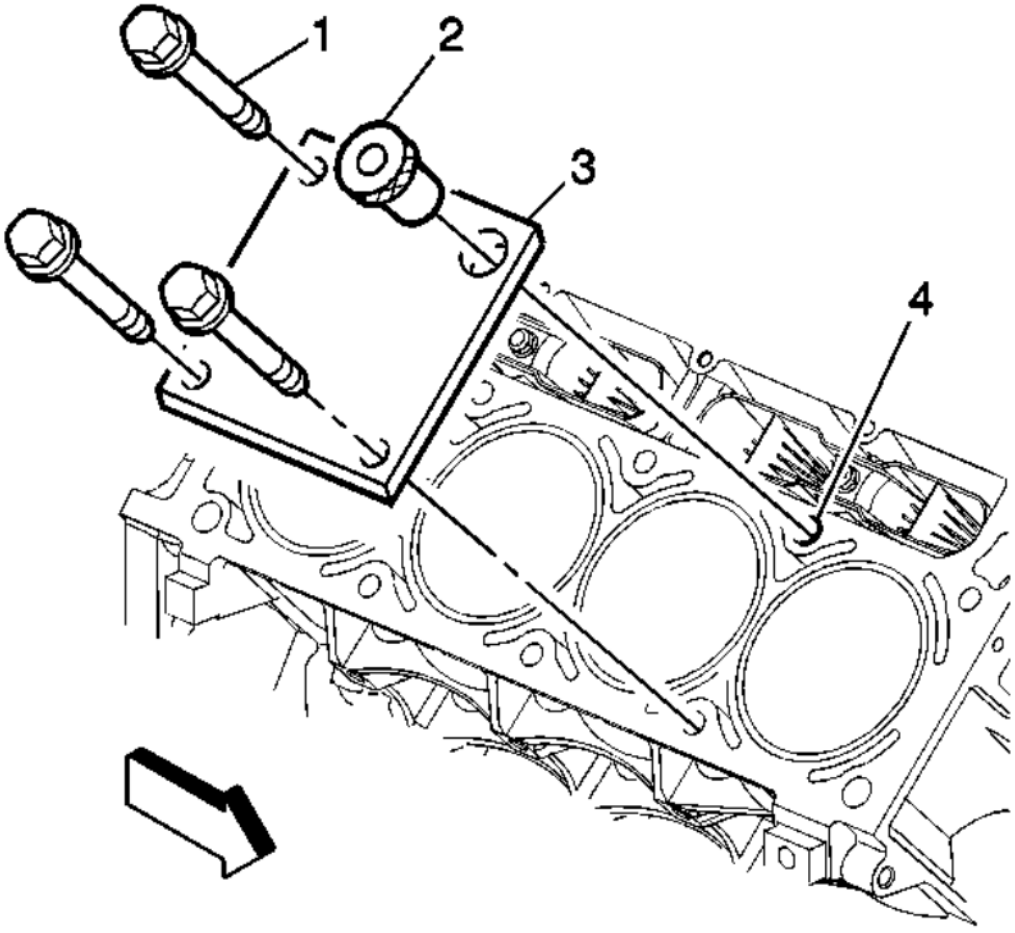

Fig. 522: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Safety Glasses Caution .

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 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).

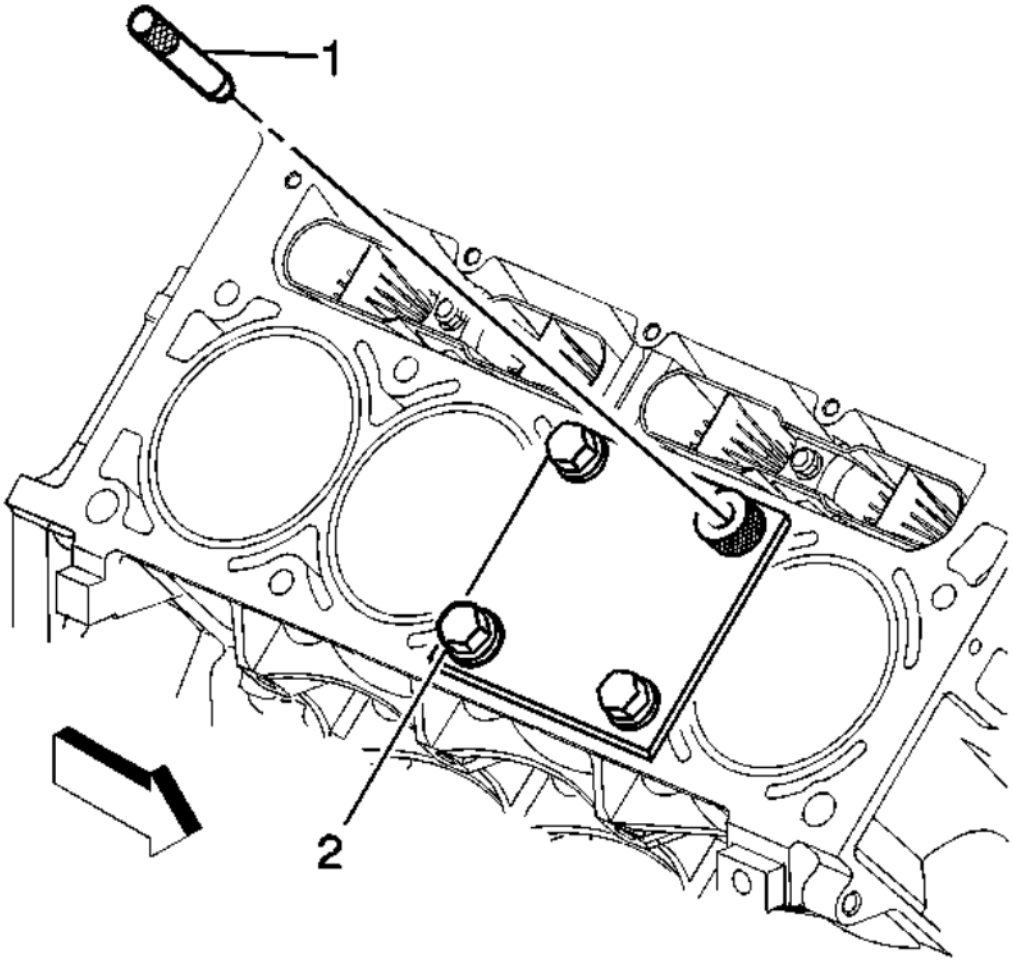

Fig. 523: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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.

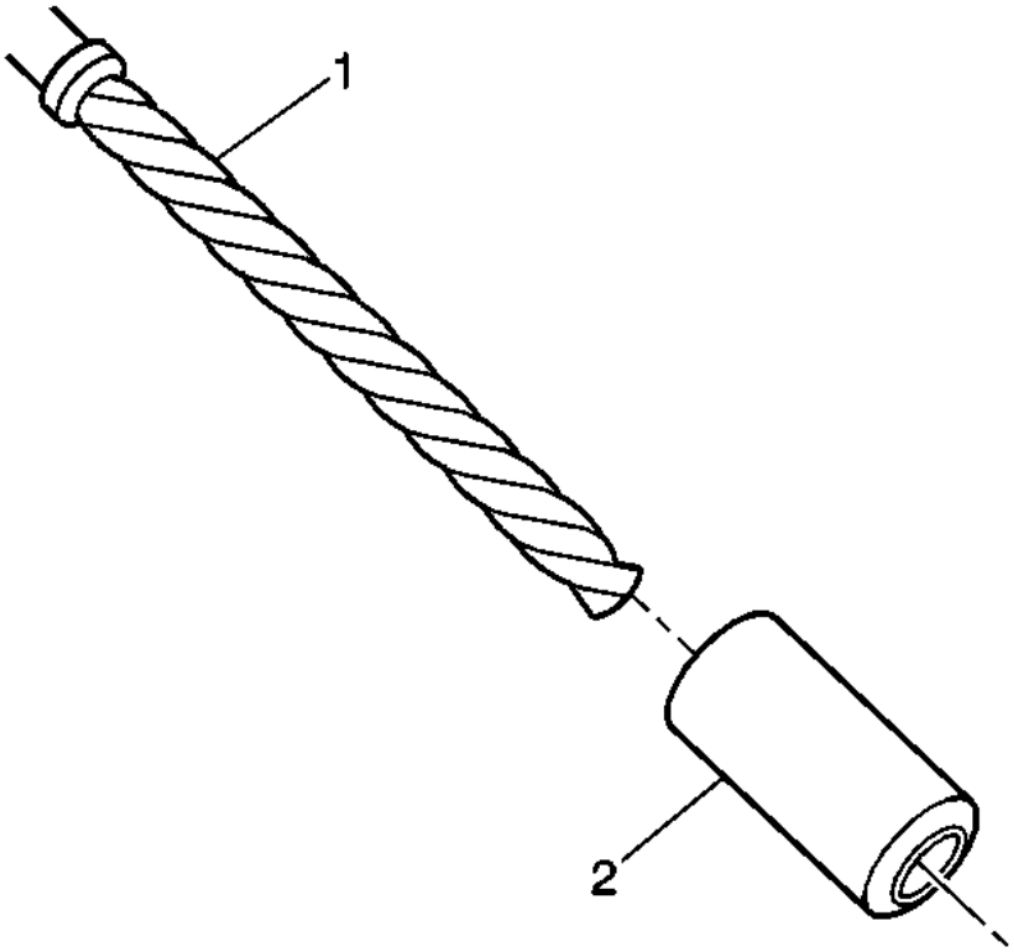

Fig. 524: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1).

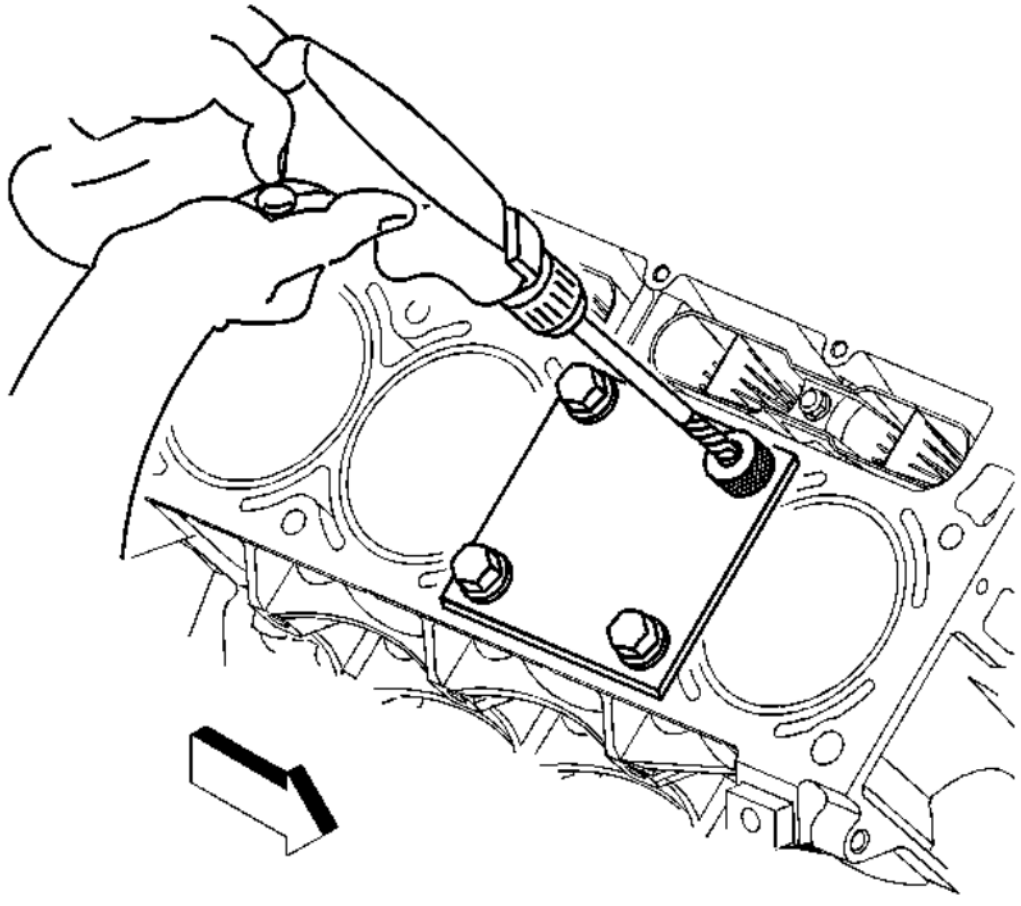

Fig. 525: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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.

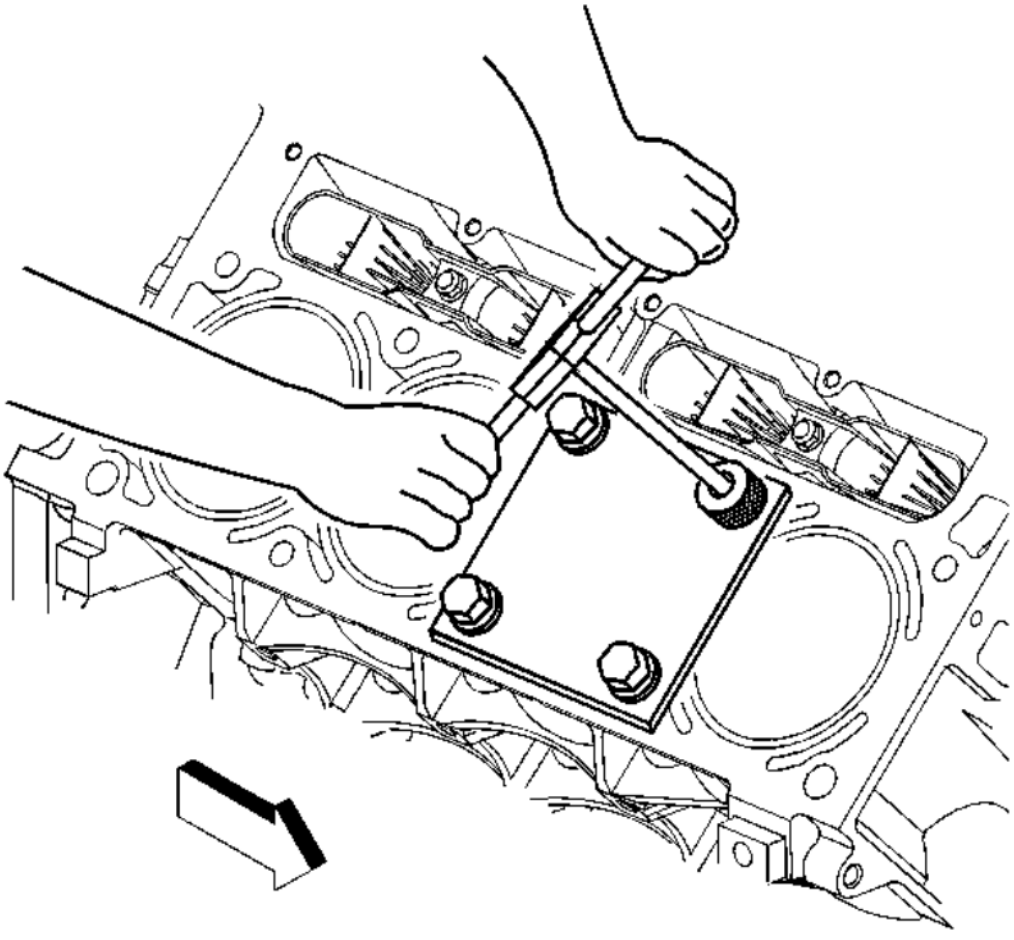

Fig. 526: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

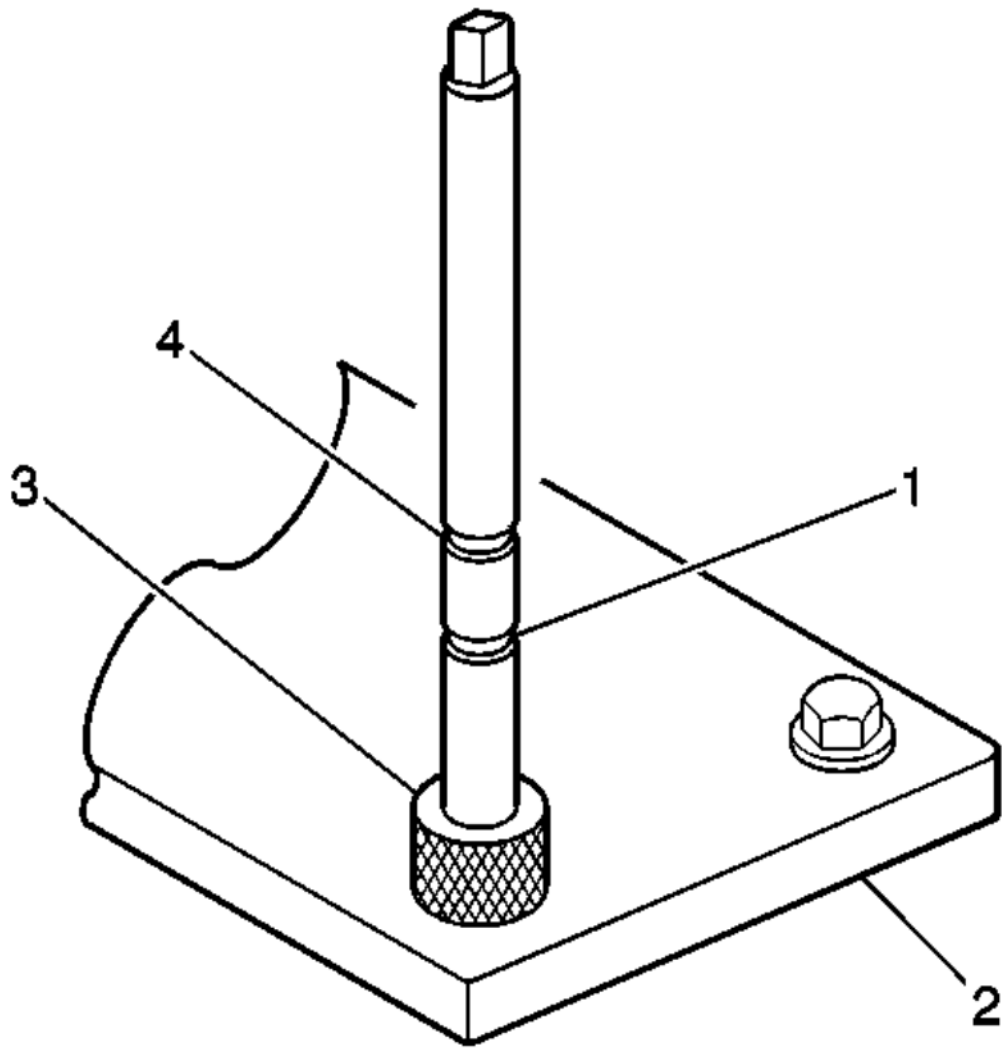

Fig. 527: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

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.

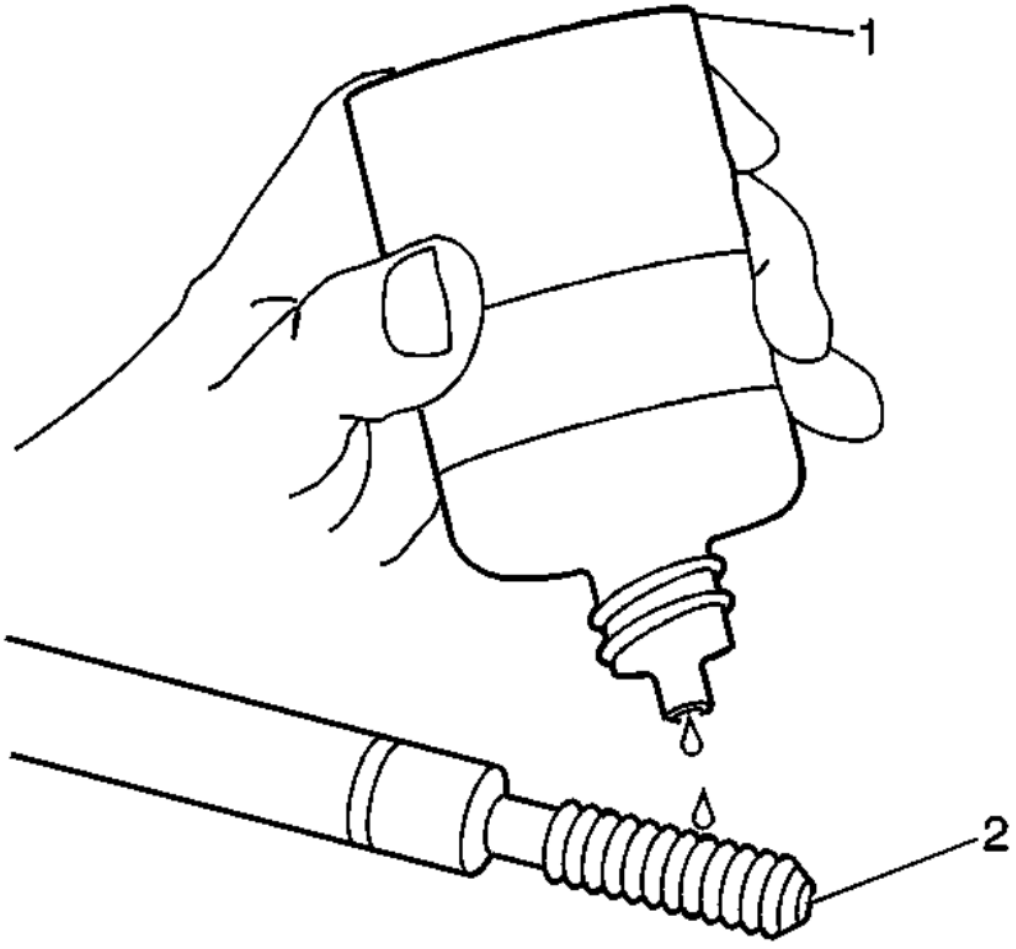

Fig. 528: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

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).

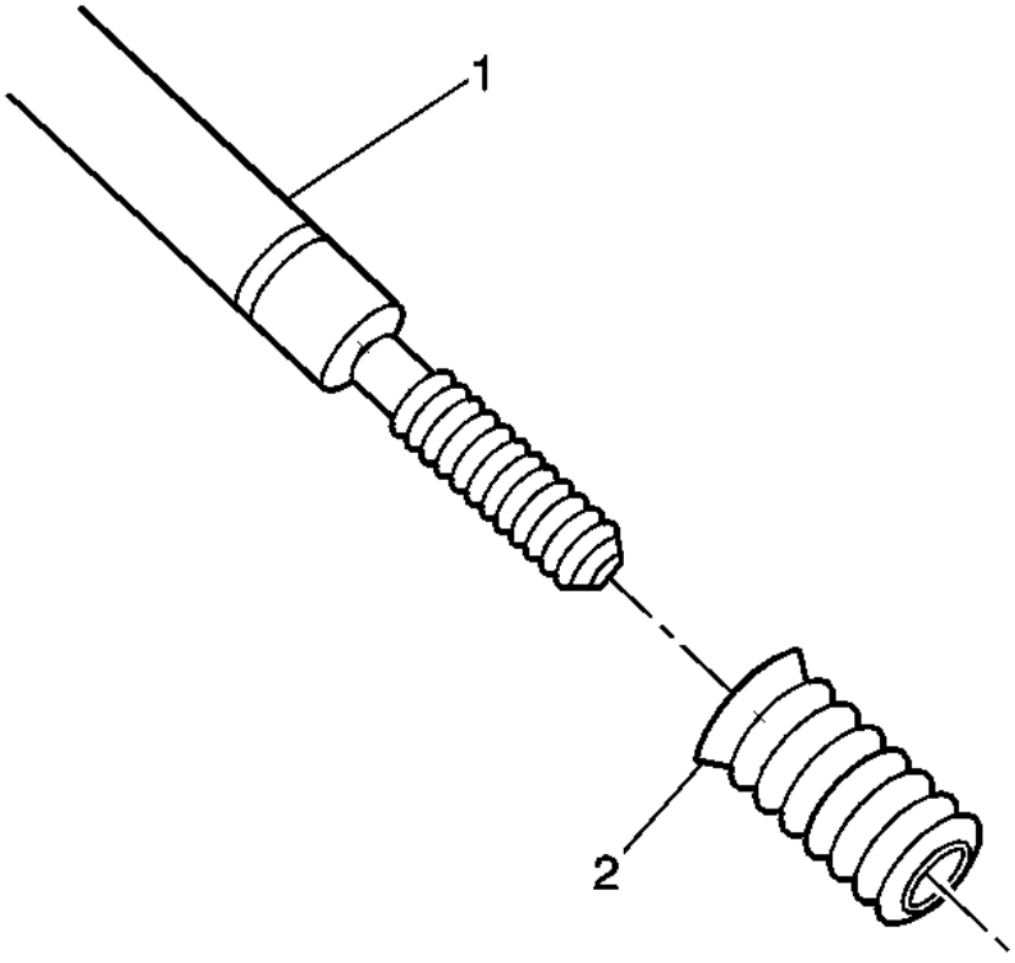

Fig. 529: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

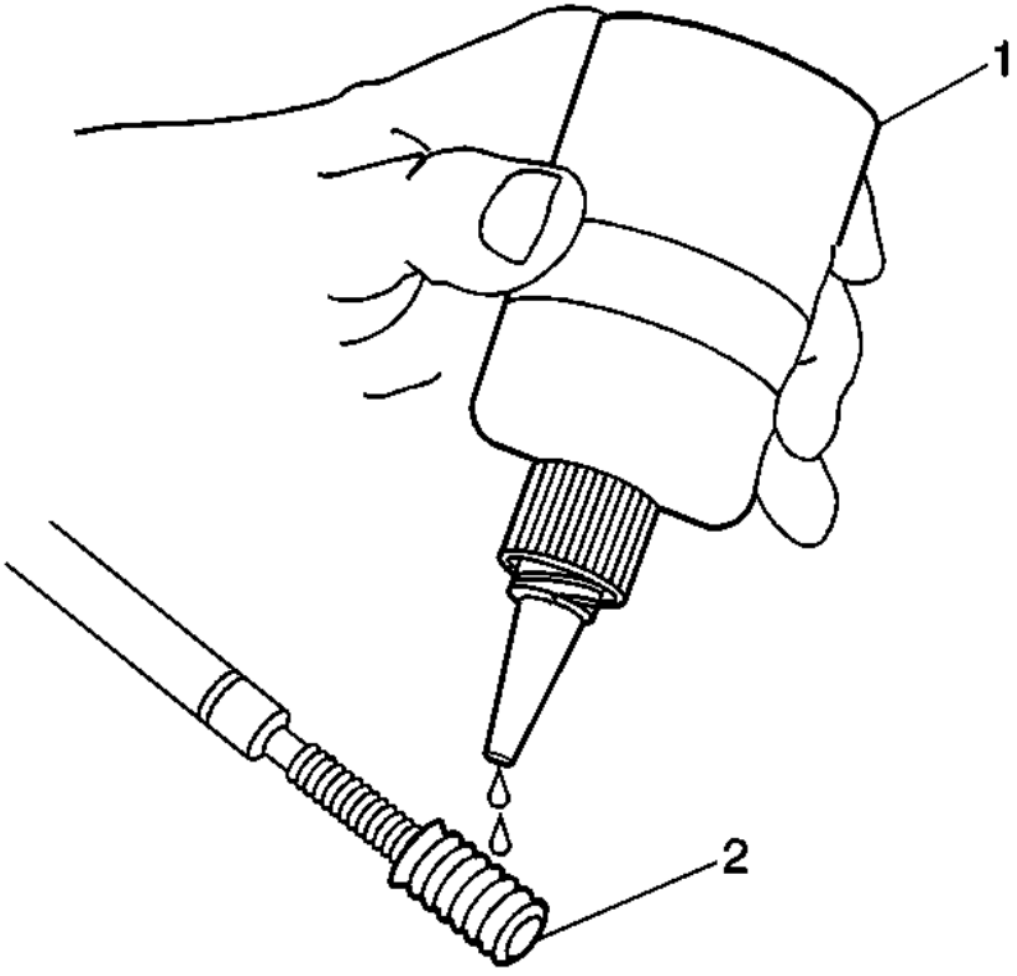

Fig. 530: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

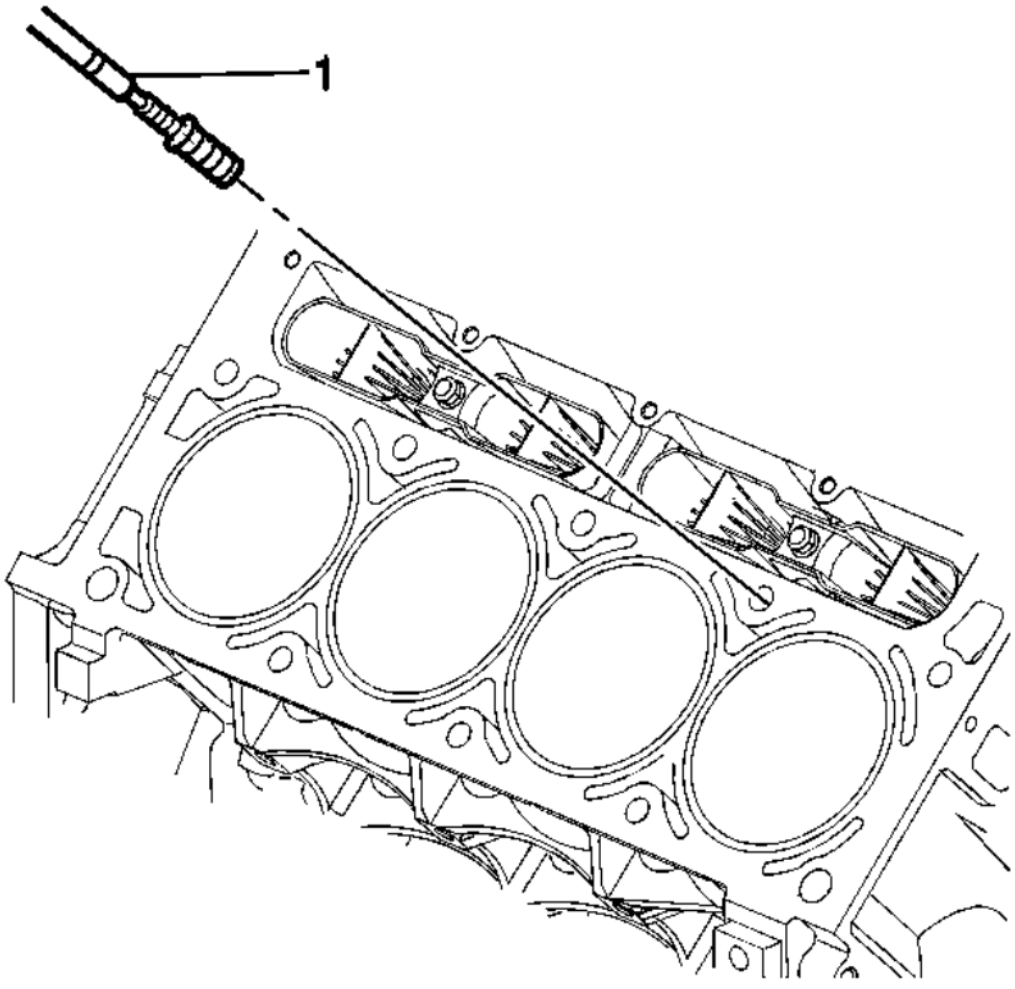

Fig. 531: Installing Insert & Driver Into Cylinder Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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