2010 ENGINE

Engine Mechanical - 5.3L - Canyon & Colorado

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
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
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		
• Step 1	150 N.m	110 lb ft
• Step 2	Loosen 360 degrees	
• Step 3	80 N.m	59 lb ft
• Final Step - with Flanged Head	125 degrees	
M8 Bolts (1-5) - First Pass in Sequence	20 N.m	15 lb ft
M8 Bolts (1-5) - Second Pass in Sequence	30 N.m	22 lb ft
M8 Bolts (6-10) - First Pass in Sequence	20 N.m	15 lb ft
M8 Bolts (6-10) - Second Pass in Sequence	30 N.m	22 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	

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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
Engine Harness Ground Strap Bolt/Stud	16 N.m	12 lb ft
Engine Harness-to-Generator Bracket Bolt	9 N.m	80 lb in
Engine Harness Retainer-to-Intake Manifold Nut	5 N.m	44 lb in
Engine Mount Bracket Through Bolt	100 N.m	74 lb ft
Engine Mount-to-Engine Block Bolts	55 N.m	41 lb ft
Evaporative (EVAP) Emission Pipe Bracket Nut	20 N.m	15 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
Flex Plate-to-Torque Converter Bolts	60 N.m	44 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
Negative Battery Cable Stud	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 Tube Bolt	25 N.m	18 lb ft
Oil Pan Baffle Bolts		

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	10 N.m	89 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 Relief Valve	27 N.m	20 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
Valve Lifter Guide Bolts	12 N.m	106 lb in
Valve Lifter Oil Manifold Bolts	25 N.m	18 lb ft
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	5.3L	325 CID
• RPO	LH9	
• VIN	L	
• Bore	96.0-96.018 mm	3.779-3.78 in
• Stroke	92.0 mm	3.622 in

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• Compression Ratio	9.95:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Active Fuel Management Cylinders	1-4-6-7	
• Spark Plug Gap	1.02 mm	0.04 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.58-59.63 mm	2.345-2.347 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 3 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.871-69.889 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	96.0-96.018 mm	3.779-3.78 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.57-234.82 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.990-55.015 mm	2.165-2.166 in
• Camshaft Bearing Diameter	55.063-55.088 mm	2.1678-2.1688 in
• Camshaft Journal-to-Bearing Clearance	0.048-0.098 mm	0.0002-0.0038 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Intake	7.20 mm	0.283 in
• Camshaft Lobe Lift - Exhaust	7.20 mm	0.283 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Camshaft Position Actuator		
• Range of Authority	52 degrees	
• Park Position	7 degrees Advanced	
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

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• 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	0.1 mm	0.004 in

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Overall Length of the Cylinder Head		
• 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 RPM 124 kPa at 2,000 RPM 165 kPa at 4,000 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 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 - Measured in Cylinder Bore - Service	0.18-0.81 mm	0.007-0.032 in
• Piston Ring-to-Groove Clearance - First Compression		

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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	0.9430-0.9431 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	96.002-96.036 mm	3.7796-3.7809 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 - Intake	12.24 mm	0.482 in
• Valve Lift - Exhaust	12.24 mm	0.482 in
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in

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• Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Valve Spring Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

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 Sealing Washer	Sealant	12346004	10953480
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

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THREAD REPAIR SPECIFICATIONS

Engine Block - Front/Rear Views

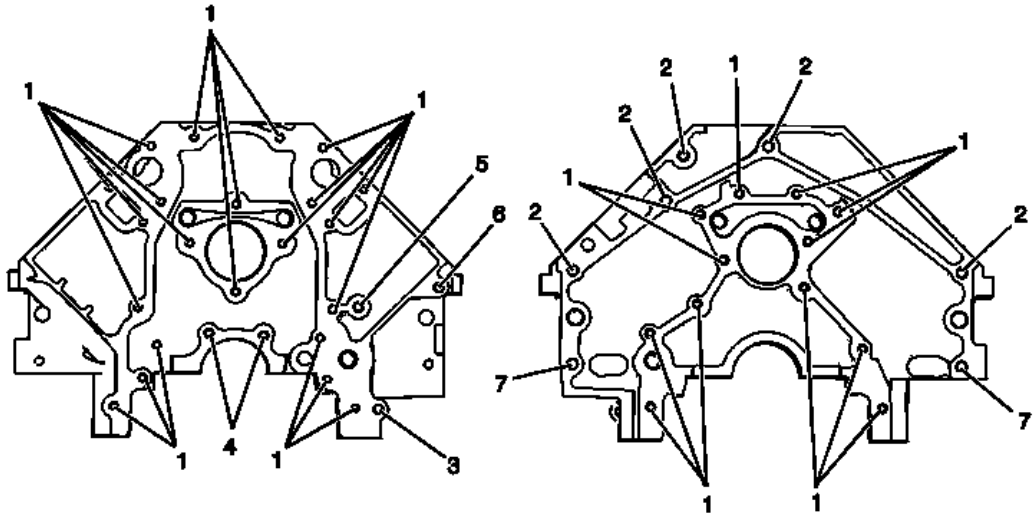

Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front/Rear Views

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	215	211	212	213	214	Thru	Thru

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	1.5							
Bolt hole 6 is drilled and tapped for aluminum block applications only.								

Engine Block - Left/Right Side Views

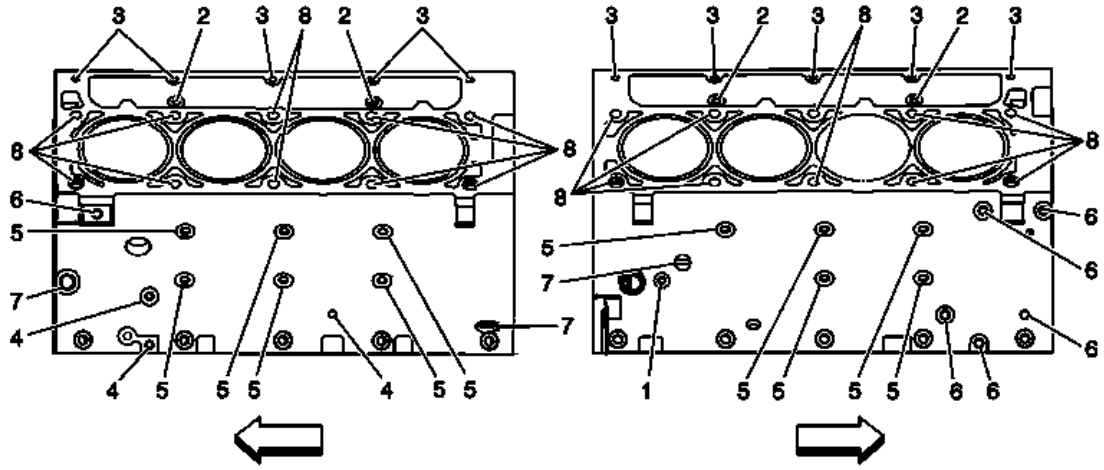

Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left/Right Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				
1	M8 x 1.25	210	206	207	208	209	22.5 (0.885)	17.5 (0.688)
2	M6 x 1.0	205	201	202	203	204	22.5 (0.885)	15.0 (0.688)
3	M8 x 1.25	210	206	207	208	209	28.5 (1.122)	23.0 (0.905)
4	M8 x 1.25	210	206	207	208	209	21.5 (0.846)	16.0 (0.629)
5	M10 x 1.25	215	211	212	213	214	29.0 (1.141)	23.0 (0.905)
6	M10 x 1.5	215	211	212	213	214	27.0 (1.062)	21.5 (0.846)
7	M16 x 1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	M11 x 2.0	108	105	N/A	106	107	69.0 (2.72)	60.0 (2.36)
Bolt hole 8 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

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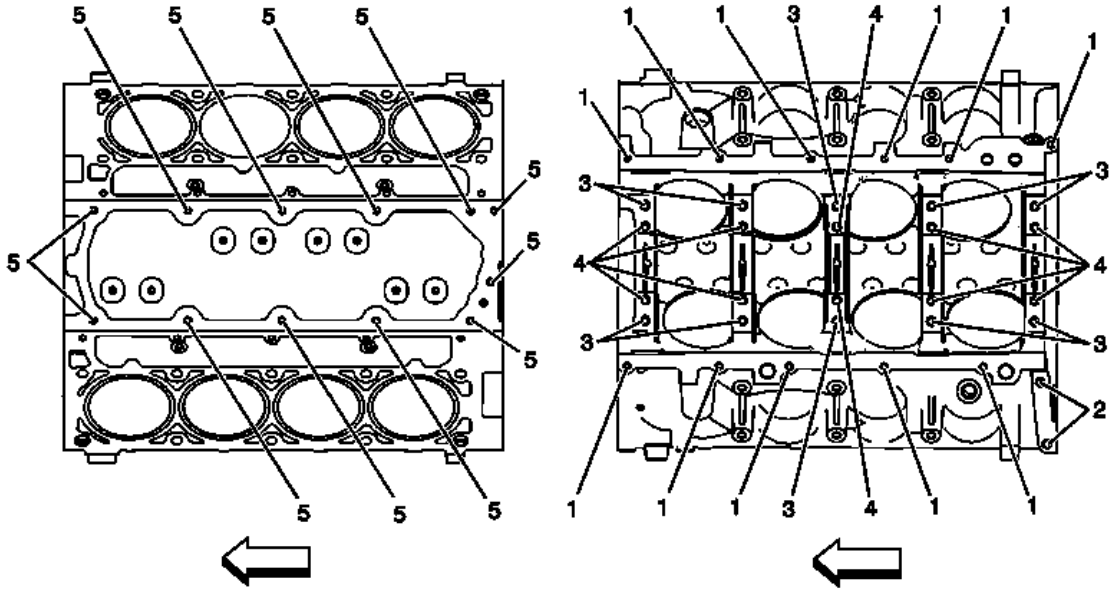

Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top/Bottom Views

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

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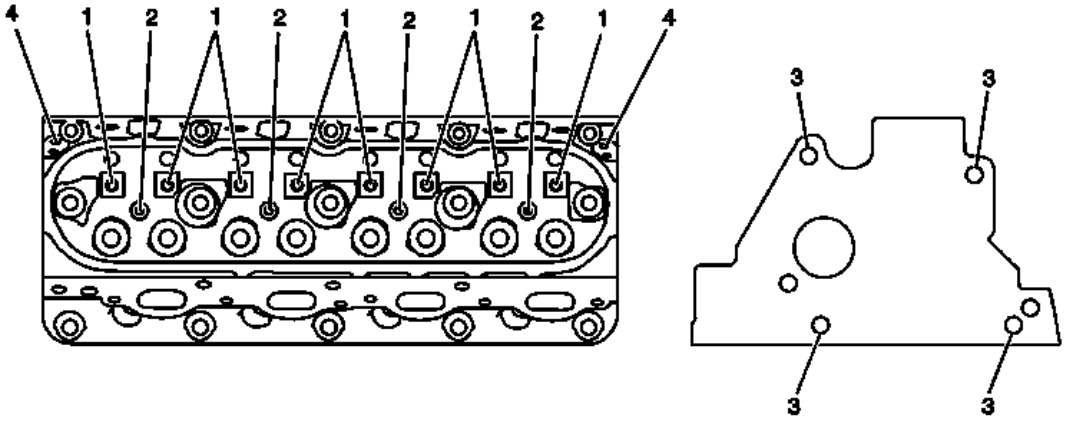

Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top/End Views

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

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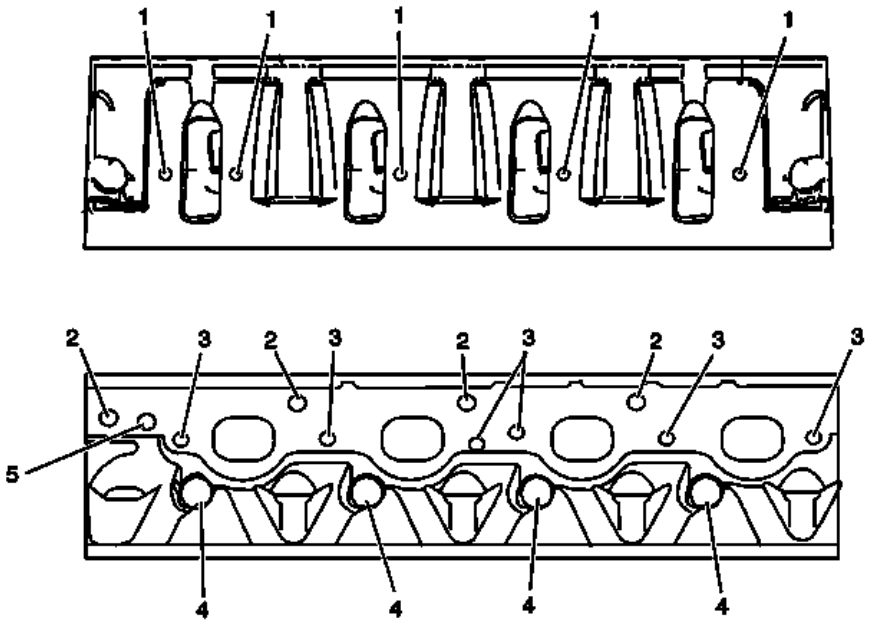

Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake/Exhaust Side Views

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

COMPONENT LOCATOR

DISASSEMBLED VIEWS

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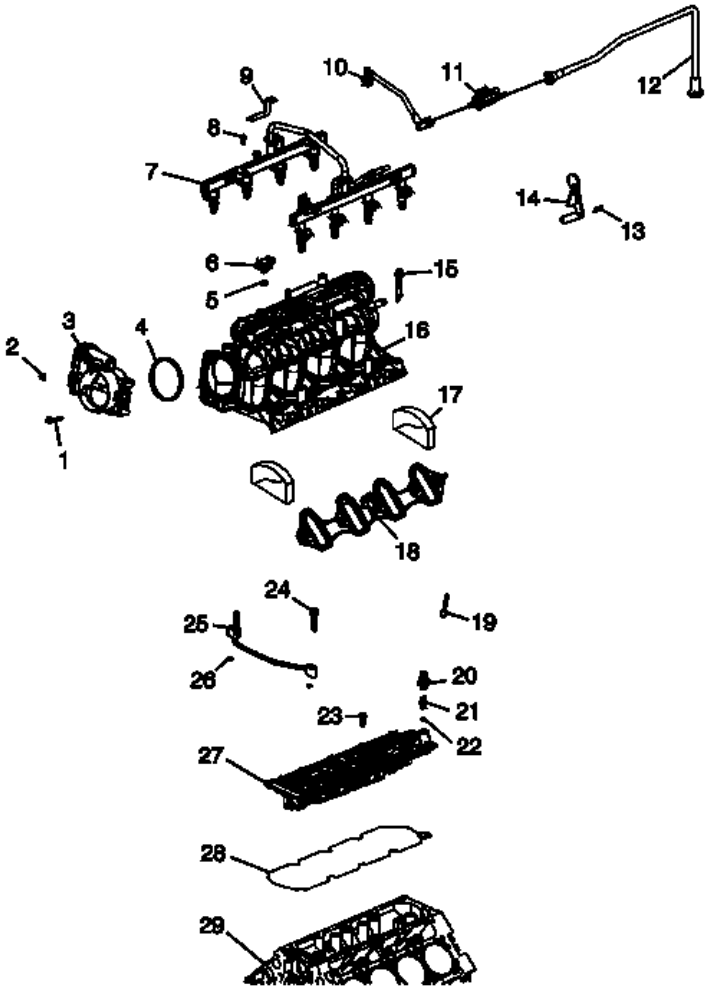

Fig. 6: Intake Manifold/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Bolt
2	Nut
3	Throttle Body
4	Throttle Body Seal
5	Manifold Absolute Pressure (MAP) Sensor O-ring Seal
6	MAP Sensor
7	Sequential Multi-Port Fuel Injector Assembly with Fuel Rail
8	Bolt
9	Fuel Injection Fuel Rail Bracket
10	Evaporative (EVAP) Emission Canister Purge Tube
11	EVAP Emission Canister Purge Solenoid Valve
12	EVAP Emission Canister Purge Tube
13	Bolt

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14	Fuel Injection Fuel Rail Stop
15	Bolt
16	Intake Manifold
17	Intake Manifold Seal
18	Intake Manifold Gasket
19	Engine Coolant Air Bleed Plug
20	Engine Oil Pressure Sensor
21	Valve Lifter Oil Filter
22	Valve Lifter Oil Filter Seal
23	Bolt
24	Bolt
25	Engine Coolant Air Bleed Pipe
26	Engine Coolant Air Bleed Pipe O-ring Seal
27	Engine Valley Cover
28	Gasket
29	Engine Block

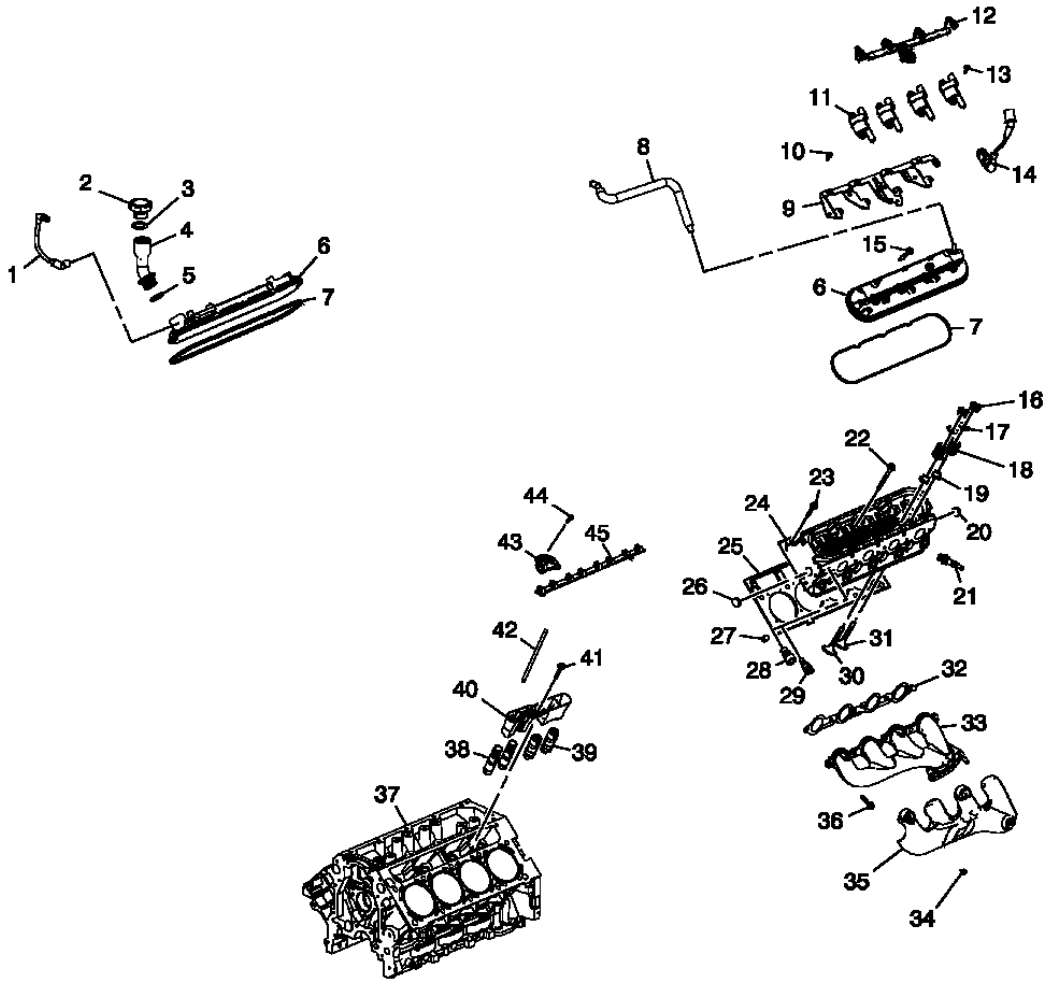

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Fig. 7: Cylinder Head/Upper Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Positive Crankcase Ventilation (PCV) Hose - Fresh Air
2	Oil Fill Cap
3	Oil Fill Cap O-Ring Seal
4	Oil Fill Tube
5	Oil Fill Tube O-Ring Seal
6	Valve Rocker Arm Cover
7	Valve Rocker Arm Cover Gasket
8	PCV Hose - Dirty Air
9	Ignition Coil Bracket
10	Ignition Coil Bracket Bolt
11	Ignition Coil
12	Ignition Coil Wire Harness Assembly
13	Ignition Coil Bolt
14	Spark Plug Wire
15	Valve Rocker Arm Cover Bolt
16	Valve Stem Key
17	Valve Spring Cap
18	Valve Spring
19	Valve Stem Oil Seal
20	Cylinder Head Core Hole Plug
21	Spark Plug
22	Cylinder Head Bolt - M10
23	Cylinder Head Bolt - M8
24	Cylinder Head
25	Cylinder Head Gasket
26	Cylinder Head Core Hole Plug
27	Cylinder Head Locating Pin
28	Cylinder Head Plug
29	Engine Coolant Temperature Sensor
30	Exhaust Valve
31	Intake Valve
32	Exhaust Manifold Gasket
33	Exhaust Manifold
34	Exhaust Manifold Heat Shield Bolt
35	Exhaust Manifold Heat Shield
36	Exhaust Manifold Flange Bolt
37	Engine Block

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38	Valve Lifter - Active Fuel Management
39	Valve Lifter - Non-Active Fuel Management
40	Valve Lifter Guide
41	Valve Lifter Guide Bolt
42	Push Rod Valve
43	Valve Rocker Arm
44	Valve Rocker Arm Pivot Support Bolt
45	Valve Rocker Arm Pivot Support

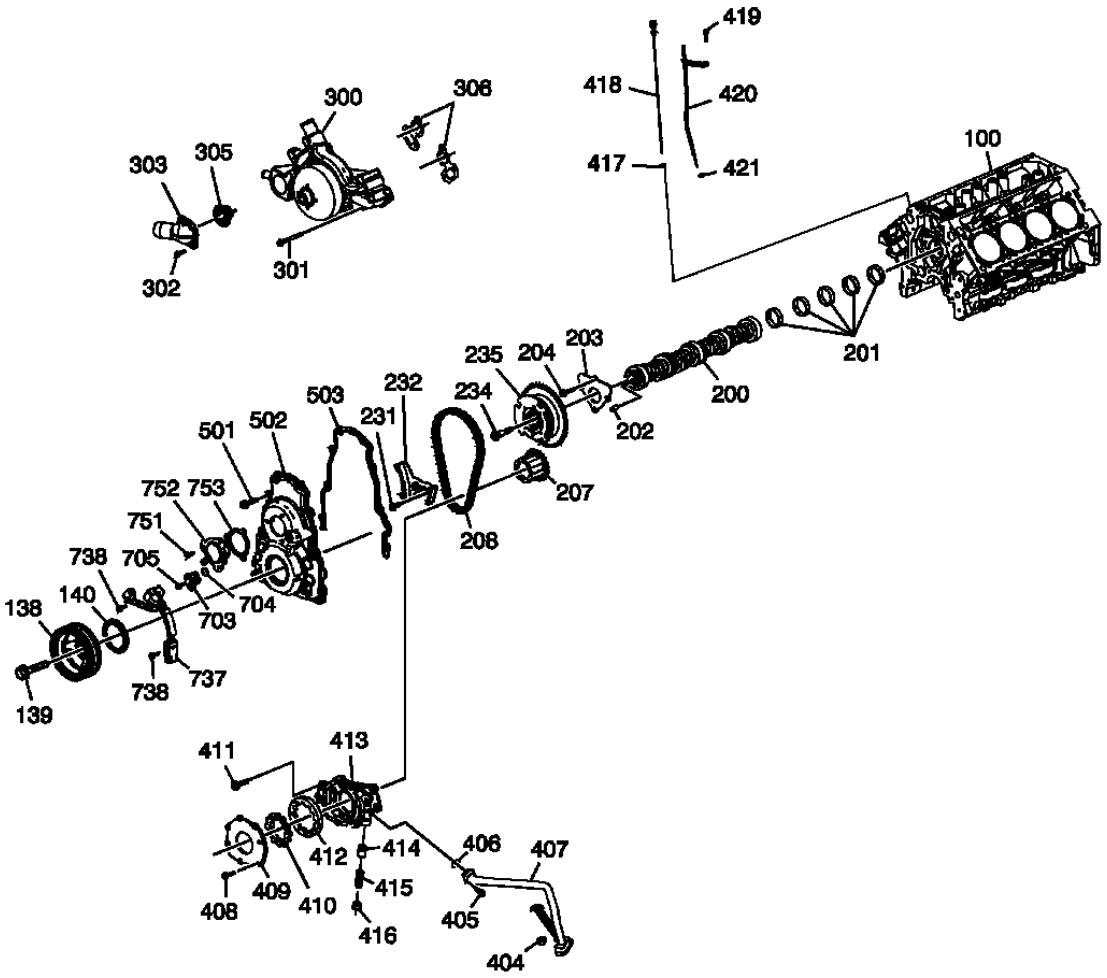

Fig. 8: Front of Engine
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
138	Crankshaft Balancer
139	Crankshaft Balancer Bolt
140	Crankshaft Front Oil Seal

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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
703	CMP Sensor
704	CMP Sensor O-Ring Seal
705	CMP Sensor Bolt

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	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

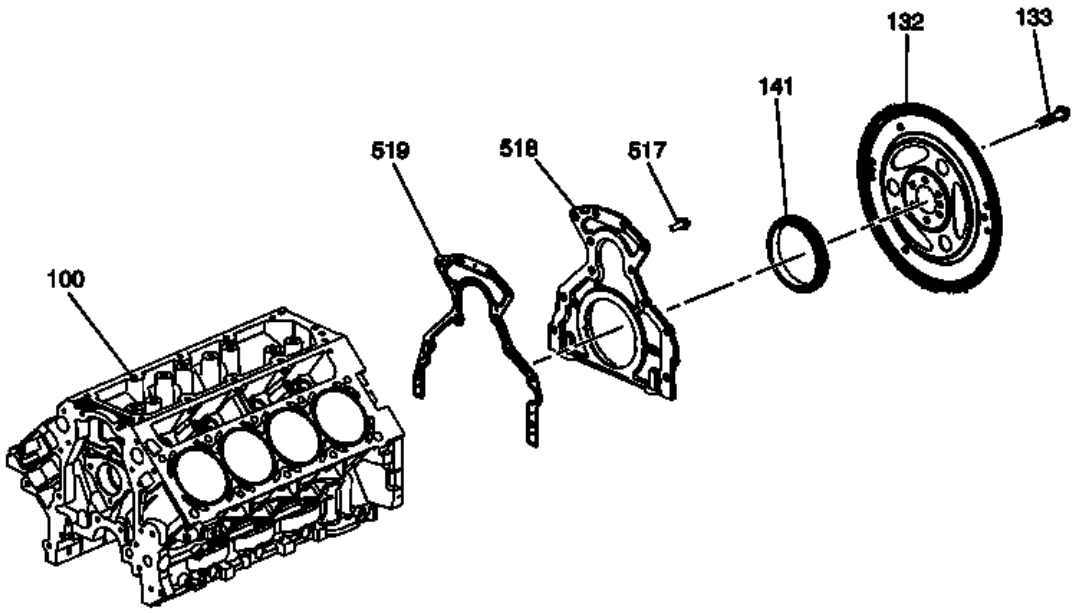

Fig. 9: Rear of Engine
Courtesy of GENERAL MOTORS CORP.

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

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519	Crankshaft Rear Oil Seal Housing Gasket

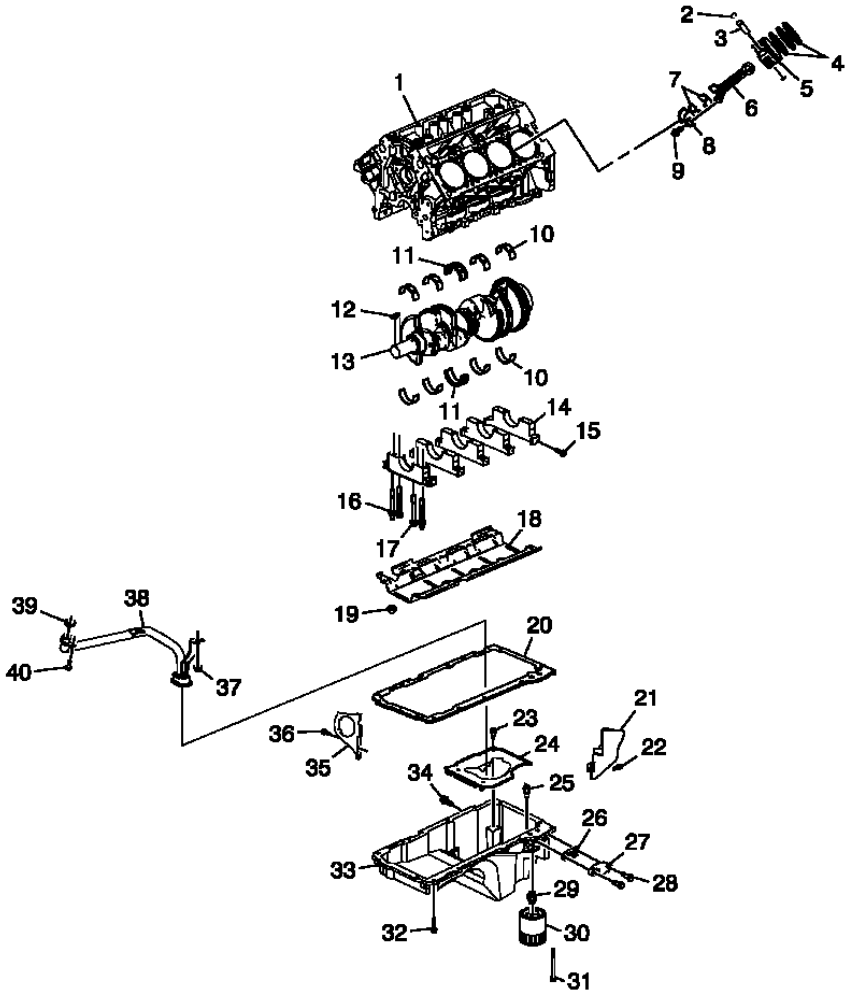

Fig. 10: Lower Engine Assembly
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Engine Block
2	Piston Pin Retainer
3	Piston Pin
4	Piston Ring Set
5	Piston
6	Connecting Rod
7	Connecting Rod Bearing
8	Connecting Rod Cap
9	Connecting Rod Bolt
10	Crankshaft Bearing
11	Crankshaft Thrust Bearing

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12	Crankshaft Balancer Key
13	Crankshaft
14	Crankshaft Bearing Cap
15	Crankshaft Bearing Cap Bolt - M8
16	Crankshaft Bearing Cap Stud - M10
17	Crankshaft Bearing Cap Bolt - M10
18	Crankshaft Oil Deflector
19	Crankshaft Oil Deflector Nut
20	Oil Pan Gasket
21	Oil Pan Closeout Cover
22	Oil Pan Closeout Cover Bolt
23	Oil Pan Baffle Bolt
24	Oil Pan Baffle
25	Active Fuel Management Oil Pressure Relief Valve
26	Oil Pan Cover Gasket
27	Oil Pan Cover
28	Oil Pan Cover Bolt
29	Oil Filter Fitting
30	Oil Filter
31	Oil Pan Bolt
32	Oil Pan Bolt
33	Oil Pan
34	Oil Pan Drain Plug
35	Oil Pan Closeout Cover
36	Oil Pan Closeout Cover Bolt
37	Oil Pump Suction Pipe Nut
38	Oil Pump Suction Pipe
39	Oil Pump O-Ring Seal
40	Oil Pump Suction Pipe Bolt

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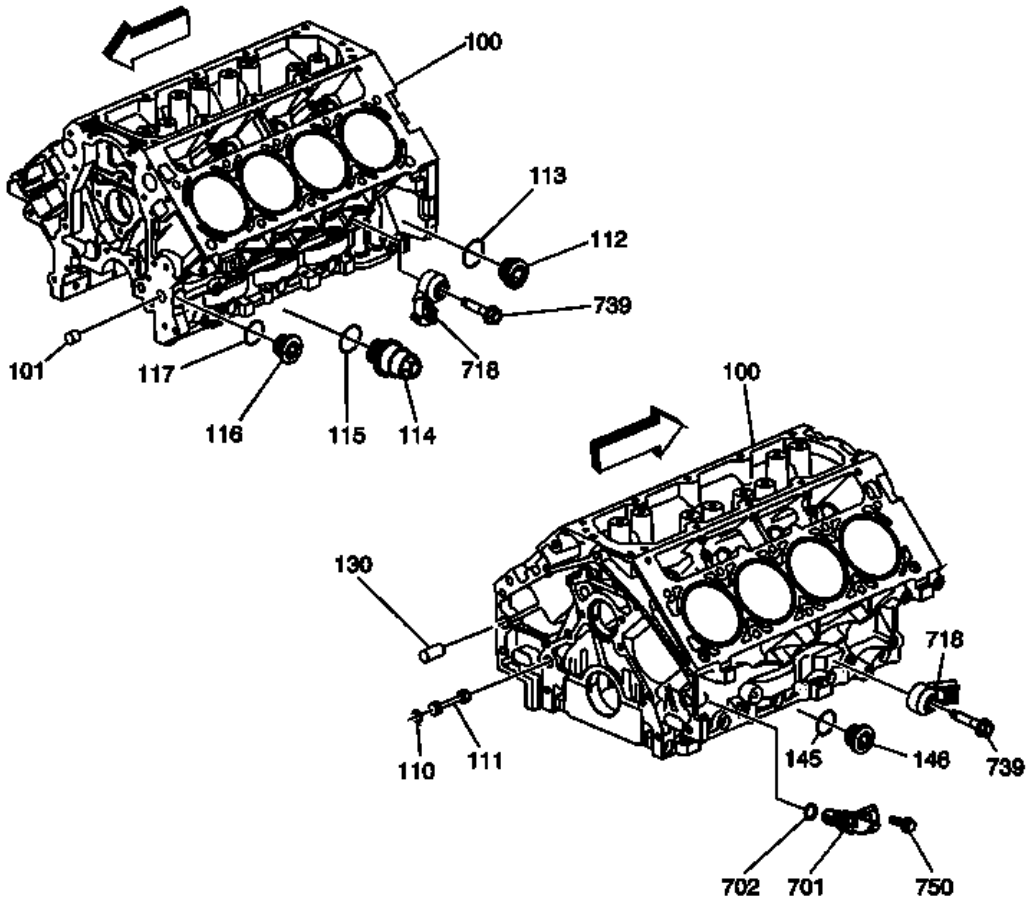

Fig. 11: Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS CORP.

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

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

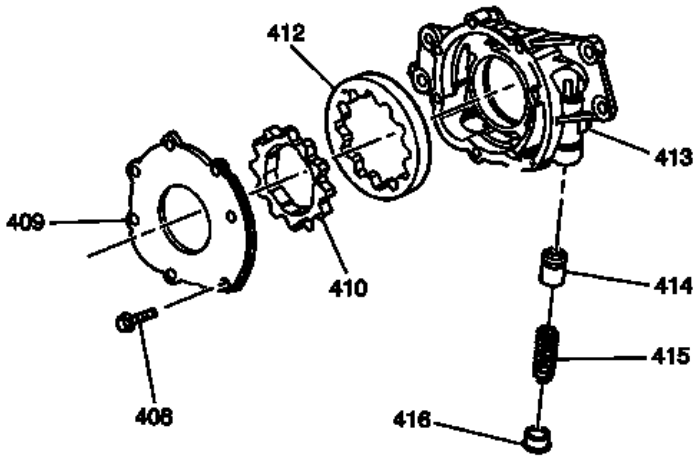

Fig. 12: Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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

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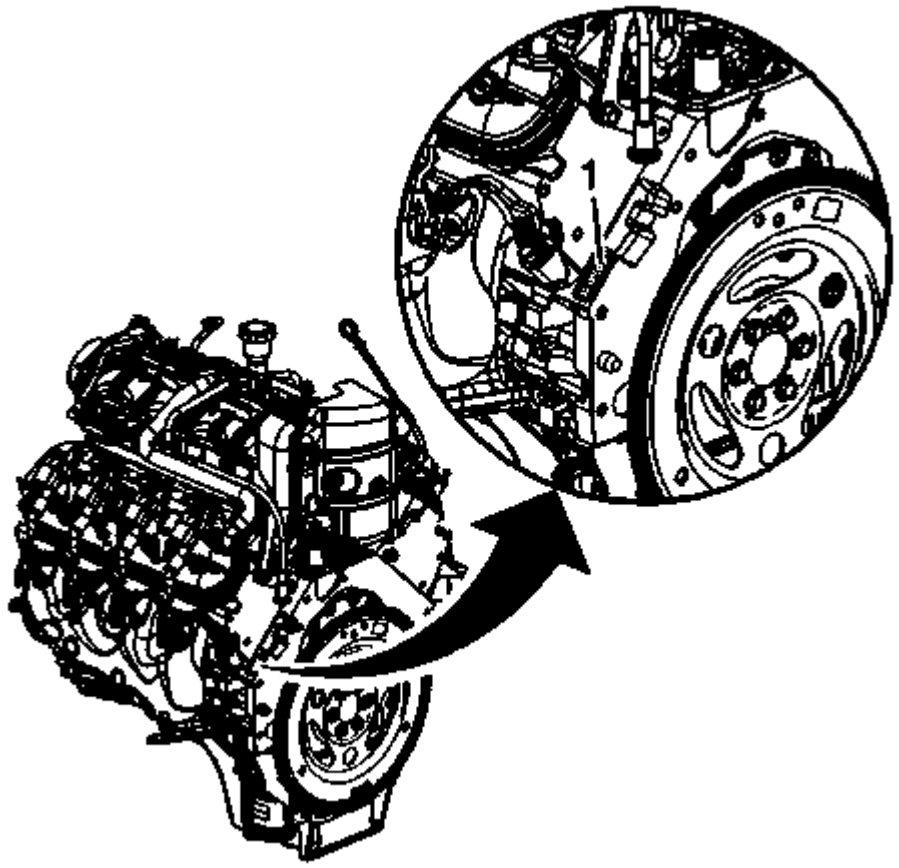

Fig. 13: Locating 9 Digit VIN Number
Courtesy of GENERAL MOTORS CORP.

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

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**, and **Lubrication Description**.

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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**
- **Oil Leak Diagnosis**

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- **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.

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	• Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
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	Replace the sensor and/or crankshaft, as required.

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damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	

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 actual misfire condition.	Replace the drive belt.
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 Removal** and **Automatic Transmission Flex Plate Installation**, or**Crankshaft Balancer Removal** and **Crankshaft Balancer Installation**.
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.

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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**.

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 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.

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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:

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	• 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.
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** .

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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.

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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

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	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.	

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1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders side-by-side on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Removal - Left Side** and **Cylinder Head Installation - Left Side**, or **Cylinder Head Removal - Right Side** and **Cylinder Head Installation - 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. Two 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 Removal - Left Side** and **Cylinder Head Installation - Left Side**, or **Cylinder Head Removal - Right Side** and

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	Cylinder Head Installation - 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 gauge 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

Special Tools

J 35667-A: Cylinder Head Leakdown Tester, or equivalent

For equivalent regional tools, refer to **Special Tools**.

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

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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**

WARNING: Refer to Battery Disconnect Warning .

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:** tester, or equivalent.

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

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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 Refer to **Crankcase Ventilation System Inspection/Diagnosis**. • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals Refer to **Spark Plug Inspection** . • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings, as necessary. Refer to **Cylinder Leakage Test**. • Piston and rings improperly installed or not fitted to the cylinder bore Refer to **Lower Engine Noise, Regardless of Engine Speed**.

OIL PRESSURE DIAGNOSIS AND TESTING

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Tools Required

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

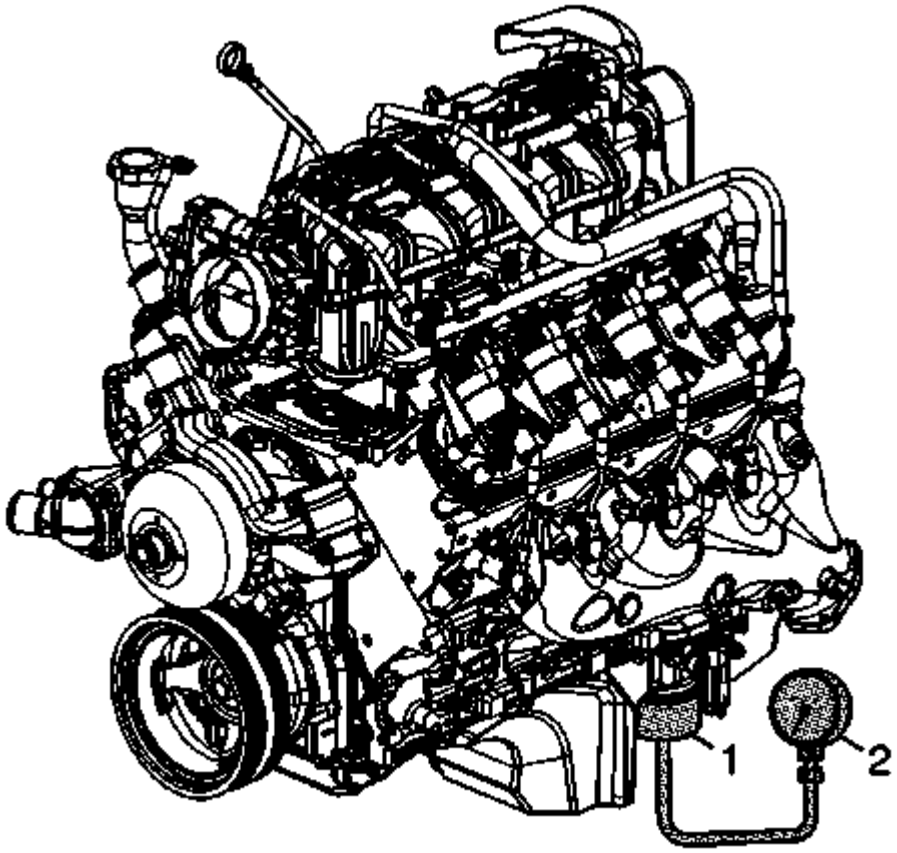

Fig. 14: View Of Special Tools Oil Pressure Gage & Adapter
Courtesy of GENERAL MOTORS CORP.

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 gauge 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

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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** .

OIL PRESSURE RELIEF VALVE DIAGNOSIS AND TESTING

Special Tools

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

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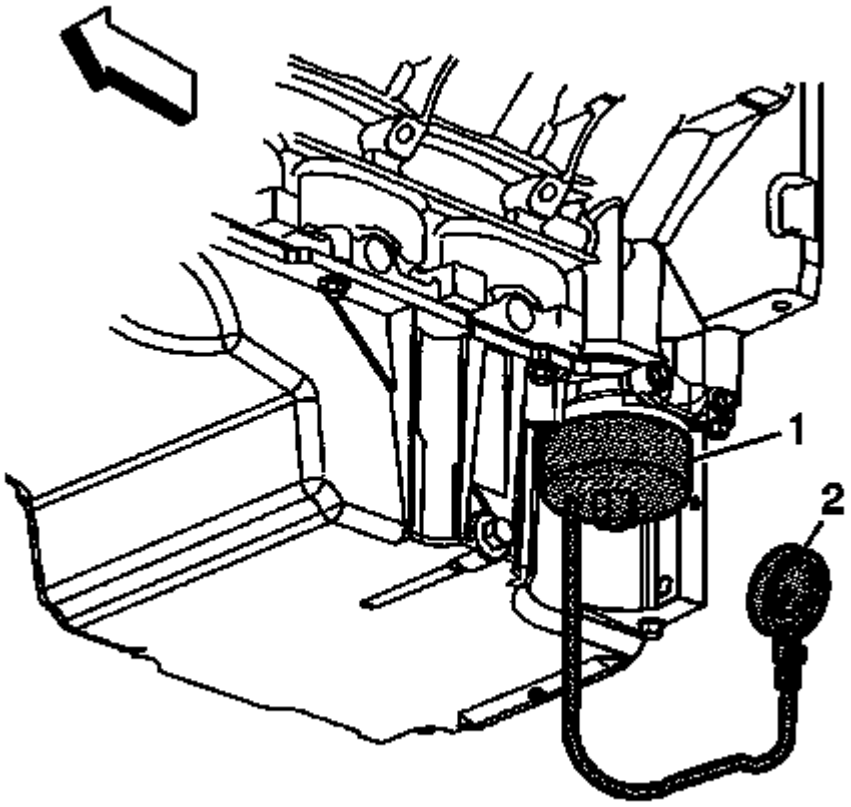

Fig. 15: Using Special Tools EN-47971 & J 21867 To Check Oil Pressure
Courtesy of GENERAL MOTORS CORP.

NOTE: 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**.

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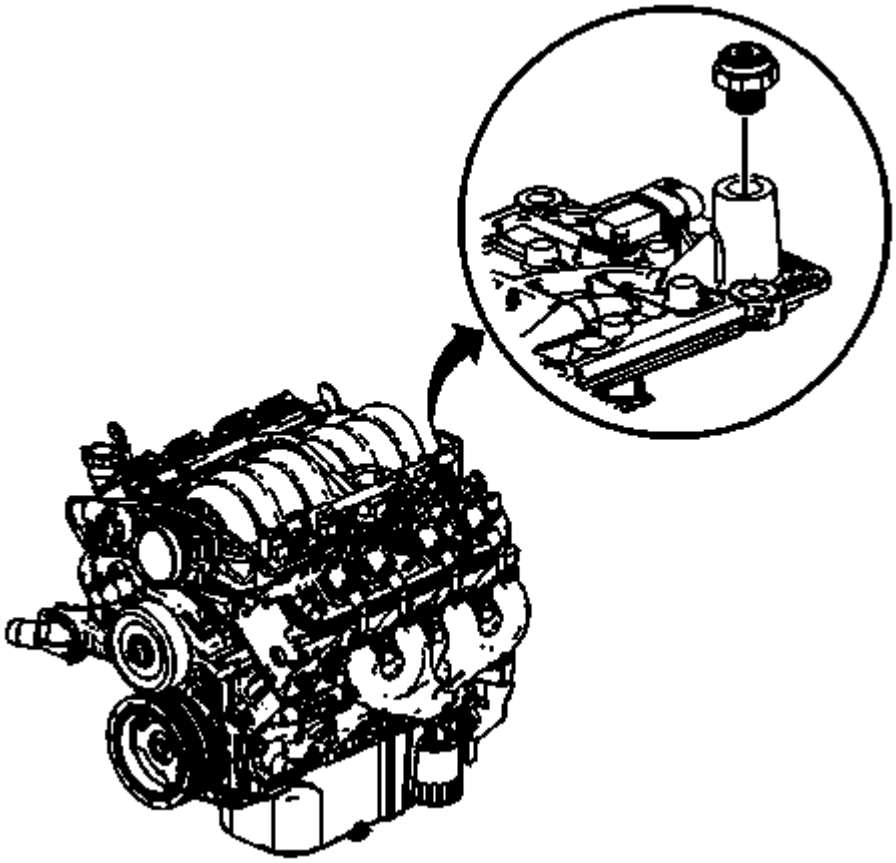

Fig. 16: Locating Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

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

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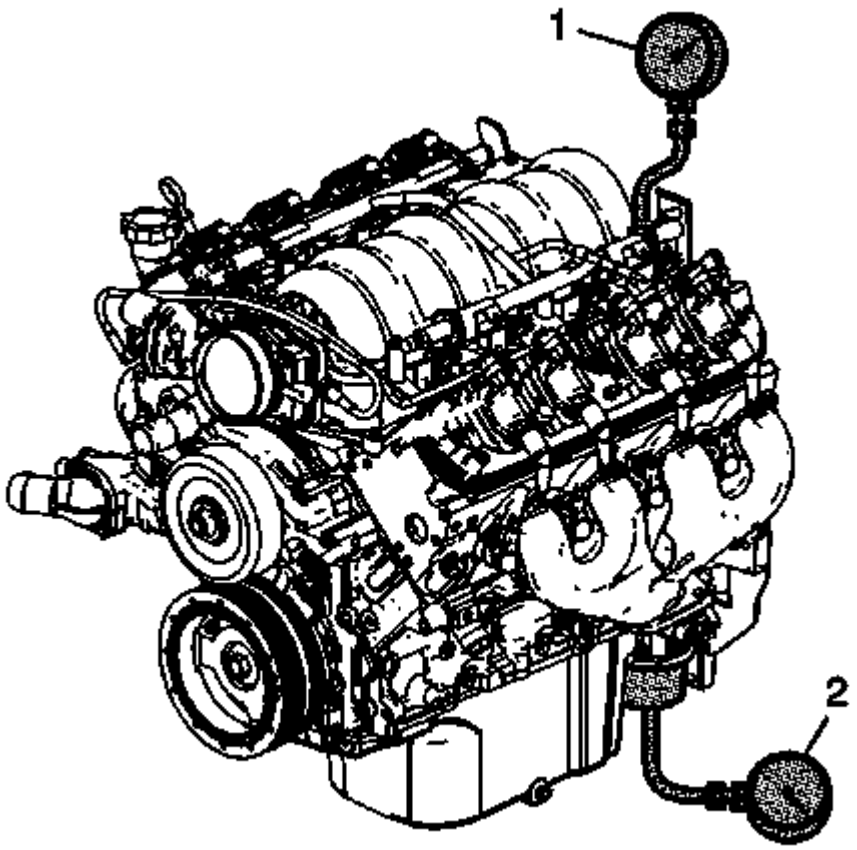

Fig. 17: Testing Oil Pressure
Courtesy of GENERAL MOTORS CORP.

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 gauges.

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

   - With the engine running and the lower pressure gauge (2) measuring below 379 kPa (55 psi), both gauges should display the same pressure reading. If the readings are not the same and the lower gauge (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 gauge (2) measuring above 379 kPa (55 psi), the upper gauge (1) should display no greater than 379-517 kPa (55-75 psi). If the reading on the upper gauge (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.

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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 CMP actuator solenoid valve for proper operation. Refer to **Camshaft Position Actuator Solenoid Valve Inspection (Off-Vehicle)** or **Camshaft Position Actuator Solenoid Valve Inspection (On-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 System Check - Vehicle** .

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**
	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles,		

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4	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**
	Use the **J 28428-E** high-intensity black light kit in order		

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8	to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. 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**	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:

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

DRIVE BELT CHIRPING, 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

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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 two or three 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 two or three 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
CAUTION: **Refer to Belt Dressing Caution .** 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			

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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 belt(s). 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**

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11	**CAUTION:** **Refer to Fastener Caution .** 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 13**
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**
14	Test the drive belt tensioner for proper 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.

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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 or felt as a lump in the belt.

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

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
CAUTION: **Refer to Belt Dressing Caution .** 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: o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove o The separation of the drive belt o A damaged drive belt DEFINITION: The following items are indications of drive belt vibration:			

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- 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	**NOTE:** **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 **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**
	CAUTION: **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener**		

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10	**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 (LH9)** . 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

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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
CAUTION: **Refer to Belt Dressing Caution .** 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	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**.		

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	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**. 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 13**
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

Step	Action	Yes	No
1	Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move		

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	the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS - ON VEHICLE

DRIVE BELT REPLACEMENT - ACCESSORY

Removal Procedure

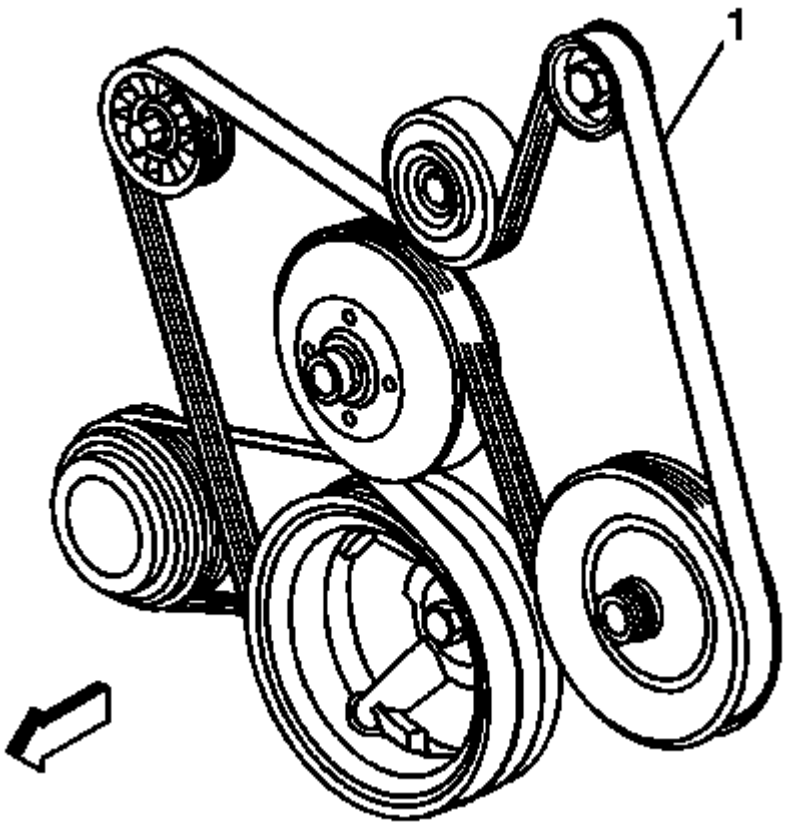

Fig. 18: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .
3. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.

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4. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt.
5. Remove the drive belt (1) 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

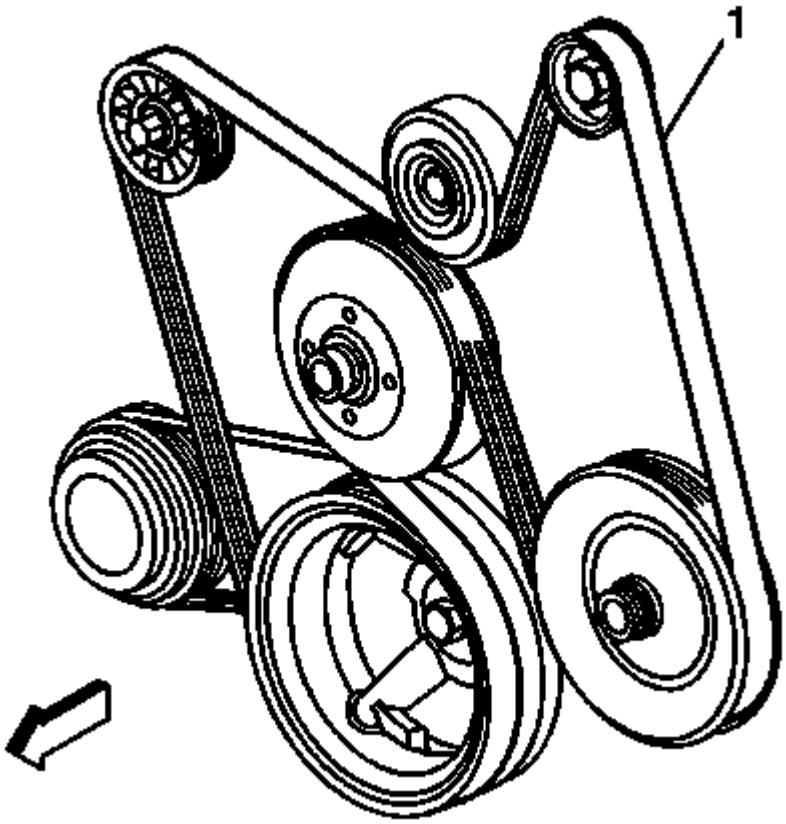

Fig. 19: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Route the drive belt (1) 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.
8. Install the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .

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9. Start the vehicle and inspect the drive belt for proper operation.
10. Close the hood.

AIR CONDITIONING COMPRESSOR BELT REPLACEMENT

Removal Procedure

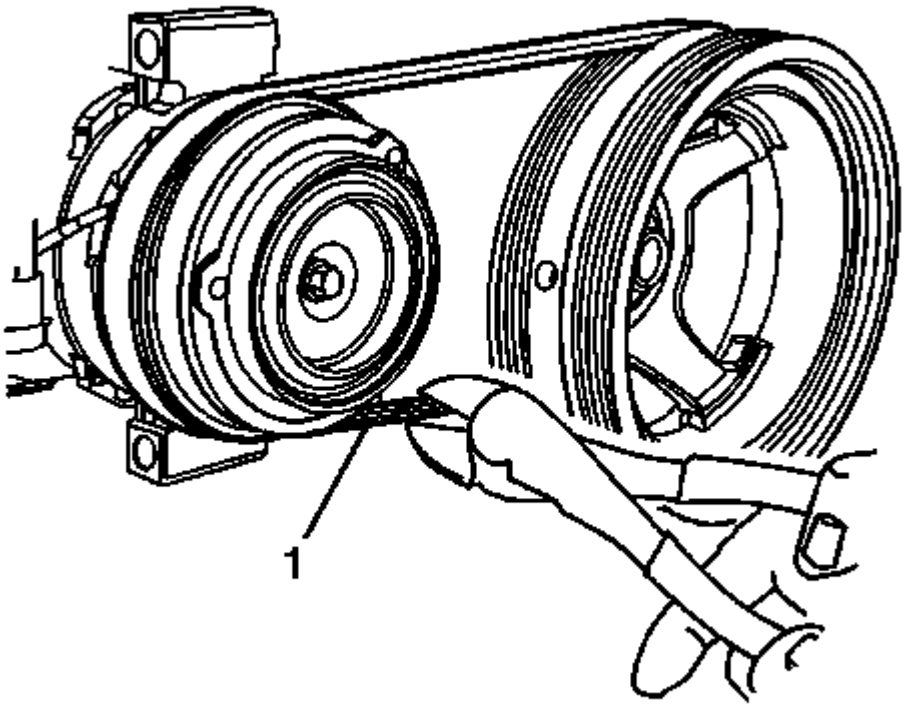

Fig. 20: Cutting Accessory Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Remove the cooling fan. Refer to **Fan Replacement (LH9)** .
3. Cut the belt (1) from air conditioning (A/C) and crankshaft pulleys.

Installation Procedure

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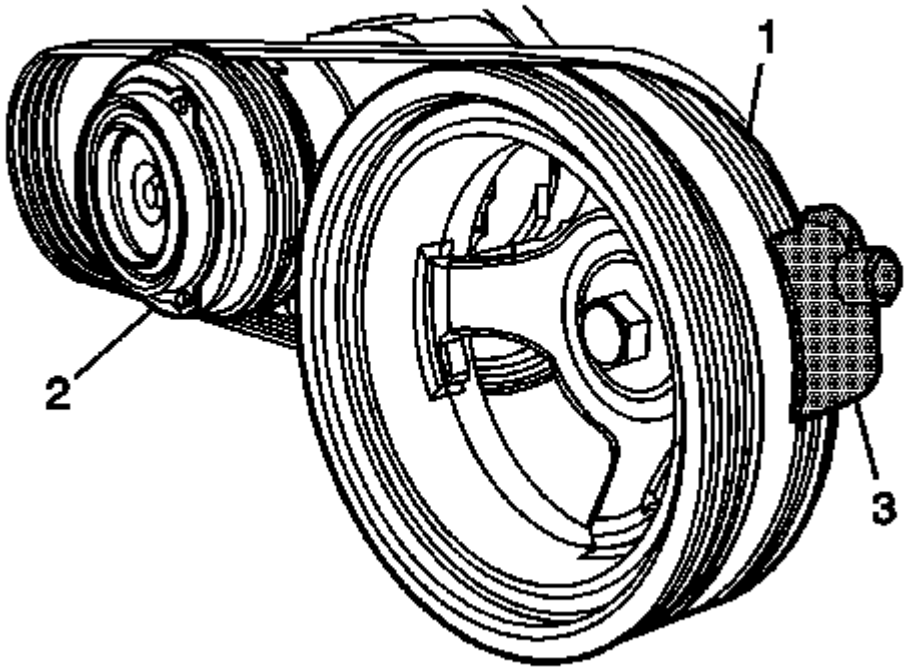

Fig. 21: Installing Belt
Courtesy of GENERAL MOTORS CORP.

1. Position the belt behind the rear face of the balancer (1) and off of the A/C pulley (2).
2. Install the belt installation tool (3) onto the balancer.

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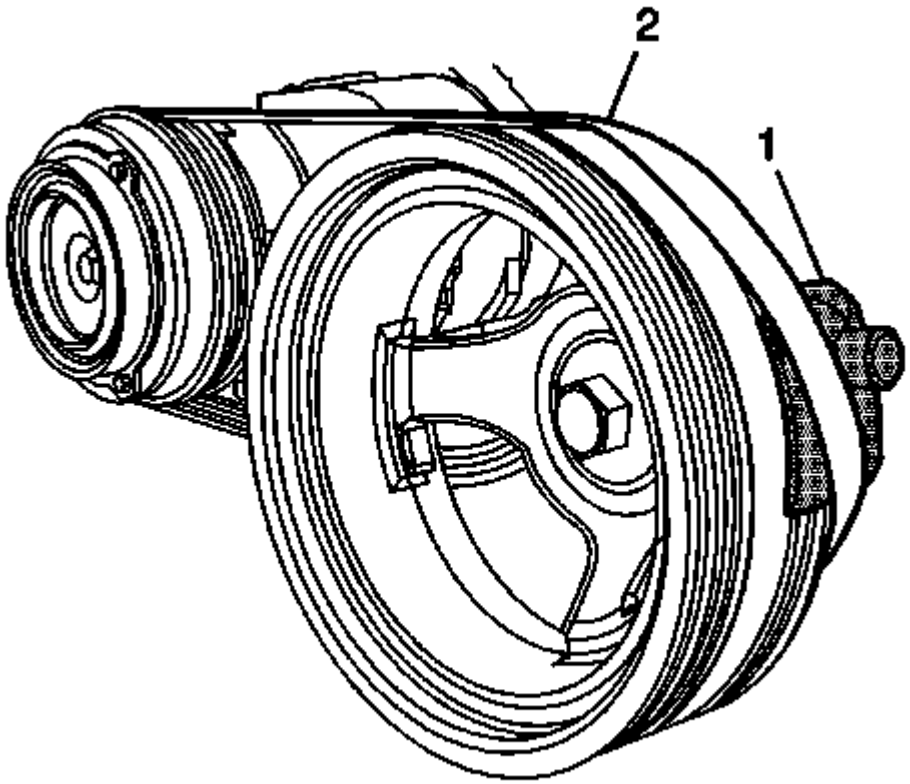

Fig. 22: Belt Installation Tool
Courtesy of GENERAL MOTORS CORP.

3. Slide the belt installation tool (1) upward, installing the belt (2) onto the belt installation tool.
4. Slide the belt installation tool downward, positioning the belt onto the A/C pulley, applying light tension to the belt.

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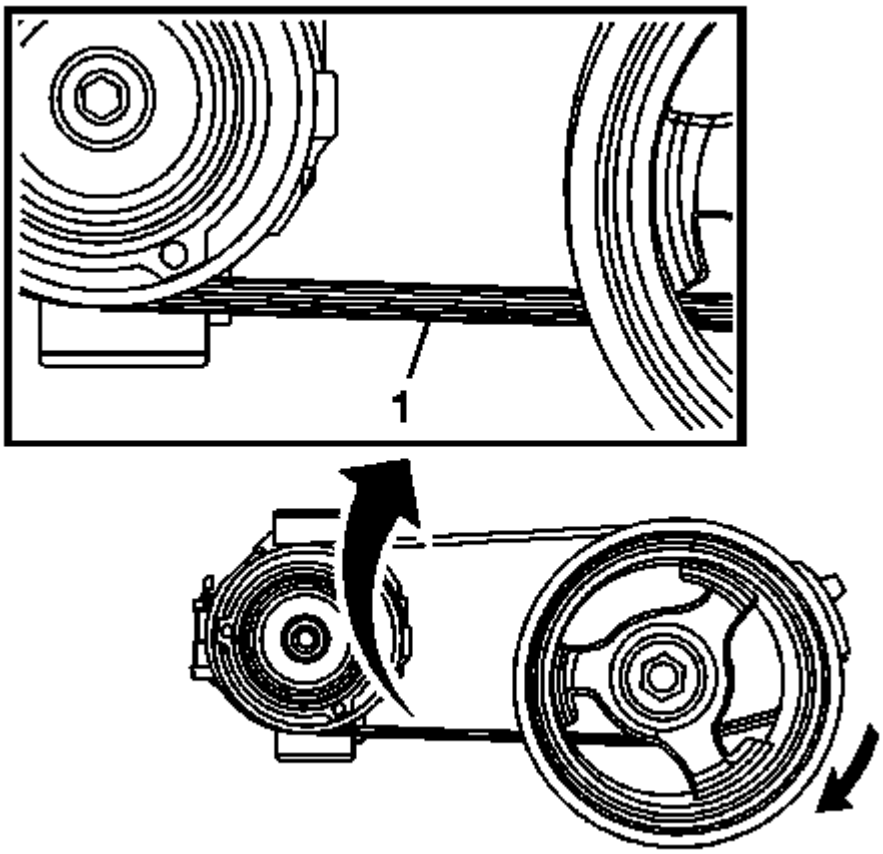

Fig. 23: Positioning Lower Portion Of Belt
Courtesy of GENERAL MOTORS CORP.

5. Position the lower portion of the belt (1) with the ribbed area facing forward.

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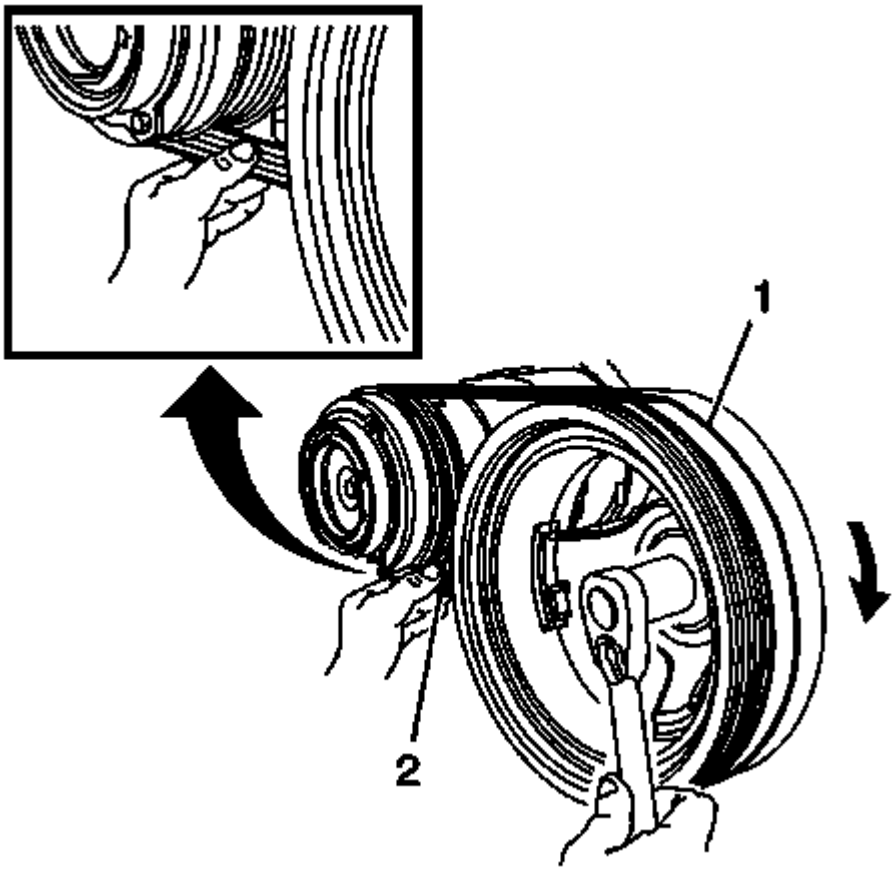

Fig. 24: Rotating Crankshaft Pulley
Courtesy of GENERAL MOTORS CORP.

6. Slowly rotate the crankshaft pulley (1) in a clockwise direction while using finger pressure to pull the belt (2) forward. Ensure that the ribbed area of the belt remains facing forward and the belt aligns properly to the A/C pulley.

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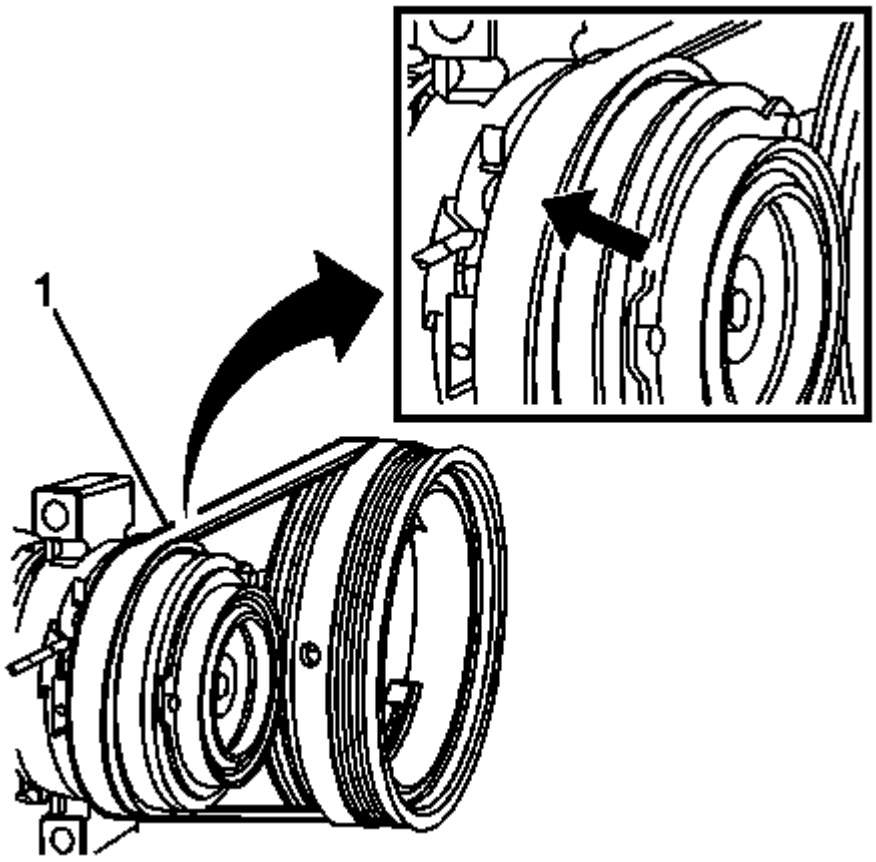

Fig. 25: Drive Belt Alignment
Courtesy of GENERAL MOTORS CORP.

7. Inspect the drive belt (1) for proper installation and alignment.

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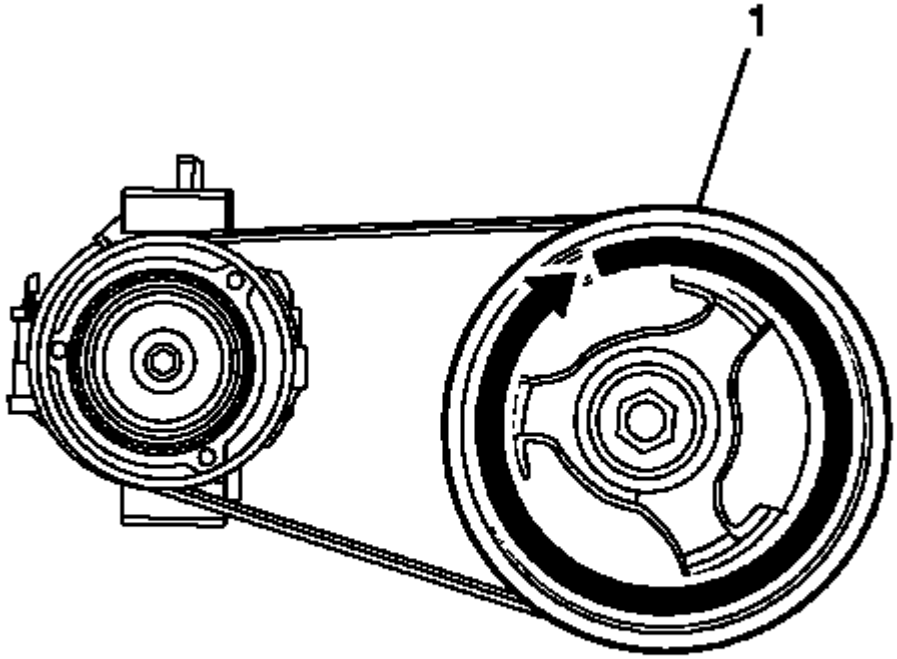

Fig. 26: A/C Compressor Drive Belt
Courtesy of GENERAL MOTORS CORP.

8. Rotate the balancer (1) and additional 360 degrees to ensure proper belt installation.
9. Install the cooling fan. Refer to **Fan Replacement (LH9)** .
10. Install the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.

DRIVE BELT IDLER PULLEY REPLACEMENT

Removal Procedure

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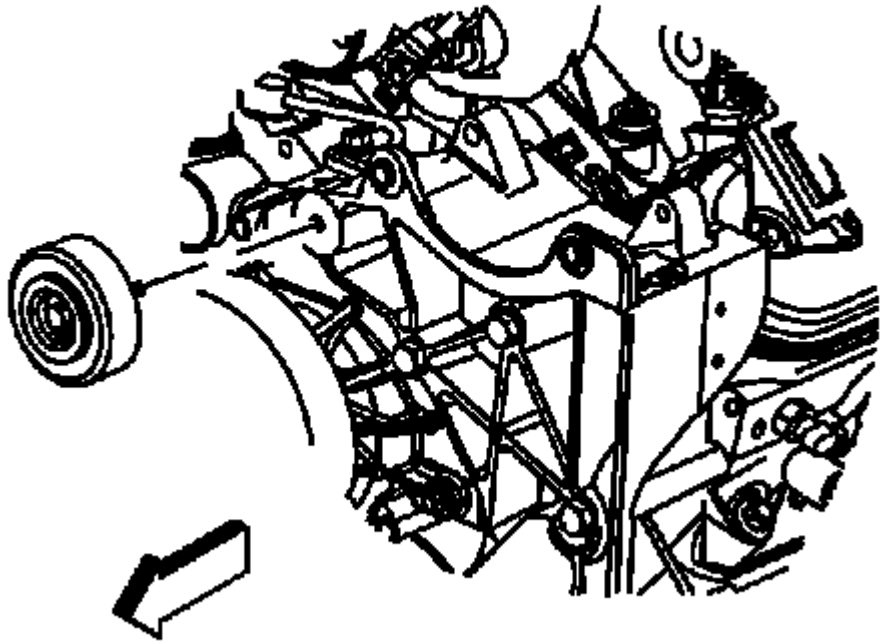

Fig. 27: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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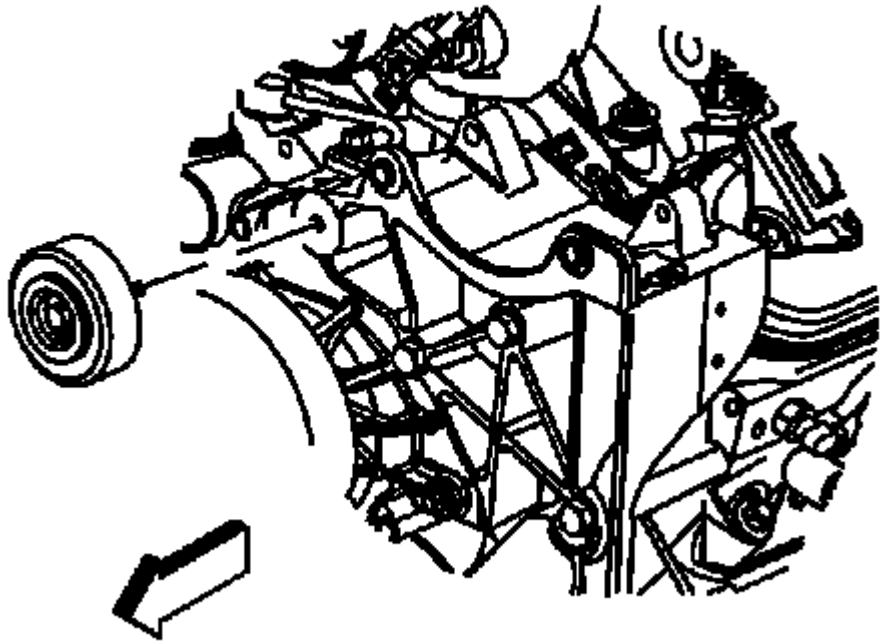

Fig. 28: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt idler pulley to the generator bracket and tighten the idler pulley bolt finger tight.

   CAUTION: Refer to Fastener Caution .

2. Tighten the drive belt idler pulley bolt.

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

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

DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY

Removal Procedure

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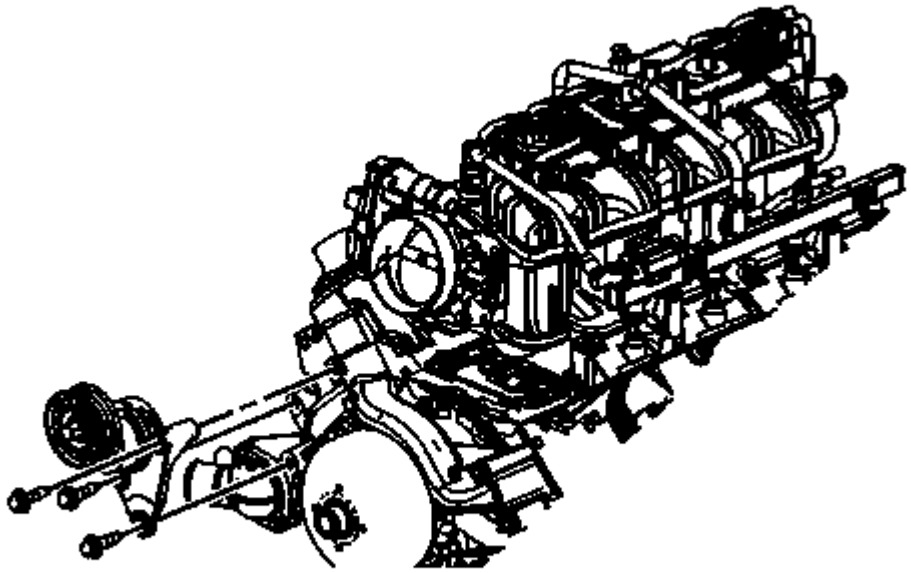

Fig. 29: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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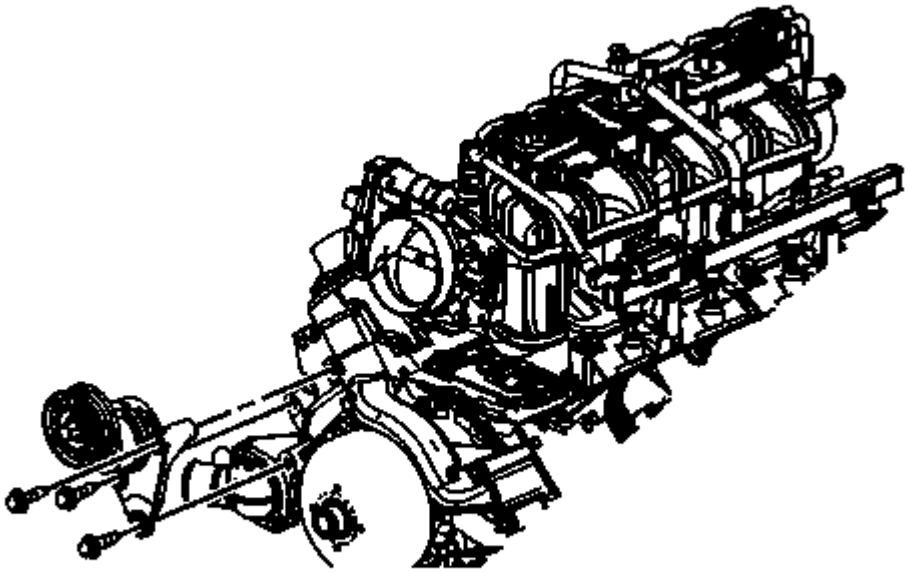

Fig. 30: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner to the water pump.

   CAUTION: Refer to Fastener Caution .

2. Install and tighten the drive belt tensioner bolts.

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

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

ENGINE MOUNT INSPECTION

CAUTION: 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.

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CAUTION: 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.

Visual/Physical Inspection

1. Support the powertrain using the appropriate support method; refer to the powertrain mount replacement procedure. Raising the powertrain removes the weight from the engine mount and creates slight tension in the rubber.
2. Clean the mount and surrounding area to ensure good visibility of the mount condition.
3. Verify all attaching fasteners are present and at the correct torque. Refer to **Engine Mount Replacement - Left Side** and/or **Engine Mount Replacement - Right Side** for any torque sequencing and/or torque specifications.

NOTE: Observe the engine mount while raising the engine. If the engine mount exhibits any of the following conditions the mount may require replacement. Refer to Engine Mount Replacement - Left Side and/or Engine Mount Replacement - Right Side.

4. Slightly raise the engine approximately 5-7 mm.
5. Inspect the mount for any of the following conditions:
   - Hard rubber surfaces - covered with extreme heat check cracks.
   - Rubber separation from the metal plate of the engine mount.
   - Rubber is split through the center of the engine mount.

NOTE: Before replacing any engine mount due to suspected fluid loss, verify that the source of the fluid is from the engine mount , and not the engine or an external source.

   - If equipped with a hydraulic mount, inspect for GLYCOL™ fluid leaking from the engine mount.

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

CAUTION: 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.

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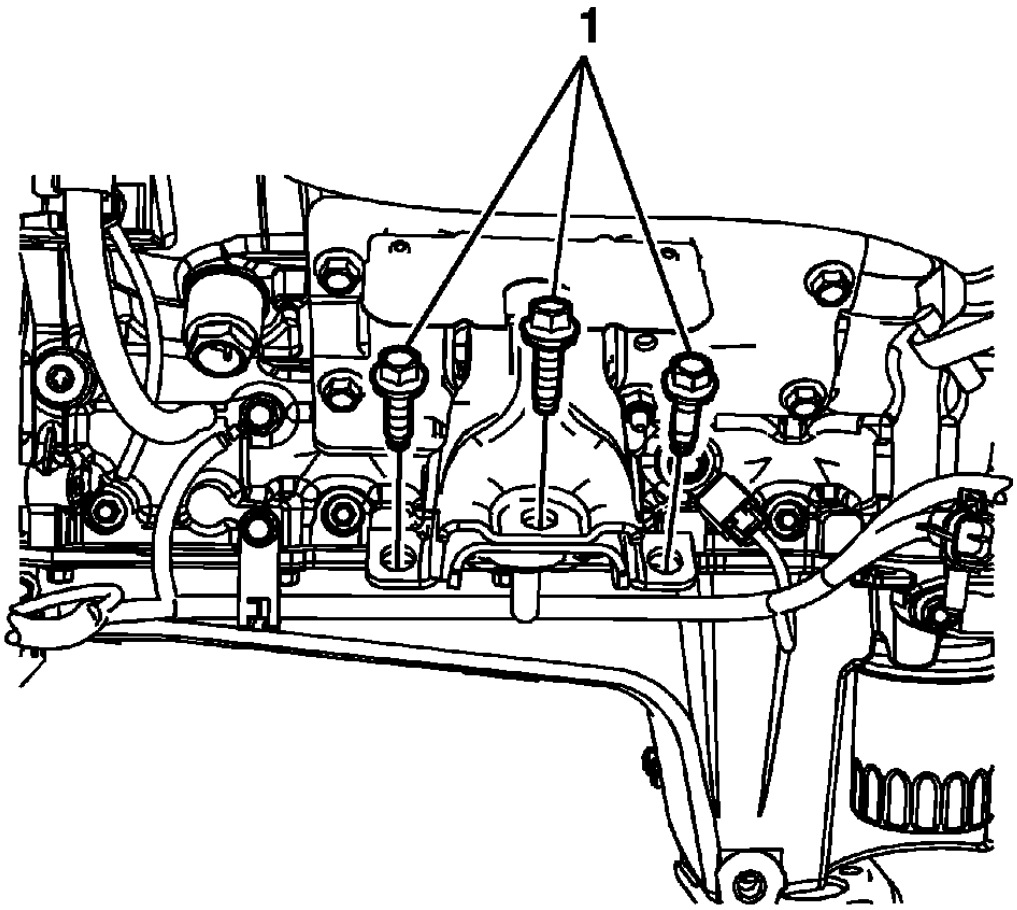

Fig. 31: Engine Mount Replacement - Left Side
Courtesy of GENERAL MOTORS CORP.

1. Remove the front tire and wheel. Refer to **Tire and Wheel Removal and Installation** .
2. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LH9)** .
3. Remove the engine mount to frame bolts (1).

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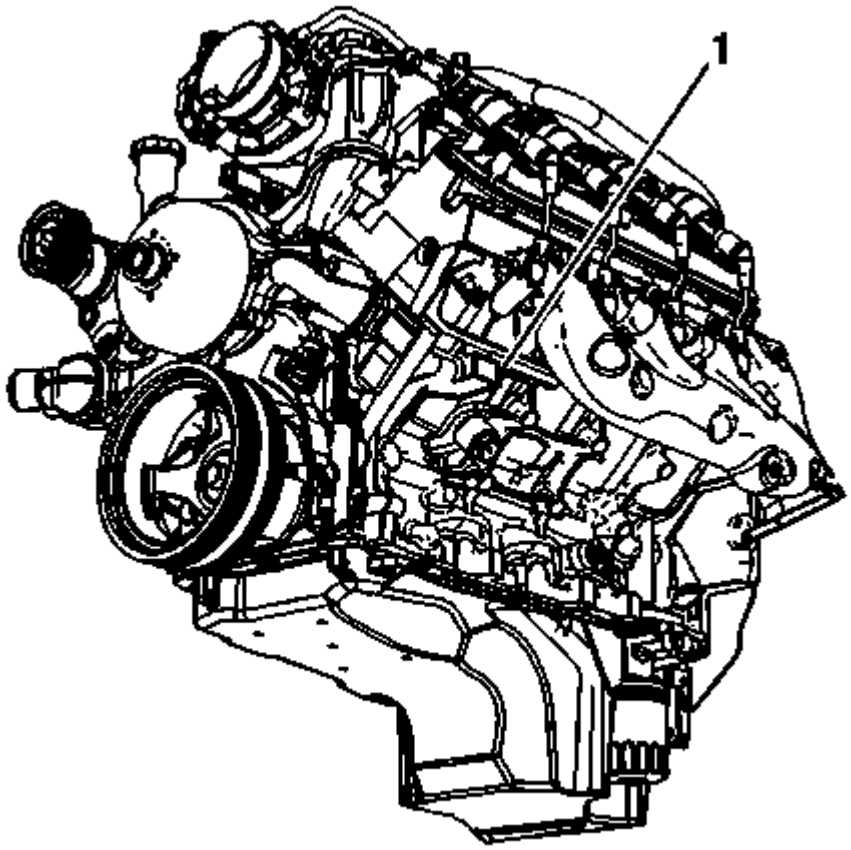

Fig. 32: View Of Engine Block Tab
Courtesy of GENERAL MOTORS CORP.

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

4. Place an adjustable (screw type) jack to the tab (1) located on the engine block.

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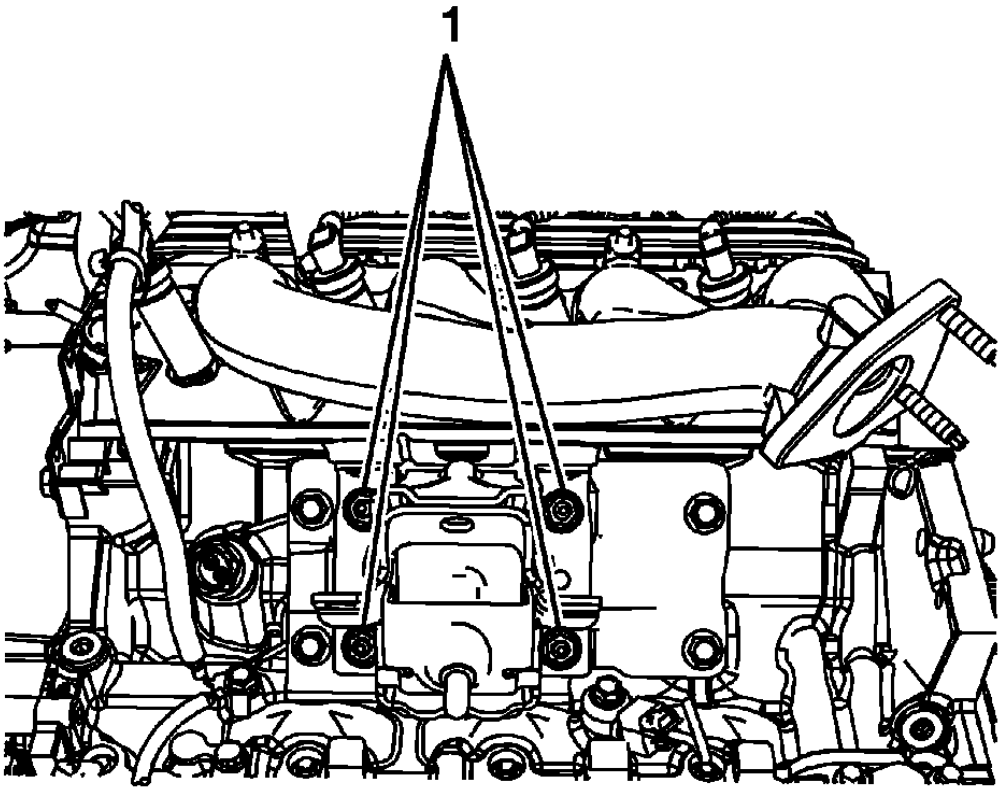

Fig. 33: Engine Mount & Engine Bolts
Courtesy of GENERAL MOTORS CORP.

5. Working through the wheelhouse opening, remove the engine mount to engine bolts (1).
6. Using the adjustable jack, raise the engine slightly until there is enough clearance to remove the engine mount.

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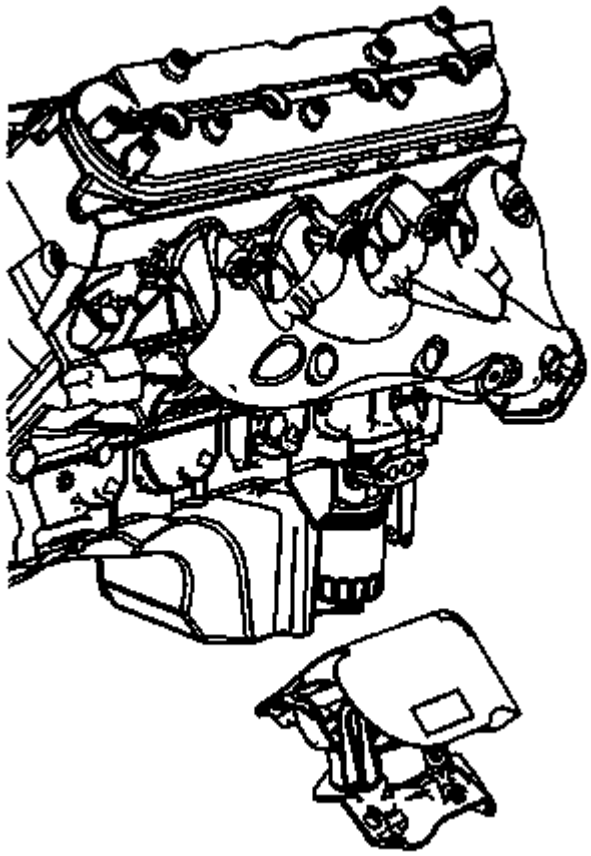

Fig. 34: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine mount.

Installation Procedure

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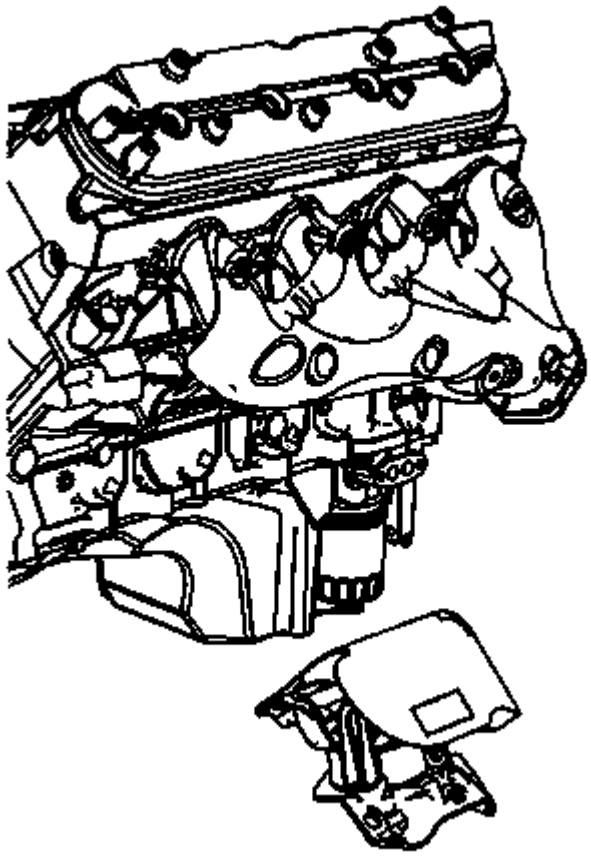

Fig. 35: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount to the engine.

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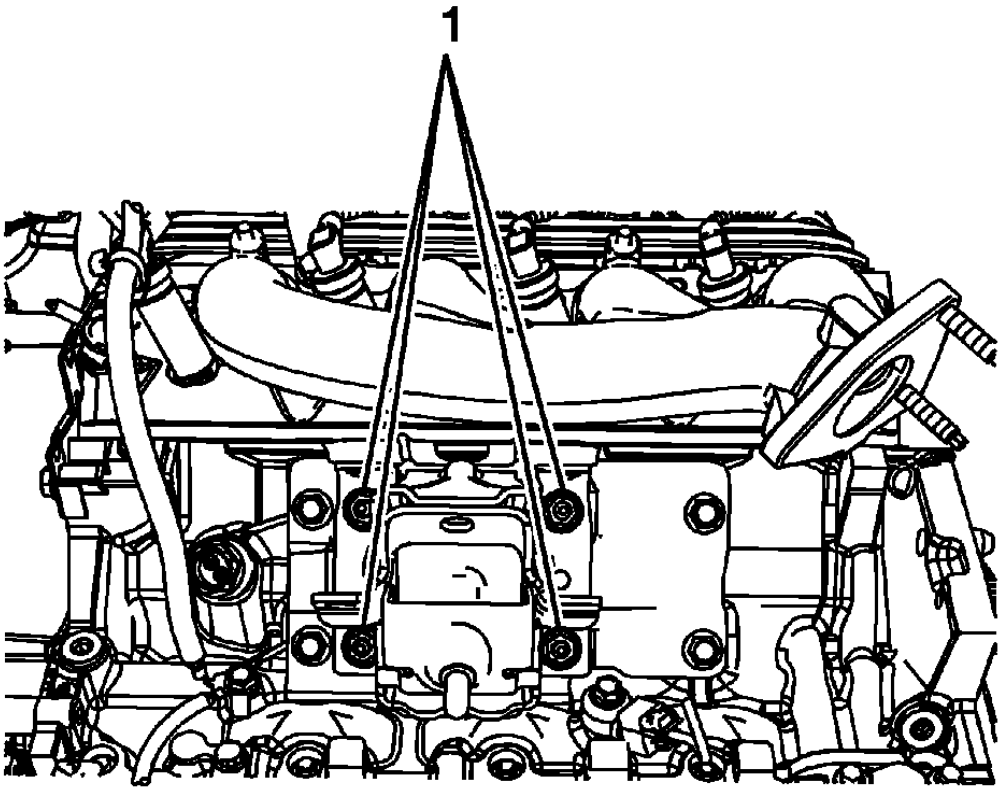

Fig. 36: Engine Mount & Engine Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Working through the wheelhouse opening, install the engine mount to engine nuts (1) and tighten to 55 N.m (41 lb ft).
3. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.
4. Remove the adjustable jack from the engine block.

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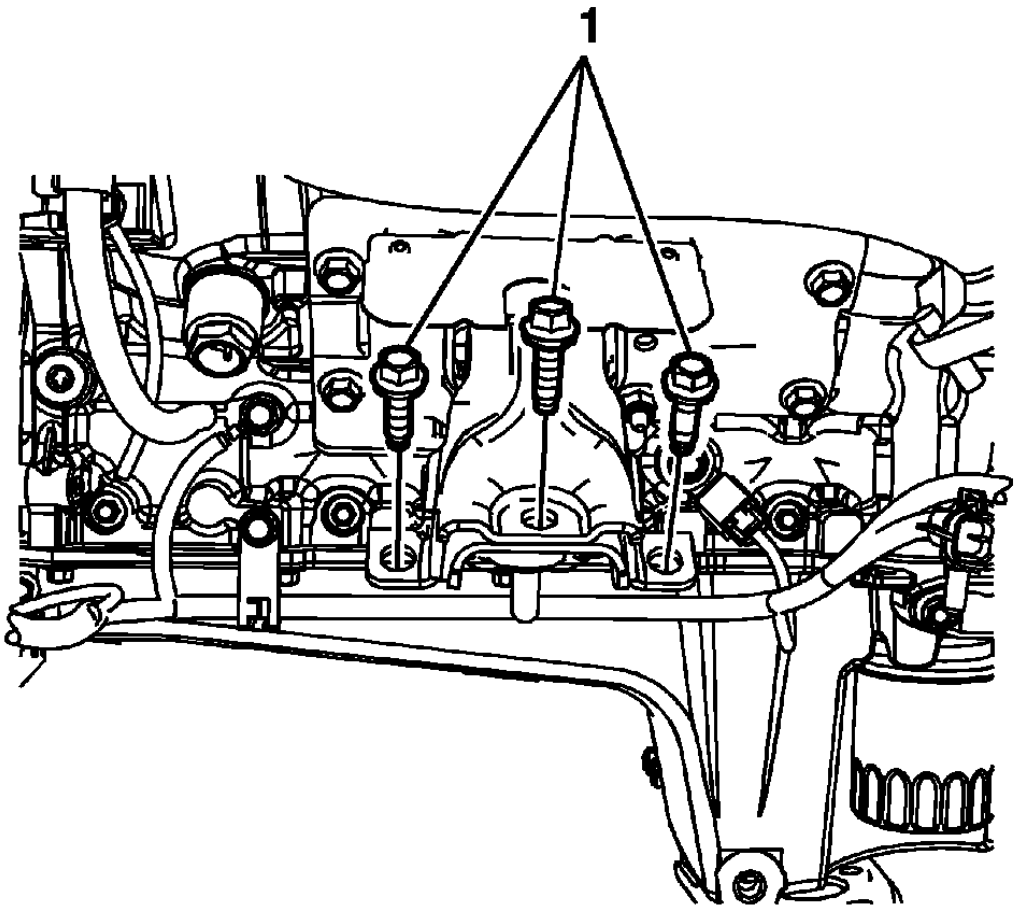

Fig. 37: Engine Mount Replacement - Left Side
Courtesy of GENERAL MOTORS CORP.

5. Install the engine mount to frame bolts (1) and tighten to 65 N.m (48 lb ft) starting with the middle bolt then either side bolt.
6. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LH9)** .
7. Lower the vehicle.

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

CAUTION: 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.

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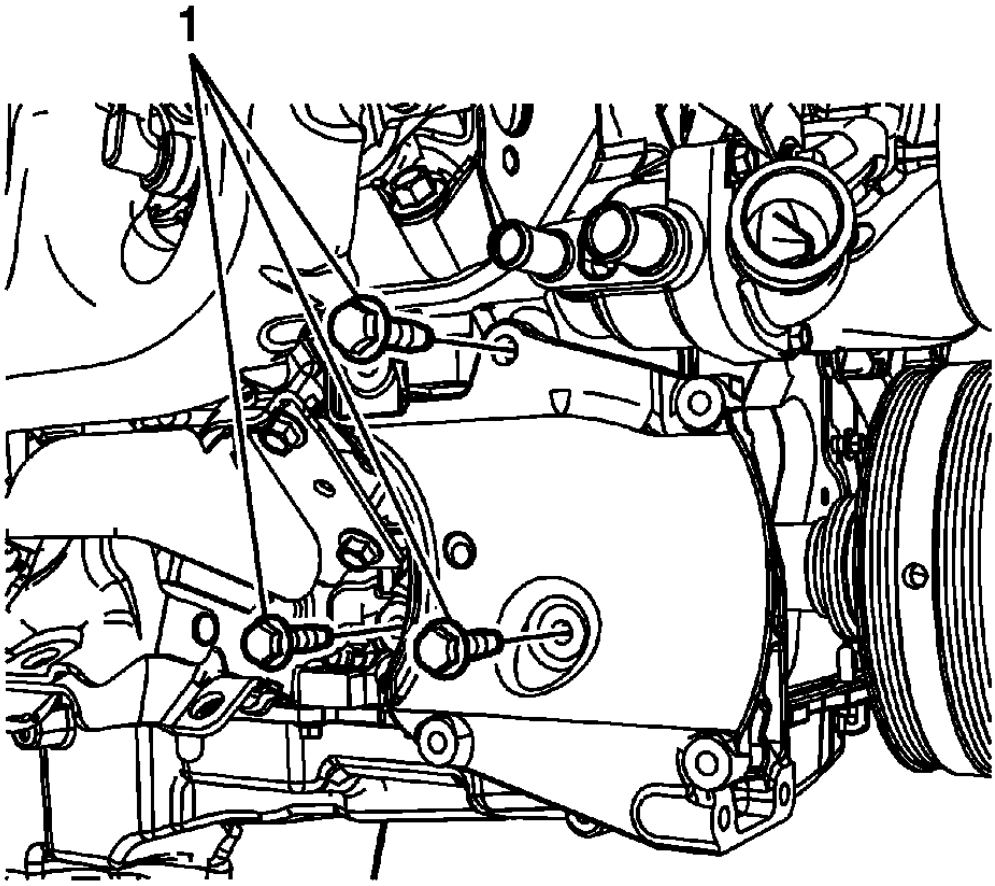

Fig. 38: Engine Mount Replacement - Right Side
Courtesy of GENERAL MOTORS CORP.

1. Remove the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** .
2. Remove the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LH9)** .
3. Unbolt the air conditioning compressor and position aside. Refer to **Air Conditioning Compressor Replacement** .
4. Remove the air conditioning bracket bolts (1).

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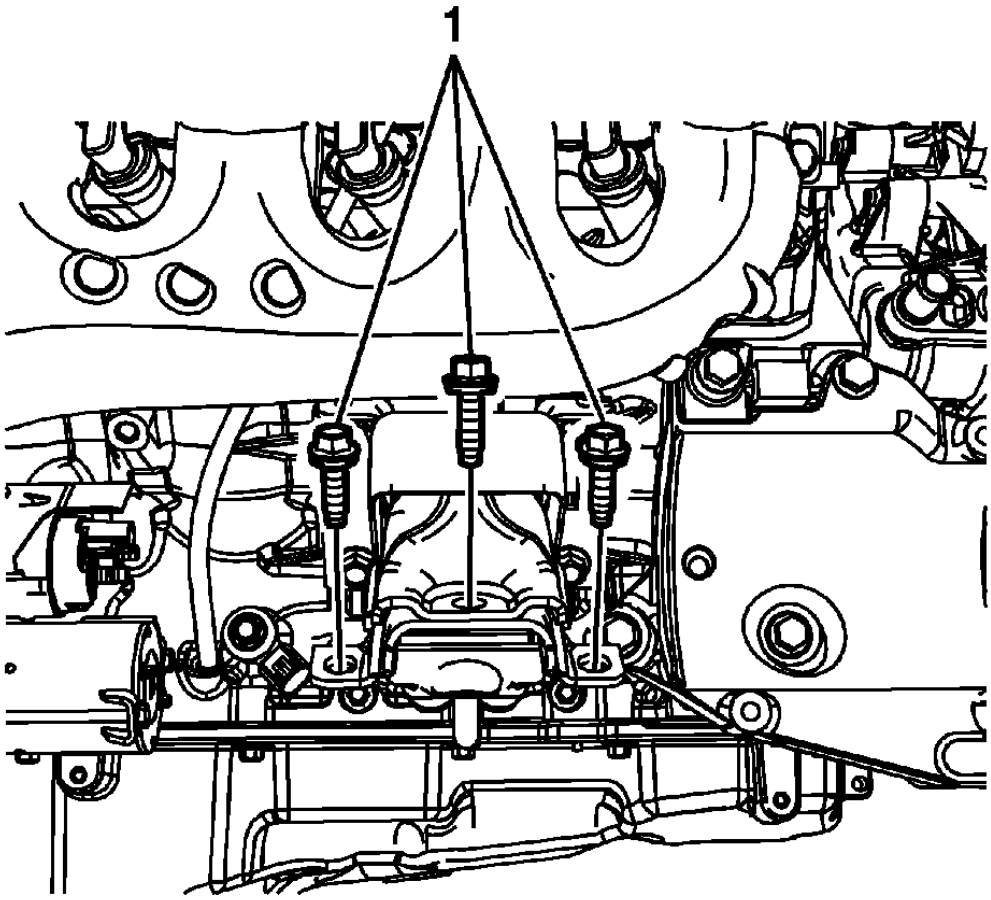

Fig. 39: Engine Mount & Frame Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the engine mount to frame bolts (1).

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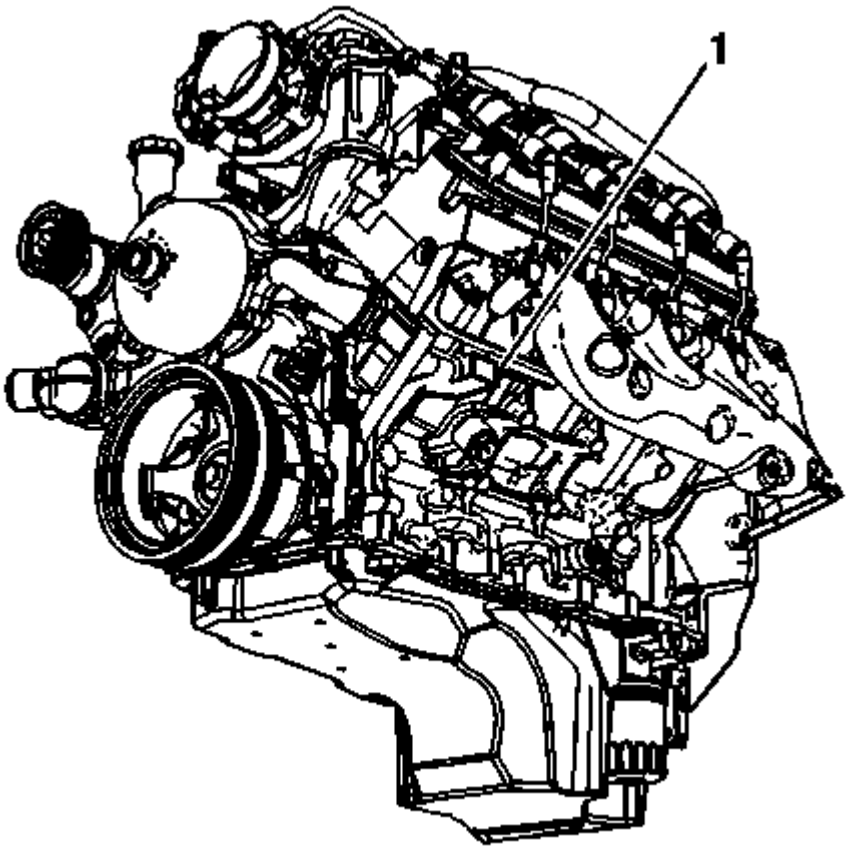

Fig. 40: View Of Engine Block Tab
Courtesy of GENERAL MOTORS CORP.

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

6. Place an adjustable (screw type) jack to the tab (1) located on the engine block.

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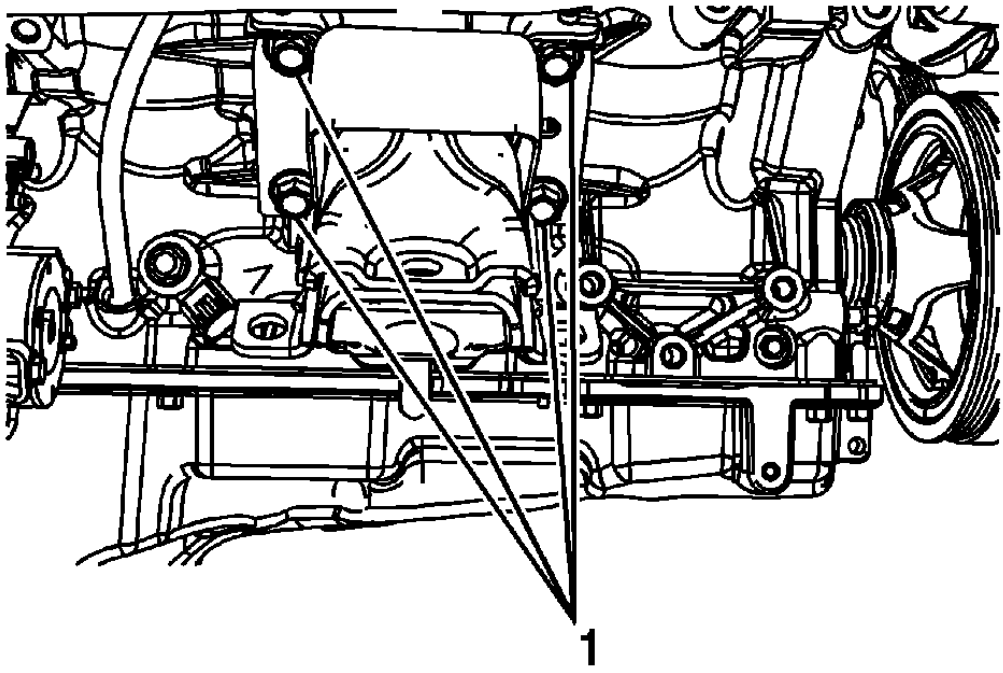

Fig. 41: Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine mount to engine bolts (1).
8. Using the adjustable jack, raise the engine slightly until there is enough clearance to remove the engine mount.

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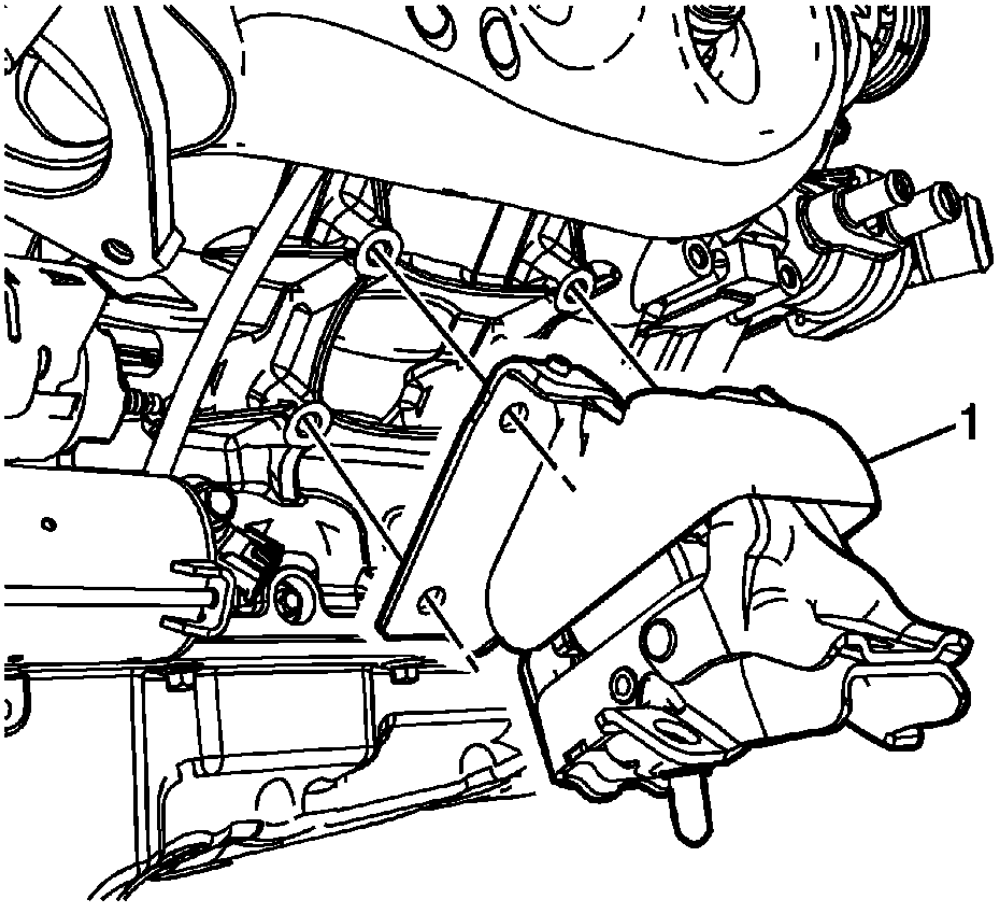

Fig. 42: Locating Engine Mount
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine mount (1).

Installation Procedure

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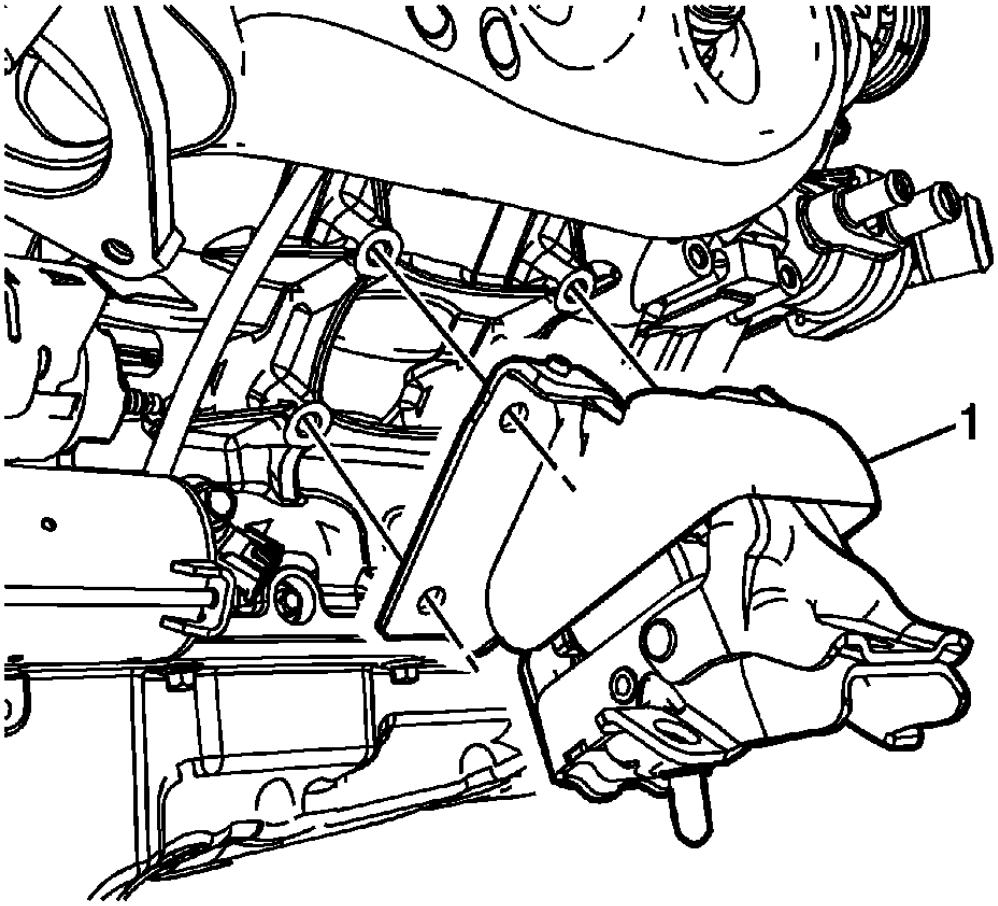

Fig. 43: Locating Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount (1) to the engine.

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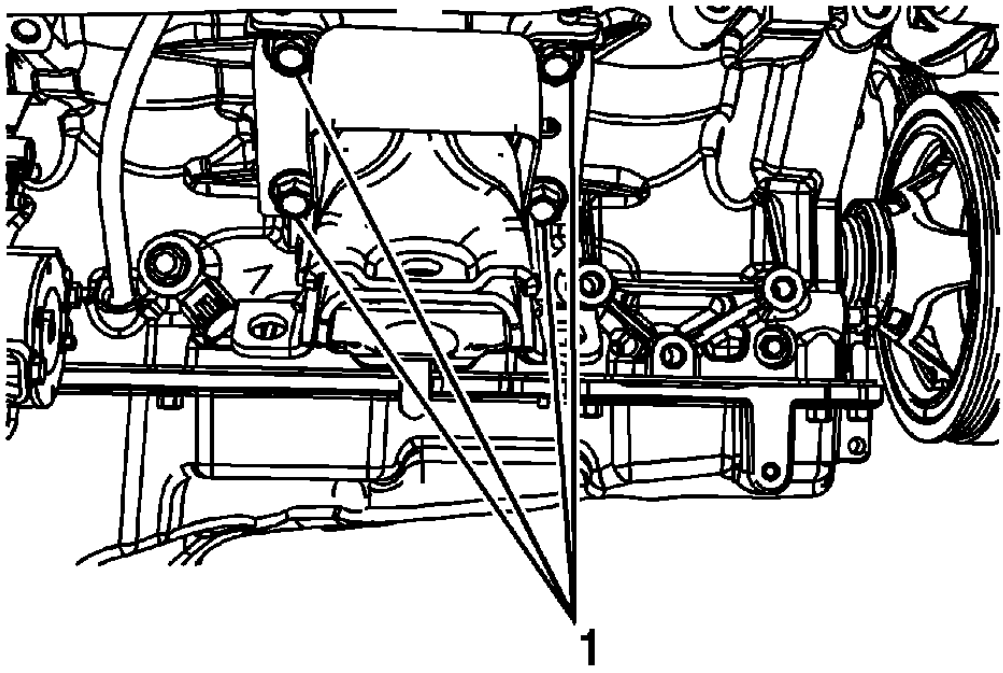

Fig. 44: Engine Mount & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install the engine mount to engine nuts (1) and tighten to 55 N.m (41 lb ft).
3. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.
4. Remove the adjustable jack from the engine block.

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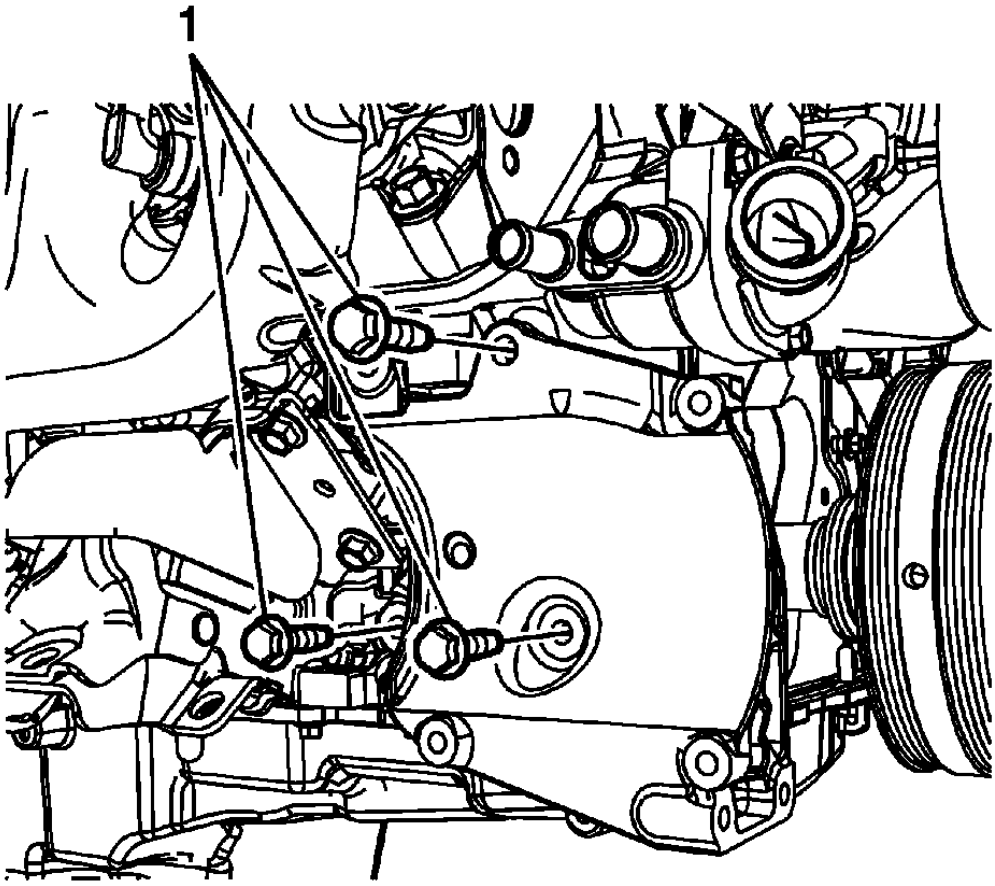

Fig. 45: Engine Mount Replacement - Right Side
Courtesy of GENERAL MOTORS CORP.

5. Install the air conditioning compressor bracket bolts (1).
6. Install the air conditioning compressor. Refer to **Air Conditioning Compressor Replacement** .

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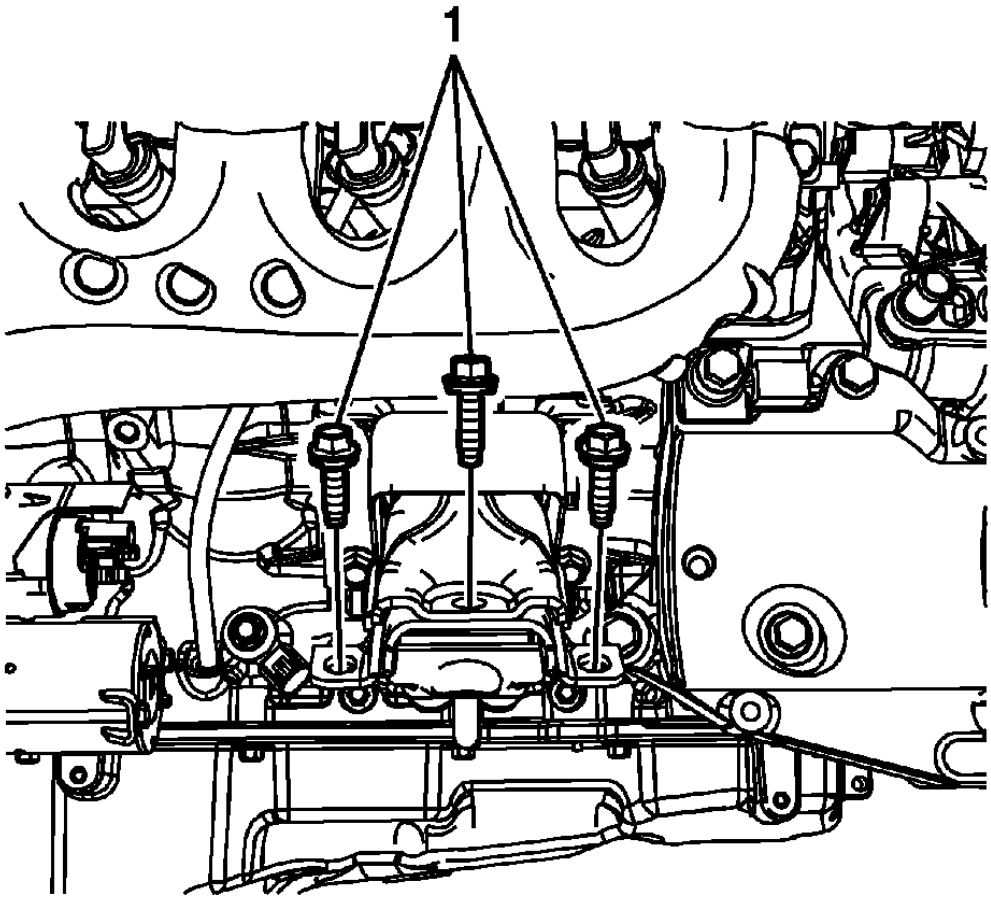

Fig. 46: Engine Mount & Frame Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the engine mount to frame bolts (1) and tighten to 65 N.m (48 lb ft) starting with the middle bolt then either side bolt.
8. Install the right side exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LH9)** .
9. Install the front tire and wheels. Refer to **Tire and Wheel Removal and Installation** .
10. Lower the vehicle.

UPPER INTAKE MANIFOLD SIGHT SHIELD REPLACEMENT

Removal Procedure

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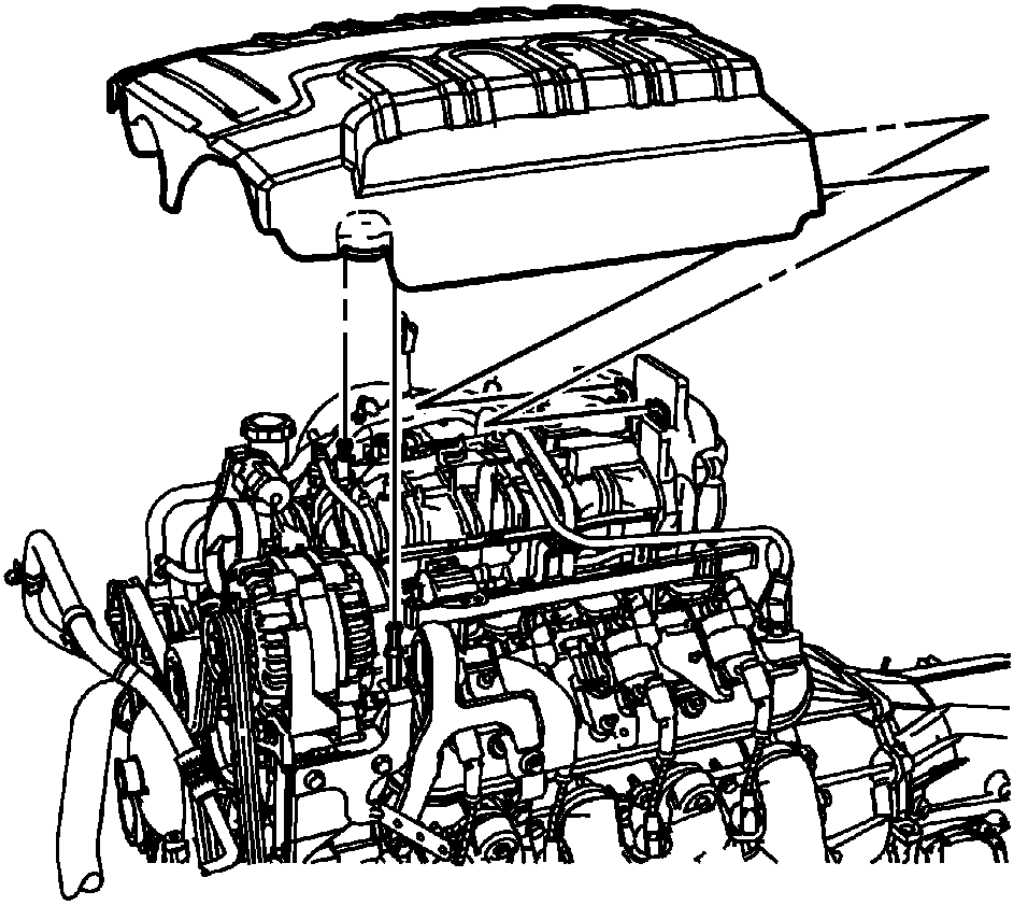

Fig. 47: Upper Intake Manifold Sight Shield Replacement
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil fill cap.
2. Grasp the front of the intake manifold sight shield and lift up disengaging the grommets from the studs.
3. Remove the intake manifold sight shield from the retainer slots.

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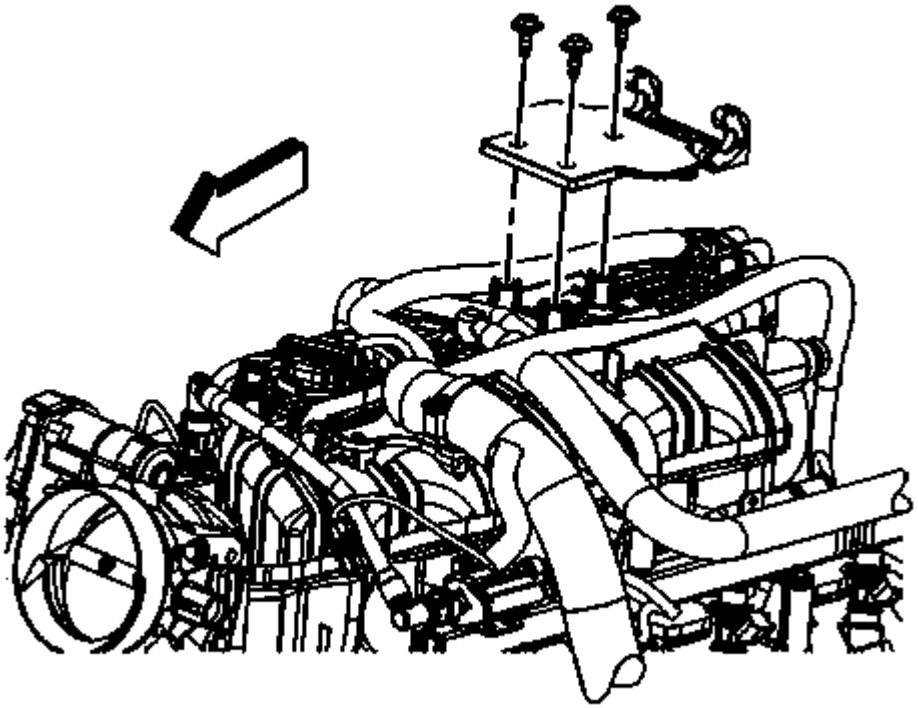

Fig. 48: View Of Intake Manifold Sight Shield Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold sight shield retainer bolts and retainer, if required.

Installation Procedure

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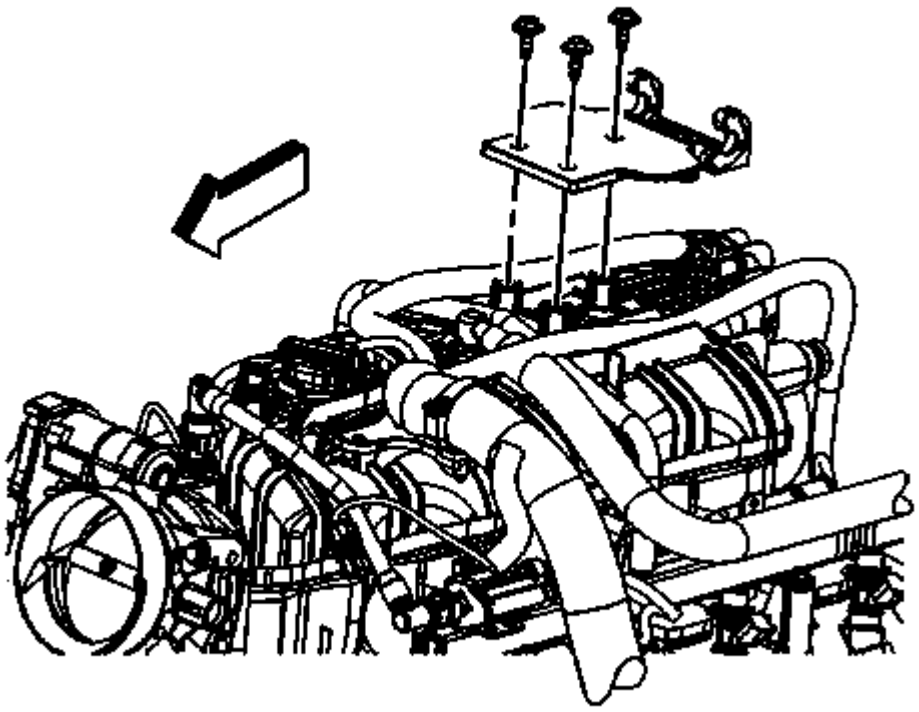

Fig. 49: View Of Intake Manifold Sight Shield Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Position the intake manifold sight shield on top of the intake manifold, aligning the holes, if required.
2. Install the intake manifold sight shield retainer bolts, if required.

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

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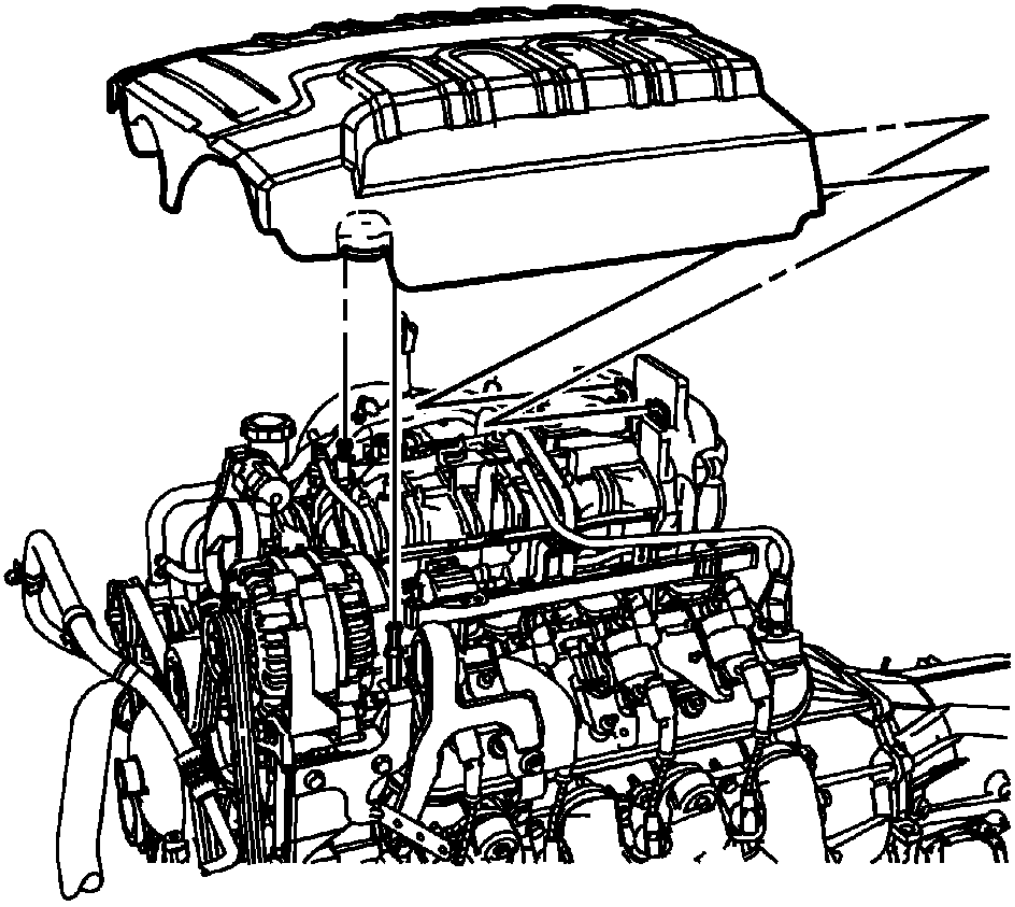

Fig. 50: Upper Intake Manifold Sight Shield Replacement
Courtesy of GENERAL MOTORS CORP.

3. Install the intake manifold sight shield tabs into the slots in the retainer.
4. Align the intake manifold sight shield grommets with the studs.
5. Gently push down on the intake manifold sight shield over the grommets, seating the intake manifold sight shield.
6. Install the oil fill cap.

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

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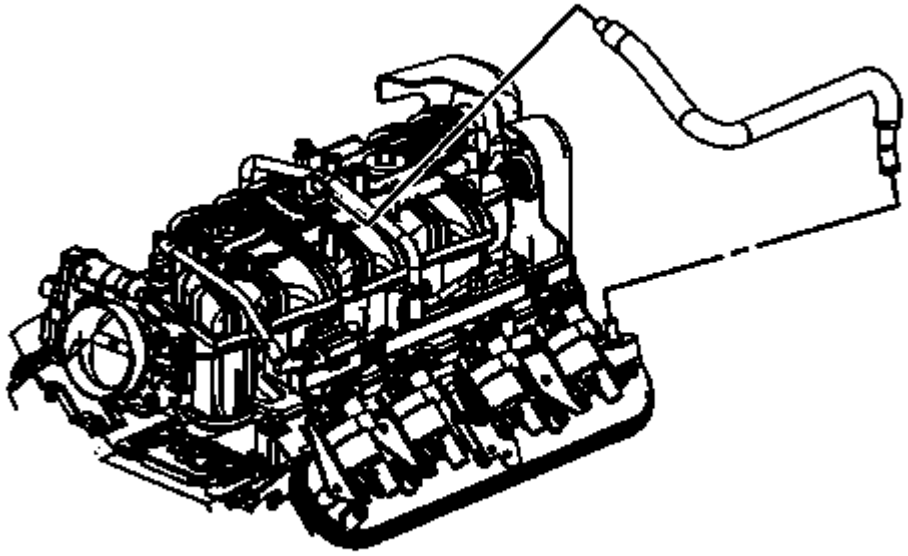

Fig. 51: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. Remove the positive crankcase ventilation (PCV) hose from the intake manifold fitting and left valve rocker arm cover, if required.

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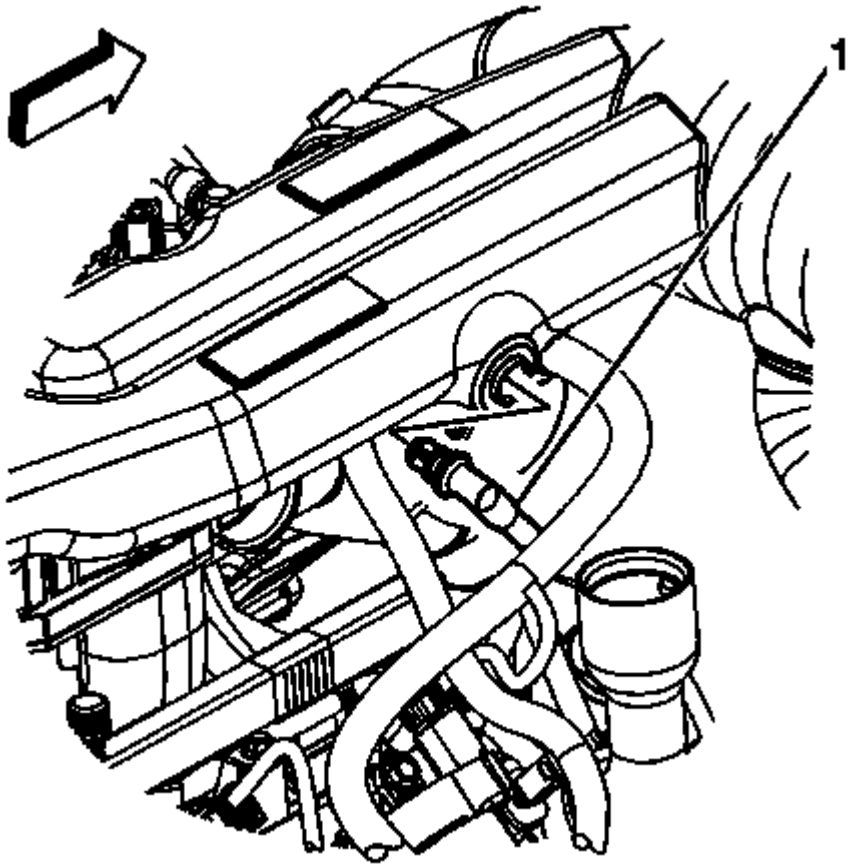

Fig. 52: View Of PCV Tube
Courtesy of GENERAL MOTORS CORP.

3. Remove the PCV tube (1) from the air cleaner outlet duct, if required.

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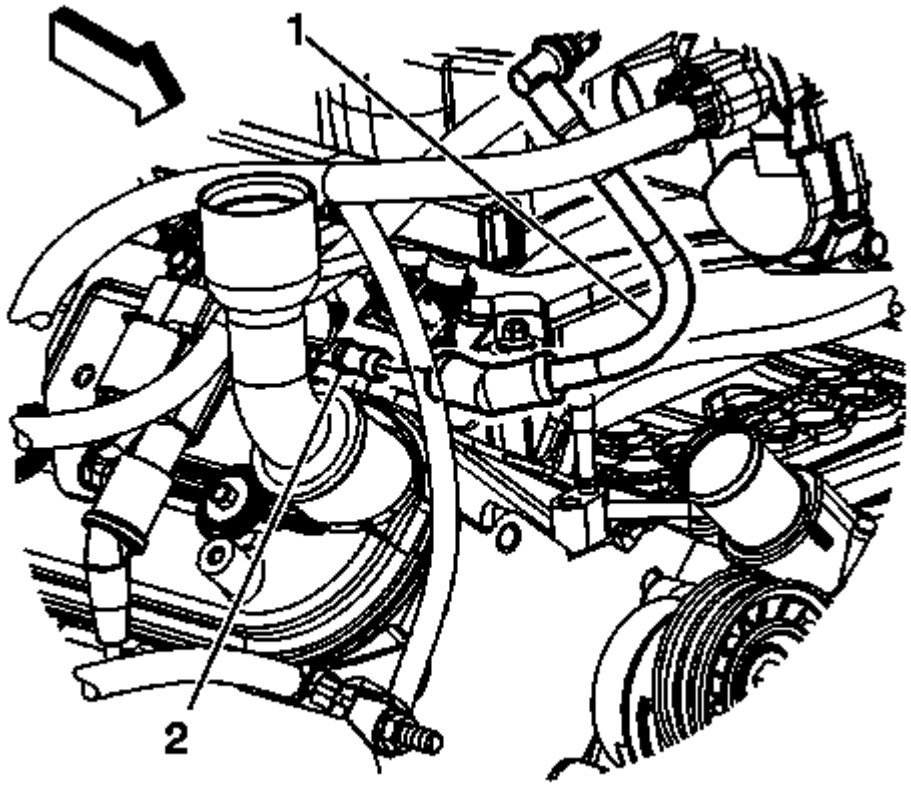

Fig. 53: View Of PCV Tube & Right Valve Rocker Arm Cover Fitting
Courtesy of GENERAL MOTORS CORP.

4. Remove the PCV tube (1) from the right valve rocker arm cover fitting (2), if required.
5. Remove the appropriate PCV hose/tube from the vehicle.

Installation Procedure

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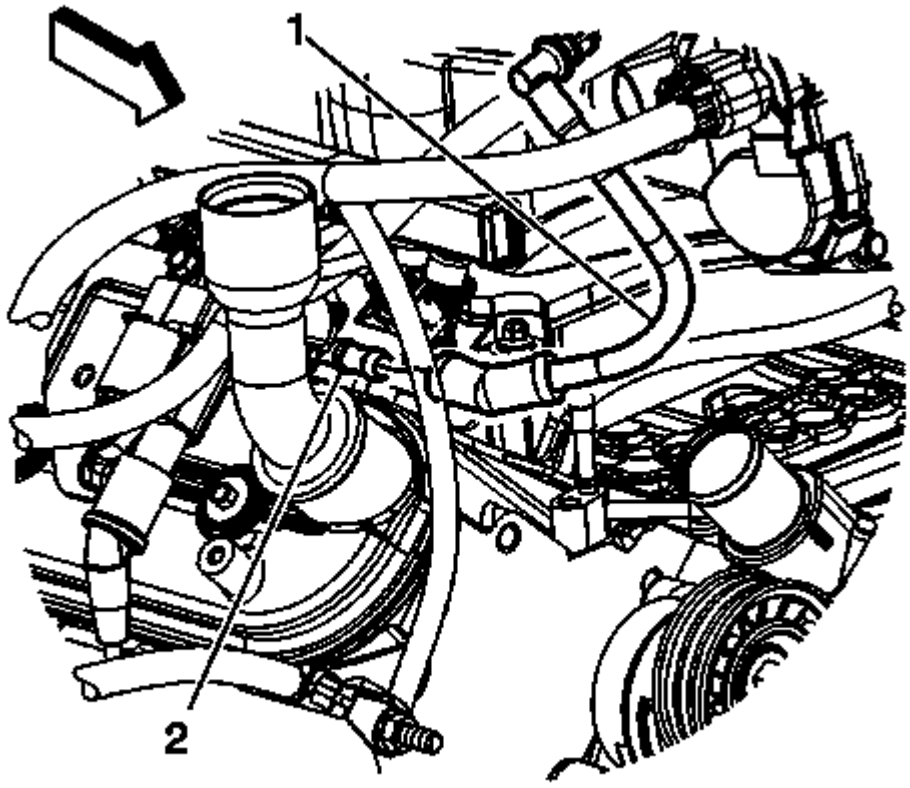

Fig. 54: View Of PCV Tube & Right Valve Rocker Arm Cover Fitting
Courtesy of GENERAL MOTORS CORP.

1. Install the appropriate PCV hose/tube to the vehicle.
2. Install the PCV tube (1) to the right valve rocker arm cover fitting (2), if required.

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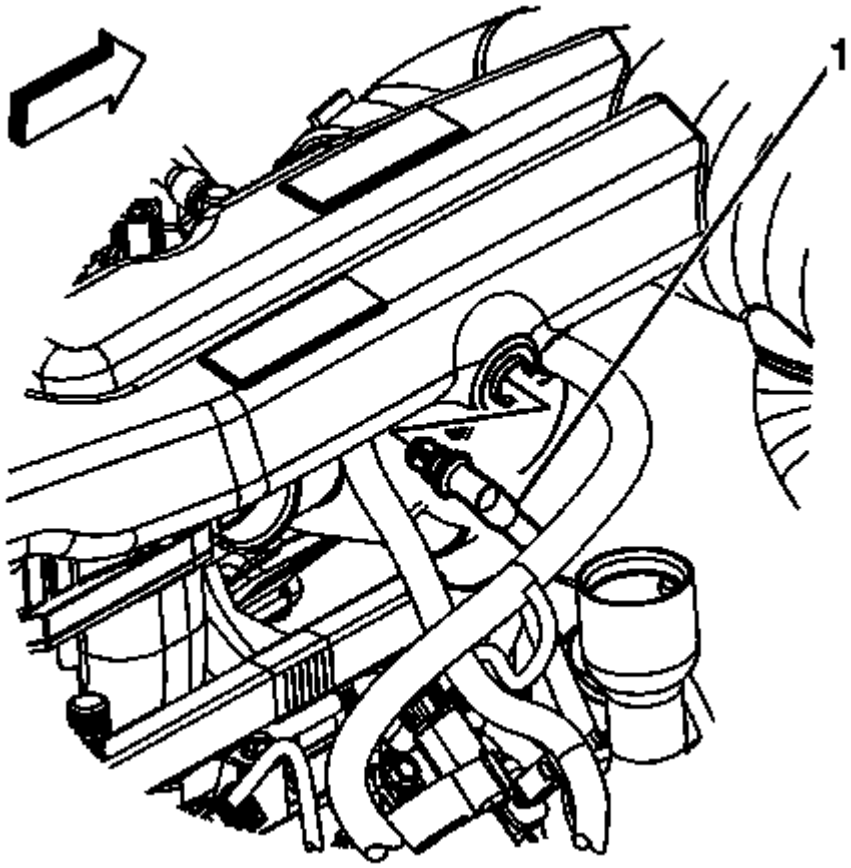

Fig. 55: View Of PCV Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Route the PCV tube between the engine harness and generator battery jumper cable.

3. Install the PCV tube (1) to the air cleaner outlet duct, if required.

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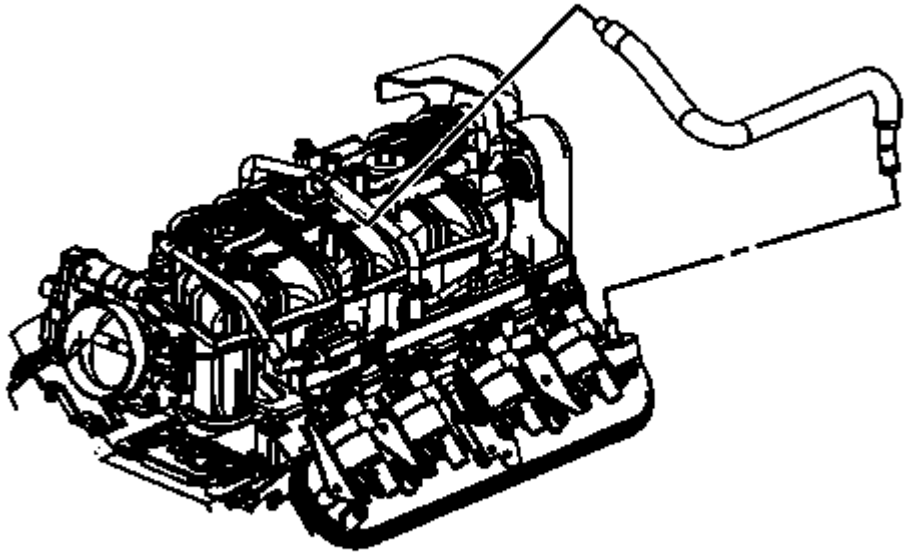

Fig. 56: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

4. Install the PCV hose to the intake manifold fitting and left valve rocker arm cover, if required.
5. Install the intake manifold sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

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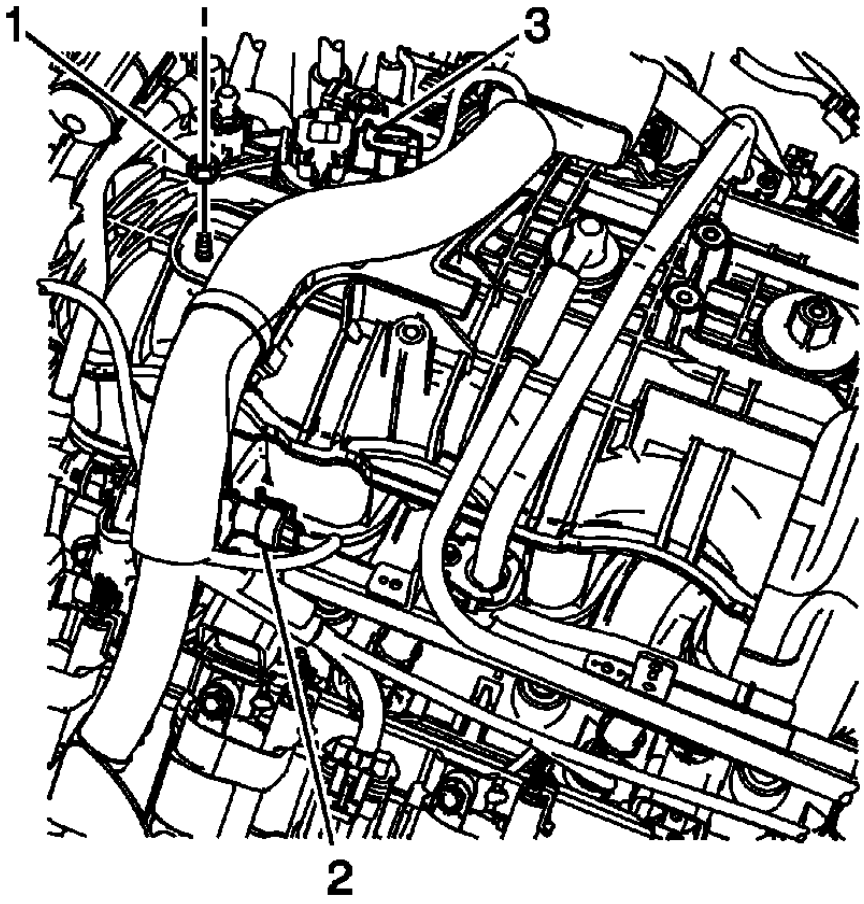

Fig. 57: PCV Hose/Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .
2. Remove the generator. Refer to **Generator Replacement** .
3. Remove the engine harness retainer nut (1).
4. Remove the engine harness retainer from the stud and locator pin.
5. Disconnect the engine harness electrical connector (2) from the evaporative emission (EVAP) canister purge solenoid.
6. Disconnect the engine wiring harness electrical connector (3) from the manifold absolute pressure (MAP) sensor.

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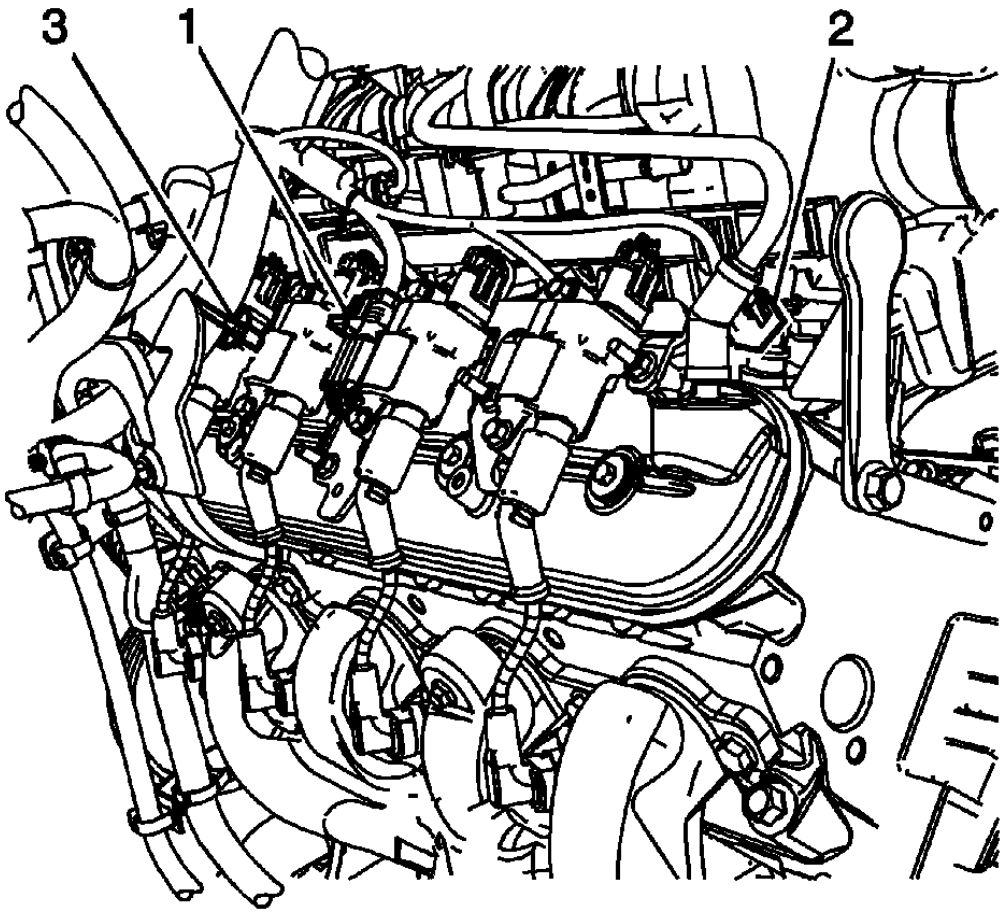

Fig. 58: Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

7. Disconnect the engine harness electrical connector (1) from the ignition coil harness electrical connector.
8. Disconnect the engine harness electrical connectors (2) from the left side fuel injectors.
9. Remove the engine harness clip (3) from the ignition coil bracket stud.

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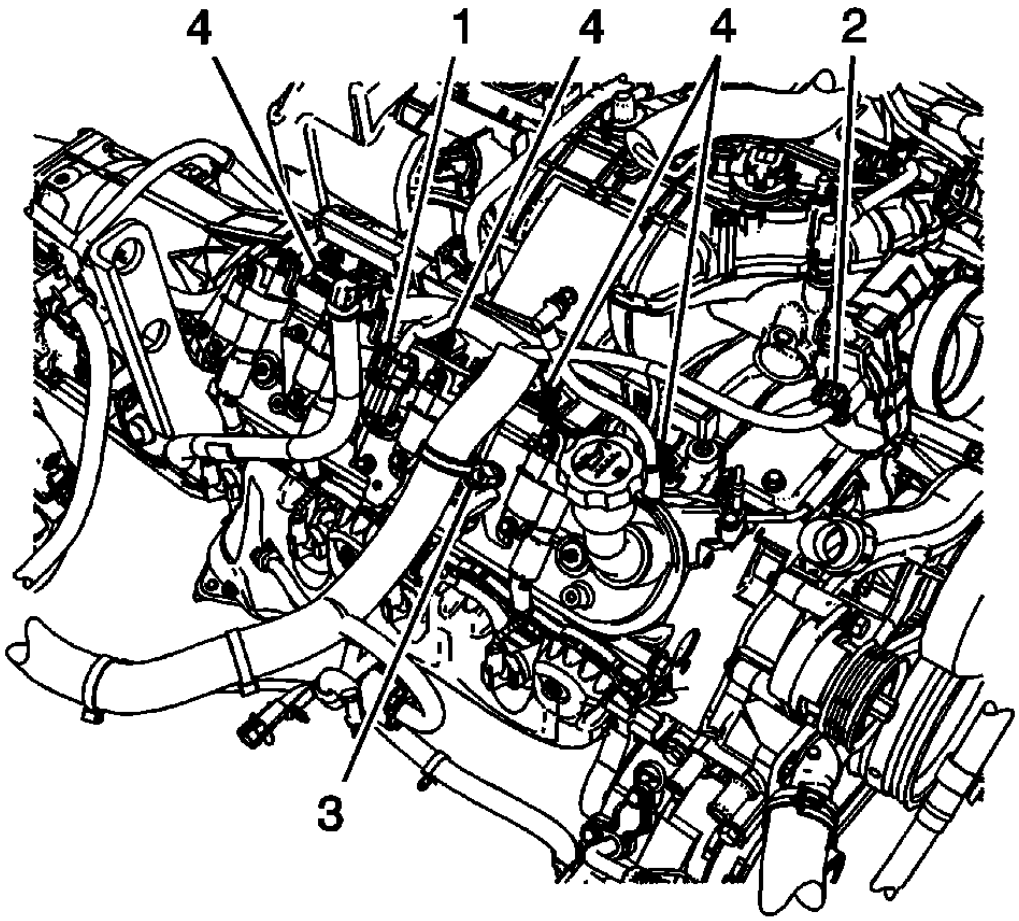

Fig. 59: Engine Harness Electrical Connector & Ignition Coil Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

10. Disconnect the engine harness electrical connector (1) from the ignition coil harness electrical connector.
11. Disconnect the engine harness electrical connector (2) from the throttle actuator.
12. Remove the engine harness clip (3) from the ignition coil bracket stud.
13. Disconnect the engine harness electrical connectors (4) from the right side fuel injectors.

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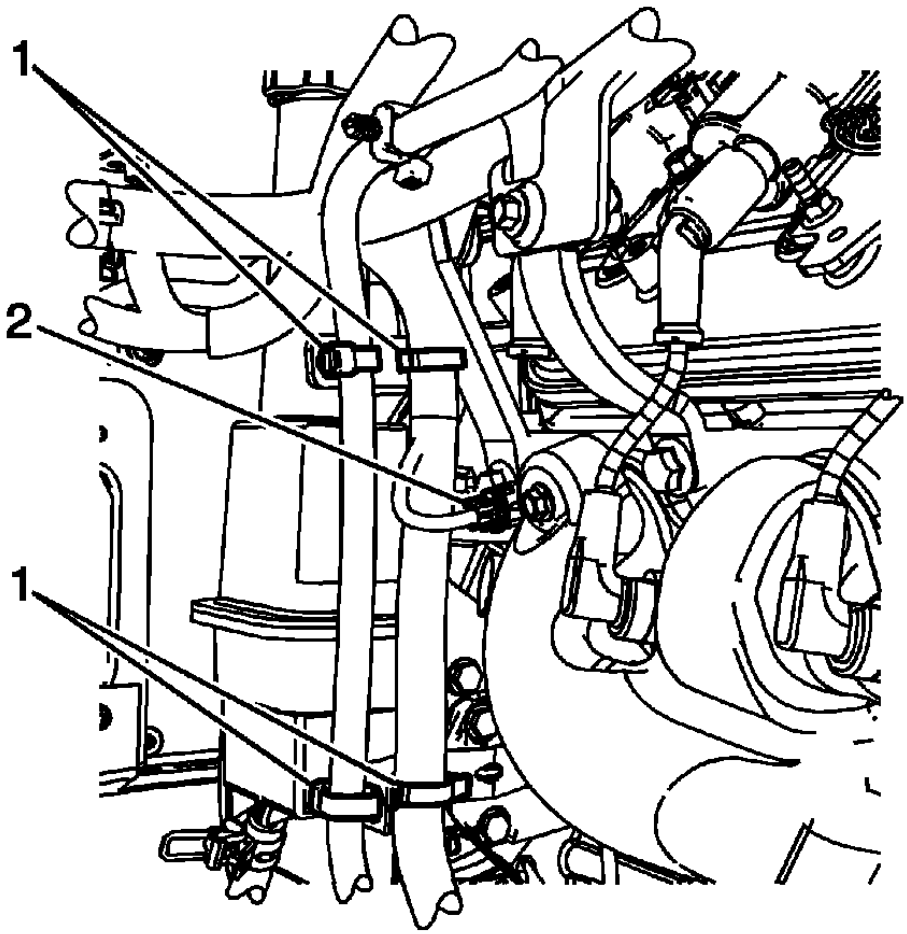

Fig. 60: Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine harness clips (1).
15. Disconnect the engine harness electrical connector (2) from the engine coolant temperature (ECT) sensor.
16. Gather the engine harness branches and tie the harness up out of the way to the front of the engine compartment.

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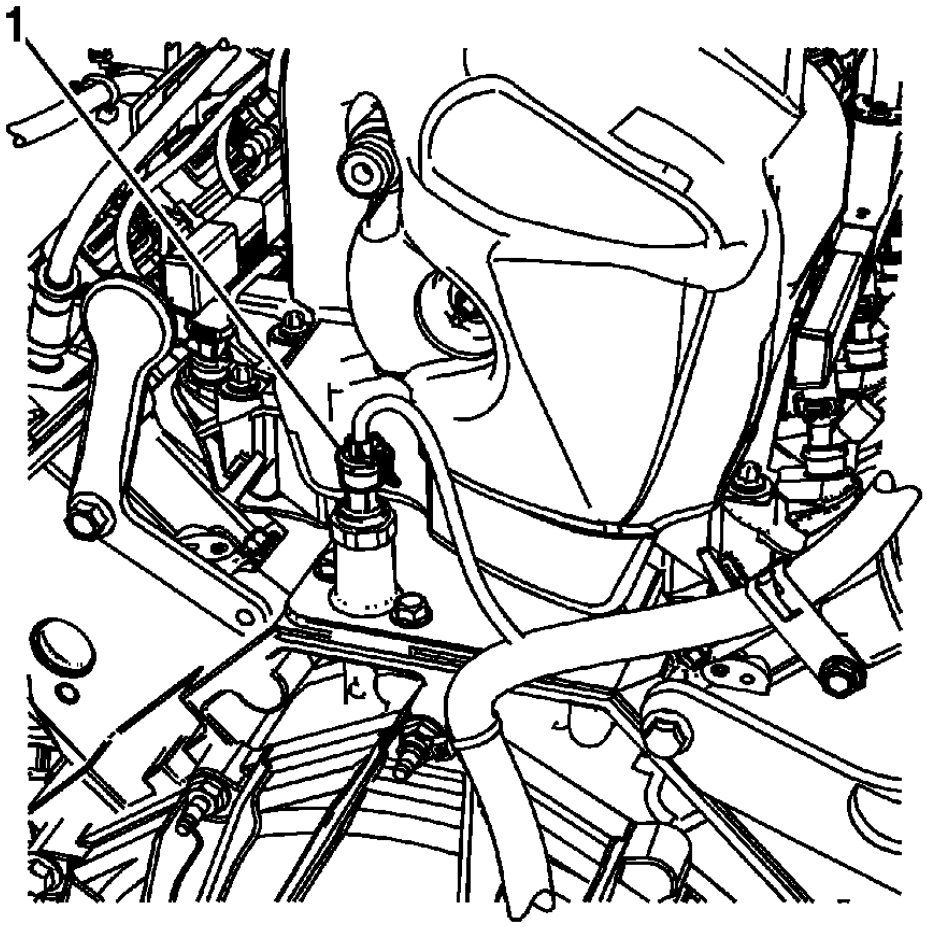

Fig. 61: Engine Oil Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

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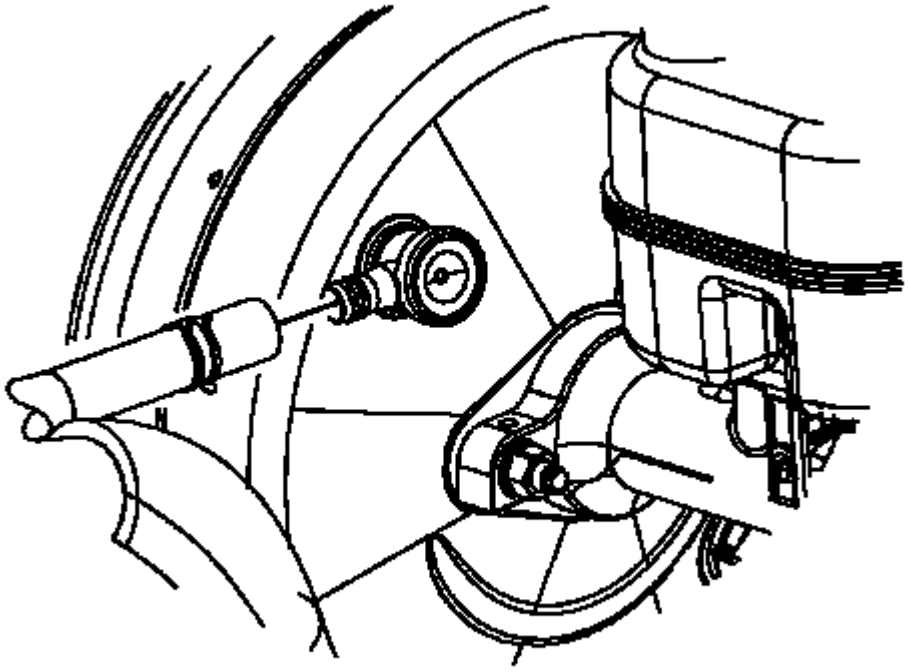

Fig. 62: View Of Brake Booster Vacuum Hose & Booster Fitting
Courtesy of GENERAL MOTORS CORP.

18. Reposition the brake booster vacuum hose clamp at the booster.
19. Remove the brake booster vacuum hose from the booster fitting.
20. Secure the brake booster vacuum hose to the intake manifold.

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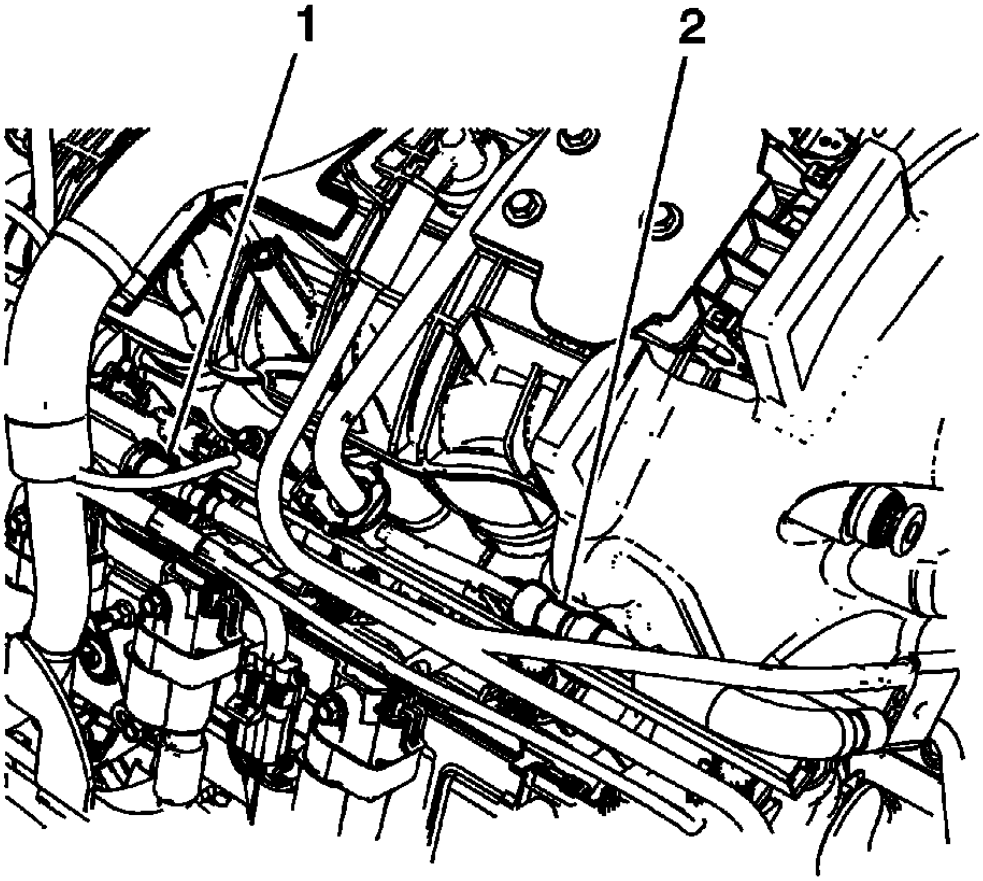

Fig. 63: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS CORP.

21. Disconnect the EVAP canister purge tube (1) quick connect fitting from the EVAP canister purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
22. Disconnect the fuel feed line quick connect fitting (2) from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .

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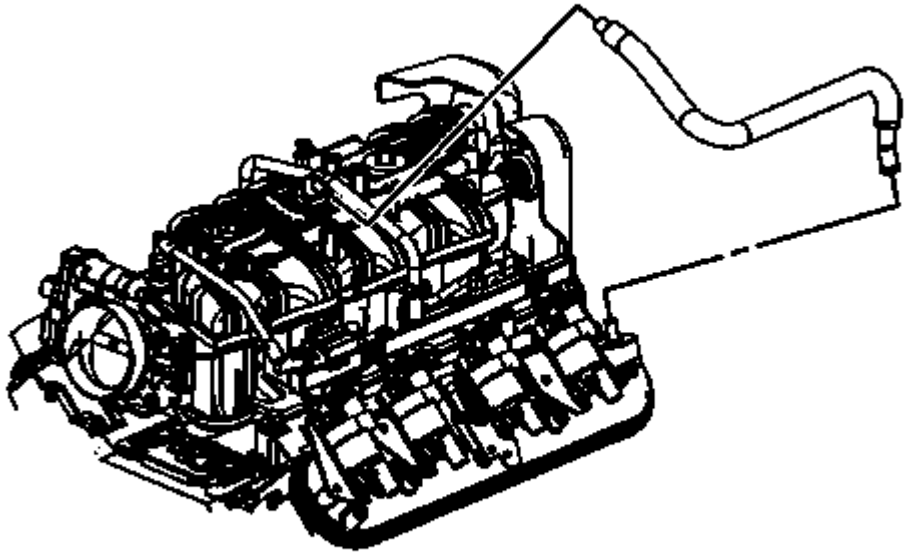

Fig. 64: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

23. Remove the positive crankcase ventilation (PCV) hose from the intake manifold fitting.
24. Position the hose out of the way.

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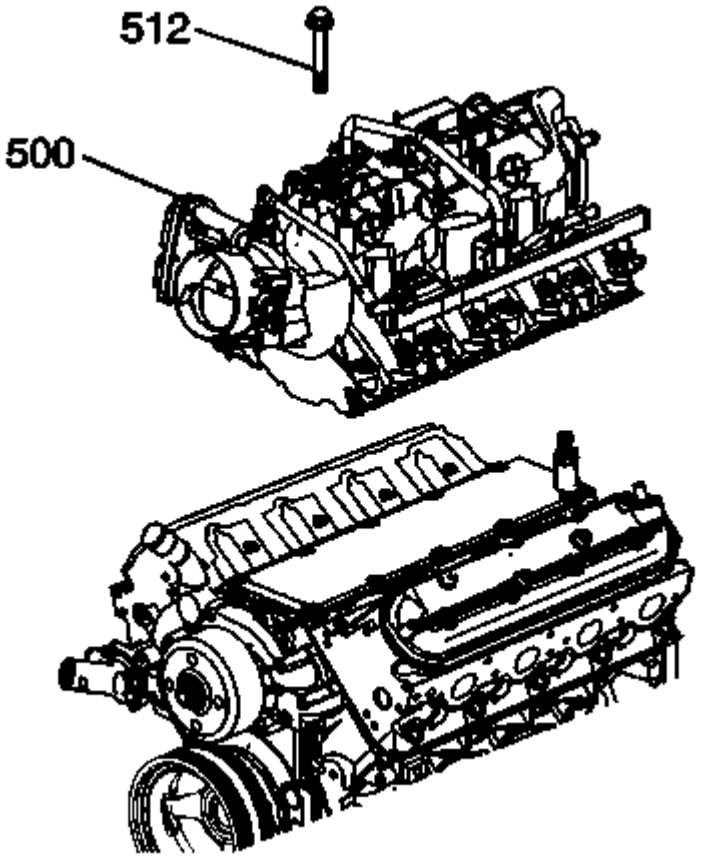

Fig. 65: Removing/Installing Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

25. Loosen the intake manifold bolts (512).

NOTE: The aid of an assistant may be helpful in holding the engine harness up out of the way so the upper intake manifold cover does not get caught against the engine harness.

26. Remove the intake manifold (500).
27. Cover the cylinder head passages in order to prevent dirt or debris from entering the passages.

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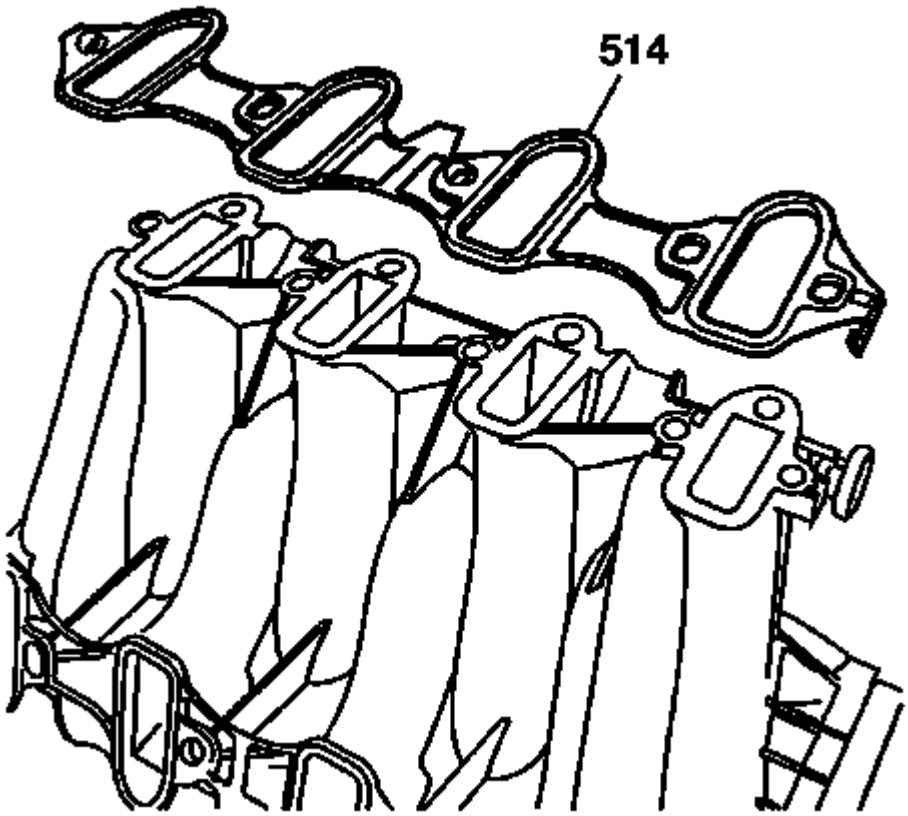

Fig. 66: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

28. Remove and discard the intake manifold gaskets (514).

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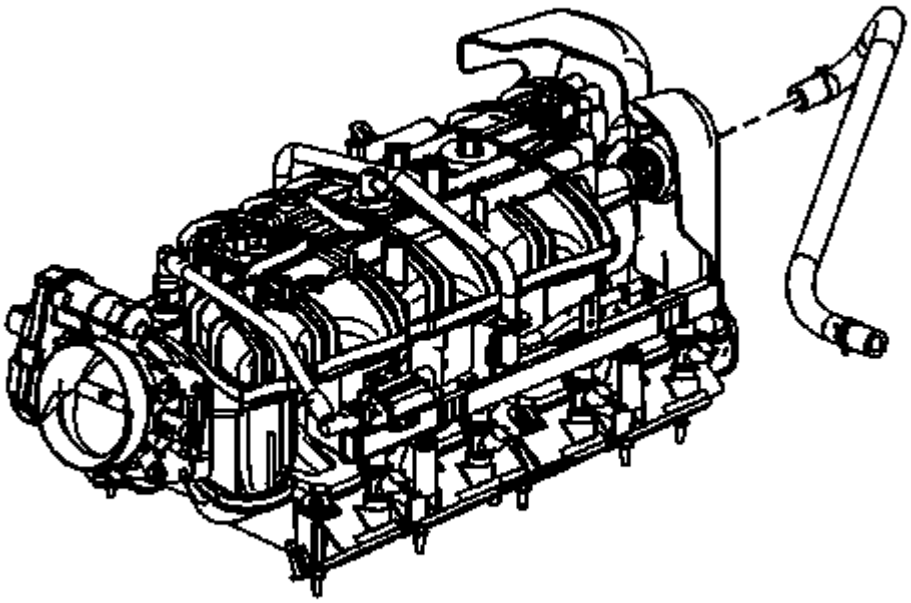

Fig. 67: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

29. If replacing the intake manifold, perform the following steps, otherwise proceed to step 21 of the installation procedure.
30. Place the intake manifold on a clean work surface.
31. Reposition the brake booster vacuum hose clamp at the intake manifold.
32. Remove the brake booster vacuum hose from the intake manifold nipple.

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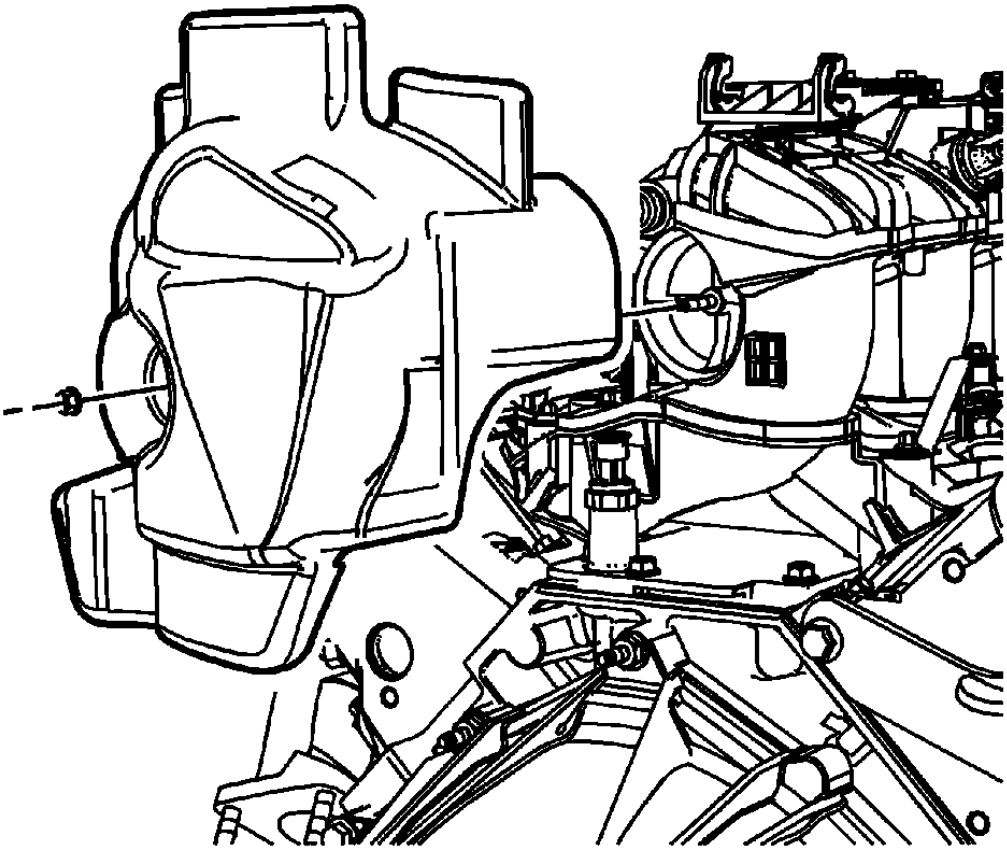

Fig. 68: Upper Intake Manifold Cover Nut
Courtesy of GENERAL MOTORS CORP.

33. Remove the upper intake manifold cover nut.
34. Remove the upper intake manifold cover.

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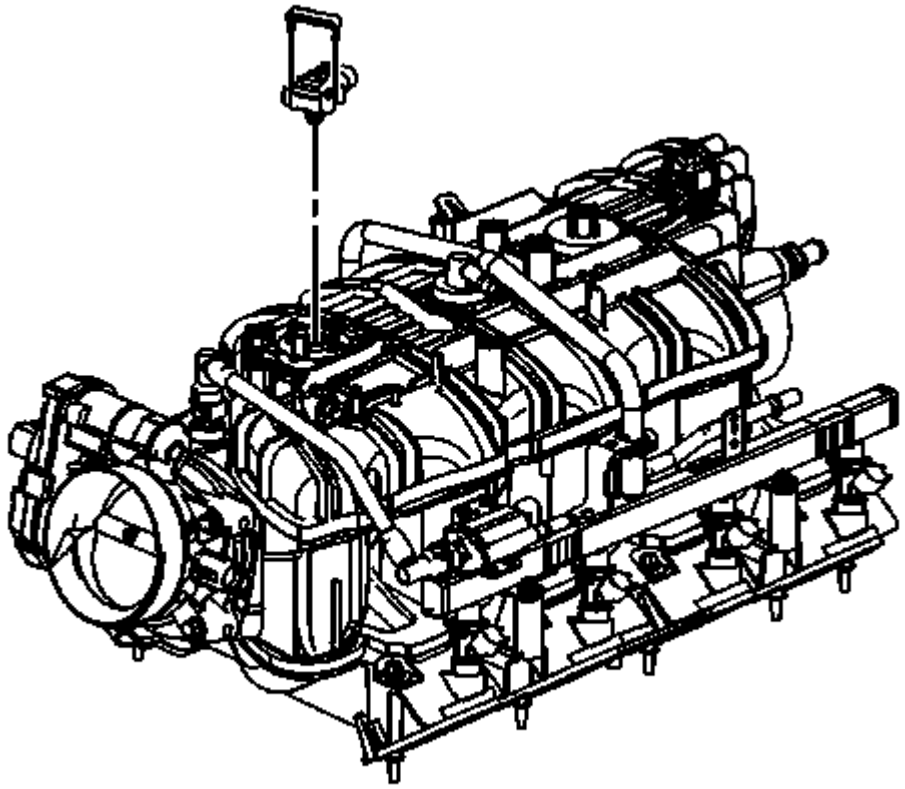

Fig. 69: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

35. Remove the manifold absolute pressure (MAP) sensor retainer.
36. Remove the MAP sensor.

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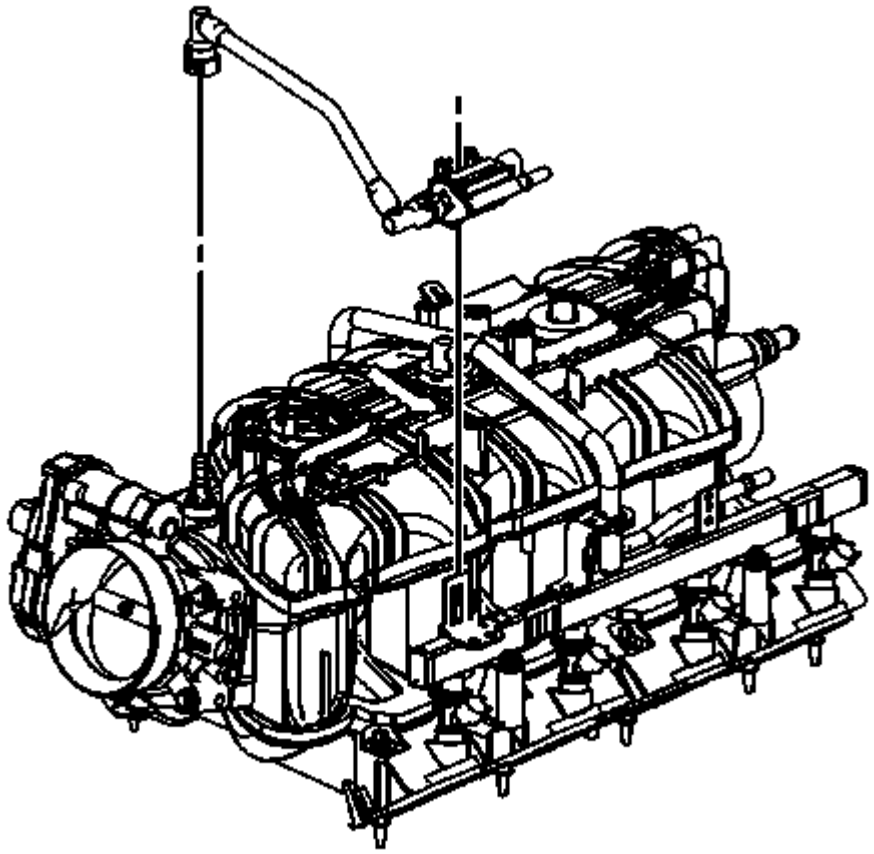

Fig. 70: View Of EVAP Tube & Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

37. Disconnect the EVAP tube quick connect fitting at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .
38. Disengage the retainer securing the EVAP canister purge solenoid to the fuel rail.
39. Remove the EVAP tube and purge solenoid.

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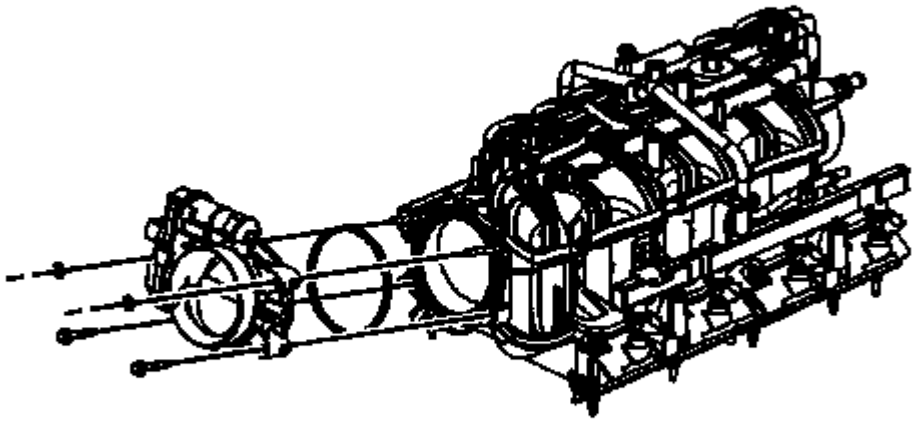

Fig. 71: View Of Throttle Body, Gasket & Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

40. Remove the throttle body bolts/nuts.
41. Remove the throttle body.
42. Remove and discard the throttle body gasket.

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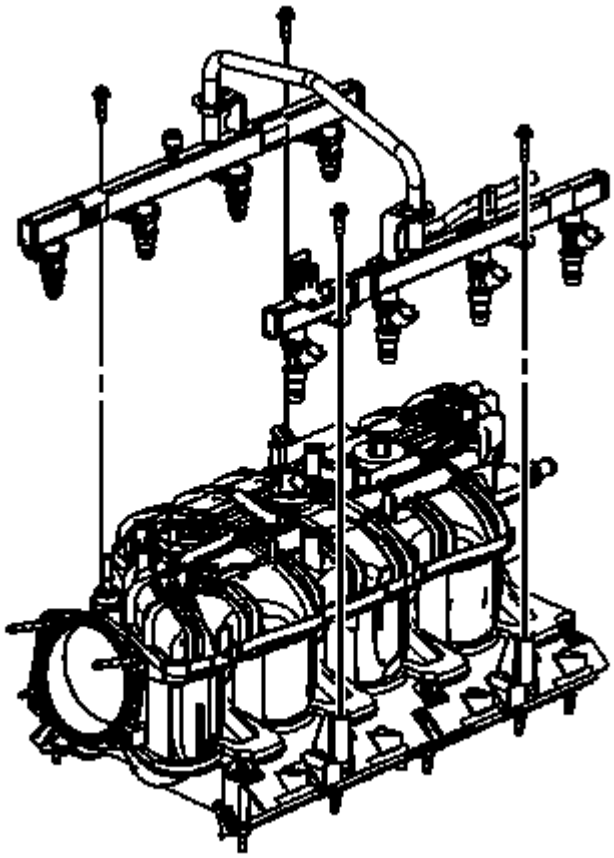

Fig. 72: View Of Fuel Rail & Bolts
Courtesy of GENERAL MOTORS CORP.

43. Remove the fuel rail bolts.

NOTE: Lift evenly on both sides of the fuel rail until all injectors are removed from their bores.

44. Remove the fuel rail.
45. Remove and discard the fuel injector lower O-ring seals.

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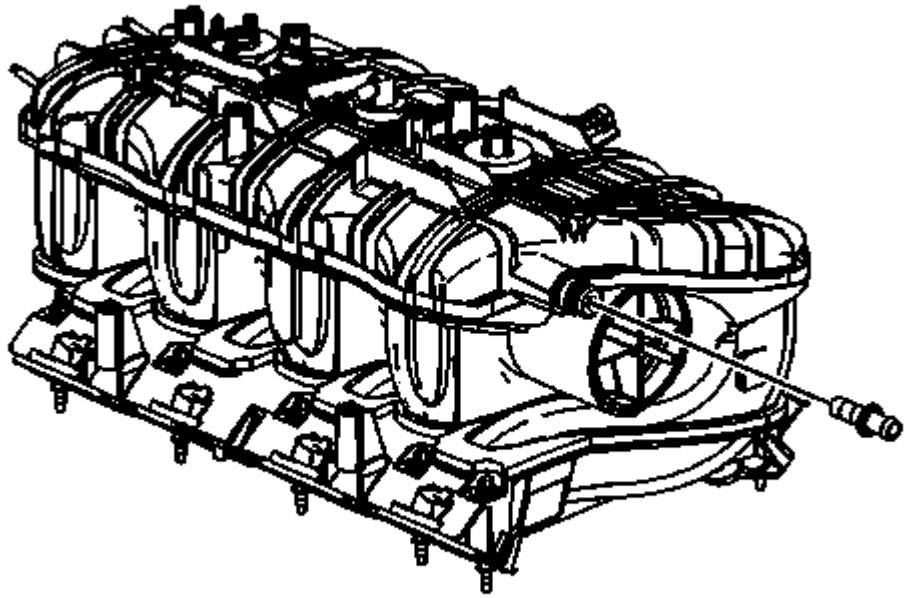

Fig. 73: View Of Brake Booster Vacuum Hose Nipple
Courtesy of GENERAL MOTORS CORP.

NOTE: Evenly push in the RED collar in order to remove the nipple.

46. Remove the brake booster vacuum hose nipple.

Installation Procedure

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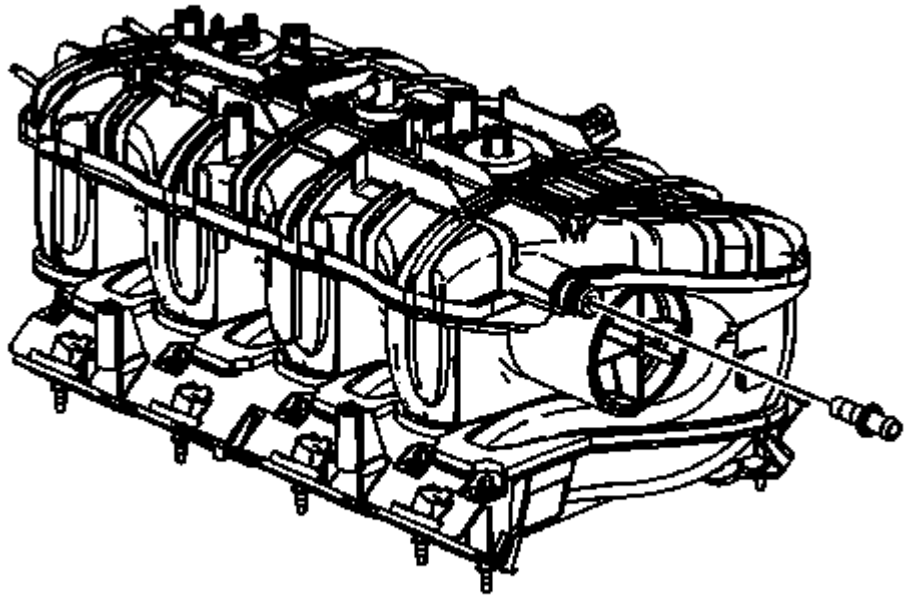

Fig. 74: View Of Brake Booster Vacuum Hose Nipple
Courtesy of GENERAL MOTORS CORP.

1. If the intake manifold was replaced perform the following steps, otherwise proceed to step 21.

NOTE: Evenly push in the RED collar in order to install the nipple.

2. Install the brake booster vacuum hose nipple to the NEW intake manifold.

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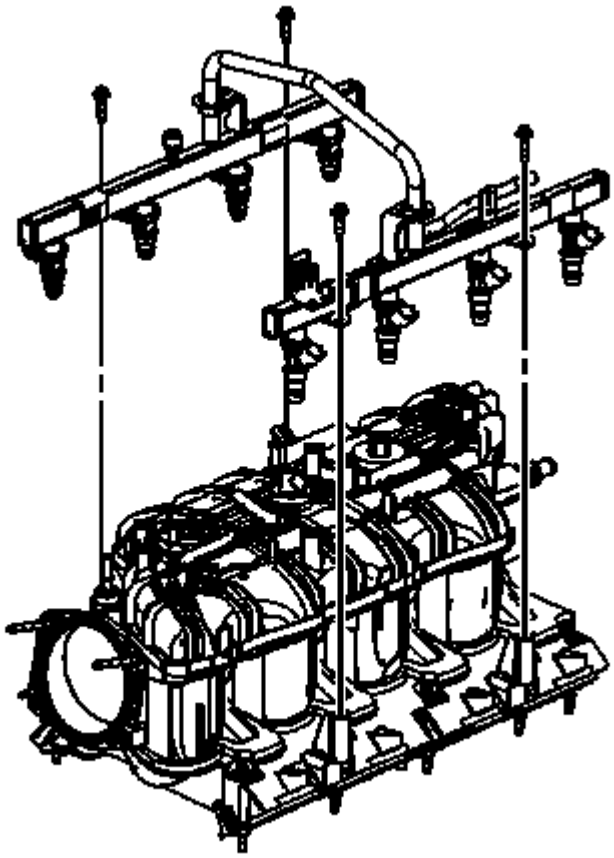

Fig. 75: View Of Fuel Rail & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install NEW fuel injector lower O-ring seals onto the injectors.
4. Lubricate the NEW O-ring seals with clean engine oil.

NOTE: Push down firmly on both sides of the rail until all the injectors have been seated into their bores.

5. Install the fuel rail.

CAUTION: Refer to Fastener Caution .

6. Install the fuel rail bolts.

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

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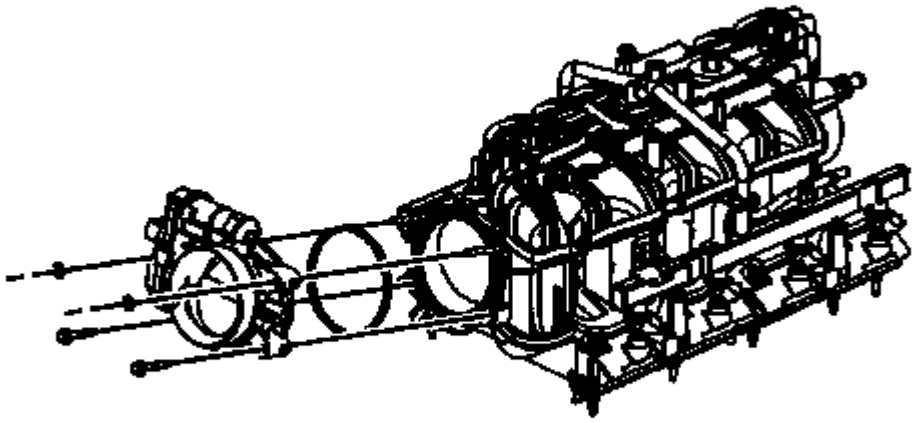

Fig. 76: View Of Throttle Body, Gasket & Bolts/Nuts
Courtesy of GENERAL MOTORS CORP.

7. Install a NEW throttle body gasket to the intake manifold.
8. Install the throttle body.
9. Install the throttle body bolts/nuts.

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

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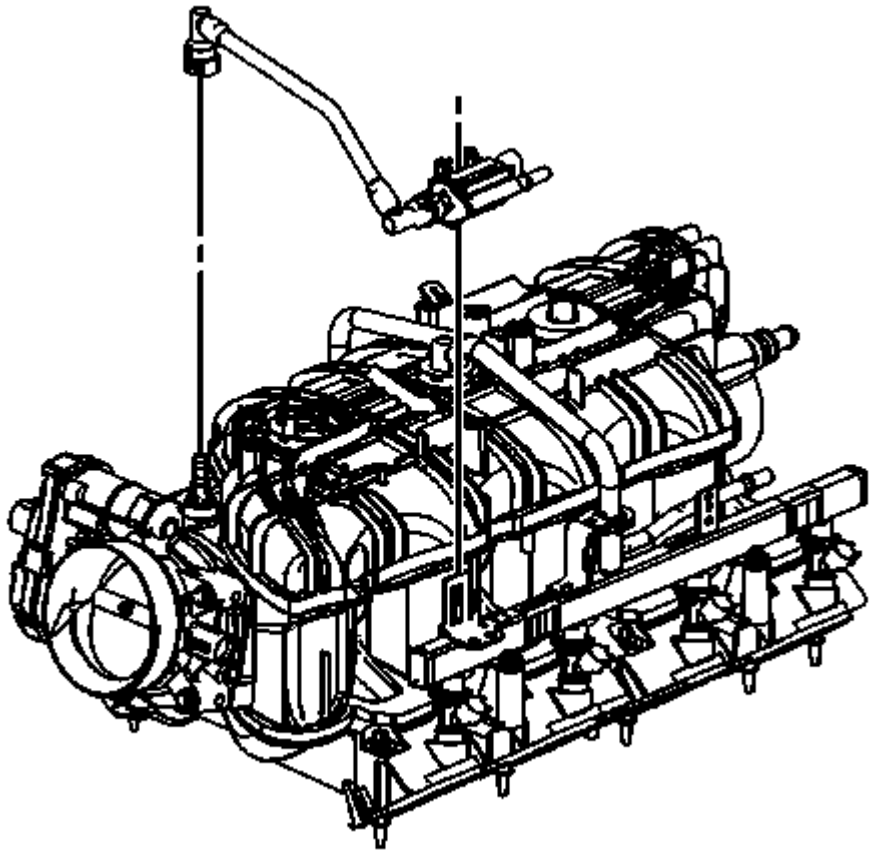

Fig. 77: View Of EVAP Tube & Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

10. Install the EVAP tube and purge solenoid.
11. Install the EVAP canister purge solenoid to the fuel rail bracket and engage the retainer.
12. Connect the EVAP tube quick connect fitting at the intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .

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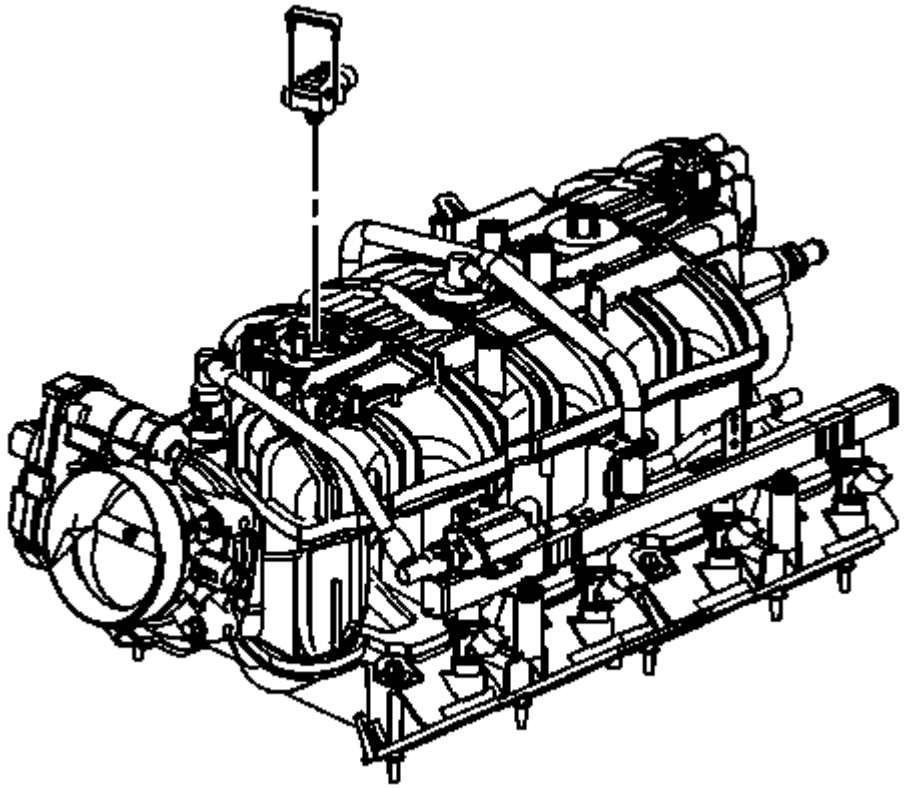

Fig. 78: View Of MAP Sensor & Retainer
Courtesy of GENERAL MOTORS CORP.

13. Lubricate the MAP sensor seal with clean engine oil.
14. Install the MAP sensor.
15. Install the MAP sensor retainer.

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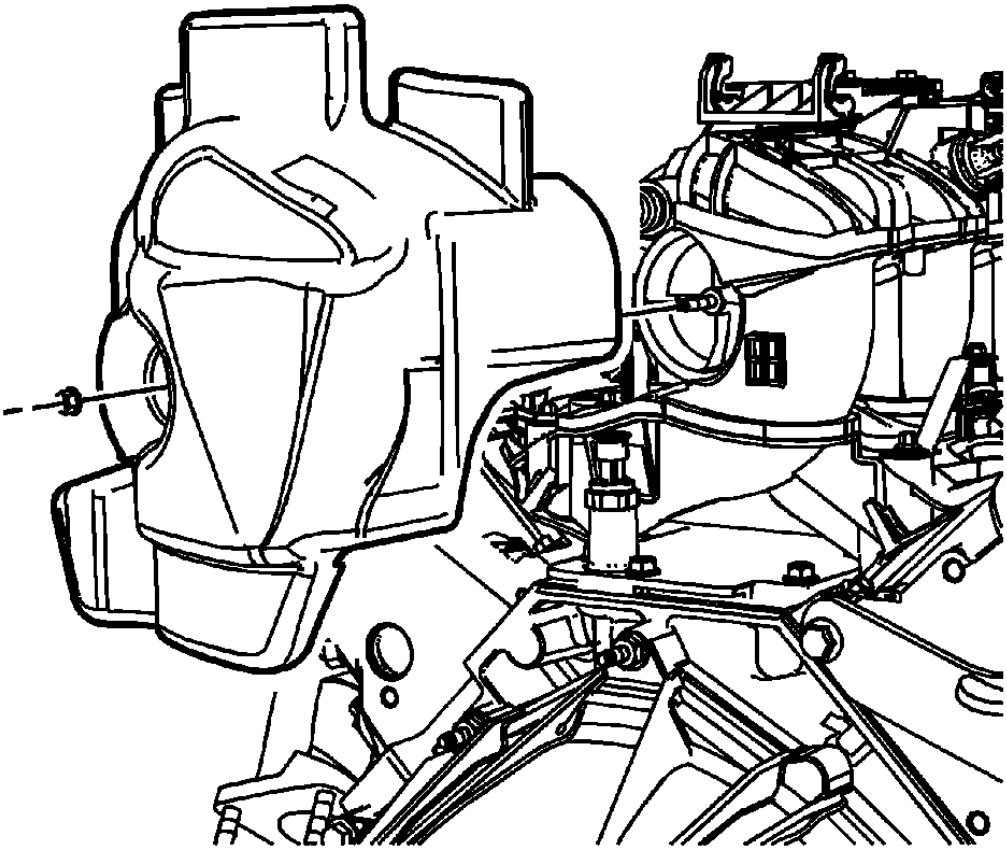

Fig. 79: Upper Intake Manifold Cover Nut
Courtesy of GENERAL MOTORS CORP.

16. Install the upper intake manifold cover.
17. Install the upper intake manifold cover nut until snug

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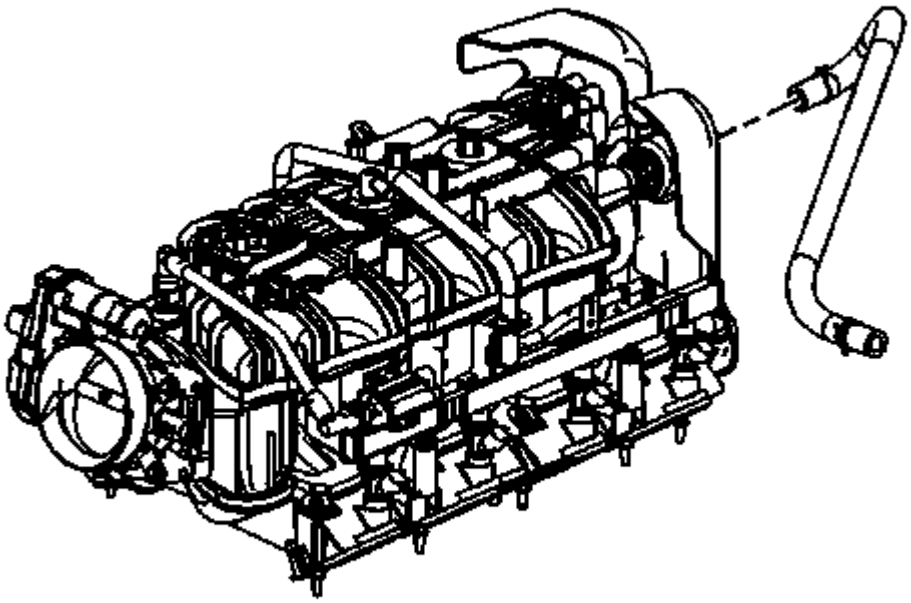

Fig. 80: View Of Vacuum Brake Booster Hose
Courtesy of GENERAL MOTORS CORP.

18. Install the brake booster vacuum hose to the intake manifold nipple.
19. Position the brake booster vacuum hose clamp at the intake manifold.
20. Secure the brake booster vacuum hose to the intake manifold.

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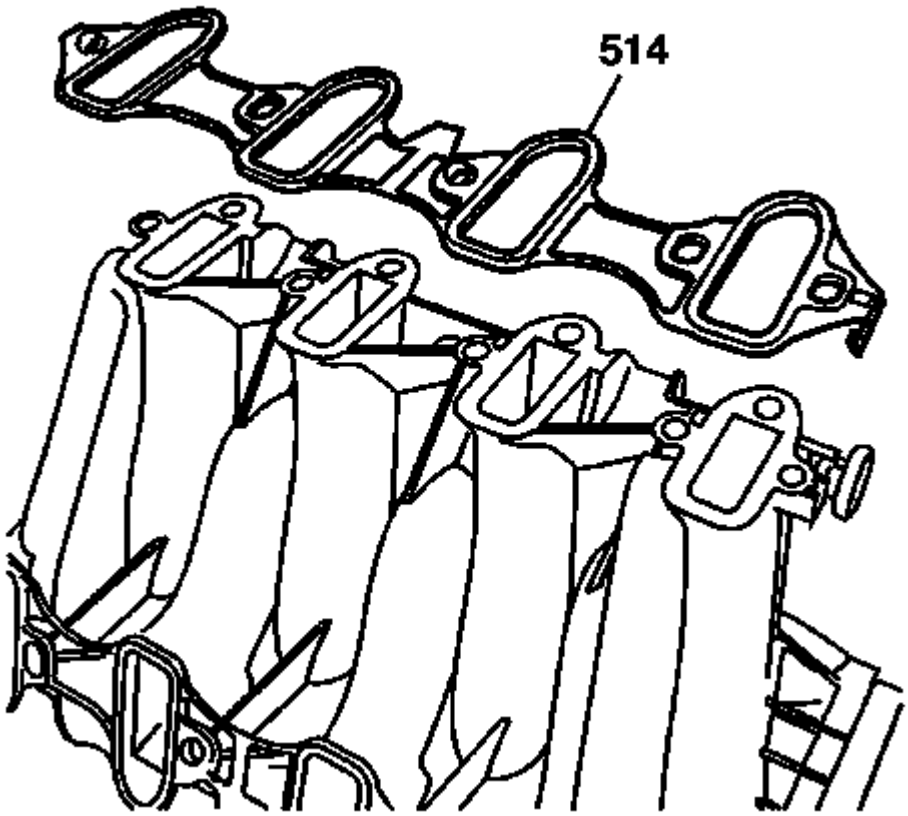

Fig. 81: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

21. Install NEW intake manifold gaskets (514) to the intake manifold.
22. Remove the covers from the cylinder head passages.

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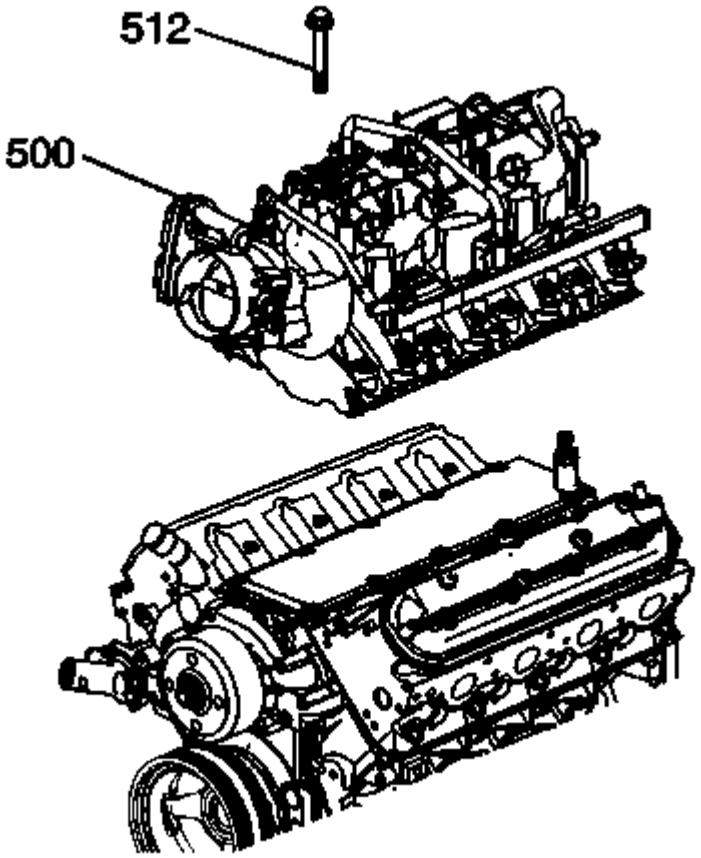

Fig. 82: Removing/Installing Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

23. Install the intake manifold (500).

NOTE: The aid of an assistant may be helpful in holding the engine harness up out of the way so the upper intake manifold cover does not get caught against the engine harness.

24. Tighten the intake manifold bolts (512) until snug.

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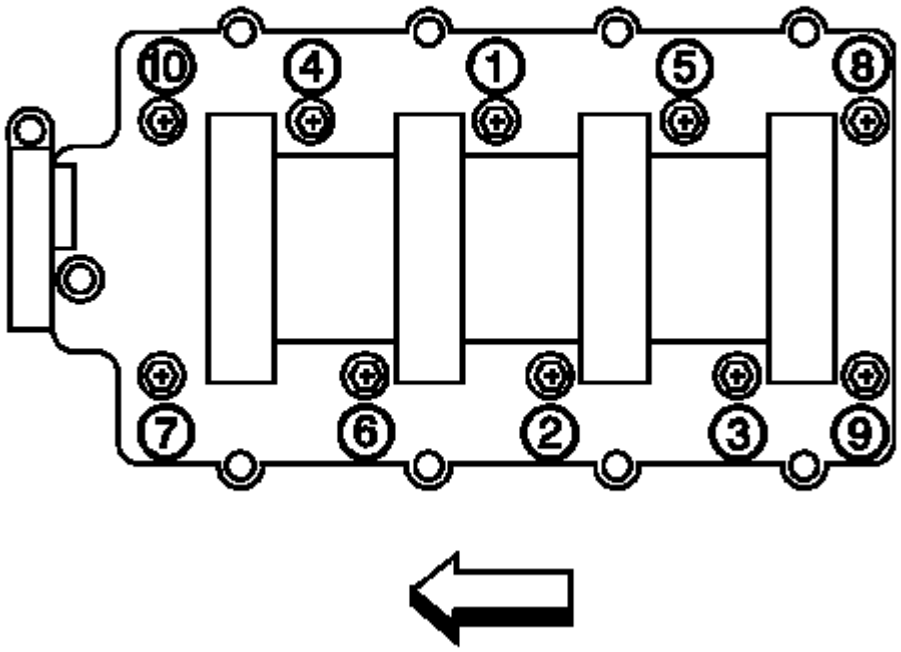

Fig. 83: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

25. Tighten the intake manifold bolts to specifications.

Tighten:

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

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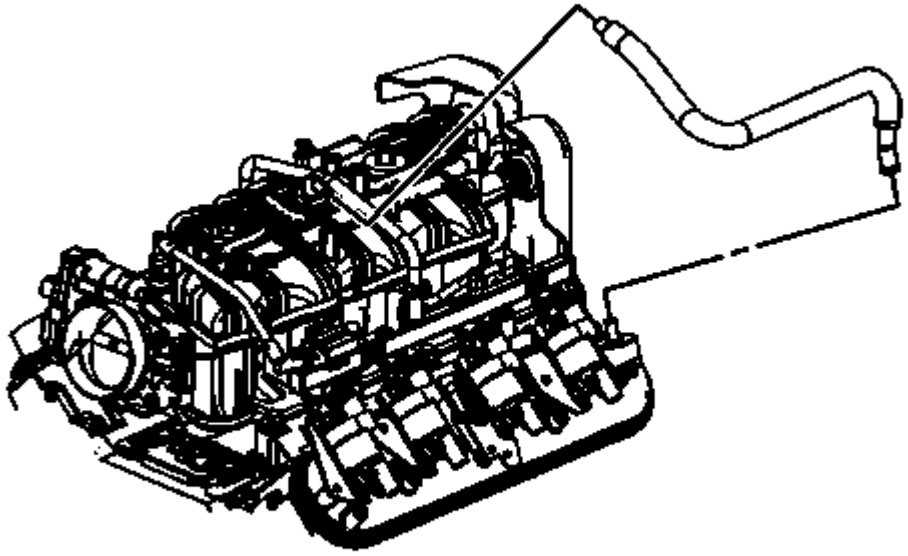

Fig. 84: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

26. Position and install the PCV hose to the intake manifold fitting.

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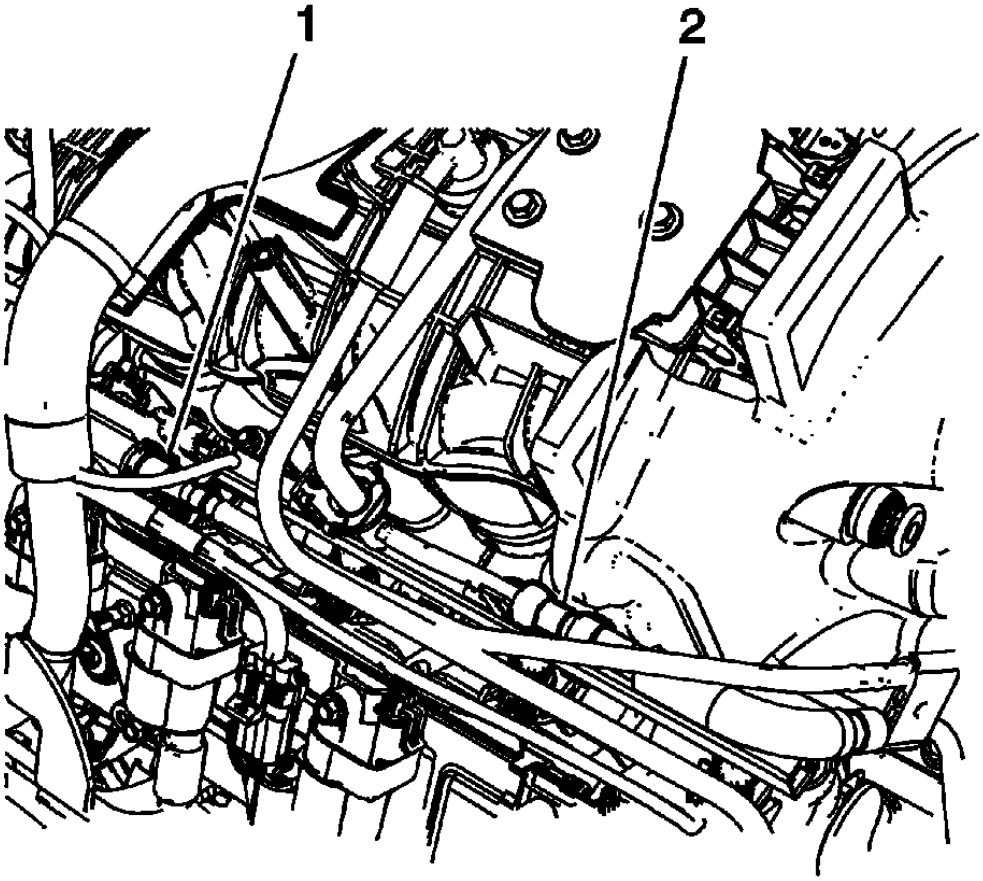

Fig. 85: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS CORP.

27. Connect the fuel feed line quick connect fitting (2) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
28. Connect the EVAP canister purge tube (1) quick connect fitting to the EVAP canister purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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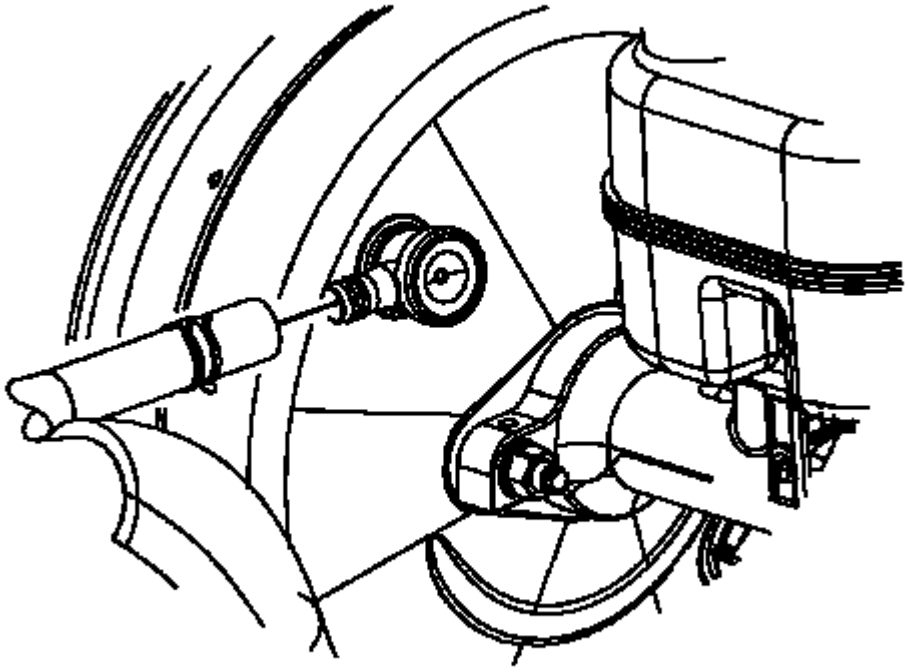

Fig. 86: View Of Brake Booster Vacuum Hose & Booster Fitting
Courtesy of GENERAL MOTORS CORP.

29. Unsecure the brake booster vacuum hose from the intake manifold.
30. Install the brake booster vacuum hose to the booster fitting.
31. Position the brake booster vacuum hose clamp at the booster.

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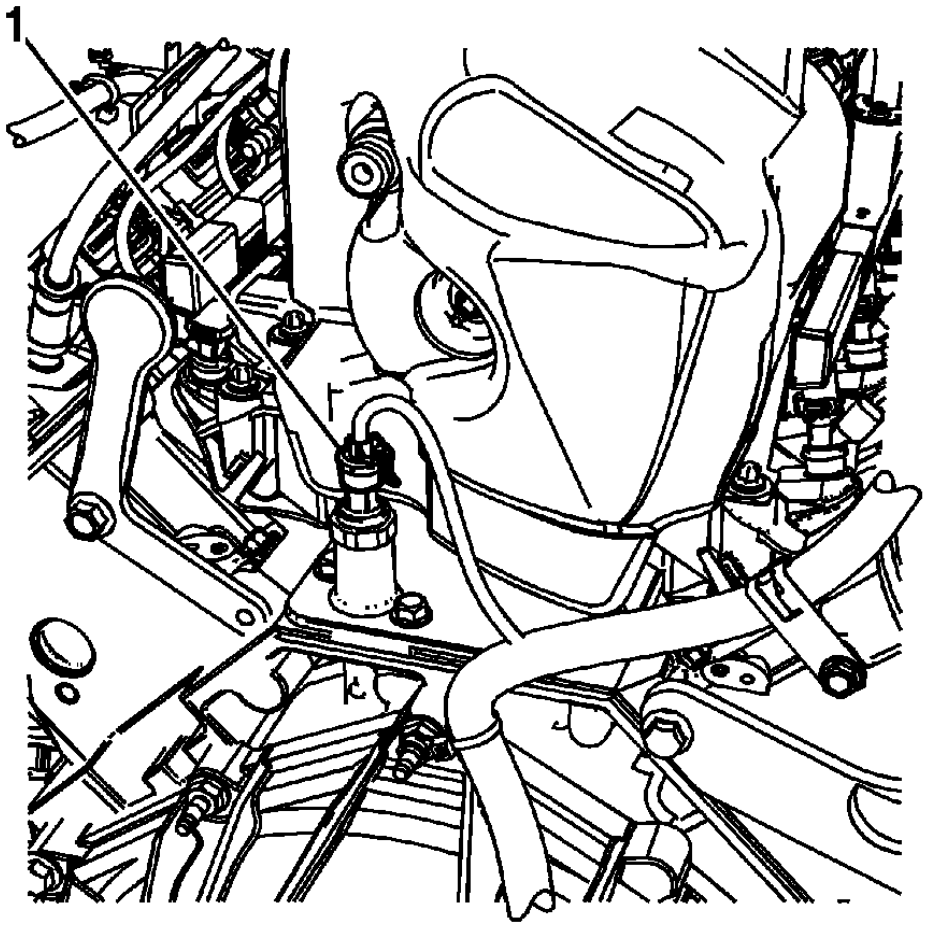

Fig. 87: Engine Oil Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

32. Connect the engine oil pressure sensor electrical connector (1).

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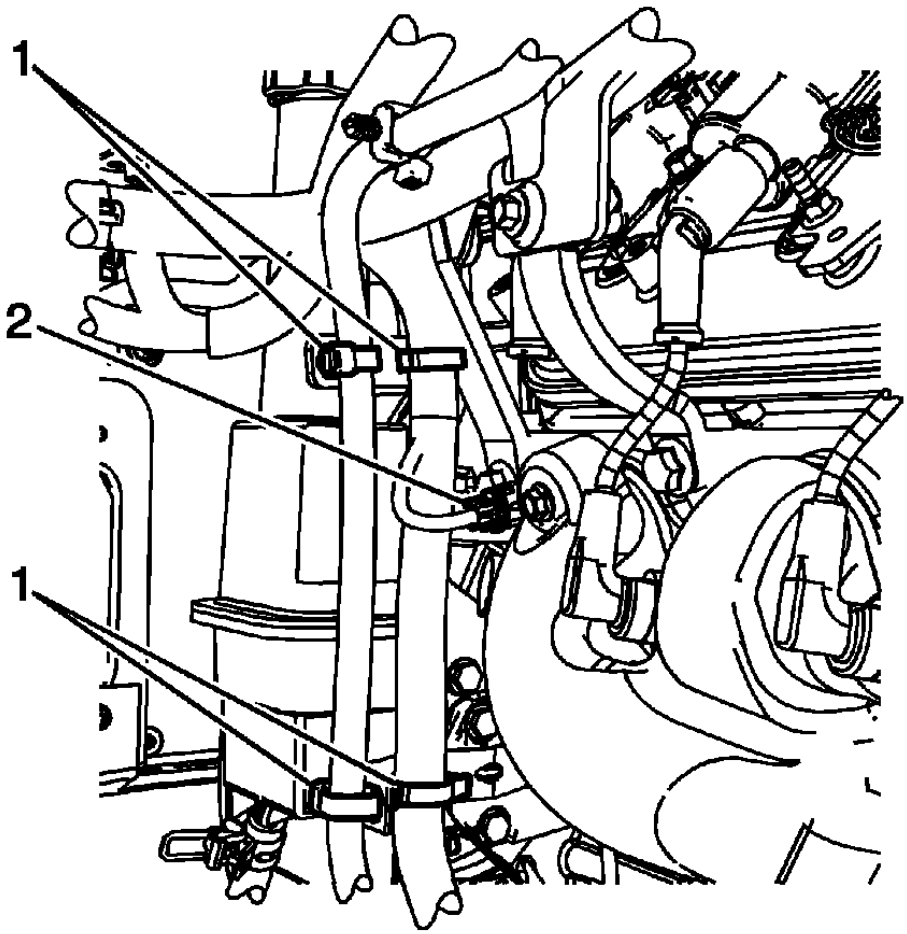

Fig. 88: Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

33. Untie the engine harness branches from the front of the engine compartment and position over the engine.
34. Connect the engine harness electrical connector (2) to the ECT sensor.
35. Position the engine harness clips (1) to the bracket.

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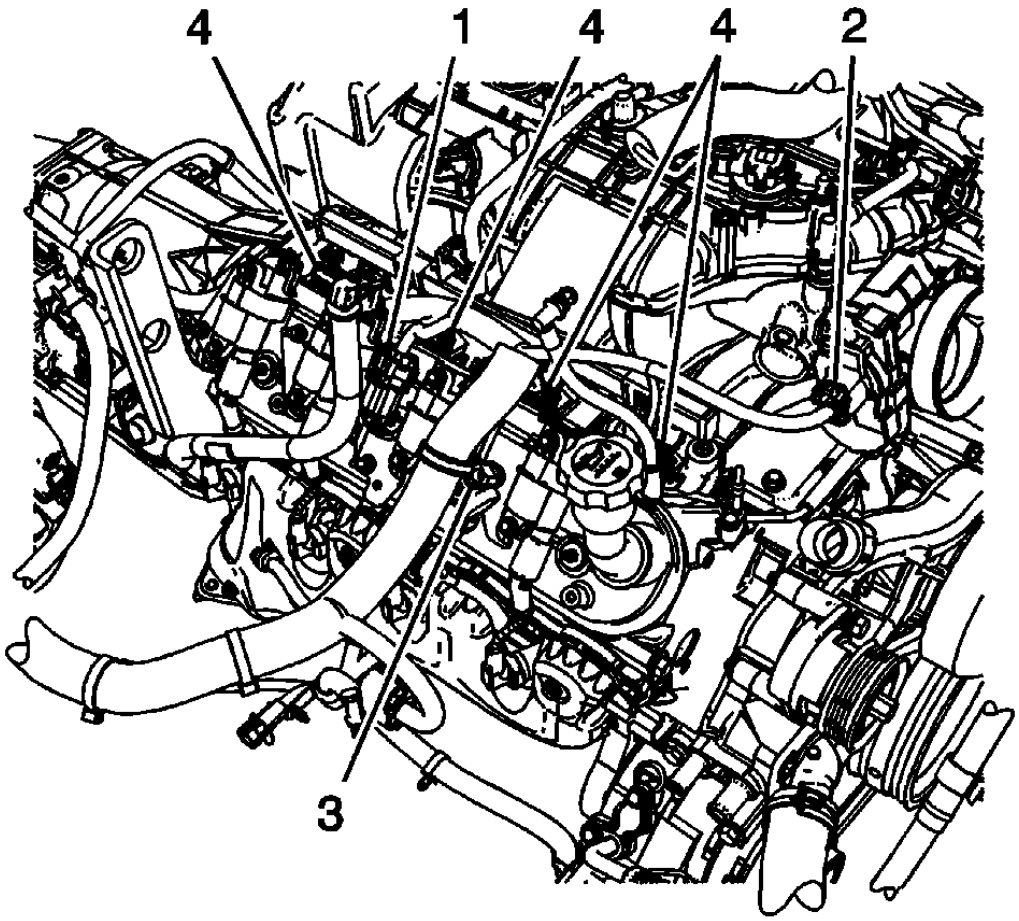

Fig. 89: Engine Harness Electrical Connector & Ignition Coil Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

36. Connect the engine harness electrical connectors (4) to the right side fuel injectors.
37. Install the engine harness clip (3) to the ignition coil bracket stud.
38. Connect the engine harness electrical connector (2) to the throttle actuator.
39. Connect the engine harness electrical connector (1) to the ignition coil harness electrical connector.

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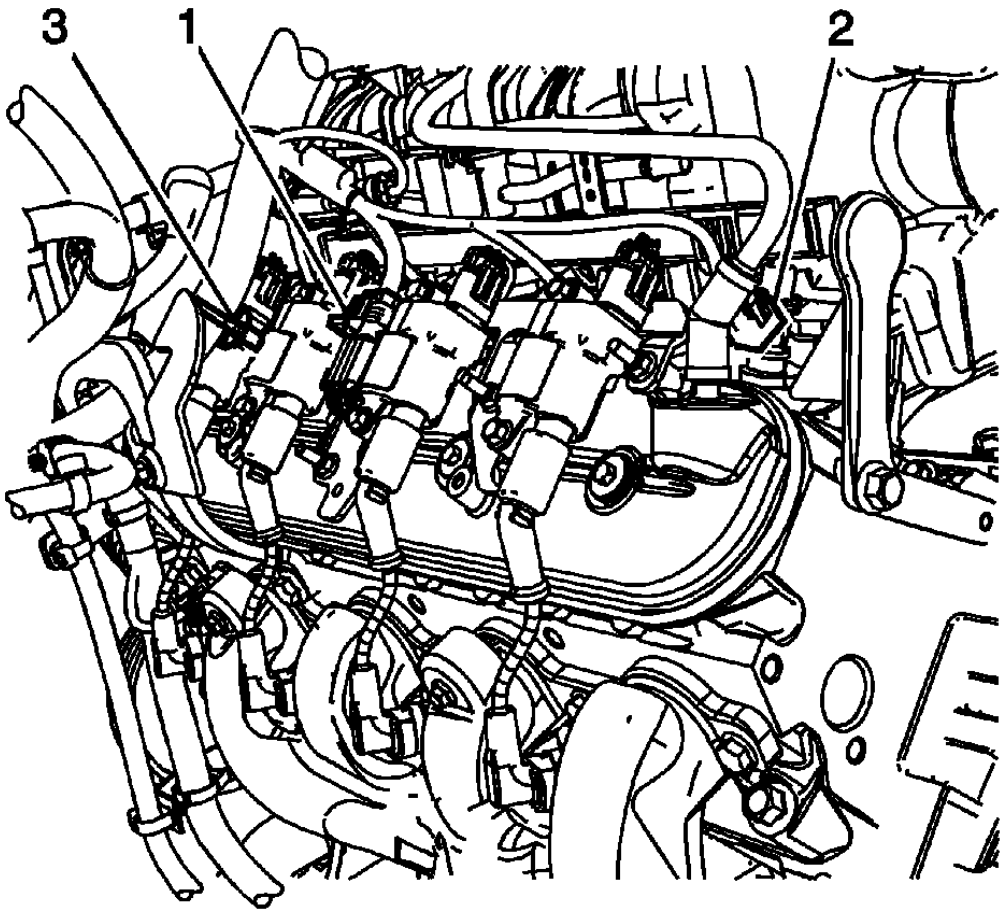

Fig. 90: Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

40. Install the engine harness clip (3) to the ignition coil bracket stud.
41. Connect the engine harness electrical connectors (2) to the left side fuel injectors.
42. Connect the engine harness electrical connector (1) to the ignition coil harness electrical connector.
43. Install the CPA retainer (1).

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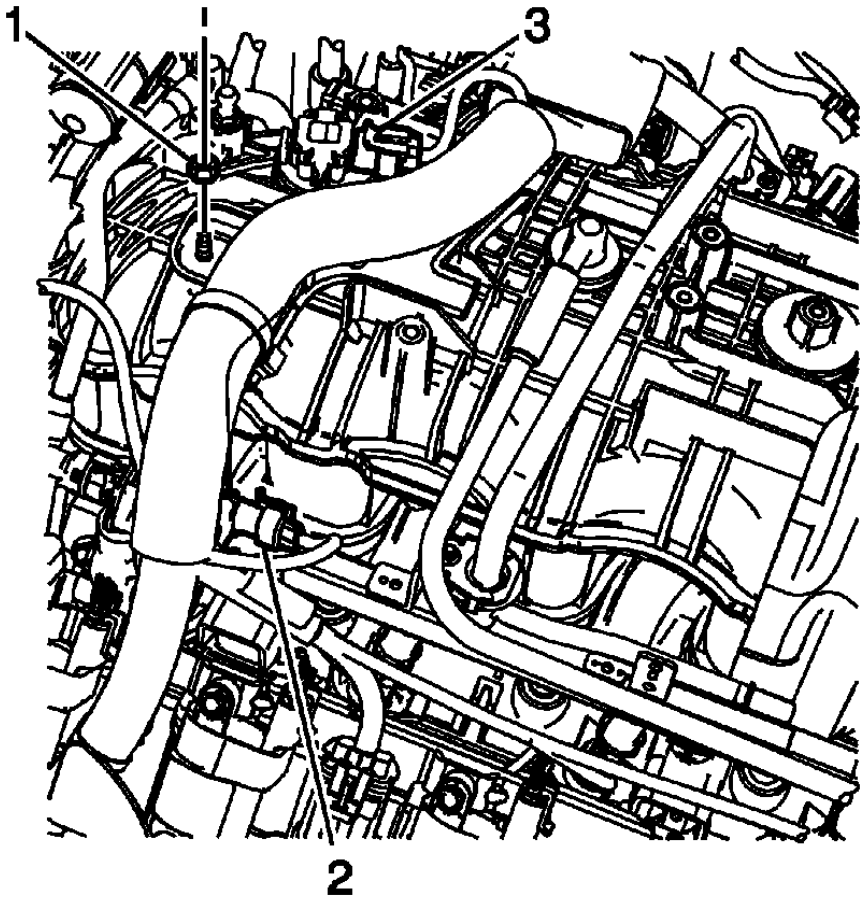

Fig. 91: PCV Hose/Tube
Courtesy of GENERAL MOTORS CORP.

44. Connect the engine wiring harness electrical connector (3) to the MAP sensor.
45. Connect the engine harness electrical connector (2) to the EVAP canister purge solenoid.
46. Install the engine harness retainer to the stud and locator pin.
47. Install the engine harness retainer nut (1).

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

48. Install the generator. Refer to **Generator Replacement** .
49. Install the air cleaner outlet duct. Refer to **Air Cleaner Resonator Outlet Duct Replacement** .

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

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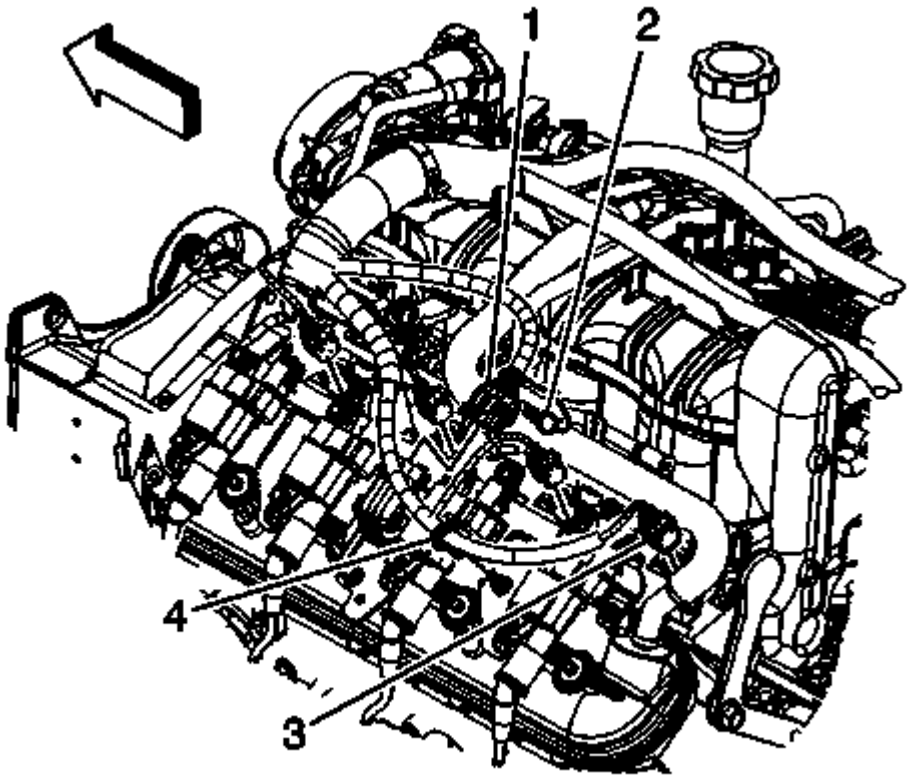

Fig. 92: View Of CPA Retainer, Electrical Connectors & Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. Remove the connector position assurance (CPA) retainer (2).
3. Disconnect the engine harness electrical connector (1) from the ignition coil wire harness.
4. Remove the engine harness clip (4) from the ignition coil bracket stud.
5. Reposition the engine harness, as necessary.

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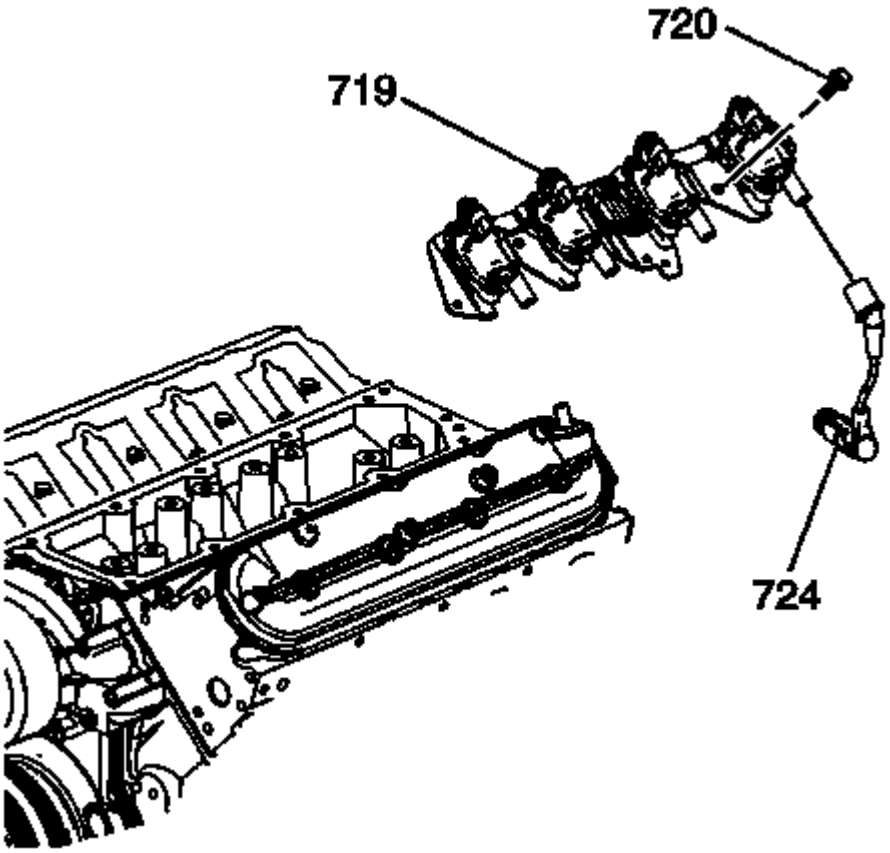

Fig. 93: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the spark plug wires (724) 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.
7. Remove the ignition coil bracket studs (720).
8. Remove the ignition coil bracket (719).

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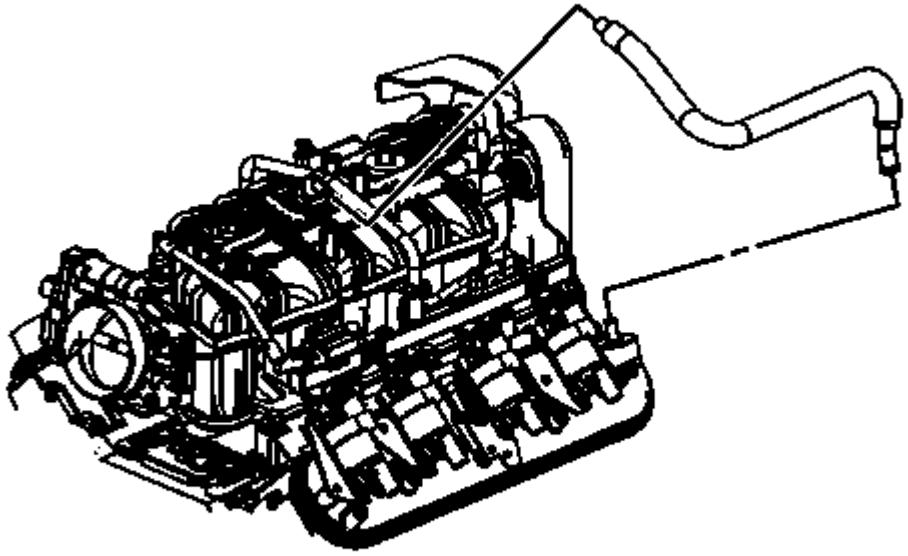

Fig. 94: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

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

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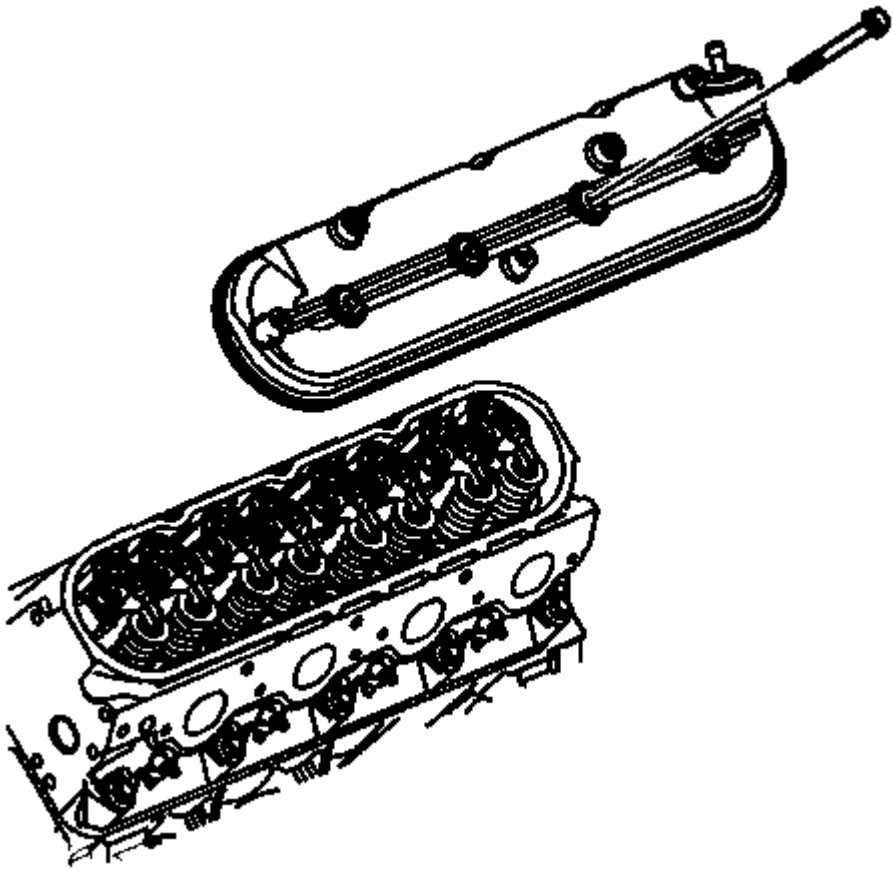

Fig. 95: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

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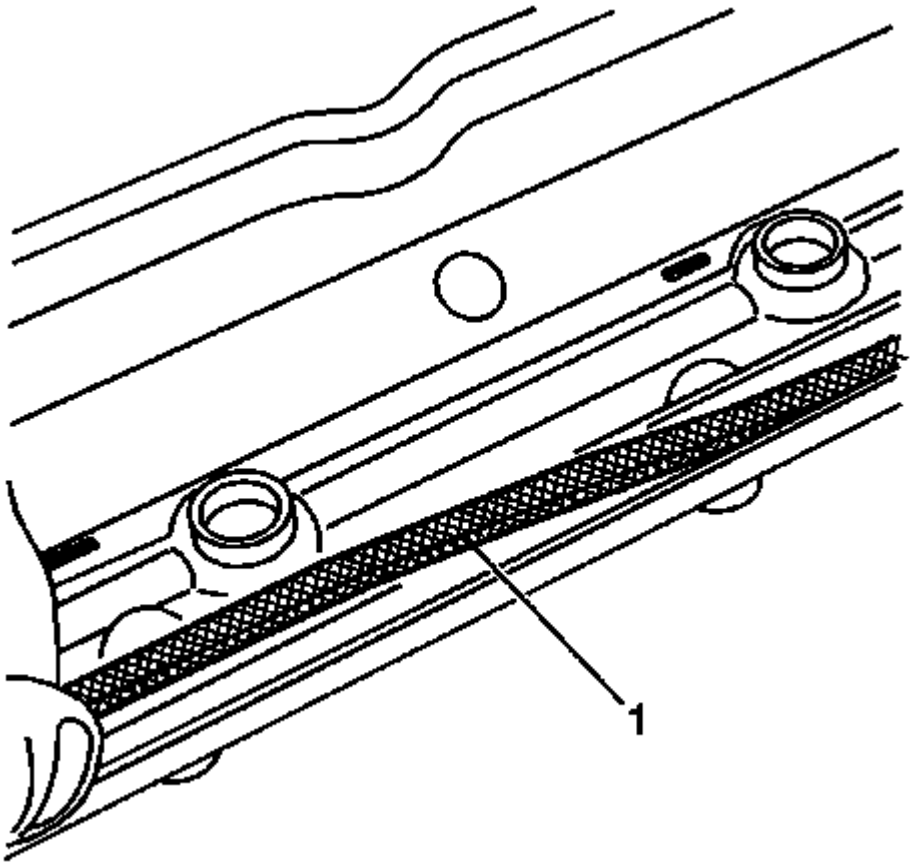

Fig. 96: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

12. Remove and discard the old gasket (1).

Installation Procedure

NOTE:

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

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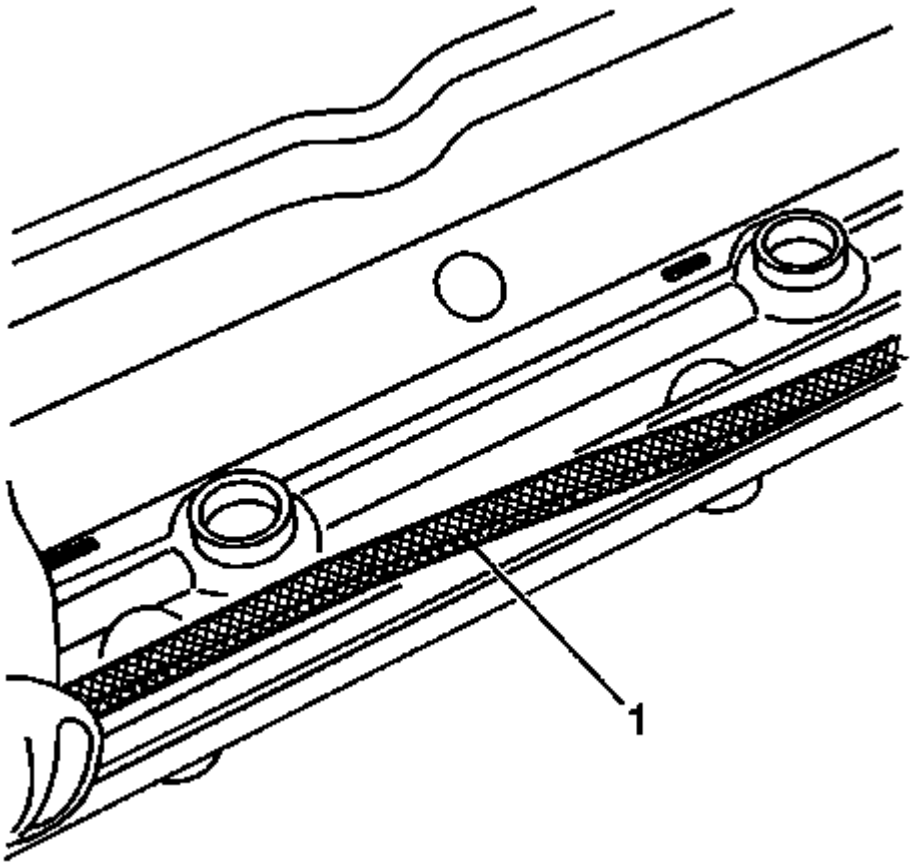

Fig. 97: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW rocker cover gasket (1).

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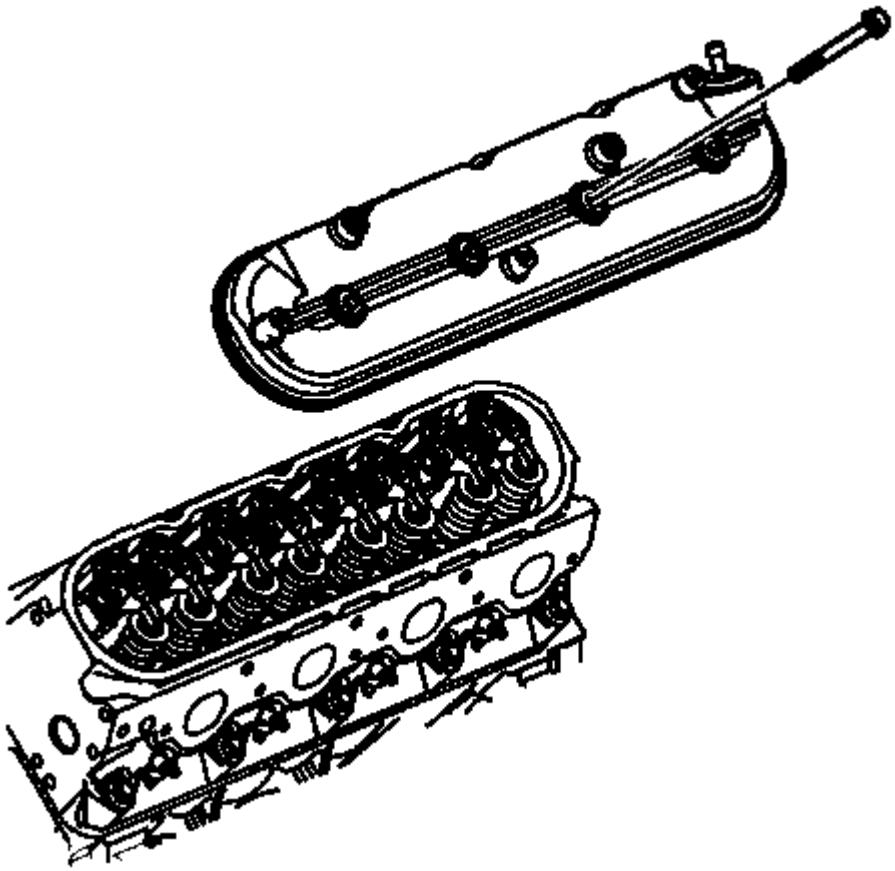

Fig. 98: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

2. Install the valve rocker arm cover.

CAUTION: Refer to Fastener Caution .

3. Tighten the rocker arm cover bolts.

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

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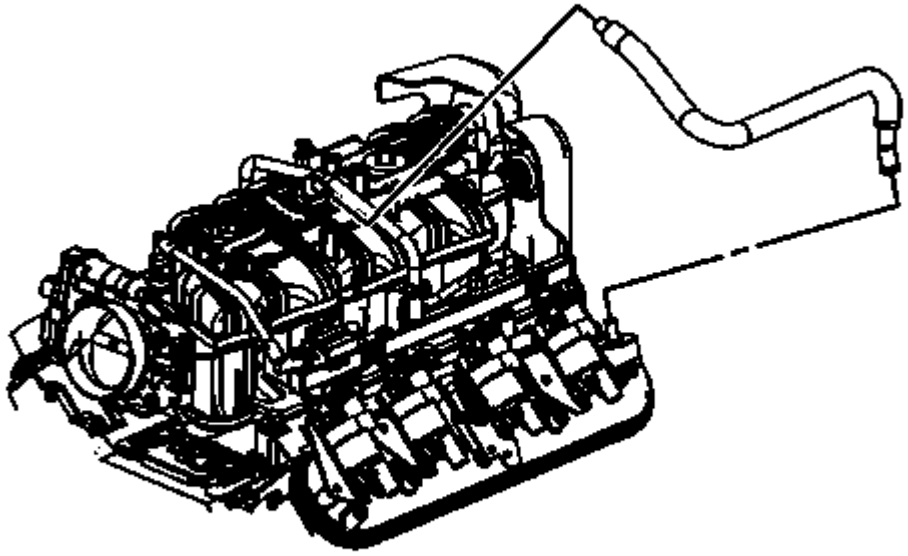

Fig. 99: View Of PCV Hose
Courtesy of GENERAL MOTORS CORP.

4. Install the PCV hose.

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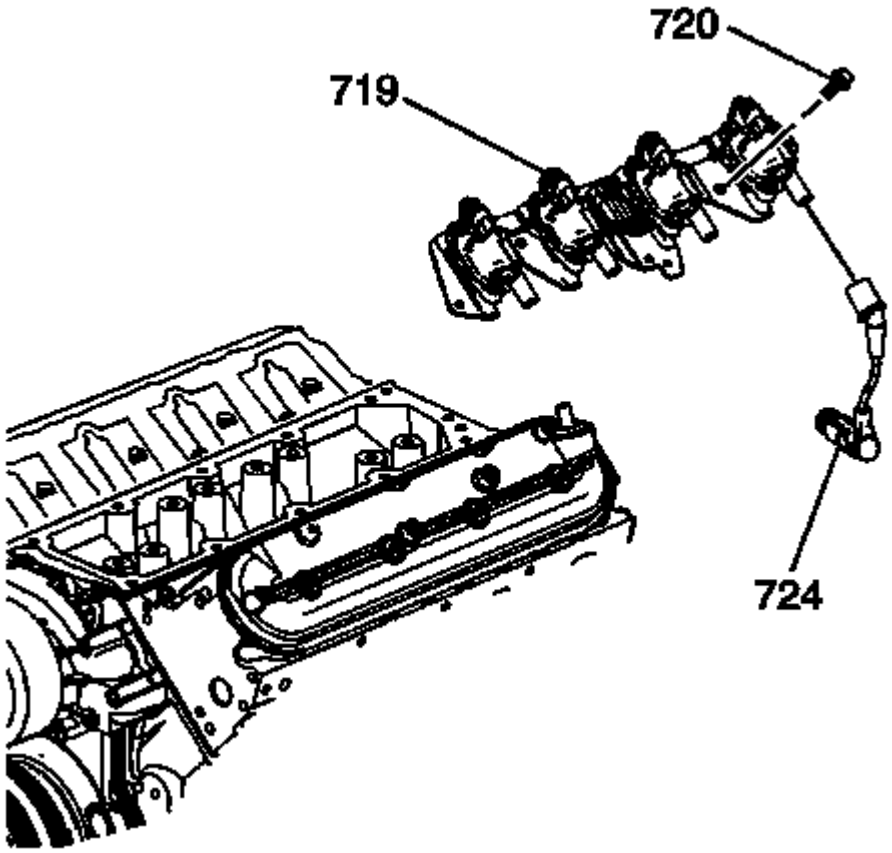

Fig. 100: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock to the threads of the ignition coil bracket studs. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
6. Position the ignition coil bracket (719) onto the rocker cover.
7. Install the ignition coil bracket studs (720).

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

8. Install the spark plug wires (724) to the ignition coils.

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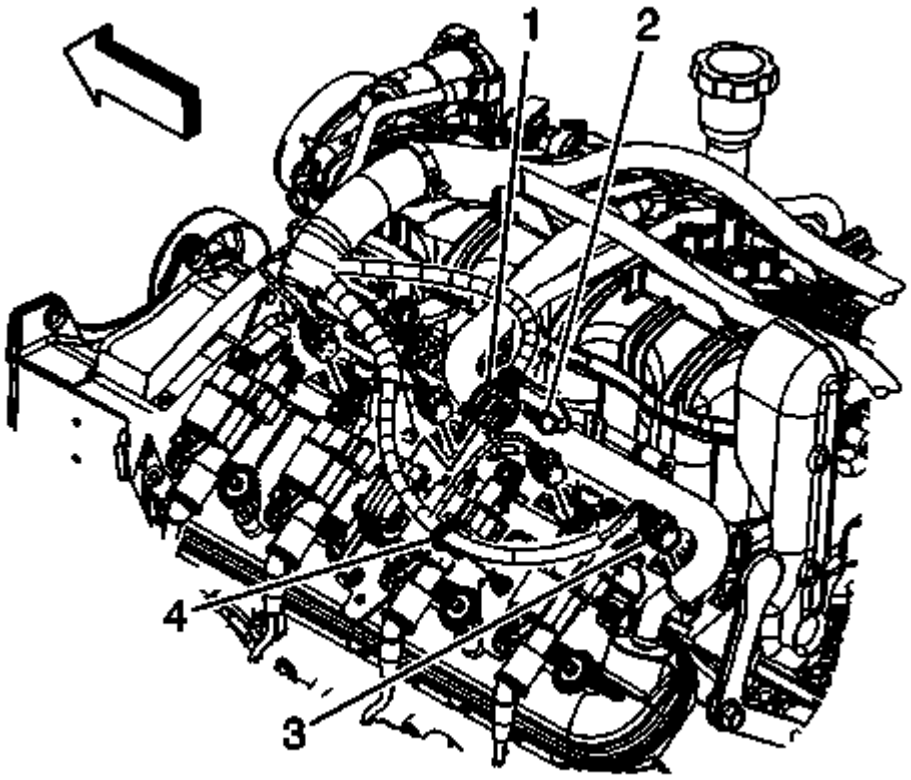

Fig. 101: View Of CPA Retainer, Electrical Connectors & Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

9. Position the engine harness, as necessary.
10. Install the engine harness clip (4) to the ignition coil bracket stud.
11. Connect the engine harness electrical connector (1) to the ignition coil wire harness.
12. Install the CPA retainer (2).
13. Install the intake manifold cover. Refer to **Upper Intake Manifold Sight Shield Replacement**.

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

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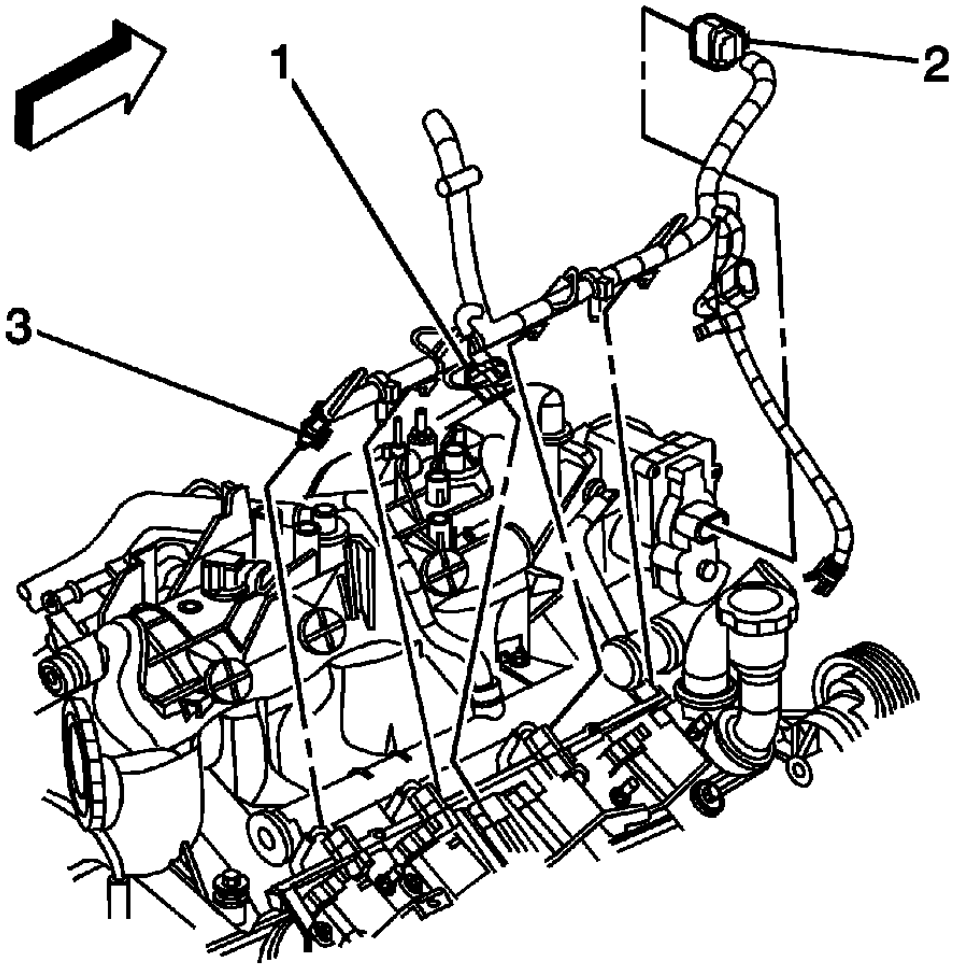

Fig. 102: Locating Electrical Components At Top Of Engine
Courtesy of GENERAL MOTORS CORP.

1. Remove the upper intake manifold sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.
2. Remove the connector position assurance (CPA) lock.
3. Disconnect the main electrical connector (1) to the ignition coil wire harness.
4. Remove the harness clips.
5. Reposition the engine harness, if necessary.
6. Remove the spark plug wires from the ignition coils.
    - Twist each plug wire 1/2 turn.
    - Pull only on the boot in order to remove the wire from the ignition coil.

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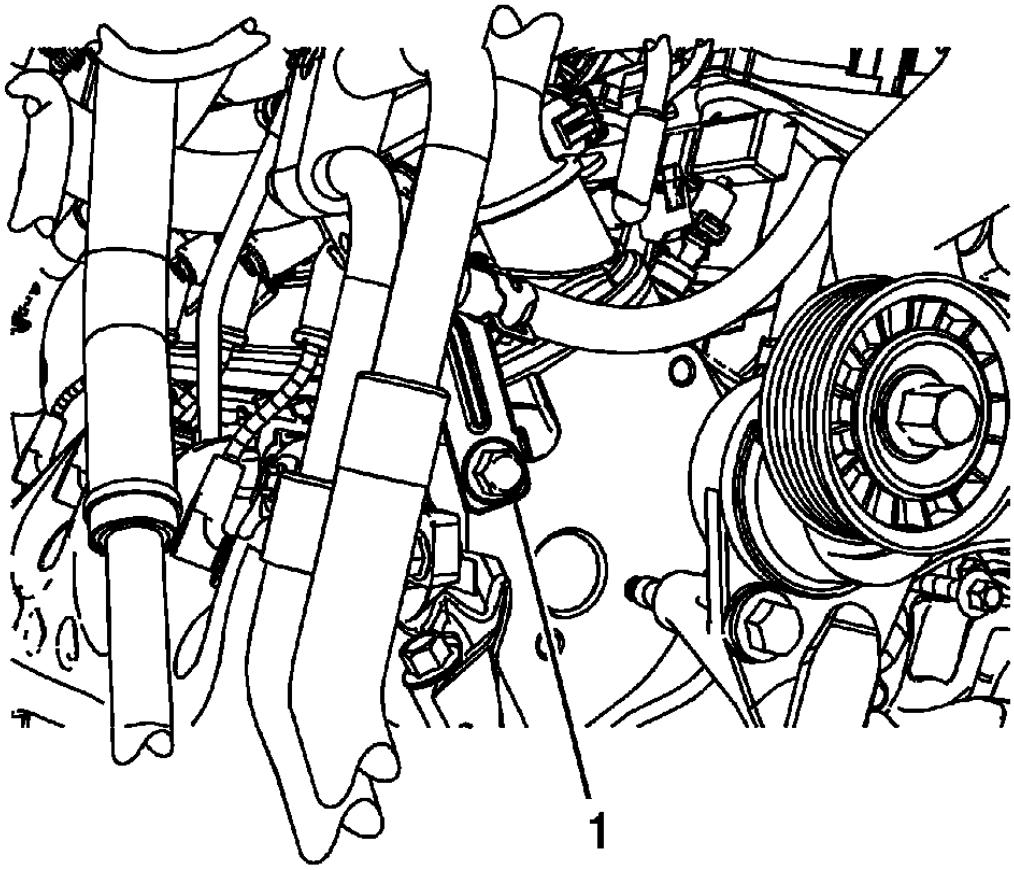

Fig. 103: Heater Hose Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the heater hose bracket bolt (1) from the front of the right cylinder head.

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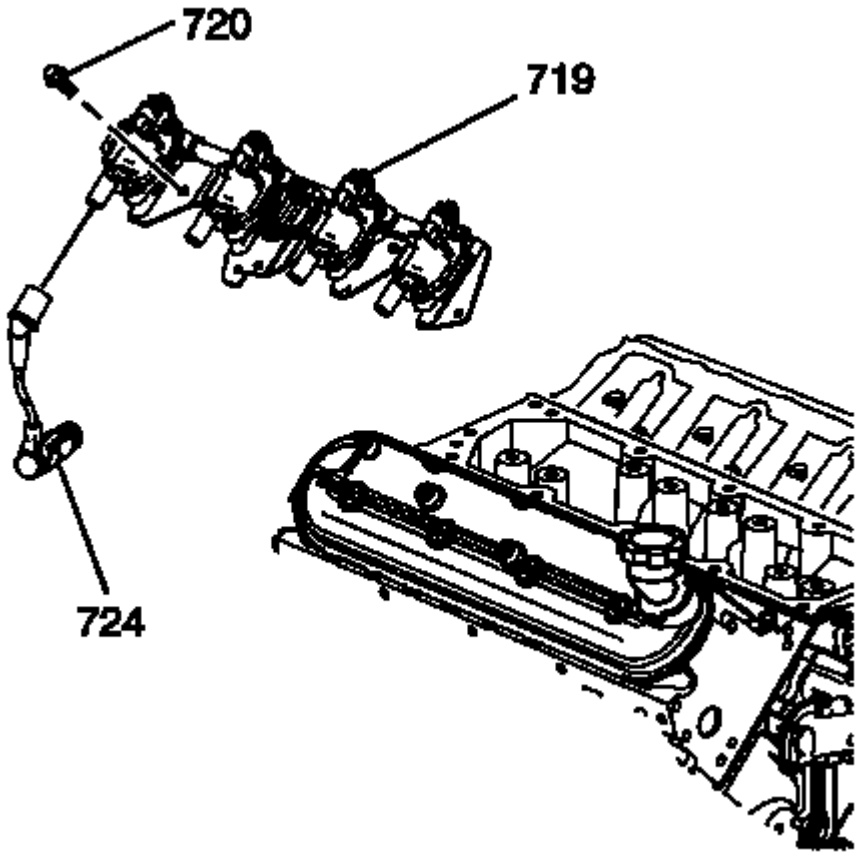

Fig. 104: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

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

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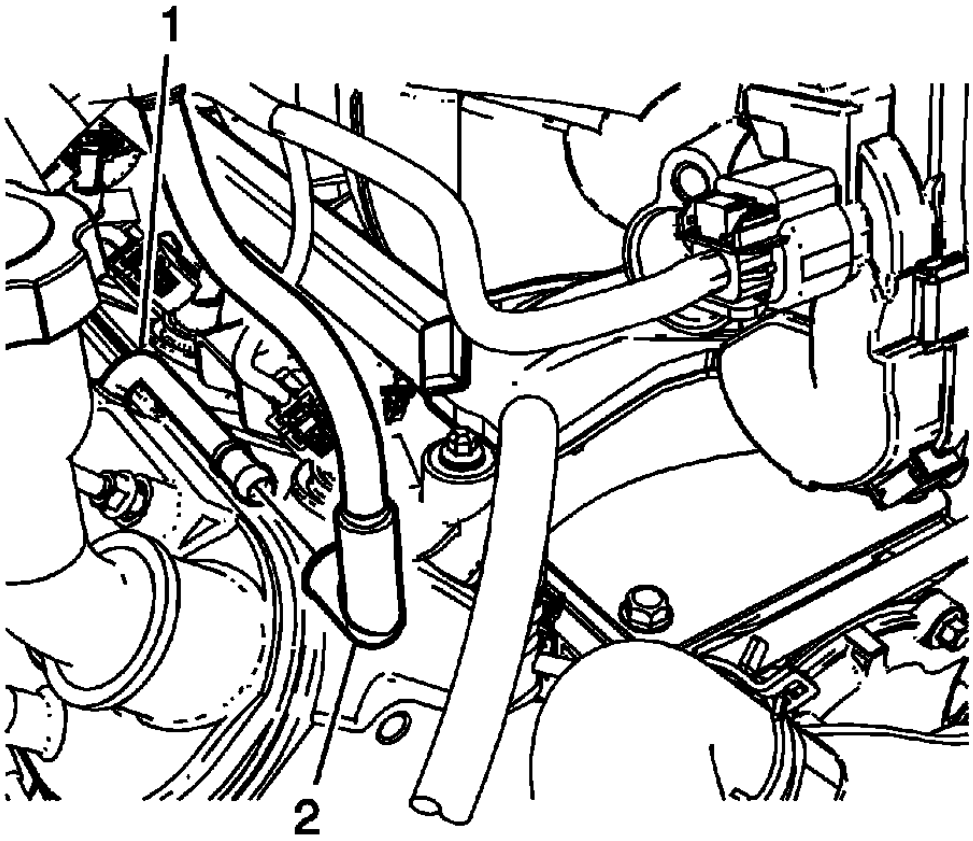

Fig. 105: Vent Hose & Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

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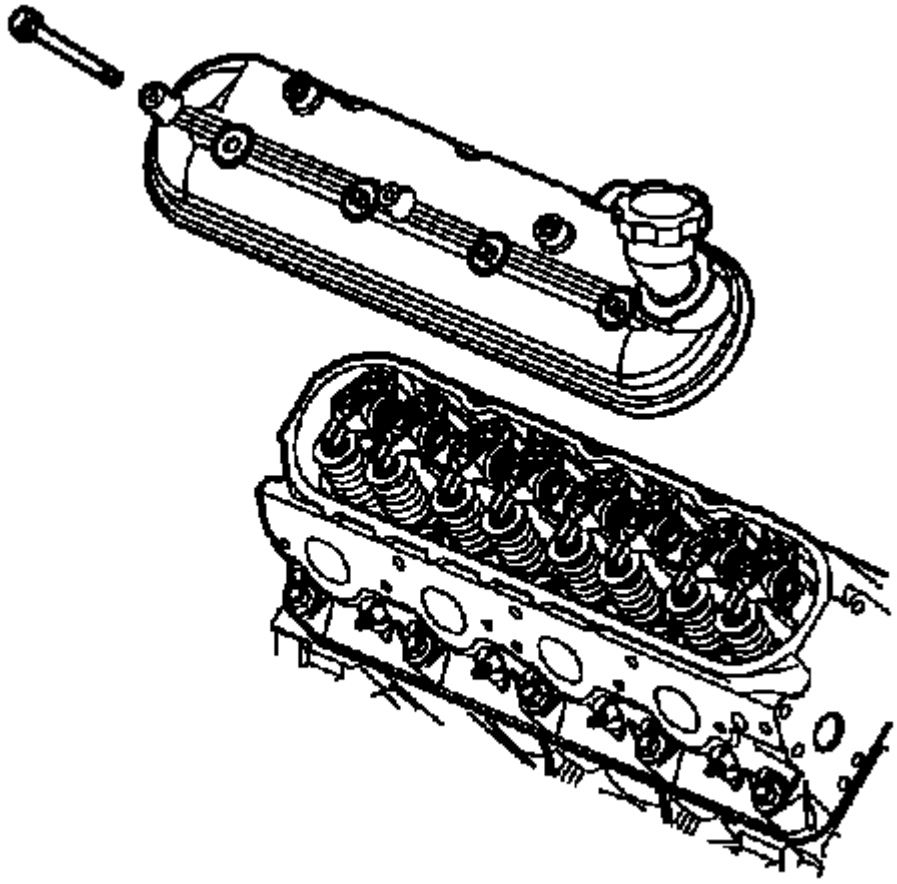

Fig. 106: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

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

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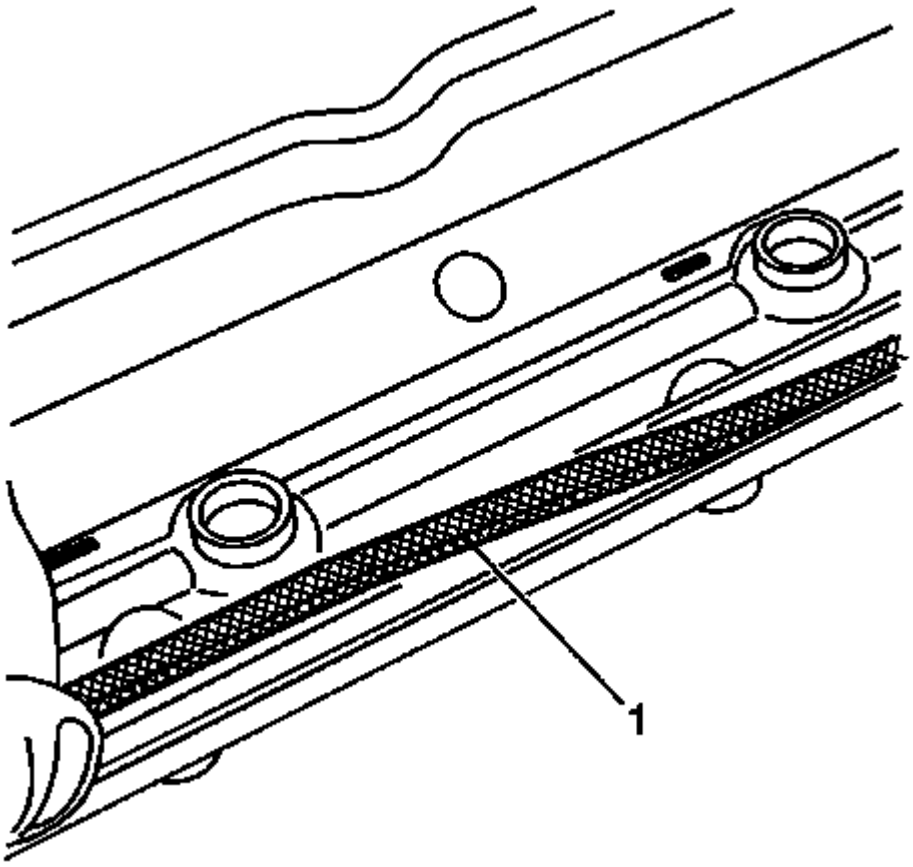

Fig. 107: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

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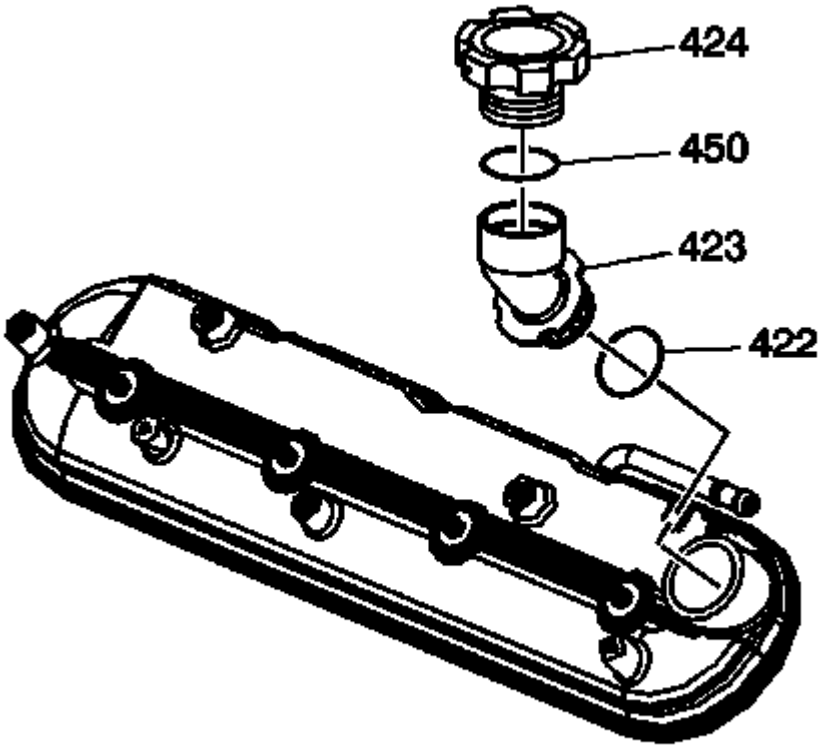

Fig. 108: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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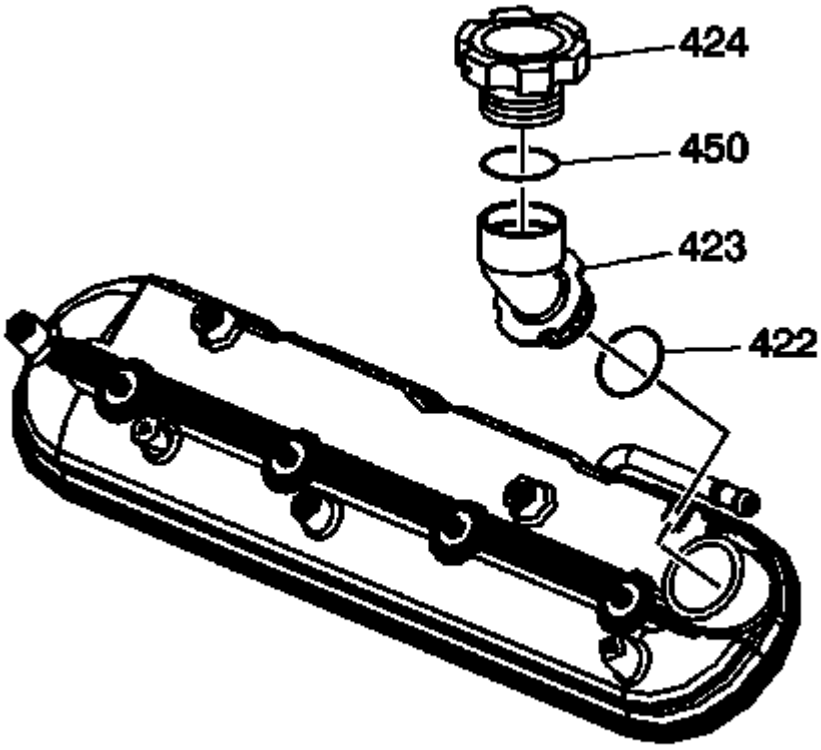

Fig. 109: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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.**

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.

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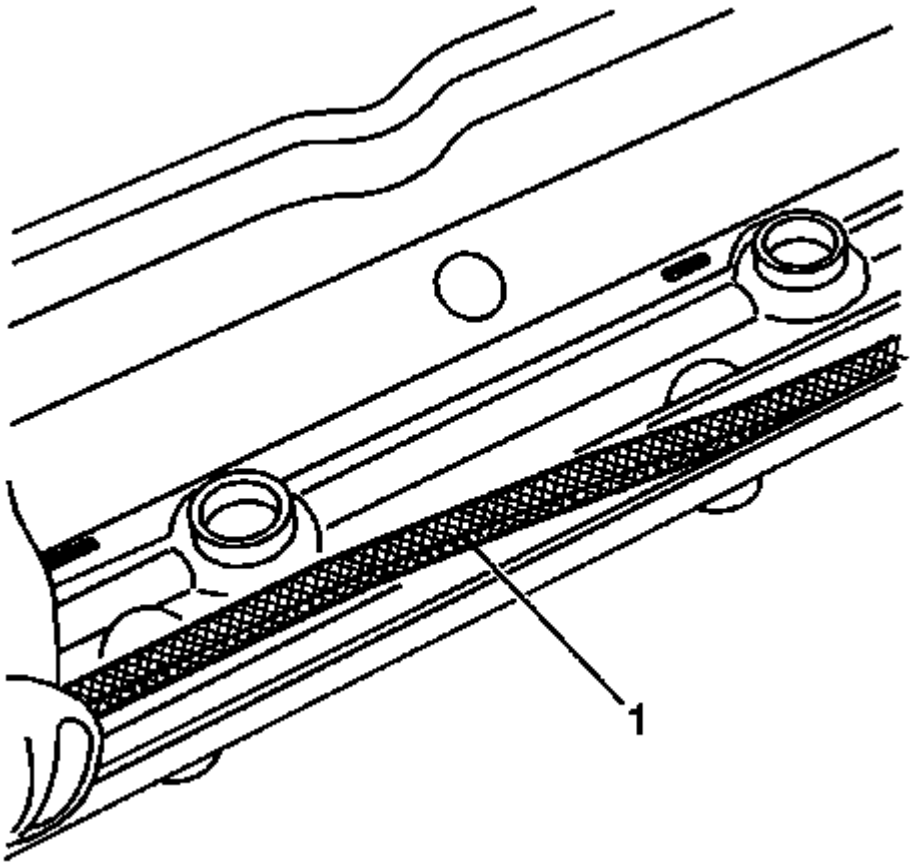

Fig. 110: Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

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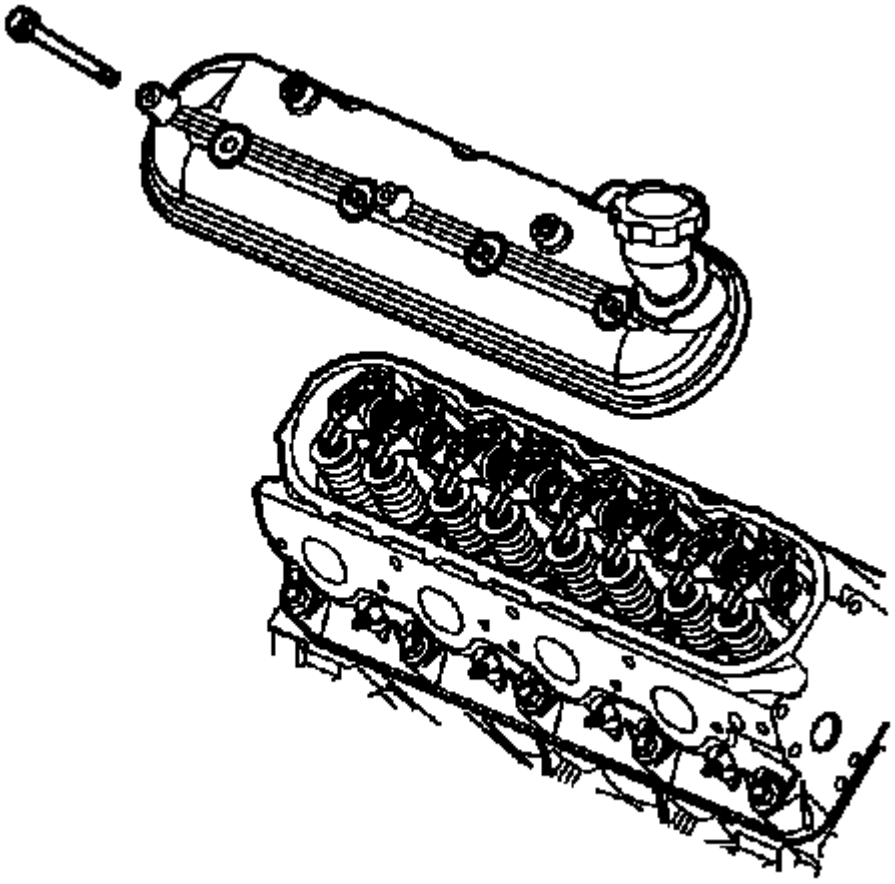

Fig. 111: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

7. Install the rocker arm cover bolts and grommets and tighten the bolts to 12 N.m (106 lb in).

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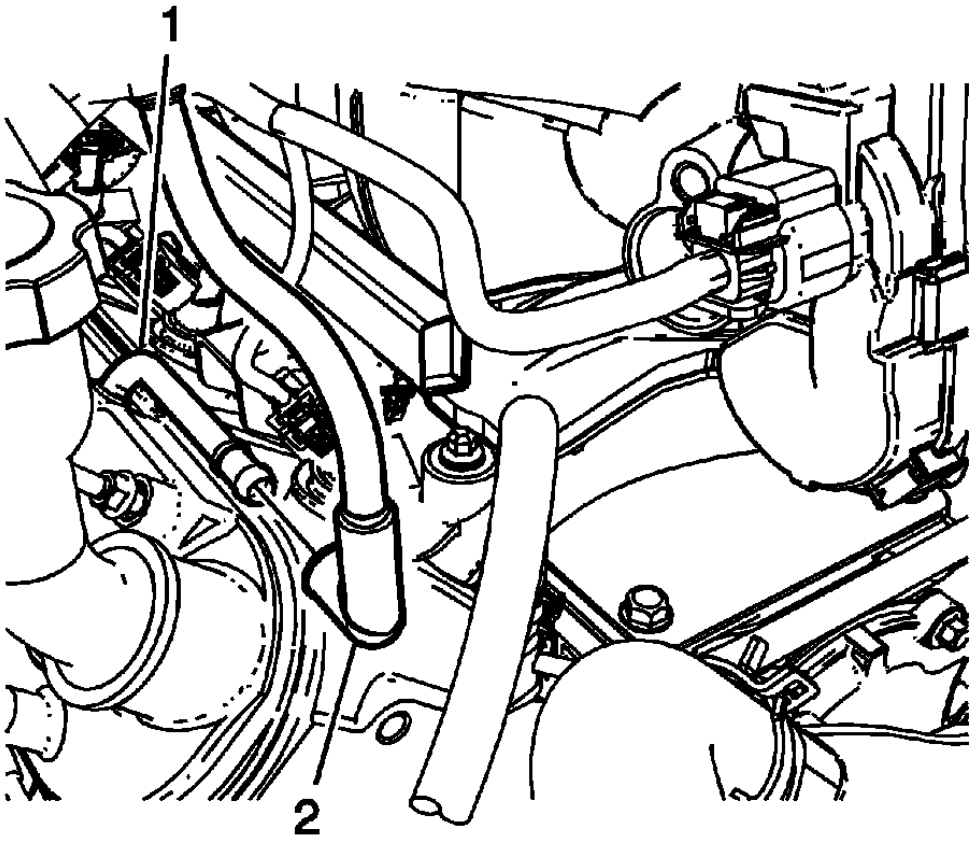

Fig. 112: Vent Hose & Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

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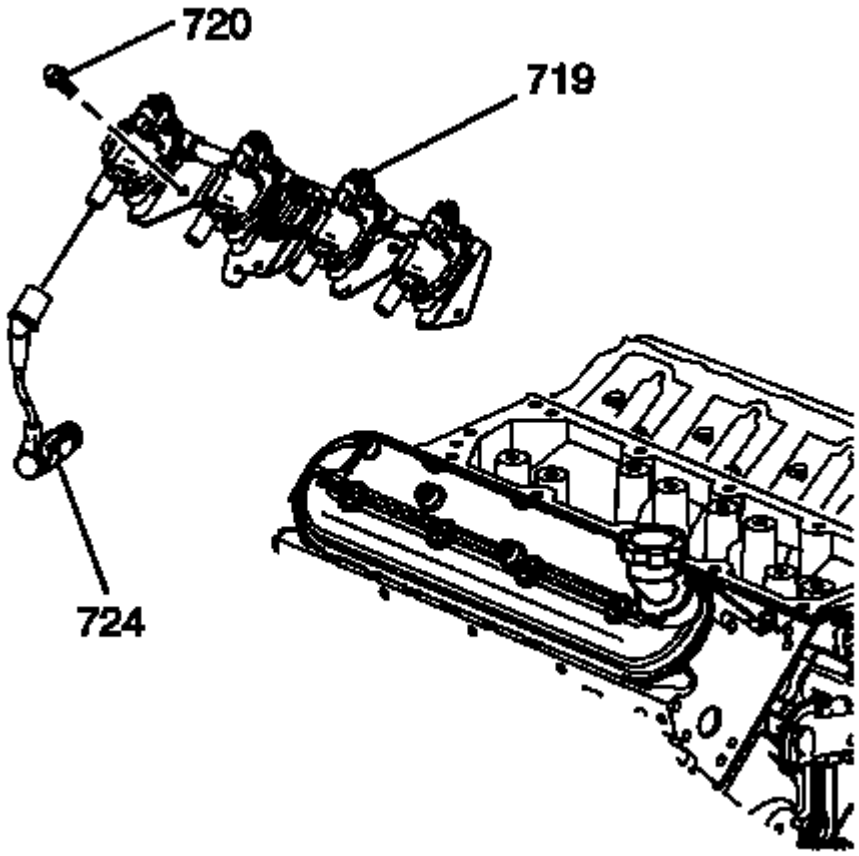

Fig. 113: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

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

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

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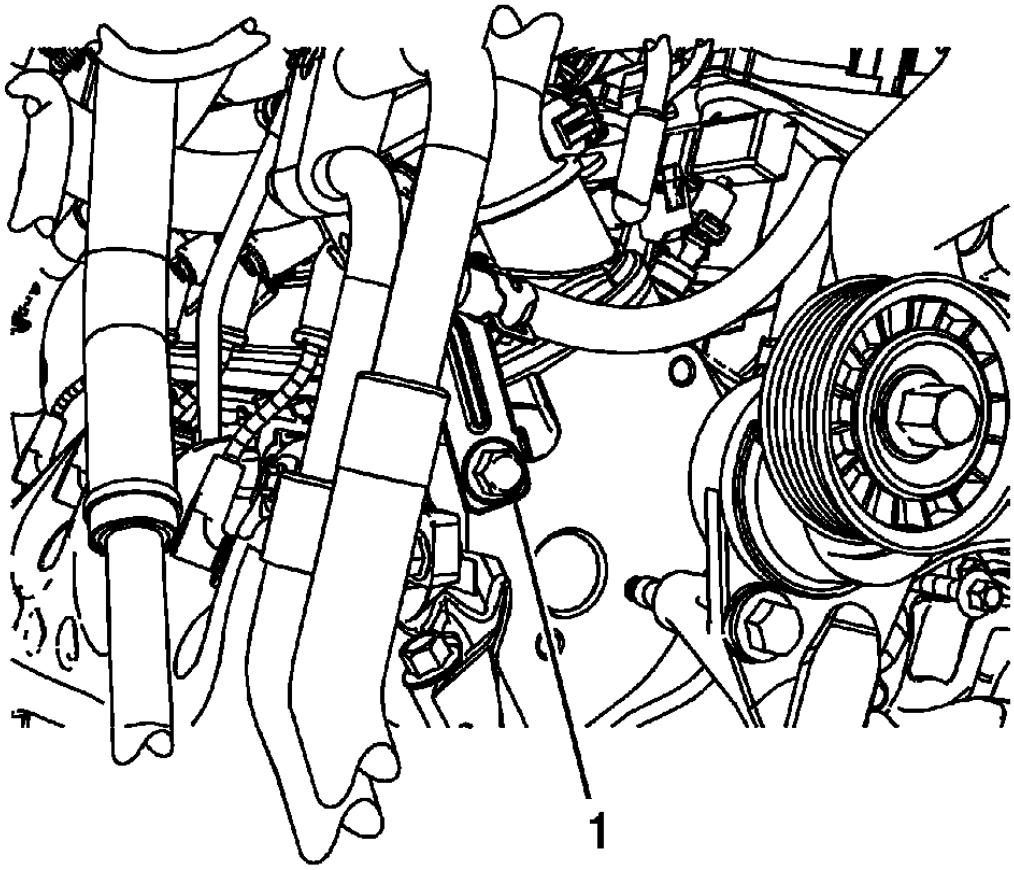

Fig. 114: Heater Hose Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

12. Install the heater hose bracket bolt (1) to the front of the right cylinder head.

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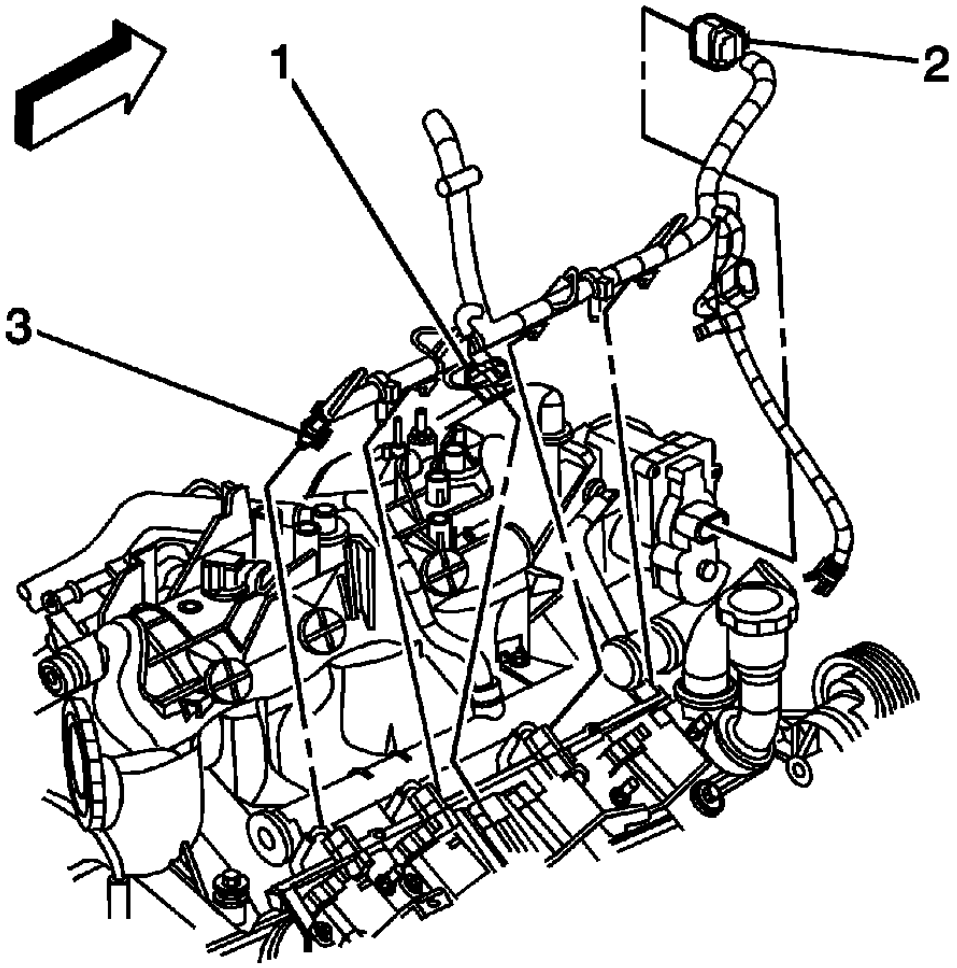

Fig. 115: Locating Electrical Components At Top Of Engine
Courtesy of GENERAL MOTORS CORP.

13. Install the spark plug wires to the ignition coils.
14. Position the engine harness, if necessary.
15. Install the harness clips.
16. Connect the main electrical connector (1) feeding the ignition coils.
17. Install the CPA lock.
18. Install the upper intake manifold sight shield. Refer to **Upper Intake Manifold Sight Shield Replacement**.

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

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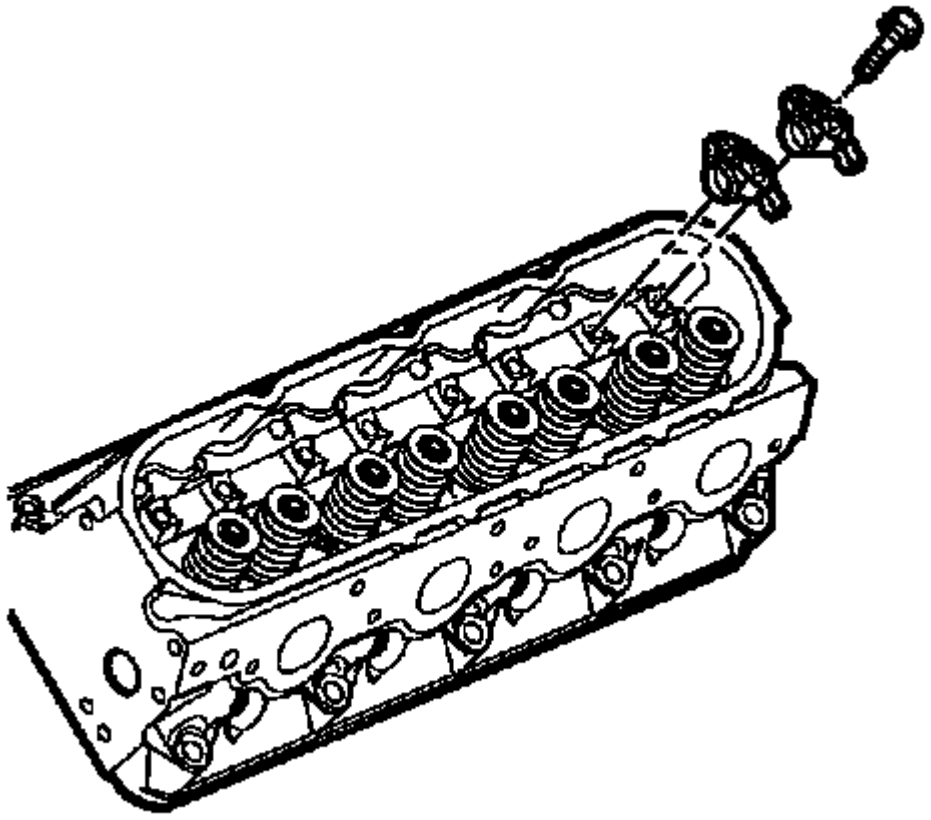

Fig. 116: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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

   NOTE: The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3. Cylinders 1, 3, 5 and 7 are the left bank.

2. Remove the number one cylinder spark plug. Refer to **Spark Plug Replacement** .

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

3. Remove the rocker arm bolts.
4. Remove the rocker arms.

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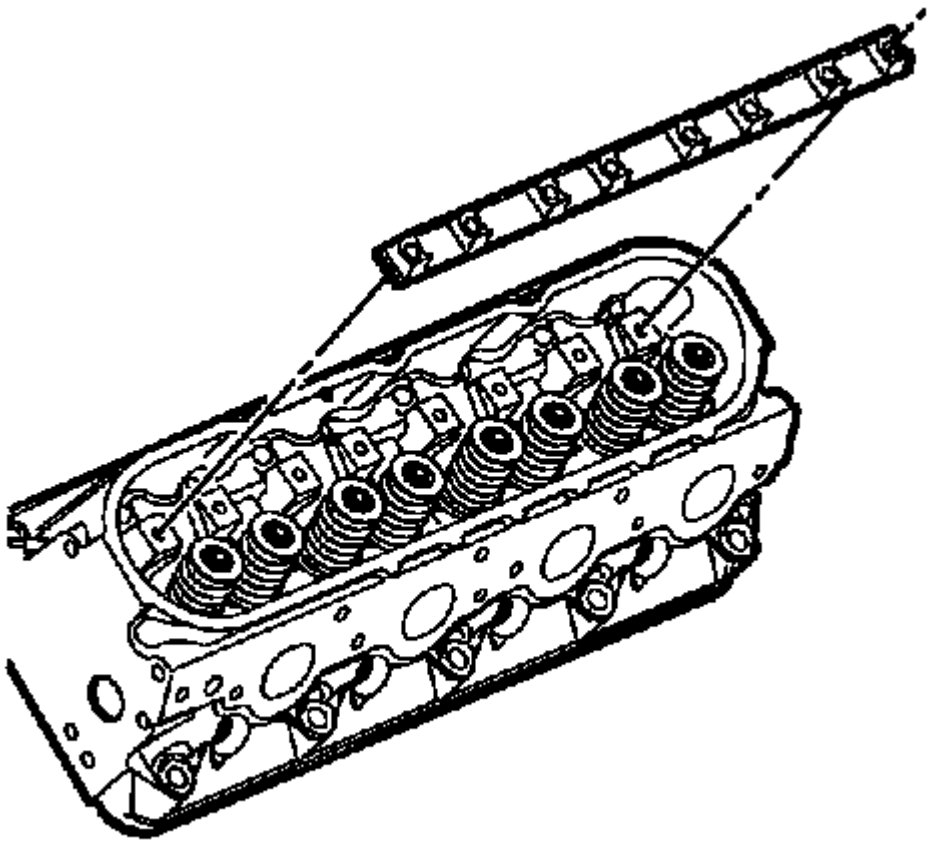

Fig. 117: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

5. Remove the rocker arm pivot support.

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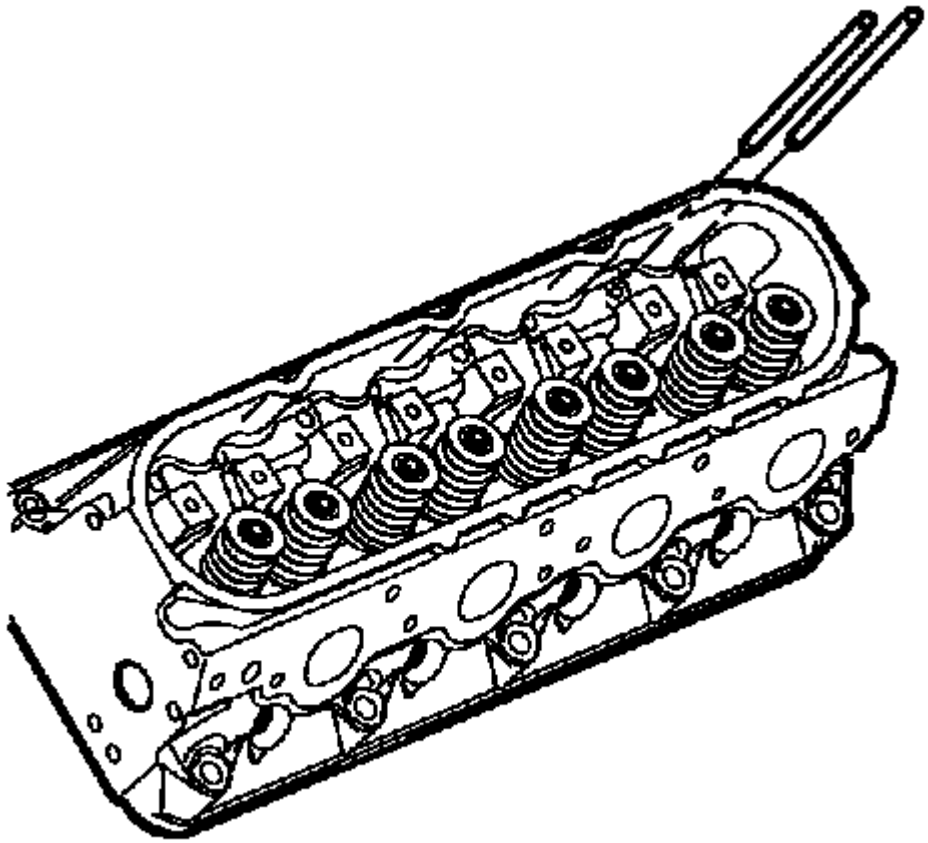

Fig. 118: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

6. Remove the pushrods.
7. Clean and inspect the rocker arms and pushrods, if required. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

NOTE: 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.

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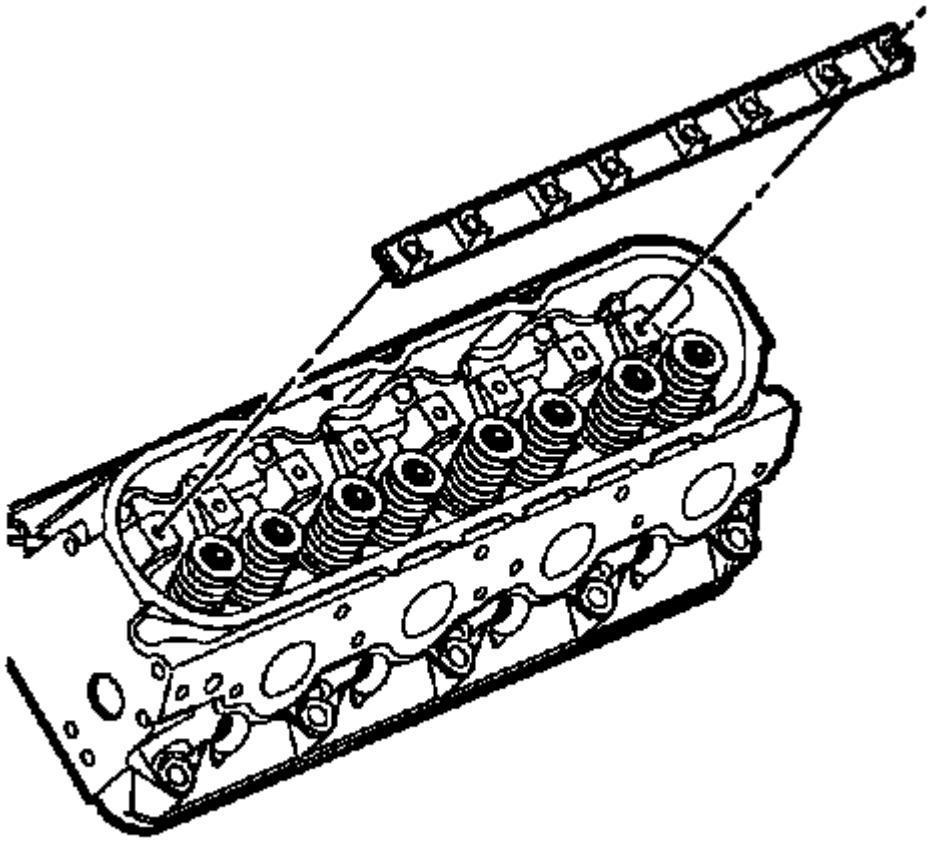

Fig. 119: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

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

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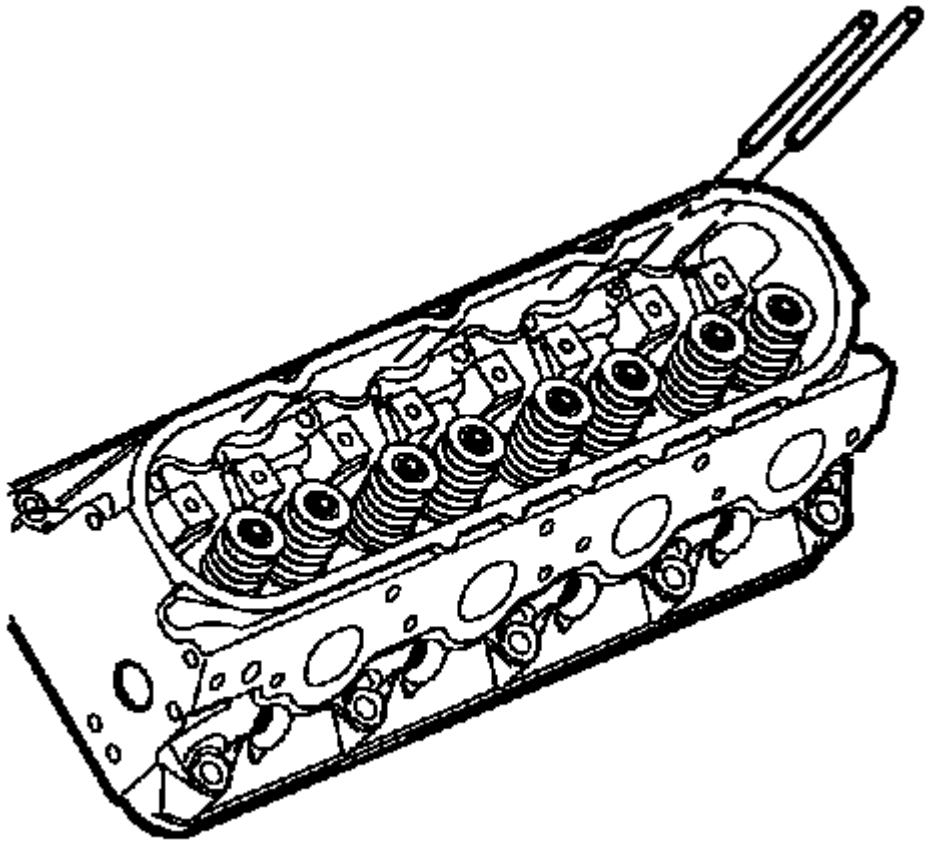

Fig. 120: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

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

4. Install the pushrods.

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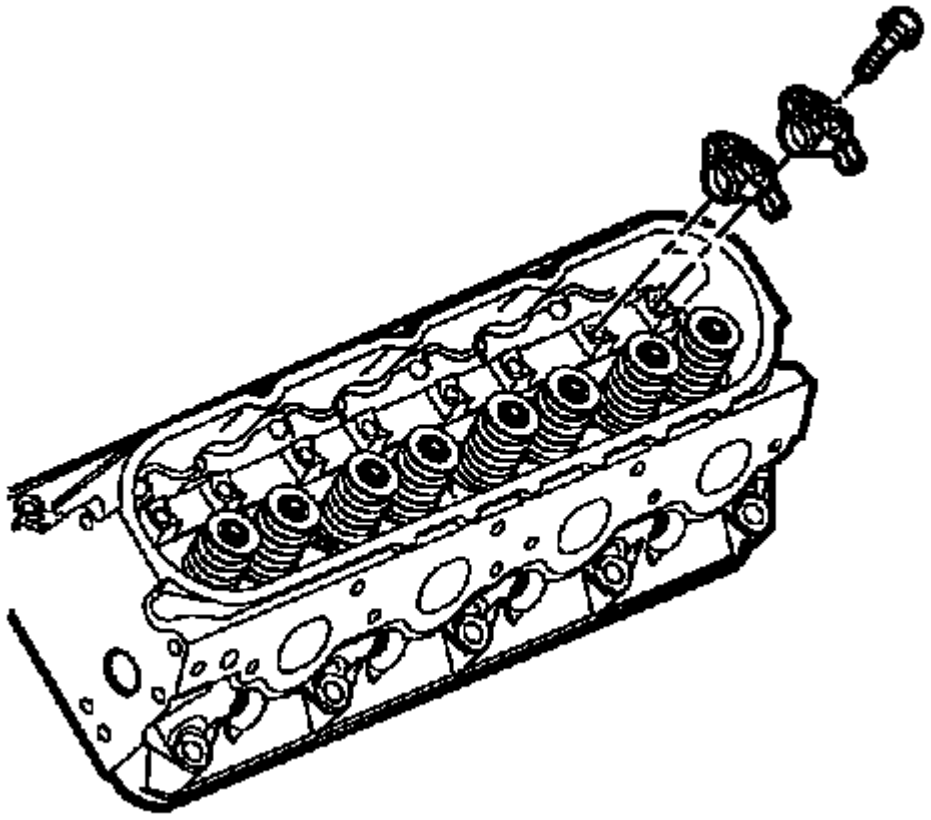

Fig. 121: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

NOTE: The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3. Cylinders 1, 3, 5 and 7 are the left bank. Cylinders 2, 4, 6 and 8 are the right bank.

6. Rotate the crankshaft until the number one piston is at top dead center (TDC) of the compression stroke. In this position, the number one cylinder rocker arms will be off lobe lift.

CAUTION: Refer to Fastener Caution .

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

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Tighten:

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

Tighten:

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

10. Install the number one cylinder spark plug. Refer to **Spark Plug Replacement** .
11. Install the 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

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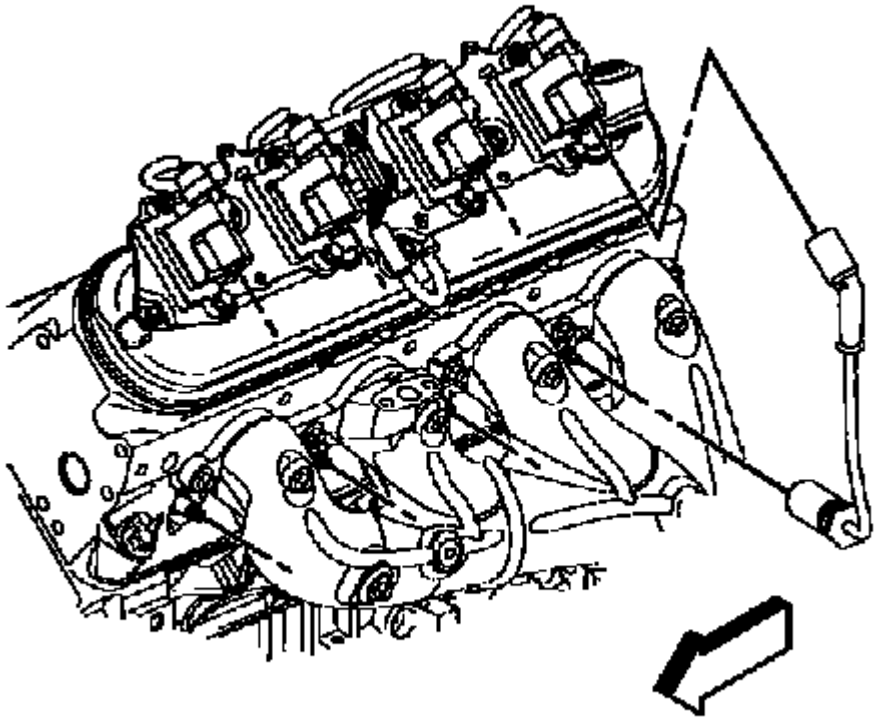

Fig. 122: View Of Spark Plug Wire & Boot
Courtesy of GENERAL MOTORS CORP.

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

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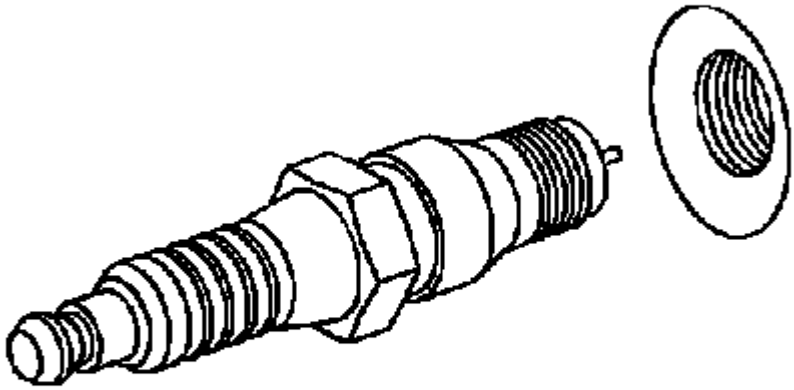

Fig. 123: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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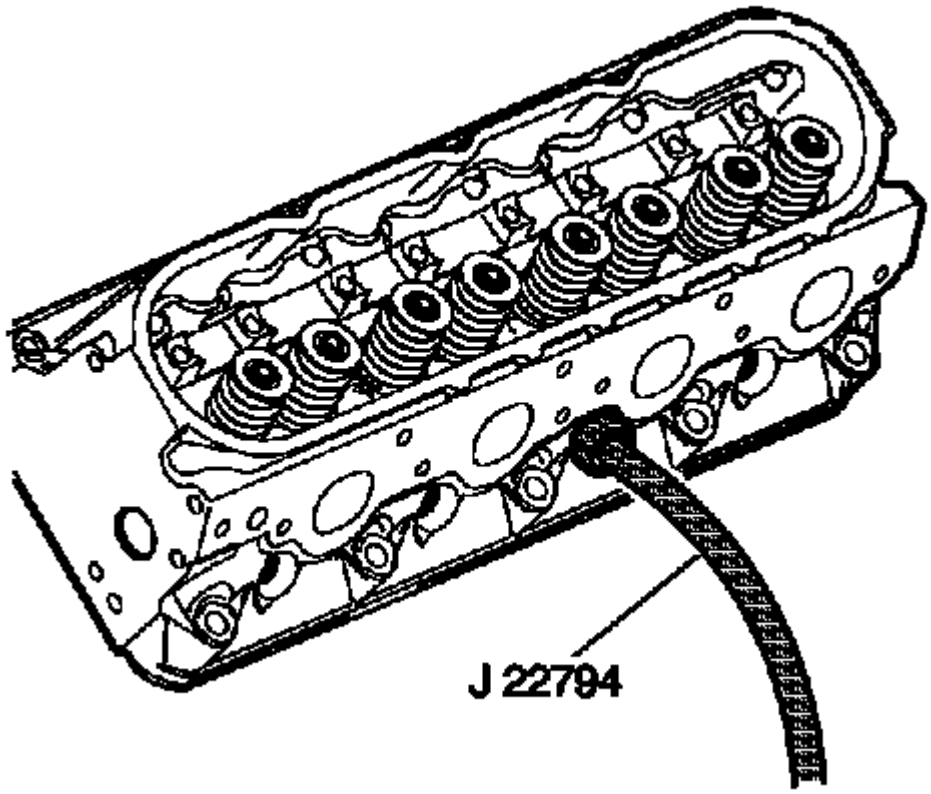

Fig. 124: Applying Compressed Air To J 22794
Courtesy of GENERAL MOTORS CORP.

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

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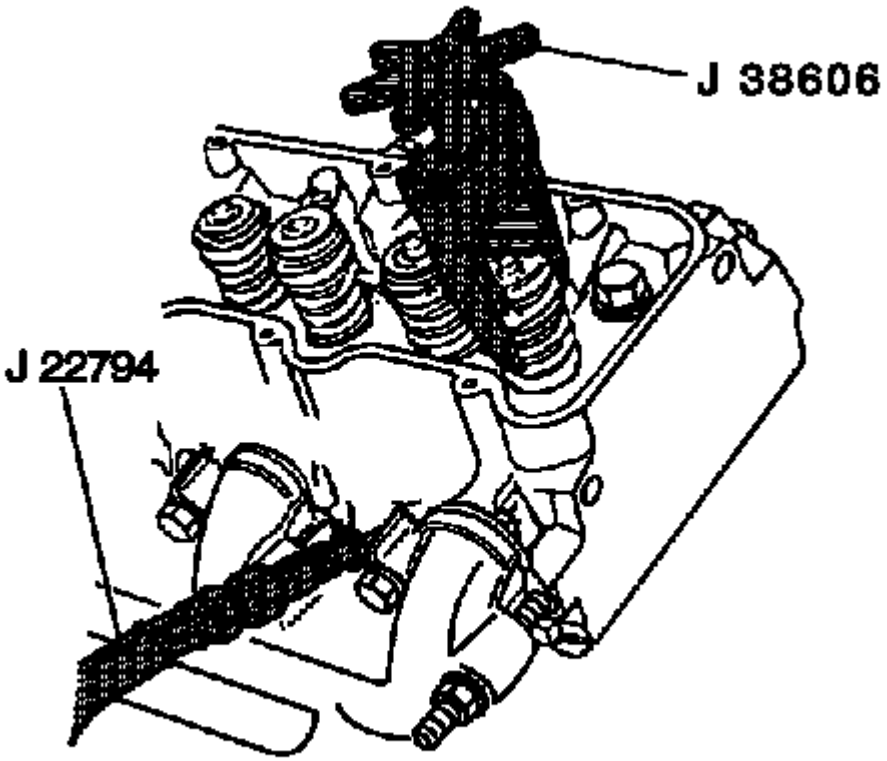

Fig. 125: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

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

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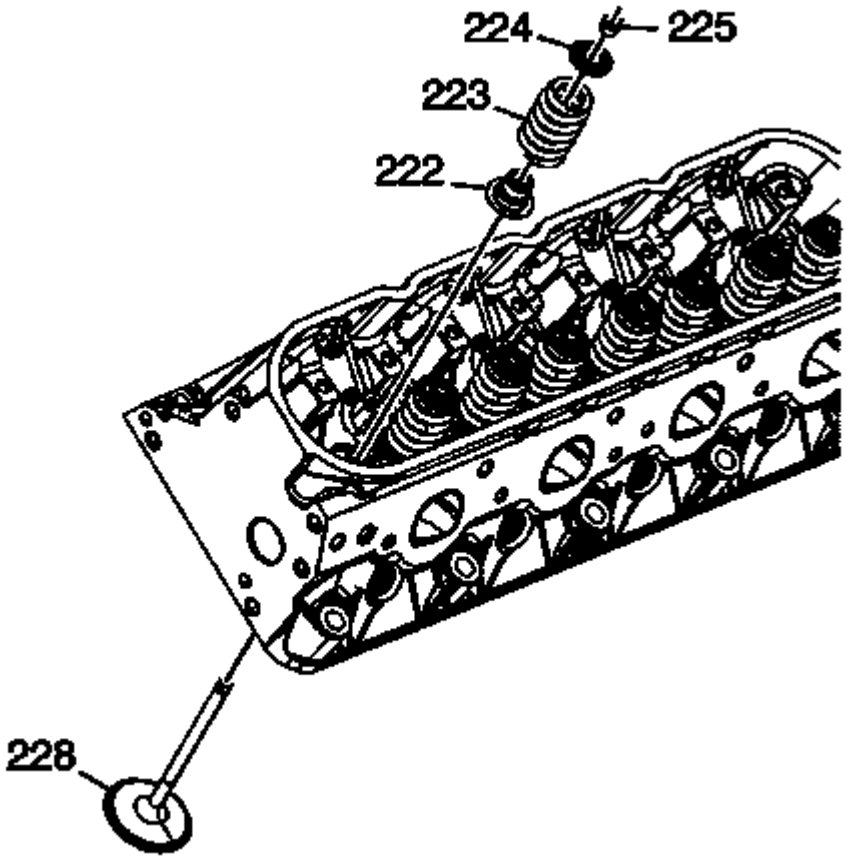

Fig. 126: Valve Stem Keys, Valve Spring Cap & Valve Spring
Courtesy of GENERAL MOTORS CORP.

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 (222).
16. Remove the valve (228).

Installation Procedure

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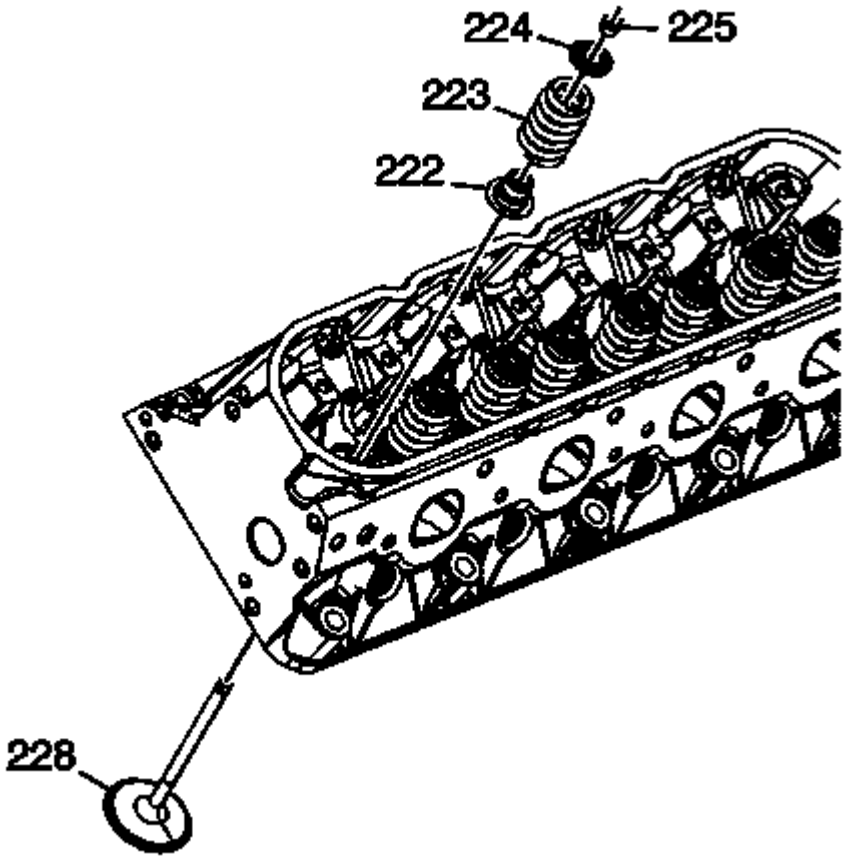

Fig. 127: Valve Stem Keys, Valve Spring Cap & Valve Spring
Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring seat area.
2. Lubricate the valve guide and valve stem oil seal with clean engine oil.
3. Install the valves (228) into the proper port.
4. Install the valve stem oil seal (222).
5. Install the valve spring (223).
6. Install the valve spring cap (224).

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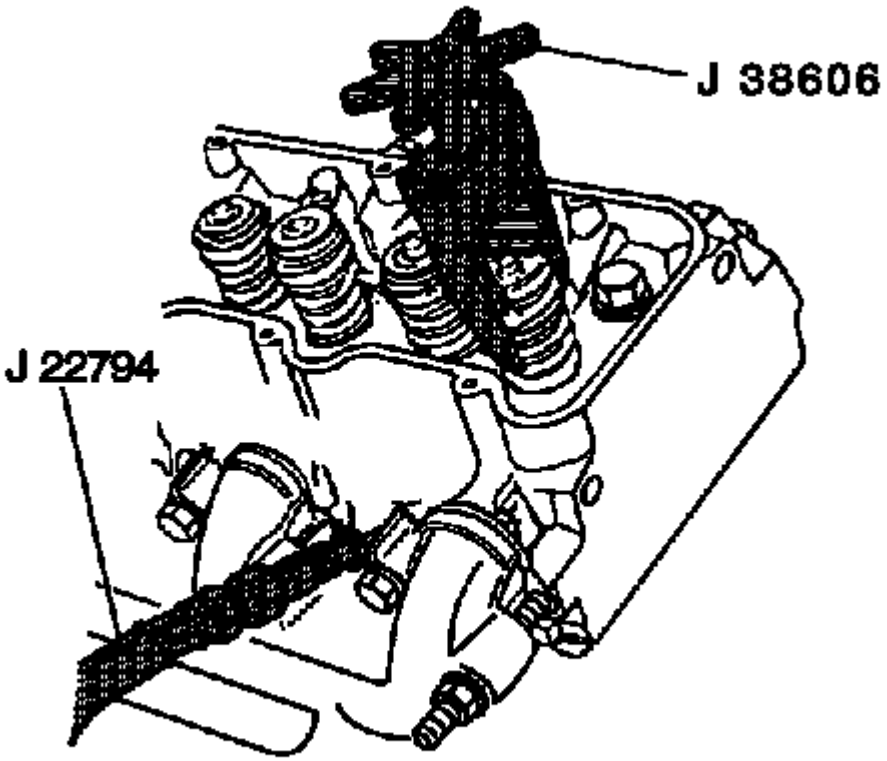

Fig. 128: Compress The Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS CORP.

7. Compress the valve spring using the **J 38606** . See **Special Tools**.
8. Install the valve keys.
    - 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.

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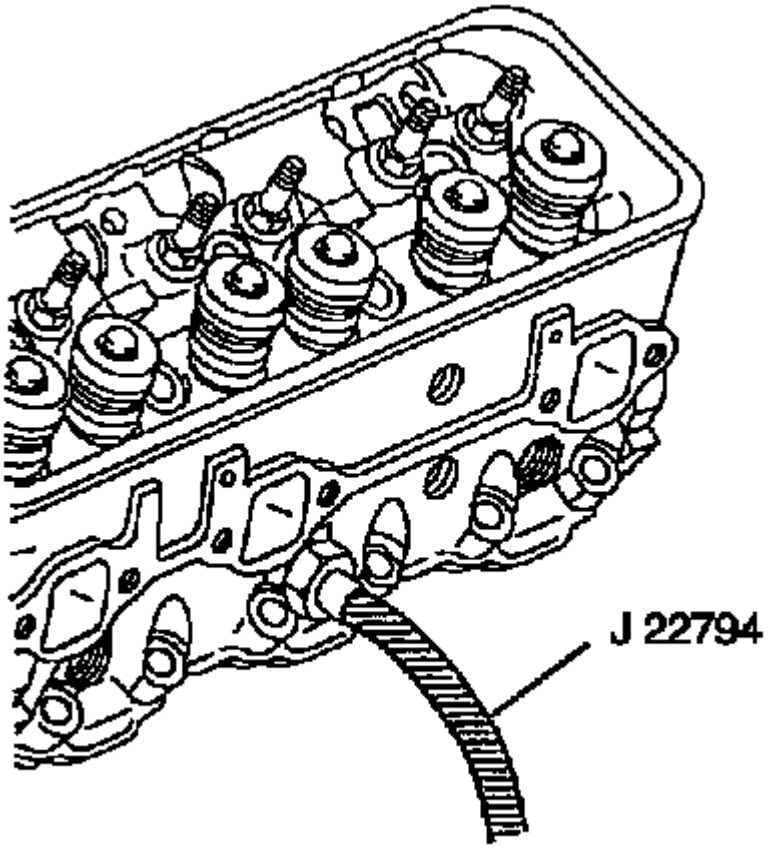

Fig. 129: View Of J 22794
Courtesy of GENERAL MOTORS CORP.

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

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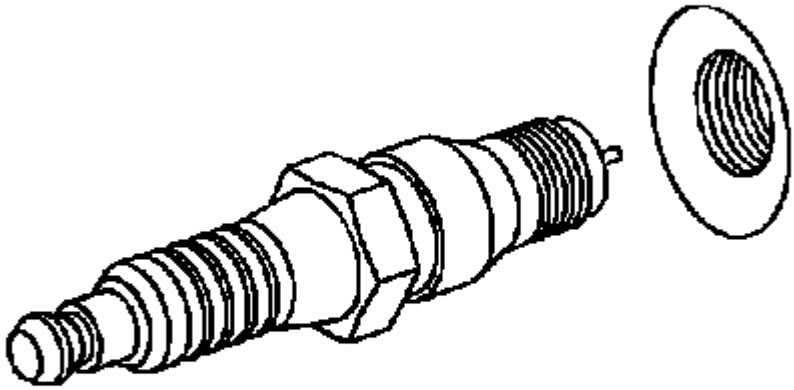

Fig. 130: View Of Spark Plug And Sparkplug Seat
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Hand start the spark plug.

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

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

OIL LEVEL INDICATOR TUBE REPLACEMENT

Removal Procedure

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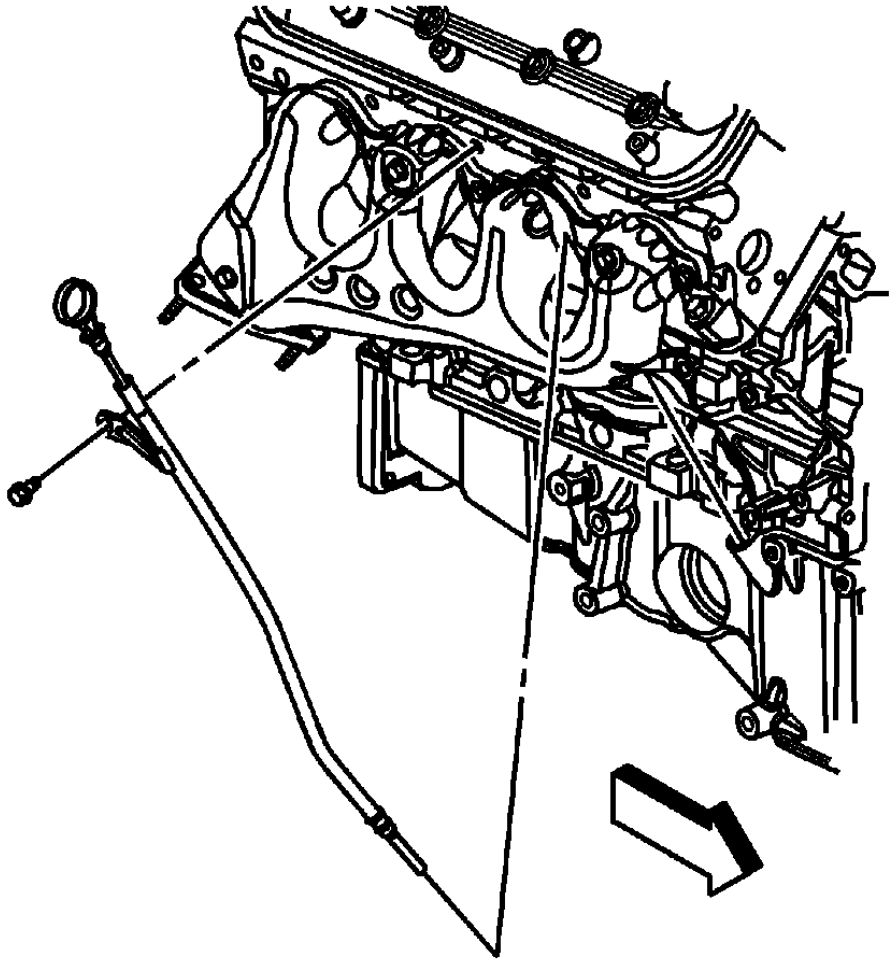

Fig. 131: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

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

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

Installation Procedure

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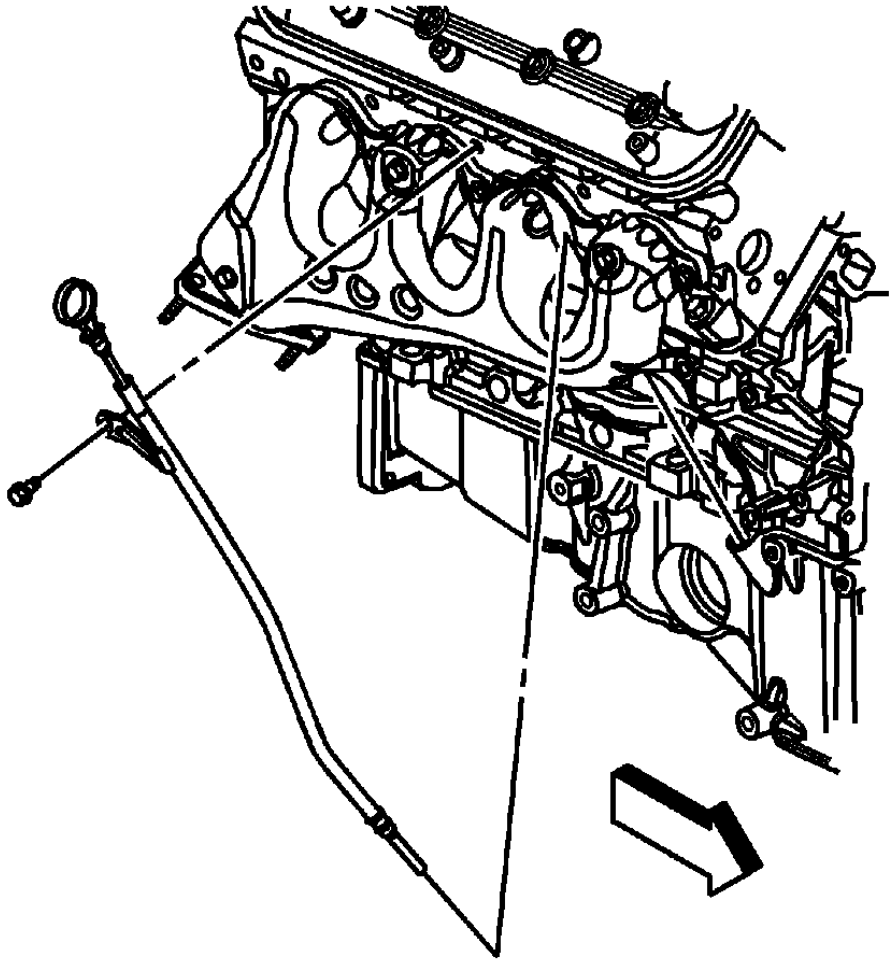

Fig. 132: View Of Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

7. Install the oil level indicator tube bolt.

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

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8. Install the oil level indicator to the tube.
9. Install the cylinder number 2 spark plug and wire. Refer to **Spark Plug Replacement** .

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Special Tools

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

Removal Procedure

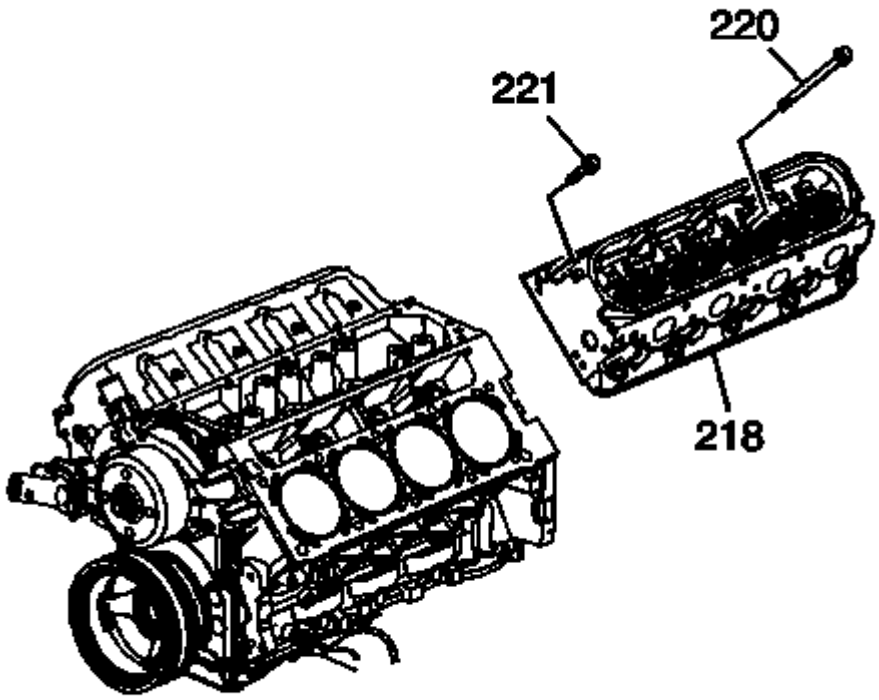

Fig. 133: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the generator bracket. Refer to **Generator Replacement** .
2. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
3. Remove the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe Replacement** .
4. Remove the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LH9)** .
5. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

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NOTE: The cylinder head bolts are of a torque-to-yield design and are NOT to be reused.

6. Remove and discard the cylinder head bolts (220, 221).

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

7. Remove the cylinder head (218).

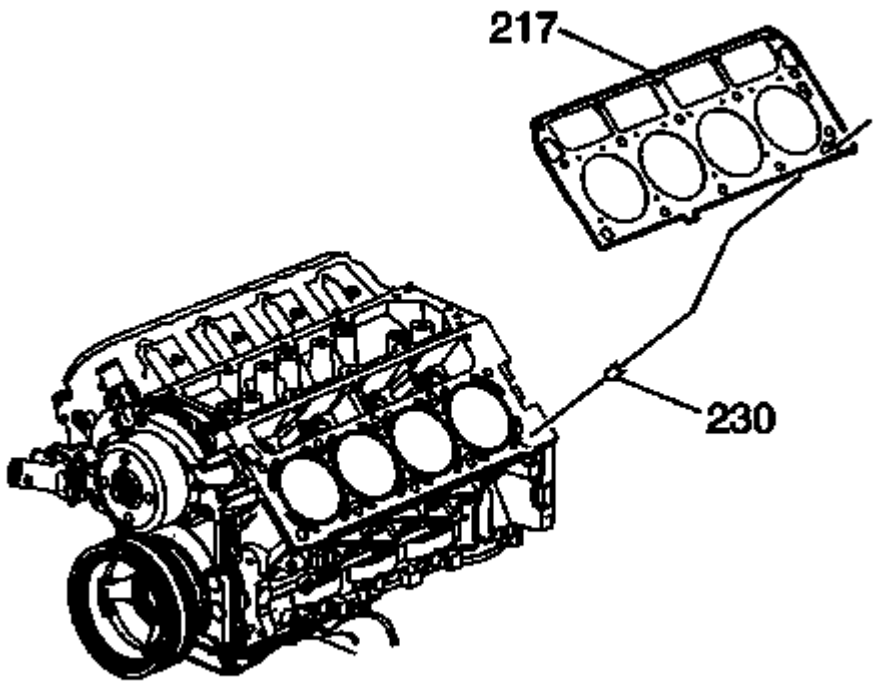

Fig. 134: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the cylinder head gasket (217).
9. If required, clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

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

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CAUTION: 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.

NOTE: If installing a new cylinder head it is necessary to install a new engine coolant air bleed plug into the rear coolant passage of the cylinder head. Refer to Cylinder Head Assemble.

NOTE:

- **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).**

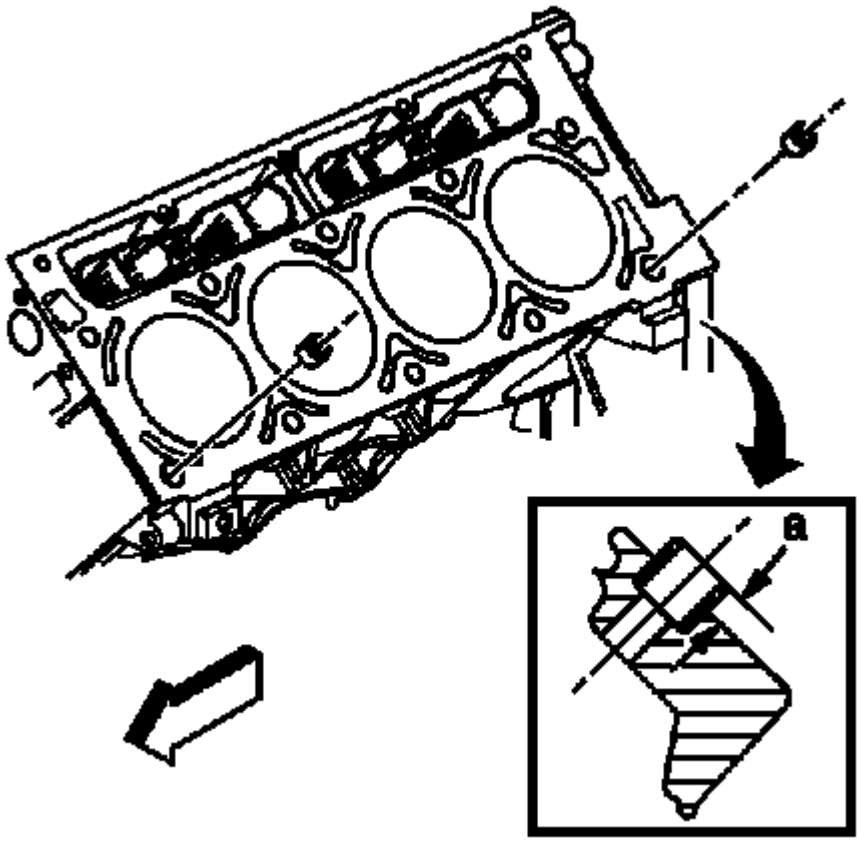

Fig. 135: Checking Cylinder Head Bolt Holes
Courtesy of GENERAL MOTORS CORP.

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. Spray cleaner GM P/N 12346139, P/N 12377981 (Canadian P/N 10953463), or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.

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4. Check the cylinder head locating pins for proper installation (a) 8.3 mm (0.327 in).

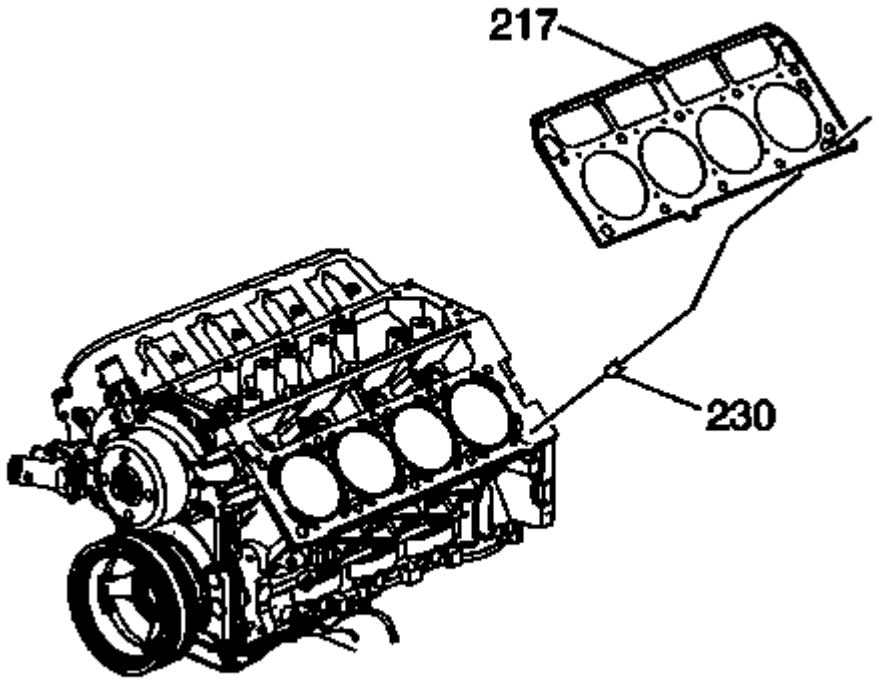

Fig. 136: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

NOTE: When properly installed, with FRONT on the left side, the tab on the cylinder head gasket should be located left of center.

5. Install the NEW cylinder head gasket (217) onto the locating pins.

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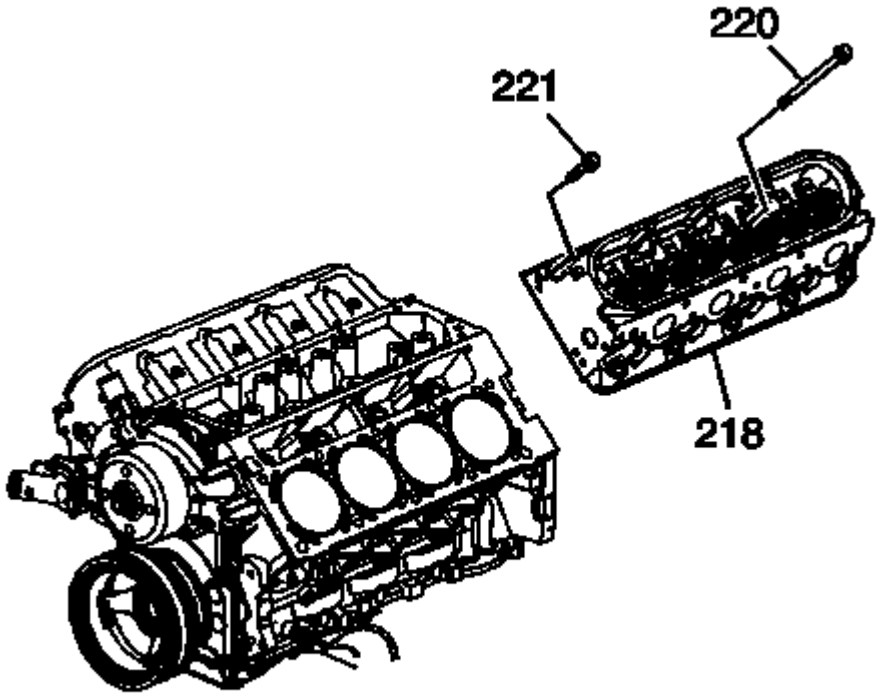

Fig. 137: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the cylinder head (218) onto the locating pins.
7. Install the NEW cylinder head bolts (220, 221).

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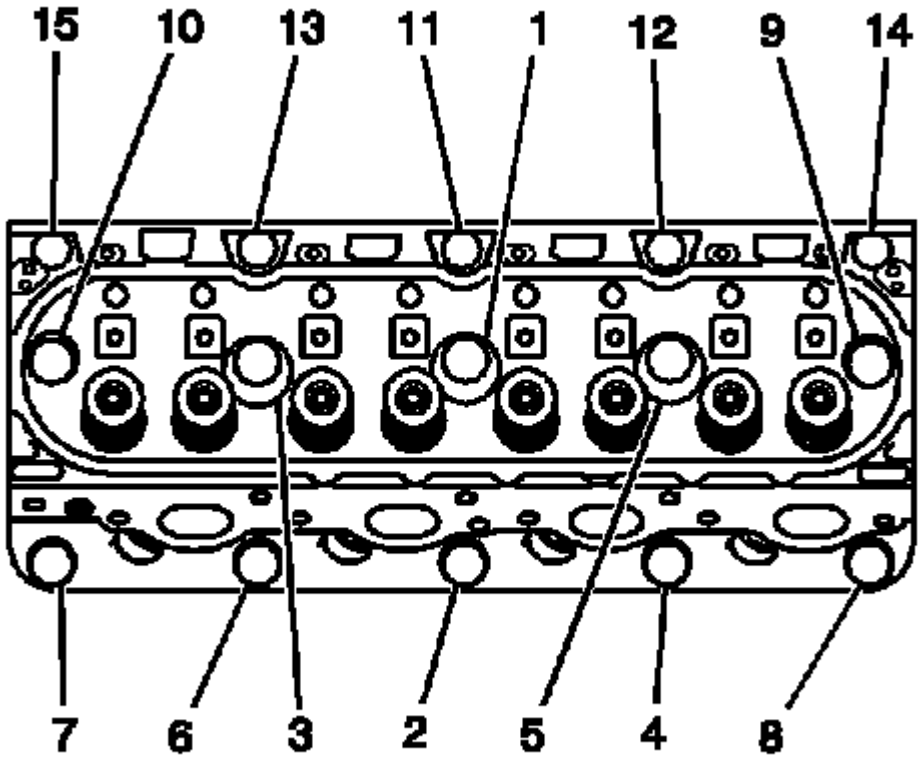

Fig. 138: Tightening Sequence For Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the cylinder head bolts.
    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** .
    3. Tighten the M11 cylinder head bolts (1-10) a final pass to 70 degrees using **J 45059** .
    4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.
9. Install the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
10. Install the left exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (LH9)** .
11. Install the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe Replacement** .
12. Install the intake manifold. Refer to **Intake Manifold Replacement**.
13. Install the generator bracket. Refer to **Generator Replacement** .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

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Special Tools

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

Removal Procedure

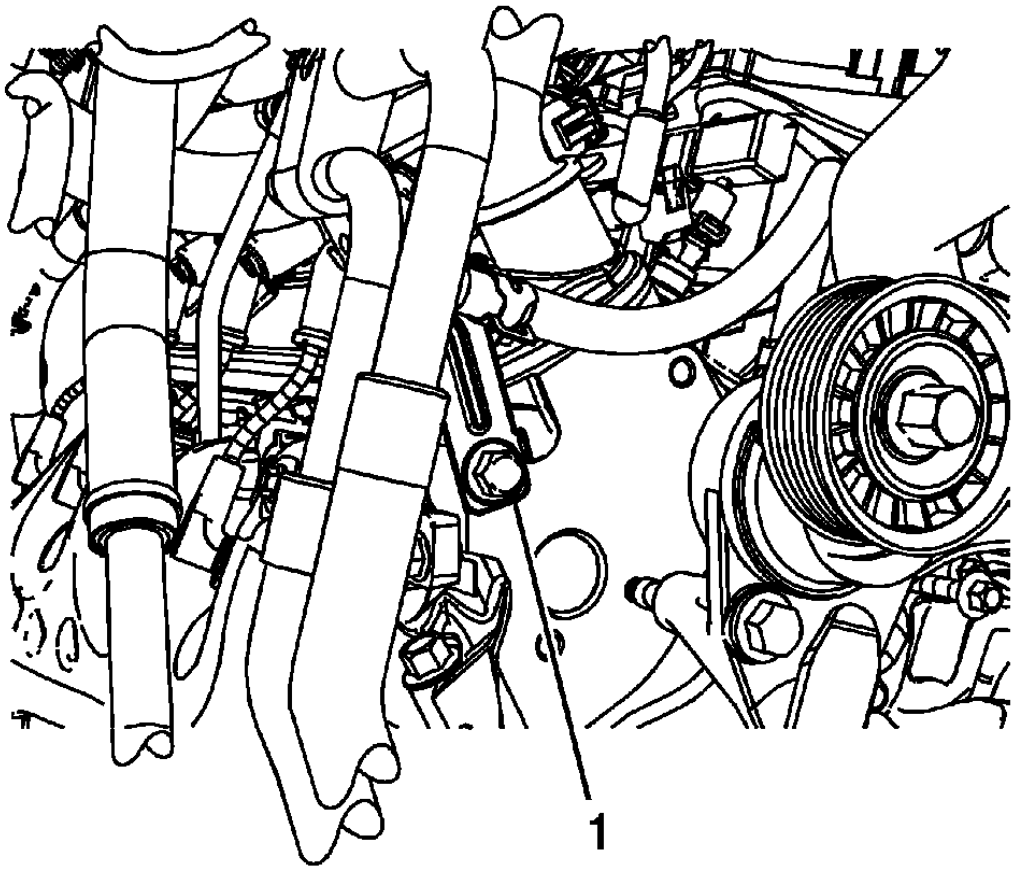

Fig. 139: Heater Hose Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator. Refer to **Oil Level Indicator Tube Replacement**.
2. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
3. Remove the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe Replacement** .
4. Remove the right exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (LH9)** .
5. Remove the pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
6. Remove the heater hose bracket bolt (1) from the front of the right cylinder head.

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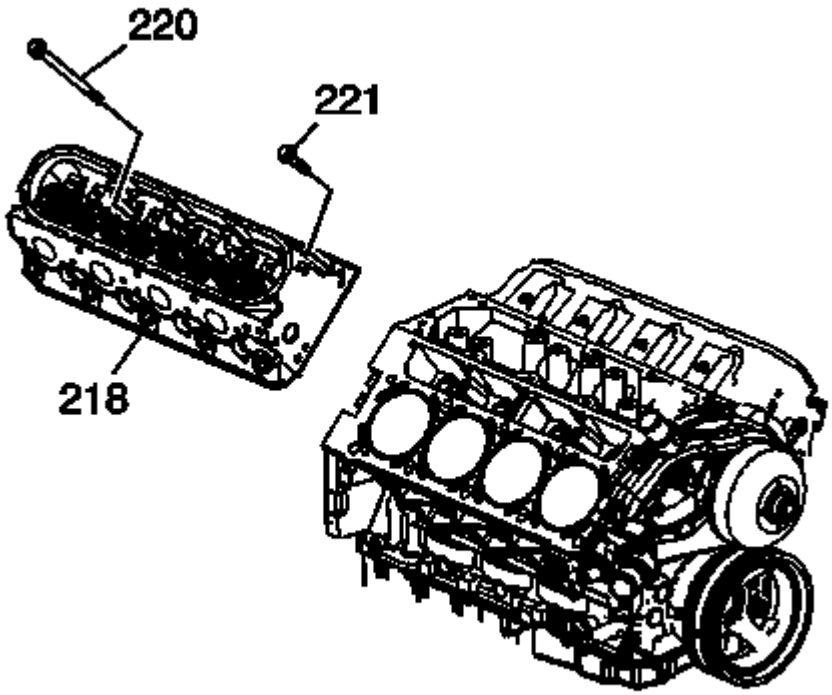

Fig. 140: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: The cylinder head bolts are of a torque-to-yield design and are NOT to be reused.

7. Remove and discard the cylinder head bolts (220, 221).

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

8. Remove the cylinder head (218).

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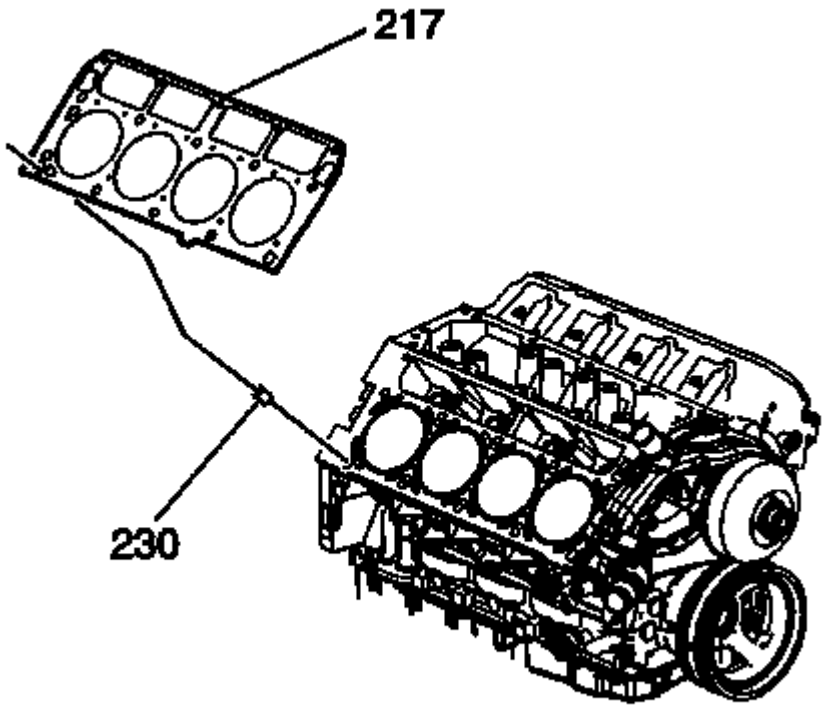

Fig. 141: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the cylinder head gasket (217).
10. If required, clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

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

CAUTION: 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.

NOTE: If installing a new cylinder head it is necessary to install a new engine coolant air bleed plug into the rear coolant passage of the cylinder head. Refer to Cylinder Head Assemble.

NOTE:

- **Do not reuse the cylinder head bolts. Install NEW cylinder head bolts**

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during assembly.

- **Do not use any type of sealant on the cylinder head gasket (unless specified).**

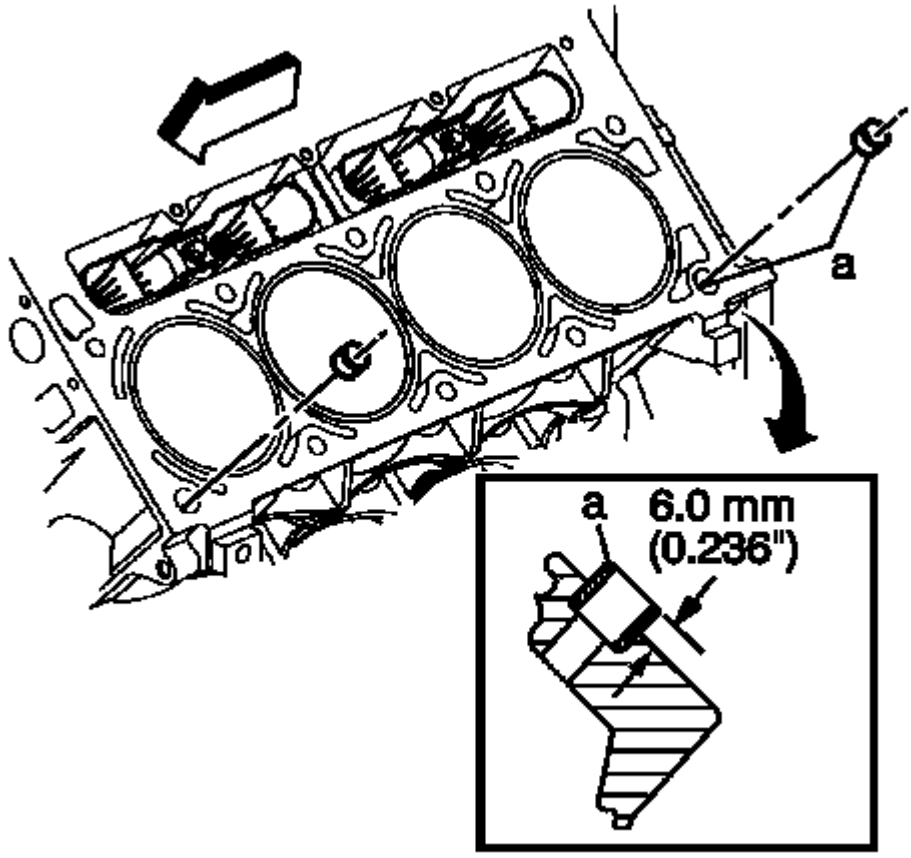

Fig. 142: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

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. Spray cleaner GM P/N 12346139, P/N 12377981 (Canadian P/N 10953463), or equivalent into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Check the cylinder head locating pins for proper installation (a) 8.3 mm (0.327 in).

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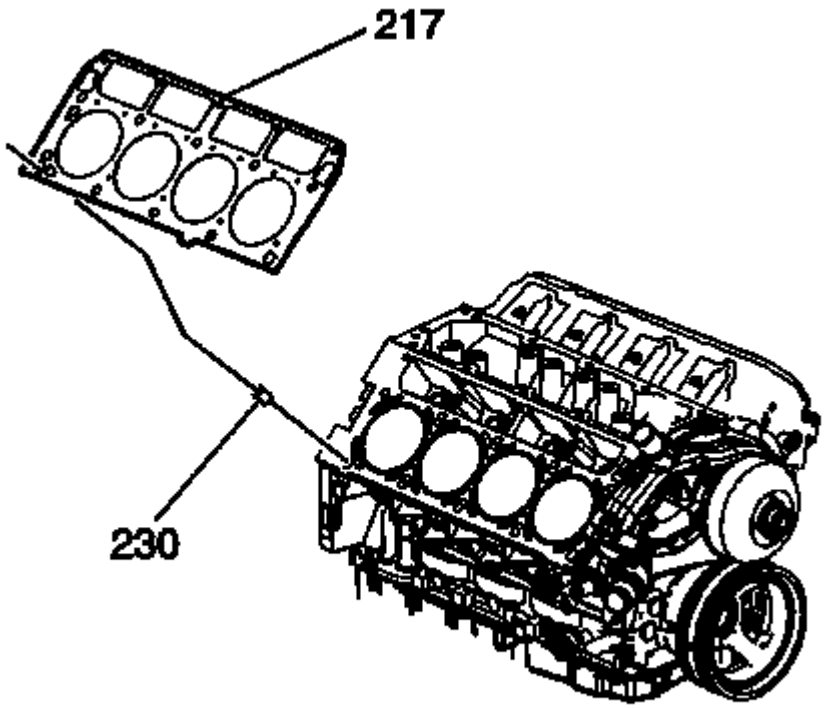

Fig. 143: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

NOTE: When properly installed, with FRONT on the right side, the tab on the cylinder head gasket should be located right of center.

5. Install the NEW cylinder head gasket (217) onto the locating pins.

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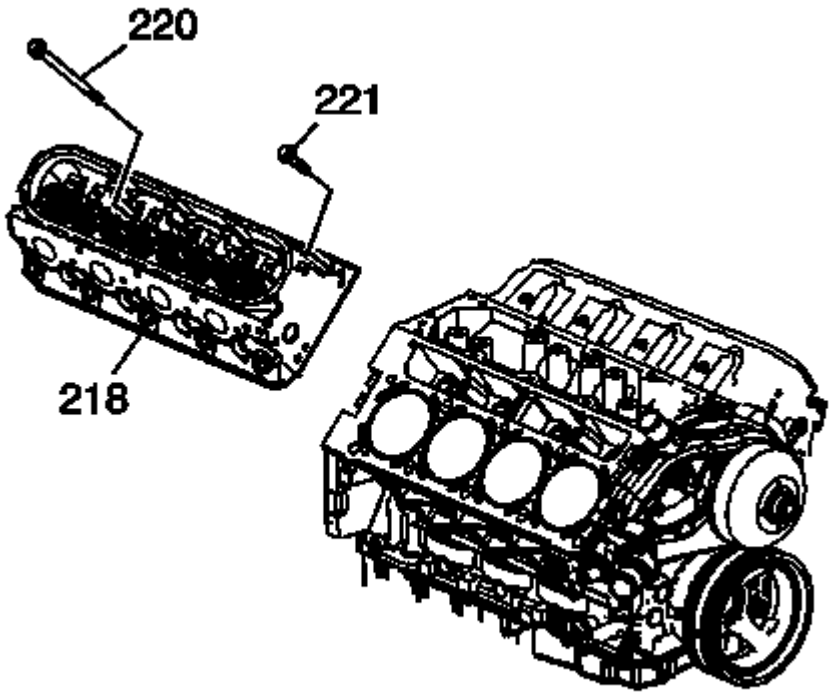

Fig. 144: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the cylinder head (218) onto the locating pins.
7. Install the NEW cylinder head bolts (220, 221).

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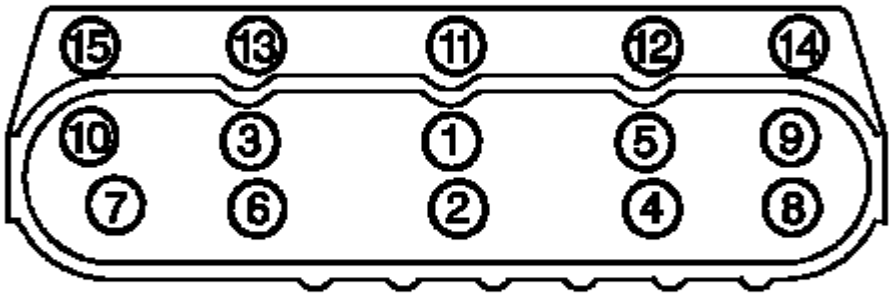

Fig. 145: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the cylinder head bolts.
    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** .
    3. Tighten the M11 cylinder head bolts (1-10) a final pass to 70 degrees in sequence using **J 45059** .
    4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

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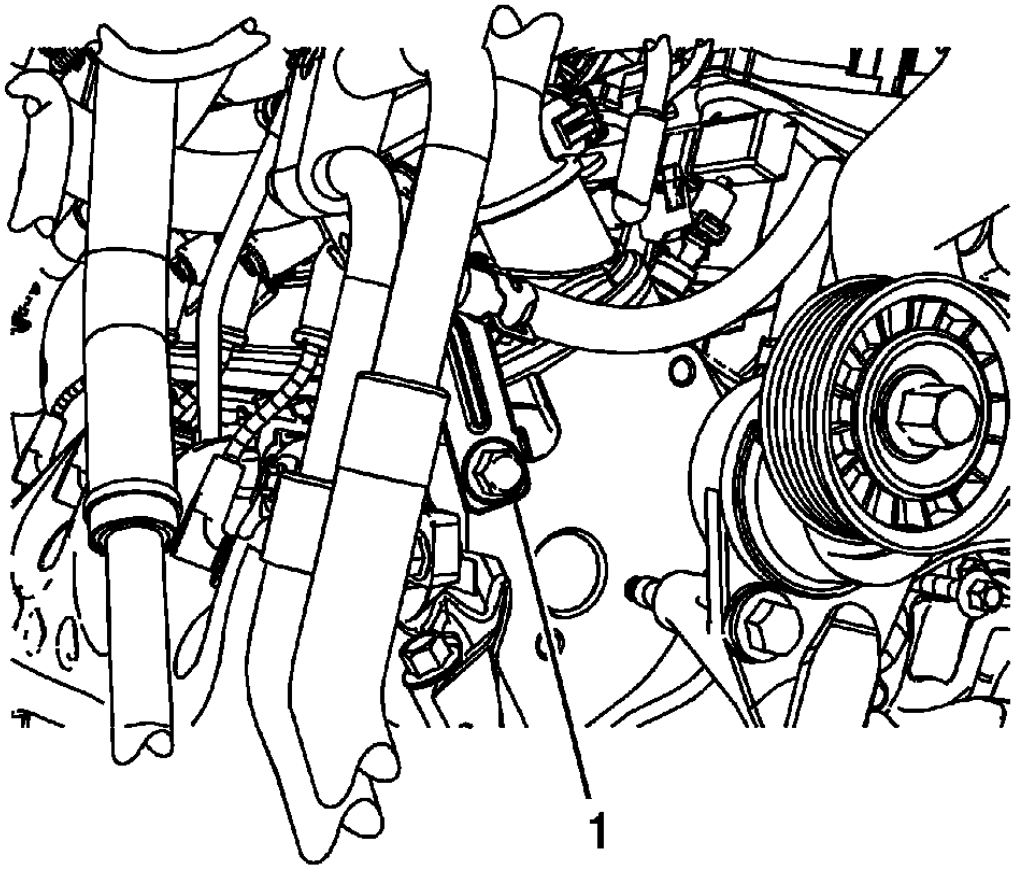

Fig. 146: Heater Hose Bracket Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the heater hose bracket bolt (1) to the front of the right cylinder head and tighten to 25 N.m (18 lb ft).
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 (LH9)** .
12. Install the coolant air bleed pipe. Refer to **Engine Coolant Air Bleed Pipe Replacement** .
13. Install the intake manifold. Refer to **Intake Manifold Replacement**.
14. Install the oil level indicator. Refer to **Oil Level Indicator Tube Replacement**.

VALVE LIFTER REPLACEMENT

Tools Required

J 3049-A Valve Lifter Remover

Removal Procedure

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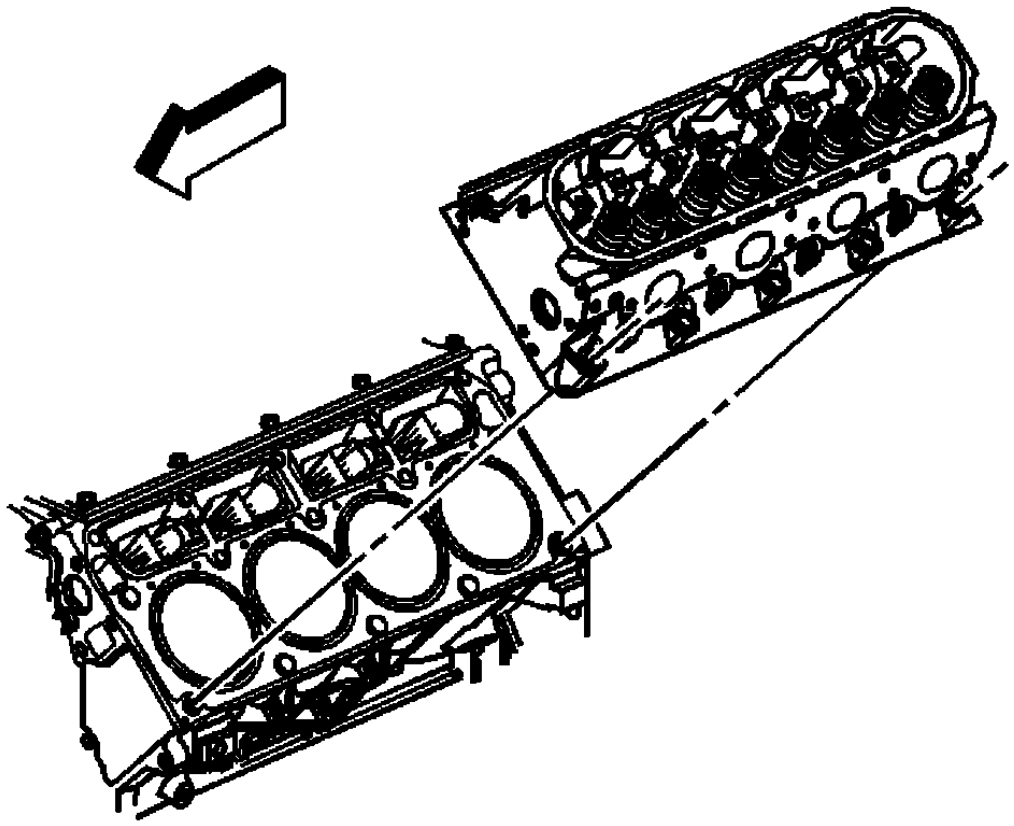

Fig. 147: View Of Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

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

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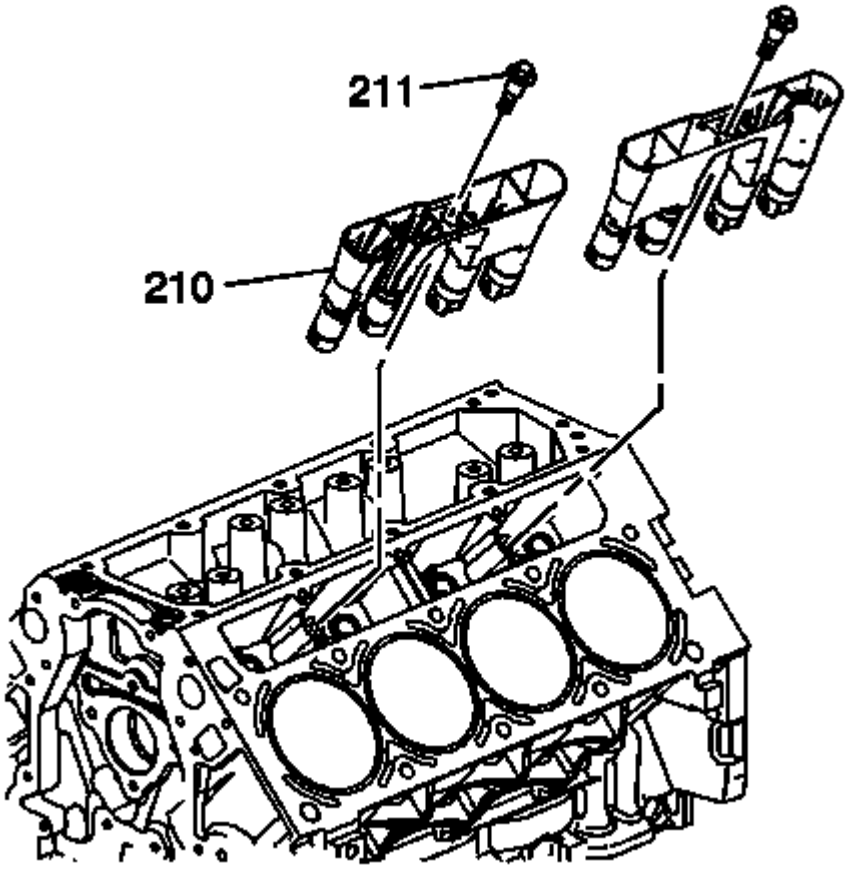

Fig. 148: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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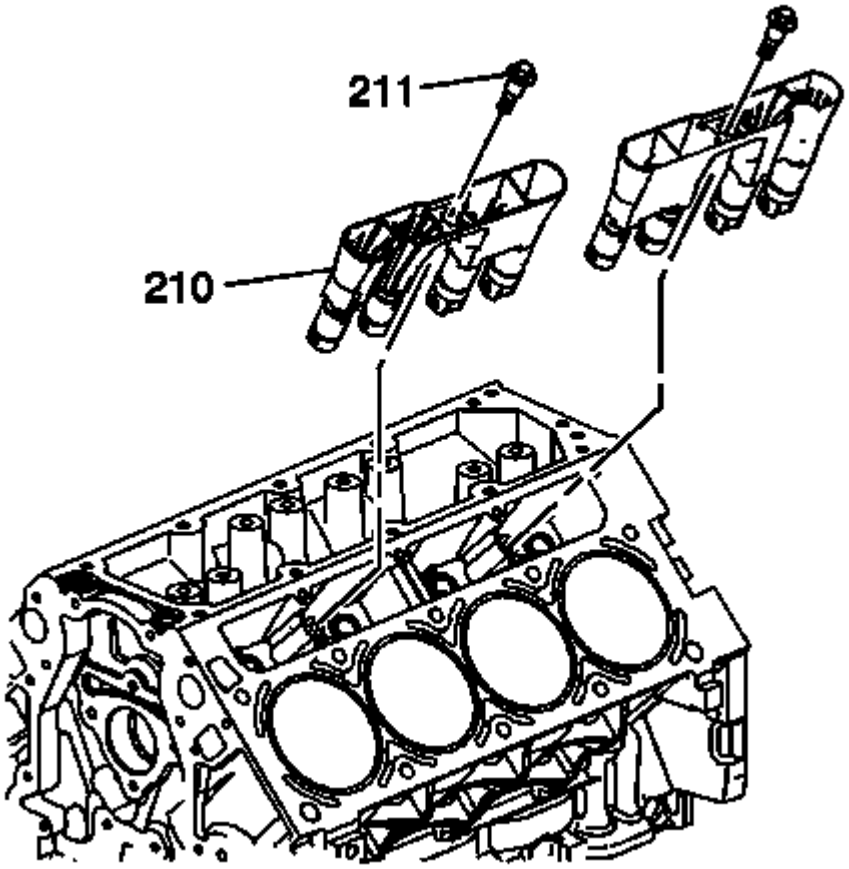

Fig. 149: View Of Lifter Guides & Lifters
Courtesy of GENERAL MOTORS CORP.

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

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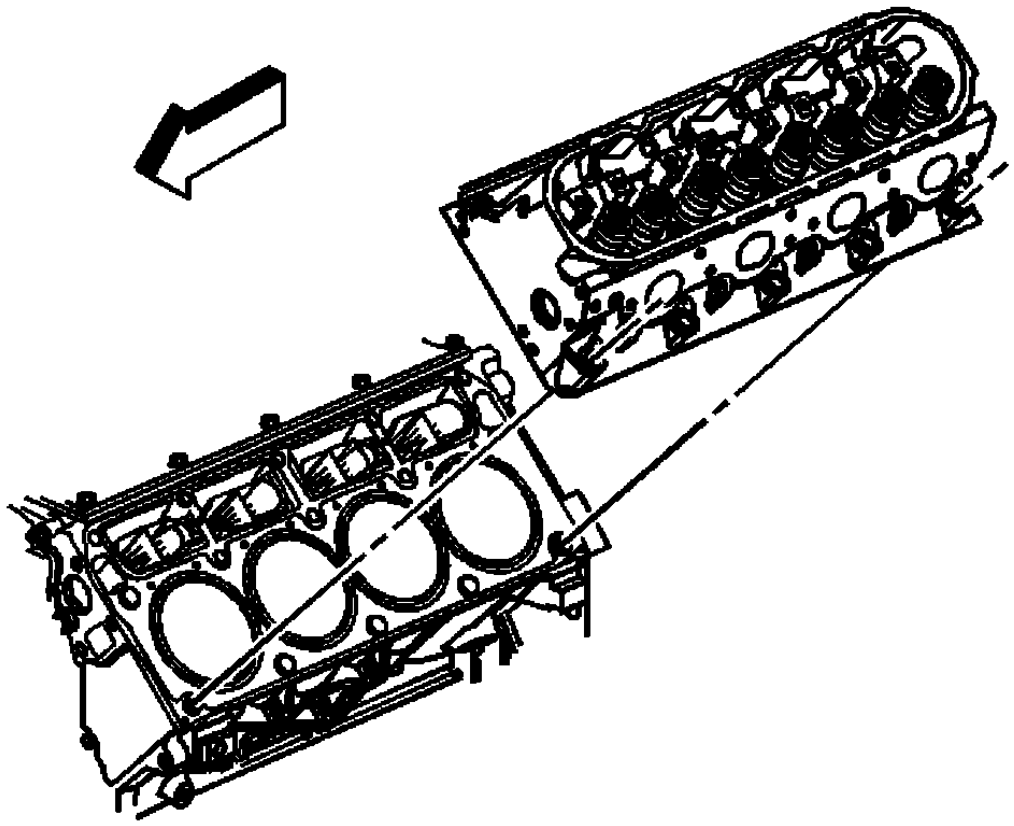

Fig. 150: View Of Cylinder Head (Left)
Courtesy of GENERAL MOTORS CORP.

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

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

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

Removal Procedure

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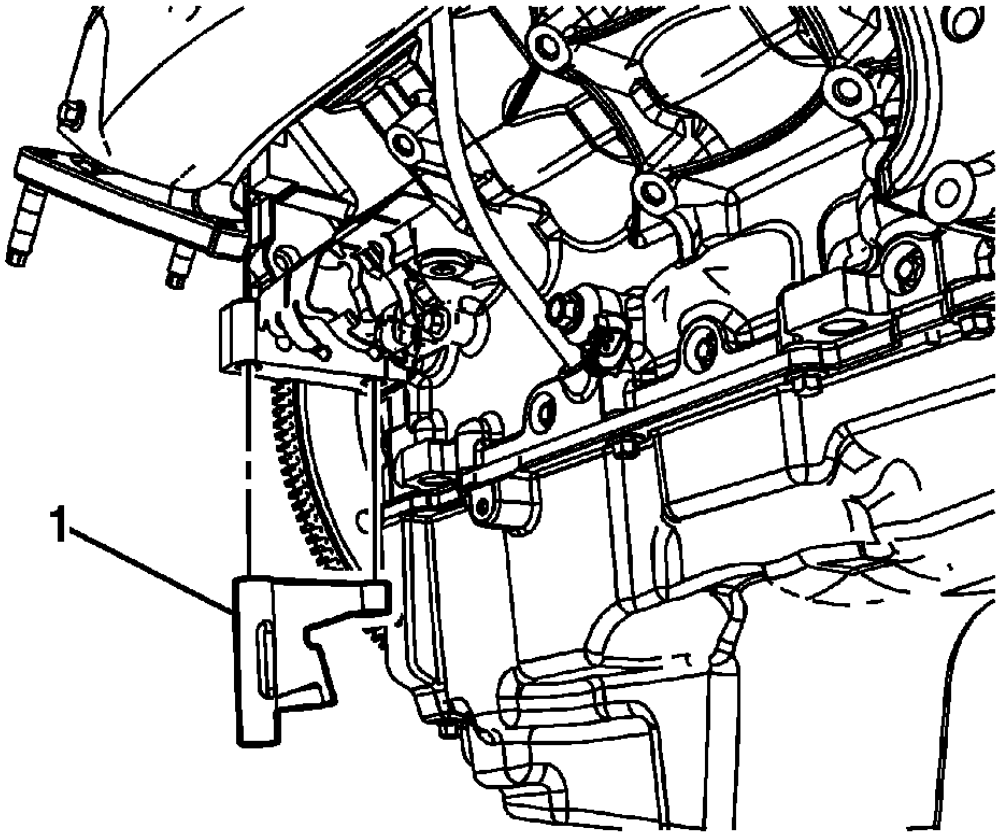

Fig. 151: Air Conditioning Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) drive belt. Refer to **Air Conditioning Compressor Belt Replacement**.
2. Remove the cooling fan and shroud. Refer to **Engine Coolant Fan Shroud Replacement (LH9)** .
3. Remove the starter motor. Refer to **Starter Replacement** .

CAUTION: Refer to Fastener Caution .

NOTE: Ensure that the teeth of the J 42386-A mesh with the teeth of the engine flywheel. See Special Tools.

4. Install the **J 42386-A** (1) and bolts. See **Special Tools**. Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool operation.

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

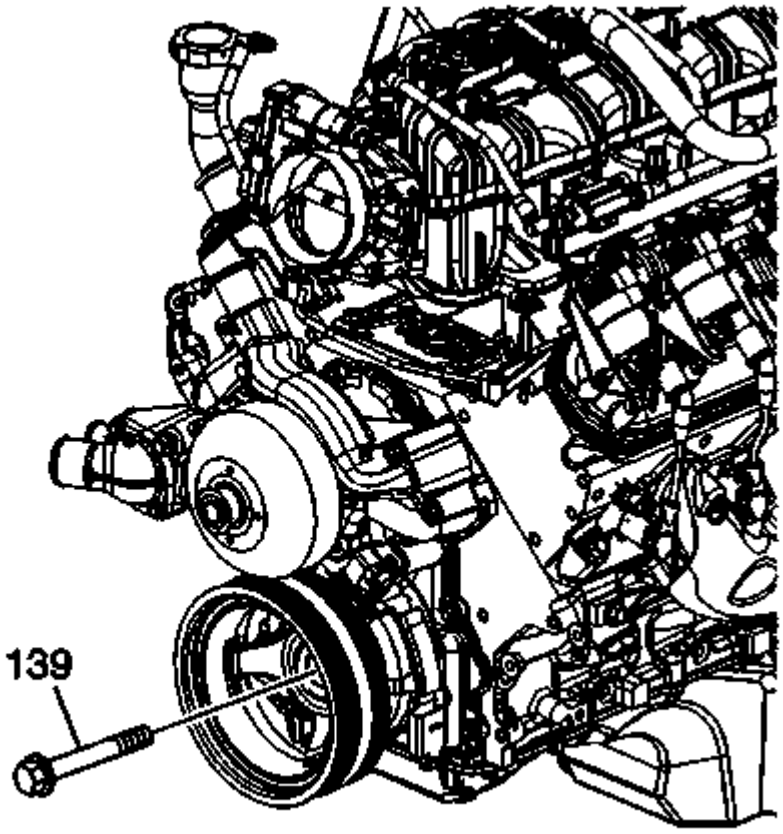

Fig. 152: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft balancer bolt (139). Do not discard the crankshaft balancer bolt at this time. The old balancer bolt will be used during the balancer installation procedure.

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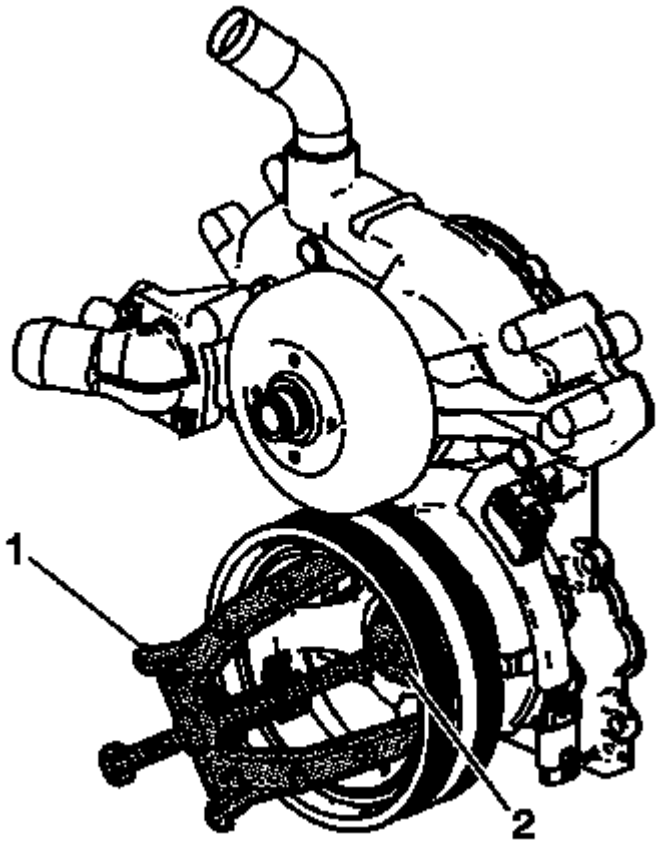

Fig. 153: Using J 41816 & J 41816-2
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 41816** (1) and **J 41816-2** (2) to the crankshaft balancer.

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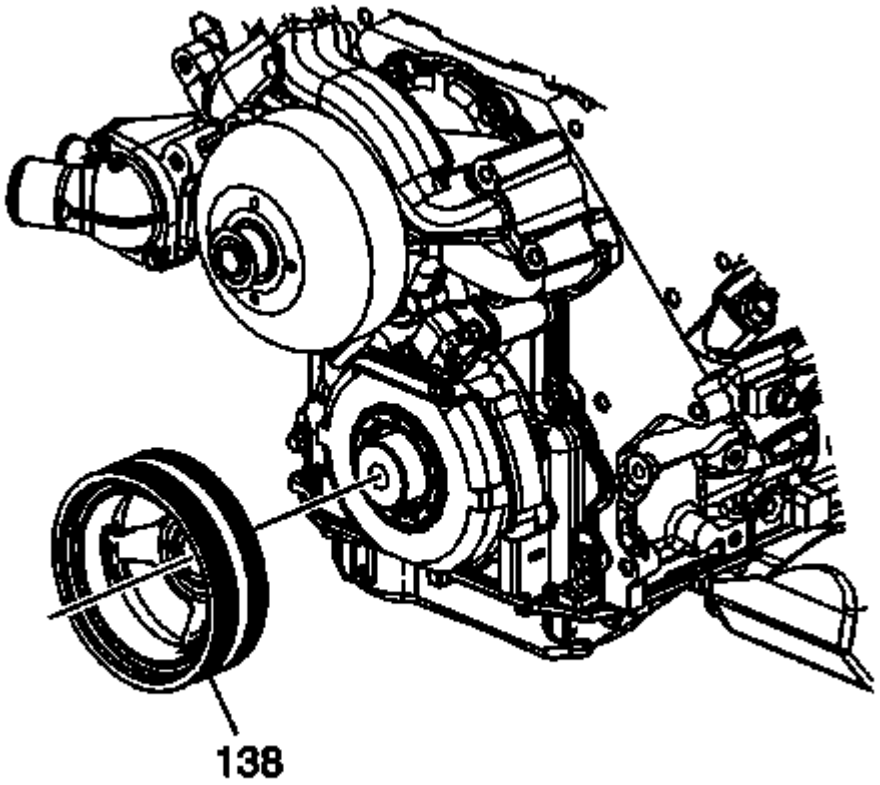

Fig. 154: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: The crankshaft balancer is balanced as an individual component. It is not necessary to mark the balancer prior to removal.

7. Use the **J 41816** and the **J 41816-2** to remove the crankshaft balancer (138).
8. Remove the **J 41816** and the **J 41816-2** from the crankshaft balancer.

Installation Procedure

NOTE:

- **The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and fourth passes tighten the NEW bolt to the proper torque.**
- **The used crankshaft balancer bolt 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 fourth passes of the balancer bolt tightening procedure.**

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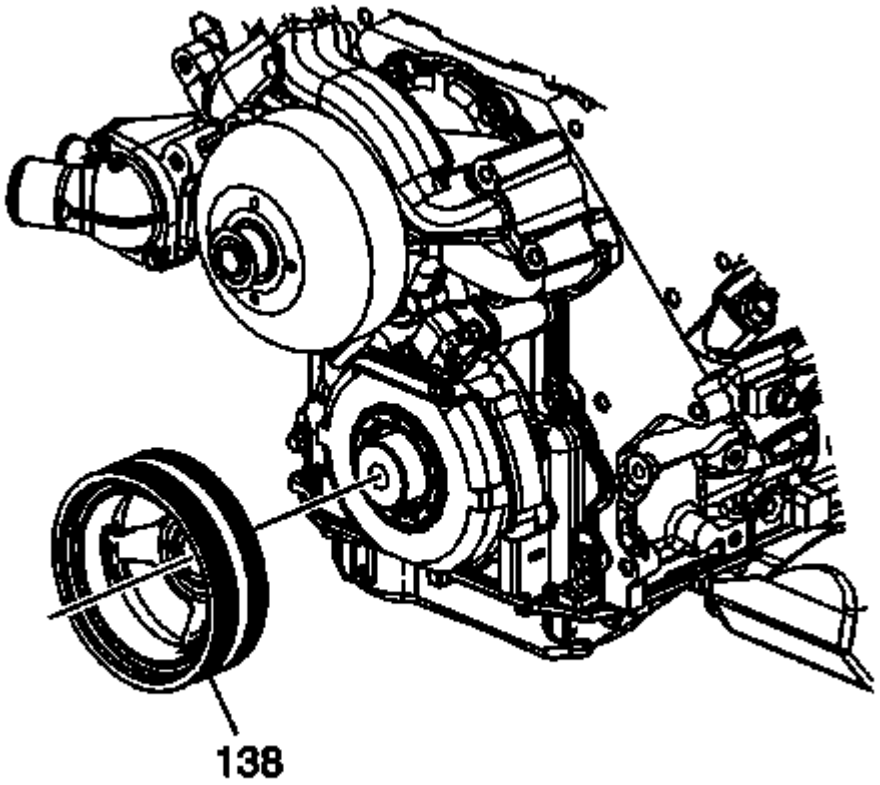

Fig. 155: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

1. Position the crankshaft balancer (138) onto the end of the crankshaft.

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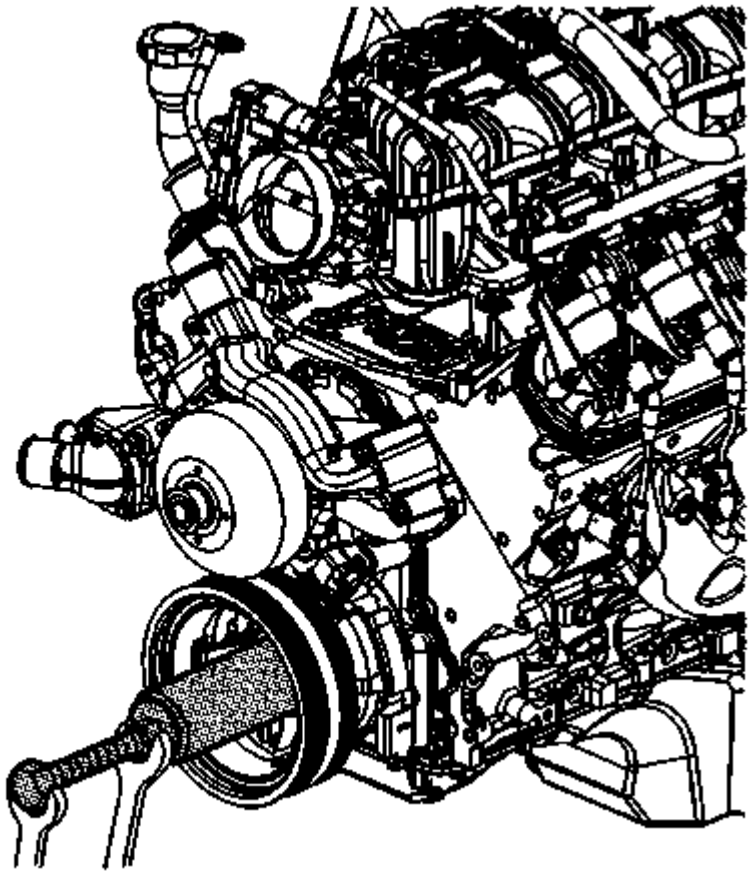

Fig. 156: View Of Balancer Installation Special Tools
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 41665** and the threaded rod from the **J 41478** to crankshaft balancer and install the balancer. See **Special Tools**.
    1. Assemble the threaded rod, nut, washer and installer. Insert the smaller end of the installer into the front of the balancer.
    2. Use a wrench and hold the hex end of the threaded rod.
    3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
    4. Remove the tool and reverse the installation tool. Position the larger end of the installer against the front of the balancer.
    5. Use a wrench and hold the hex end of the threaded rod.
    6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
    7. Remove the **J 41665** and the threaded rod. See **Special Tools**.

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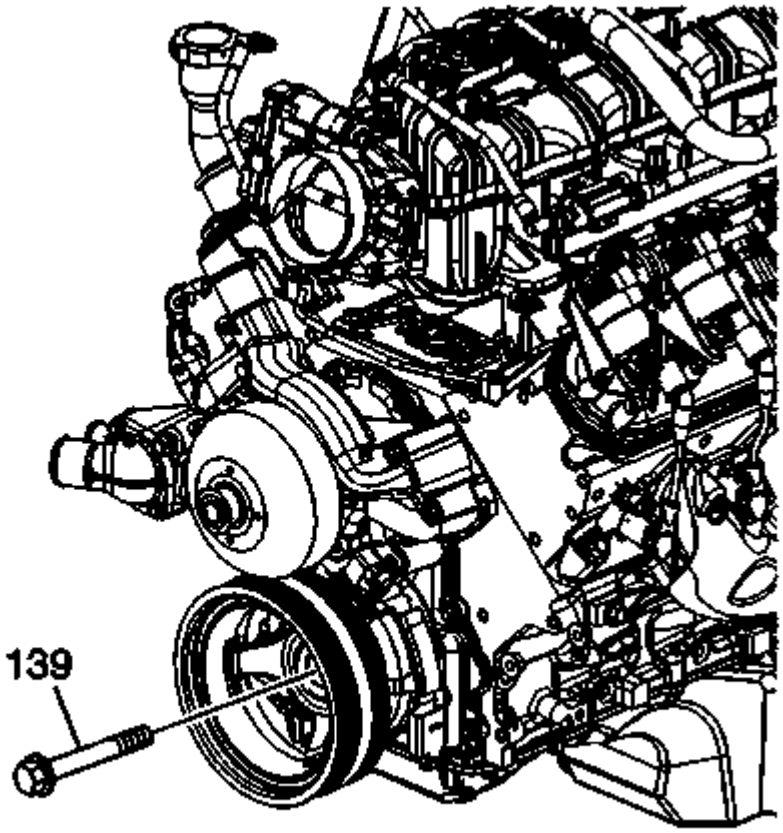

Fig. 157: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the USED crankshaft balancer bolt (139).

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

4. Remove the USED crankshaft balancer bolt.

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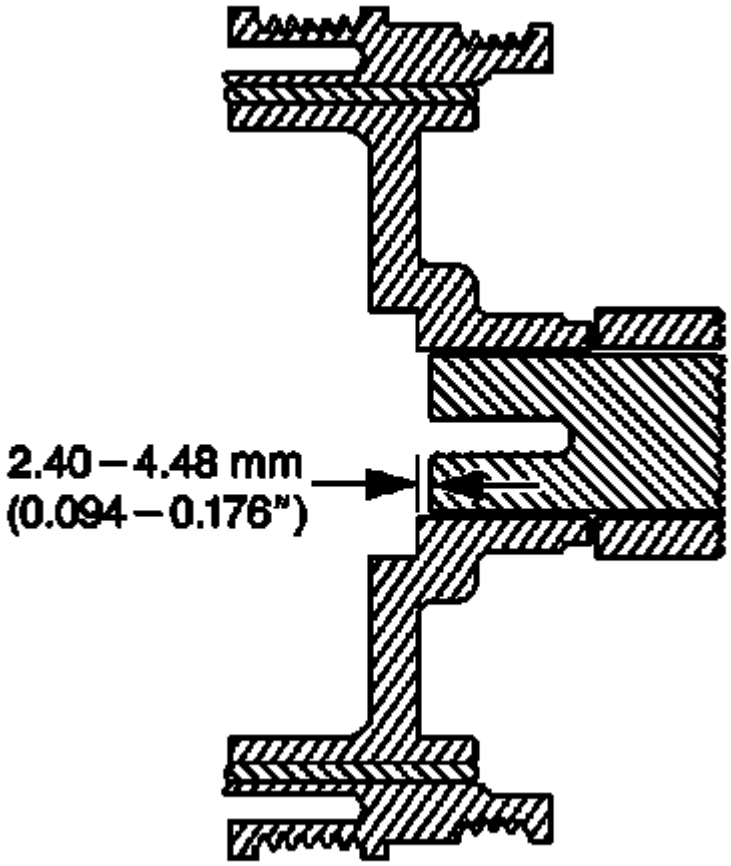

Fig. 158: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 dimension, install the **J 41665** and repeat the installation procedure. See **Special Tools**.

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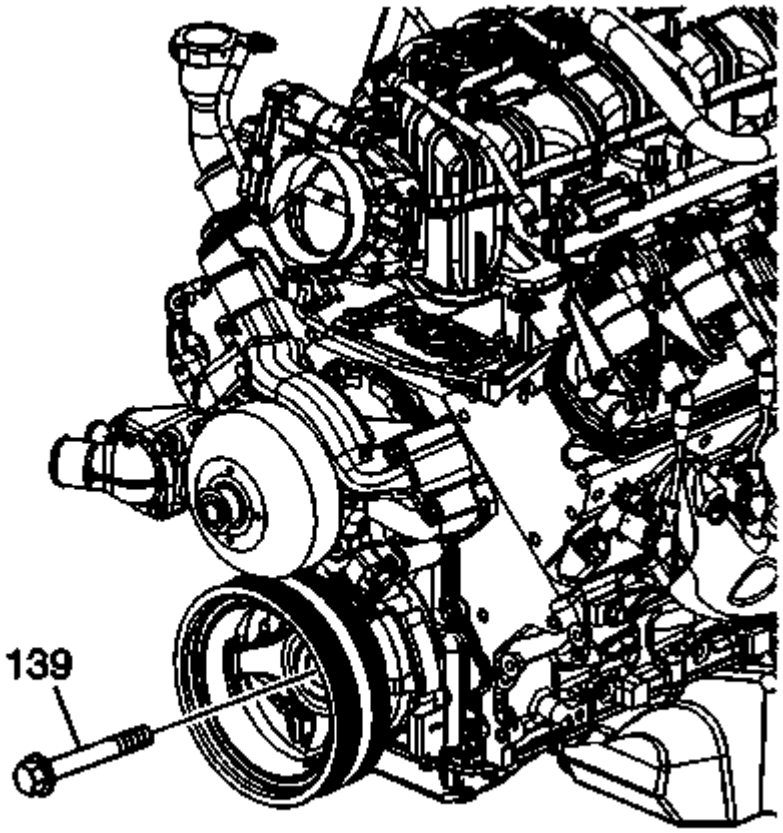

Fig. 159: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

6. Install the NEW crankshaft balancer bolt (139).

Tighten:

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

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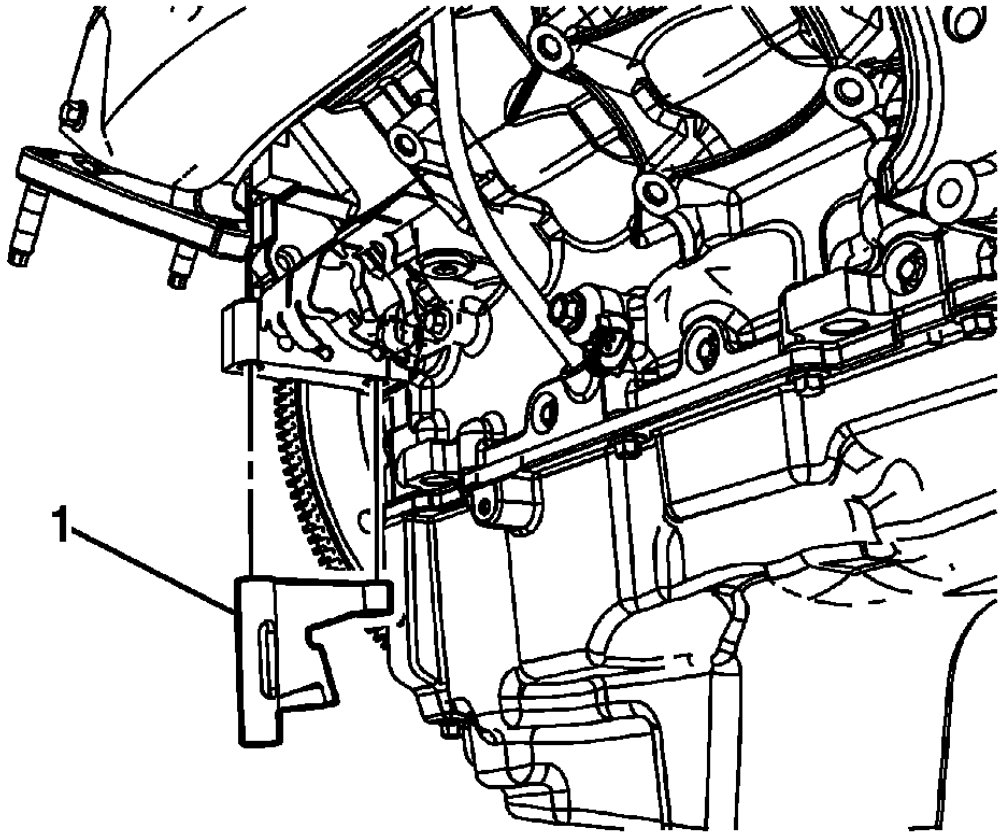

Fig. 160: Air Conditioning Drive Belt
Courtesy of GENERAL MOTORS CORP.

7. Remove the **J 42386-A** (1) and bolts. See **Special Tools**.
8. Install the starter motor. Refer to **Starter Replacement** .
9. Install the cooling fan and shroud. Refer to **Engine Coolant Fan Shroud Replacement (LH9)** .
10. Install the A/C drive belt. Refer to **Air Conditioning Compressor Belt Replacement**.
11. 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

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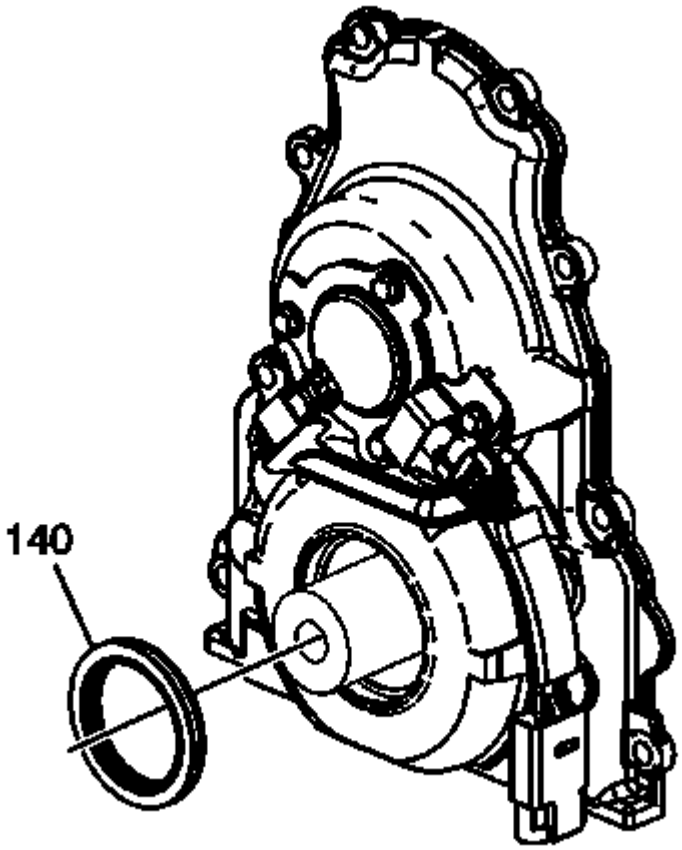

Fig. 161: View Of Outer Edge Of The Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Remove the crankshaft front oil seal (140) from the front cover.

Installation Procedure

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

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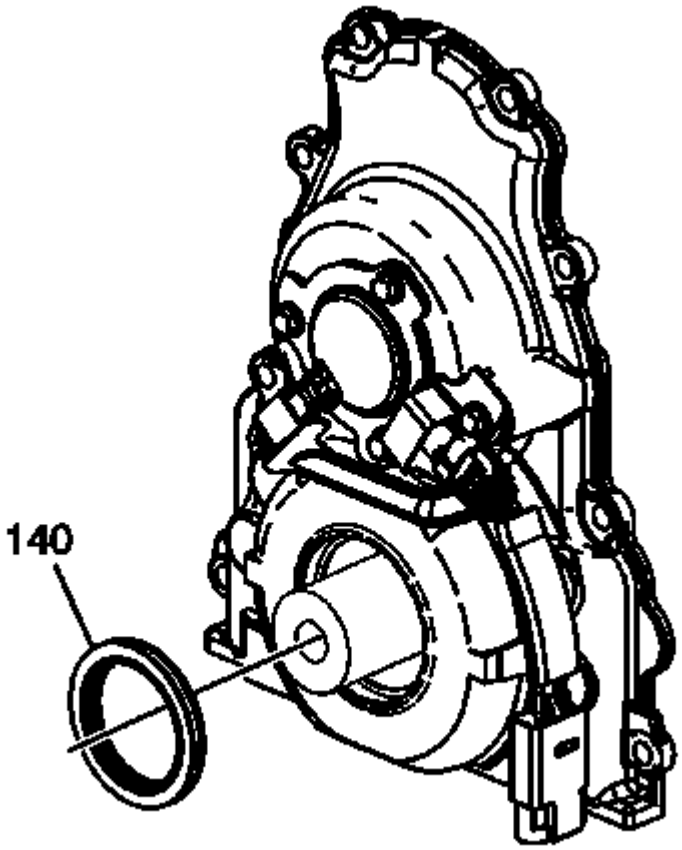

Fig. 162: View Of Outer Edge Of The Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

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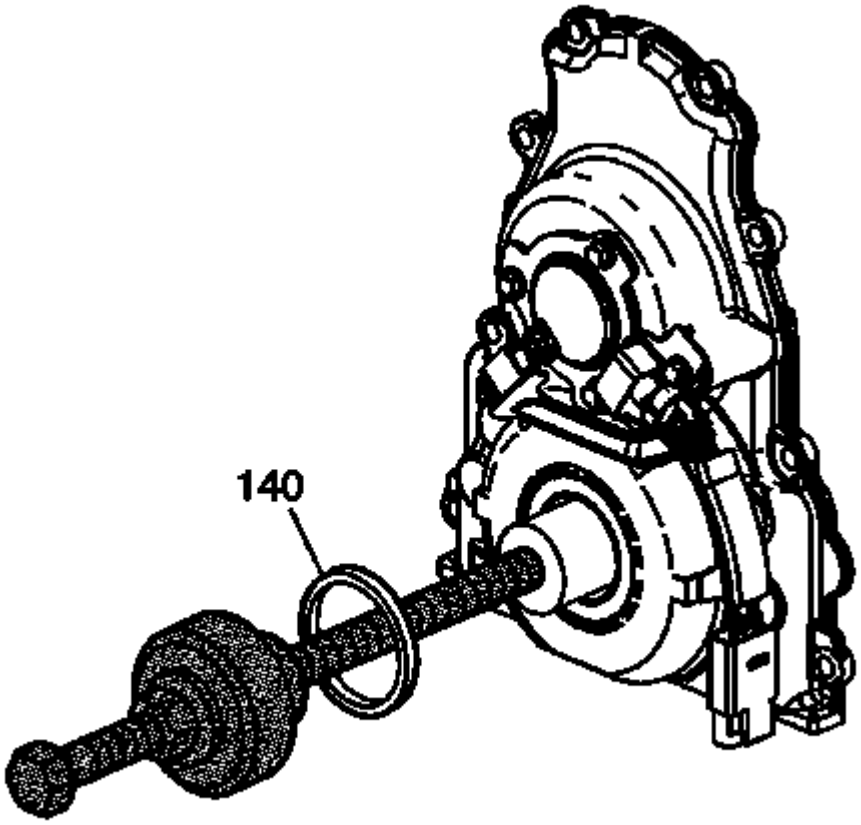

Fig. 163: View Of Front Oil Seal & Special Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) 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

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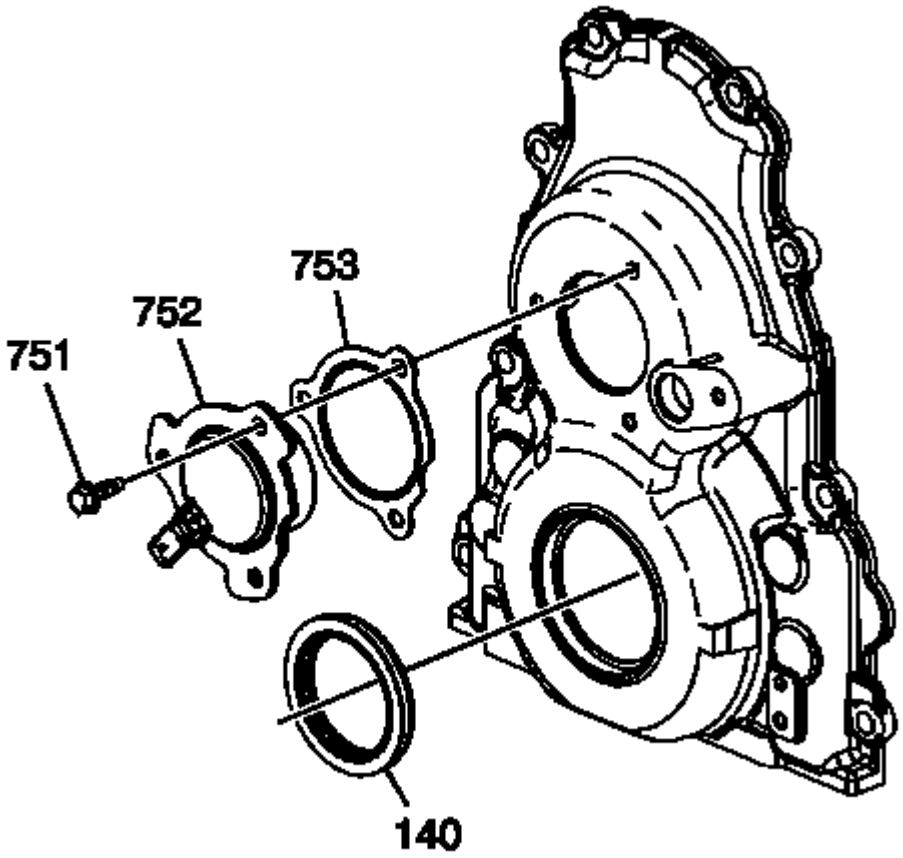

Fig. 164: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement (LH9)** .
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

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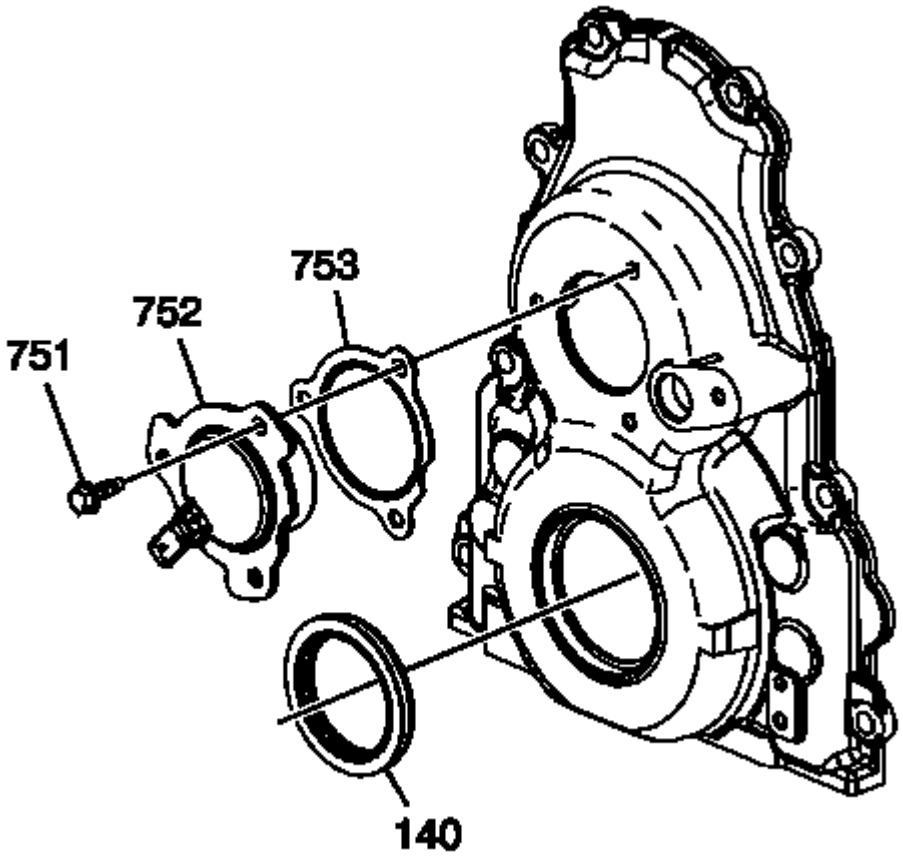

Fig. 165: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

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.

CAUTION: Refer to Fastener Caution .

3. Install the CMP actuator magnet bolts (751) and tighten 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 (LH9)** .

ENGINE FRONT COVER REPLACEMENT

Special Tools

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J 41476 Front and Rear Cover Alignment Tool. See **Special Tools**.

Removal Procedure

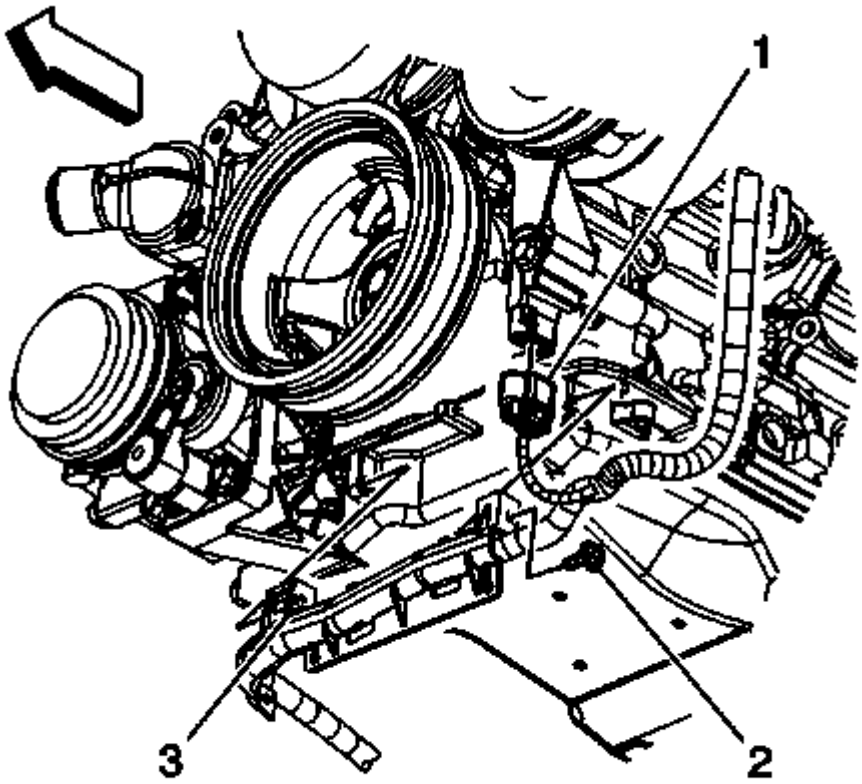

Fig. 166: View Of Electrical Connector, Cable Channel Bolt & Pin
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement (LH9)** .
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Disconnect the engine harness electrical connector (1) from the camshaft position (CMP) sensor wire harness electrical connector.

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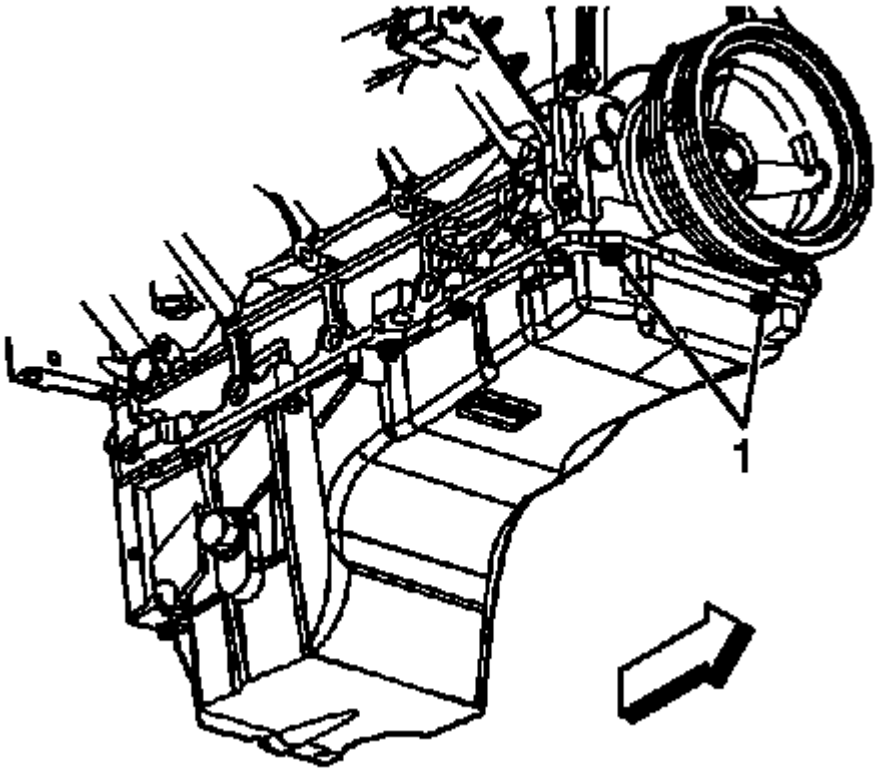

Fig. 167: View Of Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pan-to-front cover bolts (1).

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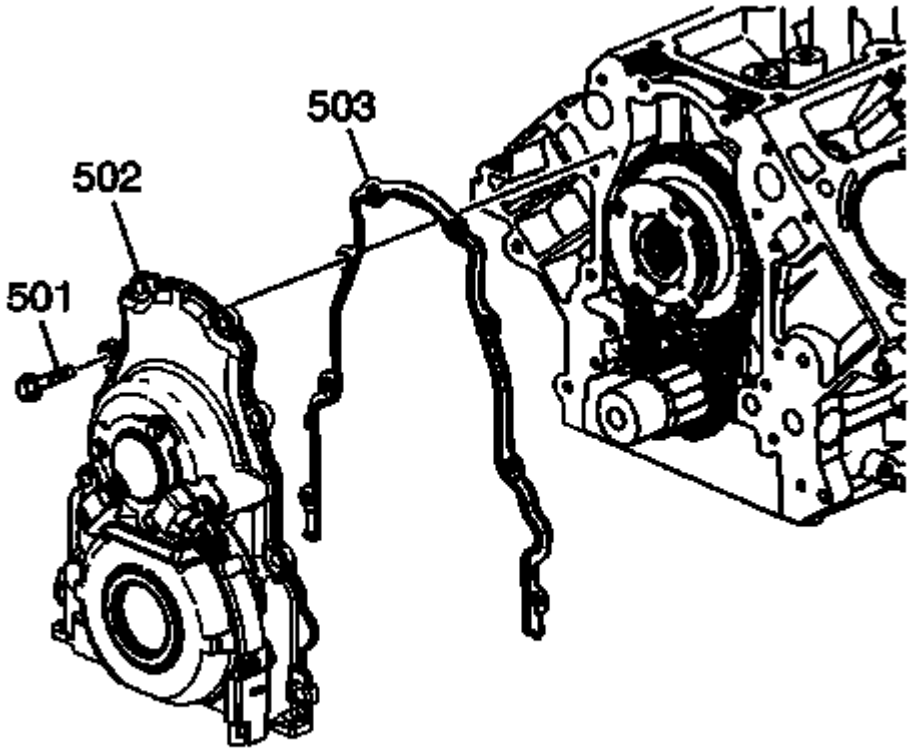

Fig. 168: View Of Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the front cover bolts (501).
6. Remove the front cover (502) and gasket (503).
7. Discard the front cover gasket.
8. Remove the crankshaft front oil seal.

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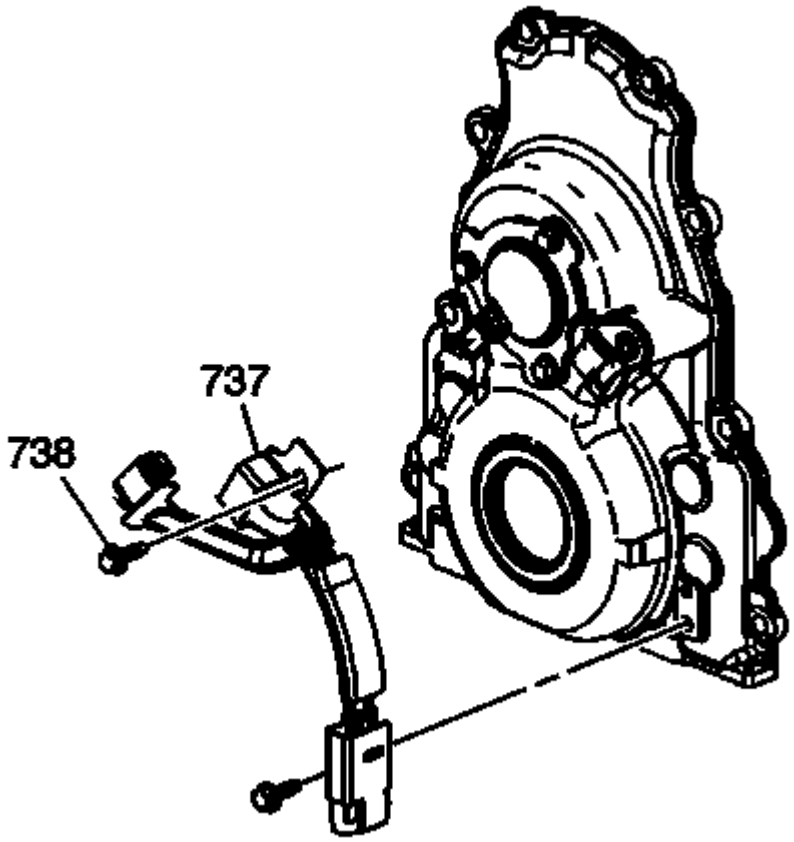

Fig. 169: View Of CMP Sensor Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

9. If replacing the engine front cover perform the following steps, otherwise proceed to step 10 of the installation procedure.
10. Remove the CMP sensor wire harness bolts (738).
11. Disconnect the CMP sensor wire harness from the CMP sensor.
12. Remove the CMP sensor wire harness (737).

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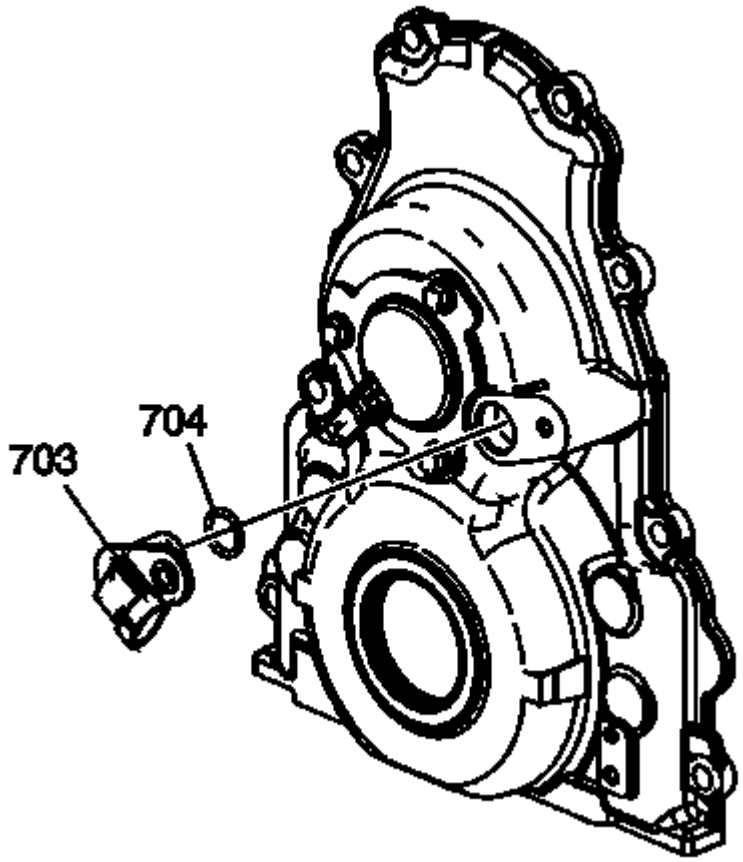

Fig. 170: View Of CMP Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

13. Remove the CMP sensor (703).

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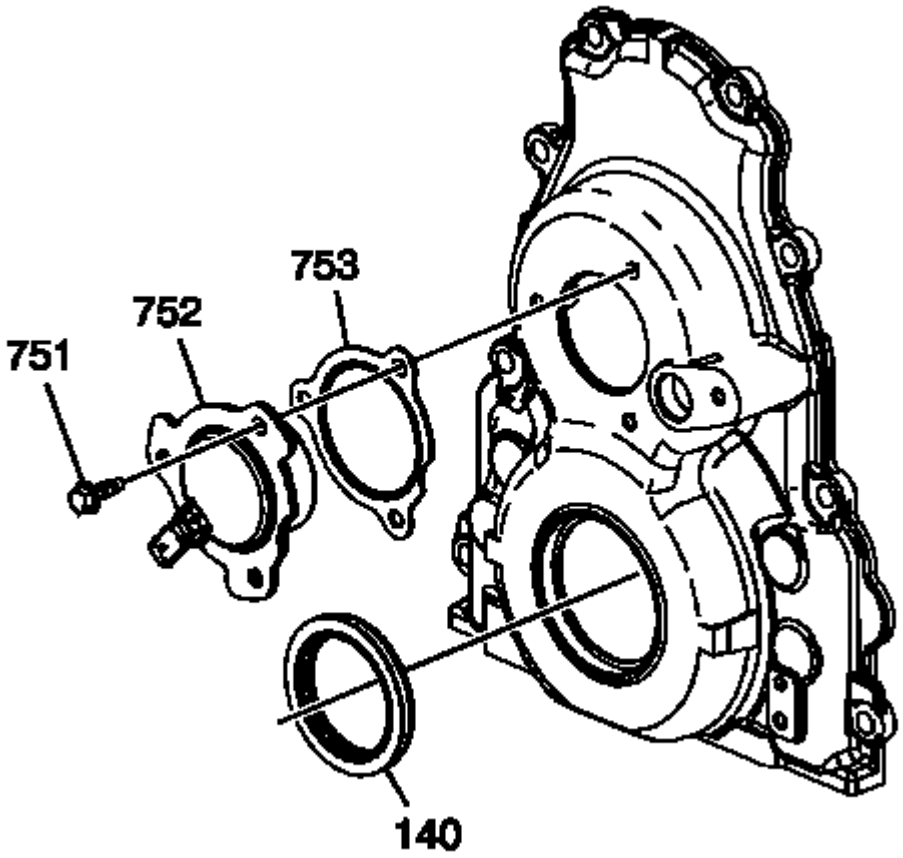

Fig. 171: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

14. Remove the CMP actuator magnet bolts (751), and magnet (752).
15. Remove and discard the CMP actuator magnet gasket (753).

Installation Procedure

NOTE:

- **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.**

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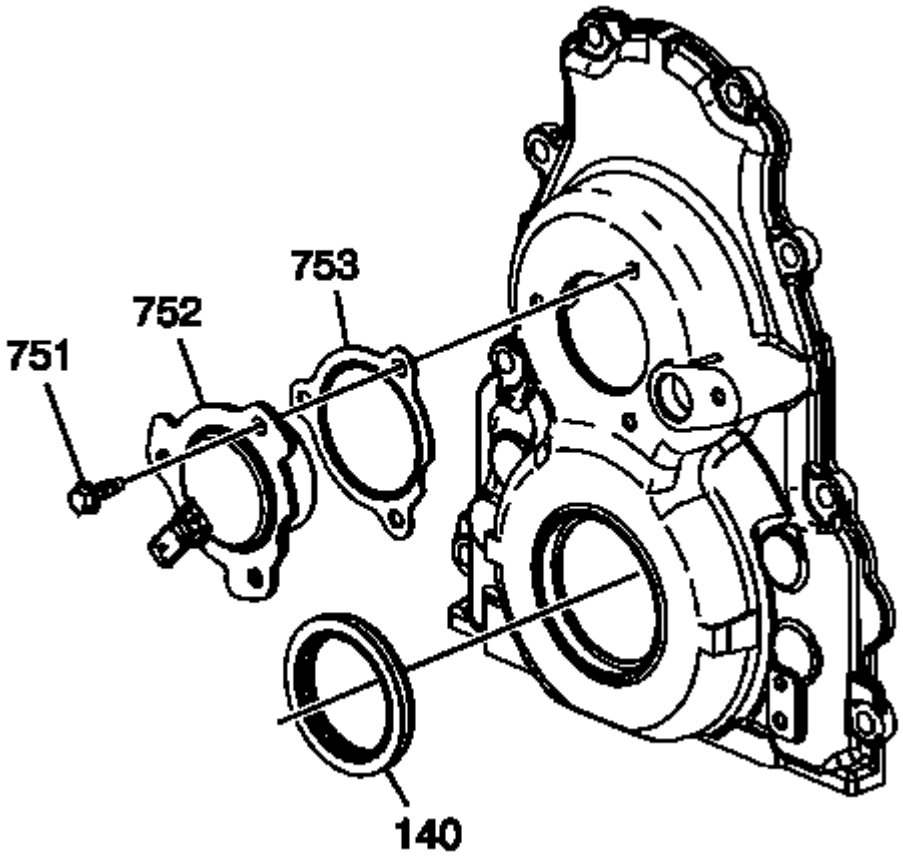

Fig. 172: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. If replacing the front cover perform the following steps, otherwise proceed to step 10.
2. Install a NEW CMP actuator magnet gasket (753) onto the magnet.

CAUTION: Refer to Fastener Caution .

3. Install the CMP actuator magnet (752) and bolts (751).

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

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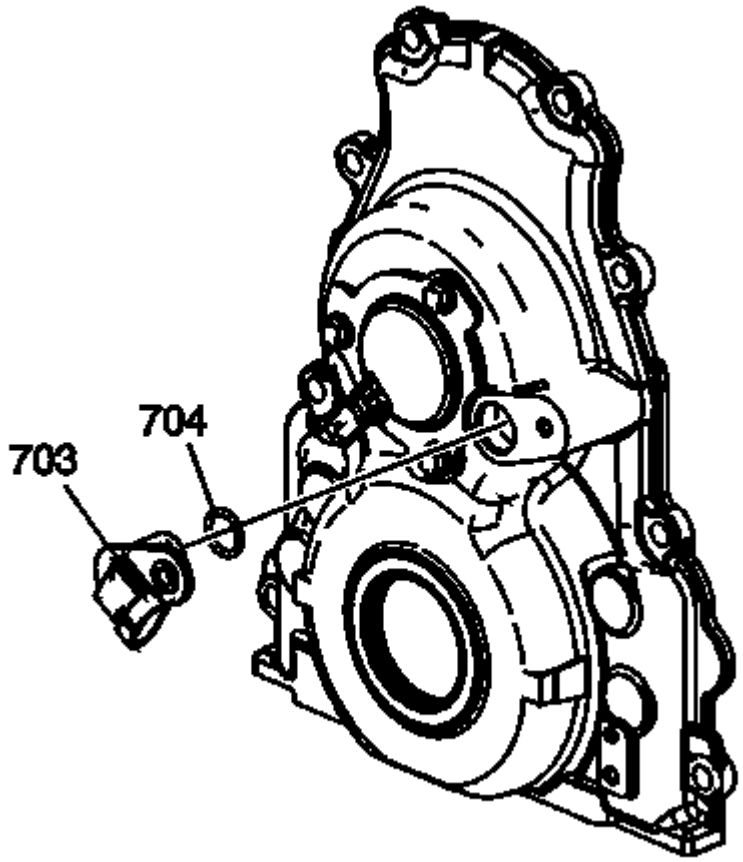

Fig. 173: View Of CMP Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

4. Inspect the CMP sensor O-ring seal for cuts or damage. If the seal is not cut or damaged, it may be reused.
5. Lubricate the O-ring seal (704) with clean engine oil.
6. Install the CMP sensor (703).

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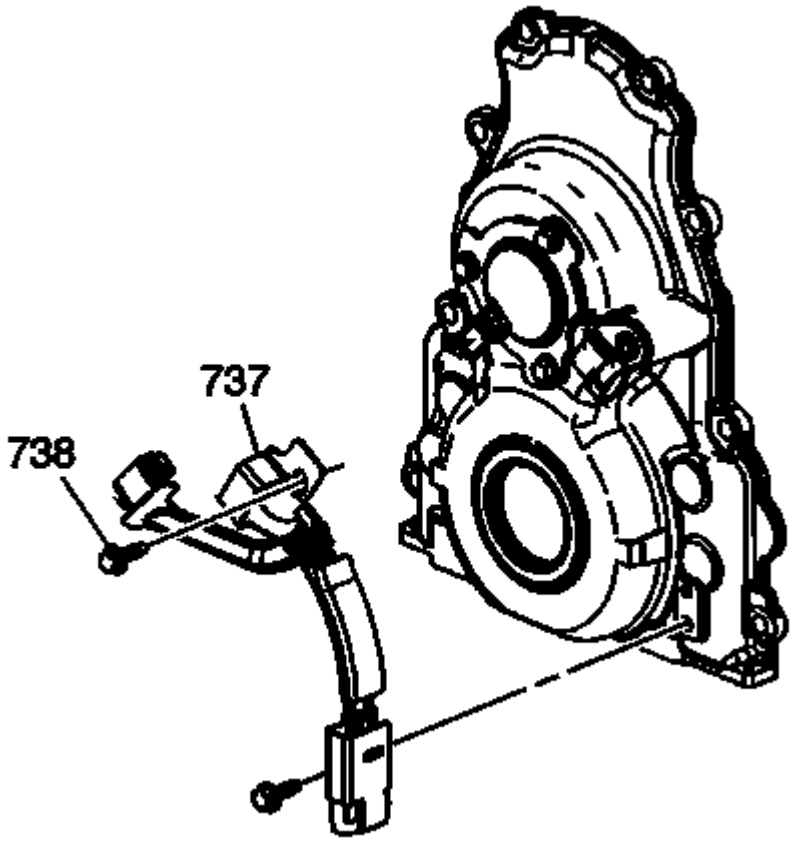

Fig. 174: View Of CMP Sensor Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Position the CMP sensor wire harness (737) to the front cover
8. Connect the CMP sensor wire harness to the CMP sensor.
9. Install the CMP sensor wire harness bolts (738).

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

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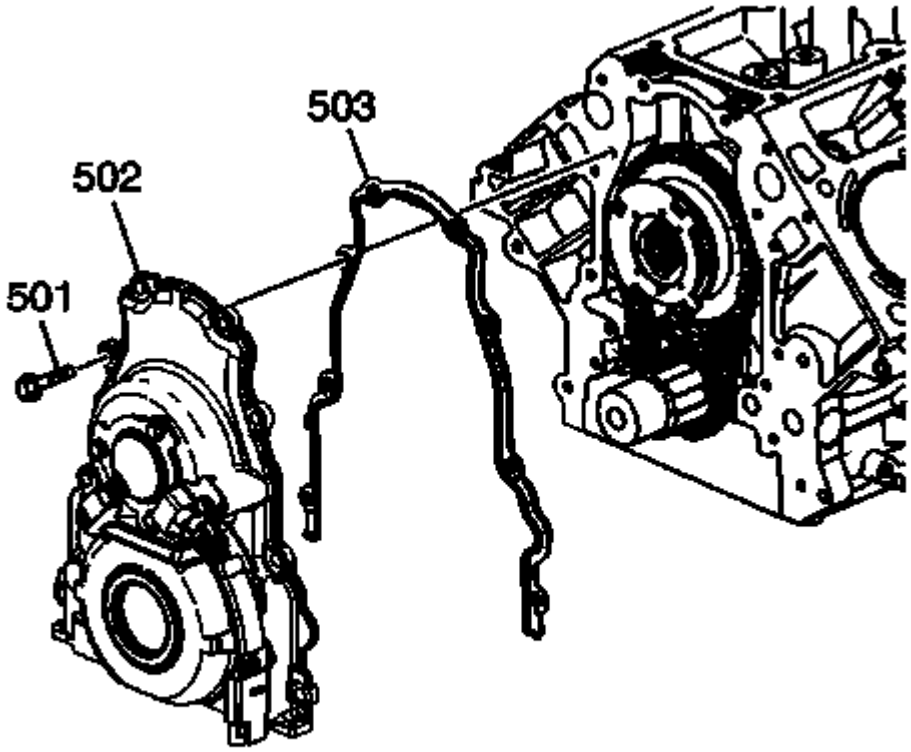

Fig. 175: View Of Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

10. 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 **Adhesives, Fluids, Lubricants, and Sealers**.
11. Position the NEW engine front cover gasket (503) and front cover (502) to the engine.
12. Install the front cover bolts (501) until snug. Do not overtighten.

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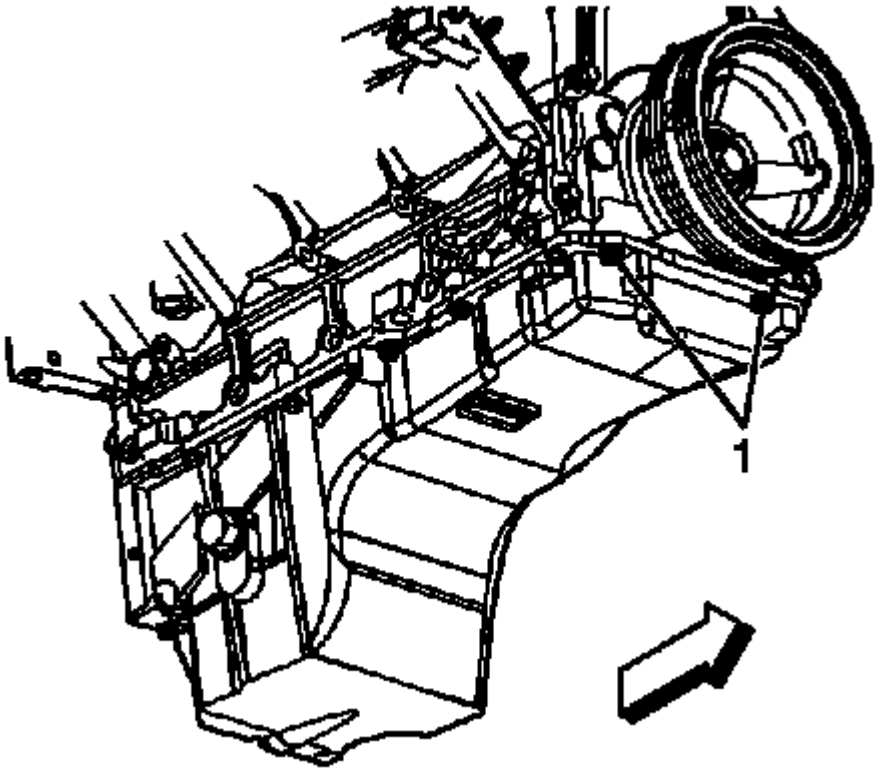

Fig. 176: View Of Oil Pan-To-Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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

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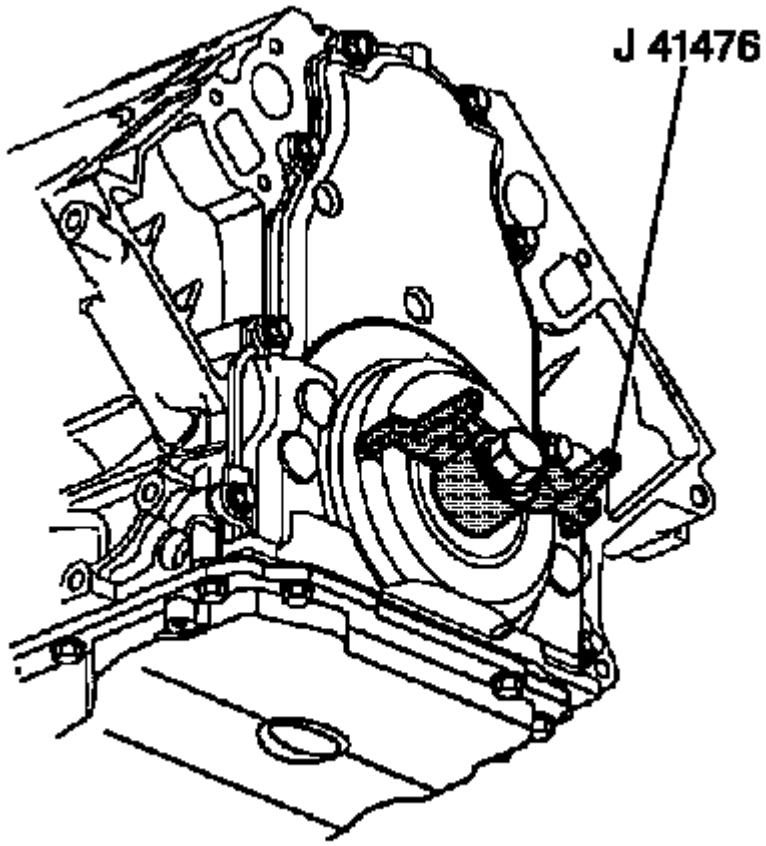

Fig. 177: View of J 41476 Installed To Front Cover
Courtesy of GENERAL MOTORS CORP.

14. Install **J 41476** to the front cover. See **Special Tools**.
15. Align the tapered legs of the **J 41476** with the machined alignment surfaces on the front cover. See **Special Tools**.
16. 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).

17. Remove the **J 41476** . See **Special Tools**.

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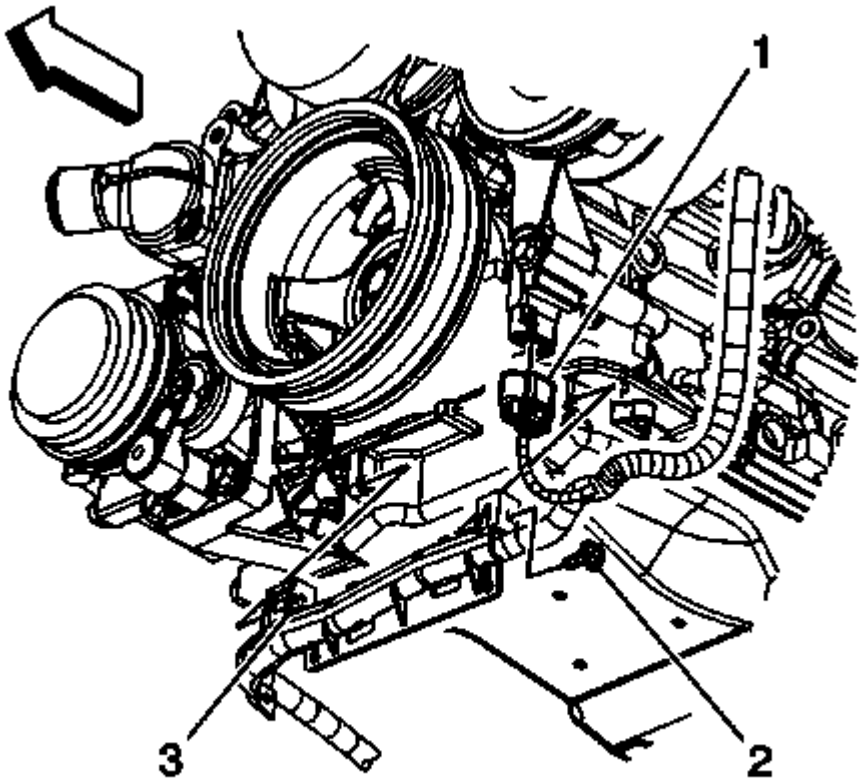

Fig. 178: View Of Electrical Connector, Cable Channel Bolt & Pin
Courtesy of GENERAL MOTORS CORP.

18. Connect the engine harness electrical connector (1) to the CMP sensor wire harness electrical connector.
19. Install a NEW crankshaft front oil seal. Refer to **Crankshaft Front Oil Seal Replacement**.
20. Install the water pump. Refer to **Water Pump Replacement (LH9)** .

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REPLACEMENT

Special Tools

- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

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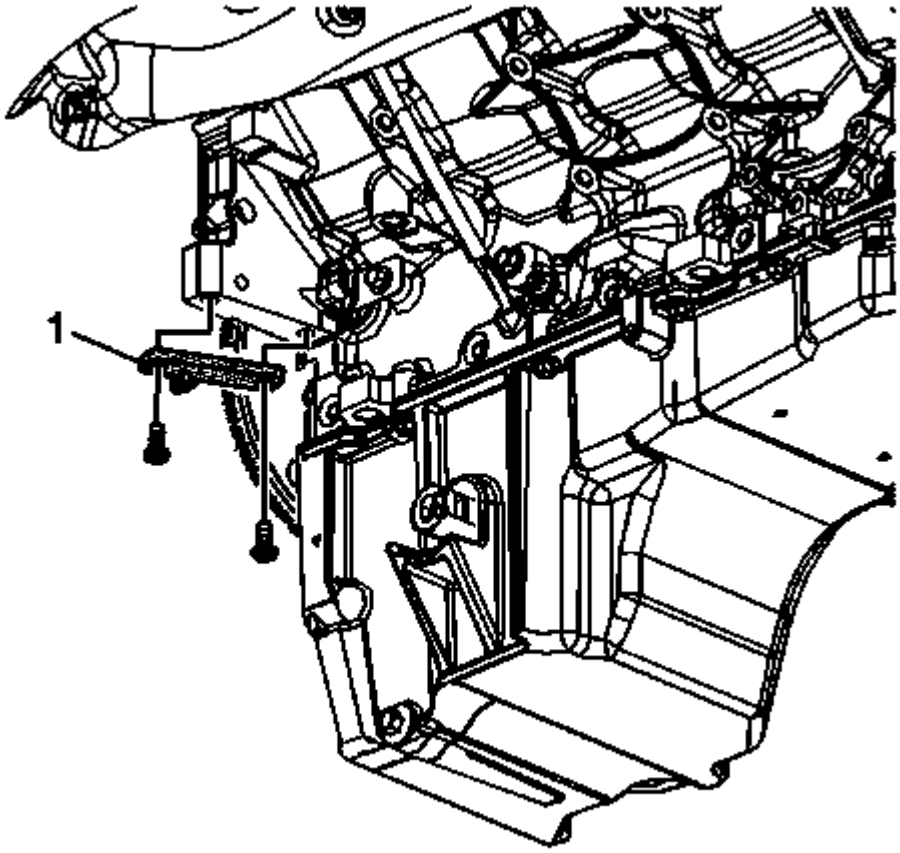

Fig. 179: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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 the **J 42386-A** bolts to 50 N. See **Special Tools**.m (37 lb ft).
2. Remove the camshaft position (CMP) actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.

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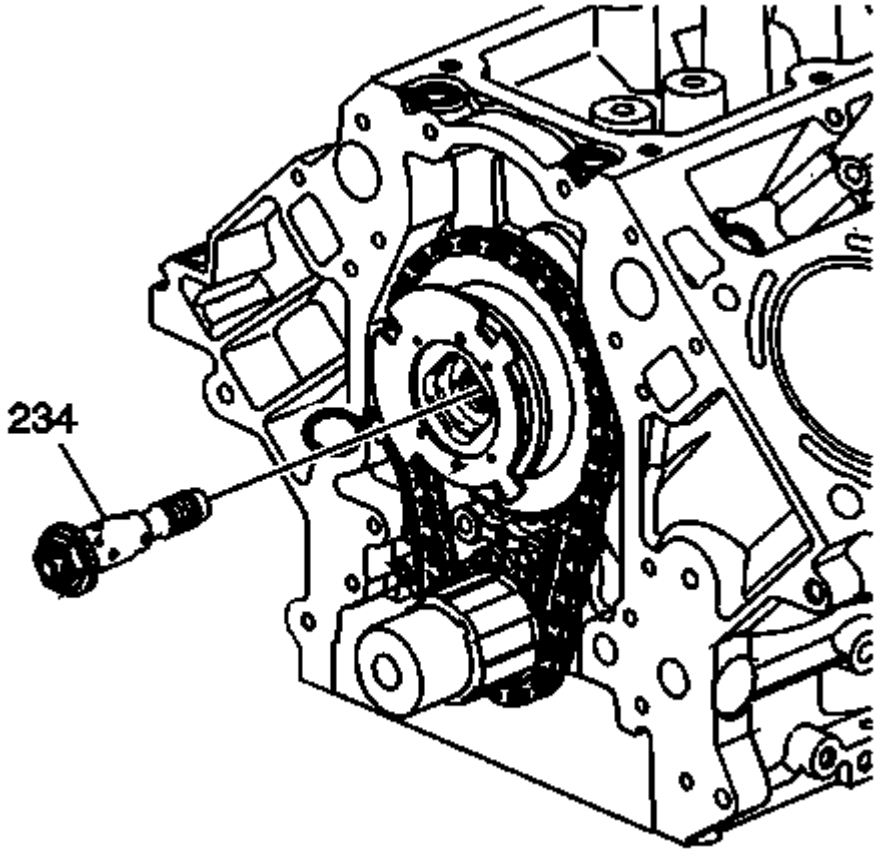

Fig. 180: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

3. Remove the CMP actuator solenoid valve (234).
4. Discard the solenoid valve.

Installation Procedure

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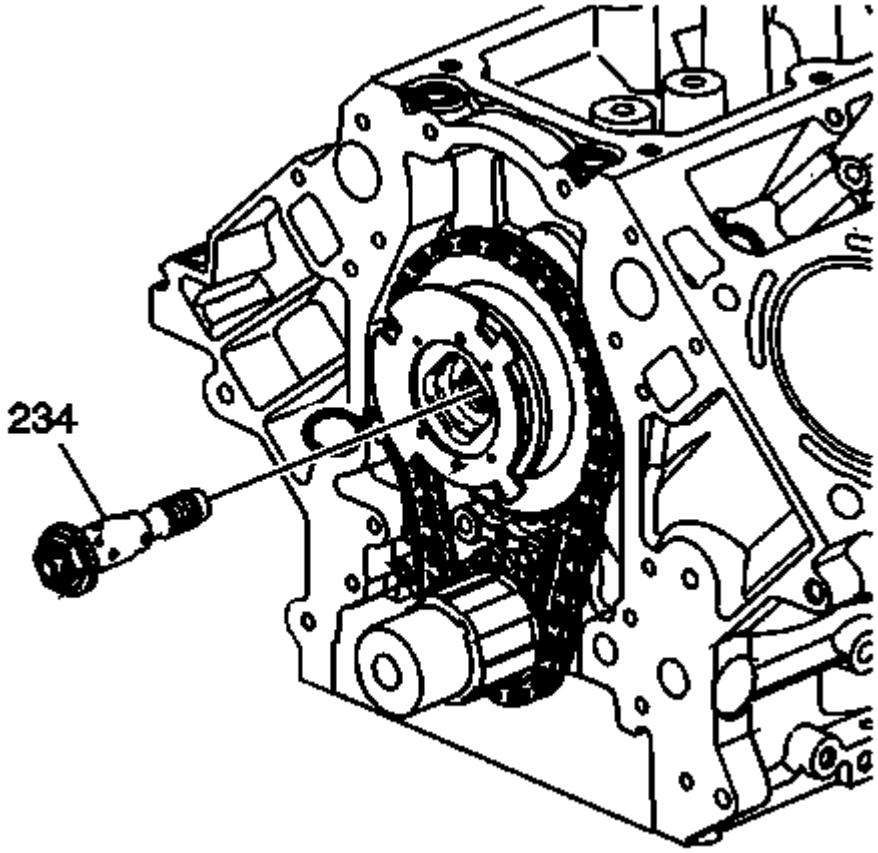

Fig. 181: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. 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.

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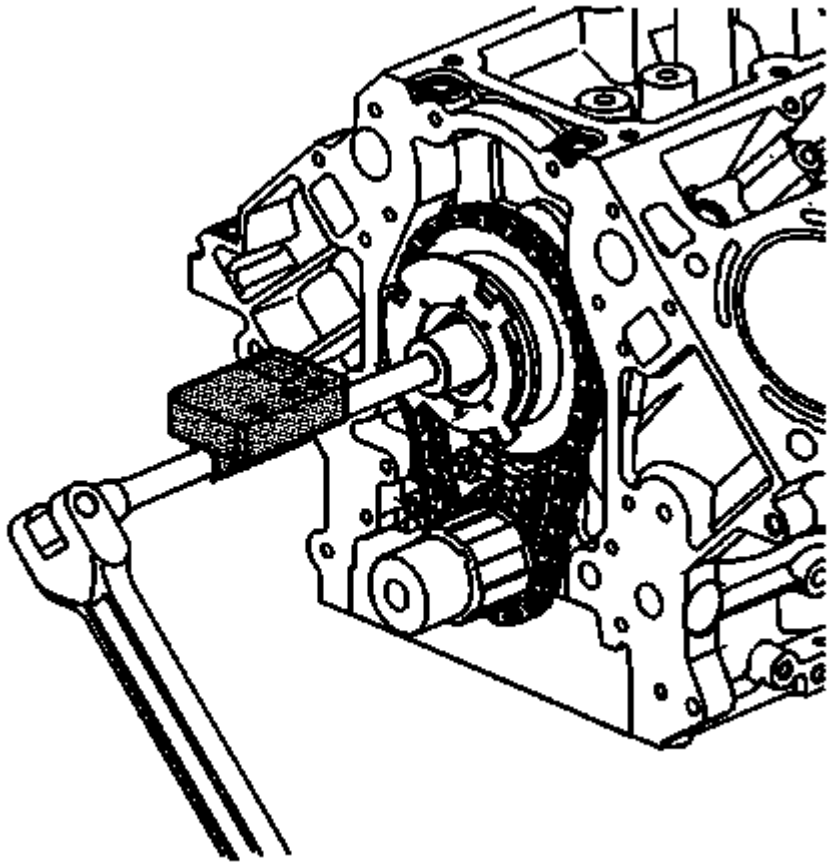

Fig. 182: Tightening The CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

2. Tighten the CMP actuator solenoid valve.
    1. Tighten the CMP actuator solenoid valve a first pass to 65 N.m (48 lb ft).
    2. Tighten the CMP actuator solenoid valve a final pass an additional 90 degrees using the **J 45059** .

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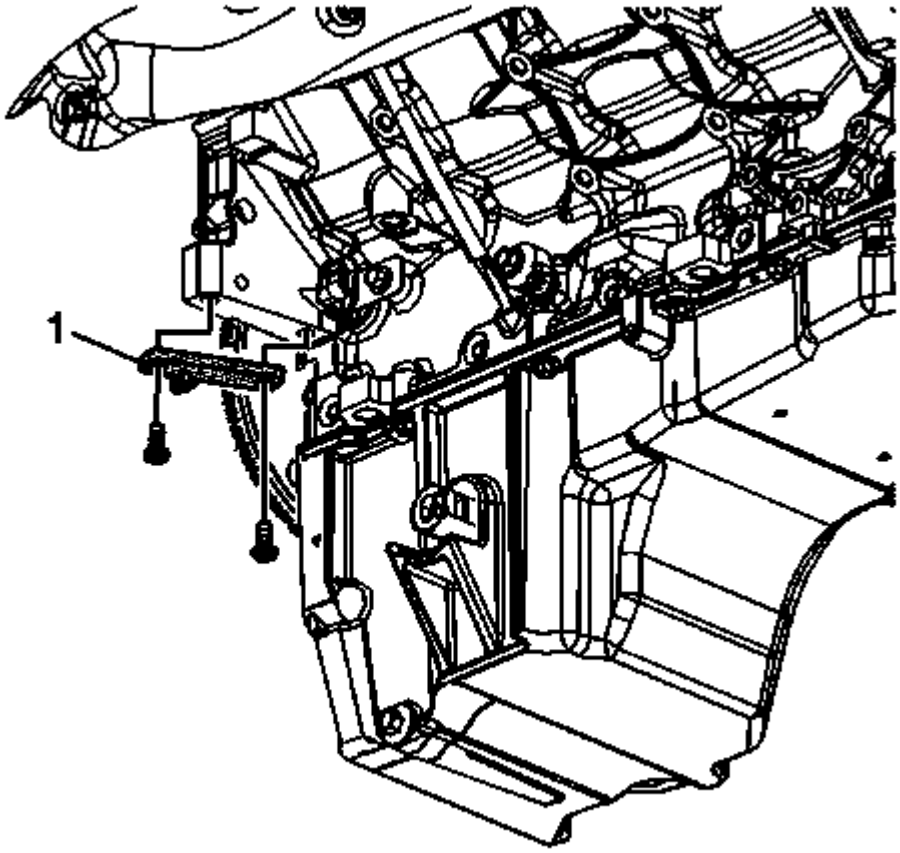

Fig. 183: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the **J 42386-A** (1). See **Special Tools**.
4. Install the CMP actuator magnet. Refer to **Camshaft Position Actuator Magnet Replacement**.

CAMSHAFT POSITION ACTUATOR REPLACEMENT

Special Tools

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

Removal Procedure

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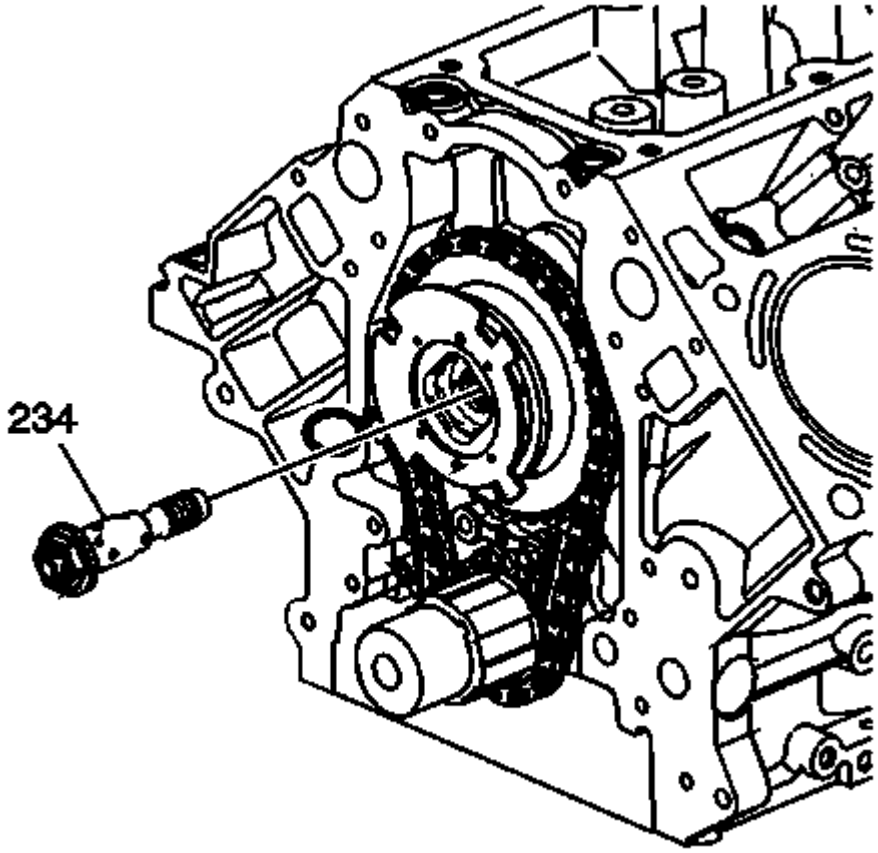

Fig. 184: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

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).

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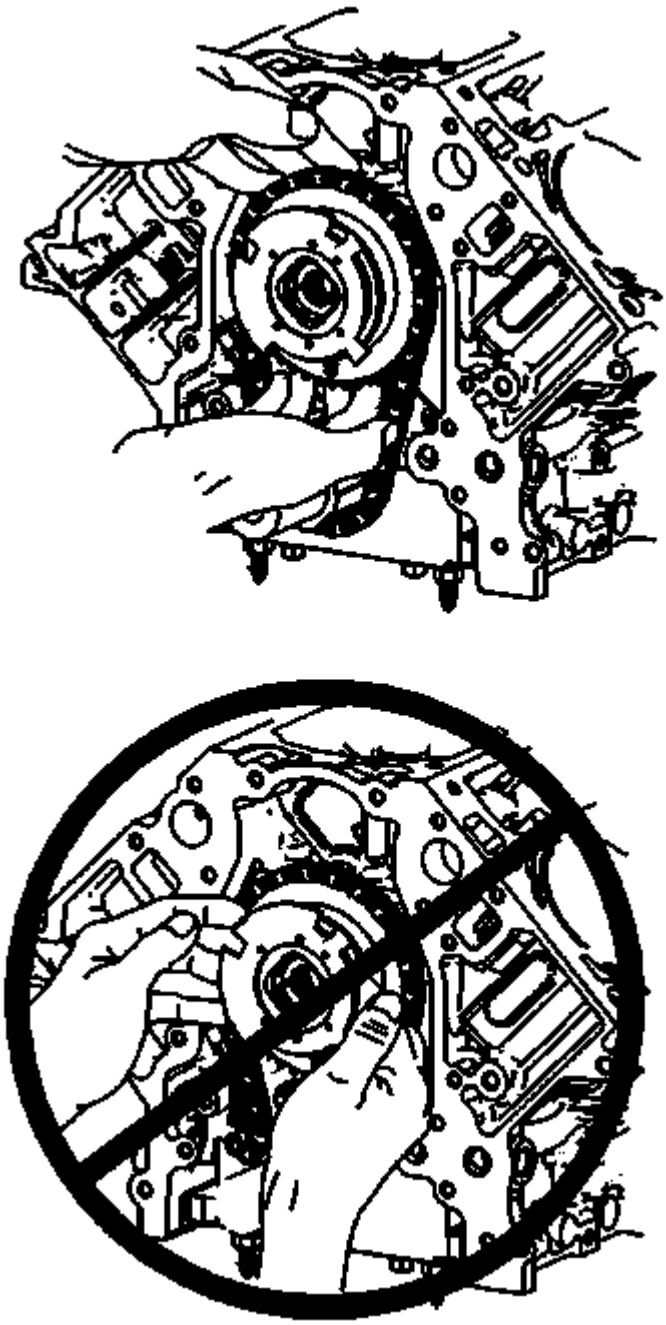

Fig. 185: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS CORP.

WARNING: 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.

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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.

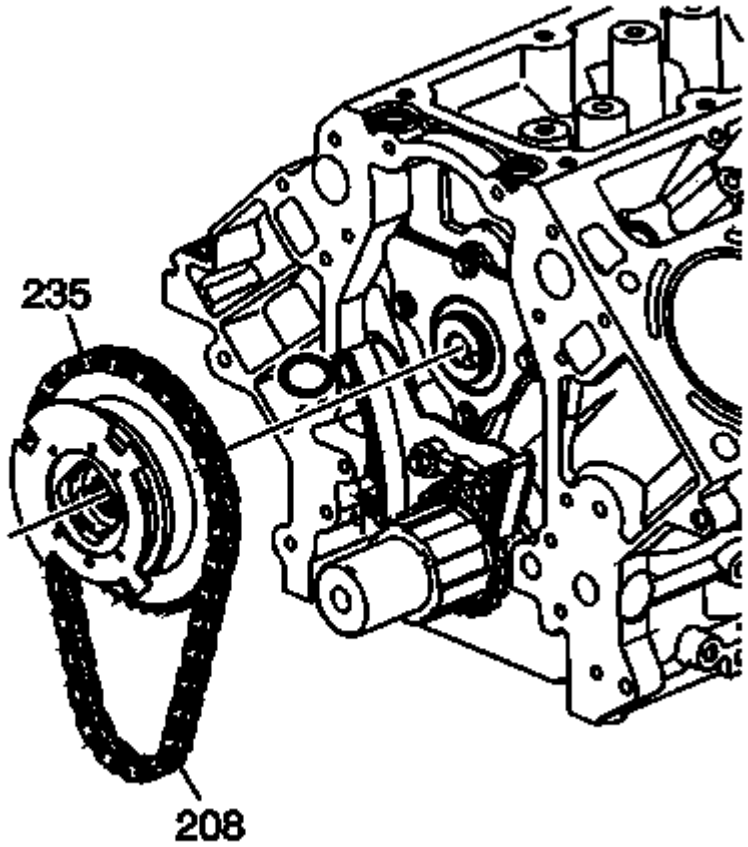

Fig. 186: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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

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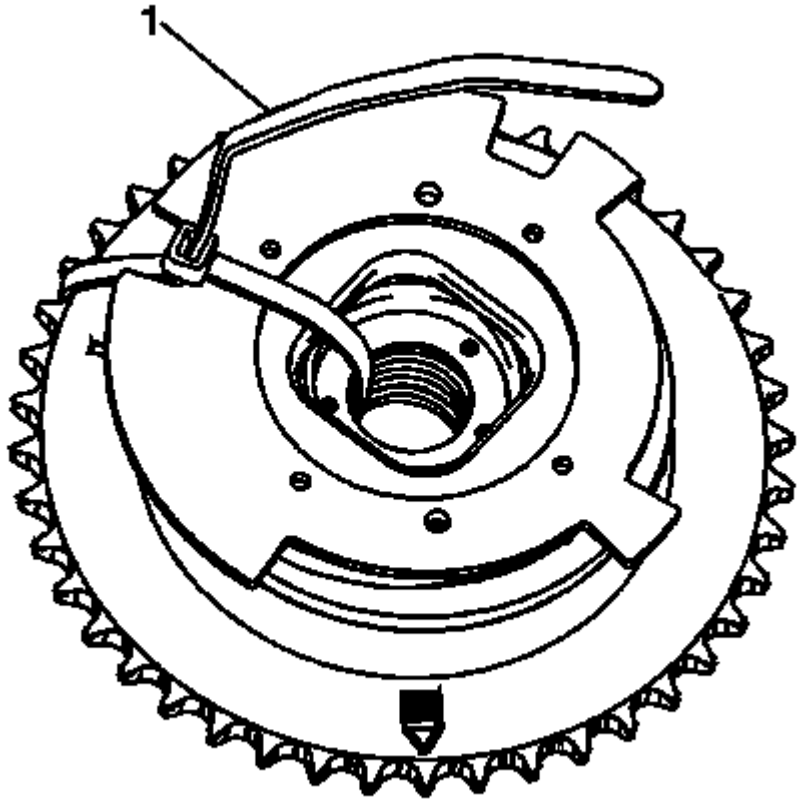

Fig. 187: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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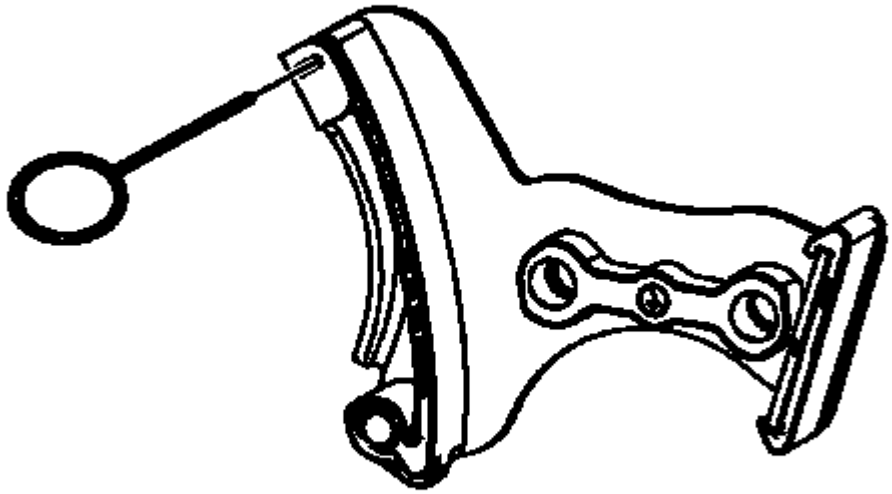

Fig. 188: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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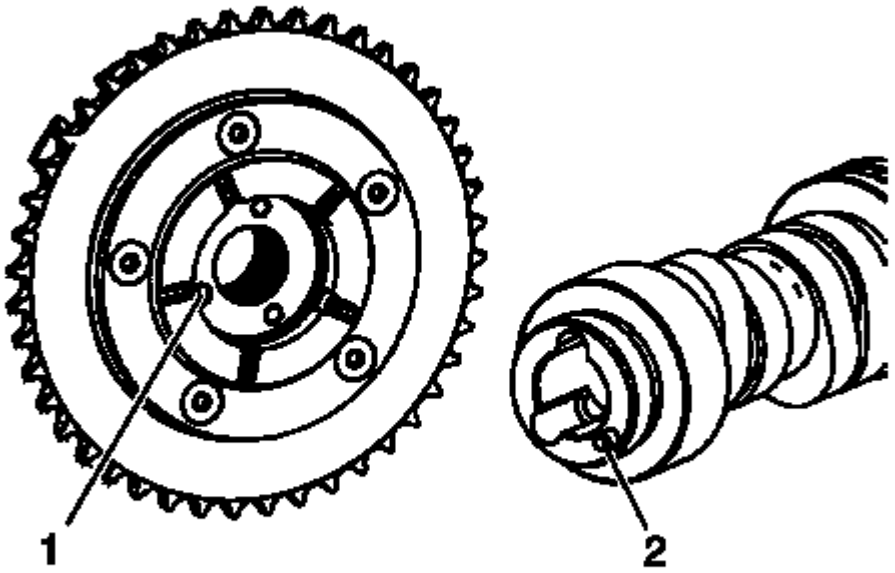

Fig. 189: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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.

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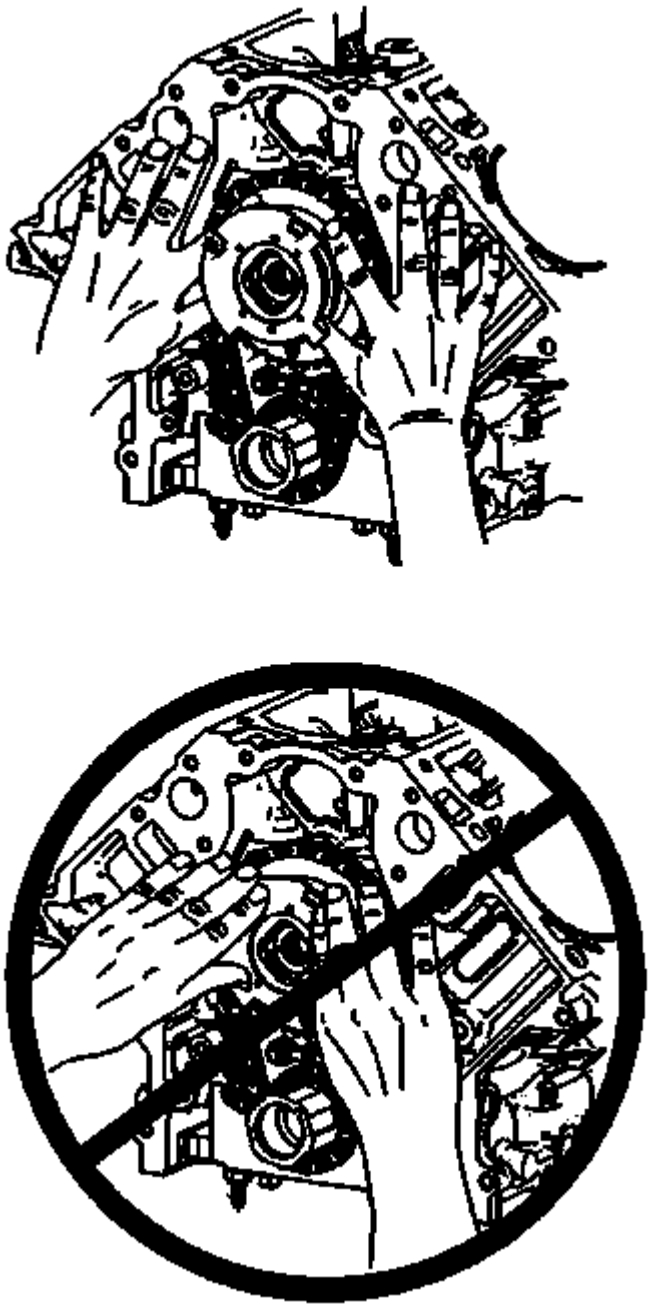

Fig. 190: Proper Installation Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: 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.

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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.

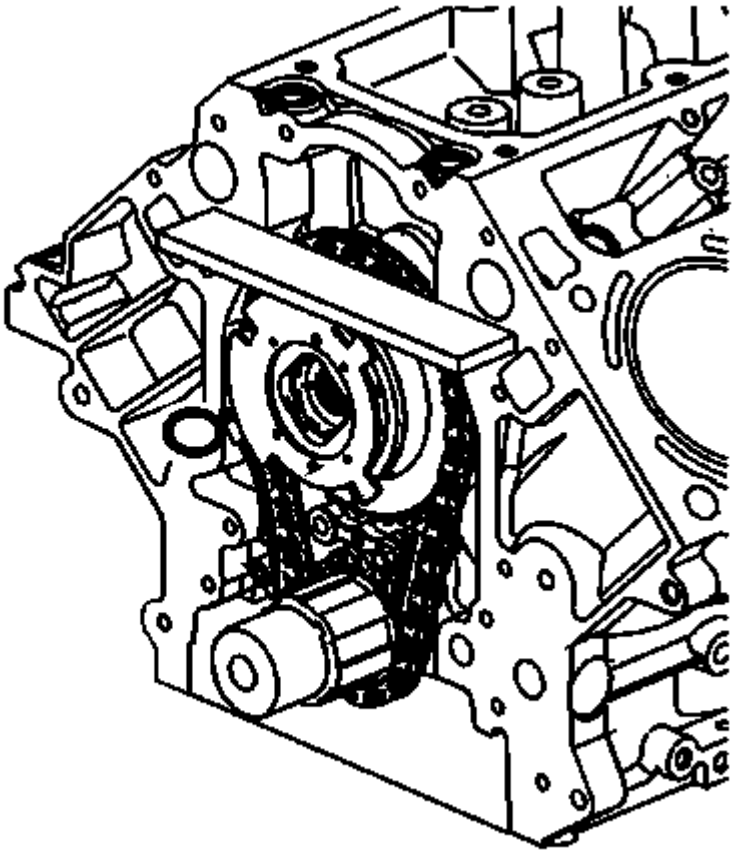

Fig. 191: Inspecting For Proper Installation Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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.

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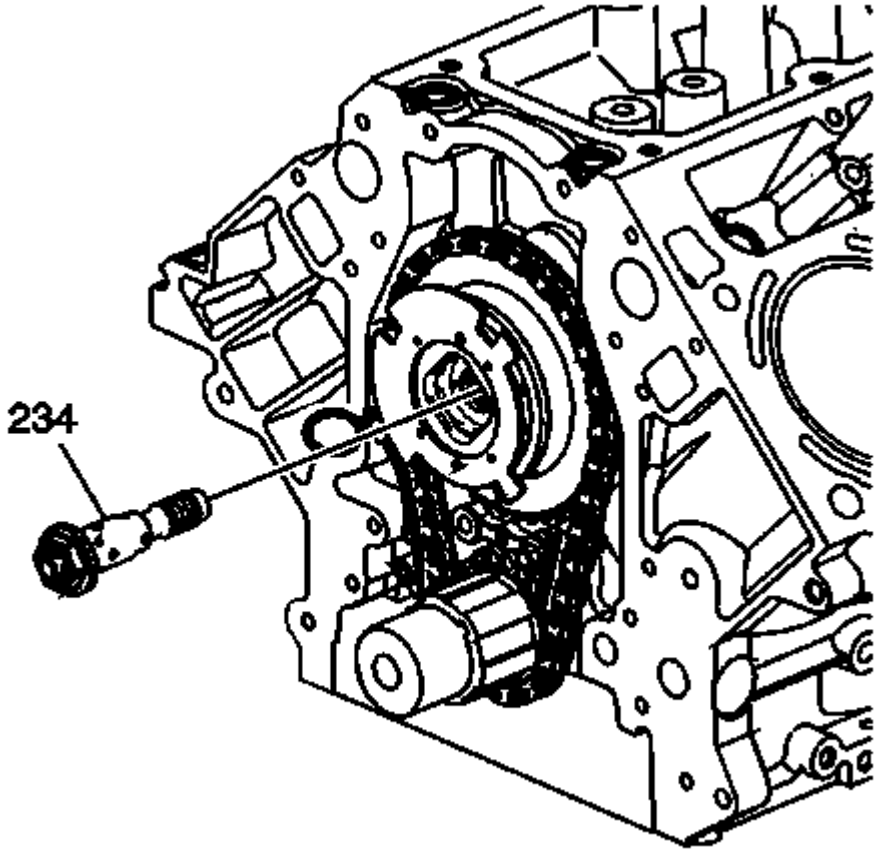

Fig. 192: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

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.

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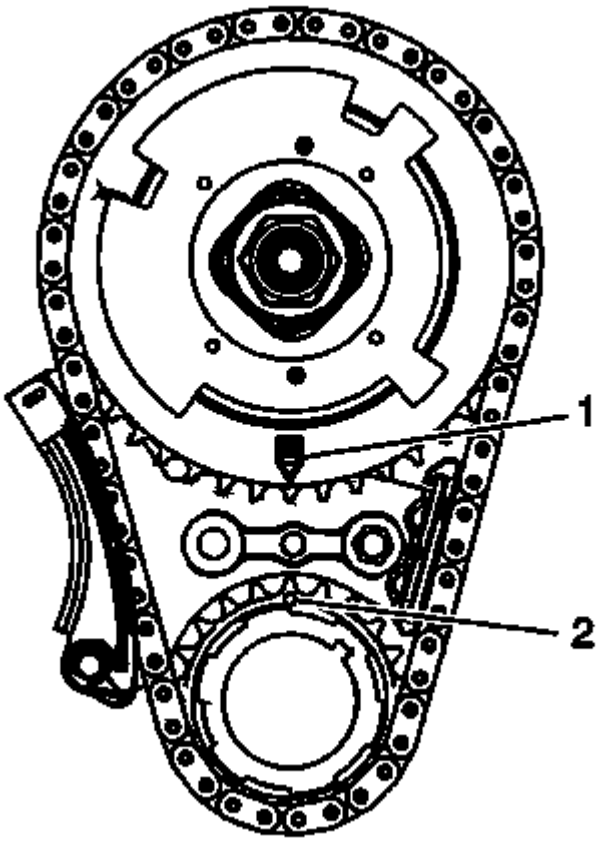

Fig. 193: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS CORP.

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.

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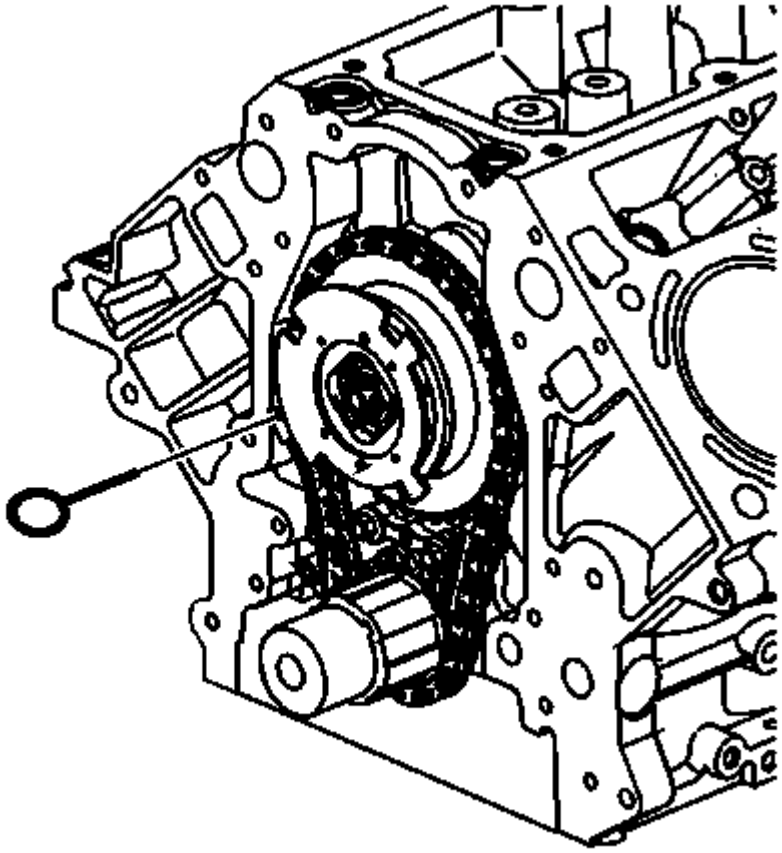

Fig. 194: View Of Special Tool EN 46330
Courtesy of GENERAL MOTORS CORP.

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

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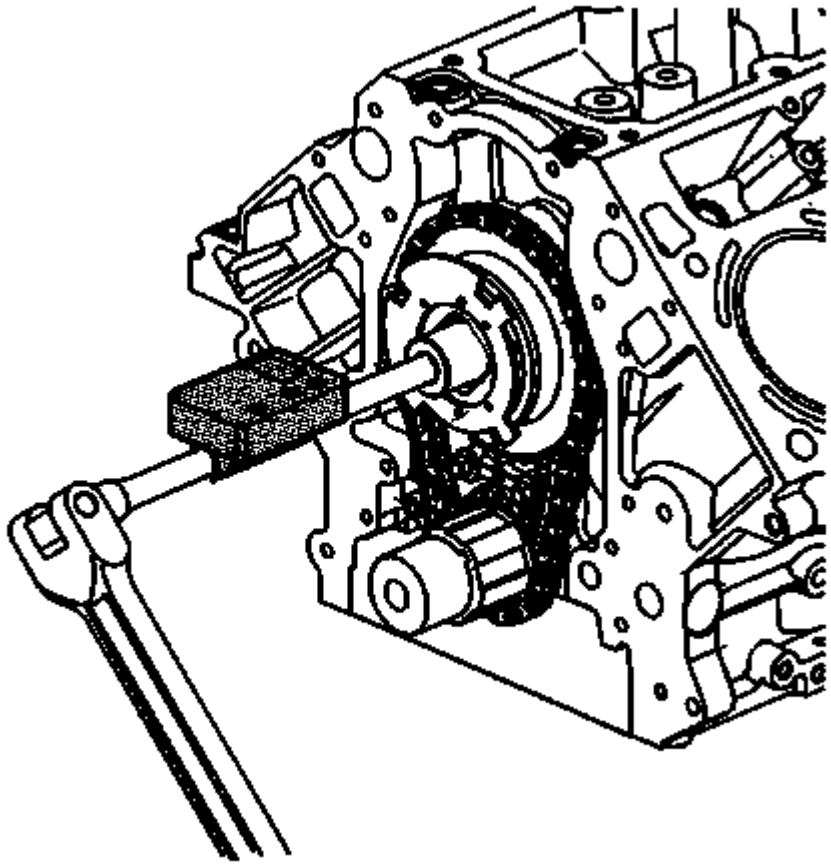

Fig. 195: Tightening The CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the CMP actuator solenoid valve.
    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** .
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

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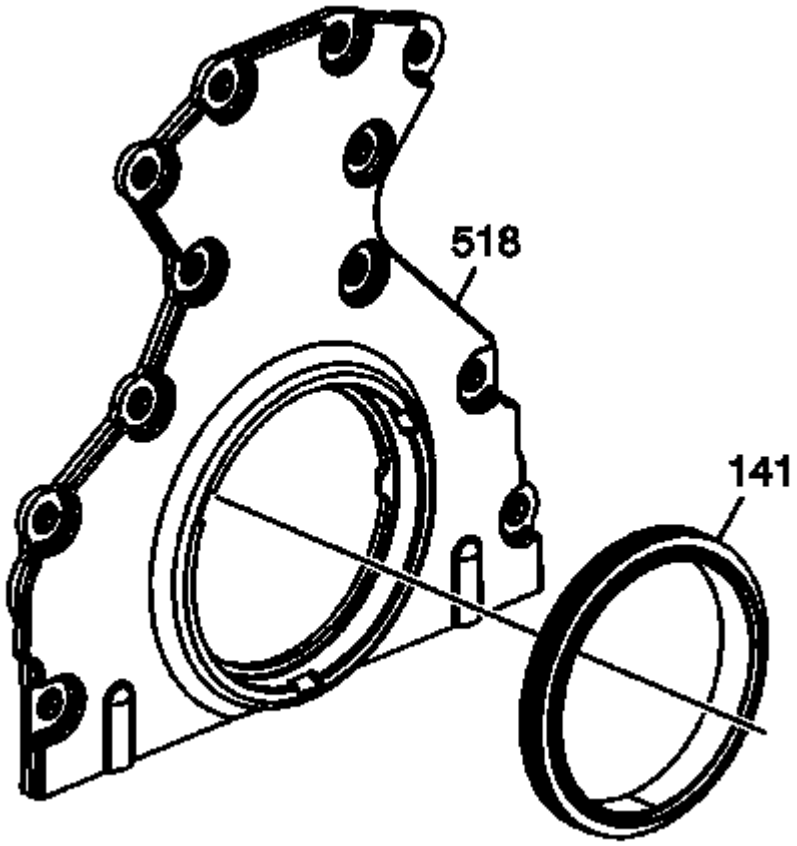

Fig. 196: Crankshaft Rear Oil Seal & Housing
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transmission flexplate, refer to **Automatic Transmission Flex Plate Replacement**.
2. Remove and discard the crankshaft rear oil seal (141).

Installation Procedure

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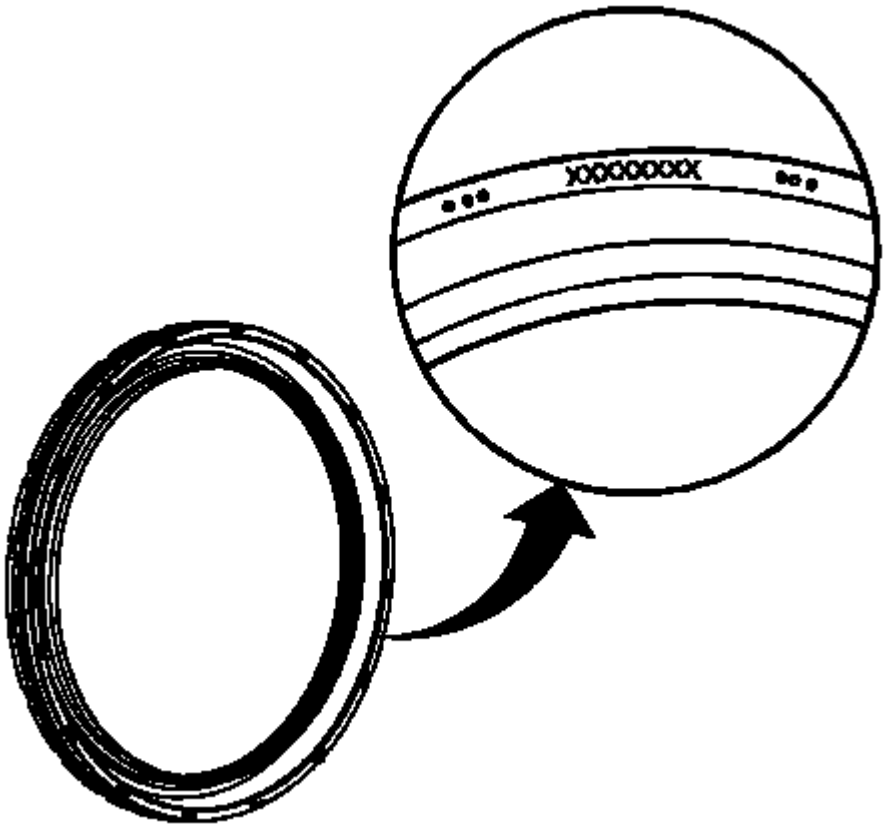

Fig. 197: Identifying Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. The part number is applied to the outside face of the seal, as shown.

1. Inspect the seal and identify the part number markings for proper orientation.

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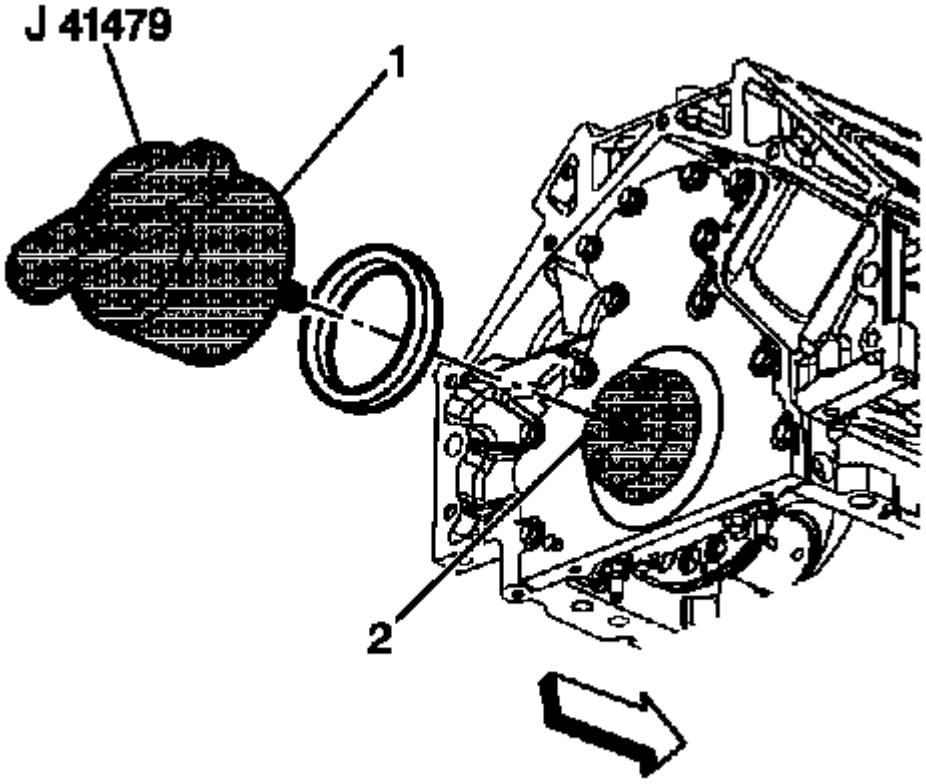

Fig. 198: View Of J 41479 Cone & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 41479** cone (2) and bolts onto the rear of the crankshaft. See **Special Tools**.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with the part number markings facing away from the engine.
5. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.
6. Align the oil seal into the tool (1).
7. Rotate the handle of the tool (1) clockwise until the seal enters the rear cover and bottoms into the cover bore.
8. Remove the **J 41479** . See **Special Tools**.
9. Install the automatic transmission flexplate. refer to **Automatic Transmission Flex Plate Replacement**.

CRANKSHAFT REAR OIL SEAL HOUSING REPLACEMENT

Special Tools

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- **J-41476:** Front and Rear Cover Alignment Tool
- **J-41479-2A:** Crankshaft Rear Oil Seal Installation Guide

Removal Procedure

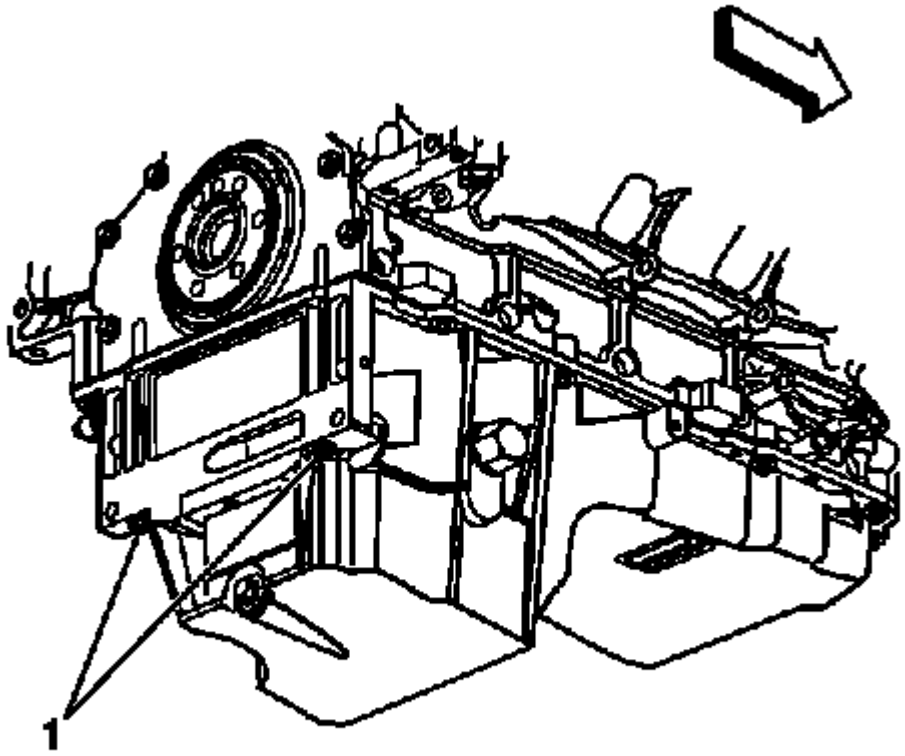

Fig. 199: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**.
2. Remove the oil pan-to-rear oil seal housing bolts (1).

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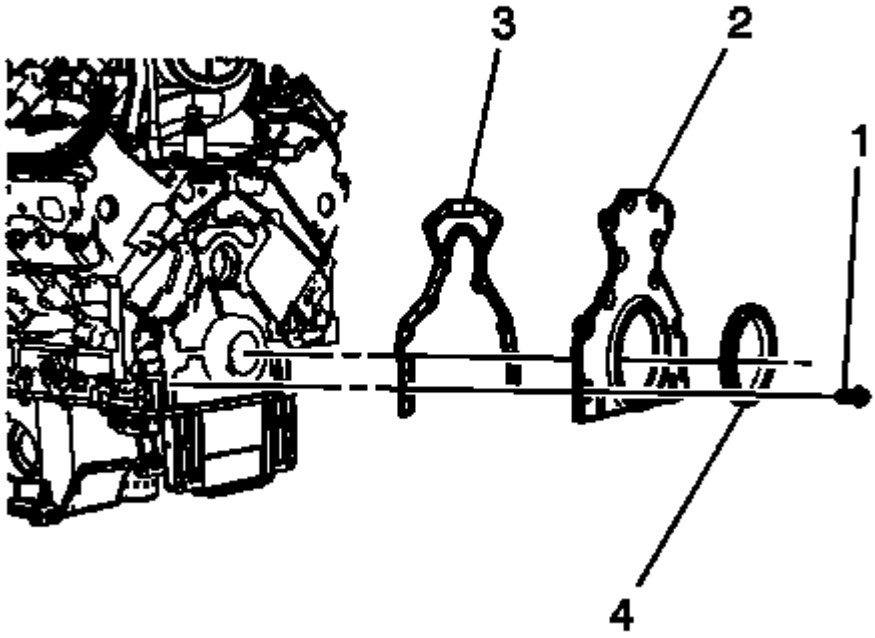

Fig. 200: Identifying Rear Oil Seal Housing Components
Courtesy of GENERAL MOTORS CORP.

3. Remove the rear oil seal housing bolts (1).
4. Remove the rear oil seal housing (2) and gasket (3). Discard the gasket.
5. Remove and discard the rear oil seal (4).

Installation Procedure

NOTE:

- **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.**
- **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**

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wear and/or engine assembly oil leaks.

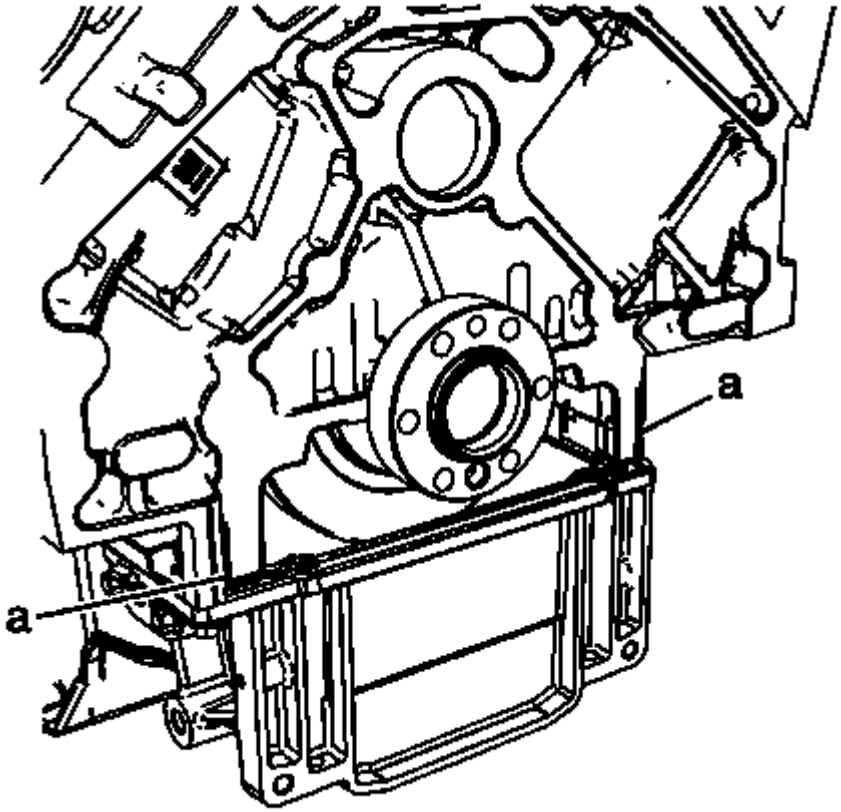

Fig. 201: Locating Joints At Rear Of Block/Pan
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.2 in) bead of sealant, 20 mm (0.8 in) to the 2 joints (a) at the rear of the block/pan. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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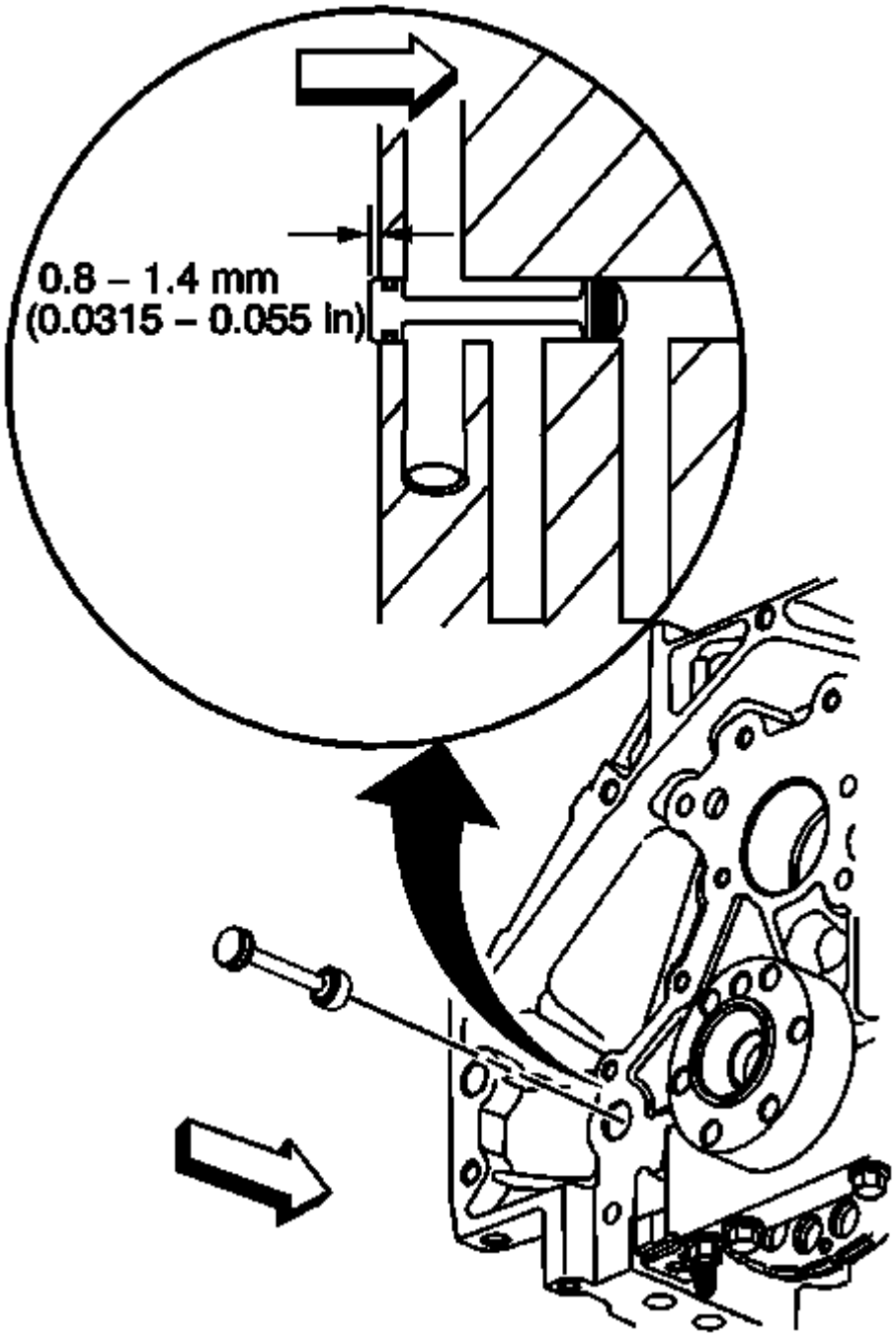

Fig. 202: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

2. Inspect the rear oil gallery plug for proper installation.

Installation Procedure - Cover with Seal

1. Install the **J-41479-2A:** guide cone and bolts onto the rear of the crankshaft.

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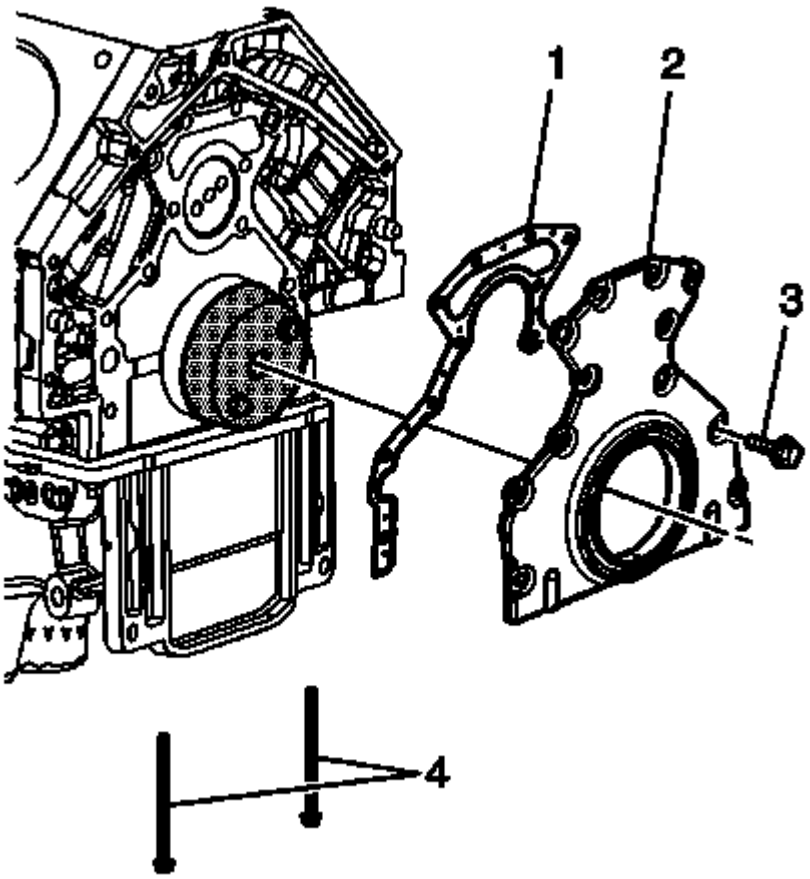

Fig. 203: Identifying Rear Housing Components
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW rear housing gasket (1), rear housing with seal (2), rear housing-to-engine bolts (3) and oil pan-to-rear housing bolts (4).

CAUTION: Refer to Fastener Caution .

3. Tighten the rear housing-to-engine bolts (3) until snug. Do not overtighten.
4. Tighten the oil pan-to-rear housing bolts (4) to 12 N.m (106 lb in).
5. Tighten the rear housing-to-engine bolts (3) to 30 N.m (22 lb ft).
6. Remove the **J-41479-2A:** guide.
7. Install the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**.

Installation Procedure - Cover without Seal

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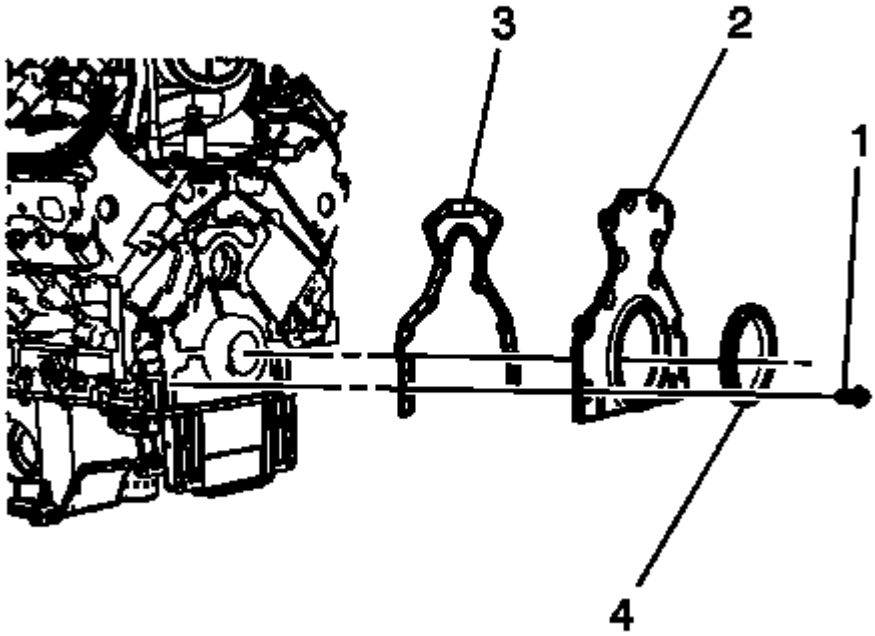

Fig. 204: Identifying Rear Oil Seal Housing Components
Courtesy of GENERAL MOTORS CORP.

1. Position a NEW rear oil seal housing gasket (3) and the housing (2) to the engine.
2. Install the rear oil seal housing bolts (1) until snug. Do not overtighten.
3. Rotate the crankshaft until 2 opposing flywheel bolts holes are parallel to the oil pan surface.

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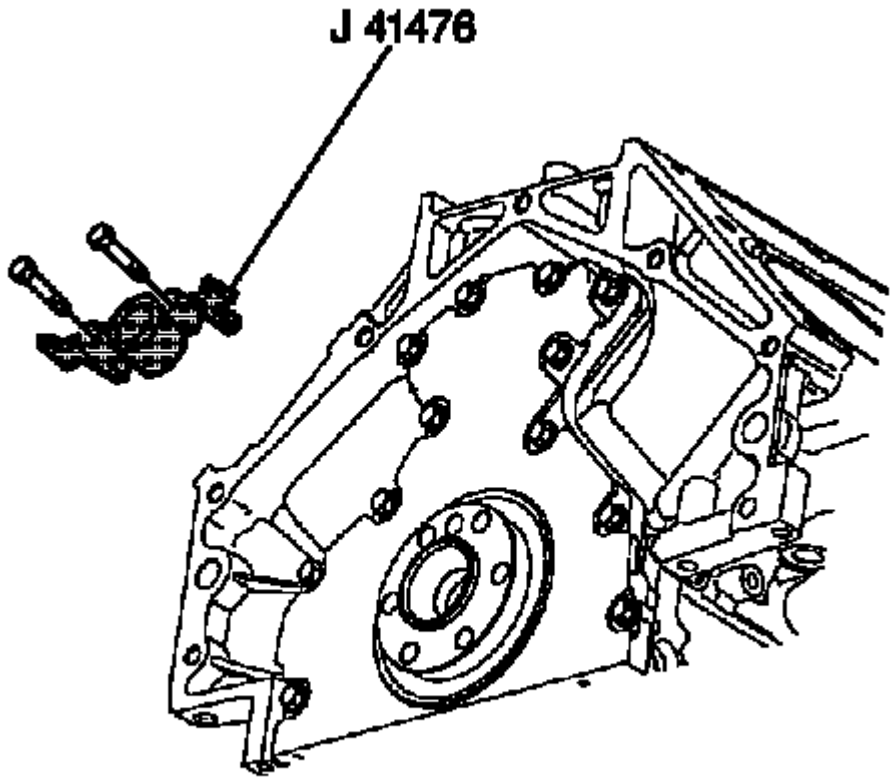

Fig. 205: View Of J 41476
Courtesy of GENERAL MOTORS CORP.

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

4. Install the **J-41476:** tool and bolts onto the rear of the crankshaft.
5. Tighten the **J-41476:** tool bolts until snug. Do not overtighten.

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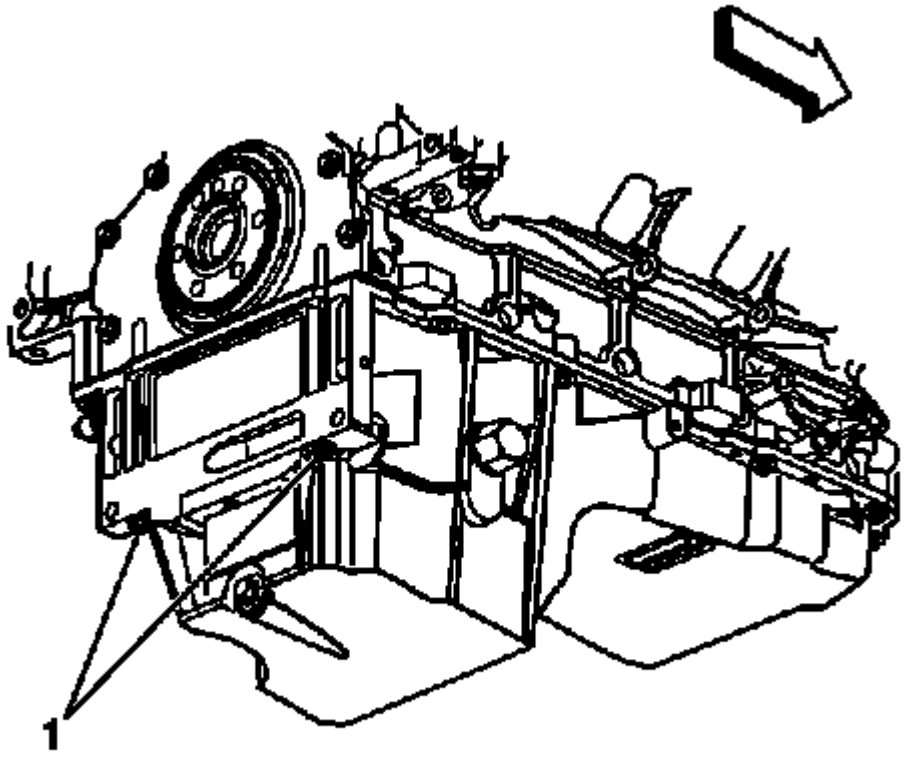

Fig. 206: View Of Oil Pan-To-Rear Cover Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan-to-rear oil seal housing bolts (1).
    1. Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in).
    2. Tighten the rear oil seal housing-to-engine bolts to 30 N.m (22 lb ft).
7. Remove the **J-41476:** tool.
8. Install a NEW crankshaft rear oil seal. Refer to **Crankshaft Rear Oil Seal Replacement**.
9. Install the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**.

OIL FILTER ADAPTER REPLACEMENT

Removal Procedure

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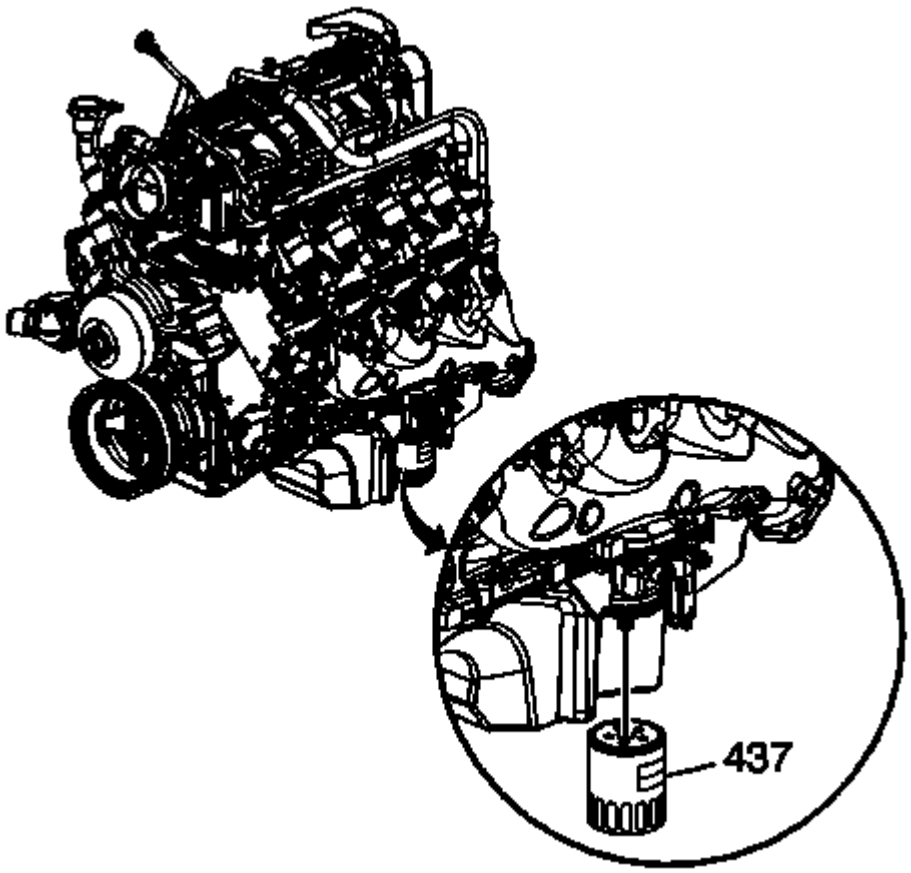

Fig. 207: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a suitable drain pan under the oil filter.
3. Remove the oil filter (437).

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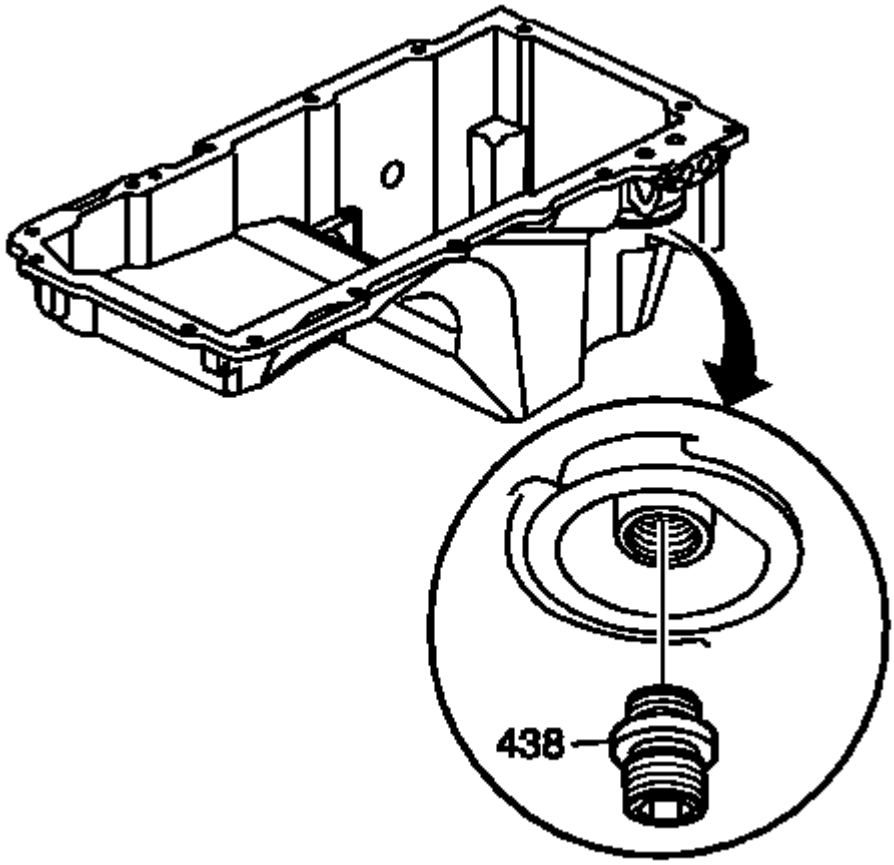

Fig. 208: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil filter adapter (438).

Installation Procedure

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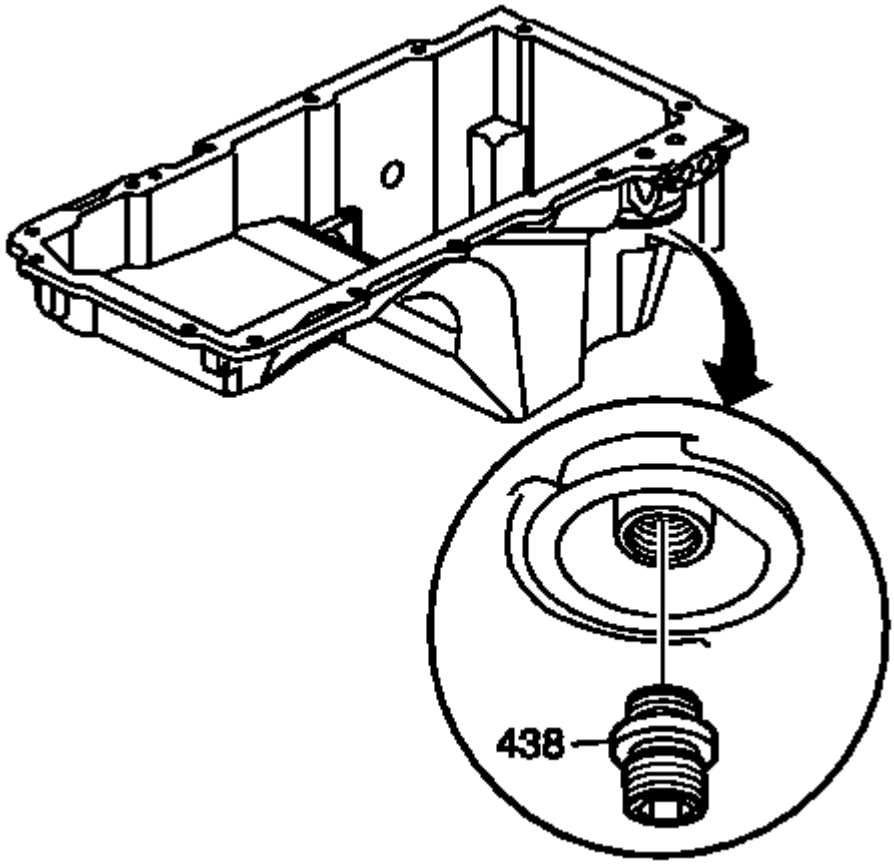

Fig. 209: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the oil filter adapter (438).

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

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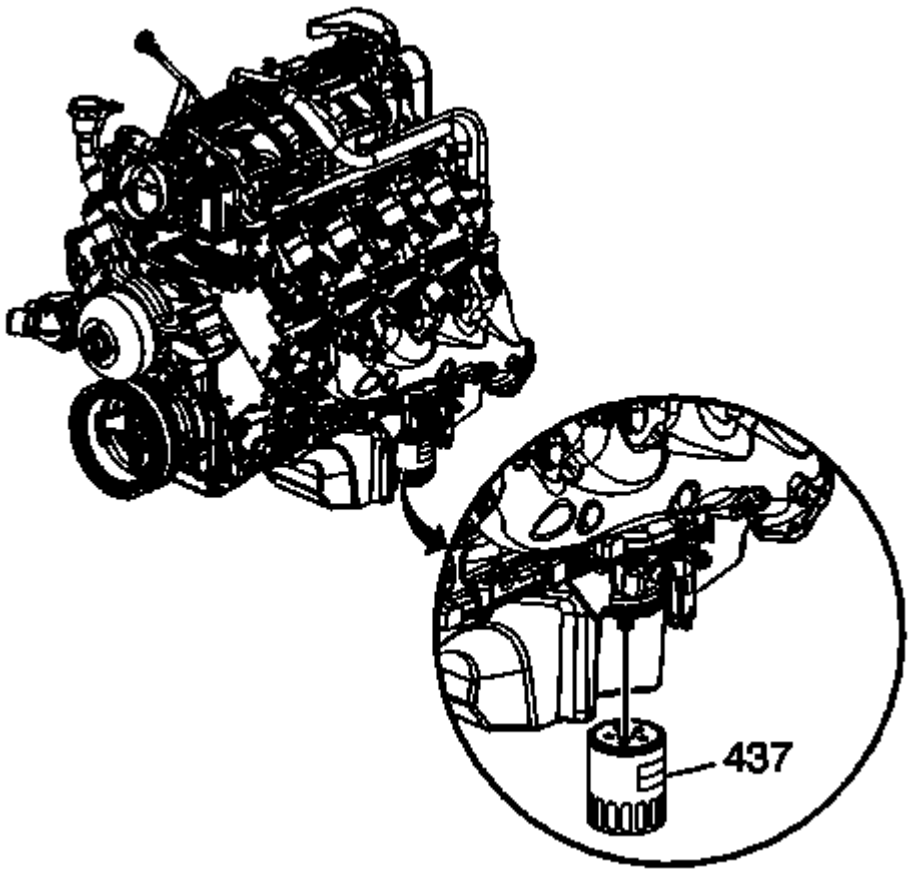

Fig. 210: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the oil filter seal with clean engine oil.
3. Install the oil filter (437).

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

4. Lower the vehicle.
5. Refill the engine oil. Refer to **Approximate Fluid Capacities** and/or **Fluid and Lubricant Recommendations (USA and Canada)** .
6. Start the engine and inspect for leaks.

OIL PAN REPLACEMENT

Removal Procedure

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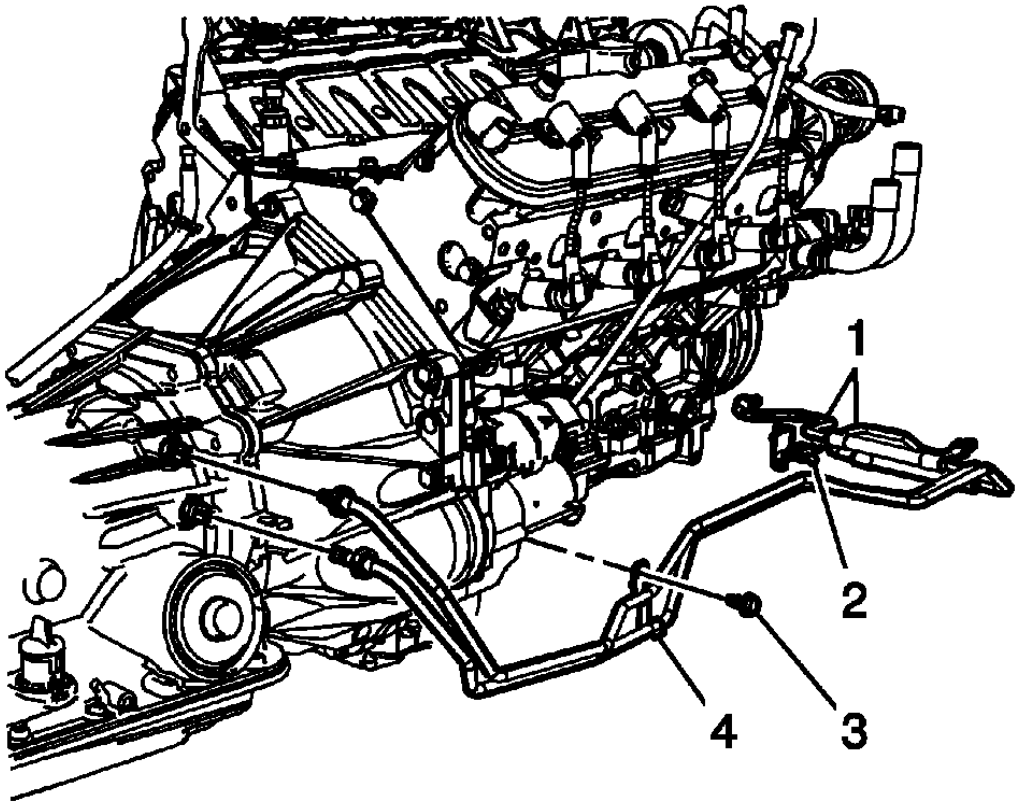

Fig. 211: Transmission Cooler Lines And Brackets
Courtesy of GENERAL MOTORS CORP.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
3. Remove the front differential, if equipped. Refer to **Differential Carrier Assembly Replacement** .
4. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
5. Remove the transmission oil cooler lines (1) from the retainer (2).
6. Remove the transmission oil cooler line retaining bracket bolt (3) and bracket (4).
7. Remove the inner axle shaft. Refer to **Front Drive Axle Inner Shaft and Inner Shaft Housing Replacement** .
8. Remove the starter. Refer to **Starter Replacement** .
9. Remove the flywheel inspection cover from the left side of the transmission.

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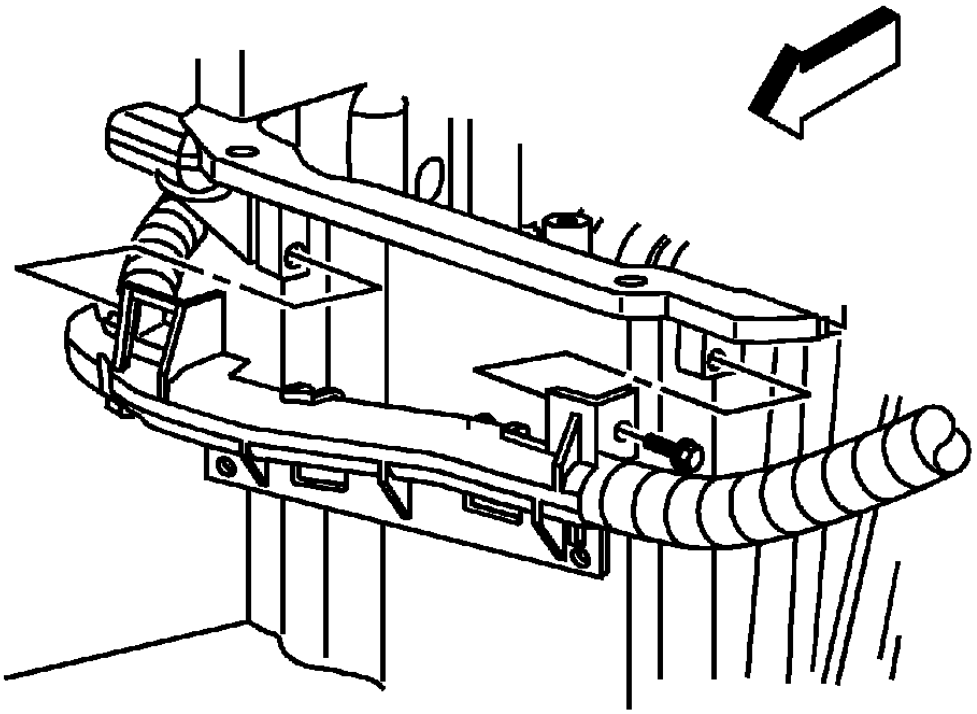

Fig. 212: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

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

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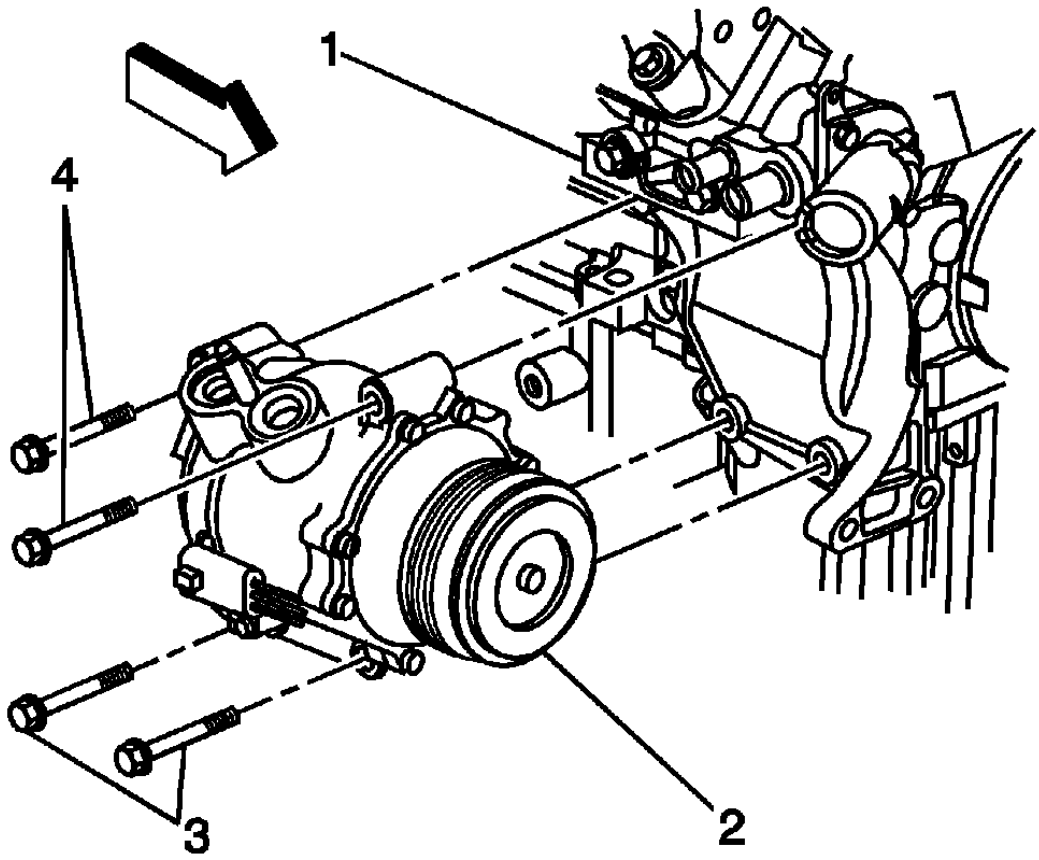

Fig. 213: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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

Position the A/C compressor aside and secure.

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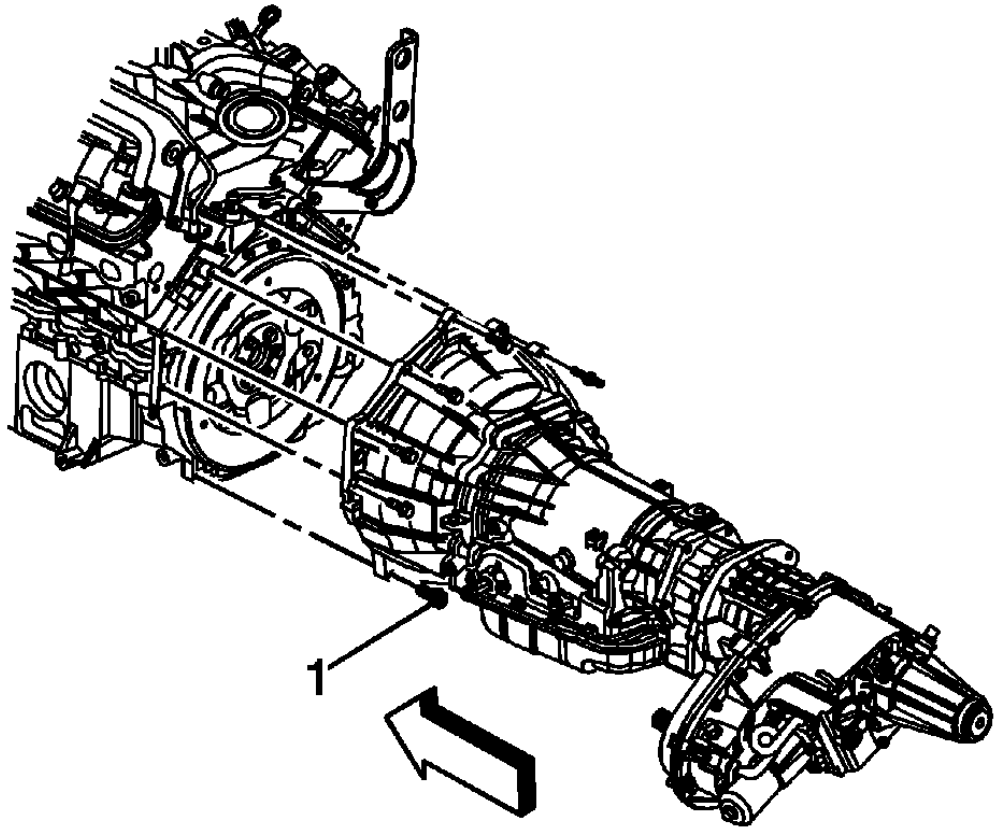

Fig. 214: View Of Lower Bellhousing Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the 2 lower bellhousing bolts (1).

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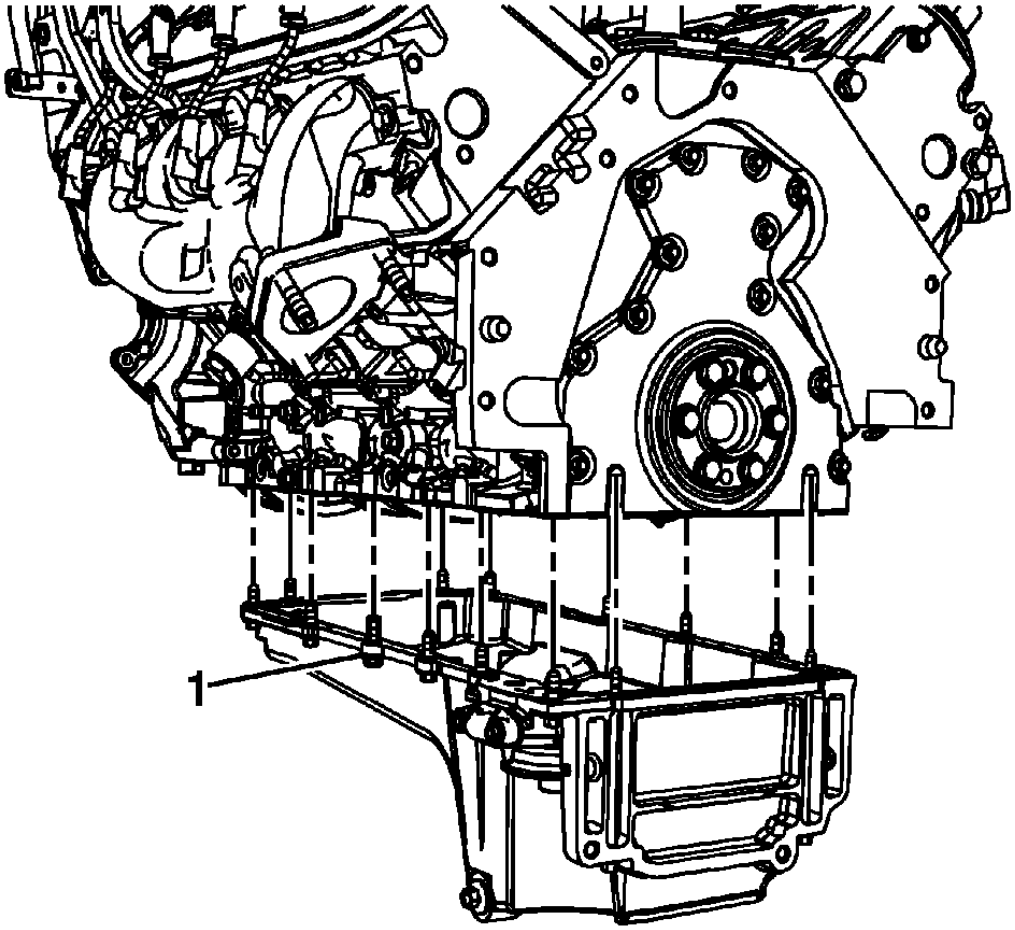

Fig. 215: Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

15. Remove the oil pan bolts (1).
16. Remove the oil pan by tilting the rear of the oil pan down to clear the transmission, pull the oil pan rearward past the front wire harness, then lower the oil pan clear of the vehicle.

NOTE:

- **The oil pan gasket is reusable. It is NOT necessary to remove the oil pan gasket unless damaged.**
- **DO NOT allow foreign material to enter the oil passages of the oil pan, cap or cover the openings as required.**

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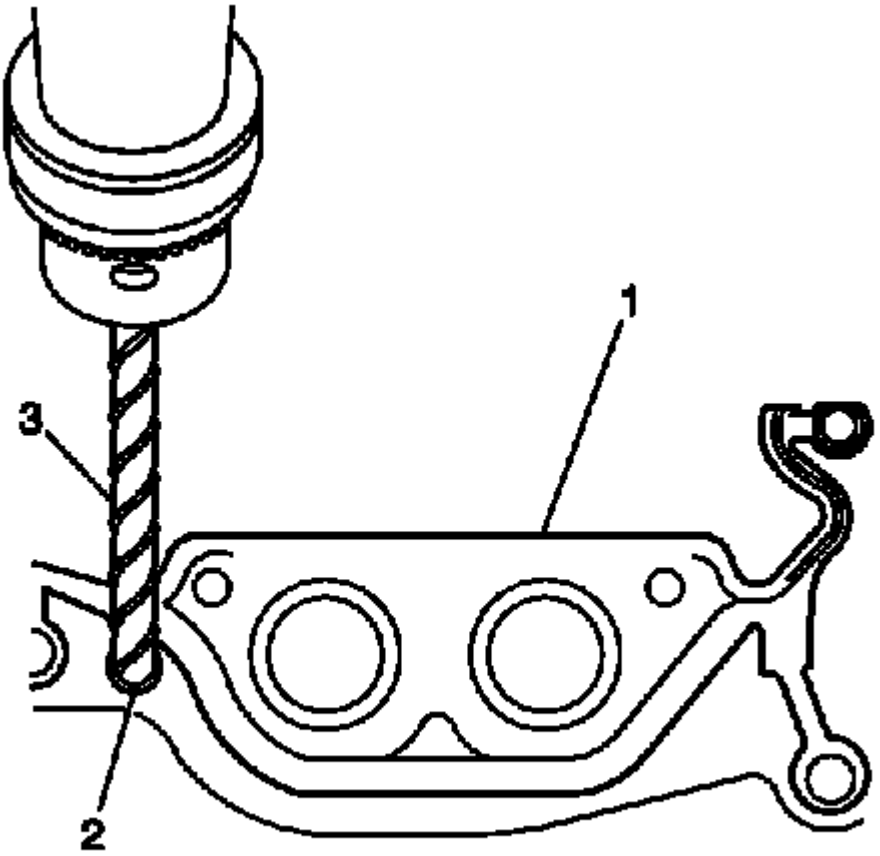

Fig. 216: Drilling Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

NOTE:

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

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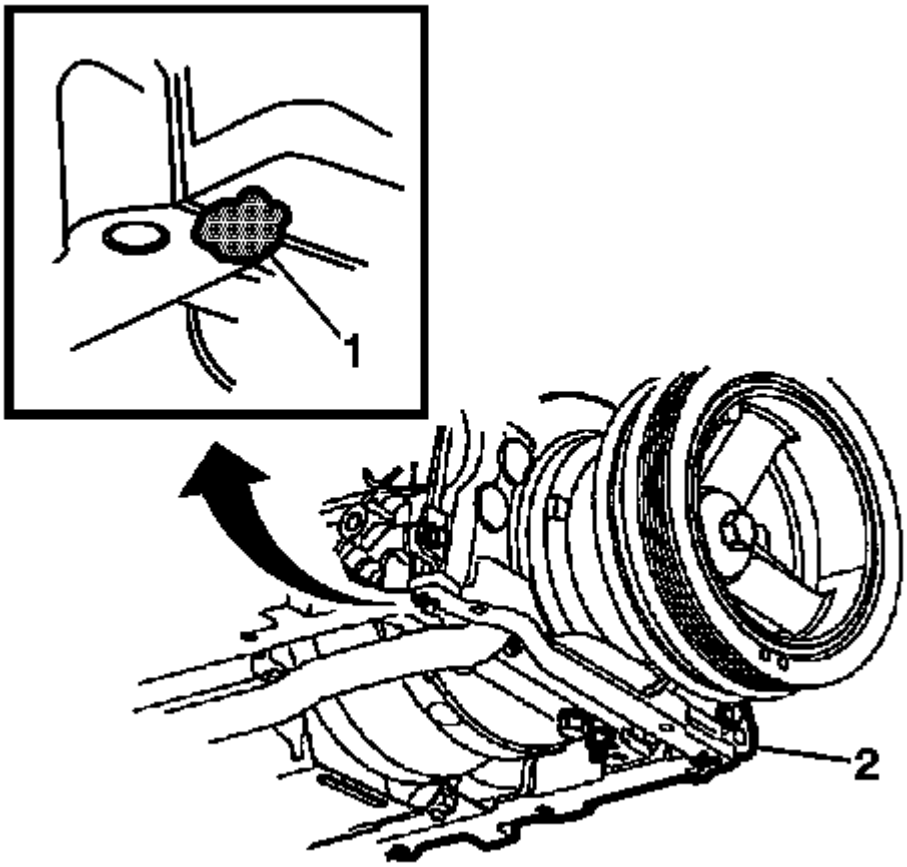

Fig. 217: View Of Sealant Applied To Front Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

1. Apply a 5 mm (0.2 in) bead of sealant 20 mm (0.8 in) long to the engine block. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number. Apply the sealant directly onto the tabs of the front cover gasket that protrudes into the oil pan surface.

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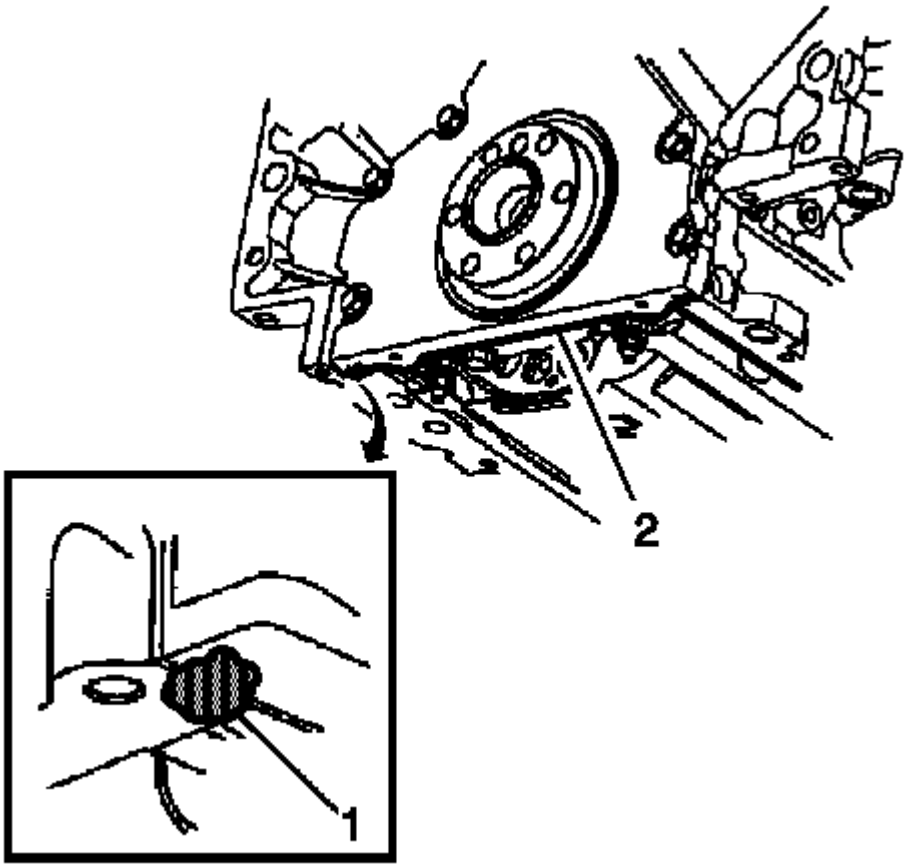

Fig. 218: View Of Sealant Applied To Rear Oil Pan-To-Engine Block Junction
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.2 in) bead of sealant 20 mm (0.8 in) long to the engine block. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number. Apply the sealant directly onto the tabs of the rear cover gasket that protrudes into the oil pan surface.

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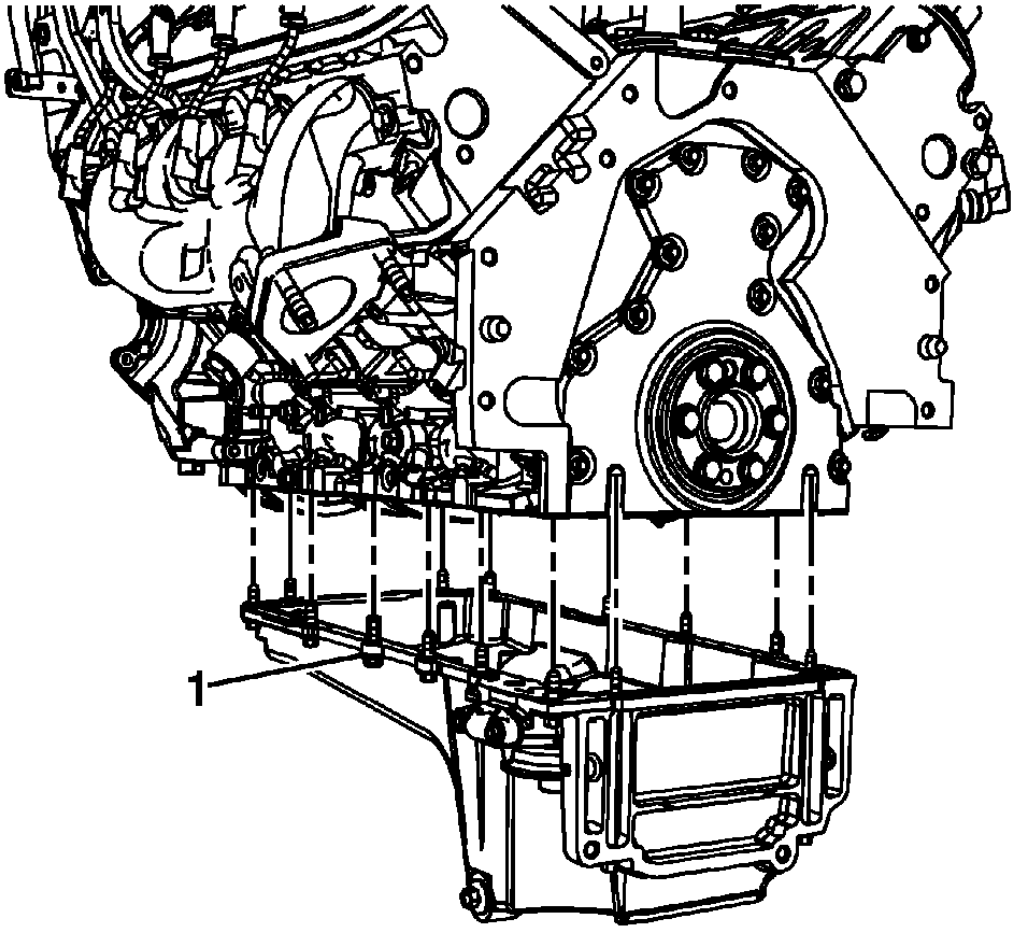

Fig. 219: Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

3. Pre-assemble the oil pan gasket and bolts (1) to the pan.
    - Install the gasket onto the pan.
    - Install the oil pan bolts to the pan and through the gasket.
4. Install the oil pan, oil pan gasket, and bolts to the engine block as an assembly.
5. Hand thread the oil pan bolts into the engine block until snug. Do not tighten at this time.

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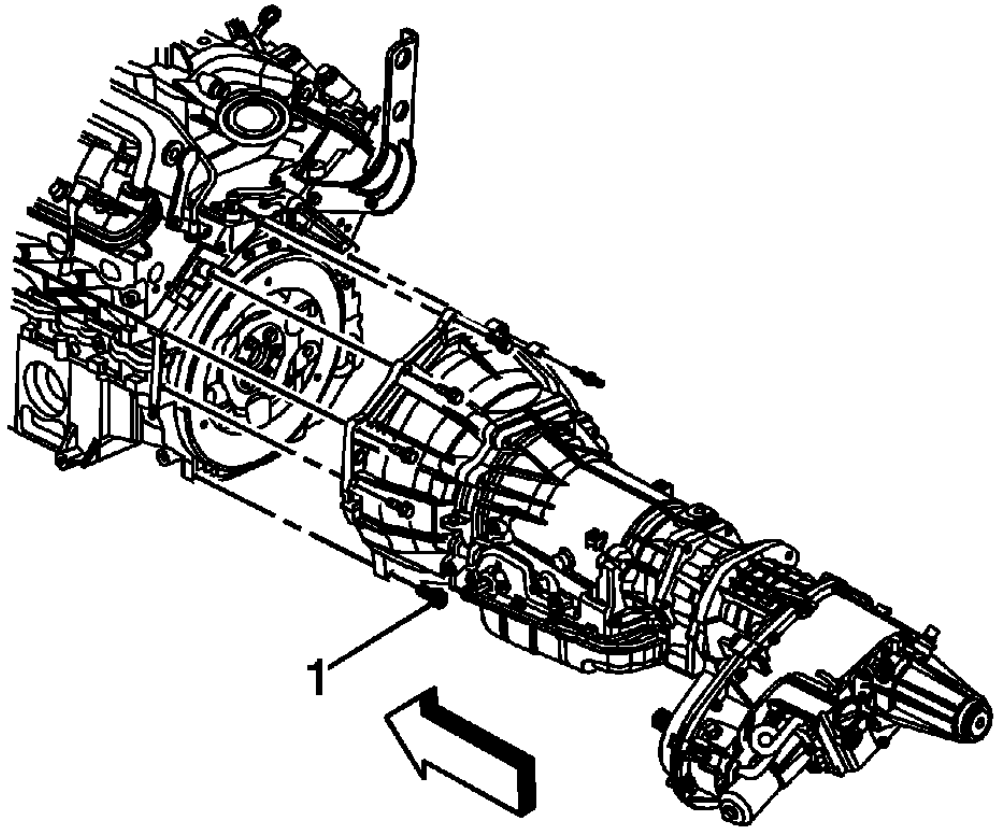

Fig. 220: View Of Lower Bellhousing Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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

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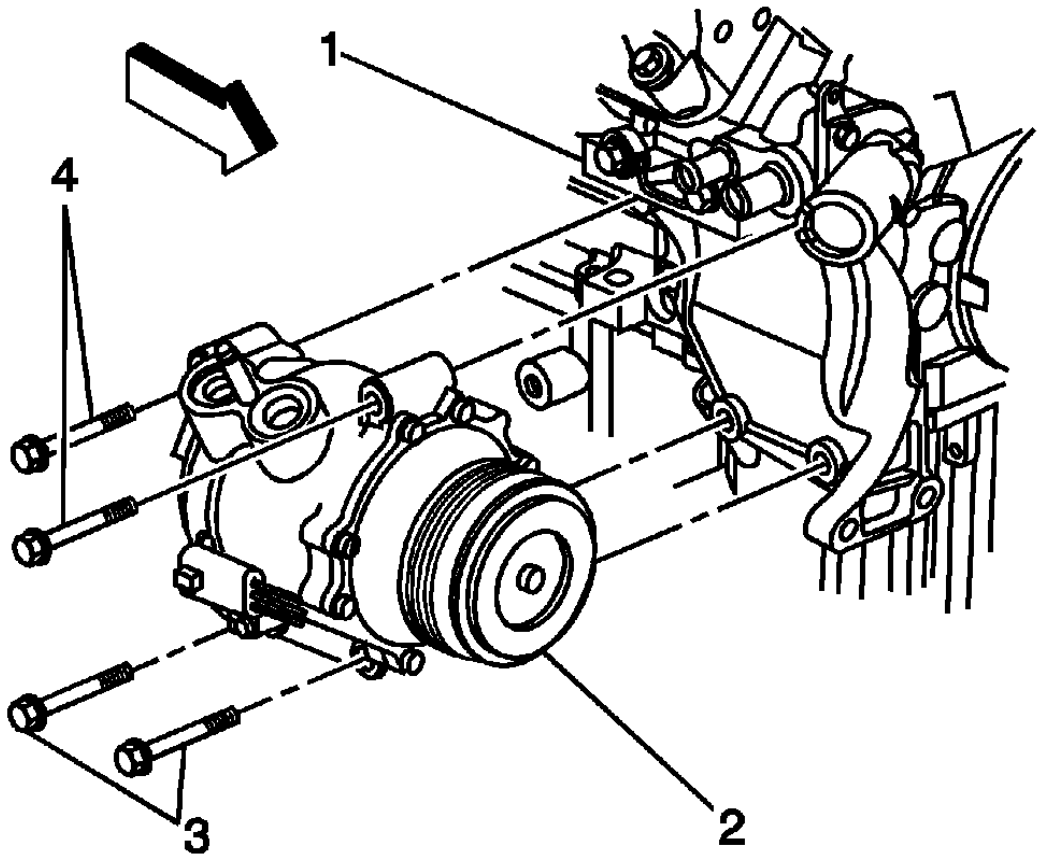

Fig. 221: View Of A/C Compressor Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the 2 lower A/C compressor bracket bolts (3) and tighten to 50 N.m (37 lb ft).
8. Tighten the 2 upper A/C compressor bracket bolts (4) to 50 N.m (37 lb ft).

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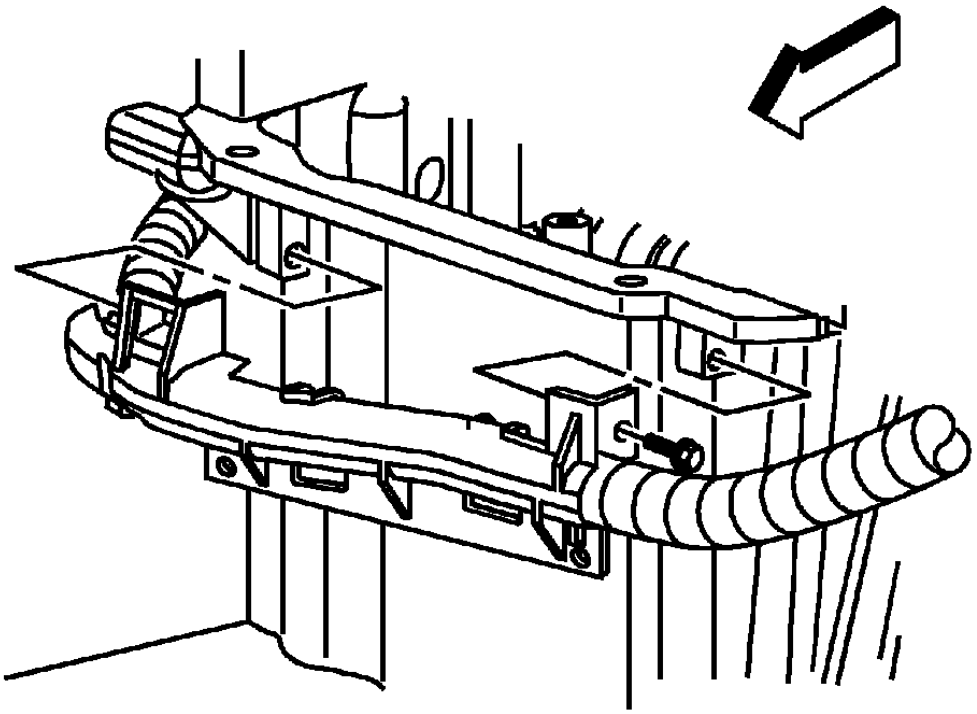

Fig. 222: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Install the battery cable channel to the oil pan.
10. Install the battery cable channel bolt to the oil pan and tighten the bolt to 12 N.m (106 lb in).
11. Install the flywheel inspection cover to the left side of the transmission.

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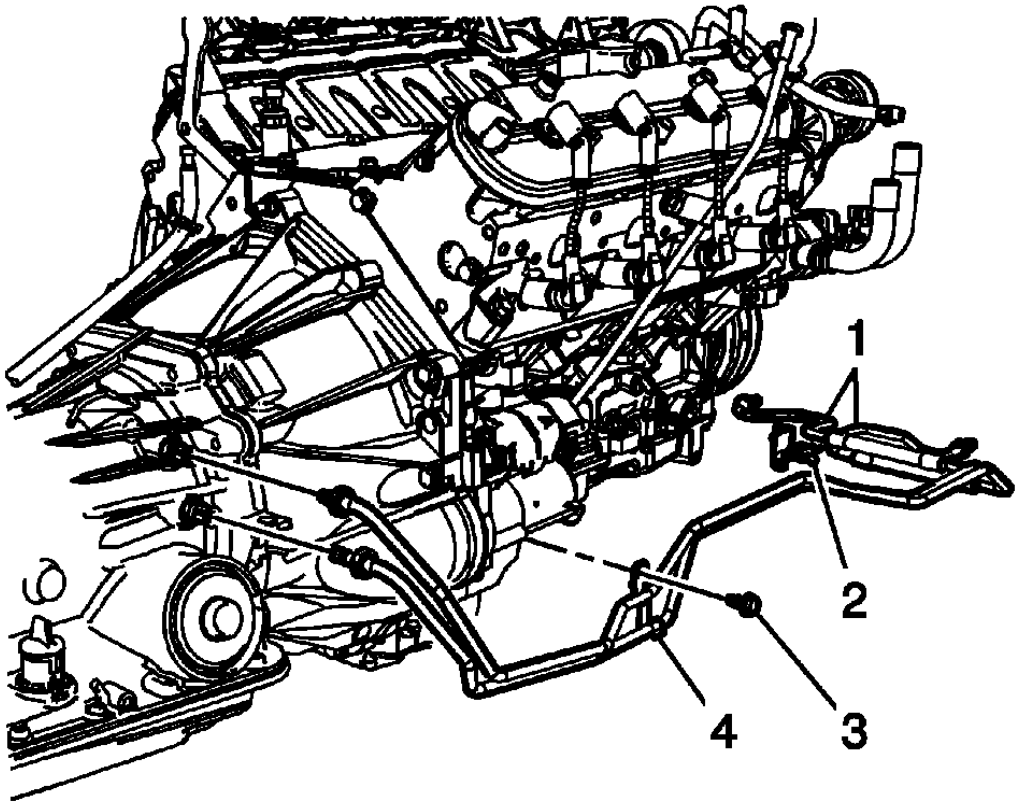

Fig. 223: Transmission Cooler Lines And Brackets
Courtesy of GENERAL MOTORS CORP.

12. Install the starter. Refer to **Starter Replacement** .
13. Install the inner axle shaft. Refer to **Front Drive Axle Inner Shaft and Inner Shaft Housing Replacement** .
14. Install the transmission oil cooler line retaining bracket (4) and bolt (3) and tighten to 9 N.m (80 lb in).
15. Install the transmission oil cooler lines (1) to the retainer (2).
16. Install the oil level indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
17. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
18. Install the front differential, if equipped. Refer to **Differential Carrier Assembly Replacement** .
19. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

ENGINE OIL PRESSURE SENSOR AND/OR SWITCH REPLACEMENT

Special Tools

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

Removal Procedure

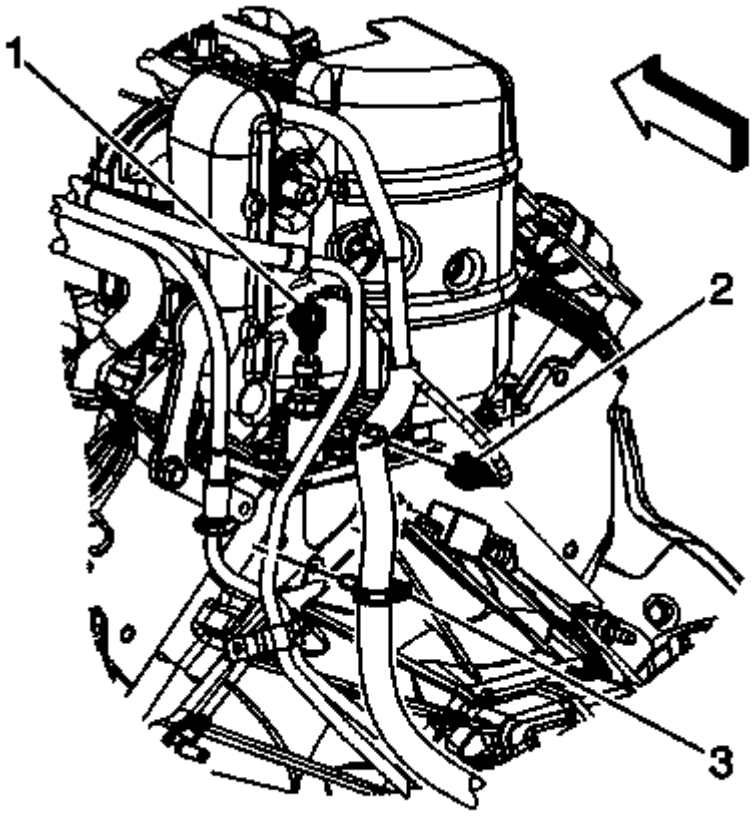

Fig. 224: View Of Engine Harness Electrical Connectors & Inlet Hose Clamp
Courtesy of GENERAL MOTORS CORP.

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

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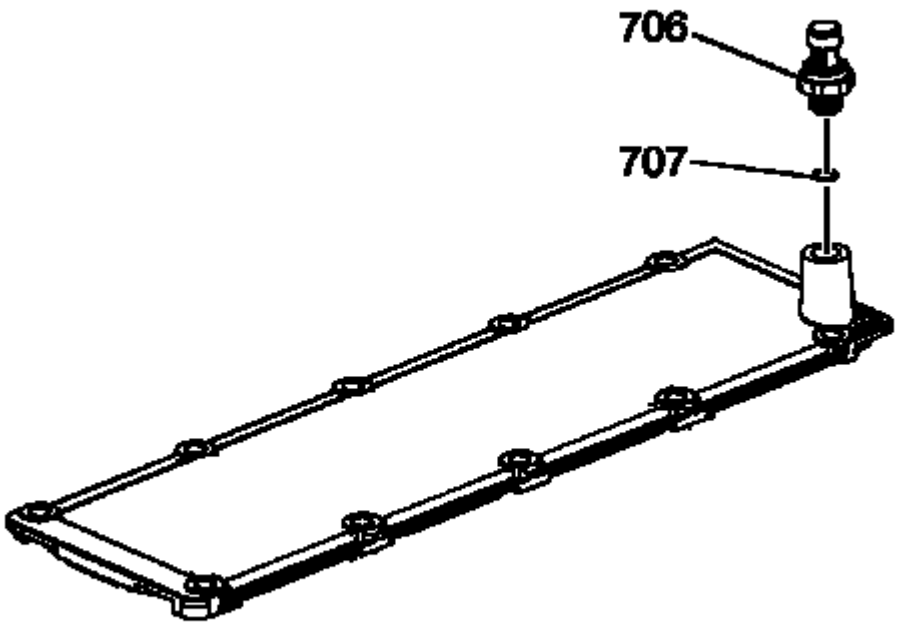

Fig. 225: Removing/Installing Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

3. If not equipped with active fuel management perform the following step, using **J 41712** or equivalent, remove the oil pressure sensor (706) and washer (707). See **Special Tools**.

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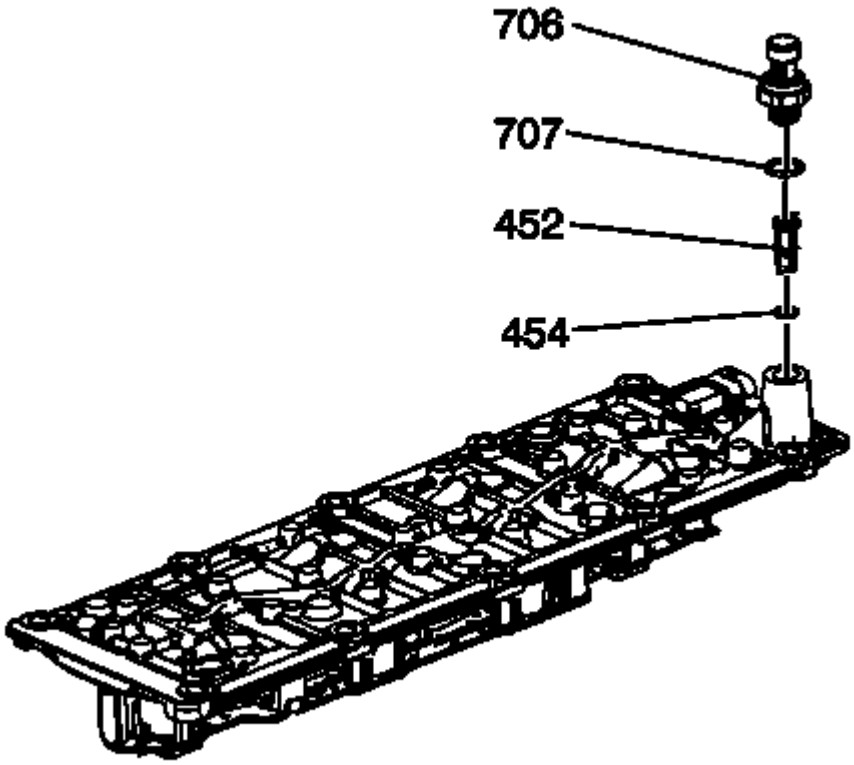

Fig. 226: View Of Oil Pressure Sensor, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

4. If equipped with active fuel management perform the following step, using **J 41712** or equivalent, remove the oil pressure sensor (706) and washer (707). See **Special Tools**.

Installation Procedure

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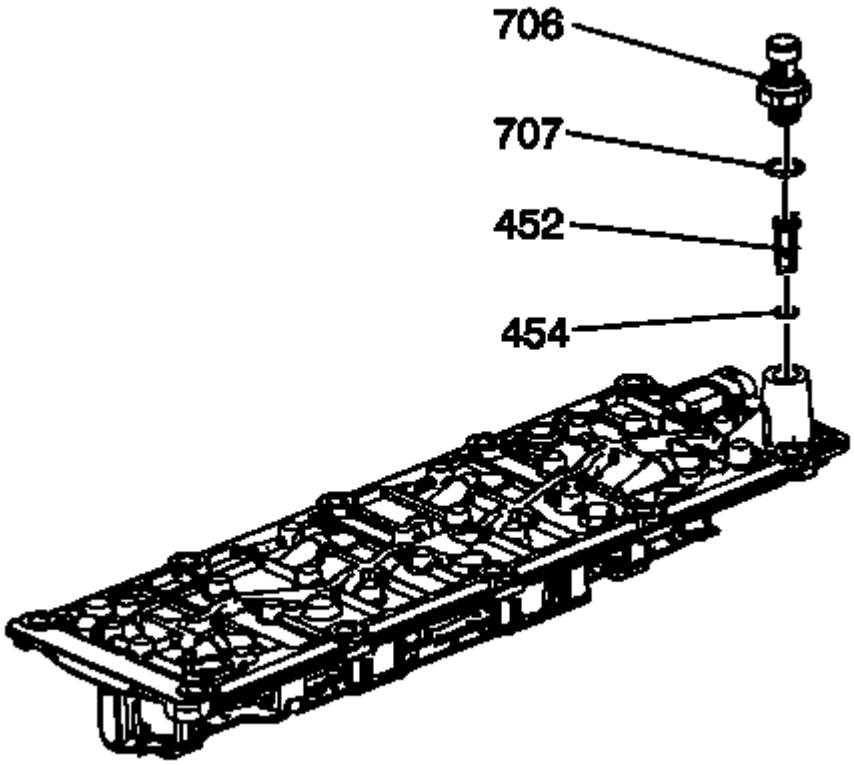

Fig. 227: View Of Oil Pressure Sensor, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant to the threads of the NEW oil pressure sensor. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

   CAUTION: Refer to Fastener Caution .

2. If equipped with active fuel management perform the following step, using **J 41712** or equivalent. See **Special Tools**. Install the oil pressure sensor (706) and washer (707).

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

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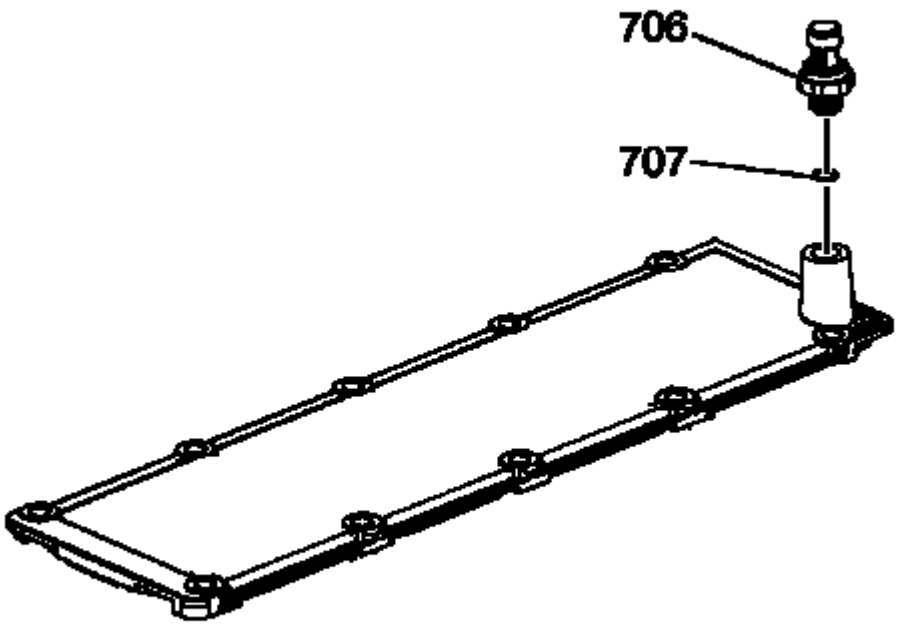

Fig. 228: Removing/Installing Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

3. If not equipped with active fuel management, perform the following step, using **J 41712** or equivalent. See **Special Tools**. Install the oil pressure sensor (706) and washer (707).

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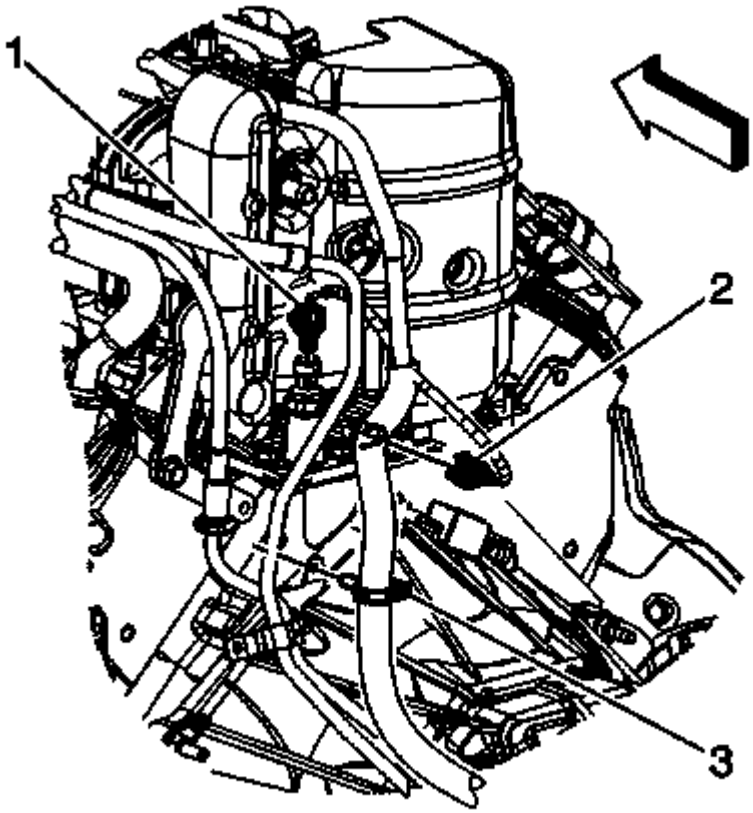

Fig. 229: View Of Engine Harness Electrical Connectors & Inlet Hose Clamp
Courtesy of GENERAL MOTORS CORP.

4. Connect the engine harness electrical connector (1) to the oil pressure sensor. Tighten the sensor to 35 N.m (26 lb ft).
5. Install the intake manifold. Refer to **Intake Manifold Replacement**.

OIL PUMP, SCREEN, AND CRANKSHAFT OIL DEFLECTOR REPLACEMENT

Removal Procedure

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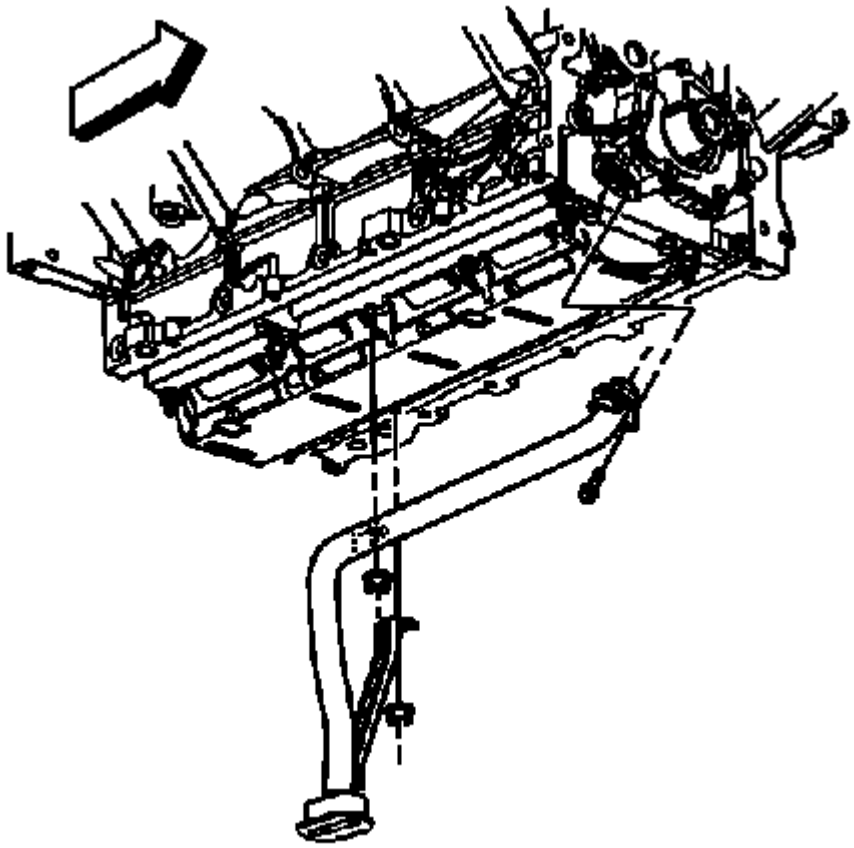

Fig. 230: View Of Oil Pump Screen & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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.

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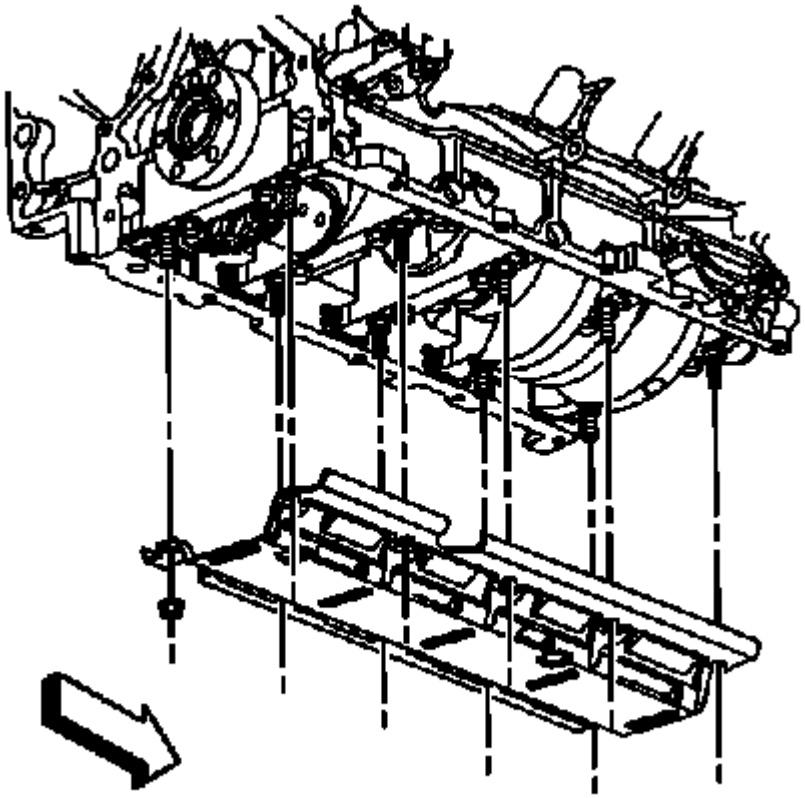

Fig. 231: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

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

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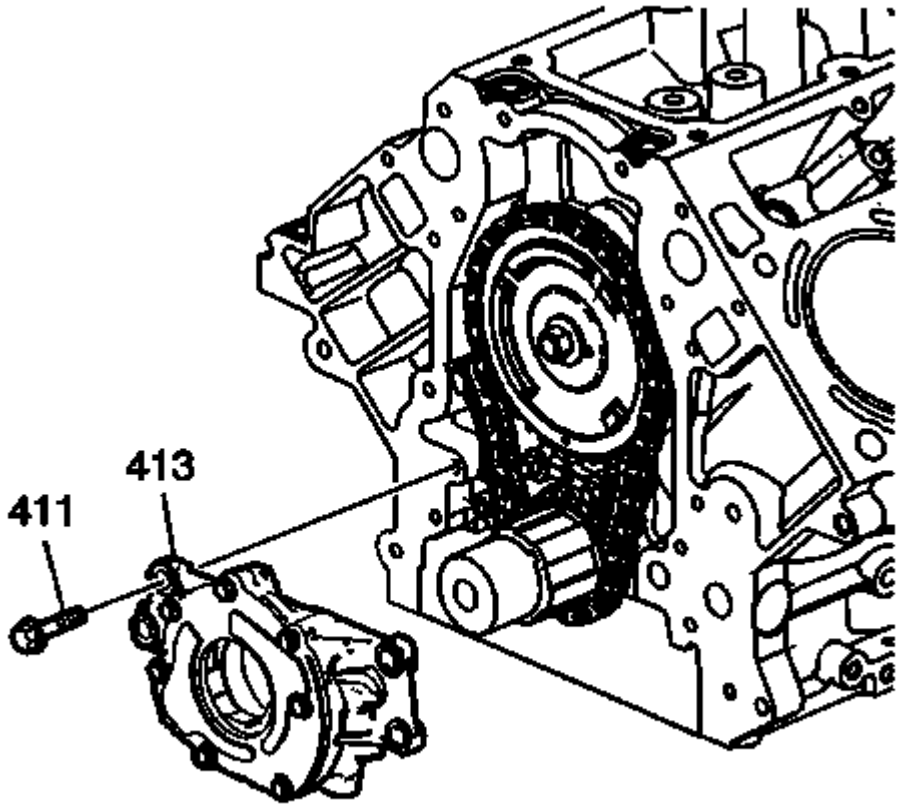

Fig. 232: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pump bolts (411).

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

10. Remove the oil pump (413).

Installation Procedure

NOTE: Inspect the engine block oil galley passages. These areas must be free and clear of debris or restrictions.

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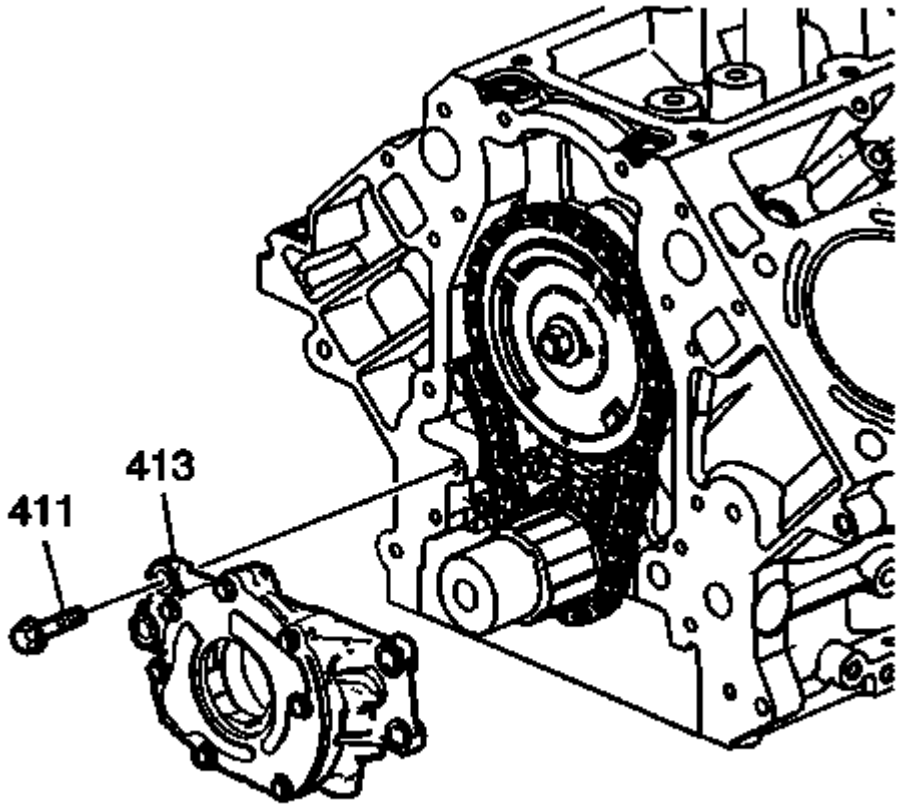

Fig. 233: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump (413) onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

CAUTION: Refer to Fastener Caution .

3. Install the oil pump bolts (411).

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

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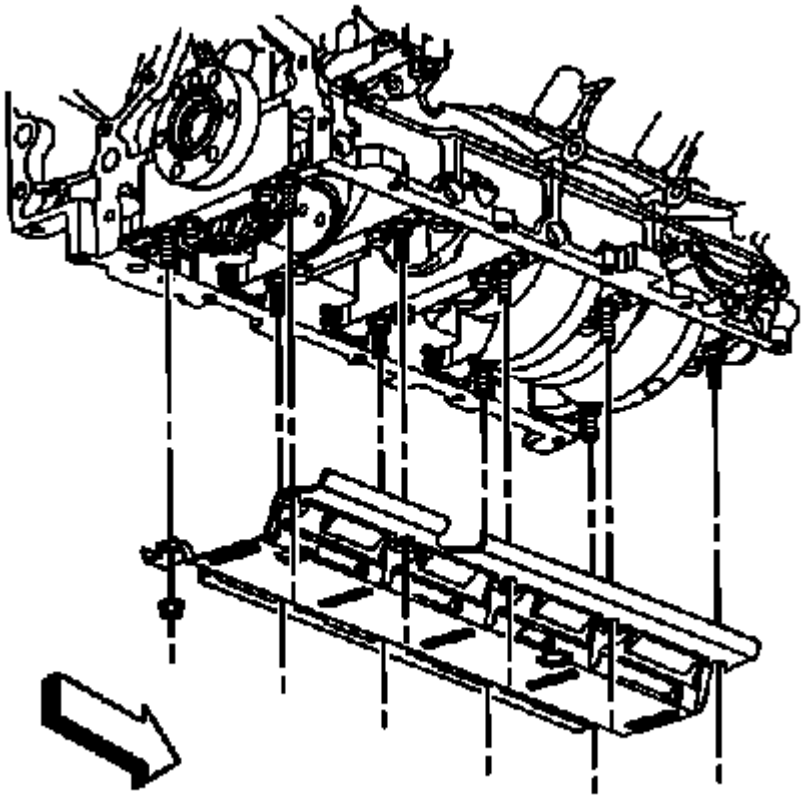

Fig. 234: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

4. Position the crankshaft oil deflector and install the nuts until snug.

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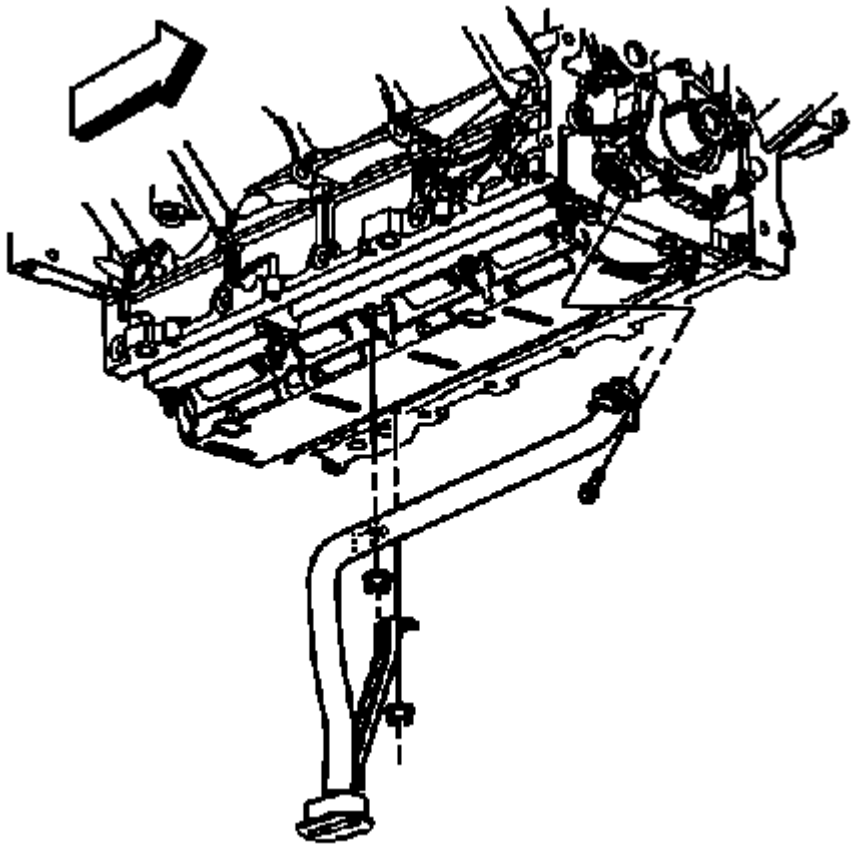

Fig. 235: View Of Oil Pump Screen & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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.

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

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

Tighten:

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

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

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TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE REPLACEMENT

Special Tools

- **EN 46330** Timing Belt Tensioner Retaining Pin. See **Special Tools**.
- **J 8433** Two Jaw Puller. See **Special Tools**.
- **J 41478** Crankshaft Front Oil Seal Installer. See **Special Tools**.
- **J 41558** Crankshaft Sprocket Remover. See **Special Tools**.
- **J 41665** Crankshaft Balancer and Sprocket Installer. See **Special Tools**.
- **J 41816-2** Crankshaft End Protector
- **J 42386-A** Flywheel Holding Tool. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

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

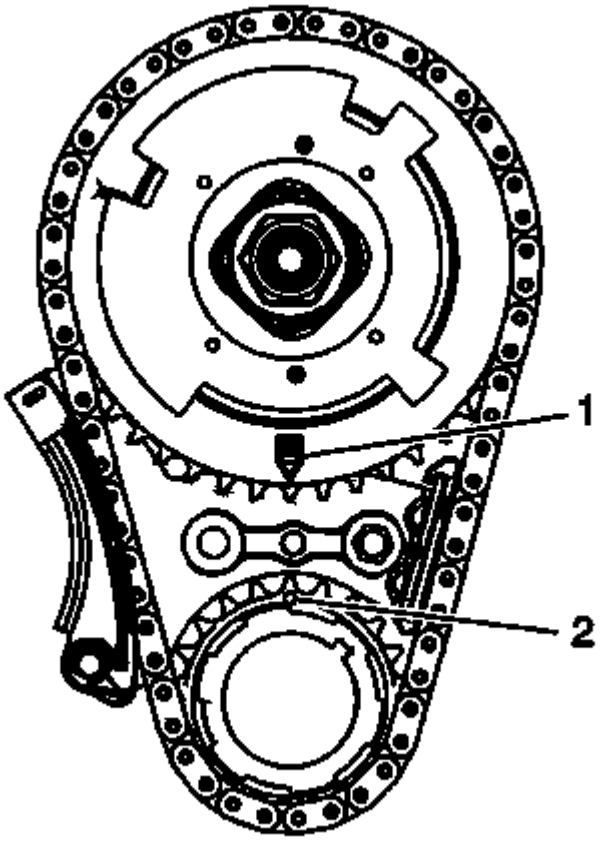

Fig. 236: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS CORP.

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CAUTION: Refer to Fastener Caution .

NOTE: Ensure that the teeth of the J 42386-A . See Special Tools.

2. Rotate the crankshaft sprocket until the camshaft position (CMP) actuator alignment mark (1) and the crankshaft sprocket alignment mark (2) are aligned.
3. Install the **J 42386-A** . See **Special Tools**.

   Tighten: Tighten the **J 42386-A** . See **Special Tools**.

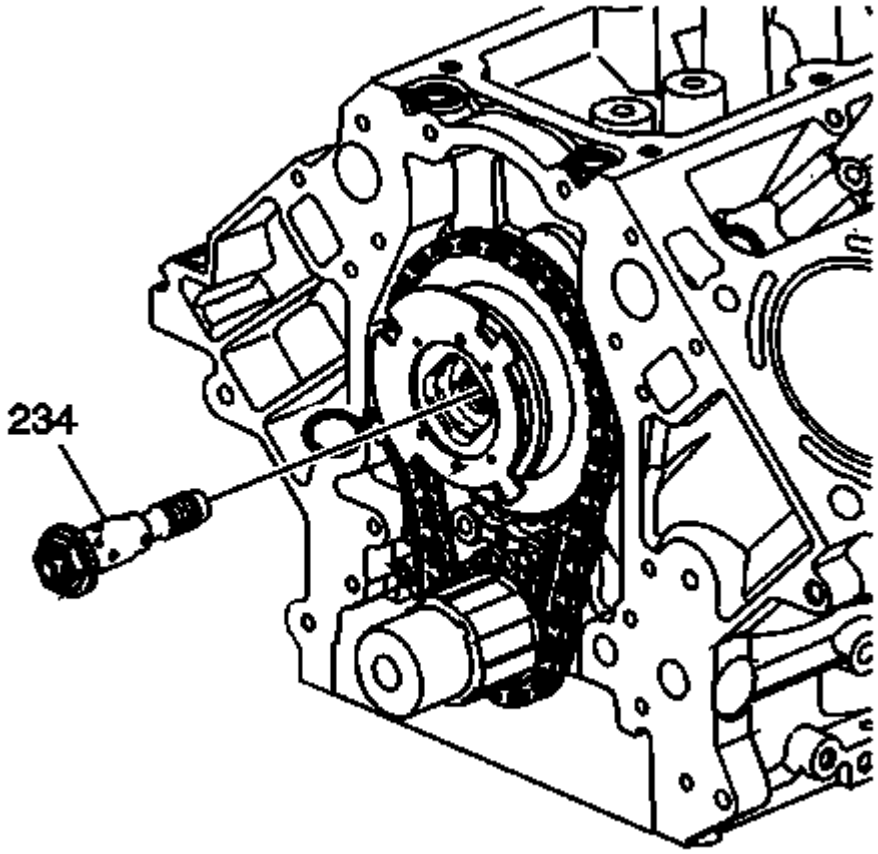

Fig. 237: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the CMP actuator solenoid valve (234).

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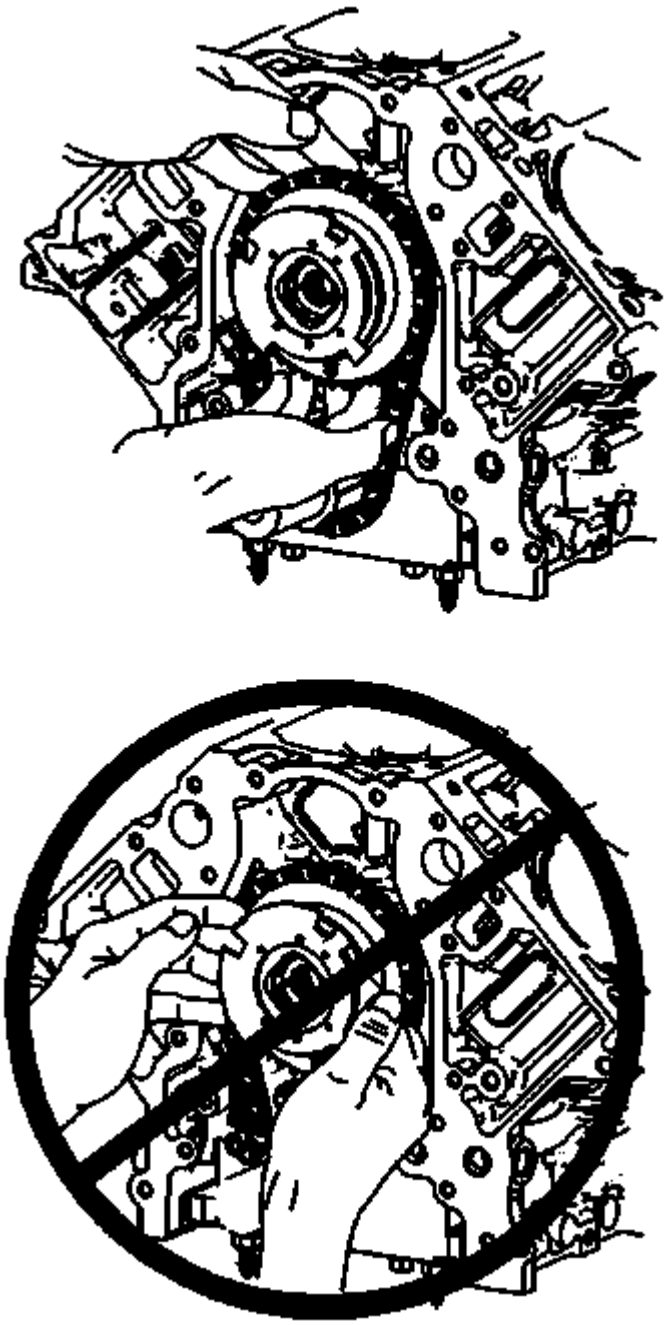

Fig. 238: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS CORP.

5. 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.

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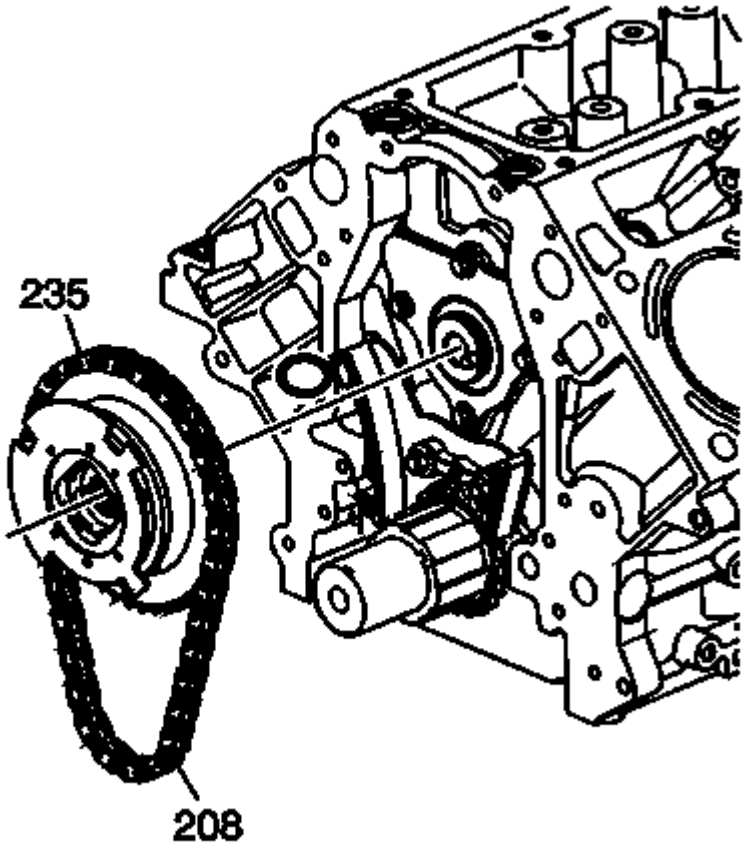

Fig. 239: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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

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

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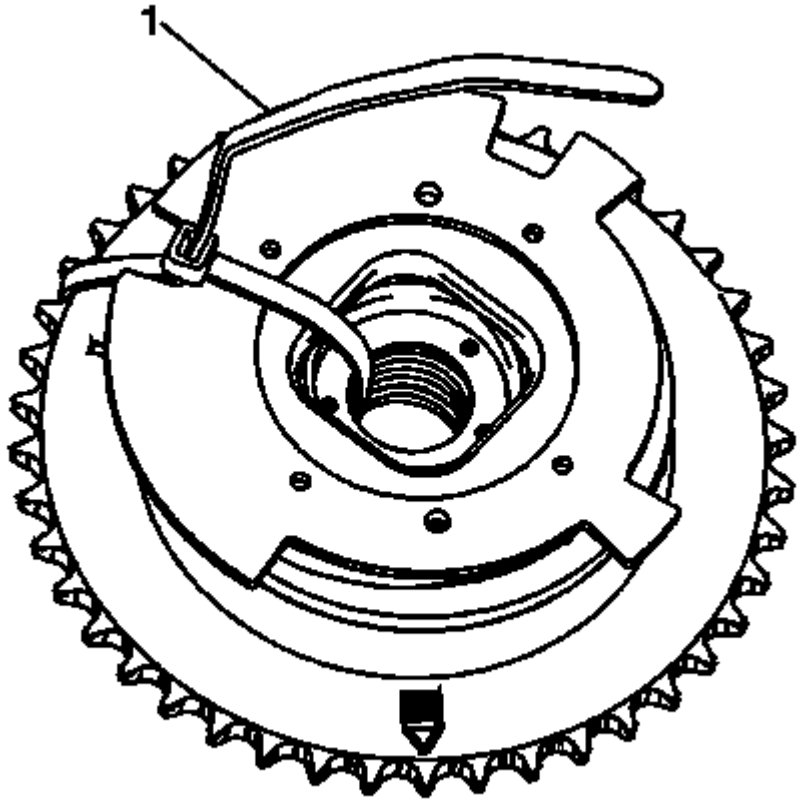

Fig. 240: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

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

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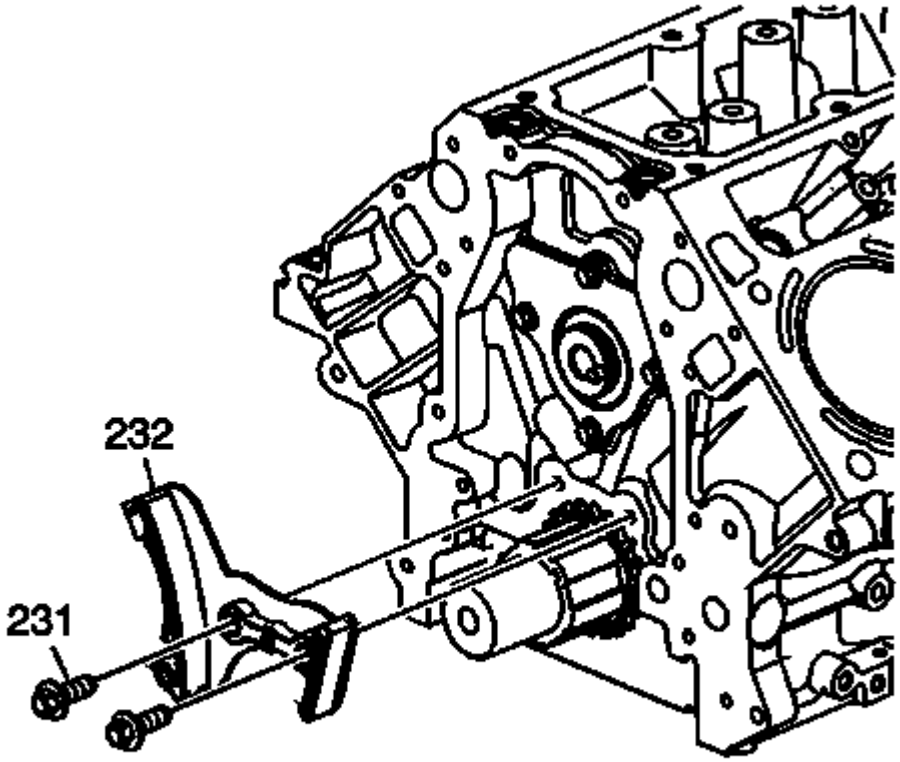

Fig. 241: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the timing chain tension bolts (231) and tensioner (232).

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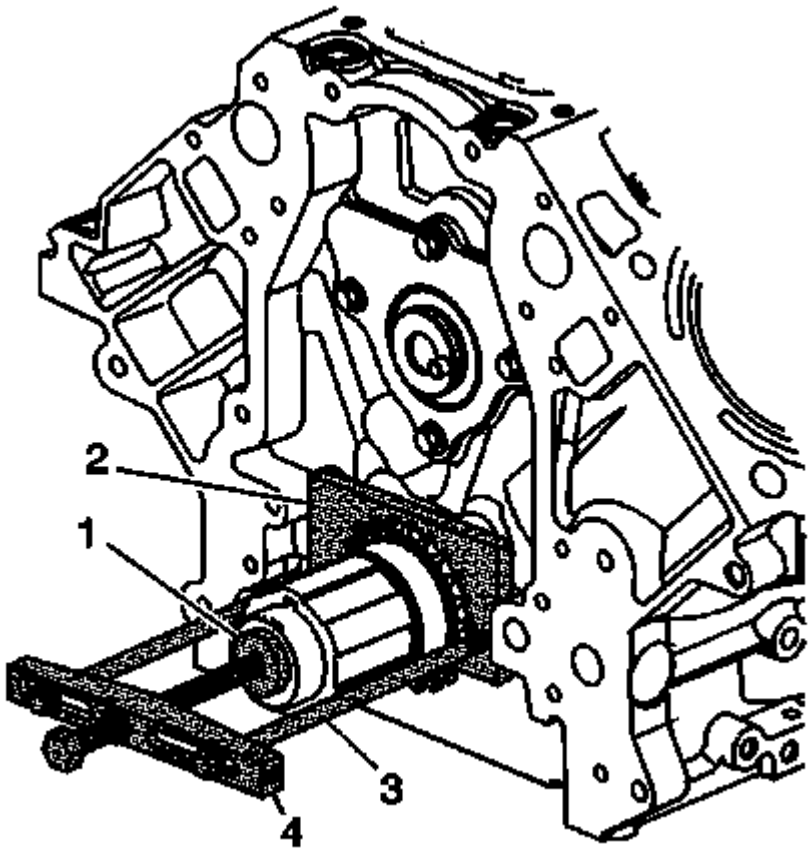

Fig. 242: View Of Crankshaft Sprocket Special Tools
Courtesy of GENERAL MOTORS CORP.

9. Using the J 41816-2 (1), the J 41558 (2), bolts (3) and the J 8433 (4) in order to remove the crankshaft sprocket.

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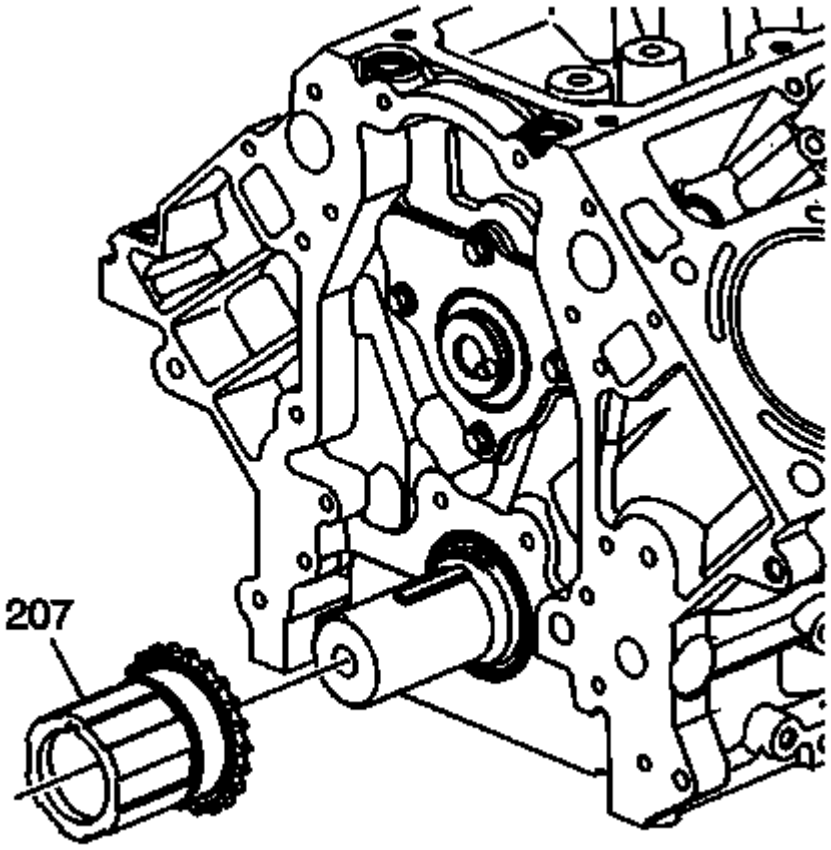

Fig. 243: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft sprocket (207).

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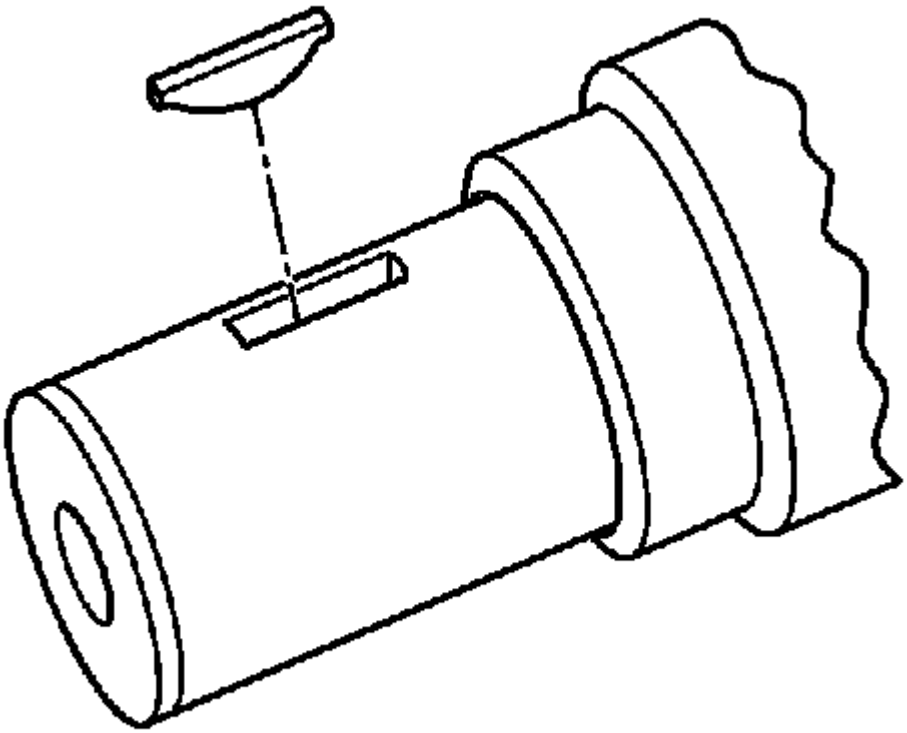

Fig. 244: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft sprocket key, if required.

Installation Procedure

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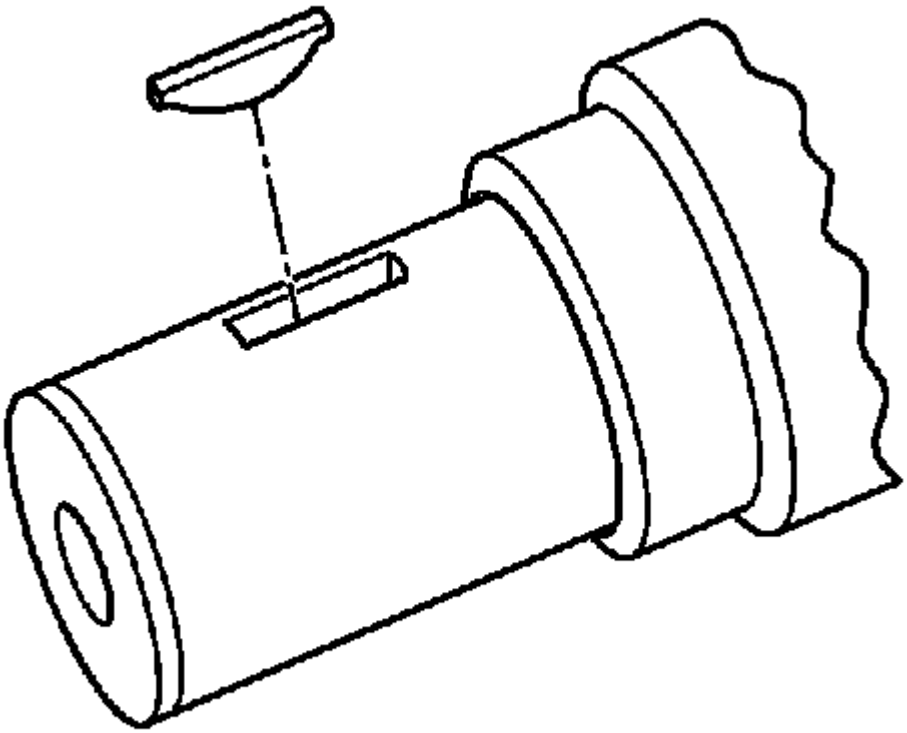

Fig. 245: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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

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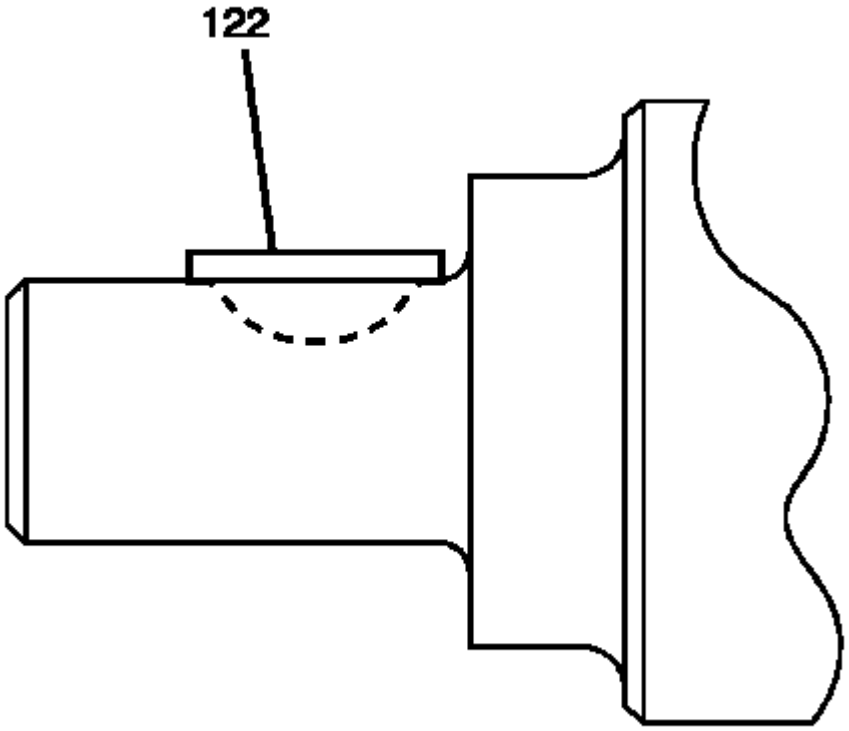

Fig. 246: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.

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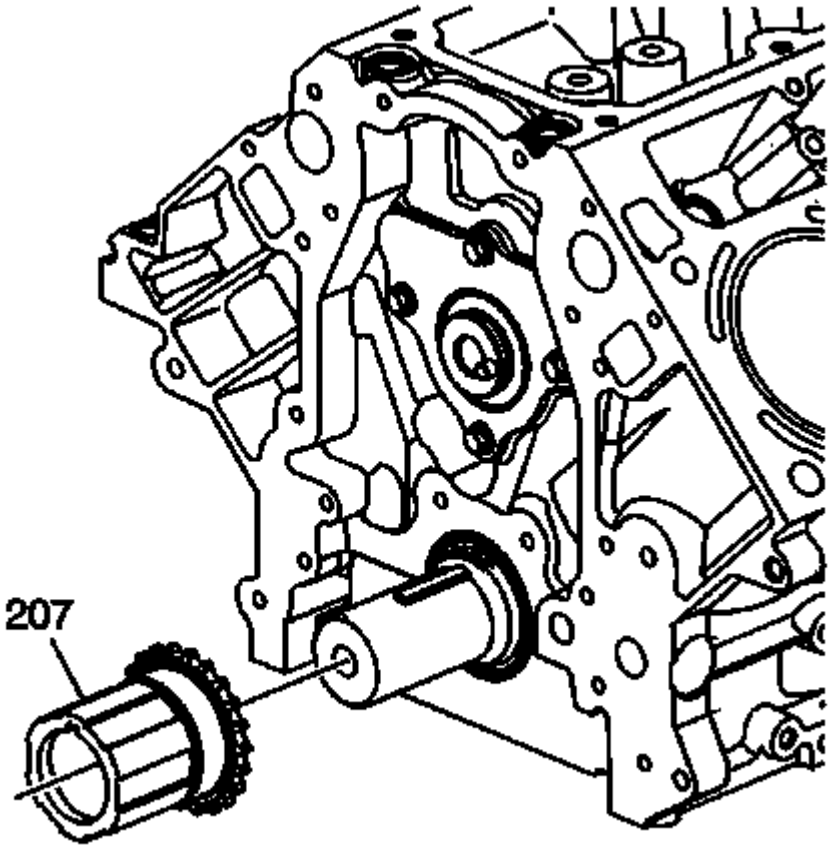

Fig. 247: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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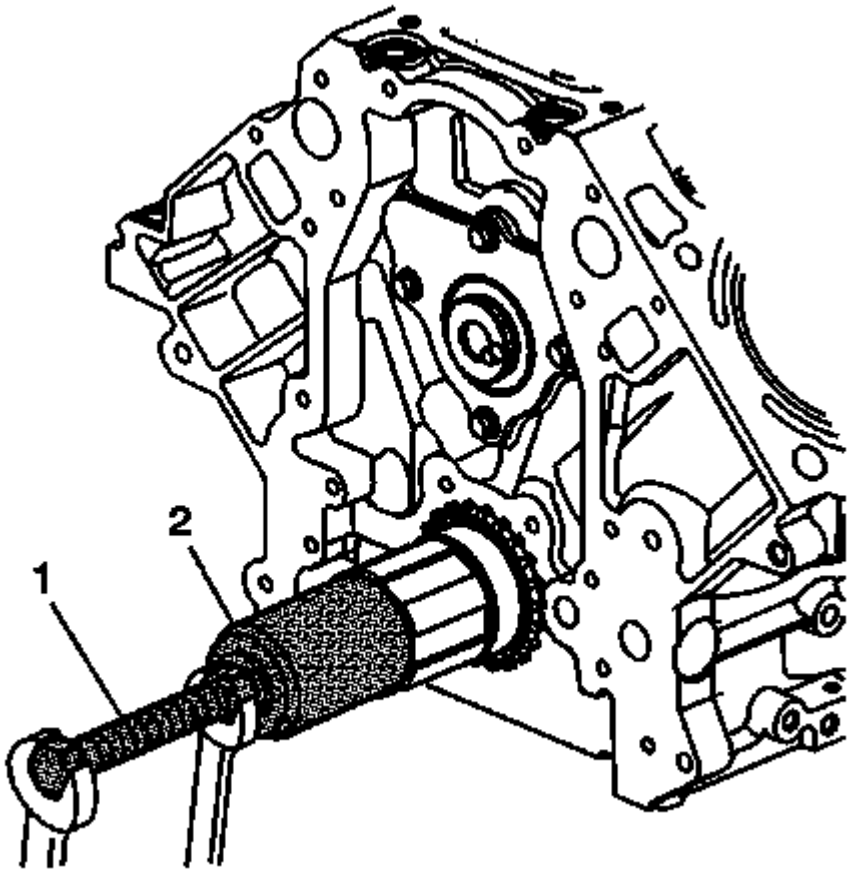

Fig. 248: View Of Crankshaft Sprocket & Installer
Courtesy of GENERAL MOTORS CORP.

4. Use the J 41478 (1) and the J 41665 (2) in order to install the crankshaft sprocket. Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.

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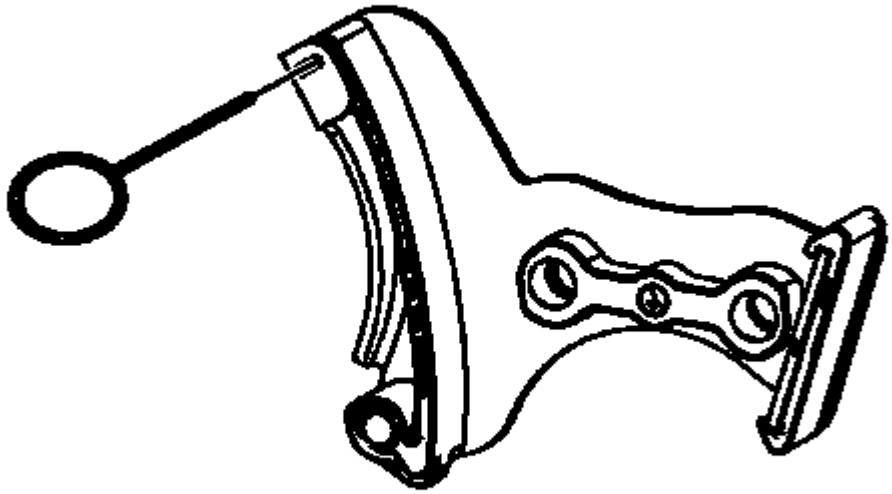

Fig. 249: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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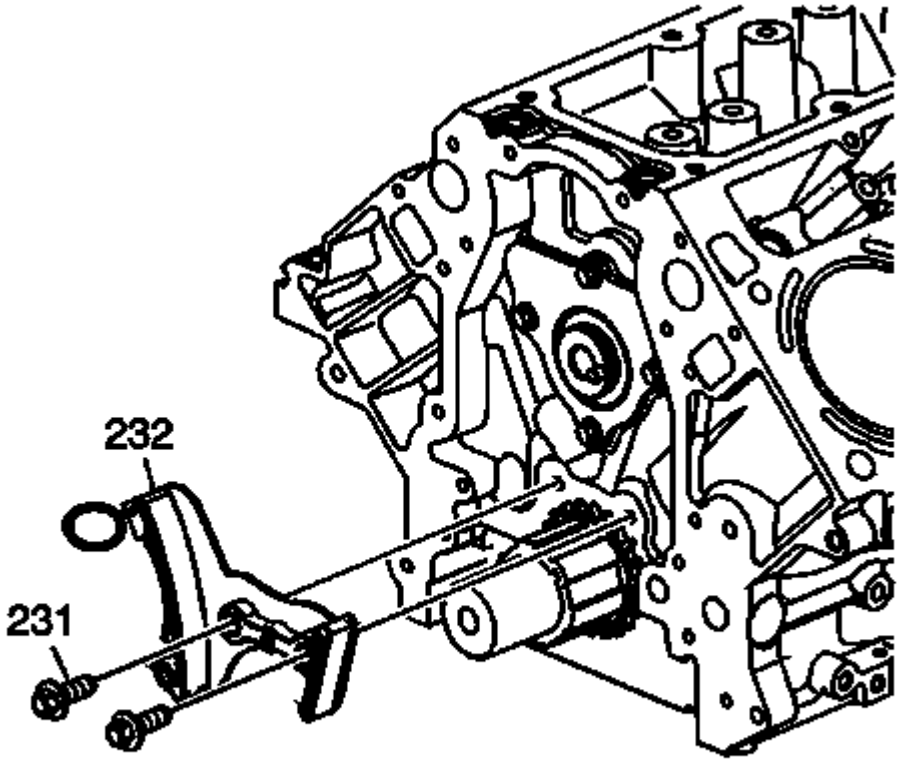

Fig. 250: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the timing chain tensioner (232) and bolts (231).

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

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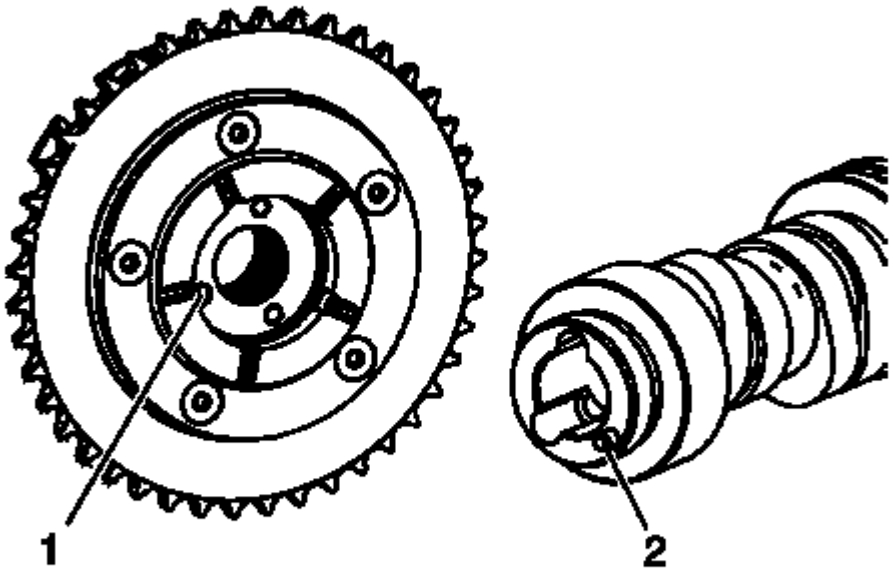

Fig. 251: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain teeth must mesh.**
- **The camshaft and the crankshaft sprocket alignment MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW CMP valve during assembly.**

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

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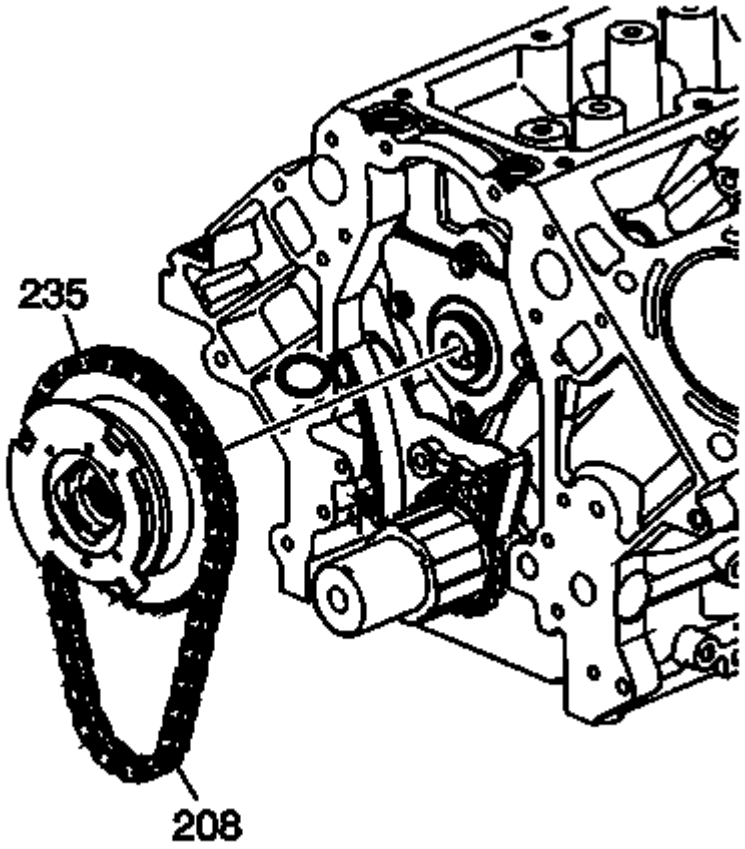

Fig. 252: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

8. Align the CMP actuator so the timing mark is in the 6 o'clock position.
9. Install the CMP actuator (235) and timing chain (208). Align the hole in the face of the CMP actuator with the locating pin on the front face of the camshaft.

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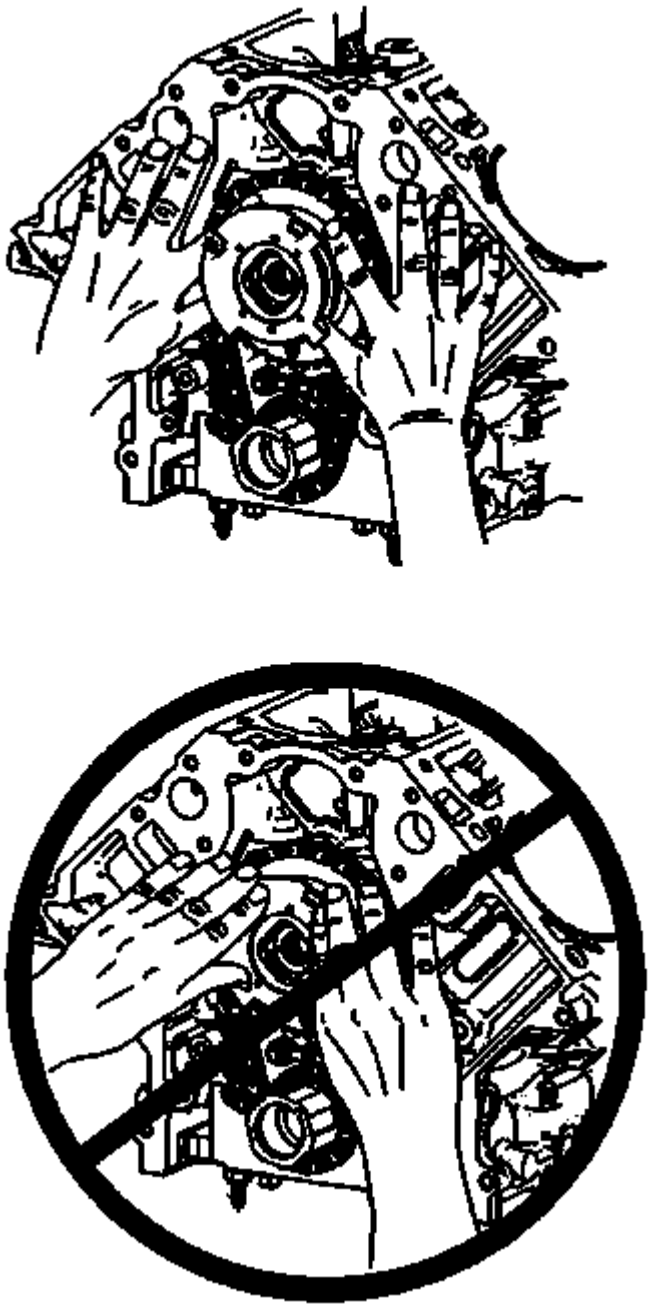

Fig. 253: Proper Installation Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: 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.

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10. 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.

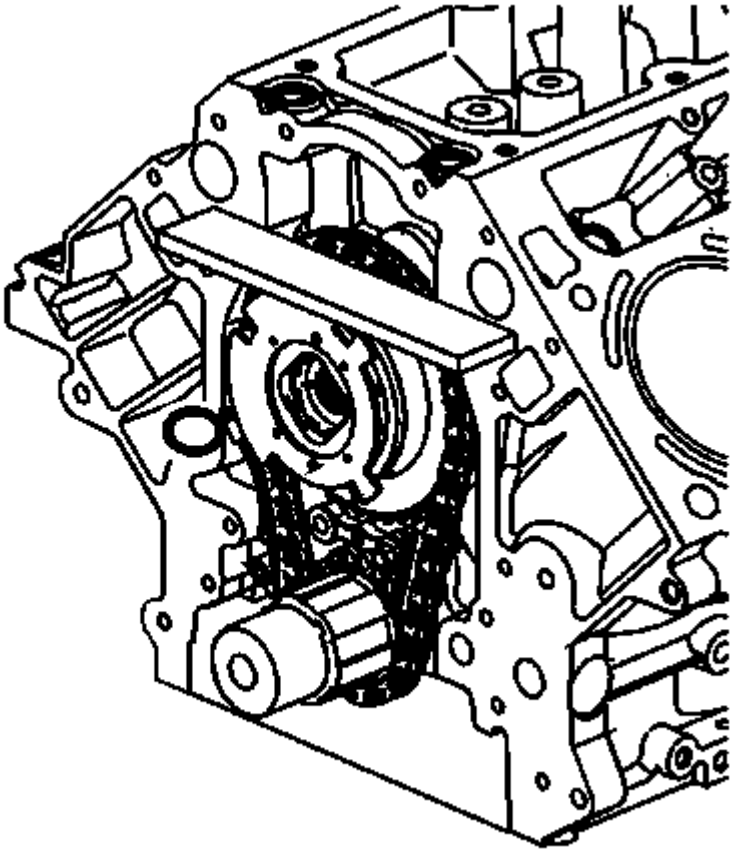

Fig. 254: Inspecting For Proper Installation Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

11. 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.

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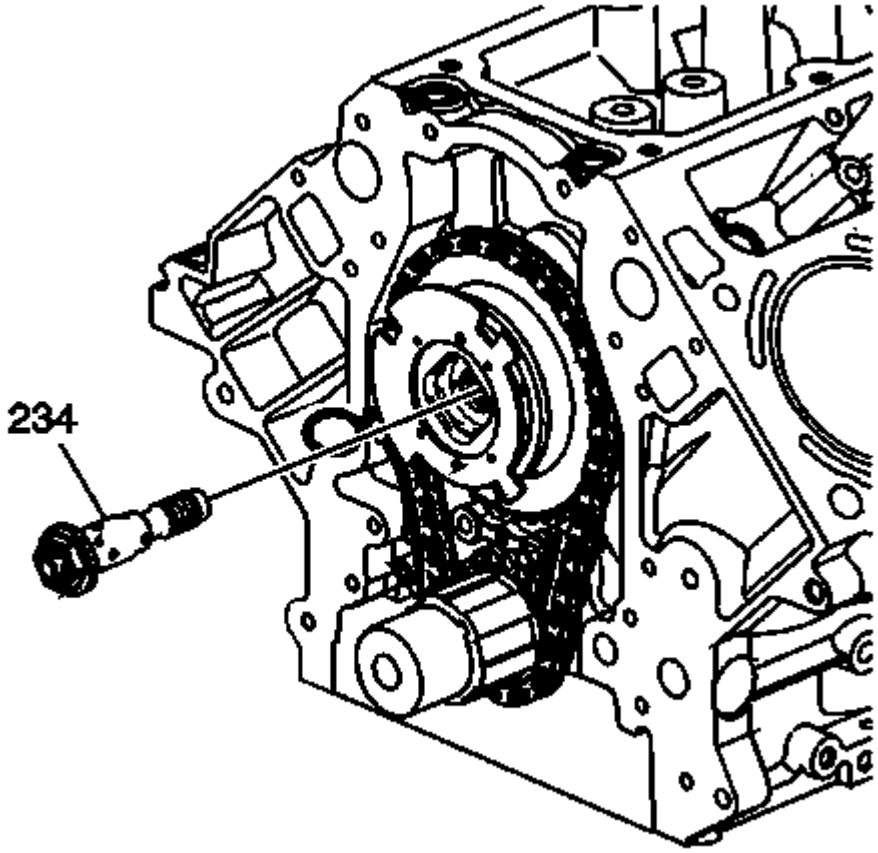

Fig. 255: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

12. Install a NEW CMP actuator 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.

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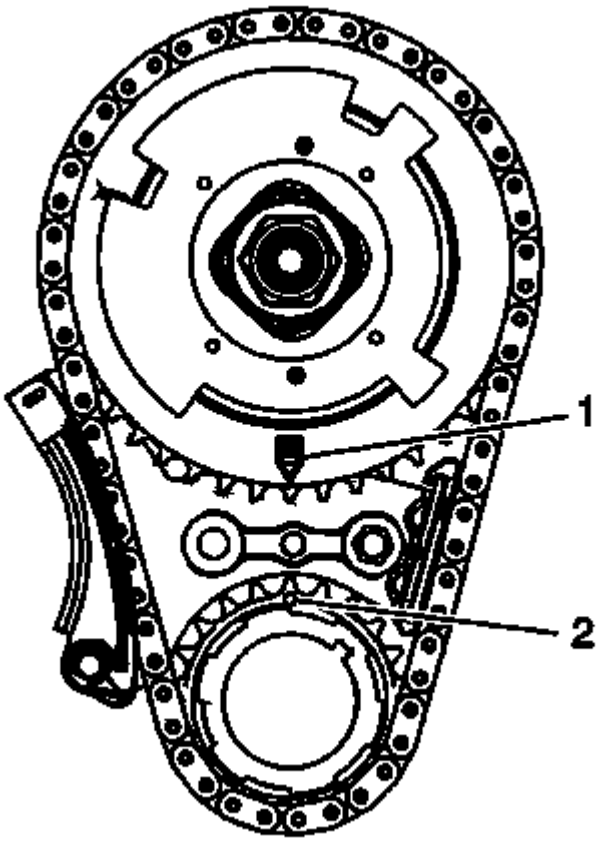

Fig. 256: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS CORP.

13. Inspect the sprockets for proper alignment. The mark on the CMP (1) actuator sprocket 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.

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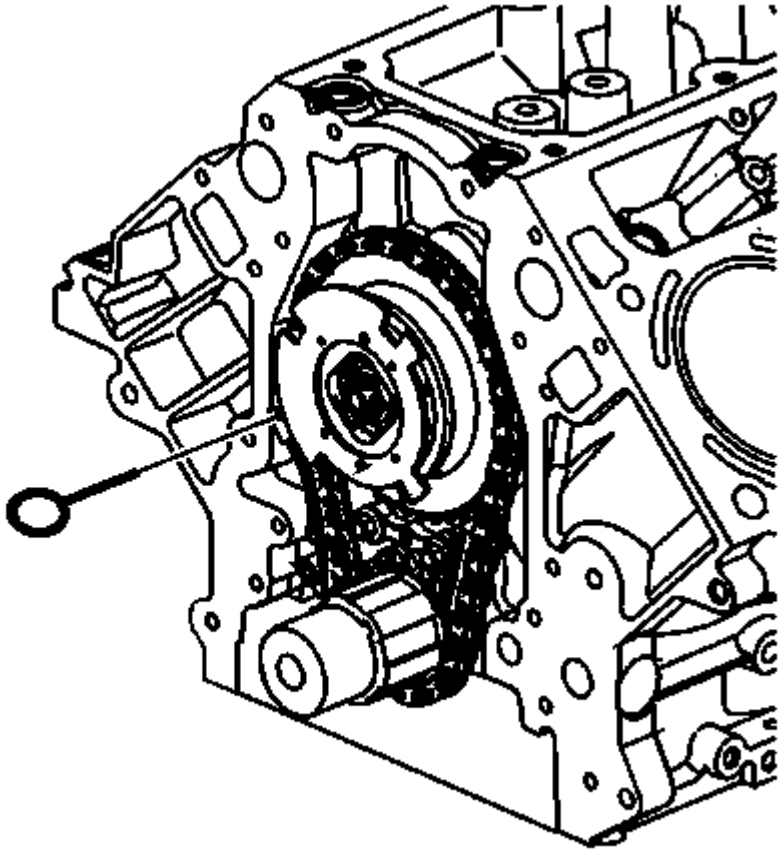

Fig. 257: View Of Special Tool EN 46330
Courtesy of GENERAL MOTORS CORP.

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

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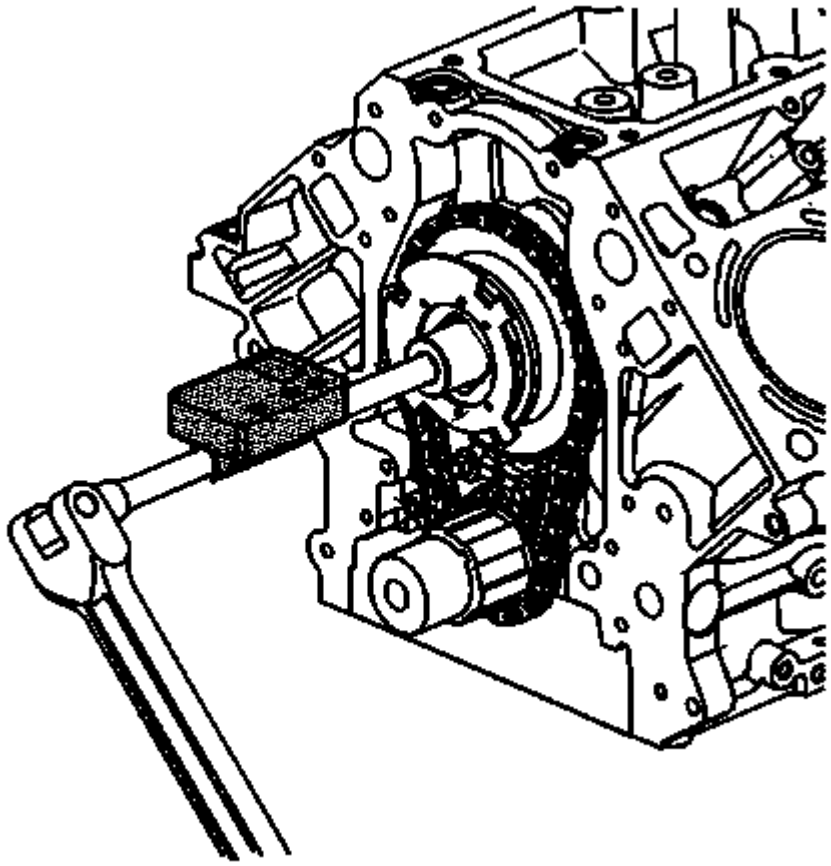

Fig. 258: Tightening The CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

15. Tighten the CMP actuator bolt.

    Tighten:
    1. Tighten the bolt a first pass to 65 N.m (48 lb ft).
    2. Tighten the bolt a final pass an additional 90 degrees using **J 45059** .

16. Remove the **J 42386-A** . See **Special Tools**.
17. Install the oil pump. Refer to **Oil Pump, Screen, and Crankshaft Oil Deflector Replacement**.

CAMSHAFT REPLACEMENT

Special Tools

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

Removal Procedure

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1. Remove the condenser. Refer to **Air Conditioning Condenser Replacement** .
2. Remove the valve lifters. Refer to **Valve Lifter Replacement**
3. Remove the Timing Chain, Camshaft Position Actuator, and Solenoid Valve. Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**

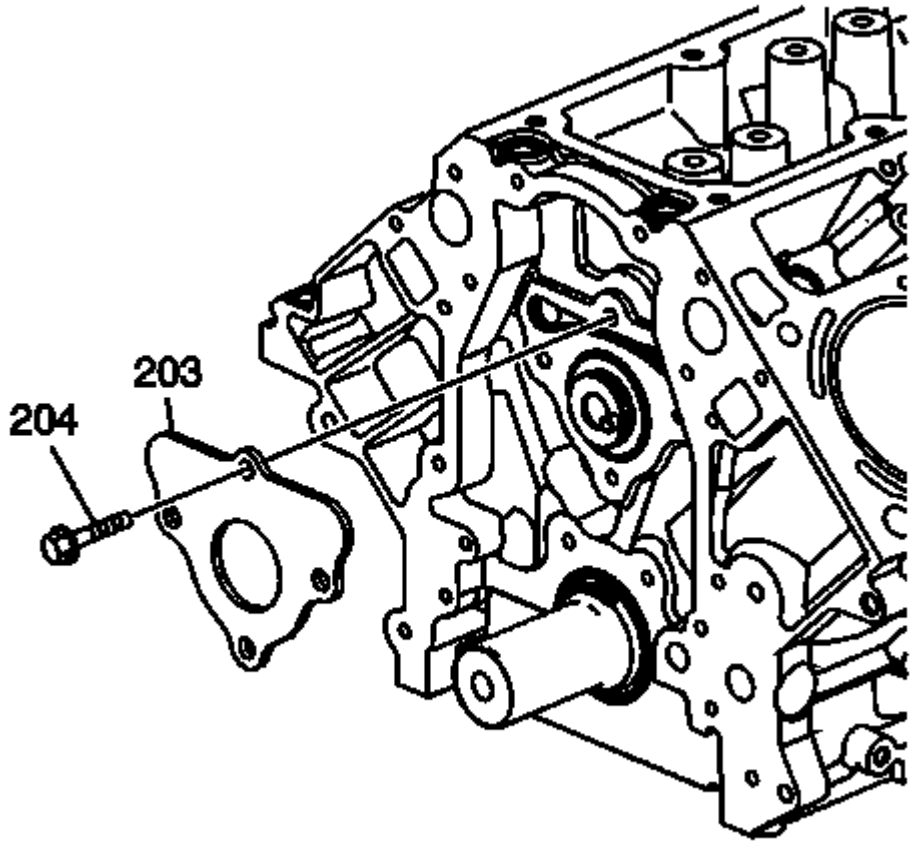

Fig. 259: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft retainer bolts (204) and retainer (203).

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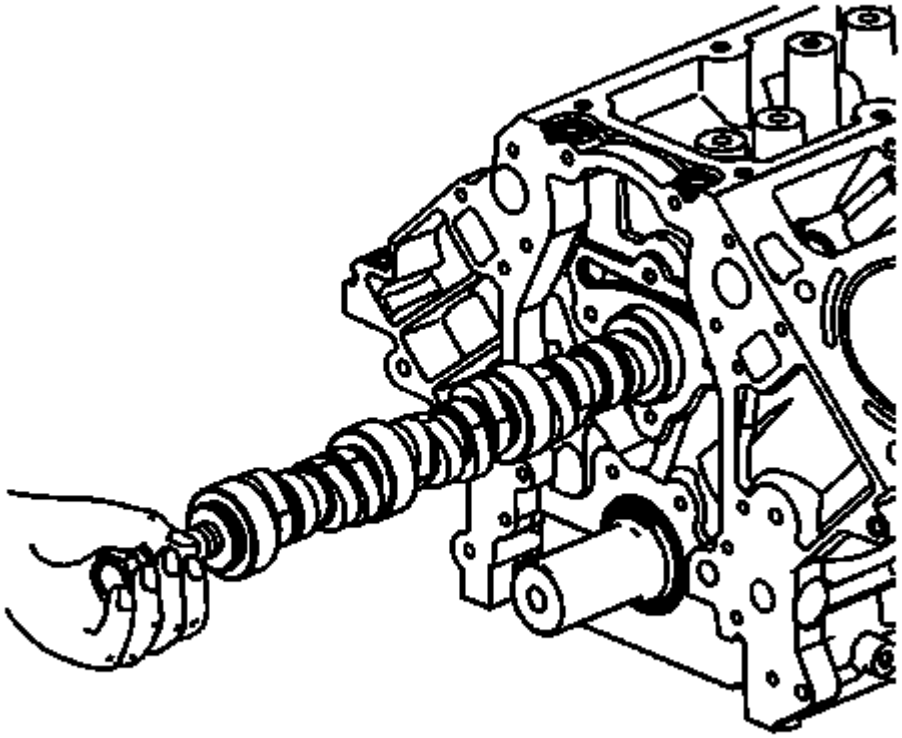

Fig. 260: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

5. Install a bolt into the camshaft.
6. Using the bolt as a handle, carefully rotate and pull the camshaft out of the engine block.
7. Clean and inspect the camshaft and bearings. Refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

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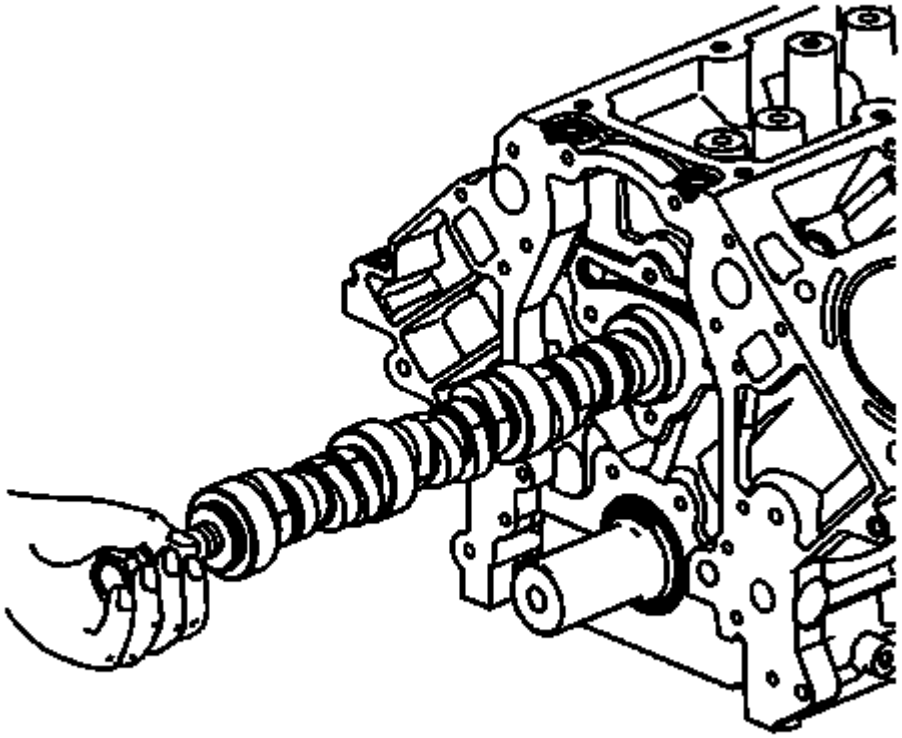

Fig. 261: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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

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

CAUTION: 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. Using the bolt as a handle, carefully install the camshaft into the engine block.
3. Remove the bolt from the front of the camshaft.

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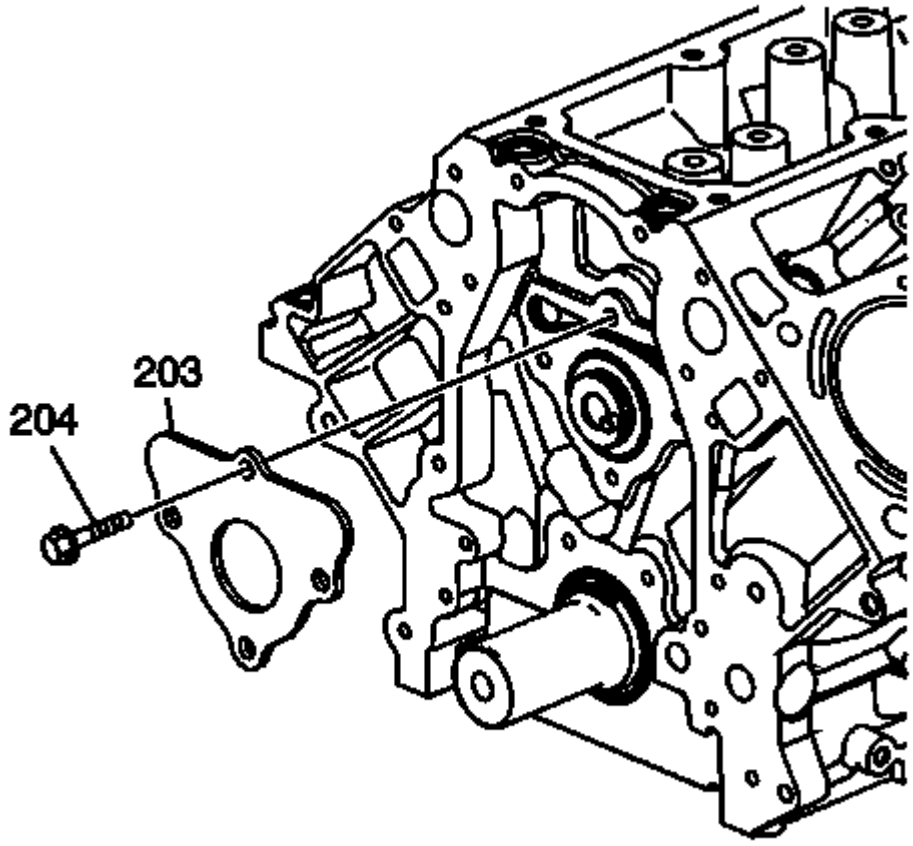

Fig. 262: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the retainer with the sealing gasket facing the engine block. The gasket surface on the engine block should be clean and free of dirt and/or debris.

4. Install the camshaft retainer (203) and bolts (204).

CAUTION: Refer to Fastener Caution .

5. Tighten the camshaft retainer bolts.

Tighten:

- Tighten the first design hex head bolts (3) to 25 N.m (18 lb ft).
- Tighten the second design TORX® head bolts (4) to 15 N.m (11 lb ft).

6. Install the Timing Chain, Camshaft Position Actuator, and Solenoid Valve. Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**

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7. Install the valve lifters. Refer to **Valve Lifter Replacement**.
8. Install the condenser. Refer to **Air Conditioning Condenser Replacement** .

ENGINE FLYWHEEL REPLACEMENT

Removal Procedure

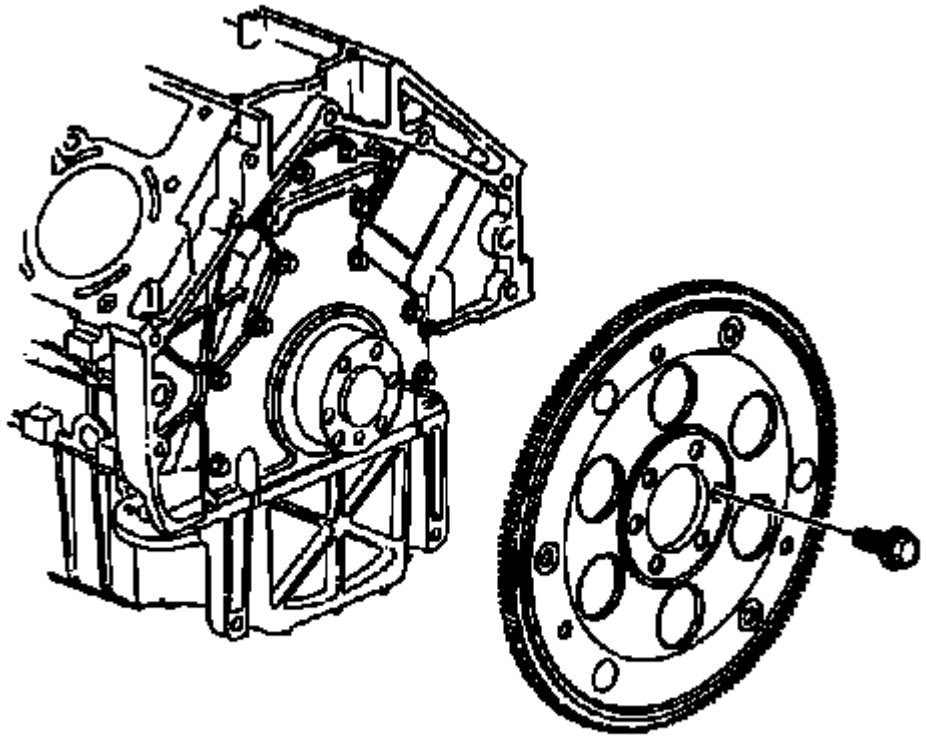

Fig. 263: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the transmission. Refer to **Transmission Replacement (4WD 5.3L)** or **Transmission Replacement (2WD 5.3L)** .
2. Remove the engine flywheel bolts.
3. Remove the engine flywheel.
4. Clean and inspect the engine flywheel. Refer to **Automatic Transmission Flex Plate Cleaning and Inspection**.

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Installation Procedure

NOTE: The flywheel does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts. This procedure requires a three stage tightening process.

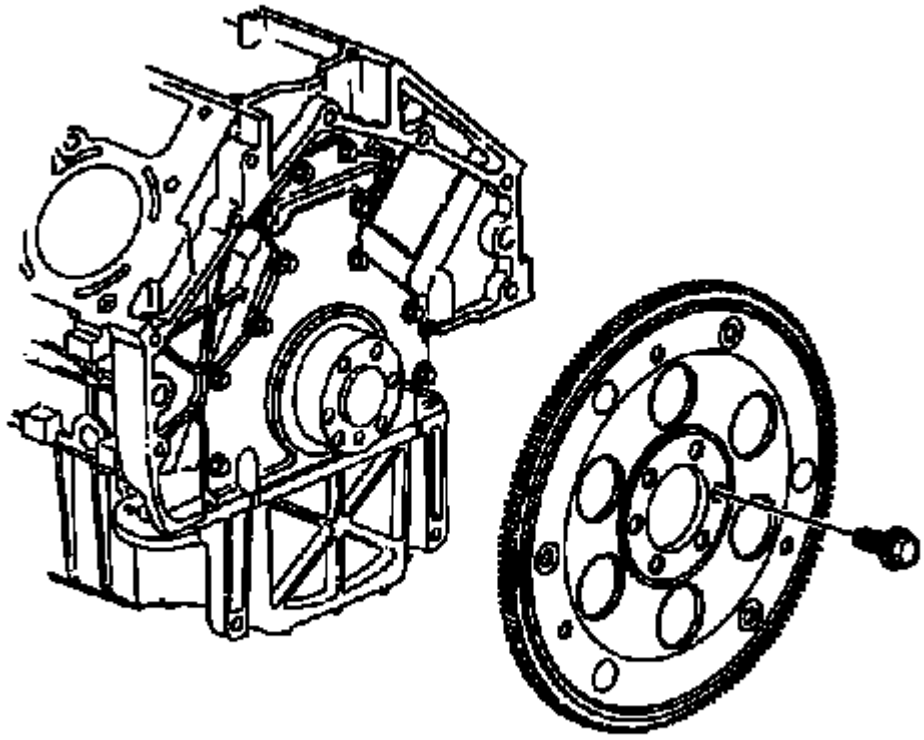

Fig. 264: View Of Engine Flywheel & Bolt
Courtesy of GENERAL MOTORS CORP.

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

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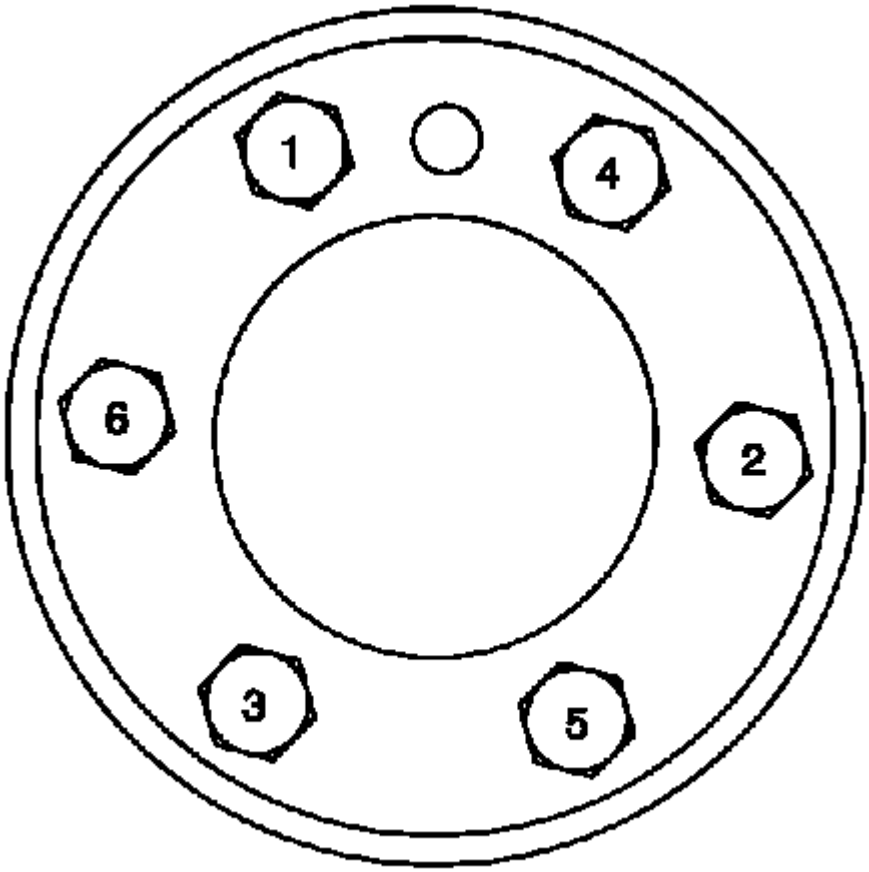

Fig. 265: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the engine flywheel bolts.
   - Tighten the bolts a first pass in sequence to 20 N.m (15 lb ft).
   - Tighten the bolts a second pass in sequence to 50 N.m (37 lb ft).
   - Tighten the bolts a final pass in sequence to 100 N.m (74 lb ft).
4. Install the transmission. Refer to **Transmission Replacement (4WD 5.3L)** or **Transmission Replacement (2WD 5.3L)** .

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Removal Procedure

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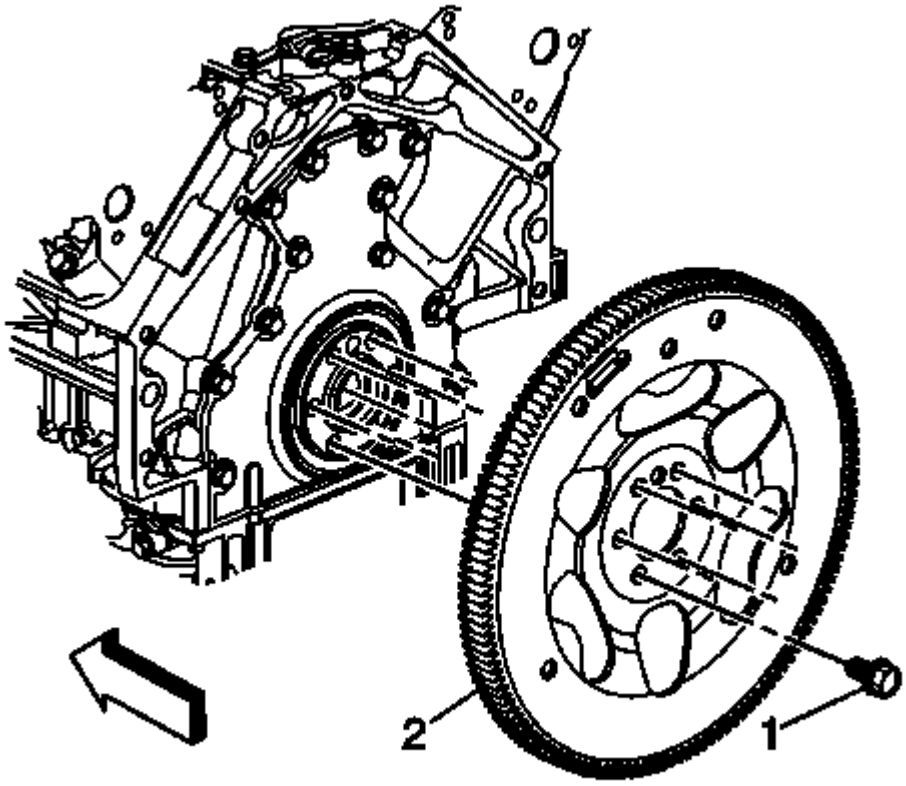

Fig. 266: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the automatic transmission. Refer to **Transmission Replacement (4WD 5.3L)** or **Transmission Replacement (2WD 5.3L)** for the 4L60-E.

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

2. Remove the flywheel bolts.
3. Remove the flywheel.

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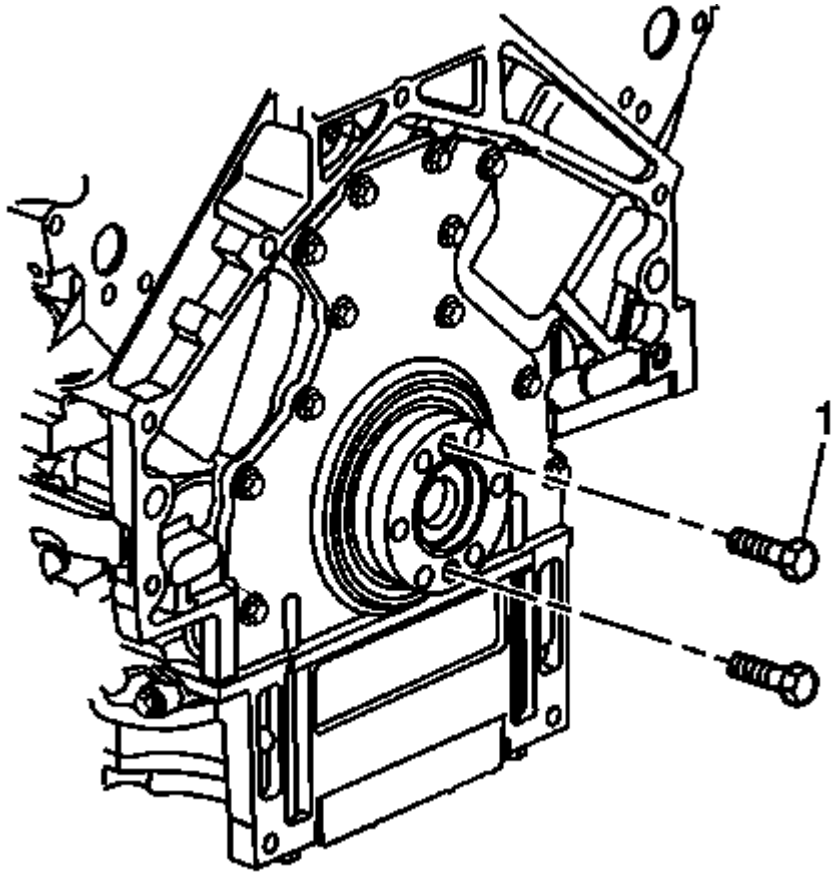

Fig. 267: View Of Bolts & Spacer
Courtesy of GENERAL MOTORS CORP.

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.

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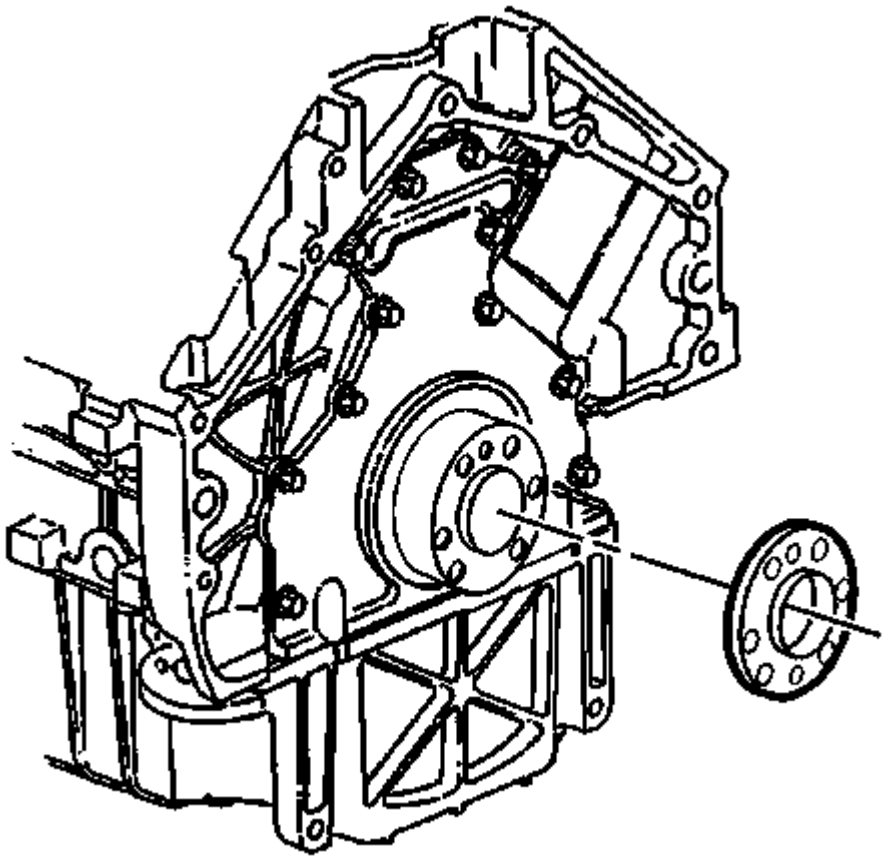

Fig. 268: View Of Spacer & Crankshaft Rear
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

NOTE:

- **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.**

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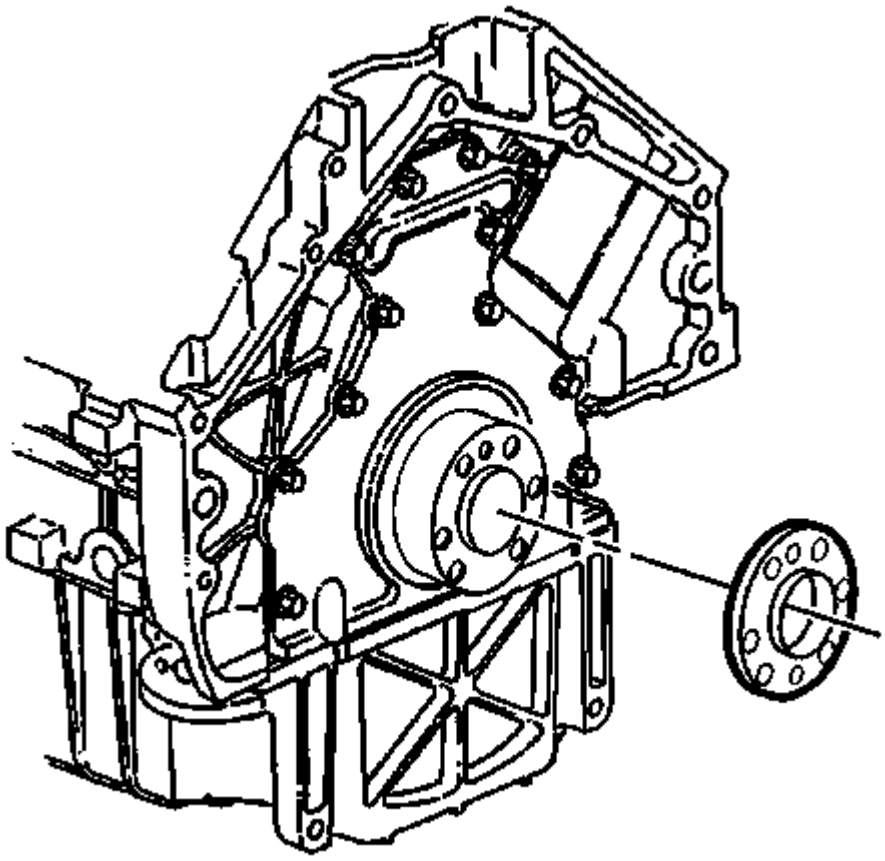

Fig. 269: View Of Spacer & Crankshaft Rear
Courtesy of GENERAL MOTORS CORP.

1. Install the spacer, if applicable, onto the rear of the crankshaft.

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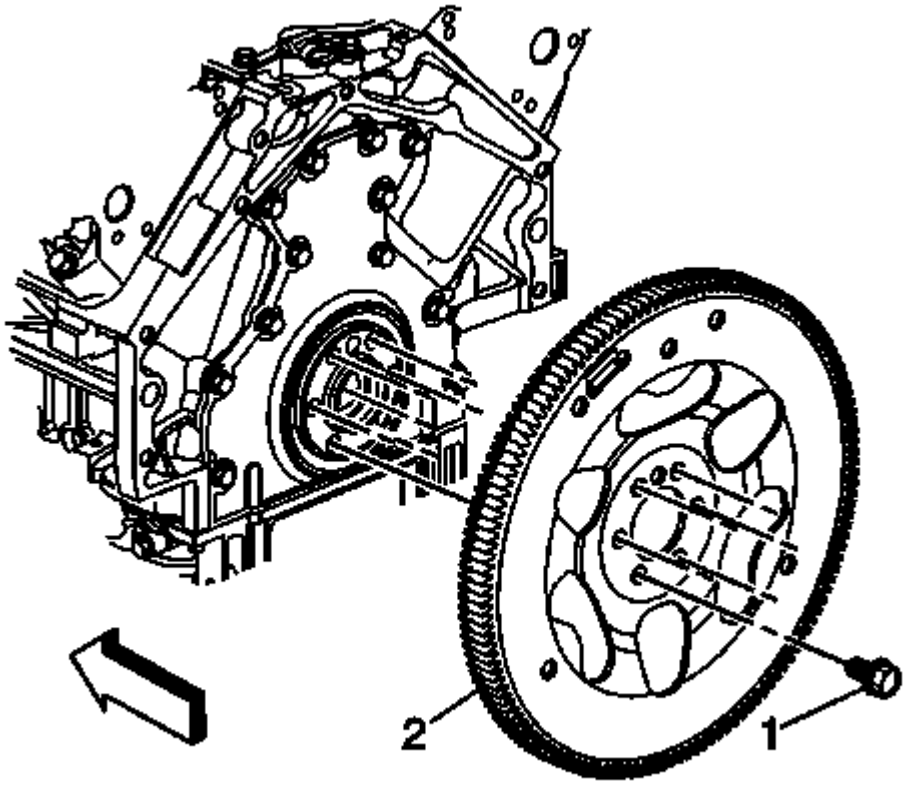

Fig. 270: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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

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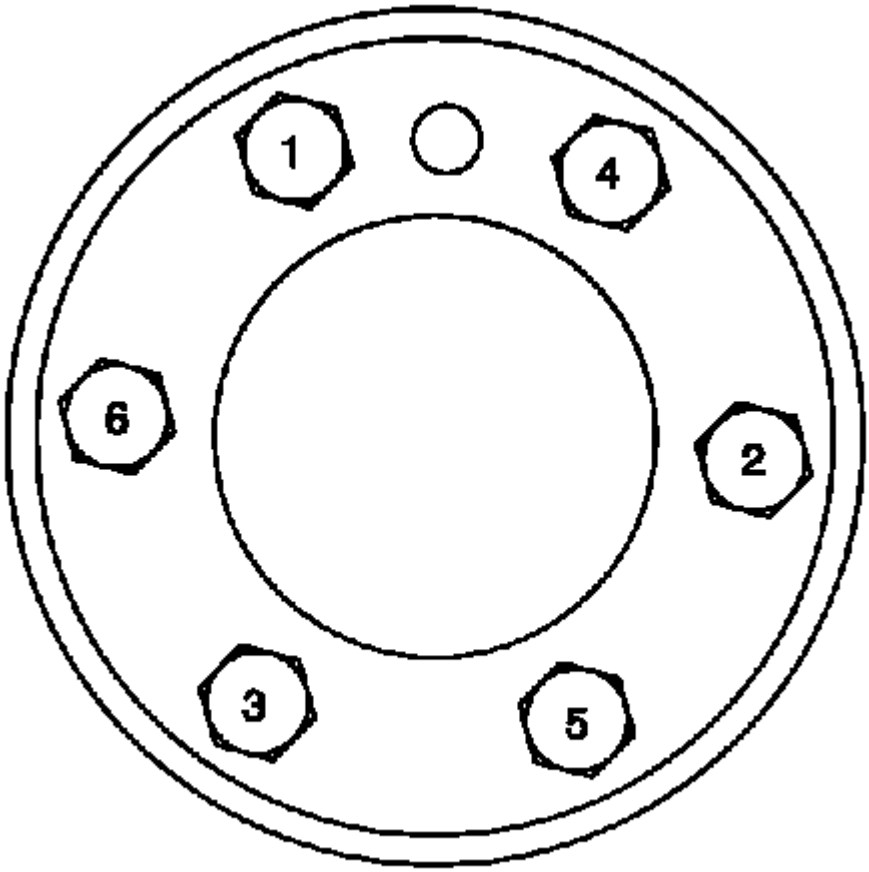

Fig. 271: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Tighten the flywheel bolts.
   - Tighten the bolts (1-6) a first pass in sequence to 20 N.m (15 lb ft).
   - Tighten the bolts (1-6) a second pass in sequence to 50 N.m (37 lb ft).
   - Tighten the bolts (1-6) a final pass in sequence to 100 N.m (74 lb ft).
5. Install the automatic transmission. Refer to **Transmission Replacement (4WD 5.3L)** or **Transmission Replacement (2WD 5.3L)** for the 4L60-E.

ENGINE REPLACEMENT

Special Tools

- **J 21366** Converter Holding Strap. See **Special Tools**.
- **J 38185** Hose Clamp Pliers

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- **J 41798** Engine Lift Bracket. See **Special Tools**.

Removal Procedure

1. Remove the hood. Refer to **Hood Replacement** .
2. Place fender covers over both fenders.
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
4. Recover the refrigerant. Refer to **Refrigerant Recovery and Recharging** .
5. Remove the radiator. Refer to **Radiator Replacement** .
6. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
7. Disconnect the oil pressure sensor and the oxygen sensors from the rear of the engine.

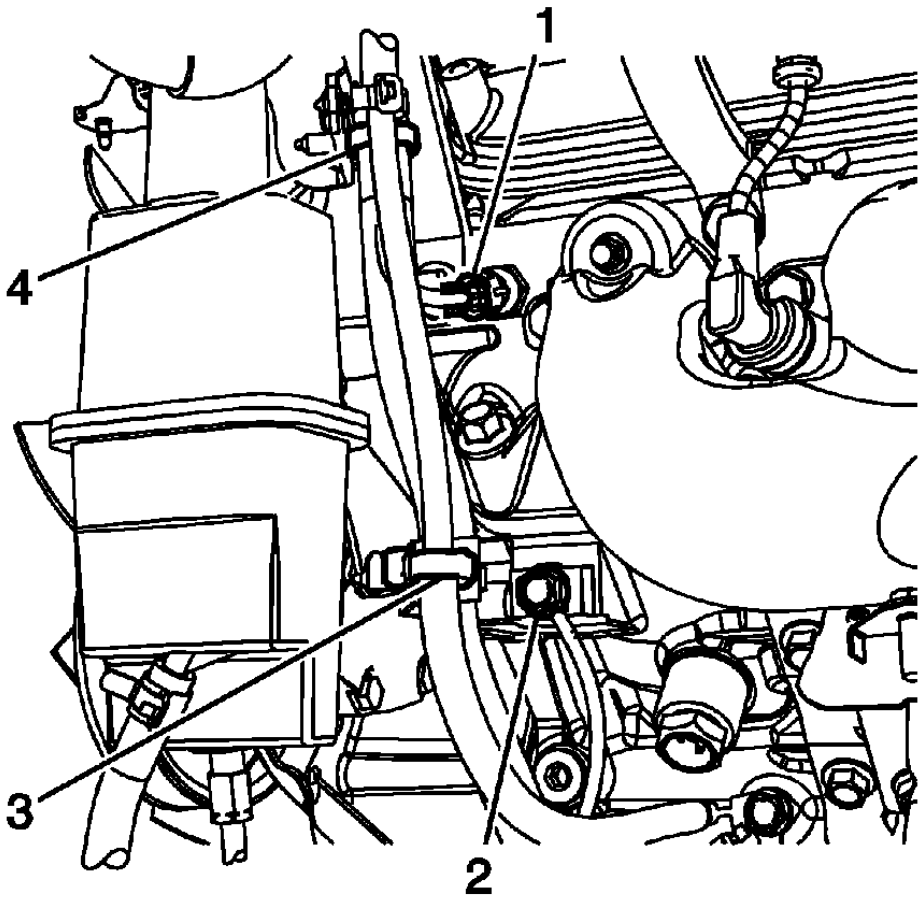

Fig. 272: Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the engine coolant temperature (ECT) sensor (1).

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9. Remove the ground terminal bolt (2).
10. Remove the retaining clips (3, 4) from the brackets.
11. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
12. Remove the starter. Refer to **Starter Replacement** .

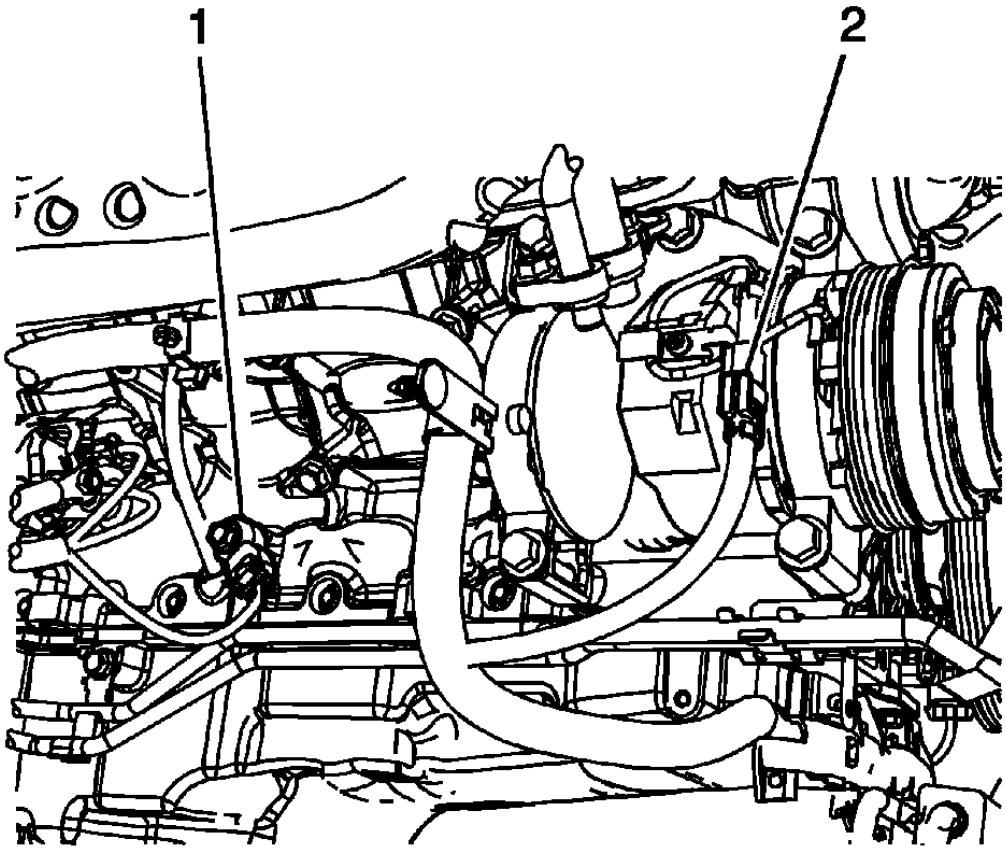

Fig. 273: Knock Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the following connectors:
    - Left and right side knock sensor electrical connector (1).
    - A/C pressure switch electrical connector (2).
    - Block heater electrical connector.

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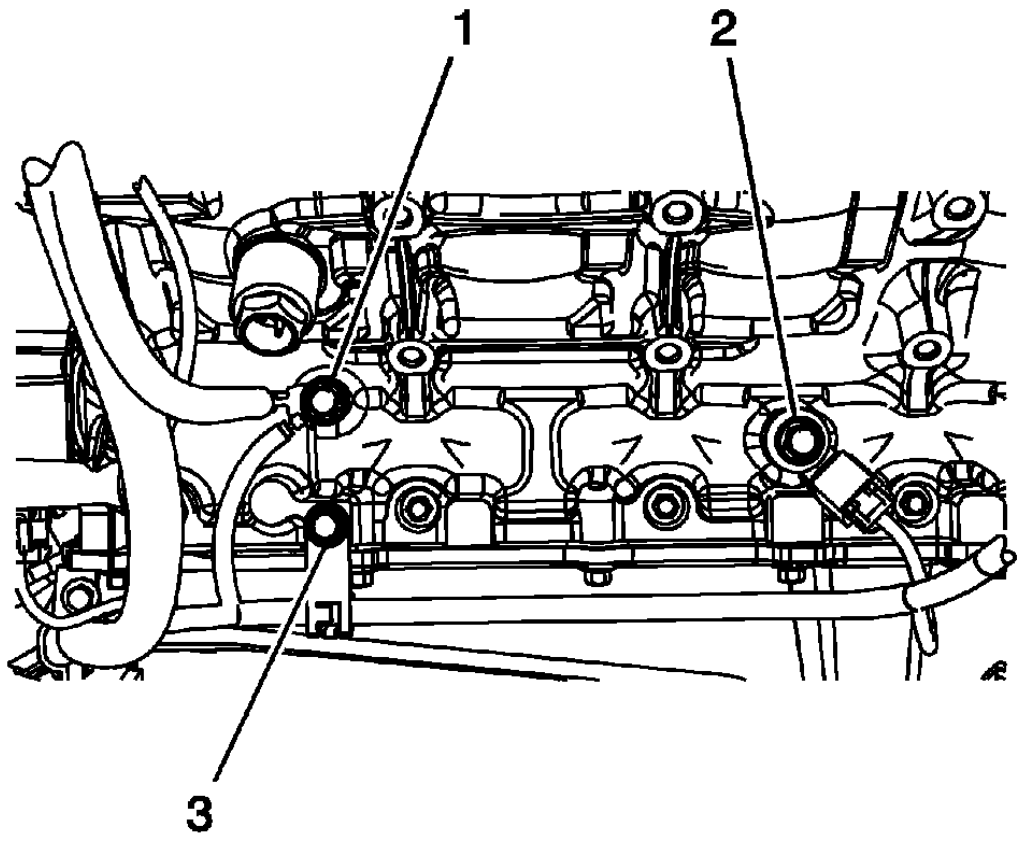

Fig. 274: Ground Terminal Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the ground terminal bolt (1).
15. Remove the engine harness bracket bolt (3).

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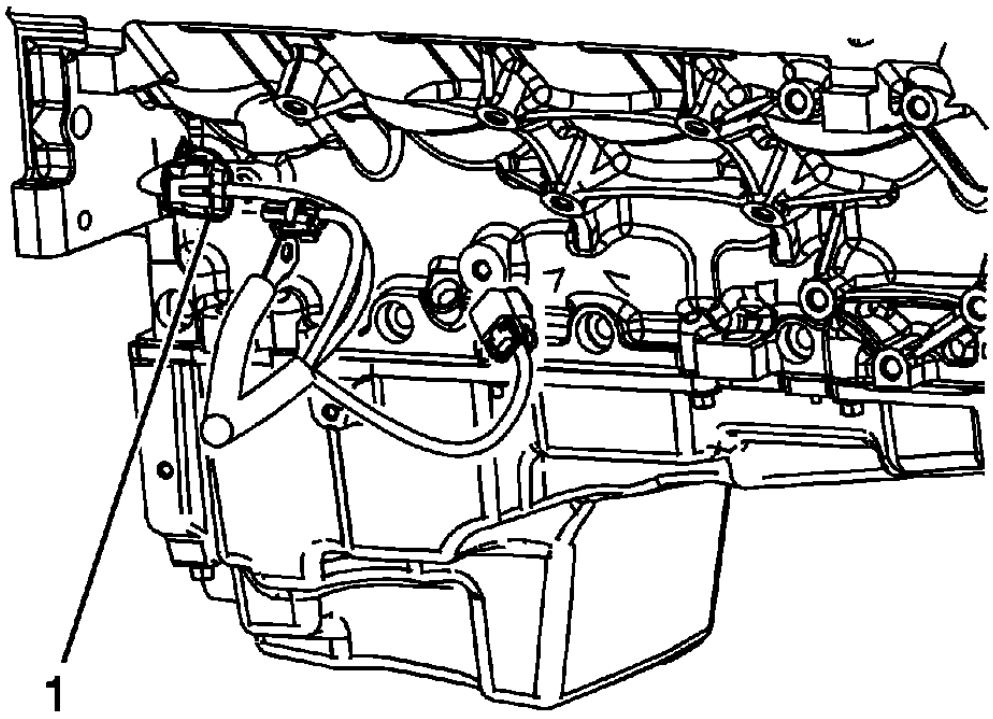

Fig. 275: Engine Wiring Harness Electrical Connector & Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

16. Disconnect the engine wiring harness electrical connector (1) from the crankshaft position (CKP) sensor.

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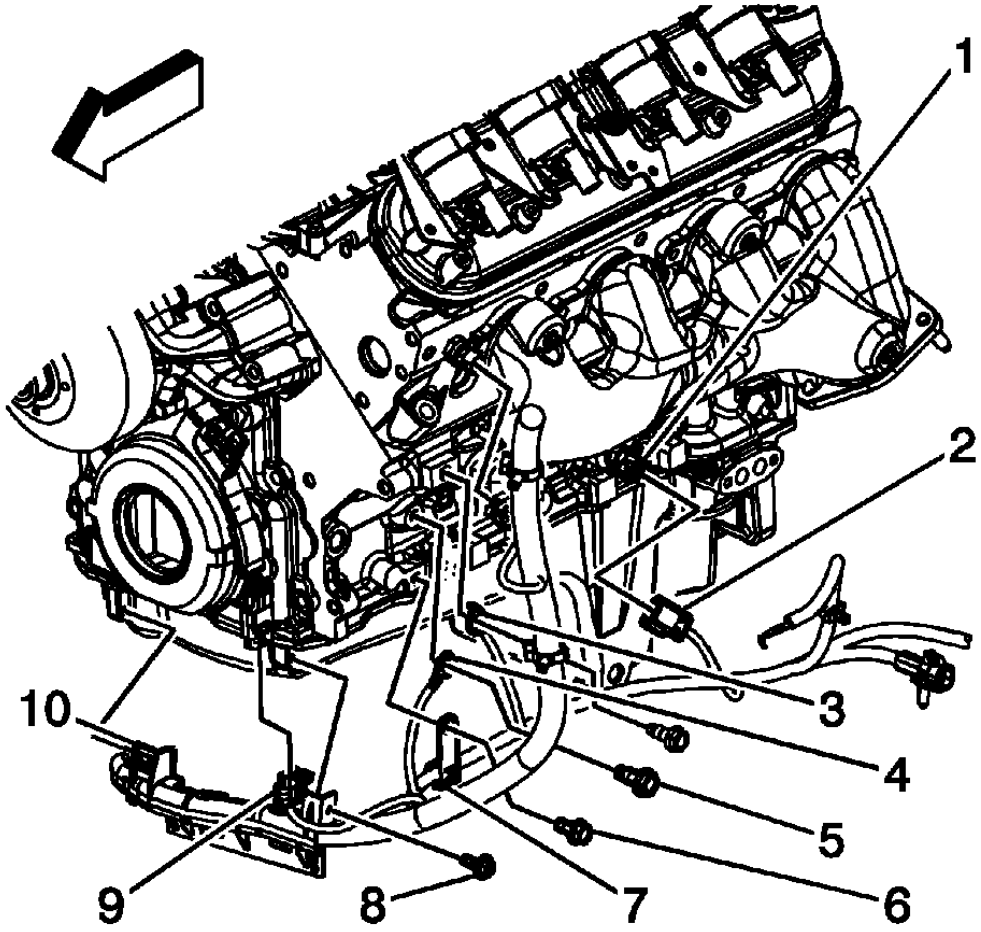

Fig. 276: Engine Wiring Harness Electrical Connector & Crankshaft Position (CKP) Sensor Wire Harness
Courtesy of GENERAL MOTORS CORP.

17. Disconnect the engine wiring harness electrical connector (9) from the camshaft position (CMP) sensor wire harness.

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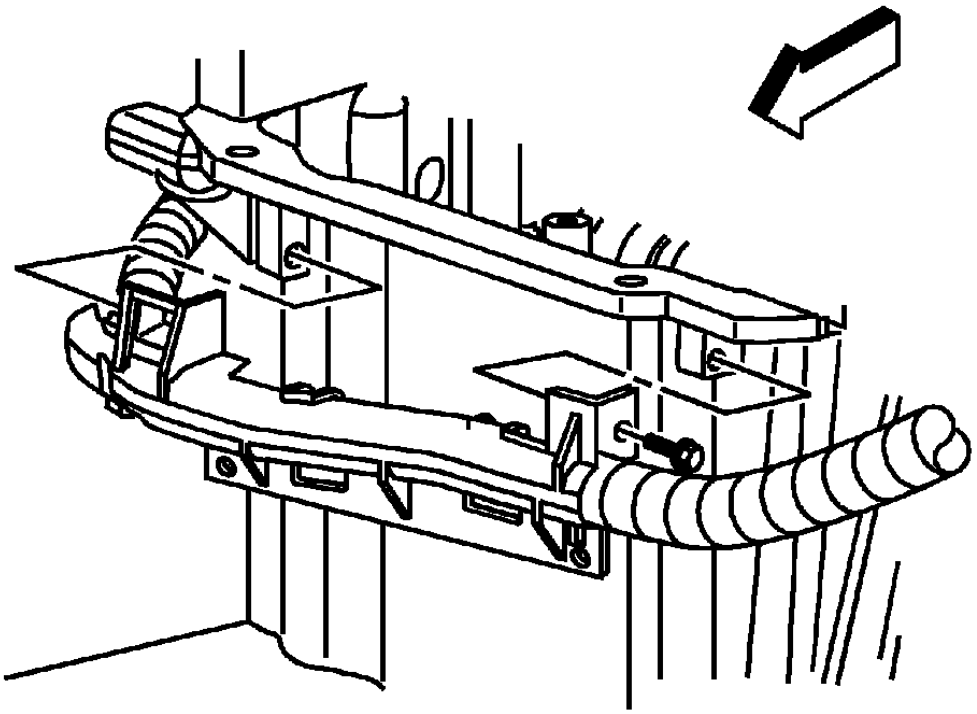

Fig. 277: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

18. Remove the battery cable channel bolt.
19. Remove the battery cable channel from the oil pan.
20. Lower the vehicle.
21. Gather all branches of the engine wiring harness and reposition the harness off to the side.

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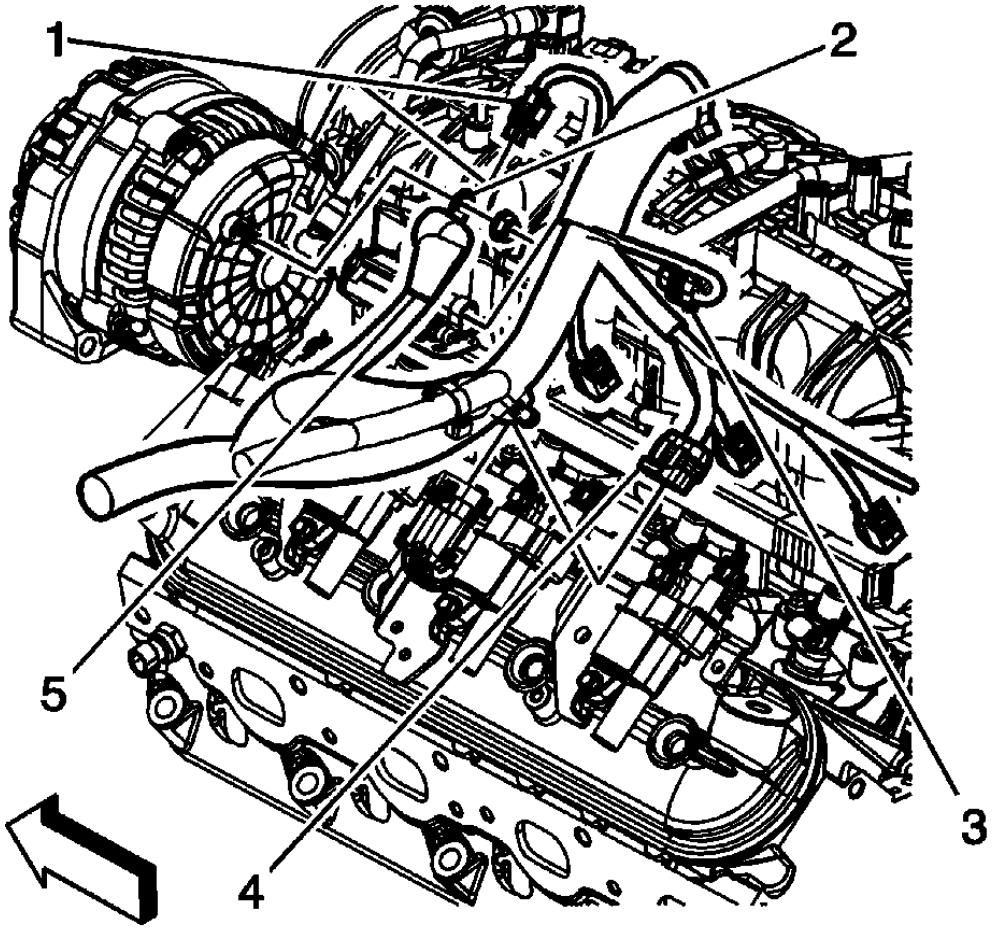

Fig. 278: Engine Wiring Harness Electrical Connector & Generator
Courtesy of GENERAL MOTORS CORP.

22. Disconnect the engine wiring harness electrical connector (1) from the generator.
23. Reposition the engine wiring harness/positive battery cable boot (5).
24. Remove the engine wiring harness/positive battery cable nut from the generator.
25. Remove the engine wiring harness/positive battery cable (2) from the generator.

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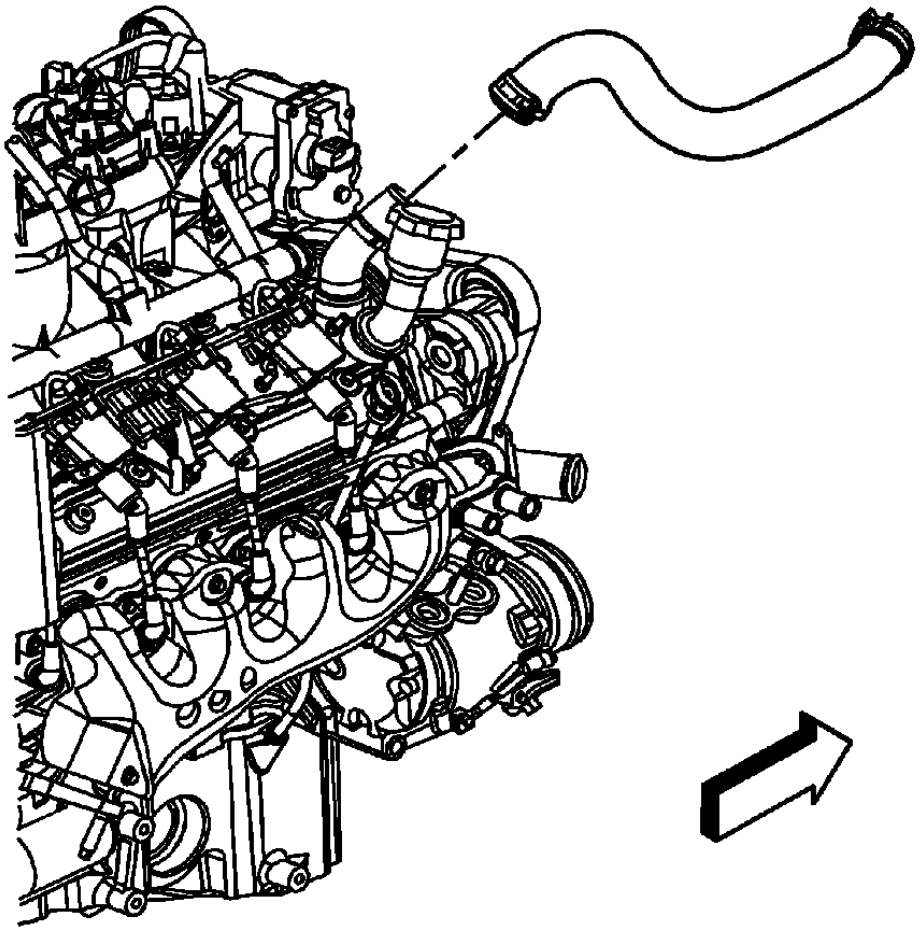

Fig. 279: View Of Inlet Hose
Courtesy of GENERAL MOTORS CORP.

26. Using **J 38185** , remove the inlet hose from the water outlet.

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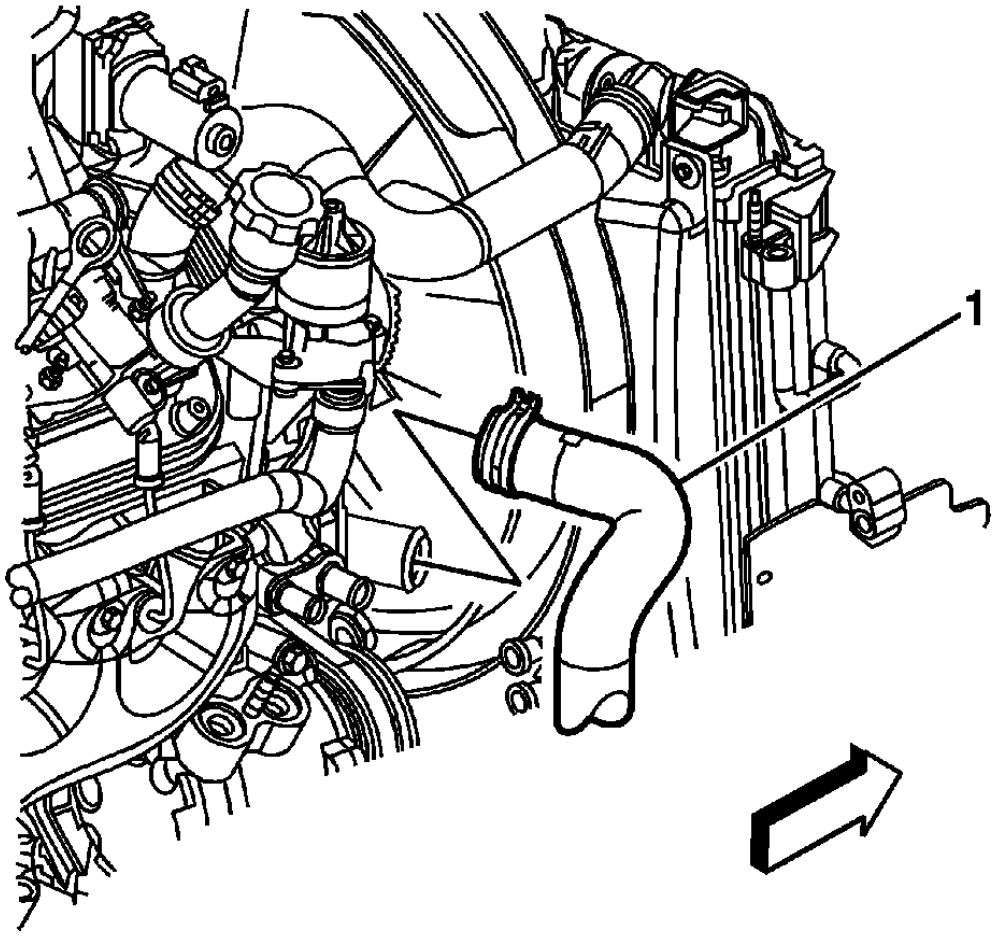

Fig. 280: Outlet Hose & Water Outlet
Courtesy of GENERAL MOTORS CORP.

27. Using **J 38185** , remove the outlet hose (1) from the water outlet.
28. Remove the heater inlet and outlet hoses. Refer to **Heater Inlet Hose Replacement** and **Heater Outlet Hose Replacement** .
29. Raise the vehicle.
30. Remove the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side** and **Catalytic Converter Replacement - Right Side** .
31. Remove the 3 bracket bolts from both the right and the left side engine mounts. Refer to **Engine Mount Replacement - Left Side** and **Engine Mount Replacement - Right Side**

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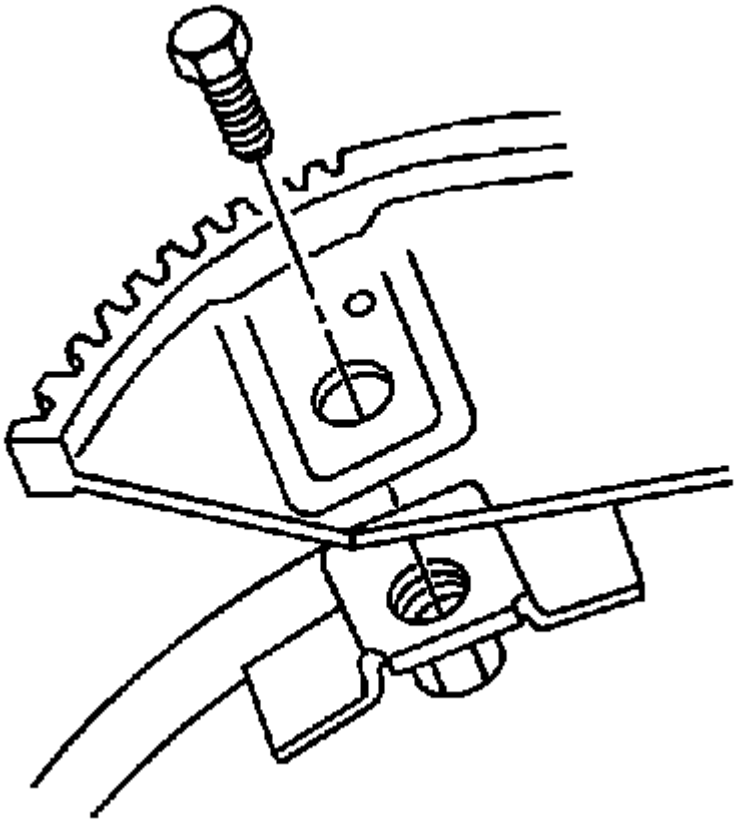

Fig. 281: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

32. Remove the torque converter bolts.
33. Remove the transmission oil level indicator tube. Refer to **Transmission Fluid Filler Tube and Seal Replacement (5.3L)** .

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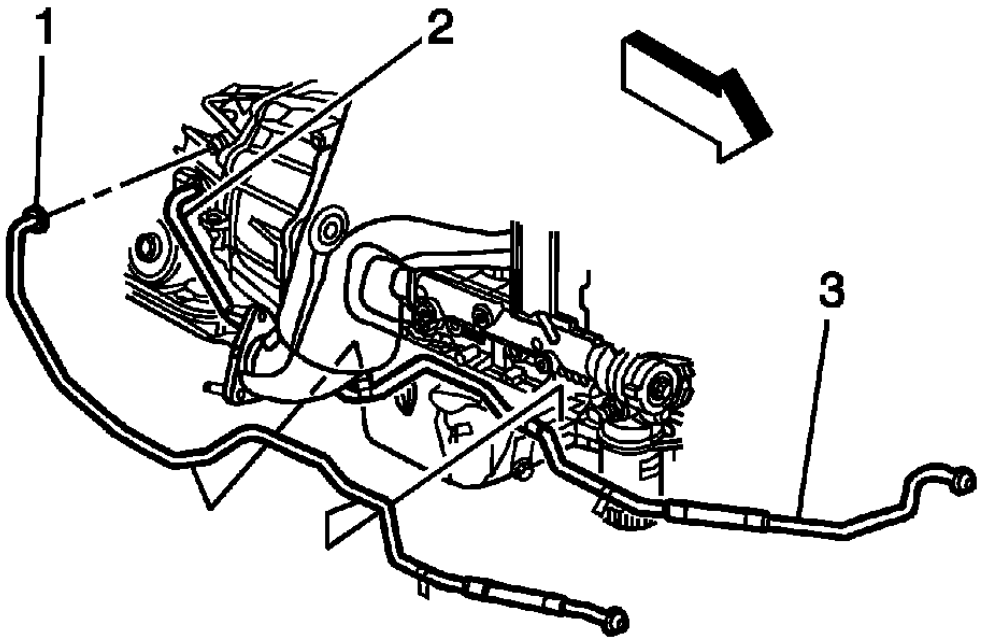

Fig. 282: View Of Transmission Fluid Cooler Lines
Courtesy of GENERAL MOTORS CORP.

34. Remove the transmission fluid cooler lines from the retainer located on the right side of the engine.

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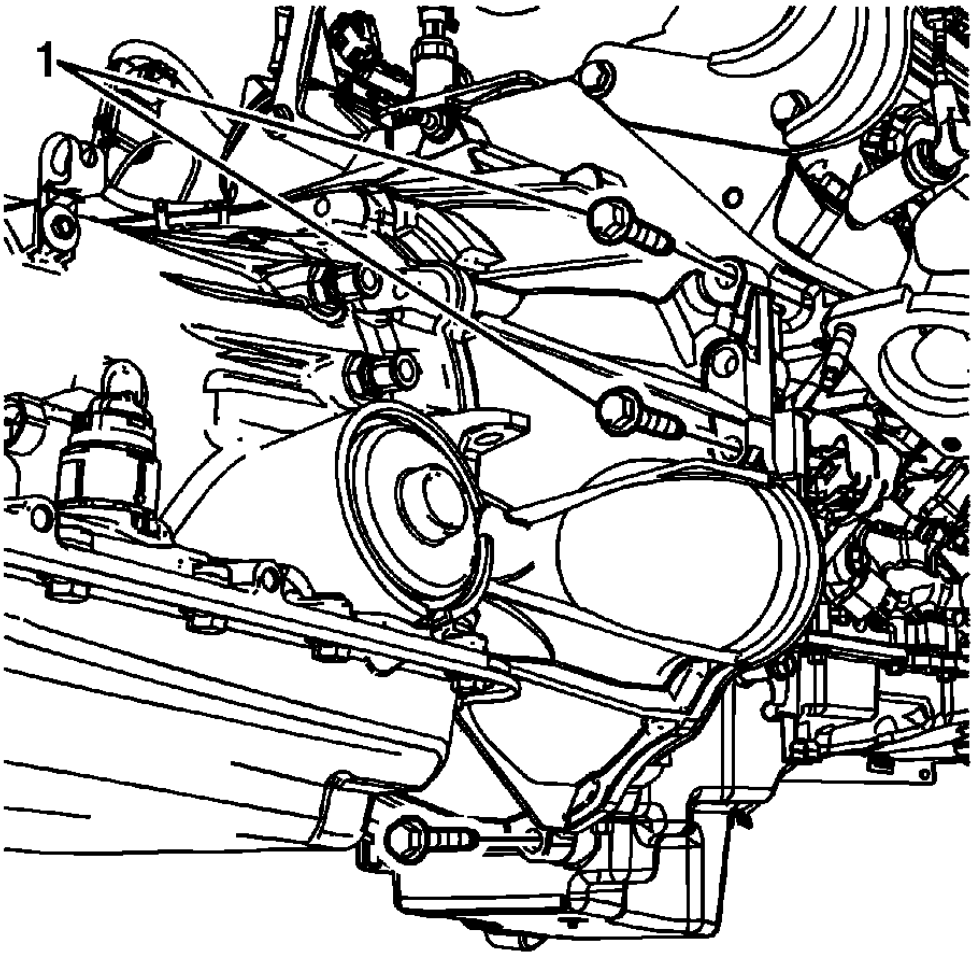

Fig. 283: Lower Transmission Bolt/Studs - Right & Left Side
Courtesy of GENERAL MOTORS CORP.

35. Remove the lower transmission bolts (1) on the right and left side.

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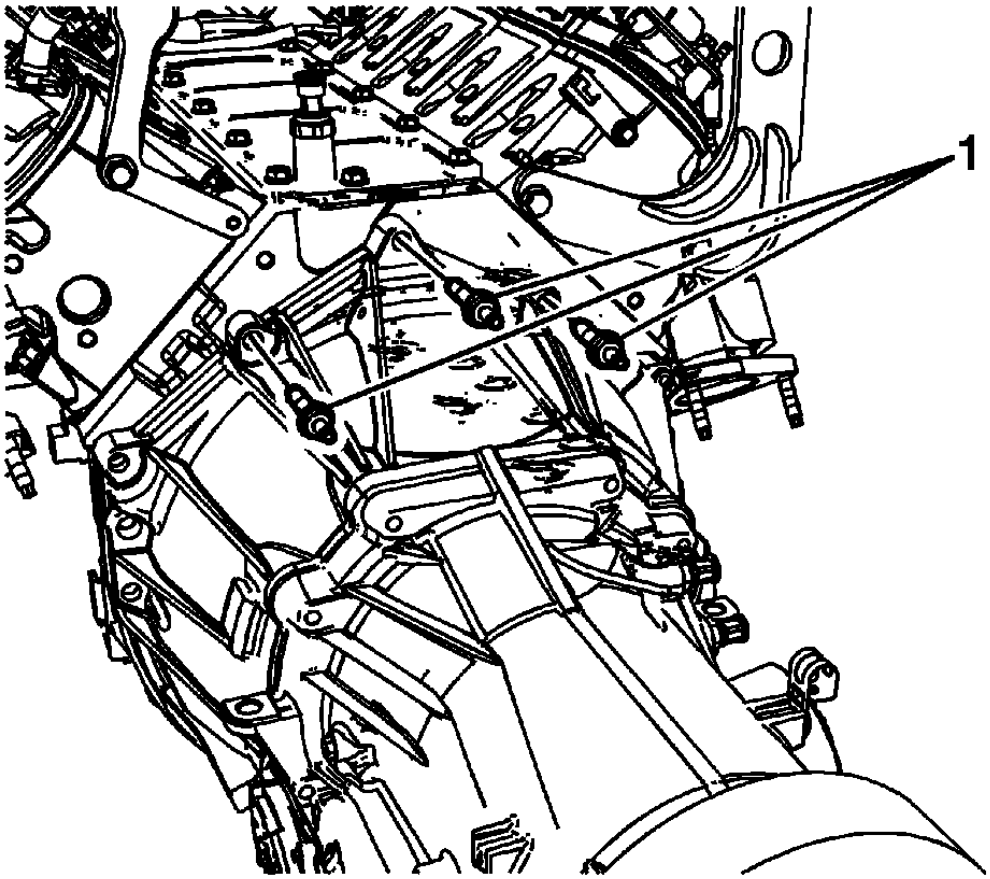

Fig. 284: Lower Transmission Bolt/Studs
Courtesy of GENERAL MOTORS CORP.

36. Remove the lower transmission bolt/studs.
37. Lower the vehicle.
38. Remove the 3 upper transmission bolts/studs (1).
39. Install an engine hoist to **J 41798** . See **Special Tools**.
40. Install a floor jack under the transmission for support.
41. Separate the engine from the transmission.
42. Remove the engine.
43. Install the engine to an engine stand.
44. Install **J 21366** . See **Special Tools**.

Installation Procedure

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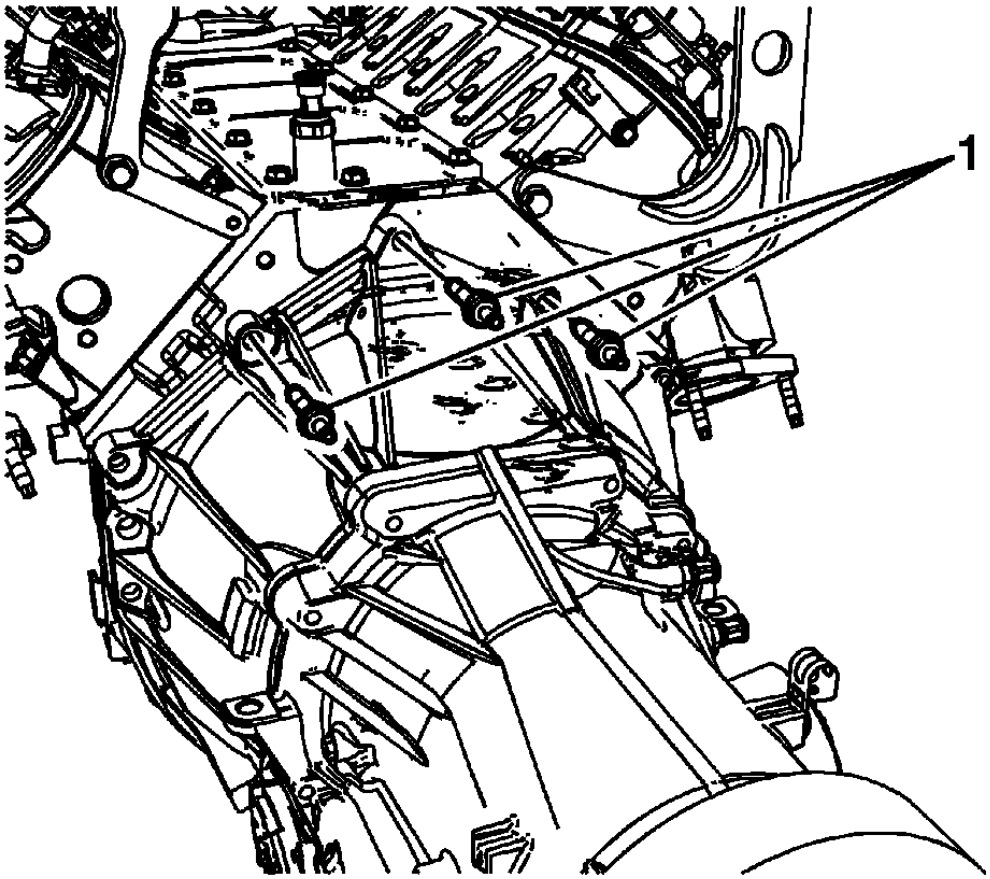

Fig. 285: Lower Transmission Bolt/Studs
Courtesy of GENERAL MOTORS CORP.

1. Remove **J 21366** . See **Special Tools**.
2. Install an engine hoist to **J 41798** . See **Special Tools**.
3. Remove the engine from the engine stand.
4. Install the engine.
5. Mate the engine to the transmission.
6. Remove the floor jack from under the transmission for support.

CAUTION: Refer to Fastener Caution .

7. Install the 3 upper transmission bolts/studs (1) and tighten to 50 N.m (37 lb ft).
8. Raise the vehicle.
9. Install the lower transmission bolt/studs and tighten to 50 N.m (37 lb ft).

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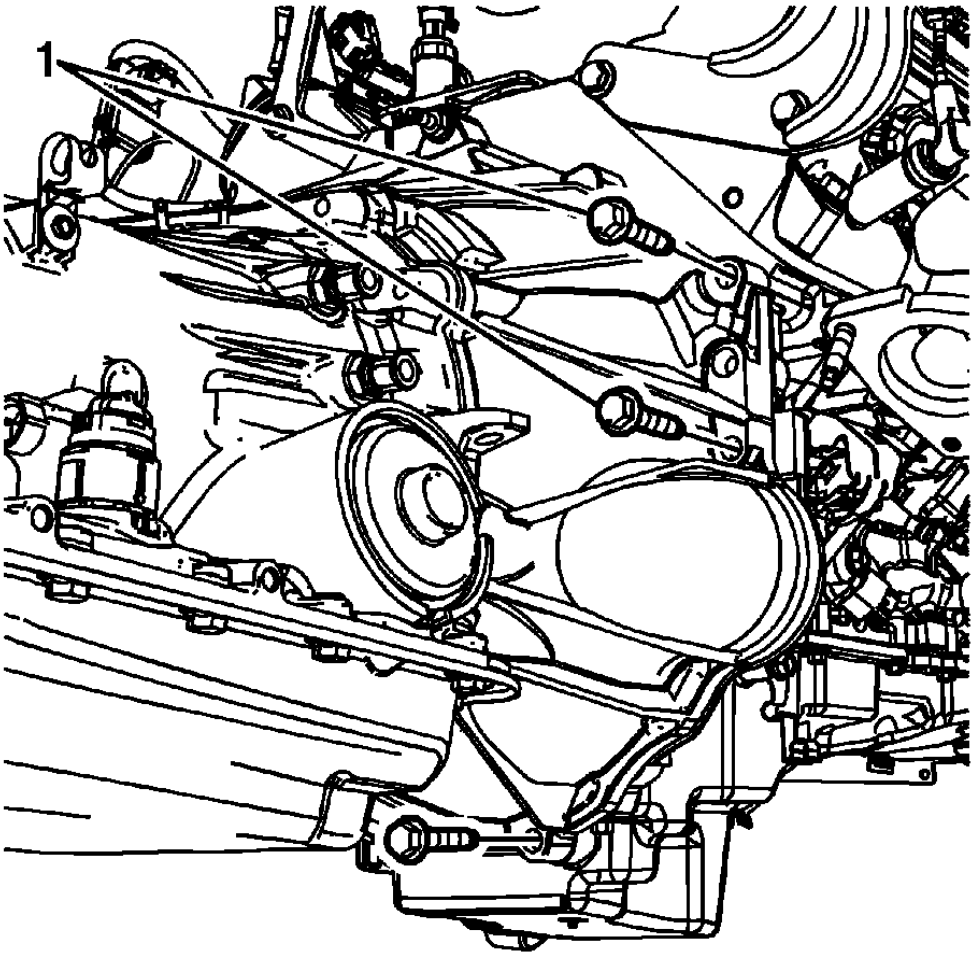

Fig. 286: Lower Transmission Bolt/Studs - Right & Left Side
Courtesy of GENERAL MOTORS CORP.

10. Install the lower transmission bolts (1) on the right and left side and tighten to 50 N.m (37 lb ft).

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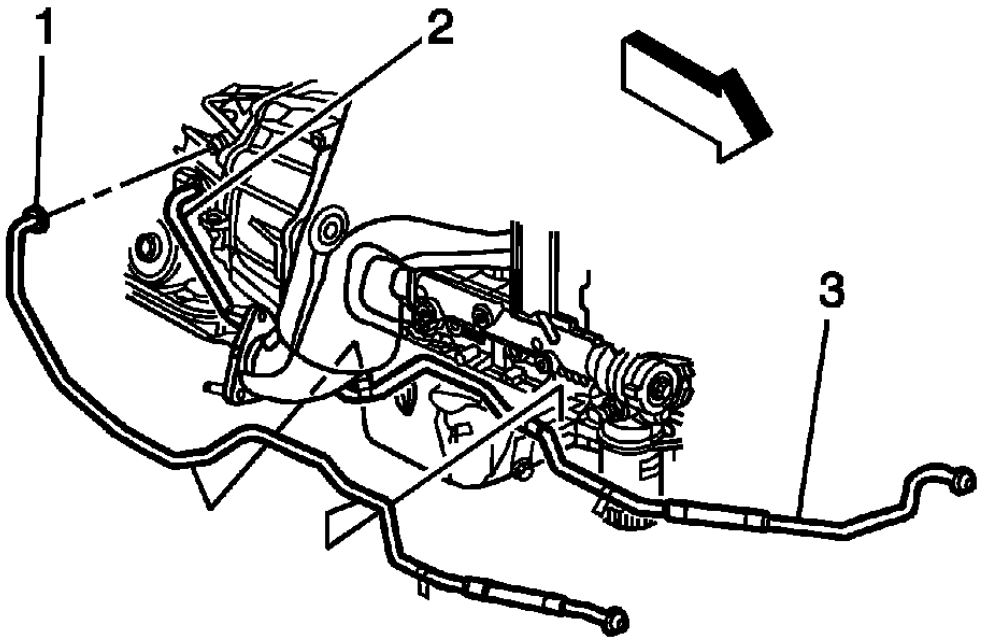

Fig. 287: View Of Transmission Fluid Cooler Lines
Courtesy of GENERAL MOTORS CORP.

11. Install the transmission fluid cooler lines to the right side of the engine.
12. Install the transmission oil level indicator tube. Refer to **Transmission Fluid Filler Tube and Seal Replacement (5.3L)** .

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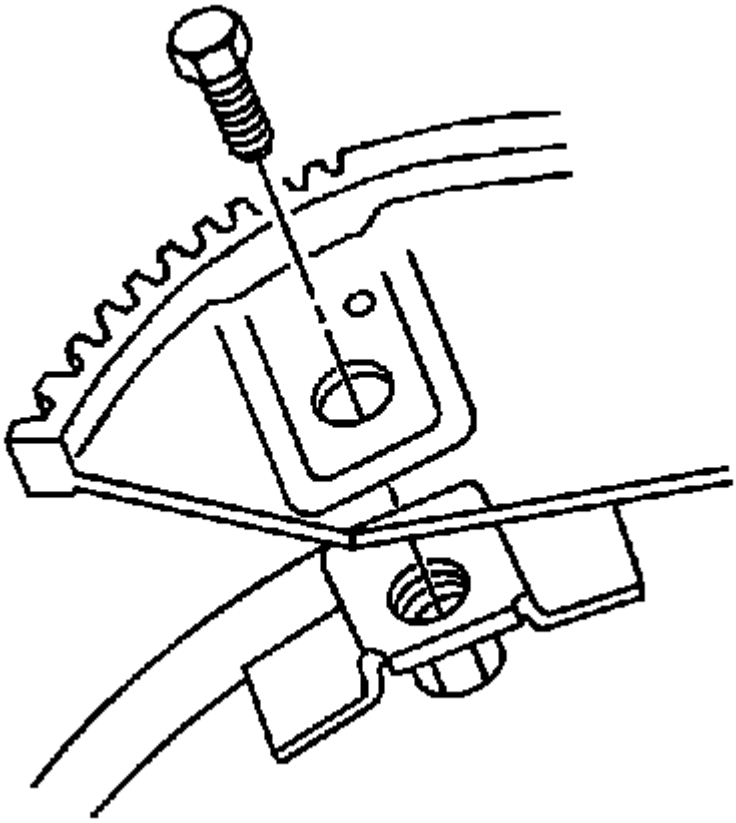

Fig. 288: Flywheel-To-Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

13. Install the torque converter bolts and tighten to 60 N.m (44 lb ft).
14. Install the 3 bracket bolts from both the right and the left side engine mounts. Refer to **Engine Mount Replacement - Left Side** and **Engine Mount Replacement - Right Side**
15. Install the catalytic converters. Refer to **Catalytic Converter Replacement - Left Side (LH9)** and **Catalytic Converter Replacement - Right Side (LH9)** .
16. Lower the vehicle.
17. Install the heater inlet and outlet hoses. Refer to **Heater Inlet Hose Replacement** and **Heater Outlet Hose Replacement** .

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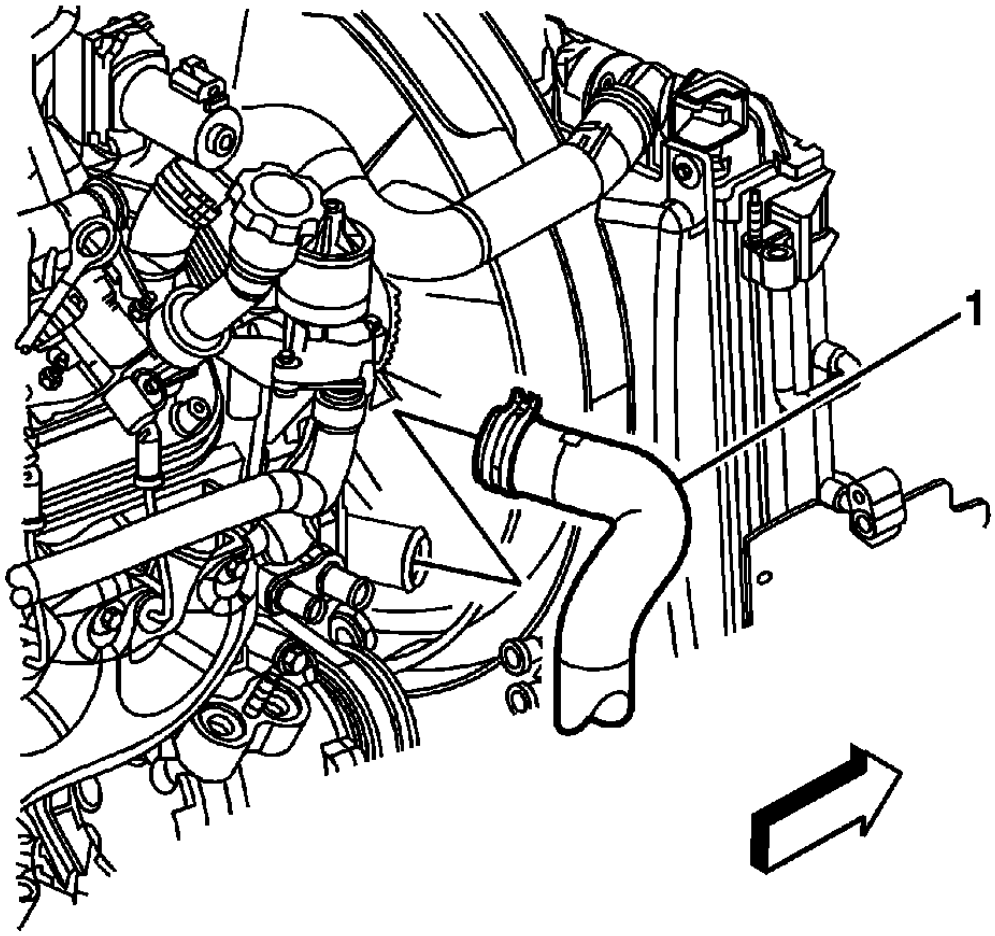

Fig. 289: Outlet Hose & Water Outlet
Courtesy of GENERAL MOTORS CORP.

18. Using **J 38185** , install the outlet hose (1) to the water outlet.

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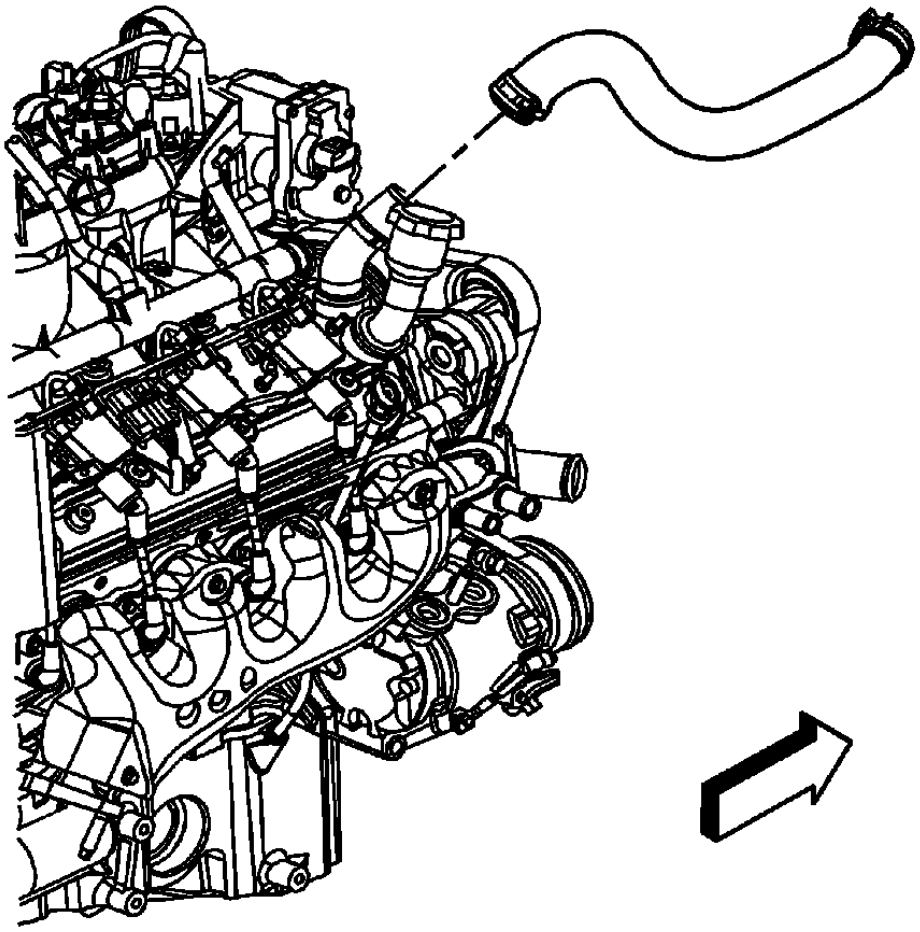

Fig. 290: View Of Inlet Hose
Courtesy of GENERAL MOTORS CORP.

19. Using **J 38185** , install the inlet hose to the water outlet.

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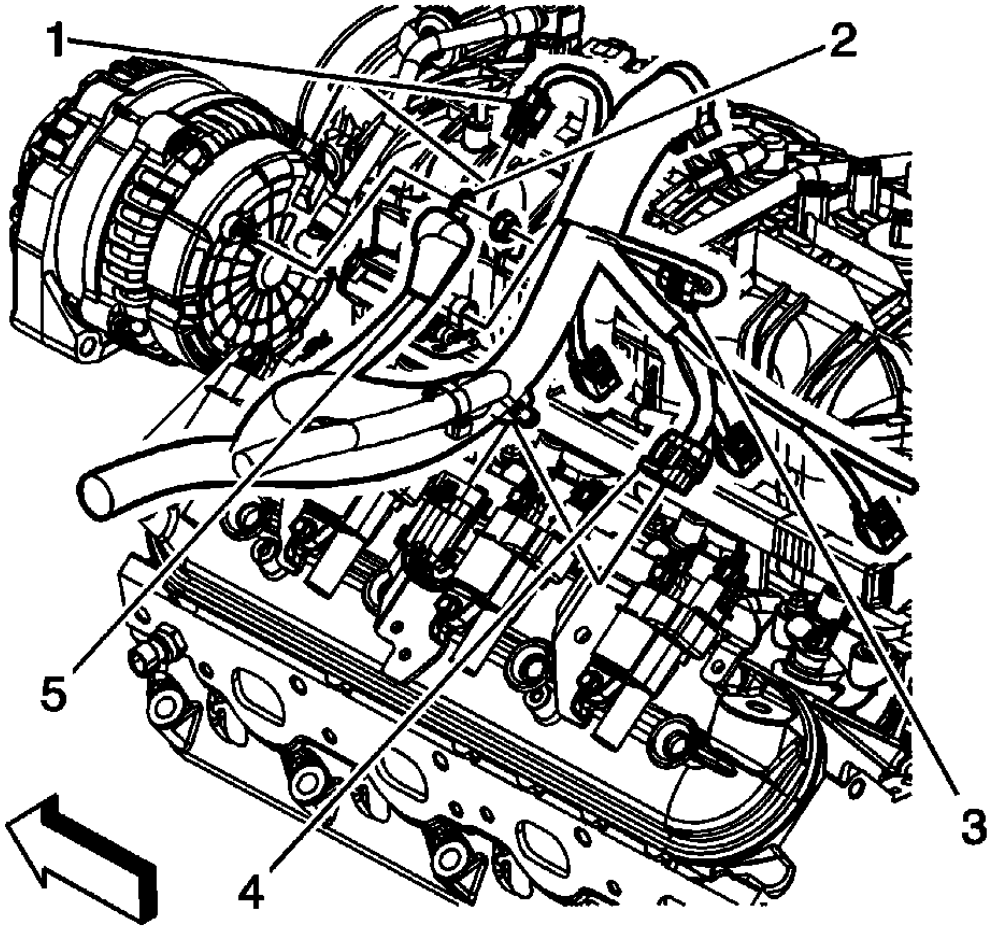

Fig. 291: Engine Wiring Harness Electrical Connector & Generator
Courtesy of GENERAL MOTORS CORP.

20. Install the engine wiring harness/positive battery cable (2) to the generator.
21. Install the engine wiring harness/positive battery cable nut to the generator and tighten the nut to 9 N.m (80 lb in).
22. Position the engine wiring harness/positive battery cable boot (5).
23. Connect the engine wiring harness electrical connector (1) to the generator.

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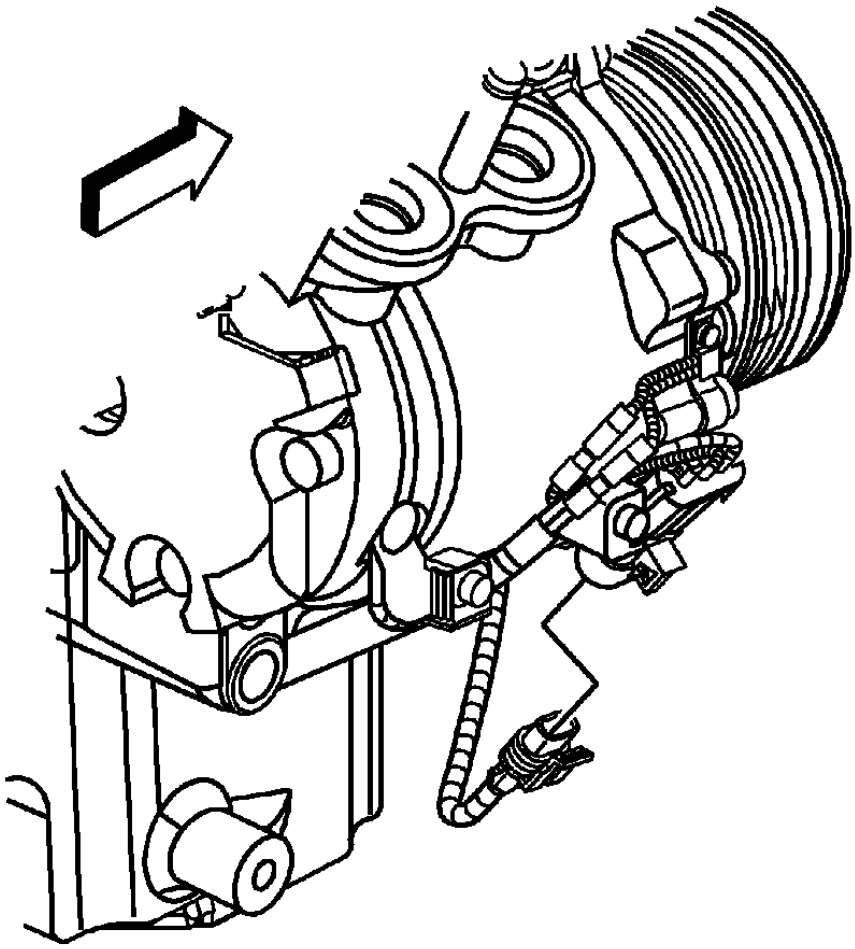

Fig. 292: View Of A/C Compressor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

24. Gather all branches of the engine wiring harness and position the harness over the engine.
25. Raise the vehicle.
26. Install the starter. Refer to **Starter Replacement** .

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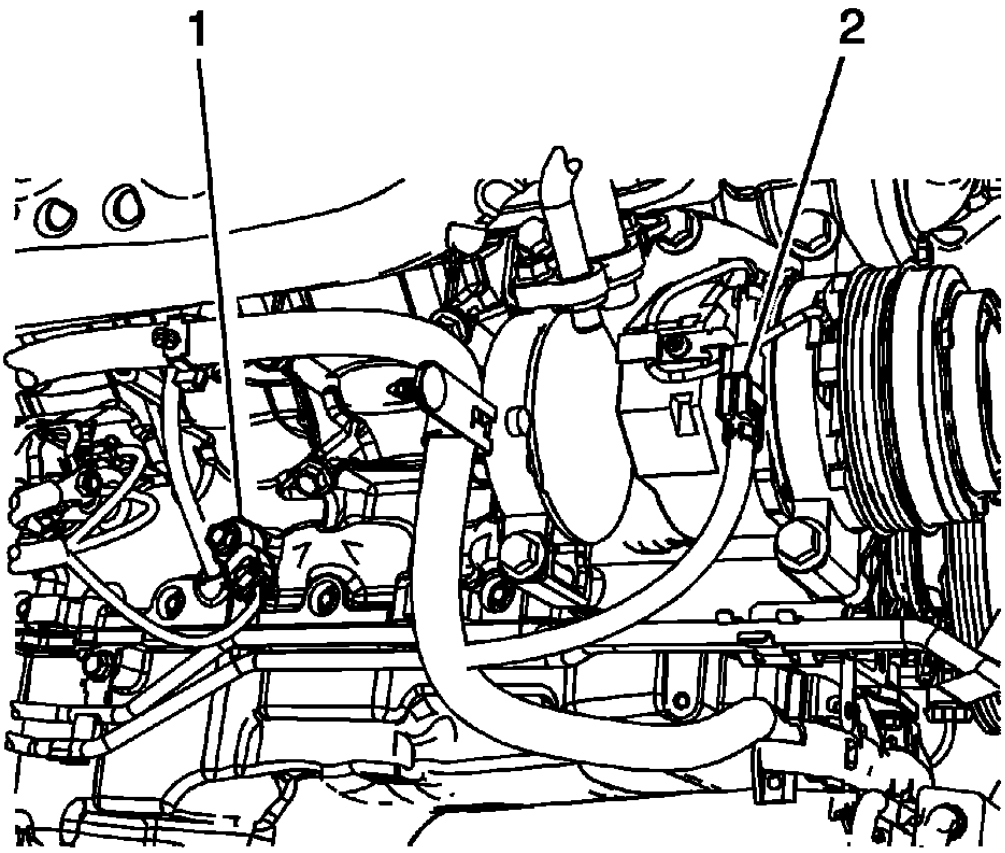

Fig. 293: Knock Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

27. Connect the following connectors:
    - Block heater electrical connector.
    - A/C pressure switch electrical connector (2).
    - Left and right side knock sensor electrical connector (1).

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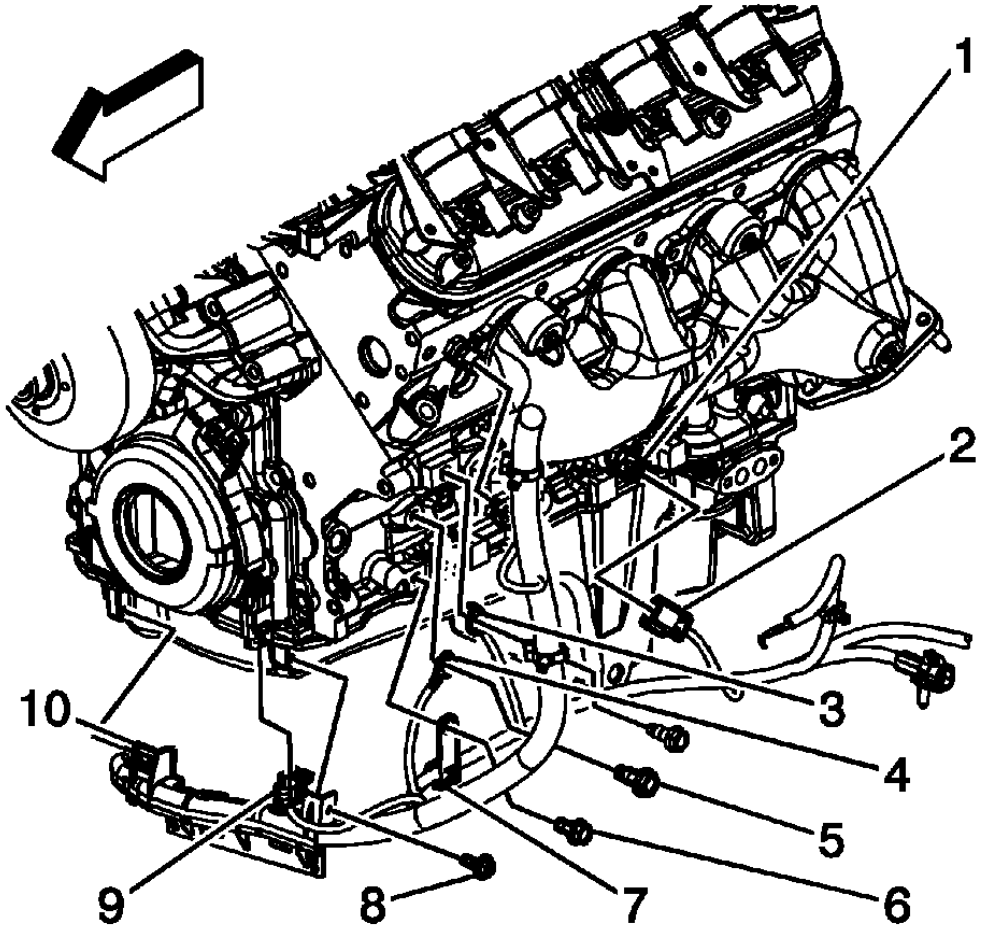

Fig. 294: Engine Wiring Harness Electrical Connector & Crankshaft Position (CKP) Sensor Wire Harness
Courtesy of GENERAL MOTORS CORP.

28. Connect the engine wiring harness electrical connector (9) to the CMP sensor wire harness.

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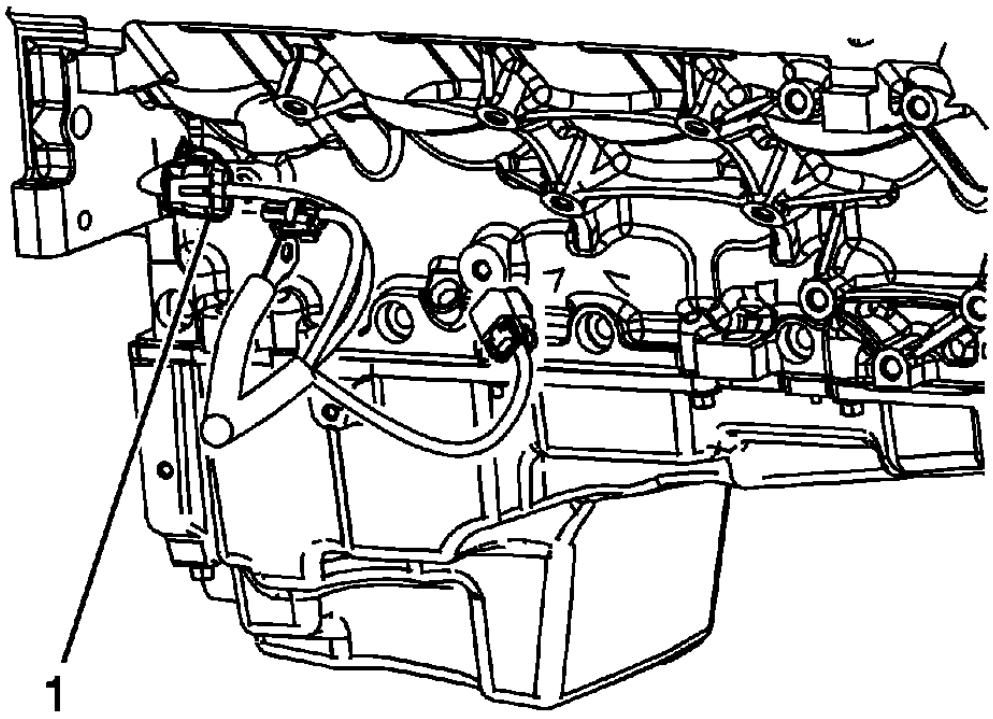

Fig. 295: Engine Wiring Harness Electrical Connector & Crankshaft Position (CKP) Sensor
Courtesy of GENERAL MOTORS CORP.

29. Connect the engine wiring harness electrical connector (1) to the CKP sensor.

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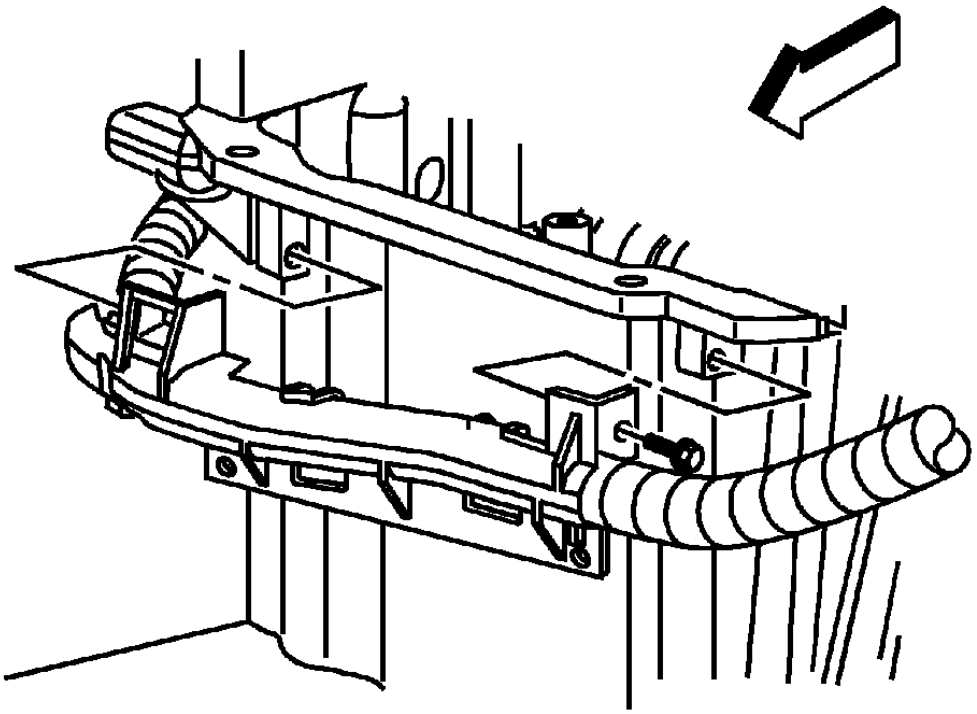

Fig. 296: View Of Battery Cable Channel & Bolt
Courtesy of GENERAL MOTORS CORP.

30. Install the battery cable channel to the oil pan.
31. Install the battery cable channel bolt and tighten to 12 N.m (106 lb in).

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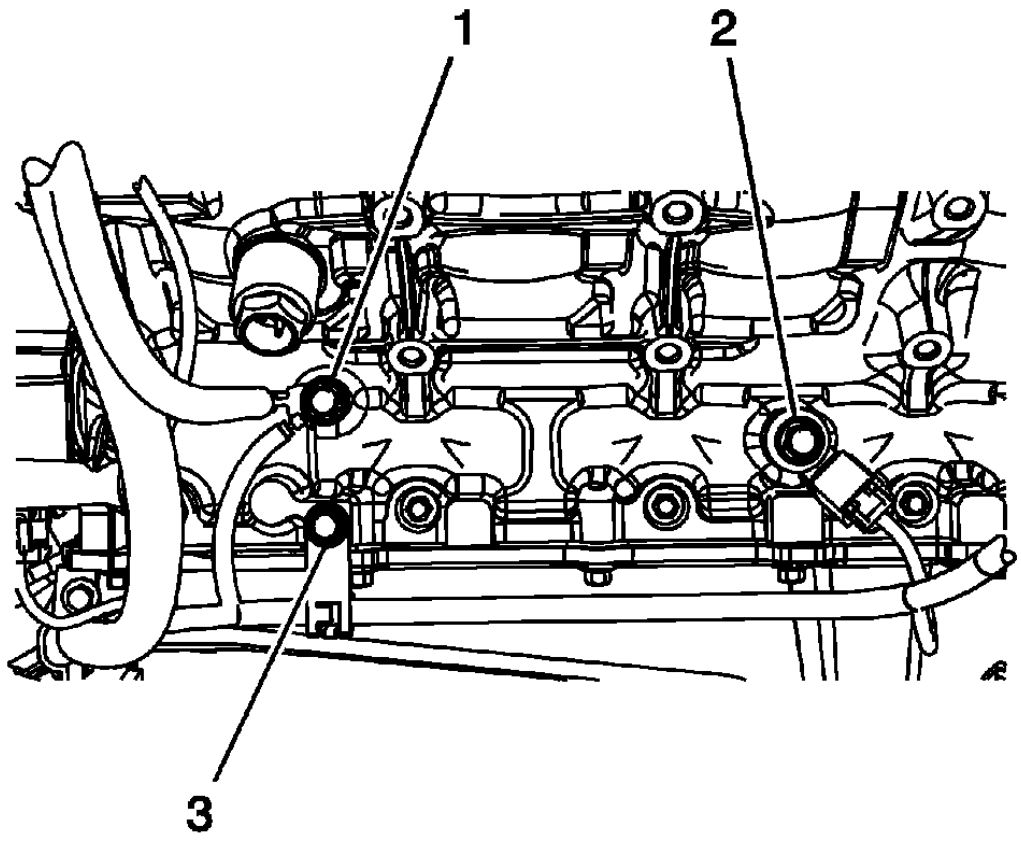

Fig. 297: Ground Terminal Bolt
Courtesy of GENERAL MOTORS CORP.

32. Install the engine harness bracket bolt (3).
33. Install the ground terminal bolt (1) and tighten to 25 N.m (18 lb ft).

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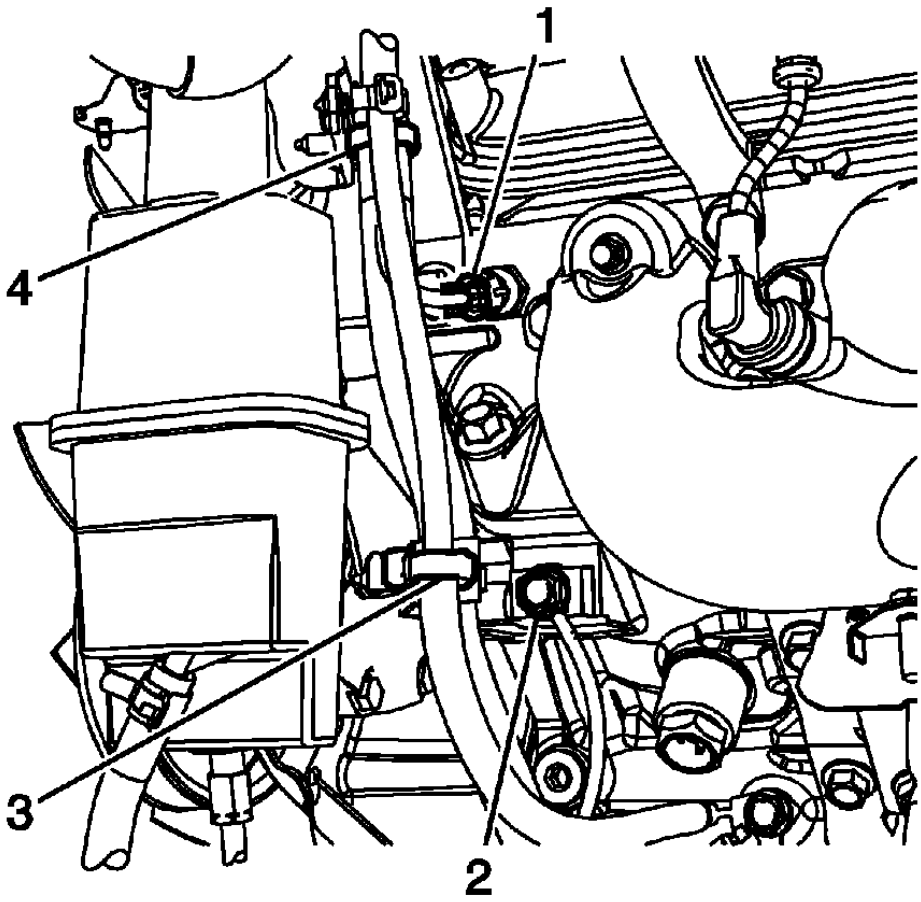

Fig. 298: Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

34. Install the retaining clips (3, 4) to the brackets.
35. Install the ground terminal bolt (2) and tighten to 25 N.m (18 lb ft).
36. Connect the ECT sensor (1).
37. Connect the oil pressure sensor and the oxygen sensors at the rear of the engine.
38. Lower the vehicle.
39. Install the intake manifold. Refer to **Intake Manifold Replacement**.
40. Install the radiator. Refer to **Radiator Replacement** .
41. Recharge the refrigerant. Refer to **Refrigerant Recovery and Recharging** .
42. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
43. Remove the fender covers from both fenders.
44. Prelube the engine. Refer to **Engine Prelubing**.
45. Perform the CKP system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

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46. Install the hood. Refer to **Hood Replacement** .

NOTE: After an overhaul, the engine should be tested. Use the following procedure after the engine is installed in the vehicle.

47. Test the vehicle using the following procedure:
    1. Disable the ignition system.
    2. Crank the engine several times. Listen for any unusual noises or evidence that parts are binding.
    3. Enable the ignition system.
    4. Start the engine and listen for unusual noises.
    5. Check the vehicle oil pressure gauge or light and confirm that the engine has acceptable oil pressure.
    6. Run the engine speed at about 1,000 RPM until the engine has reached normal operating temperature.
    7. Listen for sticking lifter and other unusual noises.
    8. Inspect for fuel, oil and/or coolant leaks while the engine is running.
    9. Close the hood.

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

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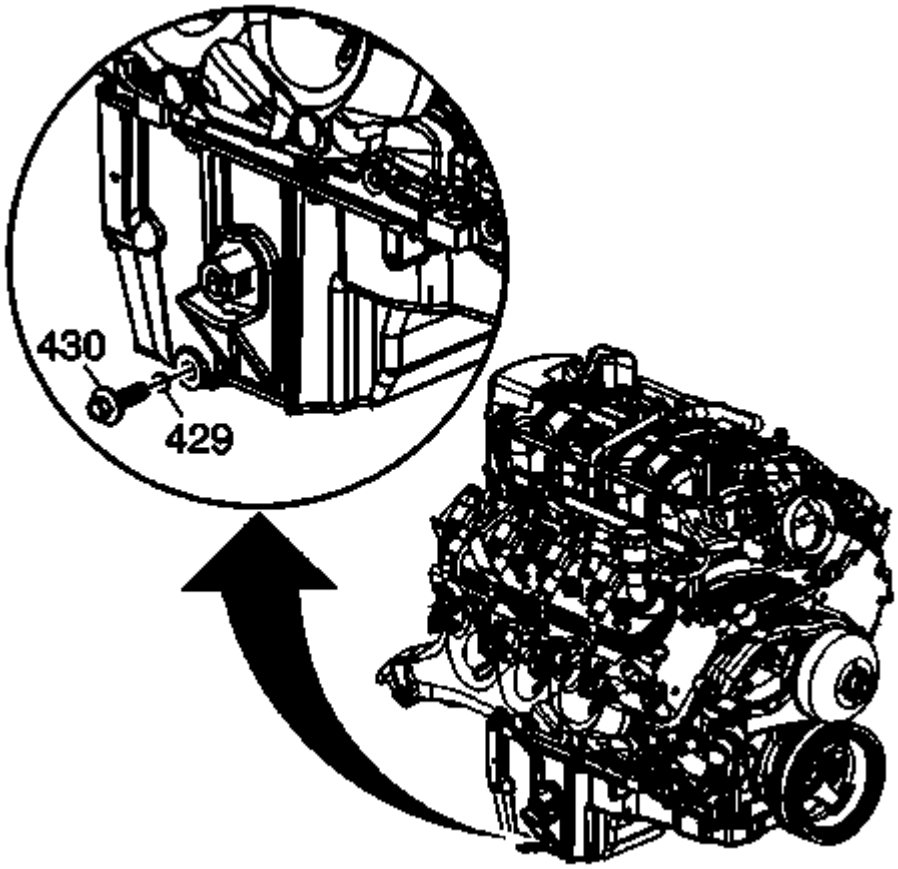

Fig. 299: View Of Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

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 (430).
6. Allow the oil to drain completely.
7. Clean and inspect the oil pan drain plug, replace if necessary.
8. Clean and inspect the oil pan sealing surface, replace the oil pan if necessary.
9. Wipe any remaining oil from the drain plug hole and reinstall the oil pan drain plug until snug.

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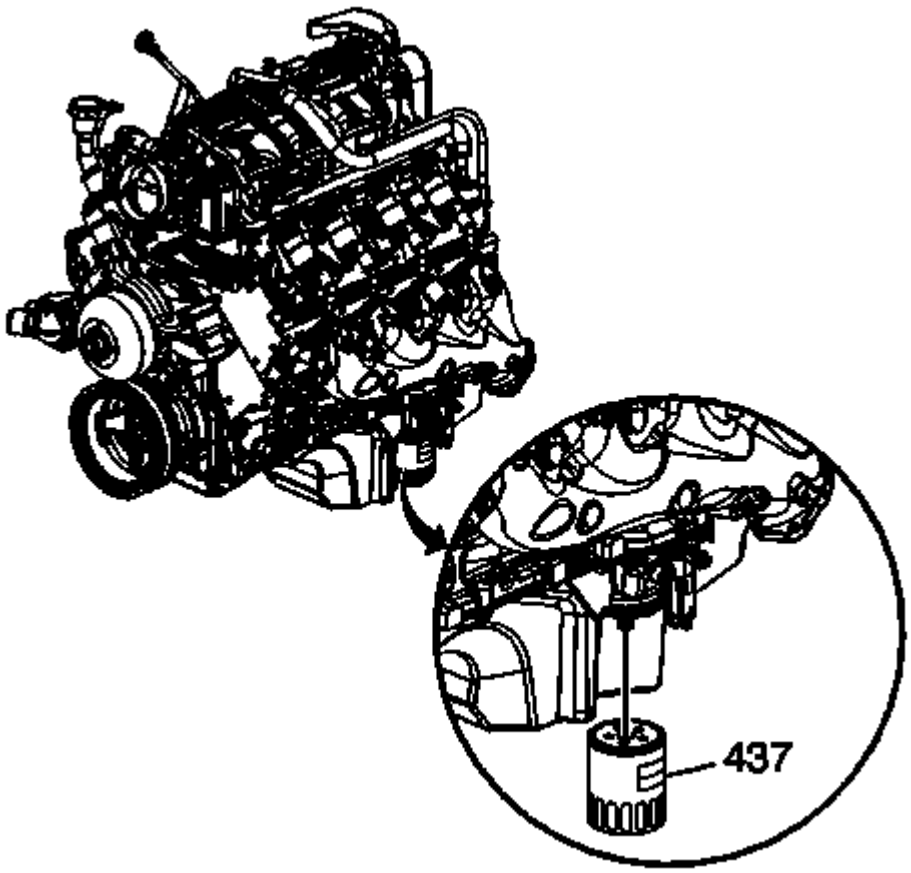

Fig. 300: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

10. Position the drain pan under the oil filter (437).
11. Remove the oil filter.
12. Ensure that the oil filter gasket is still on the old filter if not, remove the oil filter gasket from the oil pan.

Installation Procedure

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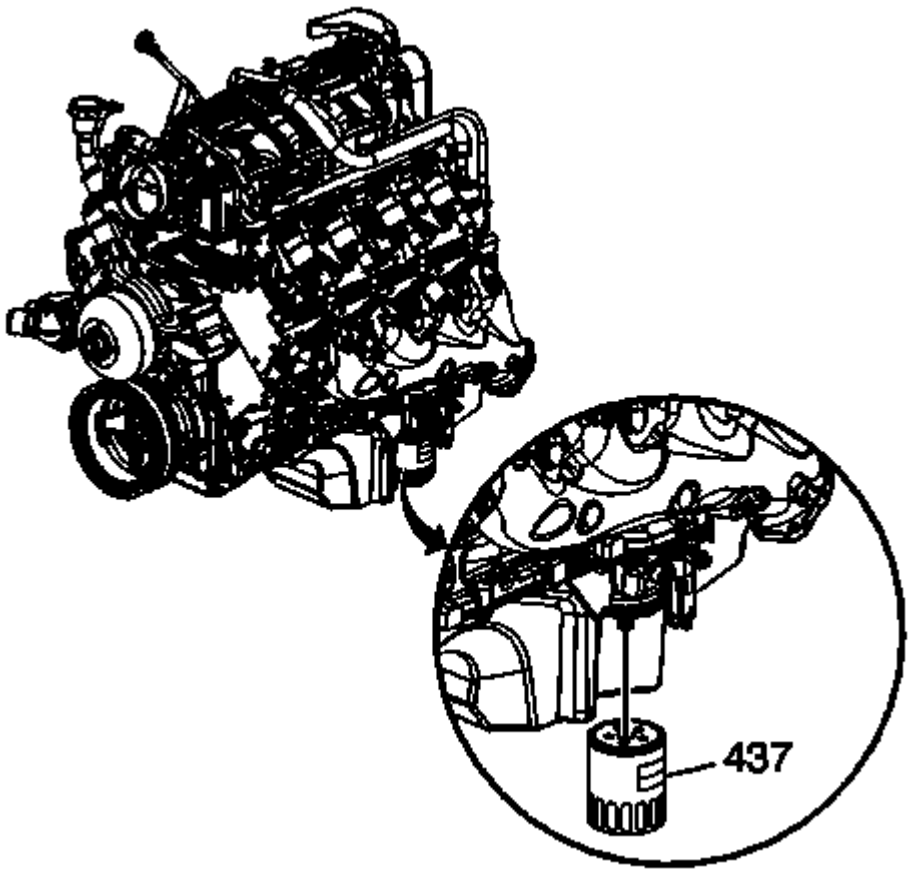

Fig. 301: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Apply clean engine oil to the NEW oil filter seal.

CAUTION: Refer to Fastener Caution .

2. Install the NEW oil filter (437) and tighten to 30 N.m (22 lb ft).

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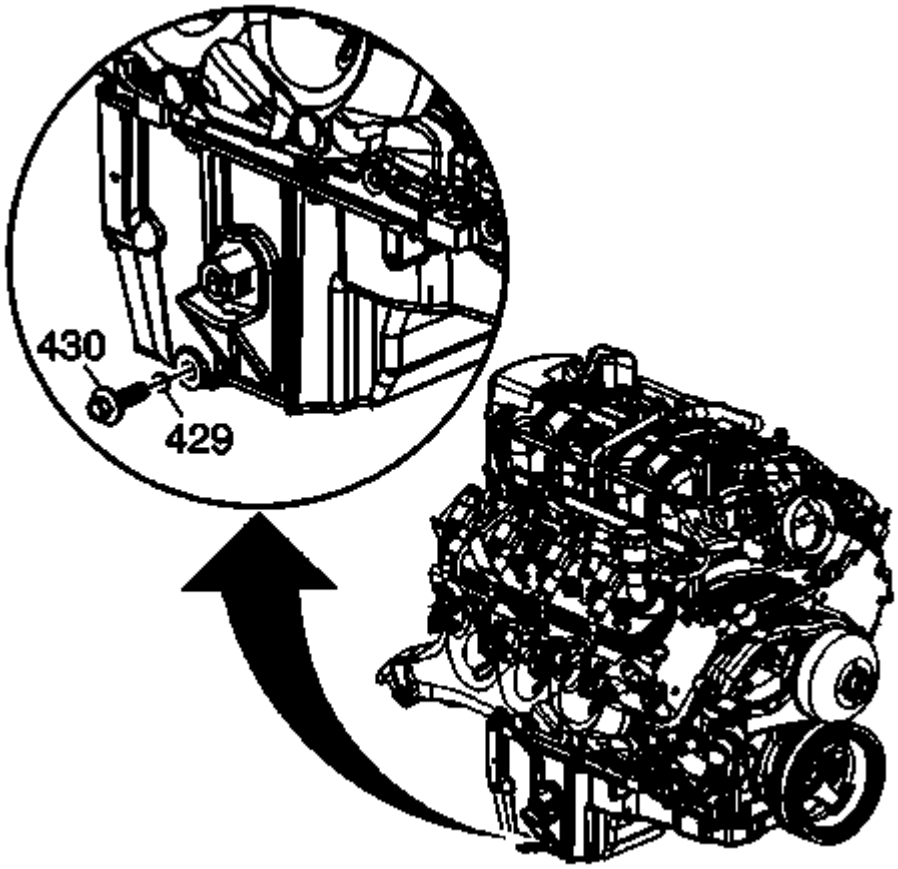

Fig. 302: View Of Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

3. Tighten the oil pan drain plug (430) to 25 N.m (18 lb ft).
4. Remove the oil drain pan from under the vehicle.
5. Lower the vehicle.
6. Fill the engine with new engine oil. Refer to **Approximate Fluid Capacities** and **Fluid and Lubricant Recommendations (USA and Canada)** .
7. Start the engine.
8. Inspect for oil leaks after engine start up.
9. Turn off the engine and allow the oil a few minutes to drain back into the oil pan.
10. Remove the oil level indicator from the indicator tube.
11. Clean off the indicator end of the oil level indicator with a clean paper towel or cloth.
12. Install the oil level indicator into the oil level indicator tube until the oil level indicator handle contacts the top of the oil level indicator tube.
13. Again, remove the oil level indicator from the oil level indicator tube keeping the tip of the oil level indicator down.
14. Check the level of the engine oil on the oil level indicator.
15. If necessary, adjust the oil level by adding or draining oil.

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16. Check for oil leaks.
17. Close the hood.

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

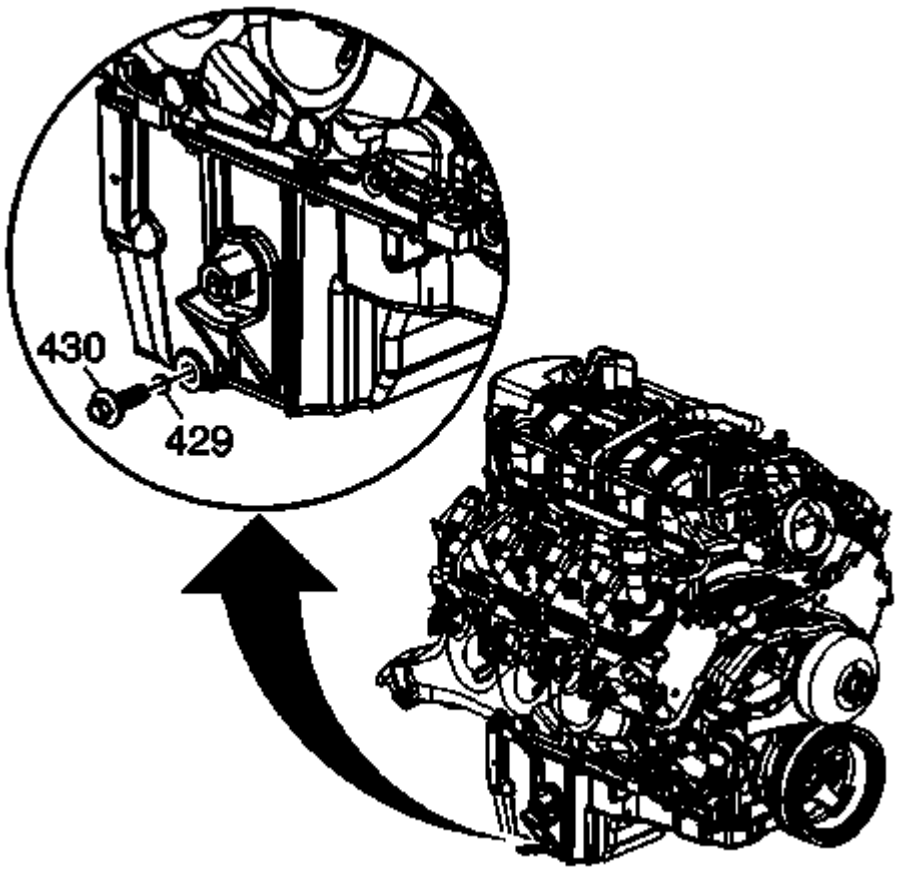

Fig. 303: View Of Oil Pan Drain Plug & Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan drain plug (430) and O-ring (429).

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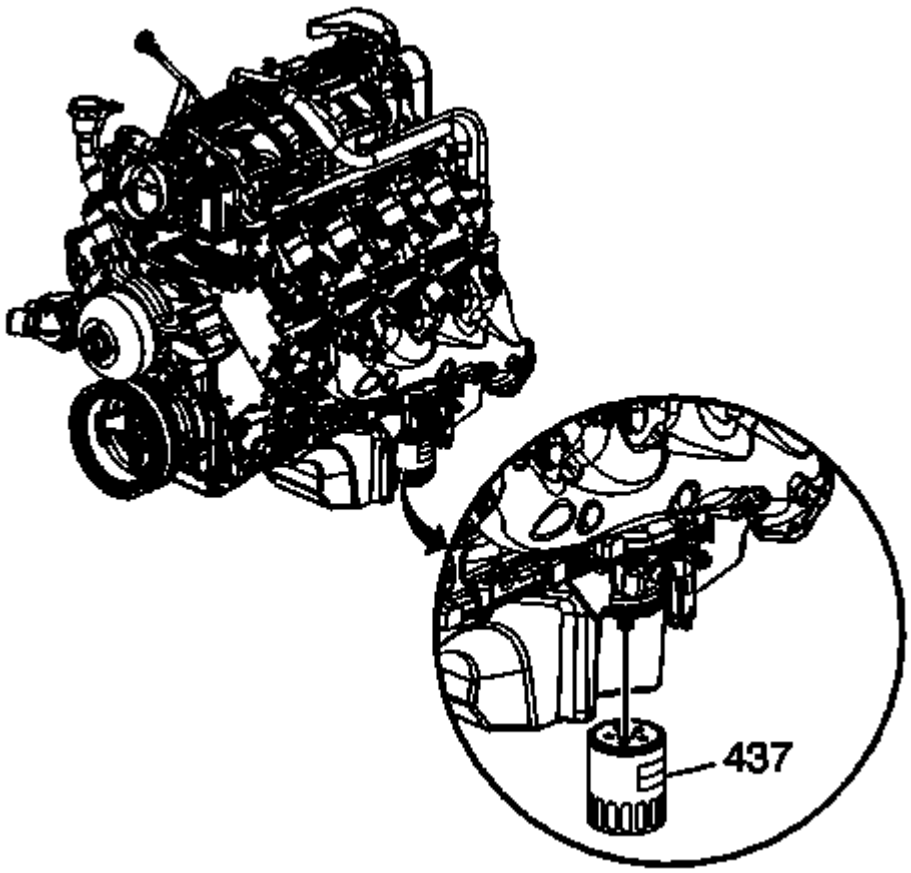

Fig. 304: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine oil filter (437).

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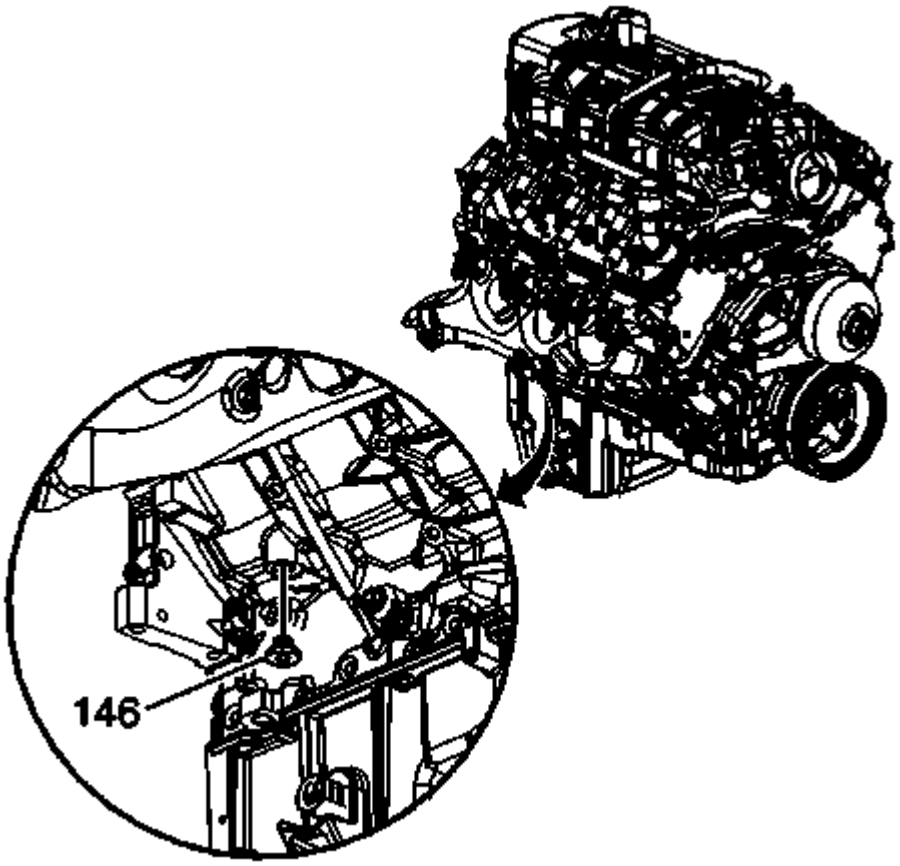

Fig. 305: View Of Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

3. Remove the right side engine block coolant drain hole plug (146).

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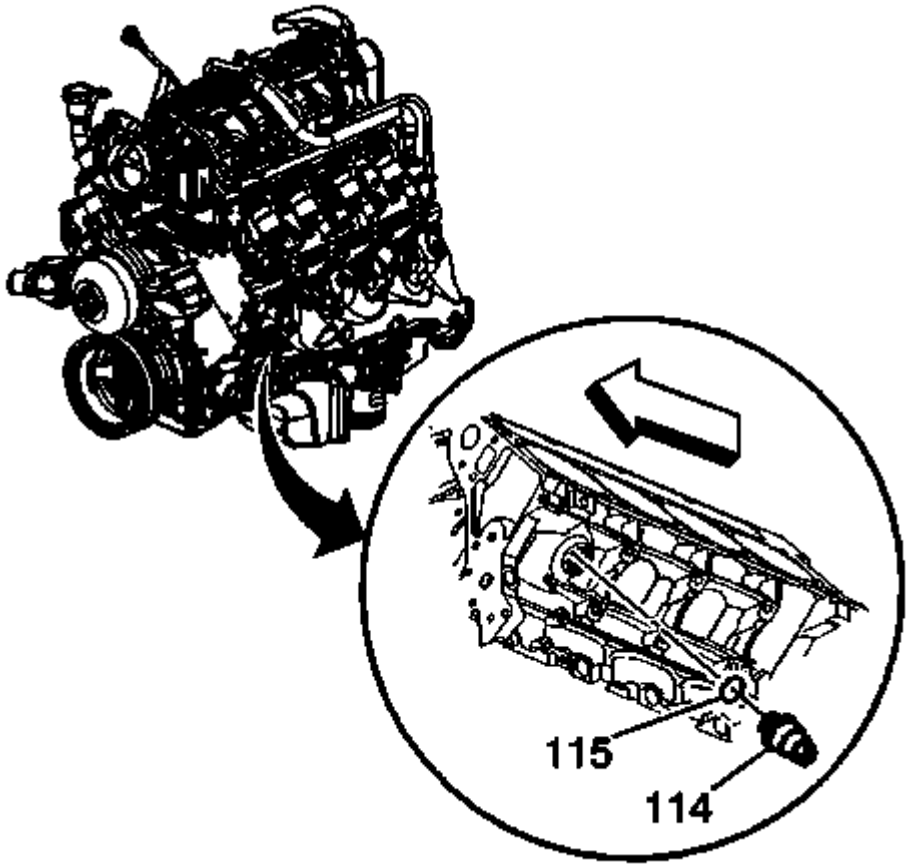

Fig. 306: View Of Engine Block Coolant Heater & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the left side engine block coolant heater (114) and washer (115).

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **J 41816-A:** Crankshaft Balancer Remover
- **J 41816-2:** Crankshaft End Protector
- **J 42386-A:** Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**.

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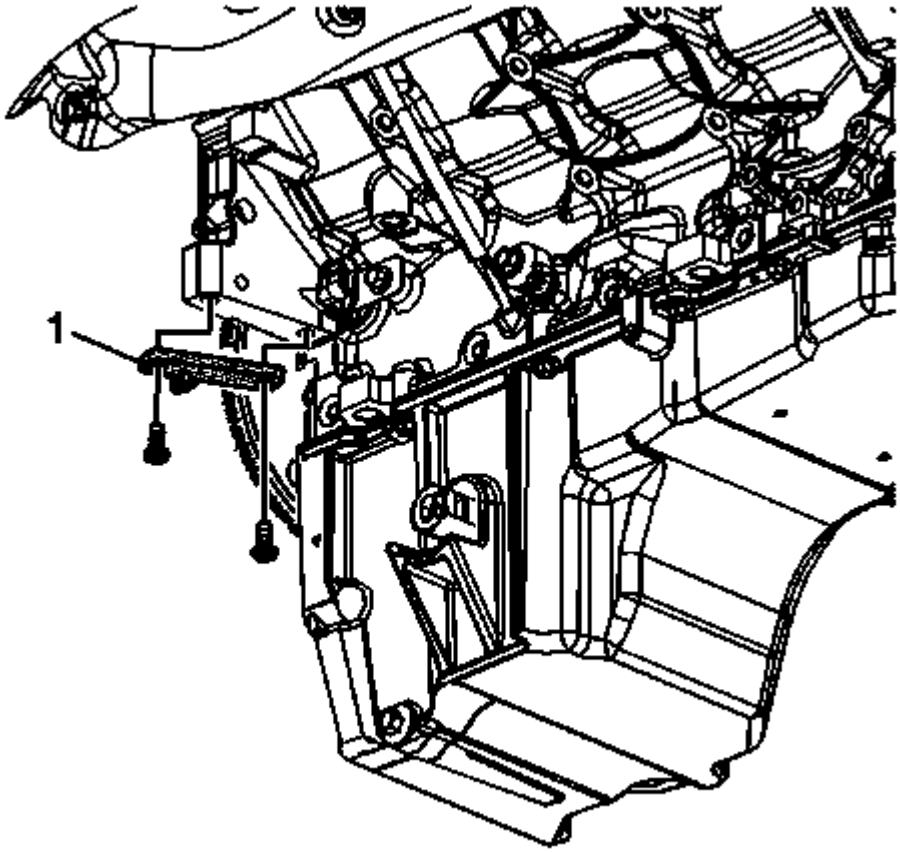

Fig. 307: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Do not use the crankshaft balancer bolt again. Install a NEW crankshaft balancer bolt during final assembly.

1. Install the **J 42386-A:** tool (1) and bolts.

   Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten the **J 42386-A:** tool bolts to 50 N.m (37 lb ft).

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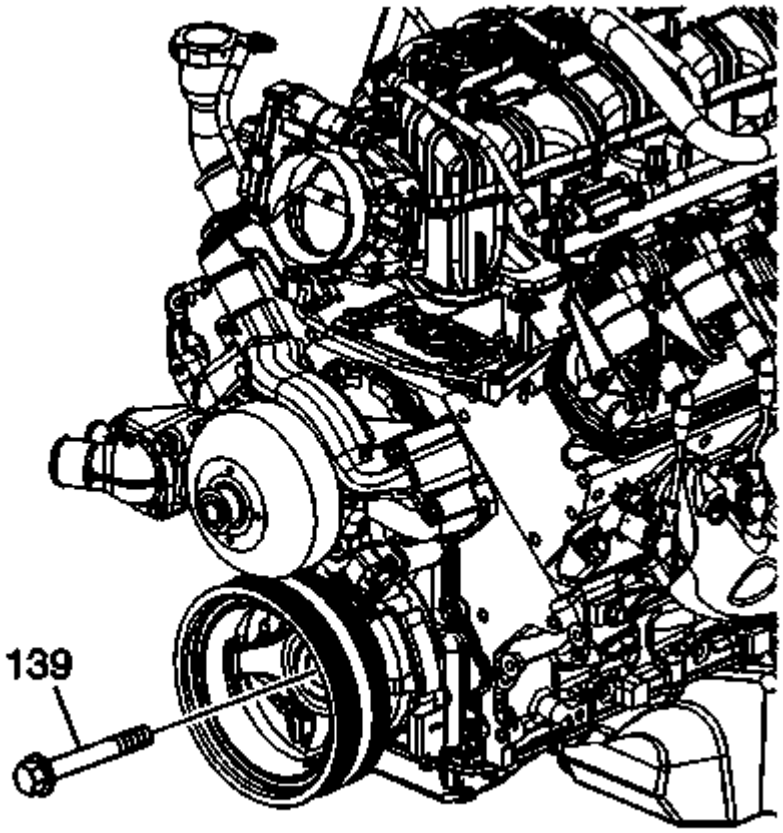

Fig. 308: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt (139). Do not discard the crankshaft balancer bolt. The balancer bolt will be used during the balancer installation procedure.

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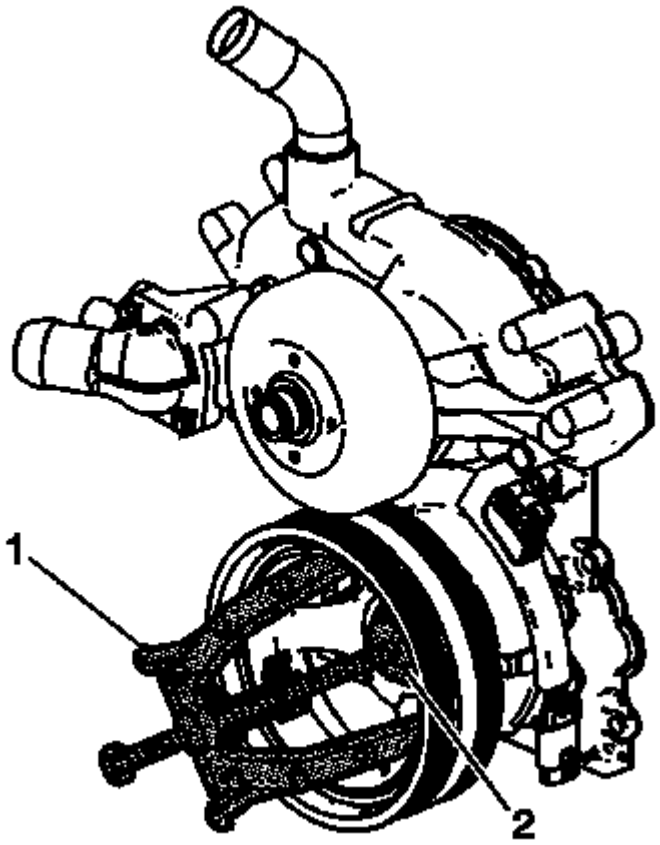

Fig. 309: Using J 41816 & J 41816-2
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41816-A:** remover (1) and the **J 41816-2:** protector (2) in order to remove the crankshaft balancer.

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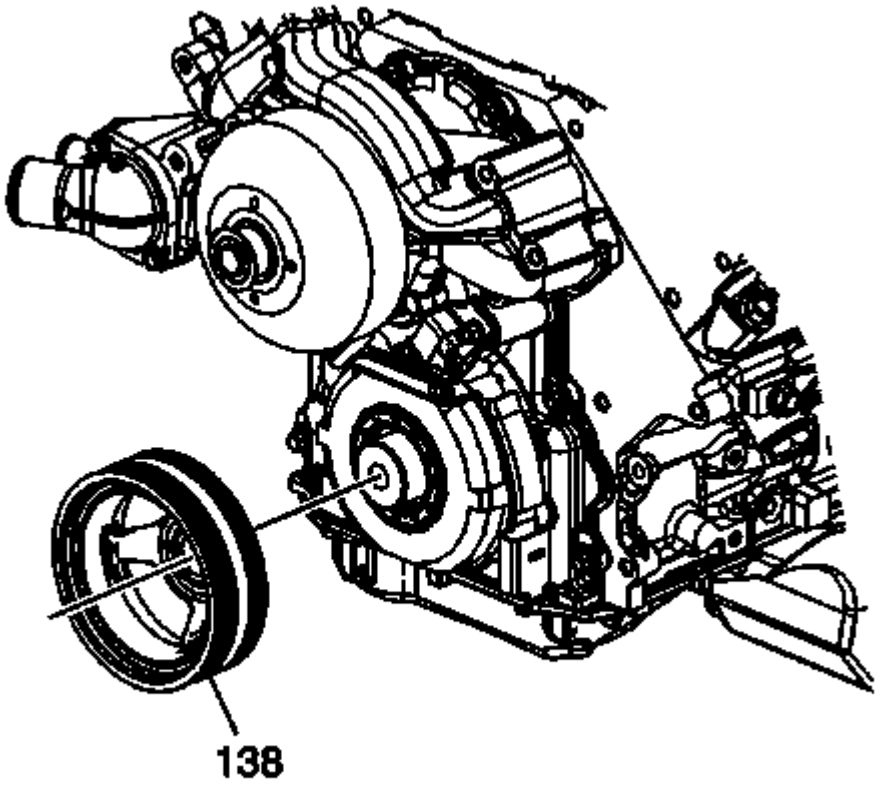

Fig. 310: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the balancer (138).

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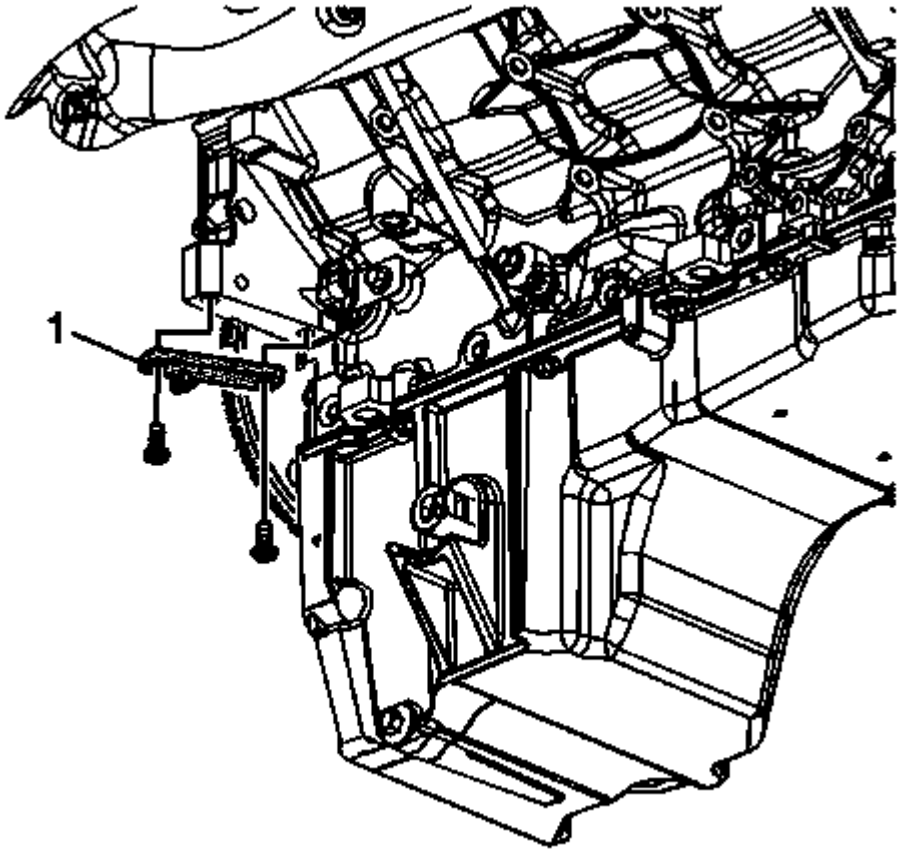

Fig. 311: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 42386-A:** tool (1) and bolts.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

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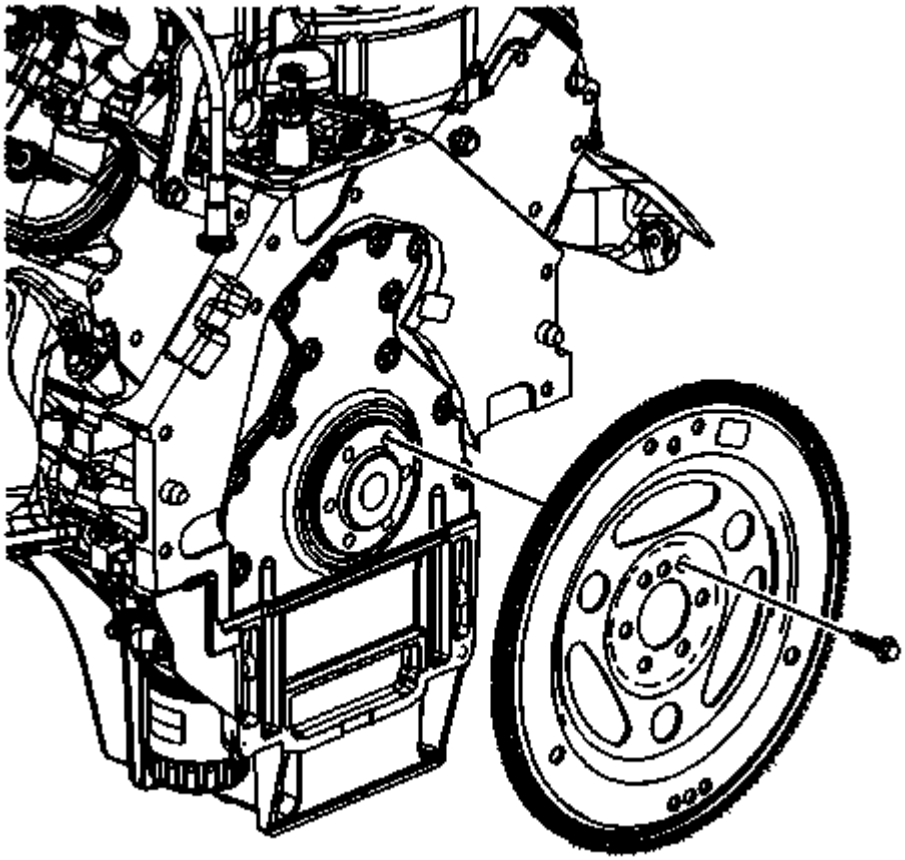

Fig. 312: View Of Flex Plate & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

OIL LEVEL INDICATOR AND TUBE REMOVAL

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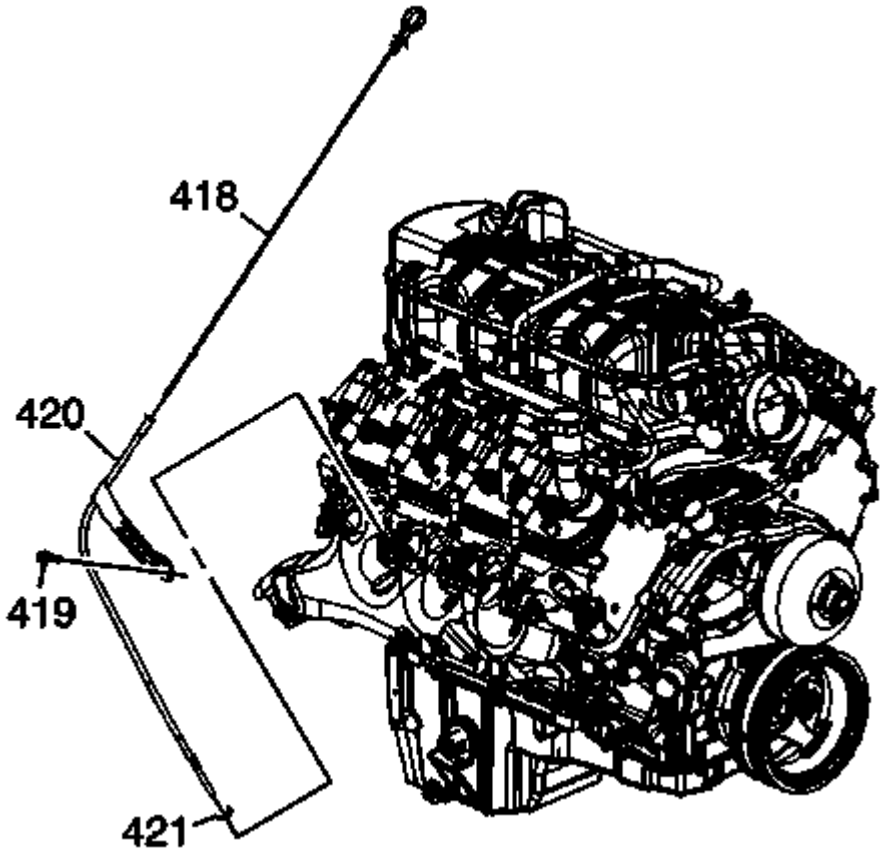

Fig. 313: View Of Oil Level Indicator, Tube Bolt, Indicator Tube & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

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

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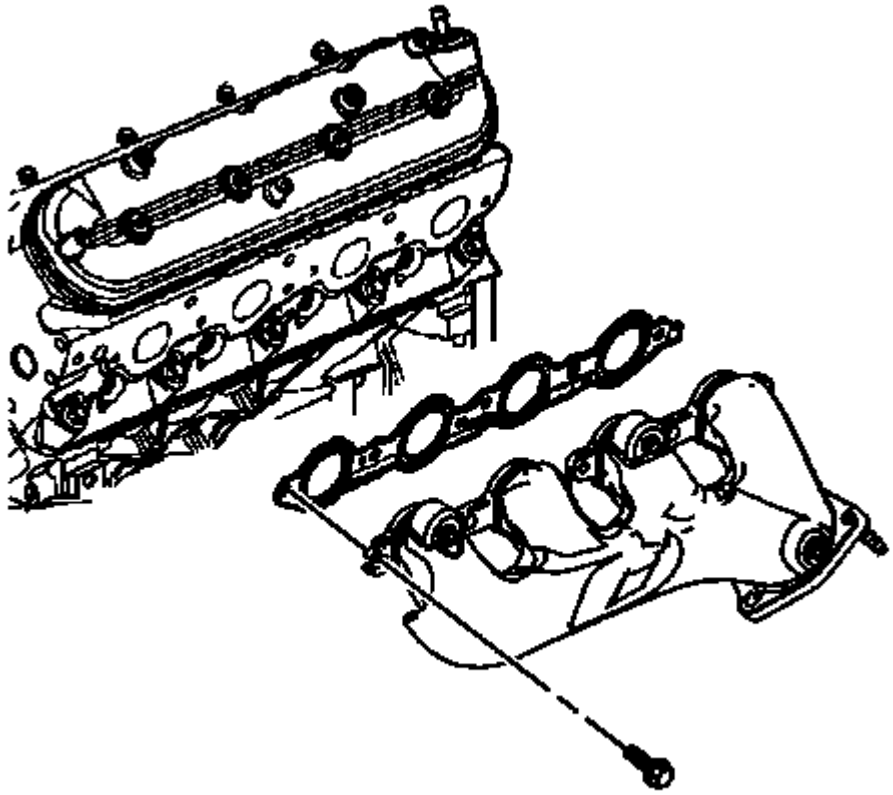

Fig. 314: Exhaust Manifold Removal - Left Side
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

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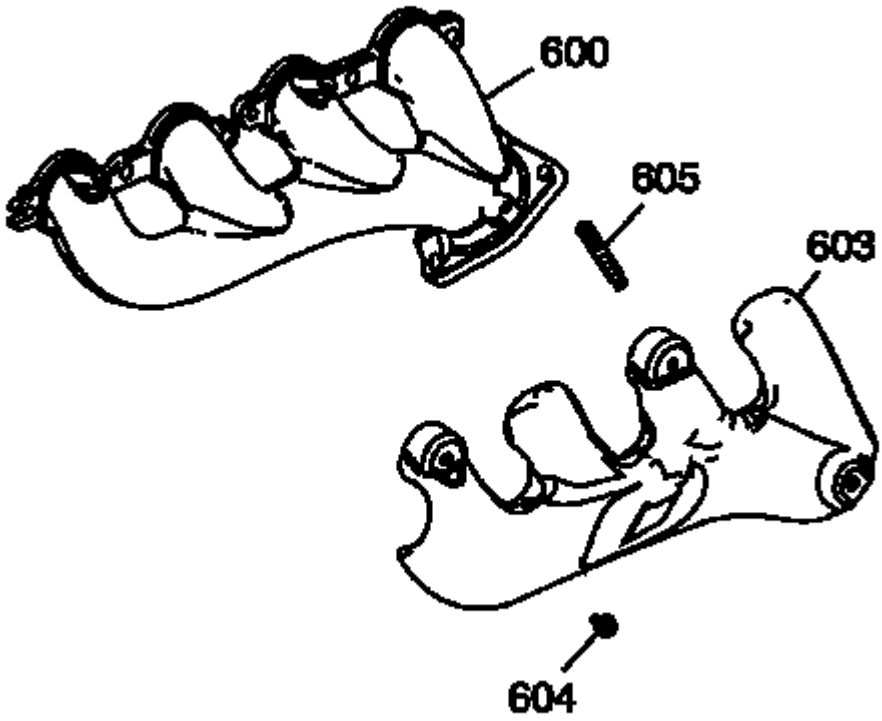

Fig. 315: Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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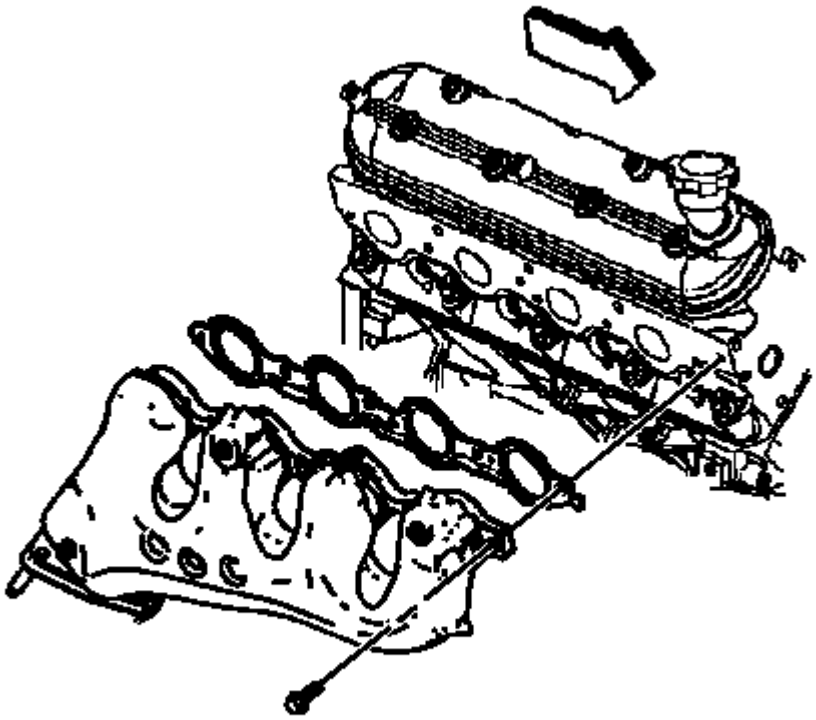

Fig. 316: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires from the spark plugs.
2. Remove the exhaust manifold, bolts, and gasket.
3. Discard the gasket.

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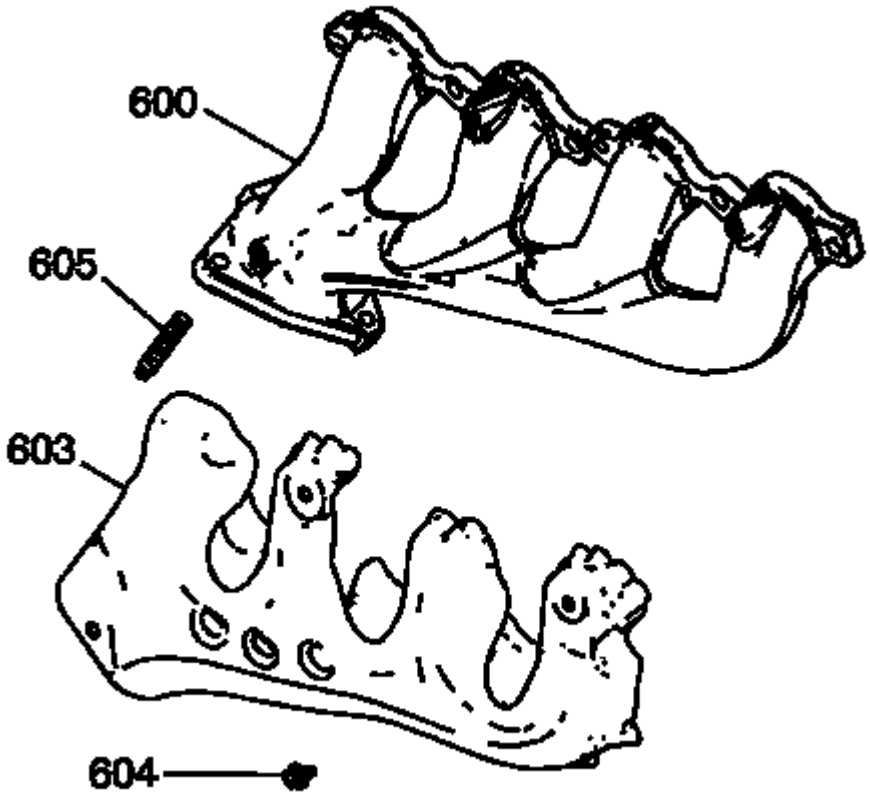

Fig. 317: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

4. Remove the heat shield (603) and bolts (604) from the manifold (600), as required.
5. Remove the studs (605), as required.

WATER PUMP REMOVAL

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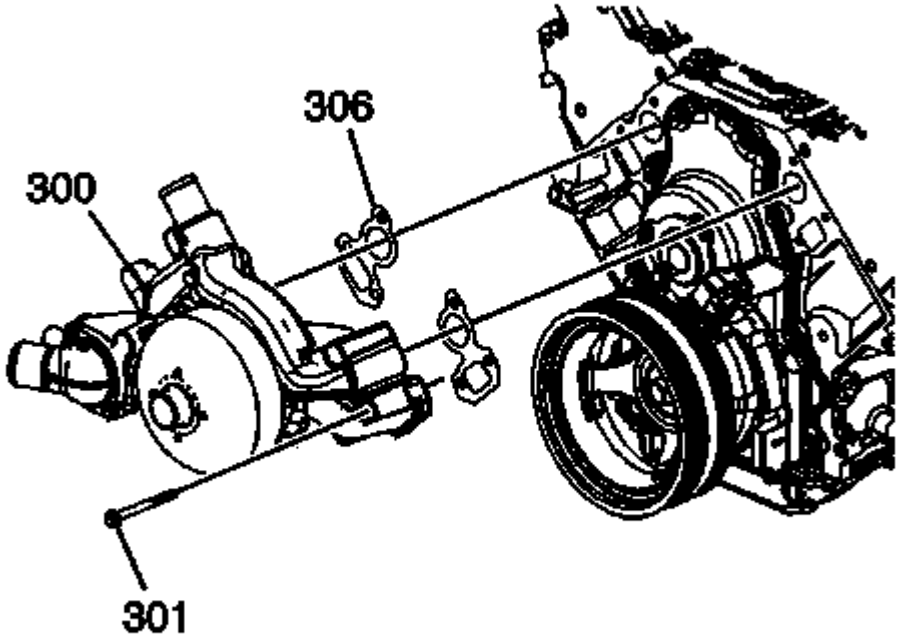

Fig. 318: View Of Water Pump, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump bolts (301).
2. Remove the water pump (300) and gaskets (306).
3. Discard the water pump gaskets.

THROTTLE BODY ASSEMBLY REMOVAL

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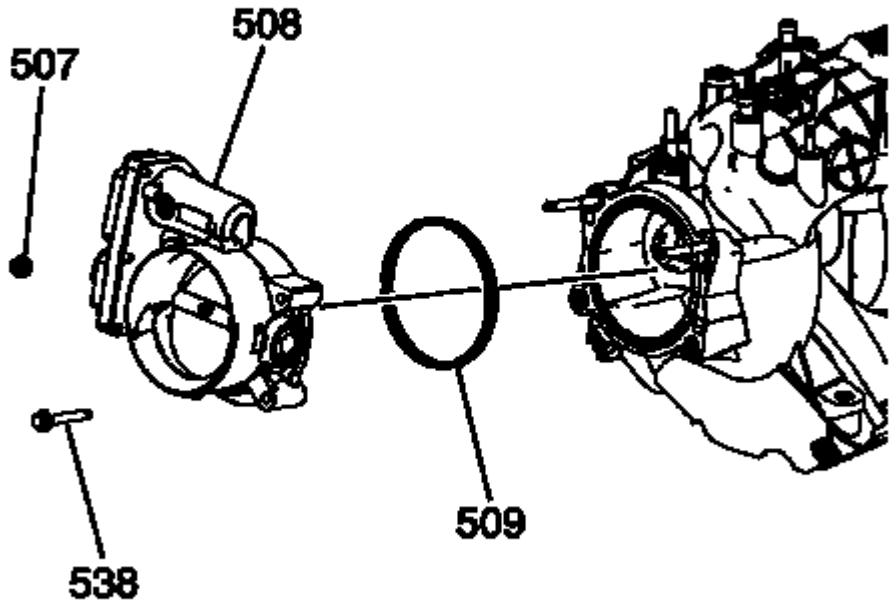

Fig. 319: Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

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

1. Remove the electrical wire harness connectors from the throttle body.
2. Remove the throttle body nuts (507) and bolts (538).
3. Remove the throttle body (508).
4. Remove the throttle body gasket (509).
5. Discard the gasket.

FUEL RAIL AND INJECTORS REMOVAL

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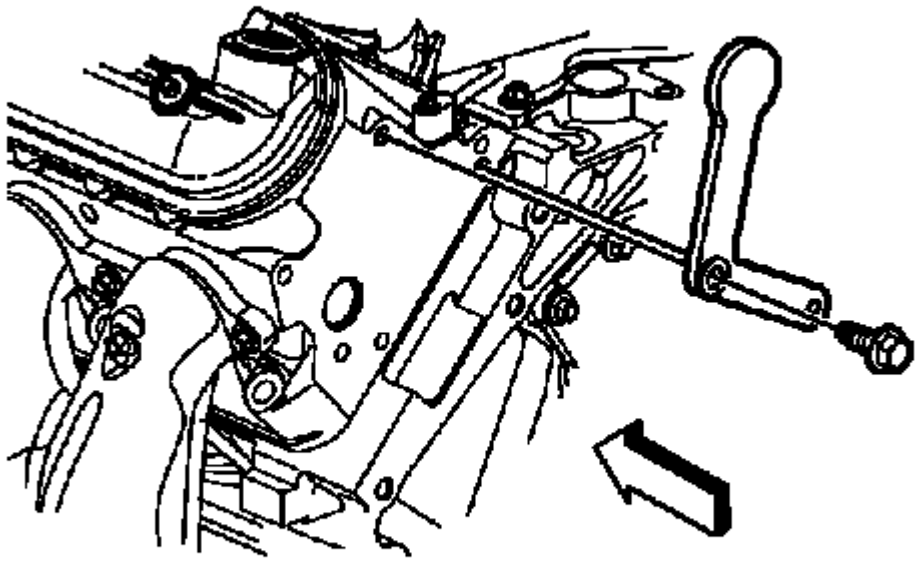

Fig. 320: View Of Fuel Rail Stop Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Fuel Rail Stop Bracket Installation Warning .

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

1. Remove the fuel rail stop bracket and bolt, as required.

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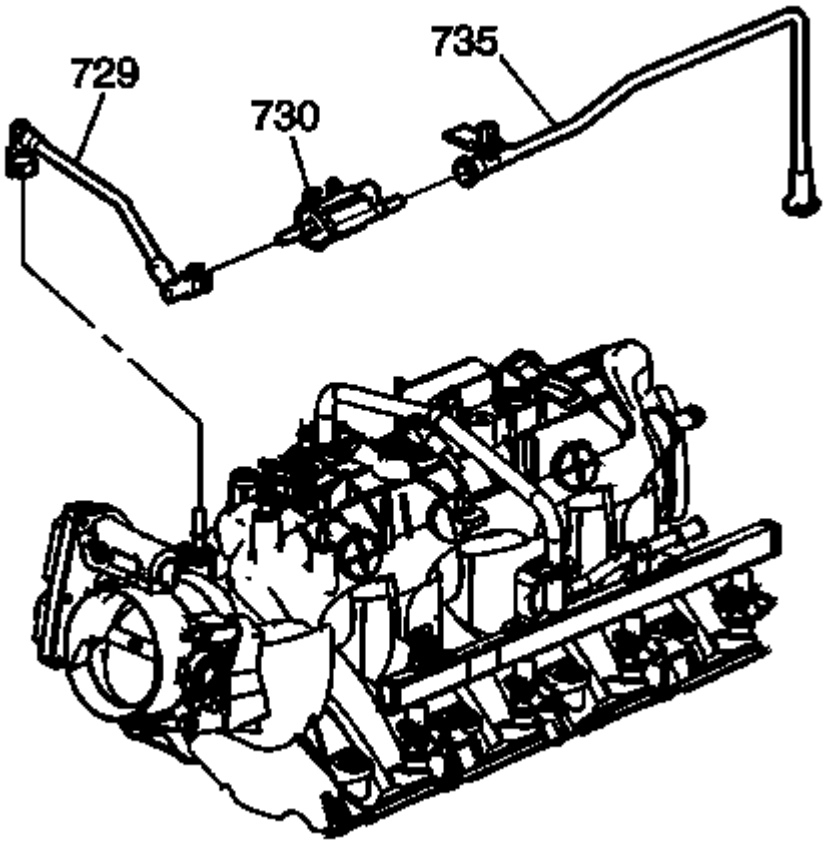

Fig. 321: EVAP Purge Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

2. Remove the evaporative emission (EVAP) canister purge solenoid valve (730) and tubes (729, 735).

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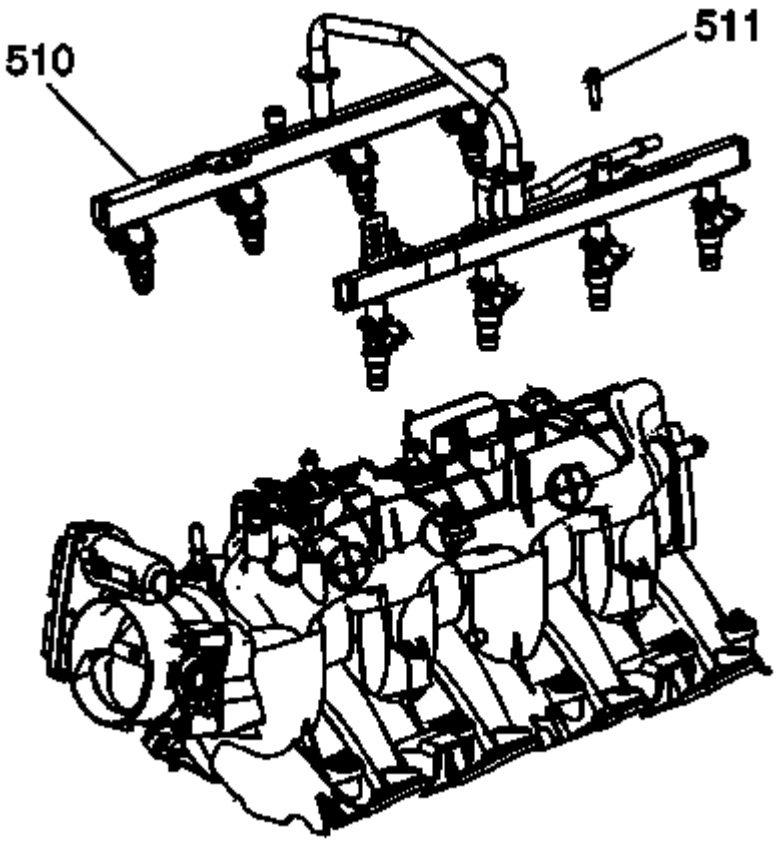

Fig. 322: Fuel Rail
Courtesy of GENERAL MOTORS CORP.

3. Remove the fuel rail bolts (511).

NOTE:

- **Do not separate the fuel injectors from the fuel rail, unless component service is required.**
- **Use cleanliness and care when handling the fuel system components.**
- **Do not allow dirt or debris to enter the fuel injectors or fuel rail components. Cap ends, as necessary.**

4. Remove the fuel rail (510) with injectors. Lift evenly on both sides of the fuel rail until all the injectors have left their bores.

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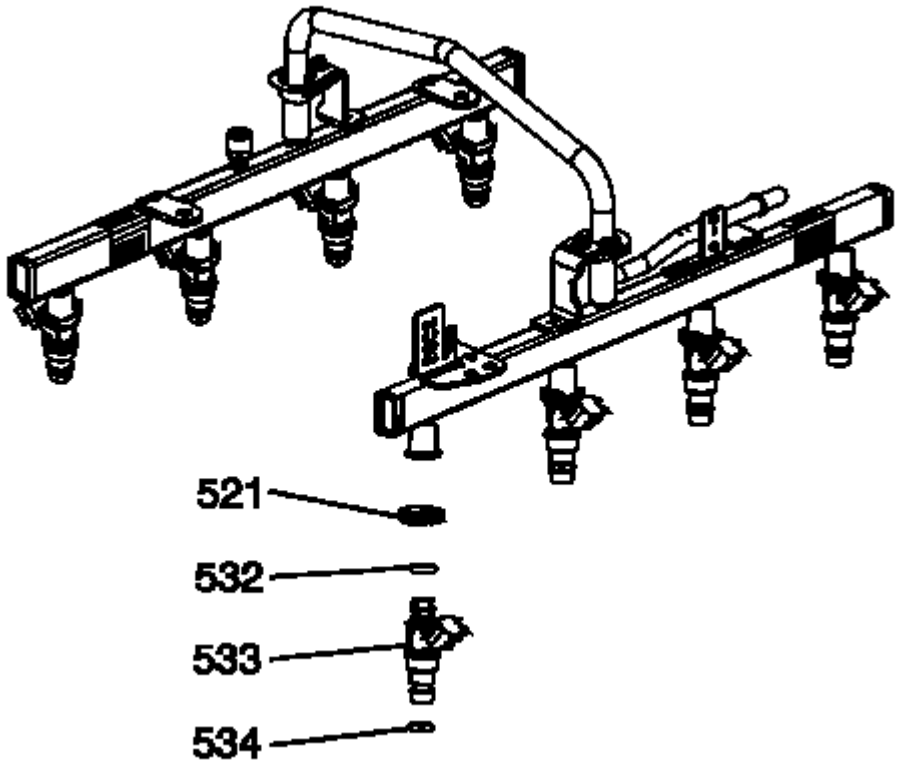

Fig. 323: Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

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.

INTAKE MANIFOLD REMOVAL

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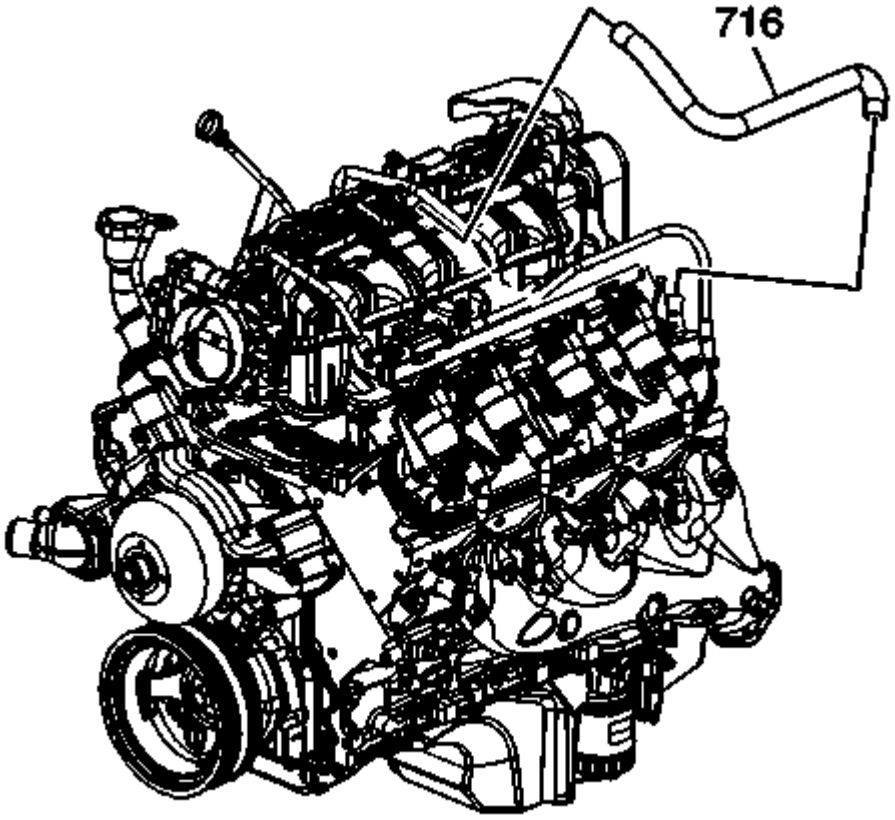

Fig. 324: View Of PCV Dirty-Air Hose
Courtesy of GENERAL MOTORS CORP.

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).

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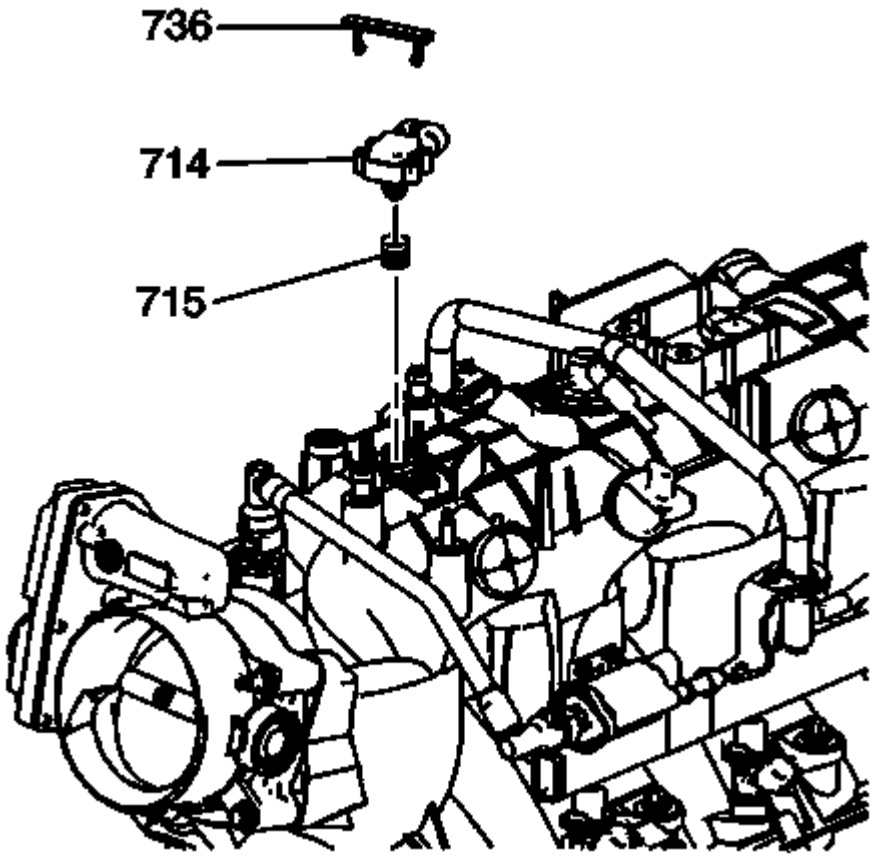

Fig. 325: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor (714) and retainer (736), as required.
3. Remove the O-ring (715) from the sensor, as required.

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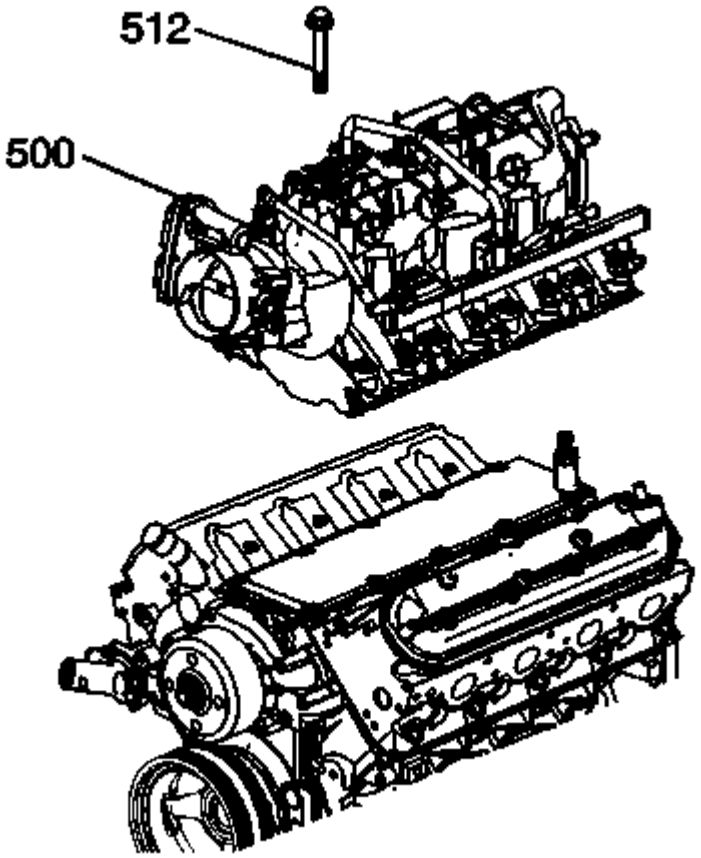

Fig. 326: Removing/Installing Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the intake manifold bolts (512).
5. Remove the intake manifold (500) with gaskets.

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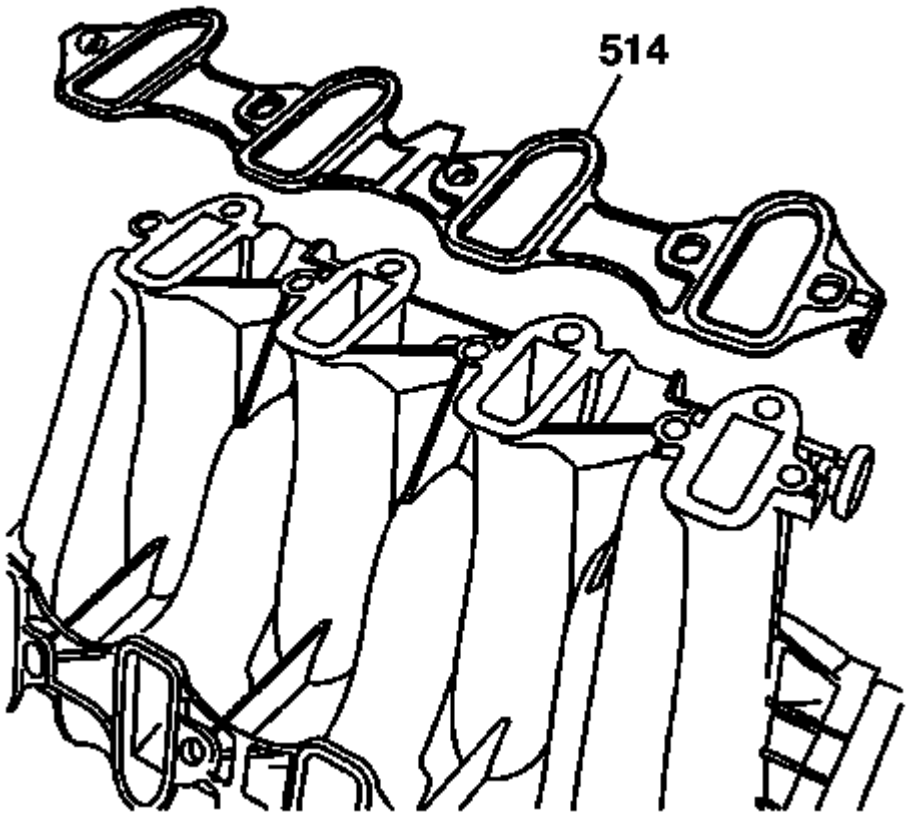

Fig. 327: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

6. Remove the intake manifold gaskets (514).
7. Discard the intake manifold gaskets.

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER REMOVAL

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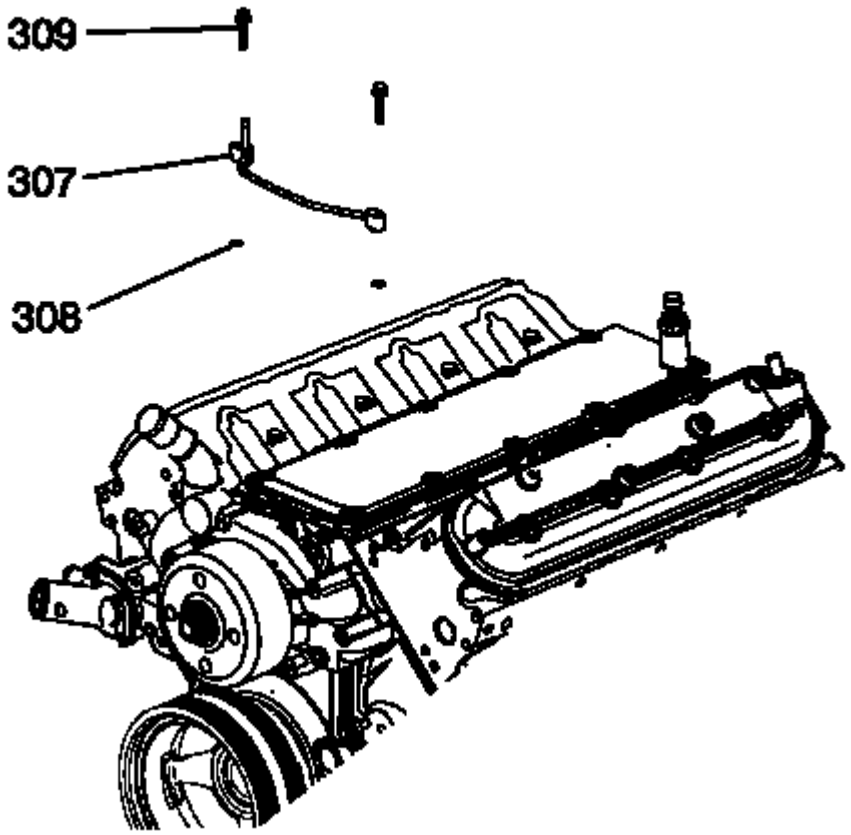

Fig. 328: Removing/Installing Engine Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant air bleed pipe bolts (309).
2. Remove the pipe (307) with seals (308).

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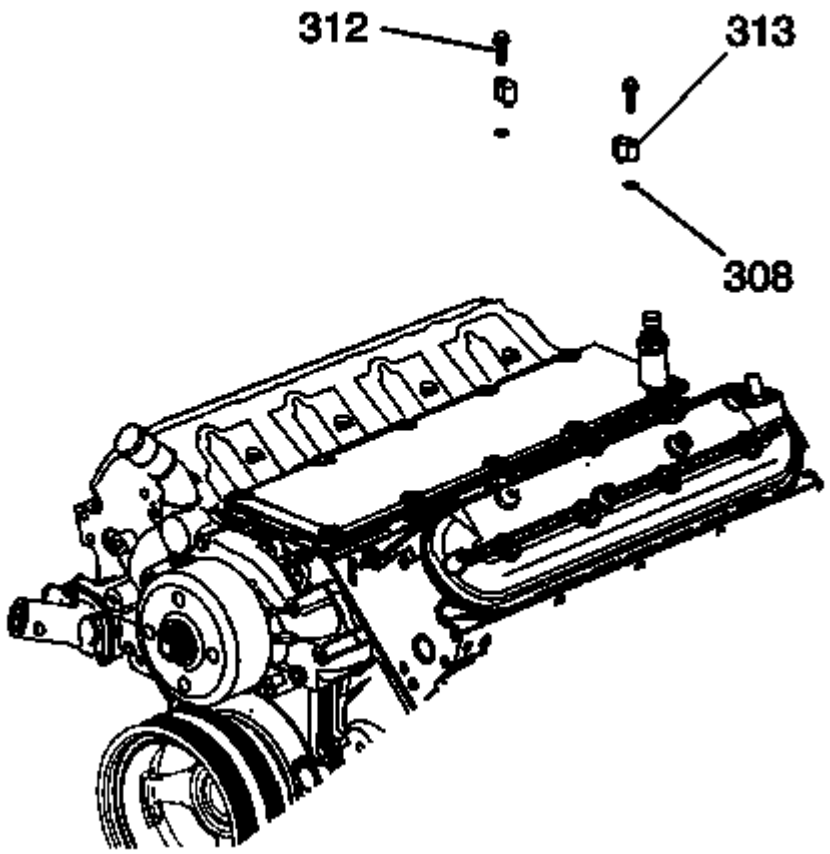

Fig. 329: Removing/Installing Coolant Air Bleed Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine coolant air bleed cover bolts (312).
4. Remove the covers (313) with seals (308).

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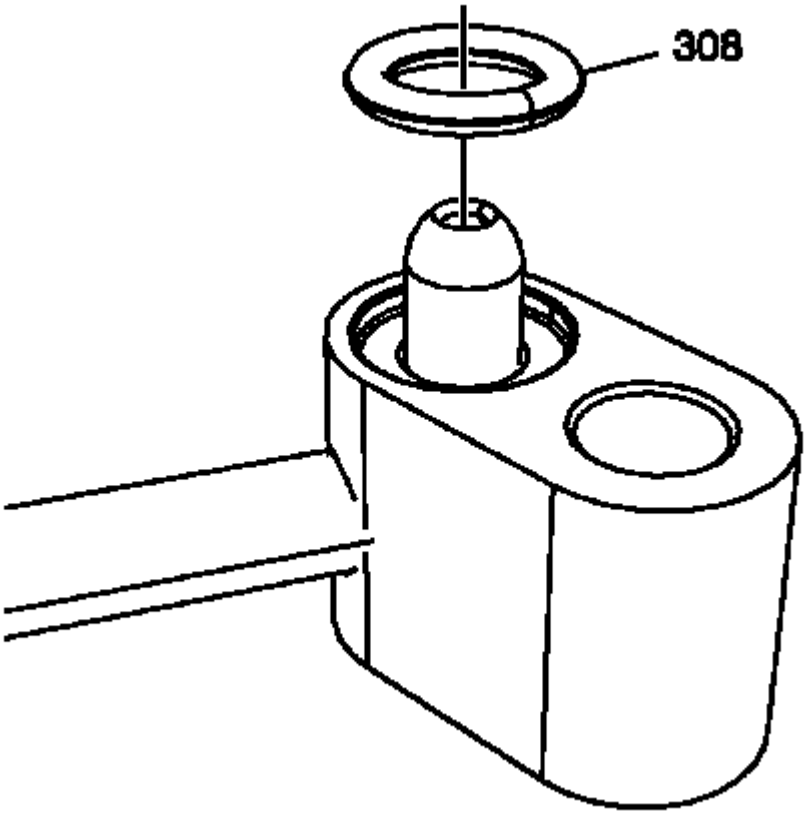

Fig. 330: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

5. Remove the seals (308) from the pipe and covers.
6. Discard the seals.

ENGINE BLOCK VALLEY COVER REMOVAL

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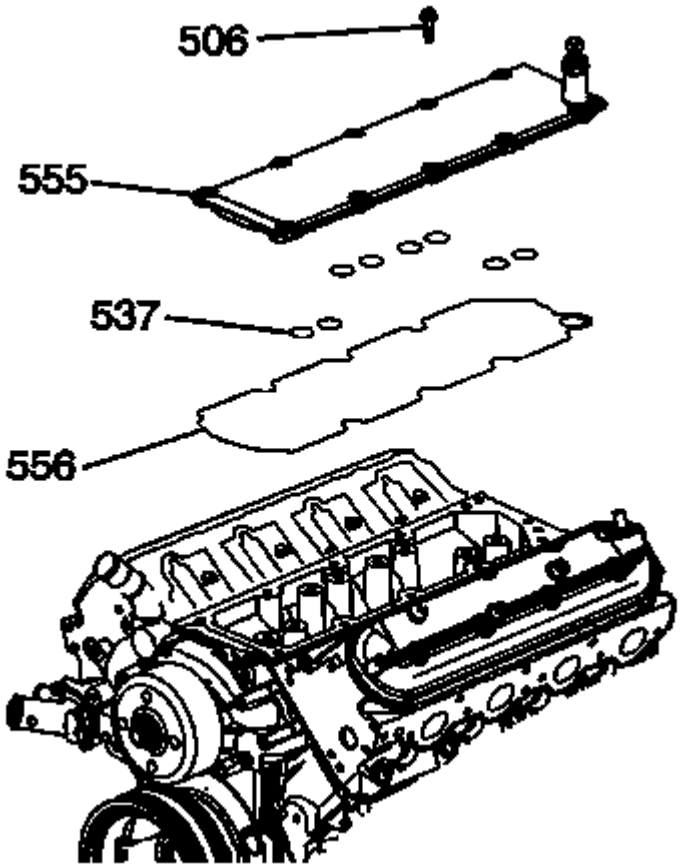

Fig. 331: Removing/Installing Engine Valley Cover
Courtesy of GENERAL MOTORS CORP.

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.

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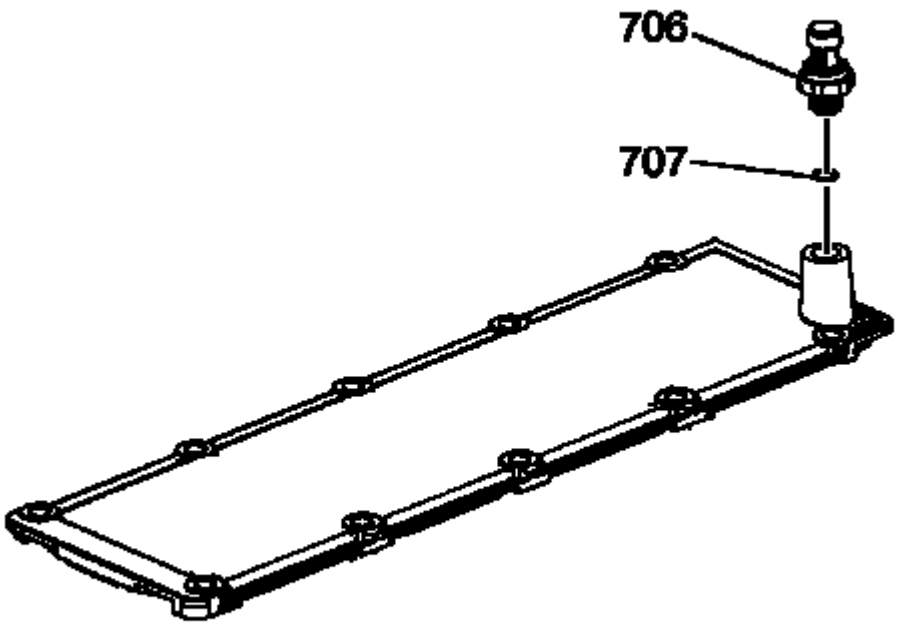

Fig. 332: Removing/Installing Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil pressure sensor (706) and washer (707), as required.

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

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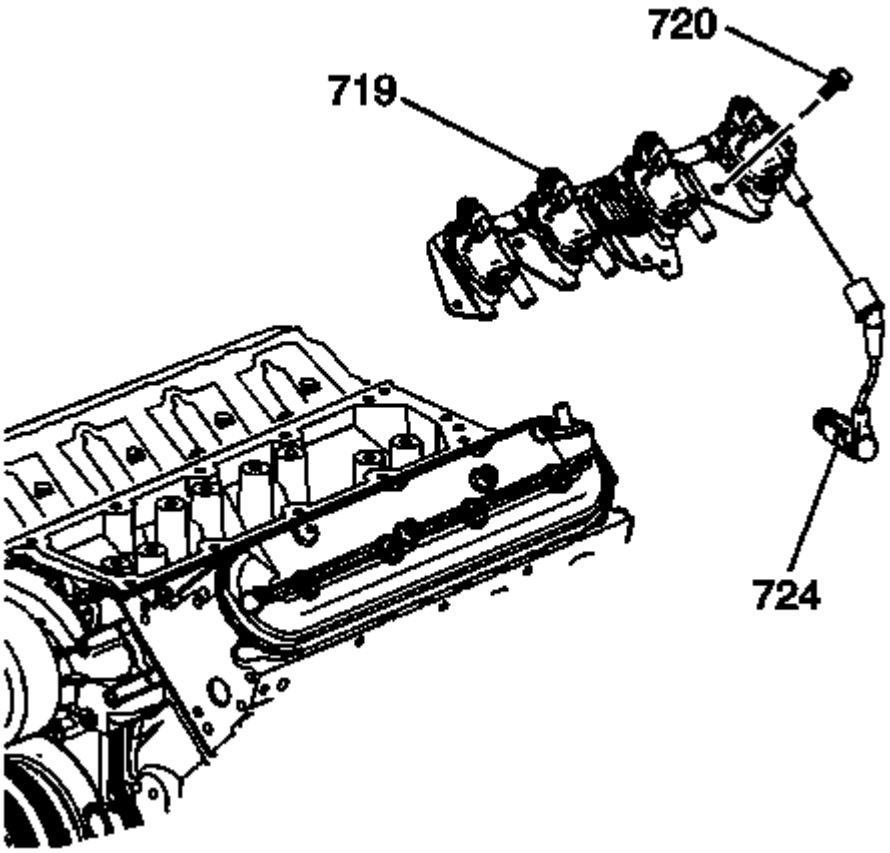

Fig. 333: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plug wires (724).
2. Remove the ignition coil bracket studs (720).
3. Remove the ignition coil and bracket assembly (719).

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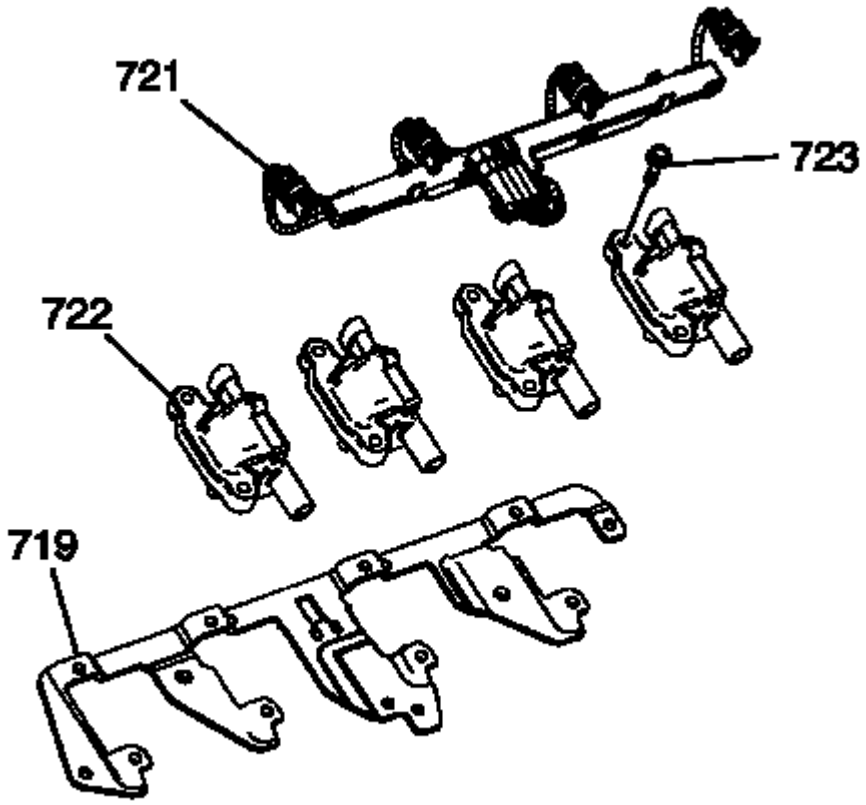

Fig. 334: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.

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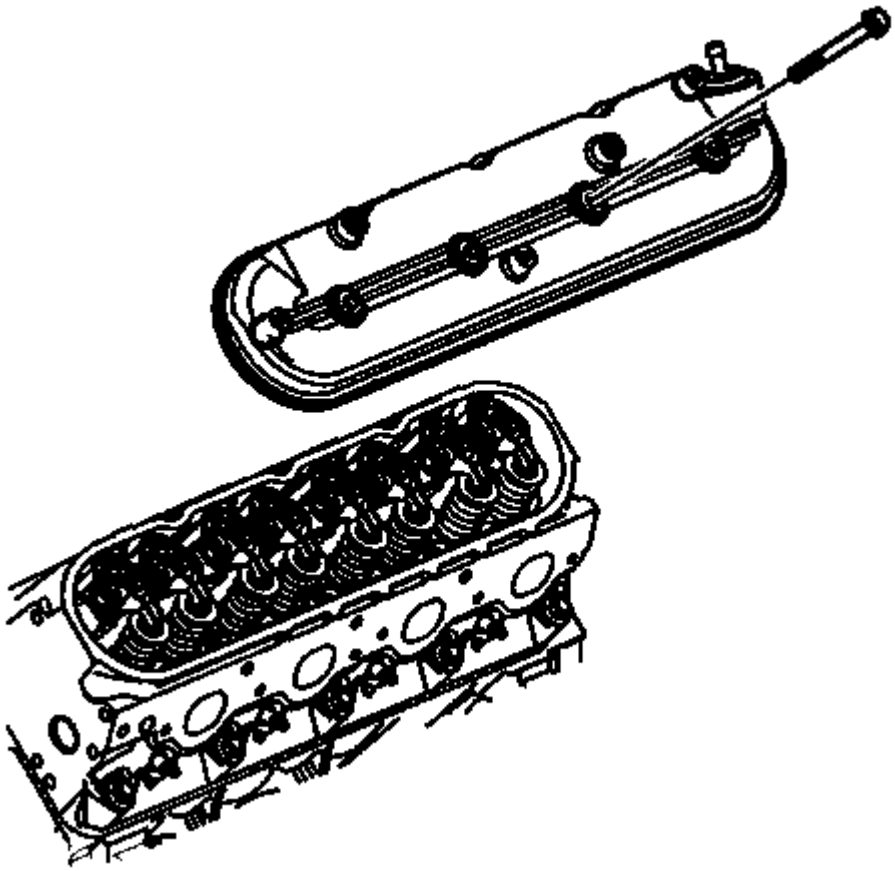

Fig. 335: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.
7. If the valve rocker arm cover grommets are cracked or damaged, replace the valve rocker arm cover bolts. The grommet is serviced with the rocker arm cover bolt.

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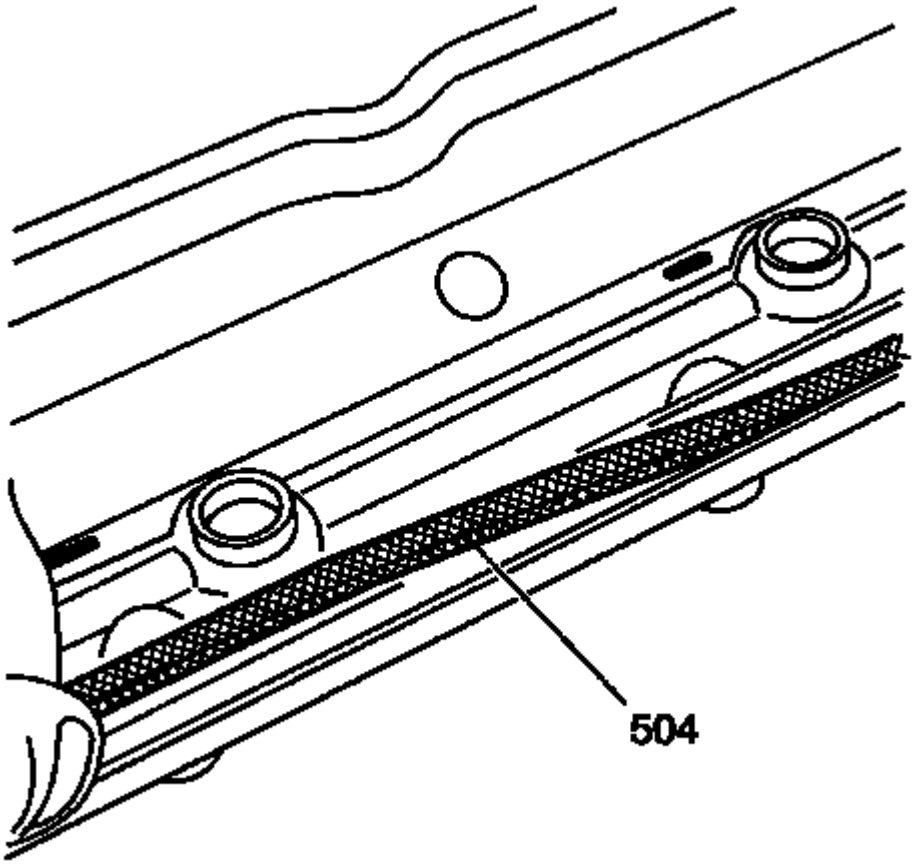

Fig. 336: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the valve rocker arm cover gasket (504) from the cover.

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

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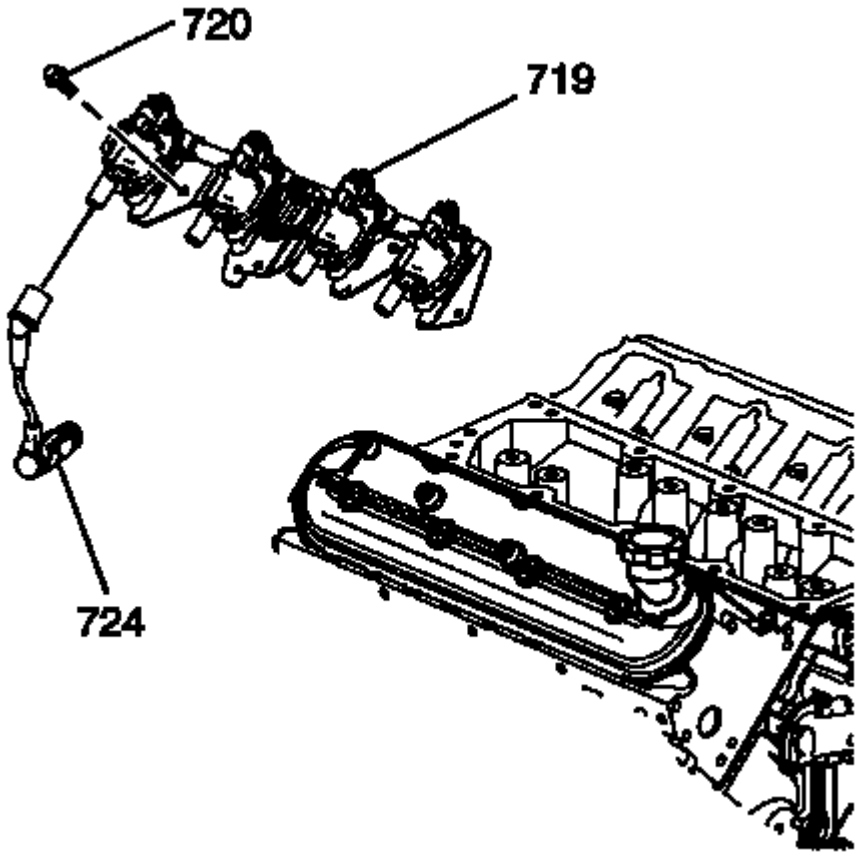

Fig. 337: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

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).

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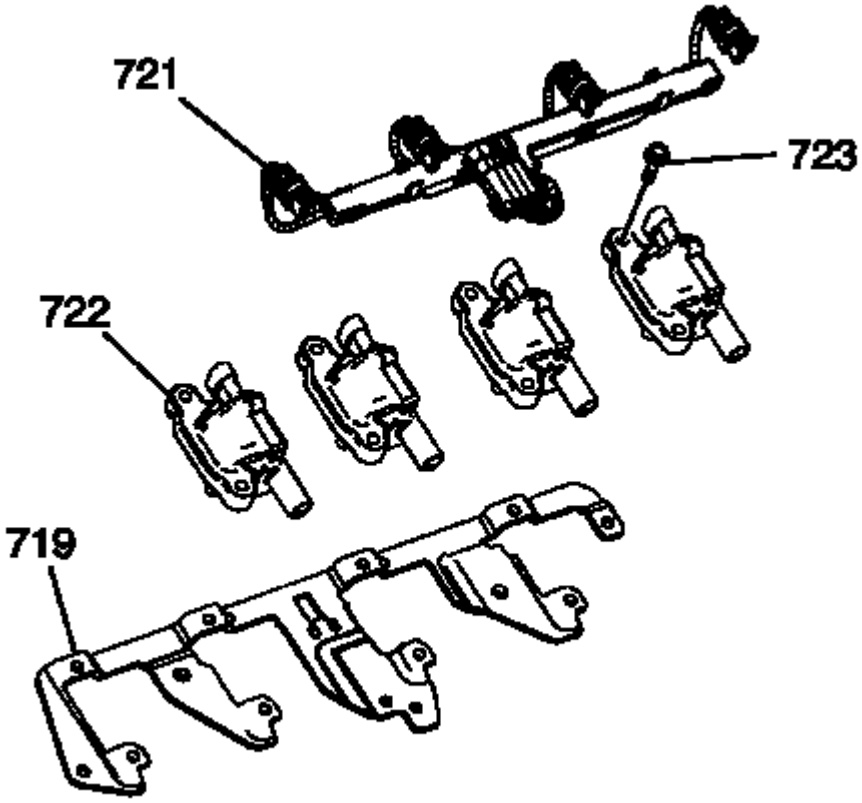

Fig. 338: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

4. Disconnect the ignition coil electrical connectors.
5. Remove the bolts (723), coils (722), and wire harness (721) from the bracket (719), as required.

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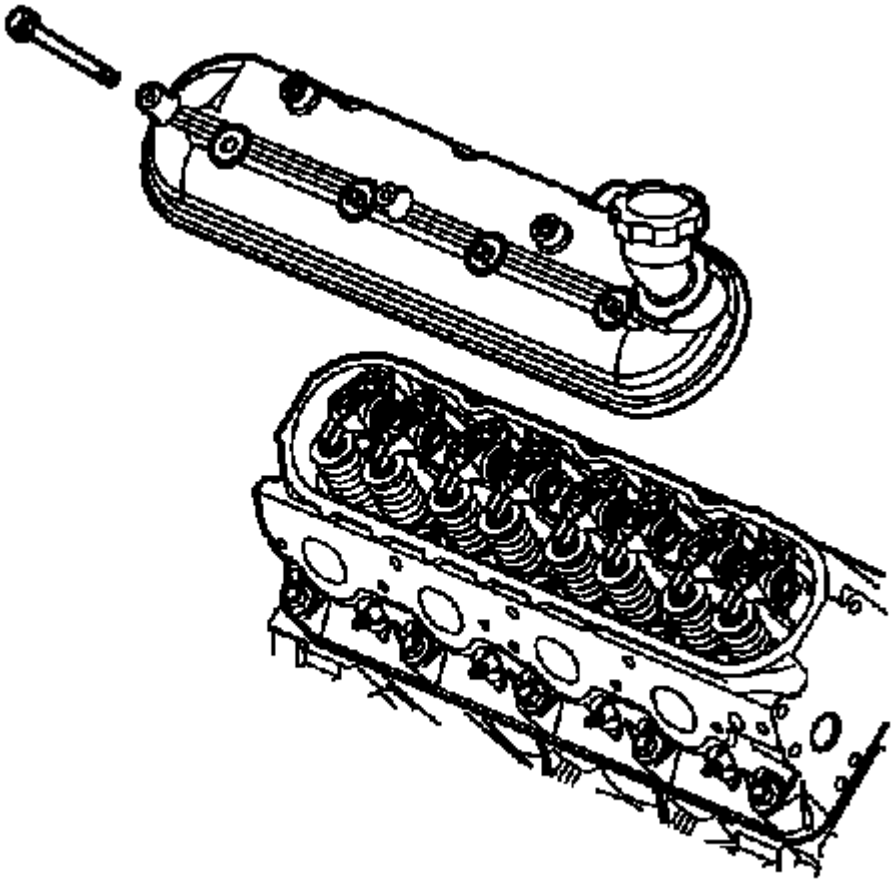

Fig. 339: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

6. Remove the valve rocker arm cover bolts and cover.
7. If the valve rocker arm cover grommets are cracked or damaged, replace the valve rocker arm cover bolts. The grommet is serviced with the rocker arm cover bolt.

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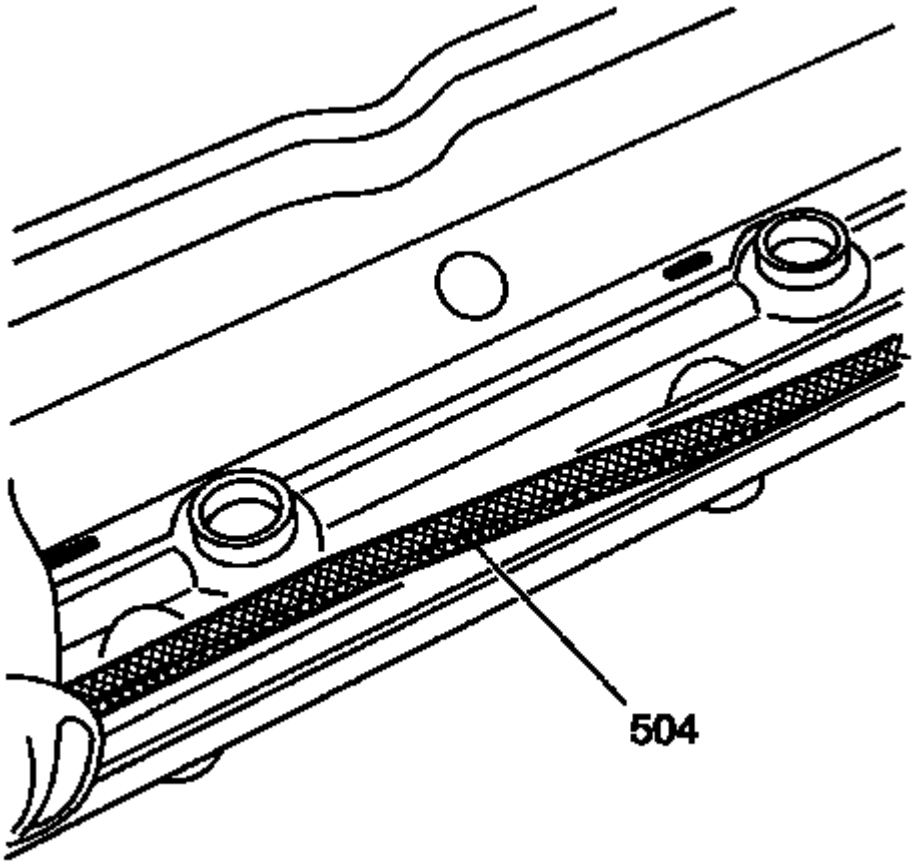

Fig. 340: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

8. Remove and discard the valve rocker arm cover gasket (504) from the cover.

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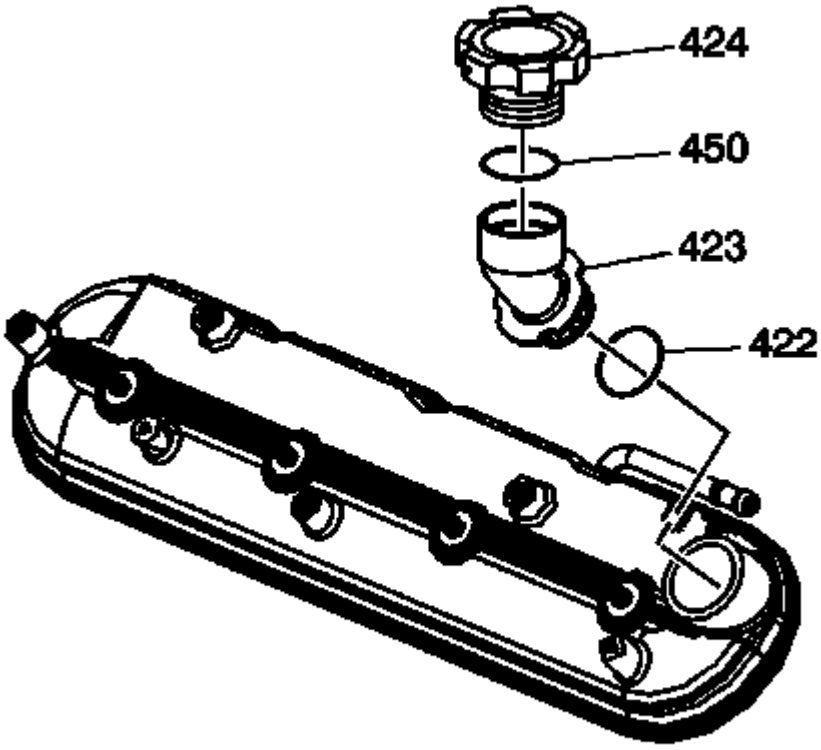

Fig. 341: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil fill cap (424) from the oil fill tube (423).
10. Remove the oil fill tube, as required.
11. Discard the oil fill tube.

VALVE ROCKER ARM AND PUSH ROD REMOVAL

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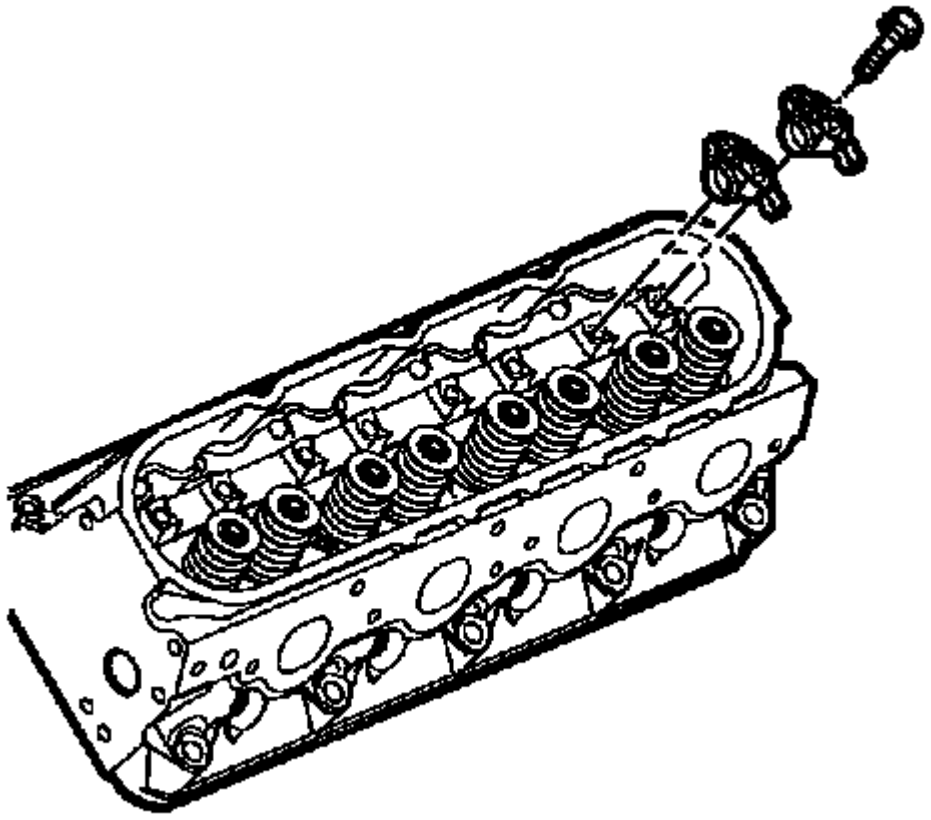

Fig. 342: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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

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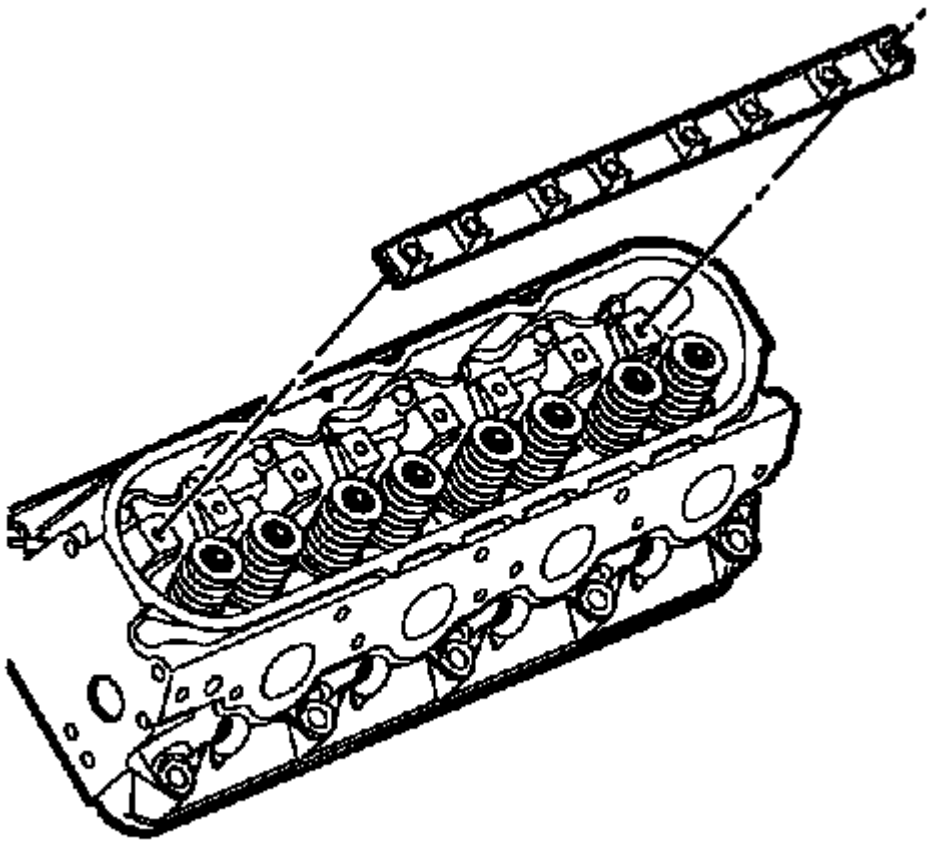

Fig. 343: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm pivot support.

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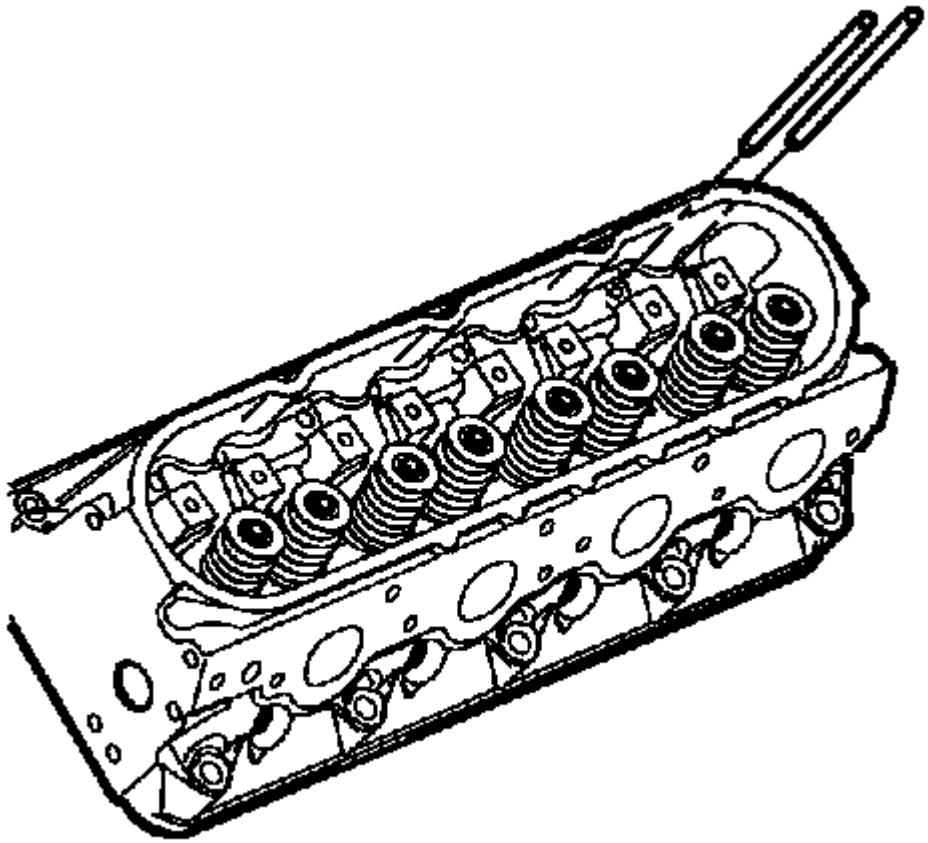

Fig. 344: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

4. Remove the pushrods.

CYLINDER HEAD REMOVAL - LEFT SIDE

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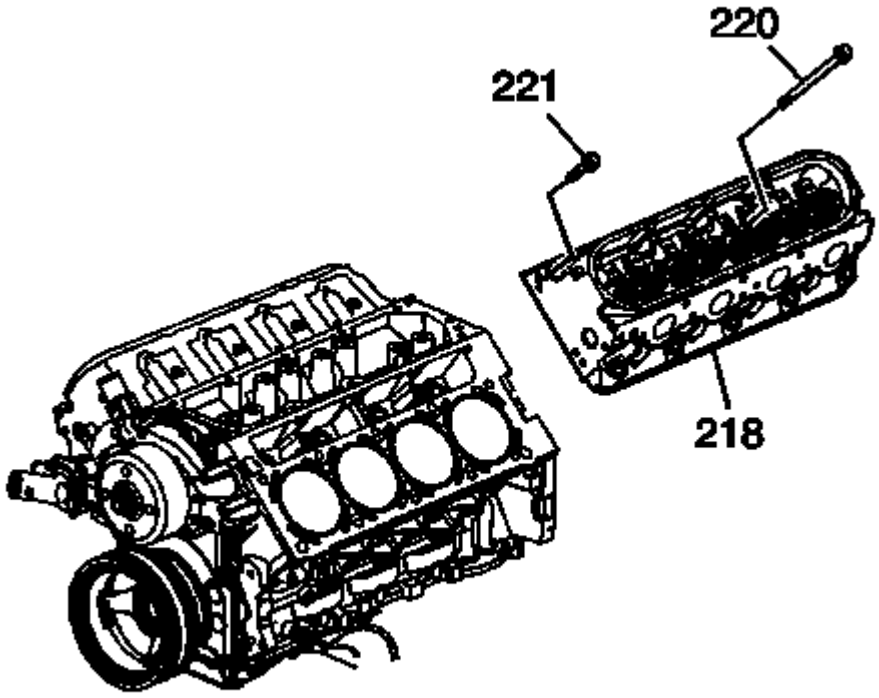

Fig. 345: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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).

CAUTION: 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).

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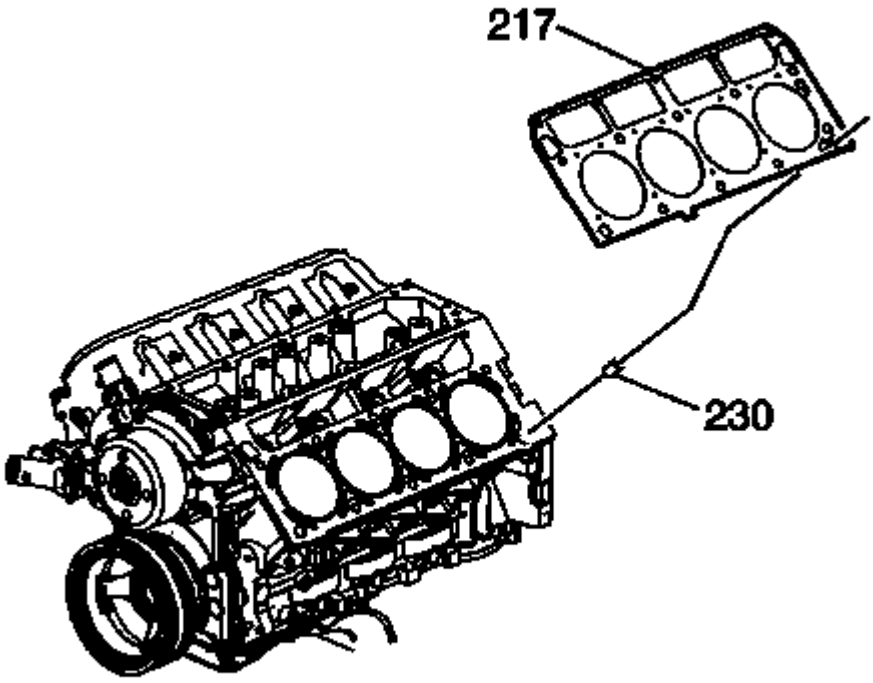

Fig. 346: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

CYLINDER HEAD REMOVAL - RIGHT SIDE

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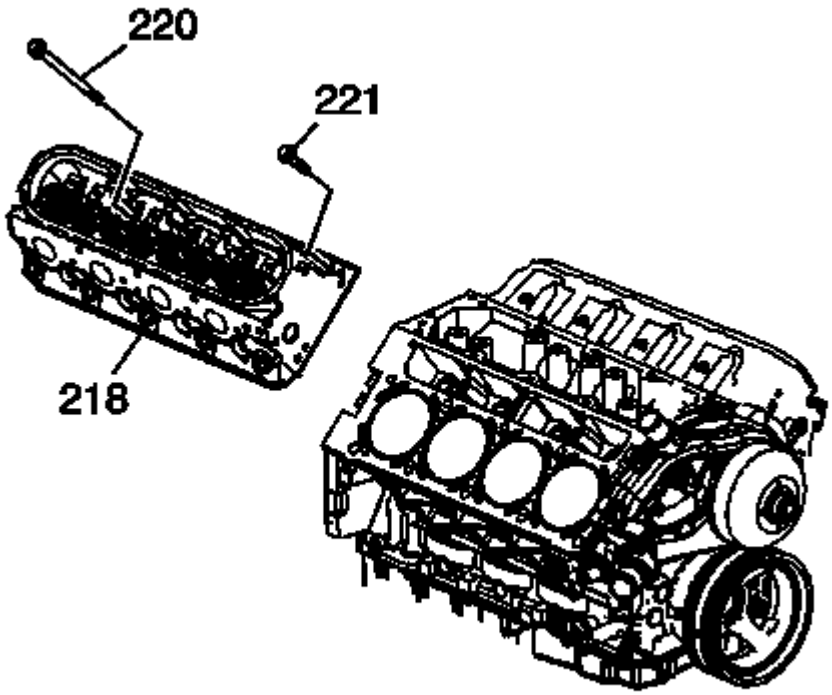

Fig. 347: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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).

CAUTION: 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).

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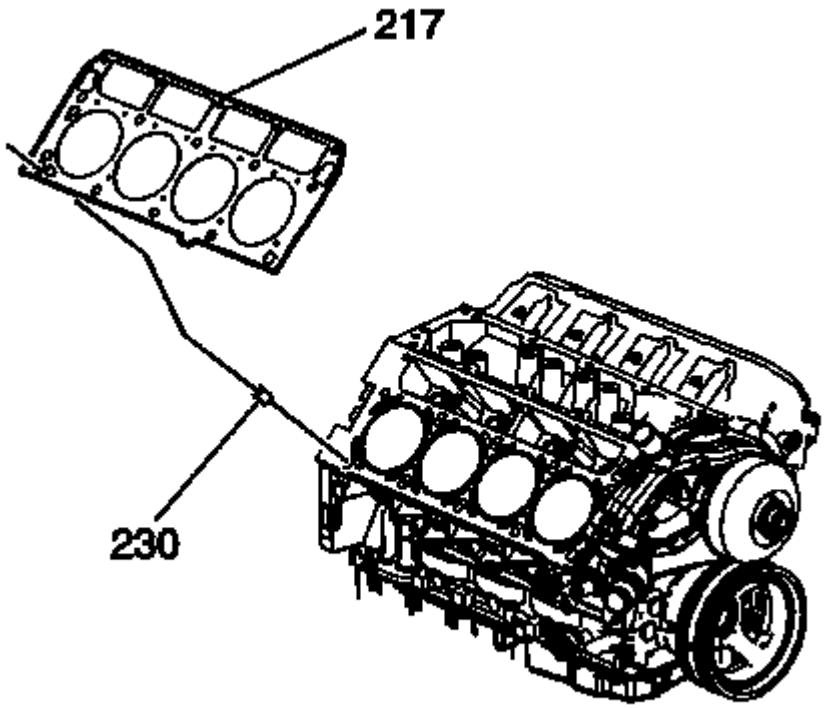

Fig. 348: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the gasket (217) and locating pins (230).
4. Discard the gasket and cylinder head bolts.

VALVE LIFTER REMOVAL

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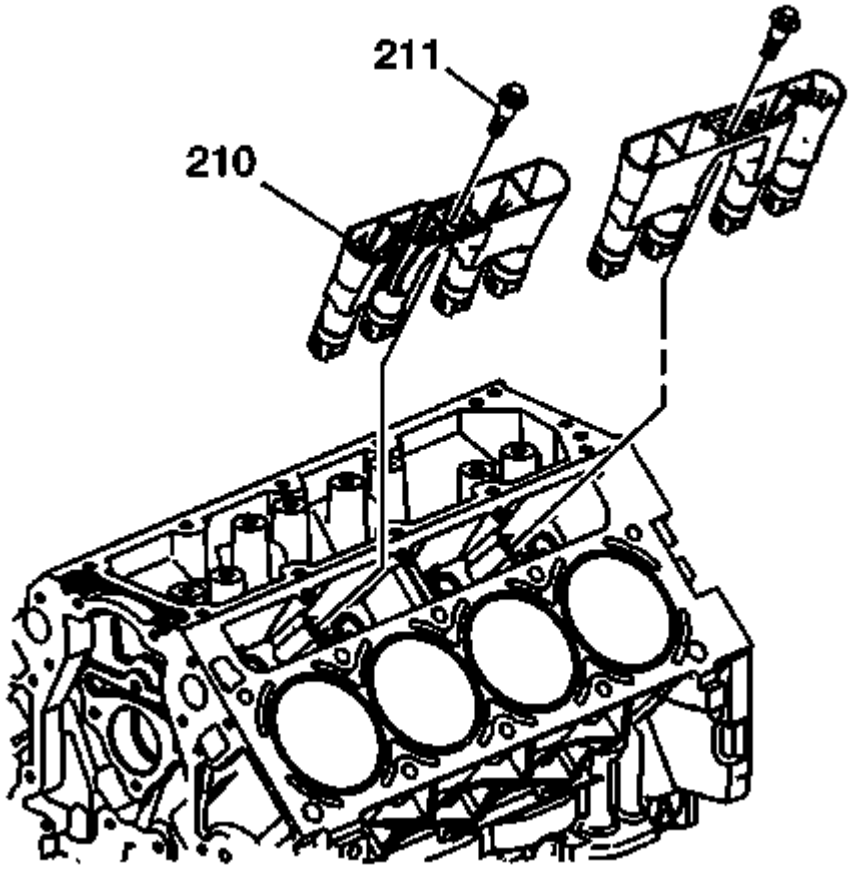

Fig. 349: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

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.

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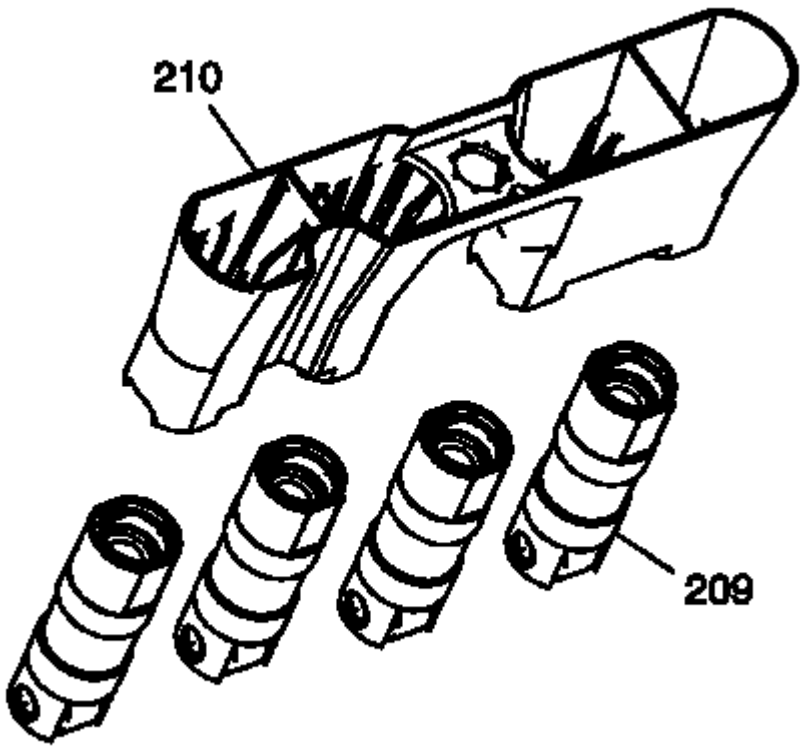

Fig. 350: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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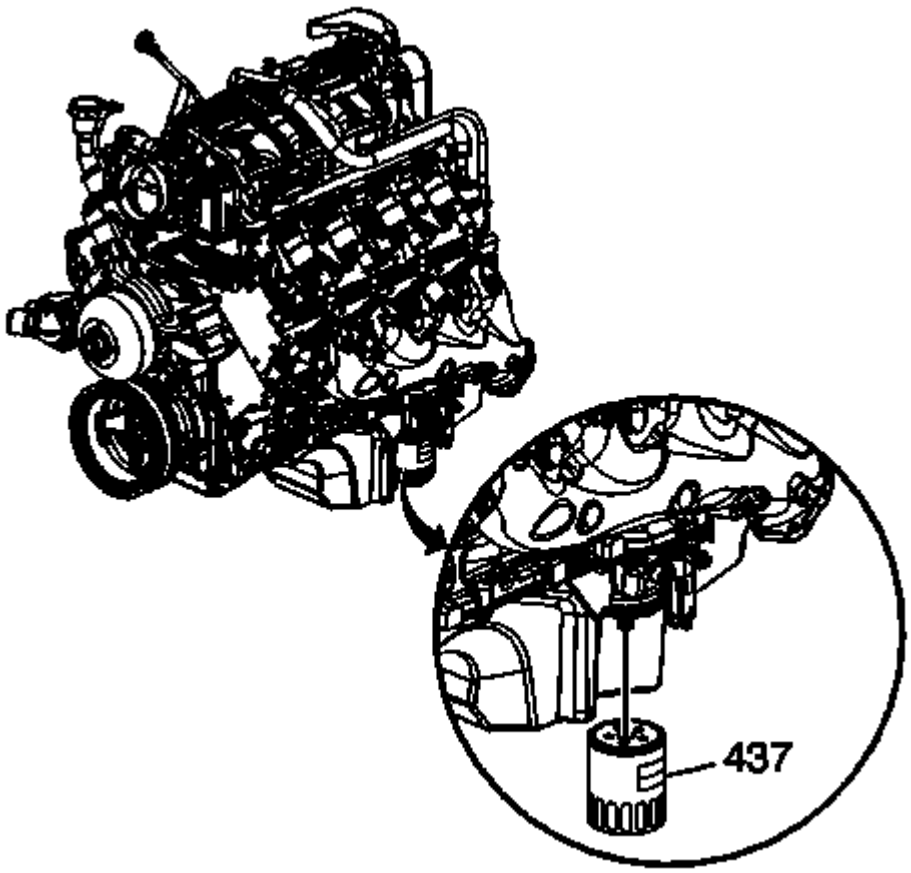

Fig. 351: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter (437).

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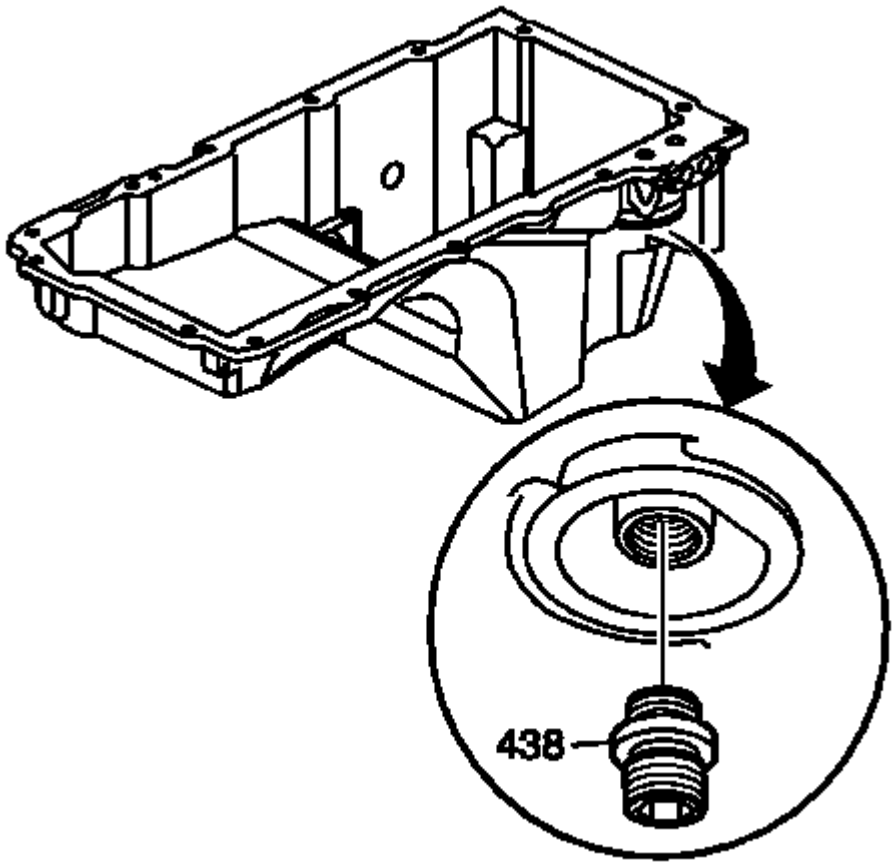

Fig. 352: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting (438).

OIL PAN REMOVAL

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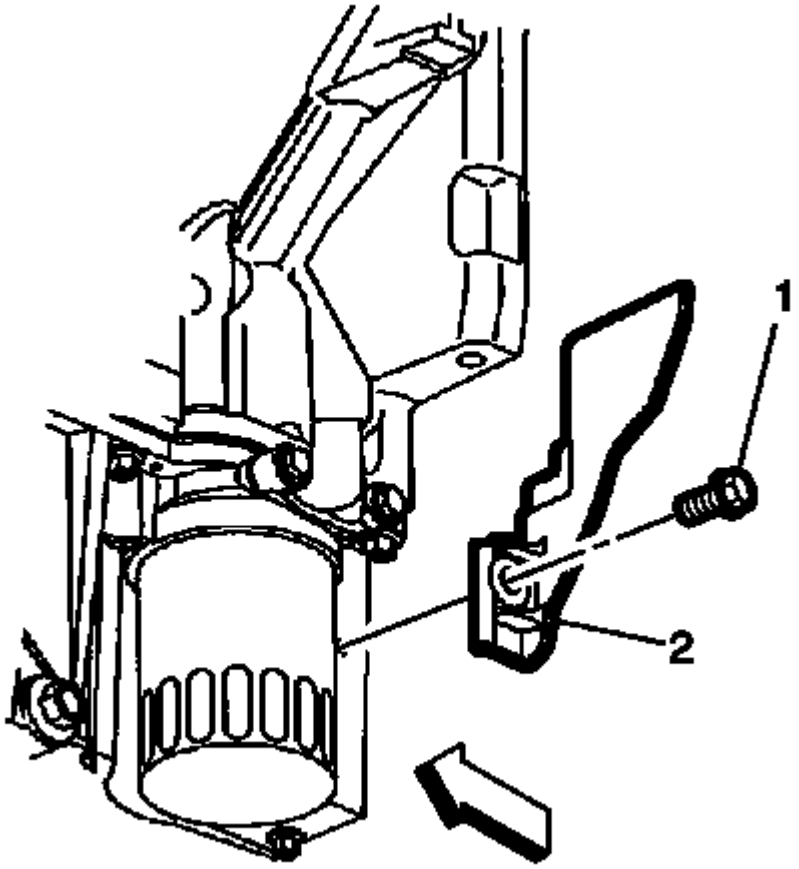

Fig. 353: View Of Left Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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 applicable and if service is required.**

1. Remove the left closeout cover (2) and bolt (1).

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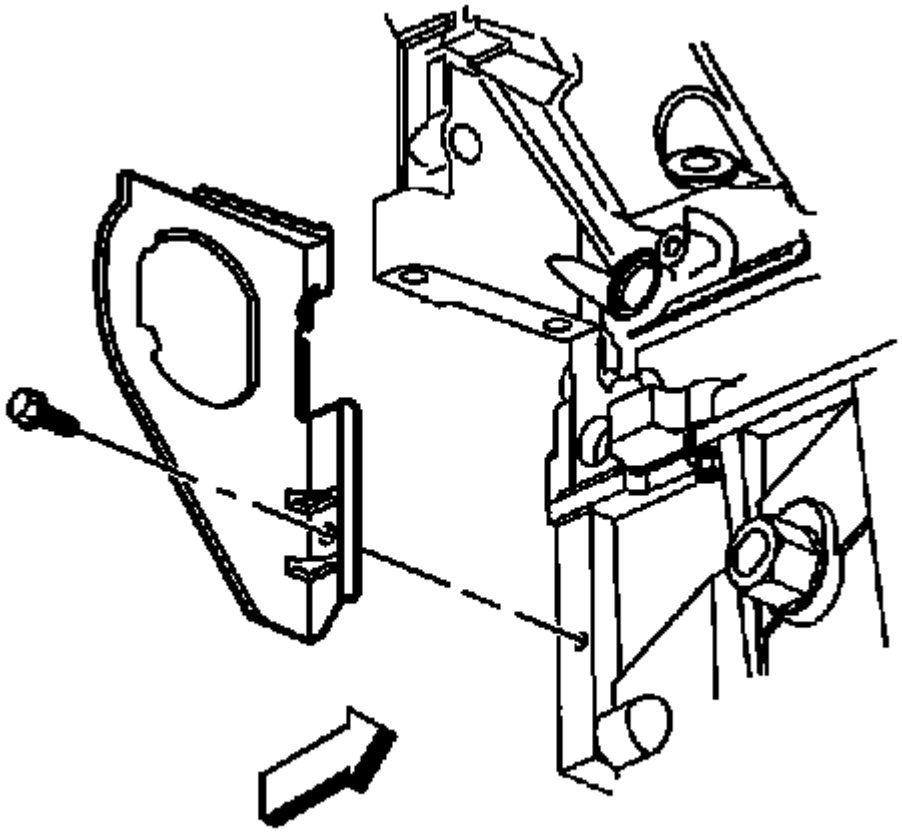

Fig. 354: View Of Right Closeout Cover & Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the right closeout cover and bolt.

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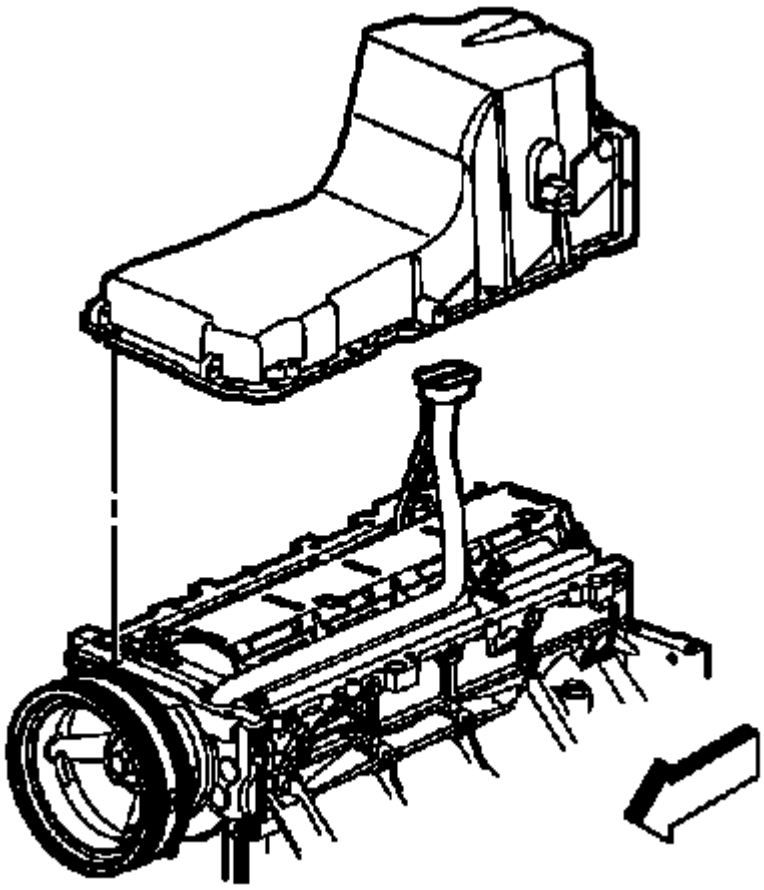

Fig. 355: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil pan bolts.
4. Remove the oil pan.

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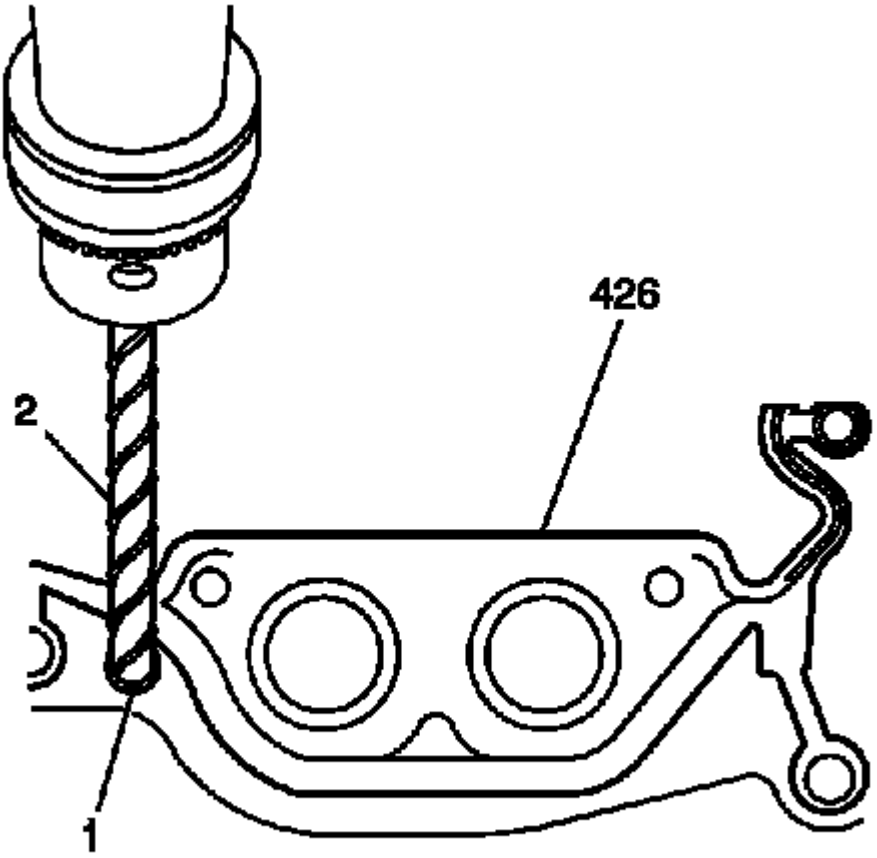

Fig. 356: Drilling Out Oil Pan Gasket Retaining Rivets
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **DO NOT allow foreign material to enter the oil passages of the oil pan. Cap or cover the openings, as required.**
- **Use care not to gouge, score, or damage the oil pan sealing surface.**

5. Drill (2) out the oil pan gasket retaining rivets (1), if required.
6. Remove the gasket (426) from the pan.
7. Discard the gasket and rivets.

ENGINE FRONT COVER REMOVAL

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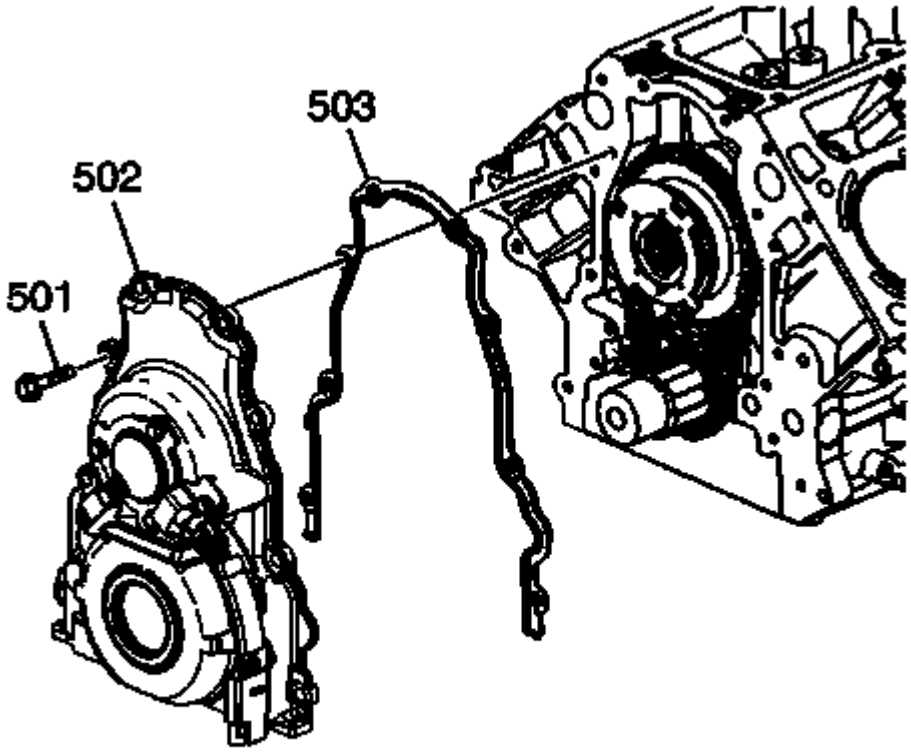

Fig. 357: View Of Front Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove the front cover bolts (501).
2. Remove the front cover (502) and gasket (503).
3. Discard the front cover gasket.

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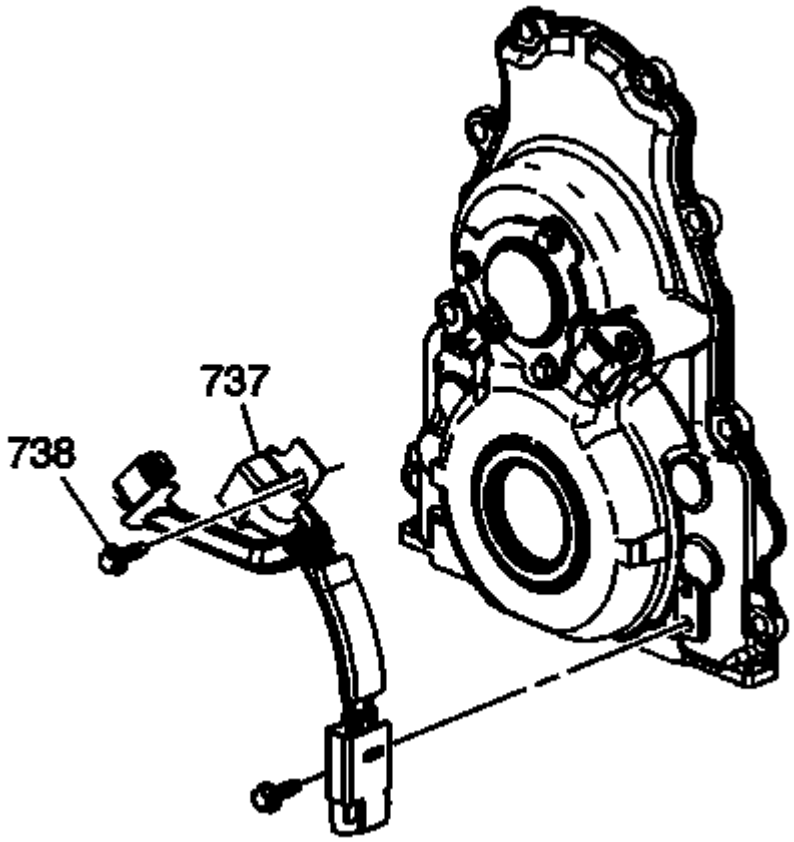

Fig. 358: View Of CMP Sensor Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft position (CMP) sensor wire harness (737) and bolts (738).

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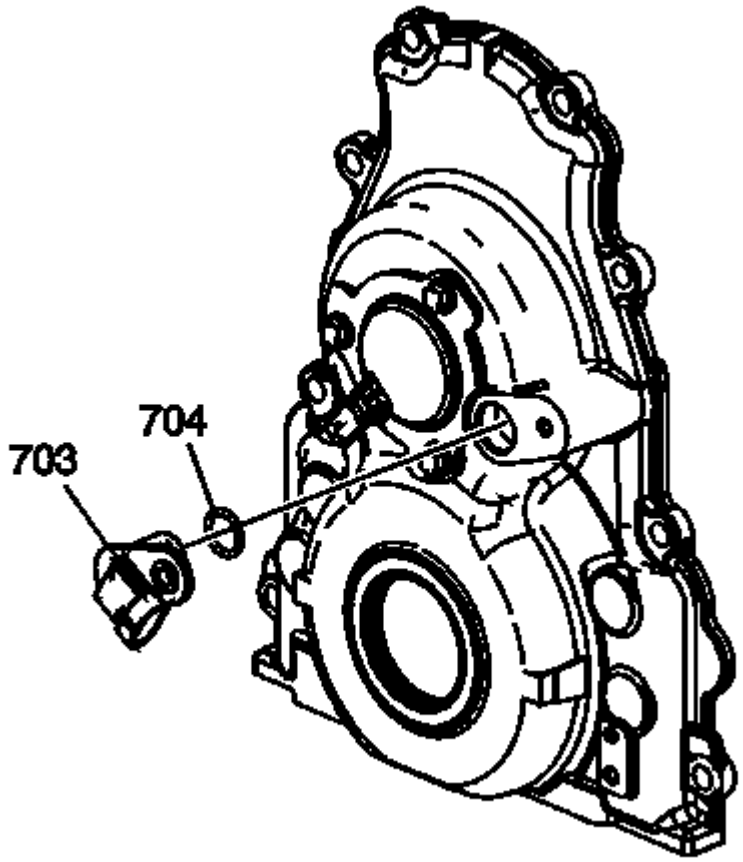

Fig. 359: View Of CMP Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

5. Remove the CMP sensor (703).
6. Remove the O-ring (704) from the sensor, as required.

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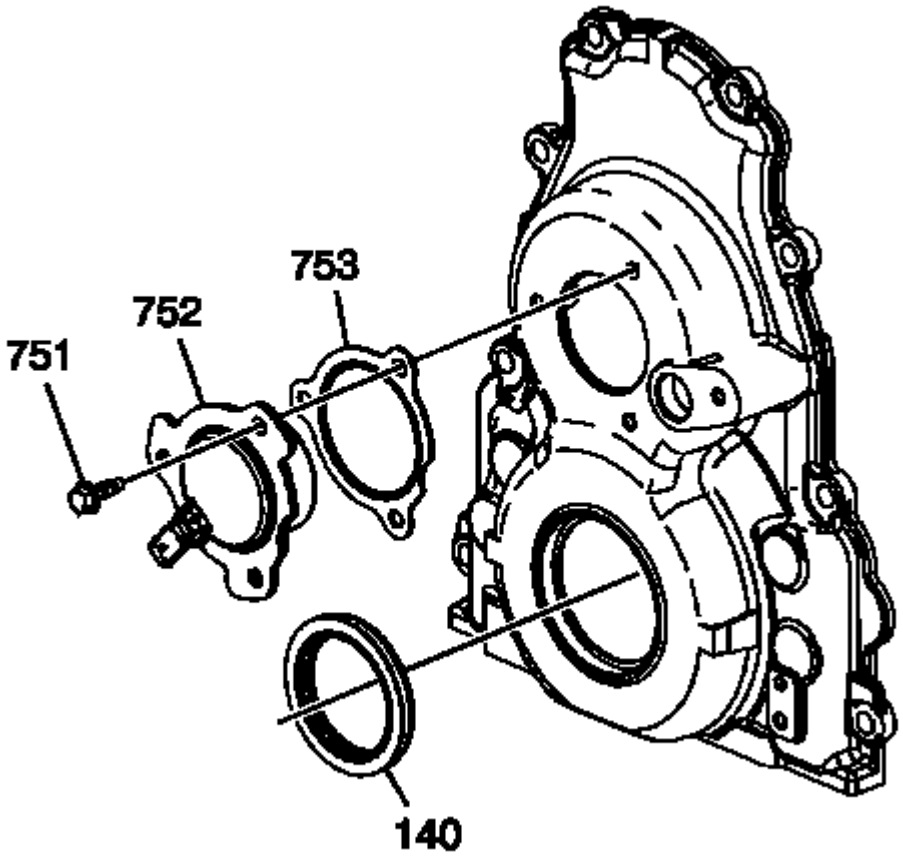

Fig. 360: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

7. Remove the CMP actuator magnet (752), bolts (751), and gasket (753).
8. Remove the oil seal (140).

CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

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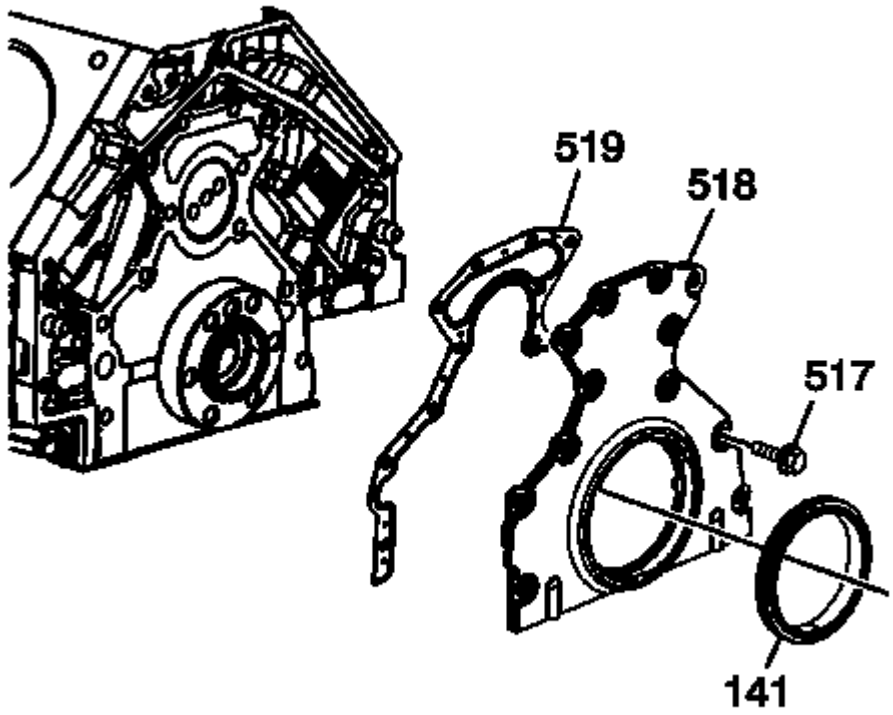

Fig. 361: View of Rear Housing, Gasket and Seal
Courtesy of GENERAL MOTORS CORP.

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

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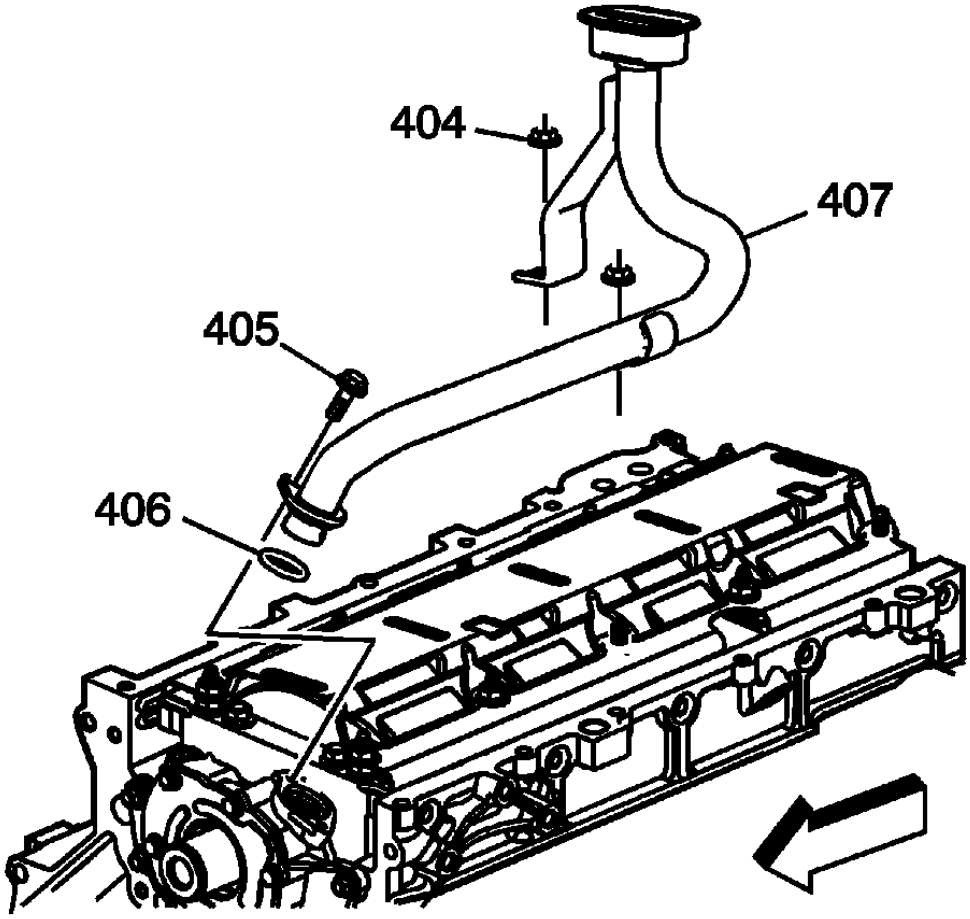

Fig. 362: Oil Pump, Screen and Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

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.

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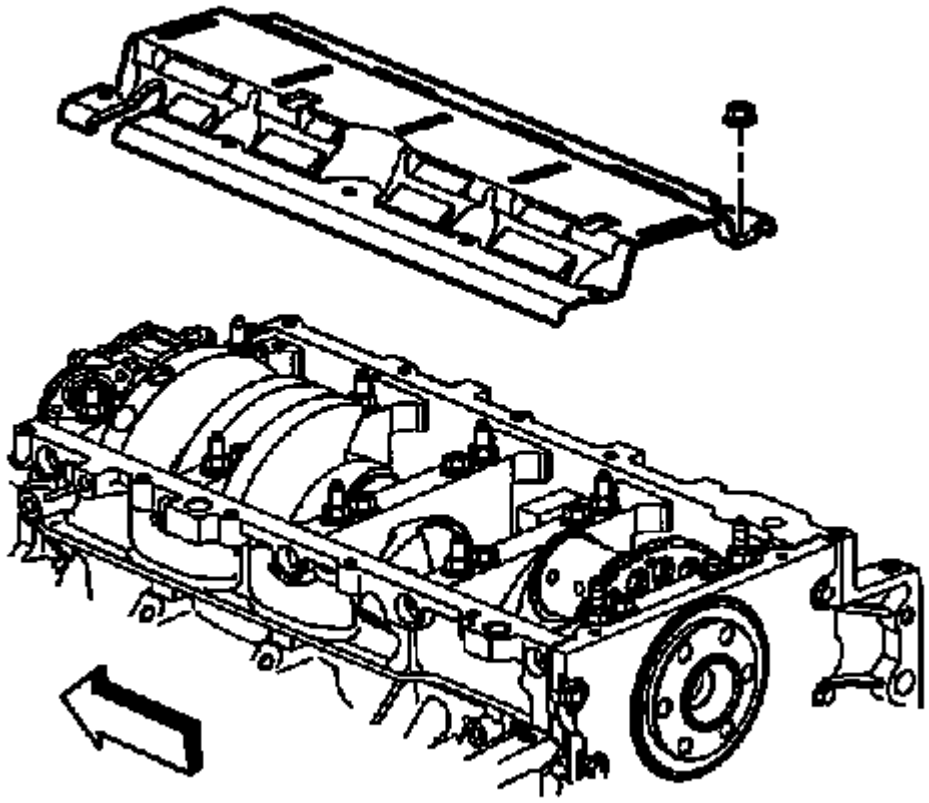

Fig. 363: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Remove the remaining crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

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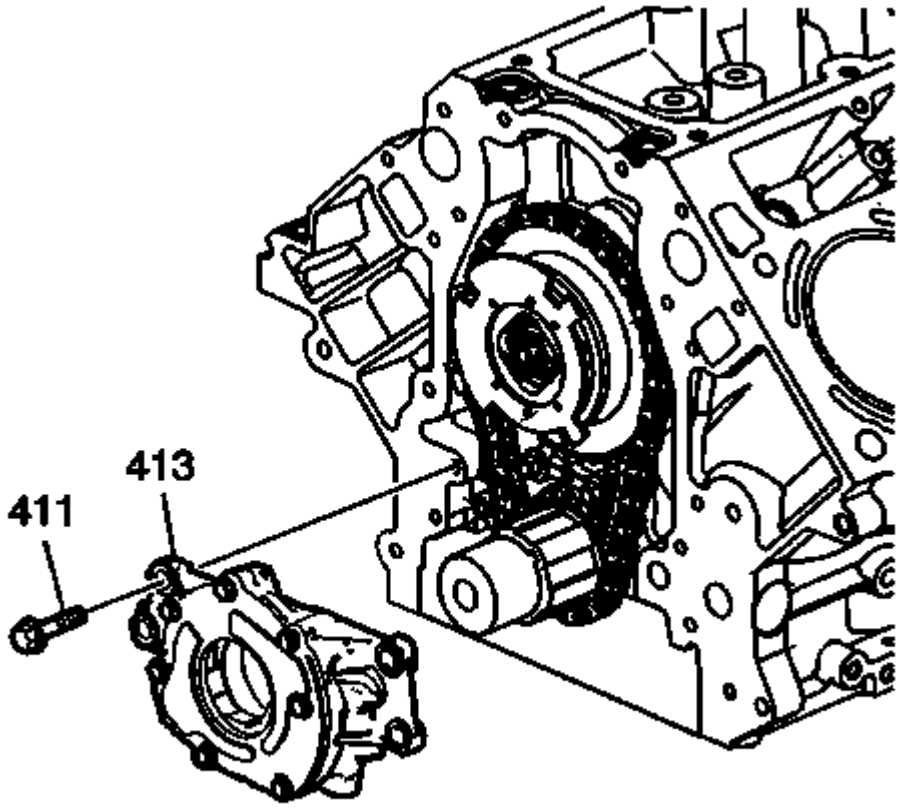

Fig. 364: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pump bolts (411).

NOTE: Do not allow dirt or debris to enter the oil pump assembly. Cap ends, as necessary.

8. Remove the oil pump (413).

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE REMOVAL

Special Tools

- **J 8433:** Two Jaw Puller
- **J 41558:** Crankshaft Sprocket Remover
- **J 41816-2:** Crankshaft End Protector
- **J 42386-A:** Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**.

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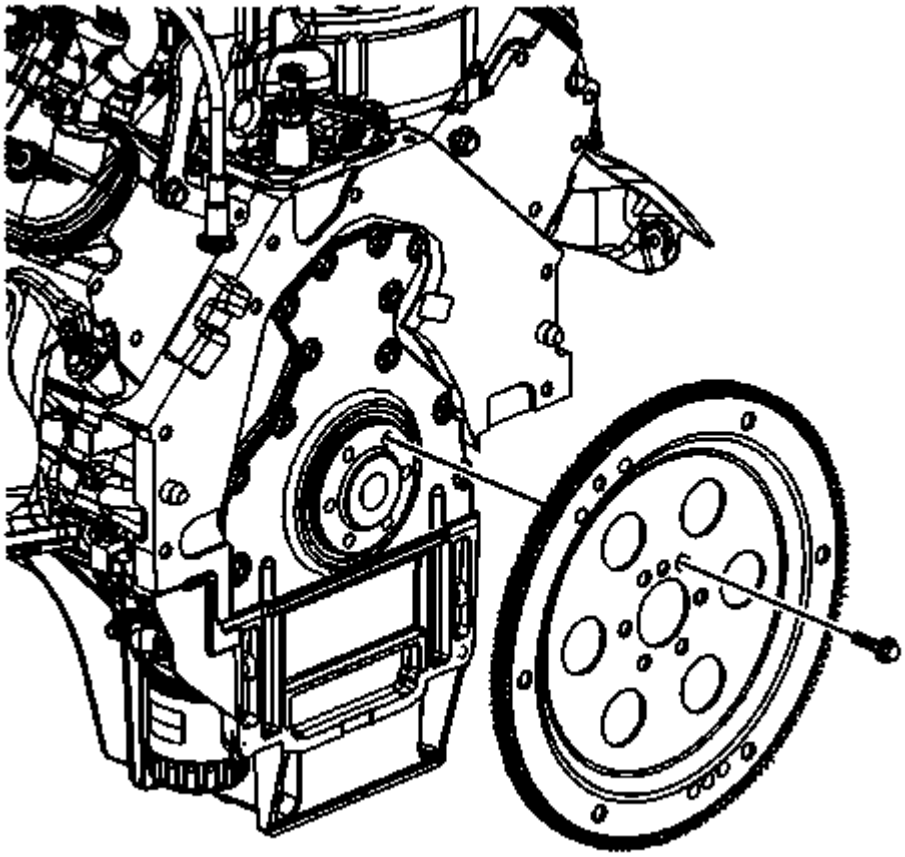

Fig. 365: View Of Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**.

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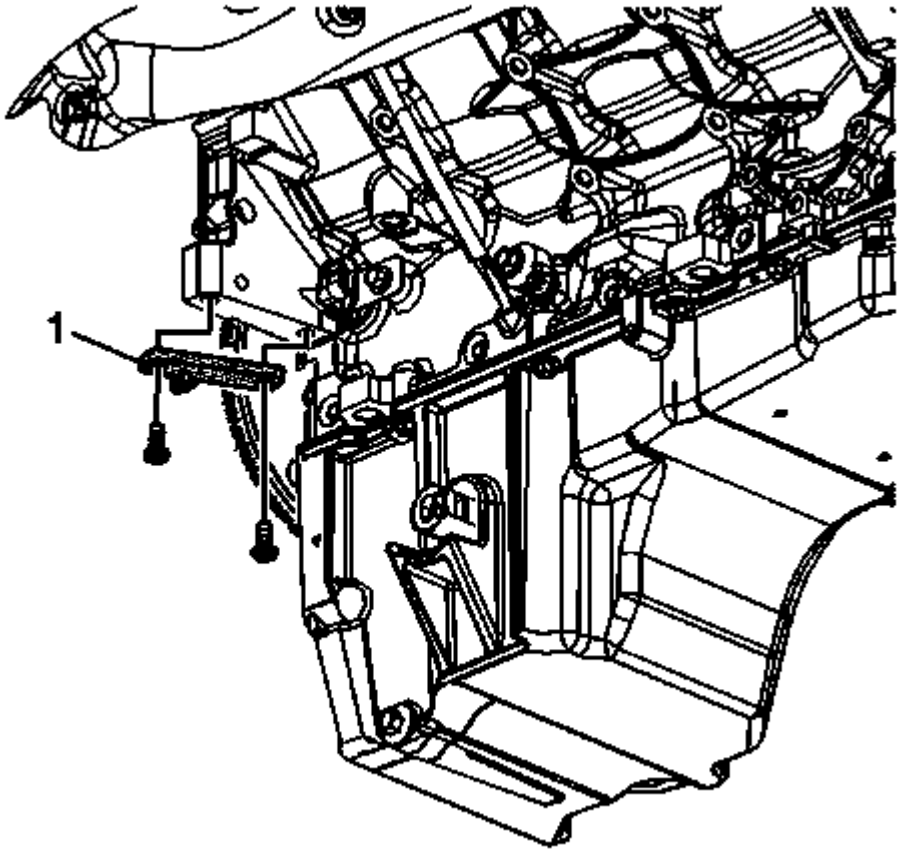

Fig. 366: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

2. Install the **J 42386-A:** tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the **J 42386-A:** tool bolts to 50 N.m (37 lb ft).

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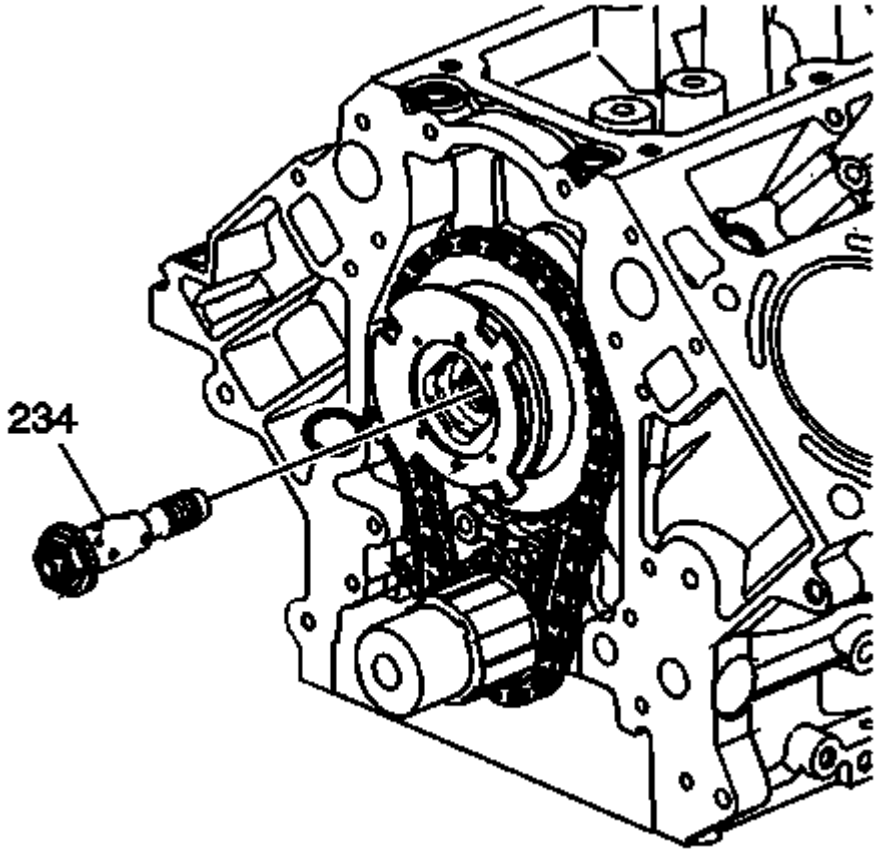

Fig. 367: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

3. Remove the CMP actuator solenoid valve (234).
4. Discard the solenoid valve.

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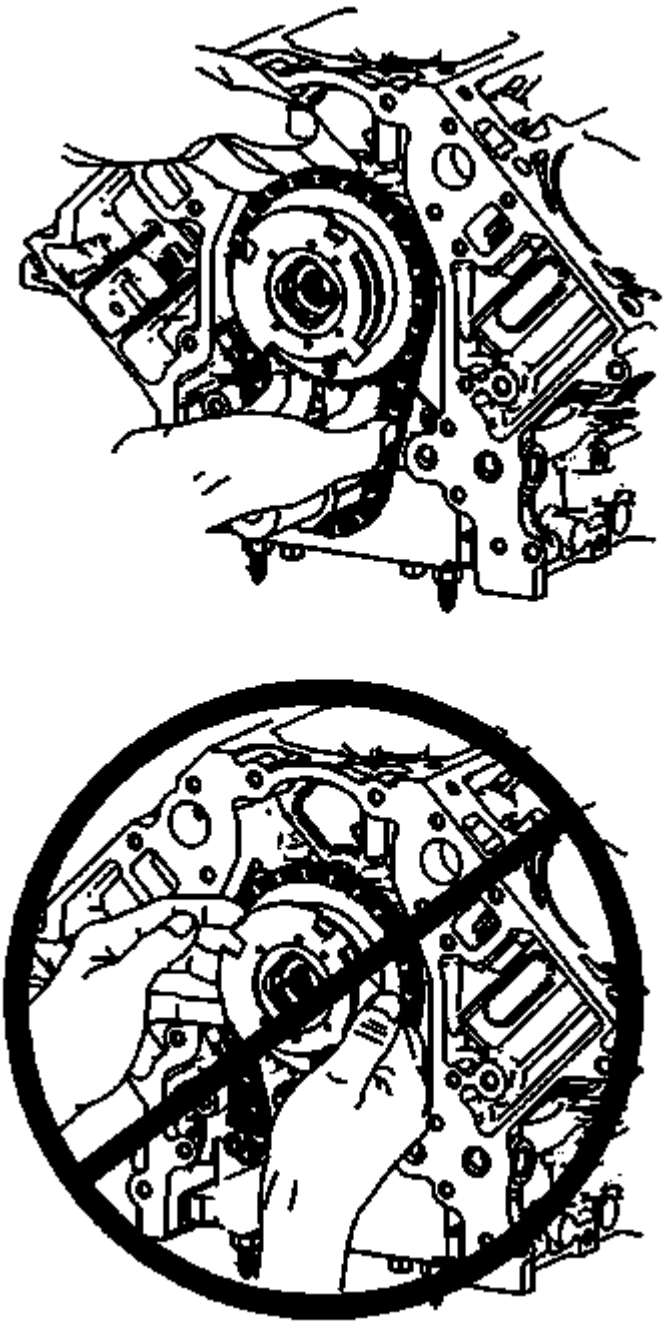

Fig. 368: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

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.

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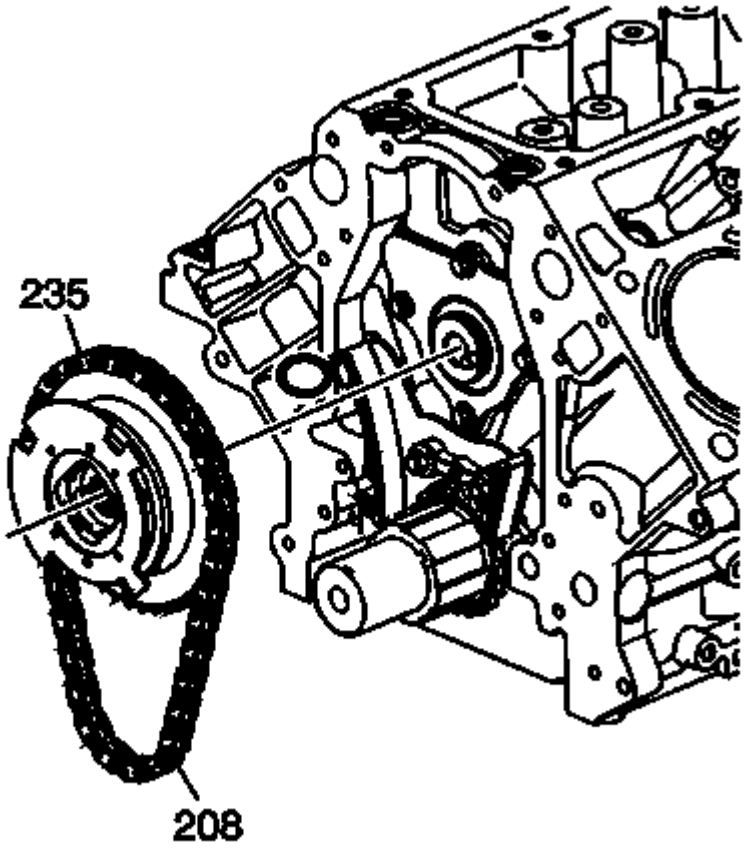

Fig. 369: View Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

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

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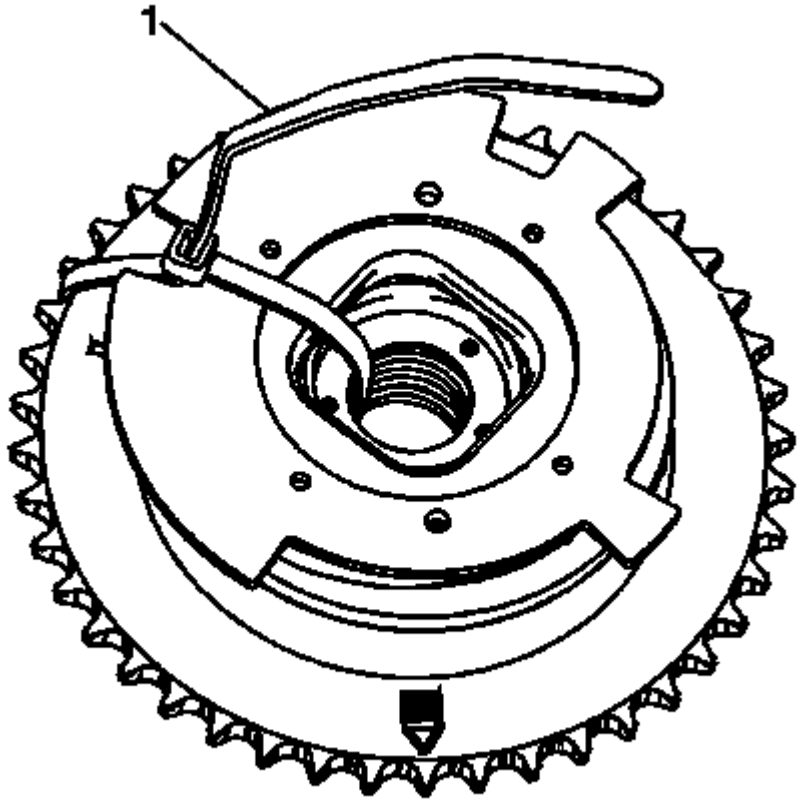

Fig. 370: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

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

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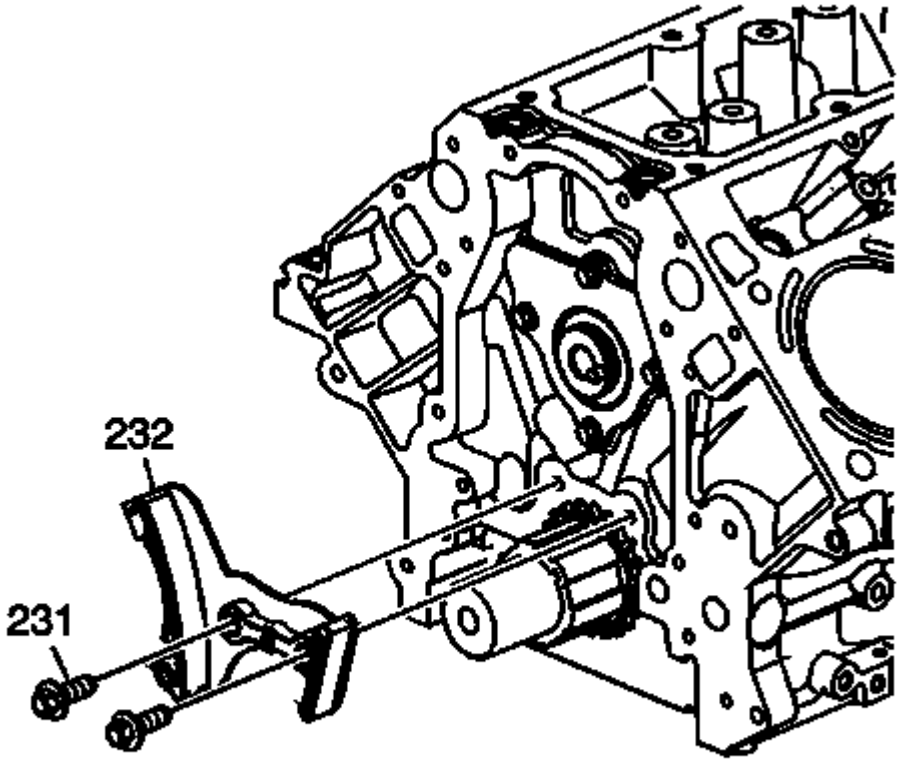

Fig. 371: View Of Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Remove the bolts (231) and timing chain tensioner (232).

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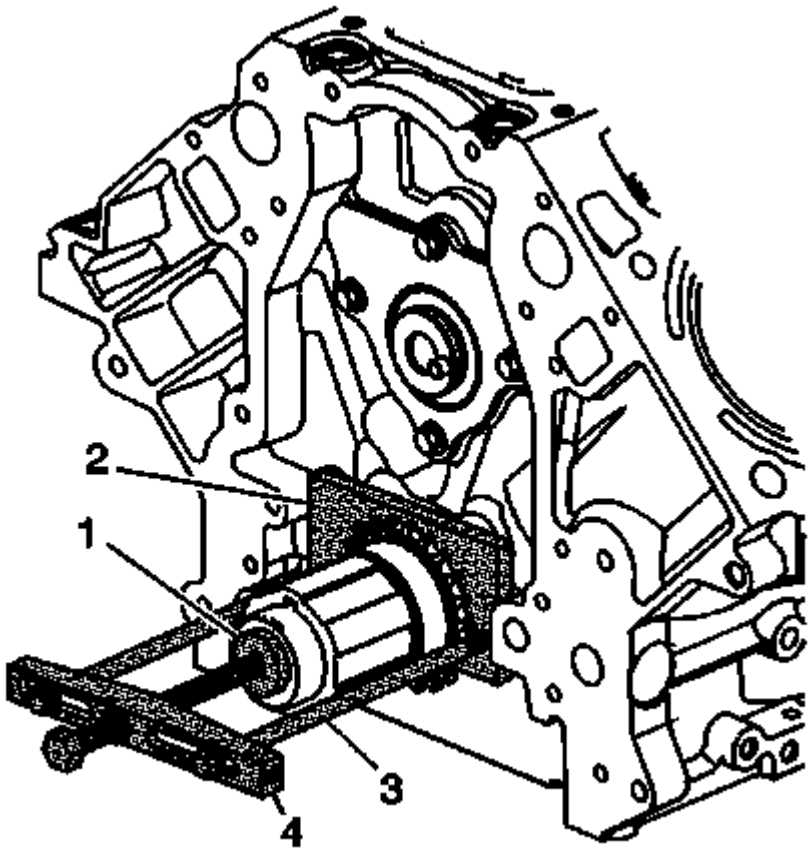

Fig. 372: View Of Crankshaft Sprocket Special Tools
Courtesy of GENERAL MOTORS CORP.

9. Use the **J 41816-2:** protector (1), the **J 41558:** remover (2), bolts (3), and the **J 8433:** puller (4) in order to remove the crankshaft sprocket.

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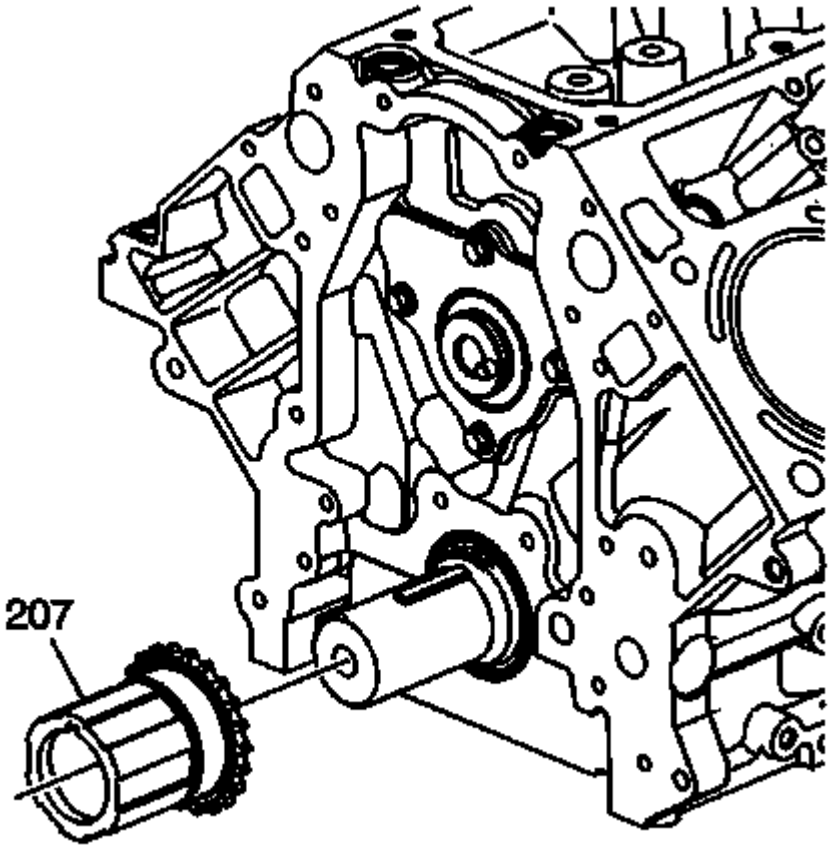

Fig. 373: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

10. Remove the crankshaft sprocket (207).

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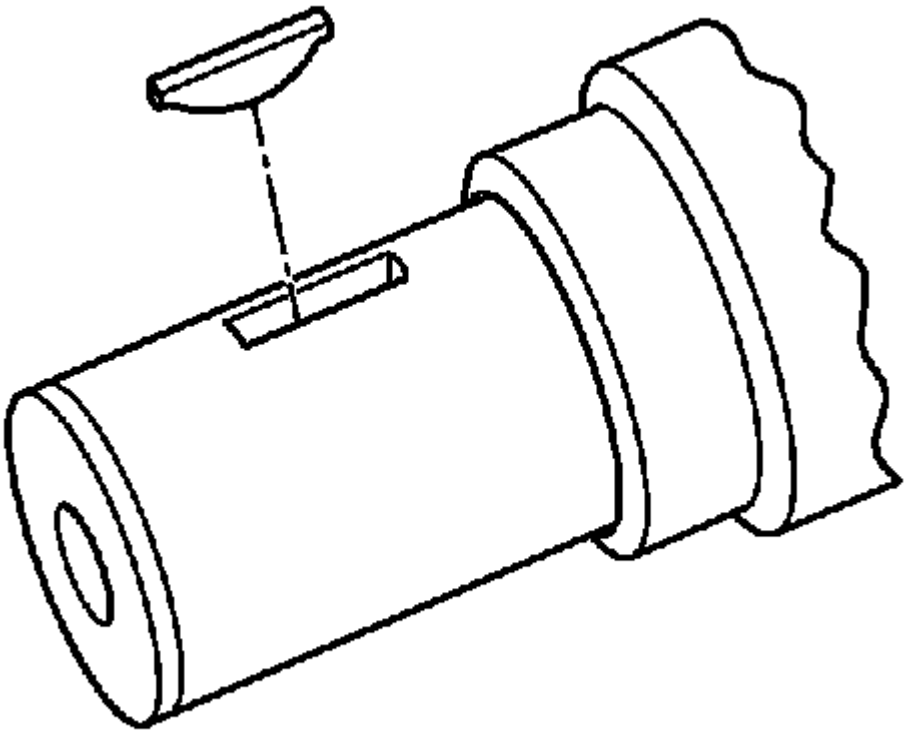

Fig. 374: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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:** tool and bolts.

CAMSHAFT REMOVAL

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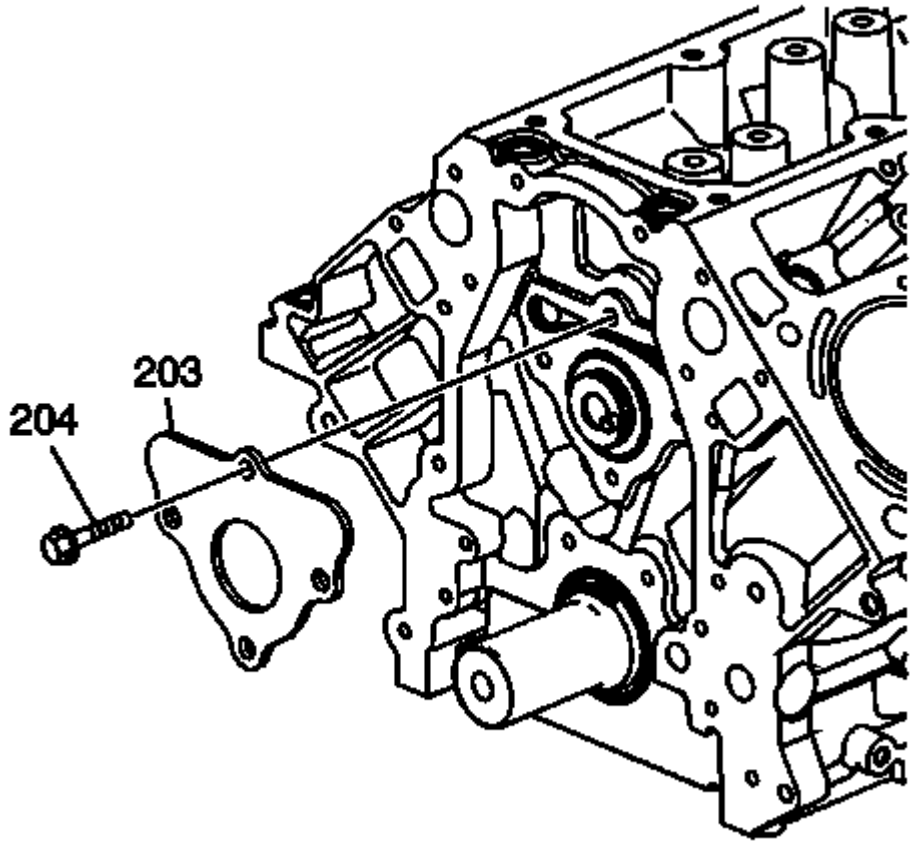

Fig. 375: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts (204) and retainer (203).

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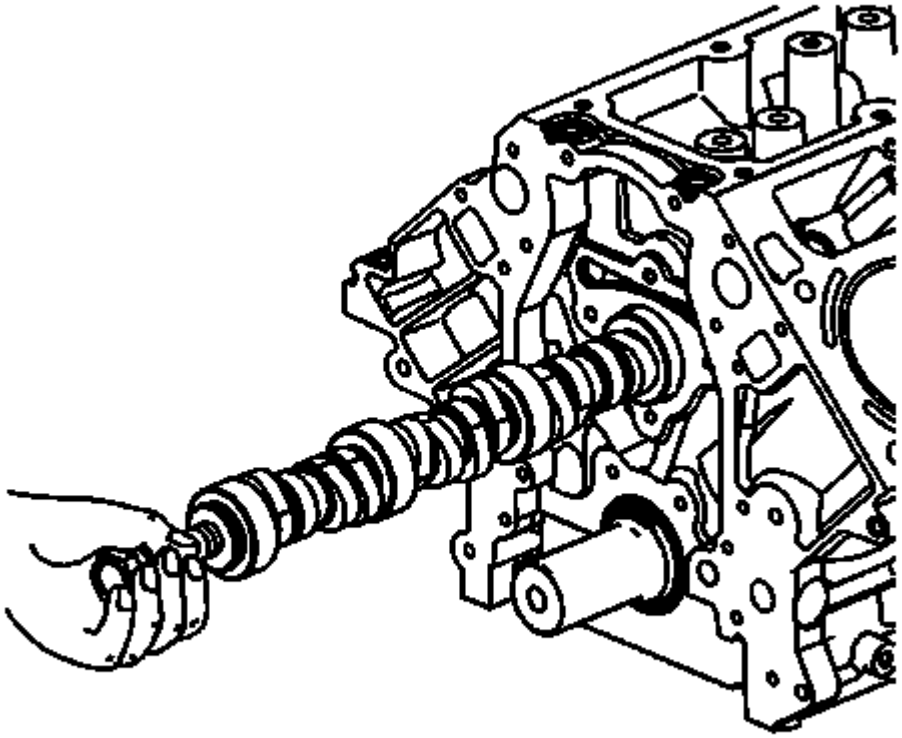

Fig. 376: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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 or solenoid valve into the camshaft front bolt hole.
    2. Using the bolt or solenoid valve as a handle, carefully rotate and pull the camshaft out of the engine block.
    3. Remove the bolt or solenoid valve from the front of the camshaft.

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Tools Required

- **J 24270** Cylinder Bore Ridge Reamer. See **Special Tools**.
- **J 41556** Connecting Rod Guide

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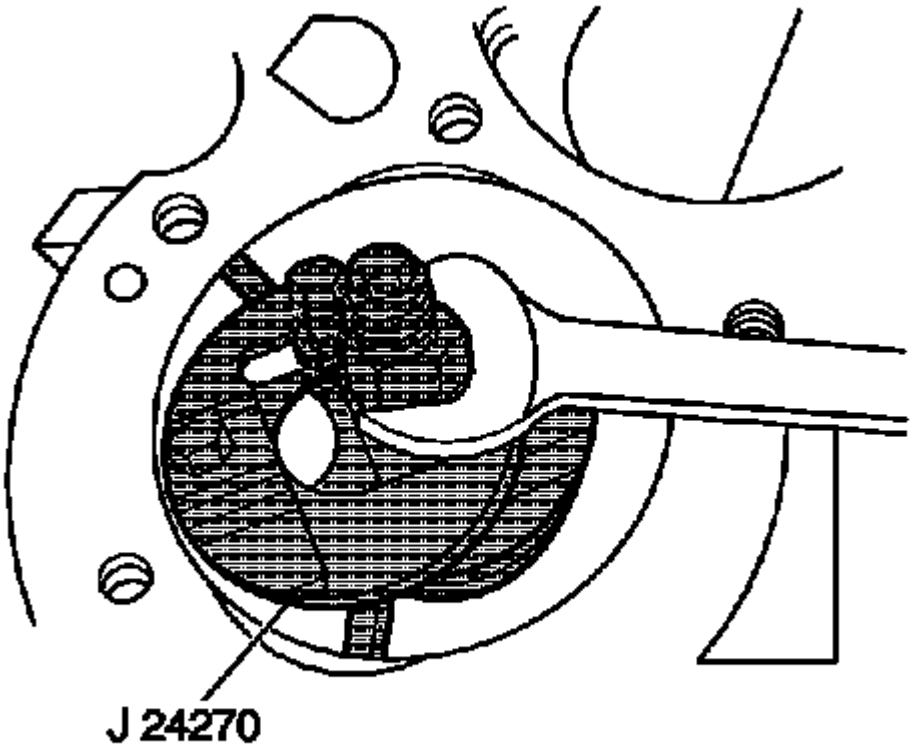

Fig. 377: View Of Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 24270** in order to remove the cylinder bore ring ridge, if required. See **Special Tools**.
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Place a cloth on top of the piston.
    3. Use the **J 24270** , or equivalent, in order to remove a cylinder ring ridge. See **Special Tools**.
    4. Turn the crankshaft so the piston is at the top of the stroke.
    5. Remove the cloth.
    6. Remove the cutting debris from the cylinder and piston.

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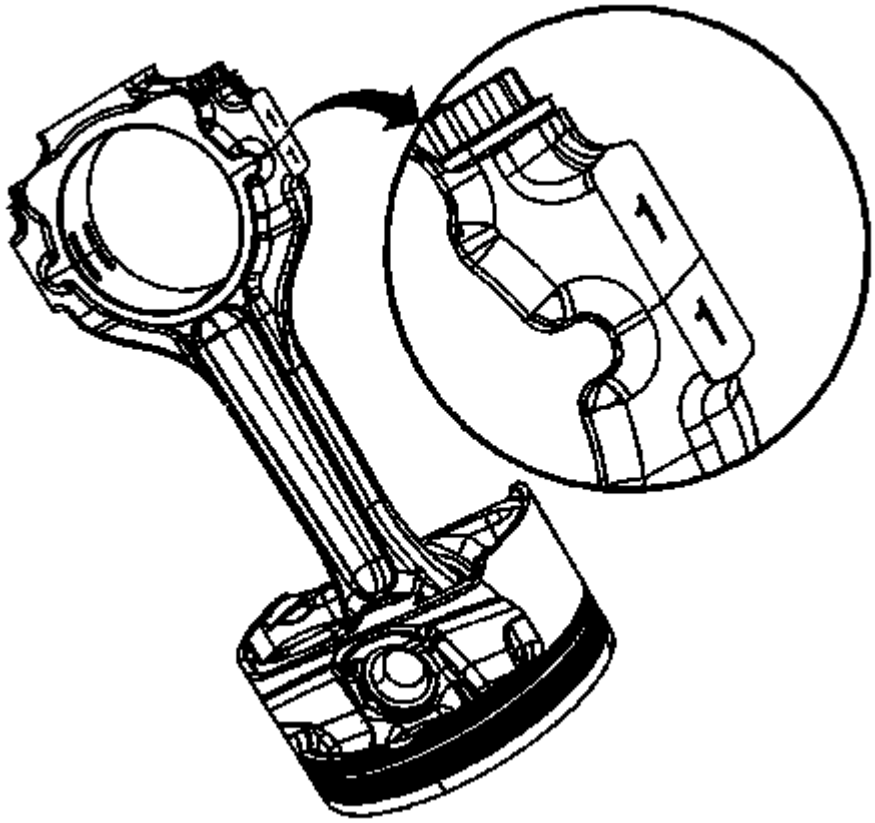

Fig. 378: Matchmarks On Connecting Rods & Caps
Courtesy of GENERAL MOTORS CORP.

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.

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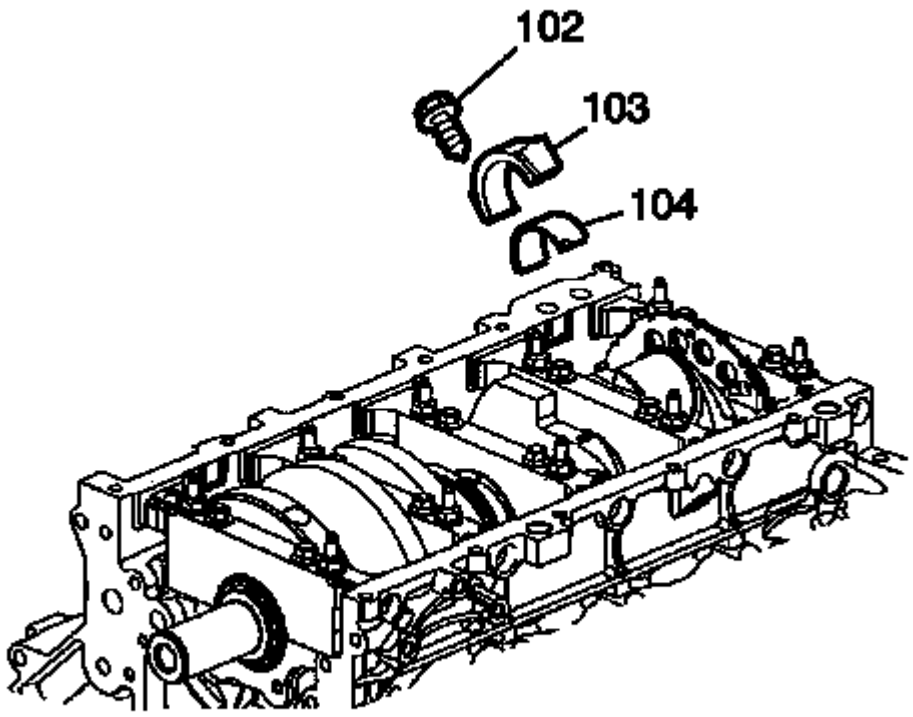

Fig. 379: Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

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).

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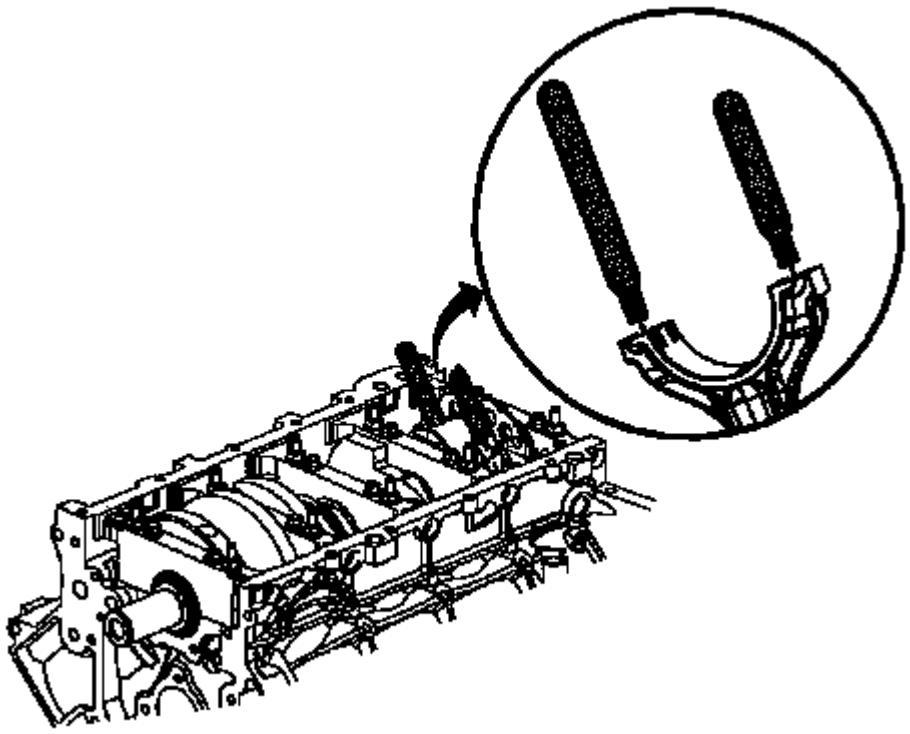

Fig. 380: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 41556** to the connecting rod.

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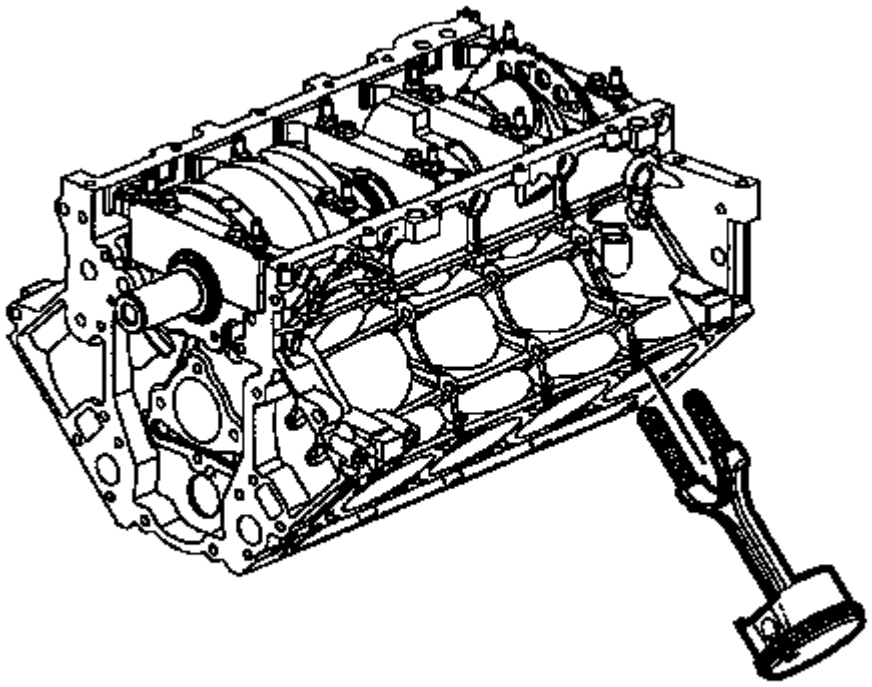

Fig. 381: Piston, Connecting Rod & Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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.
6. Remove the **J 41556** .

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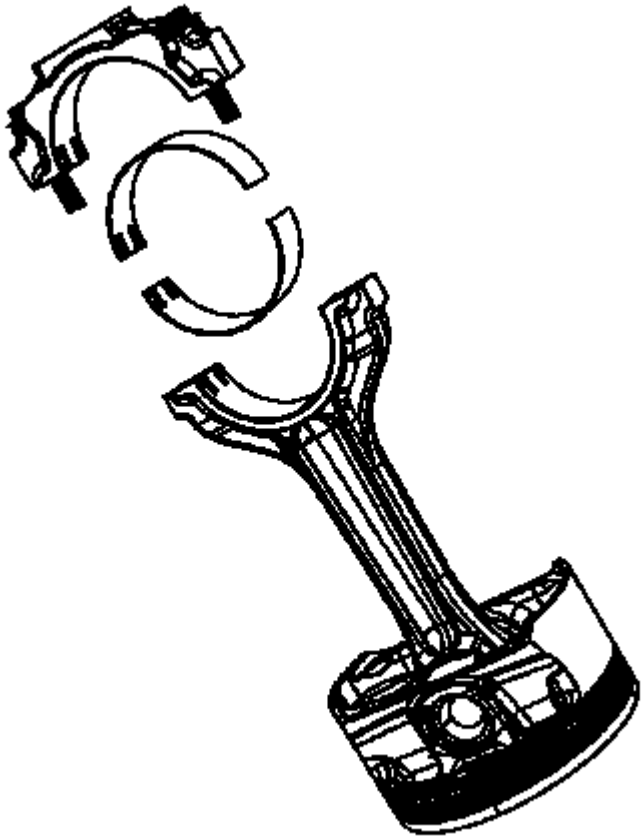

Fig. 382: View Of Piston, Connecting Rod & Cap
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

- **J 6125-1B:** Slide Hammer
- **J 41818:** Crankshaft Bearing Cap Remover

For equivalent regional tools, refer to **Special Tools**

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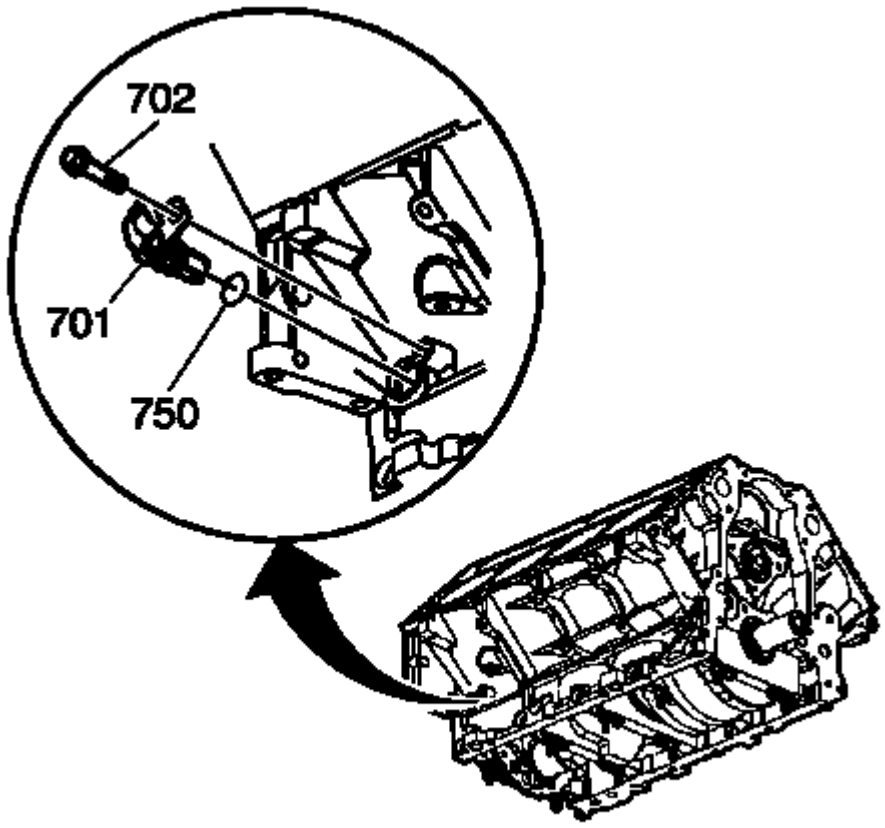

Fig. 383: CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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.**
- **All M8, and M10 bolts are to be discarded and replaced with NEW.**

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.

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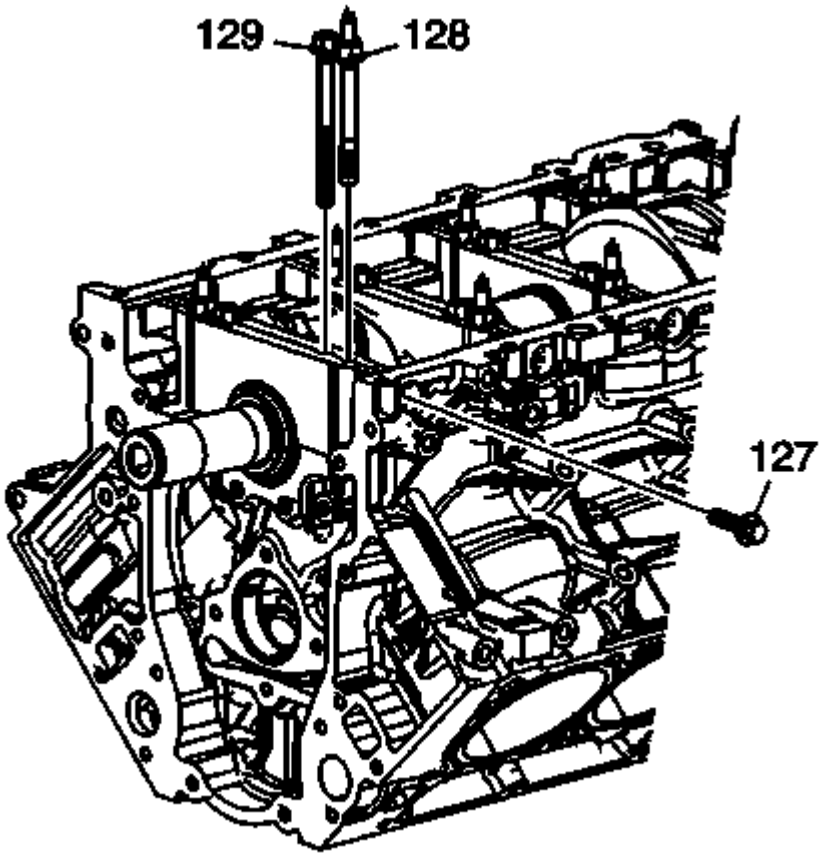

Fig. 384: Identifying Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the crankshaft bearing cap M8 bolts (127).
5. Remove and discard the bearing cap M10 bolts (129) and studs (128).

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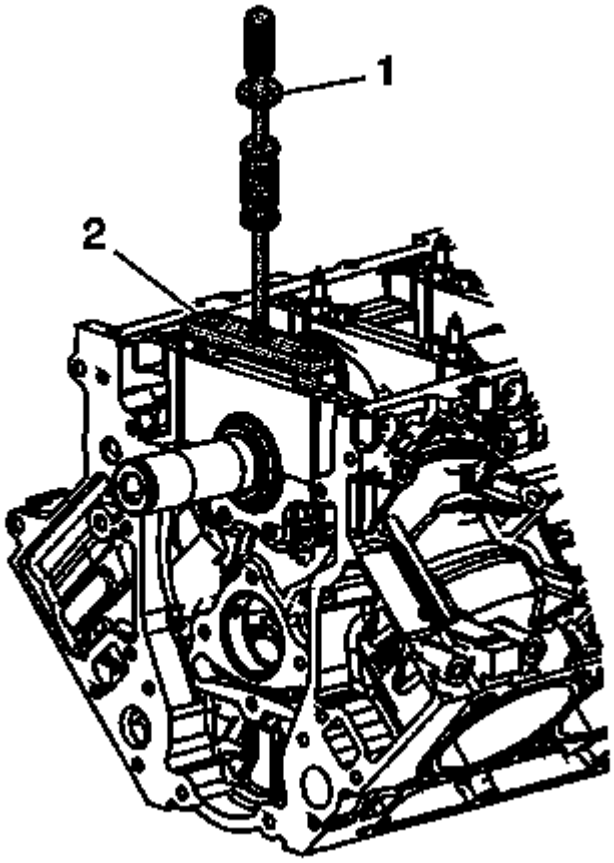

Fig. 385: View Of Crankshaft Bearing Cap Bolts (M10)
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the **J 41818:** remover (2) and tighten to 11 N.m (100 lb in).
7. Install the **J 6125-1B:** hammer (1) to the **J 41818:** remover (2) in order to remove the crankshaft bearing caps.

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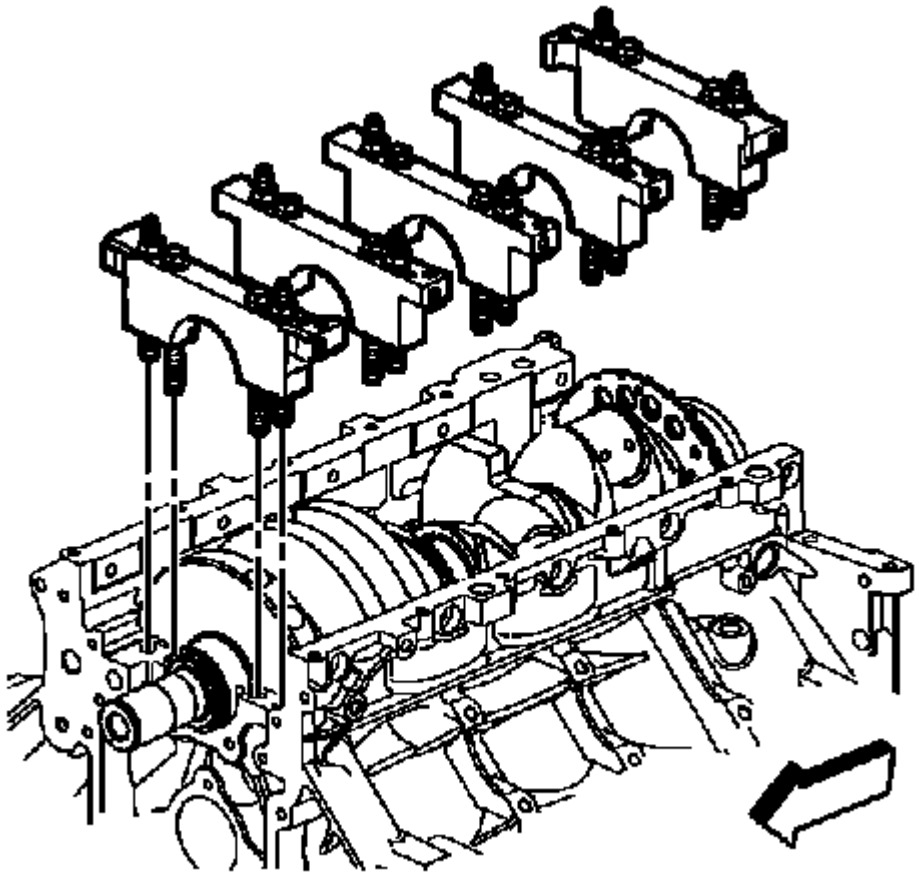

Fig. 386: View Of Crankshaft Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

8. Remove the bearing caps.

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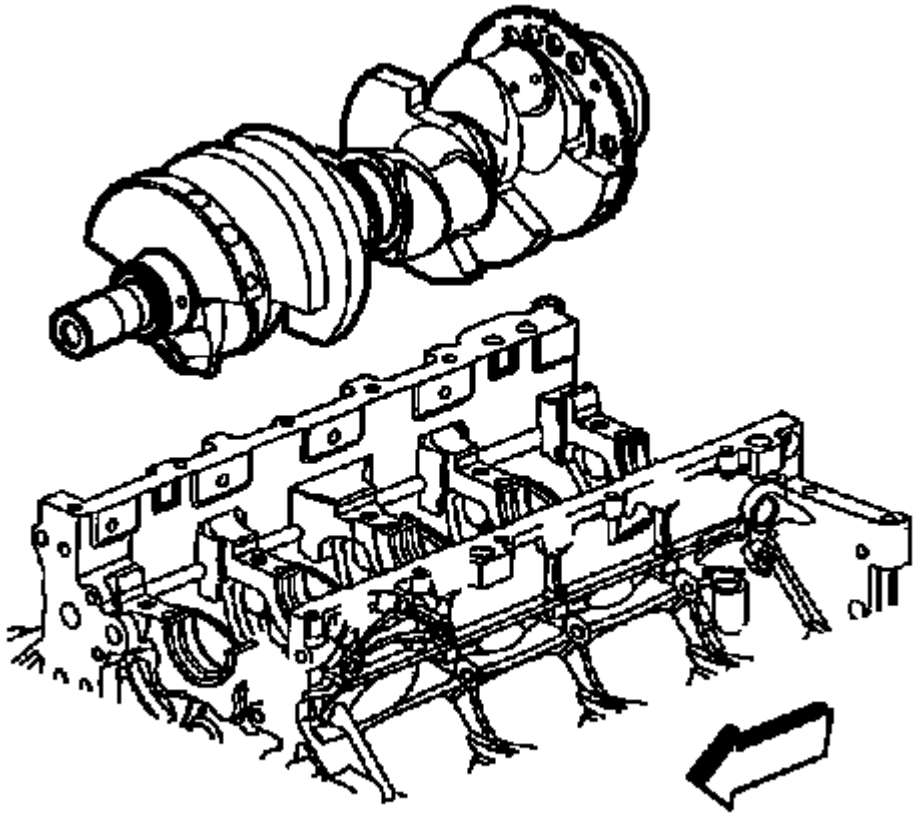

Fig. 387: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft.

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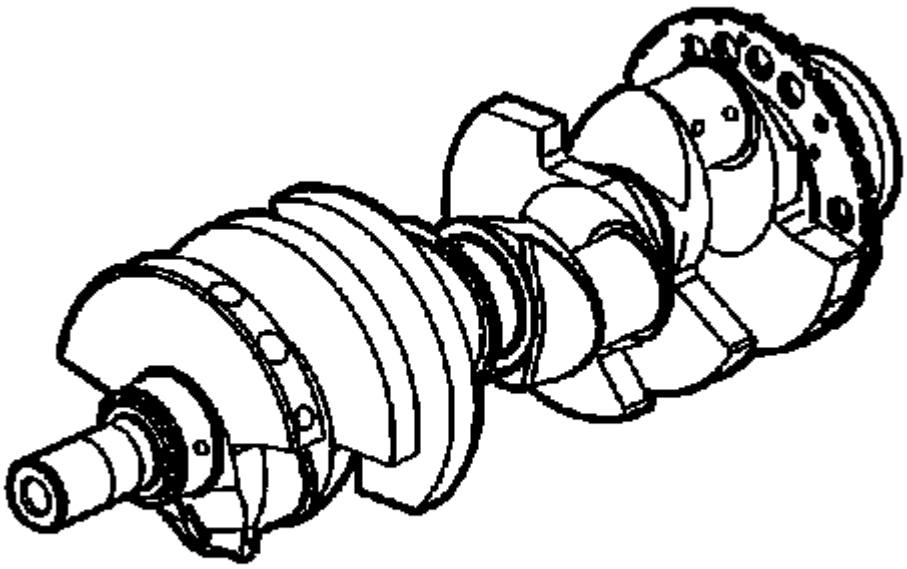

Fig. 388: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may affect on-board diagnostics (OBD) II system performance.

10. Lay the crankshaft onto 2 wooden V-blocks or other protective surface.

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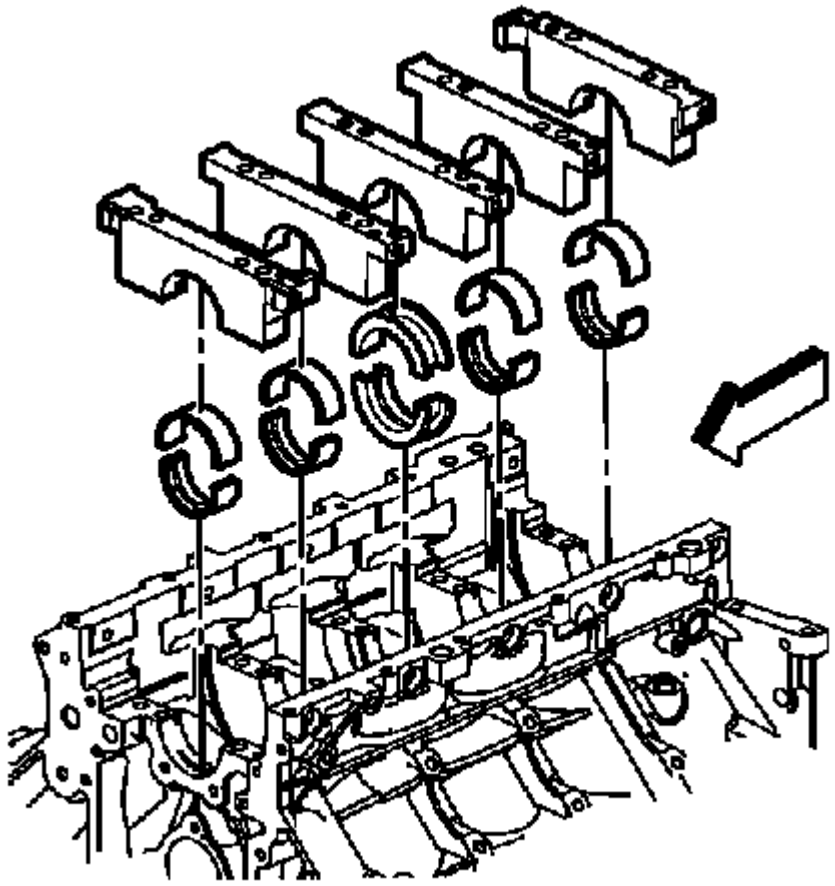

Fig. 389: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

11. Remove the crankshaft bearings from the bearing caps and the engine block.
12. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to **Separating Parts**.

ENGINE BLOCK PLUG REMOVAL

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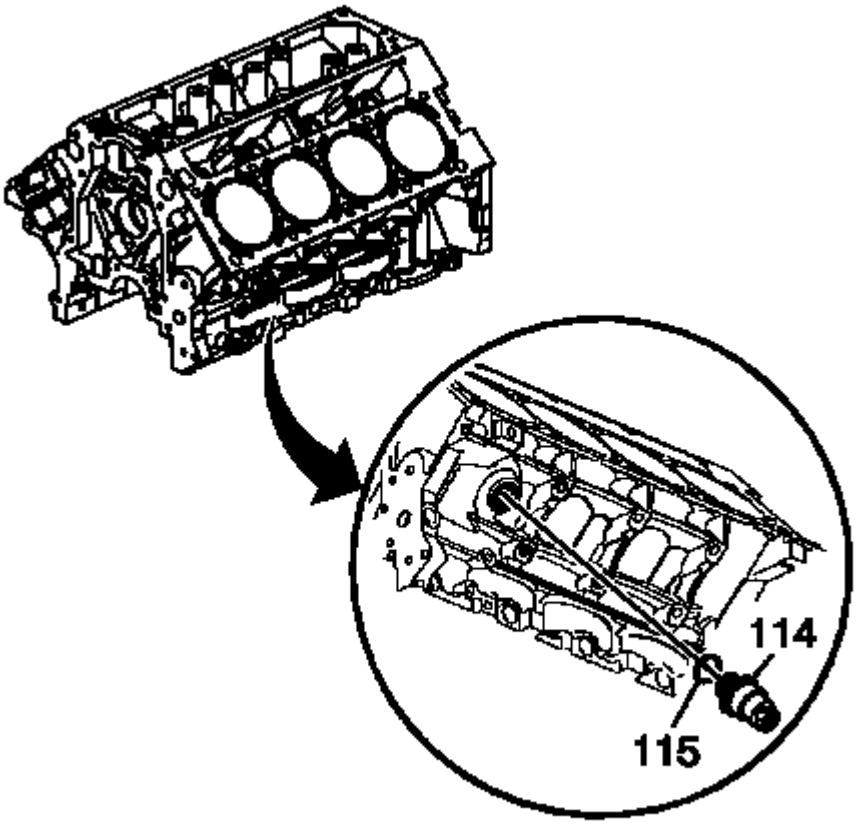

Fig. 390: Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block coolant heater (114) and seal (115).

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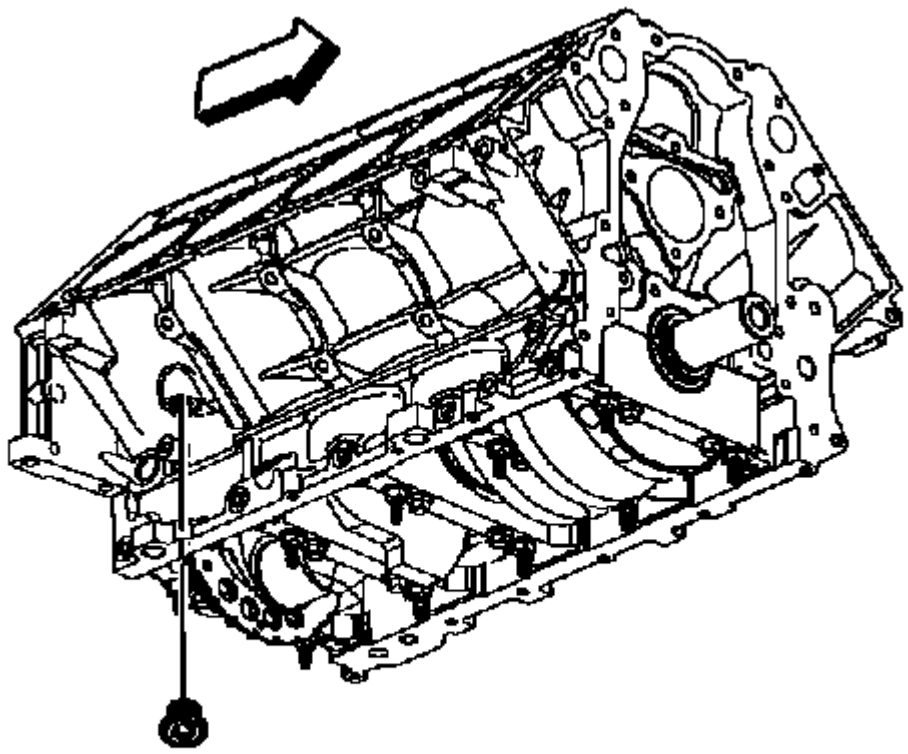

Fig. 391: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

2. Remove the engine block right rear coolant drain hole plug and seal.

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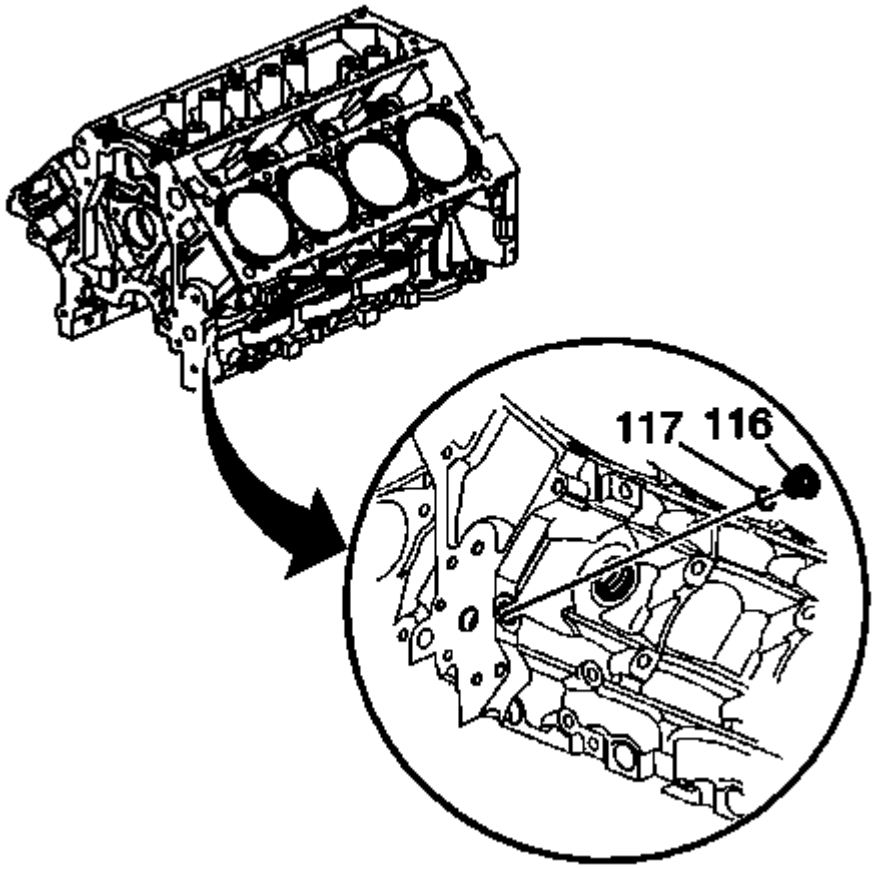

Fig. 392: Locating Engine Block Left Front Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine block left front oil gallery plug (116) and seal (117).

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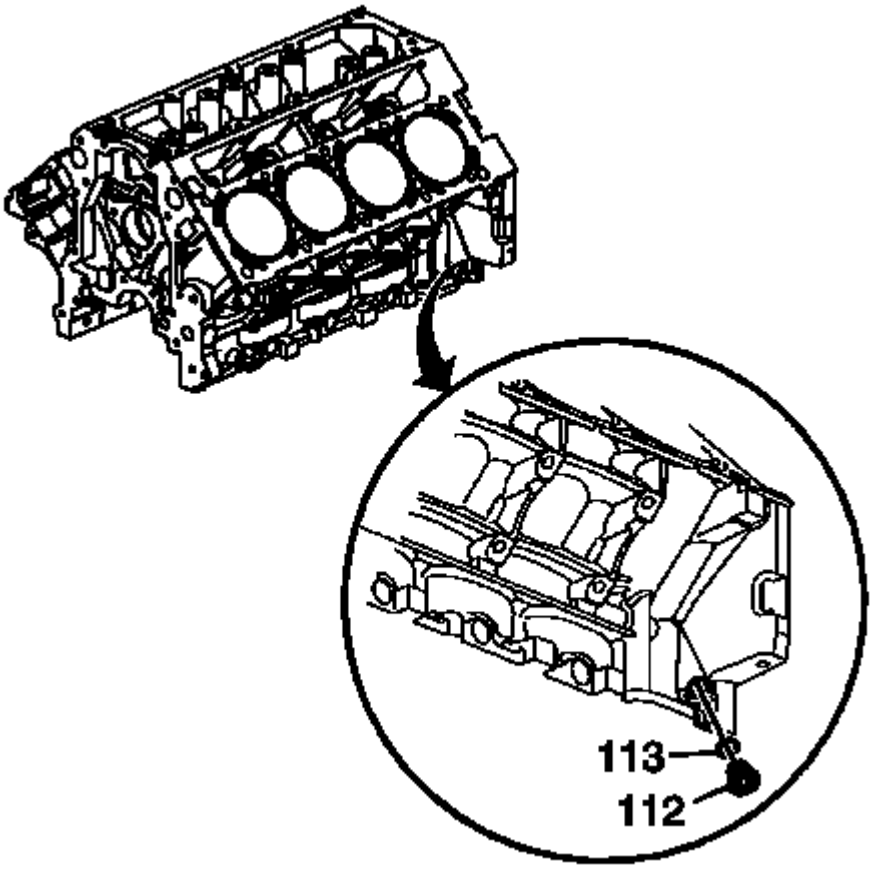

Fig. 393: Locating Engine Block Left Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

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.

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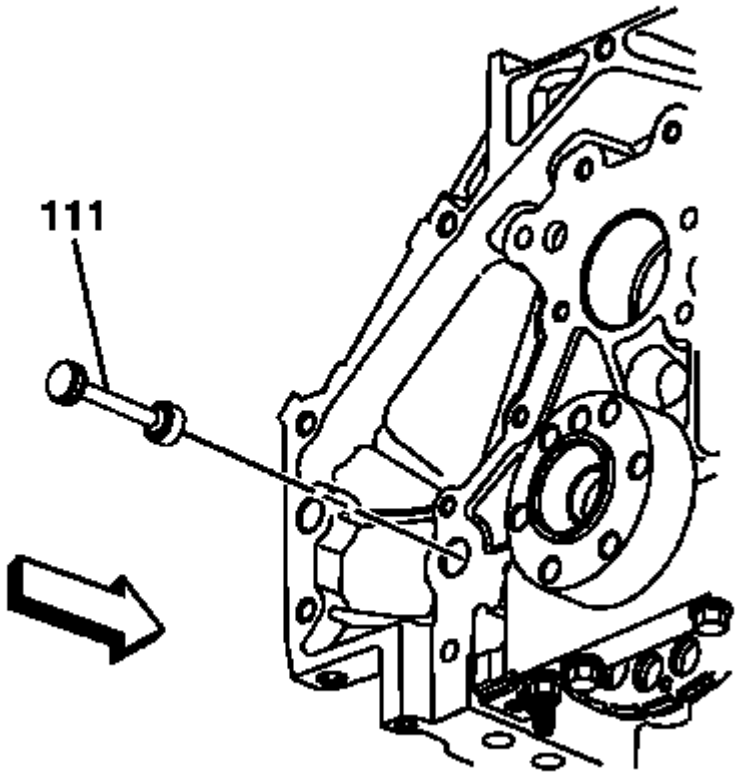

Fig. 394: Identifying Engine Block Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

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.

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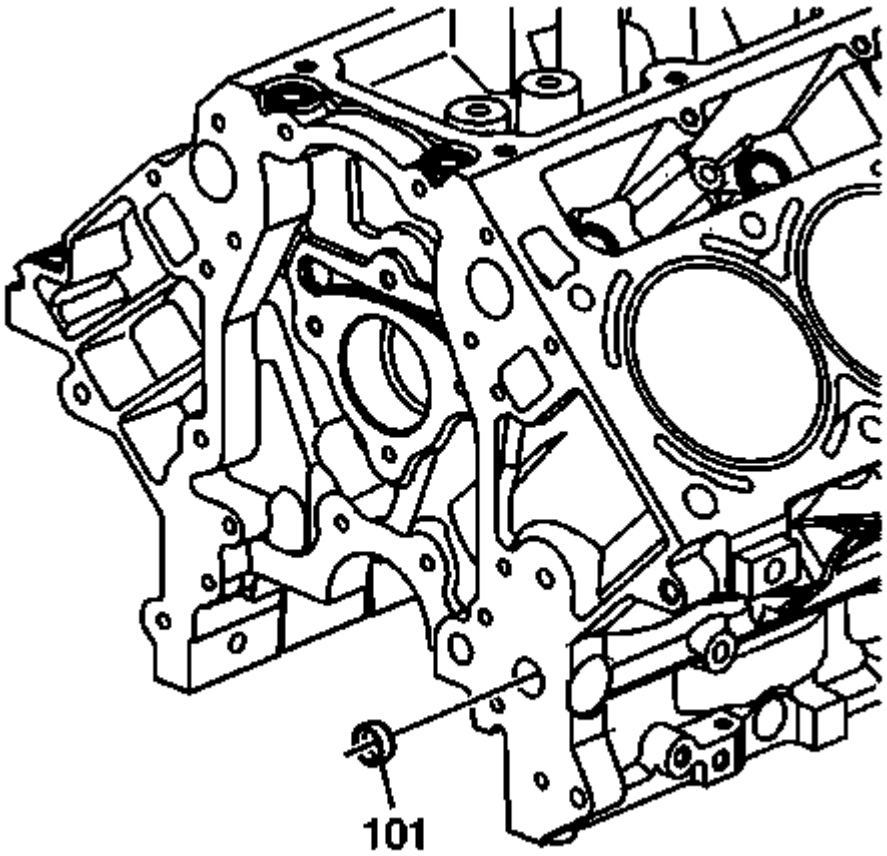

Fig. 395: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

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).

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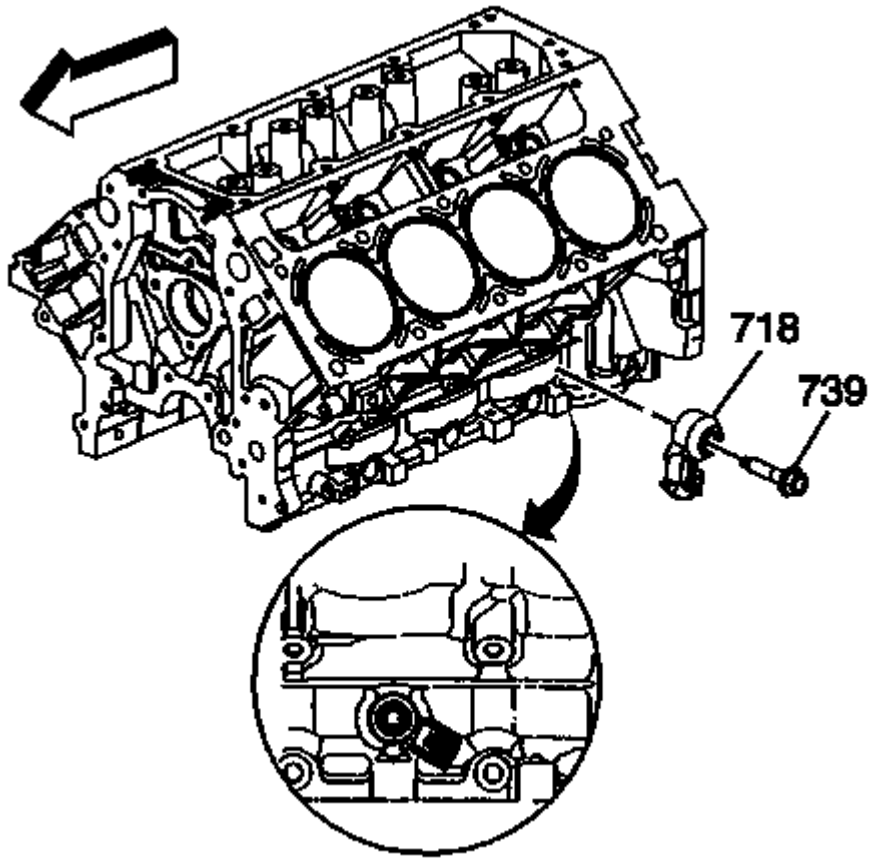

Fig. 396: Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Remove the left side knock sensor (718) and bolt (739).

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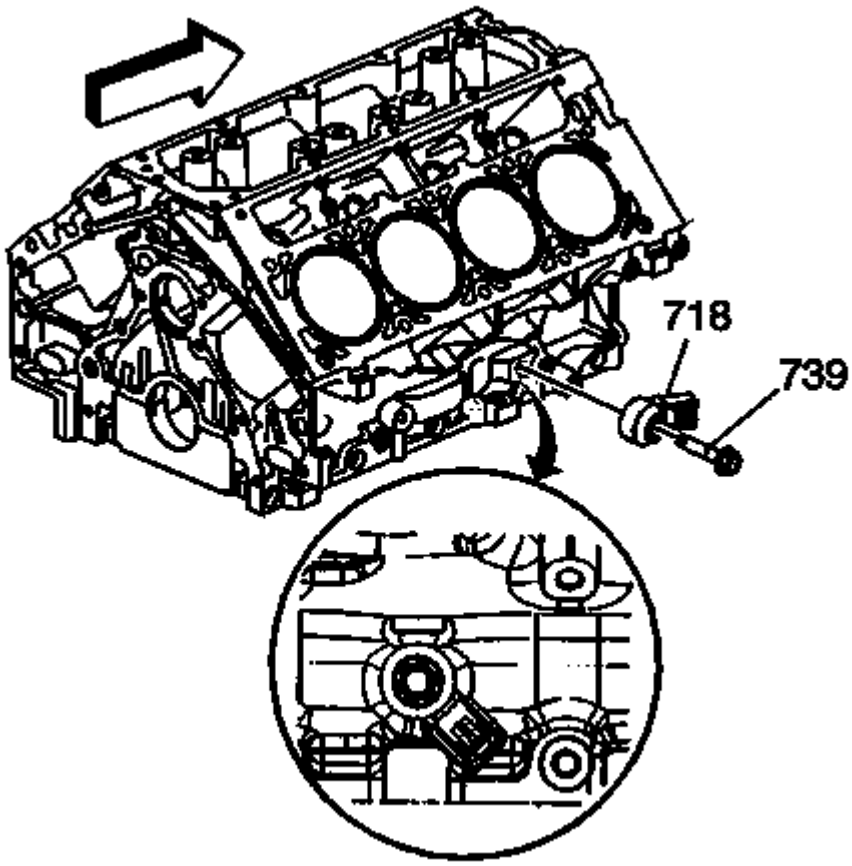

Fig. 397: Right Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

9. Remove the right side knock sensor (718) and bolt (739).

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **J 8087:** Cylinder Bore Gauge
- **42385-100:** Head/Main Bolt Thread Repair Kit

For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

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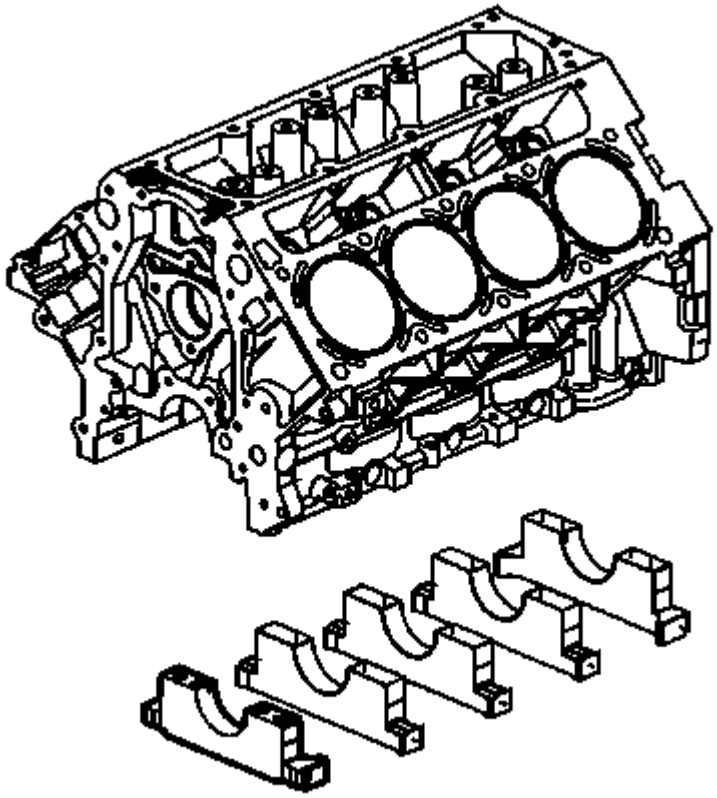

Fig. 398: Main Bearing Caps
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not use a caustic solution to clean the aluminum engine block.

NOTE: When cleaning the engine block in a thermal type oven, do not exceed 232°C (450°F).

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

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- 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

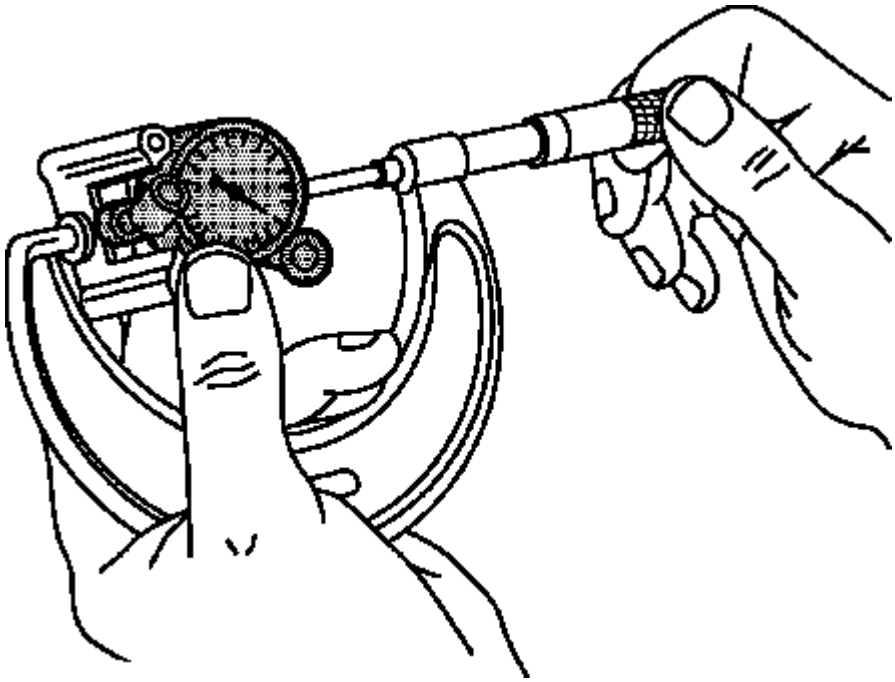

Fig. 399: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

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1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical Specifications**.
2. Insert the **J 8087:** gauge into the micrometer and zero the bore gauge dial.

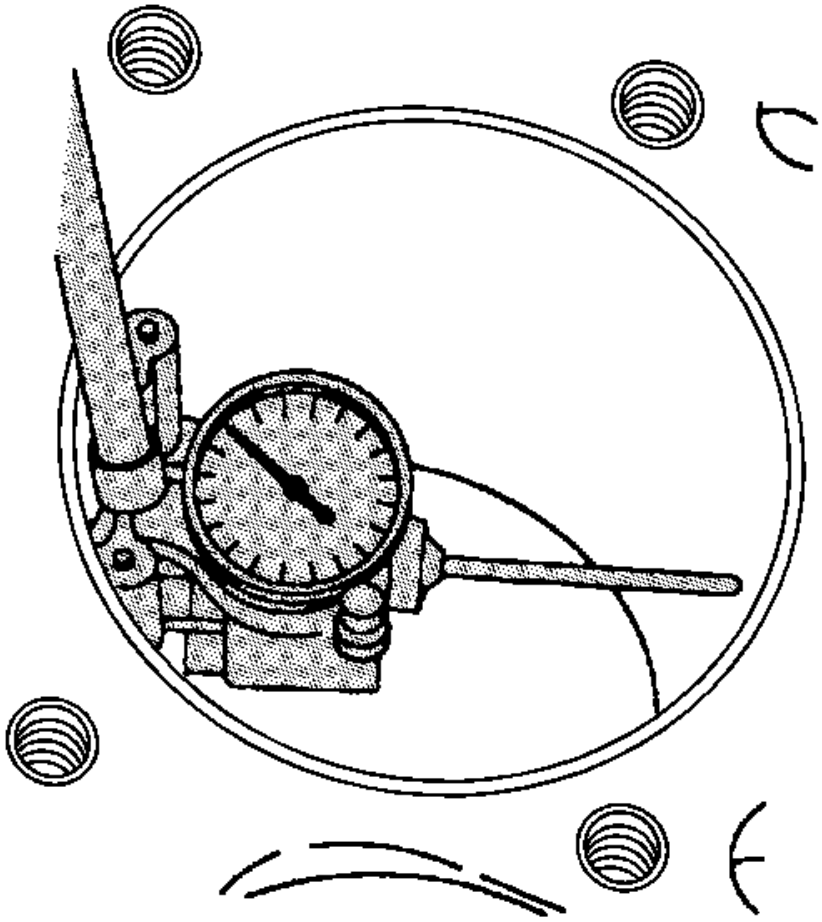

Fig. 400: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 8087:** gauge and measure the cylinder bore for oversize.

   Slide the bore gauge 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

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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

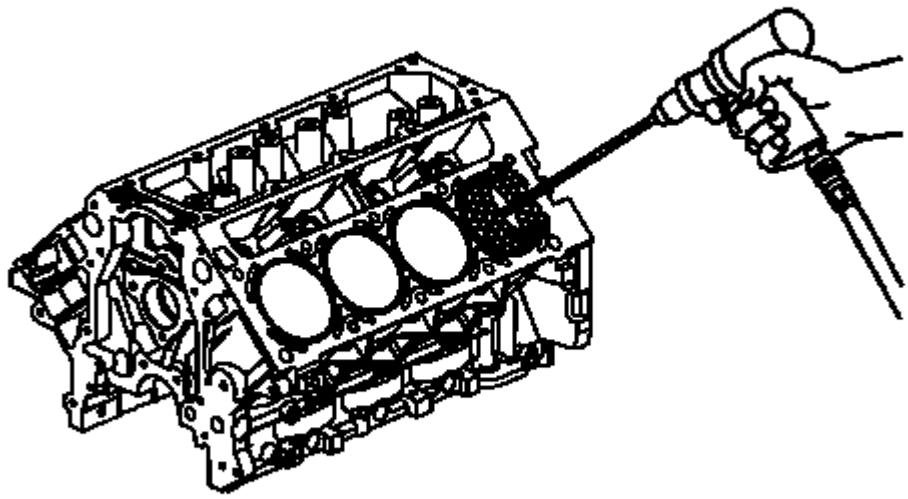

Fig. 401: View Of Honing Of Cylinders
Courtesy of GENERAL MOTORS CORP.

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

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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

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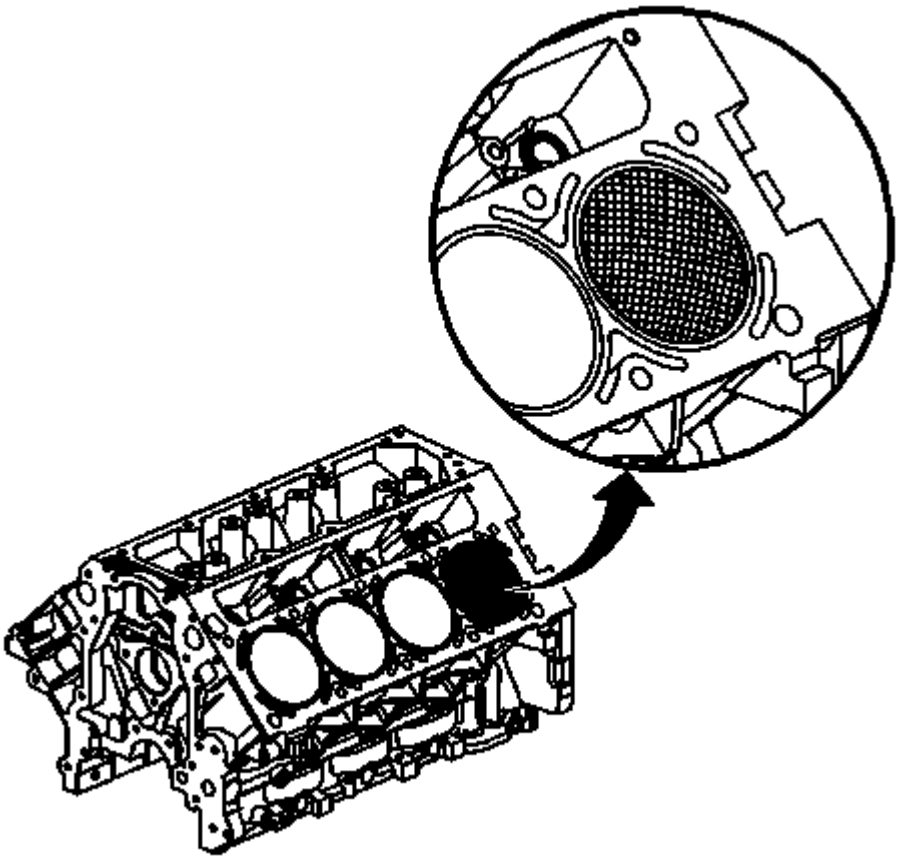

Fig. 402: Deglazing Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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 performing 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

Special Tools

- **J 7872:** Magnetic Base Dial Indicator Set
- **J 43690:** Rod Bearing Checking Tool
- **J 43690-100:** Rod Bearing Checking Tool - Adapter Kit

For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

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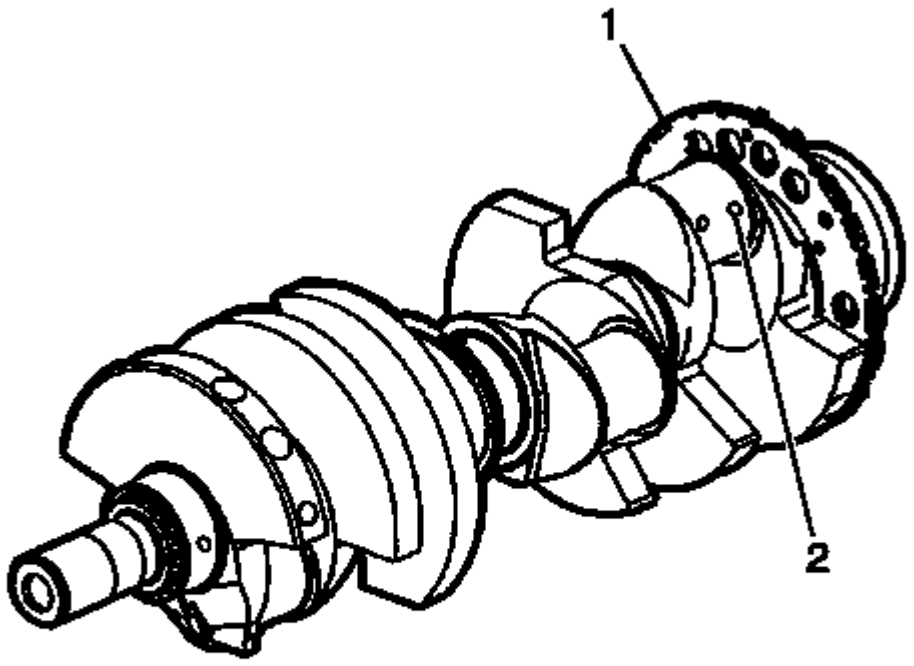

Fig. 403: Oil Passages & CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

Inspection Procedure

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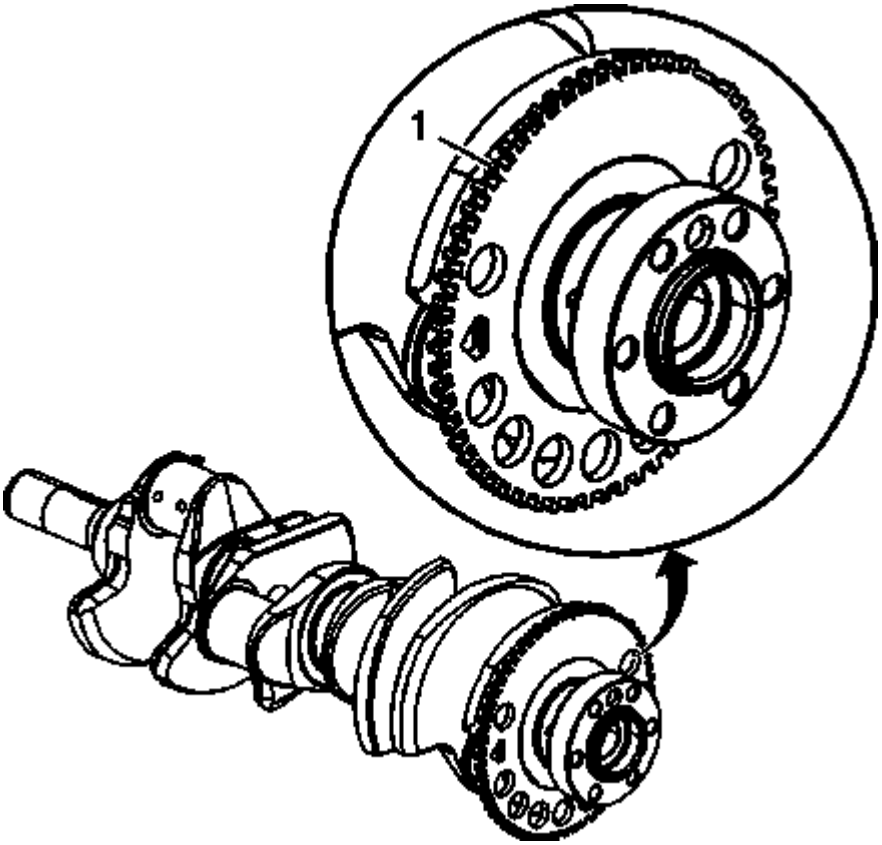

Fig. 404: View Of Reluctor Ring Teeth
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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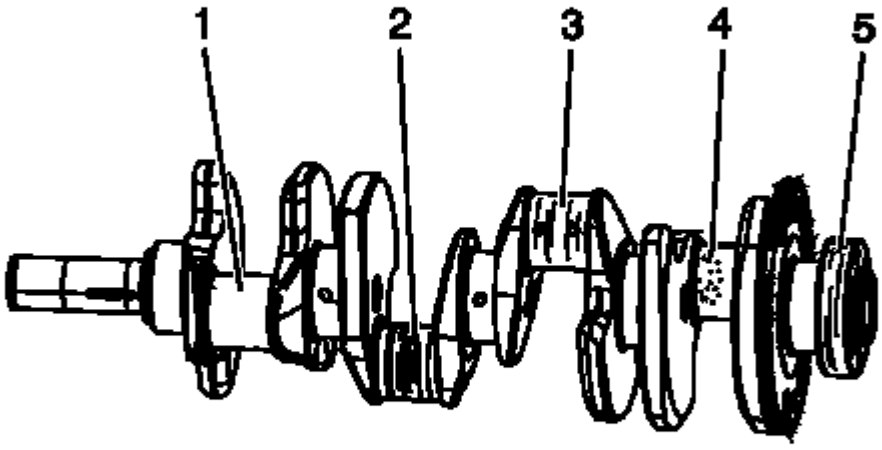

Fig. 405: View Of Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

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.

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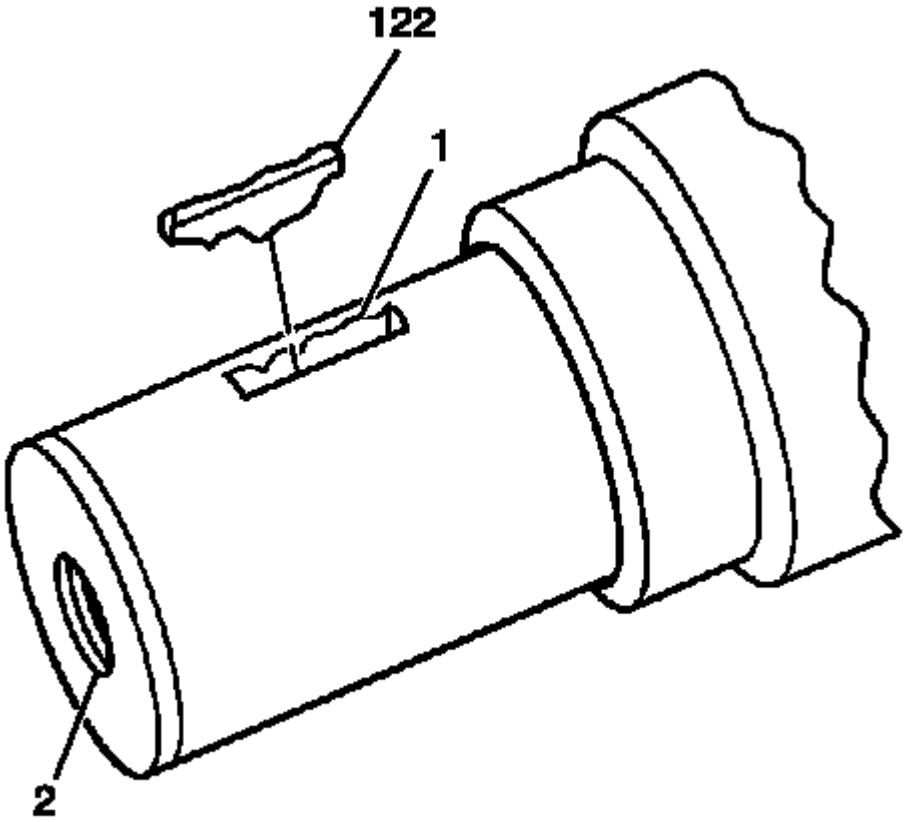

Fig. 406: View Of Crankshaft Key, Keyway & Threaded Hole
Courtesy of GENERAL MOTORS CORP.

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

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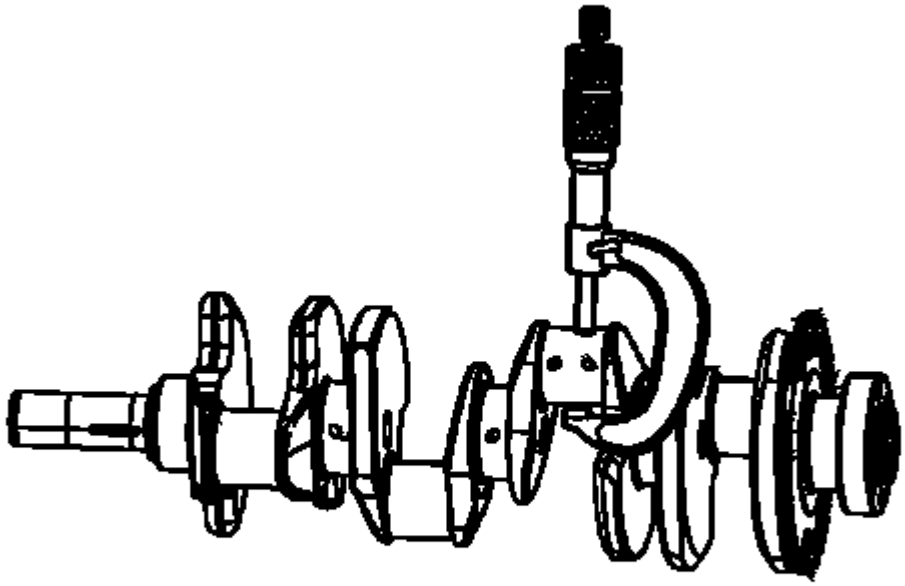

Fig. 407: Measuring Connecting Rod Journals For Out-Of-Round And Taper
Courtesy of GENERAL MOTORS CORP.

8. Measure the connecting rod journals for out-of-round and taper.

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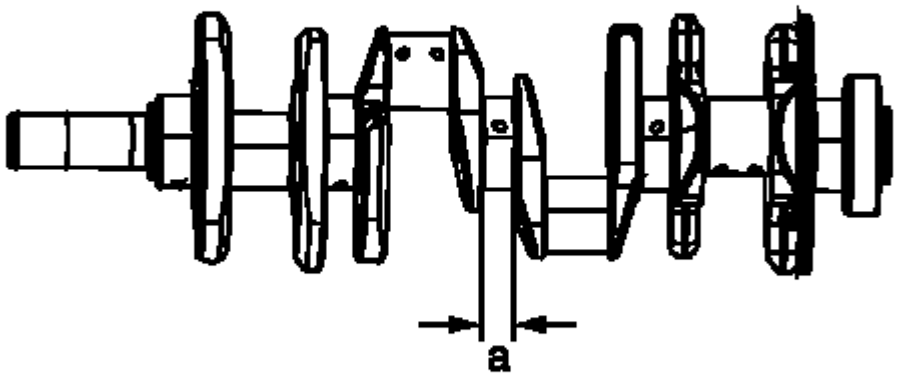

Fig. 408: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS CORP.

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.

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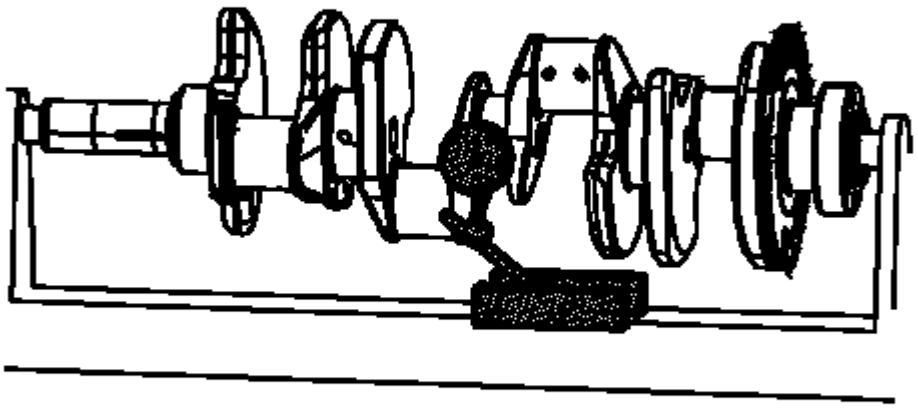

Fig. 409: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

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:** set in order to measure the crankshaft runout at the front and rear intermediate journals.
12. Use the **J 7872:** set in order to measure the runout of the crankshaft rear flange.
13. Use the **J 7872:** set in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

    If the reluctor ring has runout in excess of 0.7 mm (0.028 in), replace the crankshaft.

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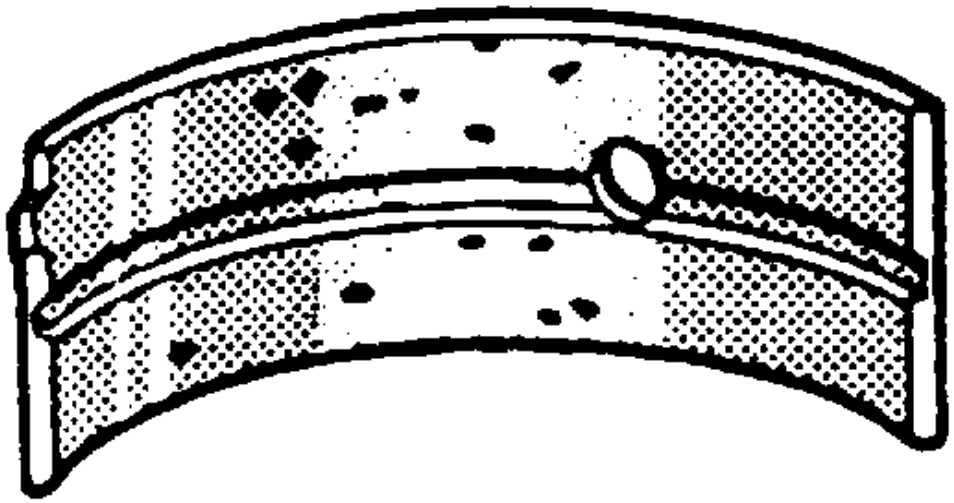

Fig. 410: Inspecting Bearings For Damage
Courtesy of GENERAL MOTORS CORP.

14. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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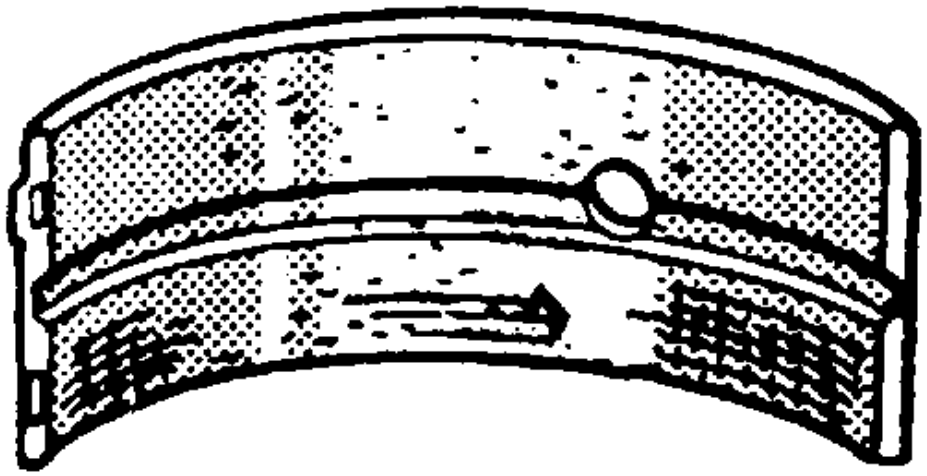

Fig. 411: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

15. Inspect the crankshaft bearings for excessive scoring or discoloration.
16. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

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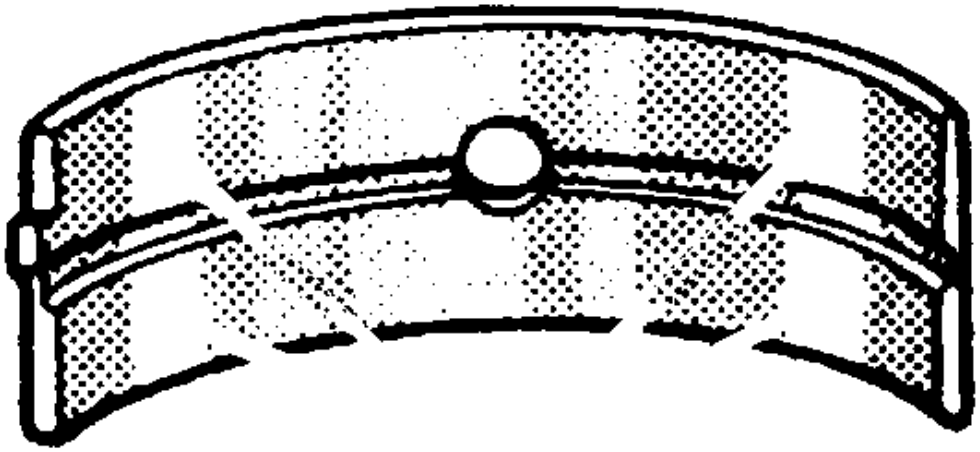

Fig. 412: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

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

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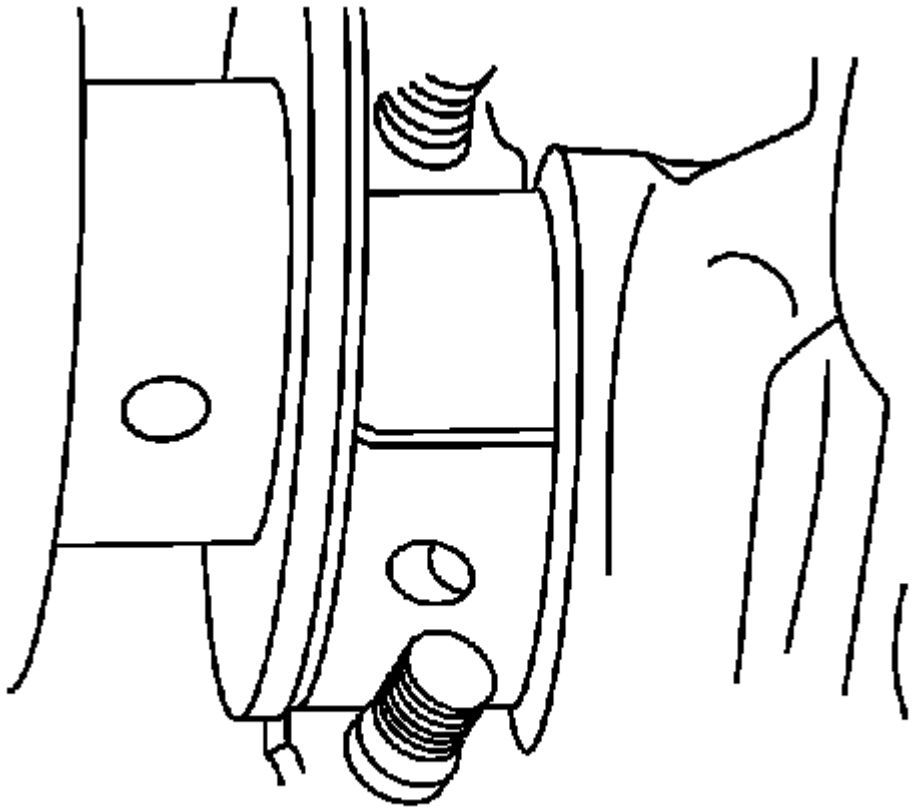

Fig. 413: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**.

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4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.

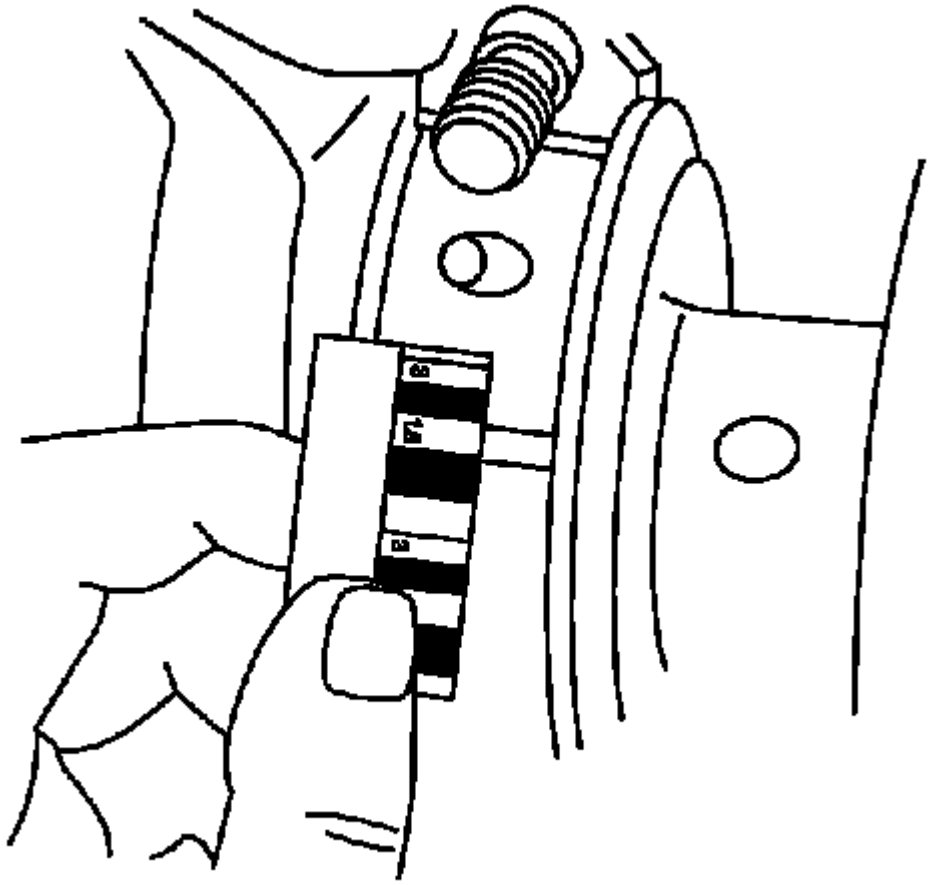

Fig. 414: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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

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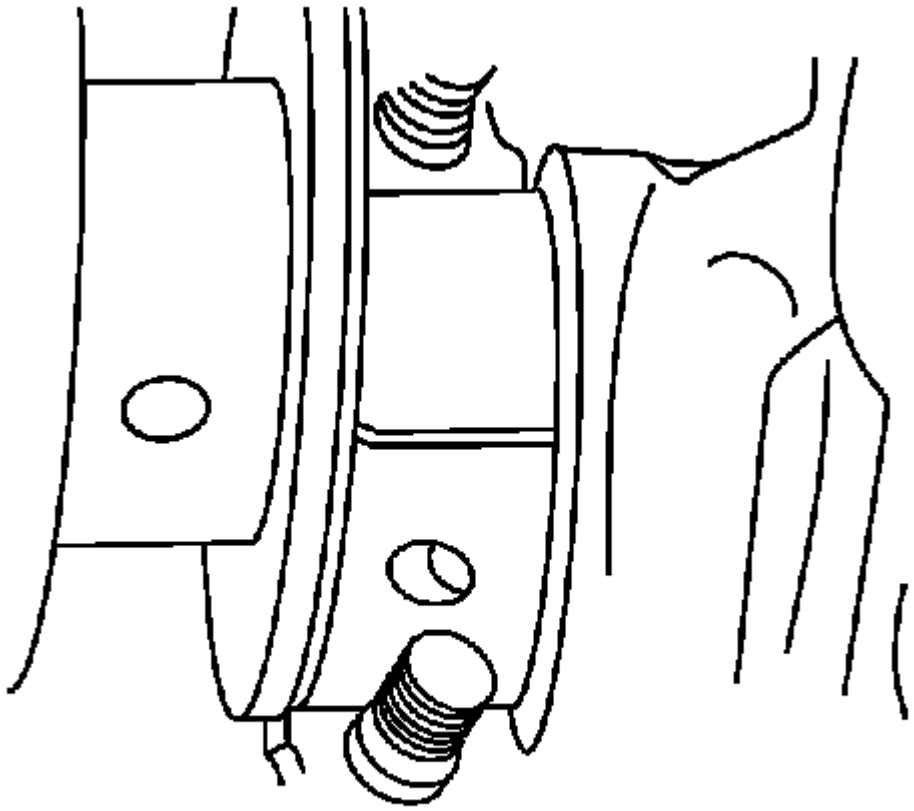

Fig. 415: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**.

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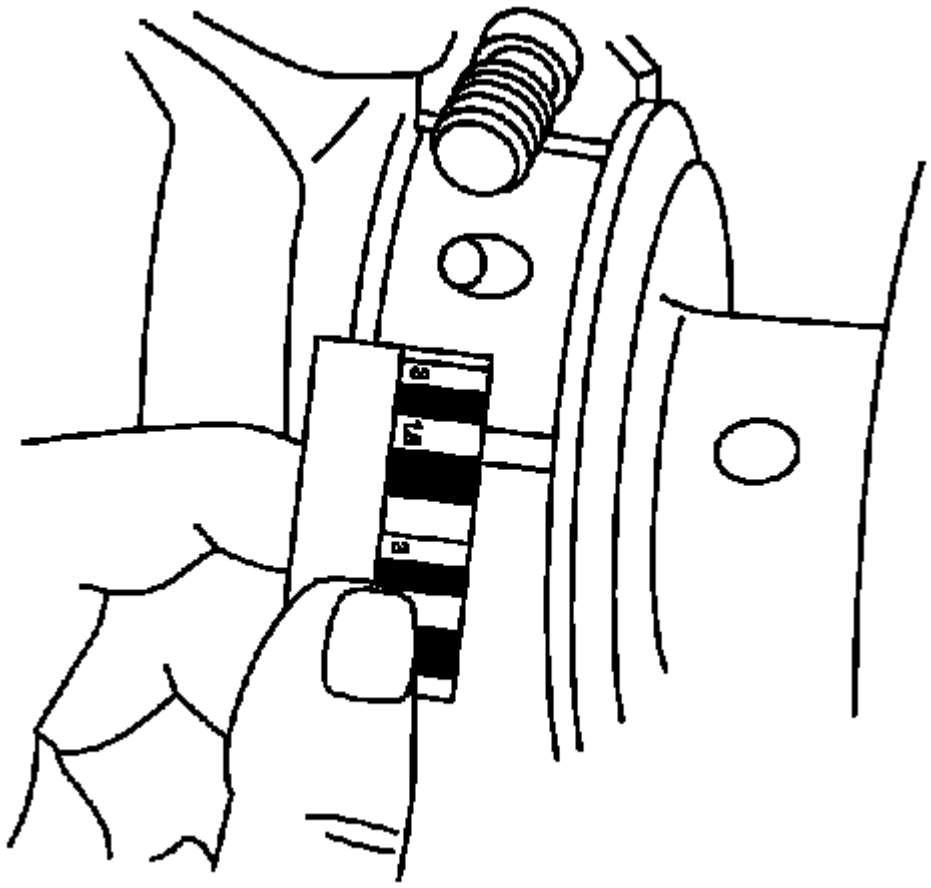

Fig. 416: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

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: tool and **J 43690-100:** kit have been developed as a more accurate method to measure connecting rod bearing clearances. 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.

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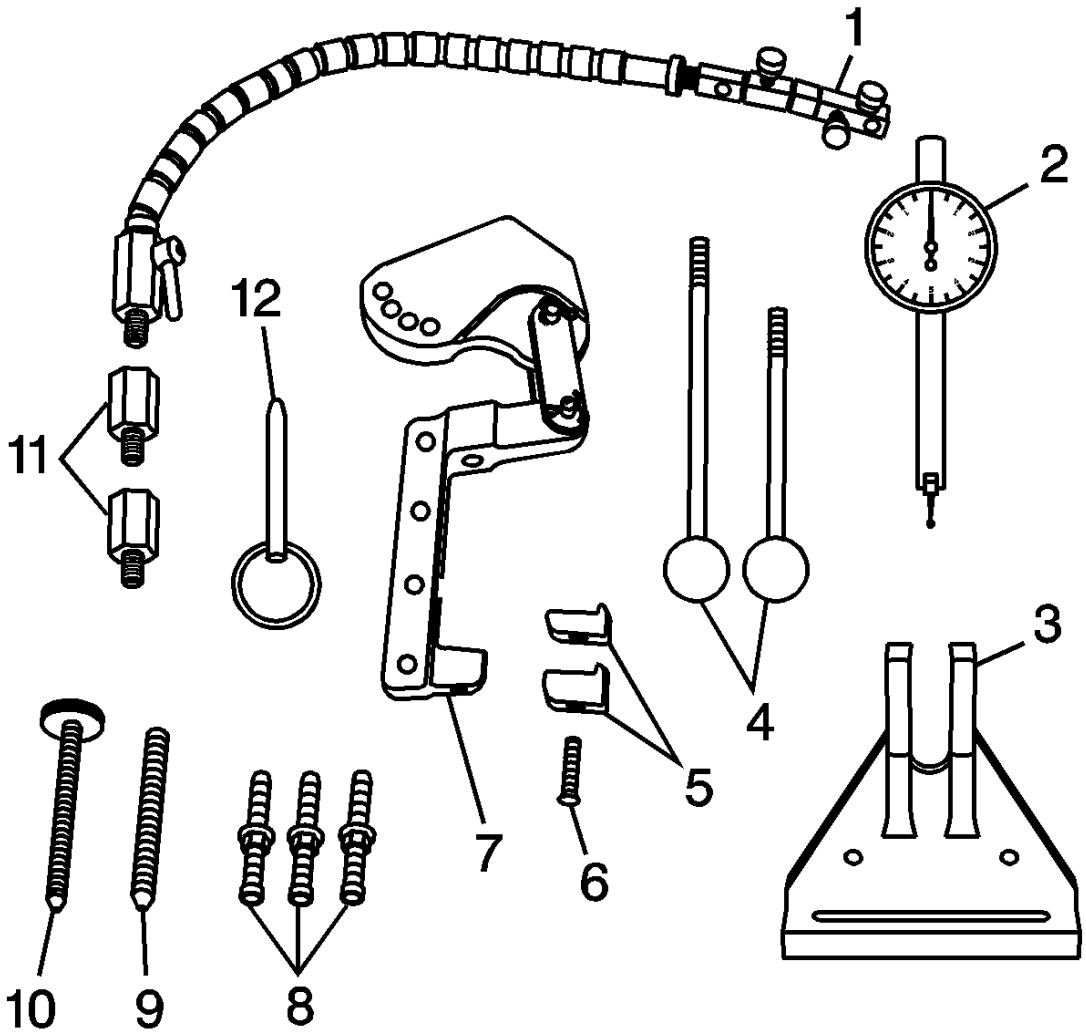

Fig. 417: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

J 43690: tool

- 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)

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- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

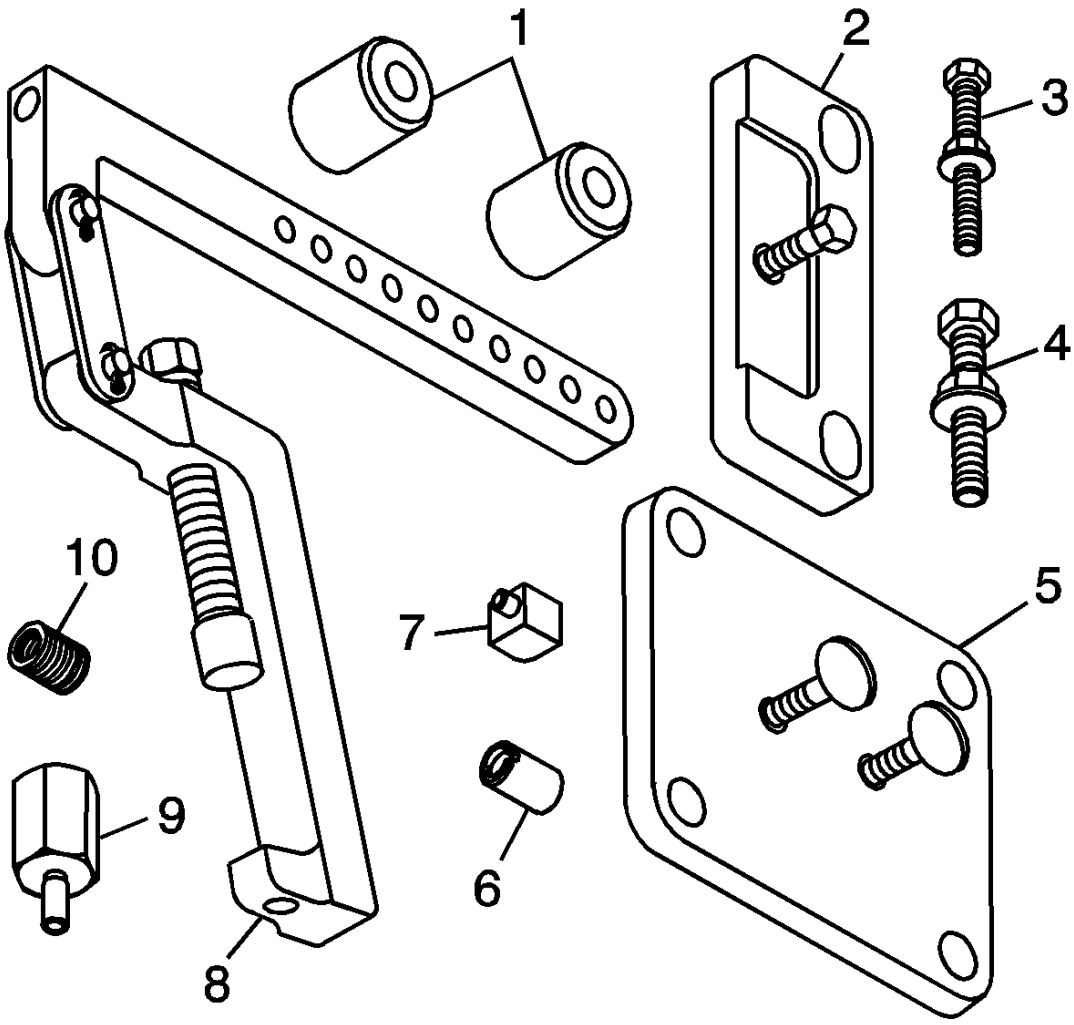

Fig. 418: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

J 43690: Rod Bearing Checking Tool

- J 43690-104 Spacer (1)
- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)

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- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

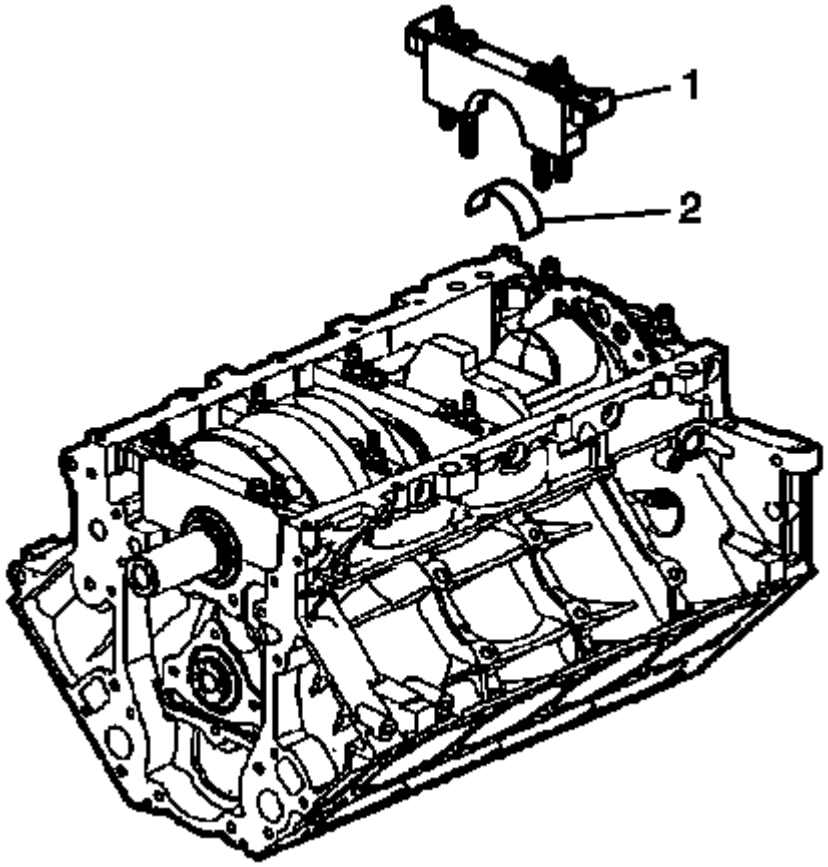

Fig. 419: View Of Bearing Cap, Bolt & Bearing Half
Courtesy of GENERAL MOTORS CORP.

NOTE: The crankshaft must be secure, with no movement or rotation, in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to **Fastener Tightening Specifications**.

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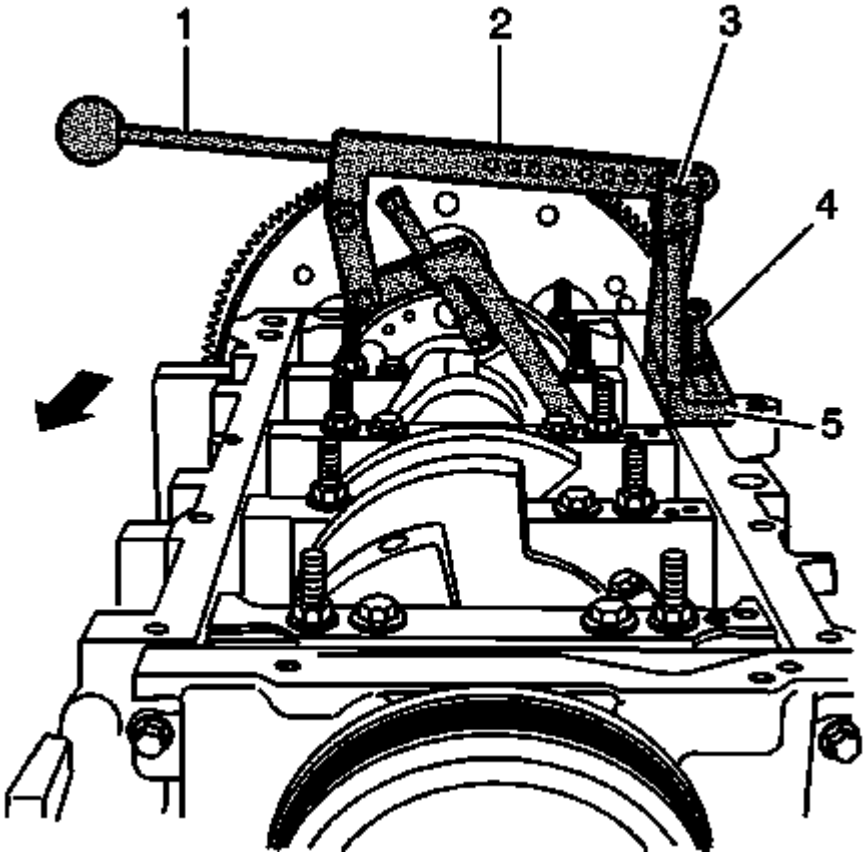

Fig. 420: View Of Special Tool Installed On Engine Block
Courtesy of GENERAL MOTORS CORP.

6. Install the following:
    1. J 43690-2 (5)
    2. J 43690-3 (4)
    3. J 43690-101 (2)
    4. 280310 (3)
    5. J 43690-5 (1)

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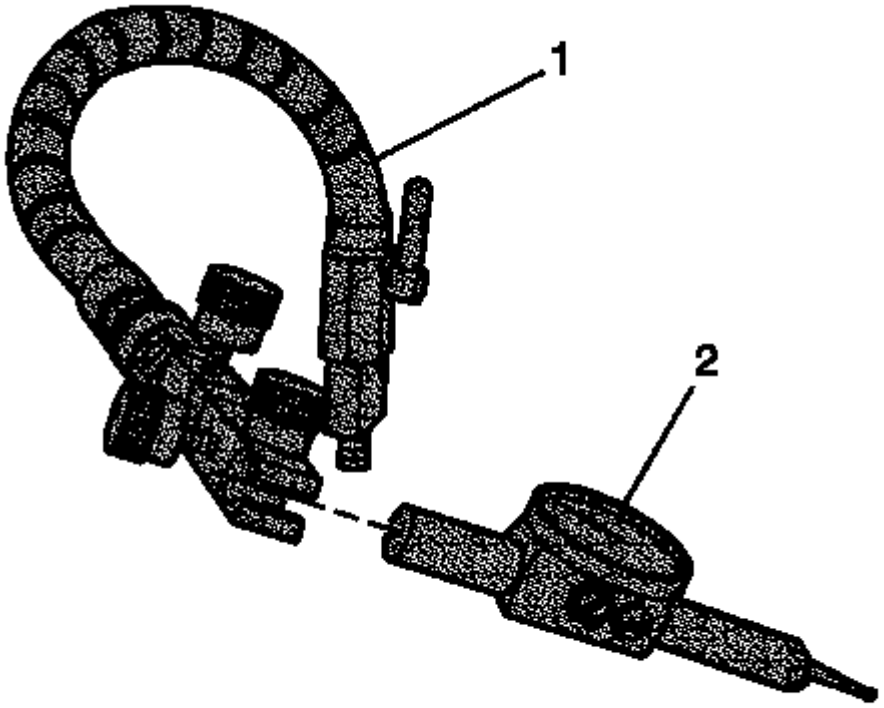

Fig. 421: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

   A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components, as required.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

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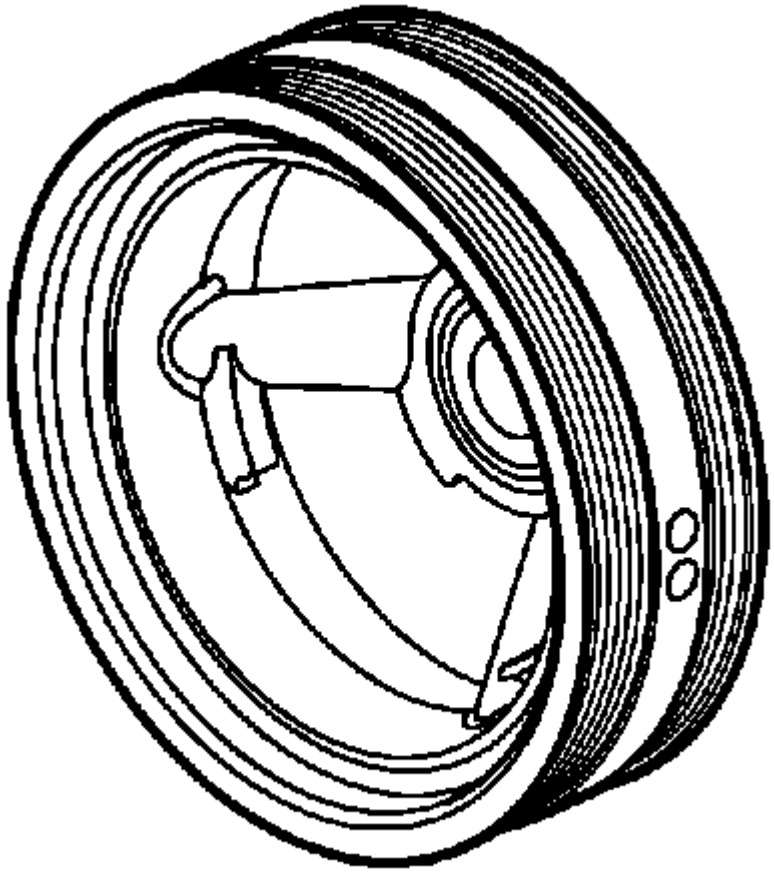

Fig. 422: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following conditions:
   - Worn, grooved, or damaged hub seal surface

     A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

     Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

     IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

   - Dirty or damaged belt grooves

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The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

Minor imperfections may be removed with a fine file.

- Worn, chunking, or deteriorated rubber between the hub and pulley

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

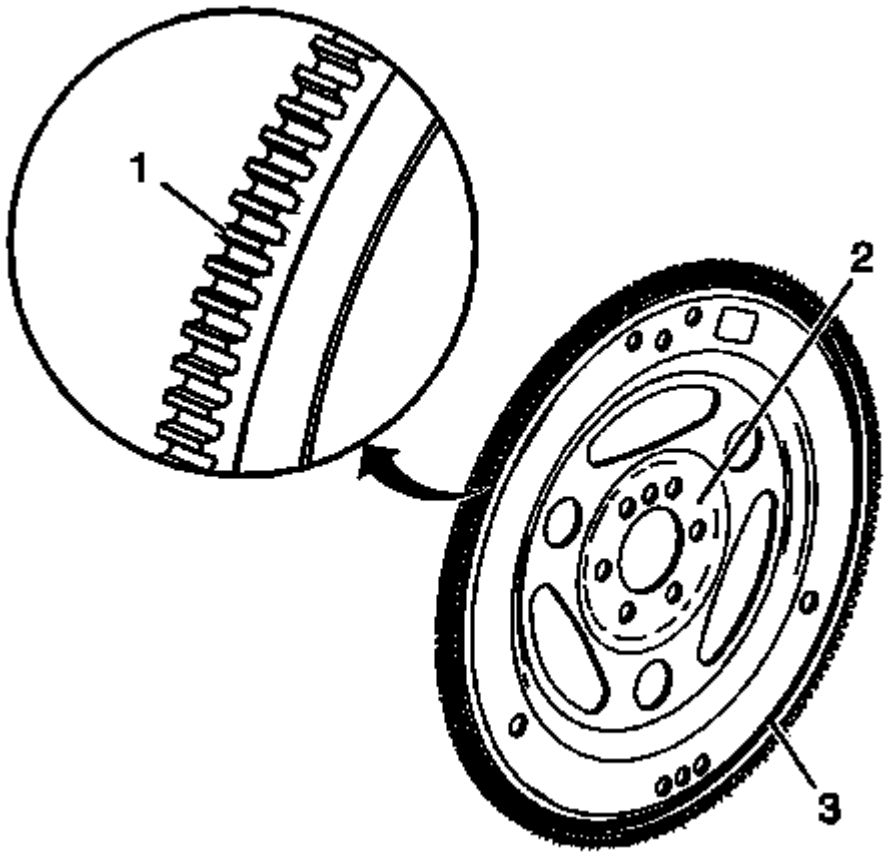

Fig. 423: View Of Ring Gear Teeth
Courtesy of GENERAL MOTORS CORP.

1. Clean the flex plate in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the flex plate with compressed air.
3. Inspect the flex plate for the following conditions:
   - Damaged ring gear teeth (1)

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- Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

NOTE: 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

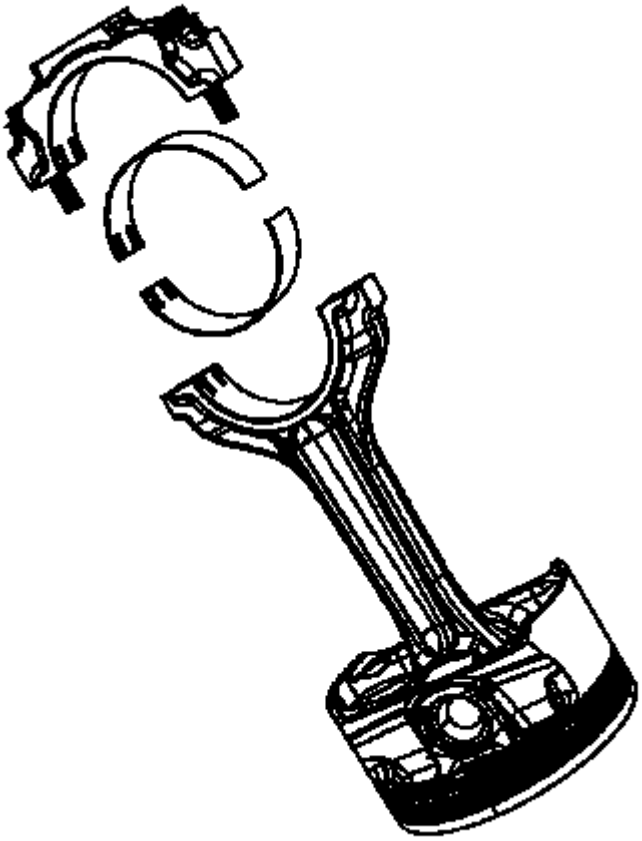

Fig. 424: View Of Piston, Connecting Rod & Cap
Courtesy of GENERAL MOTORS CORP.

1. Remove the connecting rod bearings from the rod and cap.

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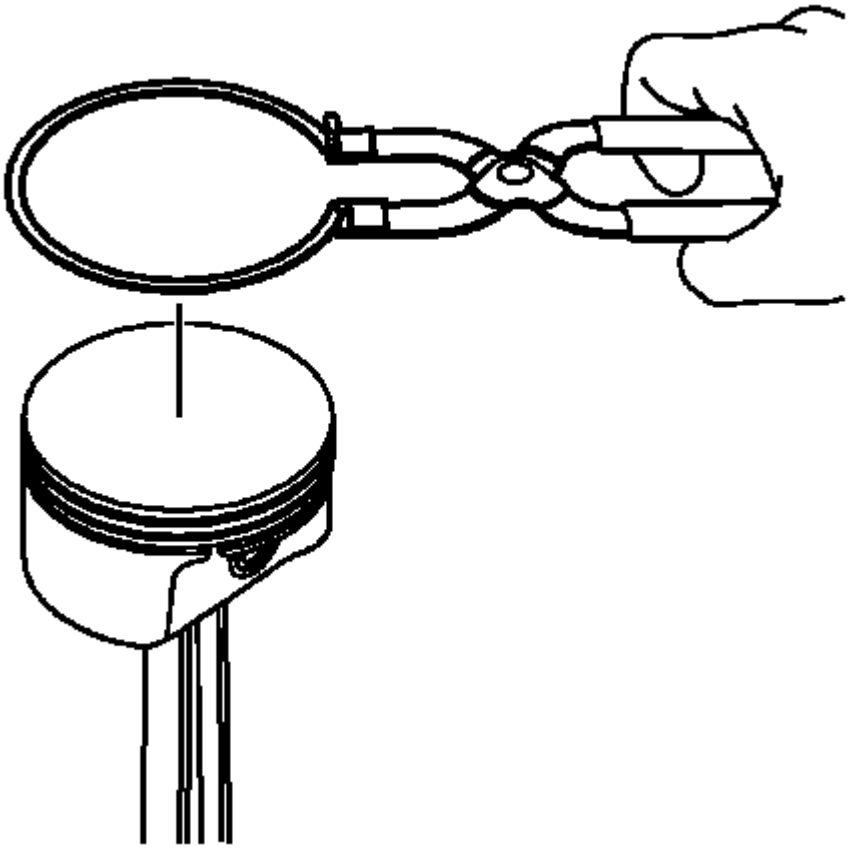

Fig. 425: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

2. Using piston ring pliers, remove the piston rings from the piston.

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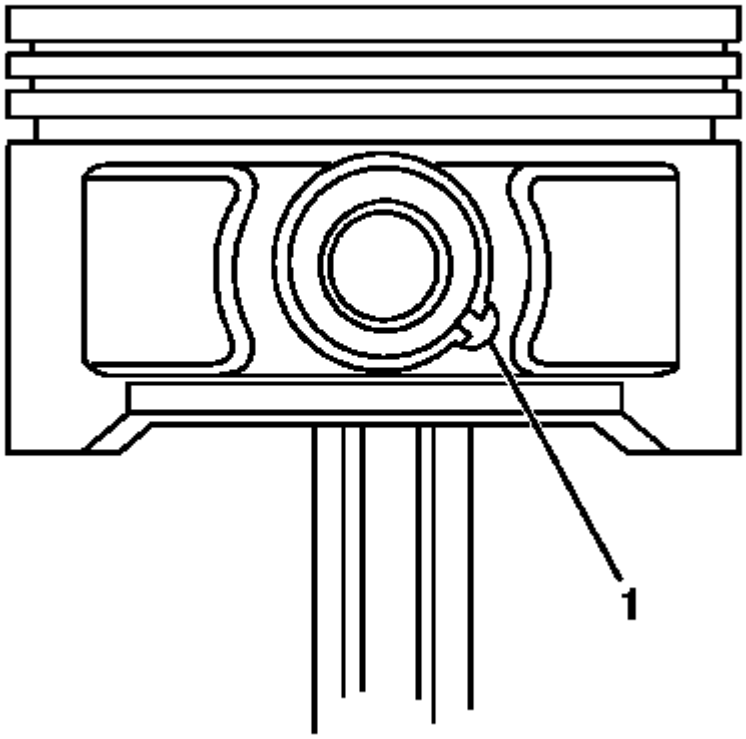

Fig. 426: View Of Piston Pin Retaining Clip & Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS CORP.

3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.

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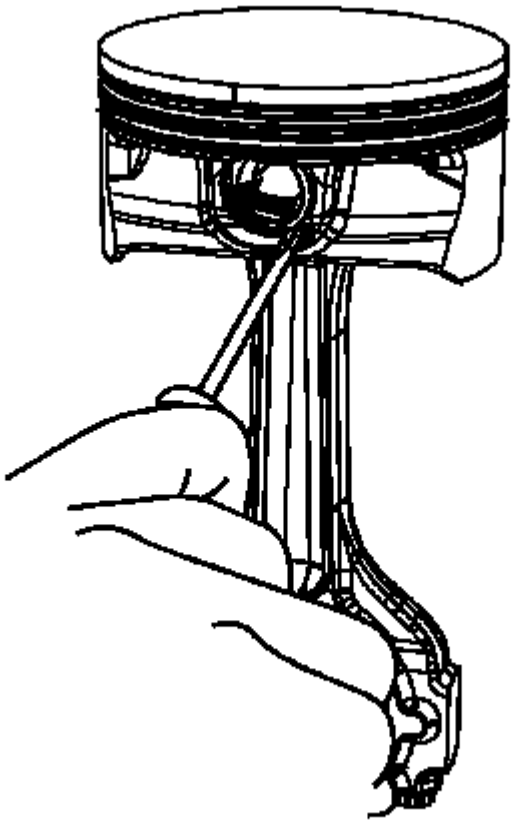

Fig. 427: Piston Pin Retainer
Courtesy of GENERAL MOTORS CORP.

4. Remove the retainers starting in the cutout area of the pin bore.

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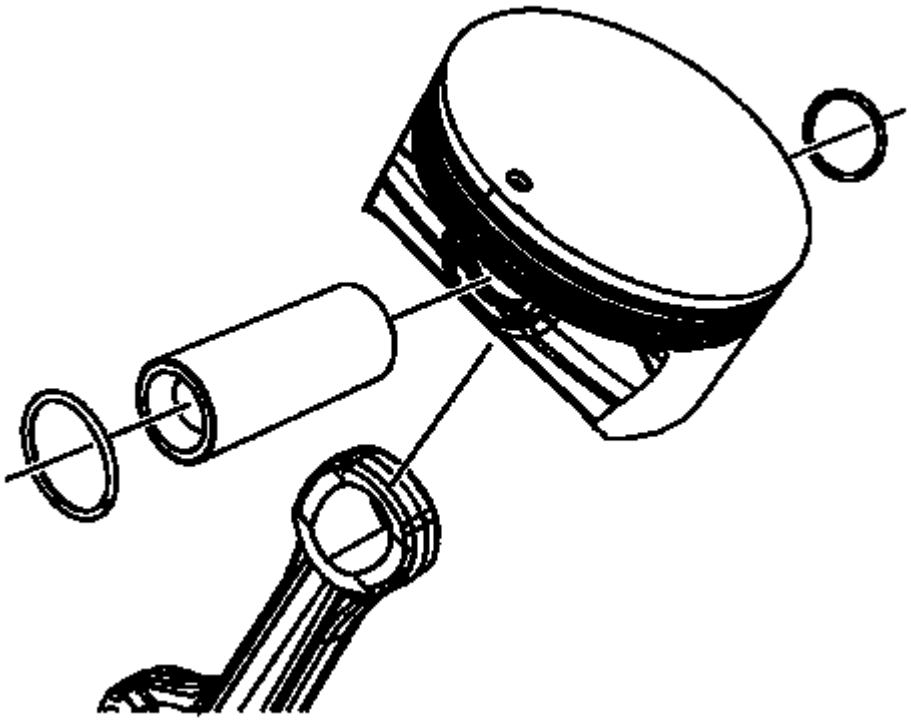

Fig. 428: Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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

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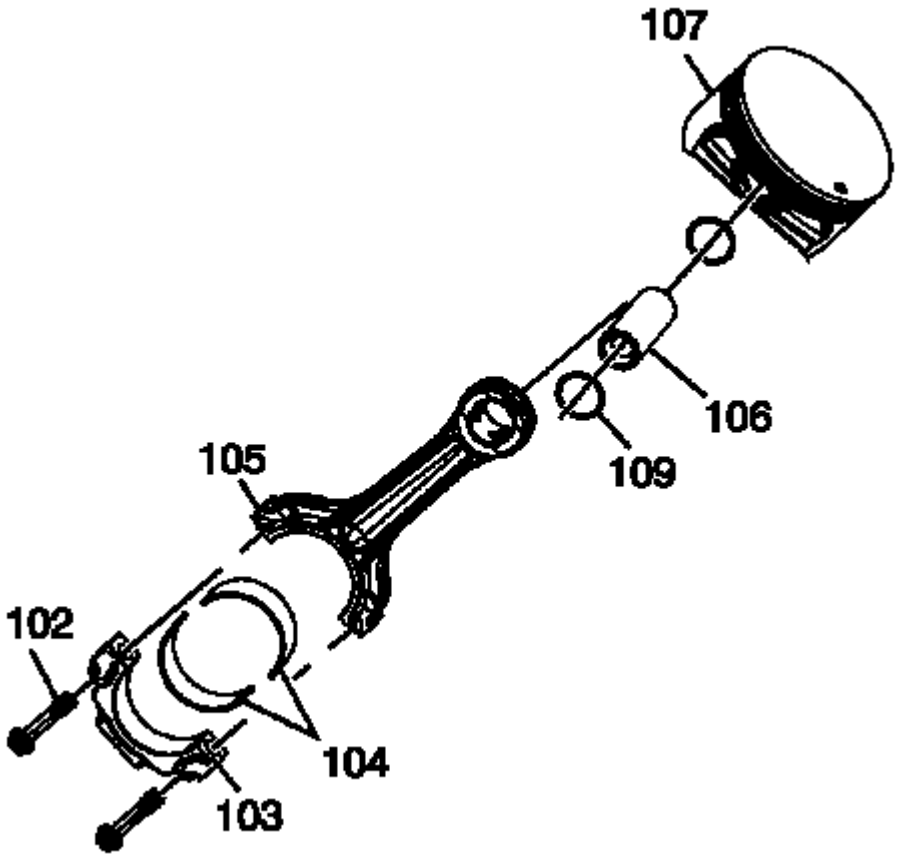

Fig. 429: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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.

   WARNING: Refer to Safety Glasses Warning .

2. Dry the components with compressed air.

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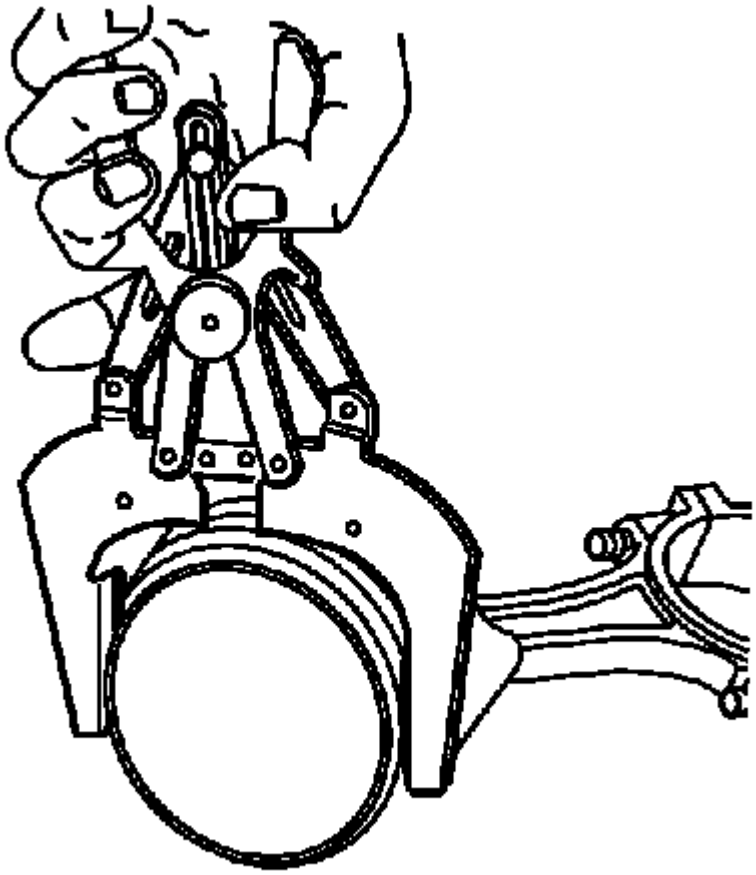

Fig. 430: Cleaning Piston Ring Grooves
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

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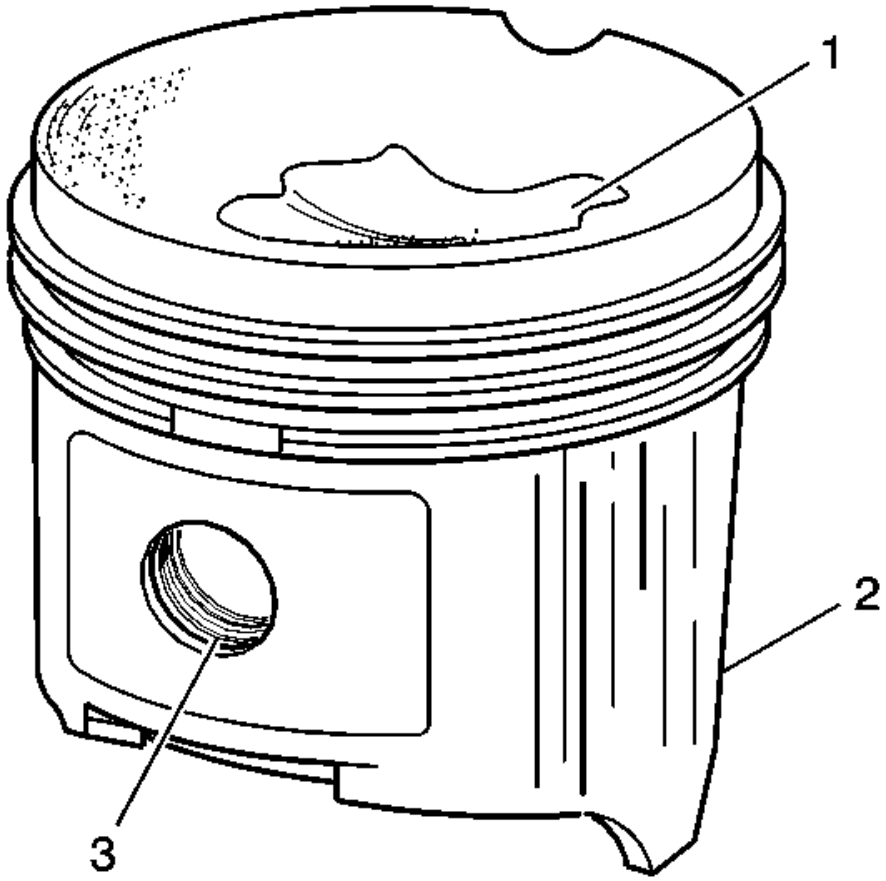

Fig. 431: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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

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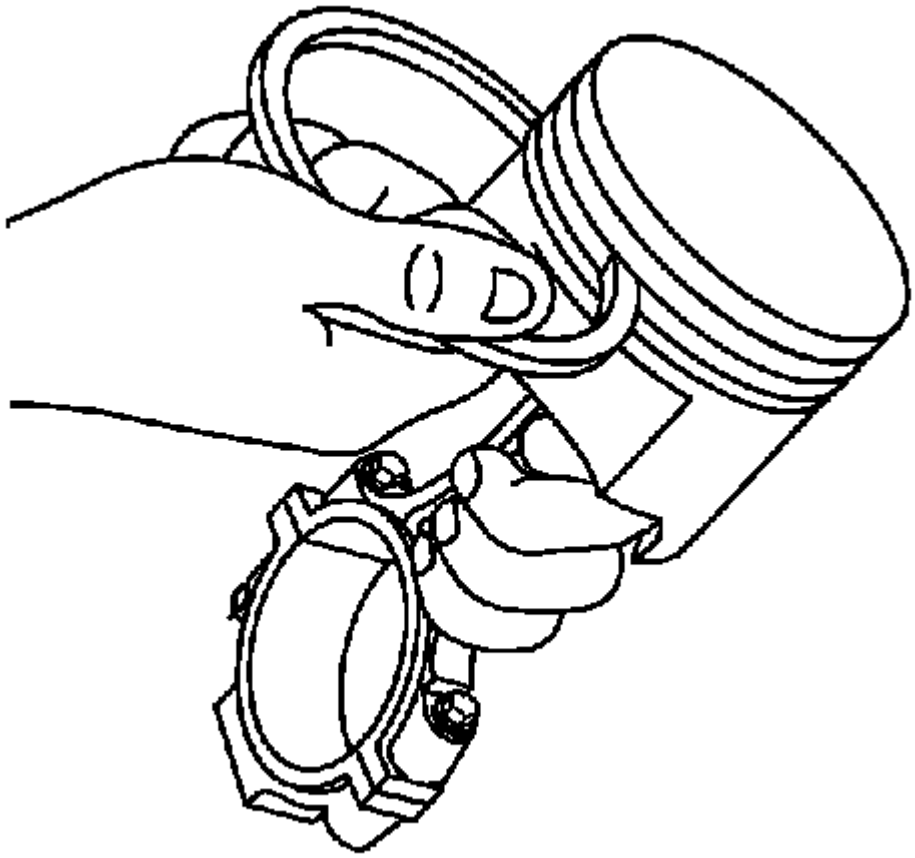

Fig. 432: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

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.

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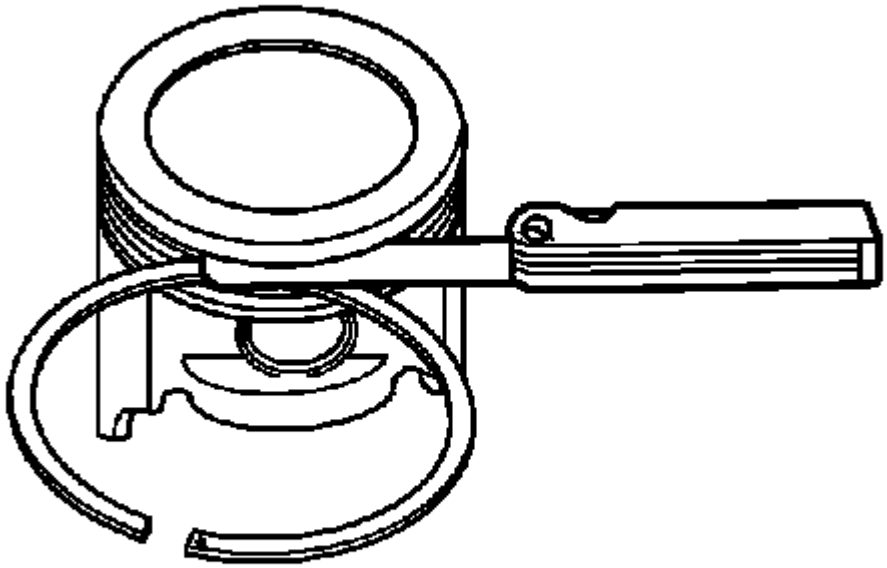

Fig. 433: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston and pin as an assembly. Refer to **Engine Mechanical Specifications**.

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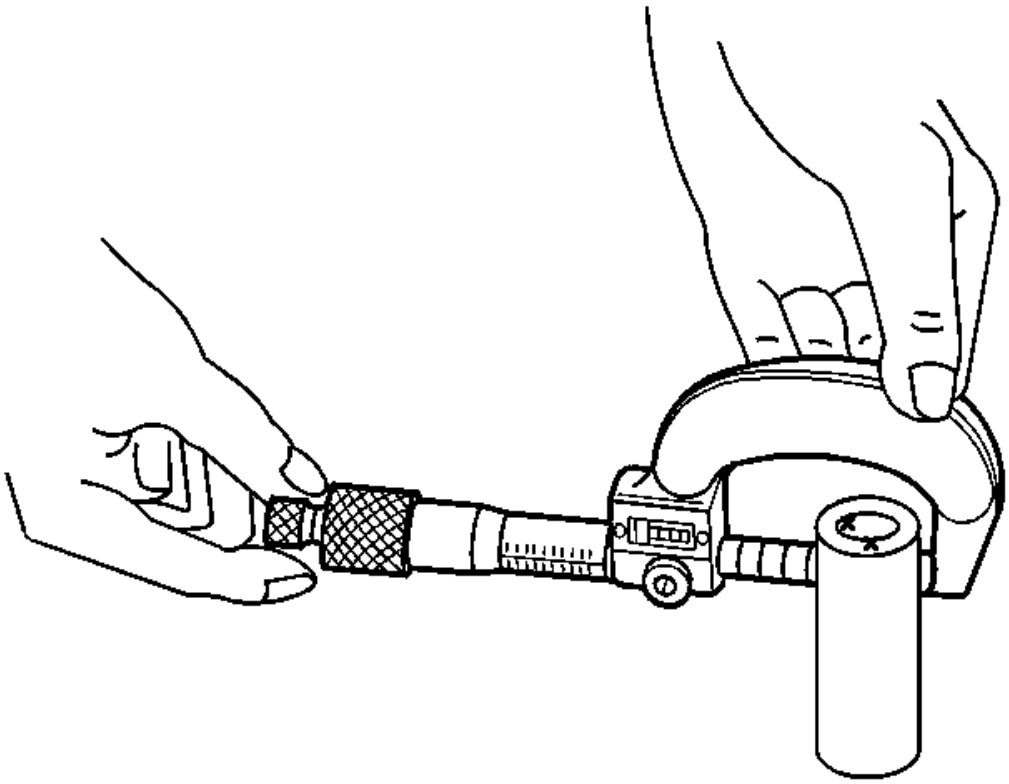

Fig. 434: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

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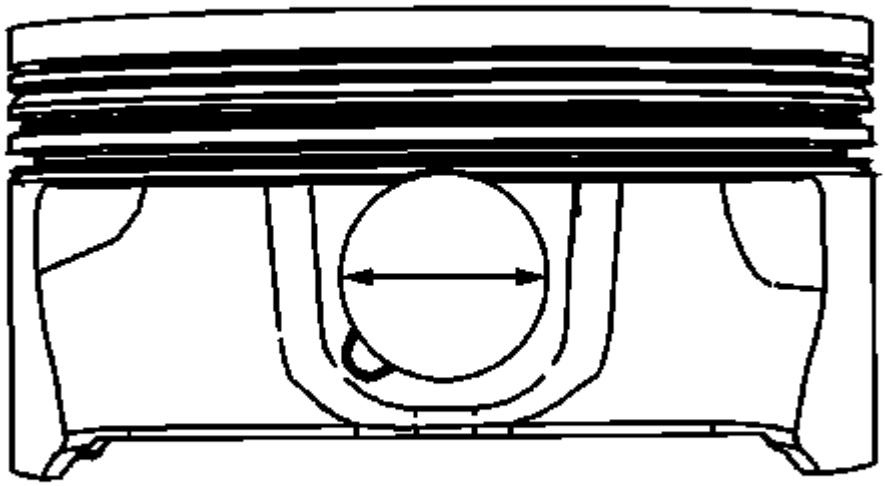

Fig. 435: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS CORP.

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

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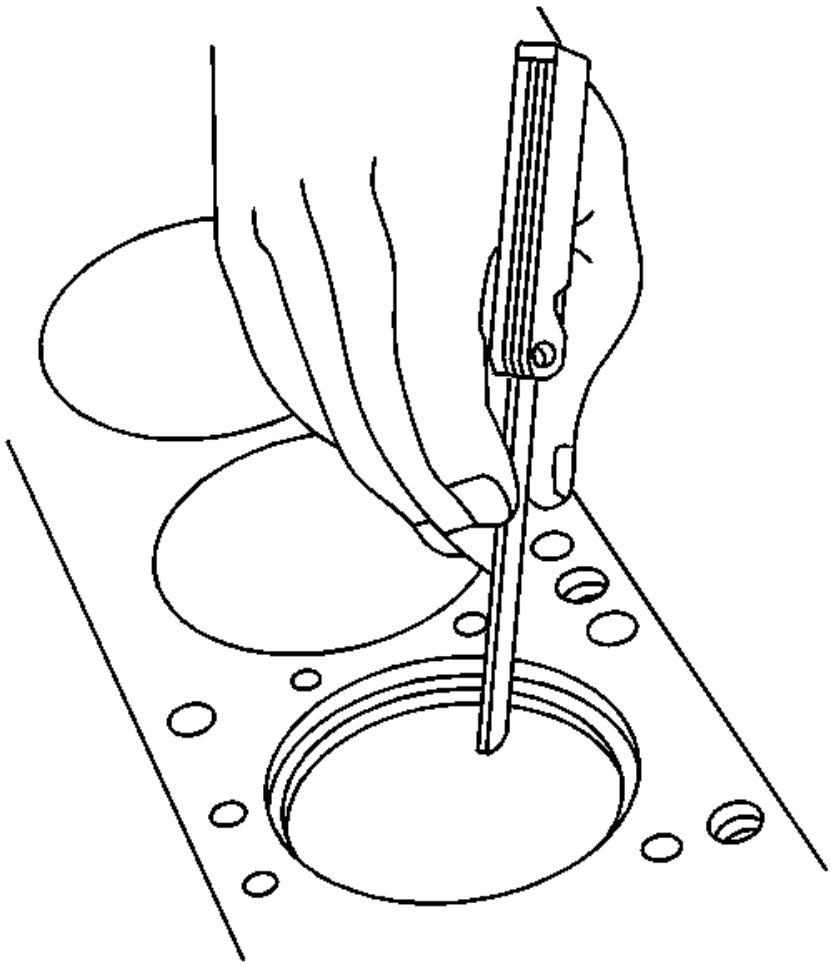

Fig. 436: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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 gauge and measure the piston ring end gap. Refer to **Engine Mechanical Specifications**.

Connecting Rod and Bearings

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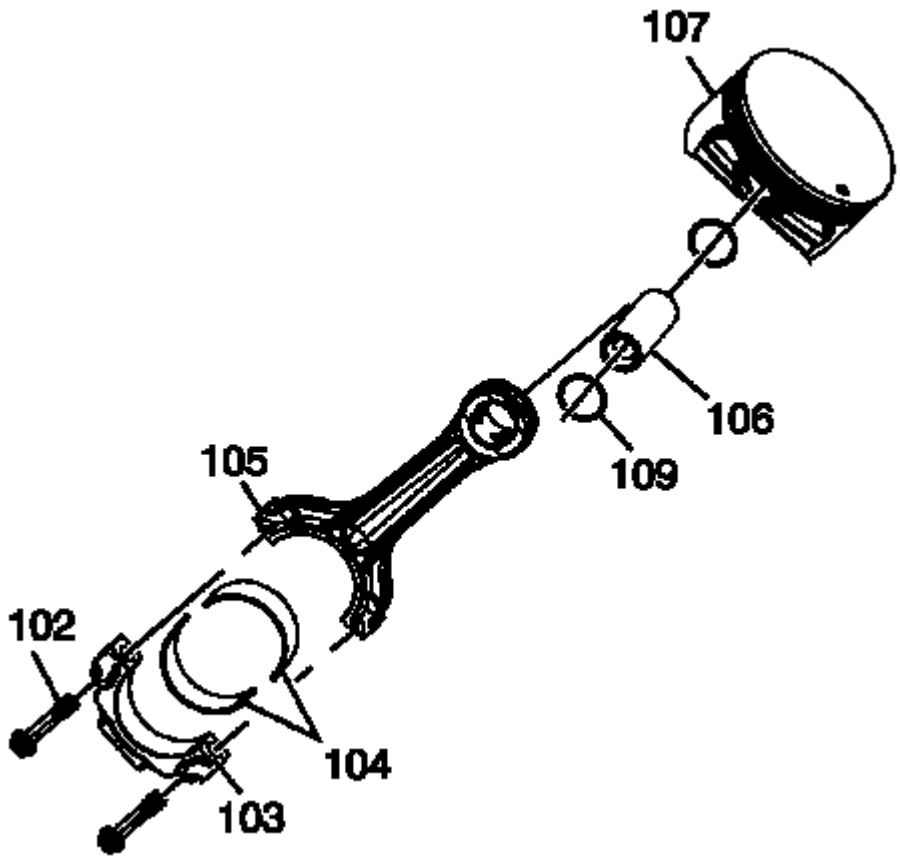

Fig. 437: View Of Piston, Pin & Piston Rings
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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.

   WARNING: Refer to Safety Glasses Warning .

2. Dry the components with compressed air.

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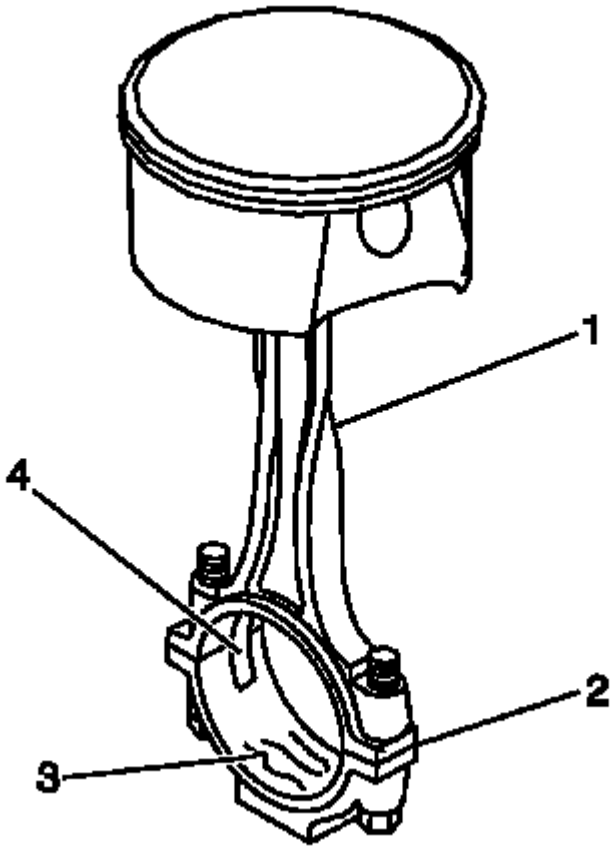

Fig. 438: Identifying Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS CORP.

3. Inspect the connecting rod for the following conditions:
    - Twisting (1)
    - Proper fit of the connecting rod and cap mating surfaces (2)
    - Nicks or gouges in the bearing bore (3)
    - Damage to the bearing locating slots (4)

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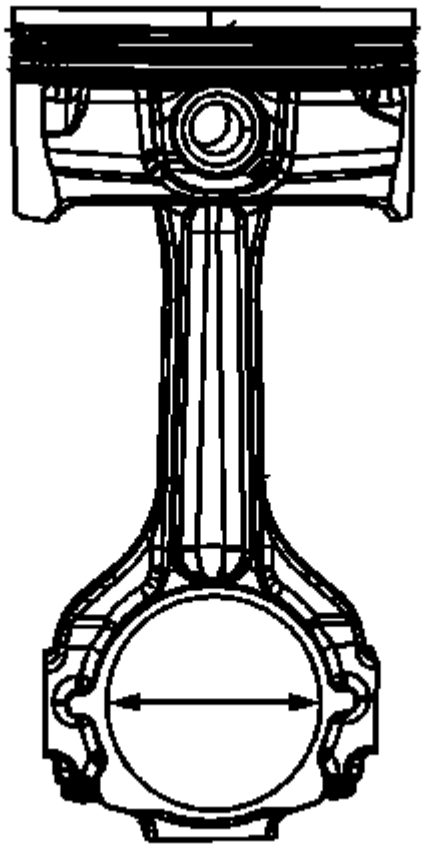

Fig. 439: Identifying Connecting Rod Bearing Bore
Courtesy of GENERAL MOTORS CORP.

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications**.

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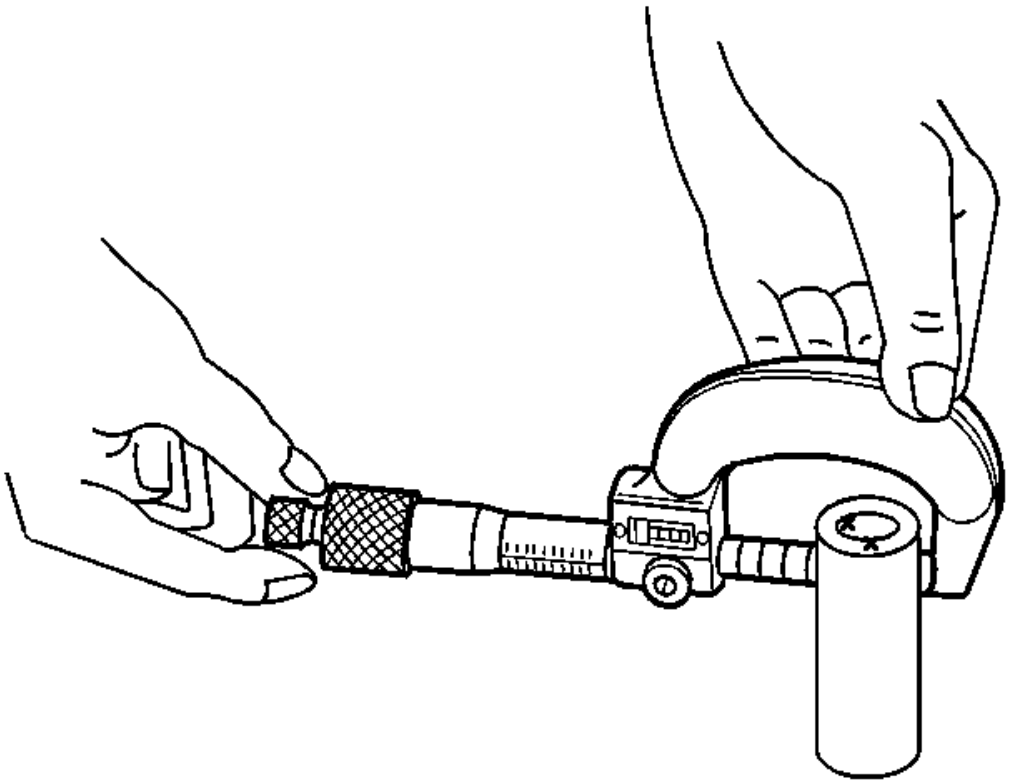

Fig. 440: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS CORP.

5. To determine piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin OD.

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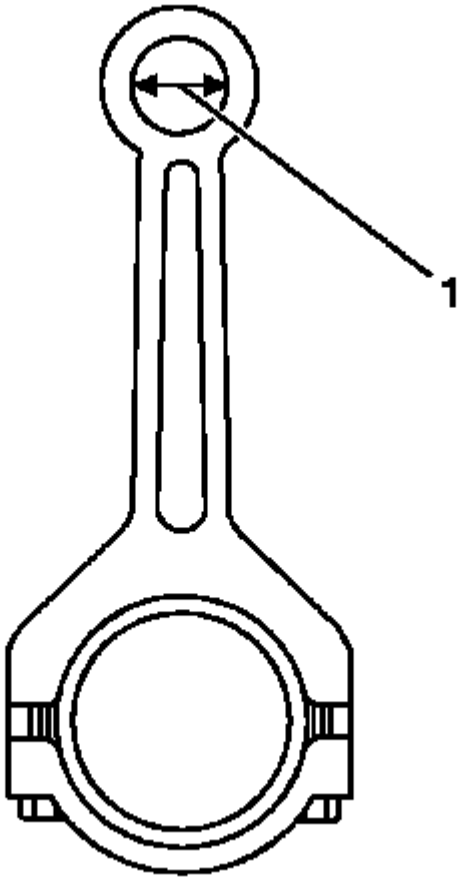

Fig. 441: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS CORP.

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**.

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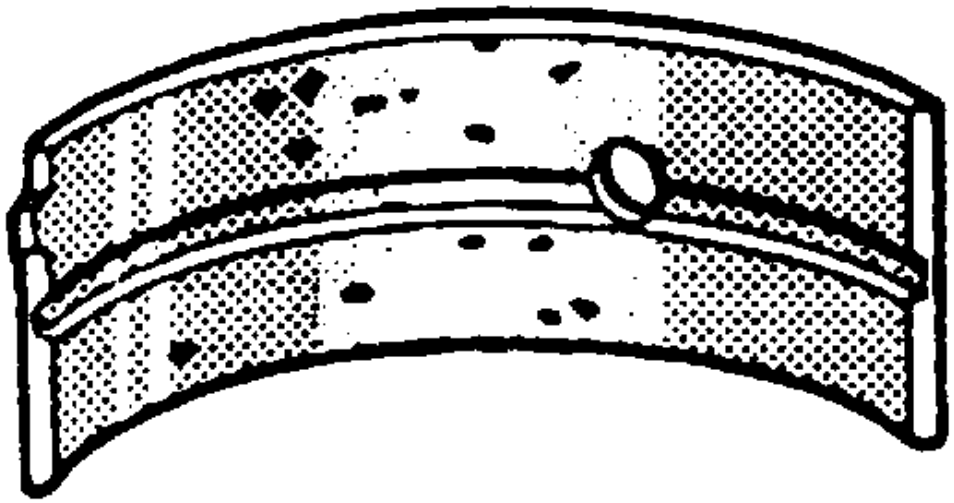

Fig. 442: Inspecting Bearings For Damage
Courtesy of GENERAL MOTORS CORP.

8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.

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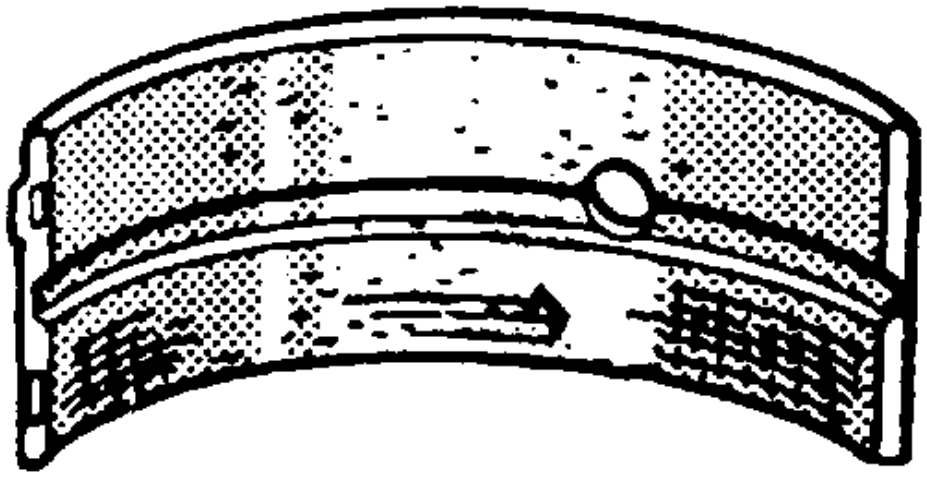

Fig. 443: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

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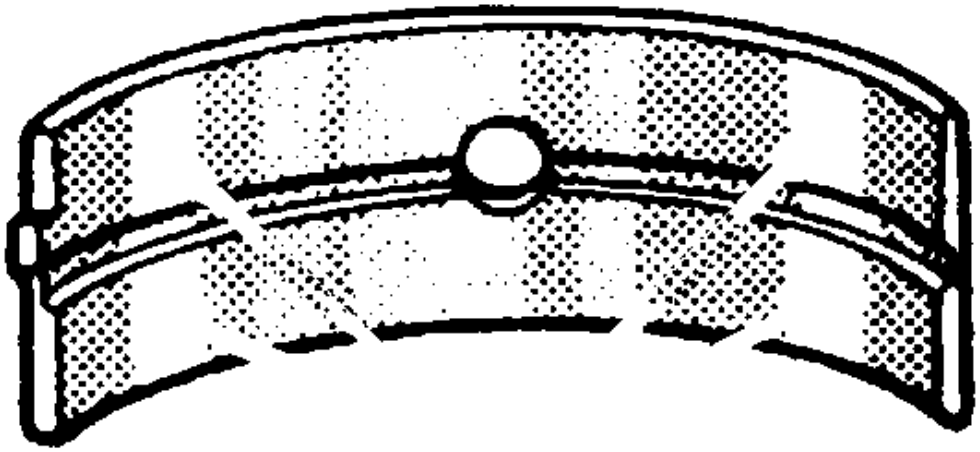

Fig. 444: View Of Improper Seating
Courtesy of GENERAL MOTORS CORP.

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

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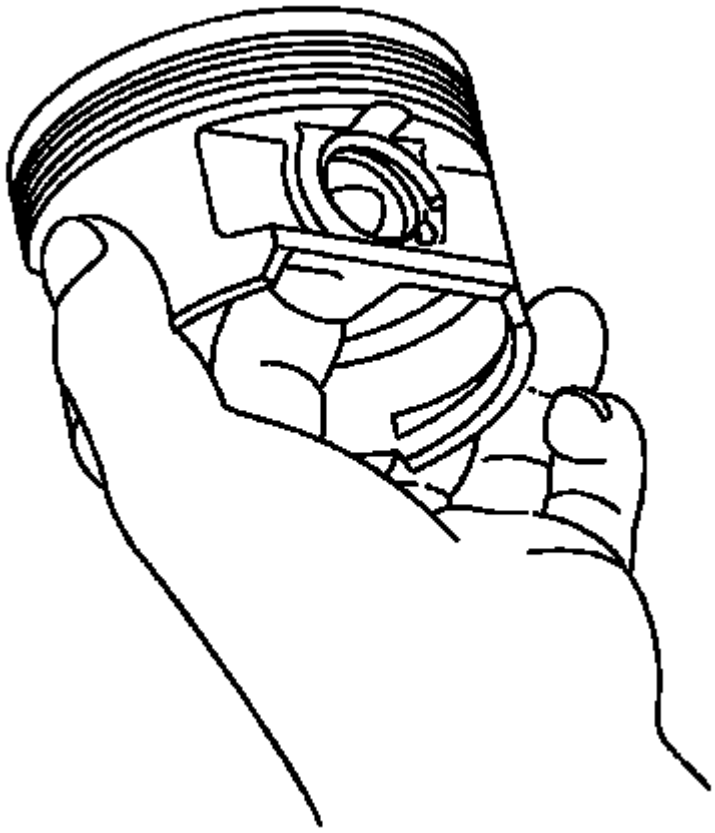

Fig. 445: View Of Retaining Clip In Pin Bore Groove
Courtesy of GENERAL MOTORS CORP.

1. Install the retainer. The retainer should be seated in the groove of the pin bore.

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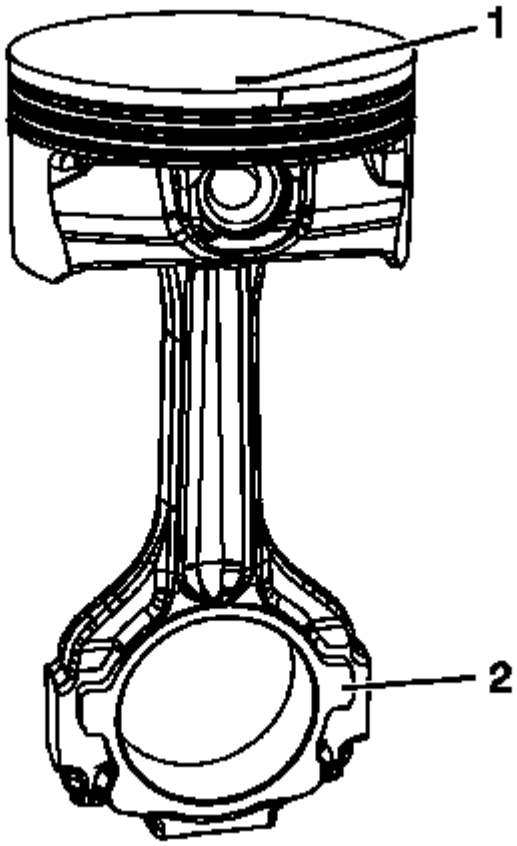

Fig. 446: Locating Mark On Top Of Piston & Connecting Rod Tab
Courtesy of GENERAL MOTORS CORP.

2. The mark (1) on the top of the piston and the large set of tabs (2) on the side of the connecting rod should be facing the same direction.

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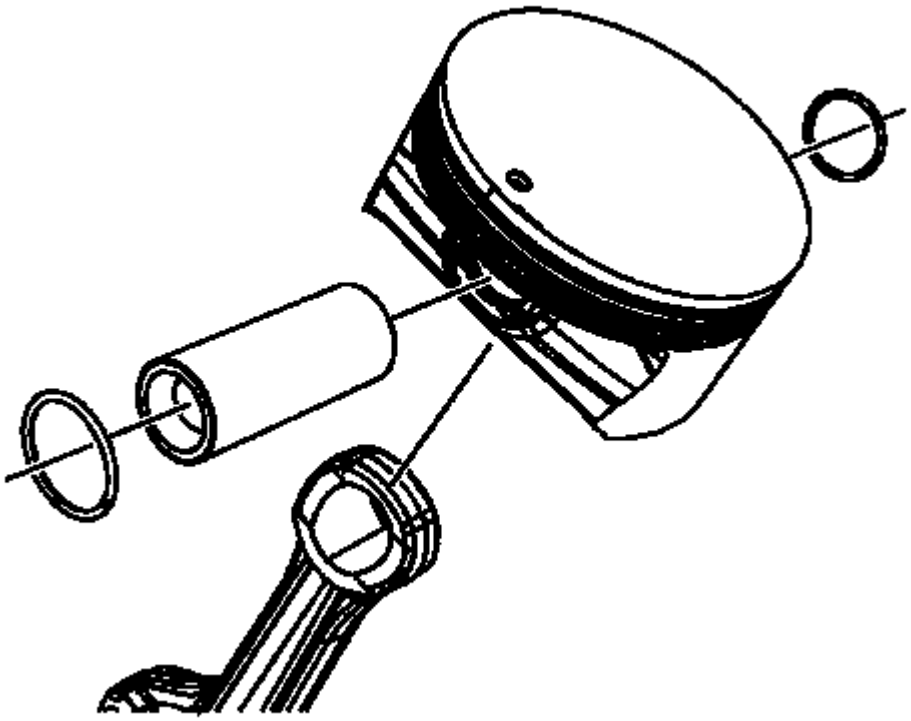

Fig. 447: Piston Pin, Piston & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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.

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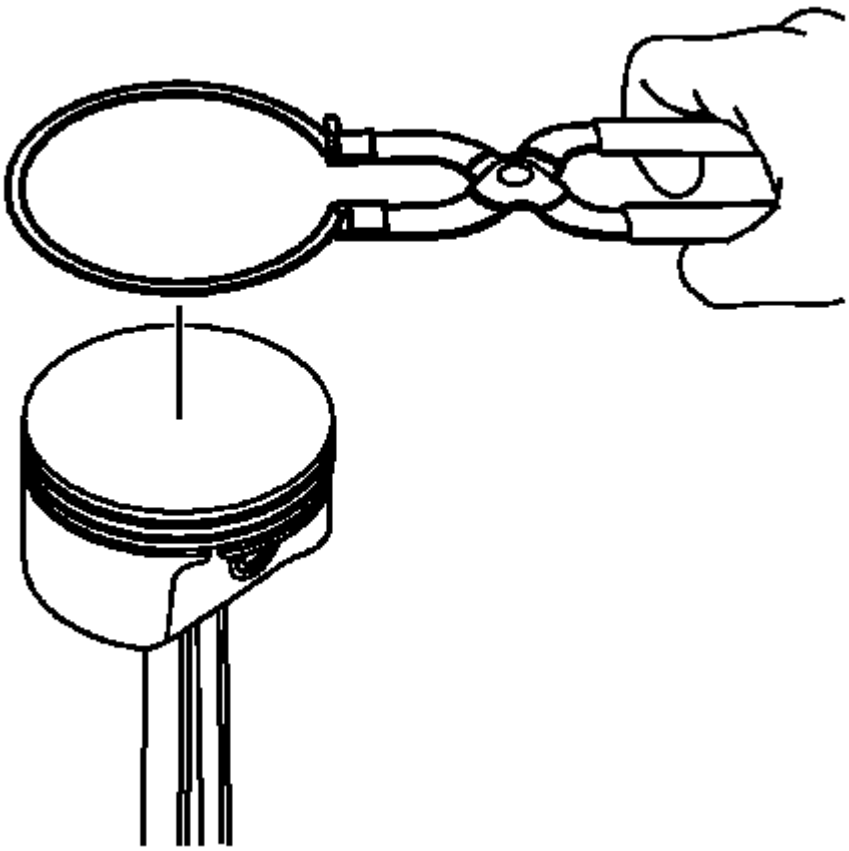

Fig. 448: Removing/Installing Piston Rings
Courtesy of GENERAL MOTORS CORP.

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 top compression ring has a shinier finish than the lower compression ring. 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 180 degrees opposite each other.
7. Position the compression ring end gaps 180 degrees opposite each other.

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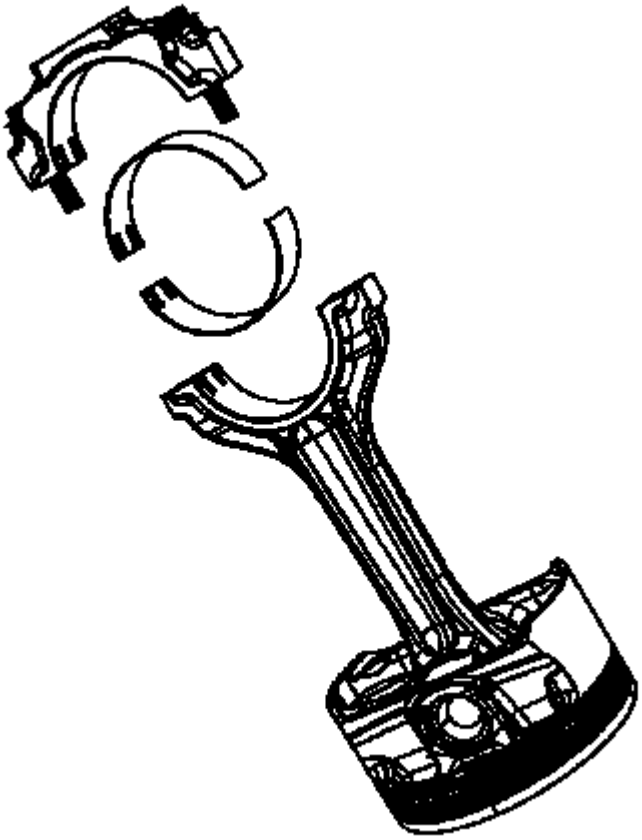

Fig. 449: View Of Piston, Connecting Rod & Cap
Courtesy of GENERAL MOTORS CORP.

8. Install the connecting rod bearings to the rod and cap.

CAMSHAFT BEARING REMOVAL

Special Tools

J 33049: Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**.

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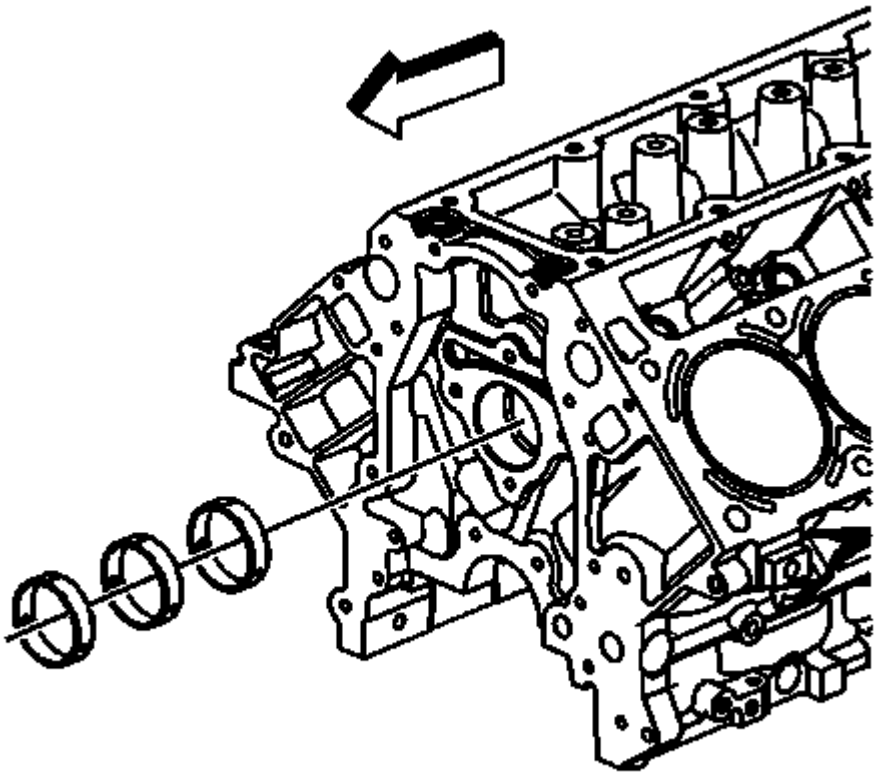

Fig. 450: Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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.

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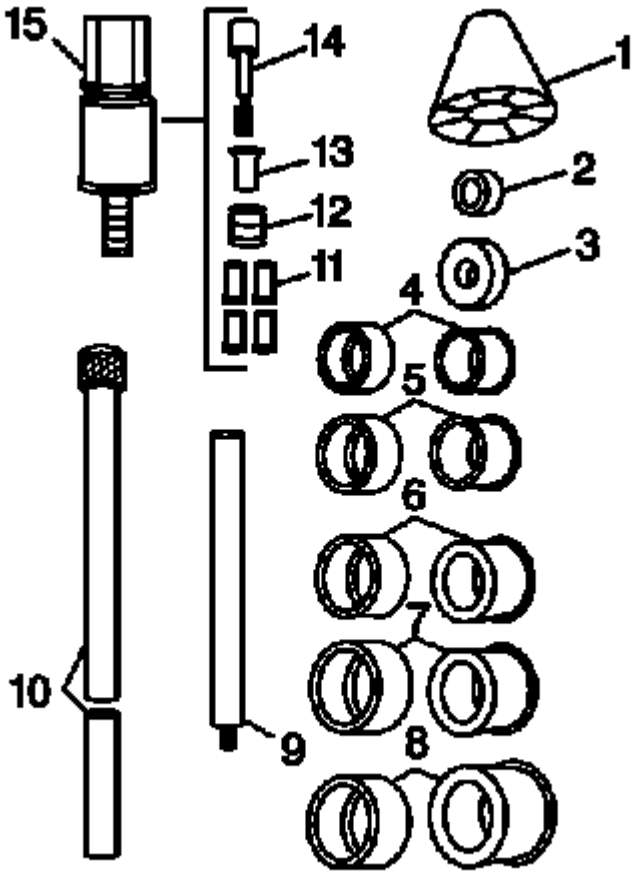

Fig. 451: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049:** service set.
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing in order to align the tool.

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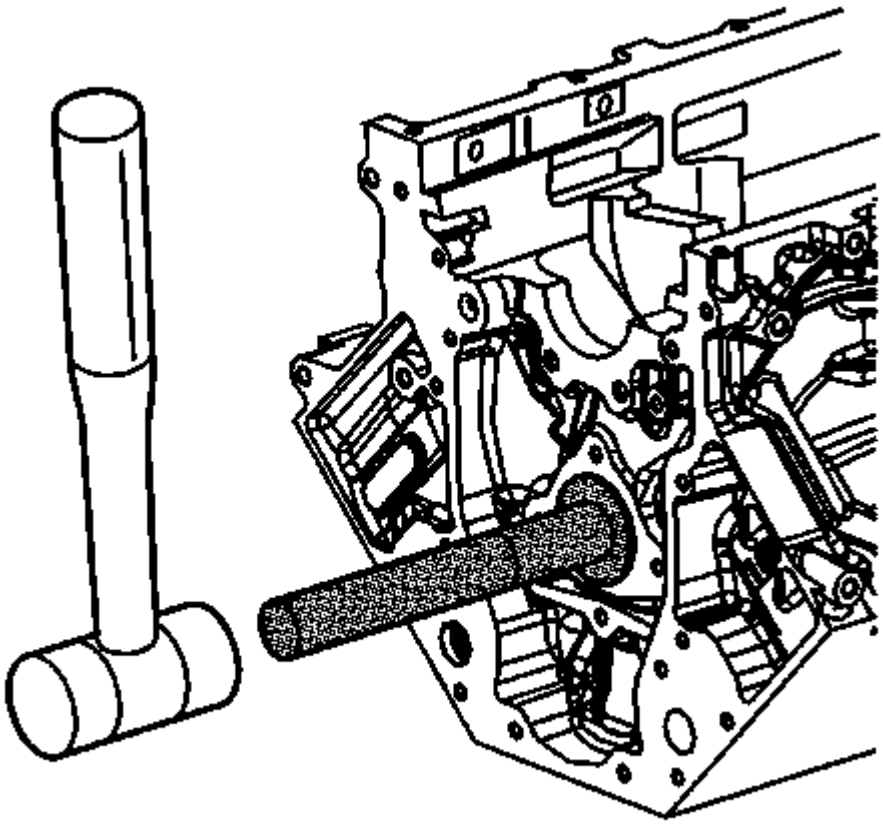

Fig. 452: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Drive the bearing from the block bore.

IMPORTANT: In order to remove the inner camshaft bearings, operate the tool from either end of the block, using the driver bar extension and the guide cone in the front or rear camshaft bearing bore.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

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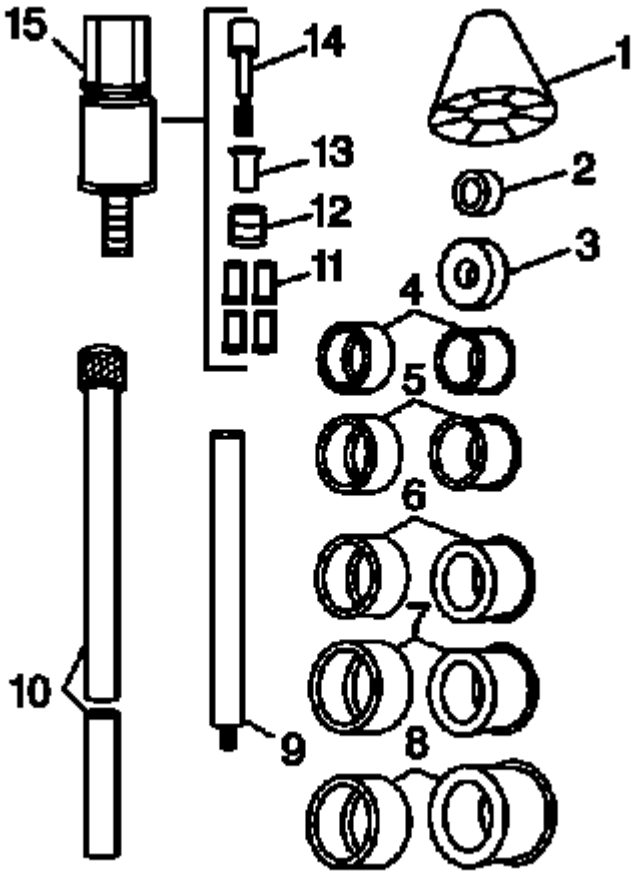

Fig. 453: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

- 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).

NOTE: The expander bearing drivers (4-8) in the J 33049: service set are stamped with a number (1-5) to assist in identifying the appropriate diameter driver.

- Expander assembly (15) is used as a driver for the bearing when inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the small washer.
- Expander bearing driver number 1 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with the expander assembly (15) and the small washer.
- Expander bearing driver number 2 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 3 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 4 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with

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expander assembly (15) and the large washer.

- Expander bearing driver number 5 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with expander assembly (15) 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.

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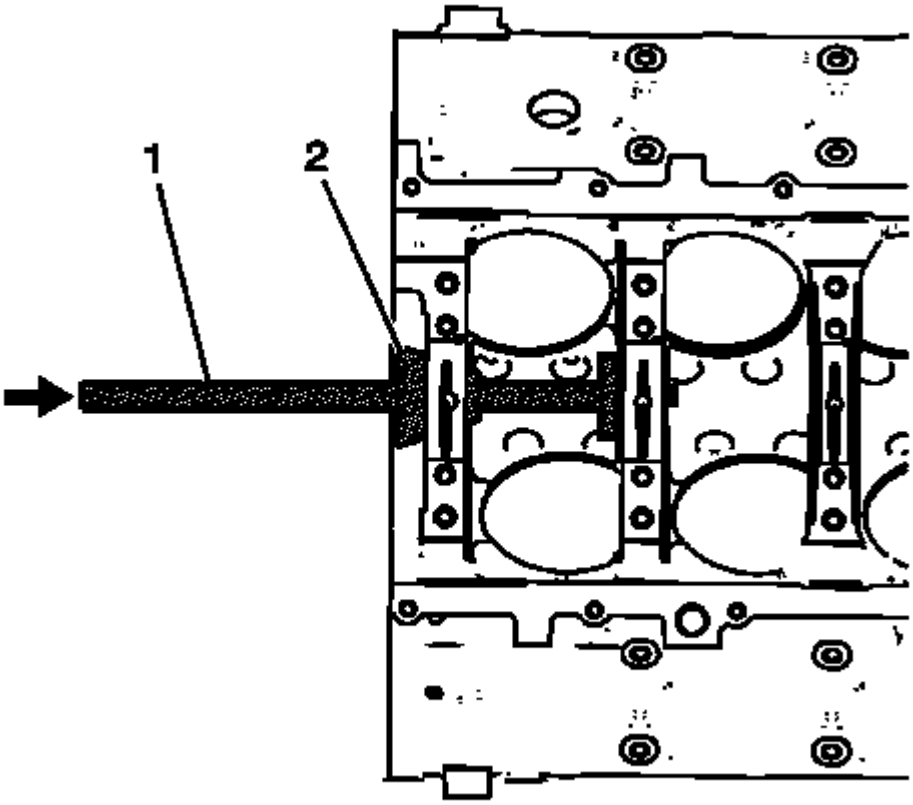

Fig. 454: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

7. Insert the tool (1) 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.

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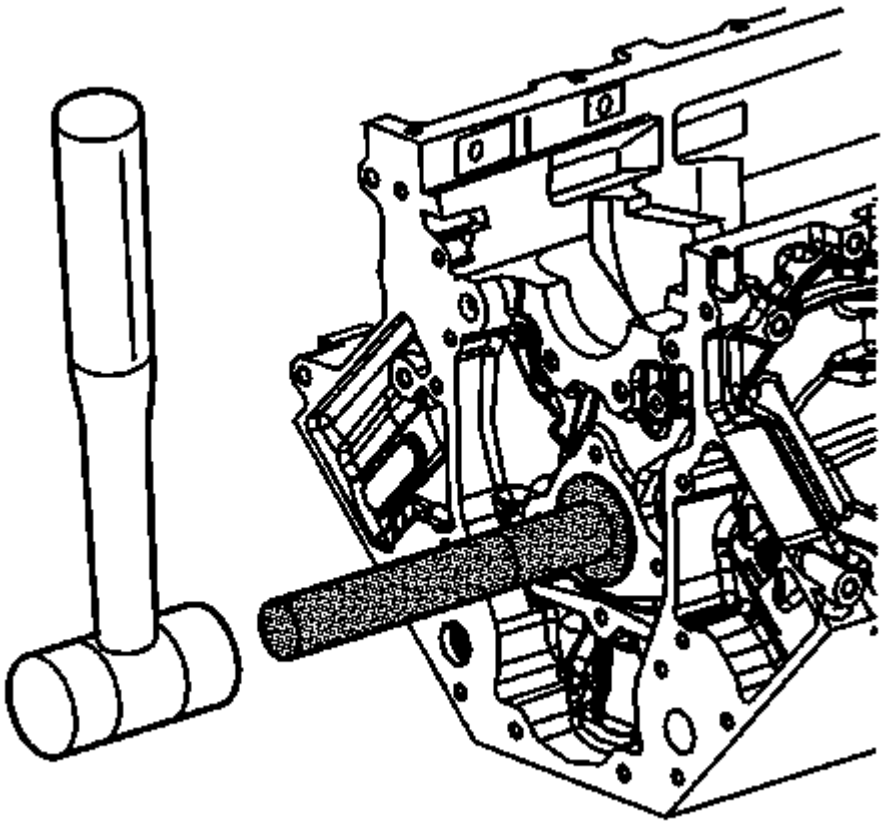

Fig. 455: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

11. For the end bearings, front, position number 1, and the rear, position number 5, 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

Special Tools

- **J 7872:** Magnetic Base Dial Indicator Set
- **J 8520:** Camshaft Lobe Lift Indicator

For equivalent regional tools, refer to **Special Tools**

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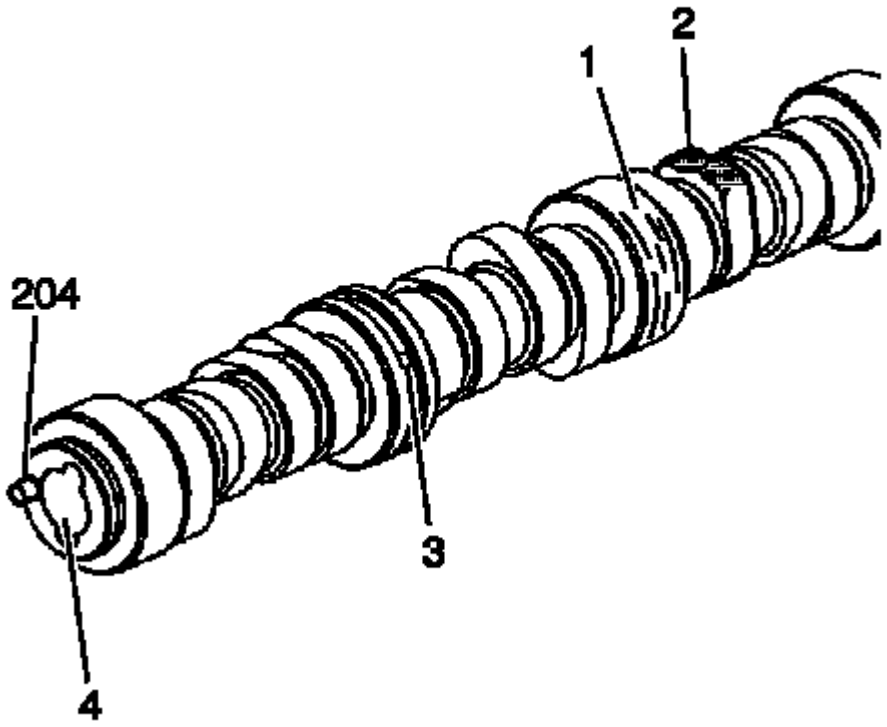

Fig. 456: View Of Camshaft Inspection Points
Courtesy of GENERAL MOTORS CORP.

1. Clean the components in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning

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.

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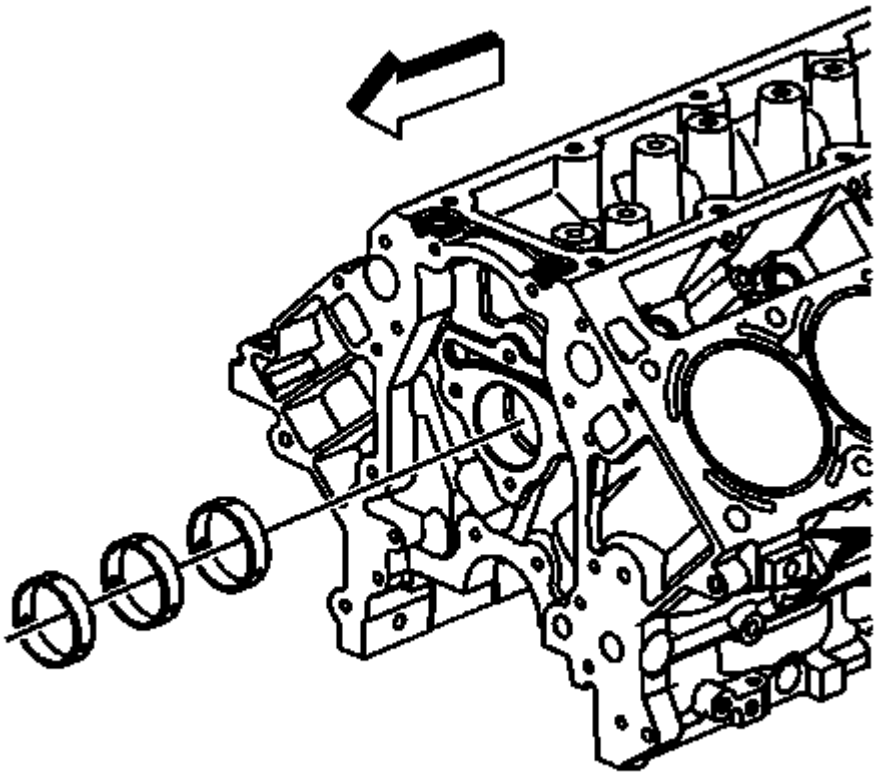

Fig. 457: Camshaft Bearings
Courtesy of GENERAL MOTORS CORP.

9. Inspect the camshaft bearings for the following:
    - Excessive wear, evidence of galling, pitting, scoring, or embedded debris. The appearance of the bearing material being different shades of gray are considered normal, and are not guideline for bearing replacement. Measure the bearing inside diameter (ID) as required for an over-sized condition. Refer to **Engine Mechanical Specifications** .
    - 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.
    - The oil lubrication feed hole in the bearing must be in alignment with the drilled out passage in the block.
    - The oil lubrication feed hole is not plugged by debris.
    - Bearings with excessive wear or scoring must be replaced.
    - Bearings with excessive wear, galling, pitting, scoring, or embedded debris must be replaced.

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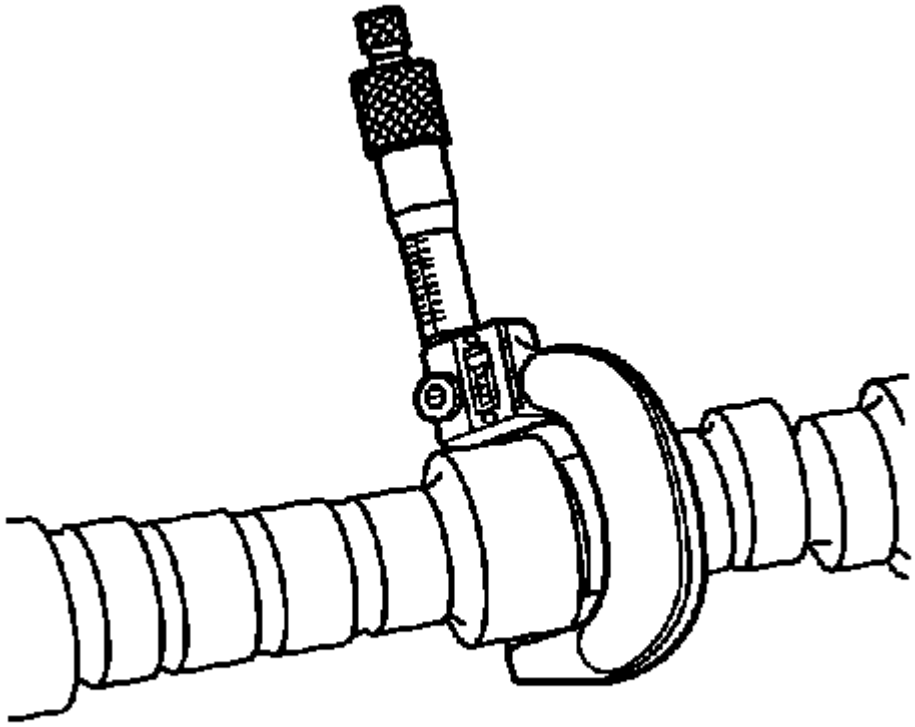

Fig. 458: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

10. Using a micrometer, measure the camshaft journals for wear and out-of-round. Refer to **Engine Mechanical Specifications**.
    - If the camshaft bearing journals are out-of-round, replace the camshaft.
    - If the camshaft bearing journal diameter is not within specification, replace the camshaft.

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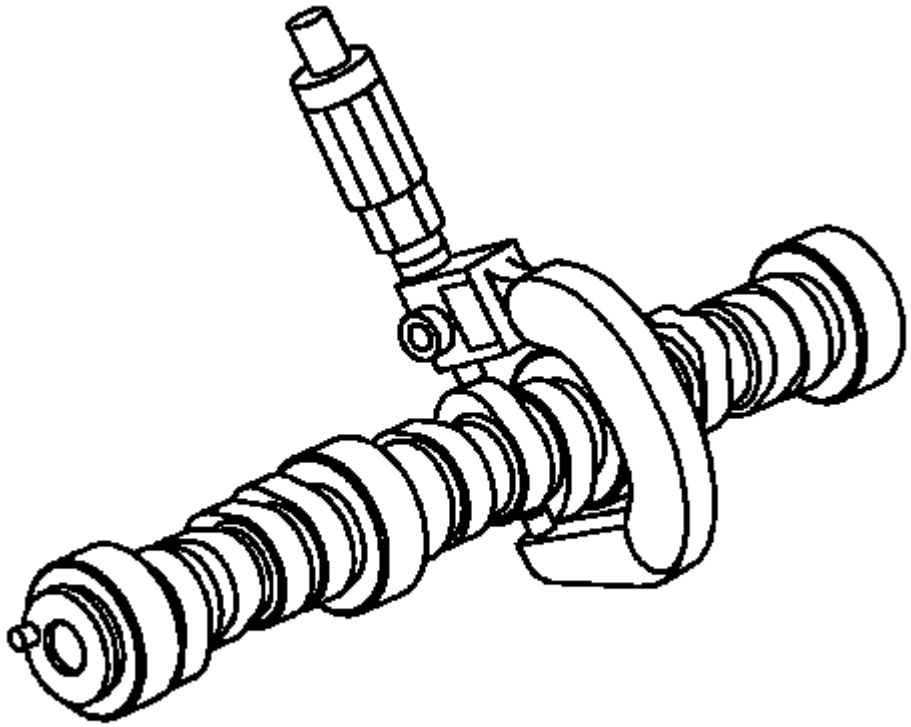

Fig. 459: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS CORP.

11. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications**.

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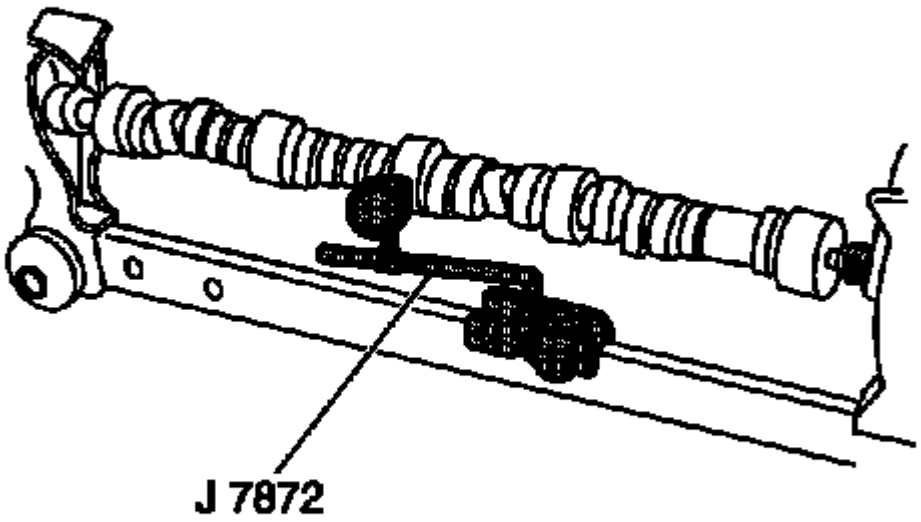

Fig. 460: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the camshaft runout.
    1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
    2. Using the **J 7872:** set , measure the runout of the intermediate camshaft bearing journals.
    3. If camshaft runout is not within specification, the camshaft is bent and should be replaced. Refer to **Engine Mechanical Specifications** .

Measuring Camshaft Lobe Lift

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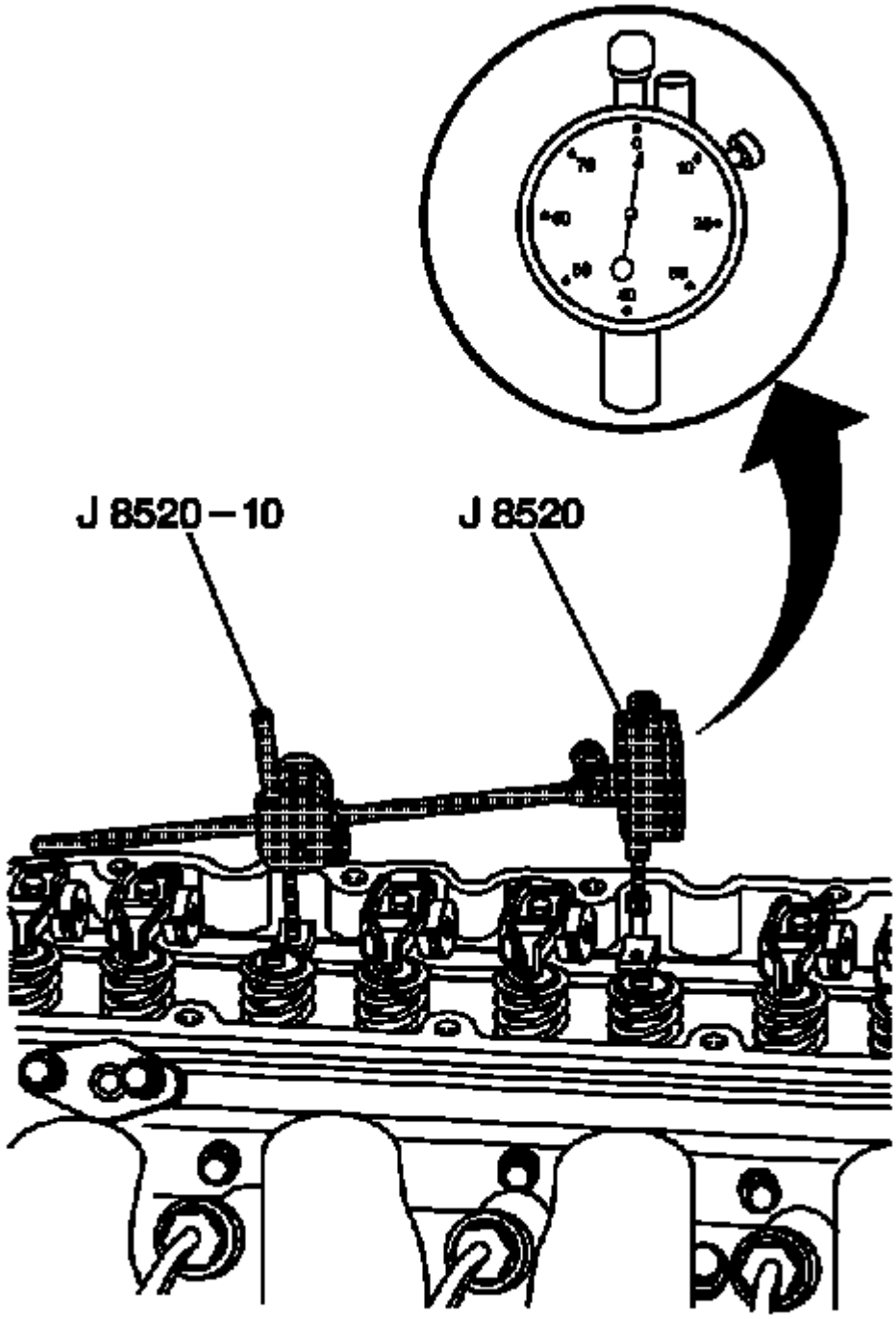

Fig. 461: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS CORP.

NOTE: **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.**

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1. Using the **J 8520:** indicator, measure camshaft lobe lift.
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:** indicator and position onto the stud.
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**. The total lobe lift is the difference between the highest and lowest reading.

CAMSHAFT BEARING INSTALLATION

Special Tools

J 33049: Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**

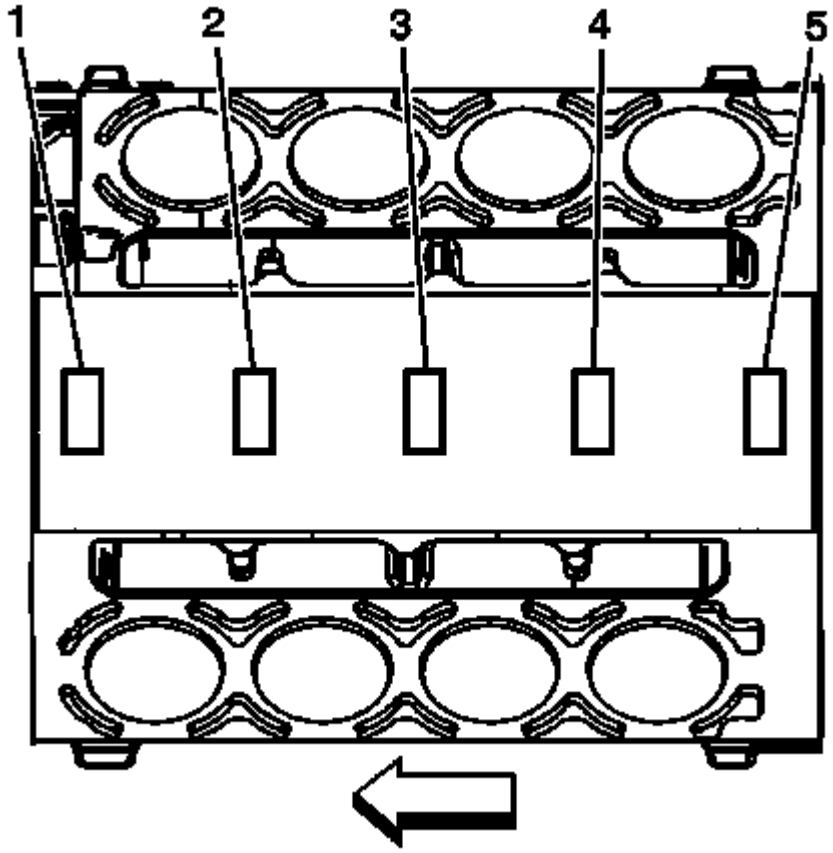

Fig. 462: Identifying Engine Block Camshaft Bearing Bores
Courtesy of GENERAL MOTORS CORP.

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NOTE: 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**.

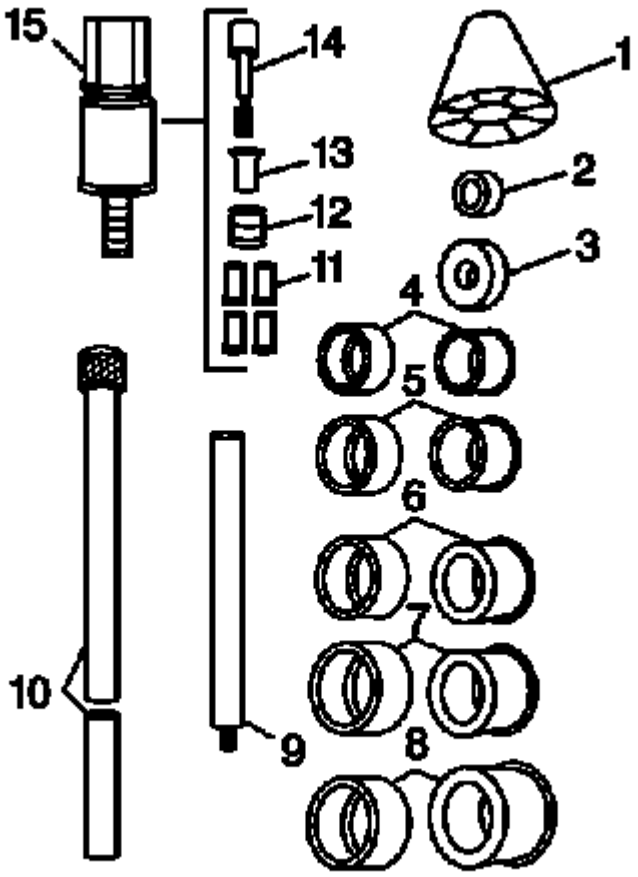

Fig. 463: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

2. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049:** set. Refer to **Camshaft Bearing Removal**.
3. Assemble the tool.

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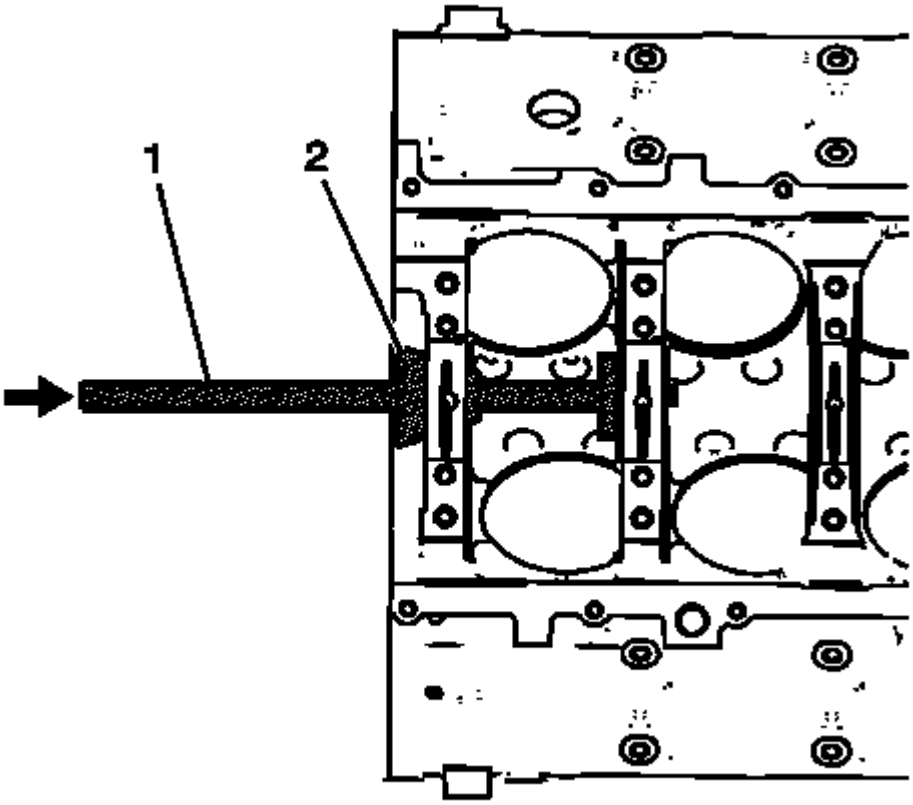

Fig. 464: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

4. Insert the tool (1) through the front or rear of the engine block and into the bearing. For installation of inner bearings, it may be necessary to install the driver bar extension.
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.

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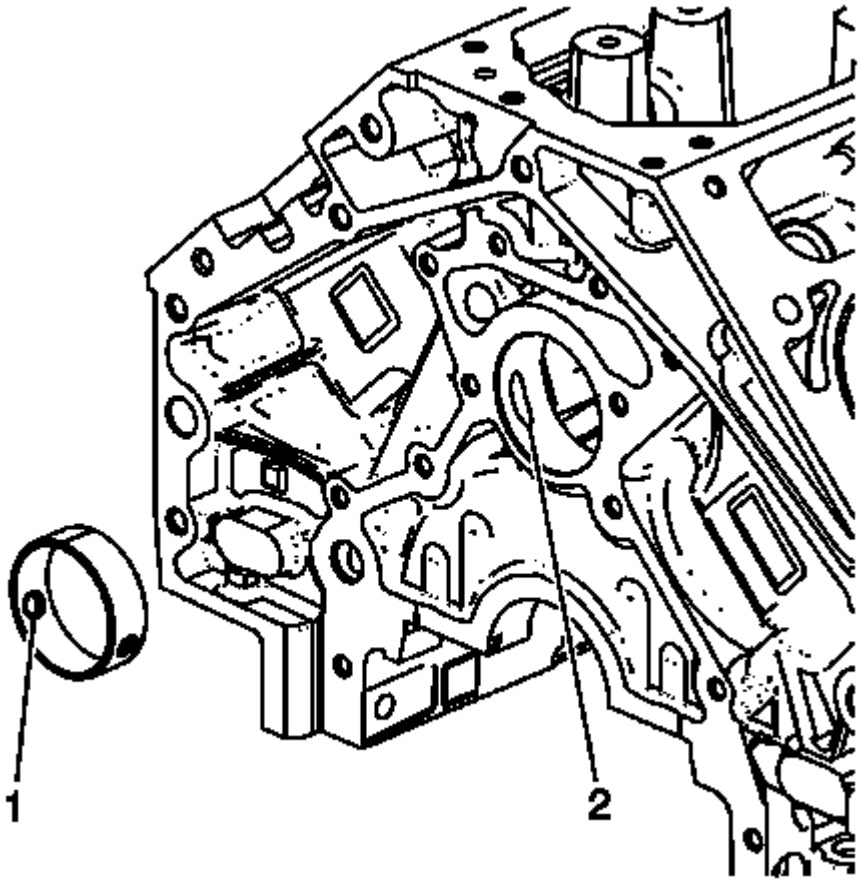

Fig. 465: Positioning Camshaft Bearing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Camshaft bearings must be installed with bearing oil feed hole in alignment with the drilled oil passage in the block bore to ensure proper oil flow to the camshaft. The split seam in the bearing must be installed in the 12 o'clock position towards the top of the block. Improperly installed bearings may restrict oil flow causing engine damage.

7. Position the camshaft bearing with oil feed hole (1) in alignment with drilled oil passage in block bore (2).

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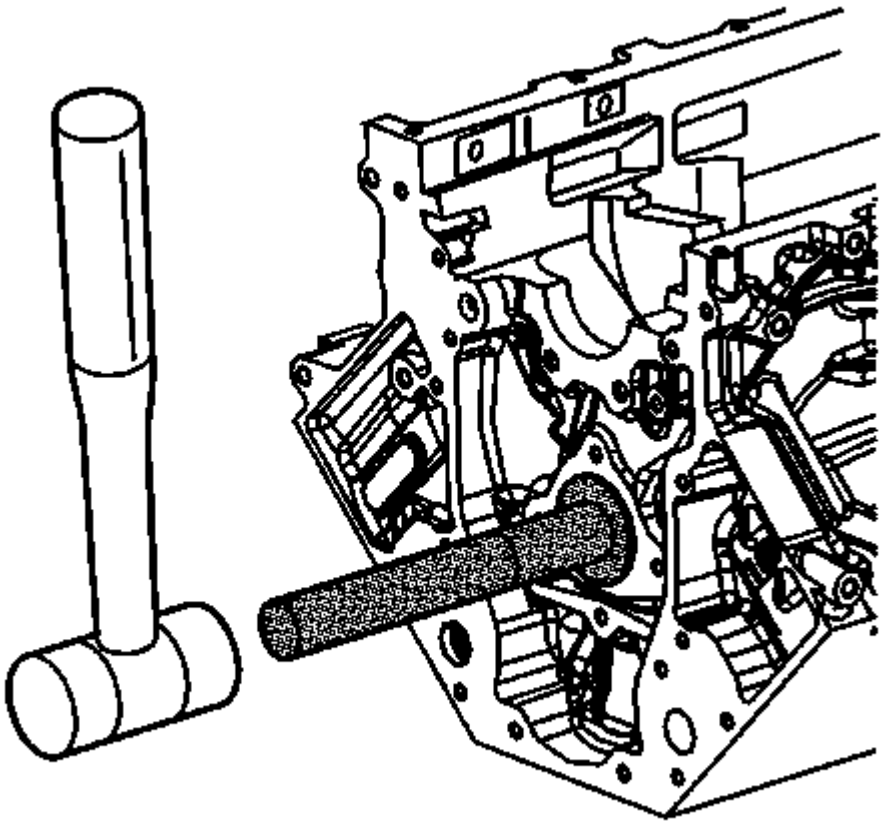

Fig. 466: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS CORP.

8. Drive the bearing into the block bore. During installation, ensure the bearing is installed straight.
9. Remove **J 33049:** service set, inspect bearing to confirm the oil hole in the bearing is in alignment with the drilled oil passage in the block bore.
10. Repeat procedure to install the remaining bearings into the block.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

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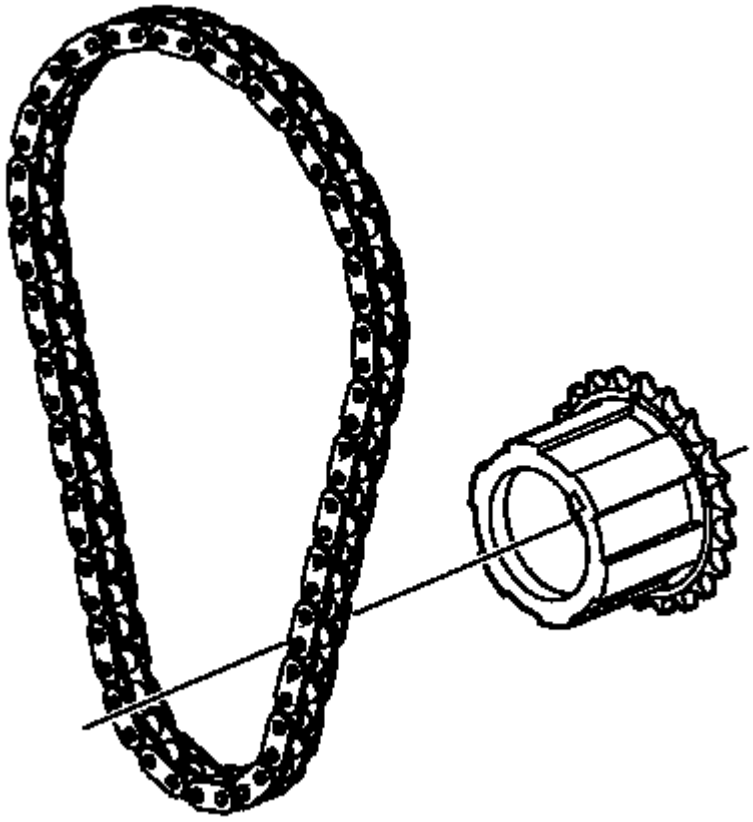

Fig. 467: Camshaft Timing Chain & Sprocket
Courtesy of GENERAL MOTORS CORP.

1. Clean the components with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.
4. Inspect the crankshaft sprocket for worn, damaged, or chipped teeth.
5. Inspect for a damaged keyway.
6. Inspect for worn oil pump drive splines.

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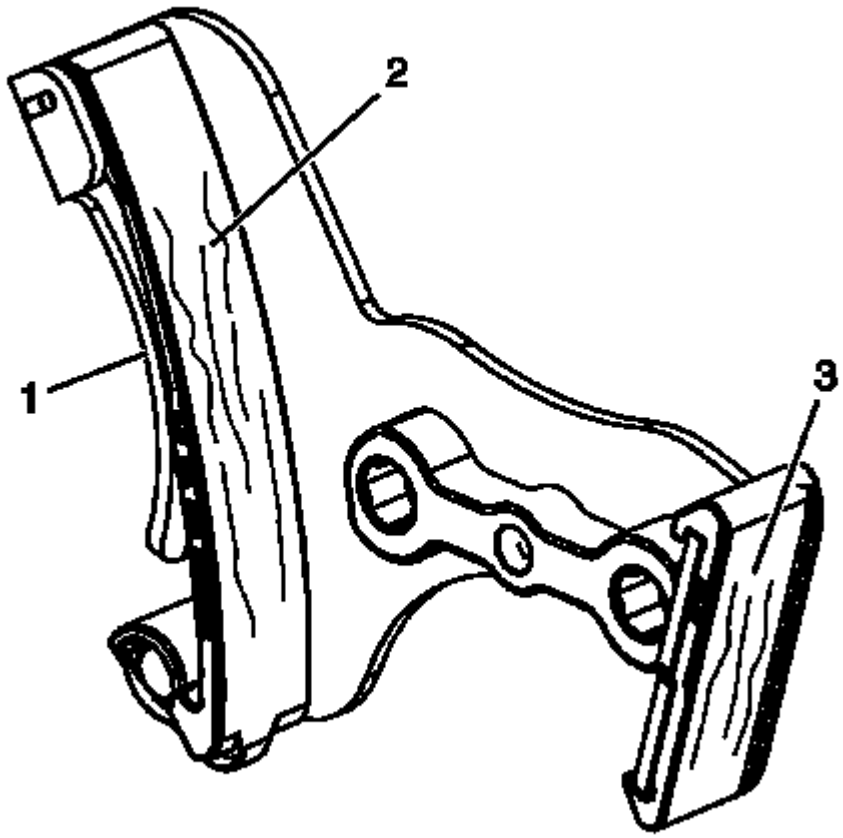

Fig. 468: View Of Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS CORP.

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 CLEANING AND INSPECTION

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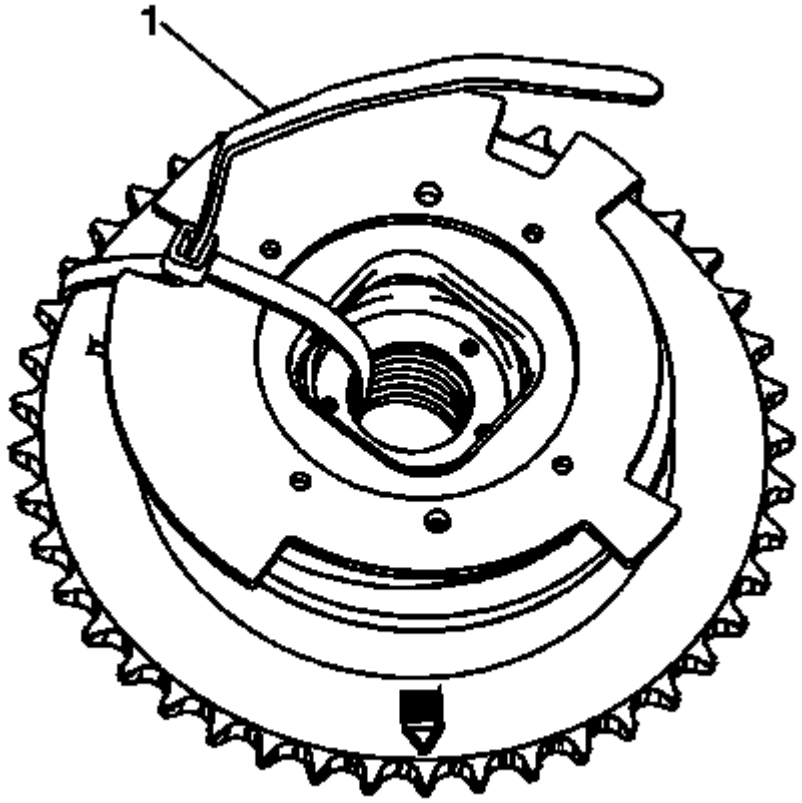

Fig. 469: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.

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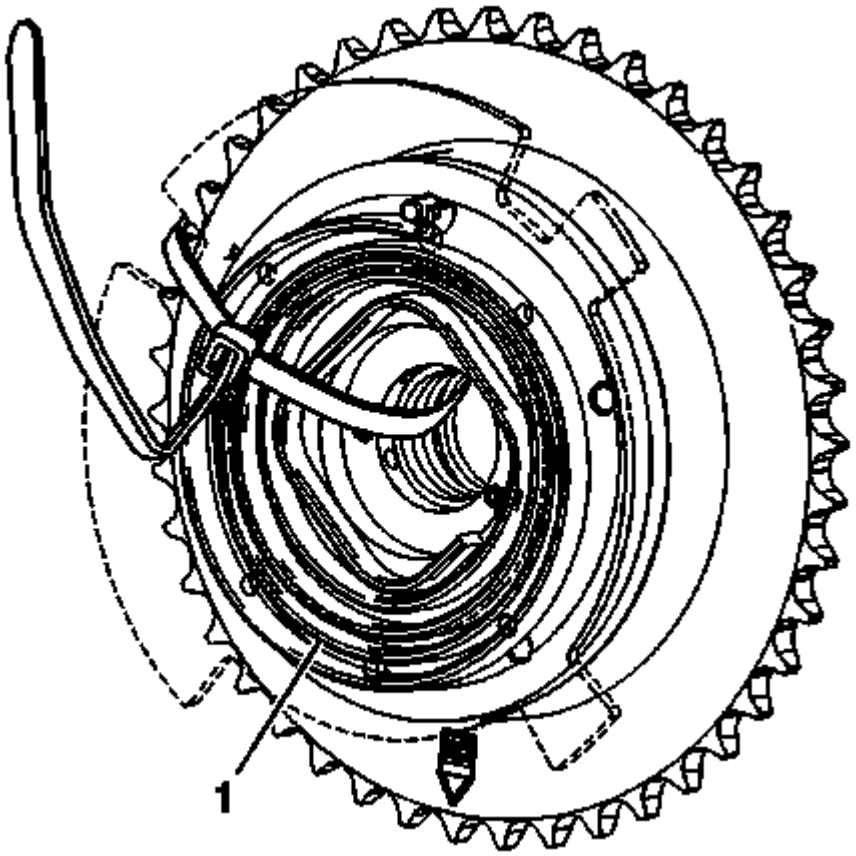

Fig. 470: Inspecting CMP Actuator For Broken Spring
Courtesy of GENERAL MOTORS CORP.

2. Clean the CMP actuator with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).

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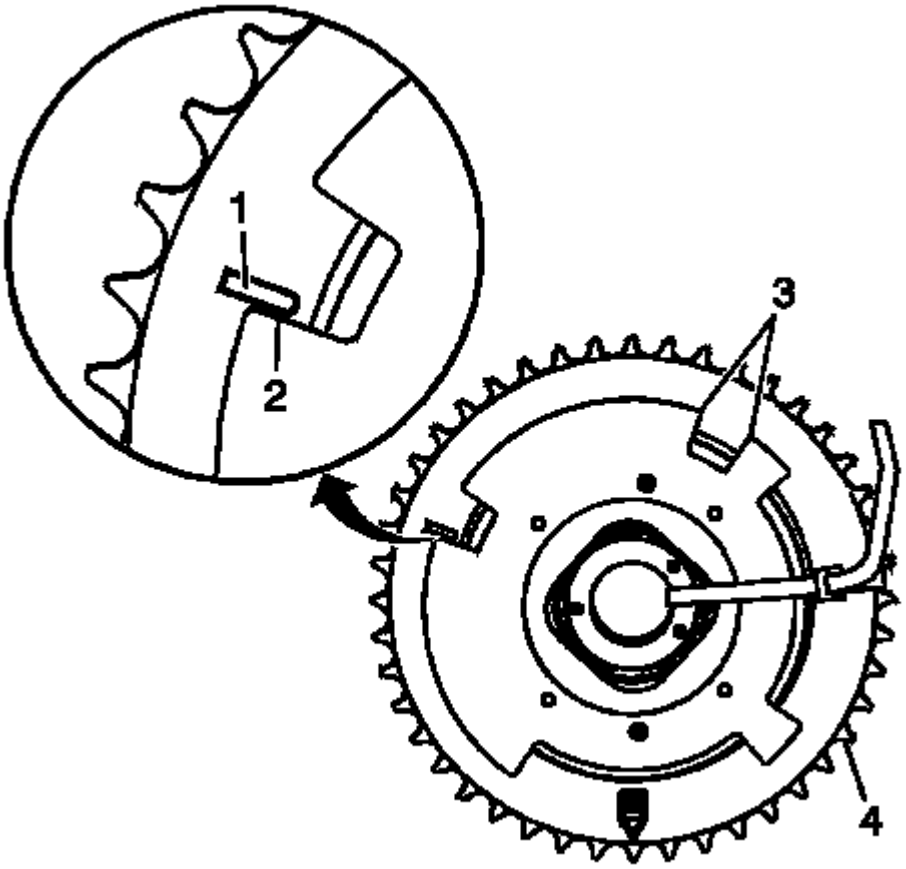

Fig. 471: CMP Actuator Inspection Points
Courtesy of GENERAL MOTORS CORP.

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 sprocket teeth (4)

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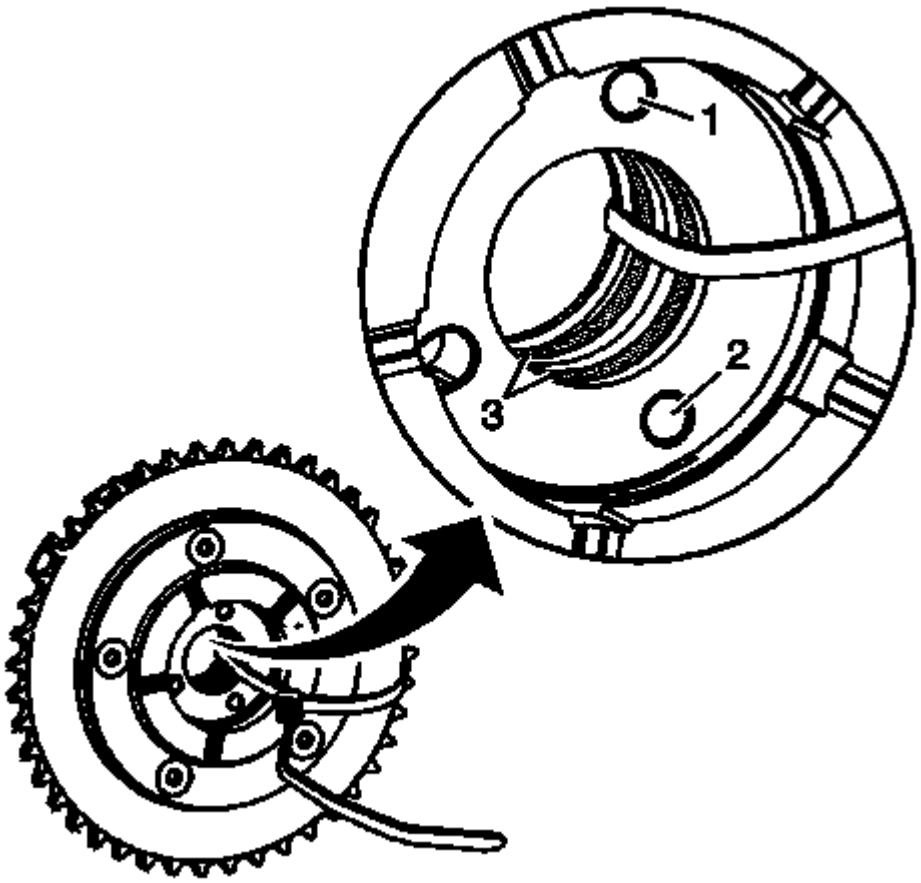

Fig. 472: View Of Oil Passages
Courtesy of GENERAL MOTORS CORP.

6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).

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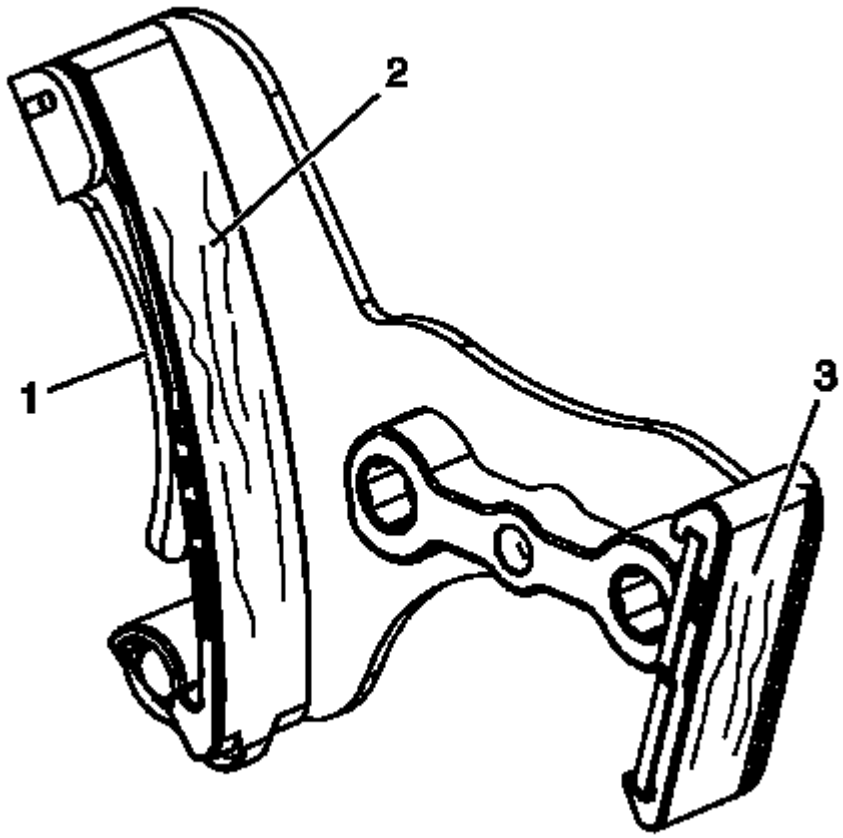

Fig. 473: View Of Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS CORP.

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

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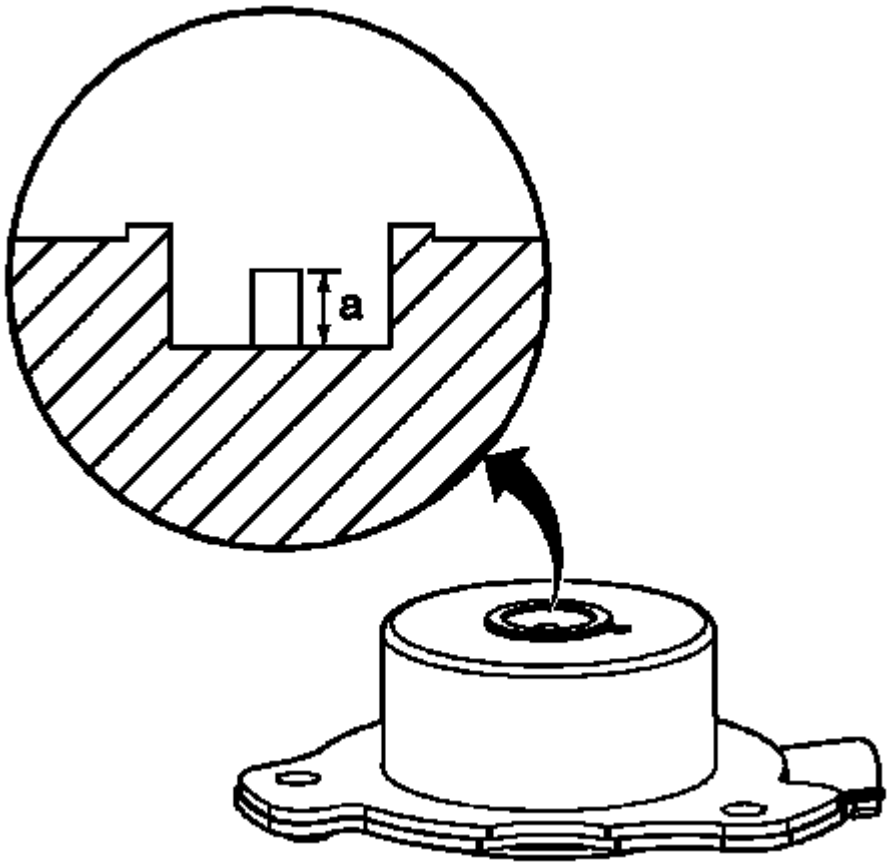

Fig. 474: Measuring The Retracted Position
Courtesy of GENERAL MOTORS CORP.

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.

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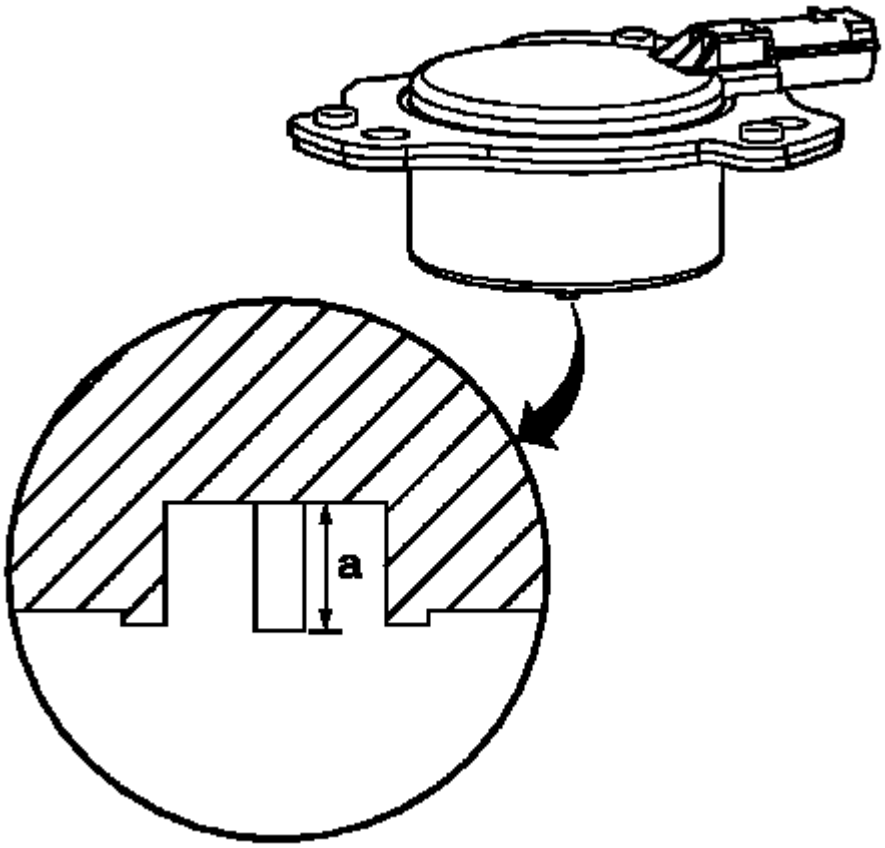

Fig. 475: Measuring The Pintle Extended Position
Courtesy of GENERAL MOTORS CORP.

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 (OFF-VEHICLE)

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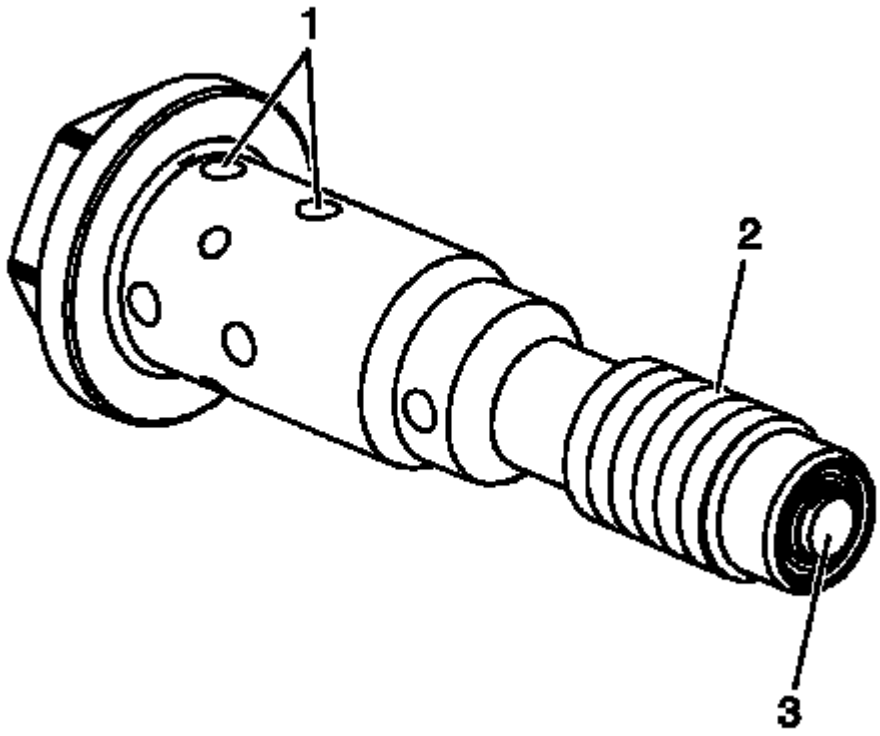

Fig. 476: View Of CMP Inspection Points
Courtesy of GENERAL MOTORS CORP.

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.

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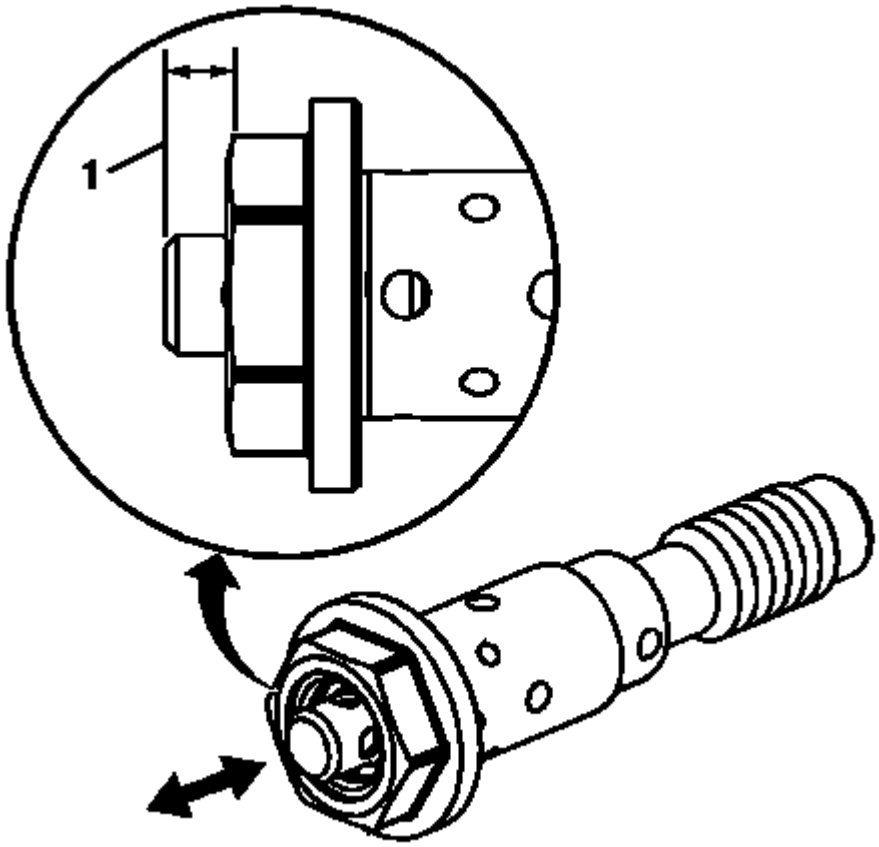

Fig. 477: View Of Proper Valve Spool Position
Courtesy of GENERAL MOTORS CORP.

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).

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSPECTION (ON-VEHICLE)

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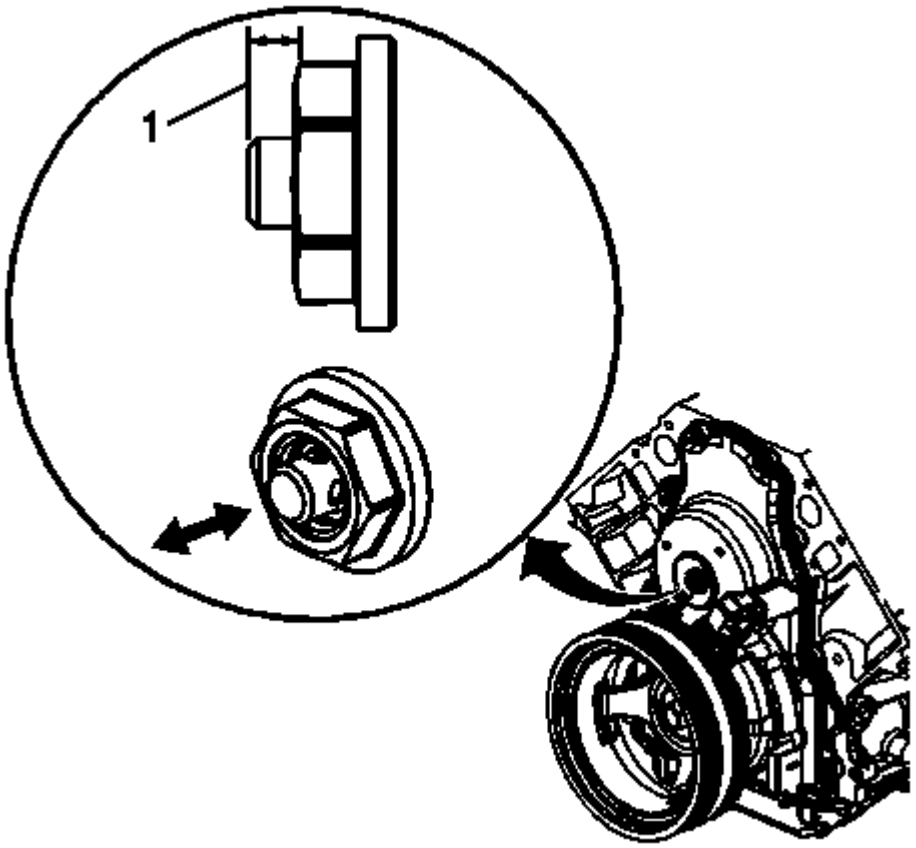

Fig. 478: View Of Proper Valve Spool Position
Courtesy of GENERAL MOTORS CORP.

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).

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

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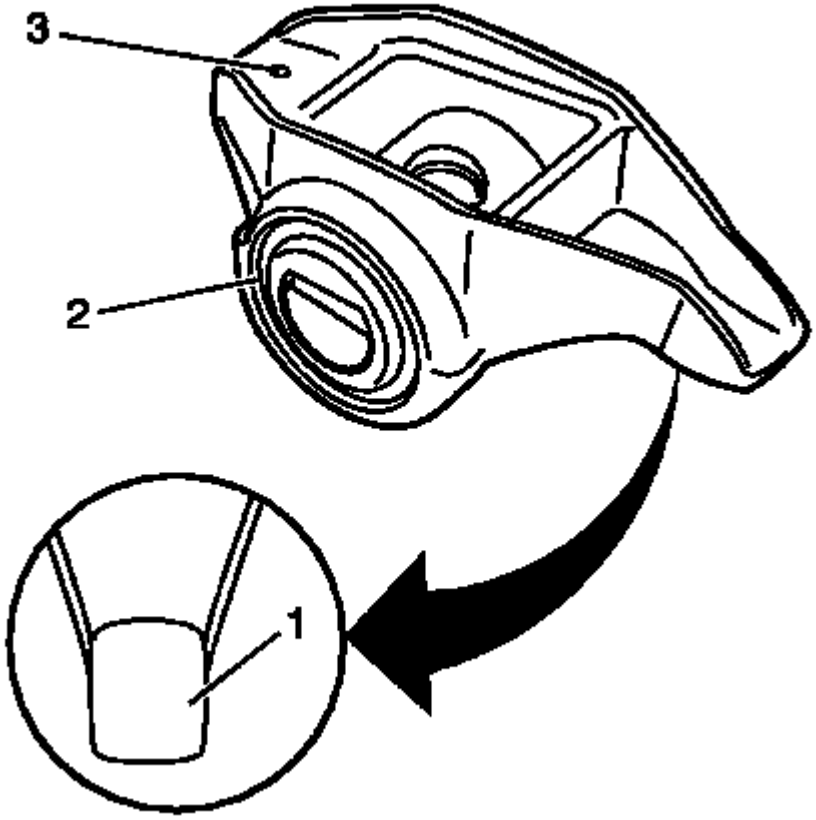

Fig. 479: Identifying Valve Rocker Arm Components
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

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.

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8. Inspect the pushrod oil passages for restrictions.
9. Inspect the rocker arm pivot supports for cracks, wear, or other damage.

VALVE LIFTER AND GUIDE CLEANING AND INSPECTION

Valve Lifters

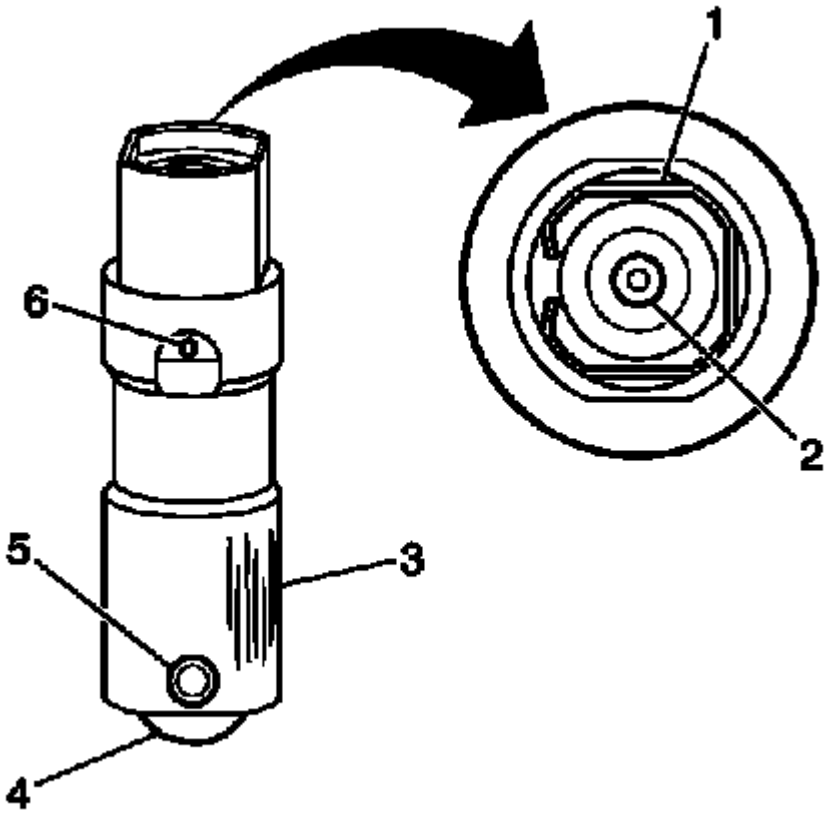

Fig. 480: Identifying Valve Lifter Inspection Areas
Courtesy of GENERAL MOTORS CORP.

NOTE: Components that are to be used again must be marked, sorted or organized for assembly.

1. Clean the components in cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.

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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

Special Tools

J 8062: Valve Spring Compressor - Head Off

For equivalent regional tools, refer to **Special Tools**.

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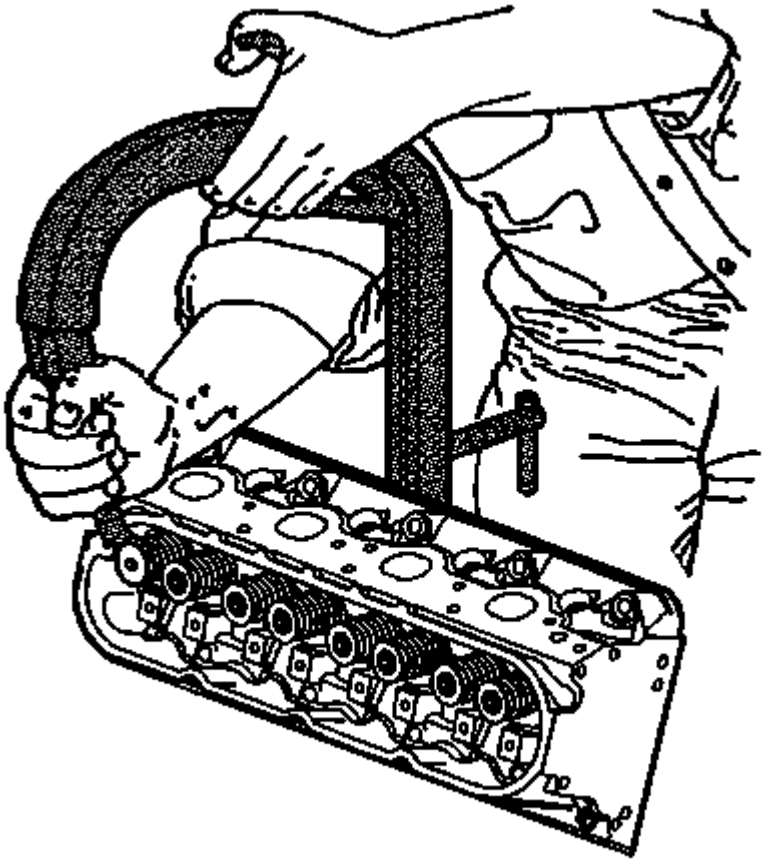

Fig. 481: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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:** valve spring compressor in order to compress the valve spring.

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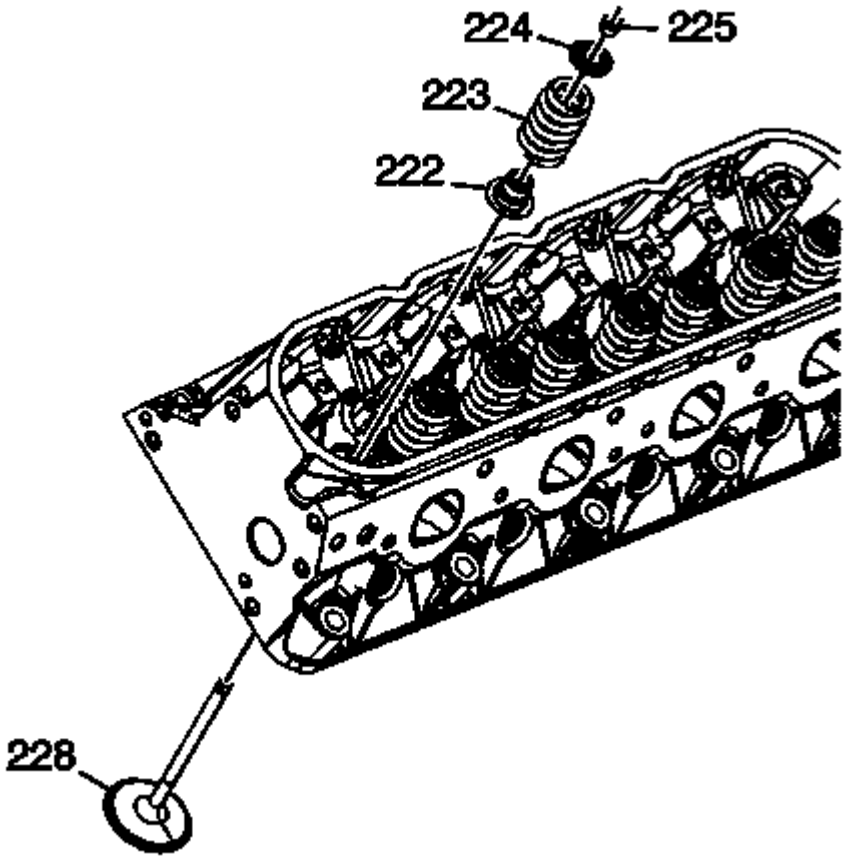

Fig. 482: Valve Stem Keys, Valve Spring Cap & Valve Spring
Courtesy of GENERAL MOTORS CORP.

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**.

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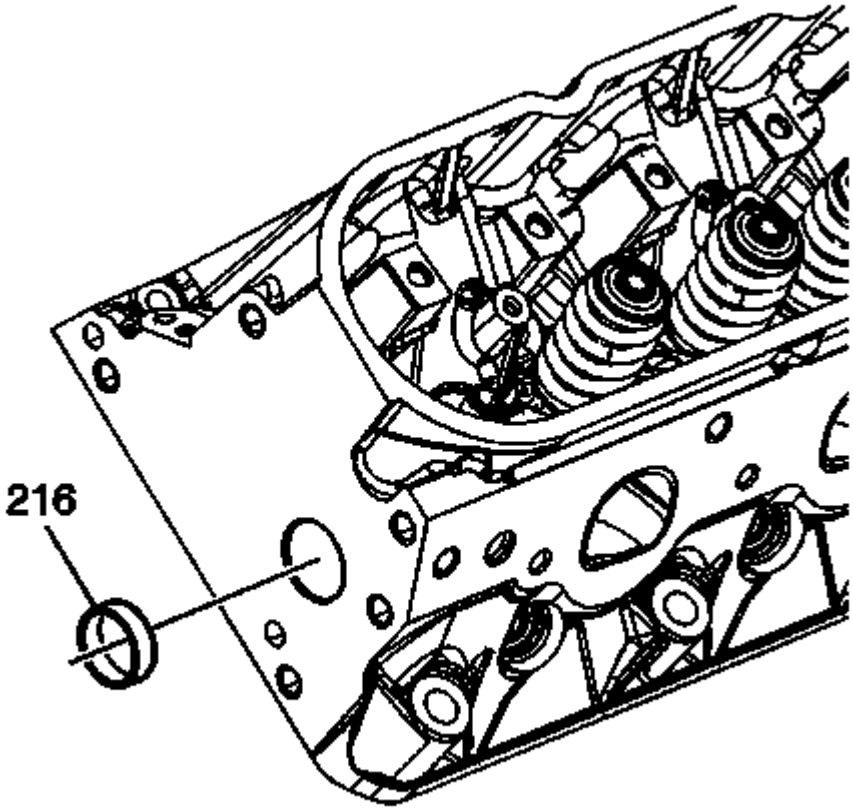

Fig. 483: Locating Cylinder Head Core Hole Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the cylinder head core hole plugs (216), as required.

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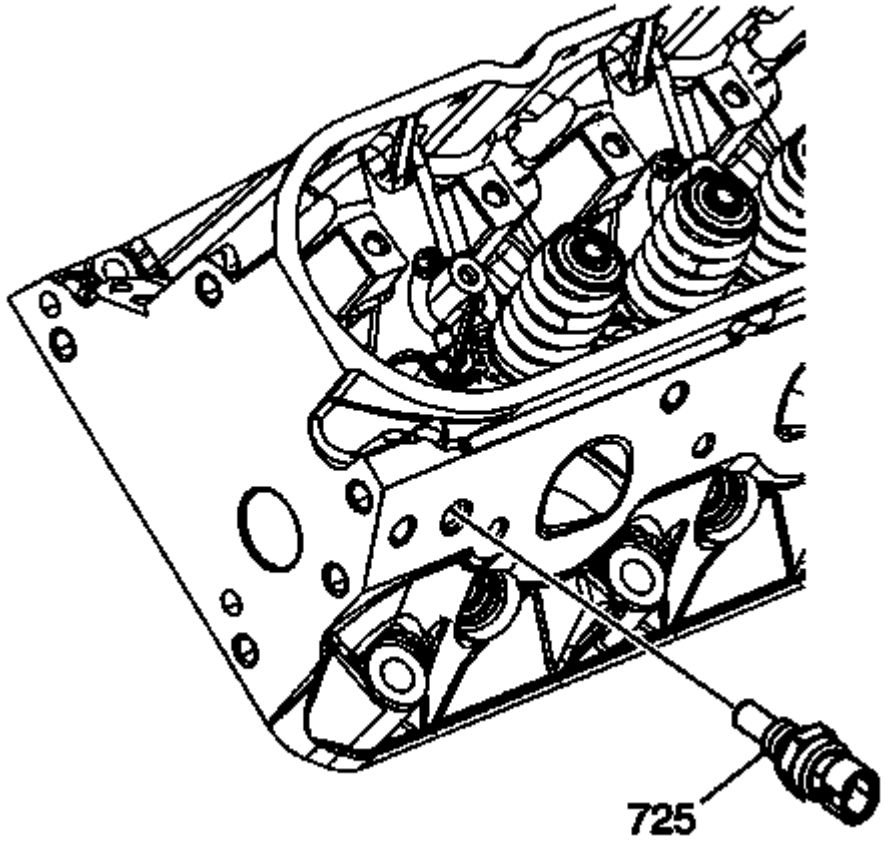

Fig. 484: Locating Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

9. Remove the coolant temperature sensor (725) from the left cylinder head.

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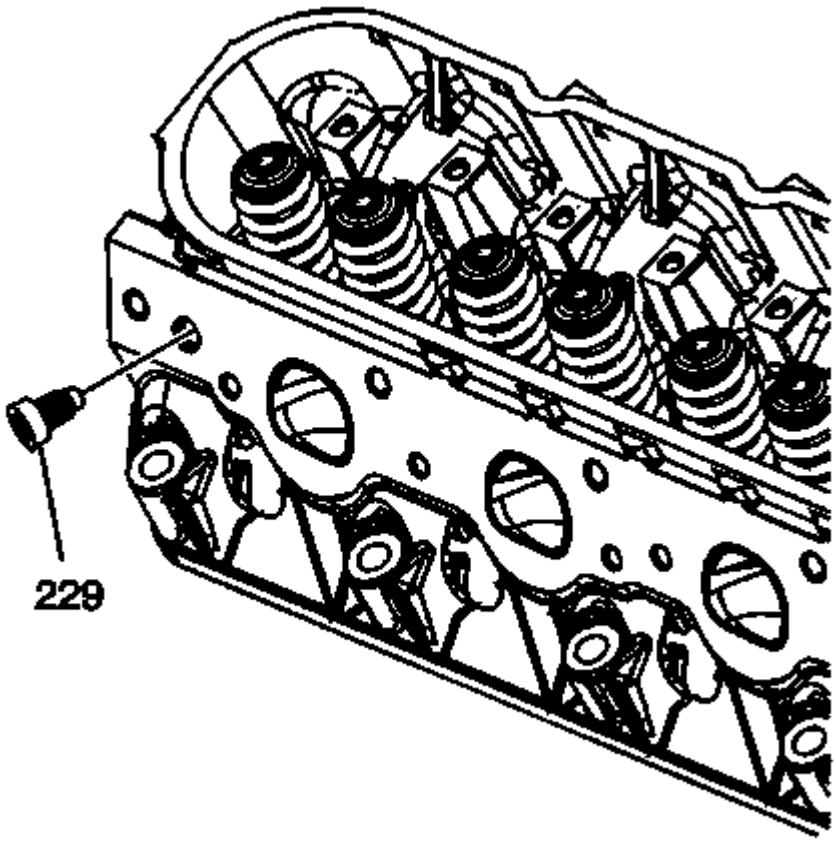

Fig. 485: Locating Coolant Plug
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plug (229) from the right cylinder head.

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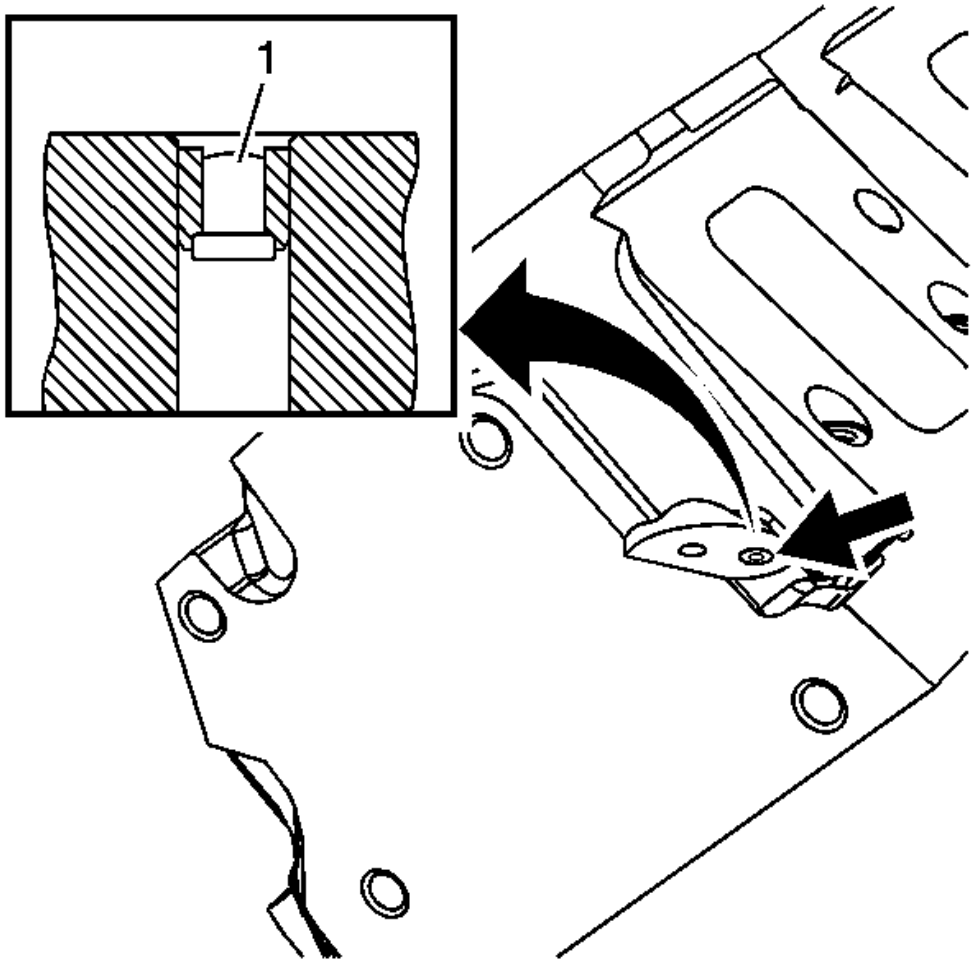

Fig. 486: Rivet-Type Plug
Courtesy of GENERAL MOTORS CORP.

11. Inspect for a leaking plug (1) at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug.

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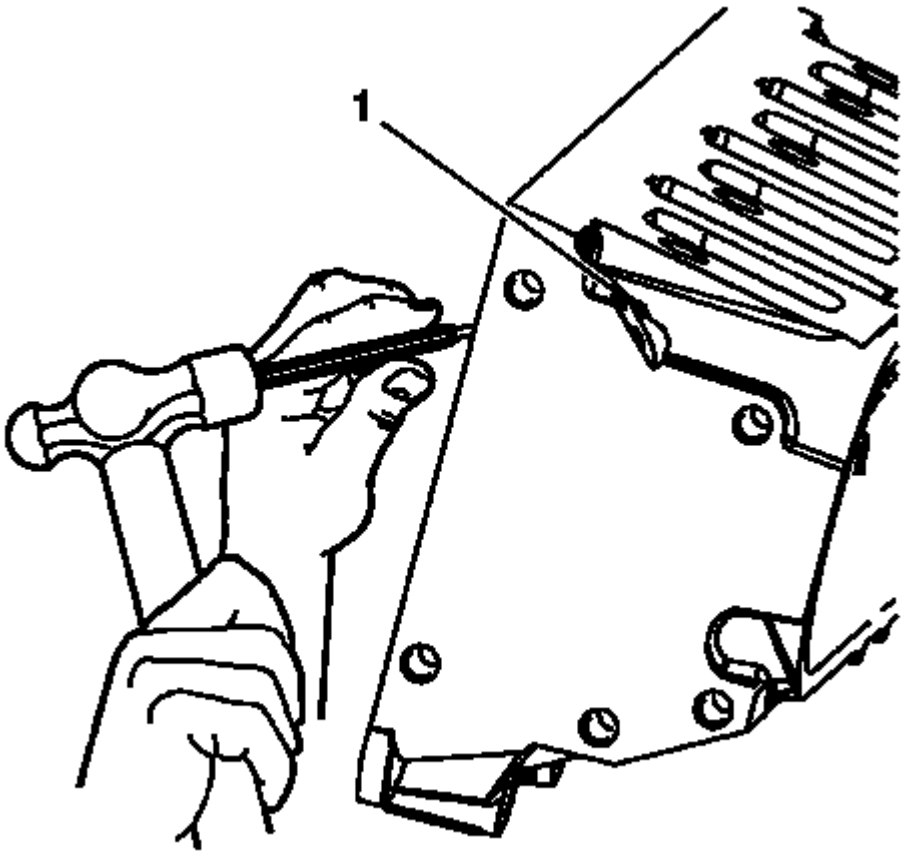

Fig. 487: View Of Plug Assembly
Courtesy of GENERAL MOTORS CORP.

12. Using a 6.43 mm (0.25 in) or smaller punch, remove the plug assembly (1) from the cylinder head.

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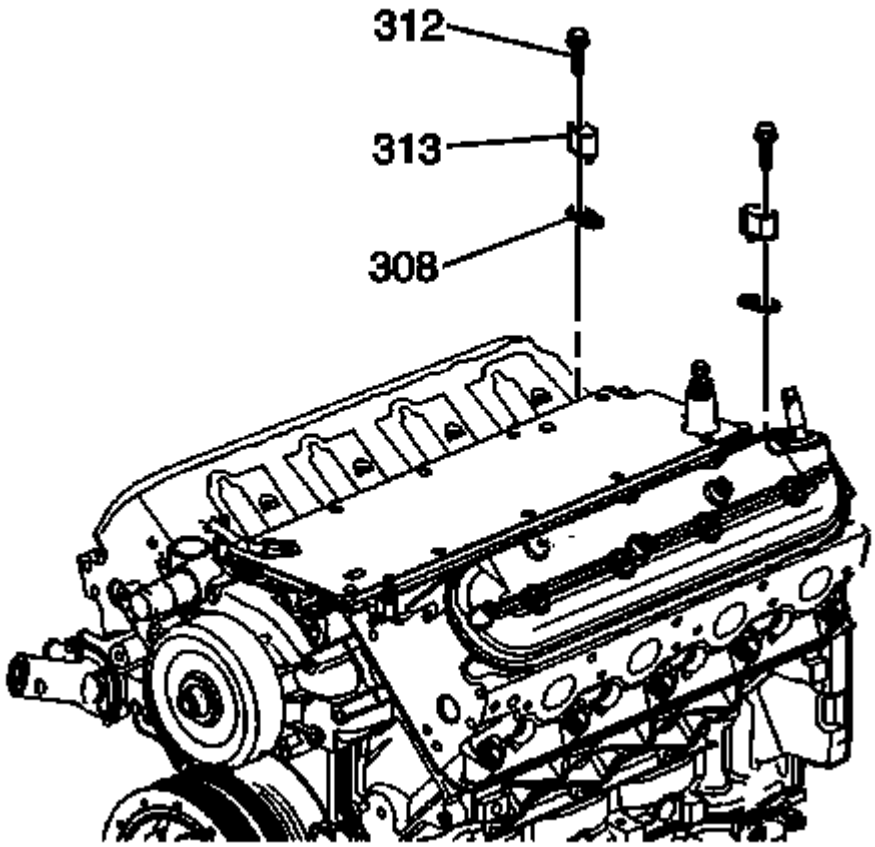

Fig. 488: Engine Coolant Air Bleed Cover, Bolts & Seals
Courtesy of GENERAL MOTORS CORP.

13. If plug removal is required, install either a new plug or a first design coolant air bleed cover (313), seal (308), and bolt (312) to complete the repair. Refer to **Cylinder Head Assemble**

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **J 8089:** Carbon Removal Brush
- **J 9666:** Valve Spring Tester

For equivalent regional tools, refer to **Special Tools**.

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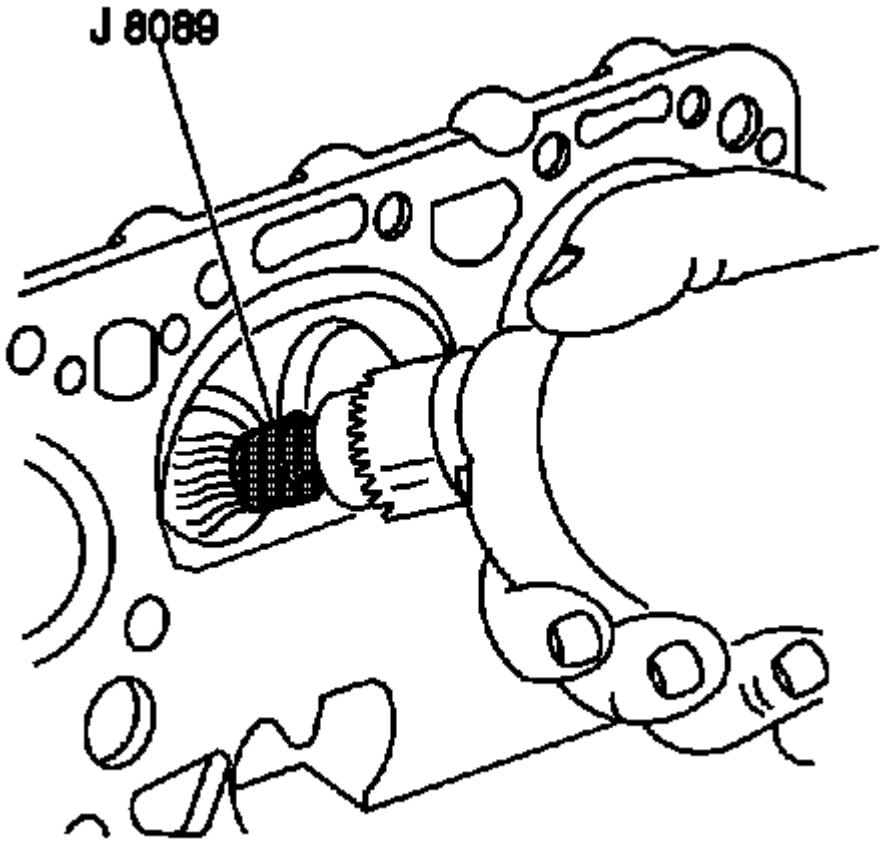

Fig. 489: Cleaning Carbon Using J 8089
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

NOTE:

- **When cleaning a cylinder head in a thermal type oven, do not exceed 204°C (400°F).**
- **Be careful not to scuff the chamber.**

1. Clean the following components:
   - Use the **J 8089:** brush in order to remove the carbon from the combustion chambers.
   - Gasket surfaces

     Refer to **Replacing Engine Gaskets** .

   - Valve stems and heads on a buffing wheel
   - Bolt hole threads

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Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:
    1. Cracks in the exhaust ports and combustion chambers
    2. External cracks in the water chambers
    3. Gasket surfaces for excessive scratches or gouging

       Refer to **Replacing Engine Gaskets** .

    4. Bolt hole threads for debris or damaged threads

       Refer to **Thread Repair** or **Thread Repair Specifications** .

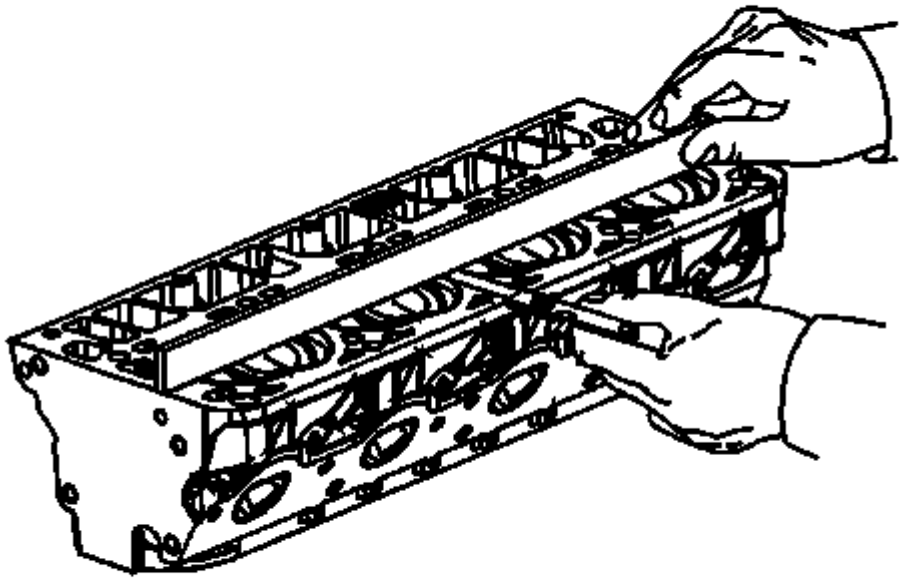

Fig. 490: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications**.

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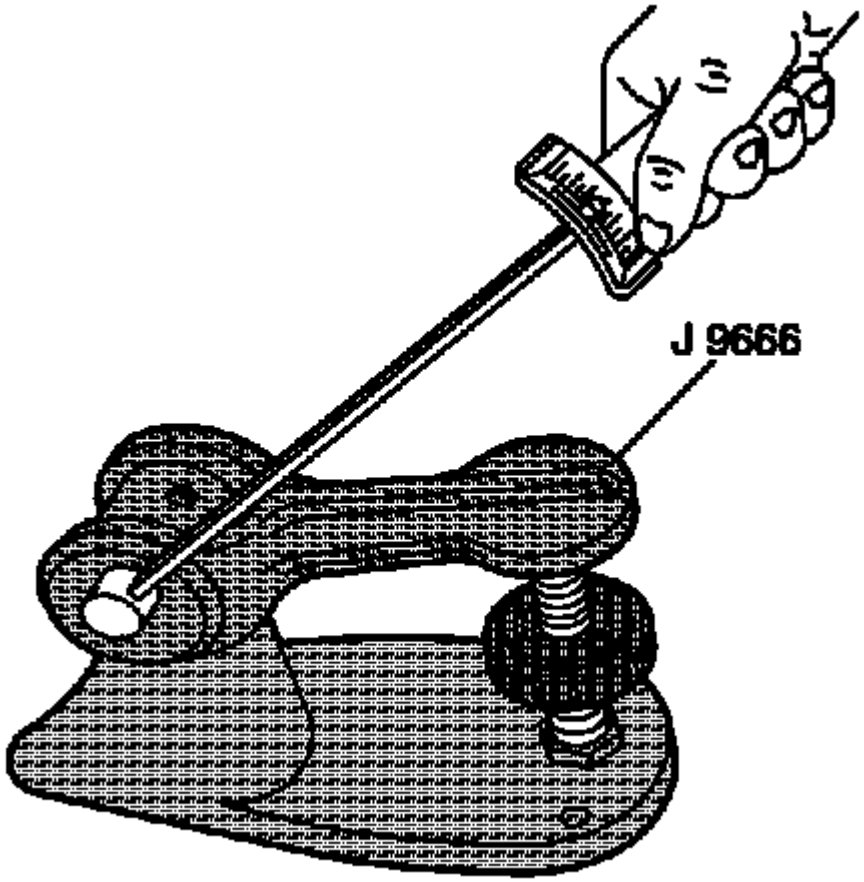

Fig. 491: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 9666:** tester in order to measure the valve spring tension. Refer to **Engine Mechanical Specifications**.

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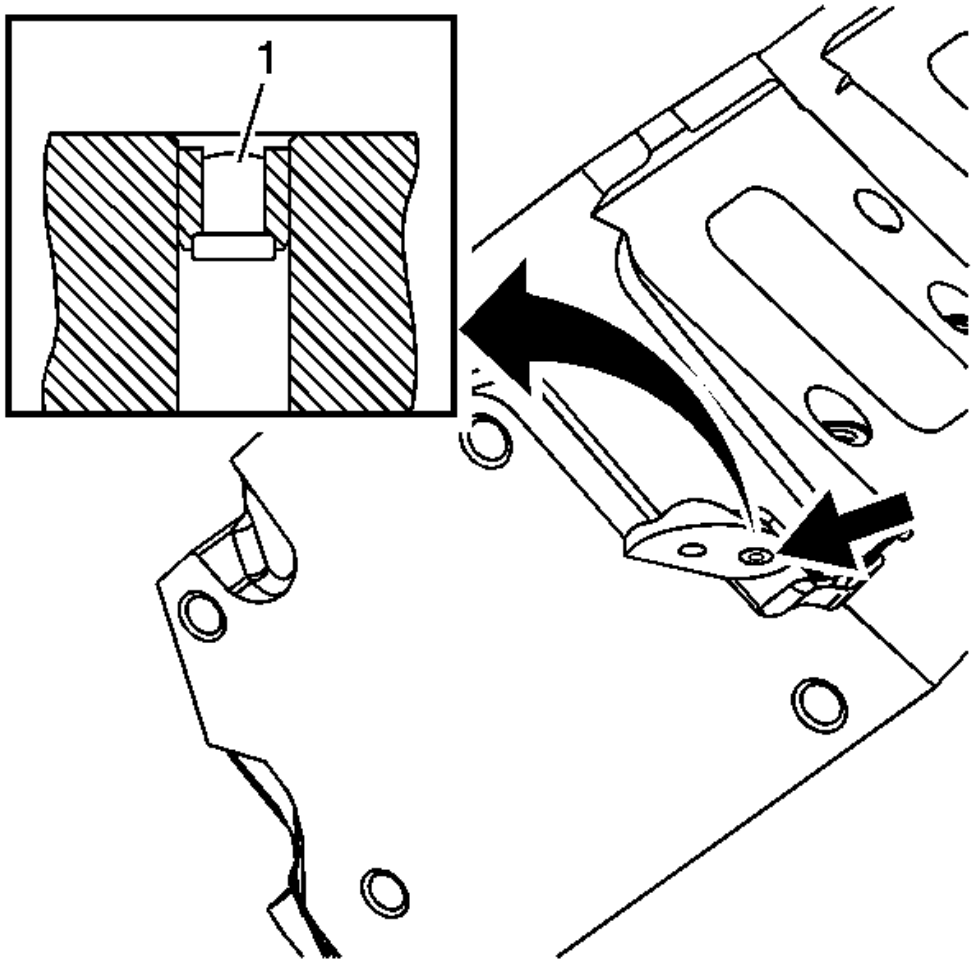

Fig. 492: Rivet-Type Plug
Courtesy of GENERAL MOTORS CORP.

5. Inspect for a leaking plug (1) at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug. Refer to **Cylinder Head Disassemble**.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Special Tools

J 8001: Dial Indicator Set

For equivalent regional tools, refer to **Special Tools**.

Valve Guide Reaming

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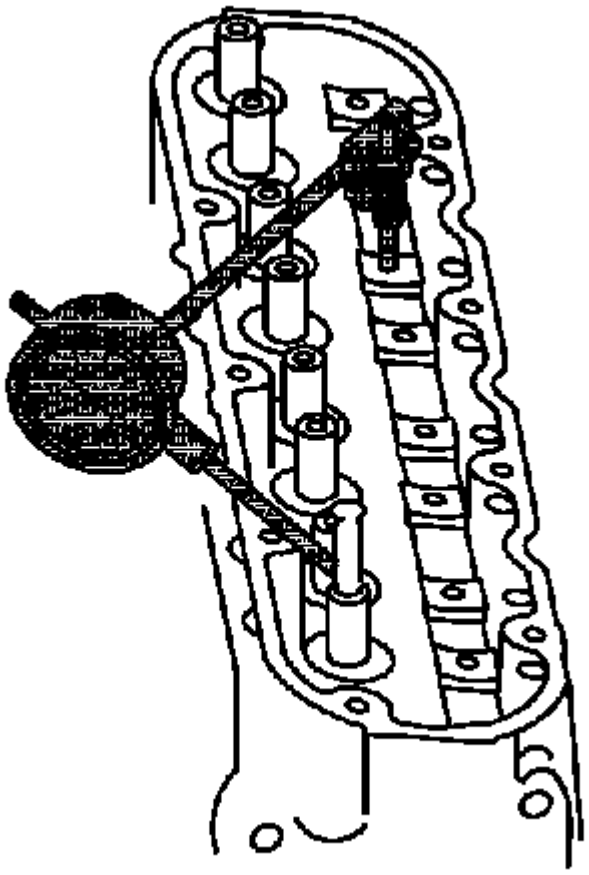

Fig. 493: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

CAUTION: 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 the **J 8001:** 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 gauge to measure the guide bore.

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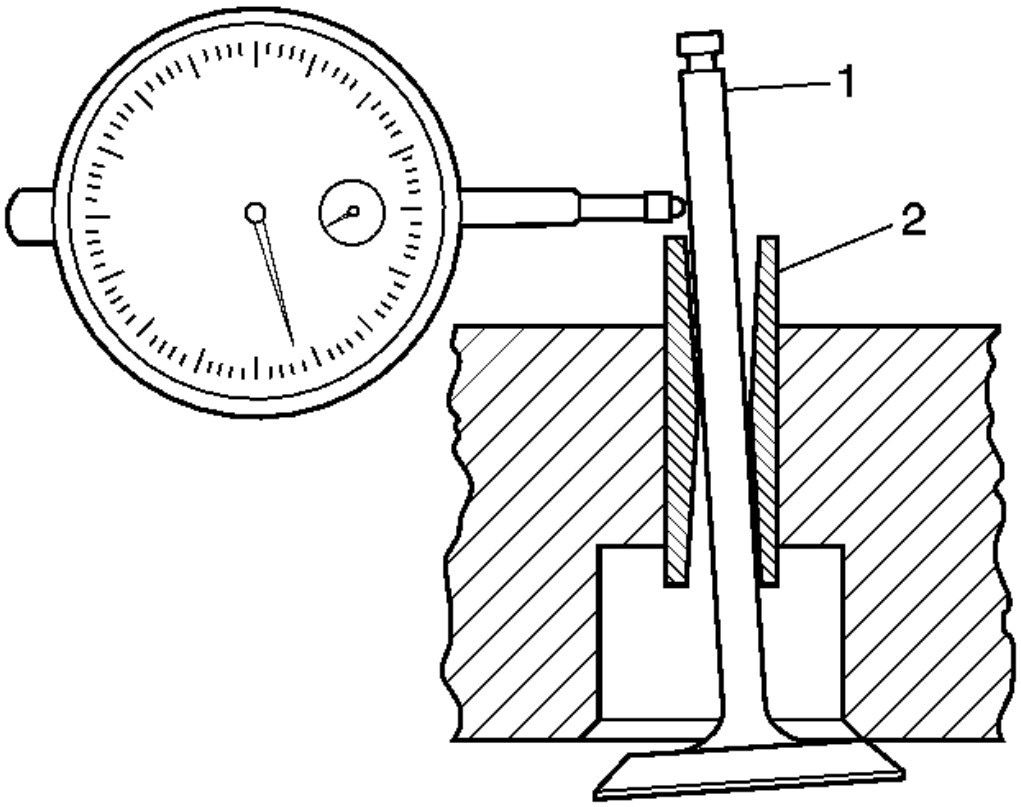

Fig. 494: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

2. If the clearance measurement between the valve stem (1) and guide (2) is not within specification, the valve and/or the cylinder head must be replaced. Refer to **Engine Mechanical Specifications**.

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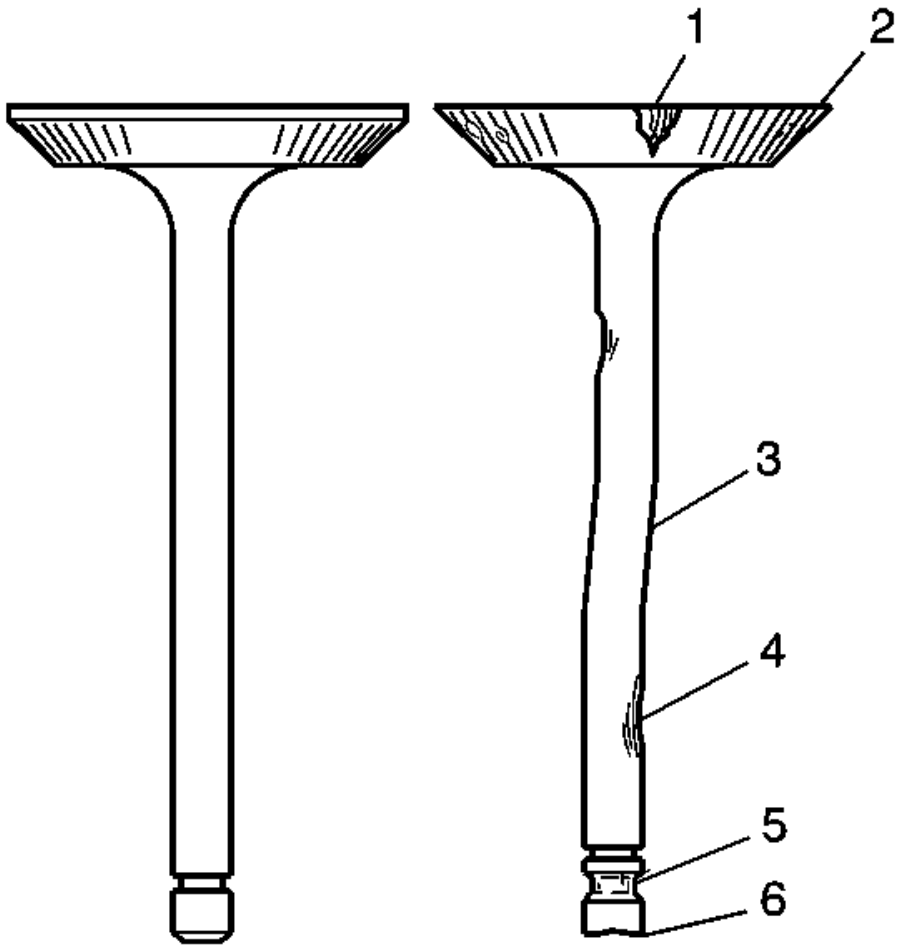

Fig. 495: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

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. If the valve stem diameter is not within specification, the valve must be replaced. Refer to **Engine Mechanical Specifications**.

   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

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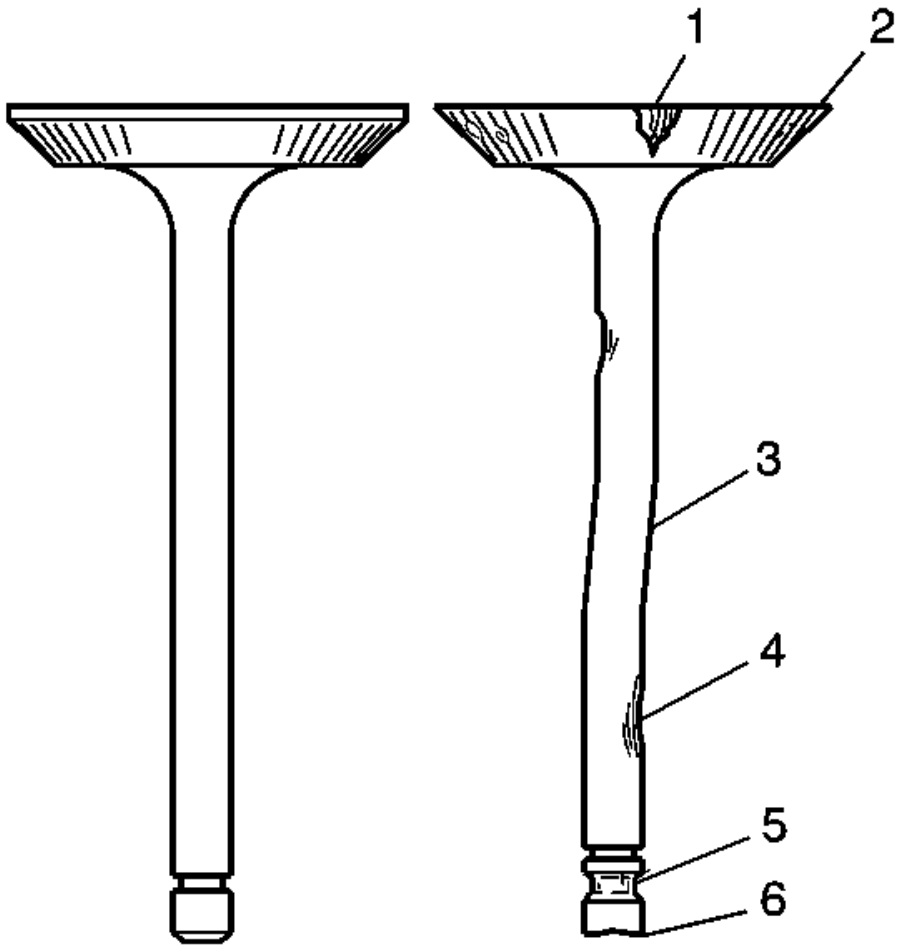

Fig. 496: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**

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stems that show excessive wear, or valves that are warped excessively must be replaced. When a valve head that is warped excessively is refaced, a knife edge may be ground on part or all of the valve head due to the amount of metal that must be removed. Knife edges lead to breakage, burning or pre-ignition due to heat localizing on this knife edge. If the edge of the valve head, margin, is not within specification 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)

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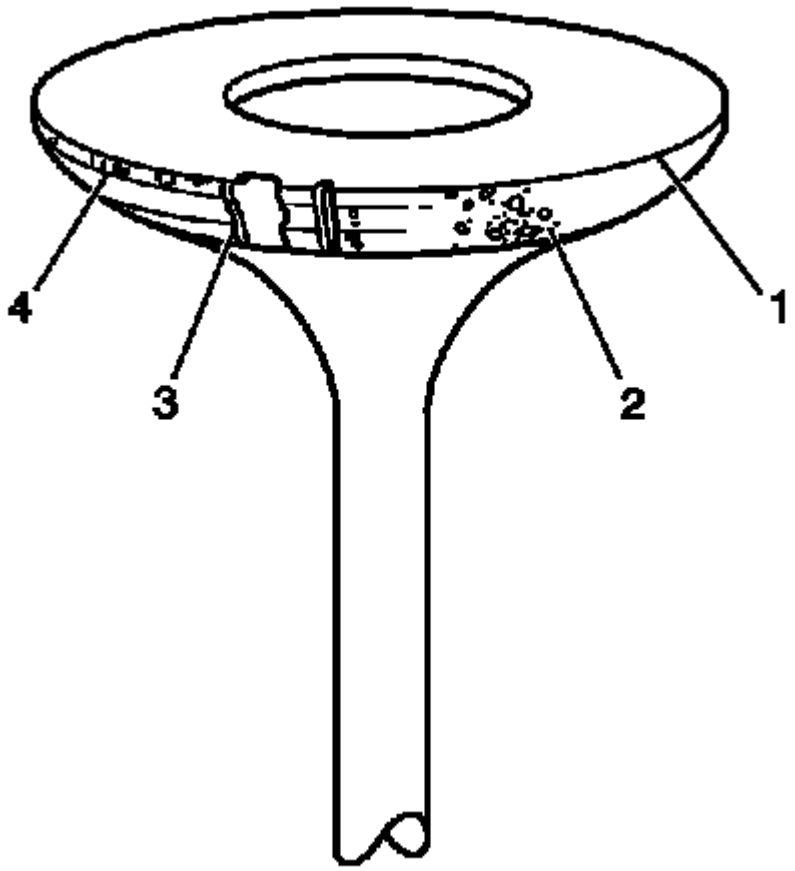

Fig. 497: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve face for the following conditions:
    - Worn or no margin (1 or 4)
    - Pitted surfaces (2)
    - Burnt or eroded areas (3)

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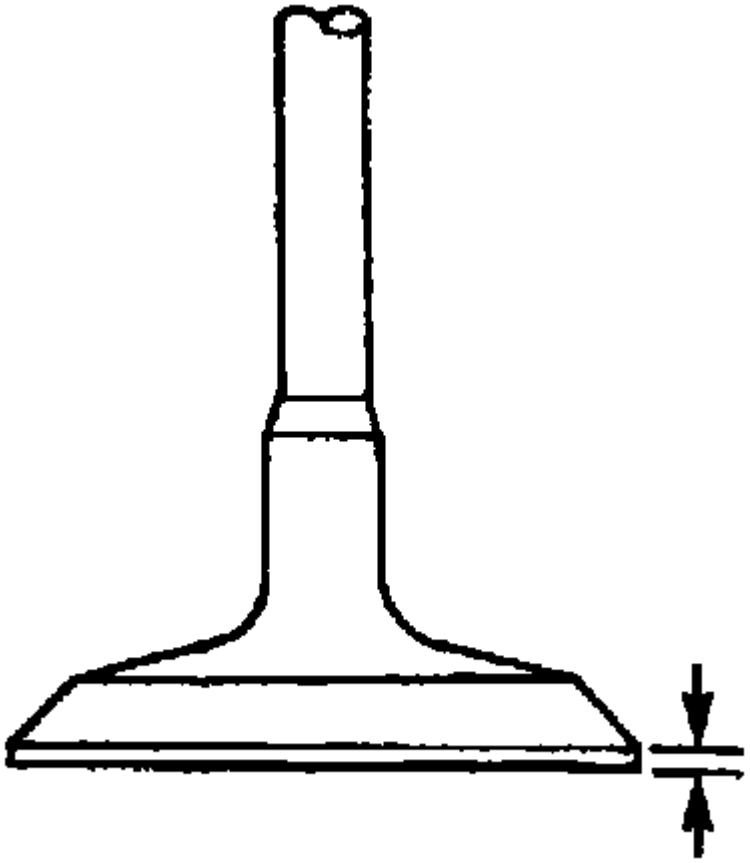

Fig. 498: Inspecting Valve Margin
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valve margin.

   The exhaust valve may be refaced if the margin is within specification before grinding. Refer to **Engine Mechanical Specifications**.

4. Reface pitted exhaust valves on a suitable valve refacing machine.
5. Replace the valve if the margin is not within specification after grinding. Refer to **Engine Mechanical Specifications**.
6. If the valve face has been ground, measure the valve spring installed height after reassembly of the cylinder head. The valve, and/or cylinder head must be replaced if the valve spring installed height is not within specification. Refer to **Cylinder Head Assemble**.
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.

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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 the centerline of the guide, measure valve seat runout. The total indicator runout reading must be within specification. Refer to **Engine Mechanical Specifications**.
    - If the valve seat has been ground, measure the valve spring installed height after reassembly of the cylinder head. The cylinder head, and/or valve must be replaced if the valve spring installed height is not within specification after seat grinding. Refer to **Cylinder Head Assemble**.

CYLINDER HEAD ASSEMBLE

Special Tools

J 8062: Valve Spring Compressor - Head Off

For equivalent regional tools, refer to **Special Tools**

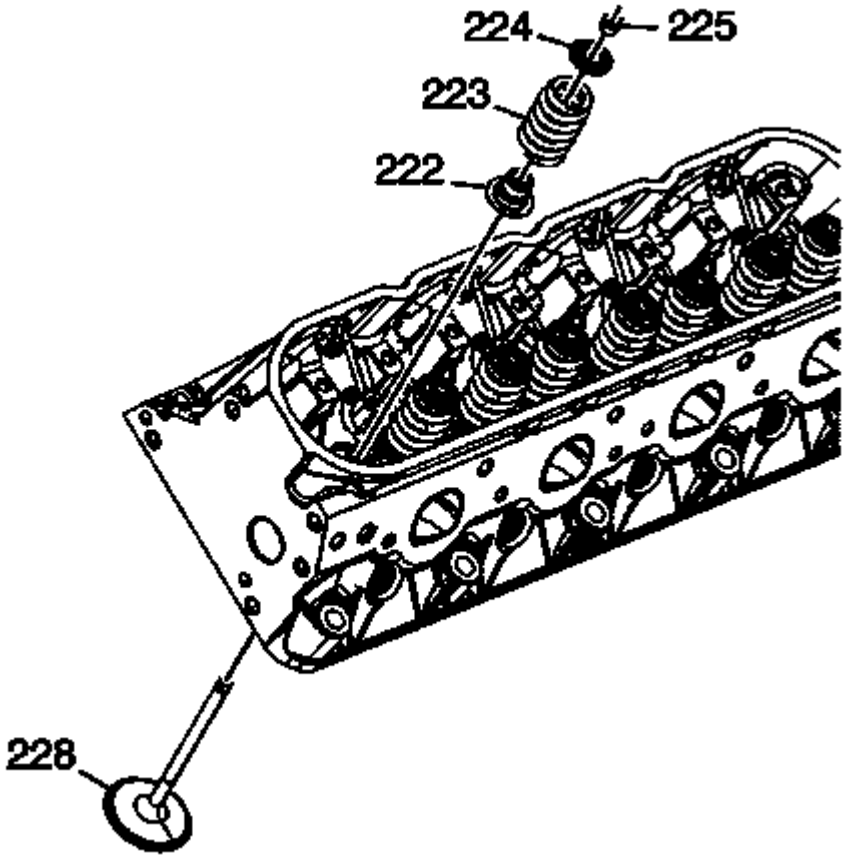

Fig. 499: Valve Stem Keys, Valve Spring Cap & Valve Spring

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Courtesy of GENERAL MOTORS CORP.

1. Clean the cylinder head valve spring shim area.

NOTE: 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 a NEW valve stem oil seal (222).
4. Install the valve spring (223).
5. Install the valve spring cap (224).

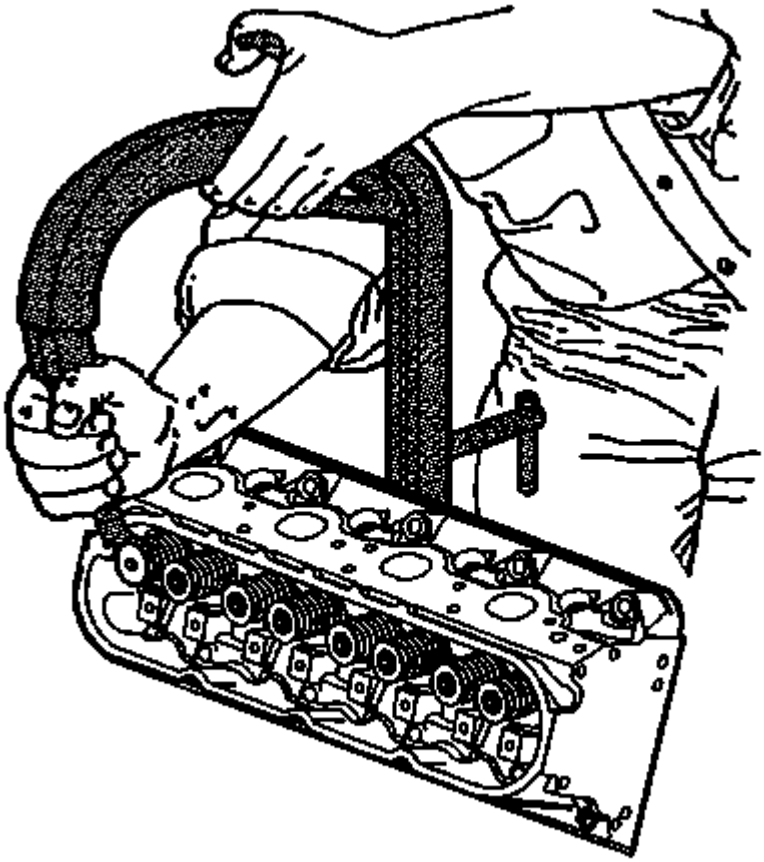

Fig. 500: Compressing Valve Spring Using
Courtesy of GENERAL MOTORS CORP.

6. Using the **J 8062:** spring compressor, compress the valve spring.
7. Install the valve stem keys.
    1. Use grease in order to hold the keys in place and remove the **J 8062:** spring compressor .

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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.

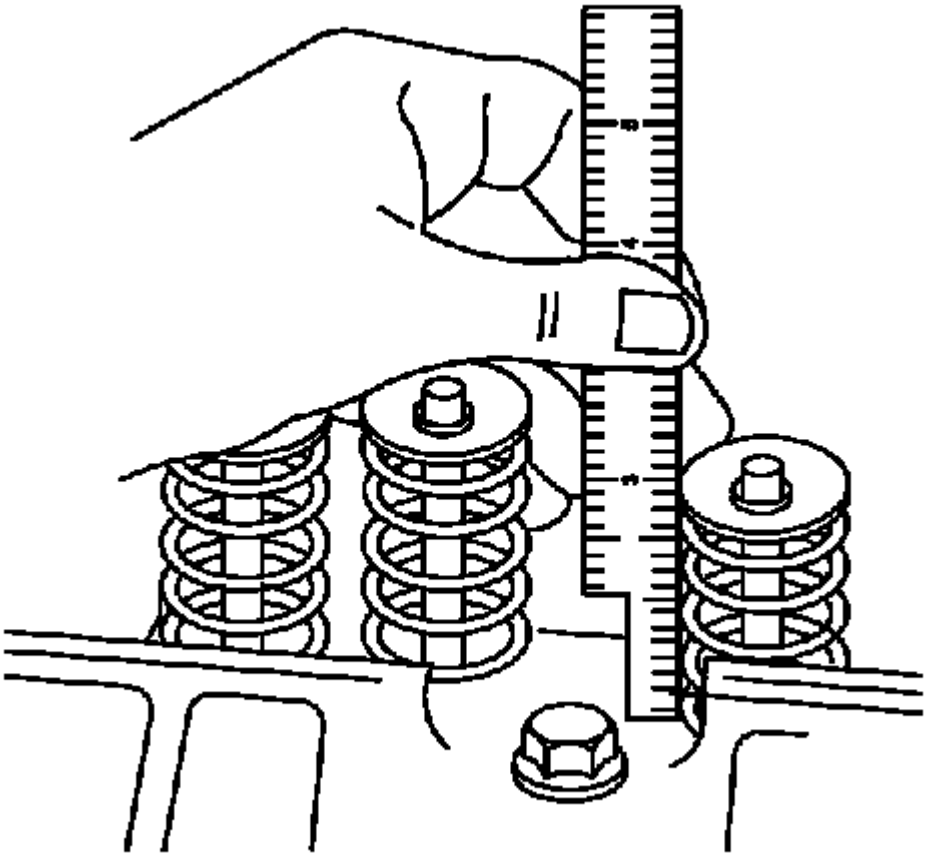

Fig. 501: Measuring Valve Spring Installed Height
Courtesy of GENERAL MOTORS CORP.

8. After installation, measure the valve spring installed height.

   Measure from the base of the valve spring to the top of the valve spring. If the spring installed height is not within specification, the valve and/or cylinder head must be replaced. Refer to **Engine Mechanical Specifications**

9. Install the remaining valves, springs, and other components.

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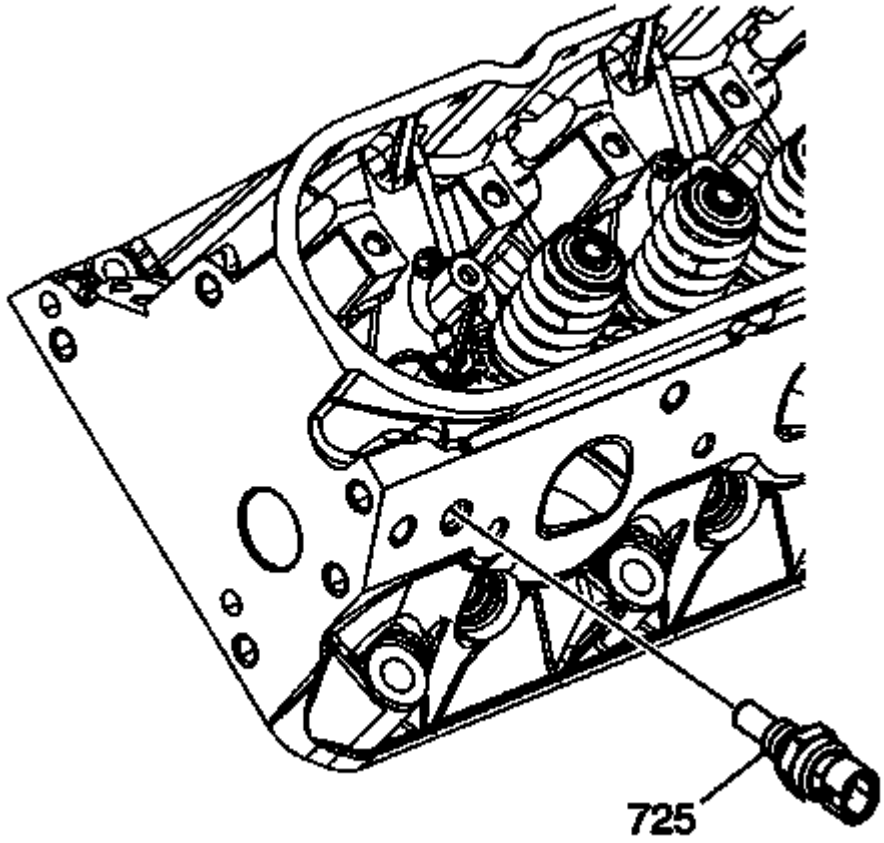

Fig. 502: Locating Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the coolant temperature sensor (725).

CAUTION: Refer to Fastener Caution

11. Install the coolant temperature sensor into the left cylinder head and tighten to 20 N.m (15 lb ft).

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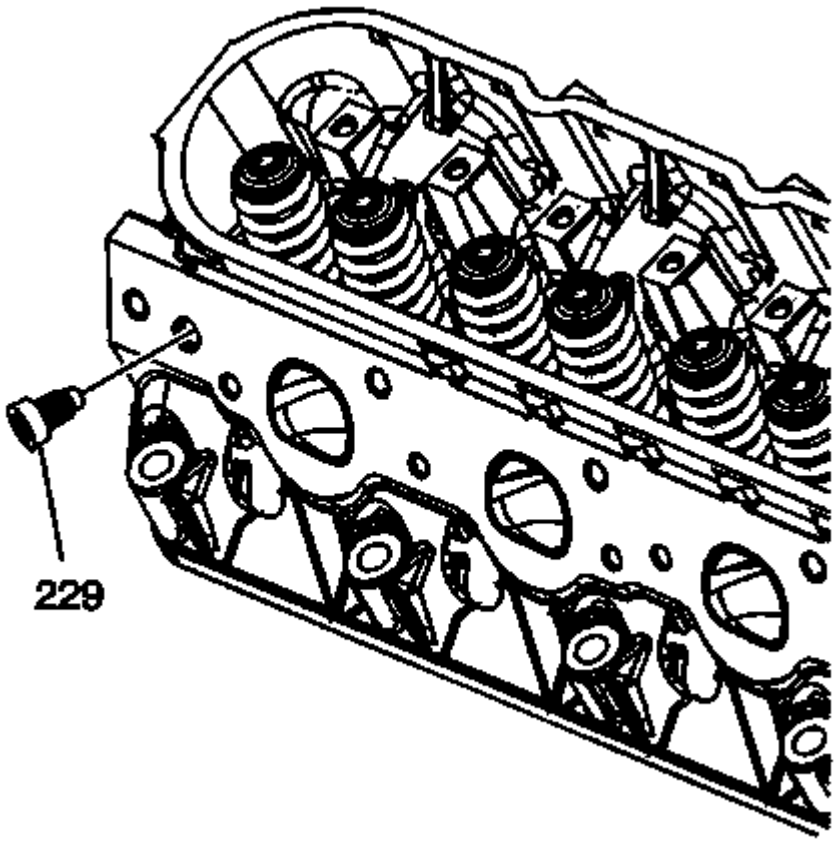

Fig. 503: Locating Coolant Plug
Courtesy of GENERAL MOTORS CORP.

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 and tighten to 20 N.m (15 lb ft).

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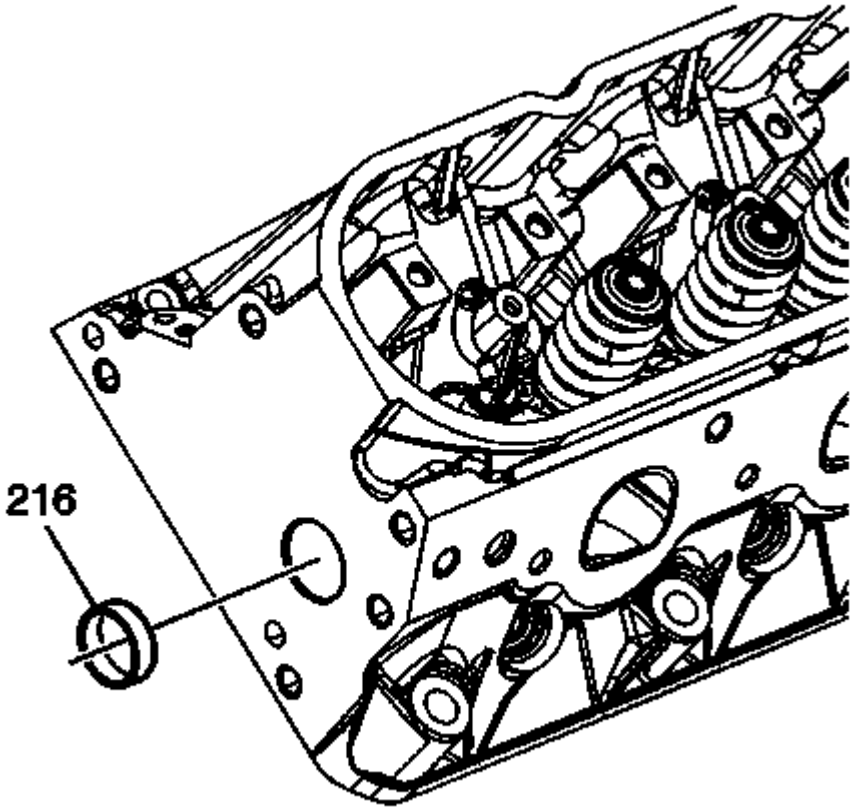

Fig. 504: Locating Cylinder Head Core Hole Plug
Courtesy of GENERAL MOTORS CORP.

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.

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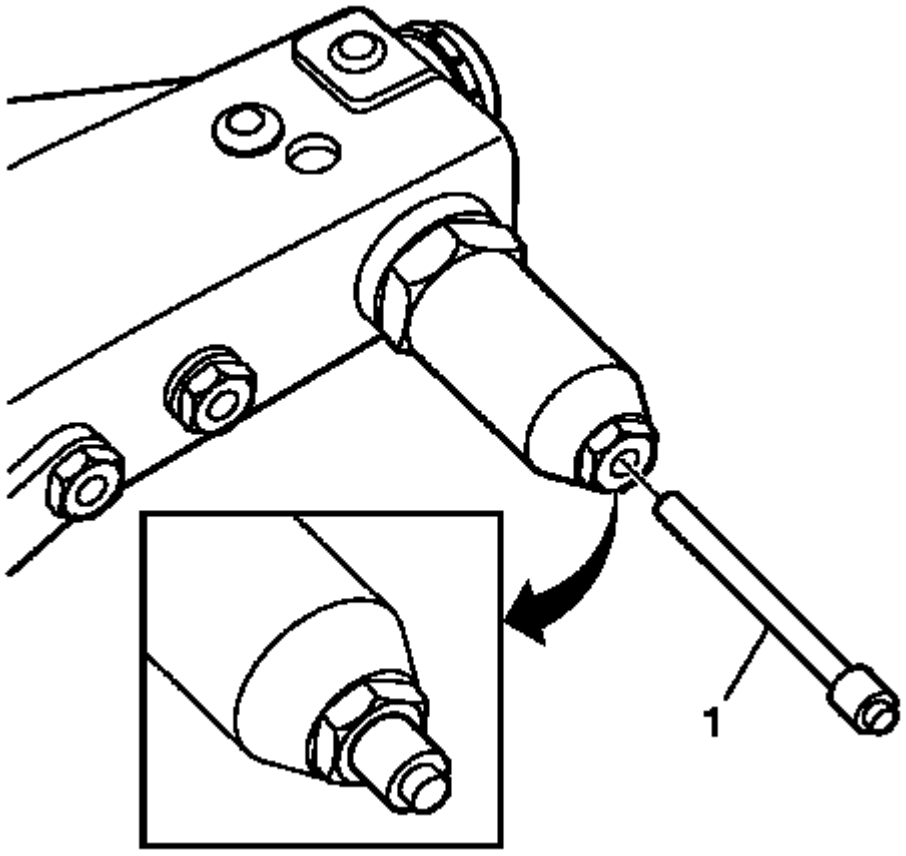

Fig. 505: Rivet Plug
Courtesy of GENERAL MOTORS CORP.

16. Install the rivet plug (1) into a rivet gun.

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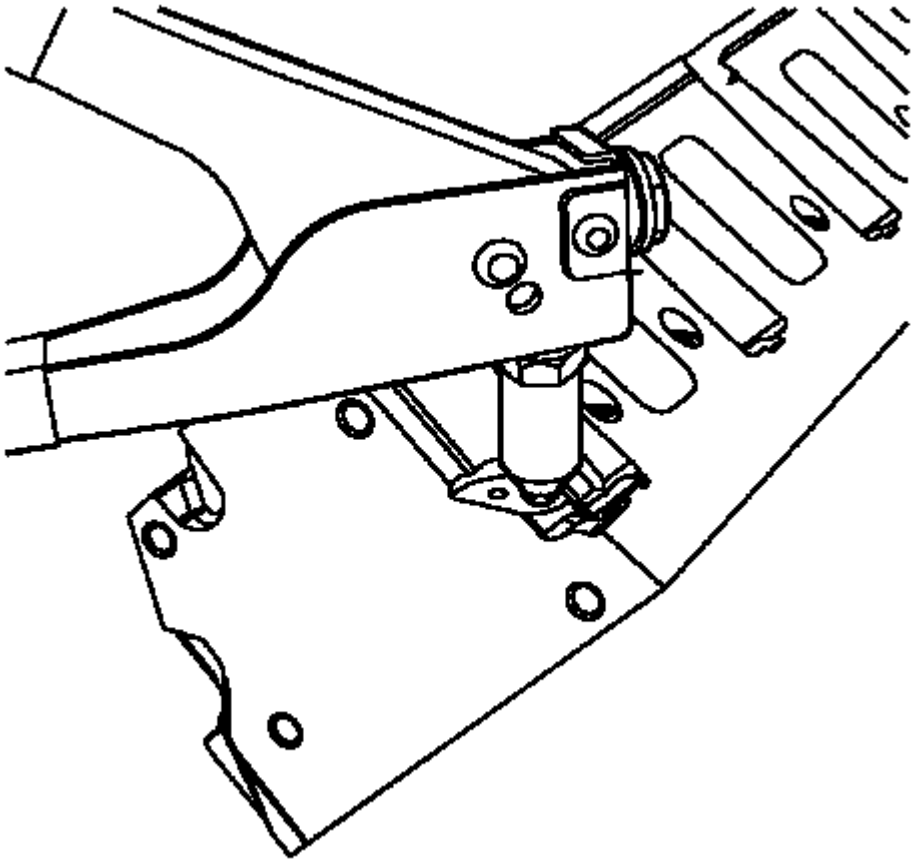

Fig. 506: Illustrating Rivet Installation
Courtesy of GENERAL MOTORS CORP.

17. Insert the rivet into the coolant passage of the cylinder head.
18. Squeezing the handle of the tool, install the rivet.

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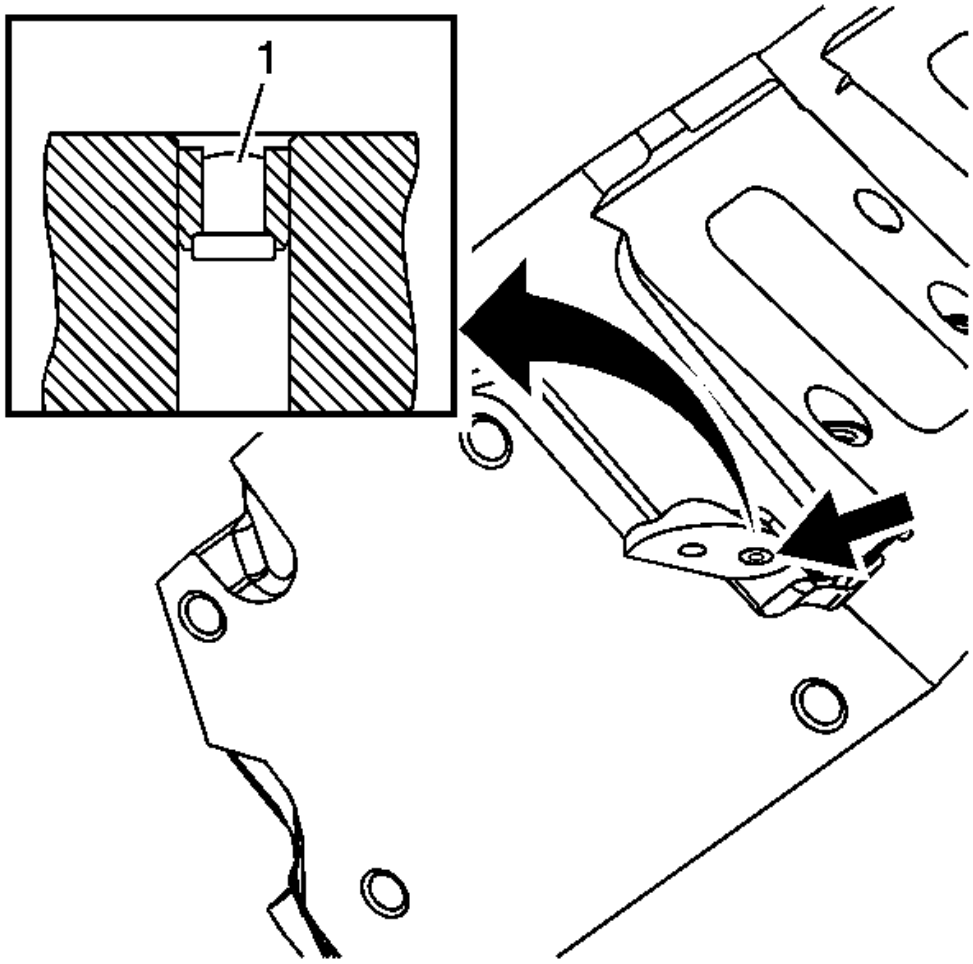

Fig. 507: Rivet-Type Plug
Courtesy of GENERAL MOTORS CORP.

19. Inspect for proper installation of the rivet (1).

    A properly installed plug should be installed flush with the surface of the head.

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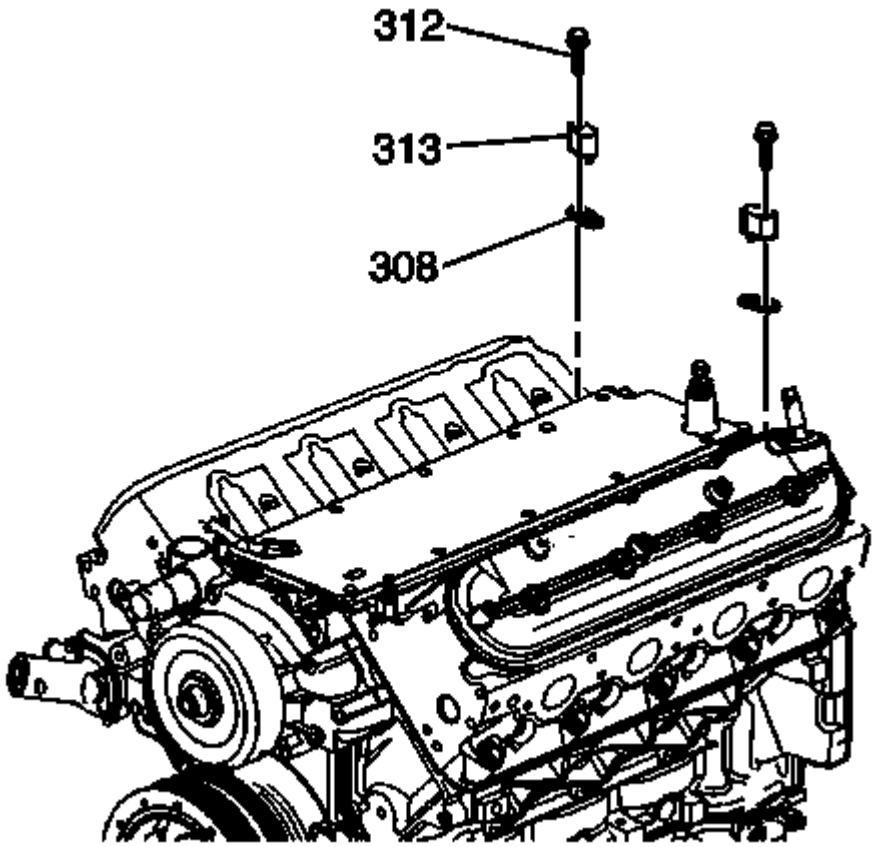

Fig. 508: Engine Coolant Air Bleed Cover, Bolts & Seals
Courtesy of GENERAL MOTORS CORP.

20. Installation of the first design coolant air bleed cover (313) and bolt (312) may be used instead of the rivet plug to complete the repair. Tighten the coolant air bleed bolts to 12 N.m (106 lb in).

OIL PUMP DISASSEMBLE

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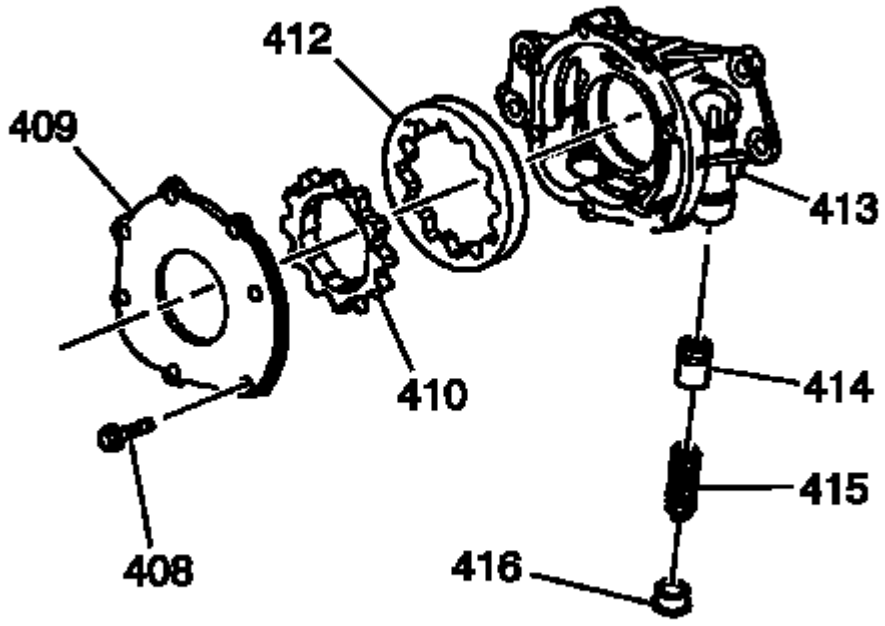

Fig. 509: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The internal parts of the oil pump assembly are not serviced separately, excluding the spring. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

1. Remove the oil pump cover bolts (408).
2. Remove the oil pump cover (409).

IMPORTANT: Mark or identify the gears for assembly. Refer to Separating Parts.

3. Remove the drive gear (410).
4. Remove the driven gear (412).
5. Remove the pressure relief valve plug (416).
6. Remove the pressure relief valve spring (415).
7. Remove the pressure relief valve (414).
8. Inspect the oil pump components. Refer to **Oil Pump Cleaning and Inspection**.

OIL PUMP CLEANING AND INSPECTION

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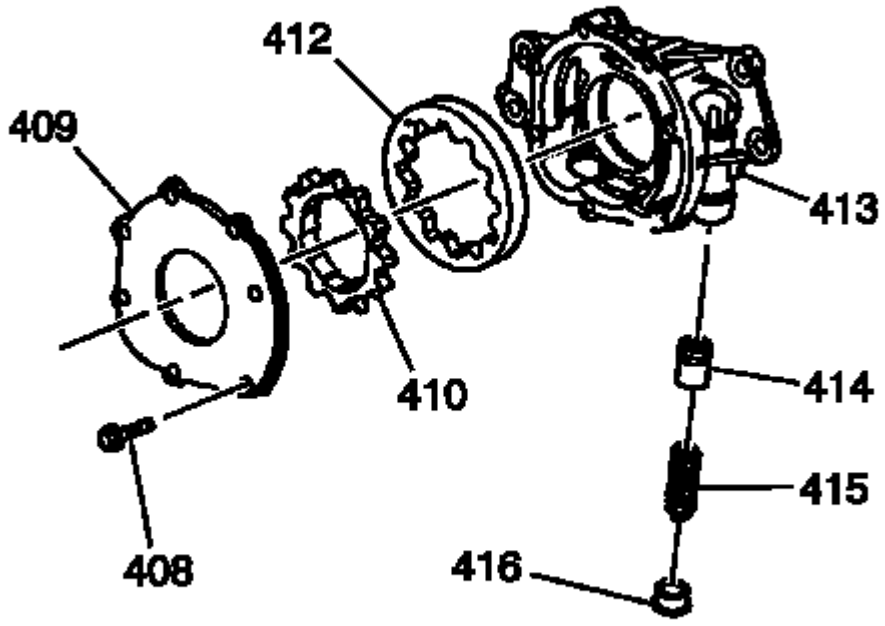

Fig. 510: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The internal components 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.

WARNING: Refer to Safety Glasses Warning .

2. Dry the parts with compressed air.
3. Inspect the oil pump housing (413) and the cover (409) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-engine block oil gallery surface for scratches or gouging.

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5. Inspect the oil pump housing for damaged bolt hole threads.
6. Inspect the relief valve plug (416) and plug bore for damaged threads.
7. Inspect the oil pump internal oil passages for restrictions.
8. Inspect the drive gear (410) and driven gear (412) for chipping, galling, or wear.

   Minor burrs or imperfections on the gears may be removed with a fine oil stone.

9. Inspect the drive gear splines for excessive wear.
10. Inspect relief valve spring (415) for cracks, scratches, and wear to coils in spring.
11. Inspect the pressure relief valve (414) and bore for scoring or wear.

    The valve must move freely in the bore, with no restrictions.

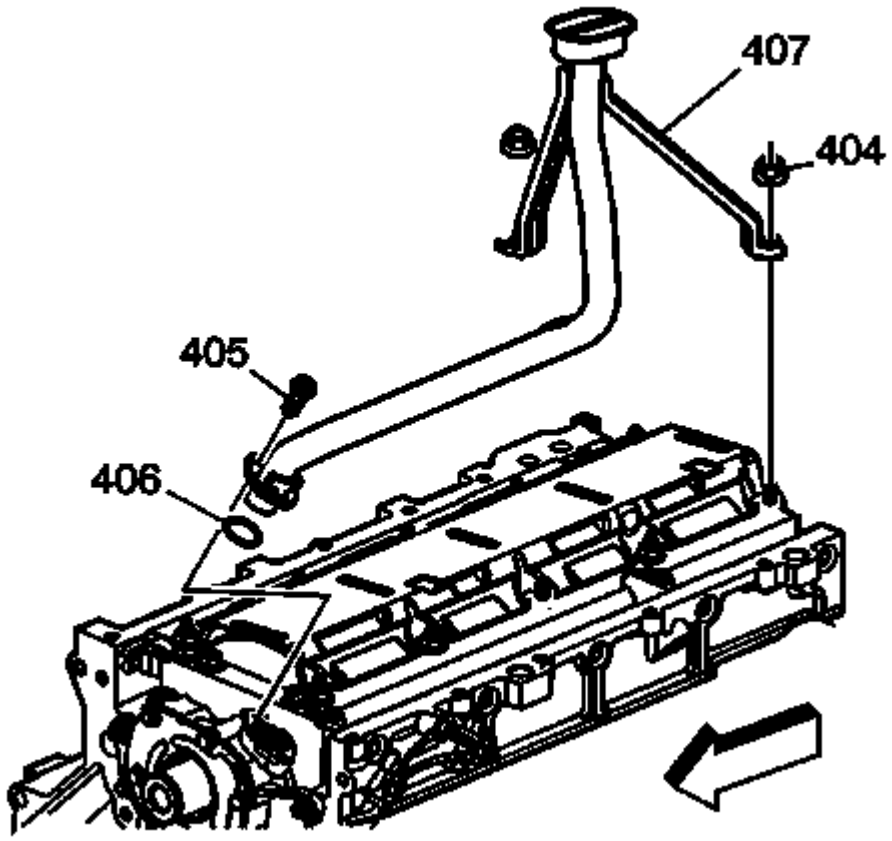

Fig. 511: View Of Oil Pump Screen, Bolt, Nuts, & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

12. Inspect the oil pump screen (407) for debris or restrictions.
13. Inspect the oil pump screen for broken or loose wire mesh.

OIL PUMP ASSEMBLE

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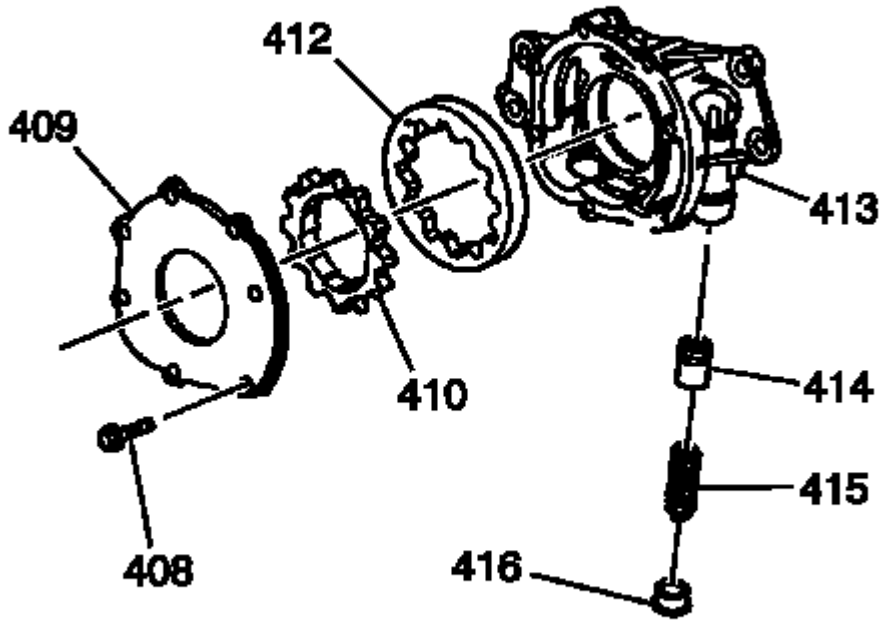

Fig. 512: Exploded View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

NOTE: 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).

CAUTION: Refer to Fastener Caution .

4. Install the oil pump cover bolts (408) and tighten 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) and tighten to 14 N.m (124 lb in).

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8. Inspect the oil pump for smooth operation by rotating the drive gear.

ENGINE FRONT COVER CLEANING AND INSPECTION

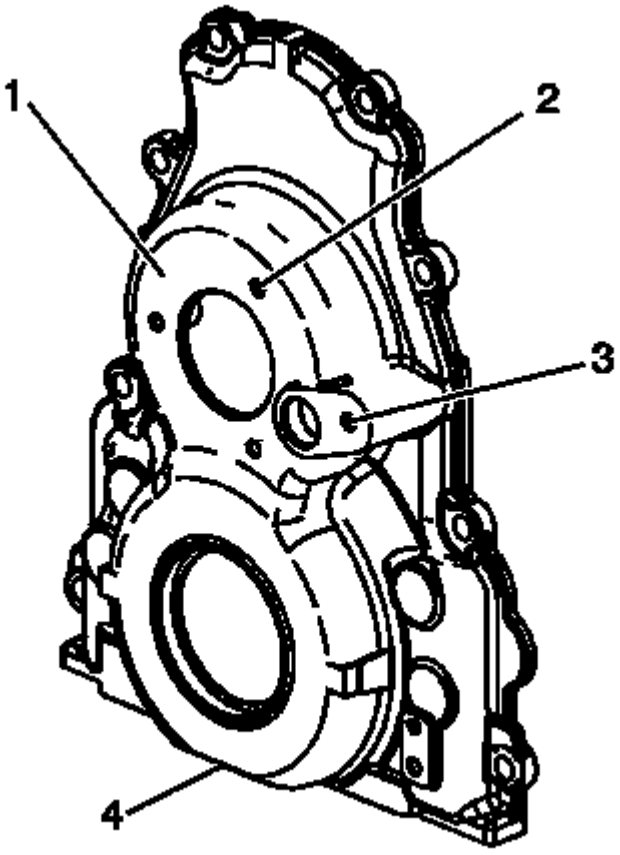

Fig. 513: View Of Gasket Sealing Surfaces & Bolt Holes
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

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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

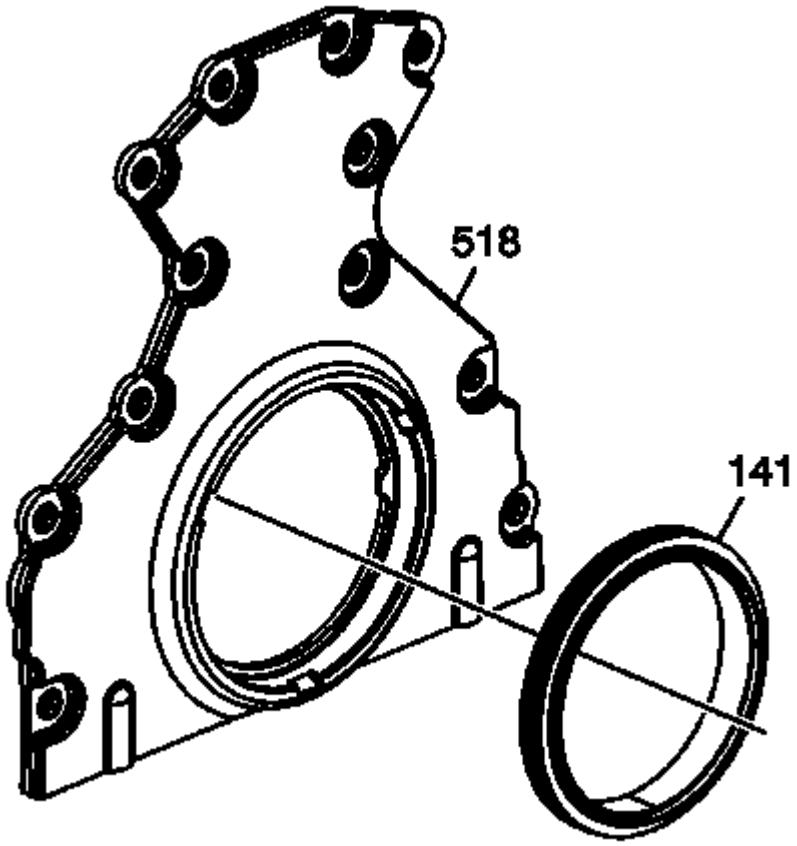

Fig. 514: Crankshaft Rear Oil Seal & Housing
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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**.

WARNING: Refer to Safety Glasses Warning .

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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

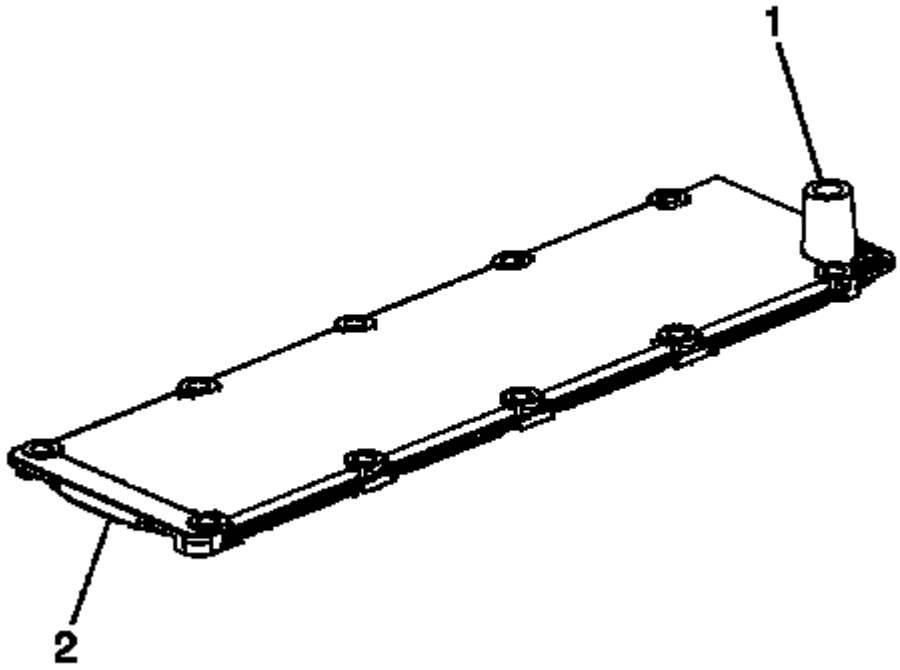

Fig. 515: View Of Engine Valley Cover
Courtesy of GENERAL MOTORS CORP.

1. Clean the valley cover in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry with compressed air.
3. Inspect for damaged threads (1) and damaged sealing surfaces (2).

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VALVE ROCKER ARM COVER CLEANING AND INSPECTION

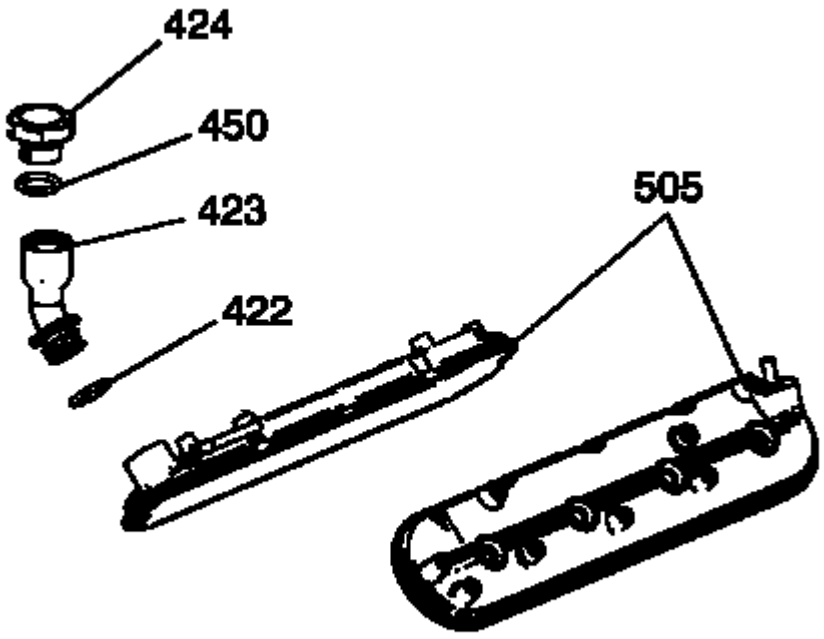

Fig. 516: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

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

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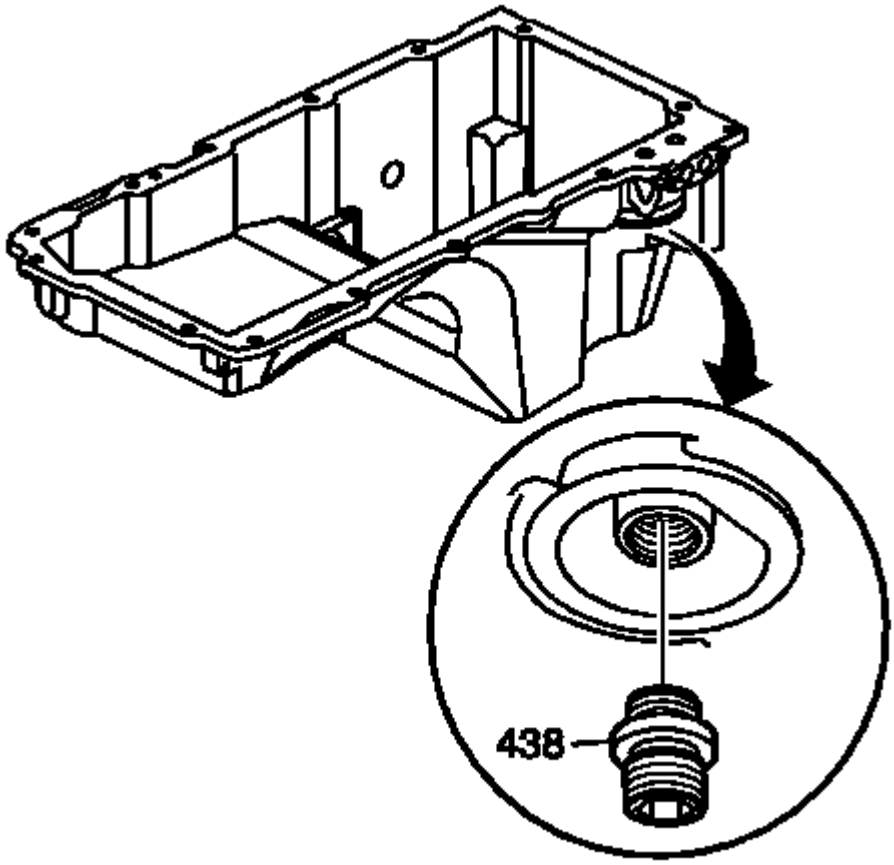

Fig. 517: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil filter fitting (438), as required.

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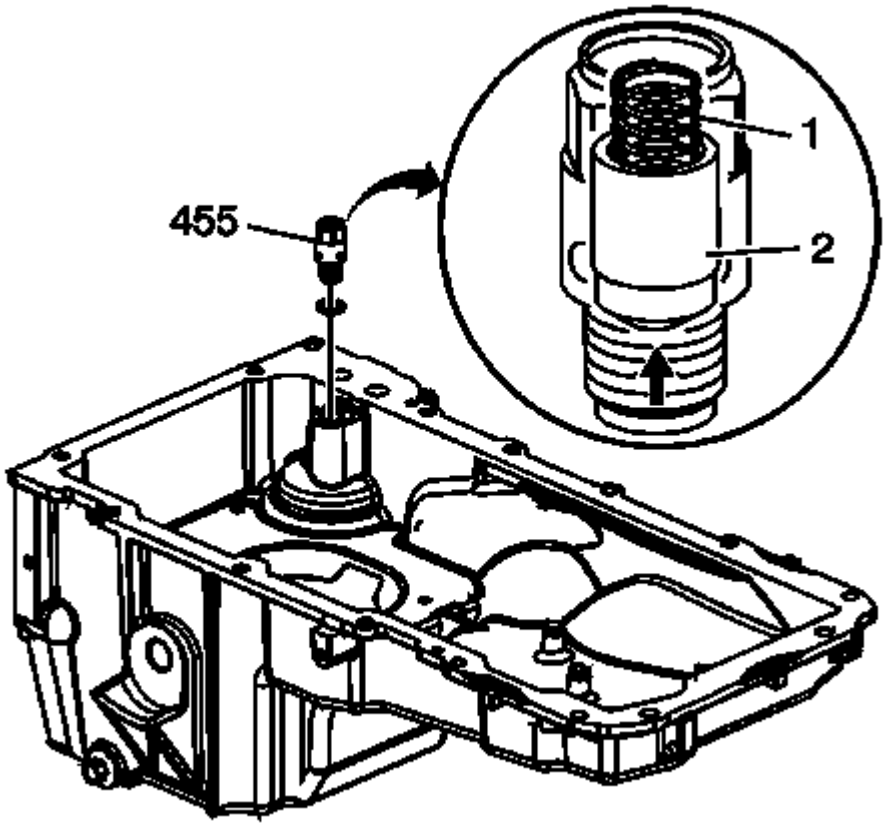

Fig. 518: View Of Oil Pressure Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

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.

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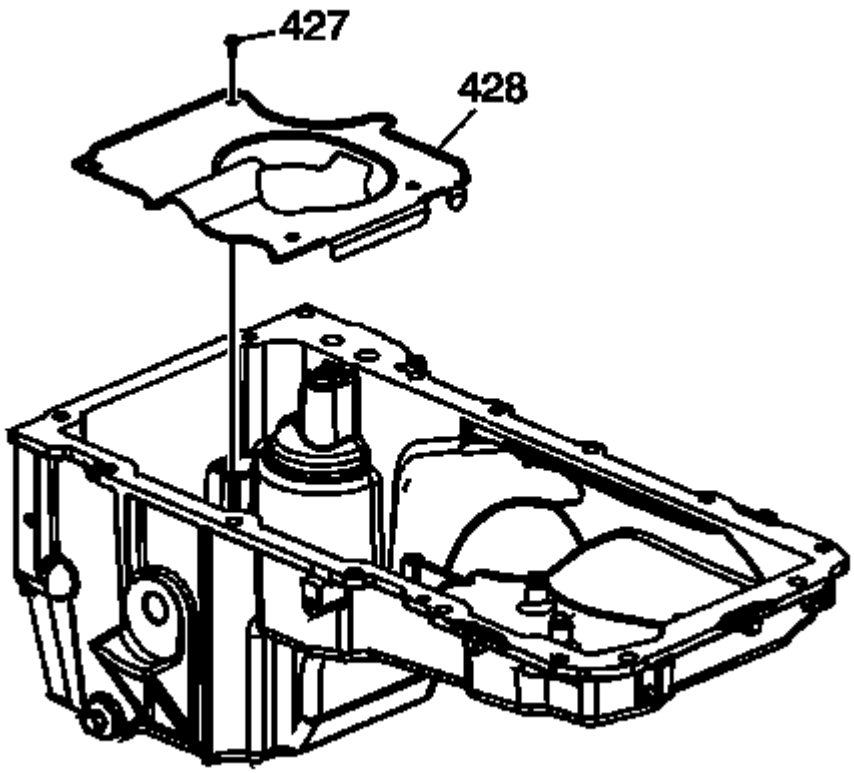

Fig. 519: View Of Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some oil pan baffles may have been attached to the oil pan with rivets. After cleaning the oil pan, if debris is present and cannot be completely removed, oil pan replacement may be necessary.

4. Remove the bolts (427) and baffle (428).

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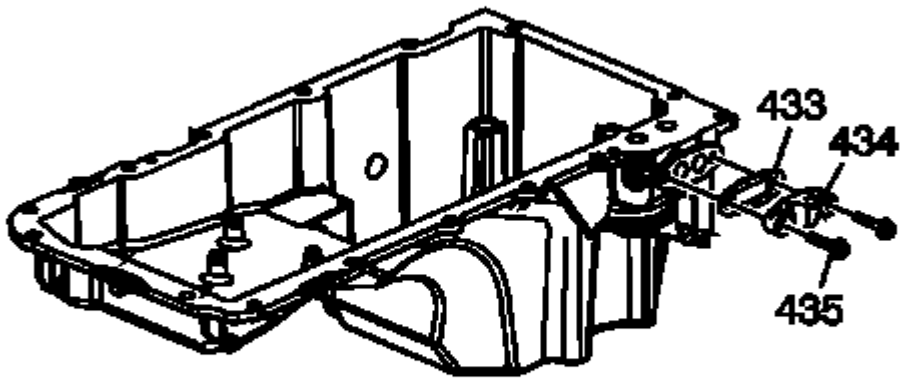

Fig. 520: View Of Oil Pan Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil pan cover (434), bolts (435), and gasket (433).
6. Clean the oil pan in solvent.

WARNING: Refer to Safety Glasses Warning .

7. Dry the oil pan with compressed air.

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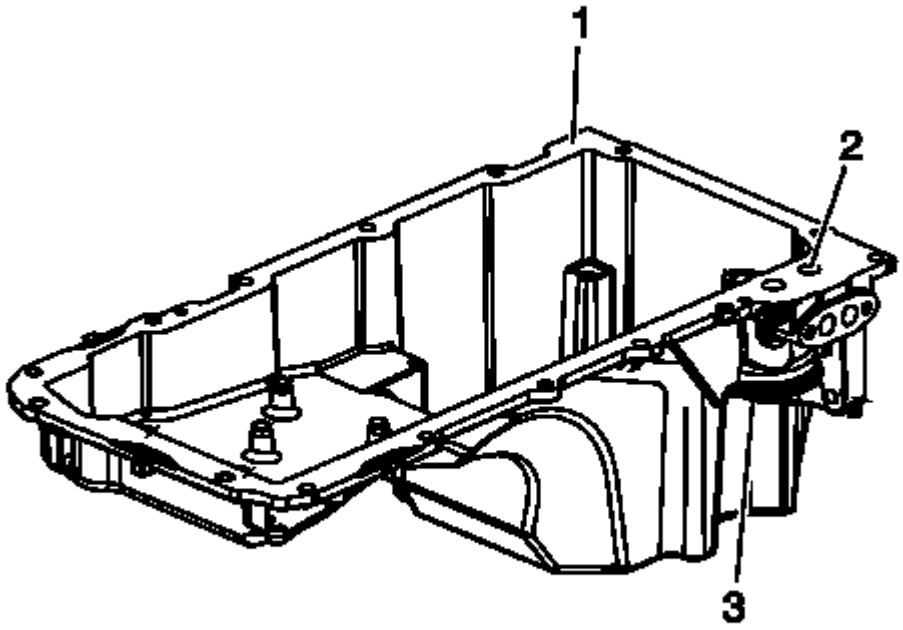

Fig. 521: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

8. 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)

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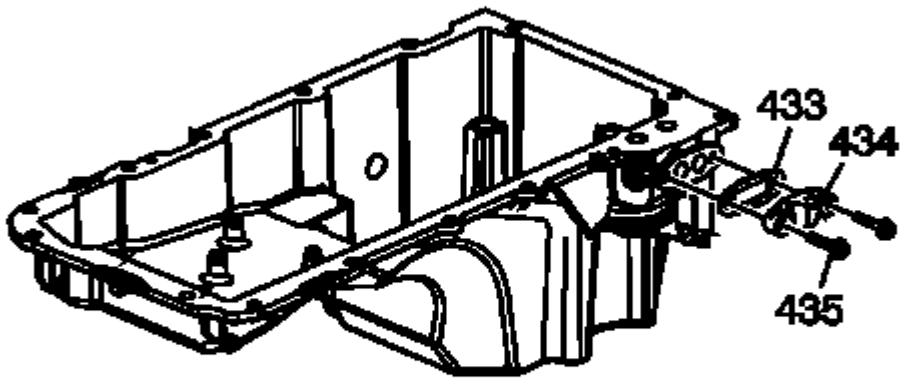

Fig. 522: View Of Oil Pan Cover, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

9. Install the oil pan cover (434), gasket (433), and bolts (435).

CAUTION: Refer to Fastener Caution .

10. Tighten the oil pan cover bolts (435) to 9 N.m (80 lb in).

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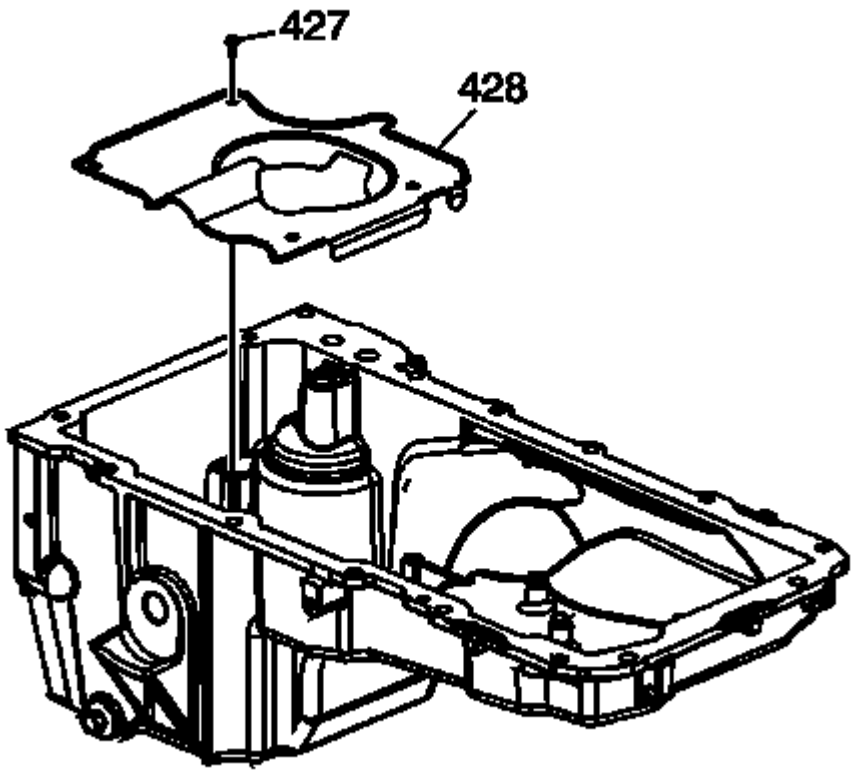

Fig. 523: View Of Baffle & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Some oil pan baffles may have been attached to the oil pan with rivets. After cleaning the oil pan, if debris is present and cannot be completely removed, oil pan replacement may be necessary.

11. Install the oil pan baffle (428) and bolts (427).
12. Tighten the oil pan baffle bolts (427) to 9 N.m (80 lb in).

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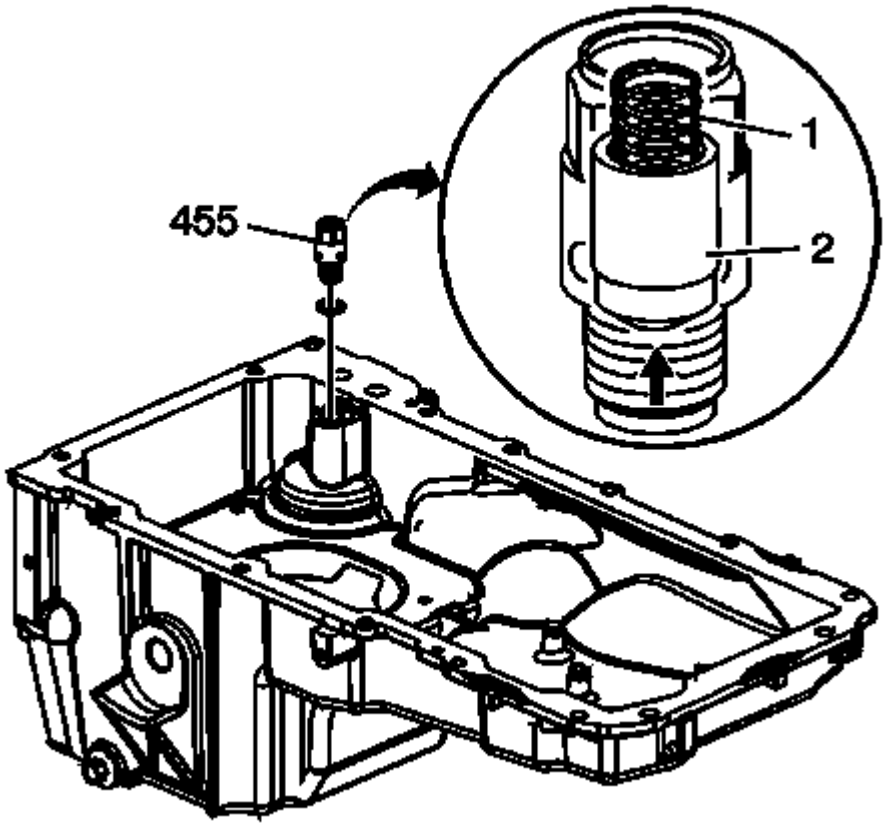

Fig. 524: View Of Oil Pressure Relief Valve Components
Courtesy of GENERAL MOTORS CORP.

13. Install the active fuel management oil pressure relief valve (455) and tighten to 27 N.m (20 lb ft).

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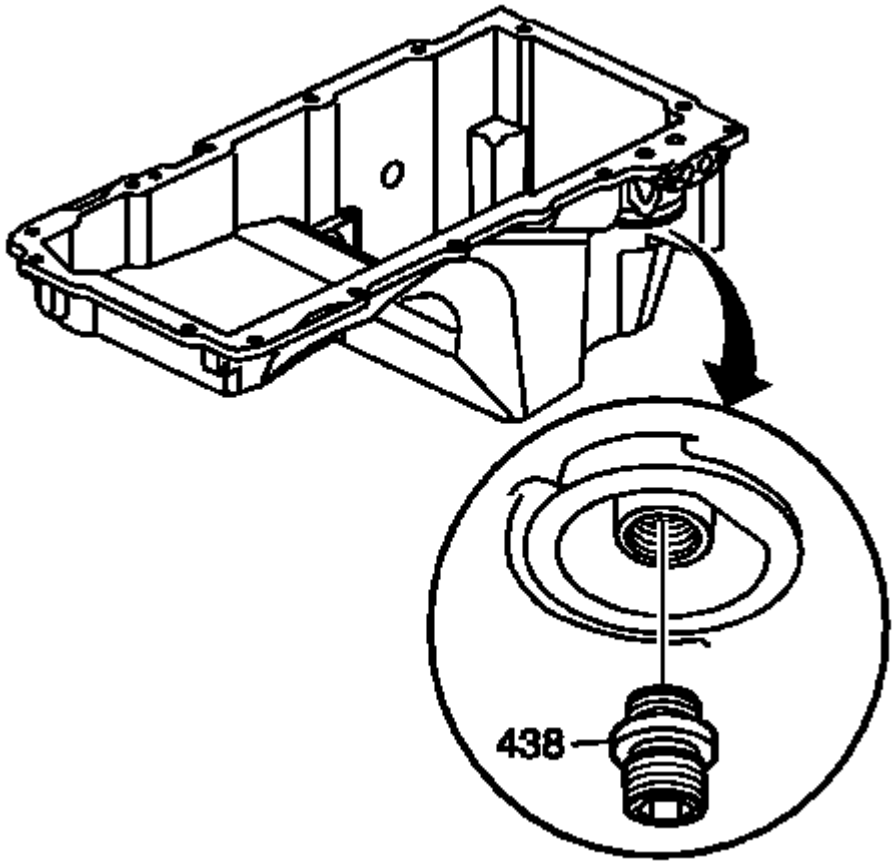

Fig. 525: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

14. Install the oil filter fitting (438), as required, and tighten to 55 N.m (40 lb ft).

INTAKE MANIFOLD CLEANING AND INSPECTION

Cleaning Procedure

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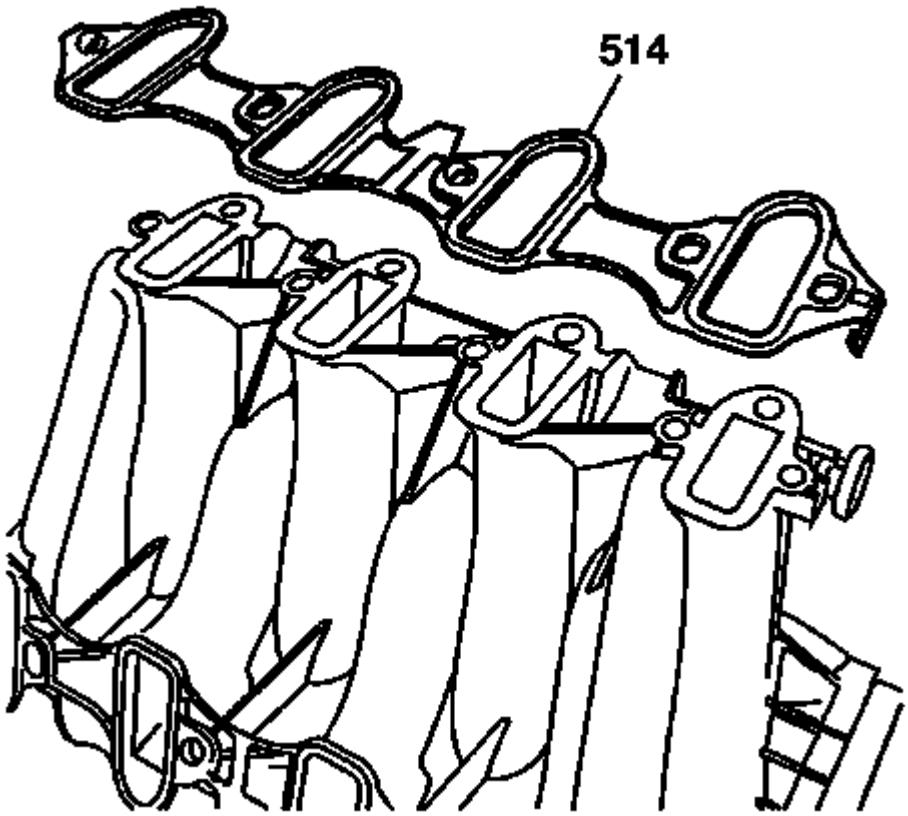

Fig. 526: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the intake manifold-to-cylinder head gaskets (514).

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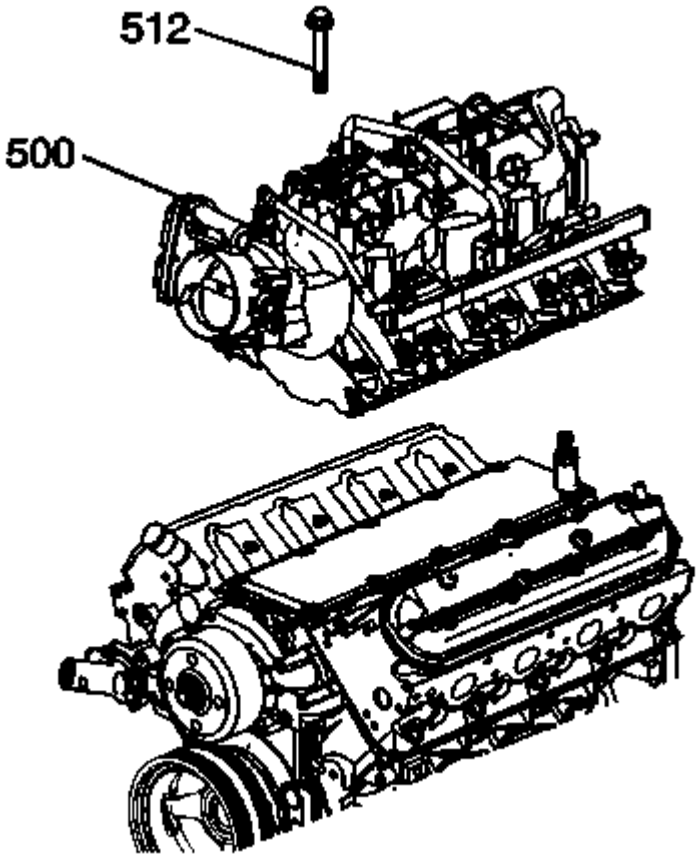

Fig. 527: Removing/Installing Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the manifold absolute pressure (MAP) sensor. Refer to **Intake Manifold Removal**.
3. Remove the evaporative emission (EVAP) canister purge solenoid valve, EVAP tubes, and fuel rail with injectors (500). Refer to **Fuel Rail and Injectors Removal**.
4. Remove the throttle body and gasket. Refer to **Throttle Body Assembly Removal**.
5. Clean the intake manifold in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

6. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the manifold for the following conditions:
   - Damaged gasket or sealing surfaces
   - Loose threaded inserts or studs
   - Debris or restrictions within the passages of the manifold

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- Damaged or broken vacuum fittings
- Inspect the composite intake manifold assembly for cracks or other damage.

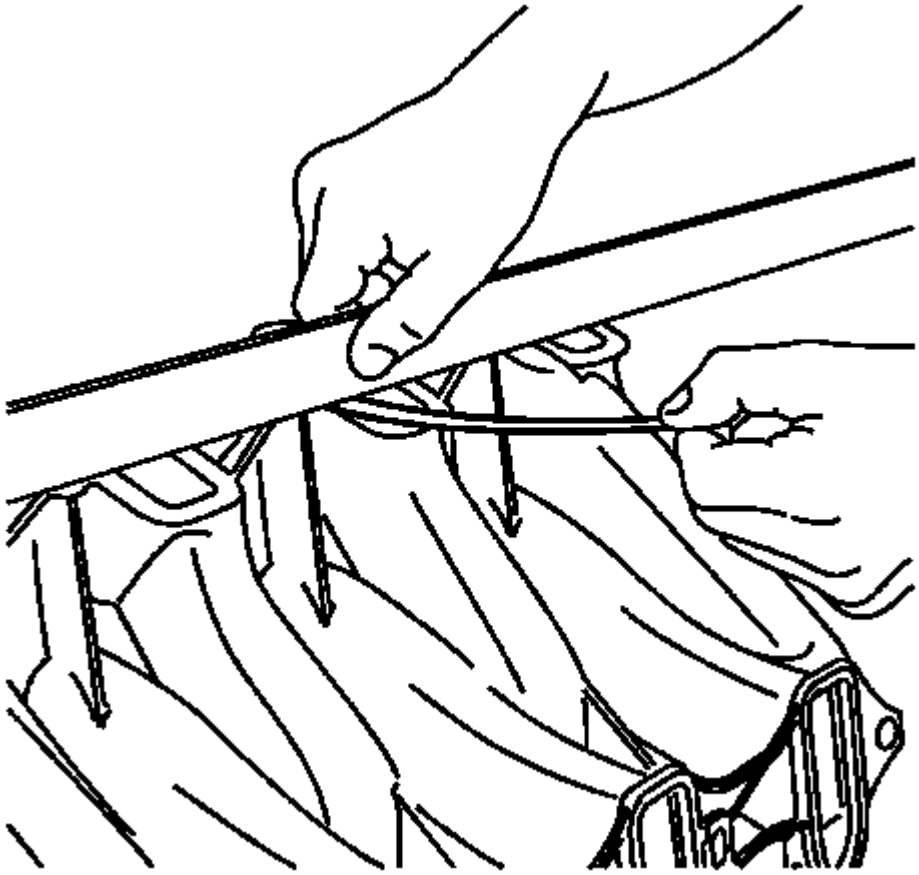

Fig. 528: Inspecting Intake Manifold Cylinder Head Deck For Warpage
Courtesy of GENERAL MOTORS CORP.

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 gauge between the intake manifold and the straight edge.

       An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION

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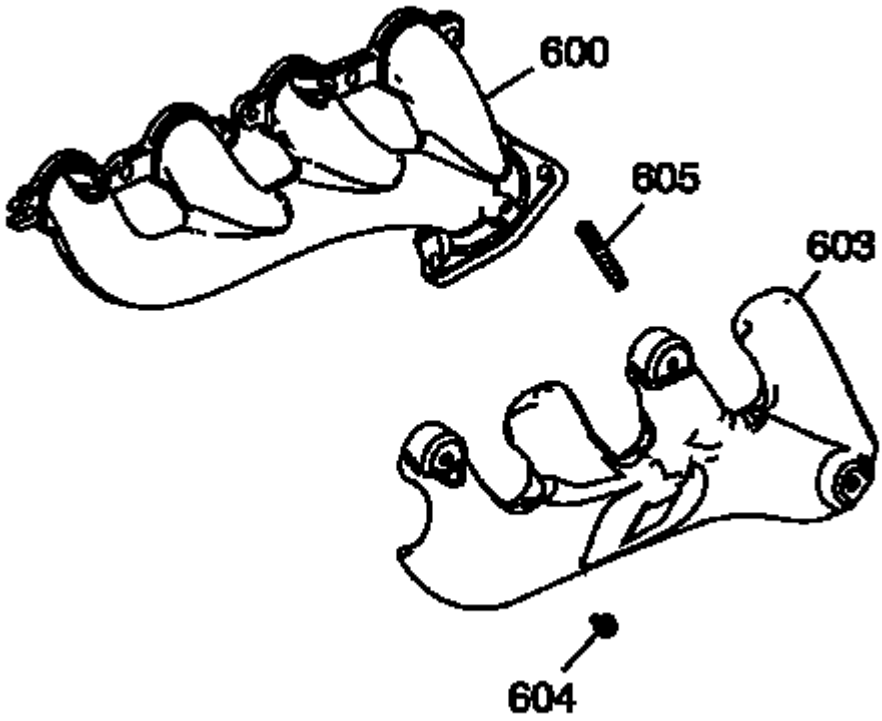

Fig. 529: Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

WARNING: Refer to Safety Glasses Warning .

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose, damaged, or cracked heat shield (603).
5. Inspect the studs (605) for damaged threads.

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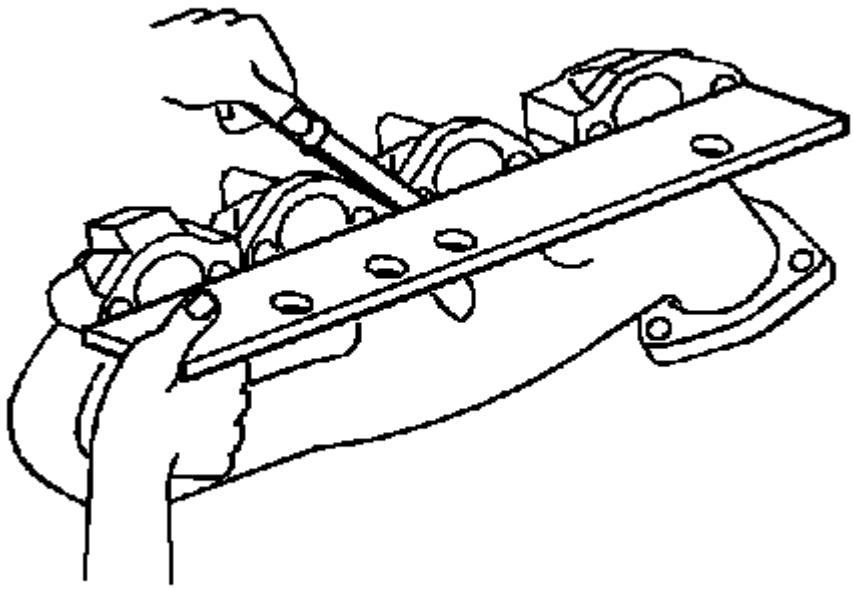

Fig. 530: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

6. Use a straight edge and a feeler gauge 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

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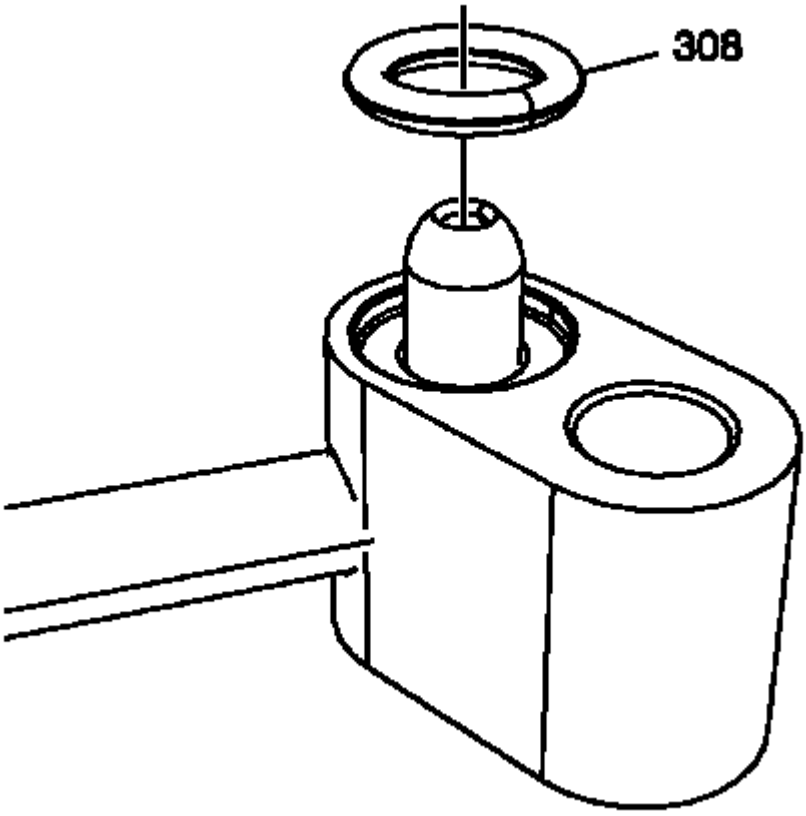

Fig. 531: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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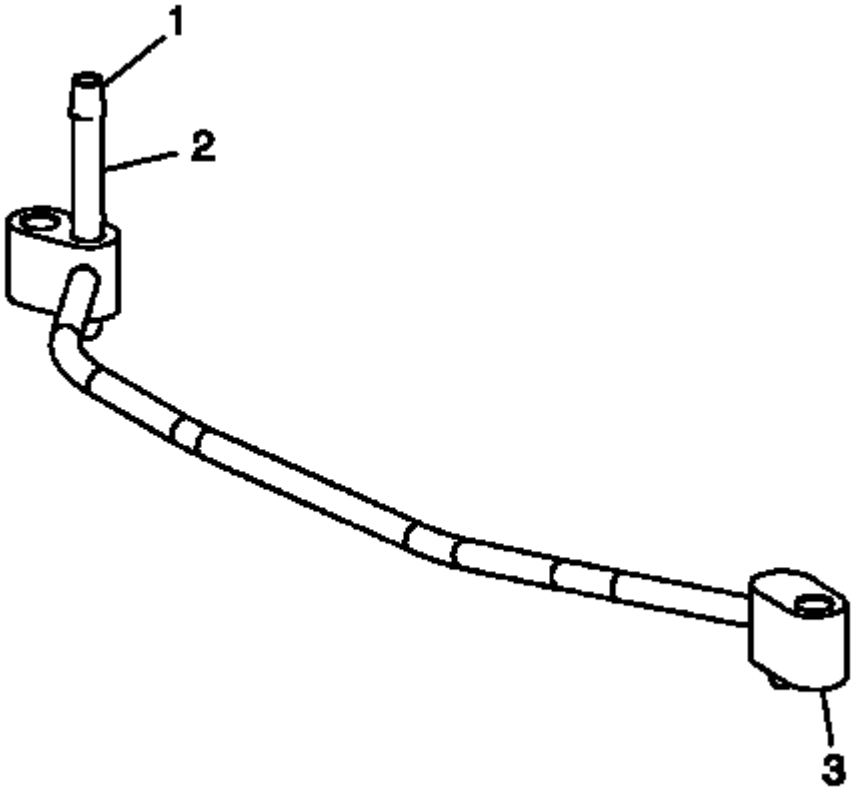

Fig. 532: View Of Coolant Air Bleed Pipe Components
Courtesy of GENERAL MOTORS CORP.

2. Clean the pipe and covers in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

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

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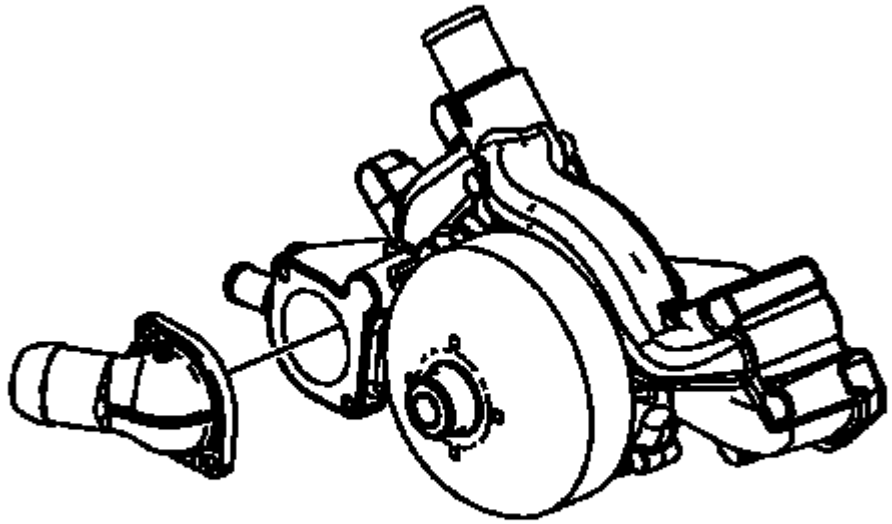

Fig. 533: View Of Water Pump
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

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- **J 42385-100:** Head/Main Bolt Thread Repair Kit
- **J 42385-300:** Fixtures and Hardware Kit

For equivalent regional tools, refer to **Special Tools**

General Thread Repair

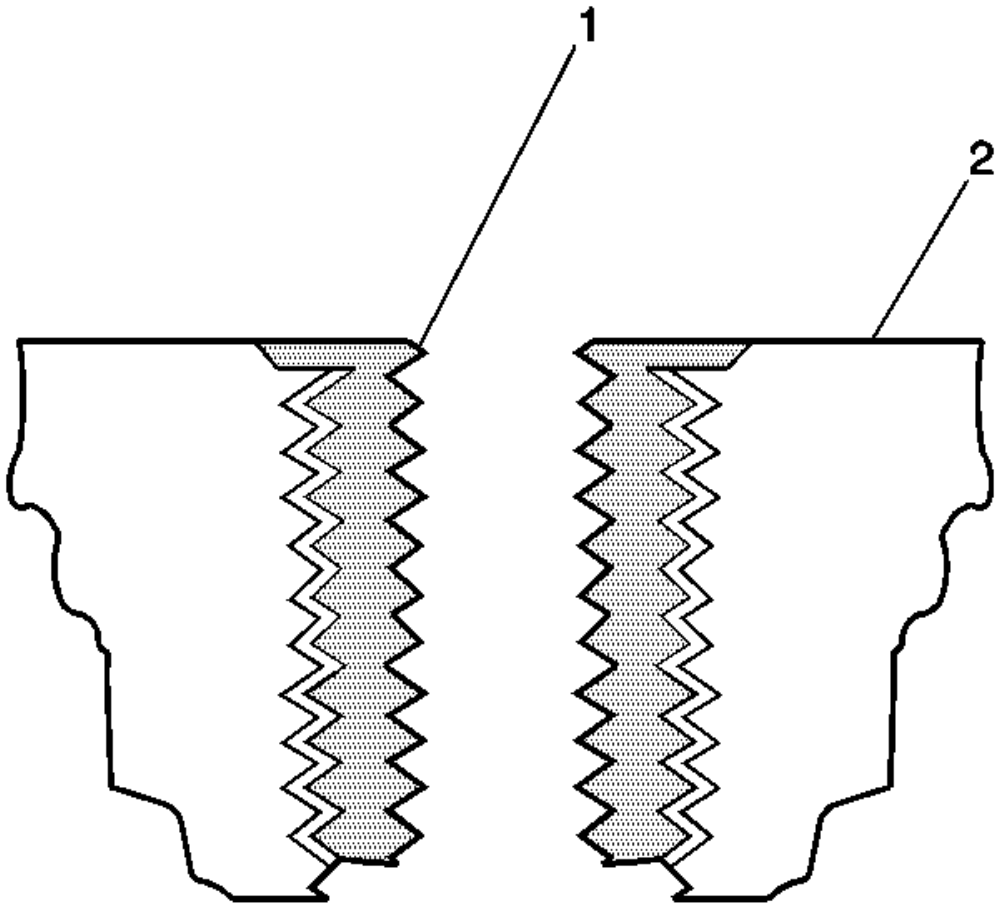

Fig. 534: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

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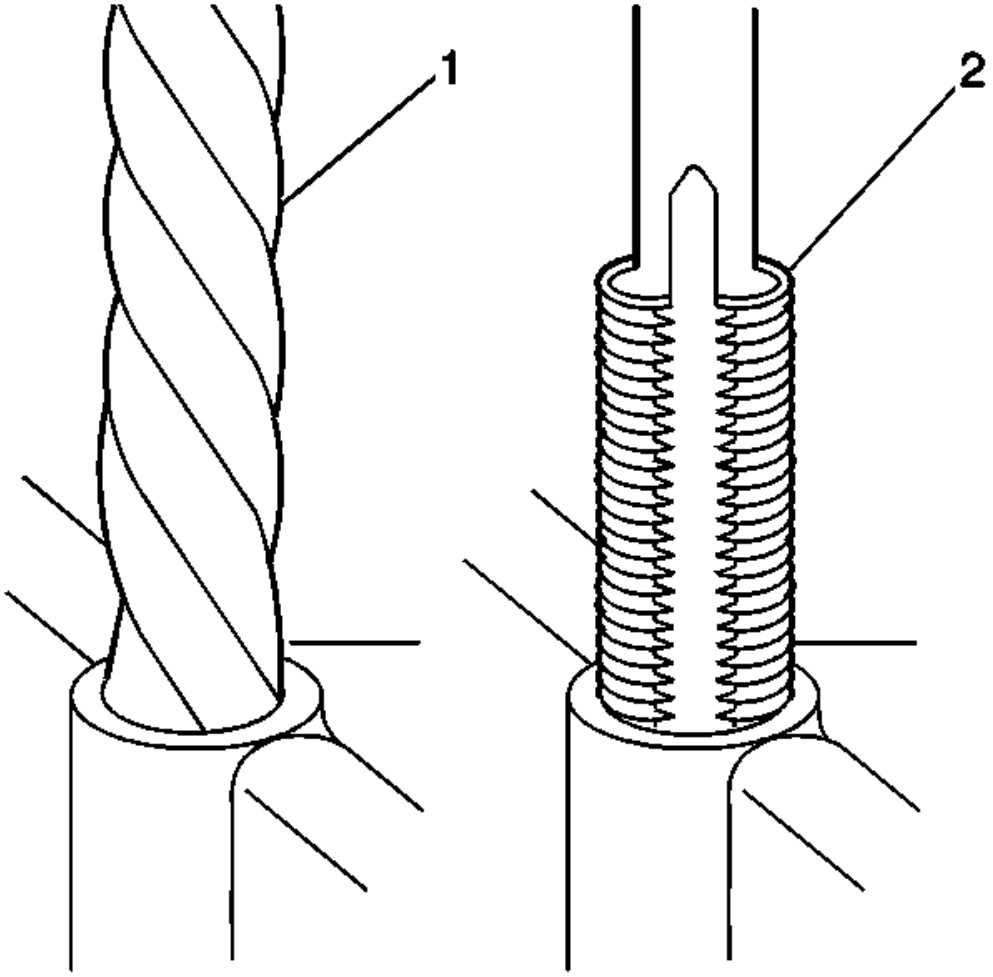

Fig. 535: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

NOTE:

- **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).

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- 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.

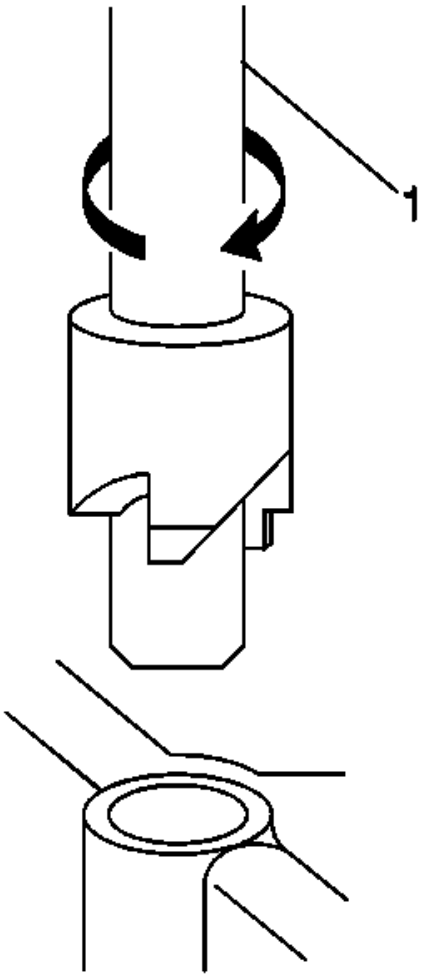

Fig. 536: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

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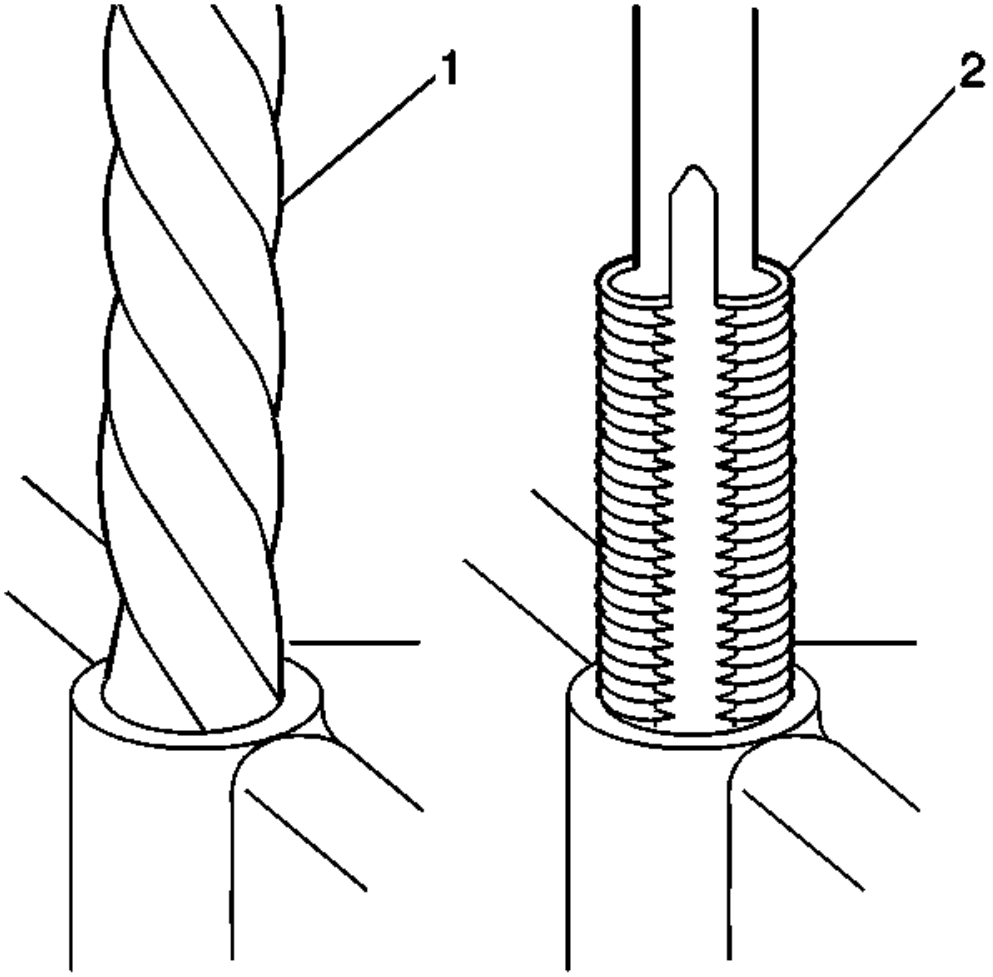

Fig. 537: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
    - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
    - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
    - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

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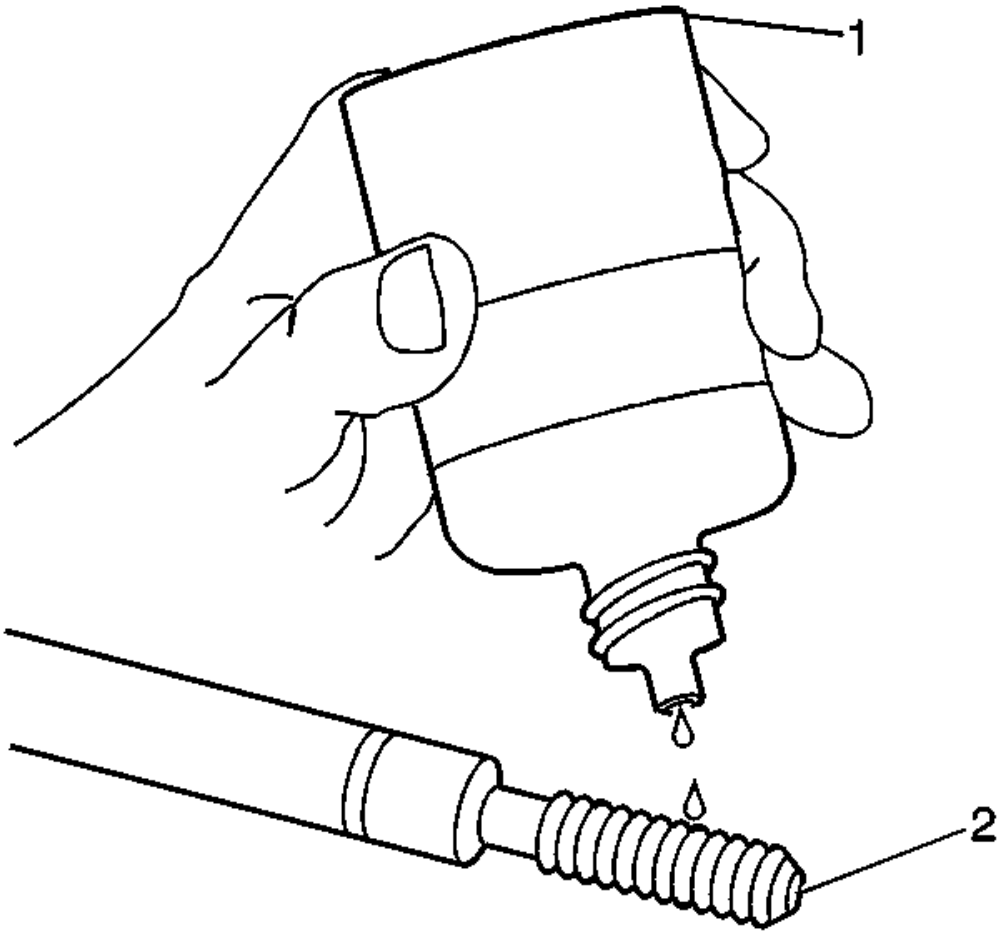

Fig. 538: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

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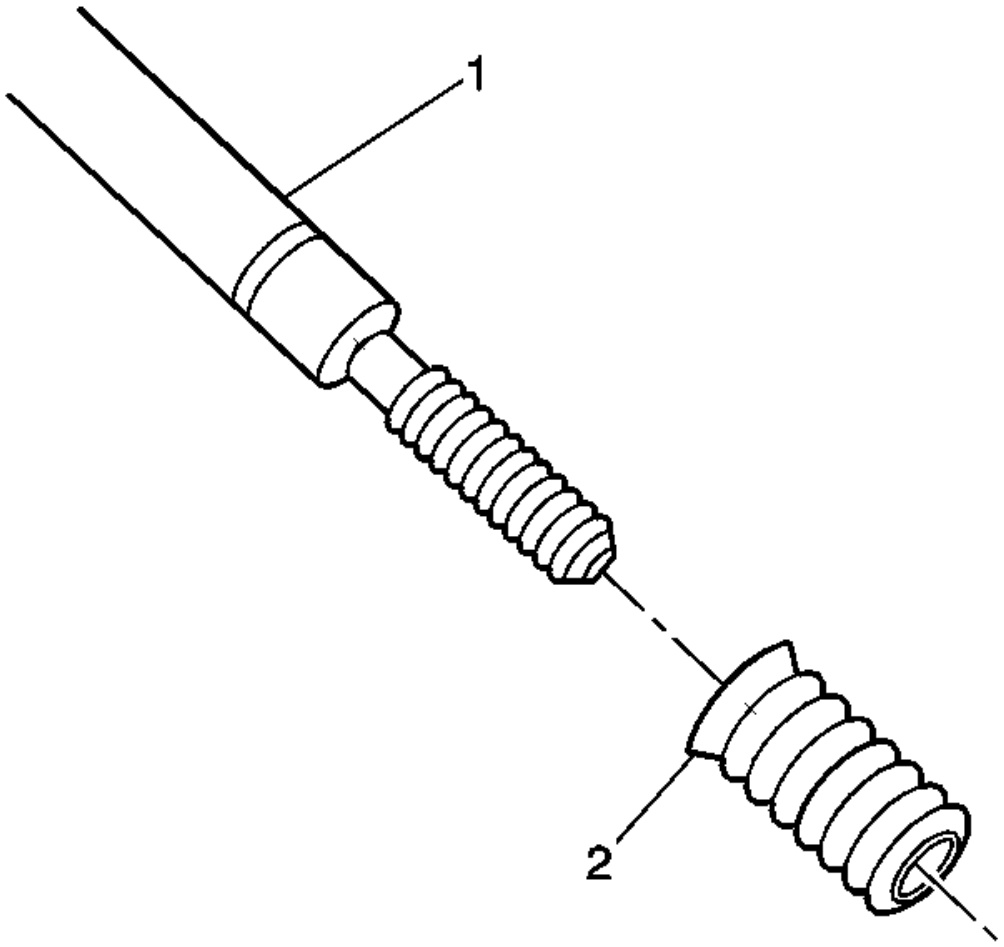

Fig. 539: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

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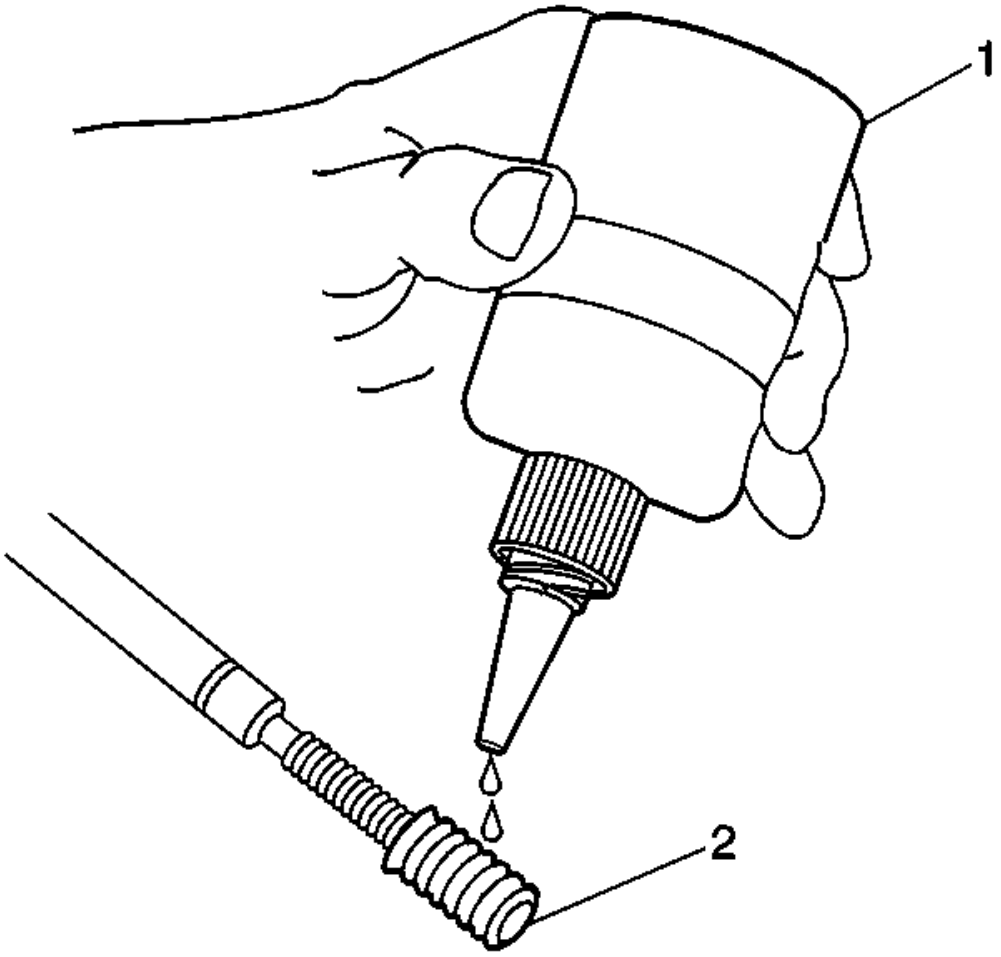

Fig. 540: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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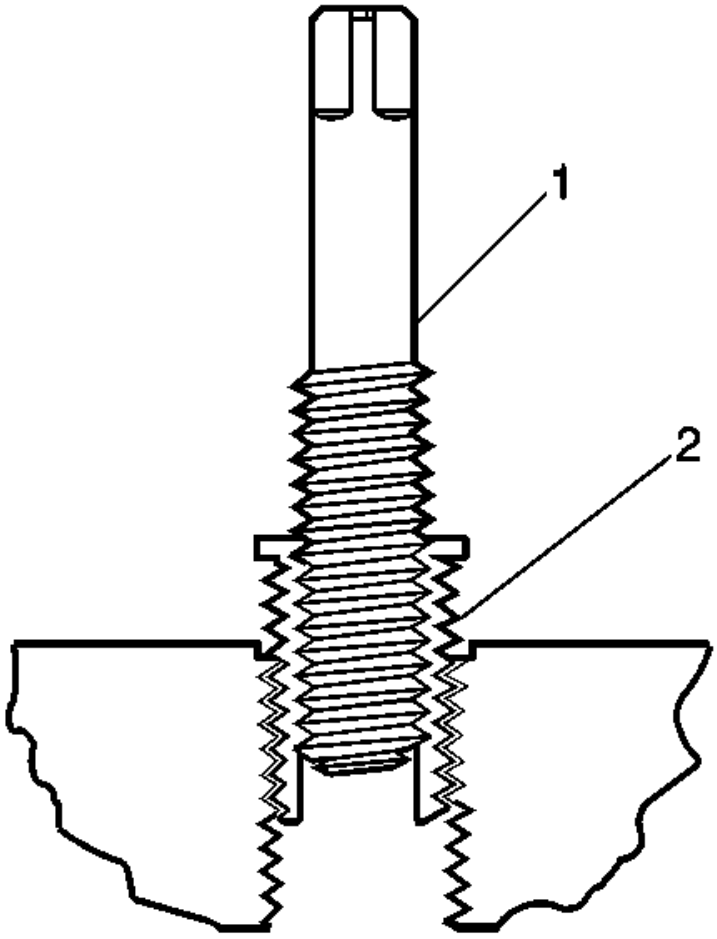

Fig. 541: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

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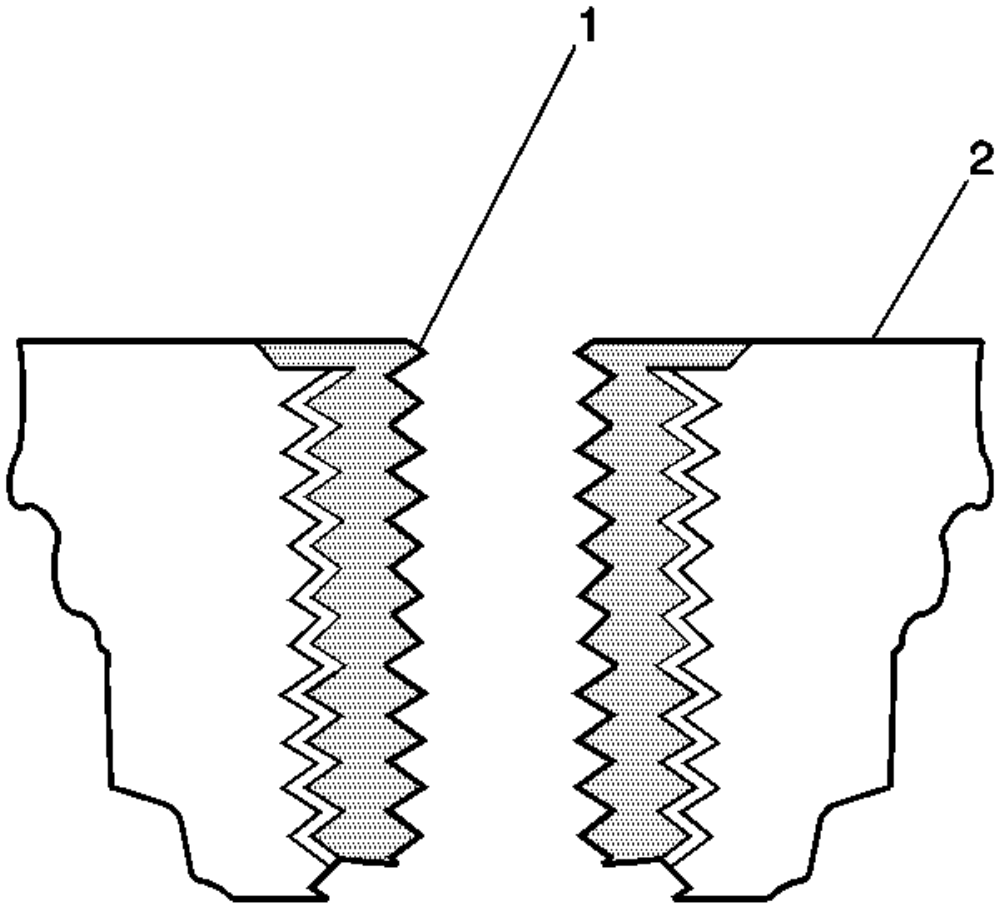

Fig. 542: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

    A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

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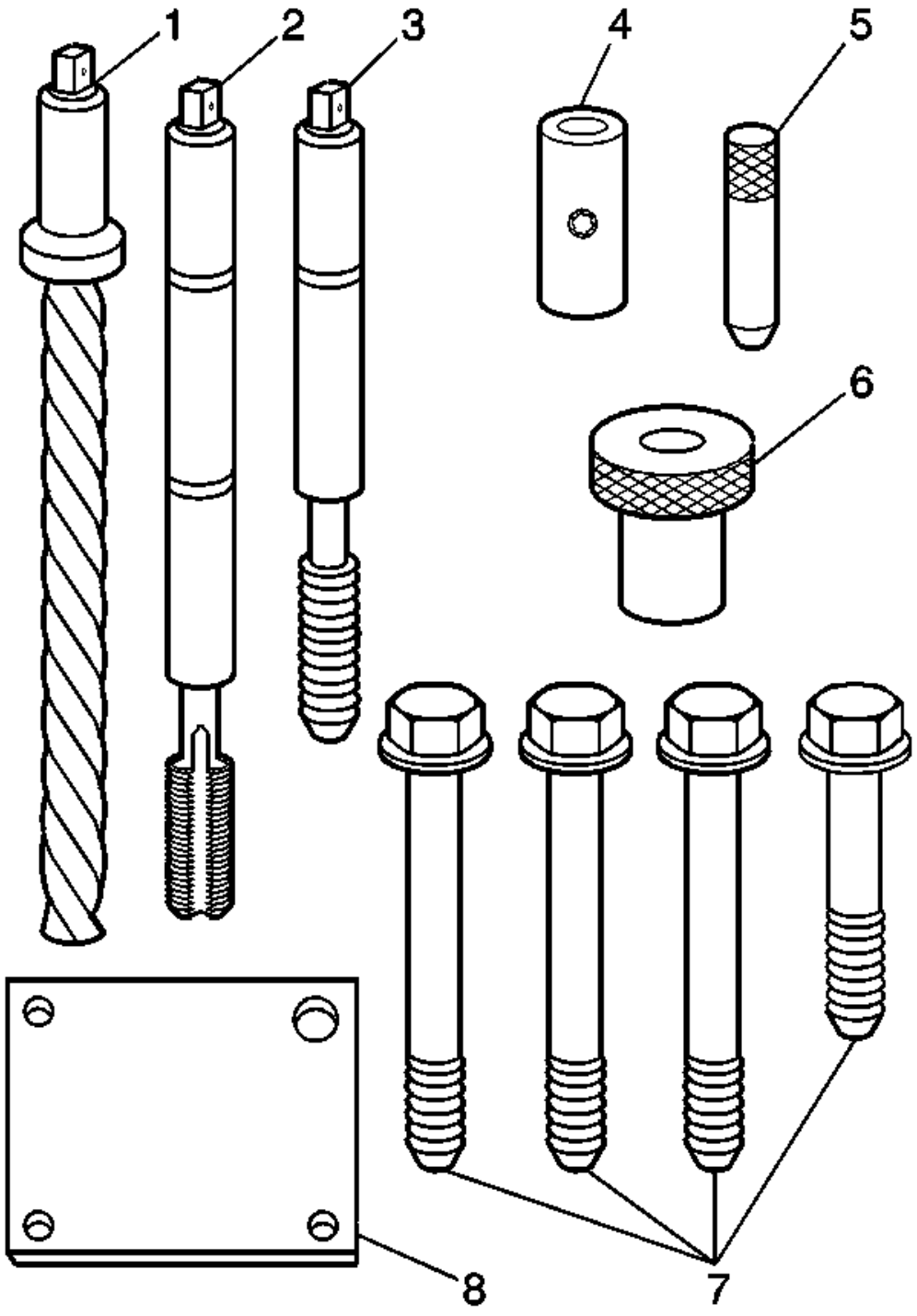

Fig. 543: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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1. The cylinder head bolt hole thread repair kit consists of the following items:
   - The drill (1)
   - The tap (2)
   - The installer (3)
   - The sleeve (4)
   - The alignment pin (5)
   - The bushing (6)
   - The bolts (7)
   - The fixture plate (8)

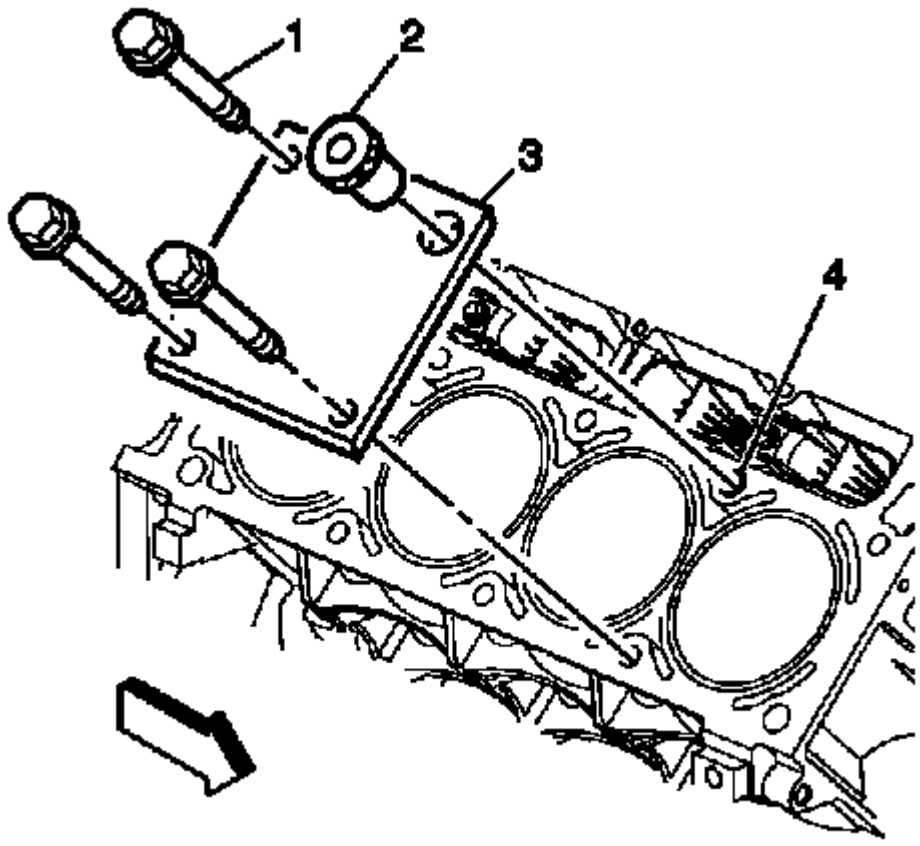

Fig. 544: View Of Fixture Plate, Bolts, Bushing & Cylinder Hole
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

NOTE:
- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N**

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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).

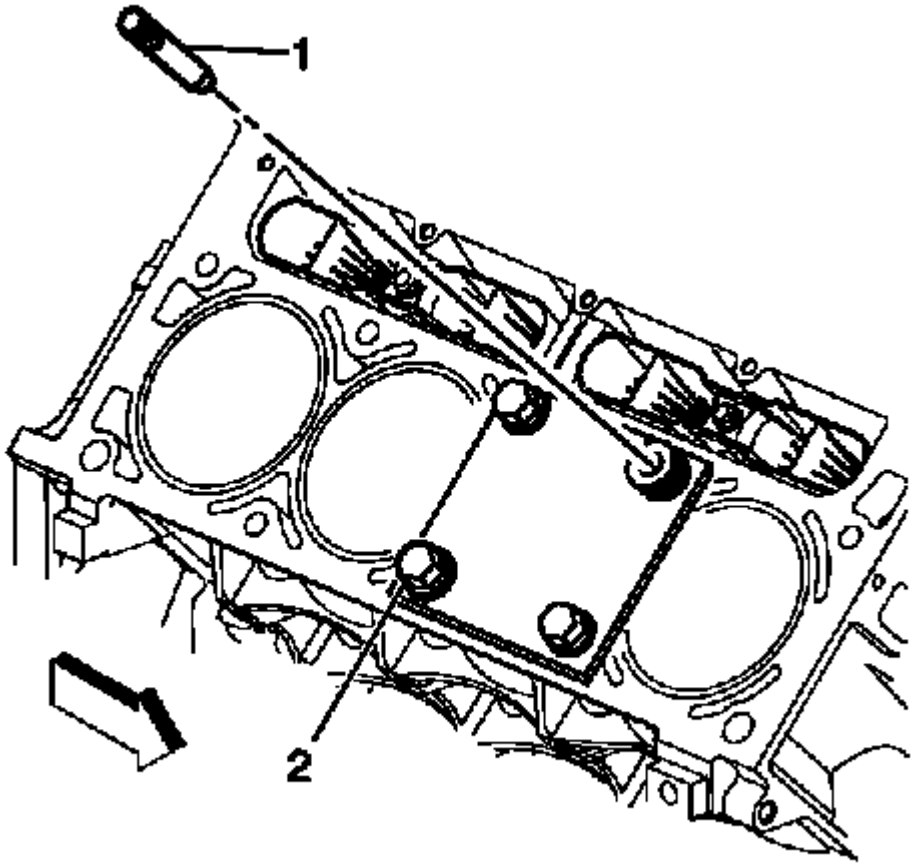

Fig. 545: View Of Alignment Pin & Fixture Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

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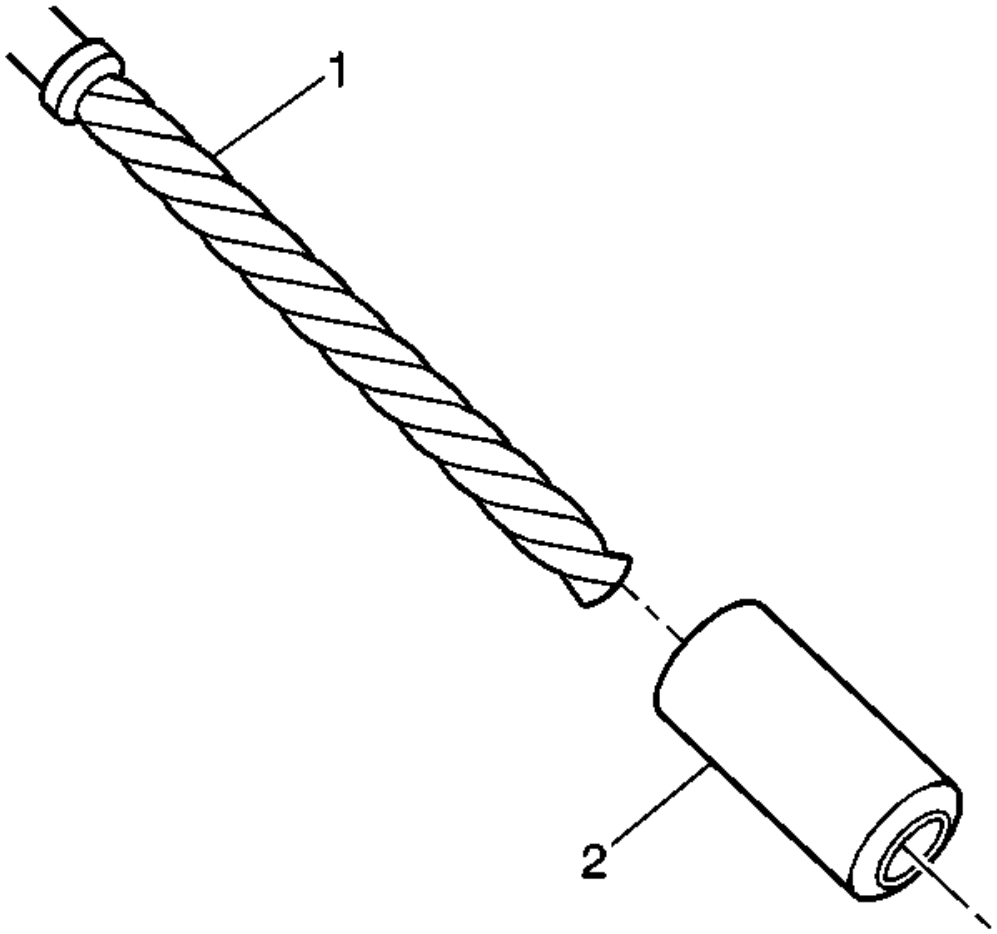

Fig. 546: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1).

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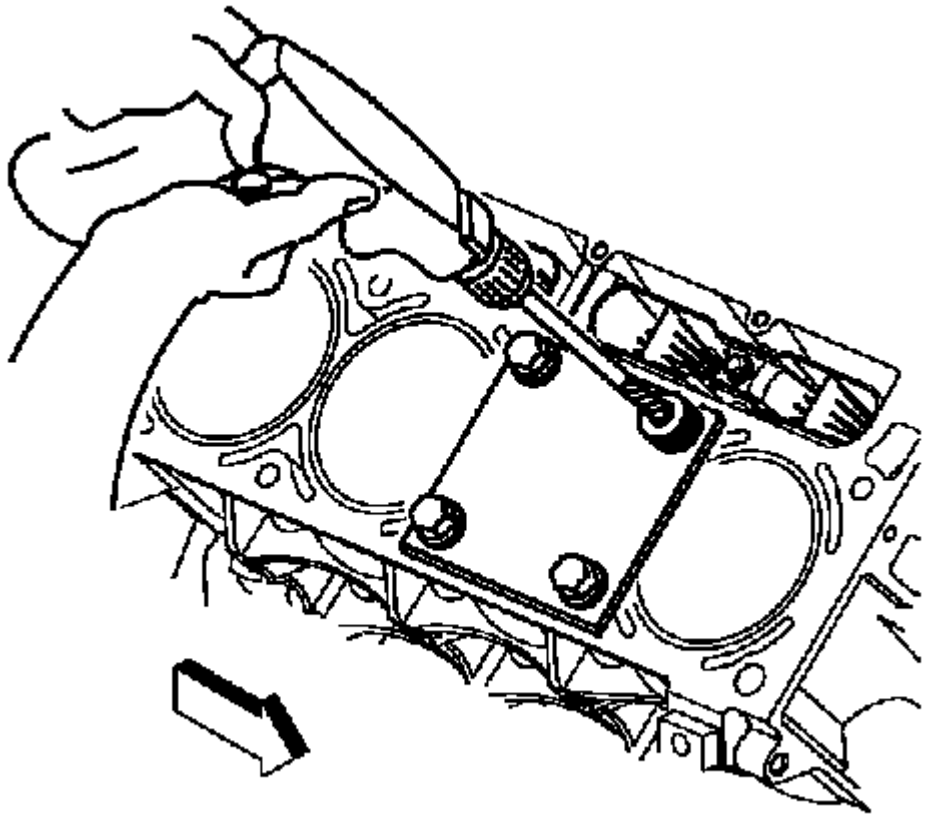

Fig. 547: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS CORP.

NOTE: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

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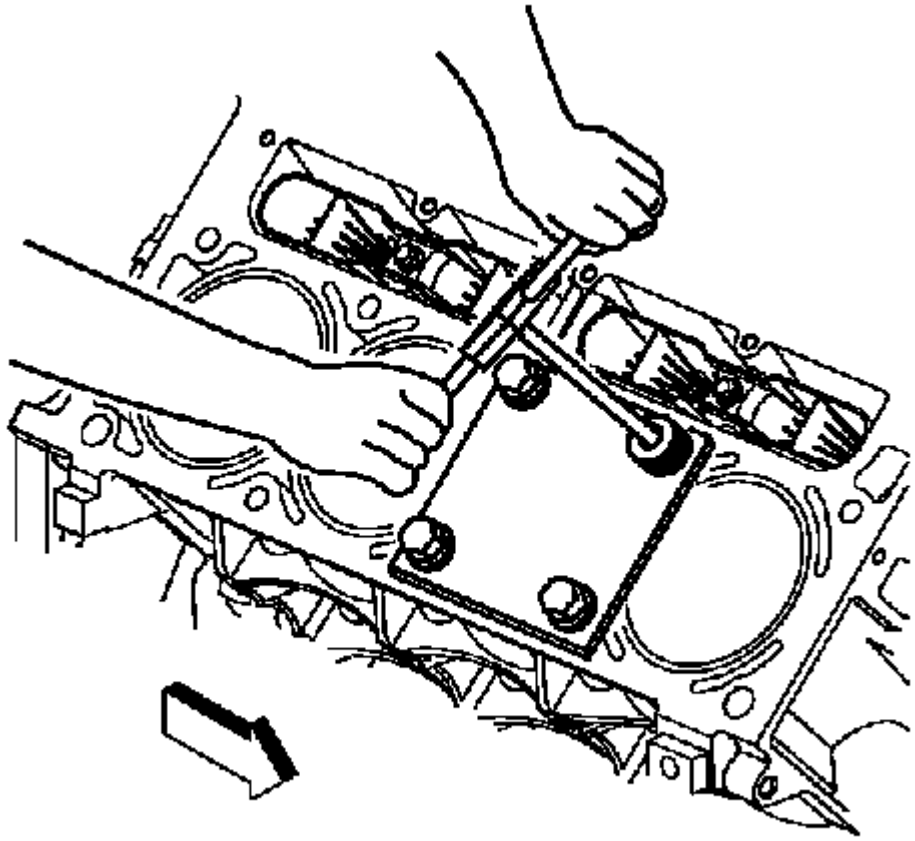

Fig. 548: Tapping Threads Of Drilled Hole Using Tapping Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

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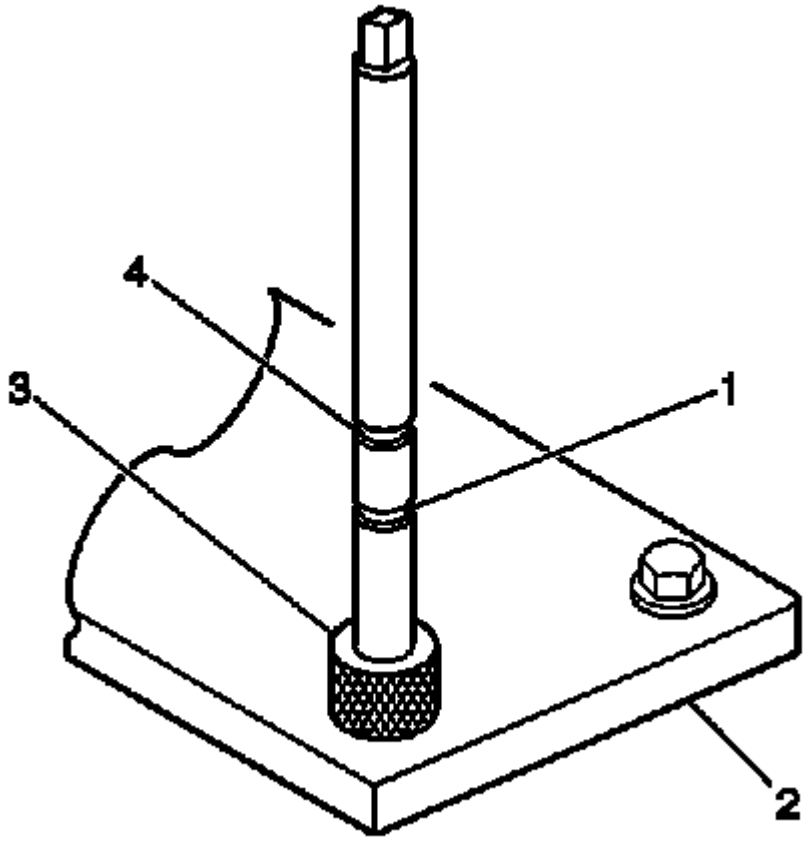

Fig. 549: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

10. In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (1) on the tap aligns with the top of the drill bushing (3).
11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

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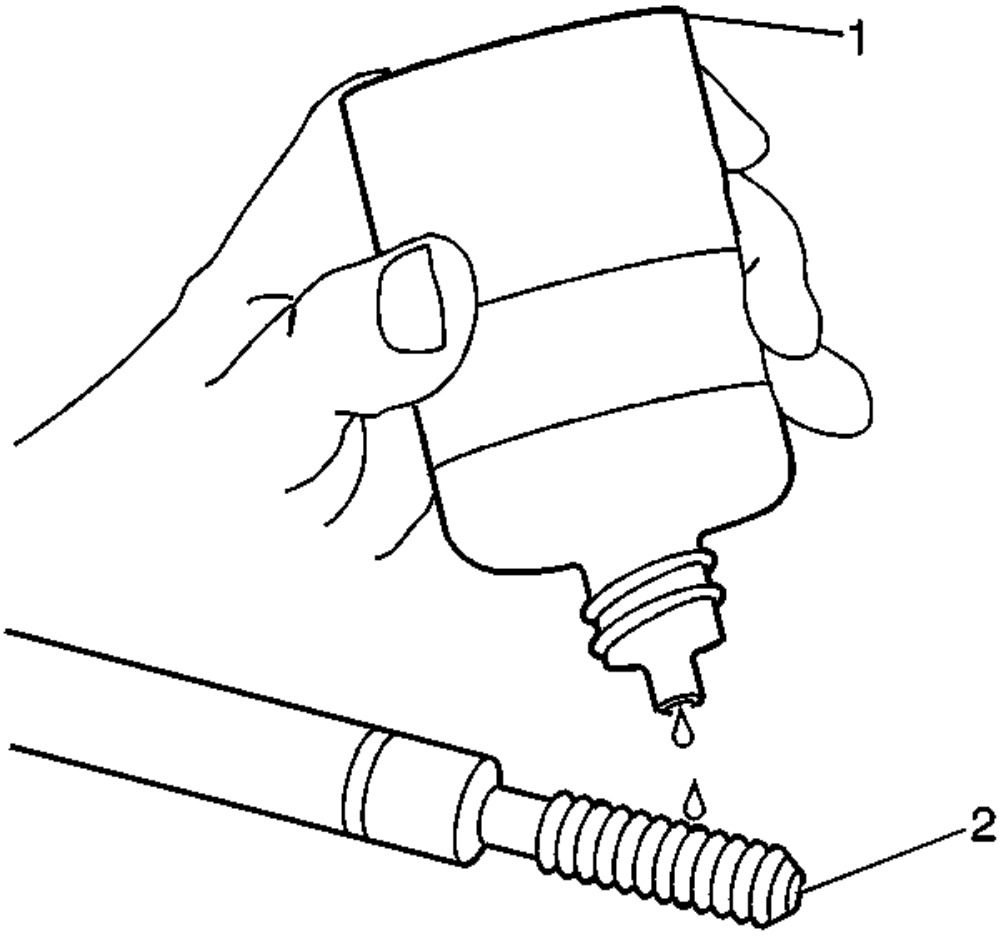

Fig. 550: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or foreign material to contact the OD of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

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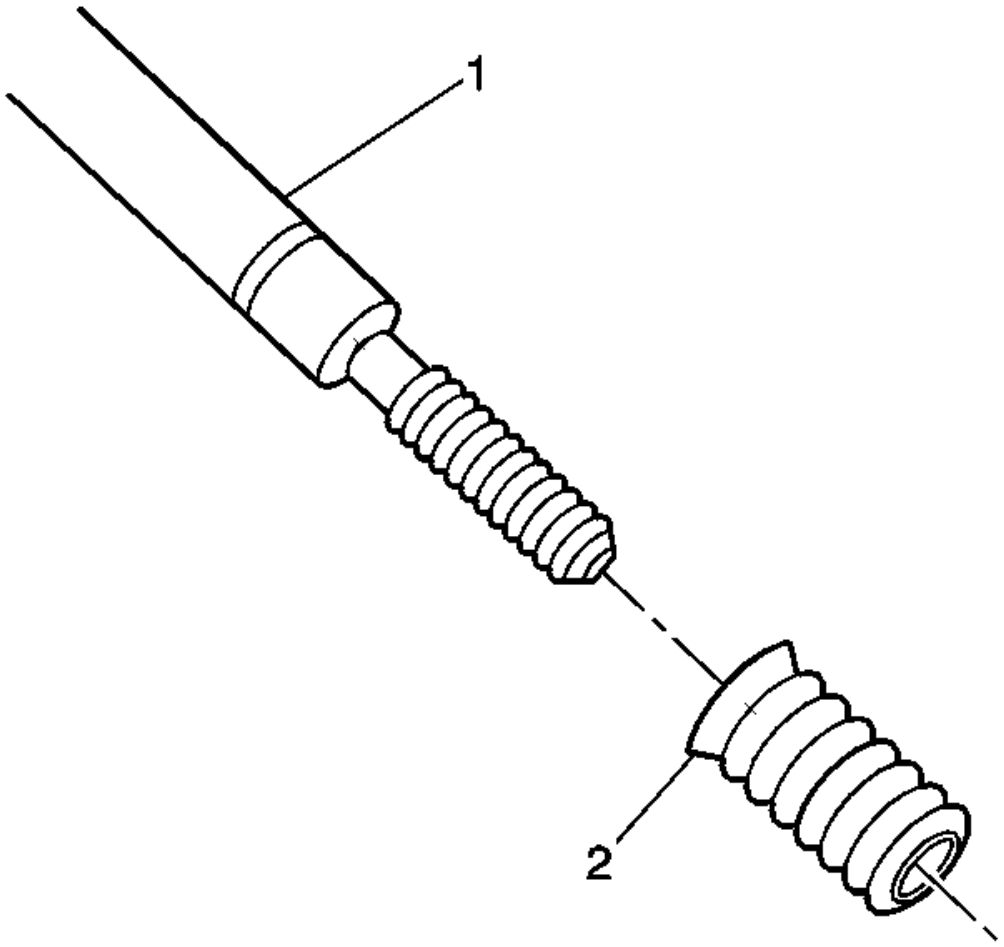

Fig. 551: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

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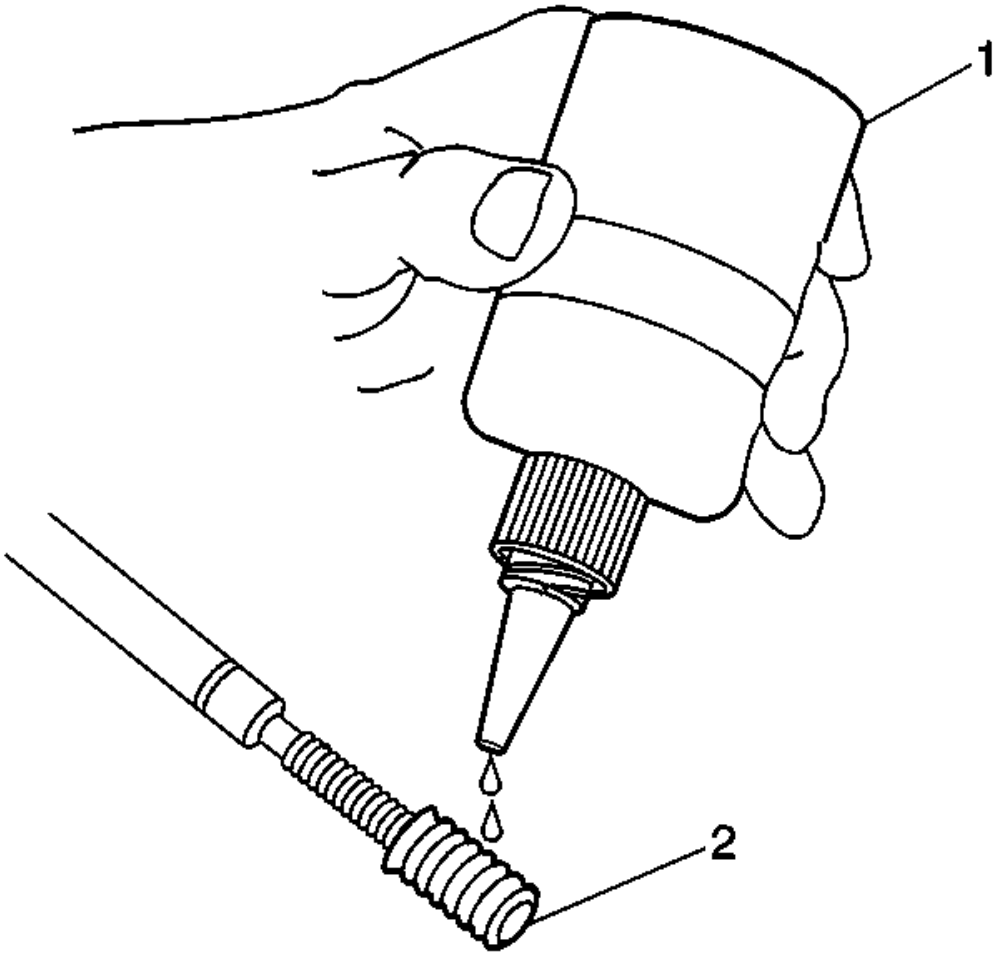

Fig. 552: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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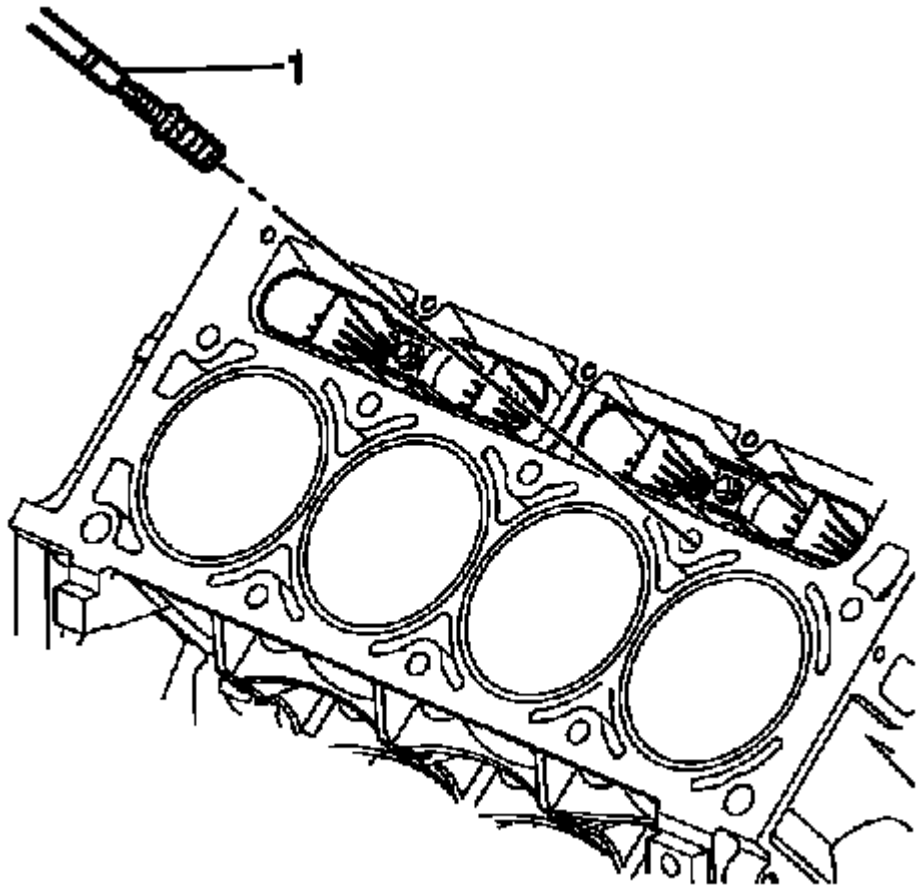

Fig. 553: Installing Insert & Driver Into Cylinder Bolt Hole
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

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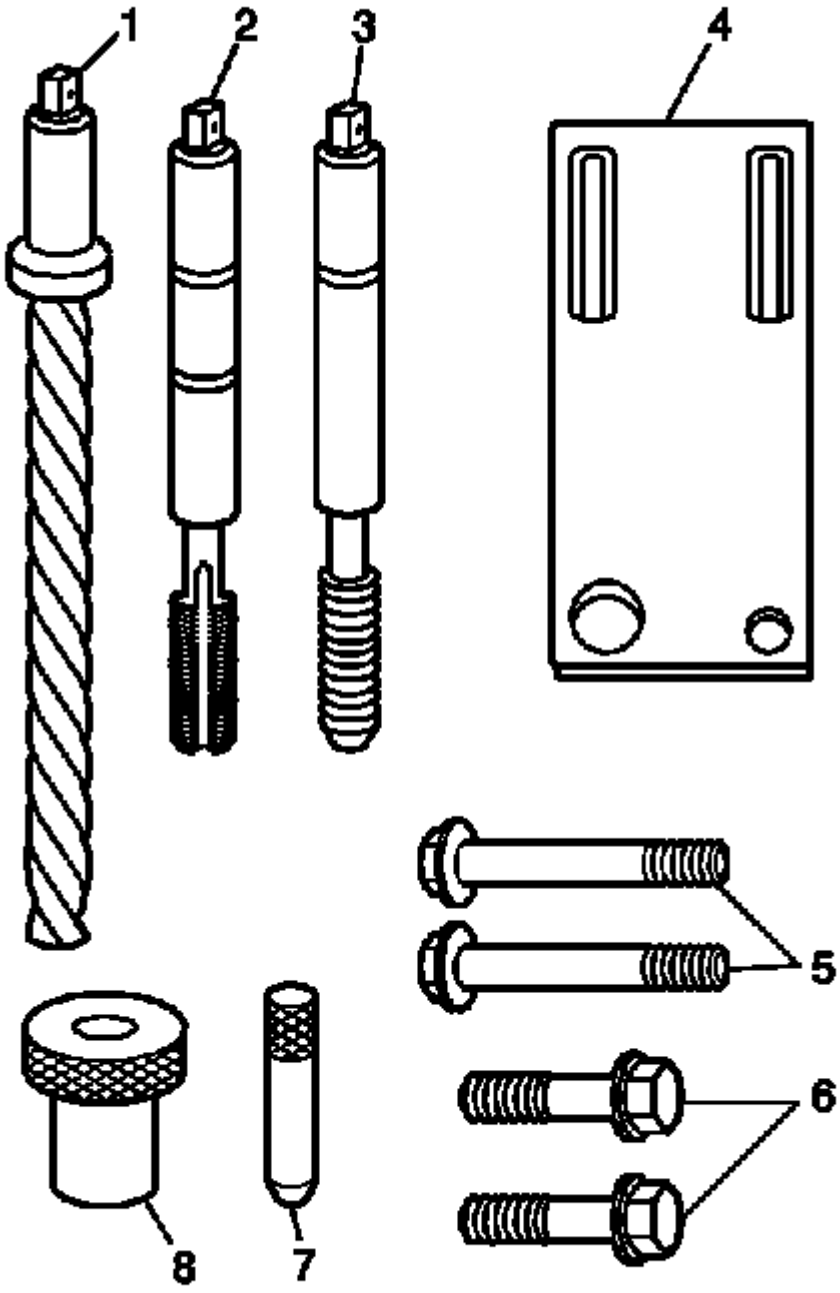

Fig. 554: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:
    - The drill (1)
    - The tap (2)
    - The installer (3)

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- The fixture plate (4)
- The long bolts (5)
- The short bolts (6)
- The alignment pin (7)
- The bushing (8)

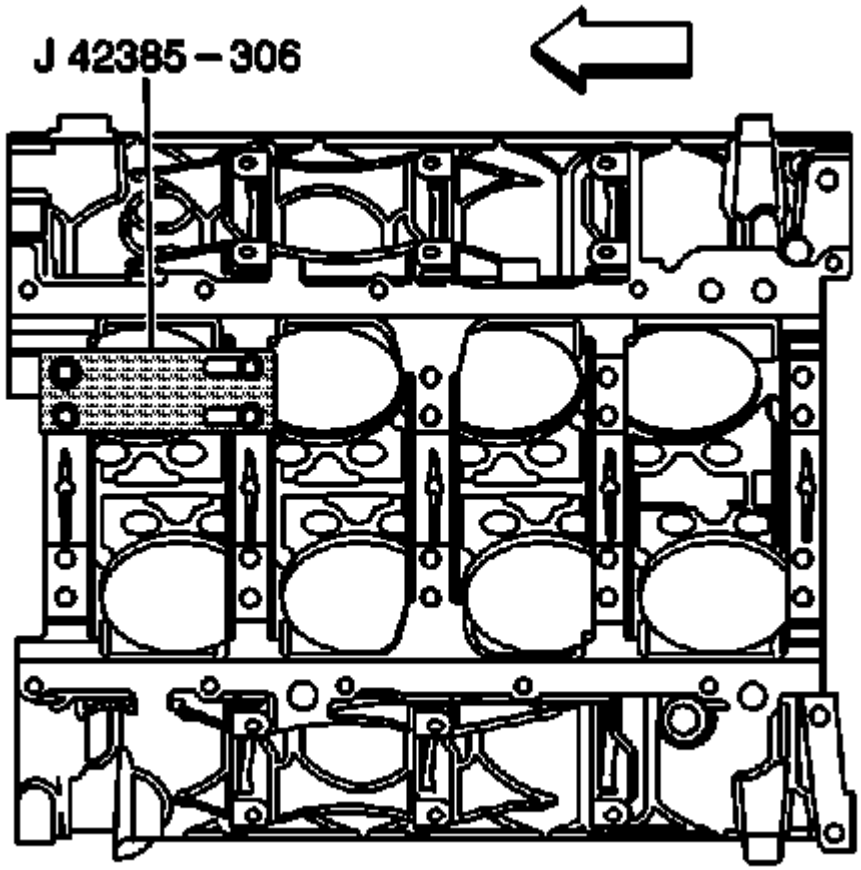

Fig. 555: View Of Fixture Plate, Bolt & Bushing
Courtesy of GENERAL MOTORS CORP.

2. Install the fixture plate, bolt, and bushing onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

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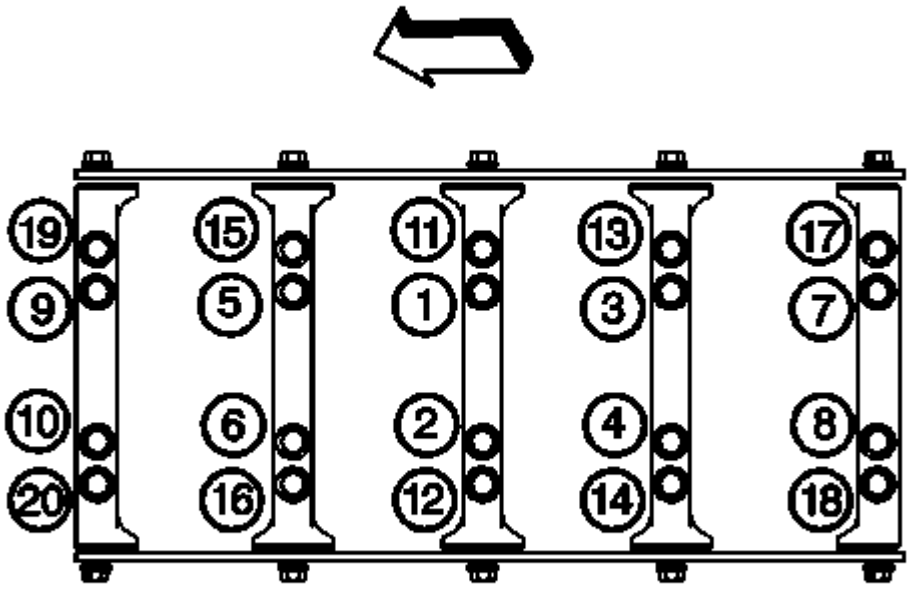

Fig. 556: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Drill out the damaged hole.

   The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

   Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.

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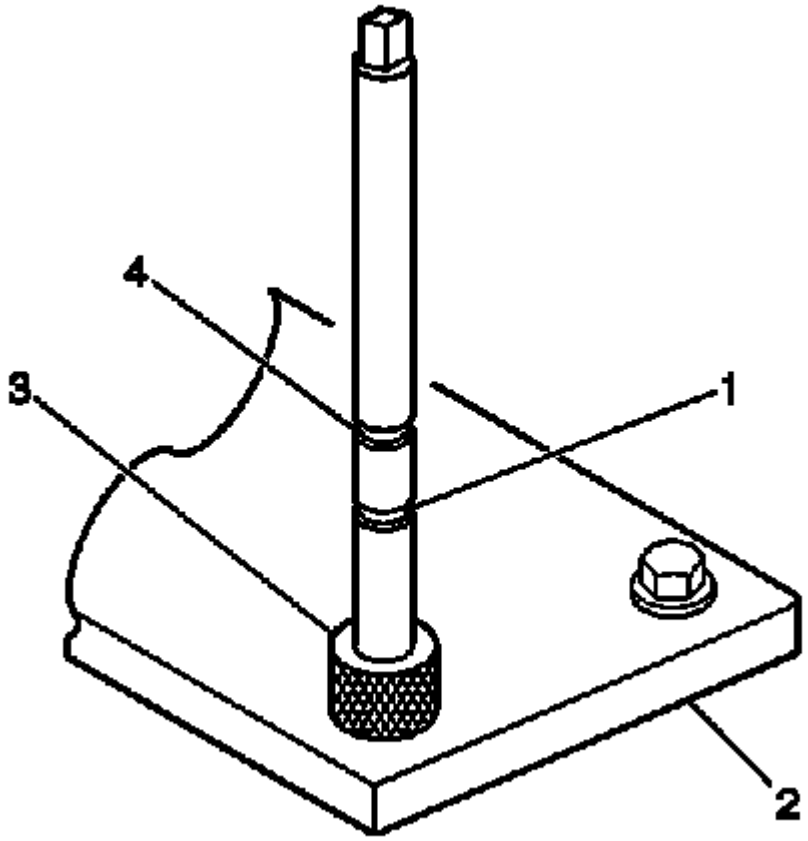

Fig. 557: View Of Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS CORP.

6. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

   For the deeper main cap holes 1-10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

   For the shallower main cap holes 11-20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), or equivalent, into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.

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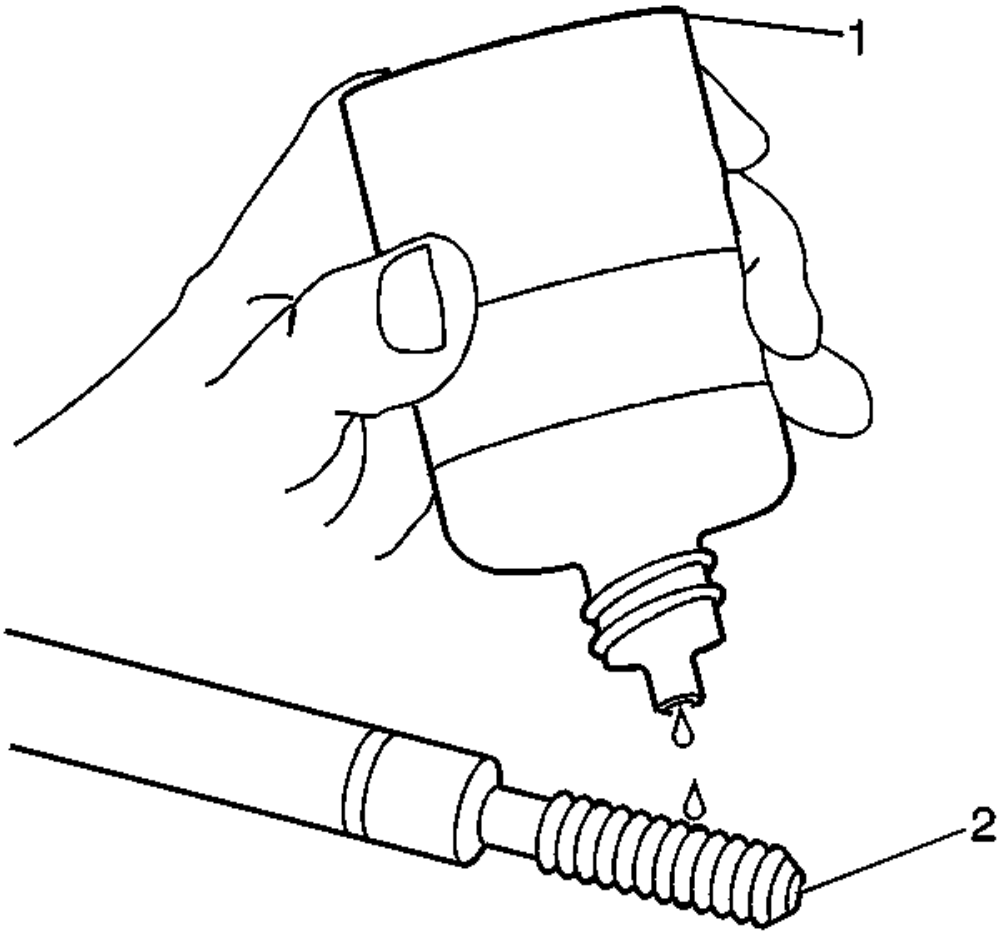

Fig. 558: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or foreign material to contact the OD of the insert.

10. Lubricate the threads of the installer tool (2) with the driver oil (1).

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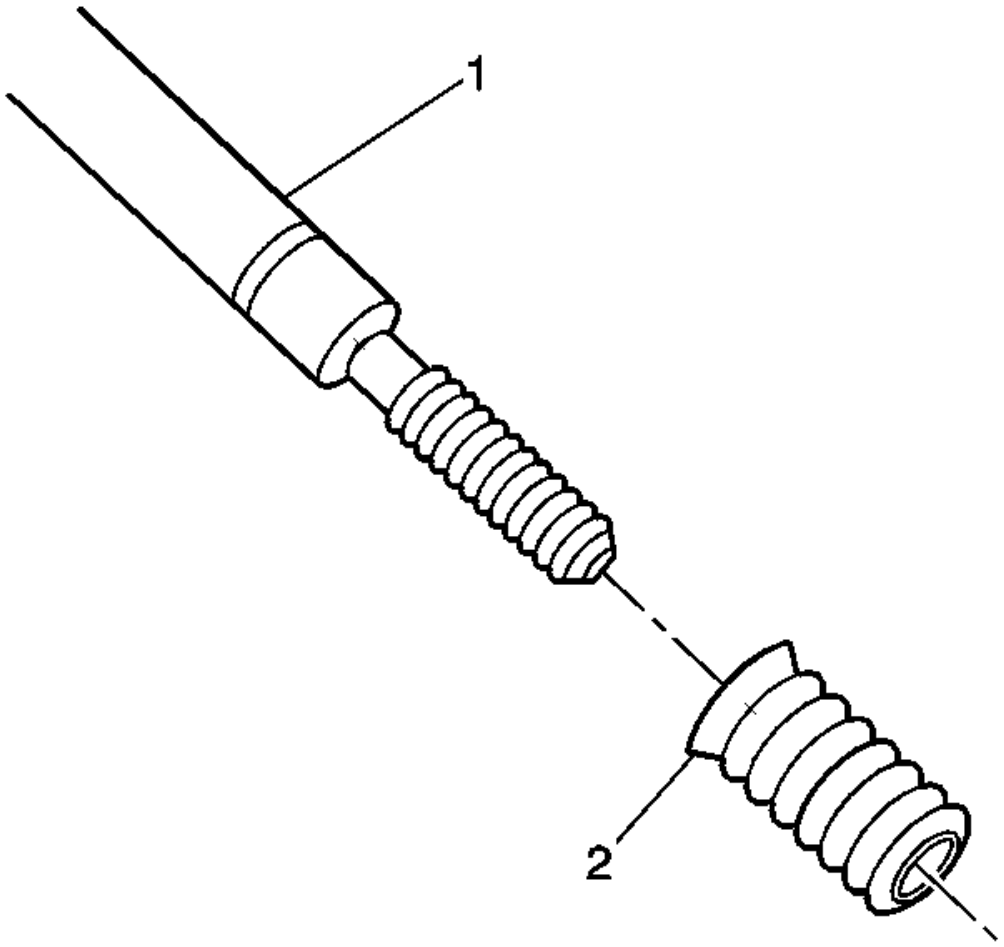

Fig. 559: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

11. Install the insert (2) onto the driver tool (1).

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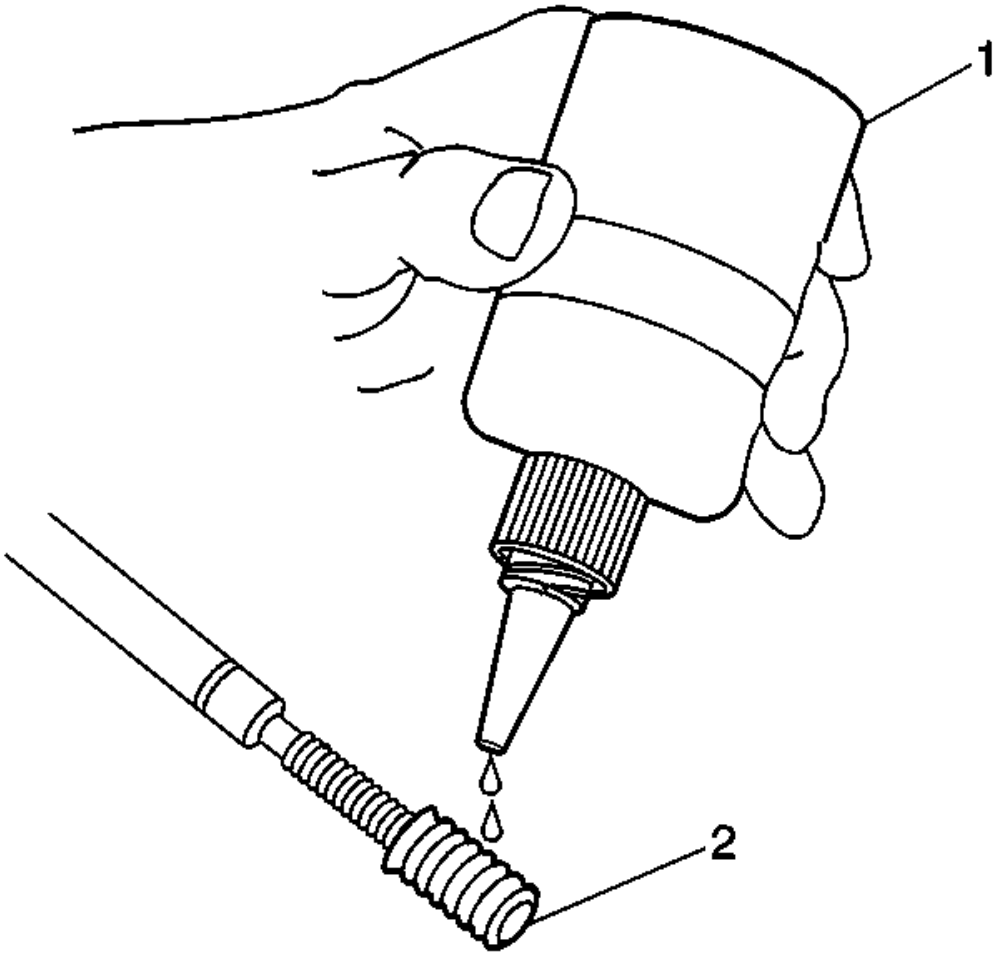

Fig. 560: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

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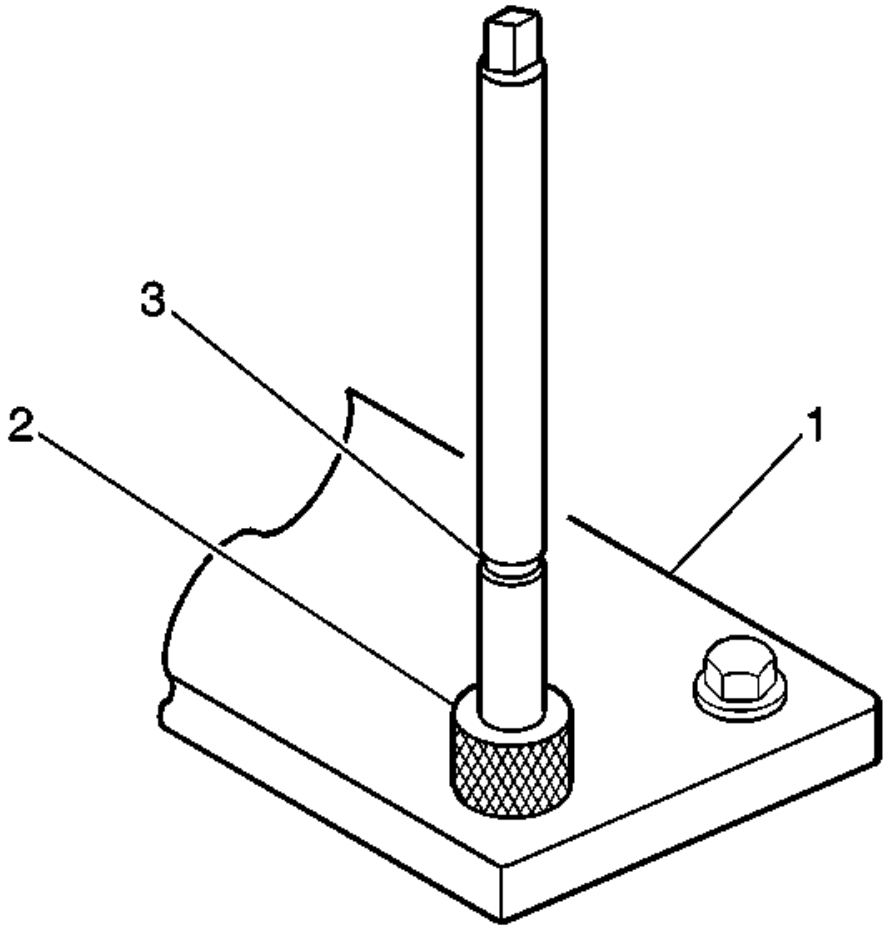

Fig. 561: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

NOTE: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

SERVICE PRIOR TO ASSEMBLY

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to **Cleanliness**

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and Care.

- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to **Separating Parts**.
- During assembly, lubricate all moving parts with clean engine oil. This provides initial lubrication when the engine is first started.

ENGINE BLOCK PLUG INSTALLATION

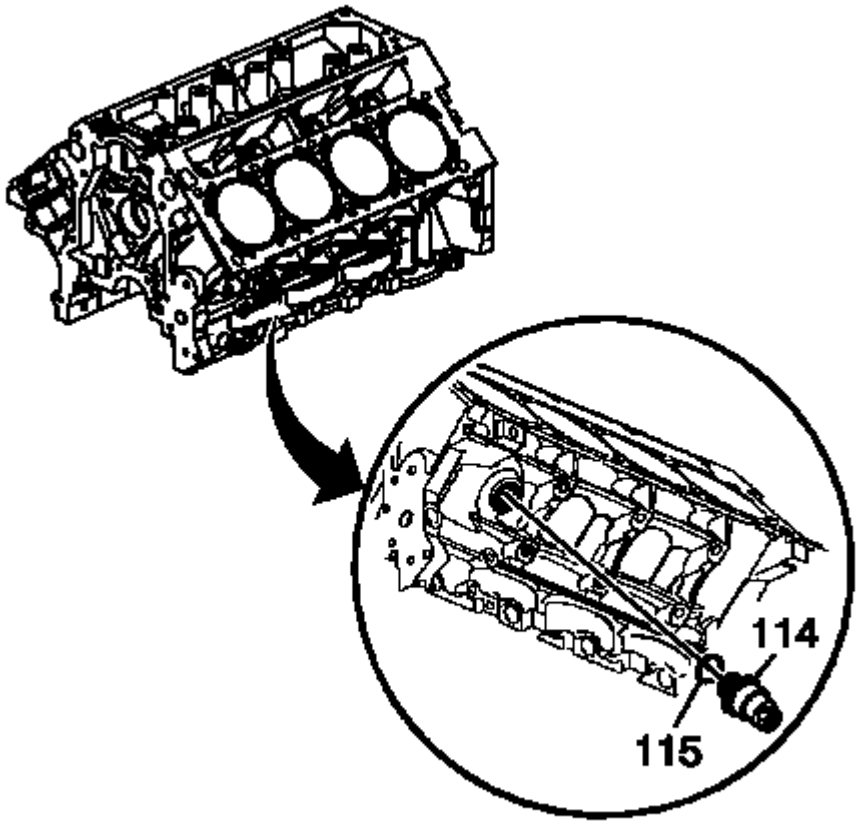

Fig. 562: Engine Block Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: Engine block plug, oil gallery, and coolant sealing washers may be used again if not bent, scored or otherwise damaged.

1. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block coolant heater sealing washer (115), if applicable. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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CAUTION: Refer to Fastener Caution .

2. Install the engine block coolant heater (114) to the engine block and tighten to 50 N.m (37 lb ft).

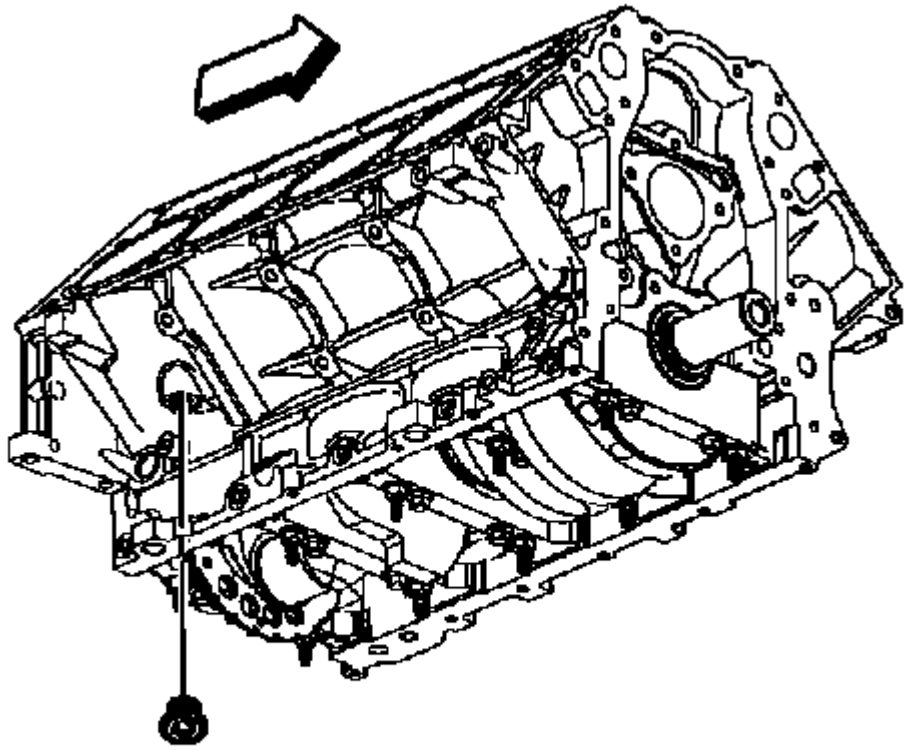

Fig. 563: Identifying Plug Location On Underside Of Block
Courtesy of GENERAL MOTORS CORP.

3. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block right rear coolant drain hole plug sealing washer.
4. Install the engine block right rear coolant drain hole plug and tighten to 60 N.m (44 lb ft).

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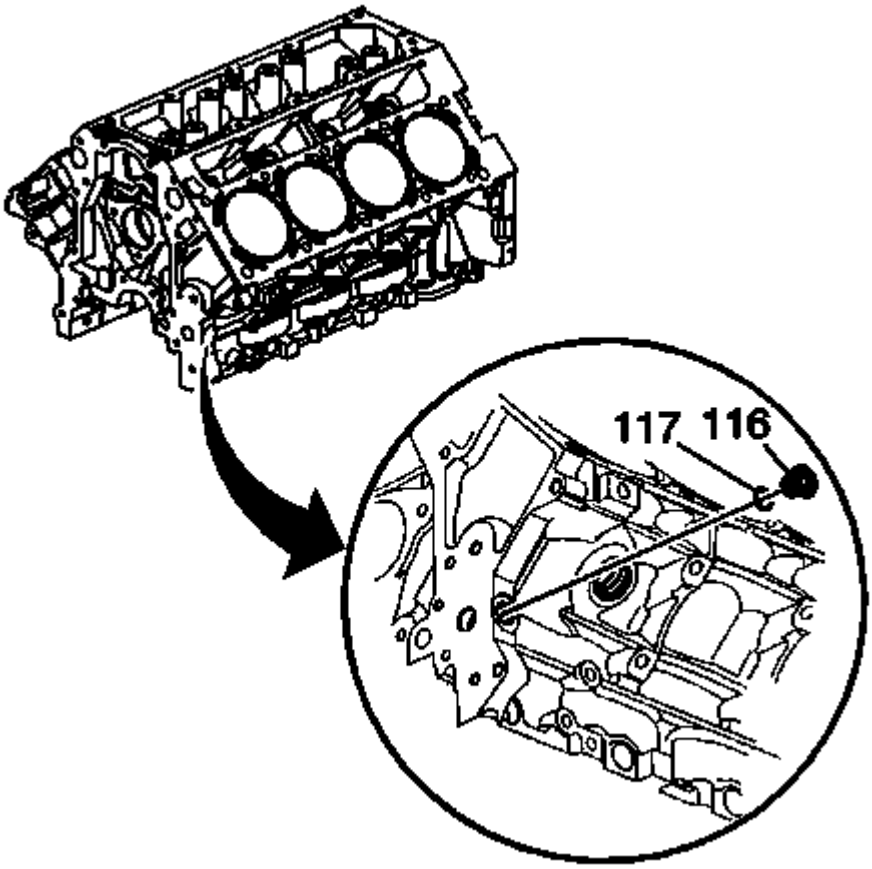

Fig. 564: Locating Engine Block Left Front Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

5. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left front oil gallery plug sealing washer (117).
6. Install the engine block left front oil gallery plug (116) and tighten to 60 N.m (44 lb ft).

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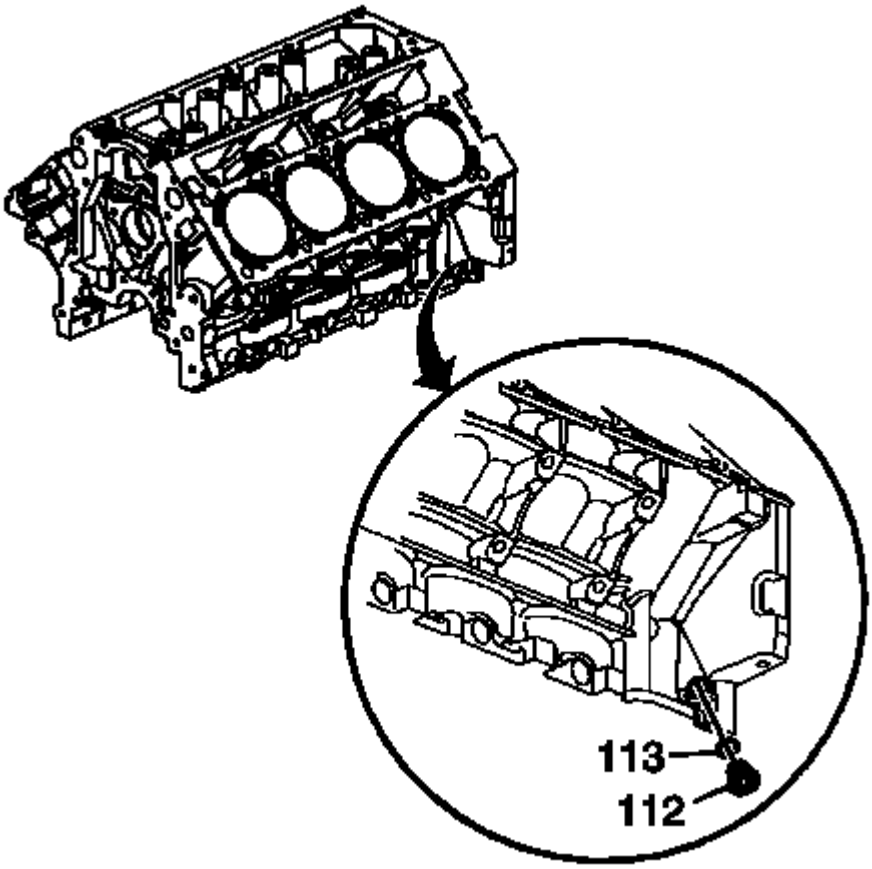

Fig. 565: Locating Engine Block Left Rear Oil Gallery Plug & Seal
Courtesy of GENERAL MOTORS CORP.

7. Apply a 3.175 mm (0.125 in) bead of sealant GM P/N 12346004 (Canadian P/N 10953480) to the engine block left rear oil gallery plug sealing washer (113).
8. Install the engine block left rear oil gallery plug (112) and tighten to 60 N.m (44 lb ft).

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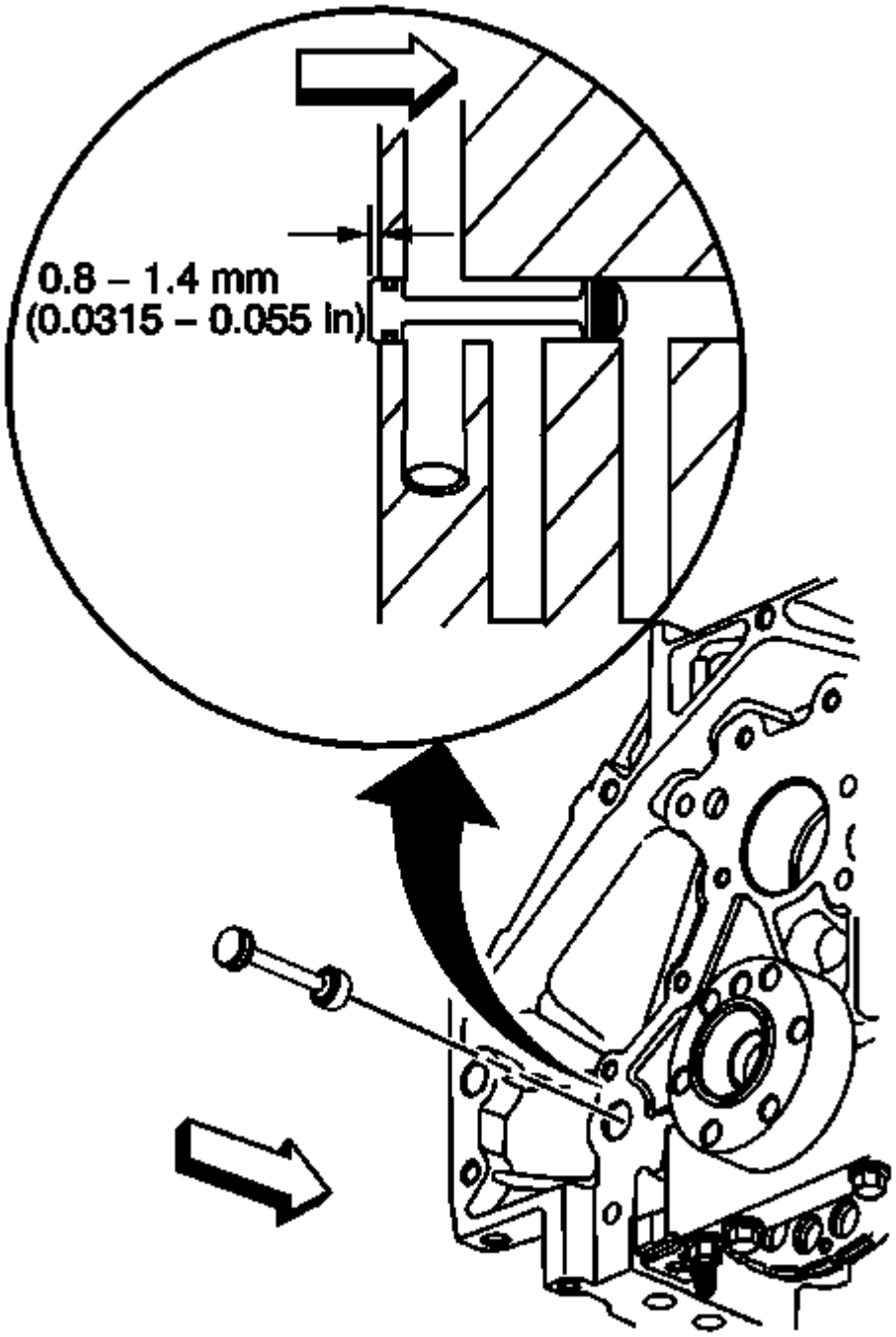

Fig. 566: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

9. Inspect the engine block rear oil gallery plug and O-ring seal. If the O-ring seal on the plug is not cut or damaged, the rear oil gallery plug may be used again.
10. Lubricate the O-ring seal with clean engine oil.
11. Install the O-ring seal onto the plug.
12. Install the engine block rear oil gallery plug into the oil gallery bore. A properly installed block plug will protrude 0.8-1.4 mm (0.0315-0.055 in) beyond the rear face of the block.

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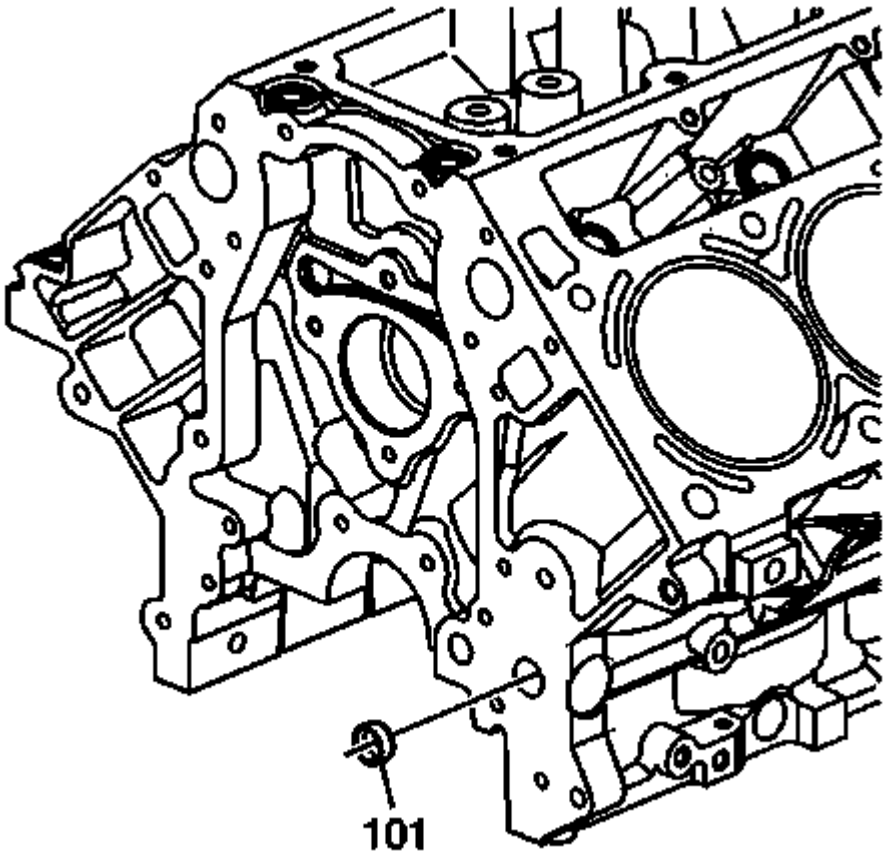

Fig. 567: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489) to the sides of the NEW front oil gallery plug (101).

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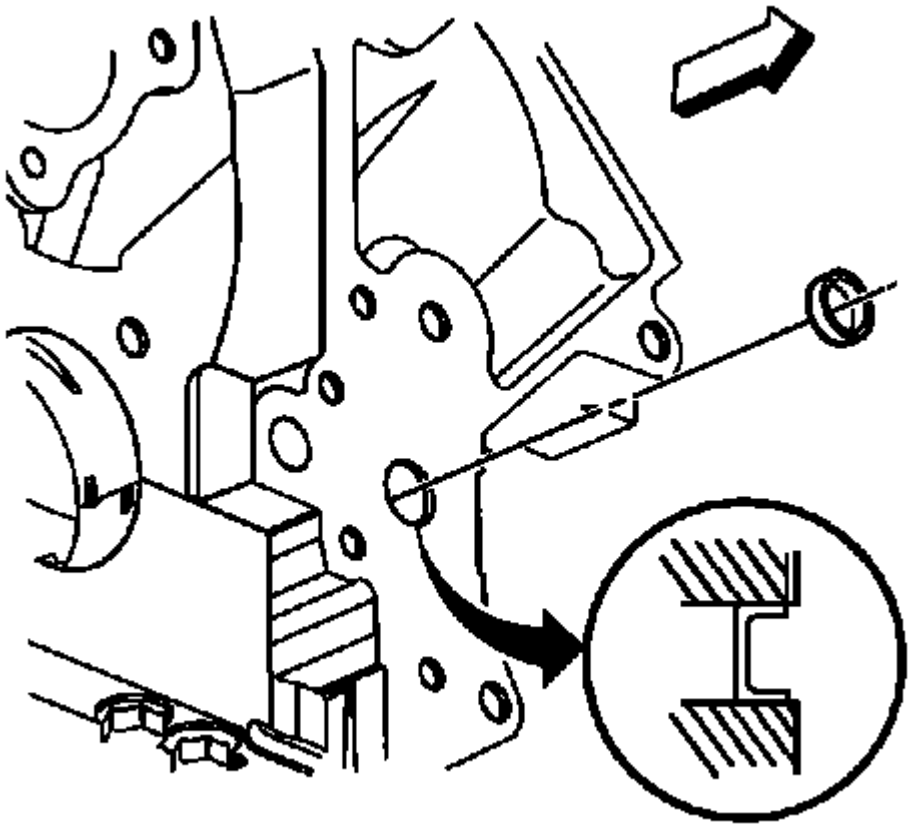

Fig. 568: View Of Engine Block Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

14. Install a NEW engine block front oil gallery plug. Install the plug into the oil gallery bore 2.2-2.8 mm (0.0086-0.011 in) below flush.

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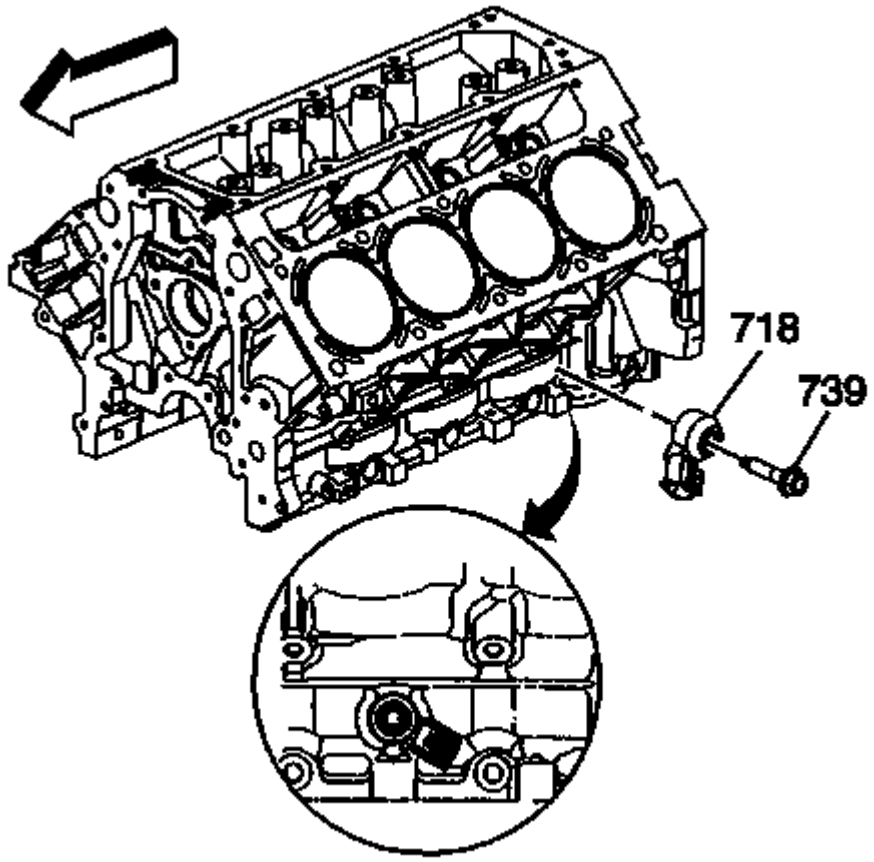

Fig. 569: Left Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

15. Install the left side knock sensor (718) and bolt (739) and tighten to 25 N.m (18 lb ft).

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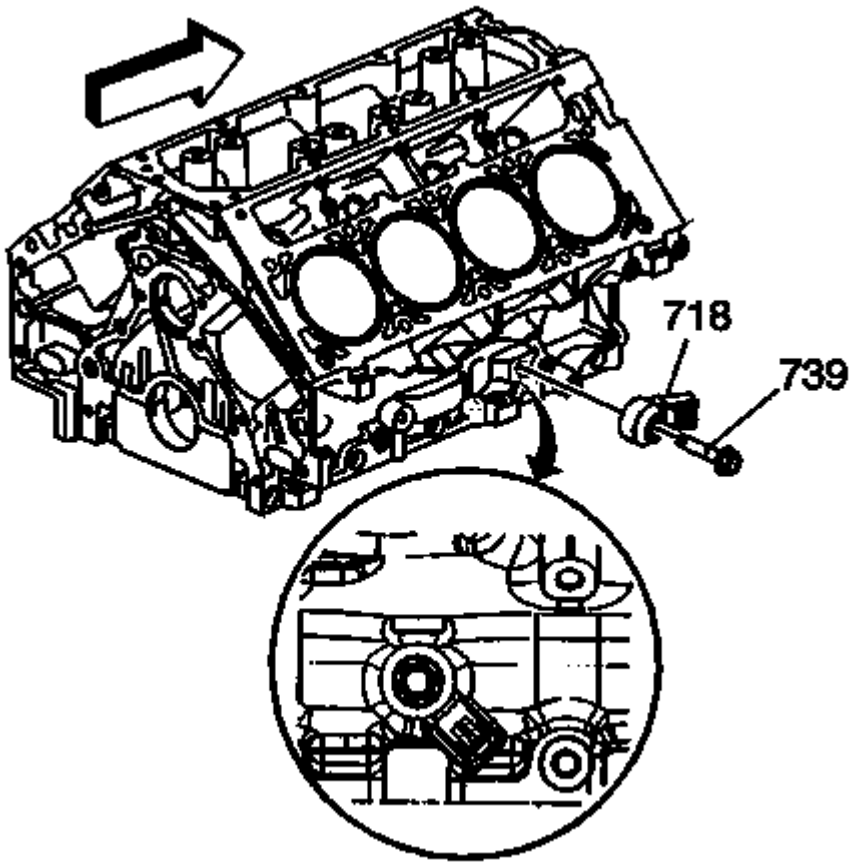

Fig. 570: Right Side Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

16. Install the right side knock sensor (718) and bolt (739) and tighten to 25 N.m (18 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

J 45059: Angle Meter

For equivalent regional tools, refer to **Special Tools**

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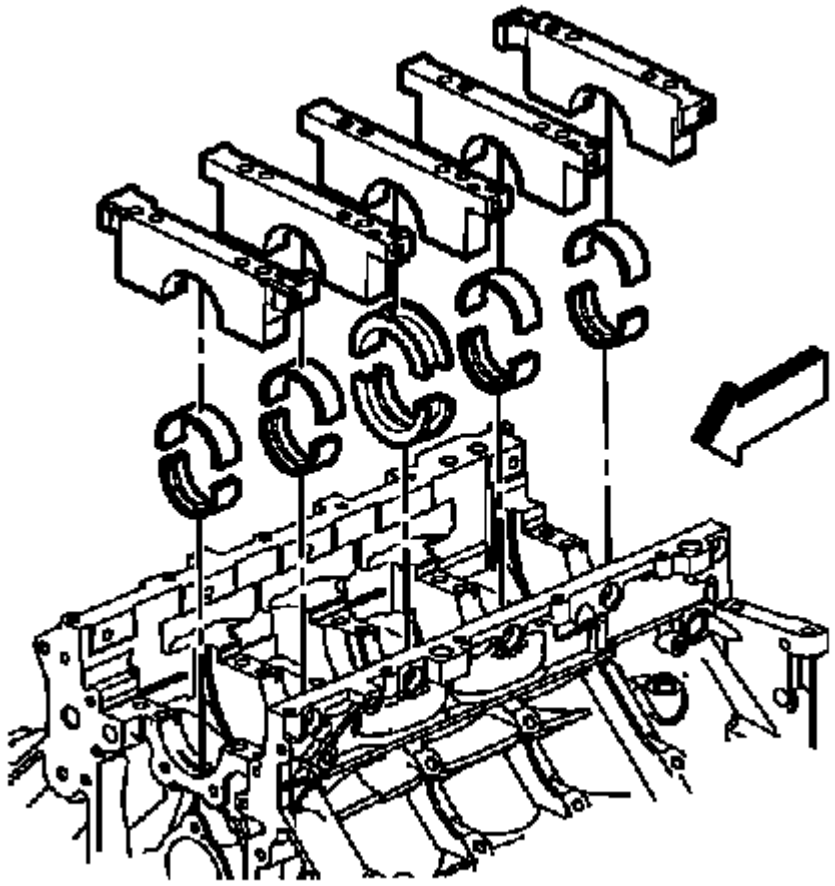

Fig. 571: View Of Crankshaft Bearings & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may affect crankshaft position (CKP) sensor signals and/or on-board diagnostic (OBD) II system performance.**
- **Crankshaft bearing caps must be installed to the proper location and direction.**
- **When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.**
- **Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.**
- **In order to prevent engine block oil leakage, install NEW M8 crankshaft bearing cap side bolts.**

  The crankshaft bearing cap M8 side bolts have a pre-applied sealant patch applied to the bolt flange.

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1. Install the crankshaft bearings to the engine block and bearing caps. The thrust bearings are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

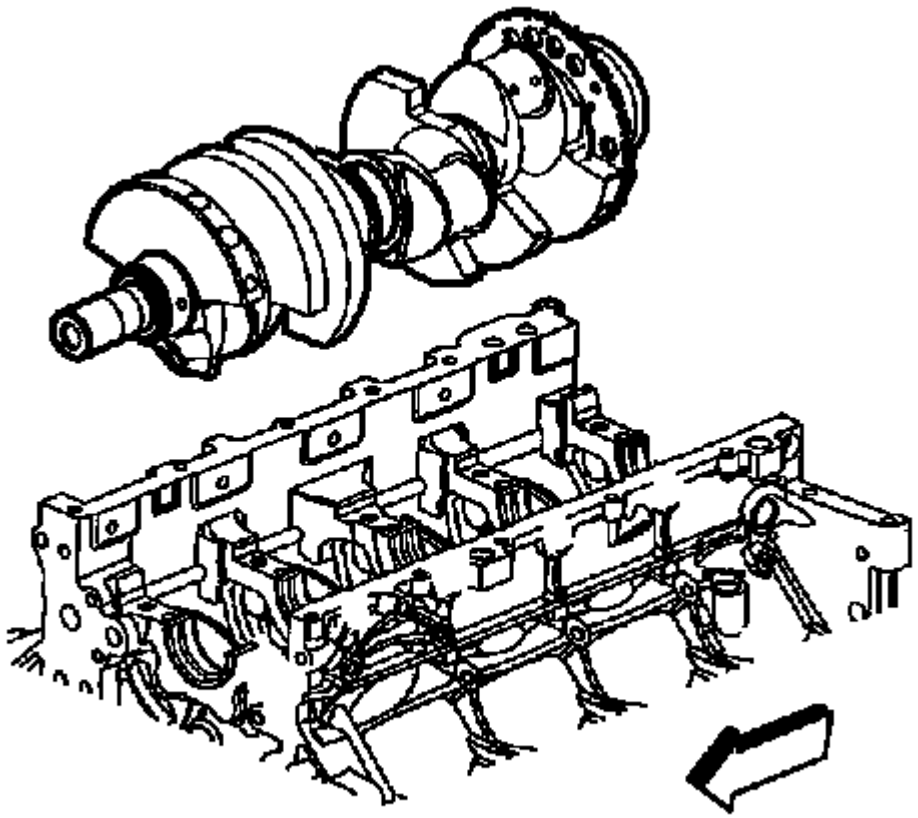

Fig. 572: View Of Crankshaft & Engine Block
Courtesy of GENERAL MOTORS CORP.

CAUTION: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft.

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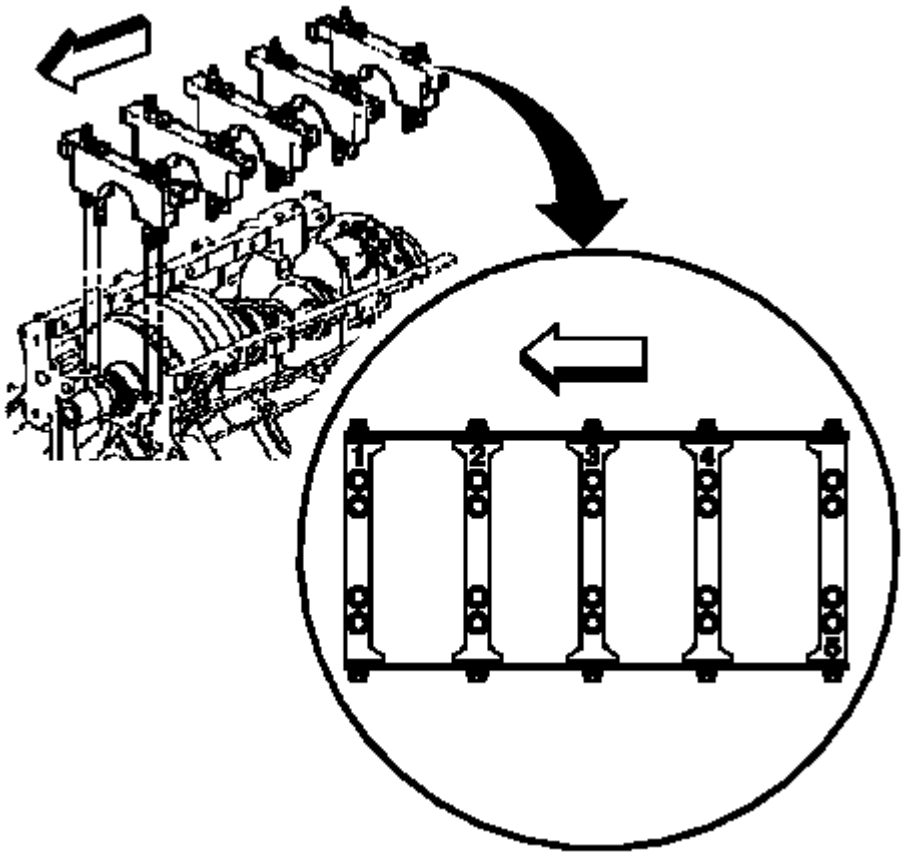

Fig. 573: View of Proper Bearing Cap Installation
Courtesy of GENERAL MOTORS CORP.

NOTE: The bearing caps must be installed in the proper location and direction.

4. Install the crankshaft bearing caps, with bearings, into the engine block.

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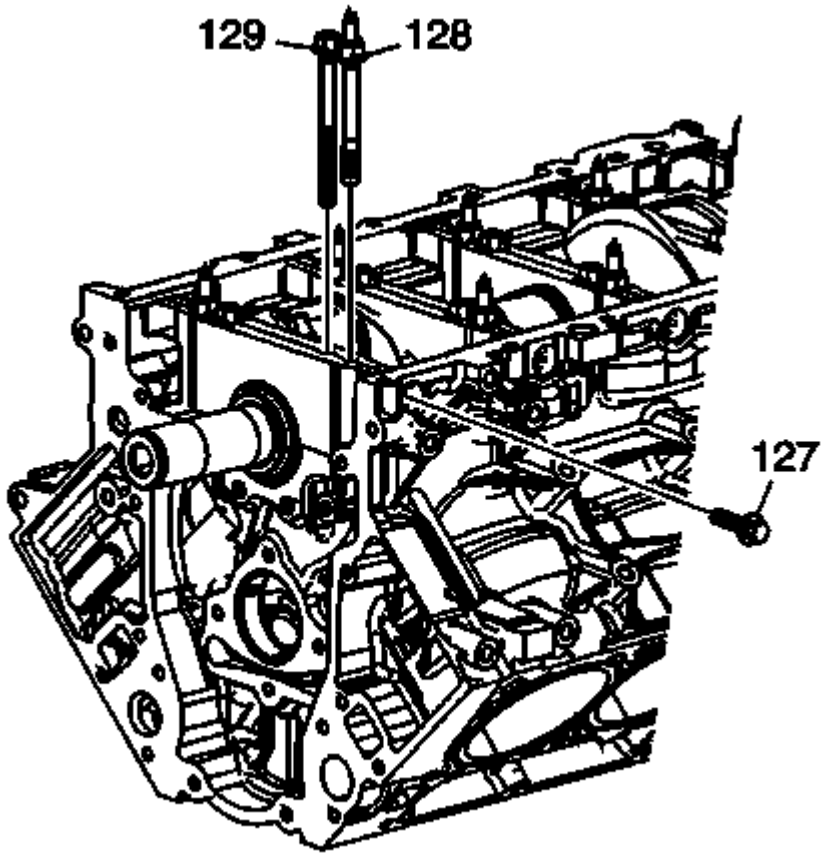

Fig. 574: Identifying Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

5. Install NEW M10 bolts (129) and NEW studs (128).
6. Using a plastic-face hammer, tap the bearing caps into place.
7. Install the NEW M8 bearing cap side bolts (127).

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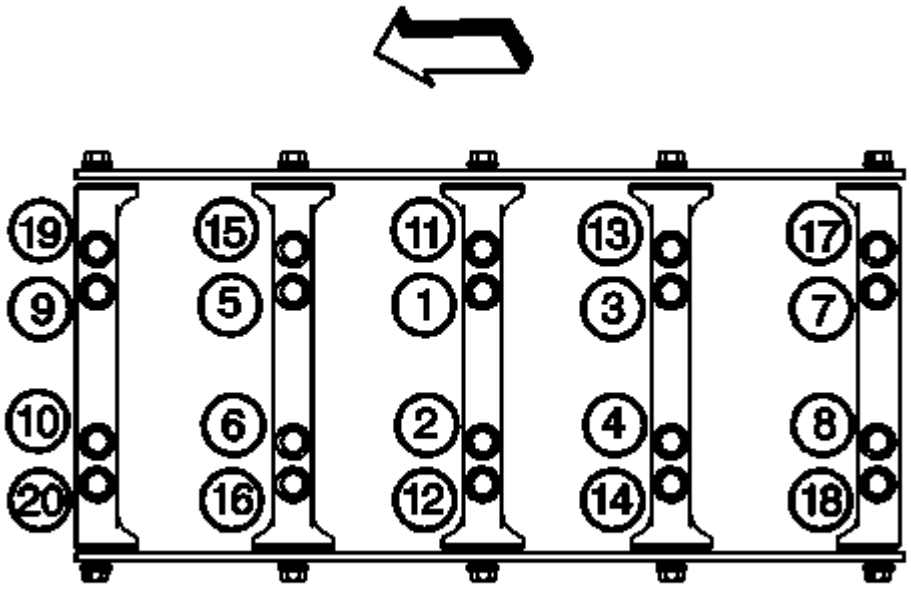

Fig. 575: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Tighten the M10 bearing cap bolts (1-10) a first pass in sequence to 20 N.m (15 lb ft).

NOTE: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward direction.

9. Using a plastic-face hammer, tap the crankshaft rearward, then forward in order to align the thrust bearings.
   - Tighten the M10 bolts (1-10) a final pass in sequence 80 degrees using the **J 45059:** meter .
   - Tighten the M10 studs (11-20) a first pass in sequence to 20 N.m (15 lb ft) .
   - Tighten the M10 studs (11-20) a final pass in sequence 51 degrees using the **J 45059:** meter .

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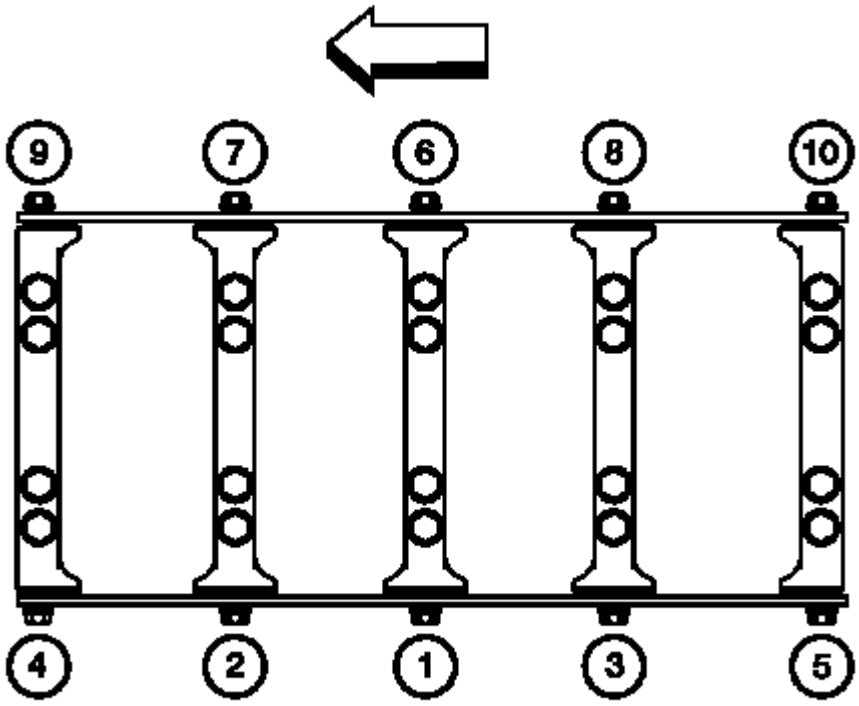

Fig. 576: Identifying M8 Main Bearing Cap Side Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

10. Tighten the M8 main bearing cap side bolts (1-10).
    - Tighten the M8 bolts (1-5) a first pass in sequence to 20 N.m (15 lb ft) .
    - Tighten the M8 bolts (1-5) a final pass in sequence to 30 N.m (22 lb ft) .
    - Tighten the M8 bolts (6-10) a first pass in sequence to 20 N.m (15 lb ft) .
    - Tighten the M8 bolts (6-10) a final pass in sequence to 30 N.m (22 lb ft) .

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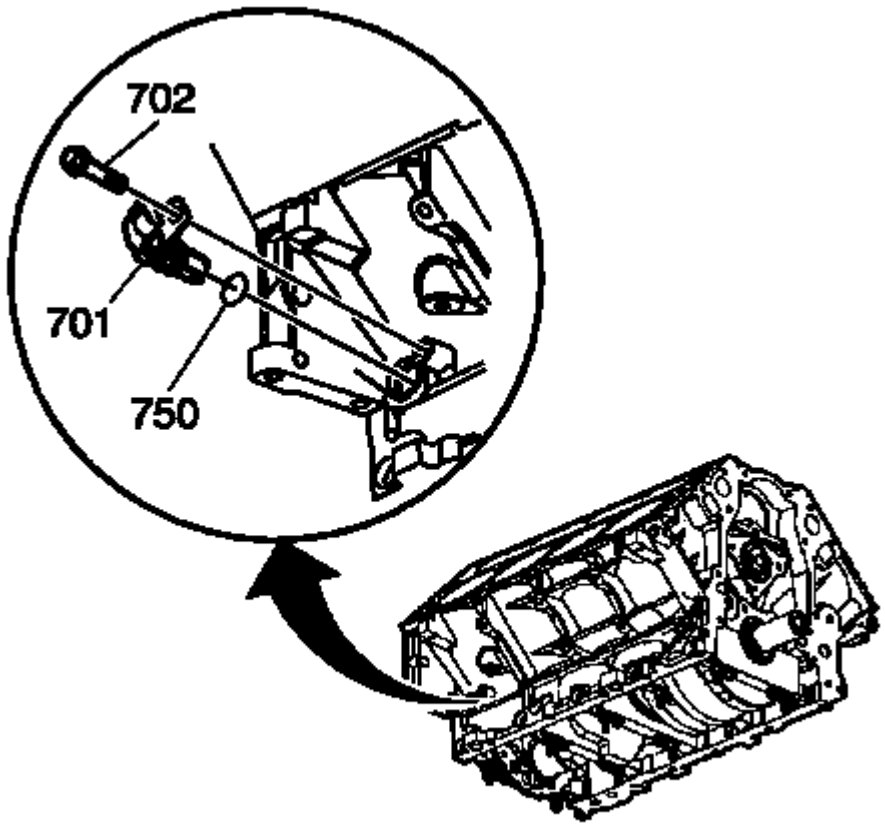

Fig. 577: CKP Sensor, Bolt & O-Ring
Courtesy of GENERAL MOTORS CORP.

11. Install the CKP sensor.
    1. Inspect the CKP sensor O-ring seal (750). If the O-ring seal is not cut or damaged, it may be used again.
    2. Coat the O-ring seal with clean engine oil.
    3. Install the O-ring onto the sensor.
    4. Install the sensor (701). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.
    5. Install the sensor bolt (702) and tighten to 25 N.m (18 lb ft) .

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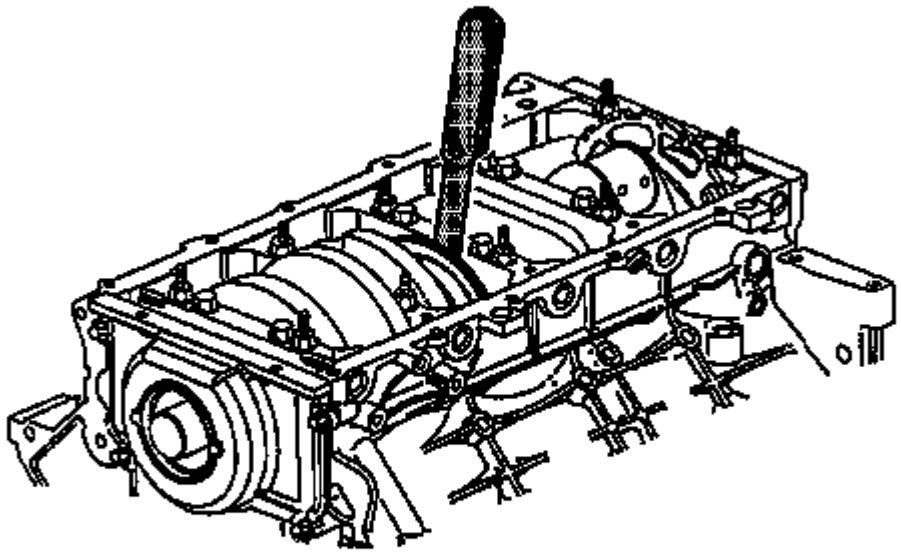

Fig. 578: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

       The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

    3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

- **J 8037:** Piston Ring Compressor
- **J 8087:** Cylinder Bore Gauge
- **J 41556:** Connecting Rod Guide

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- **J 45059:** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Piston Selection

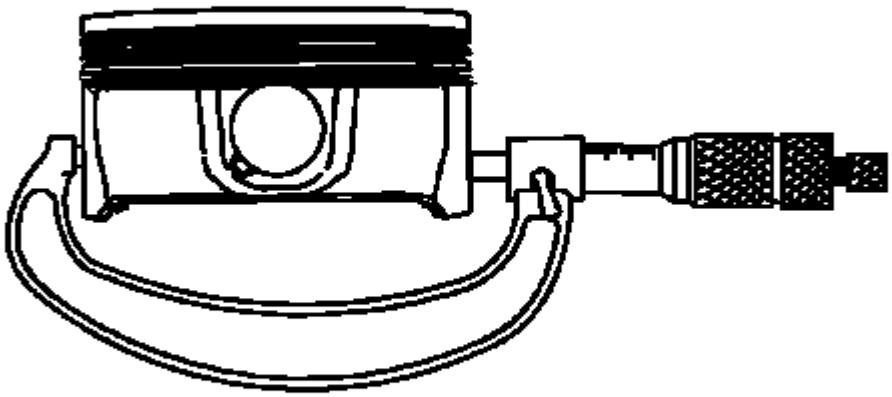

Fig. 579: Measuring Piston Outside Diameter
Courtesy of GENERAL MOTORS CORP.

NOTE: Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.

1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the piston. Refer to **Engine Mechanical Specifications**.
2. Record the piston OD.

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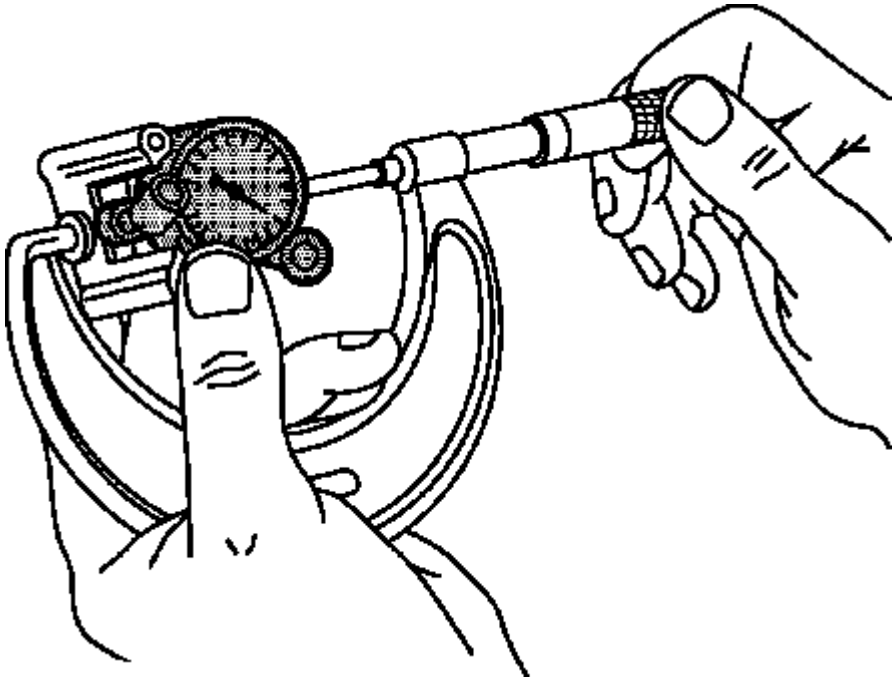

Fig. 580: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **J 8087:** bore gauge into the micrometer and zero the gauge dial.

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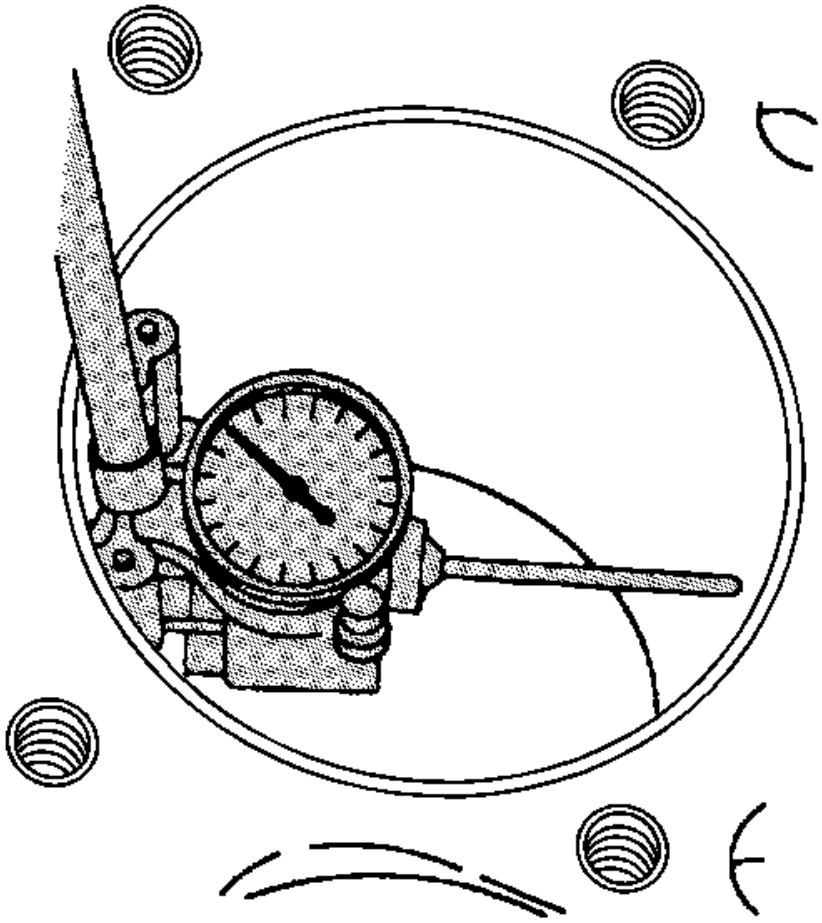

Fig. 581: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 8087:** bore gauge, measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID in order to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston and pin assembly and measure the clearances again. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

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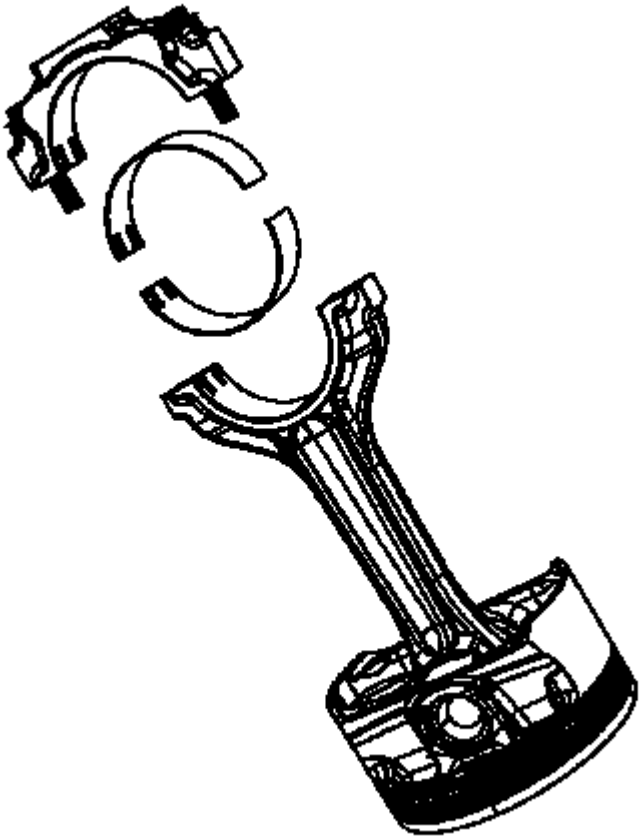

Fig. 582: View Of Piston, Connecting Rod & Cap
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the following components with clean engine oil:
   - Piston
   - Piston rings
   - Cylinder bore
   - Bearings and bearing surfaces
2. Install the bearings to the connecting rod and cap.
3. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
4. Position the compression ring end gaps 180 degrees opposite each other.

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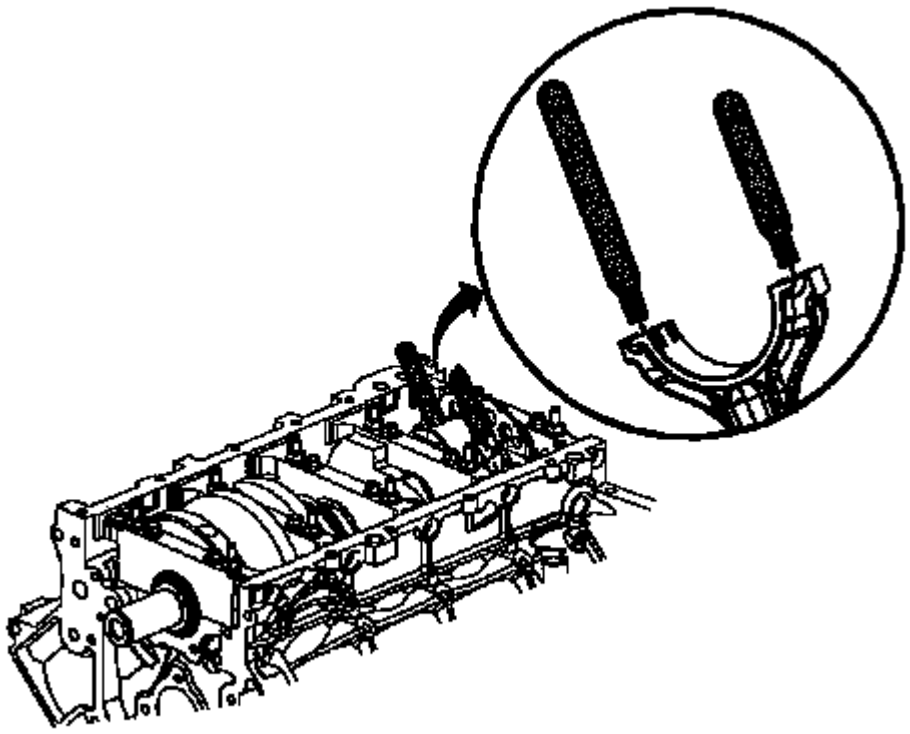

Fig. 583: View Of Piston & Connecting Rod Assembly
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 41556:** rod guide to the connecting rod.

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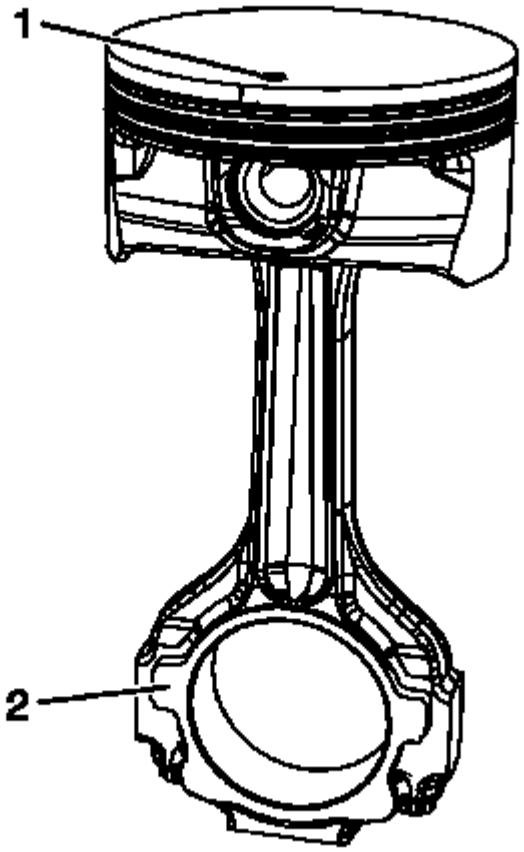

Fig. 584: View of Mark On Top Of Piston & Connecting Rod Tab
Courtesy of GENERAL MOTORS CORP.

6. Identify the proper installation direction of the piston and connecting rod assembly. When installing the piston and connecting rod assembly, the mark on the top of the piston (1) and the tab (2) on the side of the connecting rod should face the front of the engine.

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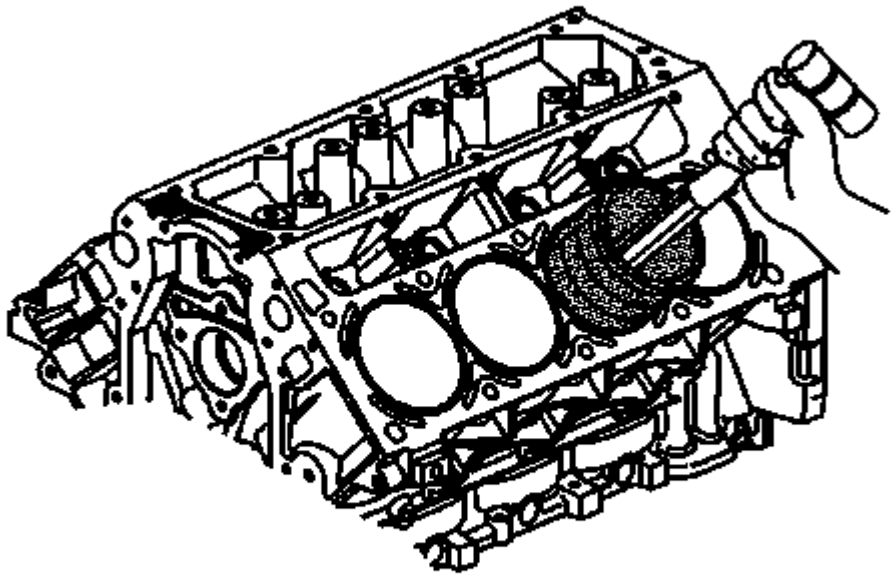

Fig. 585: Installing Piston
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 8037:** ring compressor onto the piston and compress the piston rings.

NOTE: The piston alignment mark MUST face the front of the engine block.

8. Install the piston, pin, and connecting rod assembly into the cylinder bore. Hold the piston ring compressor firmly against the engine block. Using a wooden hammer handle, lightly tap the top of the piston until all piston rings have entered the cylinder bore.
9. Use the **J 41556:** rod guide to guide the connecting rod onto the crankshaft journal.
10. Remove the **J 41556:** rod guide from the connecting rod.

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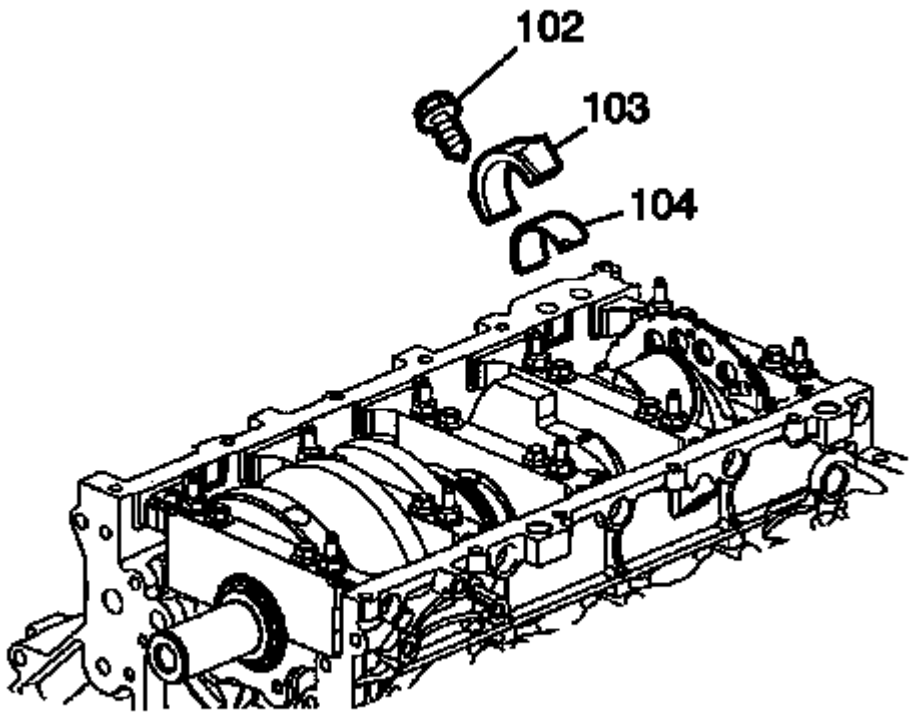

Fig. 586: Connecting Rod Bolt, Cap & Bearing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- **The connecting rod and cap must be assembled with the mating surfaces properly aligned.**
- **If re-using connecting rods, DO NOT re-use connecting rod fasteners. During an installation procedure, the new connecting rod bolts can be re-tightened a maximum of 3 times.**

11. Install the bearing cap (103), bearing (104), and bolts (102).
    1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
    2. Tighten the bolts a final pass to 85 degrees using the **J 45059:** angle meter.

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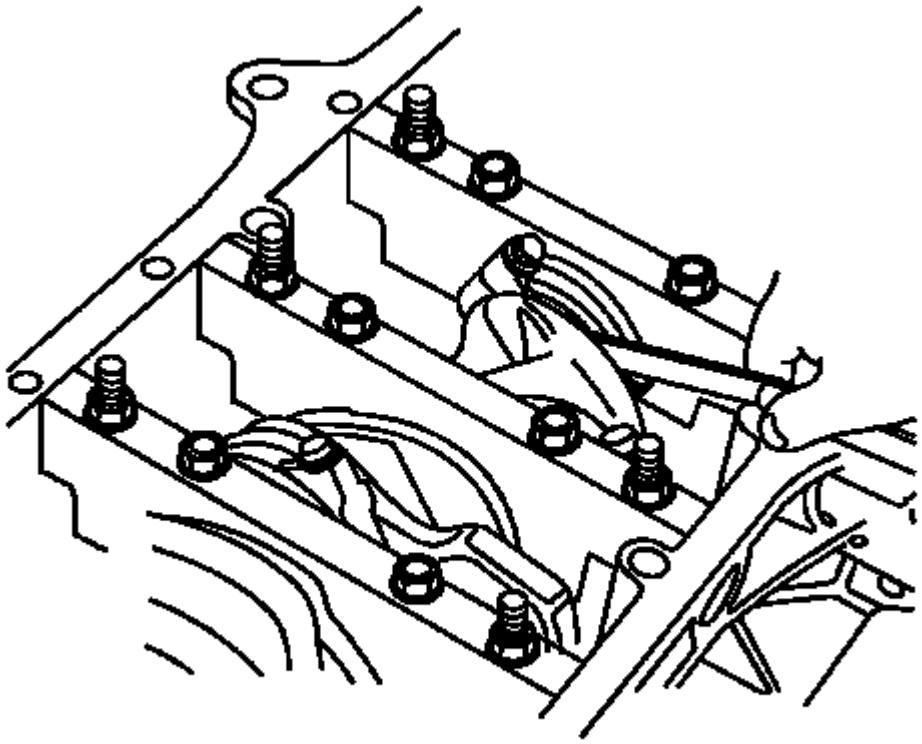

Fig. 587: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

12. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications**.

CAMSHAFT INSTALLATION

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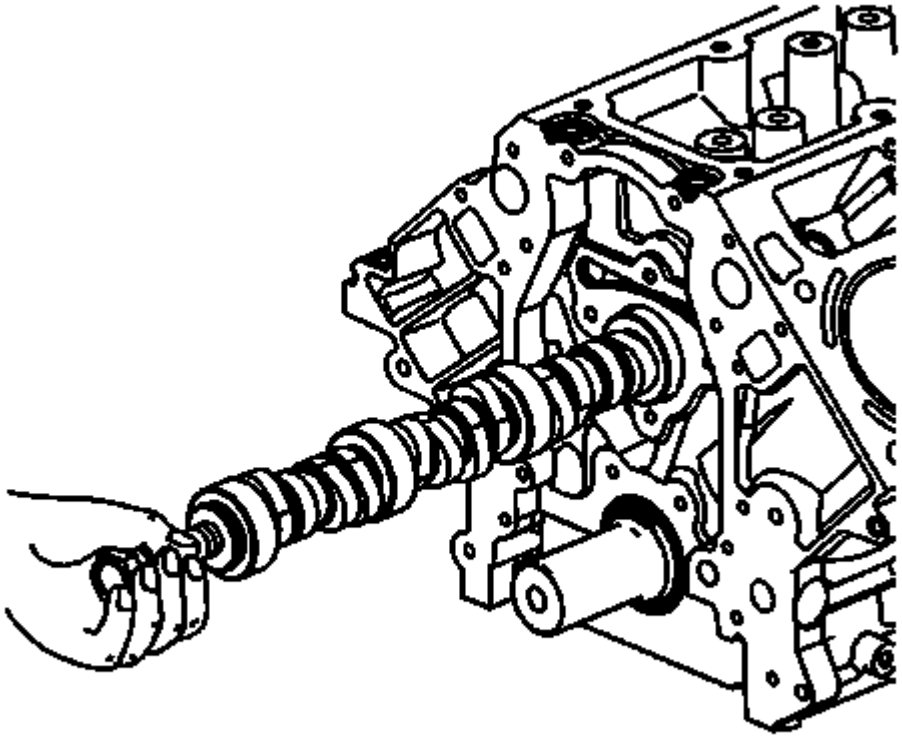

Fig. 588: View Of Camshaft
Courtesy of GENERAL MOTORS CORP.

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

1. Lubricate the camshaft journals and the bearings with clean engine oil.
2. Install the camshaft sprocket bolt into the camshaft front bolt hole.

CAUTION: 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 bolt as a handle, carefully install the camshaft into the engine block.
4. Remove the bolt from the front of the camshaft.

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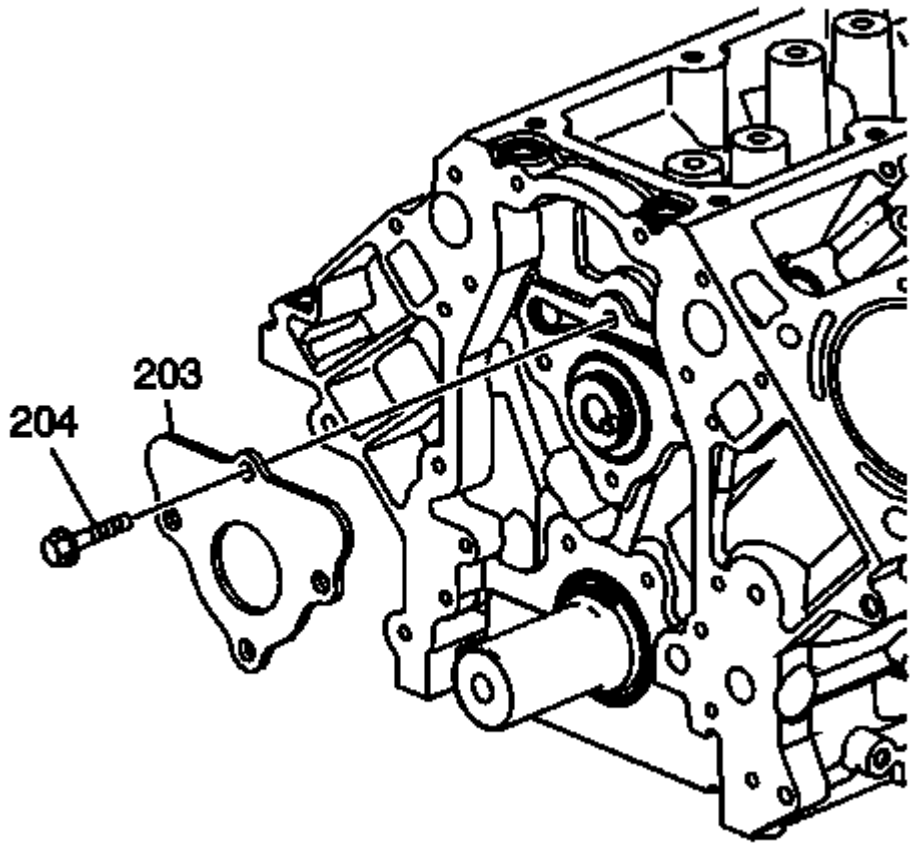

Fig. 589: View Of Camshaft Retainer & Retainer Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: The gasket surface on the engine block should be clean and free of dirt or debris.

5. Install the camshaft retainer (203) and the bolts (204). Install the retainer with the sealing gasket facing the front of the engine block.

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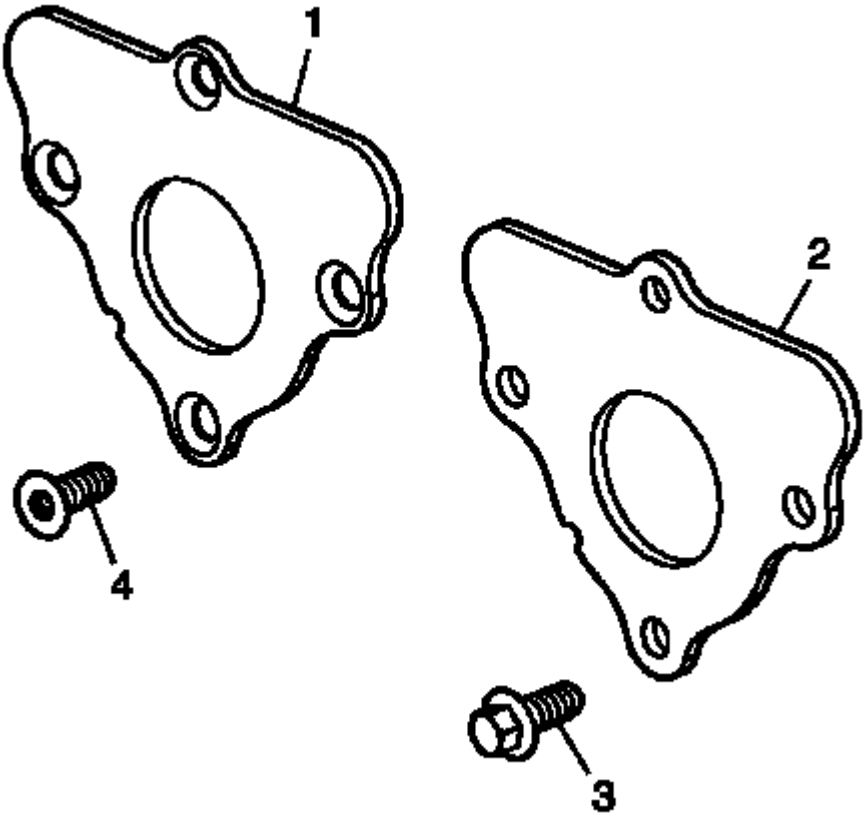

Fig. 590: Identifying Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Tighten the camshaft retainer bolts.
    - Tighten the first design hex head bolts (3) to 25 N.m (18 lb ft) .
    - Tighten the second design TORX® head bolts (4) to 15 N.m (11 lb ft) .

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE INSTALLATION

Special Tools

- **EN 46330:** Timing Belt Tensioner Retaining Pin
- **J 41478:** Crankshaft Front Oil Seal Installer
- **J 41665:** Crankshaft Balancer and Sprocket Installer
- **J 42386-A:** Flywheel Holding Tool

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- **J 45059:** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

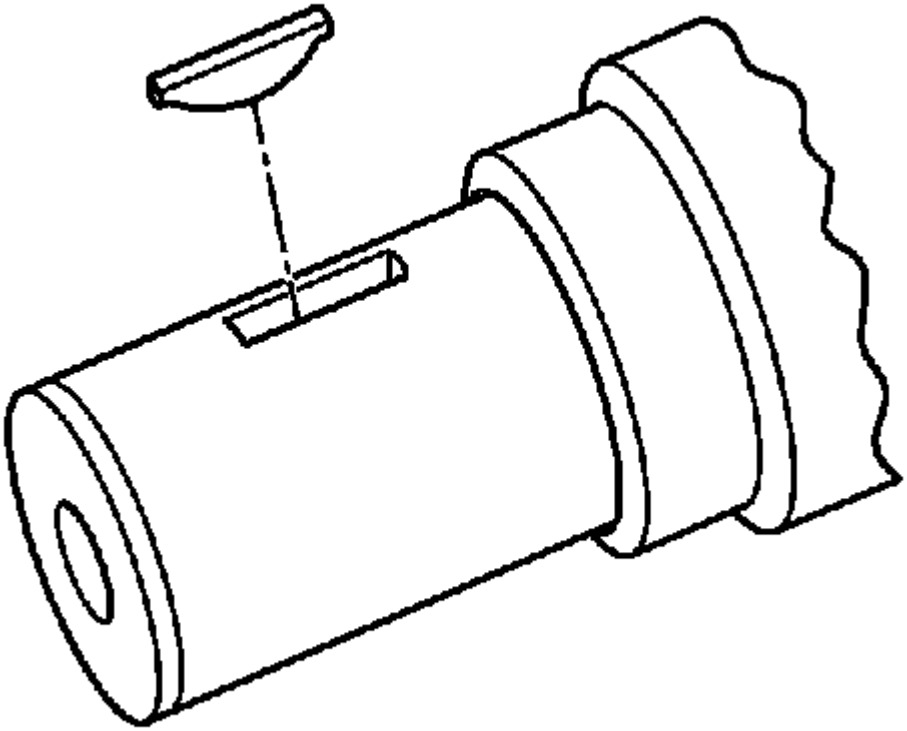

Fig. 591: View Of Crankshaft Key & Keyway
Courtesy of GENERAL MOTORS CORP.

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

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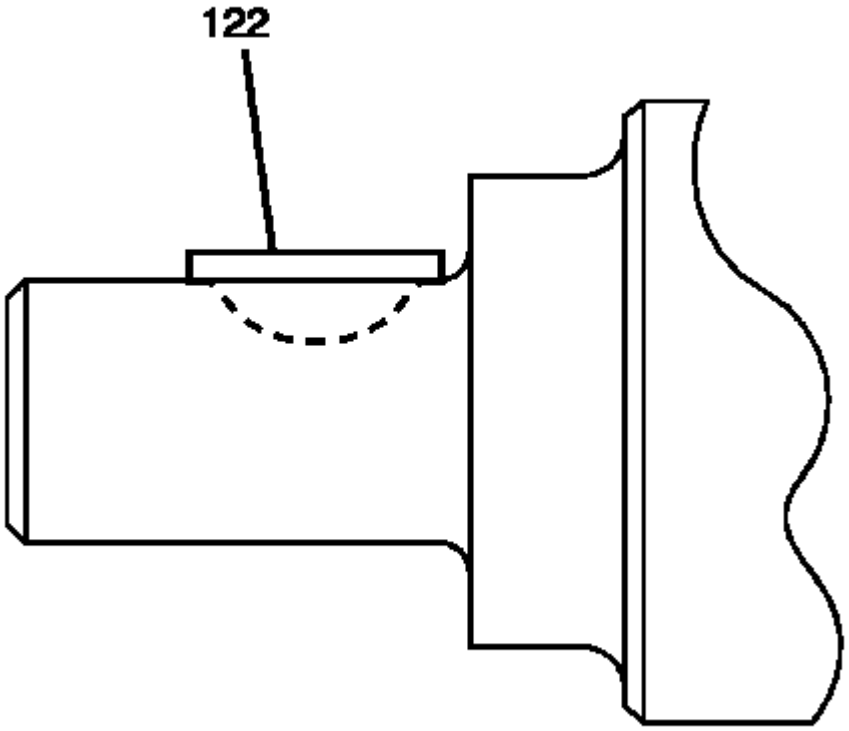

Fig. 592: View Of Installed Crankshaft Key
Courtesy of GENERAL MOTORS CORP.

2. Tap the key (122) into the keyway until both ends of the key bottom onto the crankshaft.

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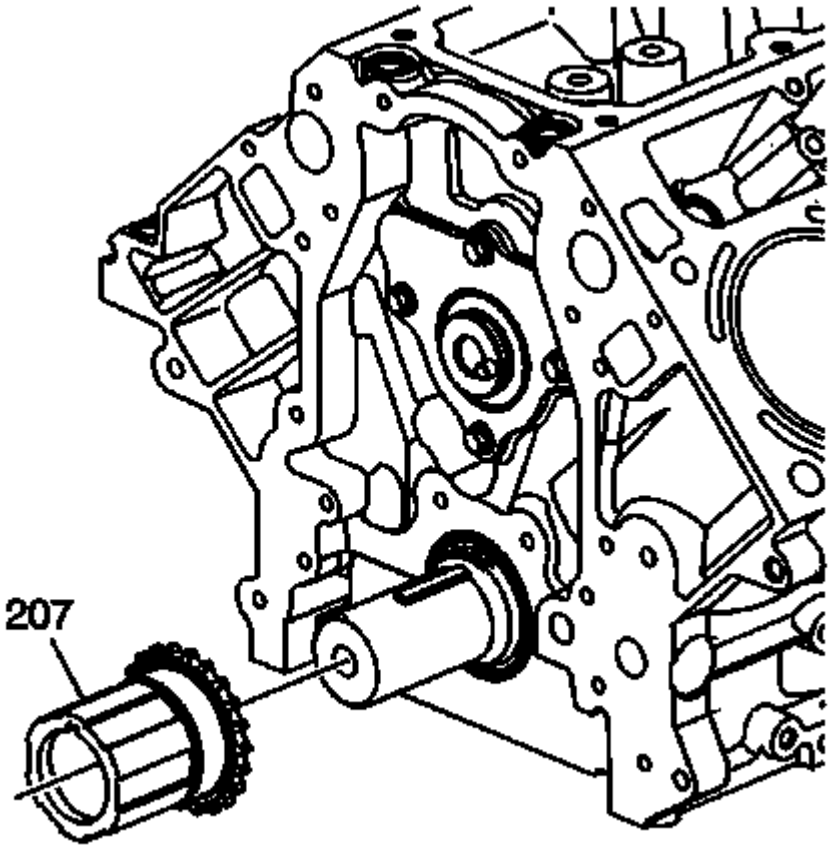

Fig. 593: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft sprocket (207) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

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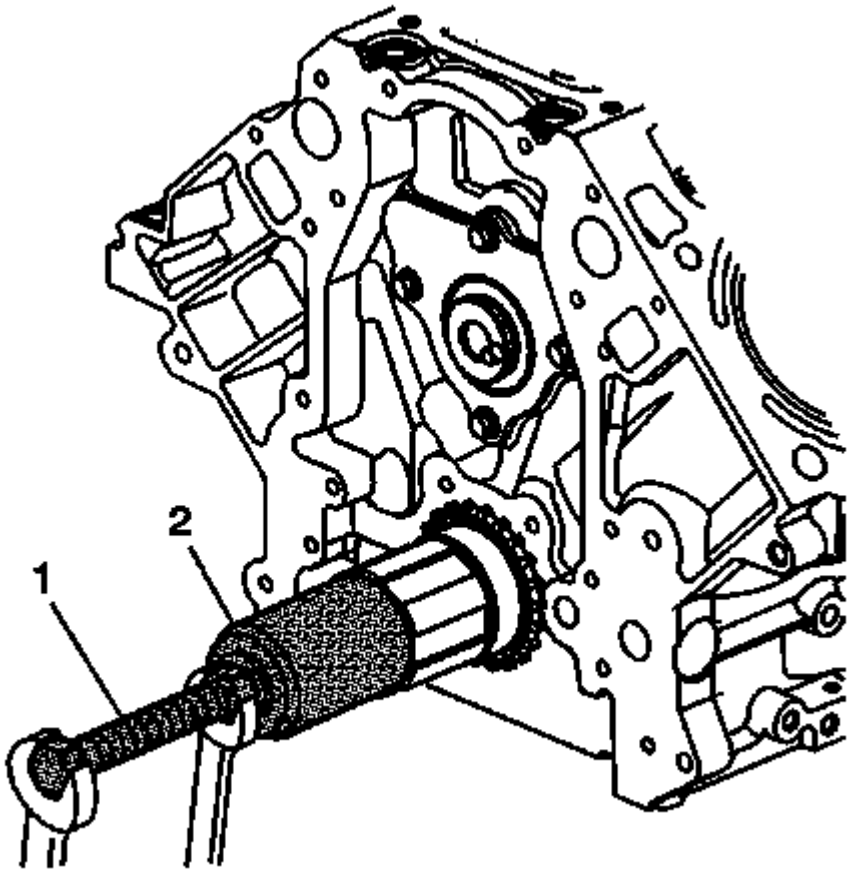

Fig. 594: View Of Crankshaft Sprocket & Installer
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41478:** installer (1) and the **J 41665:** installer (2) in order to install the crankshaft sprocket. Install the sprocket onto the crankshaft until fully seated against the crankshaft flange.
5. Rotate the crankshaft sprocket until the sprocket alignment mark is in the 12 o'clock position.

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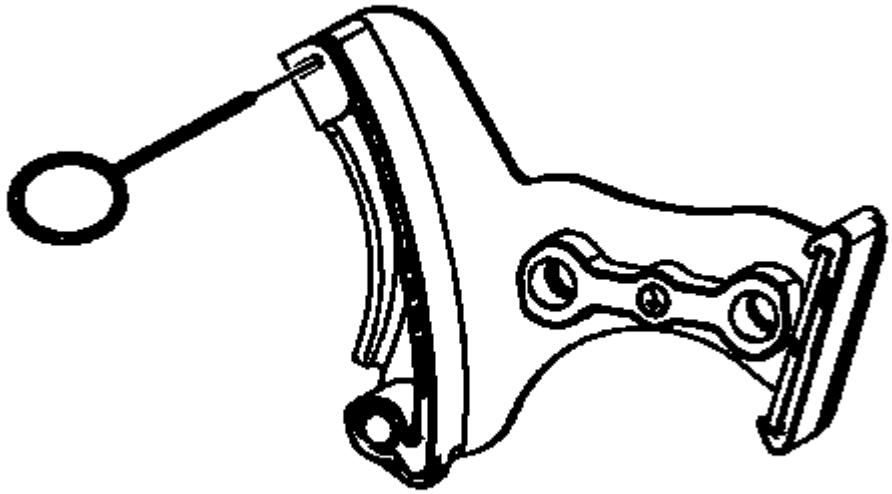

Fig. 595: View Of Compressed Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Compress the timing chain tensioner guide and install the **EN 46330:** pin.

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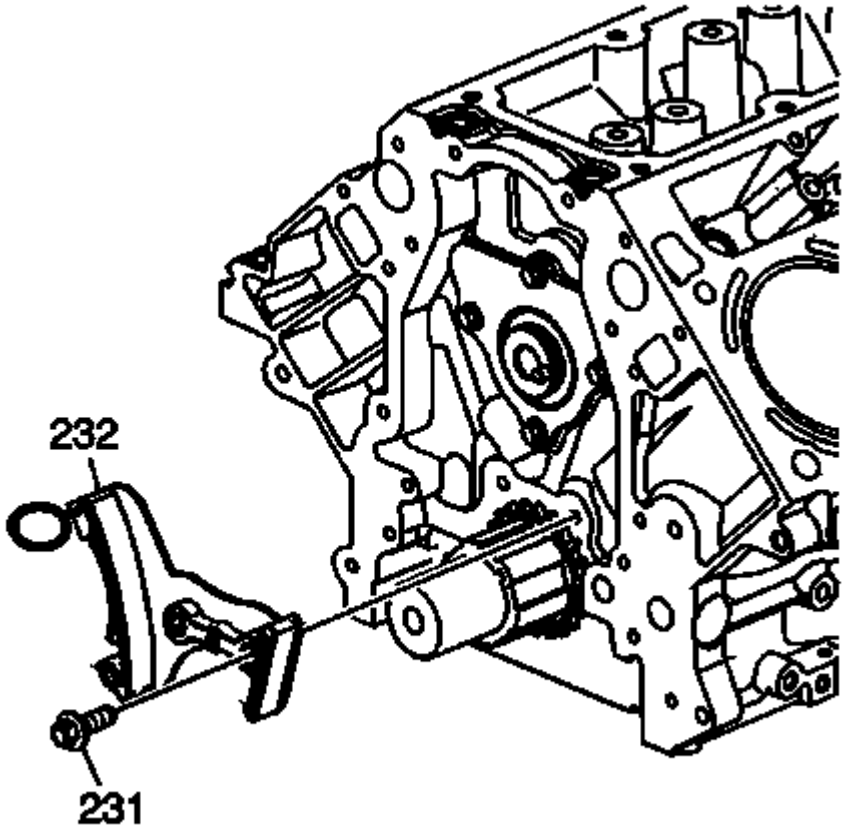

Fig. 596: View Of Timing Chain Tensioner & Left Side Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

7. Install the timing chain tensioner (232) and left side bolt (231). Do not install the right side bolt at this time. The right side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.

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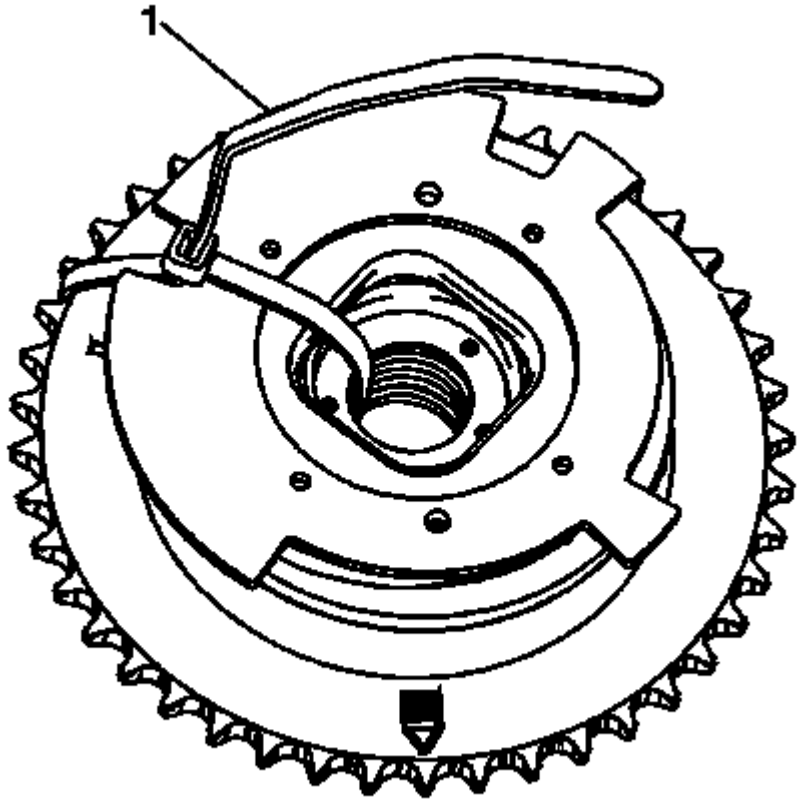

Fig. 597: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

8. Remove the tie strap (1) from the actuator.

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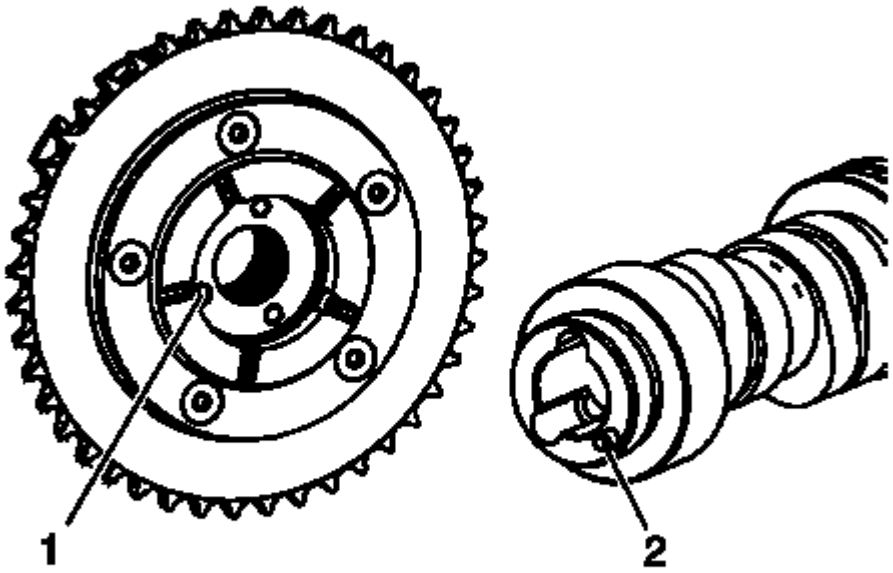

Fig. 598: Identifying Alignment Hole & Locating Pin
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW valve during assembly.**

9. 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.

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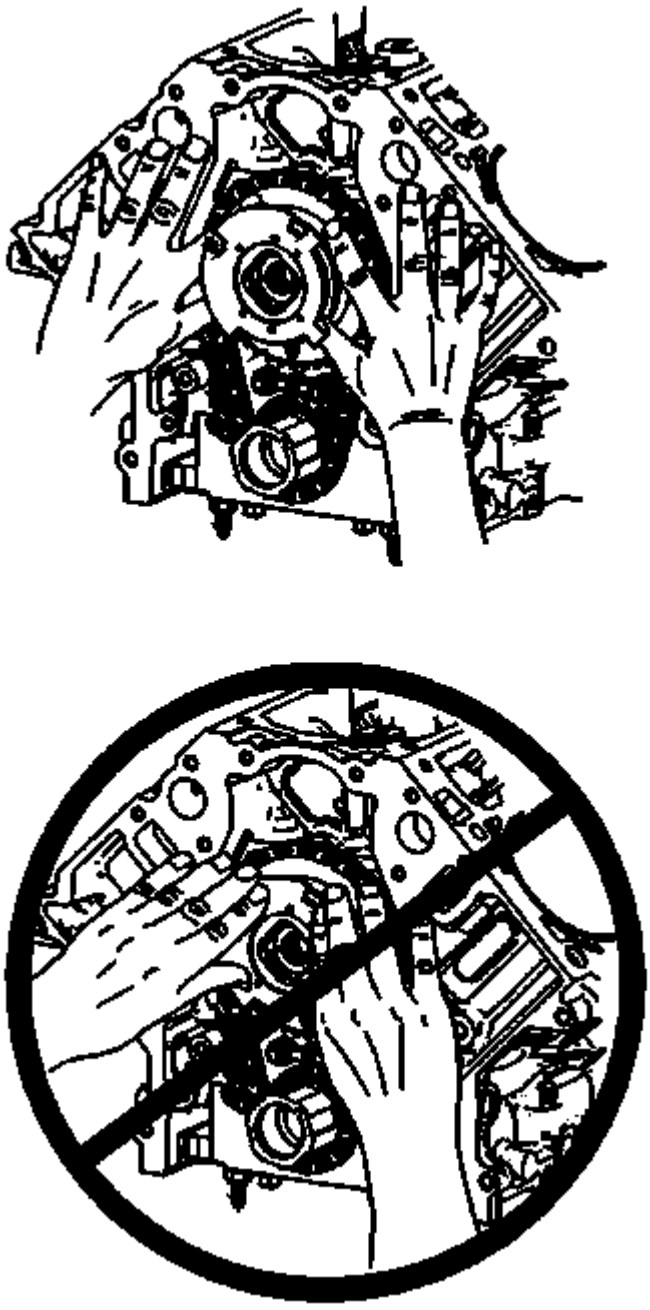

Fig. 599: Proper Installation Of CMP Actuator
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

10. 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.

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Position 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.

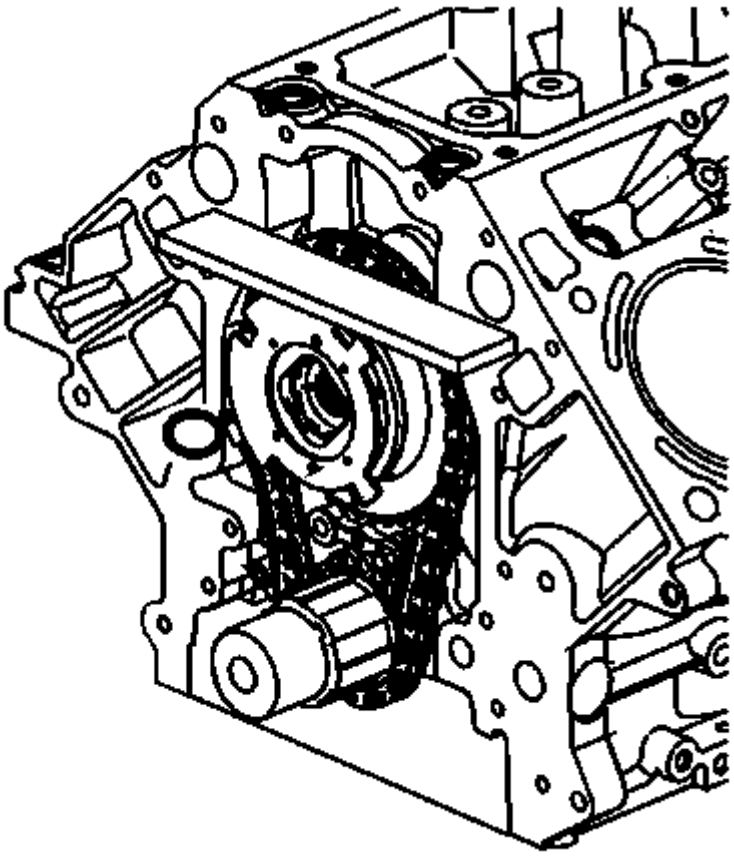

Fig. 600: Inspecting For Proper Installation Of CMP Actuator & Timing Chain
Courtesy of GENERAL MOTORS CORP.

11. Locate 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 camshaft, the timing chain will not protrude beyond the front face of engine block.

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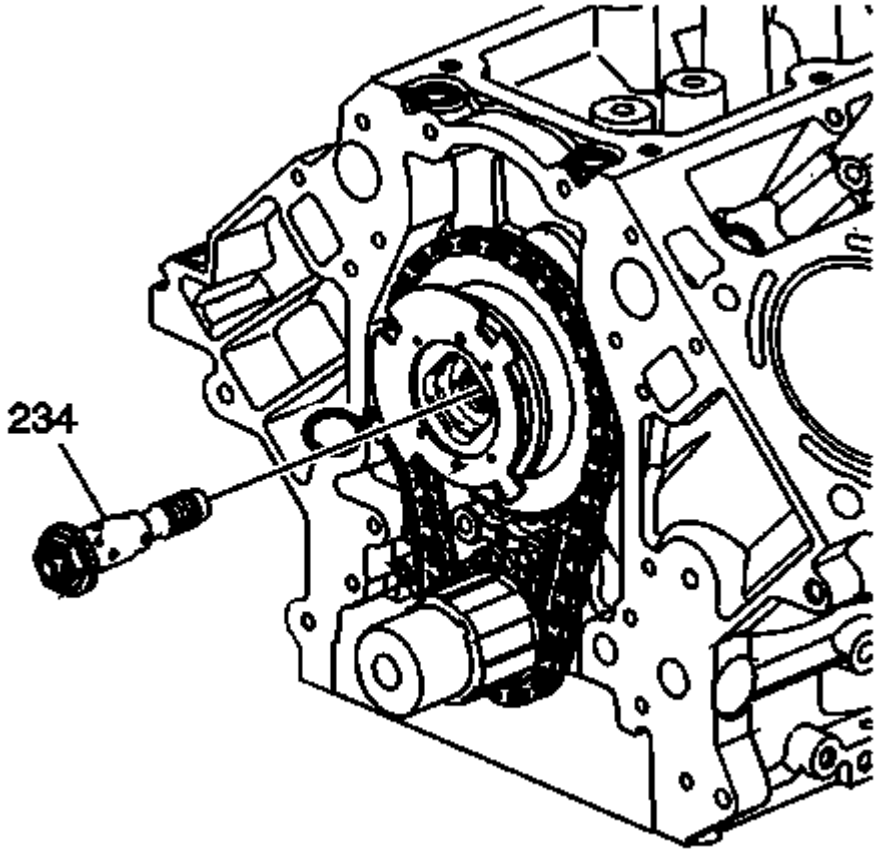

Fig. 601: View Of CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

12. 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.

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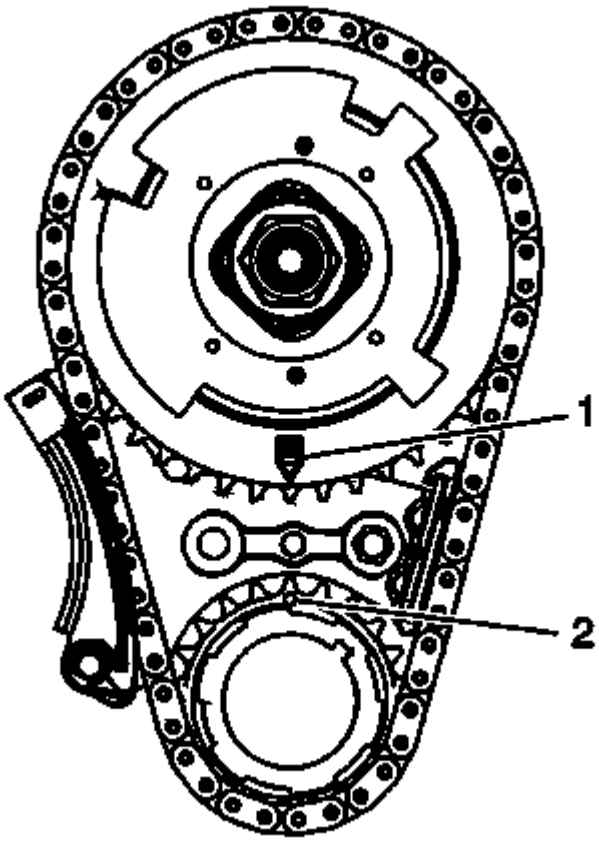

Fig. 602: View Of CMP Actuator Alignment Mark & Crankshaft Sprocket Alignment Mark
Courtesy of GENERAL MOTORS CORP.

13. 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.

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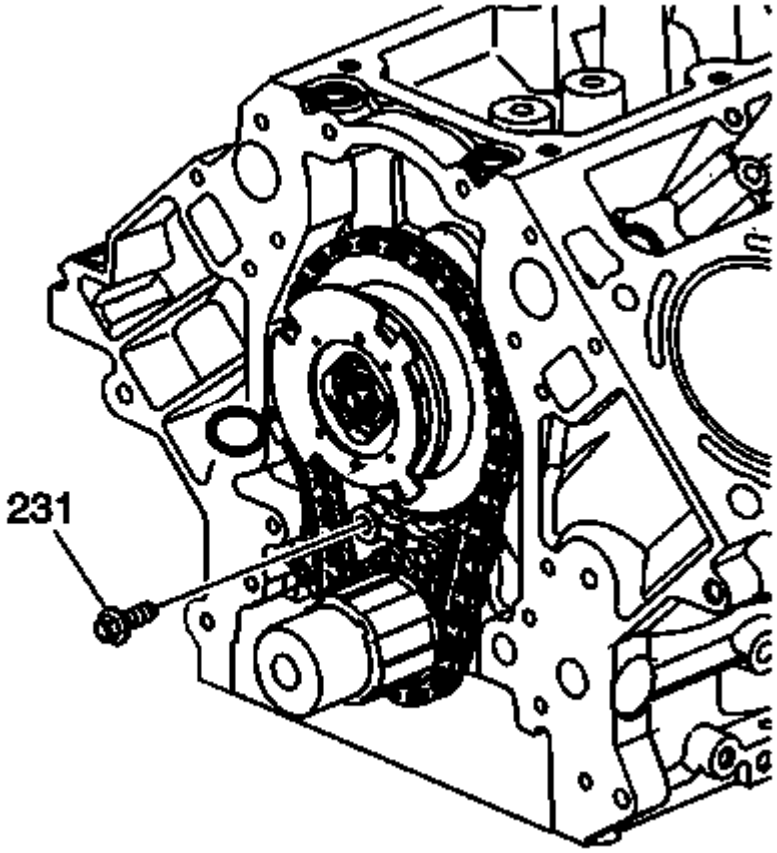

Fig. 603: View Of Timing Chain Tensioner Bolt
Courtesy of GENERAL MOTORS CORP.

14. Install the right side bolt (231) into the timing chain tensioner and tighten both bolts to 30 N.m (22 lb ft).

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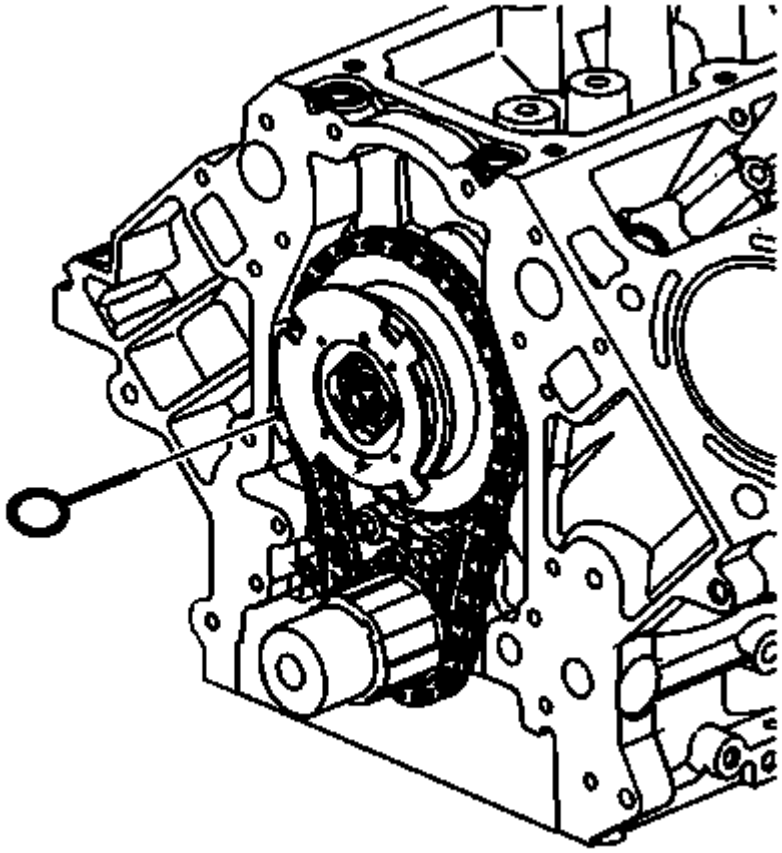

Fig. 604: View Of Special Tool EN 46330
Courtesy of GENERAL MOTORS CORP.

15. Remove the **EN 46330:** pin.

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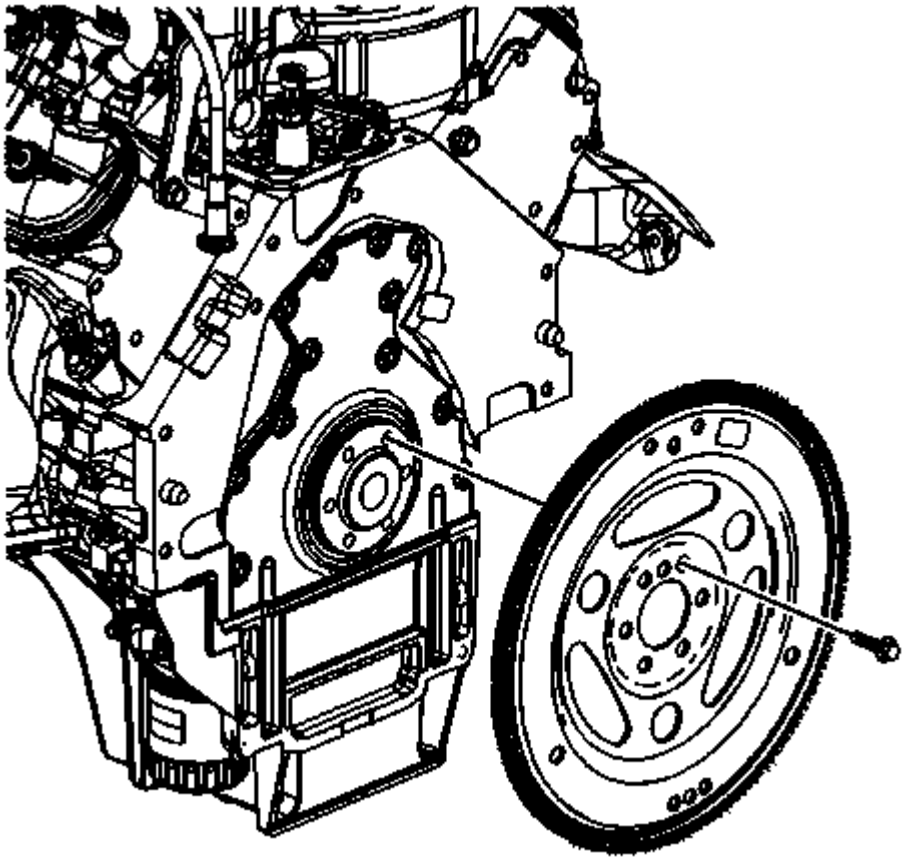

Fig. 605: View Of Flex Plate & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not apply threadlock to the flex plate bolts at this time.

16. Temporarily install the automatic transmission flex plate and bolts. Refer to **Automatic Transmission Flex Plate Installation**.

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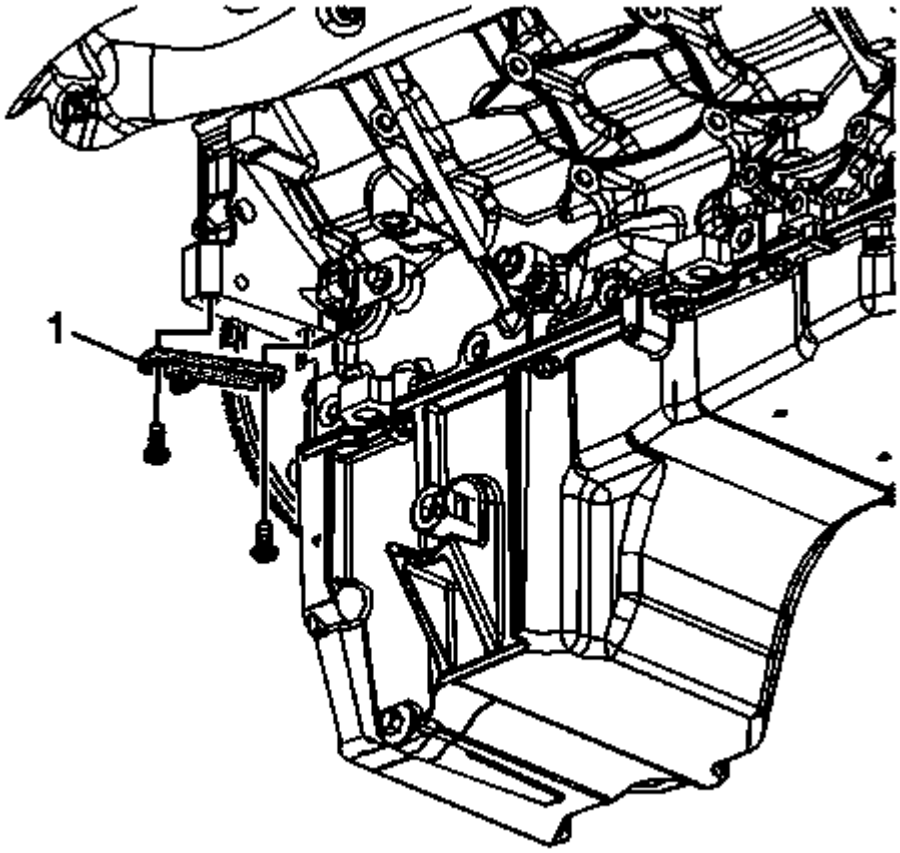

Fig. 606: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

17. Install the **J 42386-A:** tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the **J 42386-A:** tool bolts to 50 N.m (37 lb ft).

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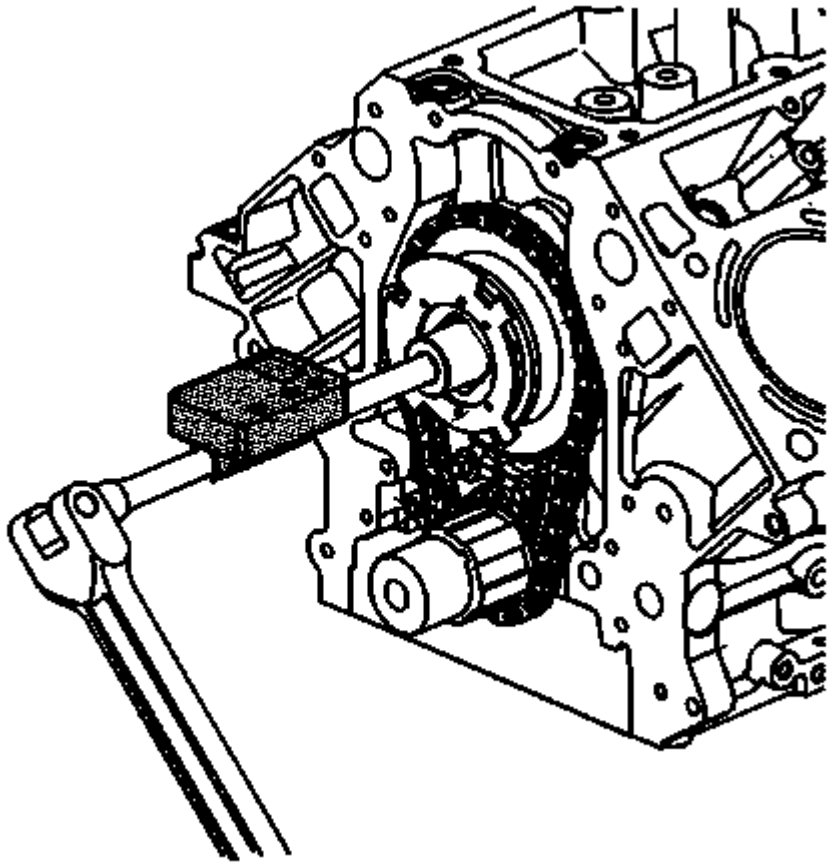

Fig. 607: Tightening The CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

18. Tighten the CMP actuator solenoid valve.
    1. Tighten the CMP actuator solenoid valve a first pass to 65 N.m (48 lb ft) .
    2. Tighten the CMP actuator solenoid valve a final pass an additional 90 degrees using the **J 45059:** meter .
19. Remove the **J 42386-A:** tool and bolts.
20. Remove the automatic transmission flex plate and bolts. Refer to **Automatic Transmission Flex Plate Removal**.

OIL PUMP, SCREEN AND CRANKSHAFT OIL DEFLECTOR INSTALLATION

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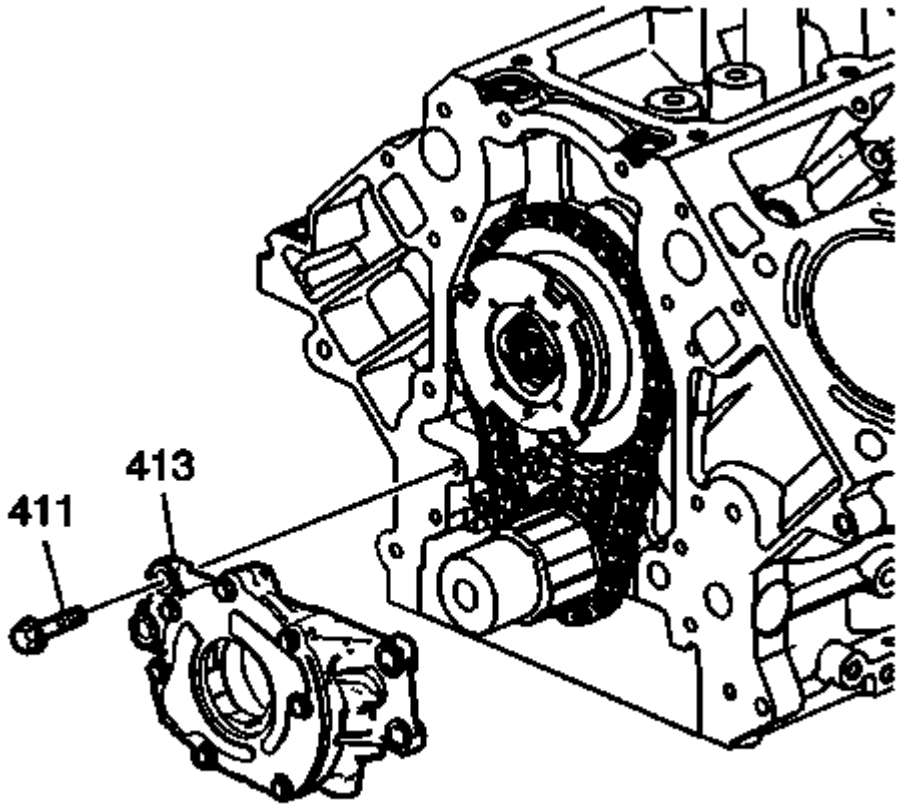

Fig. 608: View Of Oil Pump & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Inspect the oil pump and engine block oil gallery passages. These surfaces must be clear and free of debris or restrictions.

1. Align the splined surfaces of the crankshaft sprocket and the oil pump drive gear and install the oil pump (413).
2. Install the oil pump (413) onto the crankshaft sprocket until the pump housing contacts the face of the engine block.

CAUTION: Refer to Fastener Caution .

3. Install the oil pump bolts (411) and tighten to 25 N.m (18 lb ft).

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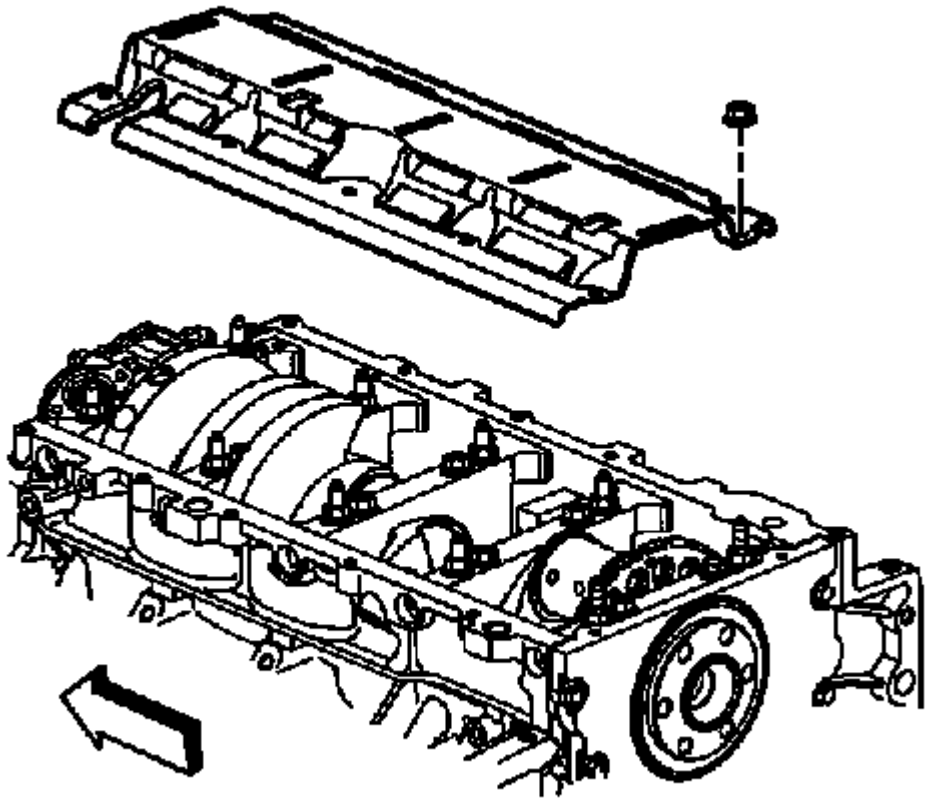

Fig. 609: View Of Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

4. Install the crankshaft oil deflector and nuts.

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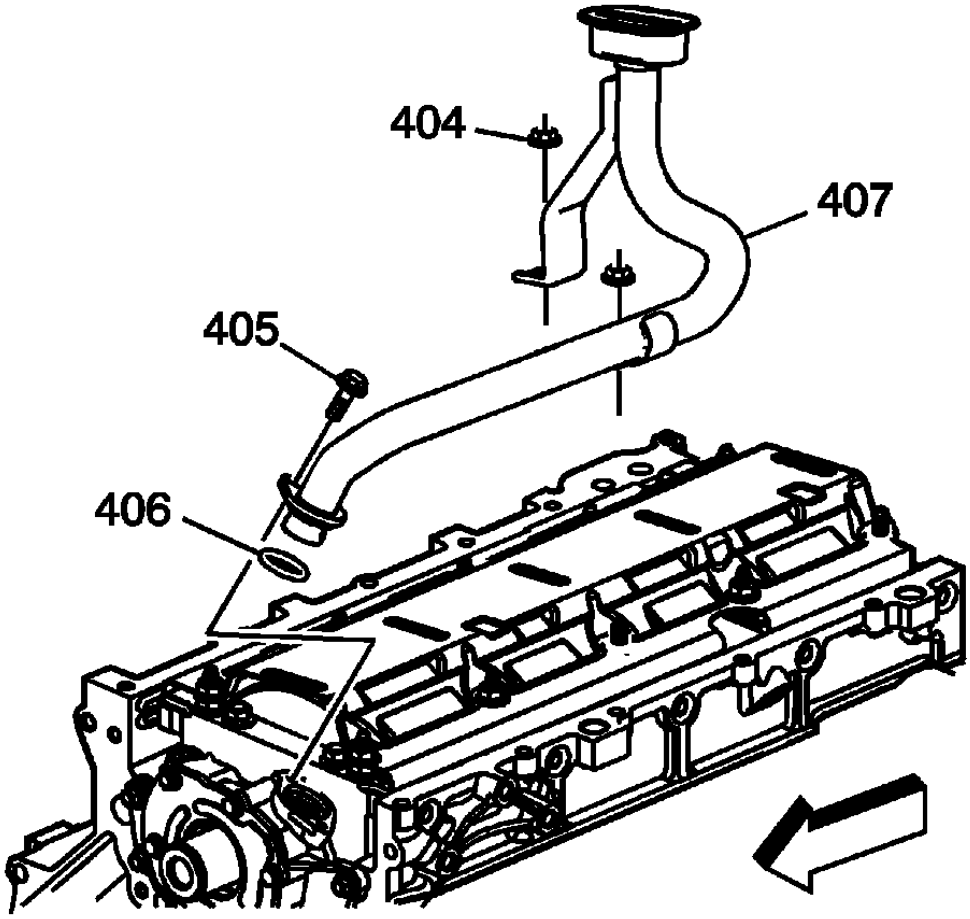

Fig. 610: Oil Pump, Screen and Crankshaft Oil Deflector
Courtesy of GENERAL MOTORS CORP.

5. Lubricate a NEW oil pump screen O-ring seal (406) with clean engine oil.
6. Install the NEW O-ring seal onto the oil pump screen.

NOTE:

- **Push the oil pump screen tube completely into the oil pump prior to tightening the bolt. Do not allow the bolt to pull the tube into the pump.**
- **Align the oil pump screen mounting brackets with the correct crankshaft bearing cap bolt/studs.**

7. Install the oil pump screen (407).
8. Install the oil pump screen bolt (405) and the nut (404).
    1. Tighten the oil pump screen bolt to 12 N.m (106 lb in) .
    2. Tighten the crankshaft oil deflector nut to 25 N.m (18 lb ft) .

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CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION (WITHOUT SEAL IN HOUSING)

Special Tools

- **J 41476:** Front and Rear Cover Alignment Tool
- **J 41480:** Front and Rear Cover Alignment

For equivalent regional tools, refer to **Special Tools**.

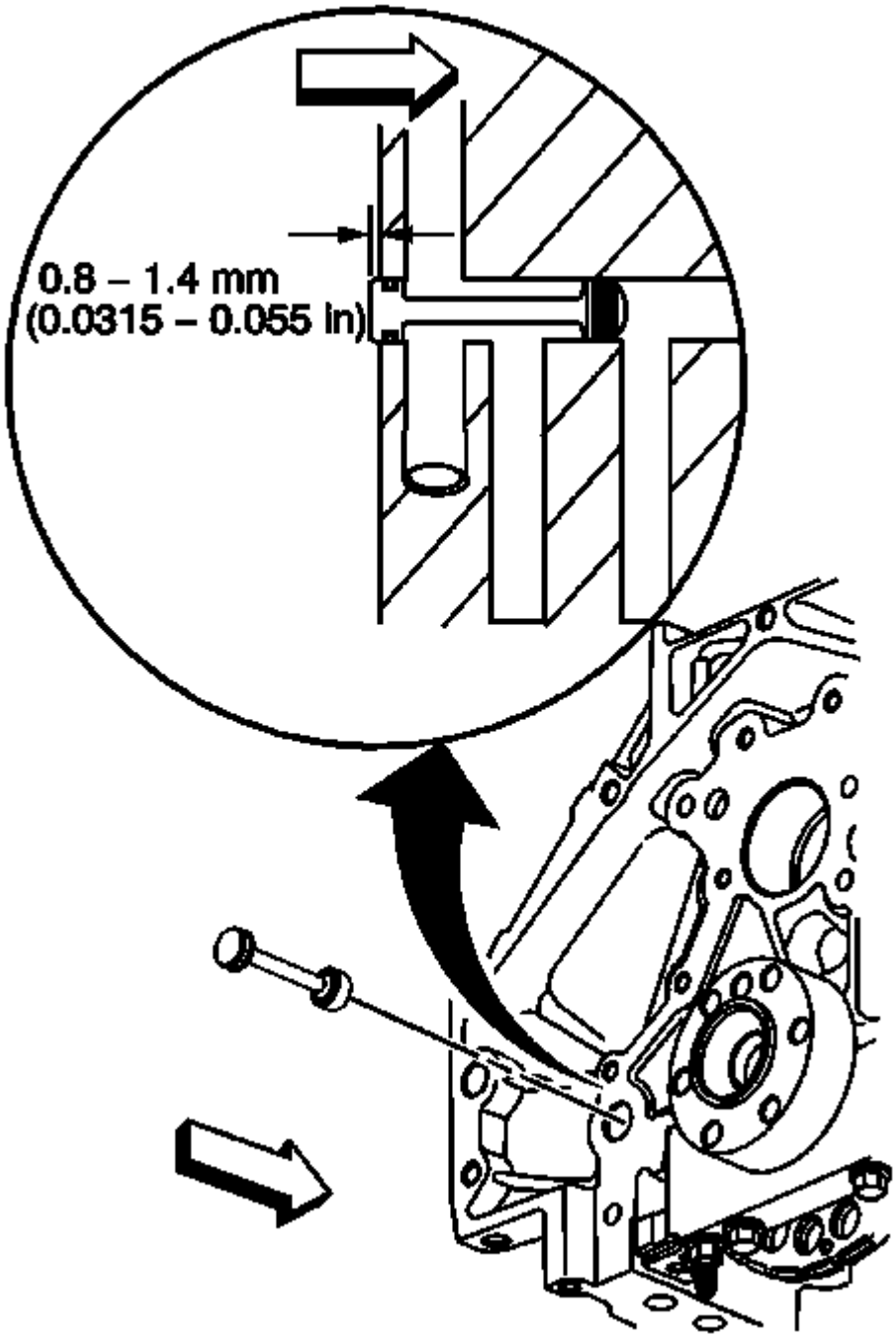

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Fig. 611: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Do not use the crankshaft rear oil seal or the engine rear housing gasket again.**
- **Do not apply any type of sealant to the rear housing gasket, unless specified.**
- **The special tools in this procedure are used to properly align the engine rear housing at the oil pan surface and to center the crankshaft rear oil seal.**
- **The crankshaft rear oil seal will be installed after the rear housing has been installed and aligned. Install the rear housing without the crankshaft oil seal.**
  - **The crankshaft rear oil seal MUST be centered in relation to the crankshaft.**
  - **The oil pan sealing surface at the rear housing, and the engine block, MUST be aligned within specifications.**
  - **An improperly aligned rear housing may cause premature rear oil seal wear and/or engine assembly oil leaks.**

1. Inspect the rear oil gallery plug for proper installation.

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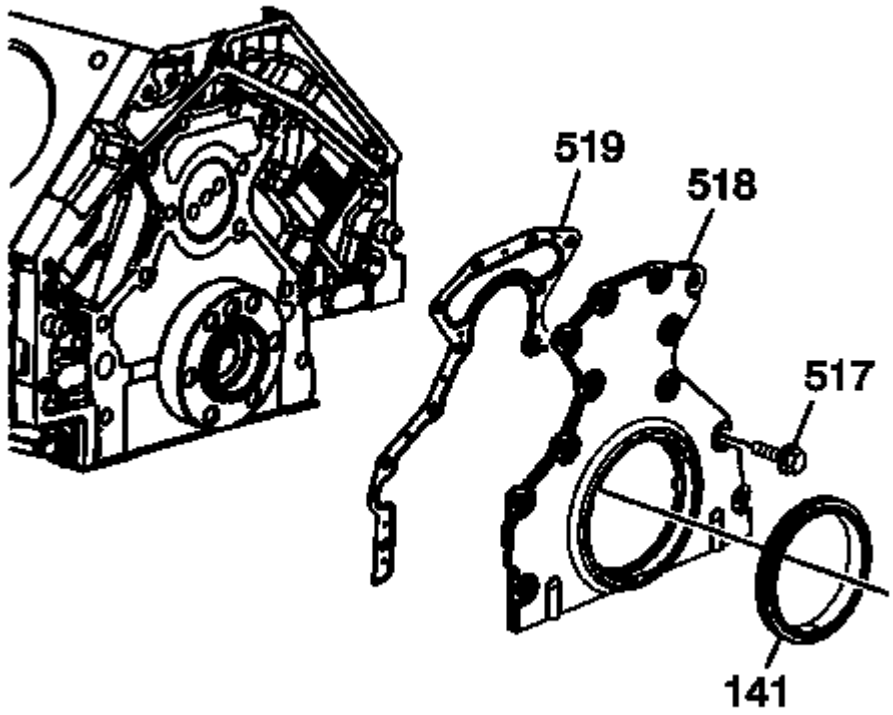

Fig. 612: View of Rear Housing, Gasket and Seal
Courtesy of GENERAL MOTORS CORP.

2. Install the rear housing gasket (519), rear housing (518), and bolts (517).
3. Tighten the bolts finger tight. Do not overtighten.

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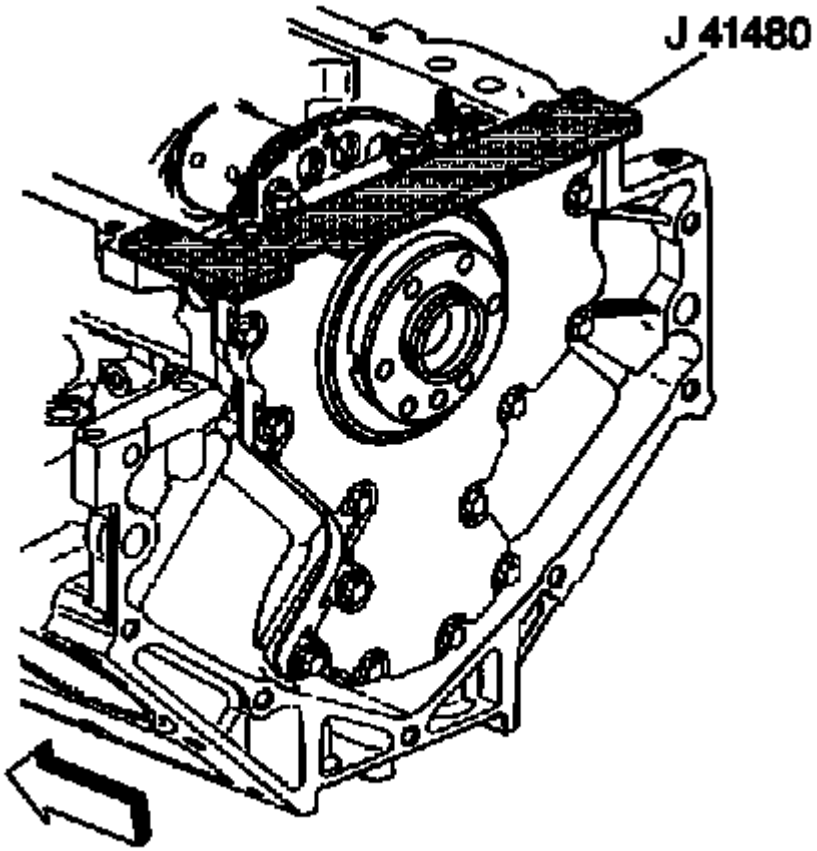

Fig. 613: View Of J 41480 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Start the J 41480: alignment tool-to-rear housing bolts. Do not tighten the bolts at this time.

4. Install the **J 41480:** alignment and bolts. Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft).

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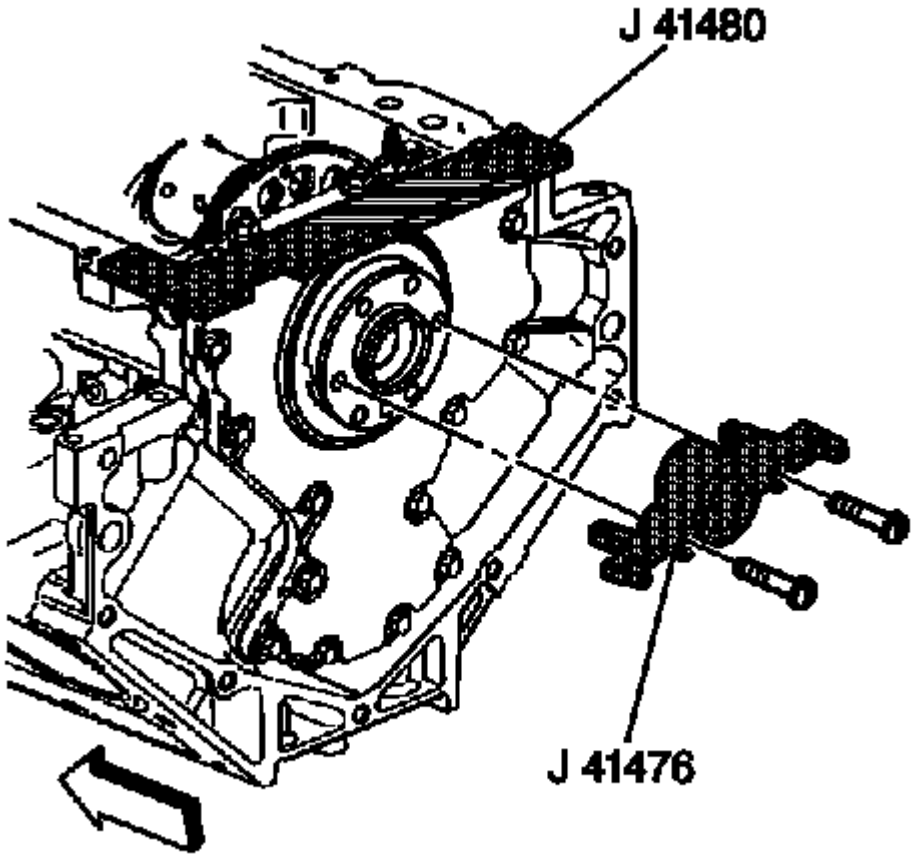

Fig. 614: View Of J 41480 & J 41476
Courtesy of GENERAL MOTORS CORP.

NOTE: To properly align the rear housing, the J 41476: tool must be installed onto the rear of the crankshaft with the tool mounting bolts parallel to the oil pan surface.

5. Rotate the crankshaft until 2 opposing flywheel bolt holes are parallel to the oil pan surface.

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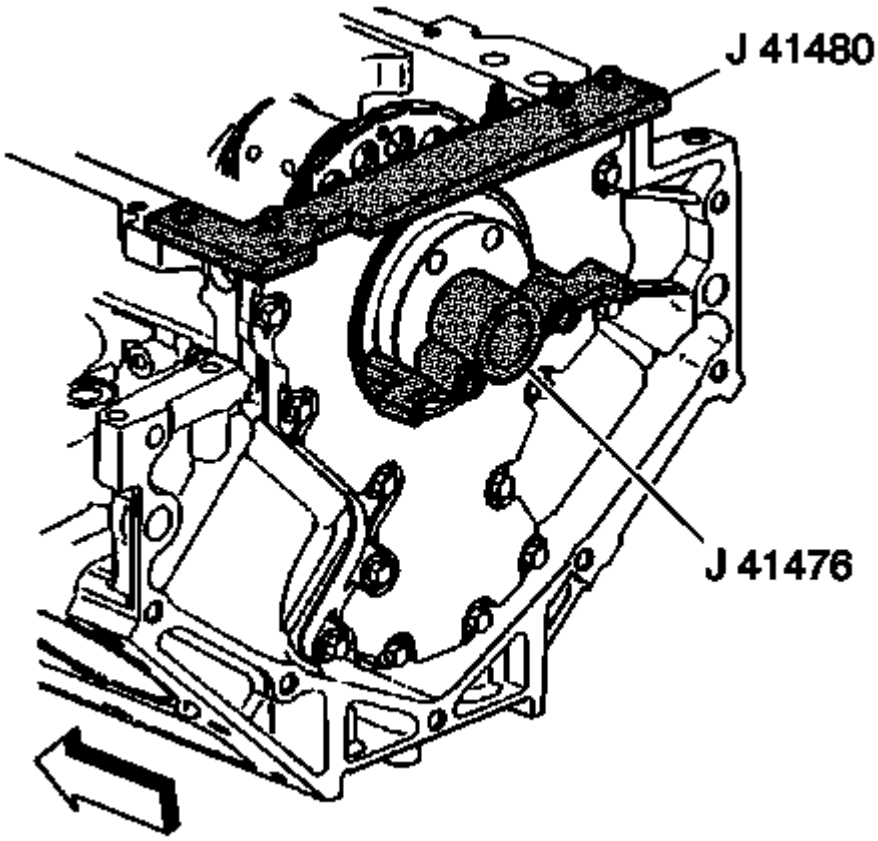

Fig. 615: View Of J 41480 & J 41476 Installed
Courtesy of GENERAL MOTORS CORP.

NOTE: The tapered legs of the alignment tool must enter the rear housing oil seal bore.

6. Install the **J 41476:** tool and bolts onto the rear of the crankshaft.
    1. Tighten the tool mounting bolts until snug. Do not overtighten.
    2. Tighten the **J 41480:** alignment tool-to-rear housing bolts evenly to 12 N.m (106 lb in) .
    3. Tighten the rear housing bolts to 30 N.m (22 lb ft) .
7. Remove the tools.

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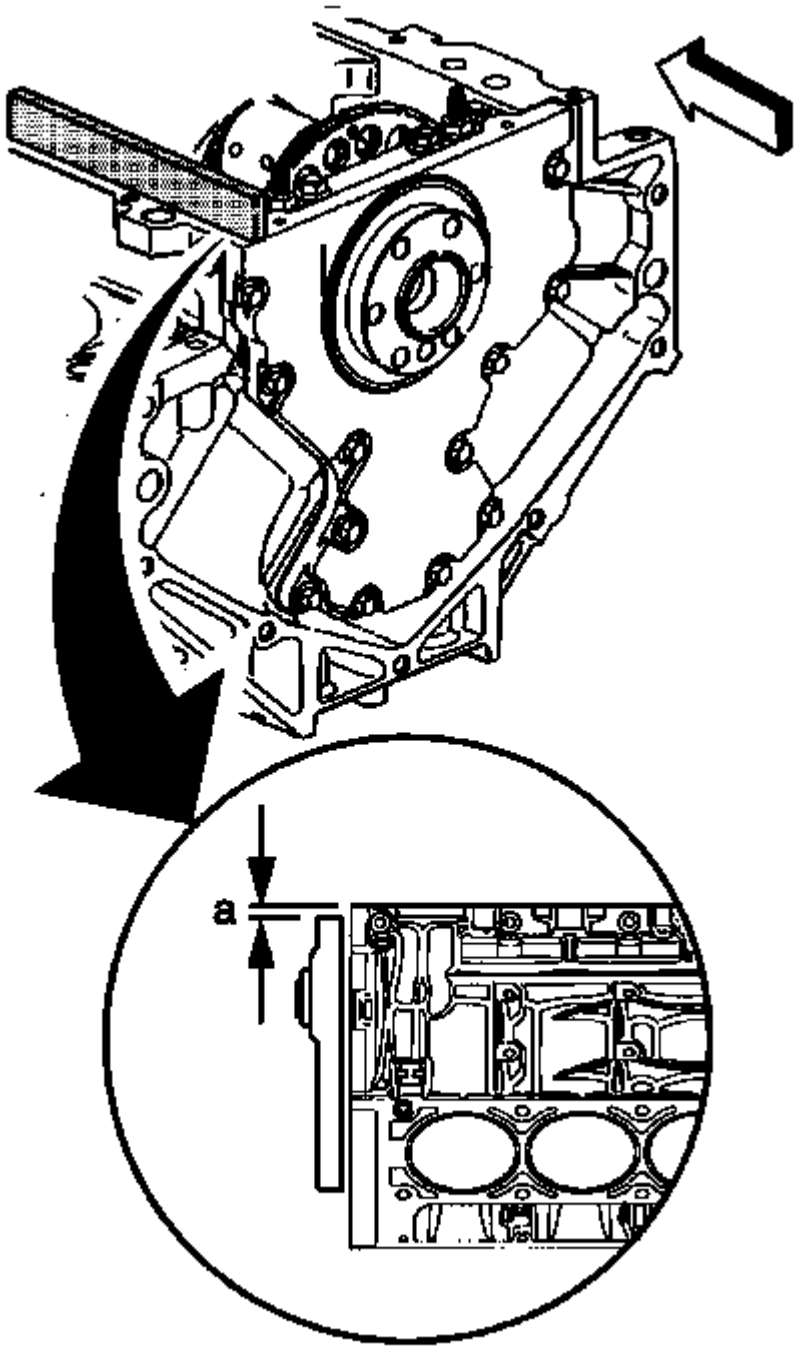

Fig. 616: Checking Rear Cover-To-Engine Block Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

8. Measure the rear housing-to-engine block oil pan surface for flatness.
    1. Place a straight edge onto the engine block and rear housing oil pan sealing surfaces.

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Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

2. Insert a feeler gauge between the rear housing and the straight edge. The housing must be flush with the oil pan or no greater than 0.5 mm (0.02 in) below flush (a).

9. If the rear housing-to-engine block oil pan surface alignment is not within specifications, repeat the housing alignment procedure.
10. If the correct rear housing-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear housing.

CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION (WITH SEAL IN HOUSING)

Special Tools

- **J 41479-2A:** Crankshaft Rear Oil Seal Installation Guide
- **J 41480:** Front and Rear Cover Alignment

For equivalent regional tools, refer to **Special Tools**

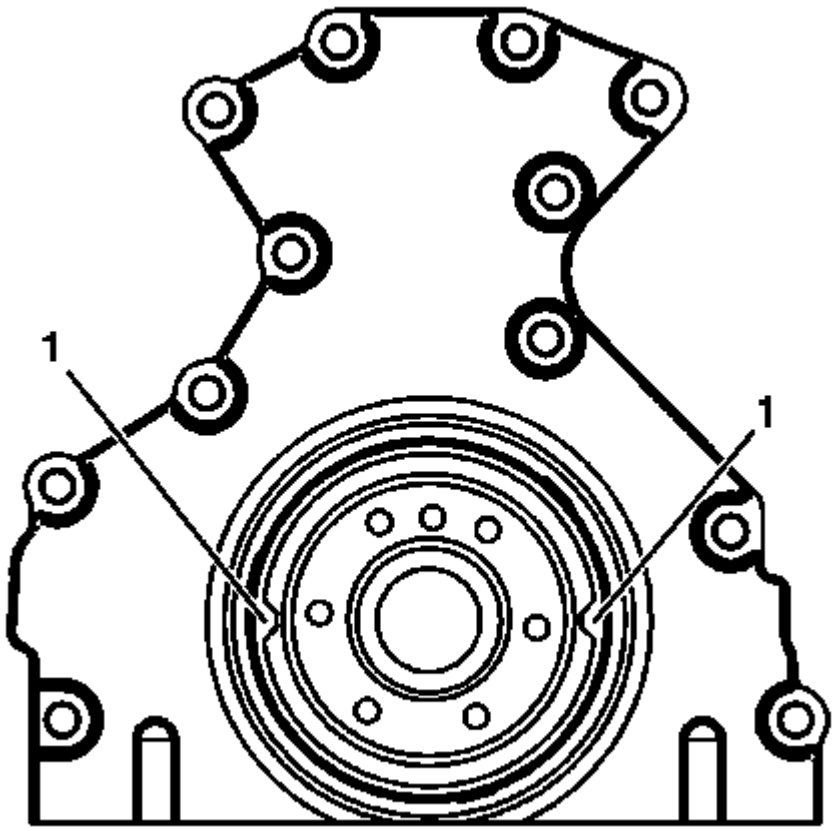

Fig. 617: View Of Rear Housing Alignment Tabs
Courtesy of GENERAL MOTORS CORP.

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NOTE:

- **Do not use the crankshaft rear oil seal or the engine rear housing gasket again.**
- **Do not apply any type of sealant to the rear housing gasket, unless specified.**
- **The special tool in this procedure is used to properly align the engine rear housing at the oil pan surface.**
- **First design rear housings do not have alignment tabs for alignment of the housing horizontally. J 41476: tool is required to properly align first design rear housings. The rear oil seal must be removed from the housing for proper use of the tool.**
- **Second design rear housings have alignment tabs for alignment of the housing horizontally. J 41476: tool is not required for proper alignment of second design rear housings. The housing may be installed and aligned with the seal already installed into the housing.**

1. Inspect the rear housing to identify for alignment tabs (1).

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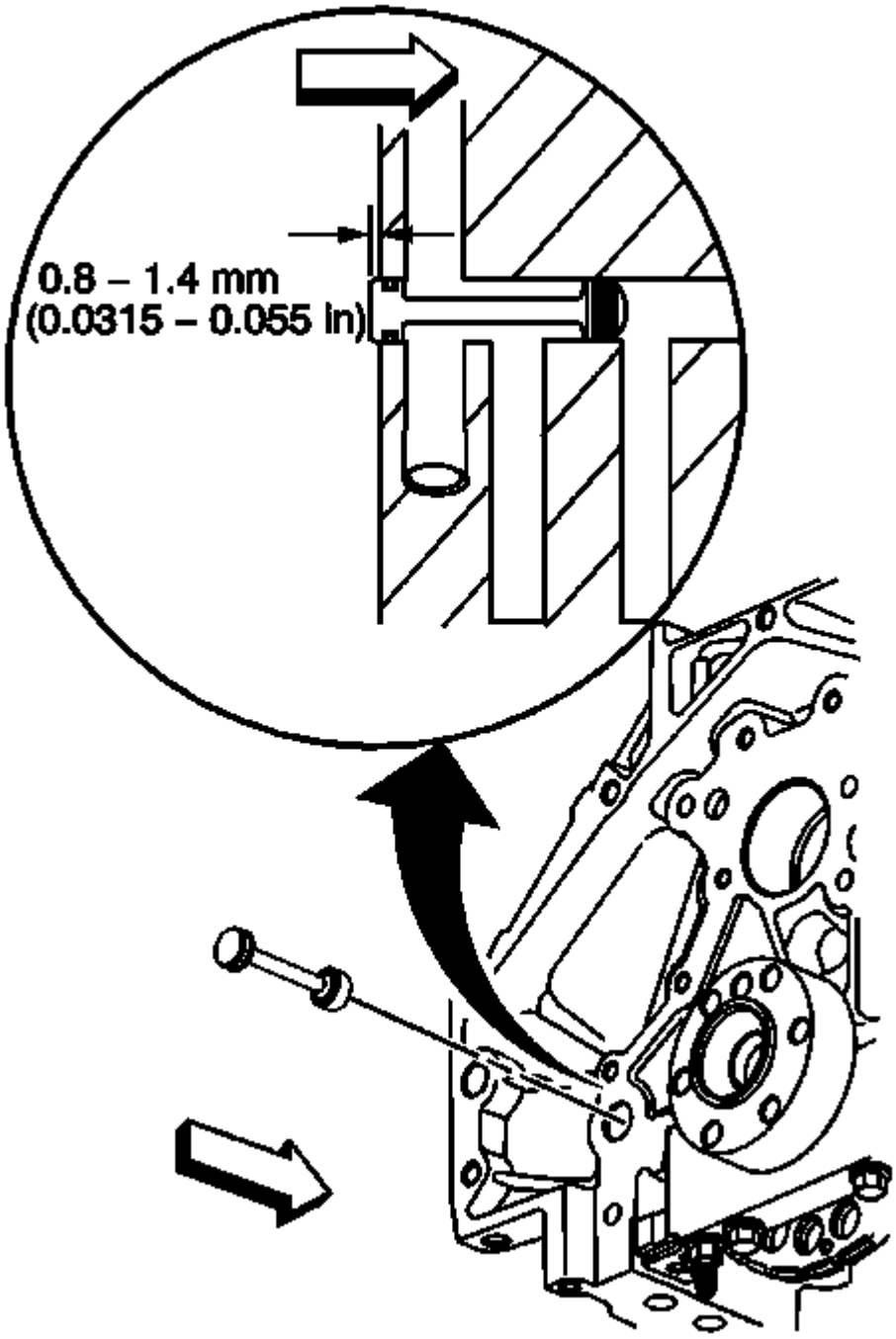

Fig. 618: View Of Engine Block Rear Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

2. Inspect the rear oil gallery plug for proper installation.

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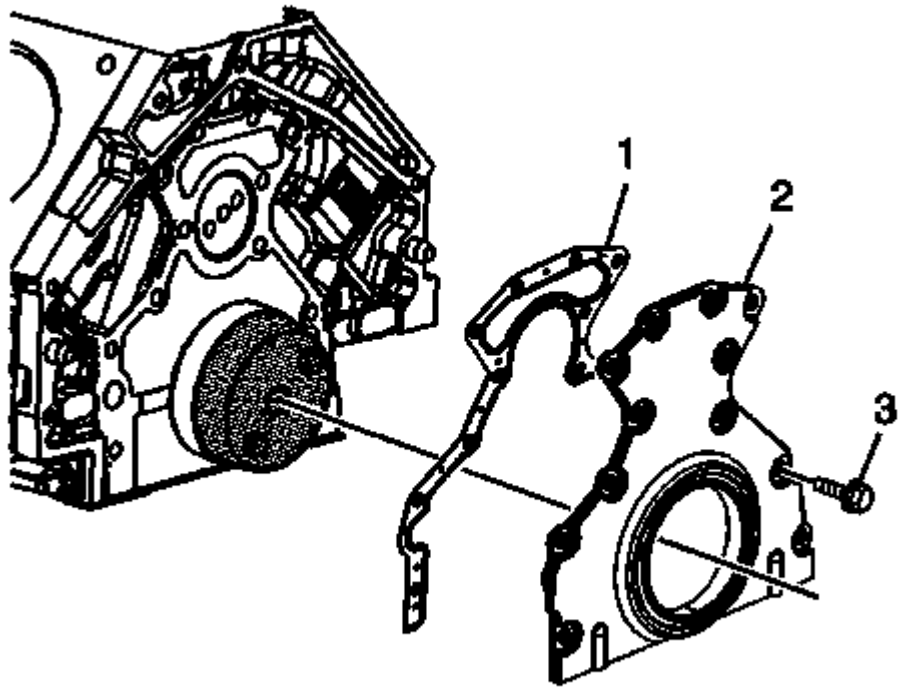

Fig. 619: View Of Rear Housing Gasket, Rear Housing With Seal And Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 41479-2A:** guide cone and bolts onto the rear of the crankshaft.
4. Tighten the bolts until snug. Do not overtighten.
5. Install the rear housing gasket (1), rear housing with seal (2), and bolts (3).
6. Tighten the bolts finger tight. Do not overtighten.
7. Remove the **J 41479-2A:** guide and bolts.

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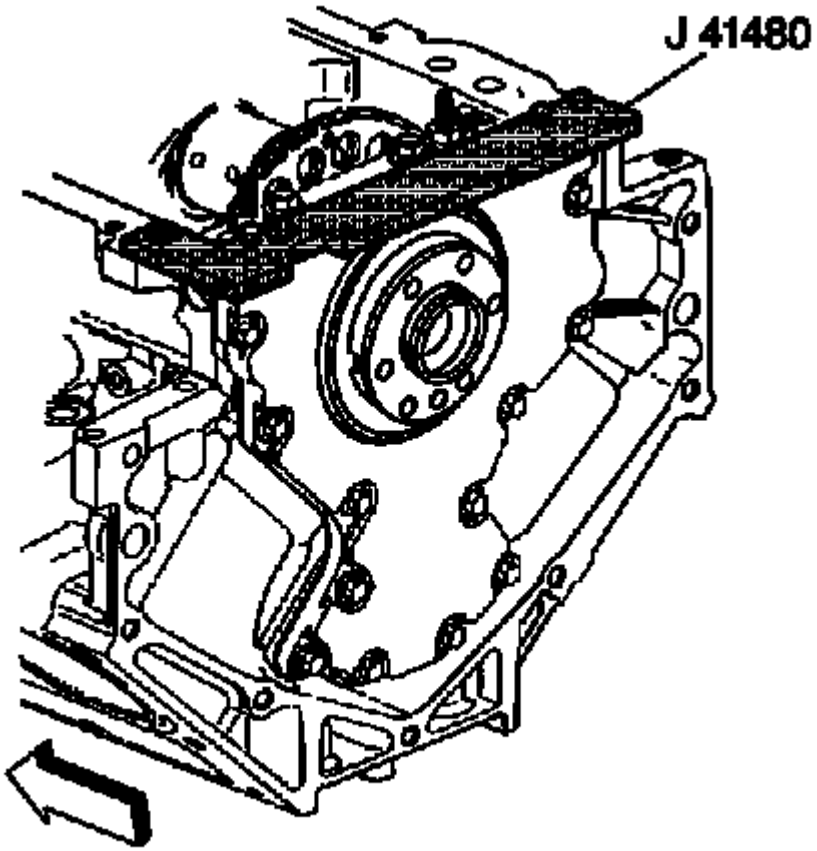

Fig. 620: View Of J 41480 Installed To Engine Block
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

8. Install the **J 41480:** alignment and bolts.
    1. Tighten the tool-to-engine block bolts to 25 N.m (18 lb ft) .
    2. Tighten the **J 41480:** alignment tool-to-rear housing bolts evenly to 12 N.m (106 lb in) .
    3. Tighten the rear housing-to-engine block bolts to 30 N.m (22 lb ft) .
9. Remove the **J 41480:** alignment and bolts.

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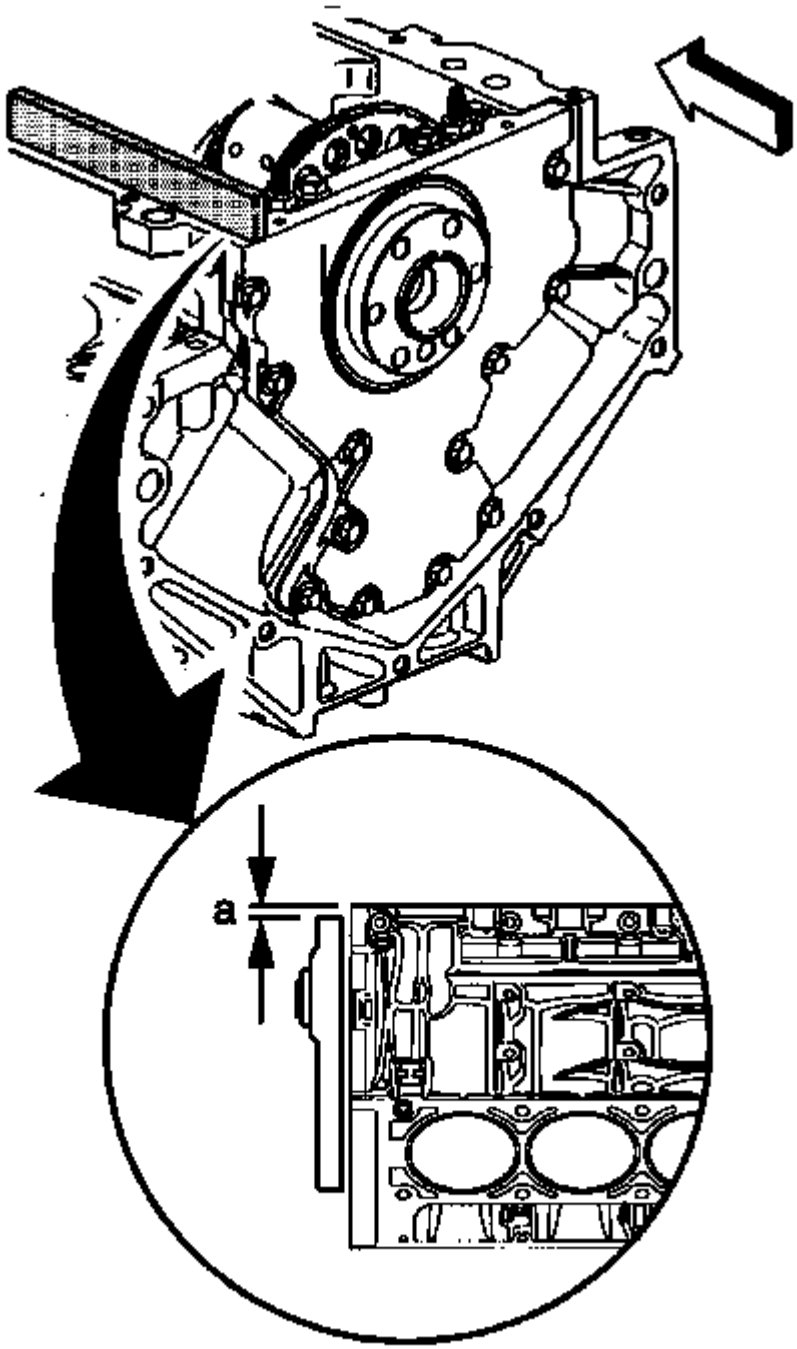

Fig. 621: Checking Rear Cover-To-Engine Block Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

10. Measure the rear housing-to-engine block oil pan surface for flatness.
    1. Place a straight edge onto the engine block and rear housing oil pan sealing surfaces.

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Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

2. Insert a feeler gauge between the rear housing and the straight edge. The housing must be flush with the oil pan or no greater than 0.5 mm (0.02 in) (a) below flush.

11. If the rear housing-to-engine block oil pan surface alignment is not within specifications, repeat the housing alignment procedure.
12. If the correct rear housing-to-engine block alignment at the oil pan surface cannot be obtained, replace the rear housing.

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

- **J 41479** Crankshaft Rear Oil Seal Installer. See **Special Tools**.
- **J 41479-2A** Crankshaft Rear Oil Seal Installation Guide

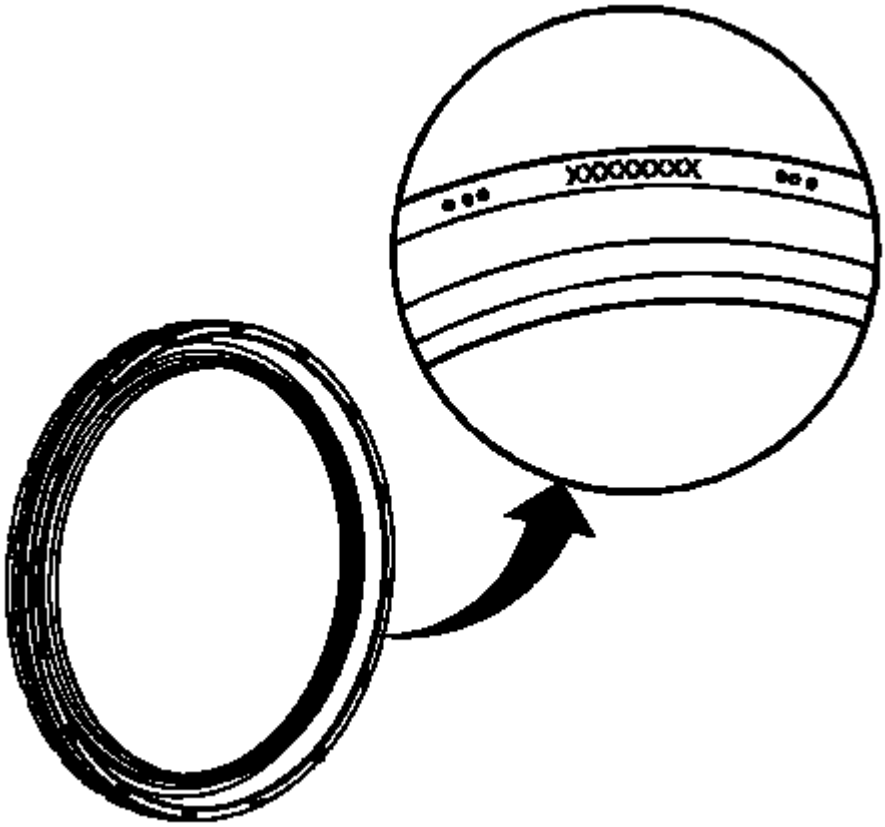

Fig. 622: Identifying Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. The part number is applied to the outside

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face of the seal, as shown.

1. Inspect the seal and identify the part number markings for proper orientation.

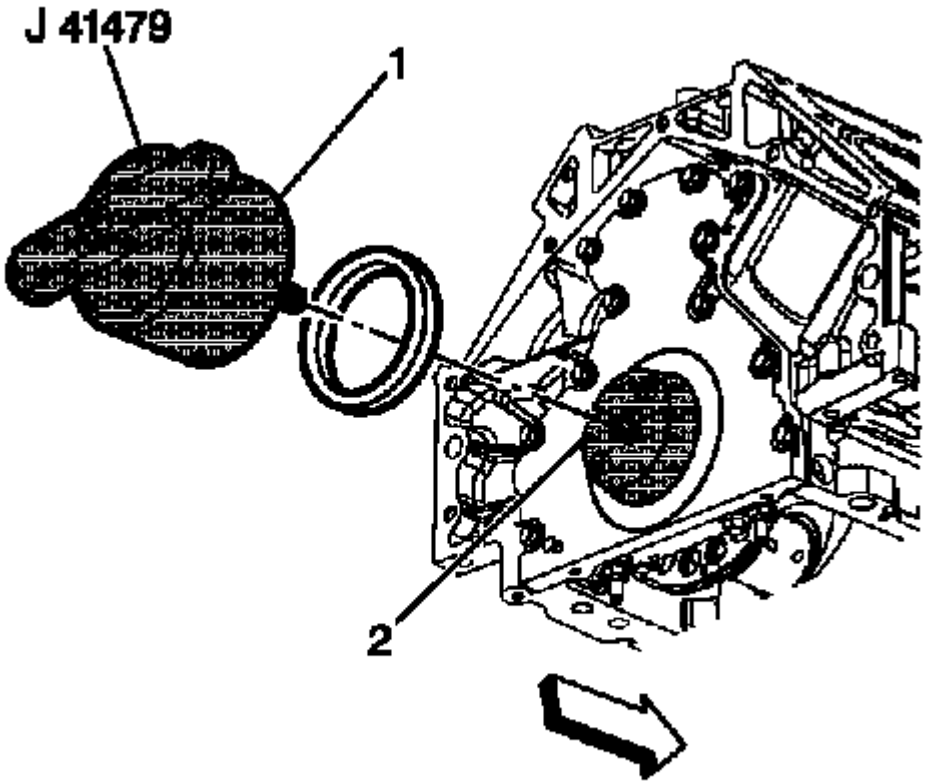

Fig. 623: View Of J 41479 Cone & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 41479** or the **J 41479-2A** cone (2) and bolts onto the rear of the crankshaft. The **J 41479-2A** may be required for manual transmission or 5.3L LS4 applications.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with the part number markings facing away from the engine.
5. Thread the **J 41479** threaded rod into the tapered cone until the tool (1) contacts the oil seal. See **Special Tools**.
6. Align the oil seal onto the tool (1).
7. Rotate the handle of the tool (1) clockwise until the seal enters the rear housing and bottoms into the seal bore.
8. Remove the tool.

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ENGINE FRONT COVER INSTALLATION

Special Tools

- **EN-48853:** Front Cover Alignment Tool
- **J 41480:** Front and Rear Cover Alignment

For equivalent regional tools, refer to **Special Tools**

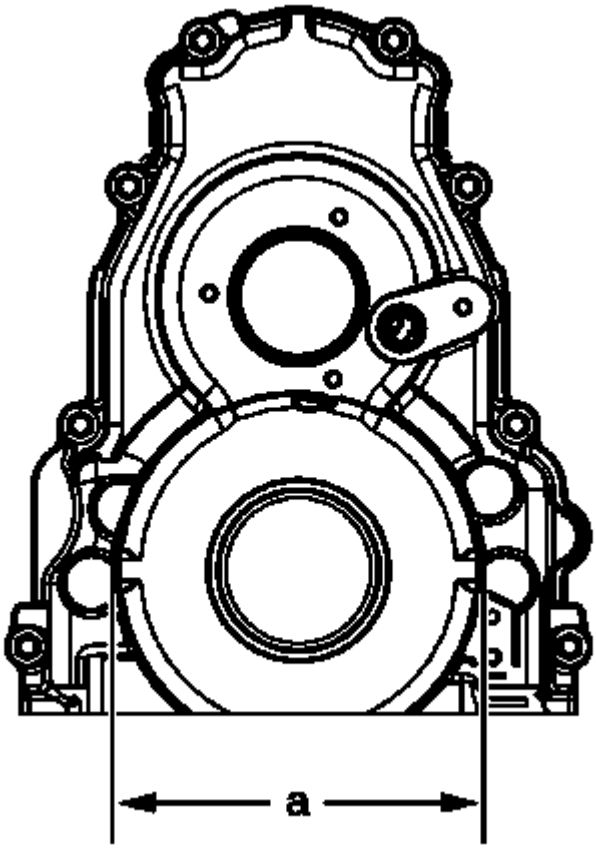

Fig. 624: Engine Front Cover Alignment Tab Distance
Courtesy of GENERAL MOTORS CORP.

1. The engine front cover alignment tab distance is 141 mm (5.55 in), see dimension (a). The **EN-48853-2:** adapters must be used with the **EN-48853:** alignment tool to properly align the front covers.

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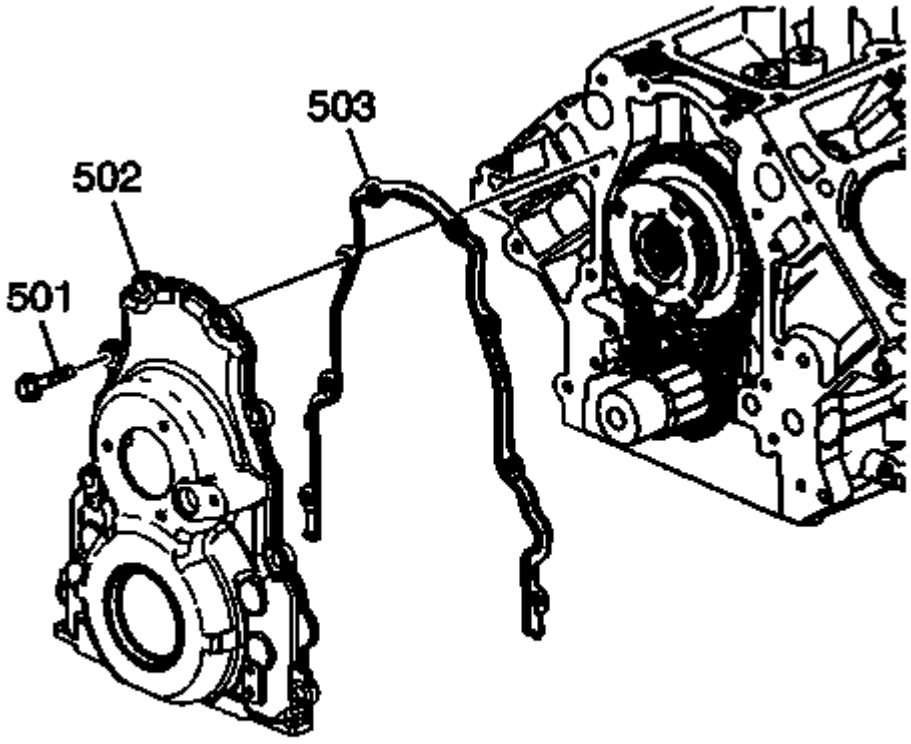

Fig. 625: Engine Front Cover Components
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- **Do not use the crankshaft oil seal or the engine front cover gasket again.**
- **Do not apply any type of sealant to the front cover gasket, unless specified.**
- **The special tools in this procedure are used to properly align the engine front cover at the oil pan surface and to center the crankshaft front oil seal.**
  - **All gasket surfaces should be free of oil or other foreign material during assembly.**

    The crankshaft front oil seal MUST be centered in relation to the crankshaft.

  - **The oil pan sealing surface at the front cover and engine block**

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MUST be aligned within specifications.

- **An improperly aligned front cover may cause premature front oil seal wear and/or engine assembly oil leaks.**

2. Install the front cover gasket (503), front cover (502), and bolts (501).
3. Tighten the cover bolts finger tight. Do not overtighten.

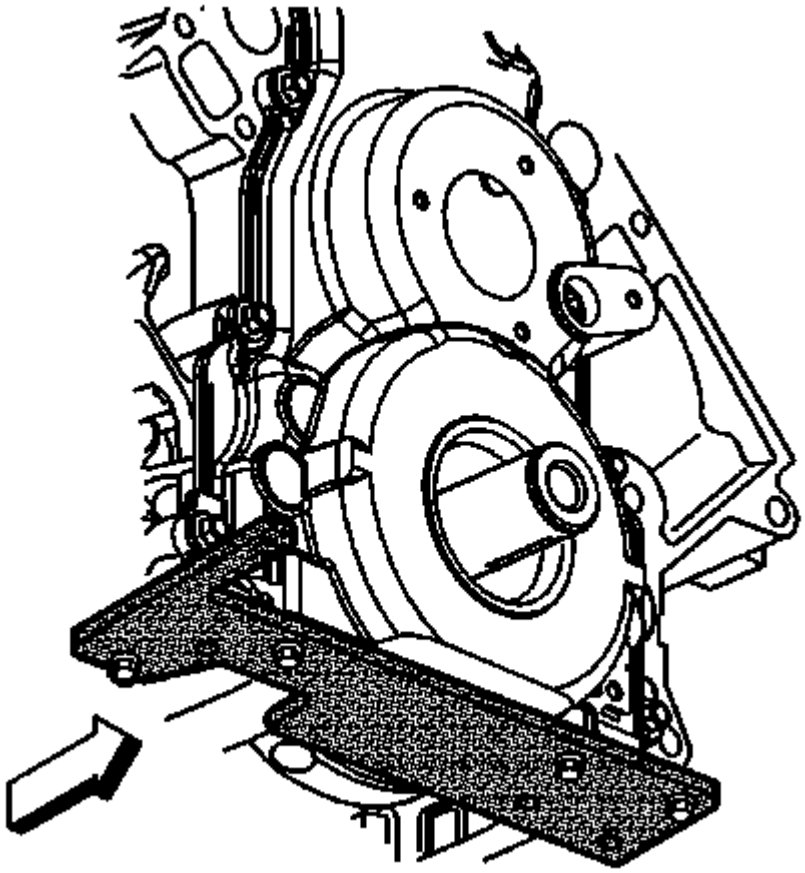

Fig. 626: Aligning Front Cover Using Special Tool J 41480
Courtesy of GENERAL MOTORS CORP.

NOTE: Start the tool-to-front cover bolts. Do not tighten the bolts at this time.

4. Install the **J 41480:** alignment and tighten to 25 N.m (18 lb ft).

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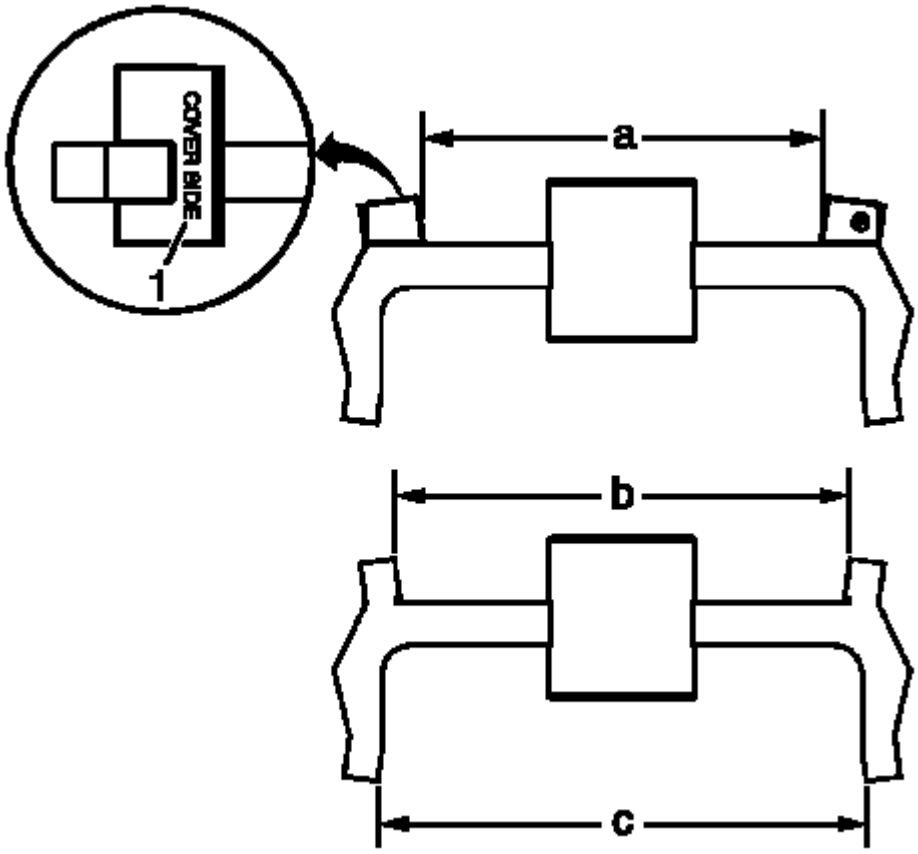

Fig. 627: Installing EN 48853-2 Adapters
Courtesy of GENERAL MOTORS CORP.

5. Install the EN 48853-2 adapters as required for usage on the 141 mm (5.55 in) dimension (a) front cover. Position the adapters against the legs of the **EN-48853:** tool with the words "cover side" (1) facing away from the tool.

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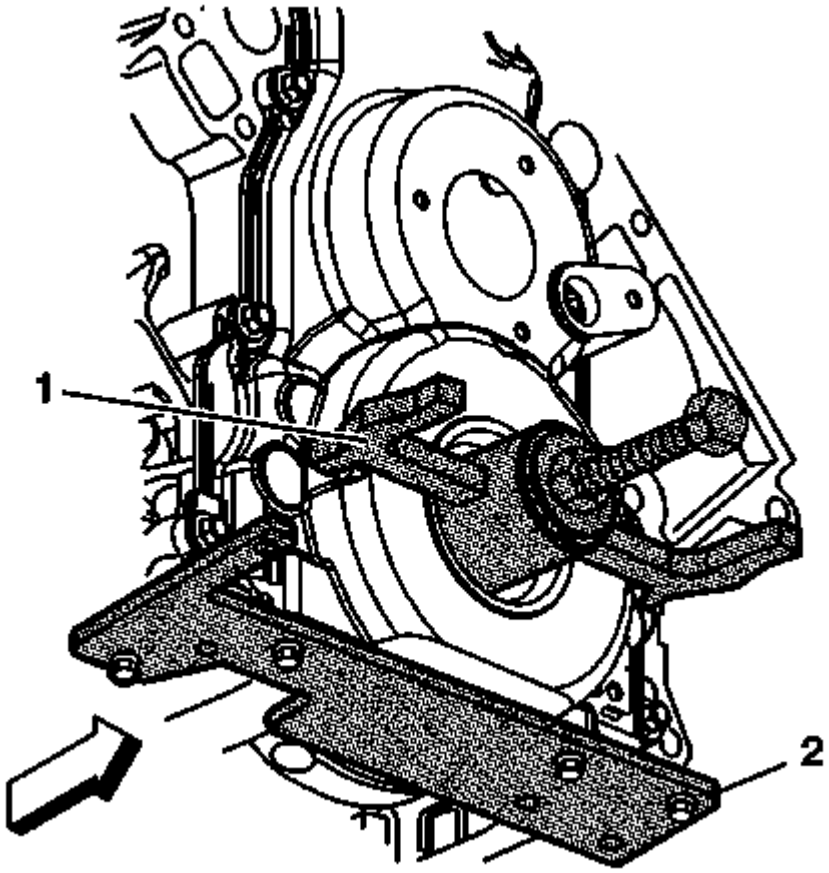

Fig. 628: View Of Special Tool EN-48853
Courtesy of GENERAL MOTORS CORP.

NOTE: Align the tapered legs of the tool with the machined alignment surfaces on the front cover.

6. Install the **EN-48853:** tool (1).
7. Install the crankshaft balancer bolt.
    1. Tighten the crankshaft balancer bolt by hand until snug. Do not overtighten.
    2. Tighten the **J 41480:** alignment (2) .
    3. Tighten the engine front cover bolts to 25 N.m (18 lb ft) .
8. Remove the tools.

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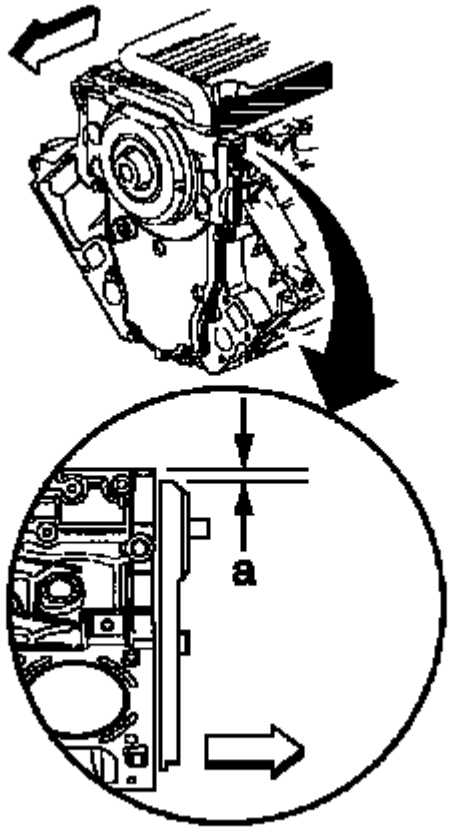

Fig. 629: Measuring Oil Pan Surface Flatness & Front Cover-To-Engine Block
Courtesy of GENERAL MOTORS CORP.

9. Measure the oil pan surface flatness, front cover-to-engine block.
    1. Place a straight edge across the engine block and front cover oil pan sealing surfaces.

       Avoid contact with the portion of the gasket that protrudes into the oil pan surface.

    2. Insert a feeler gauge between the front cover and the straight edge tool. The cover must be flush with the oil pan surface or no greater than 0.3 mm (0.0118 in) (a) below flush.
10. If the front cover-to-engine block oil pan surface alignment is not within specifications, repeat the cover alignment procedure.
11. If the correct front cover-to-engine block alignment cannot be obtained, replace the front cover.

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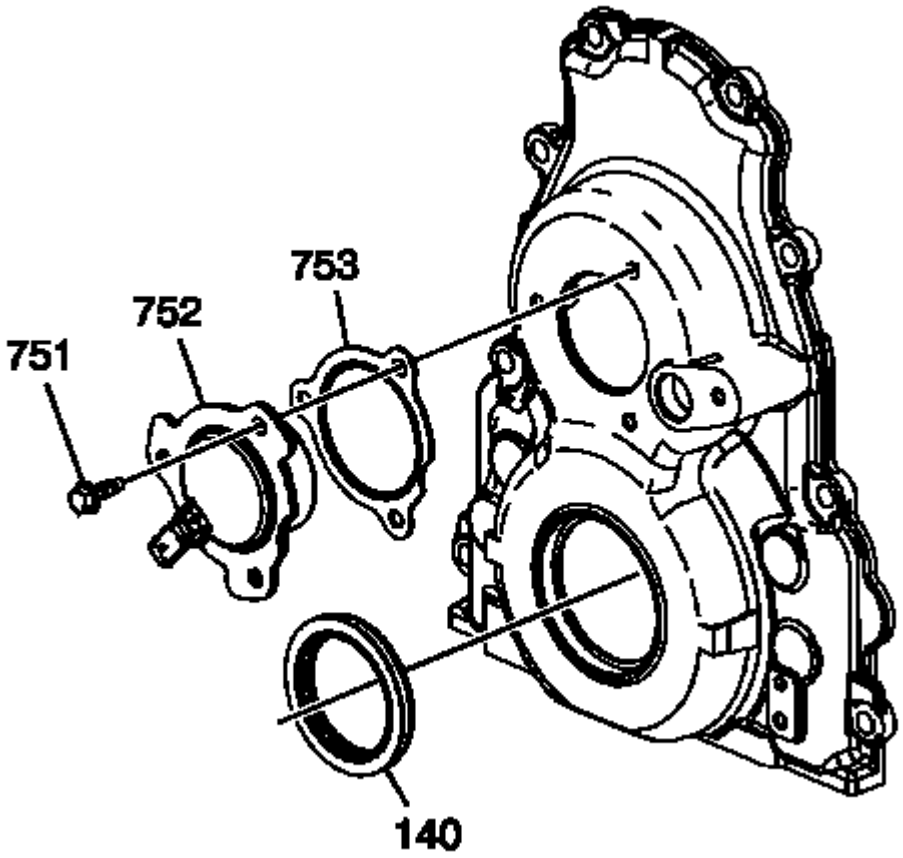

Fig. 630: View Of CMP Actuator Magnet, Bolts, Gasket & Oil Seal
Courtesy of GENERAL MOTORS CORP.

12. Install the camshaft position (CMP) actuator magnet (752), gasket (753), and bolts (751). Tighten the bolts to 12 N.m (106 lb in).

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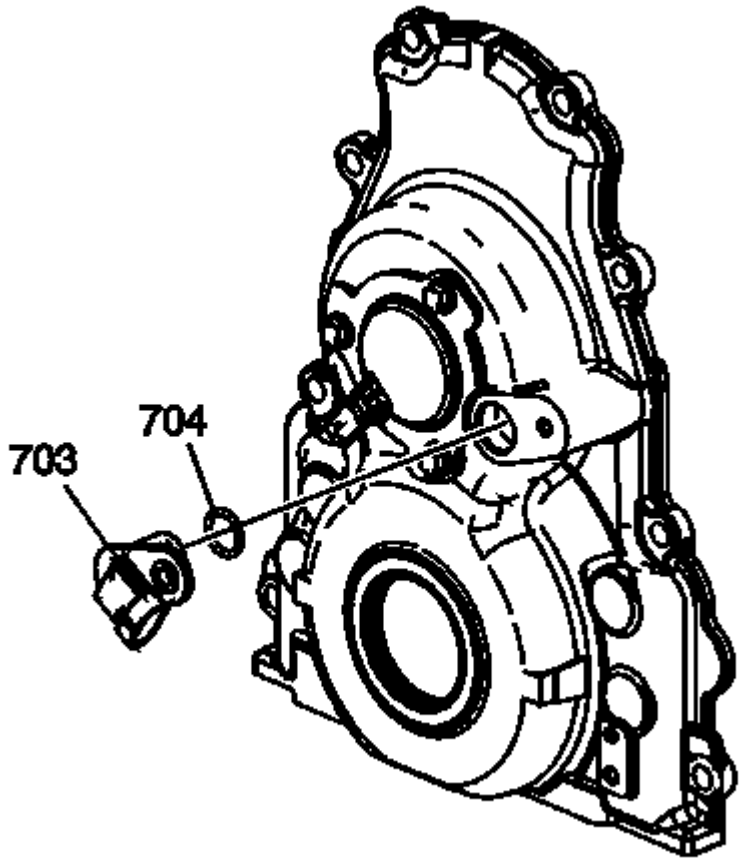

Fig. 631: View Of CMP Sensor & O-Ring
Courtesy of GENERAL MOTORS CORP.

13. Install the CMP sensor (703) and O-ring (704).

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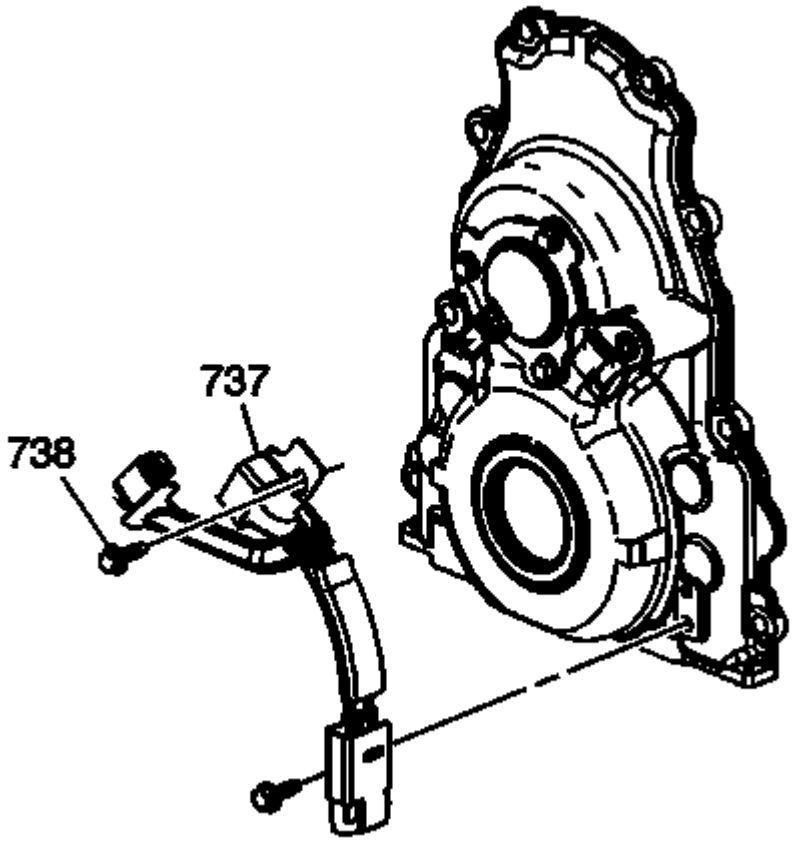

Fig. 632: View Of CMP Sensor Wire Harness & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the CMP sensor wire harness (737) and bolts (738). Tighten the bolts to 12 N.m (106 lb in).

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

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

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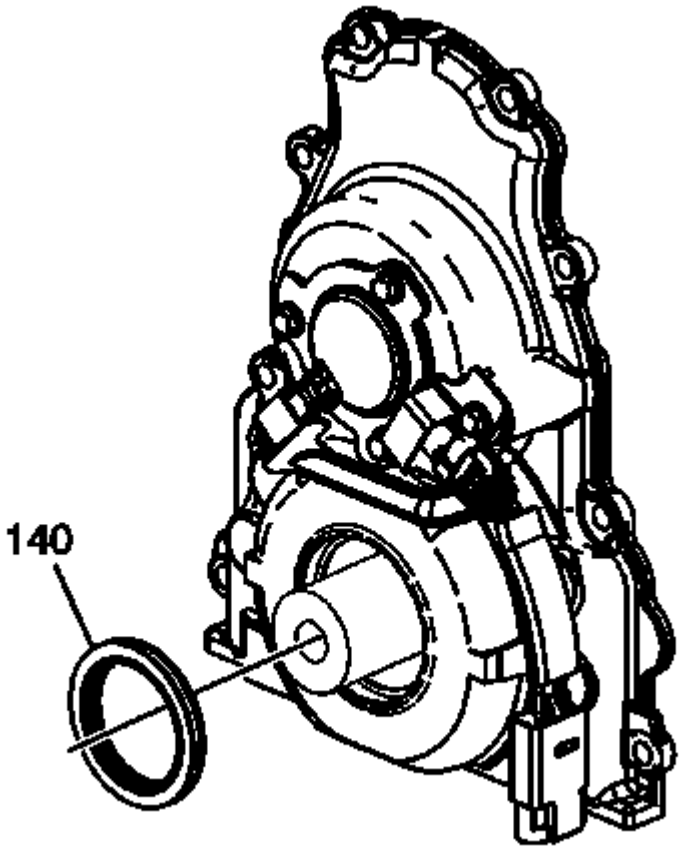

Fig. 633: View Of Outer Edge Of The Oil Seal
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:
- **Do not lubricate the oil seal sealing surface.**
- **Do not use the crankshaft front oil seal again.**

1. Lubricate the outer edge of the oil seal (140) with clean engine oil.
2. Lubricate the front cover oil seal bore with clean engine oil.

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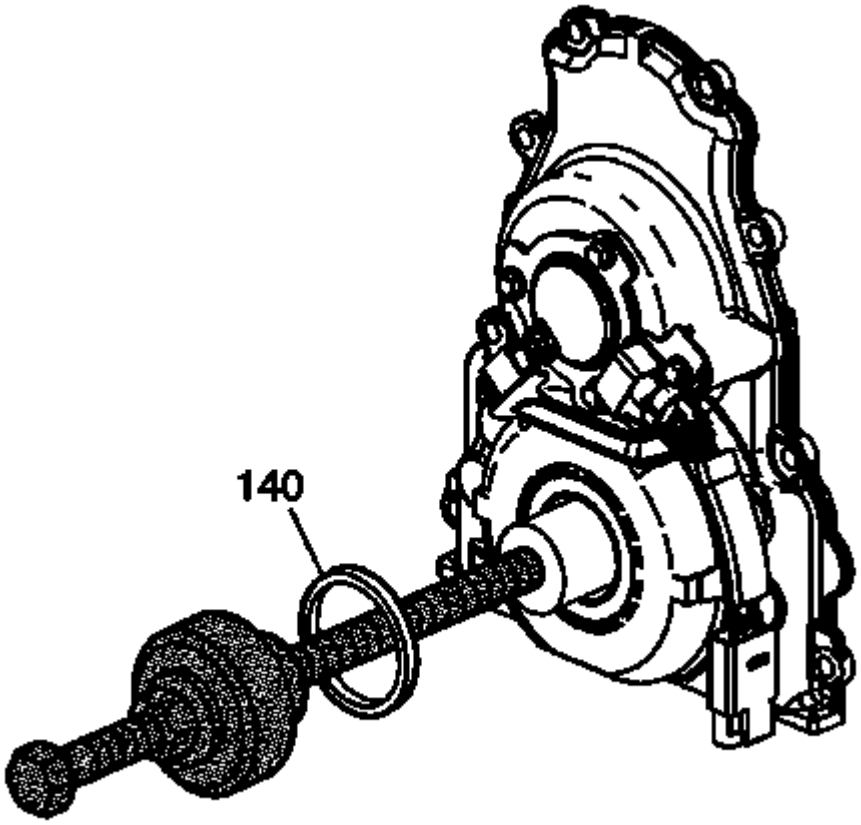

Fig. 634: View Of Front Oil Seal & Special Tool
Courtesy of GENERAL MOTORS CORP.

3. Install the crankshaft front oil seal (140) onto the **J 41478** . 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 tool.
    4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

OIL PAN INSTALLATION

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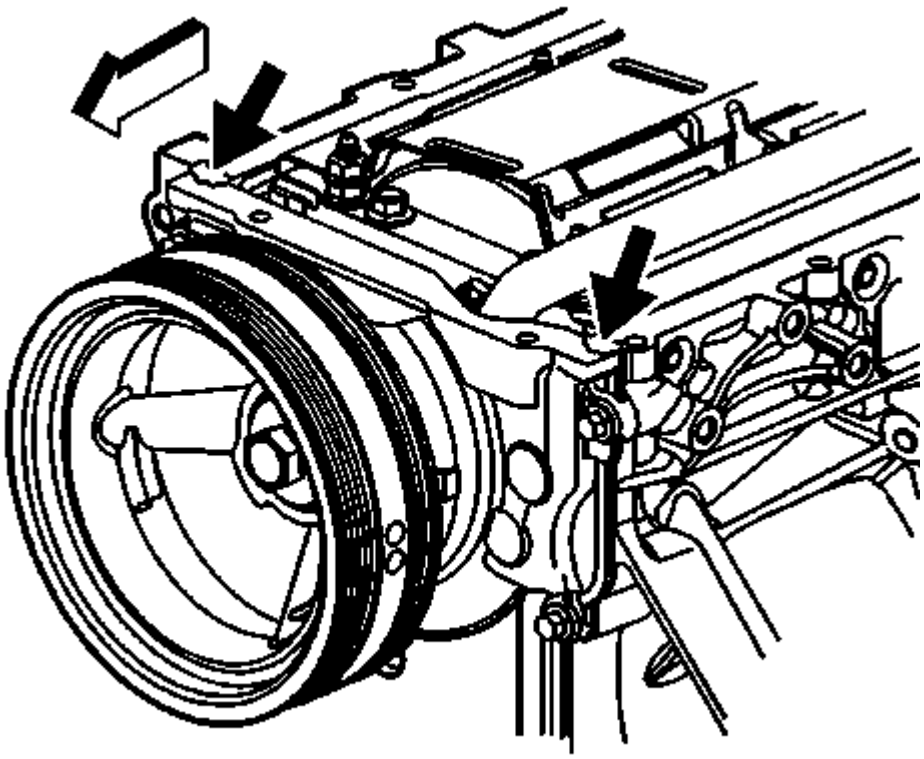

Fig. 635: View Of Sealant On Engine Front Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The alignment of the structural oil pan is critical. The rear bolt hole locations of the oil pan provide mounting points for the transmission housing. To ensure the rigidity of the powertrain and correct transmission alignment, it is important that the rear of the block and the rear of the oil pan are flush or even. The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing plane.**
- **Do not use the oil pan gasket again.**
- **It is not necessary to rivet the NEW gasket to the oil pan.**
- **It is not necessary to remove the oil level sensor prior to oil pan installation.**

1. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the front cover gasket that protrude into the oil pan surface. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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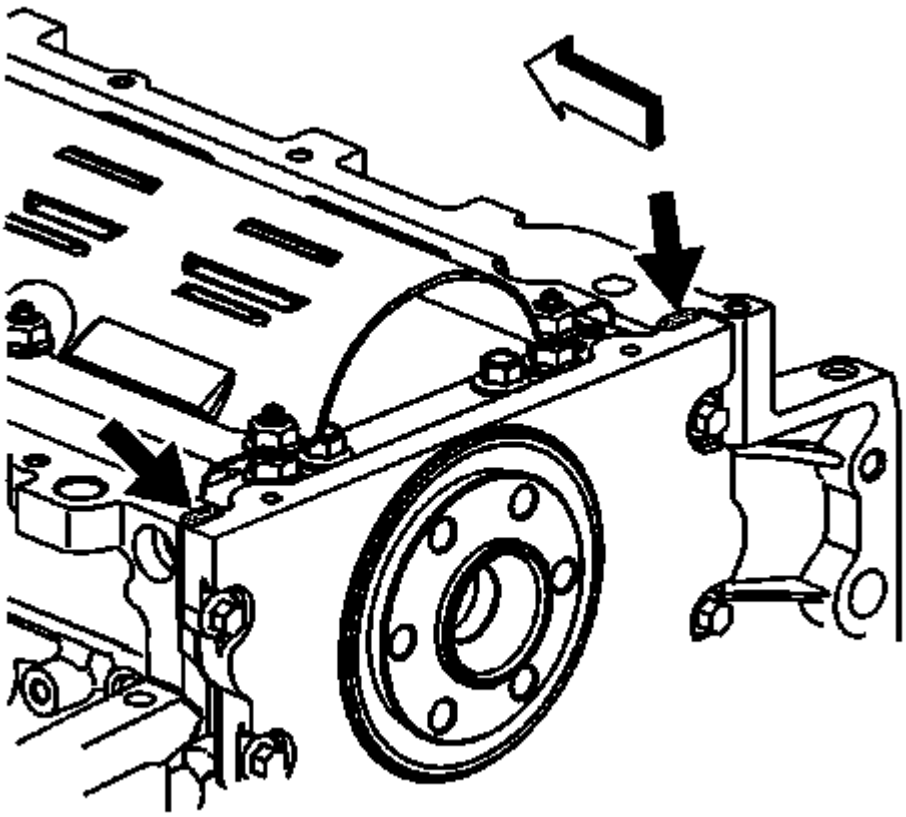

Fig. 636: View Of Sealant On Engine Rear Cover Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

2. Apply a 5 mm (0.2 in) bead of sealant GM P/N 12378521 (Canadian P/N 88901148), or equivalent, 20 mm (0.8 in) long to the engine block. Apply the sealant directly onto the tabs of the rear housing gasket that protrude into the oil pan surface.

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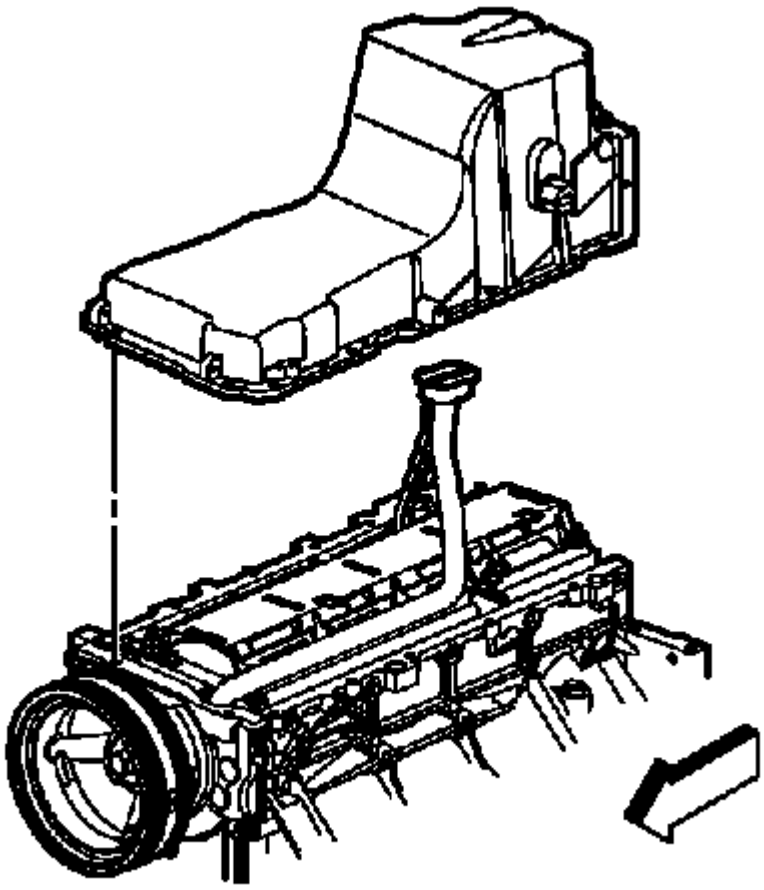

Fig. 637: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.
    1. Install the gasket onto the oil pan.
    2. 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 bolts finger tight. Do not overtighten.
6. Place a straight edge across the rear of the engine block and the rear of the oil pan at the transmission housing mounting surfaces.

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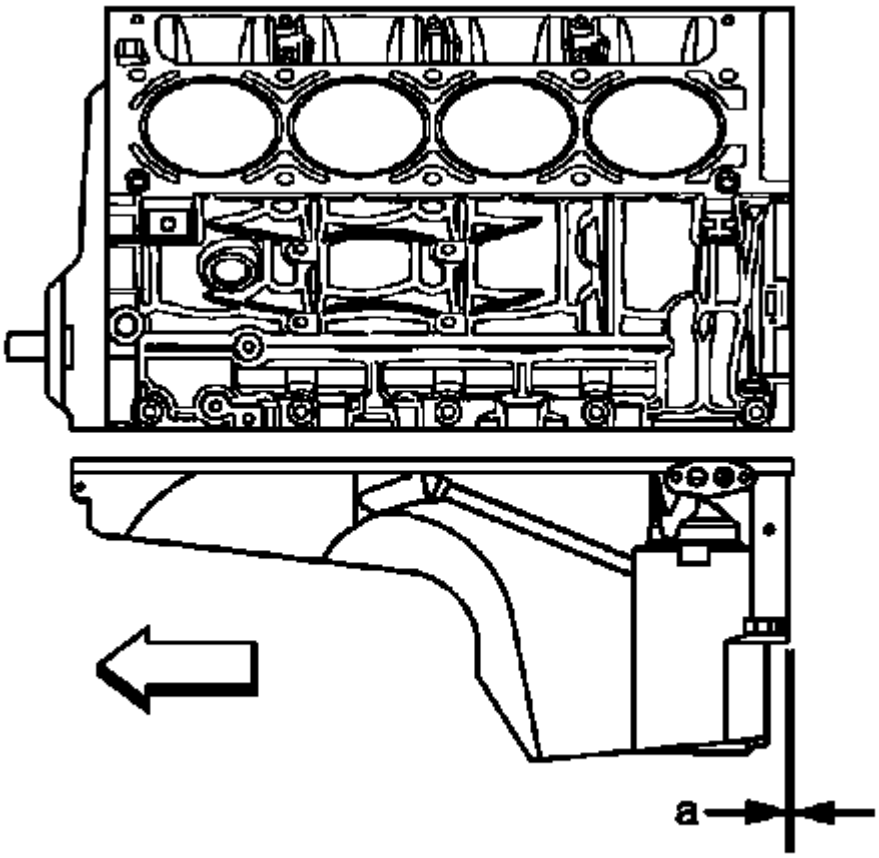

Fig. 638: Align The Oil Pan Until The Rear Of Engine Block And Rear Of Oil Pan Are Flush
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

7. Align the oil pan until the rear of engine block and rear of oil pan are flush or even.
   - Tighten the oil pan-to-block and oil pan-to-front cover bolts to 25 N.m (18 lb ft) .
   - Tighten the oil pan-to-rear cover bolts to 12 N.m (106 lb in) .
8. Measure the oil pan-to-engine block alignment (a).
   1. Place a straight edge across the rear of the engine block and rear of oil pan at the transmission housing mounting surfaces.

      NOTE: The rear of the oil pan must NEVER protrude beyond the engine block and transmission housing mounting surfaces.

   2. Insert a feeler gauge between the straight edge and the oil pan transmission housing mounting surface and measure to ensure that there is no greater than a 0.1 mm (0.004 in) gap between the pan

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and straight edge.

3. If the oil pan alignment is not within specifications, remove the oil pan and repeat the above procedure.

OIL FILTER INSTALLATION

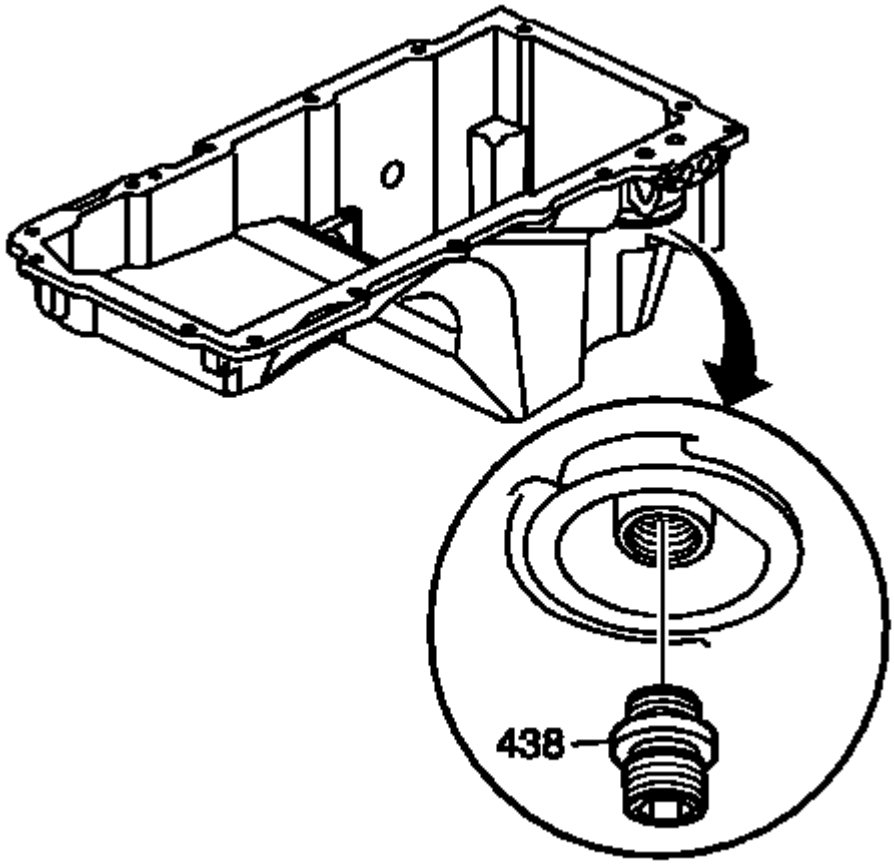

Fig. 639: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the oil filter fitting (438) and tighten to 55 N.m (40 lb ft).

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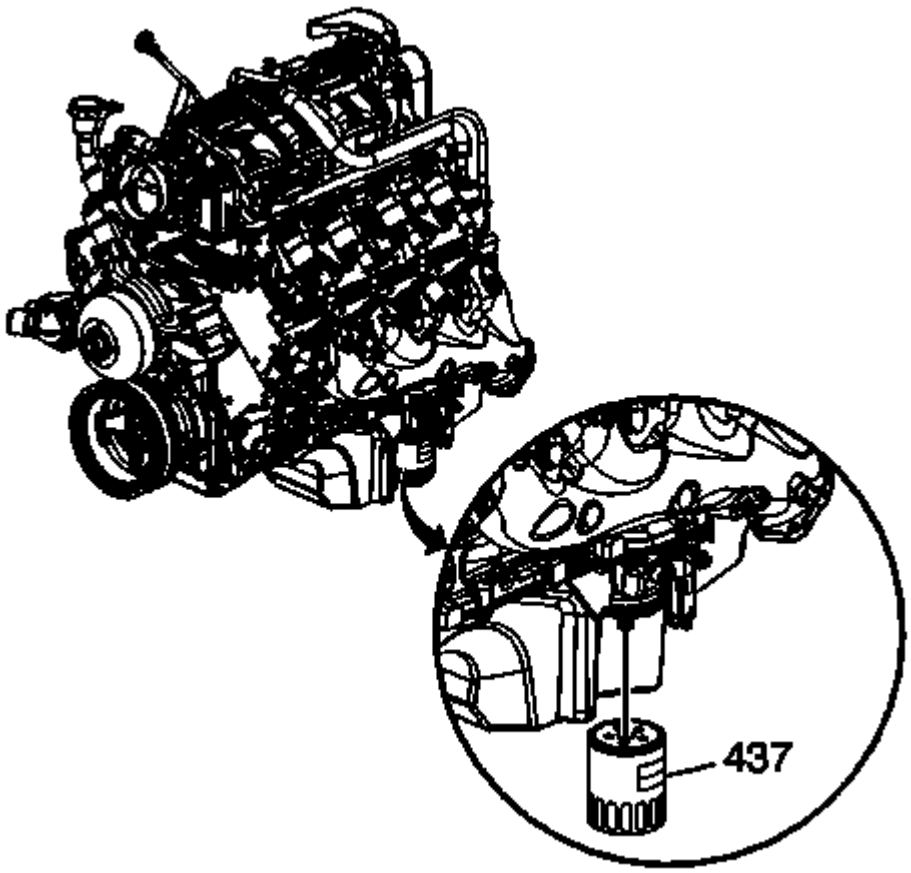

Fig. 640: View Of Engine Oil Filter
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the oil filter seal with clean engine oil.
3. Install the oil filter (437) and tighten to 30 N.m (22 lb ft).

VALVE LIFTER INSTALLATION

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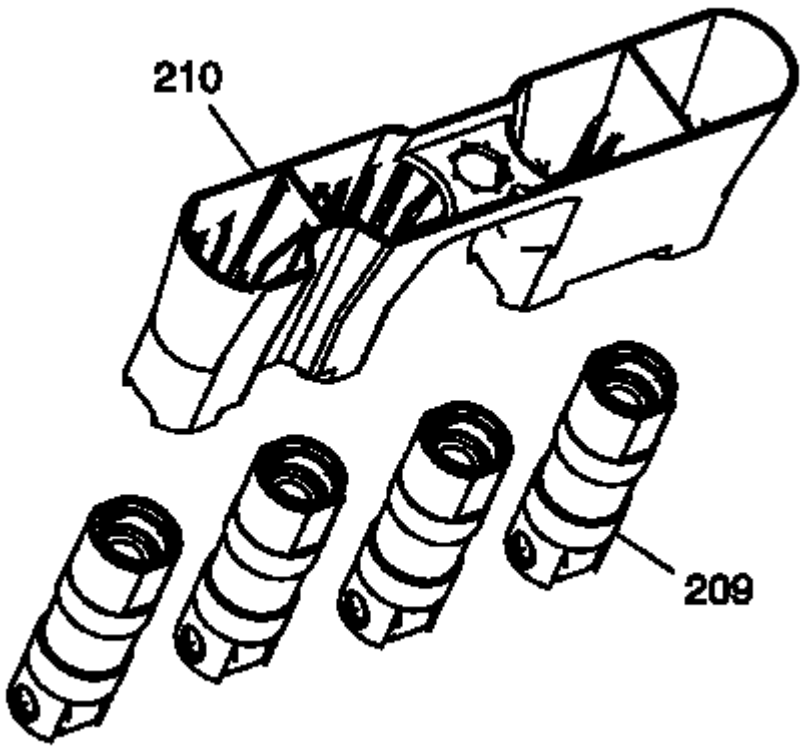

Fig. 641: Valve Lifter Guides & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**

1. Lubricate the valve lifters (209) and engine block valve lifter bores with clean engine oil.
2. Insert the valve lifters into the lifter guides (210).

   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.

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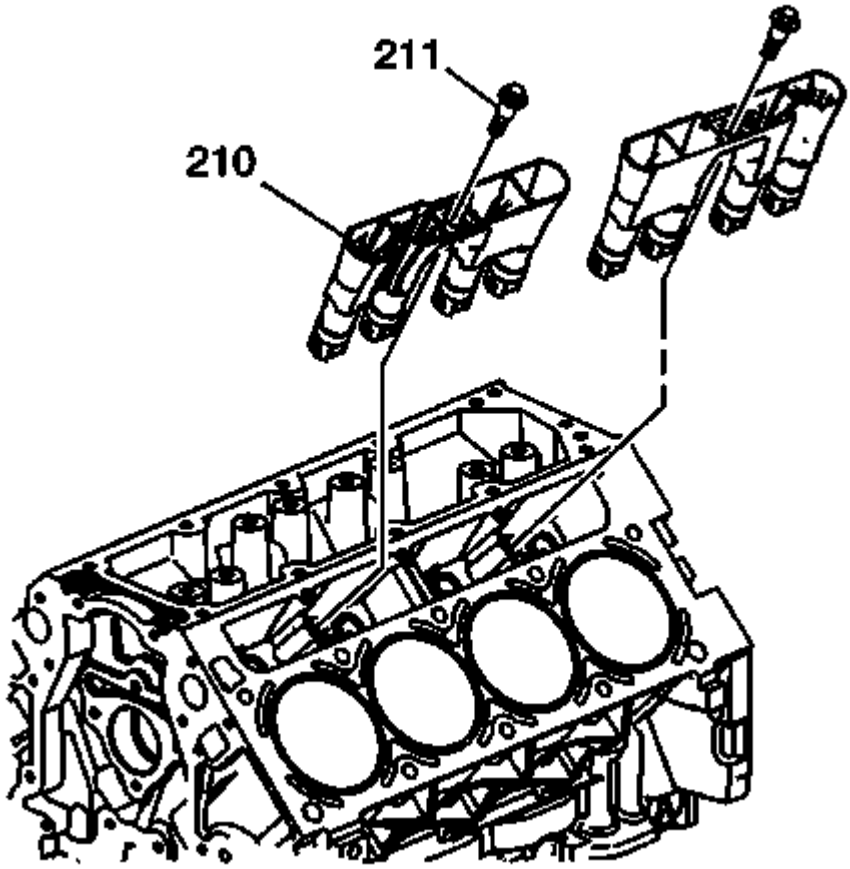

Fig. 642: Valve Lifter Guides, Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the valve lifters and guide assembly (210) to the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the valve lifter guide bolts (211) and tighten to 12 N.m (106 lb in).

CYLINDER HEAD INSTALLATION - LEFT SIDE

Special Tools

- **J 42385-100** Head/Main Bolt Thread Repair Kit. See **Special Tools**.
- **J 45059** Angle Meter

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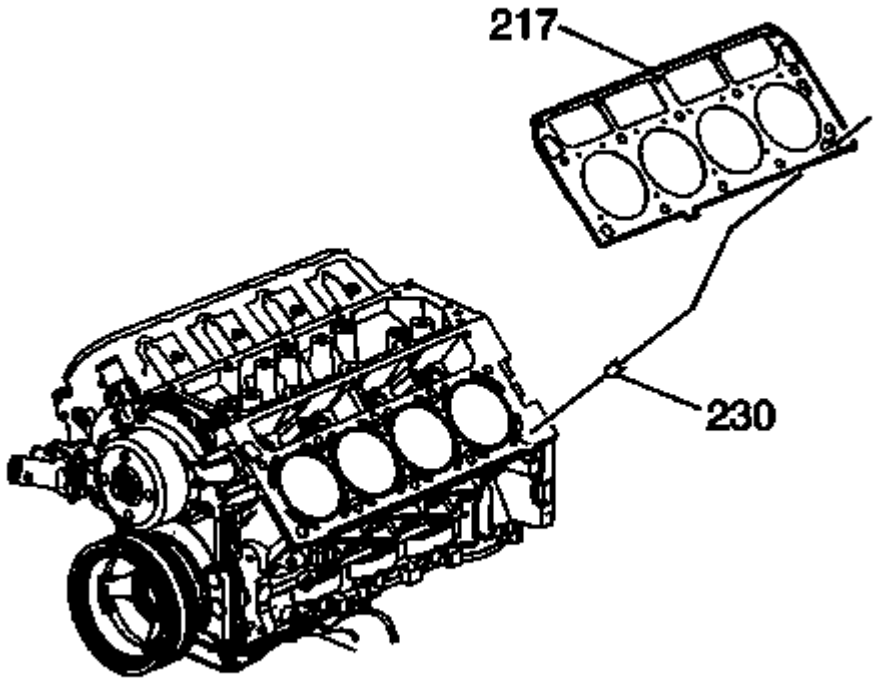

Fig. 643: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

CAUTION: 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.

NOTE:

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless specified.**

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

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

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2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

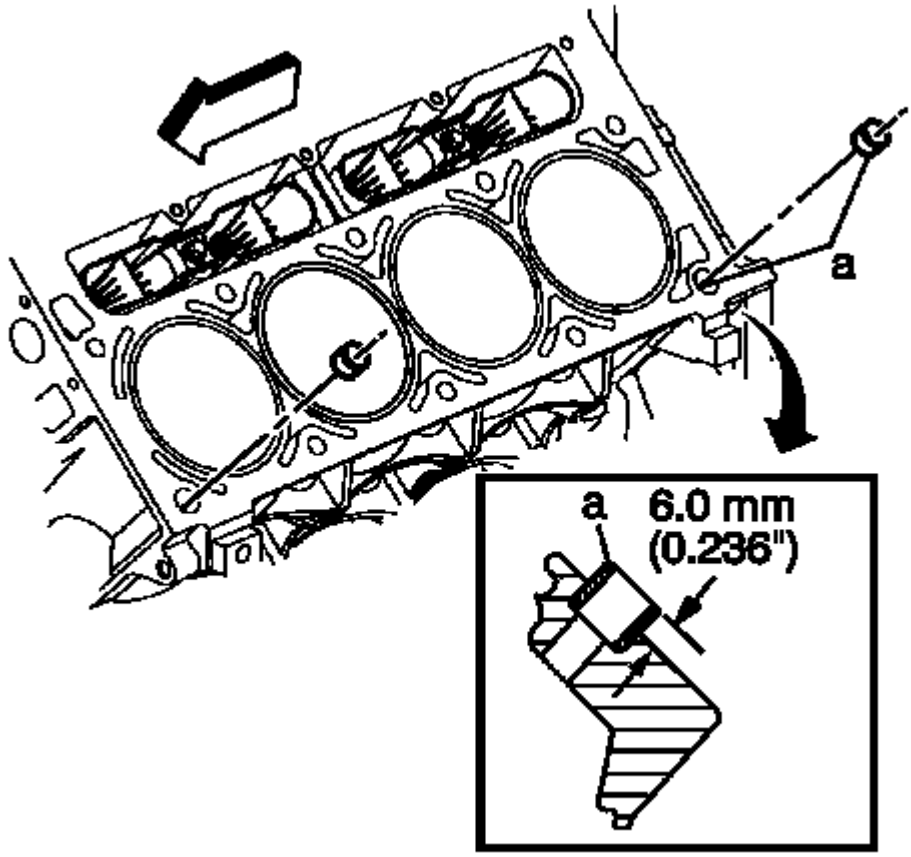

Fig. 644: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation (a).

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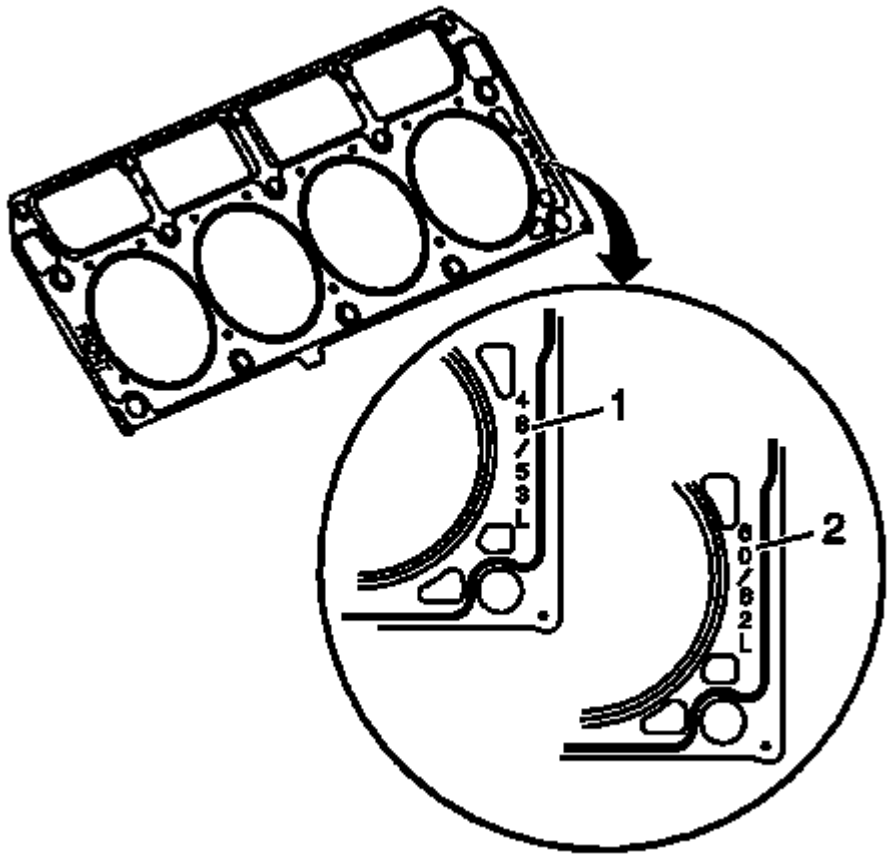

Fig. 645: View Of Displacement Markings On Gasket
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket, for proper usage.

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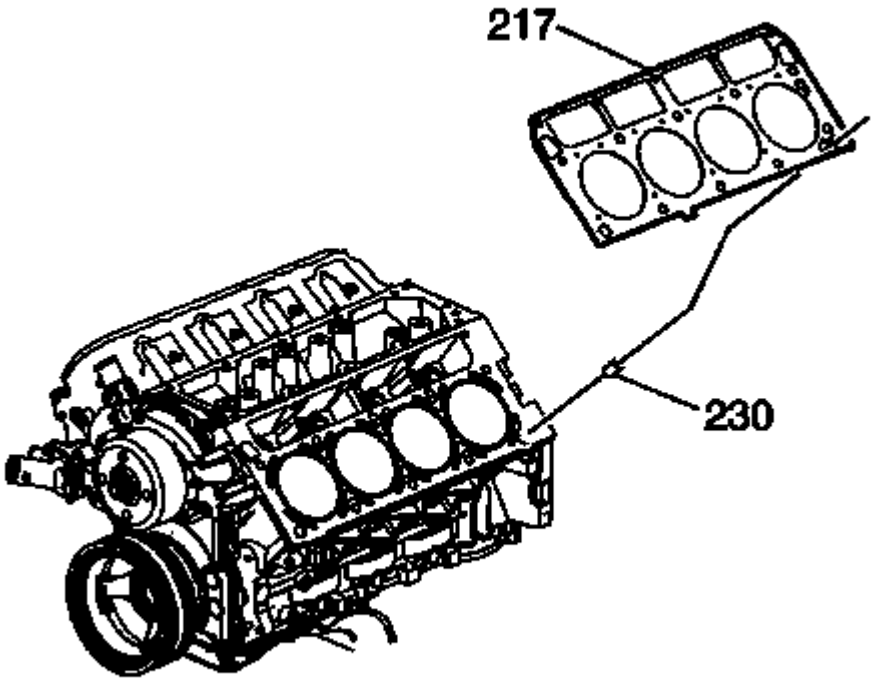

Fig. 646: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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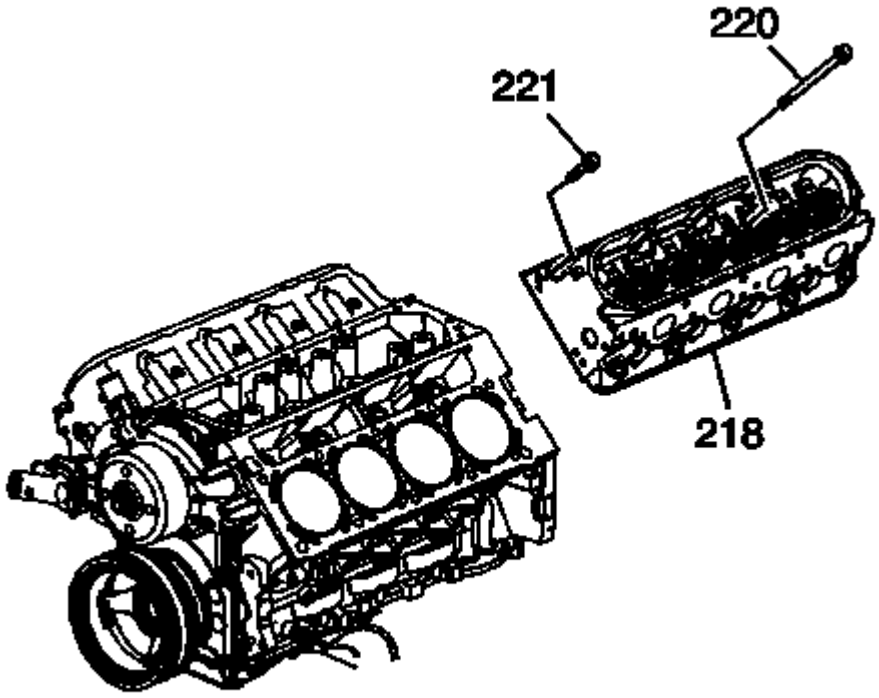

Fig. 647: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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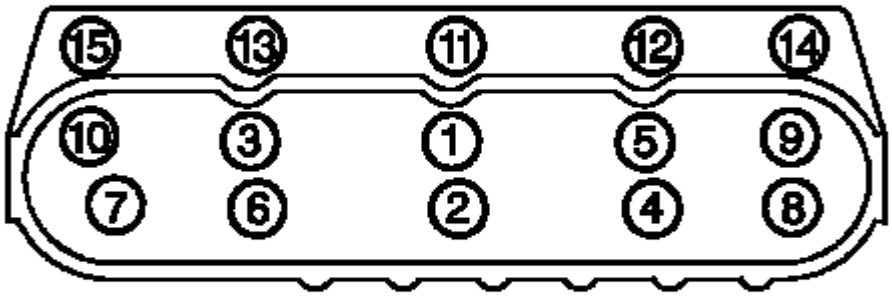

Fig. 648: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Tighten the cylinder head bolts.

Tighten:

1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059** .
3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059** .
4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

CYLINDER HEAD INSTALLATION - RIGHT SIDE

Special Tools

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- **J 42385-100:** Head/Main Bolt Thread Repair Kit
- **J 45059:** Angle Meter

For equivalent regional tools refer to **Special Tools**.

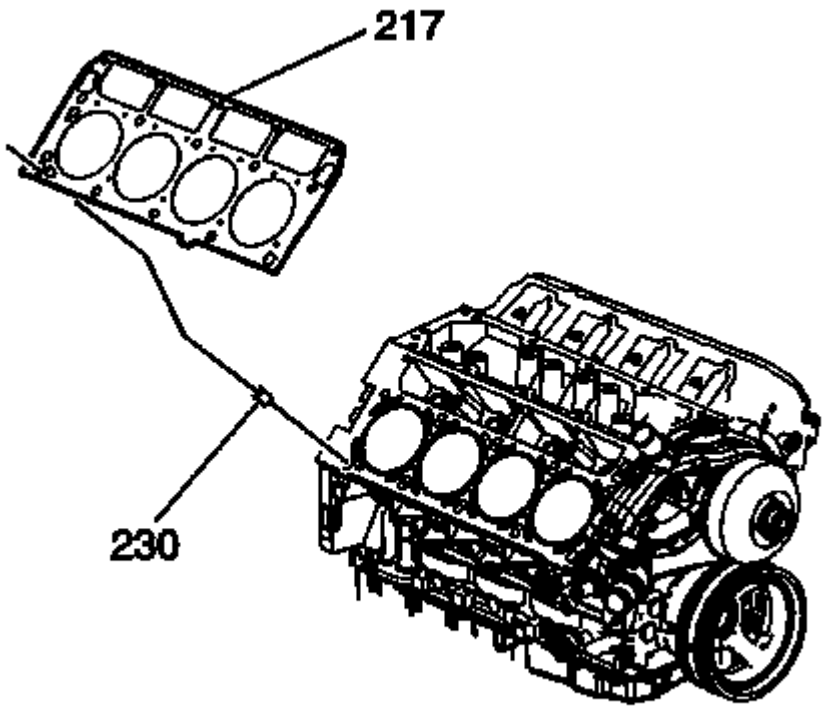

Fig. 649: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

CAUTION: 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.

NOTE:

- **Do not use the cylinder head bolts again. Install NEW cylinder head bolts during assembly.**
- **Do not use any type of sealant on the cylinder head gasket, unless**

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specified.

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

   Thread repair tool J 42385-107 may be used to clean the threads of old threadlocking material.

2. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
3. Clean the cylinder head bolt holes with compressed air.
4. Install the cylinder head locating pins (230).

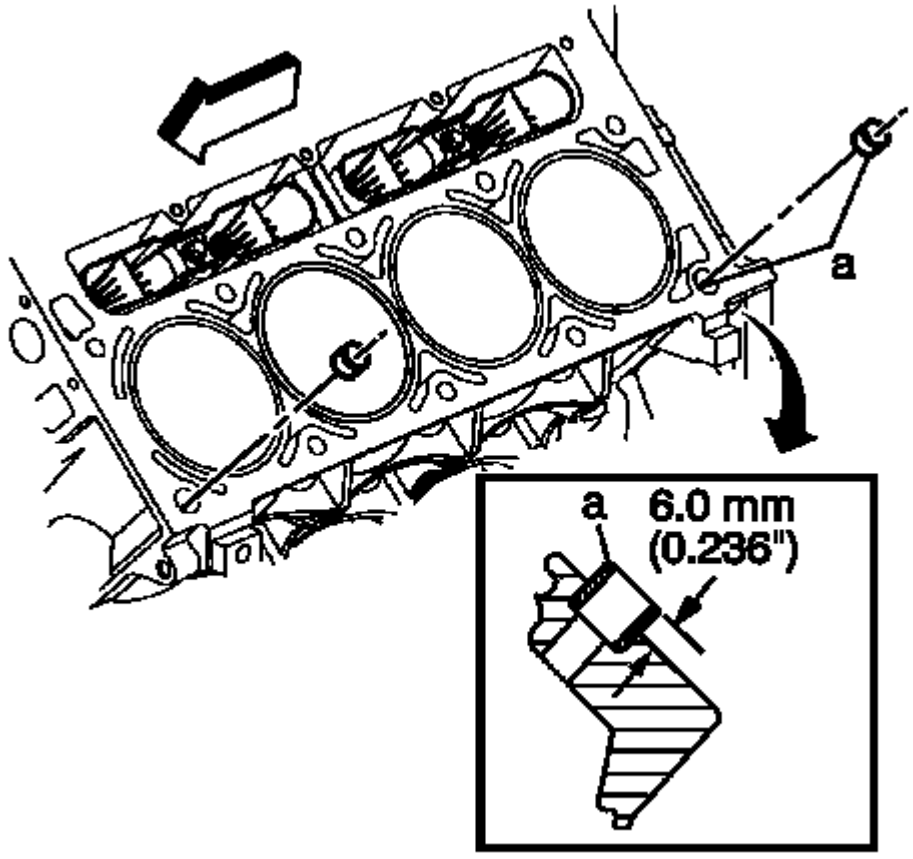

Fig. 650: Identifying Cylinder Head Locating Pins Installation Position
Courtesy of GENERAL MOTORS CORP.

5. Inspect the locating pins for proper installation.

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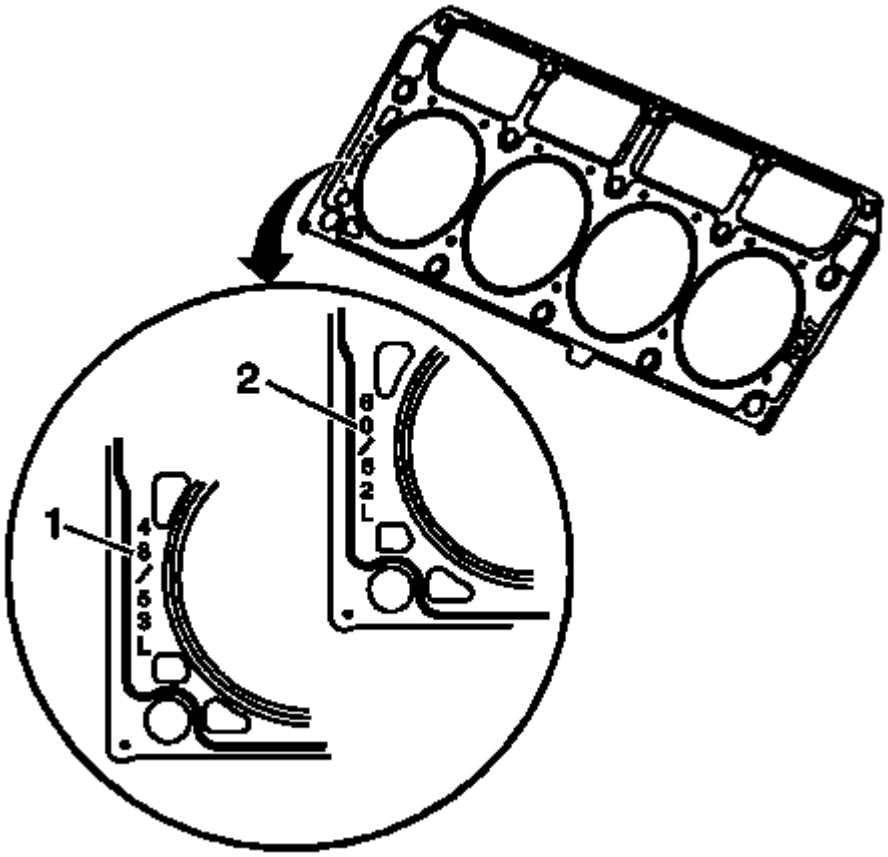

Fig. 651: View Of Displacement Markings On Gasket
Courtesy of GENERAL MOTORS CORP.

6. Inspect the displacement markings (1, 2) on the gasket, for proper usage.

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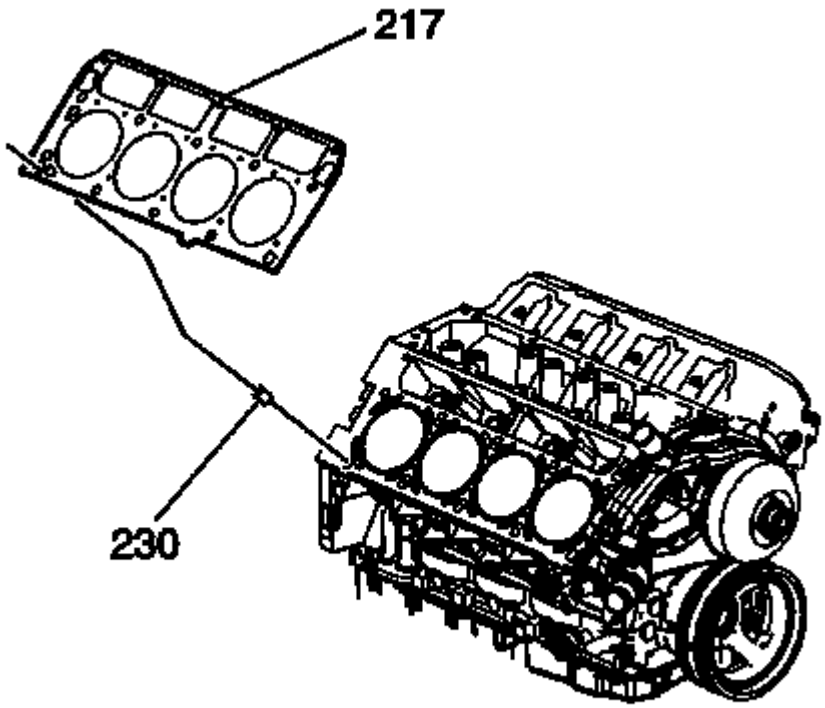

Fig. 652: View Of Cylinder Head Gasket & Locating Pins
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW cylinder head gasket (217) onto the locating pins.

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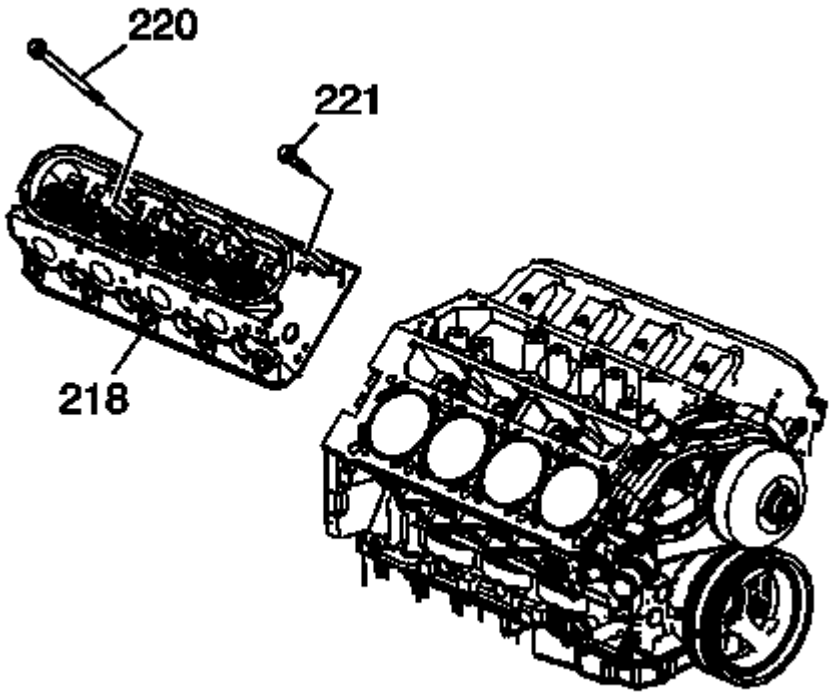

Fig. 653: View Of Cylinder Head & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the cylinder head (218) onto the locating pins and the gasket.
9. Install the NEW cylinder head bolts (220, 221).

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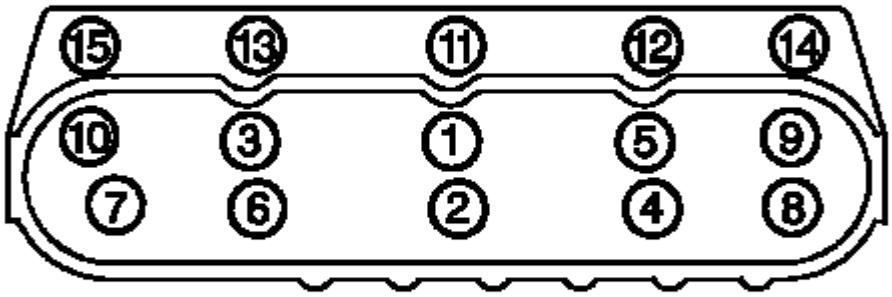

Fig. 654: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

10. Tighten the cylinder head bolts.
    1. Tighten the M11 cylinder head bolts (1-10) a first pass in sequence to 30 N.m (22 lb ft) .
    2. Tighten the M11 cylinder head bolts (1-10) a second pass in sequence to 90 degrees using the **J 45059:** angle meter .
    3. Tighten the M11 cylinder head bolts (1-10) a final pass in sequence to 70 degrees using the **J 45059:** angle meter .
    4. Tighten the M8 cylinder head bolts (11-15) to 30 N.m (22 lb ft). Begin with the center bolt (11) and alternating side-to-side, work outward tightening all of the bolts.

VALVE ROCKER ARM AND PUSH ROD INSTALLATION

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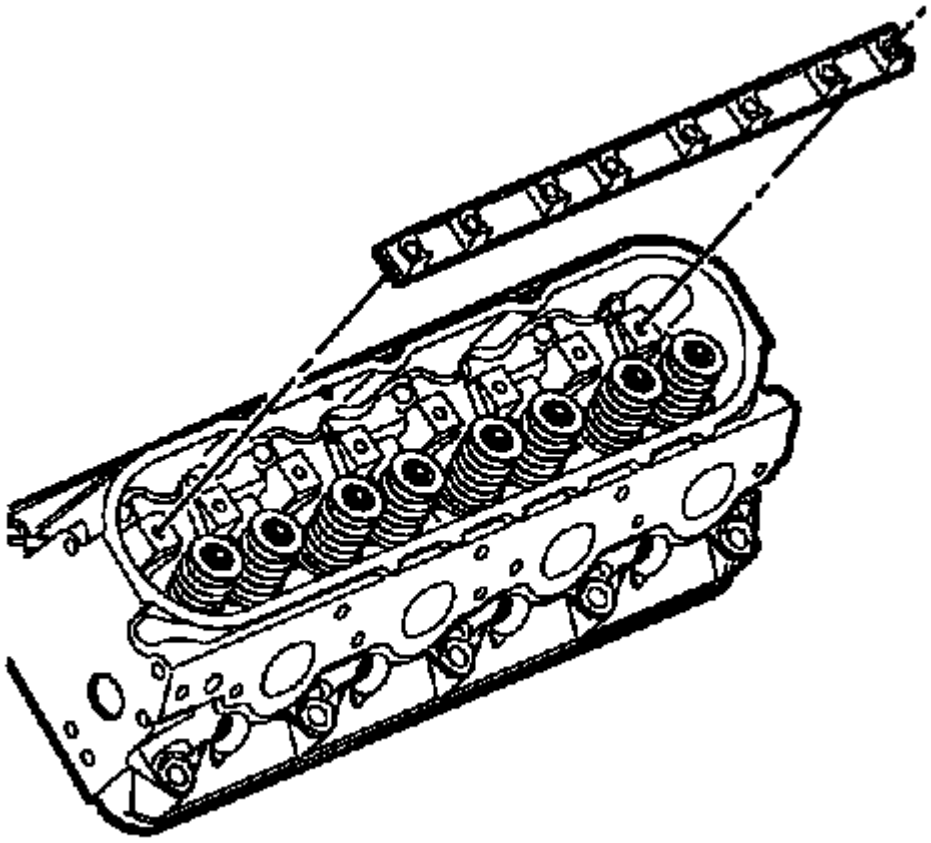

Fig. 655: View Of Valve Rocker Arm Pivot Support
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **When using the valve train components again, always install the components to the original location and position.**
- **Valve lash is net build. No valve adjustment is required.**

1. Lubricate the valve rocker arms and pushrods with clean engine oil.
2. Lubricate the flange of the valve rocker arm bolts with clean engine oil.
3. Install the valve rocker arm pivot support.

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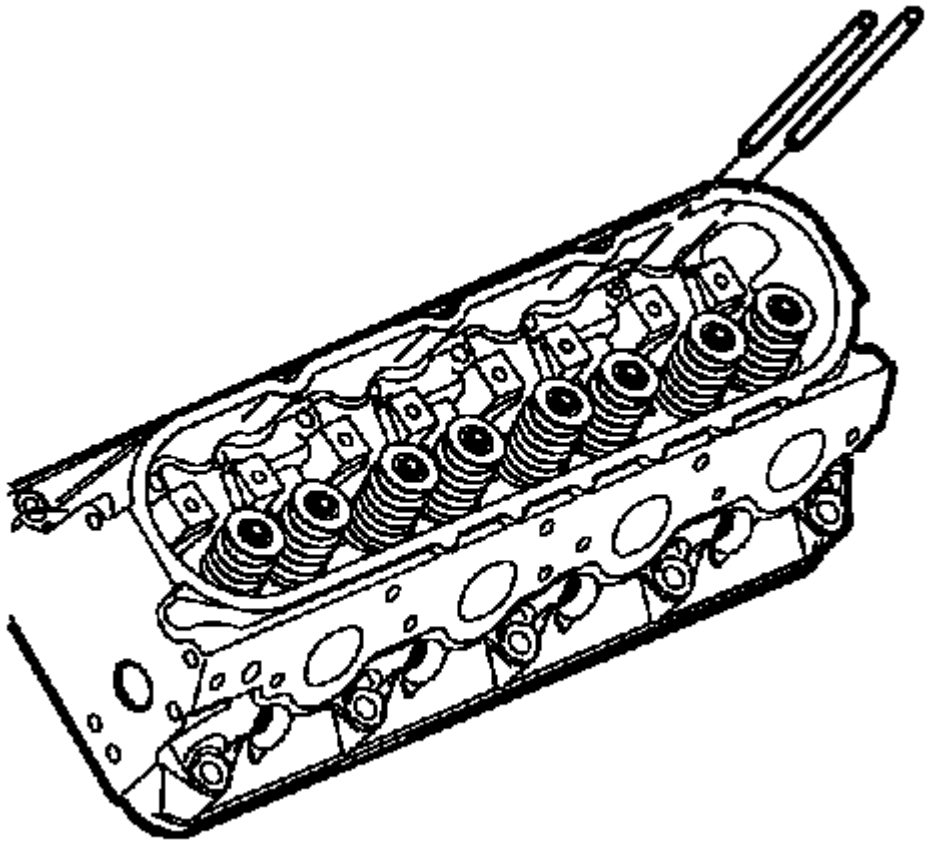

Fig. 656: View Of Pushrods
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the pushrods seat properly to the valve lifter sockets.

4. Install the pushrods.

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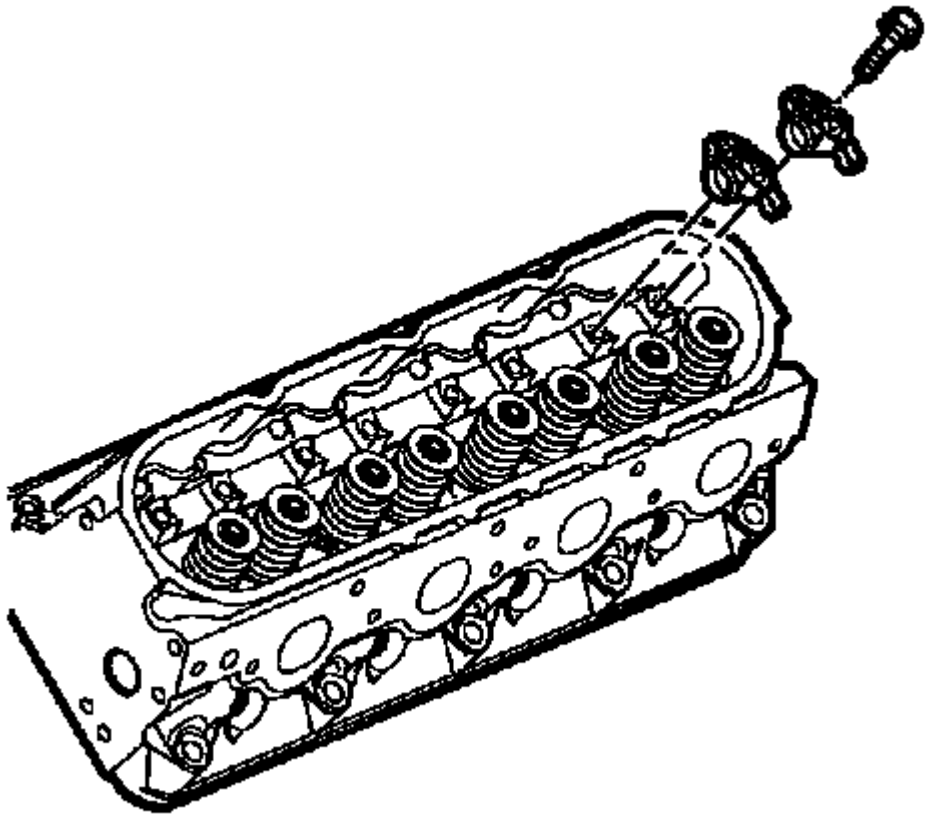

Fig. 657: View Of Rocker Arms & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Ensure the pushrods seat properly to the ends of the rocker arms.**
- **DO NOT tighten the rocker arm bolts at this time.**

5. Install the rocker arms and bolts.

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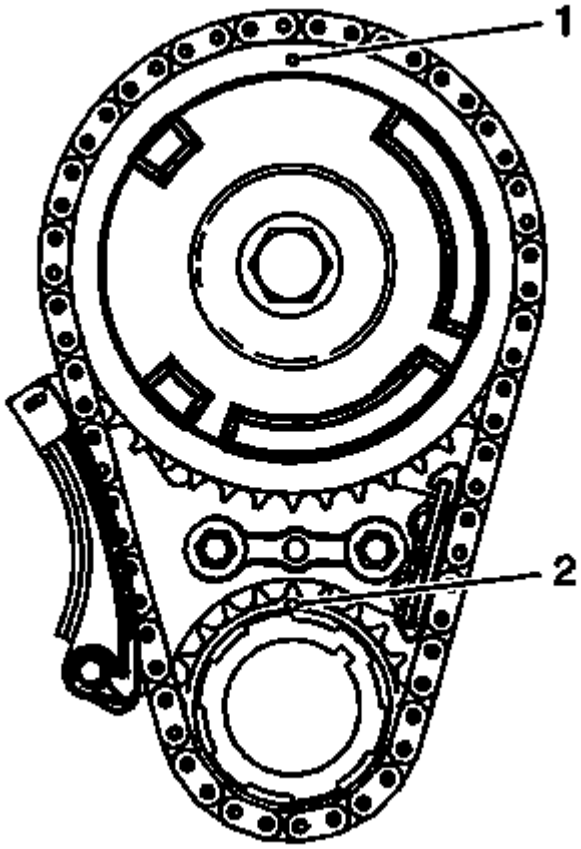

Fig. 658: View Of Camshaft & Crankshaft Sprocket Alignment Marks In 12 O'clock Position
Courtesy of GENERAL MOTORS CORP.

6. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

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

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

   Cylinders 2, 4, 6, and 8 are right bank.

   CAUTION: Refer to Fastener Caution .

7. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:

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Tighten:

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

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

Tighten:

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

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

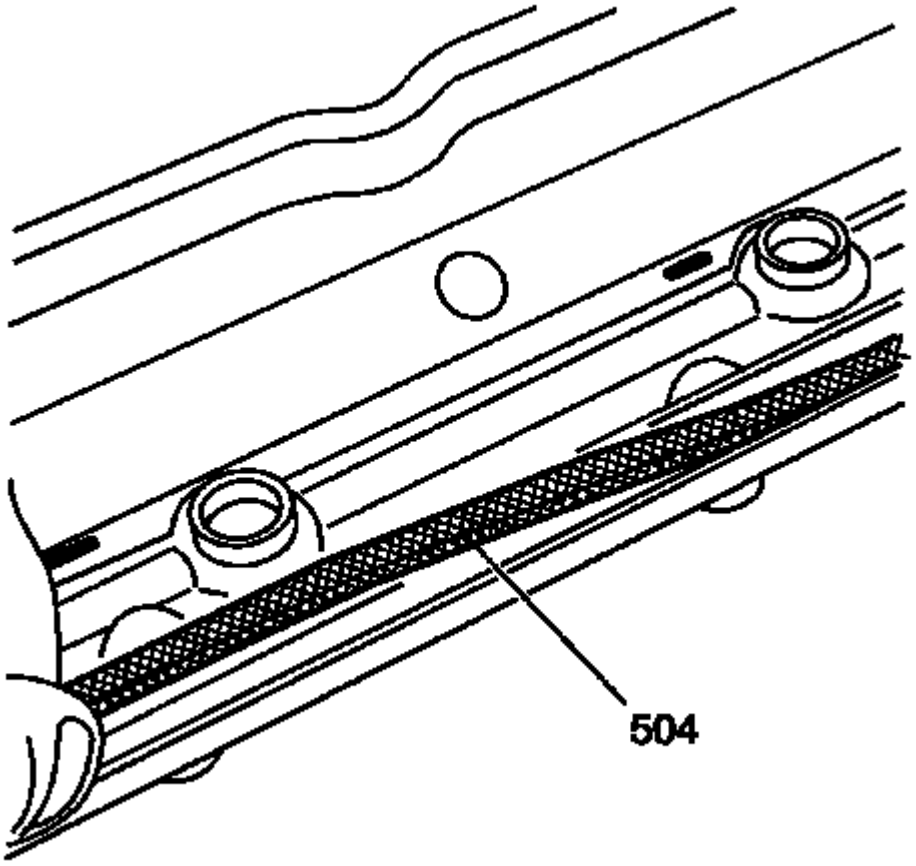

Fig. 659: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**

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1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.
2. Install a NEW gasket (504) into the valve rocker arm cover.

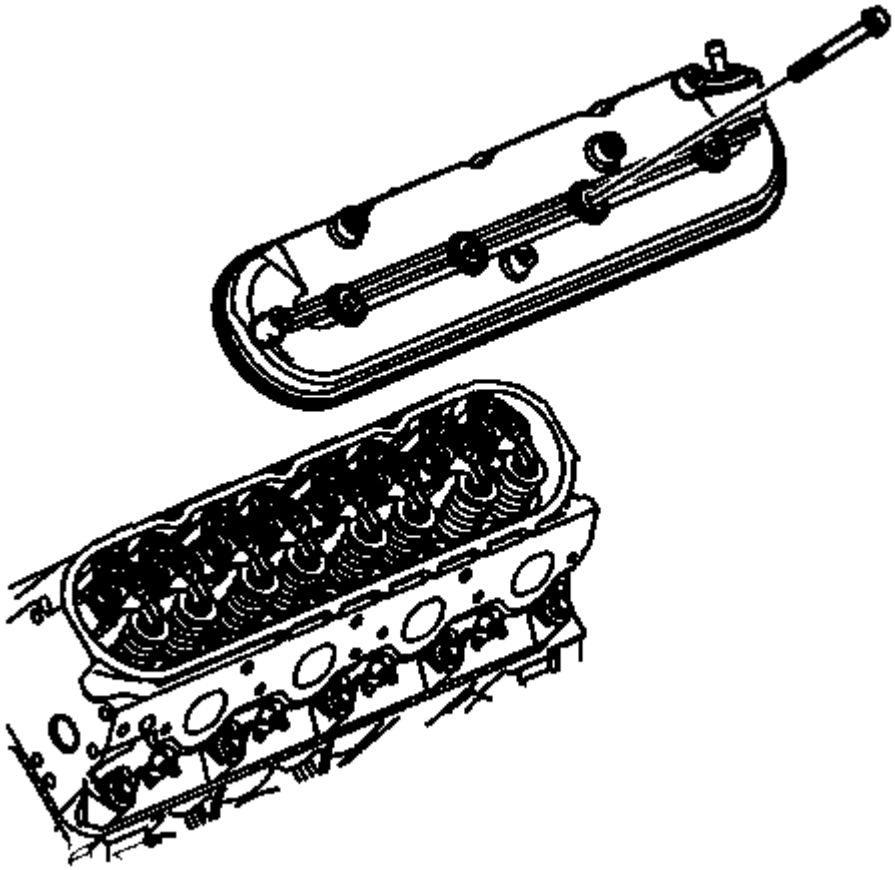

Fig. 660: View Of Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS CORP.

3. Install the valve rocker arm cover onto the cylinder head.

CAUTION: Refer to Fastener Caution .

4. Install the cover bolts with grommets and tighten to 12 N.m (106 lb in).

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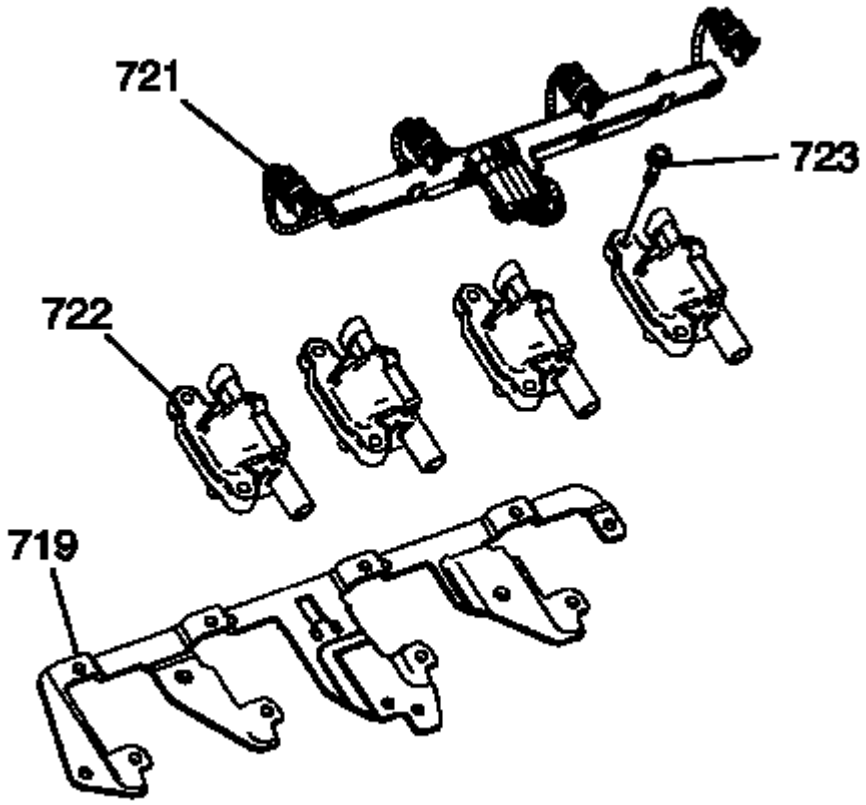

Fig. 661: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

5. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
6. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719). Tighten the ignition coil bolts to 10 N.m (89 lb in).

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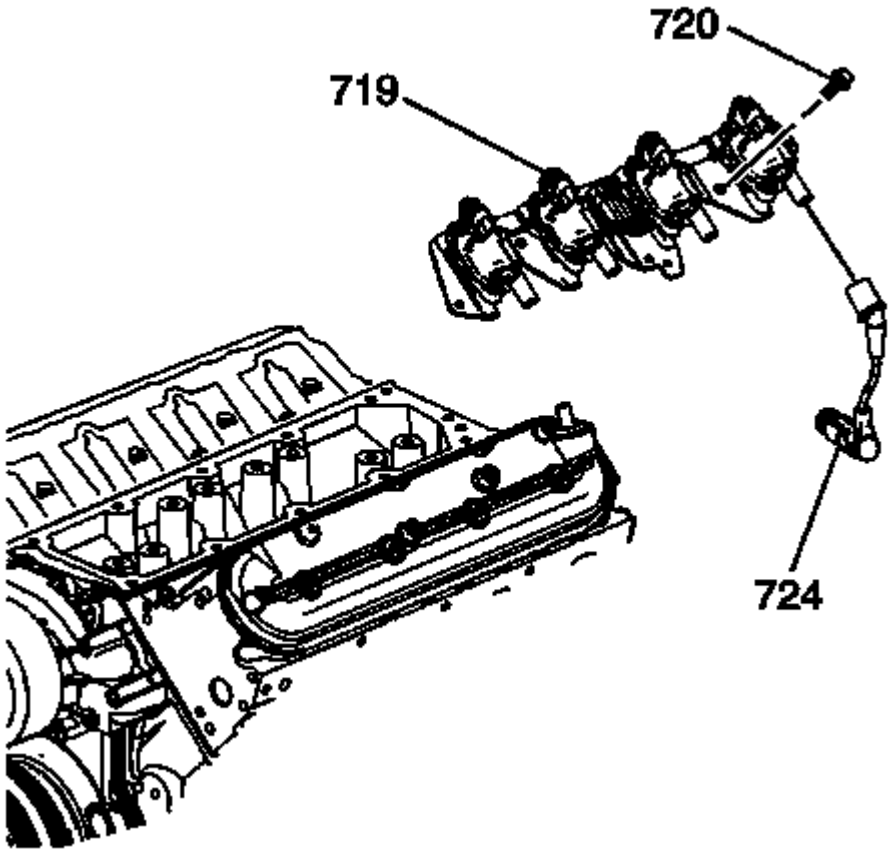

Fig. 662: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).
8. Install the ignition coil and bracket assembly (719) and studs (720). Tighten the bracket studs to 12 N.m (106 lb in).

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

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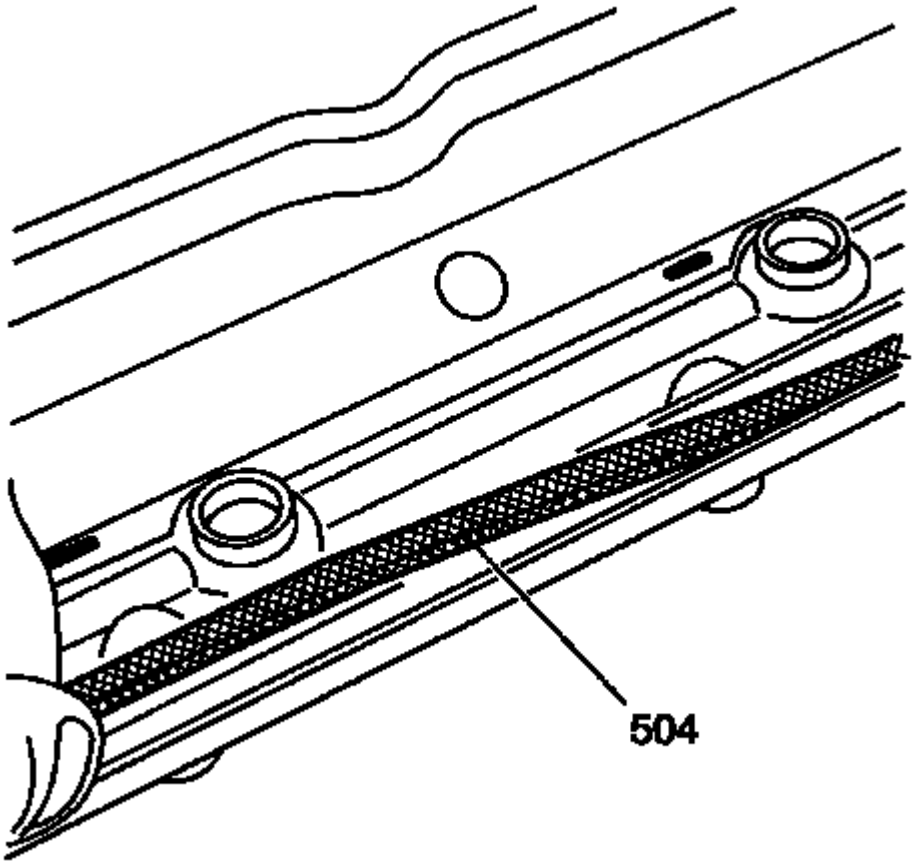

Fig. 663: View Of Valve Rocker Arm Cover Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **All gasket surfaces should be free of oil or other foreign material during assembly.**
- **DO NOT use the valve rocker arm cover gasket again.**

1. Install NEW valve rocker arm cover grommets and use NEW valve rocker arm cover bolts if they are serviced with the grommet.
2. Install a NEW gasket (504) into the valve rocker arm cover.

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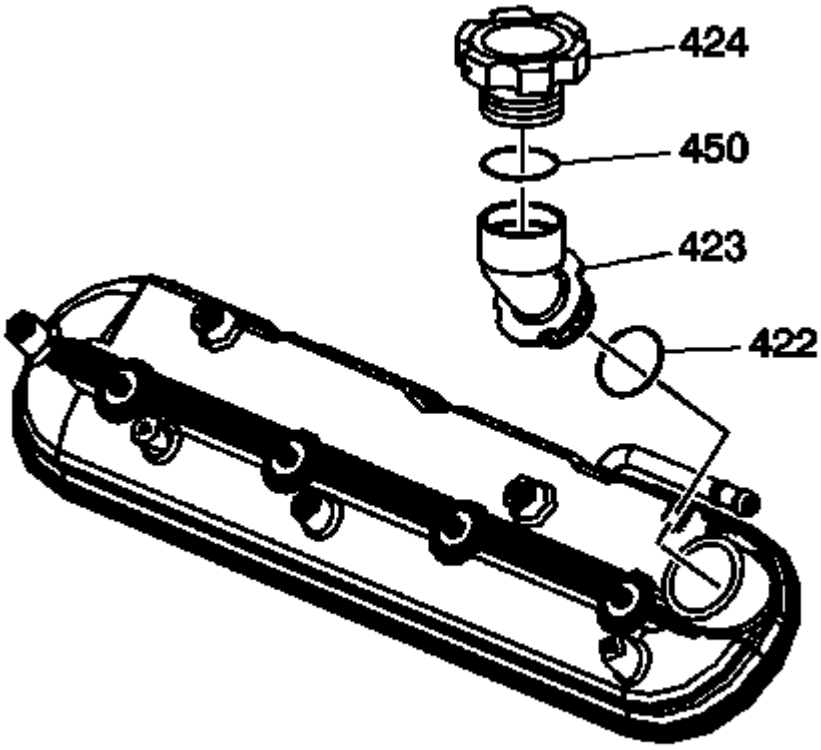

Fig. 664: Oil Fill Cap & Oil Fill Tube
Courtesy of GENERAL MOTORS CORP.

3. Install a NEW oil fill tube (423) to the valve rocker arm cover.
4. Install the oil fill cap (424).

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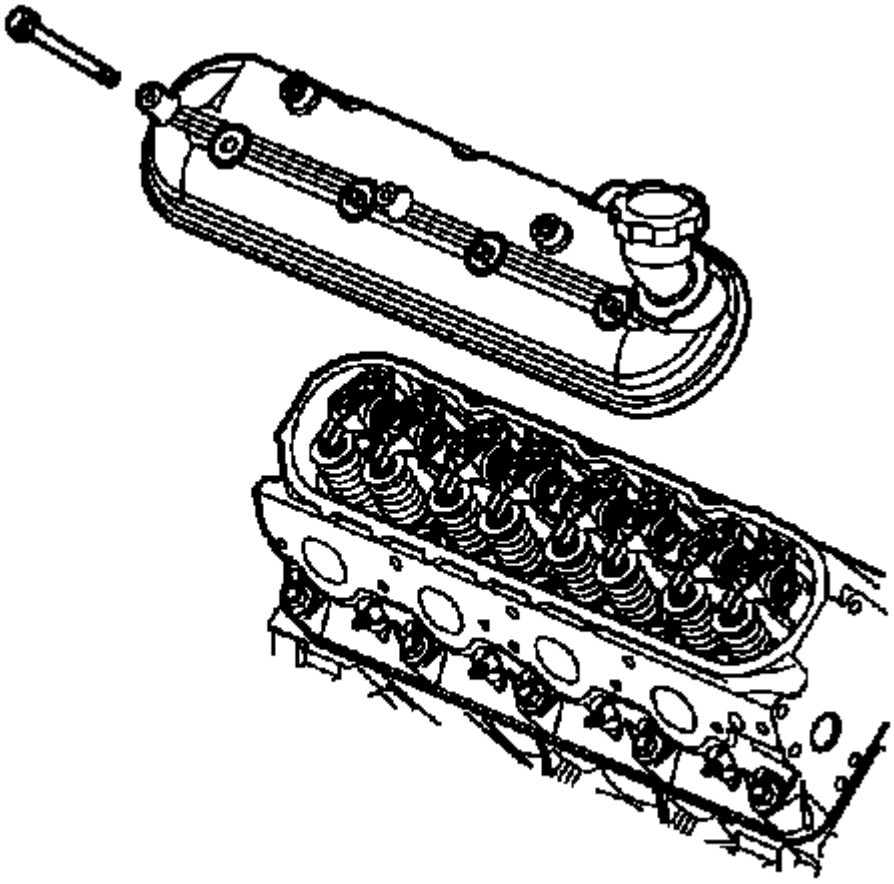

Fig. 665: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

5. Install the valve rocker arm cover onto the cylinder head.

CAUTION: Refer to Fastener Caution .

6. Install the cover bolts with grommets and tighten to 12 N.m (106 lb in).

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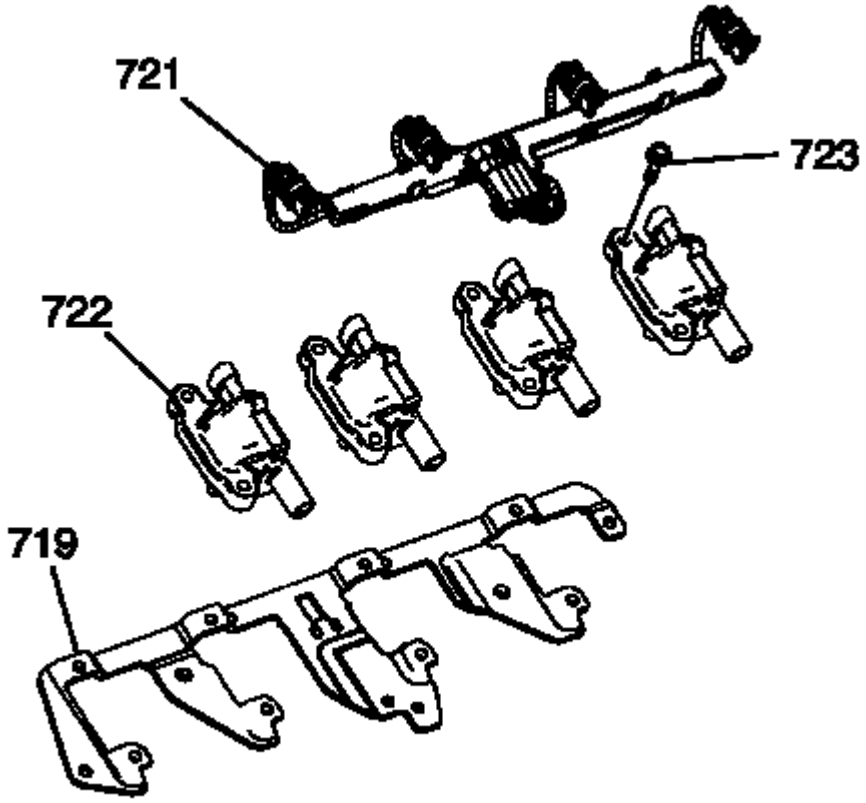

Fig. 666: View Of Bracket, Bolts, Coils & Wire Harness
Courtesy of GENERAL MOTORS CORP.

7. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bolts (723).
8. Install the ignition coils (722), wire harness (721), and bolts (723) to the bracket (719). Tighten the ignition coil bolts to 10 N.m (89 lb in).

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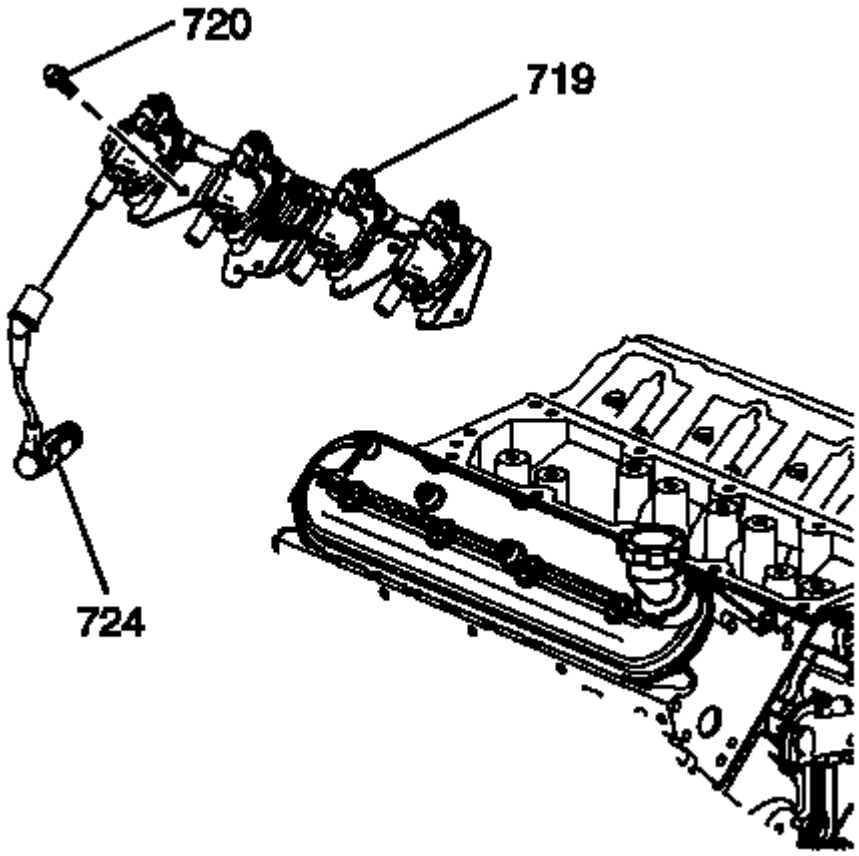

Fig. 667: Ignition Coils & Bracket
Courtesy of GENERAL MOTORS CORP.

9. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the ignition coil bracket studs (720).
10. Install the ignition coil and bracket assembly (719) and studs (720). Tighten the bracket studs to 12 N.m (106 lb in).

ENGINE BLOCK VALLEY COVER INSTALLATION

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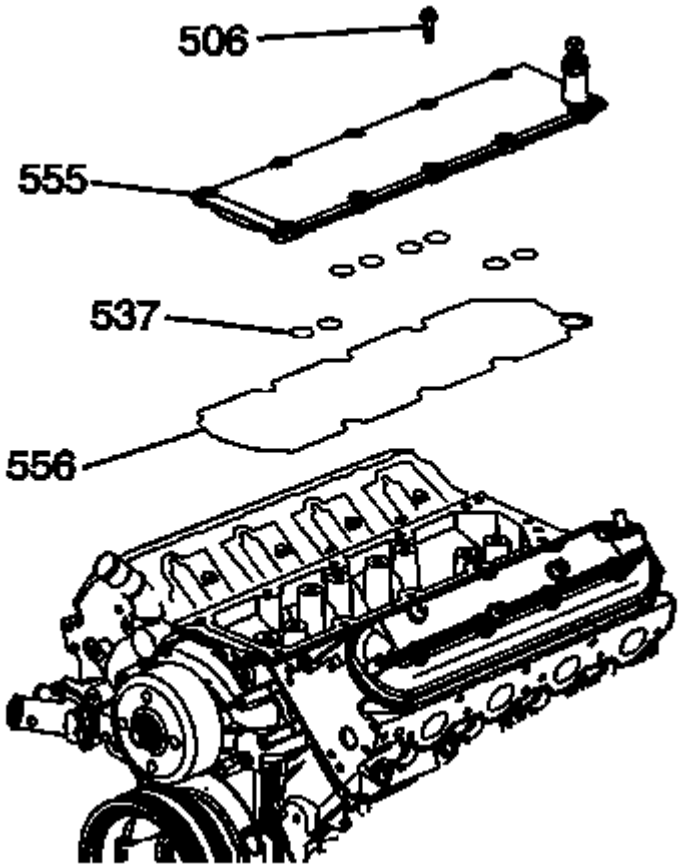

Fig. 668: Removing/Installing Engine Valley Cover
Courtesy of GENERAL MOTORS CORP.

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

1. Lubricate the O-ring seals with clean engine oil.
2. Install the O-ring seals (537) to the cover (555).

CAUTION: Refer to Fastener Caution .

3. Install the cover (555), gasket (556), and bolts (506). Tighten the manifold bolts to 25 N.m (18 lb ft).

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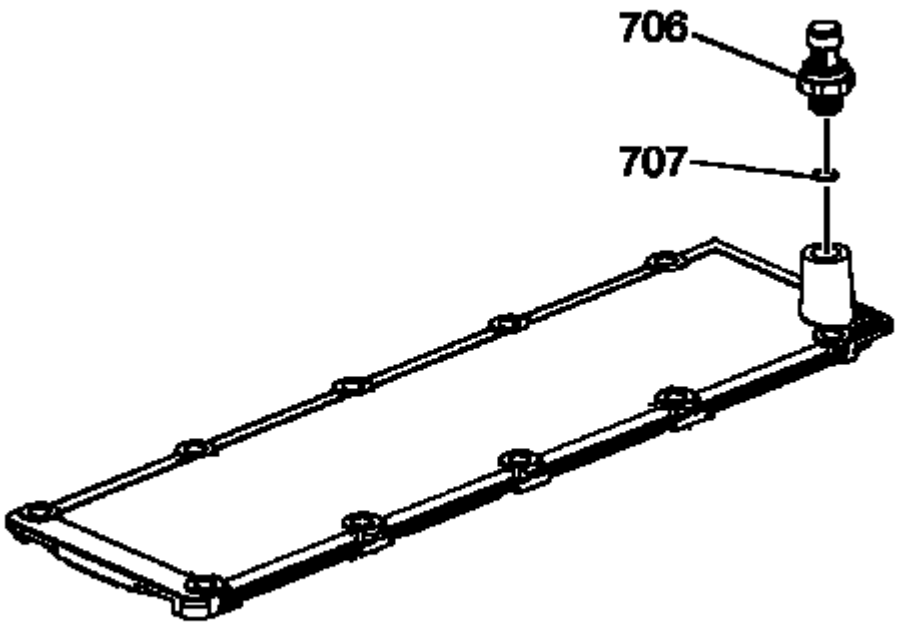

Fig. 669: Removing/Installing Oil Pressure Sensor & Washer
Courtesy of GENERAL MOTORS CORP.

4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent, to the threads of the sensor.
5. Install the oil pressure sensor (706) and sealing washer (707). Tighten the sensor to 35 N.m (26 lb ft).

ENGINE COOLANT AIR BLEED PIPE AND HOLE COVER INSTALLATION

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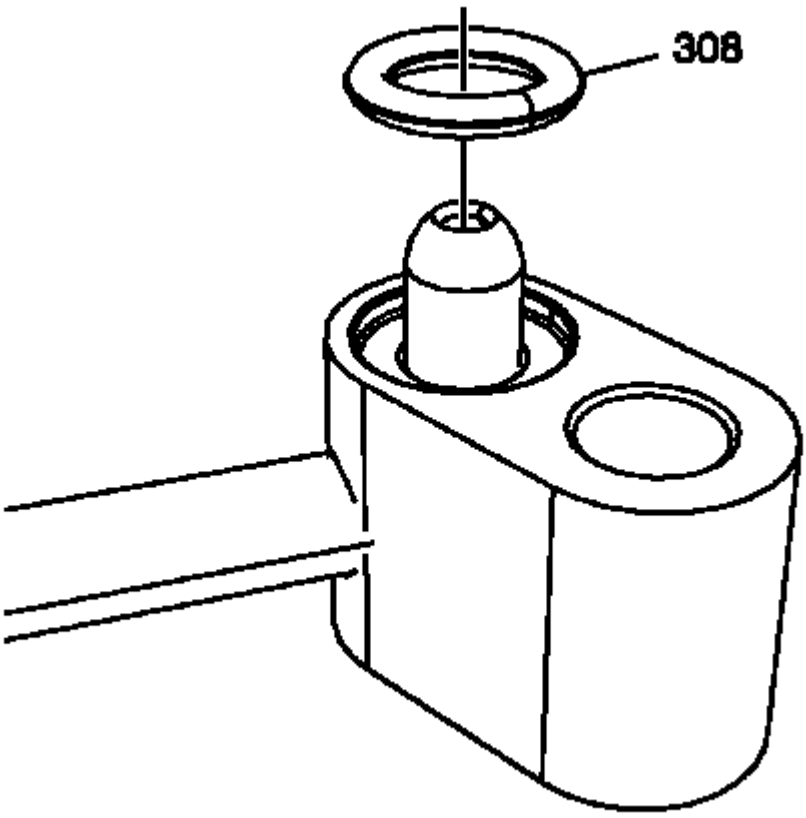

Fig. 670: View Of Coolant Air Bleed Pipe Seal
Courtesy of GENERAL MOTORS CORP.

NOTE: Position the gasket O-ring seal (308) onto the nipple portion of the pipe.

1. Install the seals onto the engine coolant air bleed pipe and covers.

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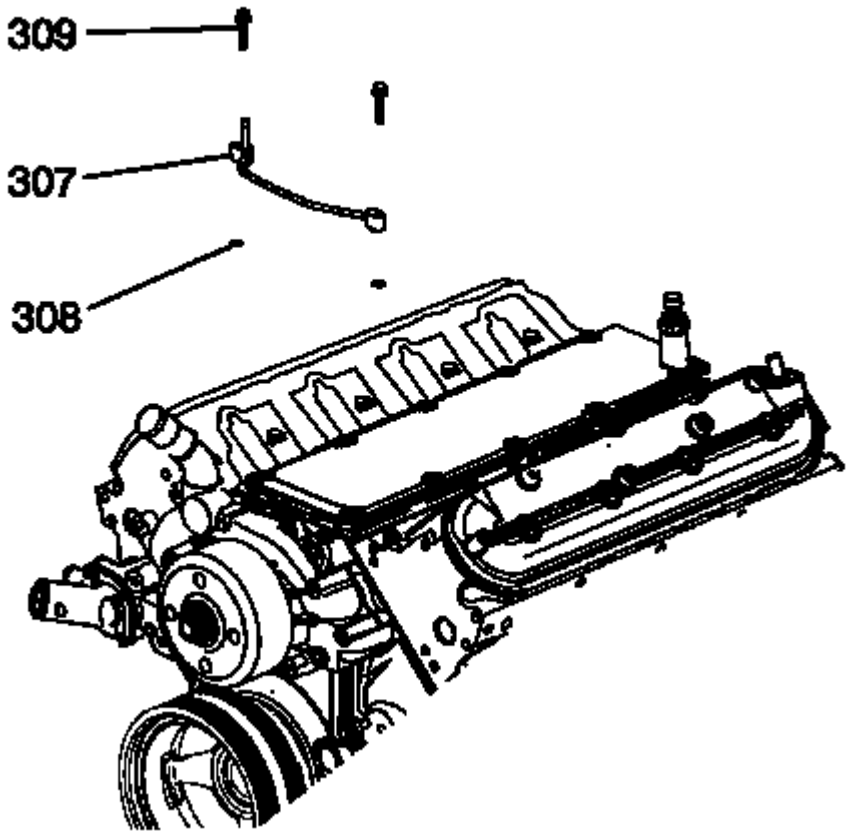

Fig. 671: Removing/Installing Engine Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS CORP.

2. Install the pipe (307) and seals (308).

CAUTION: Refer to Fastener Caution .

3. Install the bolts (309) and tighten to 12 N.m (106 lb in).

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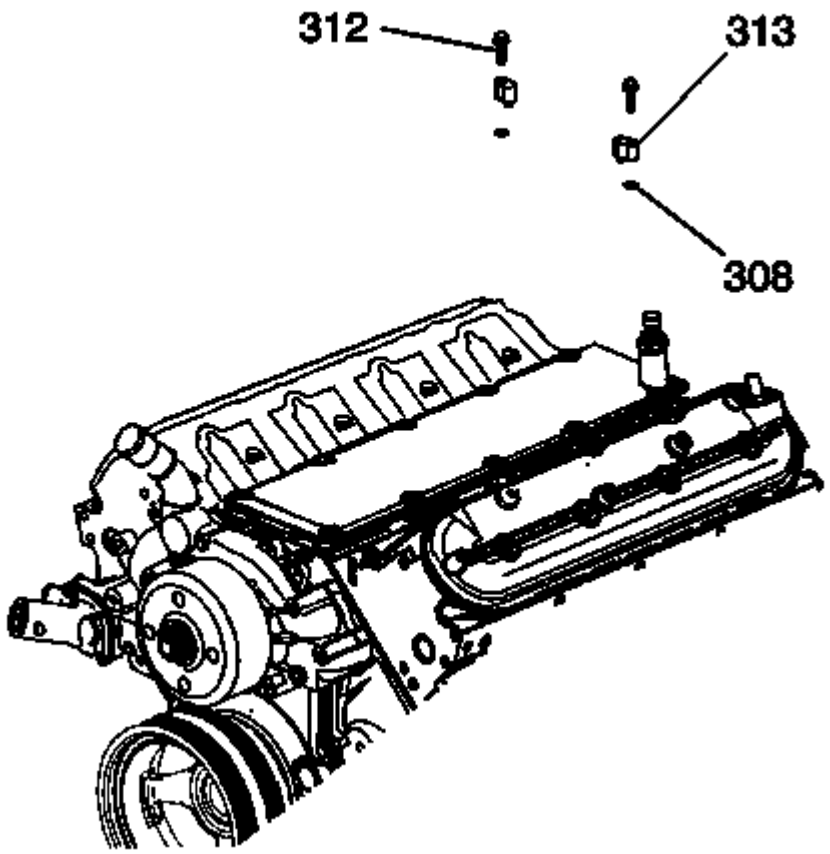

Fig. 672: Removing/Installing Coolant Air Bleed Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Production engines use a rivet-type plug at the top rear coolant passage of each cylinder head. If service of a leaking plug is required, it is necessary to remove the cylinder head from the engine to properly remove the plug. refer to Cylinder Head Disassemble.

4. As required, install either a new plug or the earlier design coolant air bleed covers (313) and gaskets (308). Refer to **Cylinder Head Assemble**.
5. Install the bolts (312).
6. Tighten the cover bolts to 12 N.m (106 lb in).

INTAKE MANIFOLD INSTALLATION

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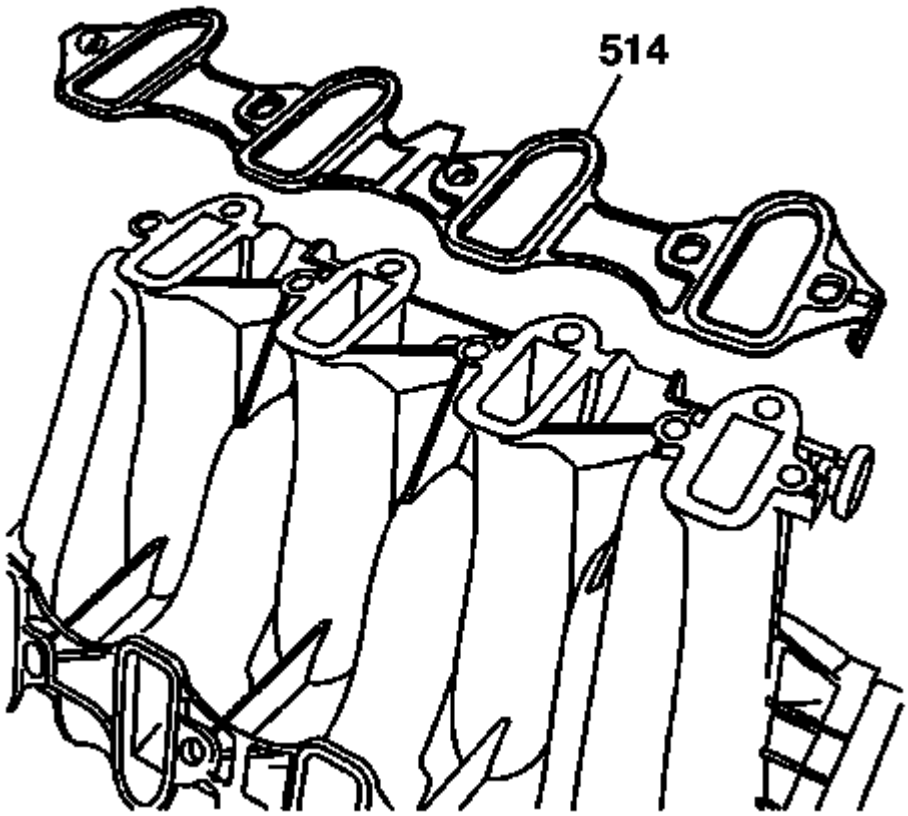

Fig. 673: View Of Intake Manifold-To-Cylinder Head Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The intake manifold, throttle body, fuel injection rail, and fuel injectors may be removed as an assembly. If not servicing the individual components, install the intake manifold as a complete assembly.**
- **DO NOT use the intake manifold gaskets again. Install NEW intake manifold-to-cylinder head gaskets.**

1. Install NEW intake manifold-to-cylinder head gaskets (514).

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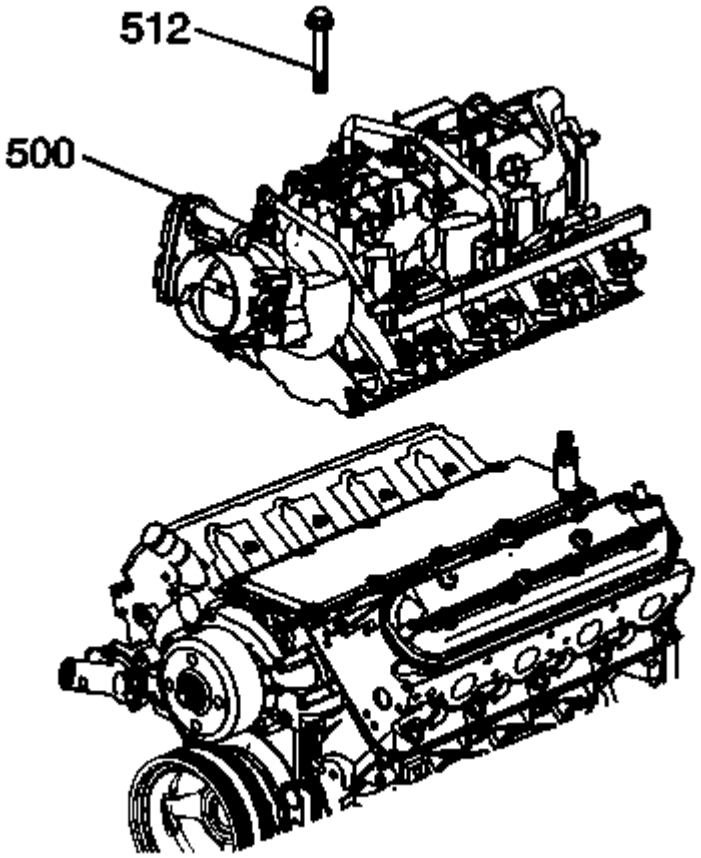

Fig. 674: Removing/Installing Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the intake manifold (500).
3. Apply a 5 mm (0.20 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489) to the threads of the intake manifold bolts (512). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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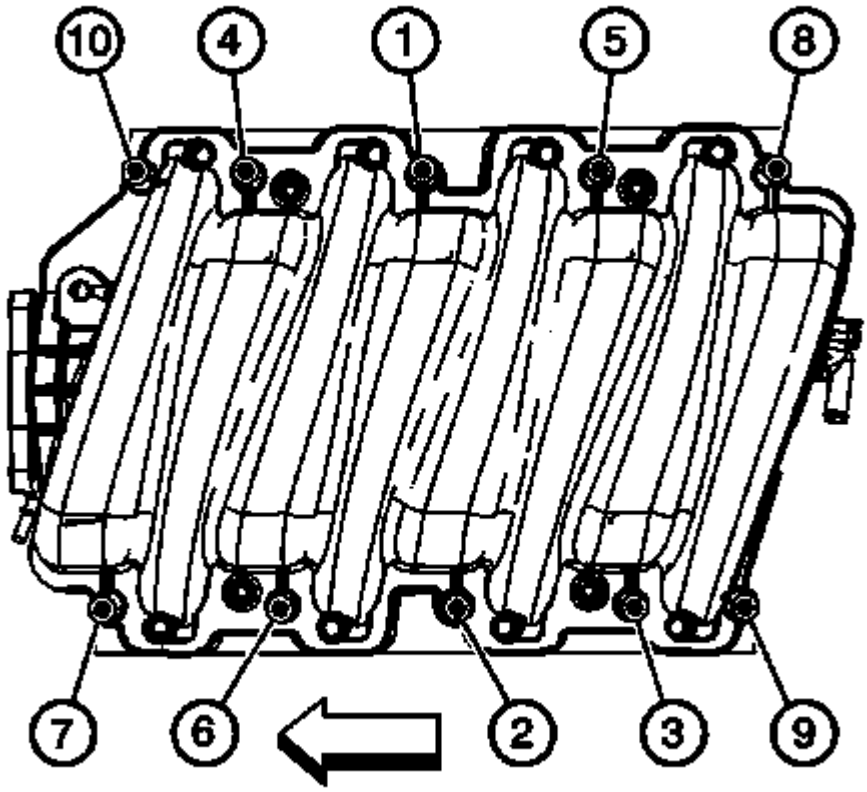

Fig. 675: Identifying Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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

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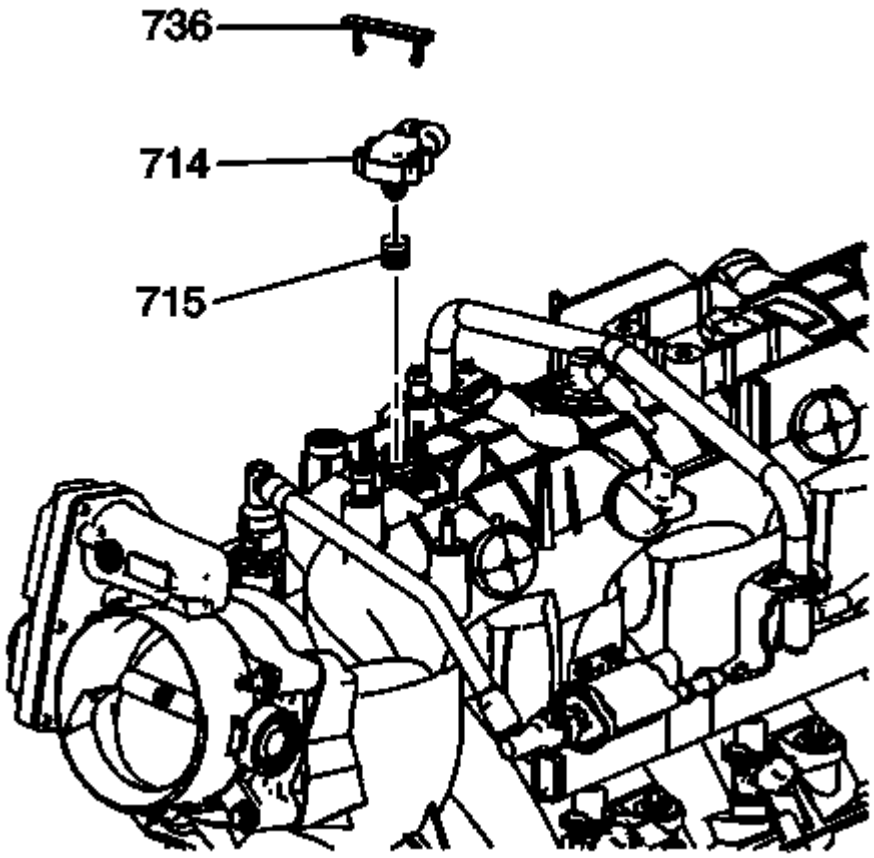

Fig. 676: MAP Sensor
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail. Refer to **Fuel Rail and Injectors Installation**.
6. Lubricate the manifold absolute pressure (MAP) sensor grommet (715) with clean engine oil.
7. Install the grommet onto the MAP sensor (714).
8. Install the MAP sensor and retainer (736).

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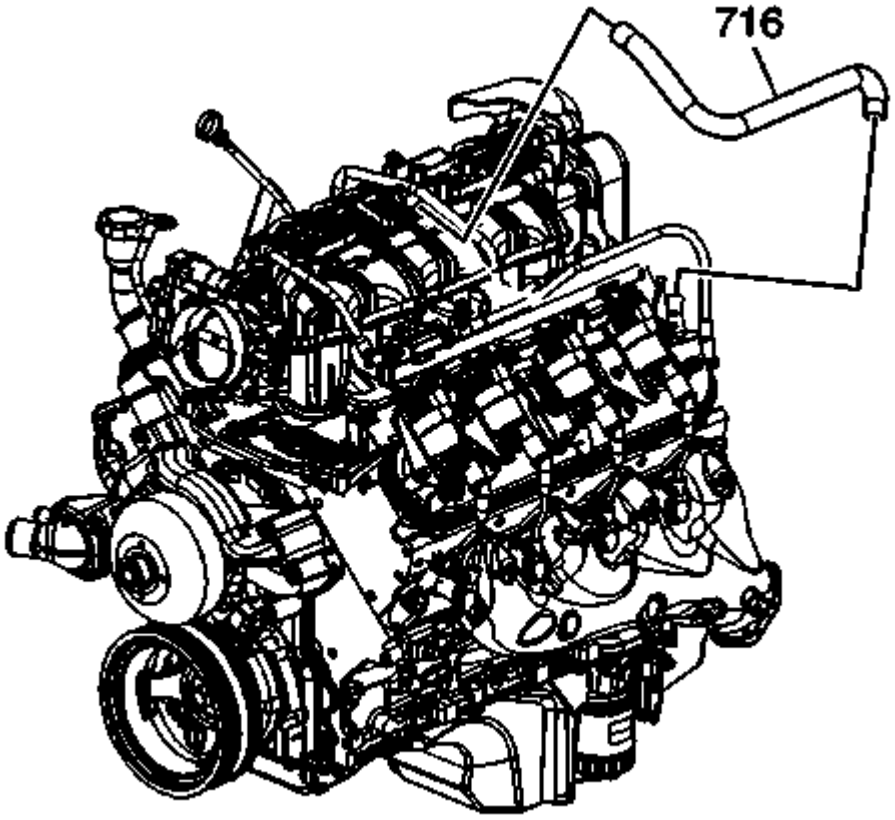

Fig. 677: View Of PCV Dirty-Air Hose
Courtesy of GENERAL MOTORS CORP.

9. Install the positive crankcase ventilation (PCV) hose - dirty air (716).

FUEL RAIL AND INJECTORS INSTALLATION

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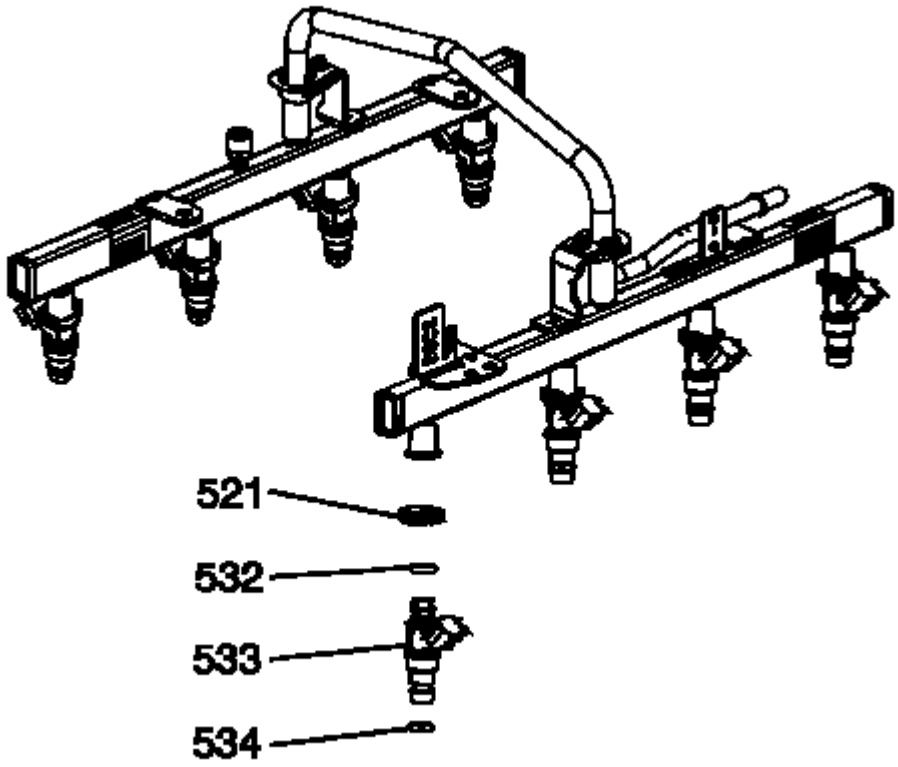

Fig. 678: Fuel Rail & Injectors
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Fuel Rail Stop Bracket Installation Warning .

NOTE: DO NOT use the fuel injector O-ring seals again. Install NEW fuel injector O-ring seals during assembly.

1. Lubricate the NEW fuel injector O-ring seals (532, 534) with clean engine oil.
2. Install the O-ring seals to the fuel injectors.
3. Install the fuel injectors (533) and retainers (521).

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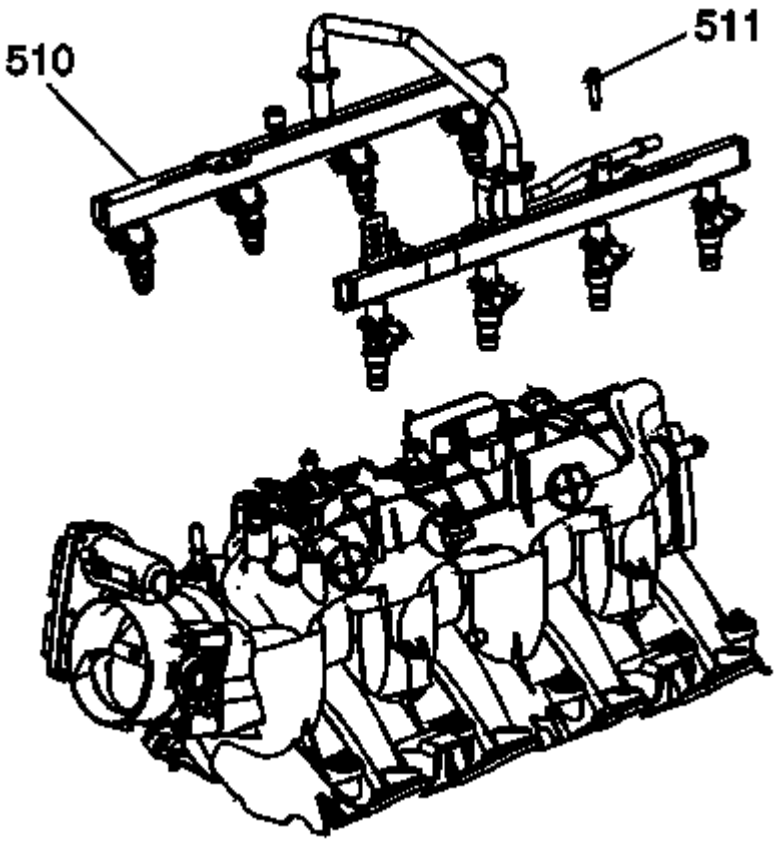

Fig. 679: Fuel Rail
Courtesy of GENERAL MOTORS CORP.

4. Install the fuel rail assembly (510) to the manifold. Push firmly on both sides of the rail until all the injectors have entered their bores.
5. Apply a 5 mm (0.2 in) band of threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the fuel rail bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

CAUTION: Refer to Fastener Caution .

6. Install the fuel rail bolts (511) and tighten to 10 N.m (89 lb in).

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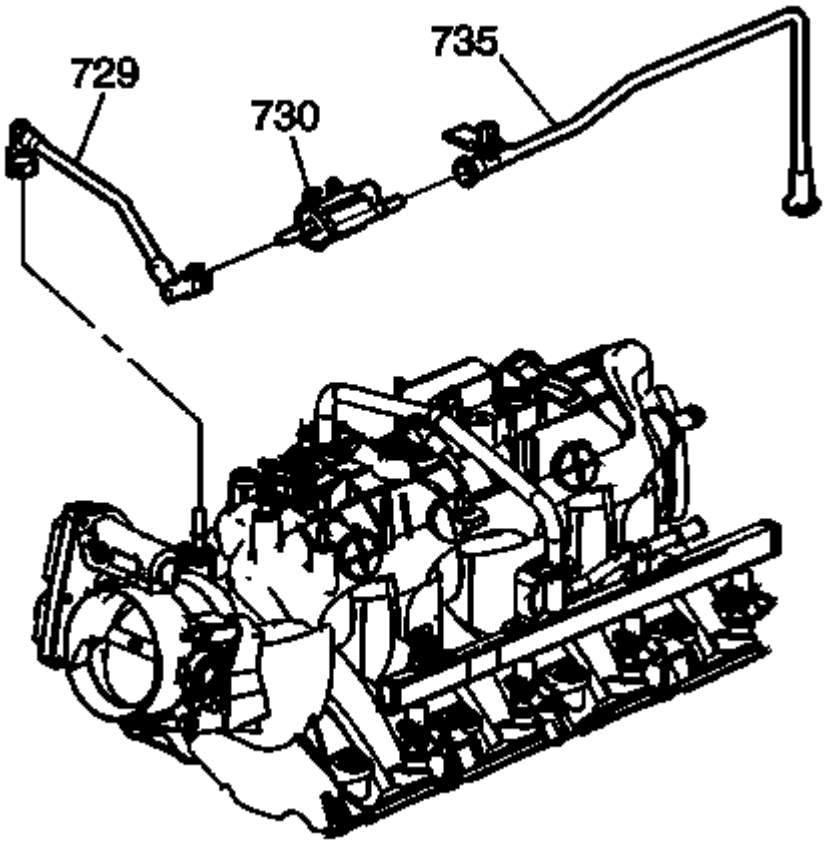

Fig. 680: EVAP Purge Valve & Tubes
Courtesy of GENERAL MOTORS CORP.

7. Install the evaporative emission (EVAP) canister purge solenoid valve (730) and tubes (729, 735).

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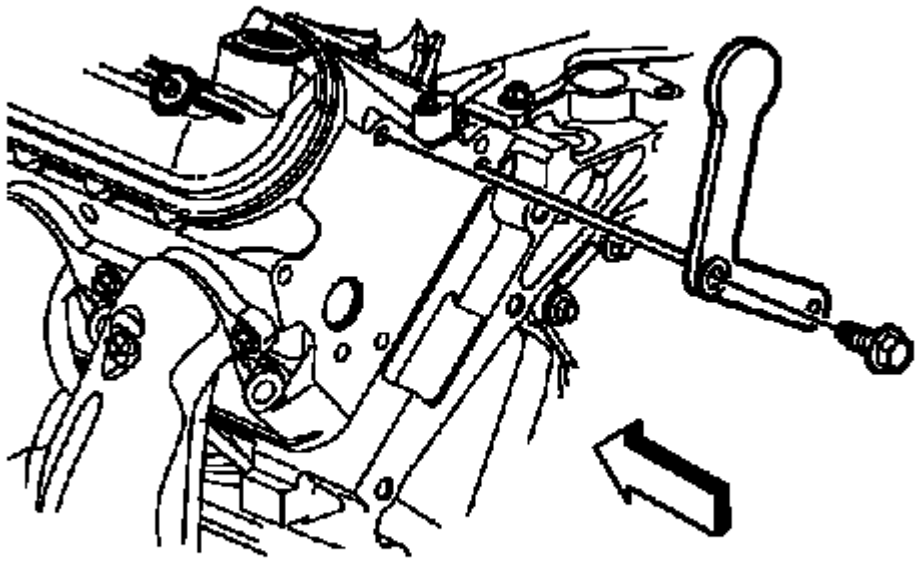

Fig. 681: View Of Fuel Rail Stop Bracket & Bolt
Courtesy of GENERAL MOTORS CORP.

8. Install the fuel rail stop bracket and bolt and tighten to 50 N.m (37 lb ft).

THROTTLE BODY ASSEMBLY INSTALLATION

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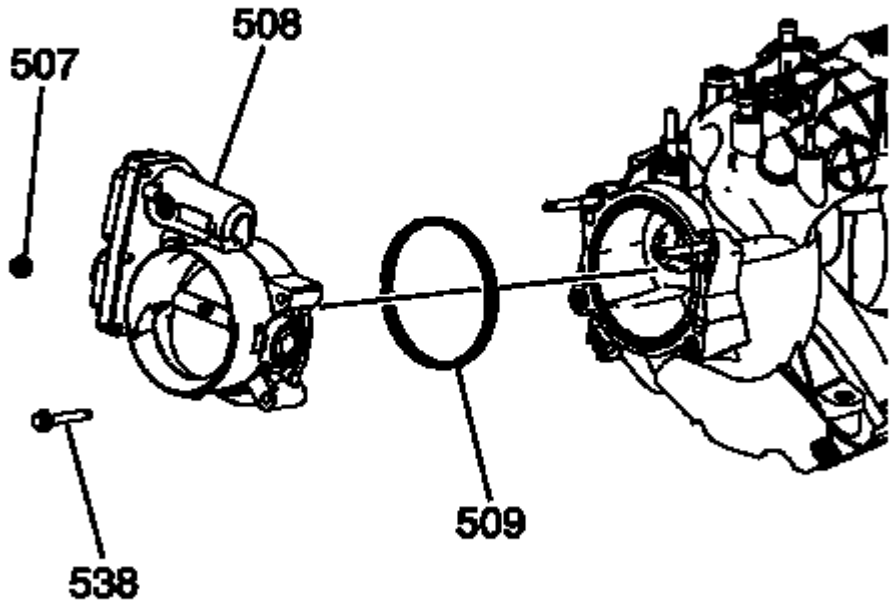

Fig. 682: Throttle Body Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the throttle body studs, as required. Tighten the throttle body studs to 6 N.m (53 lb in).

NOTE: DO NOT use the throttle body gasket again. Install a NEW gasket during assembly.

2. Install the throttle body gasket (509) to the intake manifold. Align the locating tab of the gasket with the notch in the manifold.
3. Install the throttle body (508), bolts (538), and nuts (507). Tighten the throttle body nuts and bolts to 10 N.m (89 lb in).

WATER PUMP INSTALLATION

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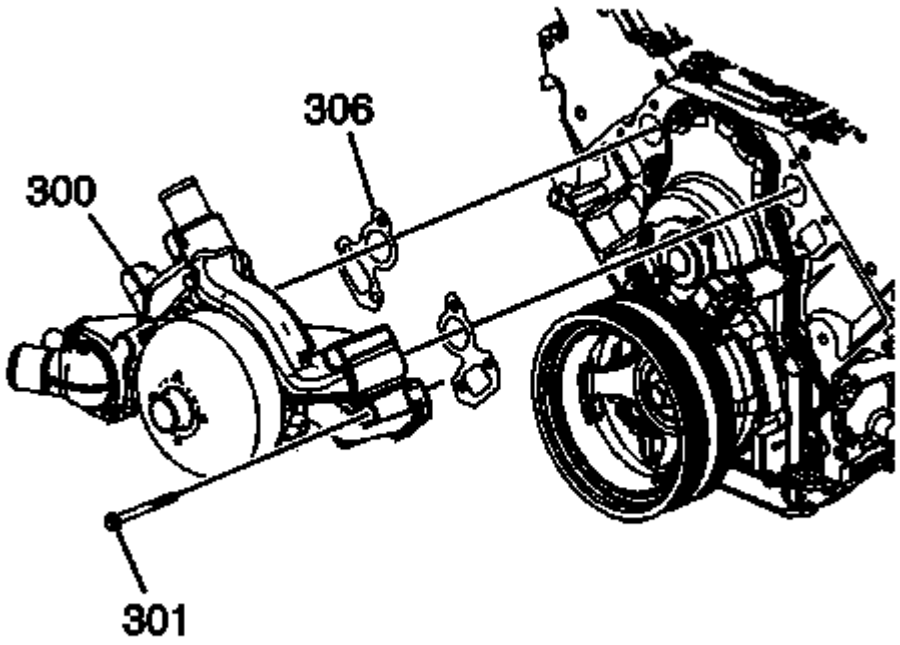

Fig. 683: View Of Water Pump, Bolts & Gaskets
Courtesy of GENERAL MOTORS CORP.

CAUTION: DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.

NOTE: All gasket surfaces are to be free of oil or other foreign material during assembly.

1. Install the water pump (300) and NEW gaskets (306).

CAUTION: Refer to Fastener Caution .

2. Install the water pump bolts (301).
   - Tighten the water pump bolts a first pass to 15 N.m (11 lb ft) .

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- Tighten the water pump bolts a final pass to 30 N.m (22 lb ft) .

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

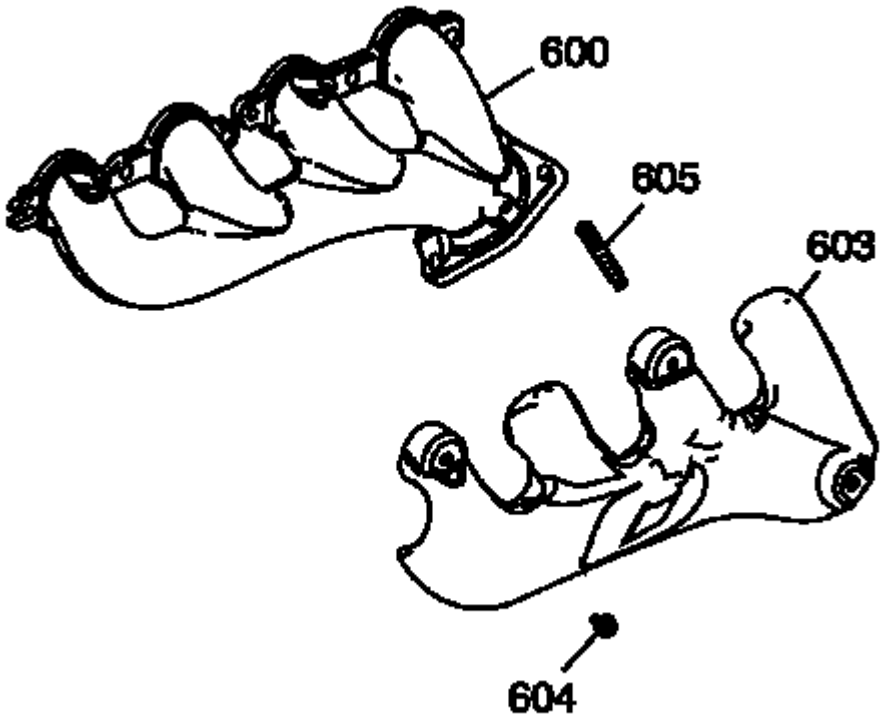

Fig. 684: Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.**
- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first 3 threads of the bolt.**

1. Install the heat shield (603) and bolts (604) and tighten to 9 N.m (80 lb in).

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2. Install the exhaust pipe studs (605) and tighten to 20 N.m (15 lb ft).

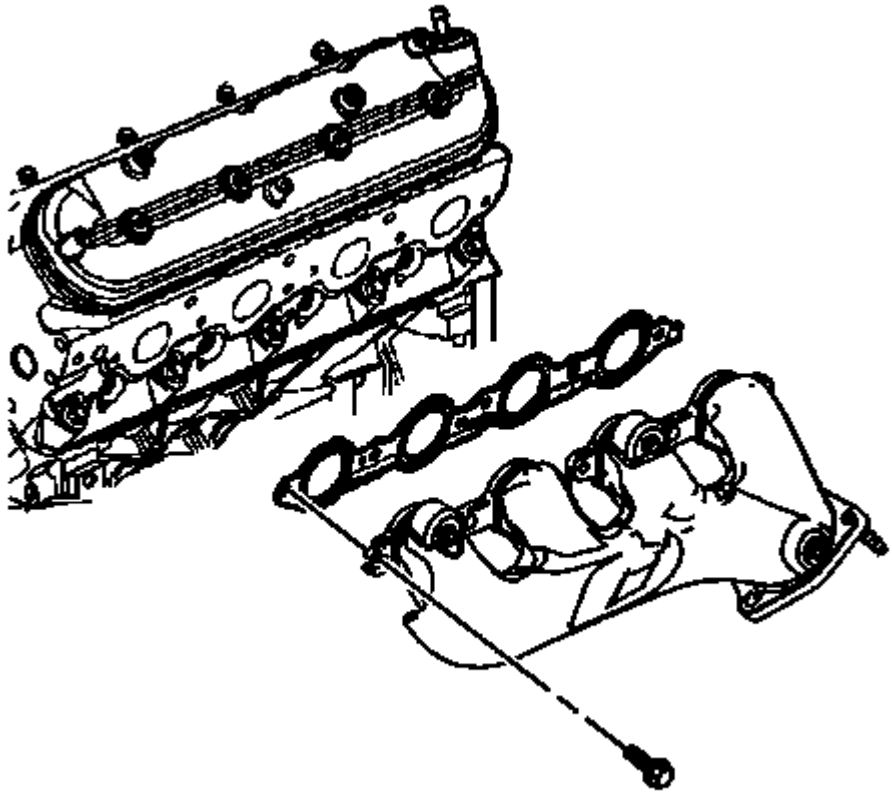

Fig. 685: Exhaust Manifold Removal - Left Side
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
4. Install the exhaust manifold, NEW gasket, and bolts.
    1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
    2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

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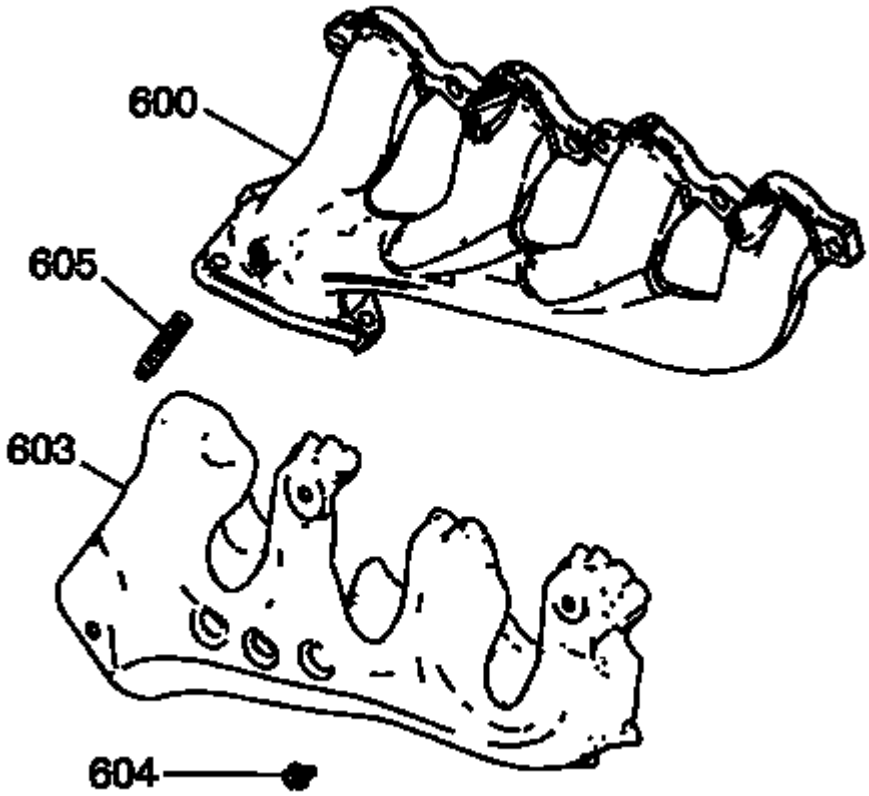

Fig. 686: Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- **Tighten the exhaust manifold bolts as specified in the service procedure. Improperly installed and/or leaking exhaust manifold gaskets may affect vehicle emissions and/or on-board diagnostic (OBD) II system performance.**
- **The cylinder head exhaust manifold bolt hole threads must be clean and free of debris or threadlocking material.**
- **Do not apply sealant to the first 3 threads of the bolt.**

1. Install the heat shield (603) and bolts (604). Tighten the heat shield bolts to 9 N.m (80 lb in).
2. Install the exhaust pipe studs (605) and tighten to 20 N.m (15 lb ft).

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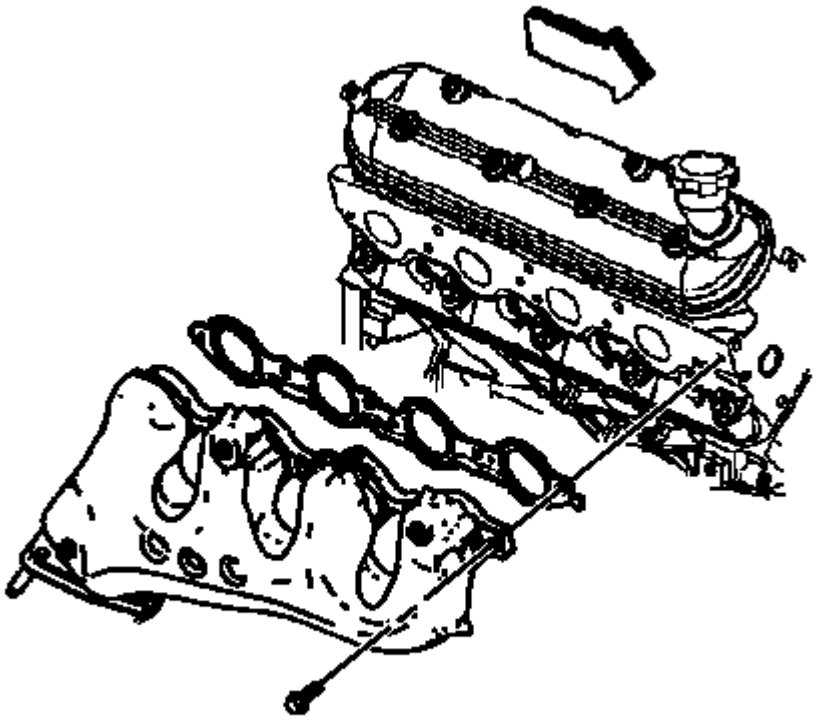

Fig. 687: Exhaust Manifold
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) wide band of threadlock GM P/N 12345493 (Canadian P/N 10953488), or equivalent, to the threads of the exhaust manifold bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
4. Install the exhaust manifold, NEW gasket and bolts.
    1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
    2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
5. Using a flat punch, bend over the exposed edge of the exhaust manifold gasket at the rear of the left cylinder head.

OIL LEVEL INDICATOR AND TUBE INSTALLATION

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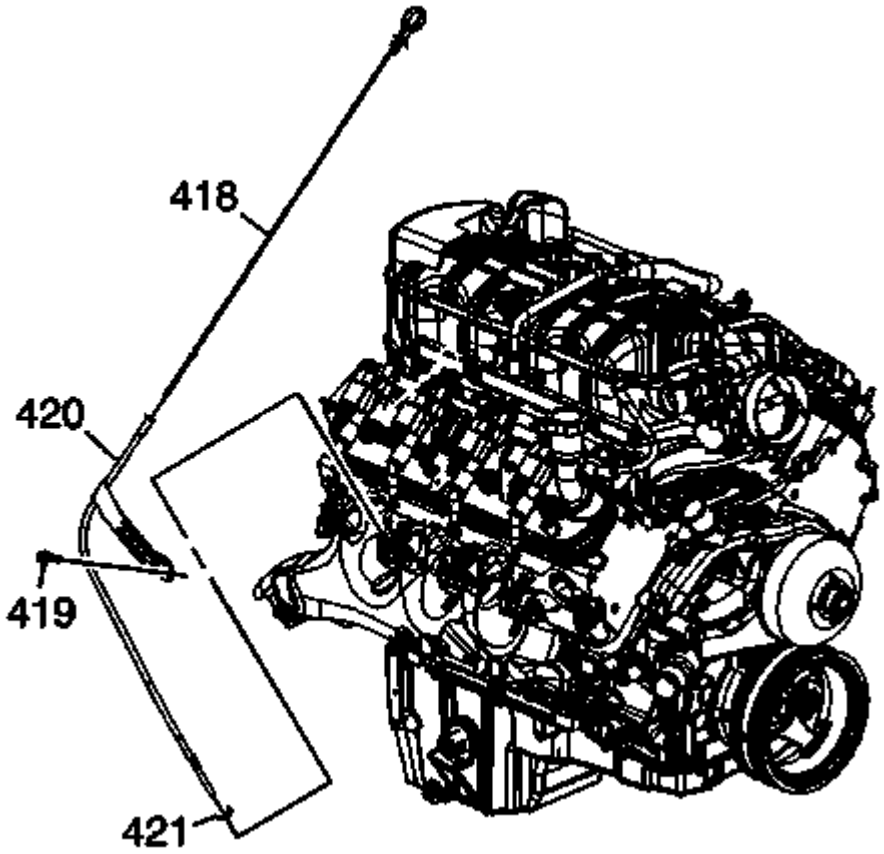

Fig. 688: View Of Oil Level Indicator, Tube Bolt, Indicator Tube & O-Ring Seal
Courtesy of GENERAL MOTORS CORP.

1. Inspect the O-ring seal (421) for cuts or damage. If the oil level indicator tube O-ring seal is not cut or damaged, it may be used again.
2. Lubricate the O-ring seal with clean engine oil.
3. Install the O-ring seal onto the oil level indicator tube (420).
4. Install the oil level indicator tube into the engine block and rotate into proper position.

CAUTION: Refer to Fastener Caution .

5. Install the tube bolt (419) and tighten to 25 N.m (18 lb ft).
6. Install the oil level indicator (418) into the tube.

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

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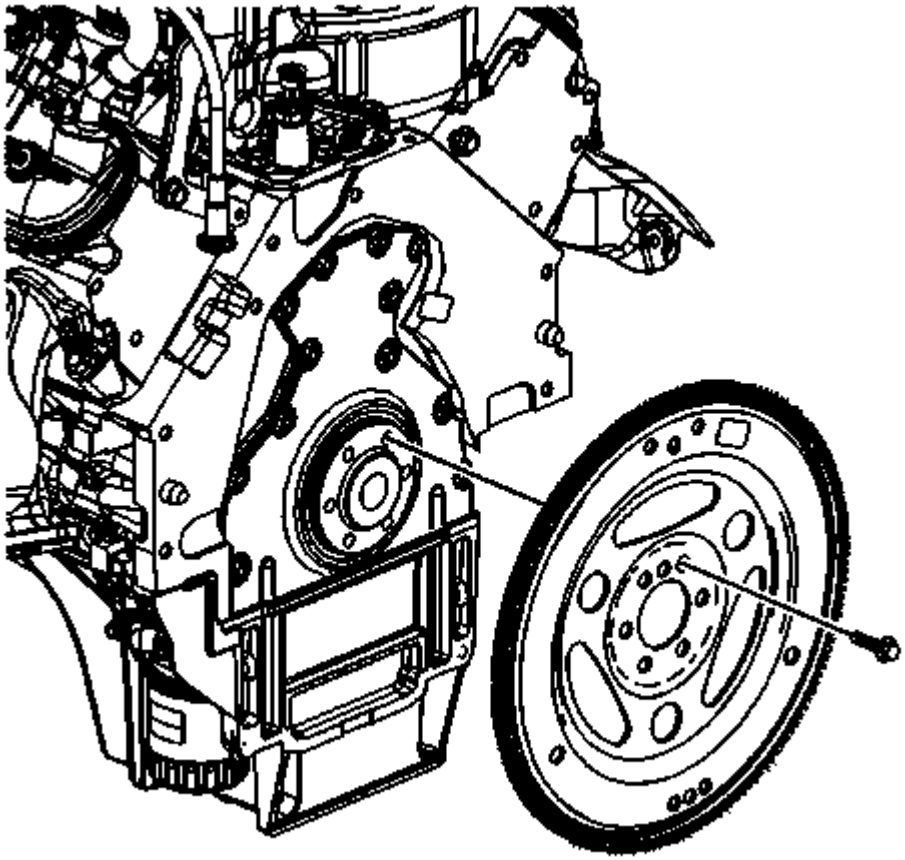

Fig. 689: View Of Flex Plate & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Install the flex plate to the crankshaft.
2. Apply threadlock GM P/N 12345382 (Canadian P/N 10953489), or equivalent, to the threads of the flex plate bolts.

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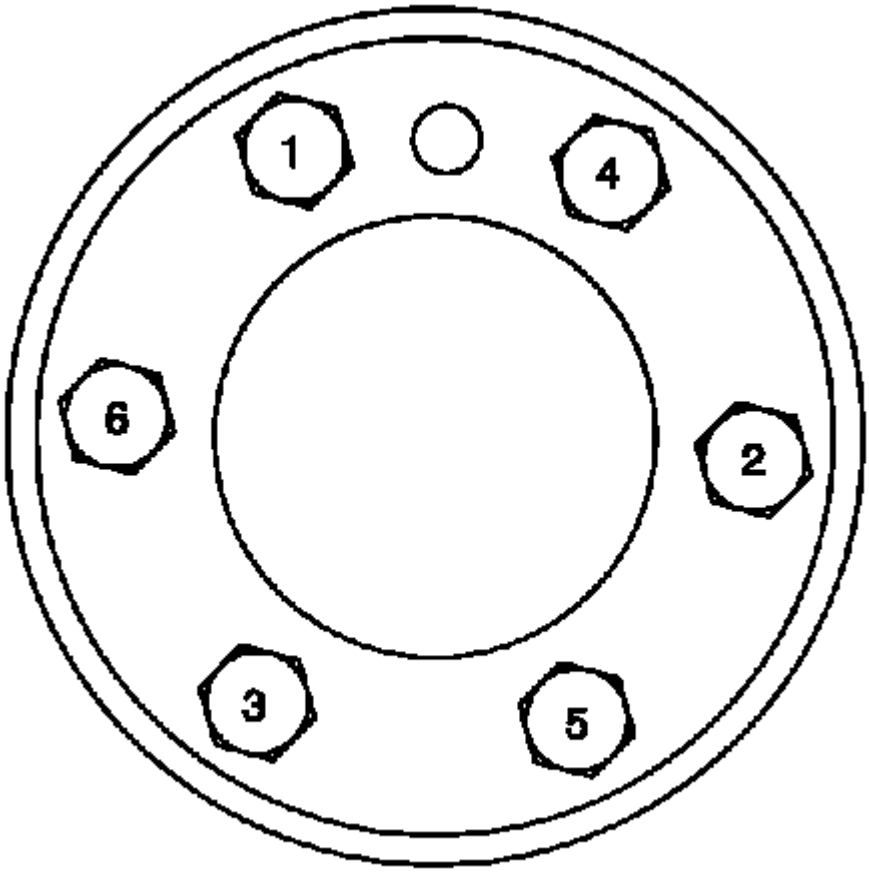

Fig. 690: Identifying Flywheel Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the engine flex plate bolts.
    1. Tighten the engine flex plate bolts (1-6) a first pass in sequence to 20 N.m (15 lb ft) .
    2. Tighten the engine flex plate bolts (1-6) a second pass in sequence to 50 N.m (37 lb ft) .
    3. Tighten the engine flex plate bolts (1-6) a final pass in sequence to 100 N.m (74 lb ft) .

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **J 41478:** Crankshaft Front Oil Seal Installer
- **J 41665:** Crankshaft Balancer and Sprocket Installer
- **J 42386-A:** Flywheel Holding Tool

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- **J 45059:** Angle Meter

For equivalent regional tools, refer to **Special Tools**

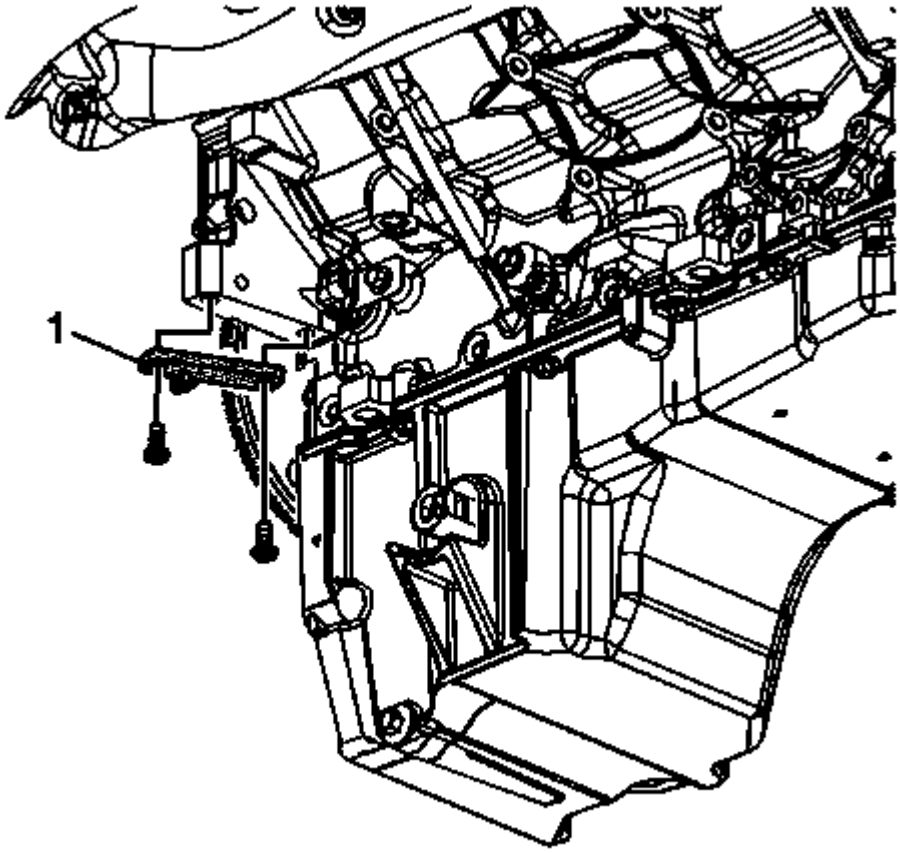

Fig. 691: View Of Special Tool & Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE:

- **Ensure the teeth of the tool engage the engine flywheel teeth.**
- **The used crankshaft balancer bolt is used only during the installation procedure. Install a NEW crankshaft balancer bolt during final assembly.**

1. Install the **J 42386-A:** tool (1) and bolts.

   Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten the **J 42386-A:** tool bolts to 50 N.m (37 lb ft).

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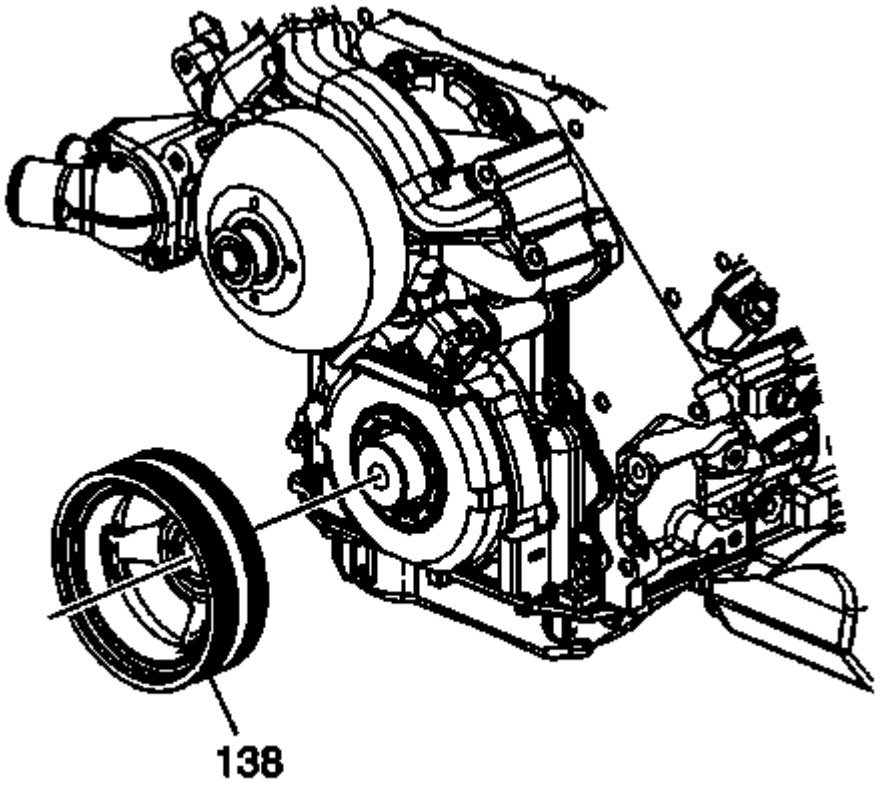

Fig. 692: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.

2. Position the balancer (138) onto the end of the crankshaft.

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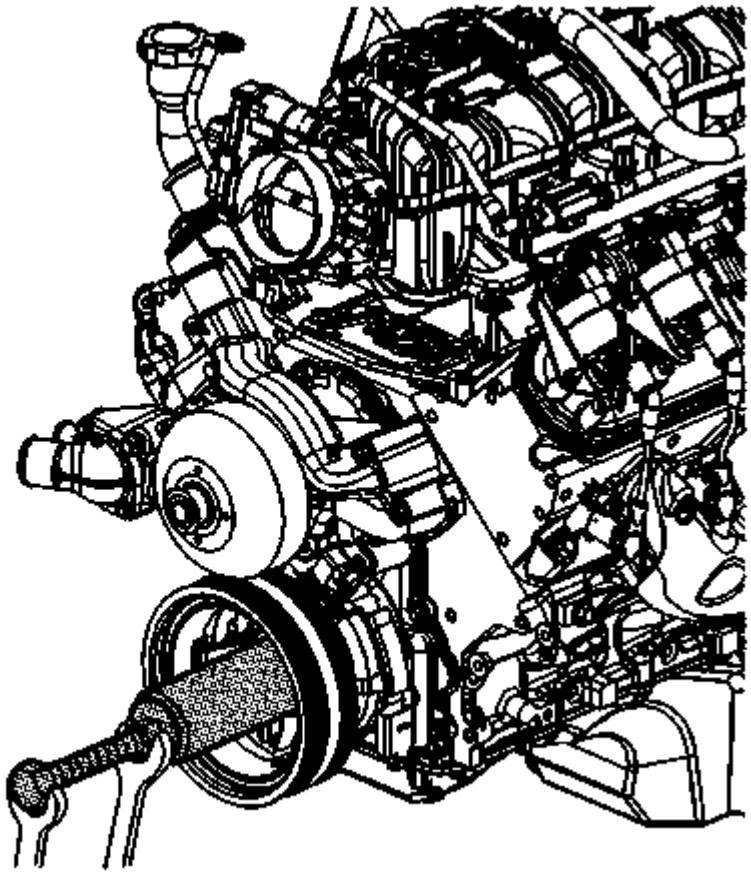

Fig. 693: View Of Balancer Installation Special Tools
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 41665:** installer and the **J 41478:** installer in order to install the balancer.
    1. Assemble the **J 41478:** installer threaded rod, nut, washer and the **J 41665:** installer .

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

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

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

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

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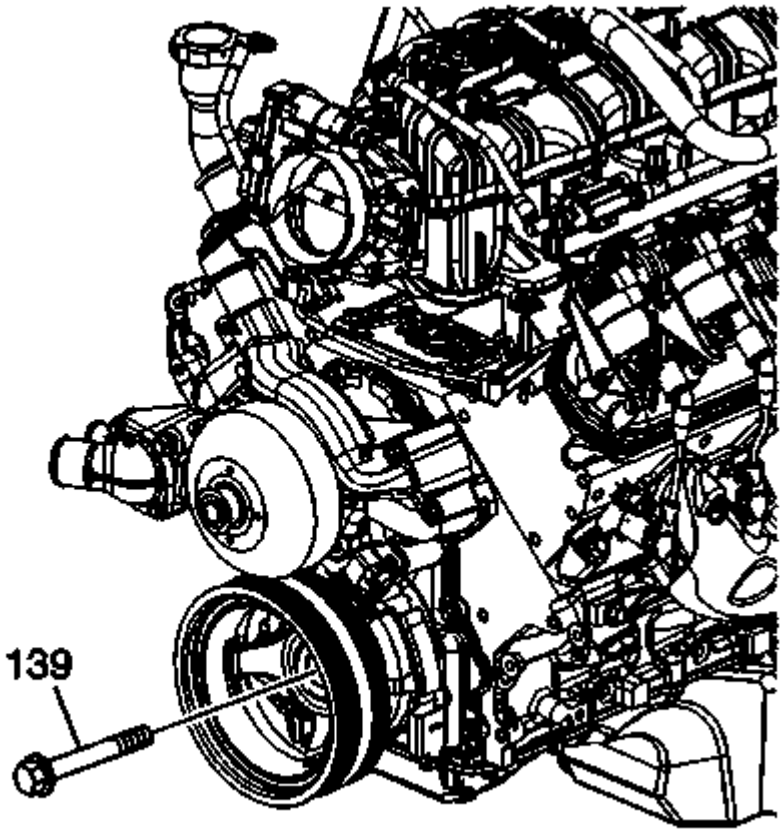

Fig. 694: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

4. Install the used crankshaft balancer bolt (139) and tighten to 330 N.m (240 lb ft) to fully seat the balancer.
5. Remove the used crankshaft balancer bolt.

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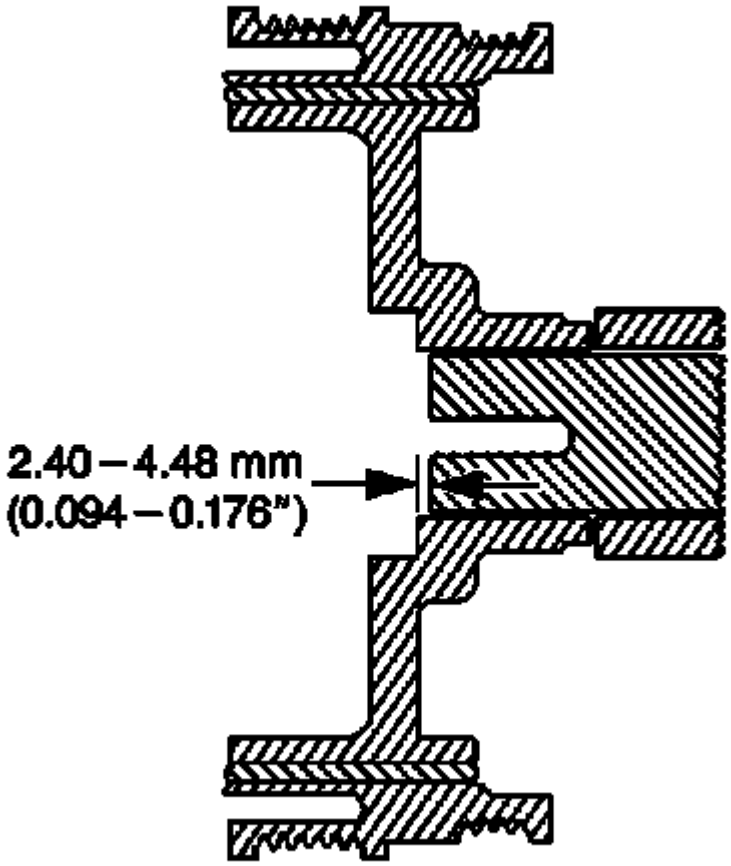

Fig. 695: Identifying Hub To Crankshaft Distance
Courtesy of GENERAL MOTORS CORP.

NOTE: The nose of the crankshaft should be recessed 2.40-4.48 mm (0.094-0.176 in) into the balancer bore.

6. Measure for a correctly installed balancer. If the balancer is not installed to the proper dimensions, install the **J 41665:** installer and repeat the installation procedure.

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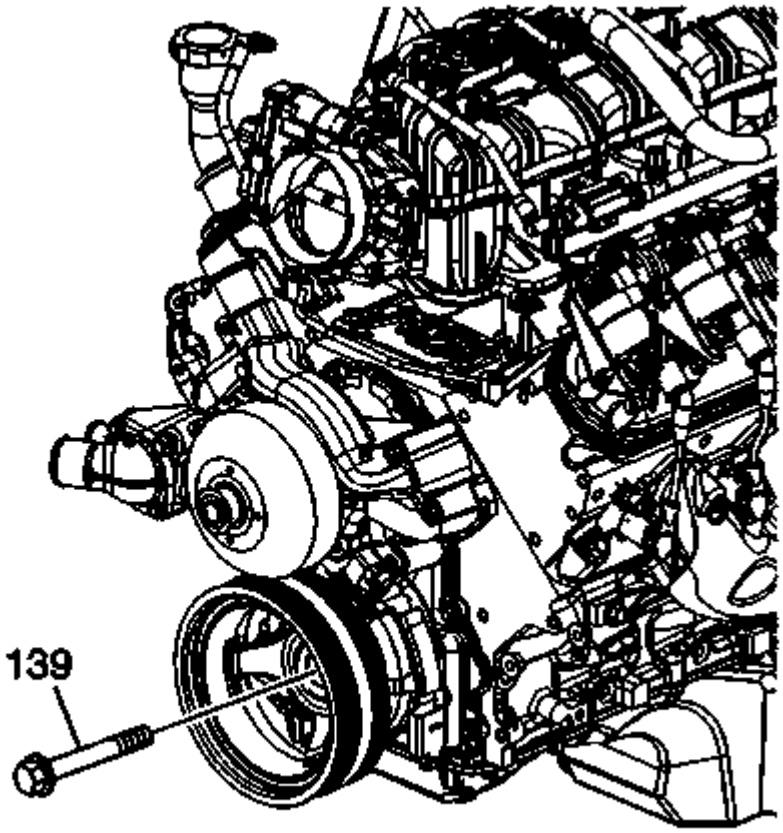

Fig. 696: View Of Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS CORP.

7. Install the NEW crankshaft balancer bolt (139):
    1. Tighten the crankshaft balancer bolt to 150 N.m (110 lb ft) .
    2. Loosen the crankshaft balancer bolt 360 degrees.
    3. Tighten the crankshaft balancer bolt to 80 N.m (59 lb ft) .
    4. Tighten the crankshaft balancer bolt a final pass to 125 degrees using the **J 45059:** meter .
8. Remove the **J 42386-A:** tool.

ENGINE PRELUBING

Special Tools

J 45299: Engine Preluber

For equivalent regional tools, refer to **Special Tools**

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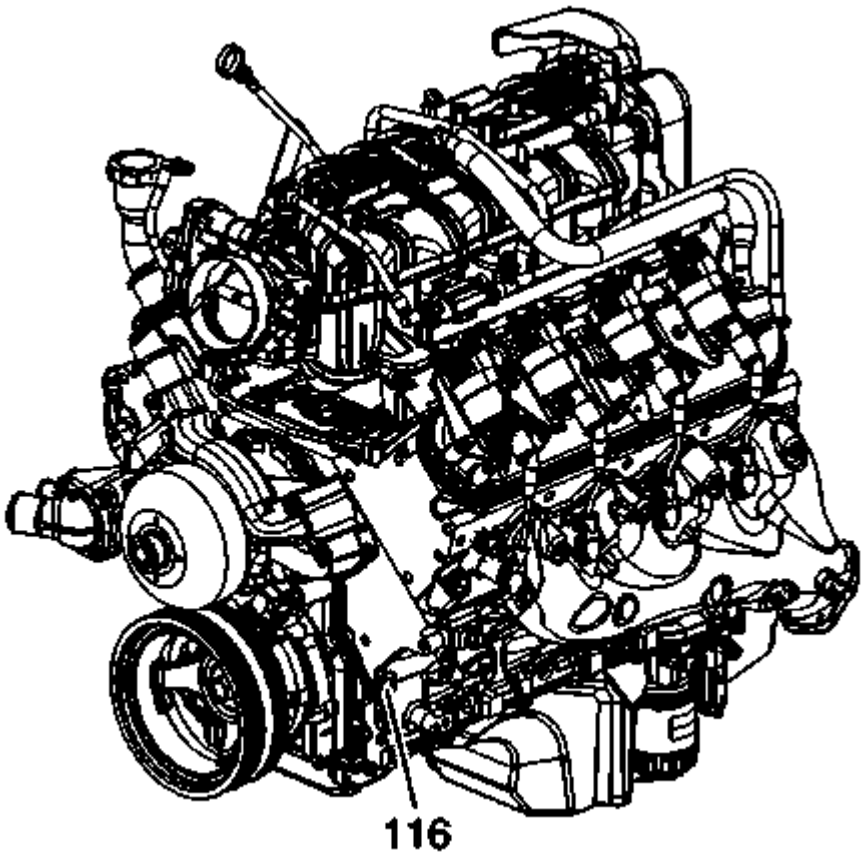

Fig. 697: View Of Engine Block Left Front Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

NOTE: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter and fill with clean engine oil.

CAUTION: Refer to Fastener Caution .

2. Install the oil filter and tighten to 30 N.m (22 lb ft).
3. Locate the engine block left front oil gallery plug (116).
4. Install the M16 x 1.5 adapter P/N 509375.

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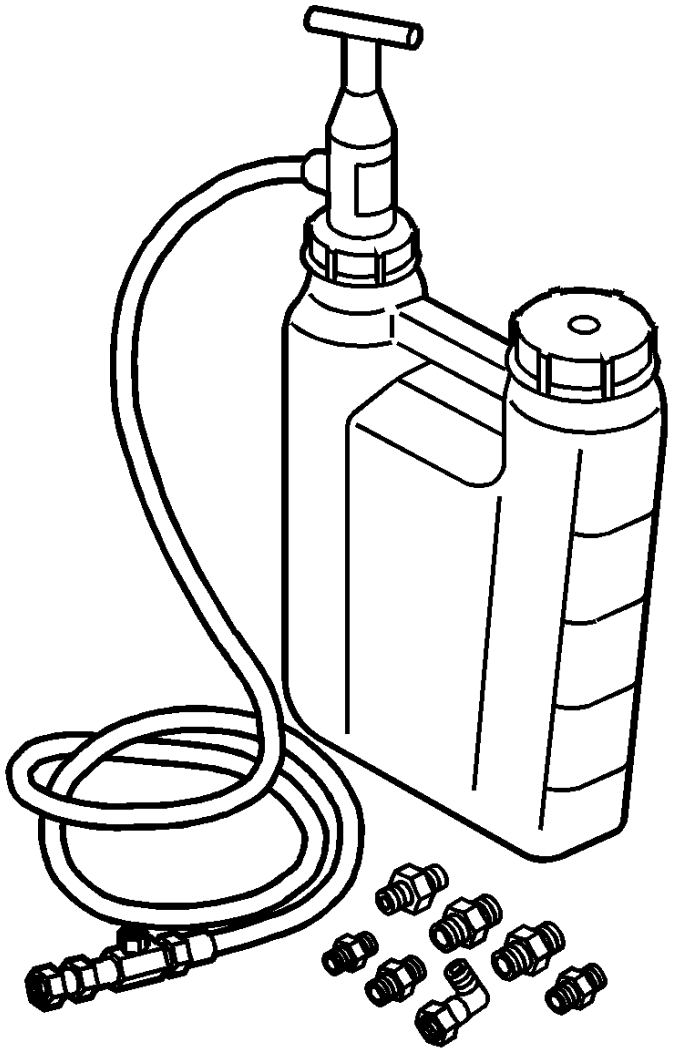

Fig. 698: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the **J 45299:** preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine and tighten to 60 N.m (44 lb ft).
9. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

A closed crankcase ventilation system provides a more complete scavenging of crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a

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crankcase ventilation pipe/passage into the intake manifold.

Results of Incorrect Operation

A plugged positive crankcase ventilation (PCV) pipe/passage way may cause any of the following conditions:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in engine

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
    - The power steering pump
    - The generator
    - The A/C compressor
    - The engine cooling fan
    - The water pump, if belt driven

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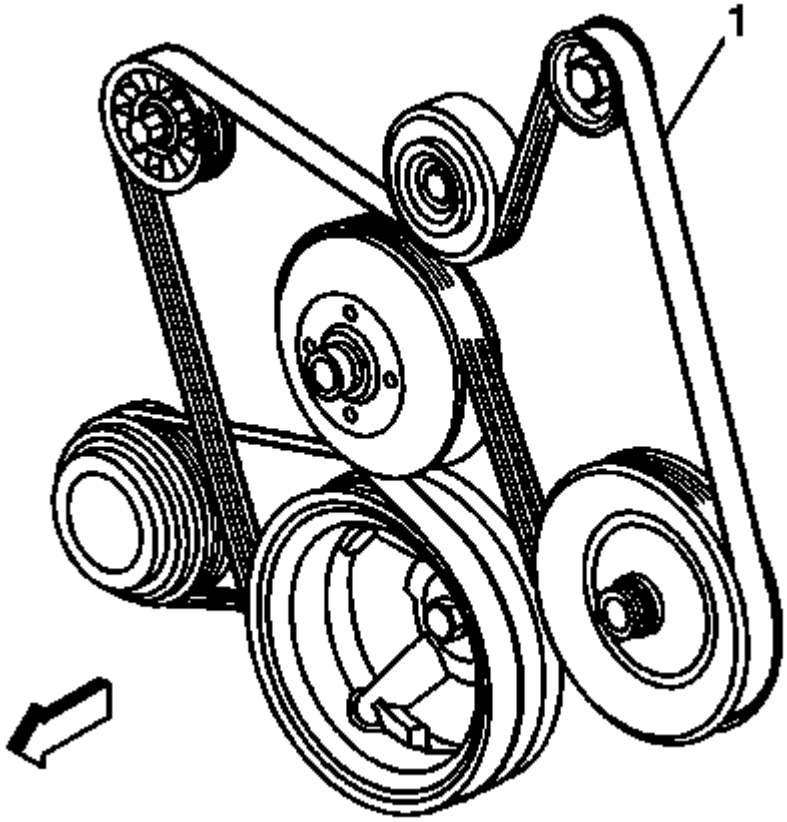

Fig. 699: Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

The drive belt system may use 2 belts. The drive belt (1) is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers - chloroprene or EPDM - and have different layers or plies containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system has an idler pulley, which is used to add wrap to the adjacent pulleys.

A/C Compressor Drive Belt

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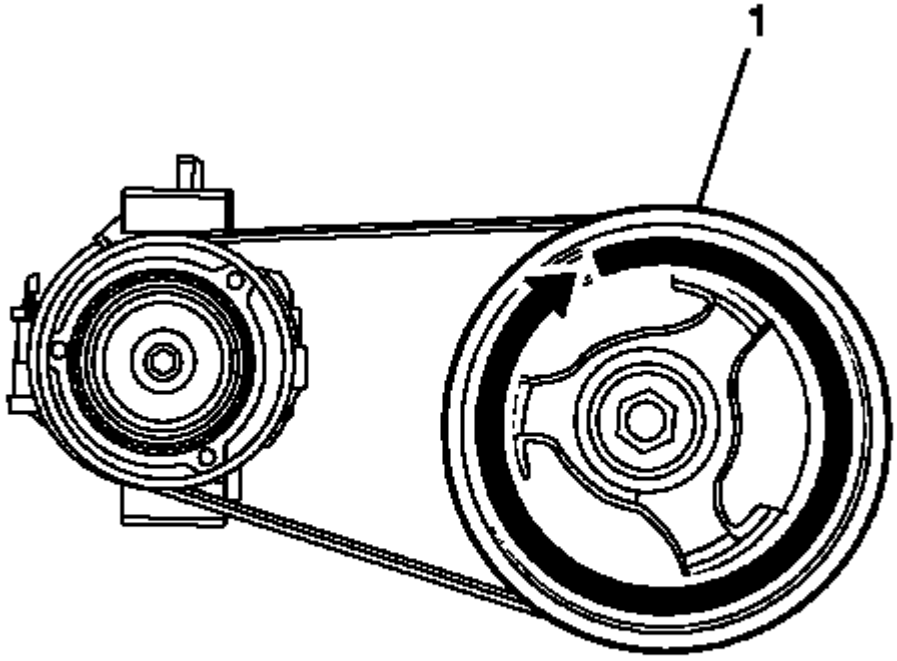

Fig. 700: A/C Compressor Drive Belt
Courtesy of GENERAL MOTORS CORP.

The outward appearance of the belt (1) is similar to the current design serpentine belt. The reinforcing cord provides its unique qualities. The belt cord is made of a polyamid material. The polyamid cord is more elastic than the more traditional aramid or polyester cord designs. A tensioner is not needed.

Polyamid cord, when combined with a more elastic backing compound, ensures the belt is able to maintain the specified tension within the specified range of usage.

ENGINE COMPONENT DESCRIPTION

5.3 Liter Engine

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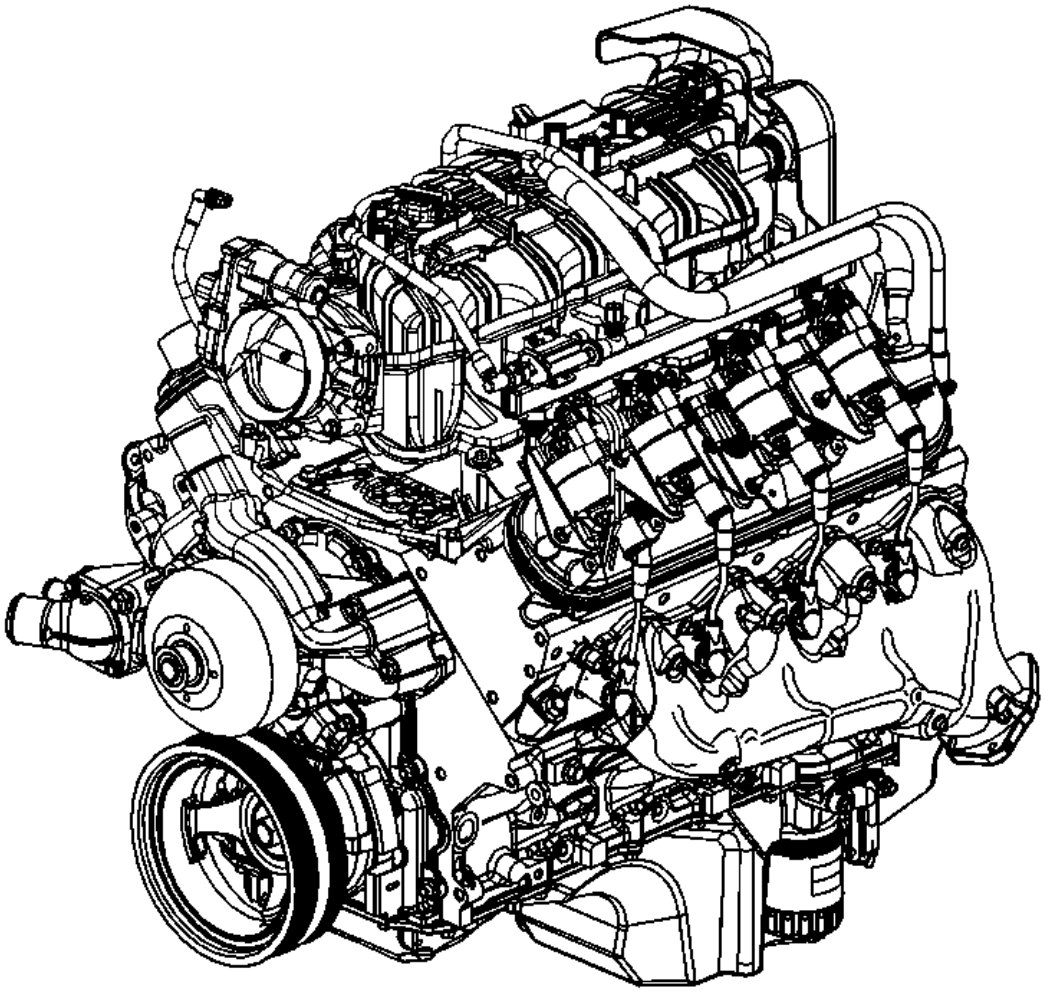

Fig. 701: The 4.8, 5.3, 6.0, and 6.2 Liter V8 Engines
Courtesy of GENERAL MOTORS CORP.

Camshaft and Drive System

A billet steel 1 piece camshaft is supported by 5 bearings pressed into the engine block. The camshaft position (CMP) actuator is mounted to the front of the camshaft and retained by the CMP solenoid valve. The CMP actuator is driven by the crankshaft sprocket through the camshaft timing chain. The CMP sensor wheel is incorporated into the front face of the CMP actuator with the CMP sensor and CMP actuator magnet mounted in the engine front cover. A timing chain tensioner is mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location. Refer to **Camshaft Position Actuator and Solenoid Valve Description**.

Crankshaft

The crankshaft is cast nodular iron. The crankshaft is supported by 5 crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A

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crankshaft position (CKP) reluctor ring is press fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.

Cylinder Heads

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. Passages for the engine coolant air bleed system are at the front of each cylinder head. The valve rocker arm covers are retained to the cylinder head by 4 center mounted rocker arm cover bolts. All RPO's use high-flow cylinder heads with an offset intake valve rocker arm design.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V configuration with 5 crankshaft bearing caps. The engine block is cast iron. The 5 crankshaft bearing caps each have 4 vertical M10 and 2 horizontal M8 mounting bolts. The camshaft is supported by 5 camshaft bearings pressed into the block.

Exhaust Manifolds

The exhaust manifolds are a 1 piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a 1 piece composite design that incorporates brass threaded inserts for mounting the fuel rail, throttle body, and wire harness studs. Each side of the intake manifold is sealed to the cylinder head by a non-reusable silicone sealing gasket/nylon carrier assembly. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a 1 piece push in place silicone gasket. The fuel rail assembly, with 8 separate fuel injectors, is retained to the intake by 4 bolts. The injectors are seated into their individual manifold bores with O-ring seals to provide sealing. A fuel rail stop bracket is retained to the rear of the left cylinder head by a mounting bolt. The manifold absolute pressure (MAP) sensor is installed and retained to the top front of the intake manifold and sealed by an O-ring seal. The evaporative emission (EVAP) canister purge solenoid valve is mounted to the fuel rail at the left front of the intake manifold. There are no coolant passages within the intake manifold.

Oil Pan

The structural rear-sump oil pan is cast aluminum. Incorporated into the design is the oil filter mounting boss, drain plug opening, and baffle. The oil filter bypass valve is now incorporated into the new design oil filter assembly and is no longer part of the oil pan assembly as in earlier design applications. The active fuel management oil pressure relief valve is also internal to the oil pan. Alignment of the structural oil pan to the rear of the engine block and transmission housing is critical.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a flat or recessed top and barrel shaped skirt. The piston pins are chromium steel and are a full-floating design. The connecting rods are powdered metal. The connecting rods are

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fractured at the connecting rod journal and then machined for the proper clearance. All applications use a piston with a graphite coated skirt. The piston and pin are to be serviced as an assembly.

Valve Rocker Arm Cover Assemblies

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the coil and bracket assemblies. Incorporated into the left cover is the positive crankcase ventilation (PCV) system dirty air passage. Incorporated into the right cover is the oil fill tube and the PCV fresh air passage.

Valve Train

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve lifter guides position and retain the valve lifters. The valve rocker arms for each bank of cylinders are mounted on pedestals or pivot supports. Each rocker arm is retained on the pivot support and cylinder head by a bolt. Valve lash is net build.

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DESCRIPTION

Camshaft

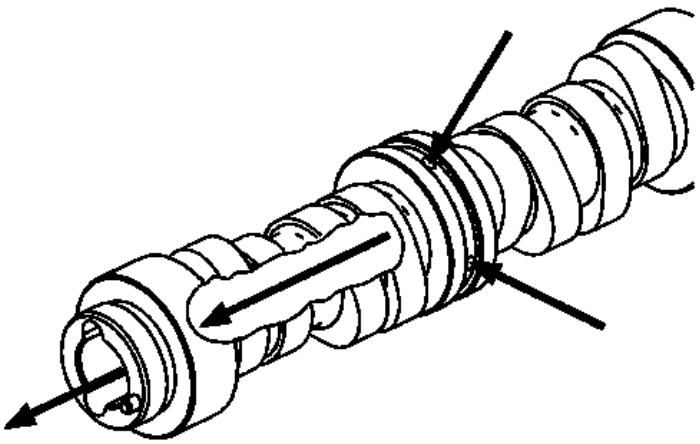

Fig. 702: Camshaft Lubrication Path
Courtesy of GENERAL MOTORS CORP.

The camshaft is designed to provide a lubrication path for pressurized engine oil to flow to the camshaft position (CMP) actuator. Pressurized engine oil enters the camshaft at bearing journal location number 2. Oil travels through the camshaft, out the front, and into the CMP actuator solenoid valve.

CMP Actuator Solenoid Valve

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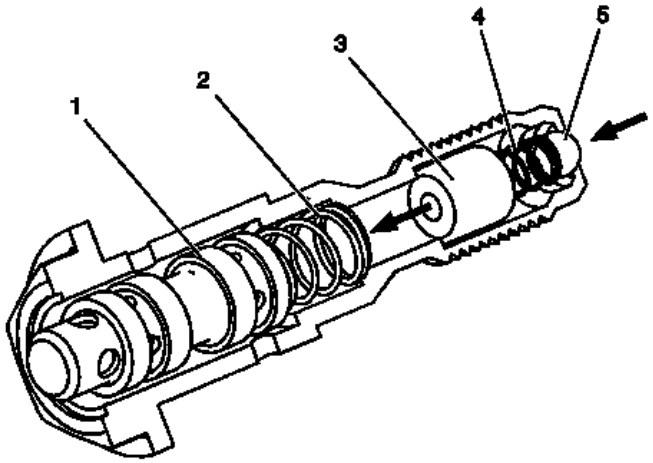

Fig. 703: CMP Actuator Solenoid Valve Components
Courtesy of GENERAL MOTORS CORP.

The CMP actuator solenoid valve consists of a housing, spool valve (1), spool return spring (2), oil filter (3), inlet check ball return spring (4), and inlet check ball (5). Pressurized engine oil enters the valve and travels through the filter to the spool. Spool position is controlled by the CMP magnet and engine control module (ECM). When the spool is moved to the proper position, oil flow is directed through the valve and into the CMP actuator assembly. The CMP solenoid valve is a torque-to-yield design and should be replaced each time it is removed.

CMP Actuator Magnet

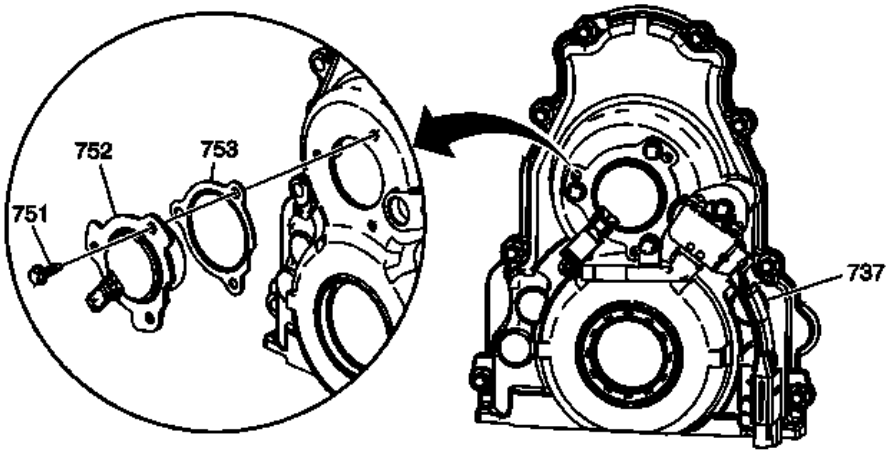

Fig. 704: View Of CMP Actuator Magnet & Components
Courtesy of GENERAL MOTORS CORP.

The CMP actuator magnet (752) is located in the engine front cover and is sealed by a gasket (753). The CMP actuator magnet is controlled by a 12-volt 150 Hz pulse width 0-100 percent duty cycle signal from the ECM. When energized, the solenoid uses electromagnetic force on the magnet pintle to position the spool valve of the CMP solenoid valve.

CMP Actuator

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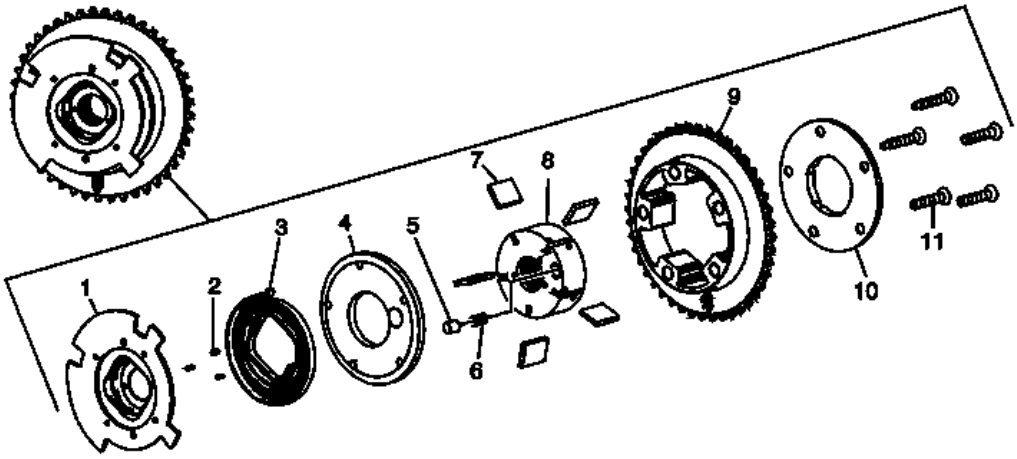

Fig. 705: View Of CMP Actuator Components
Courtesy of GENERAL MOTORS CORP.

The CMP actuator is a vane type design that hydraulically changes angle or timing of the camshaft relative to crankshaft position. The CMP actuator allows earlier or later intake and exhaust valve opening during the 4-stroke engine cycle. The CMP actuator cannot vary the duration of valve opening or valve lift. The CMP actuator is to be serviced as an assembly.

The CMP actuator consists of the CMP reluctor wheel (1), wheel retaining pins (2), return spring (3), front cover (4), park position pin (5), park position pin spring (6), vanes and vane springs (7), rotor (8), housing with chain sprocket (9), sealing cover/thrust plate (10), and bolts (11).

CMP System Operation

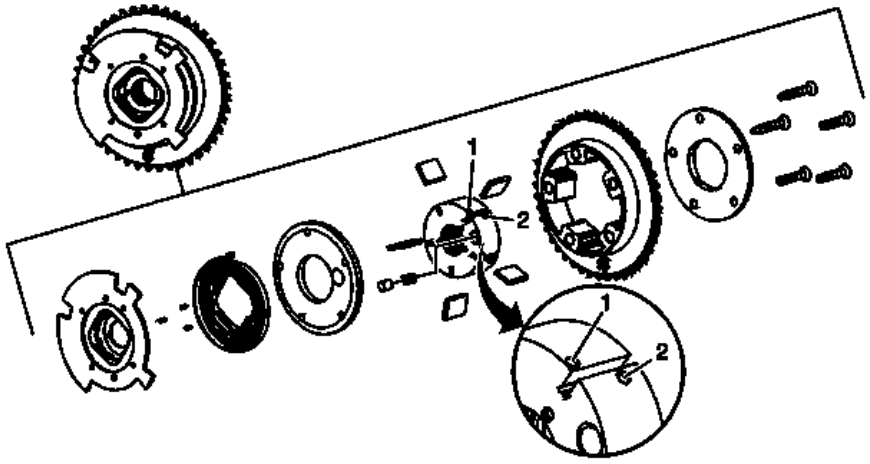

Fig. 706: CMP Actuator
Courtesy of GENERAL MOTORS CORP.

A CMP actuator dynamically changes valve timing events relative to piston timing by controlling camshaft position. This is sometimes referred to as variable valve timing or camshaft phasing. Variable valve timing or camshaft phasing does not change duration or lift.

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- By advancing camshaft timing, an improvement in low end torque can be achieved.
- By retarding camshaft timing slightly, an improvement in high end power can be achieved.
- By retarding camshaft timing significantly, an improvement in light load fuel economy can be achieved.

There are 5 cavities divided by vanes within the CMP actuator.

- When oil is directed to the advance cavities (1), the camshaft timing is advanced.
- When oil is directed to the retard cavities (2), the camshaft timing is retarded.
- When oil is directed to both cavities, the camshaft is held stationary.

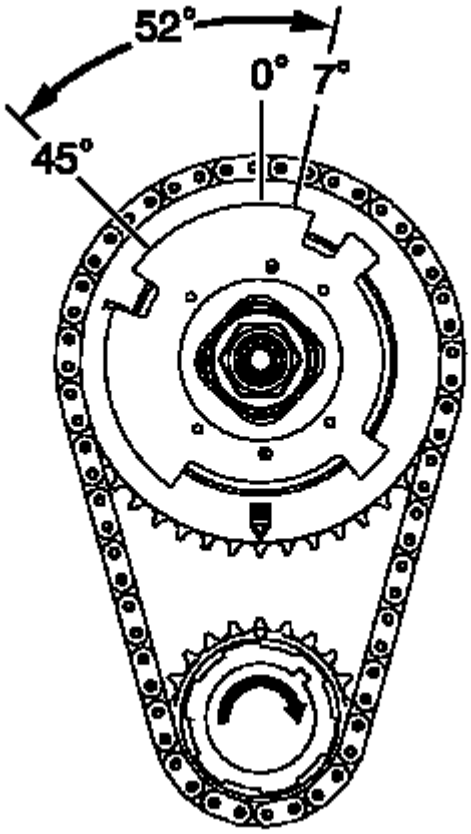

Fig. 707: Timing Camshaft - 52 Degree Range Of Authority
Courtesy of GENERAL MOTORS CORP.

The CMP actuator has a 52 degree range of authority. With the engine not running and no engine oil pressure to the CMP actuator, the high tension spring positions camshaft timing at the 7 degree advanced park position. During normal engine operation, and based on performance requirements, the ECM may adjust camshaft timing, as required, within a range from 7 degrees advanced to 45 degrees retard.

CMP System Lubrication Flow and Actuator Operation

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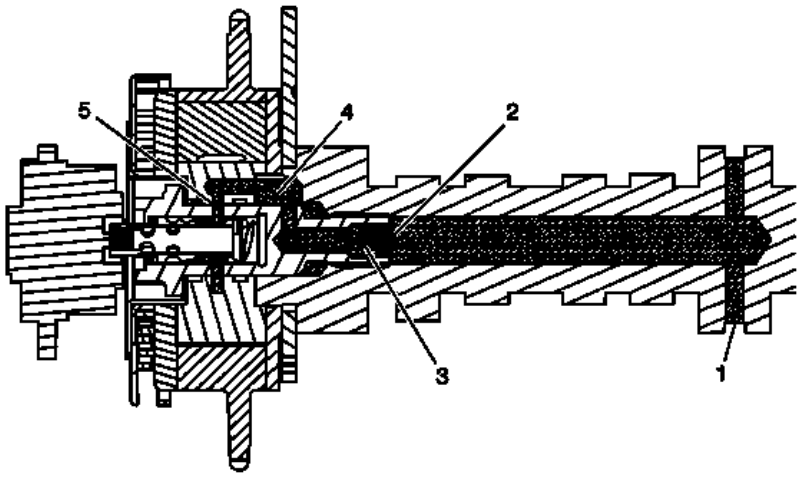

Fig. 708: Cutaway View Of Actuator
Courtesy of GENERAL MOTORS CORP.

1. Oil enters the camshaft at the second main bearing journal (1).
2. Oil travels through the camshaft into the CMP actuator valve check ball (2) and filter (3).
3. Oil exits the valve and travels through the internal passages of the camshaft (4).
4. Oil exits the camshaft and enters the actuator oil entry ports.
5. Oil travels through the actuator and is directed back into the valve (5).
6. Valve spool position directs oil to the advance or retard passages of the actuator.

The valve may also, under certain conditions, be positioned in a neutral position with no flow to either the advance or retard passages of the actuator.

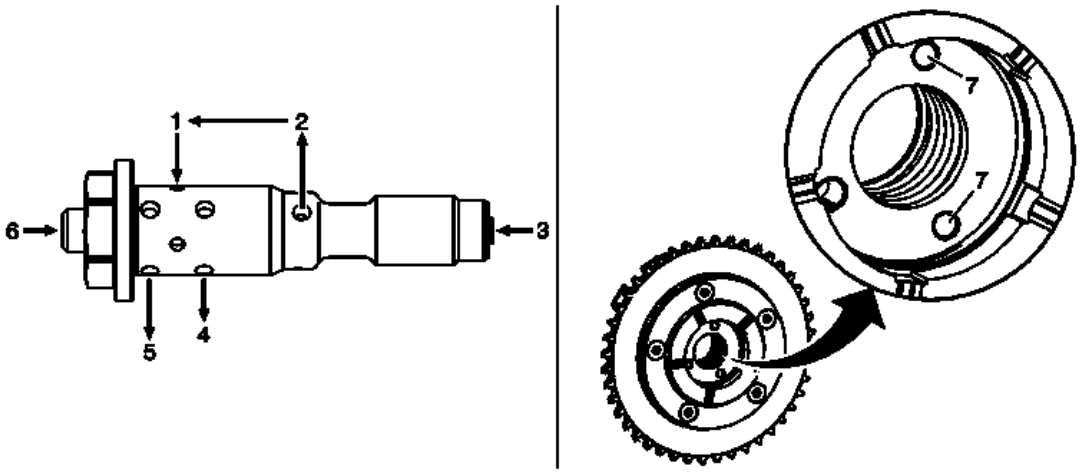

Fig. 709: Identifying Actuator Passages
Courtesy of GENERAL MOTORS CORP.

1. Oil flows from the camshaft into the valve inlet (3) through the internal check ball and filter.
2. Oil exits the valve (2) and travels within the internal passages of the camshaft into the entry ports (7) of the actuator.

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3. The center oil groove of the actuator is pressurized and oil reenters the valve (1).
4. Valve spool position directs oil out of the valve advance (5) or retard (4) ports to the actuator.

The valve may also, under certain conditions, be positioned in a neutral position with no flow to either the advance or retard passages of the actuator.

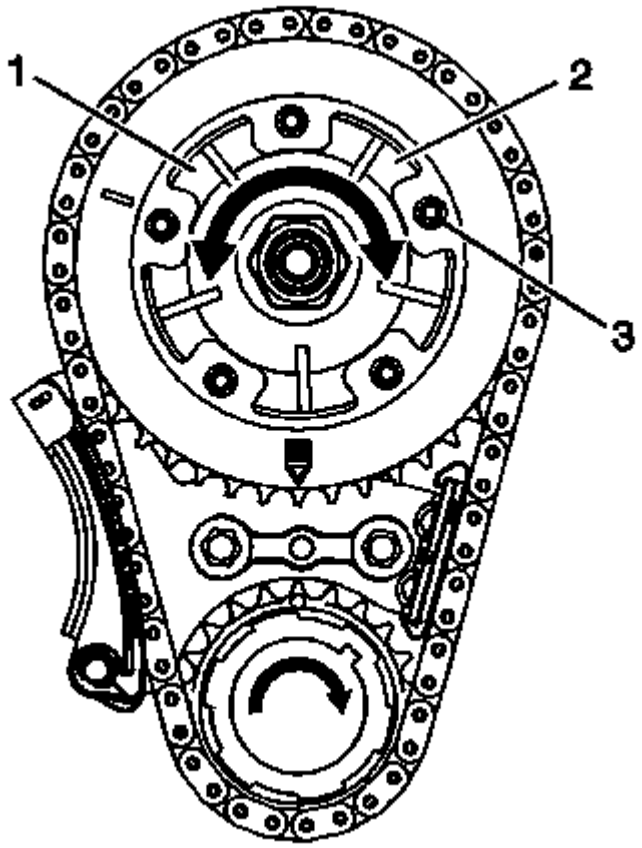

Fig. 710: View Of Advance And Retard Cavities
Courtesy of GENERAL MOTORS CORP.

1. Pressurized oil enters the retard cavities (2) of the actuator and moves the park pin (3) from the locked position.
2. As pressure increases within the retard cavities (2), the rotor and camshaft rotate counter clockwise retarding valve timing.
3. As the duty cycle decreases, the spool is repositioned and oil is sent to the advance cavities (1), rotating the rotor and camshaft clockwise, advancing valve timing.
    - With a 0 percent duty cycle signal to the magnet, the spool is positioned in the fully extended position and there is full flow to the advance cavities of the actuator. As duty cycle increases to near 50 percent, flow to the advance cavities is decreased.
    - With a 50 percent duty cycle, the spool is positioned neutral, with no flow to either the advance and retard cavities.

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- With a 51-100 percent duty cycle, the spool is positioned to provide oil flow to retard cavities. As the duty cycle increases, the flow to retard cavities increases.
- With a 100 percent duty cycle, there is full flow to the retard cavities of the actuator.
- The above duty cycle percentage values are only a guideline, as the actual duty cycle values may vary based on engine oil temperature, solenoid magnet coil temperature, magnet coil resistance, and other specifics.

CMP Actuator Park Position Verification

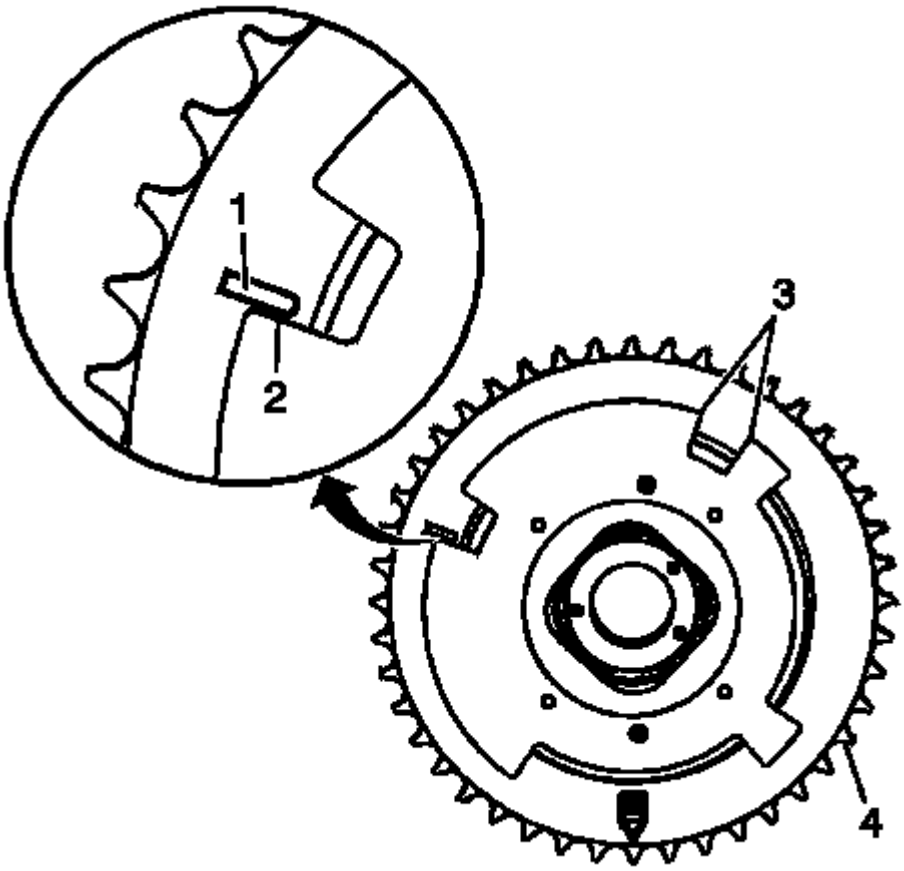

Fig. 711: CMP Actuator Park Position Verification
Courtesy of GENERAL MOTORS CORP.

The CMP actuator can be visually inspected to determine if the tension spring has returned the reluctor wheel and rotor to the park position.

With the reluctor wheel returned to the proper parked position, the edge of the notched area of the wheel (2) aligns with the marking (1) on the camshaft sprocket.

CMP Actuator Handling Safety

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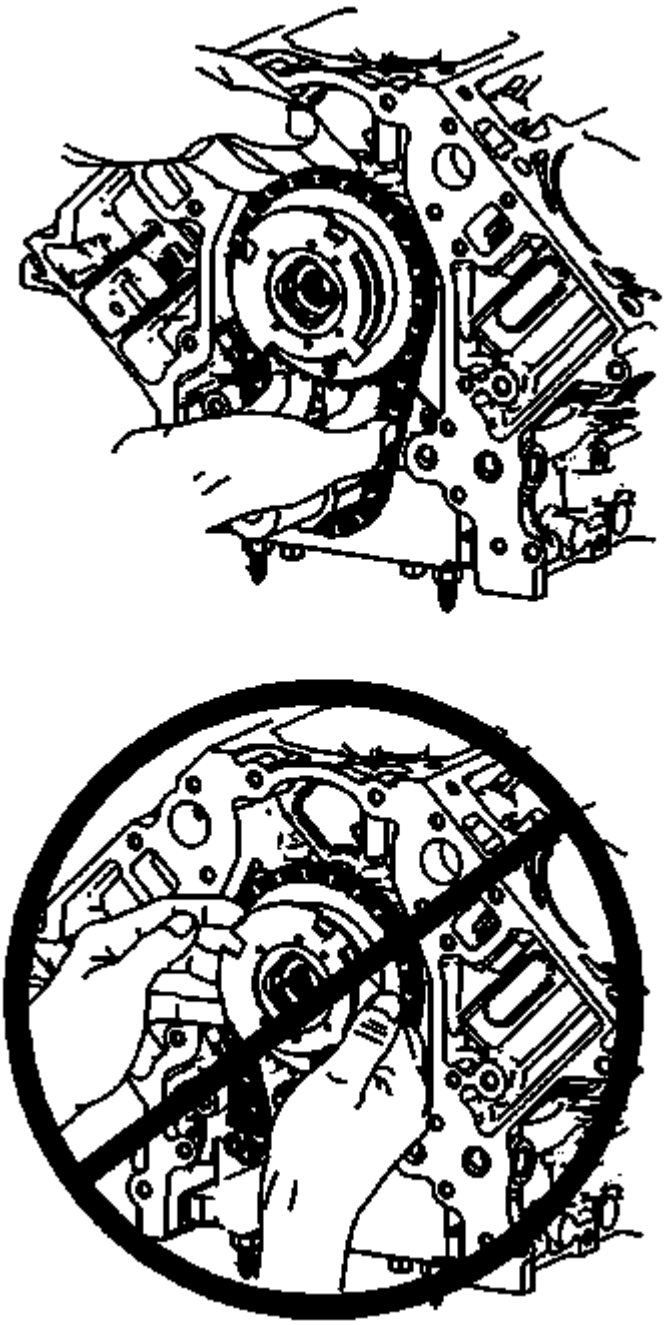

Fig. 712: View Of Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

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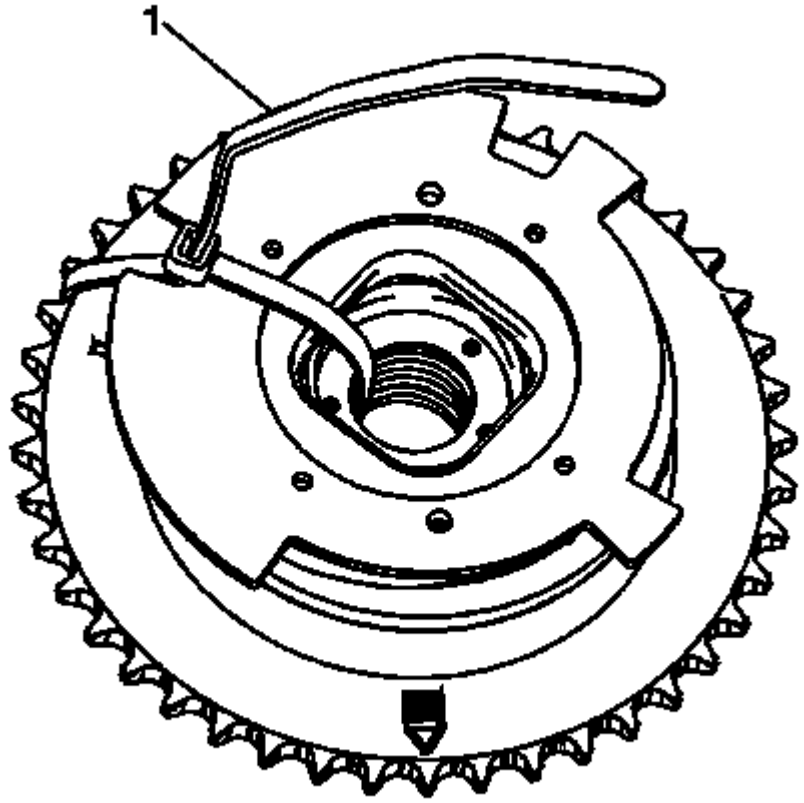

Fig. 713: View Of Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS CORP.

Install tie wrap (1) to retain the reluctor wheel to the sprocket. The reluctor wheel is mounted to the actuator body with 3 roll pins.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight, or indicate, important product changes from the previous model year.

Changes may include 1 or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

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Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes on the engine utilize metric threads.
- Certain fasteners should not be used again. Bolts, studs, or other fasteners that must be replaced, will be called out in the specific service procedure.
- The crankshaft balancer bolt is now tightened using a 4 pass method. Refer to **Fastener Tightening Specifications**.

Changed Engine Specifications

No revisions to the engine mechanical specifications.

New Sealants and/or Adhesives

Sealers and adhesives, as required, are identified within the specific service procedures. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

Disassembly and Assembly Procedure Revisions

No revisions to the disassembly or assembly procedure.

Engine Mechanical Diagnostic Procedure Revisions

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 **Diagnostic System Check - Vehicle** .

New Special Tools Required

Front cover alignment tool **EN-48853** is required to align the front cover during the installation procedure. See **Special Tools**.

A Component Comparison from the Previous Year

- A new design balancer bolt with a four step tightening process is used.
- A new second design front cover may be used.
- Front cover installation tool **EN-48853** is required for alignment of the front cover. See **Special Tools**.
- Production design engines will use a rivet-type plug replacing the coolant air bleed covers located at the top rear of each cylinder head. To properly repair a leaking plug, remove cylinder head from the engine, remove the plug from the cylinder head and install first design coolant air bleed cover and bolt.

LUBRICATION DESCRIPTION

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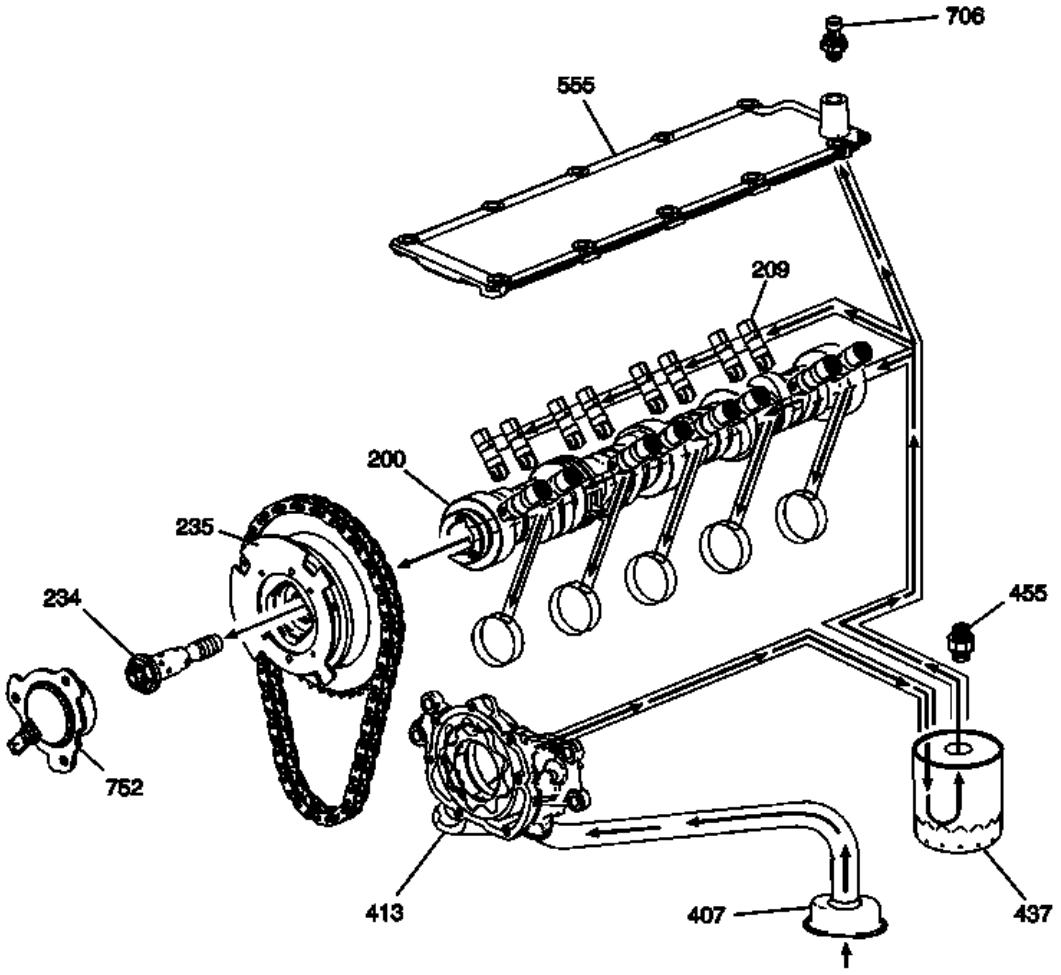

Fig. 714: View Of Lubrication System Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
200	Camshaft
209	Valve Lifter
234	Camshaft Position (CMP) Actuator Solenoid Valve
235	CMP Actuator
407	Oil Pump Screen
413	Oil Pump
437	Oil Filter
455	Oil Pressure Relief Valve
555	Valley Cover
706	Oil Pressure Sensor
752	CMP Magnet

Engine lubrication is supplied by a gerotor type oil pump assembly. The oil pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump gears rotate and draw oil from the oil

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pan sump through a pick-up screen and pipe. The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery. Contained within the oil pump assembly is a pressure relief valve that maintains oil pressure within a specified range.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter where harmful contaminants are removed. A bypass valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted. A second valve, the oil pressure relief valve is incorporated into the oil pan. The oil pressure relief valve limits oil pressure directed to the upper oil galleries to 379-517 kPa (55-75 psi) maximum. When main oil pressure exceeds 379 kPa (55 psi), the oil pressure relief valve exhausts excess oil to the sump.

Oil is then directed from the filter to the upper main oil galleries. Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems.

An oil passage at camshaft bearing location 2 permits oil flow into the center of the camshaft. Oil enters the camshaft exiting at the front and into the camshaft position (CMP) actuator solenoid valve. The CMP valve spool position is controlled by the engine control module (ECM) and CMP magnet (752). When commanded by the ECM, the CMP magnet repositions the CMP actuator solenoid valve spool directing pressurized oil into the CMP actuator to control valve timing.

Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top rear of the engine.

CLEANLINESS AND CARE

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice, even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for assembly. Refer to **Separating Parts**.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

SEPARATING PARTS

IMPORTANT:

- **Many internal engine components will develop specific wear patterns on their friction surfaces.**

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- **When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod location and orientation to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Special Tools

J 28410: Gasket Remover

For equivalent regional tools, refer to **Special Tools**.

Gasket Use and Applying Sealants

- Do not use any gasket again unless specified.
- Gaskets that can be used again will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

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Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410:** remover or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
  - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

CAUTION: Refer to Sealant Caution .

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Pipe Joint Compound

NOTE: Three types of sealer are commonly used in engines. These are room temperature vulcanizing (RTV) sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type of sealer is used where 2 non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include the exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Sealant Caution .

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- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- RTV sealant hardens when exposed to air. This type of sealer is used where 2 non-rigid parts, such as the intake manifold and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include the exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

CAUTION: Refer to Sealant Caution .

- Apply RTV sealant to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes.
- Assemble components while the RTV sealant is still wet, within 3 minutes. Do not wait for the RTV sealant to skin over.
- Tighten bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type of sealer is used where 2 rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets**.

- Apply a continuous bead of gasket eliminator to 1 flange. Surfaces to be sealed must be clean and dry.

CAUTION: Refer to Sealant Caution .

- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.

NOTE: Anaerobic sealed joints that are partially torqued and allowed to cure more

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than 5 minutes may result in incorrect shimming and sealing of the joint.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

TOOLS AND EQUIPMENT

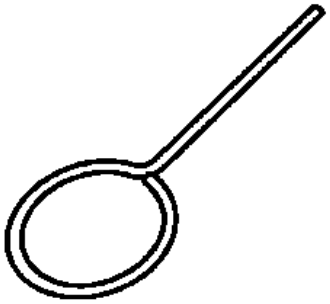
Special tools are listed and illustrated throughout this section, with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	EN-46330 Timing Belt Tensioner Retaining Pin
	EN-46999 Active Fuel Management Tester

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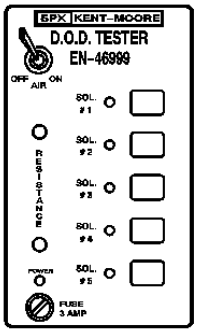
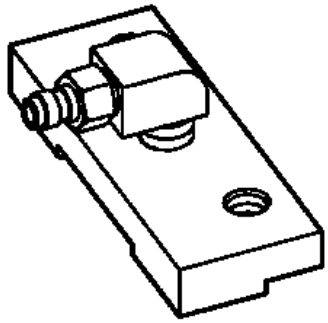
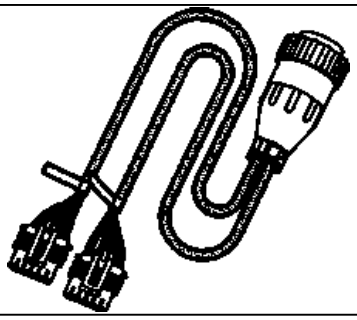
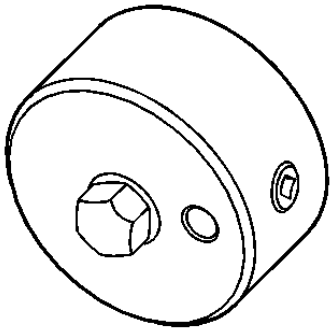
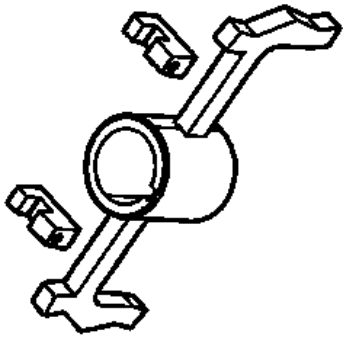
	
	EN-46999-1 Active Fuel Management Tester Air Adapter
	EN-46999-5 Active Fuel Management Tester Harness - Small Block V8
	EN-47971 Oil Pressure Gauge Adapter
	EN-48853 Front Cover Alignment Tool

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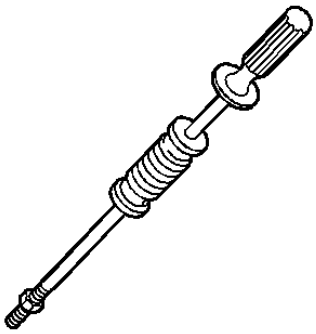
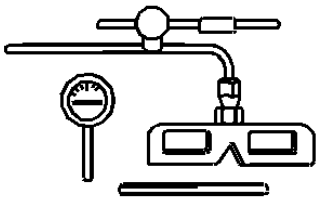
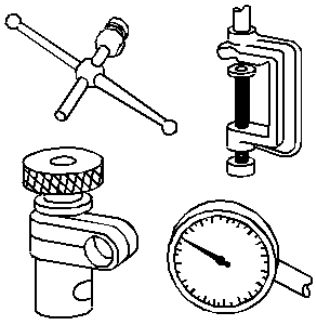
	J 2619-O1 Slide Hammer
	J 6125-1B Slide Hammer with Adapter
	J 7872 Magnetic Base Dial Indicator Set
	J 8001 Dial Indicator Set
	J 8037 Ring Compressor

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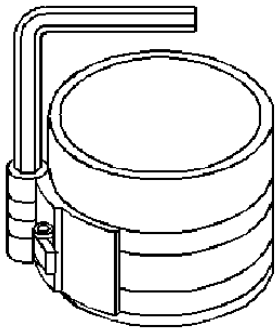
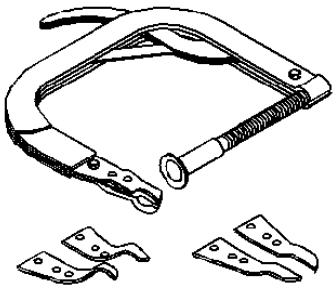
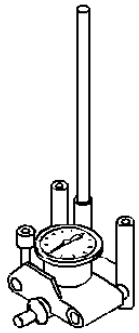
	
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gauge
	J 8089 Carbon Removal Brush
	J 8433

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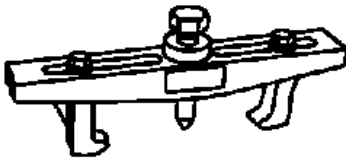
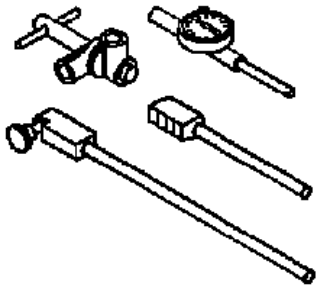
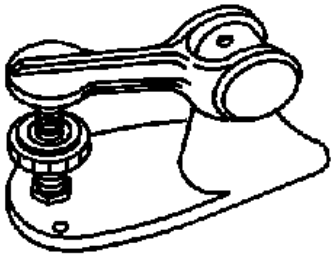
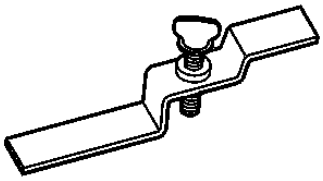
	Two Jaw Puller
	J 8520 Cam Lobe Lift Indicator
	J 9666 Valve Spring Tester
	J 21366 Converter Holding Strap
	J 21867 Pressure Gauge

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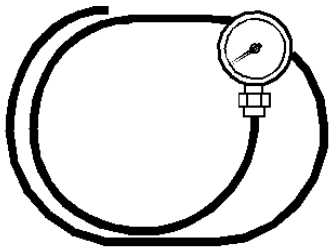
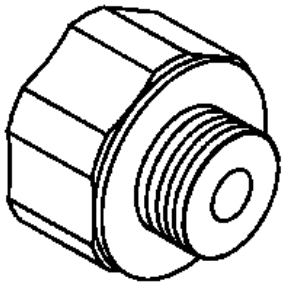
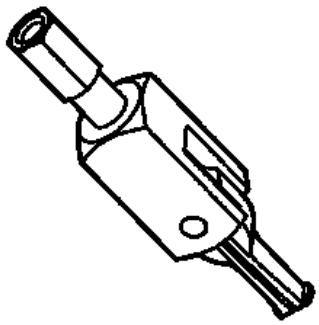
	
	J-21867-16 Oil Pressure Adapter
	J 22794 Spark Plug Port Adapter
	J 23907 Slide Hammer with Bearing Adapter
	J 24270 Cylinder Bore Ridge Reamer

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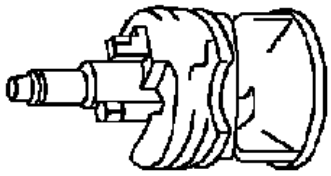
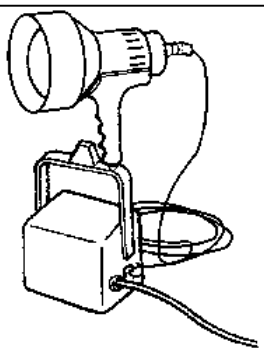
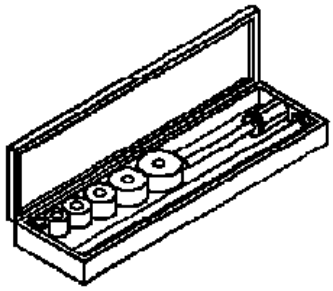
	
	J 28410 Gasket Remover
	J 28428-E High-Intensity Black Light Kit
	J 33049 Camshaft Bearing Service Set
	J 35667-A

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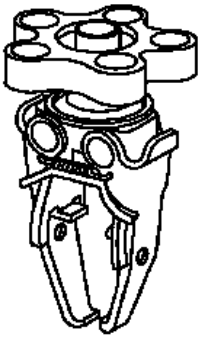
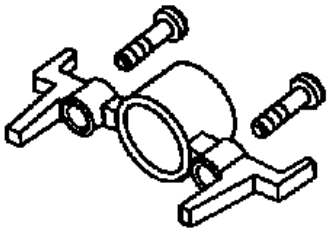
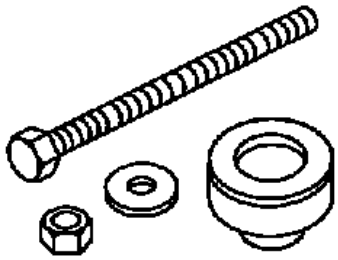
	Cylinder Head Leakdown Tester
	J 38606 Valve Spring Compressor
	J 41476 Front and Rear Cover Alignment Tool
	J 41478 Crankshaft Front Oil Seal Installer
	J 41479 Crankshaft Rear Oil Seal Installer

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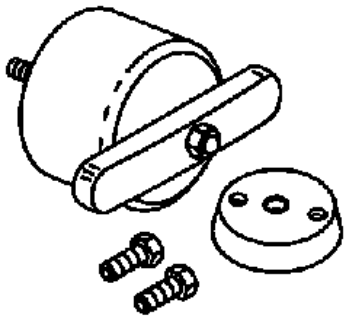
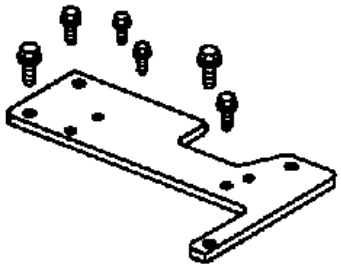
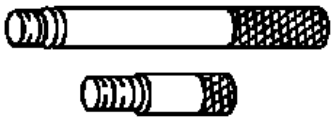
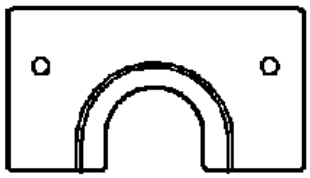
	
	J 41480 Front and Rear Cover Alignment
	J 41556 Connecting Rod Guide
	J 41558 Crankshaft Sprocket Remover
	J 41665

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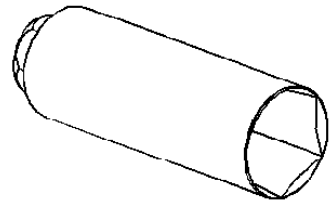
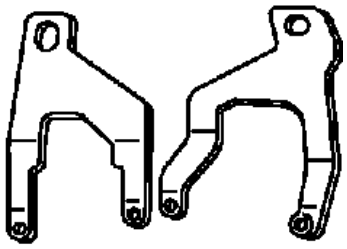
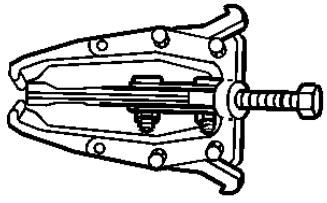
	Crankshaft Balancer and Sprocket Installer
	J 41712 Oil Pressure Switch Socket
	J 41798 Engine Lift Bracket
	J 41816-A Crankshaft Balancer Remover
	J 41816-2 Crankshaft End Protector

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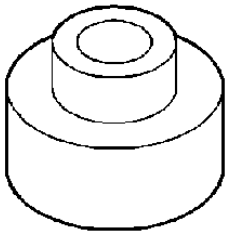	
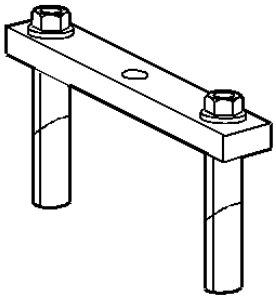	J 41818 Crankshaft Bearing Cap Remover
	J 42385-100 Head/Main Bolt Thread Repair Kit
	J 42385-200 Common Thread Repair Kit
	J 42385-300

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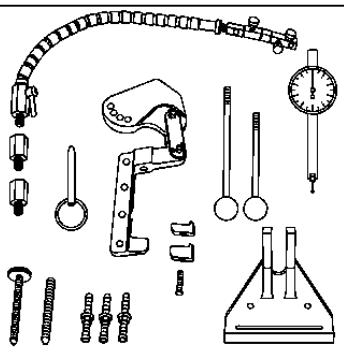
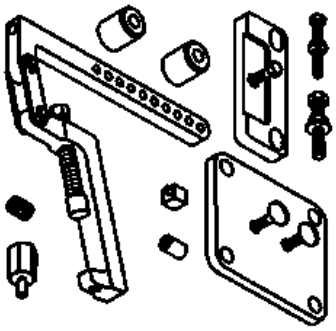
	Fixtures and Hardware Kit
	J 42386-A Flywheel Holding Tool
	J 43690 Rod Bearing Clearance Checking Tool
	J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit
	J 45059 Angle Meter

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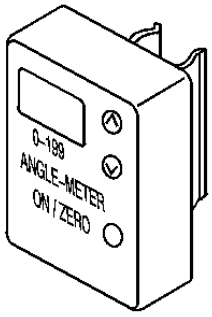	
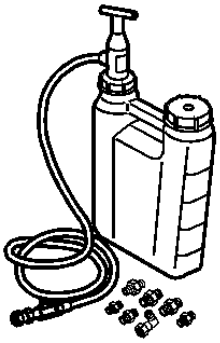	J 45299 Engine Preluber

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