2004 ENGINE

Engine Mechanical - 8.1L - C/K SUV

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Air Cleaner Outlet Duct Clamp	4 N.m	35 lb in
Air Conditioning (A/C) Belt Tensioner Bolt	50 N.m	37 lb ft
Battery Cable Channel Bolt	9 N.m	80 lb in
Camshaft Position (CMP) Sensor Bolt	12 N.m	106 lb in
Camshaft Retainer Bolt	12 N.m	106 lb in
Camshaft Sprocket Bolt	30 N.m	22 lb ft
Connecting Rod Nut - First Pass	30 N.m	22 lb ft
Connecting Rod Nut - Final Pass	90 degrees	
Crankshaft Balancer Bolt	255 N.m	189 lb ft
Crankshaft Bearing Cap Bolts - First Pass	30 N.m	22 lb ft
Crankshaft Bearing Cap Bolts - Final Pass	90 degrees	
Crankshaft Bearing Cap Studs - First Pass	30 N.m	22 lb ft
Crankshaft Bearing Cap Studs - Final Pass	80 degrees	
Crankshaft Oil Deflector Nut	50 N.m	37 lb ft
Crankshaft Position (CKP) Sensor Bolt	12 N.m	106 lb in
Crossbar Bolt	100 N.m	74 lb ft
Cylinder Head Bolts - In Sequence		
• First Pass	30 N.m	22 lb ft
• Second Pass	30 N.m + 120 degrees	22 lb ft + 120 degrees
• Final Pass - Long Bolts #1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17	60 degrees	
• Final Pass - Medium Bolts #15, 18	45 degrees	
• Final Pass - Short Bolts #4, 5, 12, 13	30 degrees	
Cylinder Head Coolant Hole Plug	50 N.m	37 lb ft
Drive Belt Idler Pulley Bolt	50 N.m	37 lb ft
Drive Belt Tensioner Bolt	50 N.m	37 lb ft
Engine Block Coolant Drain Hole M28 Plug - Left Front	60 N.m	44 lb ft
Engine Block Coolant Drain Hole Plug - Side	30 N.m	22 lb ft
Engine Block Coolant Heater	50 N.m	37 lb ft

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Engine Block Oil Gallery Plug - Front	20 N.m	15 lb ft
Engine Block Oil Gallery Plug - Rear	30 N.m	22 lb ft
Engine Block Oil Gallery Plug - Side	30 N.m	22 lb ft
Engine Block Oil Gallery Plug - Top	20 N.m	15 lb ft
Engine Coolant Crossover Bolt	50 N.m	37 lb ft
Engine Coolant Temperature (ECT) Sensor	50 N.m	37 lb ft
Engine Coolant Temperature (ECT) Sensor Bracket Bolt	50 N.m	37 lb ft
Engine Harness Bolt	5 N.m	44 lb in
Engine Harness Ground Bolt	16 N.m	12 lb ft
Engine Harness Stud	10 N.m	89 lb in
Engine Lift Bracket Bolt	40 N.m	30 lb ft
Engine Mount-to-Engine Bolt	50 N.m	37 lb ft
Engine Mount Bracket Thru Bolt	75 N.m	55 lb ft
Engine Mount-to-Engine Mount Bracket Bolt	65 N.m	50 lb ft
Engine Shield Bolt	20 N.m	15 lb ft
Engine Sight Shield Bracket Nut	5 N.m	44 lb in
Engine Wiring Harness Bolt	16 N.m	12 lb ft
Evaporative Emission (EVAP) Purge Valve Bolt	8 N.m	71 lb in
Exhaust Gas Recirculation (EGR) Valve Opening Cover Nut	22 N.m	16 lb ft
Exhaust Gas Recirculation (EGR) Valve Opening Cover Stud	7 N.m	62 lb in
Exhaust Manifold Center Bolt	35 N.m	26 lb ft
Exhaust Manifold Nut	16 N.m	12 lb ft
Exhaust Manifold Stud	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Bolt	25 N.m	18 lb ft
Exhaust Manifold Heat Shield Nut	25 N.m	18 lb ft
Flywheel Bolt - First Pass	40 N.m	30 lb ft
Flywheel Bolt - Second Pass	80 N.m	59 lb ft
Flywheel Bolt - Final Pass	100 N.m	74 lb ft
Front Cover Bolt - First Pass	6 N.m	53 lb in
Front Cover Bolt - Final Pass	12 N.m	106 lb in
Fuel Rail Bolt/Stud	12 N.m	106 lb in
Heater Hose Bracket Bolt	50 N.m	37 lb ft
Hood Hinge Bolt	25 N.m	18 lb ft
Ignition Coil Bolt	12 N.m	106 lb in
Ignition Coil Wiring Harness Bolt	12 N.m	106 lb in
Intake Manifold Bolts - First Pass In Sequence	5 N.m	44 lb in
Intake Manifold Bolts - Second Pass In Sequence	8 N.m	71 lb in
Intake Manifold Bolts - Third Pass In Sequence	12 N.m	106 lb in
Intake Manifold Bolt - Final Pass In Sequence	15 N.m	11 lb ft

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J 36857 Lift Bracket Bolt	40 N.m	30 lb ft
J 42847 Flywheel Holding Tool Bolt	50 N.m	37 lb ft
Knock Sensor	20 N.m	15 lb ft
Knock Sensor Heat Shield Bolt	12 N.m	106 lb in
Manifold Absolute Pressure (MAP) Sensor Bolt	12 N.m	106 lb in
Oil Cooler Hose Fittings	23 N.m	17 lb ft
Oil Fill Tube Bolt	12 N.m	106 lb in
Oil Filter	38 N.m	28 lb ft
Oil Filter Fitting	66 N.m	49 lb ft
Oil Level Indicator Tube Bolt	25 N.m	18 lb ft
Oil Level Sensor	20 N.m	15 lb ft
Oil Pan Bolt - First Pass	10 N.m	89 lb in
Oil Pan Bolt - Final Pass	25 N.m	18 lb ft
Oil Pan Drain Plug	28 N.m	21 lb ft
Oil Pan Skid Plate Bolt	20 N.m	15 lb ft
Oil Pressure Sensor	30 N.m	22 lb ft
Oil Pump Bolt	75 N.m	56 lb ft
Oil Pump Cover Bolt	12 N.m	106 lb in
Oil Pump Drive Bolt	25 N.m	18 lb ft
Power Steering Pump Bracket Bolt/Nut	50 N.m	37 lb ft
Power Steering Pump Bracket Stud	20 N.m	15 lb ft
Spark Plug	30 N.m	22 lb ft
Throttle Body Nut	10 N.m	89 lb in
Throttle Body Stud	12 N.m	106 lb in
Valve Lifter Guide Retainer Bolt	25 N.m	18 lb ft
Valve Rocker Arm Cover Bolt - First Pass	6 N.m	53 lb in
Valve Rocker Arm Cover Bolt - Final Pass	12 N.m	106 lb in
Valve Rocker Arm Nut	35 N.m	26 lb ft
Valve Rocker Arm Stud	50 N.m	37 lb ft
Water Outlet Bolt/Stud	30 N.m	22 lb ft
Water Pump Bolt - First Pass	25 N.m	18 lb ft
Water Pump Bolt - Final Pass	50 N.m	37 lb ft
Water Pump Pulley Bolt	25 N.m	18 lb ft

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V8	

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• Displacement	8.1L	496 CID
• RPO	L18	
• VIN	G	
• Bore	107.95 mm	4.25 in
• Stroke	111.0 mm	4.37 in
• Compression Ratio	9.1:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Spark Plug Gap	1.52 mm	0.06 in
Block		
• Crankshaft Main Bearing Bore Diameter	74.606-74.622 mm	2.9372-2.9379 in
• Cylinder Bore Diameter - Production	107.95-107.968 mm	4.25-4.2507 in
• Cylinder Bore Diameter - Service	107.94-107.99 mm	4.2496-4.2516 in
• Cylinder Bore Out-of-Round - Production, Maximum Minus Minimum Bore Diameter	0.018 mm	0.0007 in
• Cylinder Bore Out-of-Round - Service, Maximum Minus Minimum Bore Diameter	0.05 mm	0.002 in
• Cylinder Bore Taper - Production	0.018 mm	0.0007 in
• Cylinder Bore Taper - Service Thrust Axis	0.05 mm	0.002 in
• Cylinder Bore Taper - Service Pin Axis	0.05 mm	0.002 in
• Cylinder Head Deck Height - from Centerline of Crankshaft	259.875-260.125 mm	10.231-10.241 in
• Cylinder Head Deck Surface Flatness - Entire Face	0.1 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Within 150 mm (6 in)	0.05 mm	0.002 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft Bearing Inside Diameter	49.548-49.573 mm	1.9507-1.9517 in
• Camshaft Journal Diameter	49.472-49.522 mm	1.9477-1.9497 in
• Camshaft Lobe Lift - Exhaust	6.973-7.075 mm	0.2745-0.2785 in
• Camshaft Lobe Lift - Intake	6.924-7.026 mm	0.2726-0.2766 in
• Camshaft Runout - Production	0.051 mm	0.002 in
• Camshaft Runout - Service	0.076 mm	0.003 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.033-0.068 mm	0.0013-0.0027 in
• Connecting Rod Bearing Clearance - Service	0.033-0.081 mm	0.0013-0.0032 in

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• Connecting Rod Side Clearance	0.384-0.686 mm	0.0151-0.027 in
Crankshaft		
• Connecting Rod Journal Diameter	55.854-55.87 mm	2.199-2.1996 in
• Connecting Rod Journal Out-of-Round - Production	0.0102 mm	0.0004 in
• Connecting Rod Journal Taper - Production	0.0102 mm	0.0004 in
• Crankshaft End Play	0.127-0.35 mm	0.005-0.0138 in
• Crankshaft Main Bearing Clearance - #1, #2, #3, #4 Production	0.022-0.057 mm	0.0008-0.0022 in
• Crankshaft Main Bearing Clearance - #5 Production	0.034-0.069 mm	0.0013-0.0027 in
• Crankshaft Main Bearing Clearance - #1, #2, #3, #4 Service	0.022-0.089 mm	0.0008-0.0035 in
• Crankshaft Main Bearing Clearance - #5 Service Limit	0.035-0.102 mm	0.0014-0.004 in
• Crankshaft Main Journal Diameter	69.805-69.822 mm	2.7482-2.7489 in
• Crankshaft Main Journal Out-of-Round - Production	0.0102 mm	0.0004 in
• Crankshaft Main Journal Taper - Production	0.0102 mm	0.0004 in
• Crankshaft Runout - Production	0.05 mm	0.002 in
• Crankshaft Runout - Service	0.065 mm	0.0026 in
Cylinder Head		
• Cylinder Head Height/Thickness	259.875-260.125 mm	10.231-10.241 in
• Surface Flatness - Block Deck	0.05 mm	0.002 in
• Surface Flatness - Exhaust Manifold Deck	0.102 mm	0.004 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.003 in
Exhaust Manifold		
• Surface Flatness	0.254 mm	0.01 in
Lubrication System		
• Oil Capacity - Without Filter	5.7L	6.0 Qts
• Oil Capacity - With Filter	6.15L	6.5 Qts
• Oil Pressure - Minimum	34 kPa @ 1,000 RPM	5 psi @ 1,000 RPM
• Oil Pressure - Minimum	69 kPa @ 2,000 RPM	10 psi @ 2,000 RPM
Piston Rings		
Piston Ring End Gap		
• First Compression Ring - Production	0.3-0.45 mm	0.012-0.018 in
• First Compression Ring - Service	0.45-0.675 mm	0.018-0.027 in
• Second Compression Ring - Production	0.45-0.65 mm	0.017-0.025 in

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• Second Compression Ring - Service	0.675-0.975 mm	0.026-0.039 in
• Oil Control Ring - Production	0.249-0.759 mm	0.0098-0.0299 in
• Oil Control Ring - Service	0.373-1.138 mm	0.015-0.045 in
Piston Ring-to-Groove Clearance		
• First Compression Ring	0.031-0.074 mm	0.0012-0.0029 in
• Second Compression Ring	0.031-0.074 mm	0.0012-0.0029 in
• Oil Control Ring	0.051-0.203 mm	0.002-0.008 in
Piston and Pins		
Piston		
• Piston Diameter	Not Measurable	Not Measurable
• Piston-to-Bore Clearance	Interference Fit	Interference Fit
Pin		
• Pin-Piston Pin Fit in Connecting Rod Bore-Production	0.010-0.023 mm	0.0004-0.0009 in
• Pin-Piston Pin Fit in Connecting Rod Bore-Service	0.010-0.023 mm	0.0004-0.0009 in
• Pin-Piston Pin Clearance-to-Piston Pin Bore-Production	0.003-0.011 mm	0.00019-0.00043 in
• Pin-Piston Pin Clearance-to-Piston Pin Bore-Service	0.003-0.011 mm	0.00019-0.00043 in
• Pin-Piston Pin Diameter	26.416-26.419 mm	1.039-1.040 in
Valve System		
Valves		
• Valve Face Angle - Exhaust	45 degrees	
• Valve Face Angle - Intake	45 degrees	
• Valve Head Diameter - Exhaust	43.69 mm	1.72 in
• Valve Head Diameter - Intake	55.63 mm	2.19 in
• Valve Lash - Exhaust	Net Lash	Net Lash
• Valve Lash - Intake	Net Lash	Net Lash
• Valve Seat Angle - Exhaust	46 degrees	
• Valve Seat Angle - Intake	46 degrees	
• Valve Seat Runout - Exhaust	0.05 mm	0.002 in
• Valve Seat Runout - Intake	0.05 mm	0.002 in
• Valve Seat Width - Exhaust	1.651-2.159 mm	0.060-0.095 in
• Valve Seat Width - Intake	0.8-1.2 mm	0.03-0.06 in
• Valve Stem Diameter - Exhaust	9.431-9.449 mm	0.3713-0.372 in
• Valve Stem Diameter - Intake	9.436-9.454 mm	0.3715-0.3722 in

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• Valve Stem-to-Guide Clearance - Exhaust - Production	0.03-0.079 mm	0.0012-0.0031 in
• Valve Stem-to-Guide Clearance - Intake - Production	0.025-0.074 mm	0.001-0.0029 in
• Valve Stem-to-Guide Clearance - Exhaust - Service	0.03-0.104 mm	0.0012-0.0041 in
• Valve Stem-to-Guide Clearance - Intake - Service	0.025-0.099 mm	0.001-0.0039 in
Rocker Arms		
• Valve Rocker Arm Ratio	1.7:1	
Valve Springs		
• Valve Spring Free Length	56.35 mm	2.218 in
• Valve Spring Installed Height	45.92-46.69 mm	1.808-1.838 in
• Valve Spring Load - Closed	381-419 N at 45.92 mm	86-94 lb at 1.808 in
• Valve Spring Load - Open	964-1056 N at 33.99 mm	216-236 lb at 1.338 in

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Bearing Hole Plug	Sealant	12377901	10953504
Crankshaft Position (CKP) Sensor Bolt	Thread Adhesive	12345493	10953488
Crankshaft Rear Bearing Cap	Sealant	1052942	10953466
Cylinder Head Bolts	Sealant	12346004	10953480
Cylinder Head Coolant Hole Plug	Sealant	12346004	10953480
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480
Engine Block Coolant Heater	Sealant	12346004	10953480
Engine Block Oil Gallery Plug	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004	10953480
Engine Front Cover	Sealant	12346286	10953472
Engine Oil Supplement	Lubricant	1052367	992869
Evaporative Emission Purge Valve Bolt	Thread Adhesive	12345493	10953488
Intake Manifold	Sealant	12346141	10953433
Intake Manifold Bolts	Thread Adhesive	12345382	10953489
Intake Manifold Engine Block/Cylinder Head	Sealant	12346141	10953433
Knock Sensors	Sealant	12346004	10953480
Oil Cooler Hose Fittings	Sealant	12346004	10953480
Oil Fill Tube	Sealant	9985409	9985409
Oil Pan - At Corners	Sealant	12346286	10953472
Oil Pressure Sensor	Sealant	12346004	10953480

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Valve Rocker Arm Studs	Sealant	12346004	10953480
Water Pump Bolts	Sealant	12346004	10953480

COMPONENT LOCATOR

DISASSEMBLED VIEWS

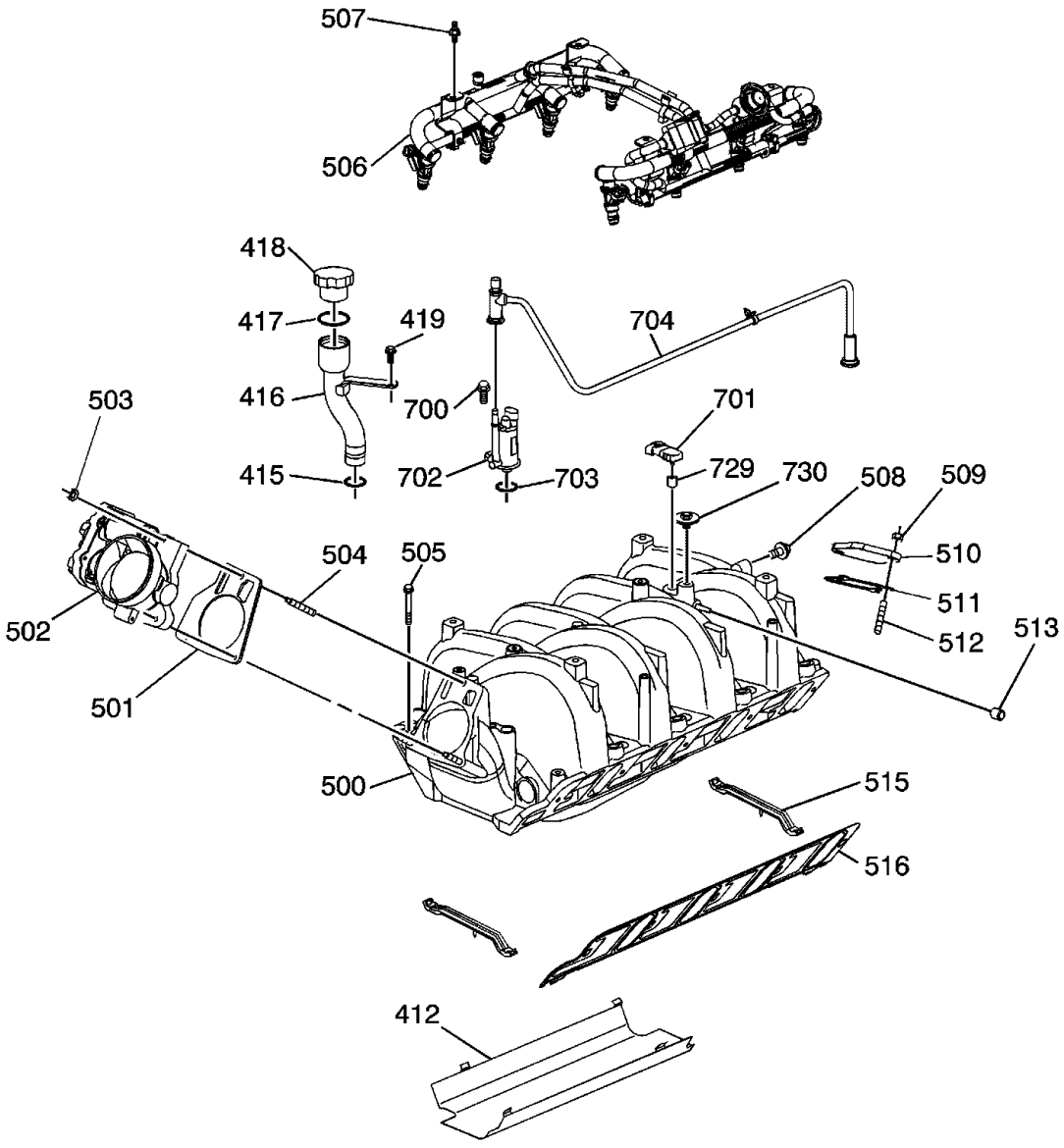

Fig. 1: Intake Manifold/Upper Engine Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name

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412	Splash Shield
415	Oil Fill Tube O-ring
416	Oil Fill Tube
417	Oil Fill Cap O-ring
418	Oil Fill Cap
419	Oil Fill Tube Bolt
500	Intake Manifold
501	Throttle Body Gasket
502	Throttle Body
503	Throttle Body Nut
504	Throttle Body Stud
505	Intake Manifold Bolt
506	Fuel Rail with Injectors
507	Fuel Rail Bolt/Stud
508	Intake Manifold Plug
509	Exhaust Gas Recirculation (EGR) Cover Nut
510	EGR Cover
511	EGR Cover Gasket
512	EGR Cover Stud
513	Vacuum Fitting Plug
515	Intake Gasket - End Seal
516	Intake Gasket - Side
700	Evaporative Emission (EVAP) Valve Bolt
701	Manifold Absolute Pressure (MAP) Sensor
702	EVAP Valve
703	EVAP Valve O-ring
704	EVAP Tube
729	MAP Sensor Grommet
730	MAP Sensor Bolt

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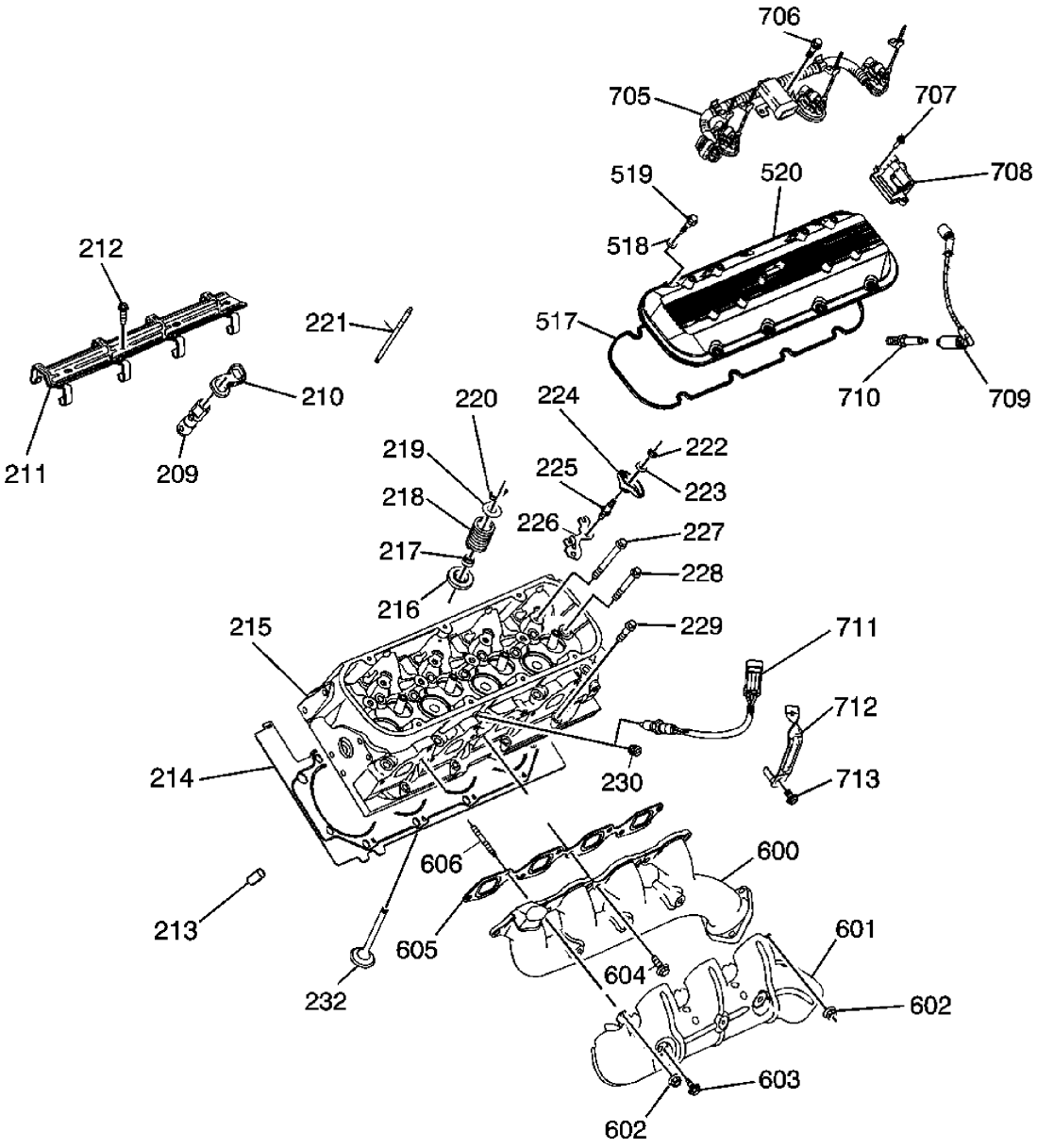

Fig. 2: Cylinder Head/Upper Engine Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
209	Valve Lifter
210	Valve Lifter Guide
211	Valve Lifter Retainer
212	Valve Lifter Retainer Bolt
213	Cylinder Head Locating Pin
214	Cylinder Head Gasket

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215	Cylinder Head
216	Valve Rotator
217	Valve Stem Oil Seal
218	Valve Spring
219	Valve Spring Cap
220	Valve Stem Keys
221	Pushrod
222	Rocker Arm Nut
223	Rocker Arm Ball
224	Rocker Arm
225	Rocker Arm Bolt/Stud
226	Pushrod Guide
227	Cylinder Head Bolt - Long
228	Cylinder Head Bolt - Medium
229	Cylinder Head Bolt - Short
230	Cylinder Head Coolant Plug
232	Valve
517	Valve Cover Gasket
518	Valve Cover Bolt Grommet
519	Valve Cover Bolt
520	Valve Cover
600	Exhaust Manifold
601	Exhaust Manifold Heat Shield
602	Exhaust Manifold Nut
602	Exhaust Manifold Nut
603	Exhaust Manifold Heat Shield Bolt
604	Exhaust Manifold Bolt
605	Exhaust Manifold Gasket
606	Exhaust Manifold Stud
705	Ignition Coil Wire Harness
706	Ignition Coil Wire Harness Bolt
707	Ignition Coil Bolt
708	Ignition Coil
709	Spark Plug Wire
710	Spark Plug
711	Engine Coolant Temperature (ECT) Sensor
712	ECT Sensor Bracket
713	ECT Sensor Bracket Bolt

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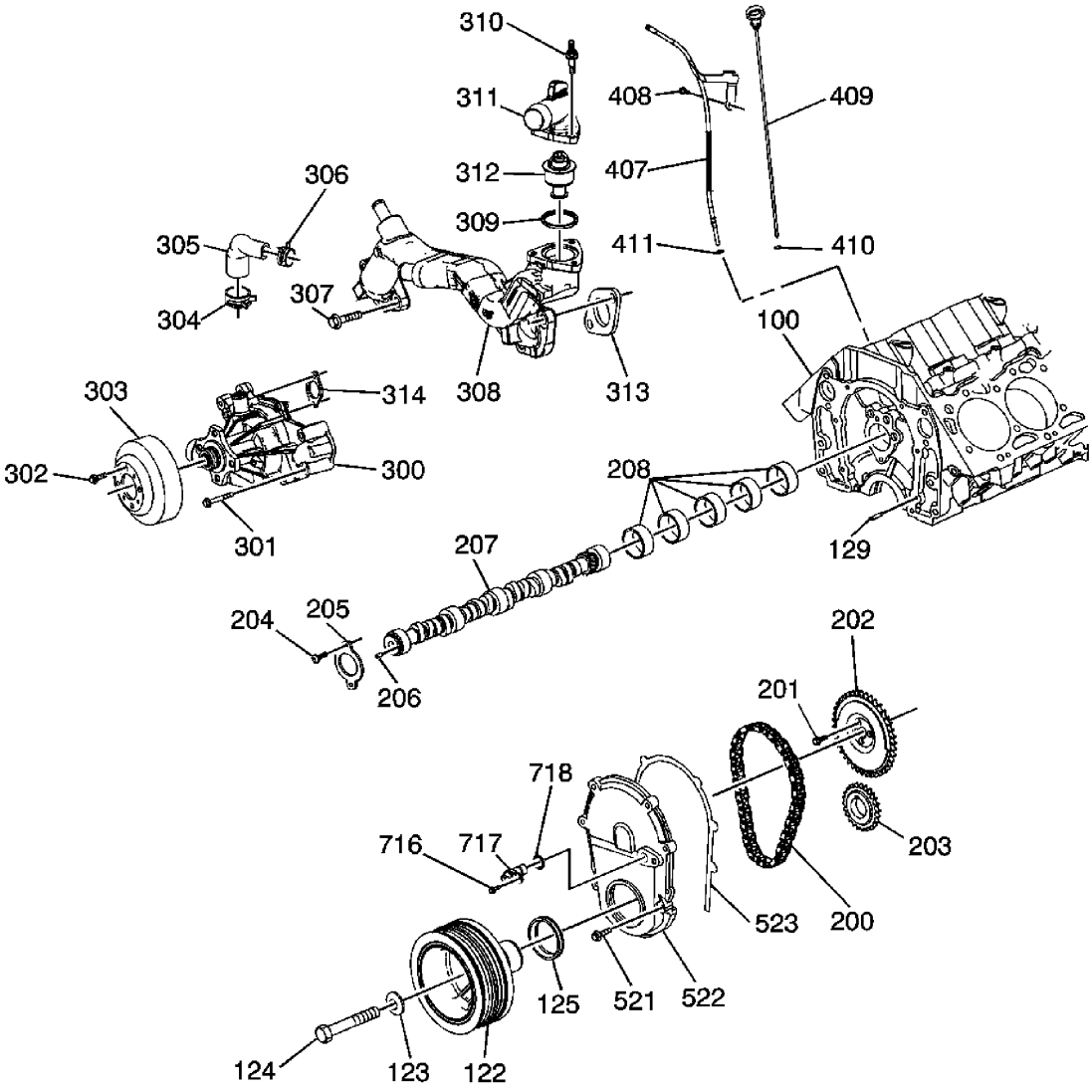

Fig. 3: Front of Engine Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
122	Crankshaft Balancer
123	Crankshaft Balancer Bolt Washer
124	Crankshaft Balancer Bolt
125	Crankshaft Front Oil Seal
129	Front Cover Locating Pin
200	Timing Chain
201	Camshaft Sprocket Bolt
202	Camshaft Sprocket

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203	Crankshaft Sprocket
204	Camshaft Retainer Bolt
205	Camshaft Retainer
206	Camshaft Sprocket Locating Pin
207	Camshaft
208	Camshaft Bearings
300	Water Pump
301	Water Pump Bolt
302	Water Pump Pulley Bolt
303	Water Pump Pulley
304	Thermostat Bypass Hose Clamp
305	Thermostat Bypass Hose
306	Thermostat Bypass Hose Clamp
307	Engine Coolant Crossover Bolt
308	Engine Coolant Crossover
309	Thermostat O-ring
310	Water Outlet Bolt/Stud
311	Water Outlet
312	Thermostat
313	Engine Coolant Crossover Gasket
314	Water Pump Gasket
407	Oil Level Indicator Tube
408	Oil Level Indicator Tube Bolt
409	Oil Level Indicator
410	Oil Level Indicator O-ring
411	Oil Level Indicator Tube O-ring
521	Front Cover Bolt
522	Front Cover
523	Front Cover Gasket
716	Camshaft Position (CMP) Sensor Bolt
717	CMP Sensor
718	CMP Sensor O-ring

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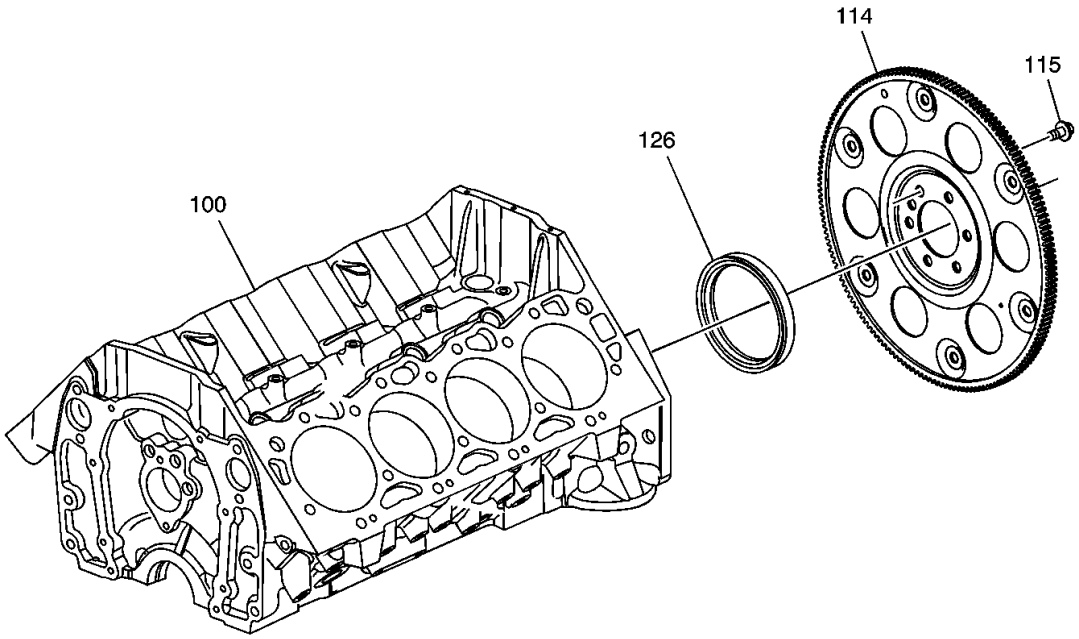

Fig. 4: Engine Flywheel Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
114	Flywheel - Automatic Transmission
115	Flywheel Bolt
126	Crankshaft Rear Oil Seal

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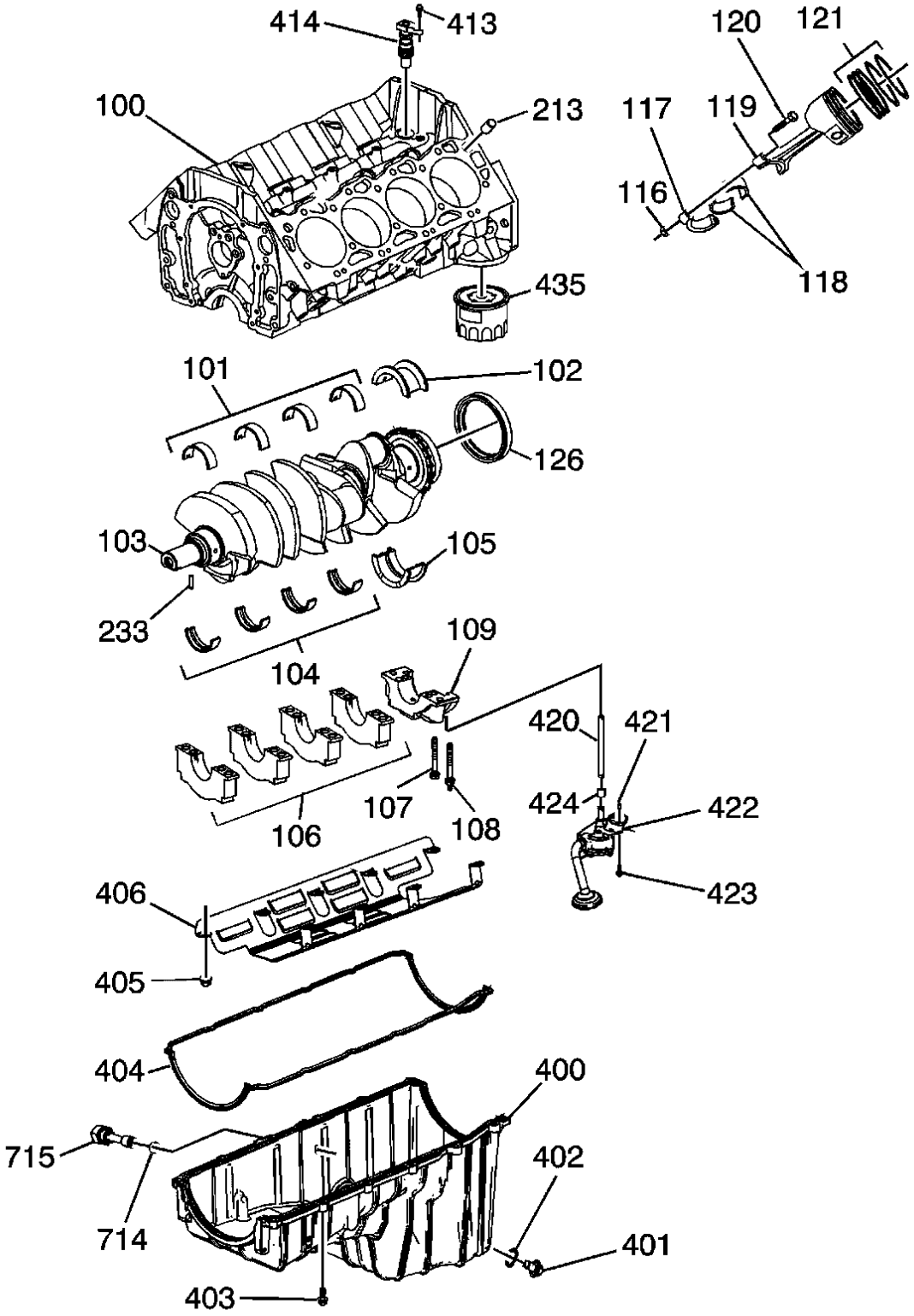

Fig. 5: Lower Engine Assembly Disassembled View

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Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Crankshaft Main Bearings - Upper
102	Crankshaft Thrust Bearing - Upper
103	Crankshaft
104	Crankshaft Main Bearing - Lower
105	Crankshaft Thrust Bearing - Lower
106	Crankshaft Bearing Cap
107	Crankshaft Bearing Cap Bolt
108	Crankshaft Bearing Cap Bolt/Stud
109	Crankshaft Bearing Cap - Thrust
116	Connecting Rod Nut
117	Connecting Rod Cap
118	Connecting Rod Bearings
119	Piston and Connecting Rod Assembly
120	Connecting Rod Bolt
121	Piston Rings
126	Crankshaft Rear Oil Seal
213	Cylinder Head Locating Pin
233	Crankshaft Sprocket Locating Pin
400	Oil Pan
401	Oil Pan Drain Plug
402	Oil Pan Drain Plug O-ring
403	Oil Pan Bolt
404	Oil Pan Gasket
405	Crankshaft Oil Deflector Nut
406	Crankshaft Oil Deflector
413	Oil Pump Drive Bolt
414	Oil Pump Drive
420	Oil Pump Driveshaft
421	Oil Pump Locating Pin
422	Oil Pump
423	Oil Pump Bolt
424	Oil Pump Driveshaft Retainer
435	Oil Filter
714	Oil Level Sensor O-ring
715	Oil Level Sensor

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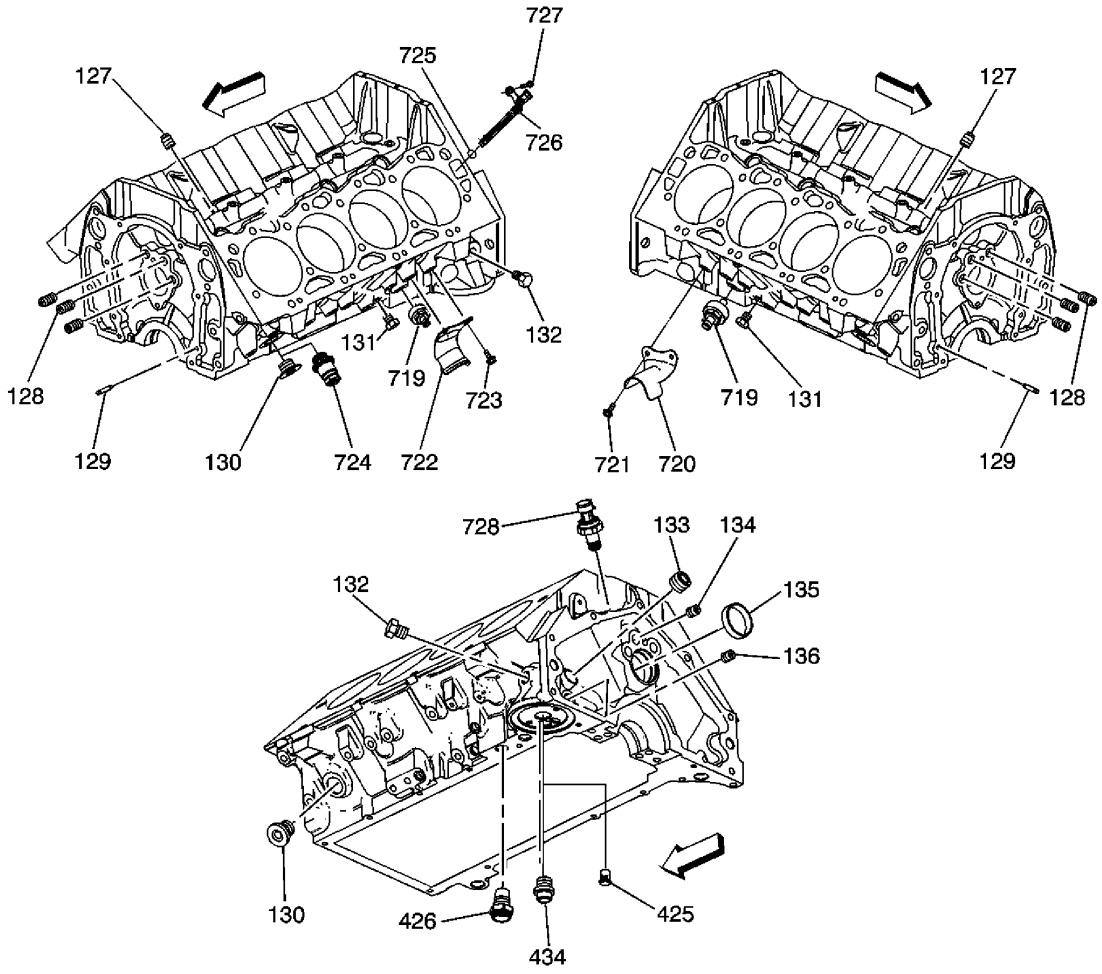

Fig. 6: Engine Block Plugs/Sensors Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
127	Oil Gallery Plug - Top
127	Oil Gallery Plug - Top
128	Oil Gallery Plug - Front
128	Oil Gallery Plug - Front
129	Front Cover Locating Pin
129	Front Cover Locating Pin
130	Coolant Drain Hole Plug
130	Coolant Drain Hole Plug
131	Oil Gallery Plug - Side
131	Oil Gallery Plug - Side
132	Oil Gallery Plug - Left Side Rear
132	Oil Gallery Plug - Left Side Rear

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133	Oil Gallery Plug - Rear
134	Oil Gallery Plug - Rear
135	Camshaft Bearing Hole Plug
136	Oil Gallery Plug - Rear
425	Oil Filter Bypass Valve
426	Oil Cooler Fitting
434	Oil Filter Fitting
719	Knock Sensor
719	Knock Sensor
720	Knock Sensor Heat Shield - Right
721	Knock Sensor Heat Shield Bolt
722	Knock Sensor Heat Shield - Left
723	Knock Sensor Heat Shield Bolt
724	Engine Block Coolant Heater
725	Crankshaft Position (CKP) Sensor O-ring
726	CKP Sensor
727	CKP Sensor Bolt
728	Oil Pressure Sensor

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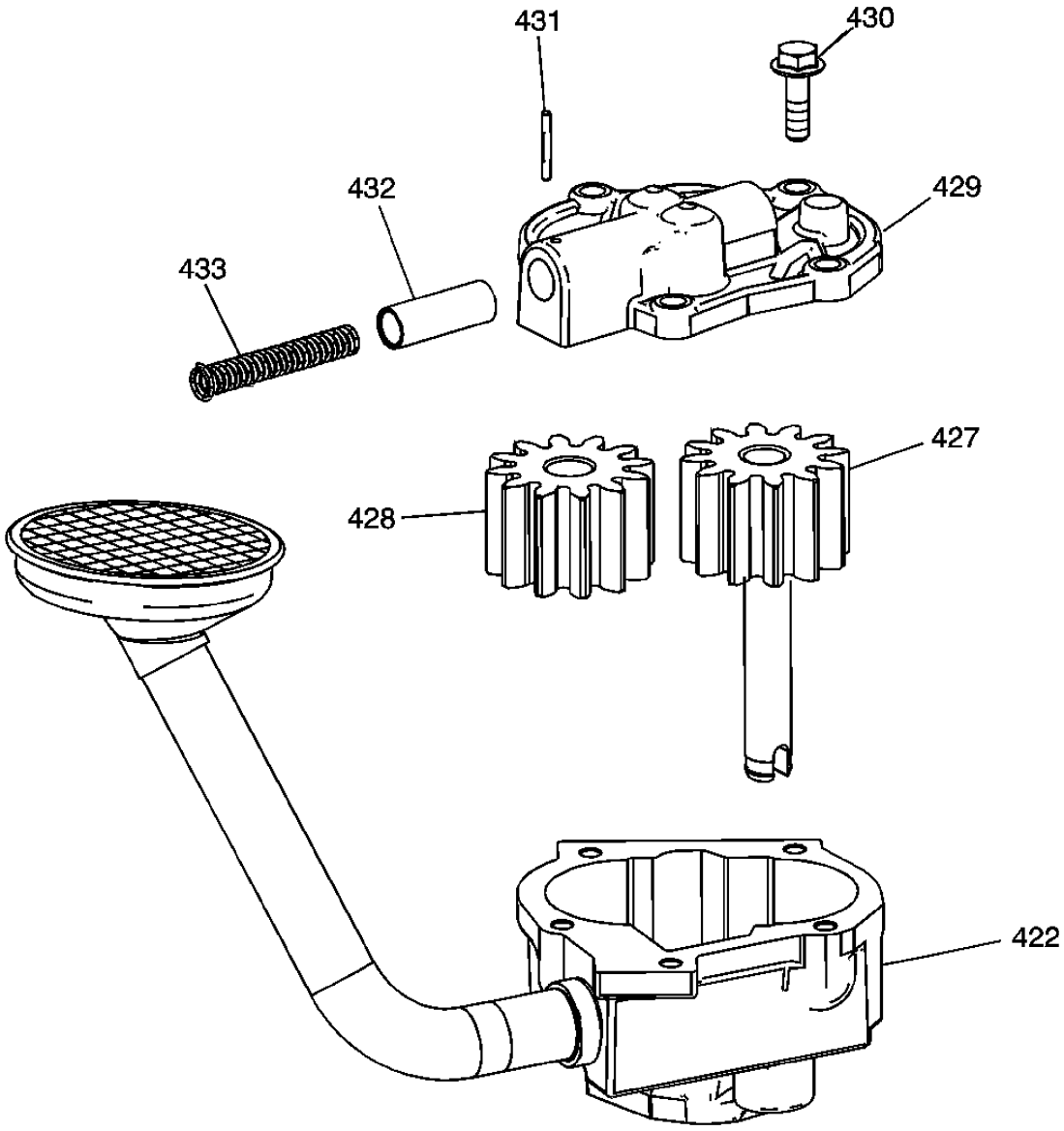

Fig. 7: Oil Pump Assembly Disassembled View
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
422	Oil Pump with Pickup Screen
427	Drive Gear
428	Driven Gear
429	Oil Pump Cover
430	Oil Pump Cover Bolt
431	Pressure Relief Valve Spring Pin
432	Pressure Relief Valve

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433	Pressure Relief Valve Spring

ENGINE IDENTIFICATION

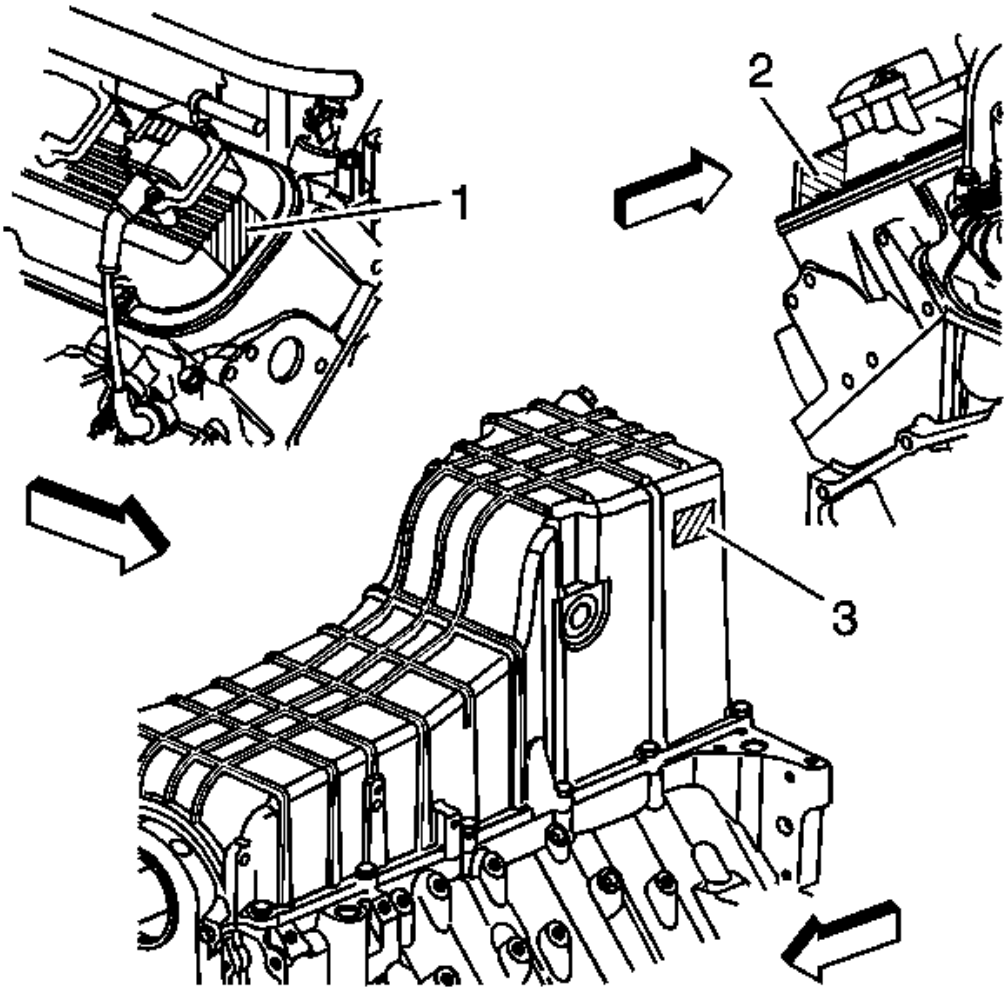

Fig. 8: Locating Engine Identification Number
Courtesy of GENERAL MOTORS CORP.

The engine identification number is located in three locations. There are labels on the front of the right rocker arm cover (1), the rear of the left rocker arm cover (2), and the right side of the engine oil pan (3). The engine identification number is used to track and identify the engine prior to installation in a vehicle.

The Vehicle Identification Number (VIN) Derivative is located on the left rear side of the engine block and is a

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nine digit number stamped or laser etched onto the engine at the vehicle assembly plant. If reading the identification number from the left, the following information can be obtained:

- 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 six digits of the Vehicle Identification Number (VIN).

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, **Lubrication Description**, **New Product Information**, and the **Drive Belt System Description** . Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to **Symptoms - Engine Mechanical** in order to identify the correct procedure for diagnosing the system and where the procedure is located.

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform a **Diagnostic System Check - Engine Controls** in Engine Controls - 8.1L before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, **Engine Component Description**, **Drive Belt System Description** , **Lubrication Description** and **New Product Information**.

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

Visual/Physical Inspection

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

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Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Coolant in Combustion Chamber**
- **Coolant in Engine Oil**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Cylinder Leakage Test**
- **Engine Compression Test**
- **Drive Belt Chirping Diagnosis**
- **Drive Belt Squeal Diagnosis**
- **Drive Belt Whine Diagnosis**
- **Drive Belt Rumbling Diagnosis**
- **Drive Belt Vibration Diagnosis**
- **Drive Belt Falls Off Diagnosis**
- **Drive Belt Excessive Wear Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.

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components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required.
Improperly installed or damaged vacuum hoses	Repair or replace as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads and/or throttle body as required.
Improperly installed or damaged 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	Repair or replace the valve rocker arms as required.
Worn or bent push rods	Replace the push rods.
Sticking valves Carbon buildup on the valve stem and/or seat can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain, camshaft retainer and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. • Perform a pressure test to the cooling system. Refer to **Loss of Coolant** in Engine Cooling. • Inspect the cylinder heads, engine block, and/or head gaskets. Refer to **Coolant in Combustion Chamber**. • Repair or replace as required.

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Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to identify the cause. Refer to **Cylinder Leakage Test**. • Repair or replace as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-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 and SEVERE reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft reluctor wheel as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

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. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual	Inspect the components, repair or replace as required.

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misfire condition.	
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer as required. Refer to **Engine Flywheel Replacement** or **Crankshaft Balancer Replacement**.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. • Repair or replace as required.
Worn Crankshaft Thrust Bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	• Check the crankshaft endplay. • Replace the crankshaft and/or bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms	Repair or replace the valve rocker arms as required.
Worn or bent push rods	Replace the push rods.
Sticking valves Carbon buildup on the valve stem and/or seat can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain, camshaft retainer and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. • Perform a pressure test to the cooling system. Refer to **Loss of Coolant** in Engine Cooling.

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	• Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to **Coolant in Combustion Chamber**. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Leaking intake gaskets	Repair or replace the intake manifold bolts and/or gaskets as required.
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. 2. Inspect the cylinders for loss of compression. Refer to **Engine Compression Test**. 3. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** in Engine Controls - 8.1L. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. • Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. • Repair or replace as required.

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

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

Cause	Correction
Incorrect oil level Too high an oil level will cause aeration within the oil	Add or remove oil as required to achieve proper level.
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	• Drain the oil. • Install the correct viscosity oil.
High valve lifter leak down rate	Replace the valve lifters as required.

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Worn crankshaft thrust bearing	• Check the crankshaft endplay. • Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Plugged oil filter	Replace the oil filter.
Low oil pressure	• Verify proper oil level. • Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm stud, nut or bolt. • Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Worn pushrod guide plate	Replace 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
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn and/or damaged valve rotators	Replace the valve rotators as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.

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Worn camshaft lobes	• Inspect the camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stick.	Inspect the following components, and repair as required: • Use GM Top Engine Cleaner, GM P/N 1050002, (Canadian P/N 992872), to eliminate carbon deposits following manufacturer's instructions • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Verify proper oil level. • Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	• Inspect the accessory drive system. • Repair or replace as required.
Loose or damaged crankshaft balancer	• Inspect the crankshaft balancer. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Detonation/Spark Knock** in Engine Controls - 8.1L.
Loose torque converter bolts	• Inspect the torque converter bolts and flywheel. • Repair or replace as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan, contacting the oil pump screen An oil pan that has been damaged may improperly	• Inspect the oil pan. • Inspect the oil pump screen.

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position the oil pump screen, preventing proper oil flow to the oil pump.	• Repair or replace as required.
Oil pump screen loose, damaged or restricted	• Inspect the oil pump screen. • Repair or replace as required.
Excessive piston-to-cylinder bore clearance	• Inspect the piston and cylinder bore. • Repair as required.
Excessive piston pin-to-bore clearance	• Inspect the piston, piston pin, and the connecting rod. • Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	• Verify the pistons, piston pins and connecting rods are installed correctly. • Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Detonation/Spark Knock** in Engine Controls - 8.1L.
Loose torque converter bolts or improperly installed torque converter	• Inspect the torque converter bolts and flywheel. • Verify correct installation of the torque converter.

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	• Repair as required.
Cracked flywheel	• Inspect the flywheel bolts and flywheel. • Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component or starter motor	1. Remove accessory drive belt or belts, and/or starter motor. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain	• Inspect timing chain, gears, and crankshaft sprocket locating pin. • Repair as required.
Seized camshaft	• Inspect camshaft and camshaft bearings. • Repair as required.
Bent valve in cylinder head	• Inspect valves and cylinder heads. • Repair as required.
Hydraulically locked cylinder: • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. Refer to **Coolant in Combustion Chamber**. 2. Inspect for a sticking fuel injector. 3. Inspect for broken head gasket or gaskets. 4. Inspect for cracked engine block or cylinder head.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.

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Material in cylinder: • Broken valve • Piston material • Foreign material	• Inspect cylinder and cylinder heads for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair as required.
Bent or broken connecting rod	• Inspect connecting rods. • Repair as required.
Broken crankshaft	• Inspect crankshaft. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. Refer to **Cylinder Leakage Test**. 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 Replacement - Left** or **Cylinder Head Replacement - Right**.
Cracked cylinder head	Replace the cylinder head and gasket.
Improper sealing of exhaust valve guide-to-cylinder head	Replace the cylinder head and gasket.
Cracked engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.
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**.

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Defective external oil cooler	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. Refer to **Cylinder Leakage Test**. 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 cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement - Left** or **Cylinder Head Replacement - Right**.
Cracked cylinder head	Replace the cylinder head and gasket.
Improper sealing of exhaust valve guide-to-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.
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**.
Faulty external engine oil cooler	Replace the components as required.

ENGINE COMPRESSION TEST

1. Disconnect the ignition coil wire harness connector at the front of the engine on the left cylinder bank and at the rear of the engine at the right cylinder bank.
2. Disconnect the fuel injector electrical harness connector at the rear of the intake manifold.
3. Remove all the spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery if the battery is not fully charged.
6. Start with the compression gauge at zero. Then crank the engine through four compression strokes (four puffs).

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7. Make the compression check the same for each cylinder. Record the reading.

   The minimum compression in any one cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any one cylinder is 1035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1035 x 70% = 725) (150 x 70% = 105).

8. If some cylinders have low compression, inject approximately 15 ml (one tablespoon) of engine oil into the combustion chamber through the spark plug hole.
   - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
   - Piston Rings Leaking - Compression is low on the first stroke. Then compression builds up with the following strokes but does not reach normal. Compression improves considerably when you add oil.
   - Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
   - If two adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the two cylinders.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

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

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

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

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1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** in Engine Controls - 8.1L.
3. Rotate the crankshaft to place the piston in the cylinder being tested at Top Dead Center (TDC) of the compression stroke.
4. Install the **J 35667-A** or equivalent.

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

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

Excessive oil consumption, not due to leaks, is the use of more than 0.95 liter (1 quart) of engine oil within 379 liters (100 gallons) of fuel used. However, during initial engine break-in periods 5 000-6 500 kilometers (3,000-4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or more per 379 liters (100 gallons) of fuel used. The causes of excessive oil consumption include the following conditions:

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

OIL PRESSURE DIAGNOSIS AND TESTING

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1. With the vehicle on a level surface, allow adequate drain down time, 2-3 minutes, and measure for the proper engine oil level. Too high an oil level will cause aeration within the oil.

   Add the recommended grade engine oil GM P/N 12345610, (Canadian P/N 993193), or equivalent, and fill the crankcase until the oil level measures FULL on the oil level indicator.

2. Operate the engine and verify low or no oil pressure on the vehicle oil pressure gage or oil indicator light.

   Listen for a noisy valve train or knocking noise.

3. Inspect for the following:
   - Engine oil diluted by moisture or unburned fuel mixtures
   - Improper engine oil viscosity for the expected temperature
   - Incorrect or faulty oil pressure gage sensor
   - Incorrect or faulty oil pressure gage
   - Plugged oil filter
   - Malfunctioning oil filter bypass valve
4. Remove the oil pressure gage sensor or another engine block oil gallery plug.
5. Install an oil pressure gage and measure the engine oil pressure.
6. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
   - Oil pump worn or dirty
   - Malfunctioning oil pump pressure relief valve
   - Oil pump screen loose, plugged, or damaged
   - Excessive bearing clearance or worn bearings
   - Cracked, porous or restricted oil galleries
   - Engine block oil gallery plugs missing or incorrectly installed
   - Broken valve lifters

OIL LEAK DIAGNOSIS

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.		

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	4. Check for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers - miles at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • 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**
	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		

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

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	• 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

A plugged positive crankcase ventilation (PCV) pipe/passage way may cause:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in the engine

DRIVE BELT CHIRPING DIAGNOSIS

Diagnostic Aids

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

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

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

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

4: Inspect all drive belt(s) for signs of pilling. Pilling is the small balls, pills or strings in the drive belt grooves caused from the accumulation of rubber dust.

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

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

12: Inspection of the accessory drive pulley(s) should include inspecting for bends, dents or other damage to the pulley(s) that would prevent the drive belt(s) from not seating properly in the pulley grooves or on the smooth surface of the pulley when the back side of the drive belt is used to drive the pulley.

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

Drive Belt Chirping Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt(s) or a accessory drive pulley. • Chirping may occur on cold damp start up conditions and will subside once the vehicle reaches normal operating temperature.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping noise. Does the engine make the chirping noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the chirping noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect for severe drive belt pilling exceeding 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the accessory drive belt pulley(s) with a suitable wire brush. Were the accessory drive pulley(s) cleaned?	Go to **Step 15**	-
6	Inspect for misaligned accessory drive pulley(s). Is there a misaligned accessory drive pulley(s)?	Go to **Step 7**	Go to **Step 8**

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7	Replace and/or repair the misaligned accessory drive pulley(s). Were the misaligned accessory drive pulley(s) replaced and/or repaired?	Go to **Step 15**	-
8	Inspect for a bent or cracked accessory drive bracket (s). Did you find any bent or cracked accessory drive bracket(s)?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent and/or cracked accessory drive bracket(s). Was the bent and/or cracked accessory drive bracket(s) replaced?	Go to **Step 15**	Go to **Step 10**
10	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose, and/or missing fasteners found?	Go to **Step 11**	Go to **Step 12**
11	Replace any incorrect and/or missing fasteners. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. Were the fasteners replaced and/or tightened?	Go to **Step 15**	-
12	Inspect for a bent accessory drive pulley(s). Was a bent accessory drive pulley(s) found?	Go to **Step 13**	Go to **Step 14**
13	Replace the bent accessory drive pulley(s). Was the bent accessory drive pulley(s) replaced?	Go to **Step 15**	-
14	Replace the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Was the drive belt(s) replaced?	Go to **Step 15**	-
15	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the chirping noise still exist?	-	System OK

DRIVE BELT SQUEAL DIAGNOSIS

Diagnostic Aids

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

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

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

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

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

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

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

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

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

Drive Belt Squeal Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt(s) (this is unusual for a drive belt with multiple ribs) • The squeal occurs when a heavy load is applied to the drive belt(s), such as an A/C compressor engagement, snapping the throttle, slipping on a seized pulley, or a faulty accessory drive component.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a squeal noise. Does the engine make the squeal noise?	Go to **Step 3**	Go to Diagnostic Aids
	1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt**		

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	Replacement - Air Conditioning. 2. Operate the engine for no longer than 30 to 40 seconds. Does the squealing noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect for a seized accessory drive component bearing or a faulty accessory drive component. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 5**
5	Inspect the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 6**
6	Check for the correct length drive belt(s). Did you find and correct the condition?	Go to **Step 9**	Go to **Step 7**
7	Inspect for misaligned pulley. Did you find and correct the condition?	Go to **Step 9**	Go to **Step 8**
8	Inspect for an incorrect size pulley. Did you find and correct the condition?	Go to **Step 9**	-
9	1. Install the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. 2. Clear any codes. 3. Run the engine in order to verify the repair. Does the squealing noise still exist?	-	System OK

DRIVE BELT WHINE DIAGNOSIS

Diagnostic Aids

The drive belt(s) will not cause the whine.

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

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

4: The inspection should include checking the drive belt tensioner and the drive belt idler pulley bearings.

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The drive belt(s) may have to be installed and the accessory drive components operated separately by varying their loads. Refer to the suspected accessory drive component for the proper removal and installation procedure.

Drive Belt Whine Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: A high pitched continuous noise that may be caused by an accessory drive component failed bearing.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a whining noise. Does the engine make the whining noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the whining noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	1. Inspect for a failed accessory drive component bearing. 2. Install the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Did you find and correct the condition?	Go to **Step 5**	-
5	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the whining noise still exist?	-	System OK

DRIVE BELT RUMBLING DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

3: This test is to verify that the drive belt(s) is causing the rumbling. Rumbling may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. Operate the engine for a few seconds, this will verify if the rumbling noise is related to the drive belt(s) or not. With the drive belt(s) removed the water pump will not operate and the engine may overheat. Also diagnostic trouble codes (DTCs) may set when the engine is operated with the drive belt(s) removed.

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

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

Drive Belt Rumbling Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt(s) or pulley(s). • Rumbling may be caused from: o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt(s) pulley groove o The separation of the drive belt(s) o A damaged drive belt(s)			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to **Step 3**	Go to Diagnostic Aids
	1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**.		

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3	2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect the drive belt(s) for damage, separation, or sections of missing ribs. Were any of these conditions found?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt groove depth. Do the drive belt grooves have pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Did you complete the repair?	Go to **Step 8**	-
7	Install a new drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Did you complete the replacement?	Go to **Step 8**	-
8	1. Clear any codes. 2. Run the engine in order to verify the repair. Does the rumbling noise still exist?	-	System OK

DRIVE BELT VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components may have an affect on engine vibration. An overcharged air conditioning (A/C) system, a power steering system restriction, or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

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

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

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

8: This step should only be performed if the fan is driven by the drive belt(s). Inspect the engine cooling fan for bent, twisted, loose, or cracked blades. Inspect the fan clutch for smooth operation. Inspect for a bent fan shaft or bent mounting flange.

9: Inspect the water pump drive shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known, good water pump.

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

Drive Belt Vibration Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that the vibration is engine related. Does the engine make the vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. 2. Operate the engine for no longer than 30 to 40 seconds. Does the engine still make the vibration?	Go to **Engine Noise on Start-Up, but Only Lasting a Few Seconds**	Go to **Step 4**
4	Inspect the drive belt(s) for wear, damage, debris build-up and missing drive belt ribs. Were any of these conditions found?	Go to **Step 5**	Go to **Step 6**
5	Install a new drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Did you complete the replacement?	Go to **Step 11**	-
6	Inspect for incorrect, loose or missing fasteners. Were any of these conditions found?	Go to **Step 7**	Go to **Step 8**
	Replace the incorrect or missing fasteners. Tighten any loose fasteners. Refer to **Fastener**		

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7	**Tightening Specifications**. Were the fasteners replaced and/or tightened?	Go to **Step 11**	-
8	Inspect for damaged fan blades or a bent fan clutch shaft. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 9**
9	Inspect for a bent water pump drive shaft. Did you find and correct the condition?	Go to **Step 11**	Go to **Step 10**
10	Inspect for bent or cracked accessory drive bracket(s). Did you find and correct the condition?	Go to **Step 11**	-
11	1. Clear any codes. 2. Run the engine in order to verify the repair. Did you correct the condition?	-	System OK

DRIVE BELT FALLS OFF DIAGNOSIS

Diagnostic Aids

If the drive belt(s) repeatedly falls off the accessory drive pulley(s), this may be caused by a pulley misalignment.

An extra load that is quickly applied or released by an accessory drive component may cause the drive belt(s) to fall off. Verify that the accessory drive component(s) are operating properly.

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

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

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

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

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

6: Accessory drive component brackets that are bent or cracked will also cause the drive belt(s) to fall off.

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

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bracket(s) moving under load. Over tightening the fasteners may cause misalignment of the accessory component bracket(s).

Drive Belt Falls Off Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: The drive belt(s) falls off the pulleys or may not ride correctly on the pulleys.			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect for a damaged drive belt(s). Was a damaged drive belt(s) found?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**. Does the drive belt(s) continue to fall off?	Go to **Step 4**	System OK
4	Inspect for a misaligned accessory drive pulley(s). Did you find and correct the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented accessory drive pulley(s). Did you find and correct the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked accessory drive bracket (s). Did you find and correct the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for incorrect, loose and/or missing fasteners. Were there any incorrect, loose and/or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	Replace and incorrect and/or missing fasteners. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for correct operation. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** or **Drive Belt Tensioner Replacement - Air Conditioning**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for a failed drive belt idler(s) and/or tensioner pulley(s) bearing. Did you find and repair the condition?	Go to **Step 12**	-
12	Run the engine in order to verify the repair. Does the drive belt still fall off?	-	System OK

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DRIVE BELT EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

Minor misalignment of the accessory drive pulley(s) will not cause excessive wear, but will probably cause the drive belt(s) to make a noise or fall off.

Excessive misalignment of the accessory drive pulley(s) will cause excessive wear and may also make the drive belt(s) fall off.

Test Description

The number(s) below refer to the step(s) in the diagnostic table.

2: This inspection is to verify that the drive belt(s) is correctly installed on all of the accessory drive pulley(s). Wear on the drive belt(s) may be caused by mis-positioning the drive belt(s) by one or more grooves on a pulley(s).

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

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

Drive Belt Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice in Cautions and Notices.** DEFINITION: Wear at the outside ribs of the drive belt(s) due to incorrect installation of the drive belt (s).			
1	Did you review the Symptoms - Engine Mechanical diagnostic information and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Inspect the drive belt(s) for proper installation. Is the drive belt(s) installed properly?	Go to **Step 5**	Go to **Step 3**
3	Inspect for the correct drive belt(s). Is the correct drive belt installed?	Go to **Step 5**	Go to **Step 4**
4	Inspect the drive belt(s) for signs of rubbing against a bracket, hose, or wiring harness. Was the drive belt(s) rubbing against anything?	Go to **Step 6**	Go to Diagnostic Aids
	Replace the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement**		

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5	**- Air Conditioning**. Did you complete the replacement?	Go to **Step 6**	-
6	Run the engine in order to verify the repair. Is there still excessive drive belt wear?	-	System OK

DRIVE BELT TENSIONER DIAGNOSIS

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

1. Remove the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**.
2. Position a hex-head socket on the belt tensioner pulley bolt head.
3. Move the drive belt tensioner through its full travel.
   - The movement should feel smooth.
   - There should be no binding.
   - The tensioner should return freely.
4. If any binding is observed, replace the drive belt tensioner(s). Refer to **Drive Belt Tensioner Replacement - Accessory** or **Drive Belt Tensioner Replacement - Air Conditioning**.
5. Install the drive belt(s). Refer to **Drive Belt Replacement - Accessory** or **Drive Belt Replacement - Air Conditioning**.

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Drive Belt Replacement - Accessory

Removal Procedure

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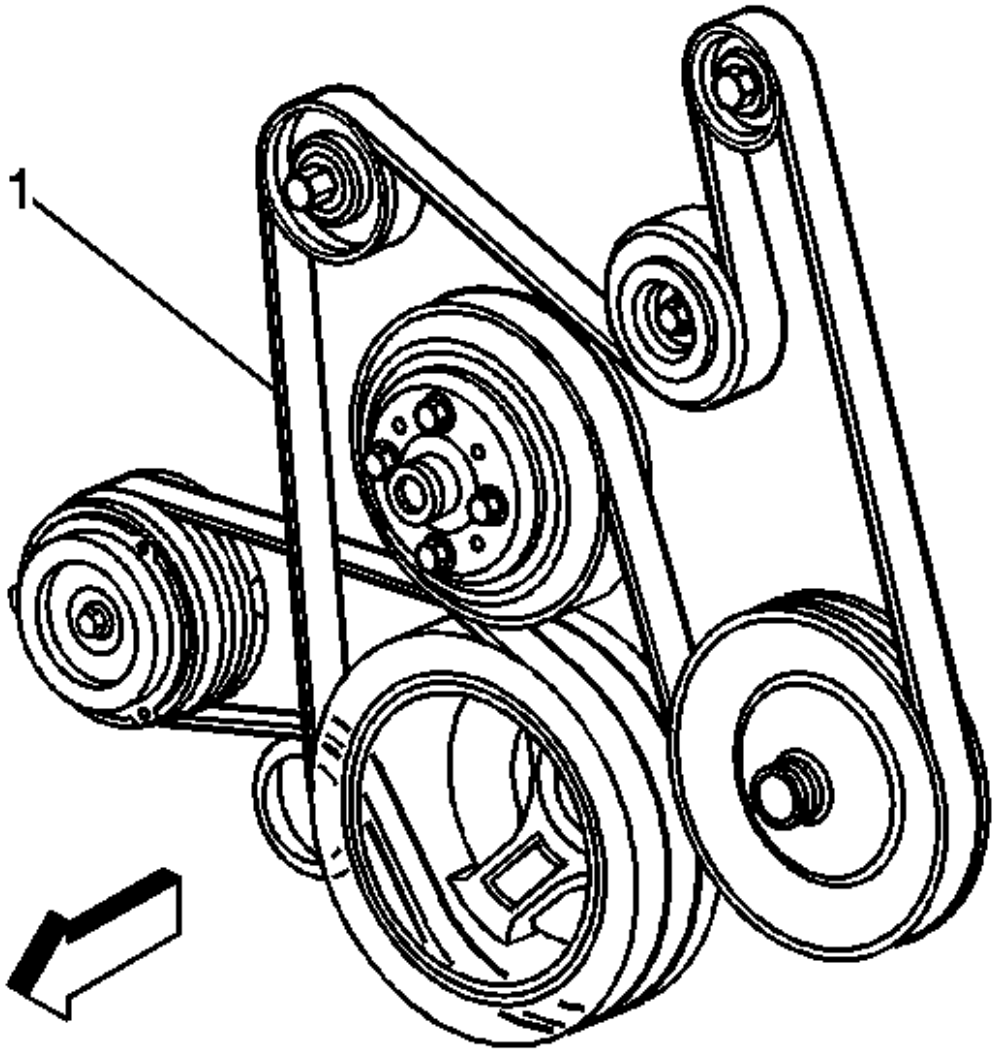

Fig. 9: View Of Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Install a breaker bar with hex-head socket to the drive belt tensioner bolt.
2. Rotate the drive belt tensioner clockwise in order to relieve tension on the belt (1).
3. Remove the belt (1) from the pulleys and the drive belt tensioner.
4. Slowly release the tension on the drive belt tensioner.
5. Remove the breaker bar and socket and from the drive belt tensioner bolt.
6. Clean and inspect the belt surfaces of all the pulleys.

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Installation Procedure

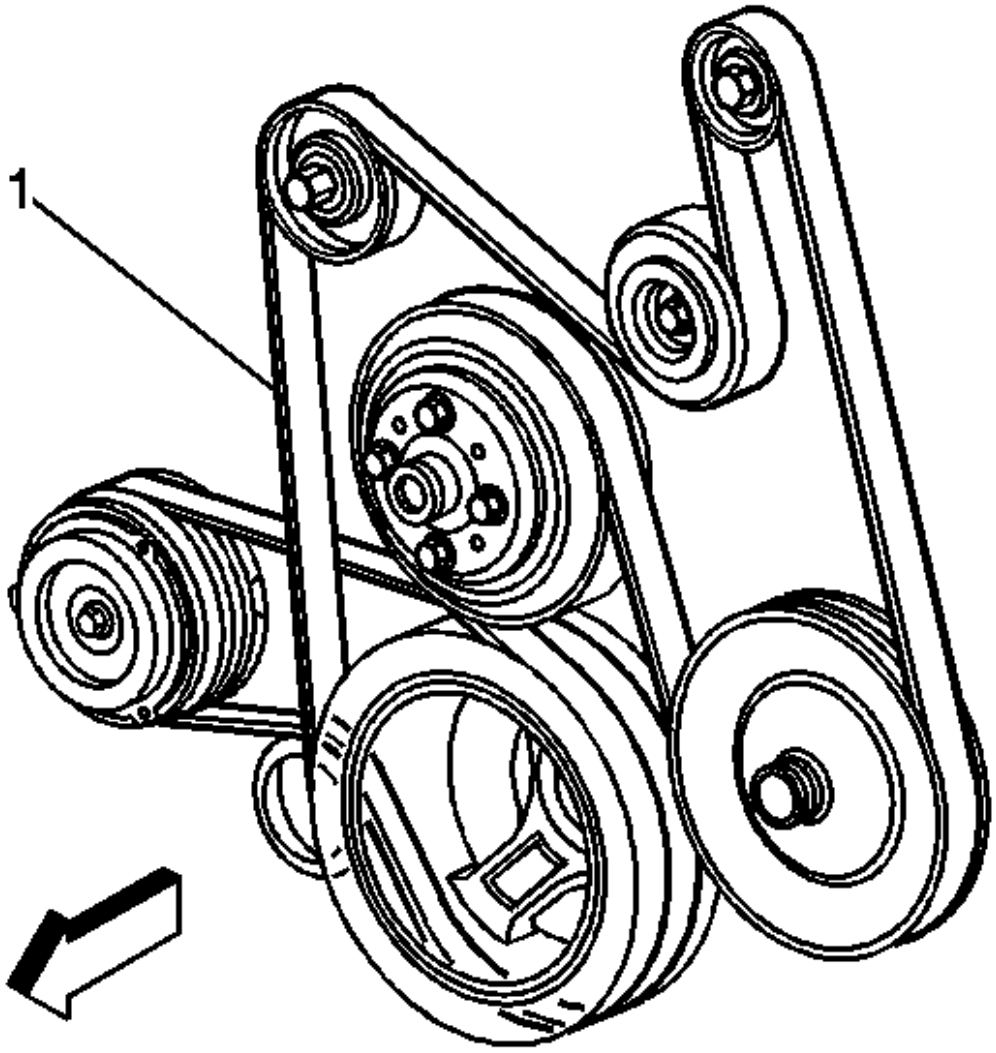

Fig. 10: View Of Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

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 (1) under the idler pulley.

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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.

Drive Belt Replacement - Air Conditioning

Removal Procedure

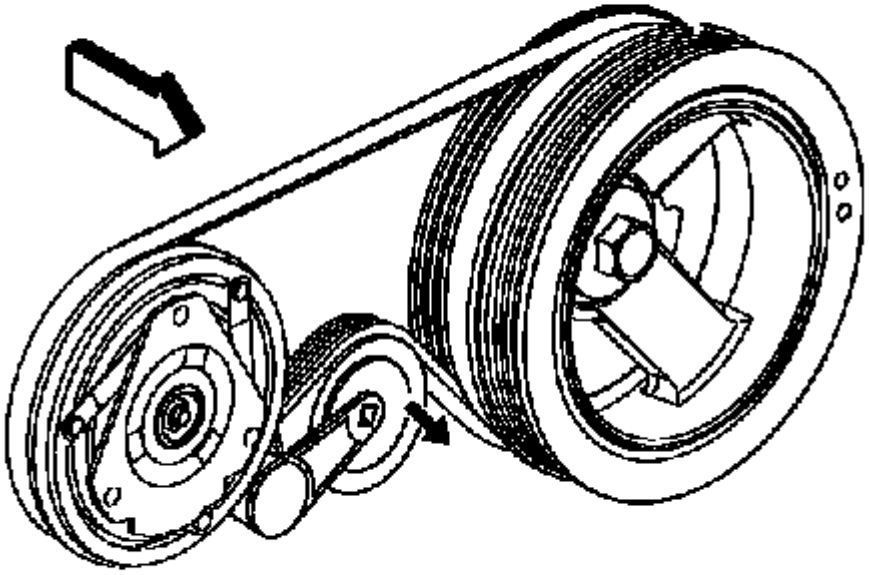

Fig. 11: View Of A/C Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt. Refer to **Drive Belt Replacement - Accessory**.
2. Install a breaker bar into the air conditioning (A/C) belt tensioner adapter opening.
3. Rotate the A/C belt tensioner clockwise in order to relieve tension on the belt.
4. Remove the A/C belt from the pulleys.
5. Slowly release the tension on the A/C belt tensioner.
6. Remove the breaker bar from the A/C belt tensioner.
7. Clean and inspect the belt surfaces of all the pulleys.

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Installation Procedure

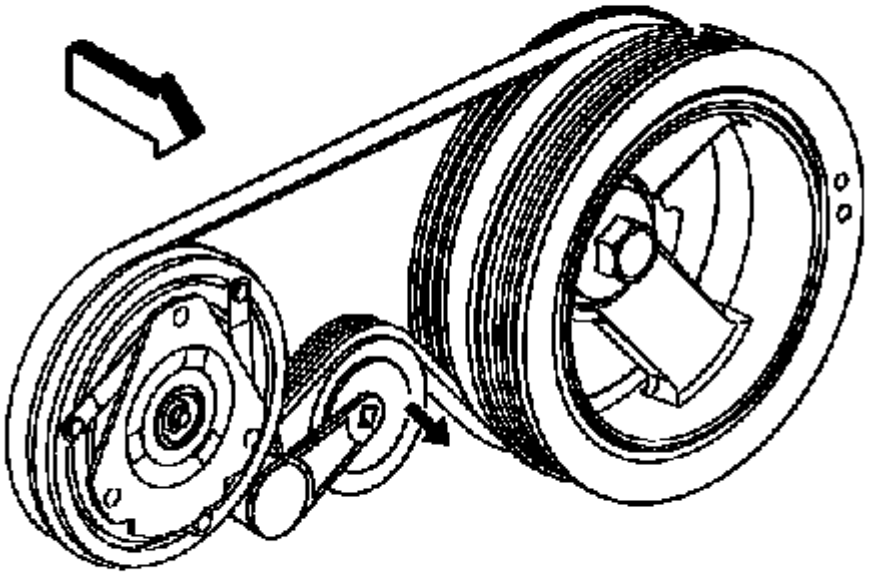

Fig. 12: View Of A/C Drive Belt Routing
Courtesy of GENERAL MOTORS CORP.

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

Drive Belt Tensioner Replacement - Accessory

Removal Procedure

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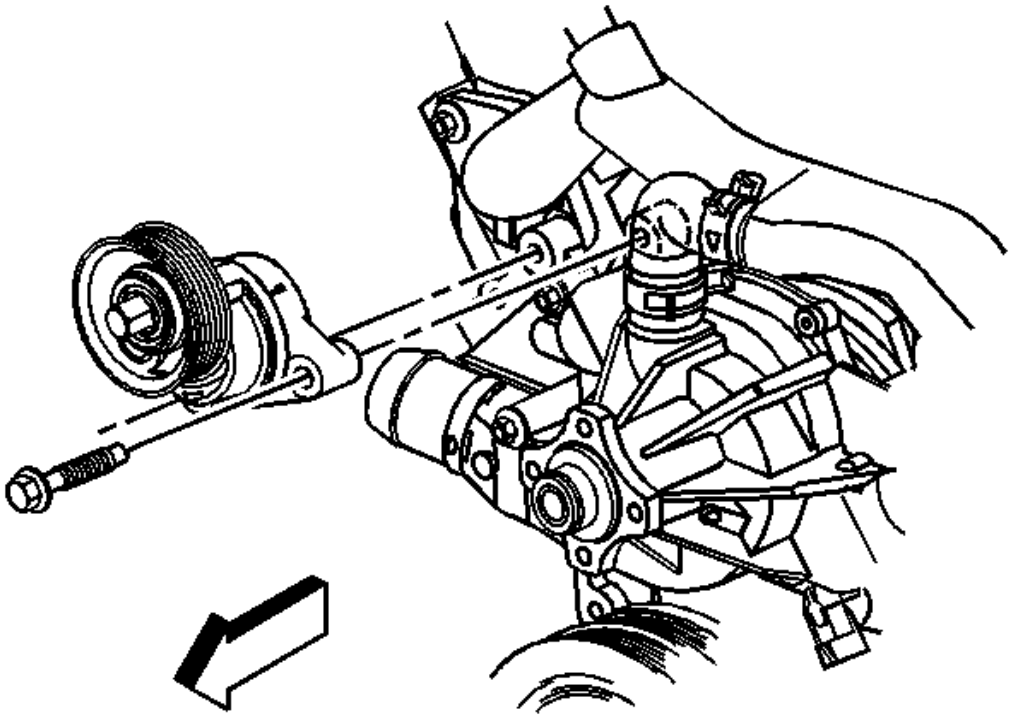

Fig. 13: View Of Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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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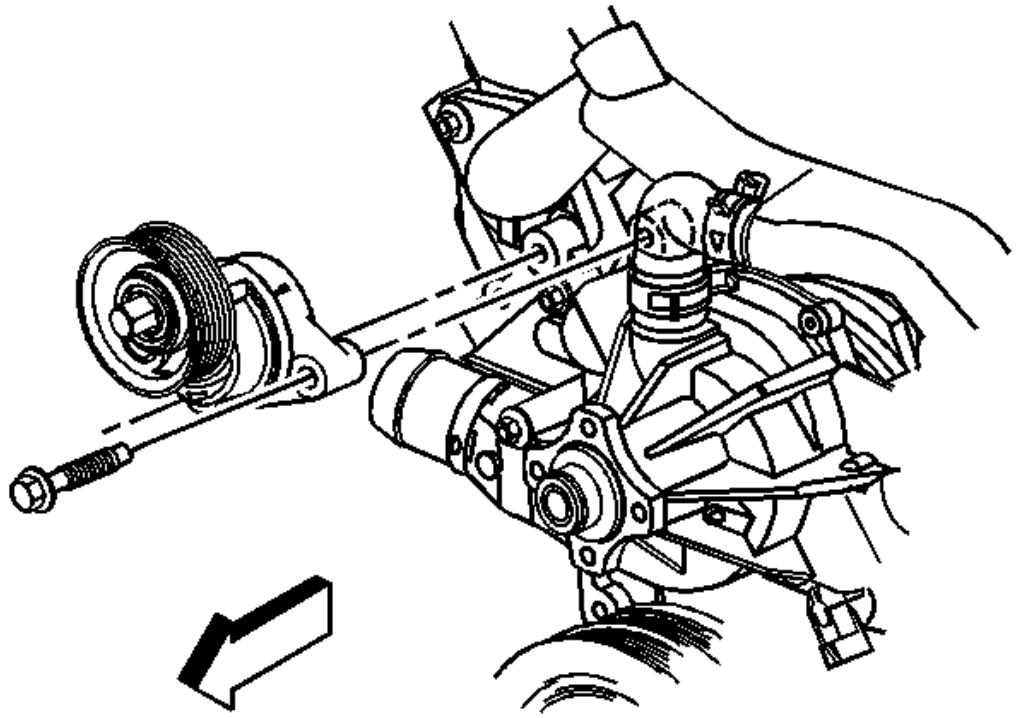

Fig. 14: View Of Accessory Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the drive belt tensioner bolts.

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

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

Drive Belt Tensioner Replacement - Air Conditioning

Removal Procedure

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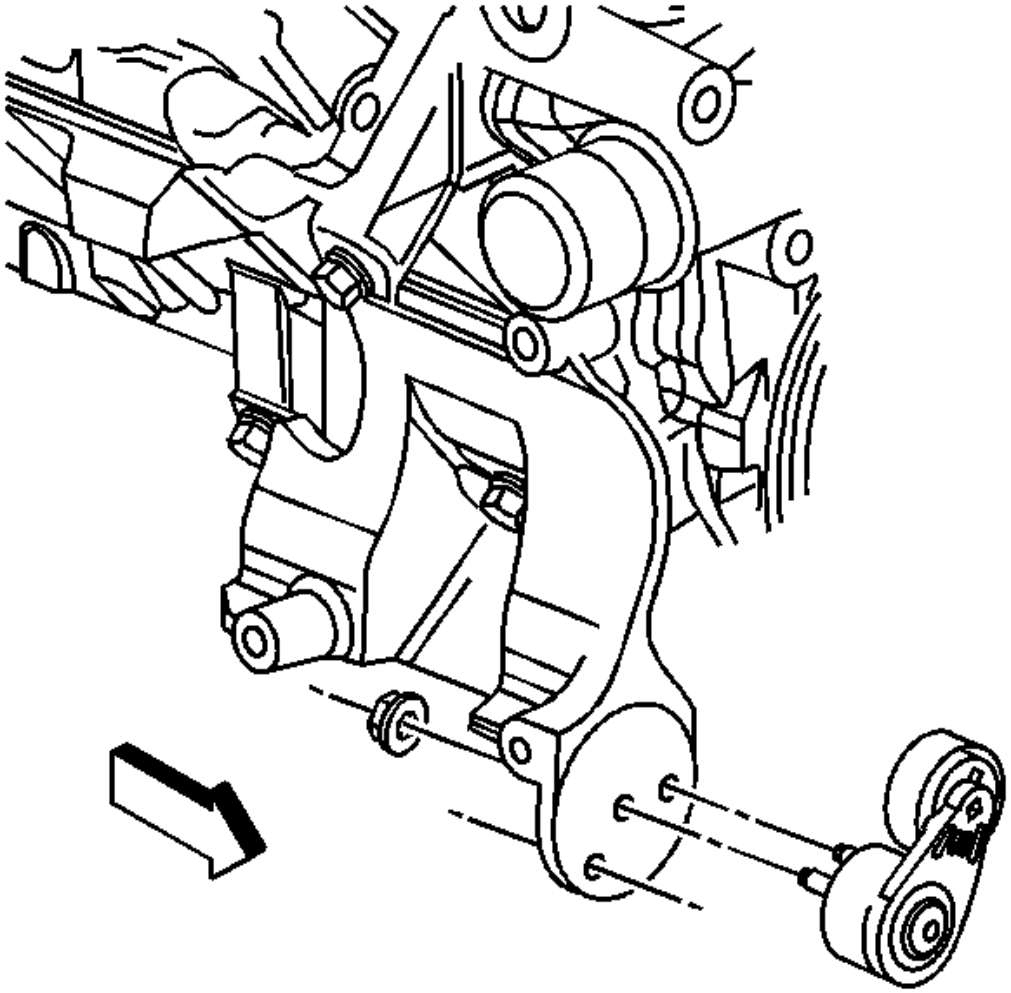

Fig. 15: View Of Air Conditioning Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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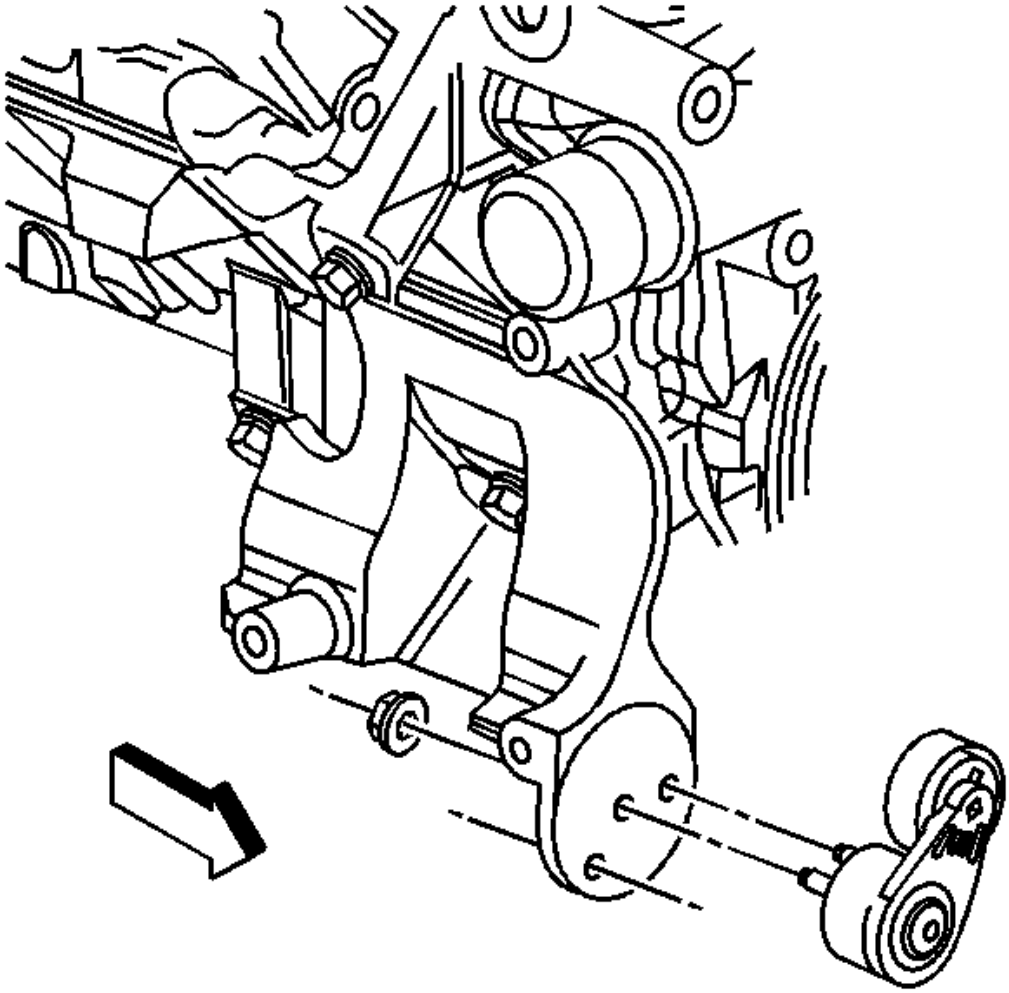

Fig. 16: View Of Air Conditioning Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

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

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Drive Belt Idler Pulley Replacement

Removal Procedure

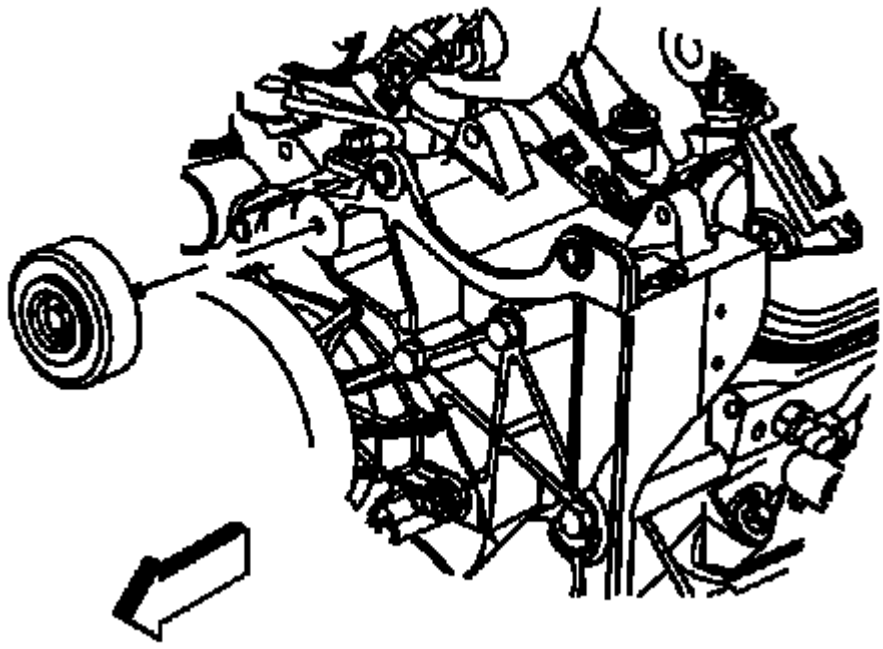

Fig. 17: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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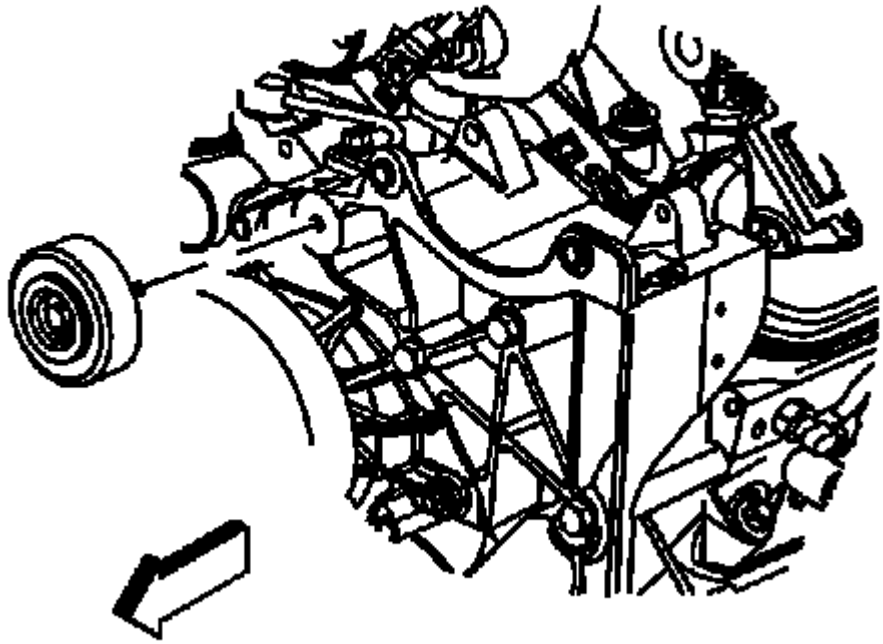

Fig. 18: View Of Drive Belt Idler Pulley
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

   Snug the bolt finger tight.

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

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

Engine Mount Inspection

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

NOTE: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance

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between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

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

Engine Mount Replacement - Left

Removal Procedure

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

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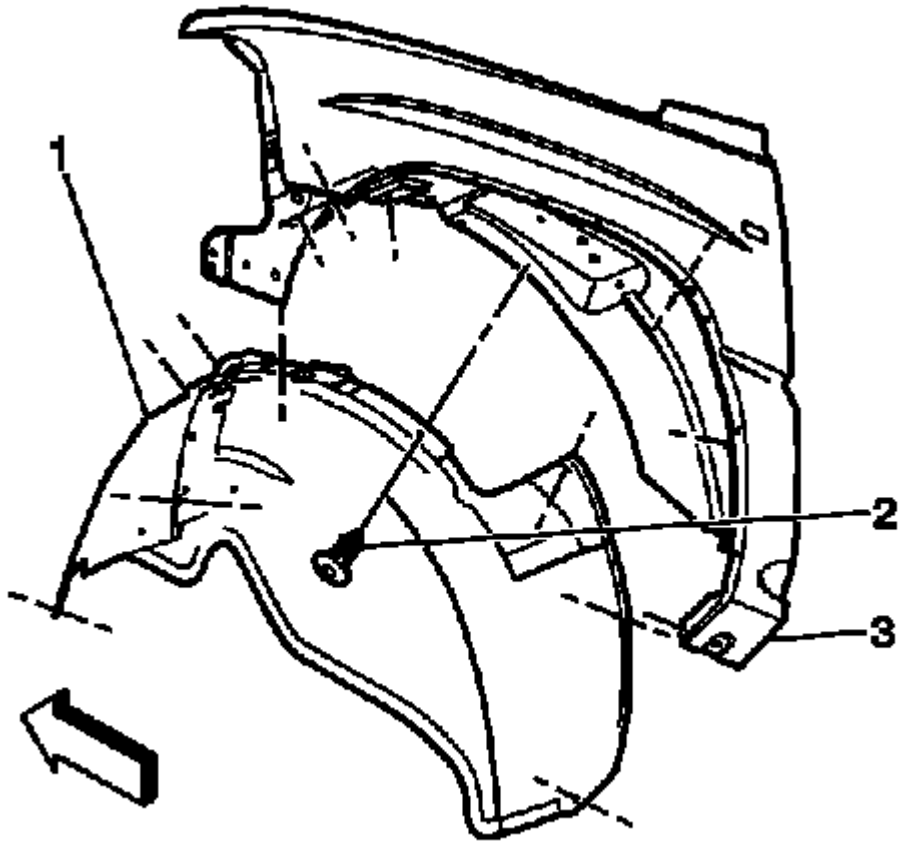

Fig. 19: View Of Wheelhouse Panel & Push-In Retainers
Courtesy of GENERAL MOTORS CORP.

1. If vehicle is a 2 wheel drive (2WD), raise the vehicle to a height to work through the front wheelhouse opening.
2. If vehicle is a 4 wheel drive (4WD), raise the vehicle in order to remove the front tires and wheels.
3. Remove the left front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
4. Remove the wheelhouse inner panel push pin retainers (2).
5. Remove the wheelhouse inner panel (1).

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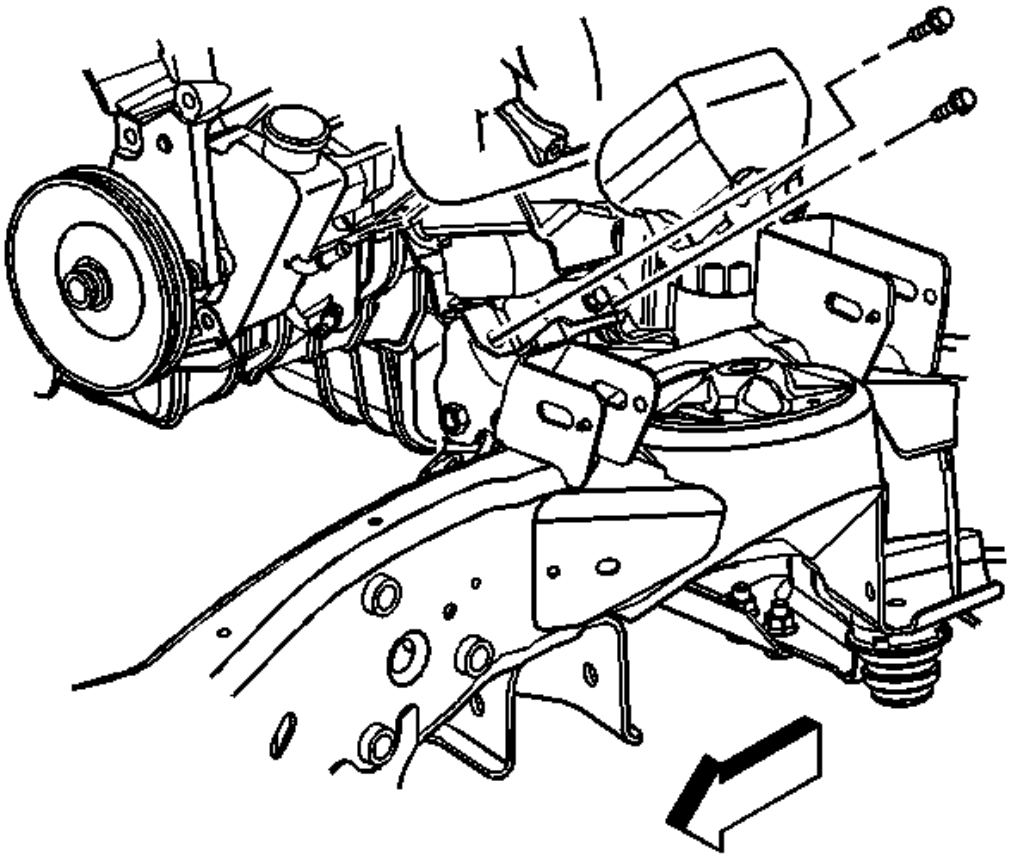

Fig. 20: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

6. Working through the wheelhouse opening, remove the engine mount heat shield bolts.
7. Remove the engine mount heat shield.

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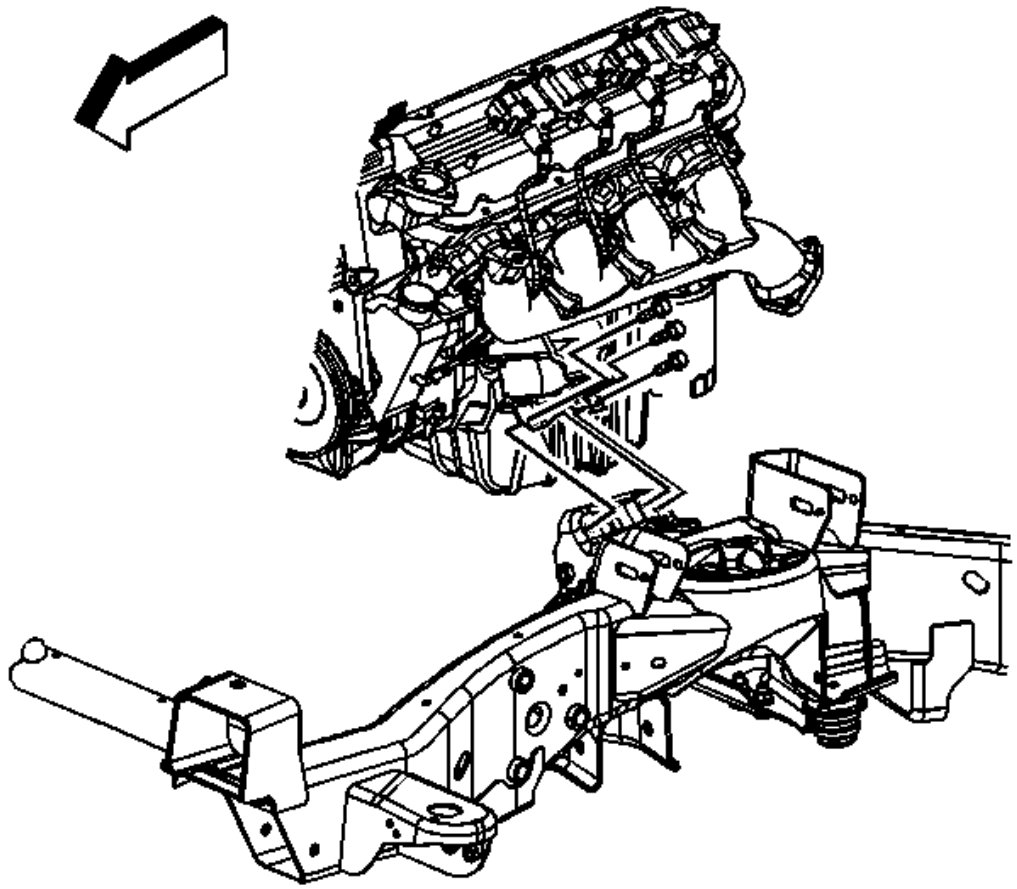

Fig. 21: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount-to-engine mount bracket bolt.

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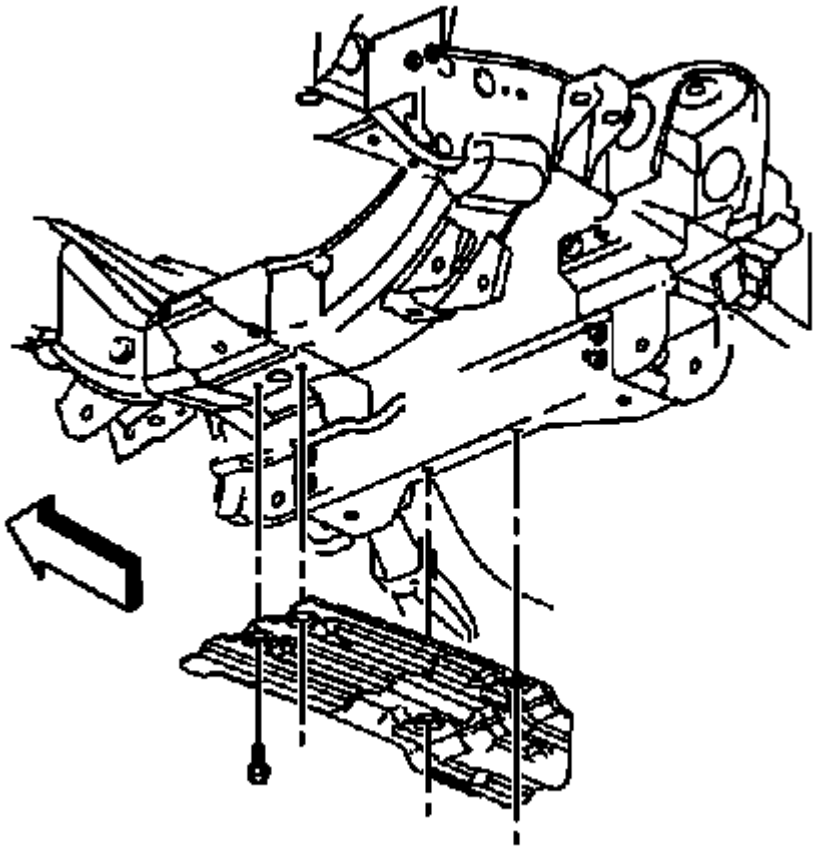

Fig. 22: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

9. If equipped, remove the oil pan skid plate bolts and plate.

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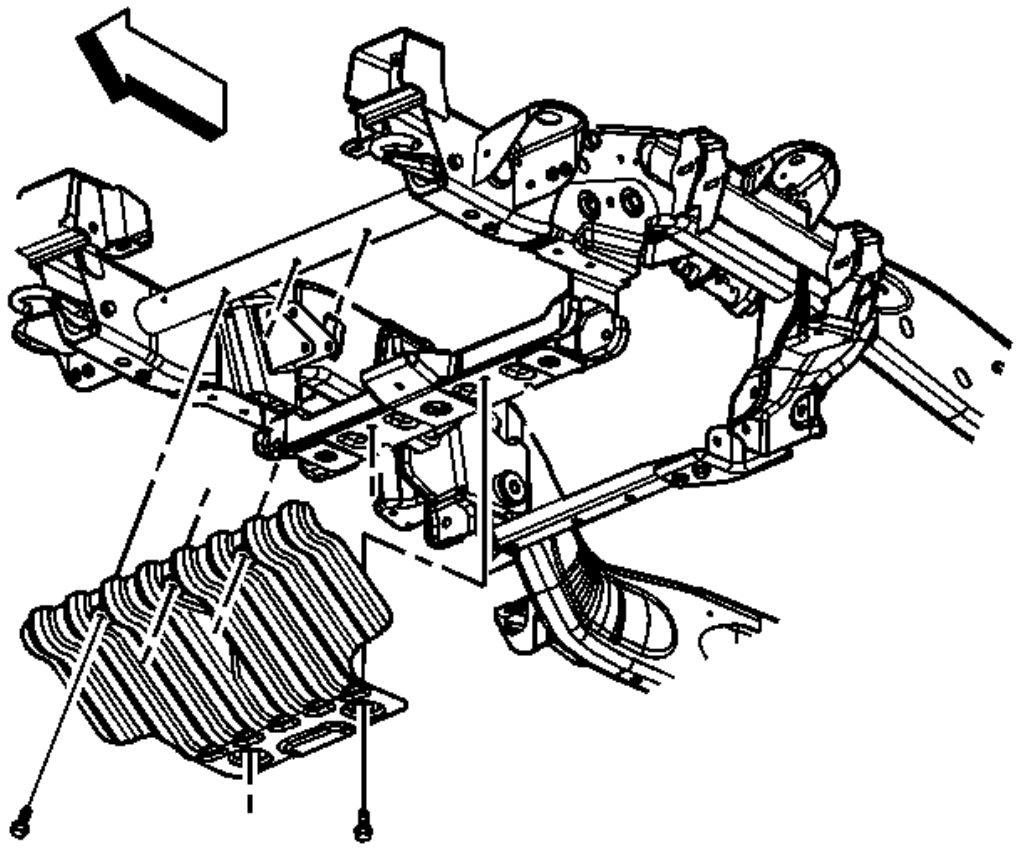

Fig. 23: View Of Engine Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When raising the engine only raise it enough to separate the engine mount from the engine mount bracket.

10. Remove the engine shield bolts and shield.
11. Raise the engine with a suitable jack in order to remove the engine mount and bracket.

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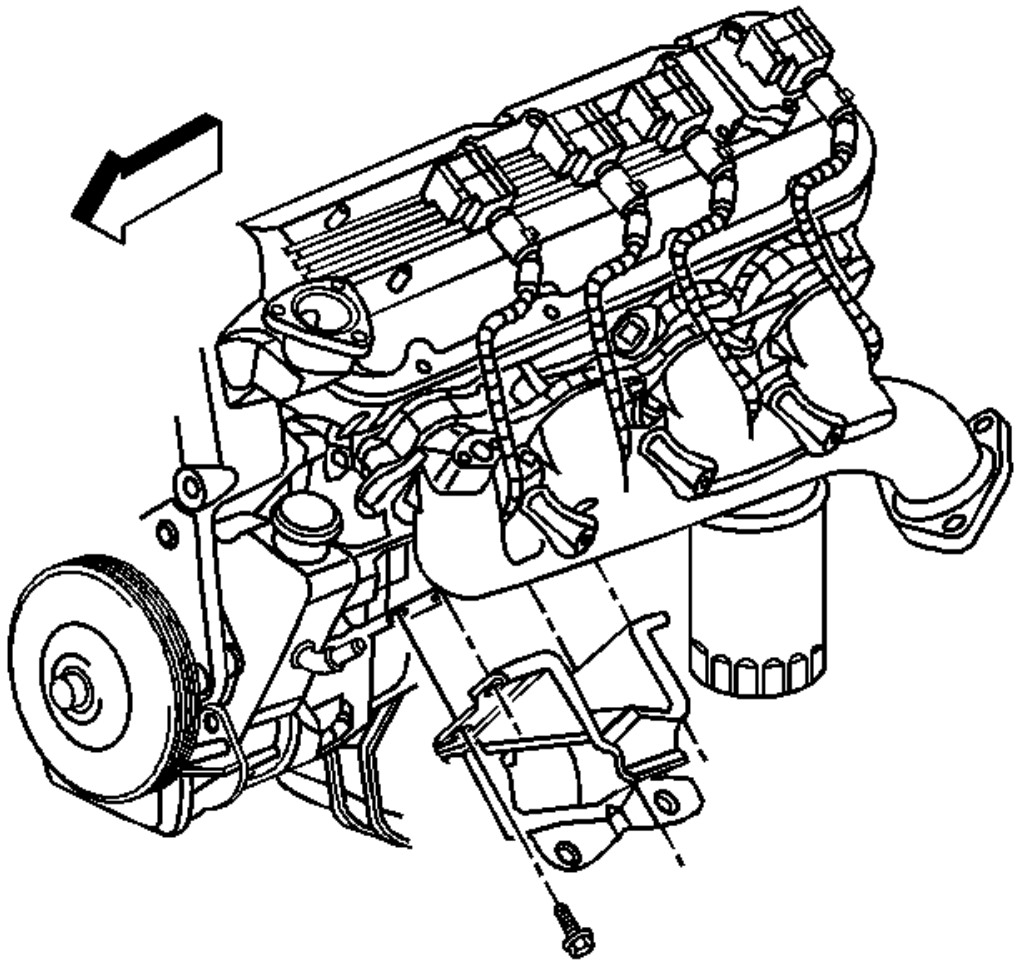

Fig. 24: View Of Engine Mount-To-Engine Bolts & Engine Mount
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine mount-to-engine bolts.
13. Remove the engine mount.

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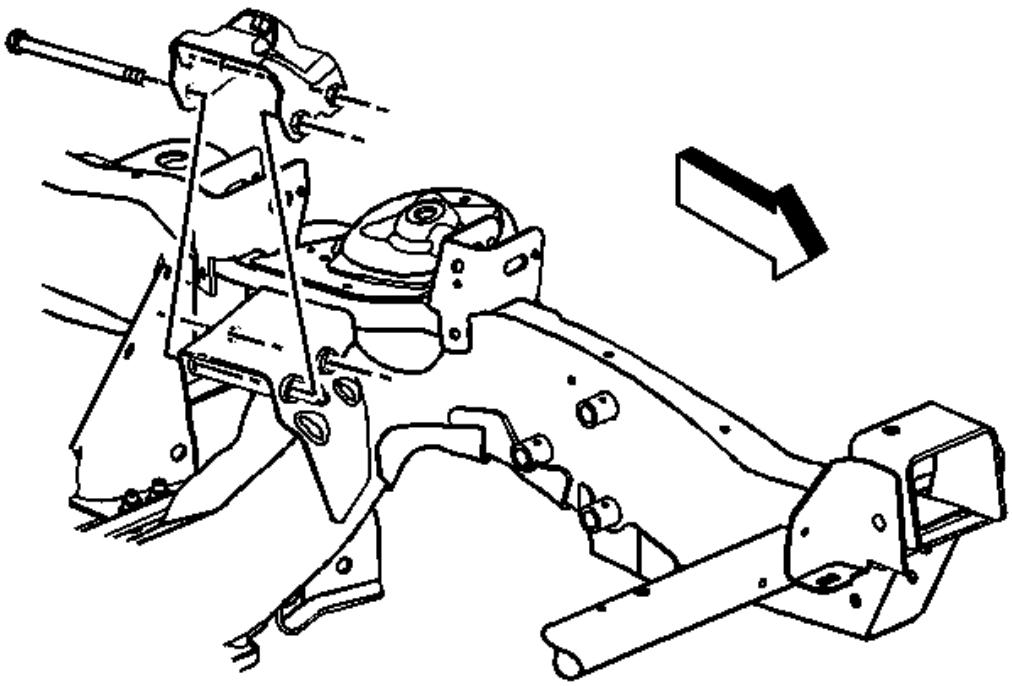

Fig. 25: View Of Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine mount bracket through bolts.
15. Remove the engine mount bracket.

Installation Procedure

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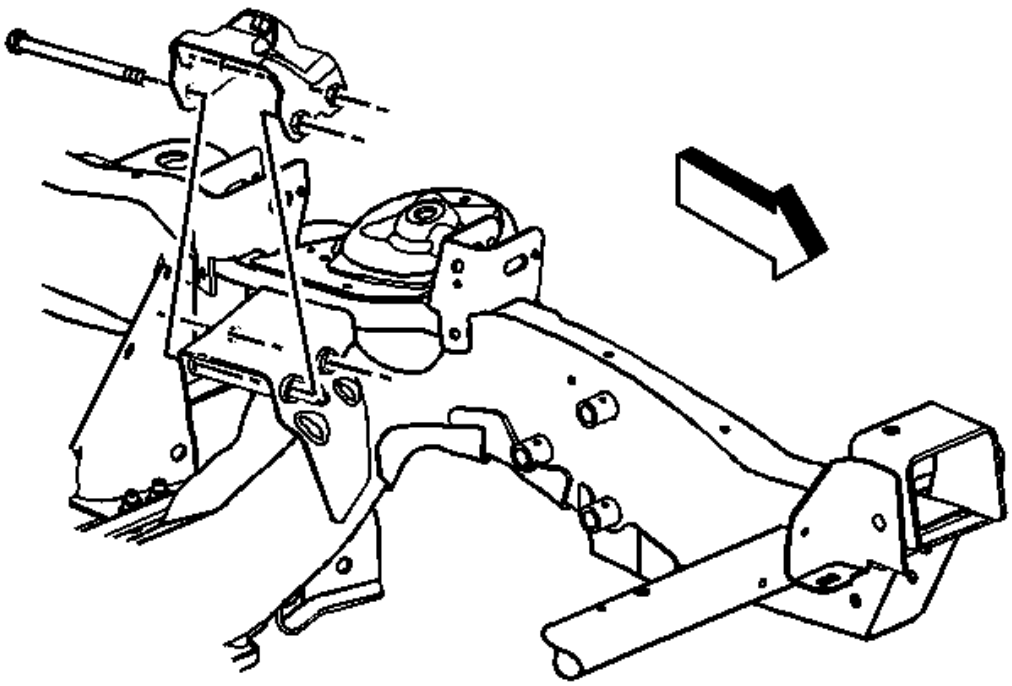

Fig. 26: View Of Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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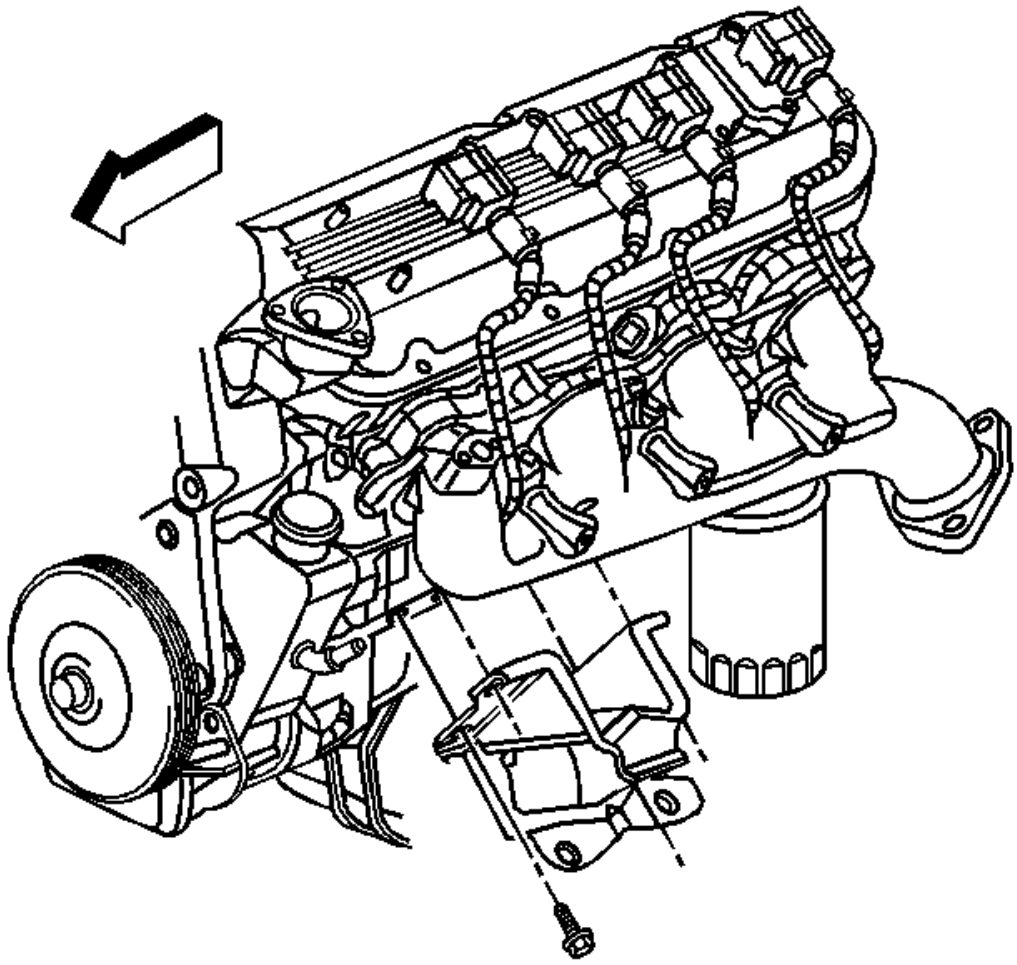

Fig. 27: View Of Engine Mount-To-Engine Bolts & Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Position the engine mount to engine.
5. Loosely install the engine mount-to-engine bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the engine mount bracket through bolts and engine mount-to-engine bolts.

Tighten:

- Tighten the engine mount bracket through bolts to 75 N.m (55 lb ft).
- Tighten the engine mount-to-engine bolts to 50 N.m (37 lb ft).

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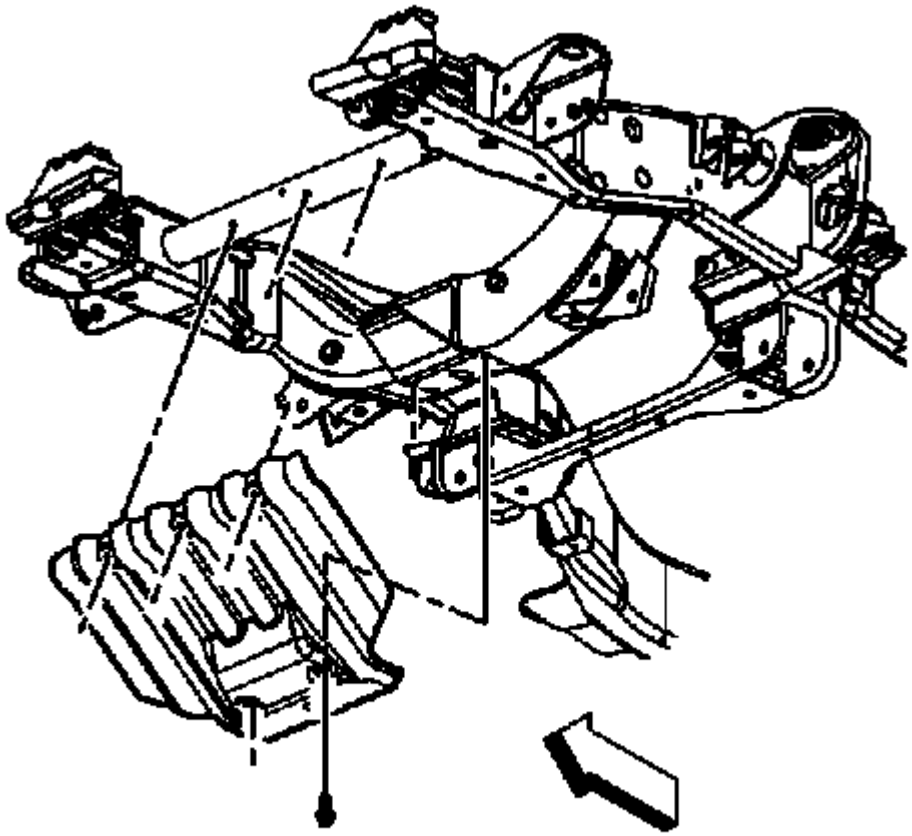

Fig. 28: Identifying Engine Shield And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the engine shield and bolts.

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

8. Lower the engine.

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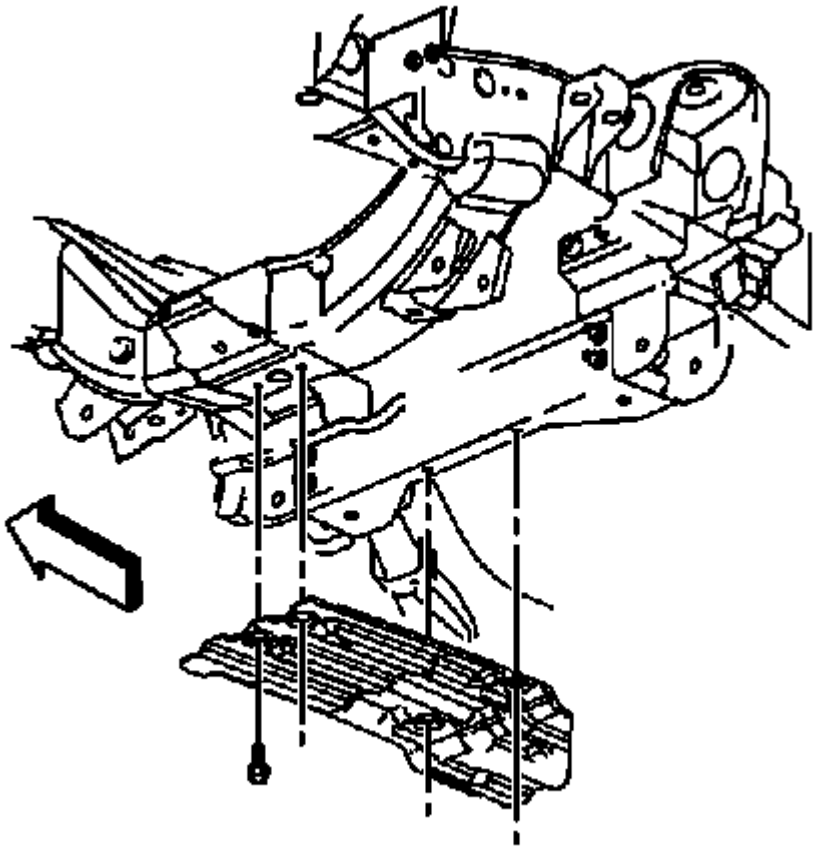

Fig. 29: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

9. If equipped, install the oil pan skid plate and bolts.

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

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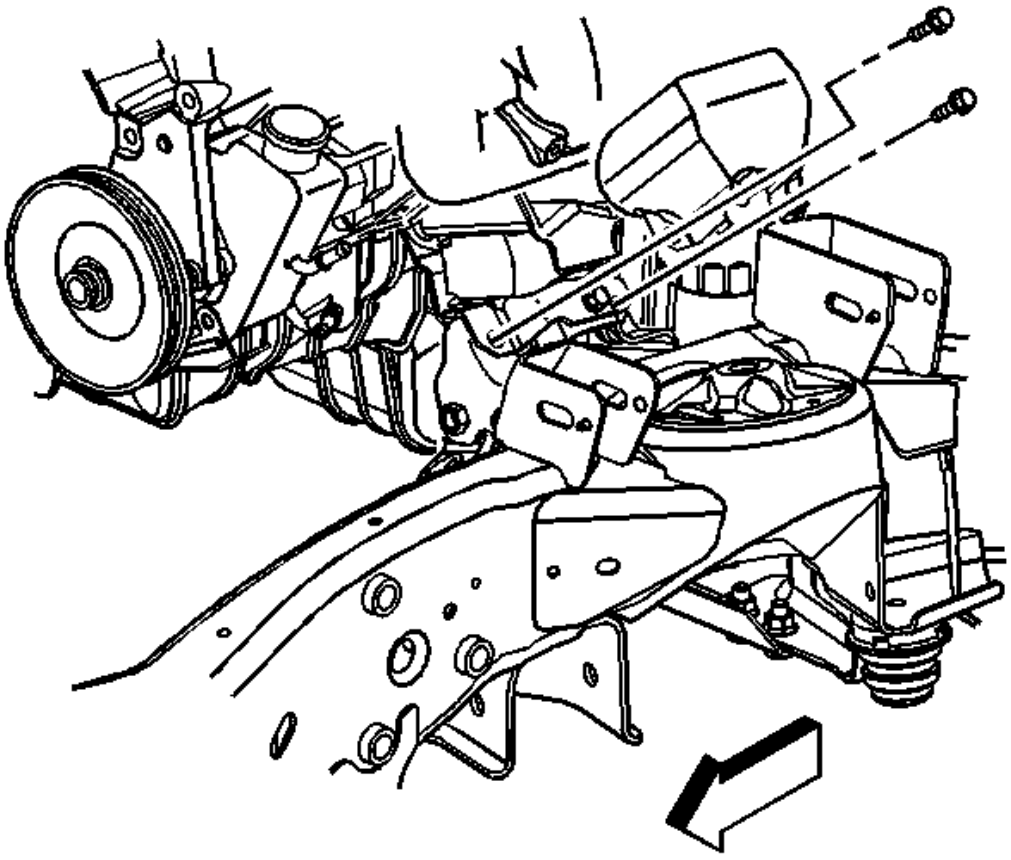

Fig. 30: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

10. Install the engine mount heat shield.

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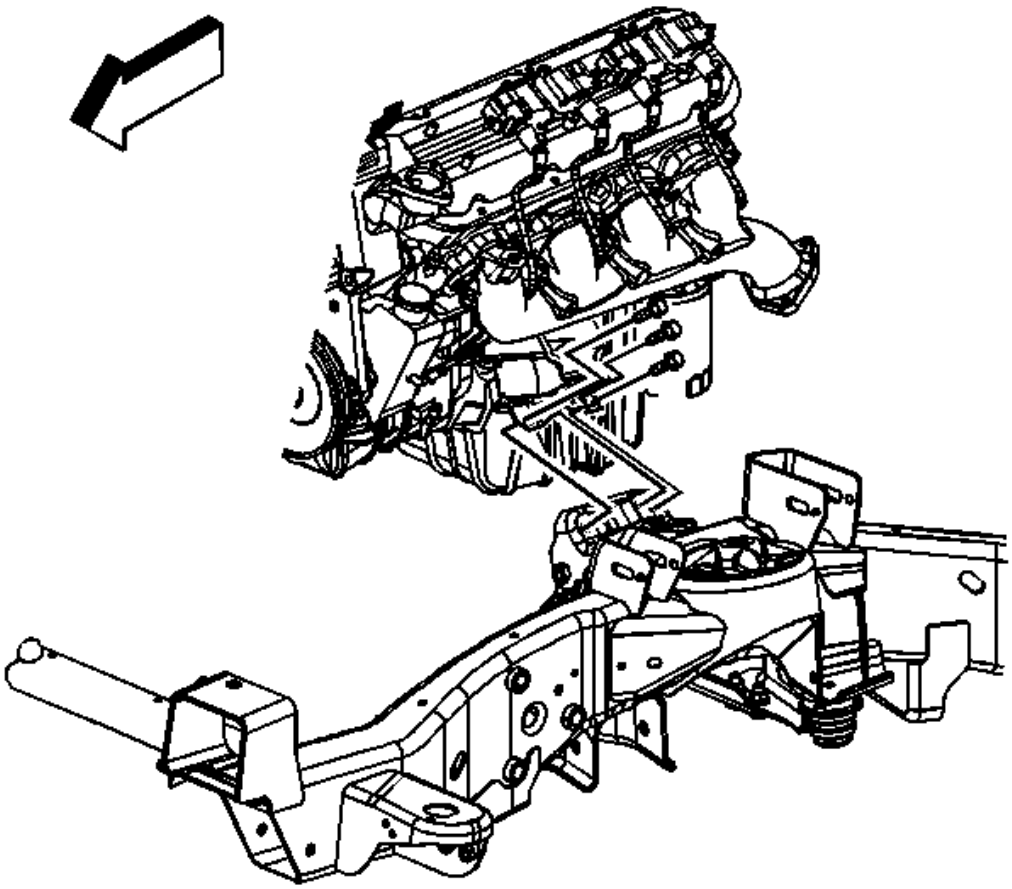

Fig. 31: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

11. Install the engine mount-to-engine mount bracket bolts.

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

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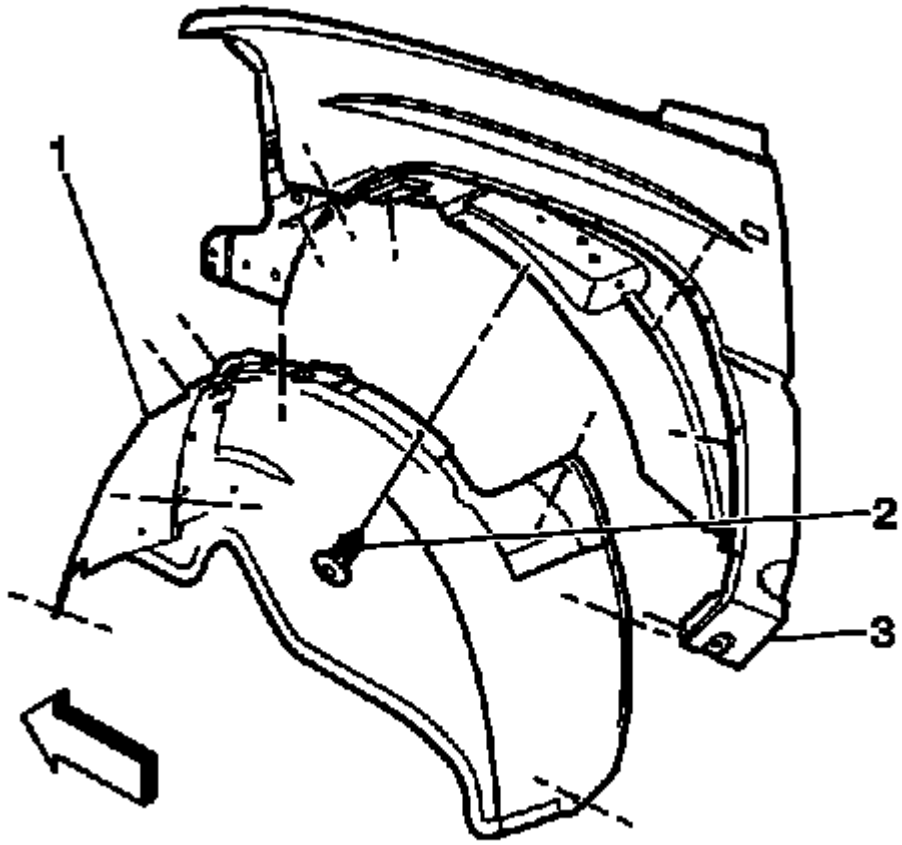

Fig. 32: View Of Wheelhouse Panel & Push-In Retainers
Courtesy of GENERAL MOTORS CORP.

12. Install the wheelhouse inner panel (1).
13. Install the wheelhouse inner panel push pin retainers (2).
14. Install the left front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
15. Lower the vehicle.

Engine Mount Replacement - Right

Removal Procedure

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

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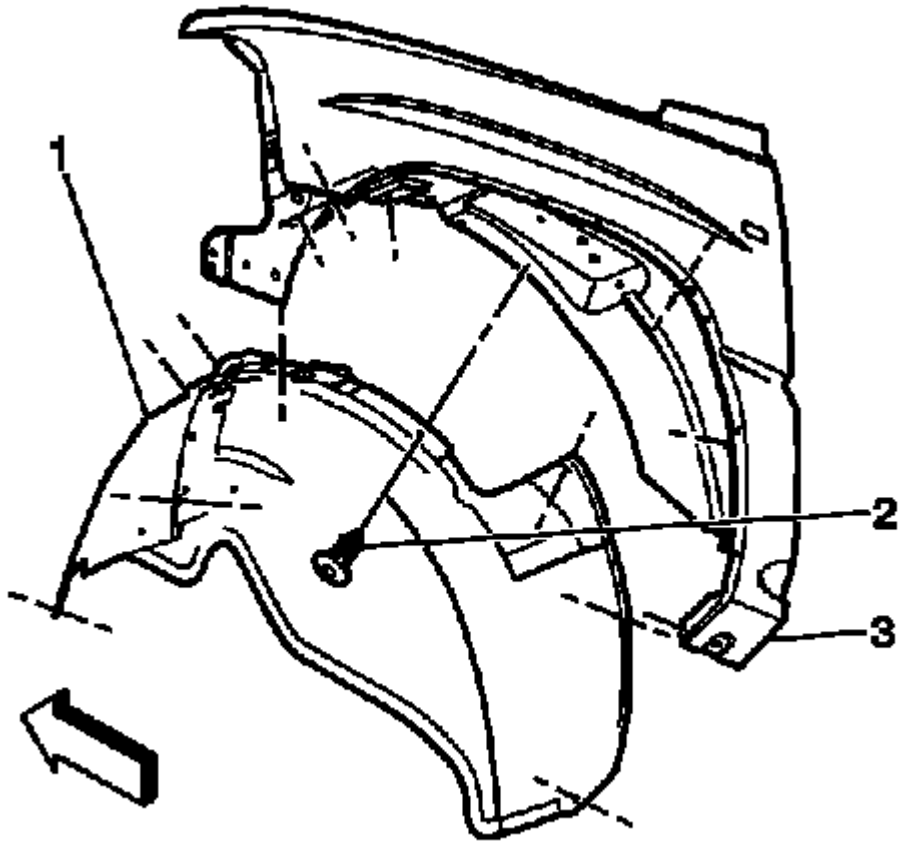

Fig. 33: View Of Wheelhouse Panel & Push-In Retainers
Courtesy of GENERAL MOTORS CORP.

1. If vehicle is a 2 wheel drive (2WD), raise the vehicle to a height to work through the front wheelhouse opening.
2. If vehicle is a 4 wheel drive (4WD), raise the vehicle in order to remove the front tires and wheels.
3. Remove the left front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
4. Remove the wheelhouse inner panel push pin retainers (2).
5. Remove the wheelhouse inner panel (1).

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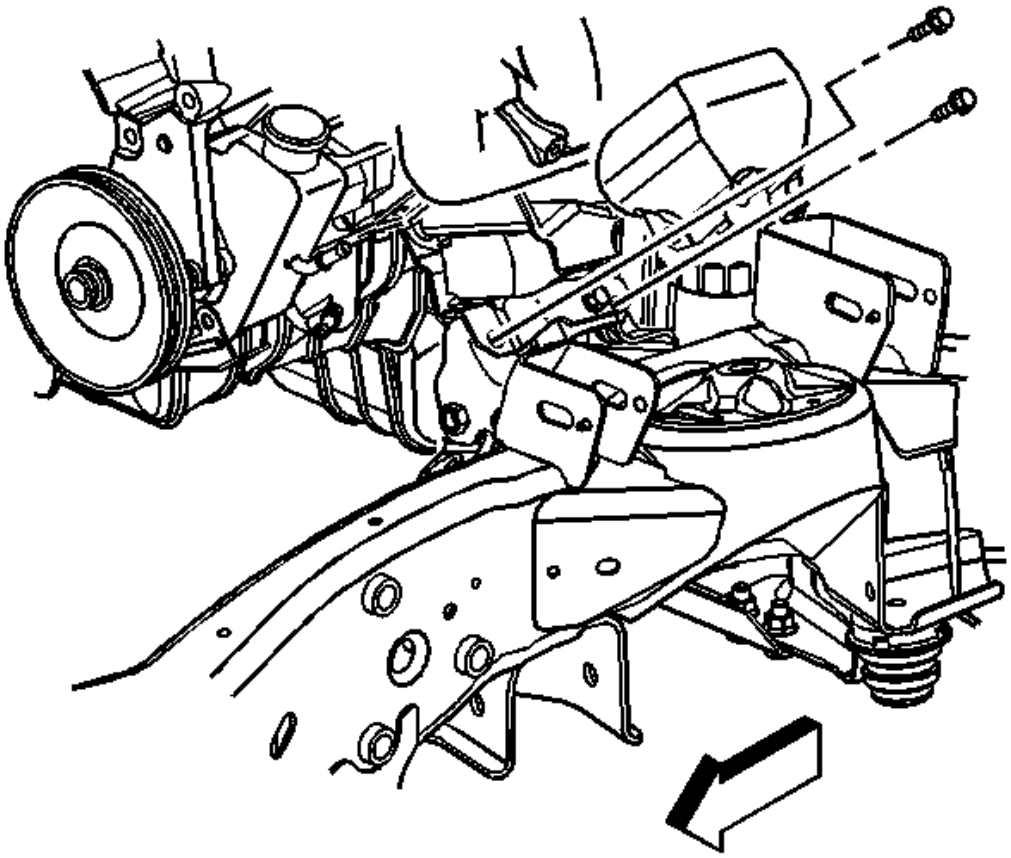

Fig. 34: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

6. Working through the wheelhouse opening, remove the engine mount heat shield bolts (left side shown, right side similar).
7. Remove the engine mount heat shield.

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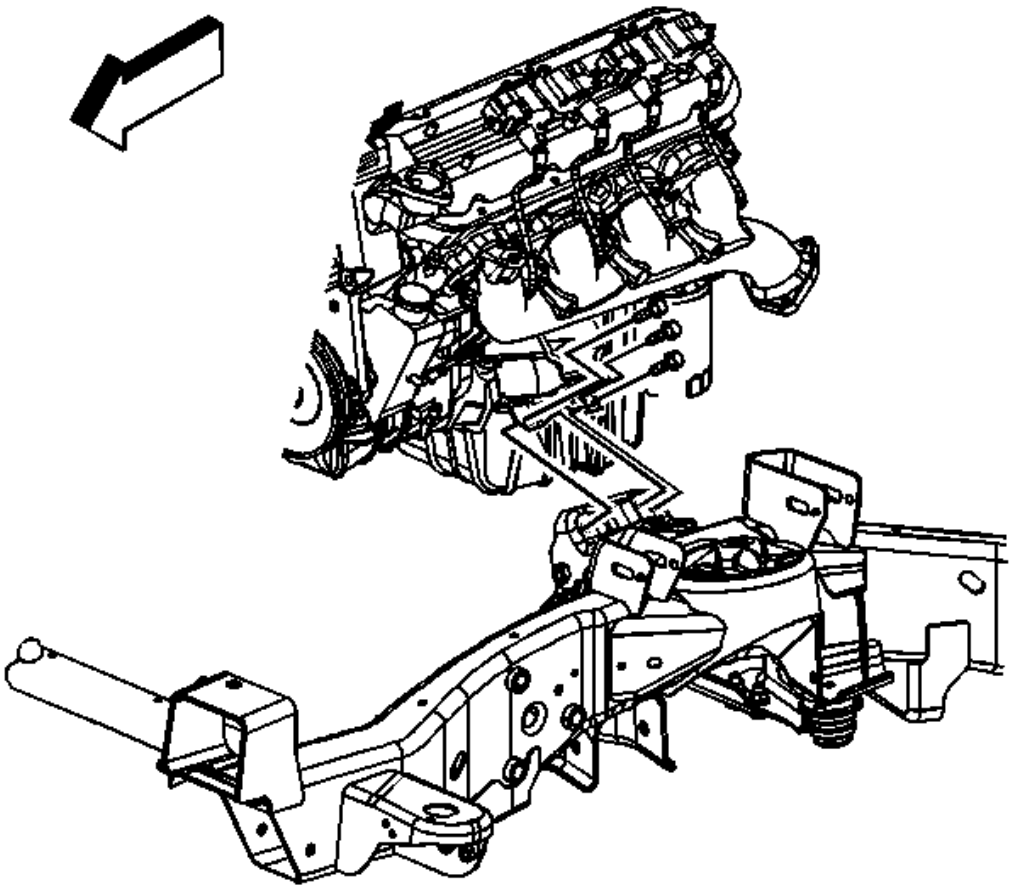

Fig. 35: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine mount-to-engine mount bracket bolt (left side shown, right side similar).

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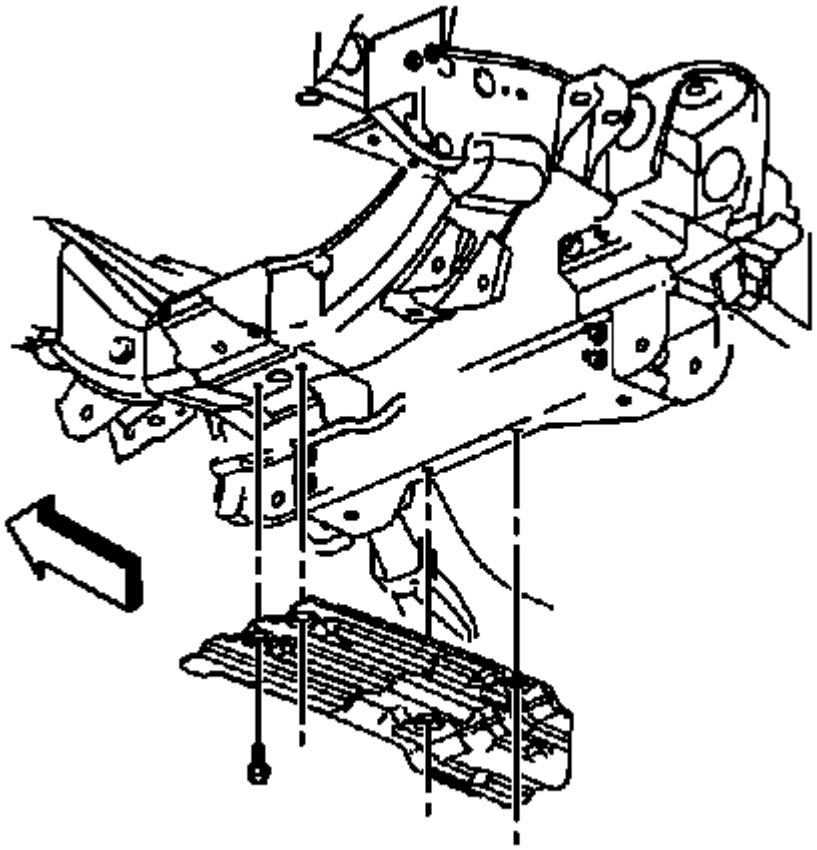

Fig. 36: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pan skid plate bolts and plate, if equipped.

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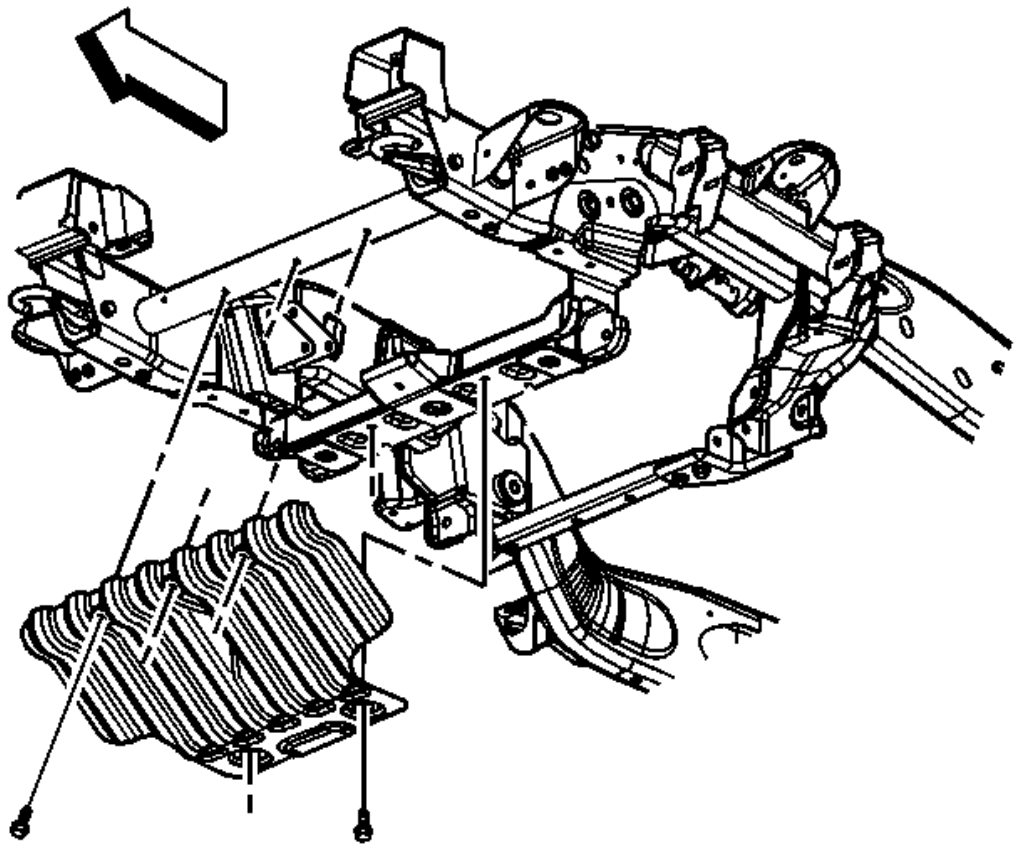

Fig. 37: View Of Engine Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When raising the engine only raise it enough to separate the engine mount from the engine mount bracket.

10. Remove the engine shield bolts and shield.
11. Raise the engine with a suitable jack in order to remove the engine mount and bracket.

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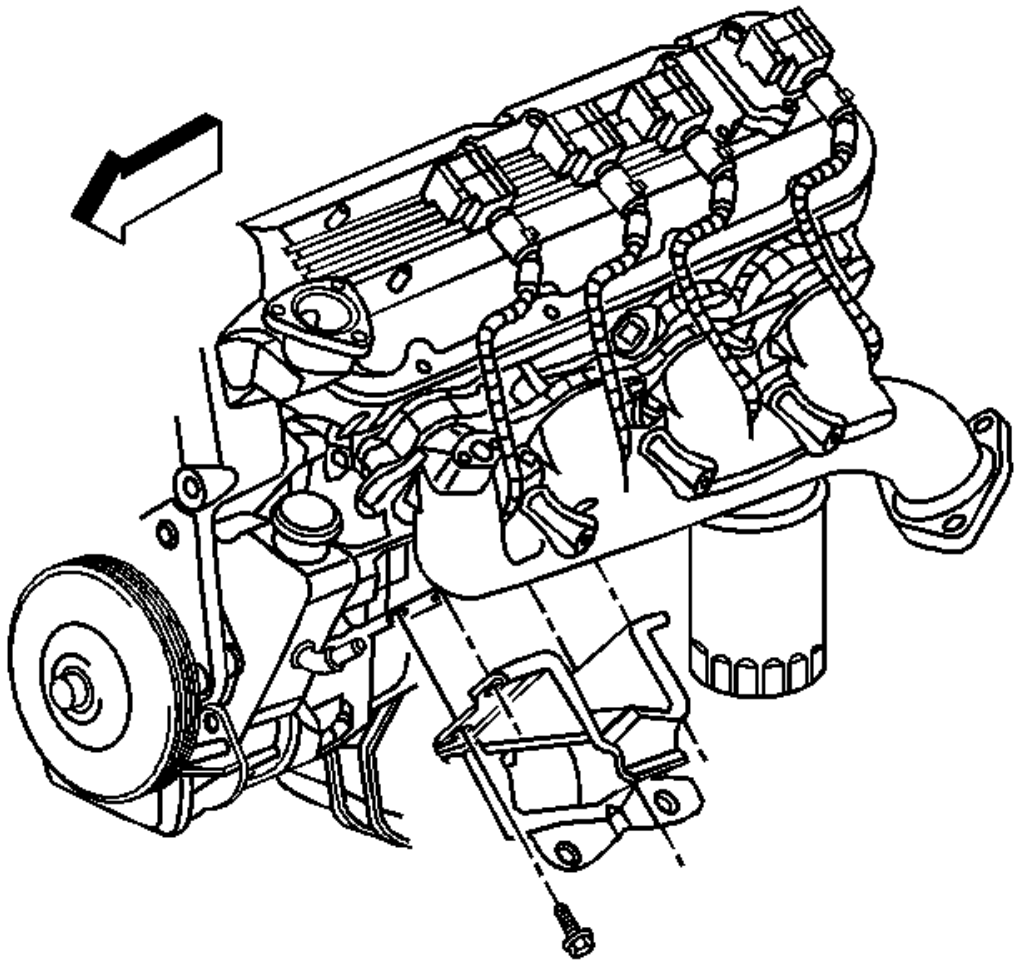

Fig. 38: View Of Engine Mount-To-Engine Bolts & Engine Mount
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine mount-to-engine bolts (left side shown, right side similar).
13. Remove the engine mount.

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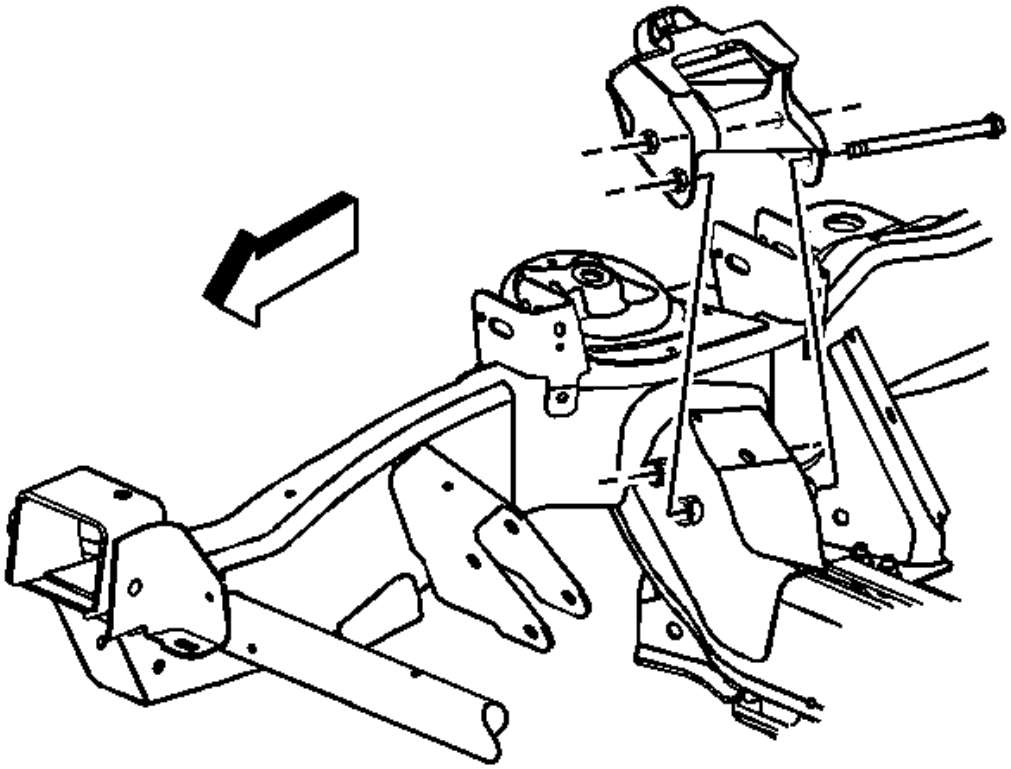

Fig. 39: View Of Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine mount bracket through bolts.
15. Remove the engine mount bracket.

Installation Procedure

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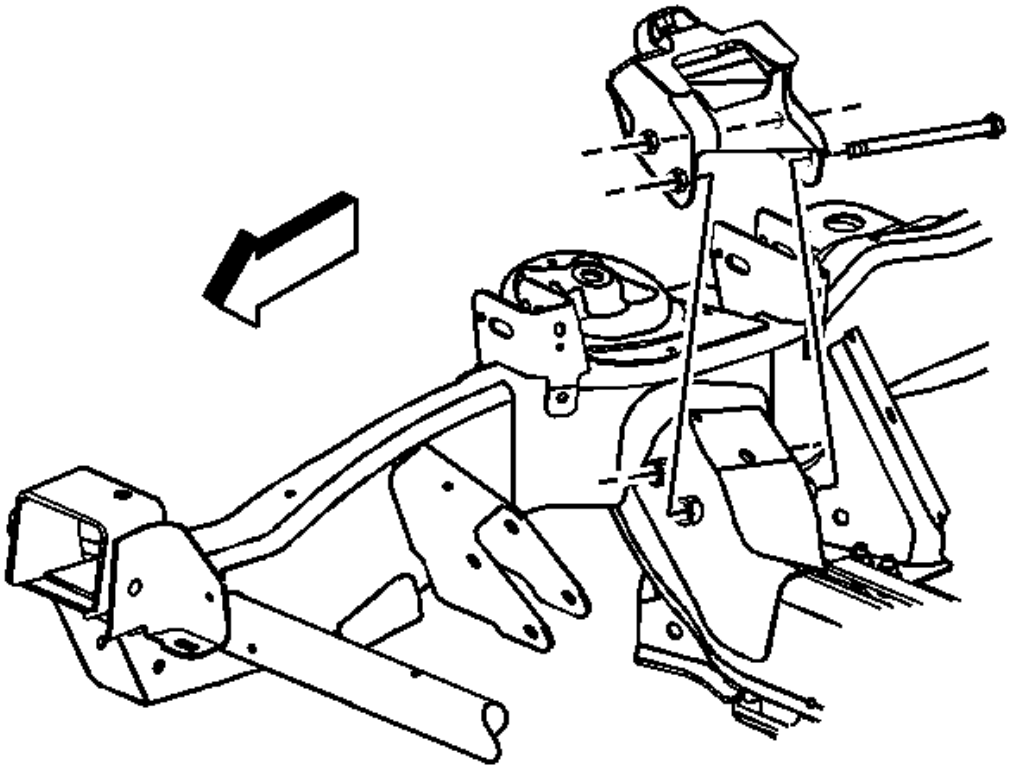

Fig. 40: View Of Engine Mount Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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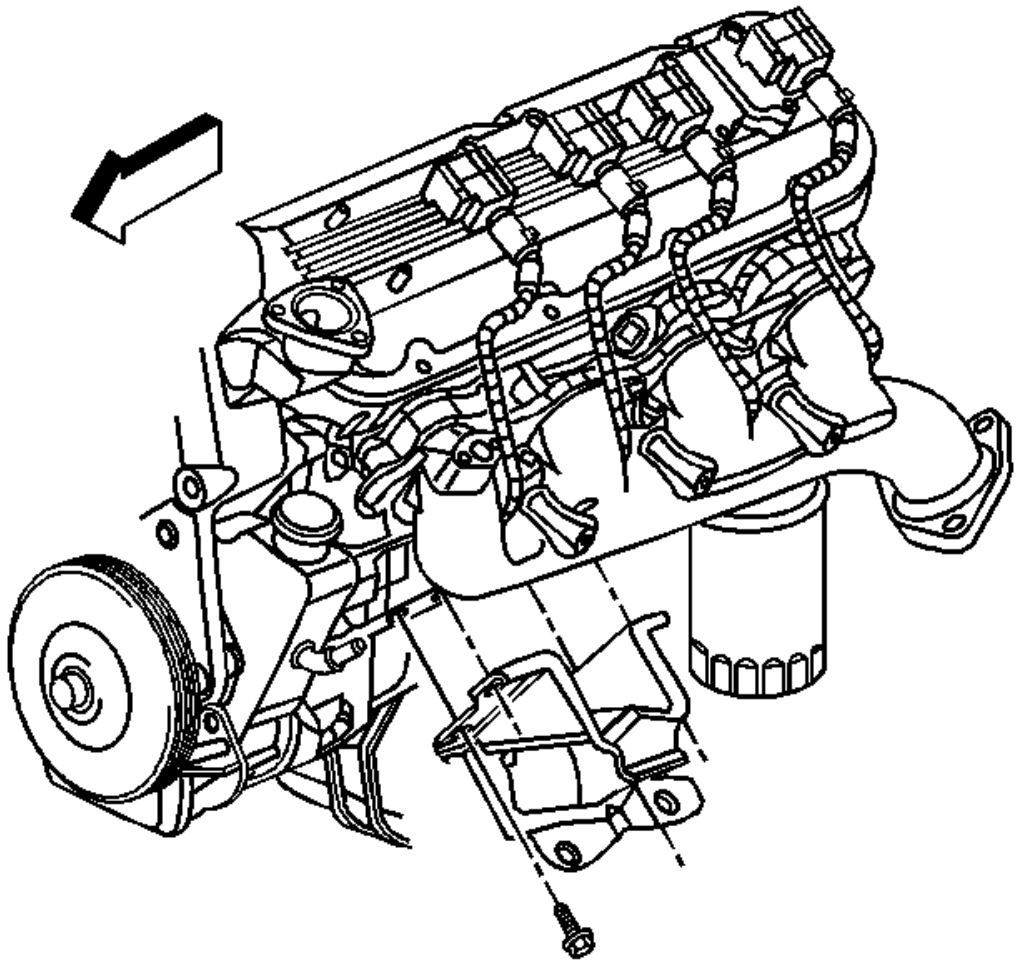

Fig. 41: View Of Engine Mount-To-Engine Bolts & Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Position the engine mount to engine (left side shown, right side similar).
5. Loosely install the engine mount-to-engine bolts.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Tighten the engine mount bracket through bolts and engine mount-to-engine bolts.

Tighten:

- Tighten the engine mount bracket through bolts to 75 N.m (55 lb ft).
- Tighten the engine mount-to-engine bolts to 50 N.m (37 lb ft).

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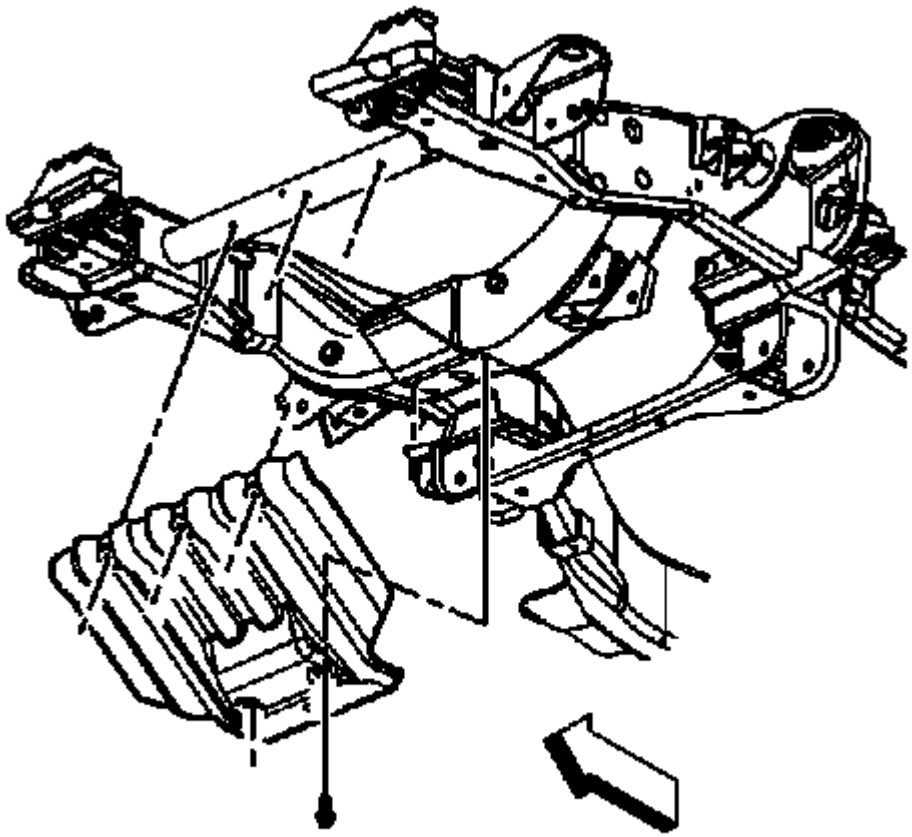

Fig. 42: Identifying Engine Shield And Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the engine shield and bolts.

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

8. Lower the engine.

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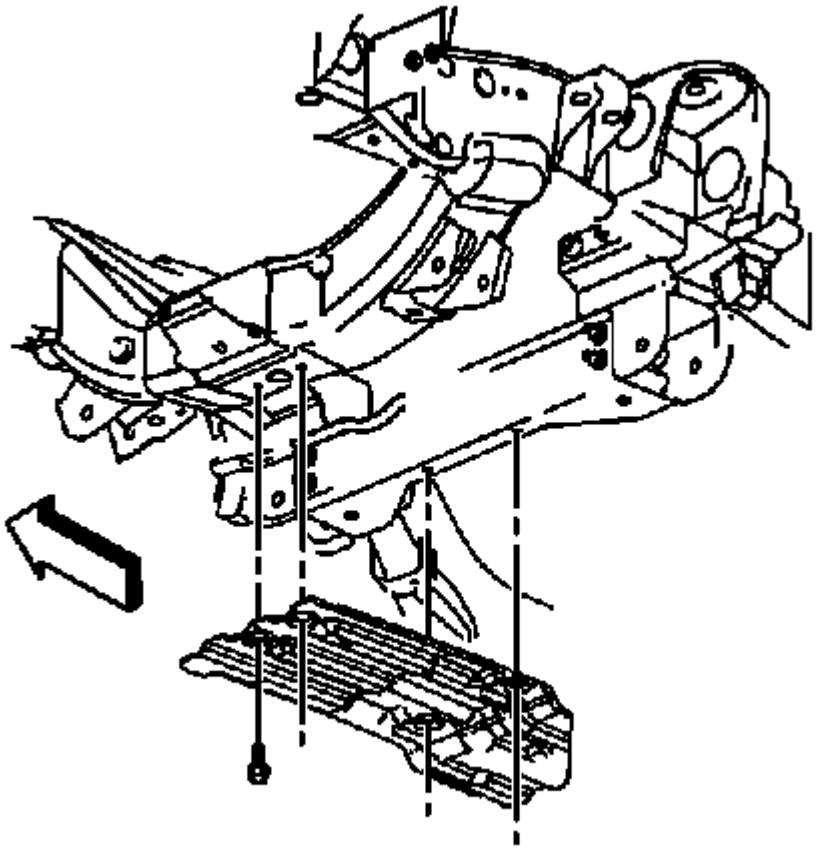

Fig. 43: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

9. If equipped, install the oil pan skid plate and bolts.

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

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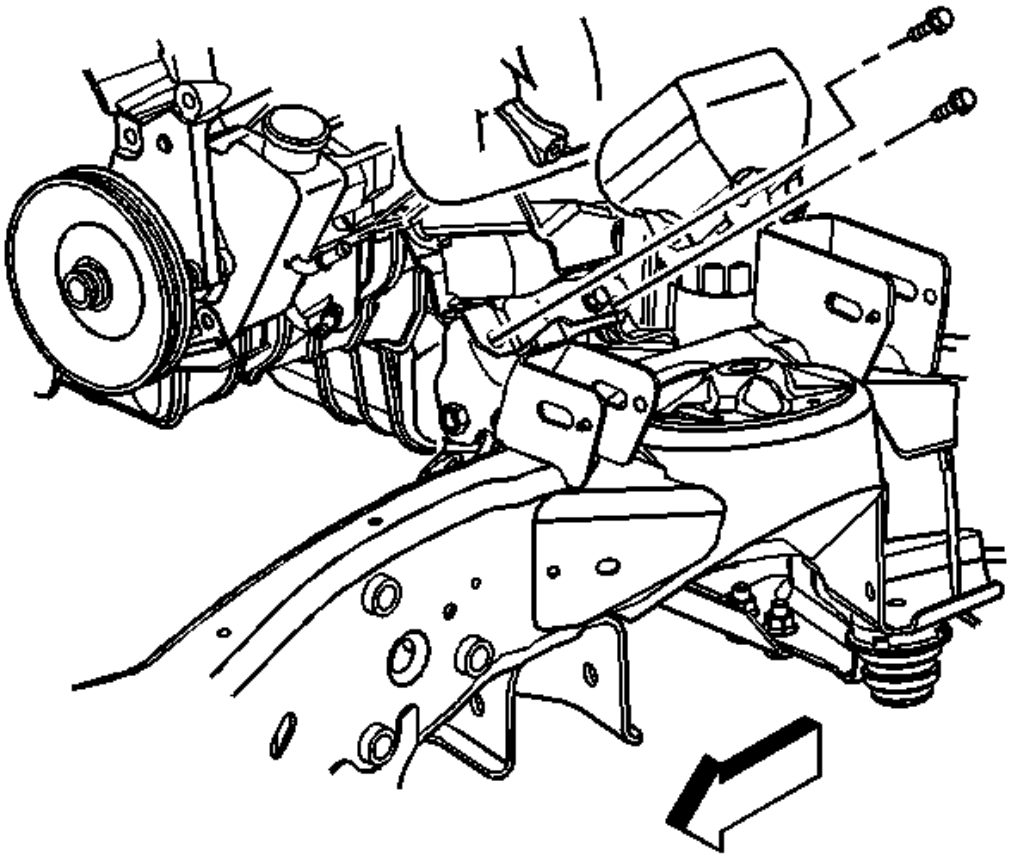

Fig. 44: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

10. Install the engine mount heat shield (left side shown, right side similar).

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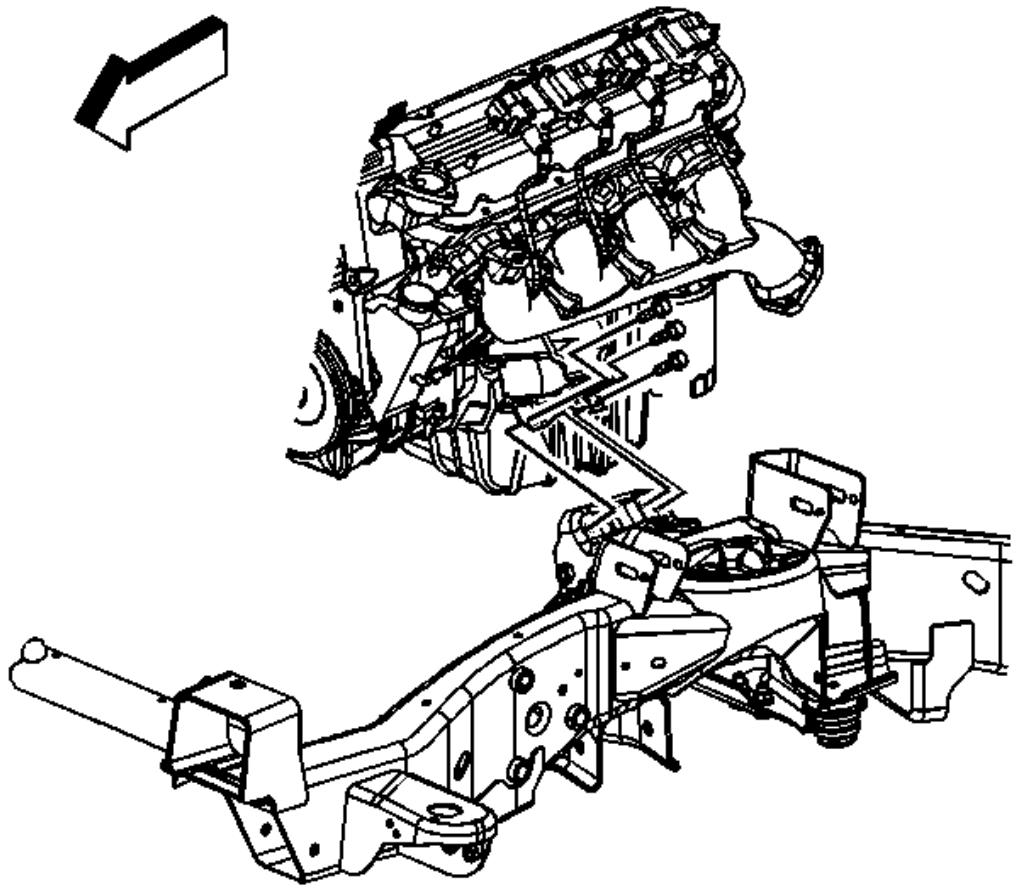

Fig. 45: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

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

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

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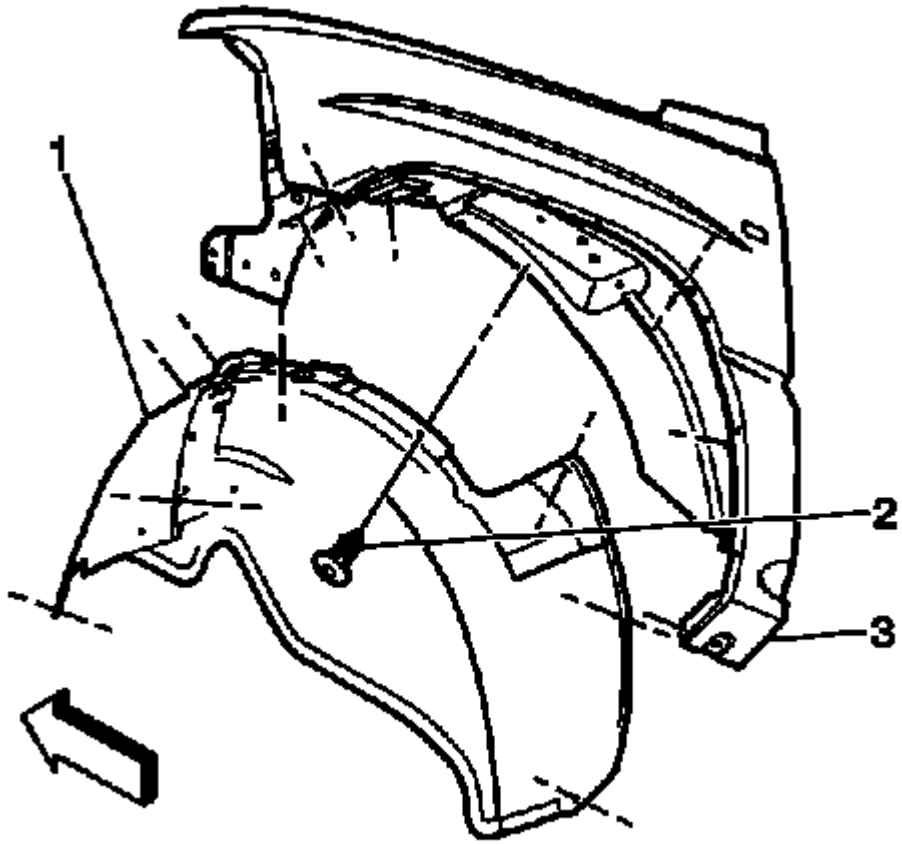

Fig. 46: View Of Wheelhouse Panel & Push-In Retainers
Courtesy of GENERAL MOTORS CORP.

12. Install the wheelhouse inner panel (1).
13. Install the wheelhouse inner panel push pin retainers (2).
14. Install the left front tire and wheel. Refer to **Tire and Wheel Removal and Installation** in Tires and Wheels.
15. Lower the vehicle.

Engine Sight Shield Replacement

Removal Procedure

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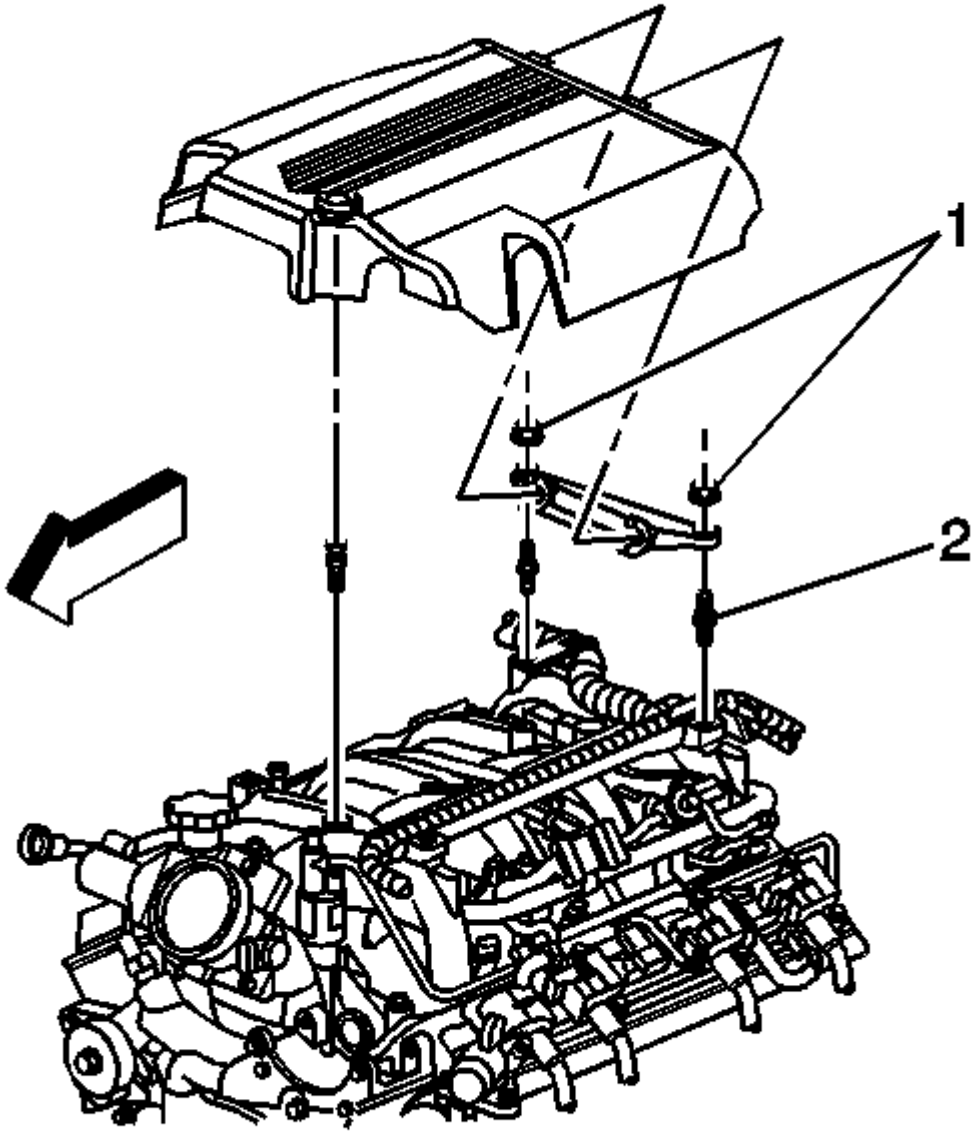

Fig. 47: View Of Sight Shield, Bracket, Retainer Nuts & Studs
Courtesy of GENERAL MOTORS CORP.

1. Unsnap the intake manifold sight shield from the stud.
2. Remove the sight shield from the sight shield bracket.
3. Remove the sight shield bracket retainer nuts (1), if necessary.
4. Remove the sight shield bracket from the studs (2), if necessary.

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Installation Procedure

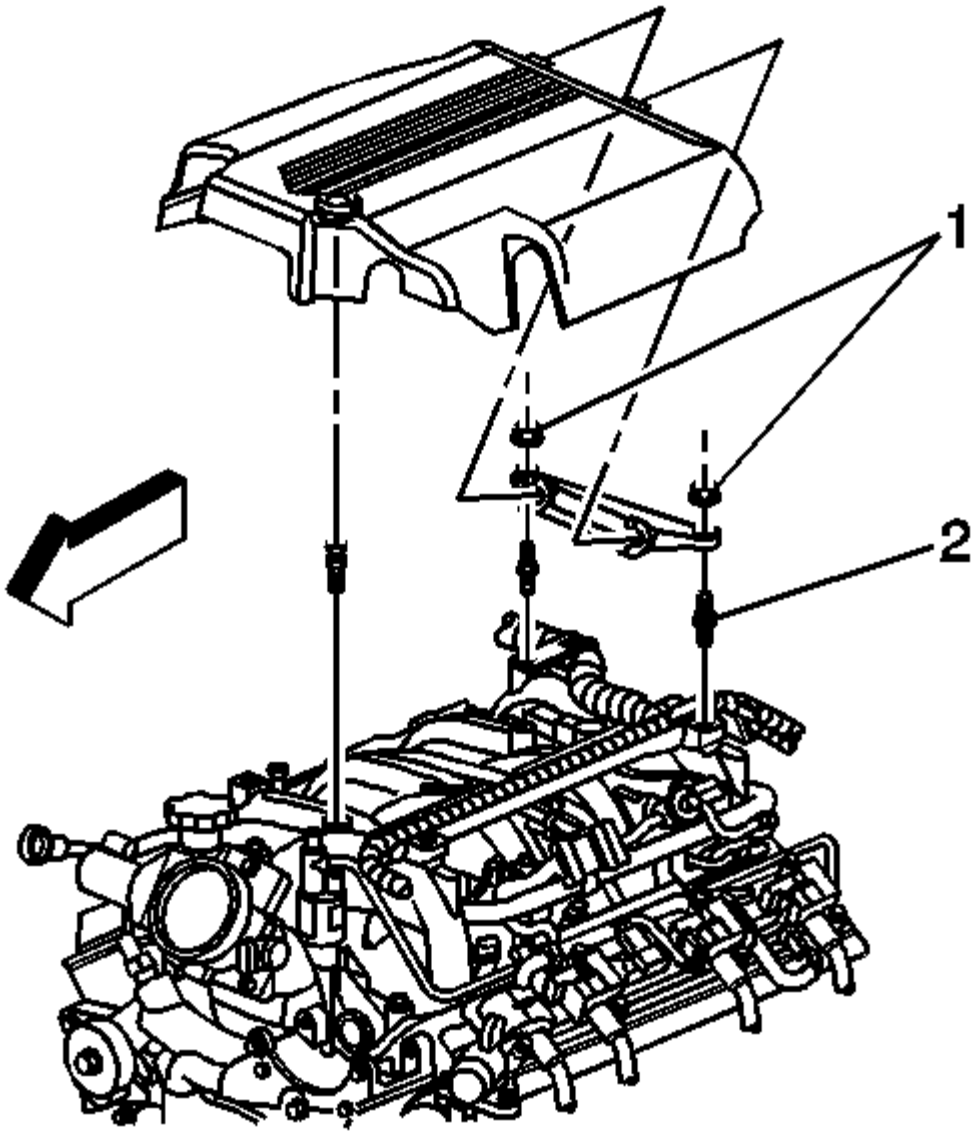

Fig. 48: View Of Sight Shield, Bracket, Retainer Nuts & Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the sight shield bracket to the studs (2), if necessary.

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2. Install the sight shield bracket nuts (1), if necessary.

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

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

3. Install the intake manifold sight shield to the bracket.
4. Snap the intake manifold sight shield onto the stud.

Intake Manifold Replacement

Removal Procedure

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

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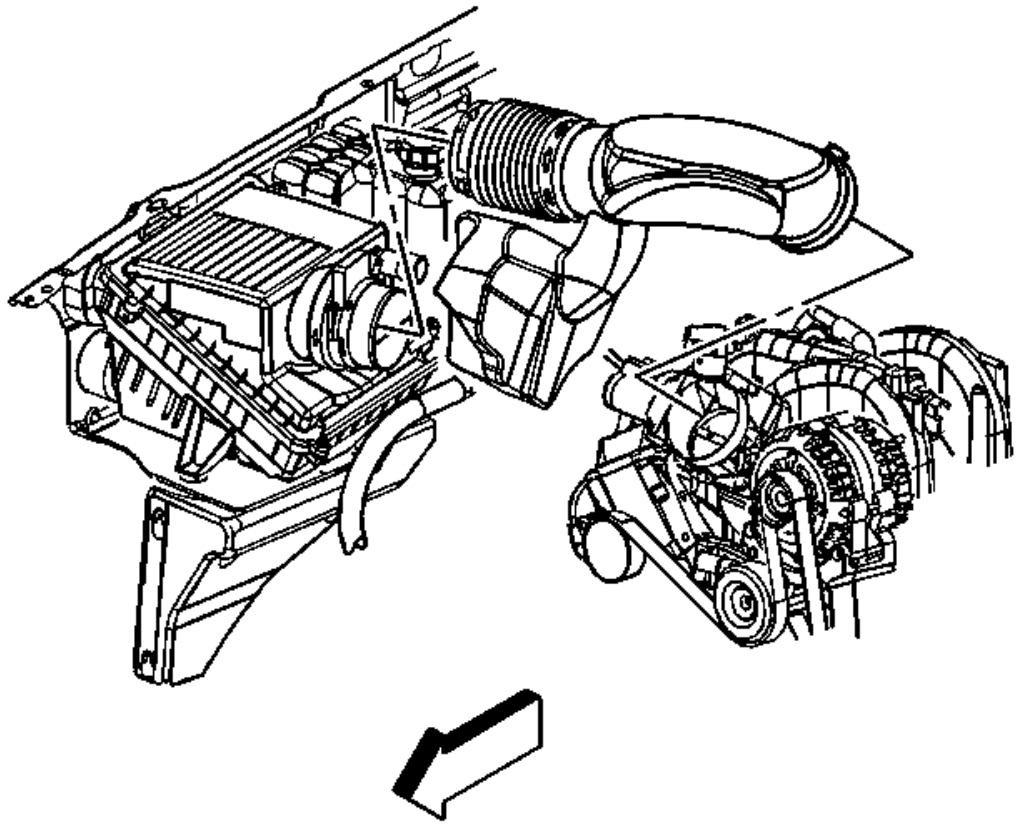

Fig. 49: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

1. Loosen the clamps at the throttle body and air cleaner.
2. Remove the air cleaner outlet duct.

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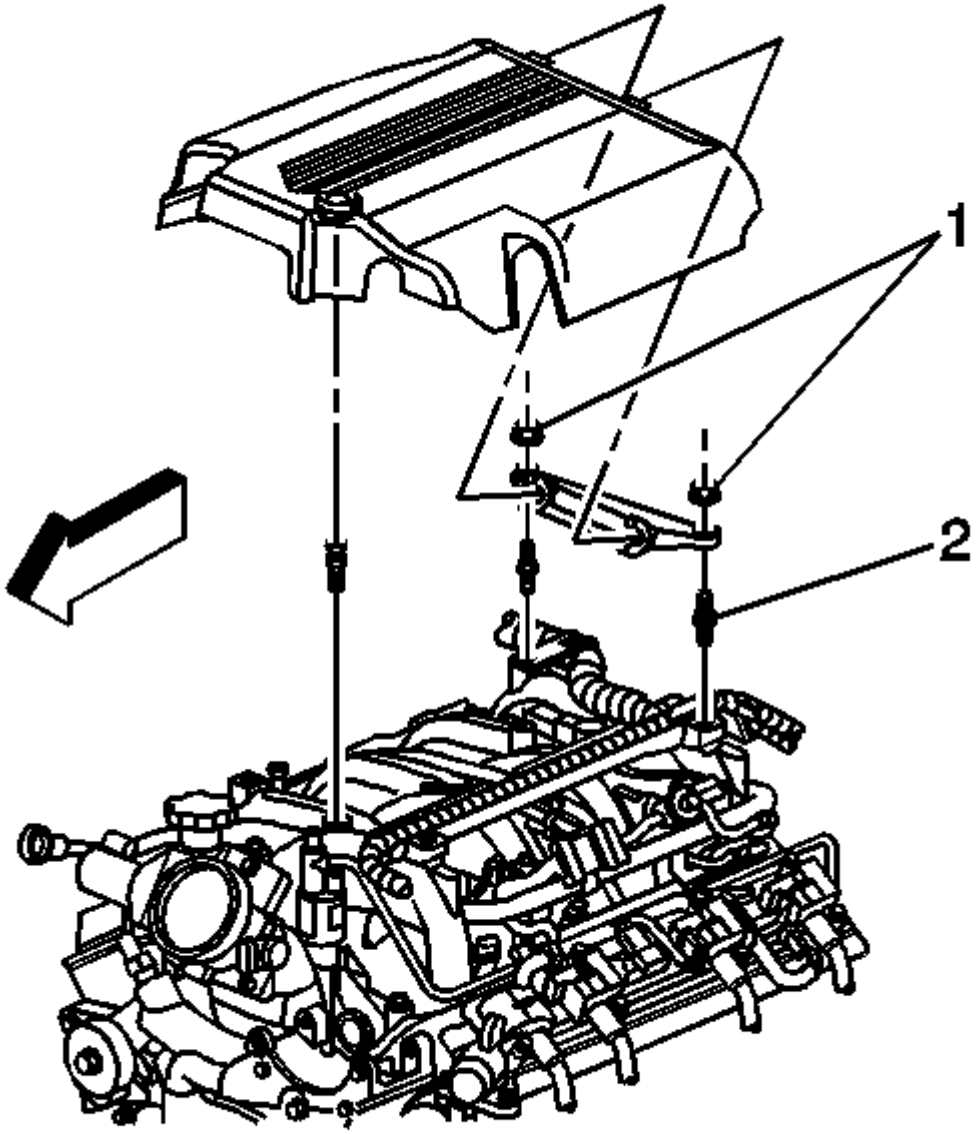

Fig. 50: View Of Sight Shield, Bracket, Retainer Nuts & Studs
Courtesy of GENERAL MOTORS CORP.

3. Unsnap the intake manifold sight shield from the stud.
4. Remove the sight shield from the bracket.
5. Remove the sight shield bracket nuts (1) and bracket, if necessary.
6. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 8.1L.

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7. Disconnect the fuel feed and return pipes. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** in Engine Controls - 8.1L.

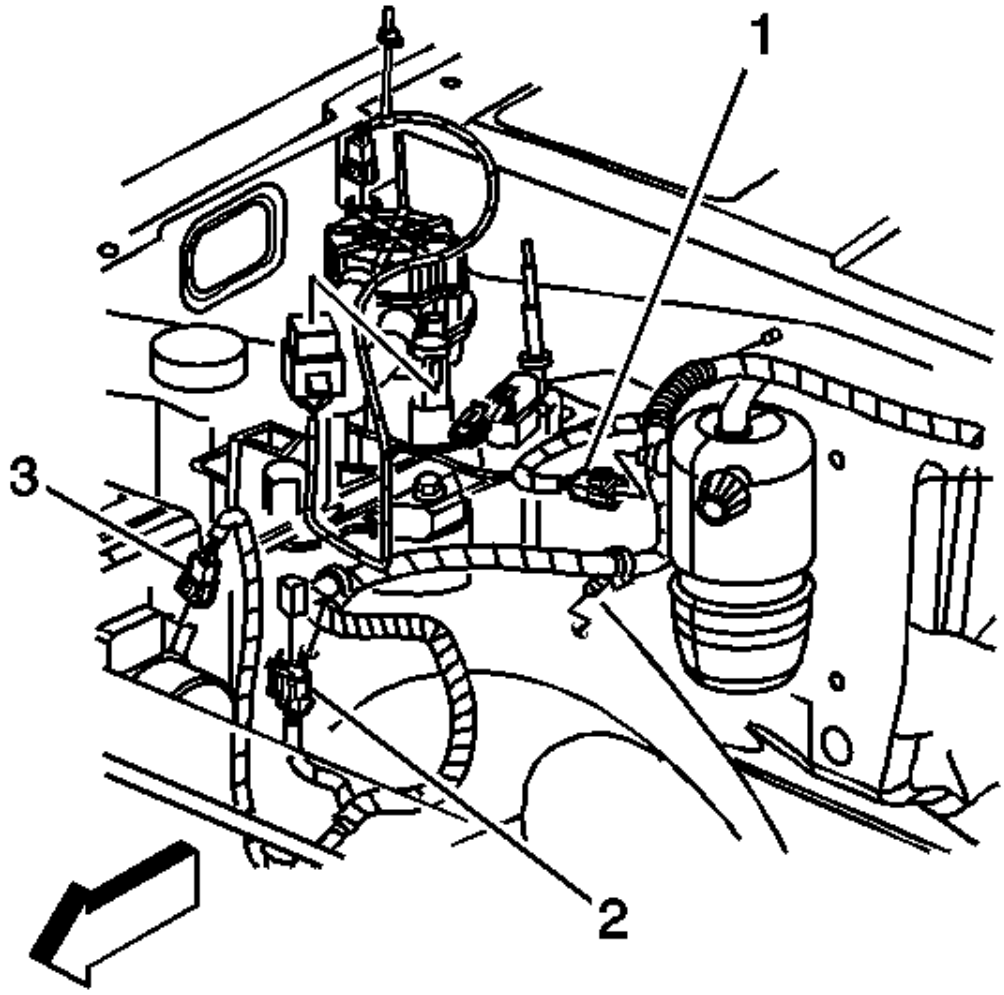

Fig. 51: View Of MAF/IAT Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

8. Disconnect the engine harness clips from the studs on the front of dash.
9. Disconnect the engine harness clip from the wheelhouse splash shield.
10. Disconnect the following electrical connectors:
    - Pressure cycling switch (1)
    - Surge tank switch (2)

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- Mass airflow (MAF) sensor (3)

11. Reposition the engine harness branch to top of engine.

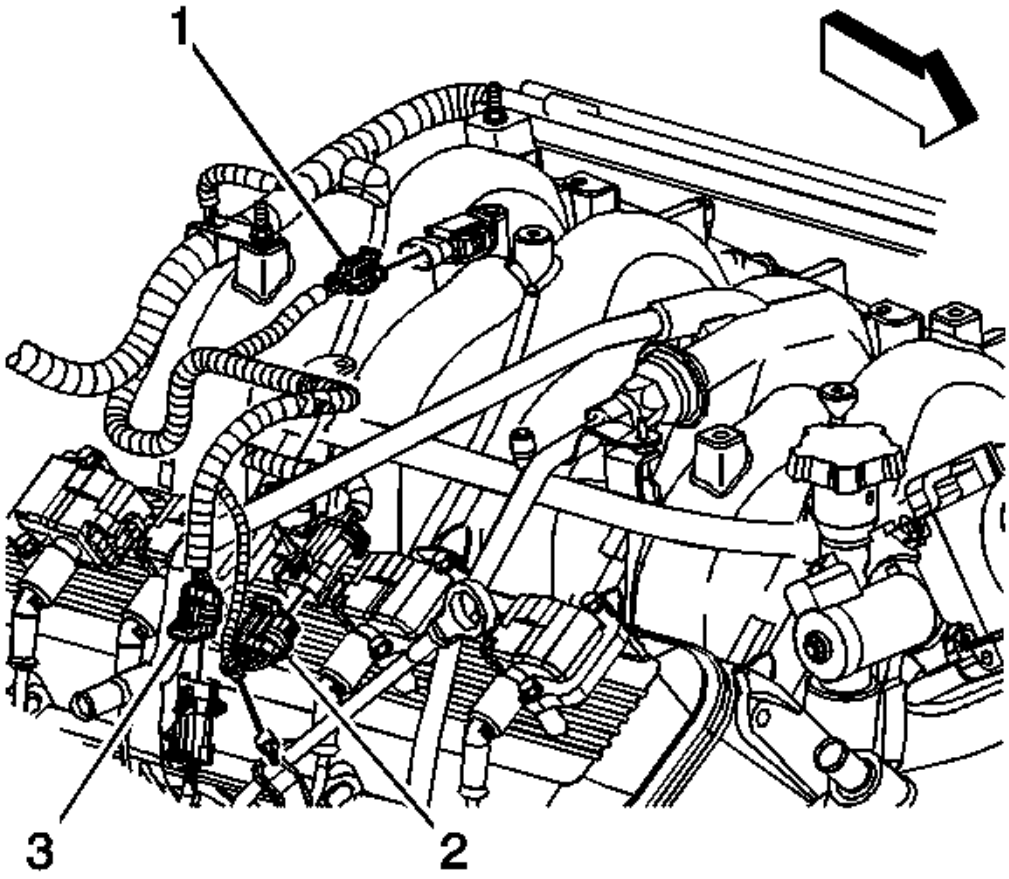

Fig. 52: View Of Ignition Coil, ECT And MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

12. Remove the connector position assurance (CPA) retainer at the ignition coil harness.
13. Disconnect the following electrical connectors:
    - Manifold absolute pressure (MAP) sensor (1)
    - Ignition coil harness (2)
    - Engine coolant temperature (ECT) sensor (3)

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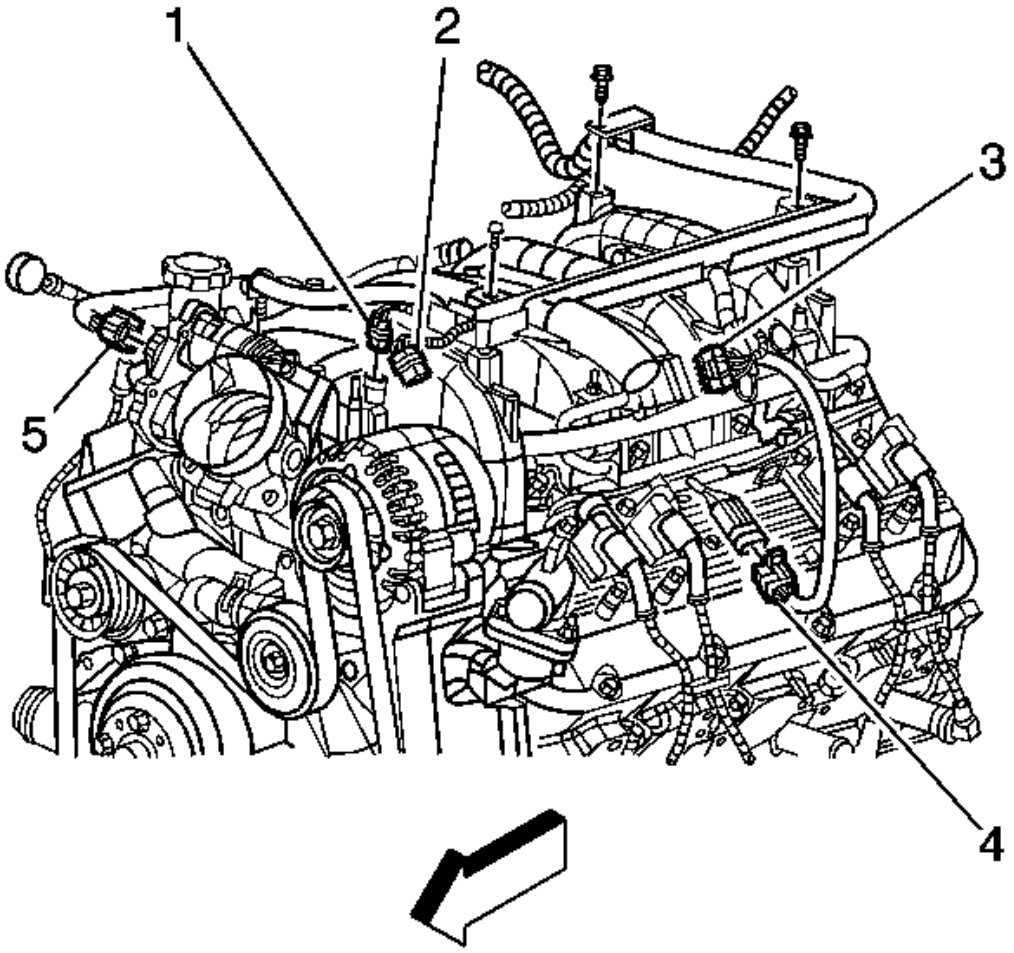

Fig. 53: View Of Generator, Injector Harness, Ignition Coil Harness, ETC & Purge Valve Solenoid Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine harness bolt and studs
15. Remove the CPA retainer at the ignition coil harness.
16. Disconnect the following electrical connectors:
    - Generator (2)
    - Injector harness (3)
    - Ignition coil harness (4)
    - Electronic throttle control (ETC) (5)
    - Purge valve solenoid (1)

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17. Reposition the engine harness to the drivers side of the engine compartment.

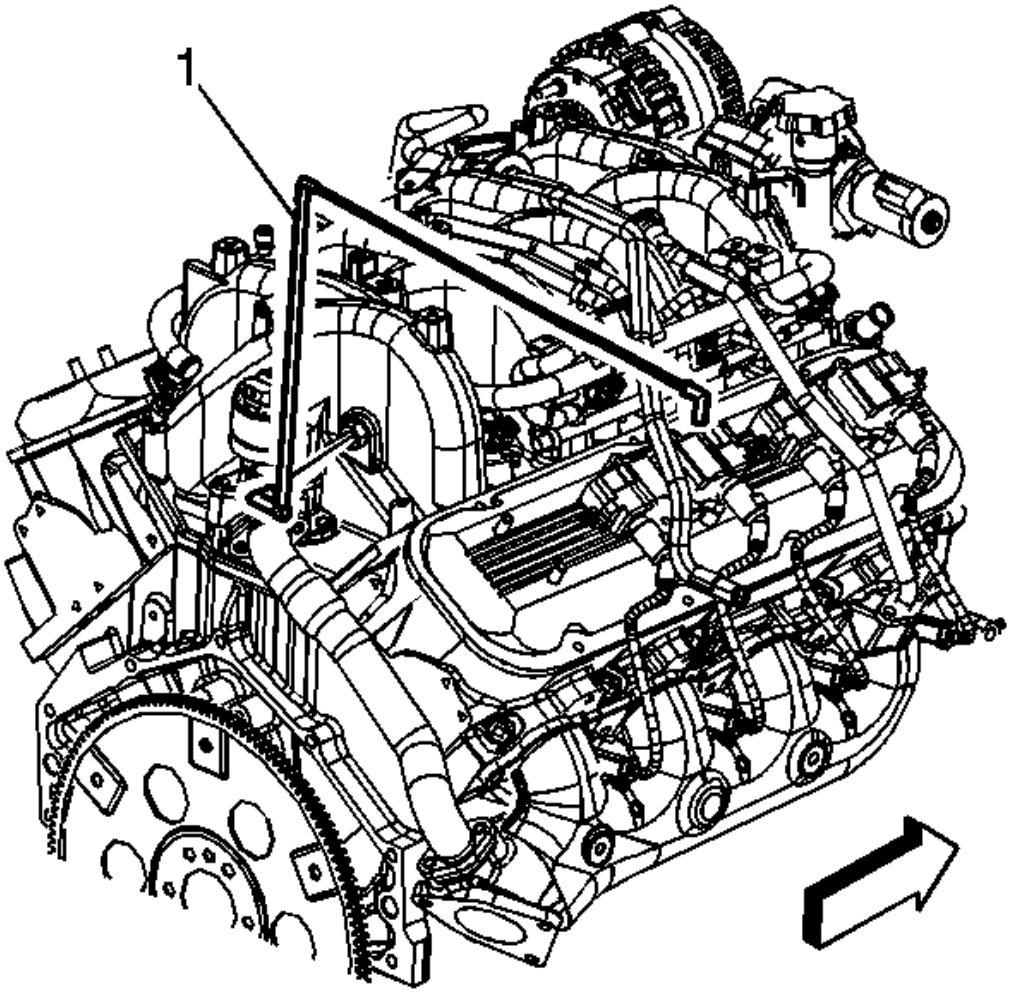

Fig. 54: View Of Bypass Valve Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

18. Remove the bypass valve vacuum hose (1) from the intake manifold.

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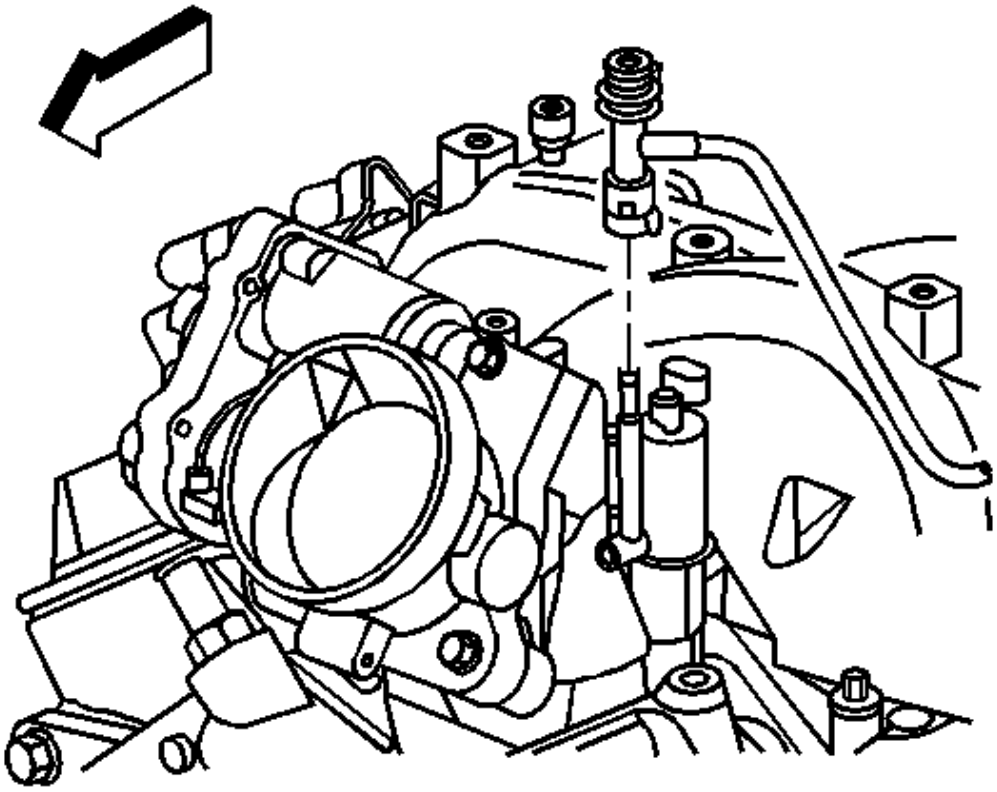

Fig. 55: View Of EVAP Purge Tube At Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

19. Disconnect the evaporative emission (EVAP) tube from the purge solenoid.

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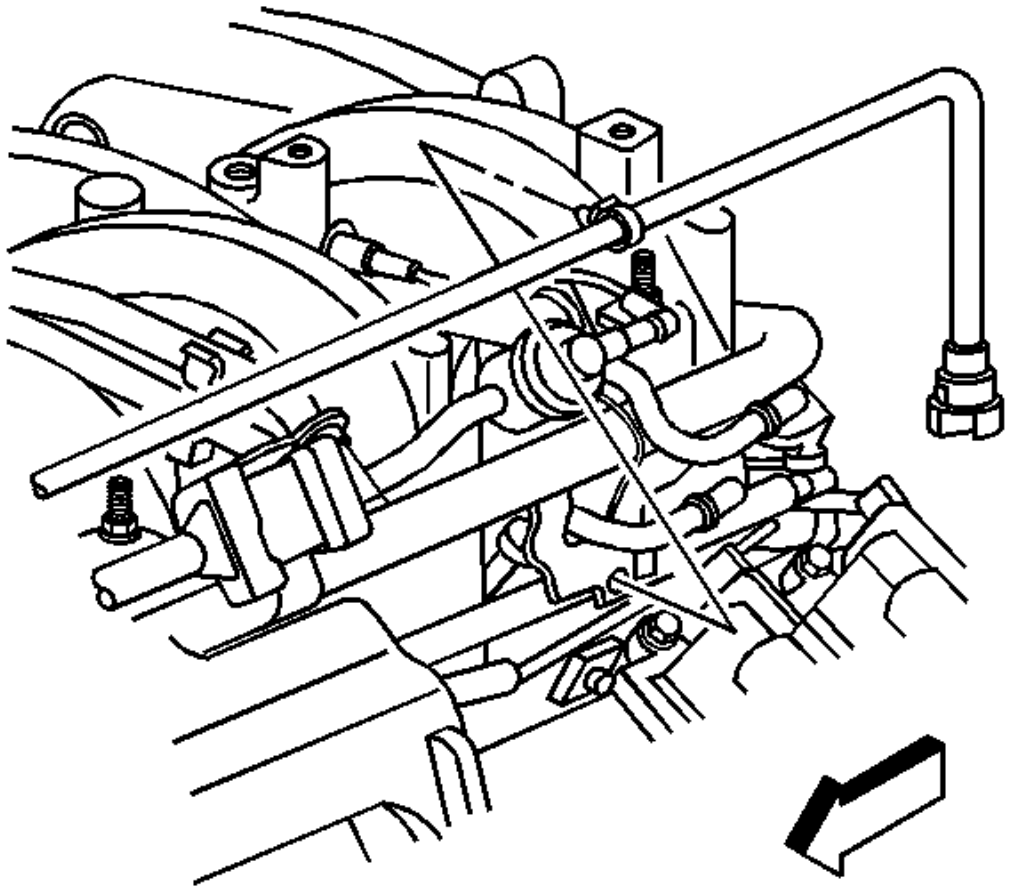

Fig. 56: View Of EVAP Tube At Fuel Rail
Courtesy of GENERAL MOTORS CORP.

20. Unclip the EVAP tube from the fuel rail.
21. Disconnect the EVAP tube from the vent pipe at the rear of the engine.
22. Remove the EVAP tube.

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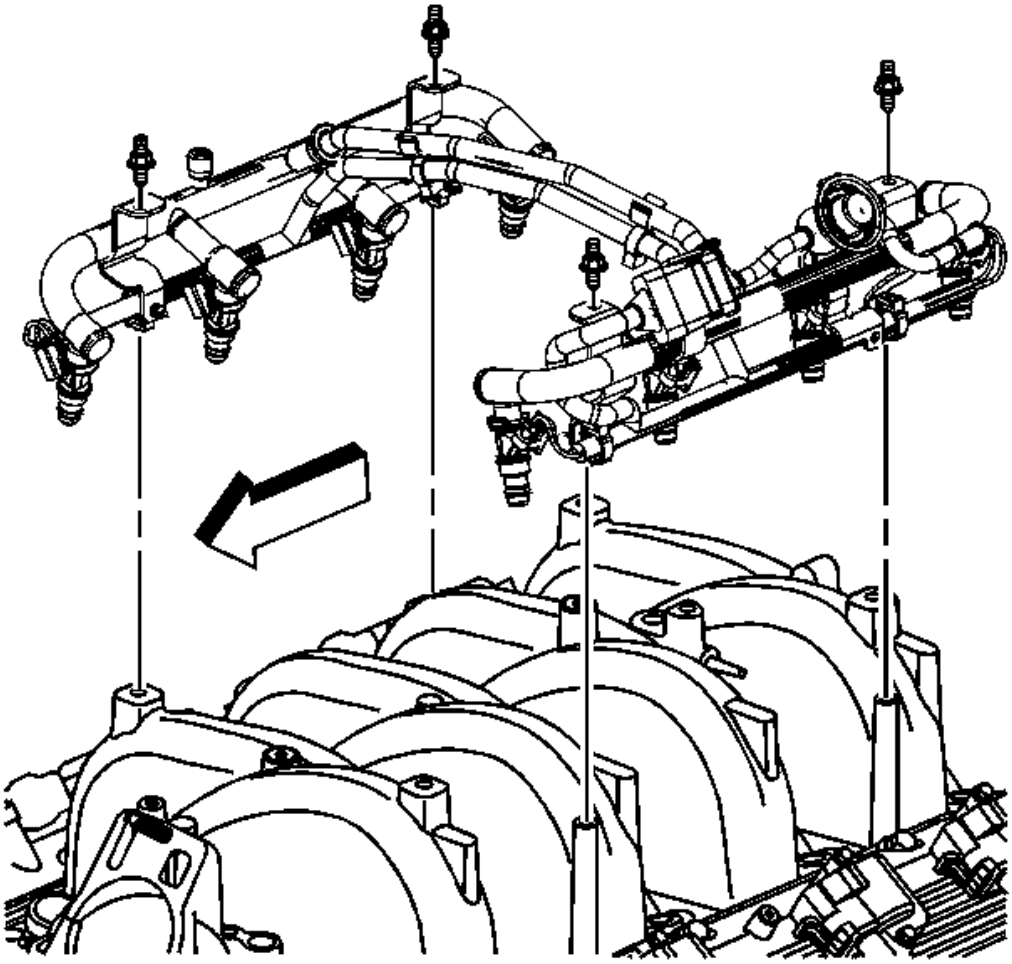

Fig. 57: View Of Fuel Injection Rail
Courtesy of GENERAL MOTORS CORP.

23. If replacing the intake manifold, remove the fuel rail studs.
24. Remove the fuel rail.

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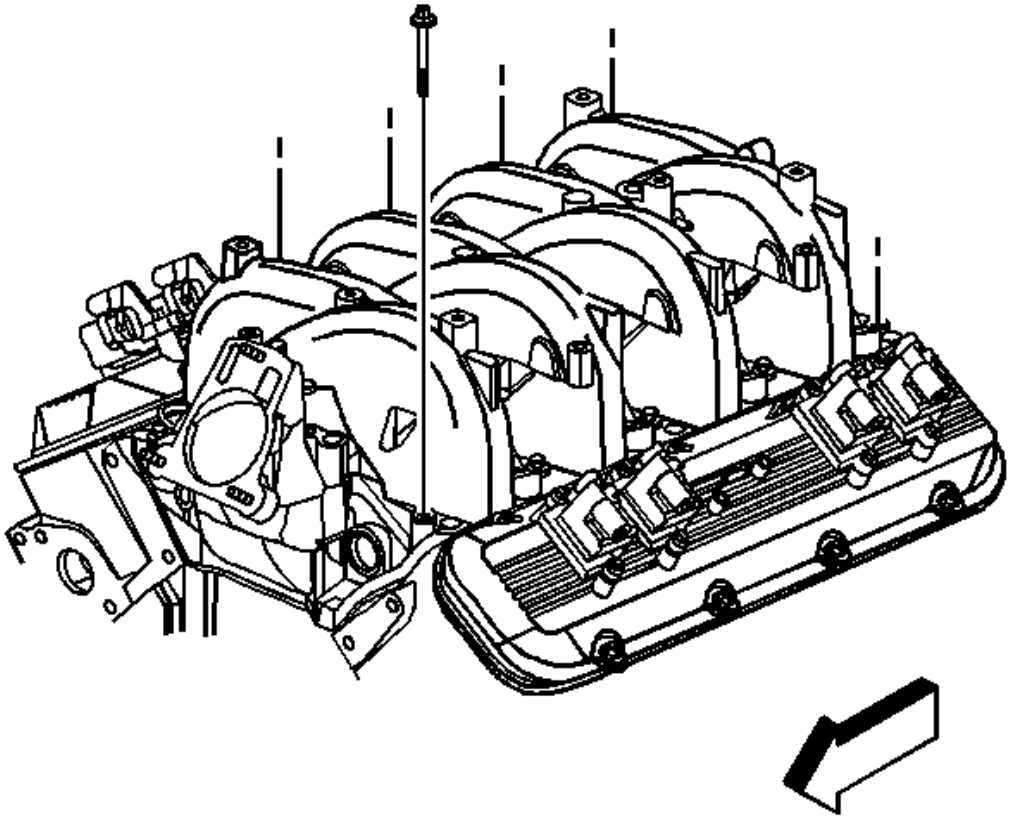

Fig. 58: View Of Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

25. Remove the intake manifold bolts.

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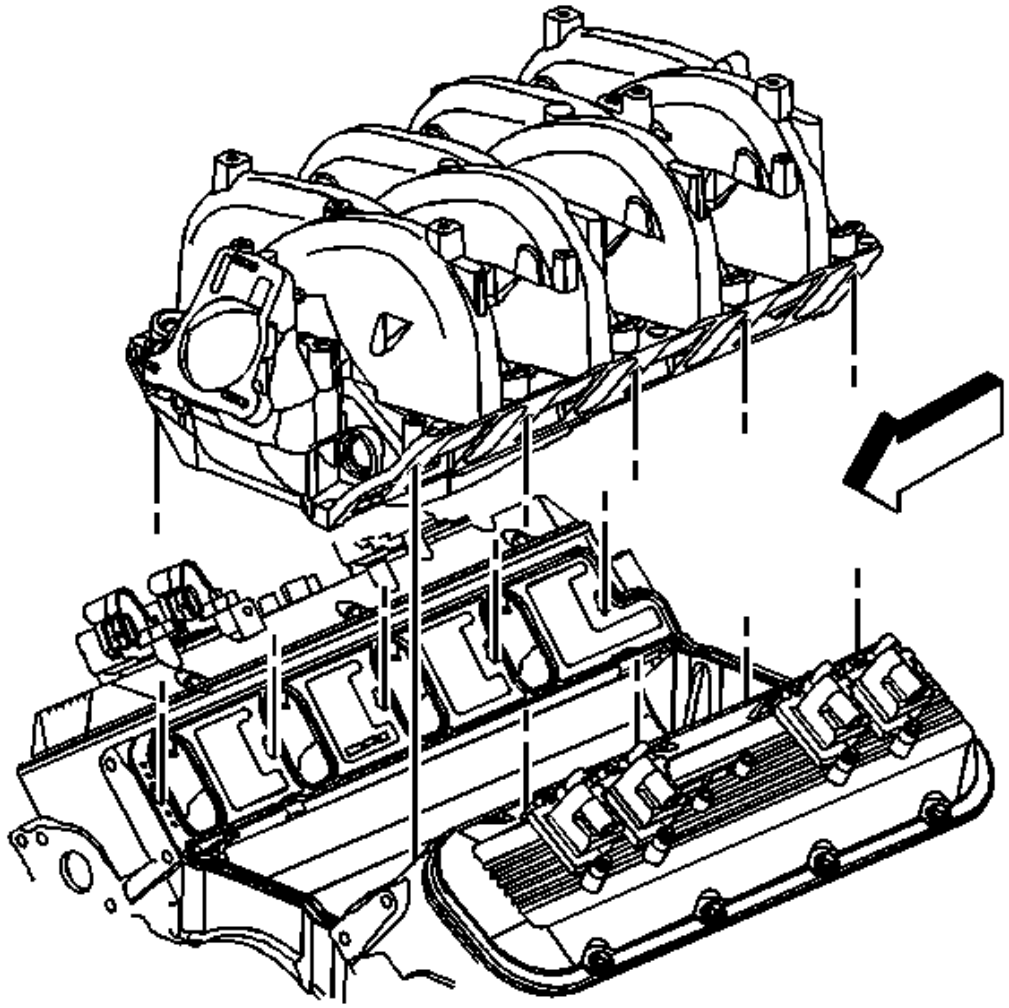

Fig. 59: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

26. Remove the intake manifold.

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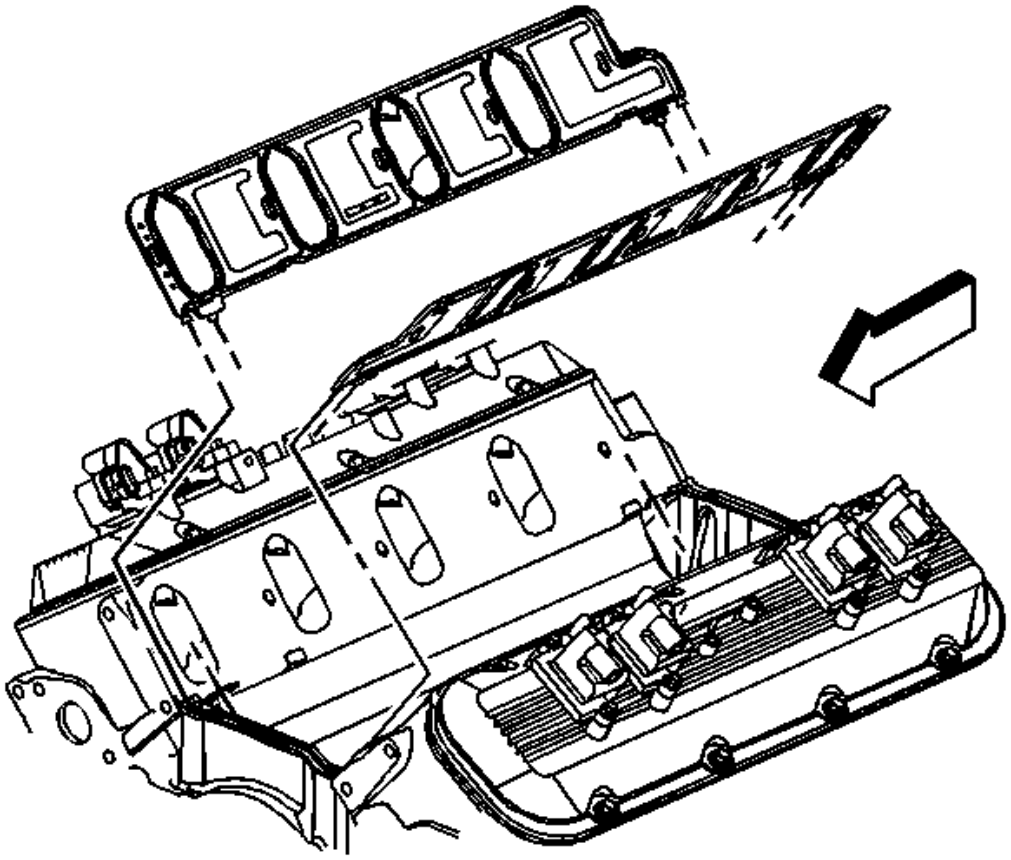

Fig. 60: View Of Intake Manifold Side Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold gaskets are not reusable.

27. Remove and discard the intake manifold side gaskets.

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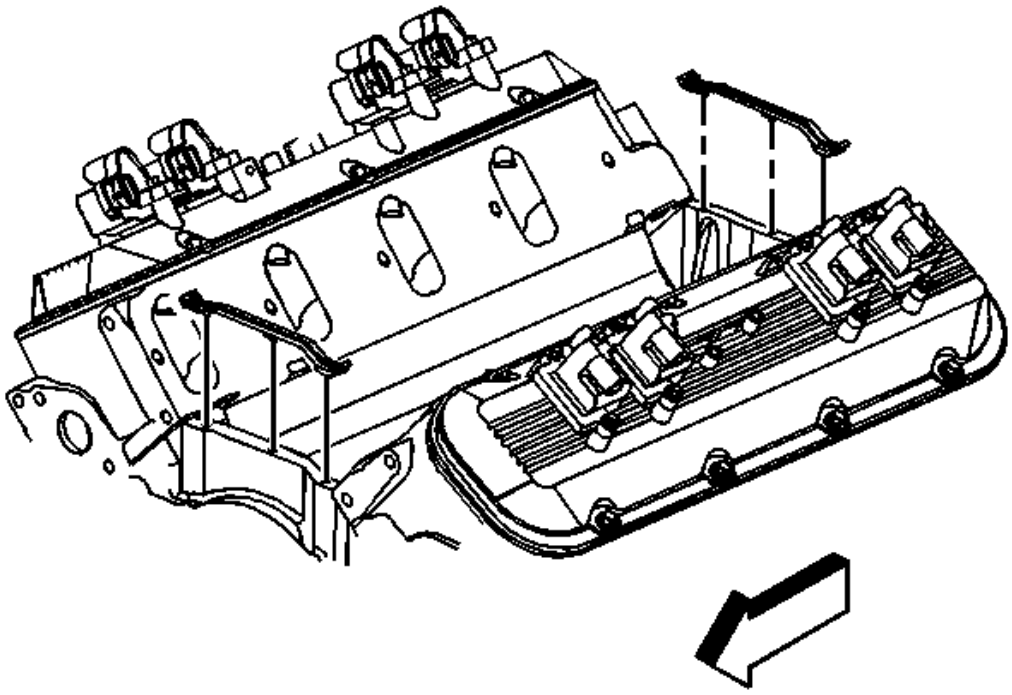

Fig. 61: View Of Intake Manifold End Seals
Courtesy of GENERAL MOTORS CORP.

28. Remove and discard the intake manifold end seals.

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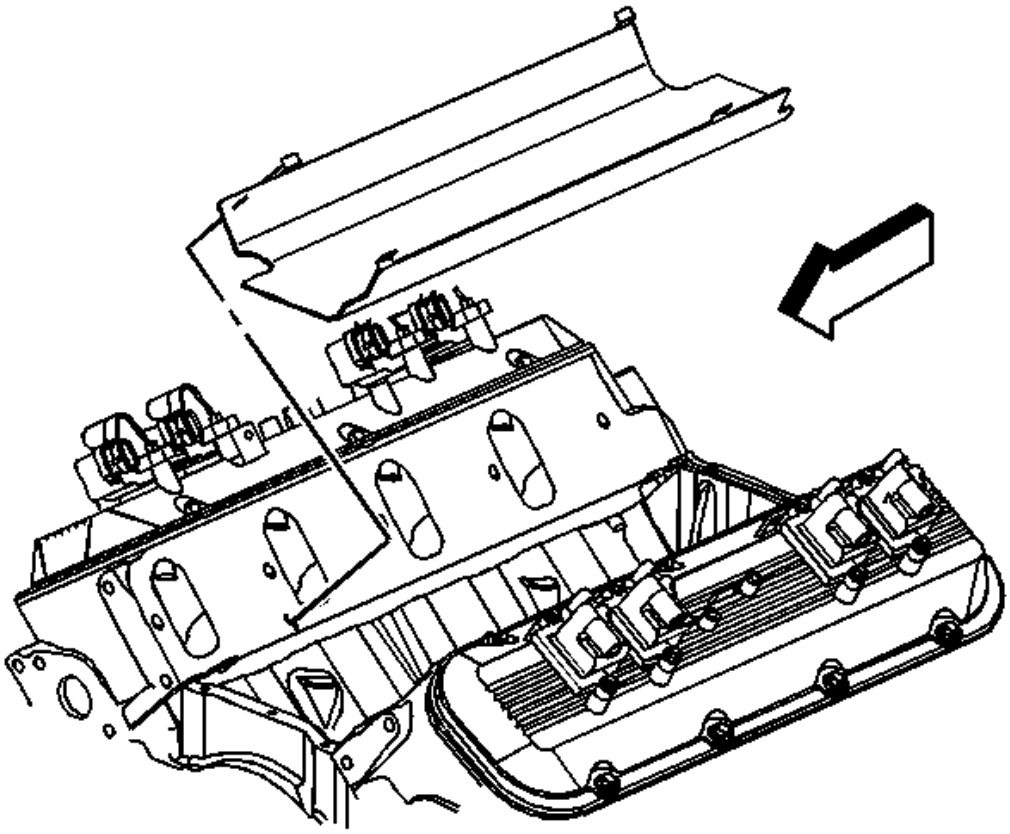

Fig. 62: View Of Splash Shield
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The splash shield is secured using a snap-in fit. Do not distort the splash shield. The splash shield is reusable.

29. Remove the splash shield.
30. If replacing the intake manifold, refer to **Intake Manifold Disassemble**.
31. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.

Installation Procedure

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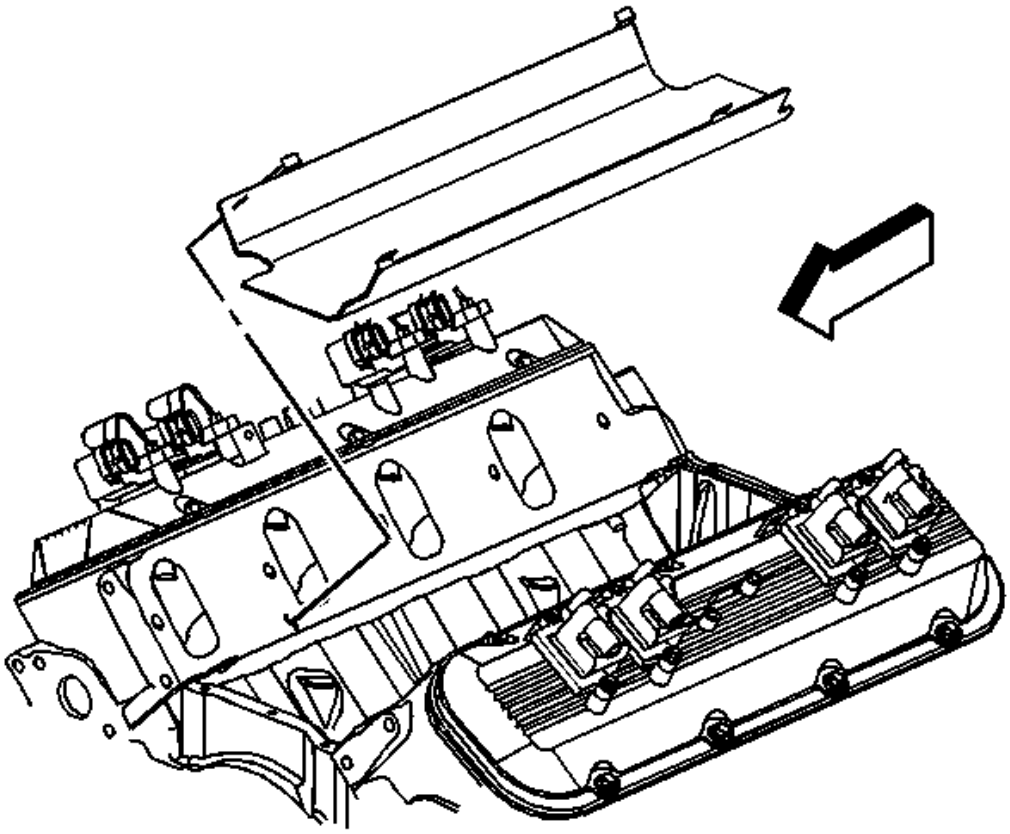

Fig. 63: View Of Splash Shield
Courtesy of GENERAL MOTORS CORP.

1. If replacing the intake manifold, refer to **Intake Manifold Assemble**.
2. Install the splash shield.

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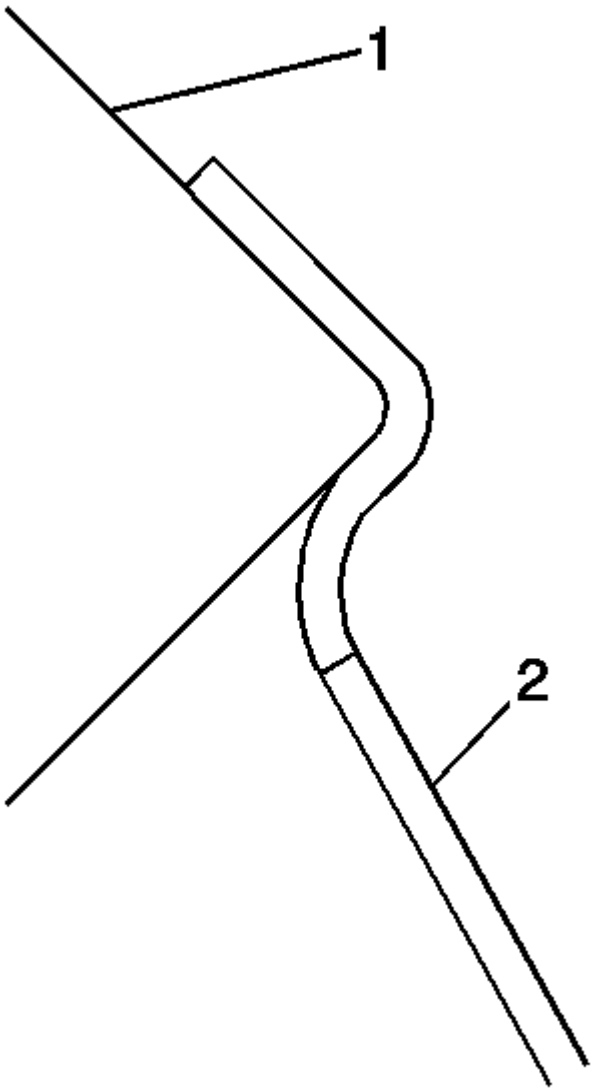

Fig. 64: Ensuring Splash Shield Snap Fits Between Cylinder Heads
Courtesy of GENERAL MOTORS CORP.

3. Ensure the splash shield (2) snap fits between the cylinder heads (1).

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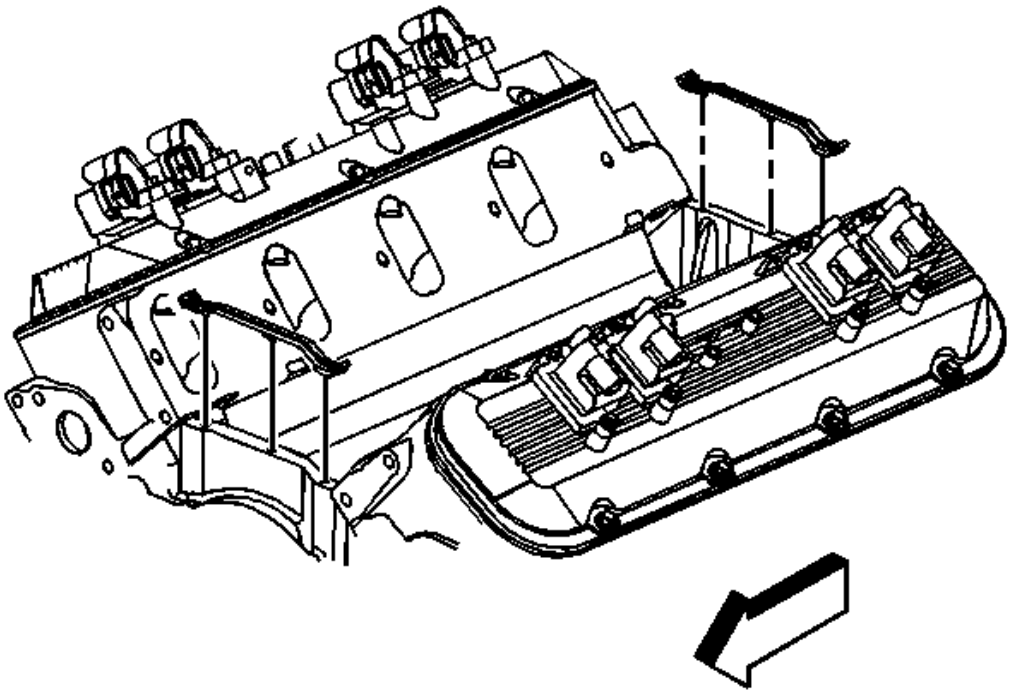

Fig. 65: View Of Intake Manifold End Seals
Courtesy of GENERAL MOTORS CORP.

4. Install the NEW intake manifold end seals.

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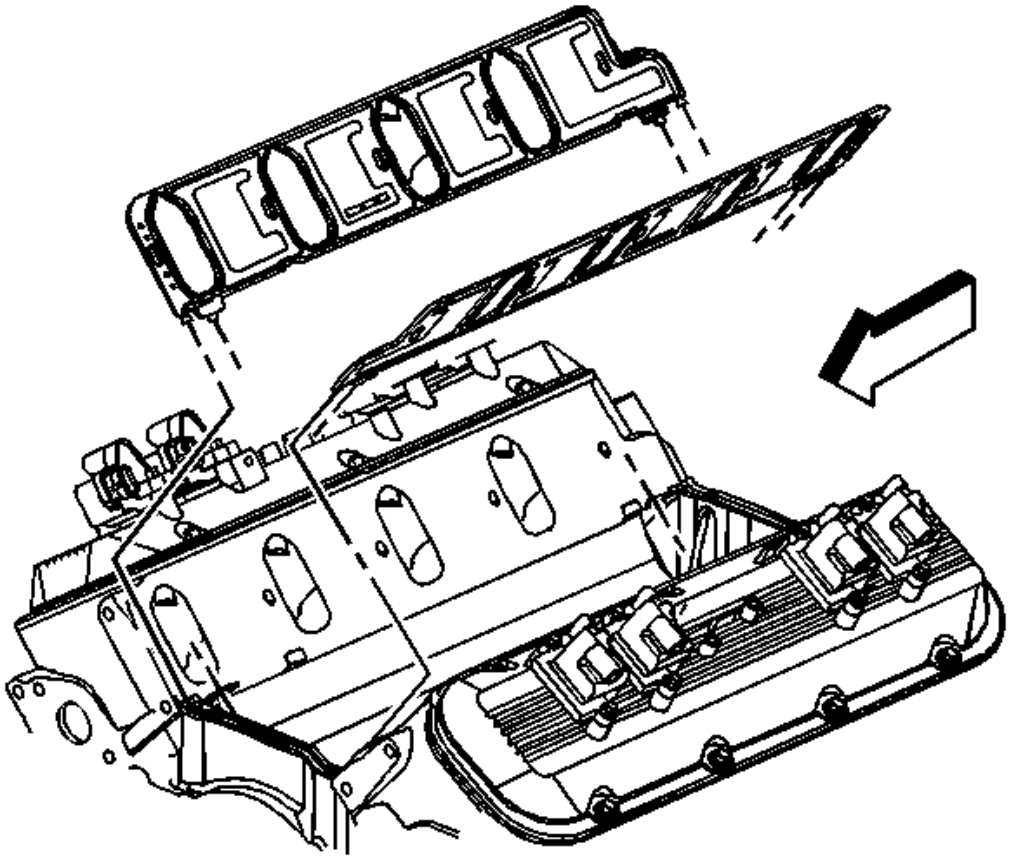

Fig. 66: View Of Intake Manifold Side Gaskets
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW intake manifold side gaskets.

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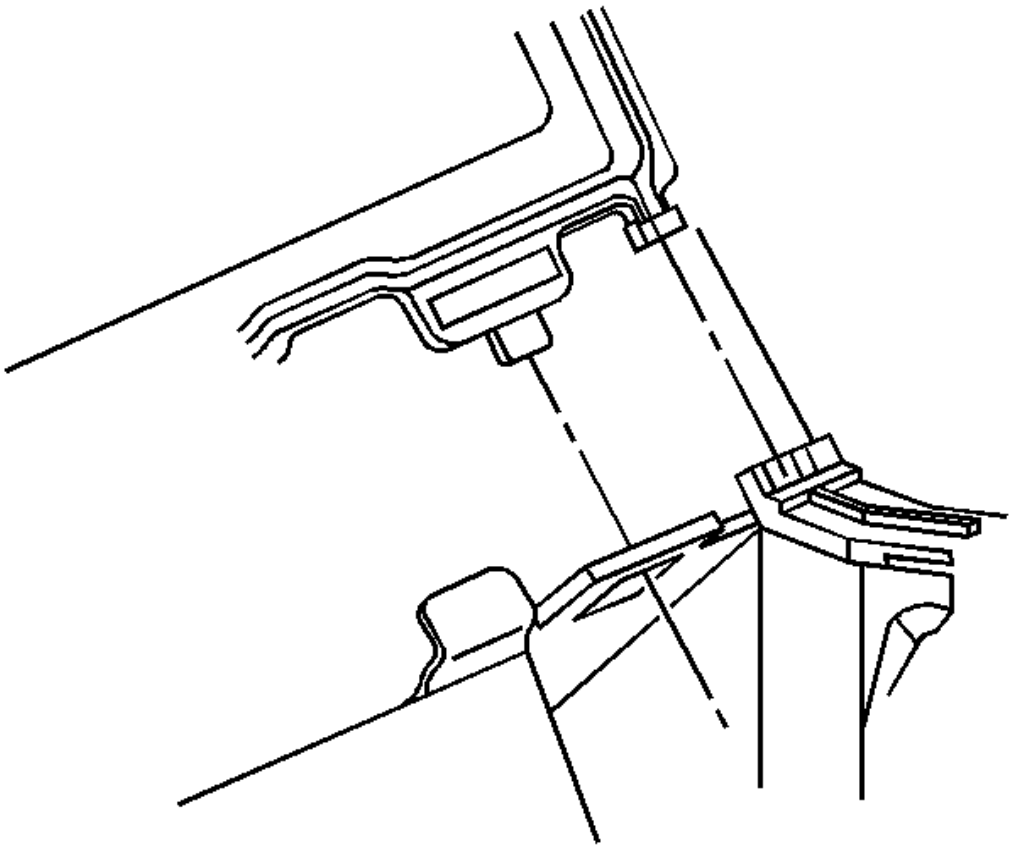

Fig. 67: Aligning Intake Manifold Gasket Tabs
Courtesy of GENERAL MOTORS CORP.

6. Ensure the intake manifold gasket tabs align with the hole in the head gasket.
7. Ensure the intake manifold gasket tabs align with the slot in the intake manifold end seals.

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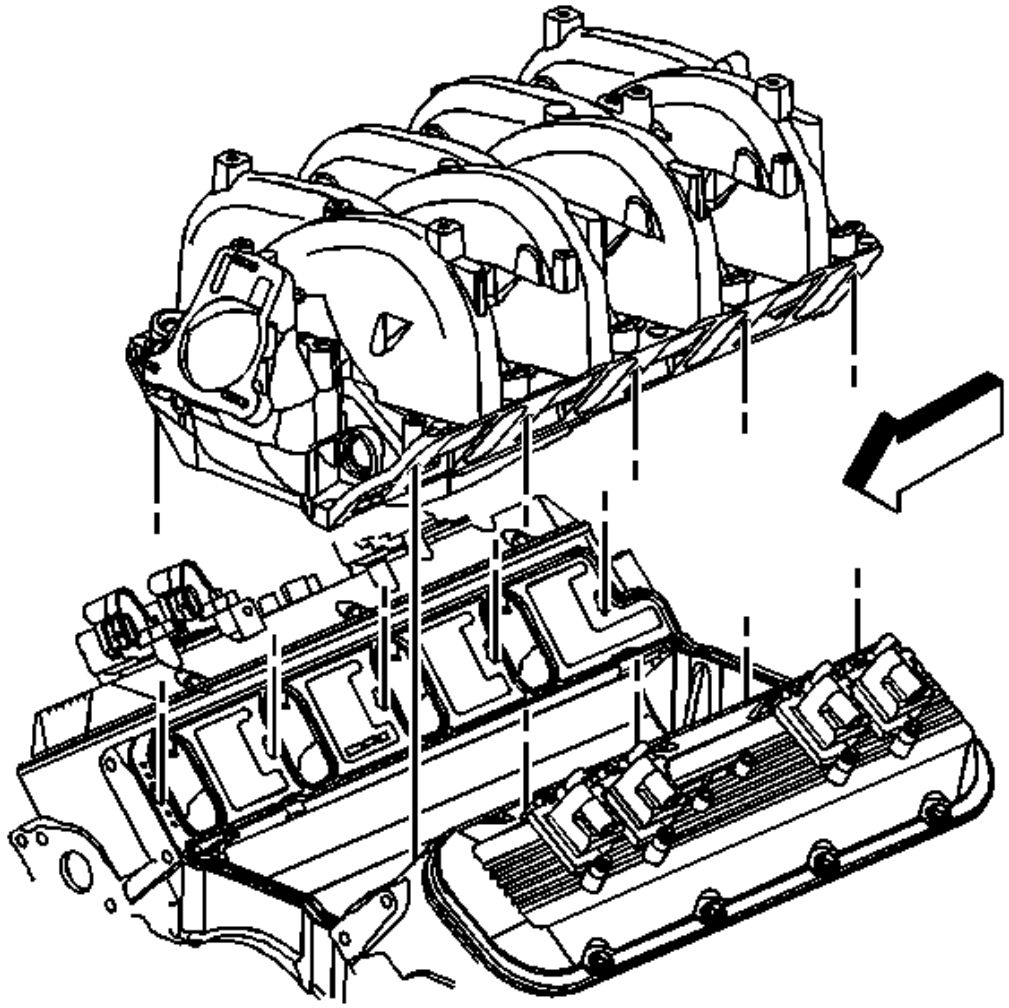

Fig. 68: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

8. Install the intake manifold.

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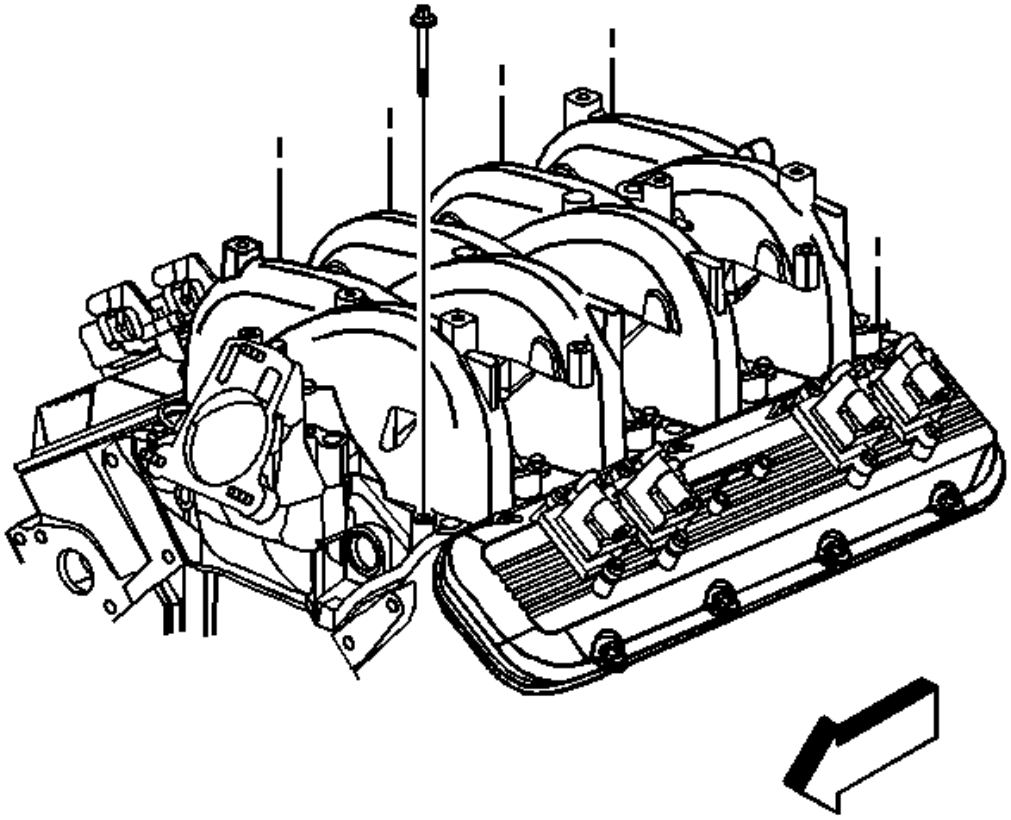

Fig. 69: View Of Intake Manifold Bolts
Courtesy of GENERAL MOTORS CORP.

9. Apply threadlock, GM P/N 12345382 (Canadian P/N 10953489), or equivalent to a minimum of eight threads of the intake manifold bolts.
10. Install the intake manifold bolts.

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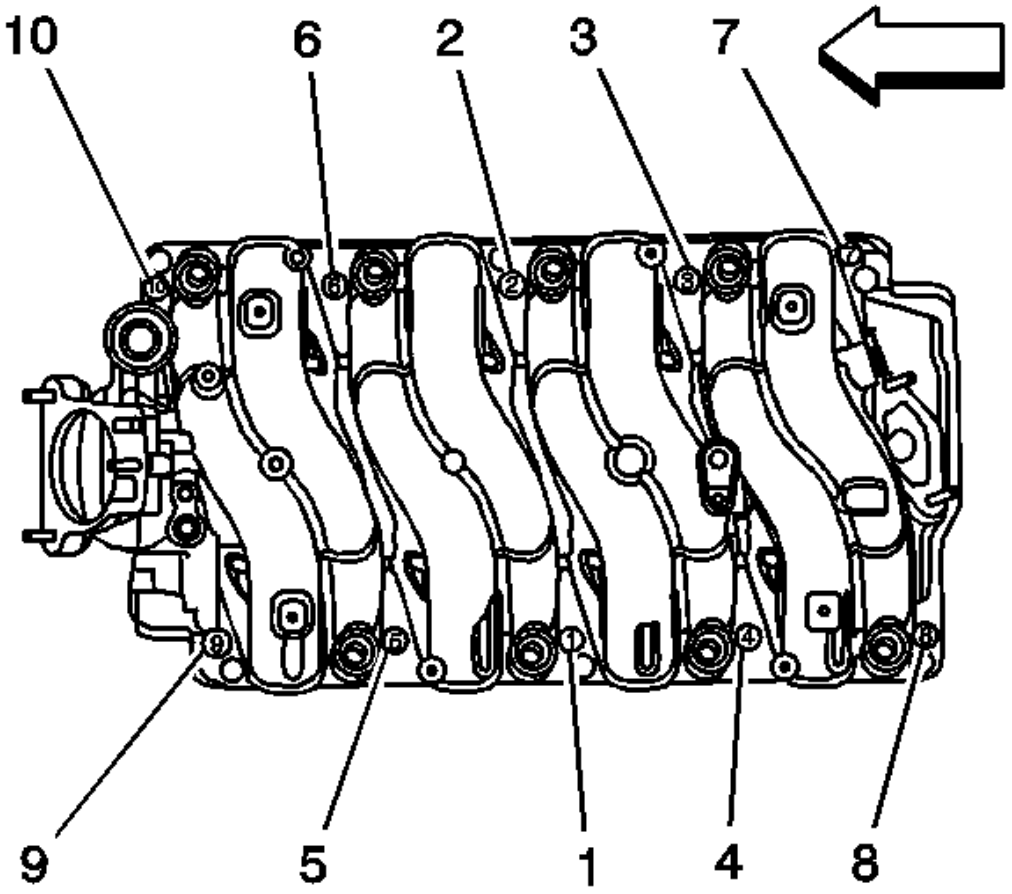

Fig. 70: Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Tighten the intake manifold bolts in the sequence shown, using four passes.

Tighten:

1. Tighten the bolts a first pass to 5 N.m (44 lb in).
2. Tighten the bolts a second pass to 8 N.m (71 lb in).
3. Tighten the bolts a third pass to 12 N.m (106 lb in).
4. Tighten the bolts a final pass to 15 N.m (11 lb ft).

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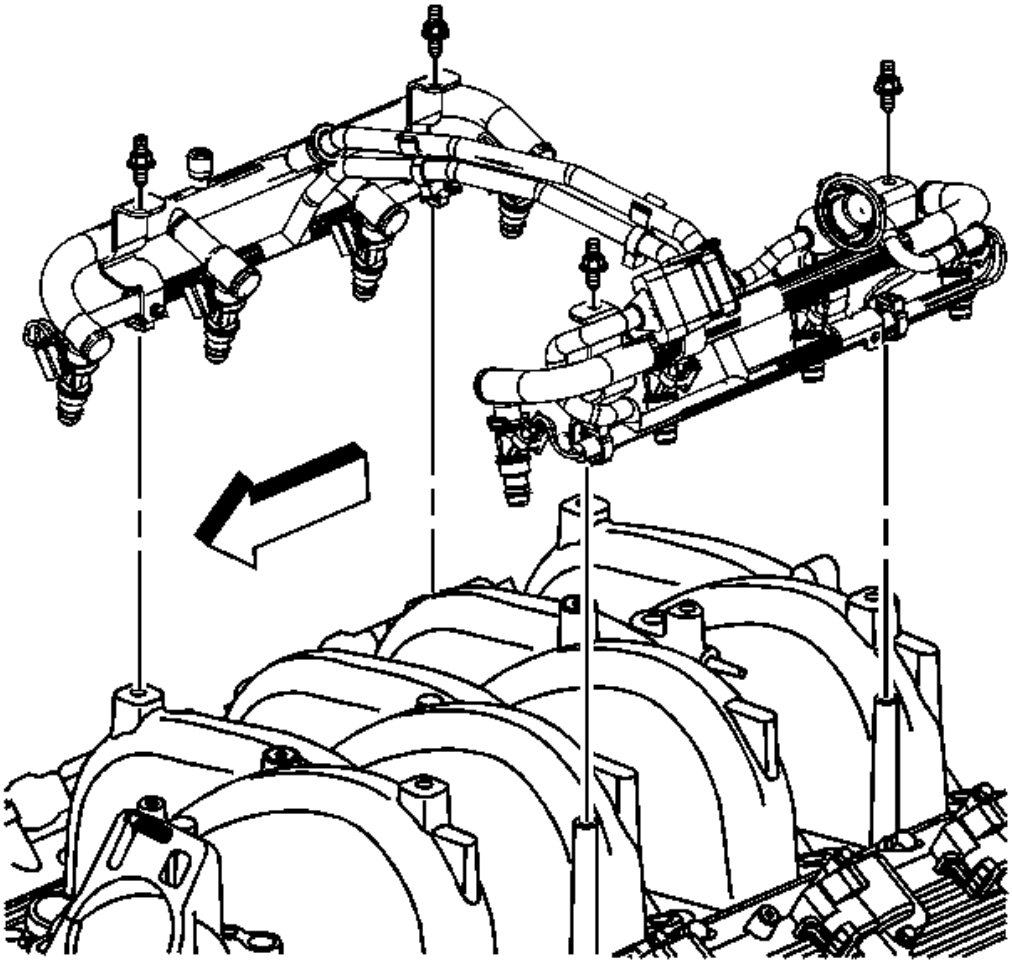

Fig. 71: View Of Fuel Injection Rail
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lubricate the fuel injector O-ring seals with clean engine oil and install onto the spray tip of each injector.

12. If replacing the intake manifold, install the fuel rail.
13. Install the fuel rail studs.

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

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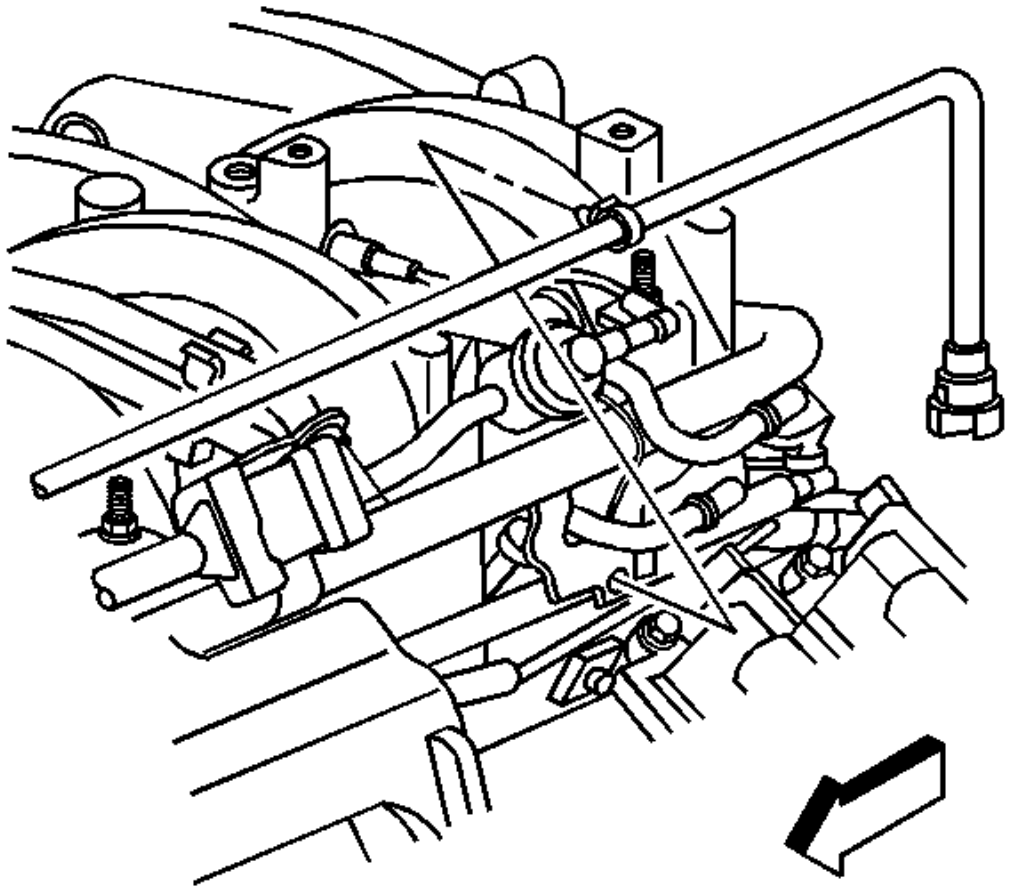

Fig. 72: View Of EVAP Tube At Fuel Rail
Courtesy of GENERAL MOTORS CORP.

14. Install the EVAP tube.
15. Connect the EVAP tube to the vent pipe at the rear of the engine.
16. Clip the EVAP tube to the fuel rail.

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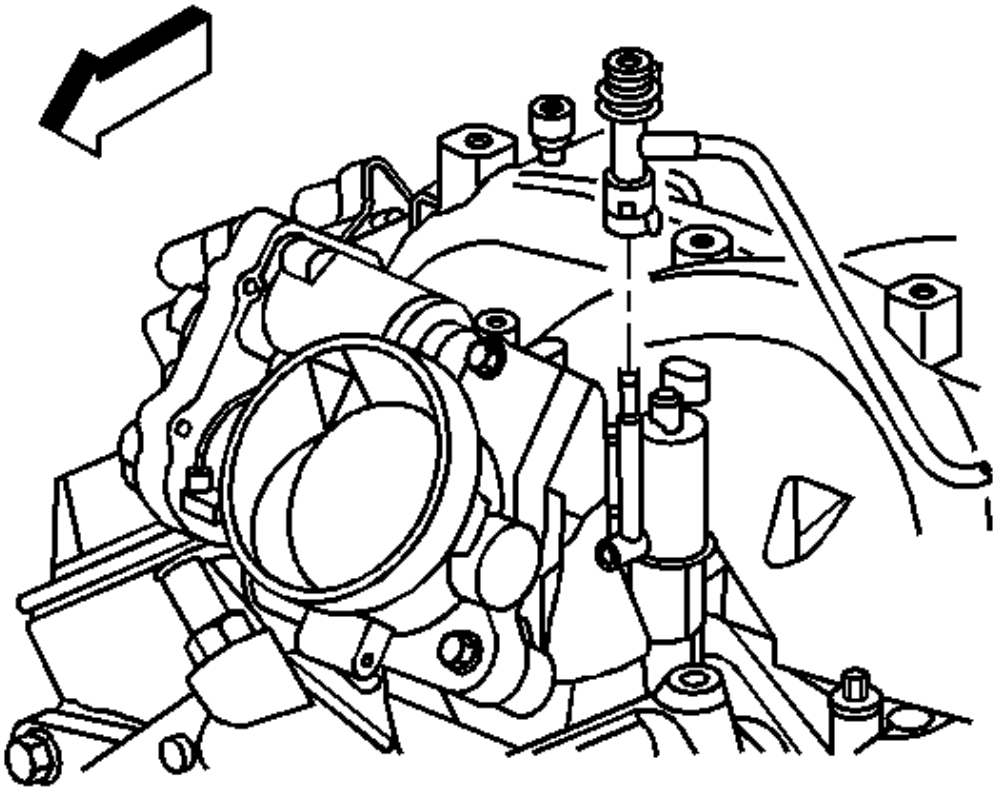

Fig. 73: View Of EVAP Purge Tube At Purge Solenoid
Courtesy of GENERAL MOTORS CORP.

17. Connect the EVAP tube to the purge solenoid.

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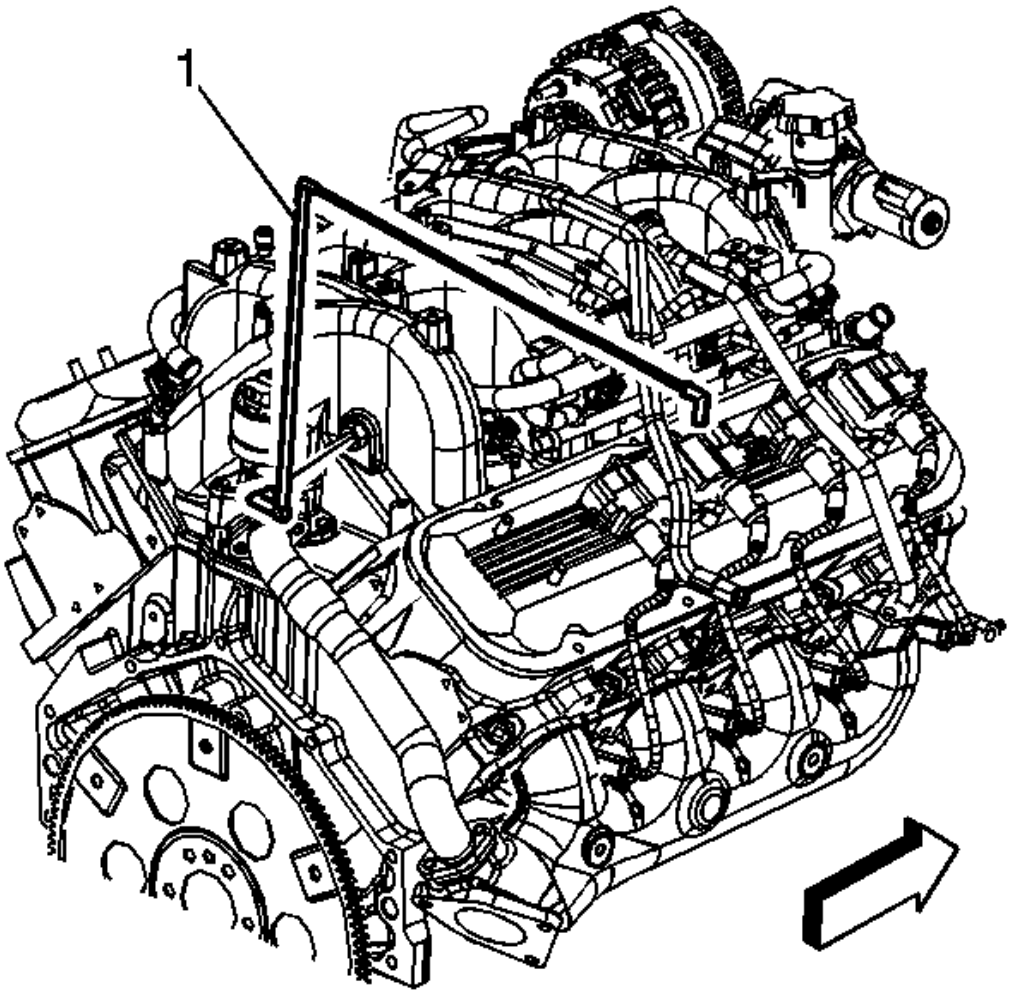

Fig. 74: View Of Bypass Valve Vacuum Hose
Courtesy of GENERAL MOTORS CORP.

18. Install the bypass valve vacuum hose (1) to the intake manifold.

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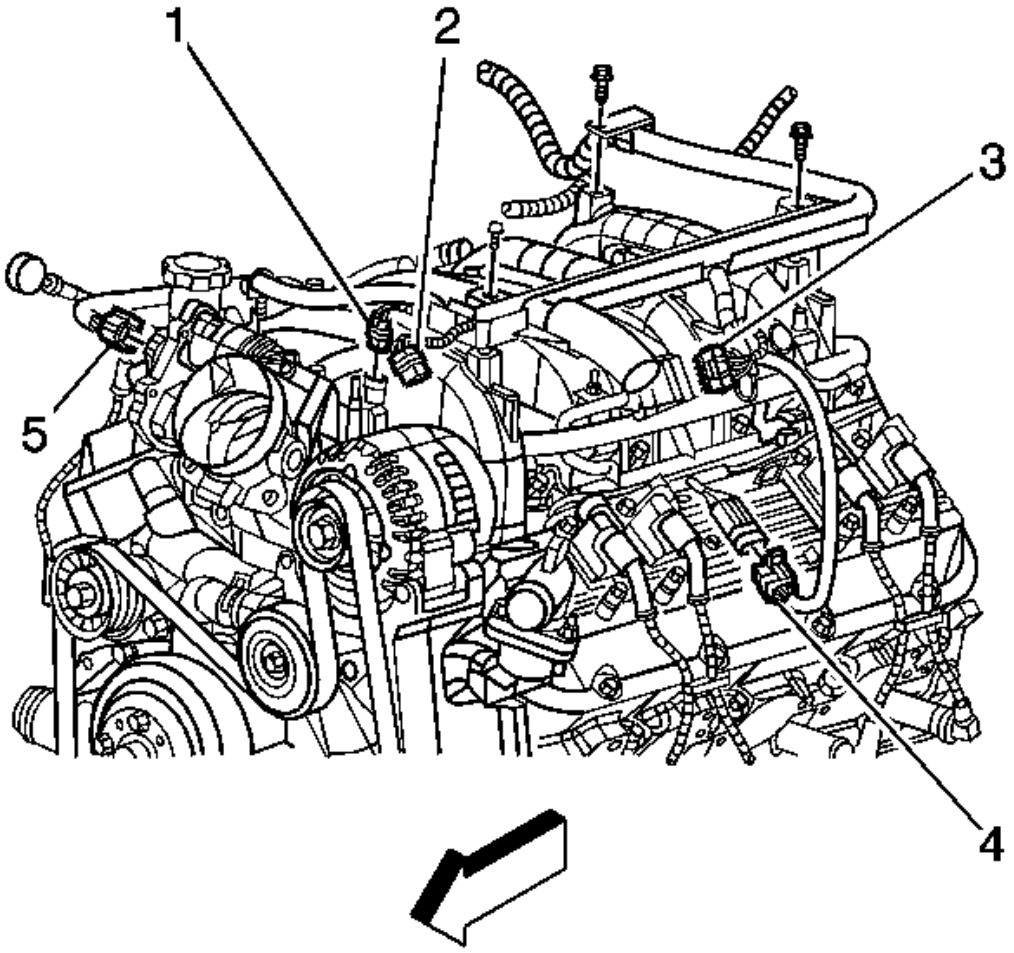

Fig. 75: View Of Generator, Injector Harness, Ignition Coil Harness, ETC & Purge Valve Solenoid Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

19. Position the engine harness over the engine compartment.
20. Connect the following electrical connectors:
    - Generator (2)
    - Injector harness (3)
    - Ignition coil harness (4)
    - ETC (5)
    - Purge valve solenoid (1)
21. Install the CPA retainer at the ignition coil harness.

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22. Install the engine harness bolt and studs

Tighten:

- Tighten the bolt to 16 N.m (12 lb ft).
- Tighten the studs to 10 N.m (89 lb in).

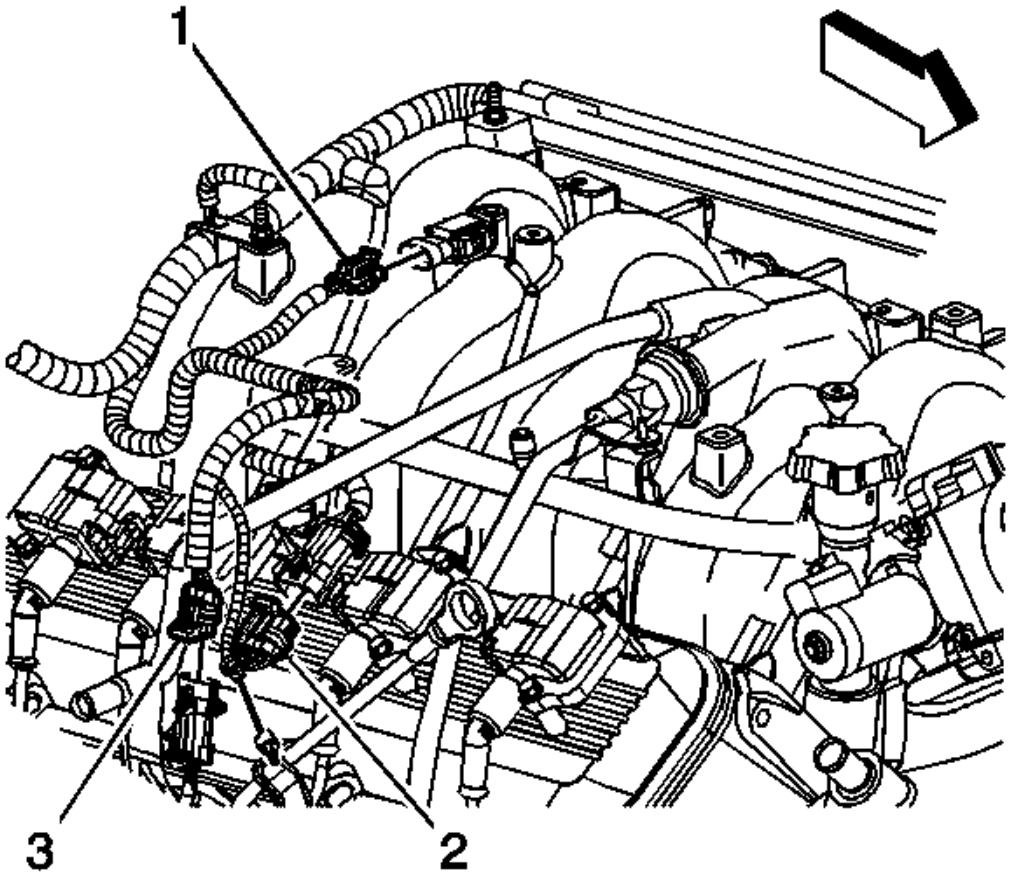

Fig. 76: View Of Ignition Coil, ECT And MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

23. Connect the following electrical connectors:
    - MAP sensor (1)
    - Ignition coil harness (2)
    - ECT sensor (3)
24. Install the CPA retainer at the ignition coil harness.

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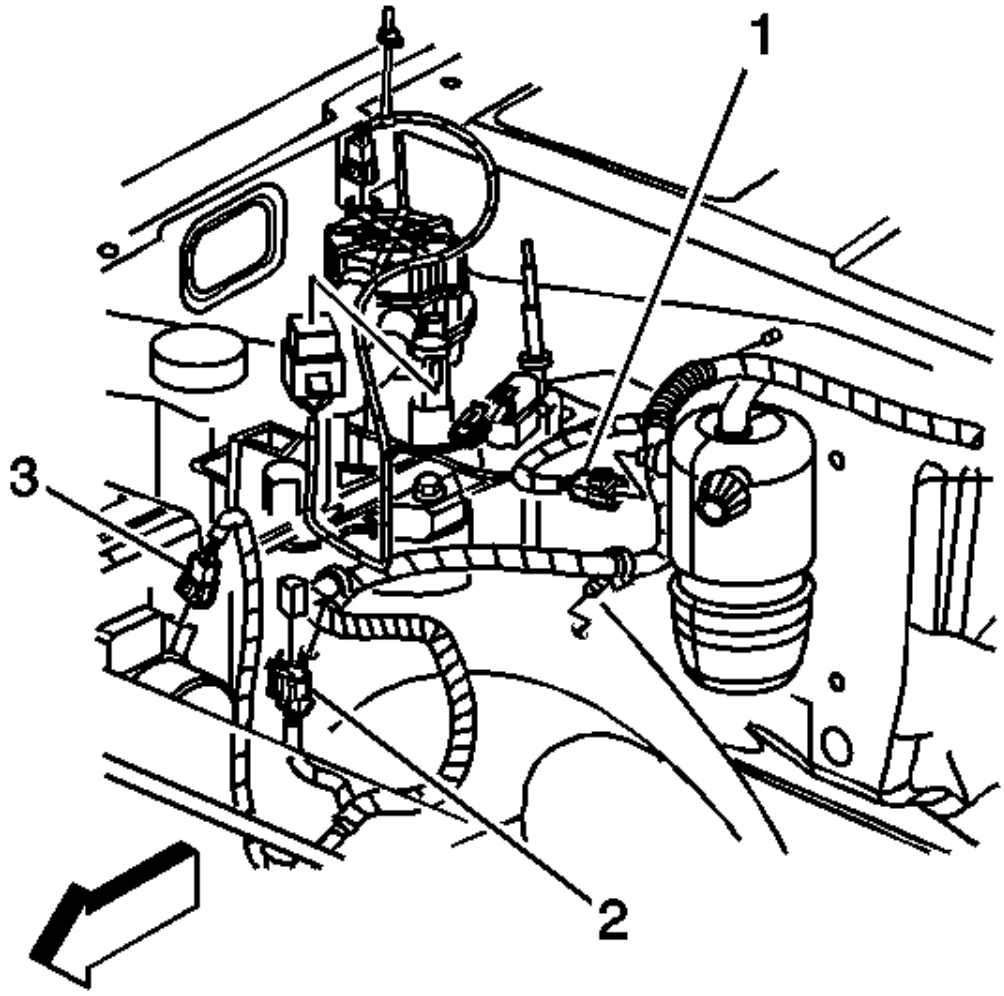

Fig. 77: View Of MAF/IAT Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

25. Position engine harness branch over the top of engine.
26. Connect the following electrical connectors:
    - Pressure cycling switch (1)
    - Surge tank switch (2)
    - MAF sensor (3)
27. Connect the engine harness clip to the wheelhouse splash shield.
28. Connect the engine harness clips to the studs on the front of dash.

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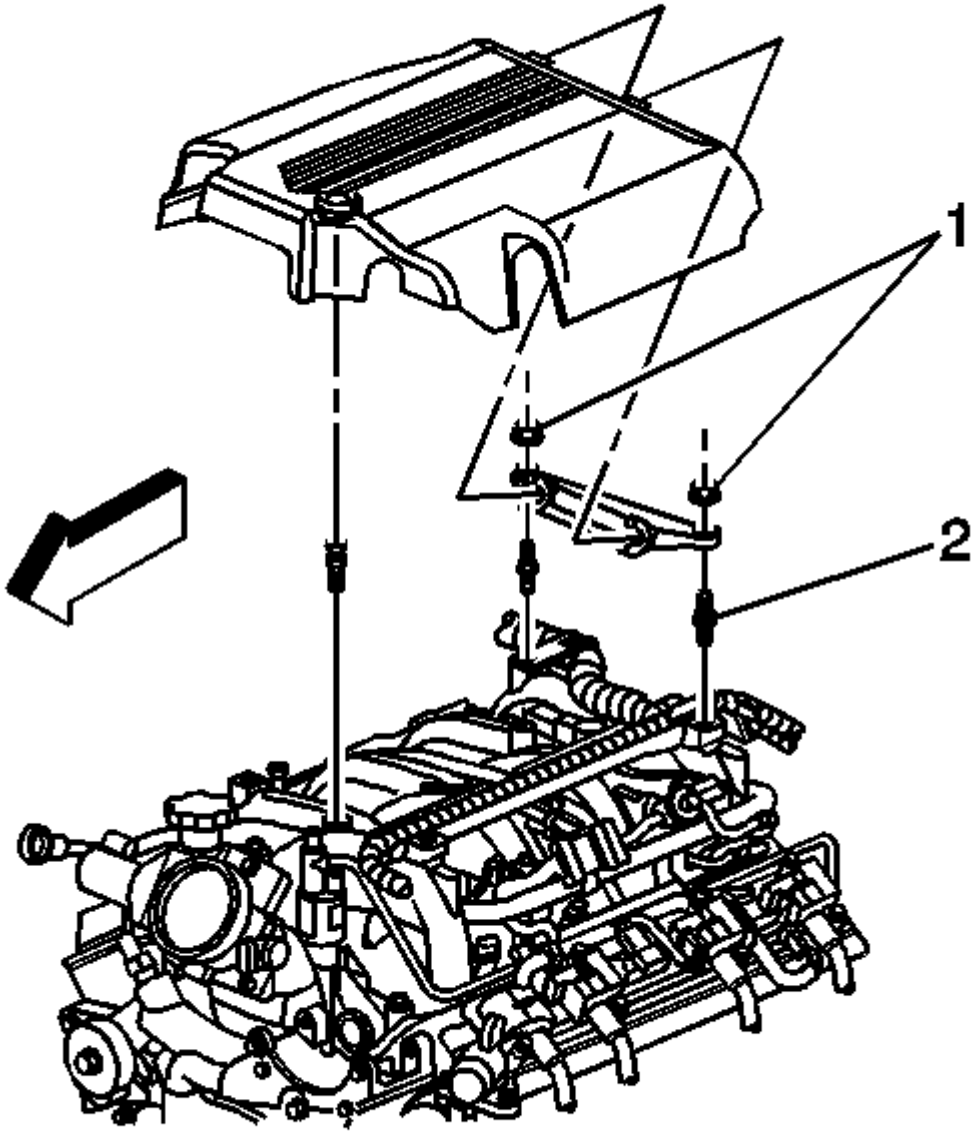

Fig. 78: View Of Sight Shield, Bracket, Retainer Nuts & Studs
Courtesy of GENERAL MOTORS CORP.

29. Connect the fuel feed and return pipes.
30. Install the sight shield bracket and nuts (1).

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

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31. Install the sight shield to the bracket.
32. Snap the intake manifold sight shield to the stud.

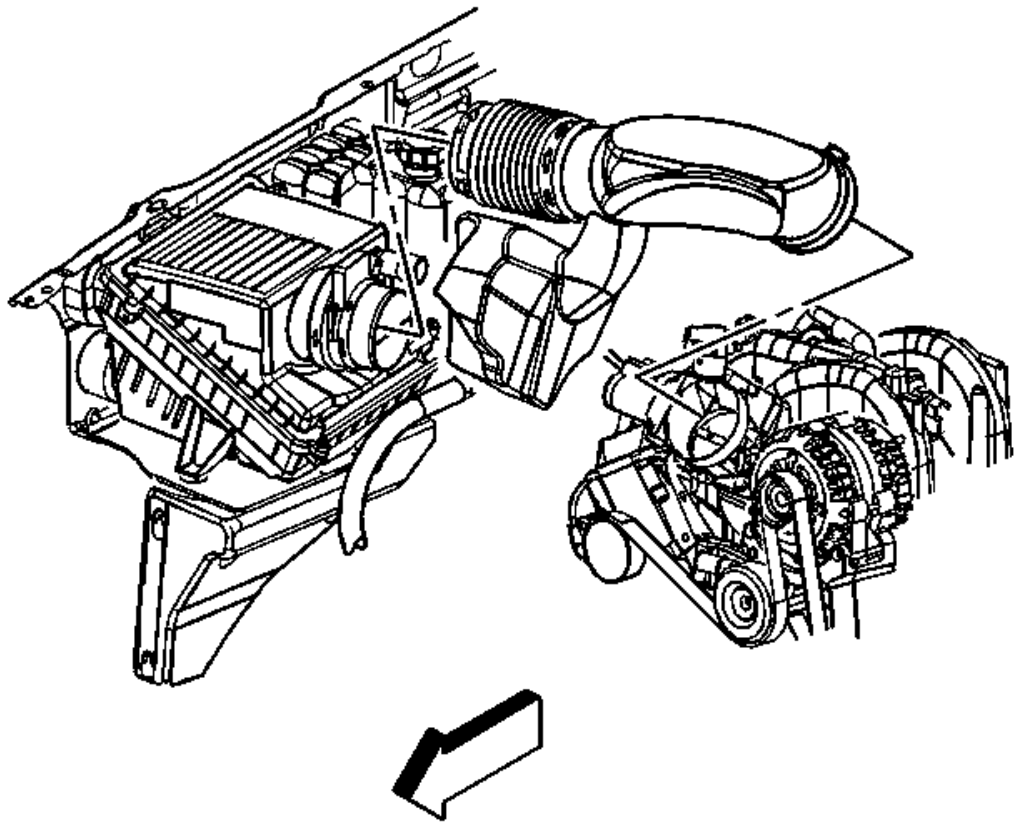

Fig. 79: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

33. Install the air cleaner outlet duct.
34. Tighten the clamps at the throttle body and air cleaner.

Tighten: Tighten the clamps to 4 N.m (35 lb in).

Valve Rocker Arm Cover Replacement - Left

Removal Procedure

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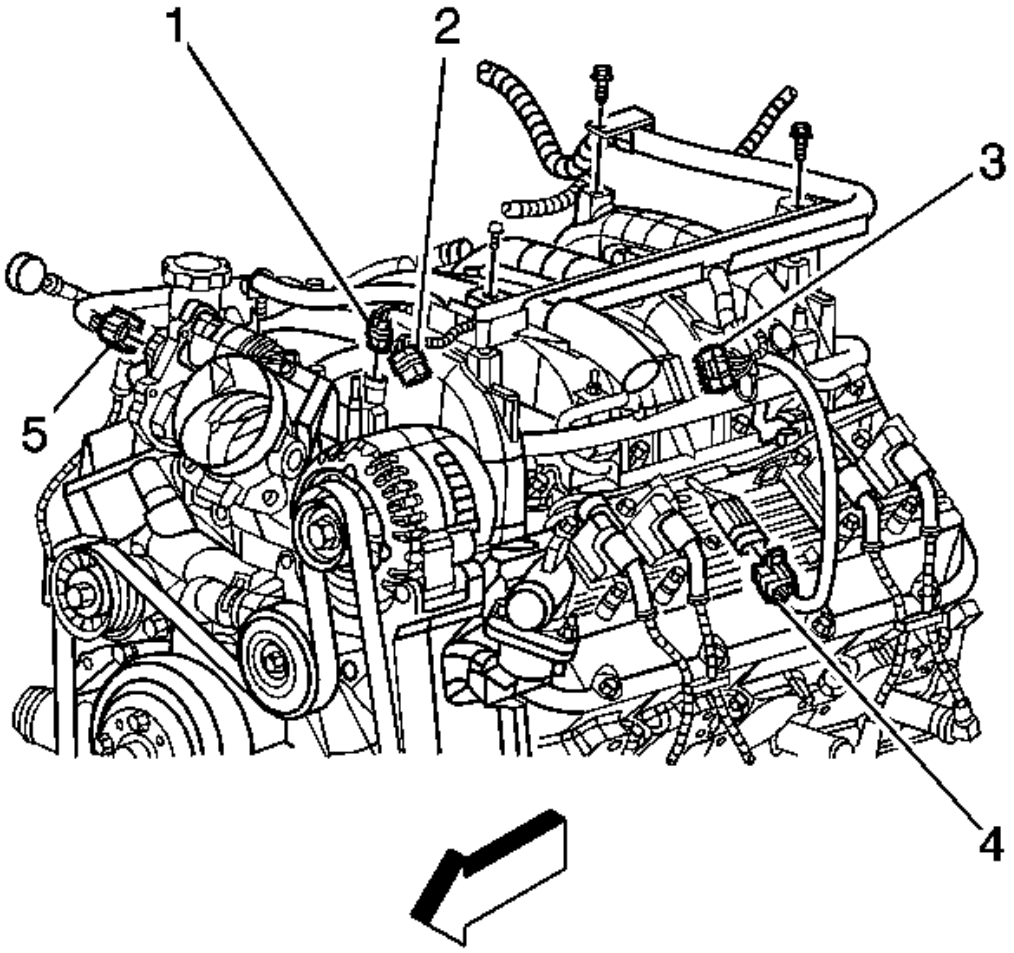

Fig. 80: View Of Generator, Injector Harness, Ignition Coil Harness, ETC & Purge Valve Solenoid Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement**.
2. Remove the connector position assurance (CPA) retainer from the ignition coil electrical connector.
3. Disconnect the ignition coil harness electrical connector (4).

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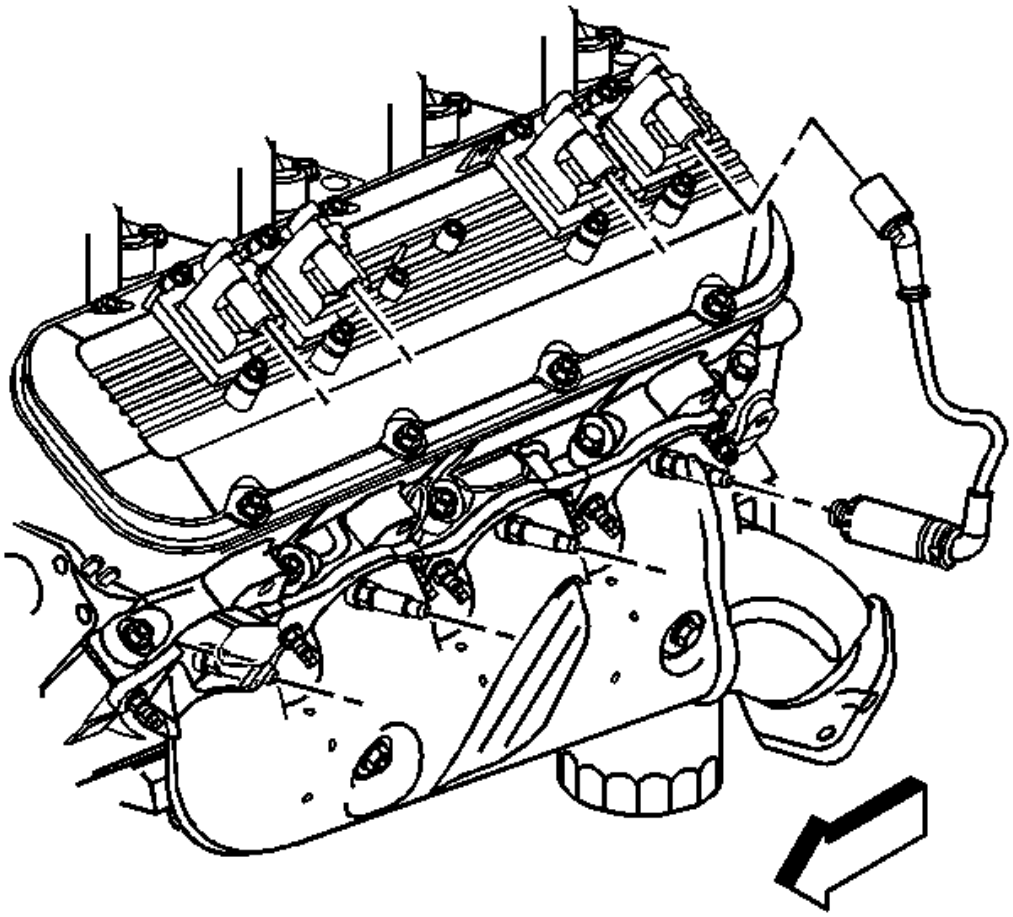

Fig. 81: View Of Spark Plug Wires (Left)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

4. Remove the spark plug wires from the spark plugs and ignition coils.

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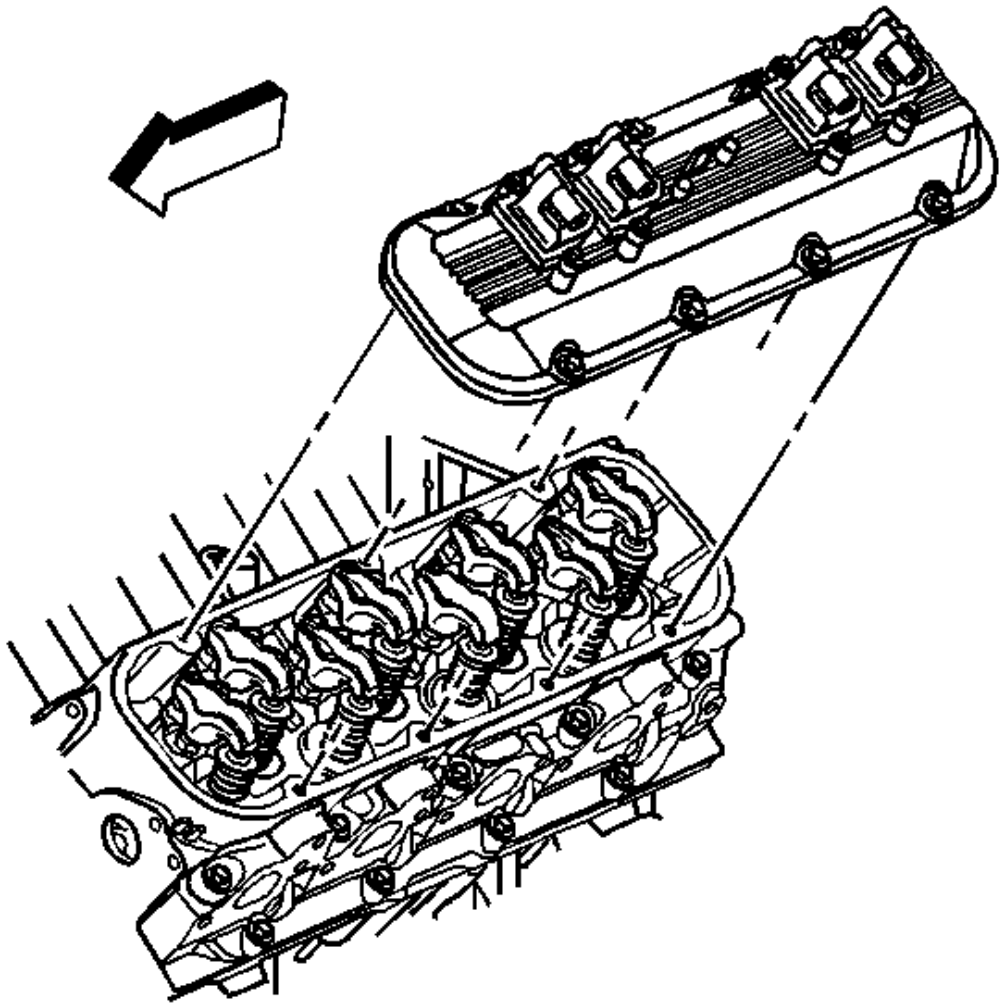

Fig. 82: View Of Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

5. Remove the valve rocker arm cover bolts.
6. Remove the valve rocker arm cover.

IMPORTANT: Valve rocker arm cover gaskets are reusable. Replace the gasket only if damaged.

7. Inspect the valve rocker arm cover gasket for cuts or damage.
8. Clean and inspect the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and**

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Inspection.

Installation Procedure

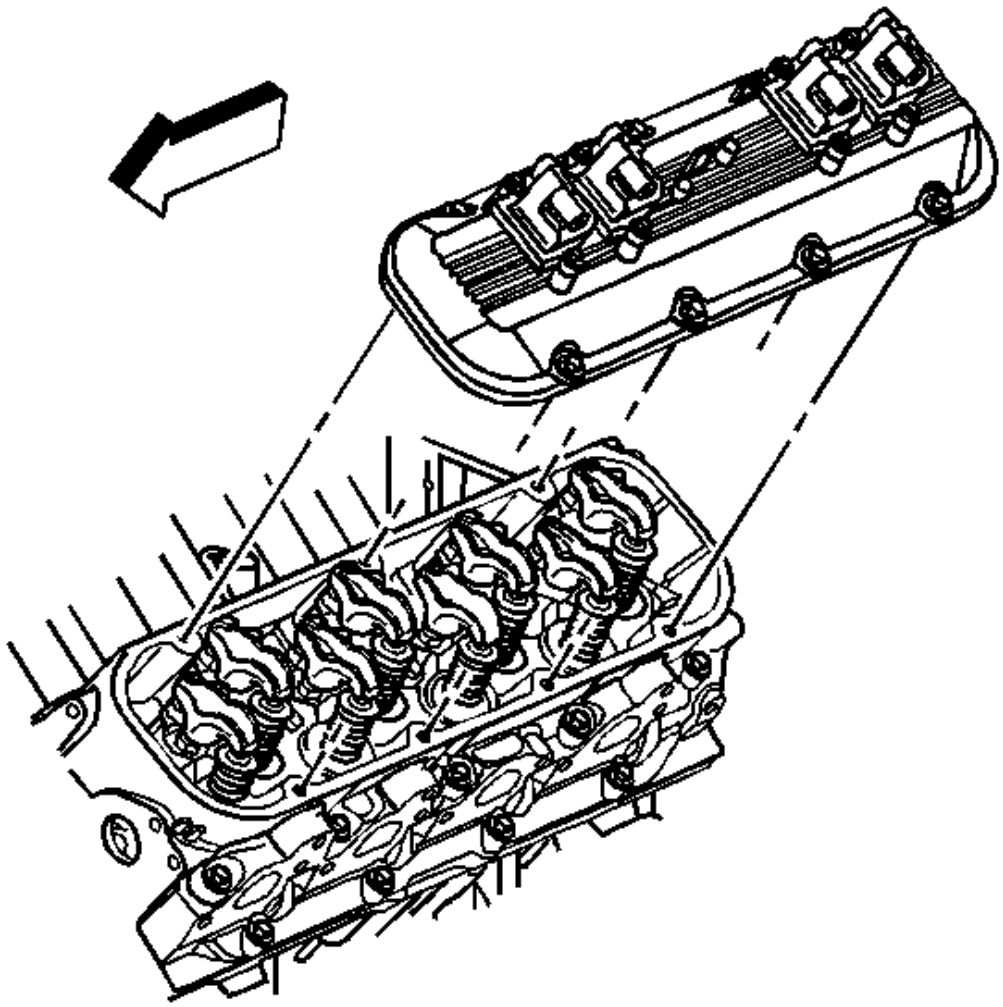

Fig. 83: View Of Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

1. Install a new valve rocker arm cover gasket if the gasket was removed from the rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.

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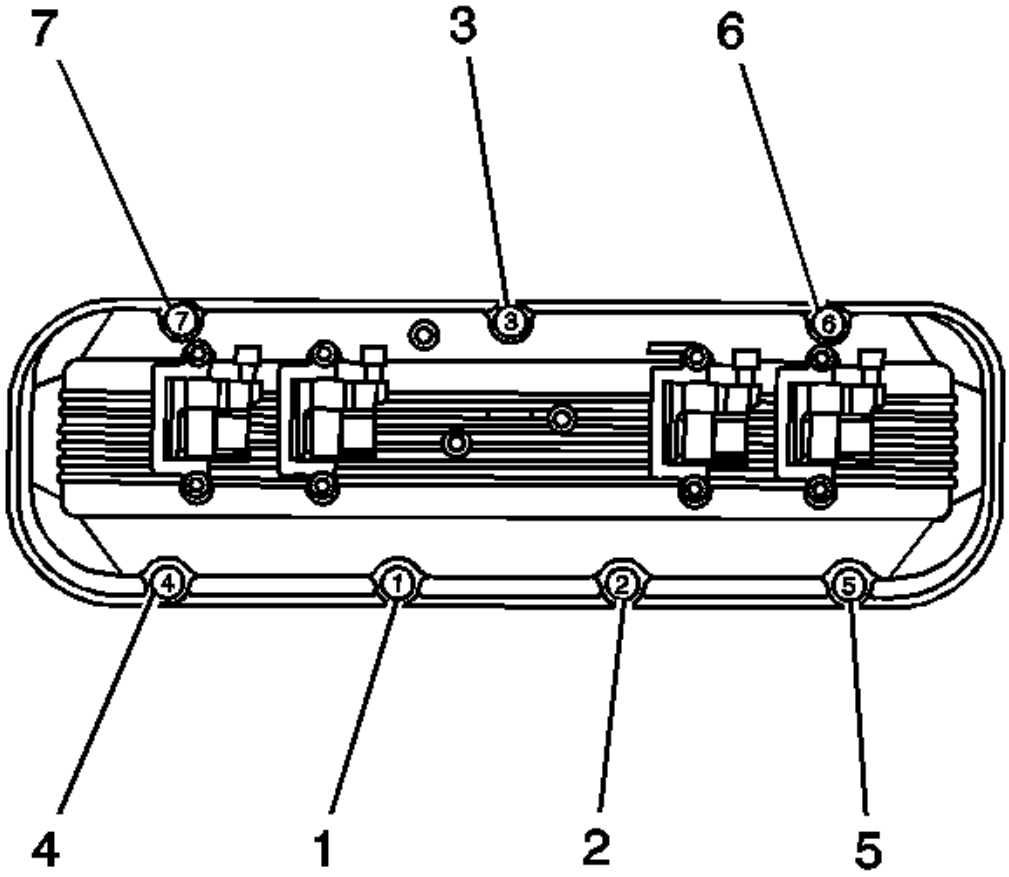

Fig. 84: Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Tighten the valve rocker arm cover bolts in the sequence shown, using two passes as shown.

Tighten:

- Tighten the bolts a first pass to 6 N.m (53 lb in).
- Tighten the bolts a final pass to 12 N.m (106 lb in).

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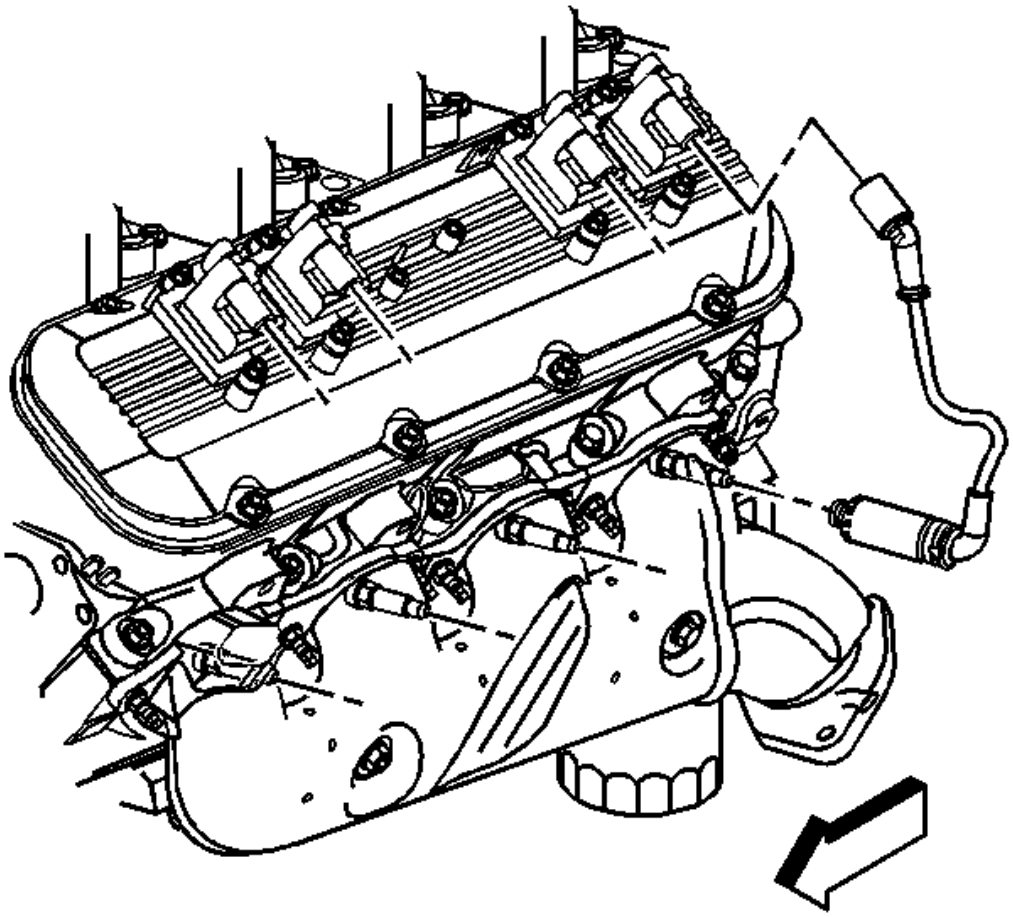

Fig. 85: View Of Spark Plug Wires (Left)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

5. Install the spark plug wires to the spark plugs and ignition coils.

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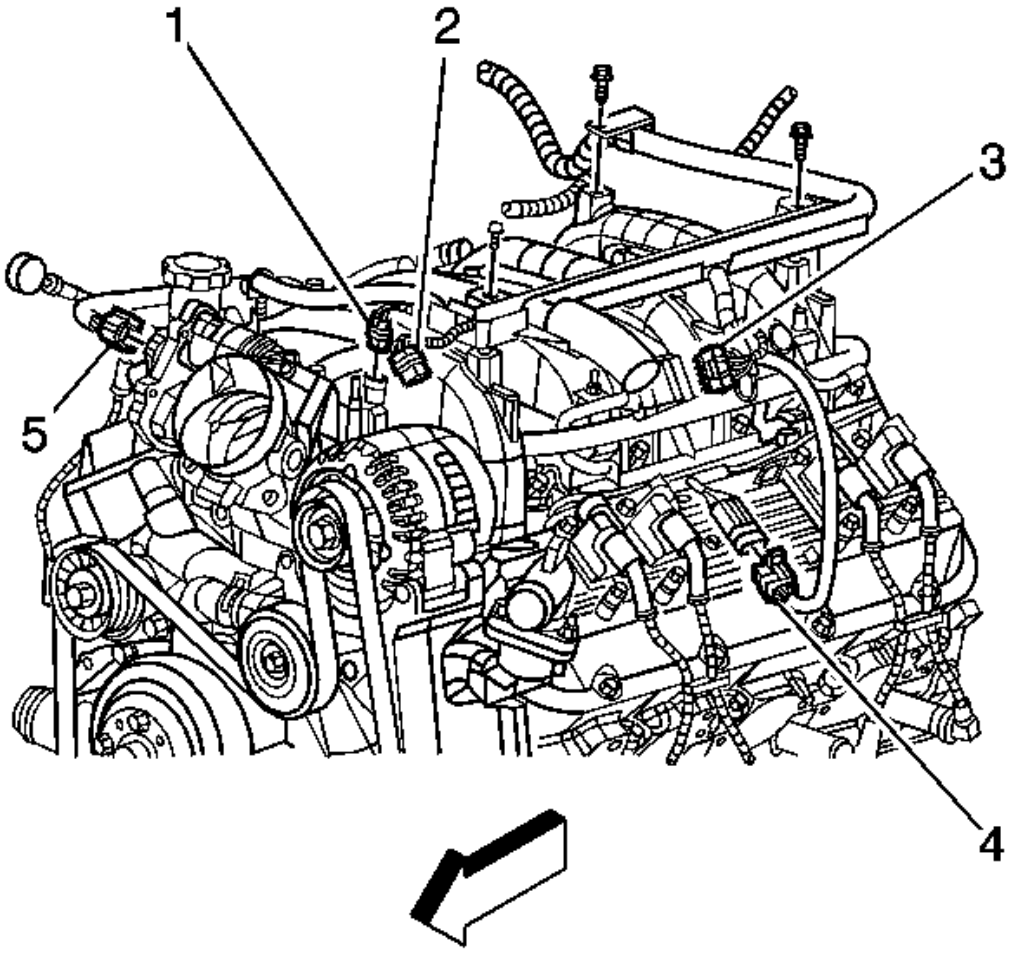

Fig. 86: View Of Generator, Injector Harness, Ignition Coil Harness, ETC & Purge Valve Solenoid Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

6. Connect the ignition coil harness electrical connector (4).
7. Install the CPA retainer to the ignition coil electrical connector.
8. Install the engine sight shield. Refer to **Engine Sight Shield Replacement**.

Valve Rocker Arm Cover Replacement - Right

Removal Procedure

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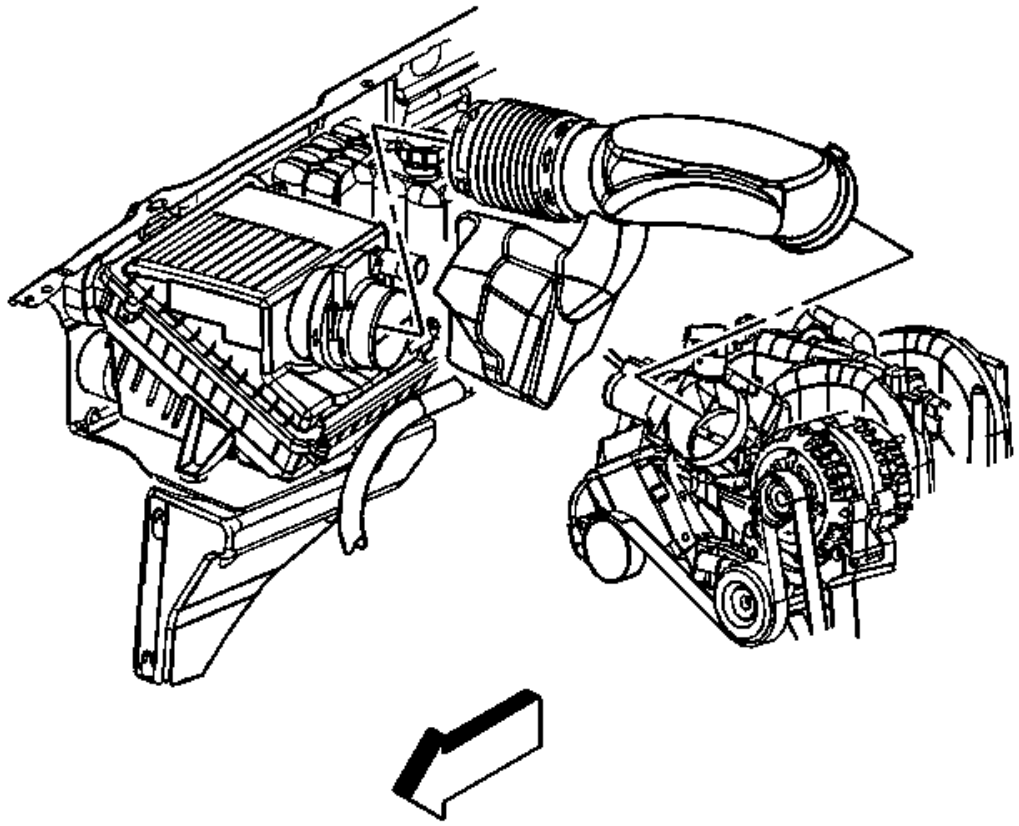

Fig. 87: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement**.
2. Loosen the clamps at the throttle body and air cleaner.
3. Remove the air cleaner outlet duct.

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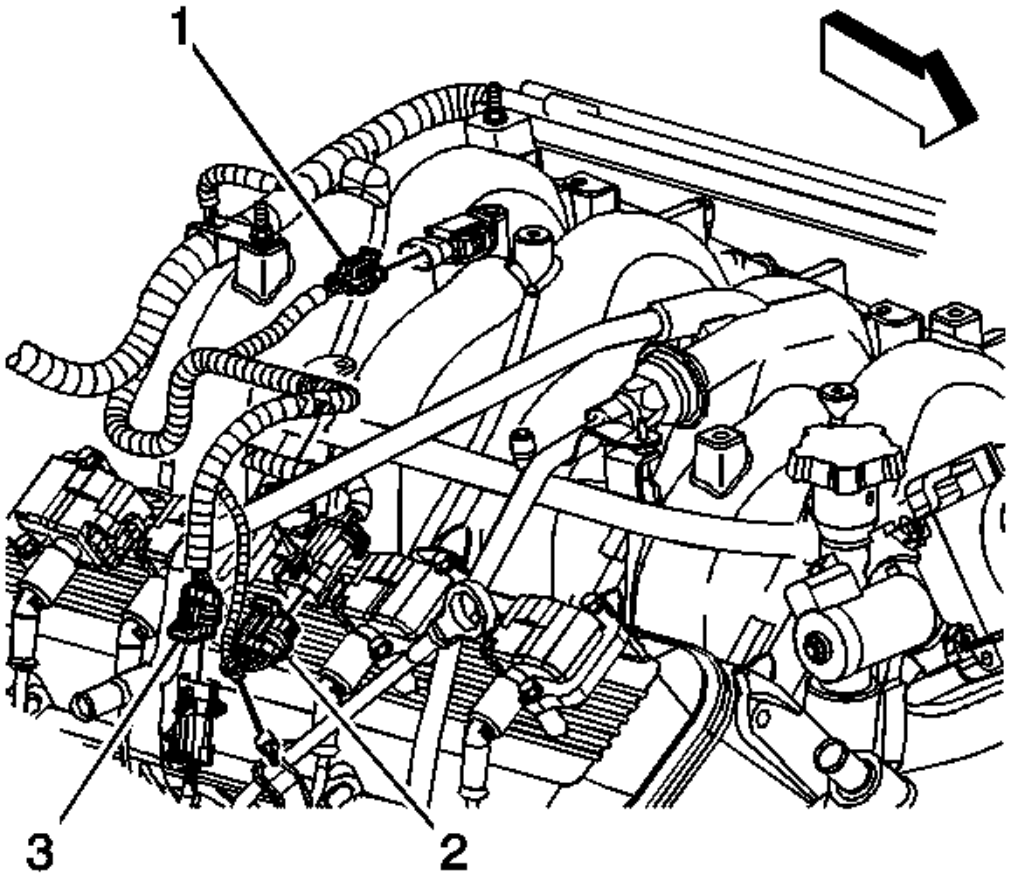

Fig. 88: View Of Ignition Coil, ECT And MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

4. Remove the connector position assurance (CPA) retainer from the ignition coil electrical connector (2).
5. Disconnect the ignition coil harness electrical connector (2).
6. Disconnect the engine coolant temperature (ECT) sensor electrical connector (3).

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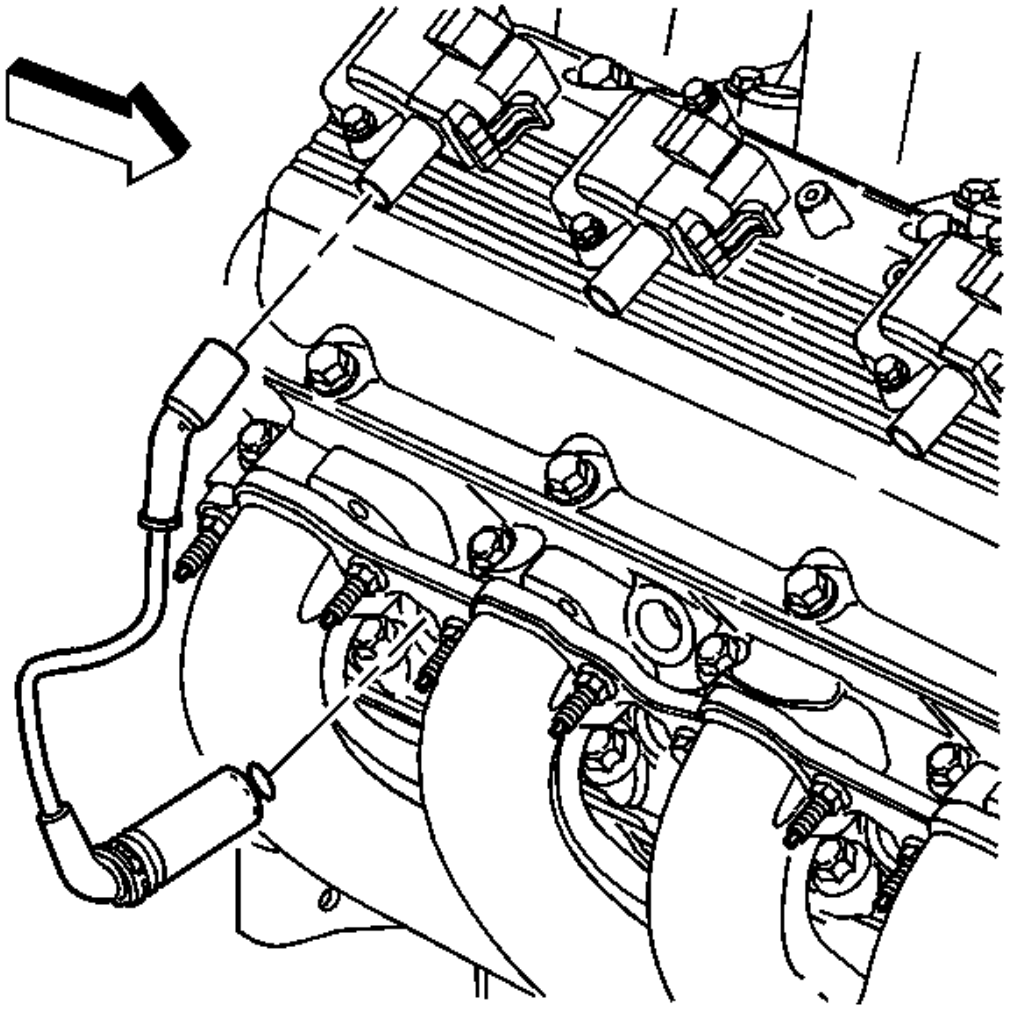

Fig. 89: View Of Spark Plug Wires (Right)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

7. Remove the spark plug wires from the ignition coils.

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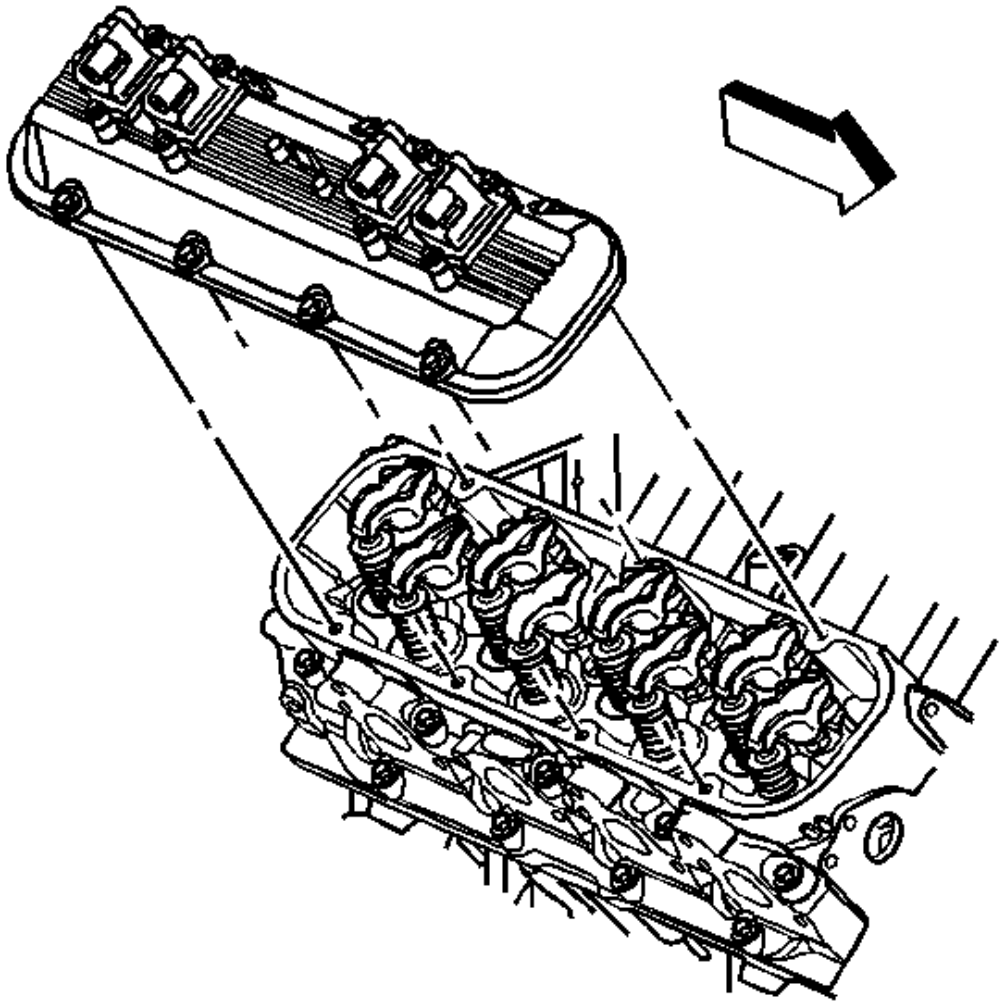

Fig. 90: View Of Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

8. Loosen the valve rocker arm cover bolts.
9. Remove the valve rocker arm cover.

IMPORTANT: The valve rocker arm cover gasket may be reused if not removed from the valve rocker arm cover.

10. Replace the valve rocker arm cover gasket if it is cut or damaged.
11. Clean and inspect the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and**

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Inspection.

Installation Procedure

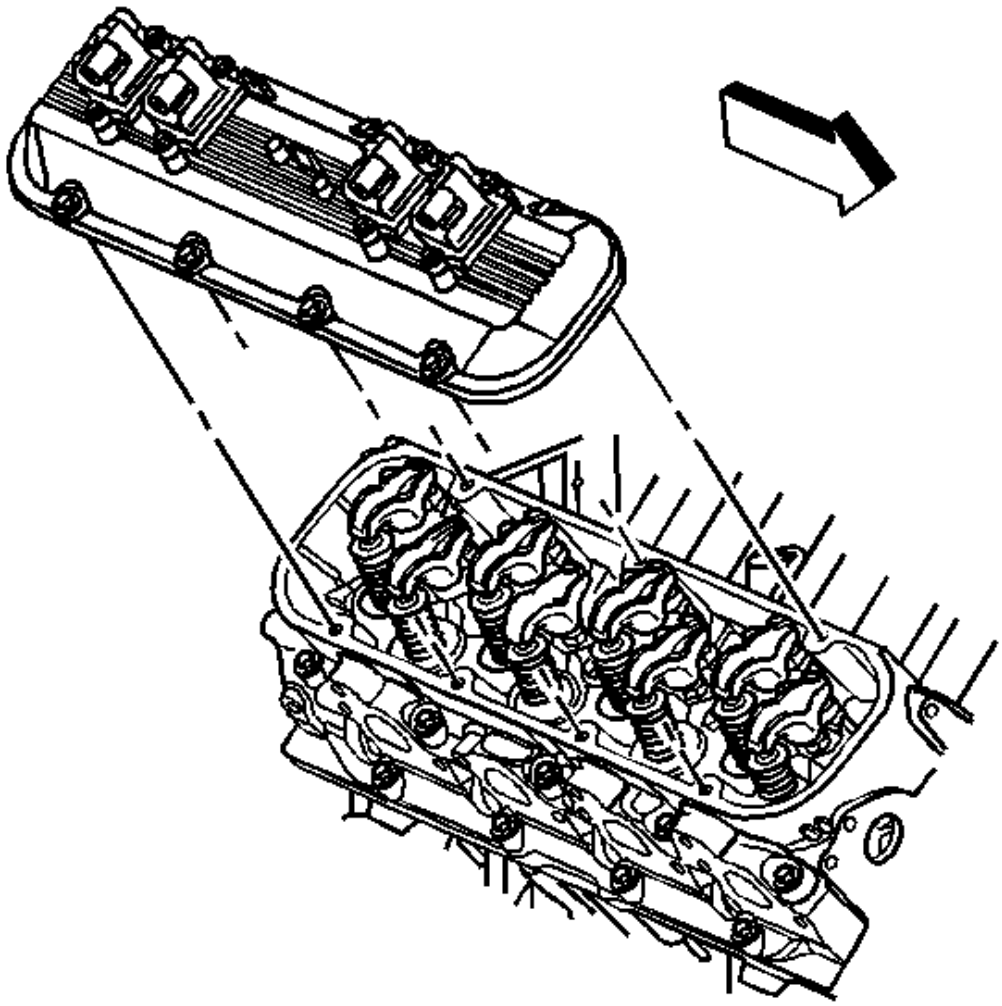

Fig. 91: View Of Valve Rocker Arm Cover (Right)
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW valve rocker arm cover gasket, if necessary.
2. Install the valve rocker arm cover.

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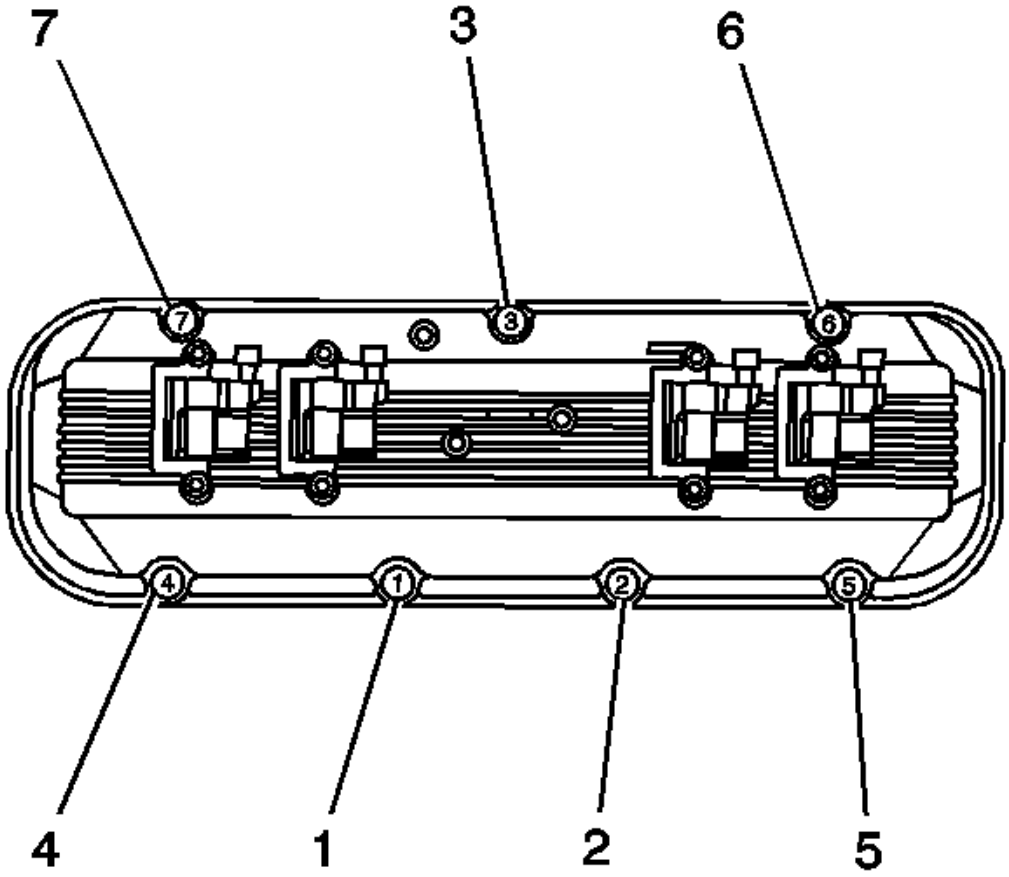

Fig. 92: Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Tighten the valve rocker arm cover bolts in sequence using two passes as shown.

Tighten:

1. Tighten the bolts a first pass to 6 N.m (53 lb in).
2. Tighten the bolts a final pass to 12 N.m (106 lb in).

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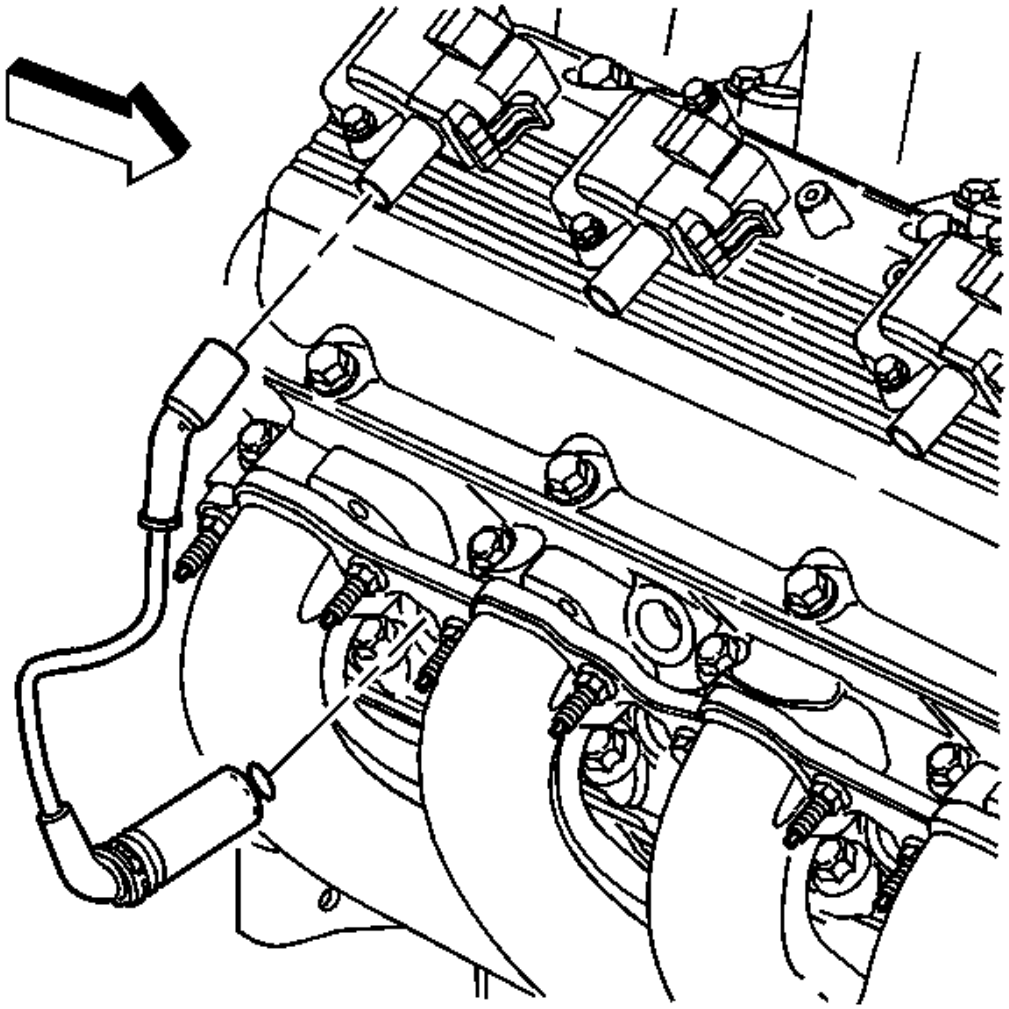

Fig. 93: View Of Spark Plug Wires (Right)
Courtesy of GENERAL MOTORS CORP.

4. Install the spark plug wires to the ignition coils.

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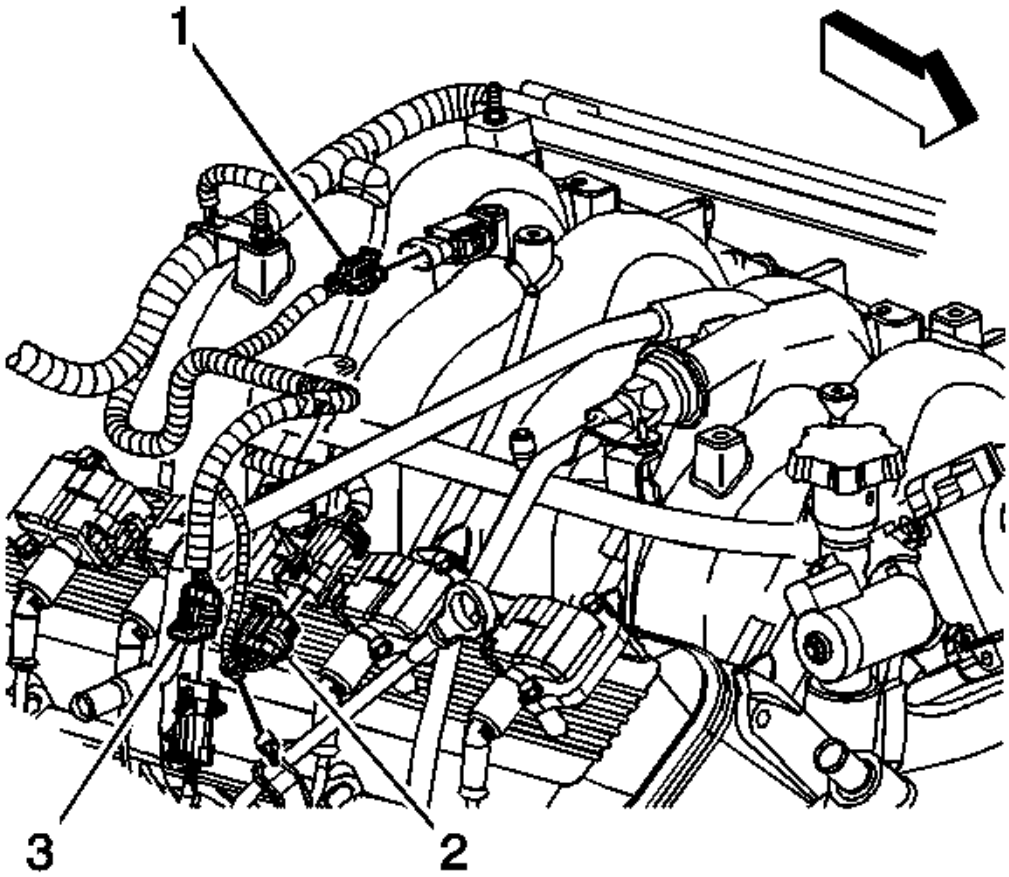

Fig. 94: View Of Ignition Coil, ECT And MAP Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

5. Connect the ECT sensor electrical connector (3).
6. Connect the ignition coil harness electrical connector (2).
7. Install the CPA retainer to the ignition coil electrical connector (2).

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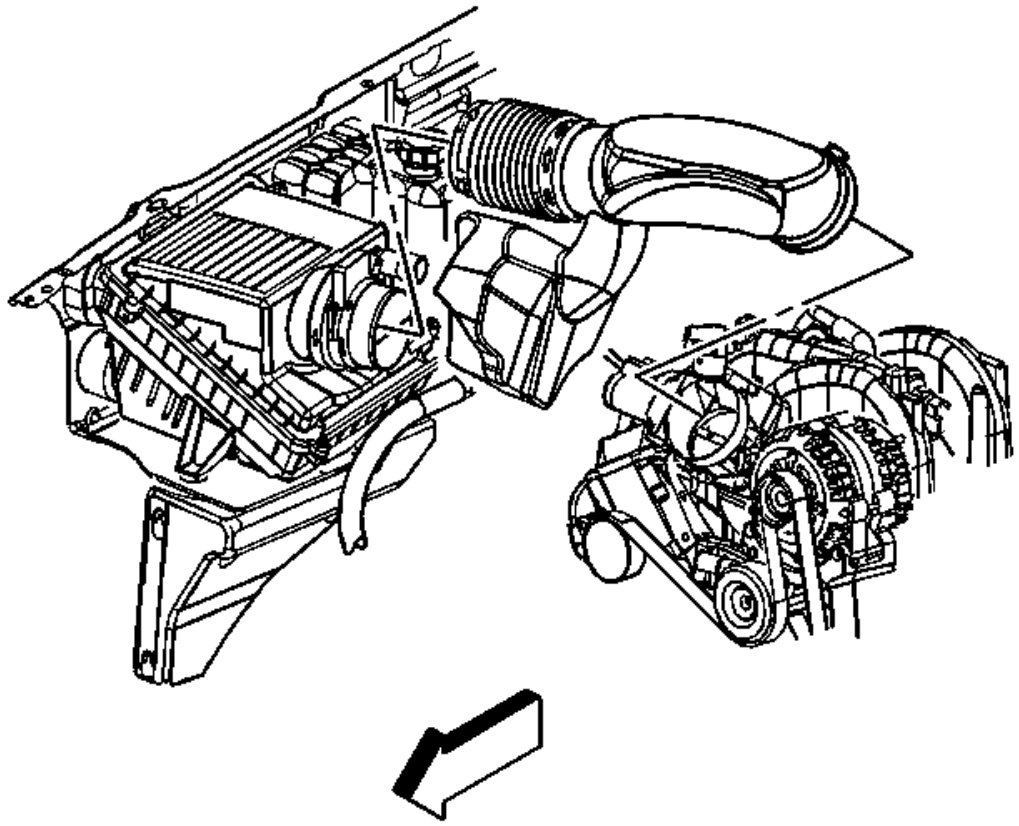

Fig. 95: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

8. Install the air cleaner outlet duct.
9. Tighten the clamps at the throttle body and air cleaner.

   Tighten: Tighten the clamps to 4 N.m (35 lb in).

10. Install the engine sight shield. Refer to **Engine Sight Shield Replacement**.

Valve Rocker Arm and Push Rod Replacement

Removal Procedure

IMPORTANT: Mark, organize, and sort the cylinder head components. Return the components to their original location during reassembly.

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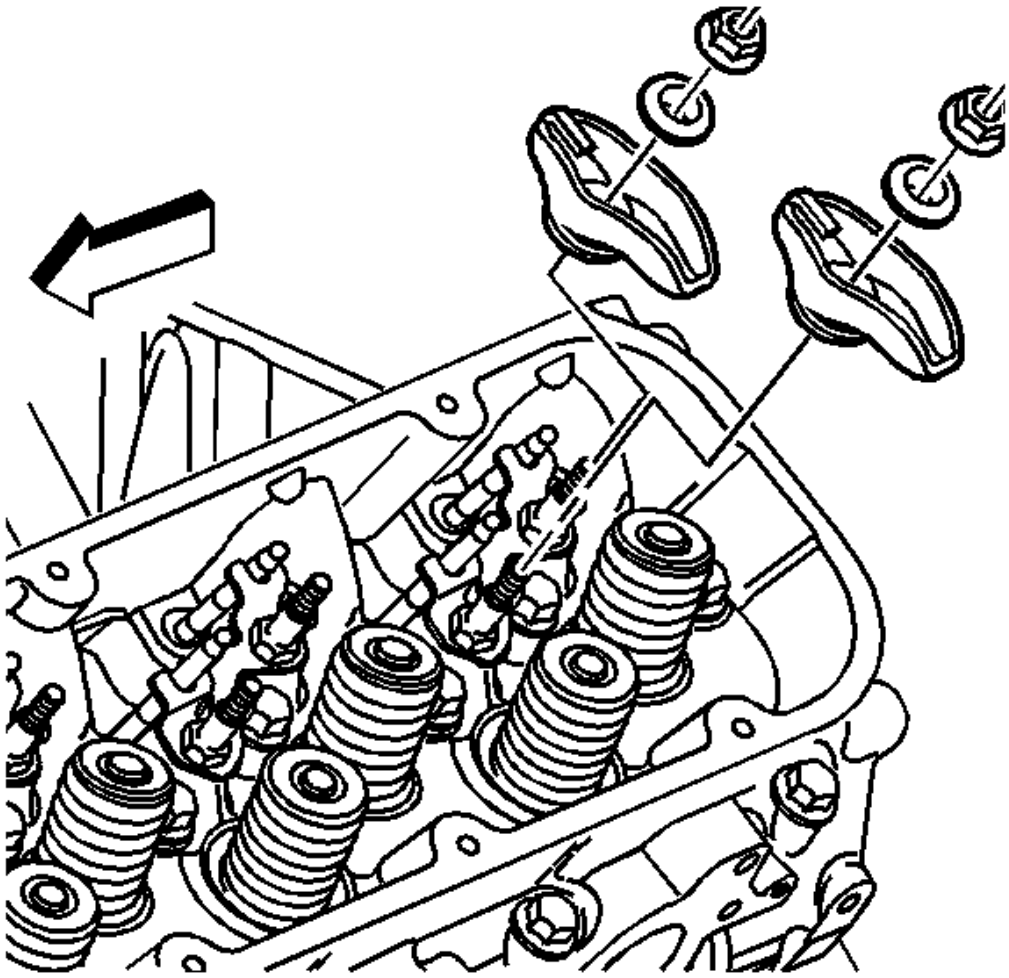

Fig. 96: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left** and/or **Valve Rocker Arm Cover Replacement - Right**.
2. Remove the valve rocker arm nuts, the valve rocker arm balls, and valve rocker arms.

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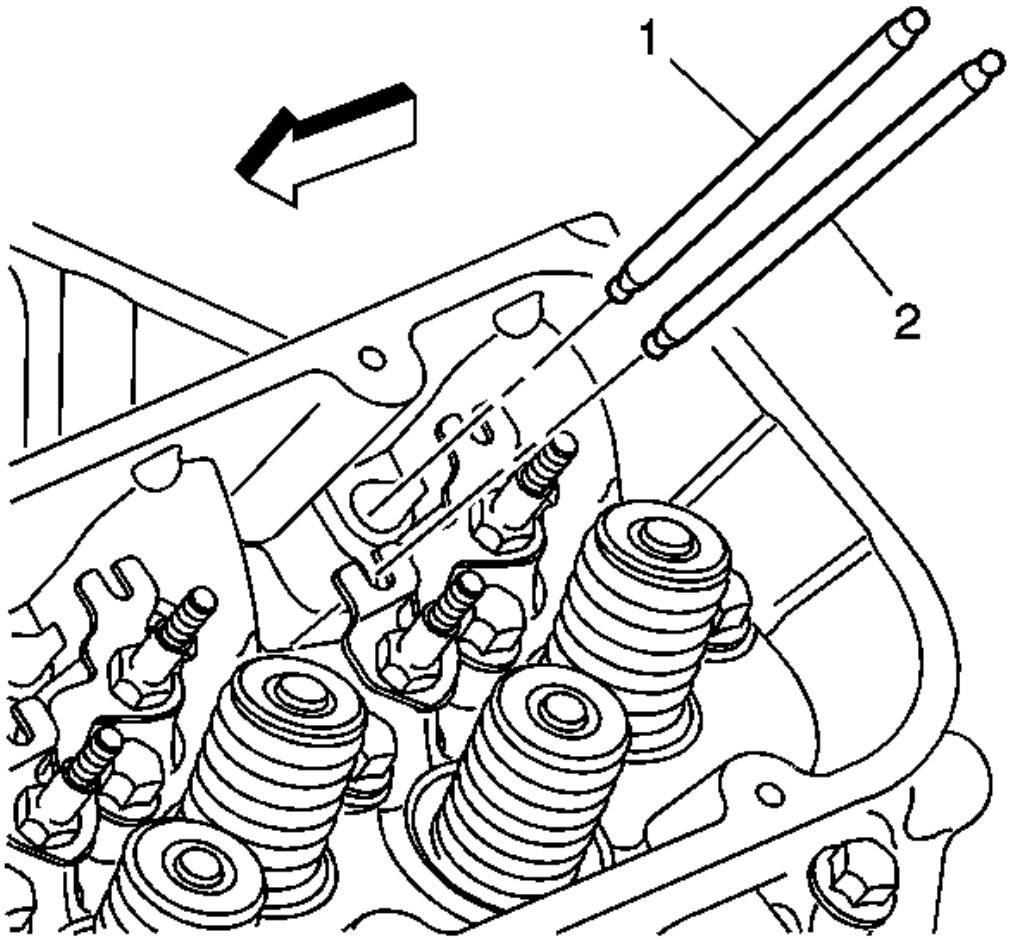

Fig. 97: View Of Intake & Exhaust Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve pushrods (2) are longer than the intake valve pushrods (1).

3. Remove the valve pushrods.

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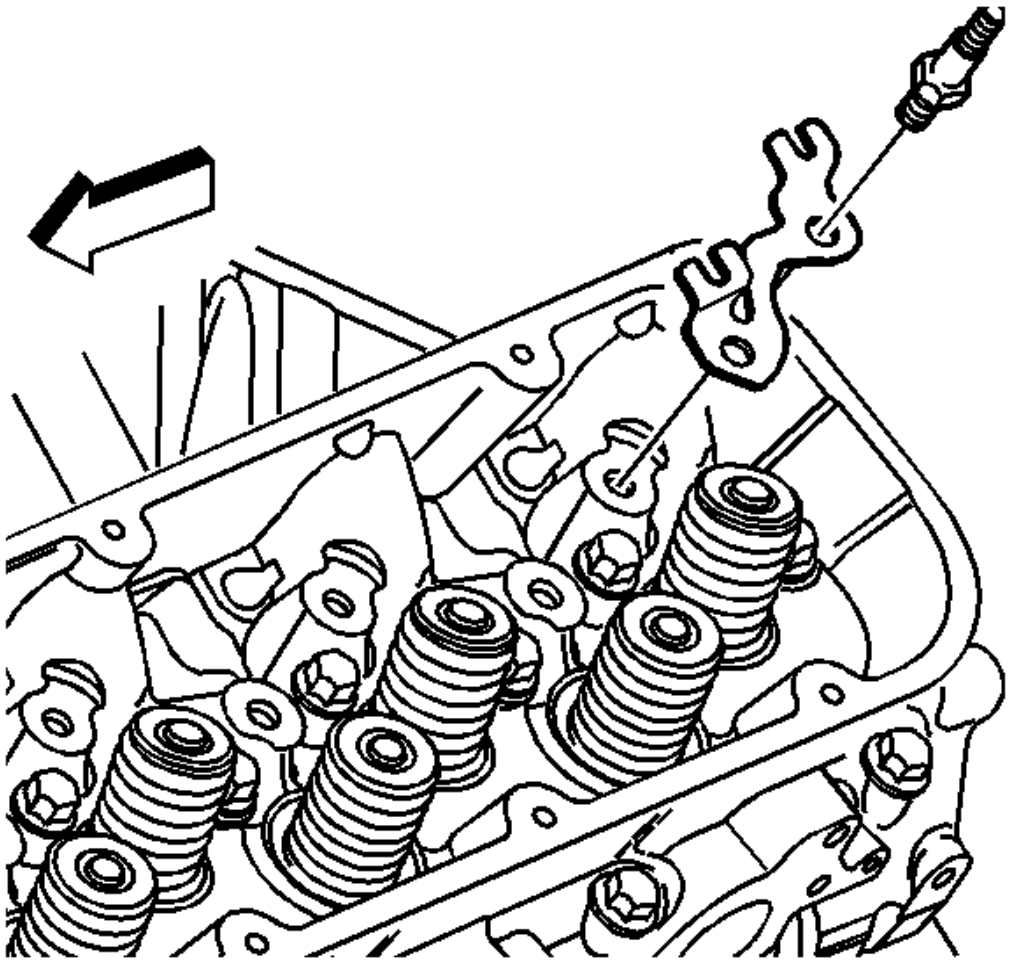

Fig. 98: View Of Valve Rocker Arm Studs & Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

4. Remove the valve rocker arm studs and pushrod guides.
5. Clean and inspect the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rods Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Be sure to keep parts in order. Parts must be put back from where they were removed.

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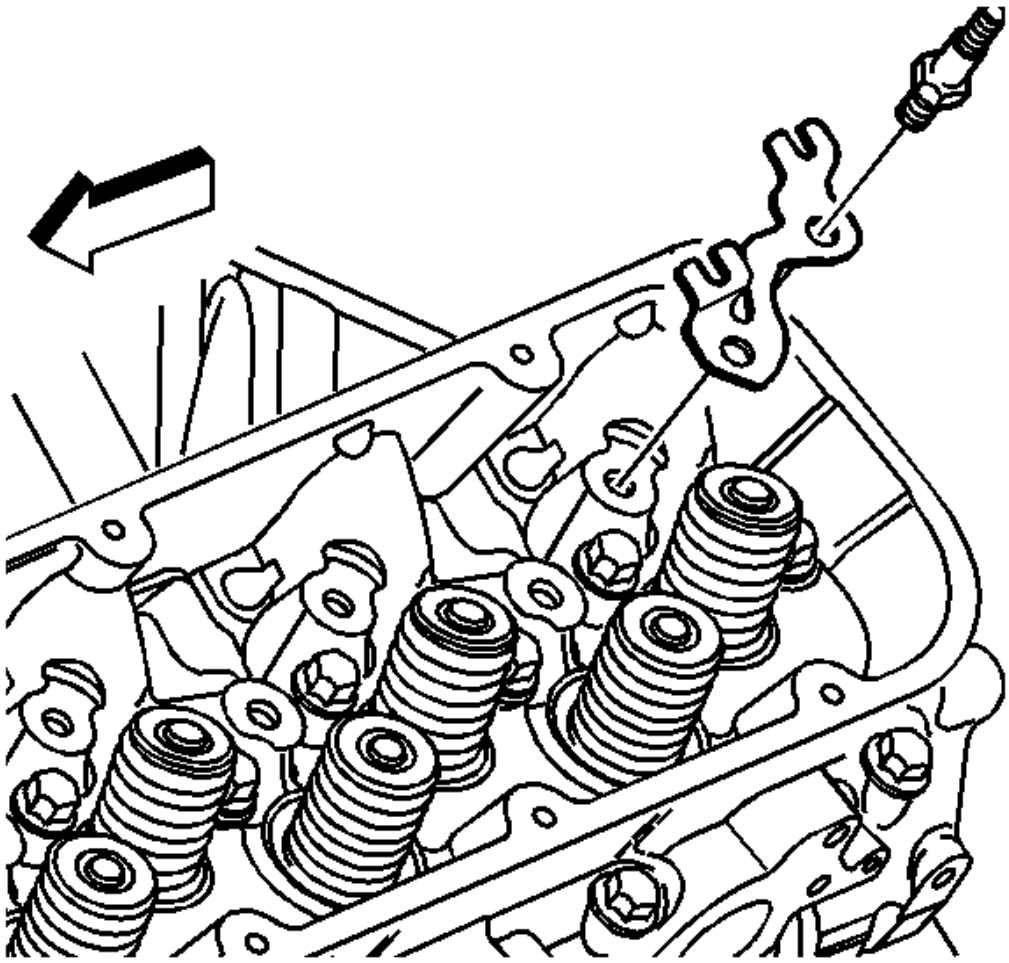

Fig. 99: View Of Valve Rocker Arm Studs & Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the valve rocker arm stud-to-cylinder head threads.
2. Install the pushrod guides and valve rocker arm studs.

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

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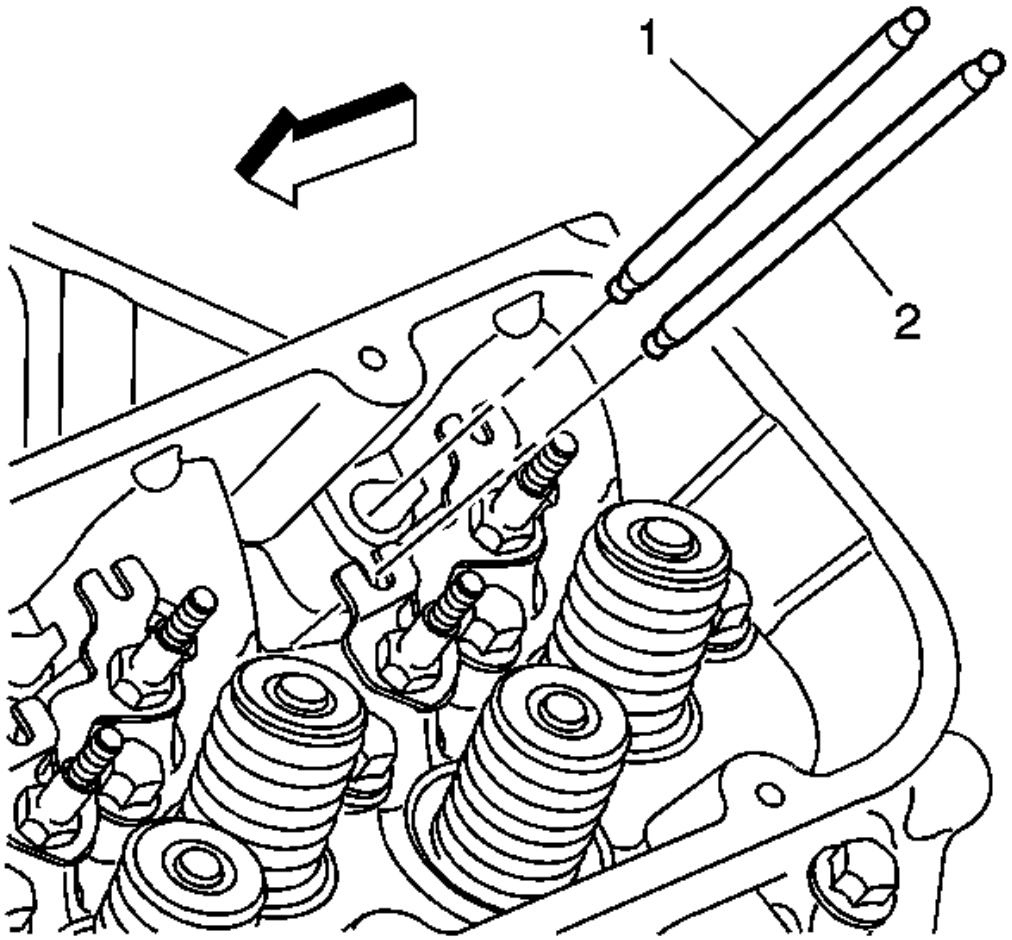

Fig. 100: View Of Intake & Exhaust Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve pushrods (2) are longer than the intake valve pushrods (1).

3. Install the valve pushrods.

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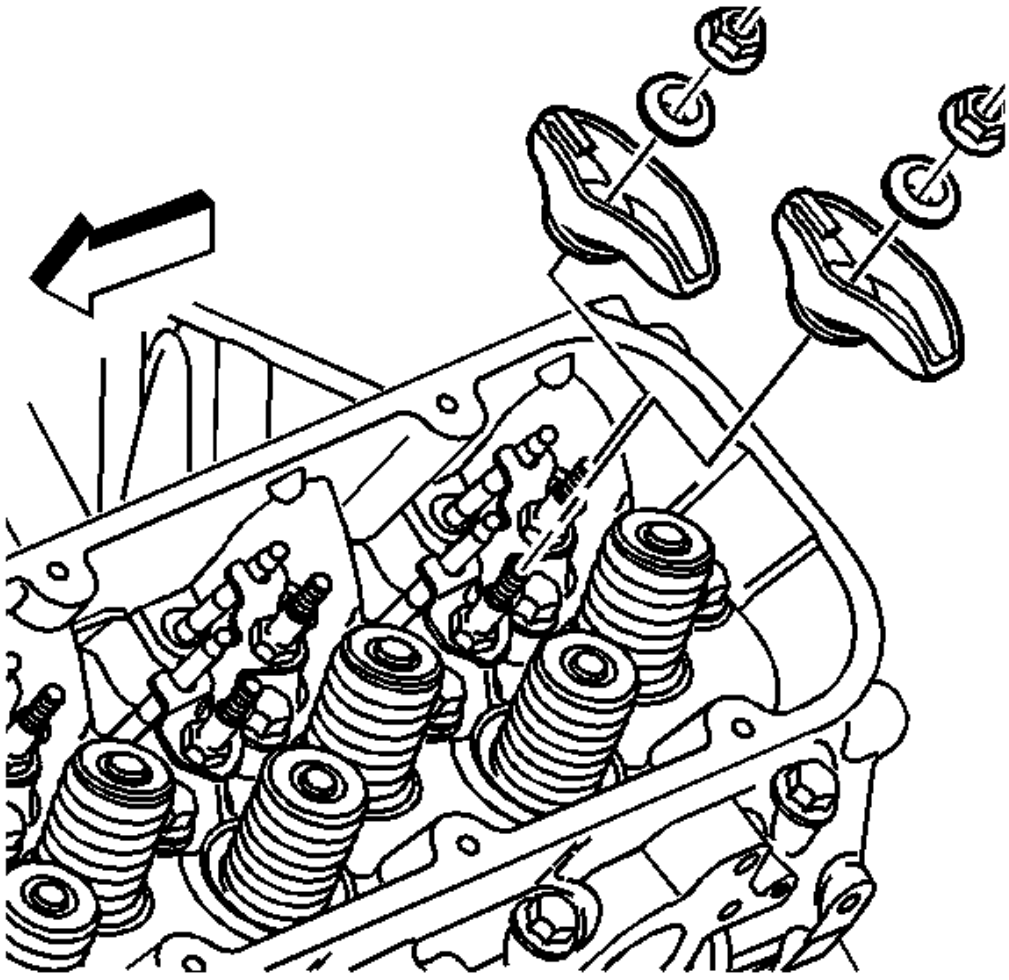

Fig. 101: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

4. Coat the valve rocker arm and valve rocker arm ball bearing surfaces with lubricant GM P/N 12345501 (Canadian P/N 992704), or equivalent.
5. Install the valve rocker arms, the valve rocker arm balls, and the valve rocker arm nuts.

   Tighten: Tighten the nuts slowly to 25 N.m (18 lb ft) while guiding the tips of the rocker arms over the tips of the valves.

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

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Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- **J 5892-D** Valve Spring Compressor. See **Special Tools and Equipment**.
- **J 22794** Spark Plug Port Adapter
- **J 43105** Valve Stem Seal Installer

Removal Procedure

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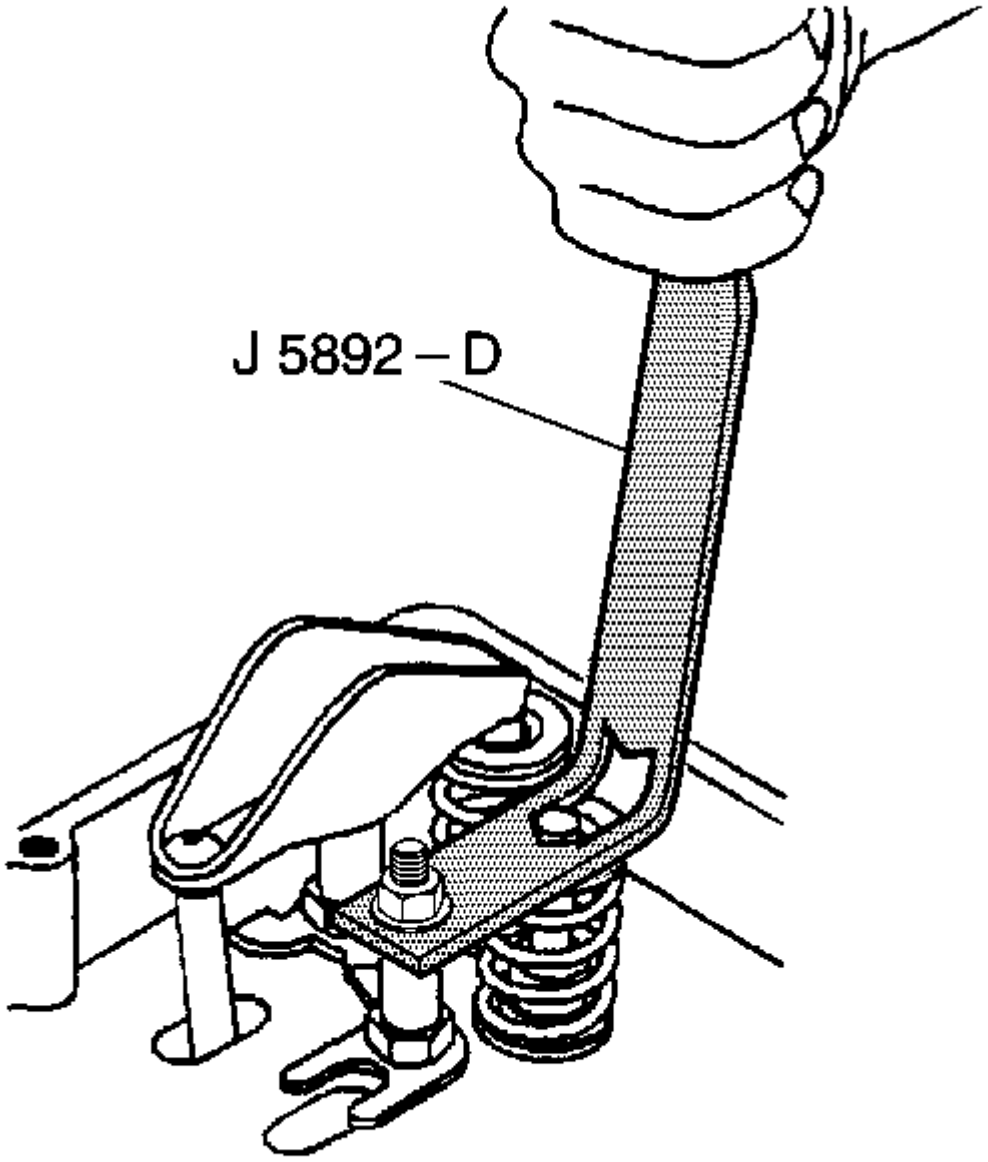

Fig. 102: Compressing Valve Spring Using J 5892-D
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Rotate the piston in the cylinder being serviced to the bottom of its stroke, to ensure that the engine does not rotate when the compressed air is applied.

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1. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Rotate the crankshaft until both valves are closed before installing the compressed air into the cylinder.
3. Remove the spark plug from the cylinder being serviced. Refer to **Spark Plug Replacement** in Engine Controls - 8.1L.
4. Remove the valve stem keys as followed:
    1. Install the **J 22794** into the spark plug hole.
    2. Apply compressed air into the cylinder in order to hold the valves closed.
    3. Lightly tap the valve spring cap to loosen the valve stem keys.
    4. Install the **J 5892-D** to the cylinder head.
    5. Install the valve rocker arm nut.

IMPORTANT: Tighten the valve rocker arm nut enough to hold J 5892-D in place.

    6. Using **J 5892-D** compress the valve spring.

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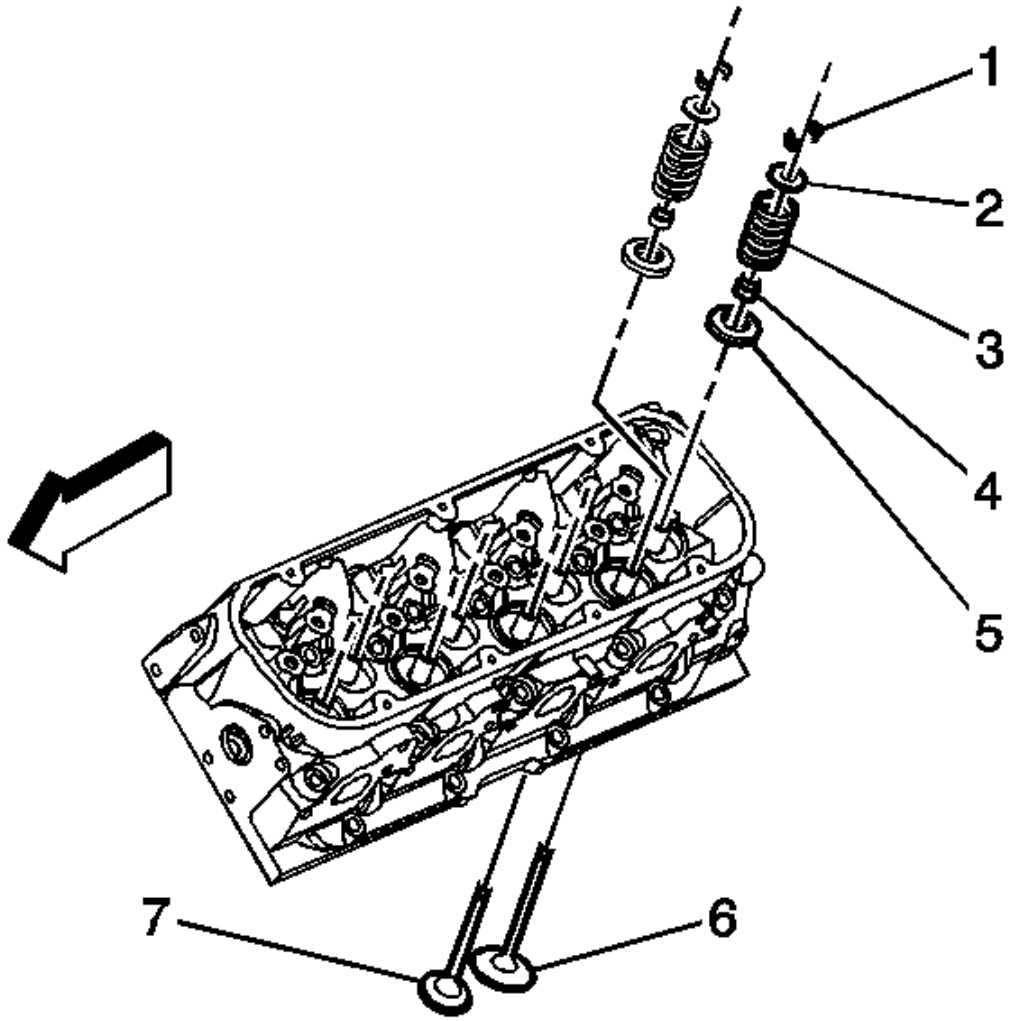

Fig. 103: View Of Valve Stem & Spring Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not release the compressed air from the cylinder being worked on. The valve will fall into the cylinder bore.

5. Remove the valve stem keys (1).
6. Slowly release the **J 5892-D** .
7. Remove the **J 5892-D** from the cylinder head.
8. Remove the valve spring cap (2) and valve spring (3).

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9. Remove the valve stem oil seal (4).

Installation Procedure

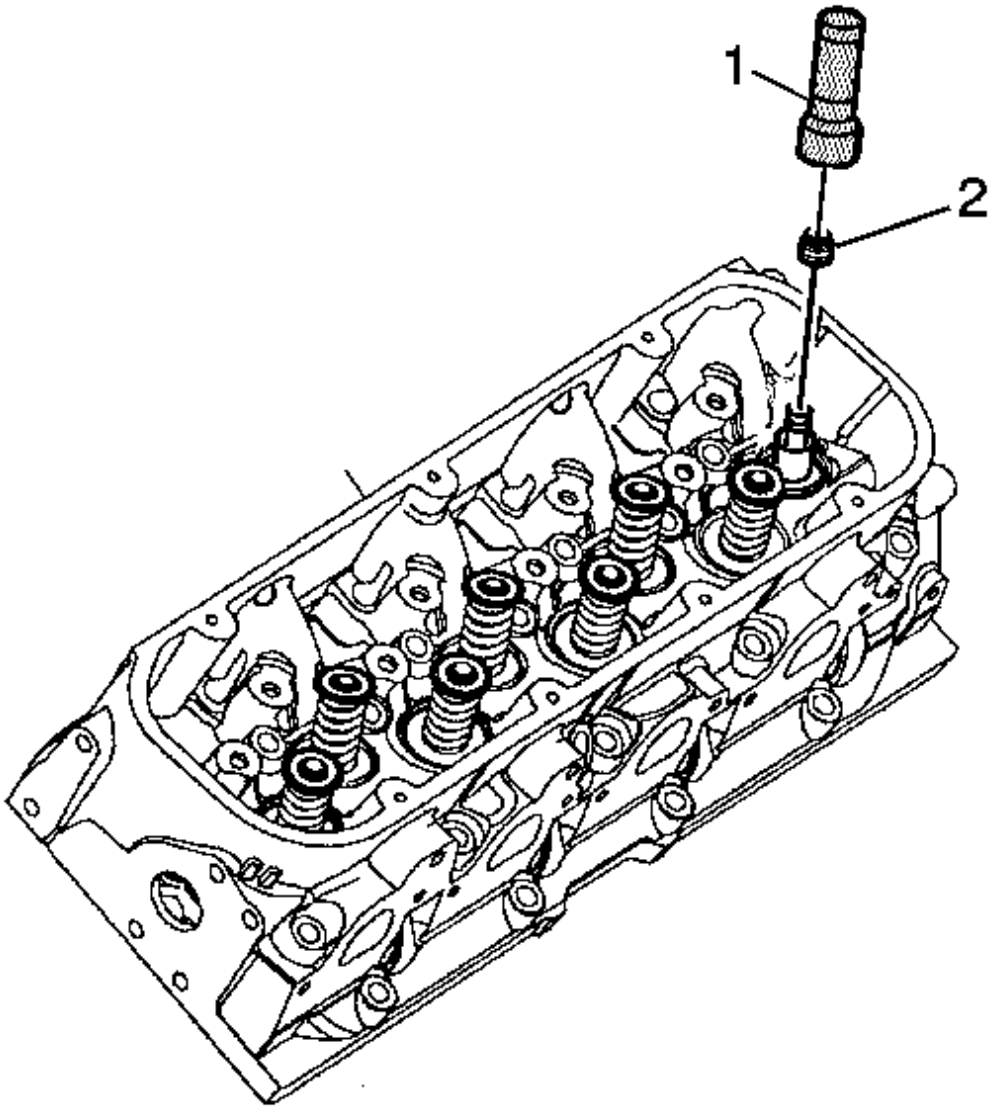

Fig. 104: Installing Valve Stem Oil Seal Using J 43105
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the valve stem and outside diameter of the valve guide seal with clean engine oil.

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2. Lubricate the rotators with clean engine oil.

IMPORTANT: When installing valve seals, J 43105 must be used to achieve correct installation. See Special Tools and Equipment. Failure to use J 43105 may cause excessive oil consumption. See Special Tools and Equipment.

3. Install the valve stem oil seal (2) over the valve tip and onto the valve guide using **J 43105** . See **Special Tools and Equipment**. Tap the valve stem seal onto the valve guide until the **J 43105** fully seats the seal. See **Special Tools and Equipment**.
4. Install the valve spring cap and the spring.

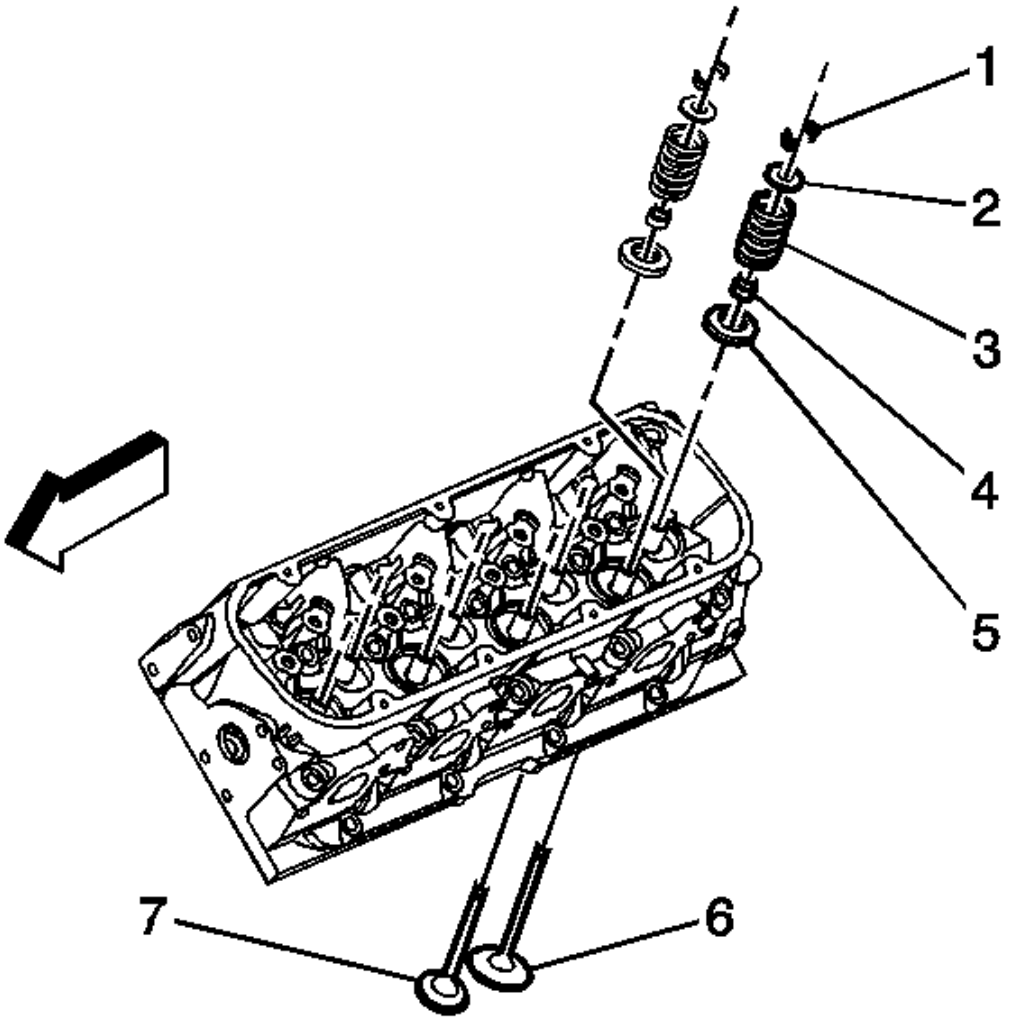

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Fig. 105: View Of Valve Stem & Spring Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing valve springs, the small end of the valve spring must be installed up.

5. Install the valve spring (3).
6. Install the valve spring cap (2).

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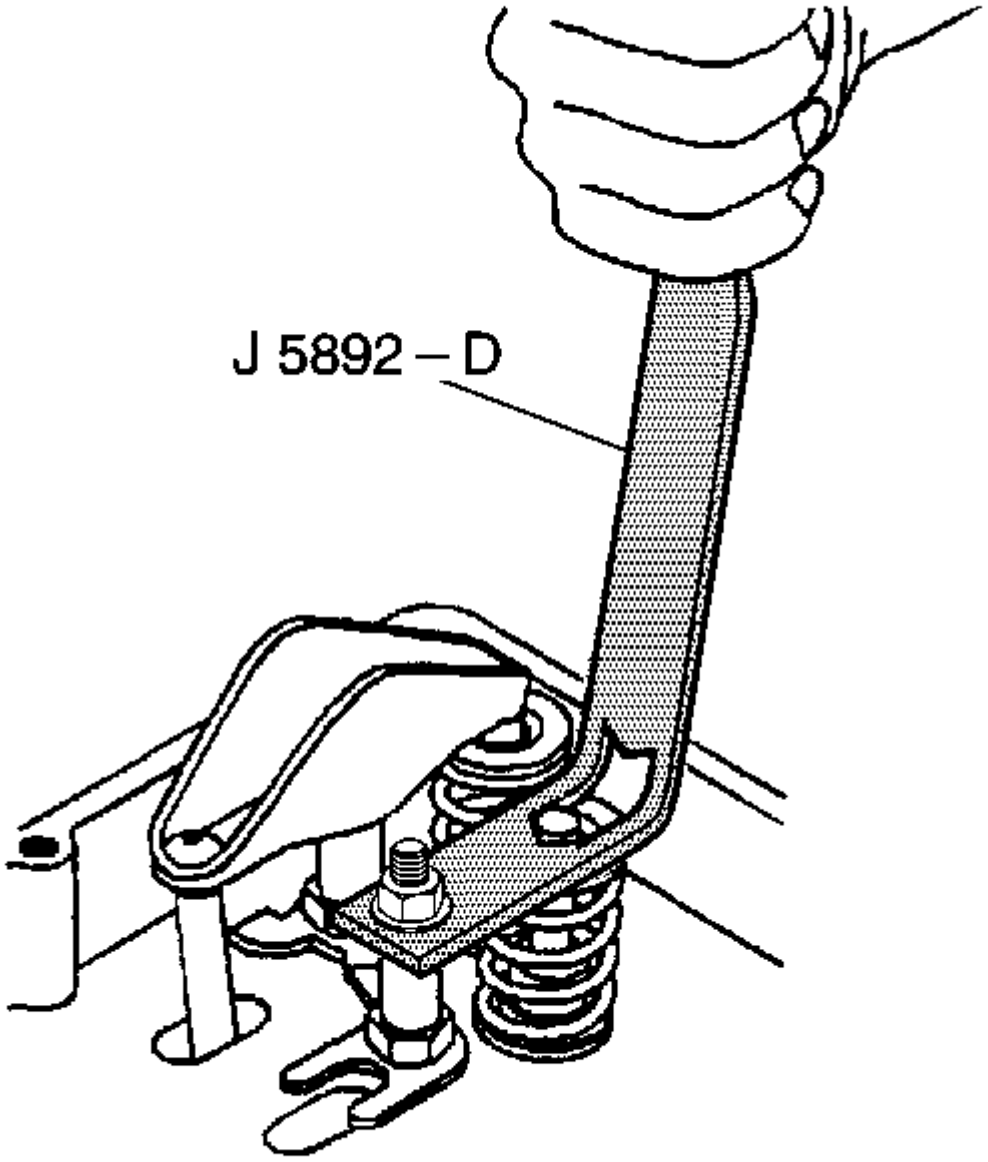

Fig. 106: Compressing Valve Spring Using J 5892-D
Courtesy of GENERAL MOTORS CORP.

7. Using **J 5892-D** compress the valve spring.
8. Install the valve stem keys as follows:
    1. Apply a small amount of clean grease to hold the valve stem keys in place.

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2. Carefully release the **J 5892-D** . Make sure the valve stem keys do not move.
3. Remove the **J 5892-D** from the valve assembly.
4. Remove the compressed air from the cylinder being worked on.

9. Install the spark plug. Refer to **Spark Plug Replacement** in Engine Controls - 8.1L.
10. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Valve Lifter Replacement

Tools Required

J 3049-A Valve Lifter Remover

Removal Procedure

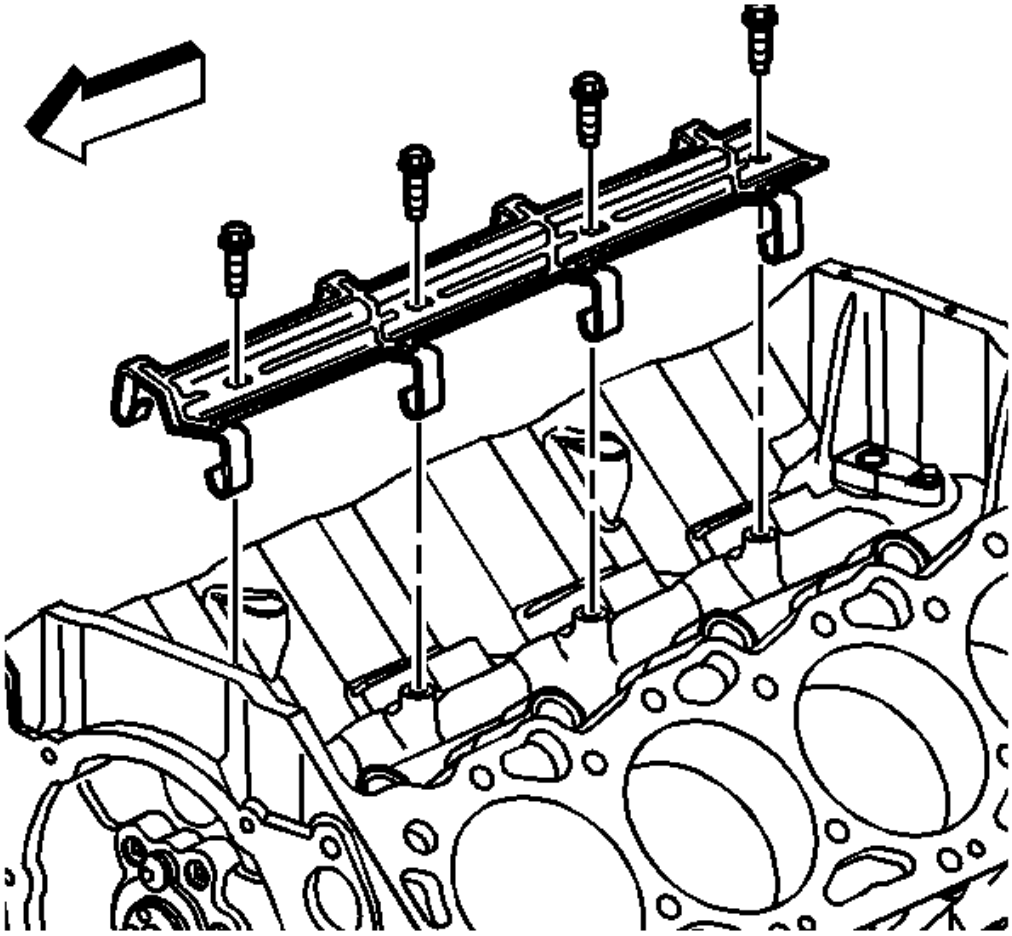

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Fig. 107: View Of Valve Lifter Guide Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
3. Remove the valve lifter guide retainer bolts and retainer.

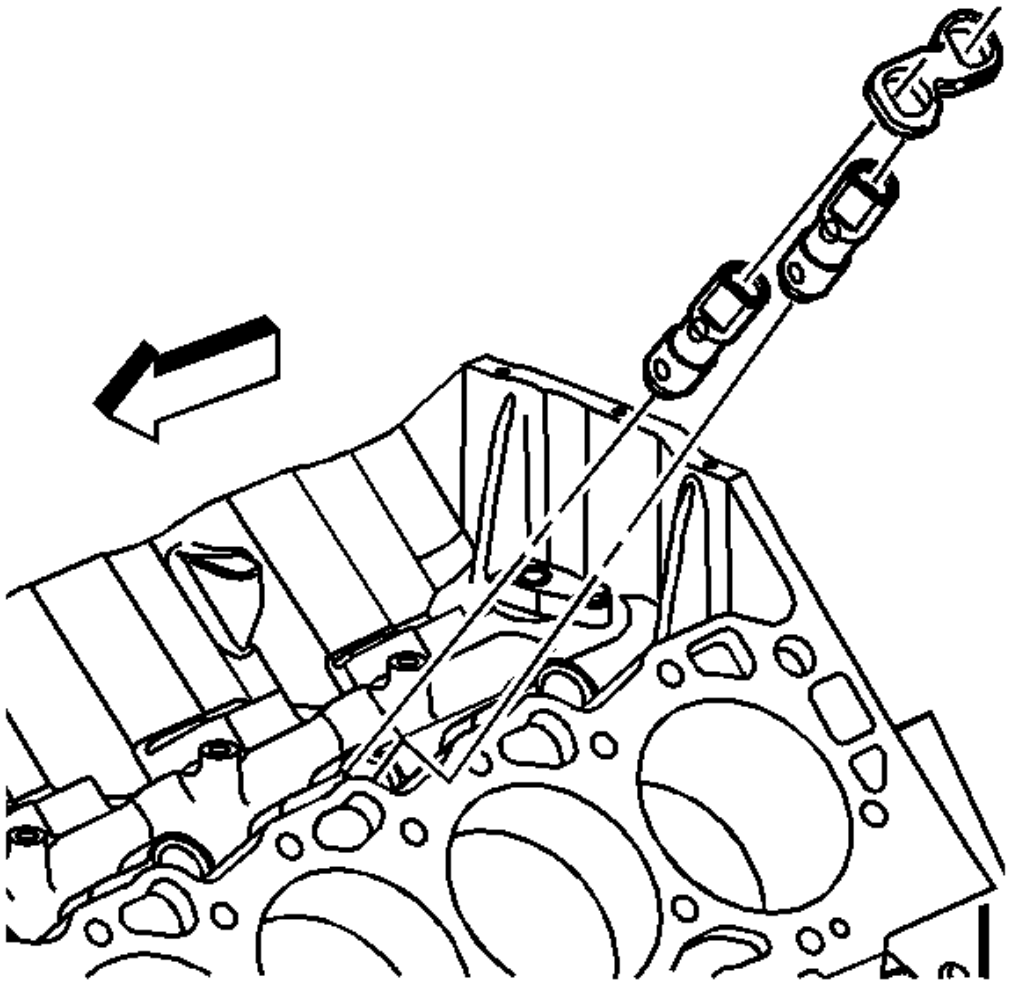

Fig. 108: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, or organize the valve lifters and guides for installation in their original location.

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4. Remove the valve lifter guides.
5. Remove the valve lifters.

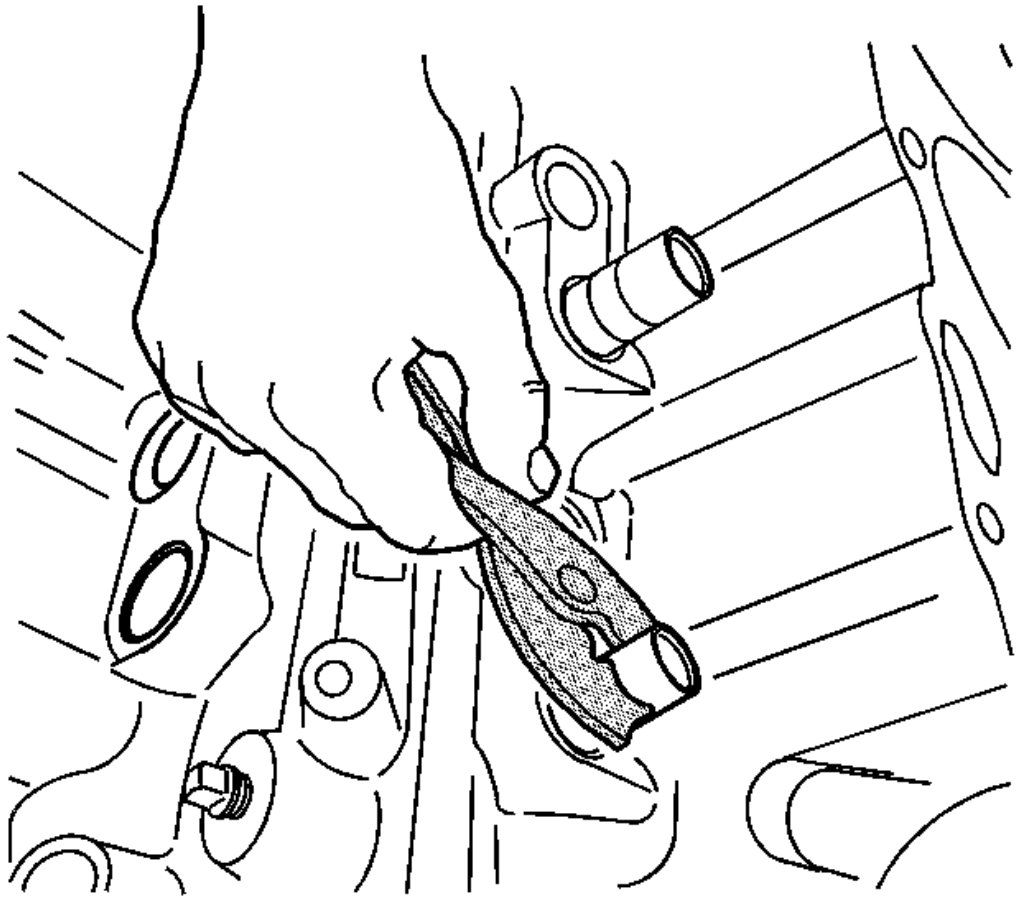

Fig. 109: Removing Valve Lifter Using J 3049-A
Courtesy of GENERAL MOTORS CORP.

6. Some valve lifter may be stuck in their bore due to gum or varnish deposits, These lifters can be removed using **J 3049-A** .
7. Clean and inspect the valve lifters. Refer to **Valve Lifters and Guides Cleaning and Inspection**.

Installation Procedure

IMPORTANT: If a new camshaft is installed, replace all the valve lifters.

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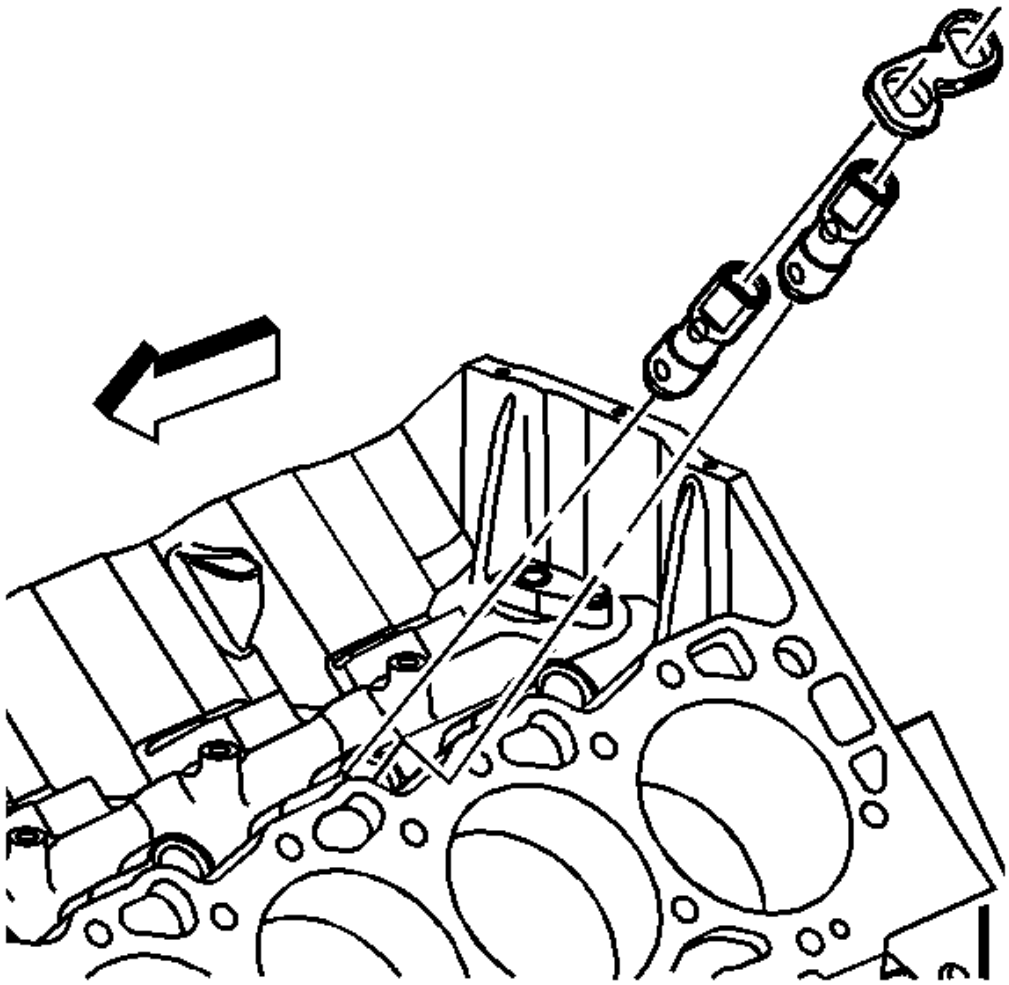

Fig. 110: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If reusing the valve lifters, install the lifters in their original location. The valve lifter guide retainer must contact all of the valve lifter guides. If the lifter guide retainer is bent, the valve lifter guide retainer must be replaced.

1. Coat the valve lifter rollers with lubricant GM P/N 12345501 (Canadian P/N 992704), or equivalent.
2. Install the valve lifters.
3. Install the valve lifter guides over the flats on the valve lifters, making sure the rollers of the valve lifters are properly aligned with the camshaft lobes.

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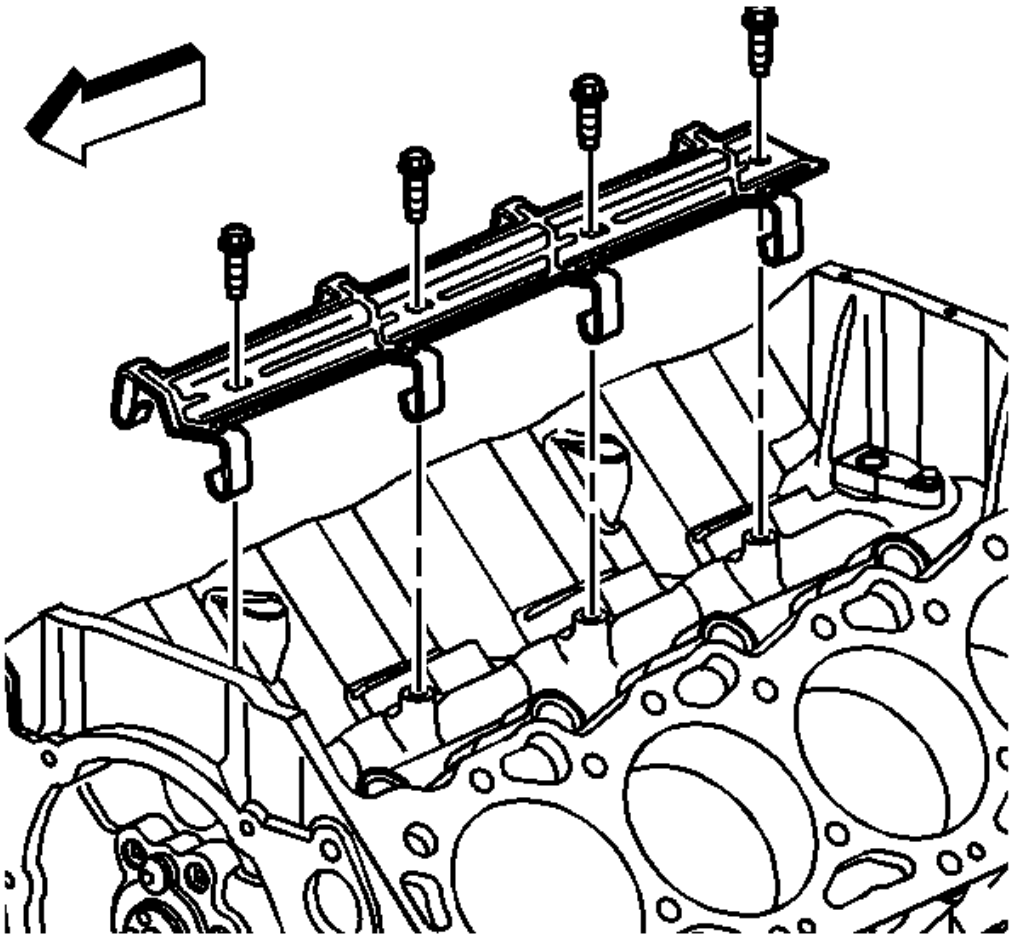

Fig. 111: View Of Valve Lifter Guide Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the valve lifter guide retainer.
5. Install the valve lifter guide retainer bolts.

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

6. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
7. Install the intake manifold. Refer to **Intake Manifold Replacement**.

Oil Level Indicator and Tube Replacement

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Removal Procedure

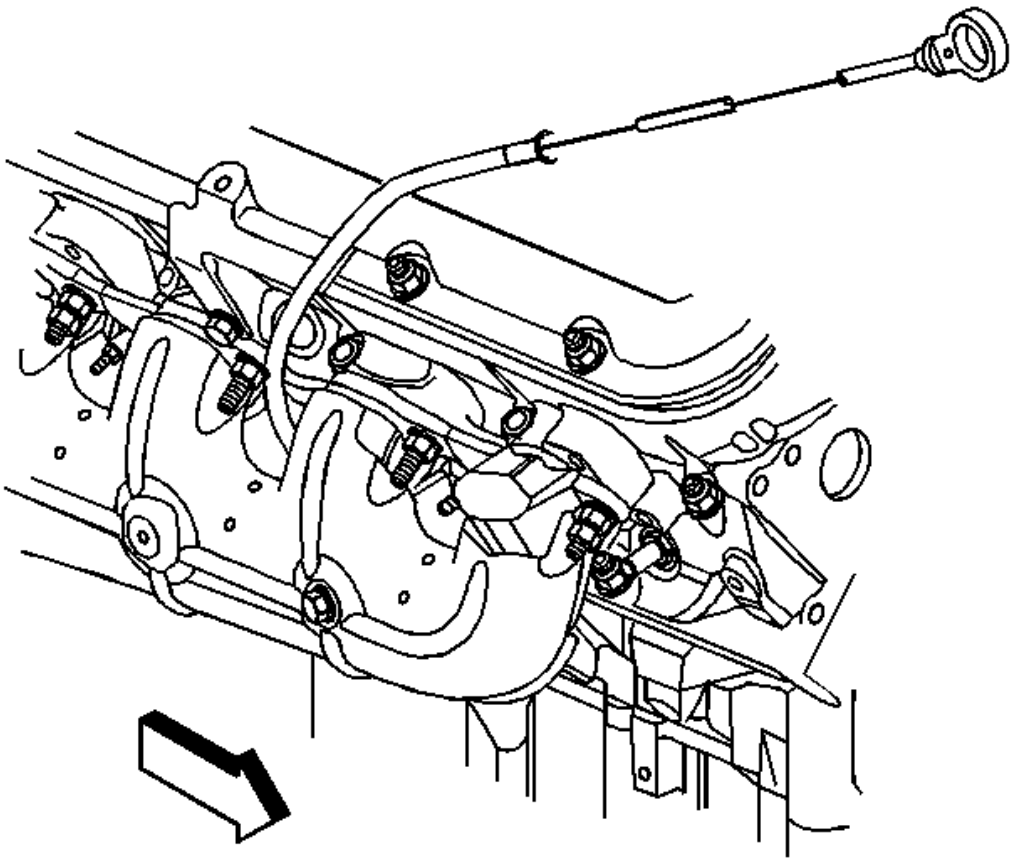

Fig. 112: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the indicator tube.

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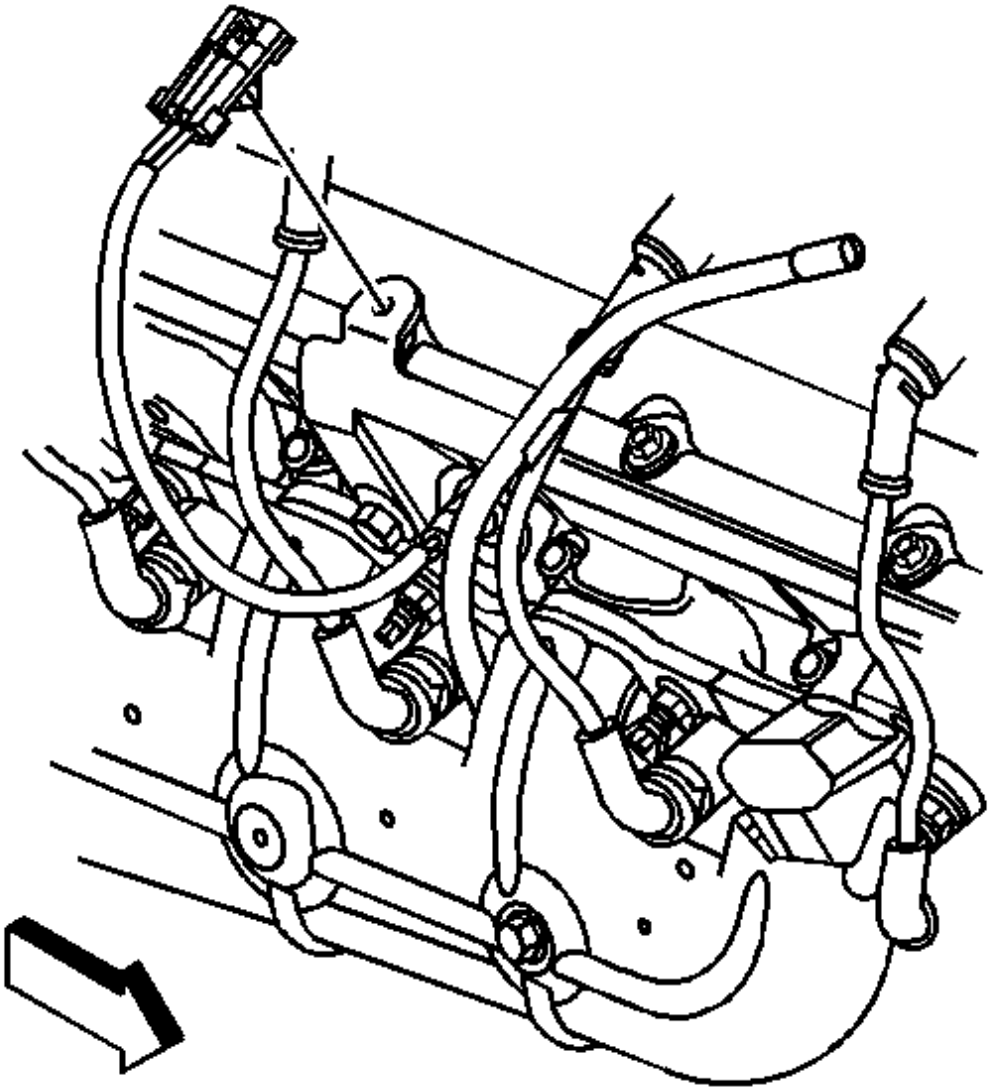

Fig. 113: View Of Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Disconnect the engine coolant temperature (ECT) sensor electrical connector.
3. Remove the ECT sensor connector from the indicator tube.

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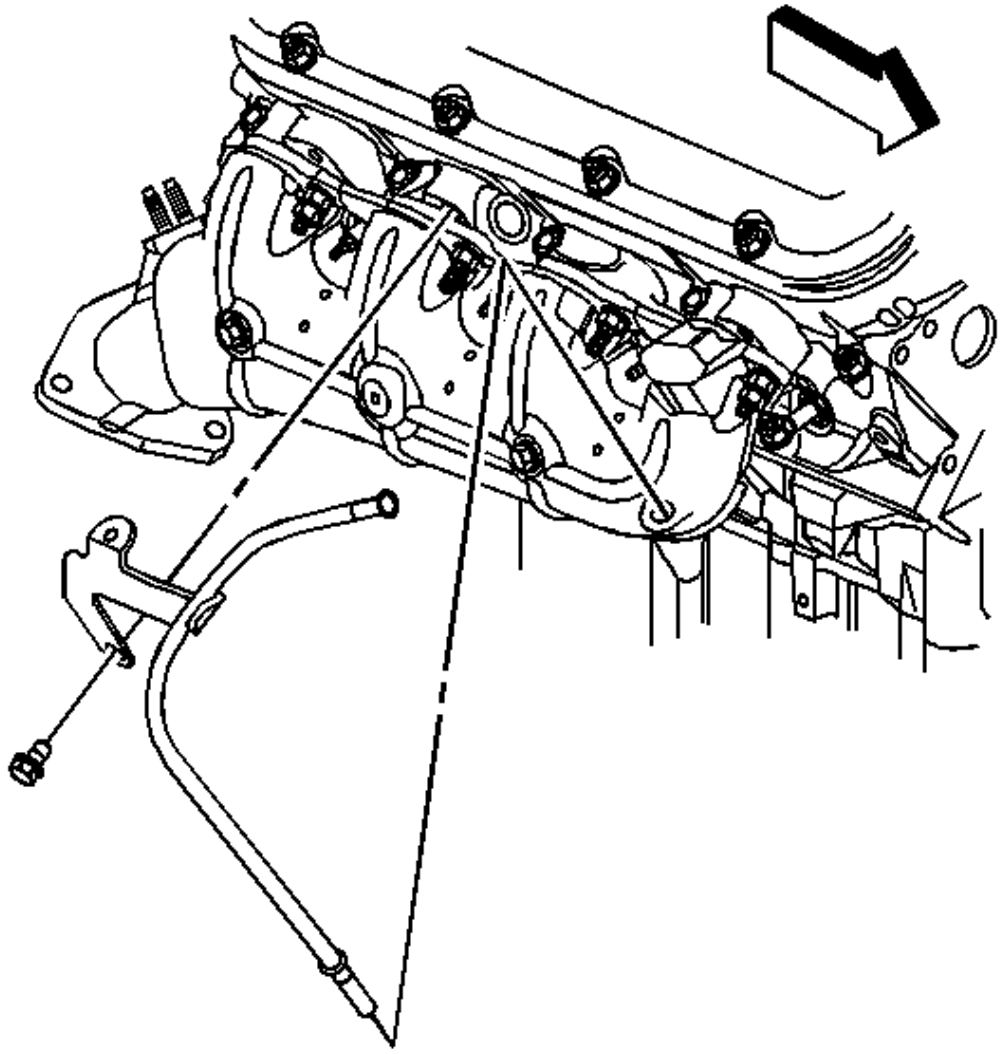

Fig. 114: View Of Indicator Tube, Bolt & Bracket
Courtesy of GENERAL MOTORS CORP.

4. Remove the indicator tube bolt.
5. Remove the indicator tube bracket.
6. Remove the O-ring seal from the indicator tube.

Installation Procedure

IMPORTANT: Make sure the indicator tube does not come in contact with spark plug wires.

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Ensure that the spark plug wires are routed around the indicator tube.

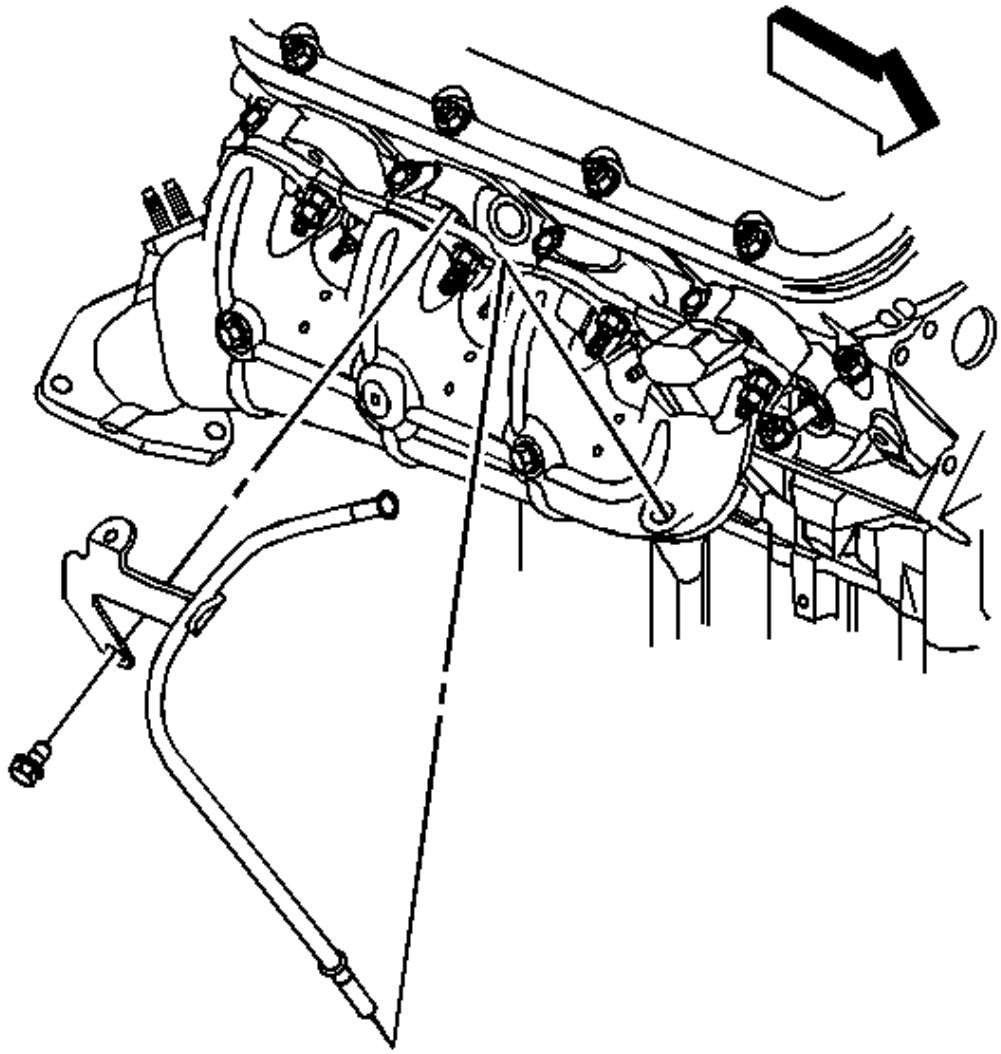

Fig. 115: View Of Indicator Tube, Bolt & Bracket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW O-ring seal onto the indicator tube.
2. Install the indicator tube into the oil pan.
3. Align the indicator tube bracket with the bolt hole in the block.

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NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the indicator tube bolt.

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

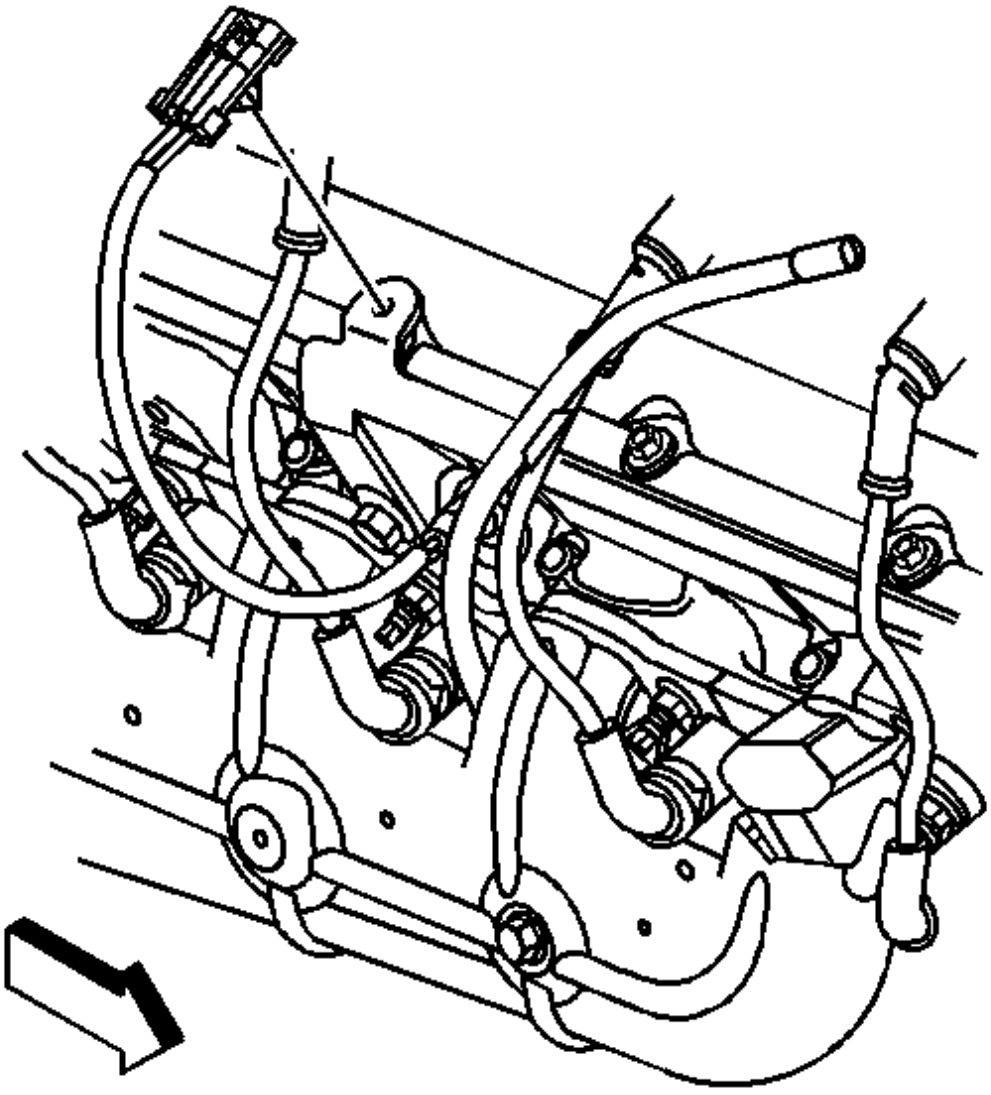

Fig. 116: View Of Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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5. Install the ECT sensor connector to the indicator tube.
6. Connect the ECT sensor electrical connector.

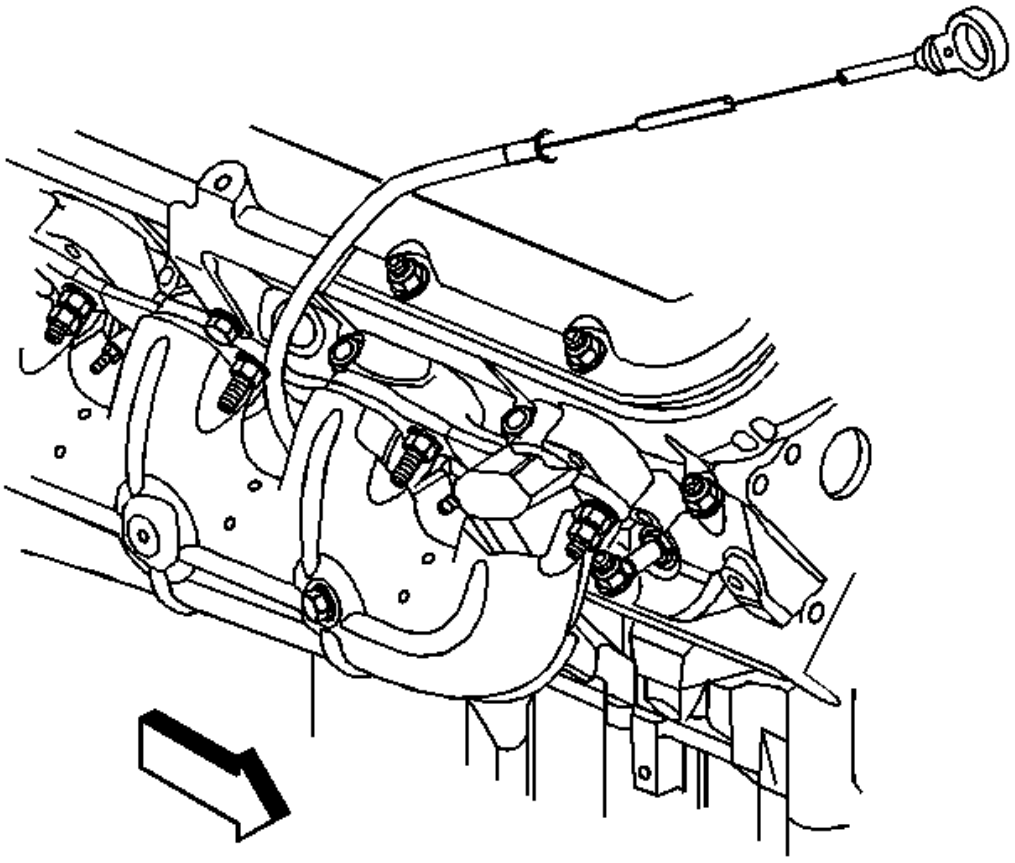

Fig. 117: View Of Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

7. Install the oil level indicator to the indicator tube.

Cylinder Head Replacement - Left

Tools Required

J 45059 Angle Meter

Removal Procedure

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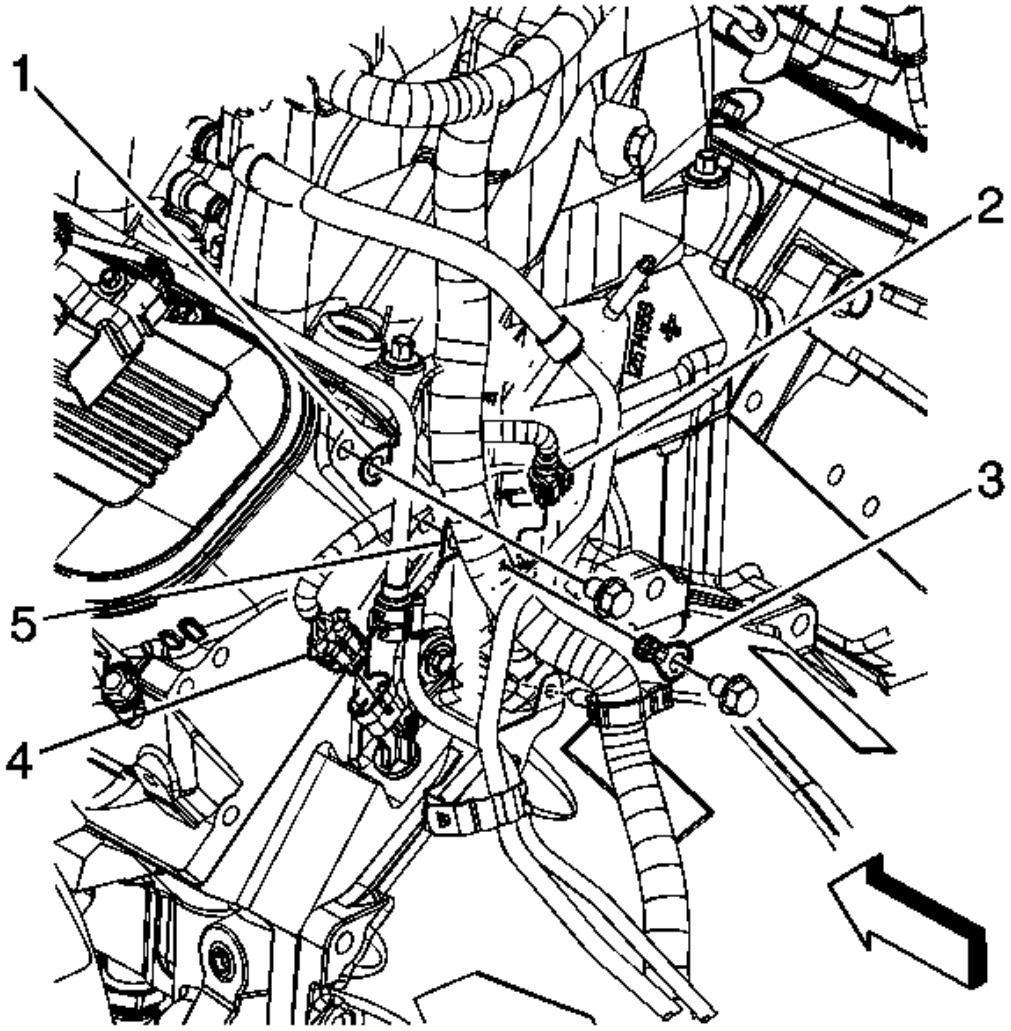

Fig. 118: View Of Engine Harness Grounds And CKP Sensor And Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the water crossover. Refer to **Coolant Crossover Pipe Replacement (8.1L Engine)** in Engine Cooling.
3. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
4. Remove the engine harness ground bolts.
5. Reposition the engine harness grounds (1 and 5) and ground strap (4) from the cylinder head.

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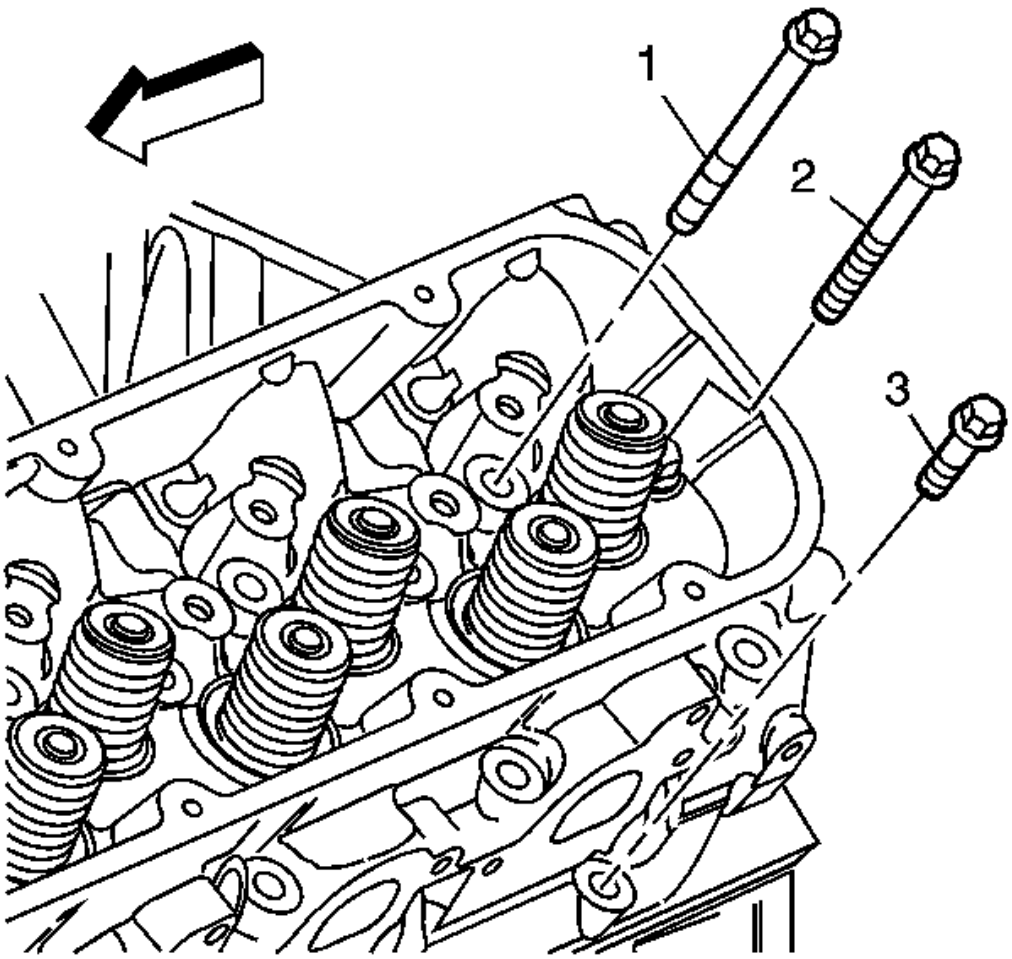

Fig. 119: View Of Cylinder Left Head Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left (8.1L Engine)** in Engine Exhaust.
7. Remove and discard the cylinder head bolts (1, 2, and 3).

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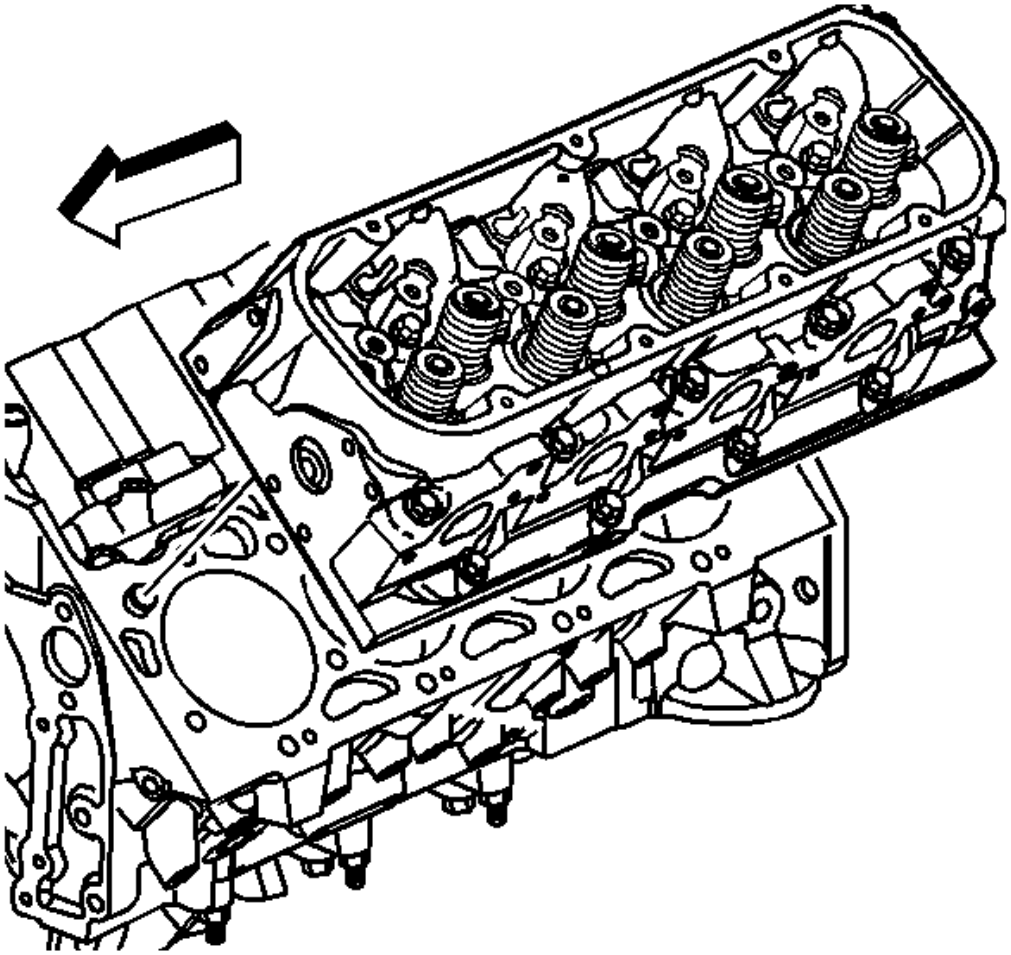

Fig. 120: View Of Left Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the cylinder head on two wood blocks to prevent damage to the sealing surfaces.

8. Remove the cylinder head.

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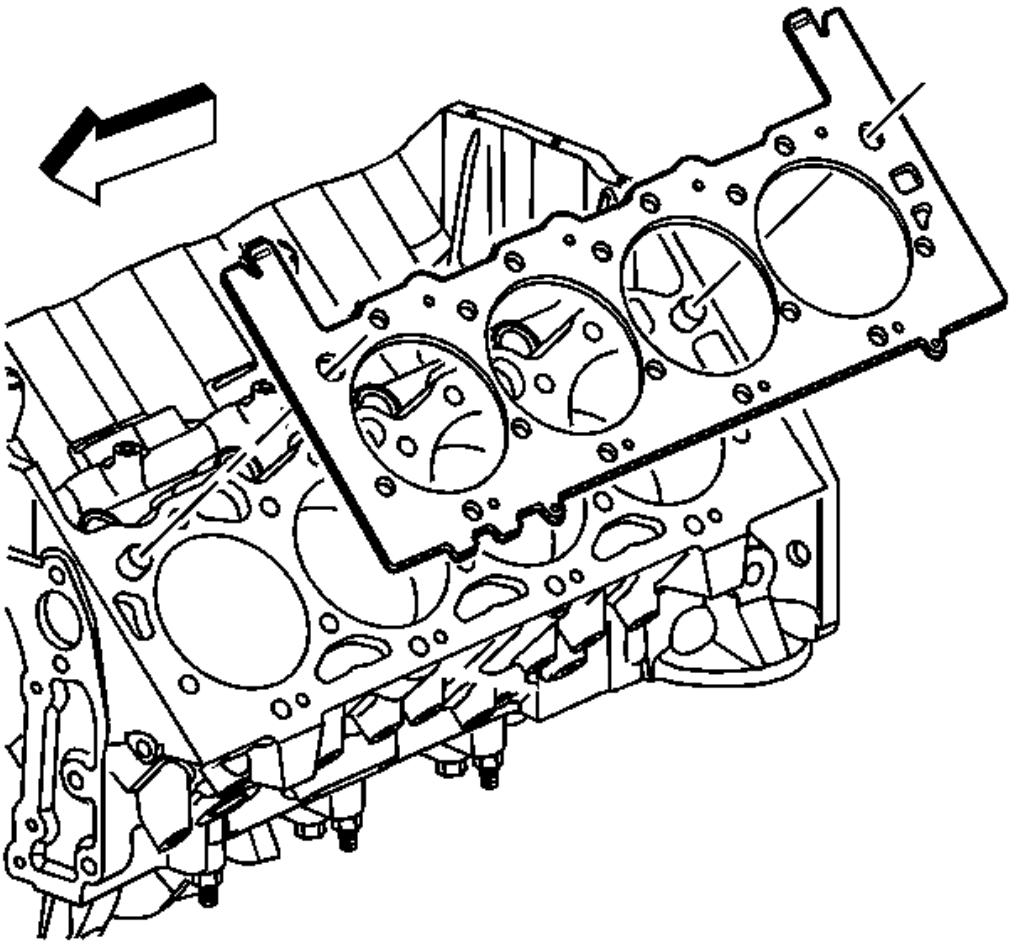

Fig. 121: View Of Left Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

9. Remove and discard the cylinder head gasket.
10. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket. Align the cylinder head gasket locating marks to face up. Ensure that the head gasket tabs are located over the numbers 1 and 2 cylinders for correct installation.

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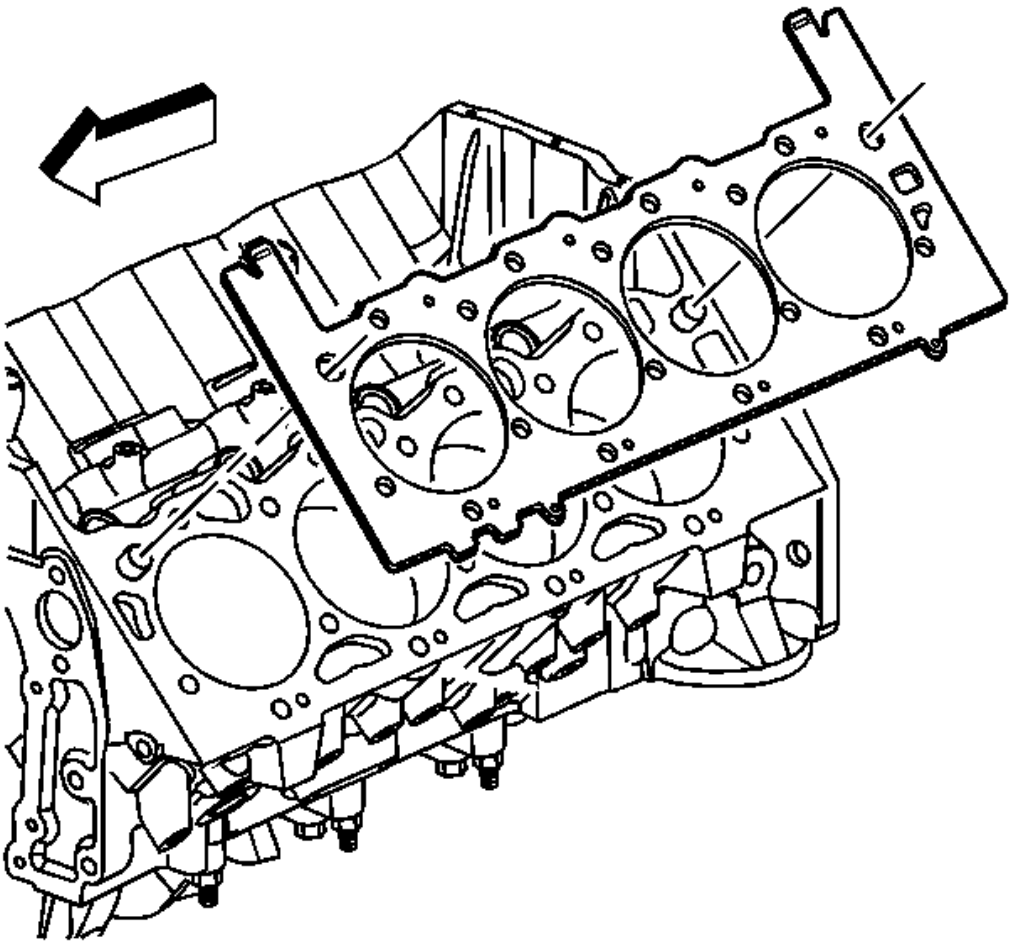

Fig. 122: View Of Left Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Place a NEW cylinder head gasket into position.

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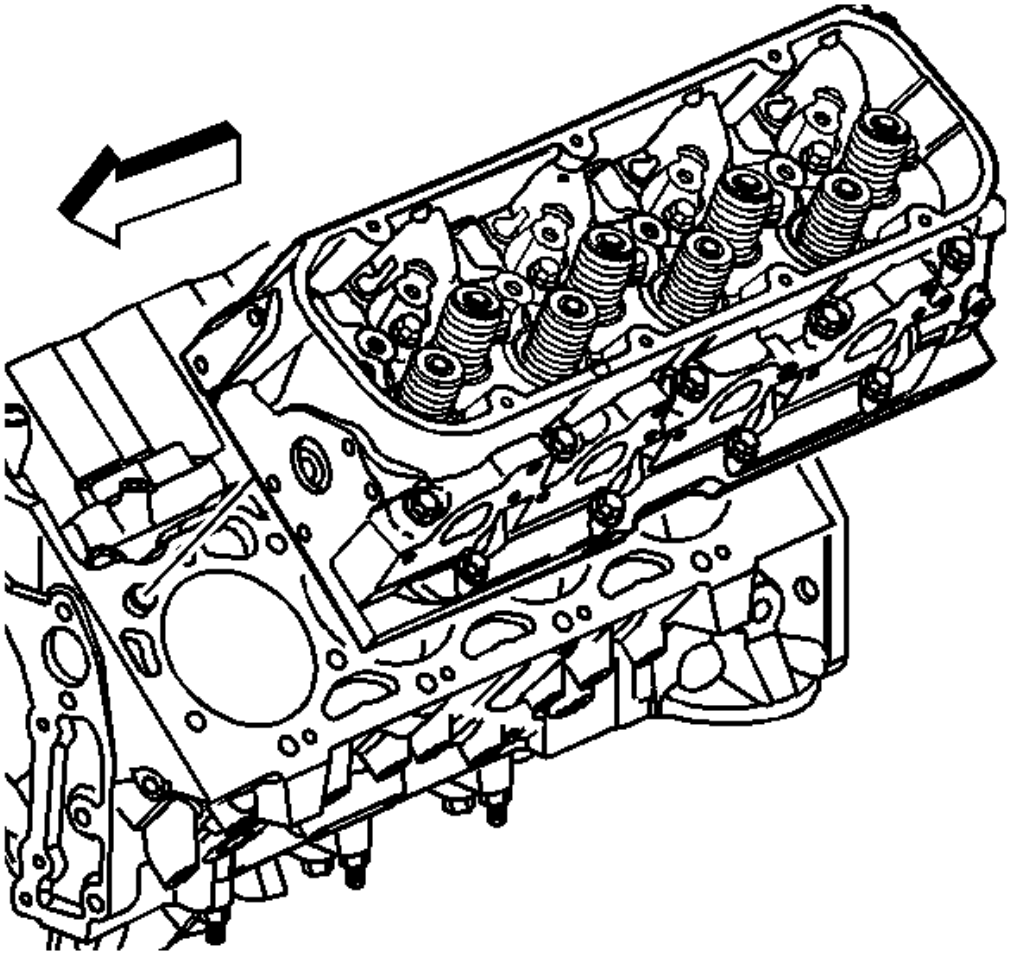

Fig. 123: View Of Left Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

2. Install the cylinder head.

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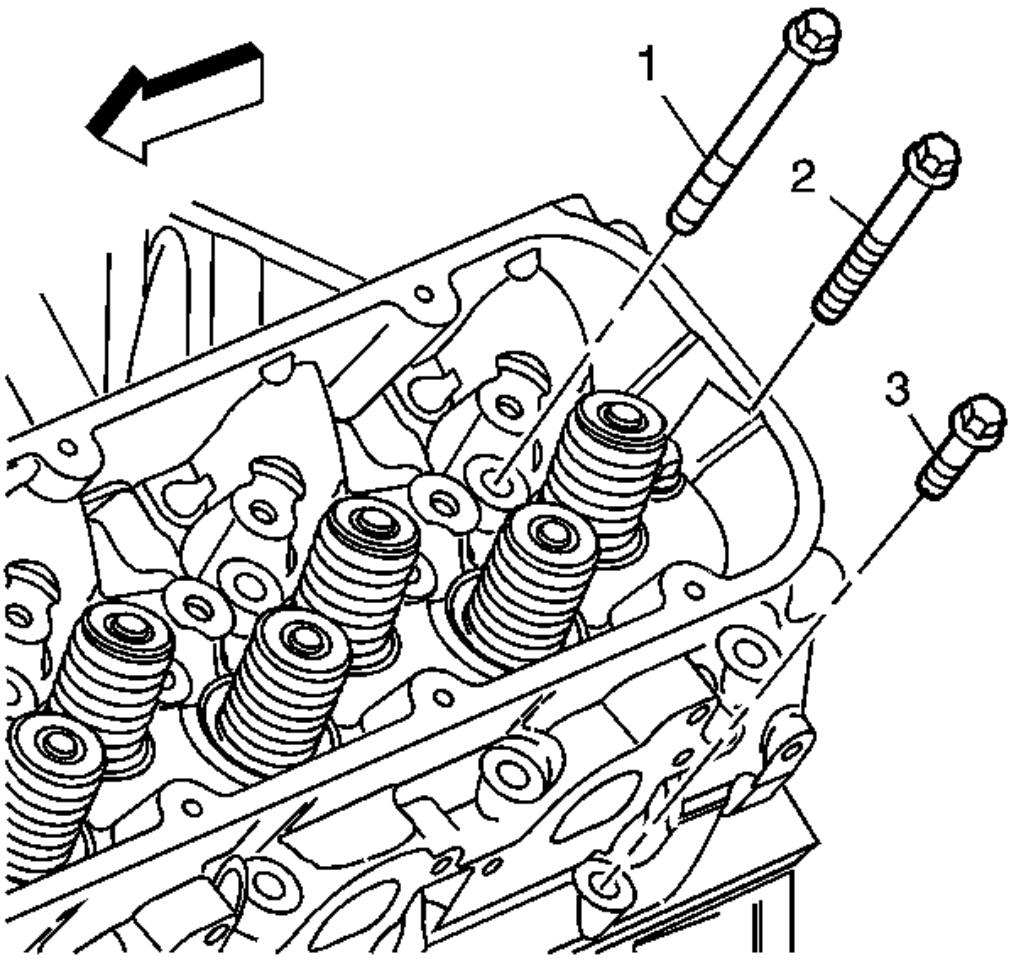

Fig. 124: View Of Cylinder Left Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.**

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IMPORTANT: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the NEW cylinder head bolts, apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the cylinder head bolts.
4. Install the cylinder head bolts (1, 2, and 3).

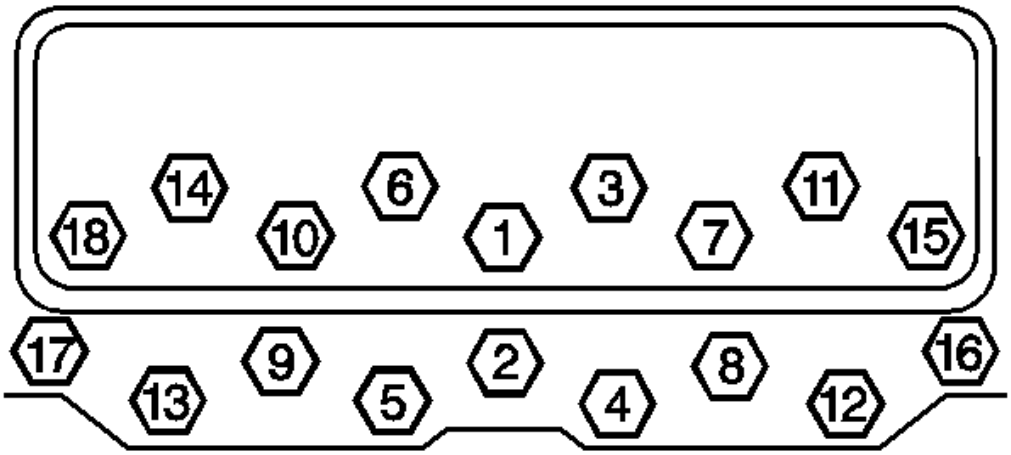

Fig. 125: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12, and 13.

5. Tighten the cylinder head bolts.

Tighten:

1. Tighten the bolts a first pass in sequence to 30 N.m (22 lb ft)
2. Tighten the bolts a second pass in sequence to 30 N.m (22 lb ft) then an additional 120 degrees using **J 45059** .
3. Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17) an additional 60 degrees, bolts (15, and 18) an additional 45 degrees, and bolts (4, 5, 12, and 13) an additional 30 degrees a final pass in sequence using **J 45059** .

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6. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left (8.1L Engine)** in Engine Exhaust.
7. Install the water crossover. Refer to **Coolant Crossover Pipe Replacement (8.1L Engine)** in Engine Cooling.

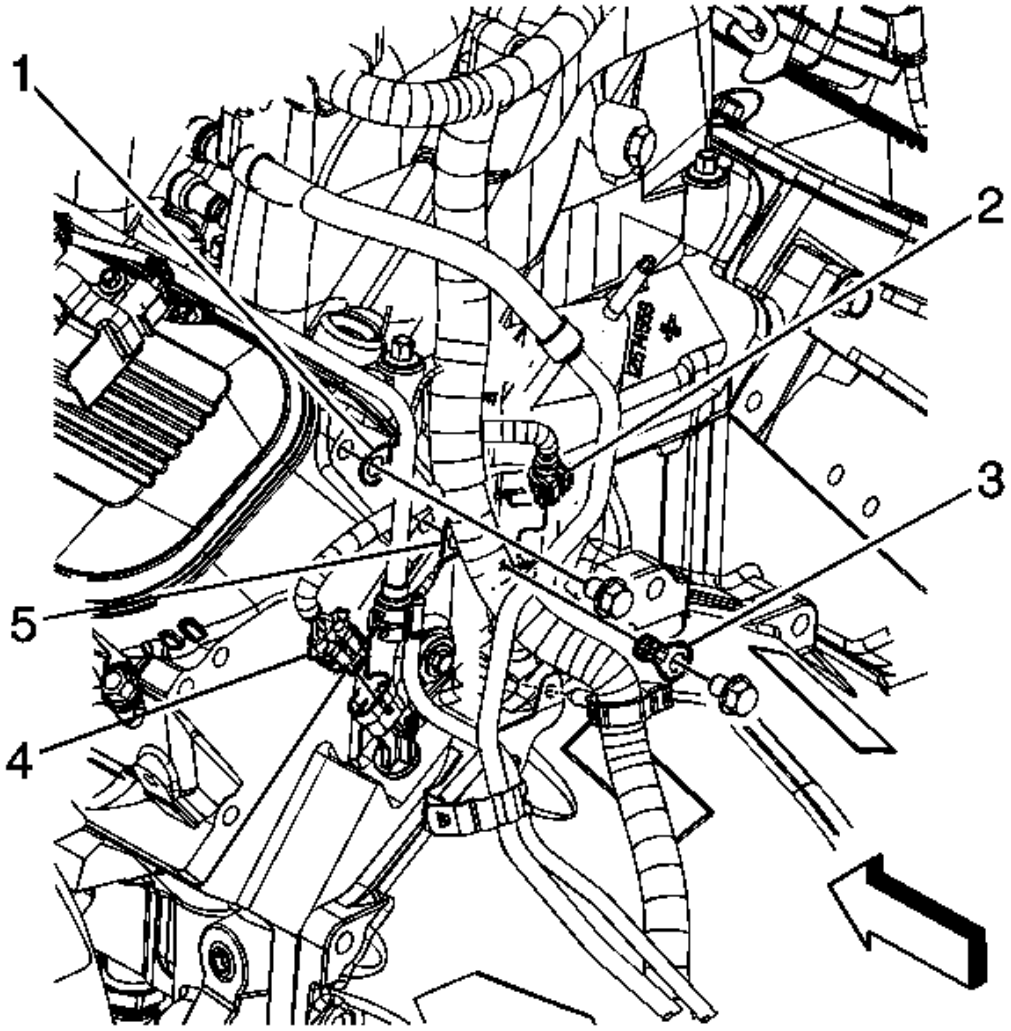

Fig. 126: View Of Engine Harness Grounds And CKP Sensor And Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

8. Position the engine harness grounds (1 and 5) and ground strap (4) to the cylinder head.
9. Install the engine harness ground bolts.

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Tighten: Tighten the bolts to 16 N.m (12 lb ft).

10. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
11. Install the intake manifold. Refer to **Intake Manifold Replacement**.

Cylinder Head Replacement - Right

Tools Required

J 45059 Angle Meter

Removal Procedure

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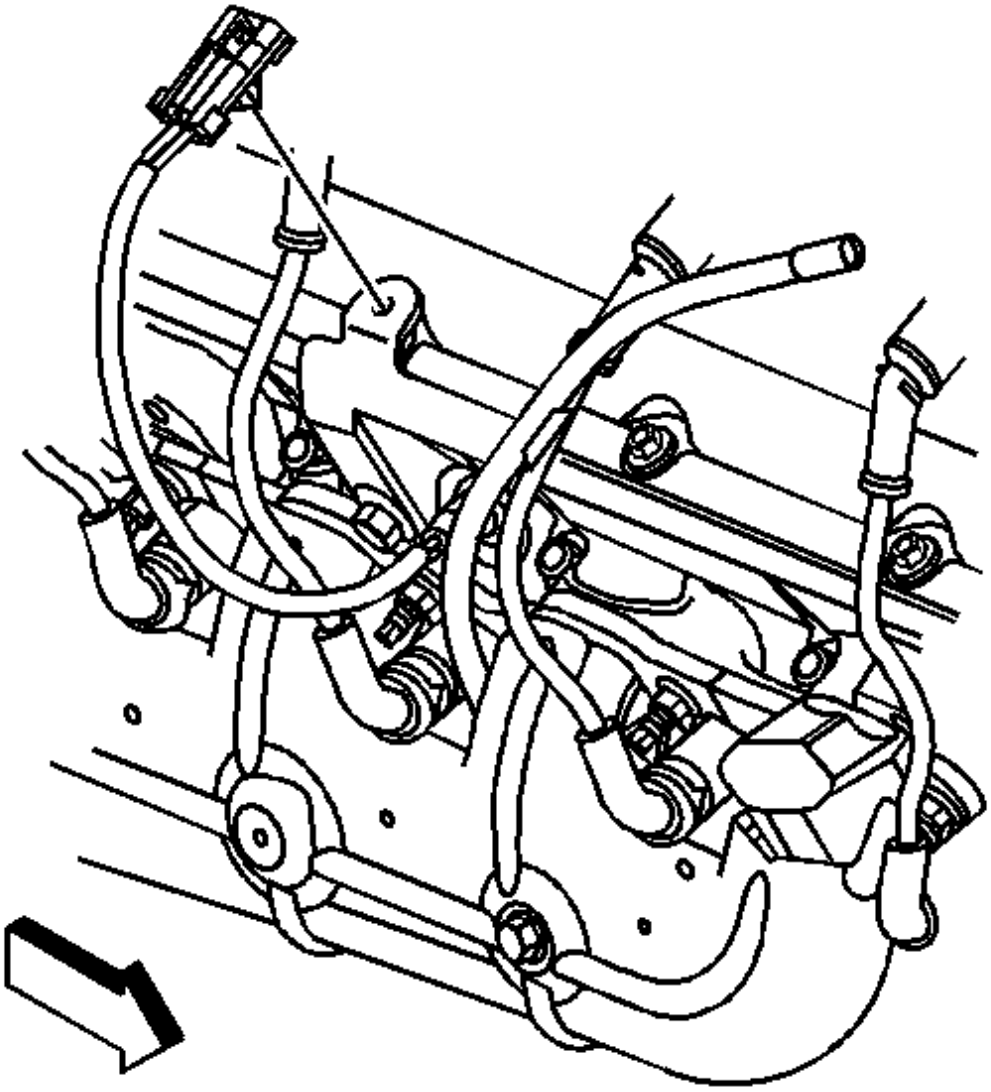

Fig. 127: View Of Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.
2. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
3. Remove the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
4. Remove the engine coolant temperature (ECT) sensor clip from the bracket.
5. Remove the ECT sensor from the cylinder head.

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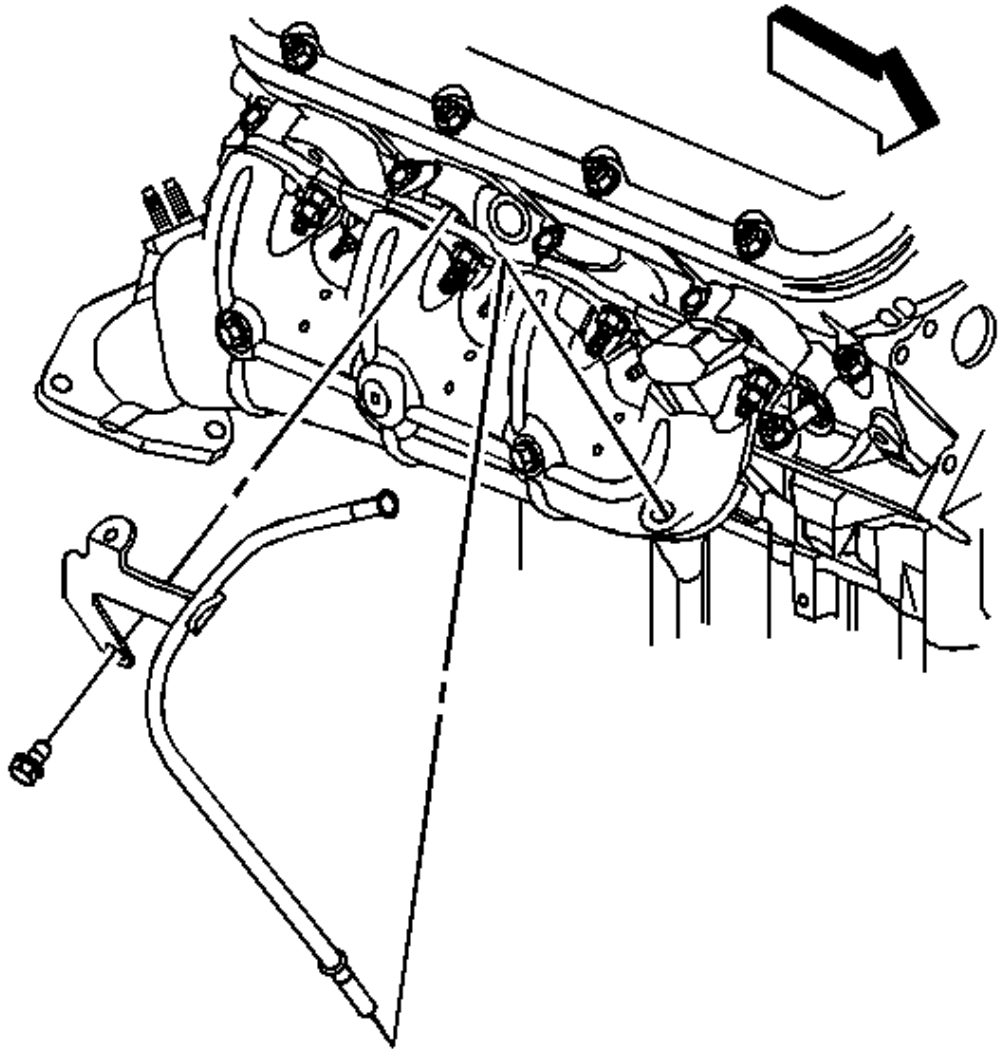

Fig. 128: View Of Indicator Tube, Bolt & Bracket
Courtesy of GENERAL MOTORS CORP.

6. Remove the indicator tube bolt.
7. Remove the indicator tube bracket.
8. Remove the O-ring seal from the indicator tube.

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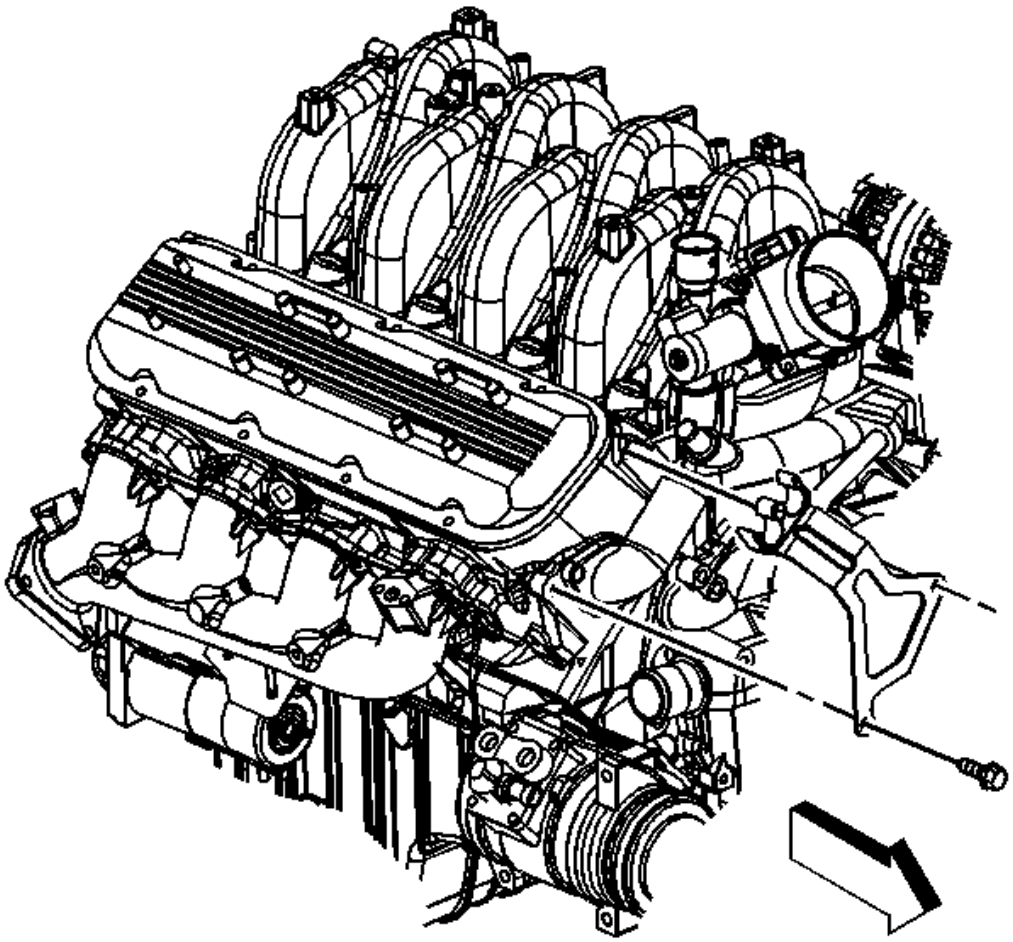

Fig. 129: View Of Heater Hose Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the heater inlet and outlet hoses from the hose bracket.
10. Remove the heater hose bracket bolts and bracket from the cylinder head.
11. Remove the water crossover. Refer to **Coolant Crossover Pipe Replacement (8.1L Engine)** in Engine Cooling.
12. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right (8.1L Engine)** in Engine Exhaust.

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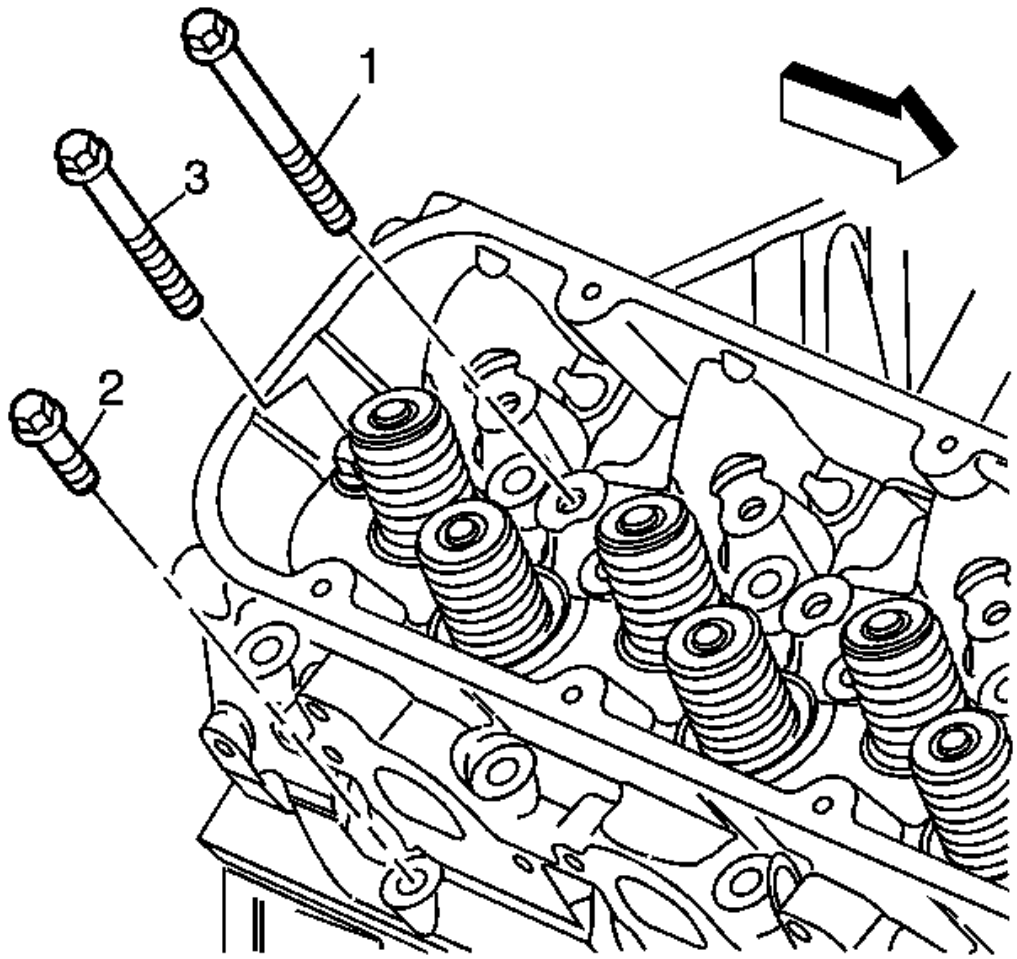

Fig. 130: View Of Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the cylinder head bolts (1, 2, and 3).

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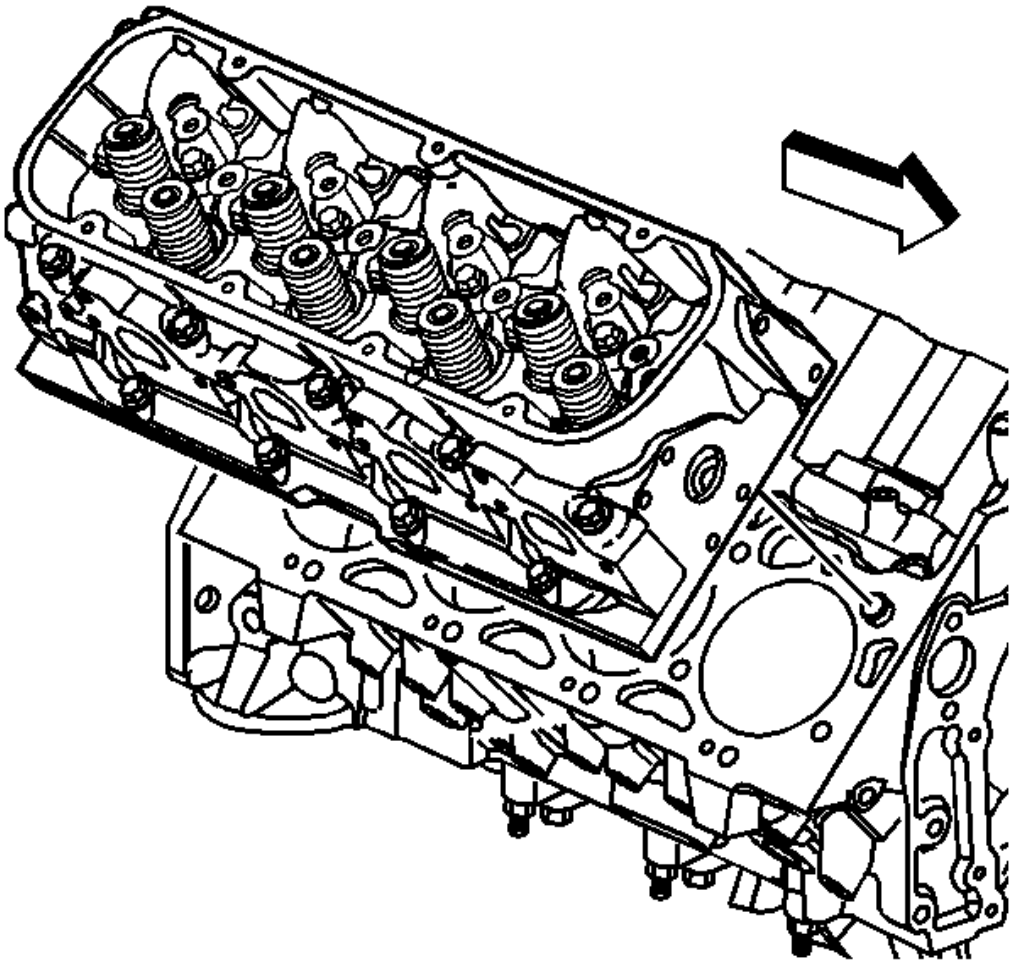

Fig. 131: View Of Right Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place the cylinder head on two wood block to prevent damage to the sealing surface.

14. Remove the cylinder head.

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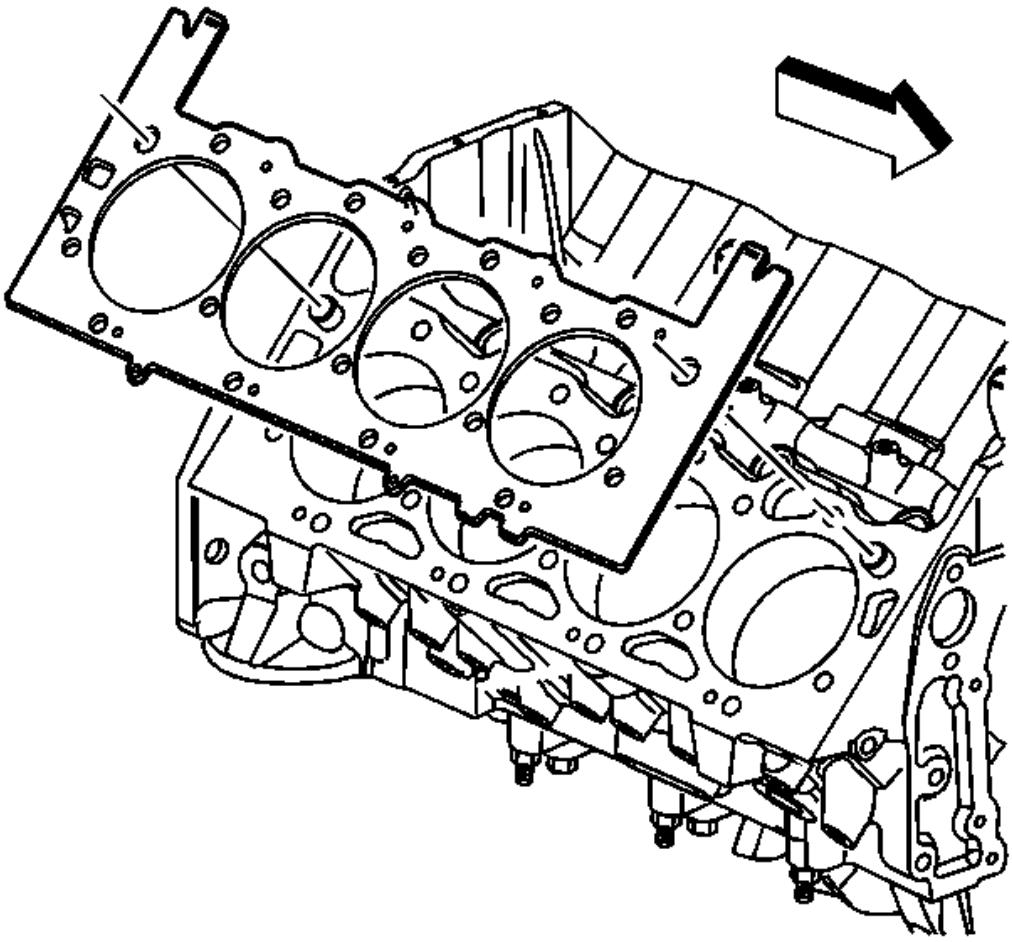

Fig. 132: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

15. Remove and discard the cylinder head gasket.
16. Clean and inspect the cylinder head. Refer to **Cylinder Head Cleaning and Inspection**.

Installation Procedure

IMPORTANT: Make sure the threaded holes in the engine block are clean and not damaged. Do not use sealer on any engines that use a composition type gasket. Align the cylinder head gasket locating mark to face up. Ensure that the head gasket tabs are located over the numbers 1 and 2 cylinders for correct installation.

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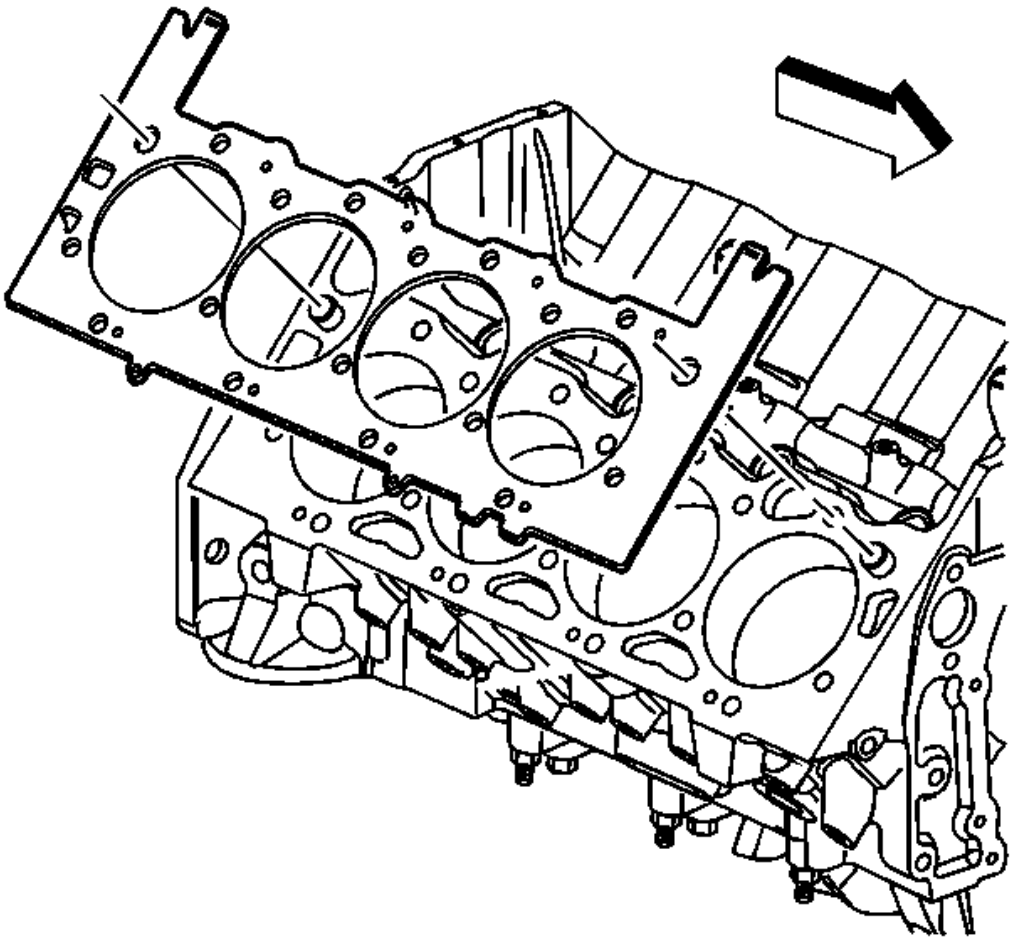

Fig. 133: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

1. Place a NEW cylinder head gasket into position.

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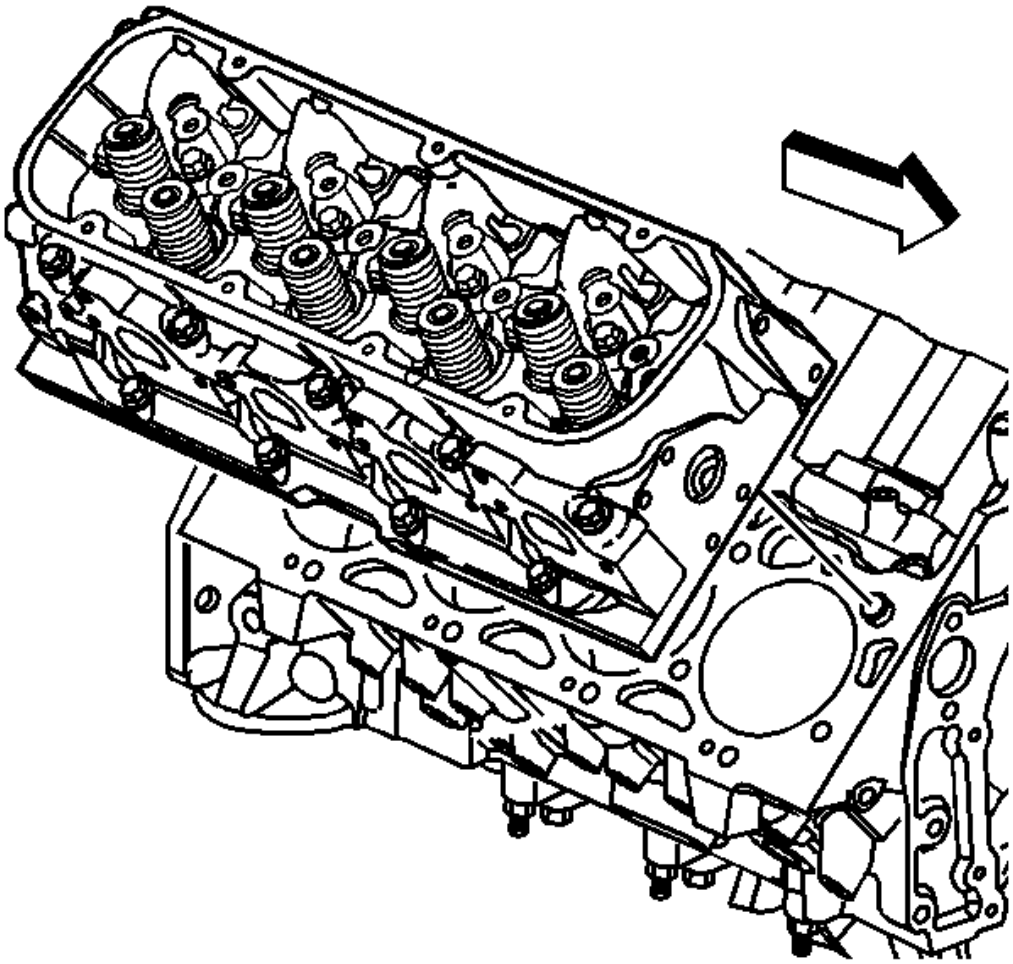

Fig. 134: View Of Right Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

2. Install the cylinder head.

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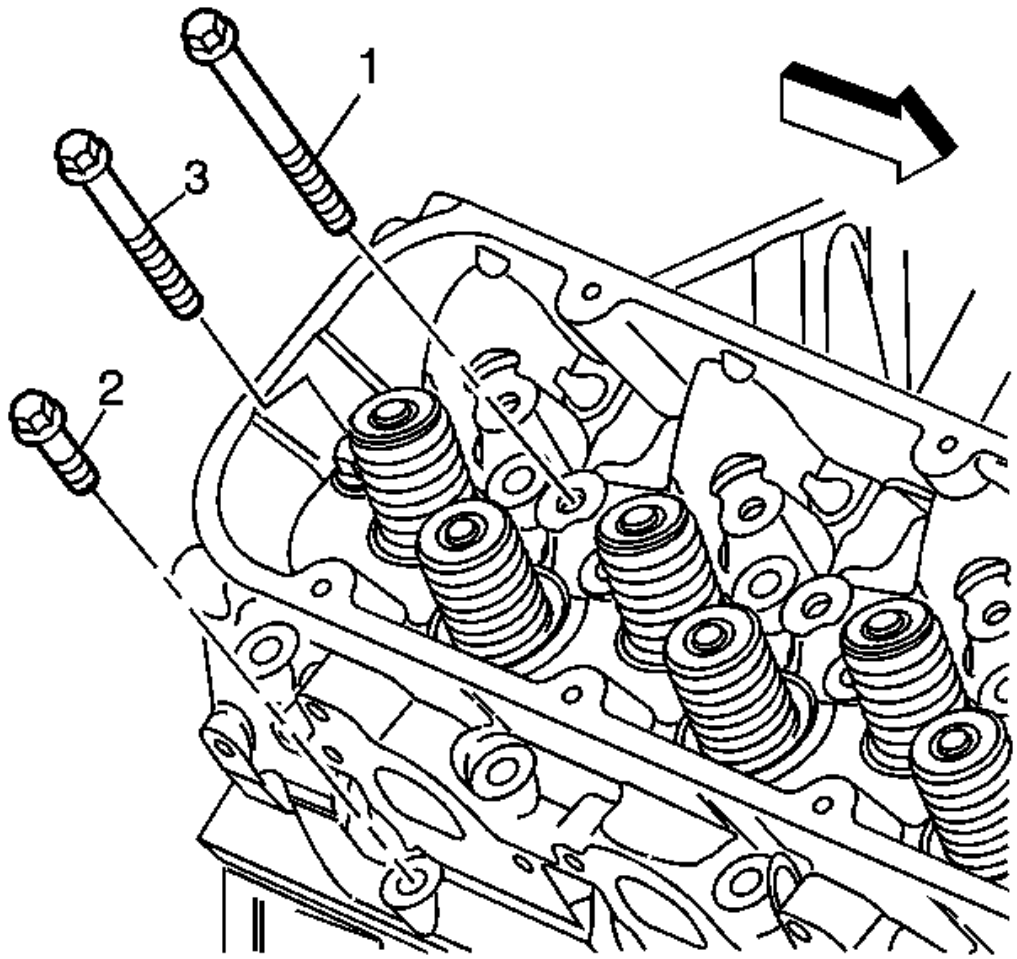

Fig. 135: View Of Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.

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IMPORTANT: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the new cylinder heads bolts, apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the cylinder head bolts.
4. Install the cylinder head bolts (1, 2, and 3).

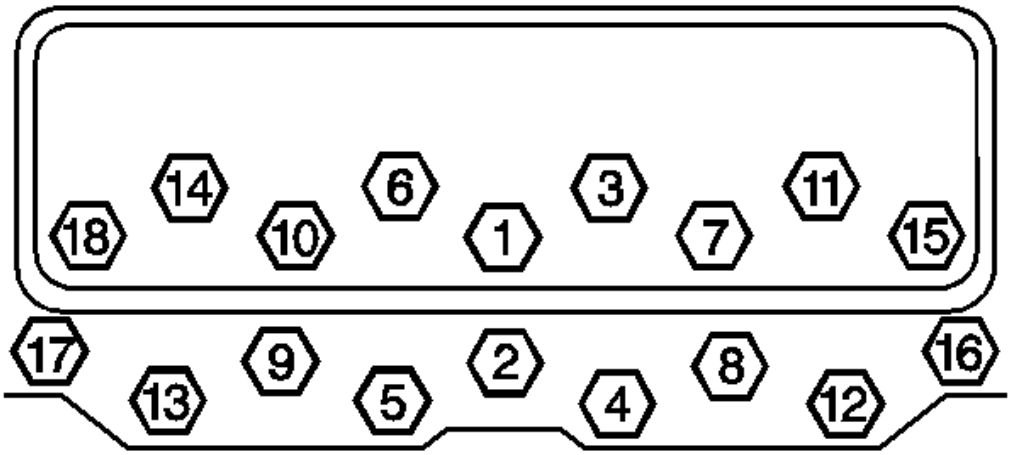

Fig. 136: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12, and 13.

5. Tighten the cylinder head bolts.

Tighten:

1. Tighten the cylinder head bolts a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the cylinder head bolts a second pass in sequence to 30 N.m (22 lb ft) then an additional 120 degrees using **J 45059** .
3. Tighten the bolts (1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, and 17) an additional 60 degrees, bolts (15, and 18) an additional 45 degrees, and bolts (4, 5, 12, and 13) an additional 30 degrees a final pass using **J 45059** .

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6. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right (8.1L Engine)** in Engine Exhaust.
7. Install the water crossover. Refer to **Coolant Crossover Pipe Replacement (8.1L Engine)** in Engine Cooling.

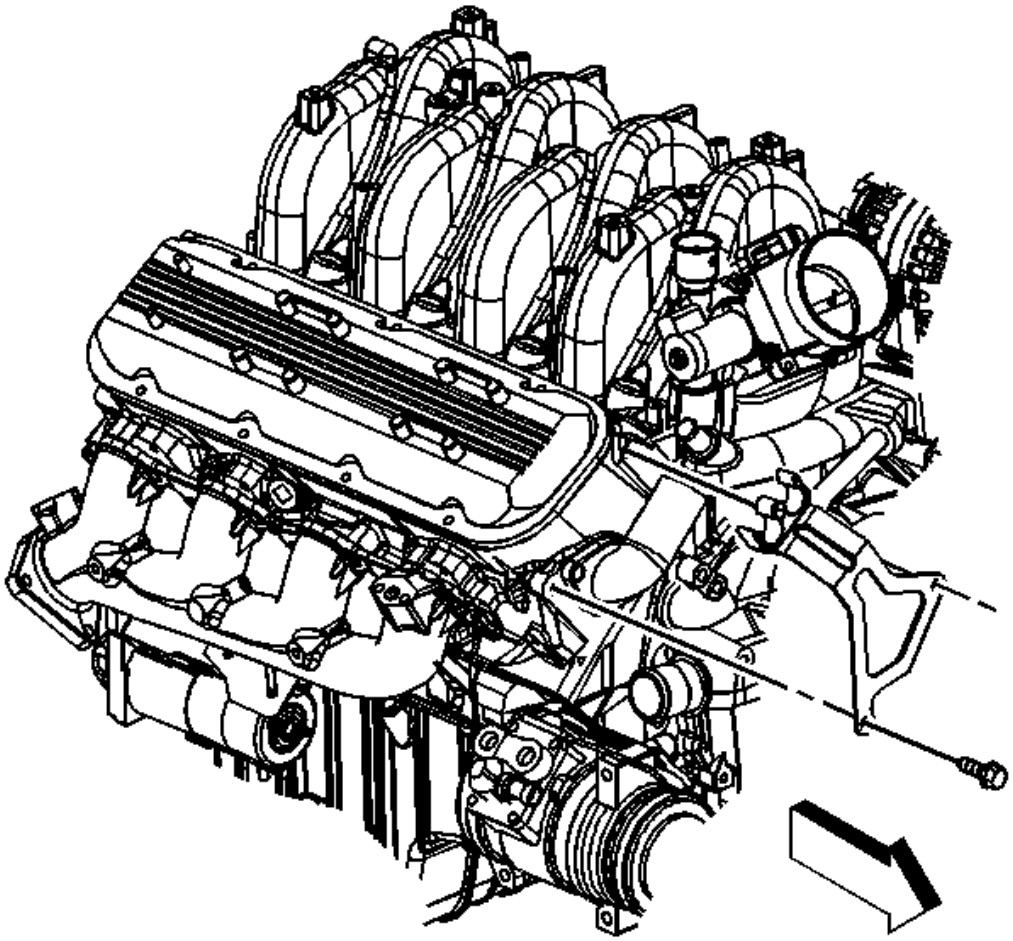

Fig. 137: View Of Heater Hose Bracket & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the heater hose bracket and bolts to the cylinder head.

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

9. Install the heater inlet and outlet hoses to the hose bracket.

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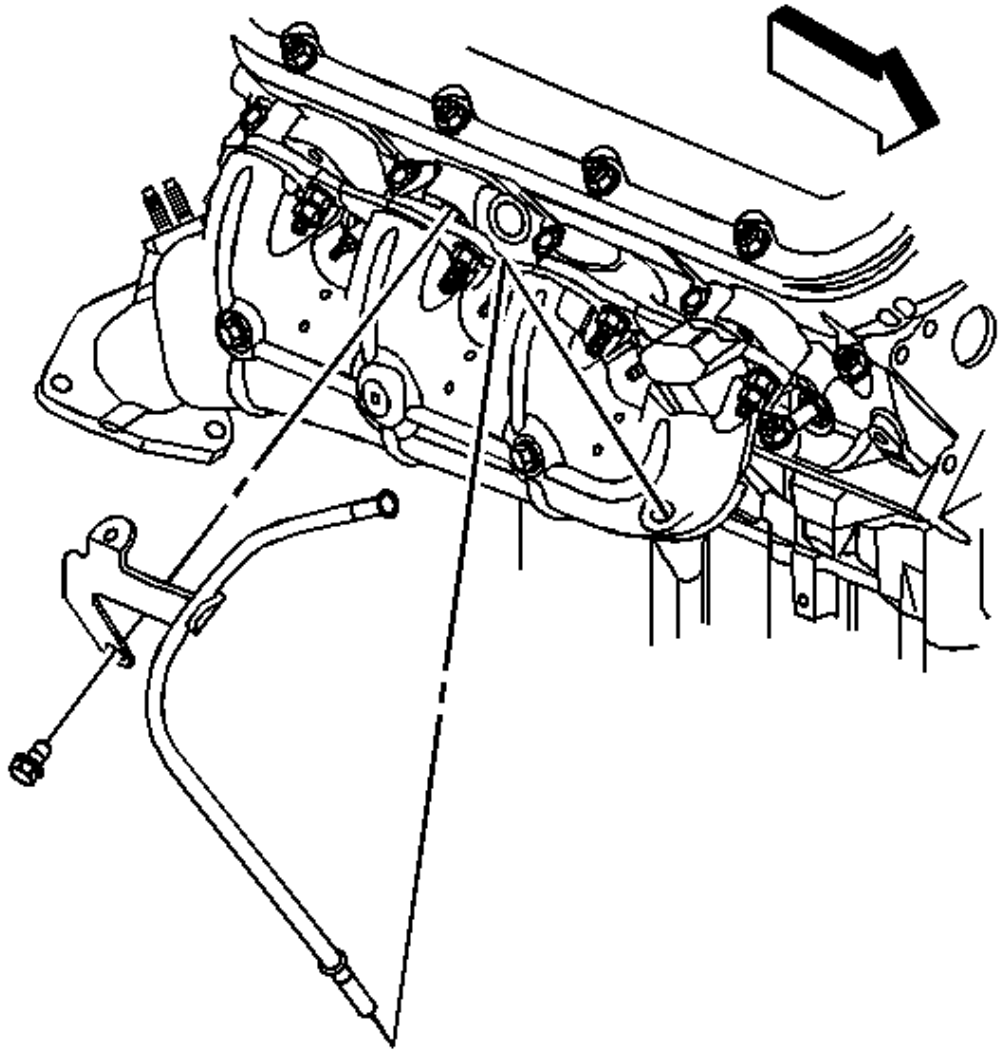

Fig. 138: View Of Indicator Tube, Bolt & Bracket
Courtesy of GENERAL MOTORS CORP.

10. Install a NEW O-ring seal onto the indicator tube.
11. Install the indicator tube into the oil pan.
12. Align the indicator tube bracket with the bolt hole in the block.
13. Install the indicator tube bolt.

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

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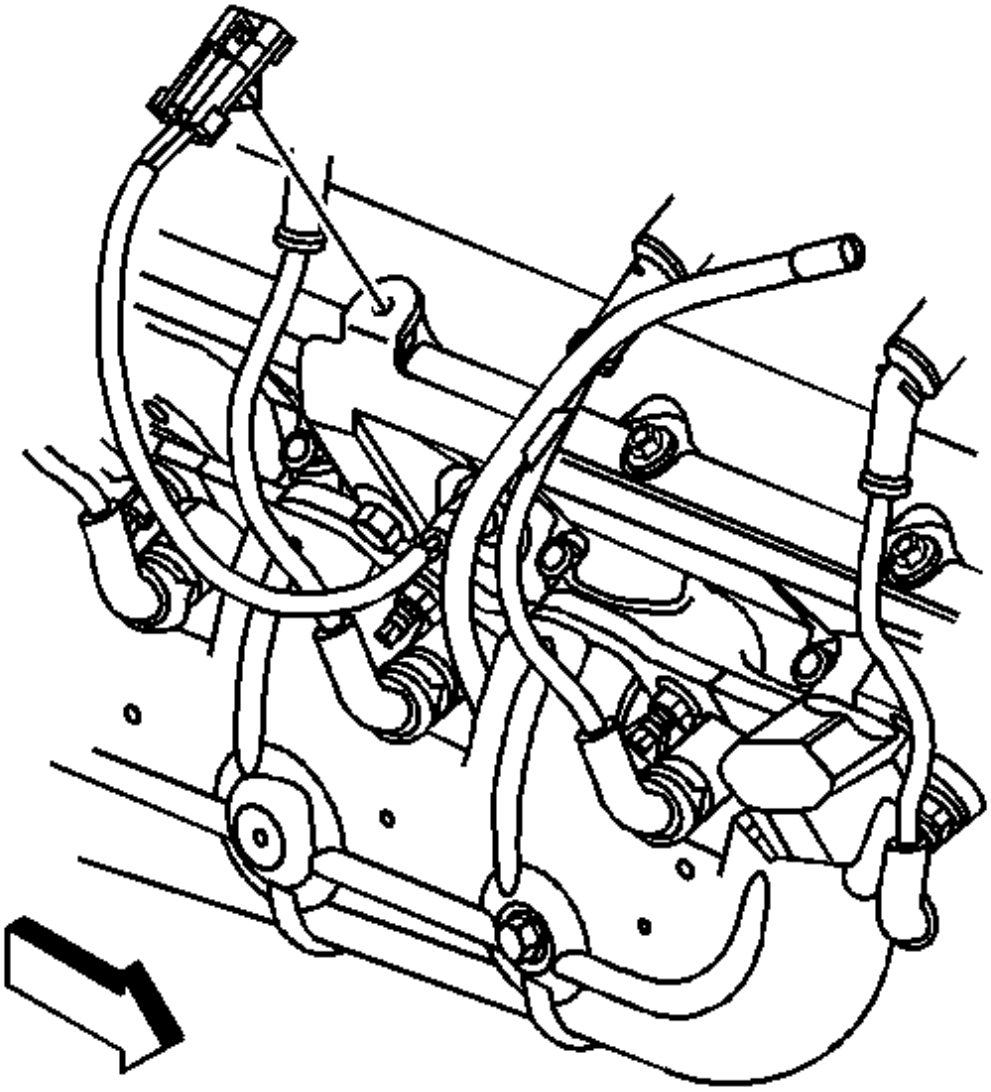

Fig. 139: View Of Engine Coolant Temperature (ECT) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

14. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the threads of the ECT sensor.
15. Install the ECT sensor to the cylinder head.

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

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16. Install the ECT sensor clip to the bracket.
17. Install the valve rocker arms and pushrods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
18. Install the intake manifold. Refer to **Intake Manifold Replacement**.
19. Drain the cooling system. Refer to **Draining and Filling Cooling System** in Engine Cooling.

Crankshaft Balancer Replacement

Tools Required

- **J 38416-B** Harmonic Balancer Remover. See **Special Tools and Equipment**.
- **J 42845** Crankshaft Balancer Installer. See **Special Tools and Equipment**.
- **J 42846** Crankshaft Balancer Protector Button. See **Special Tools and Equipment**.
- **J 42847** Flywheel Holding Tool. See **Special Tools and Equipment**.

Removal Procedure

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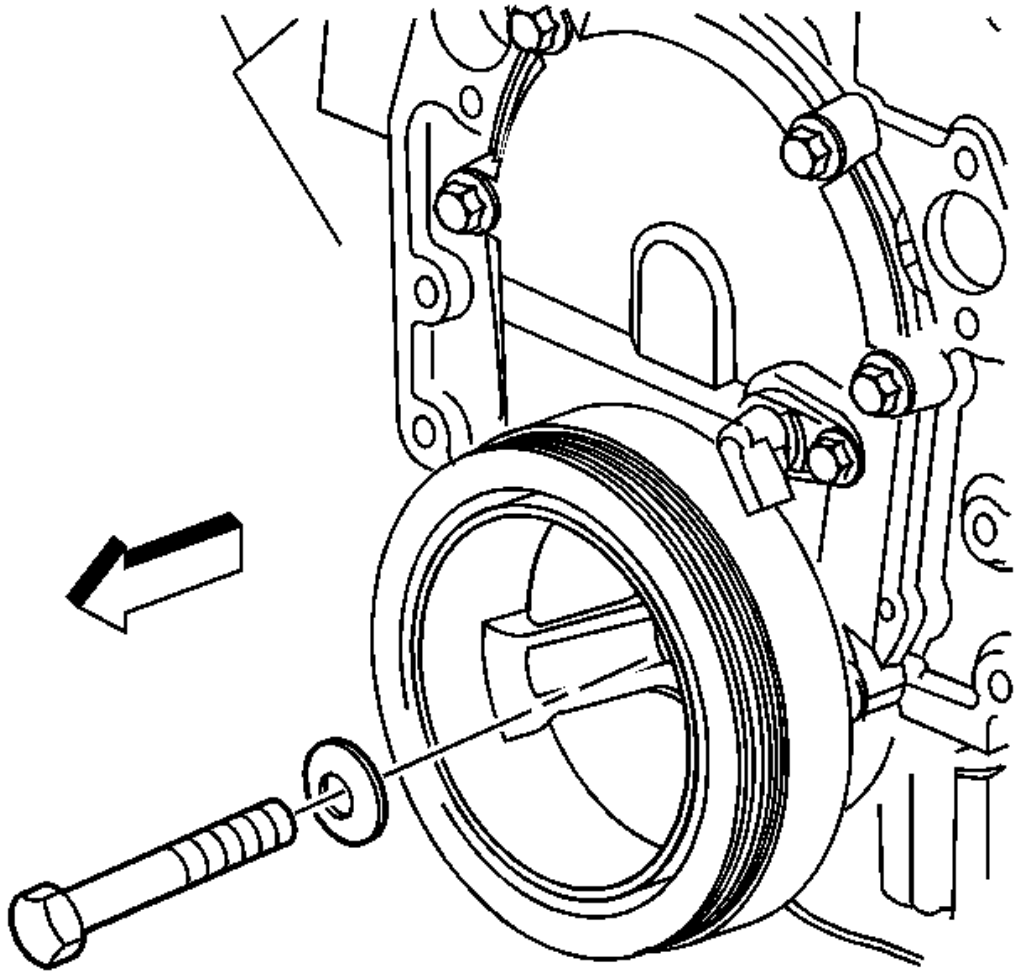

Fig. 140: View Of Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

1. Remove the air conditioning (A/C) belt. Refer to **Drive Belt Replacement - Air Conditioning**.
2. Remove the fan. Refer to **Fan Replacement** in Engine Cooling.
3. Remove the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure that the teeth of the flywheel holding tool engage the engine flywheel teeth.

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4. Install the **J 42847** to the starter bolt holes. See **Special Tools and Equipment**.

   Tighten: Tighten the **J 42847** bolts to 50 N.m (37 lb ft). See **Special Tools and Equipment**.

5. Remove the crankshaft balancer bolt and washer.

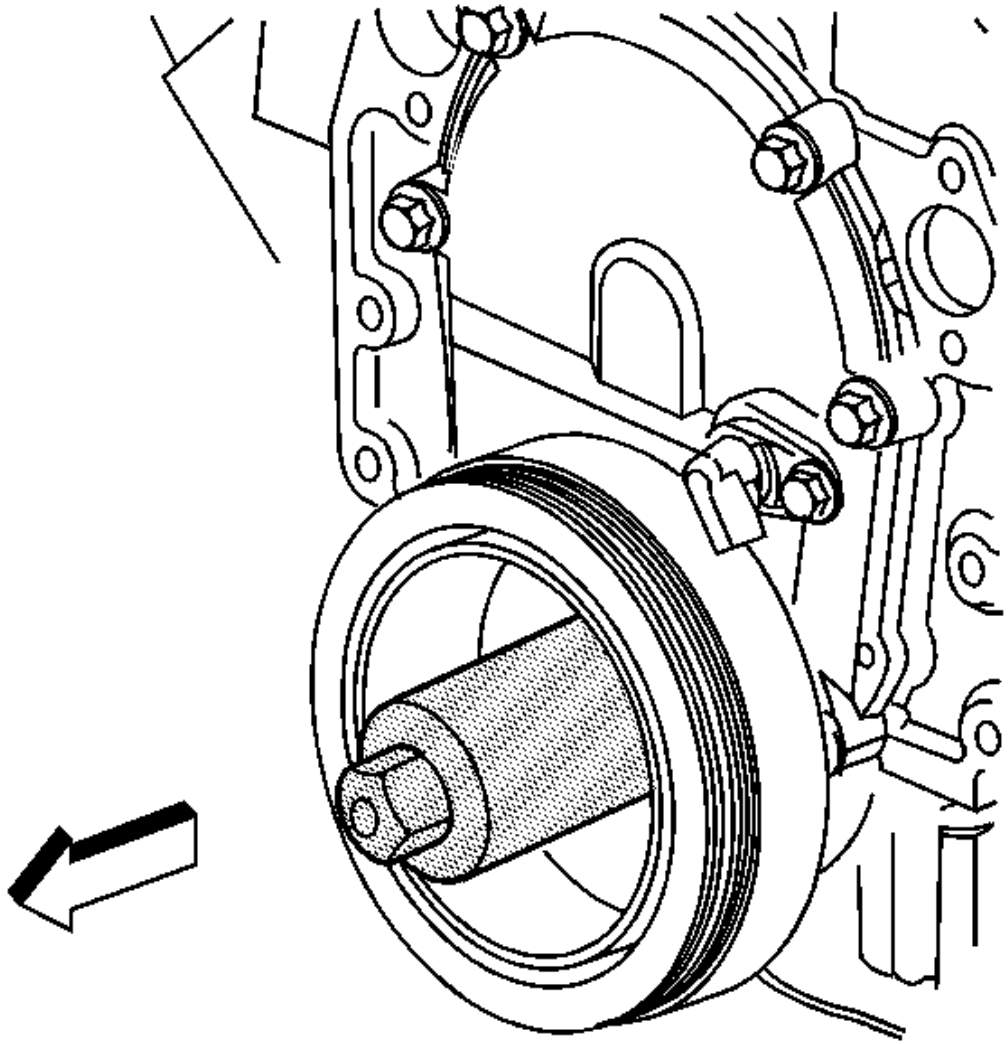

Fig. 141: Installing J 42846 Onto End Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

6. Install the **J 42846** onto the end of the crankshaft. See **Special Tools and Equipment**.

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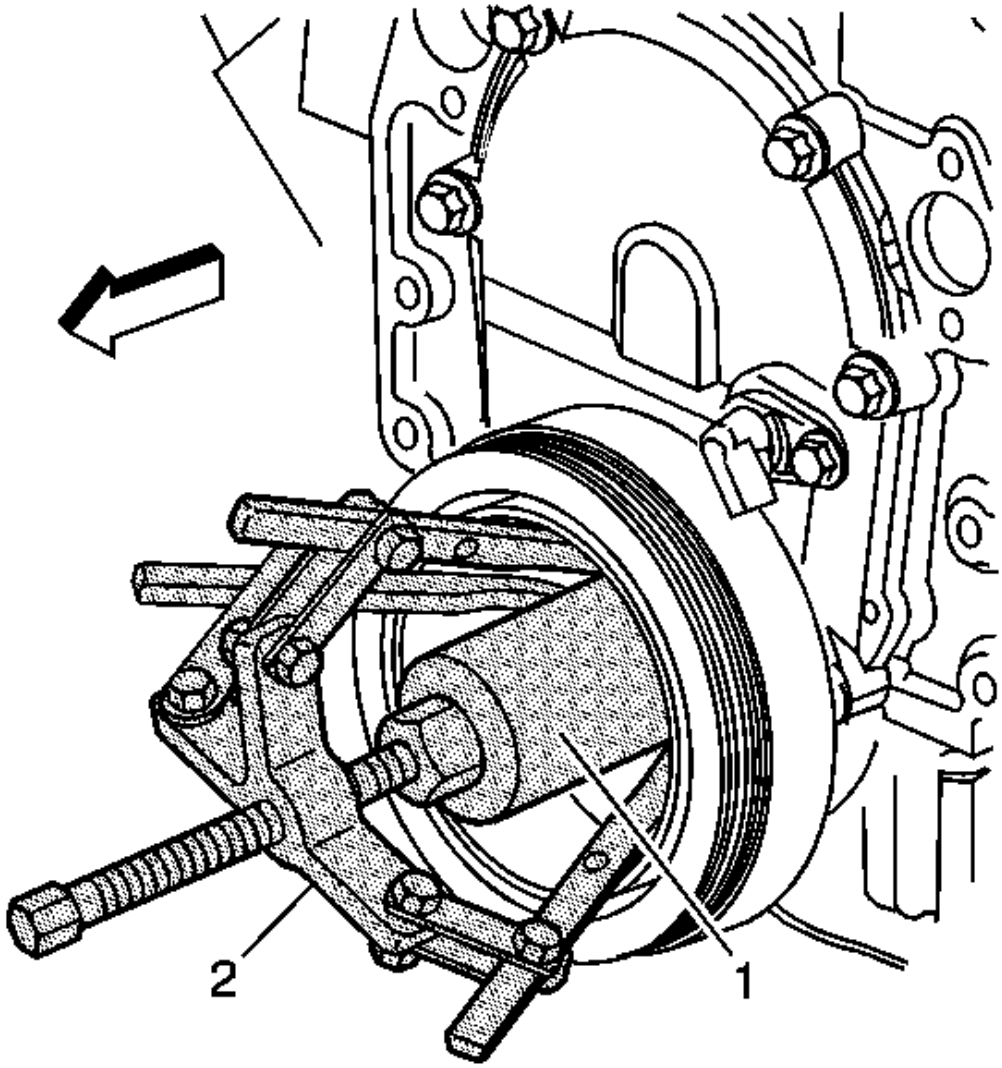

Fig. 142: Removing Crankshaft Balancer Using J 38416-B & J 42846
Courtesy of GENERAL MOTORS CORP.

7. Install the **J 38416-B** (2) onto the **J 42846** (1) in order to remove the crankshaft balancer. See **Special Tools and Equipment**. Place the legs of the **J 38416-B** into the recesses cast into the backside of the balancer inner hub. See **Special Tools and Equipment**.
8. Tighten the center screw of the **J 38416-B** until the crankshaft balancer is clear of the crankshaft nose. See **Special Tools and Equipment**.

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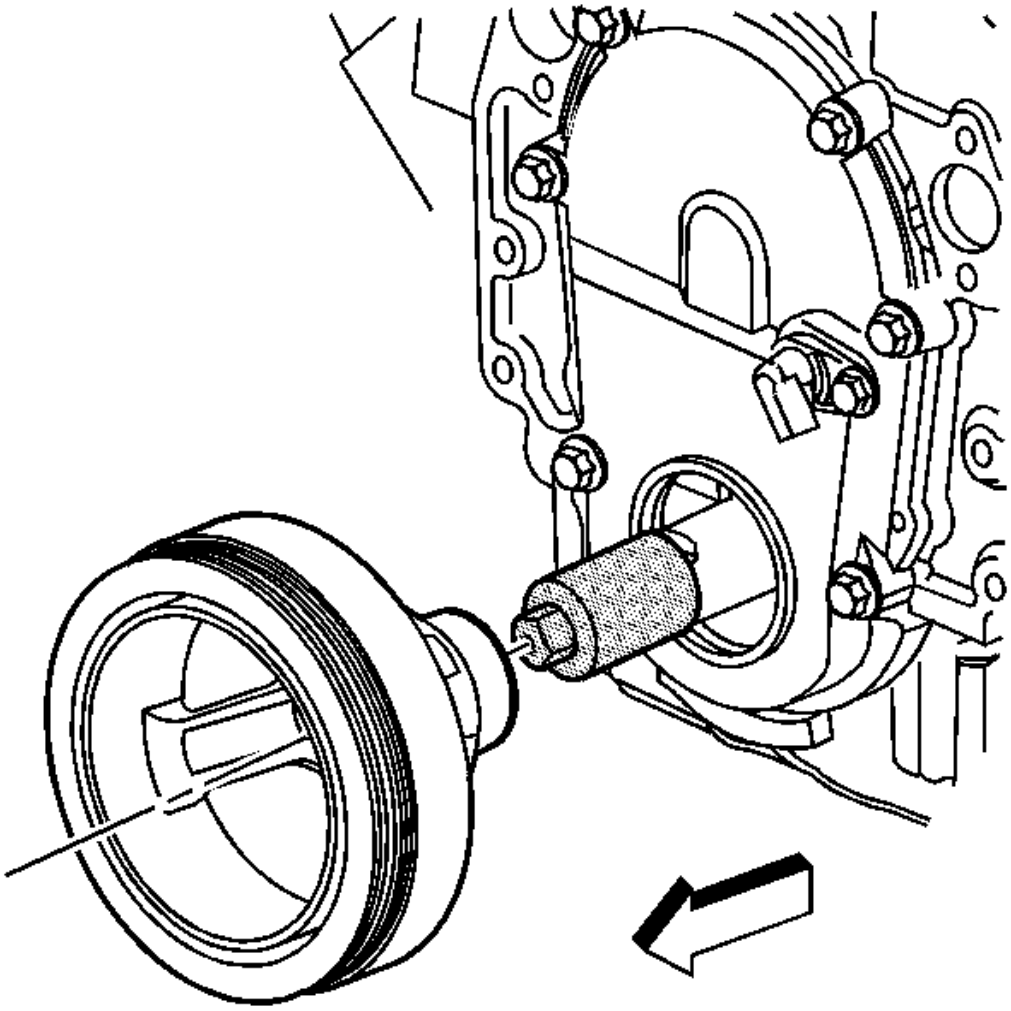

Fig. 143: Removing Crankshaft Balancer & J 42846
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft balancer.
10. Remove the **J 42846** from the end of the crankshaft. See **Special Tools and Equipment**.

Installation Procedure

IMPORTANT:

- **The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.**
- **Apply grease or clean engine oil to the inside of the crankshaft balancer**

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or the end of the crankshaft, to prevent galling during assembly.

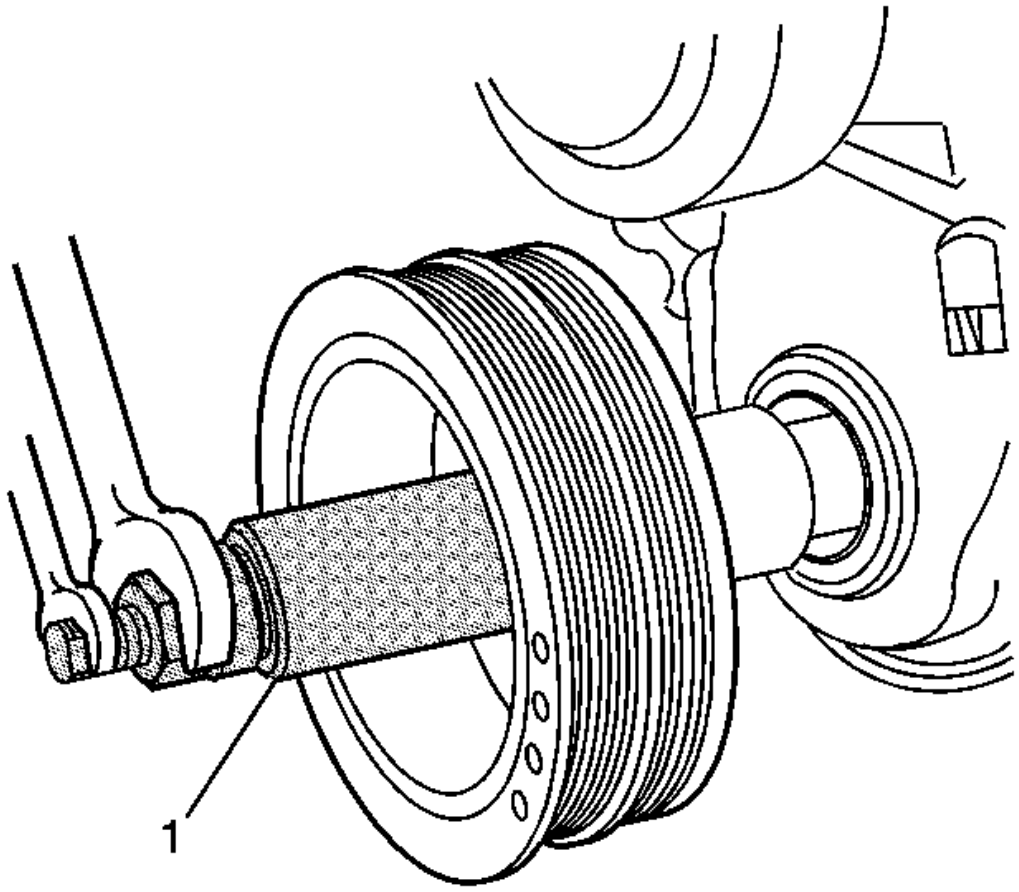

Fig. 144: Installing Crankshaft Balancer Using J 42845
Courtesy of GENERAL MOTORS CORP.

1. Install the balancer onto the end of the crankshaft.
2. Install **J 42845** to the crankshaft balancer. See **Special Tools and Equipment**.

IMPORTANT: Apply the lubricant that comes with J 42845 each time the tool is used. See Special Tools and Equipment. Failure to lubricate the J 42845 may prevent the balancer from installing completely. See Special Tools and Equipment.

3. Using **J 42845** install the balancer. See **Special Tools and Equipment**.
4. Tighten the **J 42845** until the crankshaft balancer is completely seated against the crankshaft sprocket.

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See **Special Tools and Equipment**.

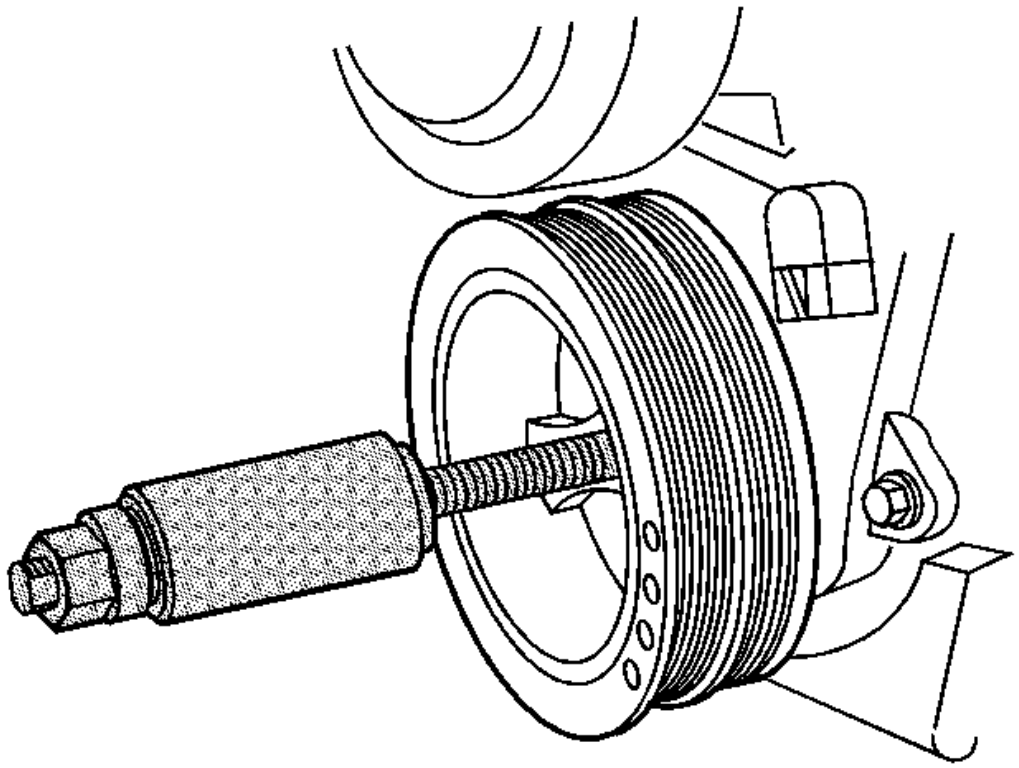

Fig. 145: View Of J 42845
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 42845** from the crankshaft. See **Special Tools and Equipment**.

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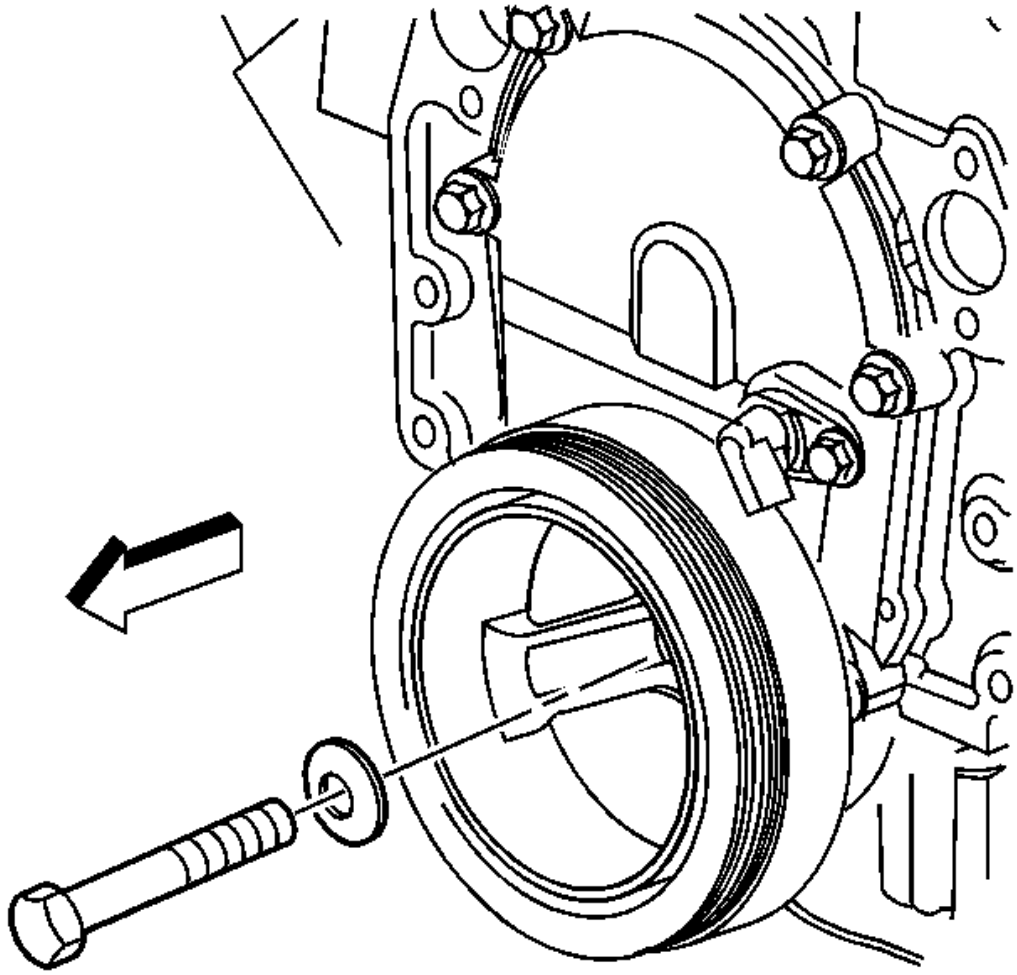

Fig. 146: View Of Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the crankshaft bolt and washer to the crankshaft.

   Tighten: Tighten the bolt to 255 N.m (189 lb ft).

7. Remove the **J 42847** . See **Special Tools and Equipment**.
8. Install the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.
9. Install the fan. Refer to **Fan Replacement** in Engine Cooling.

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10. Install the A/C belt. Refer to **Drive Belt Replacement - Air Conditioning**.

Crankshaft Front Oil Seal Replacement

Tools Required

J 42851 Front Cover Oil Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

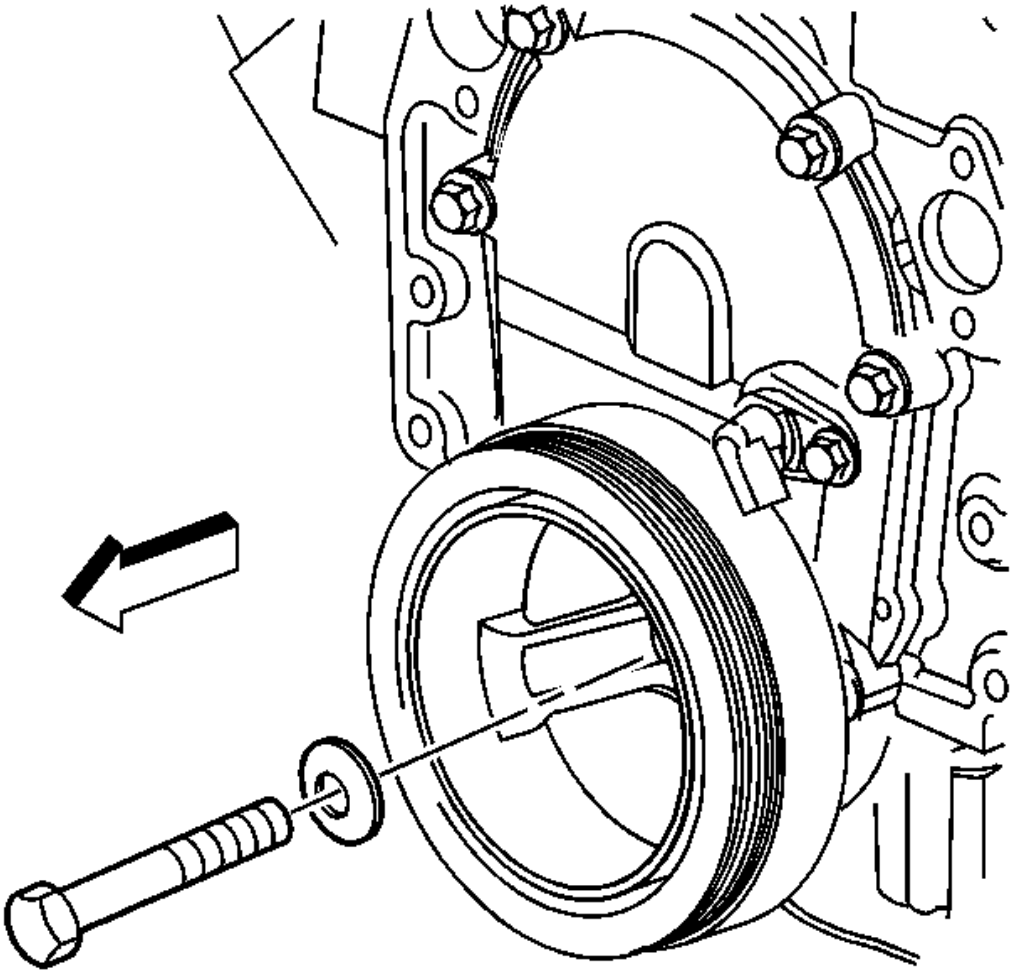

Fig. 147: View Of Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Use care as not to damage the engine front cover or the crankshaft sealing area when removing the crankshaft front cover oil seal.

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

Installation Procedure

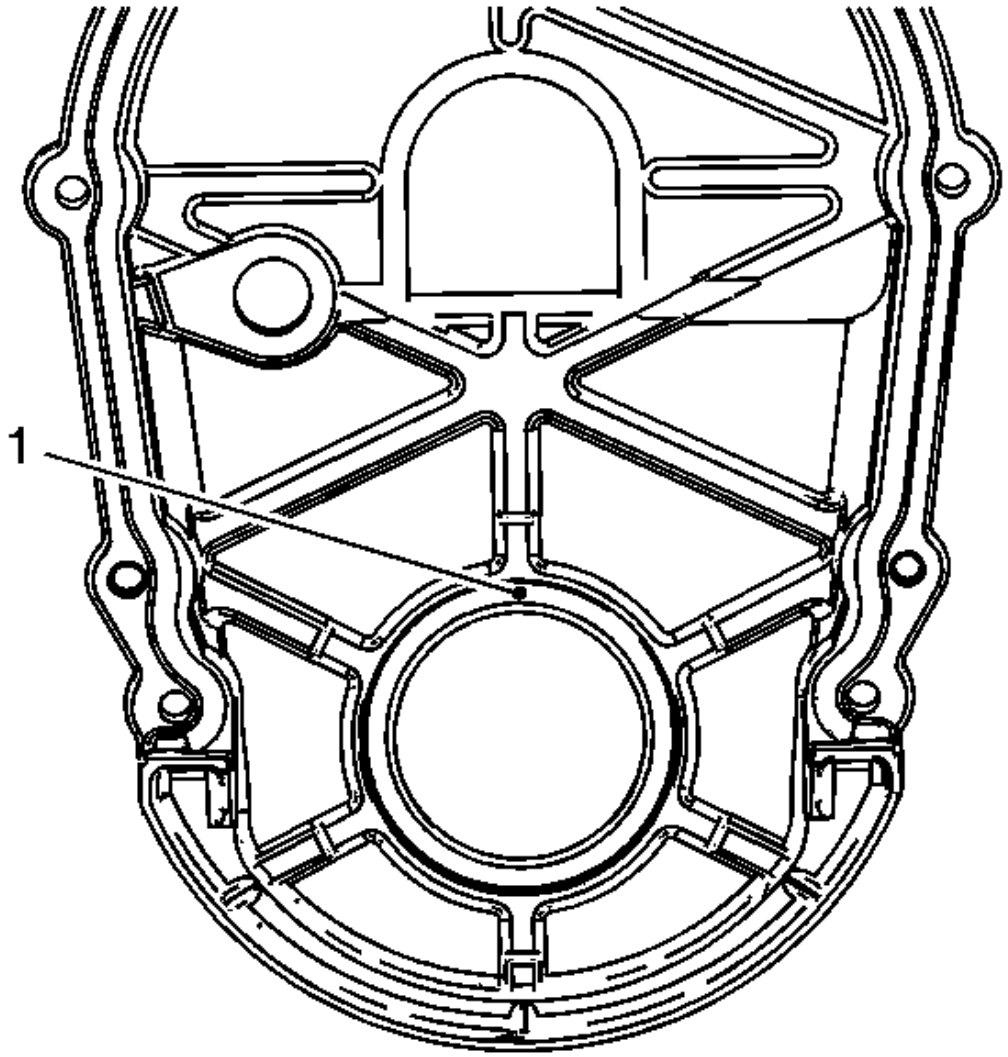

Fig. 148: Identifying Mark On Rear Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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1. Lubricate the outer sealing surface of the crankshaft front oil seal lightly with clean engine oil. DO NOT lubricate the inner portion of the seal.
2. Position the NEW seal in the front cover so that the dimple (1) on the rear of the seal is in the 12 o'clock position.
3. Using **J 42851** install the oil seal. See **Special Tools and Equipment**.
4. Remove the **J 42851** . See **Special Tools and Equipment**.
5. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Engine Front Cover Replacement

Tools Required

J 42851 Front Cover Oil Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

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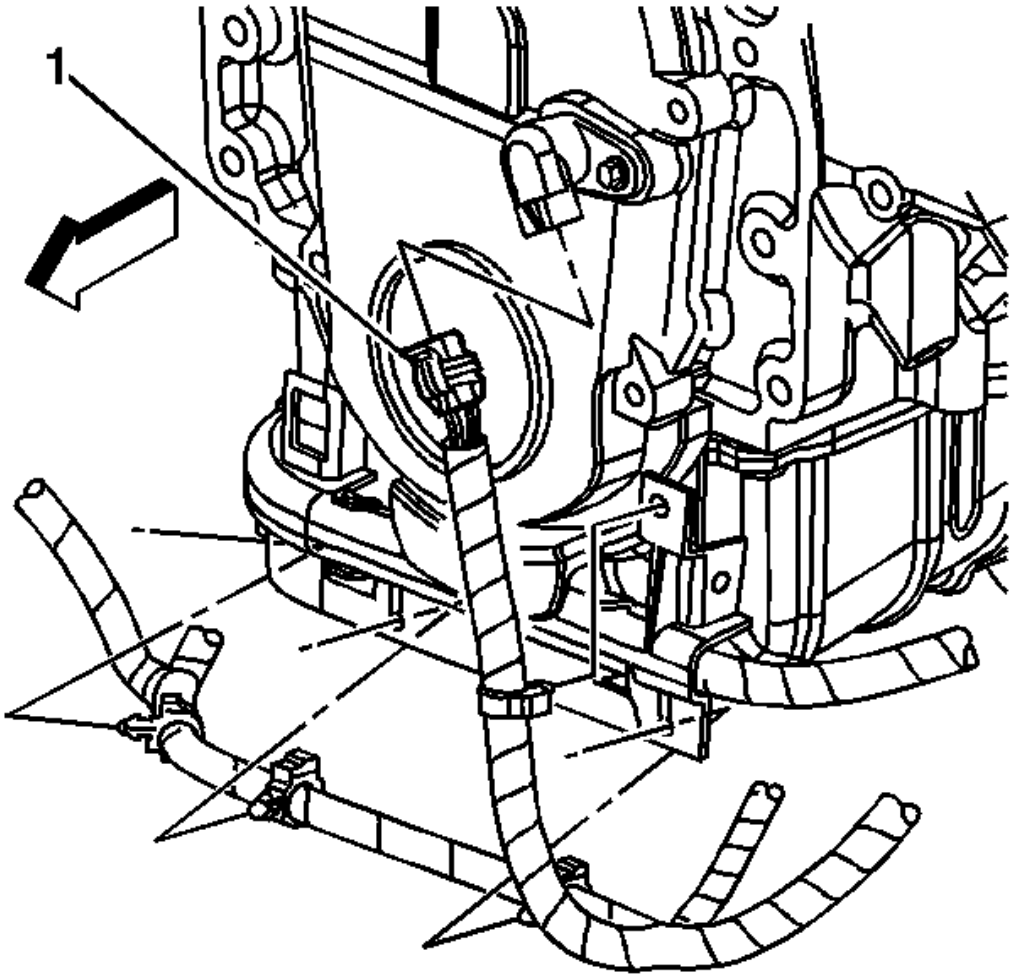

Fig. 149: View Of Camshaft Position (CMP) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Remove the water pump. Refer to **Water Pump Replacement (8.1L Engine)** in Engine Cooling.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Disconnect the camshaft position (CMP) sensor electrical connector (1).
4. Remove the engine harness clips from the battery cable channel.

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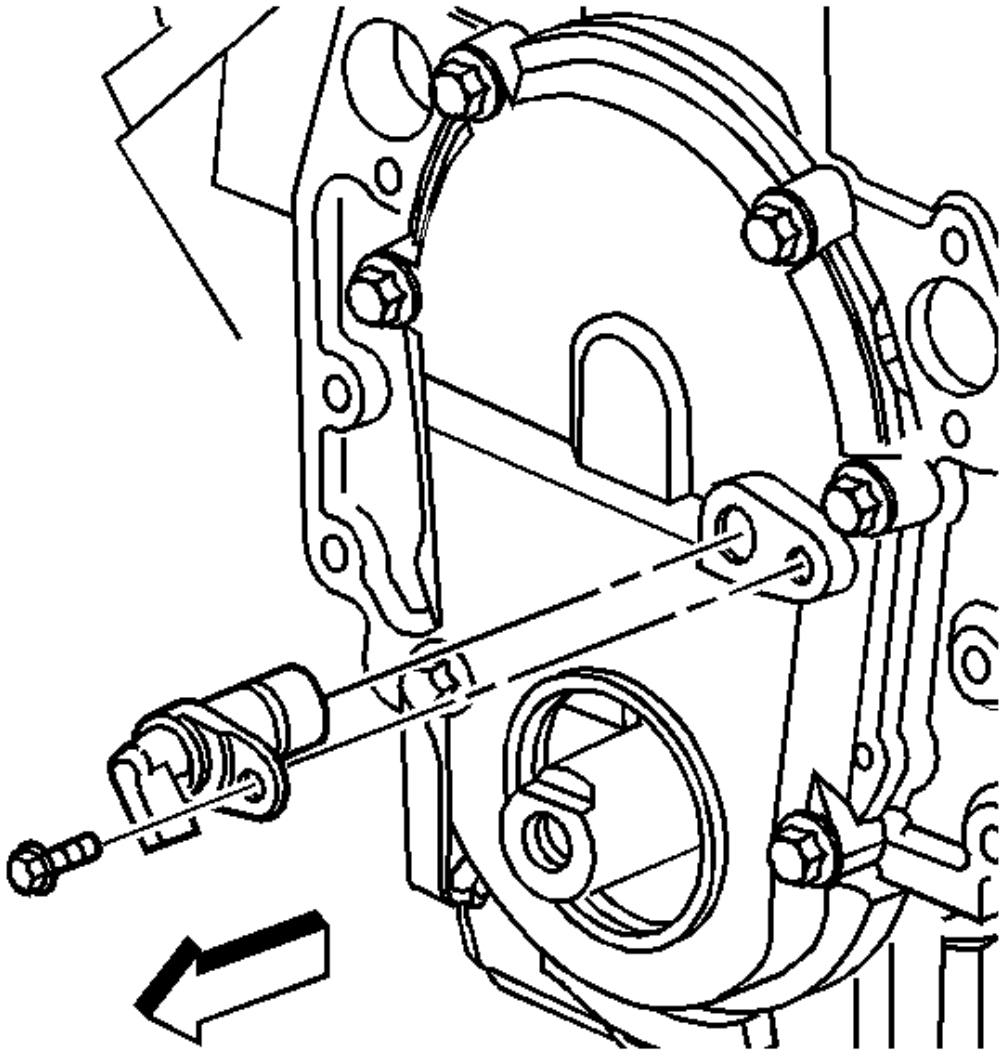

Fig. 150: View Of CMP Sensor
Courtesy of GENERAL MOTORS CORP.

5. Remove the CMP sensor bolt.
6. Remove the CMP sensor.

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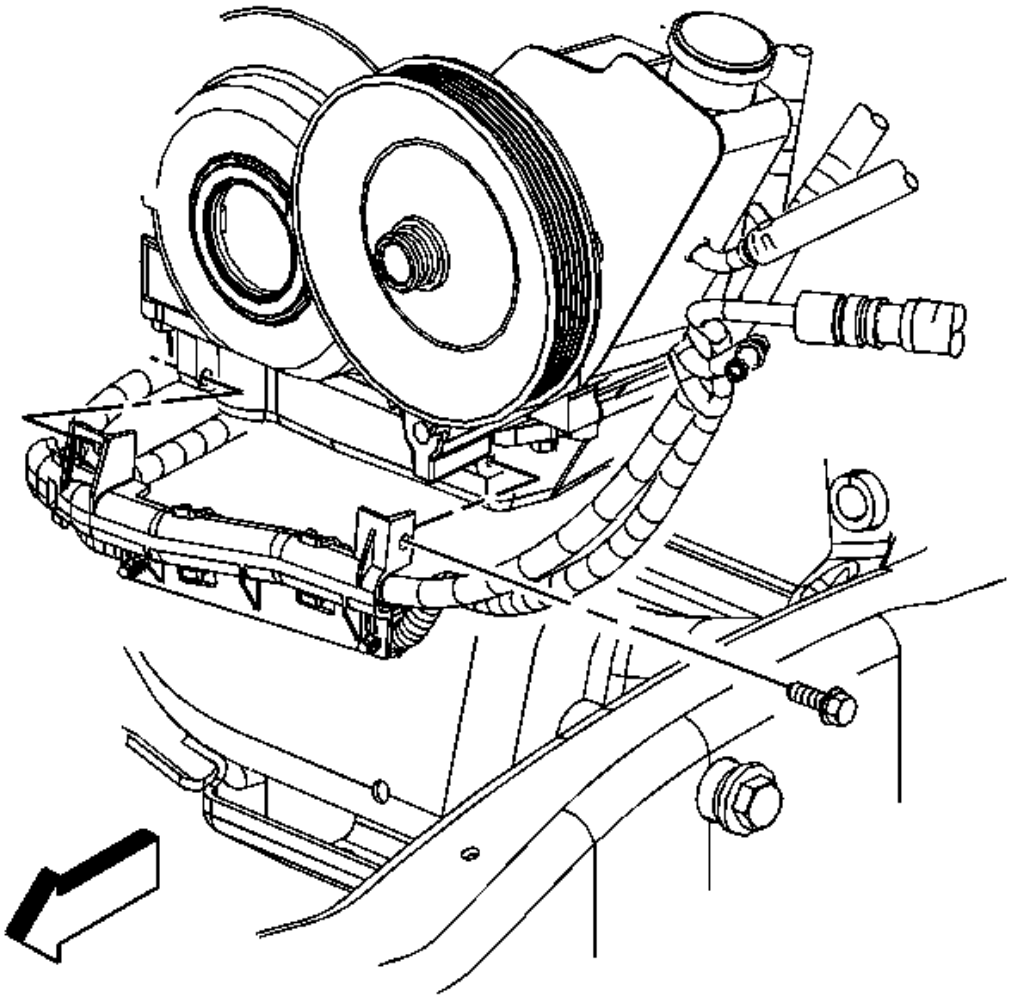

Fig. 151: View Of Battery Cable Channel Bolt
Courtesy of GENERAL MOTORS CORP.

7. Remove the battery cable channel bolt.
8. Remove and reposition the battery cable channel.

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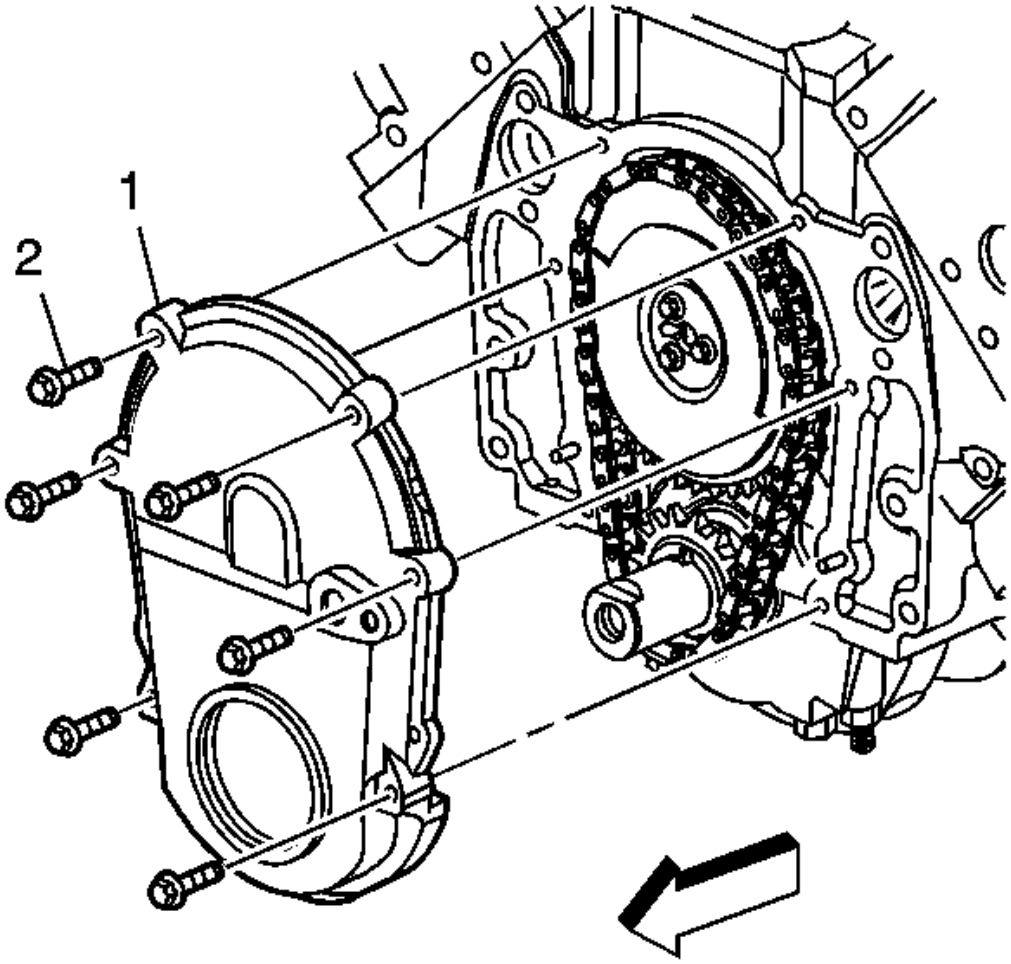

Fig. 152: View Of Engine Front Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine front cover bolts (2).
10. Remove the engine front cover (1).

IMPORTANT: The engine front cover gasket is reusable.

11. Remove the engine front cover gasket.
12. Remove the crankshaft front oil seal from the front cover.

Installation Procedure

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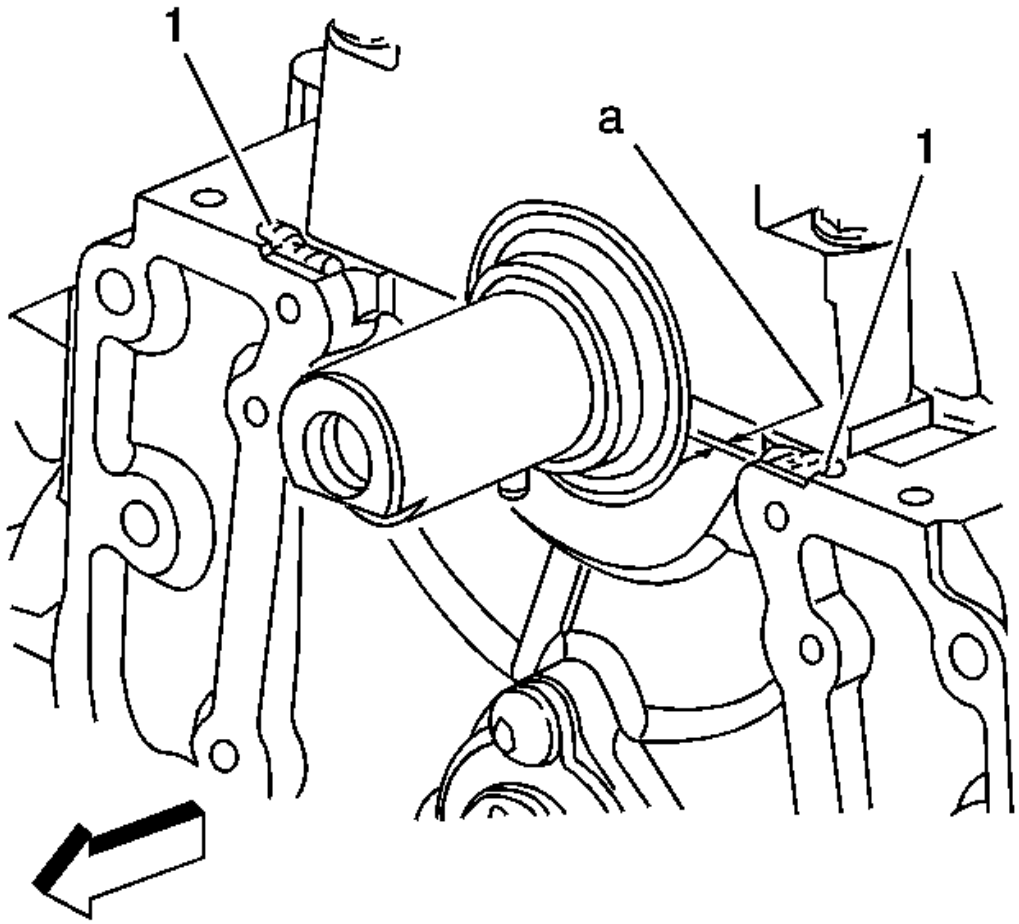

Fig. 153: Applying Sealant At 2 Places On Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW crankshaft front oil seal using **J 42851** . See **Special Tools and Equipment**.
2. Lubricate the sealing surface of the crankshaft front oil seal with clean engine oil.

IMPORTANT: The engine front cover must be installed and the fasteners tightened while the sealant is still wet to the touch.

3. Apply sealant GM P/N 12346286 (Canadian P/N 10953472) or equivalent in 2 places (1) on the engine block where the front cover meets the oil pan.

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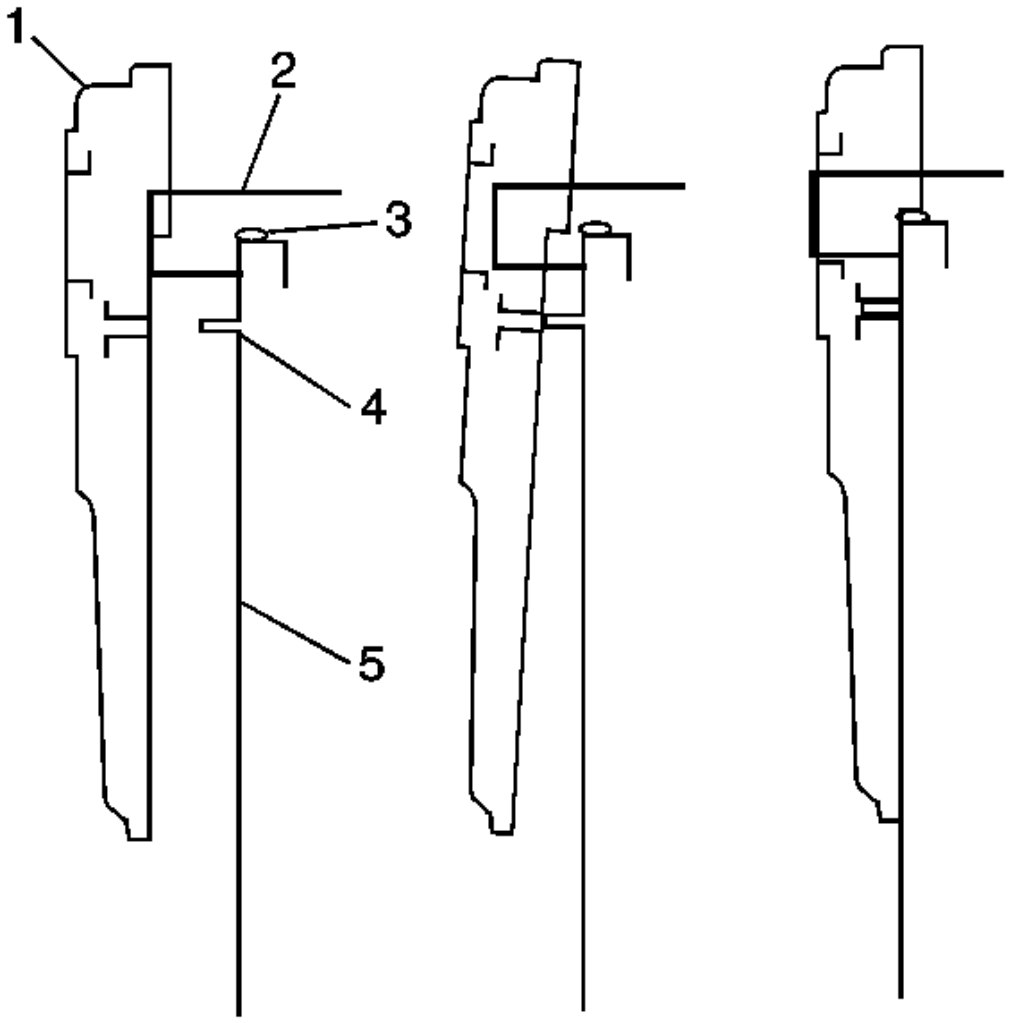

Fig. 154: View Of Front Cover & Gasket Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The following method must be used when installing the engine front cover. Failure to follow the instructions will push the sealant out, which may cause an oil leak.

4. Install the engine front cover gasket into the front cover.
5. Install the front cover and gasket.
    1. Hold the front cover (1) up to the crankshaft (2).
    2. Lift the front cover (1) while sliding the cover over the crankshaft (2).

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3. Slide the front cover towards the engine block (5) while keeping the cover raised.
4. Lower the cover down over the dowel pin (4), allowing the front cover to rest on the sealant (3).

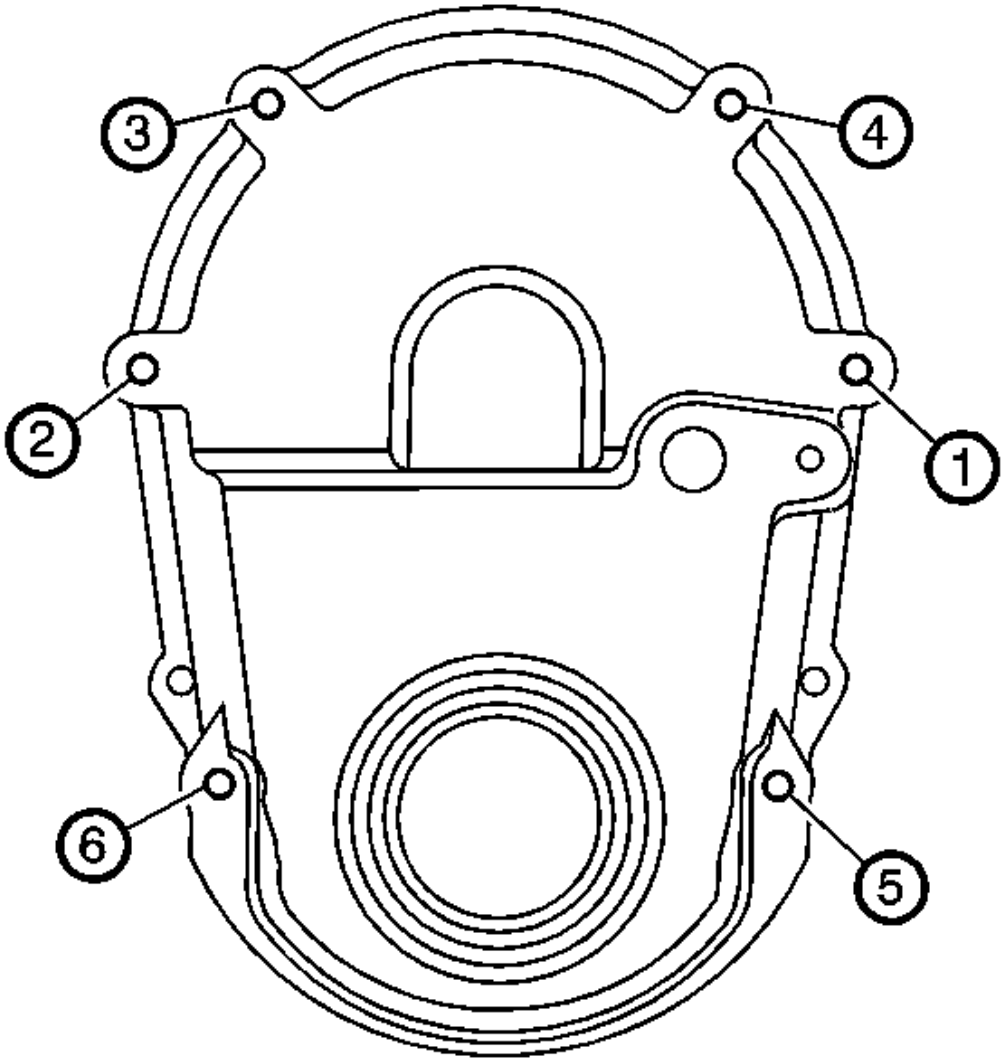

Fig. 155: Crankshaft Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the engine front cover bolts.

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7. Tighten the engine front cover bolts.

   Tighten:

   1. Tighten the engine front cover bolts in sequence a first pass to 6 N.m (53 lb in).
   2. Tighten the engine front cover bolts in sequence a final pass to 12 N.m (106 lb in).

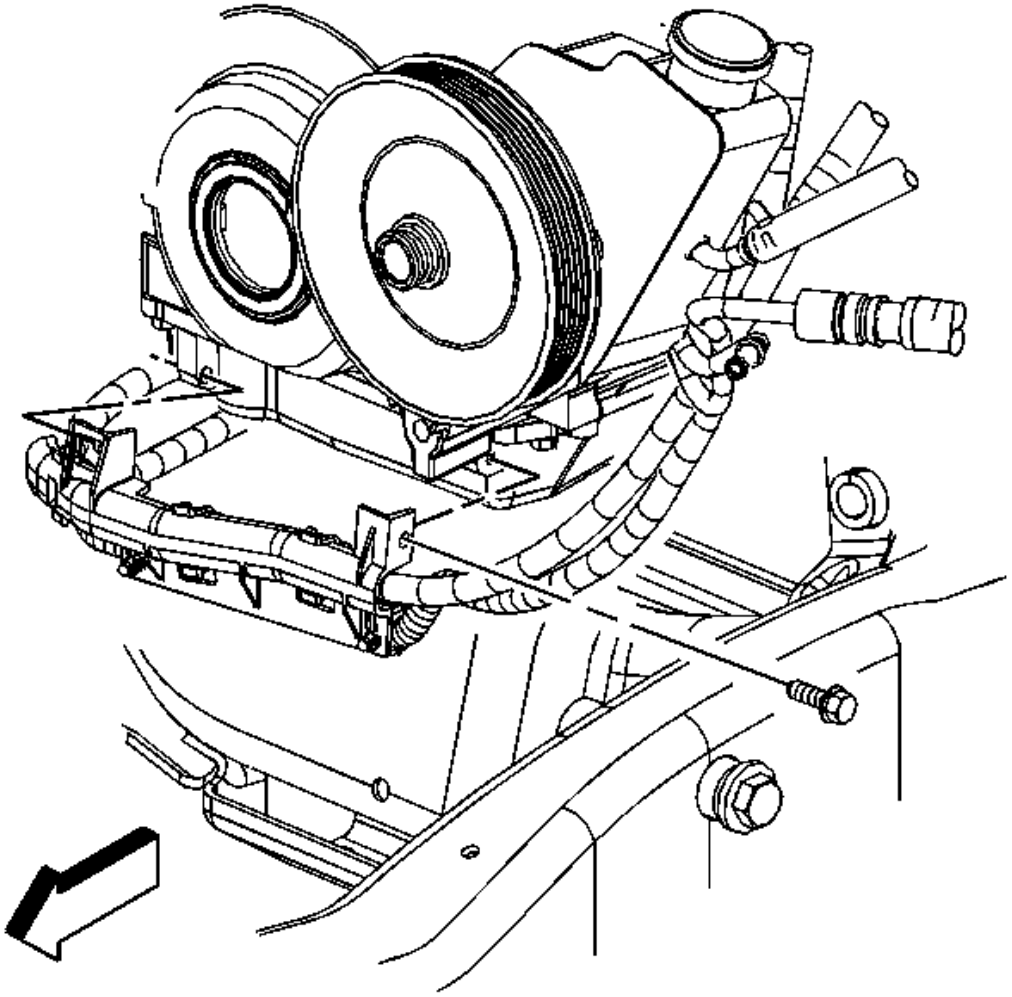

Fig. 156: View Of Battery Cable Channel Bolt
Courtesy of GENERAL MOTORS CORP.

8. Position the battery cable channel into place.
9. Install the battery cable channel bolt.

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

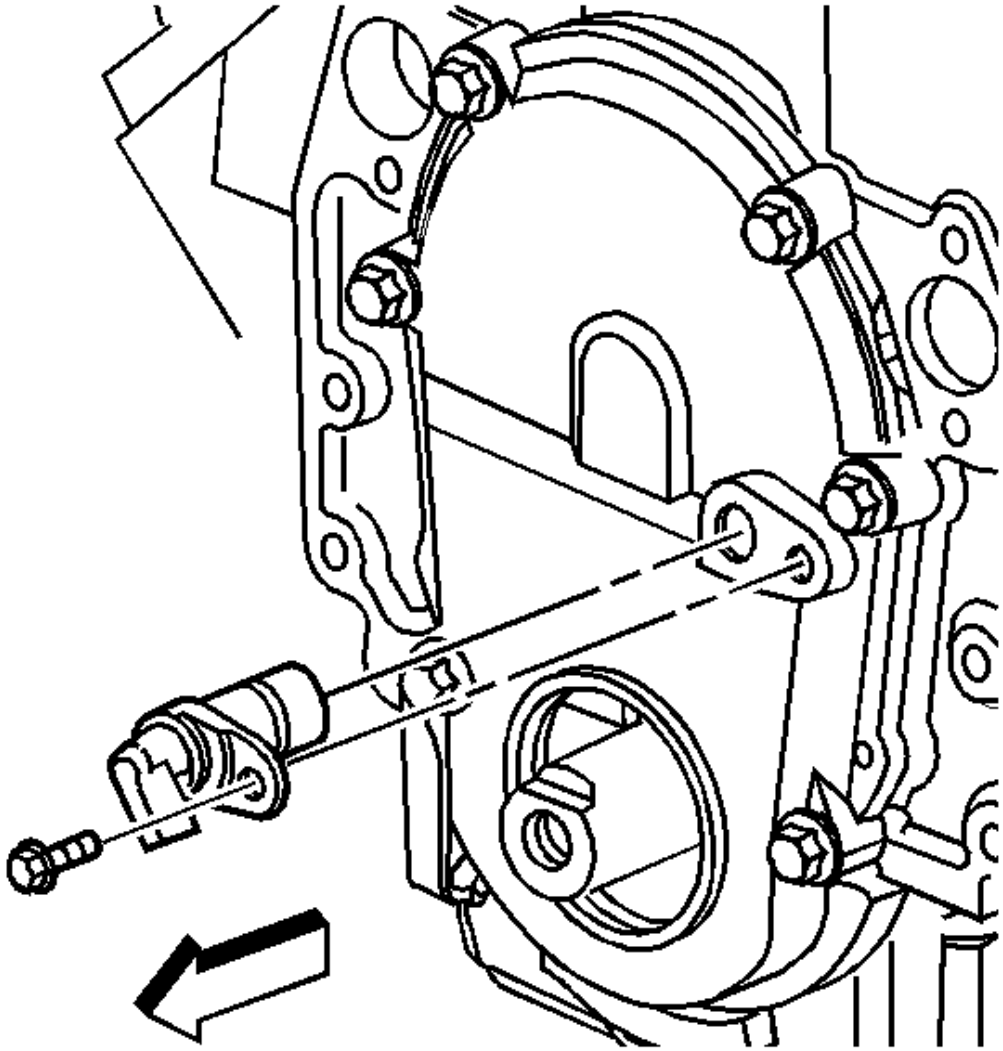

Fig. 157: View Of CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Inspect the CMP sensor O-ring for cuts, cracks, tears or damage. Replace as needed.
11. Apply a light film of clean engine oil to the CMP sensor O-ring.
12. Install the CMP sensor.

    Install the CMP sensor bolt.

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

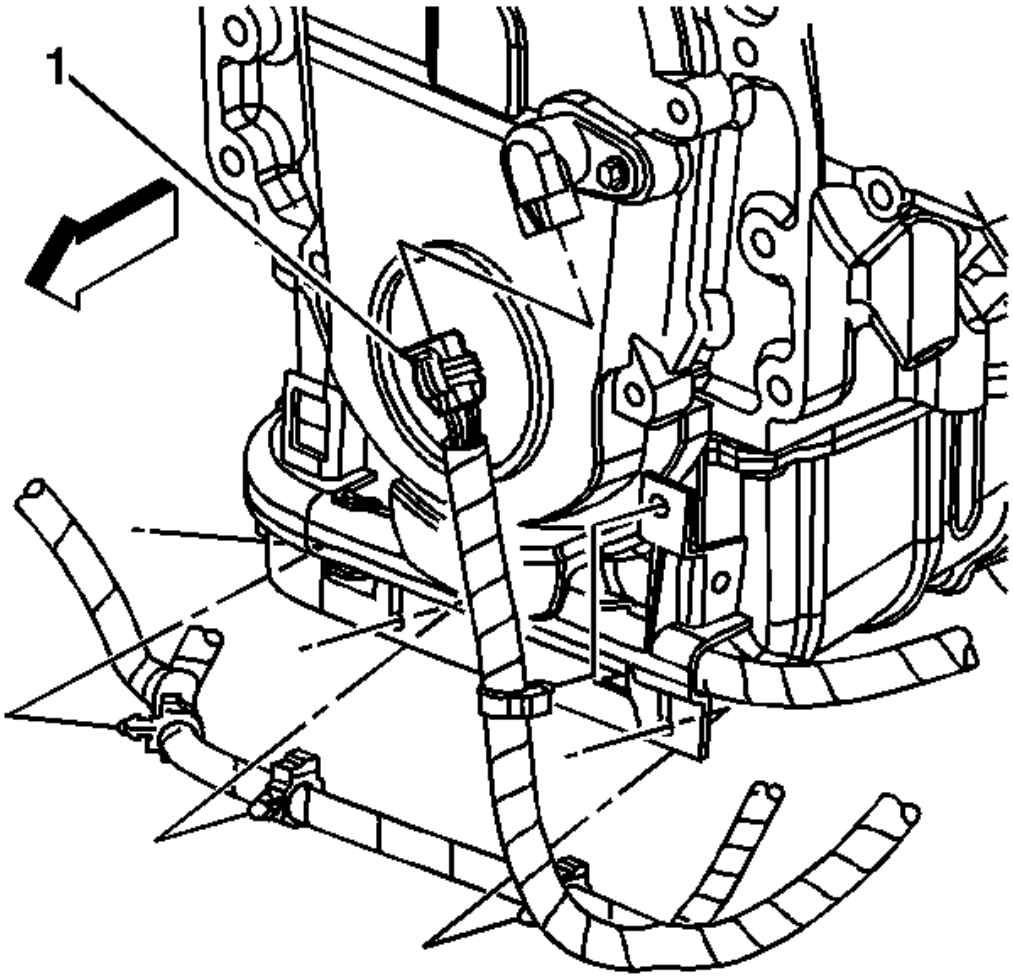

Fig. 158: View Of Camshaft Position (CMP) Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

13. Install the engine harness clips to the battery cable channel.
14. Connect the CMP sensor electrical connector (1).
15. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
16. Install the water pump. Refer to **Water Pump Replacement (8.1L Engine)** in Engine Cooling.

Timing Chain and Sprockets Replacement

Tools Required

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- **J 22102** Crankshaft Sprocket Installer
- **J 42846** Crankshaft Protector Button. See **Special Tools and Equipment**.

Removal Procedure

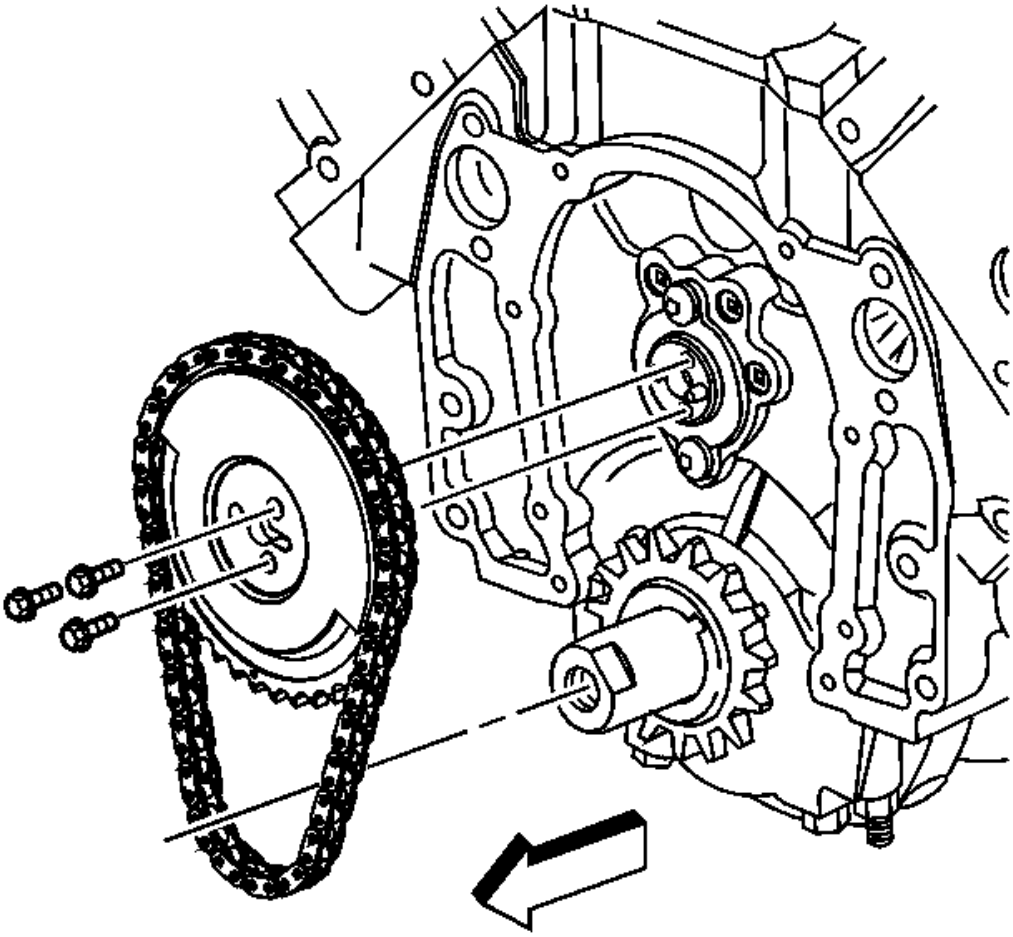

Fig. 159: View Of Camshaft Sprocket, Timing Chain & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
2. Aligned the timing marks on the camshaft and crankshaft sprockets.
3. Remove the camshaft sprocket bolts.
4. Remove the camshaft sprocket and timing chain.

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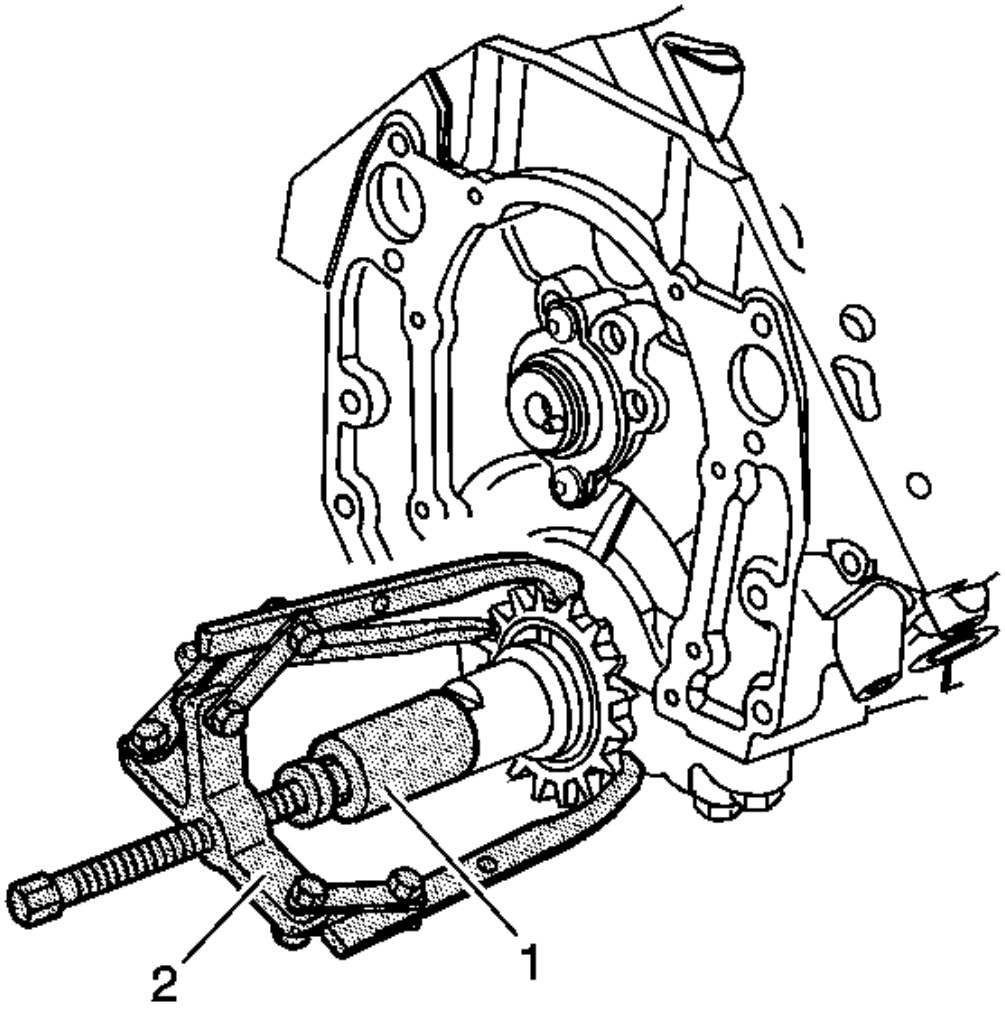

Fig. 160: Removing Crankshaft Sprocket Using J 42846
Courtesy of GENERAL MOTORS CORP.

5. Install the **J 42846** (1) into the end of the crankshaft. See **Special Tools and Equipment**.
6. Remove the crankshaft sprocket using a suitable three jaw puller.
7. Clean and inspect the timing chain and sprockets. Refer to **Timing Chain and Sprockets Cleaning and Inspection**.

Installation Procedure

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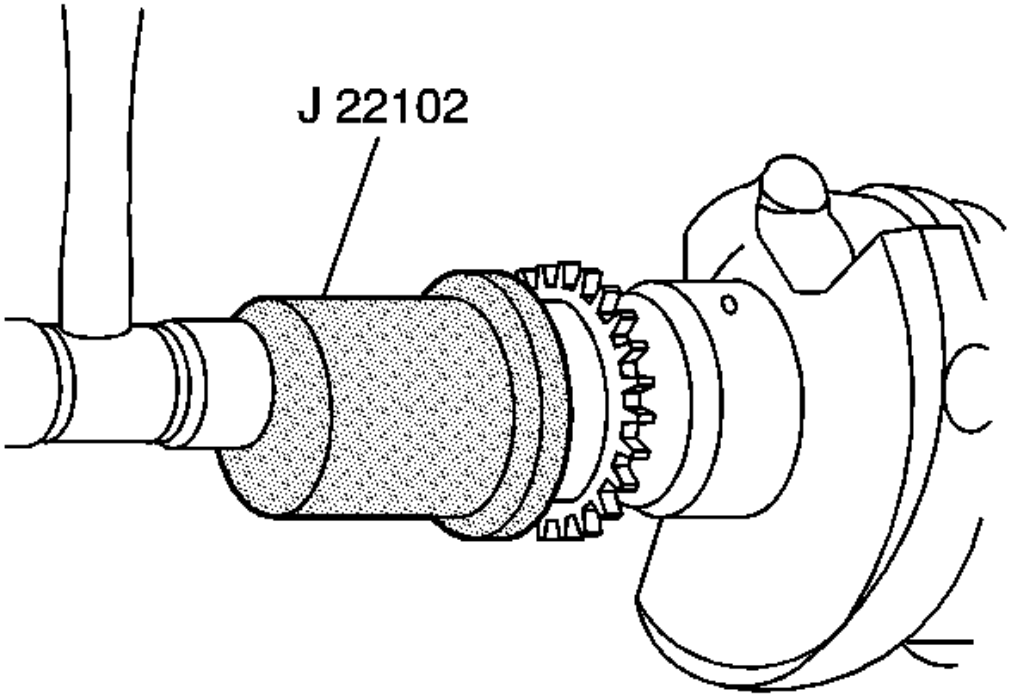

Fig. 161: Installing Crankshaft Sprocket Using J 22102
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 22102** in order to install the crankshaft sprocket.

   Align the keyway of the crankshaft sprocket with the crankshaft pin.

2. Remove the **J 22102** .
3. Rotate the crankshaft until the crankshaft sprocket alignment mark is in the 12 o'clock position.

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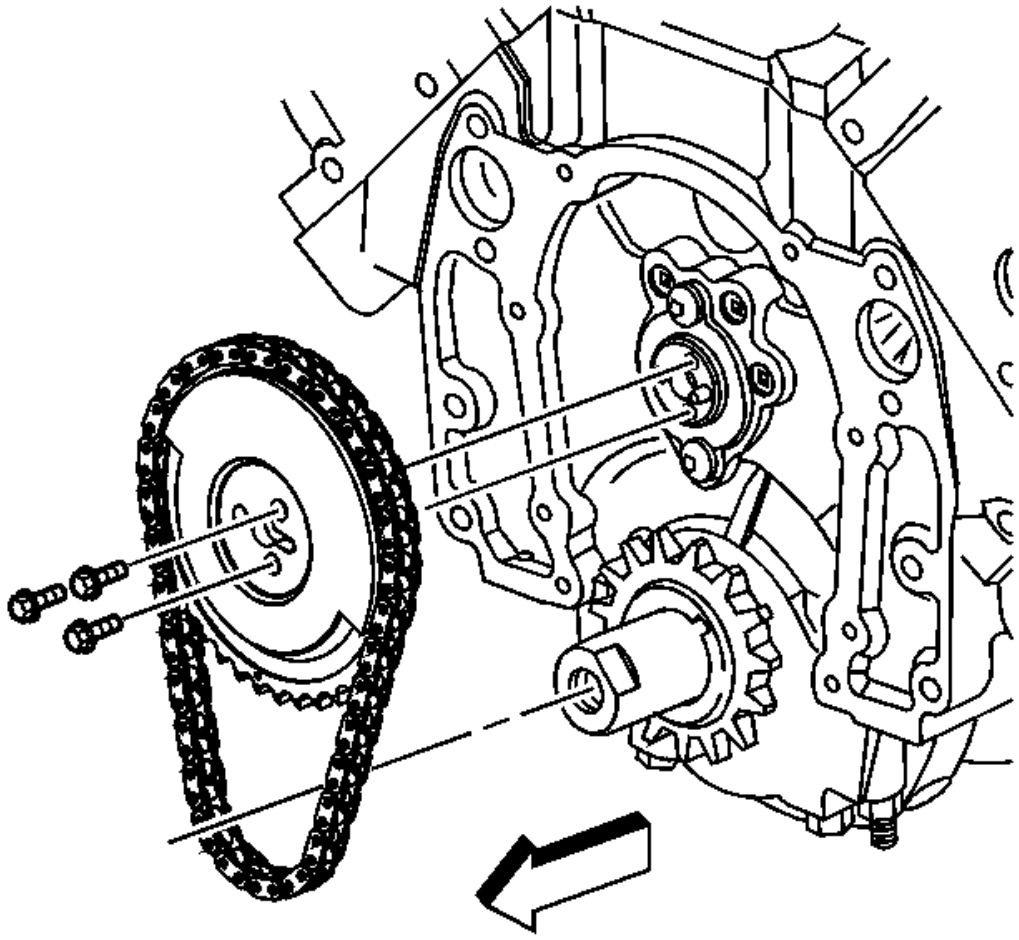

Fig. 162: View Of Camshaft Sprocket, Timing Chain & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Install the camshaft sprocket with the alignment mark in the 6 o'clock position.**
- **The sprocket teeth must mesh with the timing chain in order to prevent damage to the camshaft retainer.**
- **Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may damage the camshaft.**

4. Install the camshaft sprocket and timing chain.

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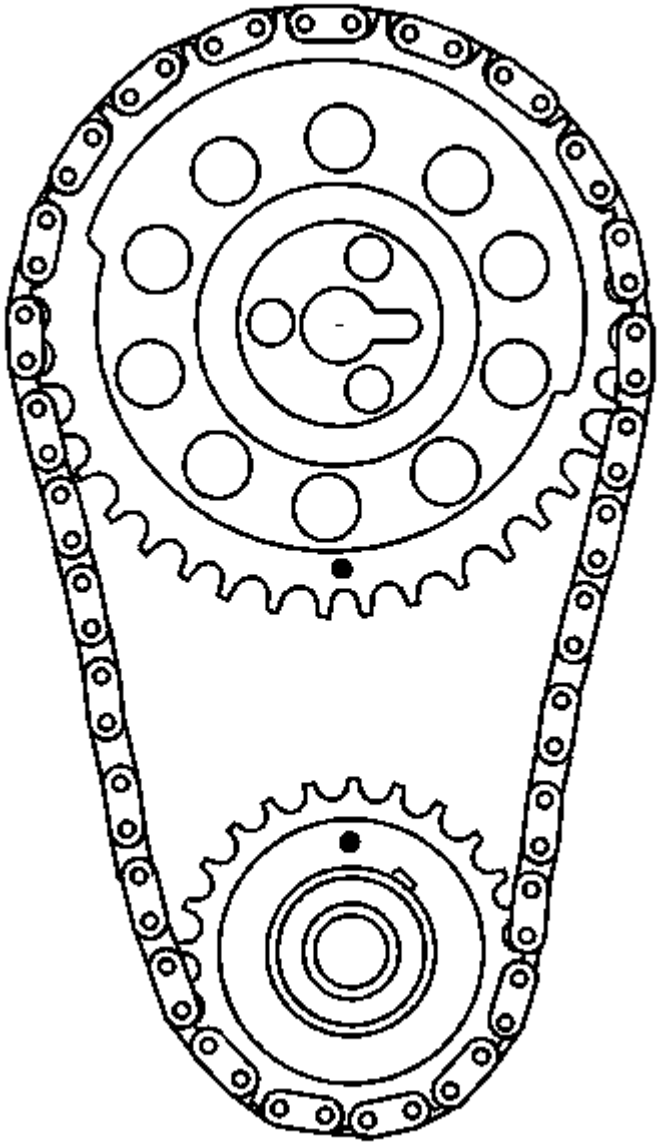

Fig. 163: Ensuring Crankshaft Sprocket & Camshaft Sprocket Alignment
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

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6. Install the camshaft sprocket bolts.

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

7. Install the engine front cover. Refer to **Engine Front Cover Replacement**.

Oil Pump Drive Replacement

Removal Procedure

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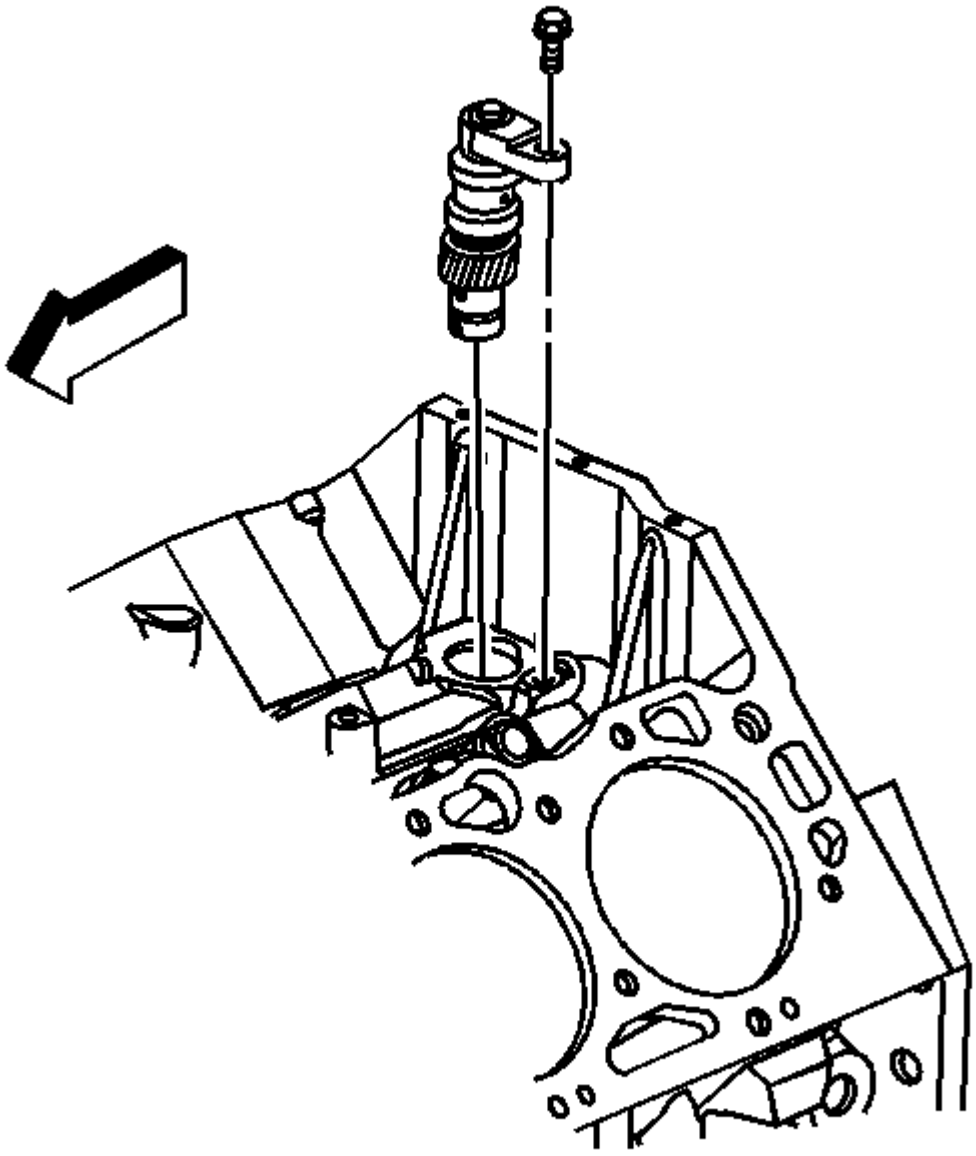

Fig. 164: View Of Oil Pump Drive & Bolt
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
2. Remove the oil pump drive bolt.
3. Remove the oil pump drive.

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4. Clean and inspect the oil pump drive. Refer to **Oil Pump Drive Cleaning and Inspection**.

Installation Procedure

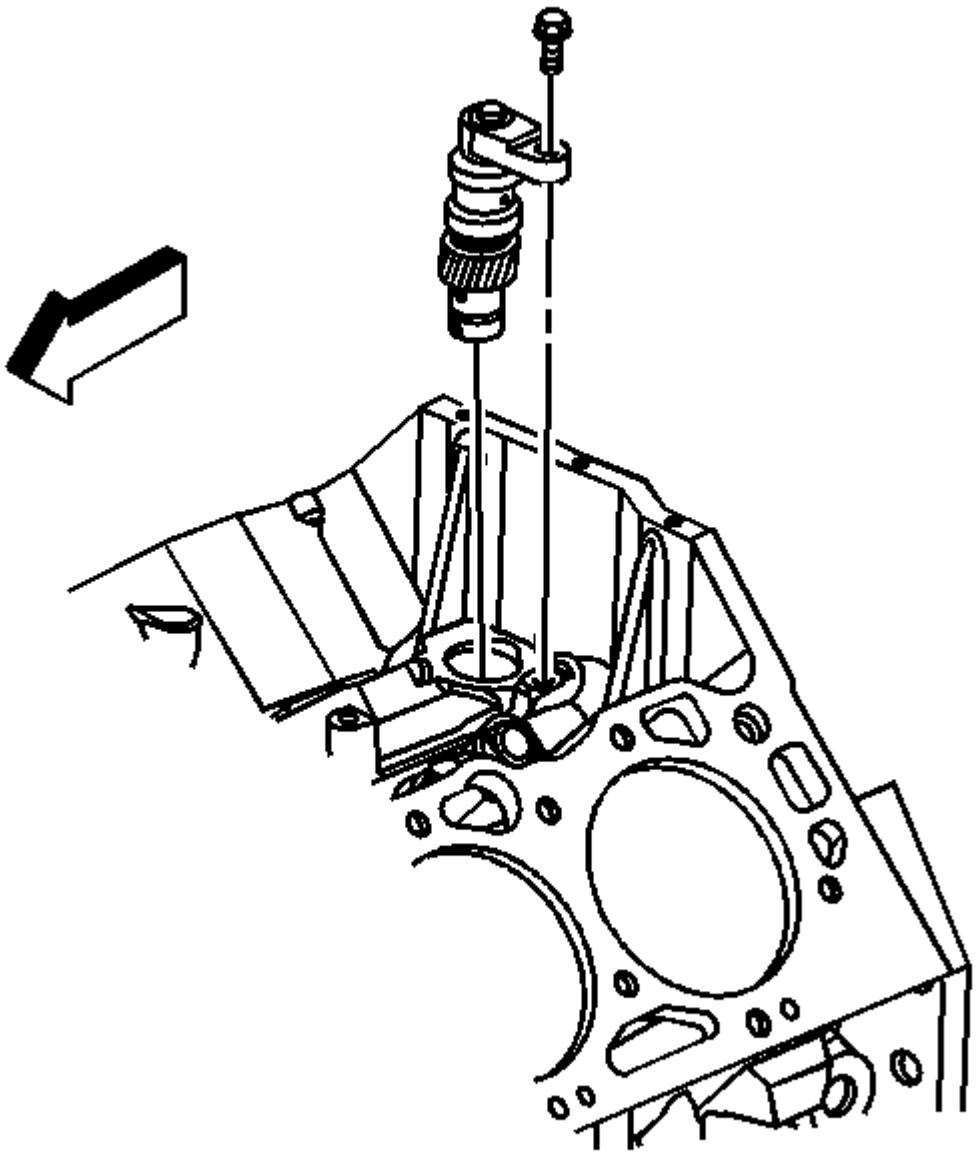

Fig. 165: View Of Oil Pump Drive & Bolt
Courtesy of GENERAL MOTORS CORP.

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1. Apply grease to the oil pump drive gear for ease of assembly.

IMPORTANT: Correct alignment of the oil pump drive and oil pump driveshaft is critical. Make sure both components mate correctly, or engine damage may occur.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Line up the oil pump drive, making sure that the oil pump is fully seated in the engine block.
3. Install the oil pump drive bolt, making sure that the oil pump drive is fully seated in the engine block.

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

4. Install the intake manifold. Refer to **Intake Manifold Replacement**.

Camshaft Replacement

Removal Procedure

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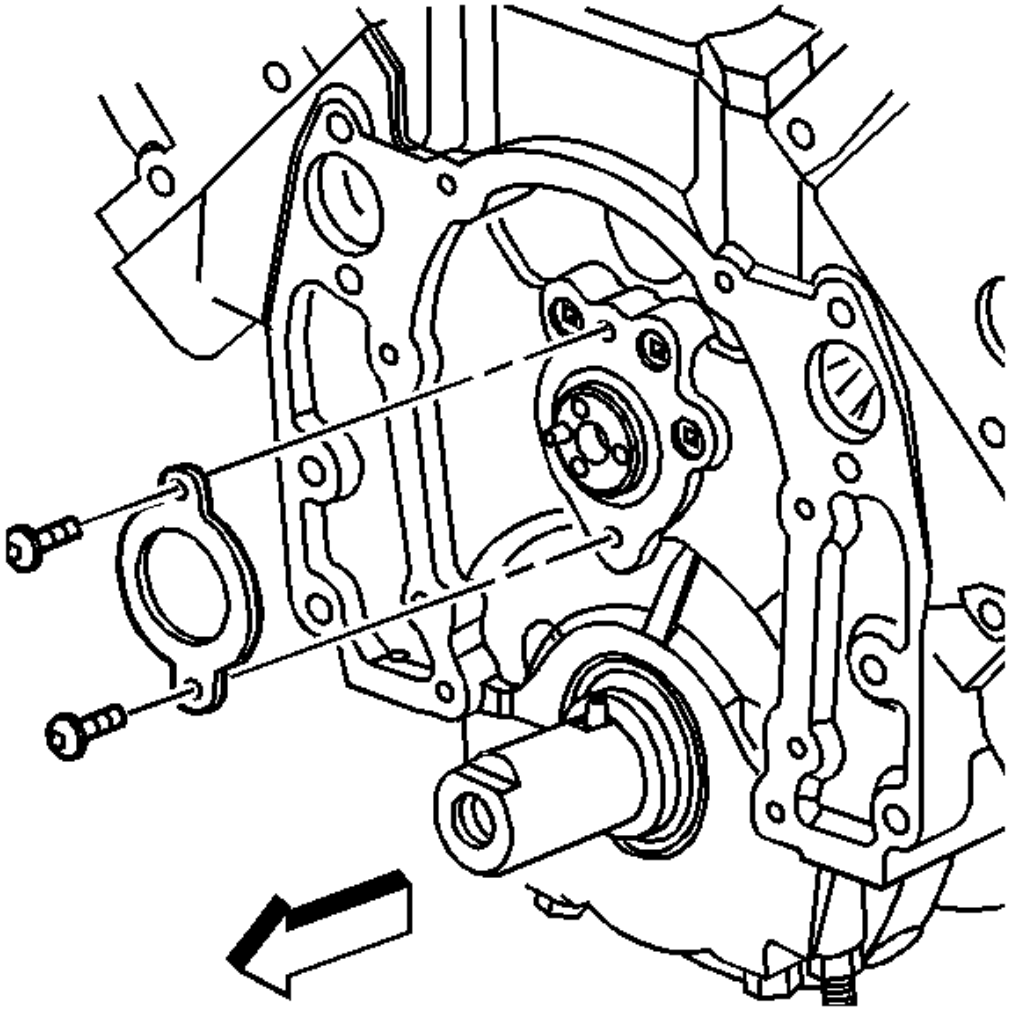

Fig. 166: View Of Camshaft Retainer
Courtesy of GENERAL MOTORS CORP.

1. Remove the grille. Refer to **Grille Replacement (Cadillac)** or **Grille Replacement (Avalanche)** or **Grille Replacement (Chevrolet)** or **Grille Replacement (GMC)** in Exterior Trim.
2. Remove the air conditioning (A/C) condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.
3. Remove the valve lifters. Refer to **Valve Lifter Replacement**.
4. Remove the timing chain and sprocket. Refer to **Timing Chain and Sprockets Replacement**.
5. Remove the camshaft retainer bolts.
6. Remove the camshaft retainer.

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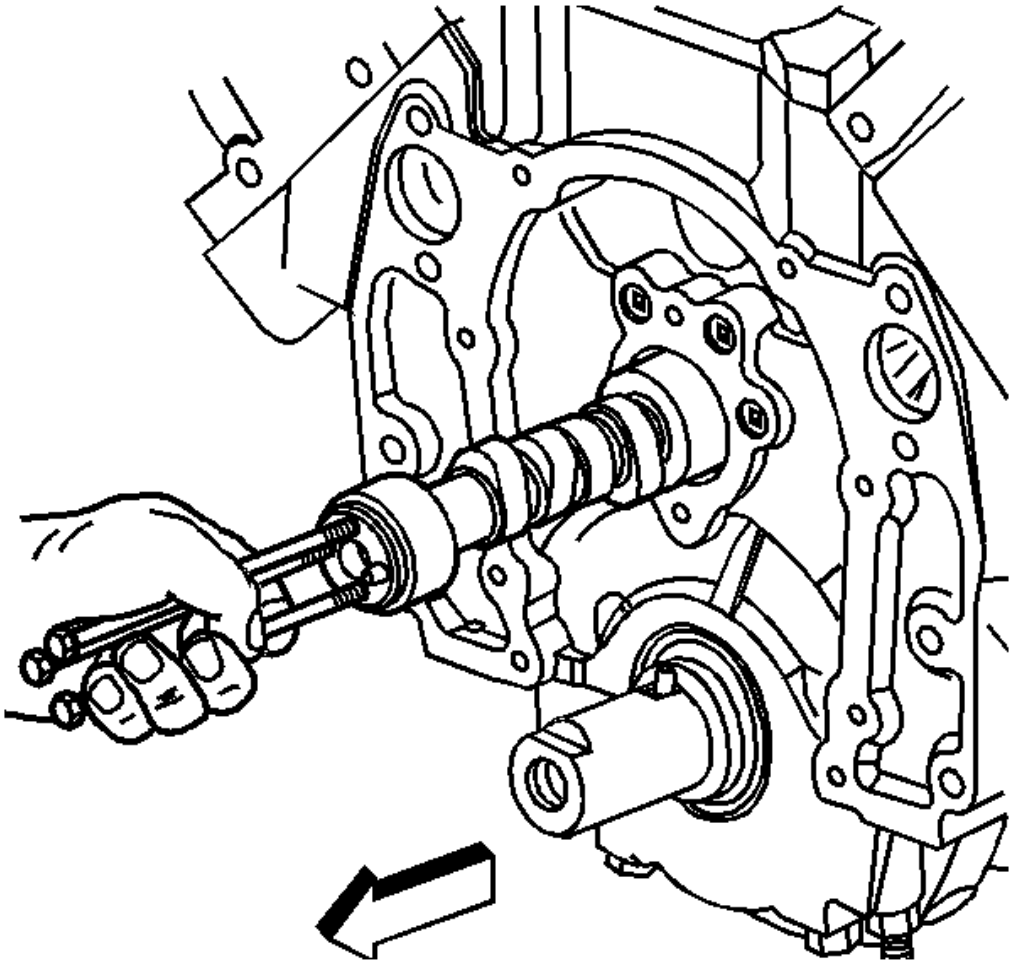

Fig. 167: View Of Bolts In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

7. Install three 8 - 1.25 x 100 mm bolts into the camshaft front bolt holes.
8. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
9. Remove the bolts from the front of the camshaft.
10. Clean and inspect the camshaft. Refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

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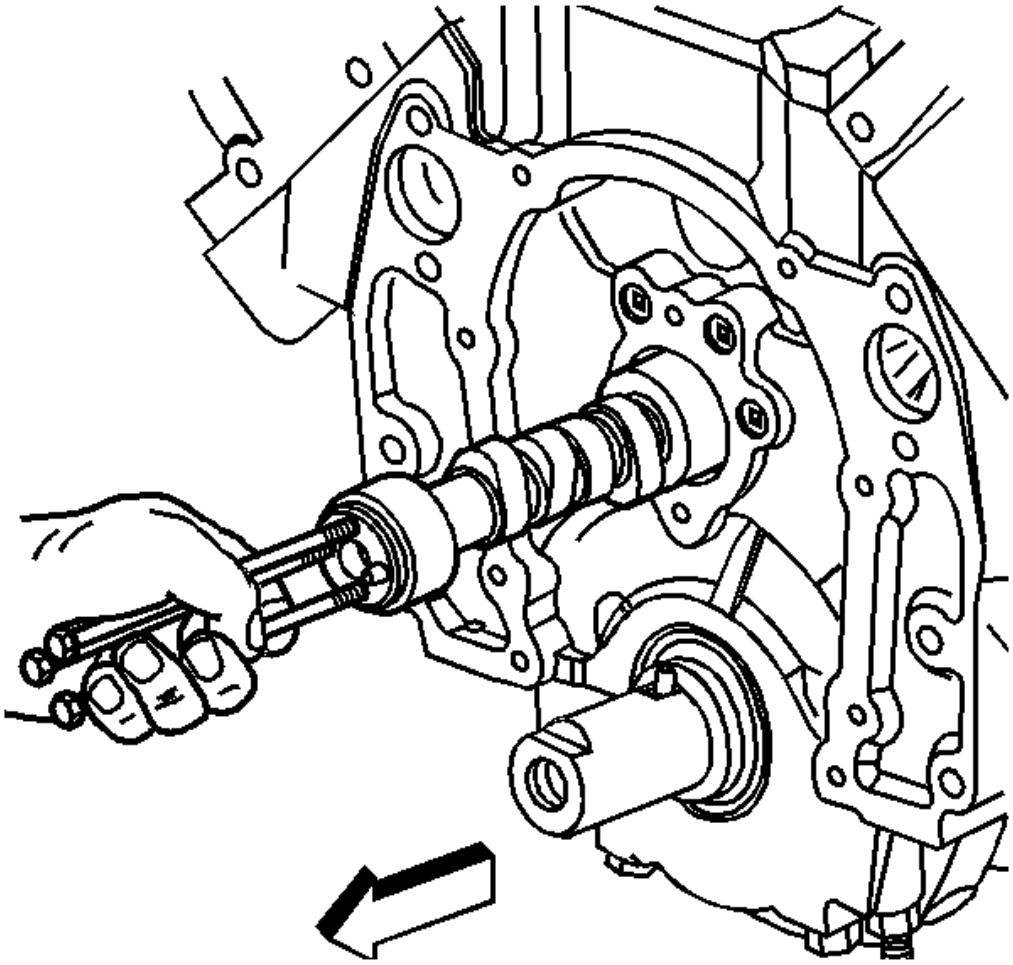

Fig. 168: View Of Bolts In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Apply lubricant GM P/N 12345501 (Canadian P/N 992704), or equivalent to the following components:
   - The camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

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

2. Install three 8 - 1.25 x 100 mm bolts into the camshaft threaded bolt holes.

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3. Using the bolts as a handle, carefully install the camshaft.
4. Remove the bolts from the front of the camshaft.

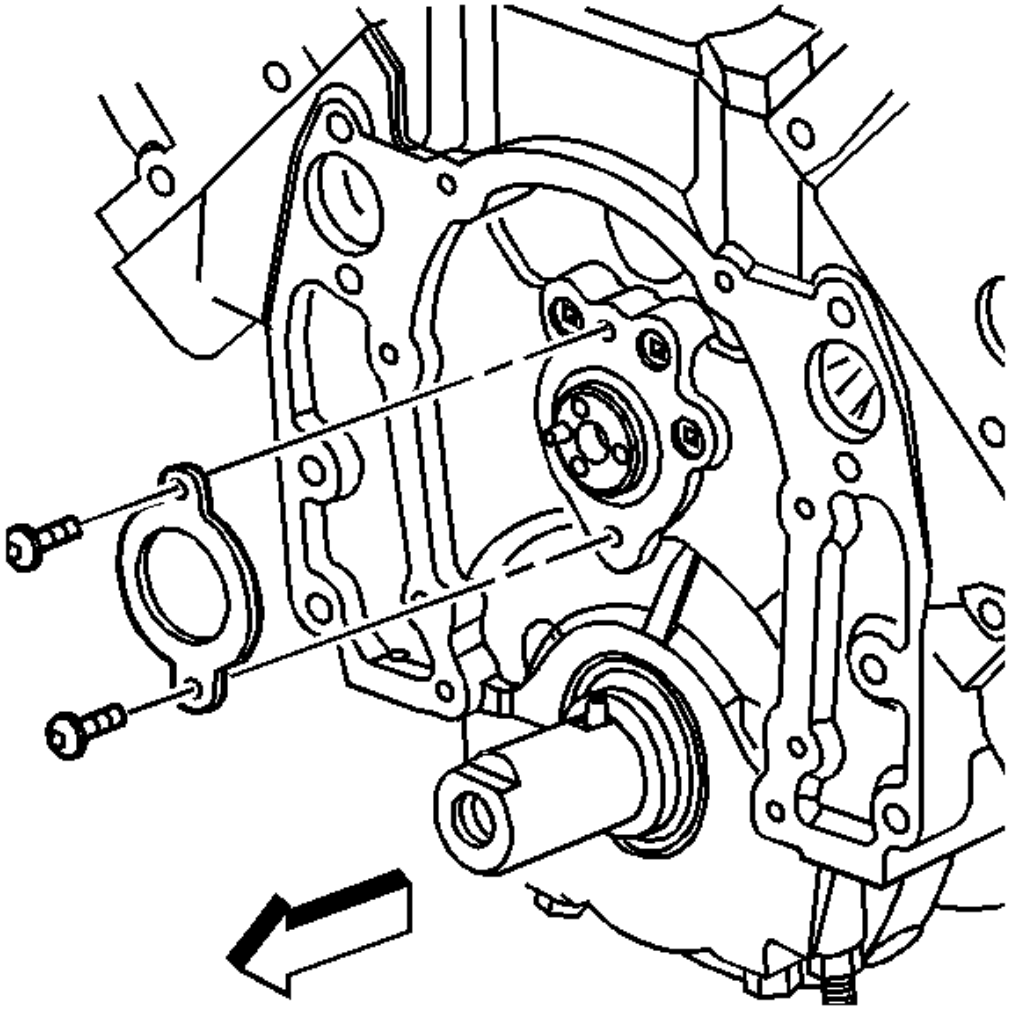

Fig. 169: View Of Camshaft Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the camshaft retainer and bolts.

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

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6. Install the timing chain and sprocket. Refer to **Timing Chain and Sprockets Replacement**.
7. Install the valve lifters. Refer to **Valve Lifter Replacement**.
8. Install the A/C condenser. Refer to **Condenser Replacement** in Heating, Ventilation and Air Conditioning.
9. Install the grille. Refer to **Grille Replacement (Cadillac)** or **Grille Replacement (Avalanche)** or **Grille Replacement (Chevrolet)** or **Grille Replacement (GMC)** in Exterior Trim.

Oil Filter Adapter and Bypass Valve Assembly Replacement

Removal Procedure

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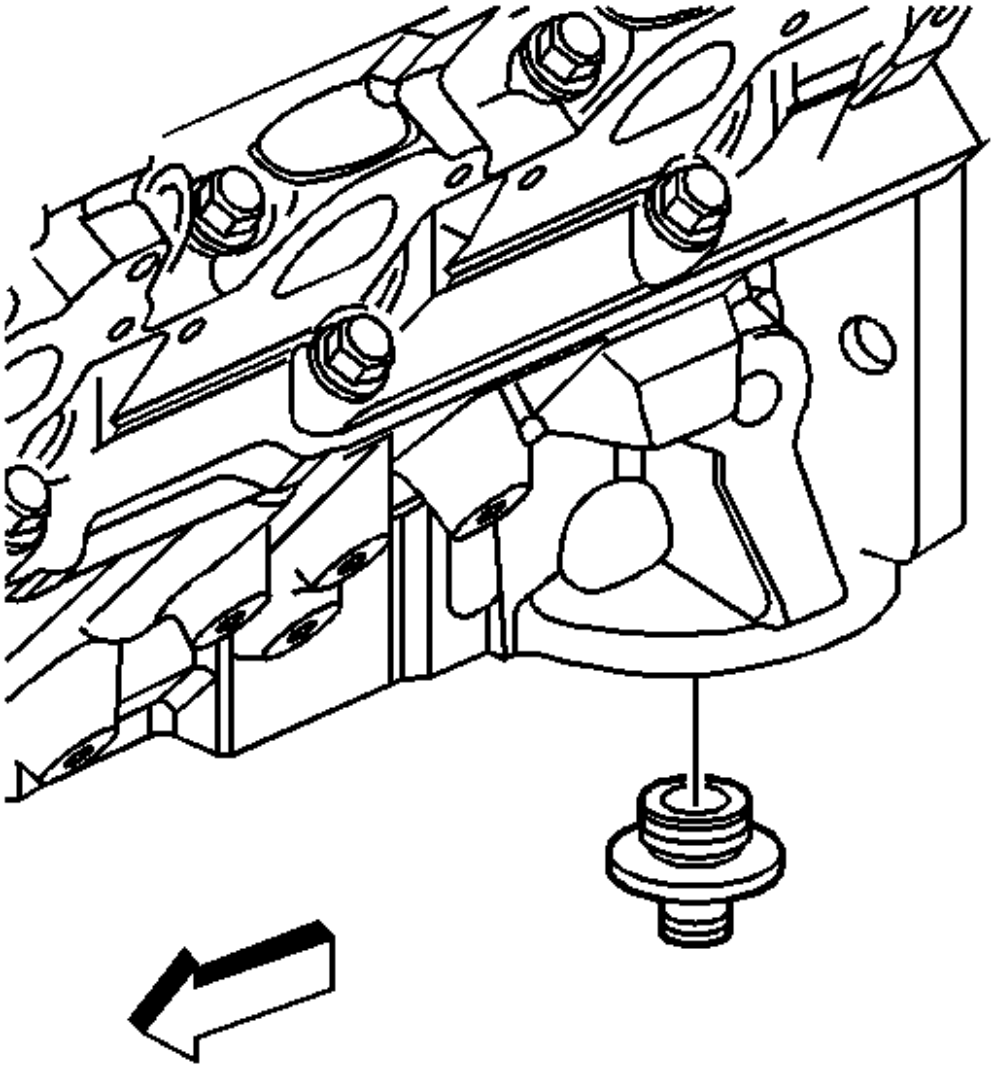

Fig. 170: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

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

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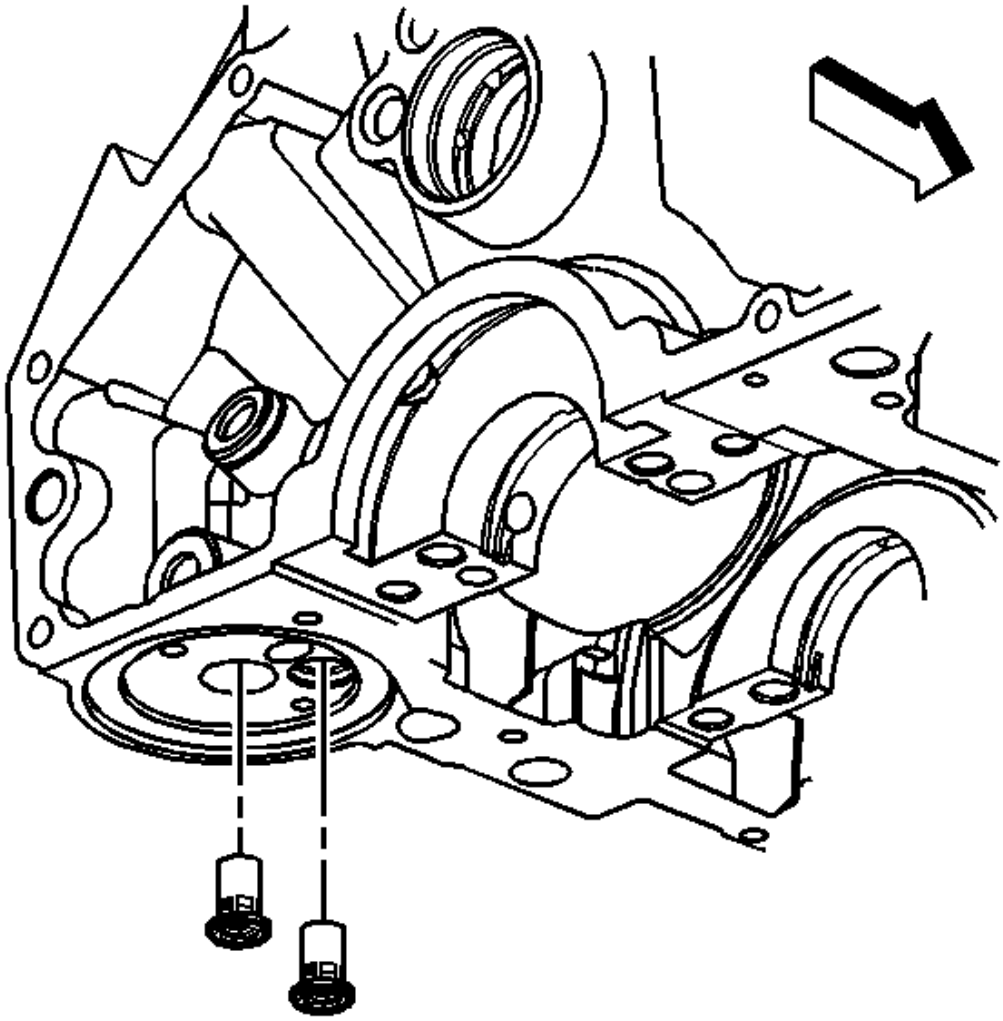

Fig. 171: View Of Oil Filter Bypass Valves
Courtesy of GENERAL MOTORS CORP.

3. Remove the oil filter bypass valves.

   Unstake the tangs on the oil bypass valves and remove with long-nose pliers.

4. Discard the oil bypass valves.

Installation Procedure

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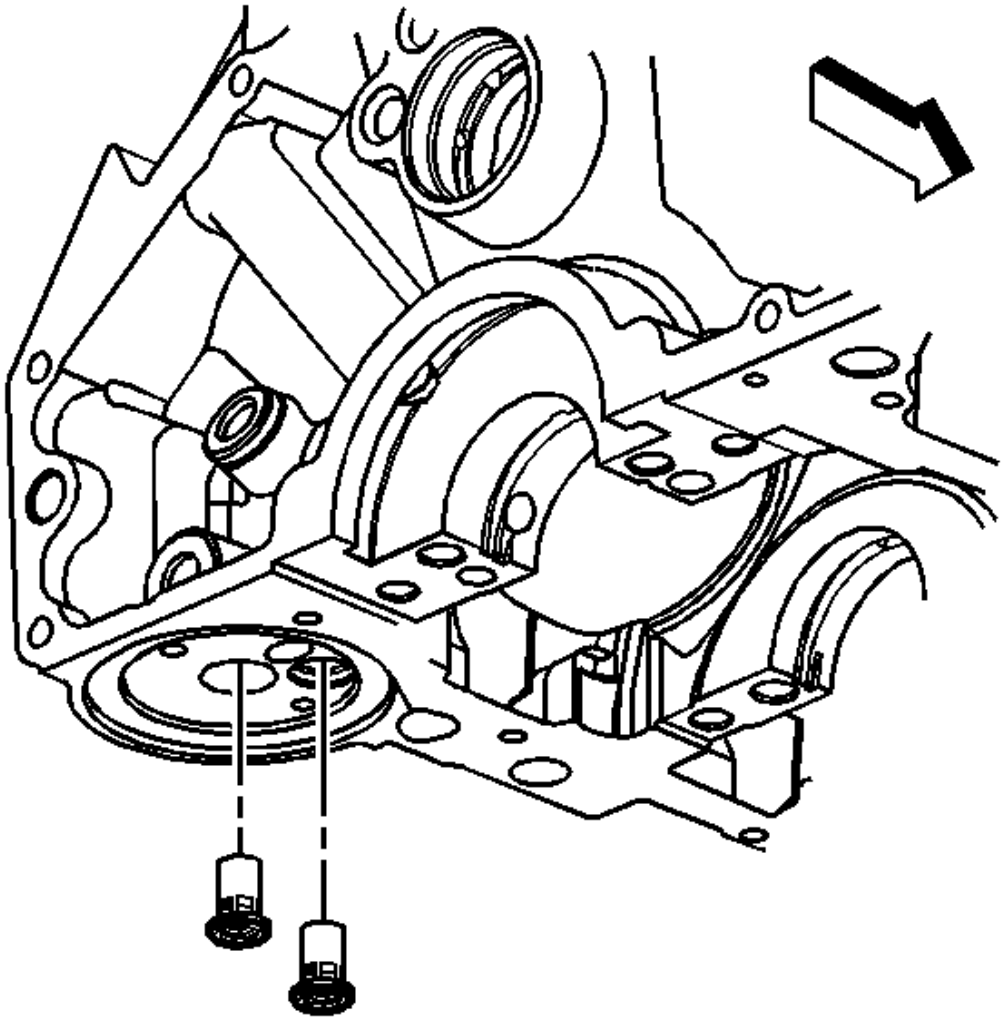

Fig. 172: View Of Oil Filter Bypass Valves
Courtesy of GENERAL MOTORS CORP.

1. Install NEW oil bypass valves. Stake the tangs on the oil bypass valves.

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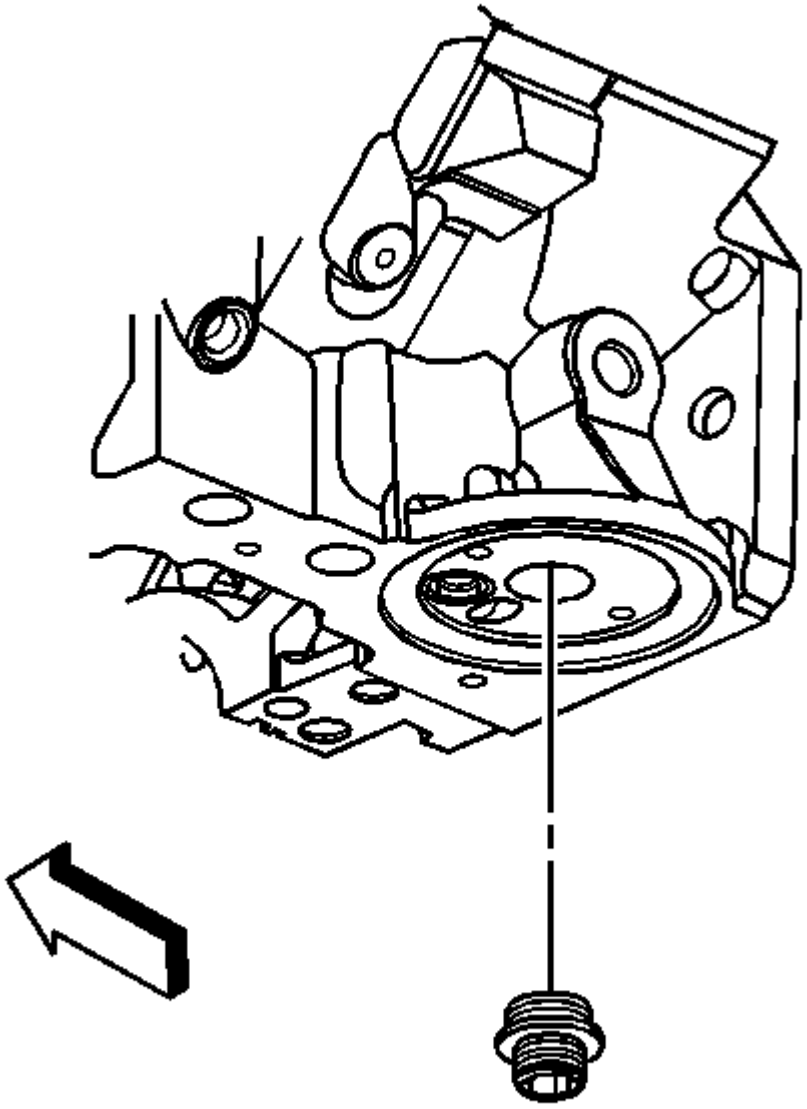

Fig. 173: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Inspect the oil filter fitting, replace as necessary.
3. Install the oil filter fitting.

Tighten: Tighten the fitting to 66 N.m (49 lb ft).

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

Oil Pan Replacement

Removal Procedure

IMPORTANT: Do not raise the engine by the crankshaft balancer to perform this service procedure. Damage to the crankshaft balancer or the crankshaft may occur.

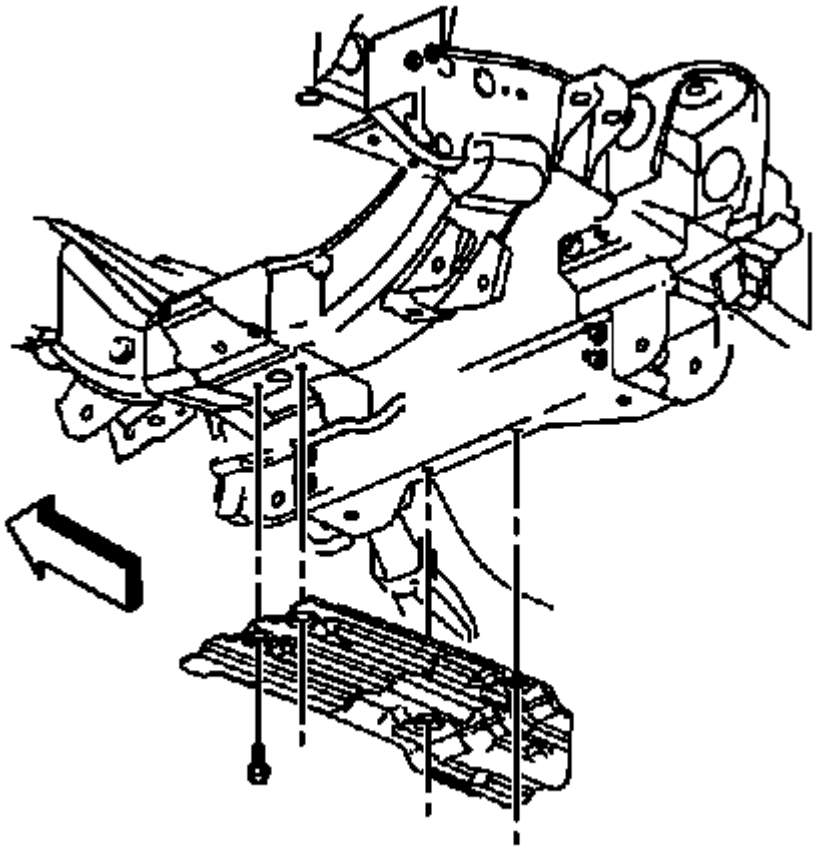

Fig. 174: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

1. Remove the front differential, if equipped with four wheel drive (4WD). Refer to **Differential Carrier Assembly Replacement** in Front Drive Axle.
2. Remove the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.
3. Remove the oil pan skid plate bolts.
4. Remove the oil pan skid plate.

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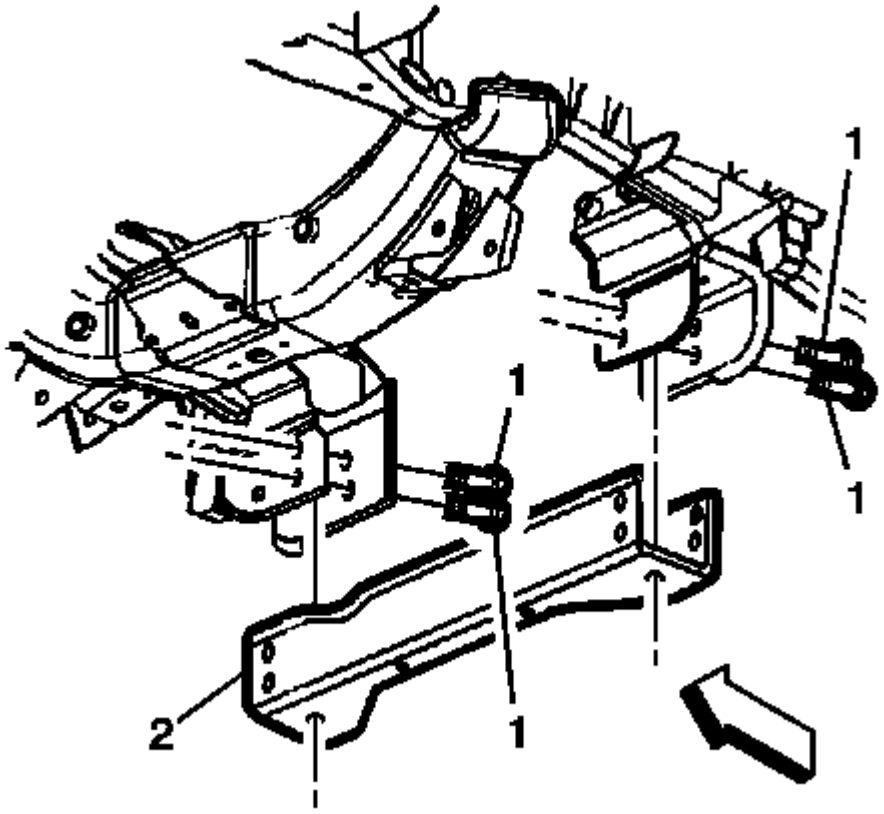

Fig. 175: View Of Crossbar Bolts & Bar (2WD)
Courtesy of GENERAL MOTORS CORP.

5. If equipped with two wheel drive (2WD), remove the crossbar bolts.
6. Remove the crossbar.

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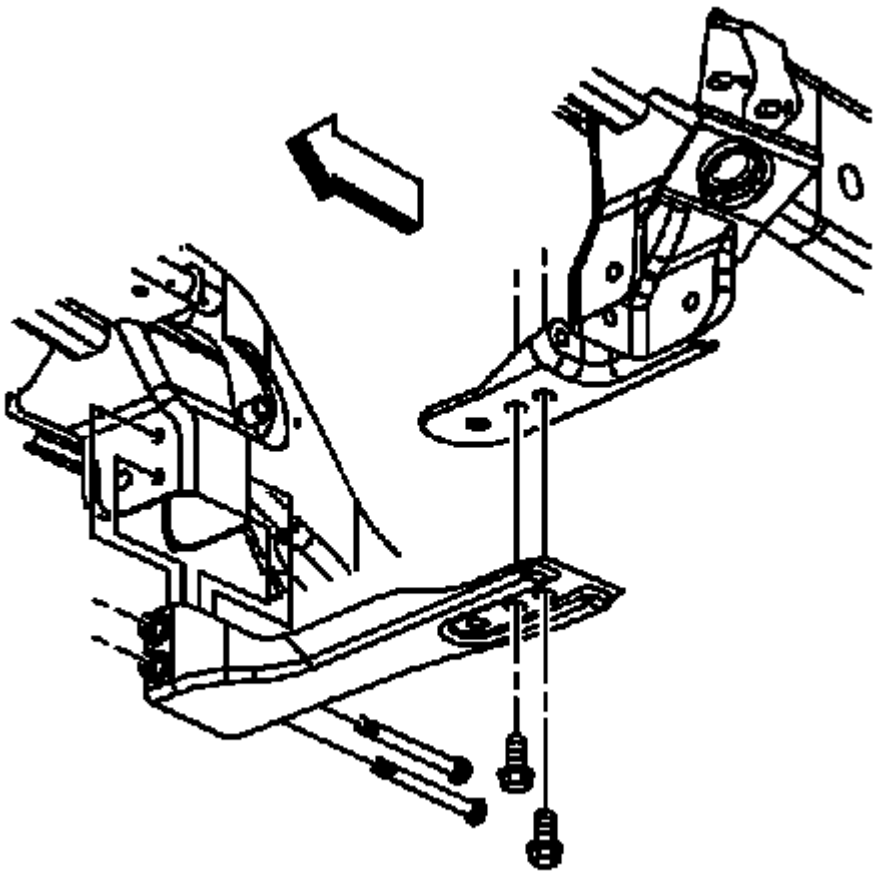

Fig. 176: View Of Crossmember Bolts & Bar (4WD Only)
Courtesy of GENERAL MOTORS CORP.

7. If equipped with 4WD, remove the crossbar bolts.
8. Remove the crossbar.

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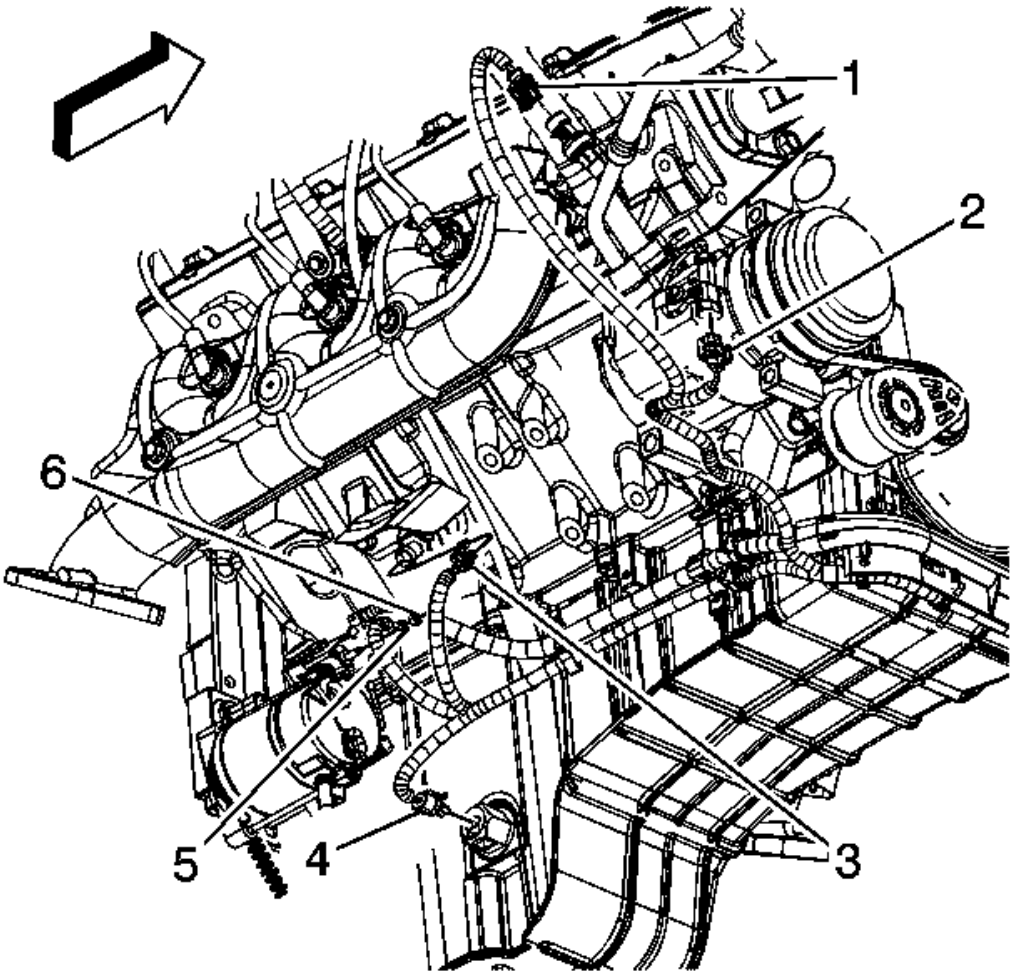

Fig. 177: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
10. Remove the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement**.
11. Disconnect the oil level sensor electrical connector (4).
12. Remove the engine harness clip from the oil pan.

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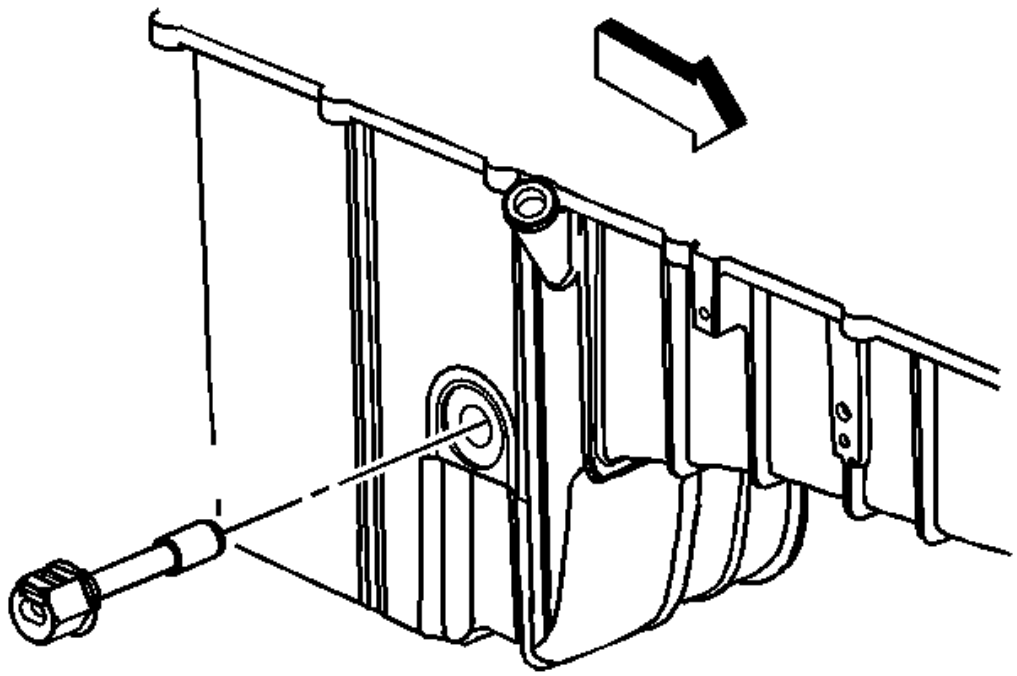

Fig. 178: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

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

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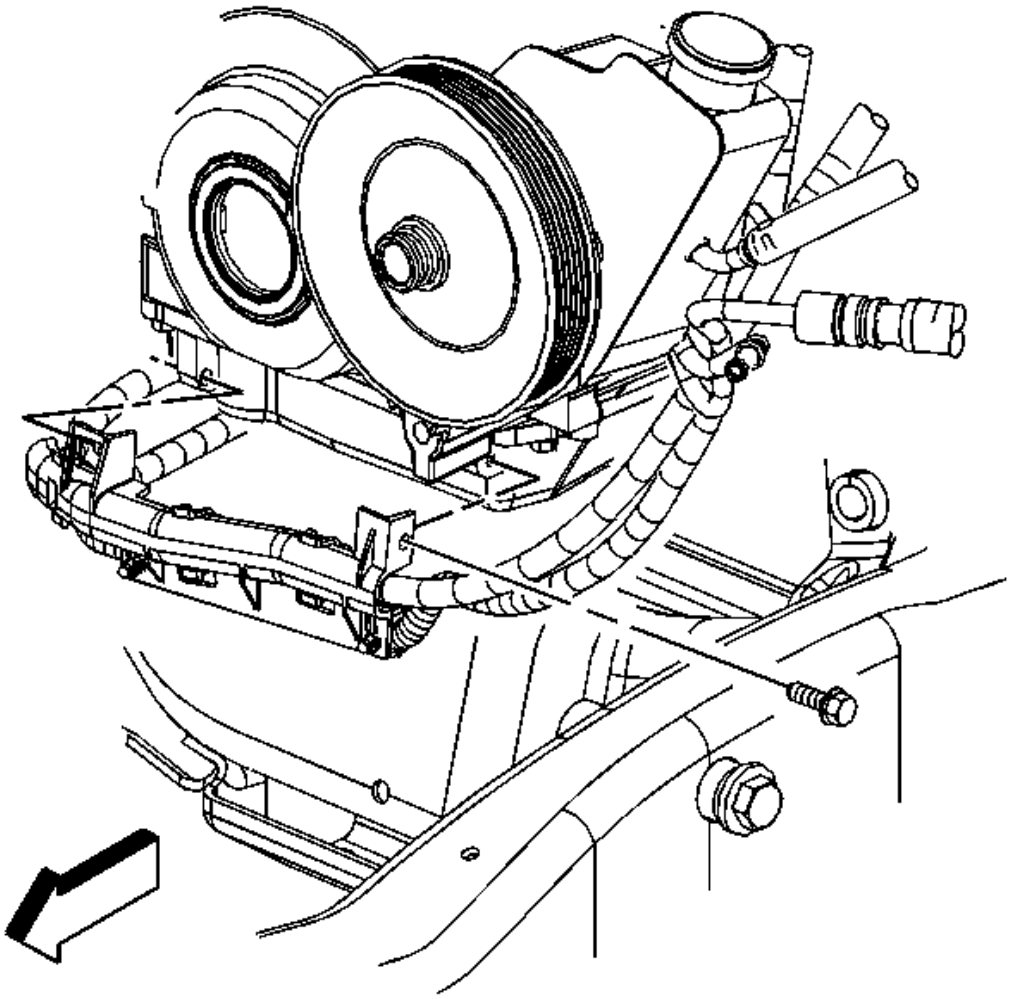

Fig. 179: View Of Battery Cable Channel Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the battery cable channel bolt.
15. Remove and reposition the battery cable channel.

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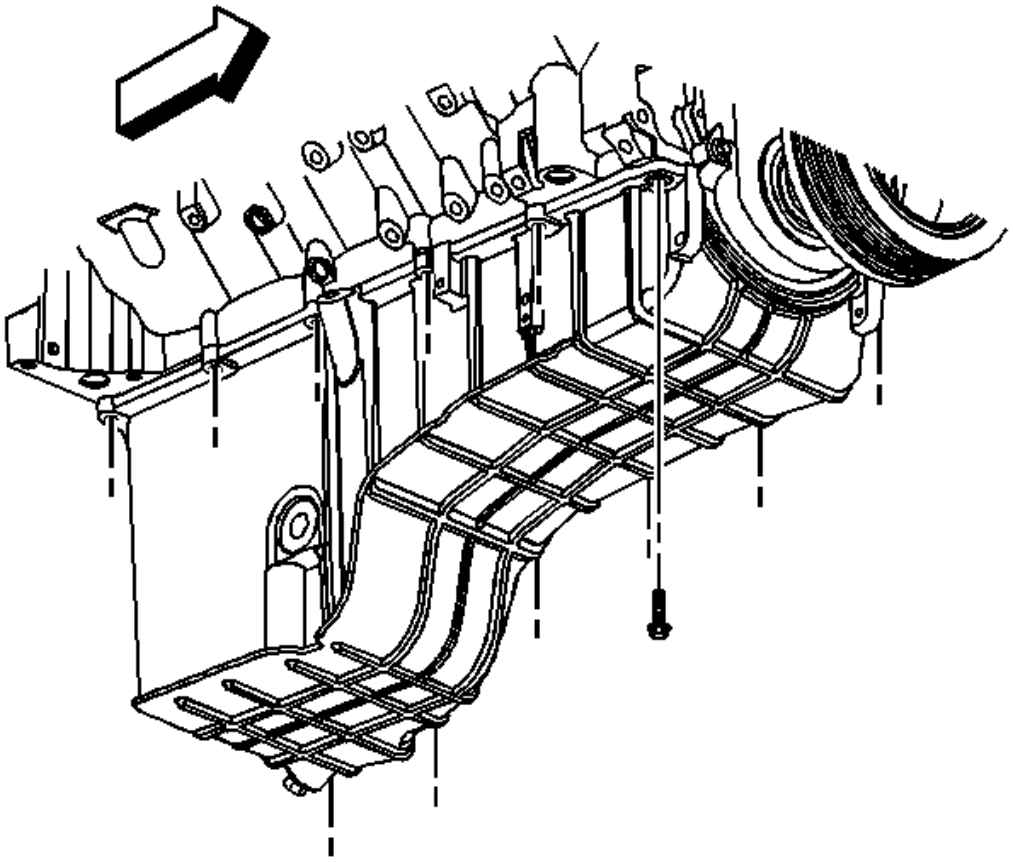

Fig. 180: View Of Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

16. Remove the oil pan bolts.

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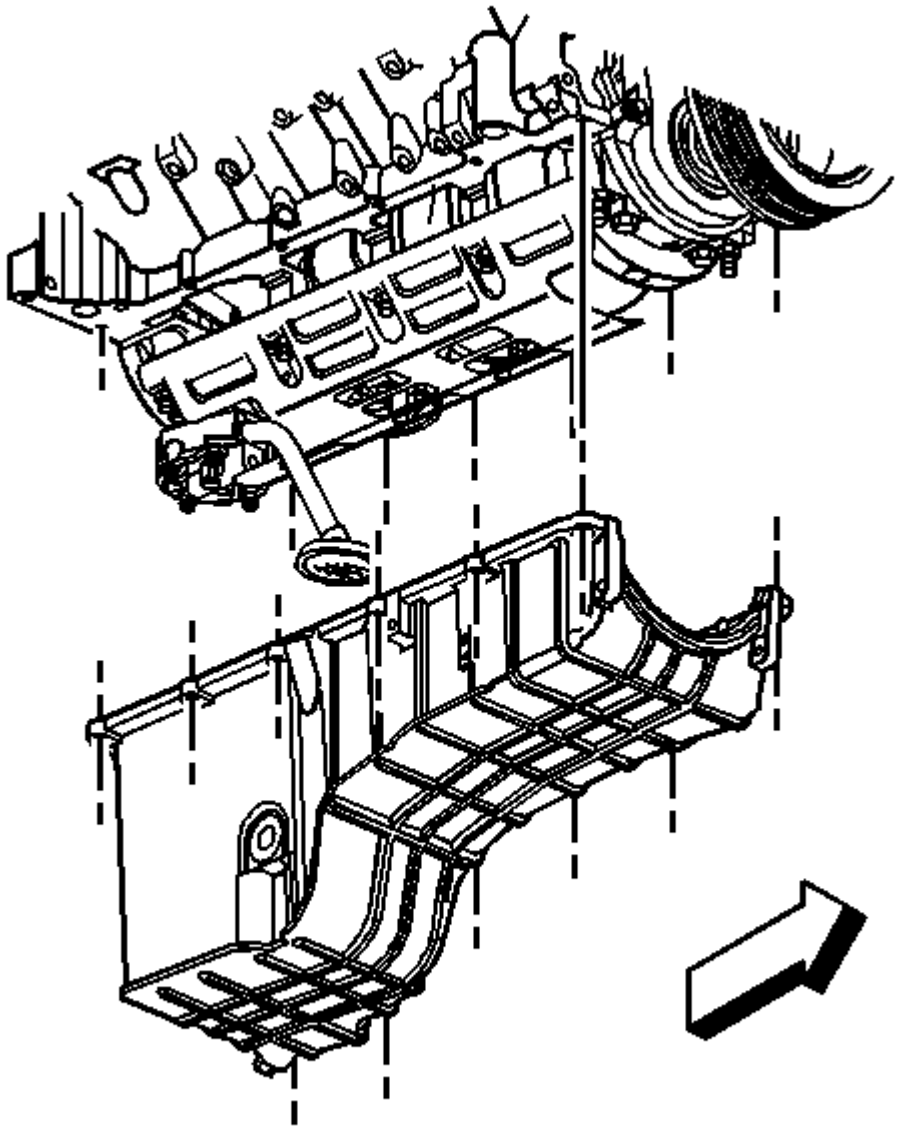

Fig. 181: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan gasket is reusable if not cut or damaged.

17. Remove the oil pan and gasket.

Installation Procedure

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IMPORTANT: The oil pan must be installed within 5 minutes of the sealer being applied or the sealer will begin to cure, causing an inadequate seal.

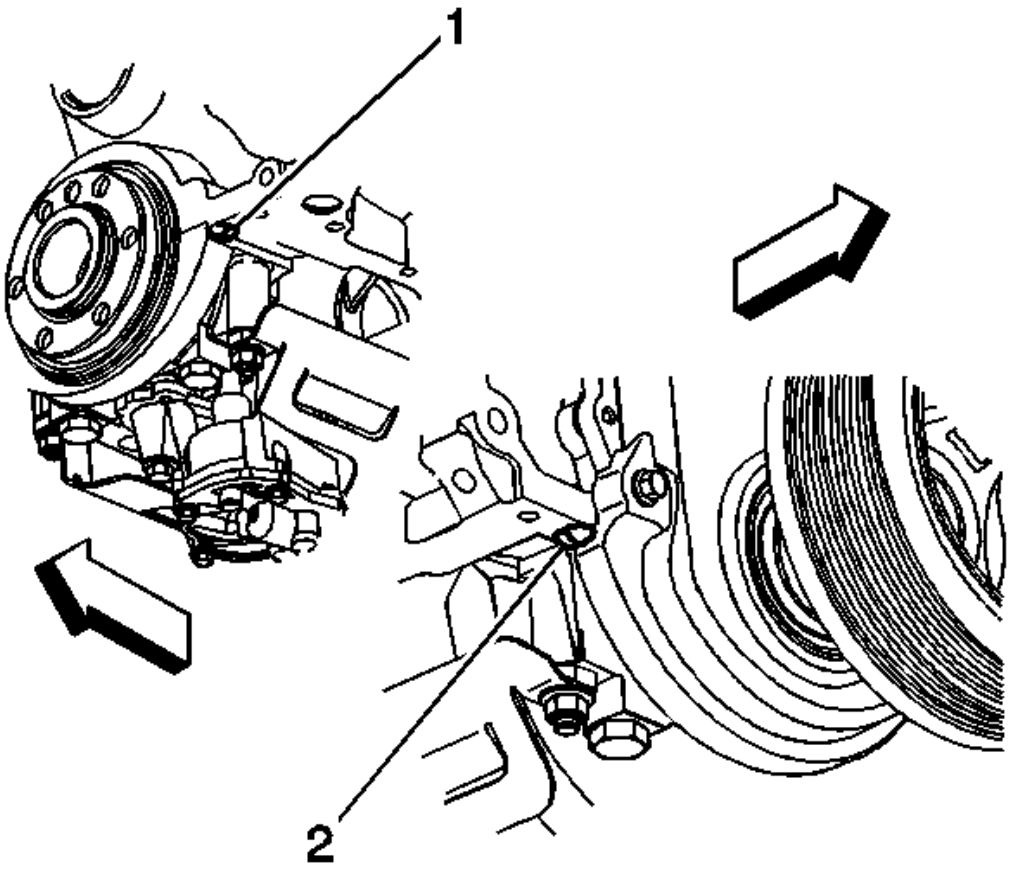

Fig. 182: Applying Sealant To Sides Of Front & Rear Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM 2346286 (Canadian P/N 10953472), or equivalent to the sides of the front (2) and rear (1) crankshaft bearing caps, on both the left and right sides (4 locations total).

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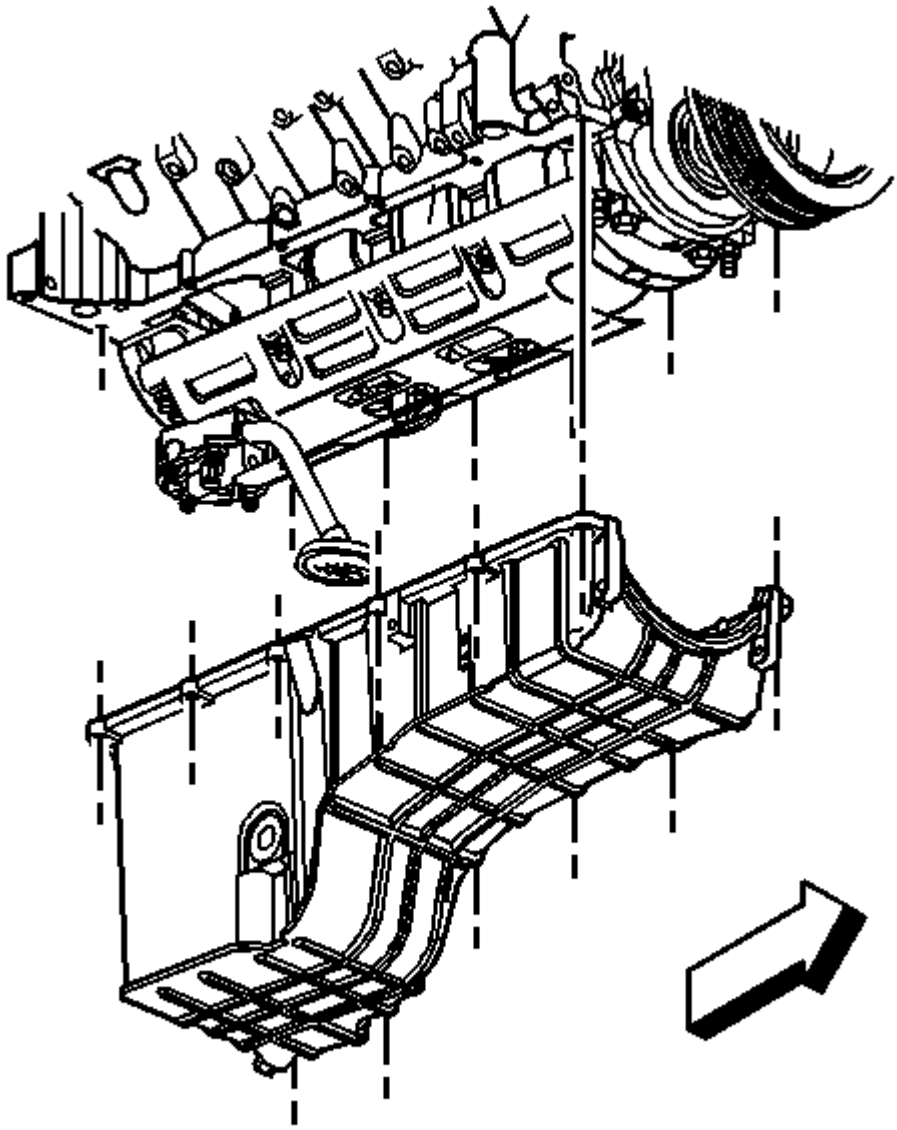

Fig. 183: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Install a NEW oil pan gasket into the oil pan groove, if required.
3. Install the oil pan.

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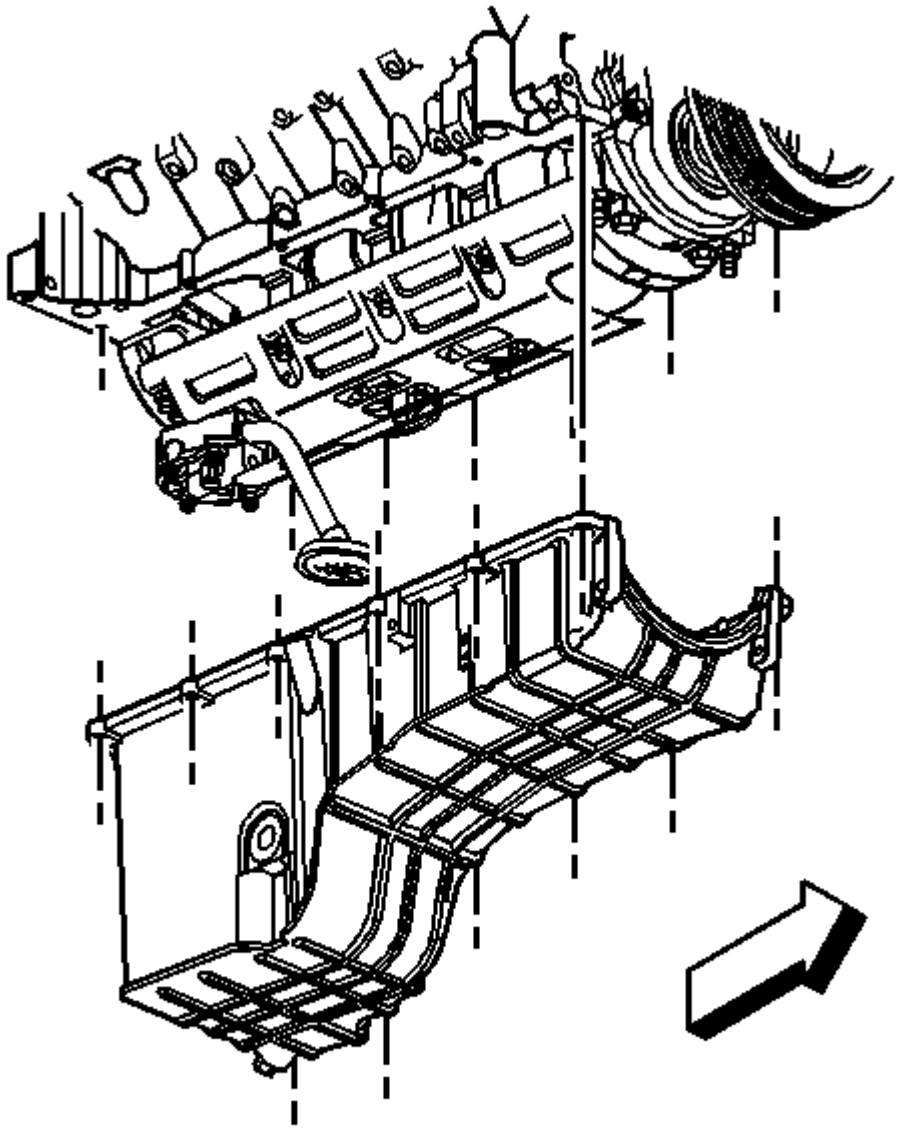

Fig. 184: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

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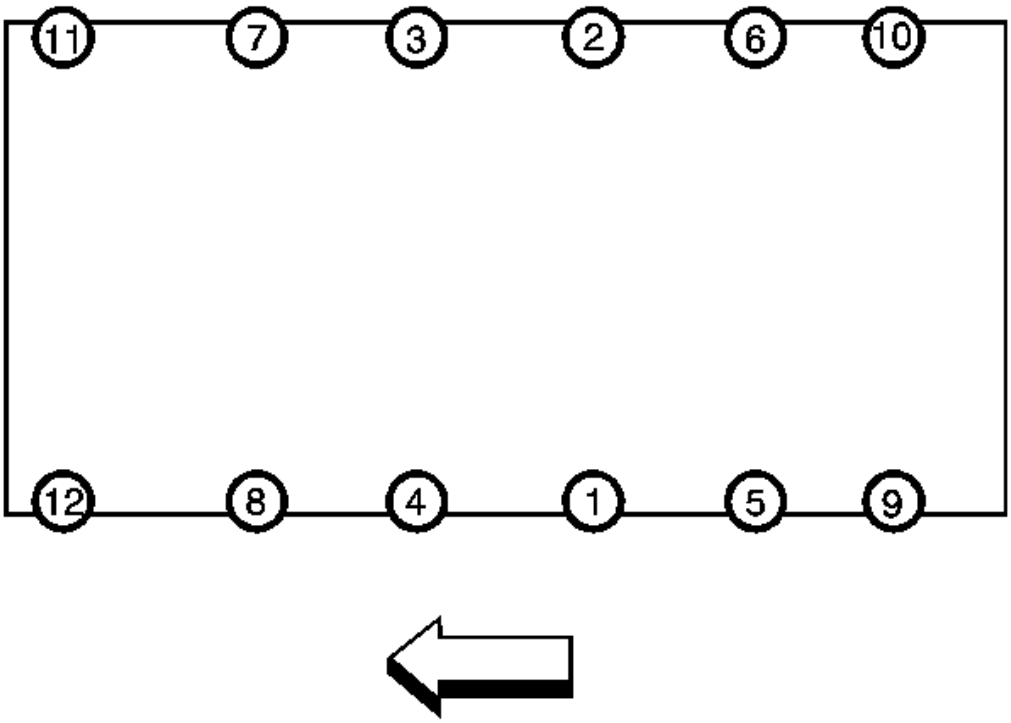

Fig. 185: View Of Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Tighten the oil pan bolts.

Tighten:

1. Tighten the bolts a first pass in sequence to 10 N.m (89 lb in).
2. Tighten the bolts a final pass in sequence to 25 N.m (18 lb ft).

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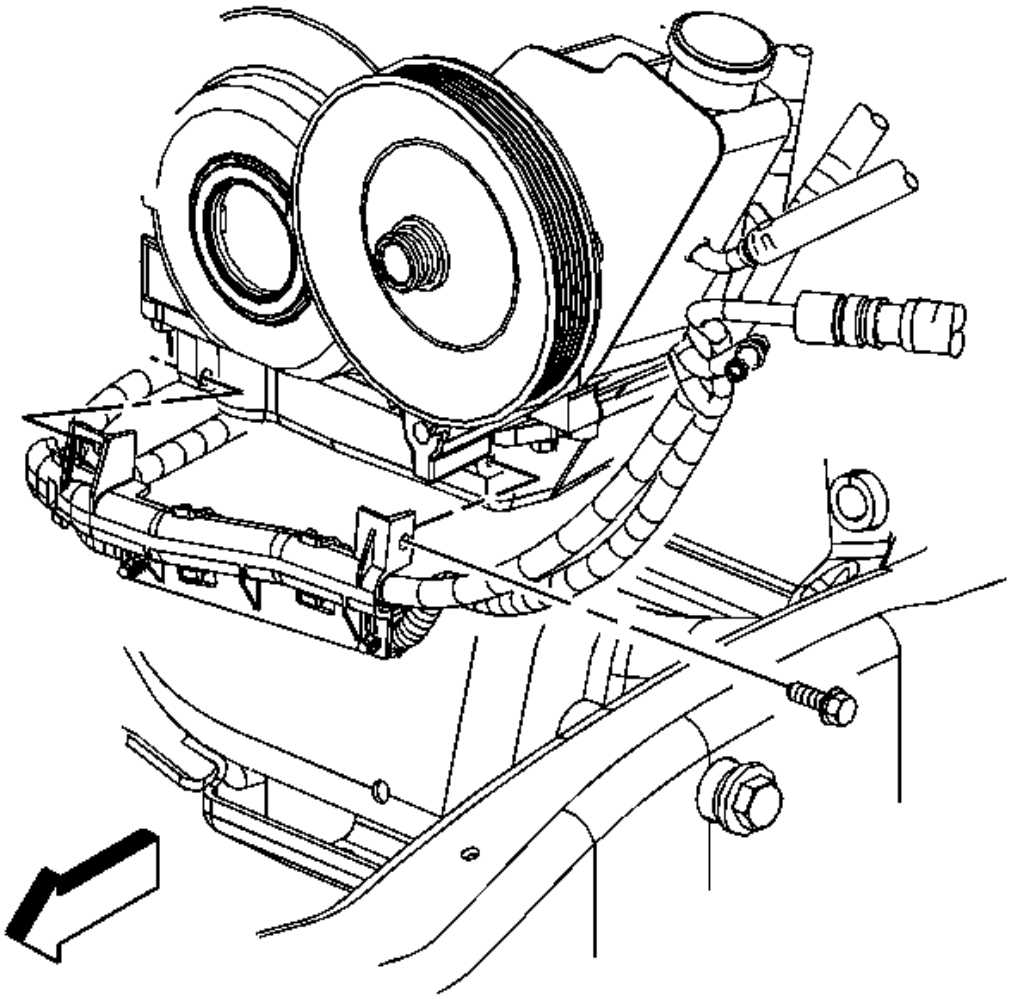

Fig. 186: View Of Battery Cable Channel Bolt
Courtesy of GENERAL MOTORS CORP.

6. Position the battery cable channel into place.
7. Install the battery cable channel bolt.

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

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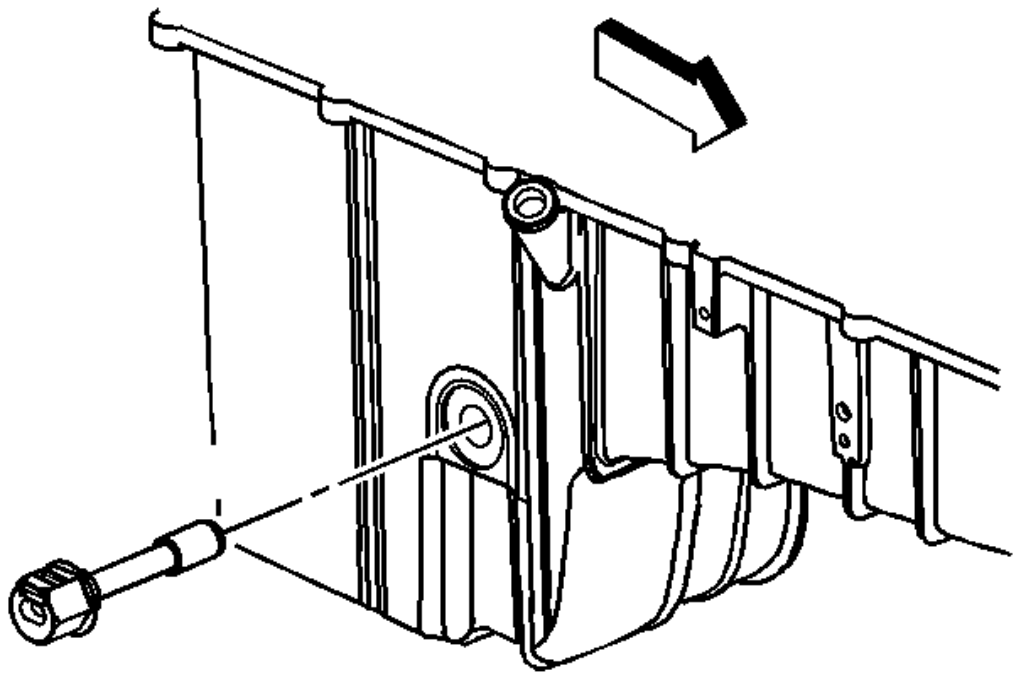

Fig. 187: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

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

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

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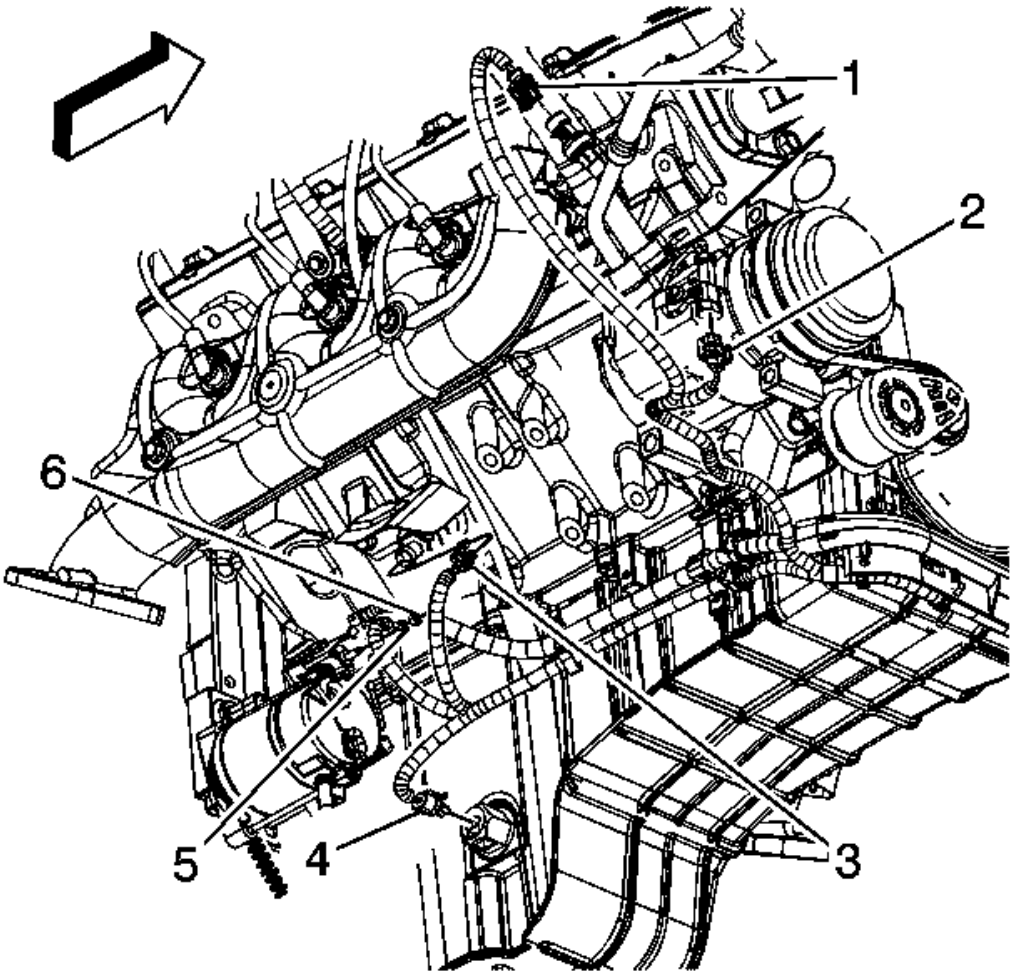

Fig. 188: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

9. Install the engine harness clip to the oil pan.
10. Connect the oil level sensor electrical connector (4).
11. Install the oil level indicator. Refer to **Oil Level Indicator and Tube Replacement**.
12. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.

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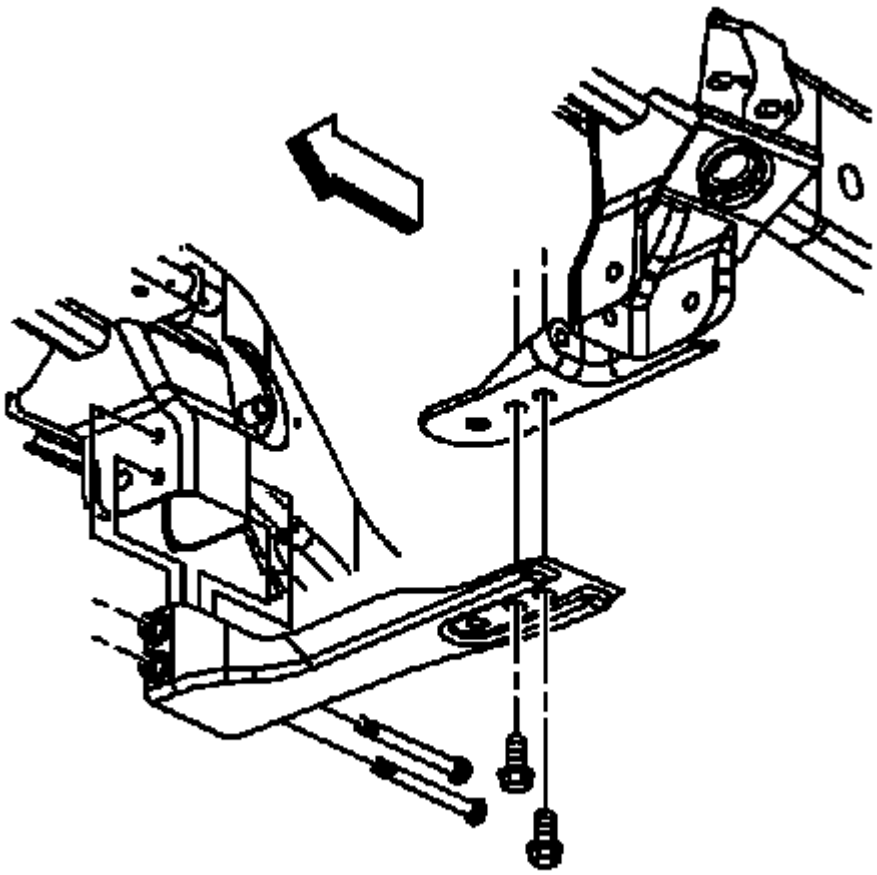

Fig. 189: View Of Crossmember Bolts & Bar (4WD Only)
Courtesy of GENERAL MOTORS CORP.

13. If equipped with 4WD, install the crossbar.
14. Install the crossbar bolts.

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

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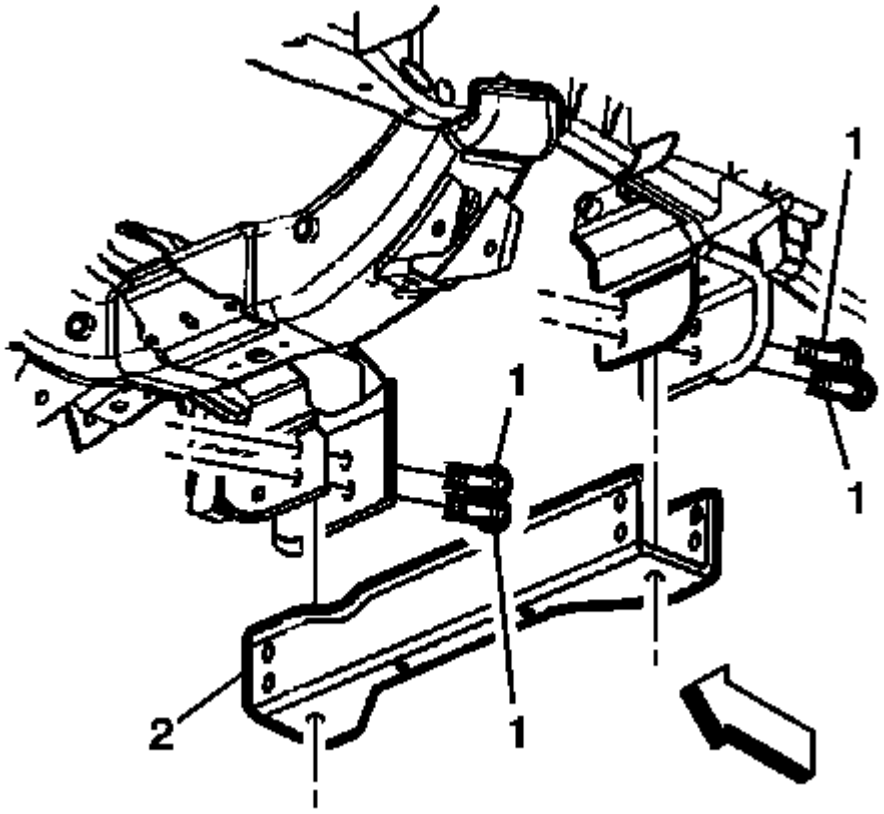

Fig. 190: View Of Crossbar Bolts & Bar (2WD)
Courtesy of GENERAL MOTORS CORP.

15. If equipped with 2WD, install the crossbar.
16. Install the crossbar bolts.

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

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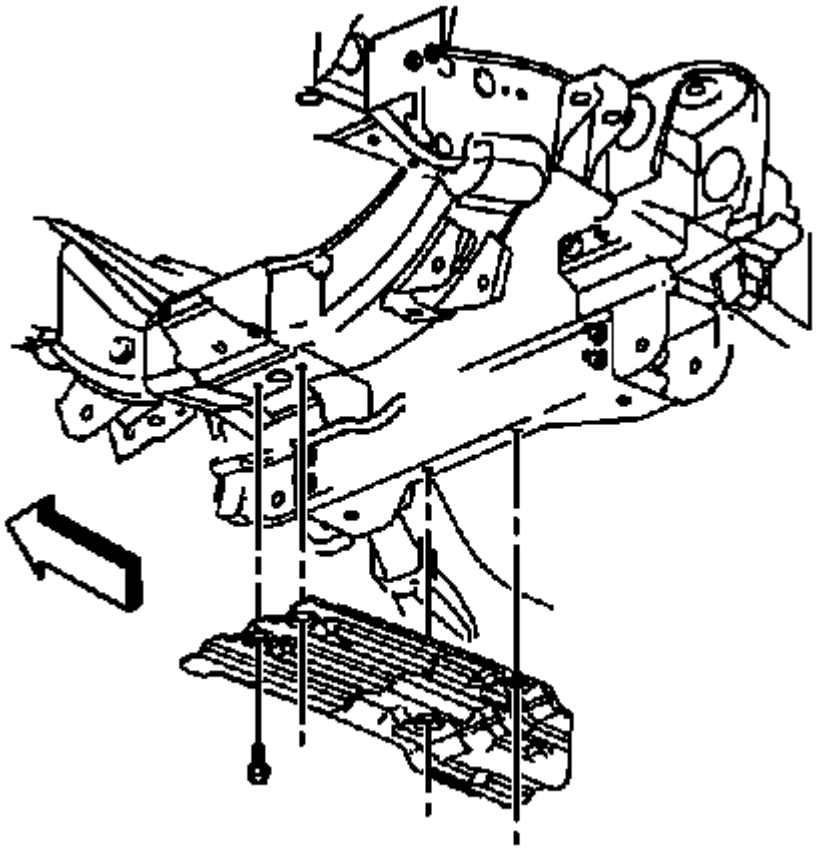

Fig. 191: Identifying Oil Pan Skid Plate
Courtesy of GENERAL MOTORS CORP.

17. Install the oil pan skid plate.
18. Install the oil pan skid plate bolts.

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

19. Install the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.
20. Install the front differential, if equipped with 4WD. Refer to **Differential Carrier Assembly Replacement** in Front Drive Axle.

Engine Oil Pressure Sensor and/or Switch Replacement

Tools Required

J 41712 Oil Pressure Sensor Socket

Removal Procedure

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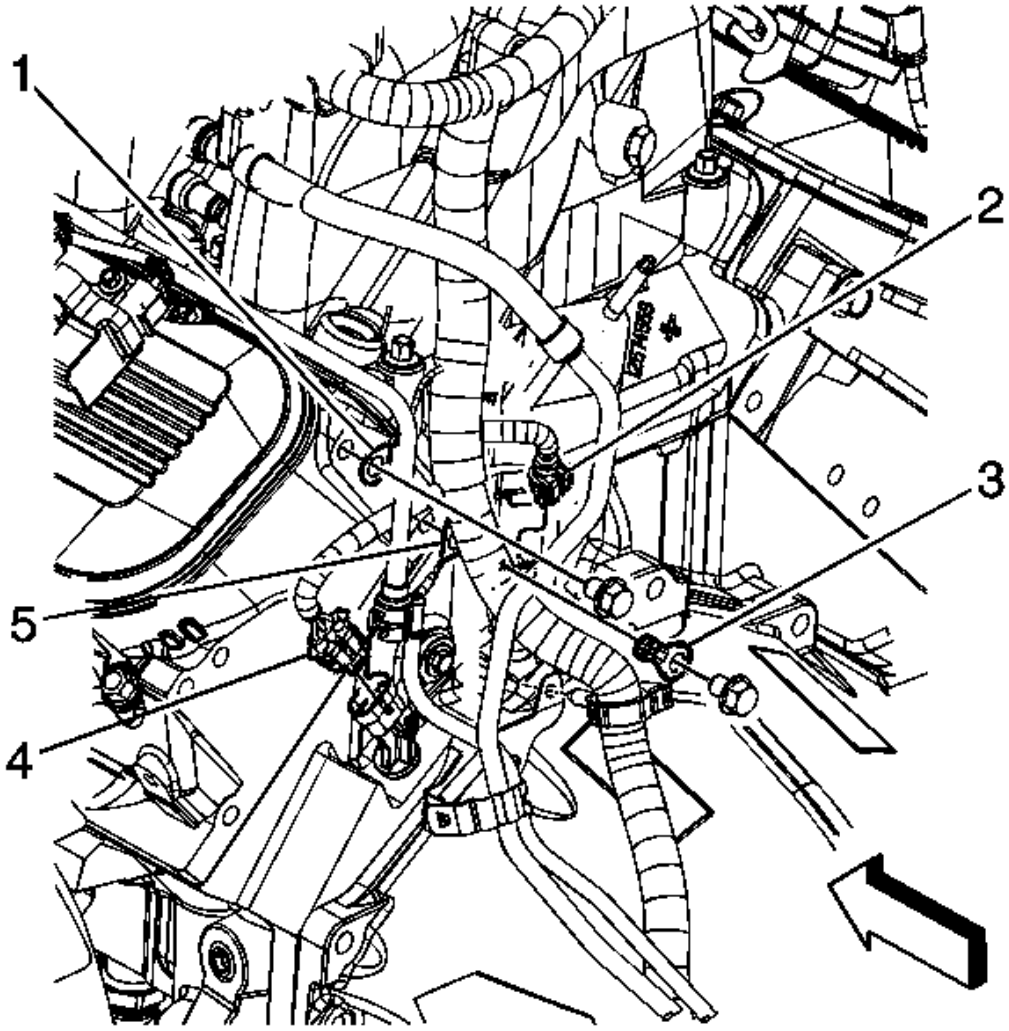

Fig. 192: View Of Engine Harness Grounds And CKP Sensor And Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine sight shield. Refer to **Engine Sight Shield Replacement**.
2. Disconnect the oil pressure sensor electrical connector (2).

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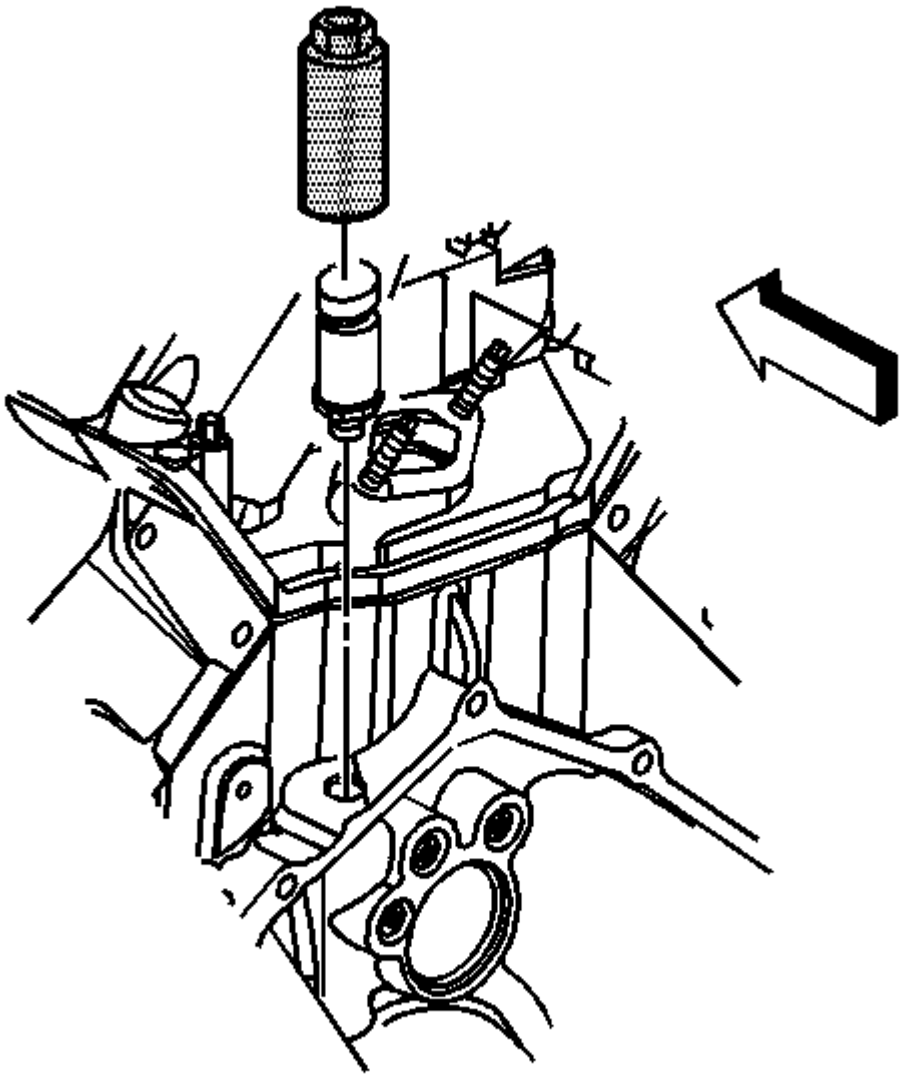

Fig. 193: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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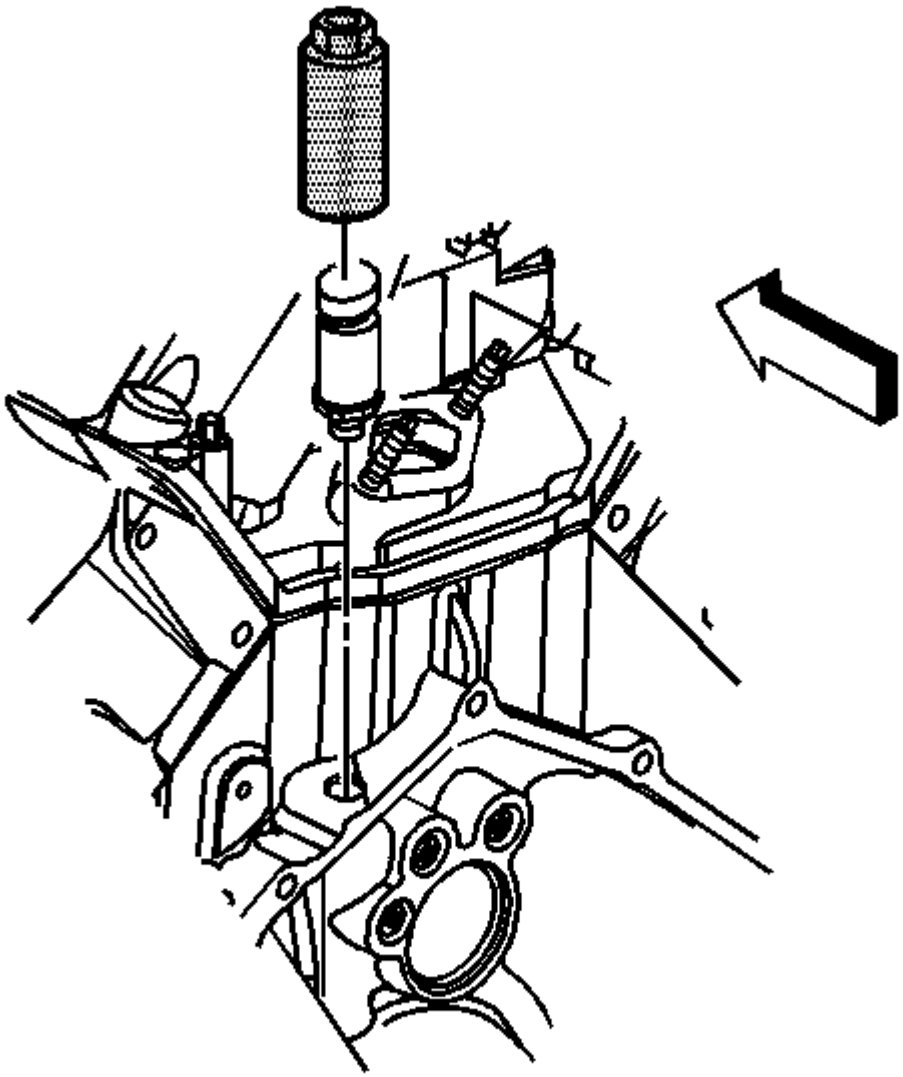

Fig. 194: View Of Oil Pressure Sensor & J 41712
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

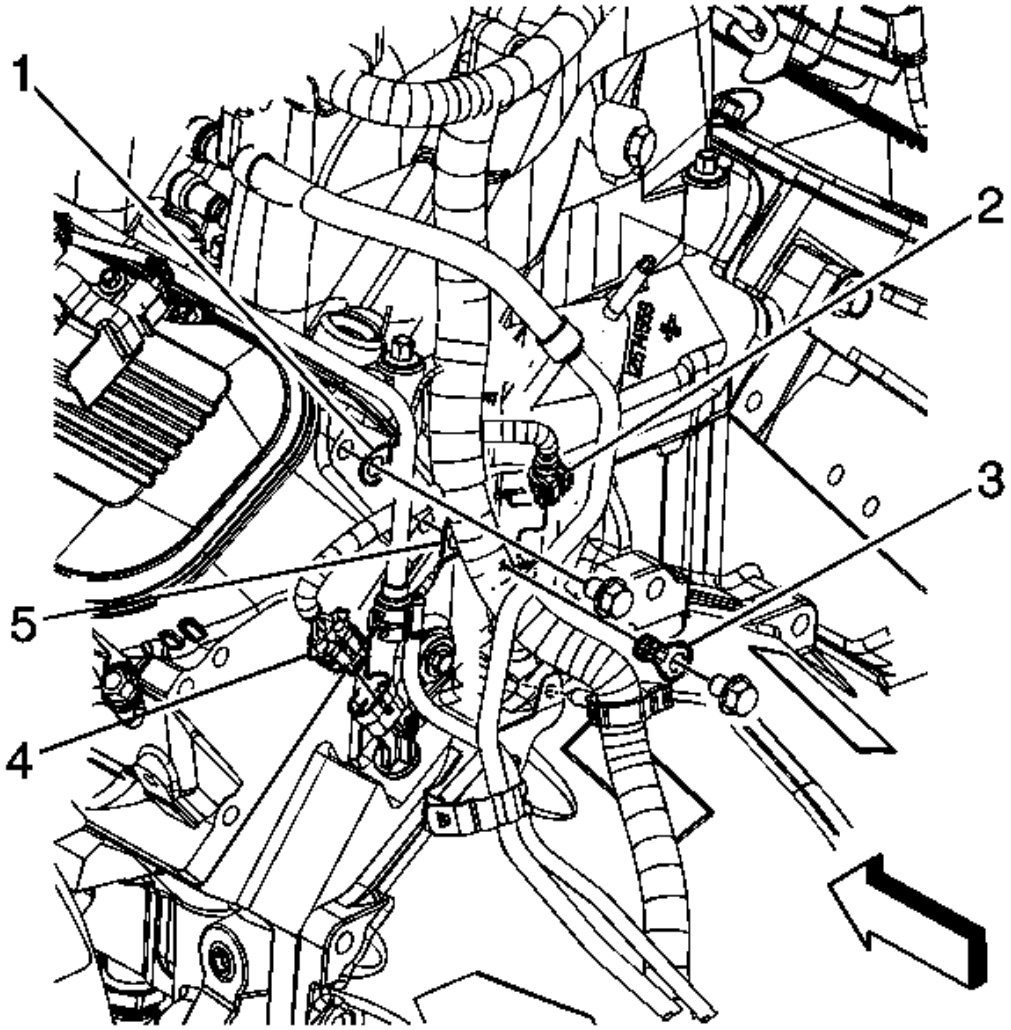

Fig. 195: View Of Engine Harness Grounds And CKP Sensor And Oil Pressure Sensor Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

3. Connect the oil pressure sensor electrical connector (2).
4. Install the engine sight shield. Refer to **Engine Sight Shield Replacement**.

Engine Oil Level Sensor and/or Switch Replacement

Removal Procedure

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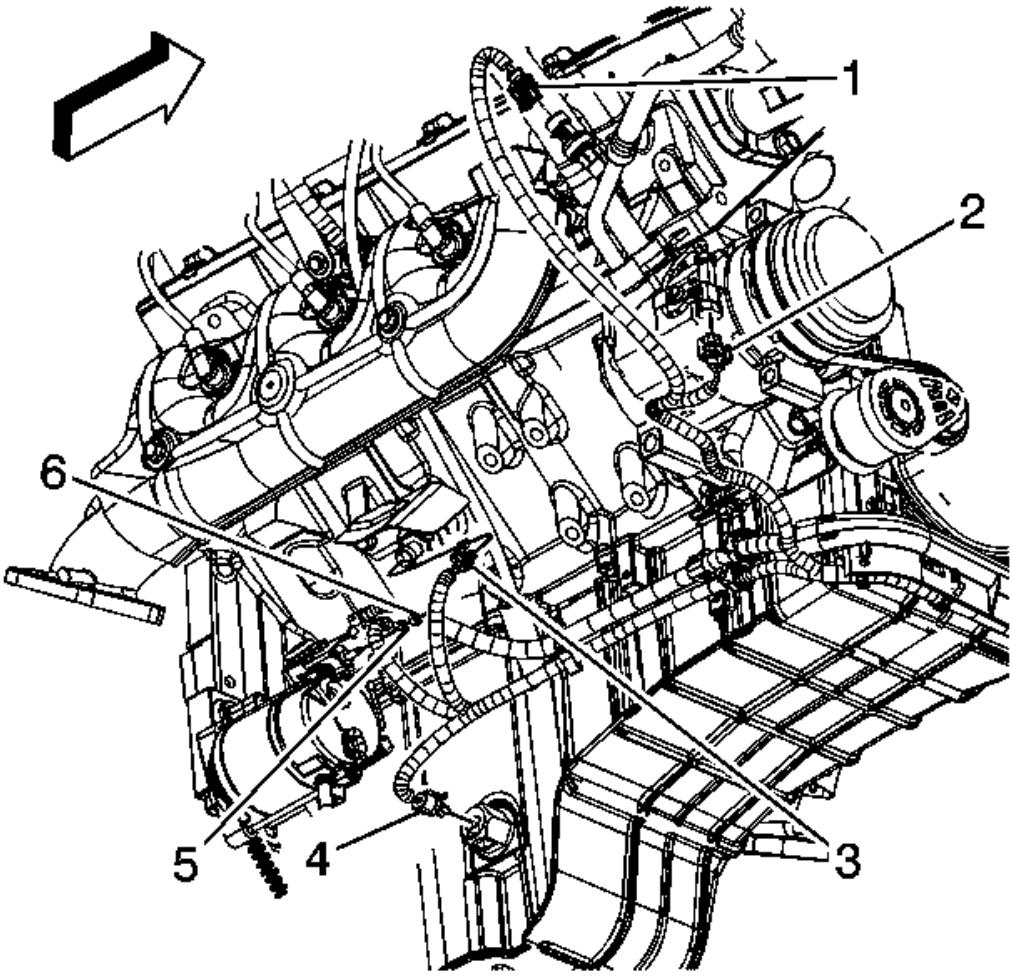

Fig. 196: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
2. Disconnect the oil level sensor electrical connector (4).

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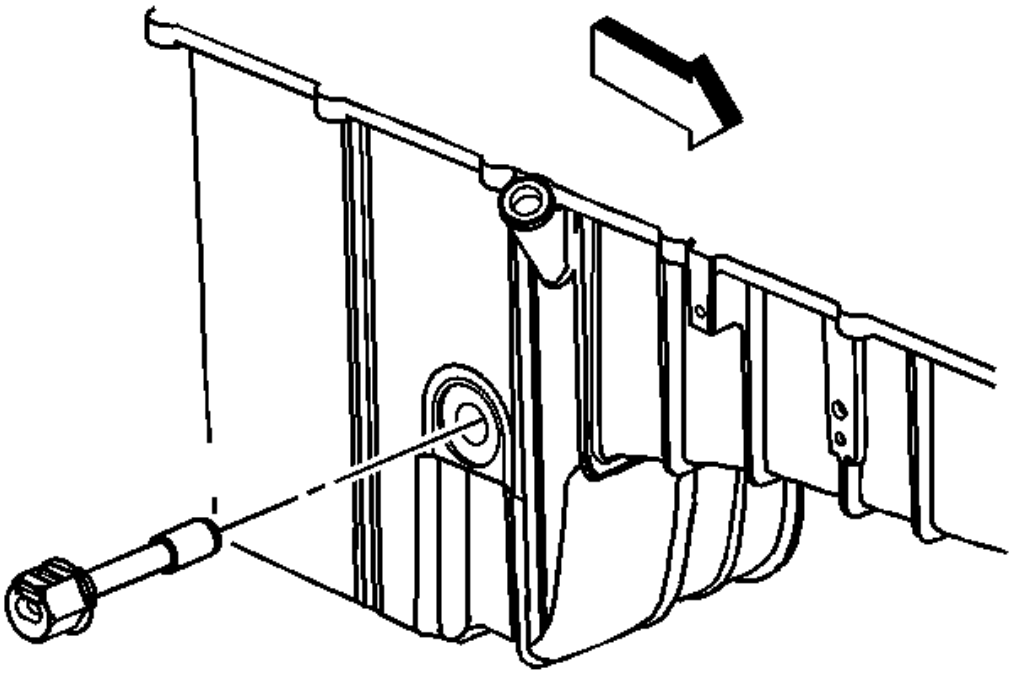

Fig. 197: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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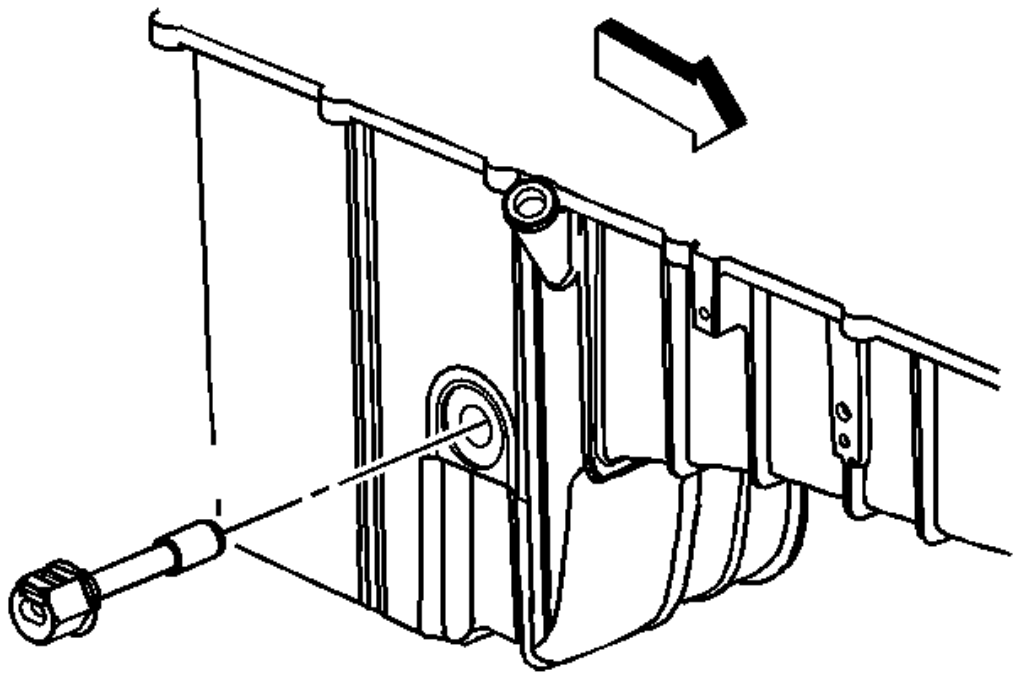

Fig. 198: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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

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

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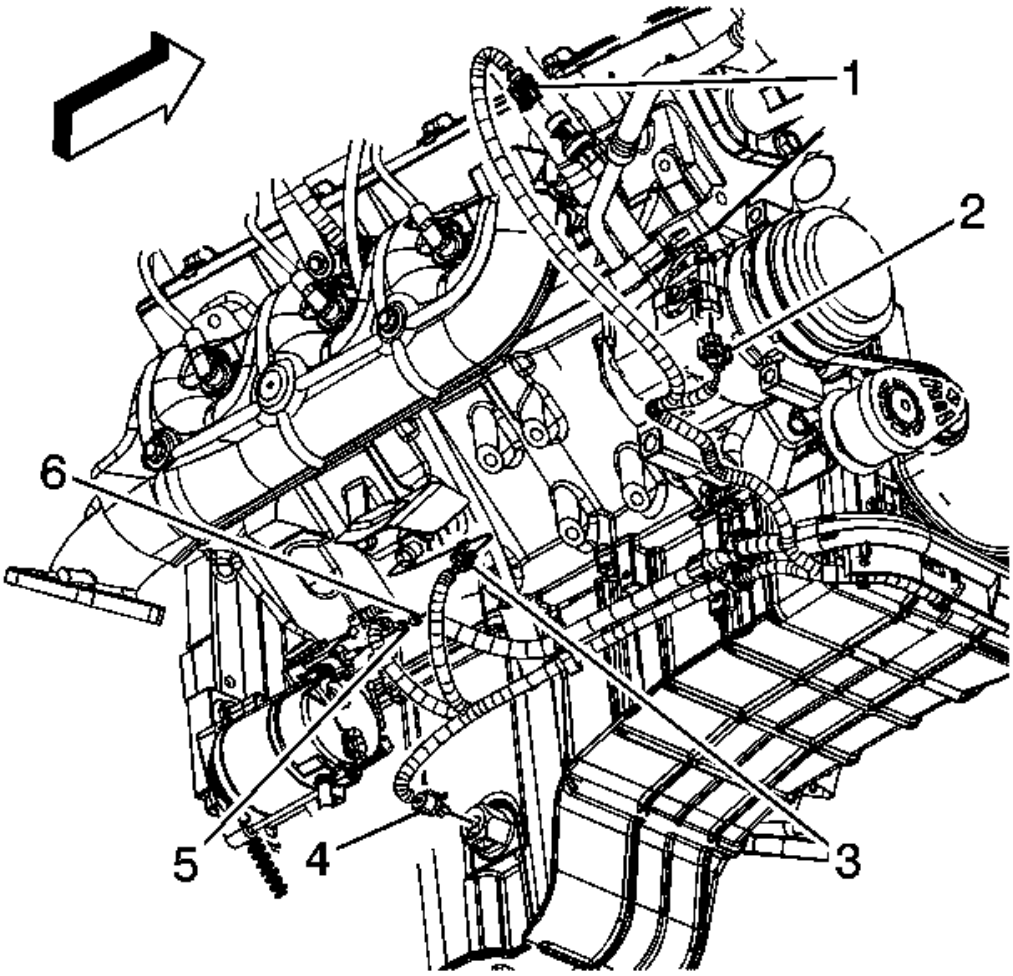

Fig. 199: View Of Oil Level Sensor Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Connect the oil level sensor electrical connector (4).
3. Fill the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

Oil Pump Replacement

Removal Procedure

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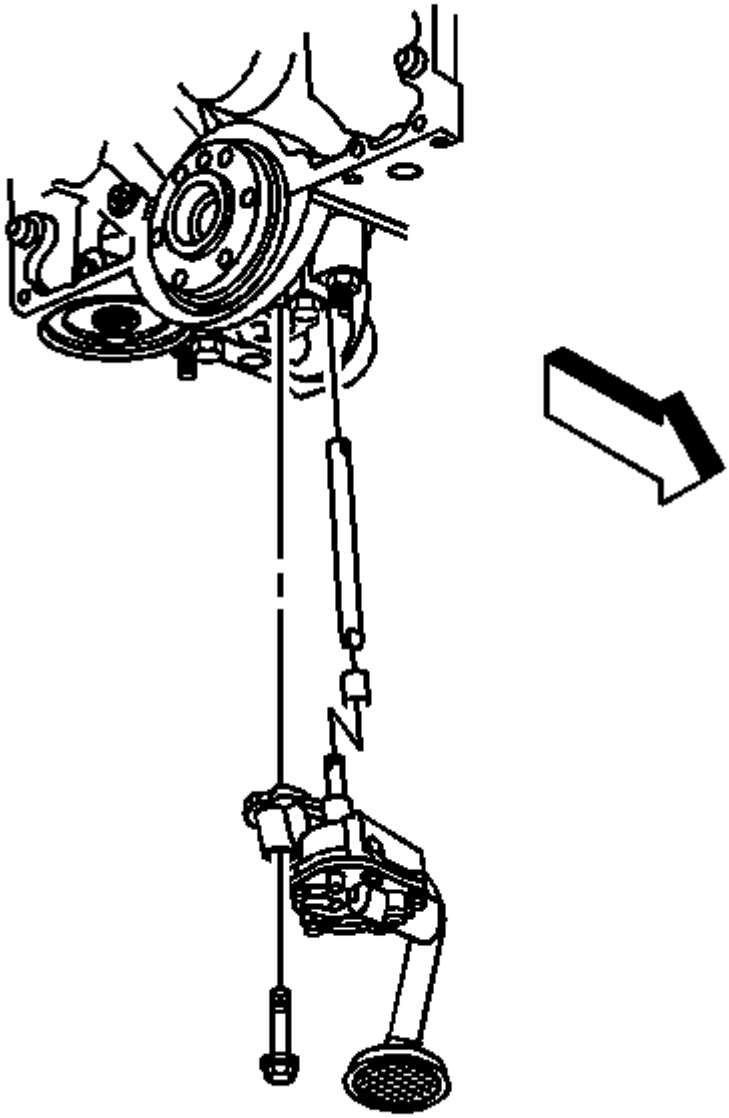

Fig. 200: View Of Oil Pump, Bolt, Retainer & Driveshaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the oil pump bolt.
3. Remove and separate the oil pump, retainer, and driveshaft.
4. Discard the driveshaft retainer.

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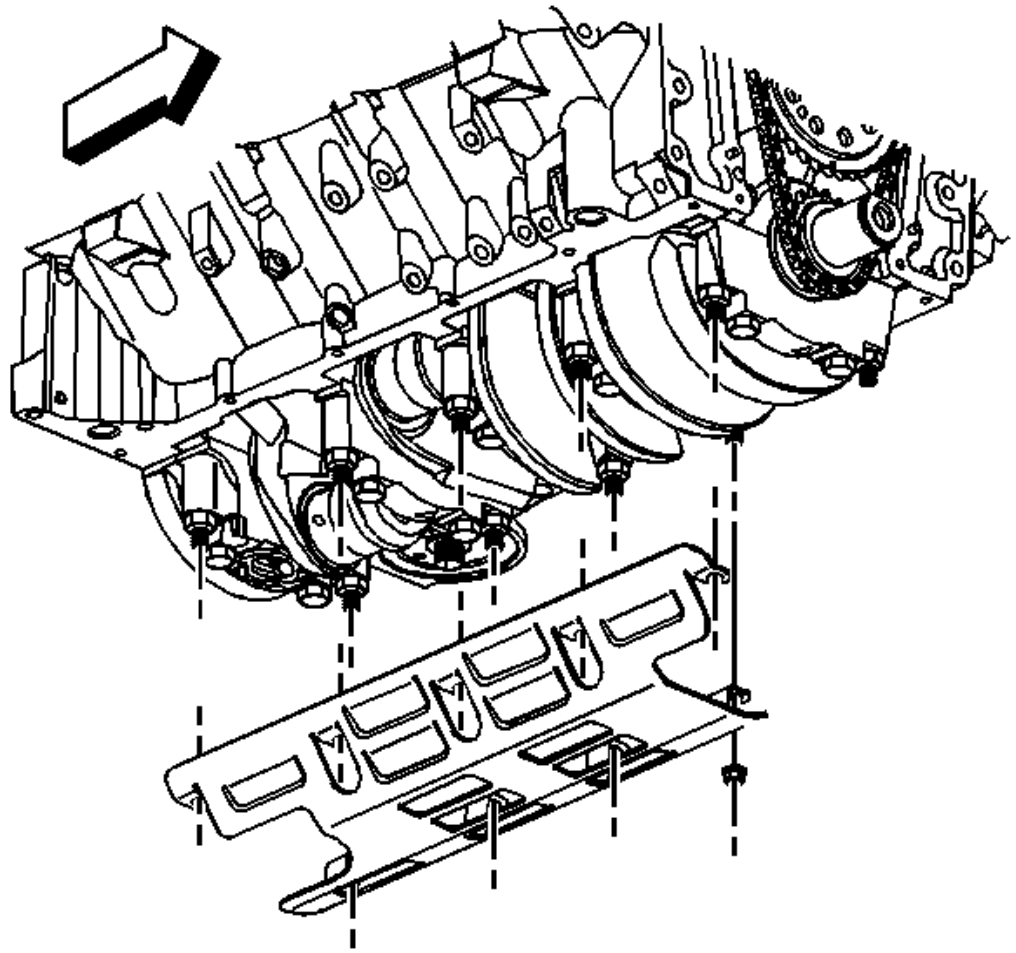

Fig. 201: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.
7. Clean and inspect the oil pump. Refer to **Oil Pump Cleaning and Inspection**.

Installation Procedure

IMPORTANT: When installing the oil pump, always replace the retainer between the oil pump and the shaft.

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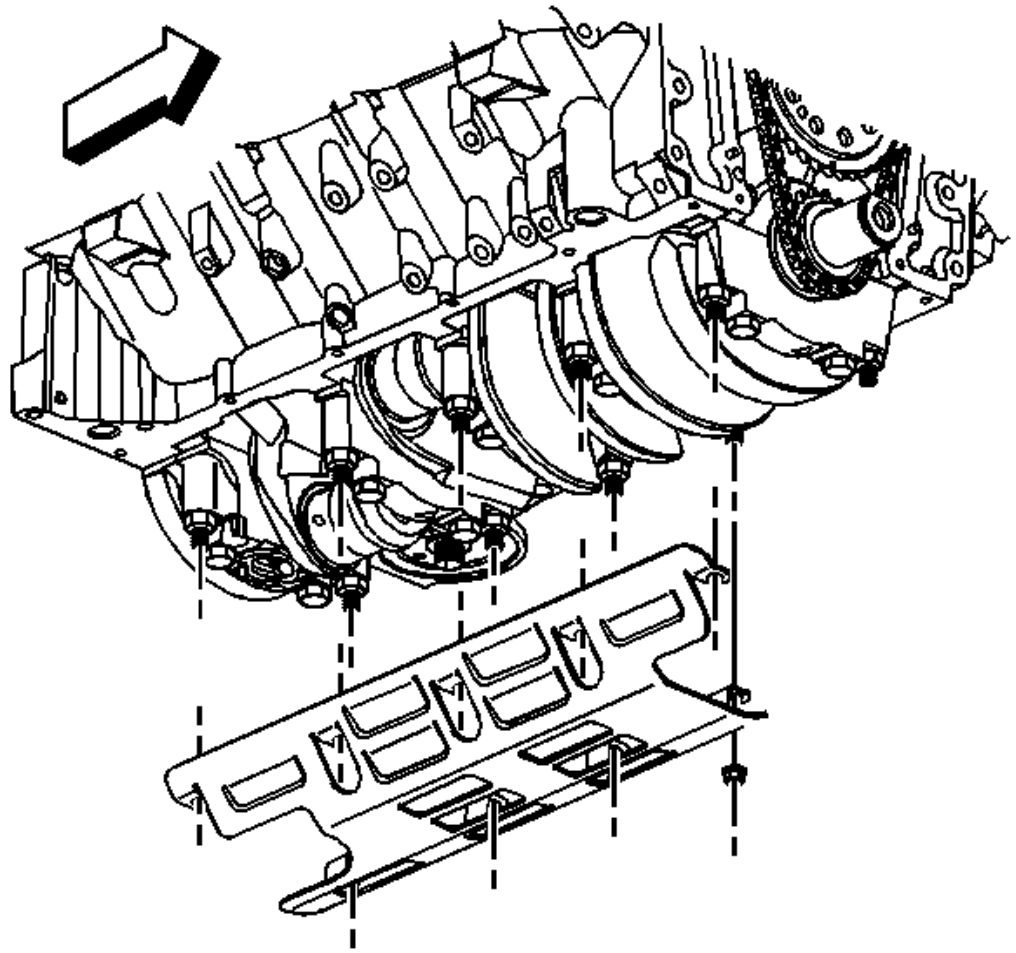

Fig. 202: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the crankshaft oil deflector.
2. Install the crankshaft oil deflector nuts.

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

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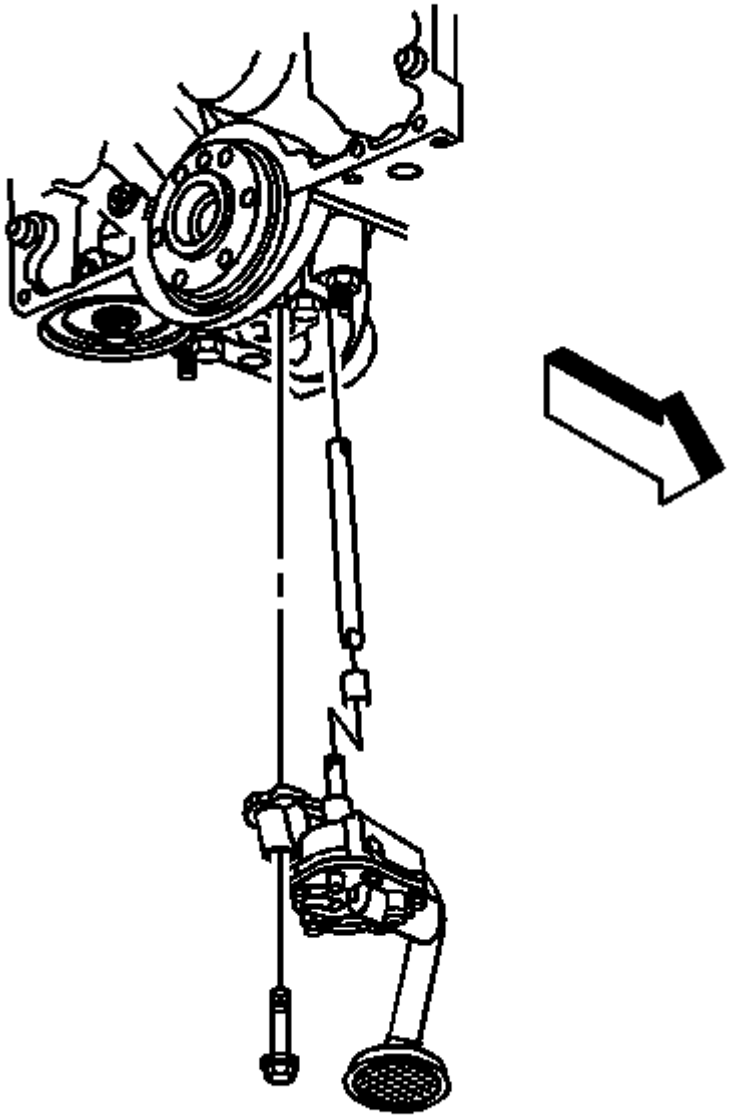

Fig. 203: View Of Oil Pump, Bolt, Retainer & Driveshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During assembly, install NEW oil pump driveshaft retainer. Slightly heat the retainer above room temperature for ease of installation onto the oil pump driveshaft.

3. Assemble the oil pump, driveshaft and a NEW retainer.

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4. Install the oil pump. Position the oil pump onto the locating pins.
5. Install the oil pump bolt.

   Tighten: Tighten the bolt to 75 N.m (56 lb ft).

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

Crankshaft Rear Oil Seal Replacement

Tools Required

- **J 43320** Crankshaft Rear Seal Puller. See **Special Tools and Equipment**.
- **J 42849** Crankshaft Rear Seal Installer. See **Special Tools and Equipment**.

Removal Procedure

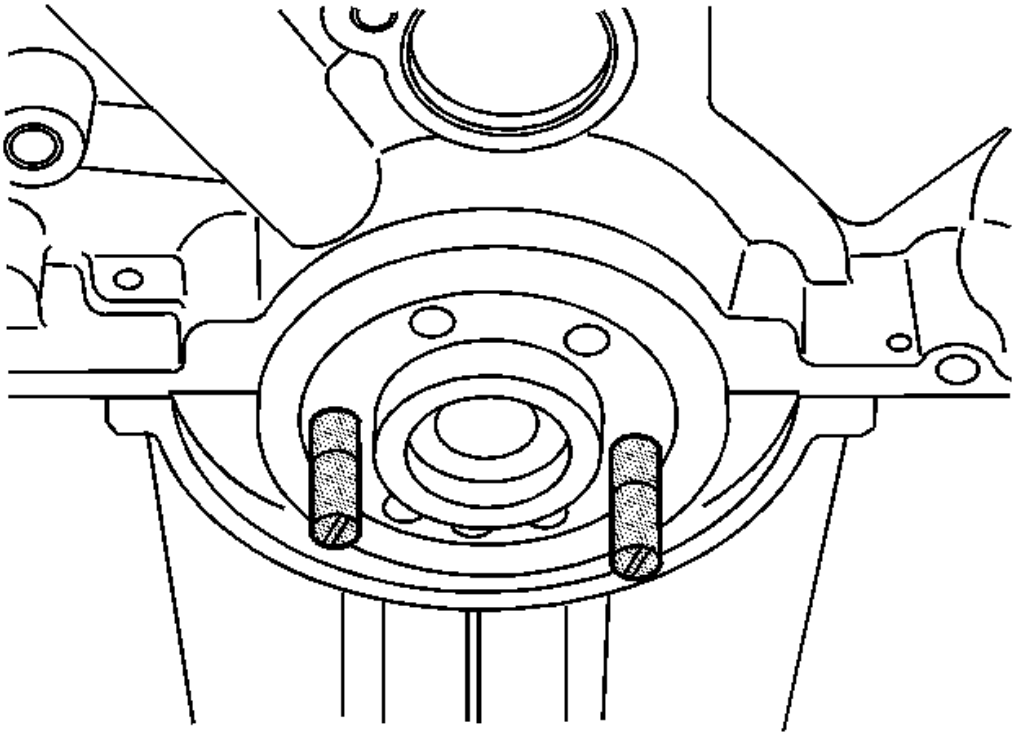

Fig. 204: View Of Guide Pins In Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Remove the flywheel. Refer to **Engine Flywheel Replacement**.

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2. Install the guide pins from **J 43320** into the crankshaft. See **Special Tools and Equipment**.

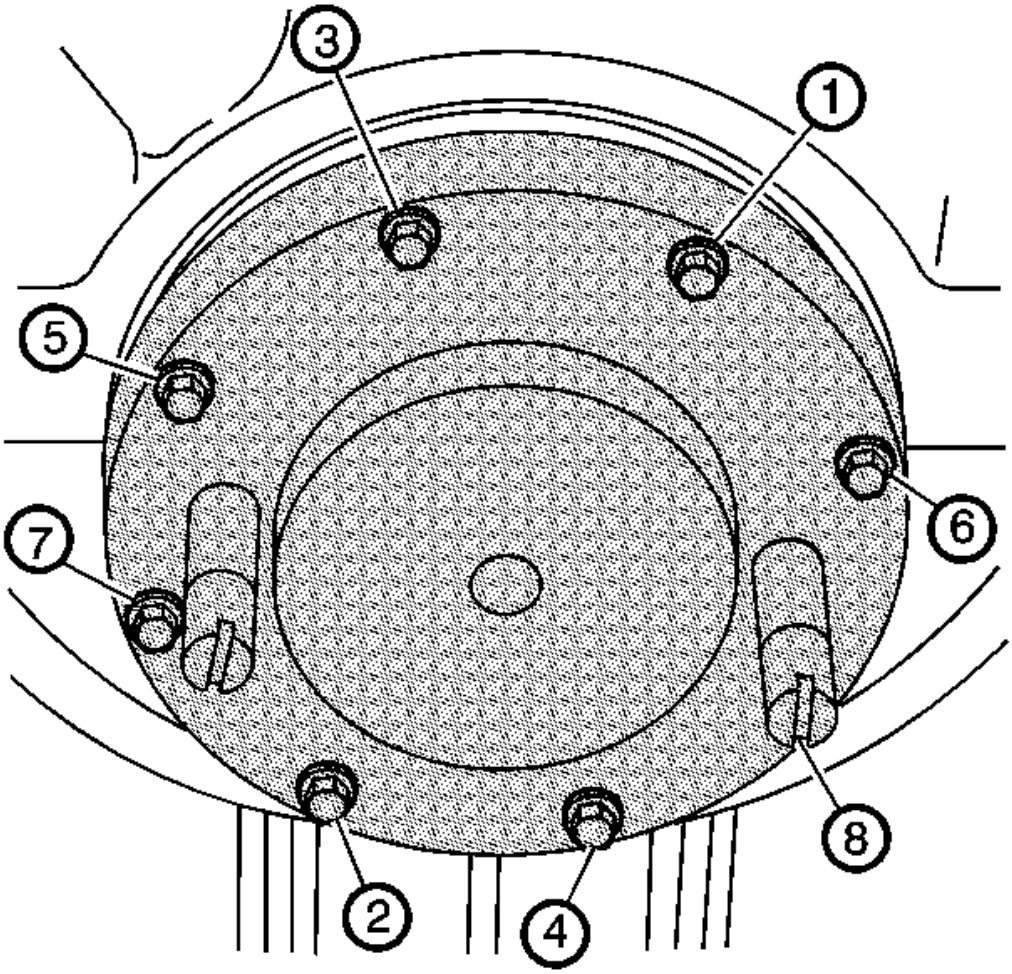

Fig. 205: J 43320 Self-Drilling Sheet Metal Screws Installation Sequence
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 43320** over the guide pins. See **Special Tools and Equipment**.
4. Using a suitable drill, insert eight of the self-drilling sheet metal screws into the rear crankshaft seal, using a criss-cross pattern. The self-tapping screws are included with the **J 43320** . See **Special Tools and Equipment**.

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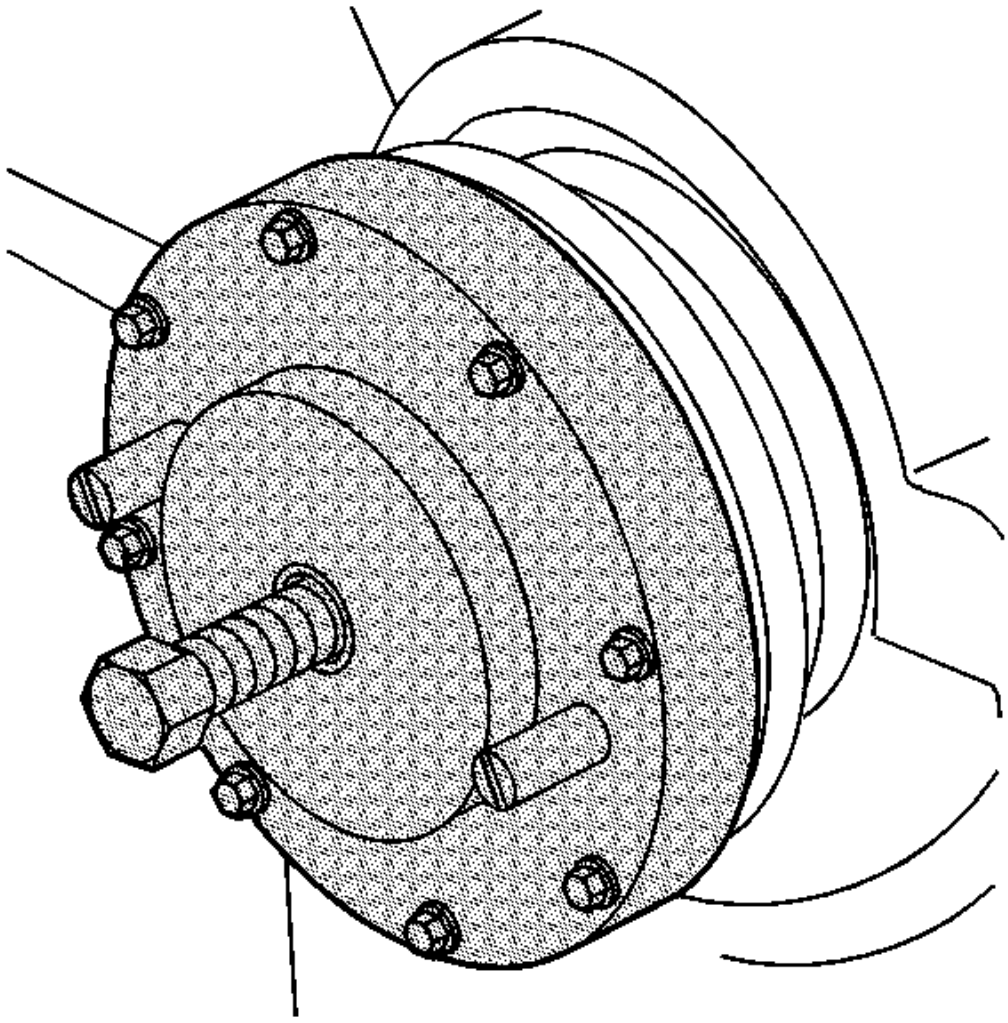

Fig. 206: View Of J 43320 & Center Bolt
Courtesy of GENERAL MOTORS CORP.

5. Thread the center bolt of **J 43320** into the crankshaft to remove the seal. See **Special Tools and Equipment**.
6. Remove the guide pins from the crankshaft.

Installation Procedure

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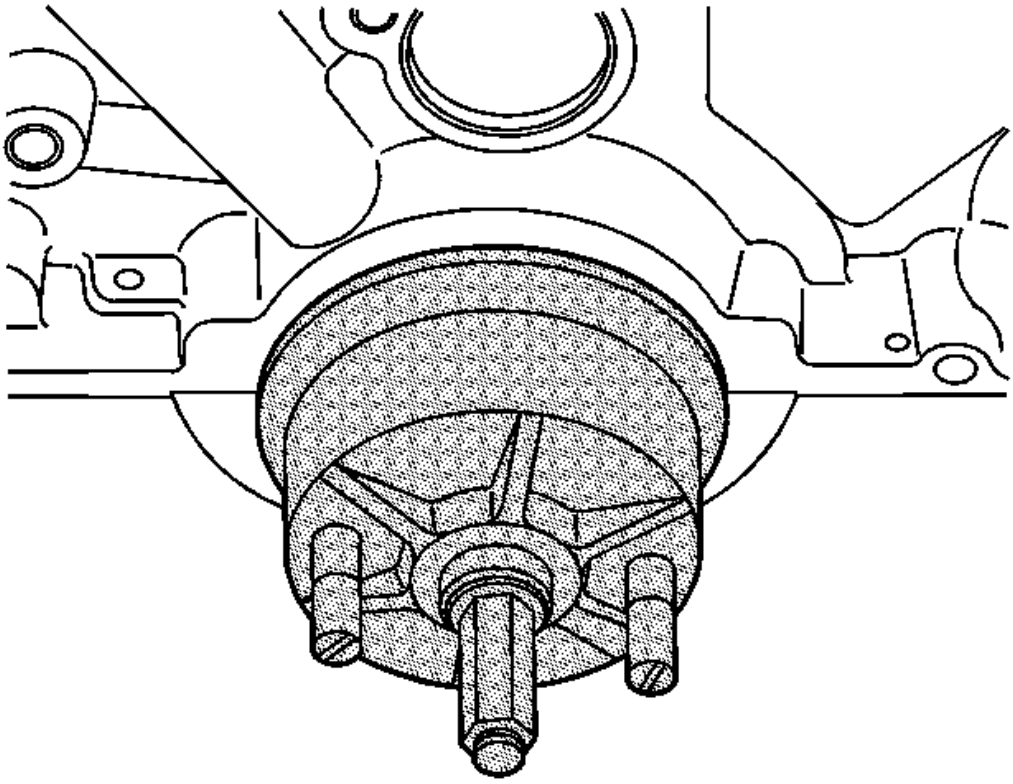

Fig. 207: View Of J 42849
Courtesy of GENERAL MOTORS CORP.

1. Make sure the crankshaft is free of grit, loose rust, and burrs. Correct as needed.
2. Apply a very light film of oil onto the crankshaft sealing surface. DO NOT apply oil to the sealing surface of the engine block.
3. Install the seal onto **J 42849** . See **Special Tools and Equipment**.
4. Position the **J 42849** against the crankshaft. See **Special Tools and Equipment**. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Rotate the center nut until the **J 42849** bottoms. See **Special Tools and Equipment**.
7. Remove the **J 42849** . See **Special Tools and Equipment**.
8. Install the flywheel. Refer to **Engine Flywheel Replacement**.

Engine Flywheel Replacement

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Removal Procedure

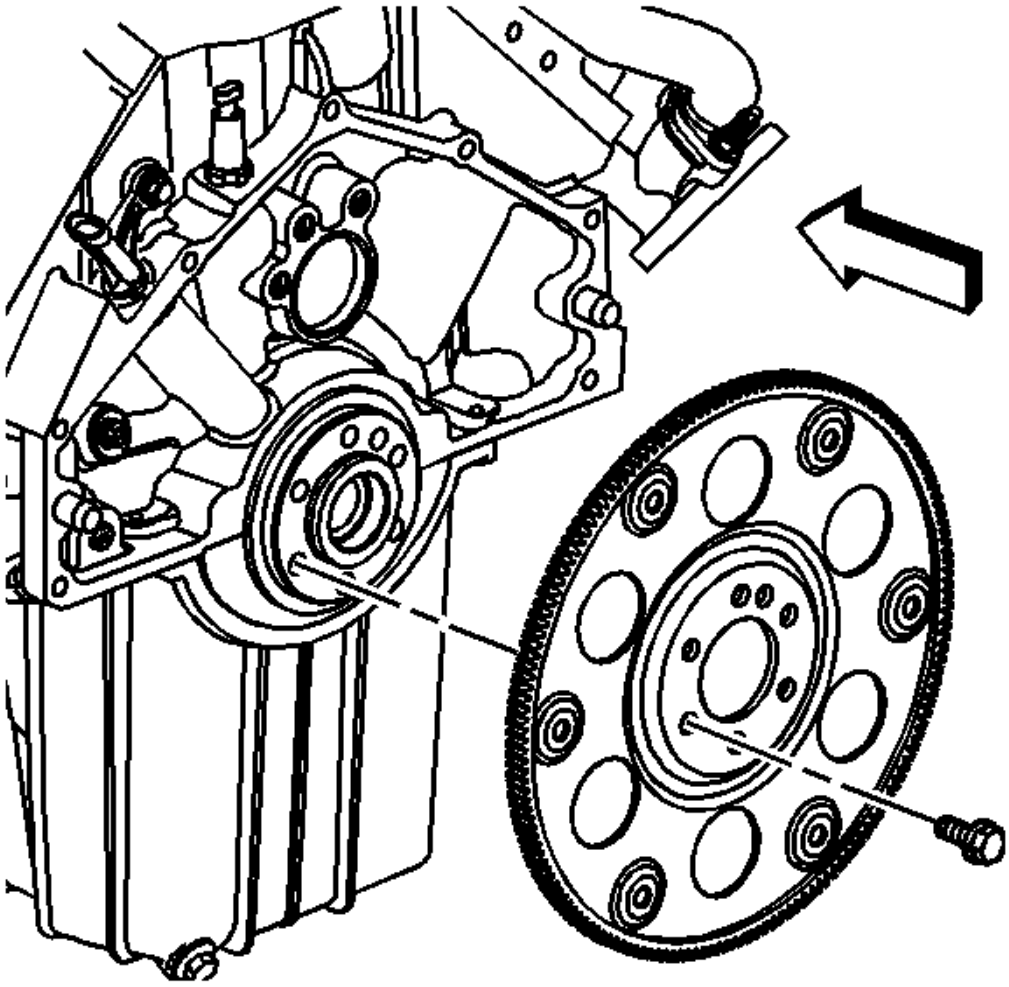

Fig. 208: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4L80-E.
2. Remove the flywheel bolts.
3. Remove the flywheel.

Installation Procedure

IMPORTANT: "Engine Side" stamped on the flywheel is to be positioned toward the engine.

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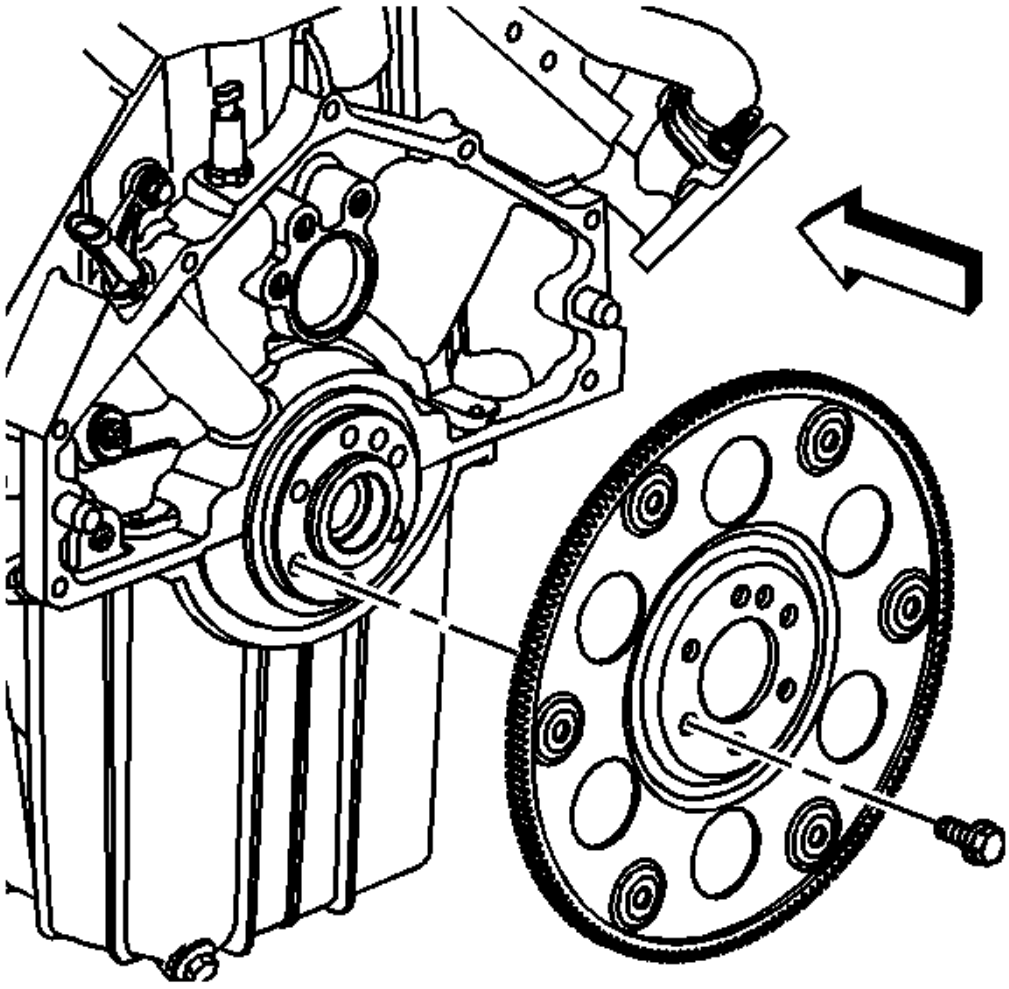

Fig. 209: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the flywheel.
2. Install the flywheel bolts.

Tighten:

1. Tighten the bolts a first pass to 40 N.m (30 lb ft).
2. Tighten the bolts a second pass to 80 N.m (59 lb ft).
3. Tighten the bolts a final pas to 100 N.m (74 lb ft).

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3. Install the transmission. Refer to **Transmission Replacement** in Automatic Transmission - 4L80-E.

Engine Replacement

Tools Required

J 36857 Engine Lift Brackets. See **Special Tools and Equipment**.

Removal Procedure

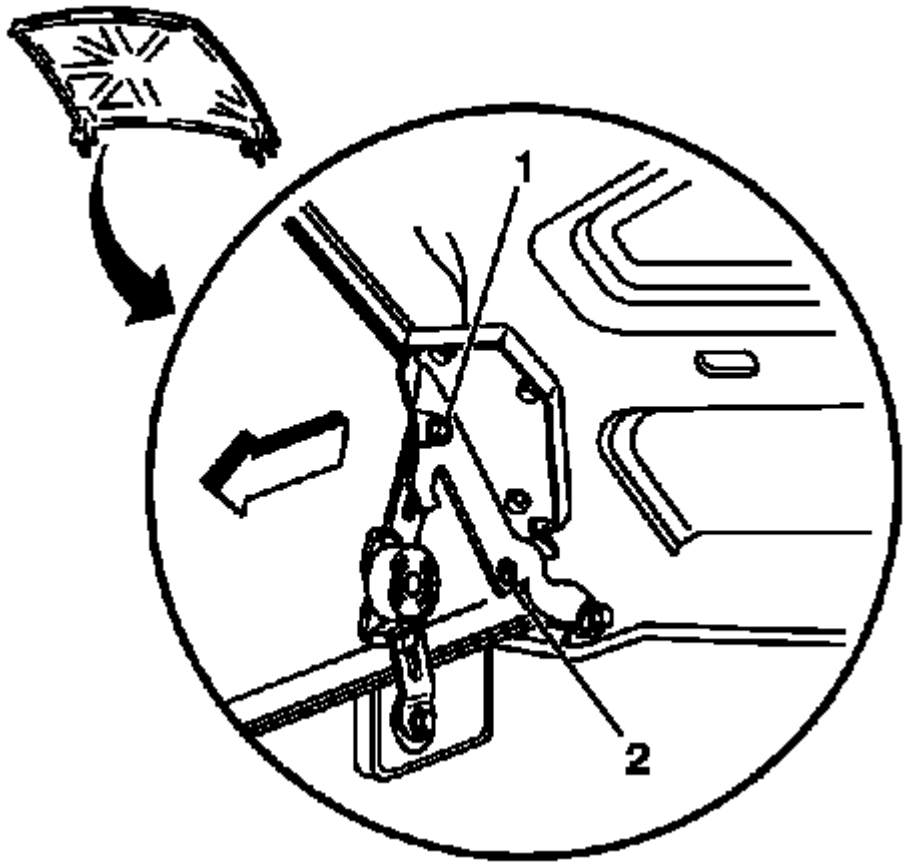

Fig. 210: Identifying Hood Hinge Normal And Service Position Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Open the hood.
2. Place fender covers over both fenders.
3. Raise the hood to the service position, perform the following:
    1. Remove the hood hinge bolts (1).
    2. Raise the hood until vertical.
    3. Install the hood hinge bolts until snug in the service position (2).

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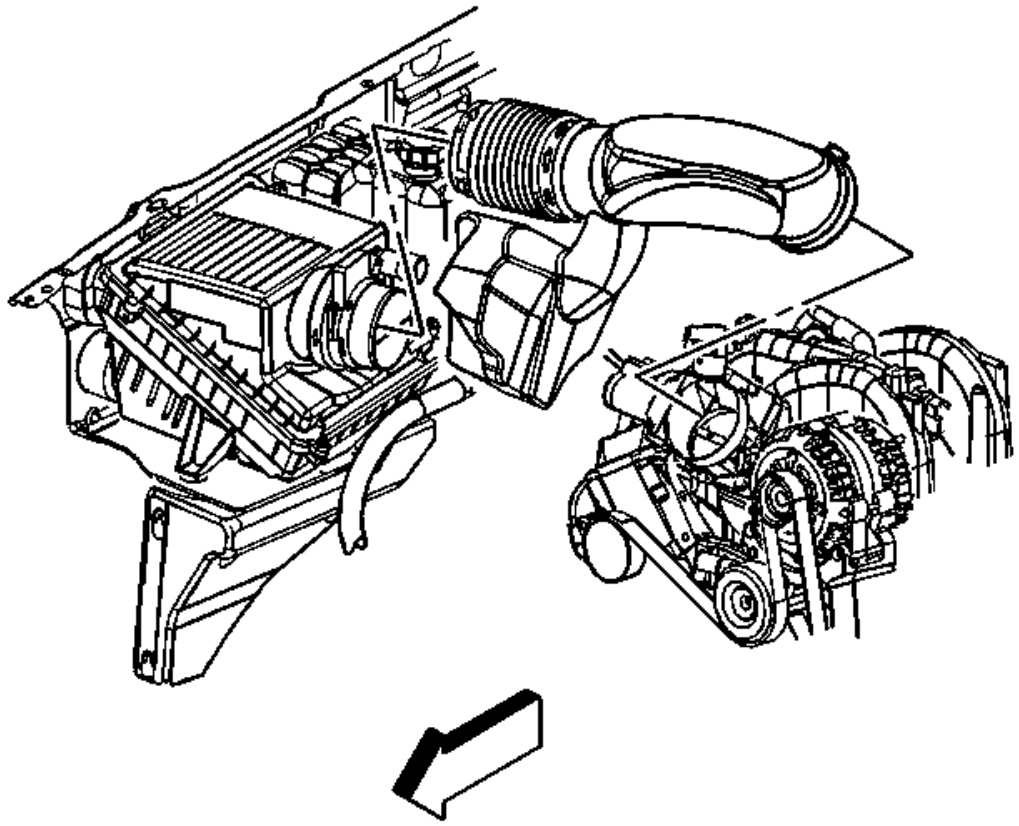

Fig. 211: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

4. Loosen the clamps at the throttle body and air cleaner.
5. Remove the air cleaner outlet duct.

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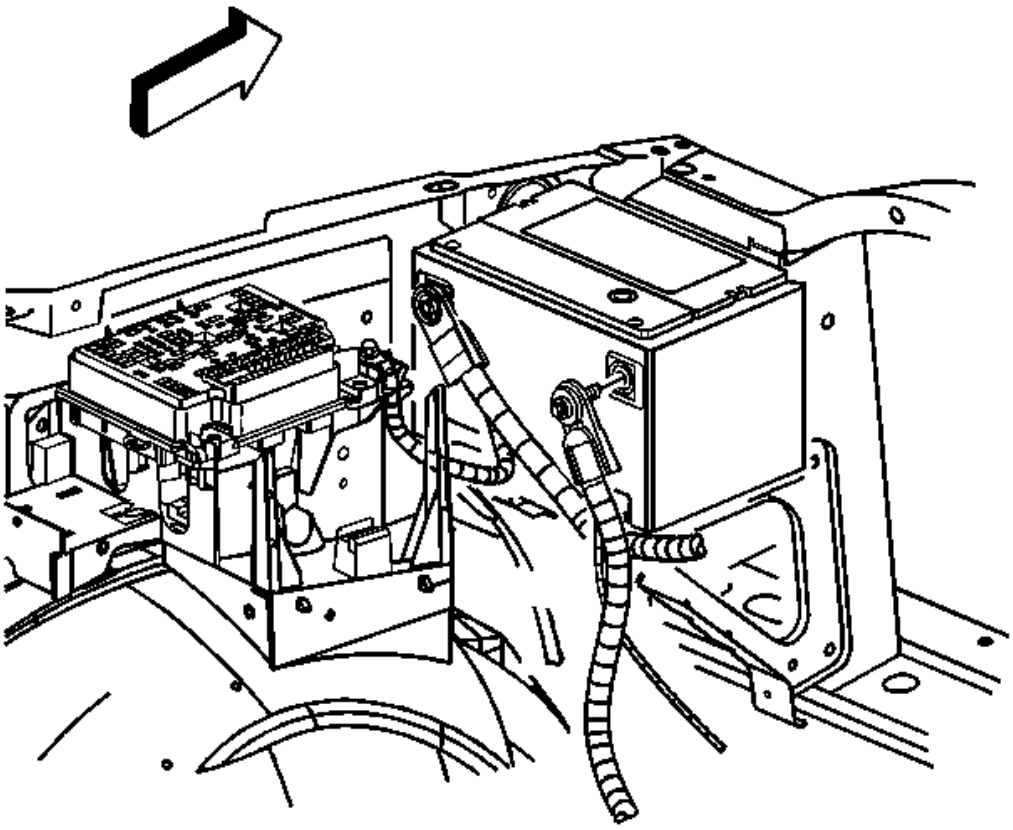

Fig. 212: View Of Battery Cables
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnect/Connect Procedure** in Engine Electrical.
7. Disconnect the positive battery cable.
8. Remove the ignition coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 8.1L.

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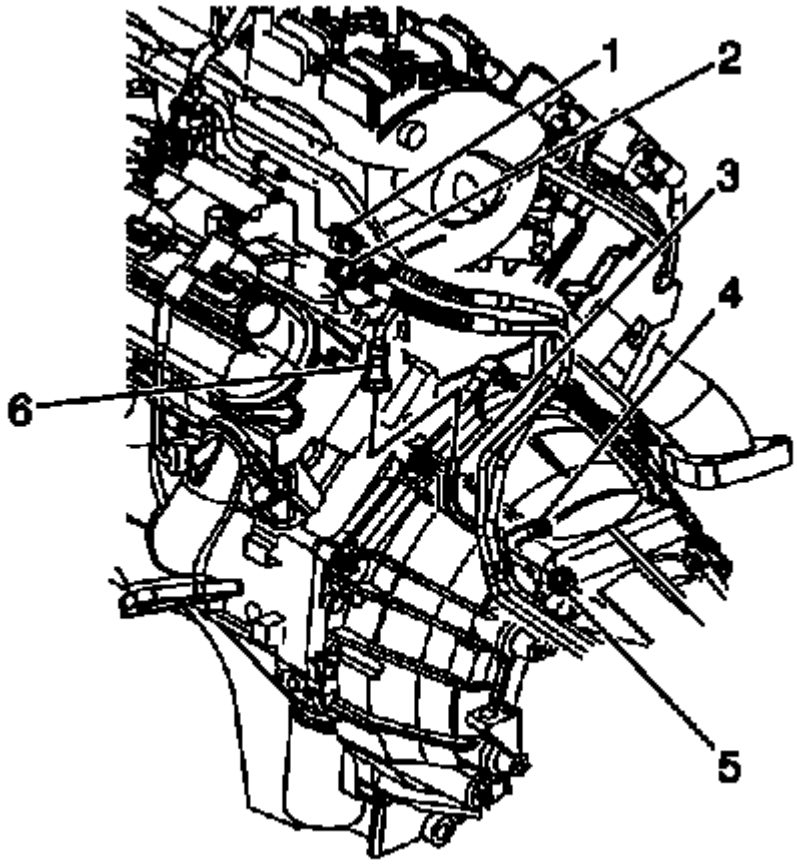

Fig. 213: View Of Rear Of Engine Fuel Pipe Connections
Courtesy of GENERAL MOTORS CORP.

9. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief Procedure** in Engine Controls - 8.1L.
10. Disconnect the fuel feed and return pipes (1, 2) from the fuel rail. Refer to **Quick Connect Fitting(s) Service (Metal Collar)** in Engine Controls - 8.1L.
11. Remove the air conditioning (A/C) compressor. Refer to **Compressor Replacement (L18)** in Heating, Ventilation and Air Conditioning.
12. Remove the radiator. Refer to **Radiator Replacement (8.1L)** in Engine Cooling.

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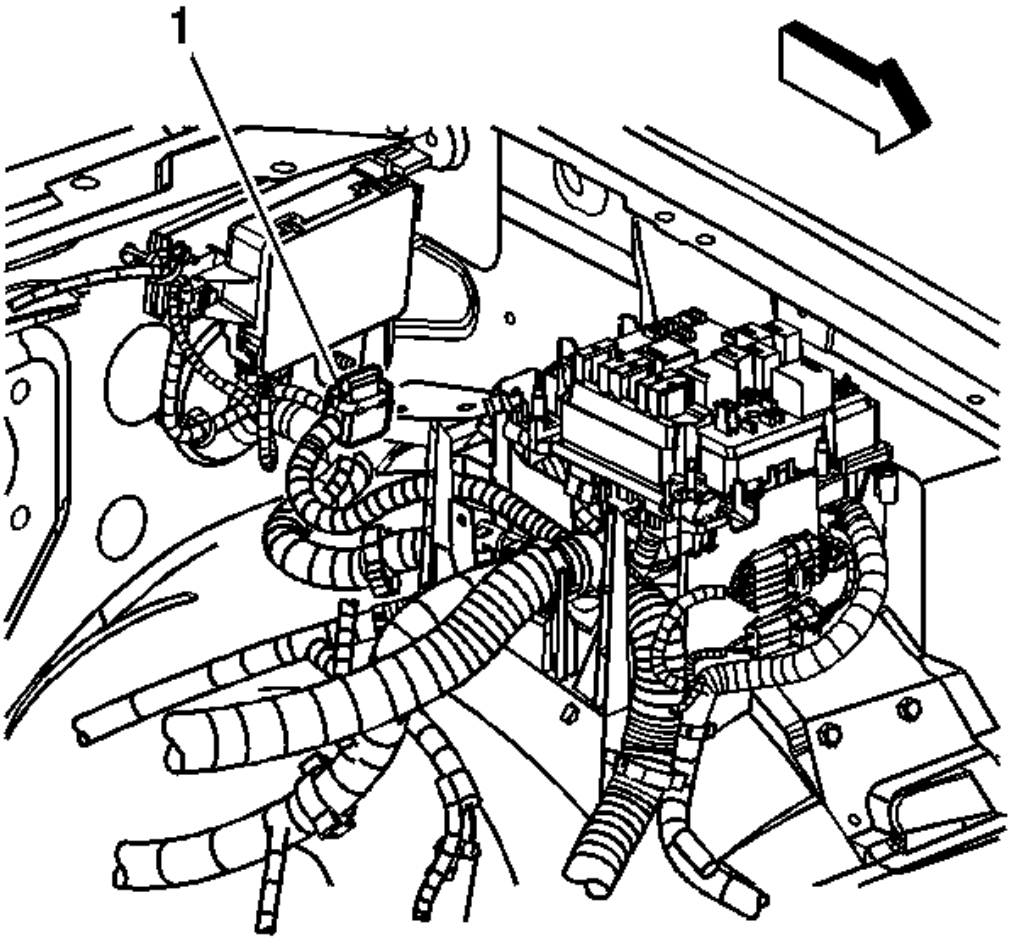

Fig. 214: View Of Throttle Actuator Control (TAC) Module Electrical Connector
Courtesy of GENERAL MOTORS CORP.

13. Disconnect the throttle actuator control (TAC) module electrical connector (1).
14. Remove the vacuum lines from the engine, as required.

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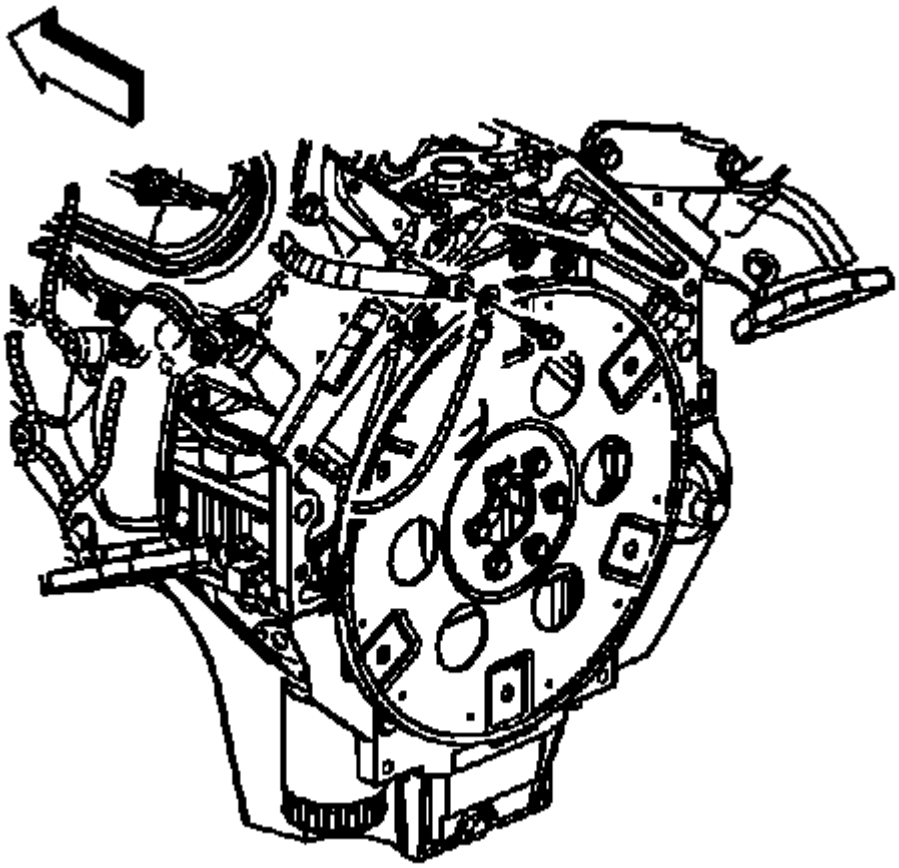

Fig. 215: View Of Ground Cable Bolt At Engine Block
Courtesy of GENERAL MOTORS CORP.

15. Remove the ground cable bolt at the engine block.
16. Remove the generator. Refer to **Generator Replacement (8.1L Engine)** in Engine Electrical.
17. Remove the engine electrical harness and tie out of the way.
18. Raise and suitably support the vehicle with safety stands. Refer to **Lifting and Jacking the Vehicle** in General Information.
19. Remove the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.
20. Remove the hoses from the power steering pump.
21. Remove the exhaust manifold pipe. Refer to **Exhaust Manifold Pipe Replacement (6.0L and 8.1L Engines)** in Engine Exhaust.
22. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (6.0L and 8.1L Engines)** in Engine Exhaust.

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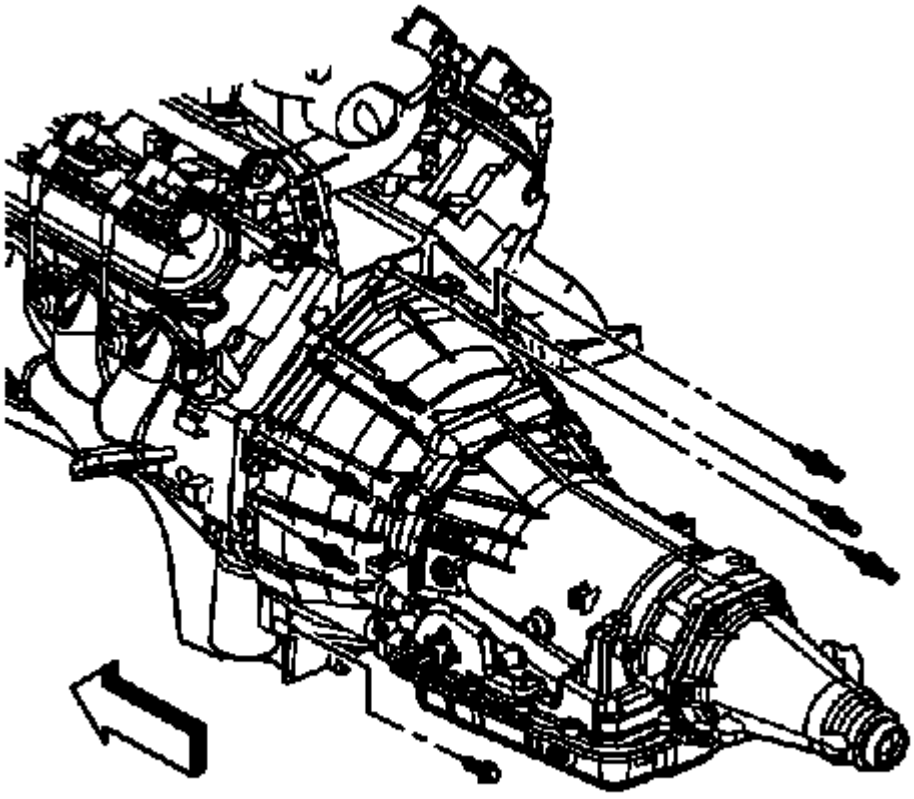

Fig. 216: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

23. Remove the torque converter bolts.
24. Remove the bolts from the transmission to the engine. Refer to **Transmission Replacement** in Automatic Transmission - 4L80-E.
25. Remove the engine oil cooler lines from the engine block. Refer to **Engine Oil Cooler Hose/Pipe Replacement (2WD)** or **Engine Oil Cooler Hose/Pipe Replacement (4WD)** in Engine Cooling.

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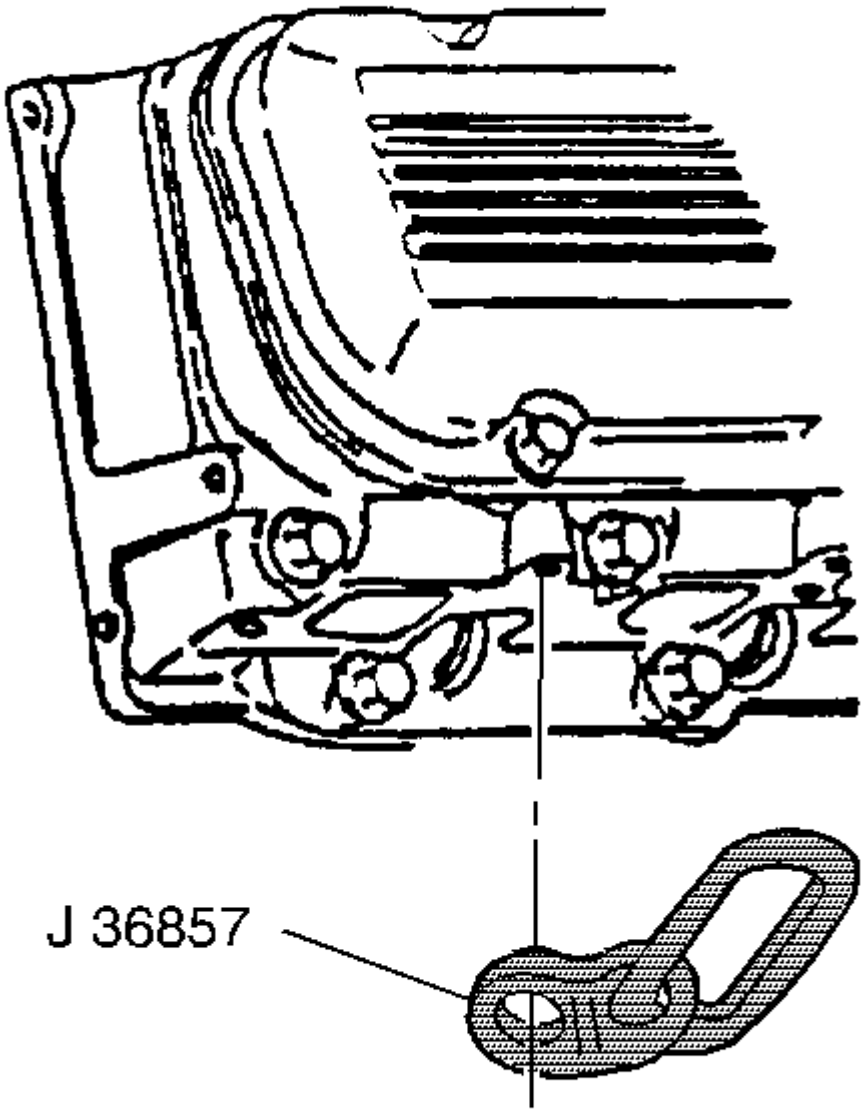

Fig. 217: View Of J 36857 At Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

26. Attach**J 36857** to the rear of the right cylinder head and to the front of the left cylinder head. See **Special Tools and Equipment**.
27. Install the attaching bolt and washer. Use GM P/N 9428217 with GM P/N 15650963.

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Tighten: Tighten the lift bracket bolts to 40 N.m (30 lb ft).

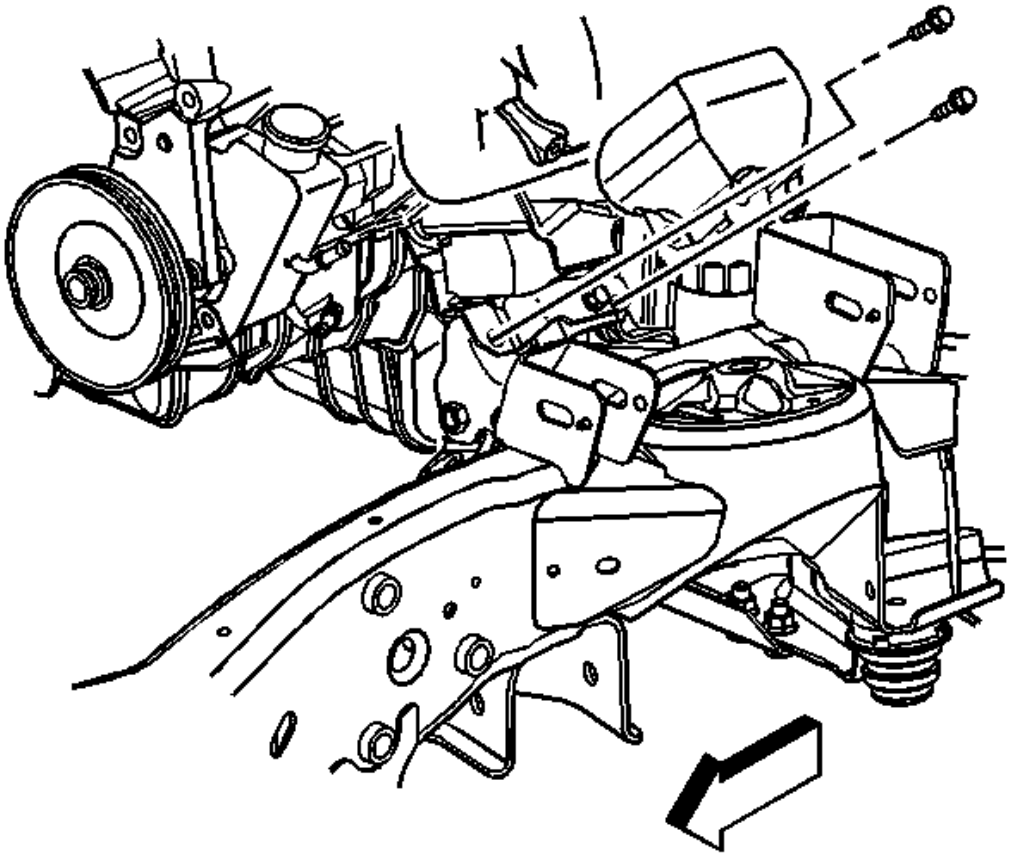

Fig. 218: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

28. Remove the engine mount heat shield bolts and shields.

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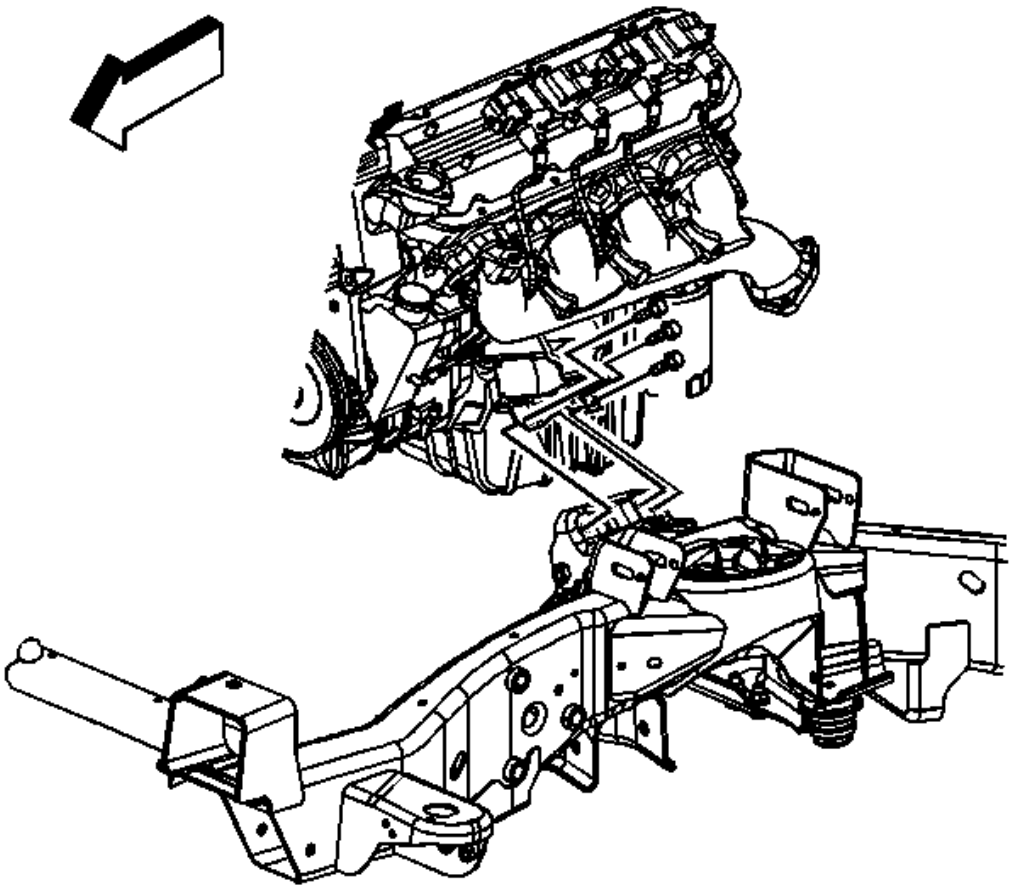

Fig. 219: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

29. Remove the engine mount to engine mount bracket bolts.
30. Remove the engine using a suitable lifting devise.
31. Install the engine onto a suitable engine stand.
32. Remove the generator mounting bracket. Refer to **Generator Bracket Replacement (8.1L Engine)** in Engine Electrical.

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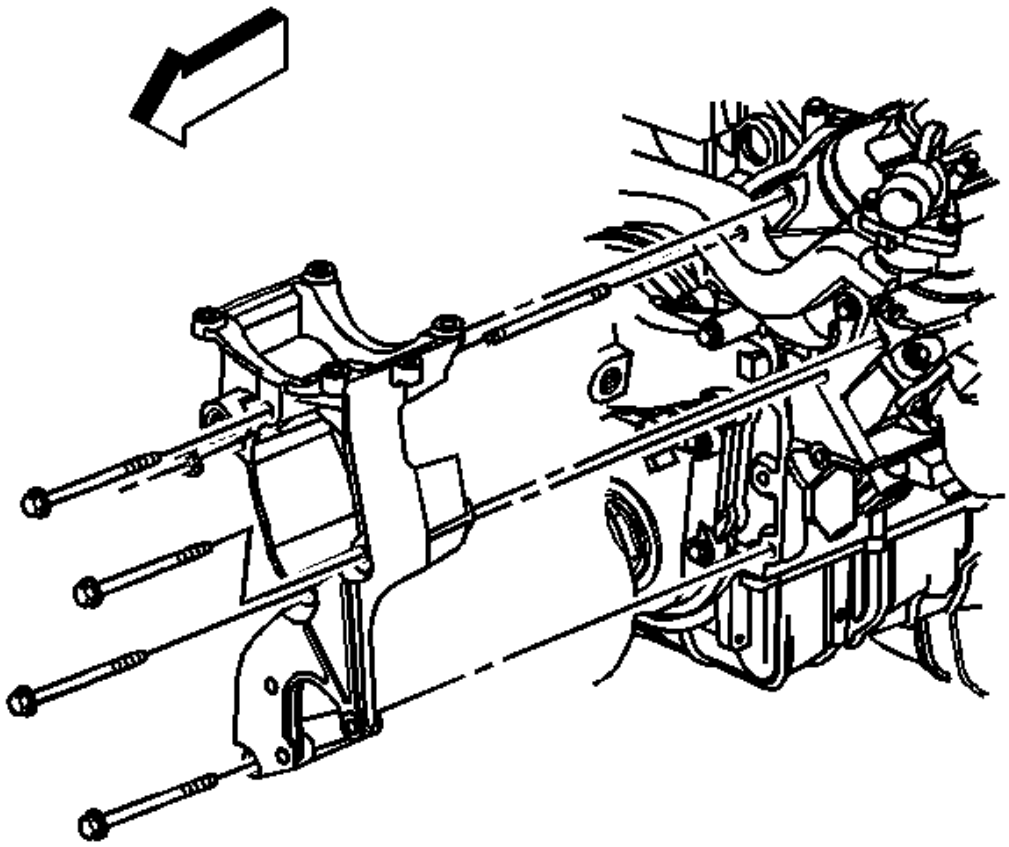

Fig. 220: View Of A/C Compressor/Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

33. Remove the A/C compressor/power steering pump bracket from the cylinder head.
34. Remove the lift brackets from the cylinder head.

Installation Procedure

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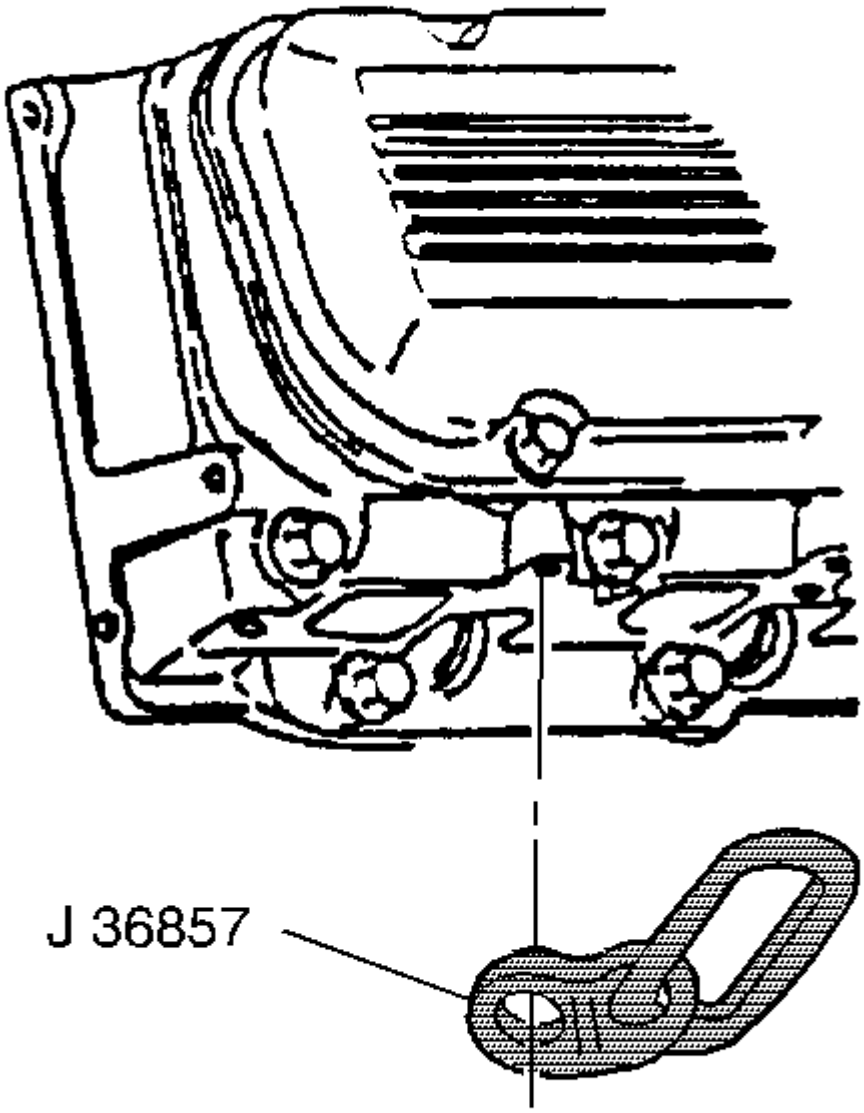

Fig. 221: View Of J 36857 At Right Cylinder Head
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Attach **J 36857** to the rear of the right cylinder head and to the front of the left cylinder head. See **Special Tools and Equipment**.
2. Install the attaching bolt and washer. Use GM P/N 9428217 with GM P/N 15650963.

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Tighten: Tighten the lift bracket bolts to 40 N.m (30 lb ft).

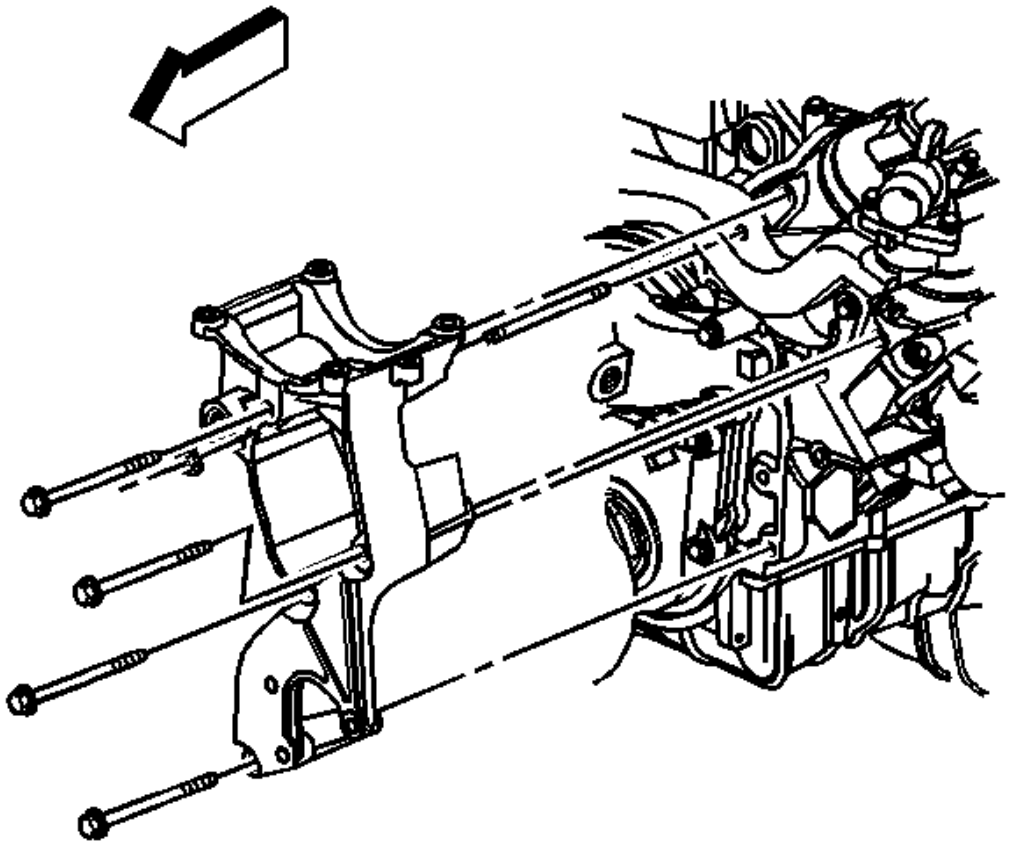

Fig. 222: View Of A/C Compressor/Power Steering Pump Bracket
Courtesy of GENERAL MOTORS CORP.

3. Install the air compressor/power steering mounting bracket to the engine block.

   Tighten: Tighten the power steering pump bracket bolts and nut to 50 N.m (37 lb ft).

4. Install the generator bracket. Refer to **Generator Bracket Replacement (8.1L Engine)** in Engine Electrical.
5. Remove the engine using a suitable lifting devise.
6. Install the engine into the vehicle.

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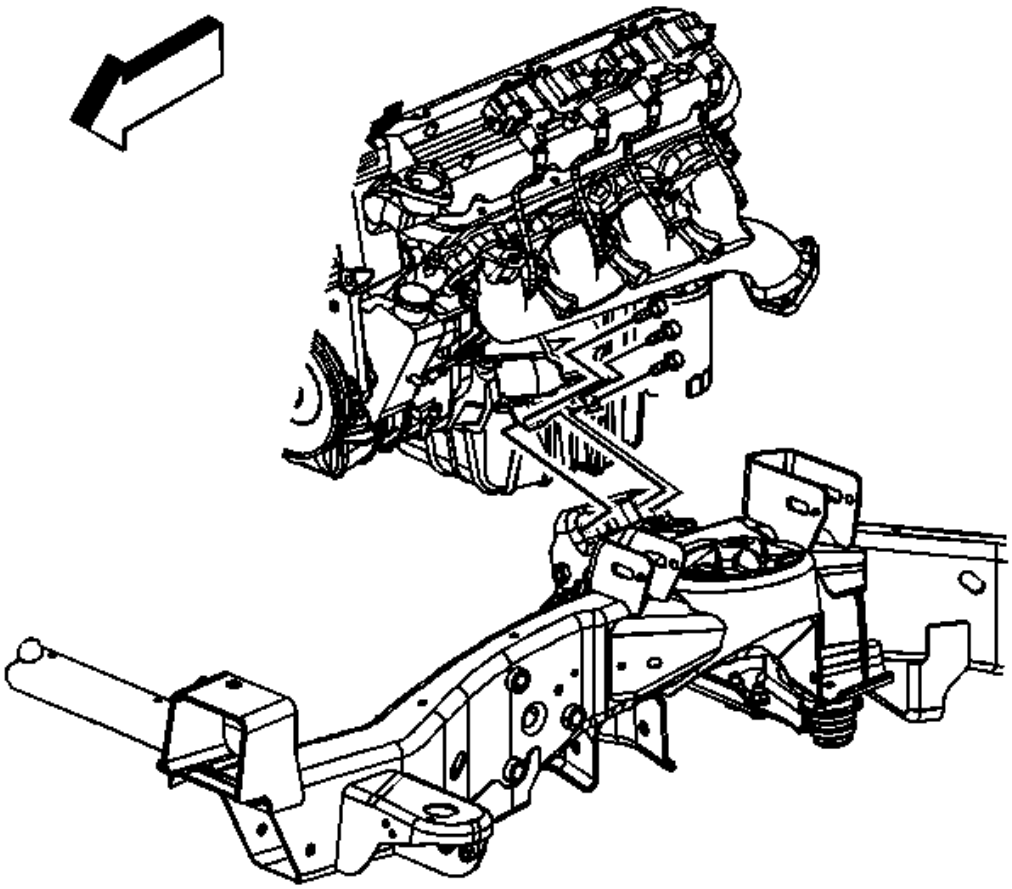

Fig. 223: View Of Engine Mount-To-Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

7. Install the engine mount to engine mount bracket bolts.

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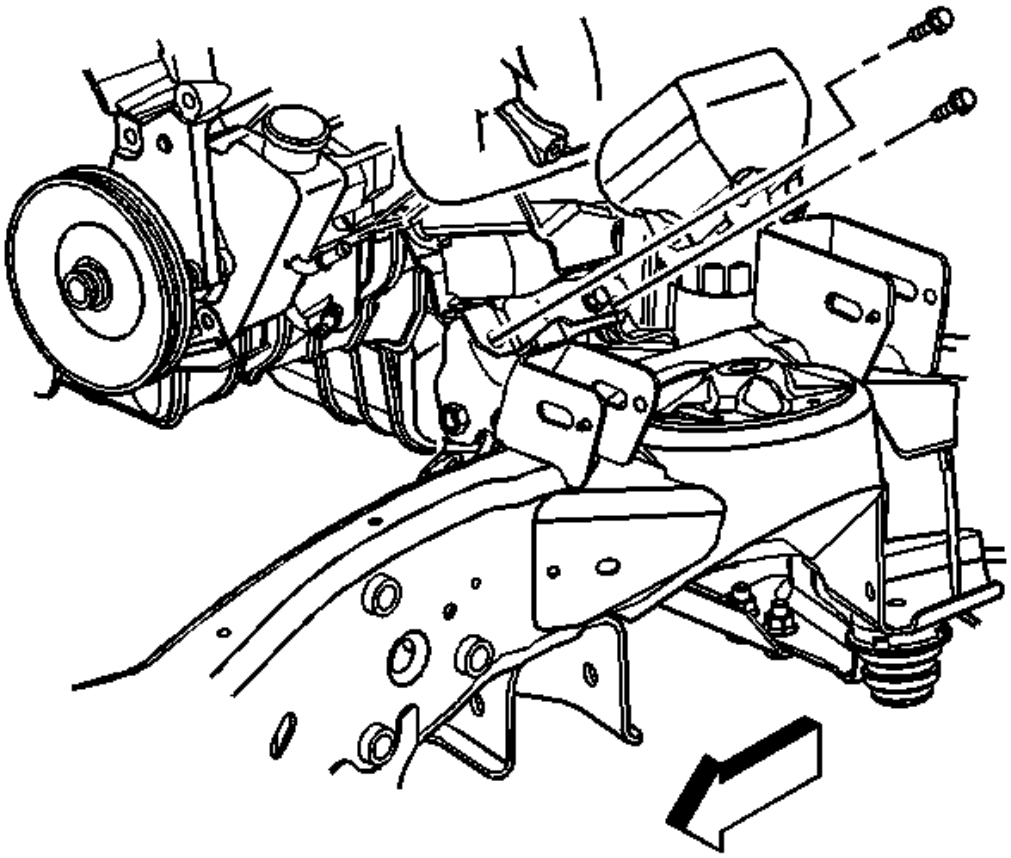

Fig. 224: View Of Engine Mount Heat Shield
Courtesy of GENERAL MOTORS CORP.

8. Install the engine mount heat shield and bolts.
9. Remove the engine lift hooks from the cylinder heads.
10. Raise the vehicle and support with safety stands.
11. Install the engine oil cooler lines to the engine block. Refer to **Engine Oil Cooler Hose/Pipe Replacement (2WD)** or **Engine Oil Cooler Hose/Pipe Replacement (4WD)** in Engine Cooling.

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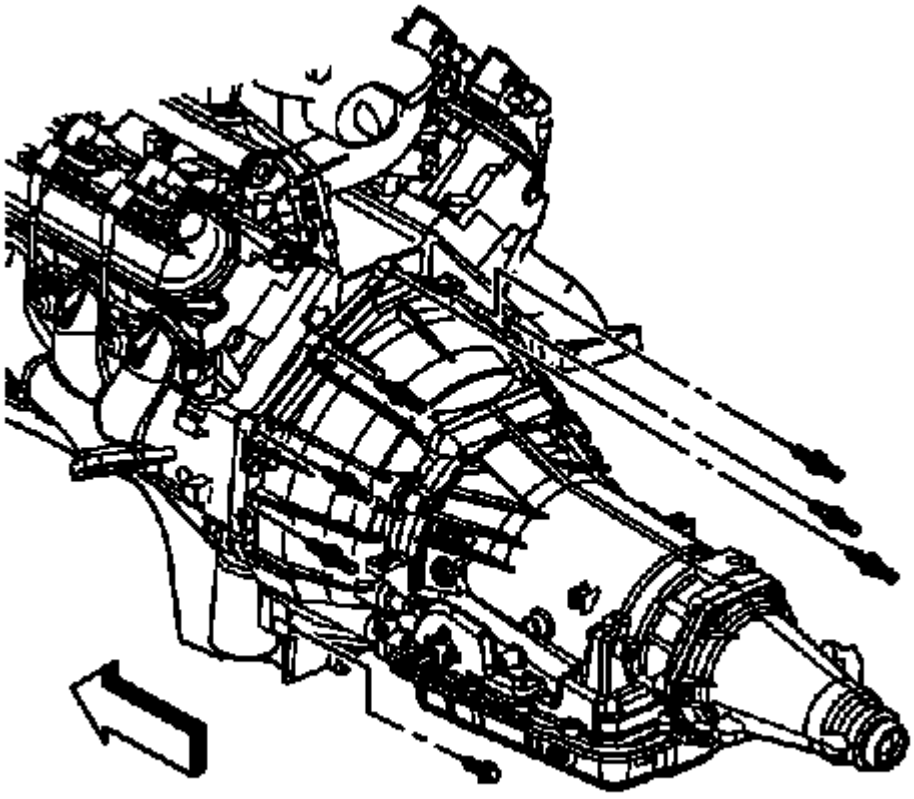

Fig. 225: Identifying Six Studs & One Bolt Securing Transmission To Engine
Courtesy of GENERAL MOTORS CORP.

12. Install the bolts from the transmission to the engine. Refer to **Transmission Replacement** in Automatic Transmission - 4L80-E.
13. Install the torque converter bolts.
14. Install the catalytic converter. Refer to **Catalytic Converter Replacement (6.0L and 8.1L Engines)** in Engine Exhaust.
15. Install the exhaust manifold pipe. Refer to **Exhaust Manifold Pipe Replacement (6.0L and 8.1L Engines)** in Engine Exhaust.
16. Install the hoses to the power steering pump.
17. Install the starter motor. Refer to **Starter Motor Replacement (8.1L Engine)** in Engine Electrical.
18. Lower the vehicle.
19. Route the engine electrical harness.
20. Install the generator. Refer to **Generator Replacement (8.1L Engine)** in Engine Electrical.

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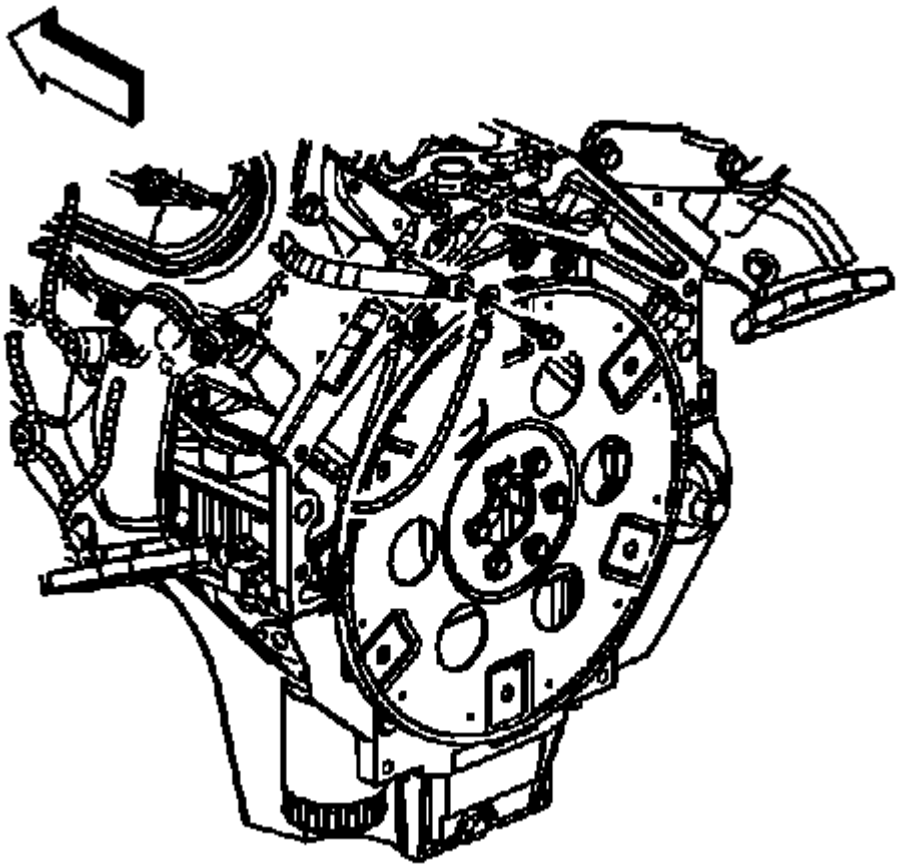

Fig. 226: View Of Ground Cable Bolt At Engine Block
Courtesy of GENERAL MOTORS CORP.

21. Install the ground cable bolt at the engine block.

    Tighten: Tighten the engine wiring harness bolt to 16 N.m (12 lb ft).

22. Install the vacuum lines to the engine.

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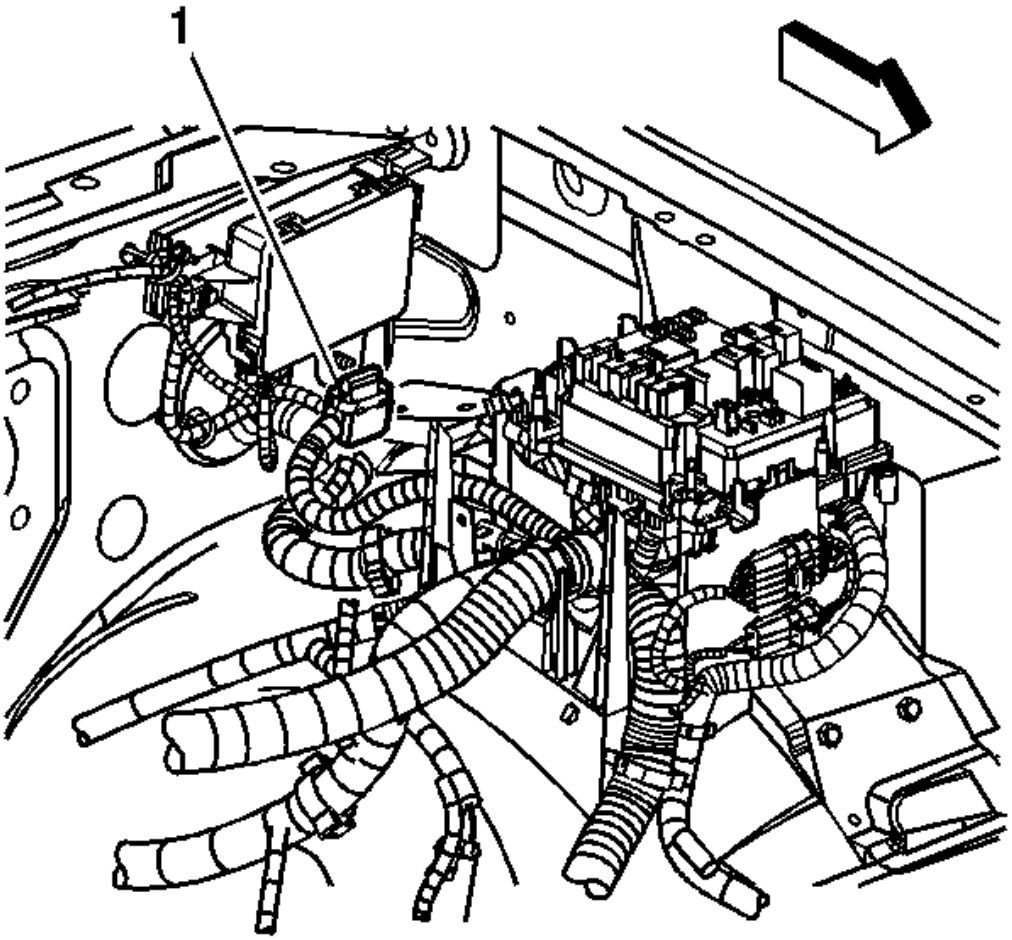

Fig. 227: View Of Throttle Actuator Control (TAC) Module Electrical Connector
Courtesy of GENERAL MOTORS CORP.

23. Connect the TAC module electrical connector (1).
24. Install the radiator. Refer to **Radiator Replacement (8.1L)** in Engine Cooling.
25. Install the A/C compressor. Refer to **Compressor Replacement (L18)** in Heating, Ventilation and Air Conditioning.

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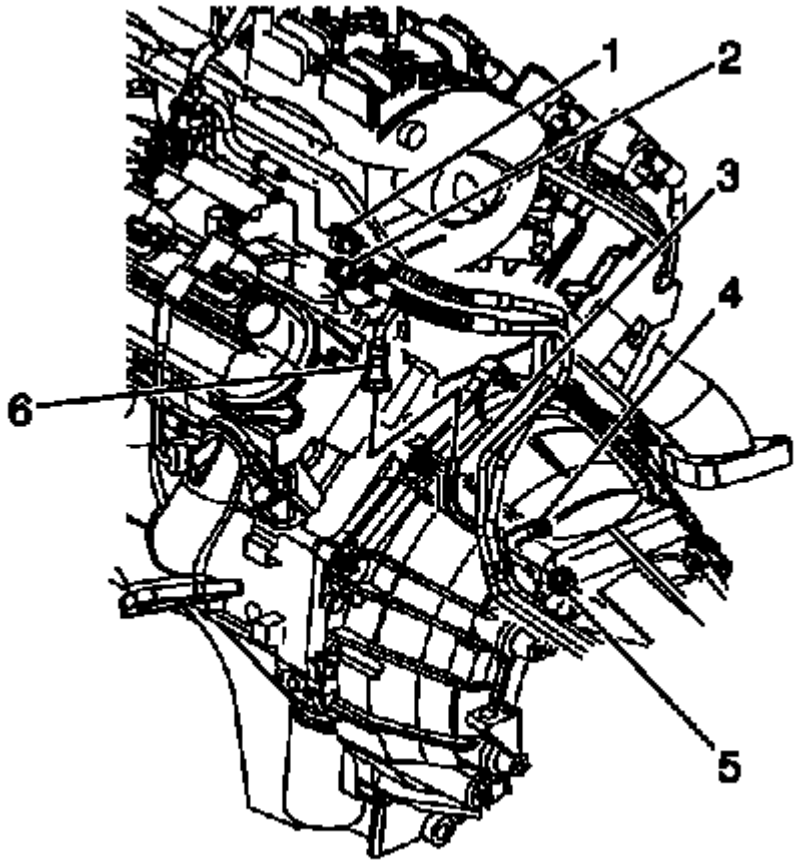

Fig. 228: View Of Rear Of Engine Fuel Pipe Connections
Courtesy of GENERAL MOTORS CORP.

26. Disconnect the fuel feed and return pipes (1, 2) from the fuel rail.
27. Install the ignition coils. Refer to **Ignition Coil(s) Replacement** in Engine Controls - 8.1L.

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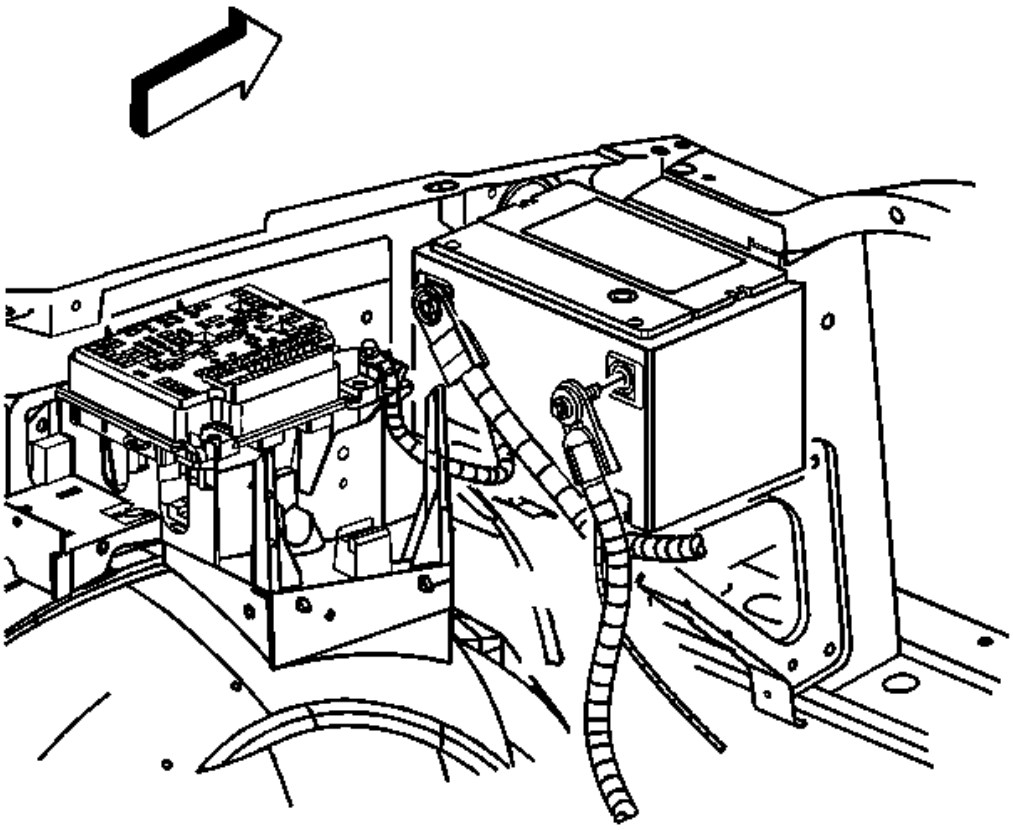

Fig. 229: View Of Battery Cables
Courtesy of GENERAL MOTORS CORP.

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

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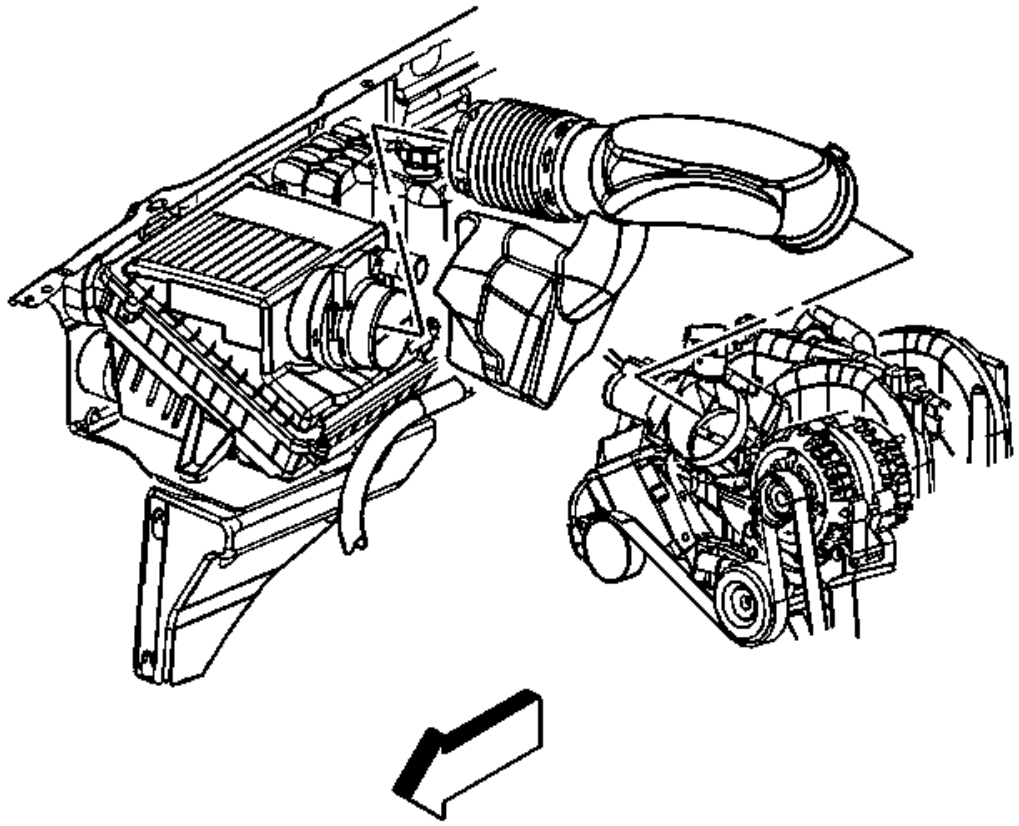

Fig. 230: View Of Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS CORP.

30. Install the air cleaner outlet duct.
31. Tighten the clamps at the throttle body and air cleaner.

    Tighten: Tighten the clamps to 4 N.m (35 lb in).

32. Remove fender covers from both fenders.

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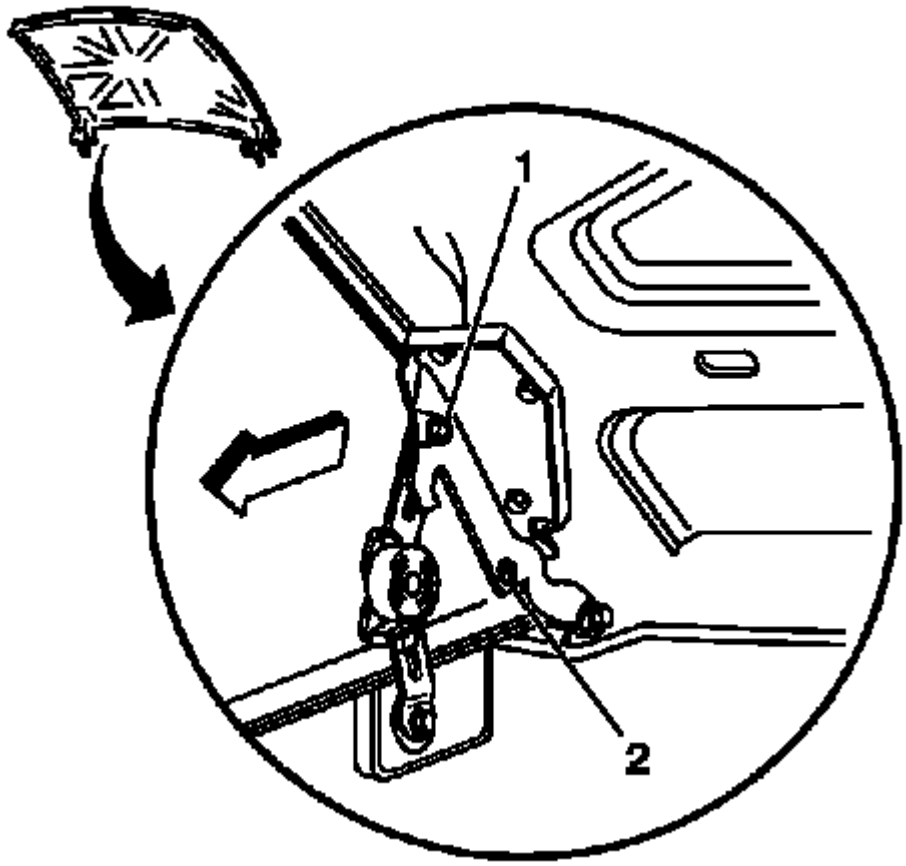

Fig. 231: Identifying Hood Hinge Normal And Service Position Bolt Holes
Courtesy of GENERAL MOTORS CORP.

33. Remove the hood hinge bolts from the service position (2).
34. Lower the hood to the normal position.
35. Install the hood hinge bolts.

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

36. Perform the engine prelubing procedure. Refer to **Engine Prelubing**.
37. Before starting a new engine or one that has been repaired, complete the following procedure:
    1. Crank the engine several times. Listen for any unusual noises or evidence that any of the parts are binding.
    2. Install the fuel pump fuse and connect the coil harness connectors and start the engine and listen for unusual noises.
    3. Check the vehicle oil pressure gage or light and confirm that the engine has acceptable oil pressure. If necessary install an oil pressure gage and measure the oil pressure.
    4. Run the engine at about 1000 RPMs until the engine has reached normal operating temperature.
    5. Inspect for oil and or coolant leaks while the engine is running.

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6. Stop the engine and perform a final inspection for the proper engine oil and coolant levels.
7. The final step is to perform the crankshaft position (CKP) sensor variation learn procedure. Refer to **CKP System Variation Learn Procedure** in Engine Controls - 8.1L.

Engine Oil and Oil Filter Replacement

Removal Procedure

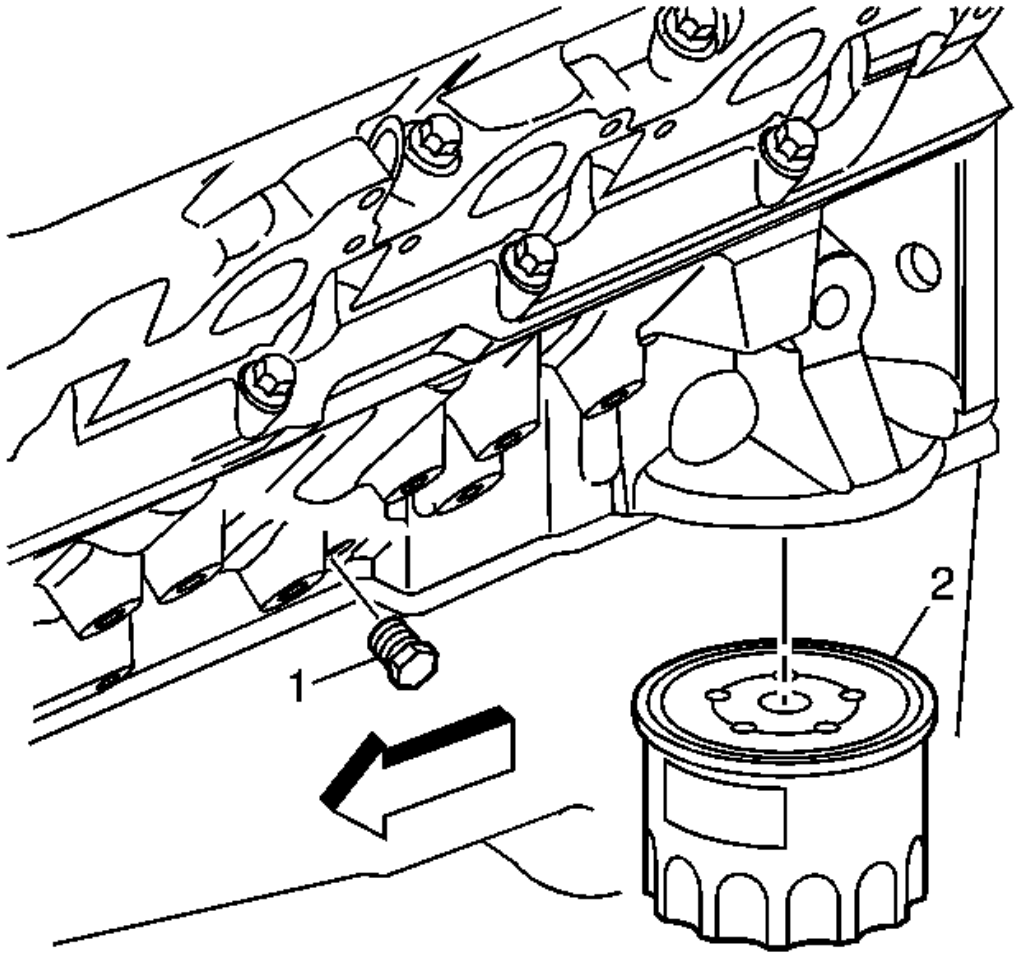

Fig. 232: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** in General Information.
2. Remove the oil pan drain plug and allow the engine oil to drain completely.

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3. Clean the oil pan drain plug surface.
4. Remove the oil filter (2) from the engine block and allow the engine oil to drain completely.
5. Clean the oil filter surface.

Installation Procedure

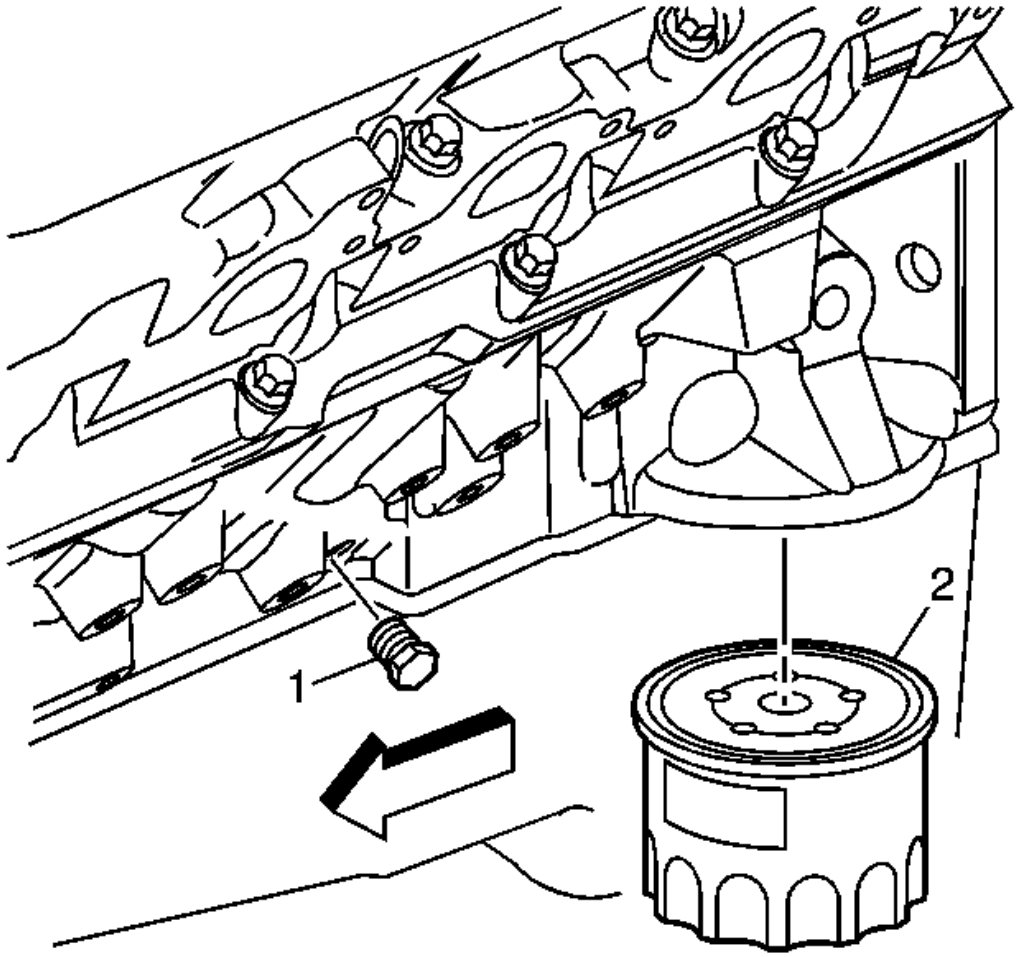

Fig. 233: View Of Oil Filter
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install a new oil filter (2) to the engine block. Tighten the oil filter per the oil filter manufacturers instruction printed on the oil filter box.

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2. Install the oil pan drain plug.

   Tighten: Tighten the plug to 28 N.m (21 lb ft).

3. Lower the vehicle.
4. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations** in Maintenance and Lubrication.

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

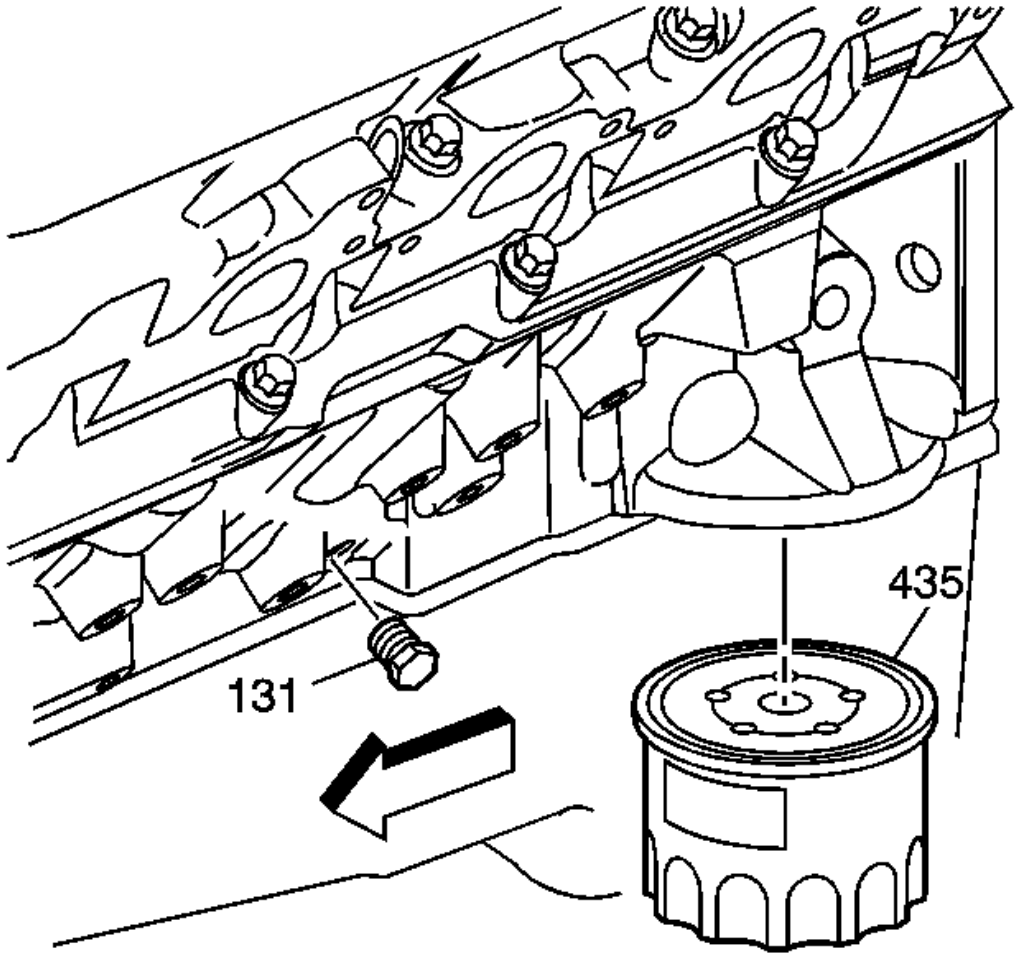

Fig. 234: View Of Oil Filter & Left Side Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil pan drain plug.
2. Drain the engine oil.
3. Remove the oil filter (435).
4. Remove the left side engine block coolant drain hole plug (131) and the right side engine block coolant drain hole plug.
5. Drain the engine coolant.

Crankshaft Balancer Removal

Tools Required

- **J 38416-B** Harmonic Balancer Remover. See **Special Tools and Equipment**.
- **J 42846** Crankshaft Protector Button. See **Special Tools and Equipment**.
- **J 42847** Flywheel Holding Tool. See **Special Tools and Equipment**.

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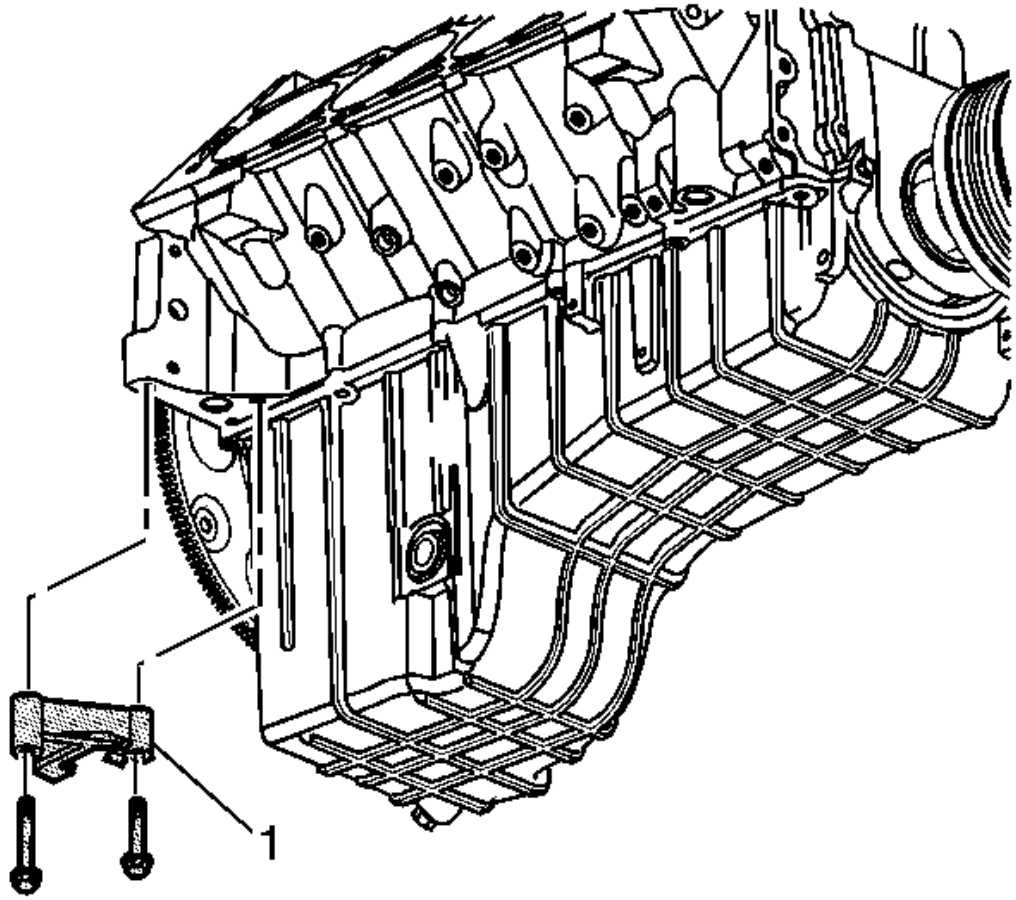

Fig. 235: View Of J 42847 & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Ensure that the teeth of the flywheel holding tool engage the engine flywheel teeth.

1. Install the **J 42847** (1) to the starter bolt holes. See **Special Tools and Equipment**.

Tighten: Tighten the **J 42847** bolts to 50 N.m (37 lb ft). See **Special Tools and Equipment**.

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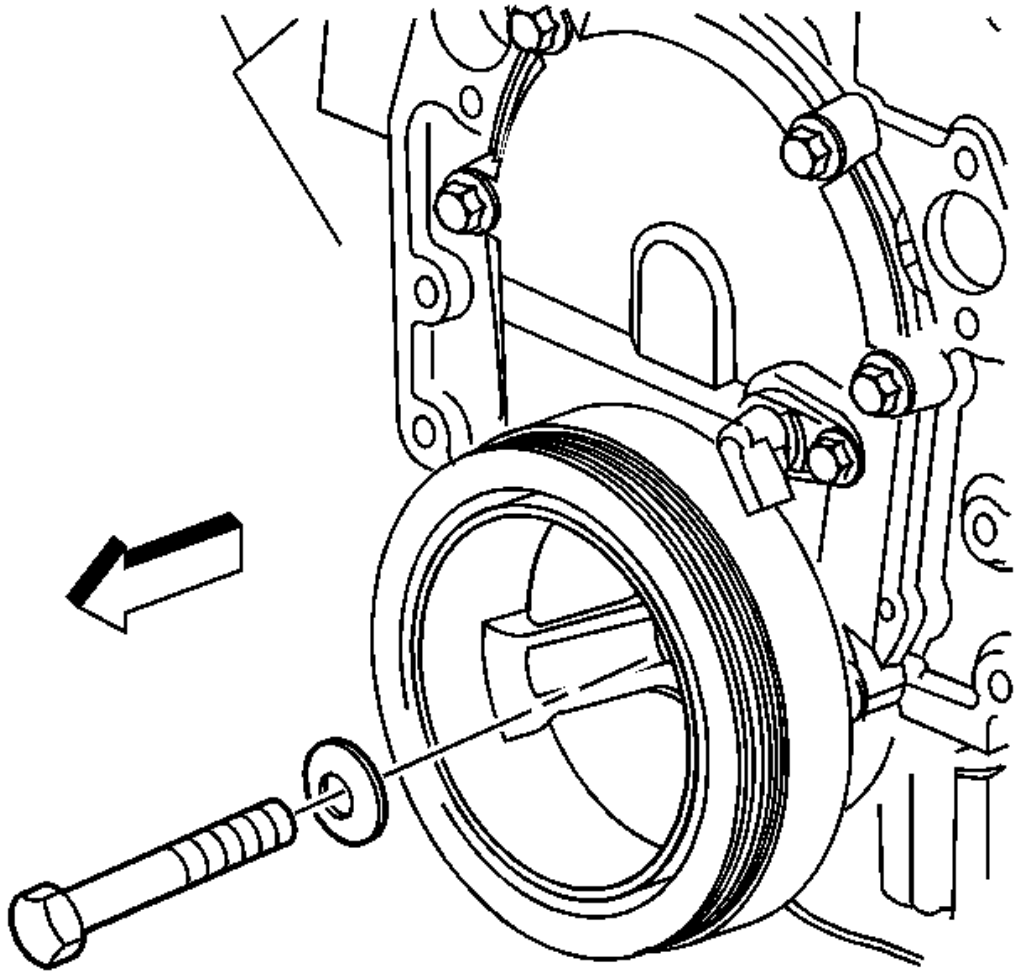

Fig. 236: View Of Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

2. Remove the crankshaft balancer bolt and washer.

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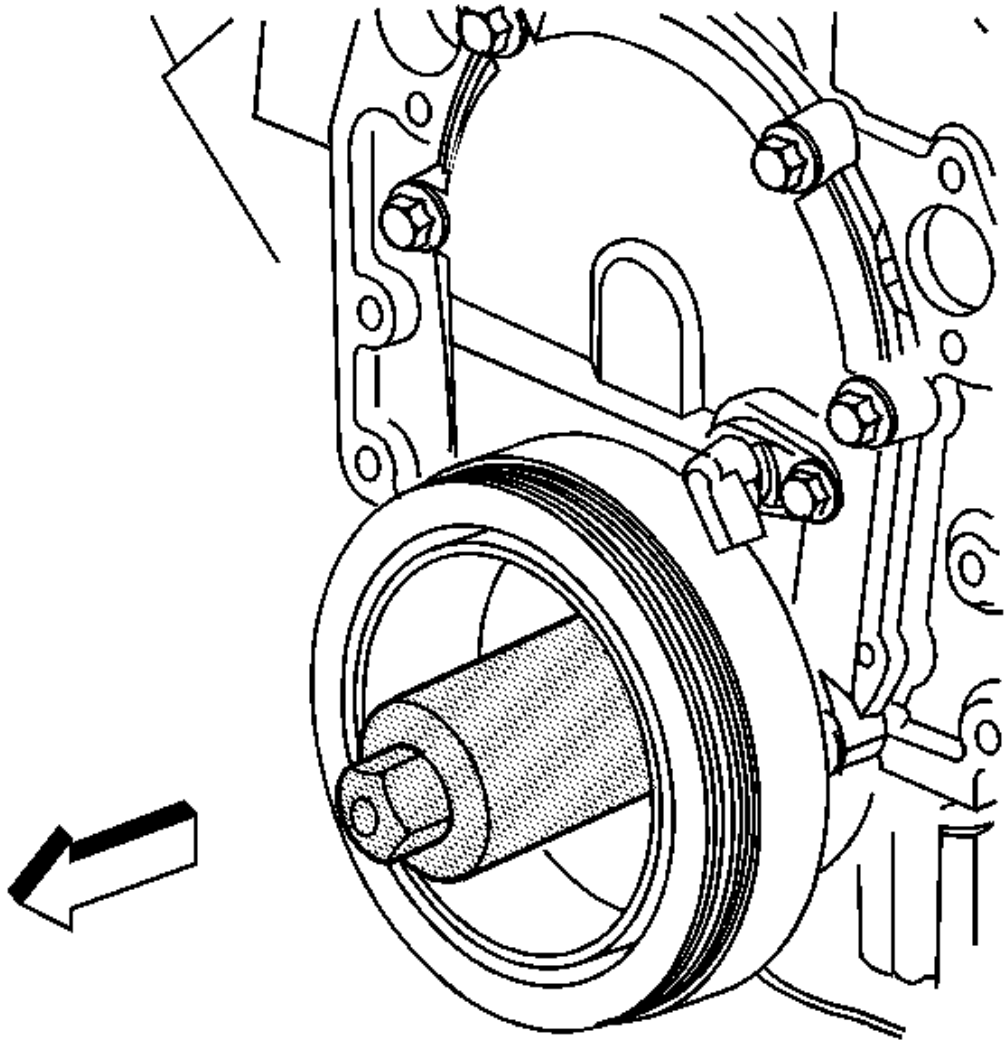

Fig. 237: Installing J 42846 Onto End Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Install the **J 42846** onto the end of the crankshaft. See **Special Tools and Equipment**.

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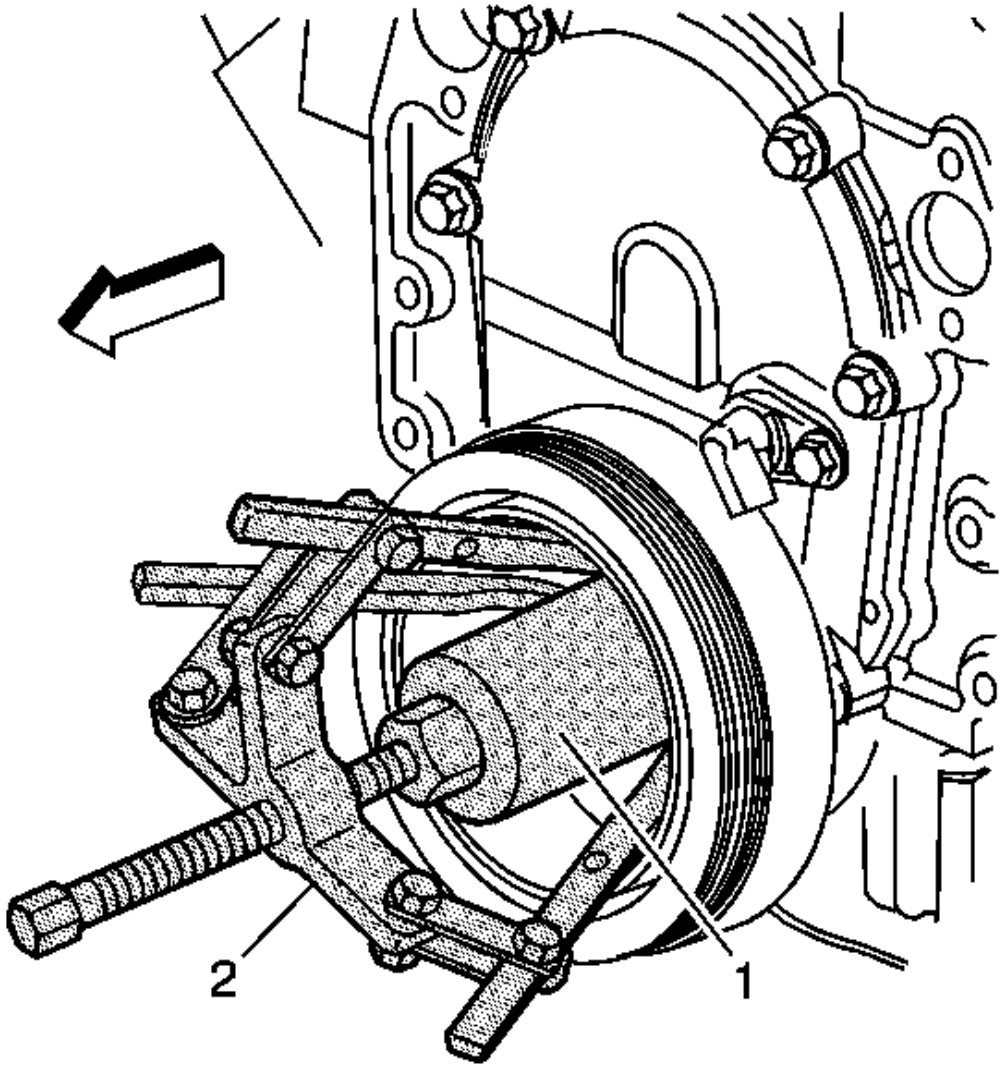

Fig. 238: Removing Crankshaft Balancer Using J 38416-B & J 42846
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 38416-B** (2) in order to remove the crankshaft balancer. See **Special Tools and Equipment**. Place the legs of the **J 38416-B** into the recesses cast into the backside of the balancer inner hub. See **Special Tools and Equipment**.
5. Tighten the center screw of the **J 38416-B** until the crankshaft balancer is removed from the end of the crankshaft. See **Special Tools and Equipment**.

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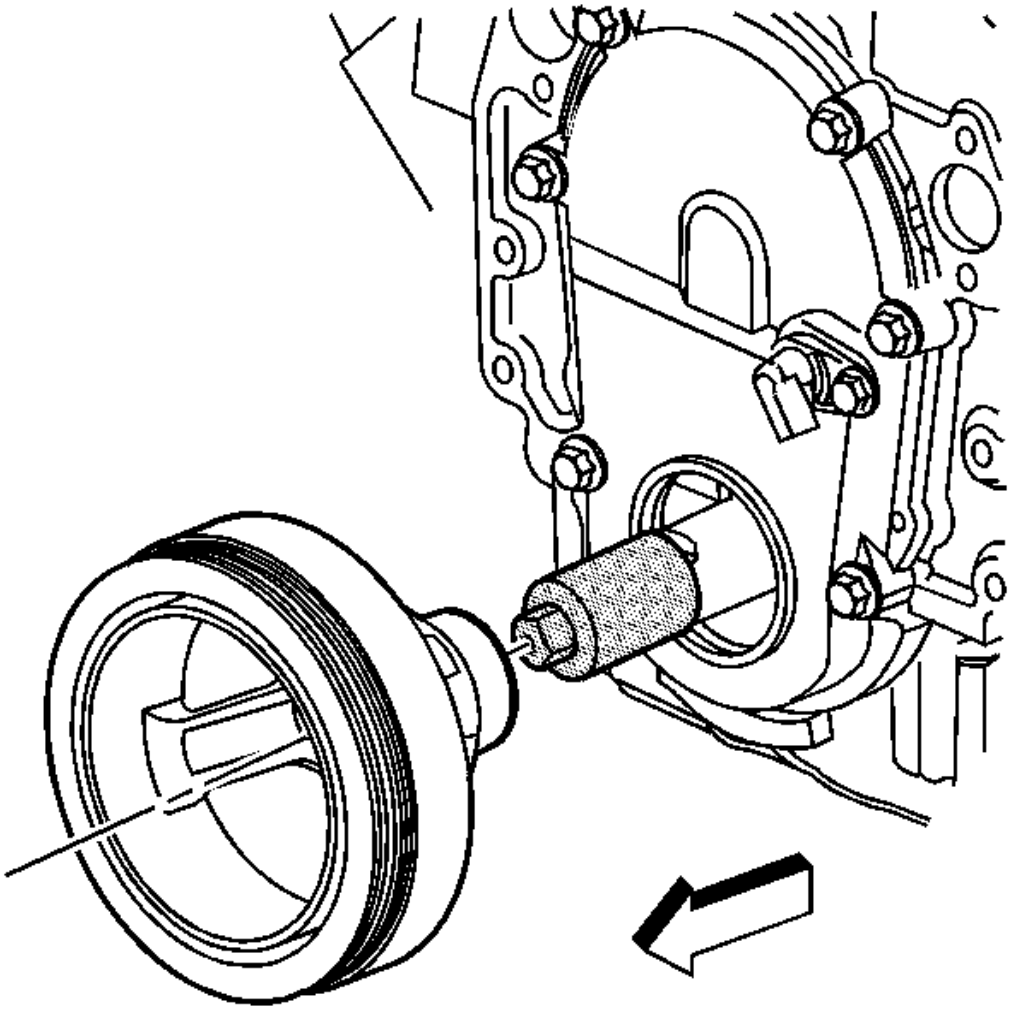

Fig. 239: Removing Crankshaft Balancer & J 42846
Courtesy of GENERAL MOTORS CORP.

6. Remove the **J 38416-B** . See **Special Tools and Equipment**.
7. Remove the crankshaft balancer.
8. Remove the **J 42846** from the end of the crankshaft. See **Special Tools and Equipment**.

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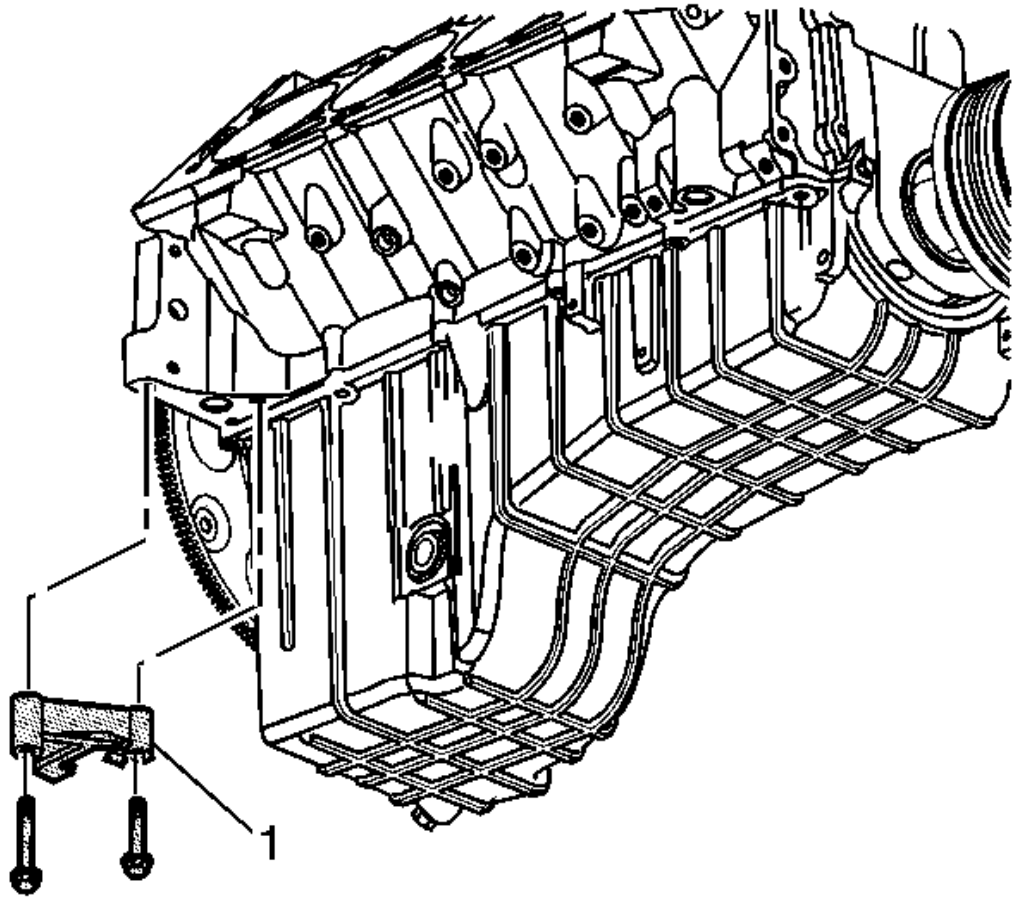

Fig. 240: View Of J 42847 & Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the **J 42847** (1). See **Special Tools and Equipment**.

Engine Flywheel Removal

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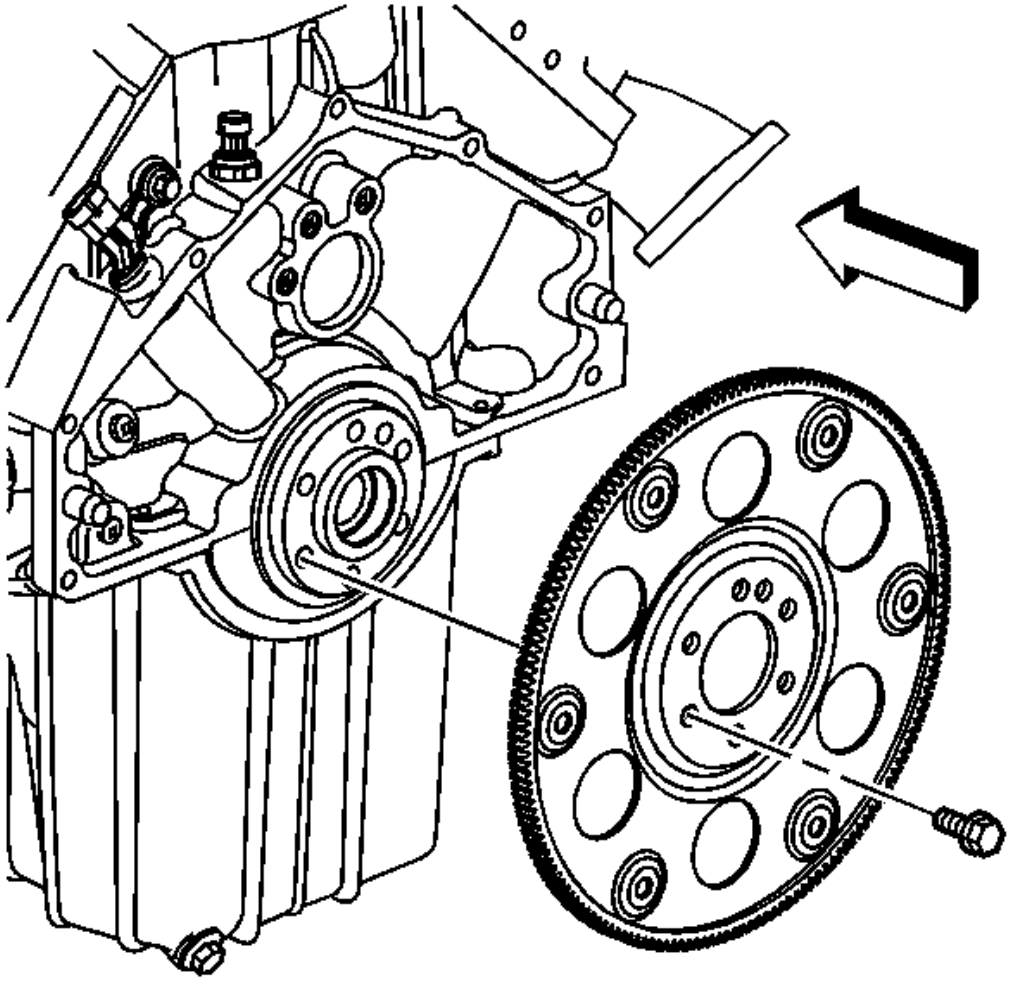

Fig. 241: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.

Crankshaft Rear Oil Seal Removal

Tools Required

J 43320 Crankshaft Rear Seal Puller. See **Special Tools and Equipment**.

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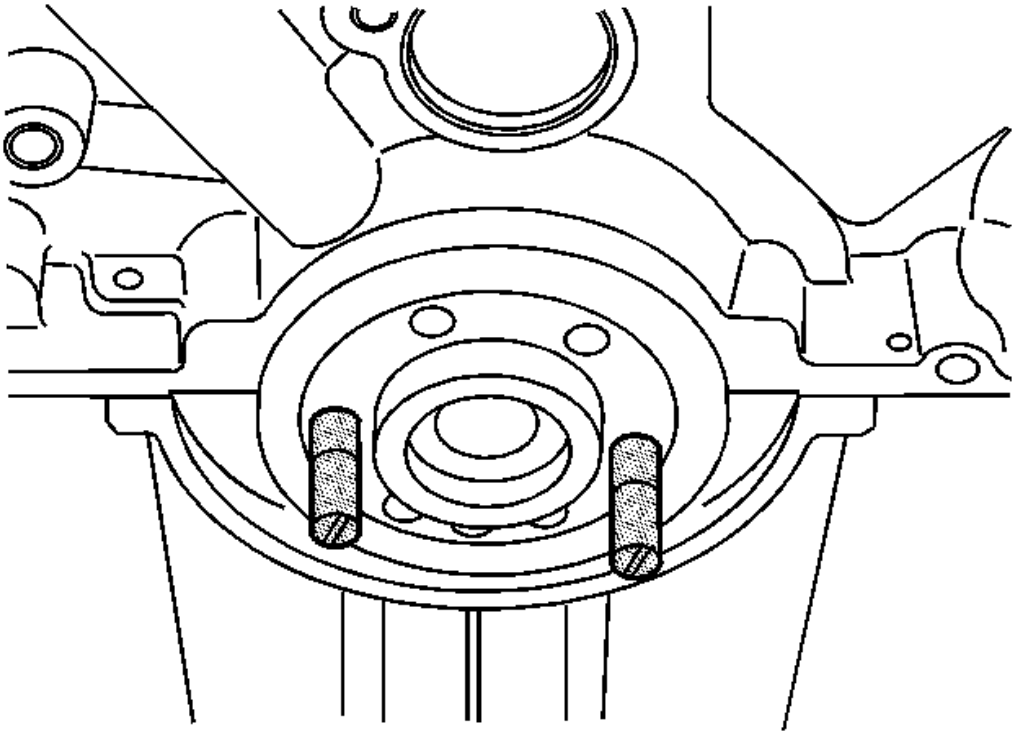

Fig. 242: View Of Guide Pins In Crankshaft
Courtesy of GENERAL MOTORS CORP.

1. Install the **J 43320** guide pins into the crankshaft. See **Special Tools and Equipment**.

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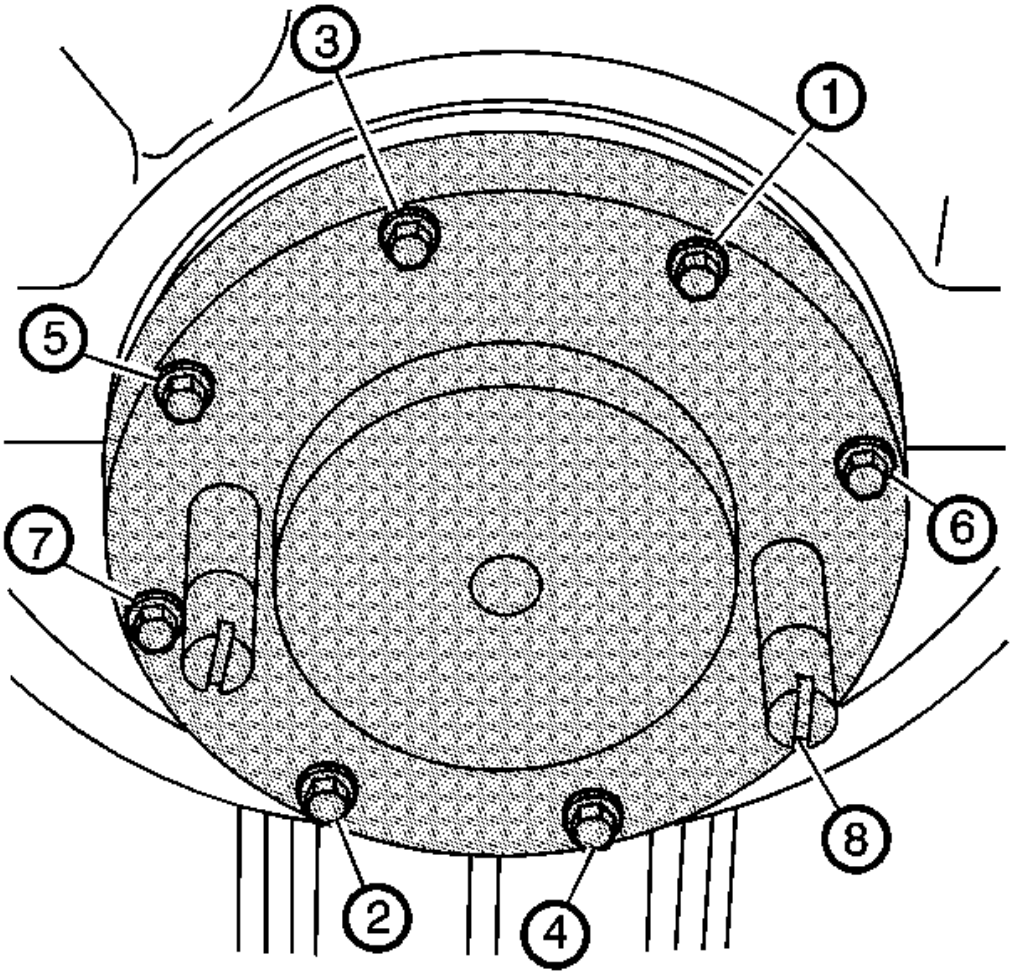

Fig. 243: J 43320 Self-Drilling Sheet Metal Screws Installation Sequence
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 43320** over the guide pins. See **Special Tools and Equipment**.
3. Using a suitable drill, insert eight of the self-drilling sheet metal screws (1-8) into the rear crankshaft seal, using a criss-cross pattern. The self-drilling screws are included with the **J 43320** . See **Special Tools and Equipment**.

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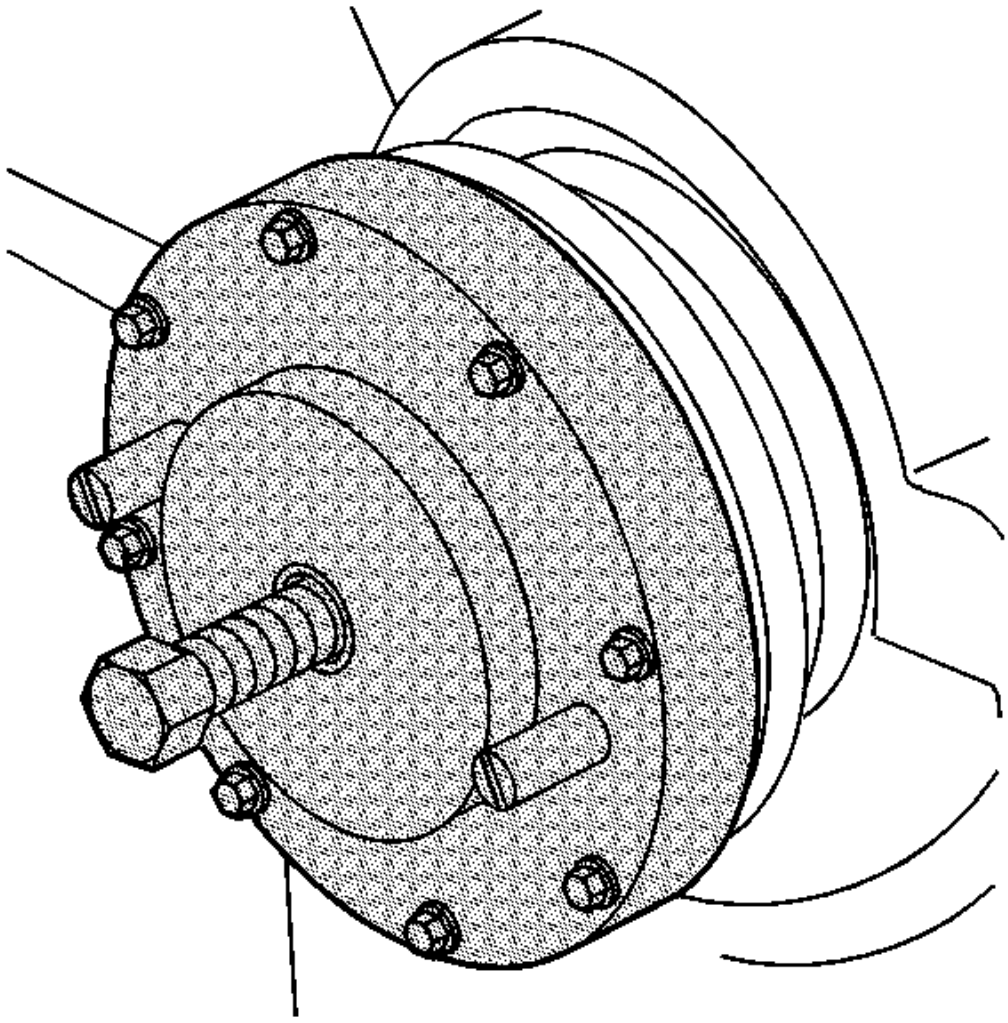

Fig. 244: View Of J 43320 & Center Bolt
Courtesy of GENERAL MOTORS CORP.

4. Thread the center bolt of **J 43320** into the crankshaft to remove the seal. See **Special Tools and Equipment**.
5. Remove the **J 43320** guide pins from the crankshaft. See **Special Tools and Equipment**.

Oil Level Indicator and Tube Removal

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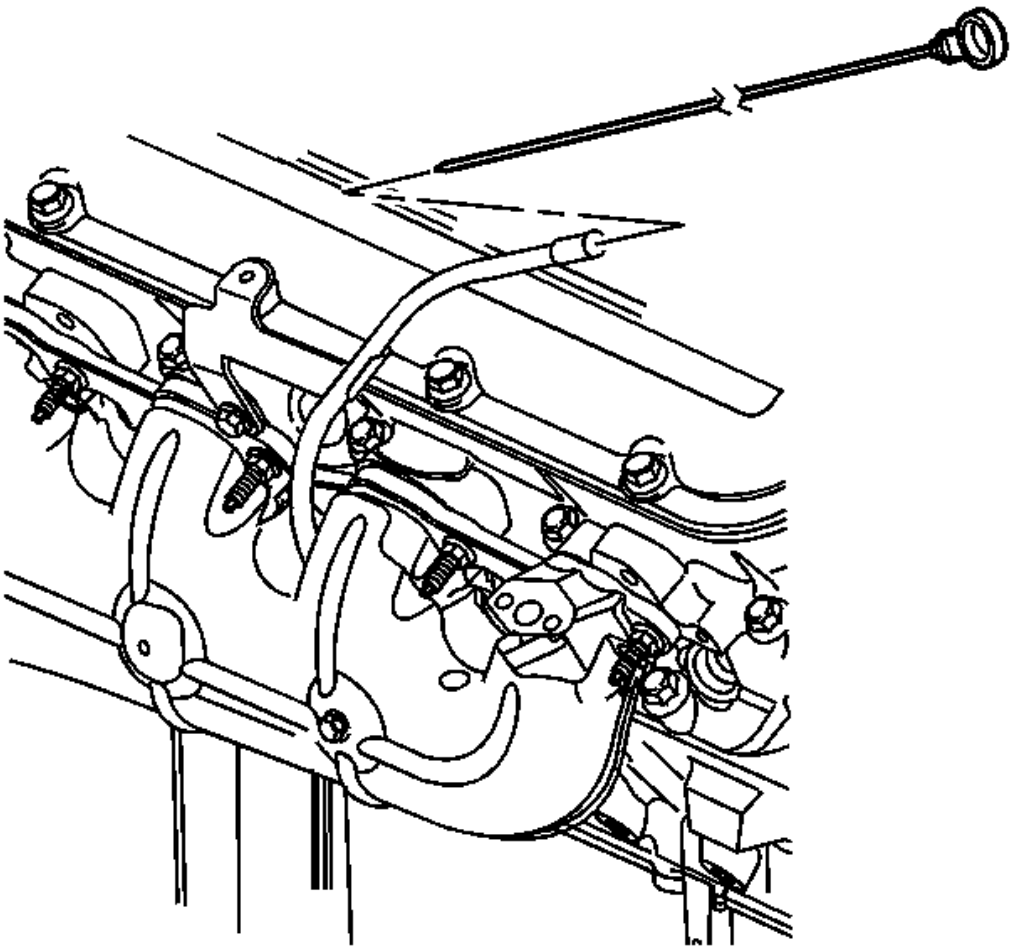

Fig. 245: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil level indicator from the oil level indicator tube.

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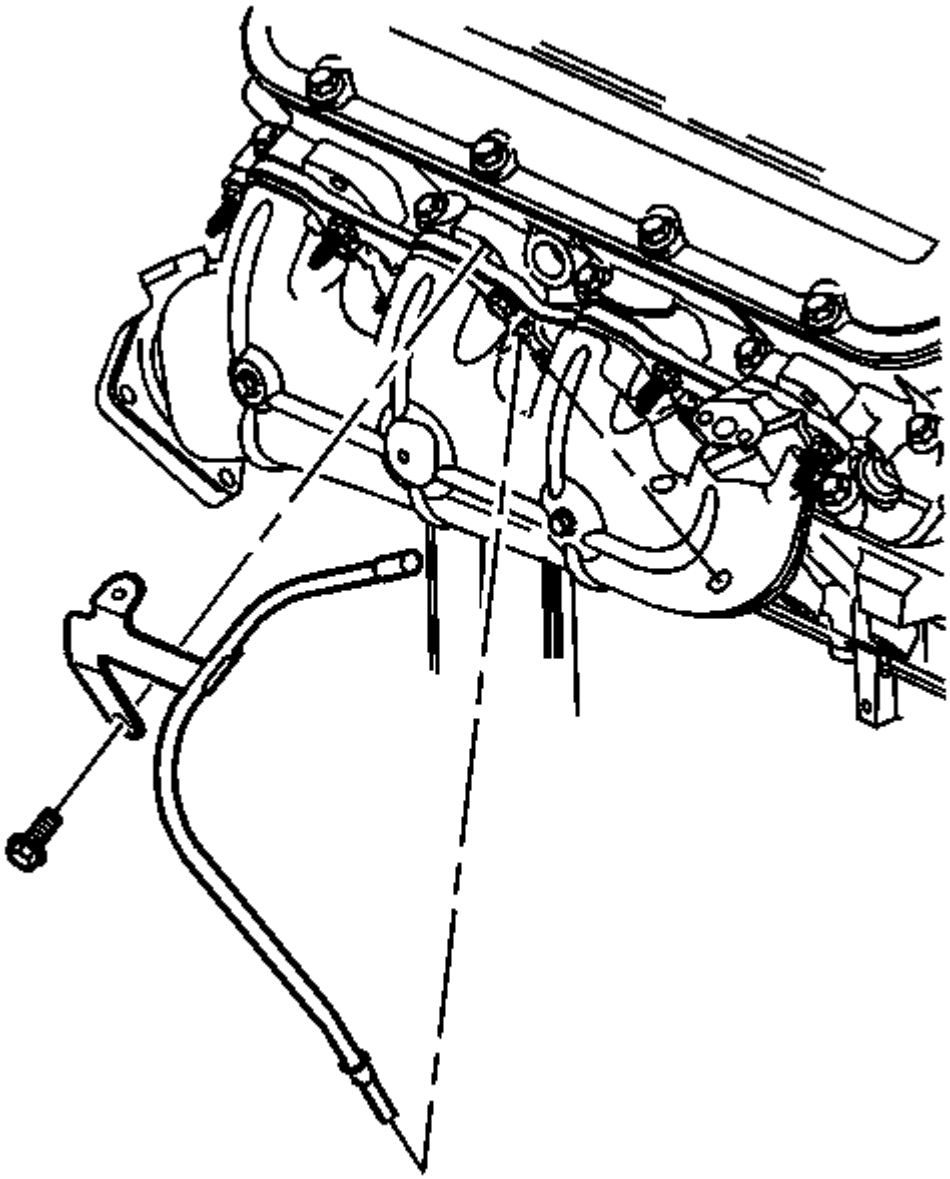

Fig. 246: View Of Oil Level Indicator Tube Bolt
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil level indicator tube bolt.
3. Remove the oil level indicator tube from the oil pan.
4. Remove the O-ring seal from the oil level indicator tube.

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Exhaust Manifold Removal - Left

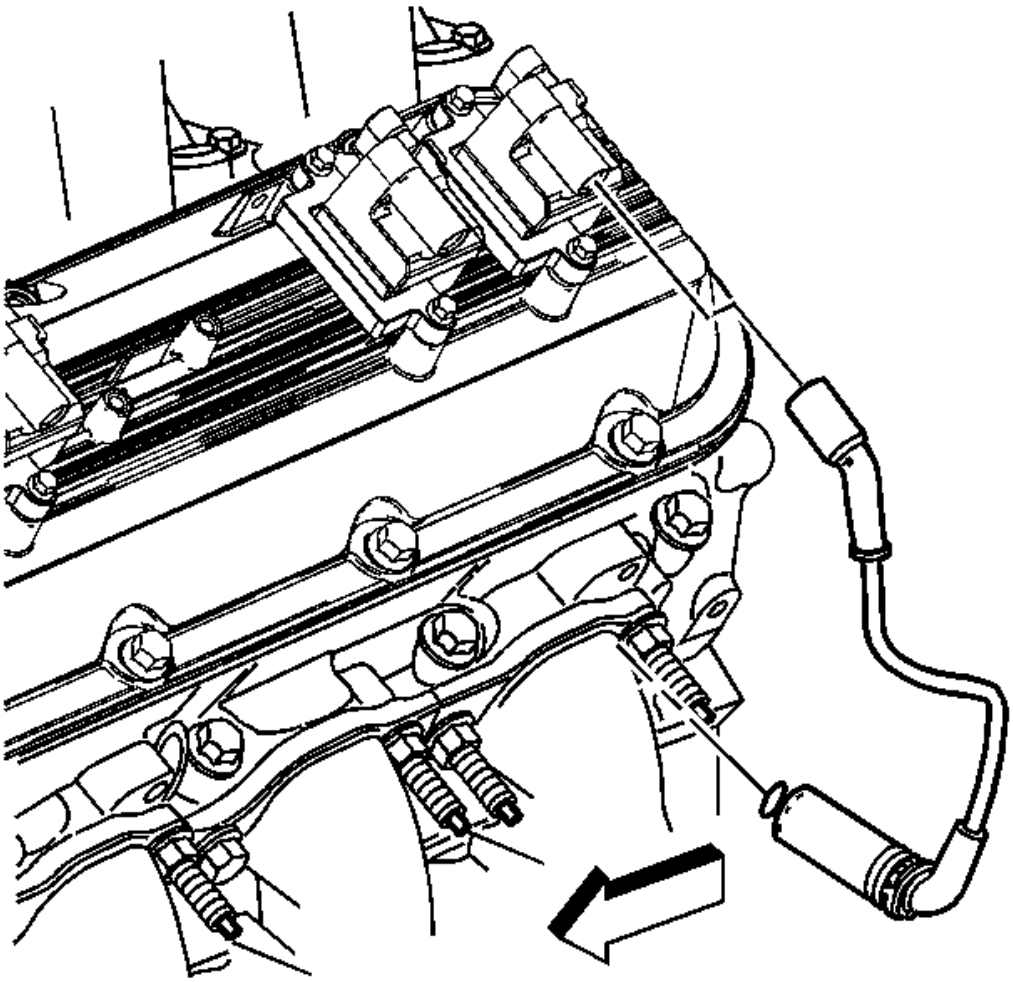

Fig. 247: View Of Spark Plug Wires
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs and ignition coils.

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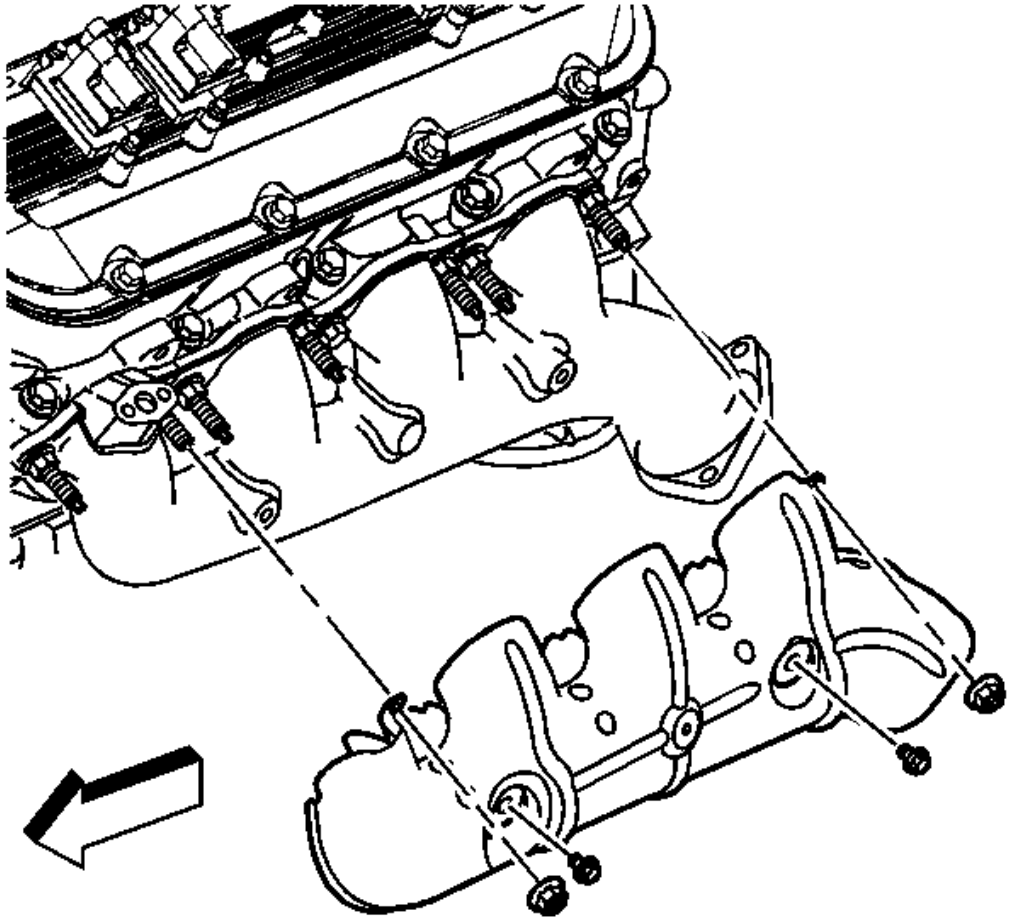

Fig. 248: View Of Exhaust Manifold Heat Shield, Bolts & Nuts (Left)
Courtesy of GENERAL MOTORS CORP.

2. Remove the exhaust manifold heat shield bolts and nuts.
3. Remove the exhaust manifold heat shield.

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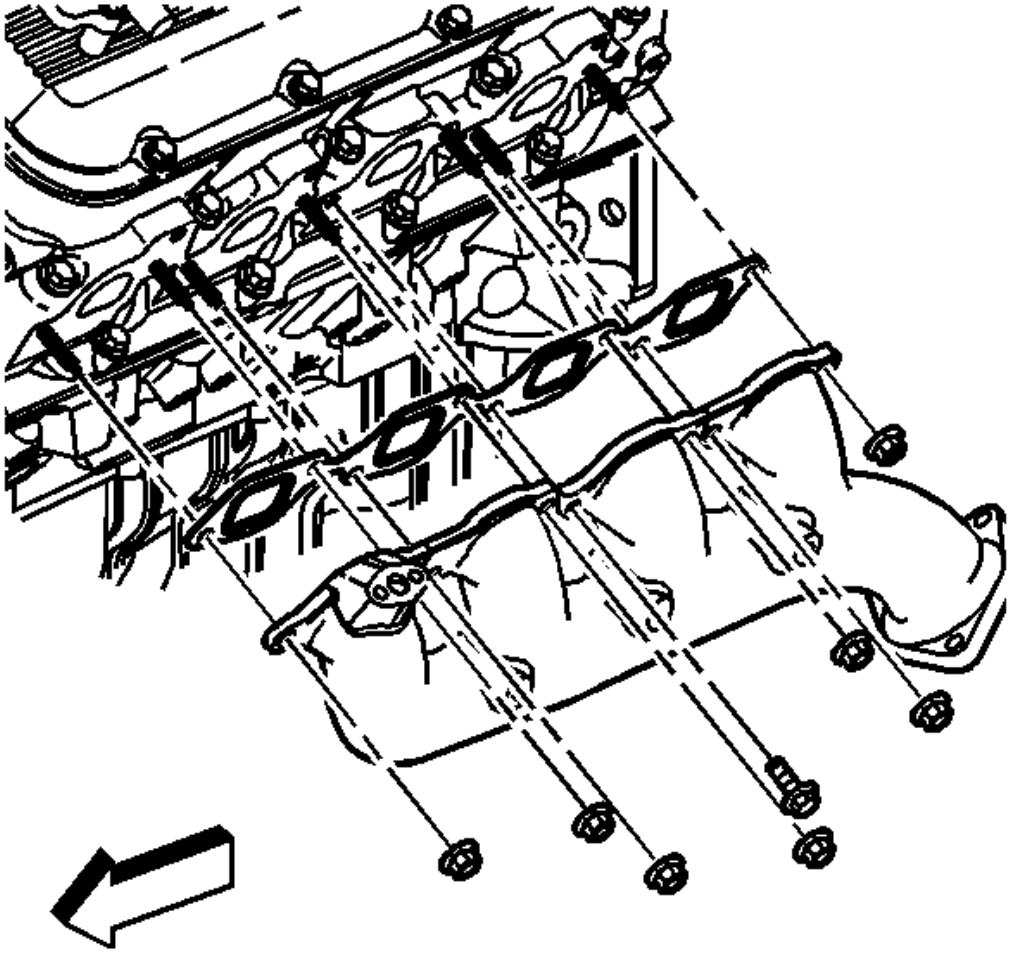

Fig. 249: View Of Left Exhaust Manifold, Gasket, Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold nuts and center bolt.
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket.

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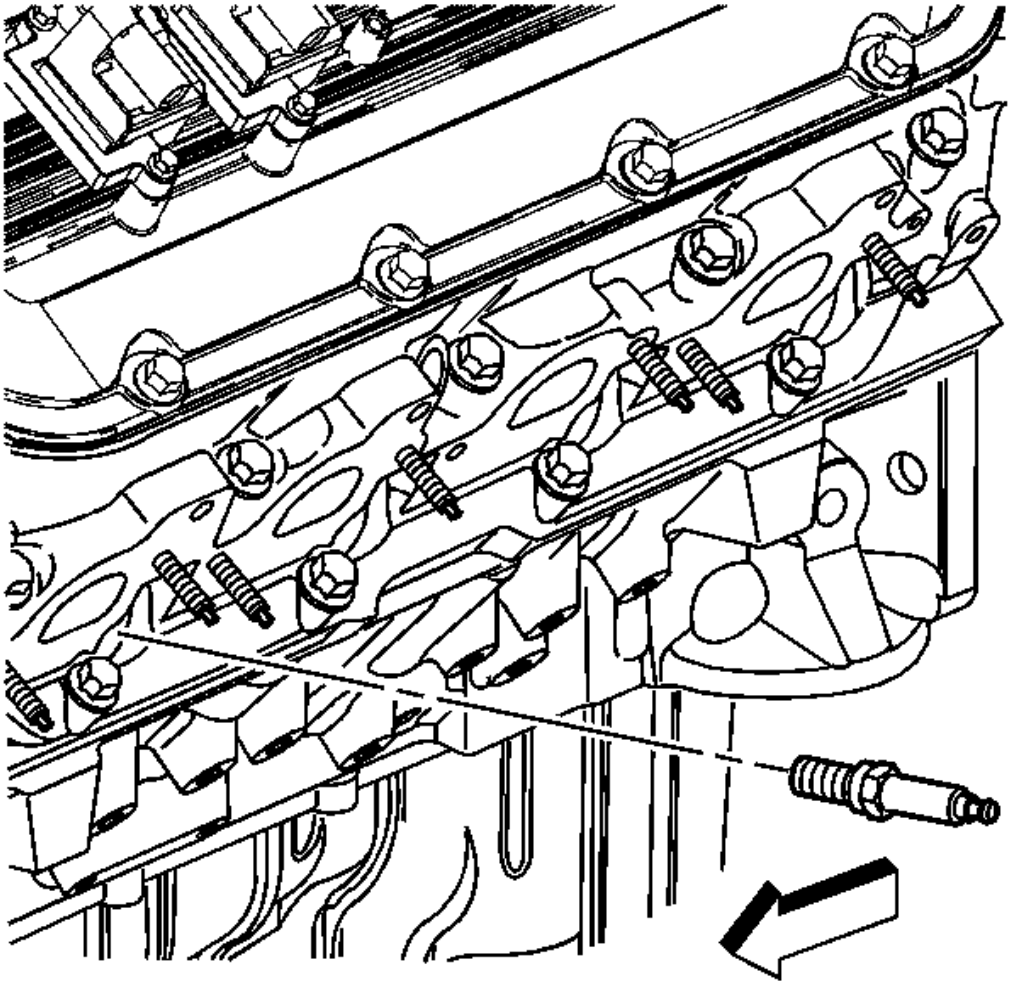

Fig. 250: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the spark plugs, if required.

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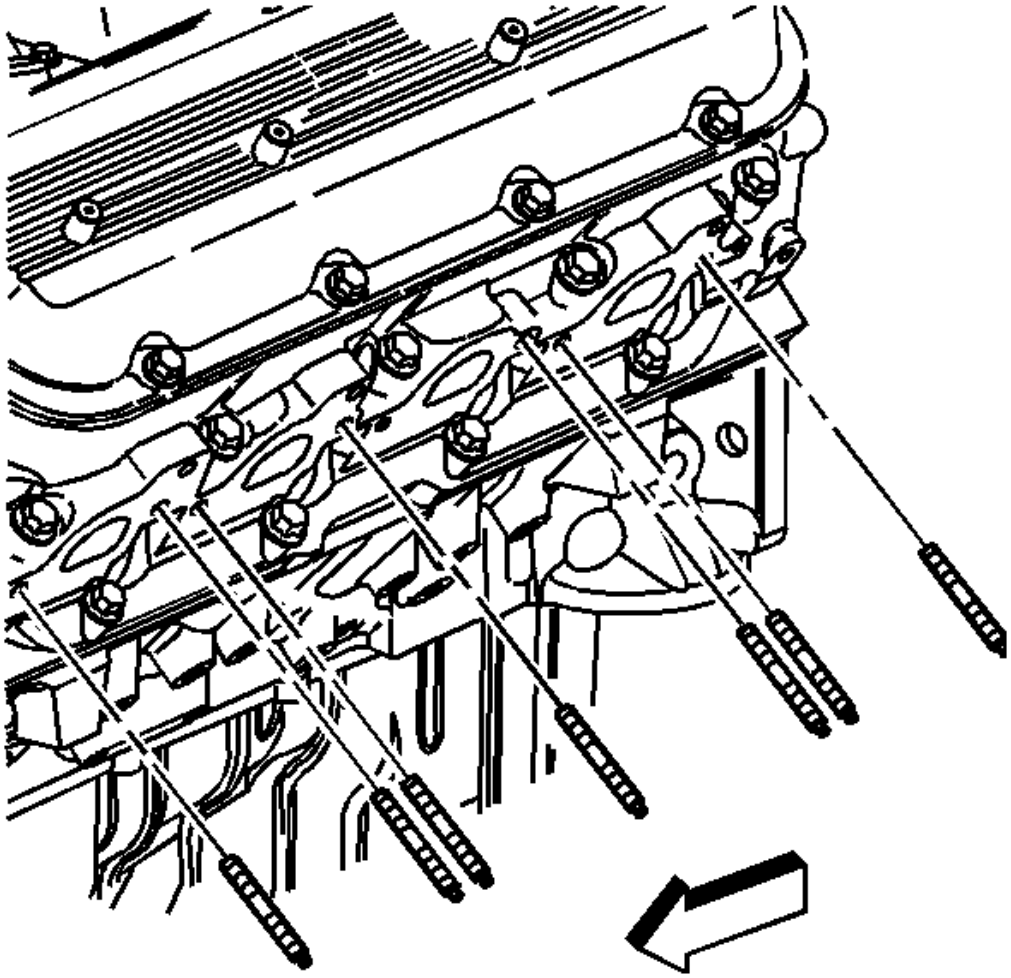

Fig. 251: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

8. Remove the exhaust manifold studs, if required.

Exhaust Manifold Removal - Right

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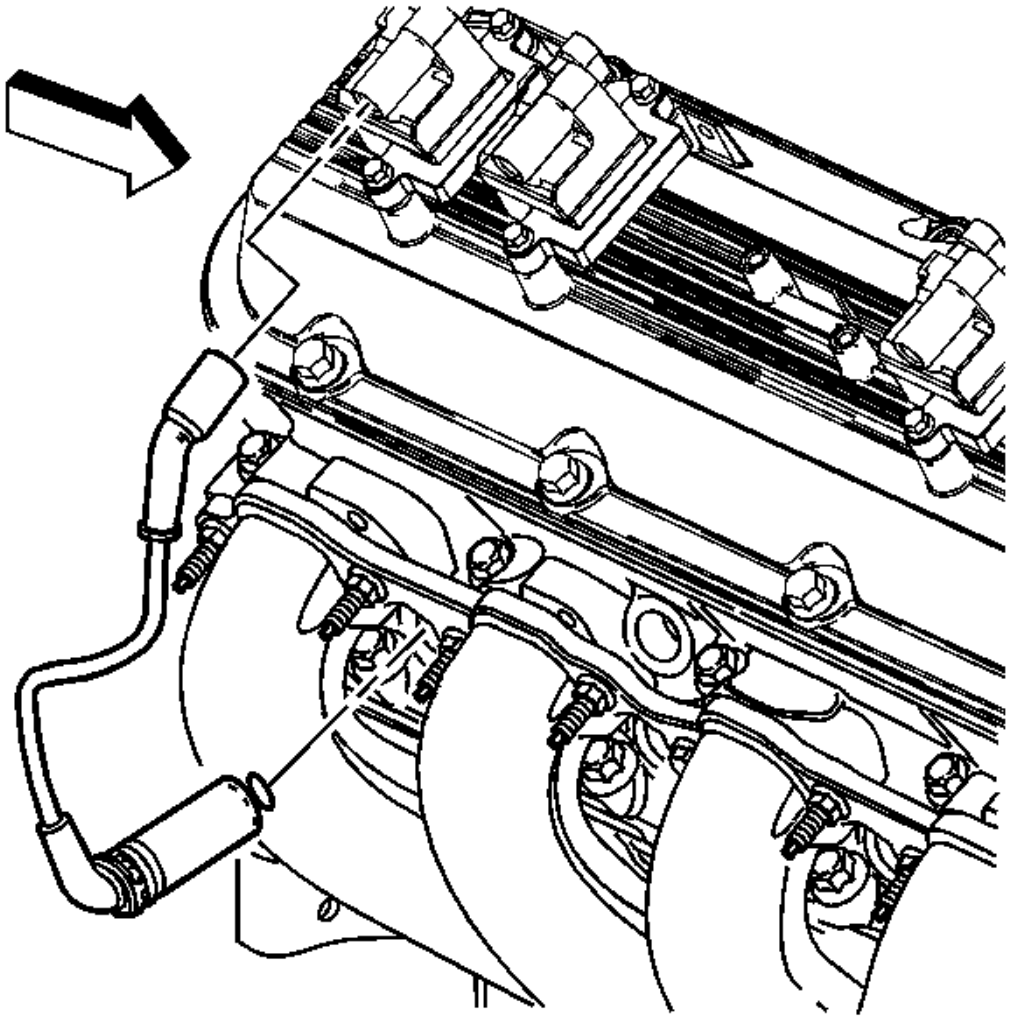

Fig. 252: View Of Spark Plug Wires
Courtesy of GENERAL MOTORS CORP.

NOTE: Twist the spark plug boot one-half turn in order to release the boot. Pull on the spark plug boot only. Do not pull on the spark plug wire or the wire could be damaged.

1. Remove the spark plug wires from the spark plugs and ignition coils.

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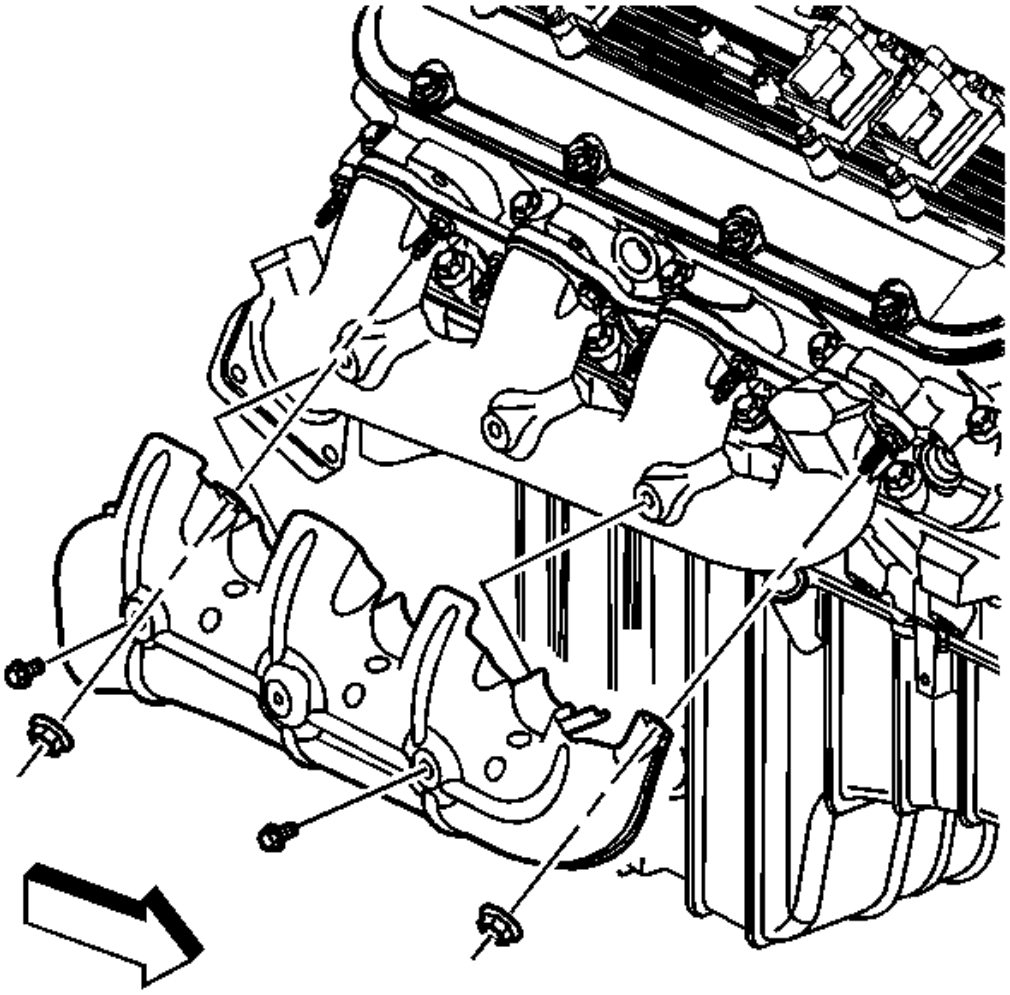

Fig. 253: View Of Exhaust Manifold Heat Shield, Bolts & Nuts (Right)
Courtesy of GENERAL MOTORS CORP.

2. Remove the exhaust manifold heat shield bolts and nuts.
3. Remove the exhaust manifold heat shield.

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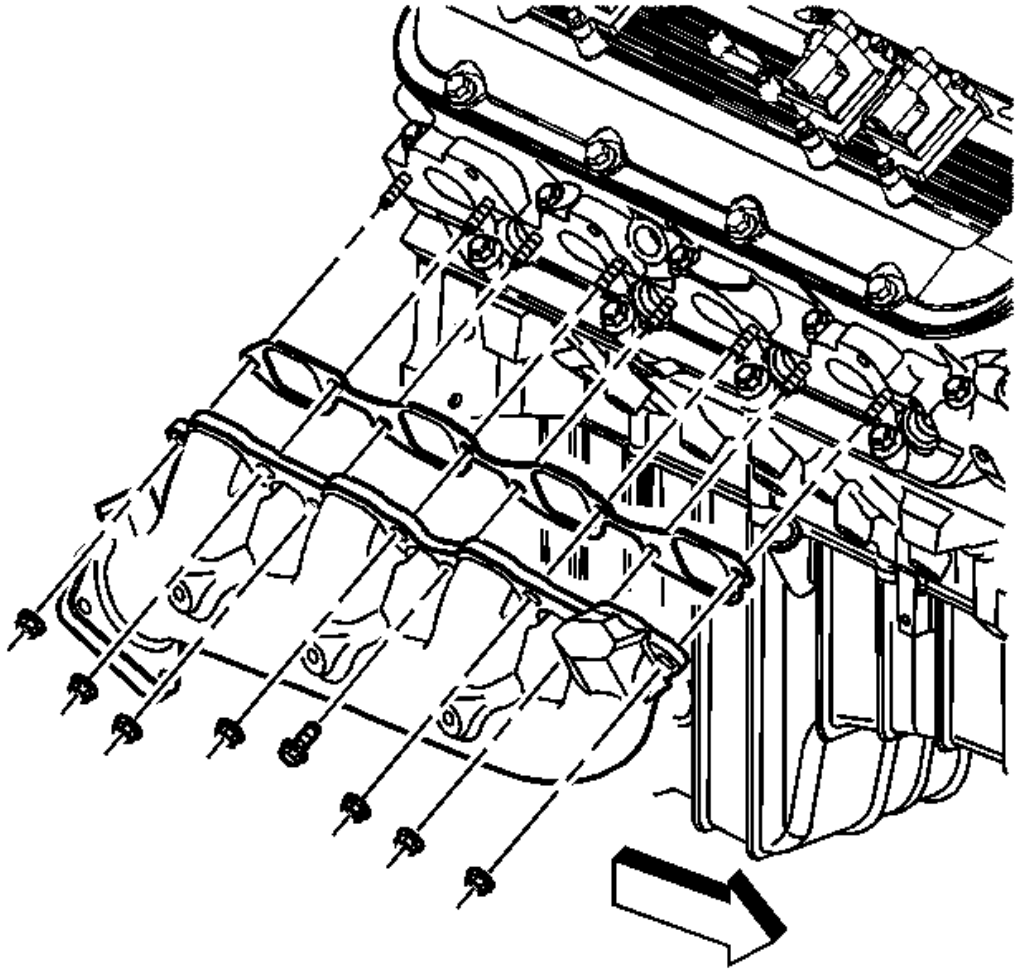

Fig. 254: View Of Exhaust Manifold, Nuts & Center Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

4. Remove the exhaust manifold nuts and center bolt.
5. Remove the exhaust manifold.
6. Remove the exhaust manifold gasket.

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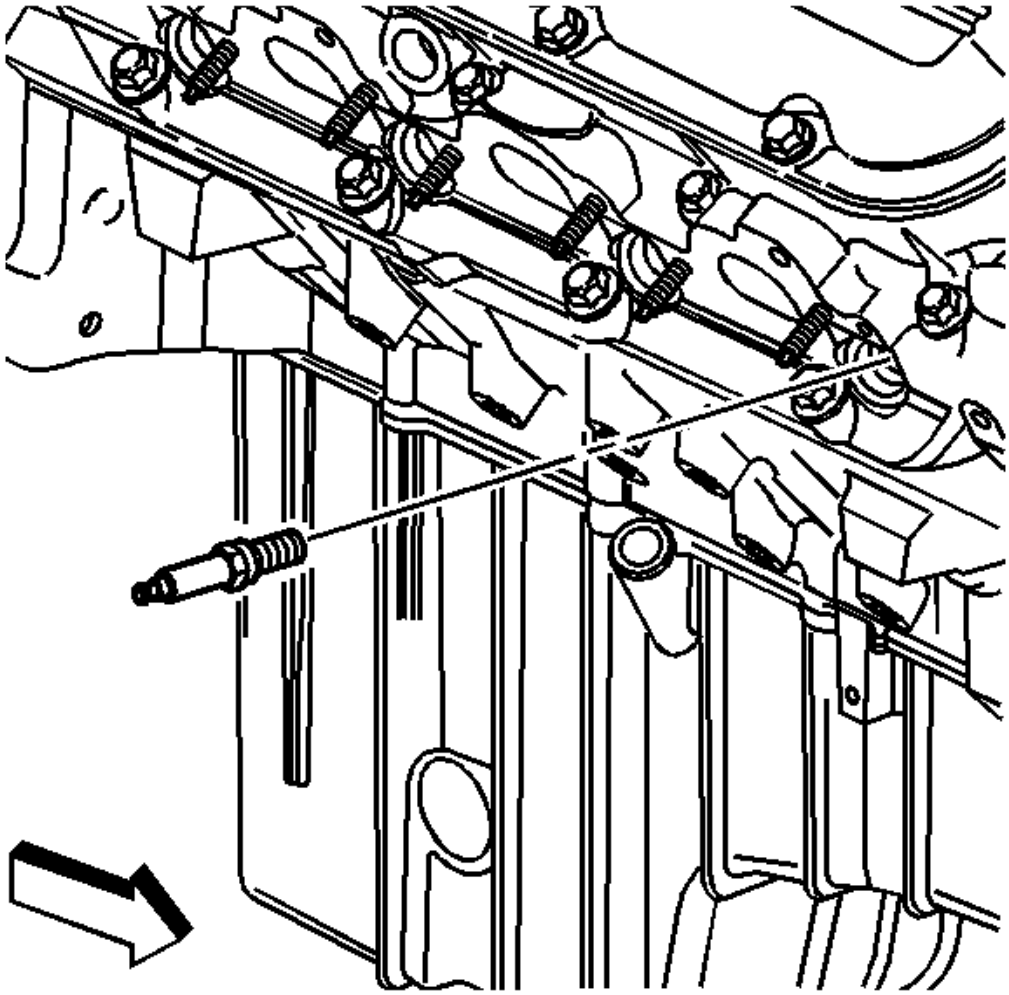

Fig. 255: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Remove the spark plugs, if required.

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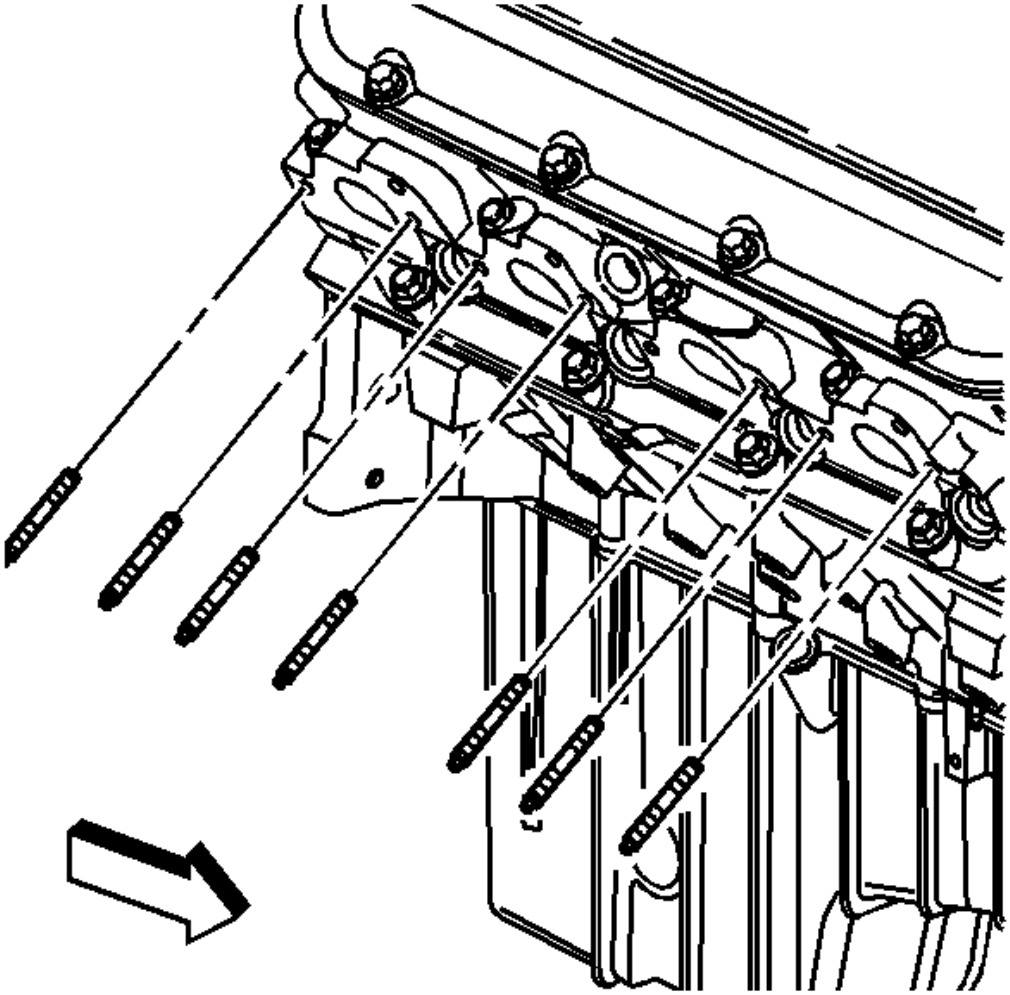

Fig. 256: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

8. Remove the exhaust manifold studs, if required.

Water Crossover Removal

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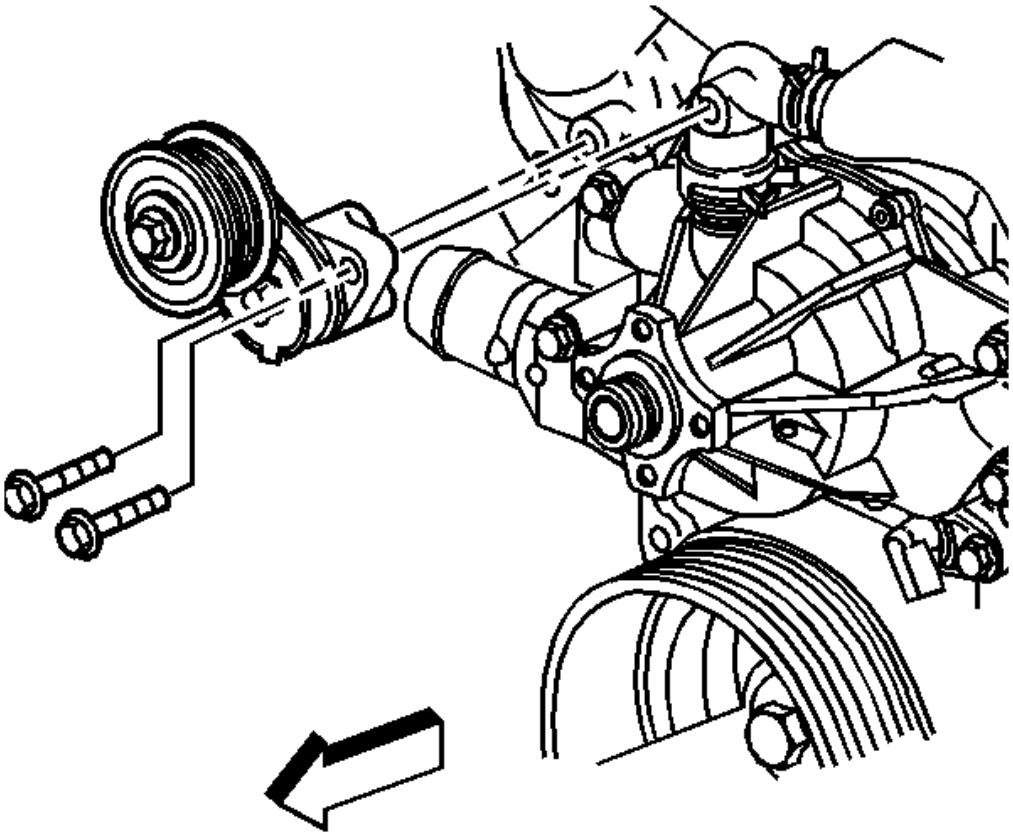

Fig. 257: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

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

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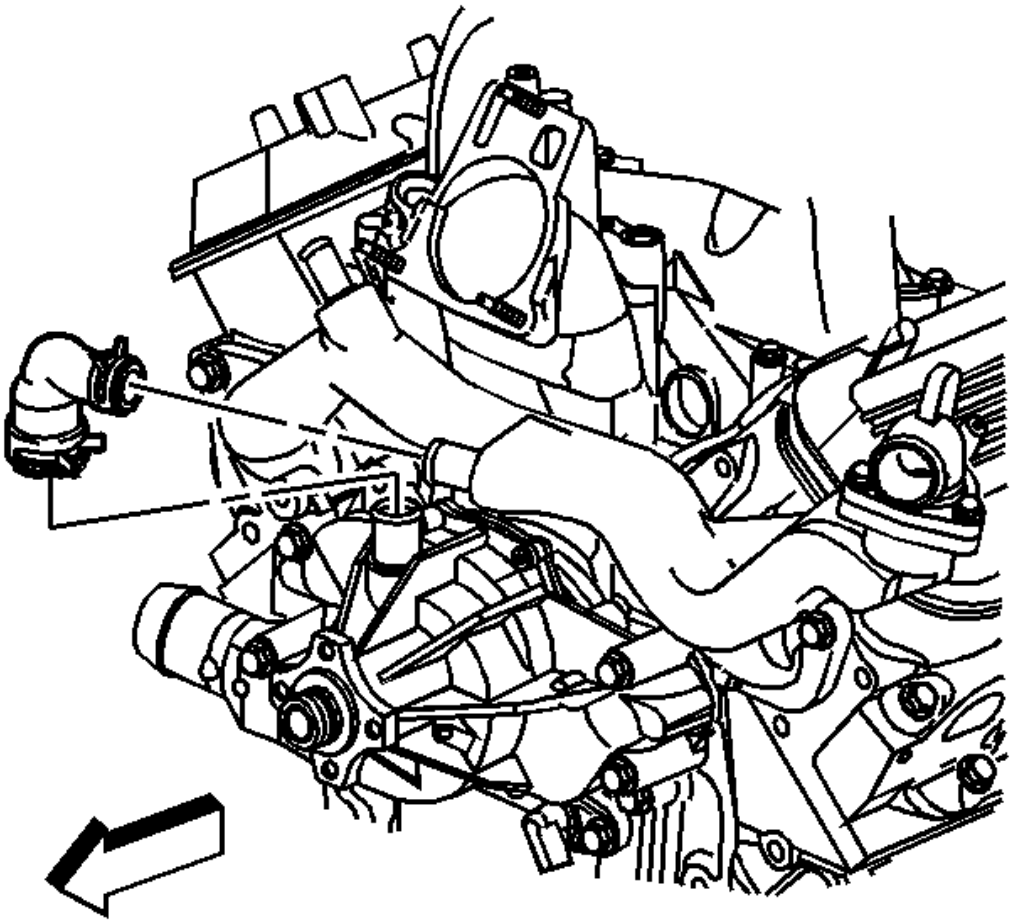

Fig. 258: Thermostat Bypass Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

3. Remove the thermostat bypass hose and clamps.

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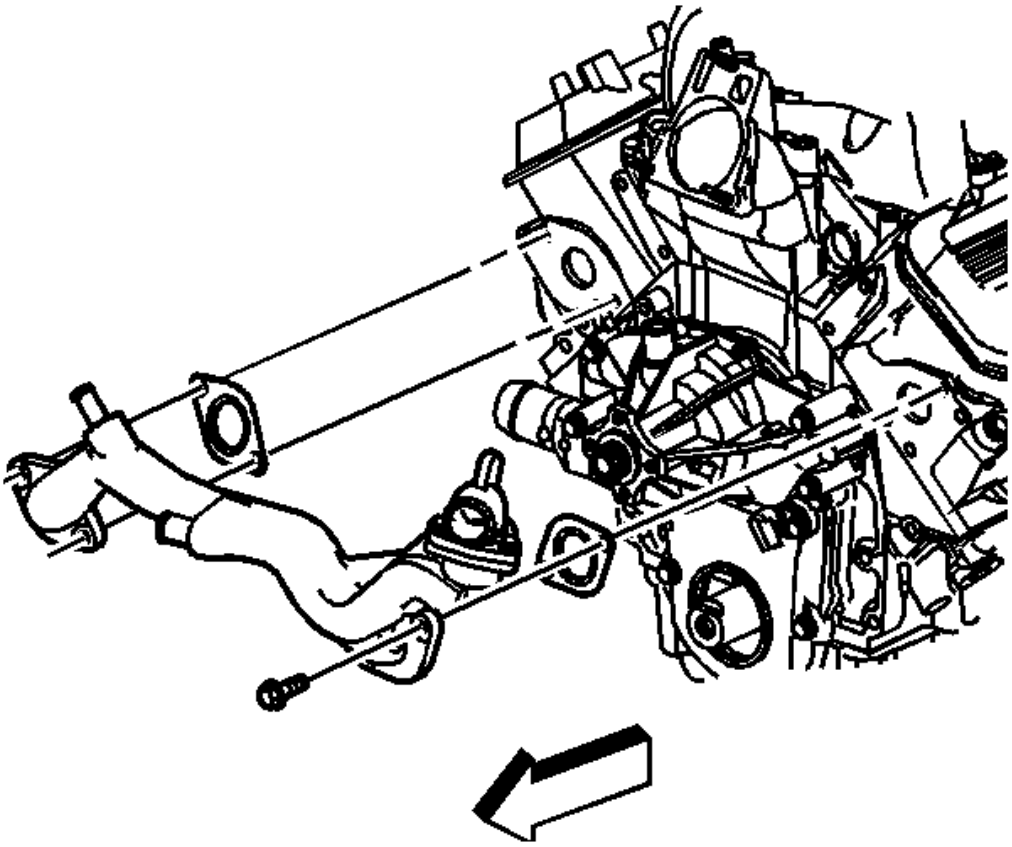

Fig. 259: View Of Engine Coolant Crossover & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine coolant crossover bolts.
5. Remove the engine coolant crossover.
6. Remove the crossover gaskets.

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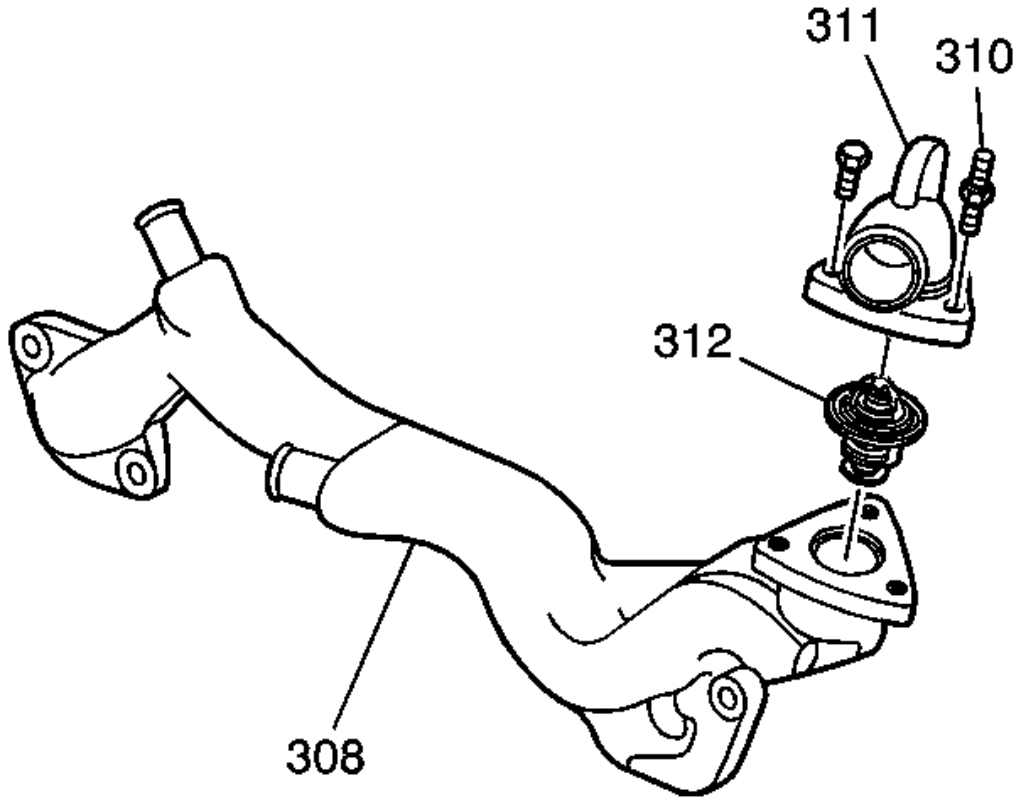

Fig. 260: View Of Water Outlet, Bolts, Thermostat & Coolant Crossover
Courtesy of GENERAL MOTORS CORP.

7. Remove the water outlet bolts/studs (310).
8. Remove the water outlet (311).
9. Remove the thermostat (312) from the coolant crossover (308).

Water Pump Removal

Tool Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools and Equipment**.

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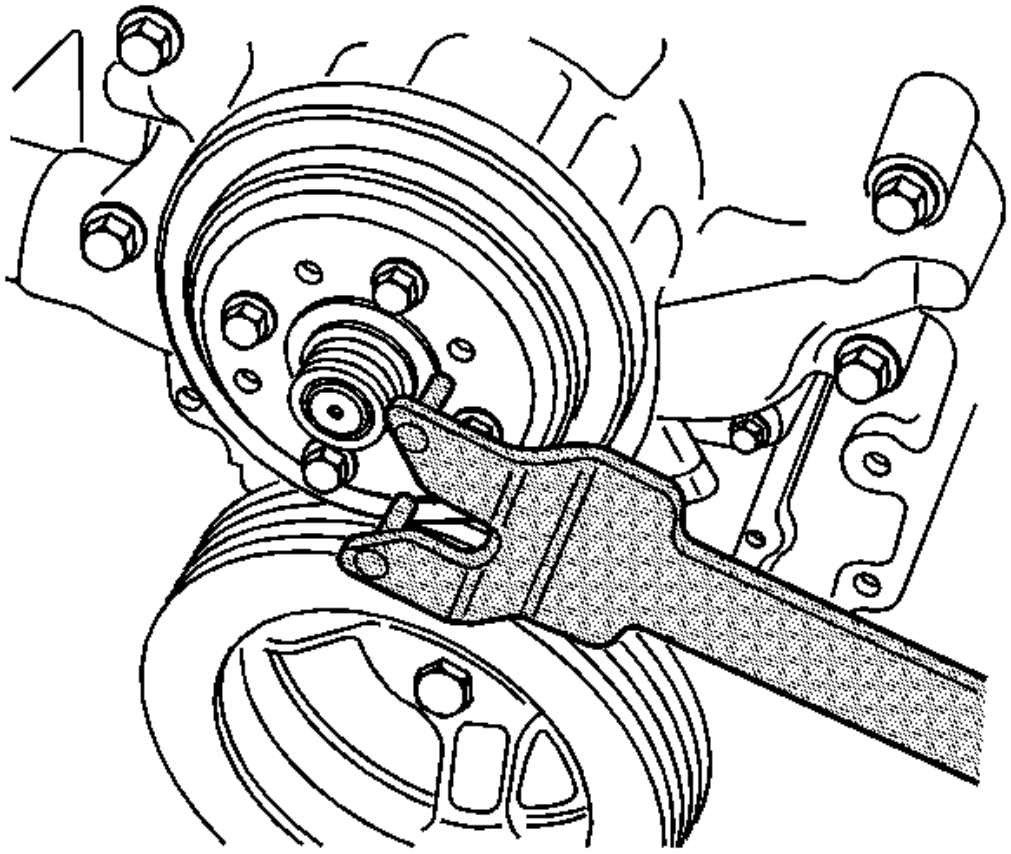

Fig. 261: View Of J 41240
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 41240** to retain the water pump pulley. See **Special Tools and Equipment**.

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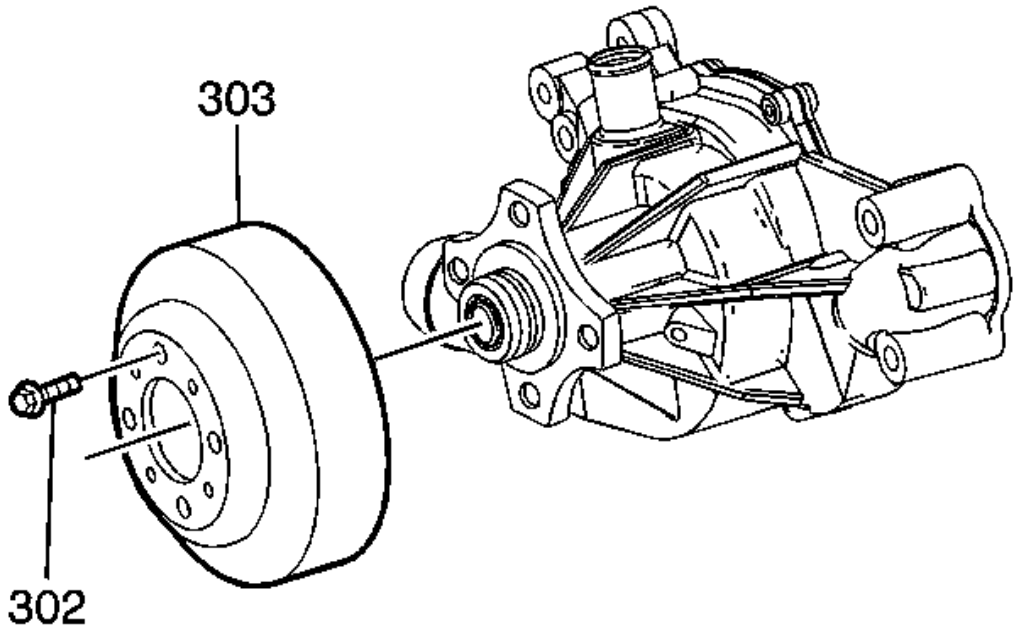

Fig. 262: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the water pump pulley bolts (302) and pulley (303).

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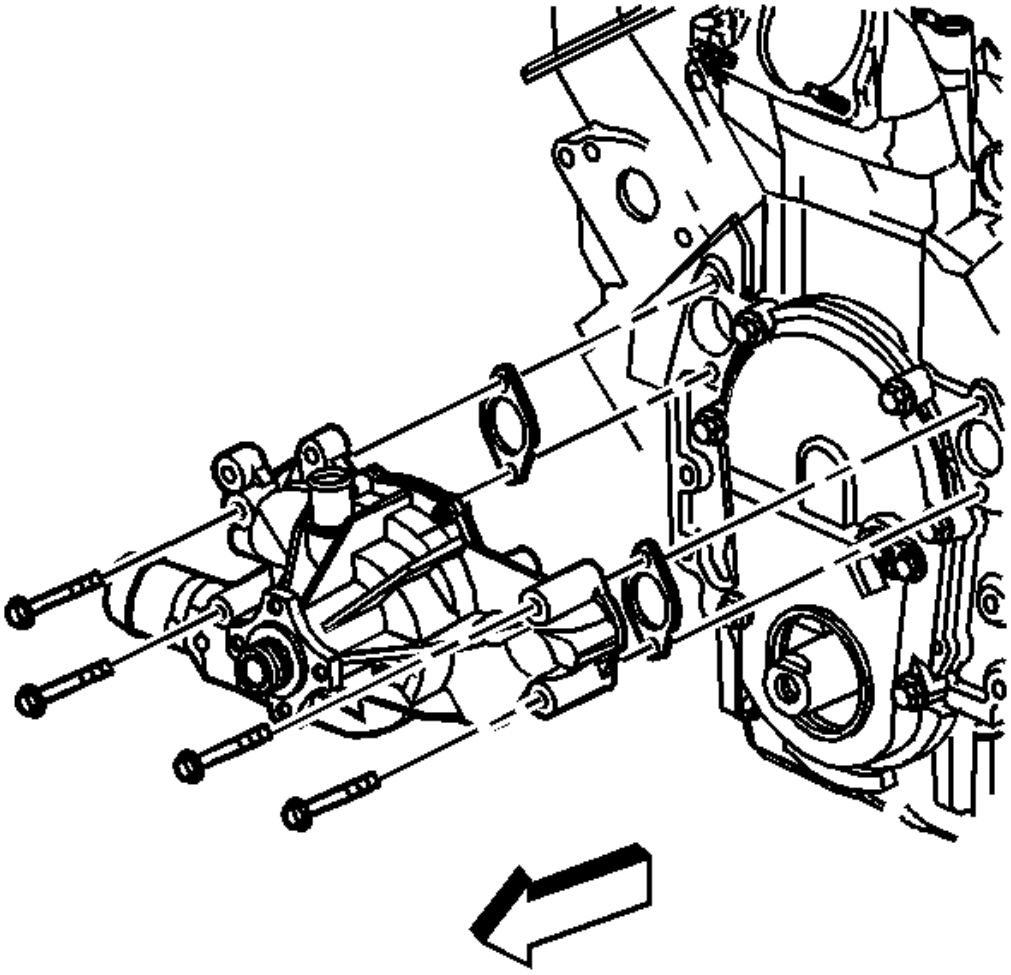

Fig. 263: View Of Water Pump & Gasket
Courtesy of GENERAL MOTORS CORP.

3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove the water pump gaskets.

Intake Manifold Removal

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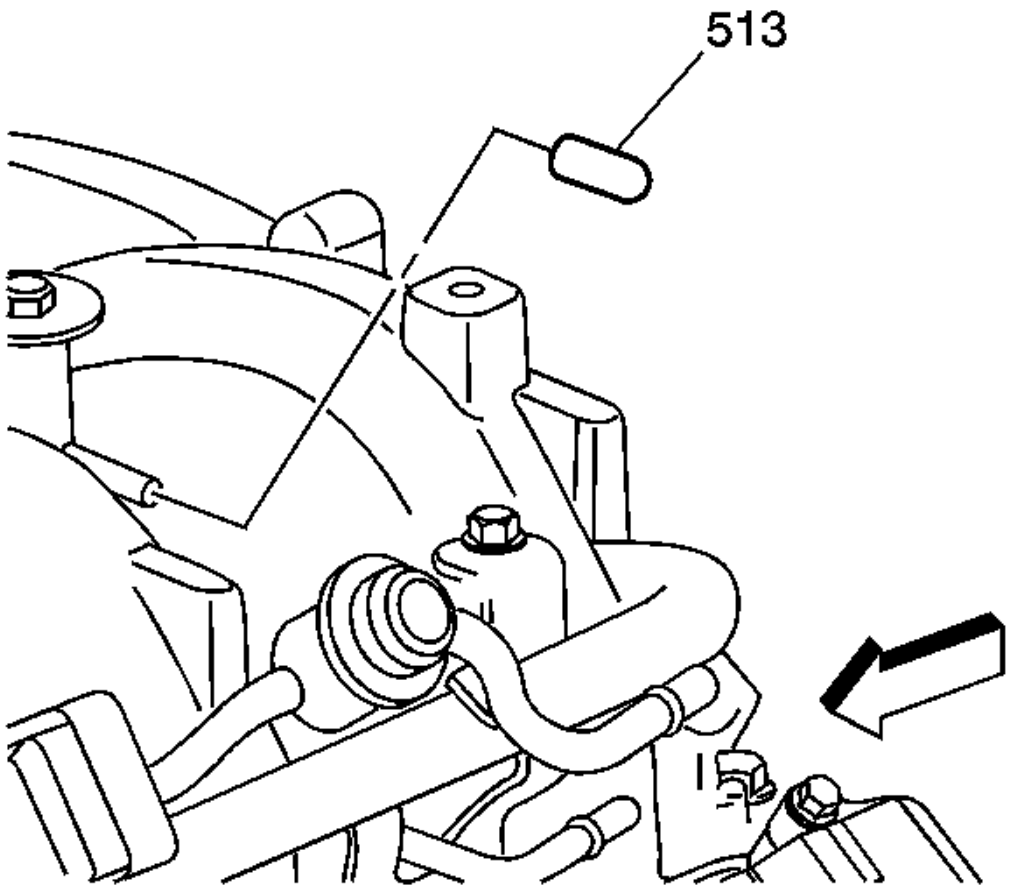

Fig. 264: View Of Vacuum Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the vacuum plug (513), if required.

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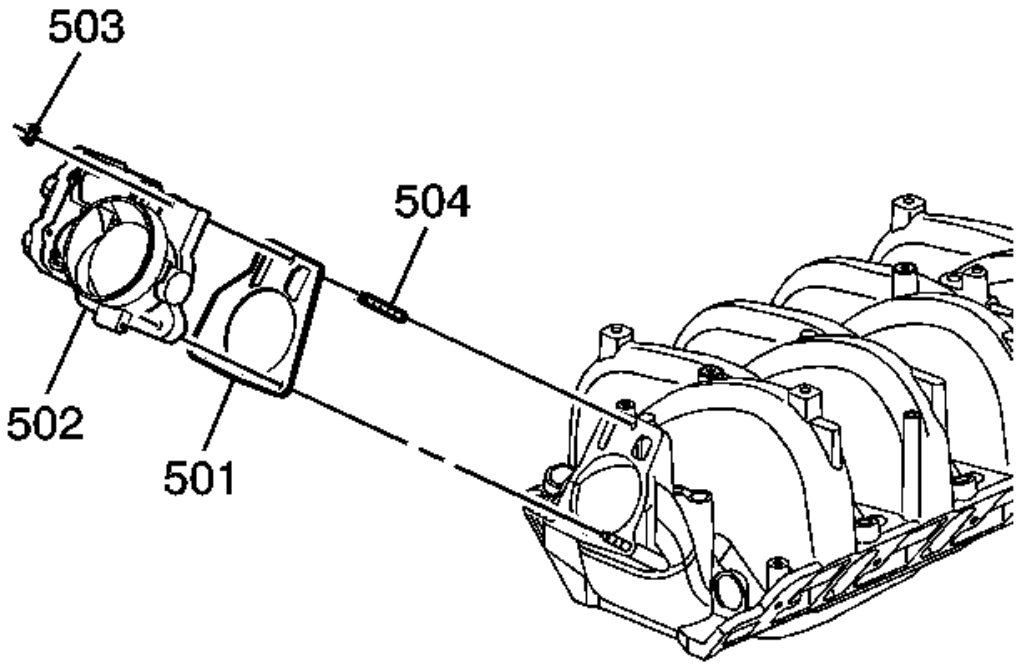

Fig. 265: View Of Throttle Body, Nuts, Studs & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the throttle body nuts (503).
3. Remove the throttle body (502) and gasket (501).
4. Remove the studs (504), if required.

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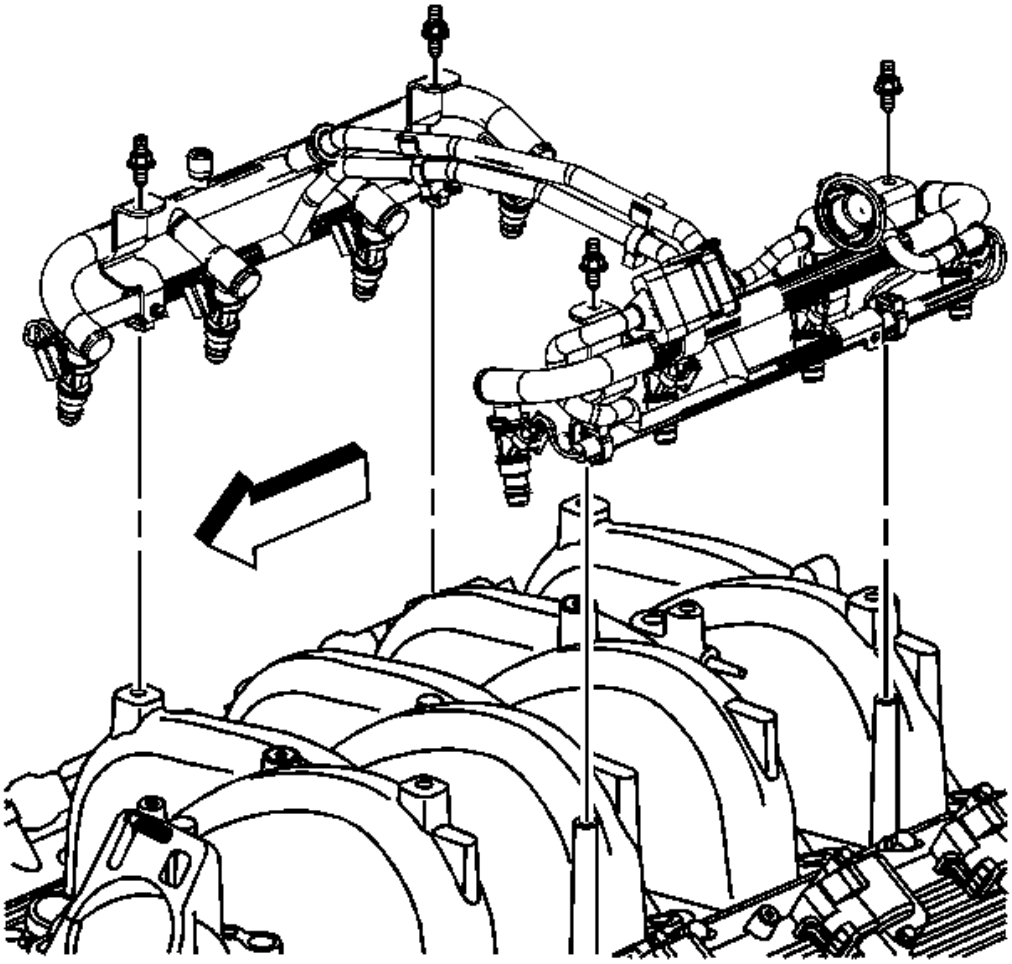

Fig. 266: View Of Fuel Injection Rail
Courtesy of GENERAL MOTORS CORP.

5. Remove the fuel injection fuel rail bolts/studs.
6. Remove the fuel injection fuel rail with injectors.

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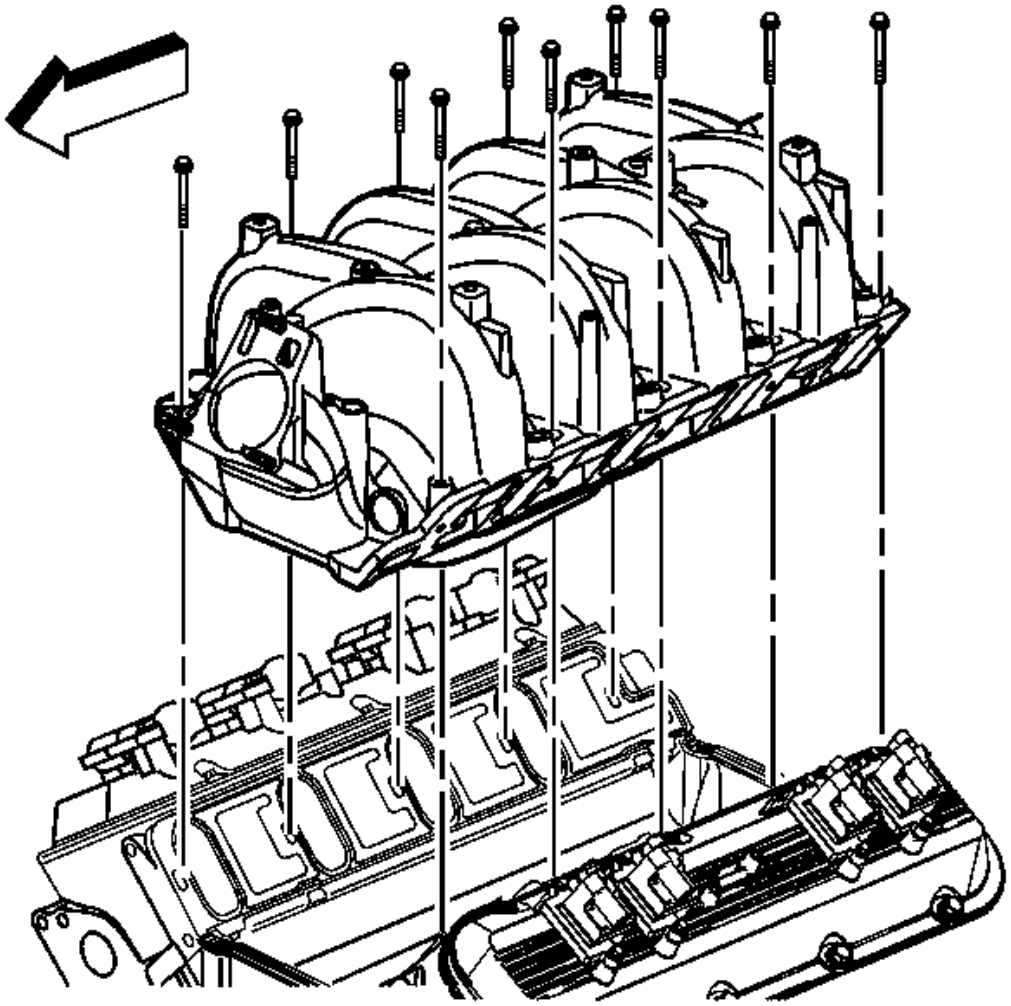

Fig. 267: View Of Intake Manifold & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the intake manifold bolts.

IMPORTANT: Do not attempt to loosen the manifold by prying under the gasket surface with any tool.

8. Remove the intake manifold.

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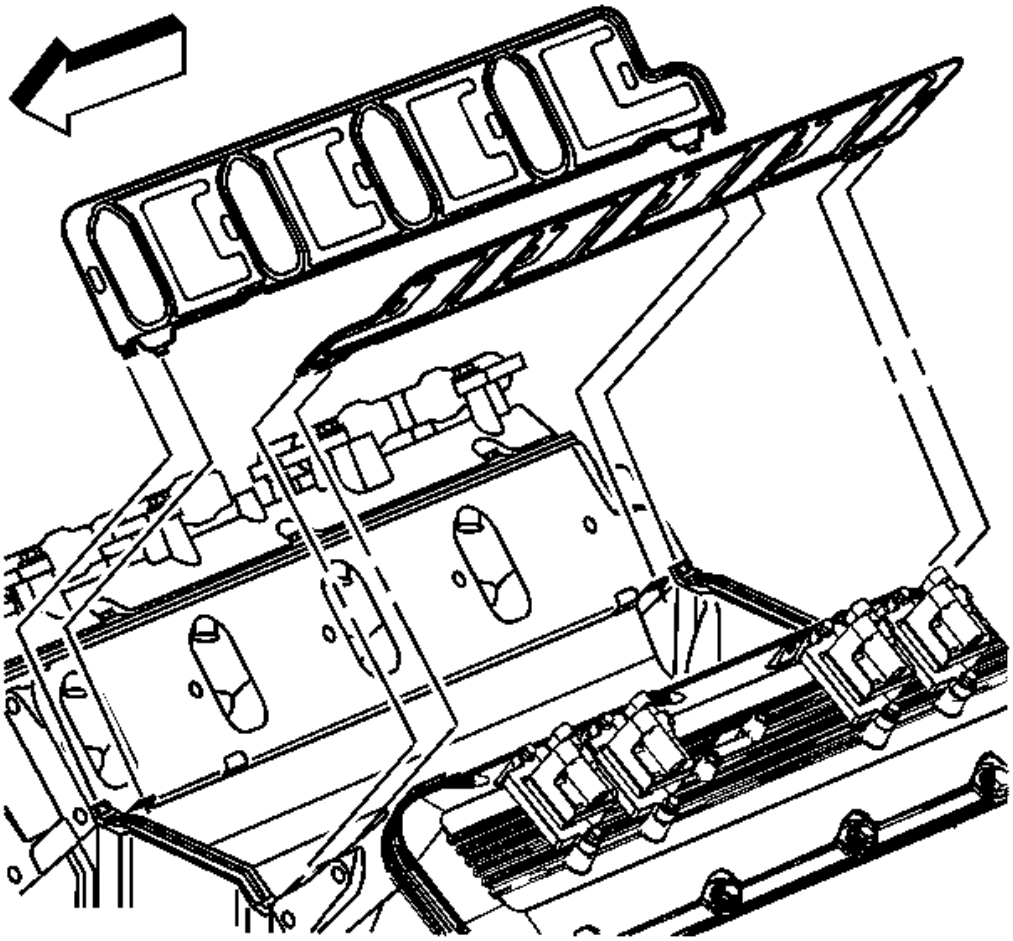

Fig. 268: View Of Intake Manifold Side Gaskets
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The intake manifold gaskets are not reusable.

9. Remove and discard the intake manifold side gaskets.

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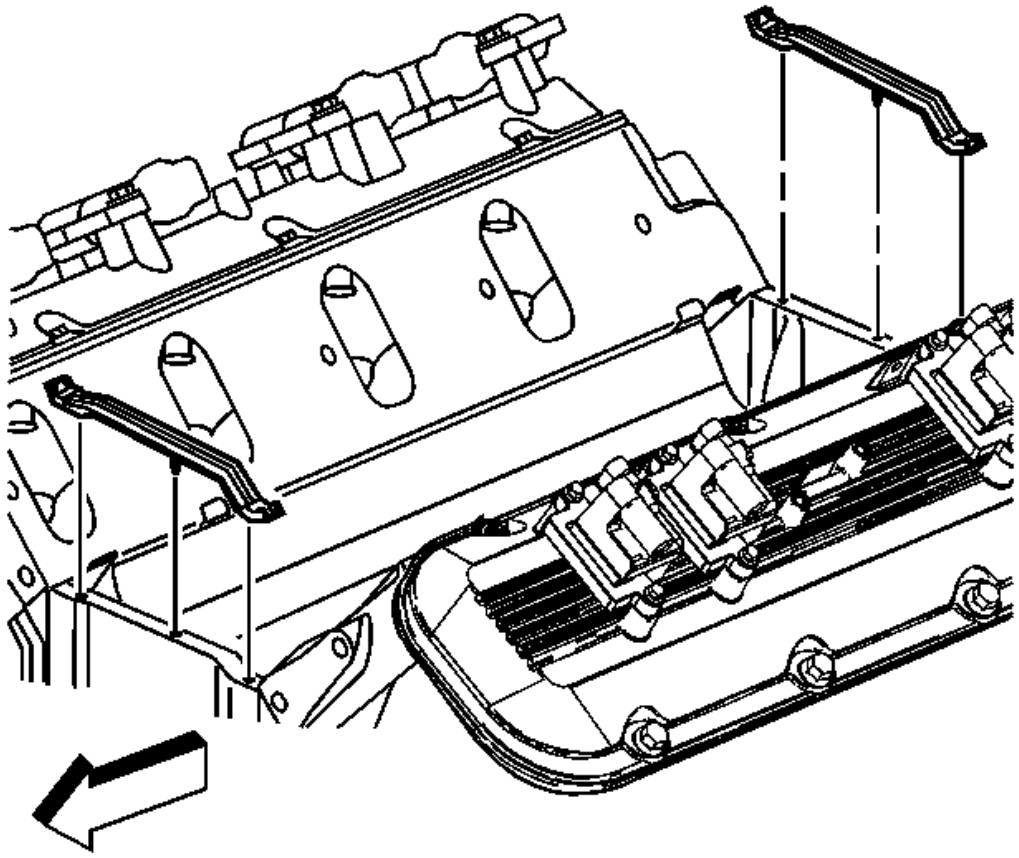

Fig. 269: View Of Intake Manifold End Seals
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the intake manifold end seals.

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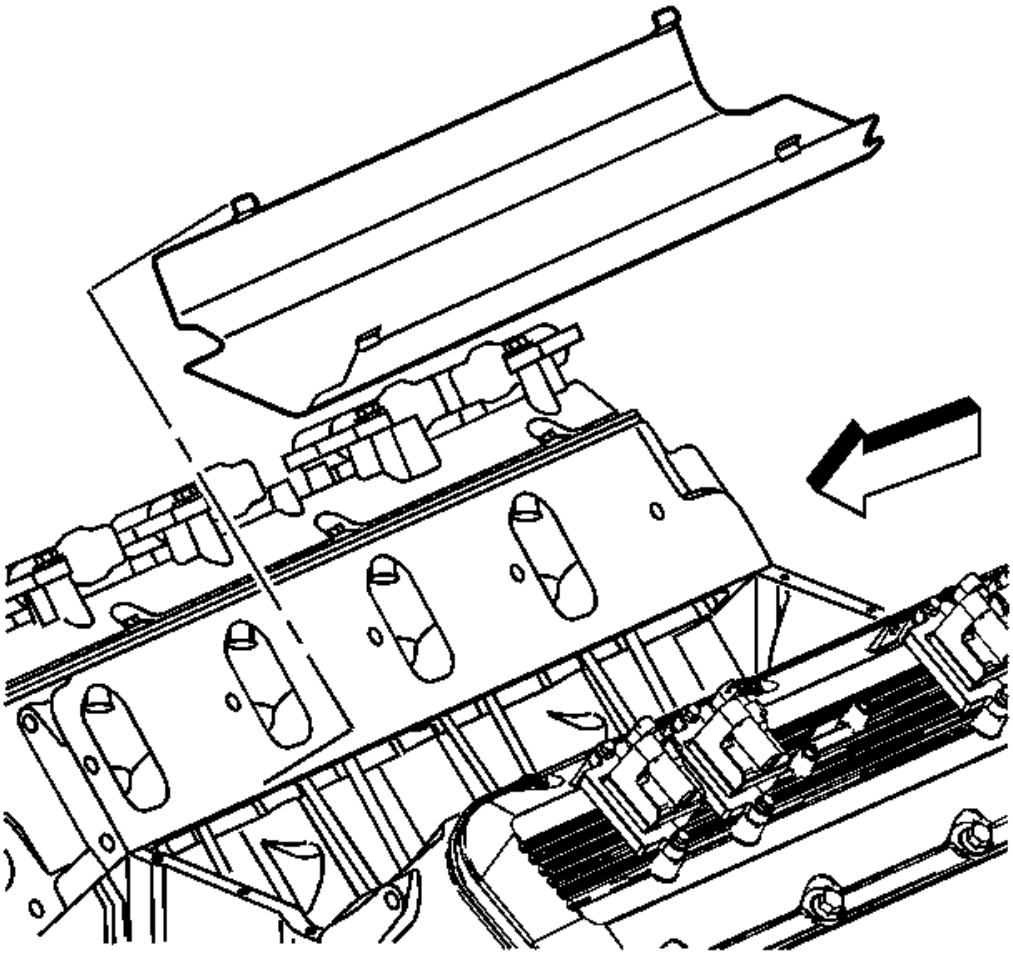

Fig. 270: View Of Splash Shield
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The splash shield is secured using a snap-in fit. Do not distort the splash shield. The splash shield is reusable.

11. Remove the splash shield.

Valve Rocker Arm Cover Removal - Left

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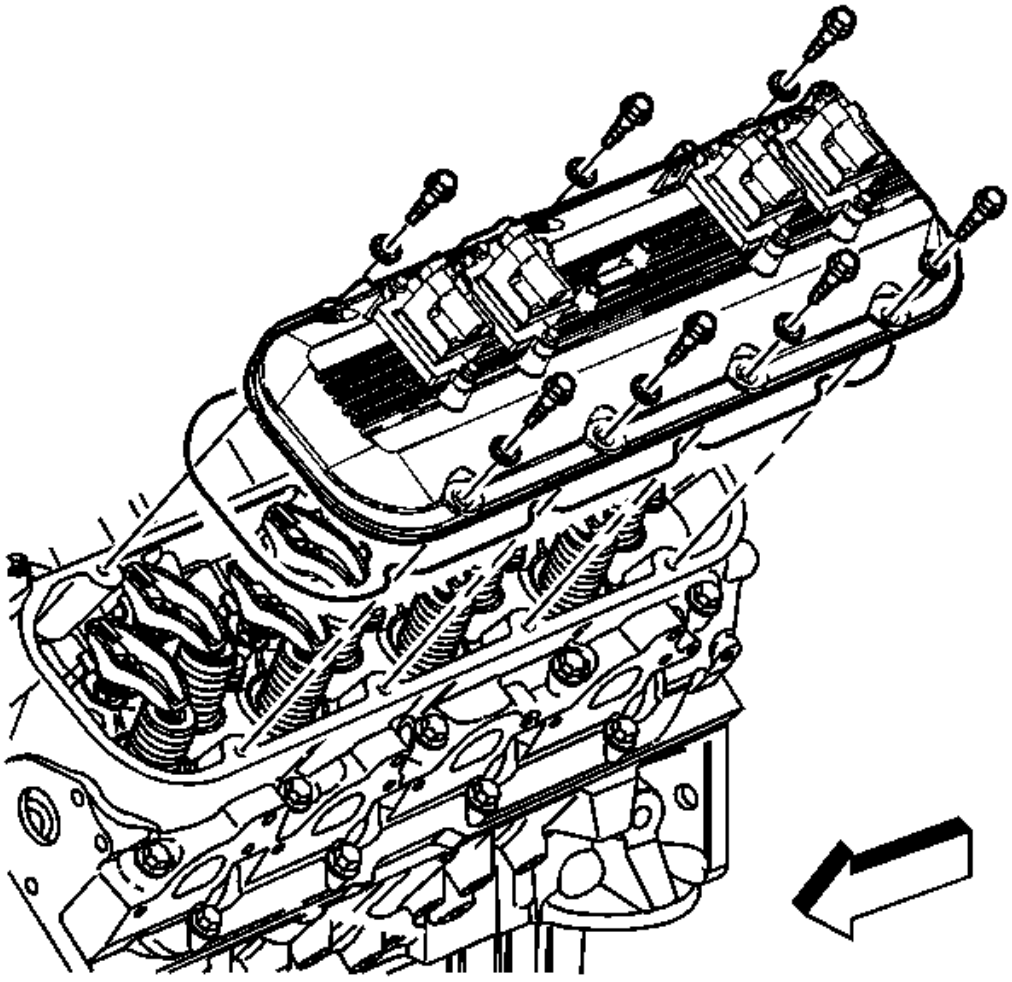

Fig. 271: View Of Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.

IMPORTANT: The valve rocker arm cover gasket may be reused if not removed from valve rocker arm cover.

3. Replace the valve rocker arm cover gasket if it is cut or damaged.

Valve Rocker Arm Cover Removal - Right

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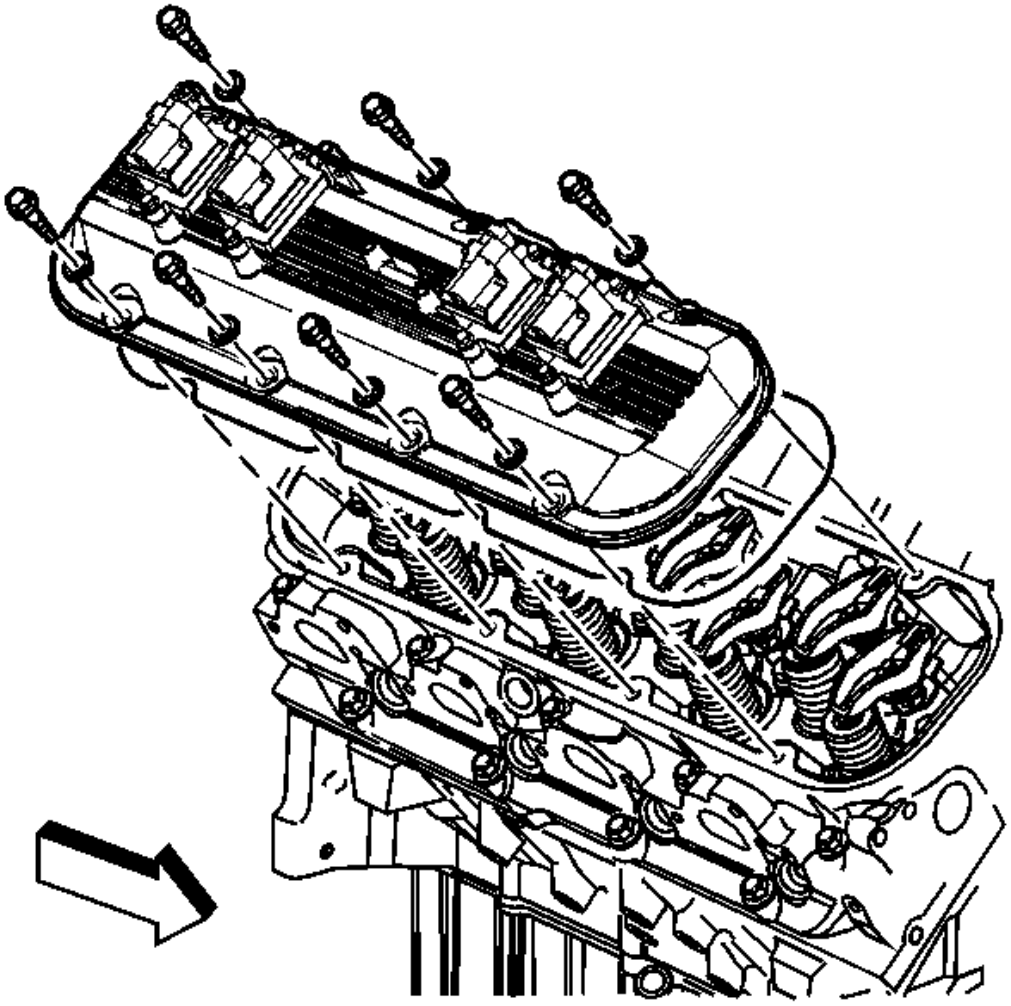

Fig. 272: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.

IMPORTANT: The valve rocker arm cover gasket may be reused if not removed from the valve rocker arm cover.

3. Replace the valve rocker arm cover gasket if it is cut or damaged.

Valve Rocker Arm and Push Rod Removal

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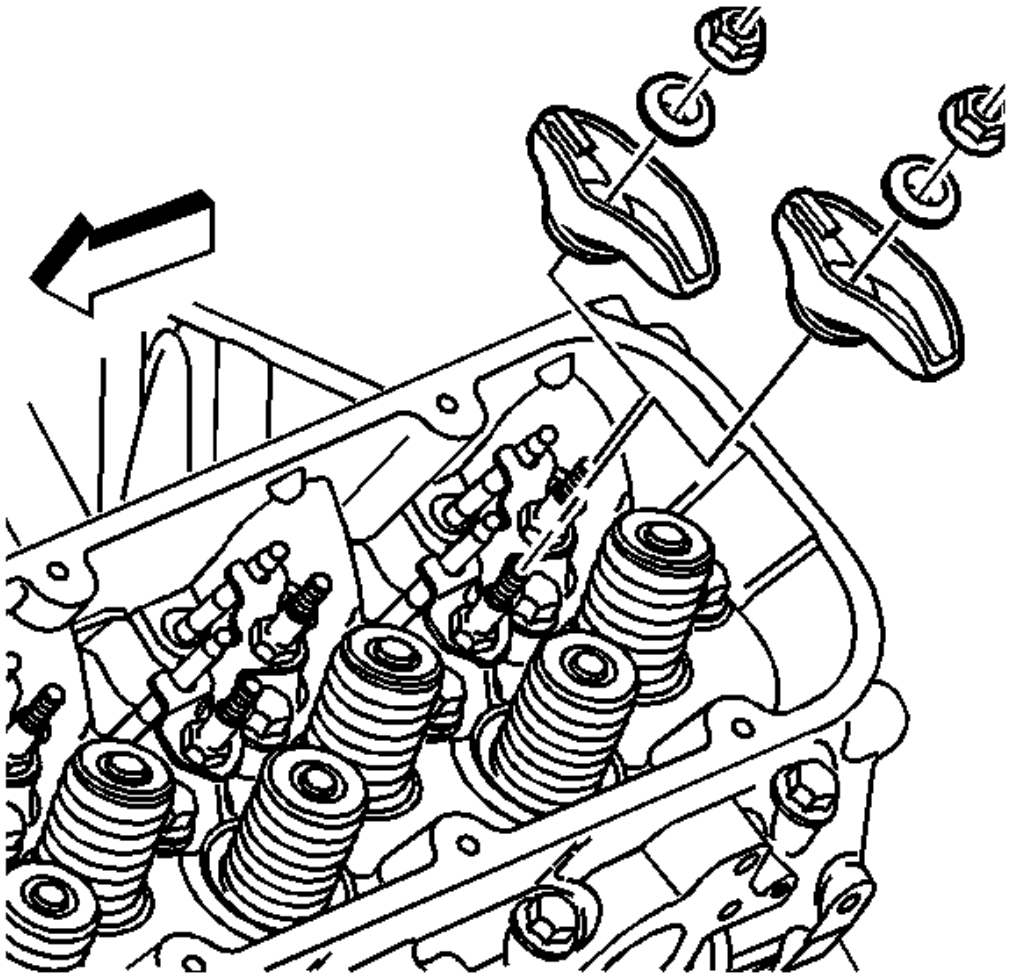

Fig. 273: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, organize and sort the cylinder head components. Return the components to their original location during reassembly. Make an organizer rack from a piece of wood.

1. Remove the valve rocker arm nuts, the valve rocker arm balls and the valve rocker arms.

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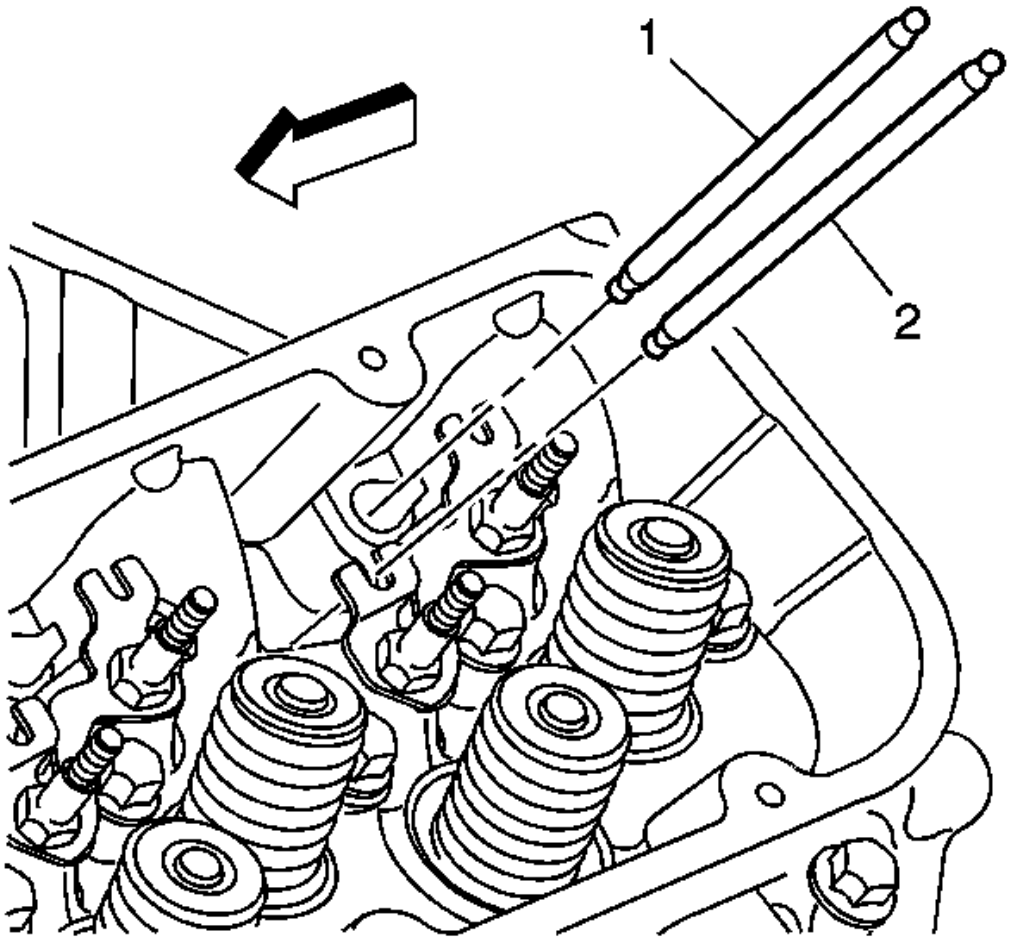

Fig. 274: View Of Intake & Exhaust Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The exhaust valve push rods (2) are longer than the intake valve push rods (1).

2. Remove the valve push rods.

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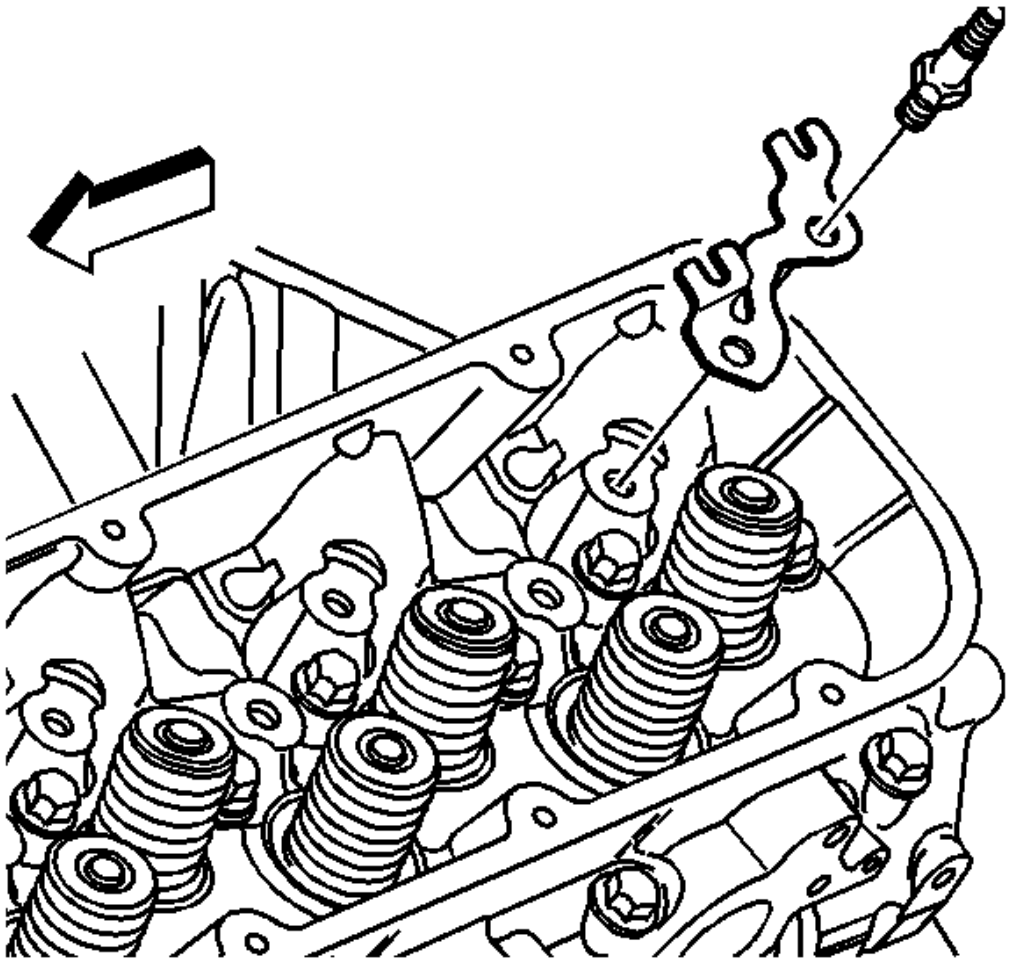

Fig. 275: View Of Valve Rocker Arm Studs & Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

3. Remove the valve rocker arm studs and push rod guides.

Cylinder Head Removal - Left

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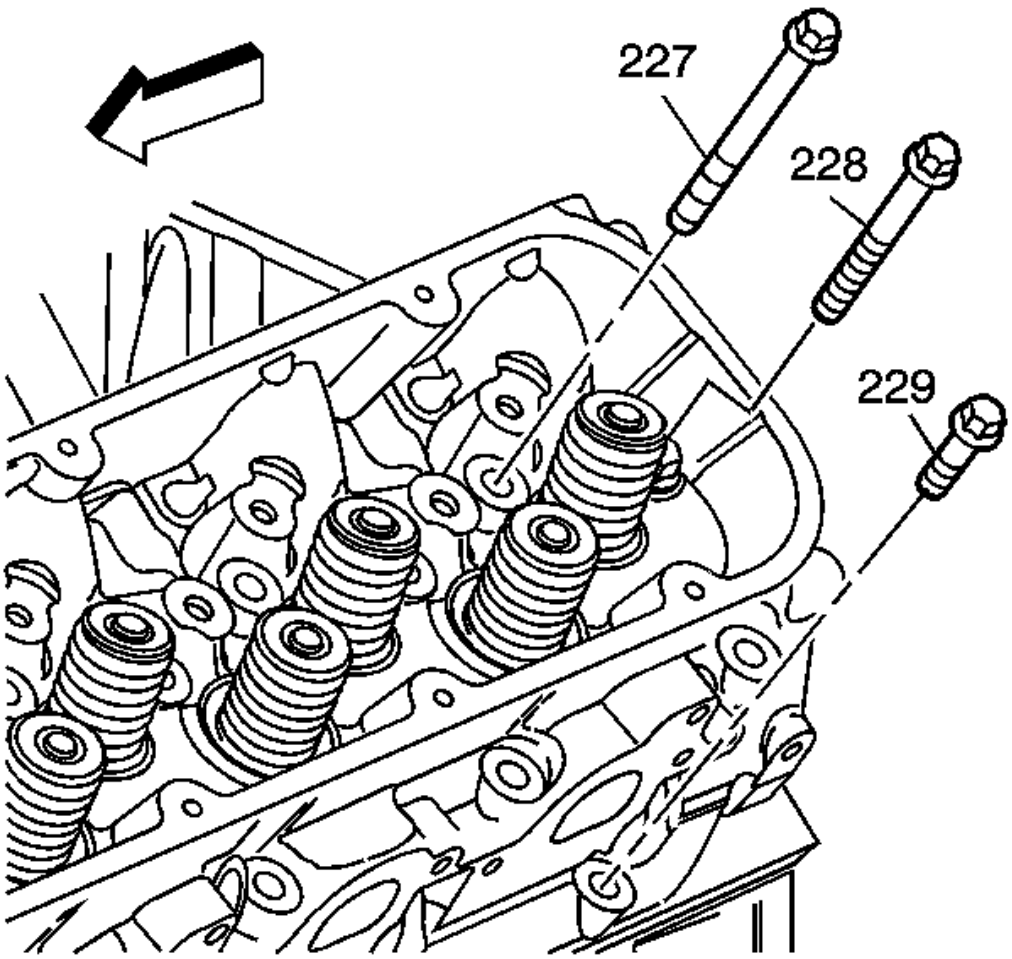

Fig. 276: Removing Cylinder Head Bolts (Left)
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the eighteen cylinder head bolts (227, 228, 229).

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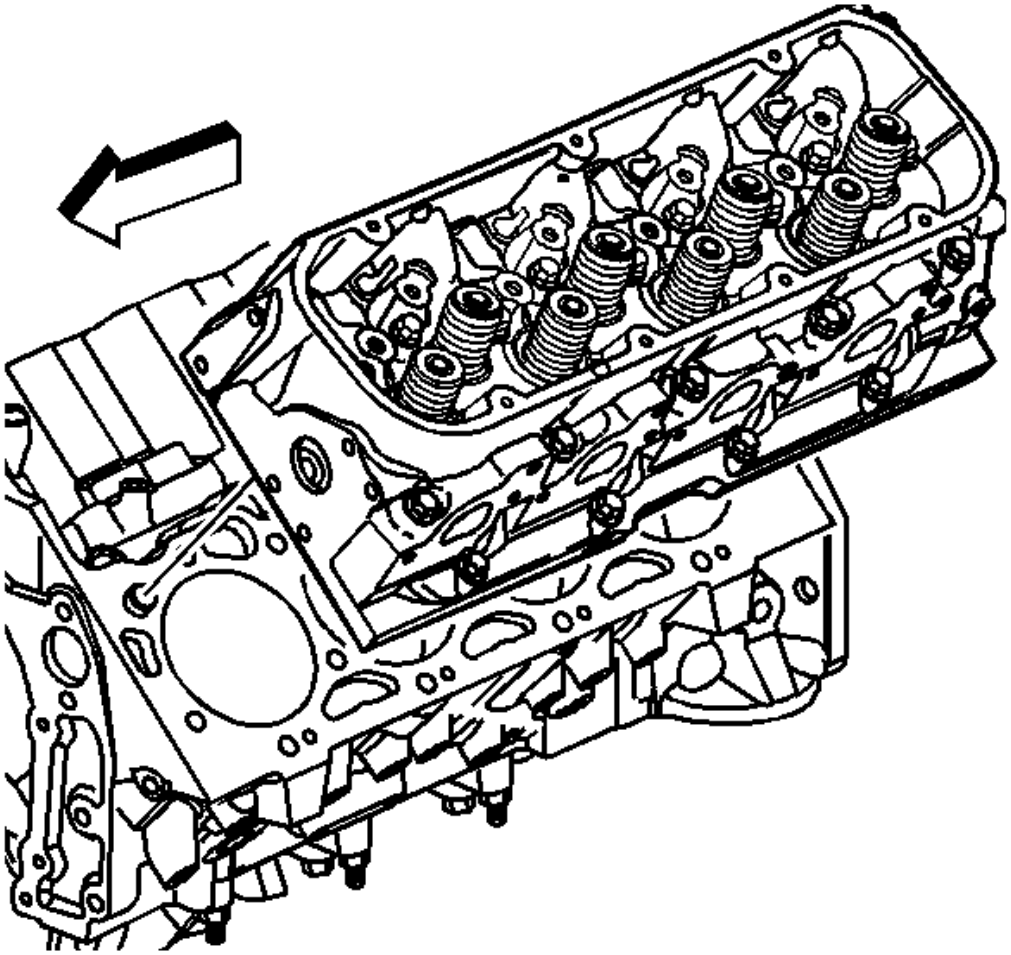

Fig. 277: View Of Left Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the cylinder head.

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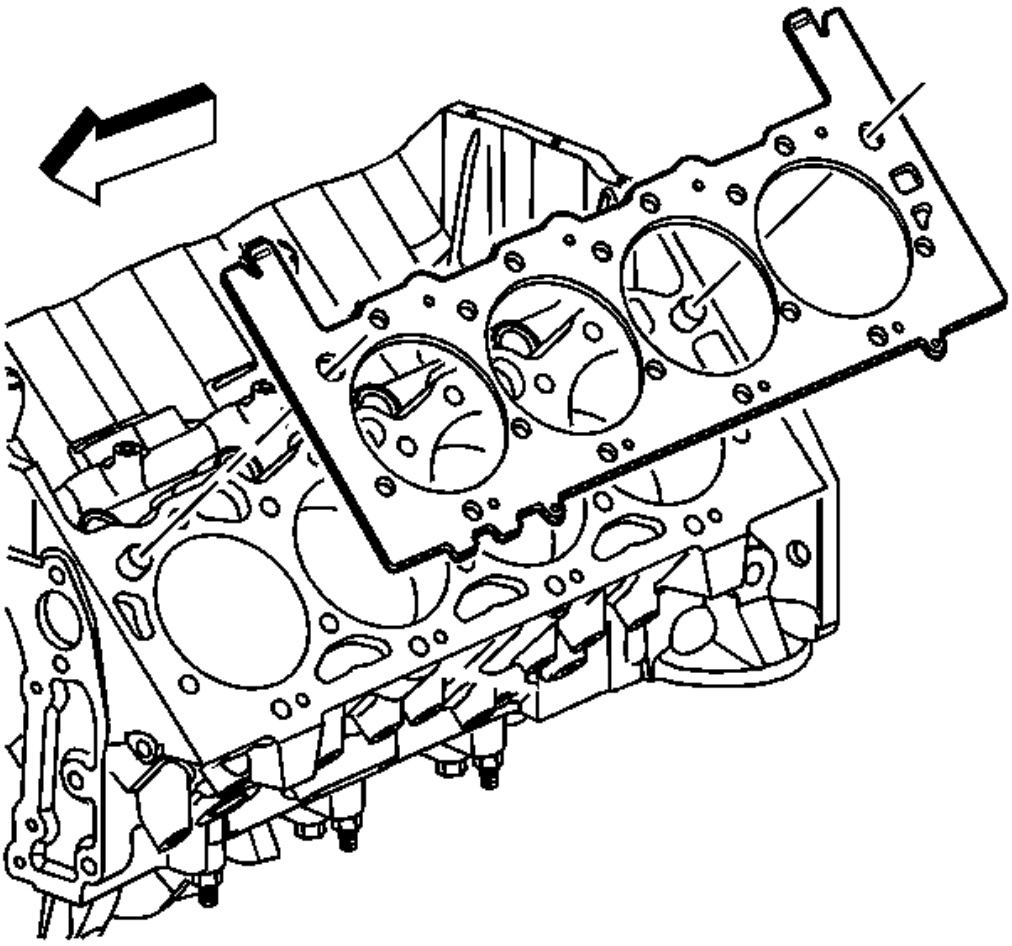

Fig. 278: View Of Left Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.

Cylinder Head Removal - Right

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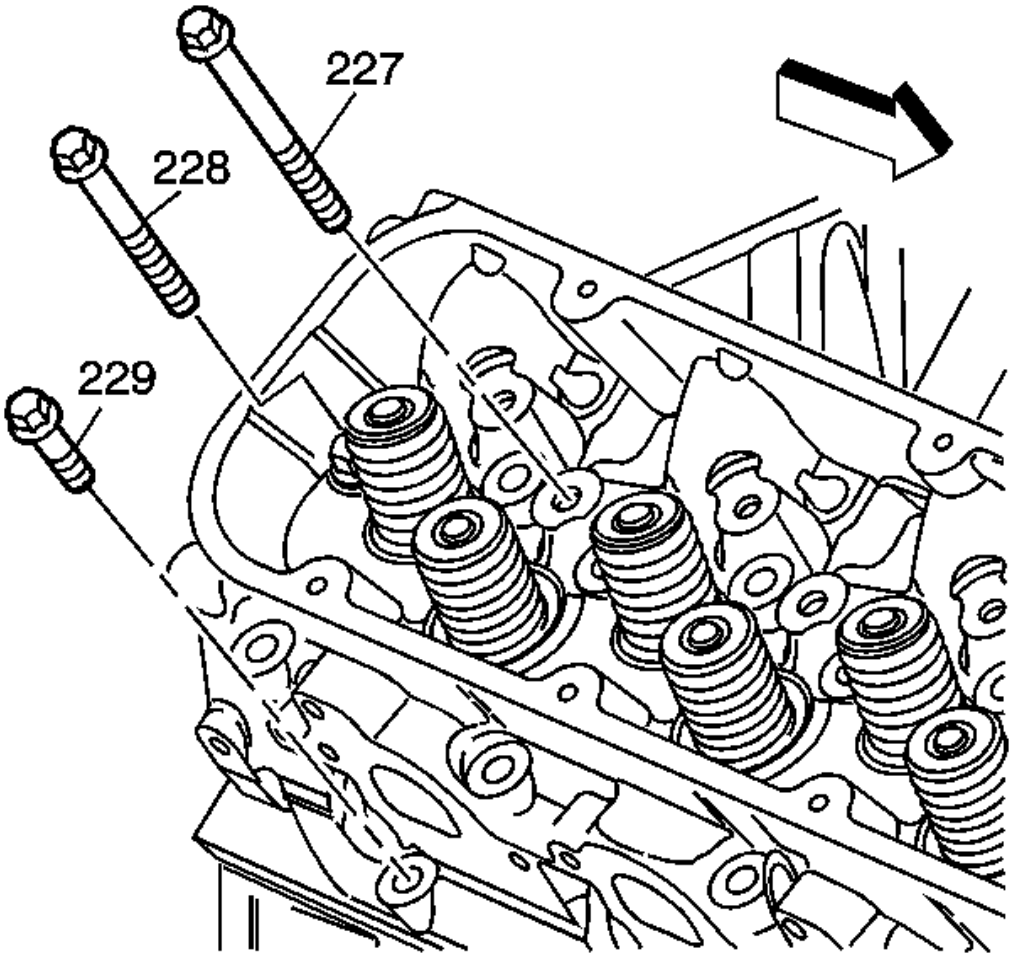

Fig. 279: Removing Cylinder Head Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

1. Remove and discard the eighteen cylinder head bolts (227, 228, 229).

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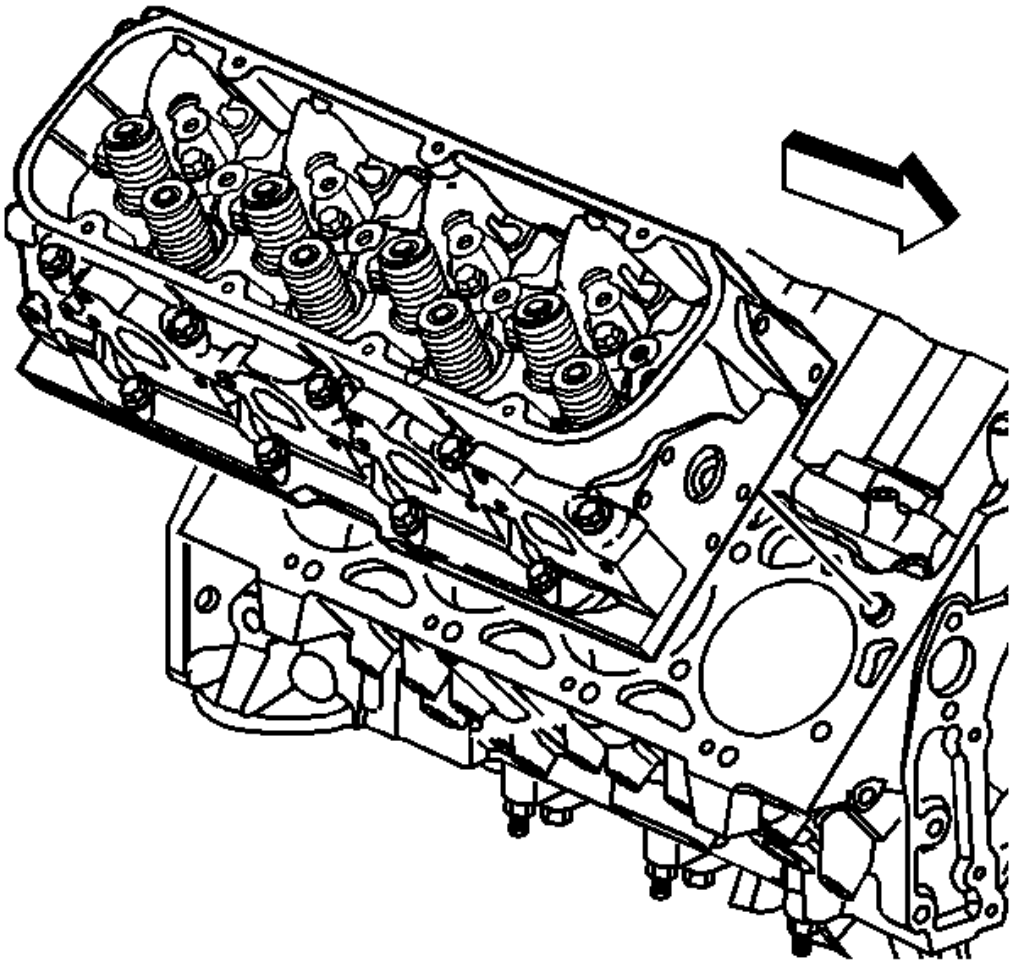

Fig. 280: View Of Right Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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

2. Remove the cylinder head.

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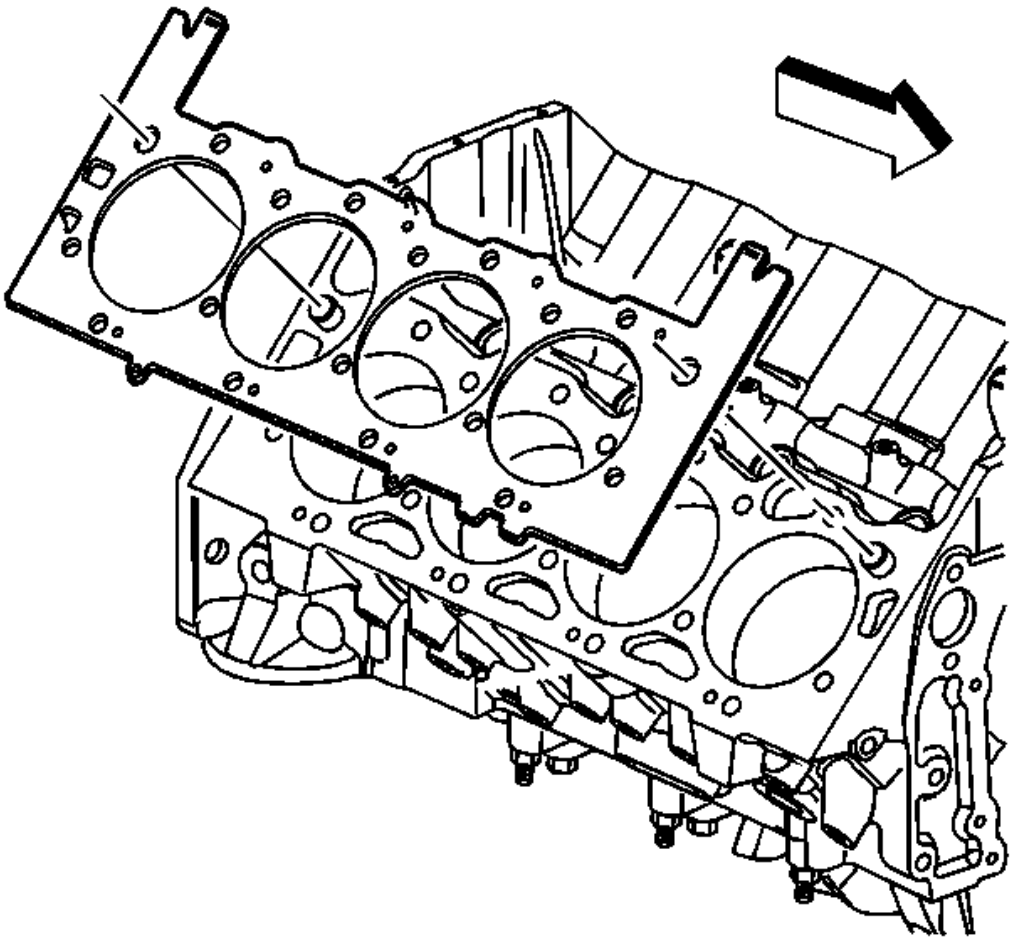

Fig. 281: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

3. Remove the cylinder head gasket.
4. Discard the cylinder head gasket.

Valve Lifter Removal

Tools Required

J 3049-A Valve Lifter Remover

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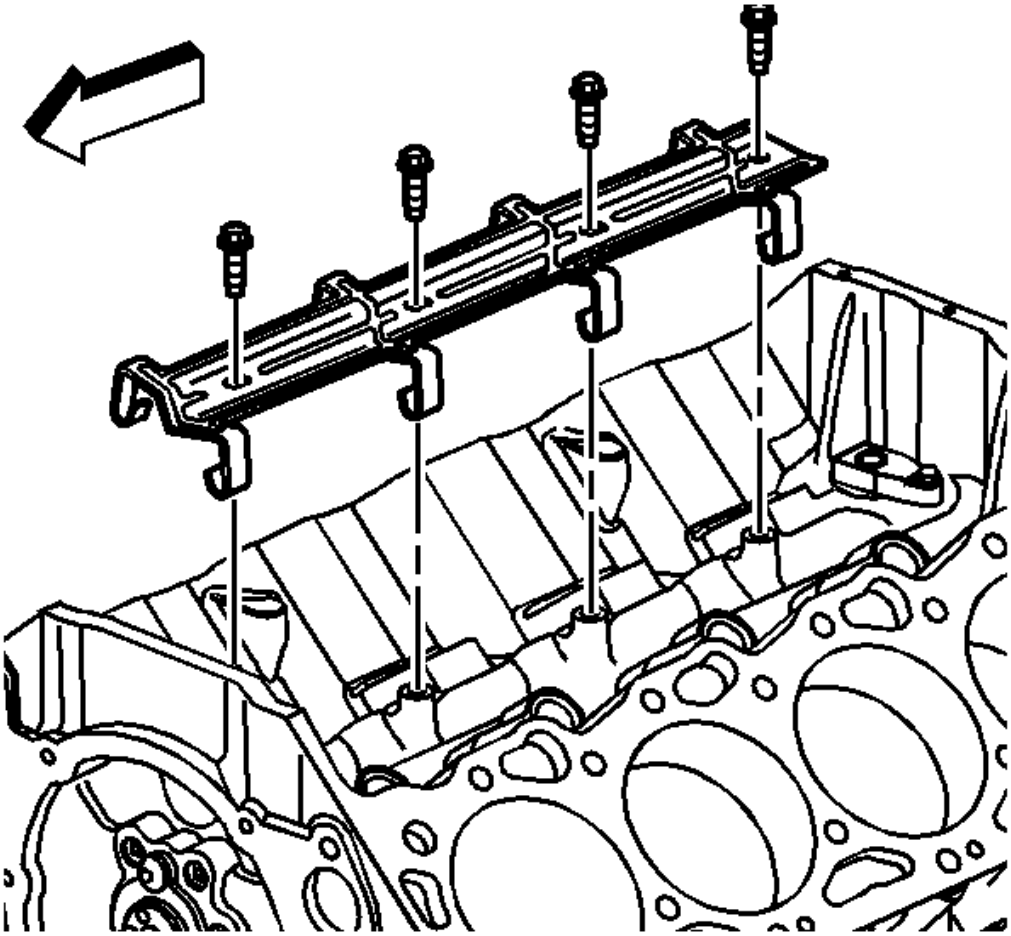

Fig. 282: View Of Valve Lifter Guide Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Mark, sort, or organize the valve lifters and guides for return to their original location during assembly.

1. Remove the valve lifter guide retainer bolts and retainer.

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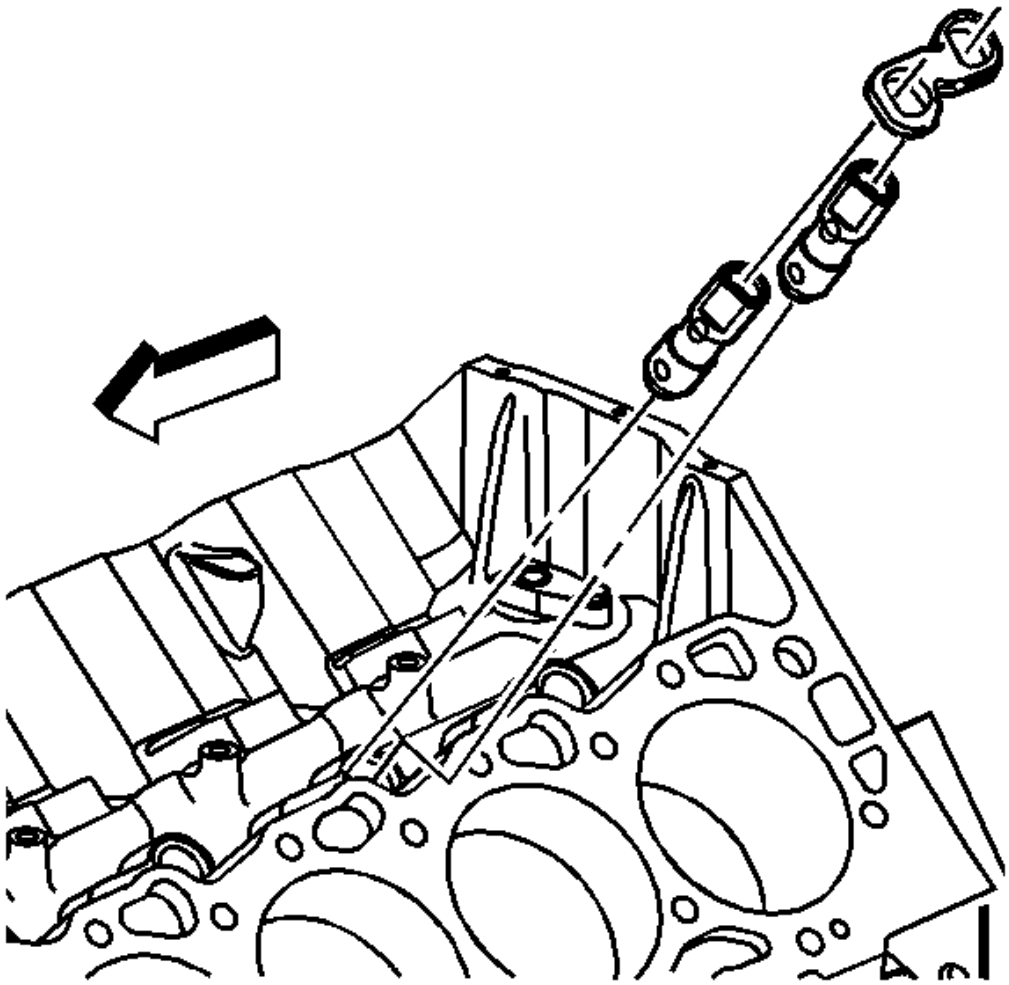

Fig. 283: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve lifter guides.

IMPORTANT: Place the valve lifters in the organizer rack or tag them in a way to ensure they can be returned to the valve lifter bore from which they were removed.

3. Remove the valve lifters.

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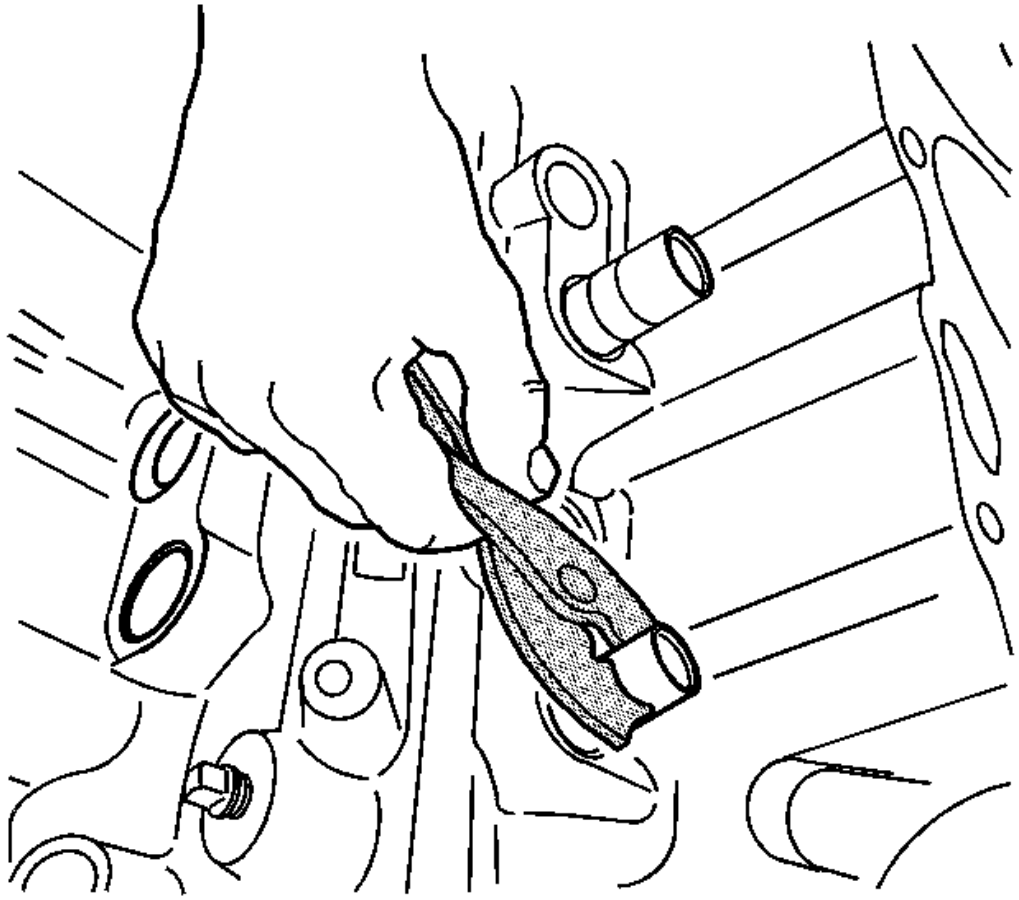

Fig. 284: Removing Valve Lifter Using J 3049-A
Courtesy of GENERAL MOTORS CORP.

4. Some valve lifters may be stuck in their bore due to gum or varnish deposits. These valve lifters can be removed using **J 3049-A** .

Oil Pump Drive Removal

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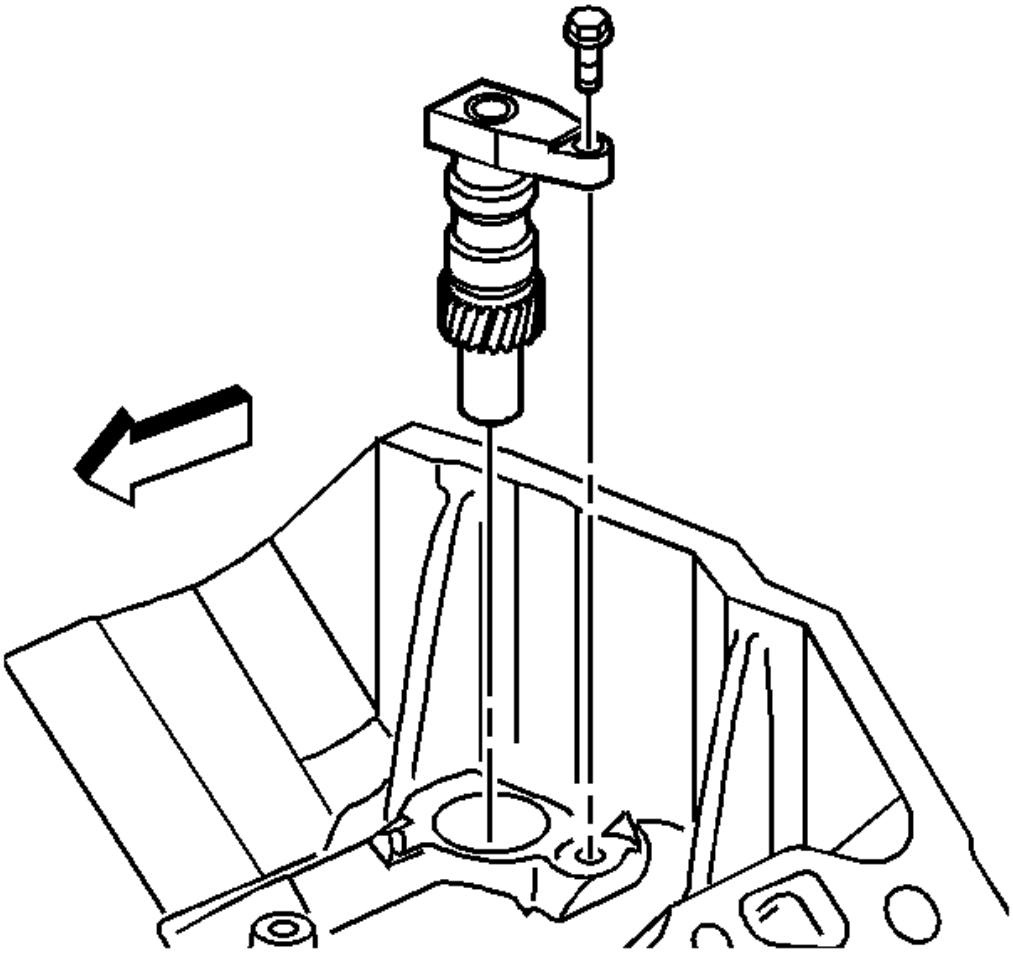

Fig. 285: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pump drive bolt.
2. Remove the oil pump drive.

Oil Pan Removal

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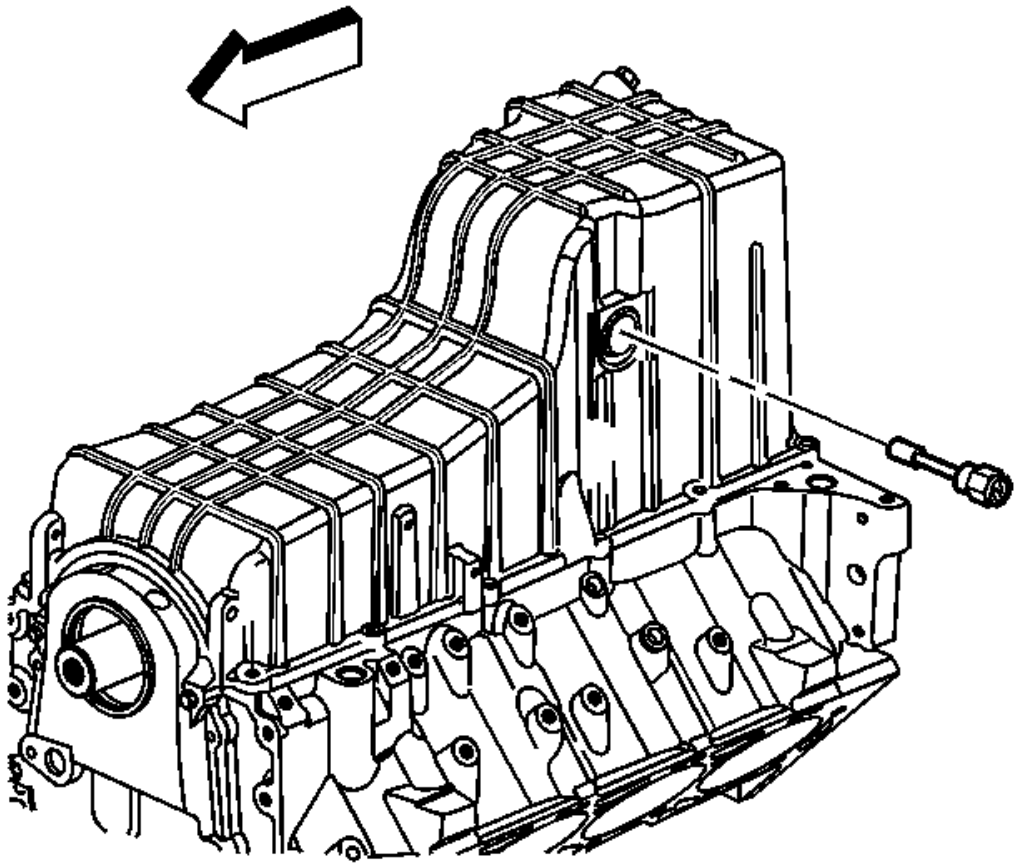

Fig. 286: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

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

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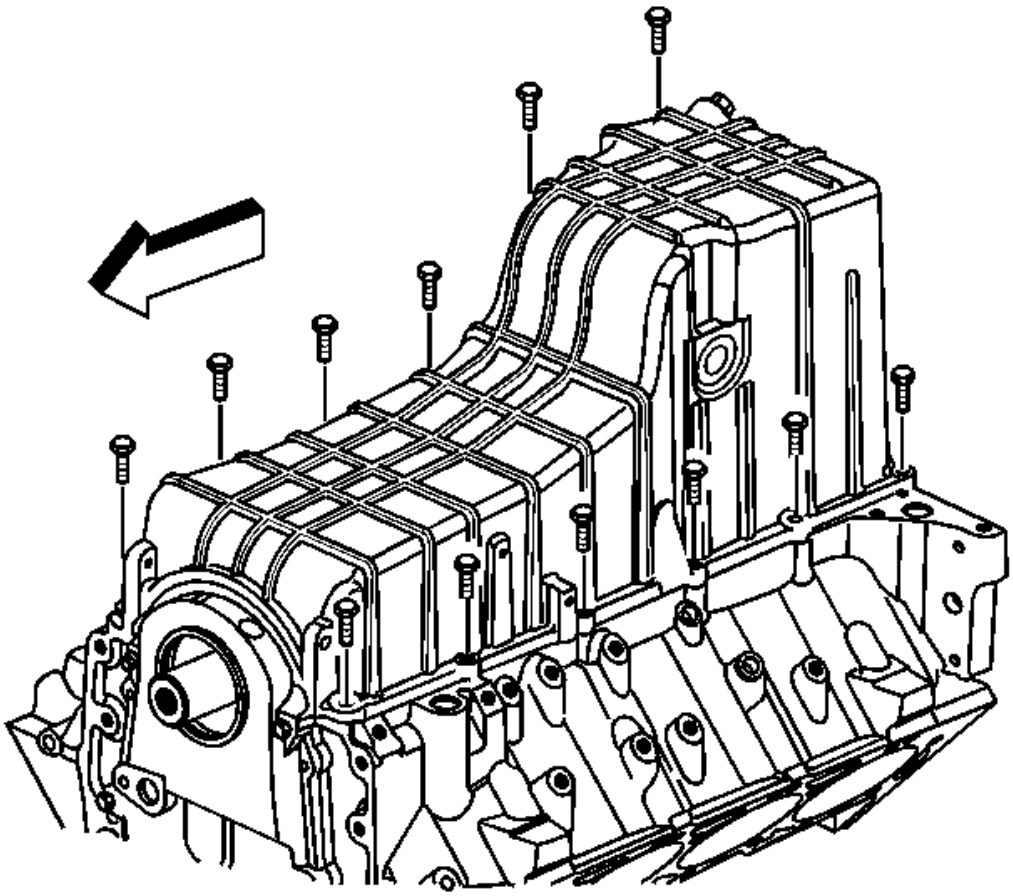

Fig. 287: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pan bolts.

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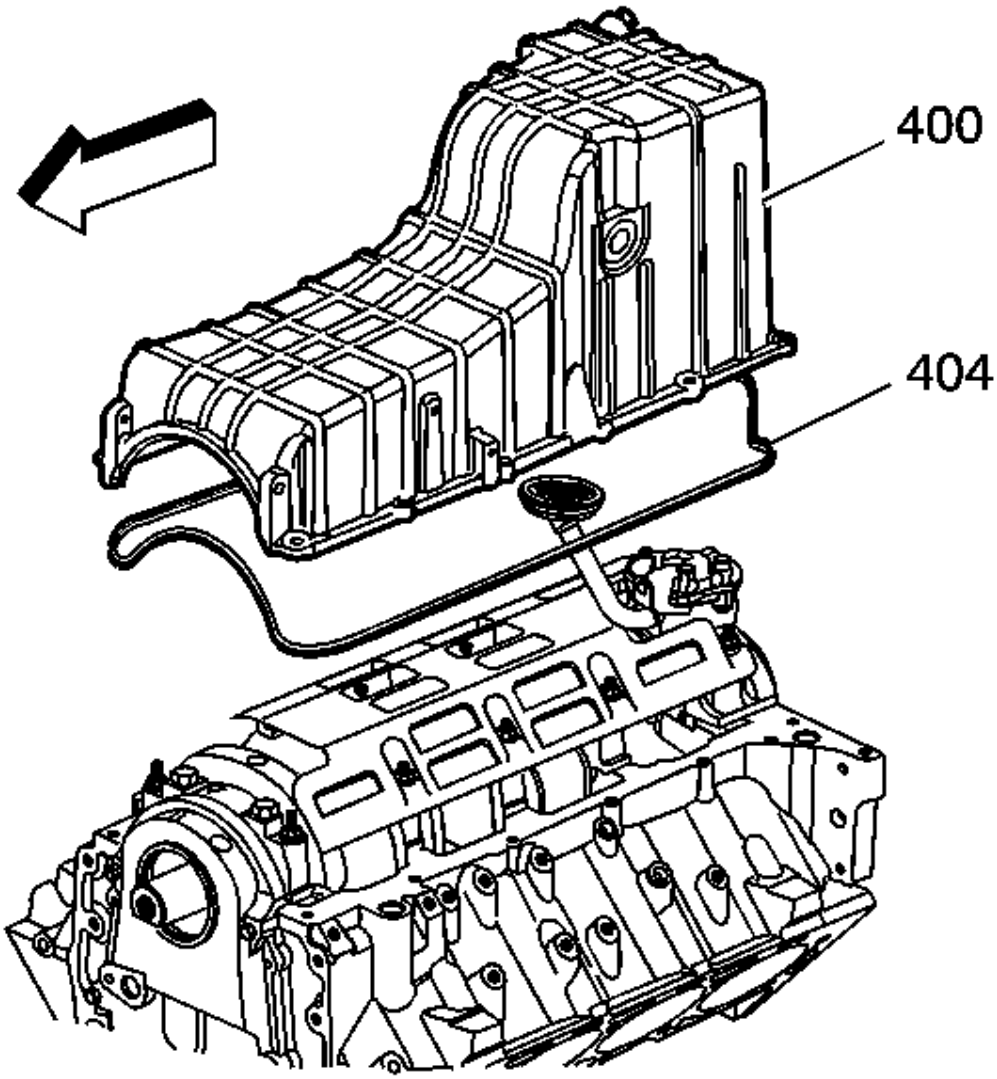

Fig. 288: View Of Oil Pan & Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan gasket is reusable if not cut or damaged.

3. Remove the oil pan (400) and the oil pan gasket (404).

Oil Pump, Pump Screen and Deflector Removal

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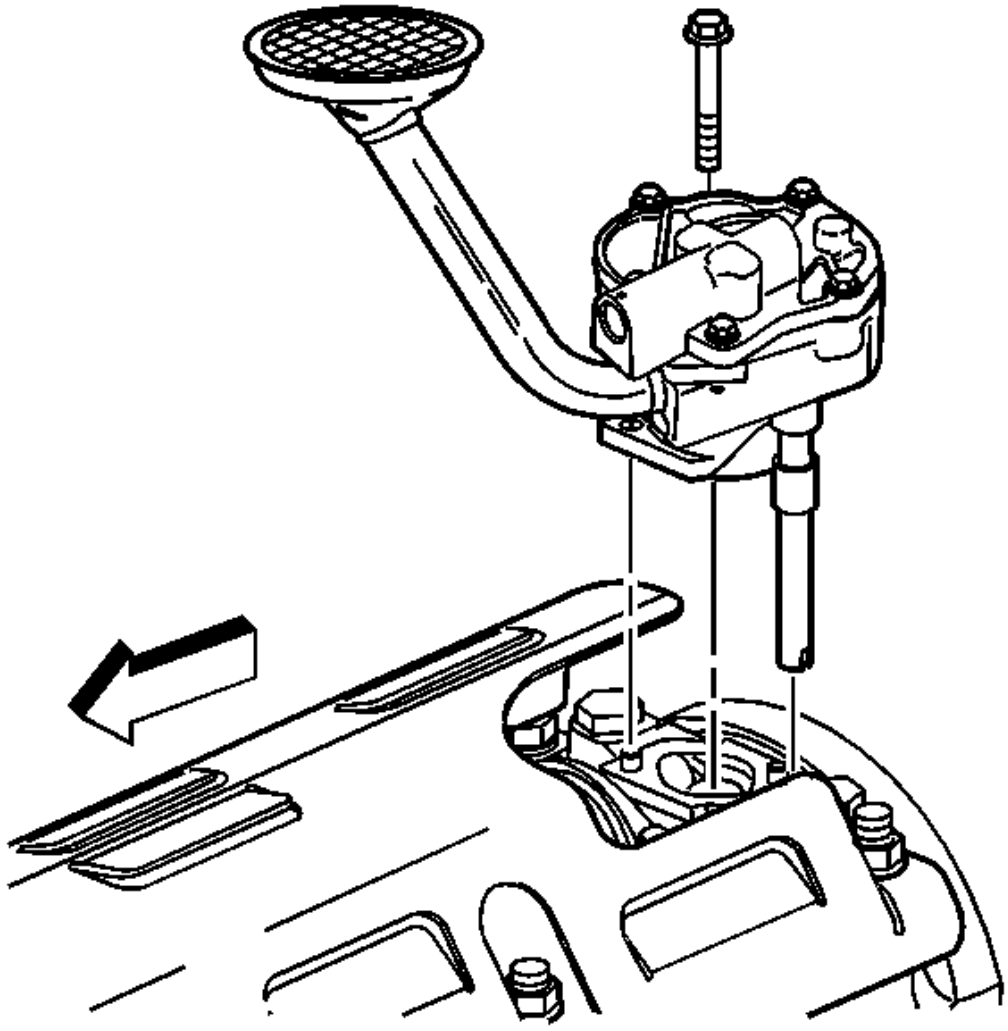

Fig. 289: View Of Oil Pump
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt that attaches the oil pump to the crankshaft rear bearing cap.
2. Remove the oil pump, driveshaft and retainer from the crankshaft rear bearing cap.

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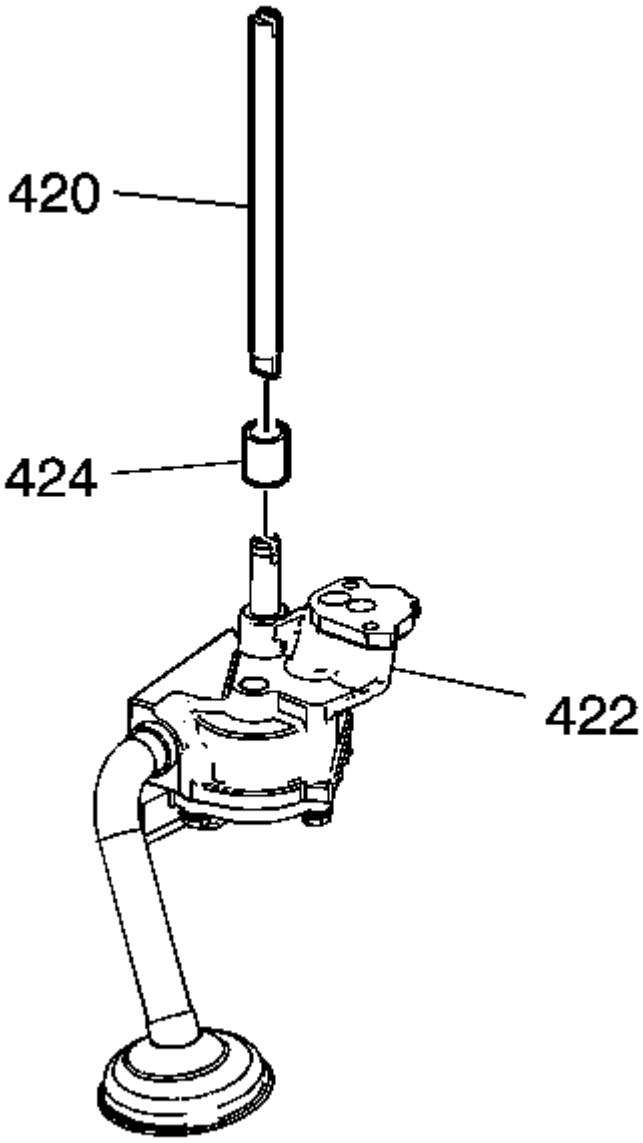

Fig. 290: View Of Oil Pump, Driveshaft & Retainer
Courtesy of GENERAL MOTORS CORP.

3. Separate the oil pump (422), driveshaft (420) and retainer (424).
4. Discard the driveshaft retainer (424).

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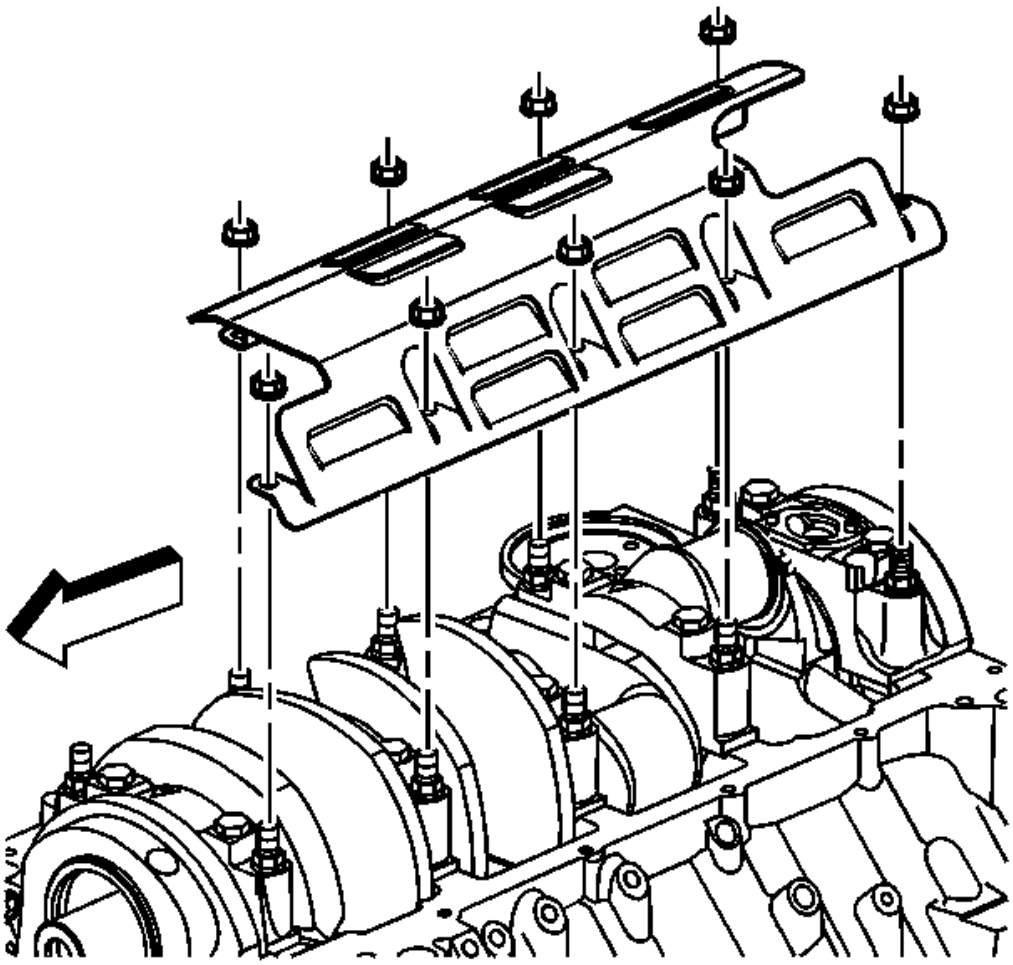

Fig. 291: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

5. Remove the crankshaft oil deflector nuts.
6. Remove the crankshaft oil deflector.

Engine Front Cover Removal

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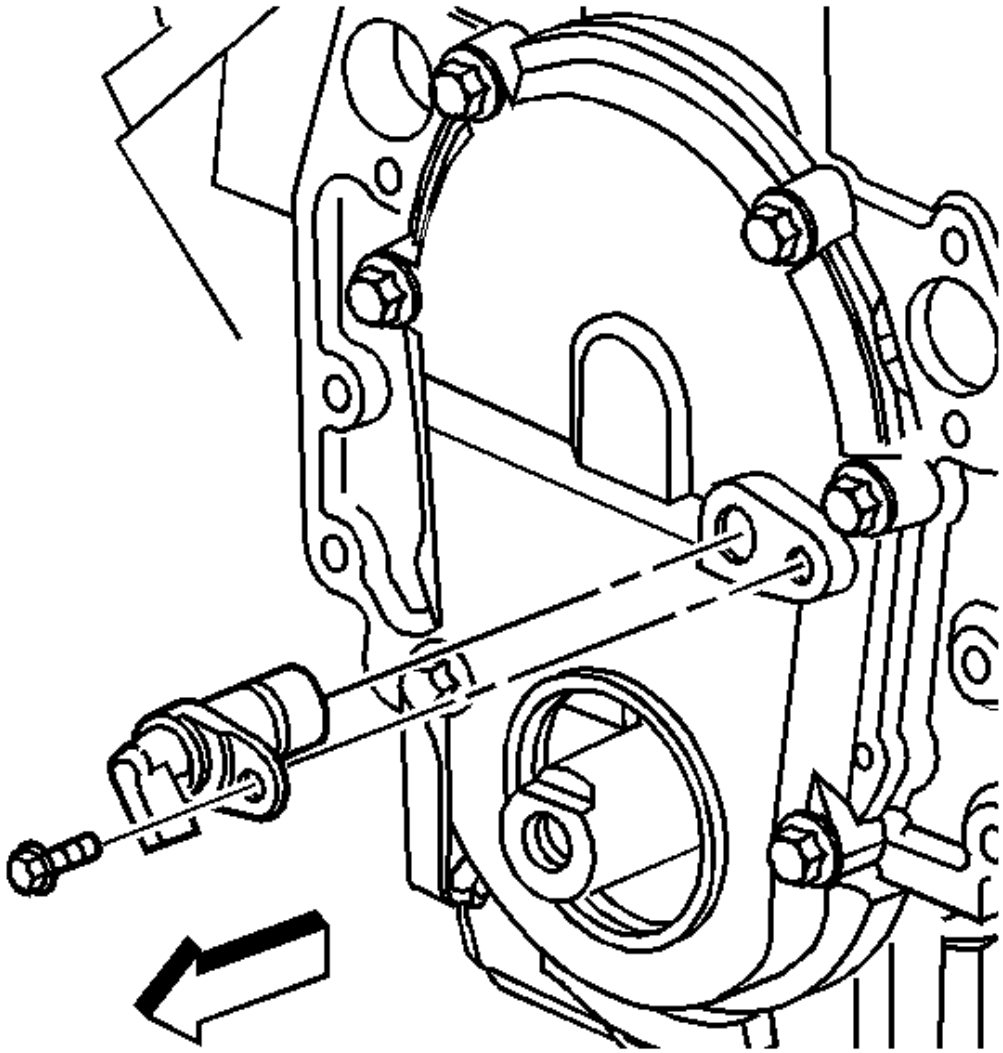

Fig. 292: View Of CMP Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: This component is initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing the self-tapping bolt(s) can lead to damage and unnecessary replacement of the self-tapping bolt (s) and/or the component the self-tapping bolt(s) is threaded into.

1. Remove the camshaft position (CMP) sensor bolt.

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2. Remove the CMP sensor.
3. Inspect the CMP sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as required.

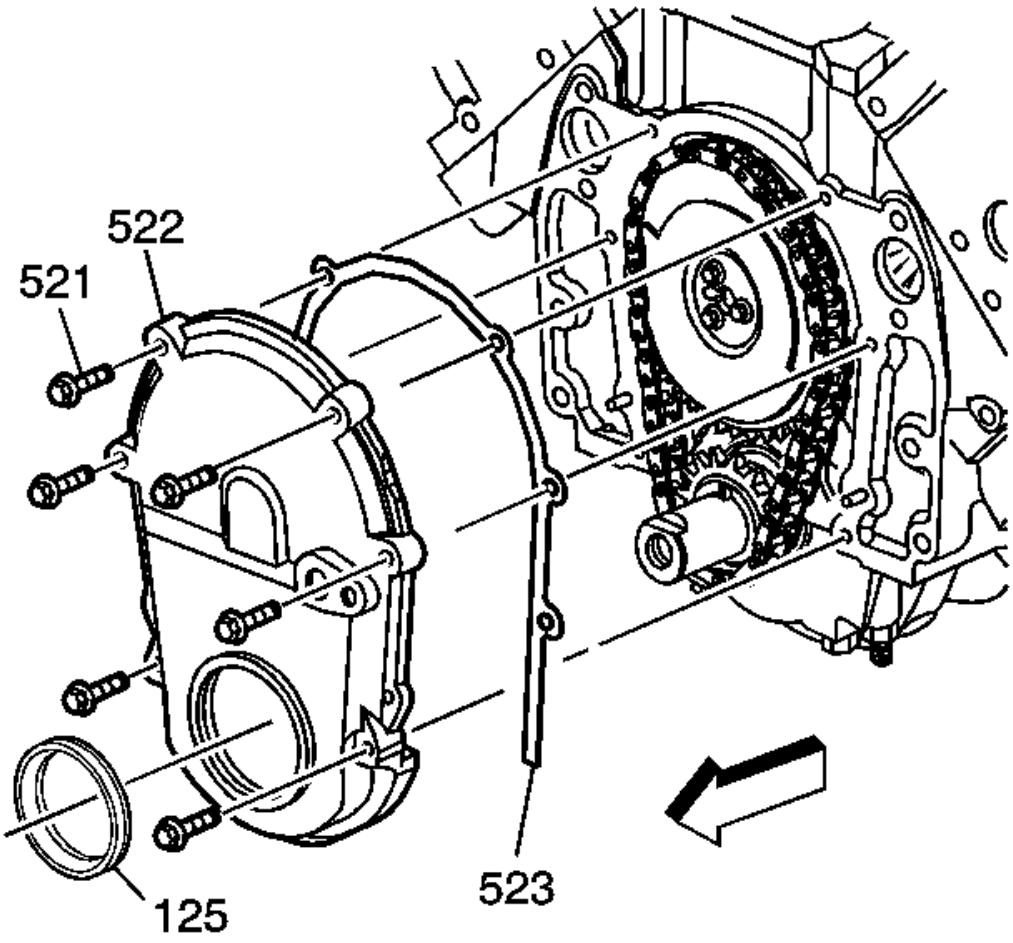

Fig. 293: View Of Engine Front Cover, Bolts, Gasket & Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine front cover bolts (521).
5. Remove the engine front cover (522).

IMPORTANT: The engine front cover gasket is reusable.

6. Remove the engine front cover gasket (523).
7. Remove the crankshaft front oil seal (125) from the engine front cover.

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Timing Chain and Sprockets Removal

Tools Required

J 42846 Crankshaft Protector Button. See **Special Tools and Equipment**.

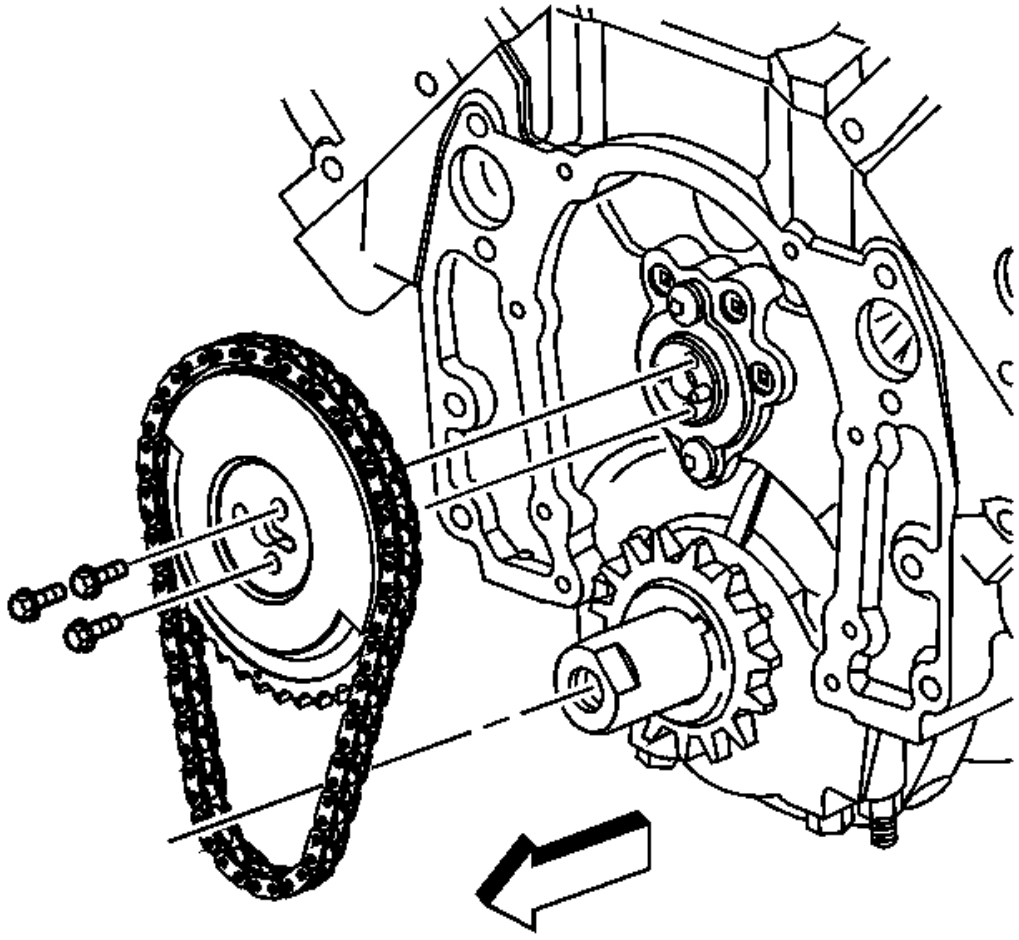

Fig. 294: View Of Camshaft Sprocket, Timing Chain & Bolts
Courtesy of GENERAL MOTORS CORP.

1. Measure the camshaft timing chain free play. If the chain can be moved back and forth in excess of 16 mm (0.625 in), replace the chain and sprockets.
2. Remove the camshaft sprocket bolts.
3. Remove the camshaft sprocket and the timing chain.

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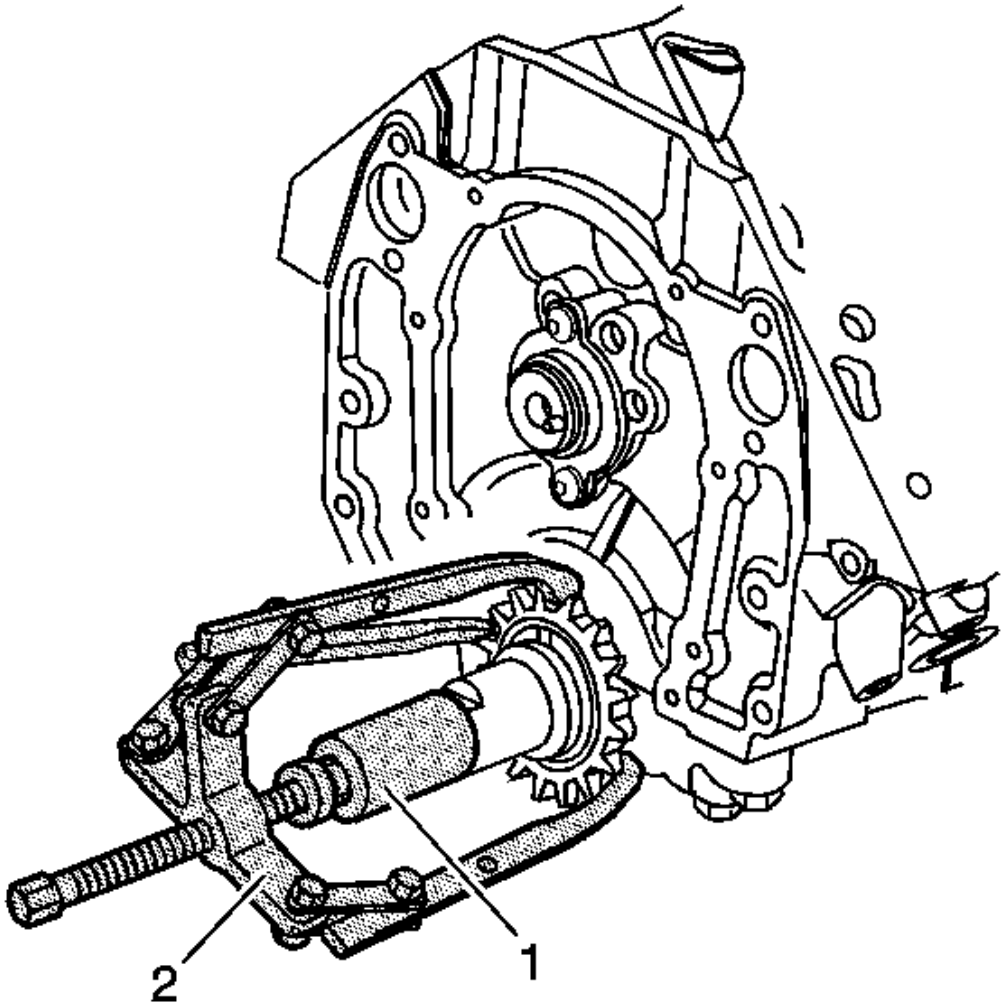

Fig. 295: Removing Crankshaft Sprocket Using J 42846
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 42846** (1) into the end of the crankshaft. See **Special Tools and Equipment**.
5. Remove the crankshaft sprocket using a three jaw puller (2).

Camshaft Removal

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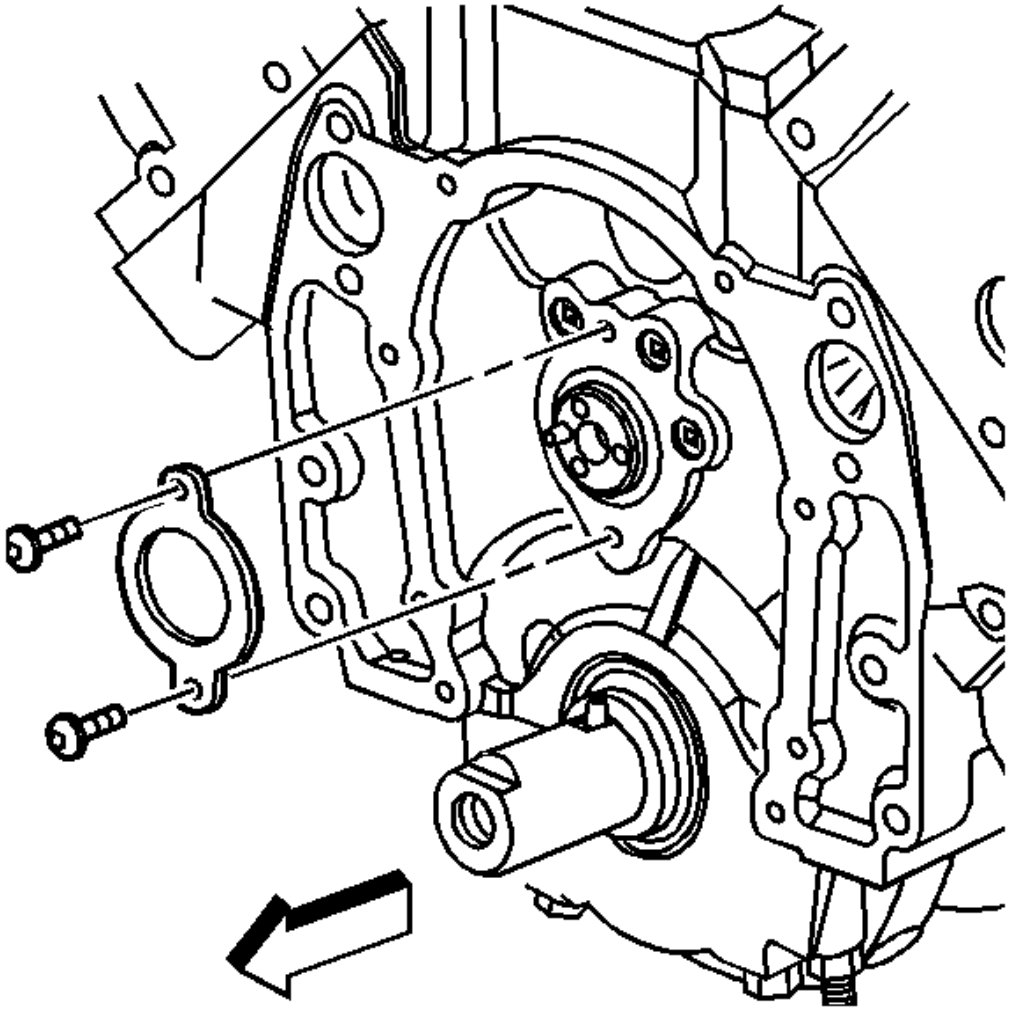

Fig. 296: View Of Camshaft Retainer
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft retainer bolts.
2. Remove the camshaft retainer.

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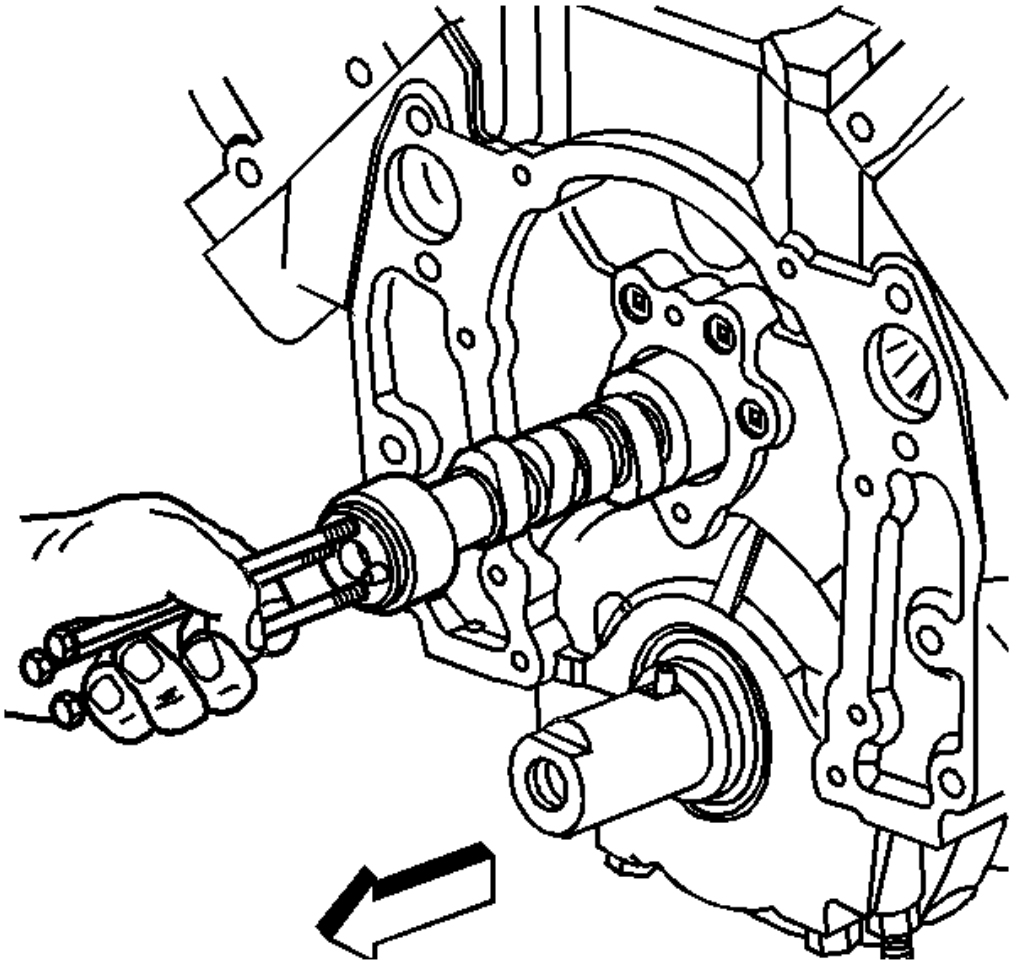

Fig. 297: View Of Bolts In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

3. Install three 8-1.25 x 100 mm bolts in the camshaft front bolt holes.

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

4. Using the bolts as a handle, carefully rotate and pull the camshaft out of the engine block.
5. Remove the bolts from the front of the camshaft.

Piston, Connecting Rod, and Bearing Removal

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Tools Required

- **J 24270** Cylinder Bore Ridge Reamer
- **J 42846** Crankshaft Protector Button. See **Special Tools and Equipment**.

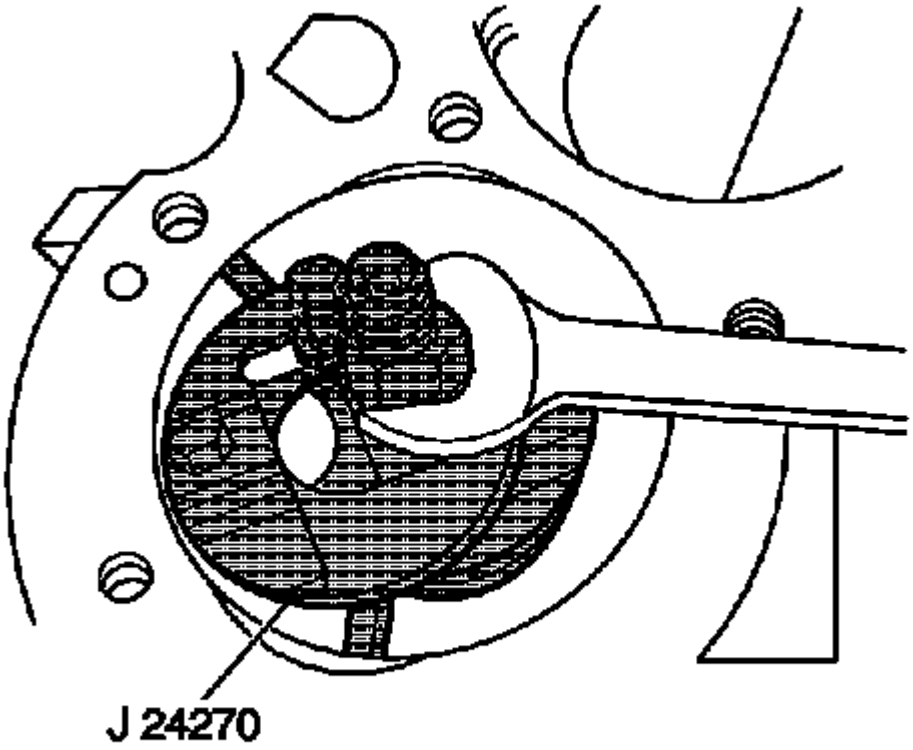

Fig. 298: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not remove the excessive material from the cylinder bore. Excessive removal of material may require cylinder boring to the next oversize.

1. Remove the cylinder bore ridge as necessary.
    1. Install the **J 42846** onto the front of the crankshaft in order to rotate the crankshaft. See **Special Tools and Equipment**.
    2. Rotate the crankshaft until the piston is at the bottom of the stroke (BDC).
    3. Place a cloth on top of the piston.
    4. Perform the cutting operation with a **J 24270** . Refer to the manufacturer's instructions before using the **J 24270** .
    5. Remove the **J 24270** .

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6. Rotate the crankshaft until the piston is at top dead center (TDC).
7. Remove the cloth and the cuttings.
8. Repeat the procedure for each piston.

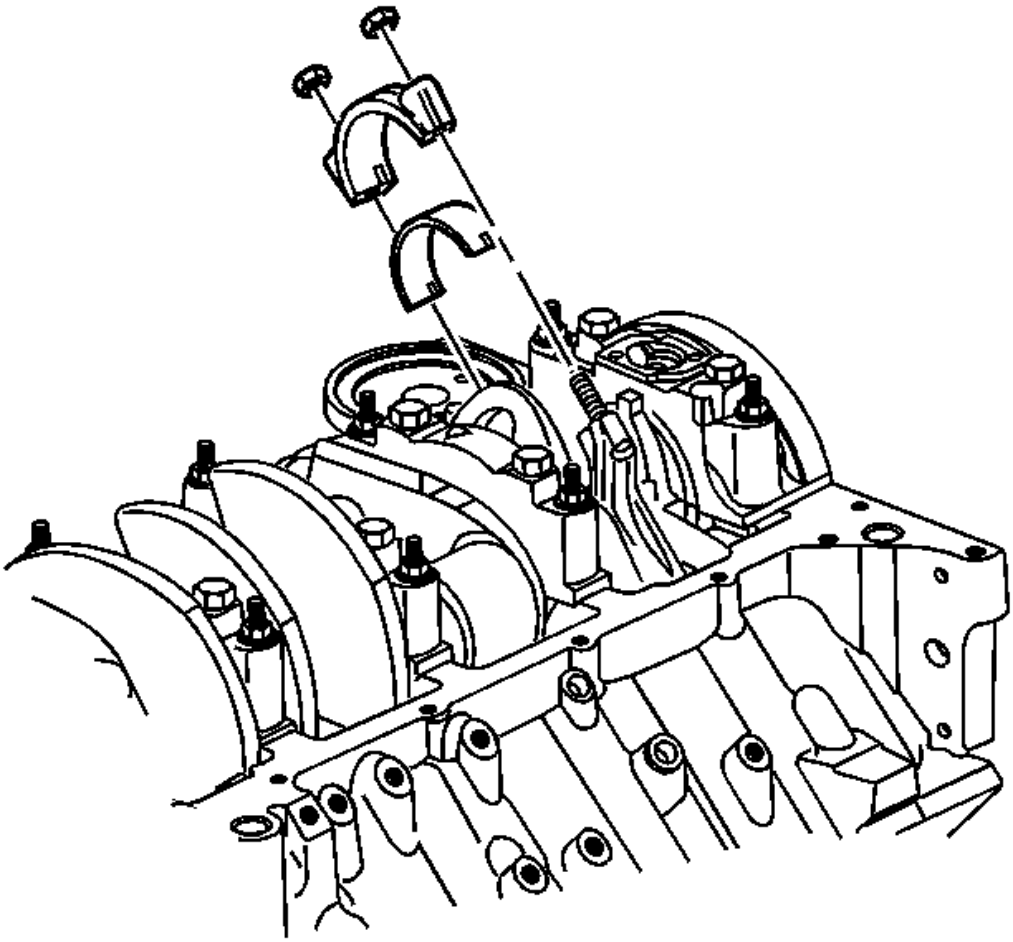

Fig. 299: View Of Connecting Rod Cap & Connecting Rod Lower Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Place matching marks or numbers on the connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

IMPORTANT: When connecting rod bearings are removed, NEW bearings must be installed during assembly.

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2. Remove the connecting rod nuts.
3. Remove the connecting rod cap and the connecting rod lower bearing.

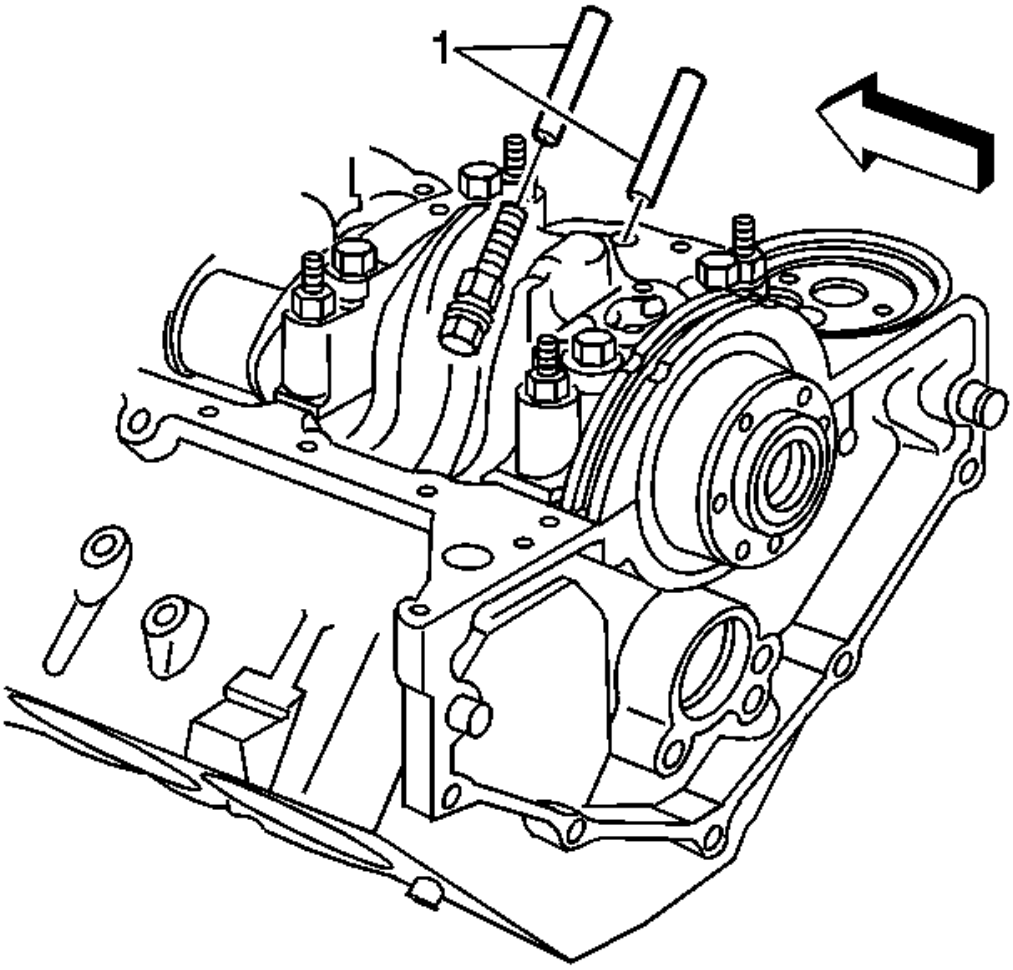

Fig. 300: Installing Rubber Fuel Line Onto Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install rubber fuel line onto the connecting rod bolts to prevent contact with the crankshaft journal.

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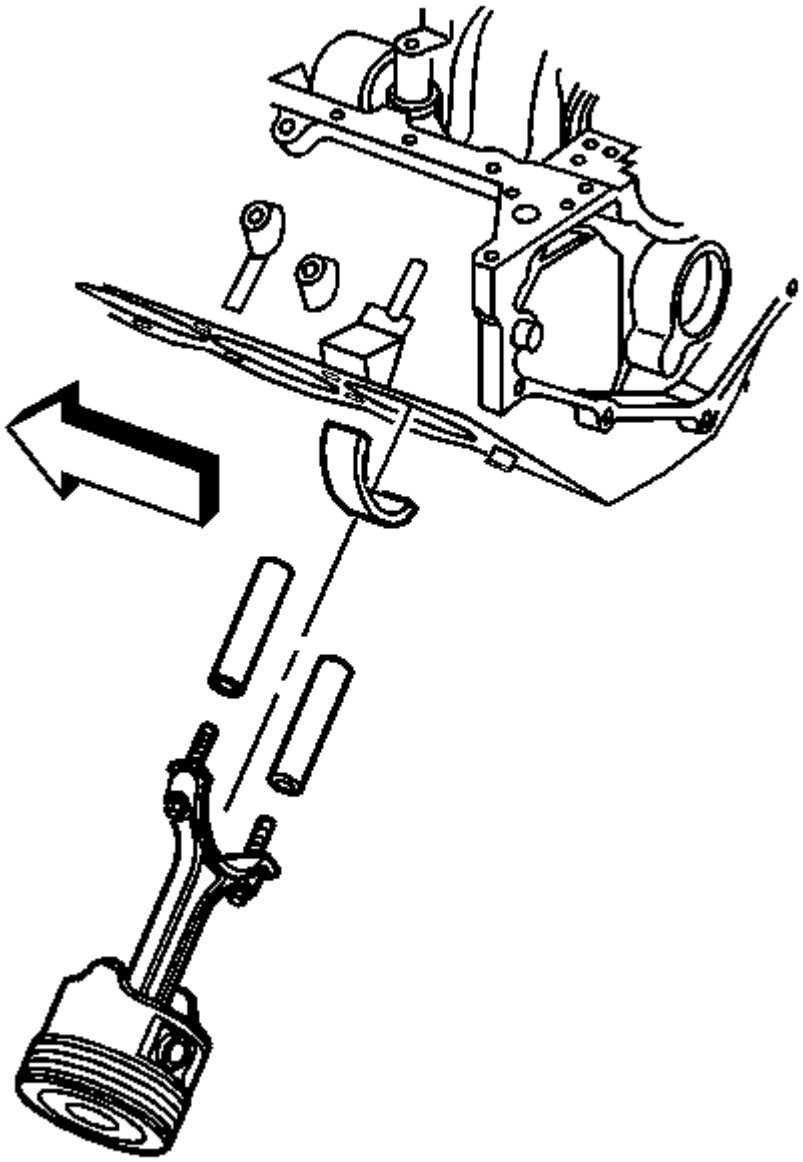

Fig. 301: View Of Piston, Connecting Rod, & Connecting Rod Upper Bearing
Courtesy of GENERAL MOTORS CORP.

5. Remove the piston, connecting rod, and connecting rod upper bearing.

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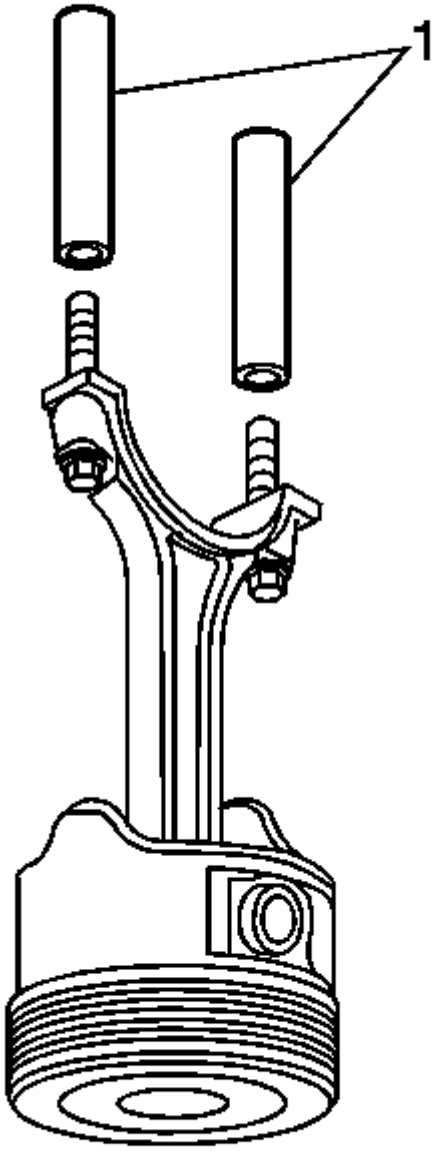

Fig. 302: View Of Rubber Fuel Line From Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the rubber fuel line from the connecting rod bolts.
7. Remove the remaining piston and the connecting rod assemblies.
8. Remove the **J 42846** from the front of the crankshaft. See **Special Tools and Equipment**.

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Crankshaft and Bearings Removal

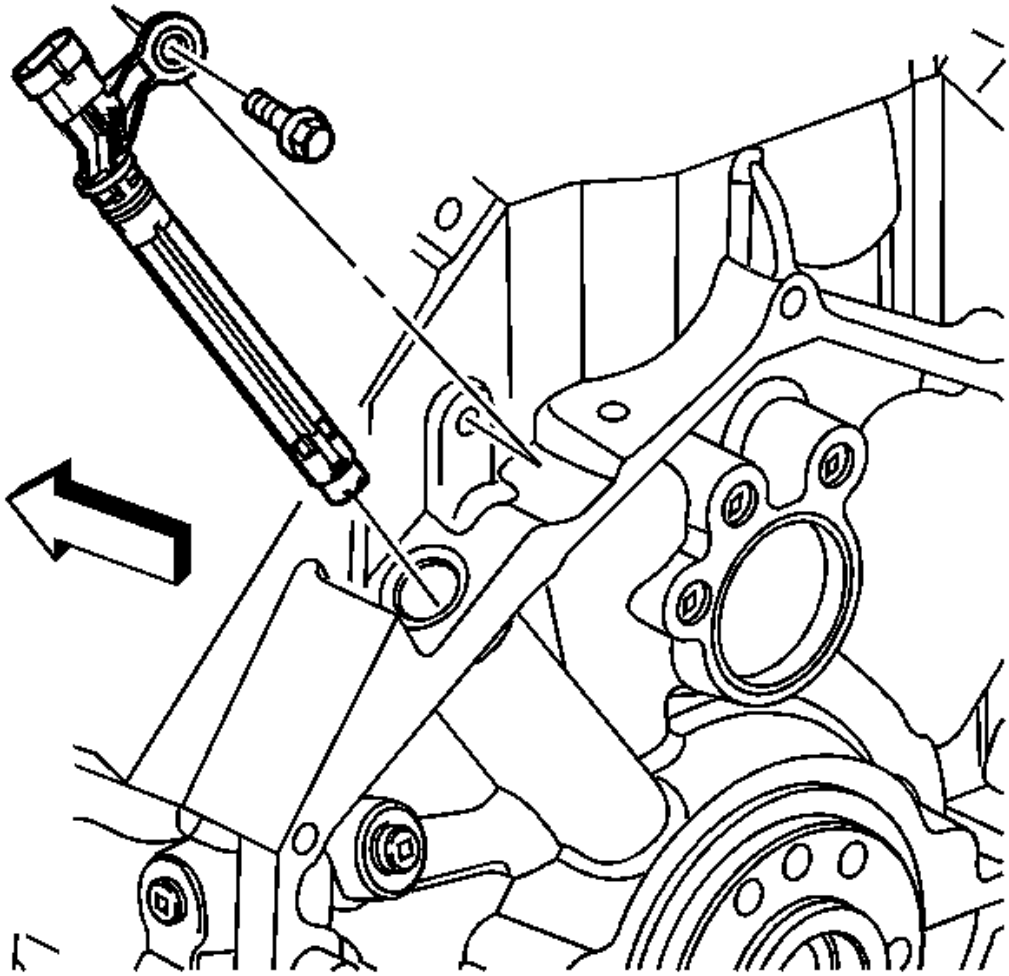

Fig. 303: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to prevent damage to the crankshaft position (CKP) sensor reluctor wheel/ring care must be used when removing or installing this component.

IMPORTANT: The crankshaft position (CKP) sensor is designed to contact the reluctor wheel of the crankshaft. Wear may be noticeable on the end of the sensor.

1. Remove the CKP sensor bolt.

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2. Apply penetrating oil to the CKP sensor-to-engine block mating surface. Allow the penetrating oil to soak for several minutes, to help loosen the O-ring from the engine block.
3. Twist the sensor to loosen the O-ring seal. When removing the sensor, pull the sensor straight out of the engine block at the same angle the sensor was installed.
4. Inspect both CKP sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed.

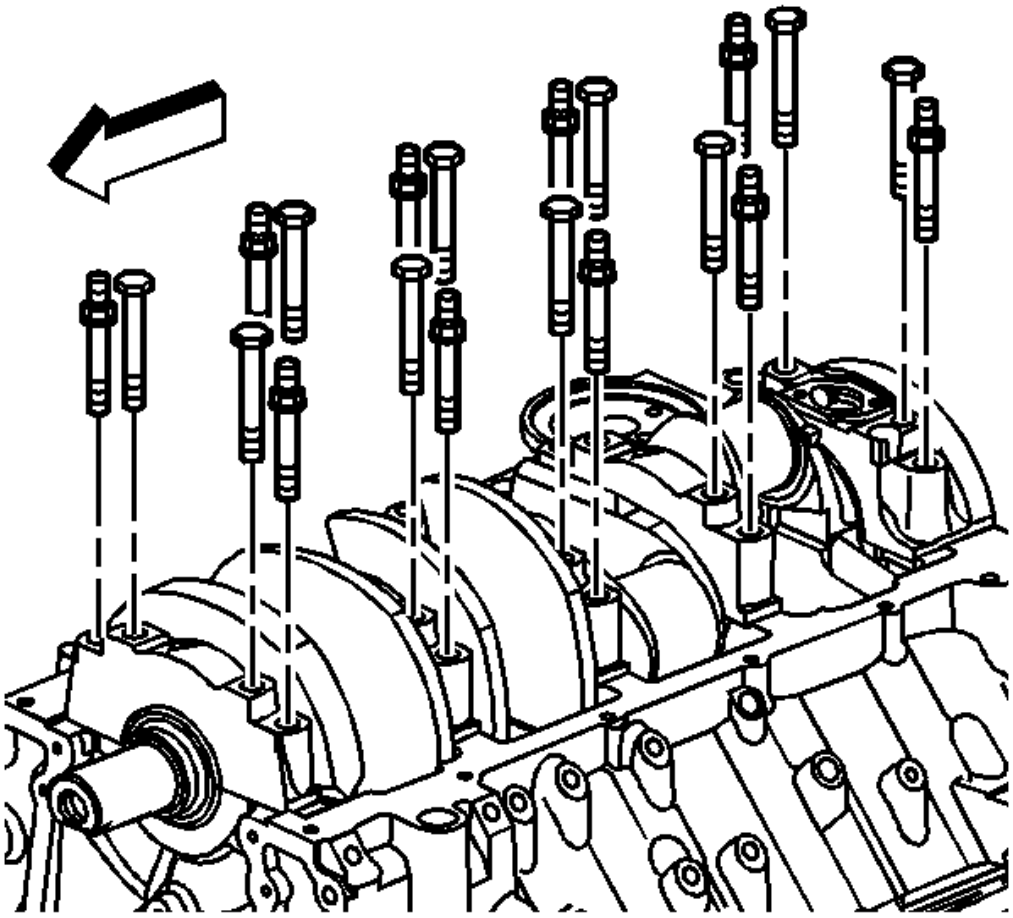

Fig. 304: View Of Crankshaft Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: 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. Crankshaft bearing caps must be installed in their original locations.

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5. Remove the crankshaft bearing cap bolts and studs.

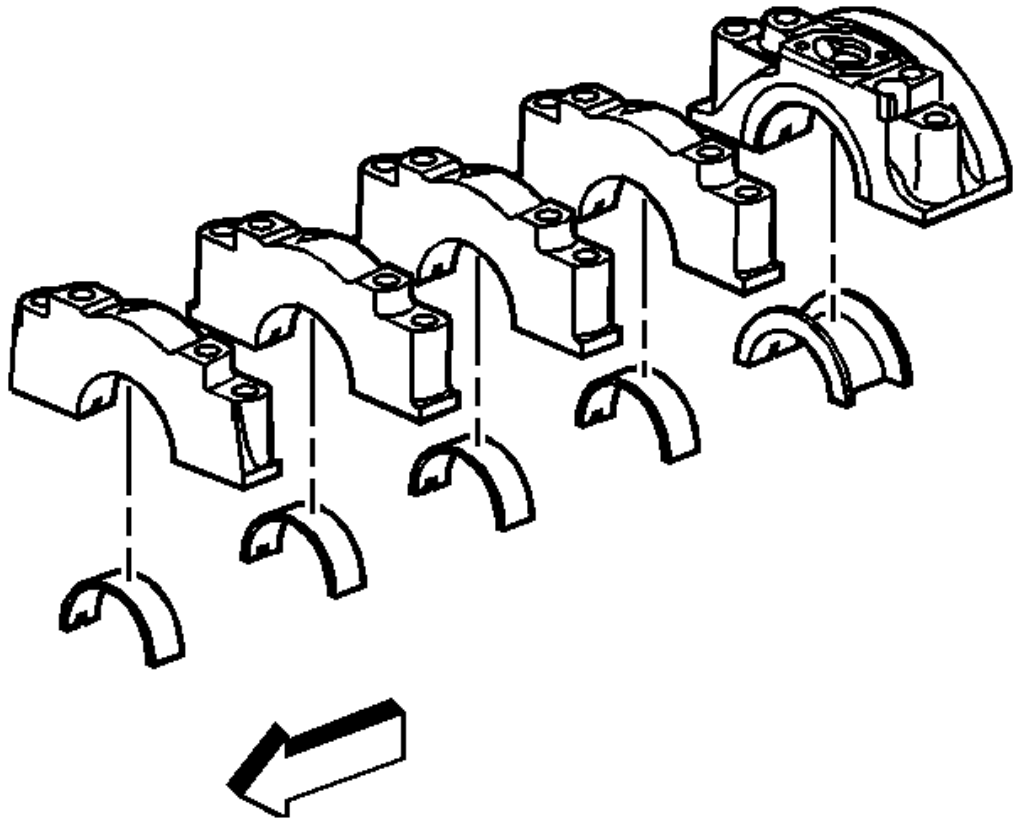

Fig. 305: View Of Crankshaft Lower Bearing & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Remove the crankshaft bearing caps.
7. Remove the crankshaft lower bearings from the crankshaft bearing caps.

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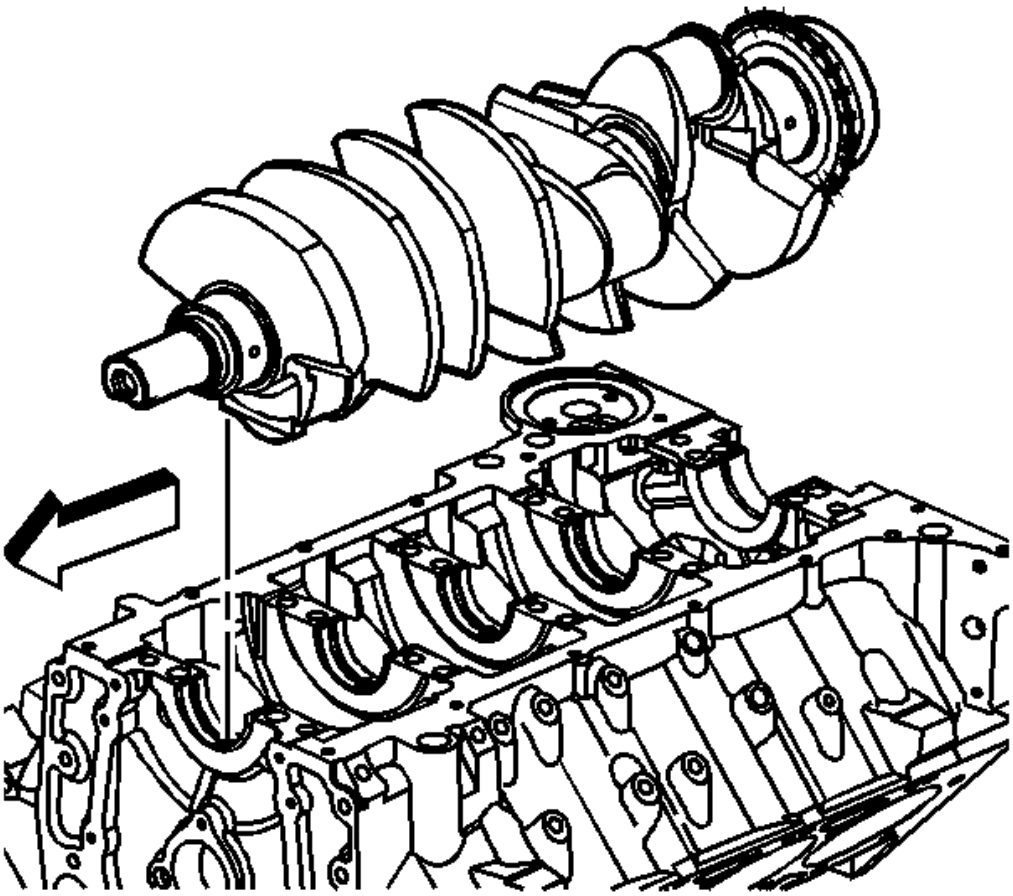

Fig. 306: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Care should be taken when removing the crankshaft so that the CKP sensor reluctor ring is not damaged.

8. Remove the crankshaft.

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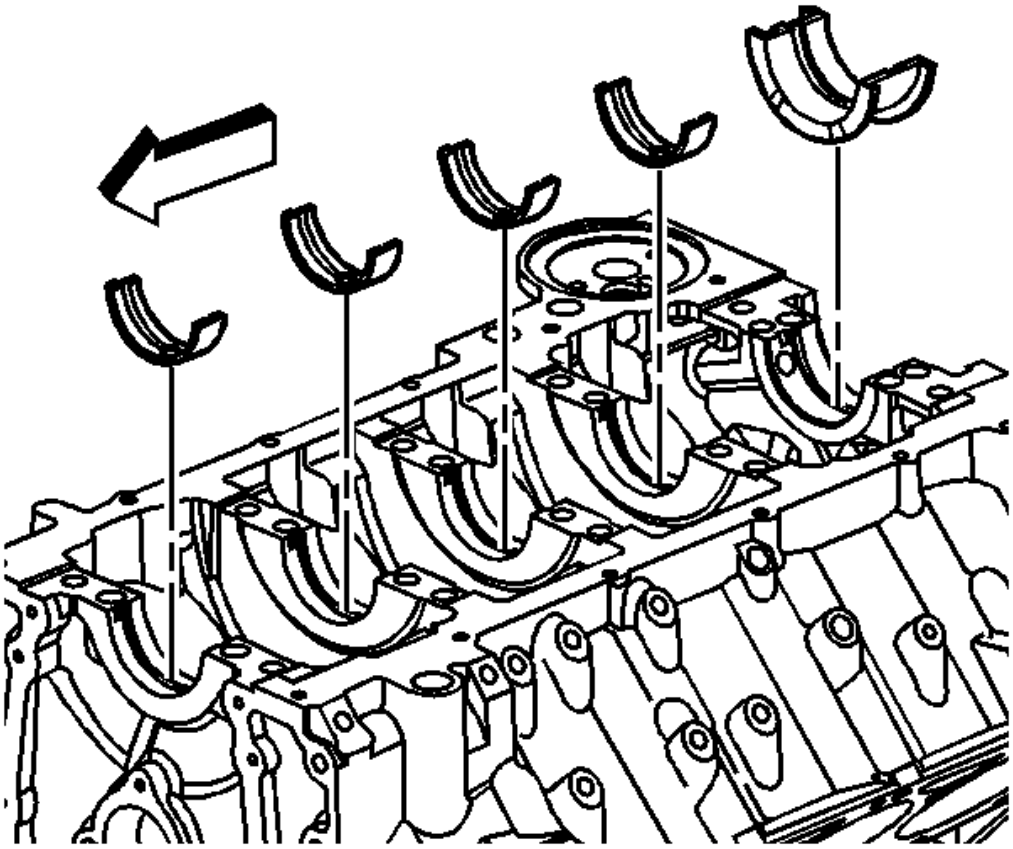

Fig. 307: View Of Crankshaft Upper Bearings
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft upper bearings from the engine block.

Oil Filter Adapter Removal

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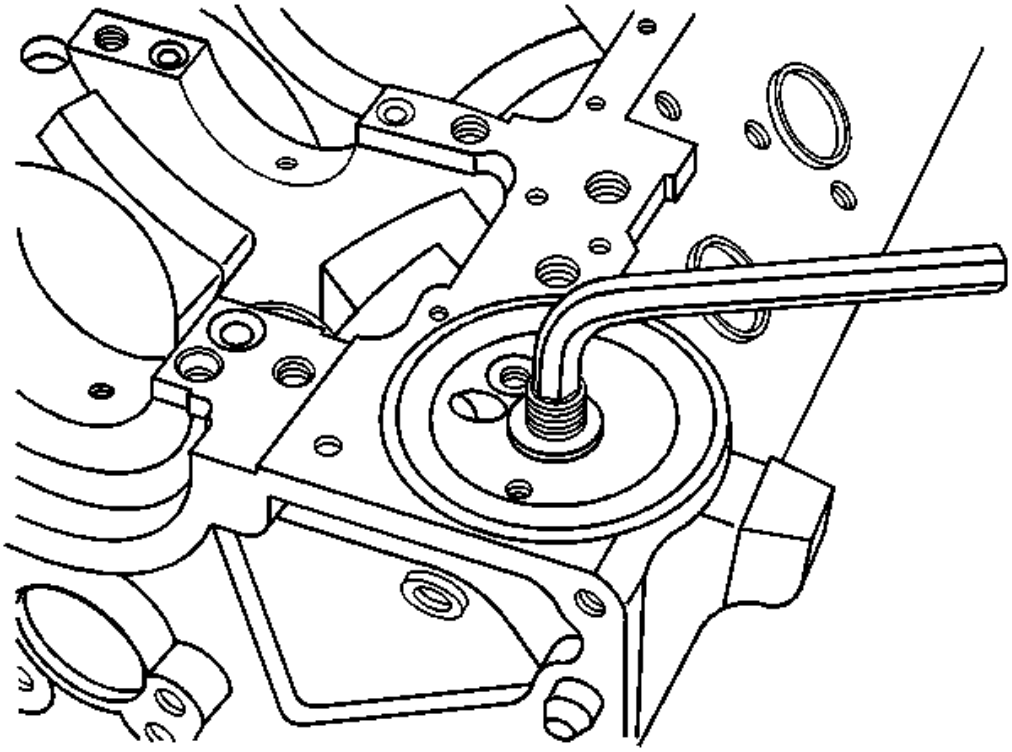

Fig. 308: Loosening Oil Filter Fitting Using Hex Wrench
Courtesy of GENERAL MOTORS CORP.

1. Loosen the oil filter fitting, using a hex wrench.

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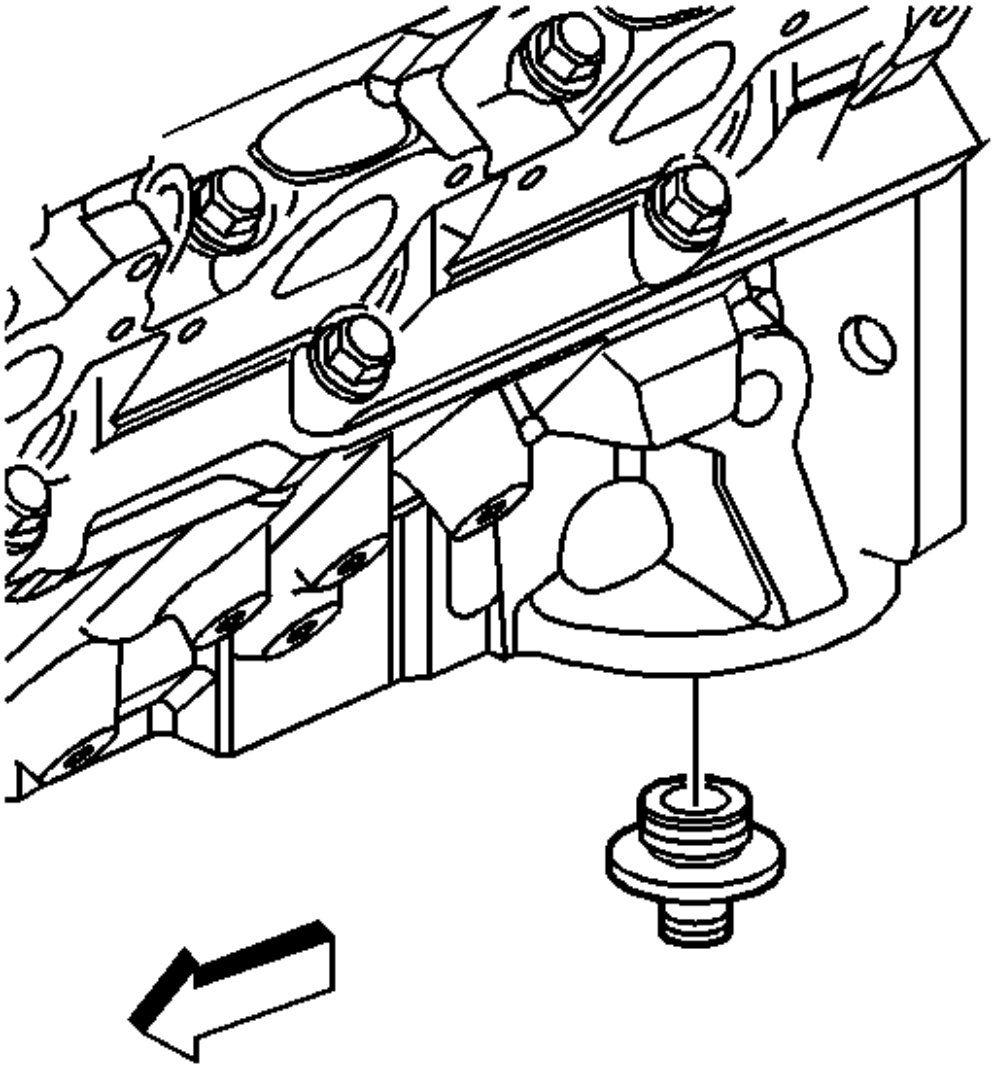

Fig. 309: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil filter fitting.
3. Inspect the oil filter fitting, replace if necessary.

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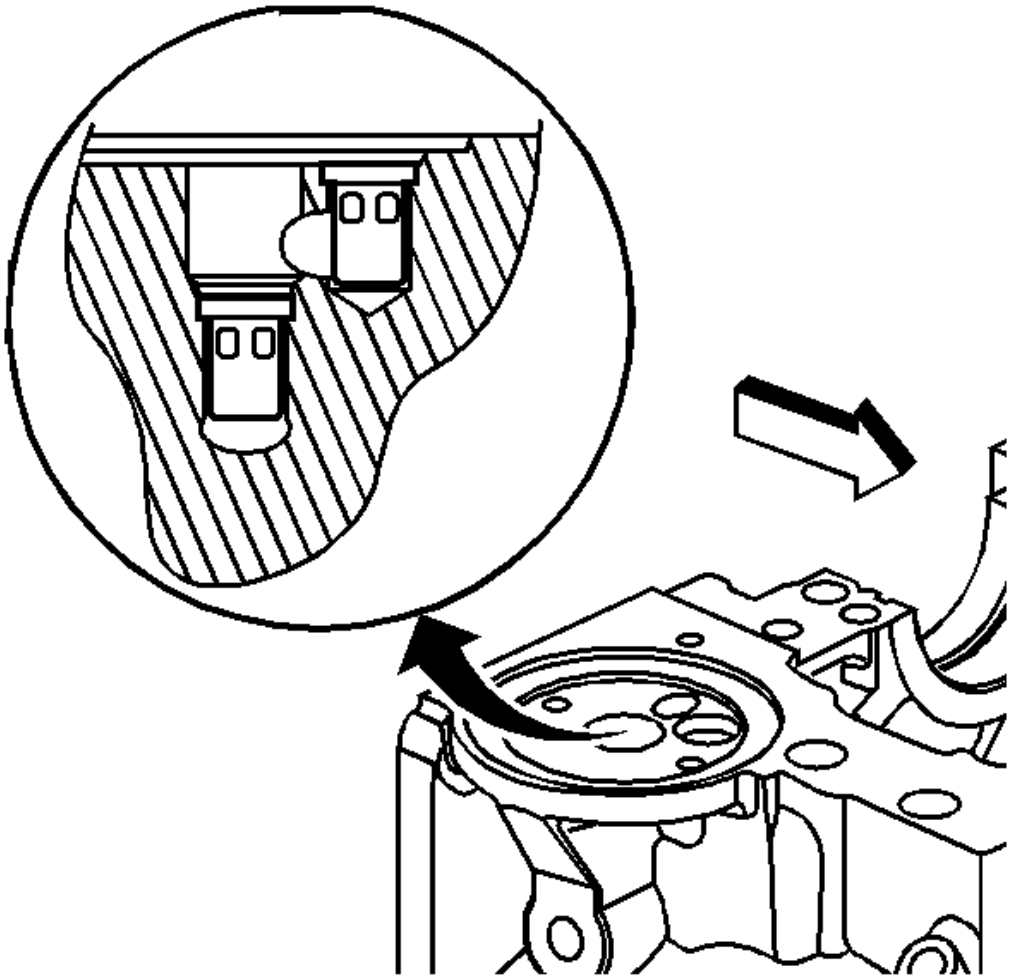

Fig. 310: View Of Tangs On Oil Bypass Valves
Courtesy of GENERAL MOTORS CORP.

4. Remove the oil bypass valves (if required). Unstake the tangs on the oil bypass valves and remove with long nose pliers.
5. Discard the oil bypass valves, if removed.

Engine Block Plug Removal

Tools Required

J 41712 Oil Pressure Switch Socket

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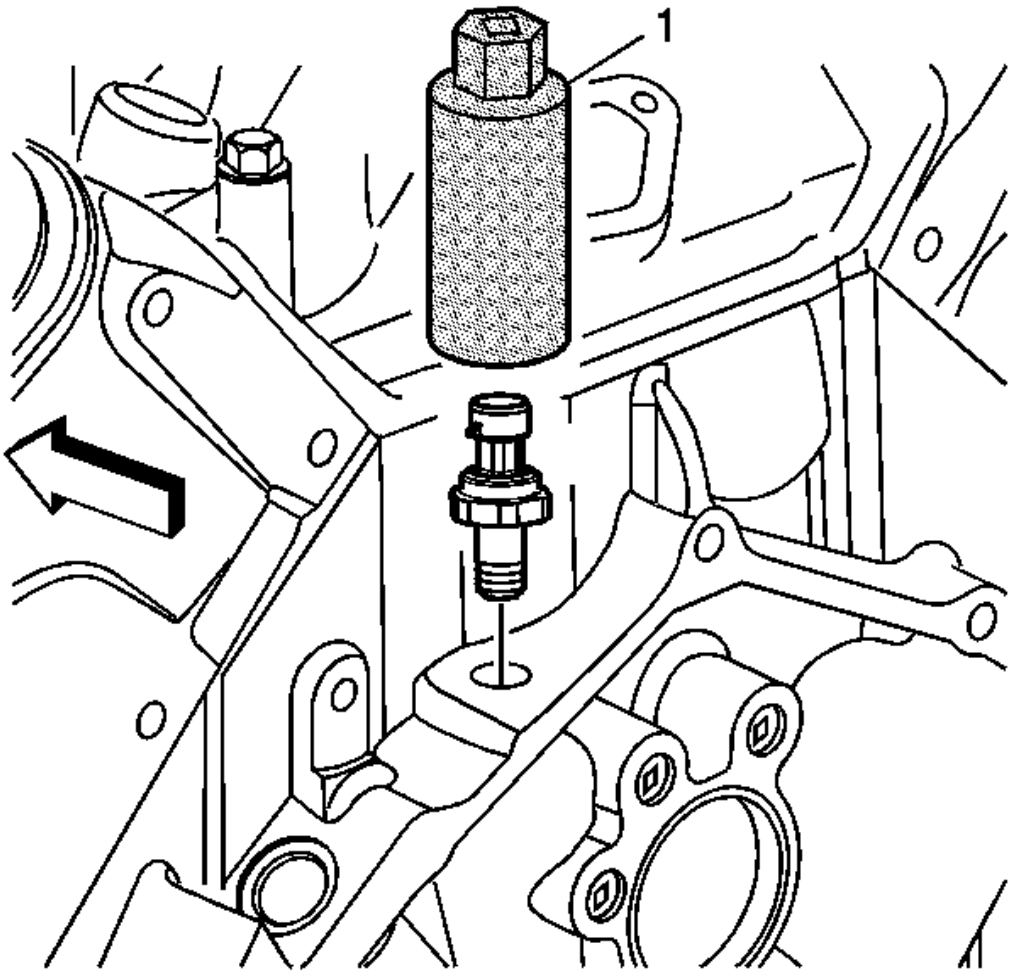

Fig. 311: Removing & Installing Oil Pressure Sensor Using J 41712
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pressure sensor using **J 41712** (1).

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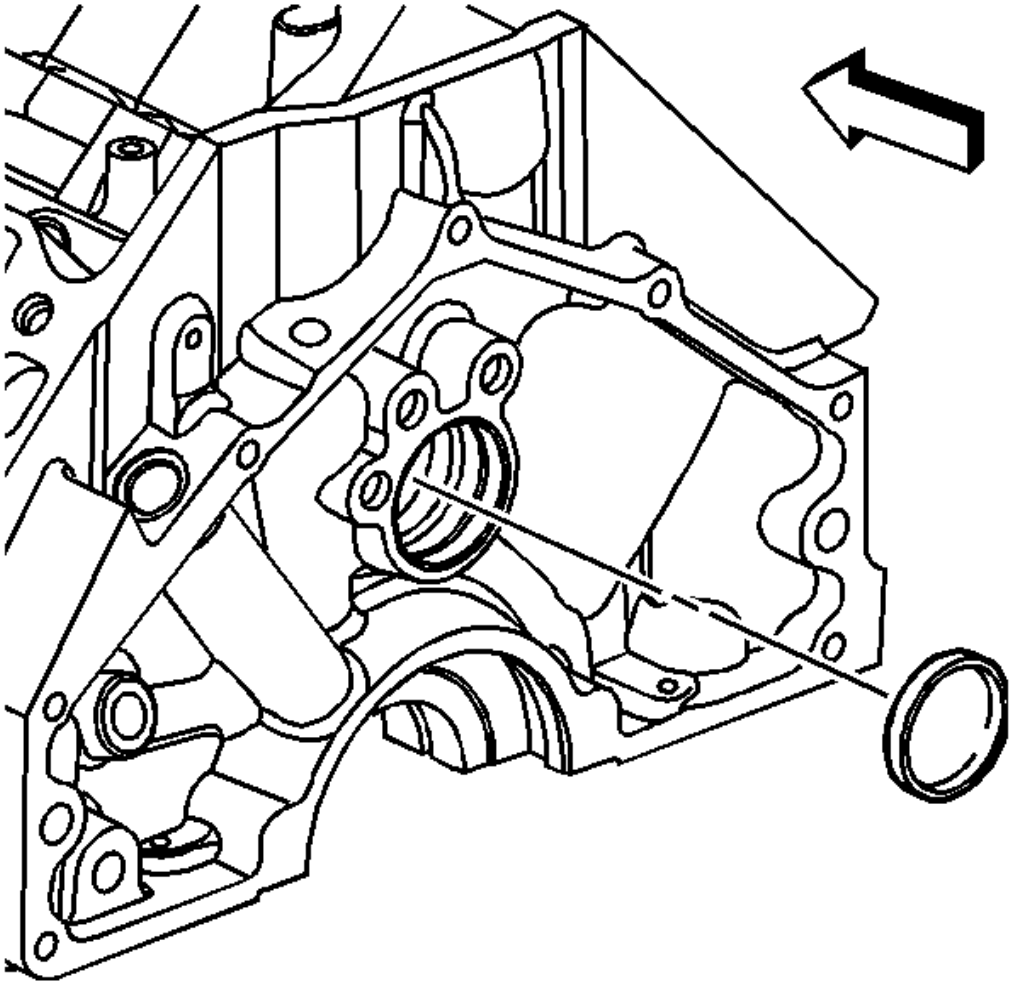

Fig. 312: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

2. Remove the camshaft rear bearing hole plug:
    1. Obtain a suitable self-threading screw.
    2. Drill a hole into the plug.
    3. Install the self-threading screw.
    4. Pull on the plug until it has left the bore.

IMPORTANT: Use care not to damage the camshaft bearings.

    5. An alternate method to remove the plug would be to insert a long shaft or bar through the front of

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the engine and drive the plug from the bore.

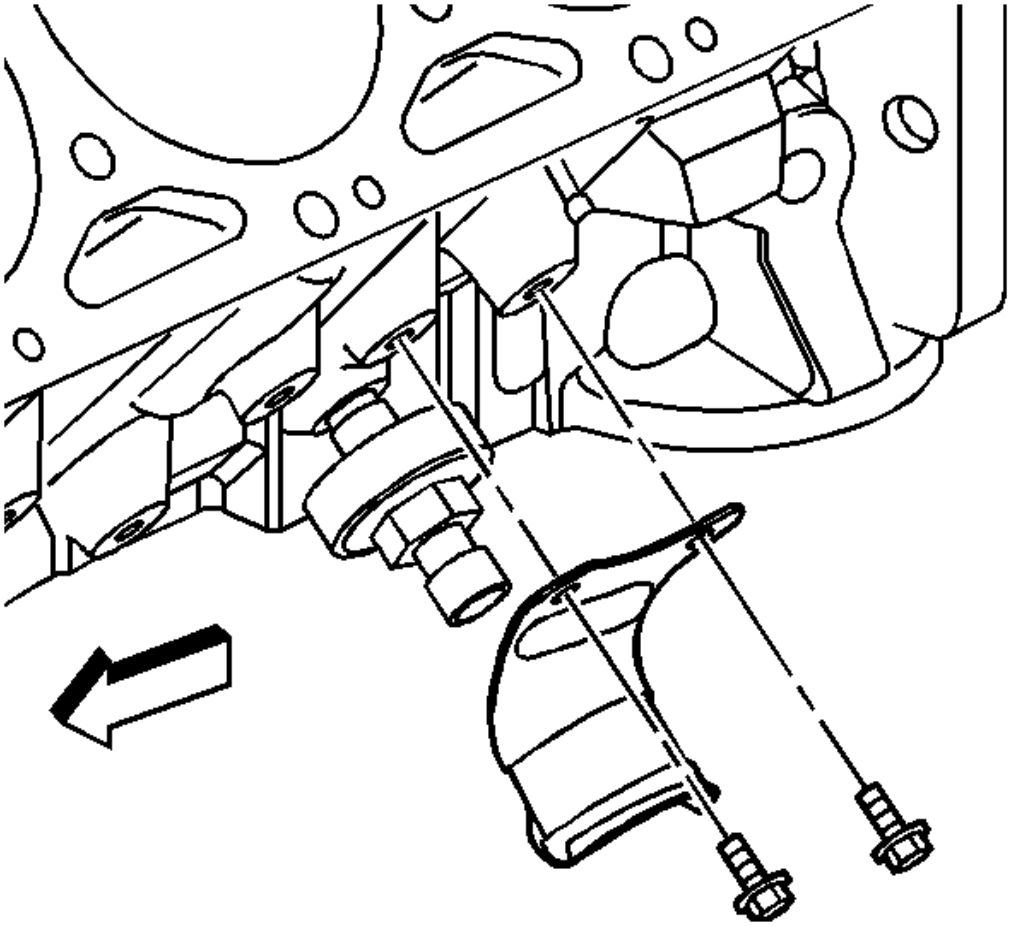

Fig. 313: View Of Left Side Knock Sensor Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the left side knock sensor heat shield bolts.
4. Remove the left side knock sensor heat shield.

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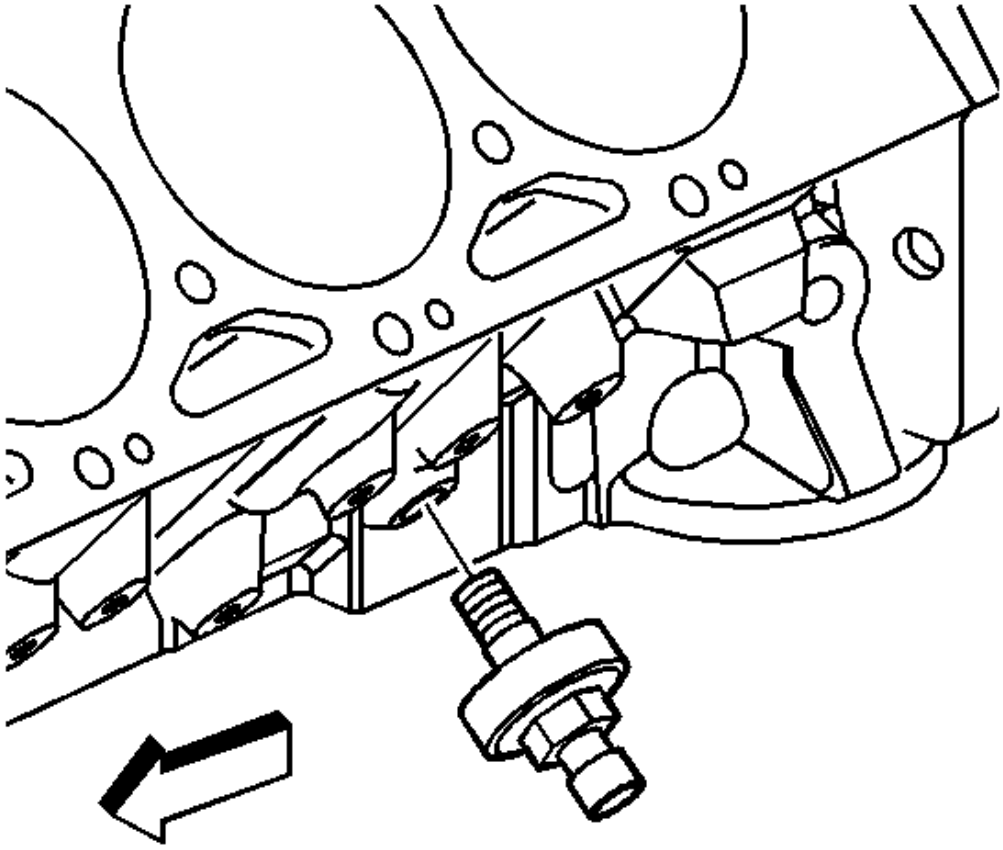

Fig. 314: View Of Left Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

5. Remove the left side knock sensor.

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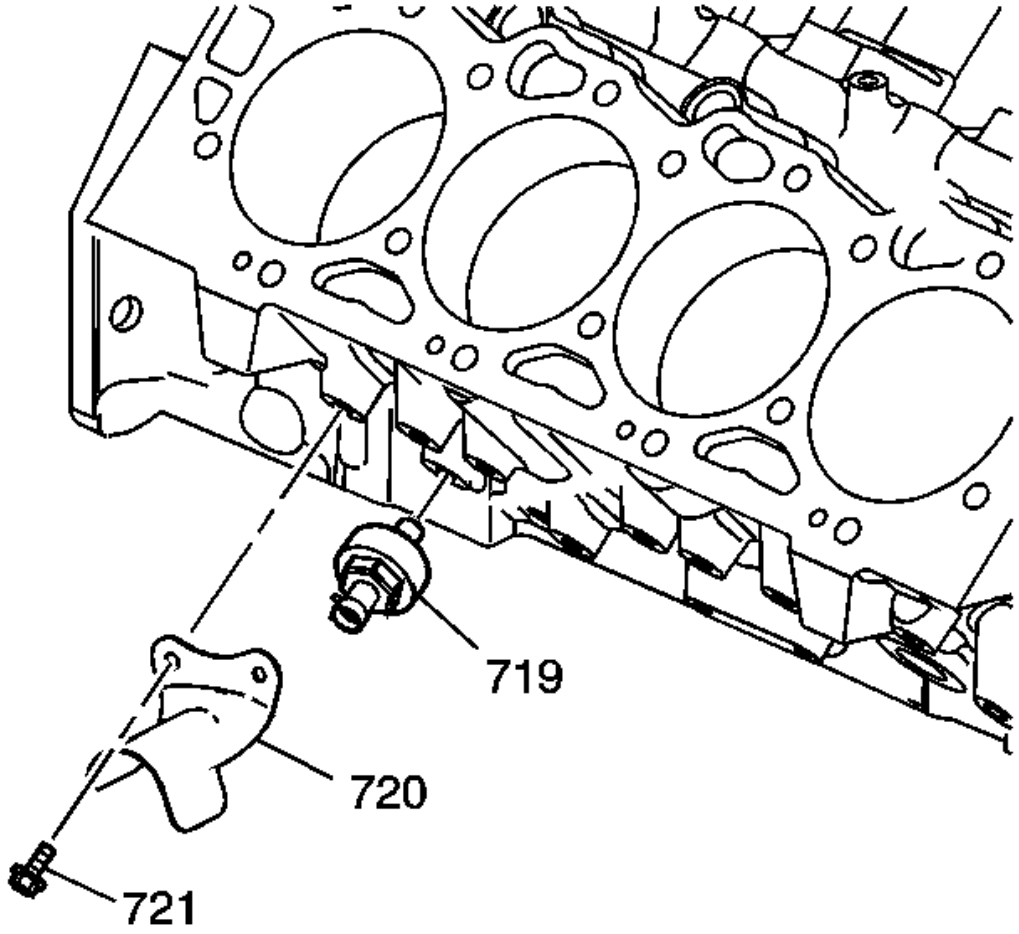

Fig. 315: View Right Side Knock Sensor, Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Remove the right side knock sensor heat shield (720) and bolts (721).
7. Remove the right side knock sensor (719).

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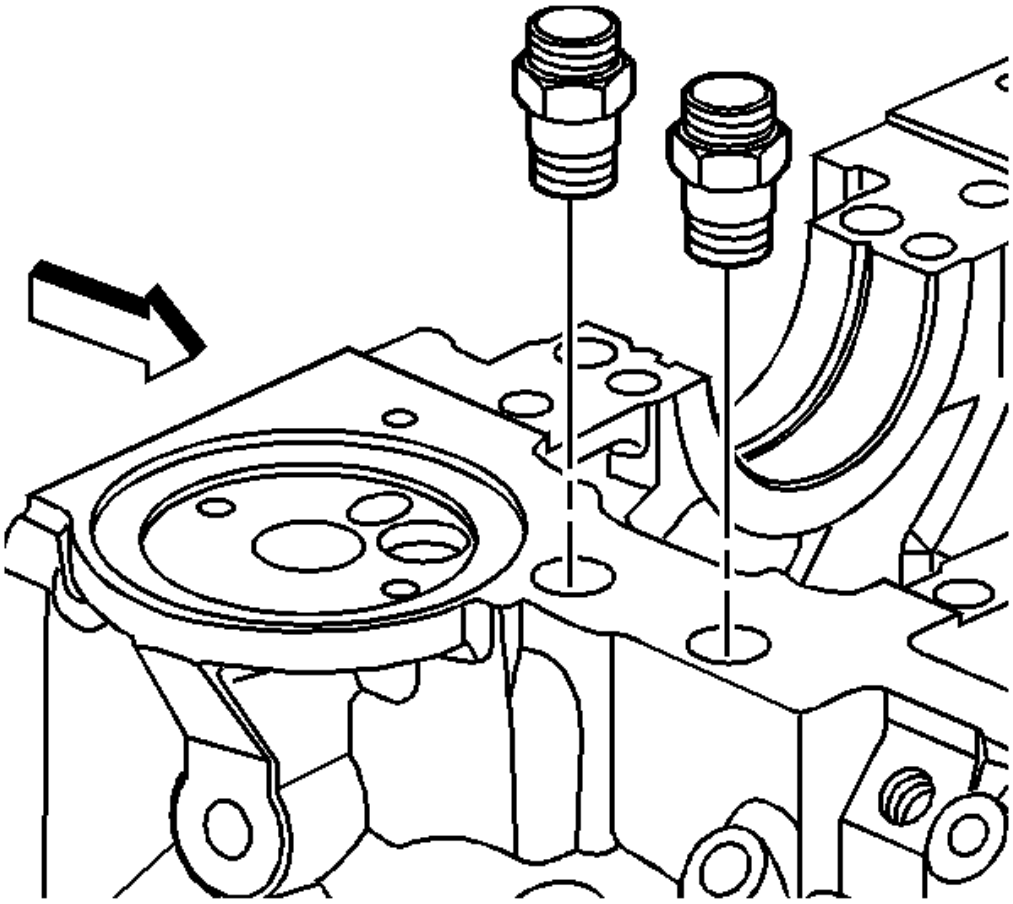

Fig. 316: View Of Engine Block Oil Cooler Hose Fittings
Courtesy of GENERAL MOTORS CORP.

8. Remove the engine block oil cooler hose fittings.

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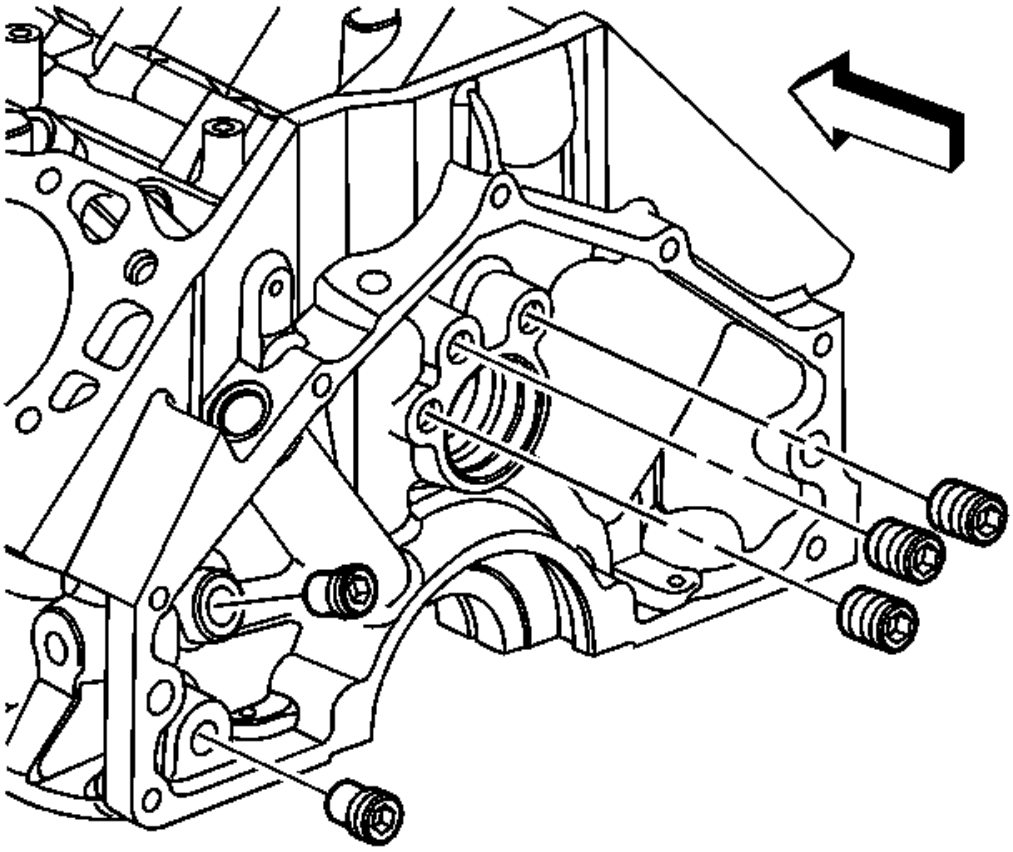

Fig. 317: View Of Rear Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

9. Remove the rear oil gallery plugs.

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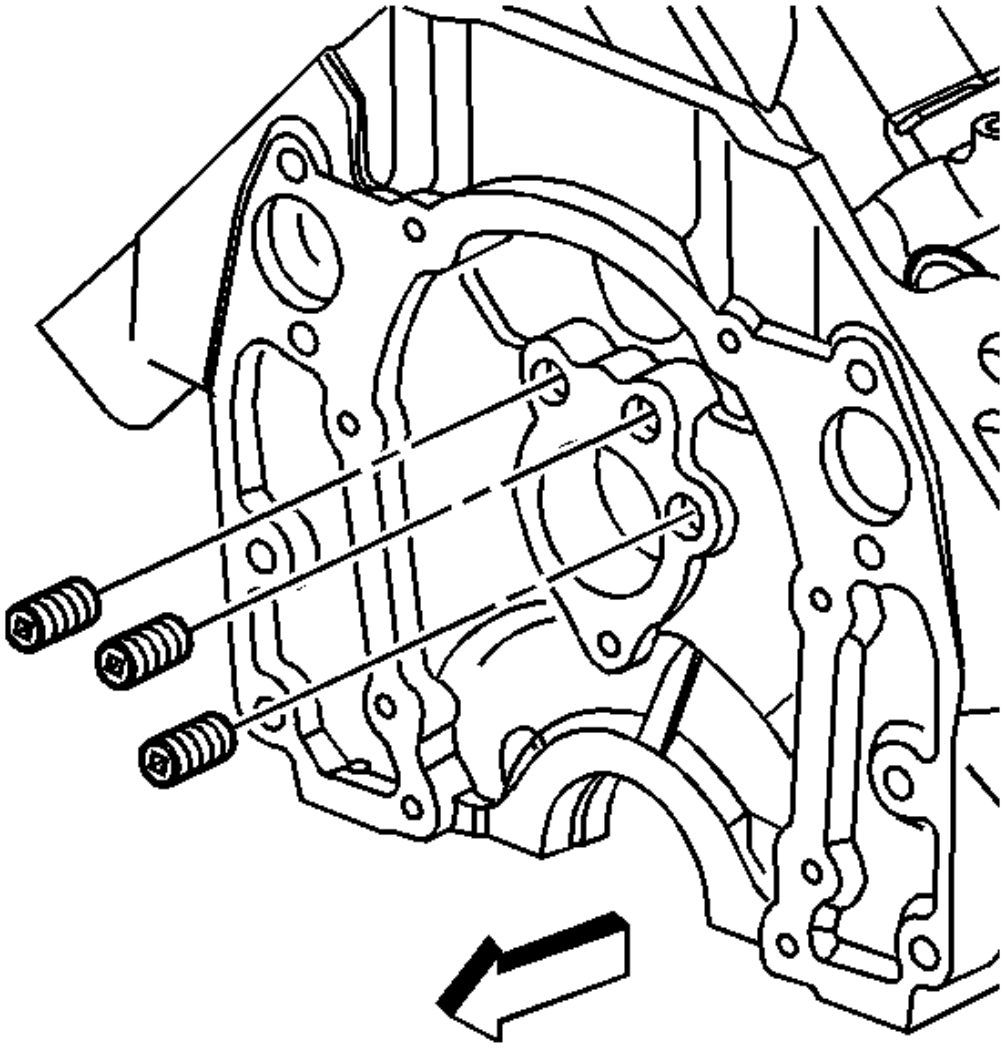

Fig. 318: View Of Front Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the front oil gallery plugs.

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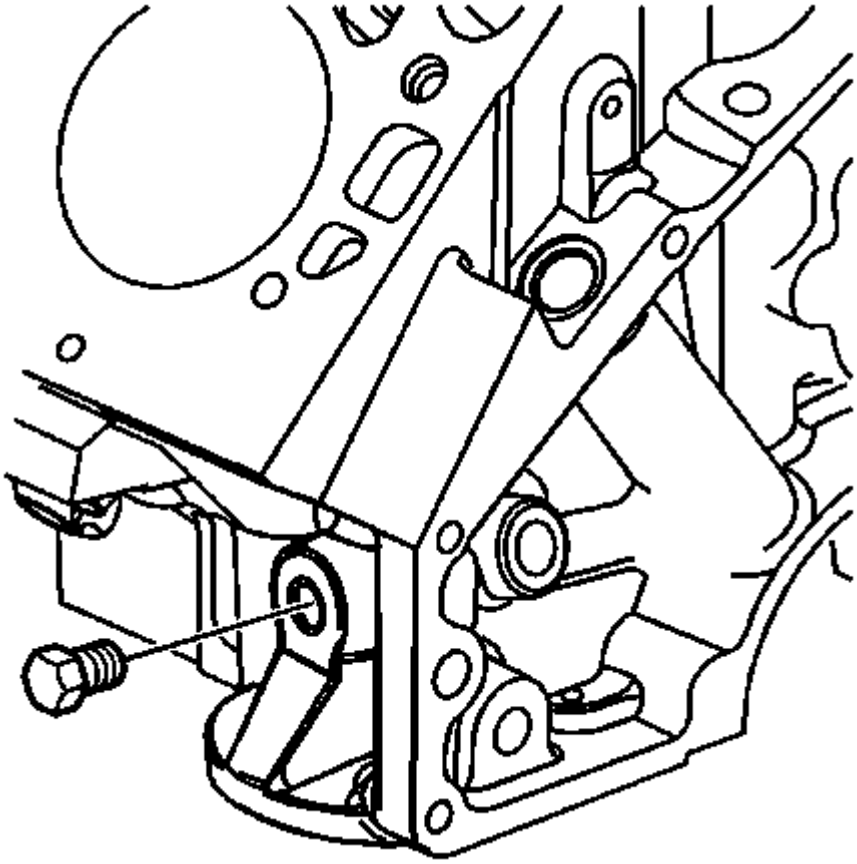

Fig. 319: View Of Engine Block Left Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the left side oil gallery plug.

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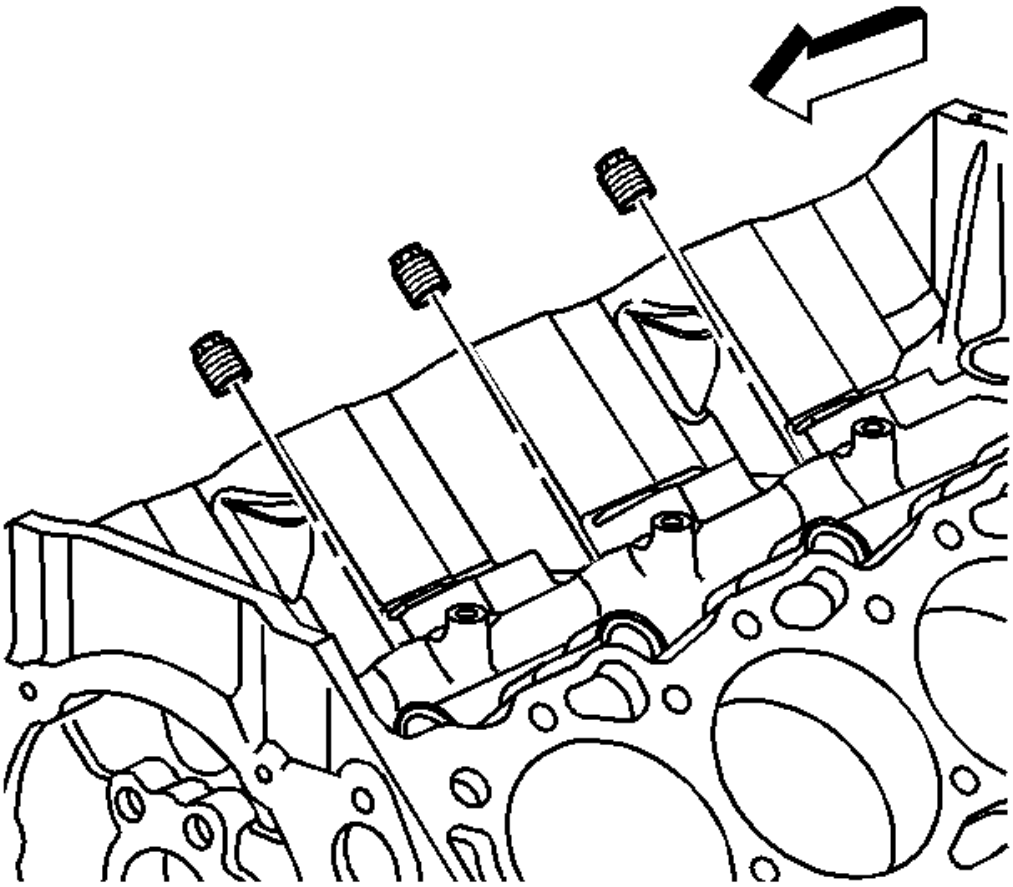

Fig. 320: View Of Top Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

12. Remove the top oil gallery plugs.

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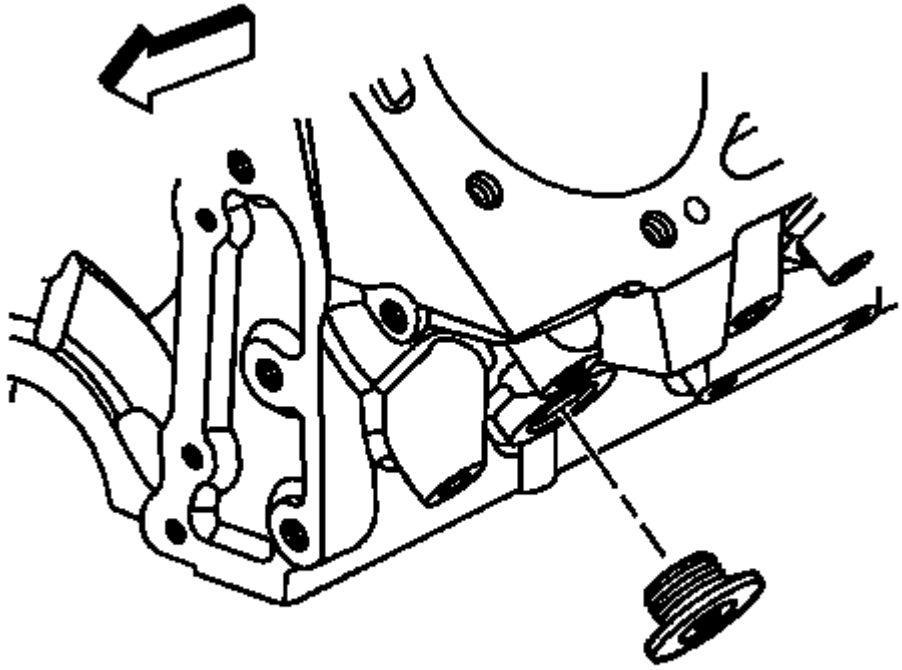

Fig. 321: View Of Engine Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

13. Remove the engine coolant drain hole plug.

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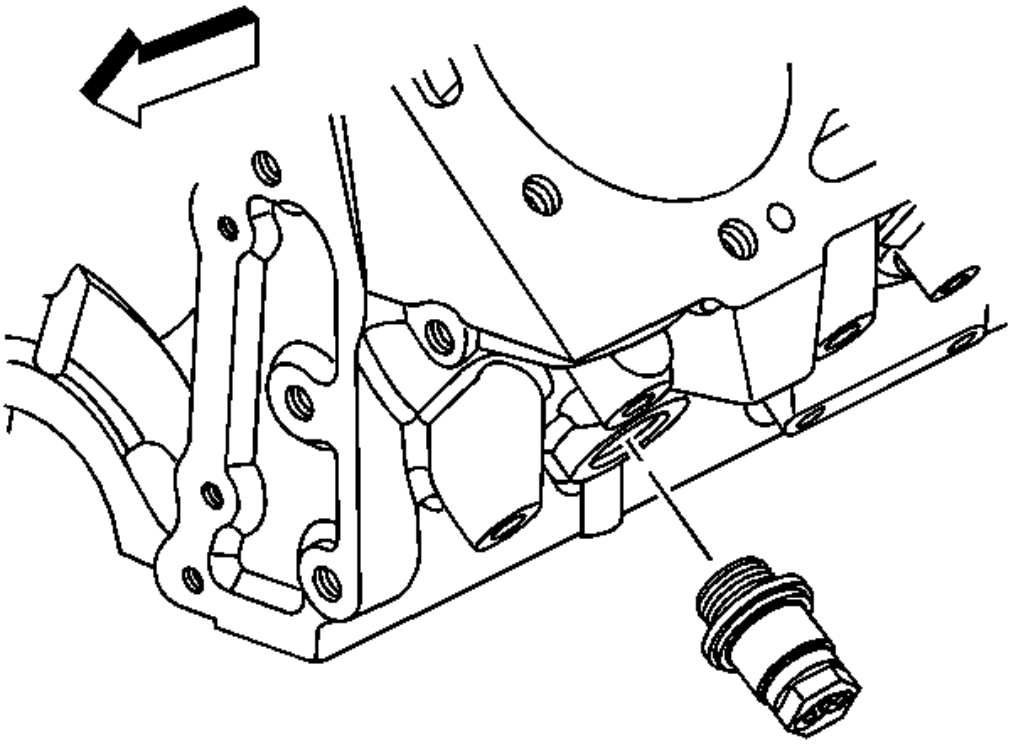

Fig. 322: View Of Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

14. Remove the engine block coolant heater, if equipped.

Camshaft Bearing Removal

Tools Required

J 33049 Camshaft Bearing Service Set

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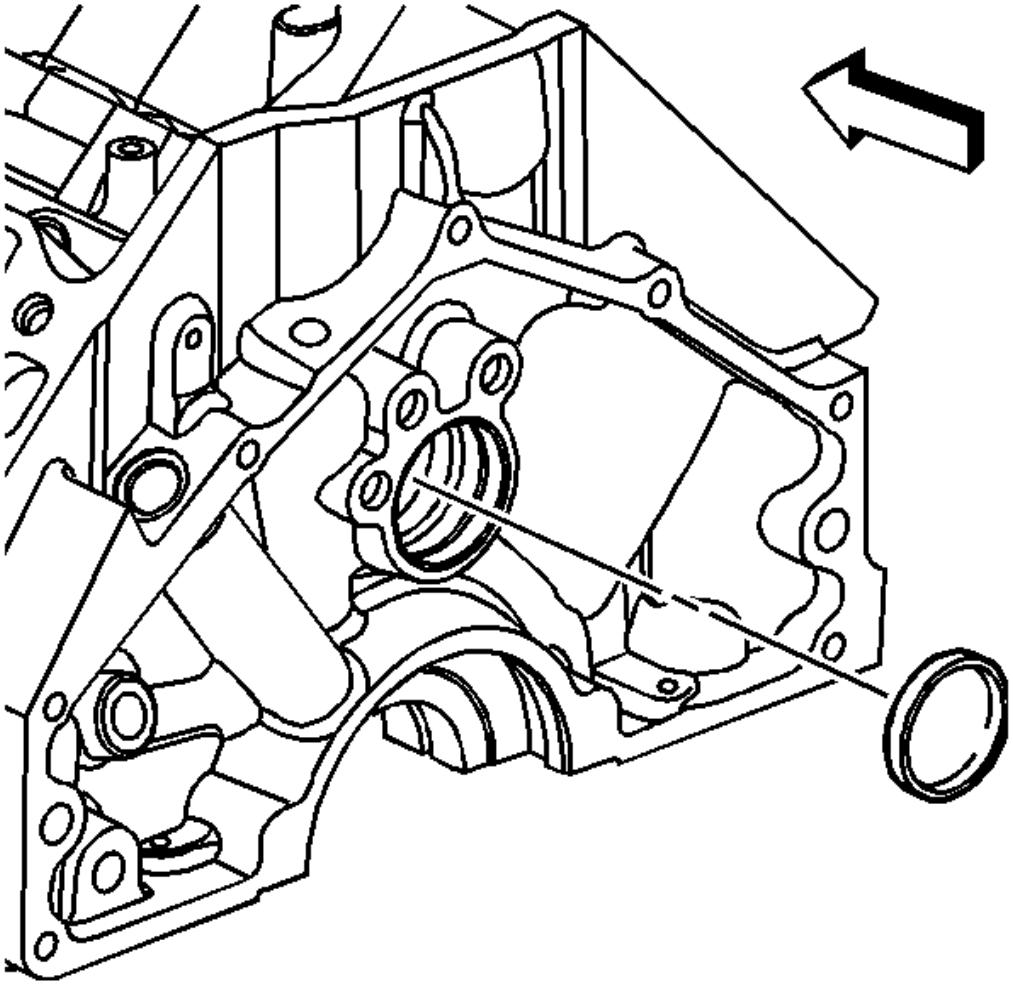

Fig. 323: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft rear bearing hole plug, if not previously removed.

   Insert a long bar through the front of the engine and drive the plug out of the rear bore.

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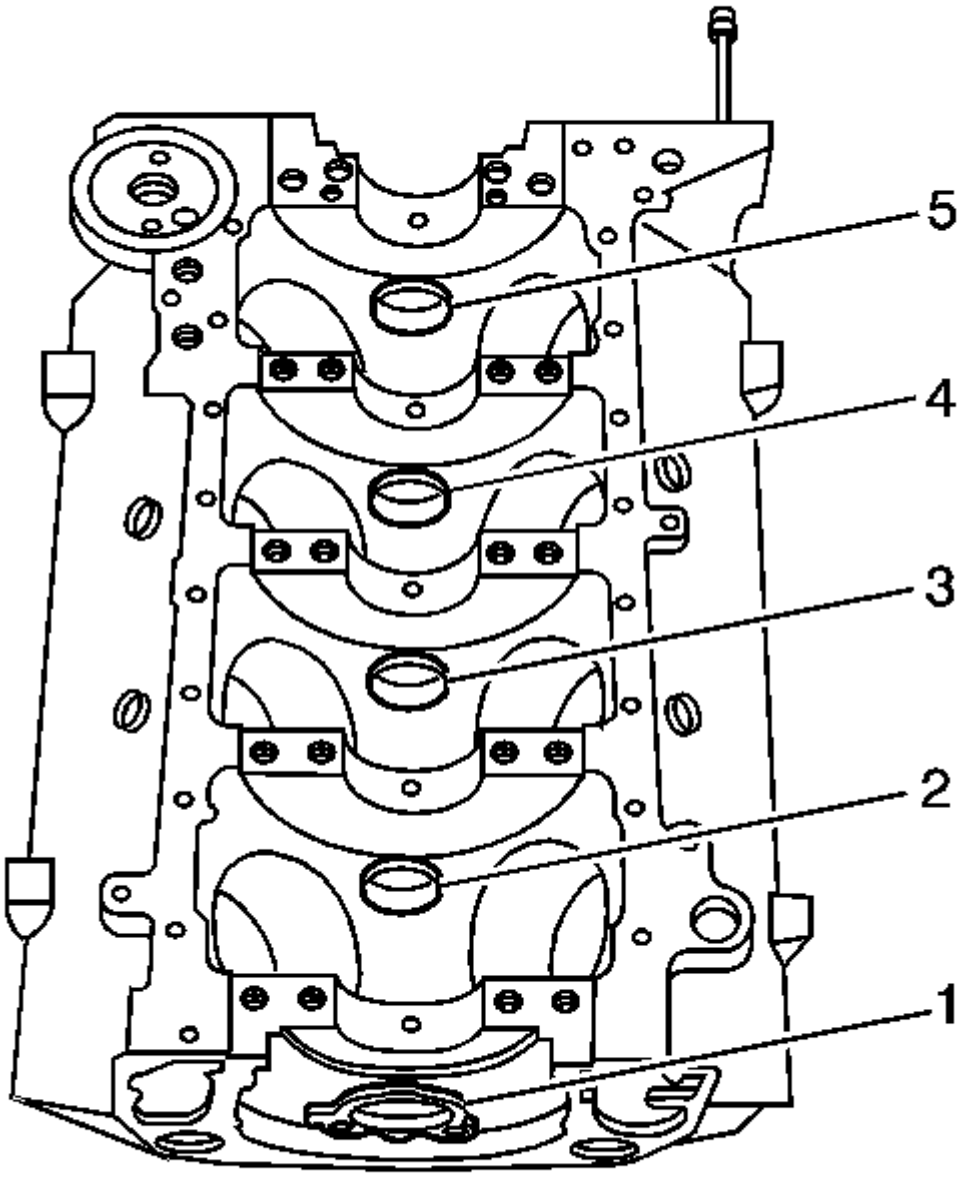

Fig. 324: View Of Engine Block Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out-of-round, or damaged engine block bearing bore.

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2. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores (positions 1-5).

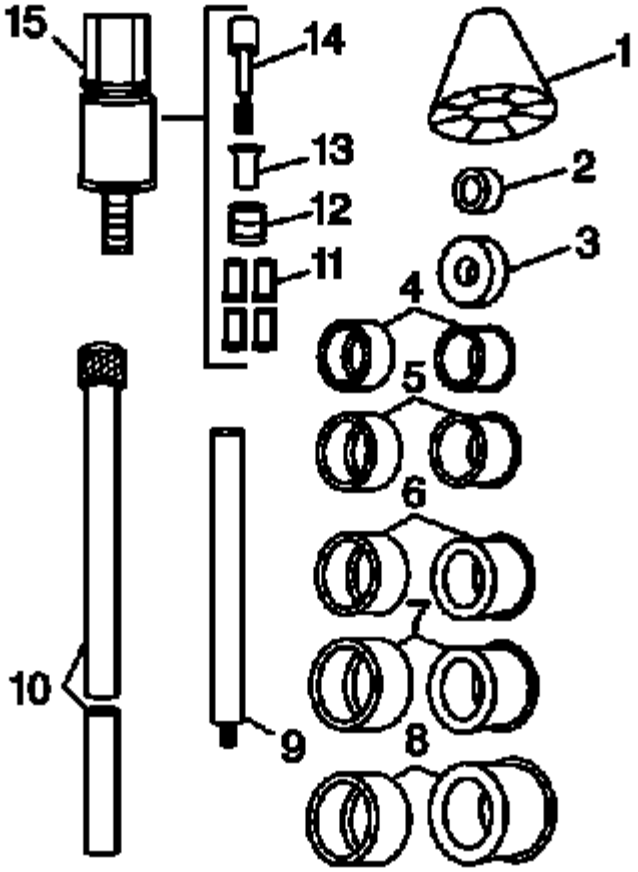

Fig. 325: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** .
4. Assemble the **J 33049** .

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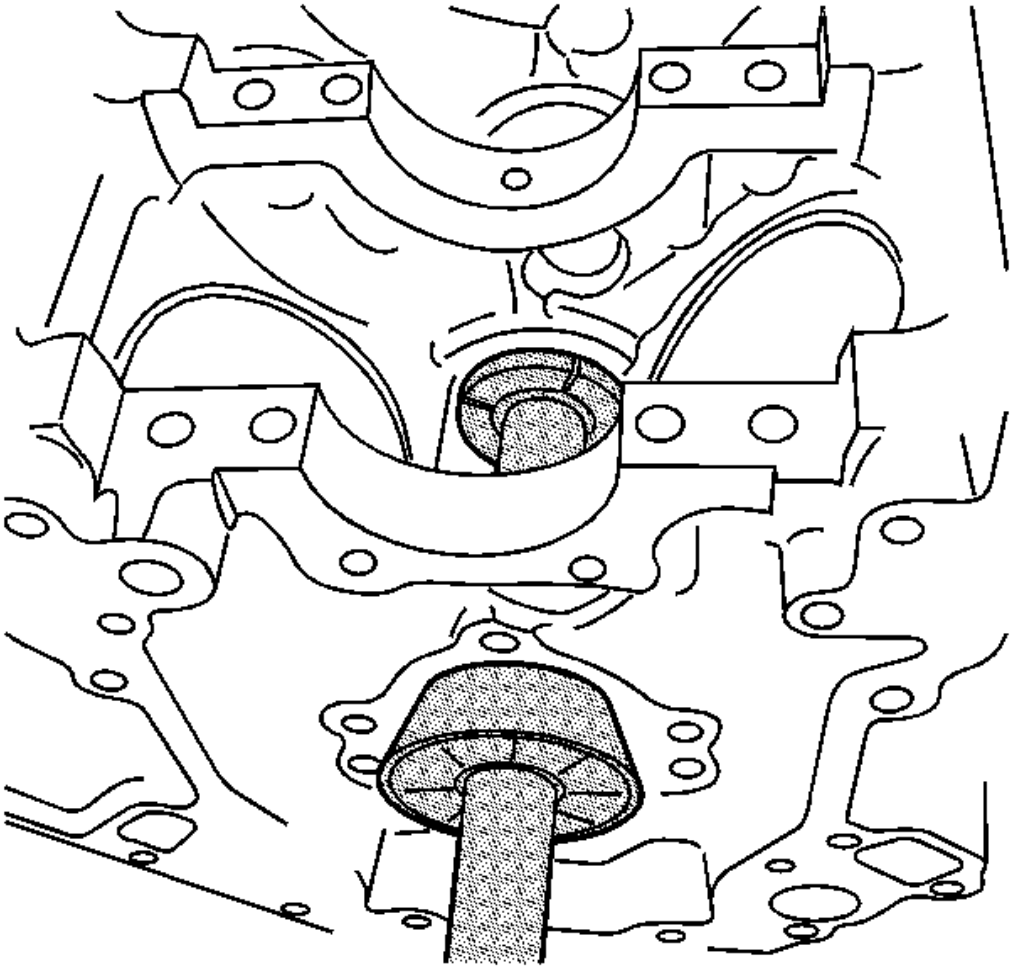

Fig. 326: View Of J 33049 Camshaft Bearing Tool & Nylon Cone
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove the inner bearings in positions 2, 3, and 4 first. The outer bearings in positions 1 and 5 serve as a guide for the J 33049 .

5. Insert the **J 33049** through the front of the engine block and into the bearing.
6. Tighten the expander assembly nut until snug.
7. Push the guide cone into the front camshaft bearing in position 1 to align the **J 33049** .
8. Drive the inner bearings in positions 2, 3, and 4 from their block bores.

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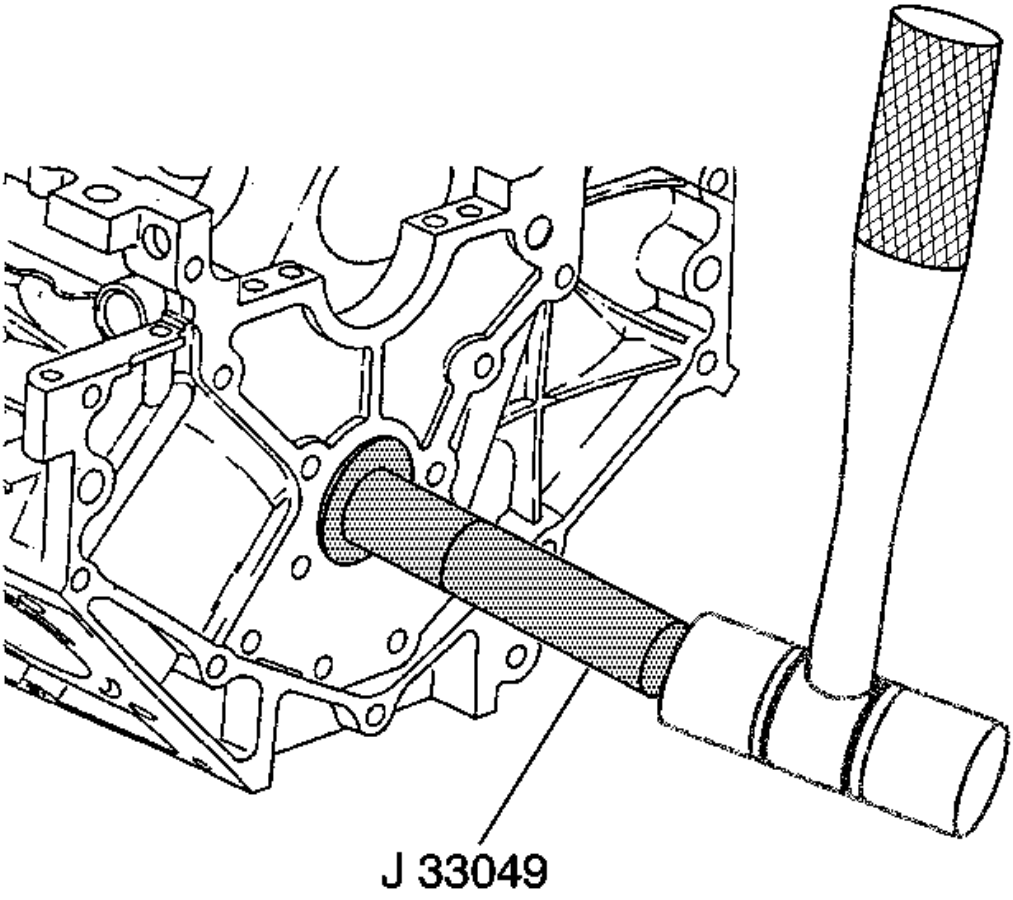

Fig. 327: Driving Bearing From/Into Block Bore
Courtesy of GENERAL MOTORS CORP.

9. Assemble the **J 33049** handle, expanding driver, and washer.
10. Insert the **J 33049** into the outer camshaft bearings.
11. Drive the outer bearings from the bore.

Engine Block Cleaning and Inspection

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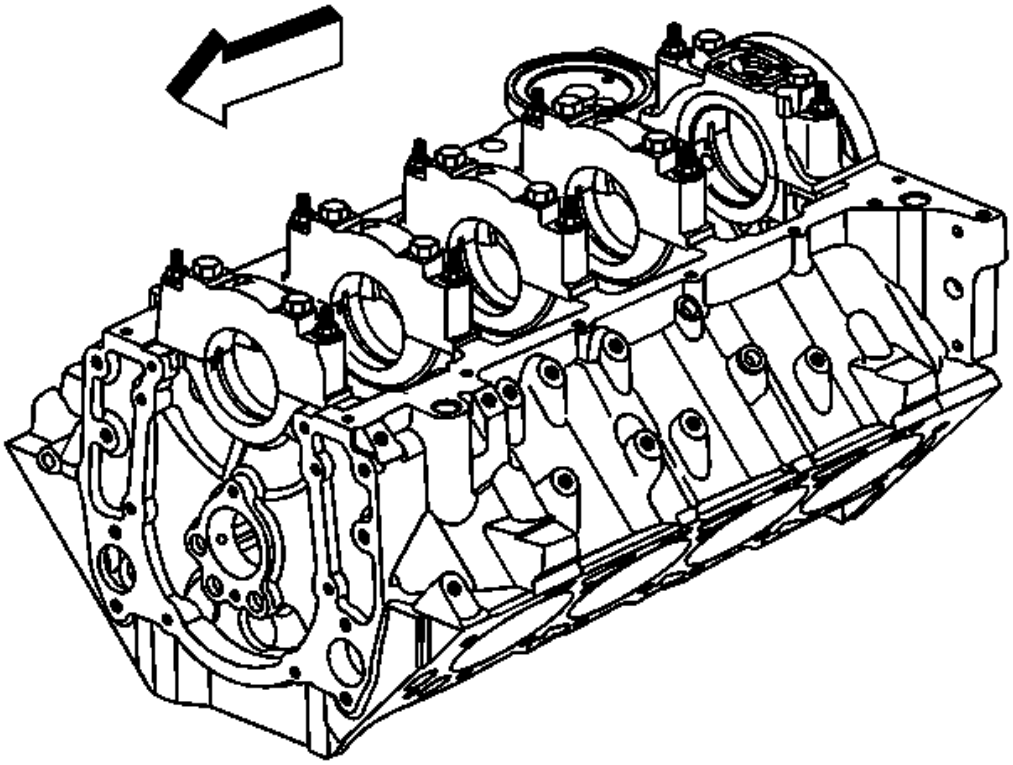

Fig. 328: View Of Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Boil the cylinder block in caustic solution.
2. Flush the cylinder block with clean water or steam.
3. Clean the following areas:
   - All gasket surfaces; Refer to **Replacing Engine Gaskets**
   - Cylinder bores, remove excessive cylinder ring ridge as required
   - Main bearing caps
   - Oil galleries, remove all sludge or restrictions
   - Scale deposits from the coolant passages
   - All dirt or debris from threaded bolt holes

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

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4. Dry the block with compressed air.
5. Lubricate the cylinder bores with clean engine oil to prevent rusting.
6. Inspect the engine block for the following conditions:
    - Gasket surfaces for deep gouges or other damage
    - Crankshaft bearing bores for wear
        - The surfaces where the crankshaft bearings contact the crankshaft bearing bore must be smooth.
        - All crankshaft bearing bores must be round and uniform in inside diameter (ID) at all the bearing supports.
        - If a crankshaft bearing cap is damaged and requires replacement, refer to **Crankshaft and Bearings Cleaning and Inspection**.
    - Camshaft bearing bores for wear or damage
    - Valve lifter bores for scuffing or wear
    - Engine block for cracks or other damage
    - Cylinder walls for scoring or gouges
    - Coolant jackets for cracks
    - Crankshaft bearing webs for cracks
    - Engine mount bosses for damage
    - The oil passages for restrictions

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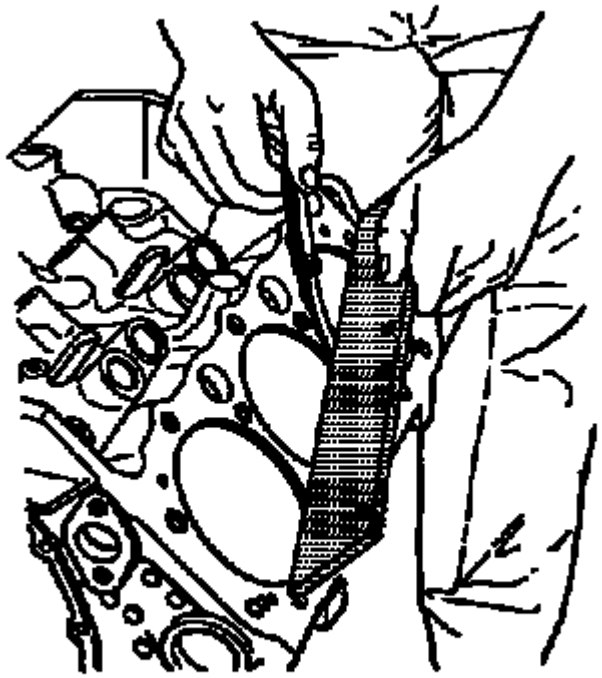

Fig. 329: Measuring Engine Block To Cylinder Head Gasket Surface Area
Courtesy of GENERAL MOTORS CORP.

7. Inspect the engine block cylinder head deck for flatness using a straight edge and a feeler gage.

   The surface must be flat within 0.100 mm (0.004 in).

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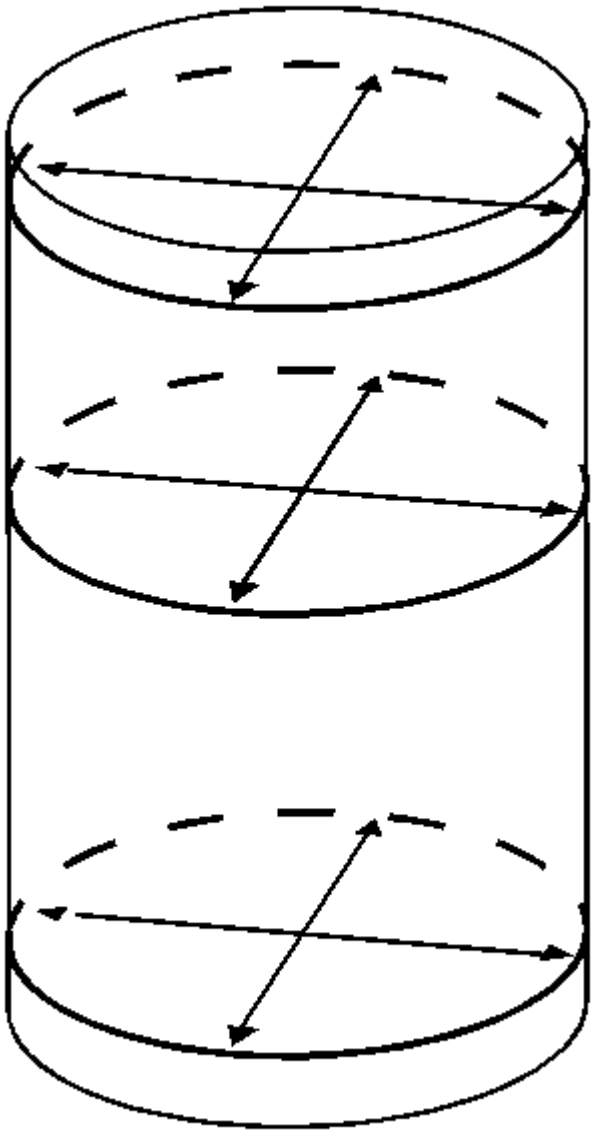

Fig. 330: Measuring Cylinder Bore For Taper, Out-Of-Round & Oversize
Courtesy of GENERAL MOTORS CORP.

8. Use a bore gage and measure the cylinder bore for taper, out-of-round and oversize. Slide the bore gage up and down throughout the length of the cylinder bore. Check the bore both parallel and perpendicular to the centerline of the crankshaft at the top, center and bottom of the bore. A cylinder bore that measures 107.940-107.990 mm (4.249-4.251 in) may be serviced with a standard size piston/connecting rod assembly. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized

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piston/connecting rod assembly.

Cylinder Boring and Honing

Boring Procedure

IMPORTANT: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.
To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston/connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications, the cylinder must be resized to accept a new, oversized piston.

IMPORTANT: If you do not check the cylinder block, the boring bar may be tilted, this may result in incorrect rebored cylinder wall to crankshaft angle.

1. Before you use any type of boring bar, clean the top of the cylinder block in order to remove any dirt or burrs.
2. Carefully follow the instructions furnished by the manufacturer regarding use of equipment.
3. When you rebore cylinders, make sure all crankshaft bearing caps are in place.
   - Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly.
   - The crankshaft must be removed prior to cylinder boring.
4. When you take the final cut with a boring bar, leave 0.03 mm (0.001 in) on the diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between pistons, rings, and cylinder bores).

Honing Procedure

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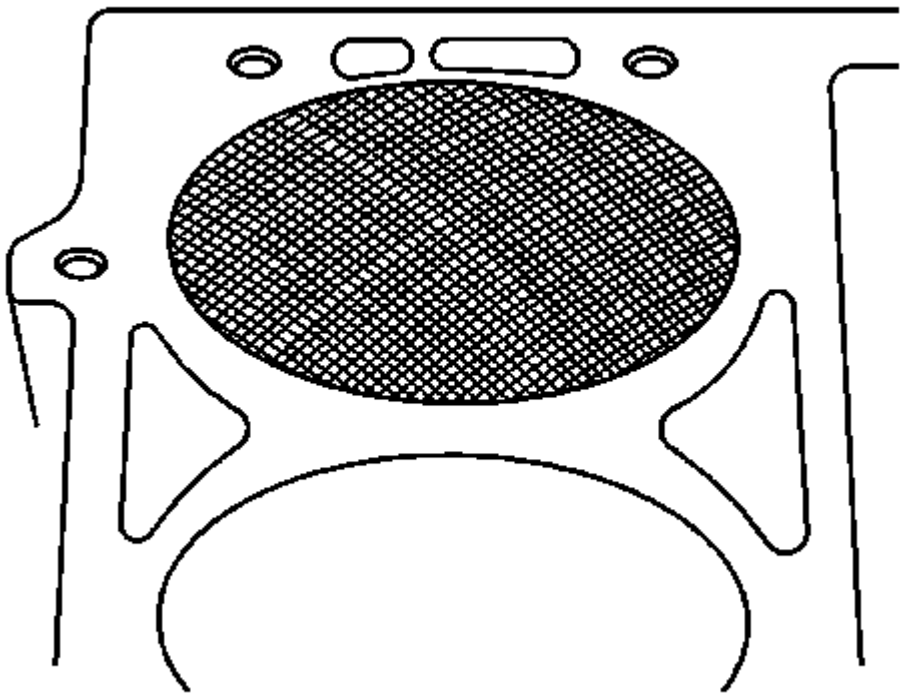

Fig. 331: Identifying Cylinder Bore Cross Hatch Pattern
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always remove all bearings and components from engine block before cleaning, boring or honing the engine block.

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 a final grade with a coarse or medium-grade stone.
   - Leave sufficient metal so that all stone marks may be removed with fine grade stones.
   - The re-honed surface finish should be 0.25-0.50 micrometer (10-20 microinch).
   - Perform final honing with a fine-grade stone and hone the cylinder in a cross hatch pattern at 20 to 30 degrees to obtain the proper clearance.
2. During the honing operation, thoroughly clean the cylinder bore.
   - Repeatedly check the cylinder bore for fit with the selected oversized piston.
   - All measurements of the cylinder bore should be made with the components at normal room temperature.
3. To eliminate taper in the cylinder, when honing, make full strokes of the hone in the cylinder. Repeatedly

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check the measurement at the top, the middle, and the bottom of the bore.

- The finish marks should be clean but not sharp.
- The finish marks should be free from embedded particles and torn or folded metal.

4. When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round or taper requirements.
5. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent.
    1. 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.
        - Abrasive material may cause premature wear of new piston rings and cylinder bores.
        - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
    2. After washing the cylinder bore, dry the bore with a clean shop towel.
6. Perform final measurements of the cylinder bore.
7. Permanently mark the piston for the specific cylinder to which it has been fitted.
8. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Crankshaft and Bearings Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator
- **J 43690** Rod Bearing Clearance Checking Tool
- **J 43690-100** Rod Bearing Clearance Checking Tool - Adapter Kit
- **J 45059** Angle Meter

Crankshaft Inspection

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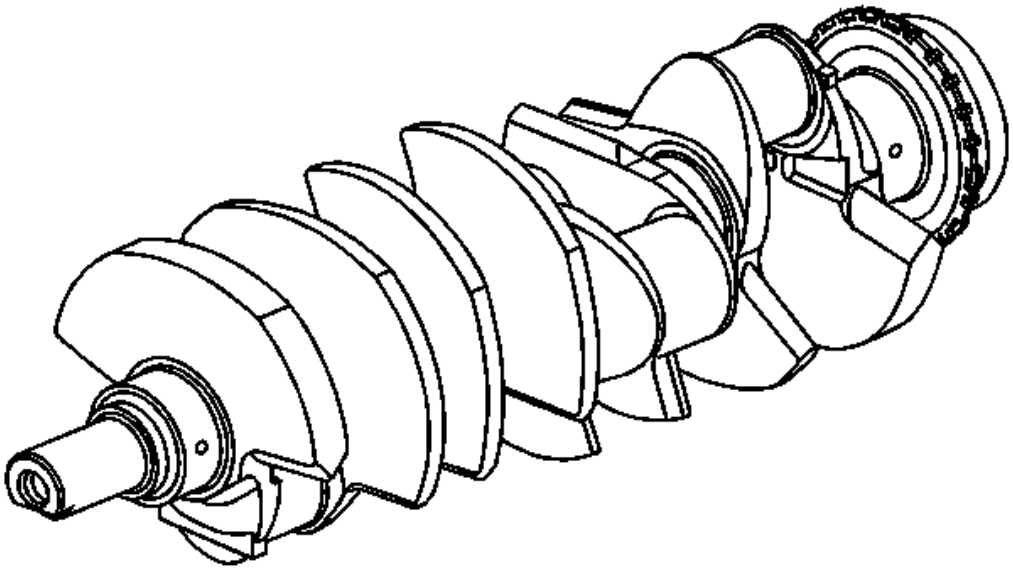

Fig. 332: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces.

1. Clean the crankshaft in solvent. Remove all sludge or restrictions from the oil passages.

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

2. Dry the crankshaft and bearings with compressed air.

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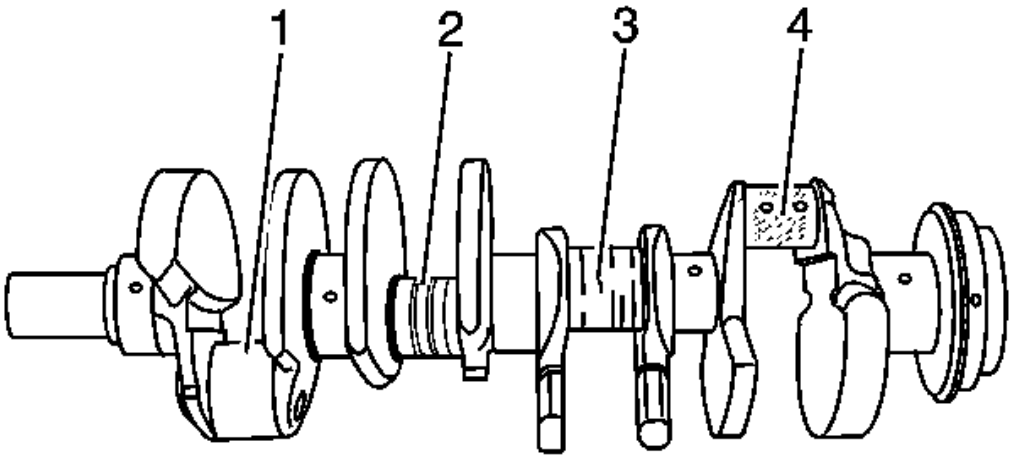

Fig. 333: Inspecting Crankshaft
Courtesy of GENERAL MOTORS CORP.

3. Inspect the crankshaft for the following conditions:
    - Crankshaft journals (1) should be smooth with no evidence of scoring or damage
    - Deep grooves (2)
    - Scratches or uneven wear (3)
    - Pitted surfaces (4)
    - Wear or damage to the thrust journal surfaces
    - Scoring or damage to the rear seal surface
    - Restrictions to oil passages
    - Damage to threaded bolt holes

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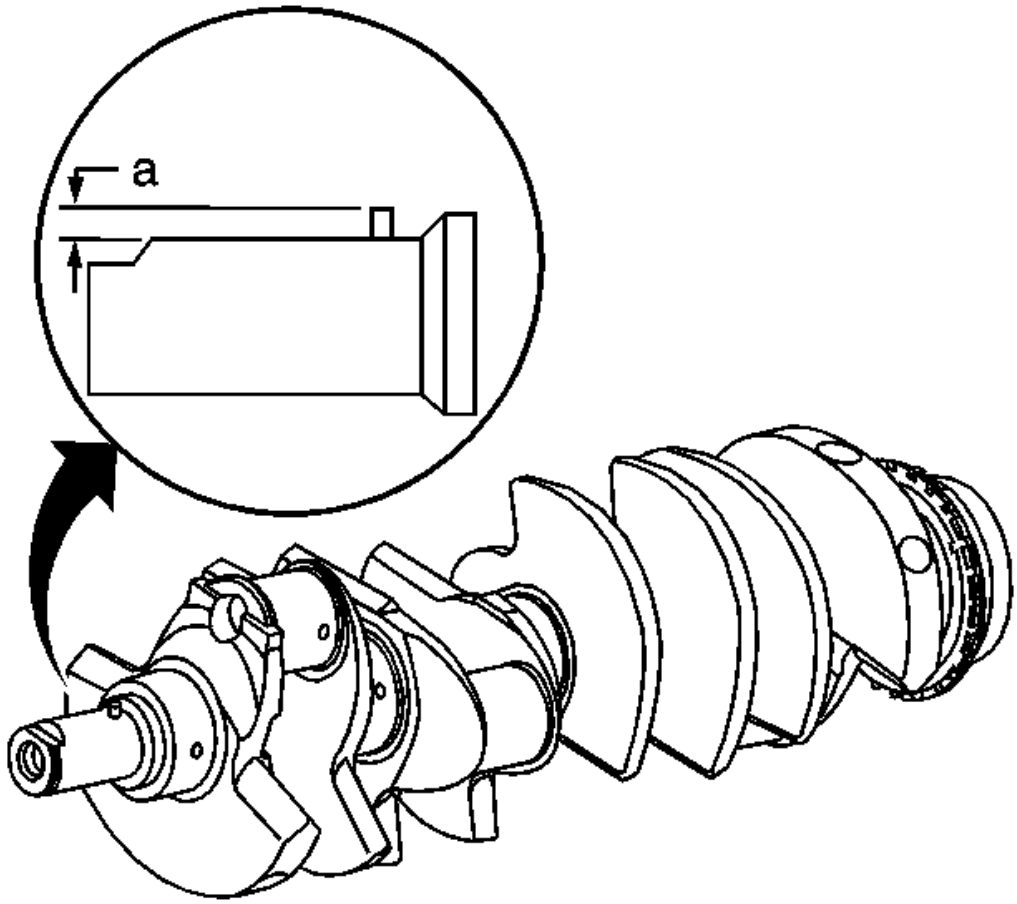

Fig. 334: Measuring Crankshaft Pin For Proper Installed Height
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft pin is a pressed-in- place roll pin. The pin only needs to be removed from the crankshaft if the pin is damaged.

4. Inspect the crankshaft pin for damage:
   - Measure for proper installed height (a). Correct height should be 2.00-2.25 mm (0.078-0.088 in).
   - Replace the crankshaft pin if it is damaged.

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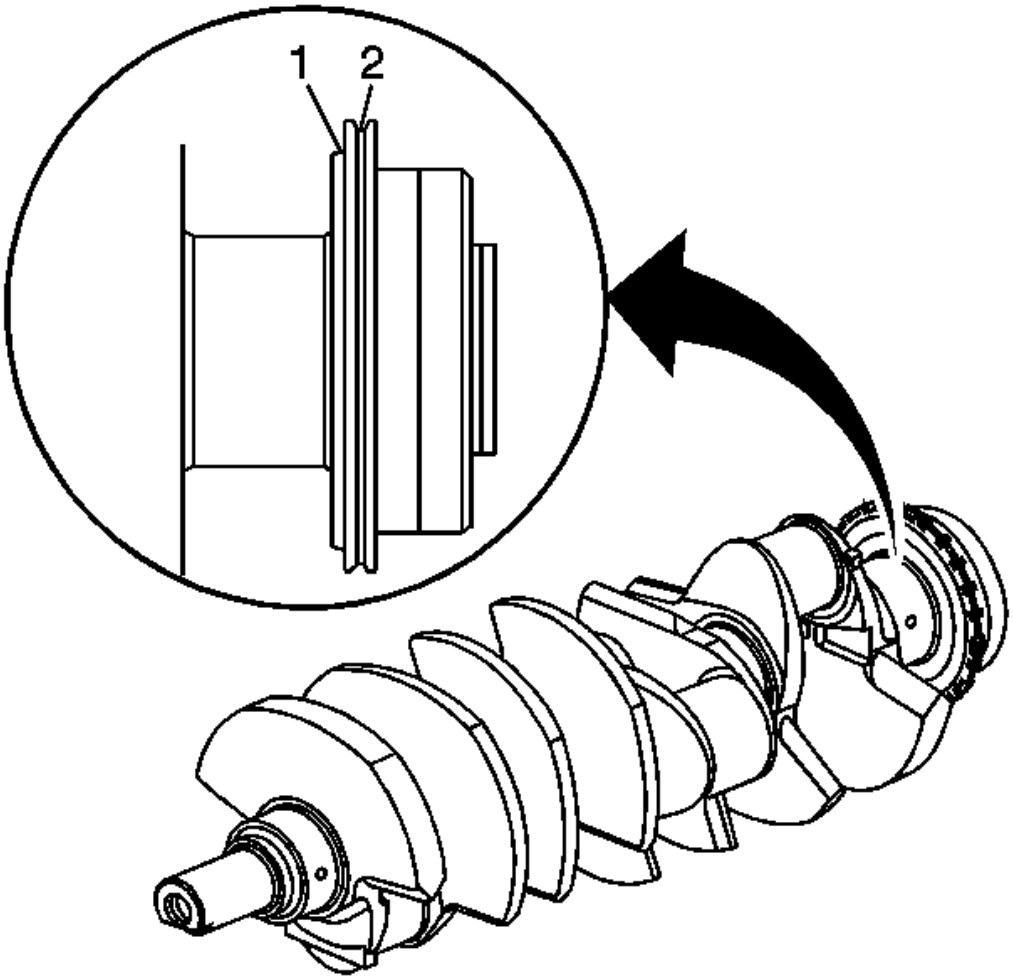

Fig. 335: Measuring Reluctor Wheel Gaps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do NOT attempt to remove the crankshaft reluctor wheels. If the reluctor wheels are damaged and/or removed, the crankshaft must be replaced.

5. Inspect the reluctor wheels for cracked, bent or broken teeth.
   - Measure between the crankshaft shoulder and the front reluctor wheel (1).
   - Measure between the gap between the front and rear reluctor wheels (2). The maximum allowable gap is 0.15 mm (0.006 in).

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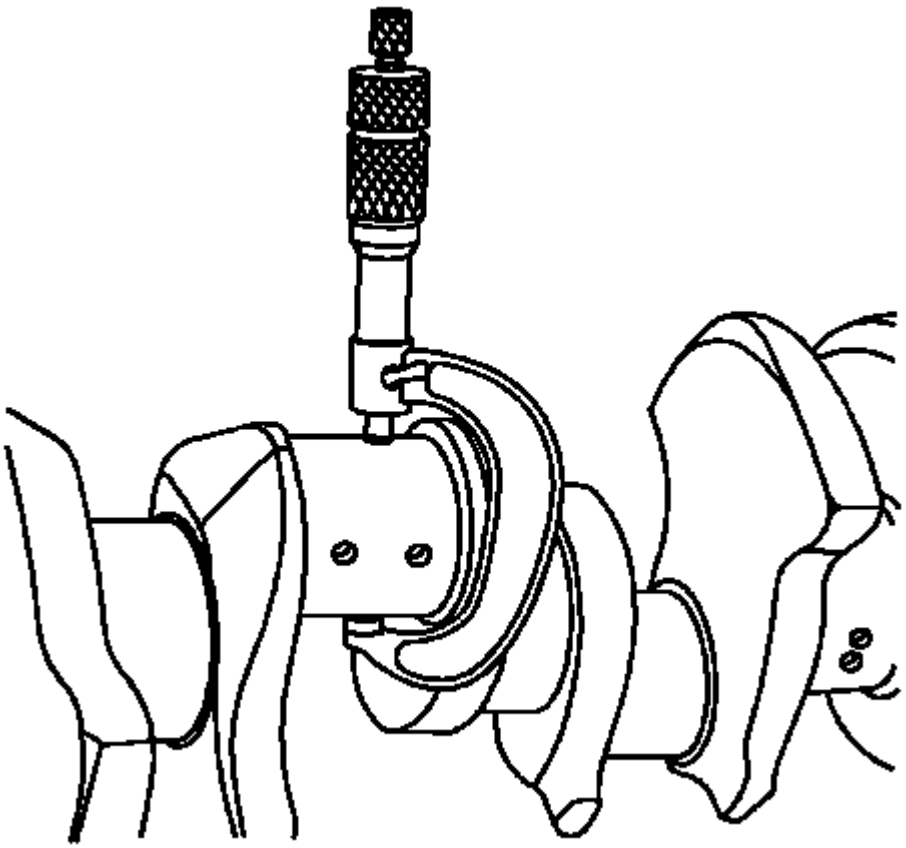

Fig. 336: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

6. Measure the crankshaft main journals and the crankpins for out-of-round and taper.

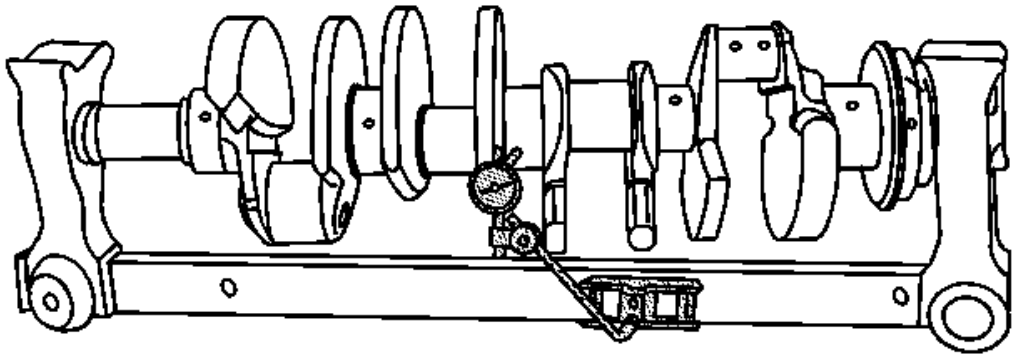

Fig. 337: Measuring Crankshaft Runout Using J 7872

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Courtesy of GENERAL MOTORS CORP.

7. Using a suitable fixture, support the crankshaft.
    1. Measure the crankshaft runout using **J 7872** .
    2. Crankshaft runout should not exceed 0.051 mm (0.002 in).

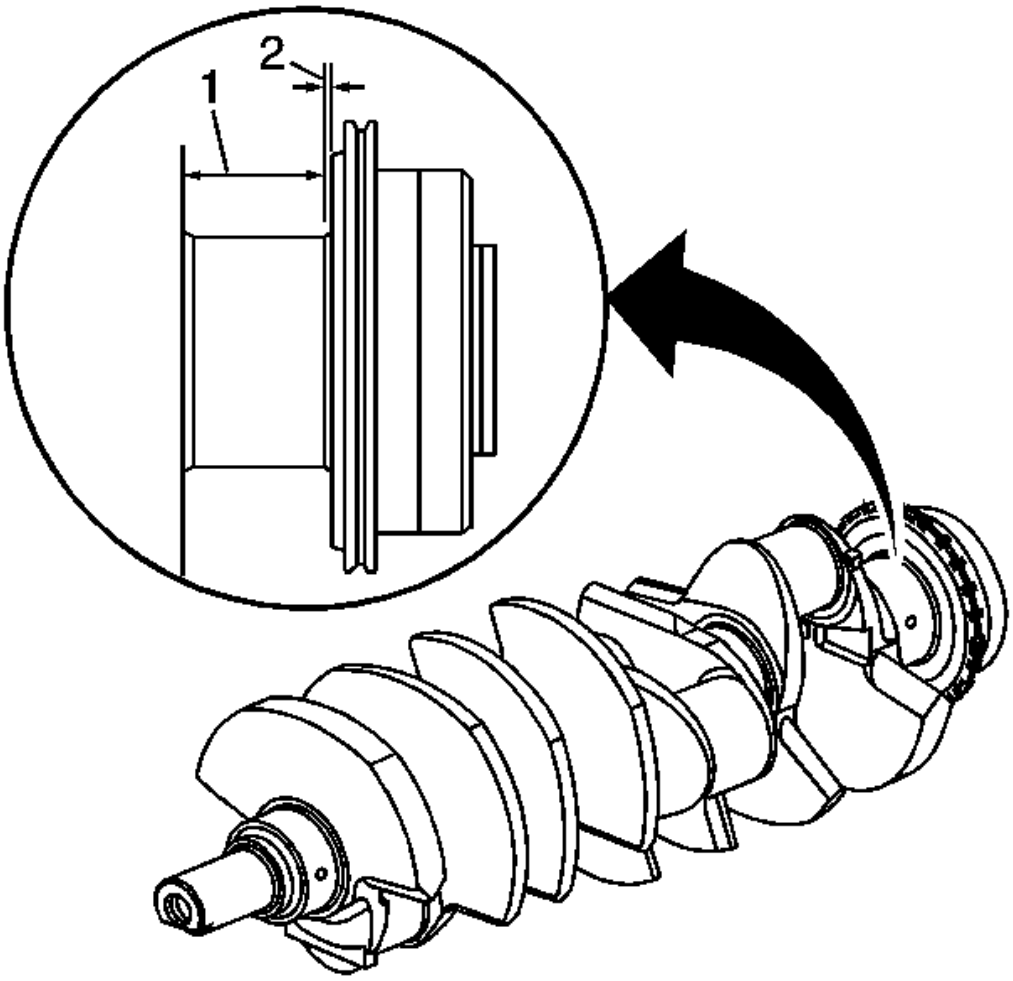

Fig. 338: Inspecting Crankshaft Thrust Wall Surface For Runout
Courtesy of GENERAL MOTORS CORP.

8. Inspect the crankshaft thrust wall surface (1) for wear and/or excessive runout (2). Refer to **Engine Mechanical Specifications**.

Crankshaft and Connecting Rod Bearing Inspection

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IMPORTANT: The crankshaft and connecting rod bearings should be inspected only to determine what kind of damage or failure has occurred. Always install NEW bearings once the bearings have been removed.

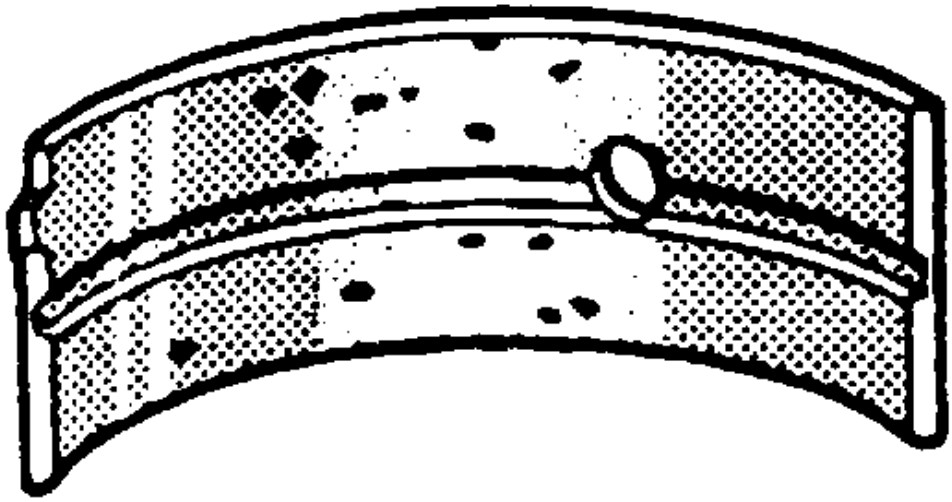

Fig. 339: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

1. Inspect the bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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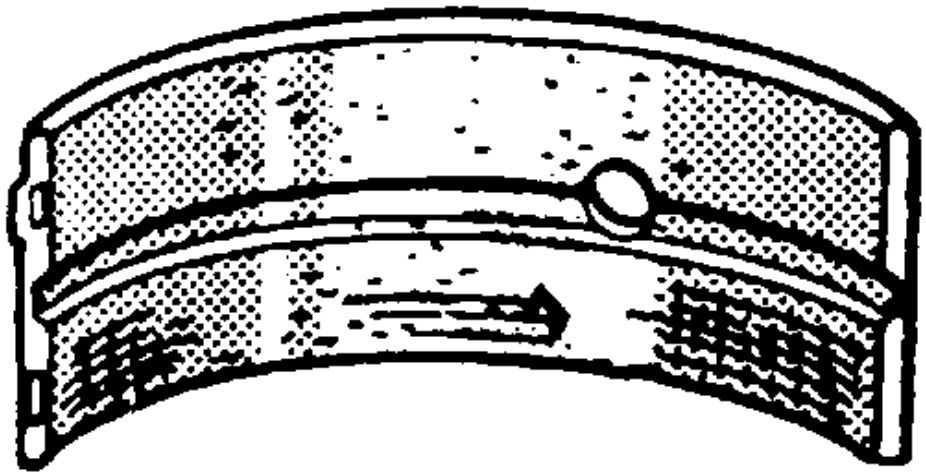

Fig. 340: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

2. Inspect the bearings for excessive scoring or discoloration.
3. Inspect the bearings for dirt or debris embedded into the bearing material.

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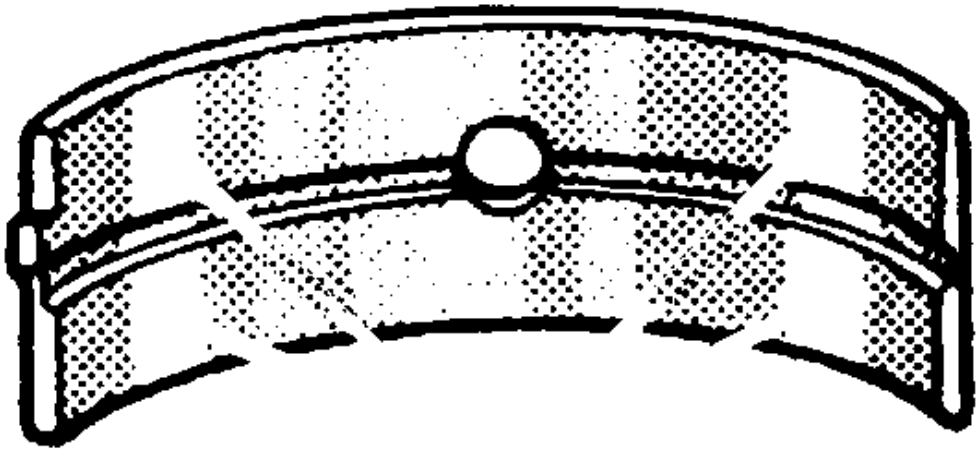

Fig. 341: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

4. Inspect the bearings for improper seating indicated by bright, polished sections of the bearings.

Crankshaft and Connecting Rod Bearing Clearance Measurement

The crankshaft and connecting rod bearings are of the precision insert type and do not use shims for adjustment.

Crankshafts with journals that measure less than minimum specifications must be replaced.

Micrometer Method for Crankshaft Bearings

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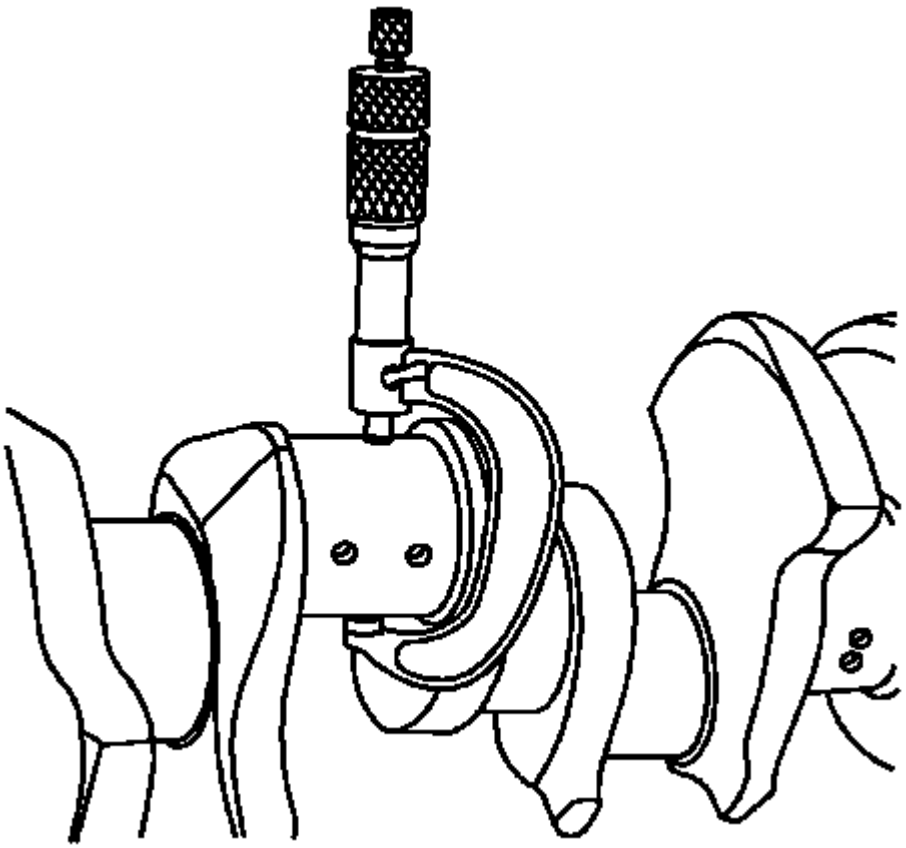

Fig. 342: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankshaft main journal diameter with a micrometer in several places along the length approximately 90 degrees apart, minimum of 4 places, and average the measurements.
2. Determine the taper and the out-of-round. Refer to **Engine Mechanical Specifications**.

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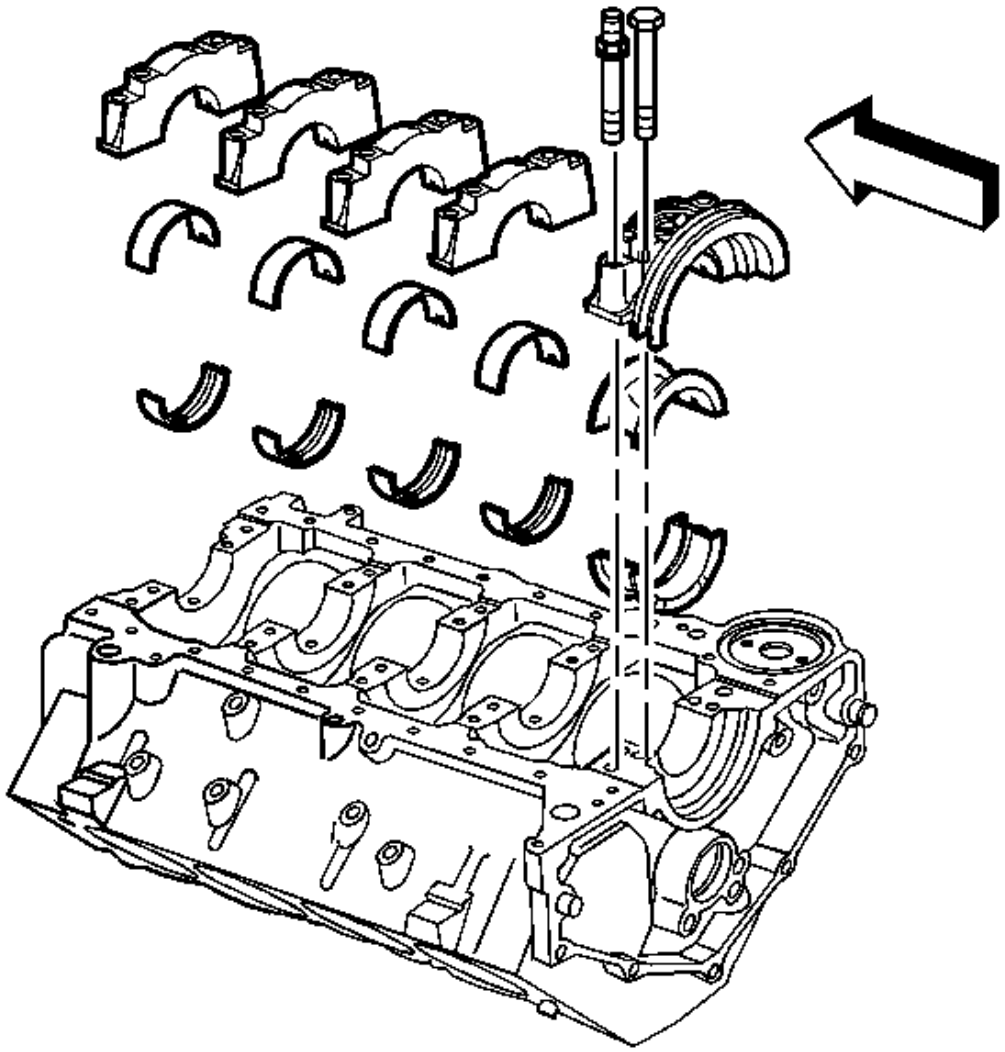

Fig. 343: Installing Crankshaft Bearings, Caps, Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

3. Install the NEW crankshaft bearings into the crankshaft bearing caps and the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Tighten the crankshaft bearing cap bolts before tightening the crankshaft bearing cap studs.

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4. Install the bearing cap bolts and studs.

   Tighten:

   1. Tighten the bearing cap 1-5 bolts a first pass to 30 N.m (22 lb ft).
   2. Tighten the bearing cap 1-5 studs a first pass to 30 N.m (22 lb ft).
   3. Tighten the bearing cap 1-5 bolts a final pass an additional 90 degrees using the **J 45059** .
   4. Tighten the bearing cap 1-5 studs a final pass an additional 80 degrees using the **J 45059** .

5. Measure the crankshaft bearing inside diameter (ID) using an inside micrometer. Measure at a minimum of four places and average the measurements.
6. In order to determine the crankshaft bearing clearance, subtract the crankshaft journal diameter from the crankshaft bearing ID.
7. Compare the crankshaft bearing clearance to the specifications. Refer to **Engine Mechanical Specifications**.
8. If the crankshaft bearing clearances exceeds specifications, install undersize crankshaft bearings to achieve the correct clearance.
9. Measure the new crankshaft bearing inside diameter (ID) using an inside micrometer.
10. Replace the crankshaft if the proper clearances cannot be obtained with standard size bearings.

Micrometer Method for Connecting Rod Bearings

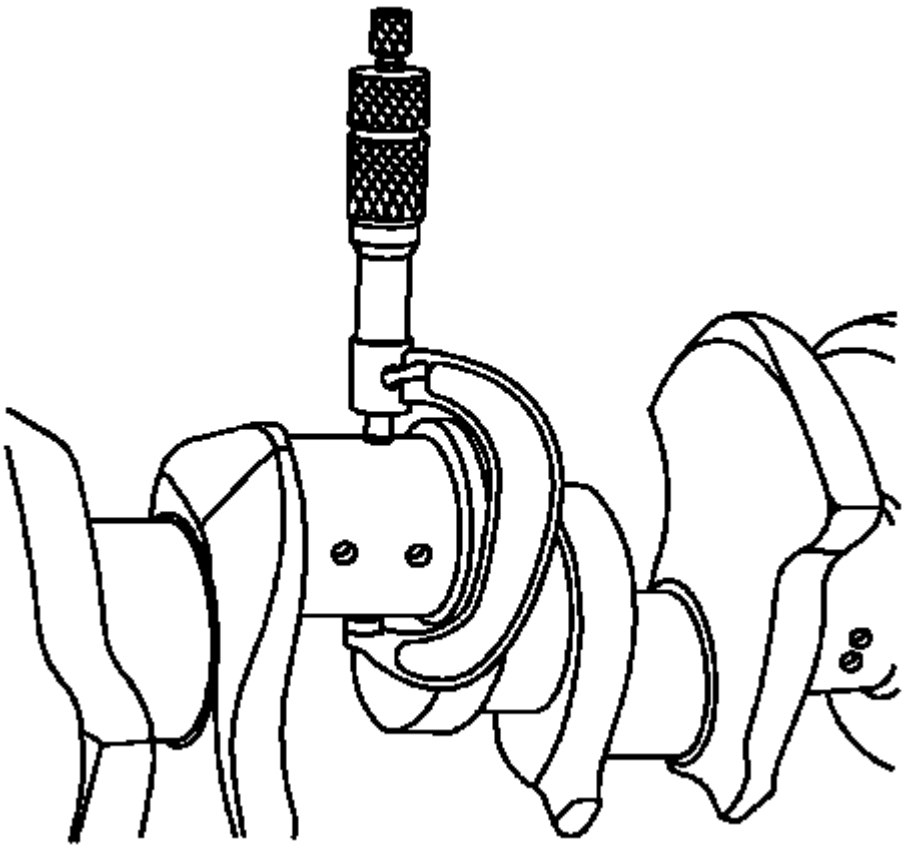

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Fig. 344: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When bearings are removed, NEW bearings must be installed during reassembly.

1. Measure the crankpin diameter with a micrometer in several places along the length, approximately 90 degrees apart, minimum of 4 places, and average the measurements.
2. Determine the taper and the out-of-round. Refer to **Engine Mechanical Specifications**.
3. Install the NEW connecting rod bearings into the connecting rod cap and the connecting rod.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Use the original connecting rod nuts for clearance measurement. During final assembly new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original, used, nuts.

Tighten:

1. Tighten the connecting rod nuts a first pass to 30 N.m (22 lb ft).
2. Tighten the connecting rod nuts a final pass an additional 90 degrees using the **J 45059** .

5. Measure the connecting rod bearing inside diameter (ID) using an inside micrometer.
6. Compare the connecting rod bearing clearance specifications. Refer to **Engine Mechanical Specifications**.
7. If the connecting rod bearing clearances exceed specifications, replace components as required.

Plastic Gage Method for Crankshaft Bearings

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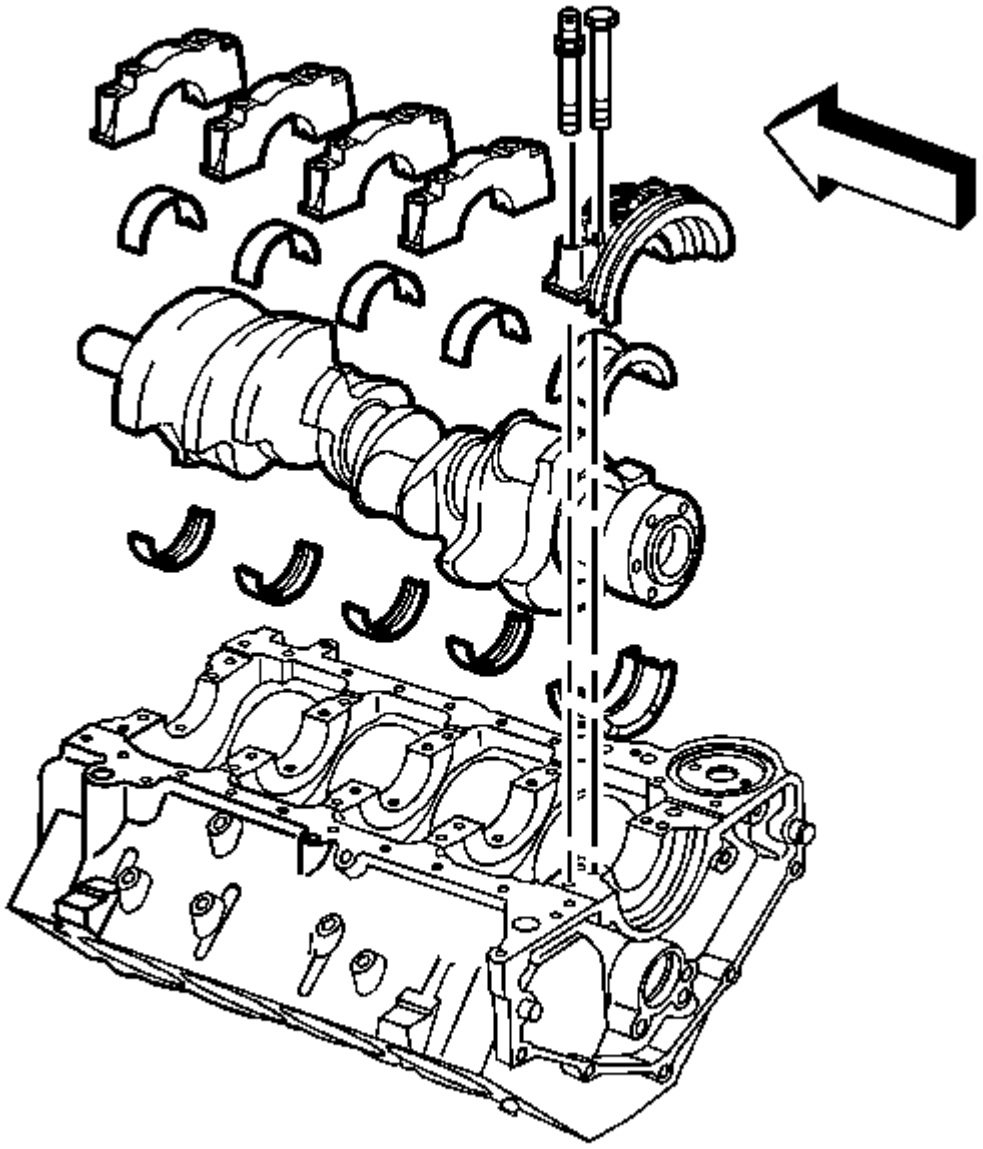

Fig. 345: Installing Crankshaft & Bearings Into Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the crankshaft and the new crankshaft bearings into the block, making sure not to damage the

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reluctor rings of the crankshaft.

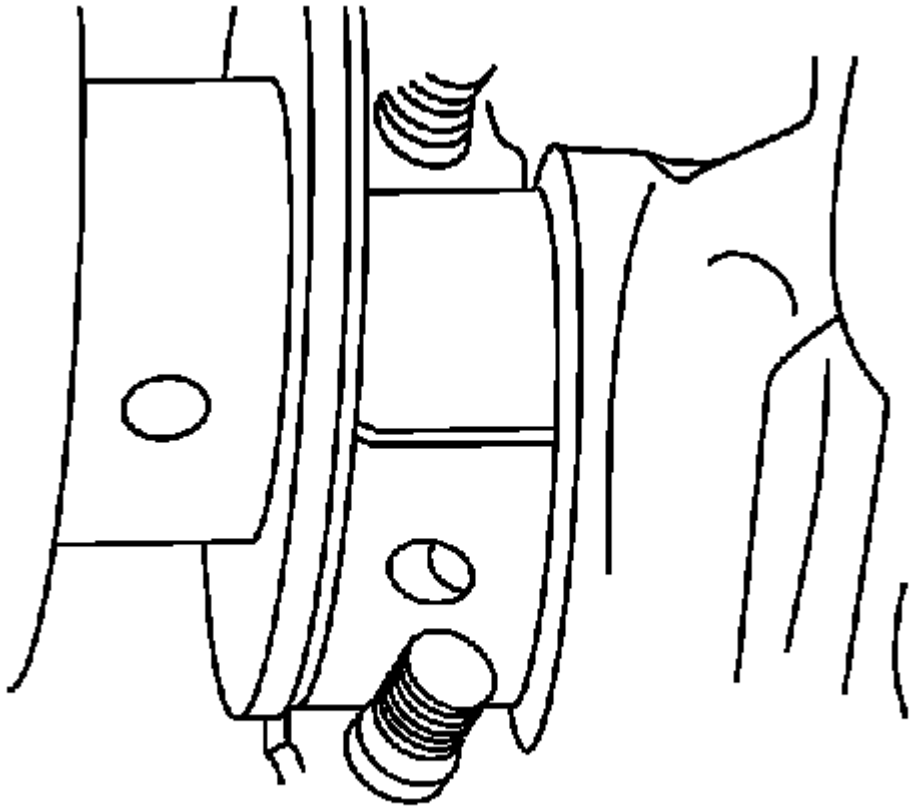

Fig. 346: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

2. Install the gaging plastic the full width of the crankshaft journal.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Tighten the inner crankshaft bearing cap bolts before tightening the outer crankshaft bearing cap studs. The crankshaft journal and the crankshaft bearing surface must be free from oil to obtain a correct measurement. Do not allow the crankshaft to rotate while performing the measurement, or an incorrect measurement will be obtained.

3. Install the bearing cap bolts and studs.

Tighten:

1. Tighten the bearing cap 1-5 bolts a first pass to 30 N.m (22 lb ft).

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2. Tighten the bearing cap 1-5 studs a first pass to 30 N.m (22 lb ft).
3. Tighten the bearing cap 1-5 bolts a final pass an additional 90 degrees using the **J 45059** .
4. Tighten the bearing cap 1-5 studs a final pass an additional 80 degrees using the **J 45059** .

4. Remove the crankshaft bearing cap bolts and the crankshaft bearing caps. The gaging plastic may adhere to either the crankshaft journal or the crankshaft bearing surfaces.

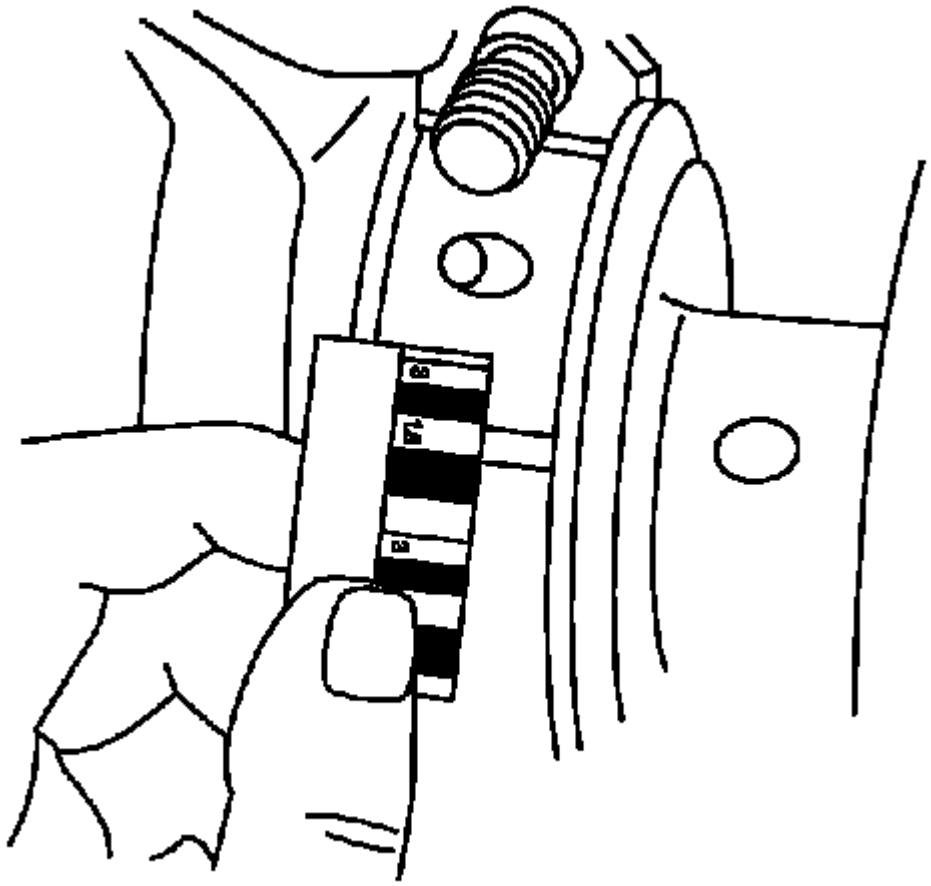

Fig. 347: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

5. On the edge of the gaging plastic envelope there is a graduated scale. Without removing the gaging plastic, measure the compressed width at the widest point.
6. If the flattened gaging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft journal.
   - Normally the crankshaft journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round 0.0254 mm (0.001 in maximum) crankshaft journal, be sure to fit to the maximum diameter of the crankshaft journal.
   - If the crankshaft bearing is fitted to the minimum diameter and the crankshaft journal is excessively out-of-round, the interference between the crankshaft bearing and the crankshaft journal will result

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in rapid crankshaft bearing failure.

7. Compare the crankshaft bearing clearance to the specifications. Refer to **Engine Mechanical Specifications**.
8. If the crankshaft bearing clearances exceeds specifications, replace components as required.
9. Measure the new crankshaft bearing inside diameter (ID) using the same method.
10. Replace the crankshaft if the proper clearances cannot be obtained with standard size bearings.
11. Remove the flattened gaging plastic.
12. Measure the remaining crankshaft journals.

Plastic Gage Method for Connecting Rod Bearings

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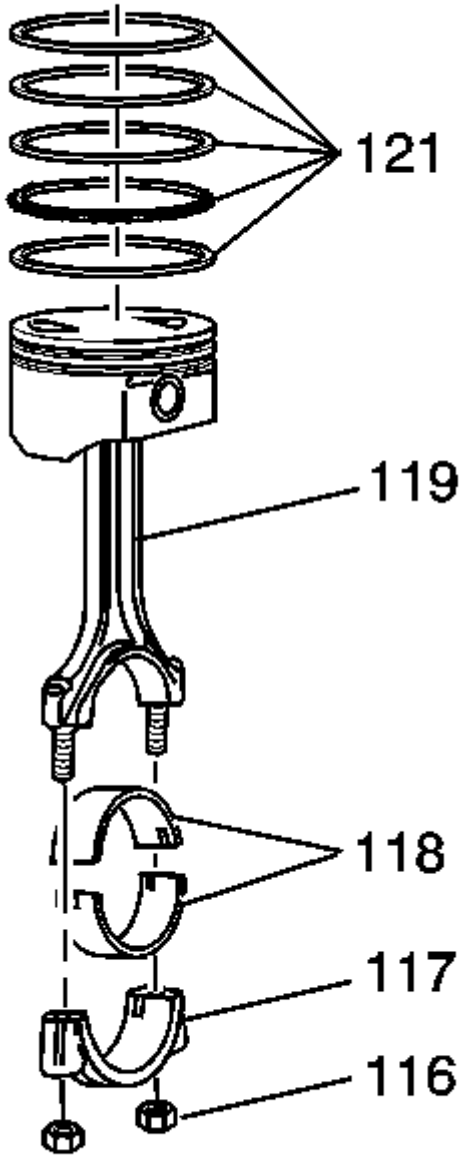

Fig. 348: View Of Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When bearings are removed, NEW bearings must be installed during reassembly.

1. Install the connecting rod bearings (118) into the connecting rod (119) and the connecting rod cap (117).

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2. Using rubber fuel line over the connecting rod bolts, install the piston and connecting rod assembly onto the crankpin journal.

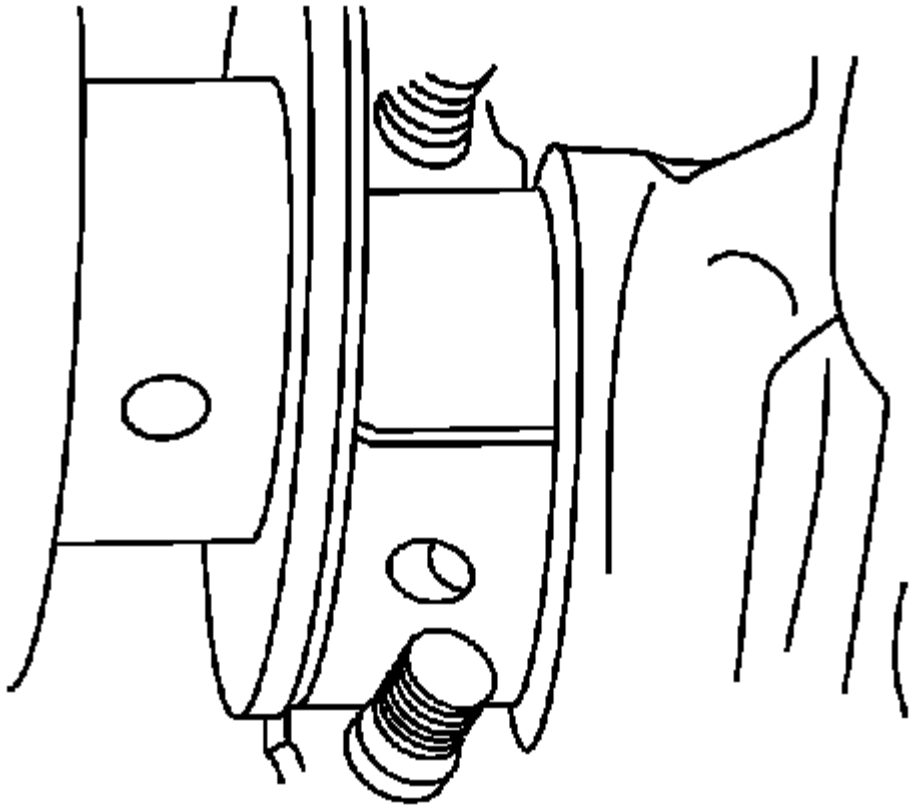

Fig. 349: View Of Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS CORP.

3. Install the gaging plastic the full width of the crankpin journal.

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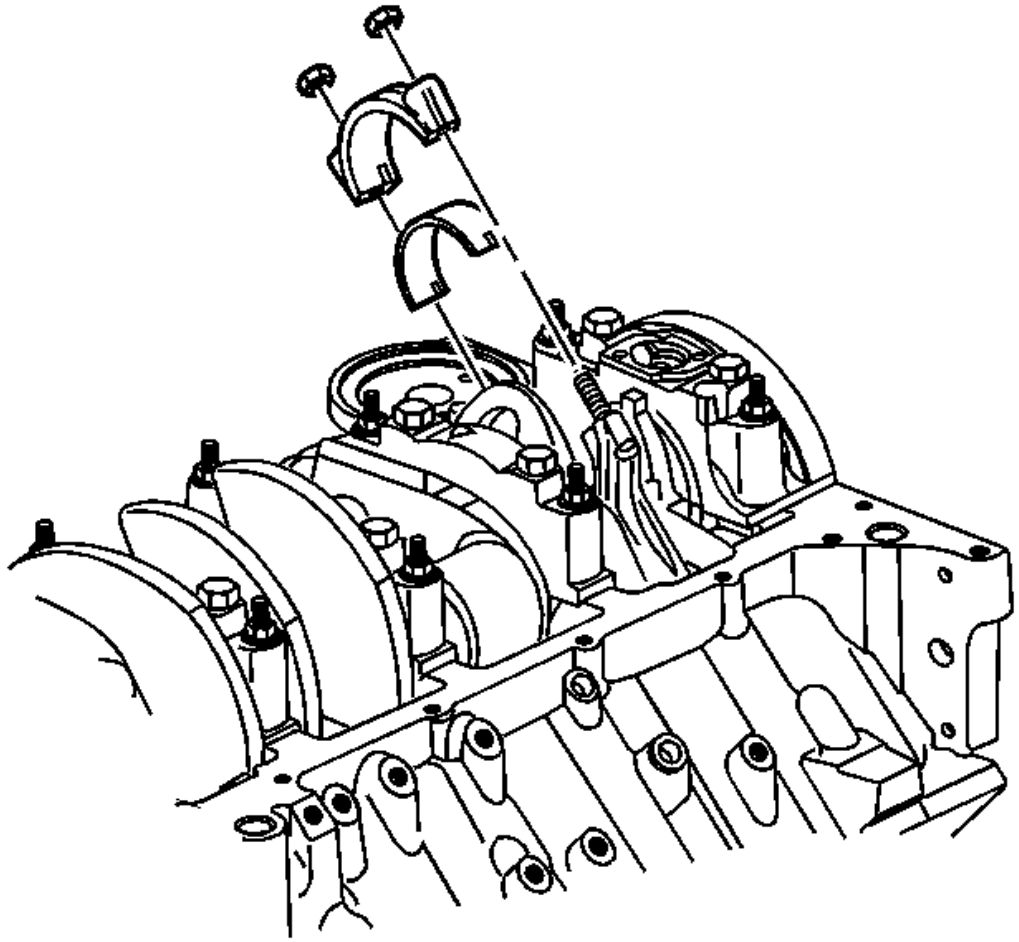

Fig. 350: View Of Connecting Rod Cap & Connecting Rod Lower Bearing
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: Use the original connecting rod nuts for clearance measurement. During final assembly, new connecting rod nuts must be used to obtain correct fastener tightening.

4. Install the connecting rod cap and the original, used, nuts.

Tighten:

1. Tighten the connecting rod nuts a first pass to 30 N.m (22 lb ft).

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2. Tighten the connecting rod nuts a final pass an additional 90 degrees using the **J 45059** .

5. Remove the connecting rod nuts and cap. The gaging plastic may adhere to either the crankpin journal or the connecting rod bearing surface.

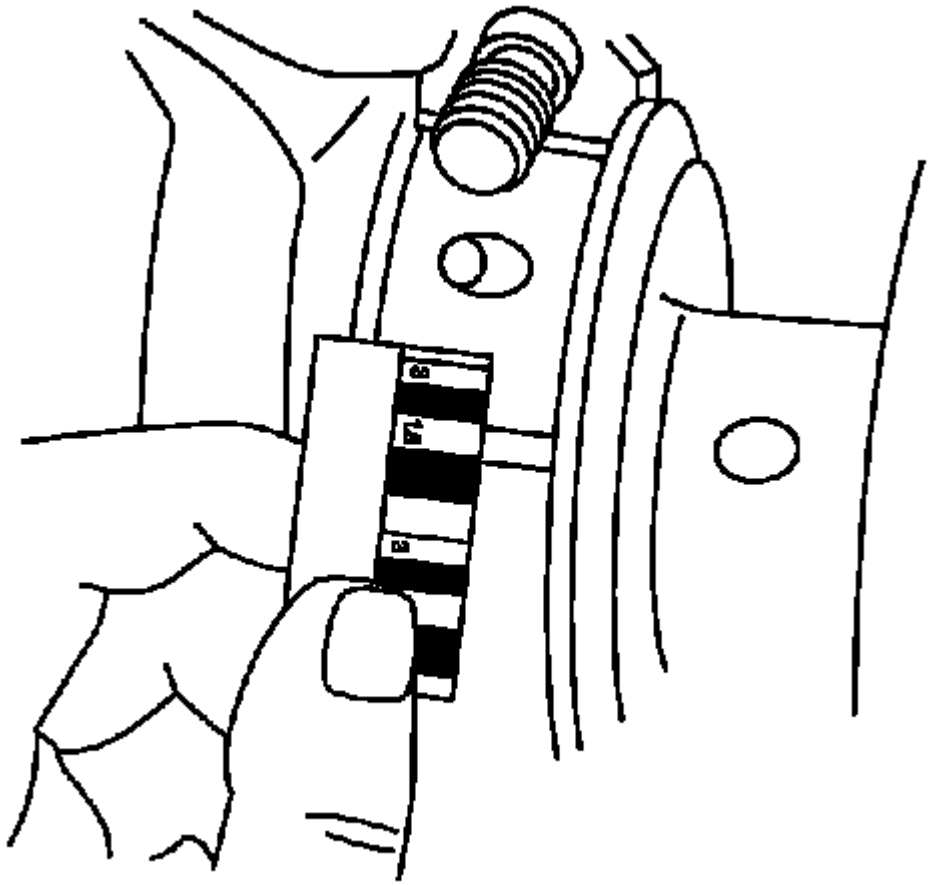

Fig. 351: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

6. On the edge of the gaging plastic envelope there is a graduated scale. Without removing the gaging plastic, measure the compressed width at the widest point.

   If the flattened gaging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankpin journal.

7. Normally the crankpin journals wear evenly and are not out-of-round. However, if a connecting rod bearing is being fitted to an out-of-round 0.0254 mm (0.001 in maximum) crankpin journal, be sure to fit to the maximum diameter of the crankpin journal. If the connecting rod bearing is fitted to the minimum diameter and the crankpin journal is excessively out-of-round, the interference between the connecting rod bearing and the crankpin journal will result in rapid connecting rod bearing failure.
8. Compare the connecting rod bearing clearance to the specifications. Refer to **Engine Mechanical**

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Specifications.

9. If the connecting rod bearing clearances exceed specifications, replace components as required.
10. Remove the flattened gaging plastic.
11. Measure the remaining crankpin journals.

Measuring Crankshaft End Play

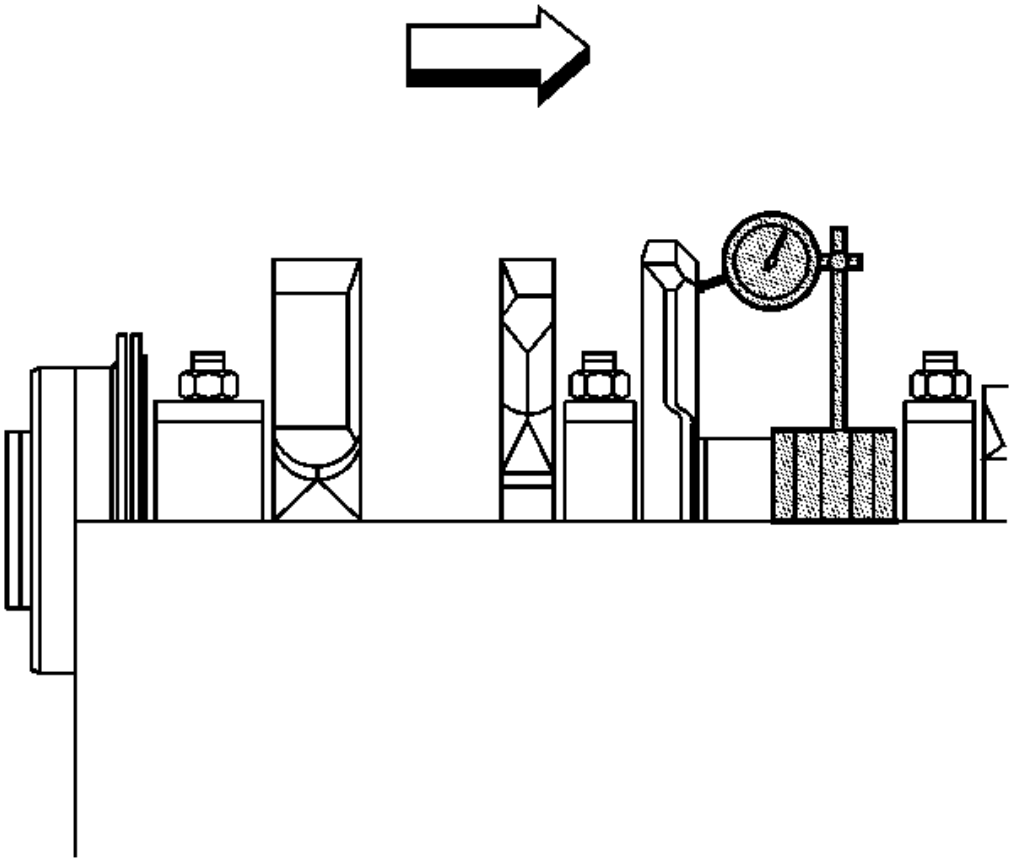

Fig. 352: Measuring Crankshaft End Play Using J 7872
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to properly measure the crankshaft end play, the crankshaft, bearings, bearing caps and fasteners must be installed into the engine block and the bolts tightened to specifications. Refer to Crankshaft and Bearings Installation.

1. Install the **J 7872** or equivalent to the cylinder block, with the dial indicator plunger against one of the

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counterweights of the crankshaft.

2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward and read the endplay measurement on the dial indicator. An optional method is to insert a feeler gage between the crankshaft and the bearing surface and measure the clearance. Refer to **Engine Mechanical Specifications**.
4. If the correct end play cannot be obtained, inspect the crankshaft thrust wall surface or surfaces for wear and/or excessive runout.
5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition or conditions could cause a lack of clearance at the bearing:
    - Burrs on the crankshaft bearing cap
    - Foreign matter between the crankshaft bearing and the block or the crankshaft bearing cap
    - A faulty crankshaft bearing

Measuring Connecting Rod Side Clearance

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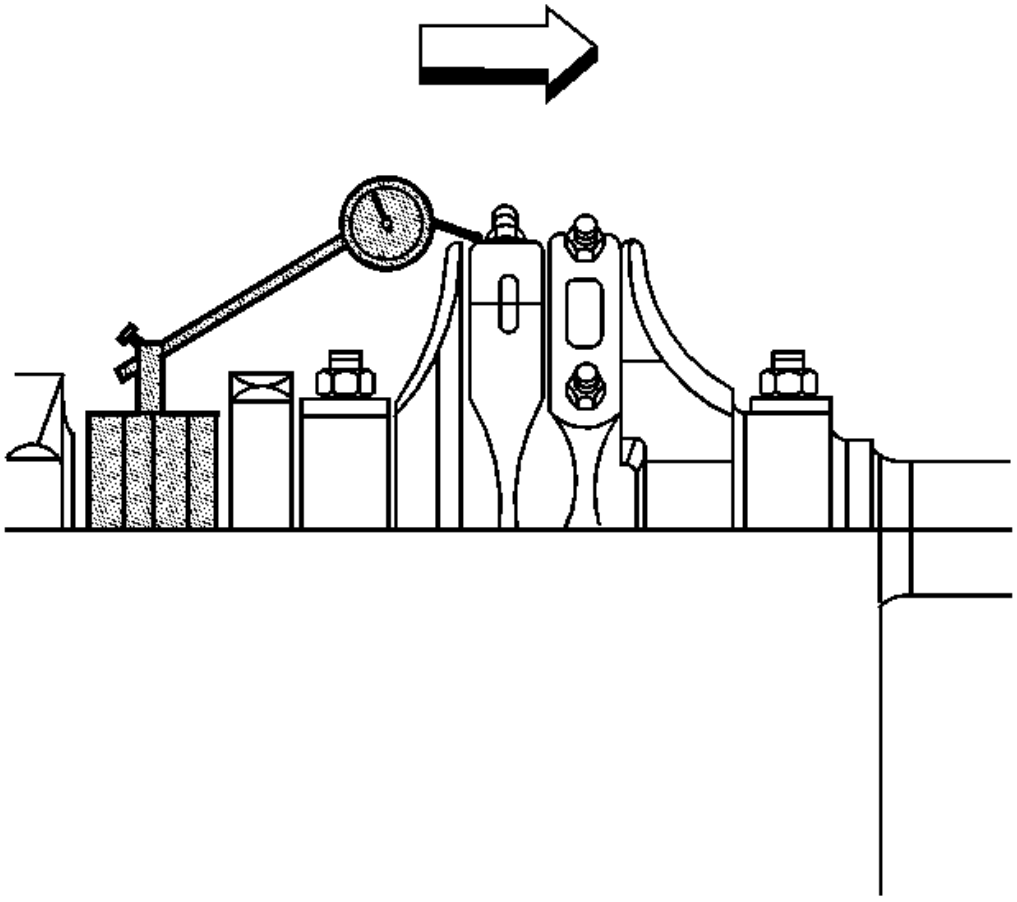

Fig. 353: Measuring Connecting Rod Side Clearance Using J 7872
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: In order to properly measure the connecting rod side clearance, the piston/connecting rod assembly and bearings must be installed into the engine block and the connecting rod nuts tightened to specifications. Refer to Piston, Connecting Rod, and Bearing Installation.

1. Install the **J 7872** or equivalent to the cylinder block, with the dial indicator plunger against the side of the pair of connecting rods.
2. With the connecting rods pushed forward, zero the dial indicator. Firmly move the pair of connecting rods side to side and read the measurement on the dial indicator. An optional method is to insert a feeler gage between the connecting rod caps and measure the connecting rod side clearance. Refer to **Engine Mechanical Specifications**.

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Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

Tools **J 43690** and adapter kit **J 43690-100** 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 as supplied by the tool manufacturer.

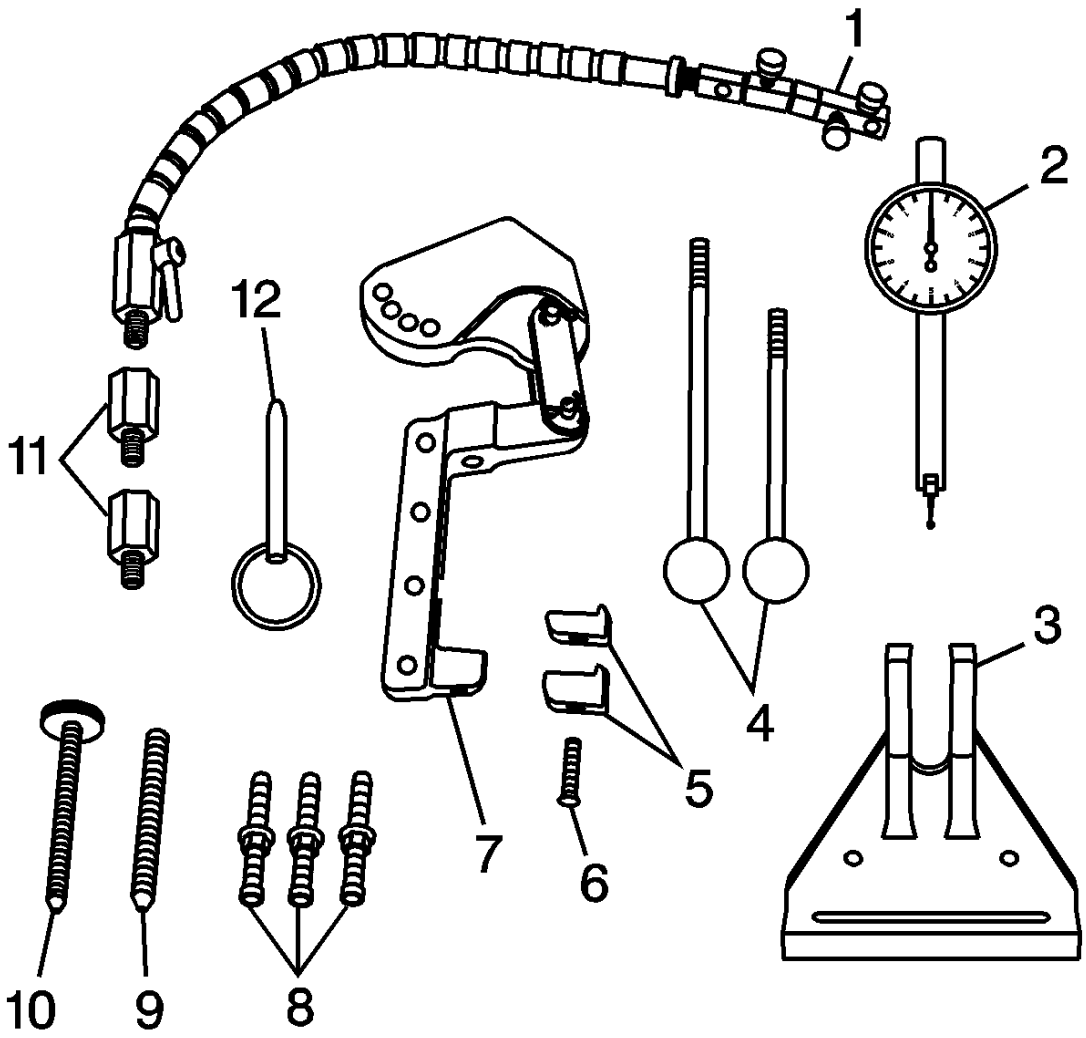

Fig. 354: Identifying Rod Bearing Clearance Checking Tool
Courtesy of GENERAL MOTORS CORP.

J 43690 Rod Bearing Clearance Checking Tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, -6 Handle (4)

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- J 43690-10, -11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, -18 Adapter (11)
- 280310 Pin (12)

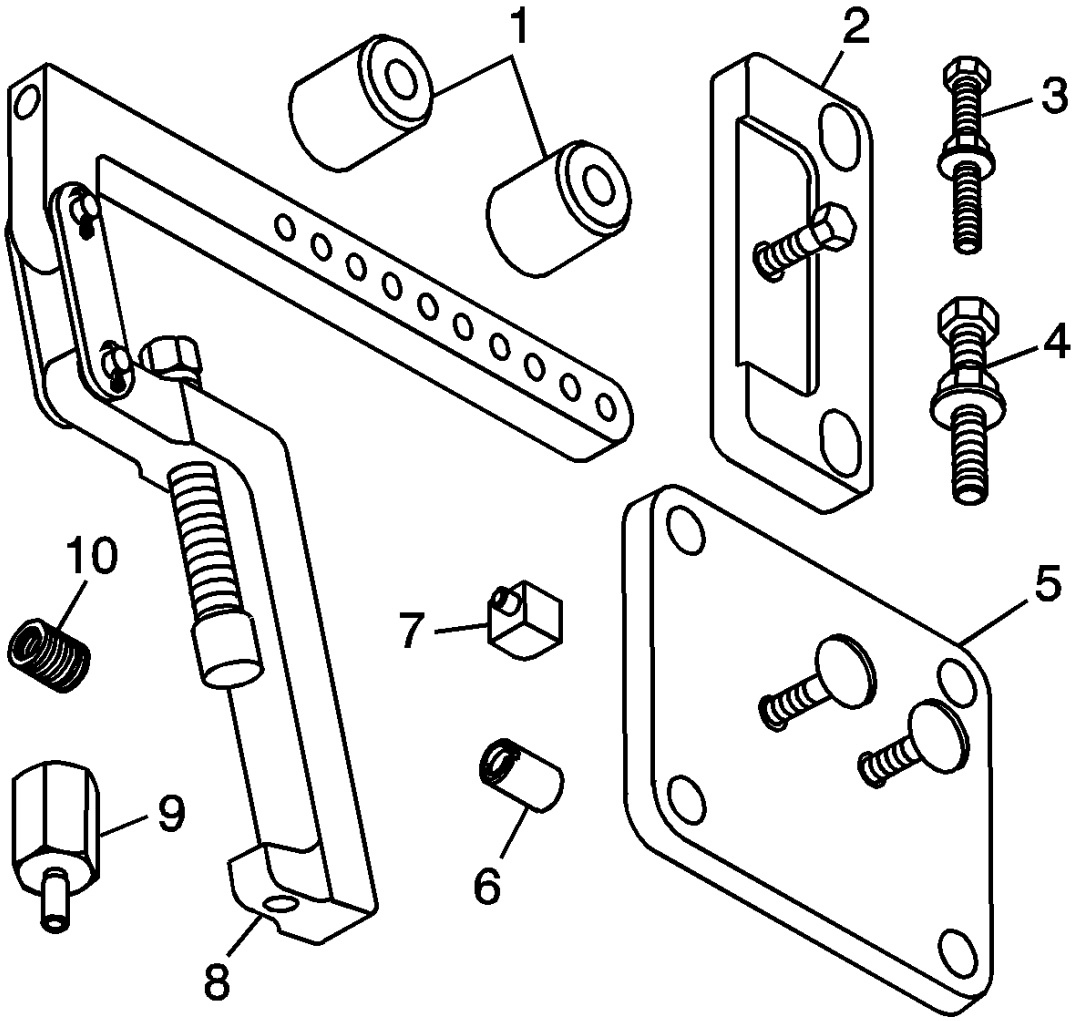

Fig. 355: Identifying Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS CORP.

J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit

- J 43690-104 Spacer (1)

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- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

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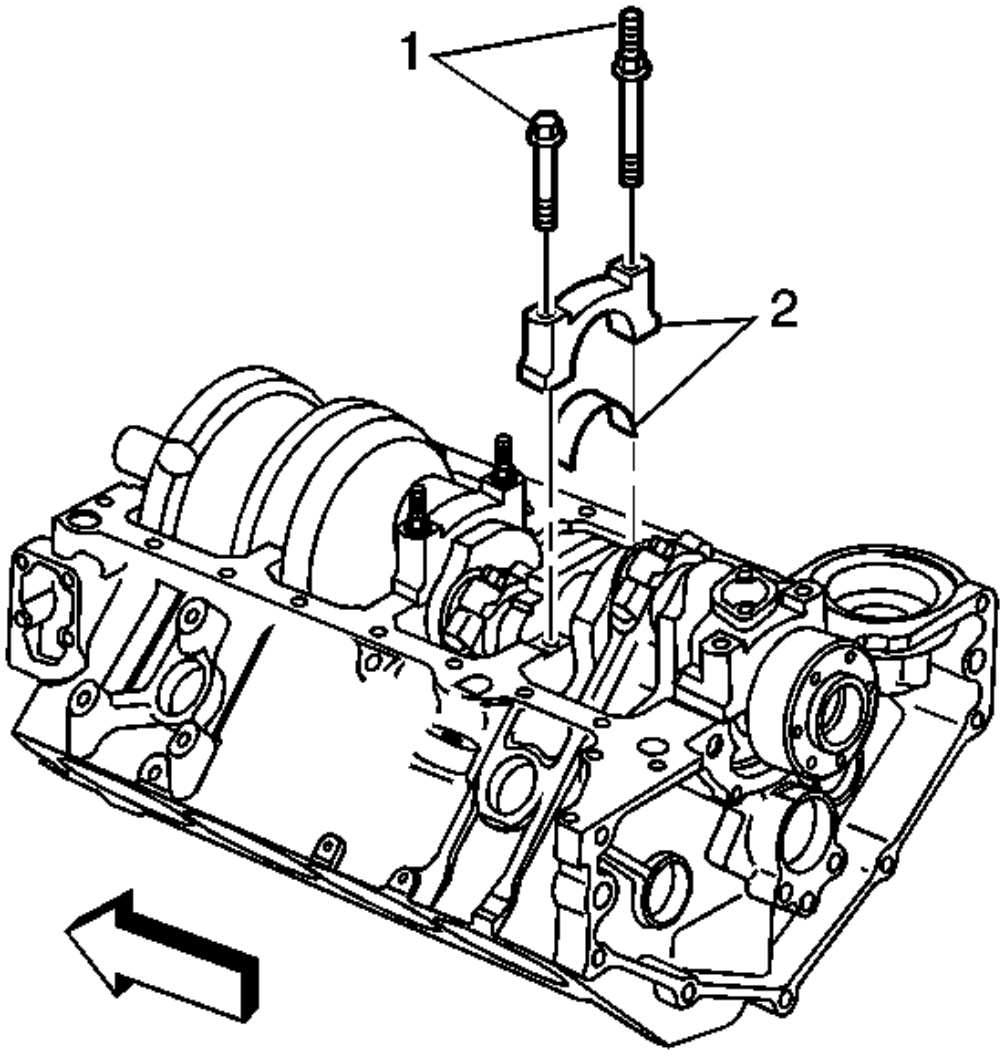

Fig. 356: View Of Bearing Cap Half & Cap & Bearing Cap Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The crankshaft must be secure with no movement or rotation in order to obtain an accurate reading.

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.
2. Remove a bearing cap bolts (1).
3. Remove the bearing half and bearing cap (2).
4. Insert a piece of paper card stock onto the crankshaft journal.

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5. Install the bearing half and cap (2) and bolts (1). Refer to **Fastener Tightening Specifications**.

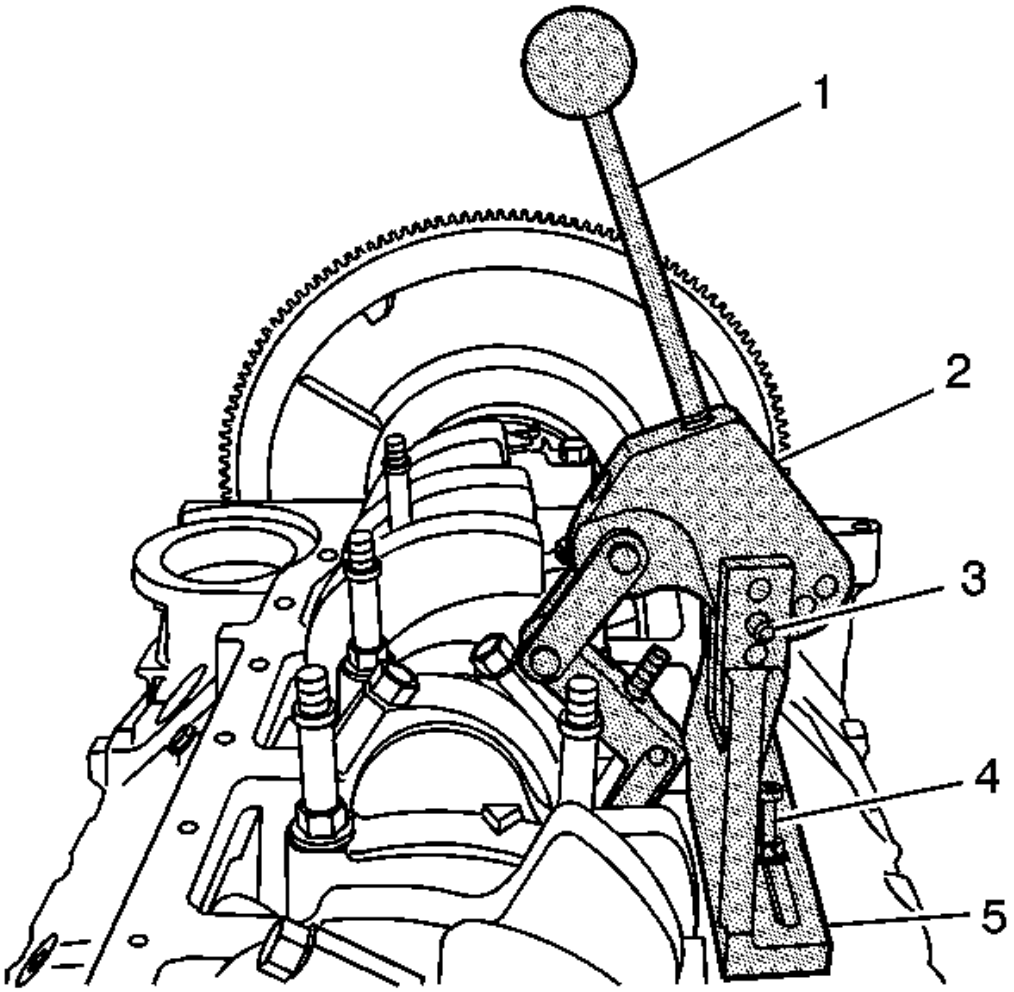

Fig. 357: View Of J 43690-1, J 43690-2, J 43690-5, J 43690-8 & 280310
Courtesy of GENERAL MOTORS CORP.

6. Install the following:
    1. J 43690-2 (5)
    2. J 43690-8 (4)
    3. J 43690-1 (2)
    4. 280310 (3)
    5. J 43690-5 (1)

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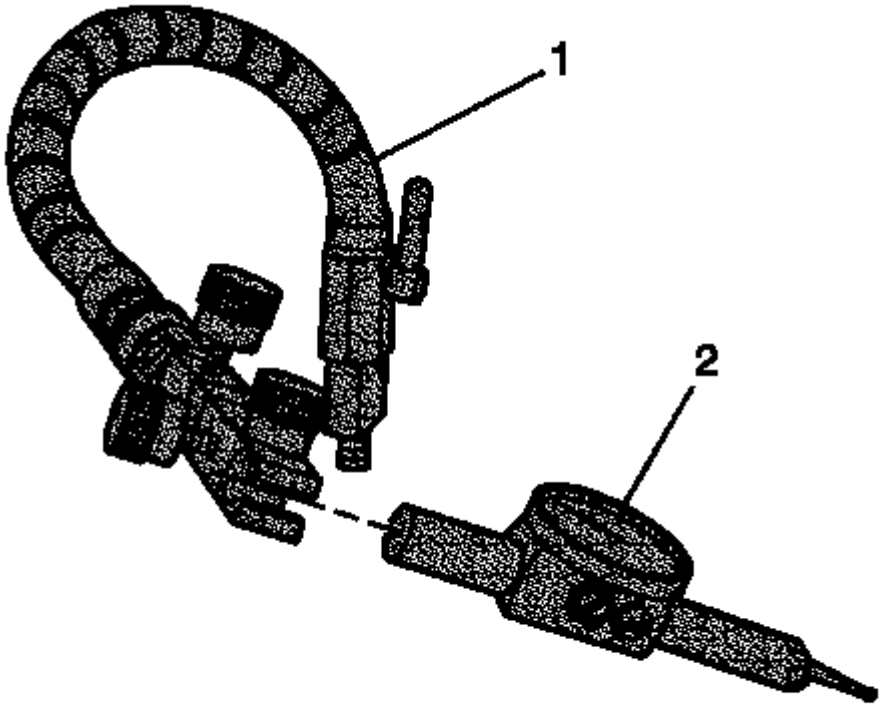

Fig. 358: View Of Swivel Base & Dial Indicator
Courtesy of GENERAL MOTORS CORP.

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 0.081 mm (0.0032 in) is considered excessive. Service components as required.

Crankshaft Balancer Cleaning and Inspection

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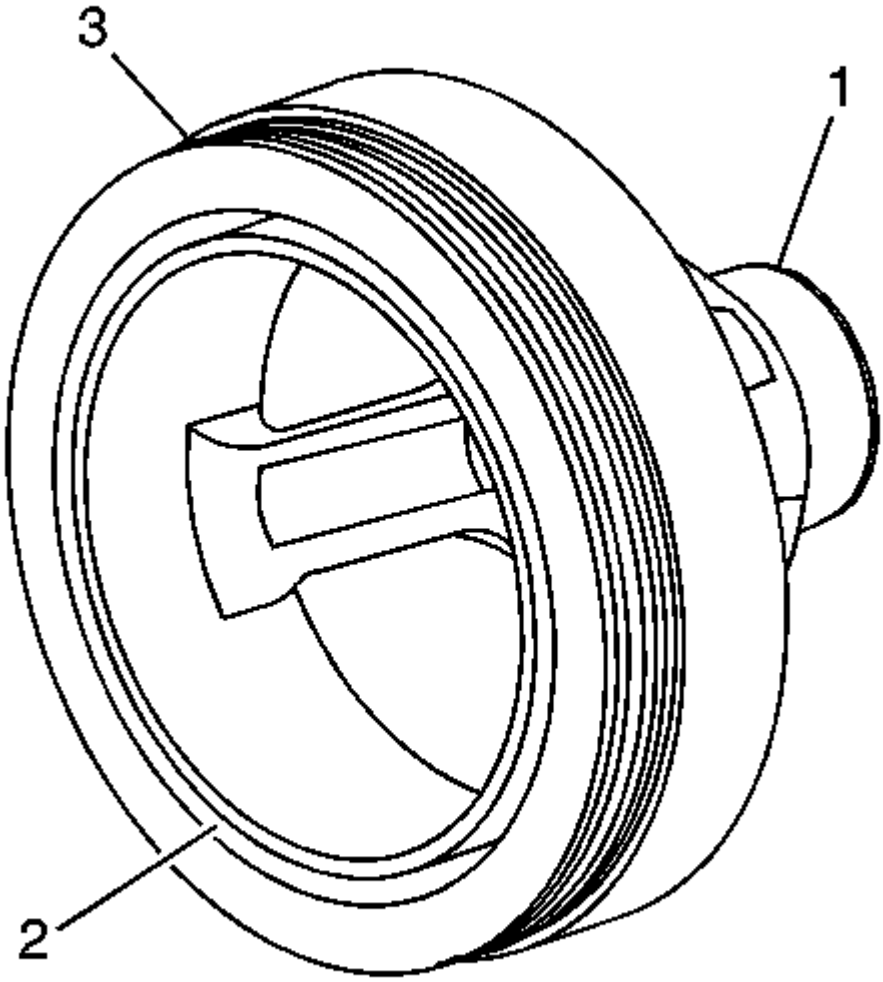

Fig. 359: Inspecting Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer in solvent.

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

2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
    - Damaged belt grooves (3)

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- Debris in the belt grooves (3)
- Worn, grooved, or damaged hub seal surface (1)
  - Minor imperfections on the hub seal surface may be removed with a polishing compound or fine grade of emery cloth.
  - A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
- Worn, chunking or deteriorated rubber between the hub and pulley (2)

4. Repair or replace the crankshaft balancer as necessary.

Engine Flywheel Cleaning and Inspection

1. Clean the engine flywheel in solvent.

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

2. Dry the engine flywheel with compressed air.

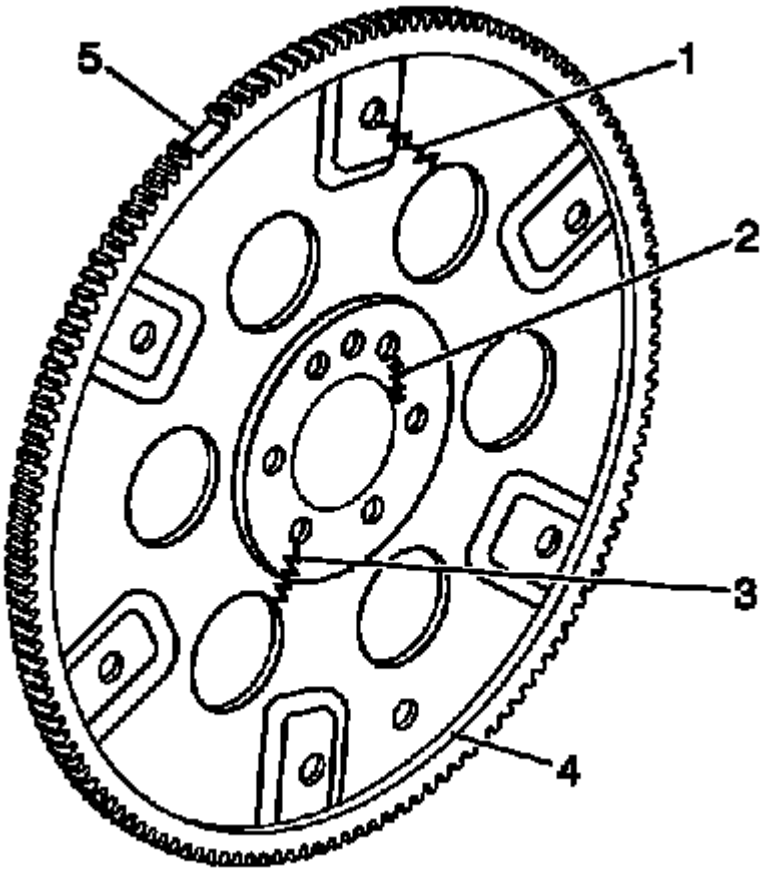

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Fig. 360: Flywheel Inspection Areas (Automatic Transmission)
Courtesy of GENERAL MOTORS CORP.

3. Inspect the engine flywheel for the following conditions:
   - Stress cracks around the engine flywheel-to-torque converter mounting bolt hole locations (1) and/or engine flywheel-to-crankshaft (2, 3)

IMPORTANT: Do not attempt to repair the welded areas that retain the ring gear to the engine flywheel plate. Install a new engine flywheel.

   - Cracks at welded areas that retain the ring gear onto the engine flywheel (4)
   - Damaged or missing ring gear teeth (5)

Piston and Connecting Rod Disassemble

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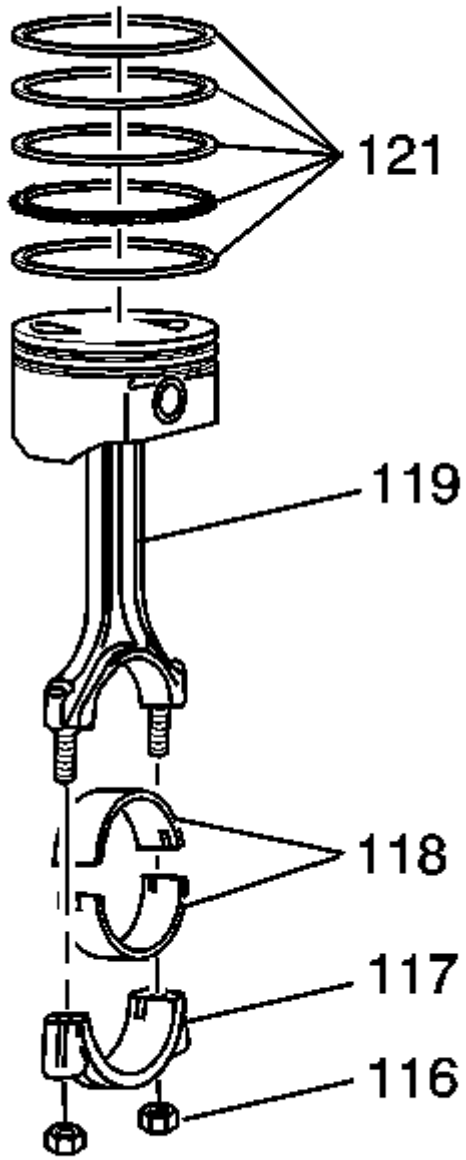

Fig. 361: View Of Piston & Connecting Rod Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The piston and connecting rod are only serviced as an assembly. If a new piston or connecting rod is required, a complete piston/connecting rod assembly must be used.

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IMPORTANT: New connecting rod nuts must be used when the pistons are reinstalled in the engine.

Remove the piston rings (121) from the piston.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

IMPORTANT: The piston diameter can NOT be measured due to the piston coating. Do NOT measure the piston diameter.

IMPORTANT: Measurement of all components should be taken with the components at room temperature.

Do not use a wire brush in order to clean any part of the piston.

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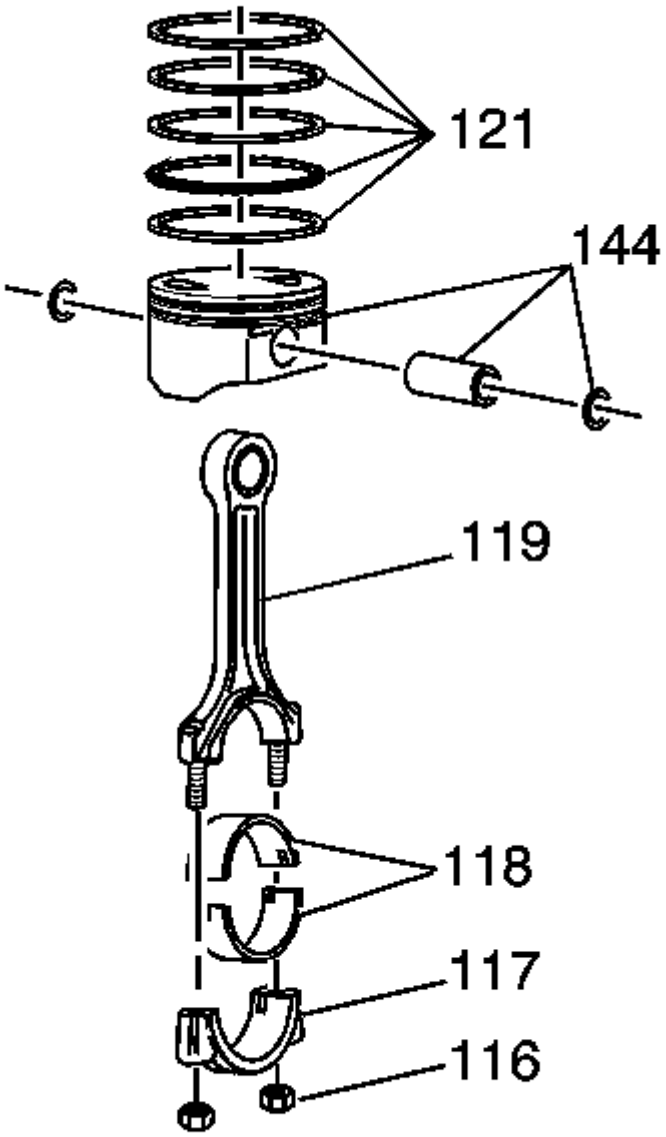

Fig. 362: View Of Piston & Pin, Connecting Rod & Cap
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston and pin (144), connecting rod (119) and cap (117) in solvent.

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

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2. Dry the components with compressed air.

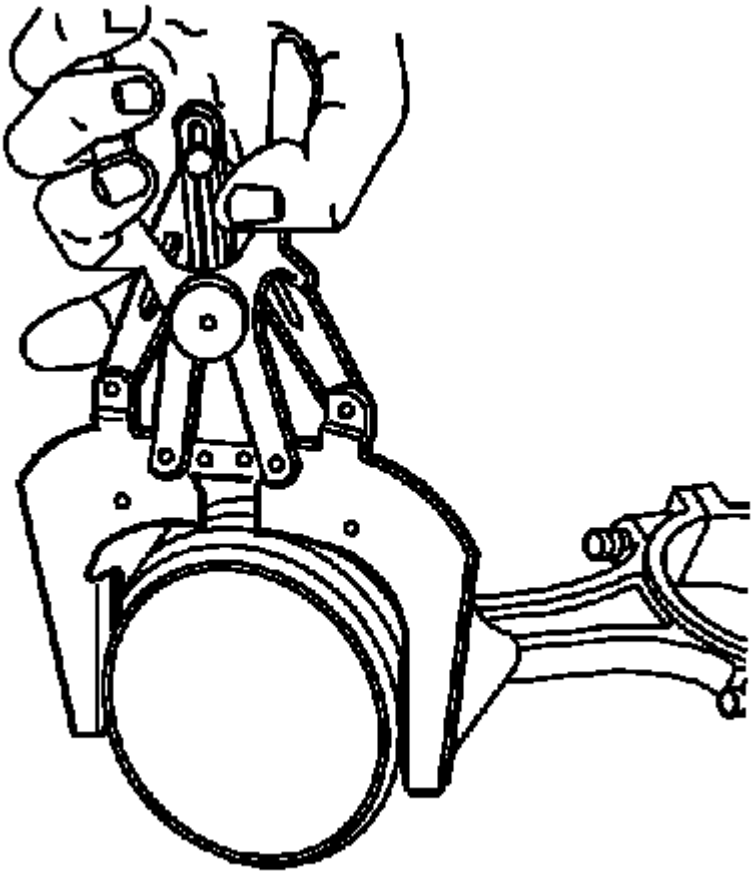

Fig. 363: Cleaning The Piston Ring Grooves With Suitable Ring Groove Cleaning Tool
Courtesy of GENERAL MOTORS CORP.

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the piston oil lubrication holes and slots.

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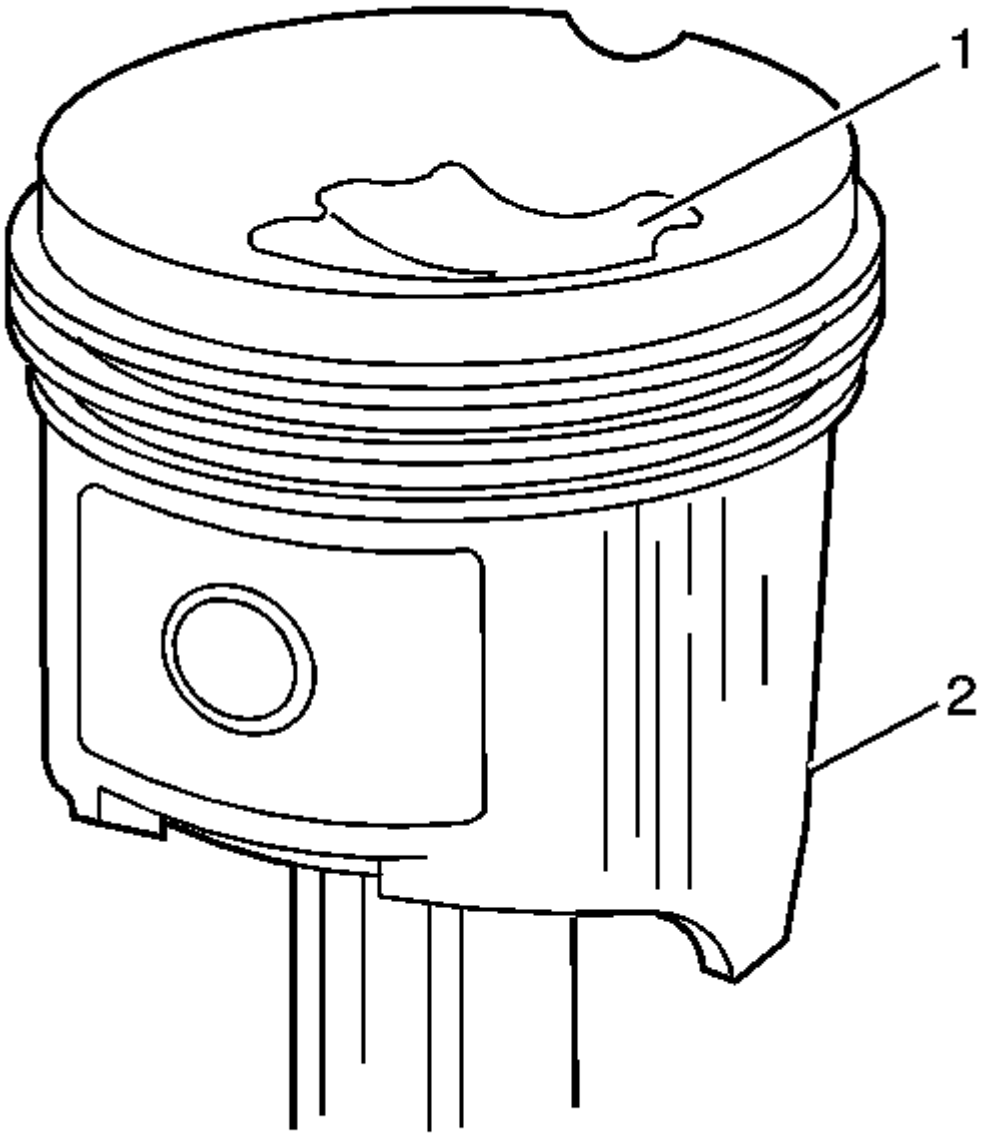

Fig. 364: Inspecting Piston For Eroded Areas & Damaged Skirt
Courtesy of GENERAL MOTORS CORP.

5. Inspect the piston for the following conditions:
    - Eroded areas (1) on the top of the piston
    - Scuffed or damaged skirt (2)
    - Cracks in the piston ring lands, the piston skirt, or the pin bosses

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- Piston ring grooves for nicks, burrs, or other warpage which may cause the piston ring to bind

6. Inspect the piston pin for scoring, wear or other damage.

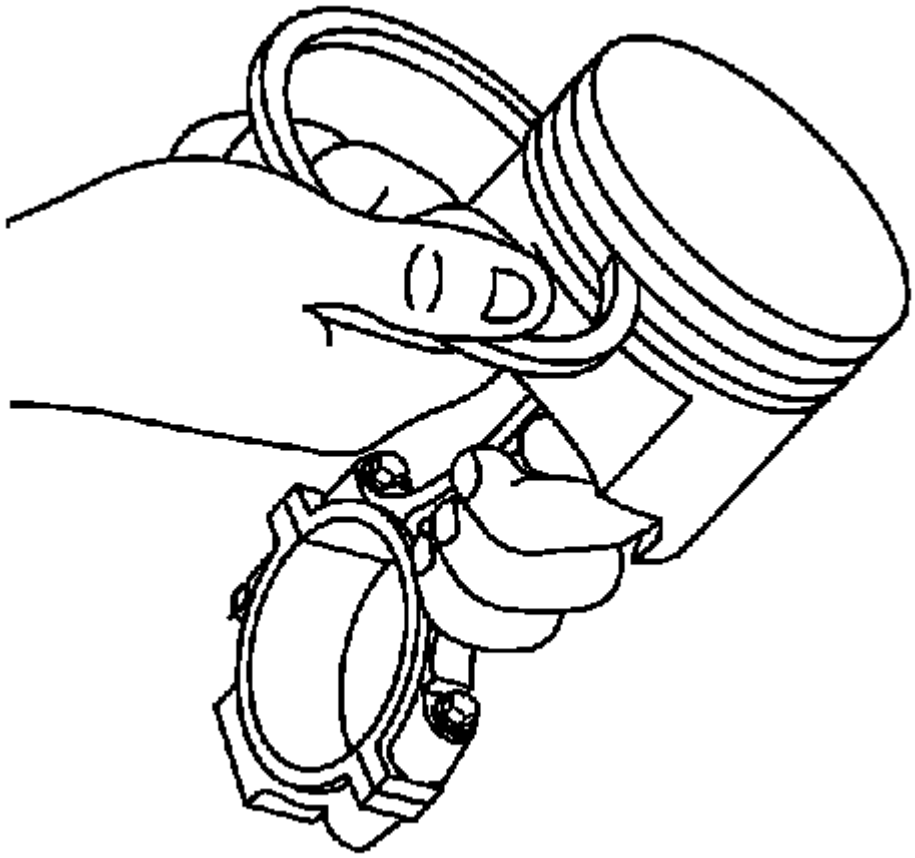

Fig. 365: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring-to-piston ring groove side clearance. Refer to **Engine Mechanical Specifications**.
    1. Insert the edge of the piston ring into the piston ring groove.

       Roll the piston ring completely around the piston.

    2. If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
    3. If binding is caused by a distorted piston ring, replace the piston ring.

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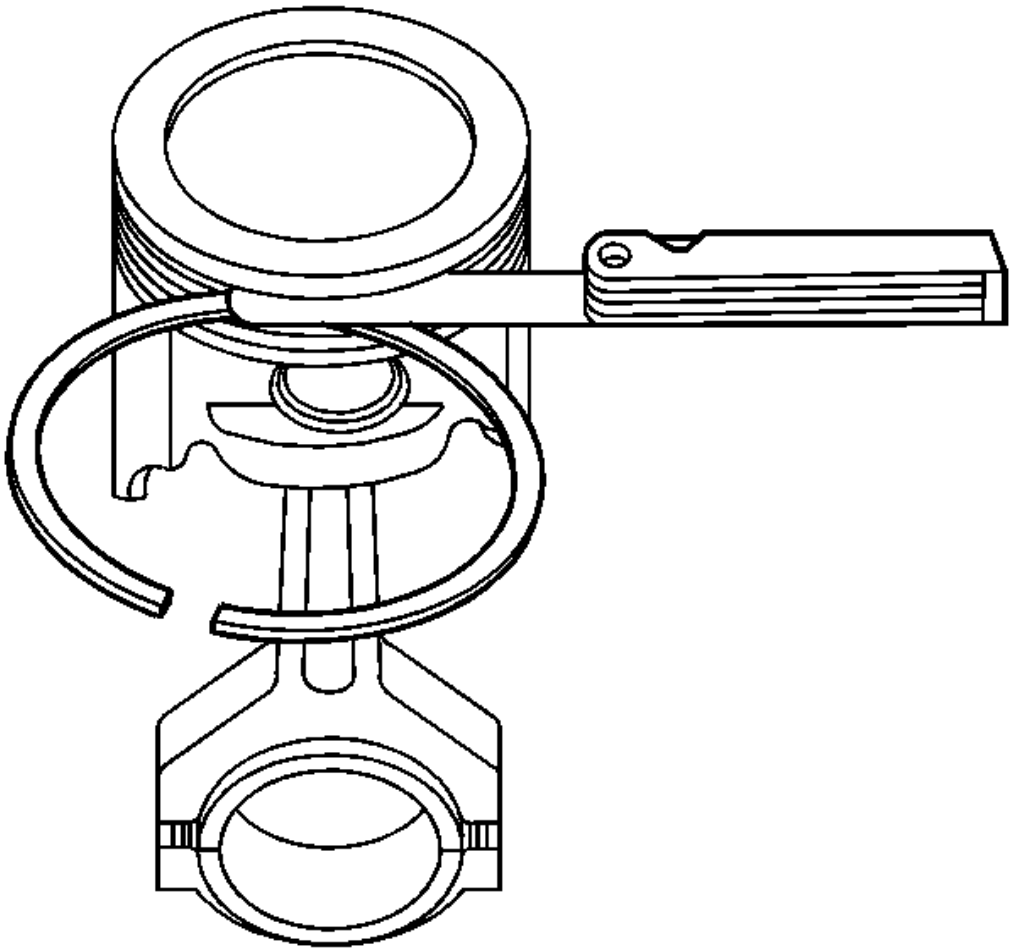

Fig. 366: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

8. Measure the piston ring side clearance with a feeler gage.
9. If the side clearance is too small, try another piston ring set. Refer to **Engine Mechanical Specifications**.
10. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.

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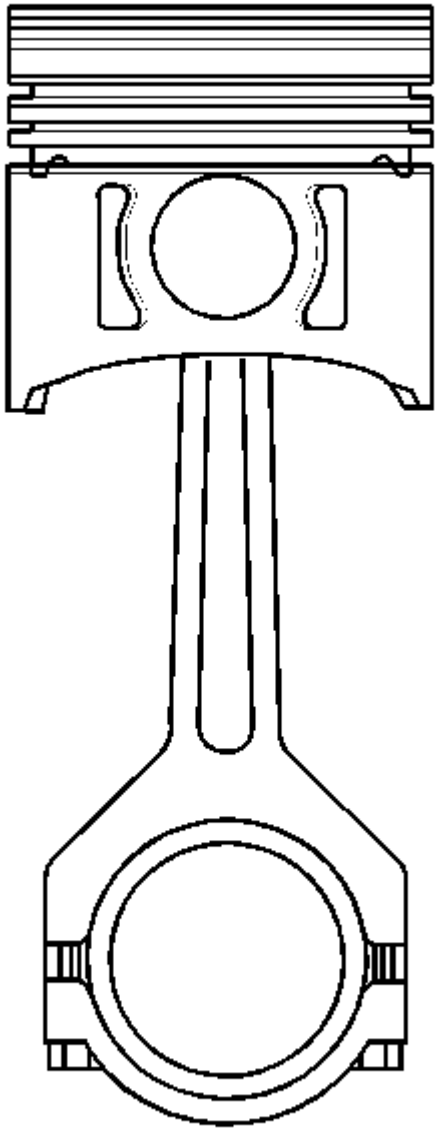

Fig. 367: Inspecting Connecting Rod For Out-Of-Round Bearing Bore
Courtesy of GENERAL MOTORS CORP.

11. Inspect the connecting rod for an out-of-round bearing bore.

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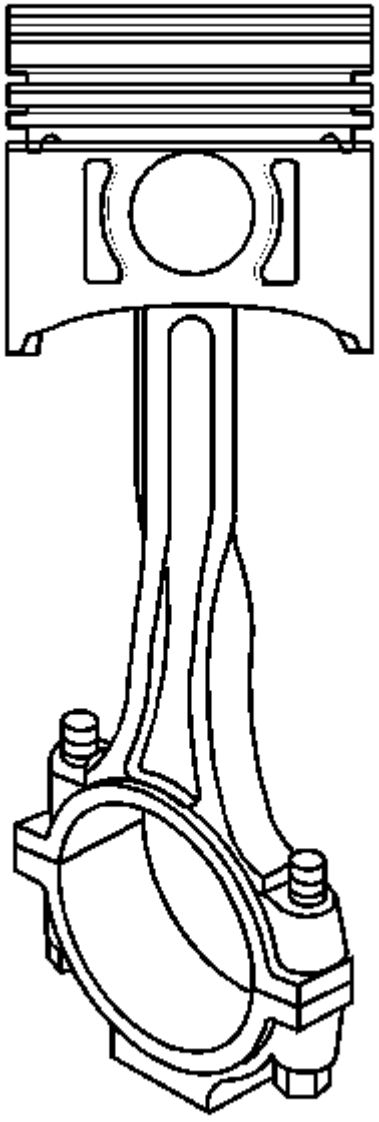

Fig. 368: Inspecting Connecting Rod For Twisting
Courtesy of GENERAL MOTORS CORP.

12. Inspect the connecting rod for twisting.
13. Inspect the connecting rod for damage to the connecting rod bolt threads.

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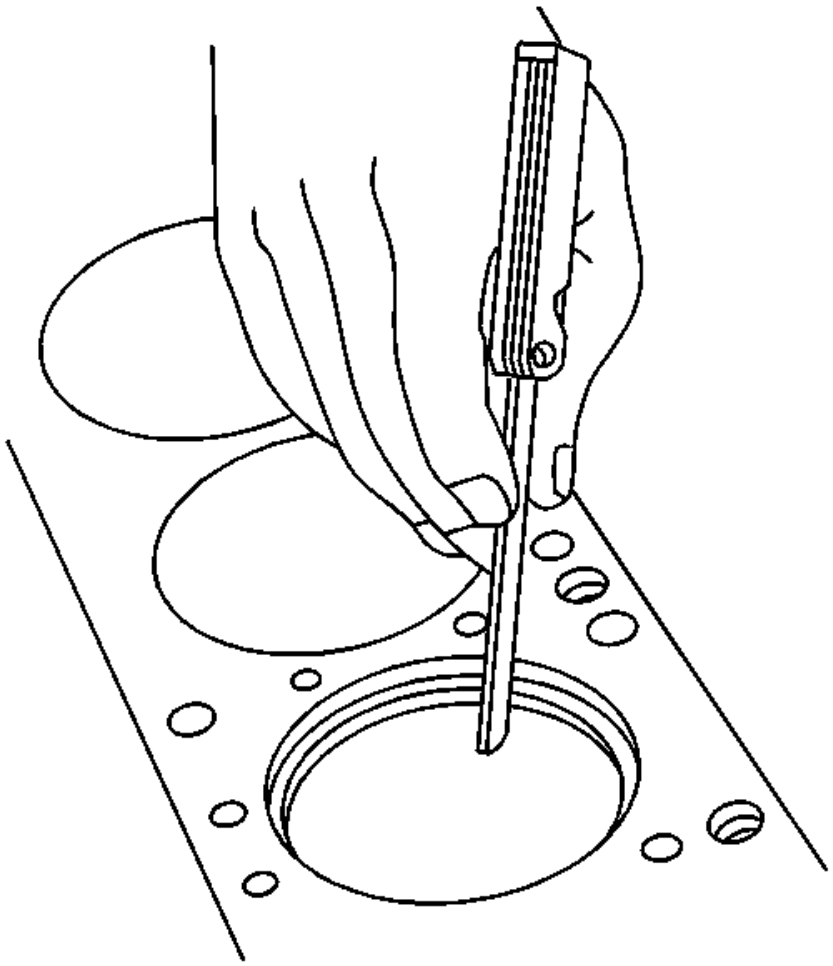

Fig. 369: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Fit each compression ring to the cylinder in which it will be used.

14. Measure the piston compression ring end gap.
    1. Place the compression ring into the cylinder bore.
    2. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel.

       The ring must be square to the cylinder wall.

    3. Use a feeler gage in order to measure the end gap.
    4. Select another size ring set if the end gap exceeds specifications.

Piston and Connecting Rod Assemble

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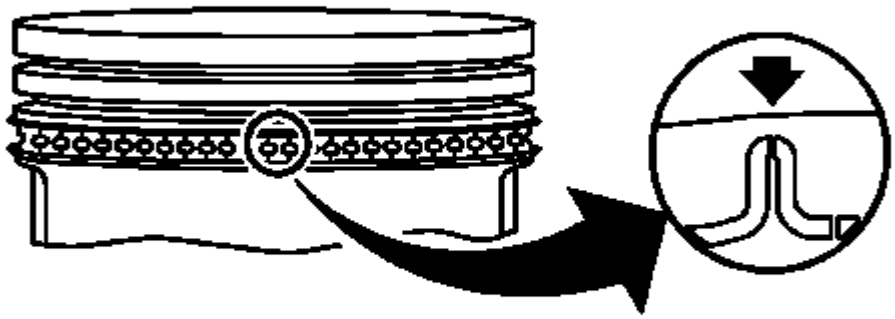

Fig. 370: View Of Lower Oil Control Piston Ring Spacer
Courtesy of GENERAL MOTORS CORP.

NOTE: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

1. Install the lower oil control piston ring spacer onto the piston.

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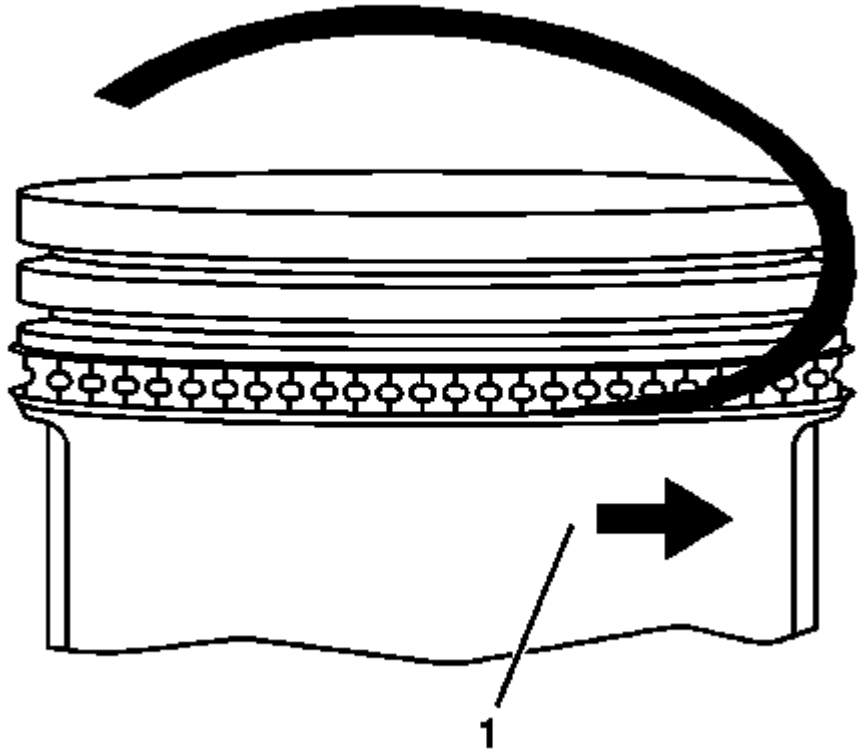

Fig. 371: View Of Lower Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

2. Install the lower oil control piston ring onto the piston (1).

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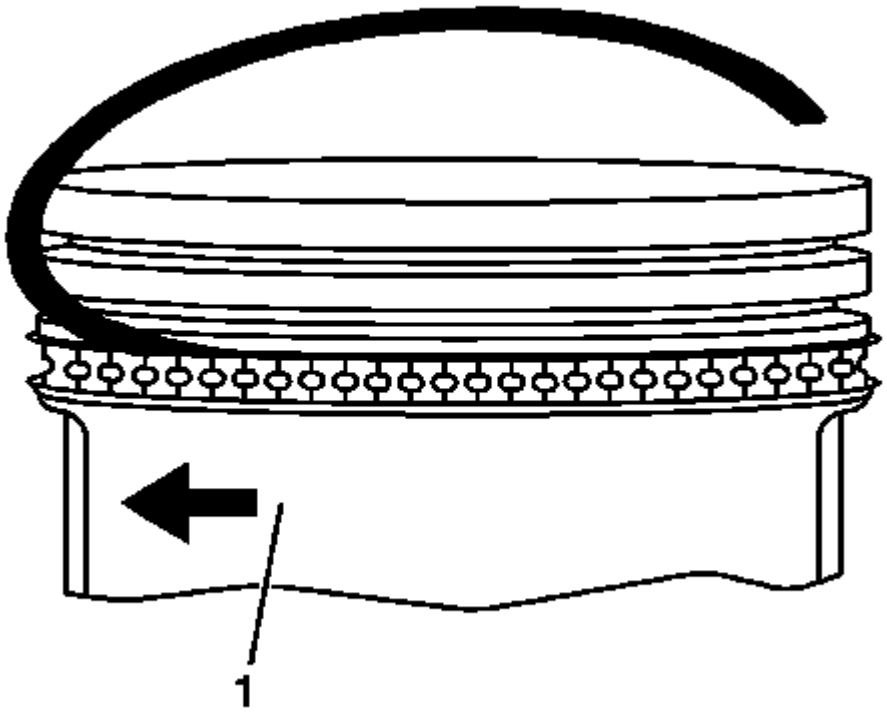

Fig. 372: View Of Upper Oil Control Piston Ring
Courtesy of GENERAL MOTORS CORP.

3. Install the upper oil control piston ring onto the piston (1).

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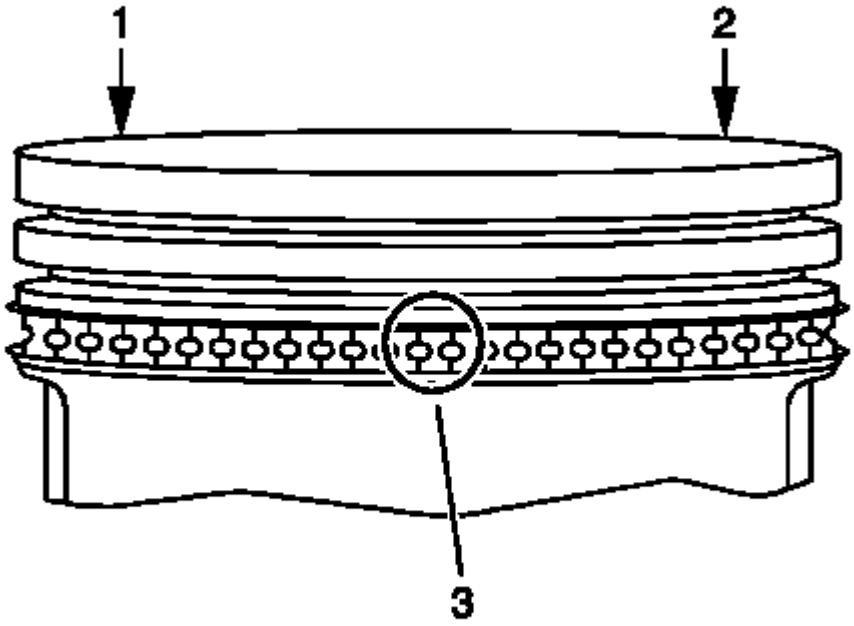

Fig. 373: View Of Oil Control Piston Rings
Courtesy of GENERAL MOTORS CORP.

4. Space the oil control piston ring end gaps a minimum of 90 degrees apart (1, 2, 3).

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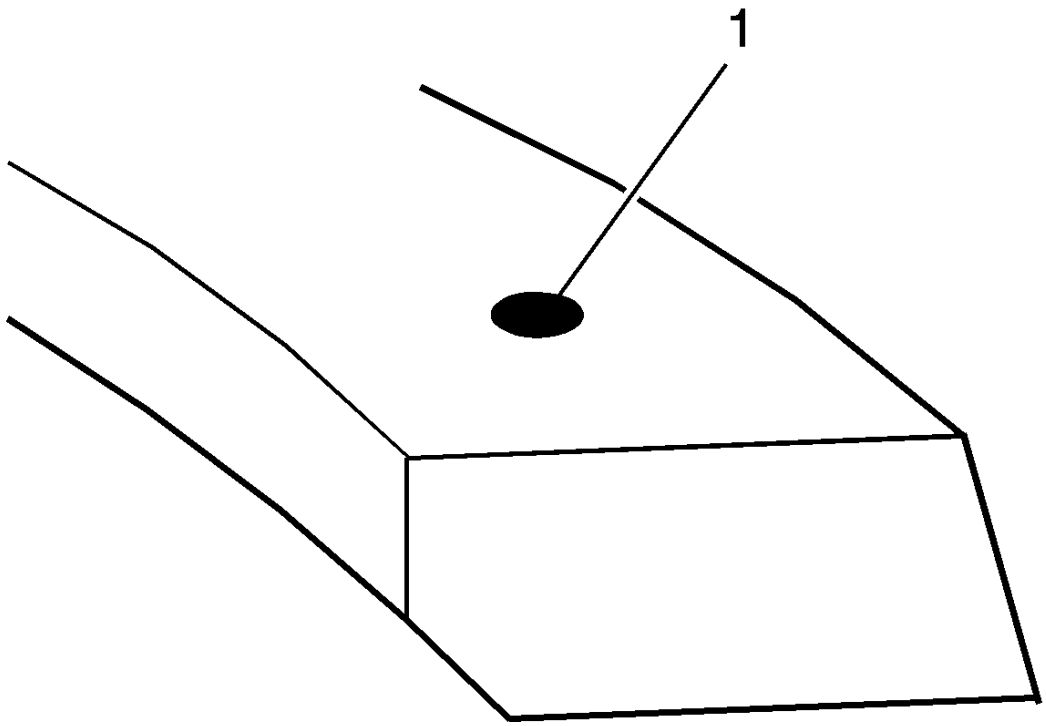

Fig. 374: View Of Lower Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

5. Install the lower compression piston ring onto the piston (1). The mark on the side of the piston ring should face the top of the piston.

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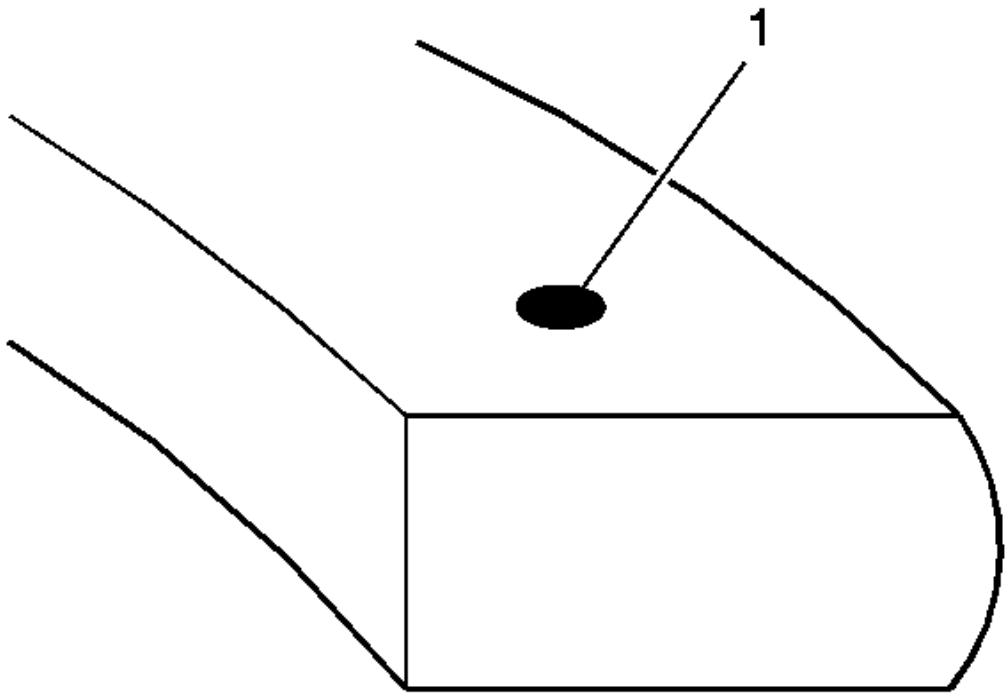

Fig. 375: View Of Upper Compression Piston Ring Mark
Courtesy of GENERAL MOTORS CORP.

6. Install the upper compression piston ring onto the piston. The mark (1) on the side of the piston ring should face the top of the piston.
7. Space the compression piston ring end gaps 120 degrees apart.

Camshaft and Bearings Cleaning and Inspection

Tools Required

J 7872 Magnetic Base Dial Indicator

1. Clean the camshaft in solvent.

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

2. Dry the camshaft with compressed air.

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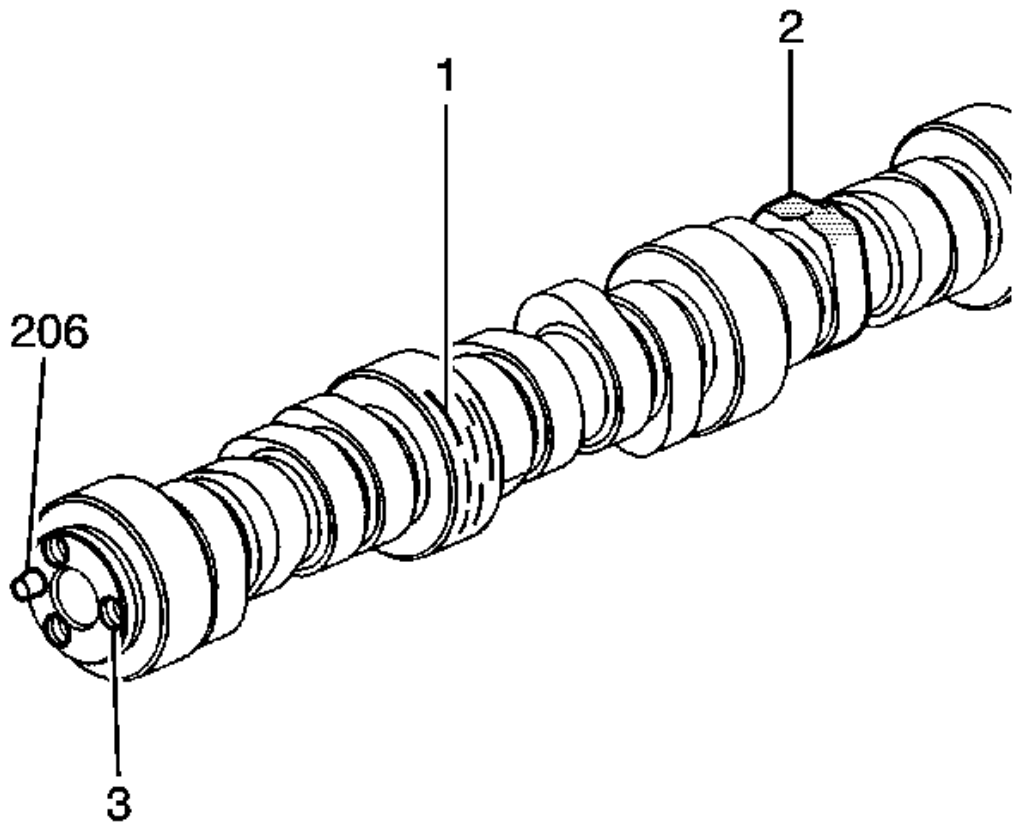

Fig. 376: Inspecting Camshaft
Courtesy of GENERAL MOTORS CORP.

3. Inspect the camshaft retainer plate for damage.
4. Inspect the camshaft for the following conditions:
    - Camshaft bearing journals (1) that are:
        - Worn
        - Scored
        - Damaged
    - Worn camshaft lobes (2)
    - Damaged sprocket bolt threads (3)
    - Damaged sprocket pin (206)

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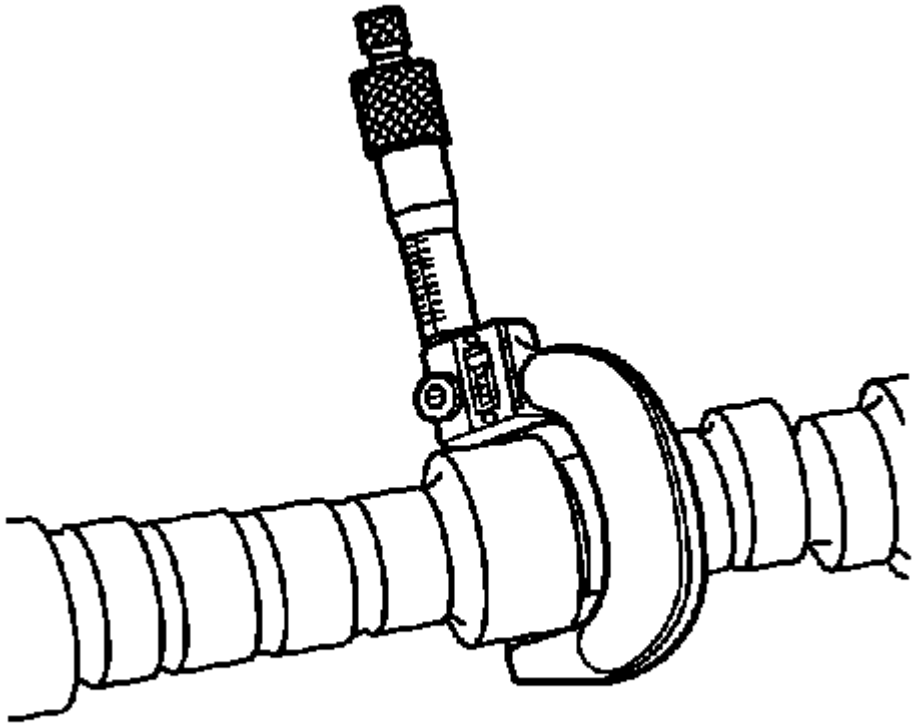

Fig. 377: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS CORP.

5. Measure the camshaft journals with a micrometer. Refer to **Engine Mechanical Specifications**.

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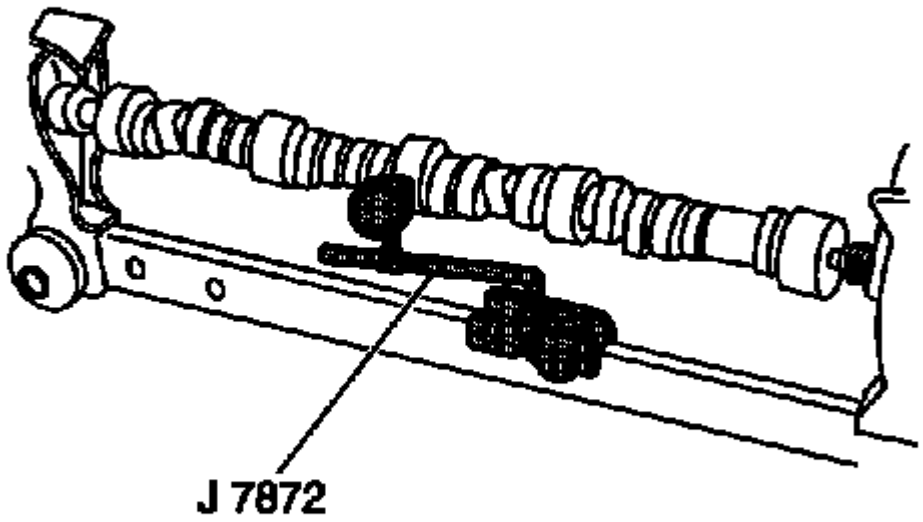

Fig. 378: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS CORP.

6. Measure for excessive camshaft runout using **J 7872** .
    1. Mount the camshaft in a suitable fixture.
    2. Use the **J 7872** in order to measure for a bent camshaft. Refer to **Engine Mechanical Specifications**.
7. Replace the camshaft if runout exceeds specifications.

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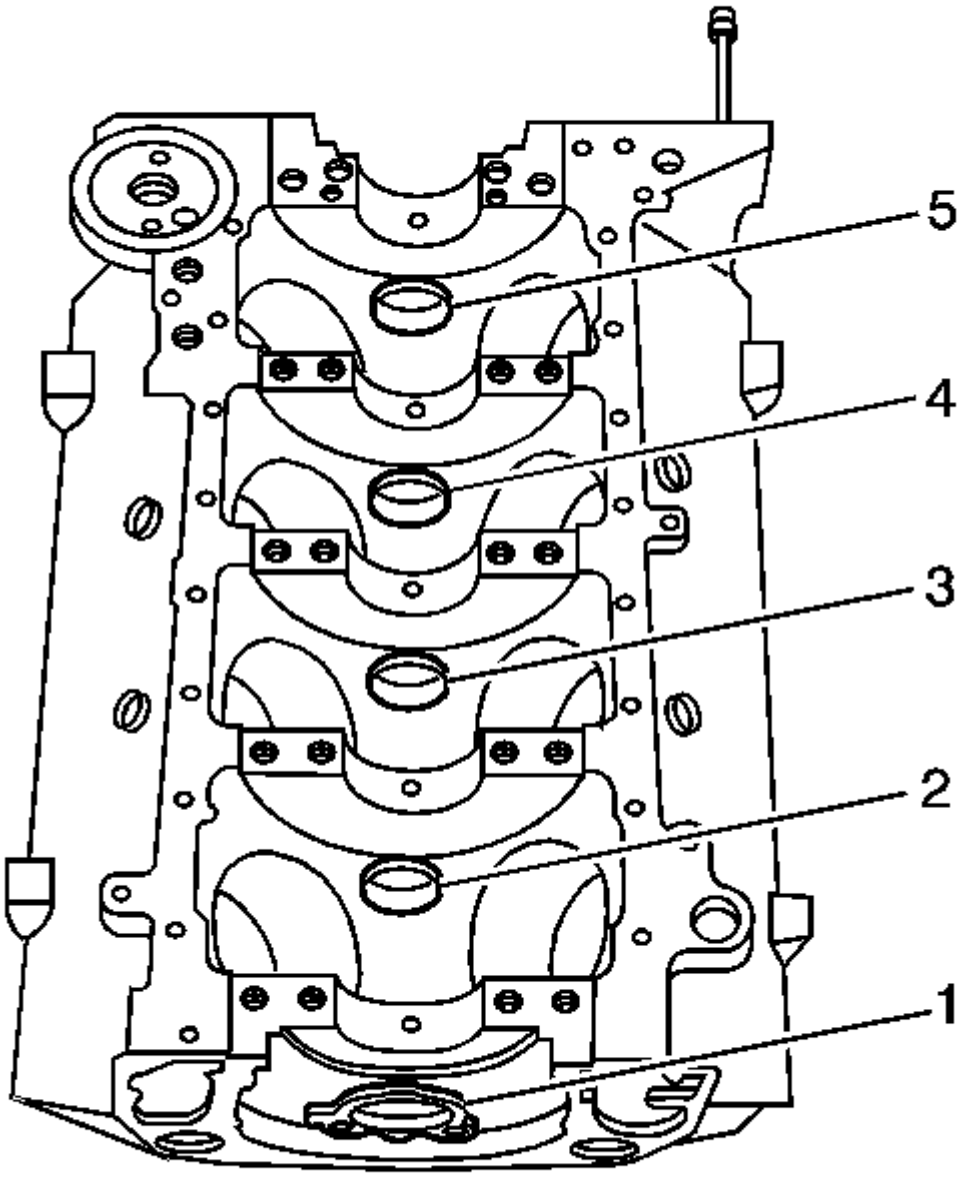

Fig. 379: View Of Engine Block Bearing Bores
Courtesy of GENERAL MOTORS CORP.

8. Inspect the camshaft bearings, 1-5, for wear or damage.
9. Replace the camshaft bearings if necessary. Refer to **Camshaft Bearing Removal** and **Camshaft Bearing Installation**.

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Camshaft Bearing Installation

Tools Required

J 33049 Camshaft Bearing Service Set

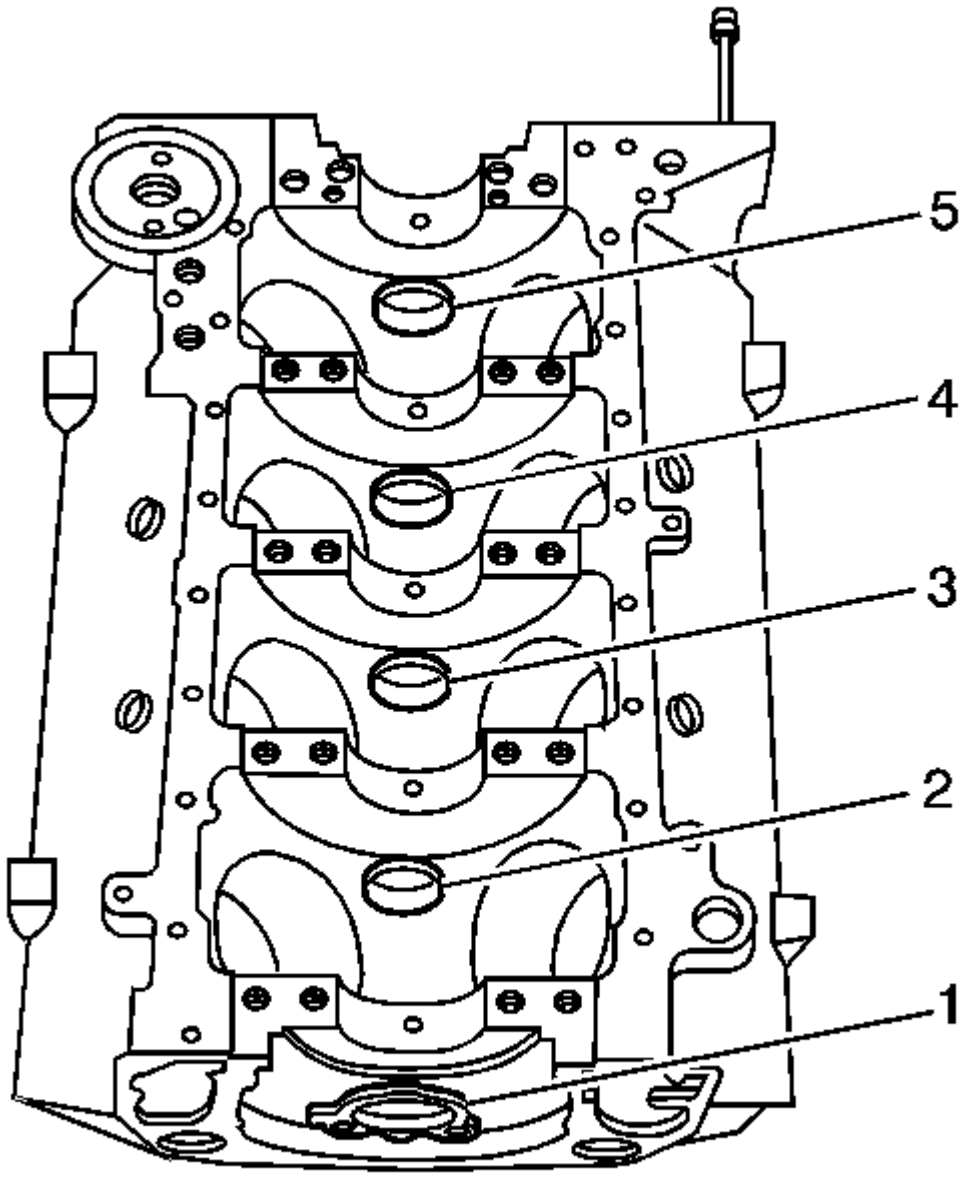

Fig. 380: View Of Engine Block Bearing Bores

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Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The outer camshaft bearings (positions 1 and 5) must be installed first. These bearings serve as guides for the tool and help center the inner bearings during the installation process.

Ensure the correct camshaft bearing fits into the proper bore. The camshaft bearing bores may vary in size.

Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the block. On some engines, the oil holes may be difficult to see. Verify that the holes are aligned.

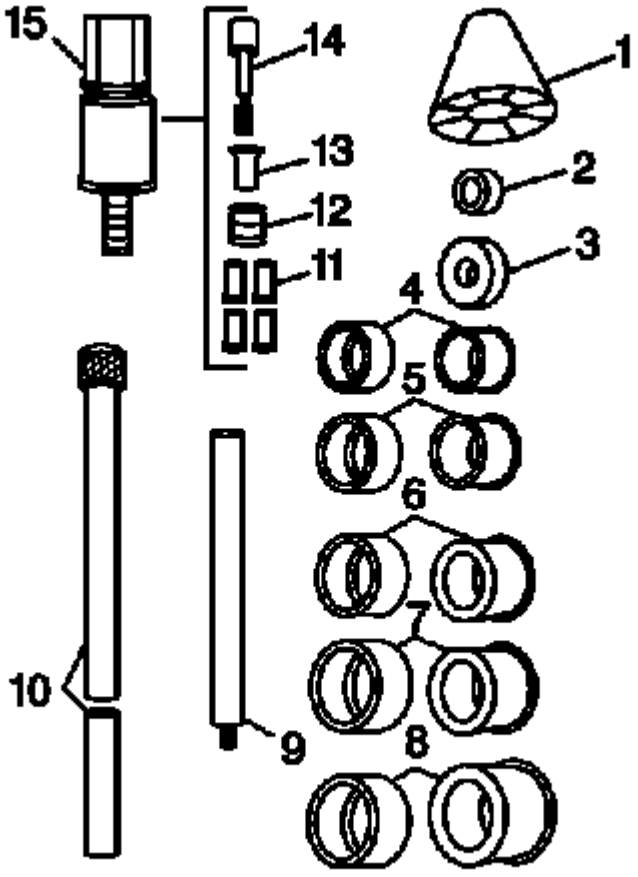

Fig. 381: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

1. Assemble the tool handle (10), expanding driver (4-8), and washer (2 or 3).

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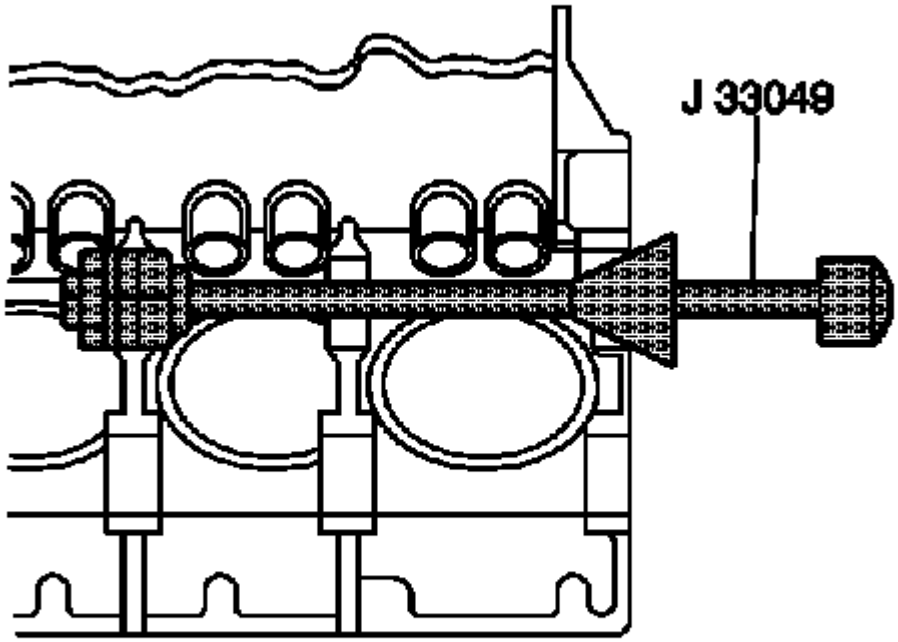

Fig. 382: Removing/Installation Camshaft Inner Bearing Using J 33049
Courtesy of GENERAL MOTORS CORP.

2. Insert the **J 33049** tool into the engine block end camshaft bearings.

NOTE: Do not shim, scrape, or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

IMPORTANT: An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

3. Drive the end bearings into the bore.

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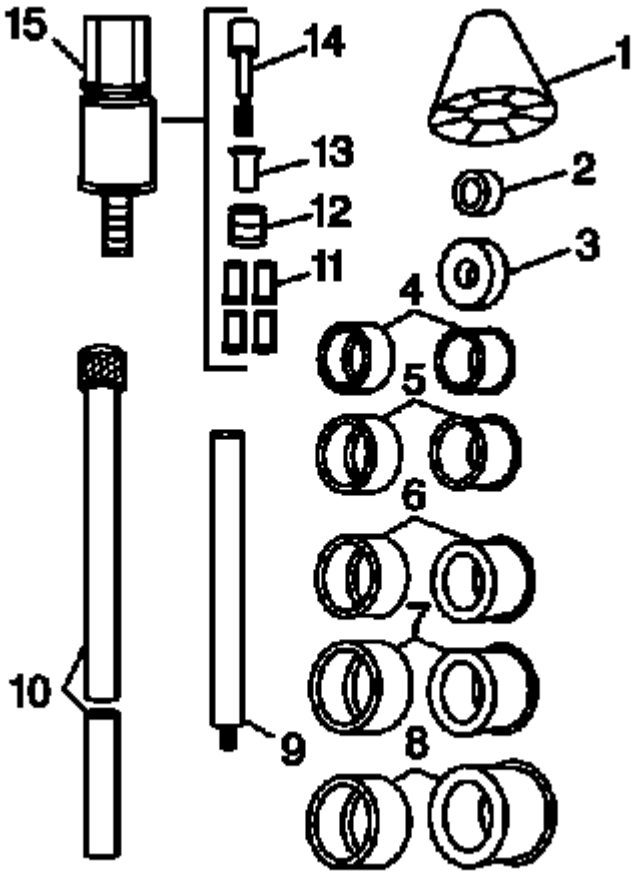

Fig. 383: View Of J 33049 Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS CORP.

4. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** .
5. Assemble the tool.

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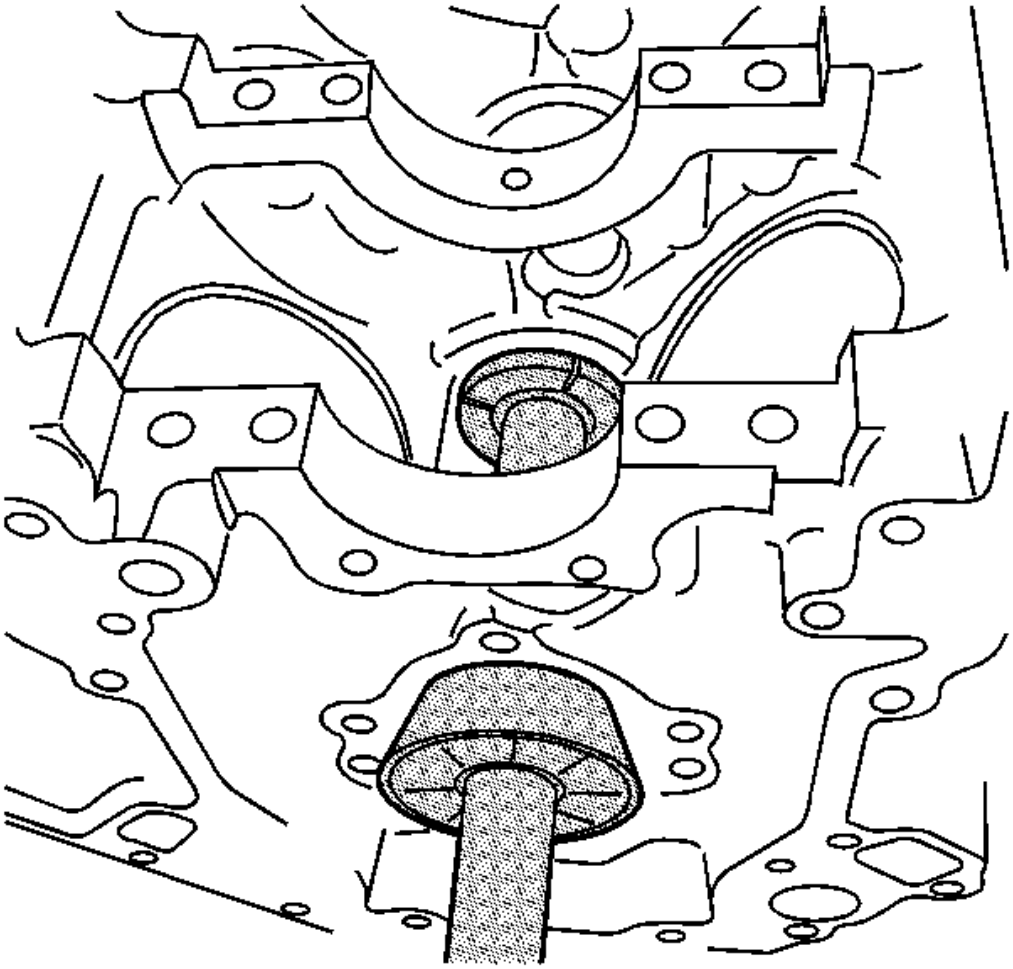

Fig. 384: View Of J 33049 Camshaft Bearing Tool & Nylon Cone
Courtesy of GENERAL MOTORS CORP.

6. Insert the **J 33049** tool through the front of the engine block and to the inner bearing bores.
7. Install the bearing onto the expanding driver.
8. Tighten the expander assembly nut until the tool is snug in the bearing.

IMPORTANT: The camshaft bearing oil holes must align with the oil galleries in the engine block.
After installation of the camshaft bearings, inspect the camshaft bearing oil holes for proper alignment with the oil galleries.
An improperly aligned camshaft bearing oil gallery hole will restrict oil flow to the bearing and the camshaft journal.

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9. Align the oil lubrication hole in the bearing with the oil galleries in the engine block.
10. Push the guide cone into the front camshaft bearing bore to align the tool.
11. Drive the bearing into the bore.

Timing Chain and Sprockets Cleaning and Inspection

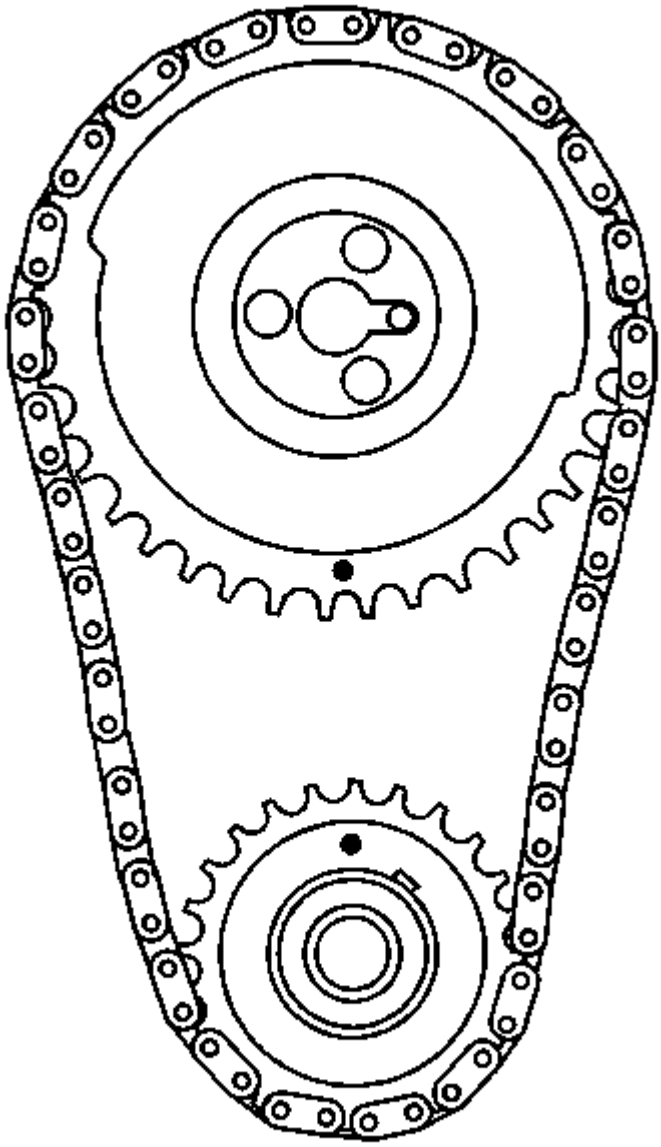

Fig. 385: View Of Crankshaft & Camshaft Sprockets Aligned

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Courtesy of GENERAL MOTORS CORP.

1. Clean the camshaft timing components in solvent.

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

2. Dry the components with compressed air.
3. Inspect the camshaft timing chain for binding or wear.

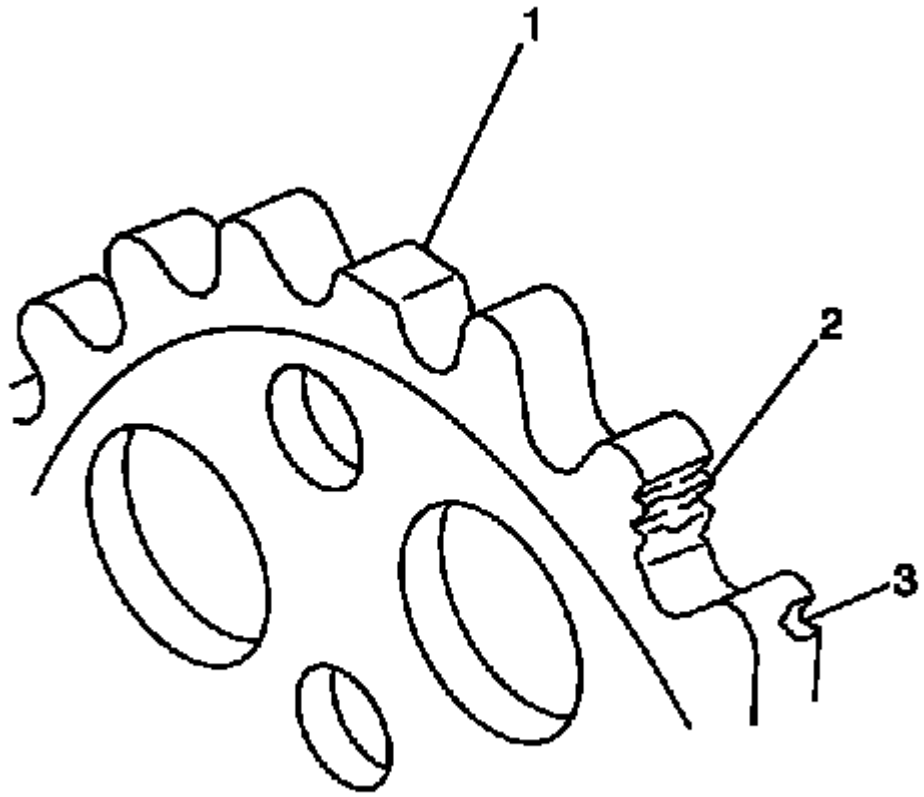

Fig. 386: Identifying Damaged Sprocket Teeth
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the sprocket or sprockets must be replaced, replace both sprockets to ensure that timing chain centerline alignment is maintained.

4. Inspect the camshaft and crankshaft sprockets for the following conditions:
   - Worn teeth (1)
   - Damaged teeth (2)

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- Chipped teeth (3)
- Uneven wear on one edge of the teeth
- Worn valleys between the sprocket teeth
- Crankshaft sprocket keyway for wear

Valve Rocker Arm and Push Rods Cleaning and Inspection

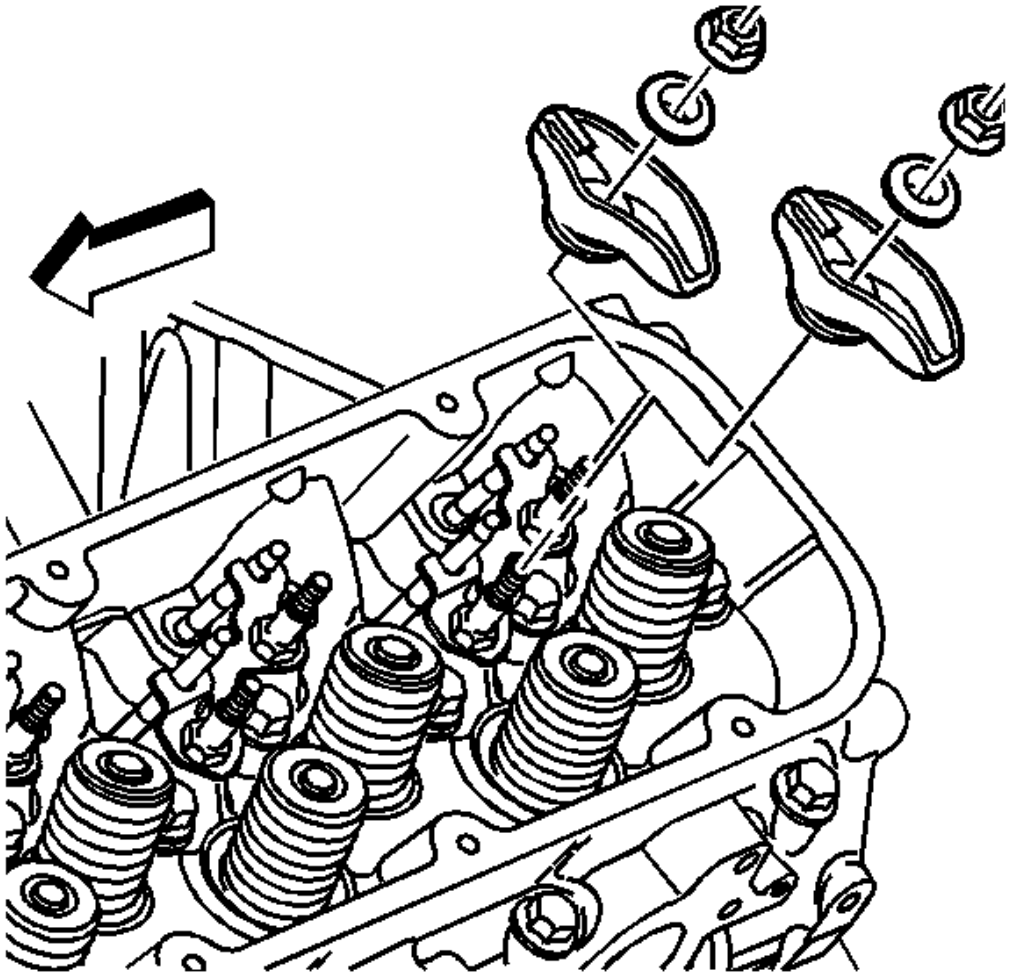

Fig. 387: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

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1. Clean the components with cleaning solvent.

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

2. Dry the components with compressed air.
3. Inspect the valve rocker arms for wear or scoring in the ball area.
4. Inspect the valve rocker arm push rod sockets and valve stem tip mating surfaces.
5. Inspect the valve rocker arm ball for wear or scoring.

   These surfaces should be smooth with no scoring or exceptional wear.

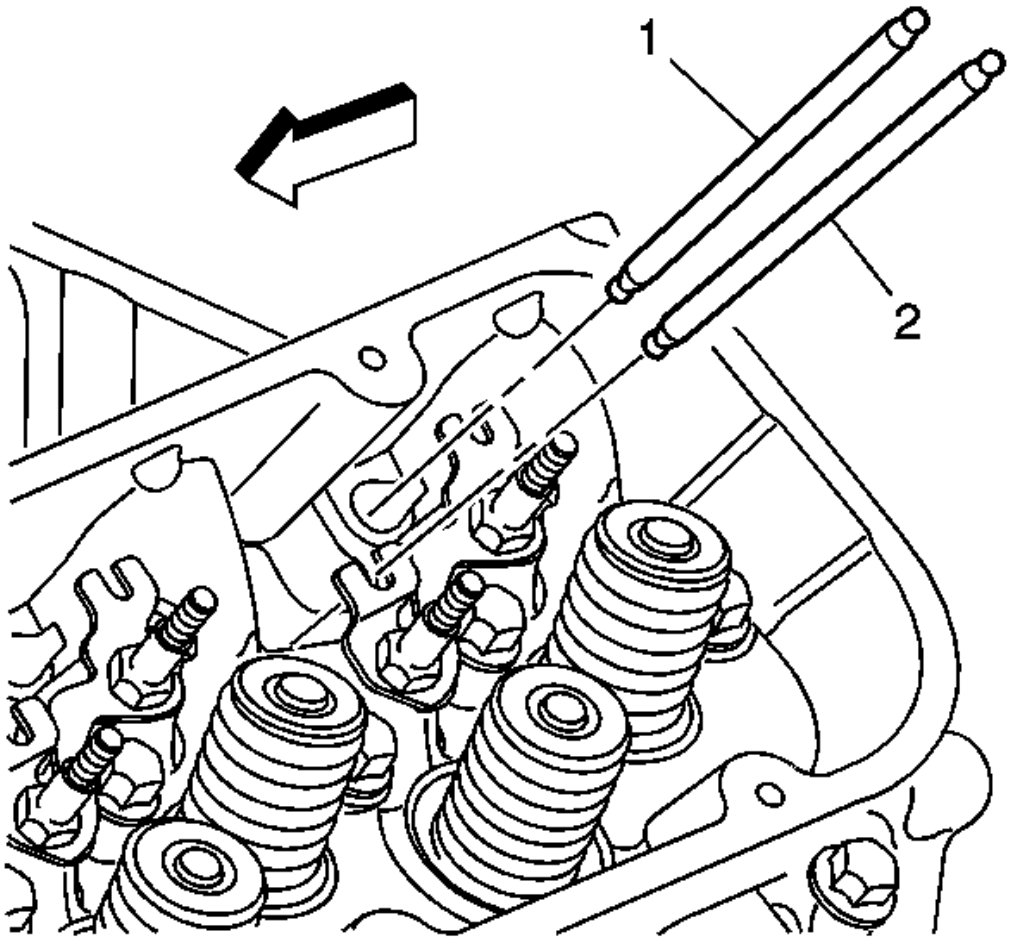

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Fig. 388: View Of Intake & Exhaust Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

6. Inspect the push rods (1, 2) for worn or scored ends.

   These surfaces should be smooth with no scoring or exceptional wear.

7. Inspect the push rods for bends. Roll the push rods on a flat surface to determine if the push rod is bent. If it rolls smoothly, it is OK. If the push rod does not roll smoothly, replace the push rod.
8. Inspect the push rod oil passages for restrictions.
   - Clean out the push rod tube with compressed air.
   - Inspect by looking through the push rod tube for obstructions. A clear push rod will allow light through.
   - Replace push rod(s) that cannot be cleaned out.

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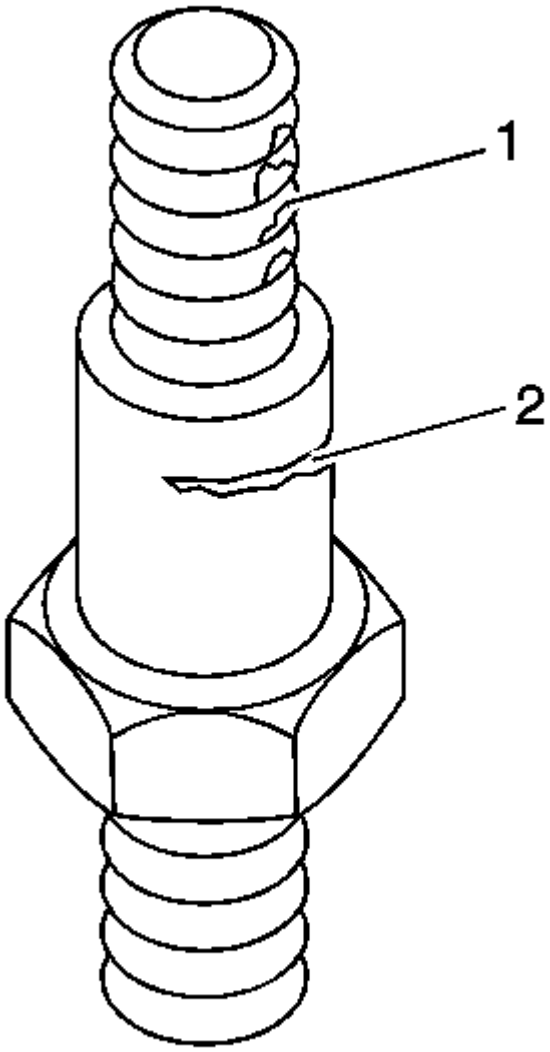

Fig. 389: Inspecting Rocker Arm Studs
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A light contact mark on the rocker arm stud is normal. A noticeable groove in the rocker arm stud is excessive wear and the rocker arm stud should be replaced.

9. Inspect the rocker arm studs for the following conditions:
    - Damaged threads (1)

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- Excessive wear or damage (2) made from contact between the rocker arm and rocker arm stud

10. Valve rocker arm studs with excessive wear and/or damage must be replaced.

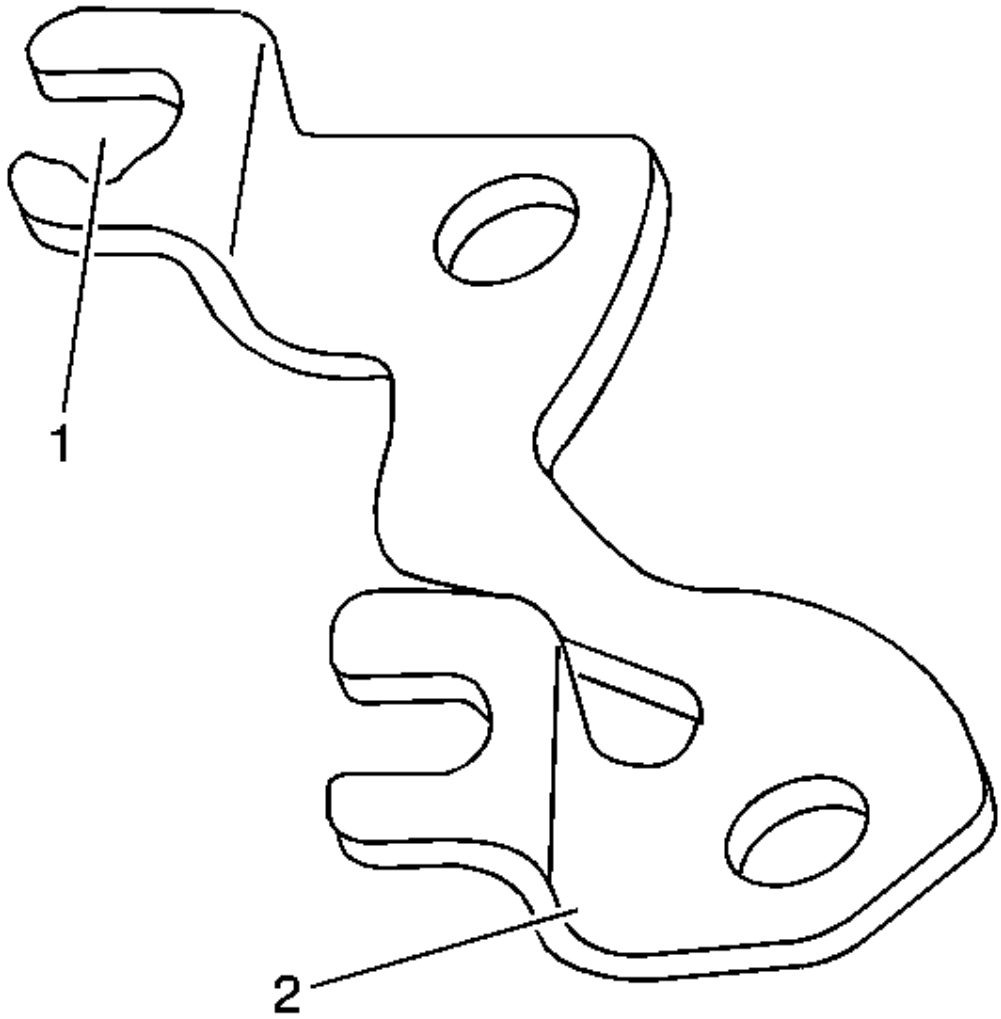

Fig. 390: Inspecting Push Rod Guides
Courtesy of GENERAL MOTORS CORP.

11. Inspect the push rod guides for the following conditions:
    - Wear between the push rod and the push rod guide (1)
    - Bent push rod guide (2)
    - Cracks

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12. Push rod guides with excessive wear and/or damage must be replaced.

Valve Lifters and Guides Cleaning and Inspection

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

IMPORTANT: Parts that are to be reused must remain sorted or organized in order to return them to their original location.

1. Dry the components with compressed air.

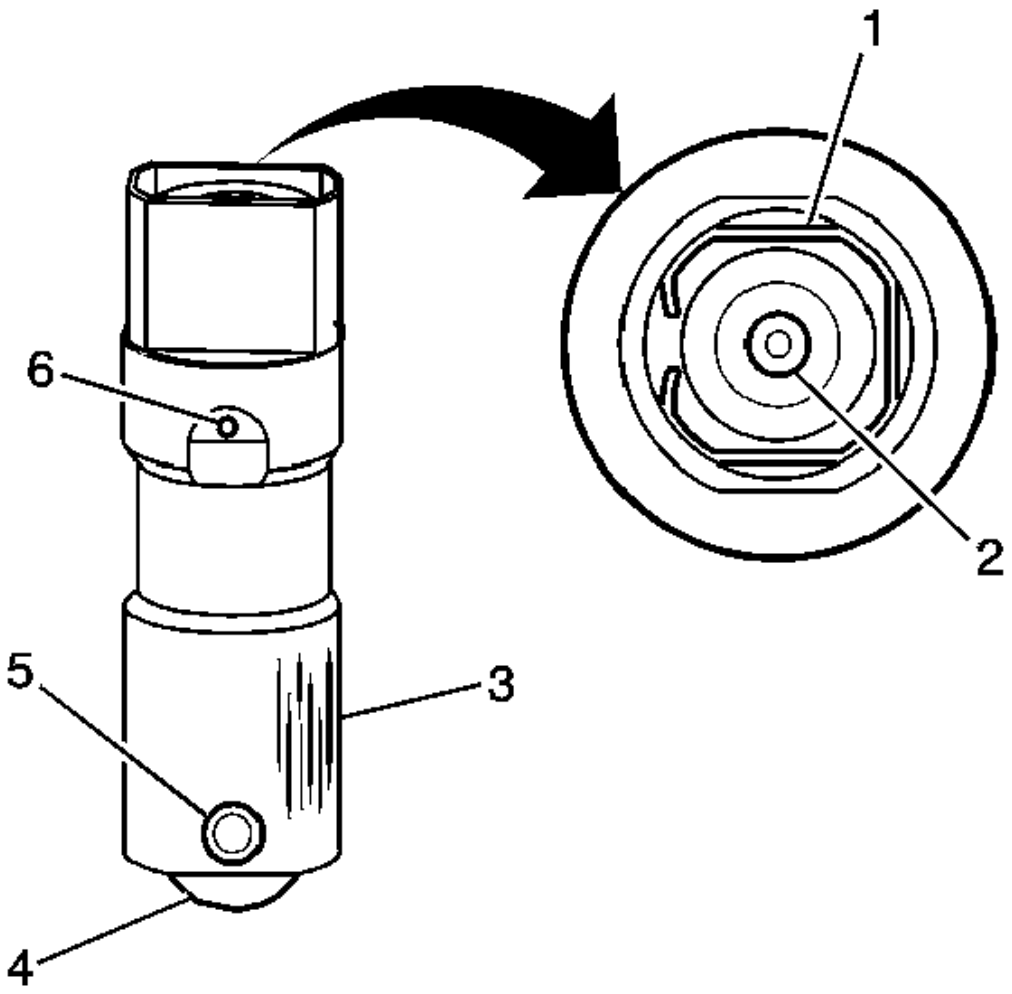

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Fig. 391: Inspecting Valve Lifters
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve lifters for the following:
    - A damaged, mispositioned or broken clip (1)
    - A scored or worn pushrod socket (2)
    - A severely scuffed or worn lifter body (3)

      If the valve lifter body shows scuffing or wear, inspect the engine block valve lifter bores for wear or damage.

    - Flat spots on the roller (4)
    - A loose pin (5)
    - A plugged oil hole (6)
3. If flat spots are found on the lifter(s), inspect the corresponding lobe on the camshaft for damage.

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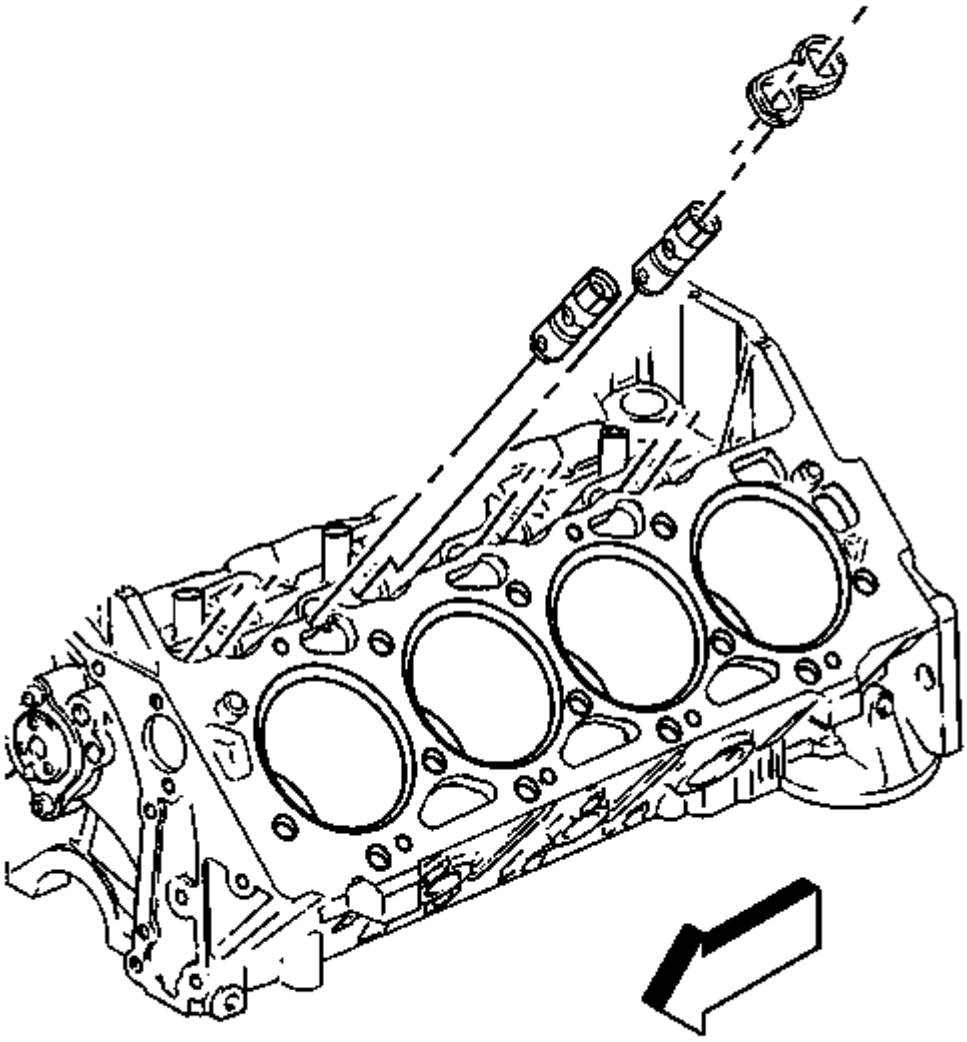

Fig. 392: View Of Valve Lifter Guides
Courtesy of GENERAL MOTORS CORP.

4. Inspect the valve lifter guides for the following:
    - Excessive guide slot side wear
    - Cracks or damage

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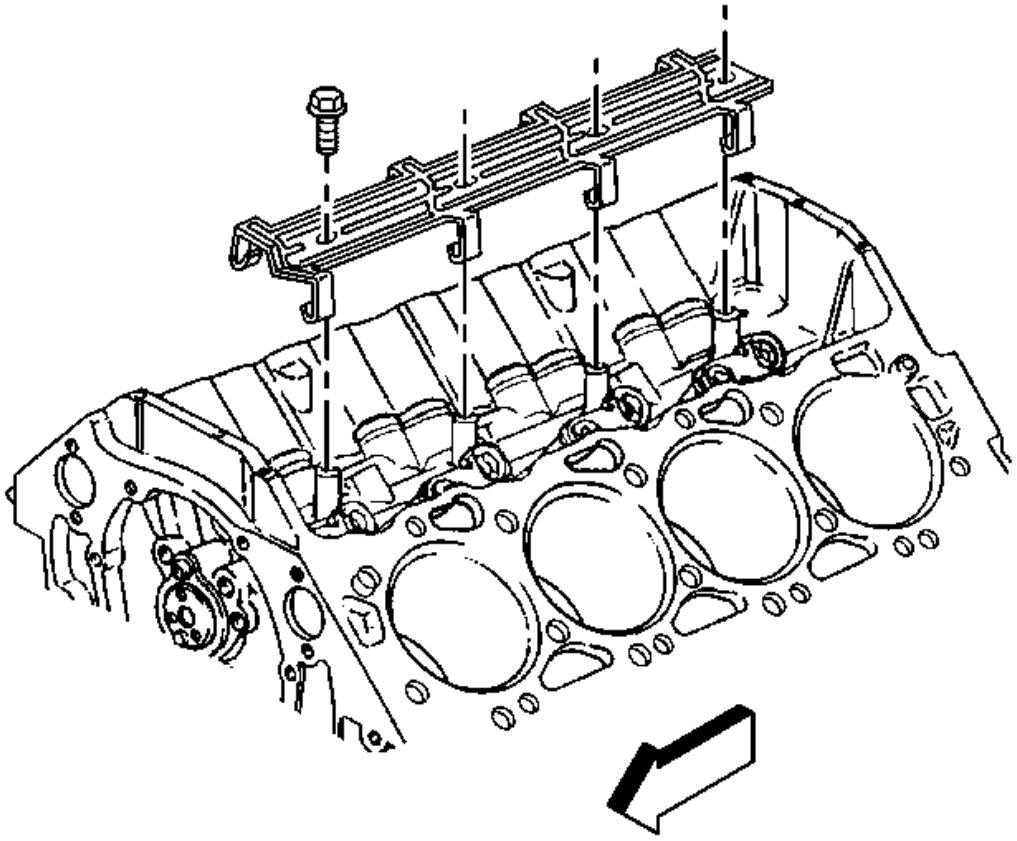

Fig. 393: View Of Valve Lifter Guide Retainer
Courtesy of GENERAL MOTORS CORP.

5. Inspect the valve lifter guide retainer for the following:
    - Wear, damage, or stress cracking in the leg areas
    - Wear or damage around the retainer bolt holes

Cylinder Head Disassemble

Tools Required

J 8062 Valve Spring Compressor - Head Off

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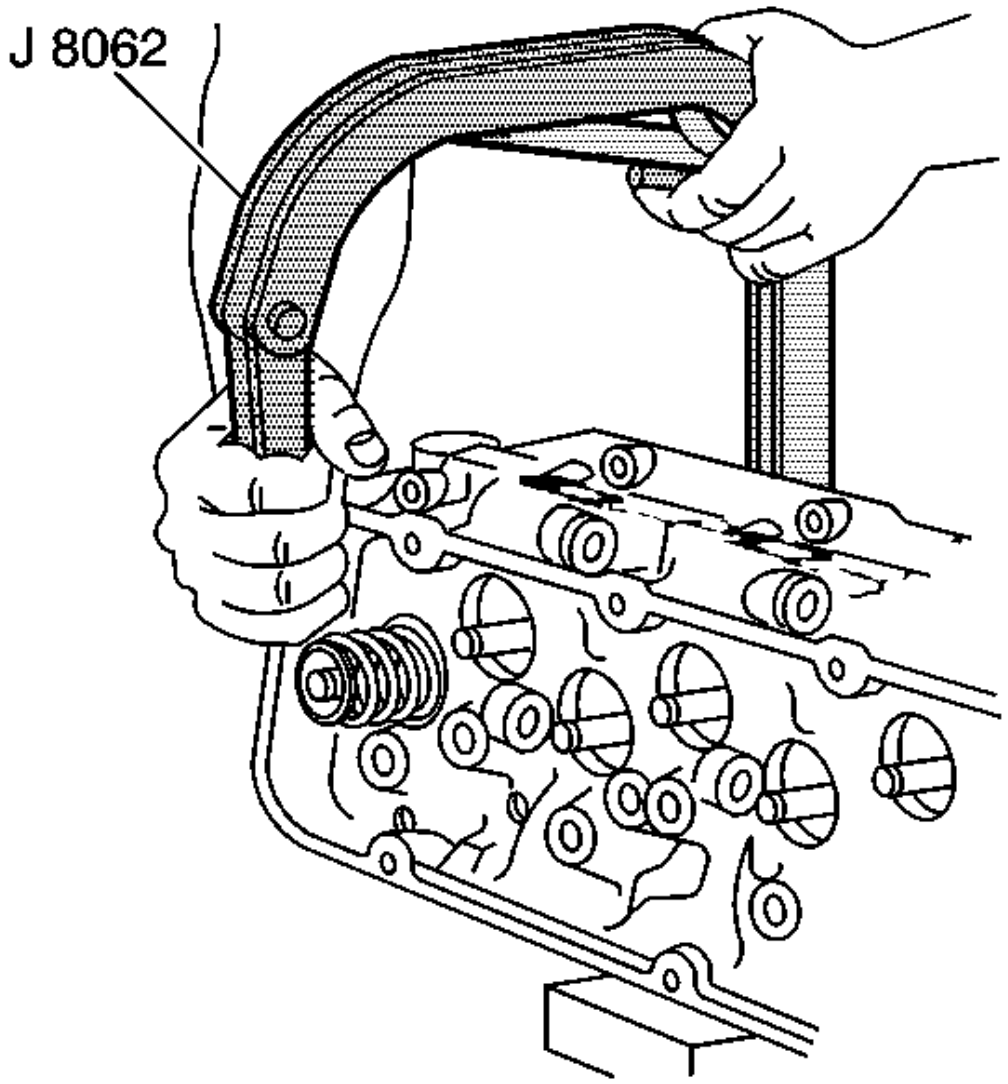

Fig. 394: Compressing Valve Springs Using J 8062
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from

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the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

IMPORTANT: Mark, sort, or organize components for return to their original locations.

1. Use **J 8062** in order to compress the valve springs.

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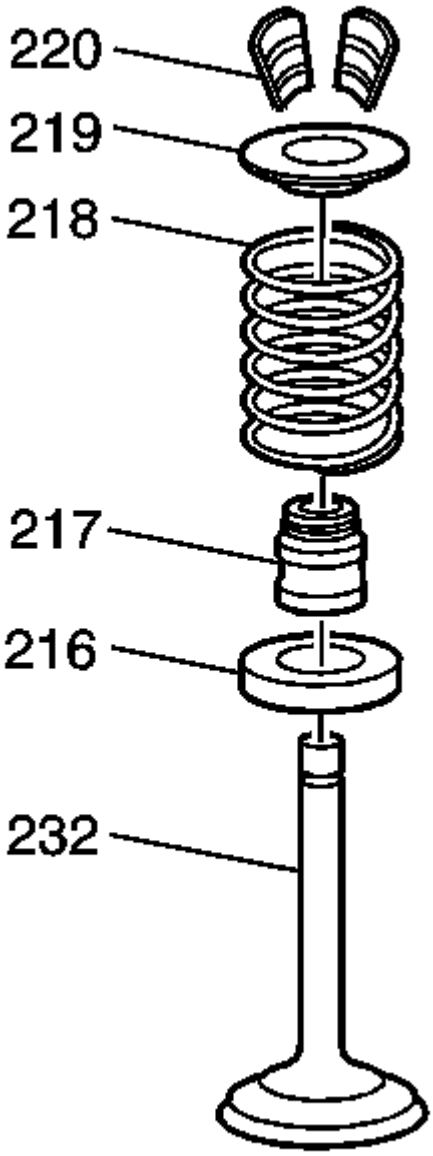

Fig. 395: View Of Valve & Components
Courtesy of GENERAL MOTORS CORP.

2. Remove the valve stem keys (220).
3. Release and remove **J 8062** .
4. Remove the cap (219).

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5. Remove the valve spring (218).
6. Remove the valve stem oil seal (217) from the valve guide.
7. Remove the valve rotator (216).

IMPORTANT: In order to prevent damage to the valve guide, small burrs on the valve tip and at the stem key groove that interfere with the valve removal can be lightly filed with a fine file or stone to facilitate valve removal.

8. Remove the valve (232).

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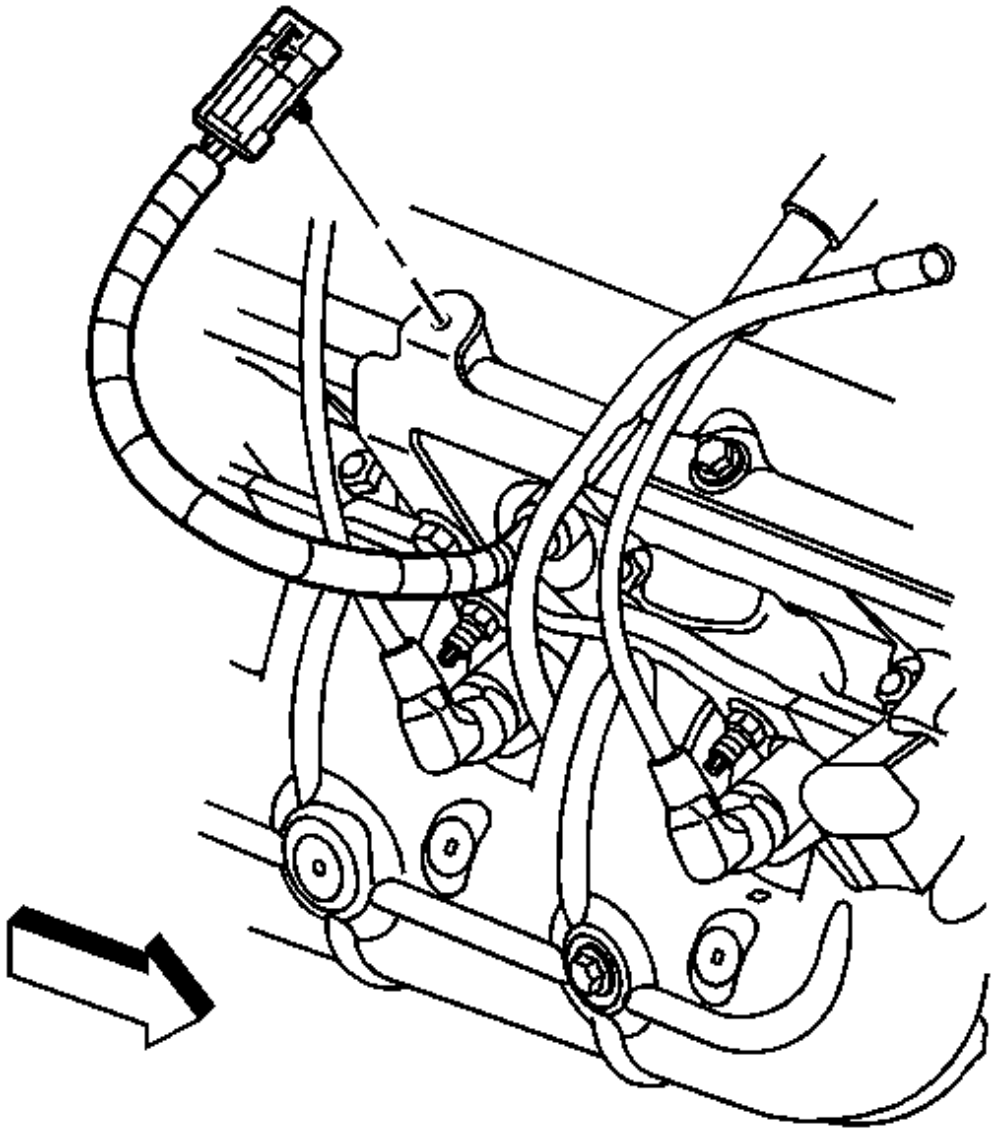

Fig. 396: View Of Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

9. Disconnect the engine coolant temperature (ECT) sensor from the bracket.
10. Remove the ECT sensor from the cylinder head.
11. Remove the ECT sensor bracket and bolt.

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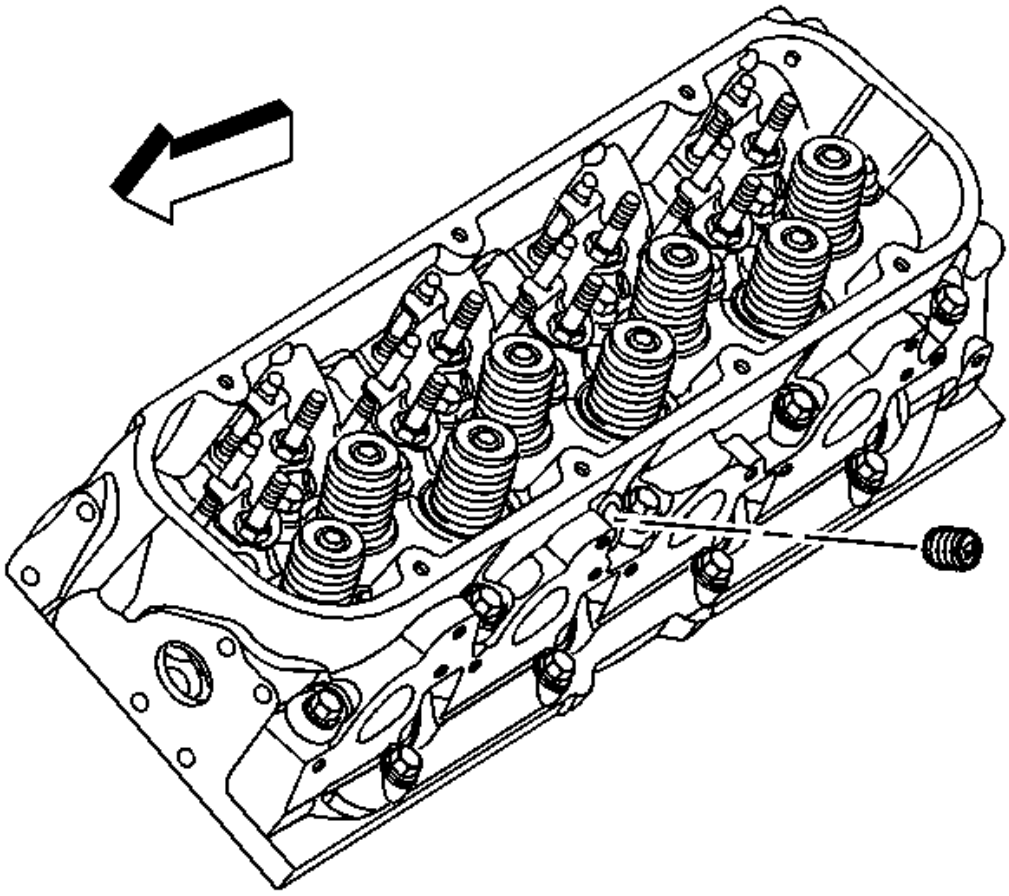

Fig. 397: View Of Cylinder Head Coolant Hole Plug
Courtesy of GENERAL MOTORS CORP.

12. Remove the cylinder head coolant hole plug from the cylinder head.

Cylinder Head Cleaning and Inspection

Tools Required

- **J 8089** Carbon Removal Brush
- **J 9666** Valve Spring Tester
- **J 8001** Dial Indicator Set

Cleaning Procedure

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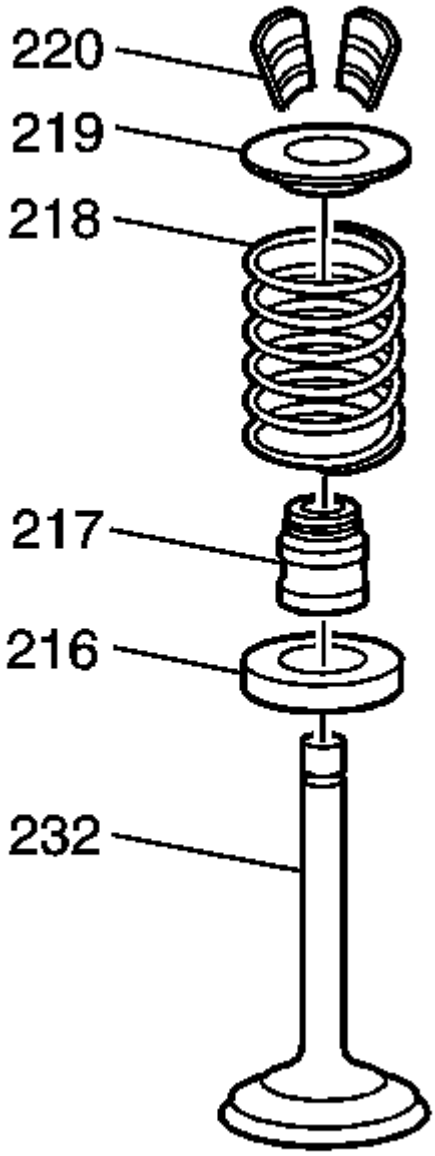

Fig. 398: View Of Valve & Components
Courtesy of GENERAL MOTORS CORP.

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

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IMPORTANT: Mark, sort, or organize components for return to their original locations.

1. Clean the valve stems and heads on a buffing wheel.
2. Clean the following components in solvent:
   - Valve stem keys (220)
   - Valve spring cap (219)
   - Valve spring (218)
   - Valve Rotators (216)
   - Valve (232)
   - Cylinder head

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

3. Dry the components with compressed air.

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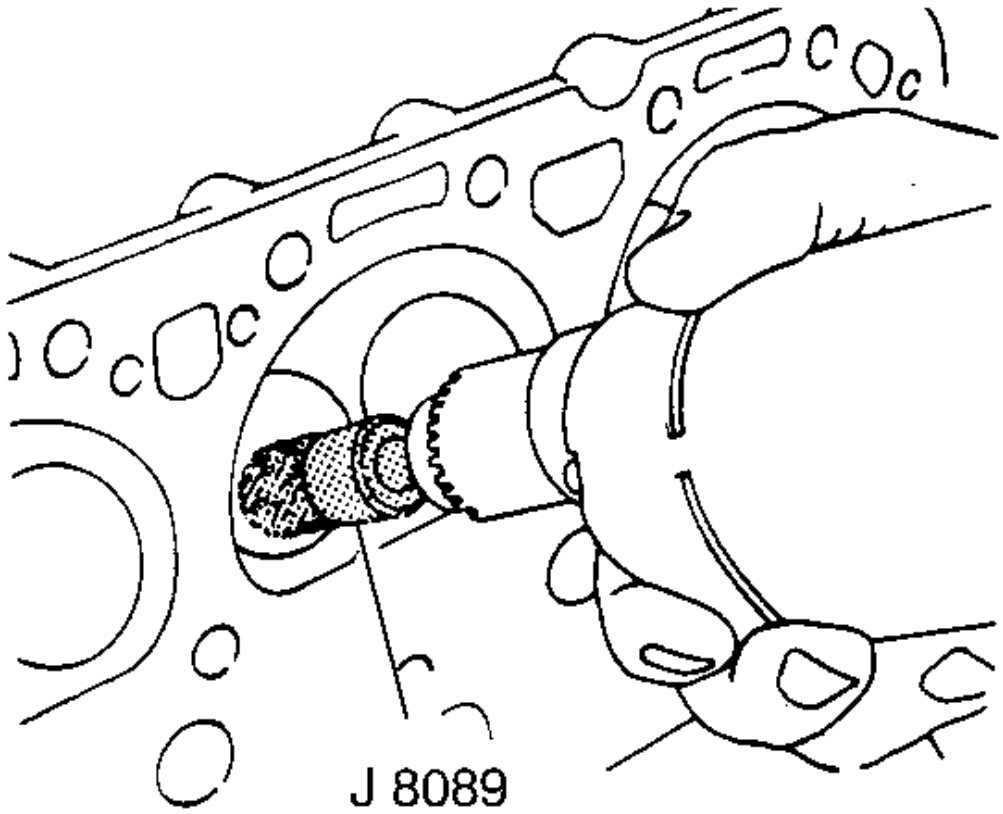

Fig. 399: Cleaning Carbon From Combustion Chambers Using J 8089
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Be careful not to damage the chamber or the valve seat.

4. Use the **J 8089** in order to clean the carbon from the combustion chambers.

Visual Inspection Procedure

Inspect the cylinder head for the following conditions:

- Damaged gasket surfaces
- Damage to threaded bolt holes
- Burnt or eroded areas in the combustion chamber
- Cracks in the exhaust ports and combustion chambers
- External cracks in the water chamber

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- Restrictions in the intake or exhaust passages
- Restrictions in the cooling system passages

Flatness Measurement Procedure

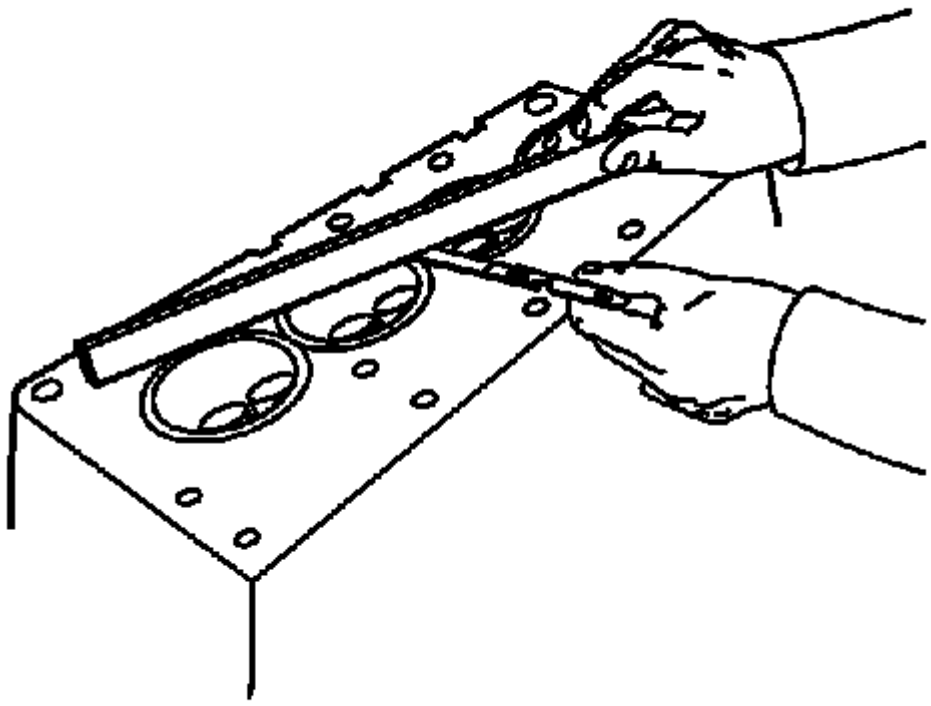

Fig. 400: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder head for warpage with a straight edge and feeler gage.
   - A cylinder head block deck with warpage in excess of 0.050 mm (0.002 in) within a 150.0 mm (6.0 in) area must be repaired or replaced.
   - A cylinder head exhaust manifold deck with an overall warpage in excess of 0.102 mm (0.004 in) must be repaired or replaced.
   - A cylinder head intake manifold deck with warpage in excess of 0.080 mm (0.003 in) must be repaired or replaced.
2. A cylinder head block deck can be resurfaced up to 0.305 mm (0.012 in) maximum removal.

IMPORTANT: Excessive cylinder head resurfacing will affect compression ratio and emission control.

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3. A cylinder head that requires excessive resurfacing must be replaced.

Valve Inspection Procedure

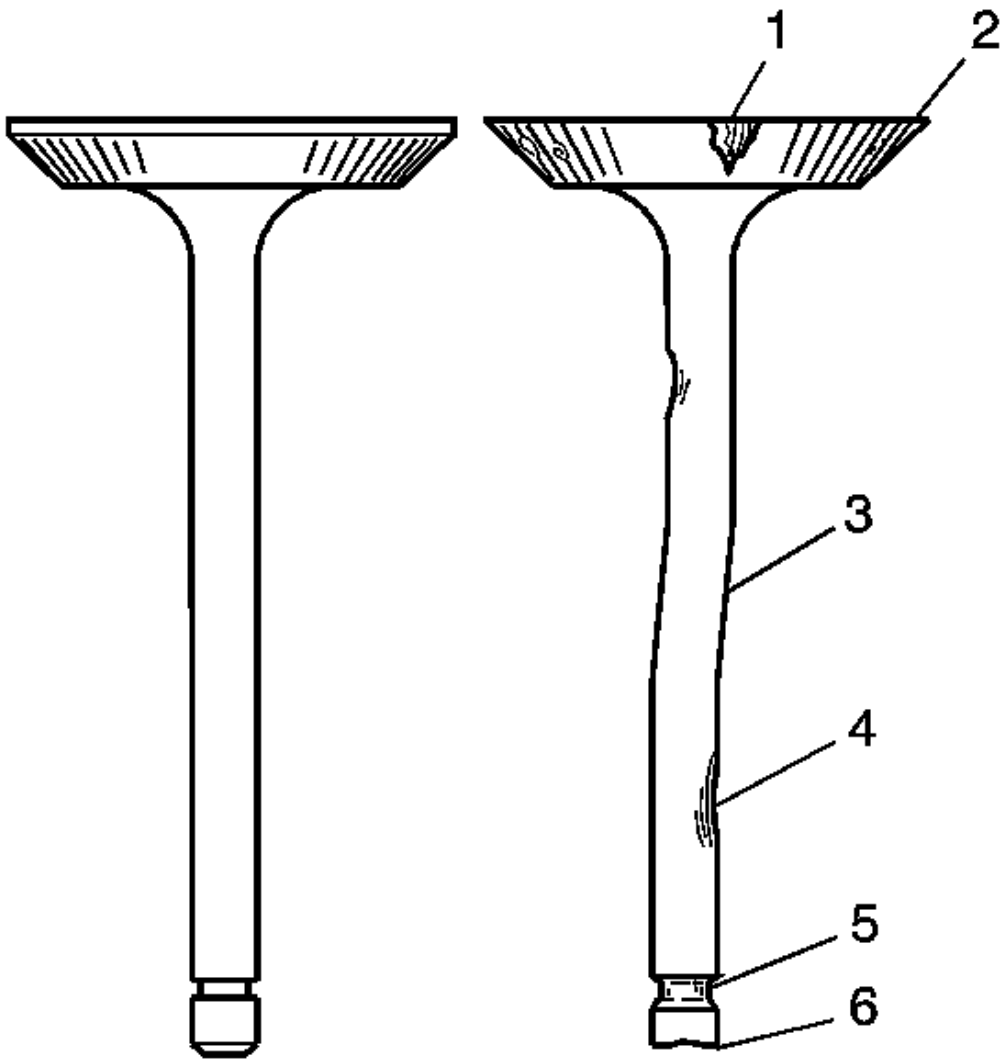

Fig. 401: Inspecting Valves
Courtesy of GENERAL MOTORS CORP.

1. Inspect the valves for the following conditions:
   - Burnt or damaged areas (1)
   - Undersized valve margin (2)

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- Bent stem (3)
- Scoring or other damage to the stem (4)
- Worn key groove (5)
- Worn stem tip (6)

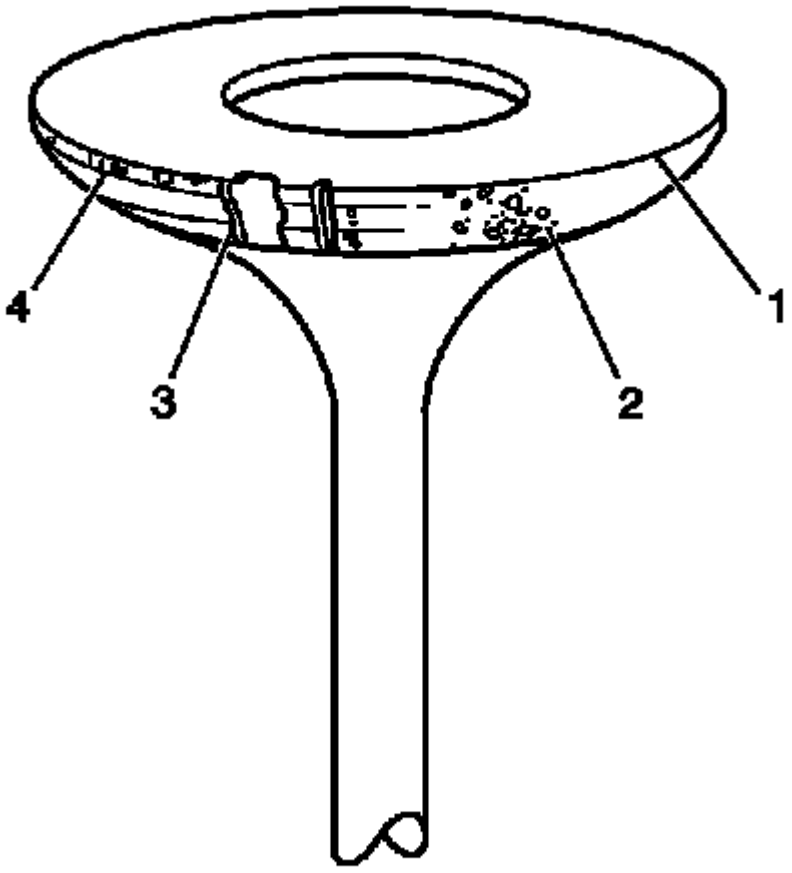

Fig. 402: Inspecting Valve Face For Burning, Pitting & Cracking
Courtesy of GENERAL MOTORS CORP.

2. Inspect the valve contact surface for the following conditions:
   - Undersized margin (1)
   - Pitted surface (2)
   - Burnt or eroded areas (3)
   - Acceptable edge, margin (4)

IMPORTANT: Minor imperfections of the valve may be corrected during reconditioning.

3. Valves with excessive damage must be replaced.

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Valve Spring Inspection and Measurement

1. Inspect the valve springs for broken coils or coil ends.

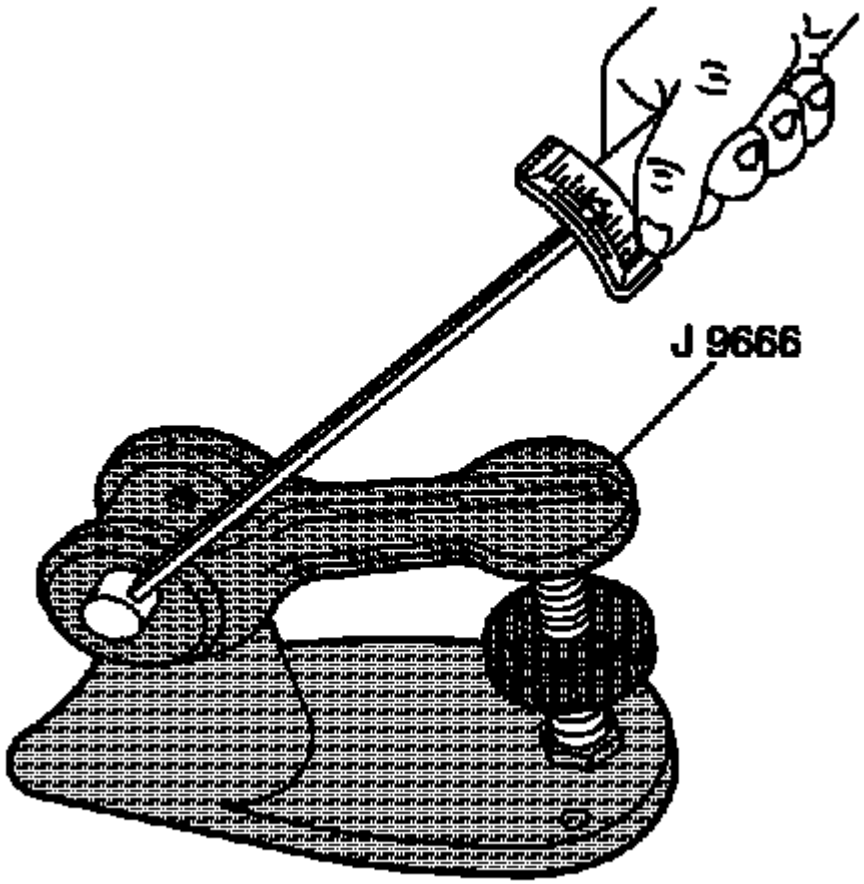

Fig. 403: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS CORP.

2. Use the **J 9666** in order to measure the valve spring force. Refer to **Engine Mechanical Specifications**.

IMPORTANT: Add a maximum of one shim up to 0.726 mm (0.030 in) thick to increase tension.

3. If the valve spring tension is low, use a shim to increase tension.
4. Recheck the valve spring tension, a valve spring that does not meet specification must be replaced.

Valve Guide Measurement Procedure

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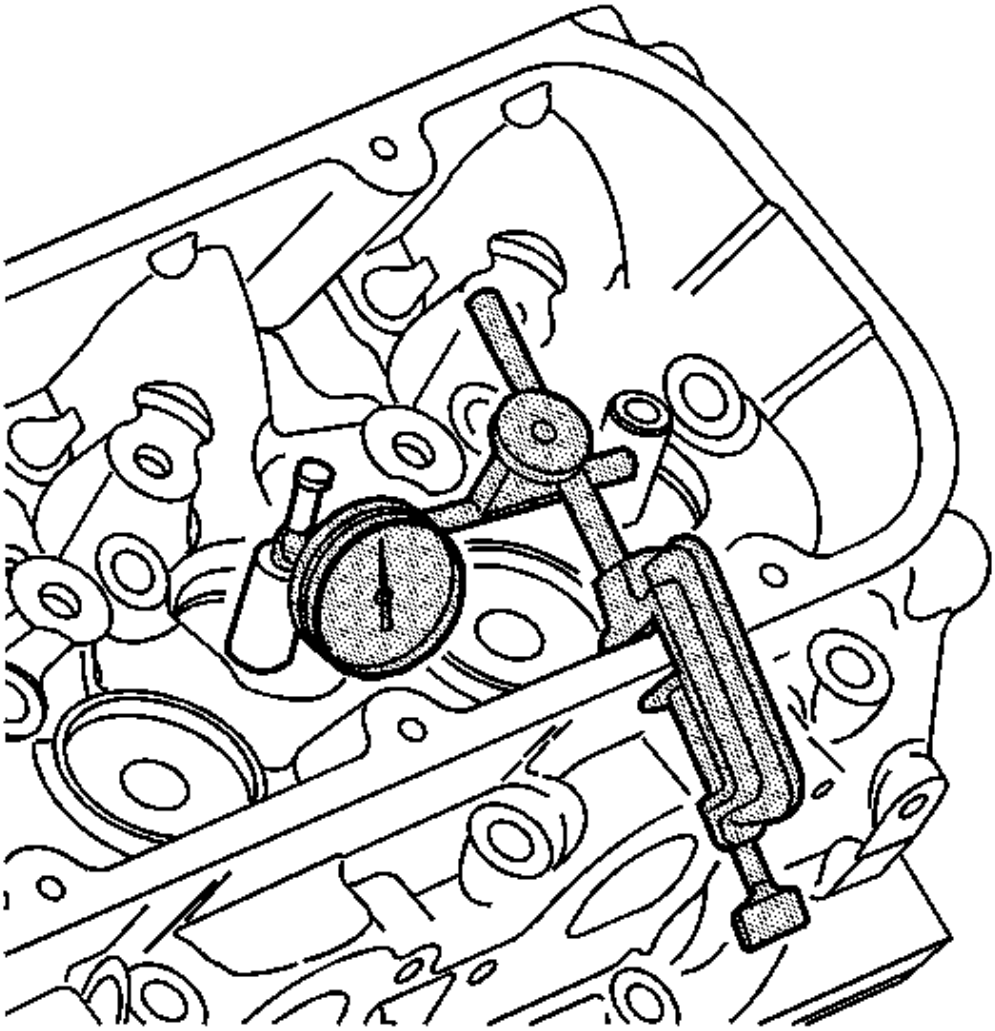

Fig. 404: Measuring Valve Stem-To-Guide Clearance
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

1. Measure the valve stem-to-guide clearance.
    1. Clamp the **J 8001** on the exhaust port side of the cylinder head.

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IMPORTANT: The indicator stem must contract the side of the valve stem just above the valve guide.

2. Locate the indicator so that the movement of the valve stem from side to side, crosswise to the cylinder head, will cause a direct movement of the indicator stem.
3. Drop the valve head about 1.6 mm (0.064 in) off the valve seat.
4. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications**.

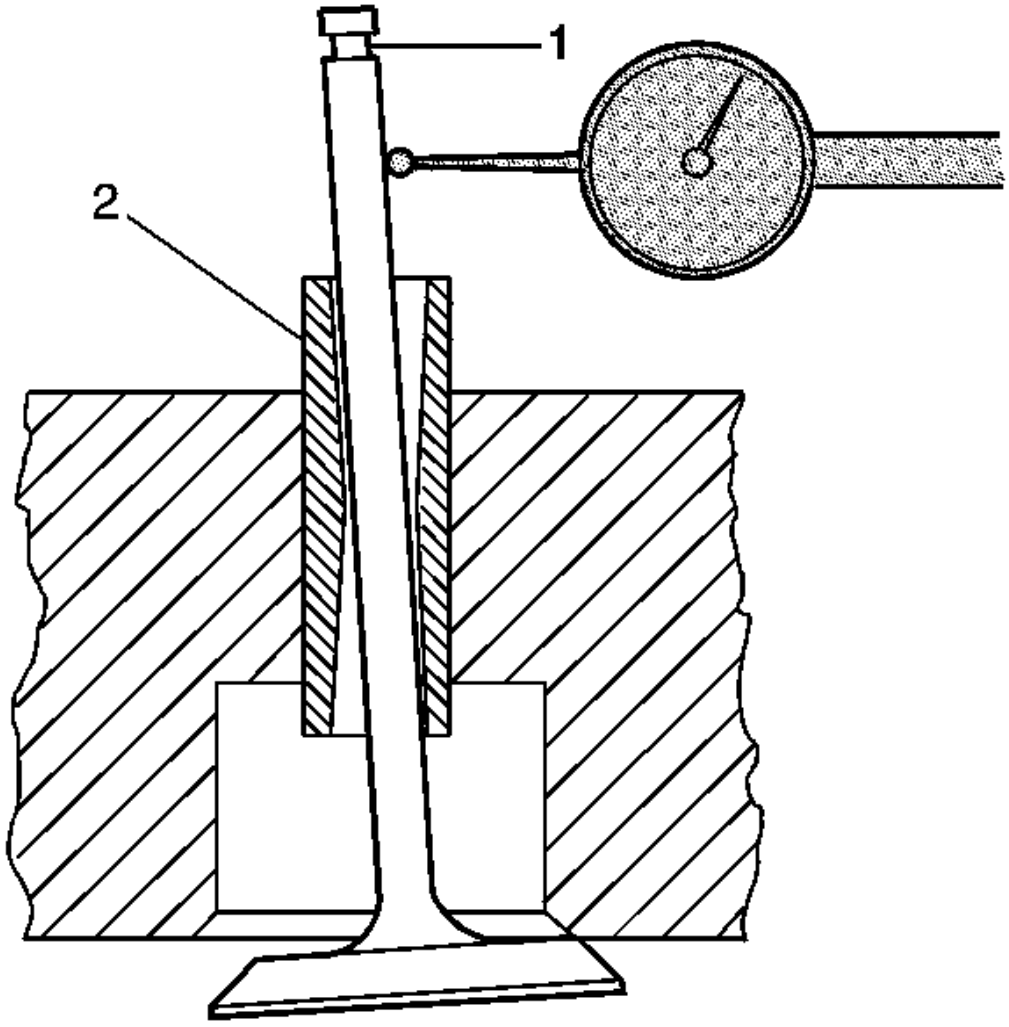

Fig. 405: Identifying Valve Guide Excessive Clearance
Courtesy of GENERAL MOTORS CORP.

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2. Valve guide (2) with excessive clearance must be repaired. Refer to **Valve Guide Reaming/Valve and Seat Grinding**.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.

Valve Guide Reaming/Valve and Seat Grinding

Valve Guide Reaming Procedure for Oversized Valve Stems

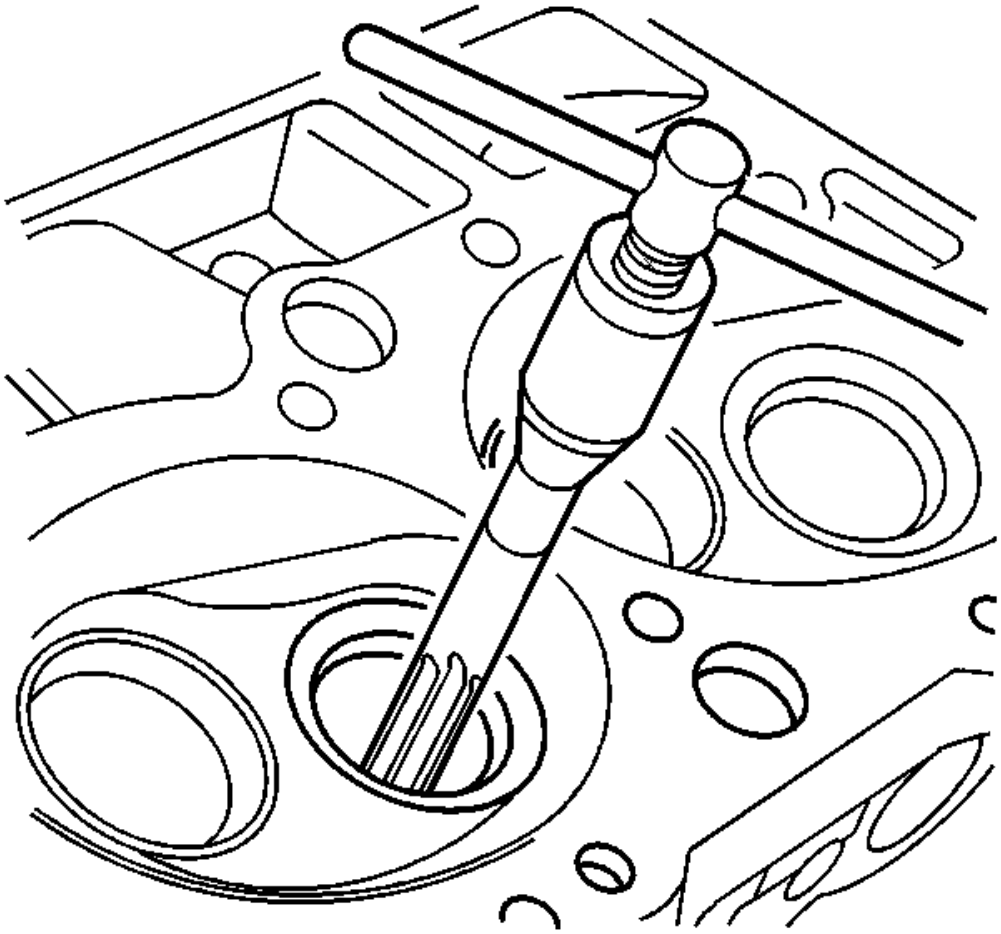

Fig. 406: Reaming Valve Guide
Courtesy of GENERAL MOTORS CORP.

1. Ream the valve guide as necessary to achieve proper valve stem-to-guide clearance with the new, oversized valve stems.
2. Always recondition the valve seat after reaming the valve guide bores or installing new valves.
3. Replace the cylinder head if the valve guide cannot be repaired or reamed to accept an oversize valve stem.

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Valve Reconditioning Procedure

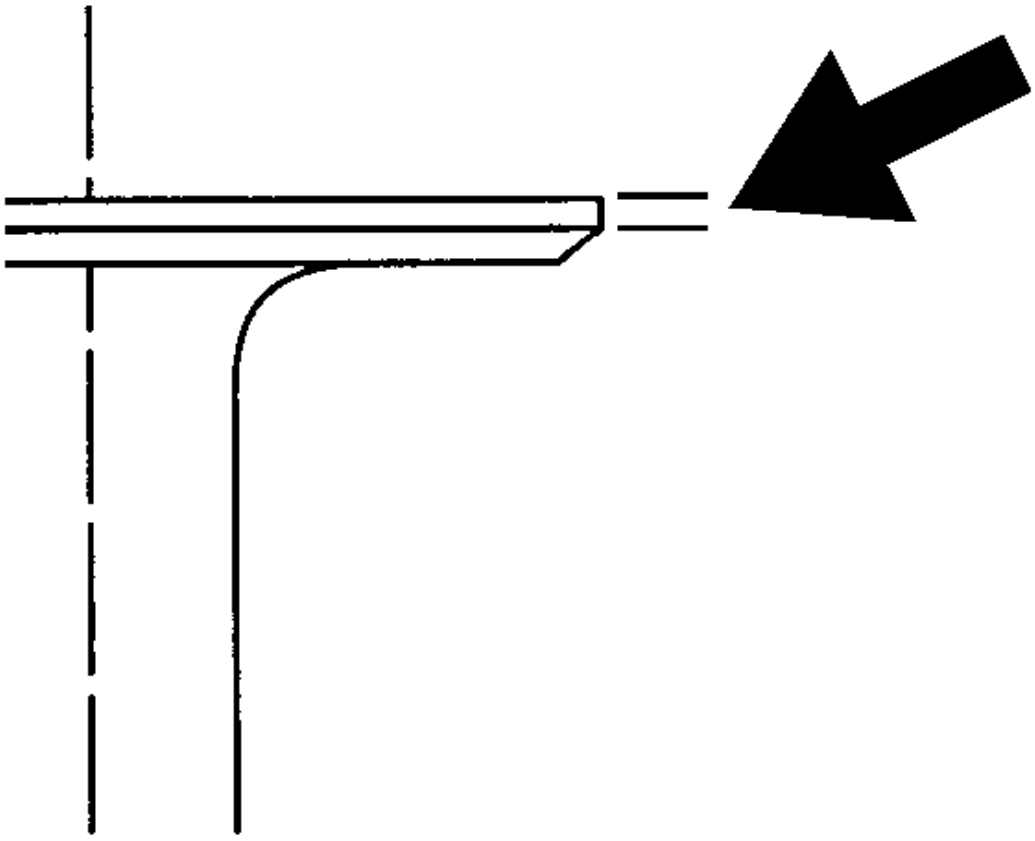

Fig. 407: View Of Valve Margin Measurement
Courtesy of GENERAL MOTORS CORP.

1. Replace the valve if the valve stem shows excessive wear or is warped.

IMPORTANT: Several different types of equipment are available for reconditioning valves. Use the manufacturers recommendations of equipment to attain the proper results.

2. Reface pitted valves on a valve refacing machine in order to insure the correct relationship between the head and the stem.
3. Replace the valve if the edge of the head is less than 0.79 mm (0.031 in) thick after grinding.

Valve Seat Reconditioning Procedure

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IMPORTANT: Several different types of equipment are available for reconditioning valve seats. Use the manufacturers recommendations of equipment to attain the proper results.

IMPORTANT: Always recondition the valve seat after reaming the valve guide bores or installing new valves.

1. Recondition the valve seats.
2. The valves must seat perfectly for the engine to deliver optimum power and performance.

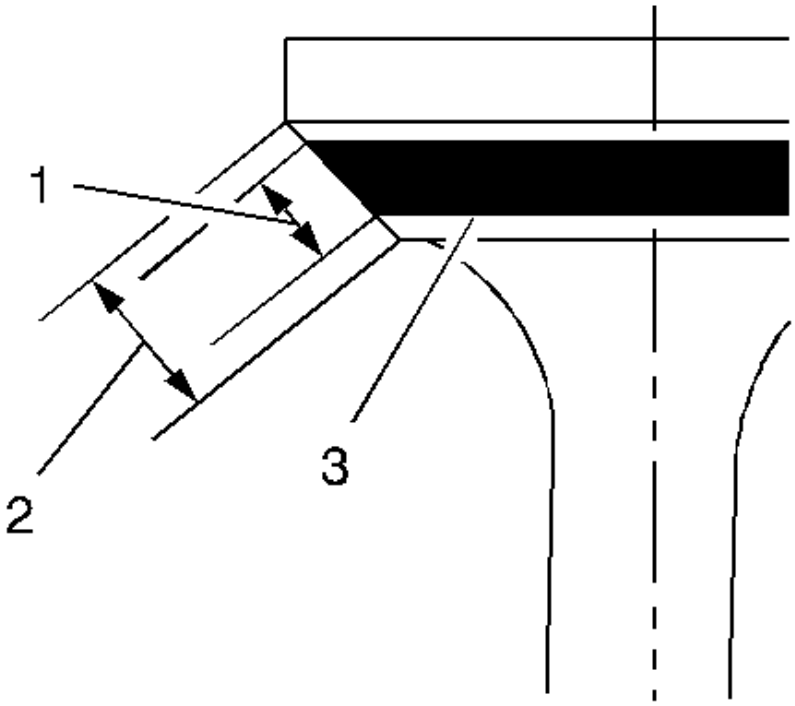

Fig. 408: View Of Valve Contact Face Measurements
Courtesy of GENERAL MOTORS CORP.

3. Correct contact (1) between each valve and its seat in the cylinder head is also essential to ensure that the heat in the valve head is properly carried away.

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IMPORTANT: Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.

4. The valve seats should be concentric to within 0.050 mm (0.002 in) total indicator runout.

Cylinder Head Assemble

Tools Required

- **J 8062** Valve Spring Compressor
- **J 43105** Valve Stem Seal Installer. See **Special Tools and Equipment**.

Checking Valve Spring Installed Height

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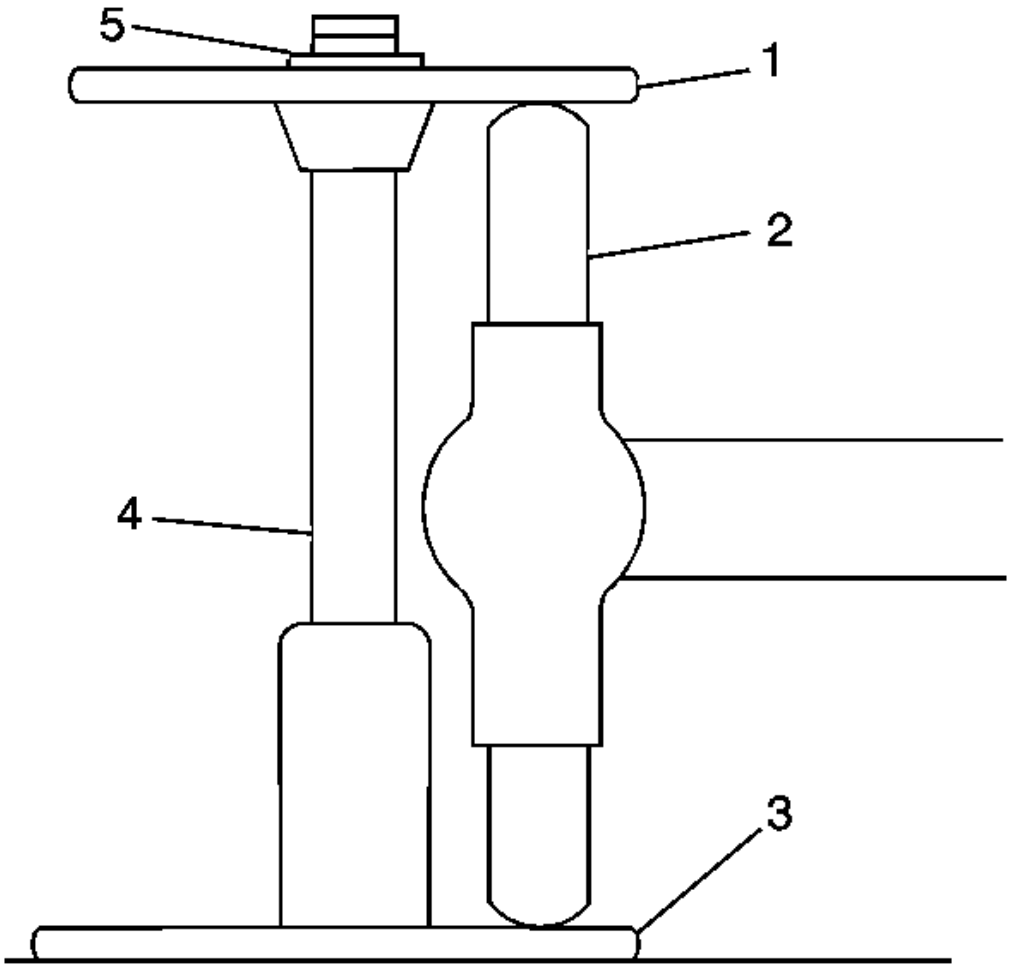

Fig. 409: View Of Valve Rotator, Valve, Valve Spring Cap & Valve Stem Keys
Courtesy of GENERAL MOTORS CORP.

1. Install the valve rotator (3), the valve (4), the valve spring cap (1) and the valve stem keys (5) into the cylinder head.
2. Using a snap gage or inside micrometer, measure the distance from the top of the valve rotator to the bottom of the valve spring cap. Refer to **Engine Mechanical Specifications** for proper valve spring installed height specifications.

IMPORTANT:

- **Never shim the spring to obtain an installed height under the specified amount.**
- **Install the valve spring seat shims under the rotator, between the rotator and the cylinder head spring seat.**

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- **Add a maximum of one valve spring seat shim, up to 0.726 mm (0.030 in) thick to achieve the valve spring installed height specification.**

3. Install a valve spring seat shim if the valve spring installed height measurement is above the specification.
4. Recheck the valve spring installed height, replace the cylinder head if the valve spring installed height cannot be obtained.

Valve Installation

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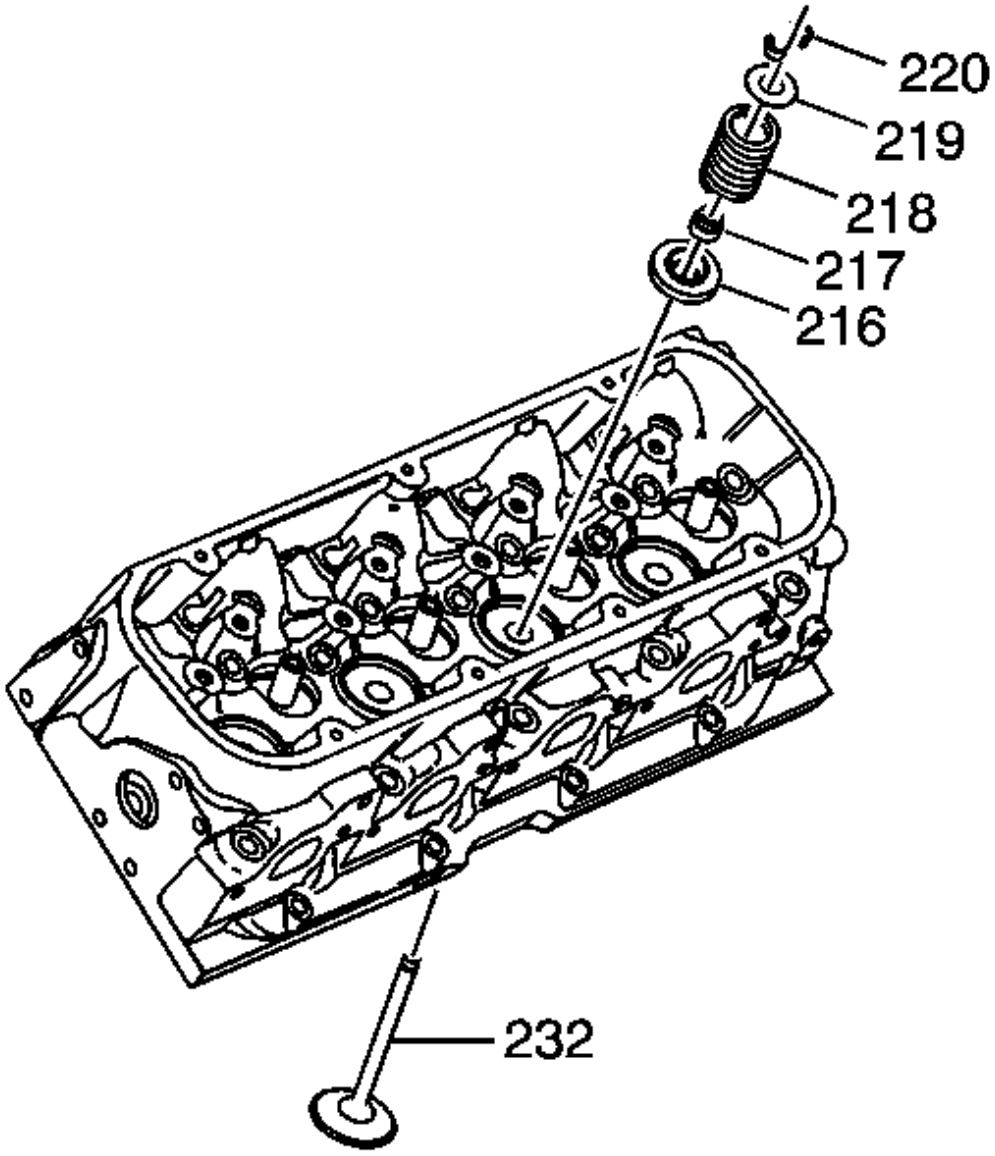

Fig. 410: View Of Valve Stems & Components
Courtesy of GENERAL MOTORS CORP.

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

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CAUTION: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

1. Lubricate the valve stems (232) with clean engine oil.
2. Insert the valves into their proper locations.
3. Install the necessary valve spring shims onto the cylinder head, if applicable.
4. Lubricate the rotators (216) with clean engine oil.
5. Install the rotators over the guide and on top of the cylinder head or valve spring shims, if applicable.

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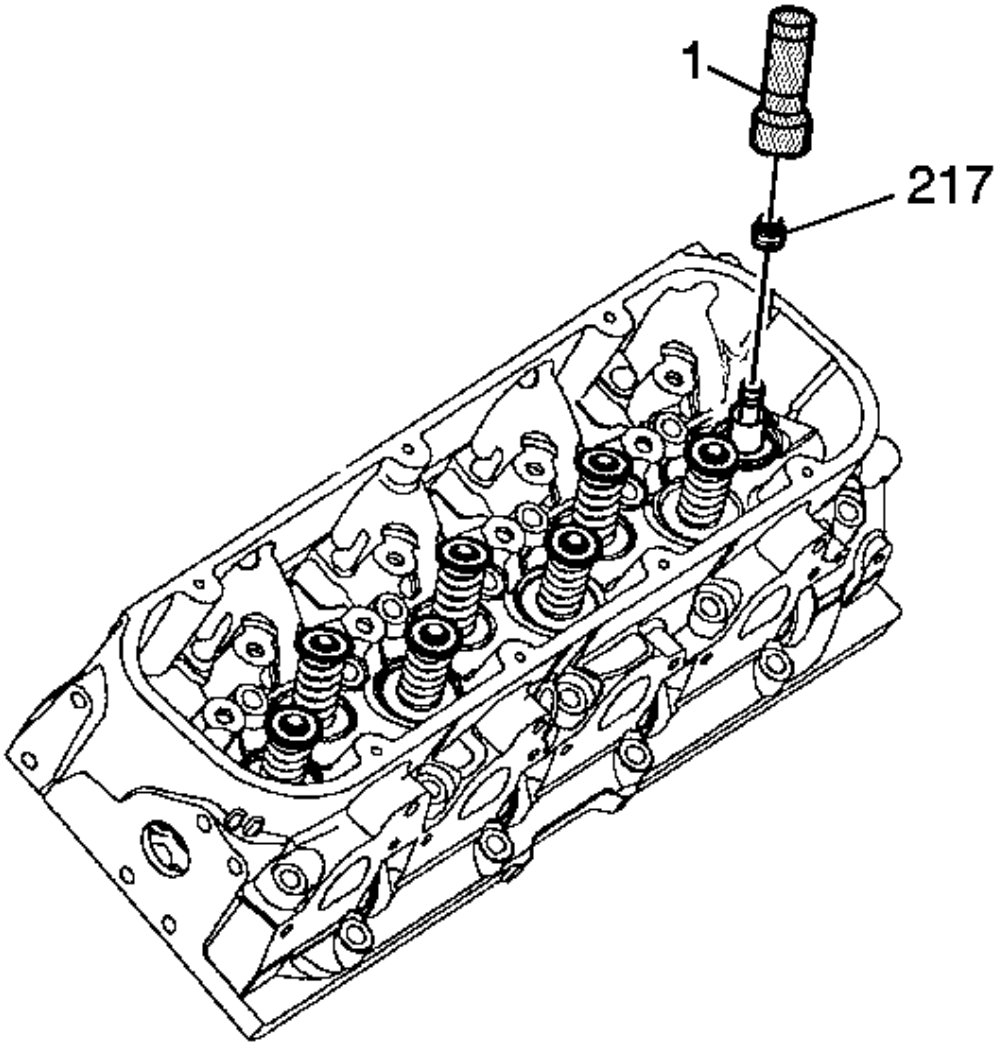

Fig. 411: Installing Valve Stem Oil Seals Using J 43105
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: When installing valve stem oil seals onto the valve guides, be careful not to tear the seal lip.

IMPORTANT: When installing valve seals, J 43105 must be used to achieve correct installation. See Special Tools and Equipment. Failure to use J 43105 may cause excessive oil consumption. See Special Tools and Equipment.

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6. Lubricate the valve stem seal and the outside diameter of the valve guide with clean engine oil.
7. Install the valve stem oil seals (217) over the valve tip and onto the valve guides using **J 43105** (1). See **Special Tools and Equipment**. Tap the valve stem seal onto the valve guide until the **J 43105** fully seats the seal. See **Special Tools and Equipment**.

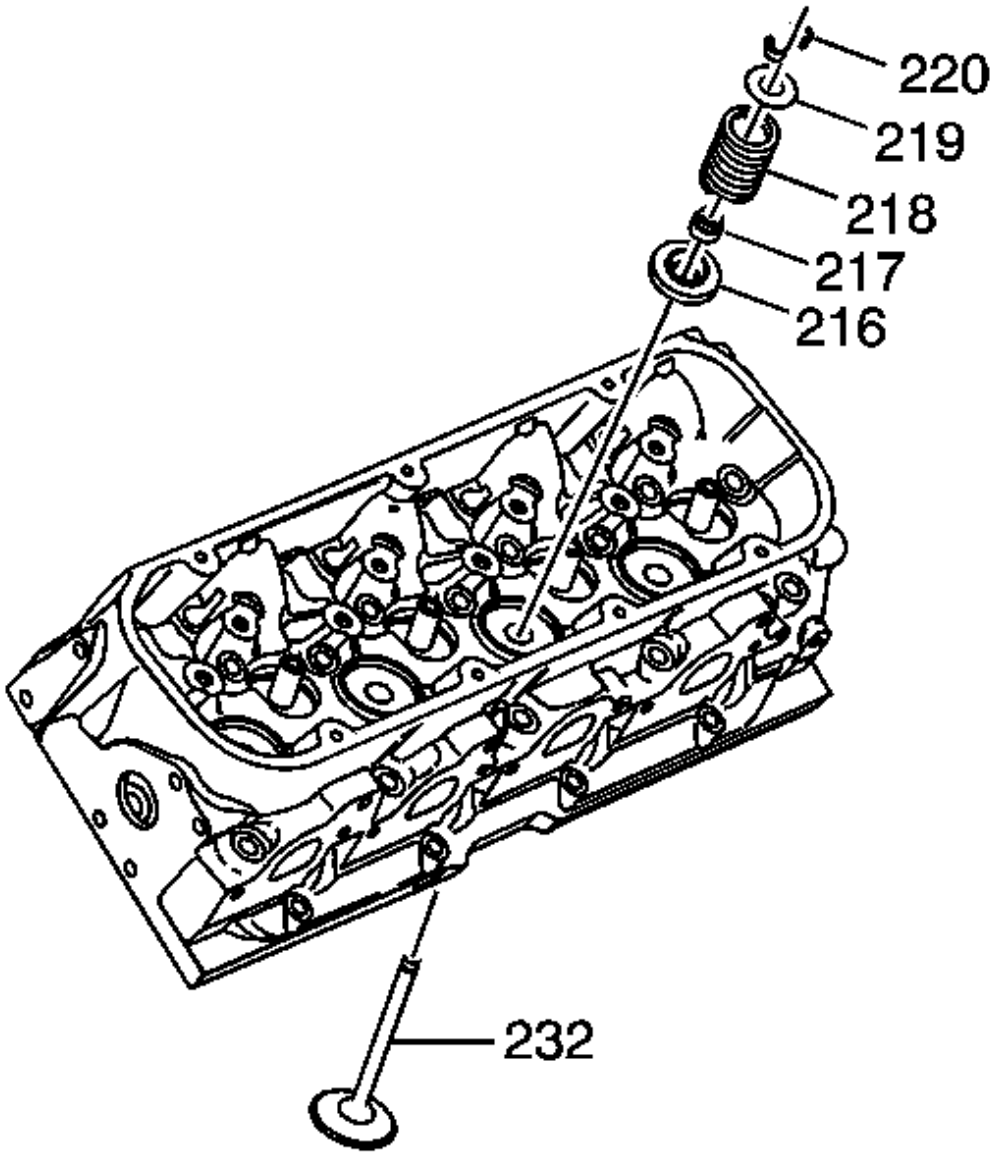

Fig. 412: View Of Valve Stems & Components
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: When installing valve springs, the small end of the valve spring must be installed up.

8. Install the valve springs (218).
9. Install the valve spring caps (219).

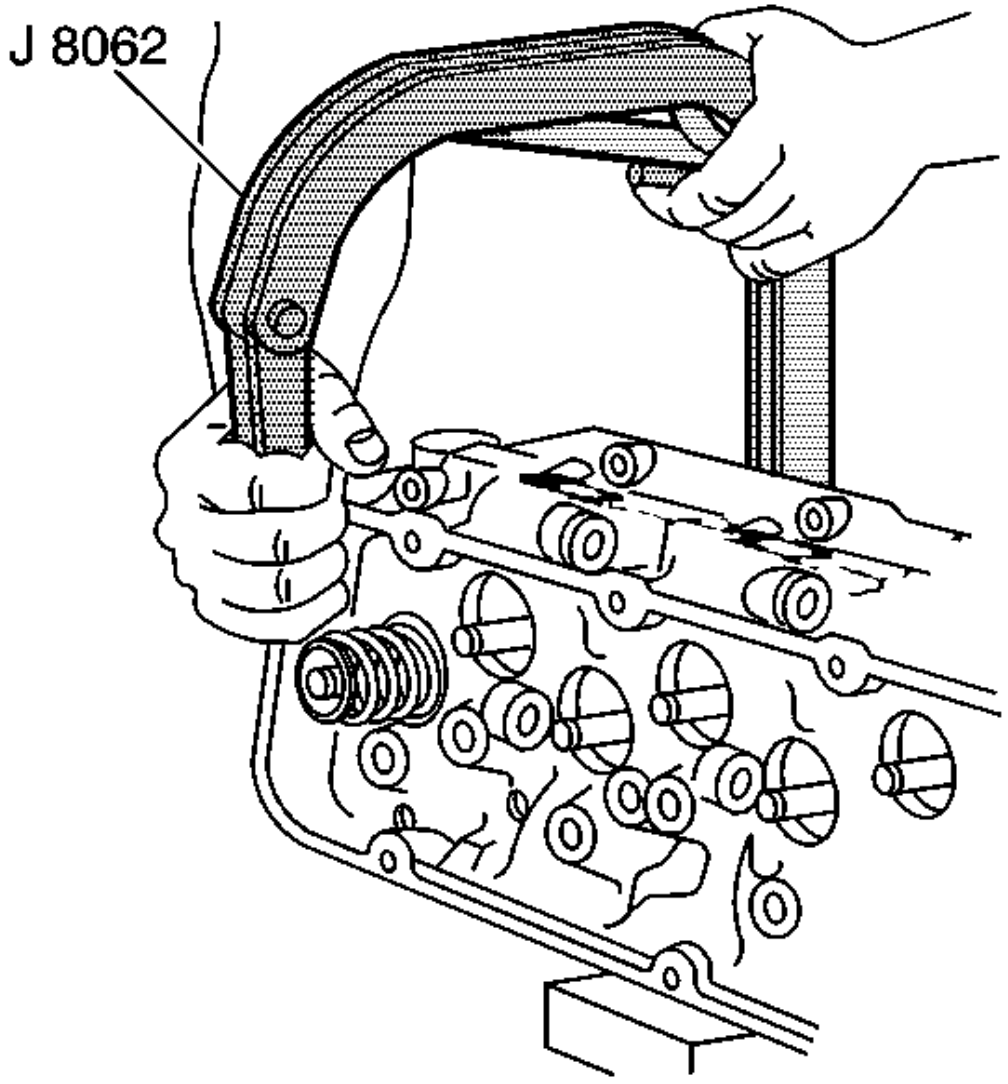

Fig. 413: Compressing Valve Springs Using J 8062
Courtesy of GENERAL MOTORS CORP.

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10. Use the **J 8062** in order to compress the valve spring. Compress the spring enough to clearly see the valve stem key grooves of the valve.
11. Install the valve stem keys.
    - Use grease to hold the keys in place.
    - Ensure that the keys seat properly in the upper groove of the valve stem.
12. Release and remove the **J 8062** .
13. Lightly tap the end of the valve stem with a plastic-faced hammer to seat the keys.

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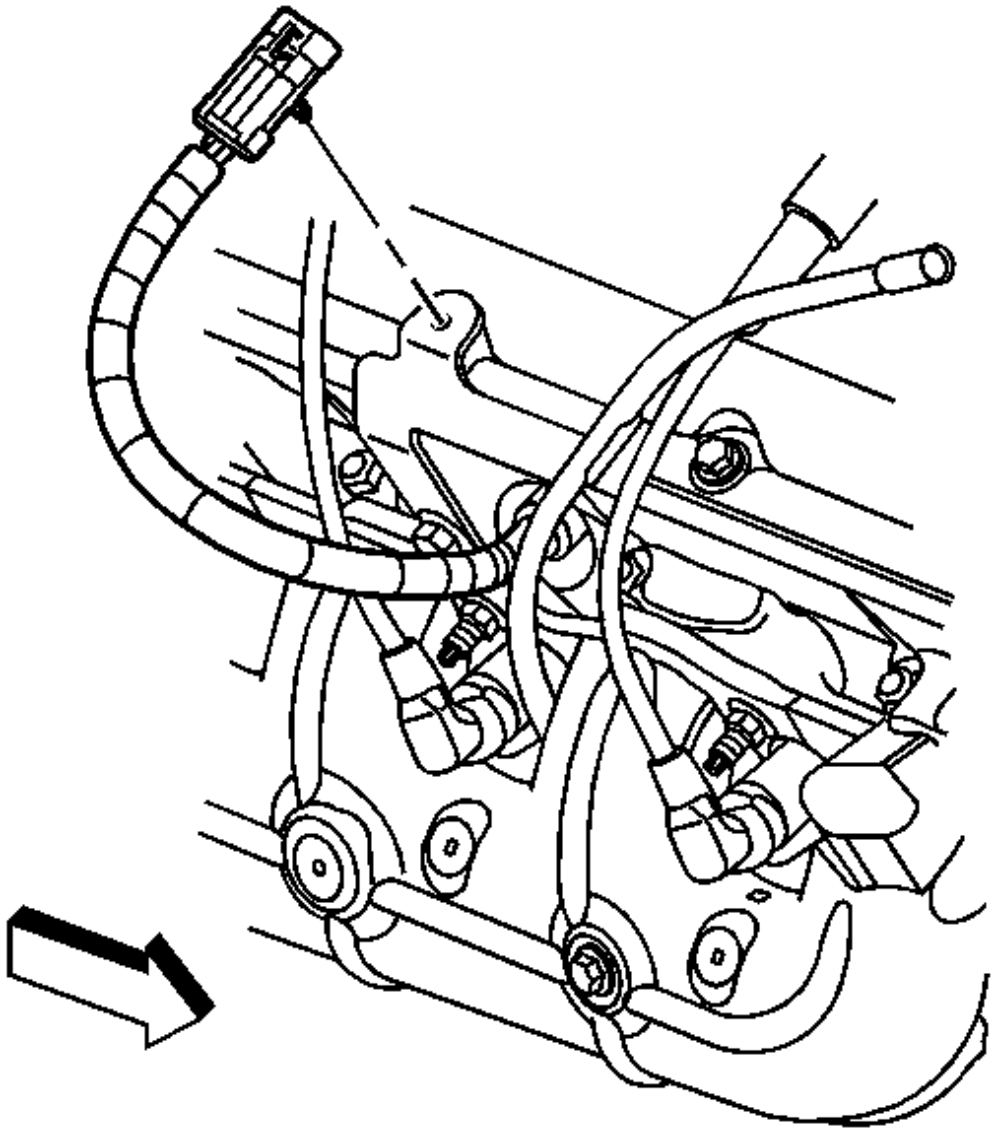

Fig. 414: View Of Engine Coolant Temperature (ECT) Sensor
Courtesy of GENERAL MOTORS CORP.

14. Apply sealant GM P/N 12346004, (Canadian P/N 10953480), or equivalent to the threads of the engine coolant temperature (ECT) sensor.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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15. Install the ECT sensor into the right cylinder head.

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

16. Install the ECT sensor bracket and bolt.

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

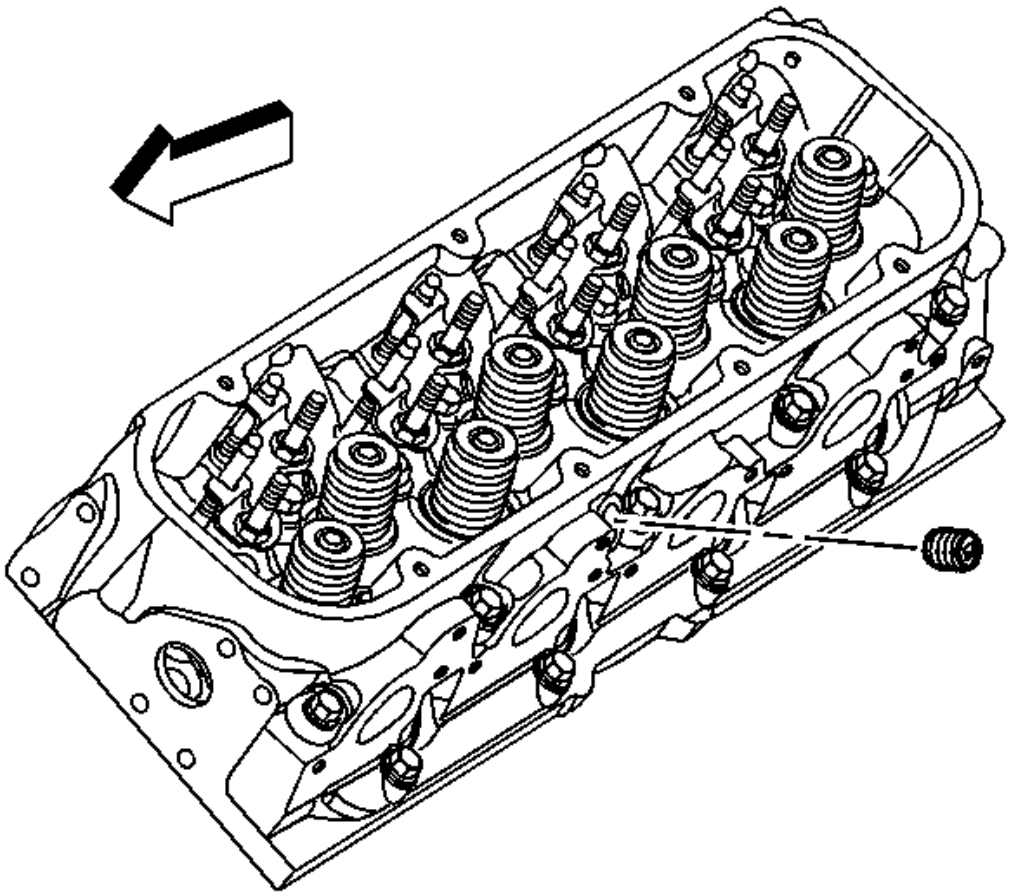

Fig. 415: View Of Cylinder Head Coolant Hole Plug
Courtesy of GENERAL MOTORS CORP.

17. Apply sealant GM P/N 12346004, (Canadian P/N 10953480), or equivalent to the threads of the cylinder head coolant hole plug.
18. Install the cylinder head coolant hole plug into the left cylinder head.

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Tighten: Tighten the cylinder head coolant hole plug to 50 N.m (37 lb ft).

Oil Pump Disassemble

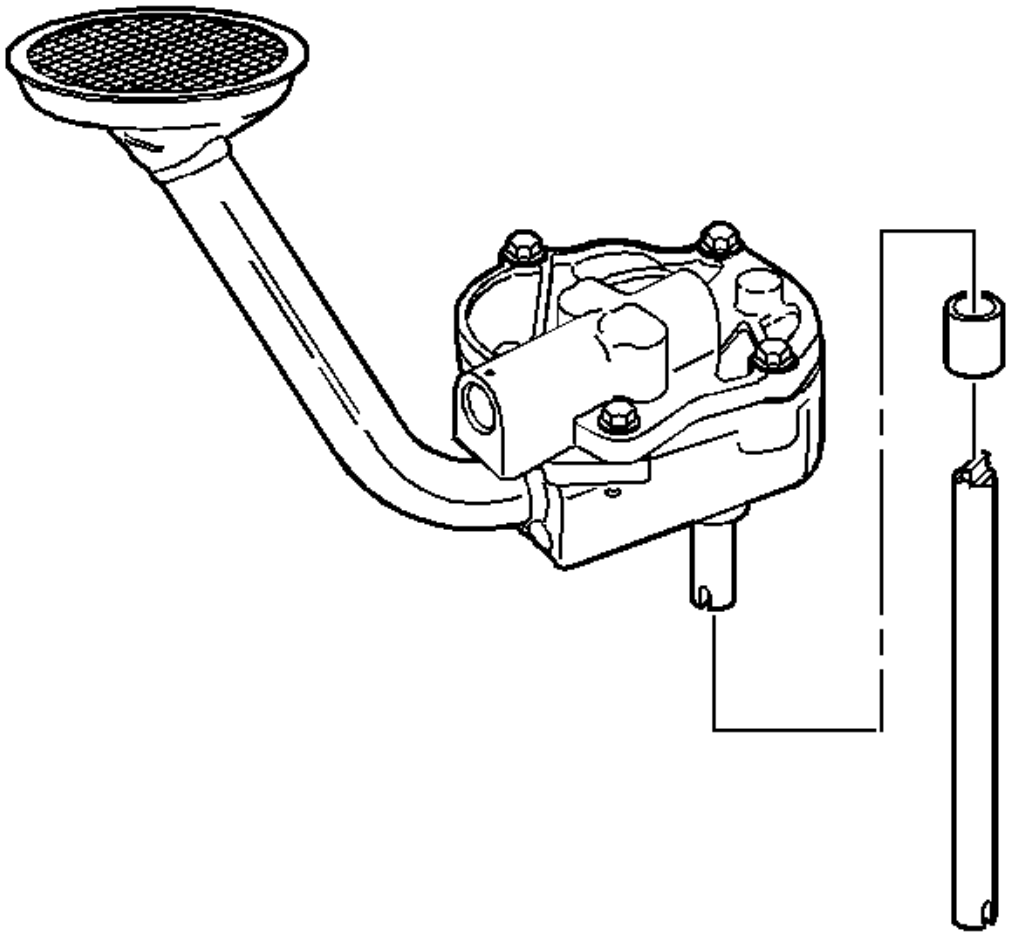

Fig. 416: View Of Oil Pump Driveshaft & Retainer
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pump pipe has a press fit into the oil pump. DO NOT remove the pipe from the oil pump. The pipe and oil pump are serviced as a complete assembly.

1. Remove the oil pump driveshaft and retainer.

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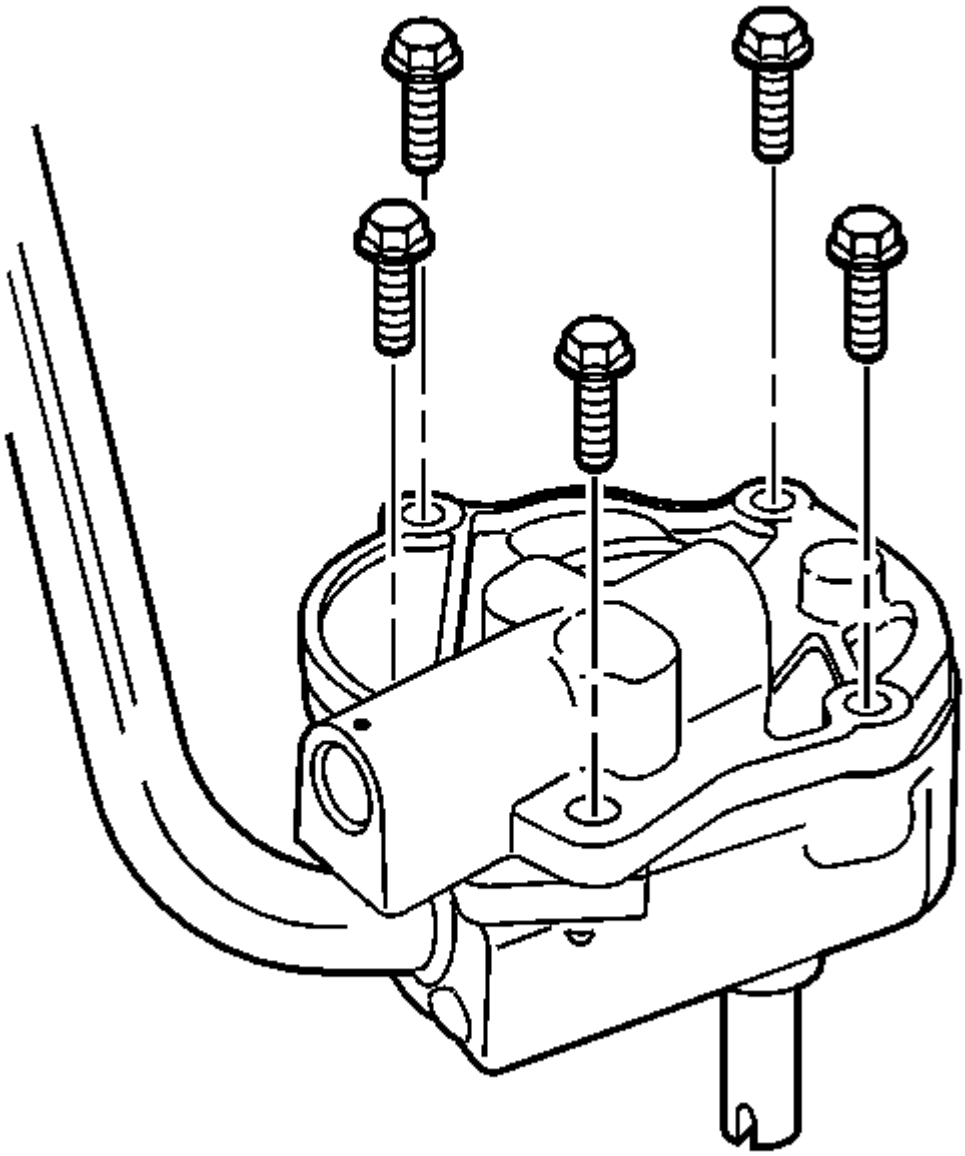

Fig. 417: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump cover bolts.

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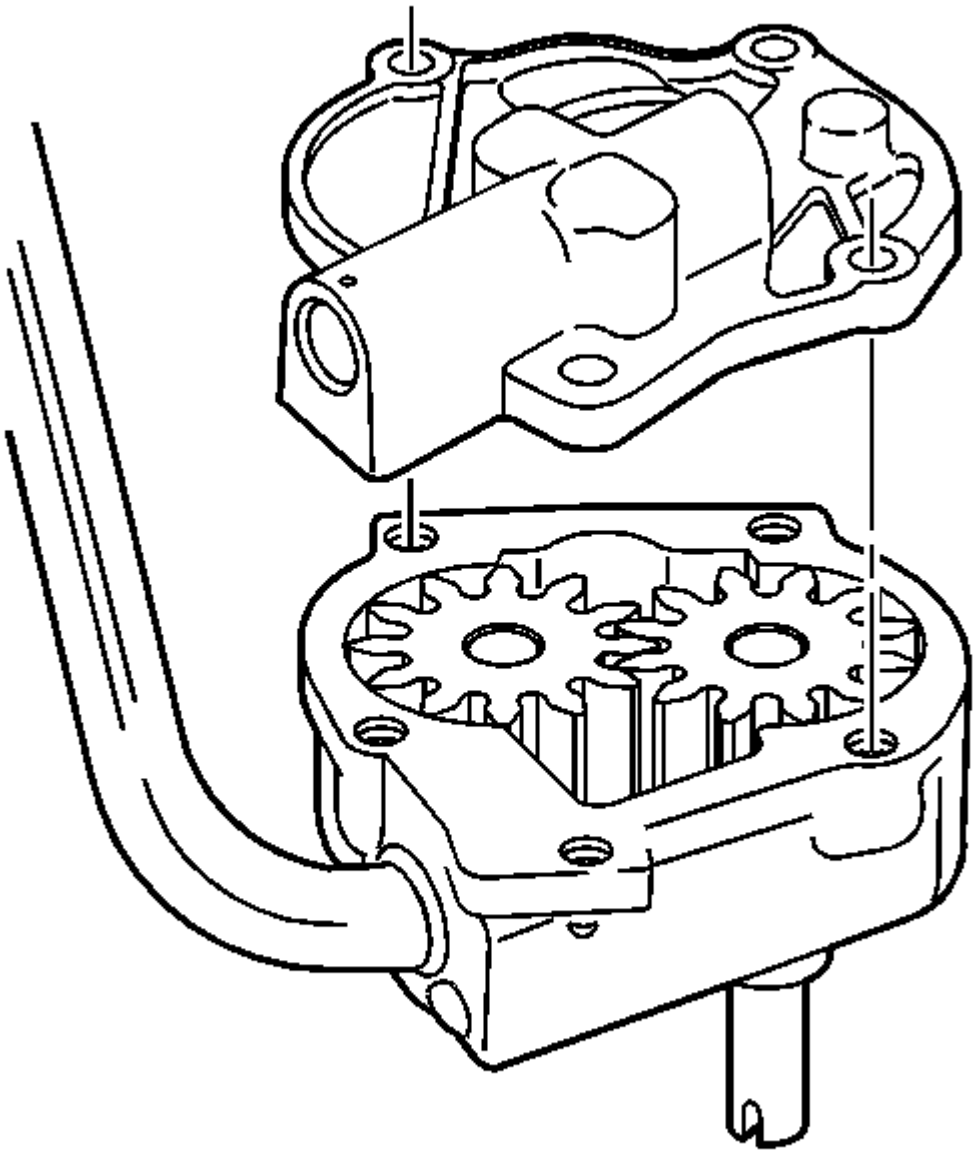

Fig. 418: View Of Pump Cover
Courtesy of GENERAL MOTORS CORP.

3. Remove the pump cover.

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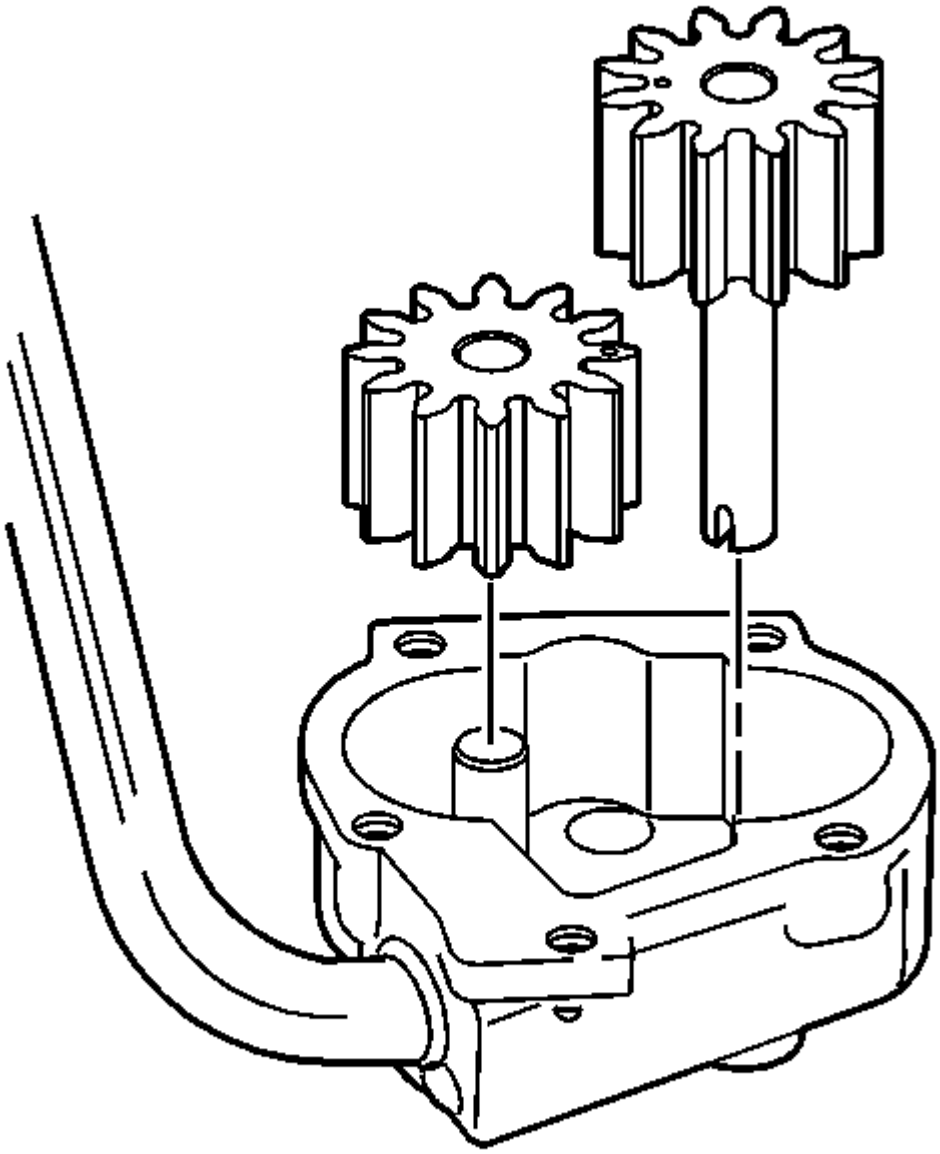

Fig. 419: View Of Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

4. Remove the drive gear and the driven gear. Matchmark the gear teeth for assembly.

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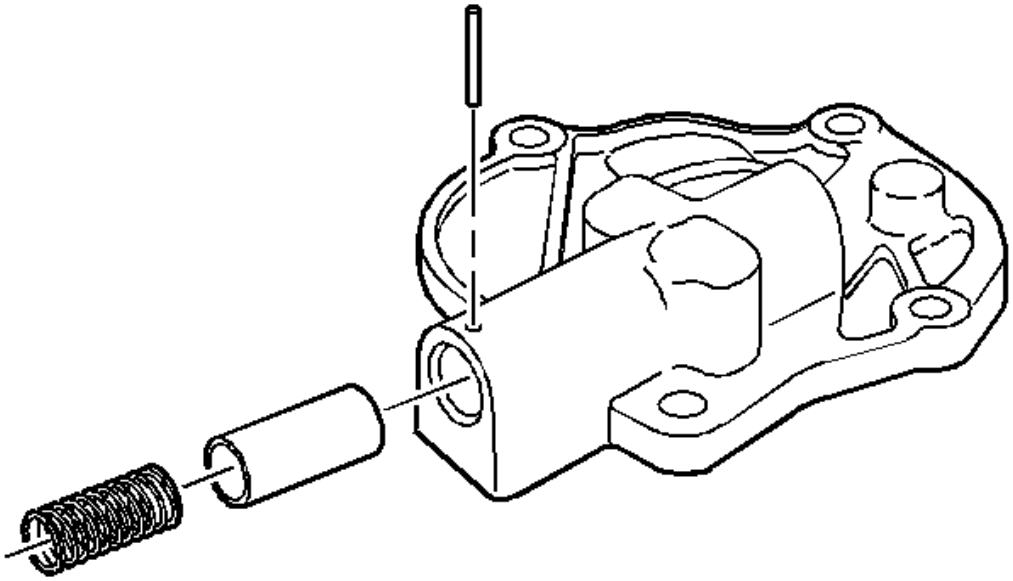

Fig. 420: View Of Pressure Relief Valve, Spring & Retaining Pin
Courtesy of GENERAL MOTORS CORP.

5. Remove the following items:
    1. The retaining pin
    2. The pressure relief spring
    3. The pressure relief valve

Oil Pump Cleaning and Inspection

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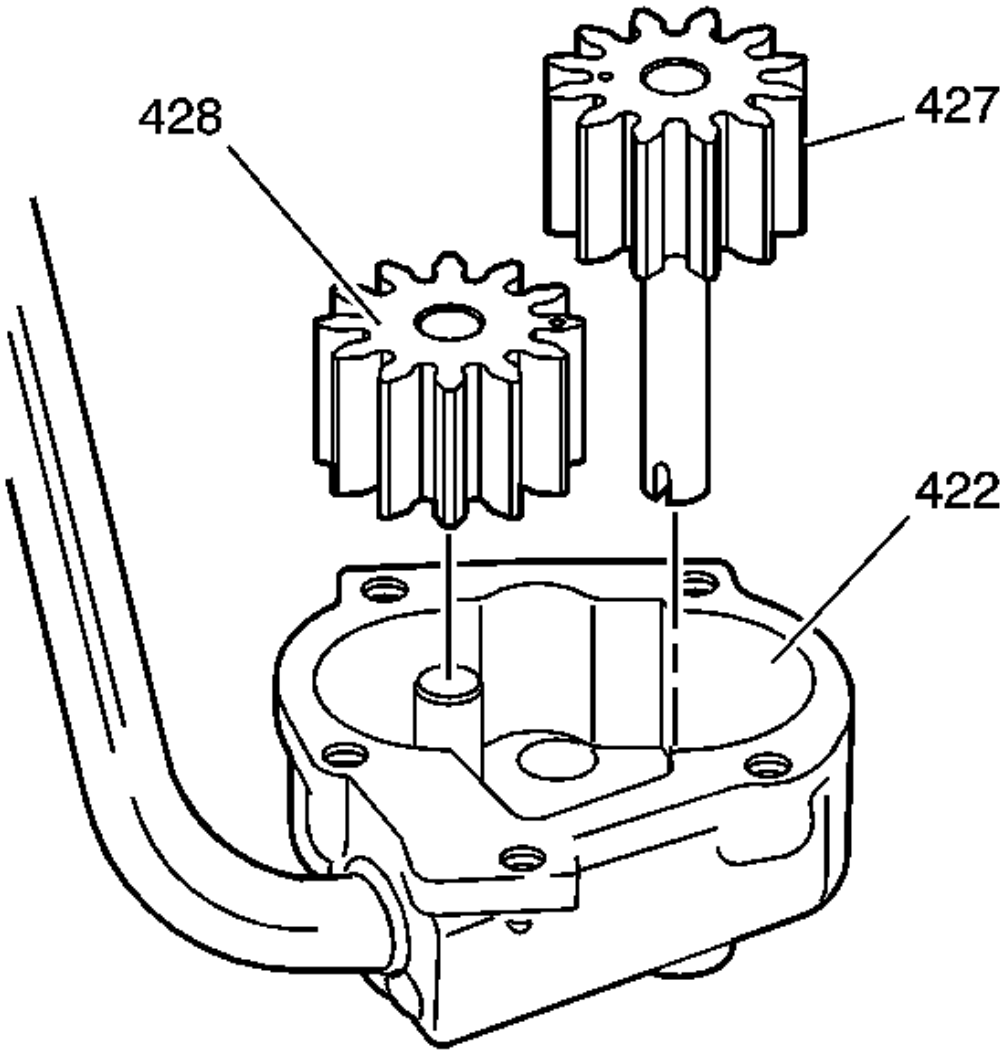

Fig. 421: View Of Oil Pump Housing & Gears
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.
3. Inspect the gears (427, 428) for the following:

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- Scoring
- Chipping
- Galling
- Excessive wear

4. Inspect the oil pump housing (422) for the following:
   - Damaged bolt hole threads
   - Worn oil pump driveshaft bore
   - Scoring or excessive wear within the housing
   - Worn driven gear shaft

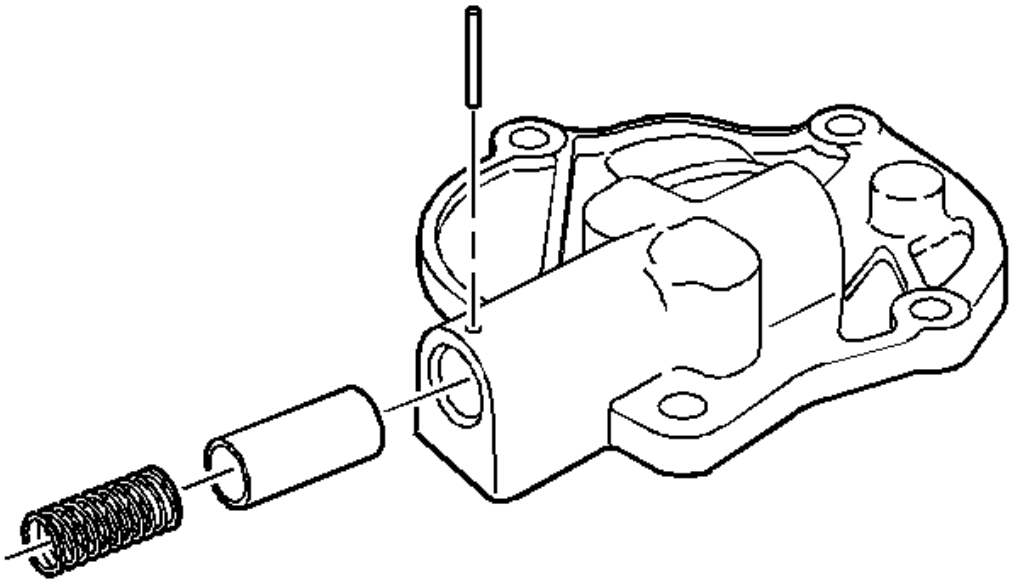

Fig. 422: View Of Pressure Relief Valve, Spring & Retaining Pin
Courtesy of GENERAL MOTORS CORP.

5. Inspect for a collapsed pressure relief spring.
6. Inspect the pressure relief valve for scoring or wear. The valve should move freely within the bore of the housing.

Oil Pump Assemble

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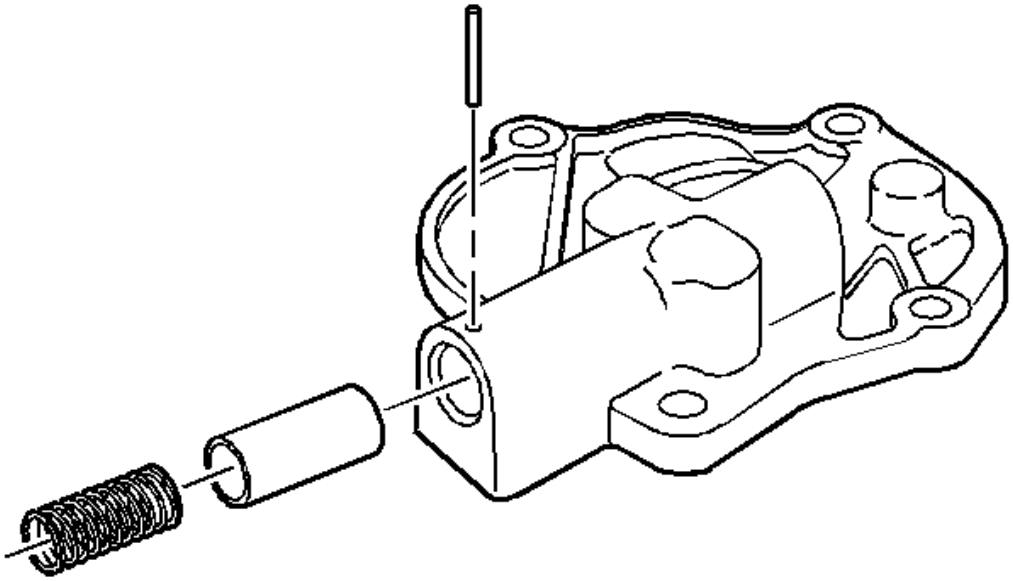

Fig. 423: View Of Pressure Relief Valve, Spring & Retaining Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Replace the pressure relief valve spring when reusing the oil pump.

1. Install the following items:
    1. The pressure relief valve
    2. The pressure relief spring
    3. The retaining pin

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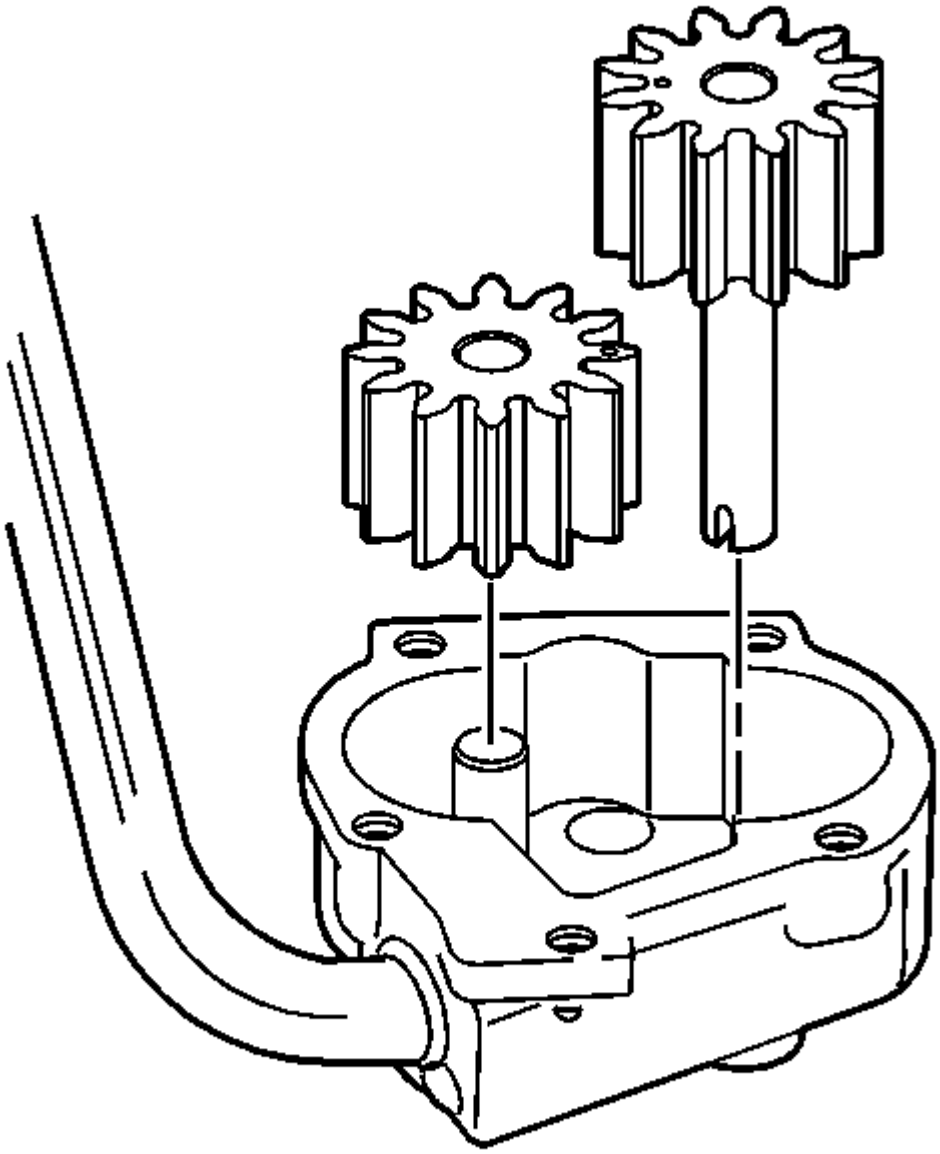

Fig. 424: View Of Drive Gear & Driven Gear
Courtesy of GENERAL MOTORS CORP.

2. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
3. Install the drive gear and the driven gear into the pump body. Align the matching marks on the gears. Install the smooth side of the gear toward the pump cover.

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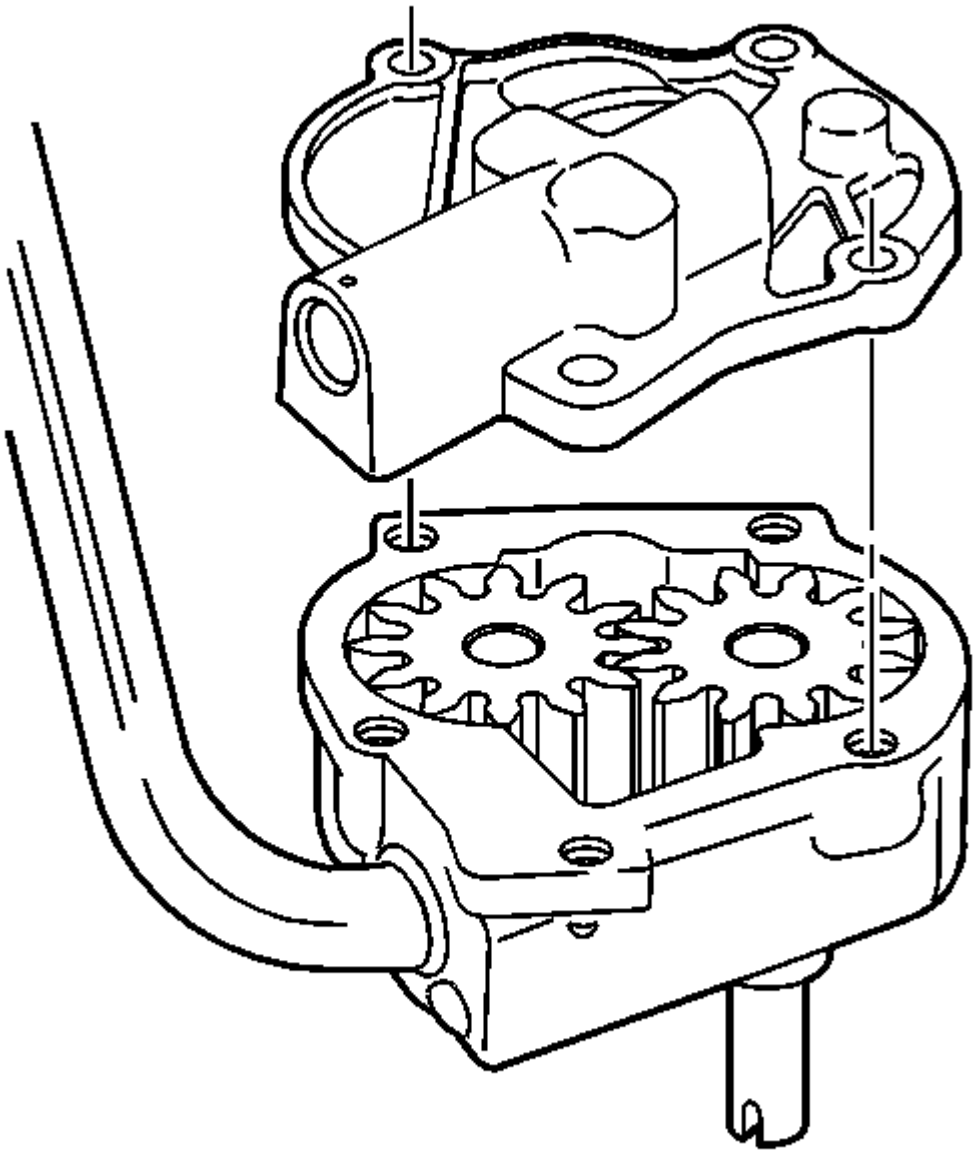

Fig. 425: View Of Pump Cover
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pump cover.

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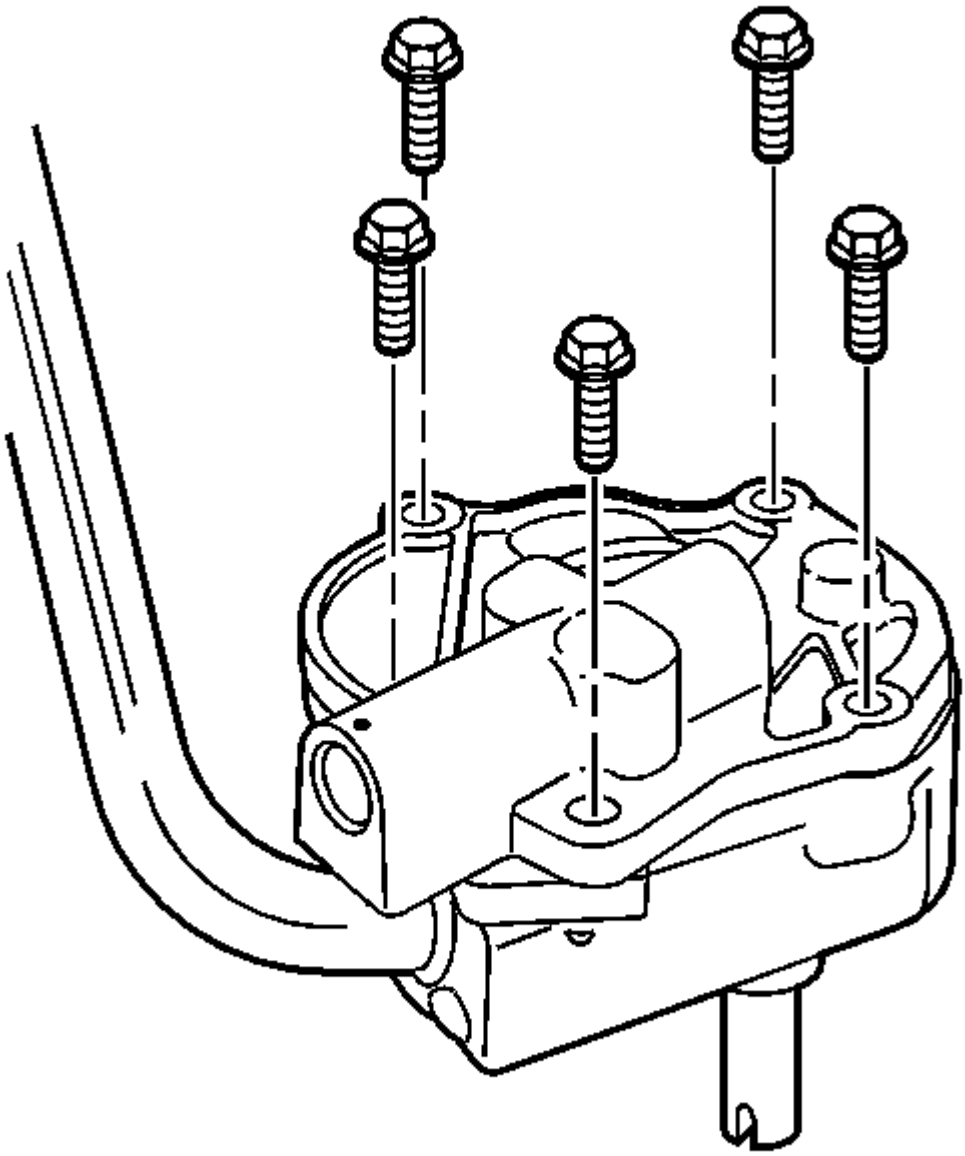

Fig. 426: View Of Oil Pump Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

5. Install the oil pump cover bolts.

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

6. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.

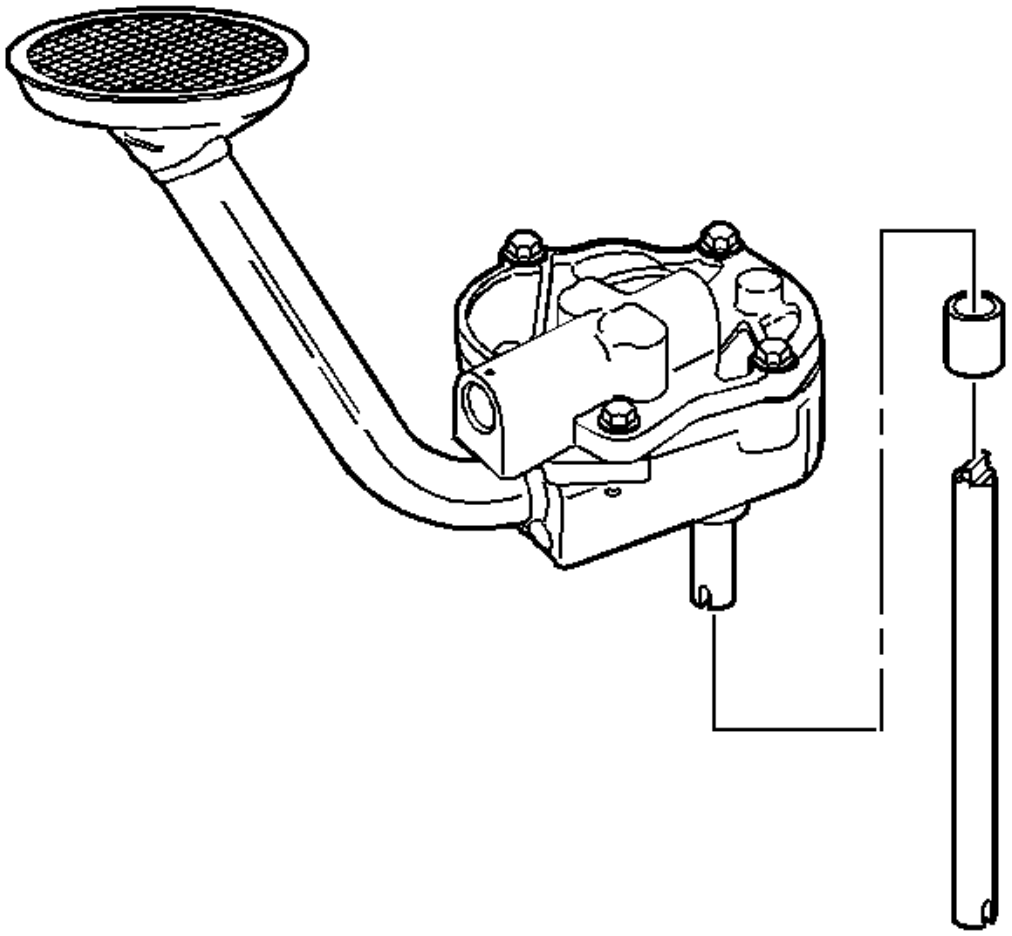

Fig. 427: View Of Oil Pump Driveshaft & Retainer
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the oil pump driveshaft is inspected for wear and/or damage, and replaced if necessary. An excessively worn or damaged oil pump driveshaft may fail causing severe engine damage.

7. Install the oil pump driveshaft and the new retainer.

Oil Pump Drive Cleaning and Inspection

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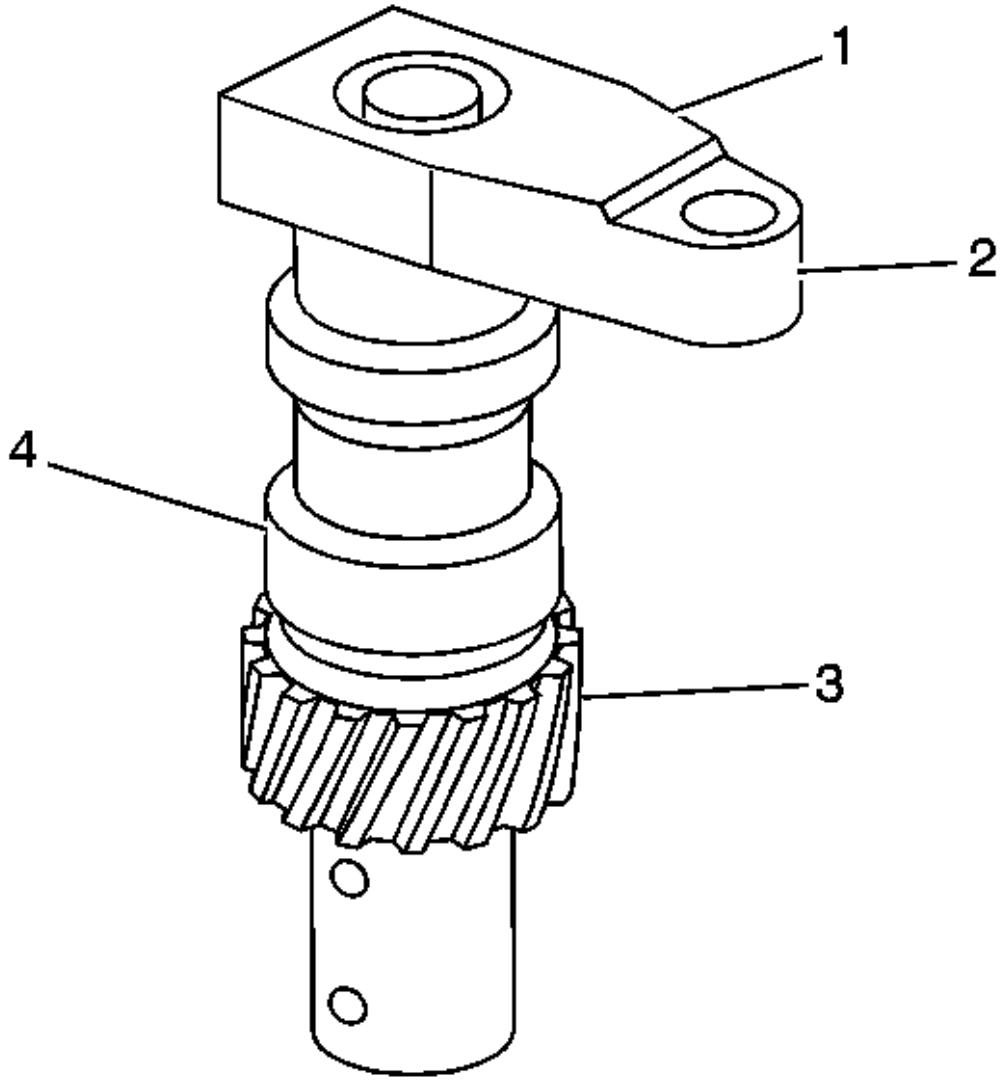

Fig. 428: View Of Oil Pump Drive, Bolt Hole, Gear & Body
Courtesy of GENERAL MOTORS CORP.

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

1. Clean the oil pump drive in cleaning solvent.
2. Dry the oil pump drive with compressed air.

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3. Inspect the oil pump drive (1) for the following conditions:
    - Excessive play in the oil pump drive bearing
    - Damage to the oil pump drive clamp bolt hole (2)
    - Damaged gear (3) for the following:
        - Chipping
        - Galling
        - Wear
        - Damage to the oil pump drive shaft tang
4. Damage to the oil pump drive body (4).
5. If the oil pump drive is to be reused, lubricate the bearing with clean engine oil, and apply grease to all gear teeth (3).

Valve Rocker Arm Cover Cleaning and Inspection

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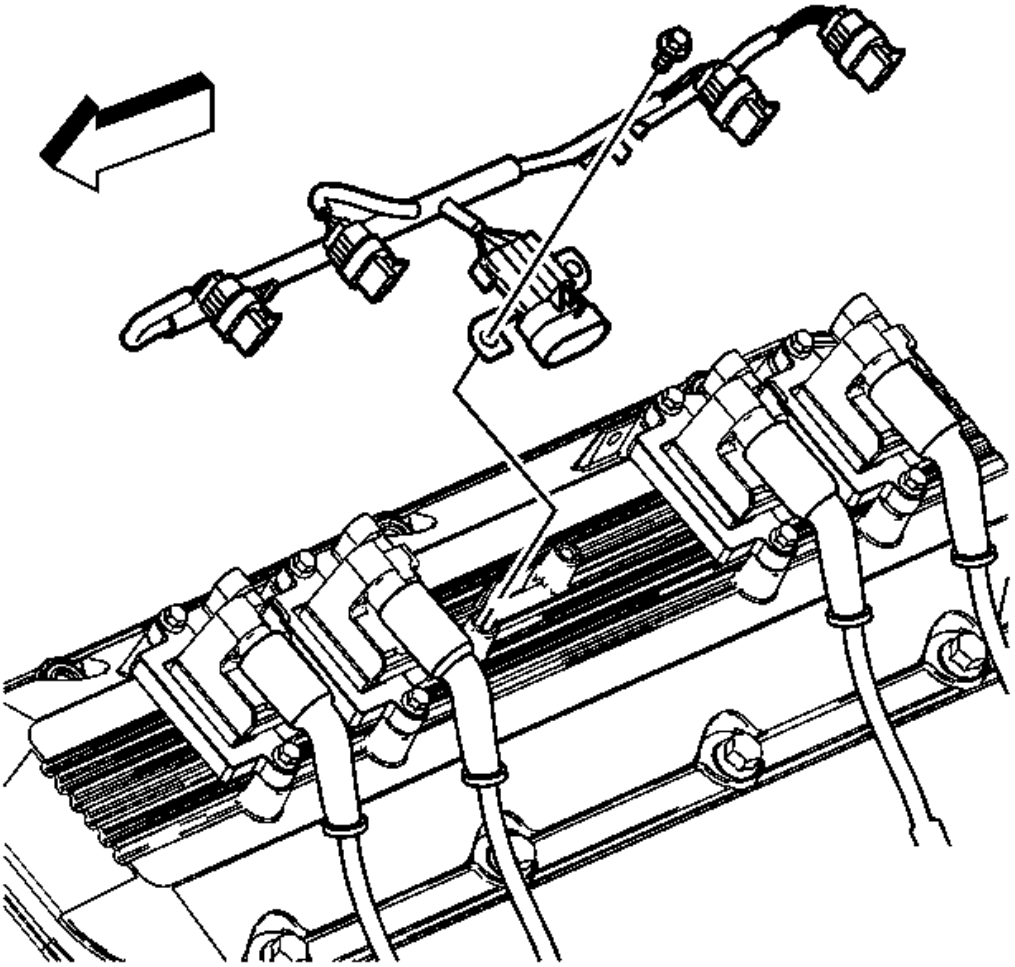

Fig. 429: View Of Ignition Coil Wiring Harness
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to ensure correct reinstallation, mark the ignition wiring harness connectors for cylinders one and three, and cylinders six and eight prior to disconnection. Failure to reconnect the ignition wiring harness connectors to the proper ignition coils may result in serious engine damage.

NOTE: This component is initially installed using a self-tapping bolt(s). Care should be taken when removing and/or installing the self-tapping bolt(s). Failure to use care when removing and/or installing the self-tapping bolt(s) can lead to damage and unnecessary replacement of the self-tapping bolt

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(s) and/or the component the self-tapping bolt(s) is threaded into.

1. Remove the white wiring harness clip locks.
2. Disconnect the ignition coil wiring harness from the ignition coils.
3. Remove the ignition coil wiring harness retainer bolts.
4. Open the 2 wiring harness retainers and remove the ignition coil wiring harness.

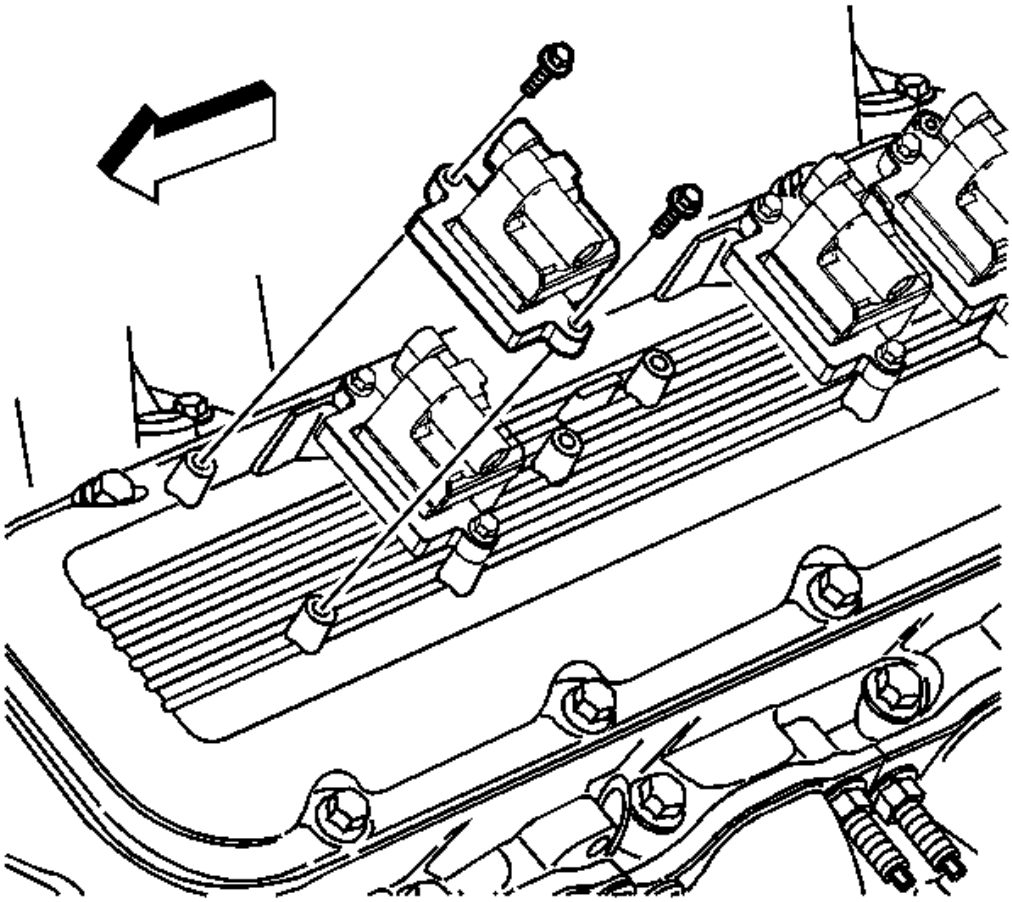

Fig. 430: View Of Ignition Coils & Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the ignition coil bolts.
6. Remove the ignition coils.

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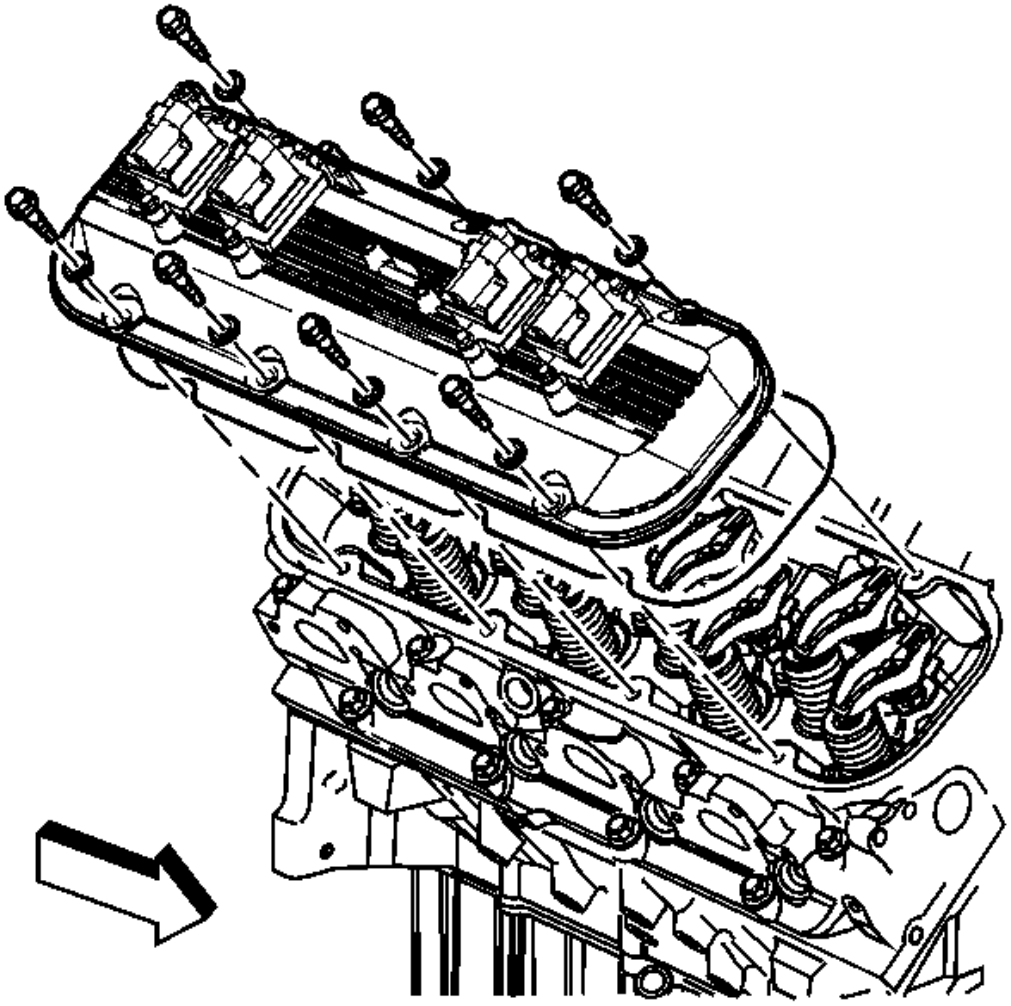

Fig. 431: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Do not clean or submerge the ignition coils in solvent. Remove the ignition coils before cleaning the cover in solvent. To prevent damage to the gasket, minimize solvent contact with the gaskets.

7. Clean the valve rocker arm cover in solvent.

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8. Dry the covers with compressed air.
9. Inspect the covers for the following:
    - Gouges or damage to the sealing surfaces
    - Cracking or damage to the valve cover gasket
    - Debris or damage to the bolt hole threads

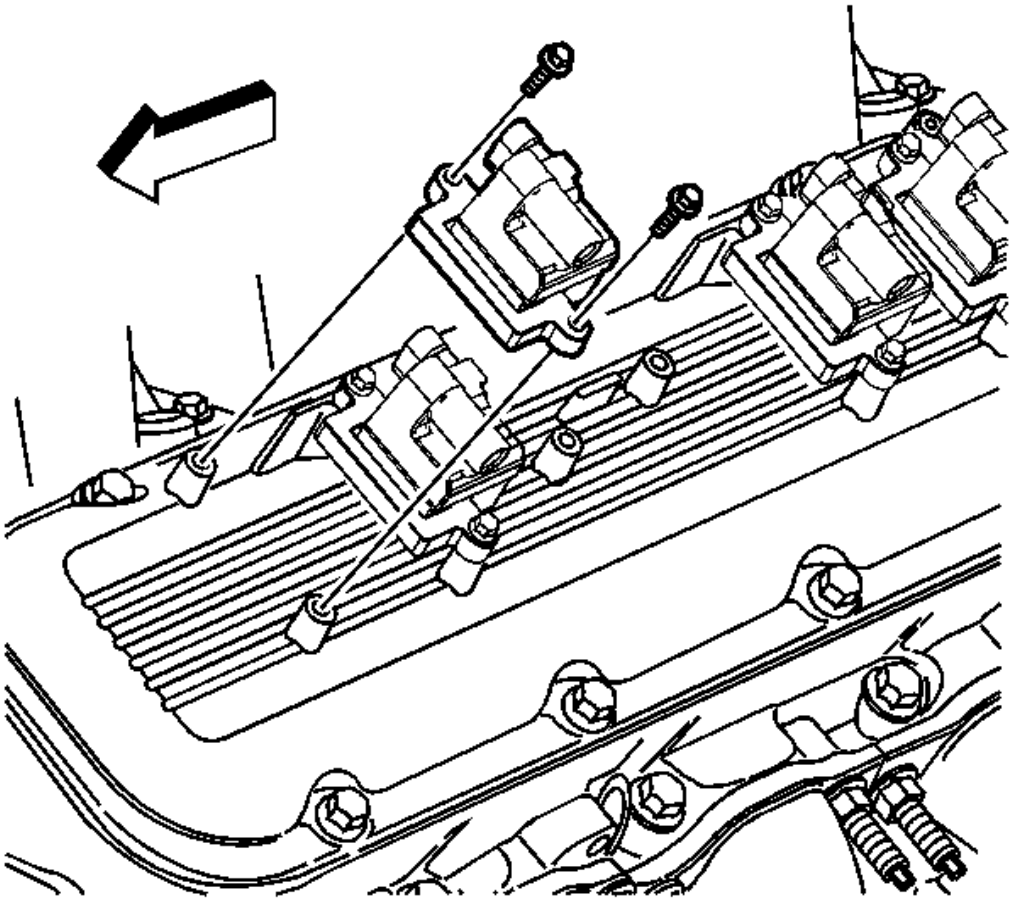

Fig. 432: View Of Ignition Coils & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

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10. Install the ignition coils.

NOTE: Refer to Fastener Notice in Cautions and Notices.

11. Install the ignition coil bolts.

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

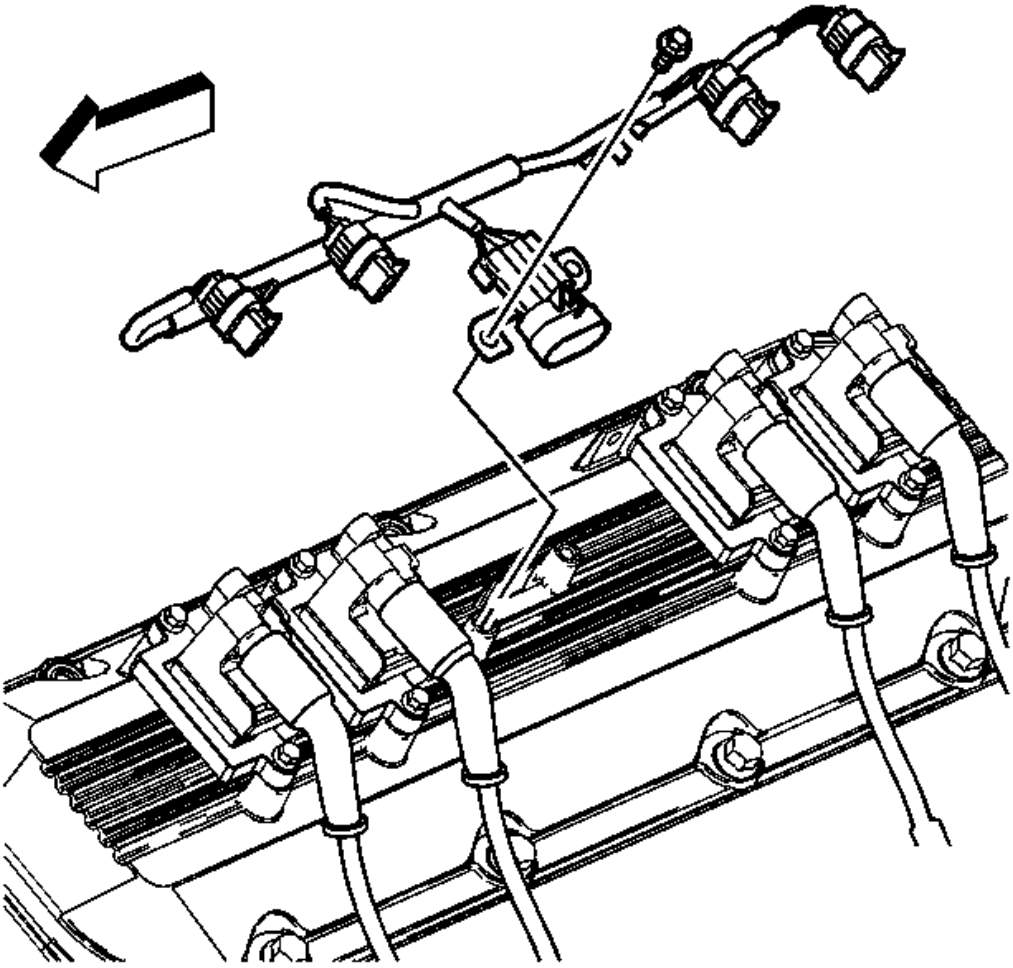

Fig. 433: View Of Ignition Coil Wiring Harness
Courtesy of GENERAL MOTORS CORP.

12. Install and secure the ignition coil wiring harness into the 2 wiring harness retainers.
13. Install the ignition coil wiring harness retainer bolts.

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Tighten: Tighten the ignition coil wiring harness retainer bolts to 12 N.m (106 lb in).

14. Connect the ignition coil wiring harness to the ignition coils, making sure the connectors for cylinders 1 and 3, and cylinders 6 and 8 are connected to the corresponding ignition coils.
15. Install the white wiring harness clip locks.

Oil Pan Cleaning and Inspection

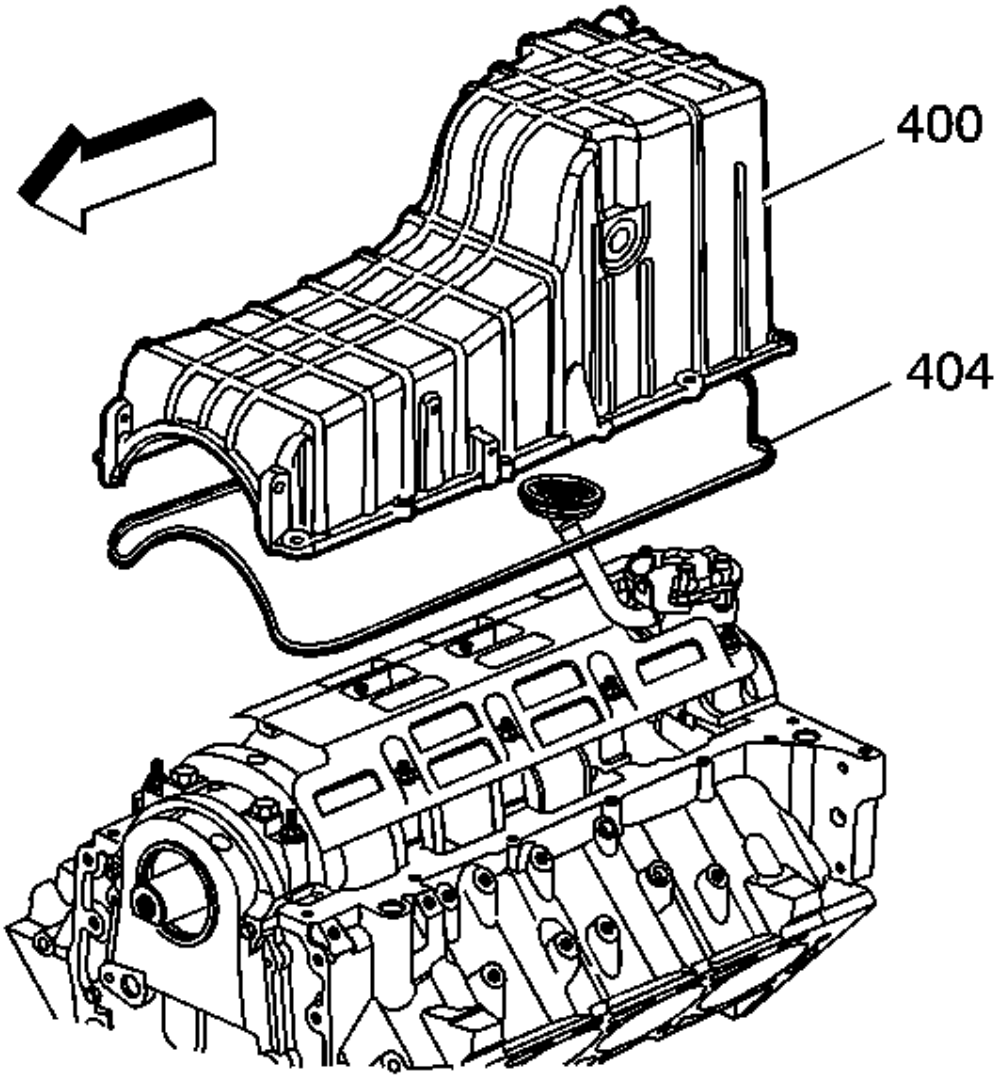

Fig. 434: View Of Oil Pan & Gasket
Courtesy of GENERAL MOTORS CORP.

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1. Remove the oil pan gasket (404) from the groove in the oil pan (400).
2. Clean the oil pan in solvent.

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

3. Dry with compressed air.
4. Inspect the oil pan for the following conditions:
    - The drain plug hole for damaged threads
    - Gouges or damage to the oil pan sealing surfaces
    - Cracks or damage to the exterior of the oil pan
    - Damage to the oil level indicator tube area
    - Damage to the oil pan gasket

Intake Manifold Disassemble

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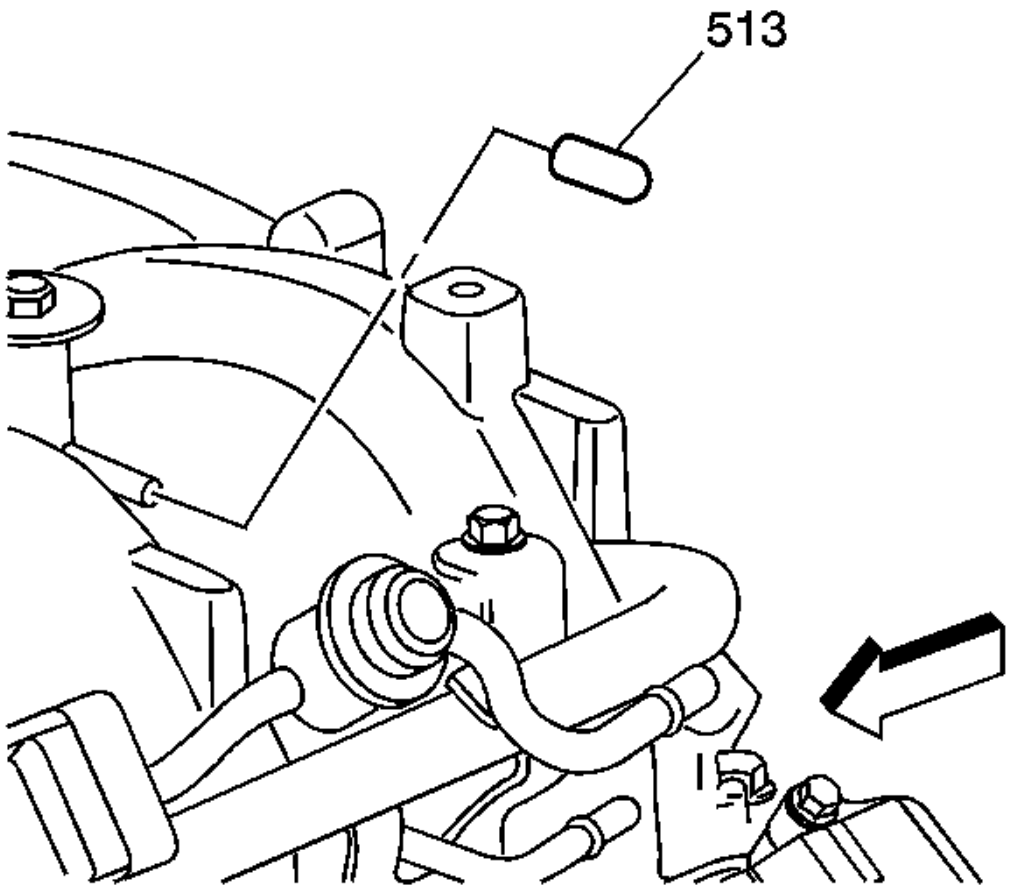

Fig. 435: View Of Vacuum Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the vacuum plug (513).

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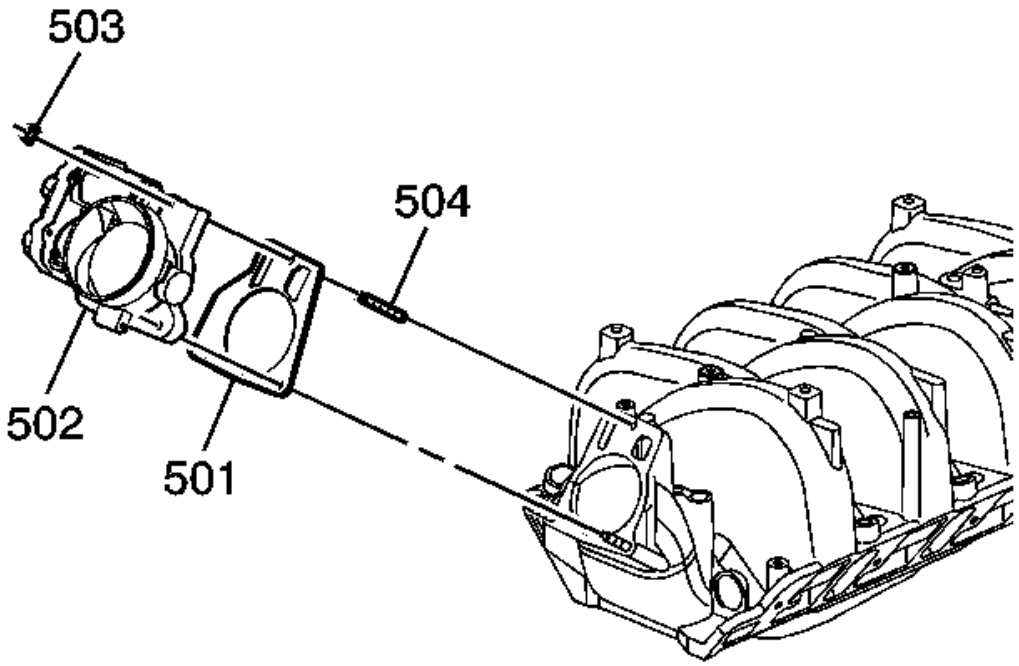

Fig. 436: View Of Throttle Body, Nuts, Studs & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the throttle body nuts (503).
3. Remove the throttle body (502) and gasket (501).
4. Discard the gasket.
5. Remove the throttle body studs (504), if required.

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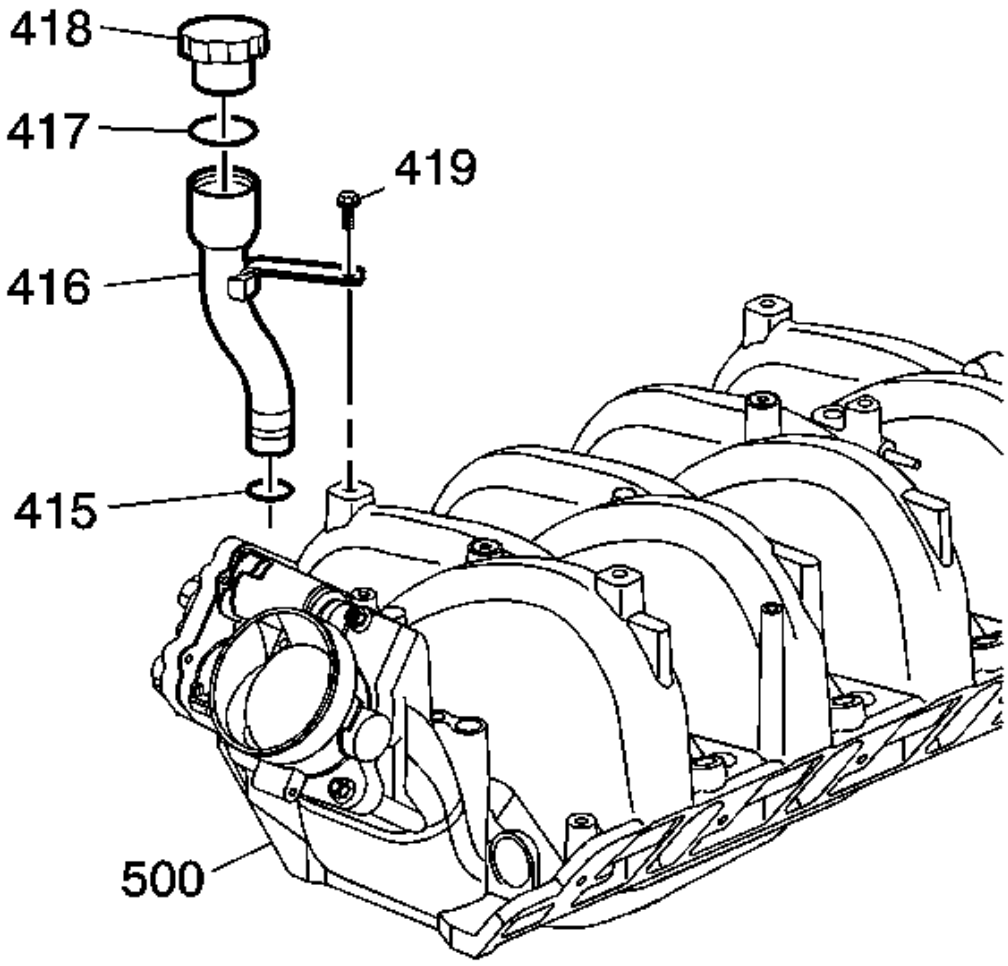

Fig. 437: View Of Oil Fill Tube & Components
Courtesy of GENERAL MOTORS CORP.

6. Remove the oil fill cap (418).
7. Remove the oil fill tube (416) and bolt (419).

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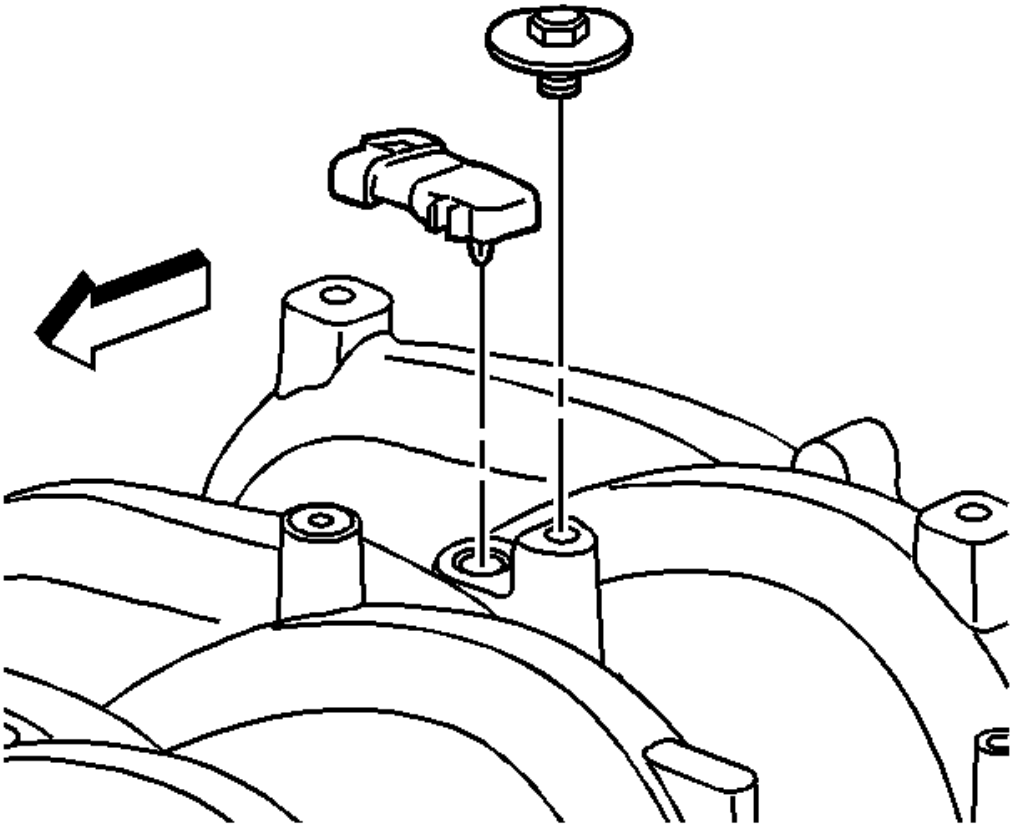

Fig. 438: View Of MAP Sensor & Grommet
Courtesy of GENERAL MOTORS CORP.

8. Remove the manifold absolute pressure (MAP) sensor bolt and MAP sensor.
9. Inspect the MAP sensor grommet for damage.

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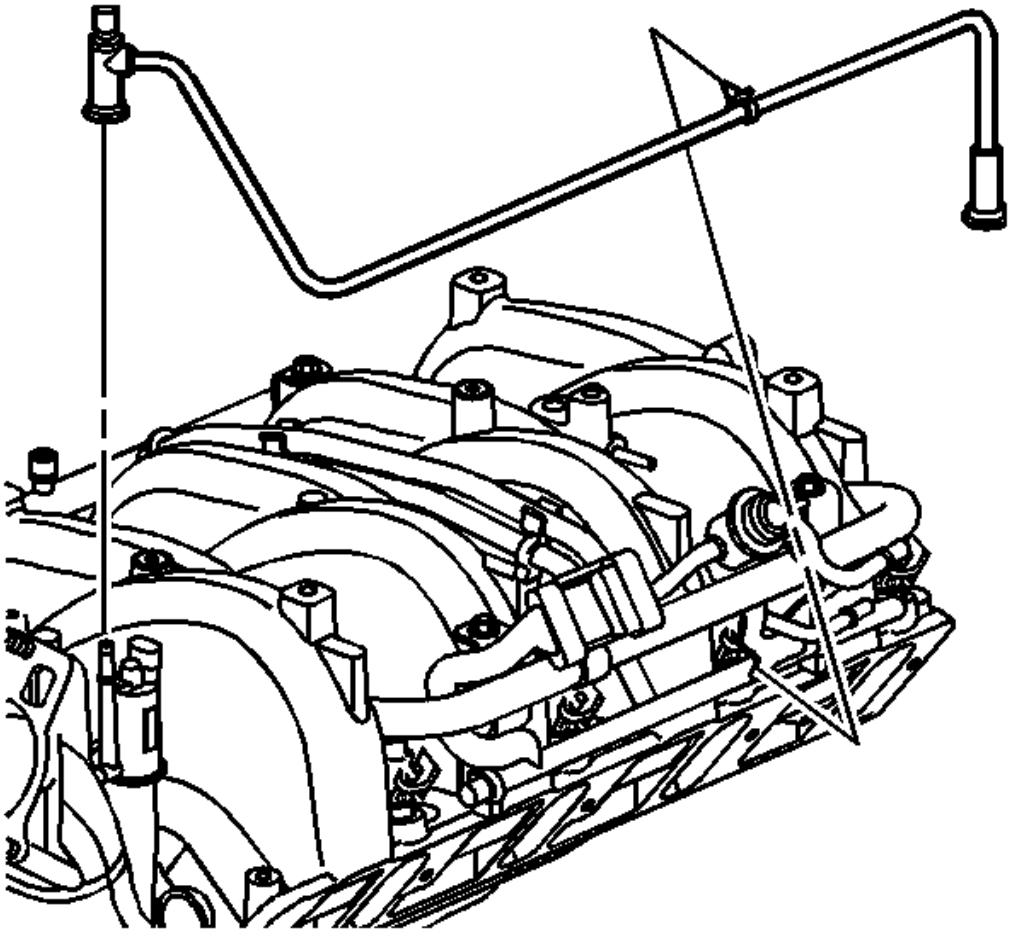

Fig. 439: View Of EVAP Tube
Courtesy of GENERAL MOTORS CORP.

10. Remove the evaporative emission (EVAP) tube.

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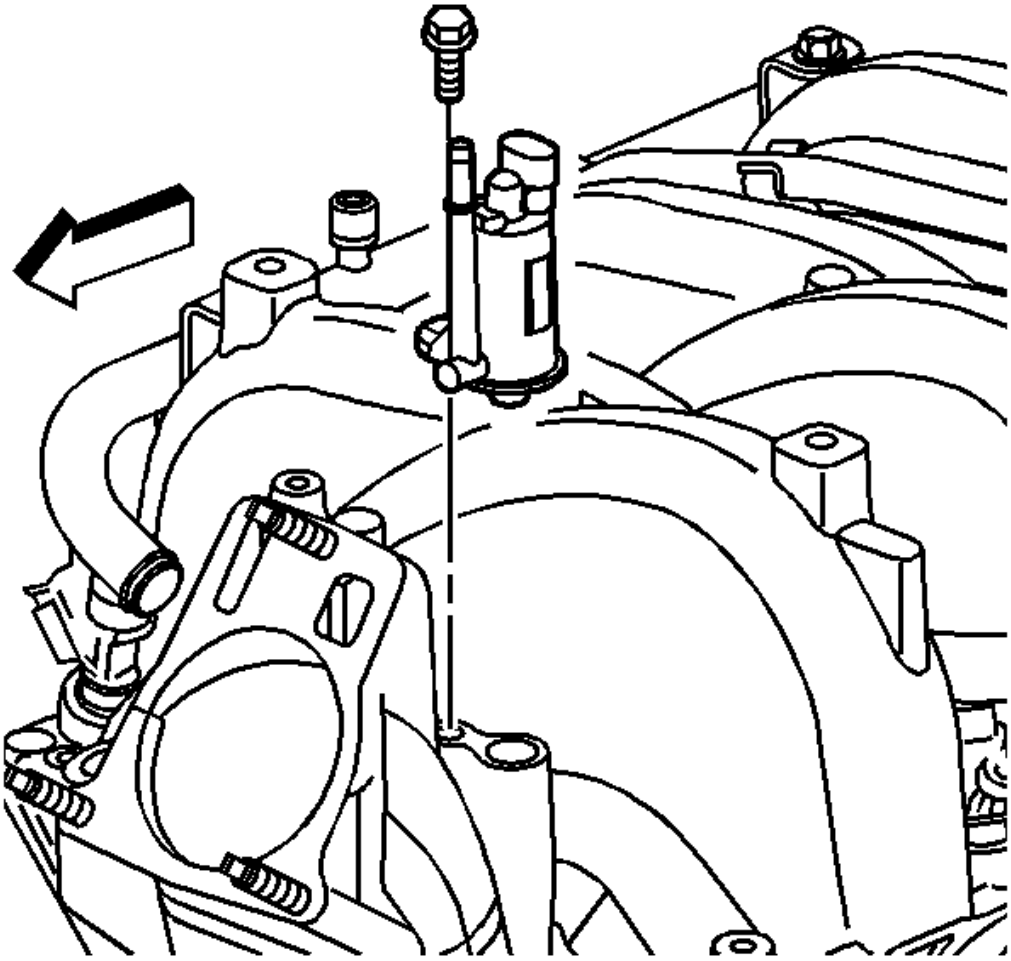

Fig. 440: View Of EVAP Purge Valve
Courtesy of GENERAL MOTORS CORP.

11. Remove the EVAP purge valve and bolt.
12. Inspect the O-ring seal for damage. Replace as needed.

Intake Manifold Cleaning and Inspection

IMPORTANT: Do not use the intake manifold gaskets or end seals again.

1. Clean the intake manifold in an approved solvent.
    - Clean debris out of all bolt holes. Clean the intake manifold gasket sealing surfaces.
    - Clean all intake manifold ports.

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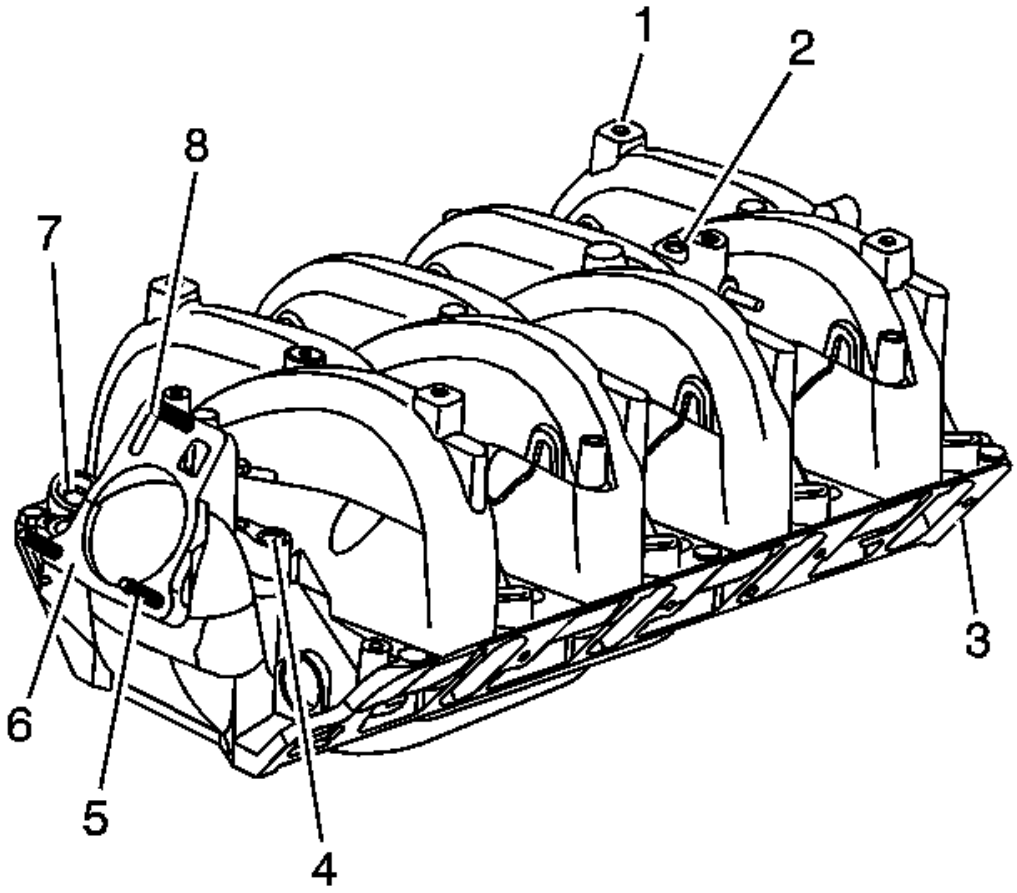

Fig. 441: View Of Intake Manifold & Components
Courtesy of GENERAL MOTORS CORP.

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

2. Dry the intake manifold with compressed air.
3. Inspect the following:
   - The intake manifold bolt holes (1) for cracks and/or damage
   - The manifold absolute pressure (MAP) sensor sealing surface (2) for damage
   - The evaporative emission (EVAP) purge solenoid sealing surface (4) for damage. The purge solenoid bolt has a sealer that may come off during removal of the bolt. Ensure all sealant is removed from the bolt hole.
   - The intake manifold-to-cylinder head sealing surfaces (3) for damage

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- The throttle body studs (5) for damage. Replace as necessary.
- The throttle body mounting surface (6) for damage
- The oil fill tube hole (7) for signs of leakage. Reseal as necessary.
- Positive crankcase ventilation (PCV) port (8) for debris or varnish buildup

Intake Manifold Assemble

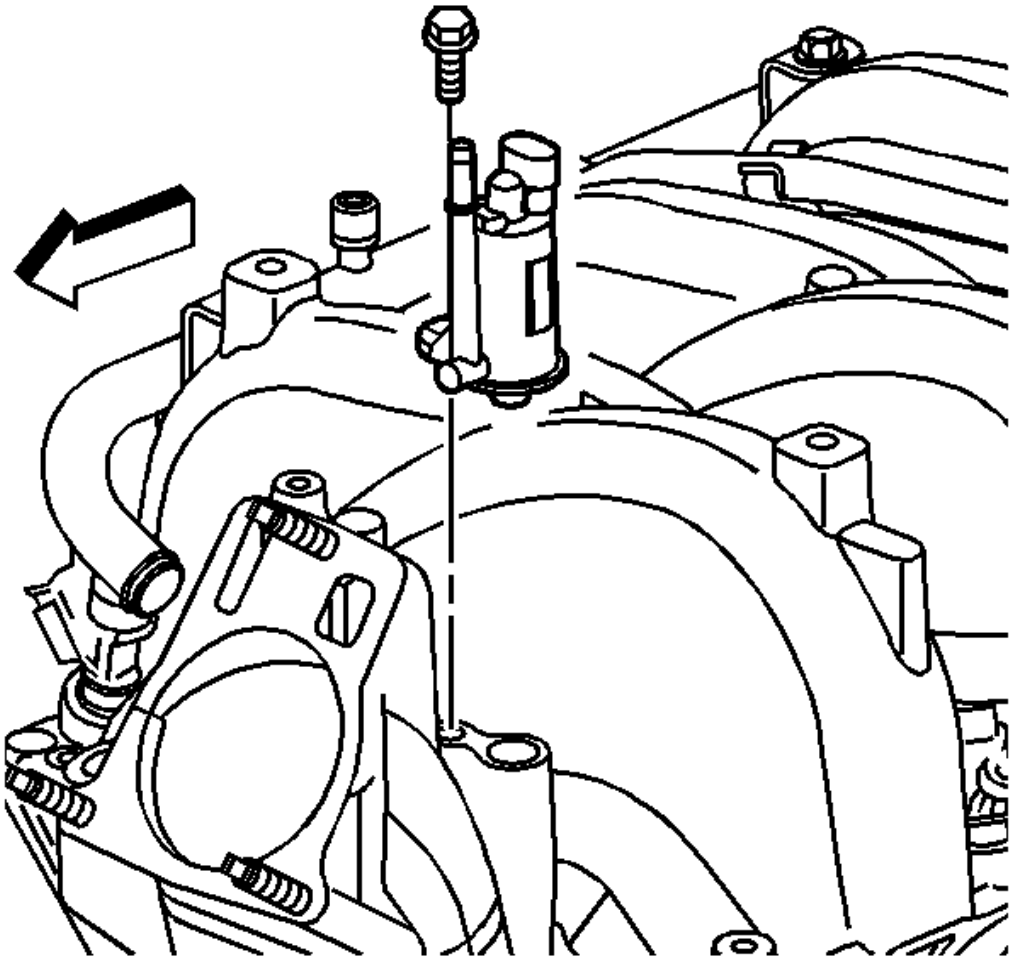

Fig. 442: View Of EVAP Purge Valve
Courtesy of GENERAL MOTORS CORP.

1. Apply a very light film of clean engine oil to the evaporative emission (EVAP) purge valve O-ring seal.
2. Install the EVAP purge valve.

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3. Apply thread sealer GM P/N 12345493, (Canadian P/N 10953488), or equivalent to the threads of the EVAP purge valve bolt.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the EVAP purge valve bolt.

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

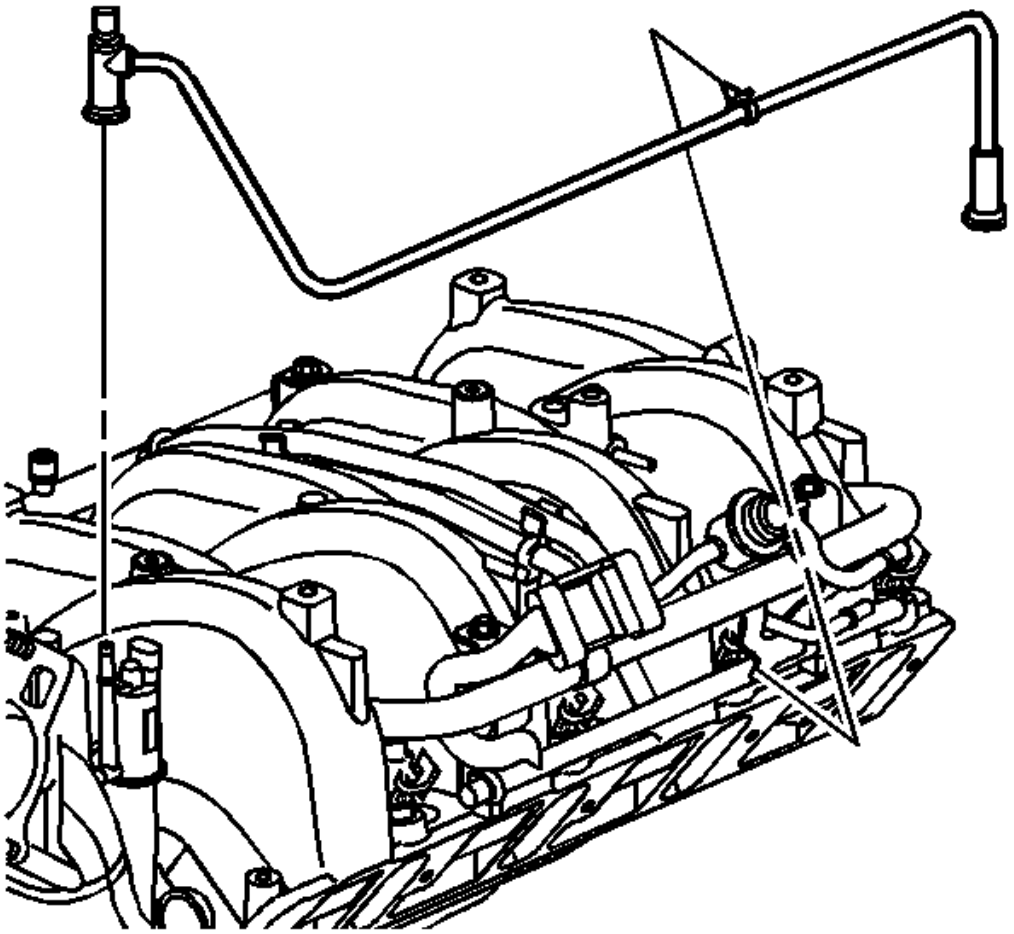

Fig. 443: View Of EVAP Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the EVAP tube.

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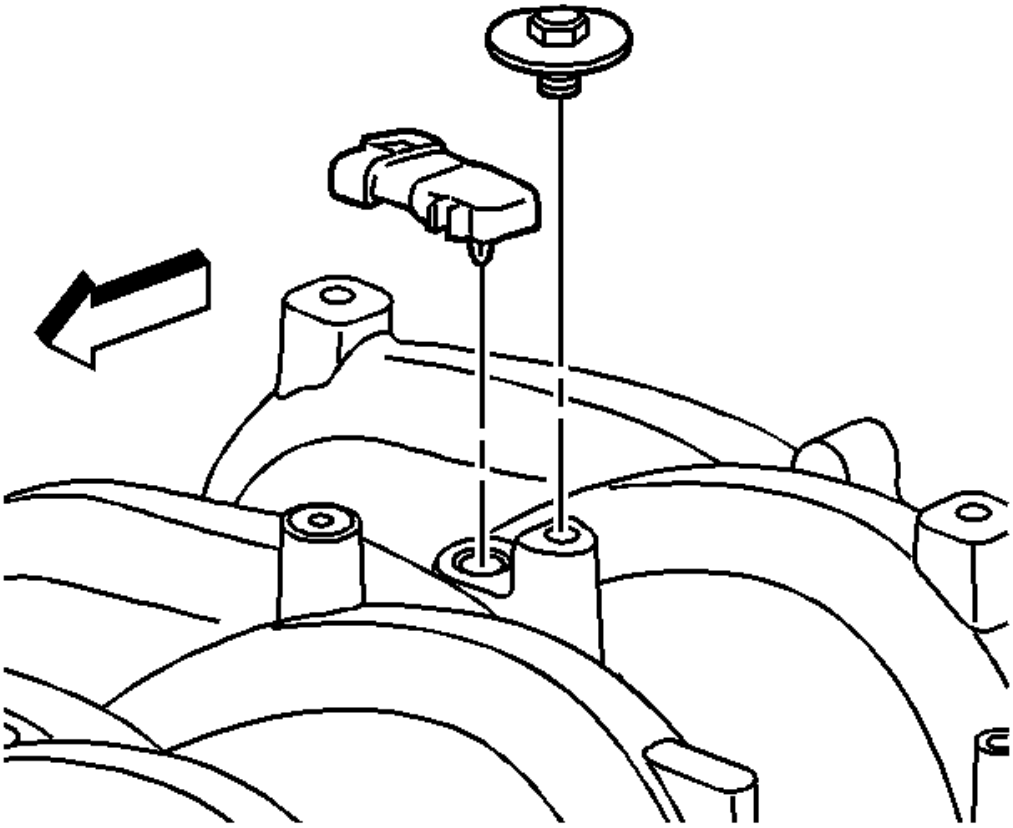

Fig. 444: View Of MAP Sensor & Grommet
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Lubricate the port of the MAP sensor with clean engine oil. Avoid dipping the sensor port directly into the lubricant or using a solid type of lubricant, as they may block the vacuum port signal.

6. Install the manifold absolute pressure (MAP) sensor.
7. Install the MAP sensor bolt.

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

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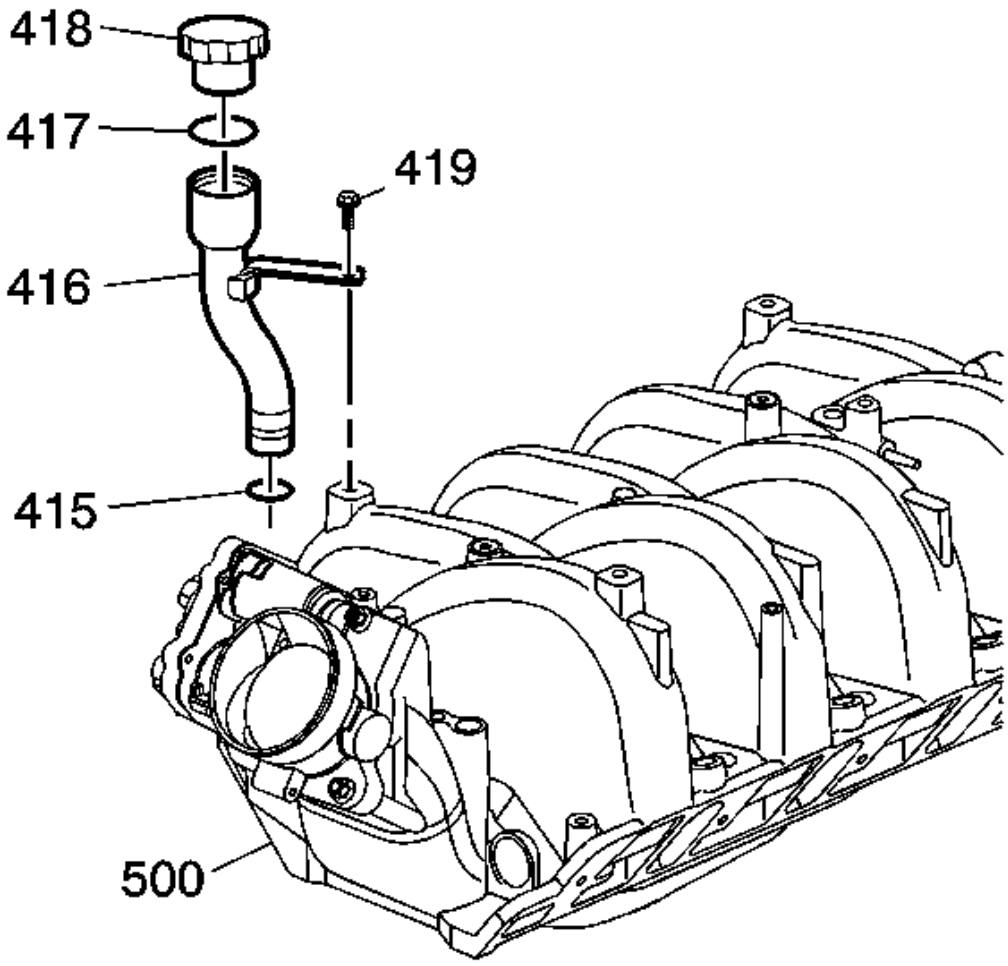

Fig. 445: View Of Oil Fill Tube & Components
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the O-ring seal (415) of the oil fill tube with clean engine oil.
9. Install the oil fill tube (416).
10. Install the oil fill tube bolt (419).

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

11. Install the oil fill cap (418).

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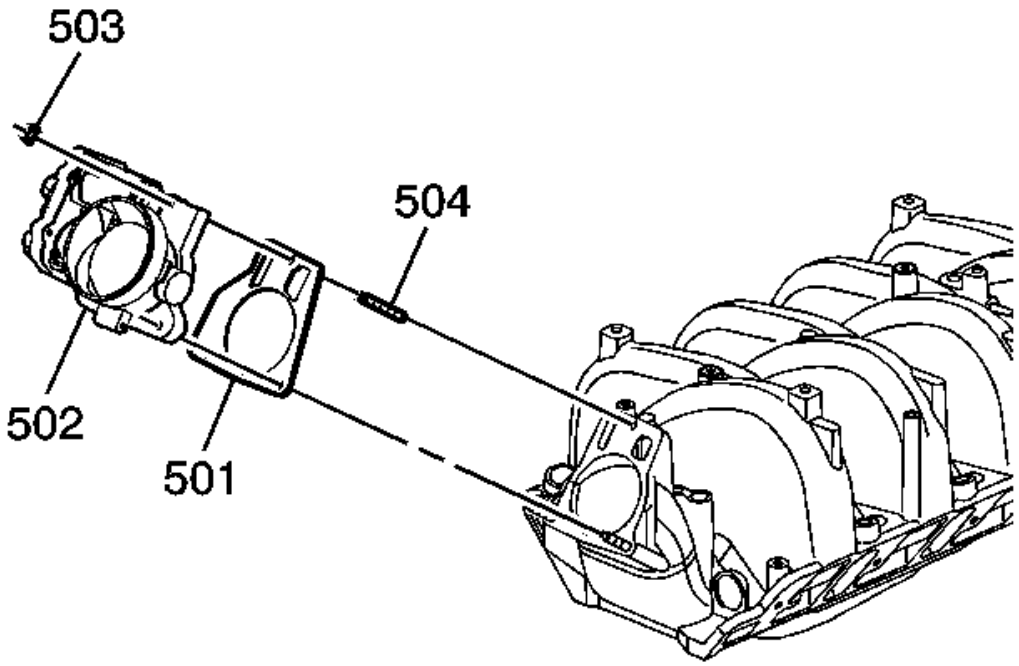

Fig. 446: View Of Throttle Body, Nuts, Studs & Gasket
Courtesy of GENERAL MOTORS CORP.

12. Install the throttle body gasket (501).
13. Install the throttle body (502).
14. Install the throttle body nuts (503).

Tighten: Tighten the throttle body nuts to 10 N.m (89 lb in).

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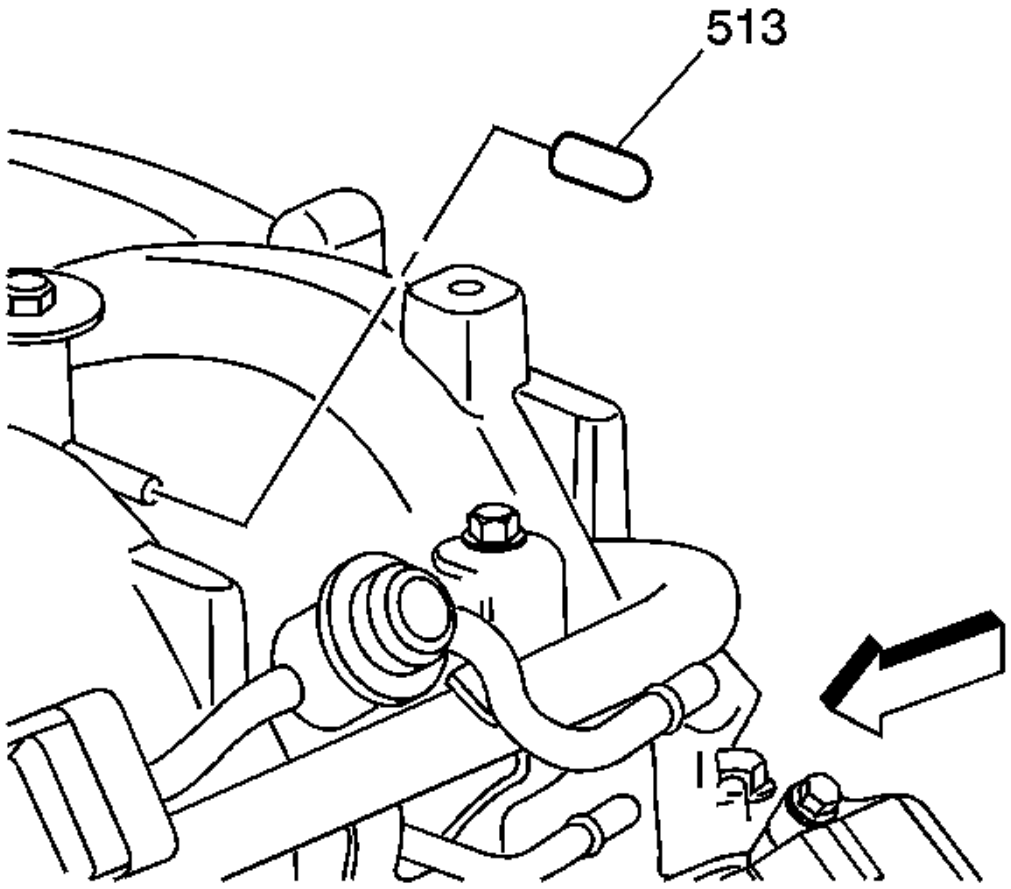

Fig. 447: View Of Vacuum Plug
Courtesy of GENERAL MOTORS CORP.

15. Install the vacuum plug (513).

Exhaust Manifold Cleaning and Inspection

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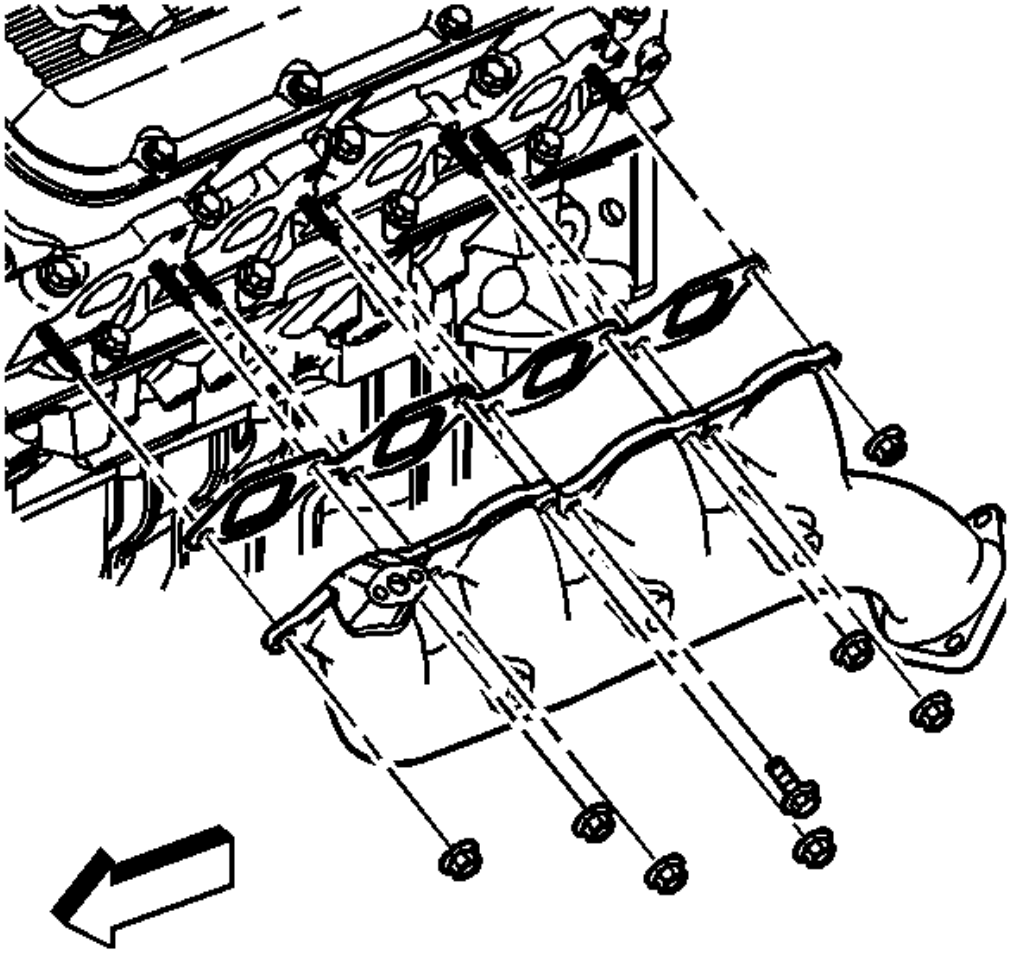

Fig. 448: View Of Left Exhaust Manifold, Gasket, Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

1. Clean the exhaust manifolds in solvent.

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

2. Dry the components with compressed air.
3. Inspect the exhaust manifolds for the following:
    - Damage to the gasket sealing surfaces
    - Damage to the exhaust manifold studs

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- Broken or damaged heat shields
- Cracks in the exhaust manifold
- Restrictions within the exhaust passages

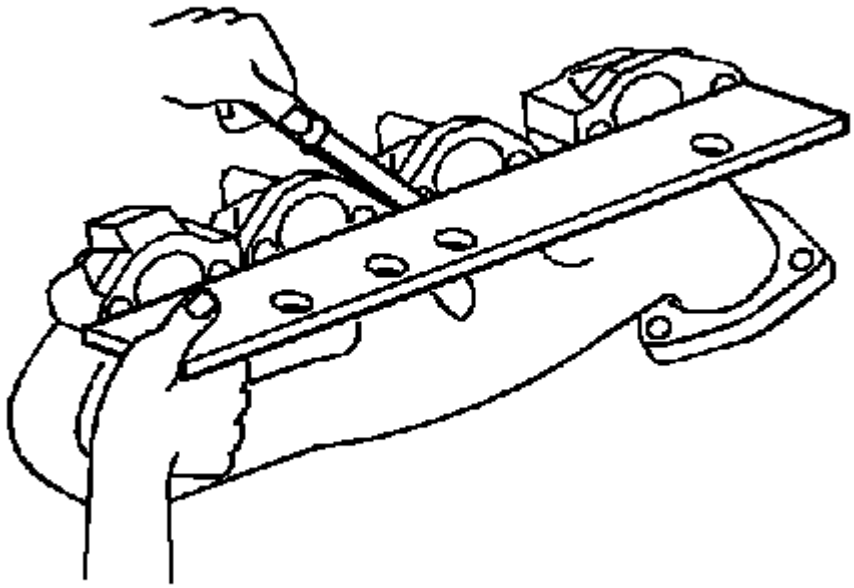

Fig. 449: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS CORP.

4. Measure the alignment or surface flatness of the exhaust manifold flanges, using a straight edge and a feeler gage. Exhaust manifold surface flatness must not exceed 0.254 mm (0.01 in).
5. If the surface flatness is not within specifications, the exhaust manifold is warped and must be replaced.

Water Crossover Cleaning and Inspection

Cleaning Procedure

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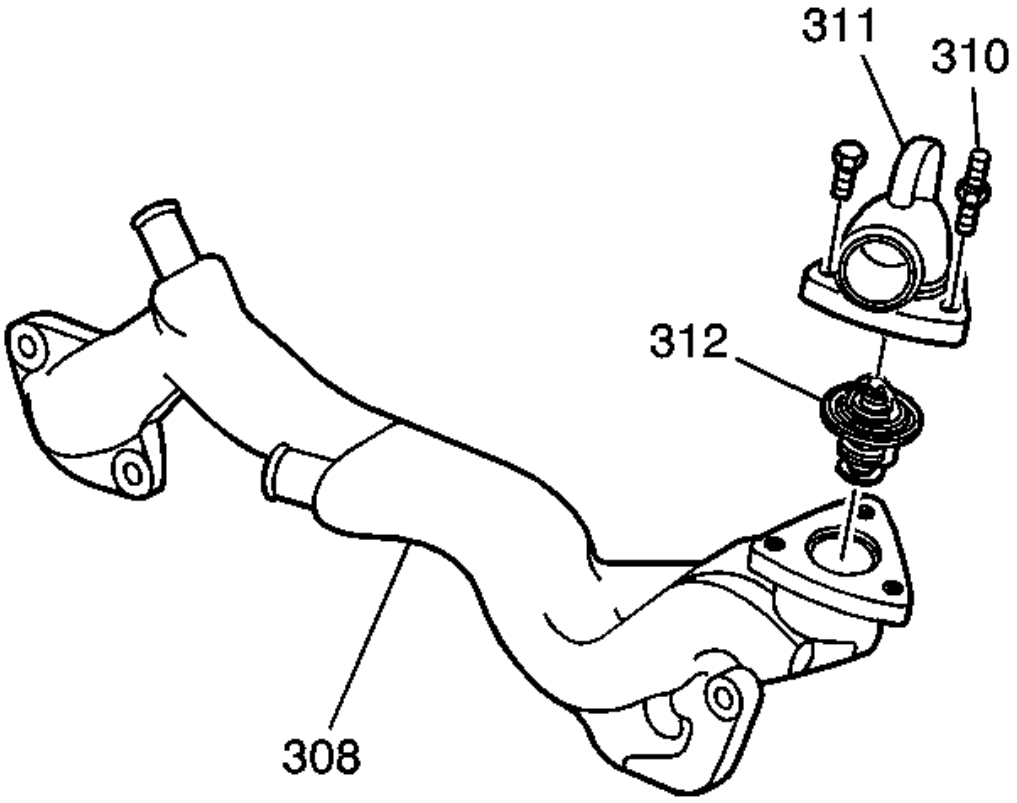

Fig. 450: View Of Water Outlet, Bolts, Thermostat & Coolant Crossover
Courtesy of GENERAL MOTORS CORP.

1. Clean the engine coolant crossover (308) and water outlet (311) in solvent.

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

2. Dry the components with compressed air.

Inspection Procedure

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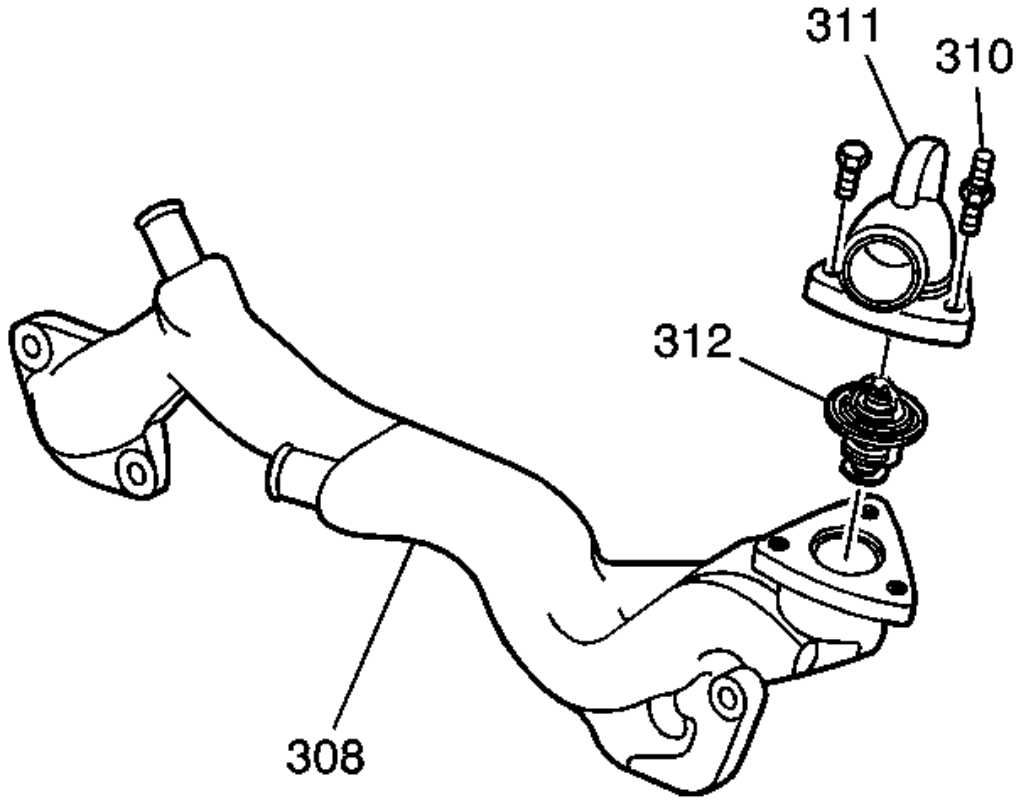

Fig. 451: View Of Water Outlet, Bolts, Thermostat & Coolant Crossover
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine coolant crossover (308) for the following:
   - Corrosion or damage to the gasket sealing surfaces
   - Corrosion or damage to the thermostat bypass hose fitting
   - Corrosion or damage to the heater hose fitting
   - Corrosion or damage to the threads of the water outlet
2. Inspect the water outlet (311) for corrosion or damage.

Water Pump Cleaning and Inspection

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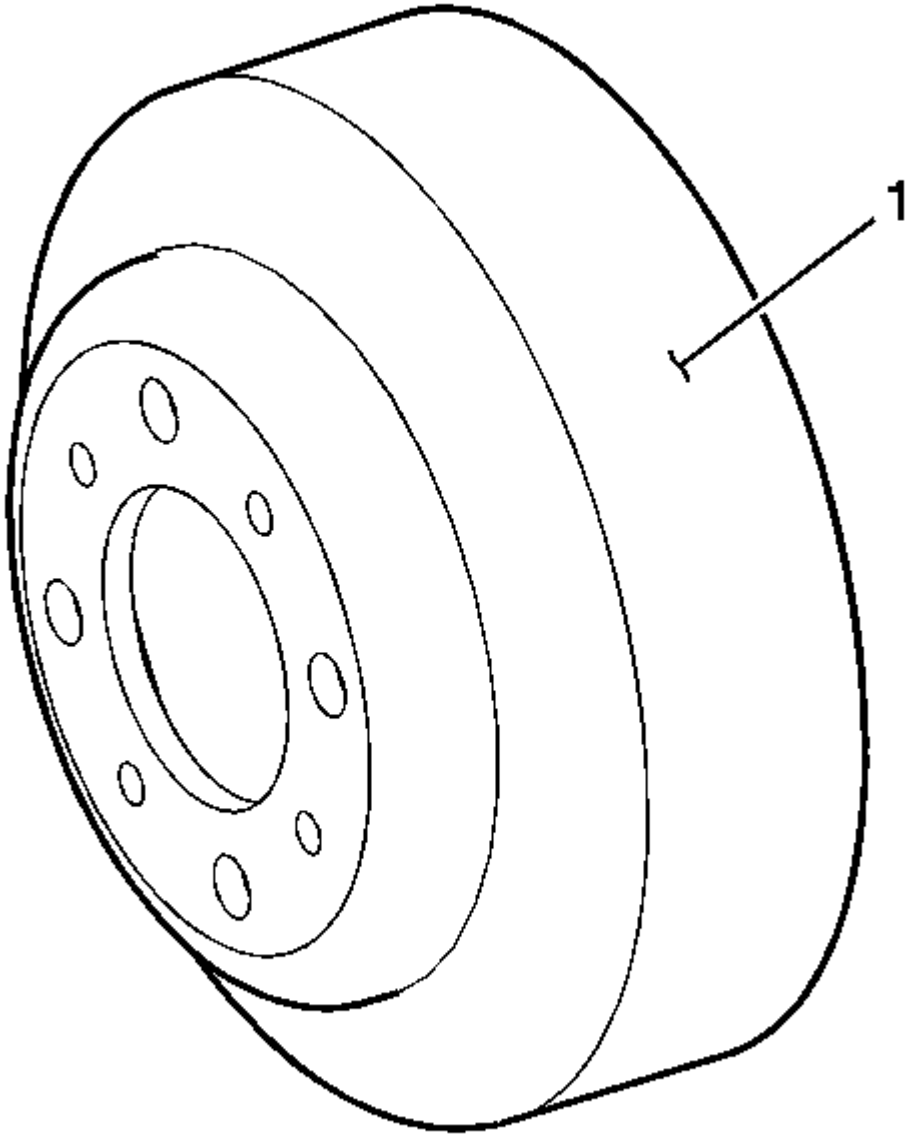

Fig. 452: Inspecting Water Pump Pulley
Courtesy of GENERAL MOTORS CORP.

1. Inspect the water pump pulley for damage at the belt contact area and the pulley-to-water pump mounting surface.

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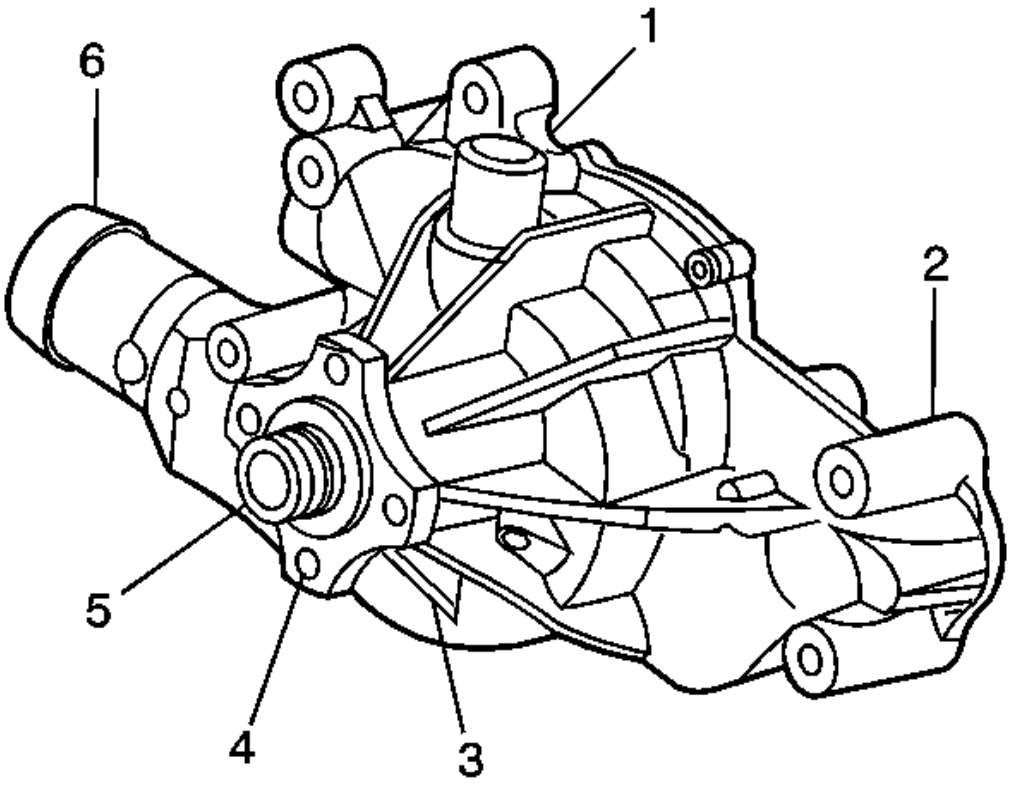

Fig. 453: View Of Water Pump Components
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

2. Clean all excess dirt and debris from the water pump housing.
3. Inspect the water pump for the following:
   - Leakage at the hose fitting (1)
   - Leakage at the water pump weep hole (3)

     A stain around the weep hole is acceptable. If leakage occurs, dripping with the engine running and the cooling system pressurized, replace the water pump.

   - Gasket sealing surfaces (2) for excessive scratches or gouging
   - Restrictions within the internal coolant passages (6)

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- Excessive side-to-side play in the pulley shaft

  If the shaft end play exceeds 0.381 mm (0.015 in), replace the water pump.

- Rotate the pump shaft by hand and inspect for roughness of operation
  - If the hub wobbles, is noisy or feels rough when rotated, replace the water pump.
  - The shaft and fan hub must turn straight and smoothly.
- Damage to threaded bolt holes (4)
- Damage to the fan clutch mounting threads (5)

Thread Repair

Tools Required

J 39345 Thread Repair Kit. See **Special Tools and Equipment**.

The following procedure is used to accomplish proper and durable thread repairs in the cylinder head and the cylinder block, using the **J 39345** . See **Special Tools and Equipment**.

IMPORTANT: Take appropriate precautions to assure that machining chips will not remain inside the engine. For example, block all intake passages, oil drainback holes and exhaust passages with a towel or tape before performing thread repairs.

1. Select the proper size drill as indicated in the schematic charts found in Thread Repair Specifications for the hole being repaired.
2. Drill out the damaged threads to the original depth or completely through for through holes.

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

3. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
4. Select the correct size tap, using the appropriate chart for the hole being repaired.
5. Coat the tap and the hole with spray machining oil.
6. Tap the hole to the original depth. In order to clean the threads, reverse the rotation of the tap periodically.
7. Use solvent to clean out all of the chips.
8. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
9. Tap the hole again to clean the threads. The tap should thread in with little resistance.

IMPORTANT: Make sure all of the chips are cleared from the hole.

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10. Use solvent to clean out all of the chips.
11. Apply compressed air with a shop towel wrapped around the air spout, in order to retain the chips forced out of the hole.
12. Use a flashlight to confirm that all of the chips are removed from the hole.
13. Continue to clean the hole until all of the chips are cleared.
14. Install the heli-coil insert as follows:
    1. In order to determine the correct size installation tool and length insert, refer to the appropriate picture and chart.
    2. Screw the insert on the mandrel of the installation tool until the driving tang is fully engaged in the driving contour.
    3. Coat the insert with spray machining oil.
    4. Install the insert as follows:
        1. Slide the prewinder over the mandrel and insert.
        2. Rotate the mandrel clockwise until 1 or 2 threads of the insert are threaded into the prewinder.
        3. Place the insert in position on the threaded hole being repaired.
        4. Rotate the mandrel clockwise until the insert is flush with the top surface of the threaded hole.
        5. Remove the prewinder except when repairing cylinder head bolts.
        6. Continue to install the insert until reaching the original thread depth.
        7. Remove the mandrel.
    5. Remove the driving tang from the thread insert as follows. The tang must be removed in order to allow passage of the fastener through the insert.
        1. Place the square end of the punch, no chamfer, on the tang after installation.
        2. Strike the punch sharply with the hammer. The tang will break off at the notch.
15. Clean the hole using compressed air. Take appropriate steps to assure that chips are not blown into the engine.

Service Prior to Assembly

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

Engine Prelubing

Tools Required

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J 45299 Engine Preluber

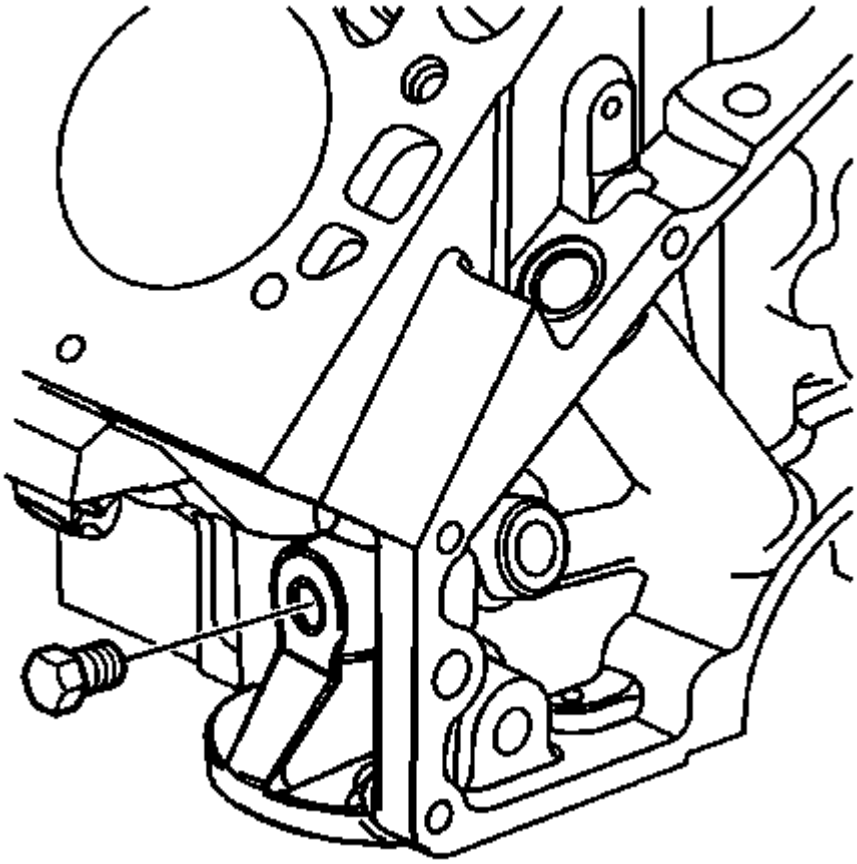

Fig. 454: View Of Engine Block Left Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the engine oil filter, fill with clean engine oil.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter.

   Tighten: Tighten the oil filter to 38 N.m (28 lb ft).

3. Locate the oil gallery plug on the left side of the engine block above the oil filter housing.
4. Install the 1/4 - 18 adapter P/N 509373.

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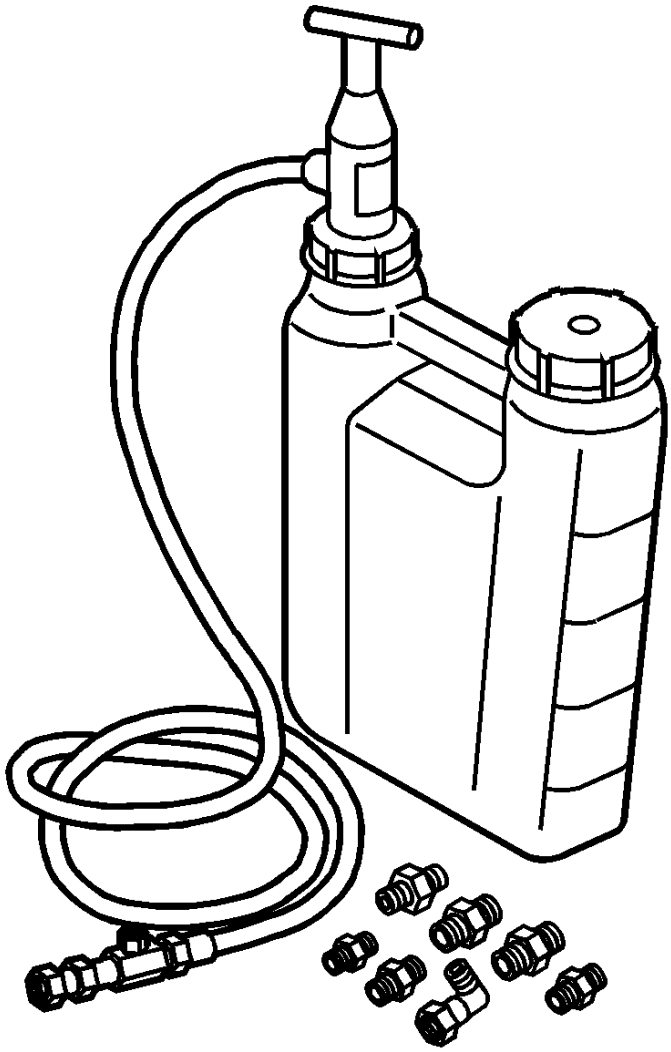

Fig. 455: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

5. Install the flexible hose to the adapter and open the valve.
6. Pump the handle on the **J 45299** in order to flow a minimum of 1-1.9 liters (1-2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
7. Close the valve and remove the flexible hose and adapter from the engine.
8. Install the gallery plug to the engine.

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

9. Top-off the engine oil to the proper level.

Engine Block Plug Installation

Tools Required

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J 41712 Oil Pressure Switch Socket

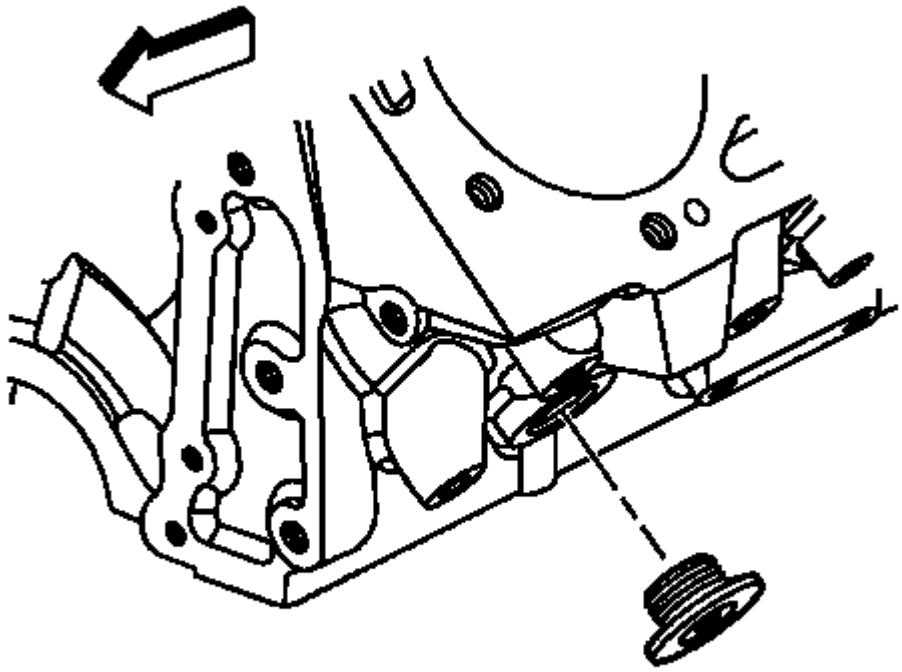

Fig. 456: View Of Engine Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

1. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the engine coolant drain hole plug.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine coolant drain hole plug into the block.

Tighten: Tighten the engine coolant drain hole plug to 60 N.m (40 lb ft).

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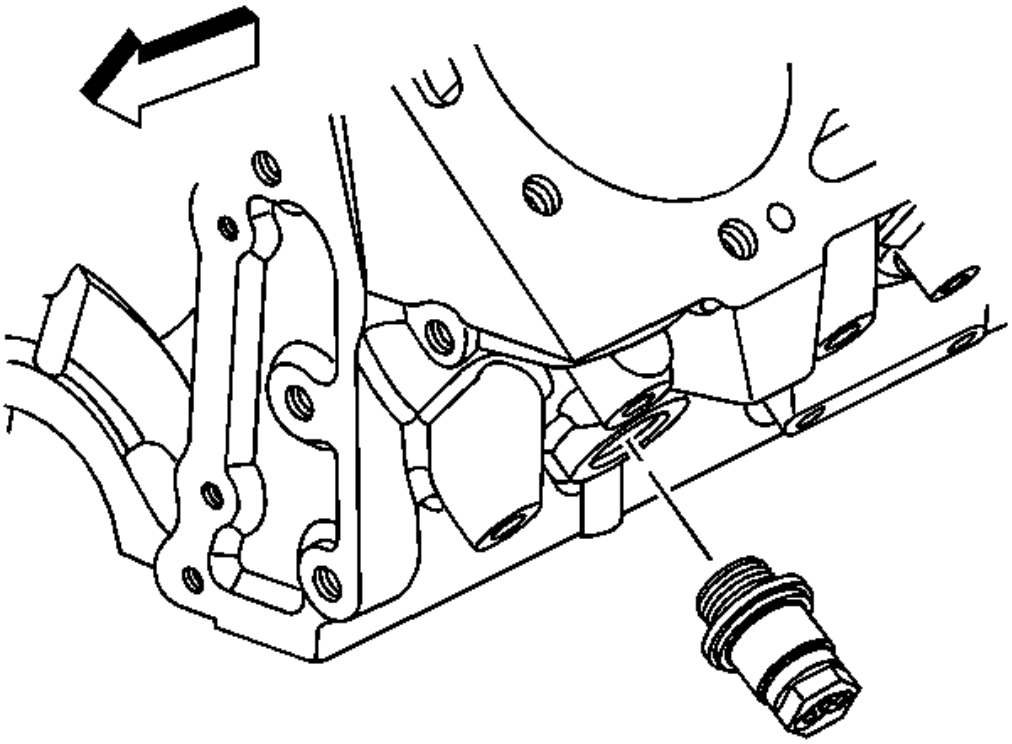

Fig. 457: View Of Engine Block Coolant Heater
Courtesy of GENERAL MOTORS CORP.

3. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the engine block coolant heater, if applicable.
4. Install the engine block coolant heater into the block.

   Tighten: Tighten the engine block coolant heater to 50 N.m (37 lb ft).

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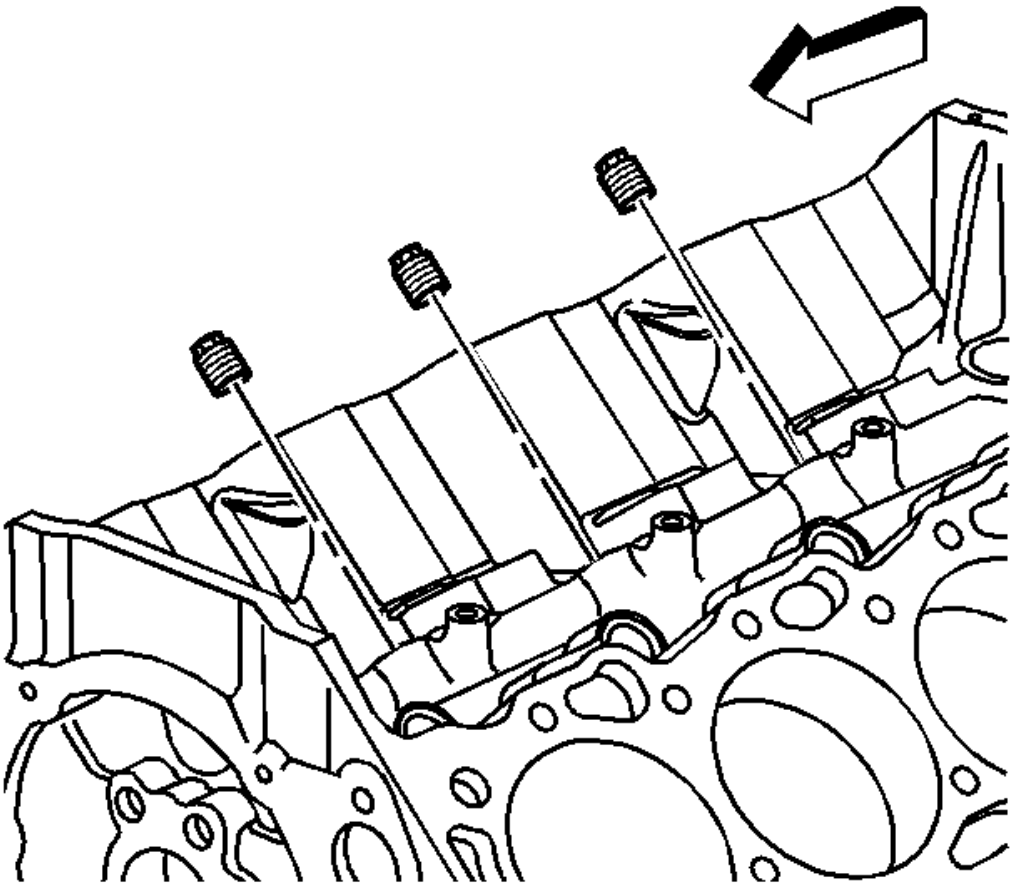

Fig. 458: View Of Top Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

5. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the oil gallery plugs.
6. Install the engine block top oil gallery plugs.

   Tighten: Tighten the top oil gallery plugs to 20 N.m (15 lb ft).

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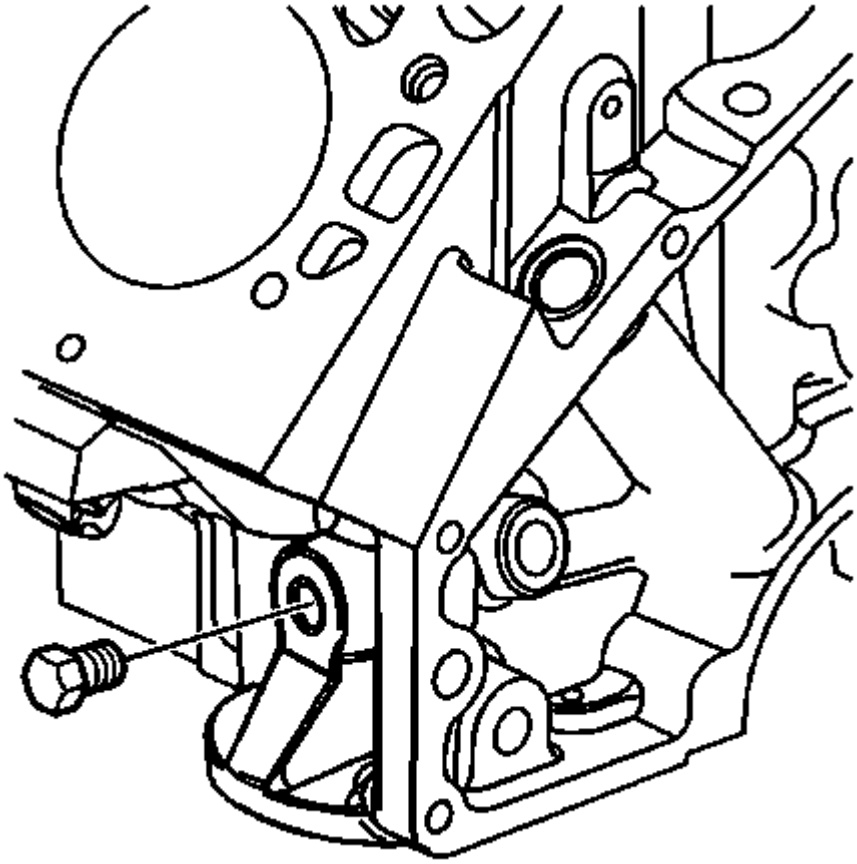

Fig. 459: View Of Engine Block Left Oil Gallery Plug
Courtesy of GENERAL MOTORS CORP.

7. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the left side oil gallery plug.
8. Install the engine block left side oil gallery plug.

   Tighten: Tighten the left side oil gallery plug to 30 N.m (22 lb ft).

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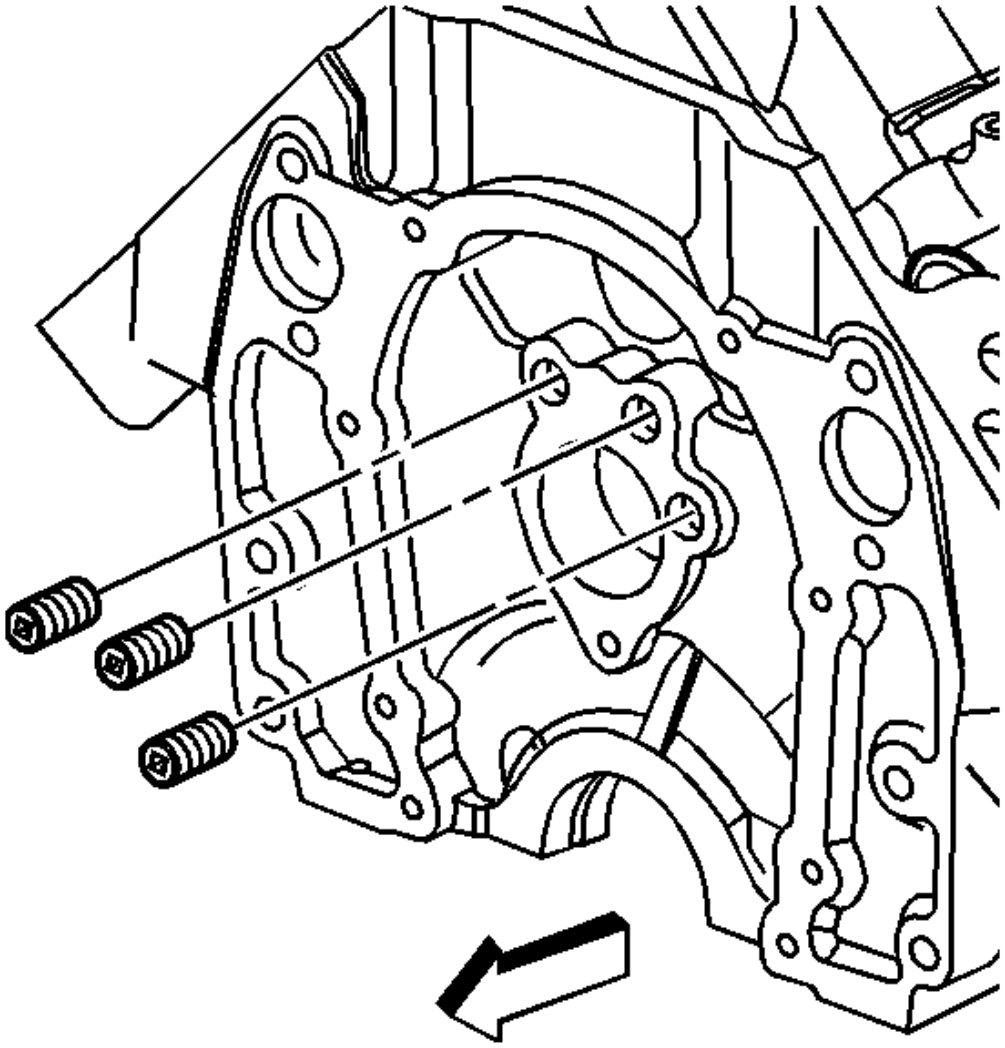

Fig. 460: View Of Front Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

9. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the front oil gallery plugs.
10. Install the front oil gallery plugs.

Tighten: Tighten the front oil gallery plugs to 30 N.m (22 lb ft).

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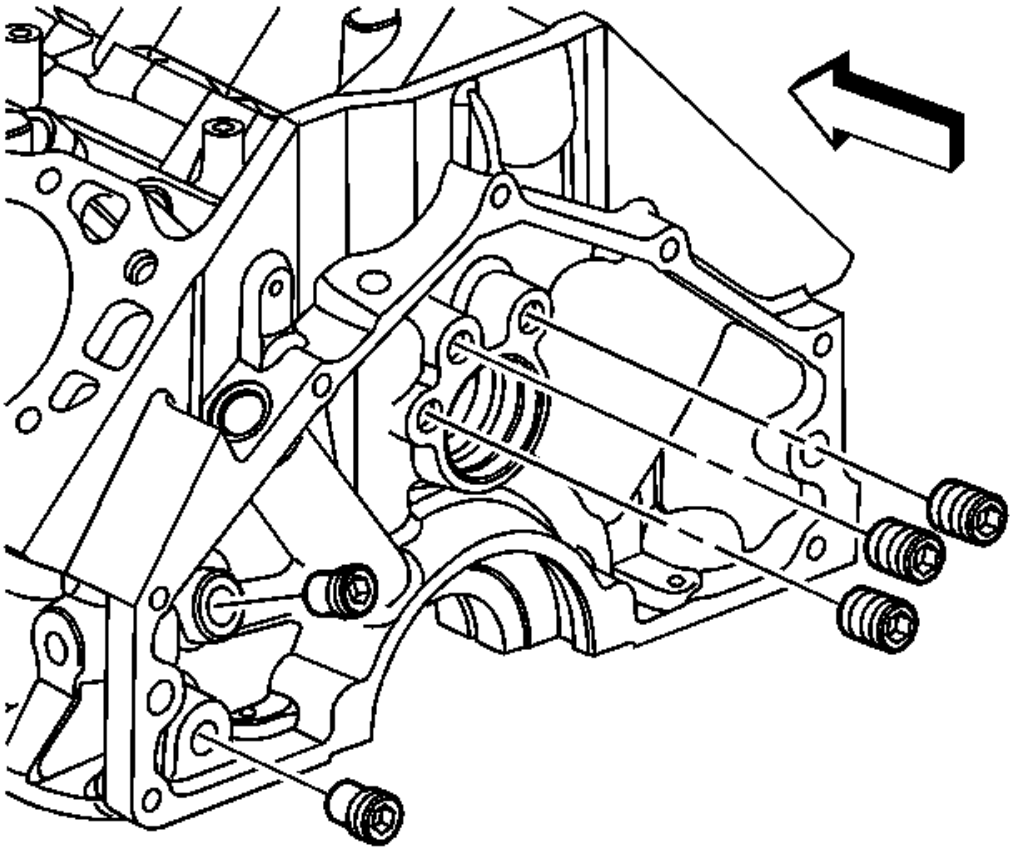

Fig. 461: View Of Rear Oil Gallery Plugs
Courtesy of GENERAL MOTORS CORP.

11. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the rear oil gallery plugs.
12. Install the rear oil gallery plugs.

    Tighten: Tighten the rear oil gallery plugs to 20 N.m (15 lb ft).

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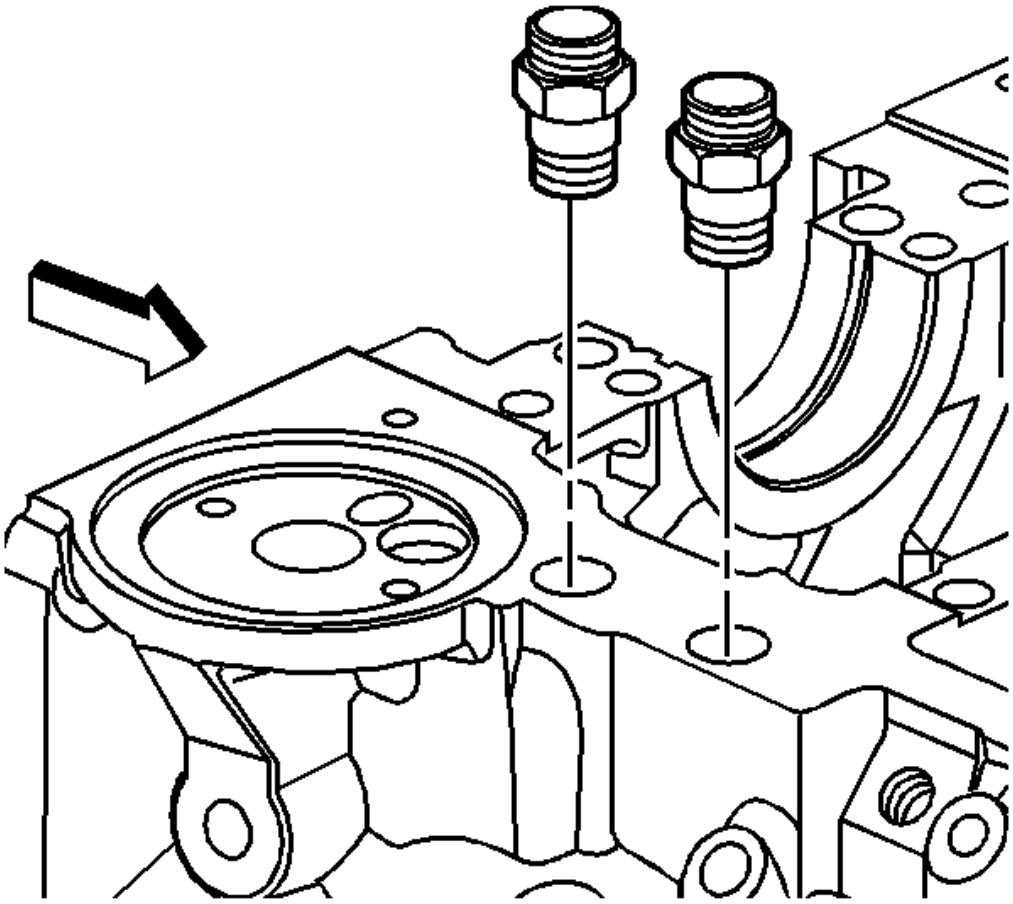

Fig. 462: View Of Engine Block Oil Cooler Hose Fittings
Courtesy of GENERAL MOTORS CORP.

13. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the engine block oil cooler hose fittings.
14. Install the engine block oil cooler hose fittings.

    Tighten: Tighten the engine block oil cooler hose fittings to 23 N.m (17 lb ft).

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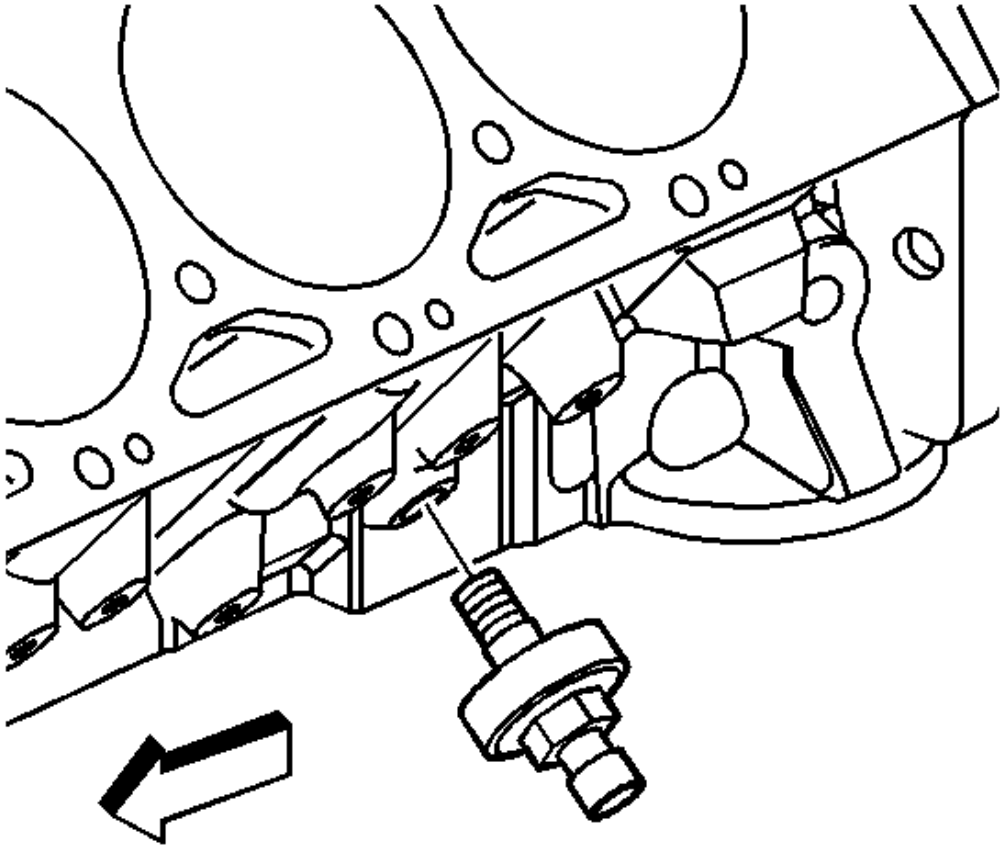

Fig. 463: View Of Left Side Knock Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not overtighten the knock sensor.

15. Install the left knock sensor to the engine block.

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

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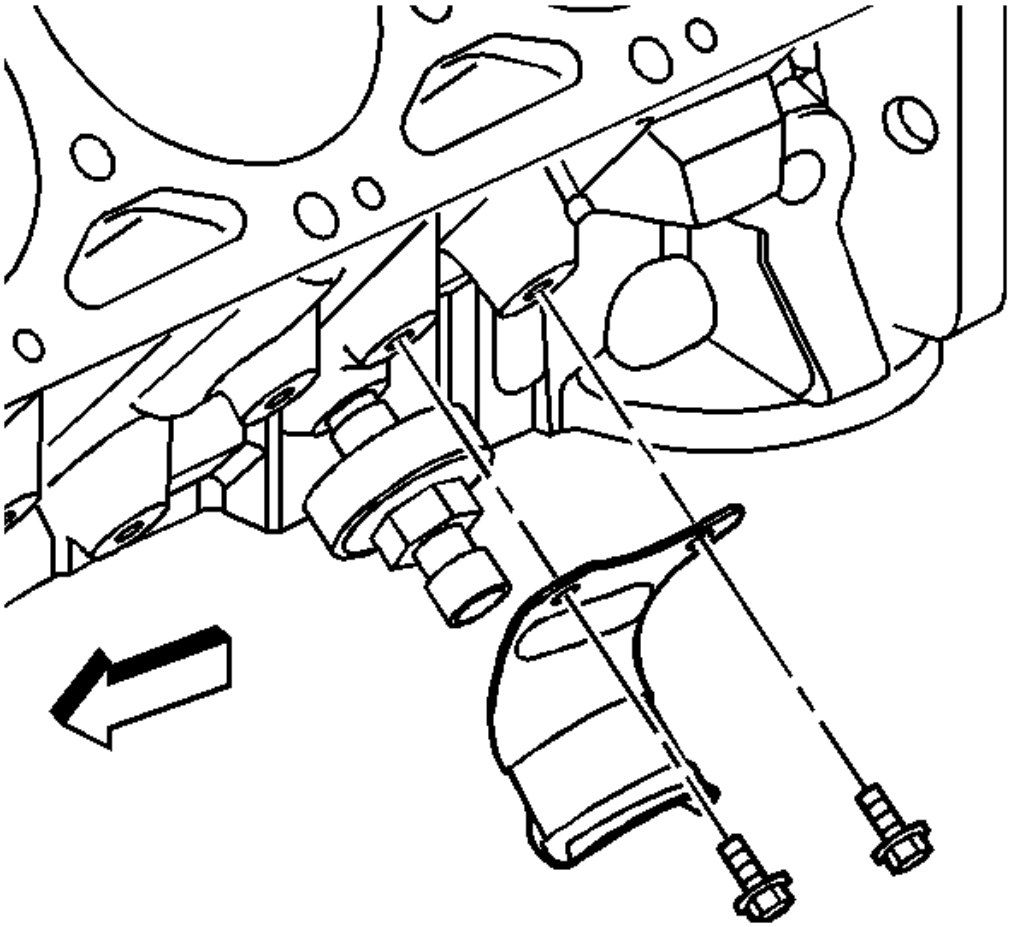

Fig. 464: View Of Left Side Knock Sensor Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

16. Install the left side knock sensor heat shield.
17. Install the left side knock sensor heat shield bolts.

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

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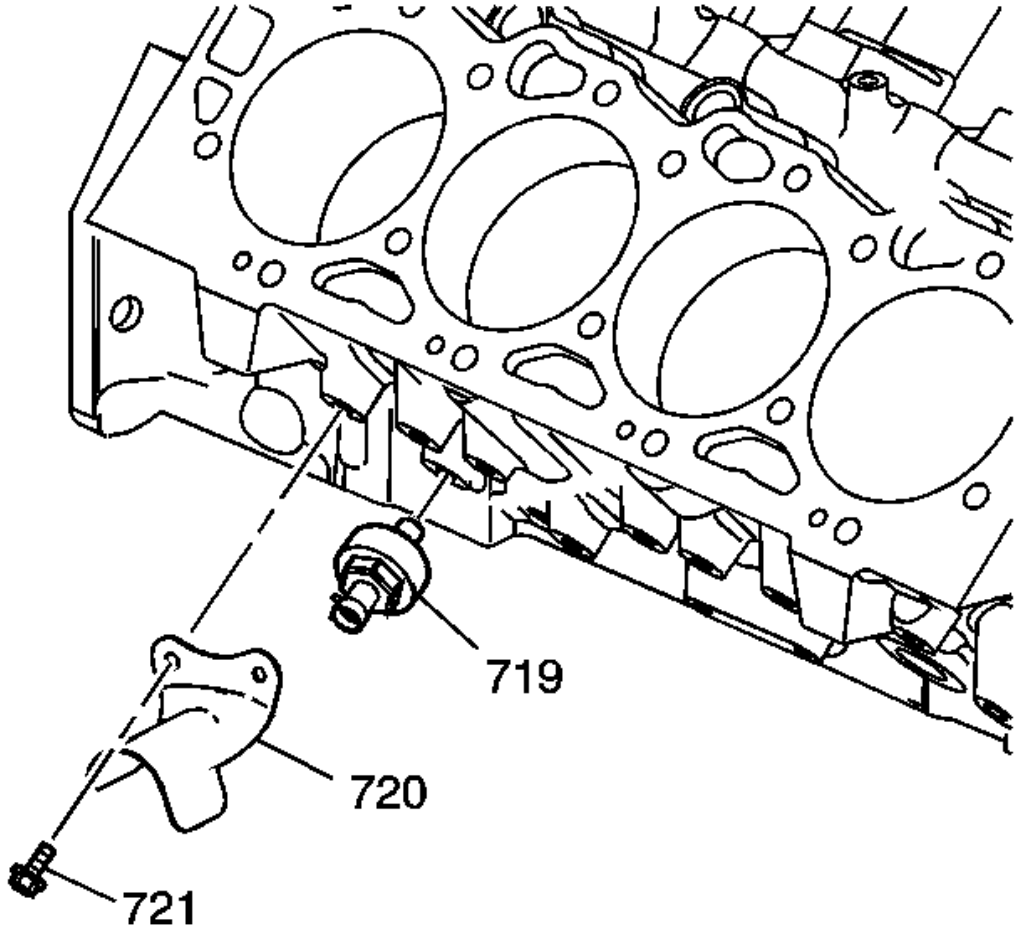

Fig. 465: View Right Side Knock Sensor, Heat Shield & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not overtighten the knock sensor.

18. Install the right knock sensor (719) to the engine block.

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

19. Install the right side knock sensor heat shield (720) and bolts (721).

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

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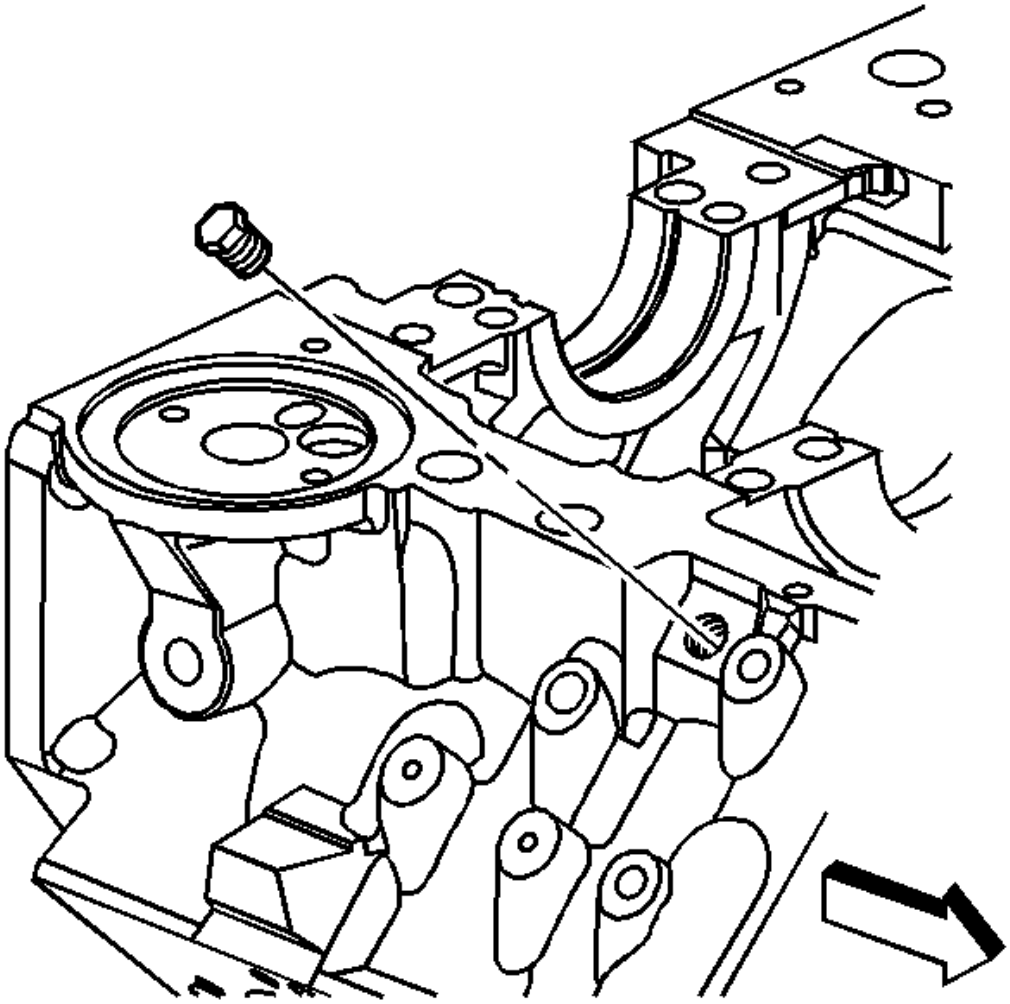

Fig. 466: View Of Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS CORP.

20. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the engine block coolant drain hole plugs.
21. Install the engine block coolant drain hole plugs.

    Tighten: Tighten the coolant drain hole plugs to 30 N.m (22 lb ft).

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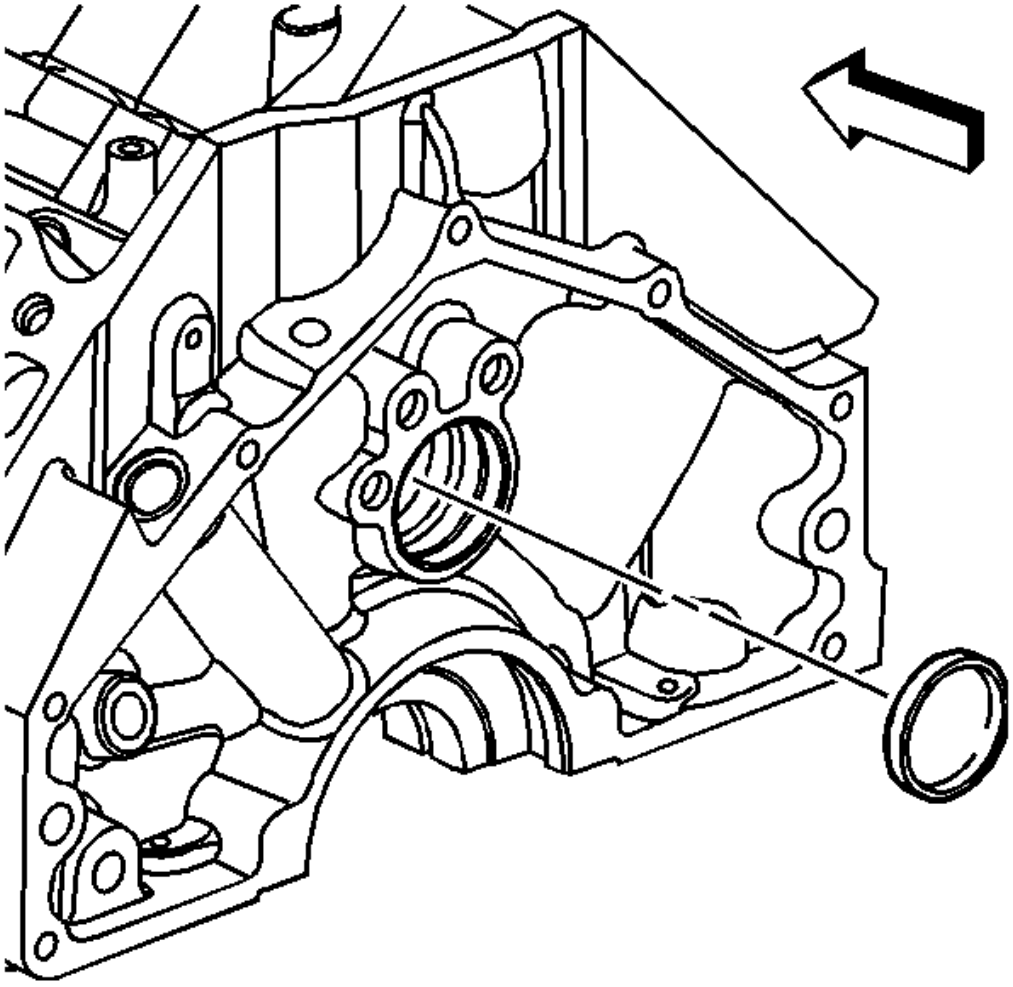

Fig. 467: View Of Camshaft Rear Bearing Hole Plug
Courtesy of GENERAL MOTORS CORP.

22. Apply sealer GM P/N 12377901 (Canadian P/N 10953504), to the outside diameter of the new camshaft rear bearing hole plug.

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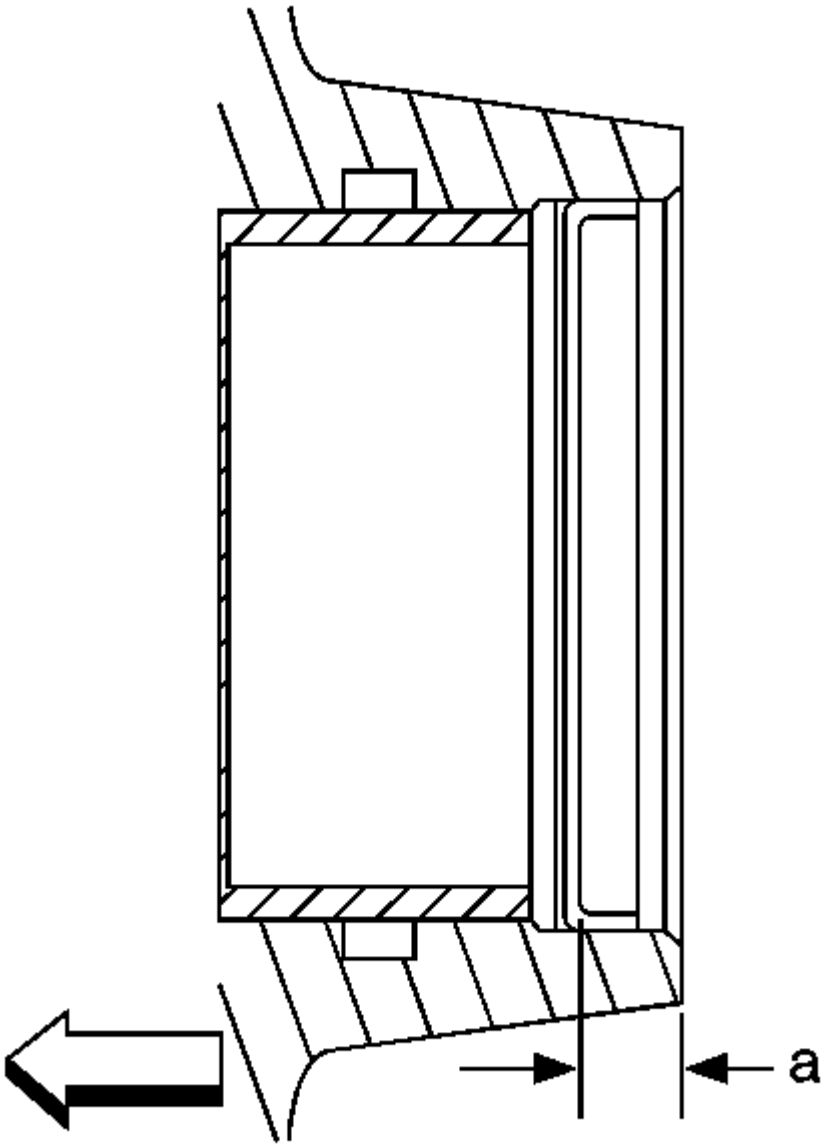

Fig. 468: Installing Camshaft Rear Bearing Hole Plug To Proper Depth
Courtesy of GENERAL MOTORS CORP.

23. Install the NEW camshaft rear bearing hole plug to the proper depth of (a) 7.600-6.200 mm (0.299-0.244 in).

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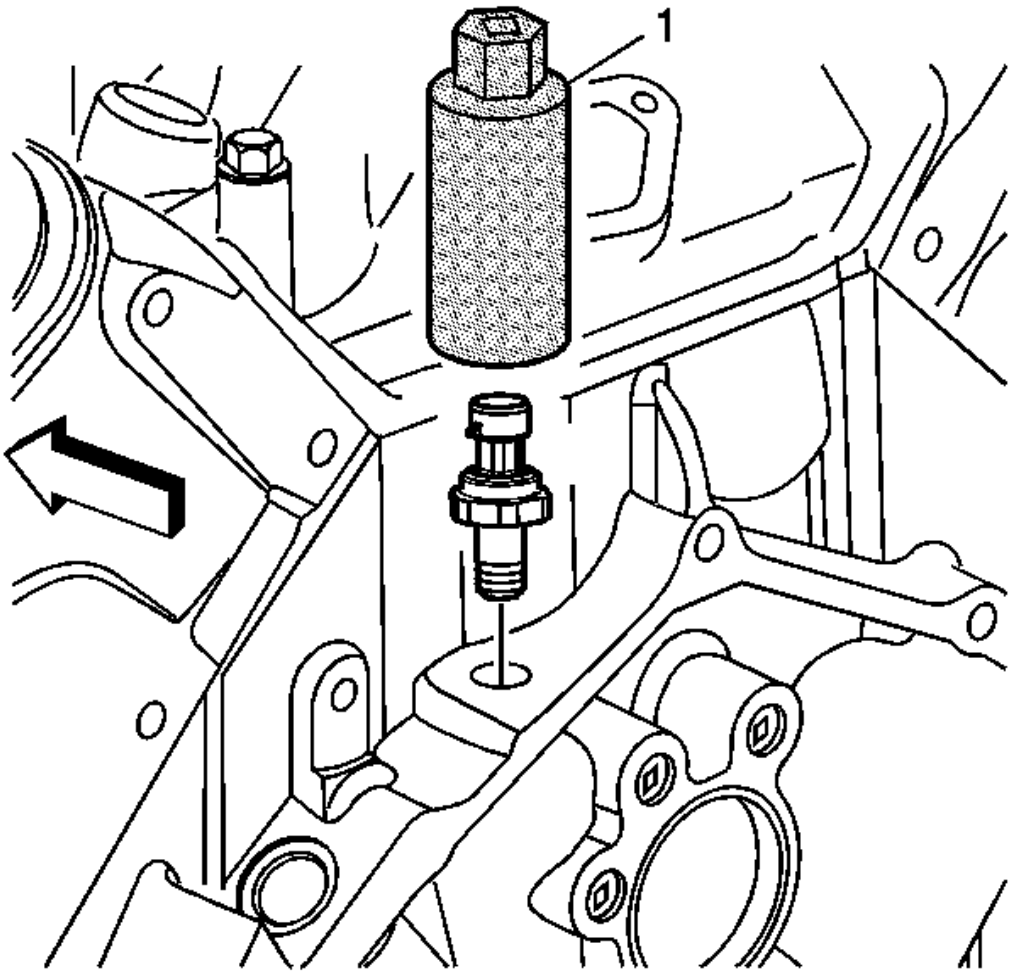

Fig. 469: Removing & Installing Oil Pressure Sensor Using J 41712
Courtesy of GENERAL MOTORS CORP.

24. Apply sealant GM P/N 12346004 (Canadian P/N 10953480), or equivalent to the threads of the oil pressure sensor.
25. Install the oil pressure sensor.

    Tighten: Using the **J 41712** (1), tighten the oil pressure sensor to 30 N.m (22 lb ft).

Oil Filter Adapter Installation

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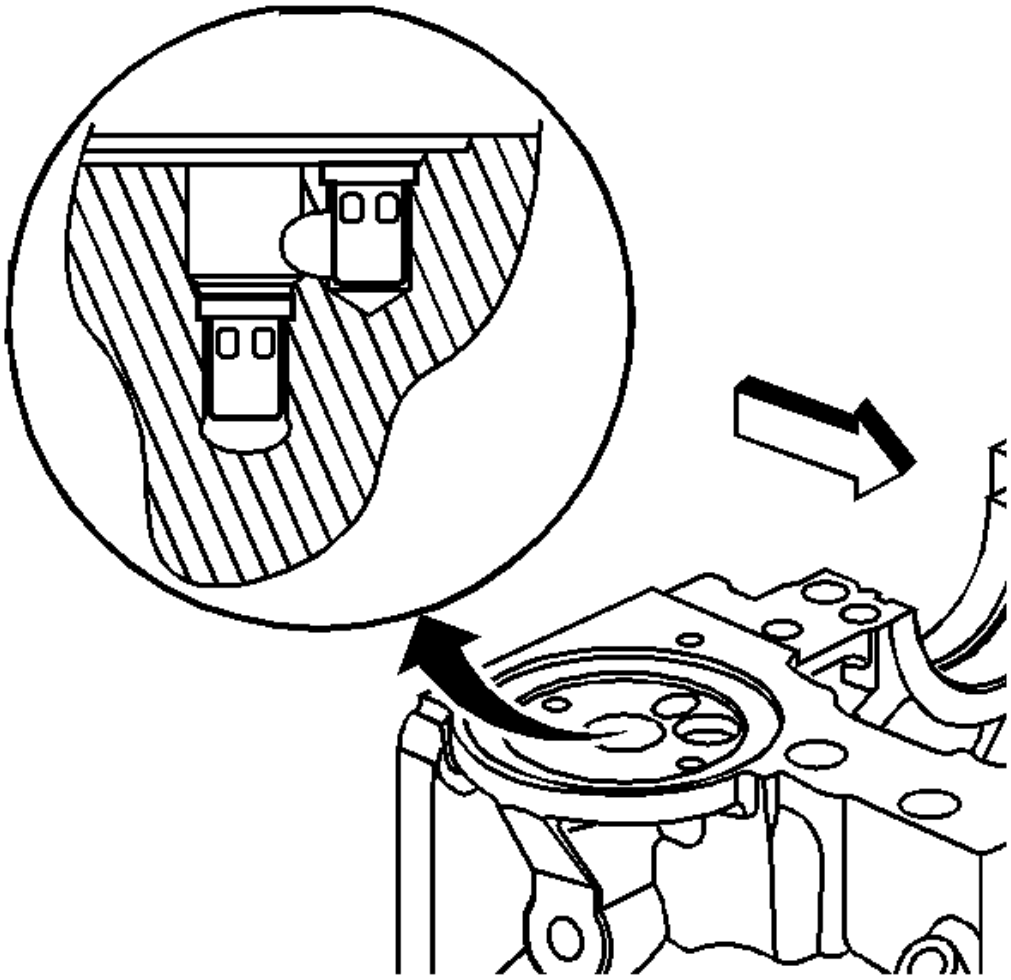

Fig. 470: View Of Tangs On Oil Bypass Valves
Courtesy of GENERAL MOTORS CORP.

1. If removed, install the new oil filter bypass valves. Stake the tangs on the oil filter bypass valves.

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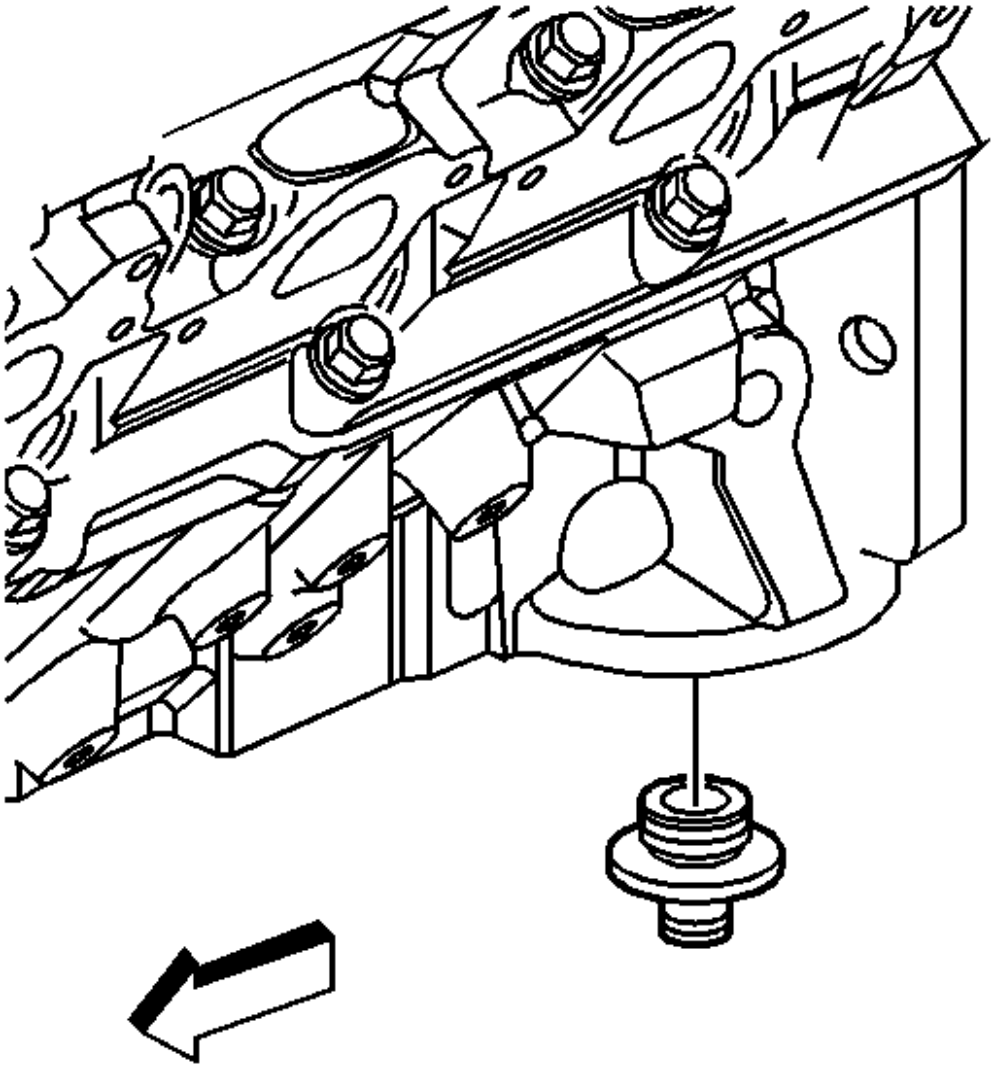

Fig. 471: View Of Oil Filter Fitting
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the oil filter fitting.

   Tighten: Tighten the oil filter fitting to 66 N.m (49 lb ft).

Crankshaft and Bearings Installation

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Tools Required

- **J 8001** Dial Indicator Set
- **J 45059** Angle Meter

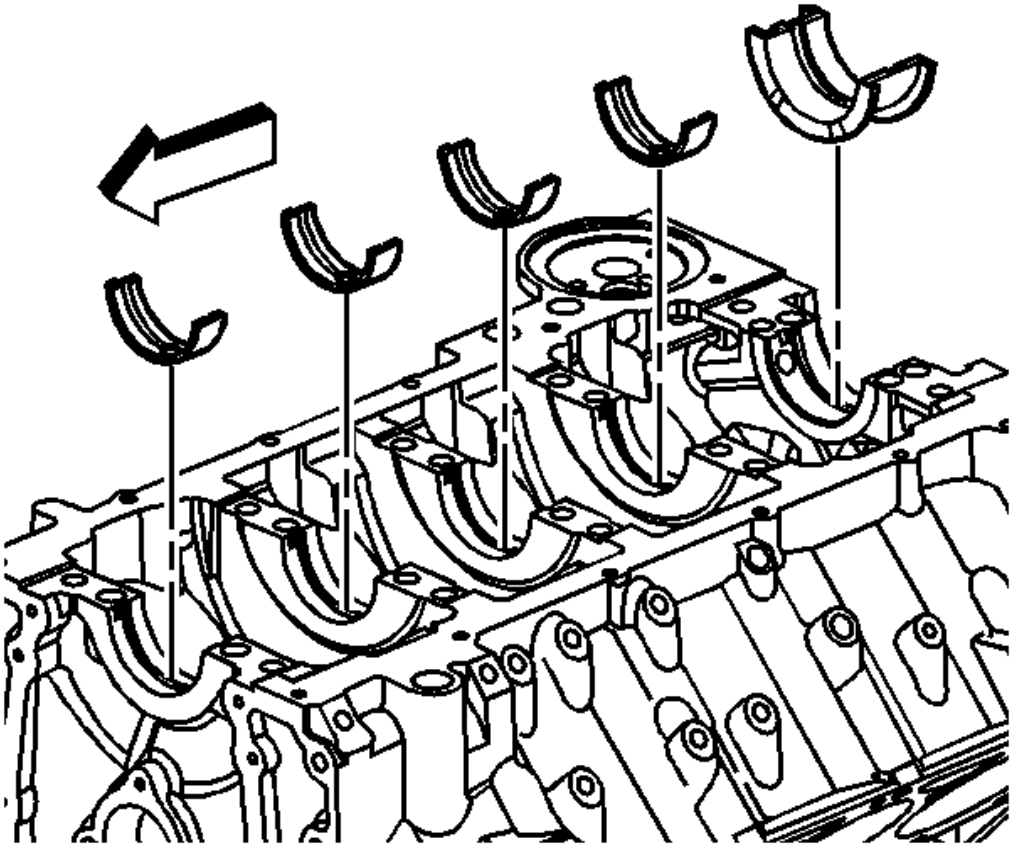

Fig. 472: View Of Crankshaft Upper Bearings
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Lubricate the crankshaft bearings and crankshaft with clean engine oil.**
- **If undersized bearings are used, ensure that the bearings are fitted to the proper journals.**

1. Install the crankshaft upper bearings into the block. Apply clean engine oil to the bearing surfaces.

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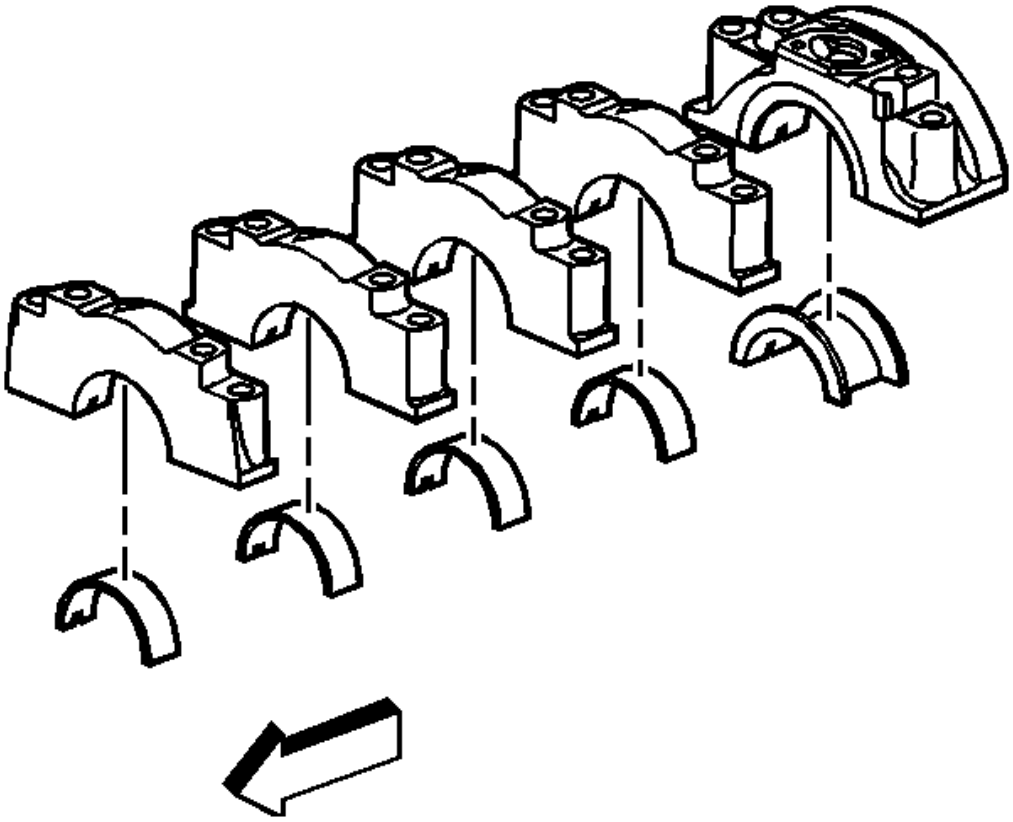

Fig. 473: View Of Crankshaft Lower Bearing & Bearing Caps
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft lower bearings into the crankshaft bearing caps. Apply clean engine oil to the bearing surfaces.

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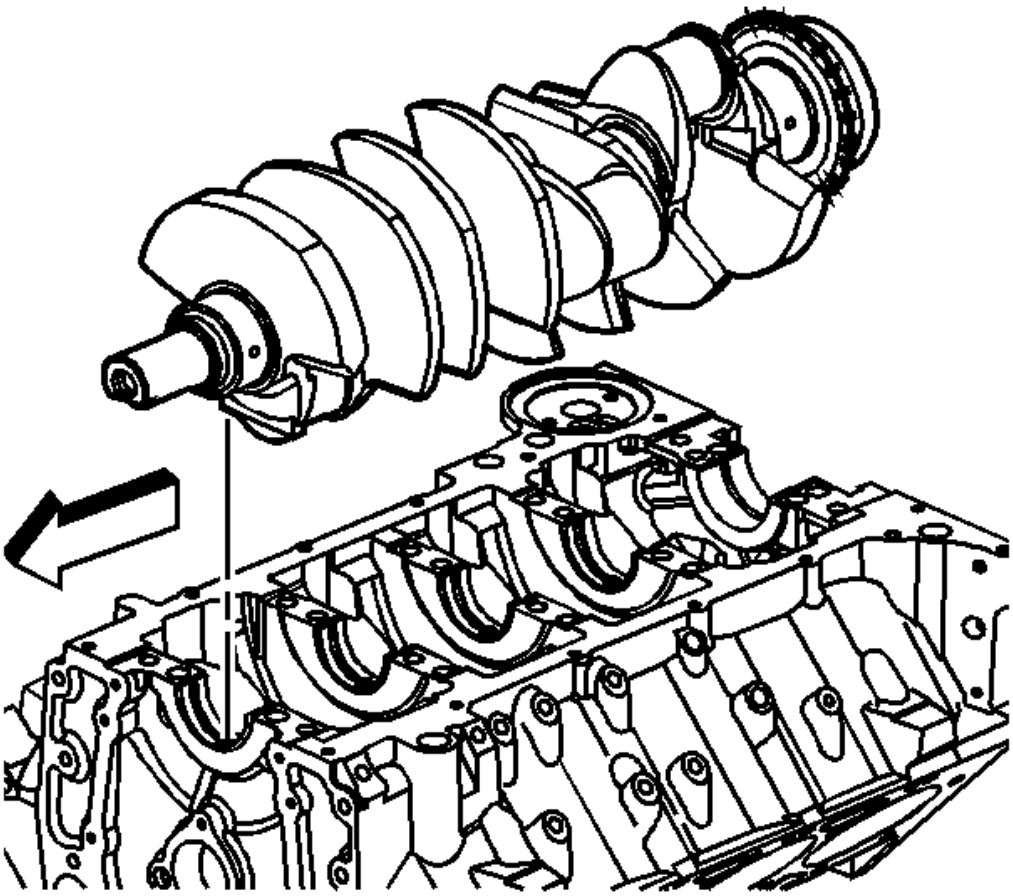

Fig. 474: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to prevent damage to the crankshaft position (CKP) sensor reluctor wheel/ring care must be used when removing or installing this component.

3. Install the crankshaft.

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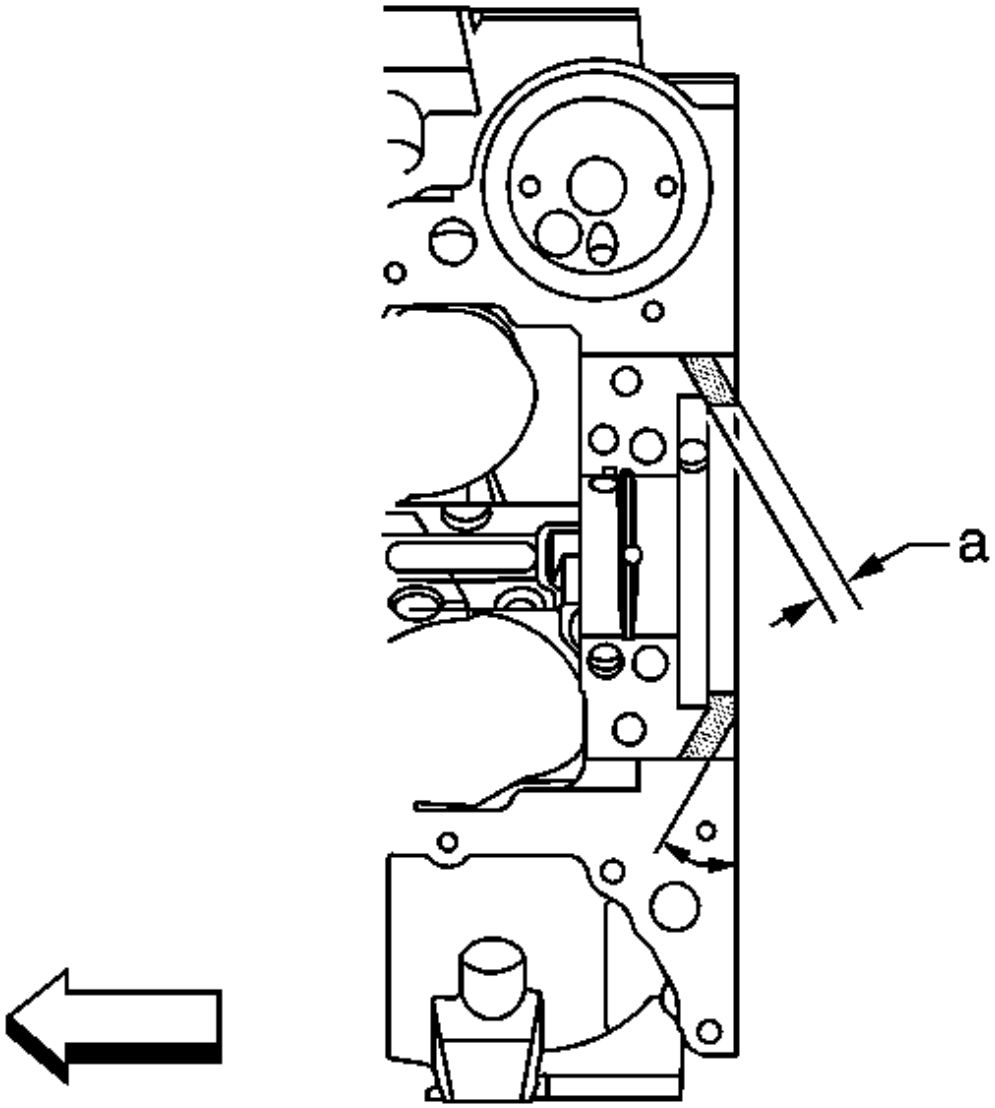

Fig. 475: Applying Sealant To Rear Bearing Cap Sealing Face
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The bearing caps must be seated within 60 minutes of the sealer being applied. The bearing cap fasteners must be tightened within 5 minutes of the bearing caps being installed onto the engine block.

4. Apply a (a) 13 mm (0.500 in) light film of sealant GM P/N 1052942, (Canadian P/N 10953466), or

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equivalent to the rear bearing cap sealing face or to the rear bearing cap channel of the engine block. Apply the sealant to the bearing cap mating surface and bearing cap channel from the rear seal bore to the oil pan surface.

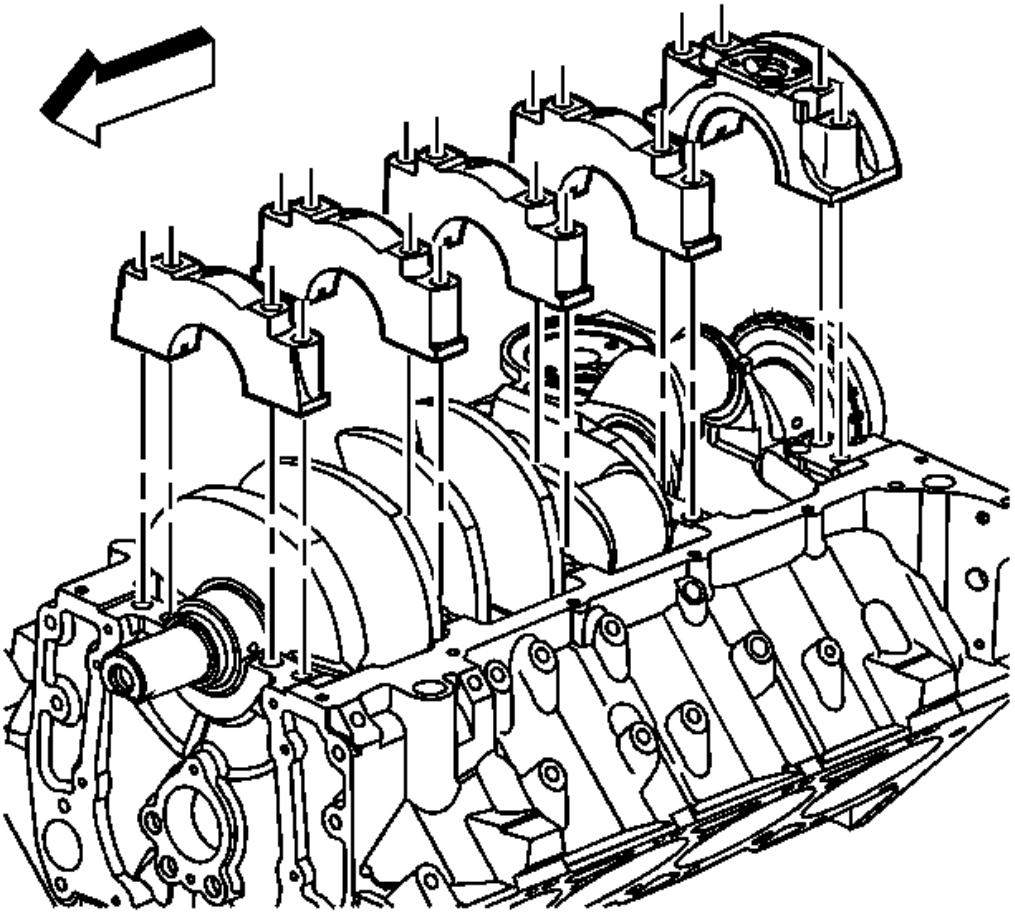

Fig. 476: View Of Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to prevent the possibility of cylinder block or crankshaft bearing cap damage, the crankshaft bearing caps are tapped into the cylinder block cavity using a brass, lead, or a leather mallet before the attaching bolts are installed. Do not use attaching bolts to pull the crankshaft bearing caps into the seats. Failure to use this process may damage a cylinder block or a bearing cap.

NOTE: The crankshaft position sensor reluctor wheel/ring is not serviced

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separately. Do not repair the crankshaft position sensor reluctor wheel/ring. If the crankshaft position sensor reluctor ring is damaged, the crankshaft assembly must be replaced.

IMPORTANT: Ensure that the triangle symbols on the crankshaft bearing caps are facing the front of the engine.

5. Install the crankshaft bearing caps in the location the caps were marked and originally removed from.

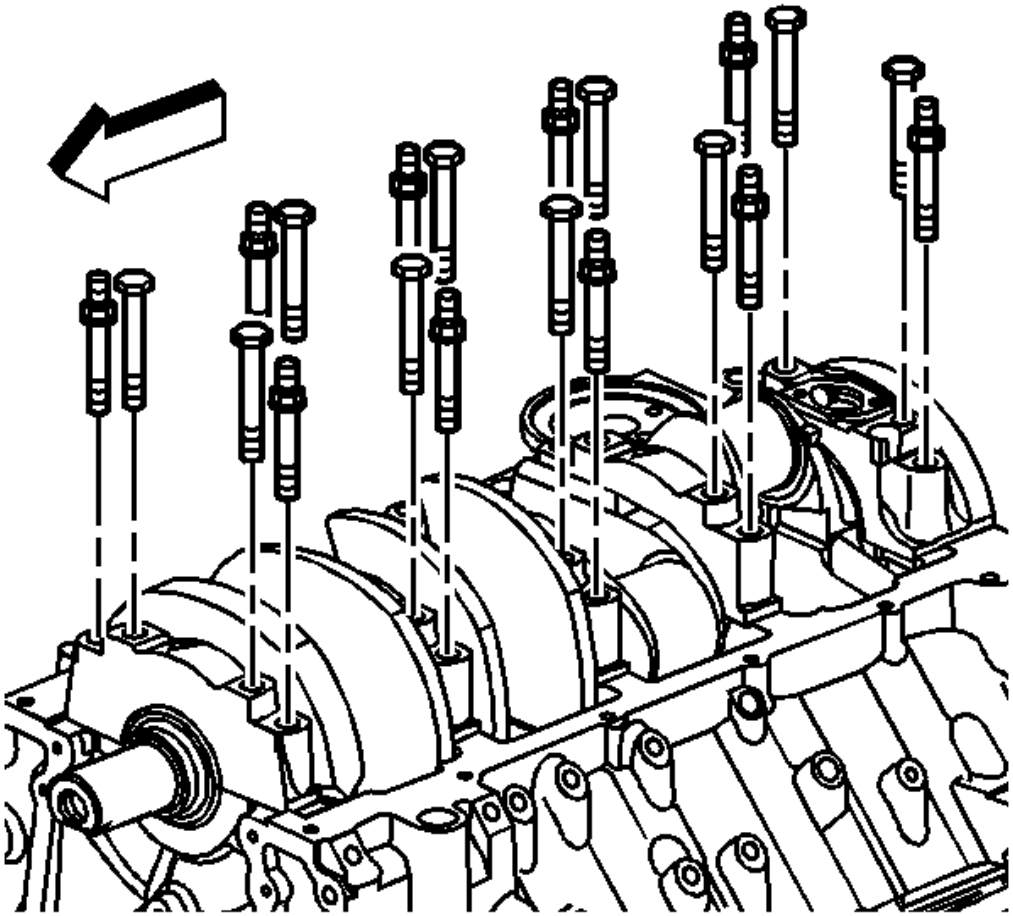

Fig. 477: View Of Crankshaft Bearing Cap Bolts & Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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IMPORTANT: Tighten the crankshaft bearing cap bolts before tightening the crankshaft bearing cap studs.

6. Install the bearing cap bolts and studs.

   Tighten:

   1. Tighten the bearing cap 1-4 bolts a first pass to 30 N.m (22 lb ft).
   2. Tighten the bearing cap 1-4 studs a first pass to 30 N.m (22 lb ft).
   3. Tighten the bearing cap 1-4 bolts a final pass an additional 90 degrees using the **J 45059** .
   4. Tighten the bearing cap 1-4 studs a final pass an additional 80 degrees using the **J 45059** .
   5. Tighten the bearing cap 5 bolts and studs to 30 N.m (22 lb ft).
   6. Loosen the bearing cap 5 bolts and studs.
   7. Tighten the bearing cap 5 bolts and studs to 5 N.m (44 lb in).

7. Thrust the crankshaft firmly rearward.
8. Thrust the crankshaft firmly forward.

   Tighten:

   1. Tighten the bearing cap 5 bolts a first pass to 30 N.m (22 lb ft).
   2. Tighten the bearing cap 5 studs a first pass to 30 N.m (22 lb ft).
   3. Tighten the bearing cap 5 bolts a final pass an additional 90 degrees using the **J 45059** .
   4. Tighten the bearing cap 5 bolts a final pass an additional 80 degrees using the **J 45059** .

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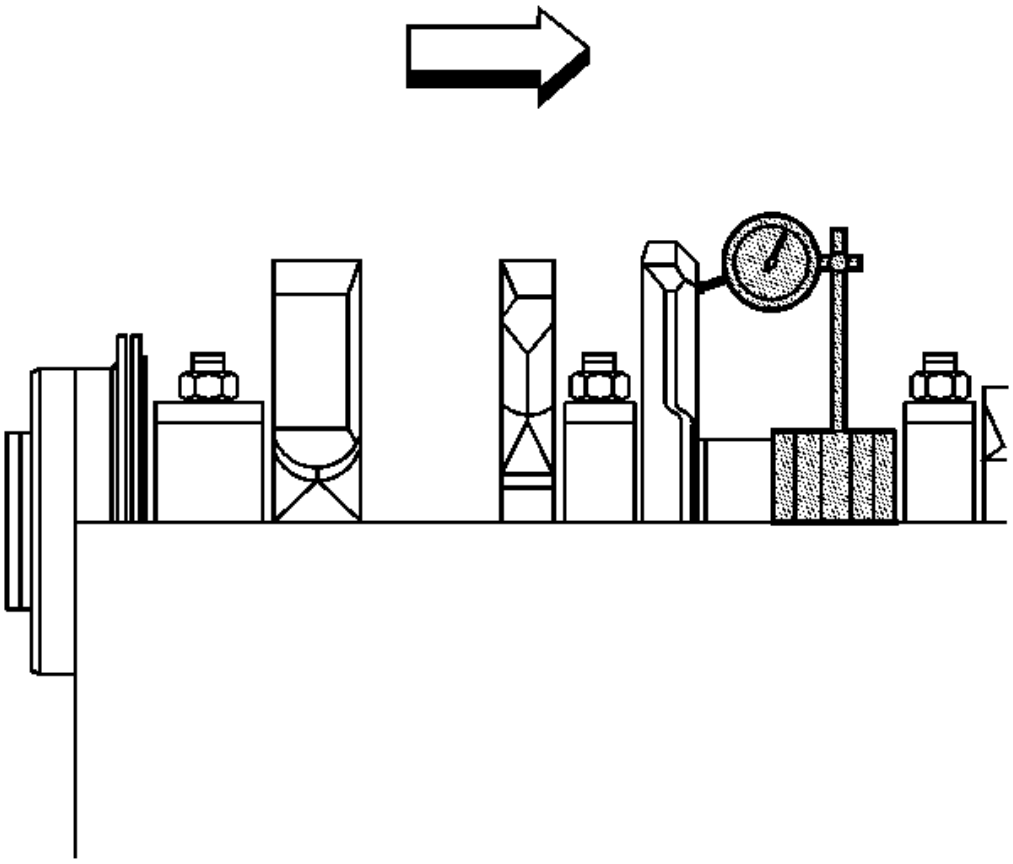

Fig. 478: Measuring Crankshaft End Play Using J 7872
Courtesy of GENERAL MOTORS CORP.

9. Measure the crankshaft end play as follows:
    1. Install the **J 8001** or equivalent to the cylinder block, with the dial indicator plunger against one of the counterweights of the crankshaft.
    2. Firmly thrust the end of the crankshaft first rearward then forward. This will line up the rear crankshaft bearing and the crankshaft thrust surfaces.
    3. With the crankshaft pushed forward, zero the dial indicator. Move the crankshaft rearward, and read the end play measurement on the dial indicator. An optional method is to insert a feeler gage between the crankshaft and the bearing surface and measure the clearance. Refer to **Engine Mechanical Specifications**.
    4. If the correct end play cannot be obtained, inspect for the following conditions:
        - Verify that the correct size crankshaft bearing has been installed. Refer to **Engine Mechanical Specifications**.

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- Inspect the crankshaft thrust wall surface or surfaces for wear and/or excessive runout. Refer to **Engine Mechanical Specifications**.

5. Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, loosen the crankshaft bearing bolts and studs, one cap at a time, until the tight bearing is located. The following condition or conditions could cause a lack of clearance at the bearing:
   - Burrs on the crankshaft bearing cap
   - Foreign material between the bearing and the block
   - Foreign material between the bearing and the bearing cap
   - A faulty crankshaft bearing
   - Improper size bearing

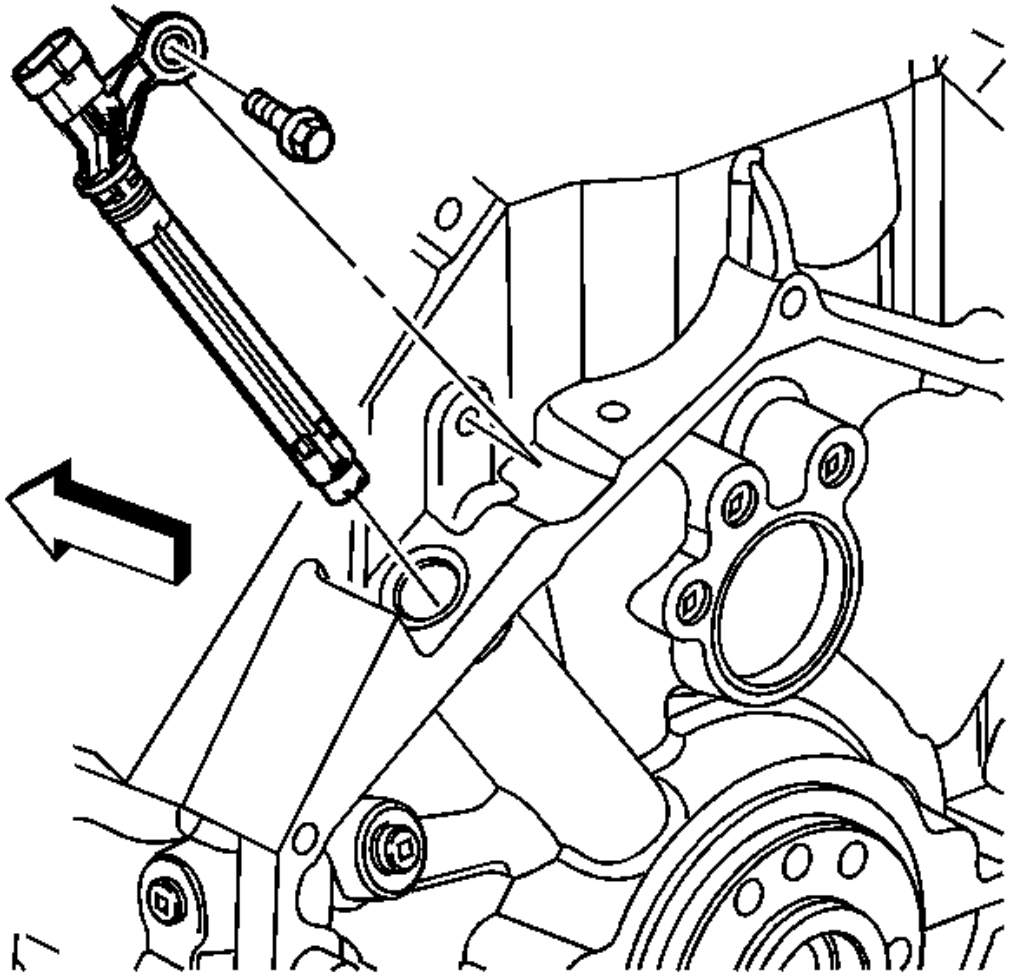

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Fig. 479: View Of CKP Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Ensure that the crankshaft position (CKP) sensor is fully seated against the crankshaft reluctor ring. The upper flange on the sensor MAY NOT seat against the engine block.**
- **The CKP sensor bolt has a thread sealant applied to the threads. The thread sealant may have come off during the removal of the bolt. Ensure that the bolt hole is clean of any debris before installing the CKP sensor bolt.**

10. Inspect the CKP sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring as needed. Lubricate the CKP sensor O-ring with clean engine oil.
11. Install the CKP sensor into the block.

    There may be a slight resistance as the O-ring seats into the engine block.

12. Apply thread adhesive GM P/N 12345493, (Canadian P/N 10953488), or equivalent to the CKP sensor bolt.
13. Install the CKP sensor bolt.

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

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **J 8037** Piston Ring Compressor
- **J 8087** Cylinder Bore Gage
- **J 45059** Angle Meter

Piston Selection

IMPORTANT: The coating on the piston allows for an interference fit between the cylinder and the bore. The piston diameter can NOT be measured accurately because the piston coating is not a consistent thickness. Do NOT measure the piston diameter.

To select the correct piston for installation, the cylinder bore must be measured. If the cylinder bore diameter is within service specifications, install the original piston/connecting rod assembly or a new, standard size piston/connecting rod assembly. A used piston/connecting rod assembly may be reinstalled if, after cleaning and inspection, the piston is not damaged. If the cylinder bore is NOT within specifications, the cylinder must be resized to accept a new, oversized piston.

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For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

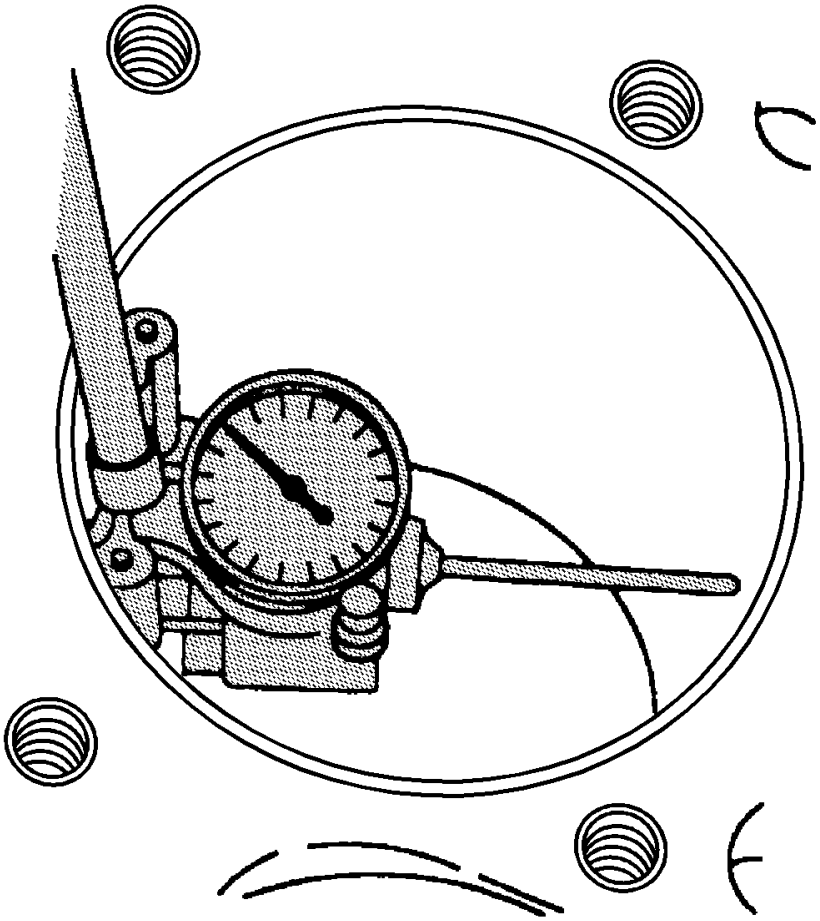

Fig. 480: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

1. Inspect the engine block cylinder bore. Refer to **Engine Block Cleaning and Inspection**.
2. Inspect the piston/connecting rod assembly for damage. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
3. Use the **J 8087** and measure the cylinder bore diameter. Refer to **Engine Block Cleaning and Inspection**.

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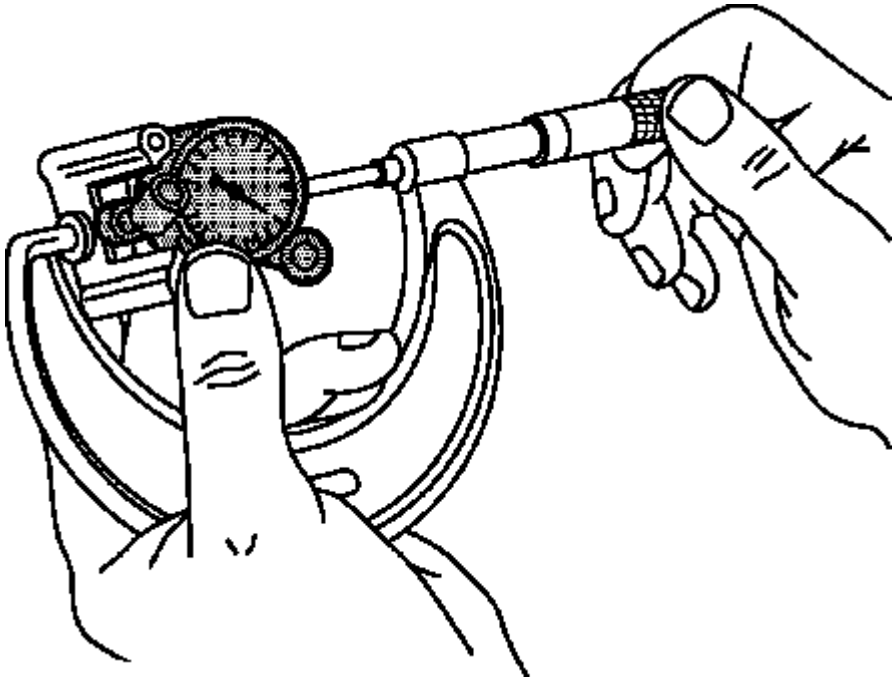

Fig. 481: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the **J 8087** with a micrometer and record the reading.
5. Compare the cylinder bore measurement to the specifications. Refer to **Engine Mechanical Specifications**.
    1. If the cylinder bore is within specifications, select the original piston or a new, original size piston.
    2. If the cylinder bore is not within specifications, select the next oversized piston/connecting rod assembly, then bore and hone the cylinder bore to fit the oversize piston.

Piston Installation

1. Coat the following components with clean engine oil:
    - The piston
    - The piston rings
    - The cylinder bore
    - The bearing surfaces

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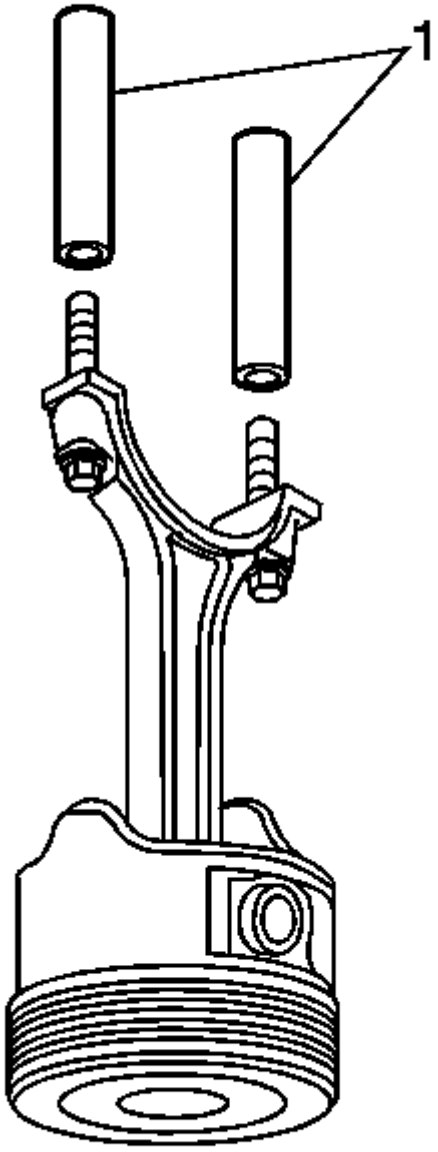

Fig. 482: View Of Rubber Fuel Line From Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install rubber fuel line onto the connecting rod bolts.

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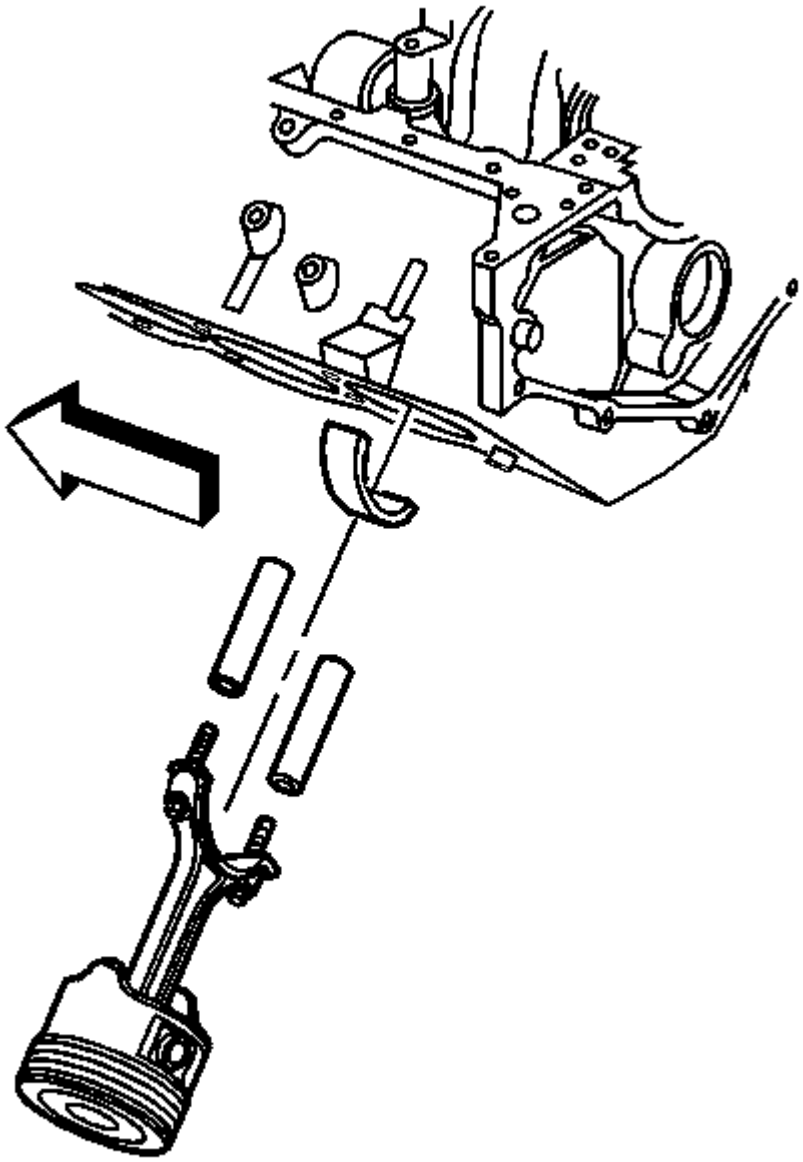

Fig. 483: View Of Piston, Connecting Rod, & Connecting Rod Upper Bearing
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The mark on the top of the piston must face the front of the engine block. When assembled, the flanges on the connecting rod and cap should face to the front of block on the left bank and to the rear of block on the right bank.

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3. Install the piston, connecting rod and upper connecting rod bearing through the top of the engine block.

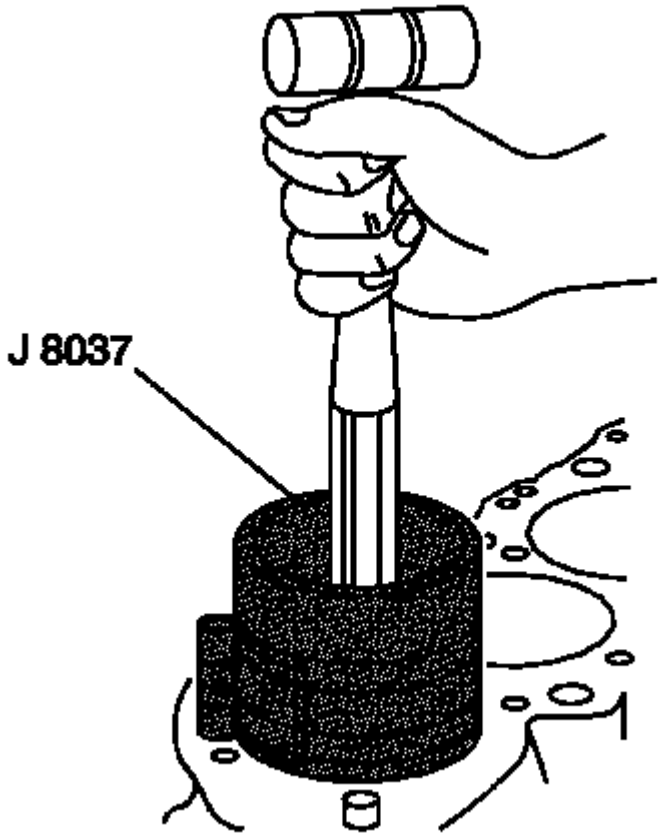

Fig. 484: Installing Piston & Connecting Rod Assembly Into Engine
Courtesy of GENERAL MOTORS CORP.

4. Install the **J 8037** onto the piston and compress the piston rings.
5. Use the **J 8037** and lightly tap the top of the piston with a wooden hammer handle.
6. Hold the **J 8037** firmly against the engine block until all of the piston rings have entered the cylinder bore.

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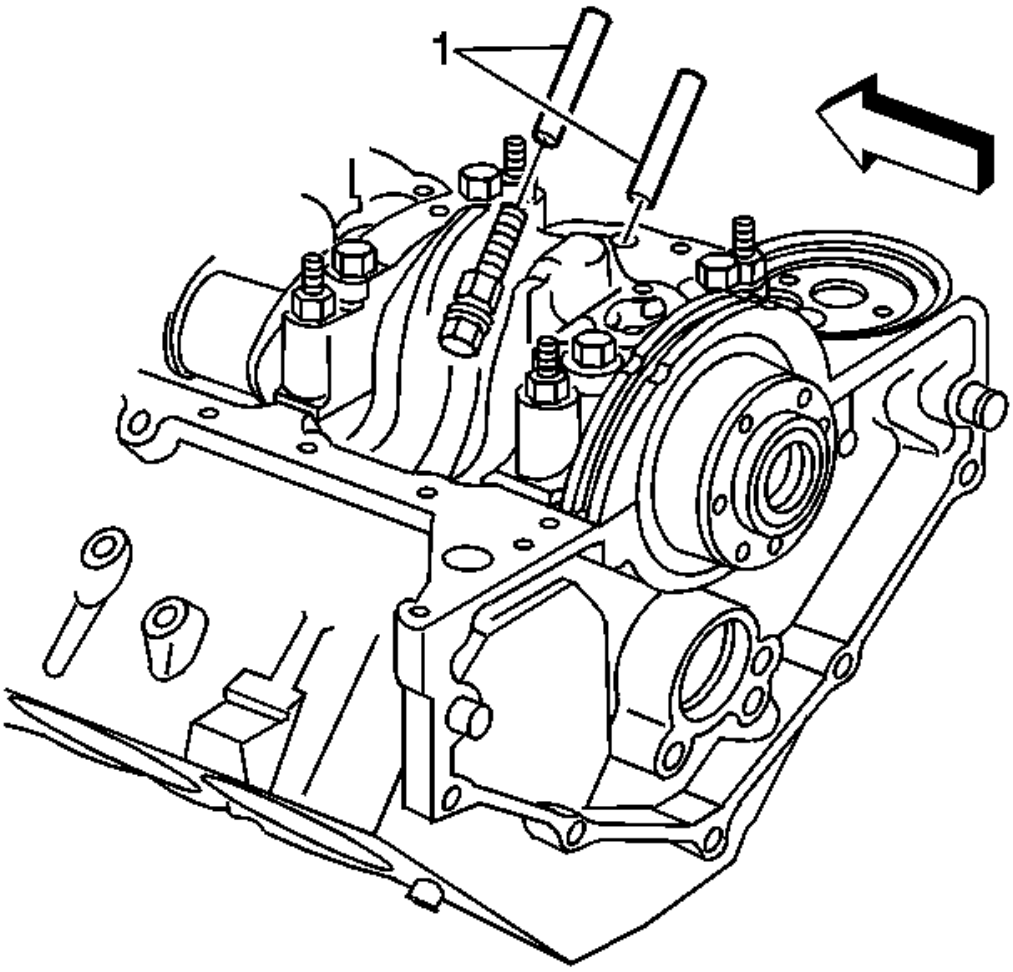

Fig. 485: Installing Rubber Fuel Line Onto Connecting Rod Bolts
Courtesy of GENERAL MOTORS CORP.

7. Use the rubber fuel line in order to guide the connecting rod onto the crankshaft journal.
8. Remove the rubber fuel line.

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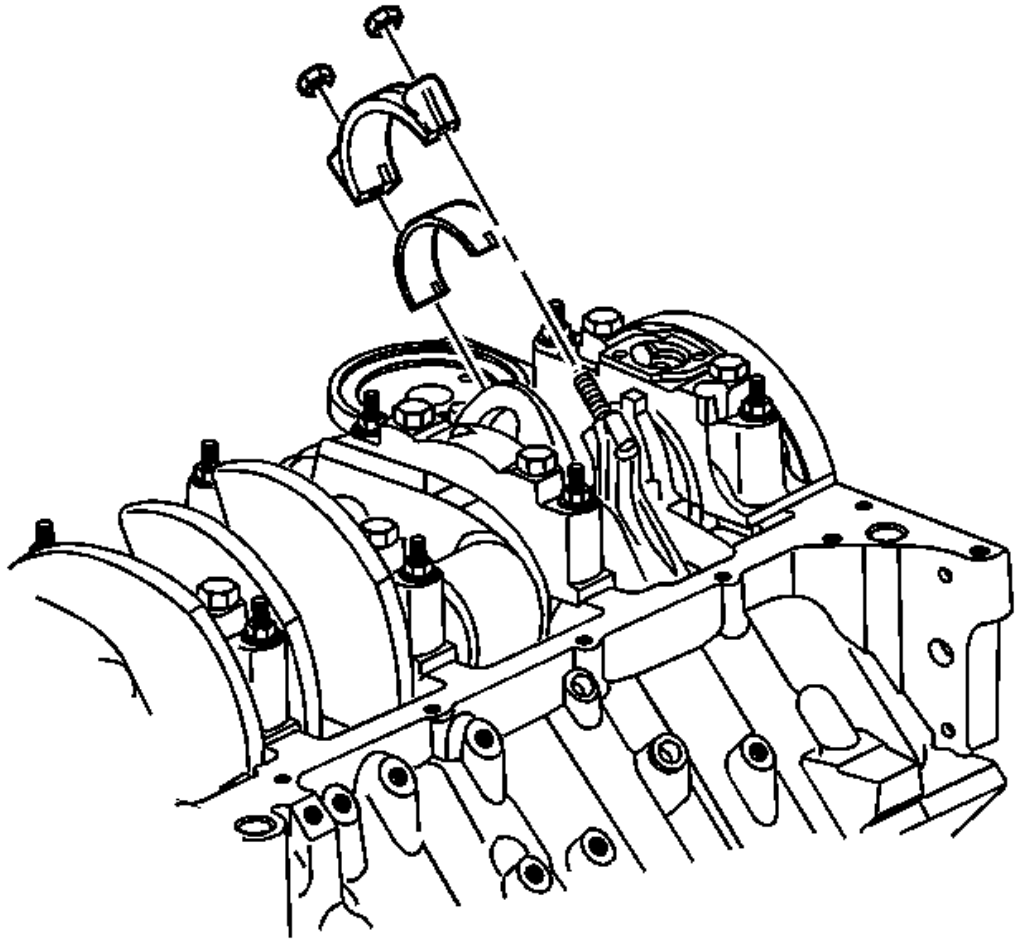

Fig. 486: View Of Connecting Rod Cap & Connecting Rod Lower Bearing
Courtesy of GENERAL MOTORS CORP.

9. Install the connecting rod cap and lower connecting rod bearing.

NOTE: Refer to Fastener Notice in Cautions and Notices.

IMPORTANT: When installing the piston/connecting rod assembly, NEW connecting rod nuts must be installed.

10. Install the new connecting rod nuts.

Tighten:

1. Tighten the connecting rod nuts a first pass to 30 N.m (22 lb ft).

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2. Tighten the connecting rod nuts a final pass 90 degrees using the **J 45059** .

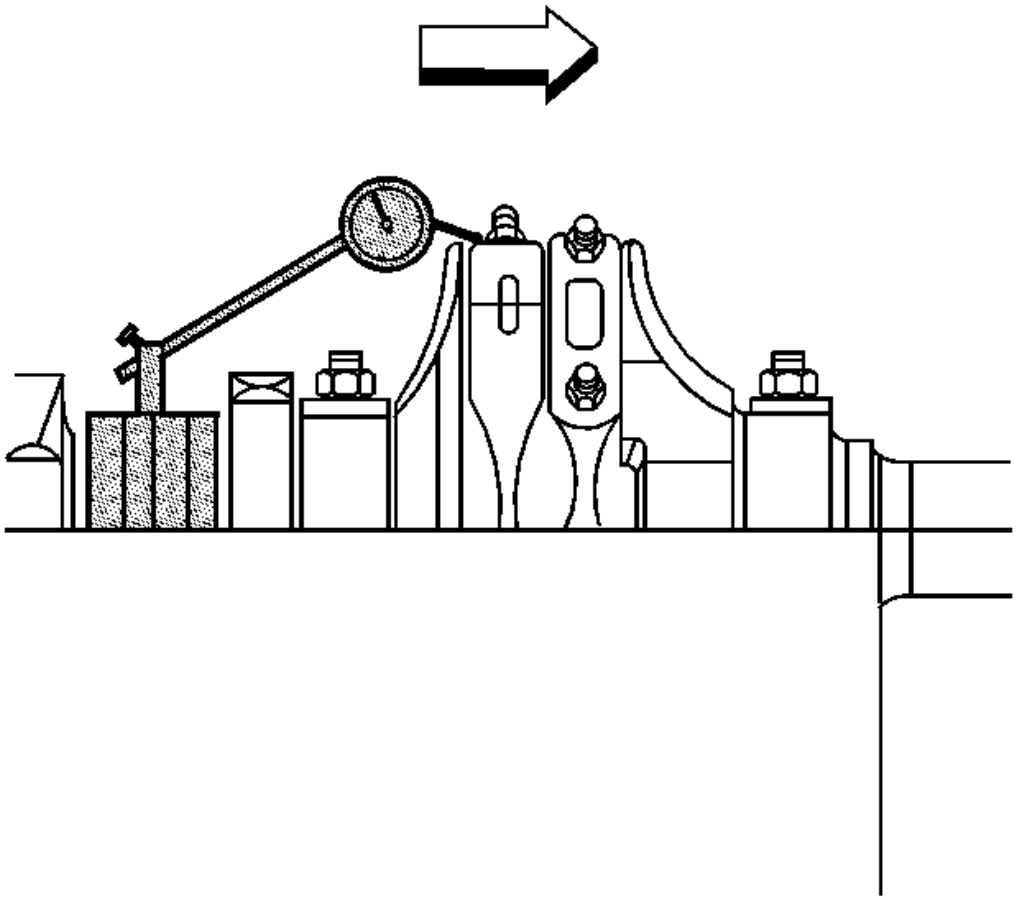

Fig. 487: Measuring Connecting Rod Side Clearance Using J 7872
Courtesy of GENERAL MOTORS CORP.

11. Once the piston and connecting rod assemblies have been installed, lightly tap each connecting rod assembly, parallel to the crankpin, in order to make sure that they have side clearance.
12. Use a feeler gage or a dial indicator to measure the side clearance between the connecting rod caps. The rod side clearance should be 0.384-0.686 mm (0.0151-0.0270 in).

Camshaft Installation

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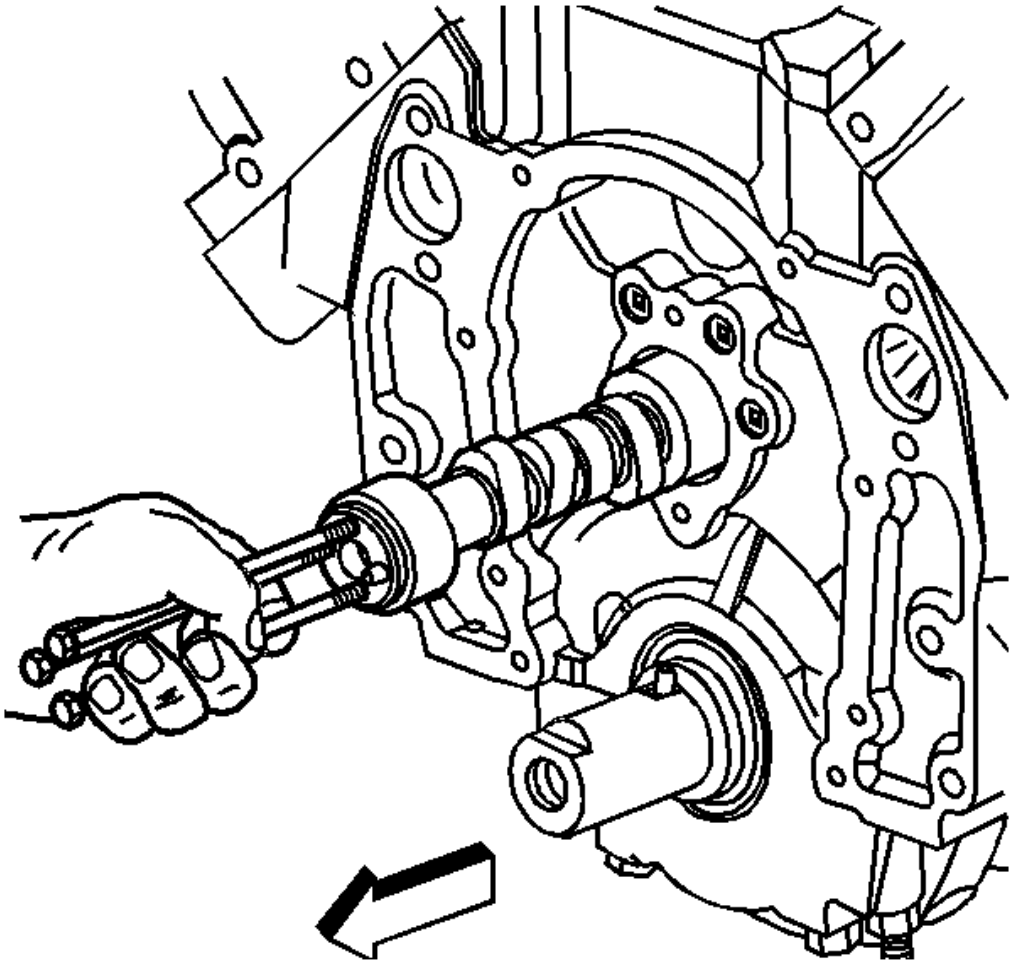

Fig. 488: View Of Bolts In Camshaft Front Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the following components with clean engine oil.
   - The camshaft lobes
   - The camshaft bearing journals
   - The camshaft bearings

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

2. Install the three 8-1.25 x 100 mm bolts in the camshaft front bolt holes.

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3. Using the bolts as a handle, install the camshaft.
4. Remove the three bolts from the front of the camshaft.

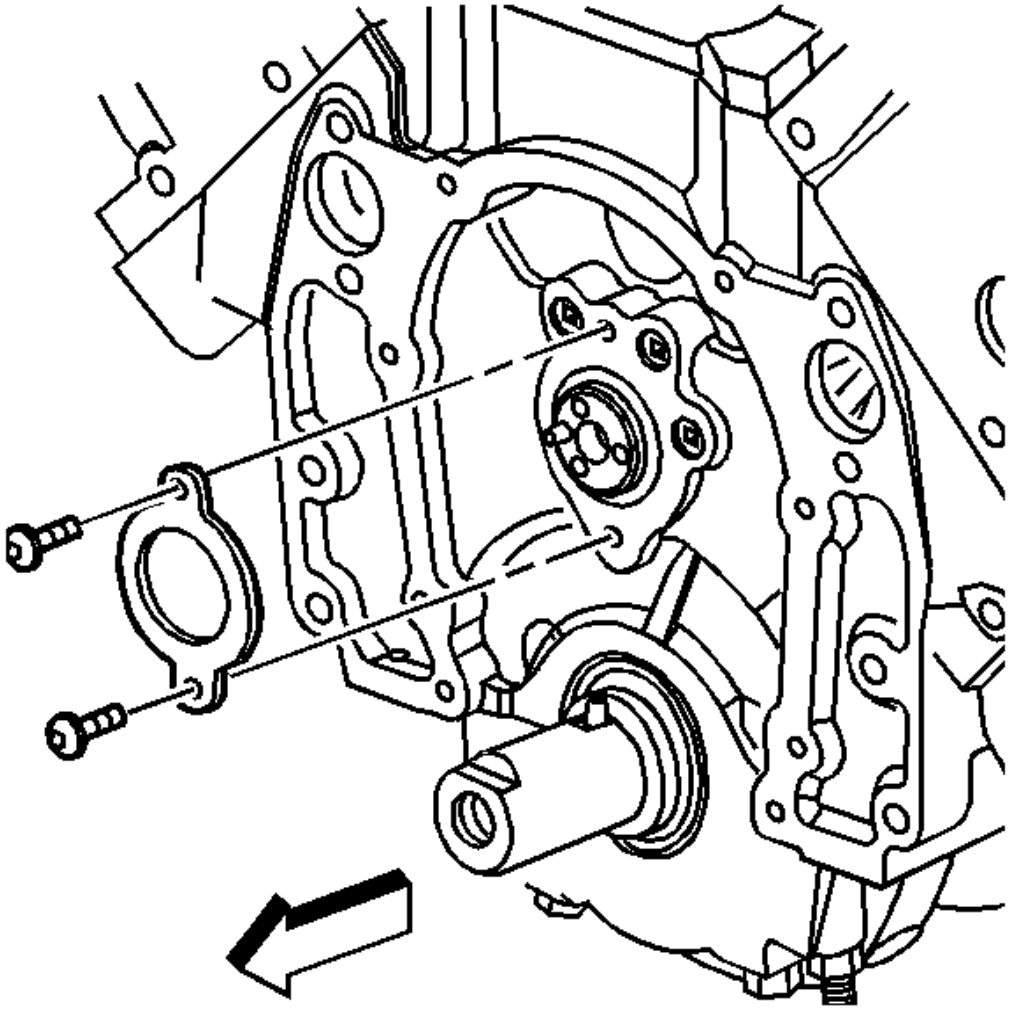

Fig. 489: View Of Camshaft Retainer
Courtesy of GENERAL MOTORS CORP.

5. Install the camshaft retainer.

NOTE: Refer to Fastener Notice in Cautions and Notices.

6. Install the camshaft retainer bolts.

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

Timing Chain and Sprockets Installation

Tools Required

J 22102 Front Cover Aligner and Seal Installer

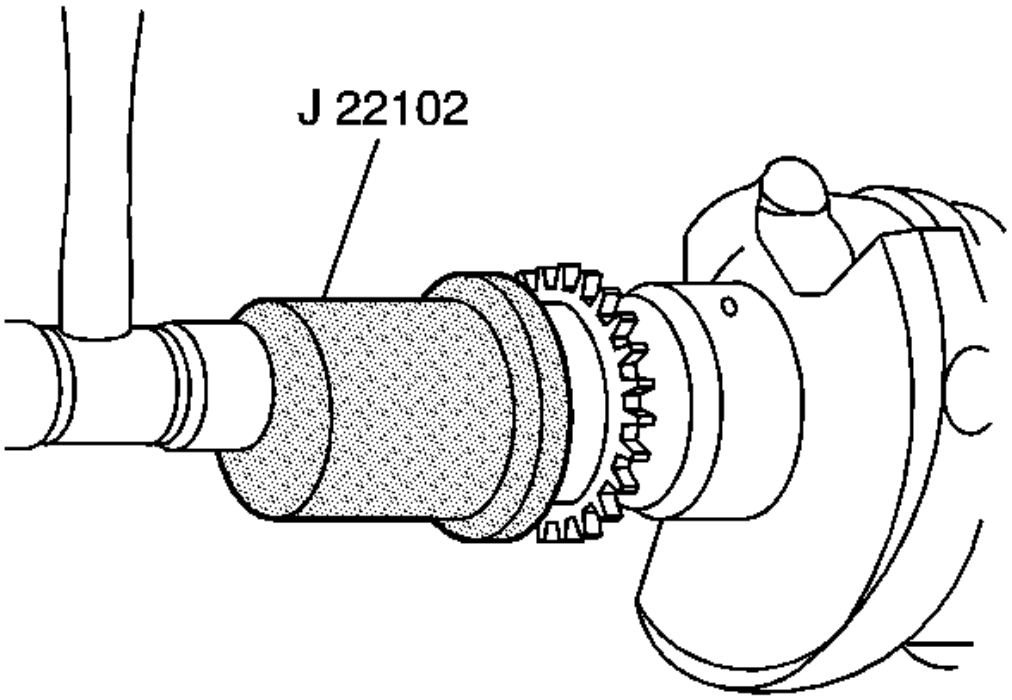

Fig. 490: Installing Crankshaft Sprocket Using J 22102
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 22102** in order to install the crankshaft sprocket.

   Align the keyway of the crankshaft sprocket with the crankshaft pin.

2. Inspect the sprocket pin for proper installation. Refer to **Crankshaft and Bearings Cleaning and Inspection**.
3. Rotate the crankshaft until the crankshaft sprocket alignment mark is in the 12 o'clock position.

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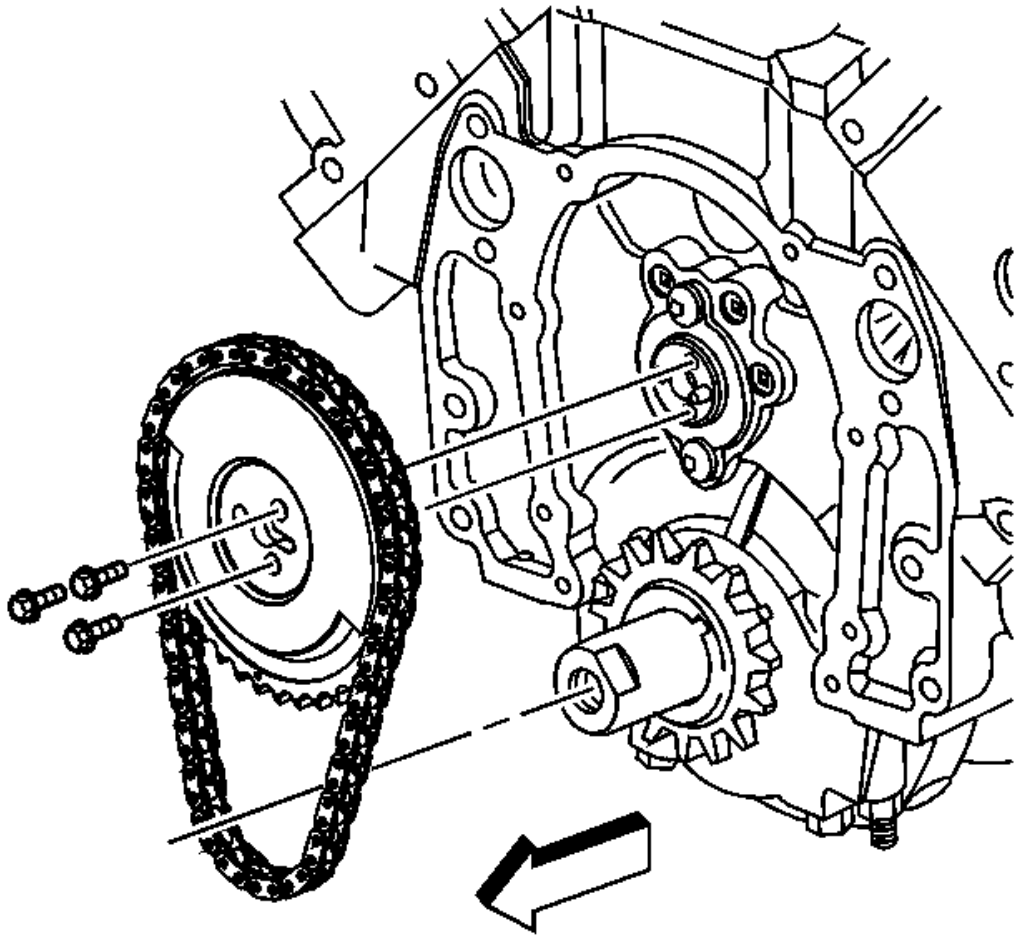

Fig. 491: View Of Camshaft Sprocket, Timing Chain & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not hammer the camshaft sprocket onto the camshaft. To do so may dislodge the rear camshaft plug and damage the camshaft.

IMPORTANT: Install the camshaft sprocket with the alignment mark in the 6 o'clock position.

IMPORTANT: The sprocket teeth must mesh with the timing chain in order to prevent damage to the camshaft retainer.

4. Install the camshaft sprocket and timing chain.

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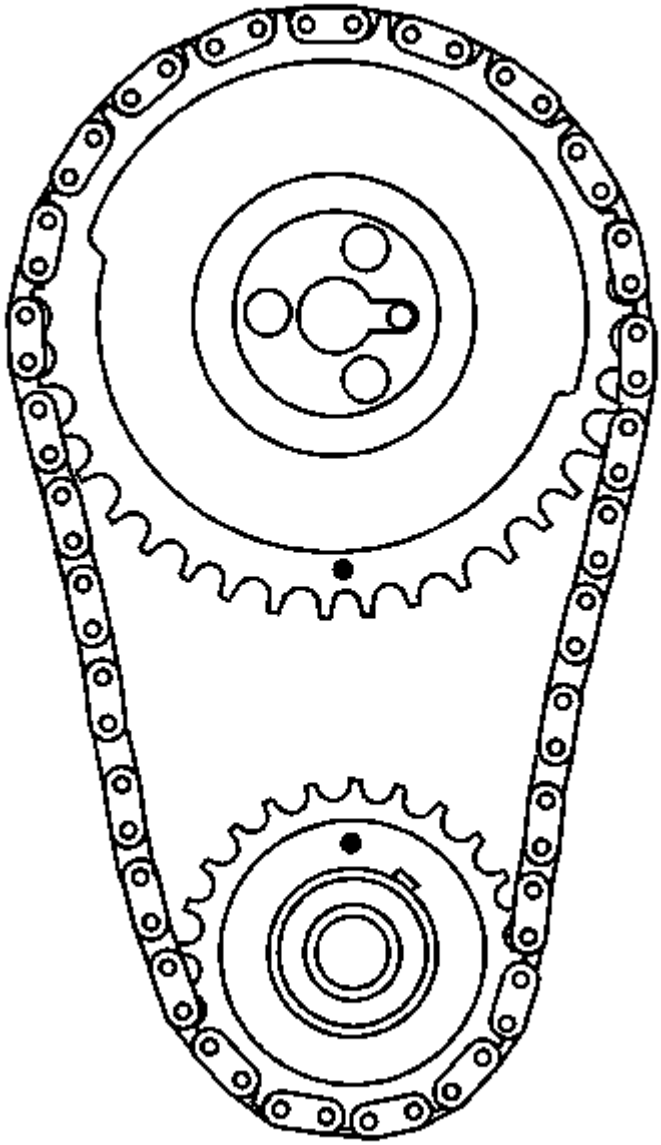

Fig. 492: View Of Crankshaft & Camshaft Sprockets Aligned
Courtesy of GENERAL MOTORS CORP.

5. Look to ensure that the crankshaft sprocket is aligned at the 12 o'clock position and the camshaft sprocket is aligned at the 6 o'clock position.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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6. Install camshaft sprocket bolts.

   Tighten: Tighten the camshaft sprocket bolts to 30 N.m (22 lb ft).

Engine Front Cover Installation

Tools Required

J 42851 Front Cover Oil Seal Installer. See **Special Tools and Equipment**.

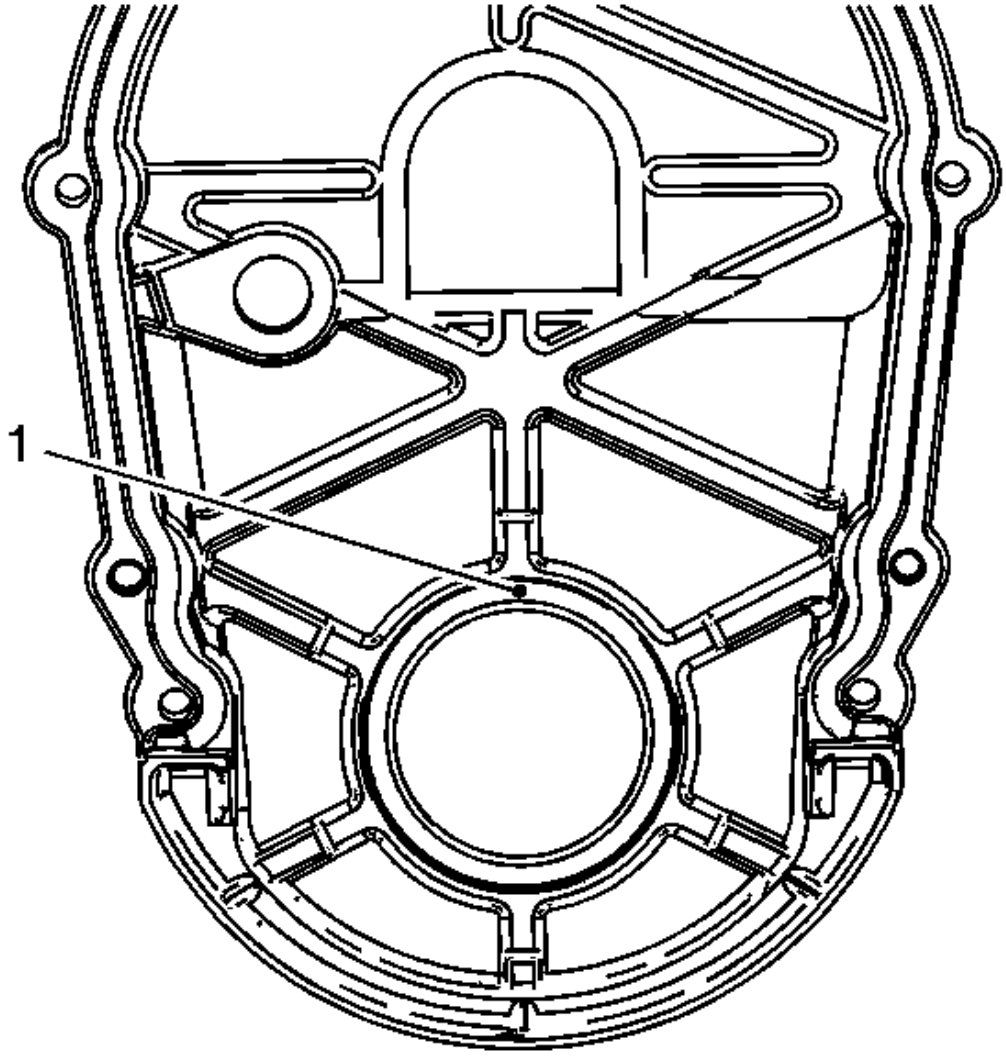

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Fig. 493: Identifying Mark On Rear Of Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the outer sealing surface of the crankshaft front oil seal lightly with clean engine oil. DO NOT lubricate the inner portion of the seal.
2. Position the NEW crankshaft front oil seal in the engine front cover so that the mark (1) on the rear of the seal is in the 12 o'clock position.

   Second design oil seals will not have an alignment mark on the rear face. The seal may be installed in any position.

3. Install the crankshaft front oil seal using the **J 42851** . See **Special Tools and Equipment**.

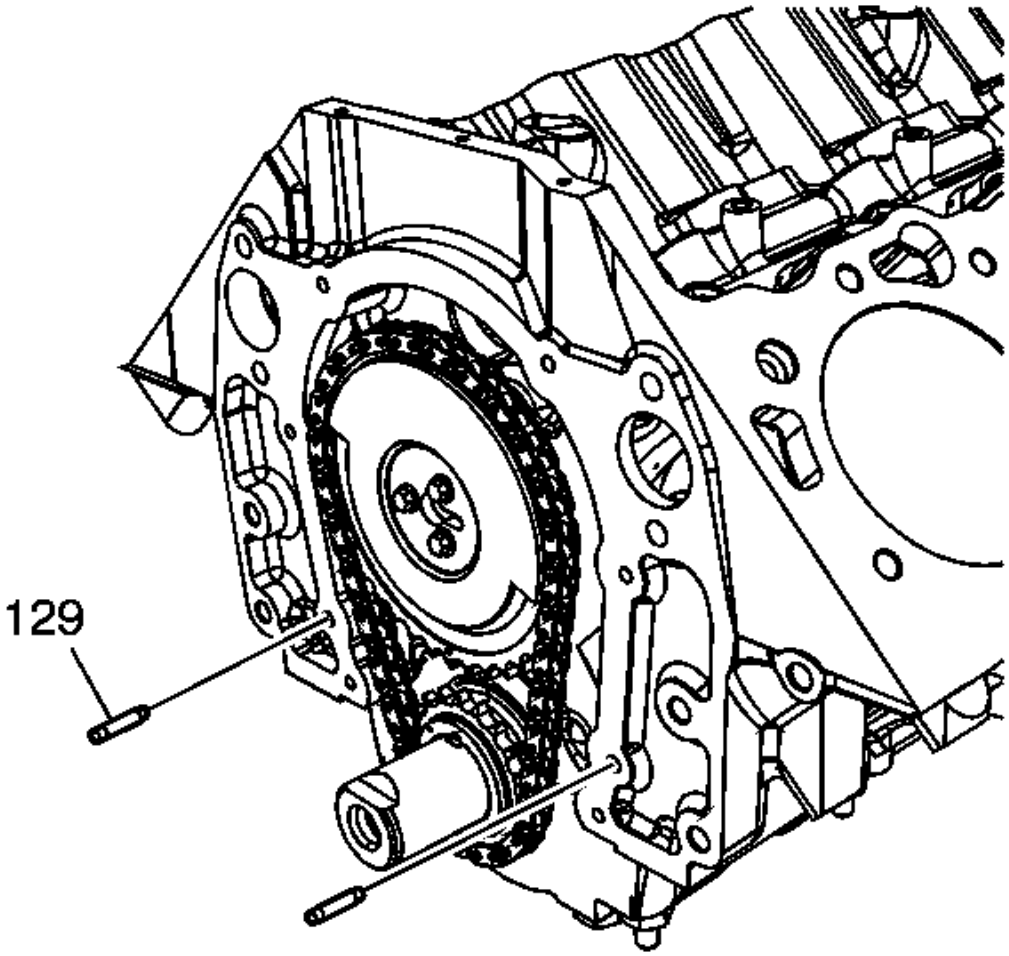

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Fig. 494: View Of Front Cover Locating Pins
Courtesy of GENERAL MOTORS CORP.

4. Install the front cover locating pins (129), if required.

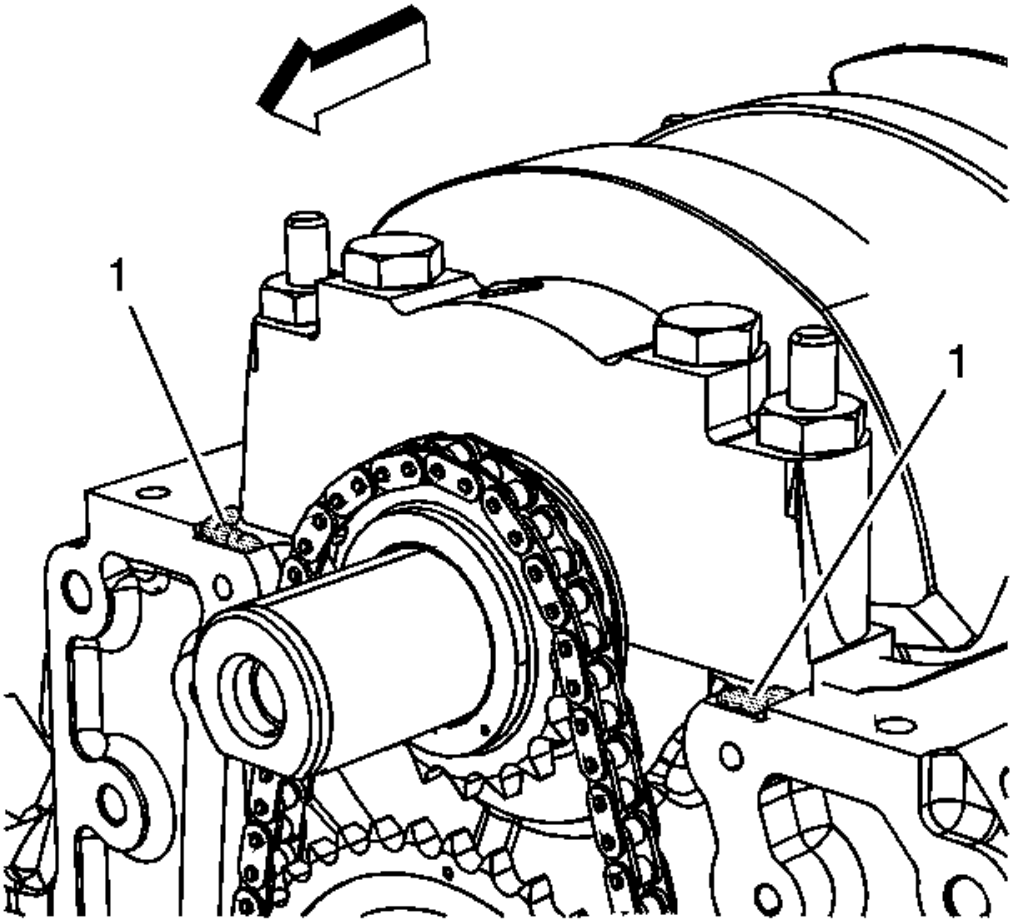

Fig. 495: Applying Sealant At Sealant Points On Engine Block
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine front cover must be installed and the fasteners tightened while the sealant is still wet to the touch.

5. Apply a 3-4 mm (0.12-0.16 in) bead of sealant GM P/N 12346286, (Canadian P/N 10953472), or equivalent in 2 sealant points (1) on the engine block where the front cover meets the oil pan.

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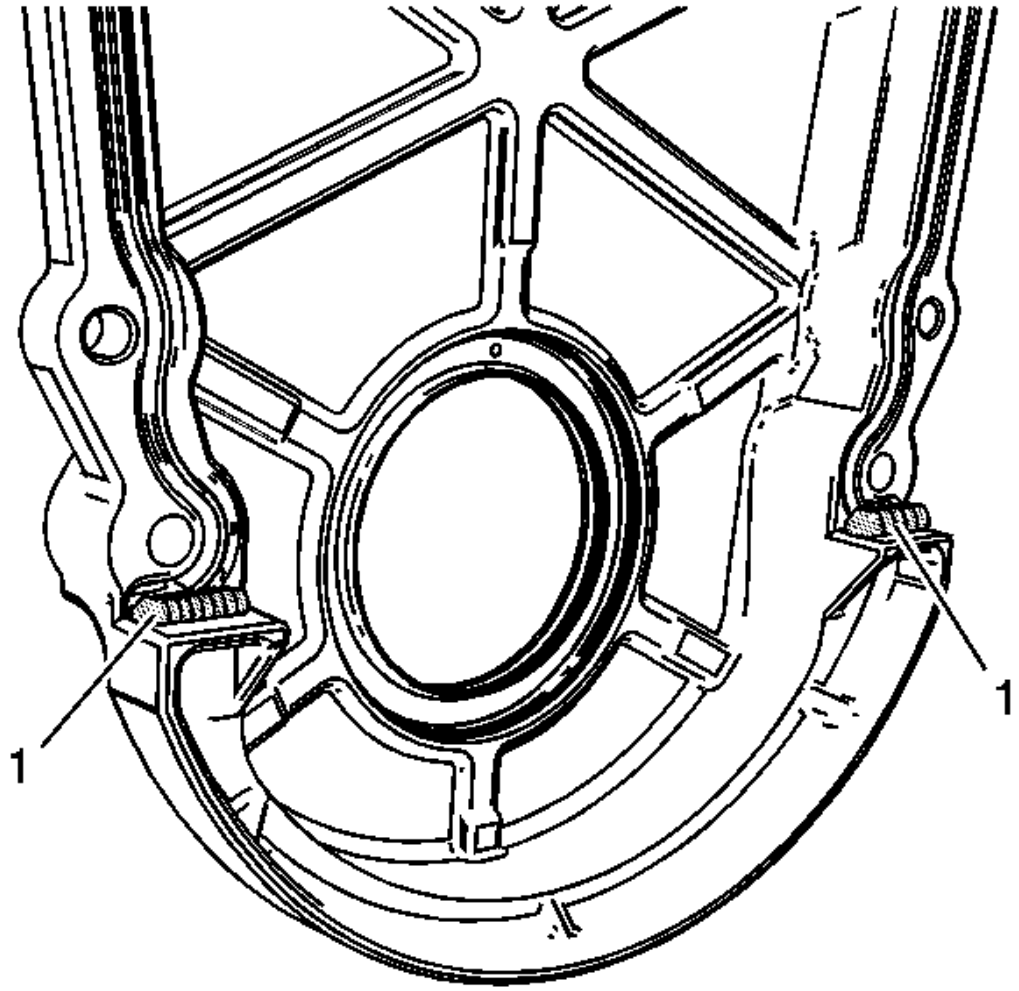

Fig. 496: Applying Sealant At Sealant Points Across Flange
Courtesy of GENERAL MOTORS CORP.

6. Apply a 3-4 mm (0.12-0.16 in) bead of sealant GM P/N 12346286, (Canadian P/N 10953472), or equivalent in 2 sealant points (1) across the flange where the gasket ends at the bottom of the front cover.

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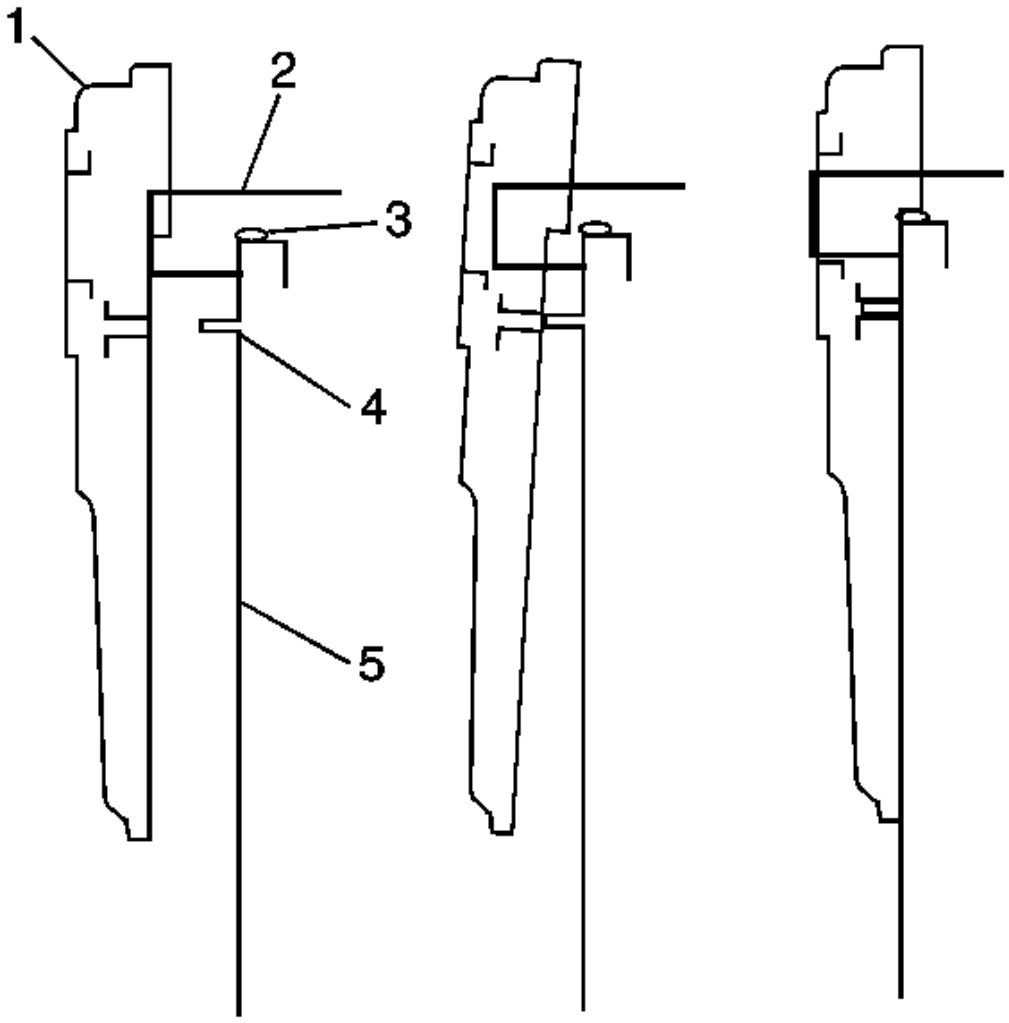

Fig. 497: View Of Front Cover & Gasket Proper Installation Position
Courtesy of GENERAL MOTORS CORP.

7. Install the engine front cover gasket into the front cover.

IMPORTANT: The following method must be used when installing the engine front cover. Failure to follow the instructions will push the sealant out, which may cause an oil leak.

8. Install the engine front cover.
    1. Hold the front cover (1) up to the crankshaft (2).

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2. Lift the front cover (1) while sliding the cover over the crankshaft (2).
3. Slide the front cover towards the engine block (5) while keeping the cover raised.
4. Lower the cover down over the dowel pin (4), allowing the front cover to rest on the sealant (3).

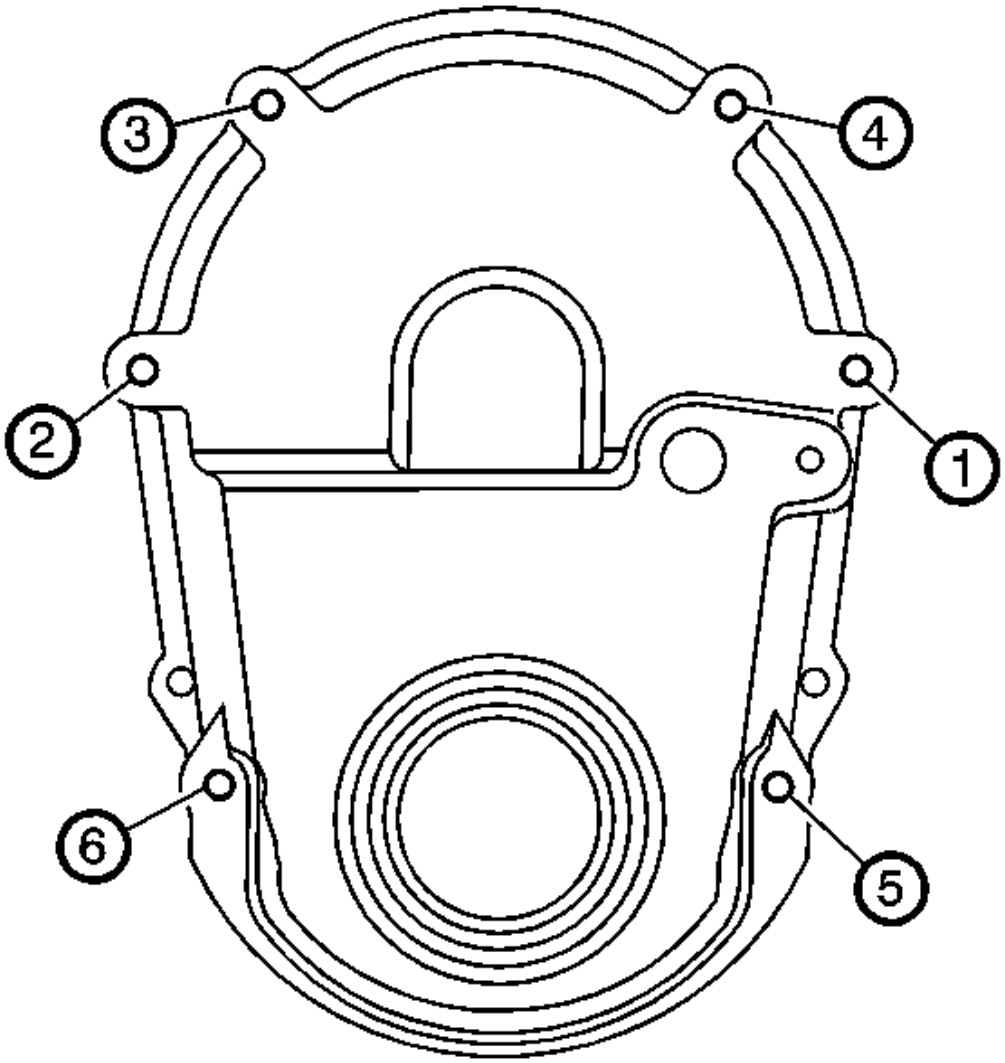

Fig. 498: Crankshaft Front Cover Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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9. Install the engine front cover bolts.

   Tighten:
   - Tighten the engine front cover bolts in sequence a first pass to 6 N.m (53 lb in).
   - Tighten the engine front cover bolts in sequence a final pass to 12 N.m (106 lb in).

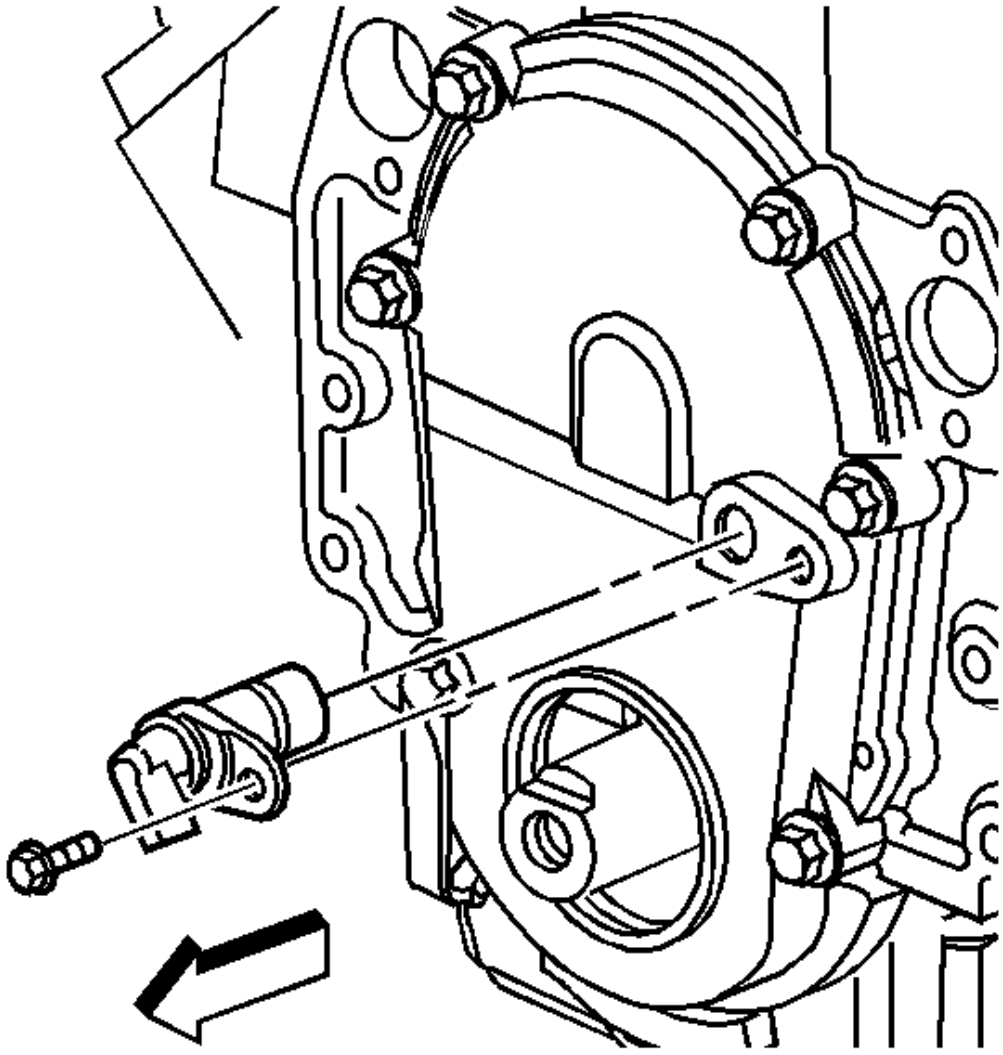

Fig. 499: View Of CMP Sensor
Courtesy of GENERAL MOTORS CORP.

10. Inspect the camshaft position (CMP) sensor O-ring for cuts, cracks, tears or damage. Replace the O-ring

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as needed.

11. Apply a light film of clean engine oil to the CMP sensor O-ring.
12. Install the CMP sensor.

NOTE: This bolt is a self-tapping bolt. If installing this bolt into a new component, installation of the bolt may be difficult. Ensure that the bolt is not over-torqued during the initial installation (thread cutting). Failure to limit torque can lead to bolt failure.

13. Install the CMP sensor bolt.

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

Oil Pump, Pump Screen and Deflector Installation

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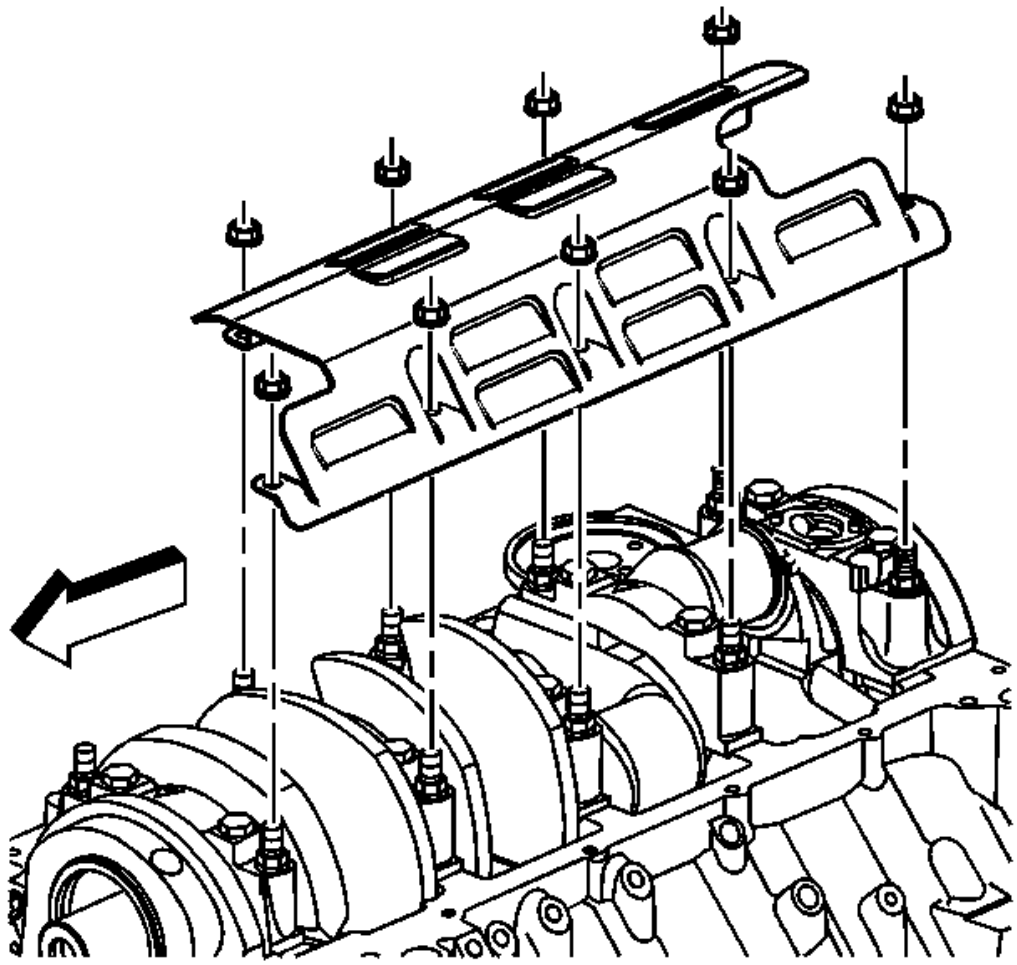

Fig. 500: View Of Crankshaft Oil Deflector & Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install the crankshaft oil deflector.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the crankshaft oil deflector nuts.

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

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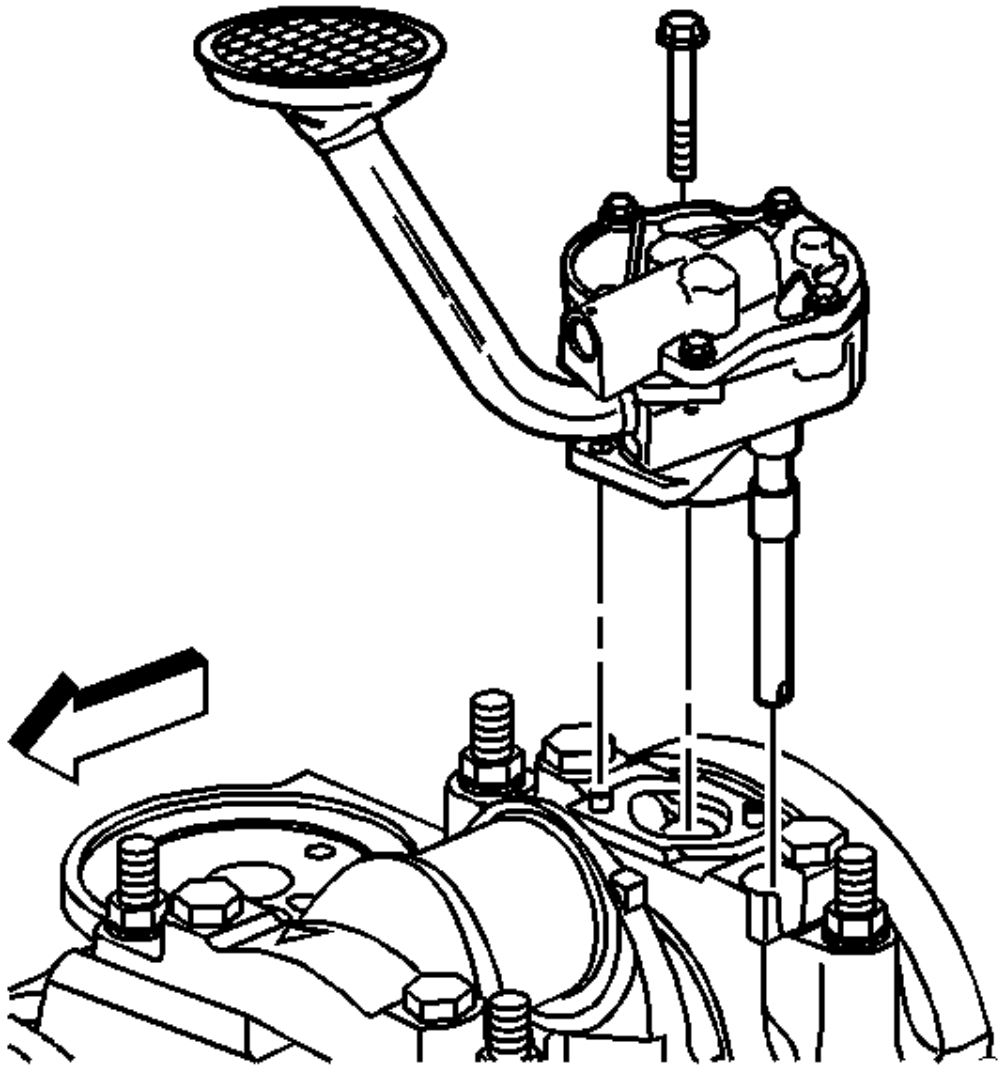

Fig. 501: View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During assembly, install a NEW oil pump driveshaft retainer. Slightly heat retainer above room temperature for ease of installation onto the oil pump driveshaft.

3. Install clean engine oil into the oil pump through the outlet oil hole. Rotate the pump in both directions to prime and lubricate.
4. Assemble the oil pump, driveshaft, and a NEW retainer.

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5. Install the oil pump assembly.

   Position the oil pump onto the locating pins.

6. Install the bolt attaching the oil pump to the rear crankshaft bearing cap.

   Tighten: Tighten the oil pump bolt to 75 N.m (56 lb ft).

7. Pour clean engine oil into the oil pump pickup screen.

Oil Pan Installation

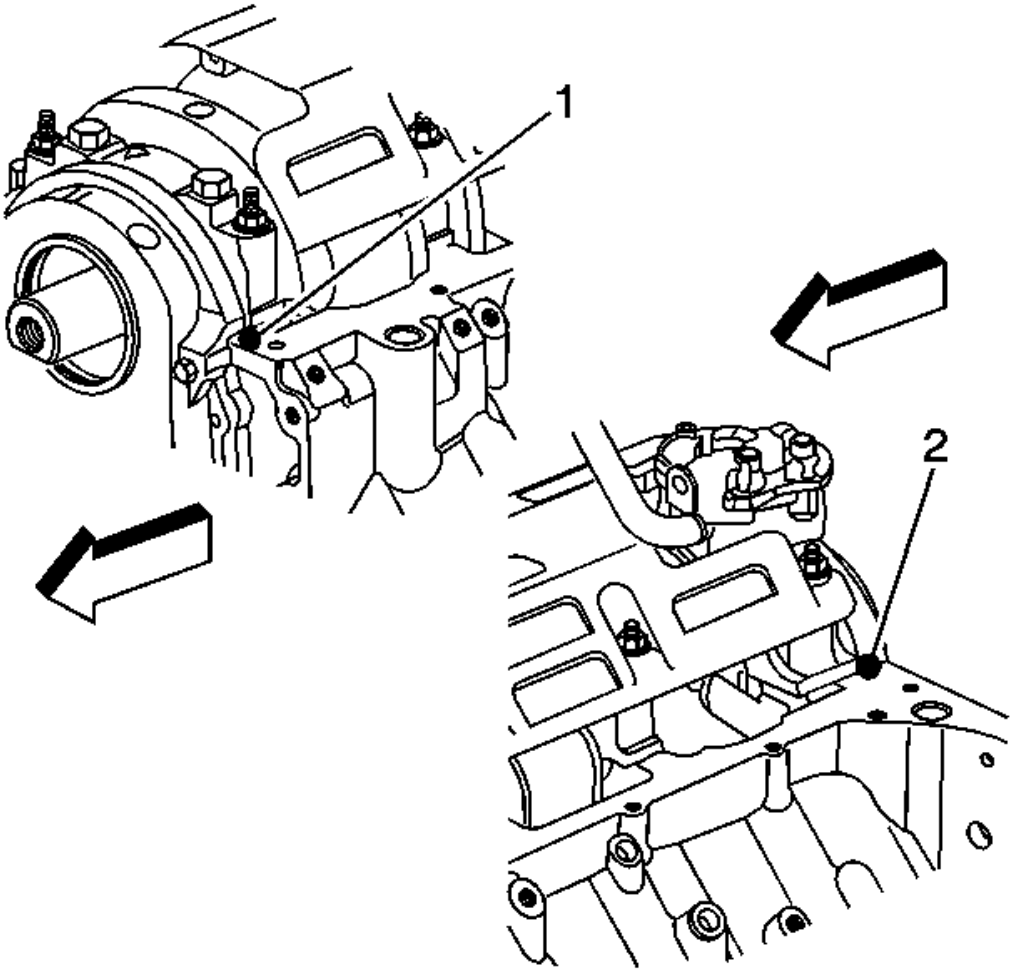

Fig. 502: Applying Sealant To Side Of Front Cover & Rear Of Crankshaft Bearing Cap

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Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The oil pan must be installed within five minutes of the sealer being applied or the sealer will begin to cure, causing an inadequate seal.

1. Apply sealant GM P/N 12346286 (Canadian P/N 10953472) to the side of the front cover (1) and rear crankshaft bearing cap (2), on both the left and right sides, 4 locations total.

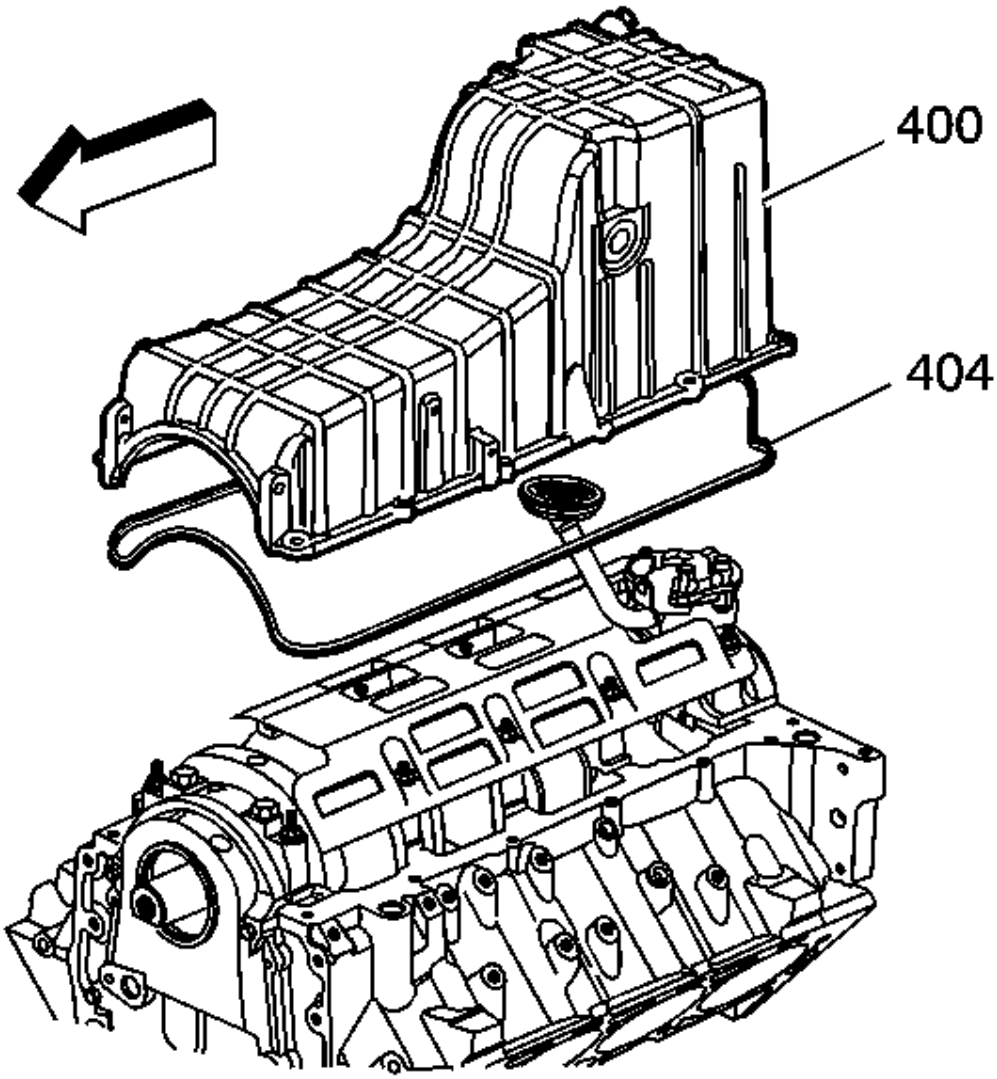

Fig. 503: View Of Oil Pan & Gasket

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Courtesy of GENERAL MOTORS CORP.

2. Install the new oil pan gasket (404) into the oil pan groove.
3. Install the oil pan (400).

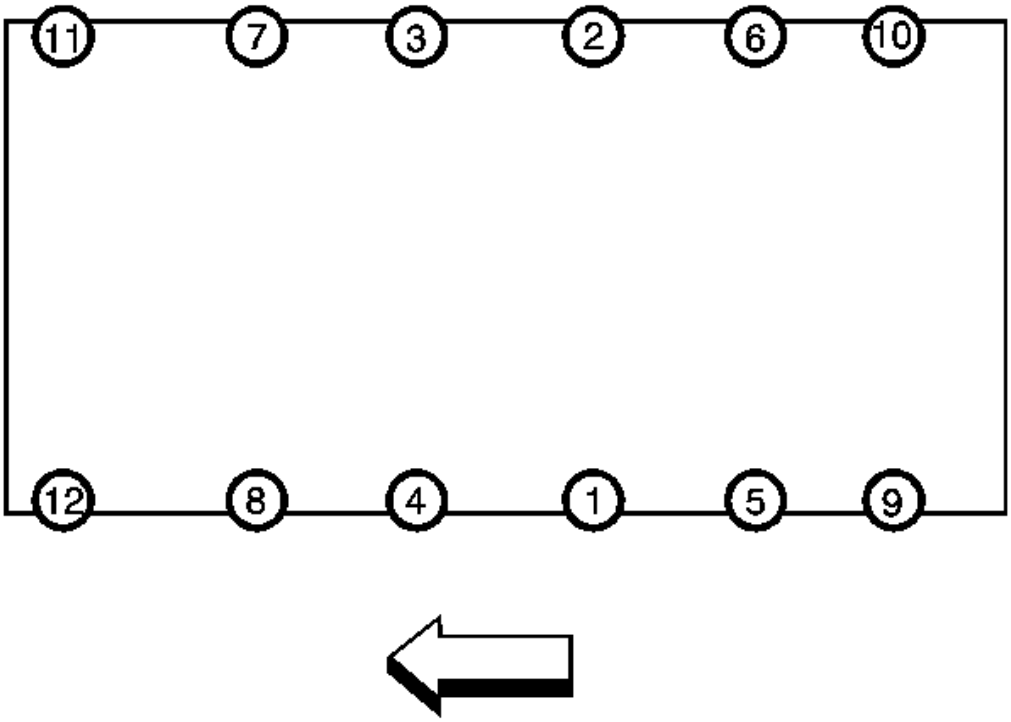

Fig. 504: View Of Oil Pan Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil pan bolts (1-12).
5. Tighten the oil pan bolts in sequence.

Tighten:

1. Tighten the oil pan bolts (1-12) a first pass in sequence to 10 N.m (89 lb in).
2. Tighten the oil pan bolts (1-12) a final pass in sequence to 25 N.m (18 lb ft).

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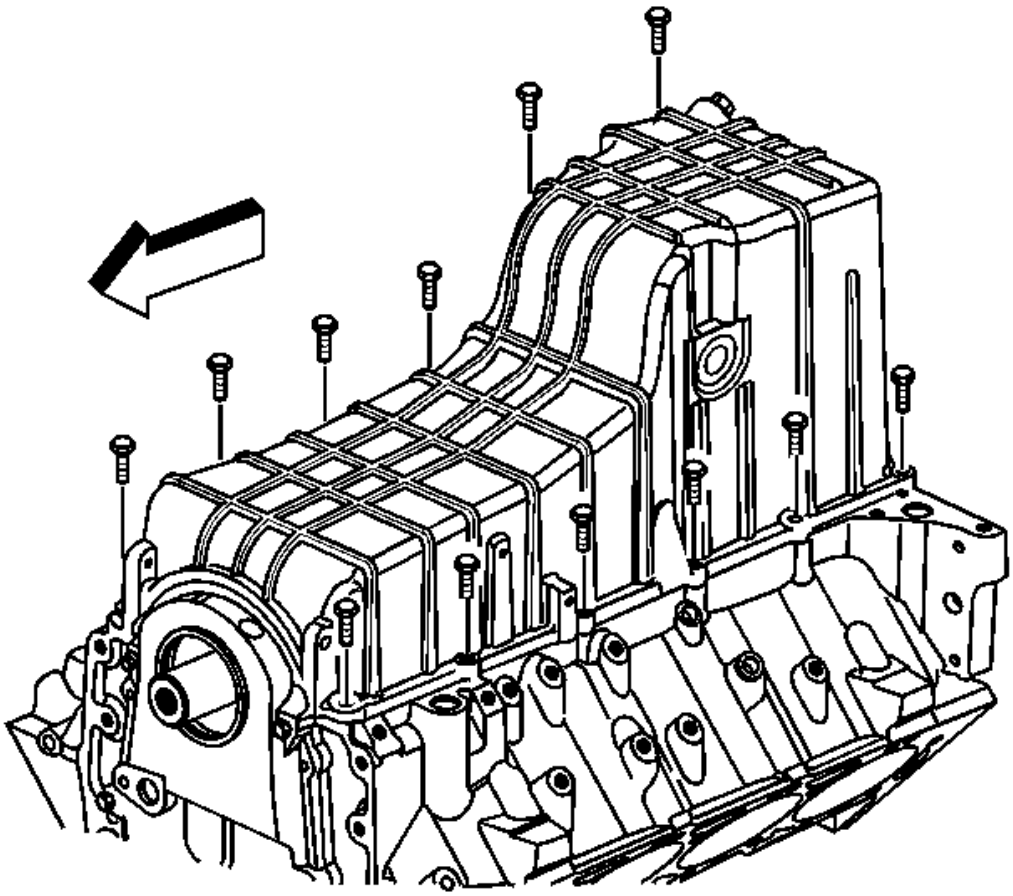

Fig. 505: View Of Oil Pan & Bolts
Courtesy of GENERAL MOTORS CORP.

6. Install the oil pan drain plug.

   Tighten: Tighten the oil pan drain plug to 28 N.m (21 lb ft).

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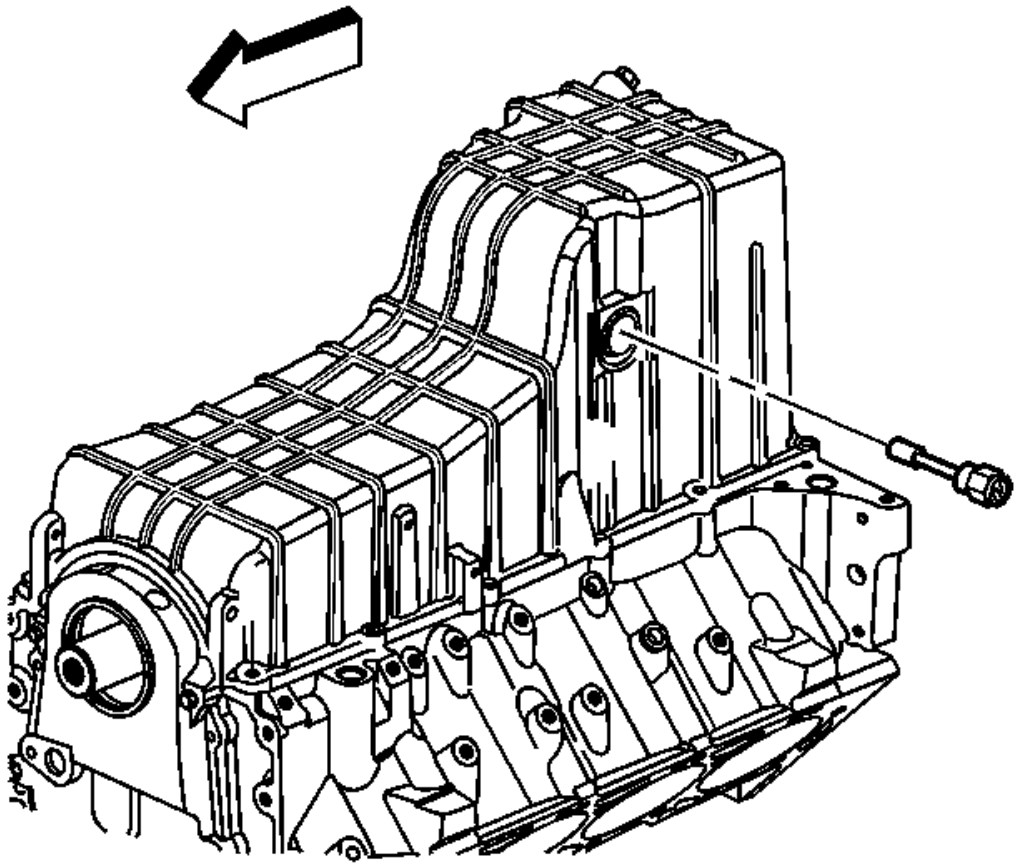

Fig. 506: View Of Oil Level Sensor
Courtesy of GENERAL MOTORS CORP.

7. Lubricate the oil level sensor O-ring with engine oil.
8. Install the oil level sensor.

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

Oil Pump Drive Installation

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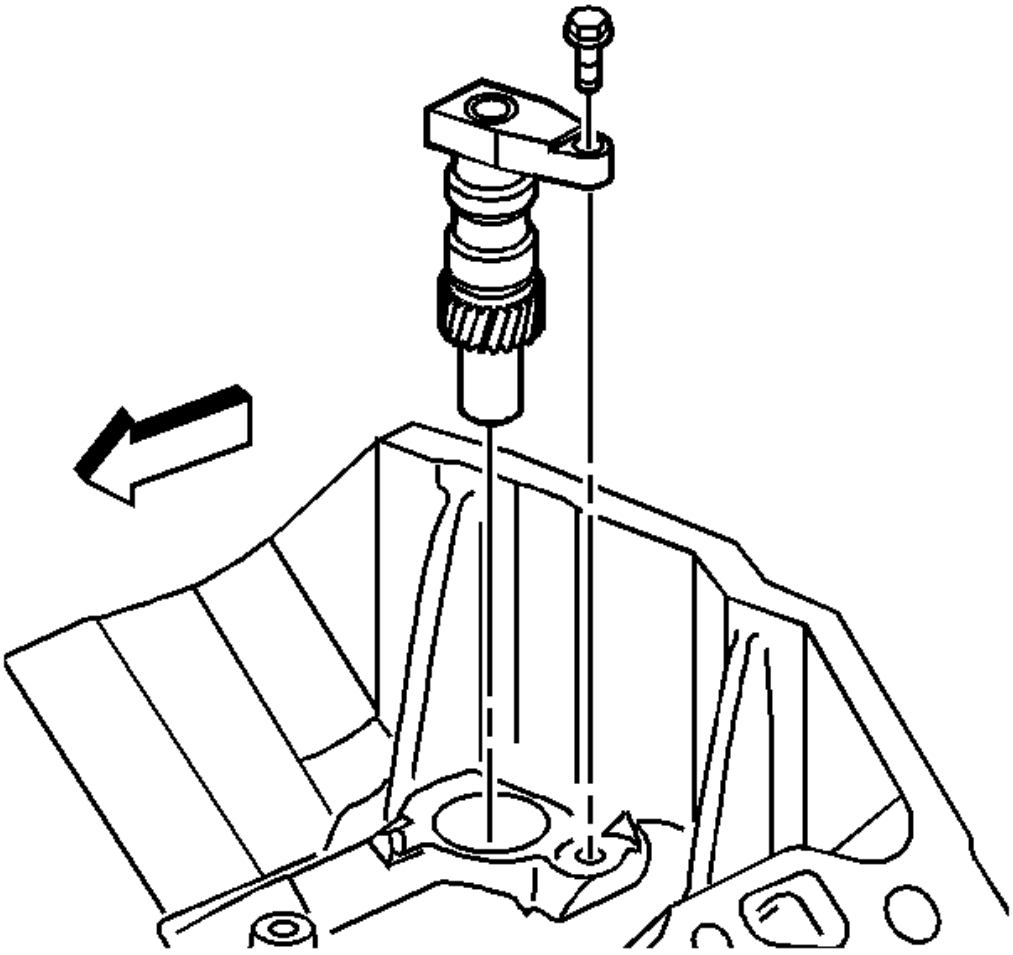

Fig. 507: View Of Oil Pump Drive
Courtesy of GENERAL MOTORS CORP.

1. Apply grease to the oil pump drive gear for ease of assembly.

NOTE: Ensure both components are aligned correctly or serious engine damage will occur.

2. Line up the oil pump drive gear with the oil pump drive shaft.
3. Install the oil pump drive, making sure that the oil pump drive is fully seated in the engine block.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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4. Install the oil pump drive bolt.

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

Valve Lifter Installation

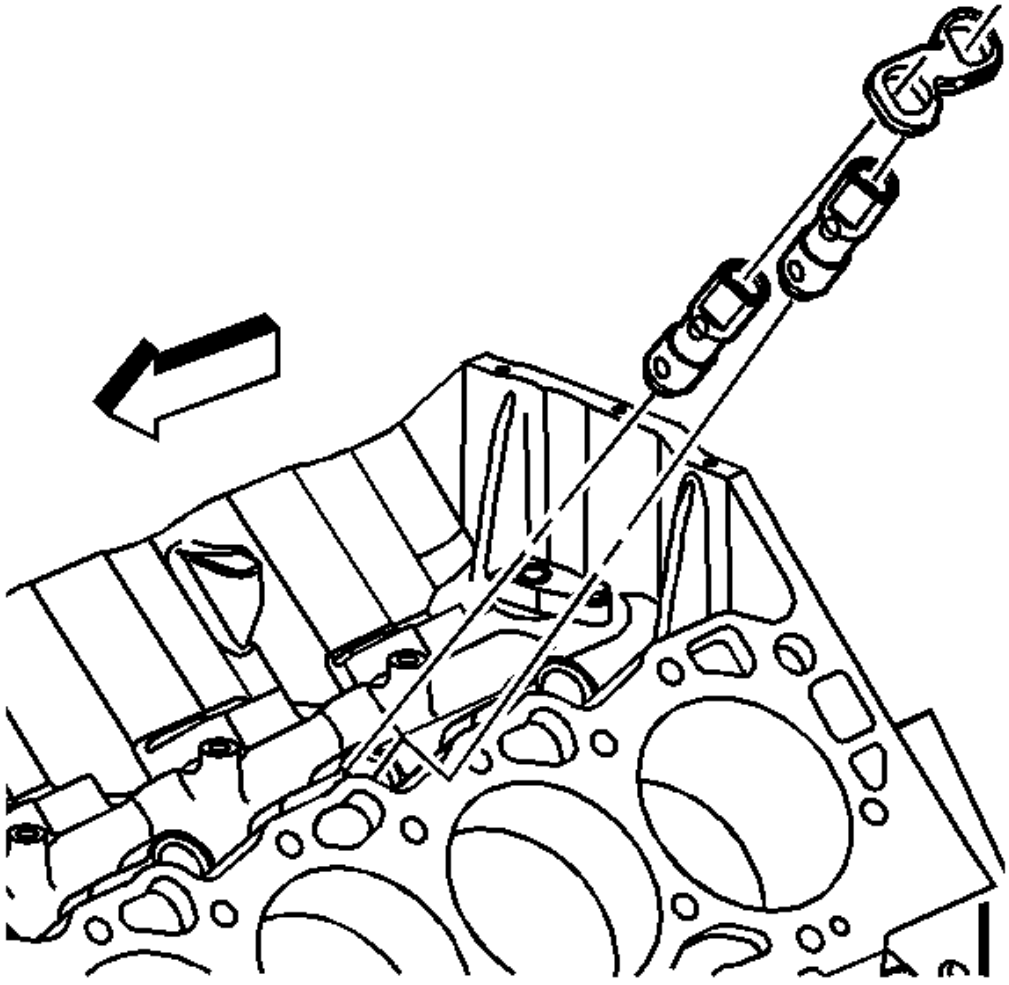

Fig. 508: View Of Valve Lifters
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If a new camshaft is installed, replace all the valve lifters.

1. Coat the valve lifter rollers with clean engine oil.

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IMPORTANT: If reusing the valve lifters, install in their original location. The valve lifter guide retainer must contact all of the valve lifter guides. If the valve lifter guide retainer is bent, the valve lifter guide retainer must be replaced.

2. Install the valve lifters.
3. Install the valve lifter guides over the flats on the valve lifters, making sure the rollers of the valve lifters are properly aligned with the camshaft lobes.

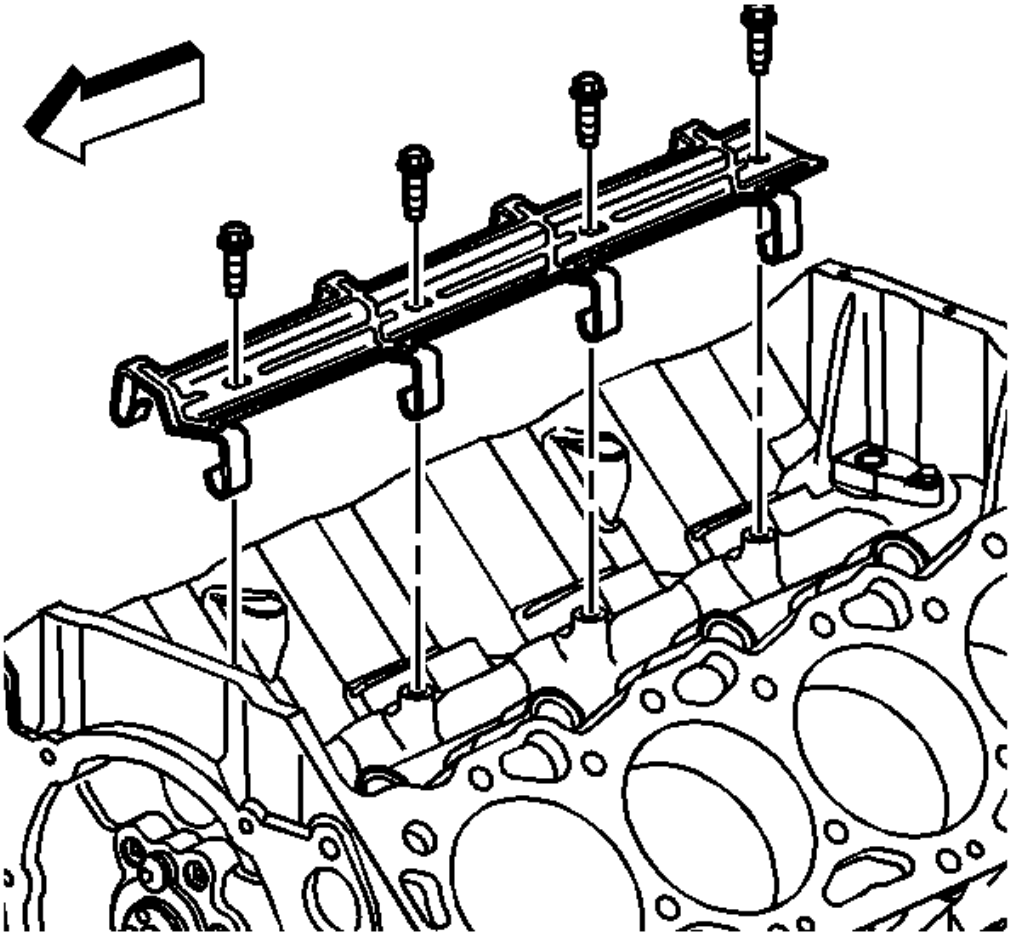

Fig. 509: View Of Valve Lifter Guide Retainer & Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the valve lifter guide retainer.

NOTE: Refer to Fastener Notice in Cautions and Notices.

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5. Install the valve lifter guide retainer bolts.

   Tighten: Tighten the valve lifter guide retainer bolts to 25 N.m (18 lb ft).

Cylinder Head Installation - Left

Tools Required

J 45059 Angle Meter

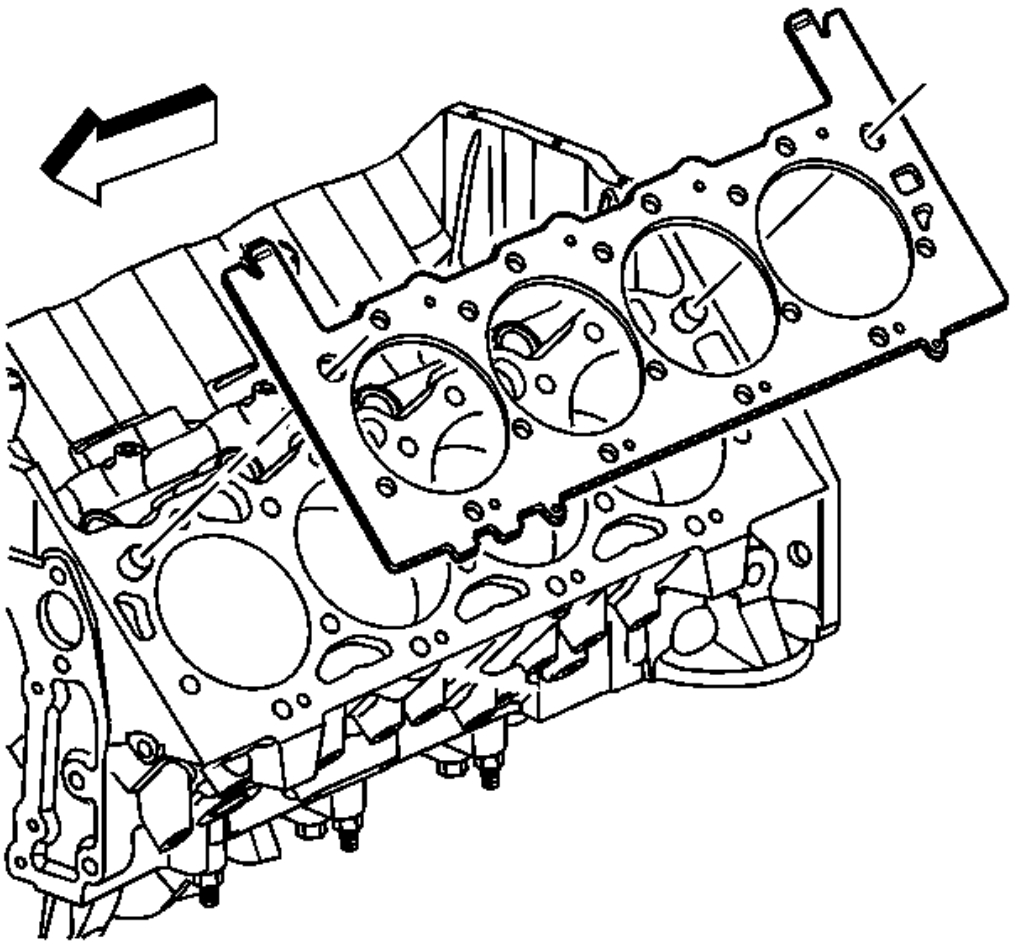

Fig. 510: View Of Left Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a sealant or adhesive when installing this component. Use of a

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sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

1. Place the cylinder head gasket in position over the cylinder head locating pins.

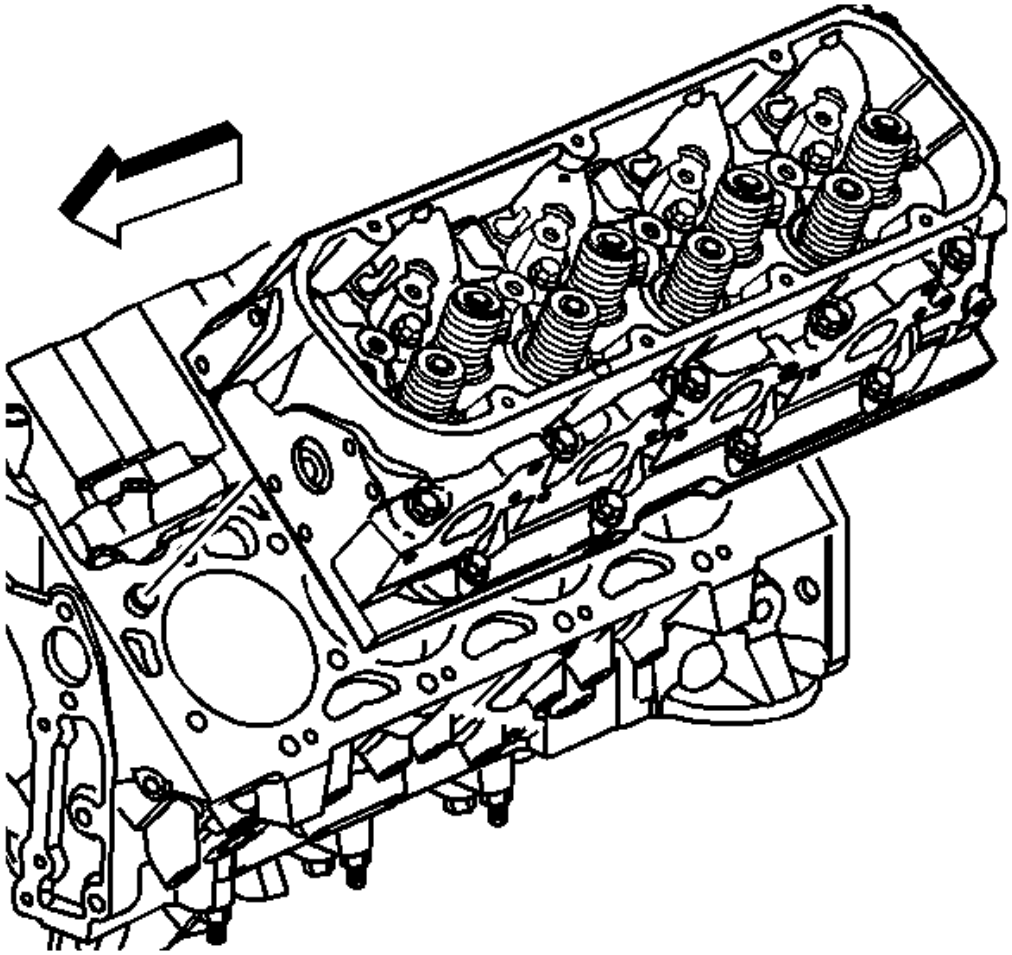

Fig. 511: View Of Left Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

2. Install the cylinder head to the block.

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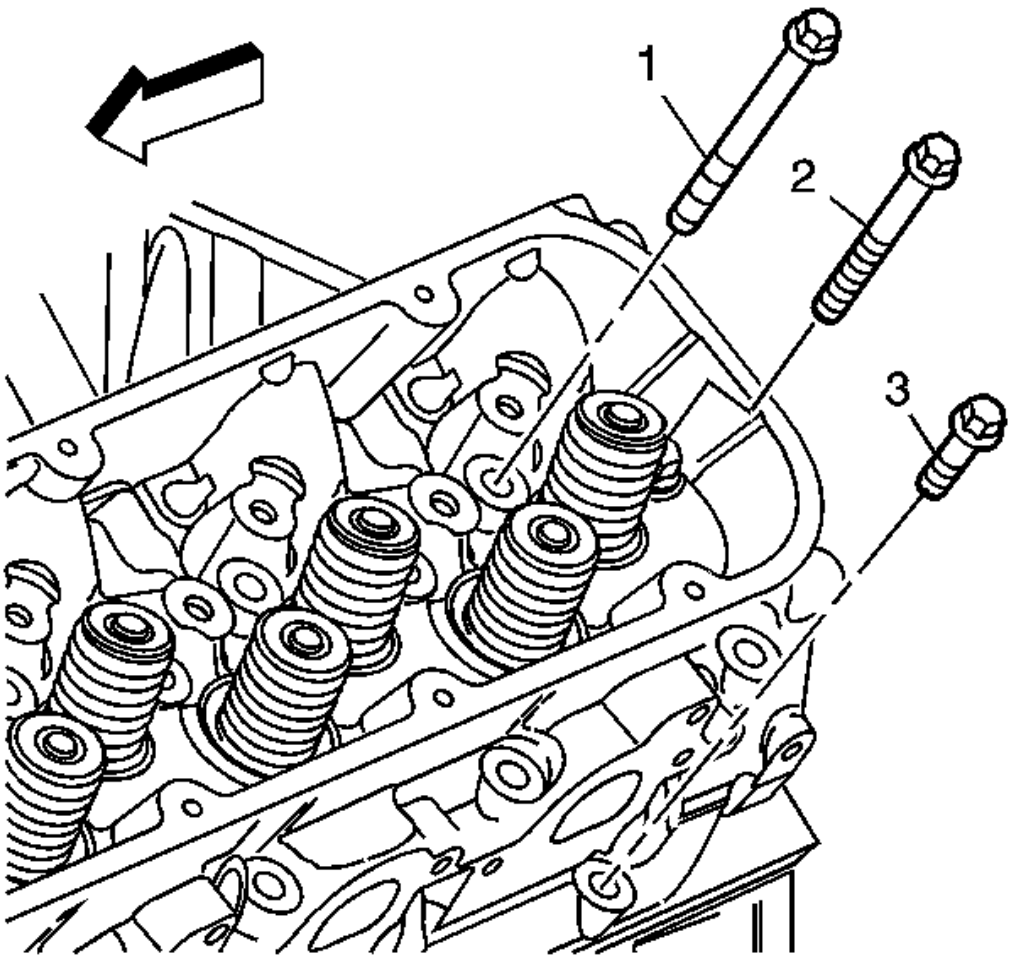

Fig. 512: View Of Cylinder Left Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: **Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.**

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IMPORTANT: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the new cylinder head bolts, apply sealer GM P/N 12346004, (Canadian P/N 10953480), or equivalent to the cylinder head bolts. Refer to Use of RTV and Anaerobic Sealer.

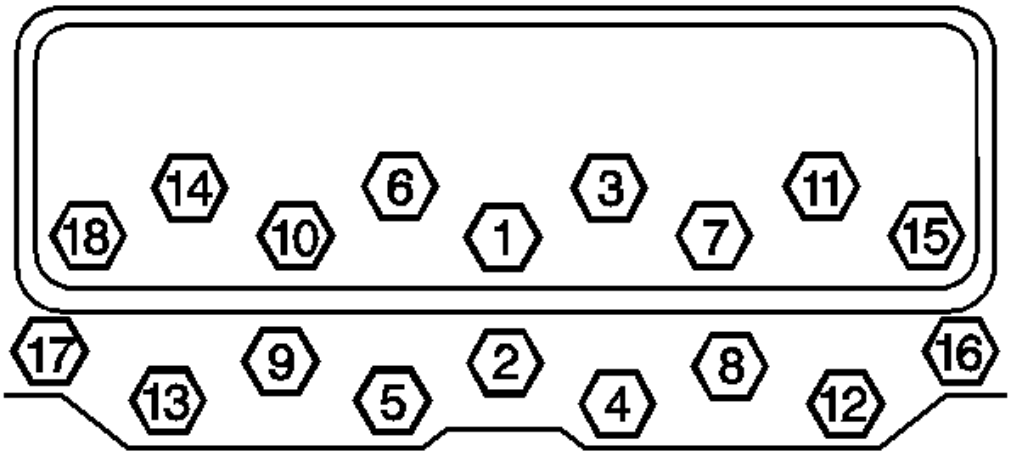

Fig. 513: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

NOTE: Do not reuse a cylinder head gasket once the initial clamping loads are applied. The initial tightening sequence procedure of the cylinder head bolts compresses the cylinder head gasket. If any bolt must be loosened once the initial sequence is started the cylinder head gasket must be replaced. Failure to replace the cylinder head gasket can lead to cylinder head bolt breakage or cylinder head gasket failure. A broken cylinder head bolt or failed cylinder head gasket can lead to extensive engine damage.

NOTE: The cylinder head bolt tightening sequence must be followed. The final angle tightening sequence of the cylinder head bolts varies depending on the length of the cylinder head bolt. Failure to angle tighten the specific length bolt the proper number of degrees can lead to cylinder head bolt failure or improper clamping load of the cylinder head gasket. Cylinder head bolt or cylinder head gasket failure can lead to extensive engine damage.

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IMPORTANT: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

Tighten:

1. Tighten the bolts (1-18) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the bolts (1-18) a second pass in sequence to 30 N.m (22 lb ft), then an additional 120 degrees using the **J 45059** .
3. Tighten the bolts, 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17, an additional 60 degrees, bolts, 15 and 18, an additional 45 degrees, and bolts, 4, 5, 12, 13, an additional 30 degrees a final pass in sequence using the **J 45059** .

Cylinder Head Installation - Right

Tools Required

J 45059 Angle Meter

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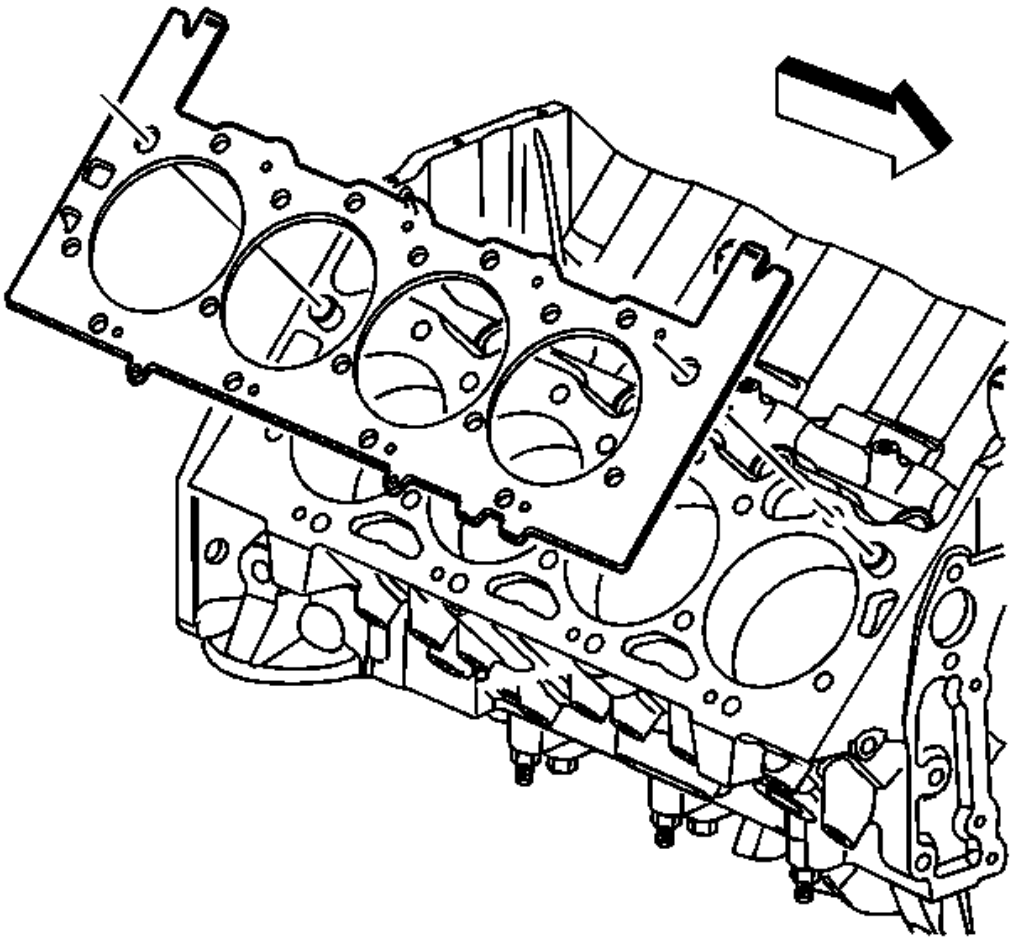

Fig. 514: View Of Right Cylinder Head Gasket And Alignment Pins
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a sealant or adhesive when installing this component. Use of a sealant or adhesive can cause improper sealing. A component that is not sealed properly can leak leading to extensive engine damage.

1. Place the cylinder head gasket in position over the cylinder head locating pins.

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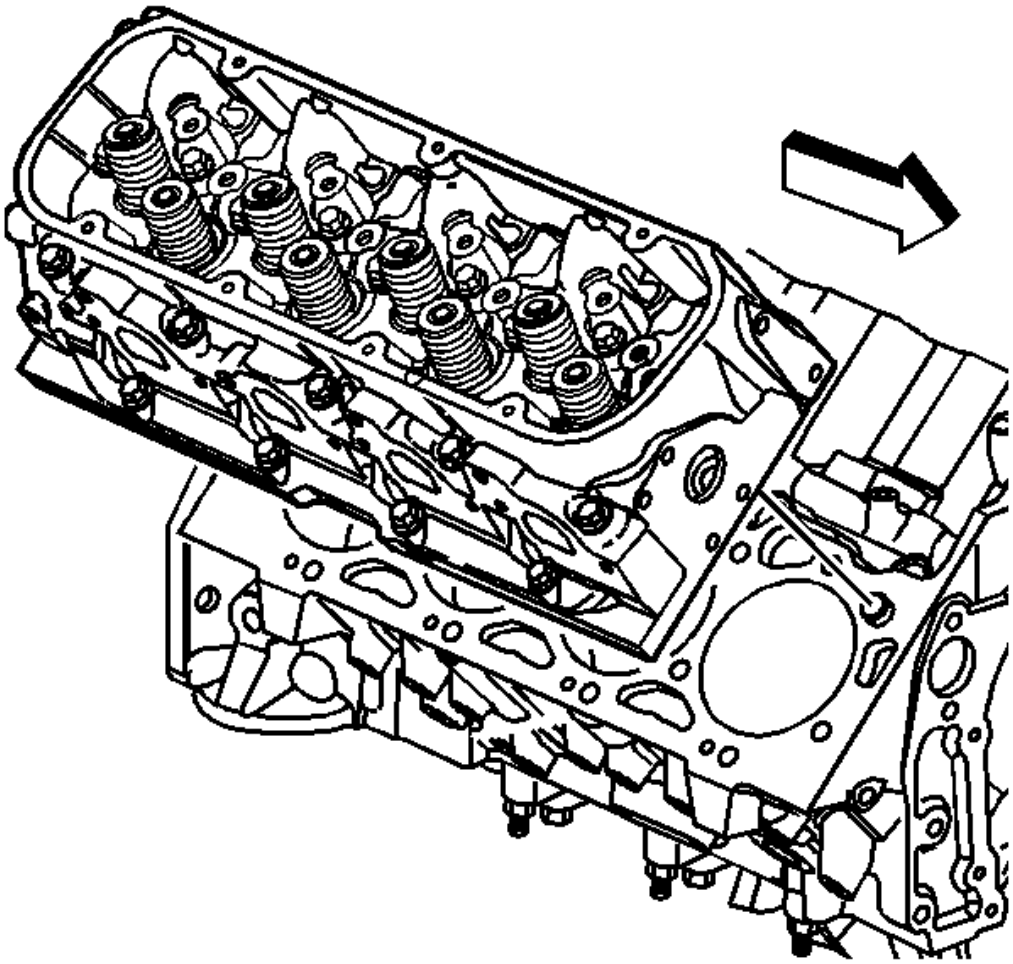

Fig. 515: View Of Right Cylinder Head And Alignment Pin
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Guide the cylinder head carefully into place over the locating pins and the cylinder head gasket.

2. Install the cylinder head to the block.

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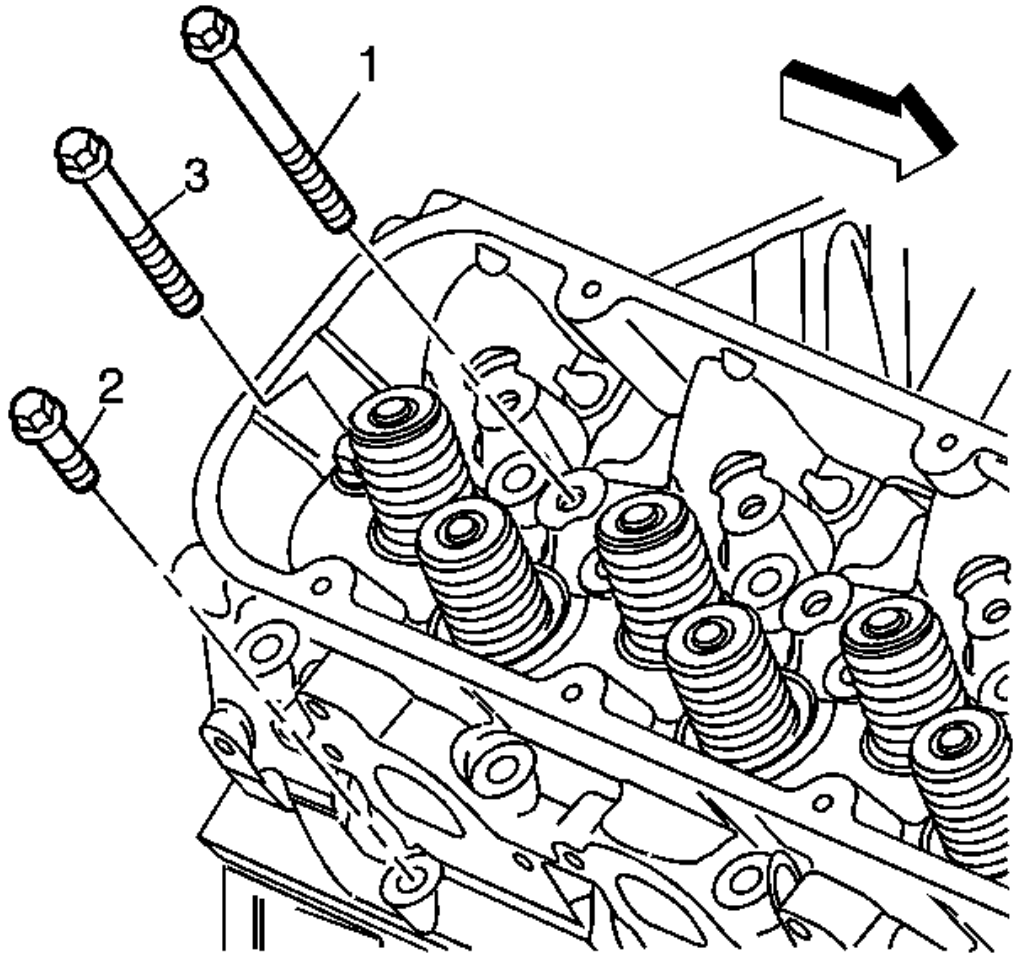

Fig. 516: View Of Right Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not reuse the cylinder head bolts. NEW cylinder head bolts must be used. The cylinder head bolts are torque-to-yield bolts and cannot be reused once the initial torque is applied. During the initial torque of the cylinder head bolt the cylinder head bolt is stretched to achieve proper clamp load. Proper clamp load will not be achieved if a used cylinder head bolt is torqued again. A stretched cylinder head bolt can also break when torqued. Failure to replace the used cylinder head bolts with NEW cylinder head bolts can lead to improper clamp loads and extensive engine damage.

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IMPORTANT: The sealer must be applied to a minimum of eight threads starting at the point of the cylinder head bolt.

3. If not pre-applied to the new cylinder head bolts (1-3), apply sealer GM P/N 12346004, (Canadian P/N 10953480), or equivalent to the cylinder head bolts. Refer to Use of RTV and Anaerobic Sealer.

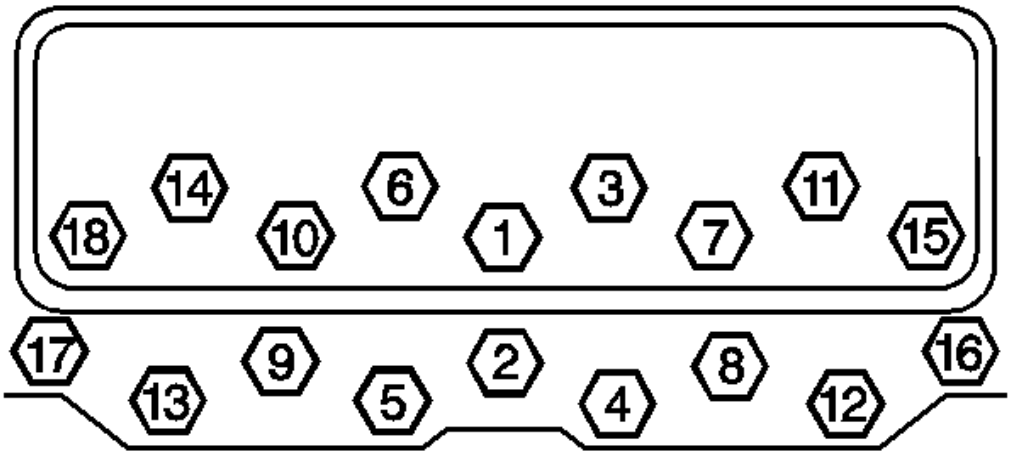

Fig. 517: Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

NOTE: Do not reuse a cylinder head gasket once the initial clamping loads are applied. The initial tightening sequence procedure of the cylinder head bolts compresses the cylinder head gasket. If any bolt must be loosened once the initial sequence is started the cylinder head gasket must be replaced. Failure to replace the cylinder head gasket can lead to cylinder head bolt breakage or cylinder head gasket failure. A broken cylinder head bolt or failed cylinder head gasket can lead to extensive engine damage.

NOTE: The cylinder head bolt tightening sequence must be followed. The final angle tightening sequence of the cylinder head bolts varies depending on the length of the cylinder head bolt. Failure to angle tighten the specific length bolt the proper number of degrees can lead to cylinder head bolt failure or improper clamping load of the cylinder head gasket. Cylinder head bolt or cylinder head gasket failure can lead to extensive engine damage.

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IMPORTANT: The long bolts are used in locations 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16 and 17. The medium length bolts are used in locations 15 and 18. The short bolts are used in locations 4, 5, 12 and 13.

4. Install the cylinder head bolts.

Tighten:

1. Tighten the bolts (1-18) a first pass in sequence to 30 N.m (22 lb ft).
2. Tighten the bolts (1-18) a second pass in sequence to 30 N.m (22 lb ft), then an additional 120 degrees using the **J 45059** .
3. Tighten the bolts, 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17, an additional 60 degrees, bolts, 15 and 18, an additional 45 degrees, and bolts, 4, 5, 12, 13, an additional 30 degrees a final pass in sequence using the **J 45059** .

Valve Rocker Arm and Push Rod Installation

IMPORTANT: Keep the parts in order. Parts must be put back from where they were removed.

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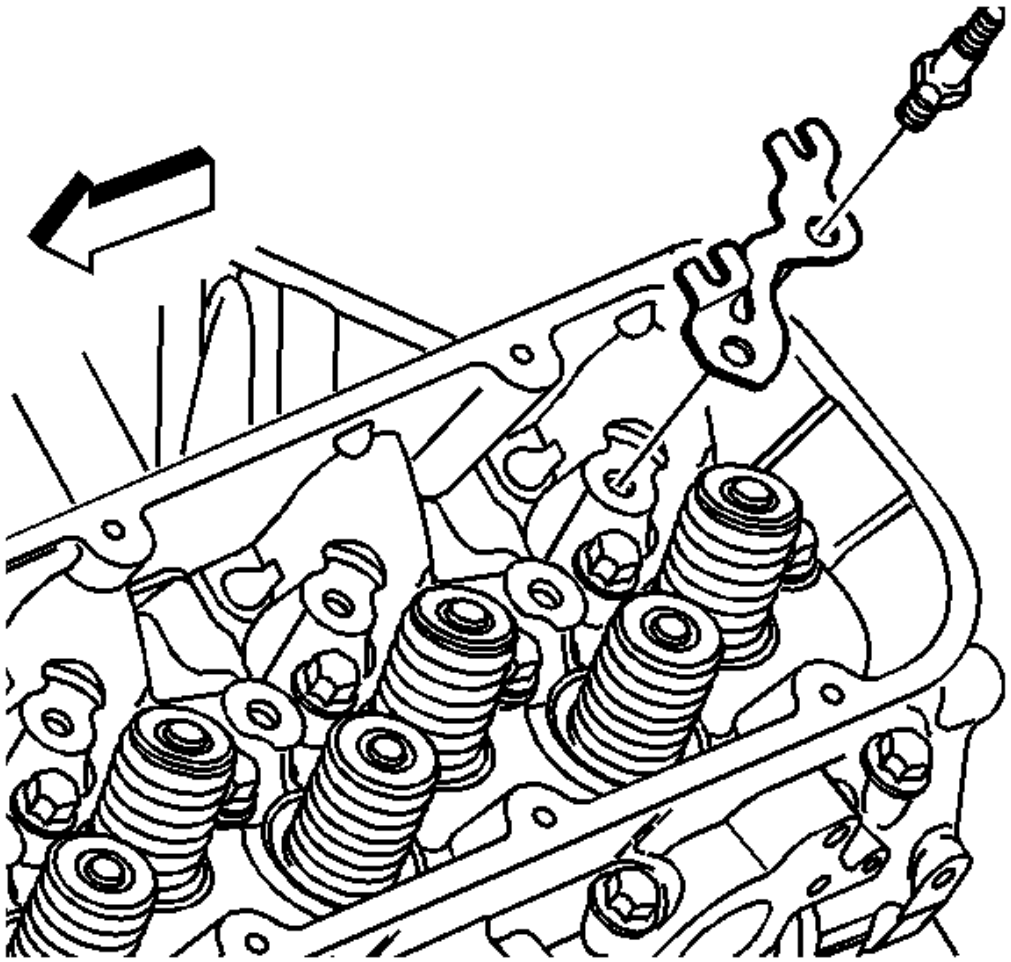

Fig. 518: View Of Valve Rocker Arm Studs & Pushrod Guides
Courtesy of GENERAL MOTORS CORP.

1. Apply sealer GM P/N 12346004, (Canadian P/N 10953480), or equivalent to the valve rocker arm stud-to-cylinder head threads.

   Apply the sealer to a minimum of 6 threads.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the push rod guides and valve rocker arm studs onto the cylinder head.

   Tighten: Tighten the valve rocker arm studs to 50 N.m (37 lb ft).

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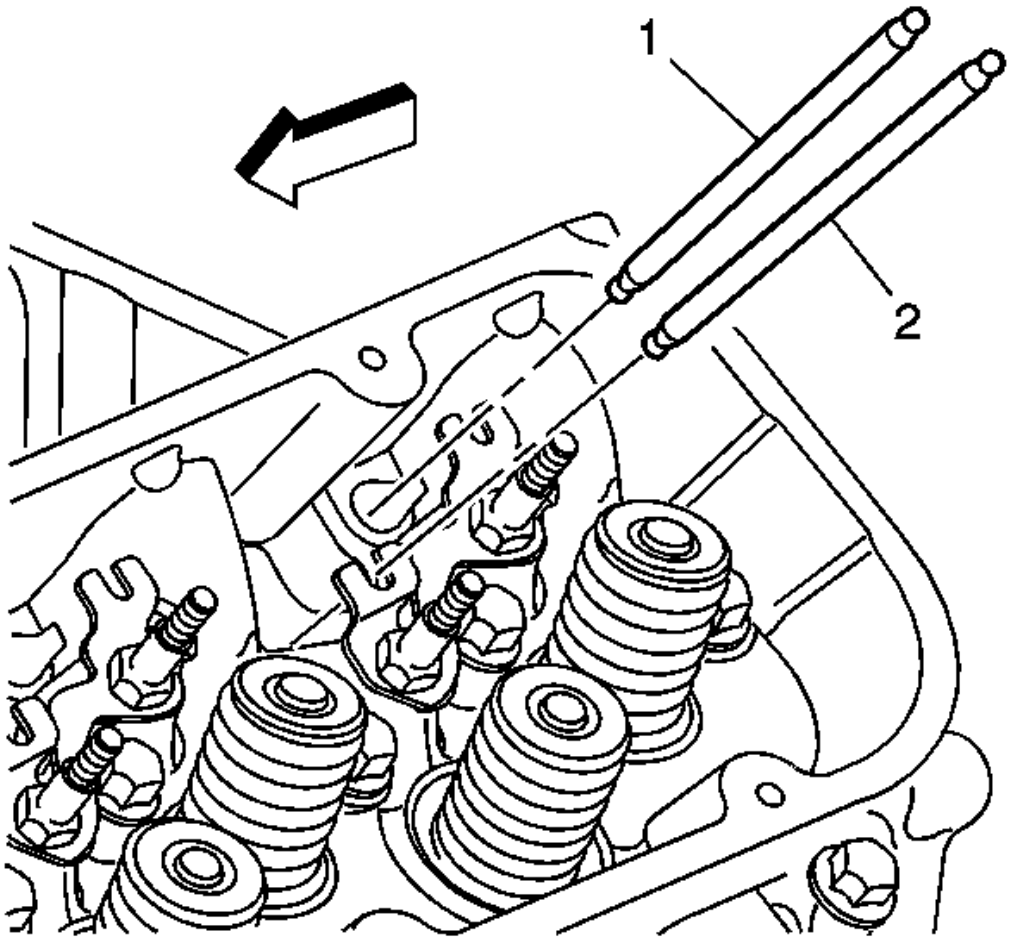

Fig. 519: View Of Intake & Exhaust Valve Pushrods
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The 8.1L engine uses different length intake and exhaust valve push rods. The exhaust valve push rods (2) are longer than the intake valve push rods (1).

3. Install the valve push rods.

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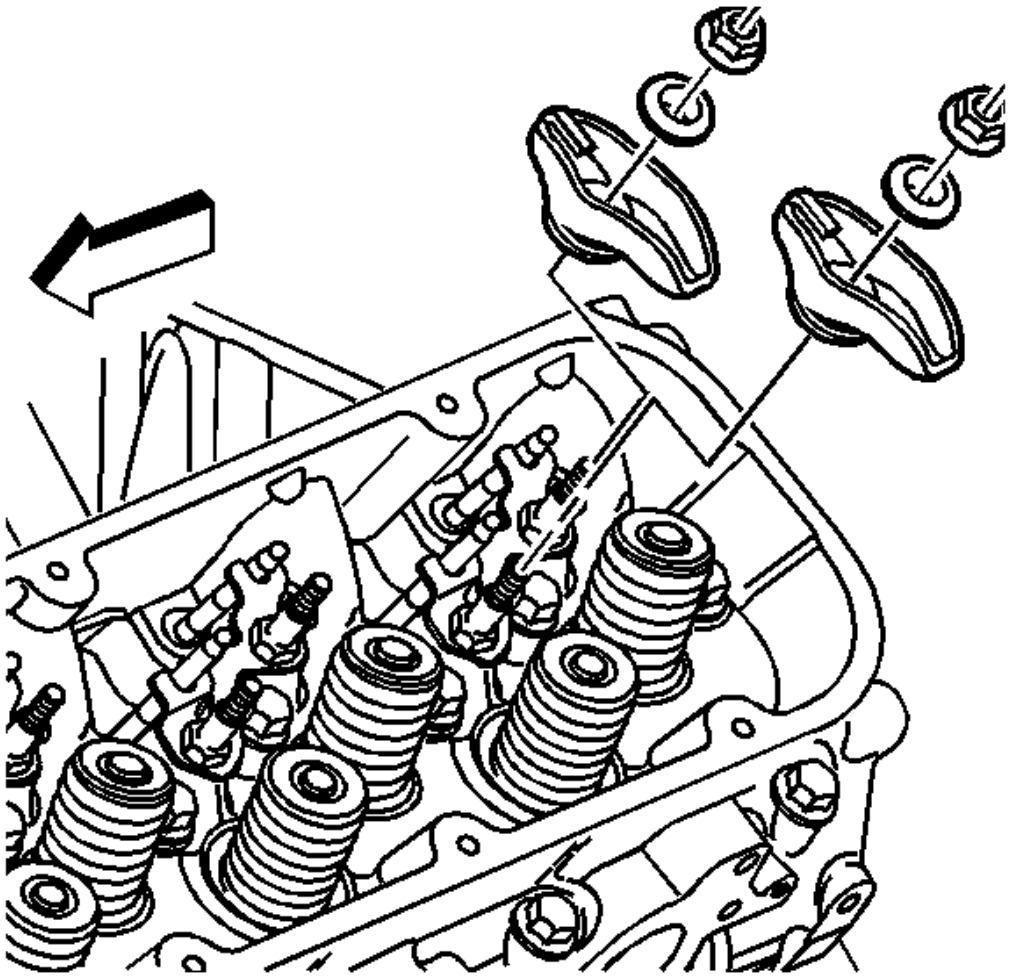

Fig. 520: View Of Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

4. Coat the valve rocker arm and valve rocker arm ball bearing surfaces with grease or clean engine oil.
5. Install the valve rocker arms, the valve rocker arm balls and the valve rocker arm nuts.

   Tighten: Tighten the valve rocker arm nuts slowly, to 35 N.m (26 lb ft), while guiding the tips of the rocker arms over the tips of the valves.

Intake Manifold Installation

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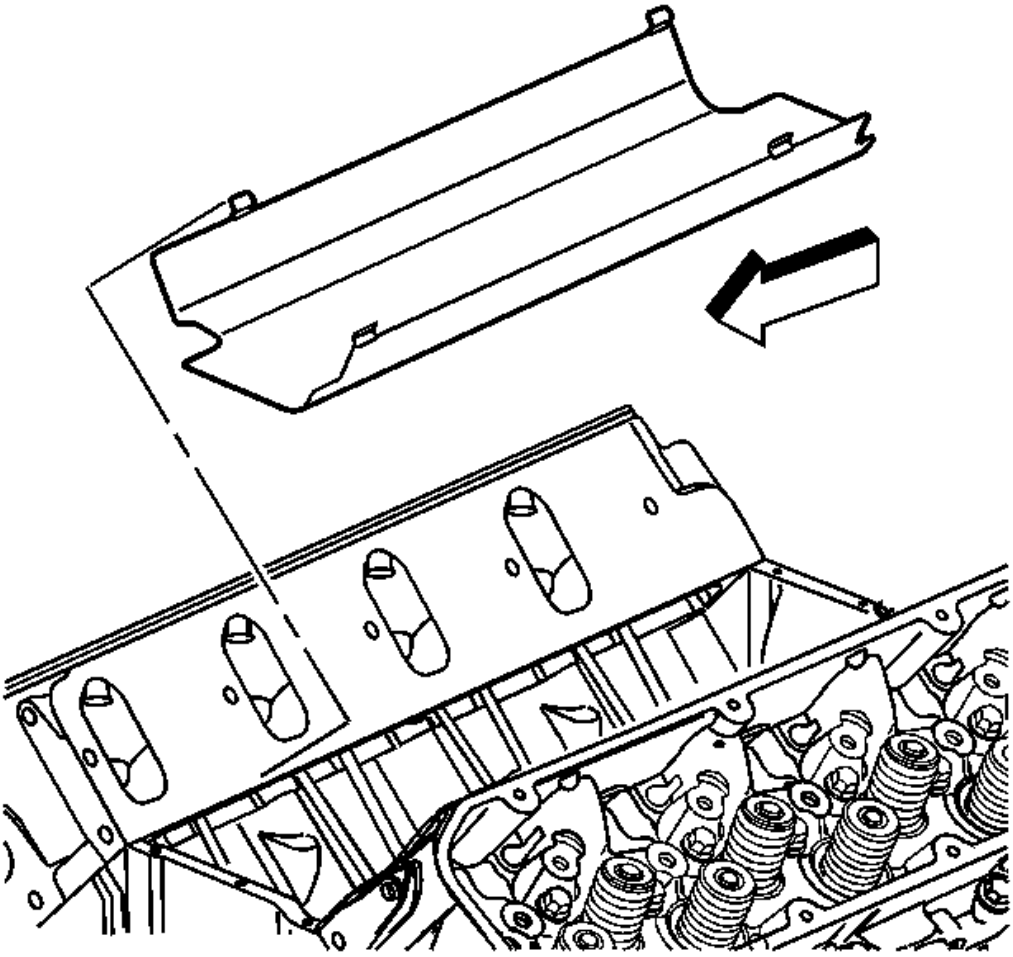

Fig. 521: View Of Splash Shield
Courtesy of GENERAL MOTORS CORP.

1. Install the splash shield.

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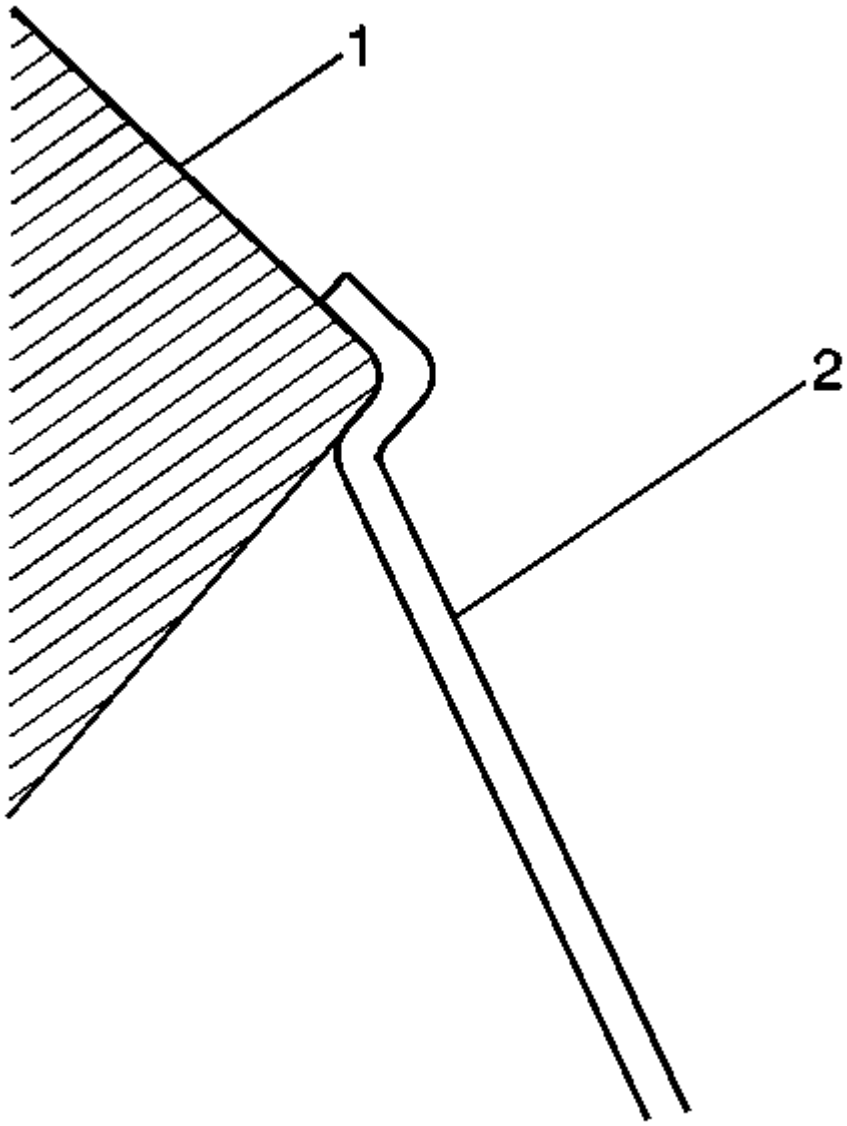

Fig. 522: Ensuring Splash Shield Snap Fits Between Cylinder Heads
Courtesy of GENERAL MOTORS CORP.

2. Ensure the splash shield (2) snap fits between the cylinder heads (1).

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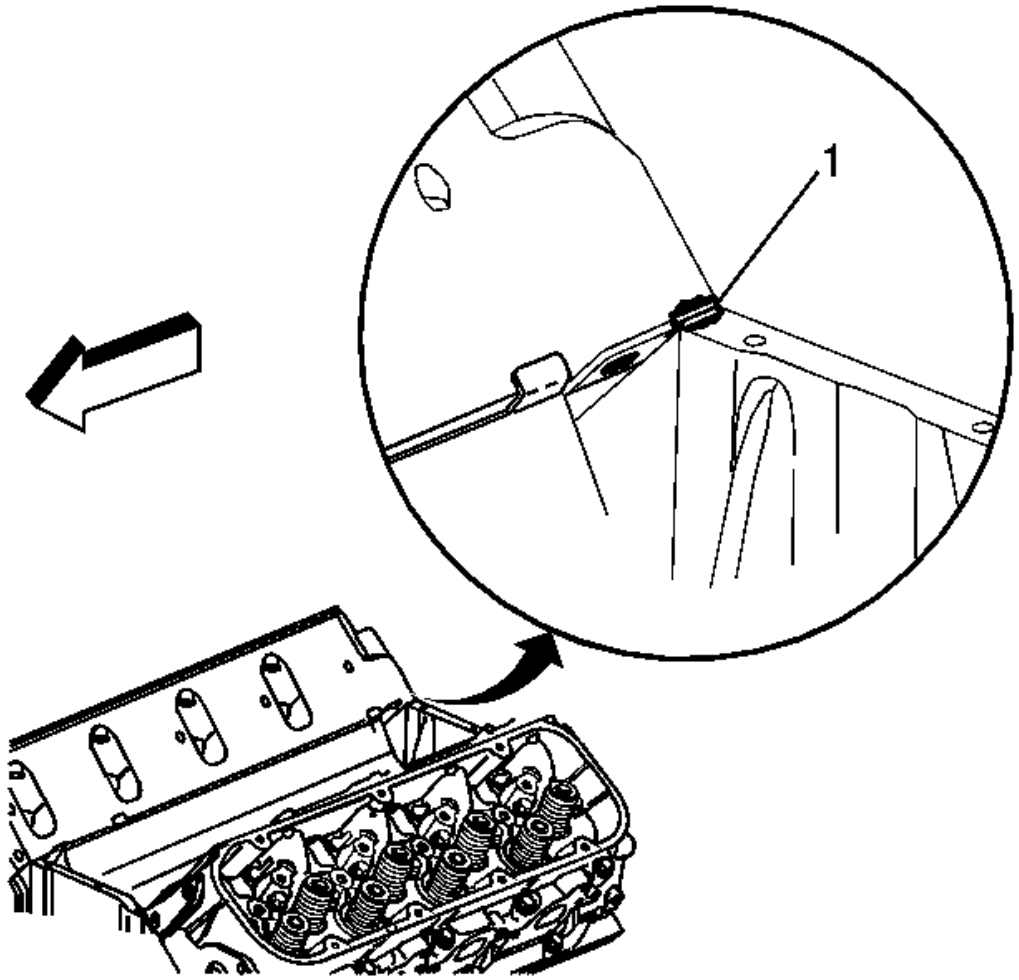

Fig. 523: Applying Sealer To Engine Block/Cylinder Head Locations
Courtesy of GENERAL MOTORS CORP.

3. Apply a 5 mm (0.2 in) bead of GM P/N 12346141 (Canadian P/N 10953433) sealer (1) to the 4 engine block/cylinder head locations.

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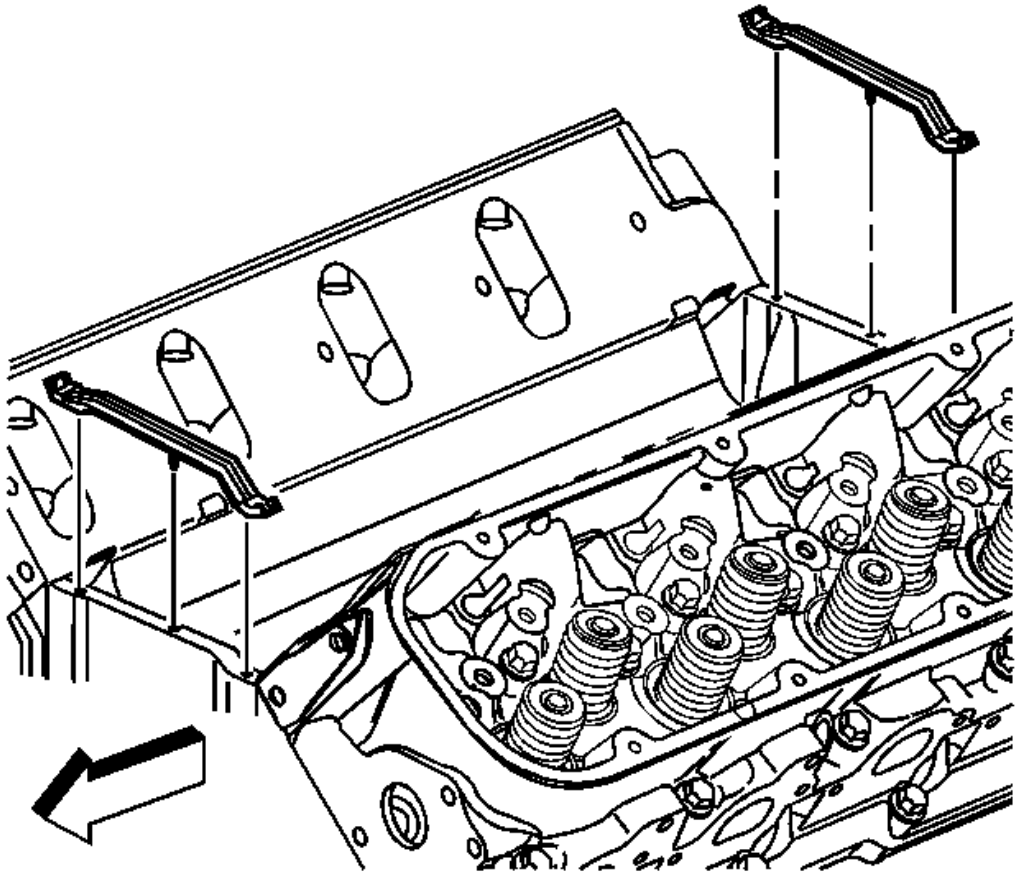

Fig. 524: View Of Intake Manifold End Seals
Courtesy of GENERAL MOTORS CORP.

4. Install the new intake manifold end seals.

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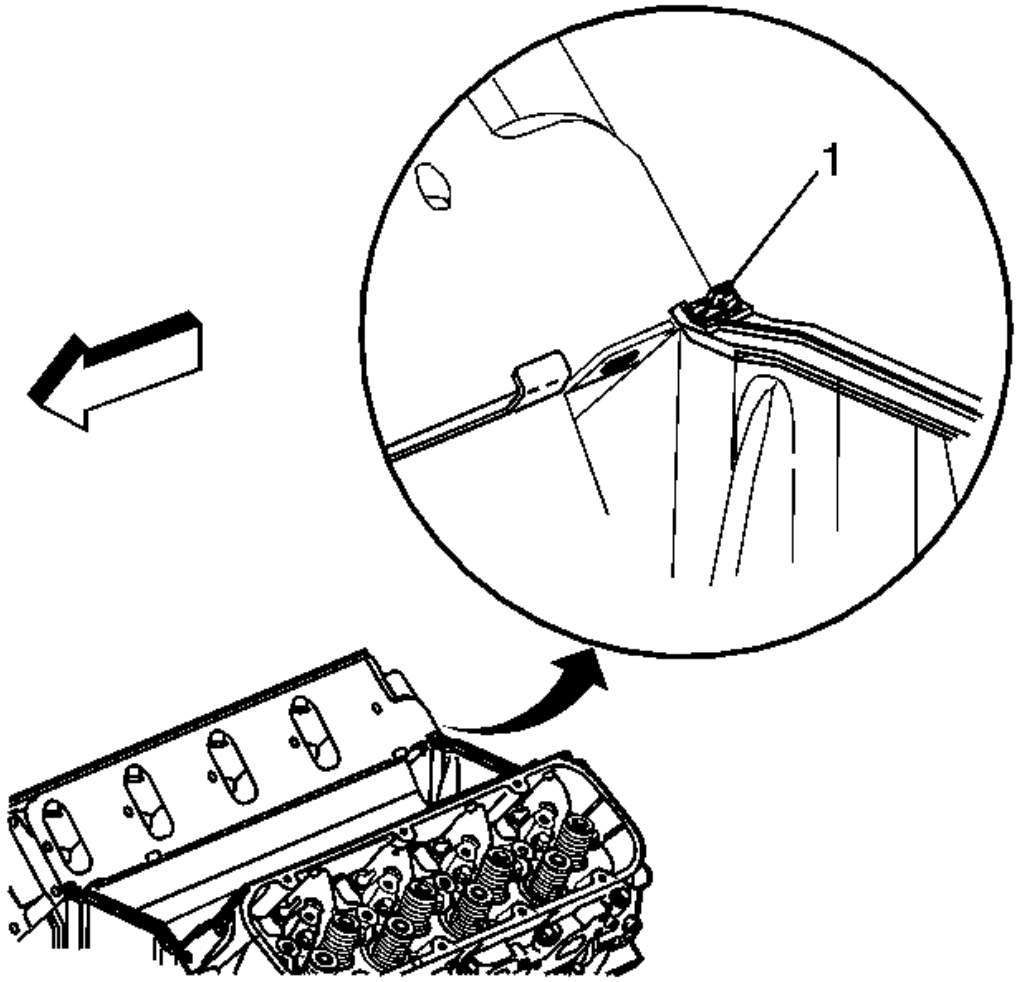

Fig. 525: Applying Sealer Onto End Seals At Engine Block/Cylinder Head Locations
Courtesy of GENERAL MOTORS CORP.

5. Apply a 5 mm (0.2 in) bead of GM P/N 12346141 (Canadian P/N 10953433) sealer (1) onto the end seals at the 4 engine block/cylinder head locations.

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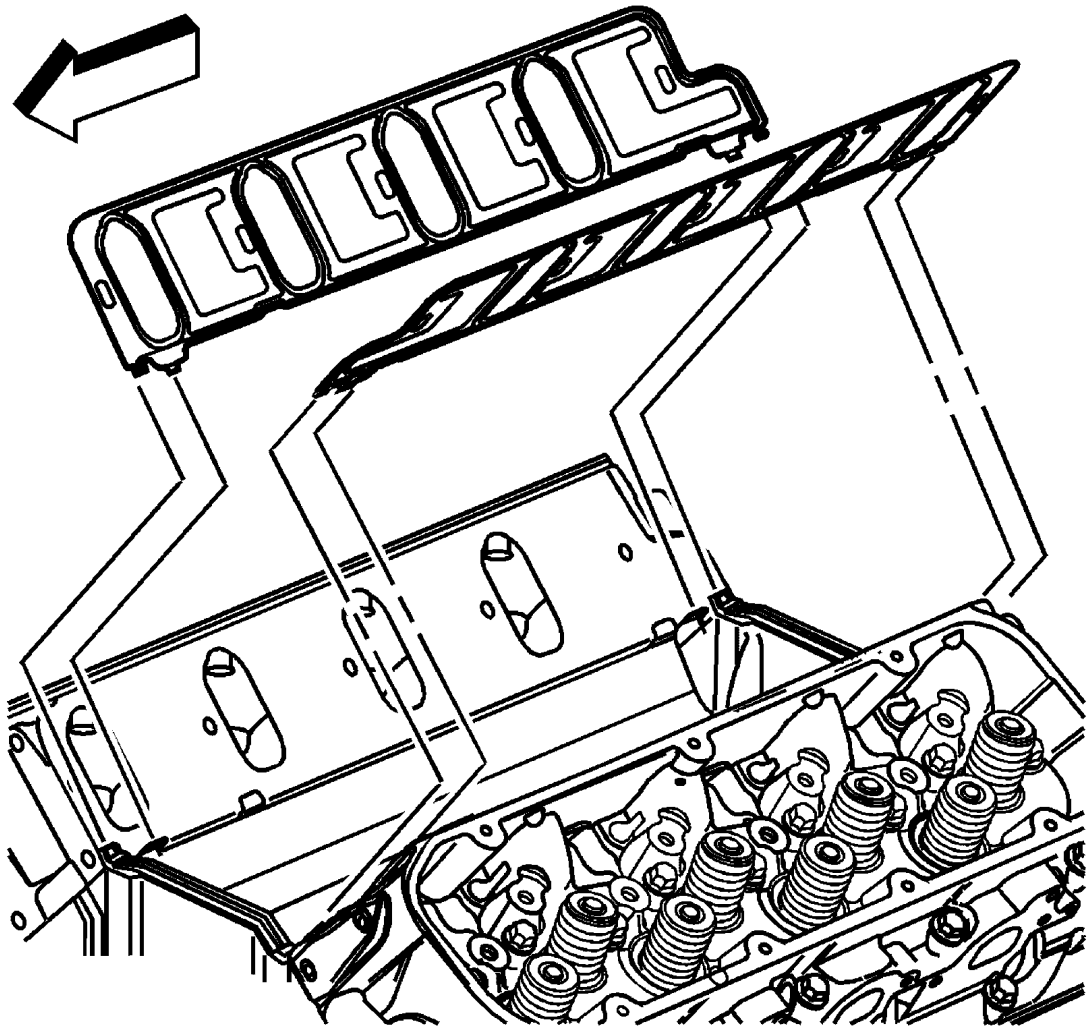

Fig. 526: View Of Intake Manifold Side Gaskets
Courtesy of GENERAL MOTORS CORP.

6. Install the new intake manifold side gaskets onto the cylinder heads.

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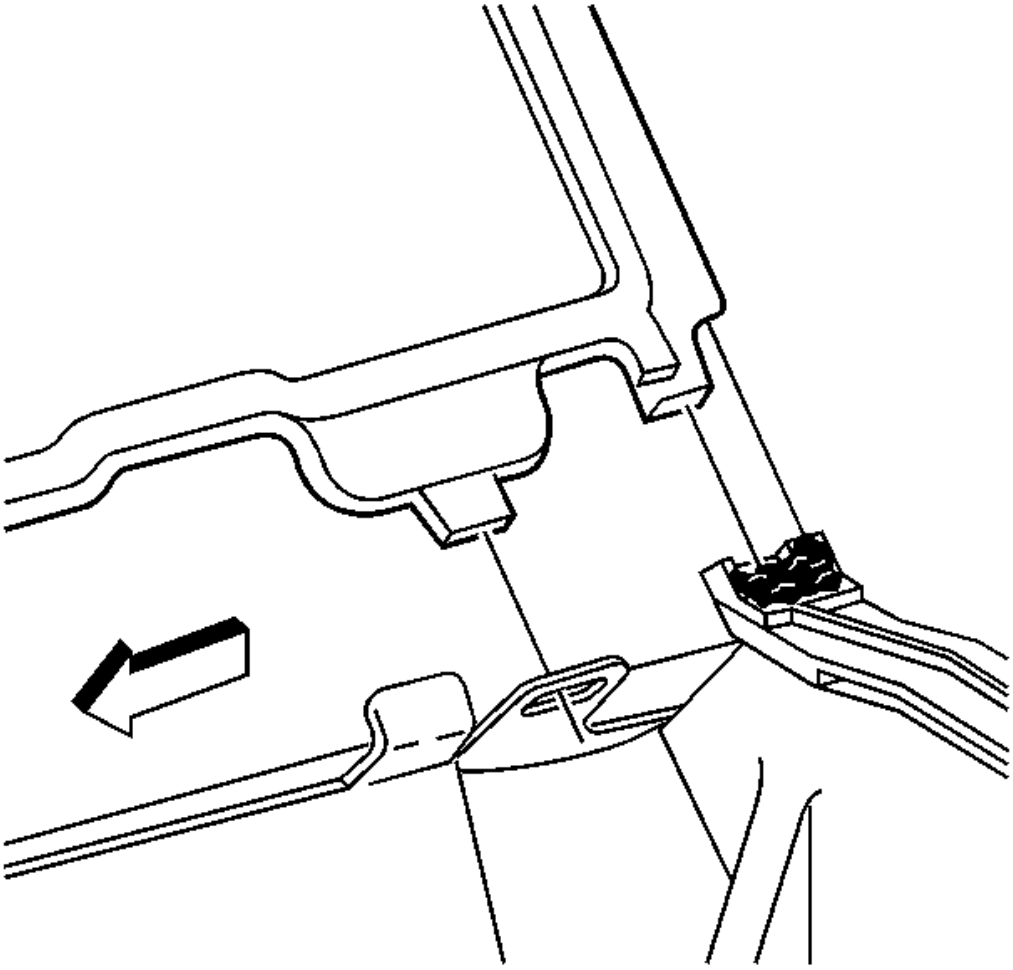

Fig. 527: Ensuring Intake Manifold Gasket Tabs Align
Courtesy of GENERAL MOTORS CORP.

7. Ensure the intake manifold gasket tabs align with the hole in the head gasket.
8. Ensure the intake manifold gasket tabs align with the slot in the intake manifold end seals.

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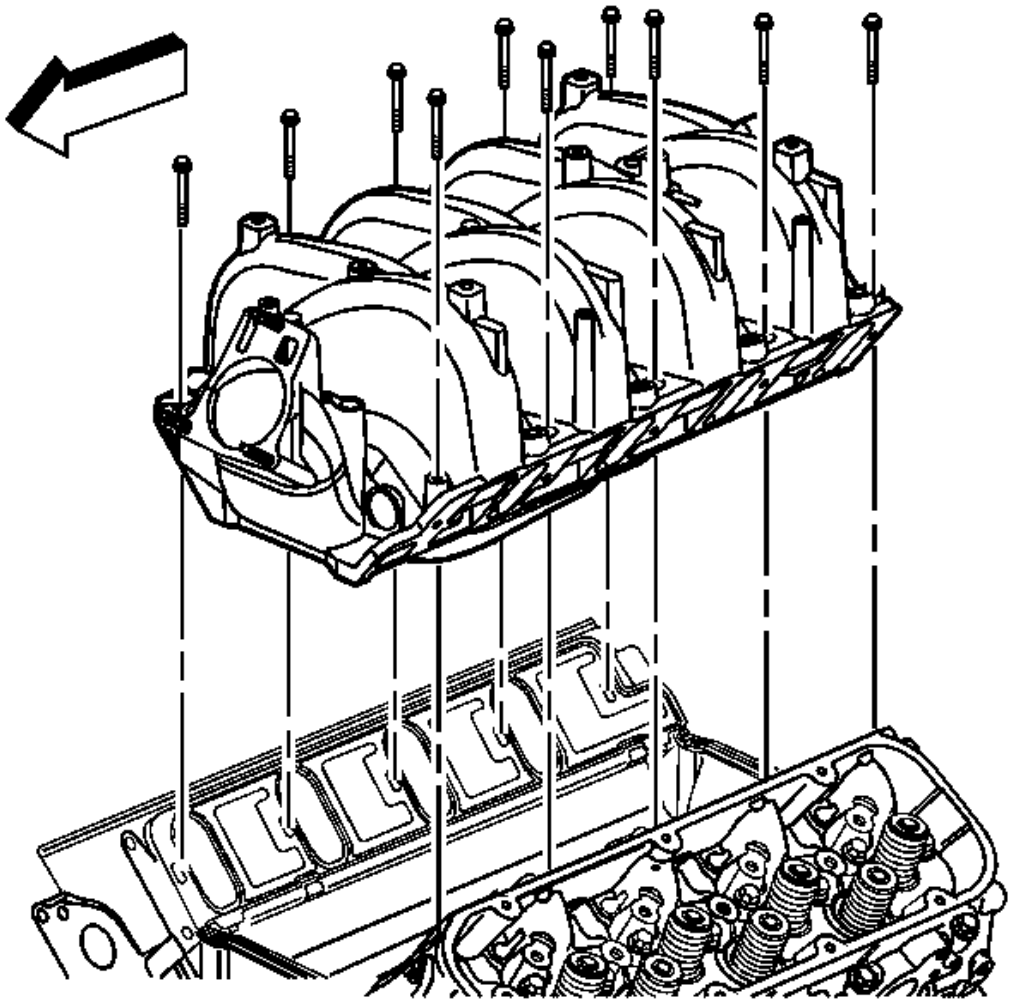

Fig. 528: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

9. Install the intake manifold onto the engine block.

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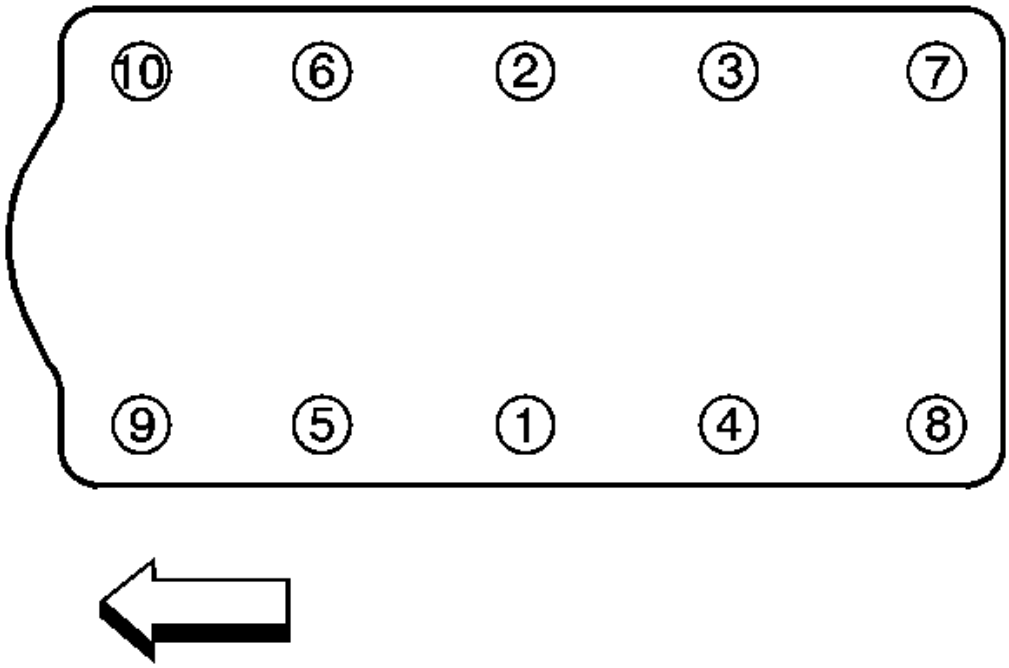

Fig. 529: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: **Ensure the intake manifold does not shift as the intake manifold bolts are tightened in the proper sequence. Failure to follow the entire intake manifold bolt tightening sequence exactly, may result in an oil leak and serious engine damage.**

IMPORTANT:

- **The entire intake manifold tightening sequence must be promptly completed due to the anaerobic thread adhesive. The final pass of the tightening sequence must be completed before the adhesive starts to cure, or false torque readings and ineffective thread locking may result.**
- **DO NOT reuse intake manifold bolts. Install NEW intake manifold bolts during assembly.**

10. Install the NEW intake manifold bolts.

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

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11. Tighten the intake manifold bolts in sequence, using 4 passes.

Tighten:

1. Tighten the intake manifold bolts a first pass in sequence to 5 N.m (44 lb in).
2. Tighten the intake manifold bolts a second pass in sequence to 8 N.m (71 lb in). Inspect the intake manifold joints for signs of intake manifold shifting. Correct as required.
3. Tighten the intake manifold bolts a third pass in sequence to 12 N.m (106 lb in).
4. Tighten the intake manifold bolts a final pass in sequence to 15 N.m (11 lb ft).

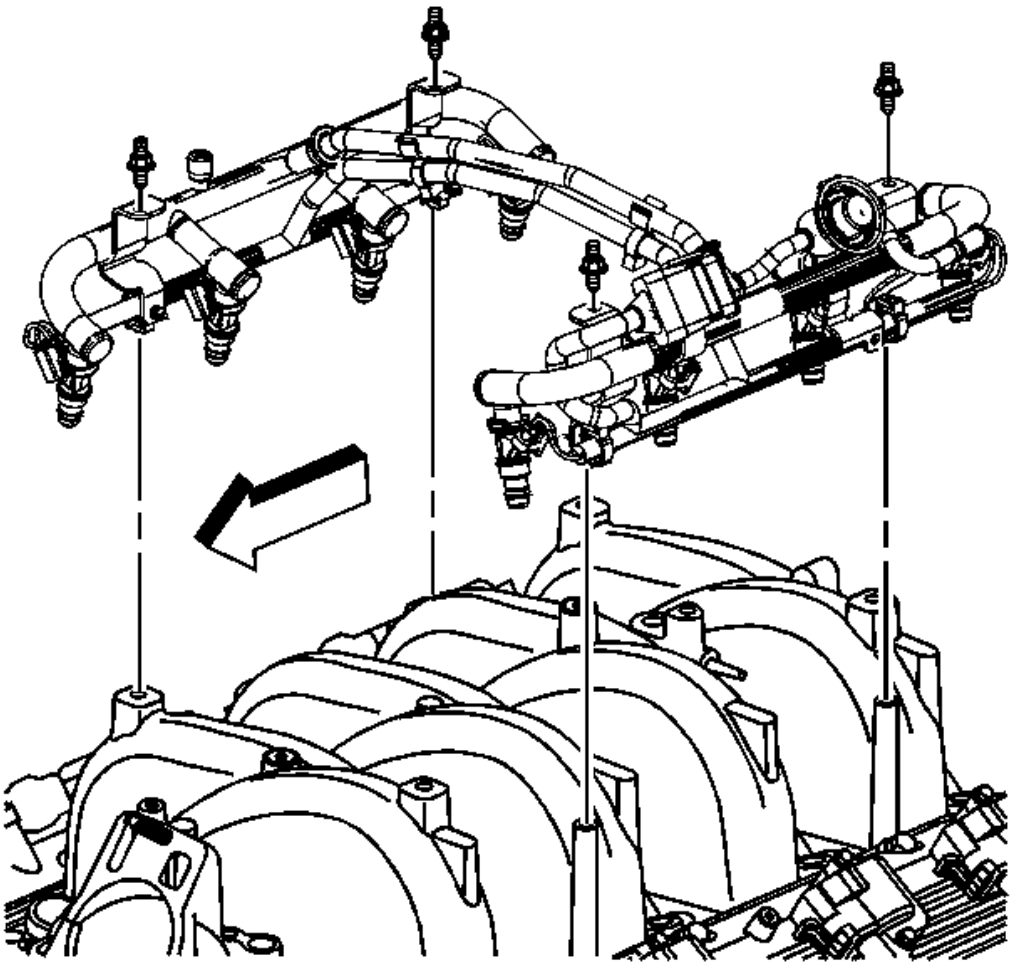

Fig. 530: View Of Fuel Injection Rail
Courtesy of GENERAL MOTORS CORP.

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IMPORTANT: Lubricate the injector O-ring seals with clean engine oil and install onto the injector.

12. Install the fuel injection fuel rail with injectors.
13. Install the fuel injection fuel rail bolts/studs.

Tighten: Tighten the fuel injection fuel rail bolts/studs to 12 N.m (106 lb in).

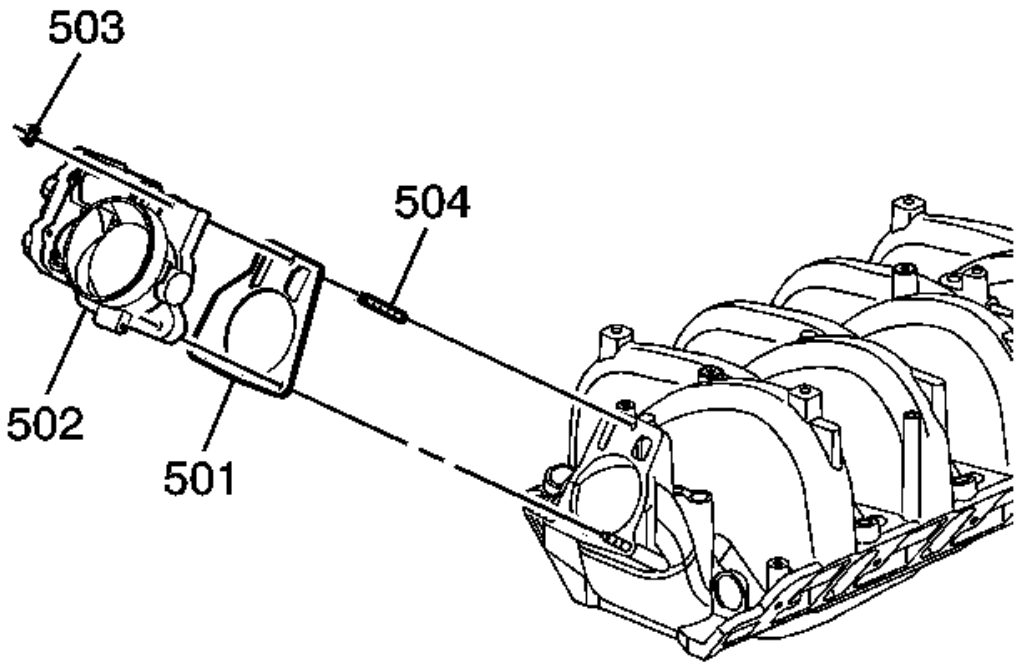

Fig. 531: View Of Throttle Body, Nuts, Studs & Gasket
Courtesy of GENERAL MOTORS CORP.

14. Install the throttle body gasket (501) and throttle body (502).
15. Install the throttle body nuts (503).

Tighten: Tighten the throttle body nuts to 10 N.m (89 lb in).

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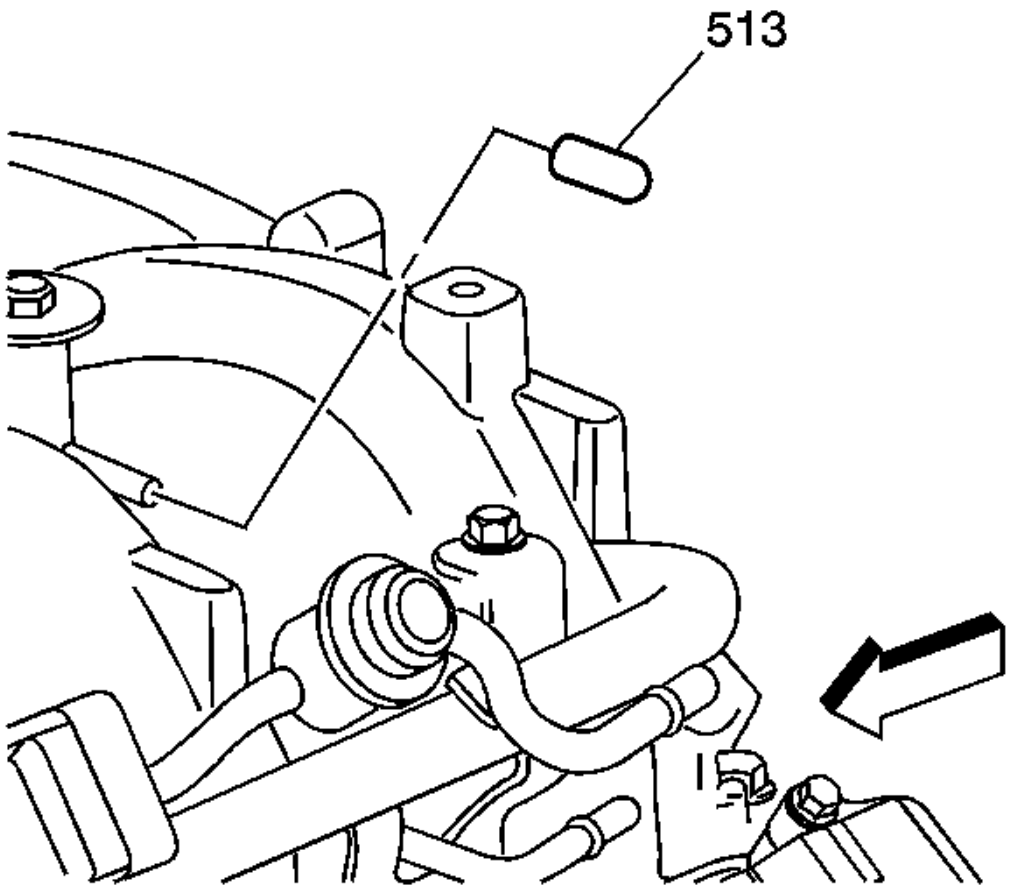

Fig. 532: View Of Vacuum Plug
Courtesy of GENERAL MOTORS CORP.

16. Install the vacuum plug (513).

Valve Rocker Arm Cover Installation - Left

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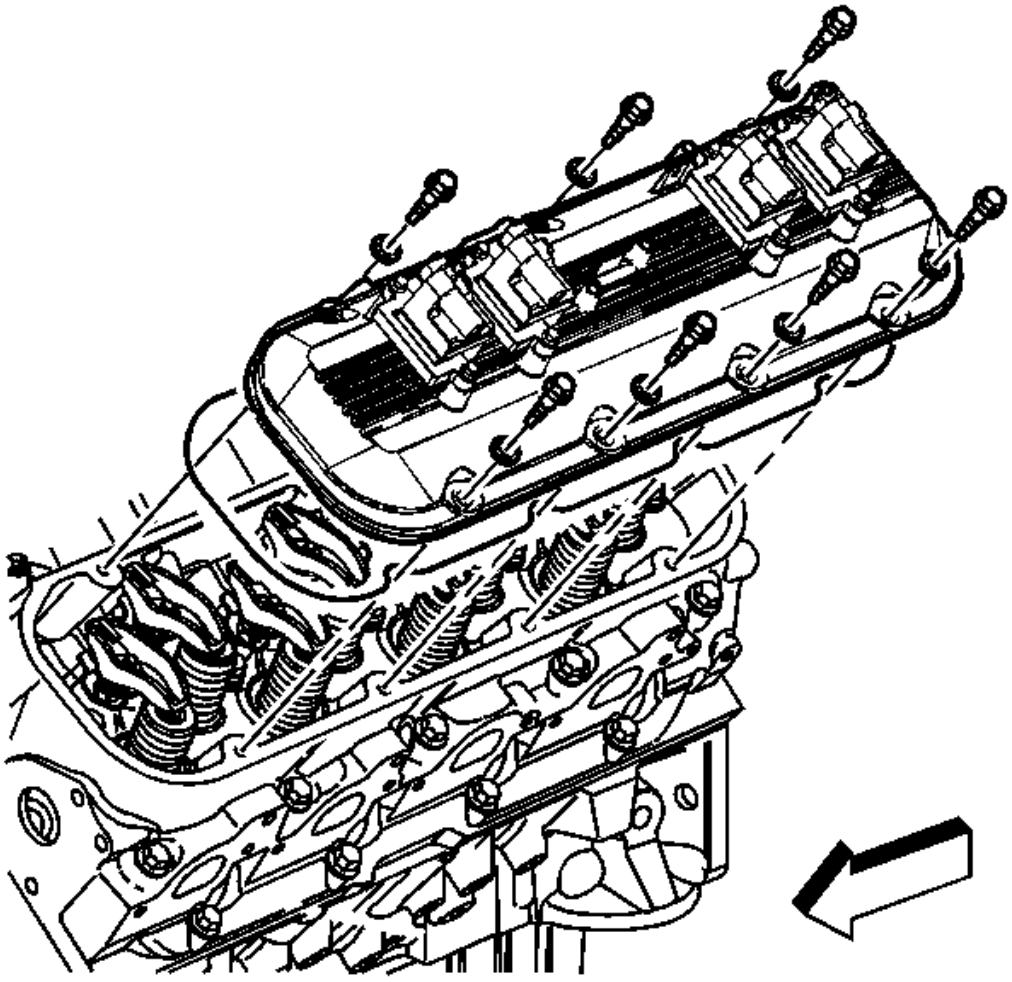

Fig. 533: View Of Valve Rocker Arm Cover (Left)
Courtesy of GENERAL MOTORS CORP.

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.

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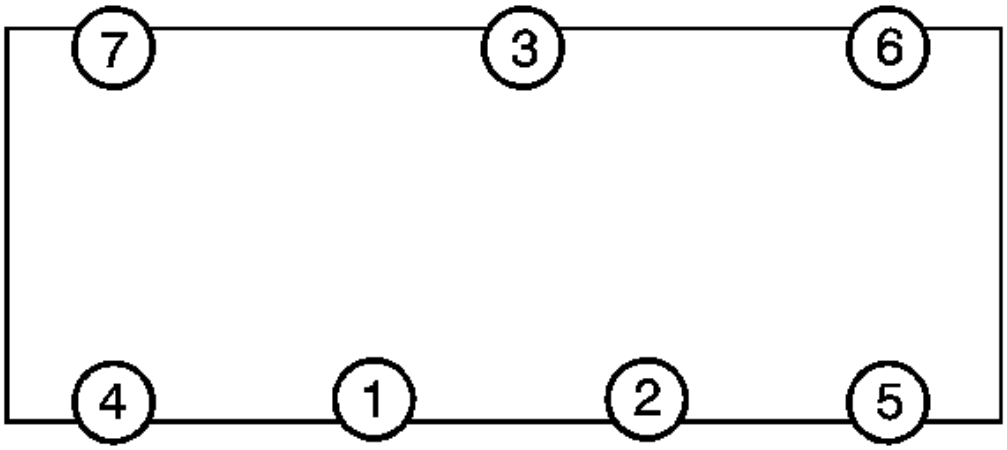

Fig. 534: View Of Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Caution and Notices.

4. Tighten the valve rocker arm cover bolts (1-8) in sequence using 2 passes.

Tighten:

- Tighten the valve rocker arm cover bolts a first pass to 6 N.m (54 lb in).
- Tighten the valve rocker arm cover bolts a final pass to 12 N.m (106 lb in).

Valve Rocker Arm Cover Installation - Right

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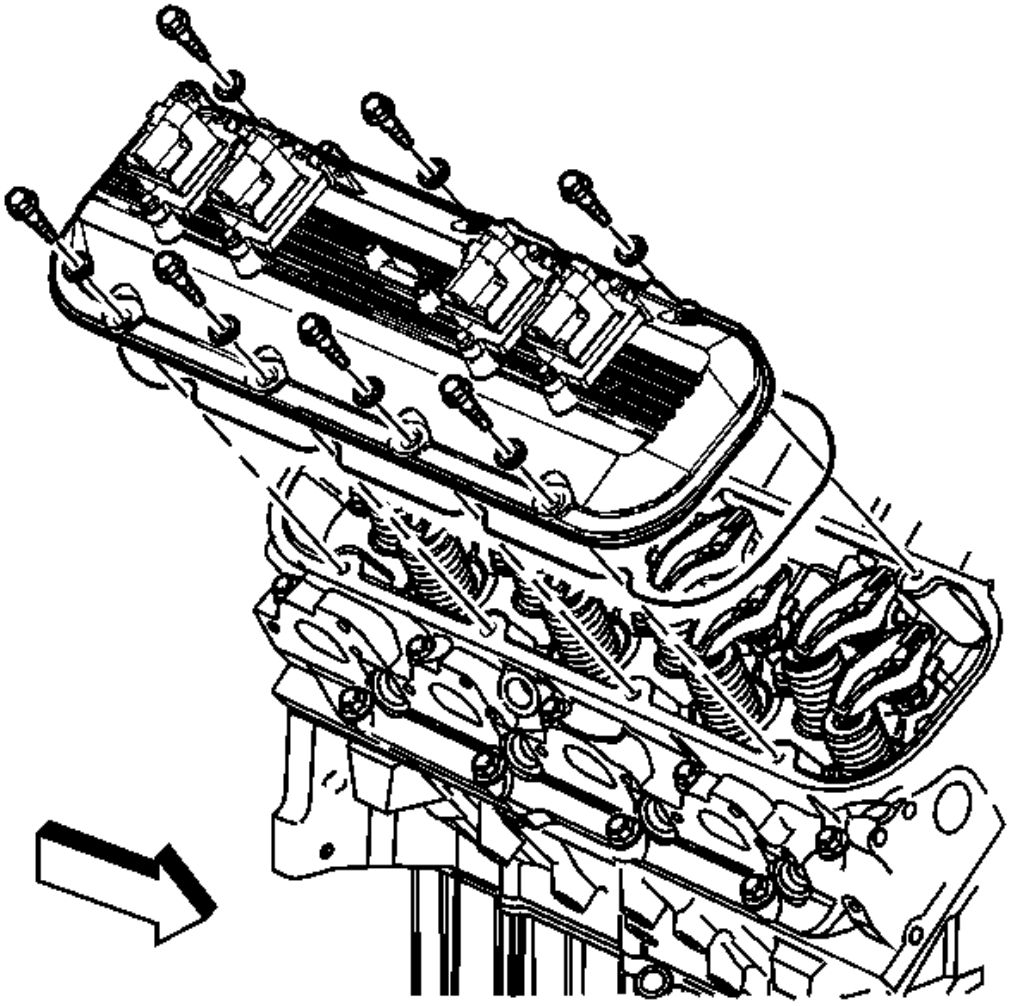

Fig. 535: View Of Valve Rocker Arm Cover & Bolts (Right)
Courtesy of GENERAL MOTORS CORP.

1. Install a new valve rocker arm cover gasket if the gasket was removed from the valve rocker arm cover.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm cover bolts.

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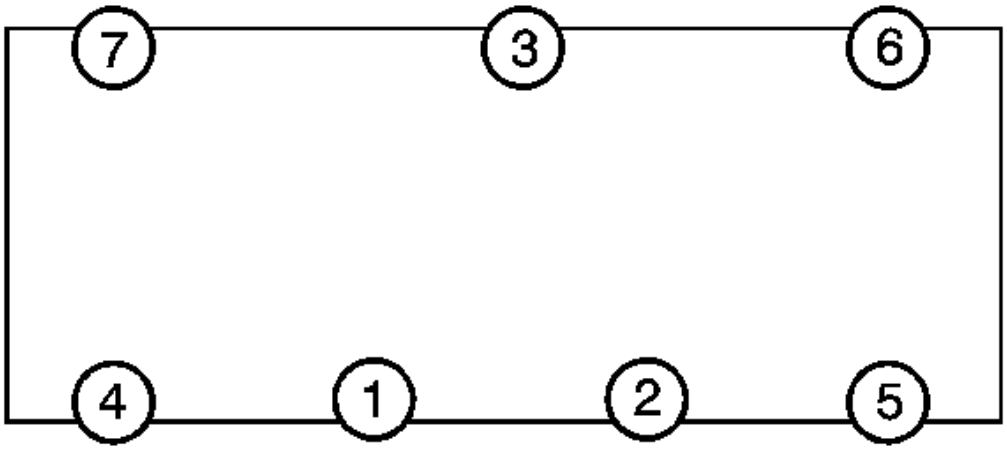

Fig. 536: View Of Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Caution and Notices.

4. Tighten the valve rocker arm cover bolts (1-8) in sequence using 2 passes.

   Tighten:
   - Tighten the valve rocker arm cover bolts a first pass to 6 N.m (54 lb in).
   - Tighten the valve rocker arm cover bolts a final pass to 12 N.m (106 lb in).

Water Pump Installation

Tools Required

J 41240 Fan Clutch Remover and Installer. See **Special Tools and Equipment**.

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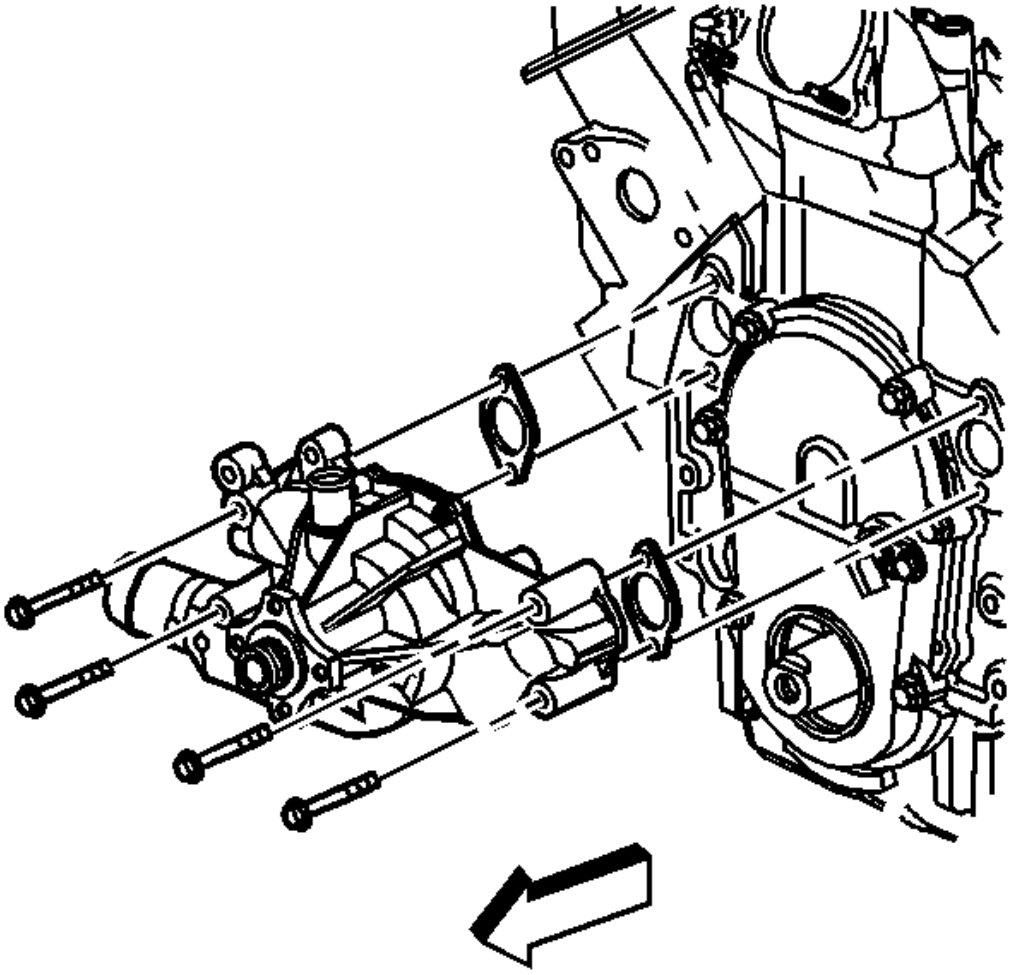

Fig. 537: View Of Water Pump & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump and gaskets.

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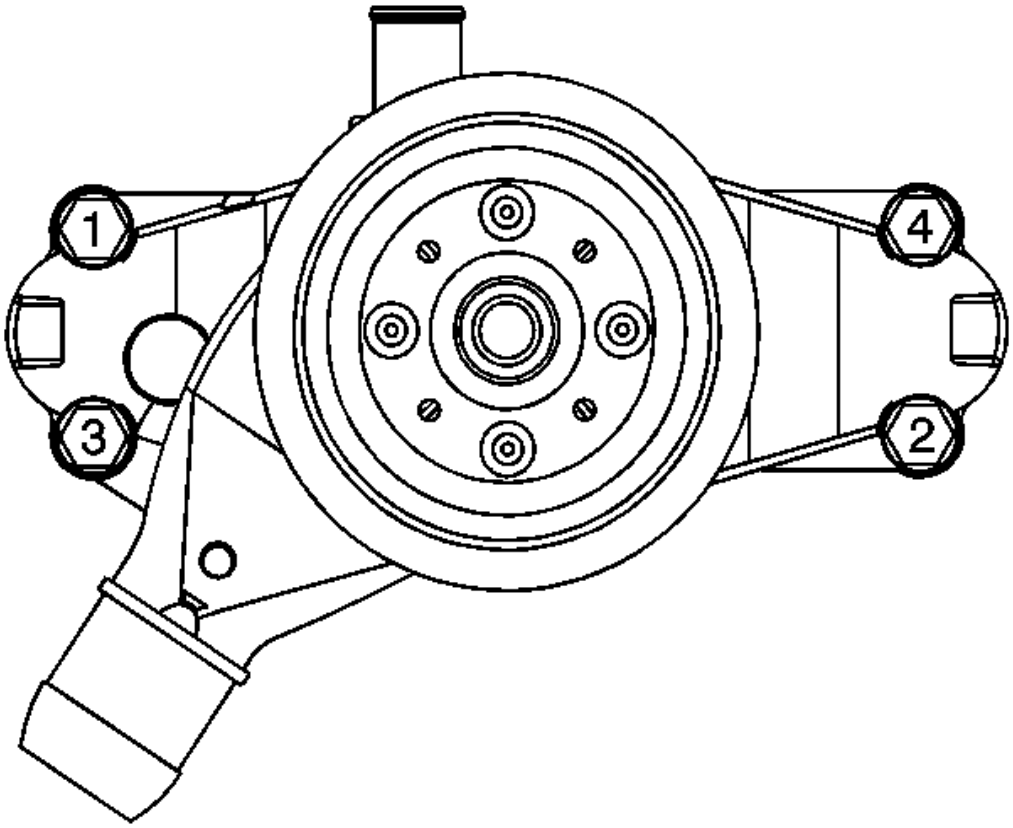

Fig. 538: Water Pump Bolts Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the water pump bolts.

Tighten:

- Tighten the water pump bolts (1-4) a first pass in sequence to 25 N.m (18 lb ft).
- Tighten the water pump bolts (1-4) a final pass in sequence to 50 N.m (37 lb ft).

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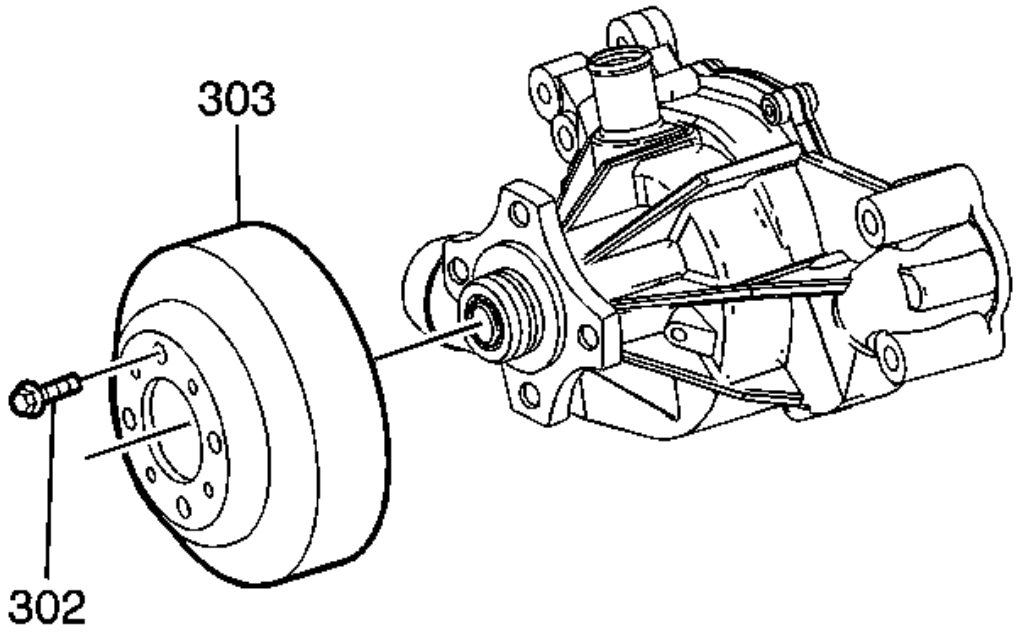

Fig. 539: View Of Water Pump Pulley & Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the water pump pulley (303) and bolts (302).

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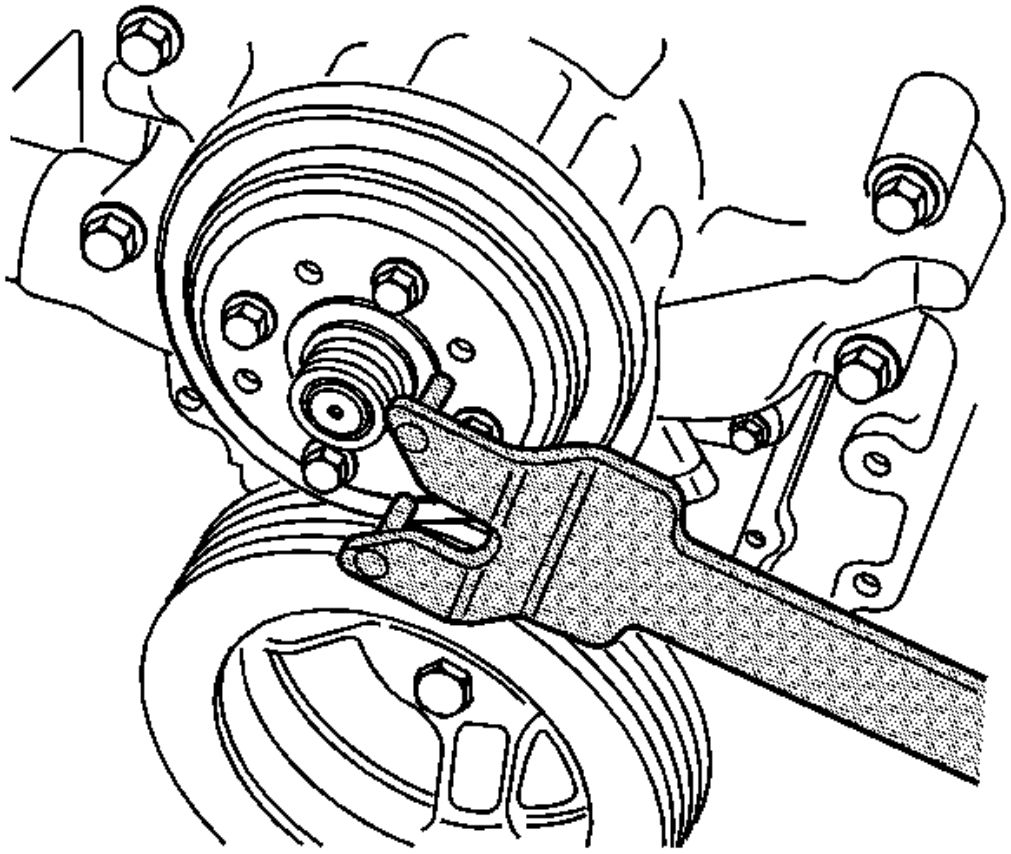

Fig. 540: View Of J 41240
Courtesy of GENERAL MOTORS CORP.

4. Use the **J 41240** in order to retain the water pump pulley. See **Special Tools and Equipment**.

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

Water Crossover Installation

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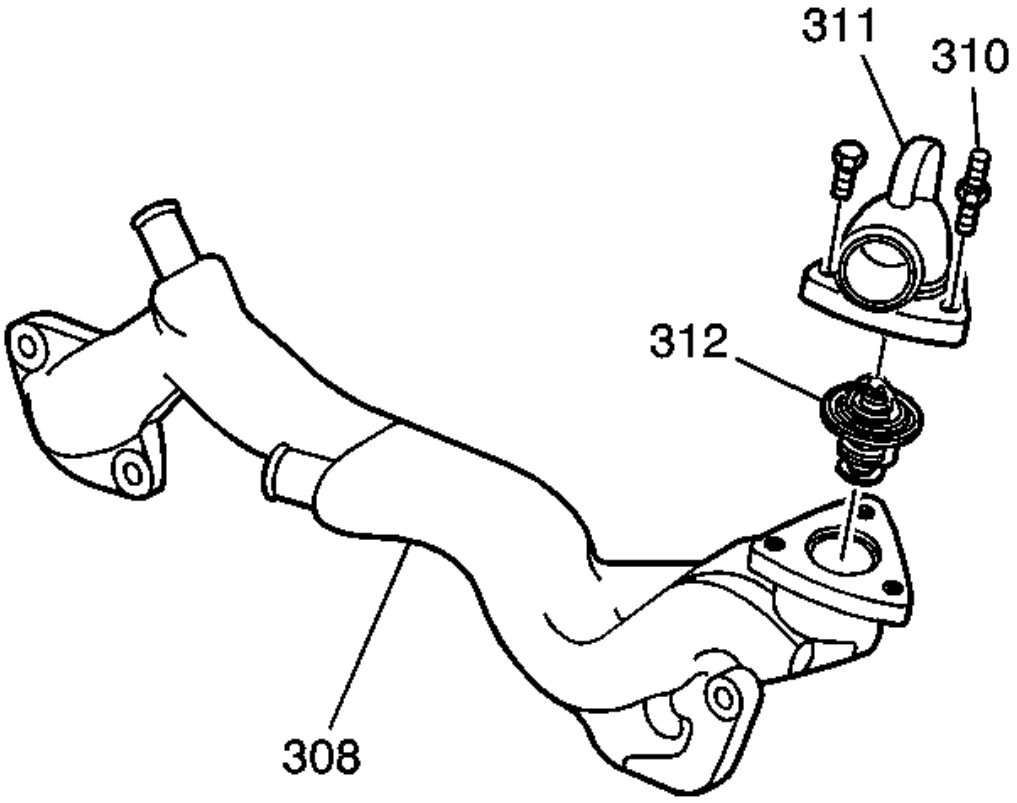

Fig. 541: View Of Water Outlet, Bolts, Thermostat & Coolant Crossover
Courtesy of GENERAL MOTORS CORP.

1. Install the thermostat (312) with the seal into the engine coolant crossover (308).
2. Install the water outlet (311).

NOTE: Refer to Fastener Notice in Cautions and Notices.

3. Install the water outlet bolts (310).

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

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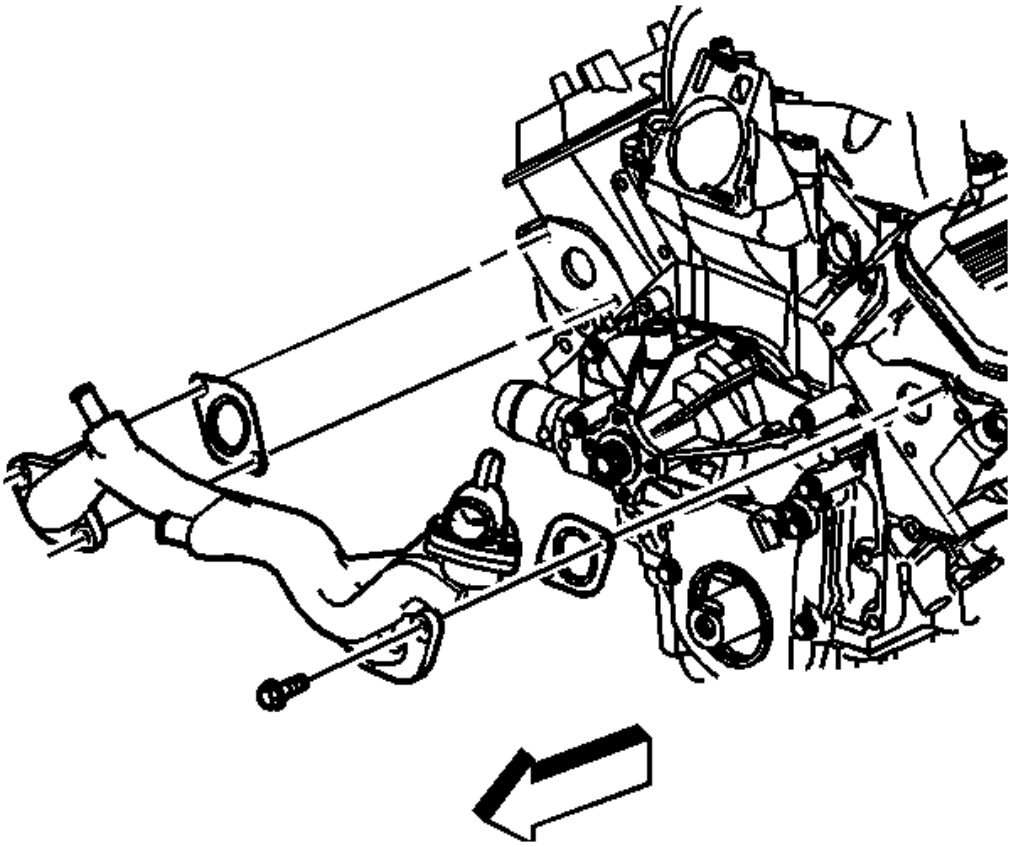

Fig. 542: View Of Engine Coolant Crossover & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Install the gaskets and the engine coolant crossover.
5. Install the bolts.

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

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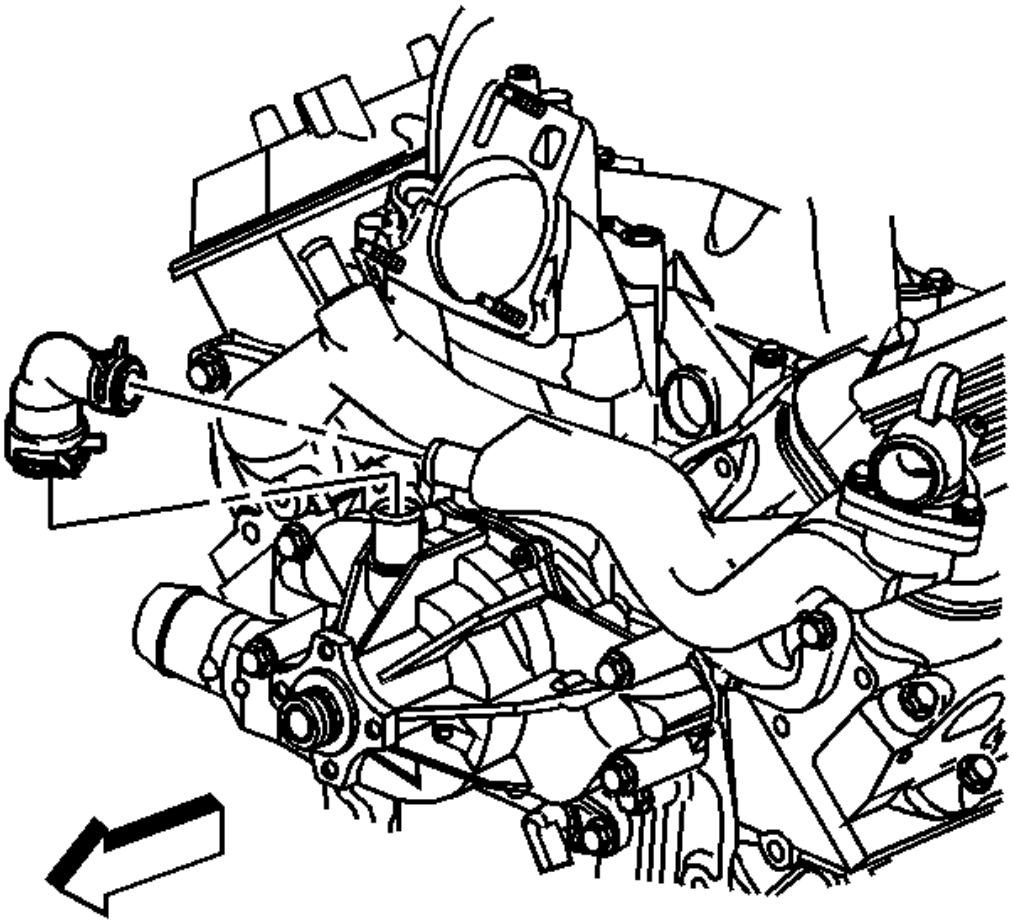

Fig. 543: Thermostat Bypass Hose & Clamps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Properly position the thermostat bypass hose clamps to avoid water pump pulley interference.

6. Install the thermostat bypass hose and clamps.

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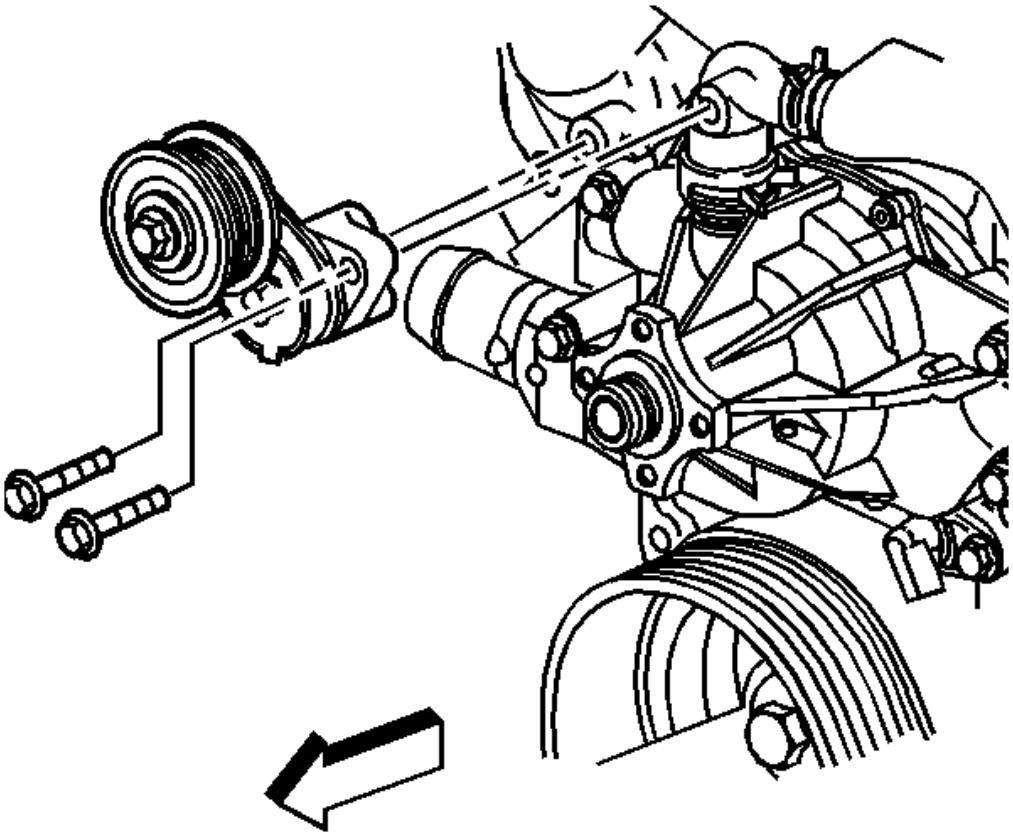

Fig. 544: View Of Drive Belt Tensioner & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the drive belt tensioner.
8. Install the drive belt tensioner bolts.

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

Exhaust Manifold Installation - Left

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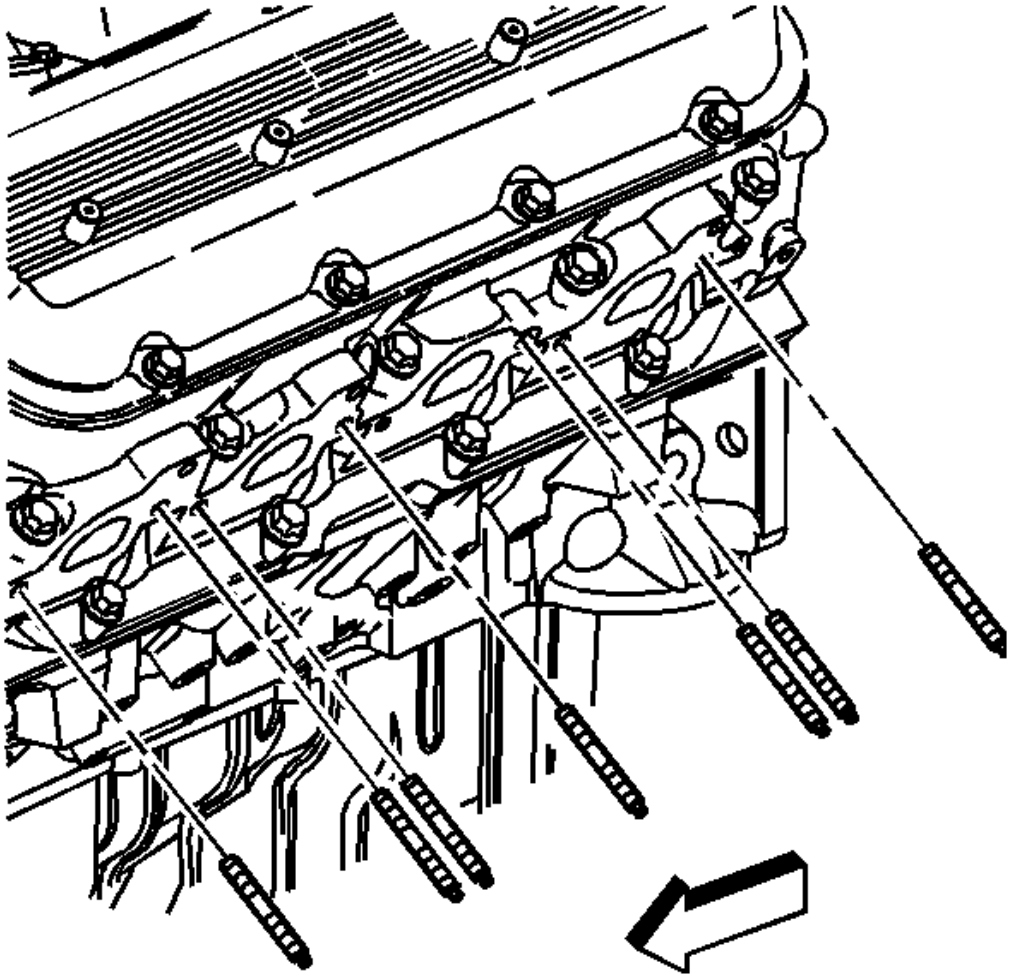

Fig. 545: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten: Tighten the exhaust manifold studs to 20 N.m (15 lb ft).

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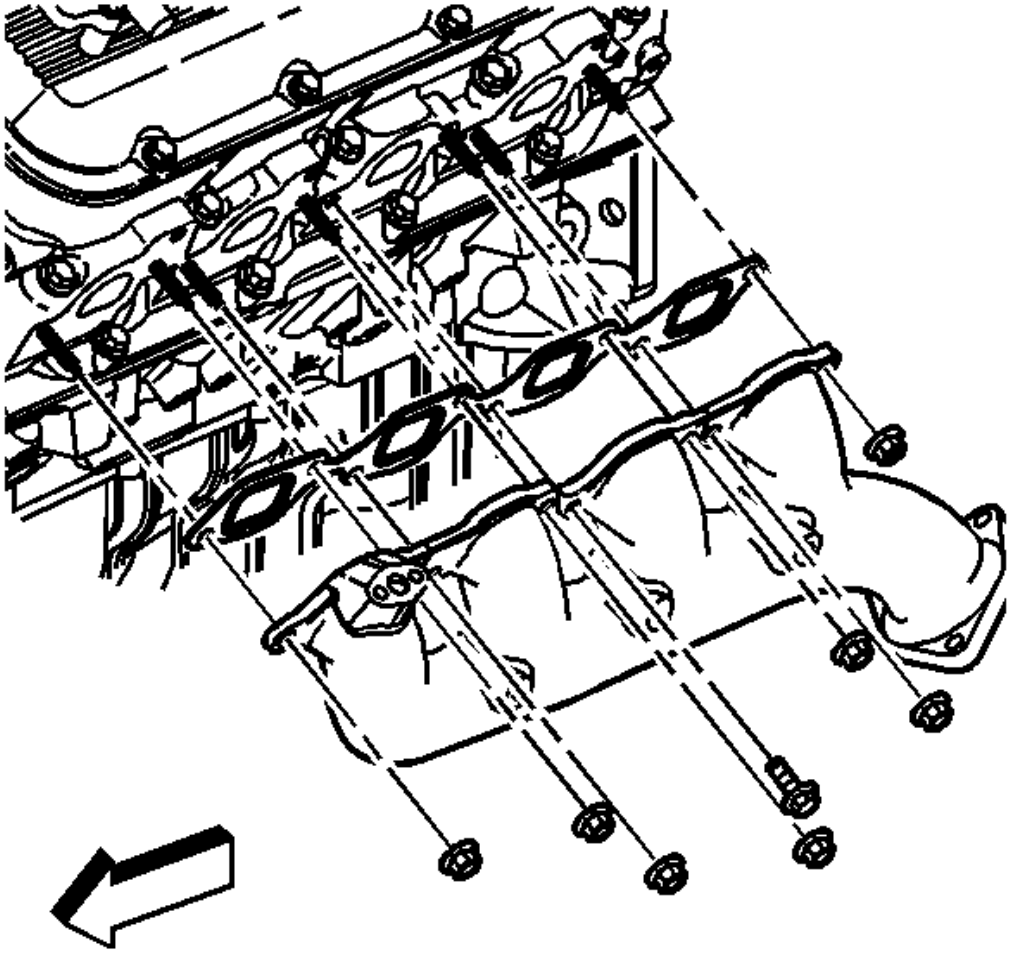

Fig. 546: View Of Left Exhaust Manifold, Gasket, Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW left exhaust manifold gasket.
3. Install the left exhaust manifold.
4. Install the left exhaust manifold nuts and center bolt.

Tighten:

- Tighten the left exhaust manifold center bolt to 35 N.m (26 lb ft).
- Tighten the left exhaust manifold nuts to 16 N.m (12 lb ft).

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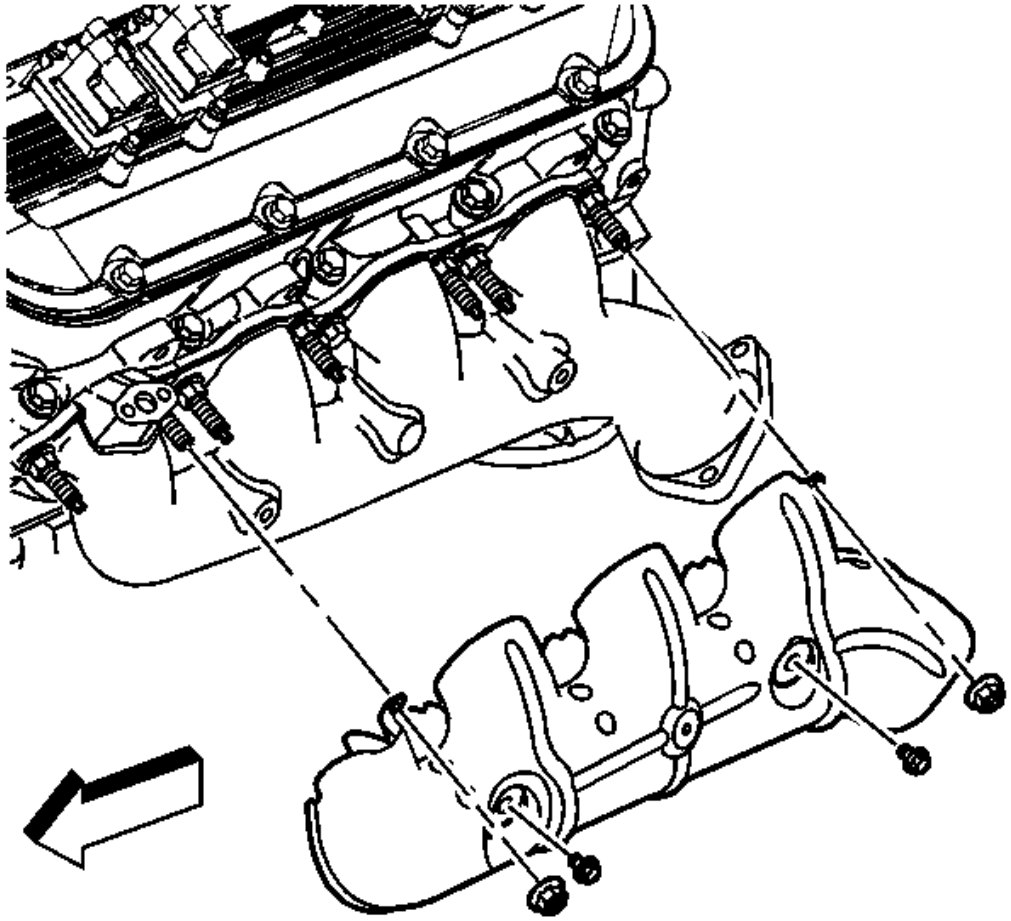

Fig. 547: View Of Exhaust Manifold Heat Shield, Bolts & Nuts (Left)
Courtesy of GENERAL MOTORS CORP.

5. Install the left exhaust manifold heat shield.
6. Install the left exhaust manifold heat shield bolts and nuts.

Tighten: Tighten the left exhaust manifold heat shield bolts and nuts to 25 N.m (18 lb ft).

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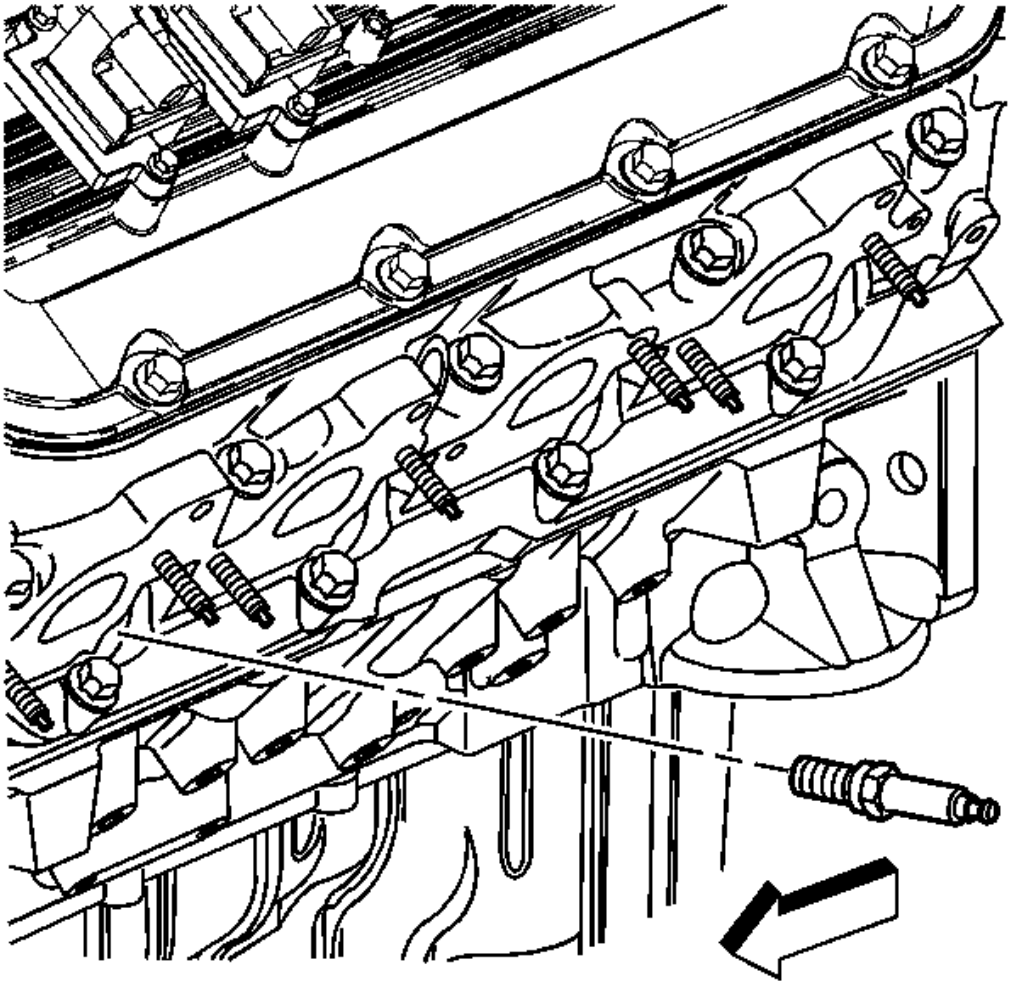

Fig. 548: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the spark plugs.

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

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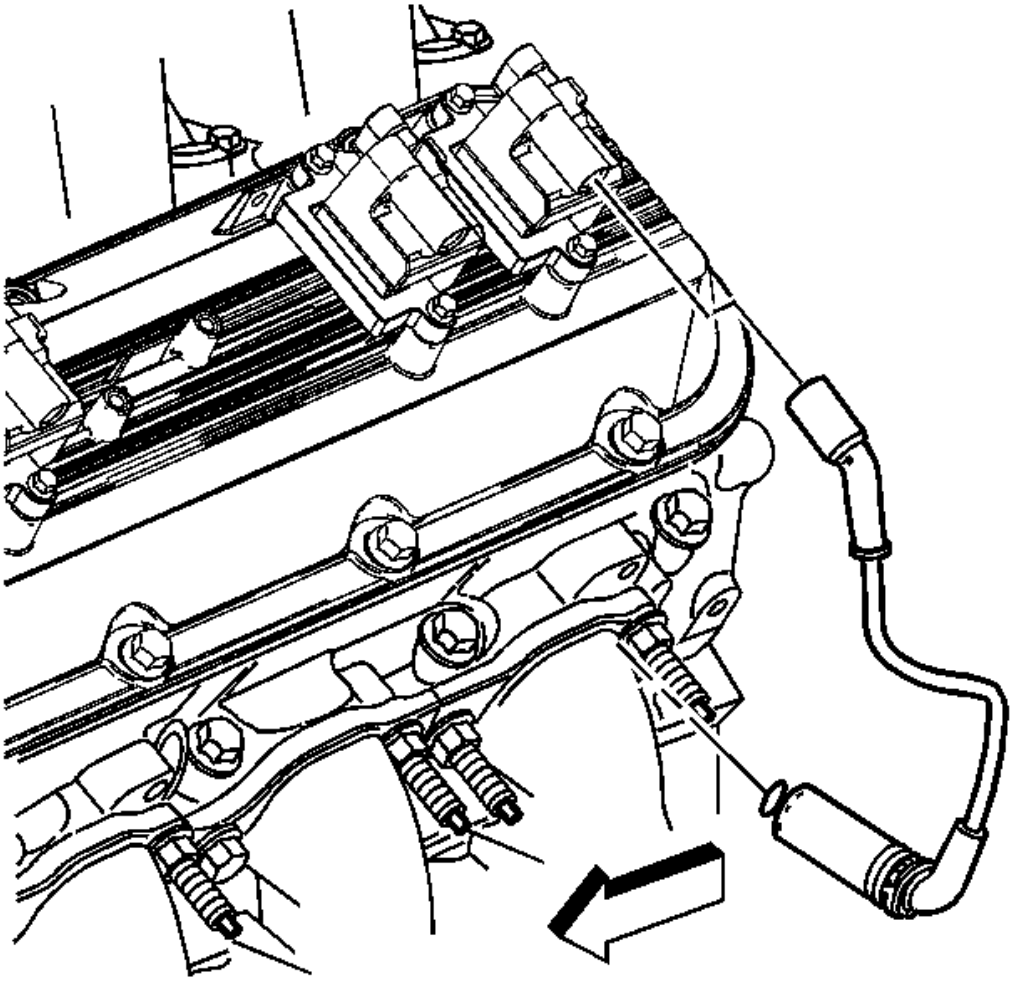

Fig. 549: View Of Spark Plug Wires
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

8. Install the spark plug wires to the spark plugs and ignition coils.

Exhaust Manifold Installation - Right

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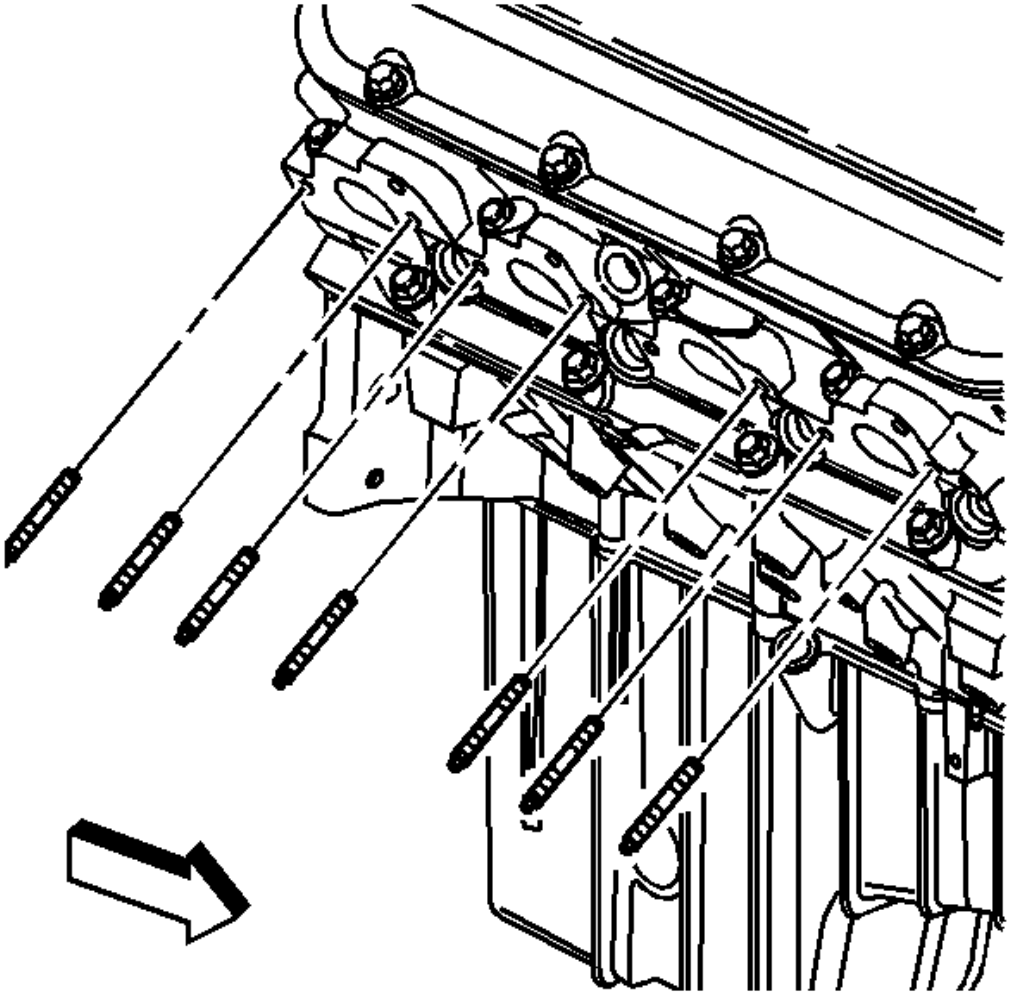

Fig. 550: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install the exhaust manifold studs into the cylinder head, if necessary.

   Tighten: Tighten the exhaust manifold studs to 20 N.m (15 lb ft).

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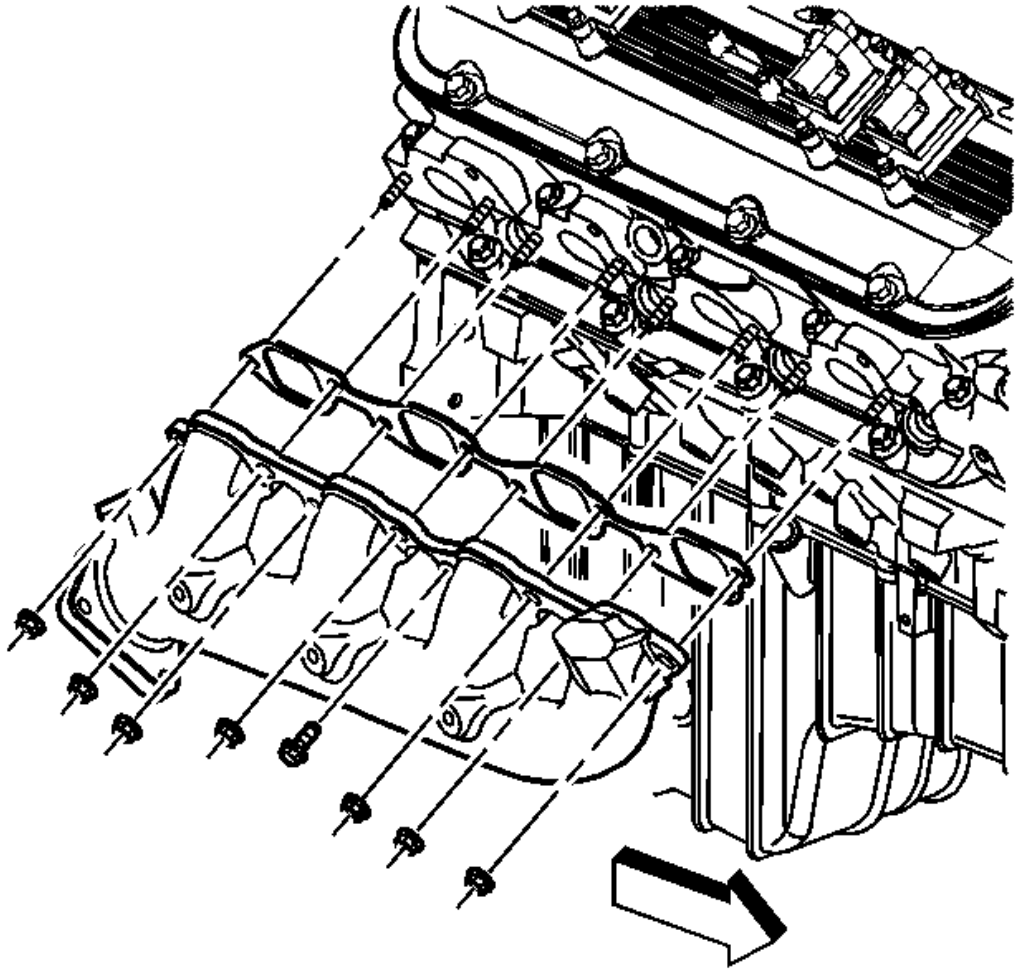

Fig. 551: View Of Exhaust Manifold, Nuts & Center Bolt (Right)
Courtesy of GENERAL MOTORS CORP.

2. Install the NEW right exhaust manifold gasket.
3. Install the right exhaust manifold.
4. Install the right exhaust manifold nuts and center bolt.

Tighten:

- Tighten the right exhaust manifold center bolt to 35 N.m (26 lb ft).
- Tighten the right exhaust manifold nuts to 16 N.m (12 lb ft).

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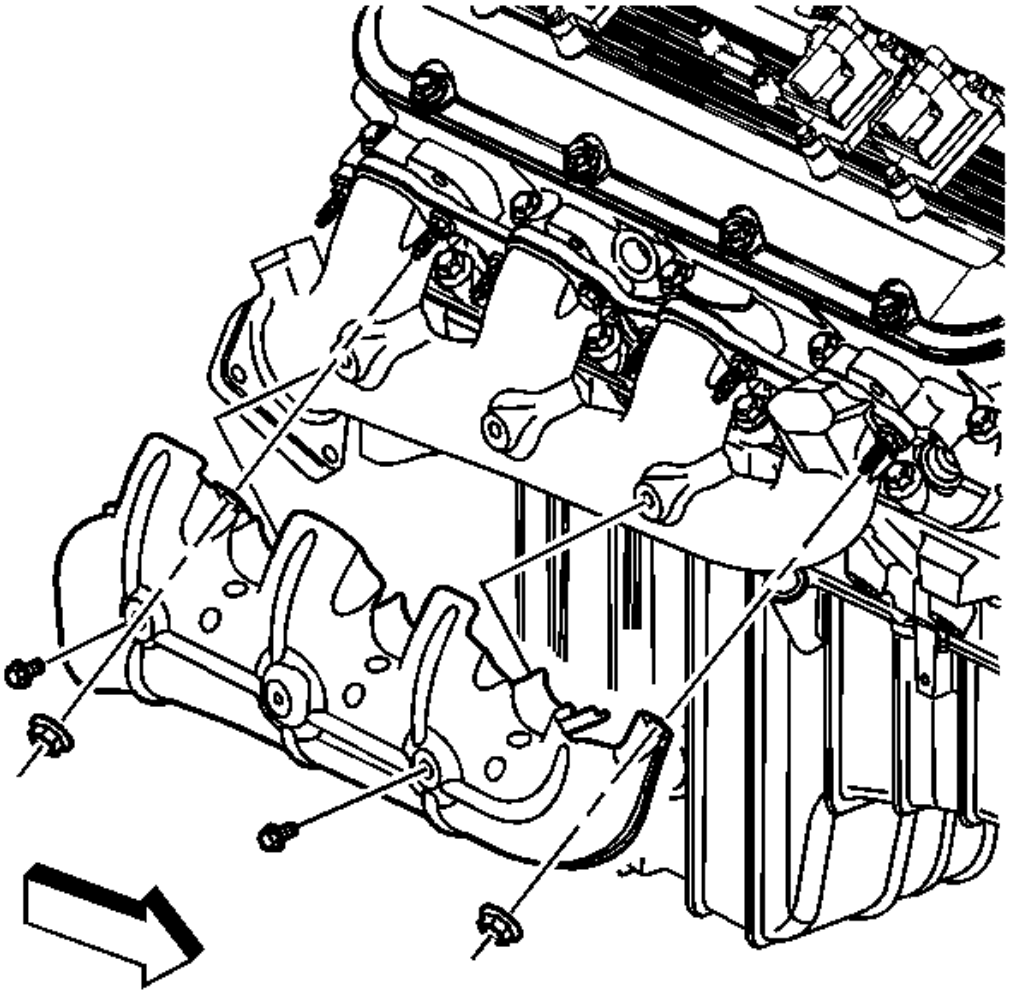

Fig. 552: View Of Exhaust Manifold Heat Shield, Bolts & Nuts (Right)
Courtesy of GENERAL MOTORS CORP.

5. Install the right exhaust manifold heat shield.
6. Install the right exhaust manifold heat shield bolts and nuts.

Tighten: Tighten the right exhaust manifold heat shield bolts and nuts to 25 N.m (18 lb ft).

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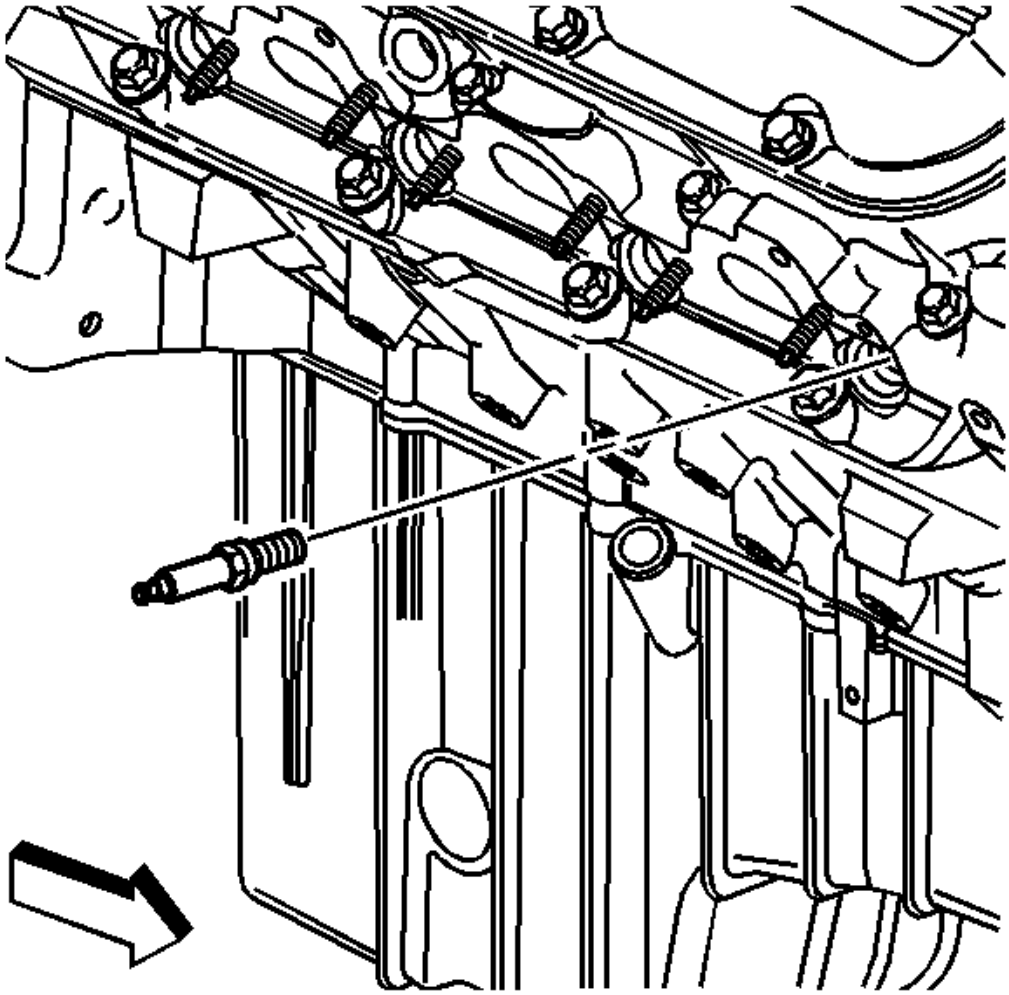

Fig. 553: View Of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the spark plugs.

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

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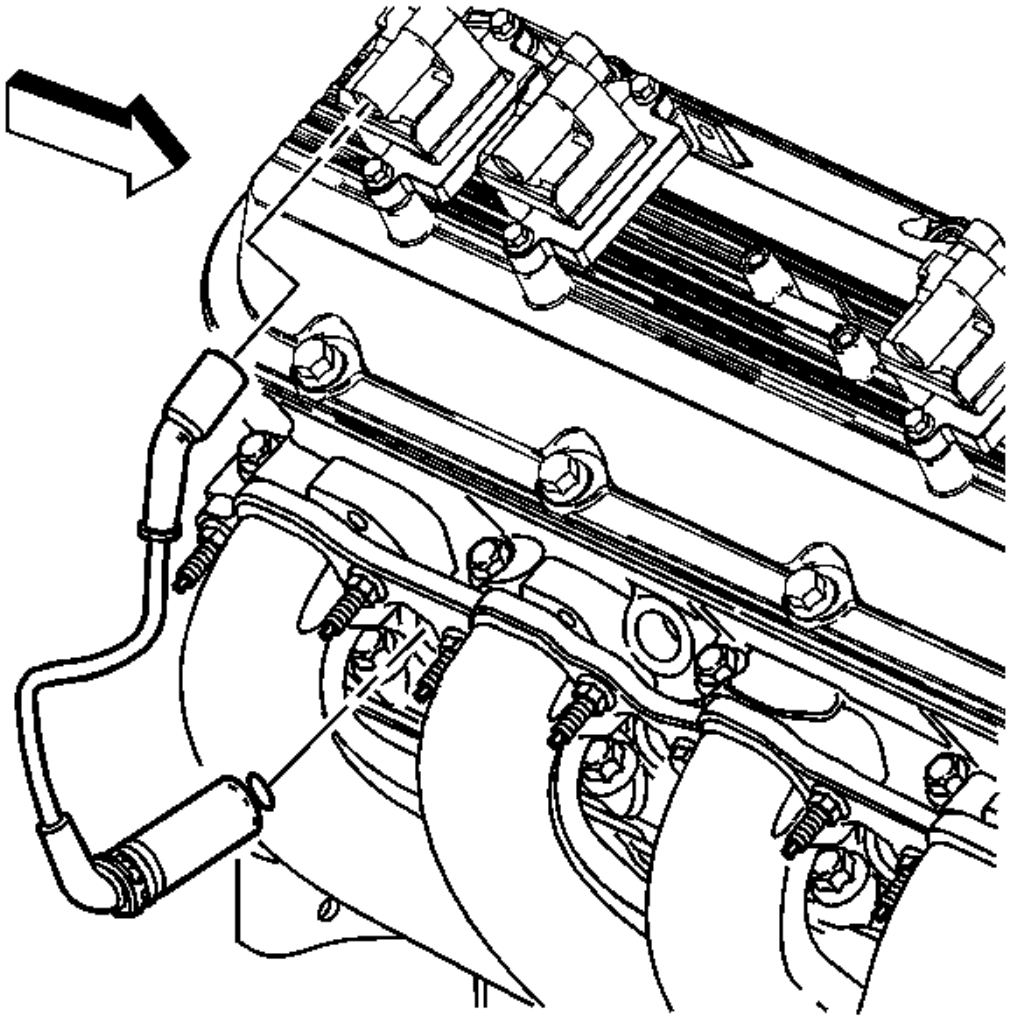

Fig. 554: View Of Spark Plug Wires
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Fully install the spark plug wire by pushing on the exposed end of the spark plug boot. Do not push the spark plug wire on to the spark plug by using the metal heat shield.

8. Install the spark plug wires to the spark plugs and ignition coils.

Oil Level Indicator and Tube Installation

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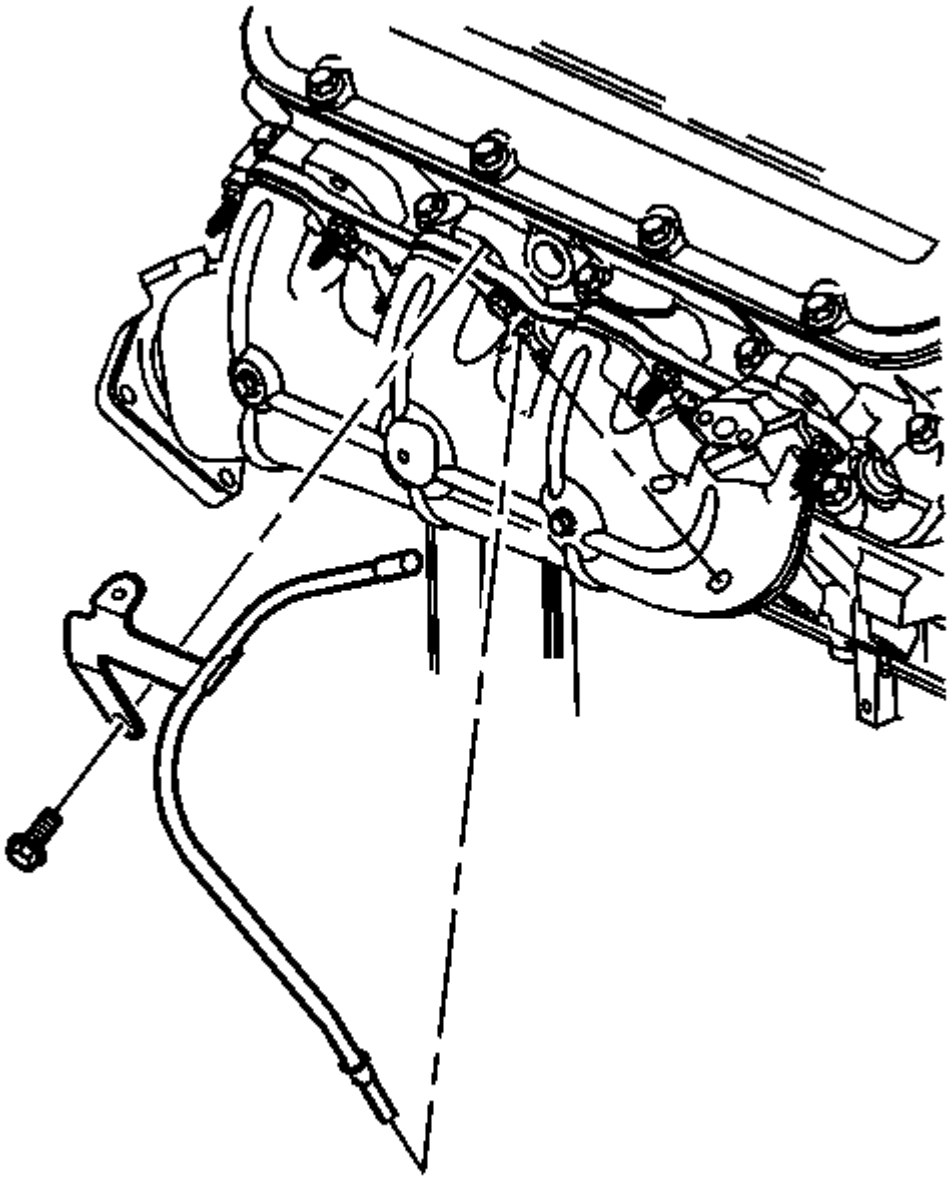

Fig. 555: View Of Oil Level Indicator Tube Bolt
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the oil level indicator tube does not come in contact with the spark plug wires. Route the spark plug wires around the oil level indicator tube.

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1. Install a NEW O-ring seal onto the oil level indicator tube.
2. Install the oil level indicator tube into the oil pan.
3. Install the oil level indicator tube bracket to the exhaust manifold stud.

NOTE: Refer to Fastener Notice in Cautions and Notices.

4. Install the oil level indicator tube bracket bolt.

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

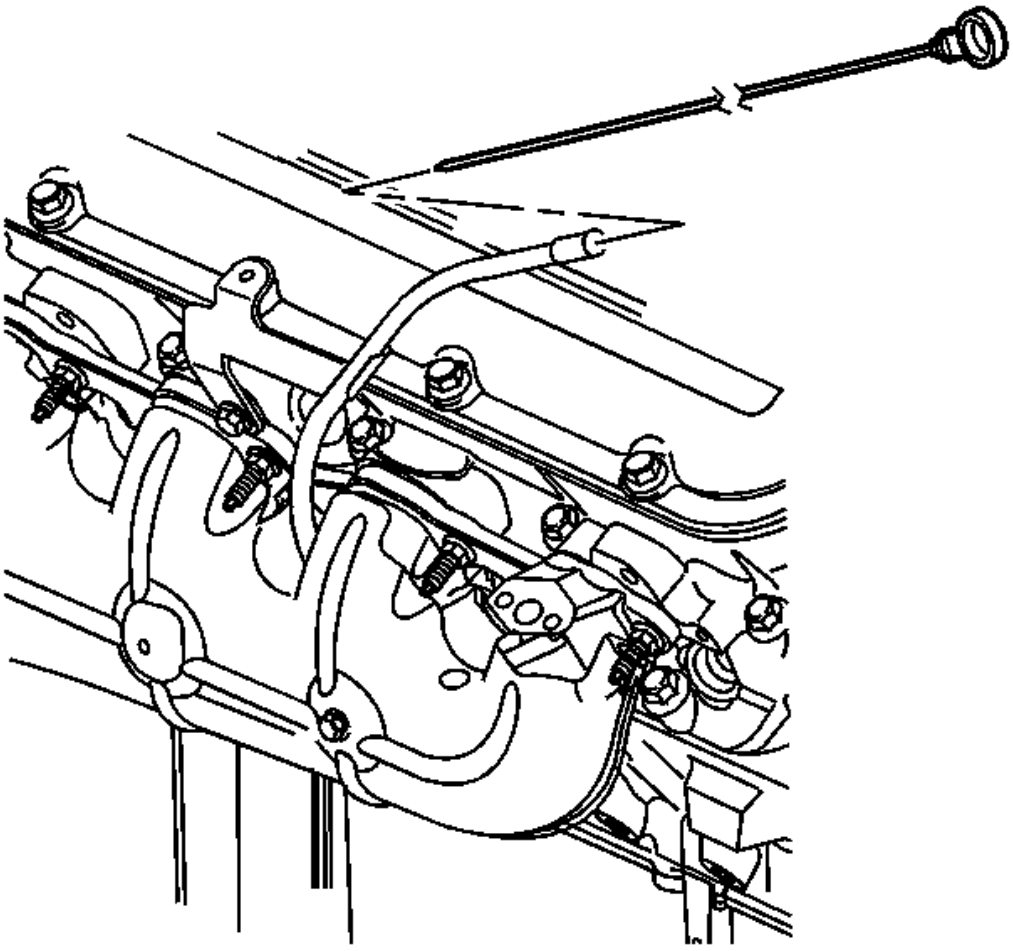

Fig. 556: View Of Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

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5. Install the oil level indicator into the oil level indicator tube.

Crankshaft Rear Oil Seal Installation

Tools Required

J 42849 Crankshaft Rear Seal Installer. See **Special Tools and Equipment**.

IMPORTANT: Crankshaft rear oil seal and engine flywheel installation requires adequate space for installation. If the engine stand does not allow suitable space to use the J 42849 , install the crankshaft rear oil seal and engine flywheel with the engine properly supported on the floor. See Special Tools and Equipment.

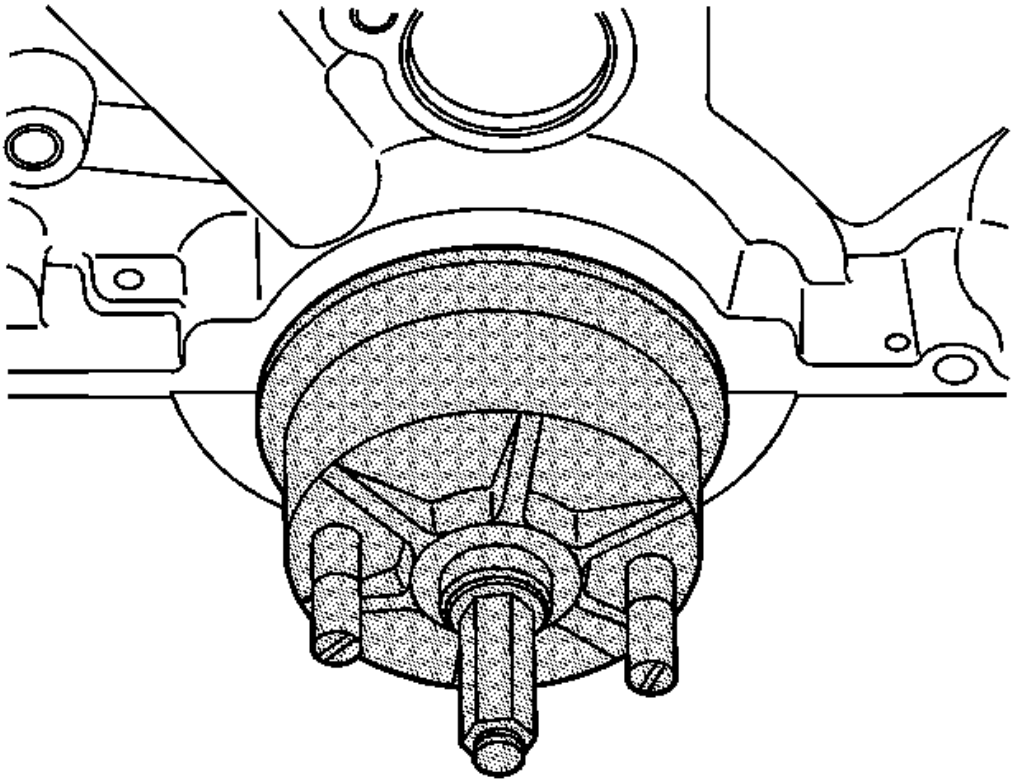

Fig. 557: View Of J 42849
Courtesy of GENERAL MOTORS CORP.

1. Make sure the crankshaft rear chamfer is free of grit, loose rust, and burrs. Correct as needed.
2. Apply a very light film of oil onto the crankshaft sealing surface.

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DO NOT apply oil to the sealing surface of the engine block.

3. Install the seal on the **J 42849** . See **Special Tools and Equipment**.
4. Position **J 42849** against the crankshaft. See **Special Tools and Equipment**. Thread the attaching screws into the tapped holes in the crankshaft.
5. Tighten the screws securely with a screwdriver in order to ensure that the seal is installed squarely over the crankshaft.
6. Rotate the center nut until the **J 42849** bottoms. See **Special Tools and Equipment**.
7. Remove the **J 42849** . See **Special Tools and Equipment**.

Engine Flywheel Installation

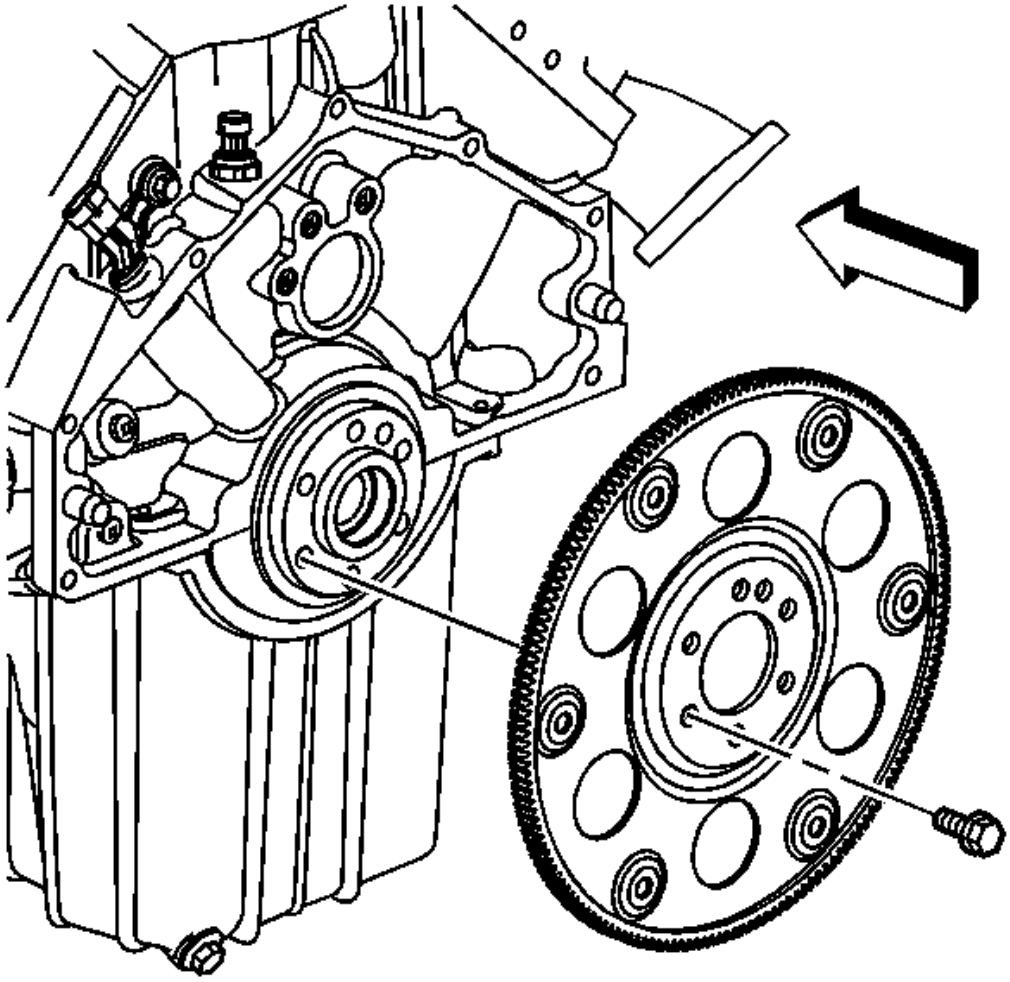

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Fig. 558: View Of Engine Flywheel & Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Make sure the flywheel is installed correctly. Engine Side is stamped on the flywheel to assist with installation.

1. Install the engine flywheel.

   NOTE: Refer to Fastener Notice in Cautions and Notices.

2. Install the engine flywheel bolts.

   Tighten the fasteners following a criss cross pattern.

   Tighten:
   - Tighten the engine flywheel bolts to 40 N.m (30 lb ft) for the first pass.
   - Tighten the engine flywheel bolts to 80 N.m (59 lb ft) for the second pass.
   - Tighten the engine flywheel bolts to 100 N.m (74 lb ft) for the final pass.

Crankshaft Balancer Installation

Tools Required

- **J 42845** Crankshaft Balancer Installer. See **Special Tools and Equipment**.
- **J 42847** Flywheel Holding Tool. See **Special Tools and Equipment**.

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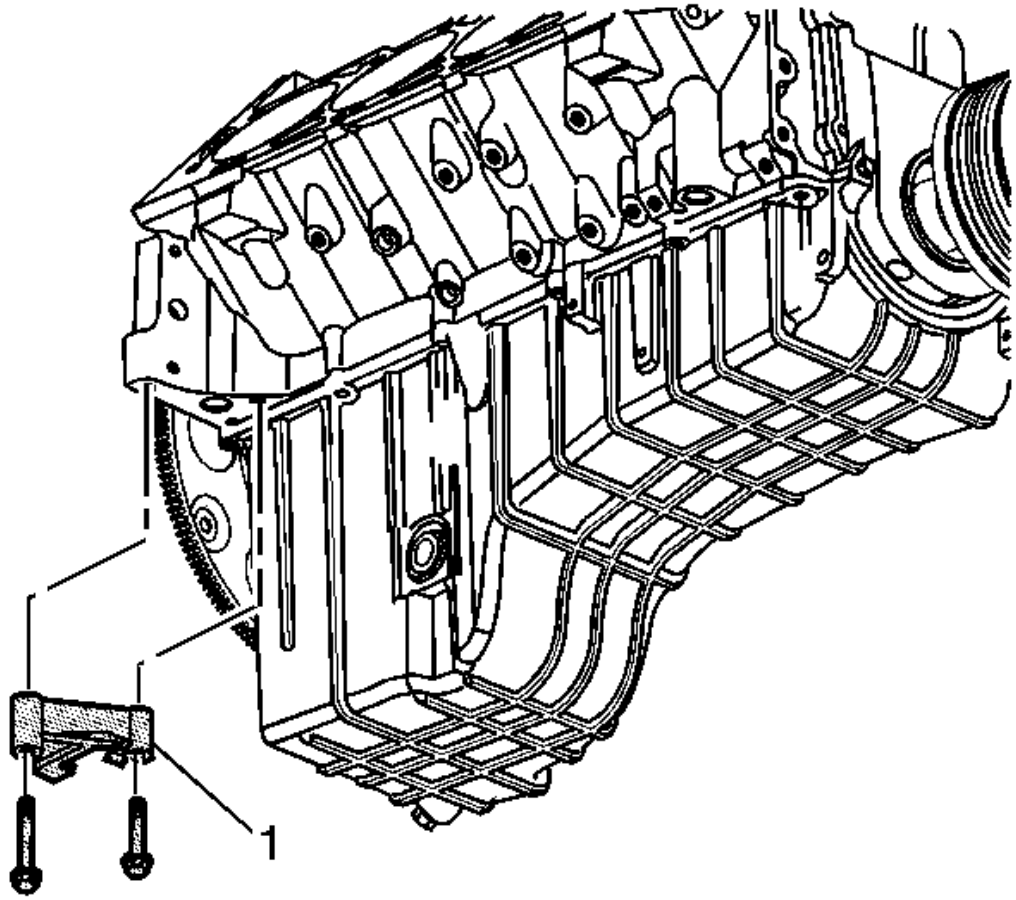

Fig. 559: View Of J 42847 & Bolts
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT:
- **Ensure that the teeth of the flywheel holding tool engage the engine flywheel teeth.**
- **The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.**

1. Install the **J 42847** (1) to the starter bolt holes. See **Special Tools and Equipment**.

Tighten: Tighten the **J 42847** bolts to 50 N.m (37 lb ft). See **Special Tools and Equipment**.

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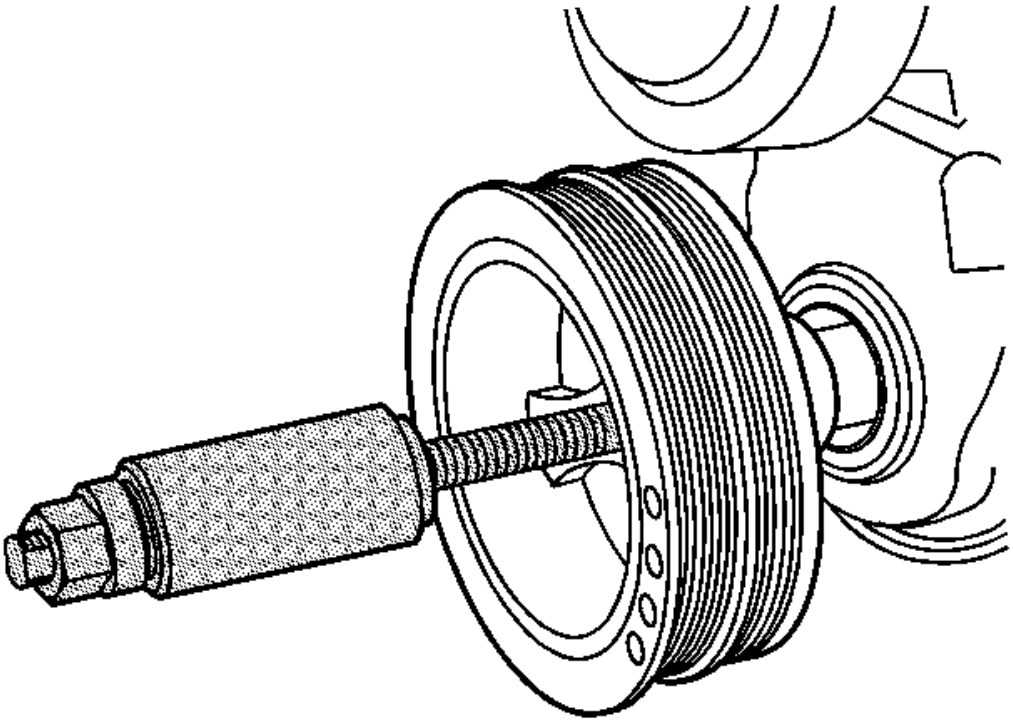

Fig. 560: Installing Balancer Onto End Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply grease or clean engine oil to the inside of the crankshaft balancer or the end of the crankshaft, to prevent galling during assembly.

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

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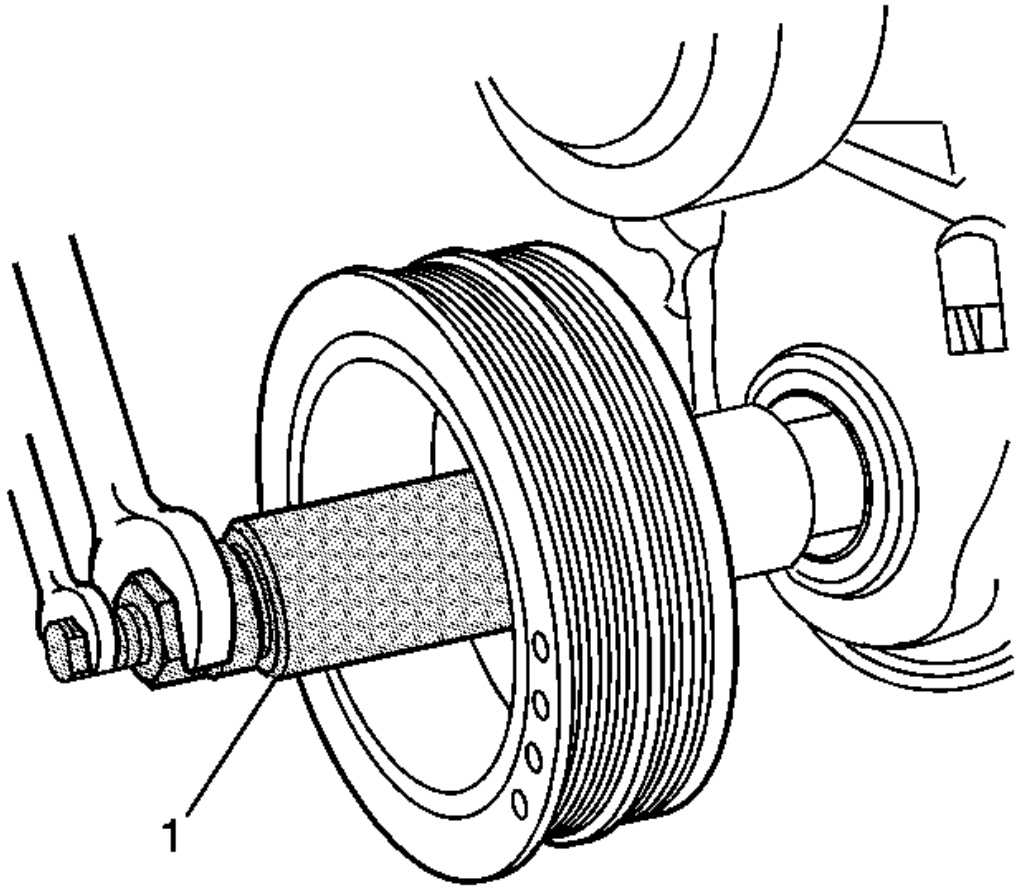

Fig. 561: Installing Crankshaft Balancer Using J 42845
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Apply the lubricant that comes with J 42845 each time the tool is used. See Special Tools and Equipment. Failure to lubricate J 42845 may prevent the balancer from installing completely. See Special Tools and Equipment.

3. Use the **J 42845** (1) in order to install the balancer. See **Special Tools and Equipment**.

NOTE: Ensure the crankshaft balancer is installed to the proper depth. The crankshaft balancer nose must be seated against the crankshaft sprocket. Failure to install the crankshaft balancer properly may result in improper torque to the crankshaft balancer bolt. An improperly torqued crankshaft balancer bolt may loosen causing serious engine damage.

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4. Tighten the **J 42845** until the crankshaft balancer is completely seated against the crankshaft sprocket. See **Special Tools and Equipment**.

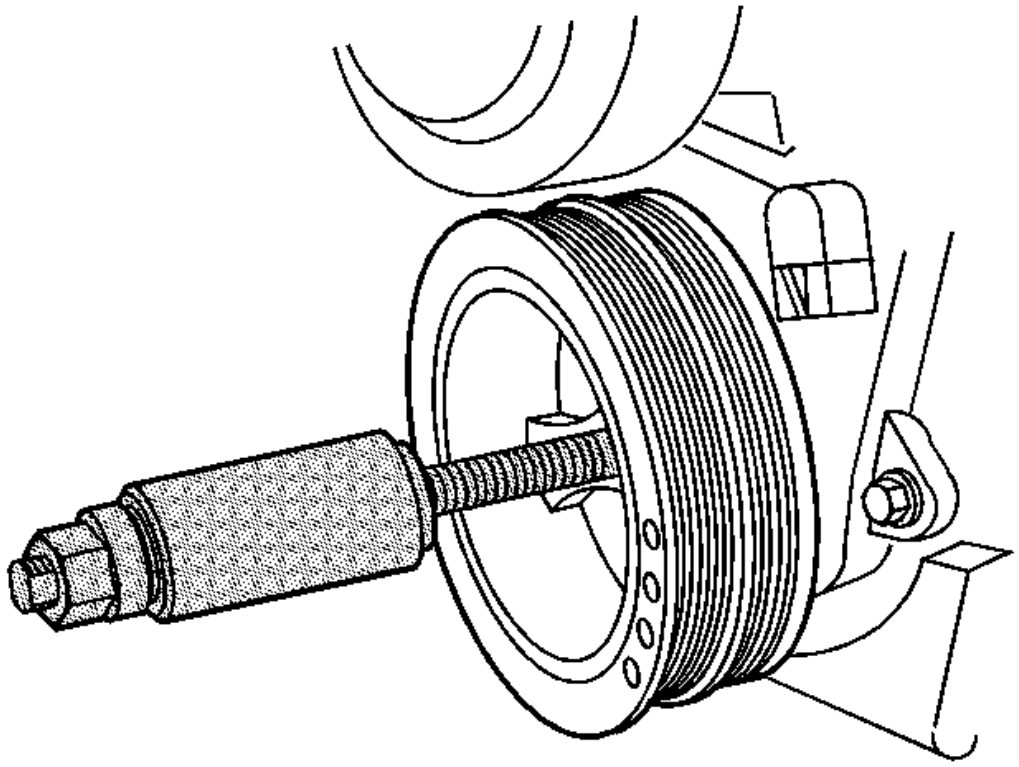

Fig. 562: View Of J 42845
Courtesy of GENERAL MOTORS CORP.

5. Remove the **J 42845** from the crankshaft. See **Special Tools and Equipment**.

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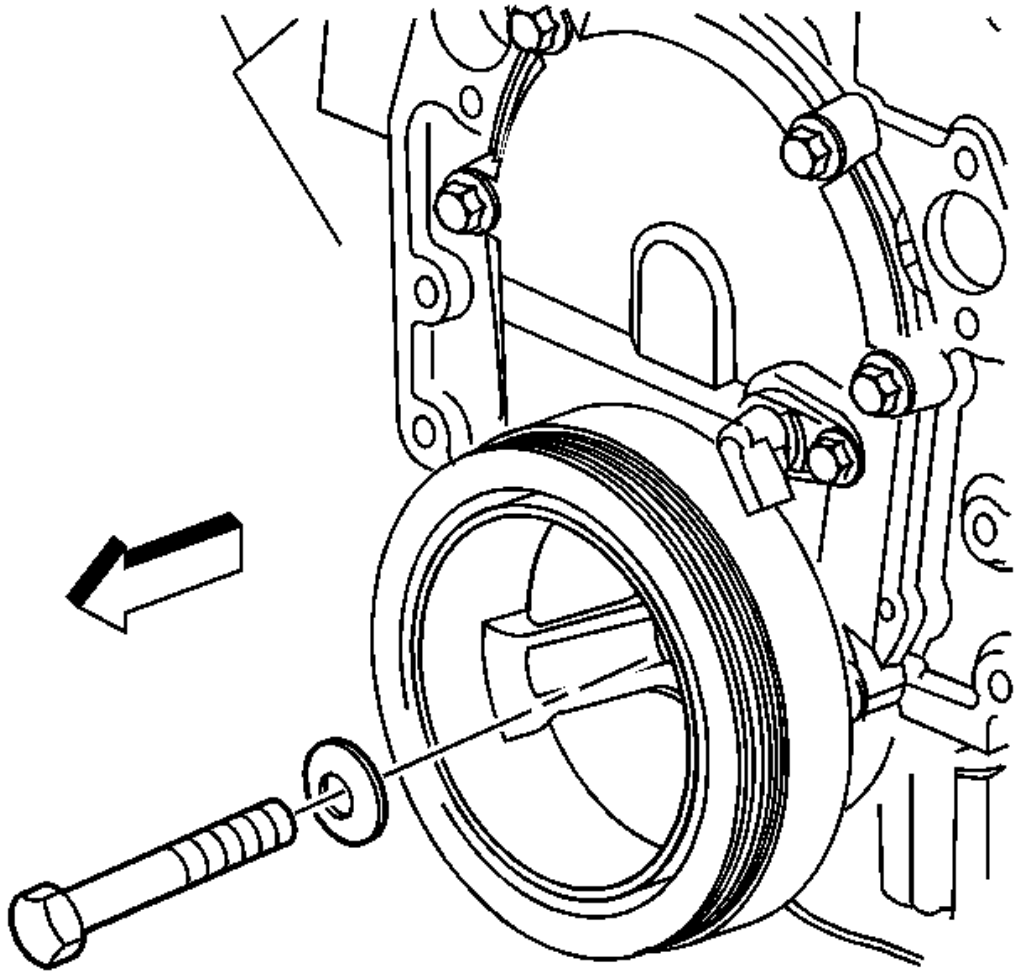

Fig. 563: View Of Crankshaft Balancer Bolt & Washer
Courtesy of GENERAL MOTORS CORP.

6. Install the crankshaft balancer washer and bolt.

   Tighten: Tighten the crankshaft balancer bolt to 255 N.m (189 lb ft).

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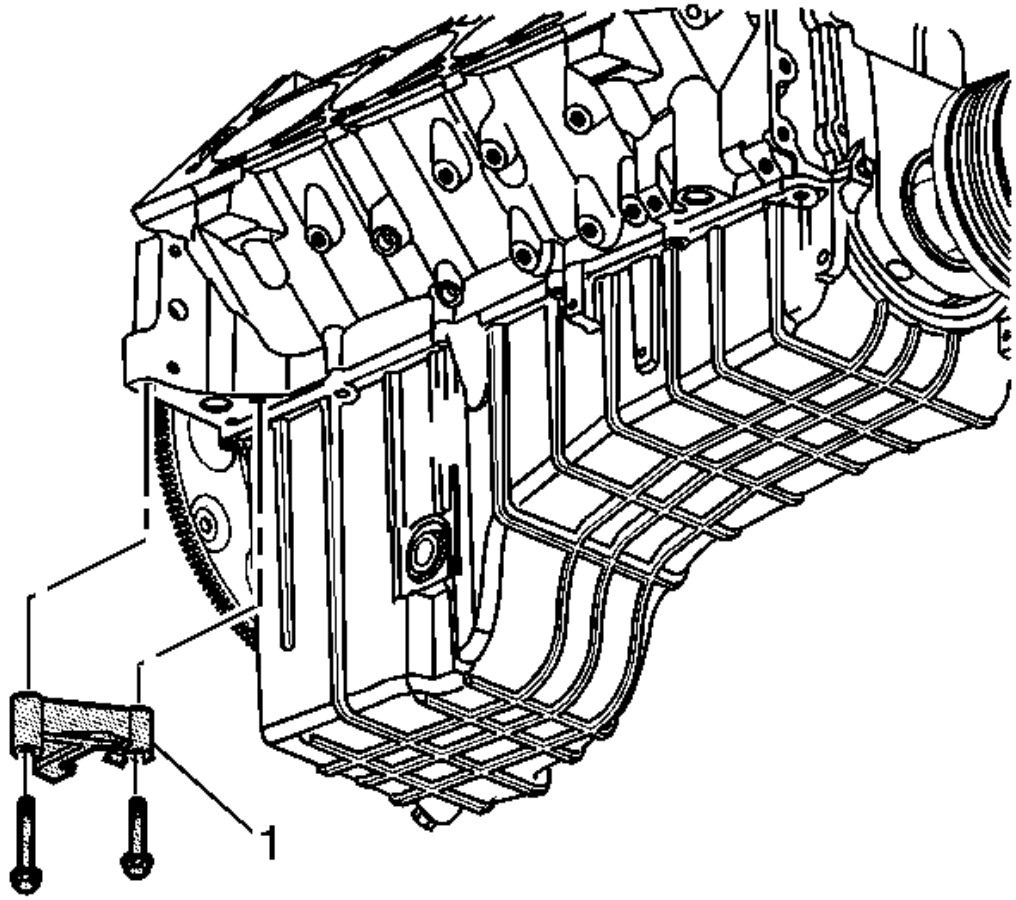

Fig. 564: View Of J 42847 & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the **J 42847** (1). See **Special Tools and Equipment**.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

The crankcase ventilation system has no serviceable components so routine maintenance of the system is not required.

A closed crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. The air cleaner supplies the fresh air through a filter to the crankcase. The crankcase mixes the fresh air blow-by gases. This mixture then passes through a pipe/passage located in the intake manifold.

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DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
    - The power steering pump, if belt driven
    - The generator
    - The A/C compressor, if equipped
    - The engine cooling fan, if belt driven
    - The water pump, if belt driven
    - The vacuum pump, if equipped
    - The air compressor, if equipped

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. There also may be a V-belt style belt used to drive certain accessory drive components. The drive belts are made of different types of rubbers - chloroprene or EPDM - and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

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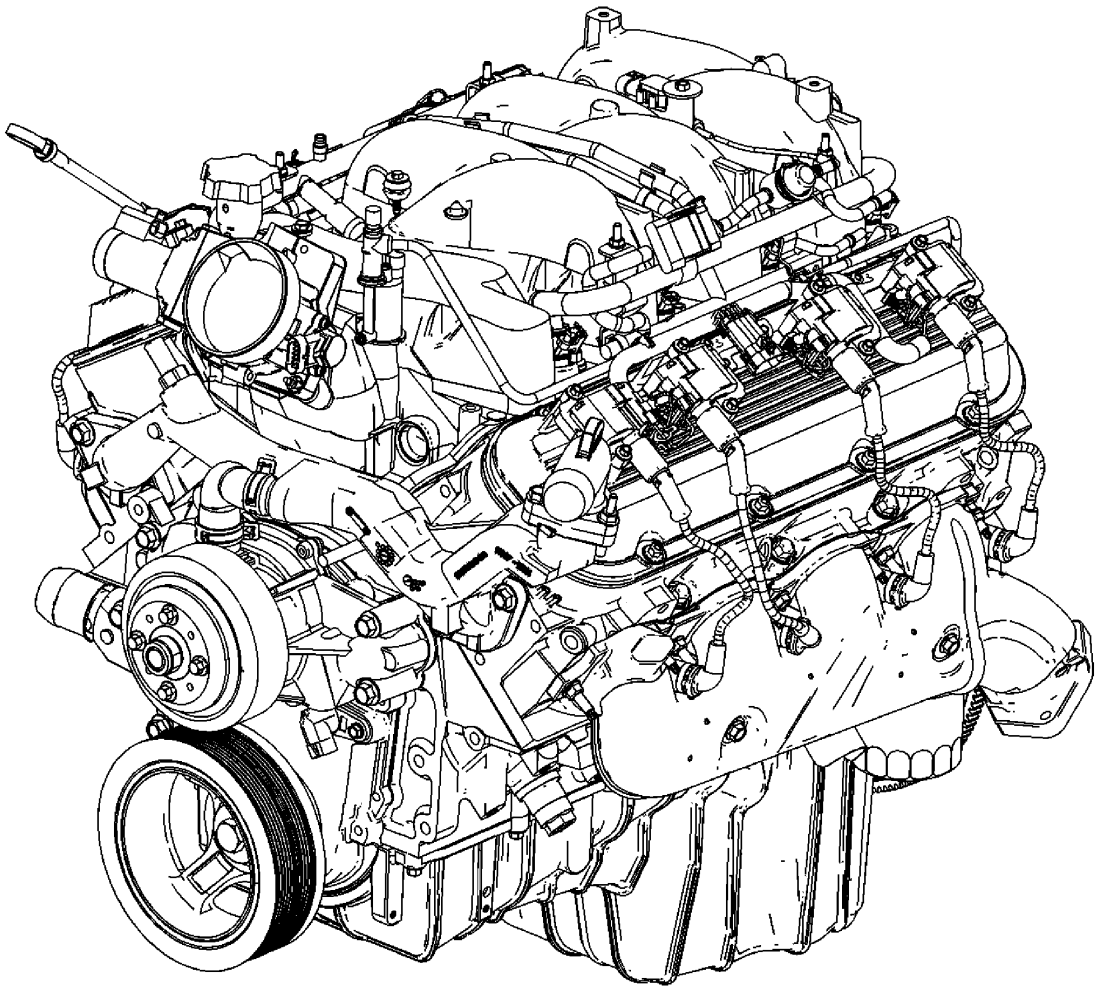

Fig. 565: View Of Engine (8.1L)
Courtesy of GENERAL MOTORS CORP.

Cylinder Block

The engine block is made of cast iron and it has eight cylinders arranged in a 90 degree V shape with four cylinders in each bank. The engine block is a one piece casting with the cylinders encircled by coolant jackets.

Cylinder Head

The cylinder heads are made of cast iron and have parent metal intake valve guides and intake valve seats. The cast iron exhaust valve guides and powdered metal valve seats are pressed into the exhaust ports. A spark plug is located between the valves in the side of the cylinder head. The water crossover pipe attaches to the front of each cylinder head.

Camshaft

A steel camshaft is supported by five bearings pressed into the engine block. The camshaft sprocket is mounted

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to the front of the camshaft and is driven by the crankshaft sprocket through a camshaft timing chain.

Motion from the camshaft is transmitted to the valves by hydraulic roller valve lifters, valve push rods, and ball-pivot type rocker arms. Gear teeth are machined into the camshaft near the rear journal in order to drive a shaft assembly which operates the oil pump driveshaft. Ignition synchronization with the camshaft is provided by a physical feature integral with the camshaft sprocket.

Crankshaft

The crankshaft is made of cast nodular iron. The crankshaft is supported by five crankshaft bearings. The crankshaft bearings are retained by the crankshaft bearing caps. The crankshaft bearing caps are machined with the engine block for proper alignment and clearance. The crankshaft bearing caps are retained by two bolts and two studs each. The number five crankshaft bearing at the rear of the engine block is the end thrust bearing. The four connecting rod journals, two rods per journal, are spaced 90 degrees apart. The crankshaft position sensor reluctor ring is pushed onto the rear of the crankshaft. The crankshaft position sensor reluctor is constructed of powdered metal. The reluctor ring has an interference fit onto the crankshaft and an internal keyway for correct positioning.

Pistons and Connecting Rods

The pistons are cast aluminum alloy that use two compression rings and one oil control ring assembly. The piston pins are a floating fit in the pistons and the piston pins are retained by a press fit in the connecting rod assembly. The pistons are coated in order to create an interference fit into the cylinder. The connecting rods are forged steel and have precision insert type crankpin bearings. The piston and connecting rod is only serviced as an assembly.

Valve Train

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular valve push rods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic roller valve lifters keep all parts of the valve train in constant contact. Each valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment. The valve rocker arm stud and nut retains the valve rocker arm and ball seat. The valve rocker arm stud is threaded into the cylinder head. The valve stem seal is pressed over the valve guide of the cylinder head.

Intake Manifold

The intake manifold is a one-piece design. The intake manifold is made of cast aluminum. The throttle body is attached to the front of the intake manifold. The fuel rail assembly with eight separate fuel injectors is retained to the intake manifold by four studs. The fuel injectors are seated in their individual manifold bores with O-ring seals to provide sealing. A Manifold Absolute Pressure (MAP) sensor is mounted on the top of the intake manifold and sealed by an O-ring seal. The MAP sensor is held in place with a retainer bolt. The evaporative emission canister solenoid is located in the front of the intake manifold. The positive crankcase ventilation (PCV) system is internally cast into the intake manifold. There is not a PCV valve. A splash shield is installed under the intake manifold. The shield prevents hot oil from contacting the bottom of the intake manifold, maintaining air inlet charge density.

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Exhaust Manifold

The two exhaust manifolds are constructed of cast stainless steel. The exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight important technical changes from the previous model year.

Changes may include one 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

Torque Values and/or Fastener Tightening Strategies

No torque or fastener tightening changes from the previous year. Refer to **Fastener Tightening Specifications**.

Changed Engine Specifications

No changed engine specifications. Refer to **Engine Mechanical Specifications**.

New Sealants and/or Adhesives

No sealant or adhesive changes from the previous year. Refer to **Sealers, Adhesives, and Lubricants**.

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 problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Strategy Based Diagnosis** in General Information or **Diagnostic Starting Point - Engine Mechanical** in Engine Mechanical.

New Special Tools Required

- A variety of new tools have been developed to assist in engine disassembly, assembly and on-vehicle service. Refer to **Special Tools**.
- Angle Meter **J 45059** has been developed to provide technicians with a convenient method to tighten bolts that require the torque angle tightening strategy.

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A Component Comparison from the Previous Year

- The exhaust gas recirculation system (EGR) has been removed. Refer to **Disassembled Views**.
- The front cover is now aligned to the engine block with 2 front cover locating pins.
- All applications use a full-floating design piston and pin assembly.

LUBRICATION DESCRIPTION

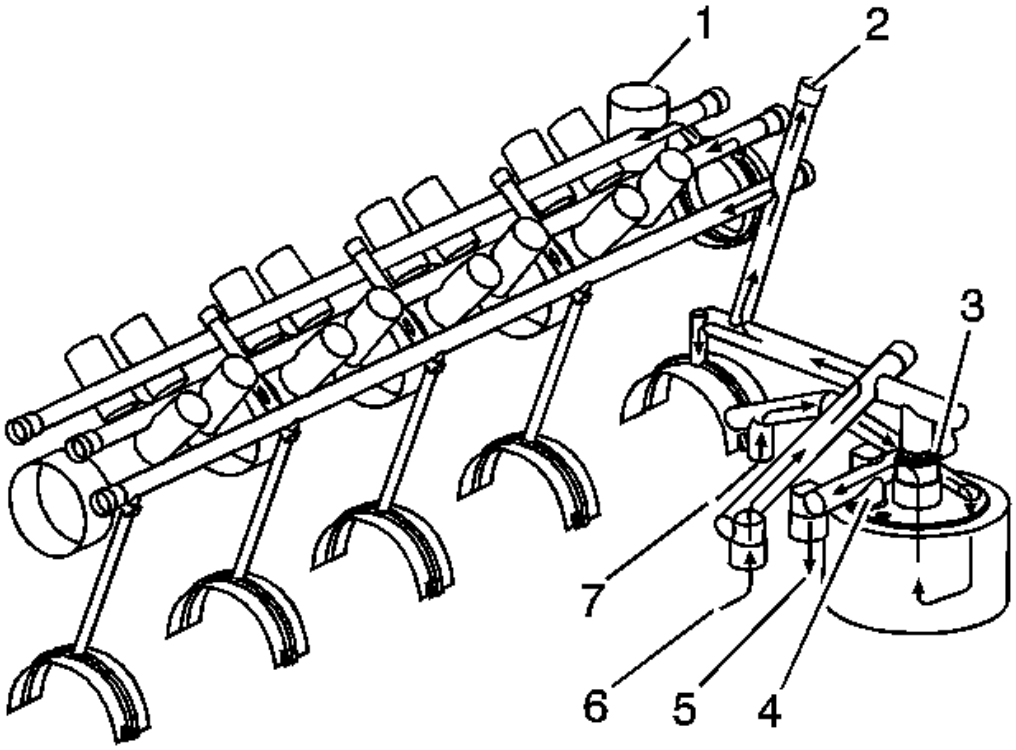

Fig. 566: View Of Lubrication Components
Courtesy of GENERAL MOTORS CORP.

The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the oil pump drive, which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube, into the oil pump (7). Pressurized oil flows through the oil filter, into the oil cooler (5), back into the engine (6), up to the oil pressure gage port (2) and rear crankshaft bearing, and is then distributed to the upper oil galleries. Oil must flow around the oil pump drive (1) in order to reach the right side valve lifters properly. The oil is delivered through internal passages in order to lubricate camshaft and crankshaft bearings and to provide lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve push rods in order to lubricate the valve rocker arms and ball pivots. Oil returning to the oil pan from the cylinder heads and the front camshaft bearing, lubricates the camshaft timing chain and the crankshaft and the camshaft

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sprockets. There are two bypass valves located in the engine block, above the oil filter. The oil filter bypass valve (4) and the oil cooler bypass valve (3).

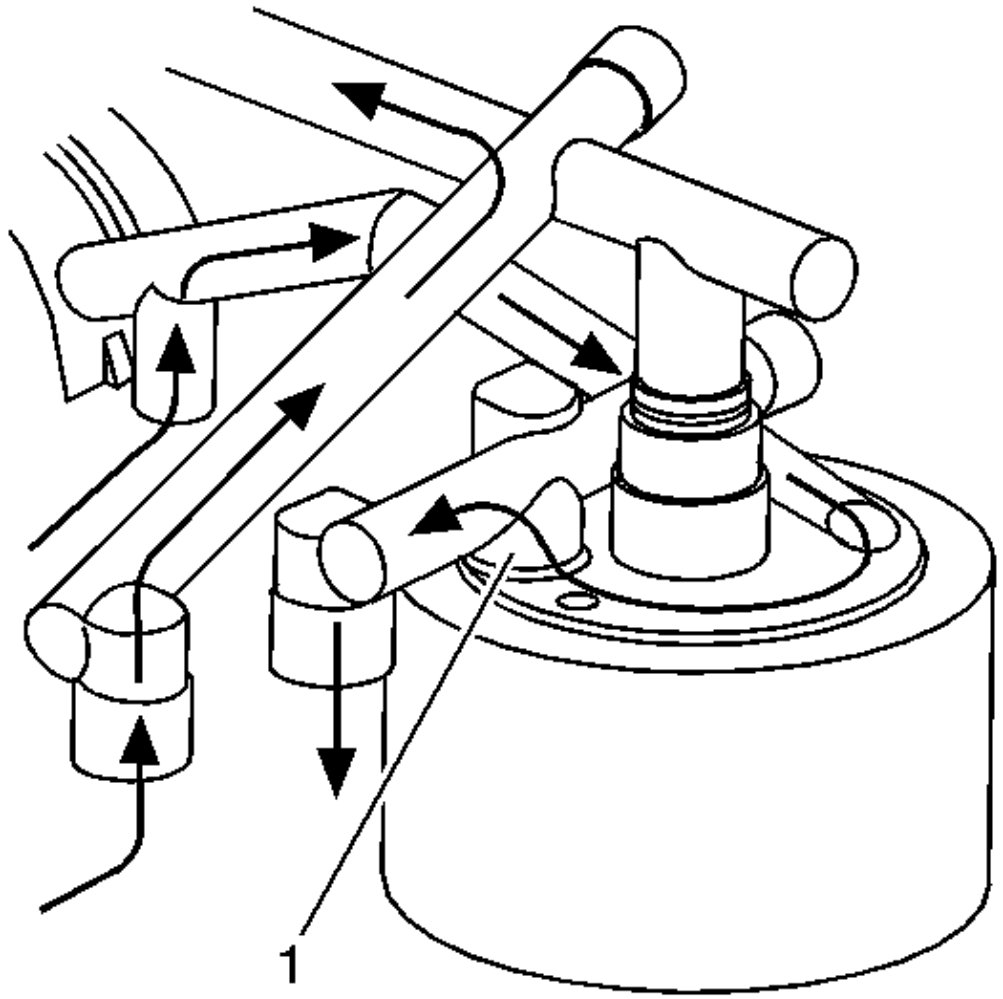

Fig. 567: View Of Oil Flow (With Oil Filter Plugged)
Courtesy of GENERAL MOTORS CORP.

If the oil filter becomes plugged, the pressurized oil is diverted around the top of the oil filter. The oil filter bypass valve (1) is forced open, allowing the oil to continue on to the oil cooler and engine oil passages. No oil filtration occurs because the oil is not allowed into the oil filter.

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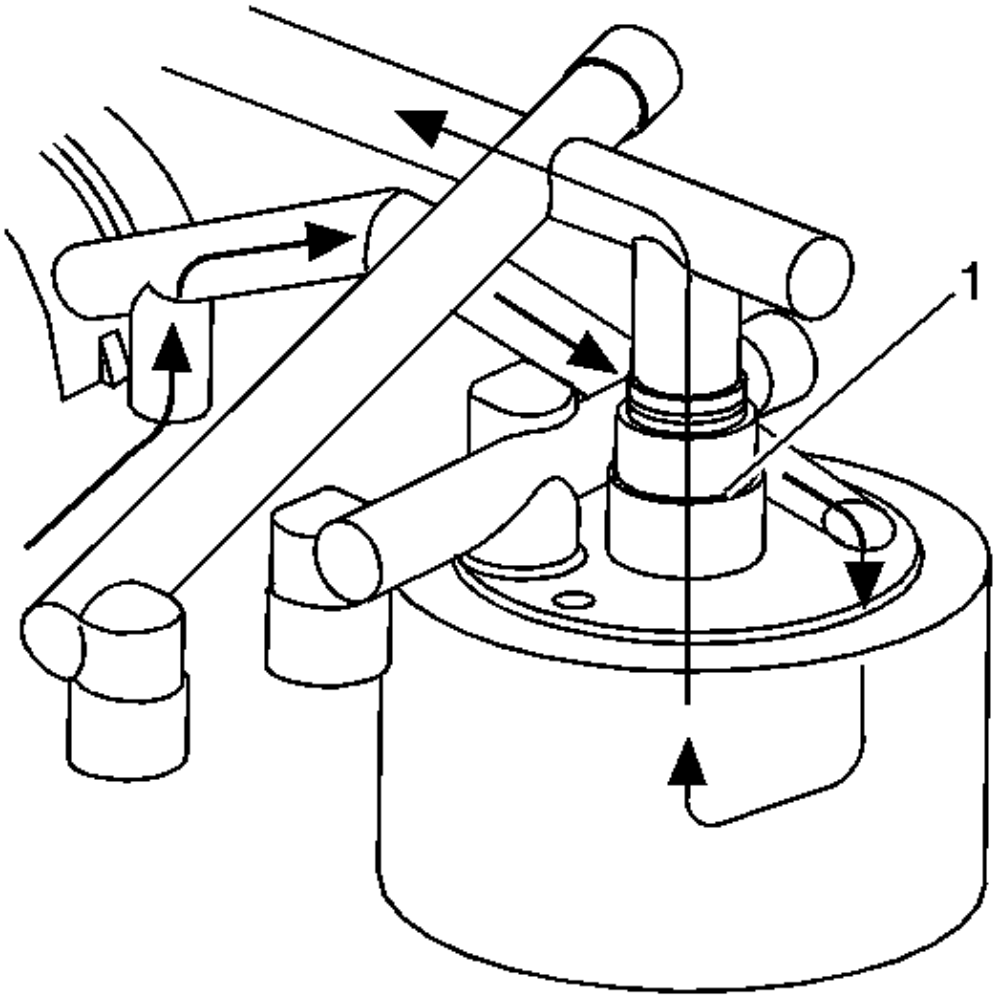

Fig. 568: View Of Oil Flow (With Oil Cooler Flow Blocked)
Courtesy of GENERAL MOTORS CORP.

If the oil cooler flow becomes blocked, either from a plugged oil cooler or blocked or kinked oil cooler line, the oil cooler bypass valve (1) is forced open, allowing oil to flow directly into the engine oil passages. Oil does not flow into or out of the engine oil cooler.

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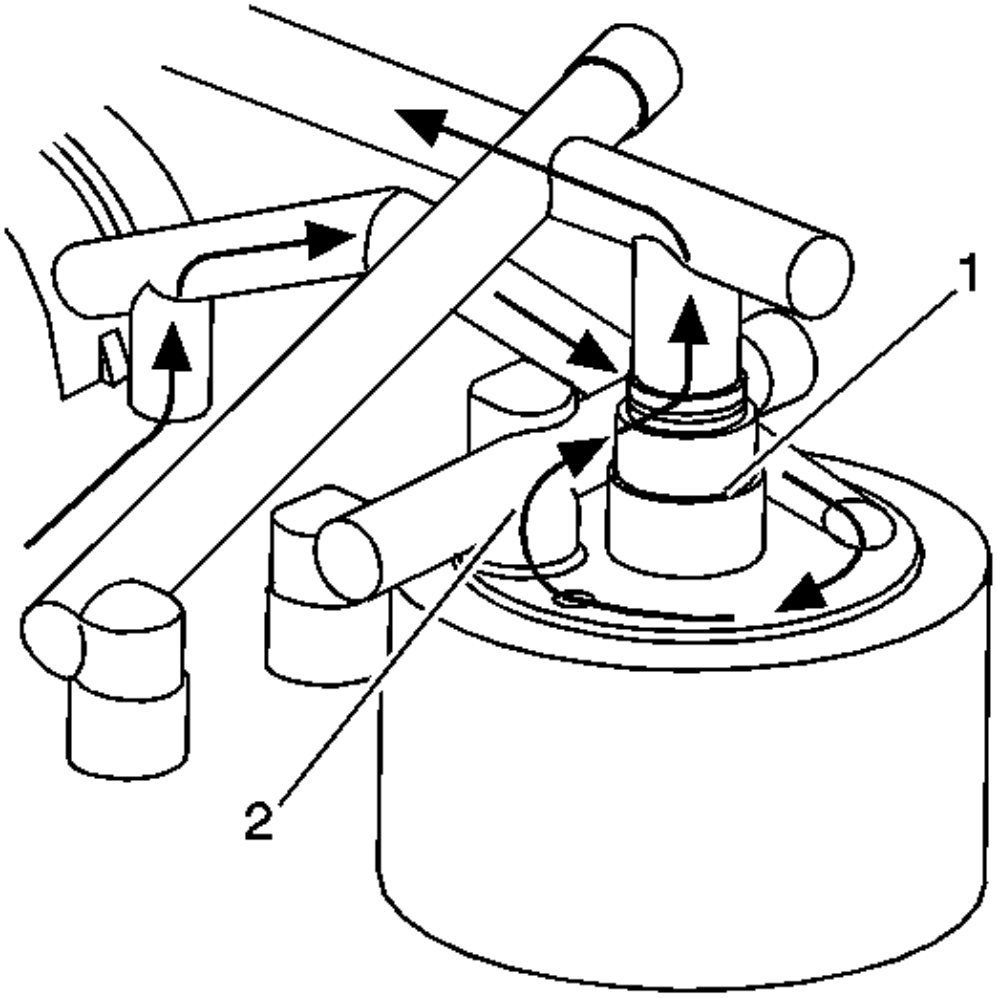

Fig. 569: View Of Oil Flow (With Oil Filter & Oil Cooler Plugged)
Courtesy of GENERAL MOTORS CORP.

If both the oil filter and the oil cooler are plugged, the pressurized oil is routed around the top of the oil filter, through the oil filter bypass valve (2), through the oil cooler bypass valve (1) and directly into the engine oil passages. Lubrication still occurs, but the oil is not filtered or directed through the oil cooler.

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.

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- 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 reassembly.
- 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.

When disassembling the engine, internal components MUST be separated, marked or organized in a way to ensure reinstallation to original location and position.

Separate, mark, or organize the following components:

- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap
- Crankshaft and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, guides, pushrods, pivot supports and rocker arms
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block crankshaft bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

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- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.

  Do not use any other method or technique to remove the sealant or the 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 engine oil.

    This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must 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.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

IMPORTANT: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Sealant Types

IMPORTANT: The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant (or equivalent) as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

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- Aerobic sealant (Room Temperature Vulcanizing (RTV))
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

Aerobic Type Room Temperature Vulcanizing (RTV) Sealant

Aerobic type Room Temperature Vulcanizing (RTV) sealant cures when exposed to air. This type of sealant is used where 2 components (such as the intake manifold and the engine block) are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the plastic and aluminum components.

IMPORTANT: Do not allow the RTV sealant to enter any blind threaded holes, as it may prevent the fasteners from clamping properly or cause damage when the fastener is tightened.

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch (within 3 minutes). Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts (such as castings) are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.

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- Apply a continuous bead of gasket eliminator sealant to one flange.

  The surfaces to be sealed must be clean and dry.

  IMPORTANT: Do not allow the gasket eliminator sealant to enter any blind threaded holes, as the gasket eliminator sealant may prevent the fasteners from clamping properly, seating properly, or cause damage when the fastener tightened.

- Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.

  IMPORTANT: Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than five minutes, may result in incorrect shimming and sealing of the joint.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.
- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

  IMPORTANT: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than five minutes, may result in incorrect clamp load of assembled components.

- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

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- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

NOTE: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence (if specified) and to the proper torque specifications. DO NOT overtighten the fasteners.

TOOLS AND EQUIPMENT

- Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.
- To properly service the engine assembly, the following items should be readily available:
  - Approved eye protection and safety gloves
  - A clean, well-lit, work area
  - A suitable parts cleaning tank
  - A compressed air supply
  - Trays or storage containers to keep parts and fasteners organized
  - An adequate set of hand tools
  - Approved engine repair stand
  - An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Special Tools

Illustration	Tool Number/Description

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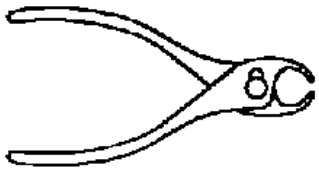
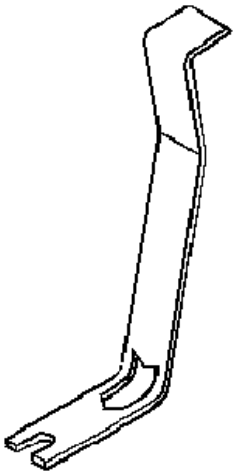
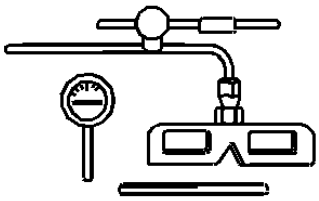
	J 3049-A Valve Lifter Remover
	J 5892-D Valve Spring Compressor
	J 7872 Magnetic Base Dial Indicator
	J 8001 Dial Indicator Set

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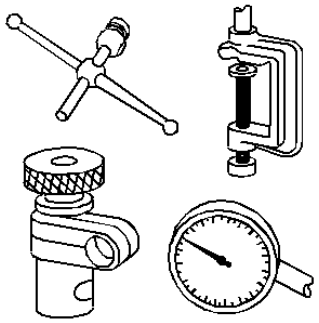
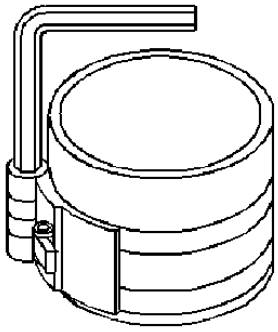
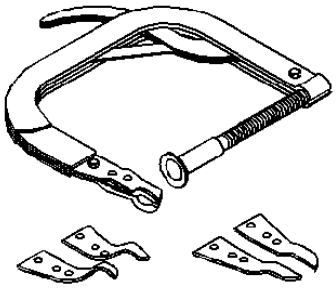
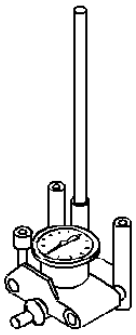
	
	J 8037 Piston Ring Compressor
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage
	J 8089

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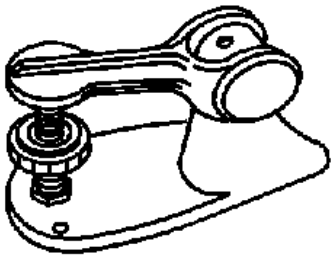
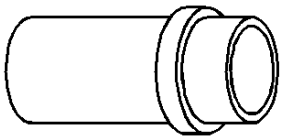
	Carbon Removal Brush
	J 9666 Valve Spring Tester
	J 22102 Front Cover Aligner and Seal Installer
	J 22794 Spark Plug Port Adapter
	J 24270 Cylinder Bore Ridge Reamer

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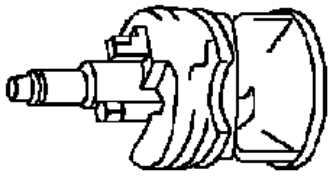
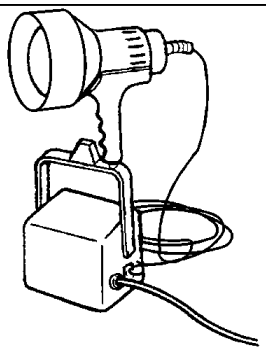
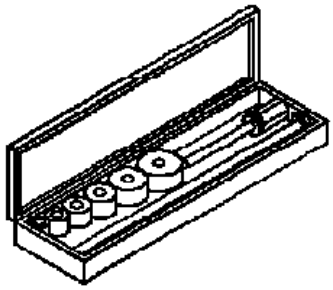
	
	J 28428-E High Intensity Black Light
	J 33049 Camshaft Bearing Service Set
	J 35667-A Cylinder Head Leakdown Tester
	J 36857

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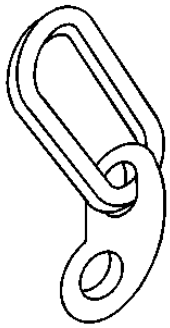
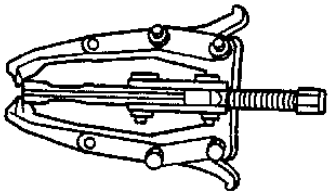
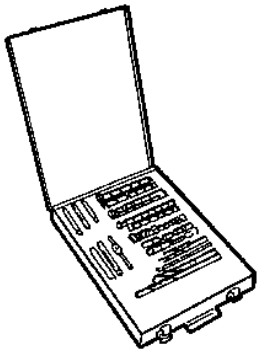
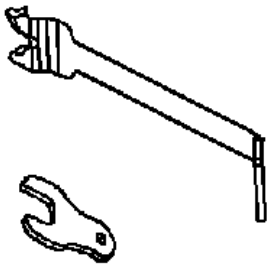
	Engine Lift Bracket
	J 38416-B Harmonic Balancer Remover
	J 39345 Thread Repair Kit
	J 41240 Fan Clutch Wrench

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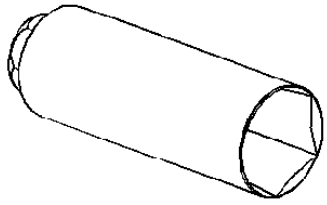
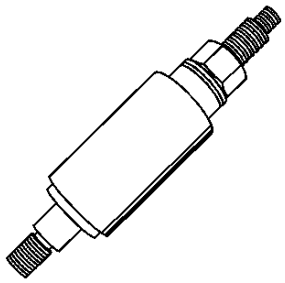
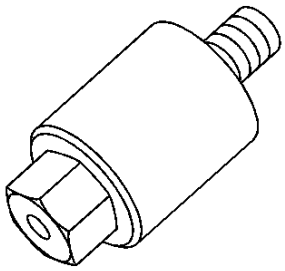
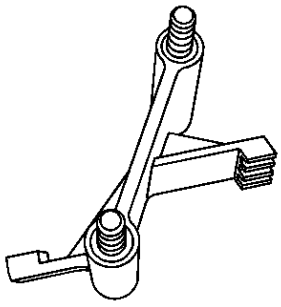
	J 41712 Oil Pressure Switch Socket
	J 42845 Crankshaft Balancer Installer
	J 42846 Crankshaft Protector Button
	J 42847 Flywheel Holding Tool

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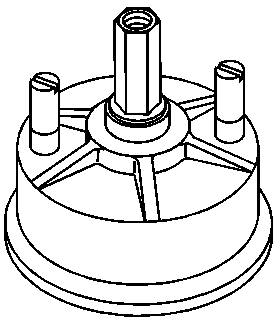
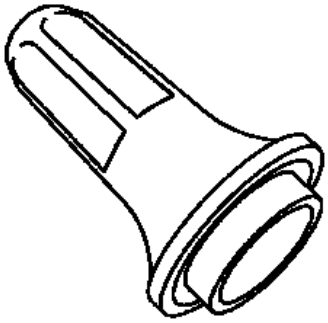
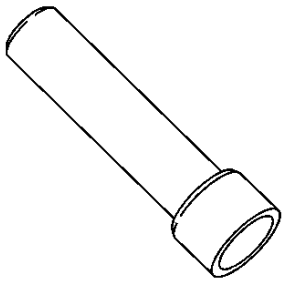
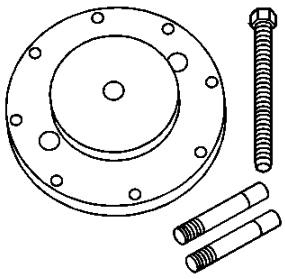
	J 42849 Crankshaft Rear Seal Installer
	J 42851 Front Cover Oil Seal Installer
	J 43105 Valve Stem Seal Installer
	J 43320 Crankshaft Rear Seal Puller

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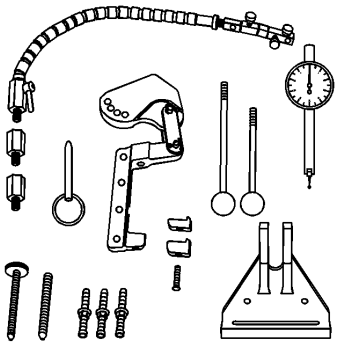
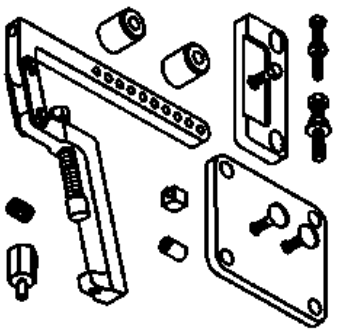
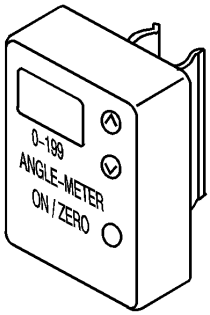
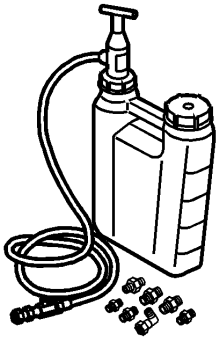
	J 43690 Rod Bearing Clearance Checking Tool
	J 43690-100 Rod Bearing Clearance Checking Tool - Adapter Kit
	J 45059 Angle Meter
	J 45299 Engine Pre-Luber

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