2007 ENGINE

Engine Mechanical - 2.4L - Cobalt, G5 & G5 Pursuit (Canadian)

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C Compressor to Block Bolt	20 N.m	15 lb ft
Balance Shaft Adjustable Chain Guide Bolt	15 N.m	11 lb ft
Balance Shaft Bearing Carrier to Block Bolt	10 N.m	89 lb in
Balance Shaft Fixed Chain Guide Bolt	15 N.m	11 lb ft
Balance Shaft Sprocket Bolt	50 N.m	37 lb ft
Block Core Plug	40 N.m	30 lb ft
Block Heater Bolt	10 N.m	89 lb in
Cam Cover to Cylinder Head Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Bolt	10 N.m	89 lb in
Cam Cover to Ground Cable Stud	10 N.m	89 lb in
Camshaft Cap Bolt	10 N.m	89 lb in
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m	89 lb in
Camshaft Position Sensor Bolt	10 N.m	89 lb in
Camshaft Timing Chain Tensioner	75 N.m	55 lb ft
Chain Guide Plug	90 N.m	59 lb ft
Connecting Rod Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Crankshaft Balancer Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	125 degrees	
Crankshaft Bearings - Lower Crankcase to Block - Bedplate		
• First Pass	20 N.m	15 lb ft
• Final Pass	70 degrees	
Crankshaft Position Reluctor Ring	15 N.m	11 lb ft
Crankshaft Position Sensor Bolt	10 N.m	89 lb in
Cylinder Head Bolt		
• First Pass	30 N.m	22 lb ft
• Final Pass	155 degrees	

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Cylinder Head Front Chaincase Bolt	35 N.m	26 lb ft
Cylinder Head Oil Gallery Plug	35 N.m	26 lb ft
Drive Belt Tensioner Bolt	45 N.m	33 lb ft
EGR Cover Bolt	25 N.m	18 lb ft
Engine Coolant Temperature Sensor	20 N.m	15 lb ft
Engine Lift Bracket Front Bolt	25 N.m	18 lb ft
Engine Lift Bracket Rear Bolt	25 N.m	18 lb ft
EVAP Canister Valve Bolt	22 N.m	16 lb ft
Exhaust Camshaft Position Actuator		
• First Pass	30 N.m	22 lb ft
• Final Pass	100 degrees	
Exhaust Manifold Pipe Flange Stud	16 N.m	12 lb ft
Exhaust Manifold to Cylinder Head Nut - 2 passes	14 N.m	124 lb in
Exhaust Manifold to Cylinder Head Stud	10 N.m	89 lb in
Flywheel Bolt - Automatic Transmission		
• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	
Flywheel Bolt - Manual Transmission		
• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	
Front Cover to Block Bolt	25 N.m	18 lb ft
Front Lift Bracket Bolt	25 N.m	18 lb ft
Fuel Pipe Bracket Bolt	10 N.m	89 lb in
Fuel Rail Bracket Stud	10 N.m	89 lb in
Generator to Block Bolt	23 N.m	17 lb ft
Heat Shield to Exhaust Manifold Bolt	22 N.m	16 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Intake Camshaft Position Actuator		
• First Pass	30 N.m	22 lb ft
• Final Pass	100 degrees	
Intake Camshaft Rear Cap Bolt	25 N.m	18 lb ft
Intake Manifold to Cylinder Head Bolt	10 N.m	89 lb in
Intake Manifold to Cylinder Head Nut	10 N.m	89 lb in
Intake Manifold to Cylinder Head Stud	6 N.m	53 lb in
Knock Sensor Bolt	25 N.m	18 lb ft
Lower Crankcase to Block Perimeter Bolt	25 N.m	18 lb ft
Oil Cooler Bolts	22 N.m	16 lb ft
Oil Filter Housing Cover	22 N.m	16 lb ft
Oil Gallery Gerotor Cover - Rear Bolt	6 N.m	53 lb in

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Oil Gallery Plug	35 N.m	26 lb ft
Oil Gallery Plug - Rear	60 N.m	44 lb ft
Oil Level Indicator Tube to Intake Manifold Bolt	10 N.m	89 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan to Block Bolts	25 N.m	18 lb ft
Oil Pressure Switch	22 N.m	16 lb ft
Oil Pump Cover Bolt	6 N.m	53 lb in
Oil Pump Pressure Relief Valve Plug	40 N.m	30 lb ft
Oxygen Sensor	42 N.m	31 lb ft
Piston Oil Squirter	15 N.m	11 lb ft
Power Steering Pump Bolt	25 N.m	18 lb ft
Spark Plug	20 N.m	15 lb ft
Starter Motor to Block Bolt	53 N.m	39 lb ft
Thermostat Housing to Block Bolts	10 N.m	89 lb in
Throttle Body Bolt	10 N.m	89 lb in
Throttle Body Nut	10 N.m	89 lb in
Throttle Body Stud	6 N.m	53 lb in
Timing Adjustable Chain Guide Bolt	10 N.m	89 lb in
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Timing Fixed Chain Guide Bolt	15 N.m	11 lb ft
Timing Upper Chain Guide Bolt	10 N.m	89 lb in
Vent Tube to Cylinder Head	15 N.m	11 lb ft
Water Jacket Drain Plug	20 N.m	15 lb ft
Water Pipe Support Bracket Bolt	10 N.m	89 lb in
Water Pump Access Cover Bolt	7 N.m	62 lb in
Water Pump/Balance Shaft Chain Tensioner Bolt	10 N.m	89 lb in
Water Pump Bolts	25 N.m	18 lb ft
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.4 L	146 CID
• RPO	LE5	
• Liter (VIN)	B	
• Bore	87.992-88.008 mm	3.4668-3.4675 in

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• Stroke	98 mm	3.861 in
• Compression Ratio	10:01	
Balance Shaft		
• Bearing Clearance	0.030-0.063 mm	0.0012-0.0025 in
• Bearing Diameter - Inside - Carrier	20.050-20.063 mm	0.7894-0.7899 in
• Bearing Diameter - Outside - Carrier	41.975-41.995 mm	1.6526-1.6534 in
• Bearing Journal Diameter	20.000-20.020 mm	0.7874-0.7882 in
• Bushing Clearance	0.033-0.102 mm	0.0013-0.0040 in
• Bushing Diameter - Inside	36.776-36.825 mm	1.4479-1.4498 in
• Bushing Journal Diameter	36.723-36.743 mm	1.4458-1.4466 in
• End Play	0.100-0.300 mm	0.0020-0.0118 in
Block		
• Balance Shaft Bearing Bore Diameter - Carrier	42.000-42.016 mm	1.6535-1.6542 in
• Balance Shaft Bushing Bore Diameter	40.763-40.776 mm	1.6048-1.6054 in
• Crankshaft Main Bearing Bore Diameter	64.068-64.082 mm	2.5224-2.5229 in
• Cylinder Bore Diameter	87.992-88.008 mm	3.4668-3.4675 in
• Cylinder Bore Out-of-Round - Maximum	0.010 mm	0.0004 in
• Cylinder Bore Taper - Maximum	0.010 mm	0.0004 in
• Cylinder Head Deck Surface Flatness - Longitude	0.050 mm	0.002 in
• Cylinder Head Deck Surface Flatness - Overall	0.08 mm	0.0031 in
• Cylinder Head Deck Surface Flatness - Transverse	0.030 mm	0.0012 in
Camshaft		
• Camshaft End Play	0.040-0.144 mm	0.0016-0.0057 in
• Camshaft Journal Diameter	26.935-26.960 mm	1.0604-1.0614 in
• Camshaft Thrust Surface	21.000-21.052 mm	0.8268-0.8252 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.029-0.069 mm	0.0011-0.0027 in
• Connecting Rod Bore Diameter - Bearing End	52.118-52.134 mm	2.0519-2.05252 in
• Connecting Rod Bore Diameter - Pin End	20.007-20.021 mm	0.7877-0.7882 in
• Connecting Rod Side Clearance	0.070-0.370 mm	0.0028-0.0146 in
• Connecting Rod Straightness - Bend - Maximum	0.021 mm	0.0083 in
• Connecting Rod Straightness - Twist - Maximum	0.04 mm	0.0157 in
Crankshaft		
• Connecting Rod Journal Diameter	49.000-49.014 mm	1.9291-1.9297 in

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• Crankshaft End Play	0.050-0.380 mm	0.0012-0.0150 in
• Crankshaft Main Bearing Clearance	0.031-0.067 mm	0.0012-0.0026 in
• Crankshaft Main Journal Diameter	55.994-56.008 mm	2.2045-2.2050 in
Cylinder Head		
• Surface Flatness - Block Deck - Longitude	0.050 mm	0.002 in
• Surface Flatness - Block Deck - Overall	0.1 mm	0.004 in
• Surface Flatness - Block Deck - Transverse	0.030 mm	0.0012 in
• Valve Guide Bore - Exhaust	6.000-6.012 mm	0.2362-0.2367 in
• Valve Guide Bore - Intake	6.000-6.012 mm	0.2362-0.2367 in
• Valve Lifter Bore Diameter - Stationary Lash Adjusters	12.013-12.037 mm	0.4730-0.4739 in
Lubrication System		
• Oil Pressure - Minimum - @1000 RPM	344.75-551.60 kPa	50-80 psi
• Oil Capacity	4.8L	5.0 quarts
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.20-0.40 mm	0.008-0.016 in
• Piston Ring End Gap - Second Compression Ring	0.35-0.55 mm	0.014-0.022 in
• Piston Ring End Gap - Oil Control Ring - Rails	0.25-0.76 mm	0.010-0.030 in
• Piston Ring to Groove Clearance - First Compression Ring	0.04-0.08 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring	0.030-0.069 mm	0.0012-0.0027 in
• Piston Ring to Groove Clearance - Oil Control Ring	0.090-0.106 mm	0.0035-0.0042 in
• Piston Ring Thickness - First Compression Ring	1.170-1.190 mm	0.0461-0.0469 in
• Piston Ring Thickness - Second Compression Ring	1.471-1.490 mm	0.0579-0.0587 in
• Piston Ring Thickness - Oil Control Ring - Rail - Maximum	0.43 mm	0.0169 in
• Piston Ring Thickness - Oil Control Ring - Spacer	1.574-1.651 mm	0.0620-0.0650 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.007-0.026 mm	0.0003-0.0010 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.002-0.012 mm	0.0001-0.0005 in
• Pin - Piston Pin Diameter	19.995-20.000 mm	0.7872-0.7874 in
• Pin - Piston Pin End Play	0.19-1.16 mm	0.0075-0.0461 in
• Piston - Piston Diameter - @14.5 mm up	85.967-85.982 mm	3.3845-3.3851 in
• Piston - Piston Pin Bore Diameter	20.002-20.007 mm	0.07875-0.7877 in

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• Piston - Piston Ring Grove Width - Oil Control	2.52-2.54 mm	0.0992-0.1000 in
• Piston - Piston Ring Grove Width - Second	1.52-1.54 mm	0.0598-0.0606 in
• Piston - Piston Ring Grove Width - Top	1.23-1.25 mm	0.0484-0.0492 in
• Piston - Piston to Bore Clearance	0.010-0.041 mm	0.0004-0.0016 in
Valve System		
• Valves - Valve Face Runout - Maximum	0.04 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.05 mm	0.0020 in
• Valves - Valve Stem Diameter - Exhaust	5.935-5.950 mm	0.2337-0.2343 in
• Valves - Valve Stem Diameter - Intake	5.955-5.970 mm	0.2344-0.2355 in
• Valves - Valve Stem to Guide Clearance - Exhaust	0.050-0.077 mm	0.0020-0.0026 in
• Valves - Valve Stem to Guide Clearance - Intake	0.030-0.057 mm	0.0012-0.0022 in
• Valve Lifters - Valve Lifter Diameter - Stationary Lash Adjuster	11.986-12.000 mm	0.0005-0.0020 in
• Valve Lifters - Valve Lifter-to-Bore Clearance - Stationary Lash Adjuster	0.013-0.051 mm	3.2210-3.2299 in
• Valve Springs - Valve Spring Load - Closed - @22.5 mm	525.0-575.0 N. - Eng Spec.	
• Valve Springs - Valve Spring Load - Open - @32.5 mm	245.0-271.0 N. - Eng Spec.	

SEALERS, ADHESIVES, AND LUBRICANTS

Sealers, Adhesives, and Lubricants

Application	Type of Material	GM Part Number	
		United States	Canada
# 6 Intake Rear Camshaft Cap	Sealant	12378521	88901148
Balance Shaft Bearings	Engine Oil	12345610	993193
Cam Lobes	Engine Oil	12345610	993193
Crank Sensor O-ring	Engine Oil	12345610	993193
Cylinder Bores	Engine Oil	12345610	993193
Cylinder Head Plugs	Sealant	12345382	10953489
Engine Block Threaded Plugs	Sealant	12346004	10953480
Engine Block to Bedplate	Sealant	12378521	88901148
Engine Oil Level Indicator Tube O-ring	Lubricant	12345501	992704
Fuel Injector O-rings	Engine Oil	12345610	993193
Fuel Injector Tip Insulators	Engine Oil	12345610	993193
Intake and Exhaust Valve Stems	Lubricant	12345501	992704
Main Bearings	Lubricant	12345501	992704
Oil Filter Cap - Threads and O-ring Lead-in			

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Chamfers	Engine Oil	12345610	993193
Oil Pan to Bedplate Joint	Sealant	12378521	88901148
Oil Pump - Pump Elements	Engine Oil	12345610	993193
Oxygen Sensor Threads	Anti-seize	12397953	-
Piston Pin to Piston/Rod - Pin Bores of Piston and Rod	Engine Oil	12345610	993193
Rod Bearings - Rod Pins of Crankshaft	Engine Oil	12345610	993193
Stationary Hydraulic Lash Adjusters	Lubricant	12345501	992704
Timing Chain Guide Bolt Access Hole Plug	Sealant	12345382	10953489
Valve Rocker Arm/Valve Tip	Lubricant	12345501	992704
Water Feed Tube O-rings	Lubricant	12345579	1974984
Water Pump Drain Plug	Sealant	12346004	10953480

THREAD REPAIR SPECIFICATIONS

Engine Block - Front View

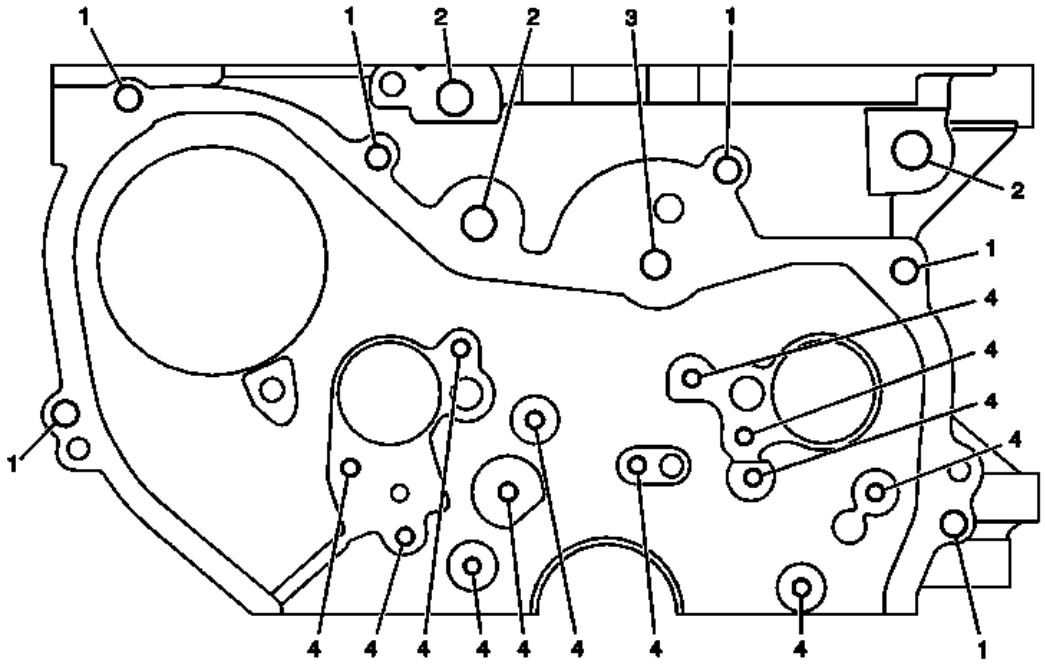

Fig. 1: Identifying Bolt Size & Locations On Engine Block - Front View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)

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1	M8 x 1.25	210	206	207	208	209	23.5	0.93	18.5	0.73
2	M12 x 1.75	855	856	857	858	859	33.5	1.32	26.5	1.04
3	M10 x 1.5	215	211	212	213	214	24.5	0.96	19.5	0.77
4	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

Engine Block - Back View

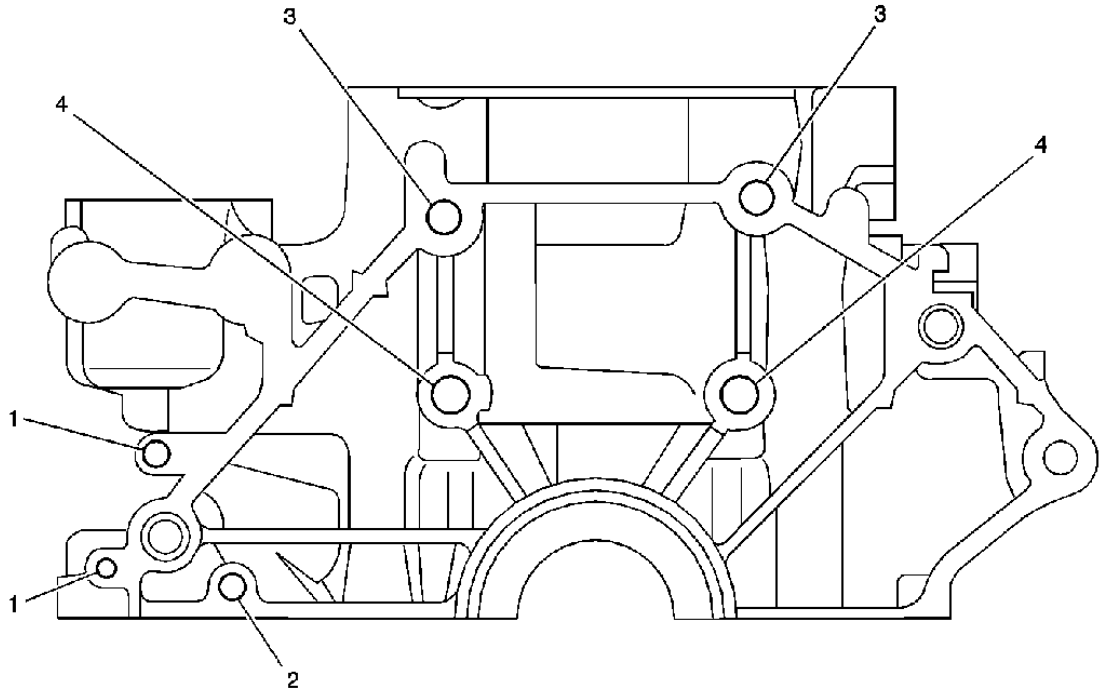

Fig. 2: Identifying Bolt Size & Locations On Engine Block - Back View
Courtesy of GENERAL MOTORS CORP.

Engine Block - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	18	0.709	THRU	
2	M10 x 1.5	215	211	212	213	214	29	1.161	THRU	
3	M12 x 1.75	855	856	857	858	859	39	1.535	33.5	1.32
4	M16 x 1.5	860	861	862	863	864	21	0.827	15	0.59

Engine Block - Left Side View

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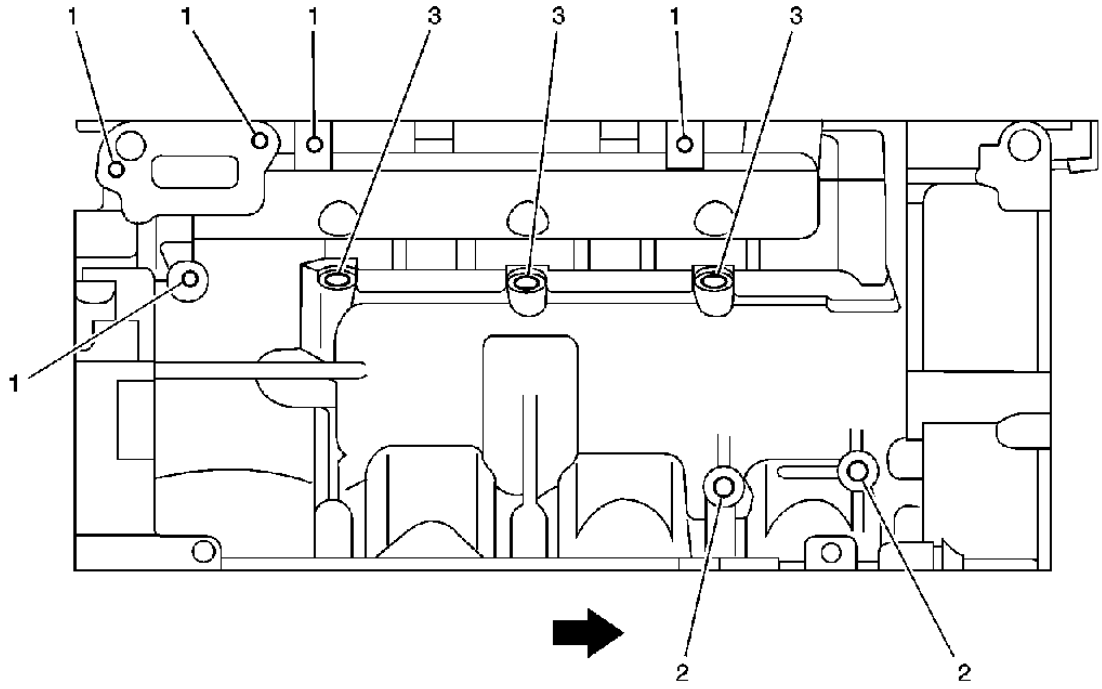

Fig. 3: Identifying Bolt Size & Locations On Engine Block - Left Side
Courtesy of GENERAL MOTORS CORP.

Engine Block - Left Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20.5	0.807	16	0.63
2	M10 x 1.5	215	211	212	213	214	23.5	0.925	18.5	0.73
3	M12 x 1.75	865	856	857	858	859	19.5	0.768	12.5	0.49

Engine Block - Bottom View

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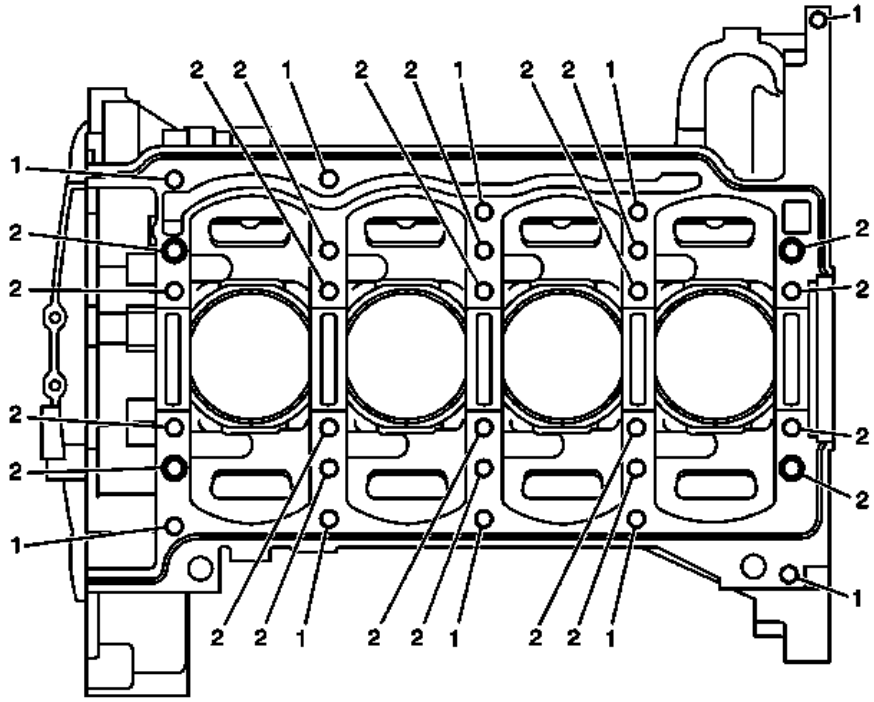

Fig. 4: Identifying Bolt Size & Locations On Engine Block - Bottom
Courtesy of GENERAL MOTORS CORP.

Engine Block - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	28	1.102	22	0.87
2	M10 x 1.5	514	511	N/A	512	513	60	2.362	53.5	2.11

Engine Block - Right Side View

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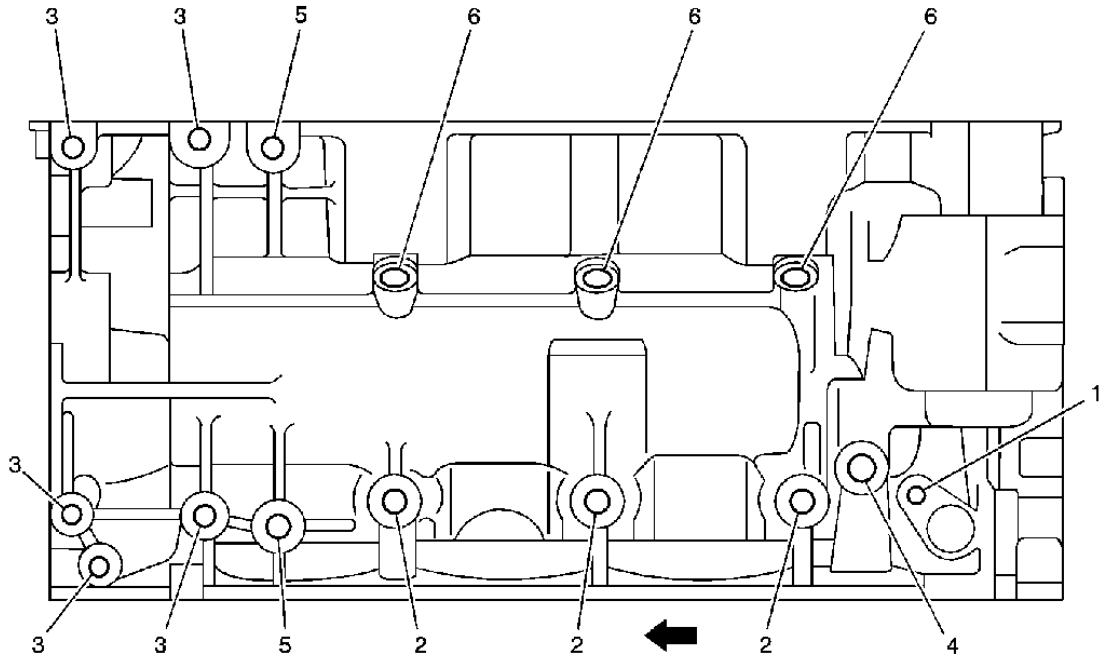

Fig. 5: Identifying Bolt Size & Locations On Engine Block - Right Side
Courtesy of GENERAL MOTORS CORP.

Engine Block - Right Side View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20.5	0.807	16.5	0.65
2	M8 x 1.25	210	206	207	208	209	23.5	0.925	18	0.71
3	M8 x 1.25	210	206	207	208	209	30.5	1.201	22.5	0.89
4	M12 x 1.75	865	856	857	858	859	15.5	0.61	12.5	0.49
5	M12 x 1.75	855	856	857	858	859	33.5	1.319	26.5	1.04
6	M12 x 1.75	865	856	857	858	859	19.5	0.778	12.5	0.49

Engine Block - Top View

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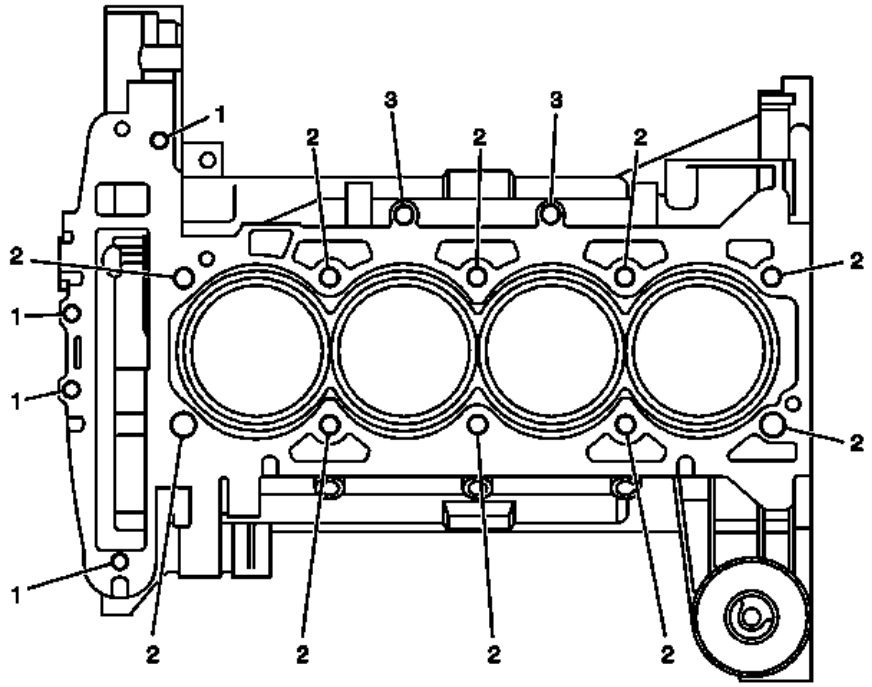

Fig. 6: Identifying Bolt Size & Locations On Engine Block - Top
Courtesy of GENERAL MOTORS CORP.

Engine Block - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73
2	M11 x 1.5	507	504	N/A	505	506	113.3	4.461	107.3	4.22
3	M12 x 1.75	865	856	857	858	859	13.5	0.531	12.5	0.49

Lower Crankcase - Front View

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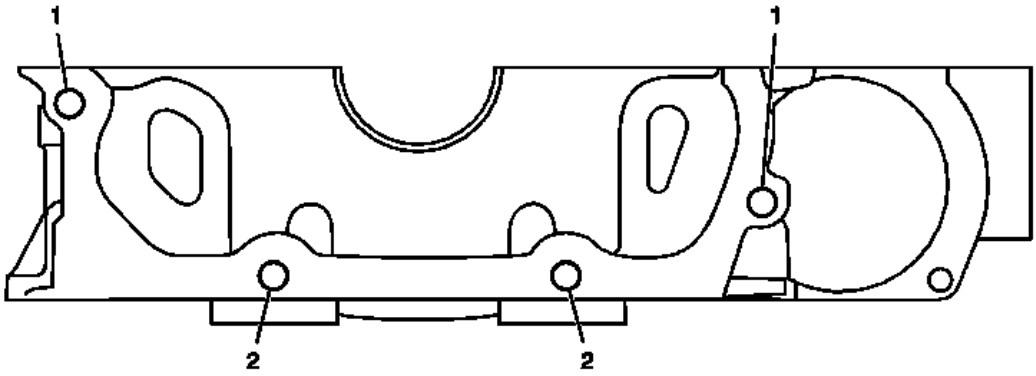

Fig. 7: Identifying Bolt Size & Locations On Engine Block - Top
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73
2	M8 x 1.25	210	206	207	208	209	30.5	1.201	25.5	1.00

Lower Crankcase - Back View

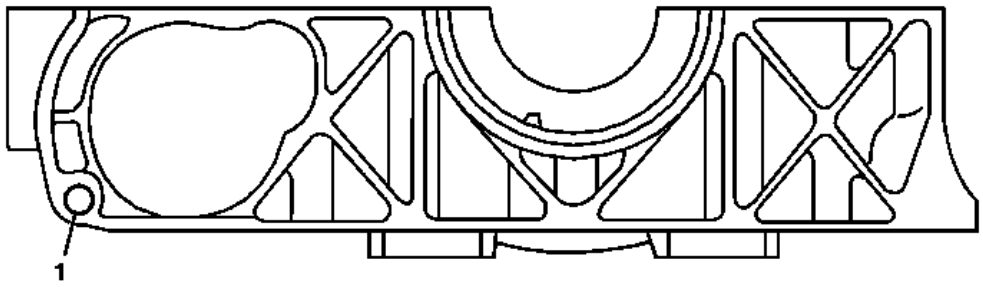

Fig. 8: Identifying Bolt Size & Locations On Lower Crankcase - Back
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)	Tap Depth (Maximum)

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J 42385-850							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	29.5	1.161	THRU	

Lower Crankcase - Bottom View

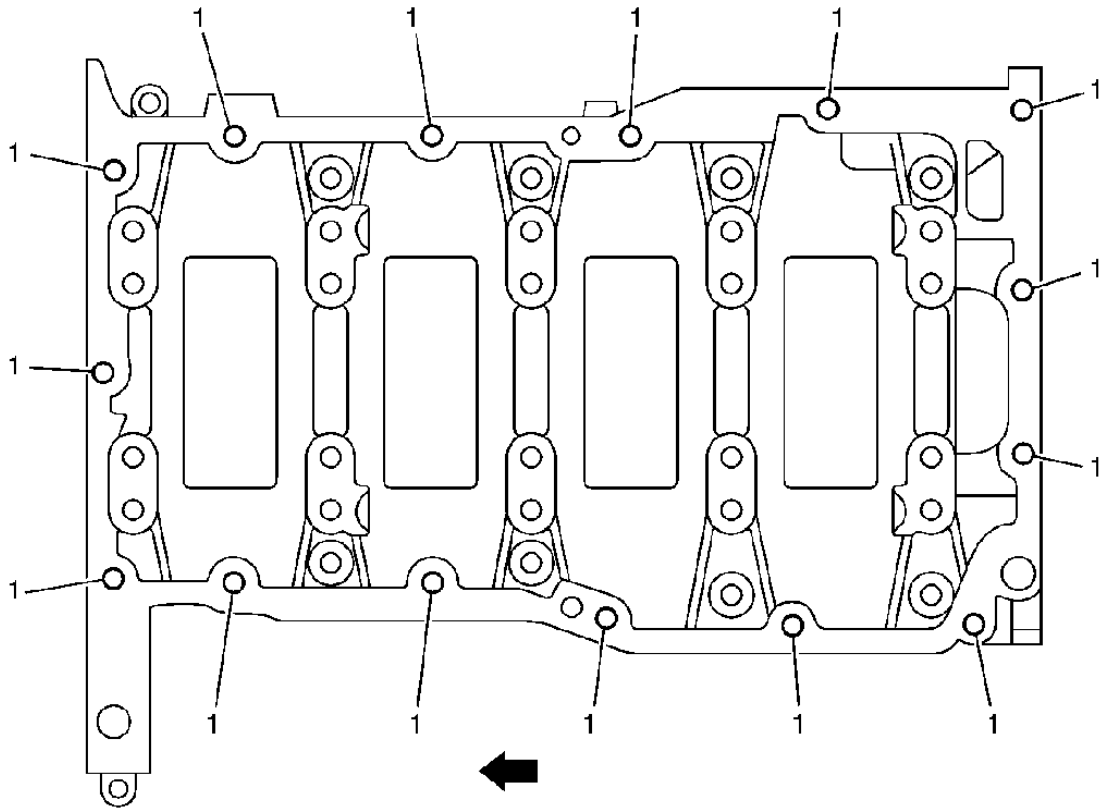

Fig. 9: Identifying Bolt Size & Locations On Lower Crankcase - Bottom
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	23.5	0.925	18.5	0.73

Lower Crankcase - Left View

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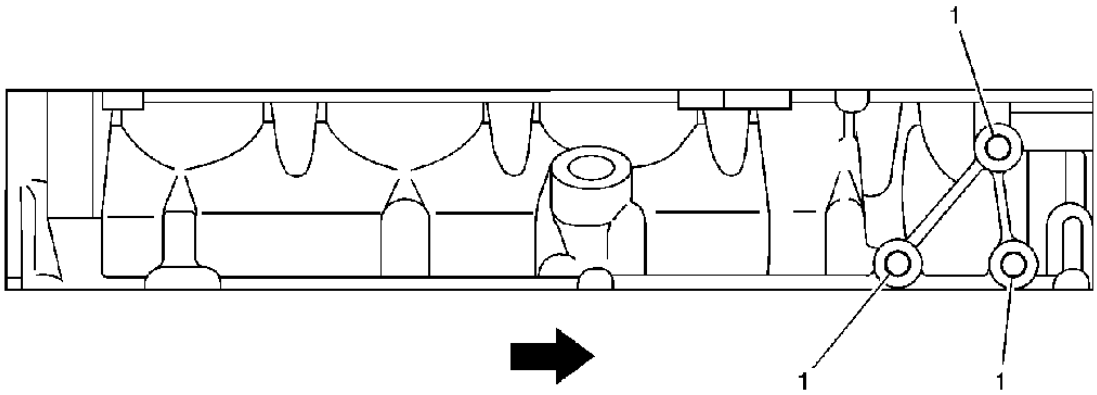

Fig. 10: Identifying Bolt Size & Locations On Lower Crankcase - Bottom
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Left View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M10 x 1.5	215	211	212	213	214	28.5	1.122	22.5	0.89

Lower Crankcase - Right View

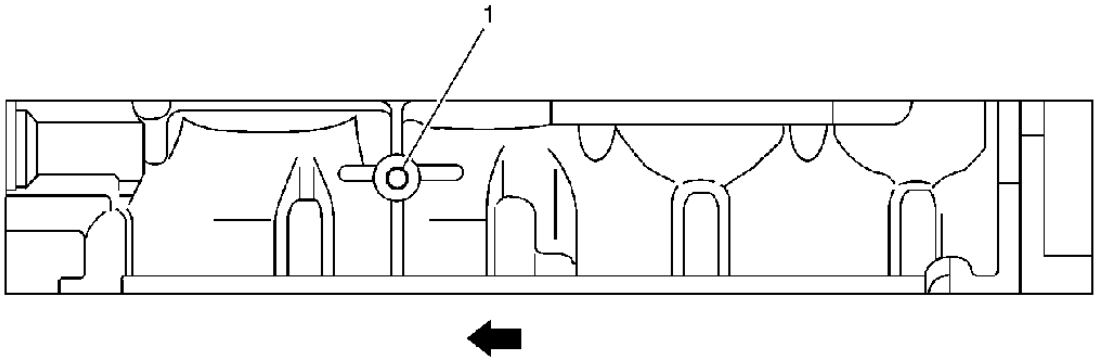

Fig. 11: Identifying Bolt Size & Locations On Lower Crankcase - Right
Courtesy of GENERAL MOTORS CORP.

Lower Crankcase - Right View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	211	212	213	214	30.5	1.201	22.5	0.886

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Cylinder Head - Top View

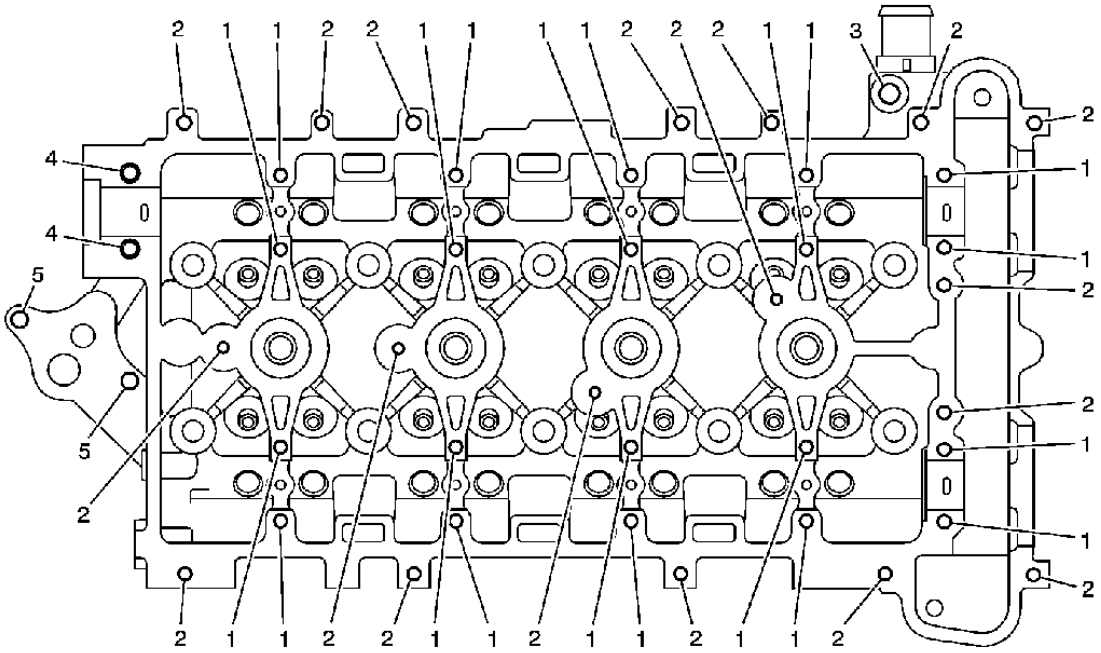

Fig. 12: Identifying Bolt Sizes & Locations On Cylinder Head - Top
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Top View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	852	N/A	203	204	24	0.945	20	0.787
2	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
3	M8 x 1.25	854	206	207	208	209	THRU		THRU	
4	M8 x 1.25	854	853	N/A	208	209	25	0.984	20	0.787
5	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787

Cylinder Head - Intake Manifold Deck View

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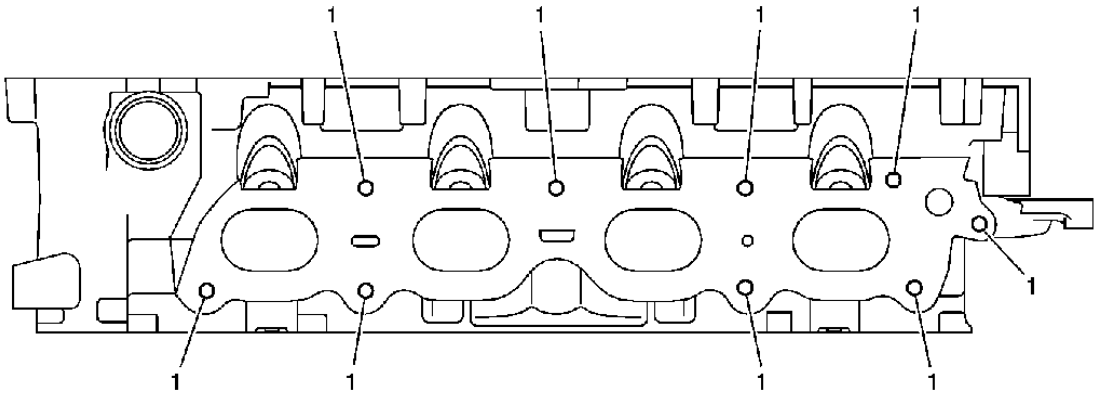

Fig. 13: Identifying Bolt Size & Locations On Cylinder Head - Intake Manifold Deck
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Intake Manifold Deck View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

Cylinder Head - Exhaust Manifold Deck View

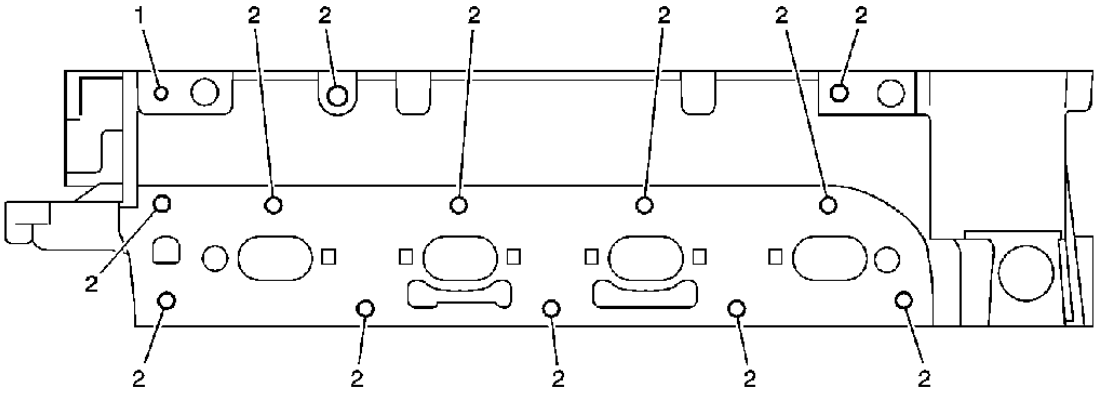

Fig. 14: Identifying Bolt Size & Locations On Cylinder Head - Exhaust Manifold Deck
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Exhaust Manifold Deck View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)

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1	M6 x 1	205	201	202	203	204	20	0.78	16	0.63
2	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.78

Cylinder Head - Front View

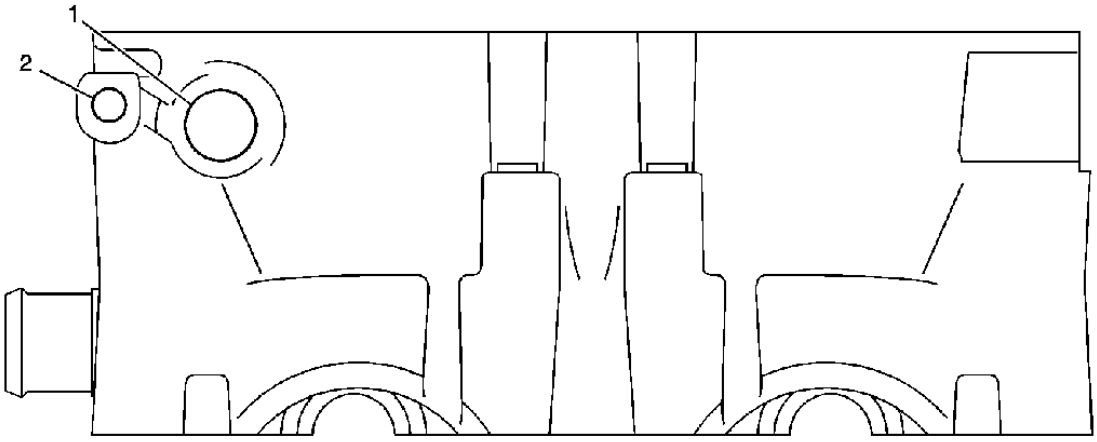

Fig. 15: Identifying Bolt Size & Locations On Cylinder Head - Front
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Front View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M6 x 1	205	201	202	203	204	20	0.787	16	0.63
2	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787

Cylinder Head - Back View

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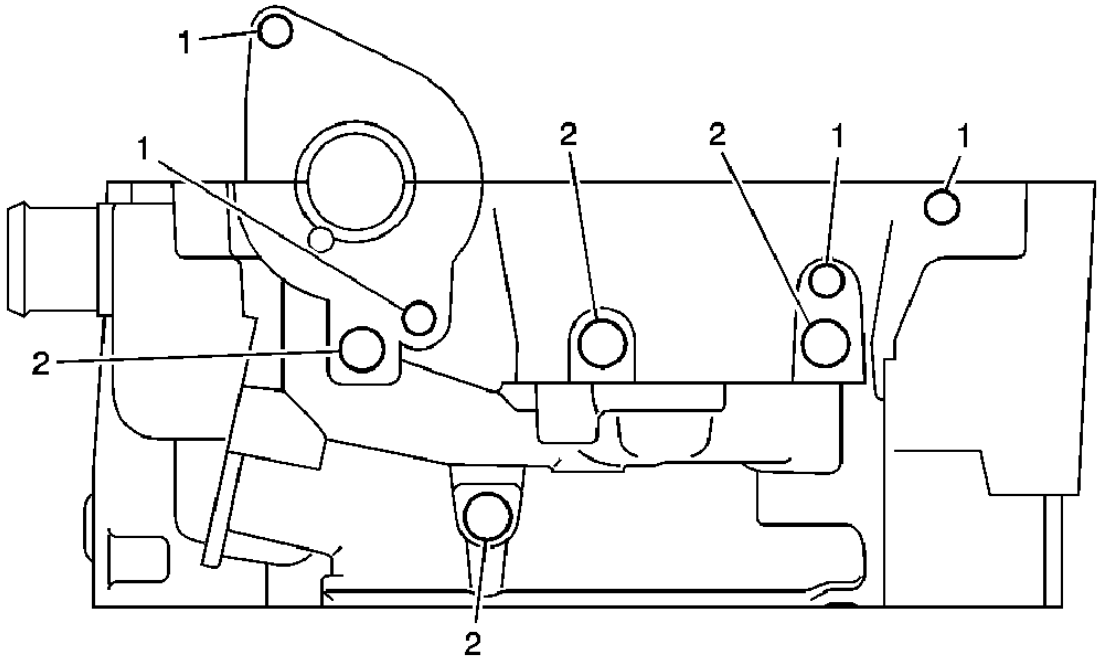

Fig. 16: Identifying Bolt Size & Locations On Cylinder Head - Back
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Back View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M8 x 1.25	210	206	207	208	209	25	0.984	20	0.787
2	M12 x 1.75	865	856	857	858	859	17	0.67	14	0.551

Cylinder Head - Bottom View

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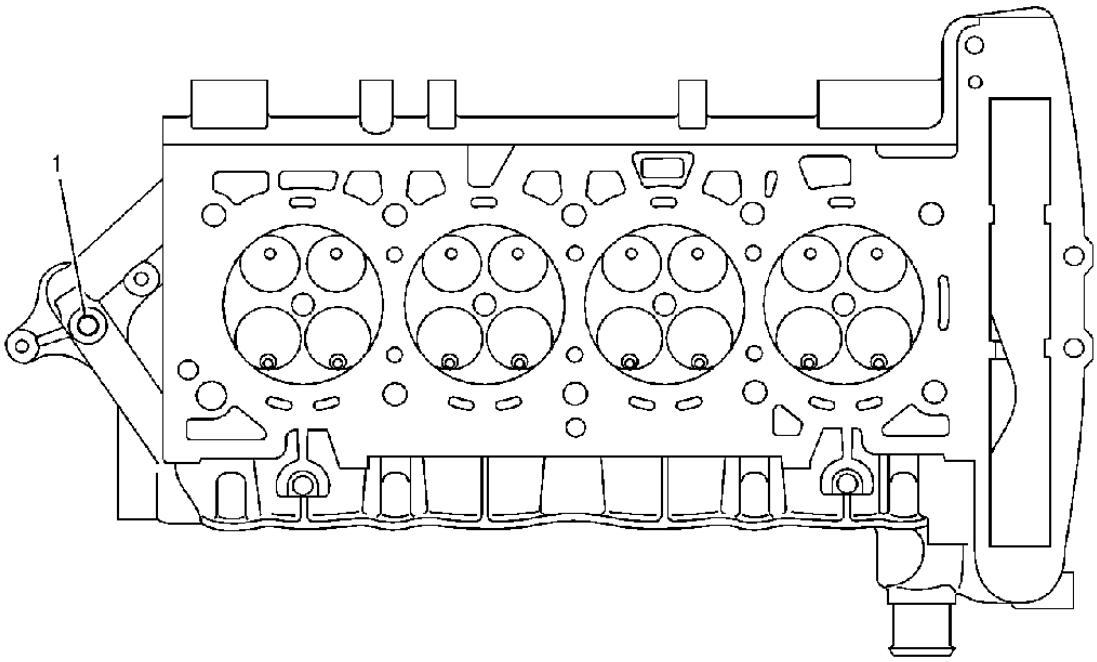

Fig. 17: Identifying Bolt Size & Locations On Cylinder Head - Bottom
Courtesy of GENERAL MOTORS CORP.

Cylinder Head - Bottom View

Service Call Out	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth (Maximum)		Tap Depth (Maximum)	
J 42385-850							MM	(IN)	MM	(IN)
1	M12 x 1.75	865	856	857	858	859	17	0.67	14	0.551

COMPONENT LOCATOR

DISASSEMBLED VIEWS

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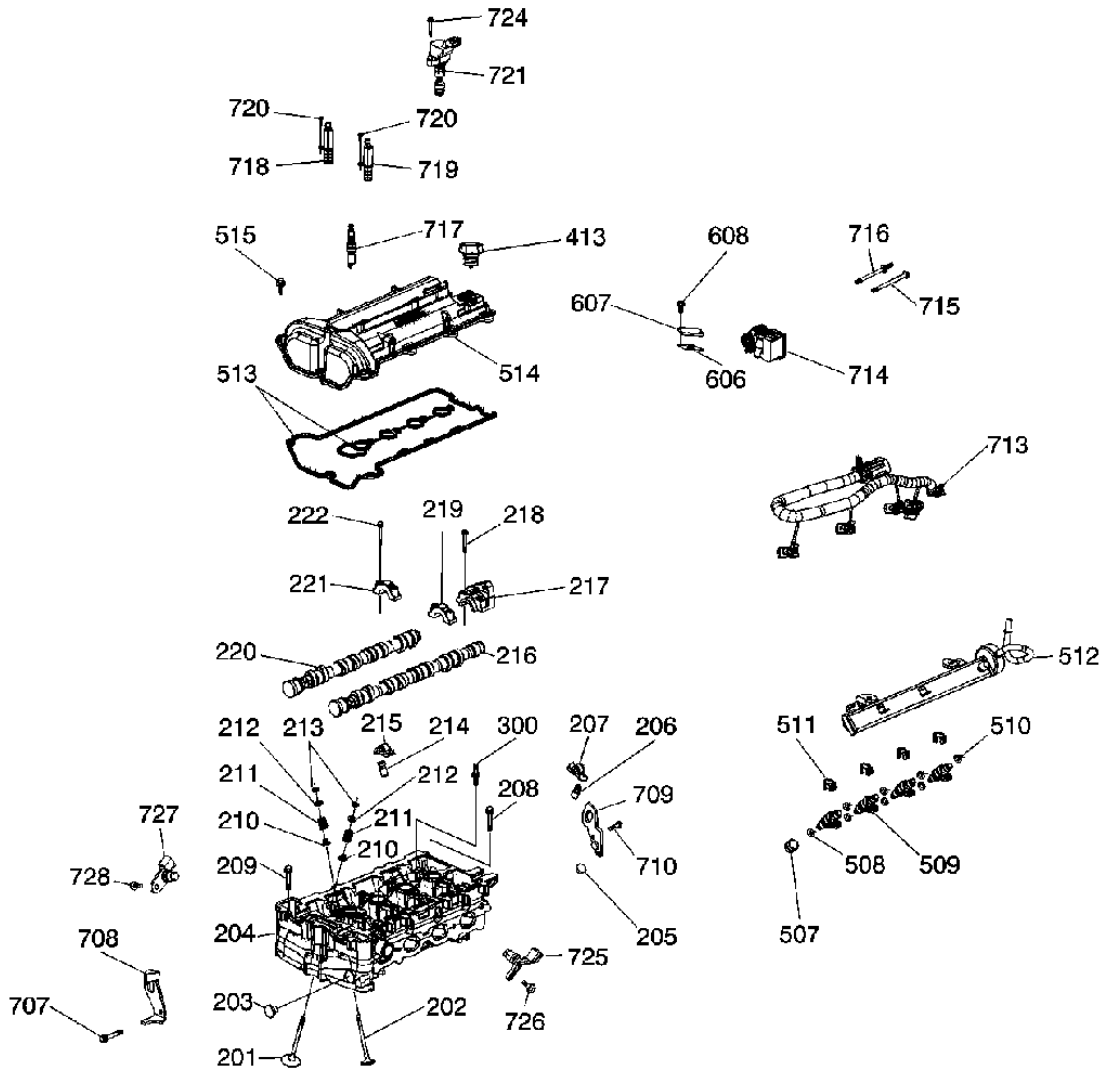

Fig. 18: Cylinder Head and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
201	Exhaust Valve
202	Intake Valve
203	Timing Chain Guide Bolt Access Hole
204	Cylinder Head
205	Cylinder Head Gallery Plug
206	Hydraulic Lash Adjuster
207	Roller Finger Follower
208	Cylinder Head Bolt
209	Small Cylinder Head Bolt
210	Valve Stem Seal

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211	Valve Spring
212	Valve Spring Retainer
213	Valve Keys
214	Hydraulic Lash Adjuster
215	Roller Finger Follower
216	lntake Camshaft
217	Camshaft Rear Cap
218	Camshaft Rear Cap Bolt
219	Camshaft Cap
220	Exhaust Camshaft
221	Camshaft Cap
222	Camshaft Cap Bolt
300	Coolant Air Bleed Fitting
413	Engine Oil Fill Cap
507	Fuel Injector Rotator Cup
508	Fuel Injector O-ring
509	Fuel Injector
510	Fuel Injector O-ring
511	Fuel Injector Clip
512	Fuel Rail
513	Camshaft Cover Gasket
514	Camshaft Cover
515	Camshaft Cover Bolt
606	EGR Port Cover Gasket
607	EGR Port Cover
608	EGR Port Cover Bolt
707	Front Lift Bracket Bolt
708	Front Lift Bracket
709	Rear Lift Bracket
710	Rear Lift Bracket Bolt
713	Fuel Injector Wiring Harness
714	Power Steering Pump
715	Power Steering Pump Bolt
716	Power Steering Pump Bolt Stud
717	Spark Plug
718	Camshaft Position Actuator Solenoid Valve - Exhaust
719	Camshaft Position Actuator Solenoid Valve - Intake
720	Camshaft Position Actuator Solenoid Valve Bolt
721	Ignition Coil
724	Ignition Coil Bolt
725	Camshaft Position Sensor

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	Camshaft Position Sensor Bolt
727	Camshaft Position Sensor
728	Camshaft Position Sensor Bolt

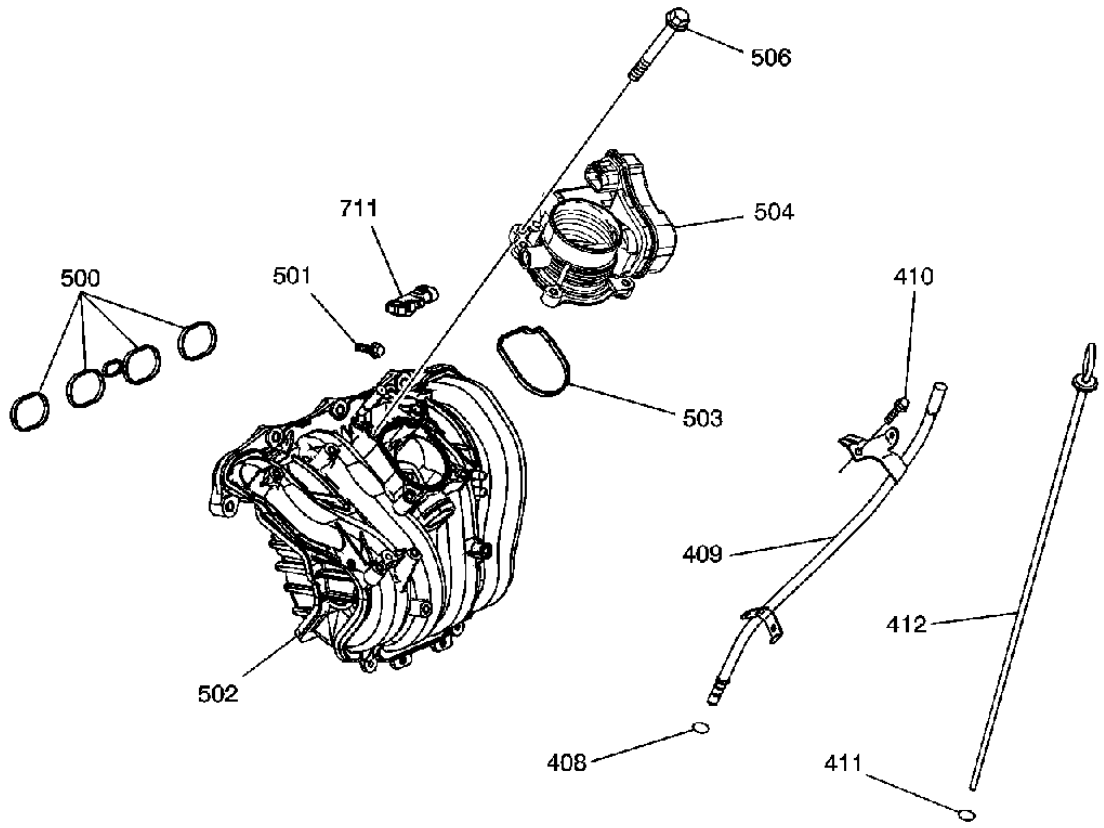

Fig. 19: Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
408	Oil Indicator Tube O-ring
409	Oil Indicator Tube
410	Oil Indicator Tube Bolt
411	Oil Indicator O-ring
412	Oil Indicator
500	Intake Manifold Gasket
501	Intake Manifold Bolt
502	Intake Manifold
503	Throttle Body Seal
504	Throttle Body
506	Throttle Body Bolt
711	Map Sensor

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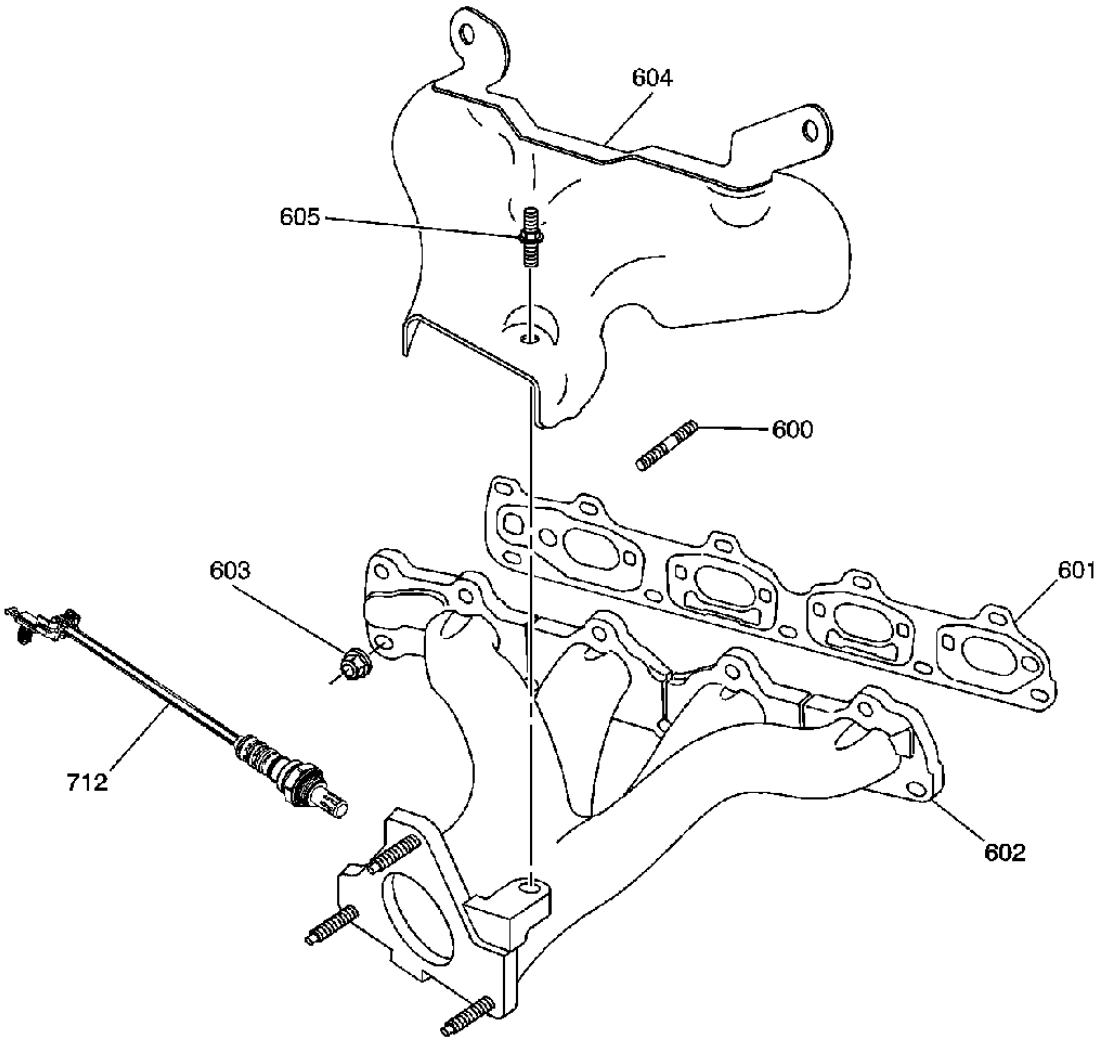

Fig. 20: Exhaust Manifold & Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
600	Exhaust Manifold Stud
601	Exhaust Manifold Gasket
602	Exhaust Manifold
603	Exhaust Manifold Nut
604	Exhaust Manifold Heat Shield
605	Exhaust Manifold Heat Shield Stud
712	Oxygen Sensor

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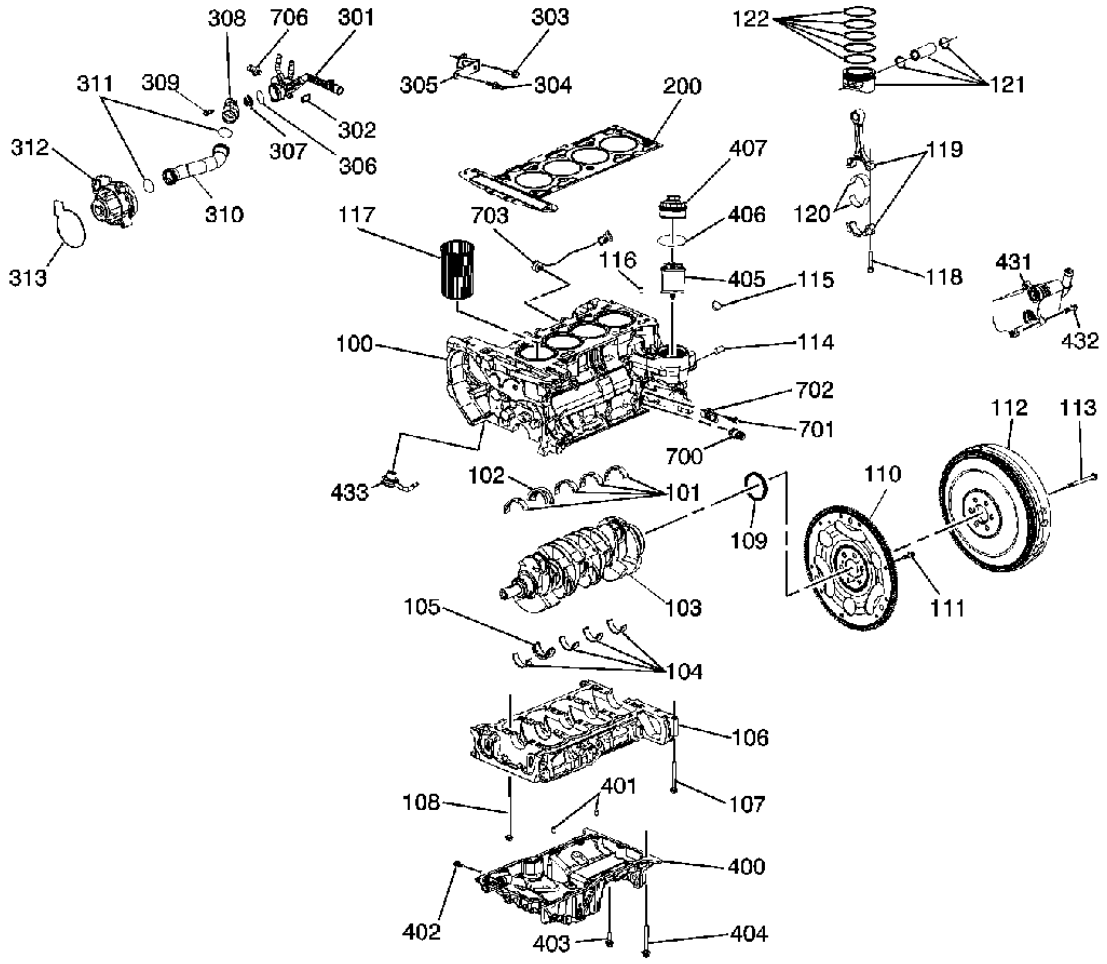

Fig. 21: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
100	Engine Block
101	Crankshaft Bearing - Upper
102	Crankshaft Thrust Bearing - Upper
103	Crankshaft
104	Crankshaft Bearing - Lower
105	Crankshaft Thrust Bearing - Lower
106	Lower Crankcase
107	Lower Crankcase Perimeter Bolt
108	Lower Crankcase Main Bearing Bolt
109	Crankshaft Rear Seal
110	Flywheel - Automatic Transmission
111	Automatic Transaxle Flywheel to Crankshaft Bolt

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112	Manual Transaxle Flywheel
113	Manual Transaxle Flywheel Bolt
114	Engine Block to Transaxle Alignment Pin
115	Engine Block Gallery Plug
116	Cylinder Head Alignment Pin
117	Cylinder Bore Sleeve
118	Connecting Rod Cap Bolt
119	Connecting Rod
120	Connecting Rod Bearing
121	Piston Assembly
122	Piston Ring Assembly
200	Cylinder Head Gasket
301	Thermostat Housing
302	Thermostat Housing to Block Gasket
303	Water Pipe Support Bracket Bolt
304	Water Pipe Support Bracket Bolt Stud
305	Water Pipe Support Bracket
306	Thermostat Gasket
307	Thermostat
308	Thermostat Housing Cap
309	Thermostat Housing Cap Bolt
310	Water Transfer Pipe
311	Water Transfer Pipe O-ring Seals
312	Water Pump
313	Water Pump to Engine Block Seal
400	Engine Oil Pan
401	Engine Oil Pan Alignment Pins
402	Engine Oil Pan Drain Plug
403	Engine Oil Pan Bolt
404	Engine Oil Pan Long Bolt
405	Oil Filter
406	Oil Filter Cap O-ring
407	Oil Filter Cap
431	Oil Cooler
432	Oil Cooler Bolt
433	Piston Oil Squirter
700	Oil Pressure Switch
701	Crankshaft Position Sensor Bolt
702	Crankshaft Position Sensor
703	Knock Sensor
706	Coolant Temperature Sensor

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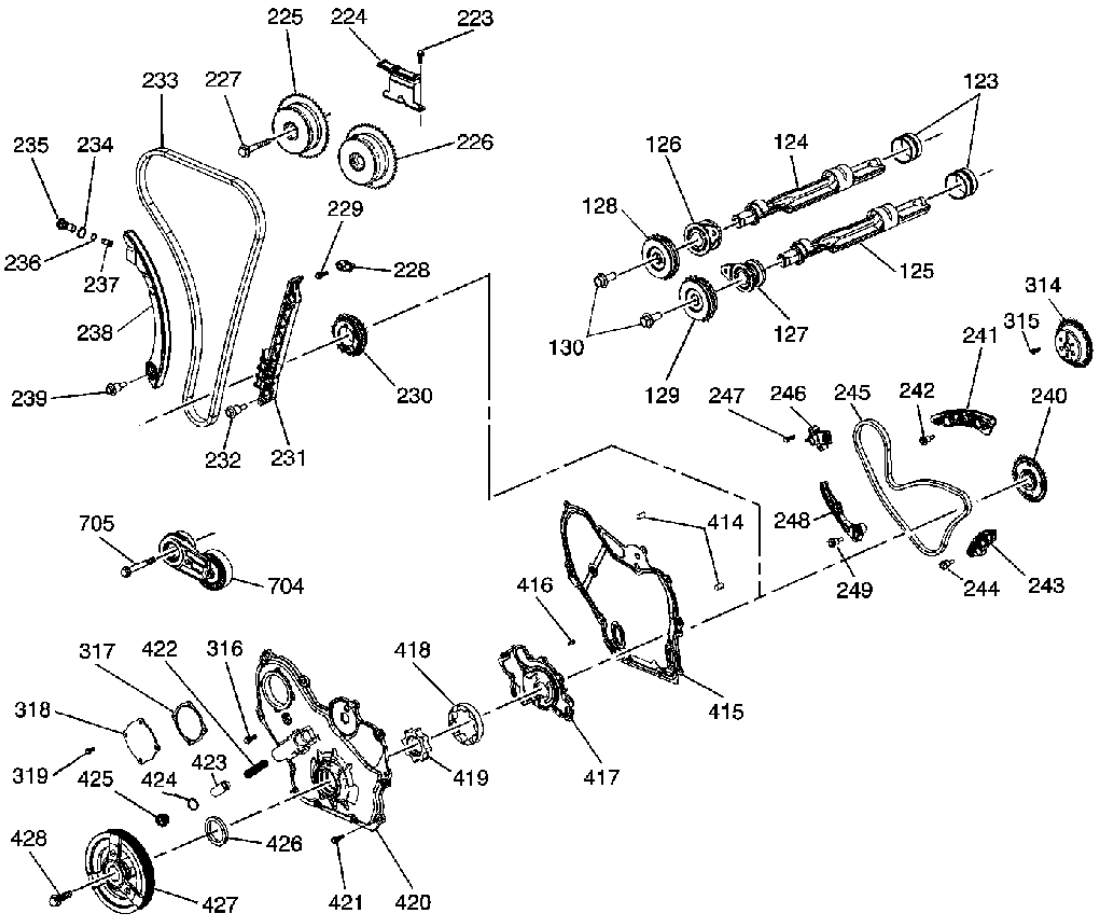

Fig. 22: Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
123	Balance Shaft Rear Bearing
124	Exhaust Balance Shaft
125	Intake Balance Shaft
126	Exhaust Balance Shaft Bearing Carrier
127	Intake Balance Shaft Bearing Carrier
128	Exhaust Balance Shaft Drive Sprocket
129	Intake Balance Shaft Drive Sprocket
130	Balance Shaft Drive Sprocket Bolts
223	Upper Timing Chain Guide Bolt
224	Upper Timing Chain Guide
225	Exhaust Camshaft Position Actuator
226	Intake Camshaft Position Actuator
227	Camshaft Position Actuator Bolt

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228	Timing Chain Oil Nozzle
229	Timing Chain Oil Nozzle Bolt
230	Timing Chain Drive Sprocket
231	Fixed Timing Chain Guide
232	Fixed Timing Chain Guide Bolt
233	Timing Chain
234	Timing Chain Tensioner Washer
235	Timing Chain Tensioner Body
236	Timing Chain Tensioner O-ring Seal
237	Timing Chain Tensioner Plunger
238	Adjustable Timing Chain Guide
239	Adjustable Timing Chain Guide Bolt
240	Balance Shaft Drive Sprocket
241	Balance Shaft Drive Chain Guide
242	Balance Shaft Drive Chain Guide Bolt
243	Balance Shaft Drive Chain Guide
244	Balance Shaft Drive Chain Guide Bolt
245	Balance Shaft Drive Chain
246	Balance Shaft Drive Chain Tensioner Assembly
247	Balance Shaft Drive Chain Tensioner Assembly Bolt
248	Adjustable Balance Shaft Drive Chain Guide
249	Adjustable Balance Shaft Drive Chain Guide Bolt
314	Water Pump Drive Sprocket
315	Water Pump Drive Sprocket Bolt
316	Water Pump Bolt
317	Engine Front Cover Access Plate Gasket
318	Engine Front Cover Access Plate
319	Engine Front Cover Access Plate Bolt
414	Engine Front Cover Alignment Pins
415	Engine Front Cover Gasket
416	Oil Pump Cover Bolt
417	Oil Pump Cover
418	Oil Pump Outer Gerotor
419	Oil Pump Inner Gerotor
420	Engine Front Cover
421	Engine Front Cover Bolt
422	Oil Pressure Relief Valve Spring
423	Oil Pressure Relief Valve Plunger
424	Oil Pressure Relief Valve O-ring Seal
425	Oil Pressure Relief Valve Plug
426	Crankshaft Front Seal

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	Crankshaft Damper
428	Crankshaft Damper Bolt
704	Belt Tensioner
705	Belt Tensioner Bolt

ENGINE IDENTIFICATION

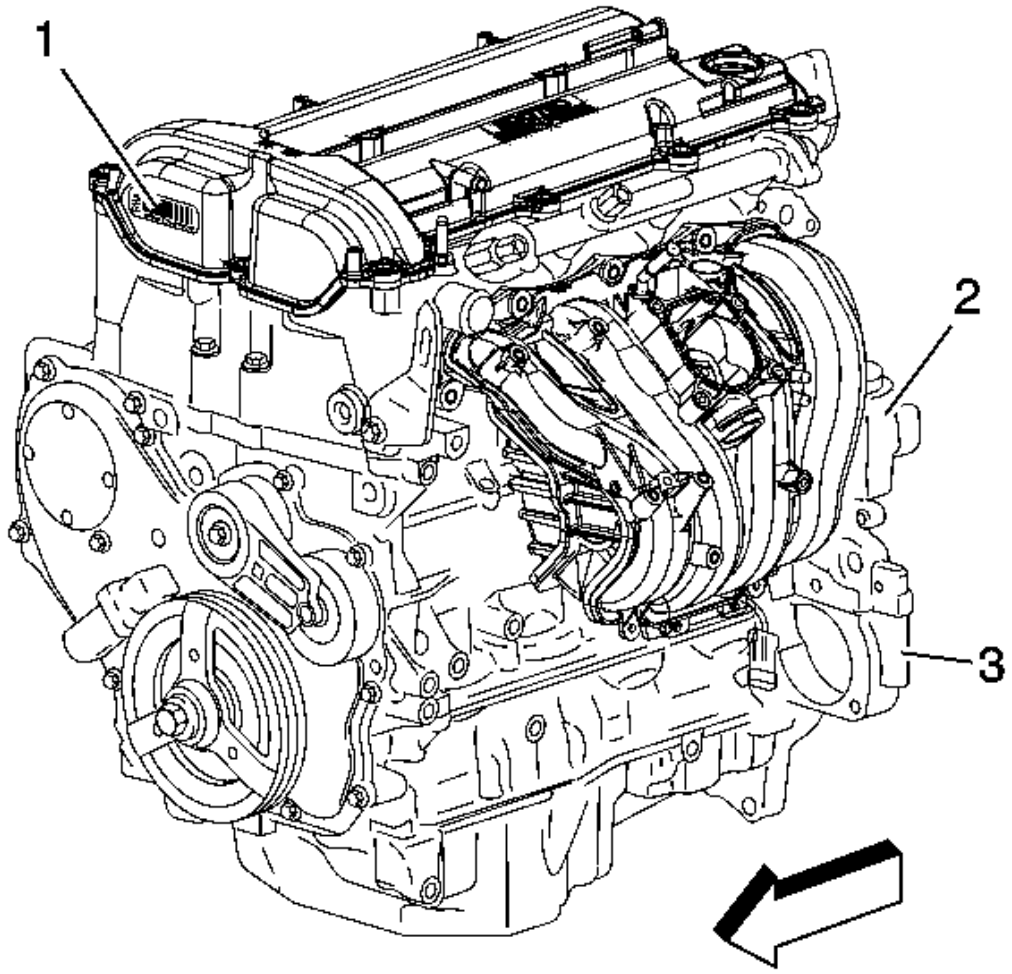

Fig. 23: Locating Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

Identification can be made through the use of the Broadcast Code label on the engine front cover (1) and the use of the partial VIN etched on the oil filter bowl (2).

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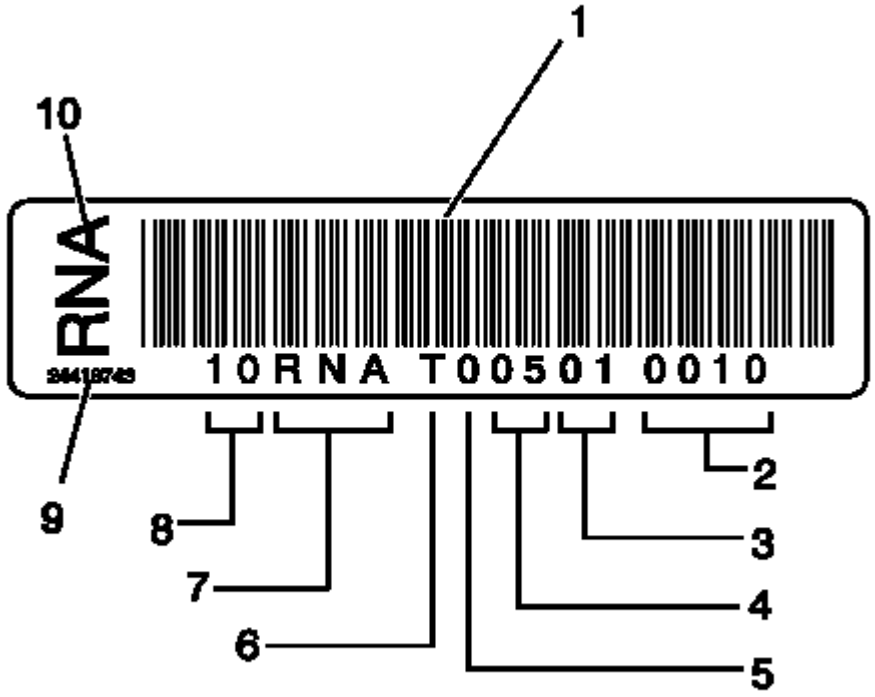

Fig. 24: View Of Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

- Barcode (1)
- Sequence Number (2)
- Day (3)
- Month (4)
- Year (5)
- Engine Assembly Plant (6)
- Broadcast Code (7)
- Part Designation (8)
- Engine Assembly Number (9)
- Broadcast Code (10)

The partial VIN identifies the specific vehicle by sequence number.

DIAGNOSTIC INFORMATION AND PROCEDURES

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL

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Begin the system diagnosis by reviewing the **Disassembled Views**, **Engine Component Description**, **Lubrication Description** , and **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 the **DIAGNOSTIC SYSTEM CHECK - VEHICLE** before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, **Engine Component Description**, and **Lubrication Description** .

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary.

Visual/Physical Inspection

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

Intermittent

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

Symptom List

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

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**

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- **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**
- **Engine Compression Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**
- **Drive Belt Falls Off and Excessive Wear Diagnosis**
- **Drive Belt Tensioner Diagnosis**

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components, and repair or replace as required.
A 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.
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	Repair or replace the MAP sensor as required.

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The sealing grommet of the MAP sensor should not be torn or damaged.	
Damage to the MAP sensor housing	Replace the intake manifold.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump up and loss of compression.	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Inspect the cylinder heads, engine block, and/or head gaskets. • Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel 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, high voltage switch, and severe reluctor ring damage may cause additional pulses and	Replace the sensor and/or crankshaft as required.

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effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities, severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine, and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt.
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.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft, and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should intact within the rocker arm assembly.	Replace the valve rocker arms as required.
Stuck valves Carbon buildup on the valve stem can cause the	Repair or replace as required.

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valve to not close properly.	
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Sticking lifters	Replace as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gasket and/or cracking, or other damage to the cylinder head and engine block cooling system passages. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. • Perform a cylinder leak down test. • Inspect the cylinder head and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	• Inspect the spark plugs for oil deposits. • 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. • Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test** . • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.

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

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

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lash adjuster leak down rate	Replace the lash adjusters as required.
Worn crankshaft thrust bearing	1. Inspect the thrust bearing and crankshaft. 2. Repair or replace as required.
Damaged or faulty oil filter by-pass valve	1. Inspect the oil filter by-pass valve for proper

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	operation. 2. Repair or replace as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace as required.
Loose and/or worn valve rocker arm attachments	• Inspect the valve rocker arm stud, nut or bolt. • Repair or replace as required.
Worn valve rocker arm	Replace the valve rocker arm.
Improper lubrication to the valve rocker arms	Inspect the following components, and repair or replace as required: • The valve rocker arm • 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 or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn, damaged, or faulty timing chain tensioners	Replace tensioners
Worn engine camshaft lobes	• Inspect the engine camshaft lobes. • Replace the camshaft and valve lifters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay open.	Inspect the following components, and repair as required: • The valves • The valve guides

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

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Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	• Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. • Repair or replace damaged components as required.
Worn accessory drive components - abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition system. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. 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 position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. 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

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Incorrect piston, piston pin, and connecting rod installation - pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Engine Noise Under Load

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. Refer to **Symptoms - Engine Controls** .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair as required.
Cracked flywheel, automatic transmission	1. Inspect the flywheel bolts and flywheel. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket.

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• Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Inspect for cracked cylinder wall.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	• Inspect cylinder for damaged components and/or foreign materials. • Inspect for fallen cylinder wall. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Inspect for fallen cylinder wall. • 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	

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bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test** .	
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection** and **Cylinder Head Replacement**.
Warped cylinder head	Replace the cylinder head and gasket. Refer to **Cylinder Head Cleaning and Inspection** .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner	Replace the components as required.
Cylinder head or block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Coolant in Engine Oil

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

ENGINE COMPRESSION TEST

Perform the following steps to conduct a compression test.

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1. Conduct the following steps to check cylinder compression.
    1. Engine should be at room temperature.
    2. Disconnect wiring from the ignition module.
    3. Remove the spark plugs.
    4. Throttle body valve should be wide open.
    5. Battery should be at or near full charge.
2. For each cylinder, crank engine through 4 compression strokes.
3. The lowest reading cylinder should not be less than 70 percent of the highest.
4. No cylinder reading should be less than 689 kPa (100 psi).

IMPORTANT: The results of a compression test will fall into the following categories:

- **Normal - Compression builds up quickly and evenly to specified compression on each cylinder.**
- **Piston rings - Compression is low on the first stroke, tends to build up on following strokes, but does not reach normal. Compression improves considerably with the addition of oil.**
- **Valves - Compression is low on the first stroke, does not tend to build up on the following strokes, and does not improve much with the addition of oil. Use approximately 3 squirts from a plunger-type oiler.**

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 leakage may indicate one or more of the following:

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

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CAUTION: Before servicing any electrical component, the ignition and start switch must be in the OFF or LOCK position and all electrical loads must be OFF, unless instructed otherwise in these procedures. If a tool or equipment could easily come in contact with a live exposed electrical terminal, also disconnect the negative battery cable. Failure to follow these precautions may cause personal injury and/or damage to the vehicle or its components.

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

IMPORTANT: It may be necessary to hold the crankshaft balancer bolt to prevent the engine 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 0.9 L (1 qt) or greater of engine oil within 3 200 kilometers (2,000 miles). 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 inspect for the correct oil level.

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- 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 mis-fitted

OIL PRESSURE DIAGNOSIS AND TESTING

- With the vehicle on a level surface, allow adequate drain down time of 2-3 minutes and measure for a low oil level.

  Add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.

- Run the engine, and verify low, or no oil pressure on the vehicle gage or light.

  Listen for a noisy valve train or a knocking noise.

- Inspect for the following:
  - Oil diluted by moisture or unburned fuel mixtures
  - Improper oil viscosity for the expected temperature
  - Incorrect or malfunctioning oil pressure sender
  - Incorrect or malfunctioning oil pressure gage
  - Plugged oil filter
  - Malfunctioning oil bypass valve
- Remove the oil pressure sender or another engine block oil gallery plug.
- Install an oil pressure gage and measure the engine oil pressure.
- Compare the readings to specifications. Refer to **Engine Mechanical Specifications**.
- If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
  - Oil pump worn or dirty

    Refer to **Oil Pump Disassemble**.

  - Oil pump-to-engine front cover bolts loose

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Refer to **Engine Front Cover and Oil Pump Installation** .

- Oil pump screen loose, plugged, or damaged
- Oil pump screen O-ring seal missing or damaged
- Malfunctioning oil pump pressure regulator valve
- Excessive bearing clearance

Refer to **Crankshaft and Bearings Cleaning and Inspection** .

- Cracked, porous or restricted oil galleries
- Oil gallery plugs missing or incorrectly installed

Refer to **Engine Block Assemble** .

- Broken lash adjusters

OIL LEAK DIAGNOSIS

Oil Leak Diagnosis

Step	Action	Yes	No
DEFINITION: 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. Refer to **Engine Mechanical Specifications**. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Check for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**

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4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several 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**
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, for example, baby powder or foot powder, to the suspected area. 3. Operate the vehicle for several miles at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Check for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**

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8	Use **J 28428-E** , Dye and 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 interest should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components. Did you complete the repair?	Go to **Step 1**	-

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

1. Disconnect the positive crankcase ventilation (PCV) hose.
2. Start the engine.

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3. Check for vacuum at the PCV hose. If there is no vacuum, inspect for a plugged hose or manifold port. Inspect for a hose that collapses when blocked with vacuum applied. Replace the plugged or the deteriorated hoses.
4. Allow the engine to idle at normal operating temperature.
5. Remove the engine oil level indicator. Install a vacuum gage into the indicator tube opening.
6. Block off the PCV system fresh air intake passage.
7. Run the engine at 1,500 RPM for 30 seconds, then read the vacuum gage while engine is running at 1,500 RPM.
    - If vacuum is present, the crankcase ventilation system is functioning properly.
    - If no vacuum is indicated, the engine may not be sealed and is drawing in outside air. Check the valve covers, the oil pan gasket, or other sealing areas for leaks.
    - If the vacuum gage registers a pressure, or if the vacuum gage is pushed out of indicator tube, check for a plugged PCV port, a plugged hose, or excessive engine blow-by.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

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

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

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

6: Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves

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across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

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

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

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

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

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

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

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

Drive Belt Chirping, Squeal, and Whine Diagnosis

Step	Action	Yes	No
	NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise.		

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- The noise may be caused by an accessory drive component failed bearing.

1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley.		

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	Did you find the condition?	Go to **Step 18**	Go to **Step 19**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. Did you find and correct the condition? If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids.	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement**. Did you complete the repair?	Go to **Step 20**	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

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

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

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

Test Description

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

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

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

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

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

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

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

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

Drive Belt Rumbling and Vibration Diagnosis

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

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3	If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to **Symptoms - Engine Mechanical** or **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement**. Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

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DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

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

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

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

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

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

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

Test Description

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

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

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

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

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

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

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

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

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

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snapping the throttle.

Drive Belt Falls Off and Excessive Wear Diagnosis

Step	Action	Yes	No
NOTE: **Refer to Belt Dressing Notice .** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	If diagnosing excessive wear, proceed to step 13. If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to **Step 3**	Go to **Step 4**
3	Install a new drive belt. Refer to **Drive Belt Replacement**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**NOTE:** **Refer to Fastener Notice .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Replacement**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Replacement**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 2**

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13	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to Diagnostic Aids
16	Replace the drive belt. Refer to **Drive Belt Replacement**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Drive Belt Tensioner Diagnosis

Step	Action	Yes	No
1	1. Remove the drive belt. Refer to **Drive Belt Replacement**. 2. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10 percent of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**. Is the repair complete?	System OK	-

REPAIR INSTRUCTIONS

ON-VEHICLE REPAIR INSTRUCTIONS

Intake Manifold Cover Replacement

Removal Procedure

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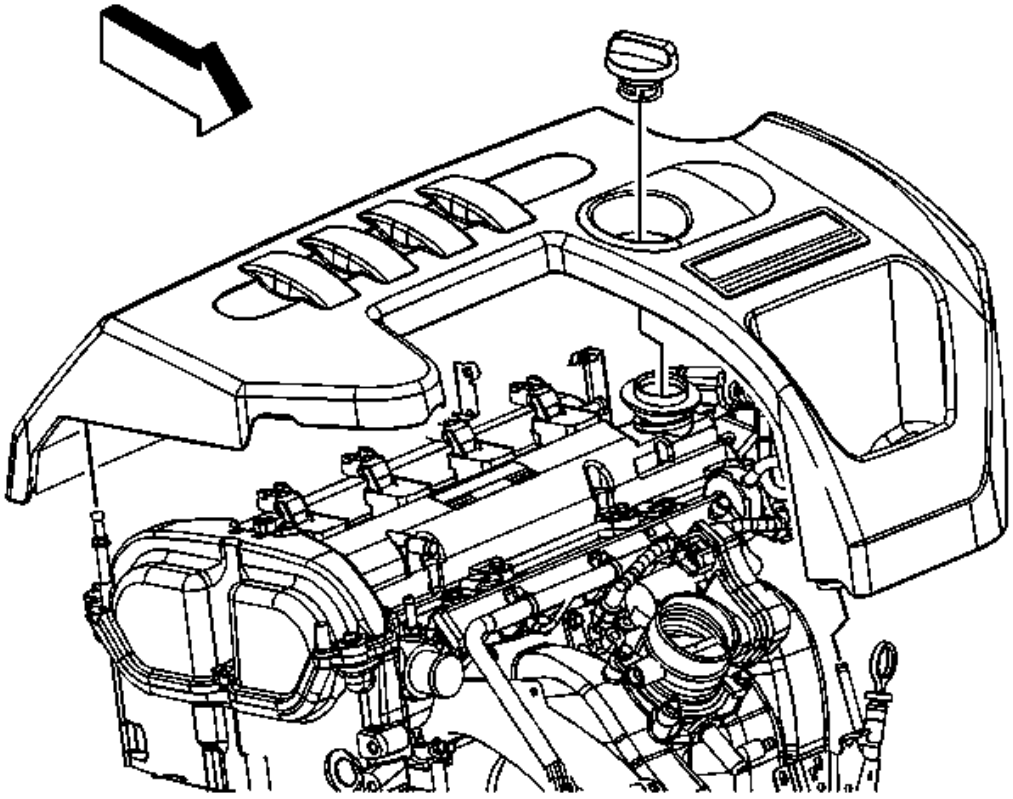

Fig. 25: View of intake manifold cover
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine oil fill cap.
2. Grasp the intake manifold cover by the lower right inboard corner and pull up to disengage the cover from the stud.
3. Grasp the intake manifold cover by the upper left corner and pull up to disengage the cover from the stud.
4. Remove the intake manifold cover.

Installation Procedure

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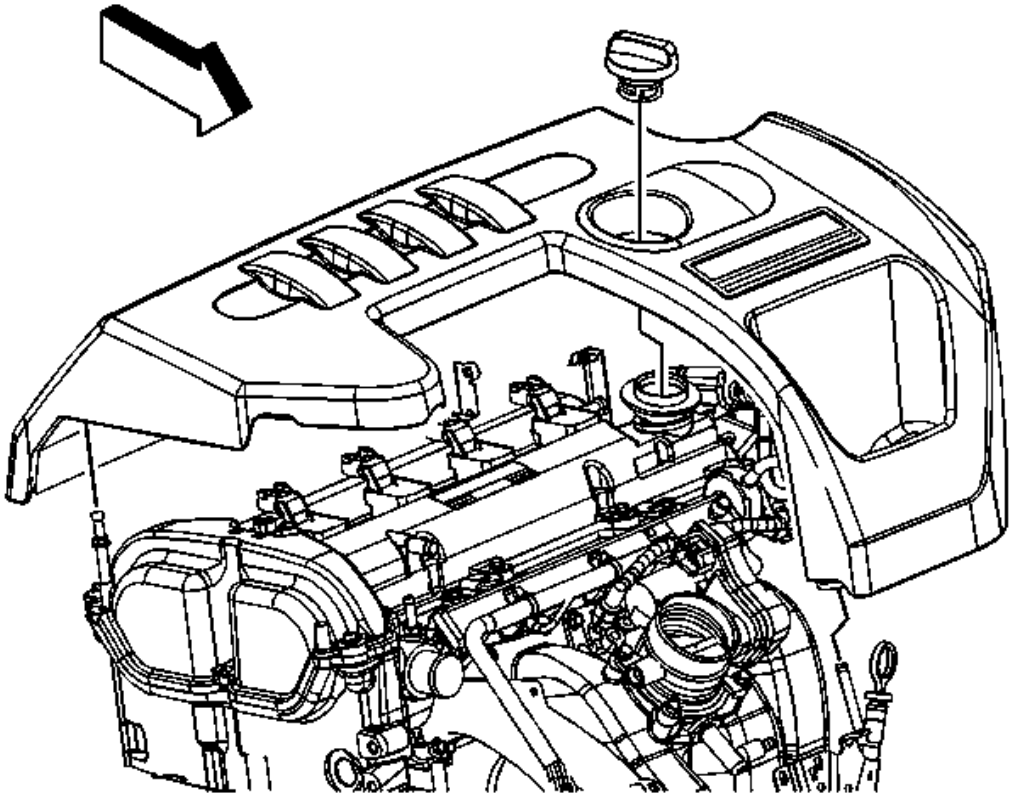

Fig. 26: View of intake manifold cover
Courtesy of GENERAL MOTORS CORP.

1. Place the intake manifold cover onto the engine over the studs.
2. Push down on the intake manifold cover directly over the lower right stud in order to engage the cover to the stud.
3. Push down on the intake manifold cover directly over the upper left stud in order to engage the cover to the stud.
4. Install the engine oil fill cap.

Drive Belt Replacement

Tools Required

J 44811 Accessory Belt Tensioner Unloader. See **Special Tools**.

Removal Procedure

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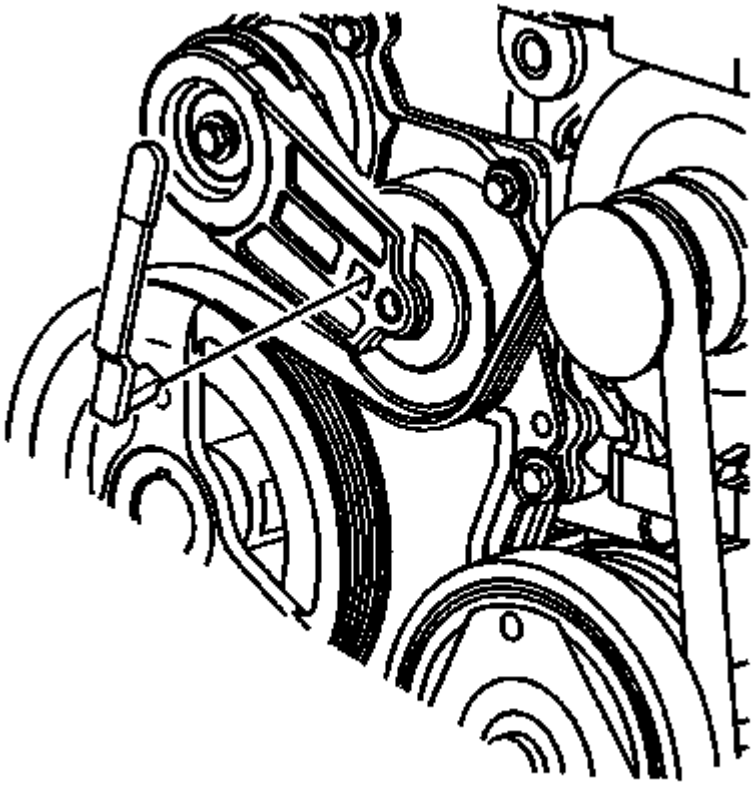

Fig. 27: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine splash shield. Refer to **Splash Shield Replacement - Engine** .
2. Install the **J 44811** to the drive belt tensioner. See **Special Tools**.
3. Using the **J 44811** , rotate the tensioner counterclockwise in order to release the tensioner from the drive belt. See **Special Tools**.

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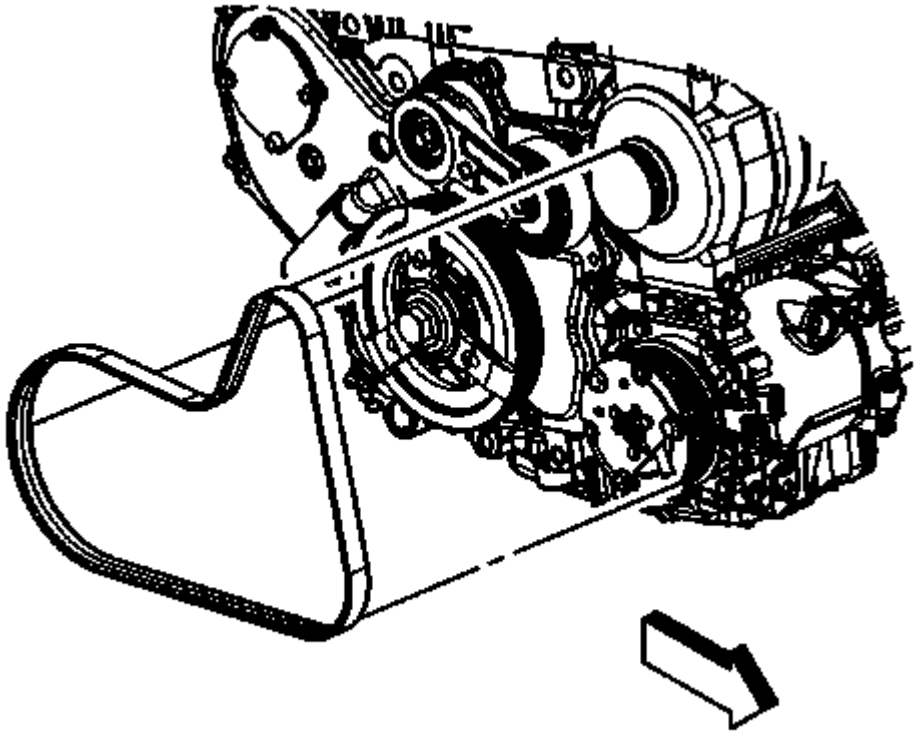

Fig. 28: View Of Drive Belt
Courtesy of GENERAL MOTORS CORP.

4. Remove the drive belt.
5. Slowly rotate the **J 44811** and the tensioner clockwise in order to allow the tensioner to rest. See **Special Tools**.
6. Remove the **J 44811** from the drive belt tensioner. See **Special Tools**.

Installation Procedure

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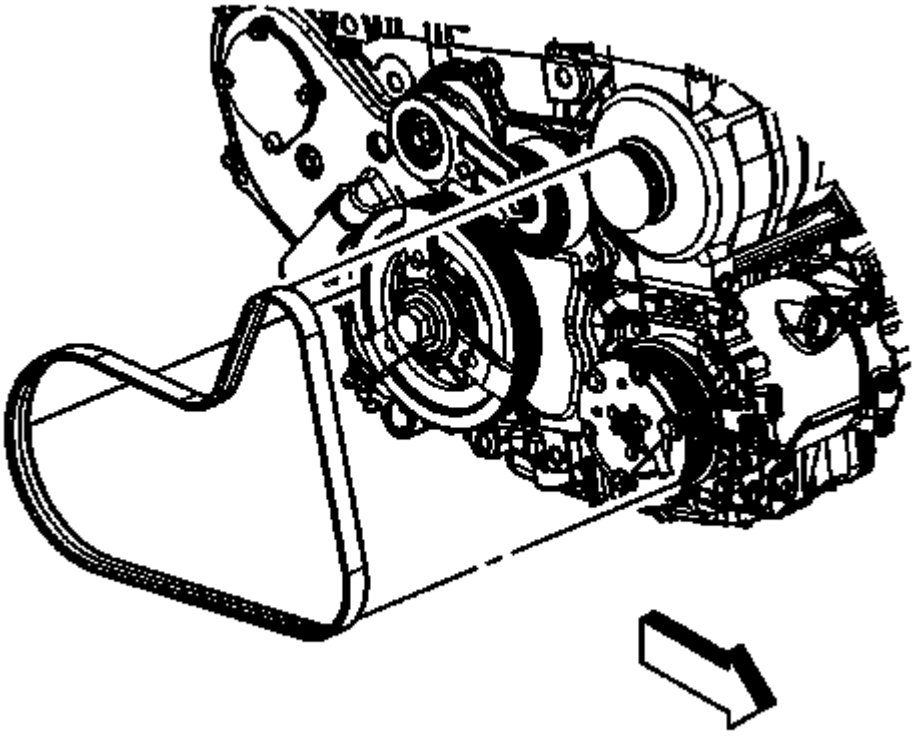

Fig. 29: View Of Drive Belt
Courtesy of GENERAL MOTORS CORP.

1. Install and position the drive belt around all of the pulleys except for the drive belt tensioner.
2. Install the **J 44811** to the drive belt tensioner. See **Special Tools**.
3. Using the **J 44811** , rotate the tensioner counterclockwise. See **Special Tools**.
4. Position the drive belt under the tensioner pulley.

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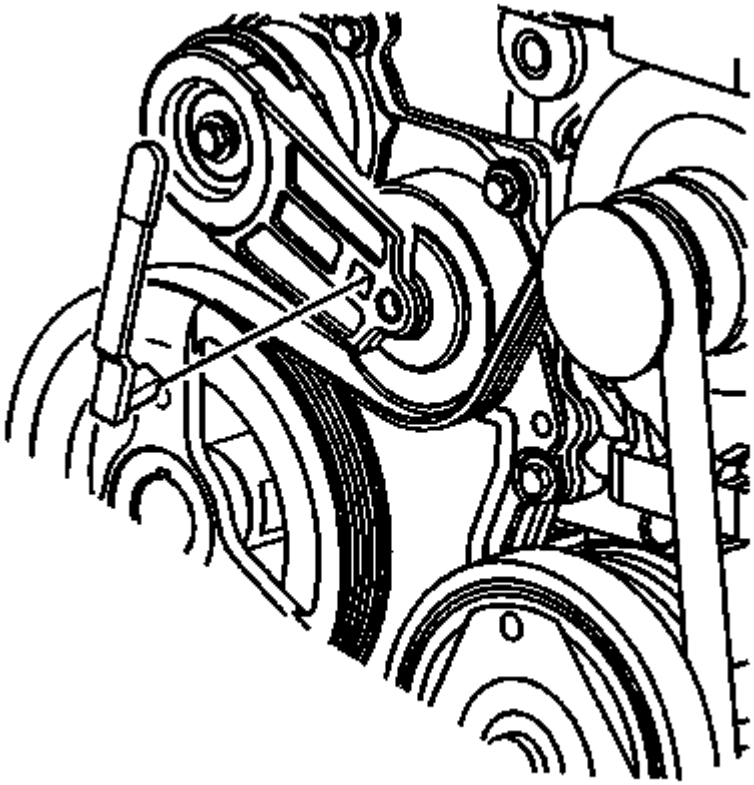

Fig. 30: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

5. Using the **J 44811** , rotate the tensioner clockwise in order to seat the tensioner pulley onto the drive belt. See **Special Tools**.
6. Install the engine splash shield. Refer to **Splash Shield Replacement - Engine** .

Drive Belt Tensioner Replacement

Removal Procedure

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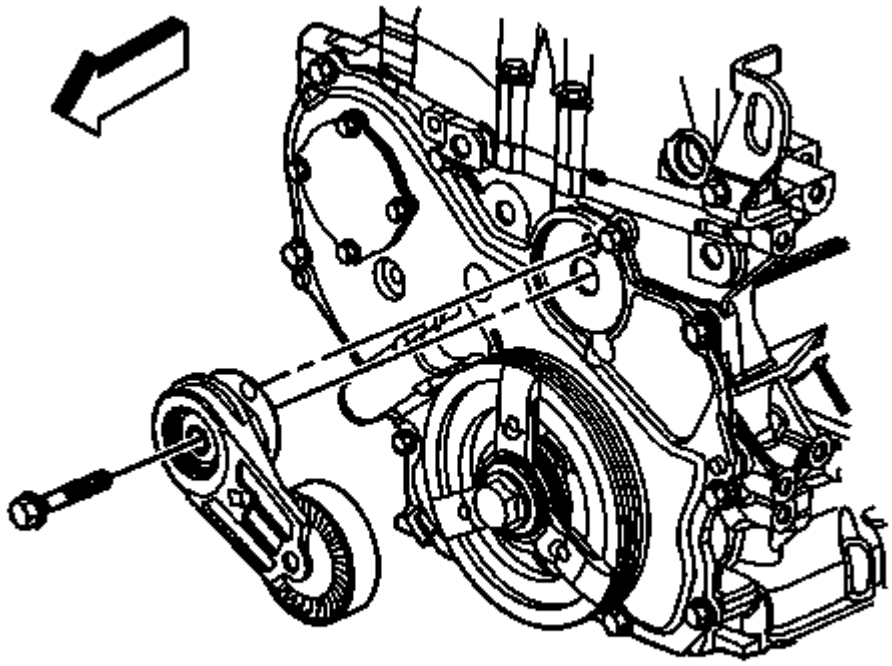

Fig. 31: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Remove the drive belt tensioner bolt.
3. Remove the drive belt tensioner.

Installation Procedure

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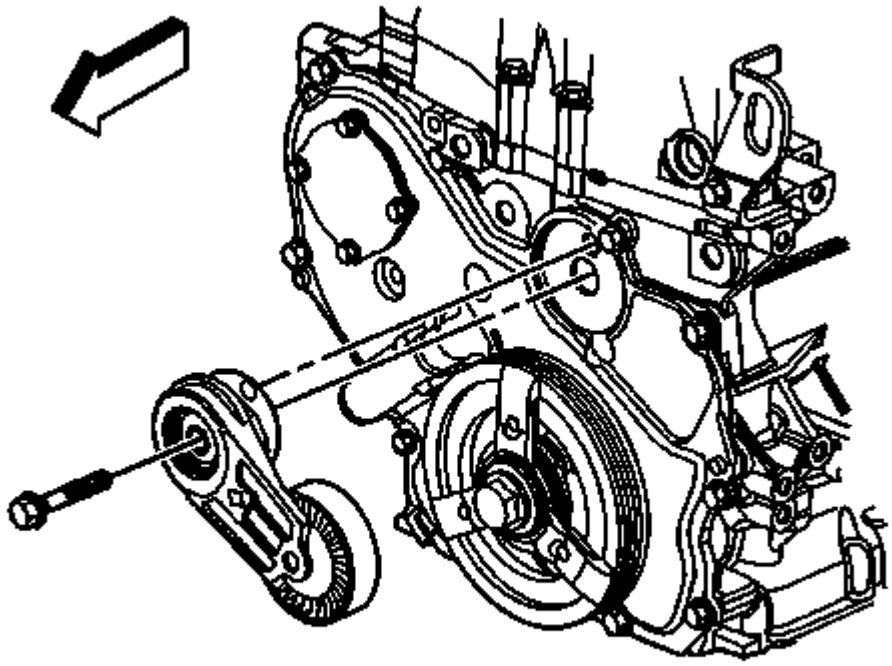

Fig. 32: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner.

NOTE: **Refer to Fastener Notice .**

2. Install the drive belt tensioner bolt.

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

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

Engine Oil Pressure Sensor and/or Switch Replacement

Removal Procedure

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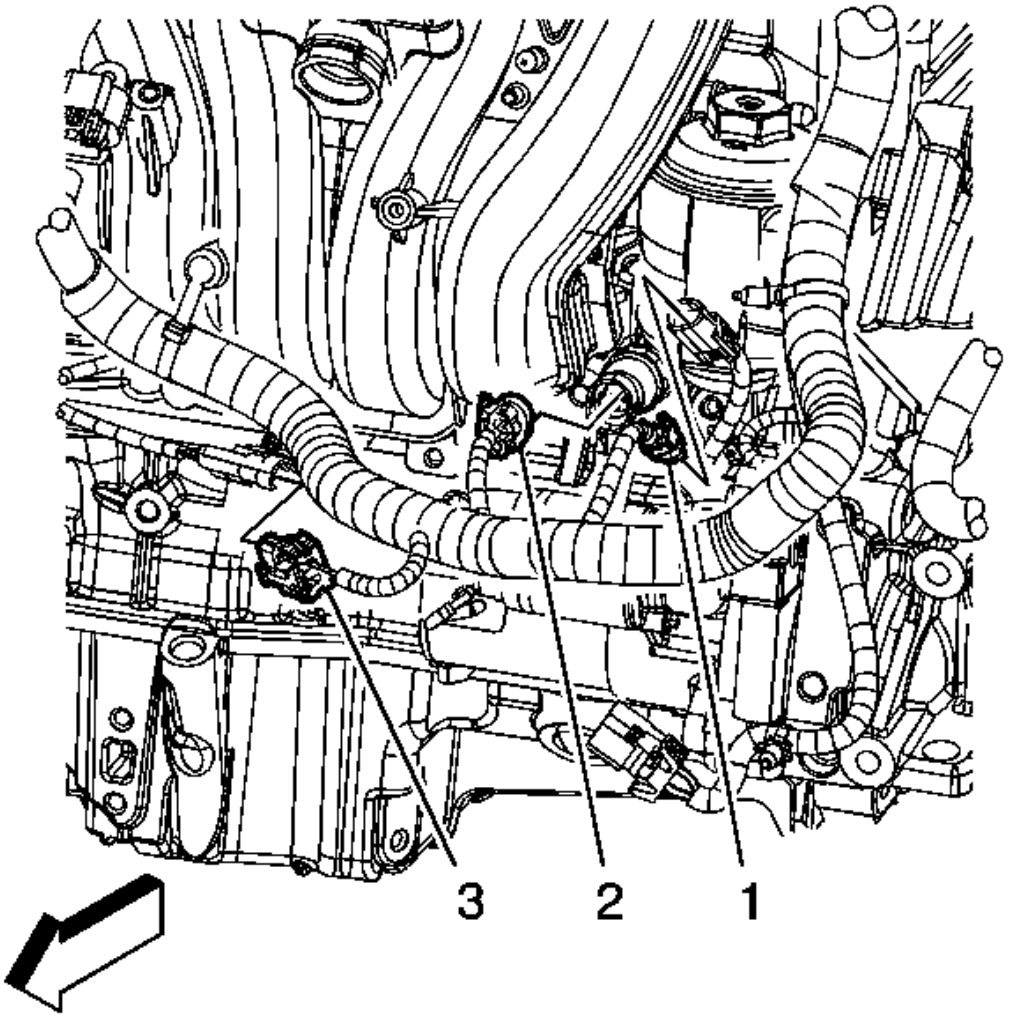

Fig. 33: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Disconnect the engine harness electrical connector (2) from the oil pressure sensor.

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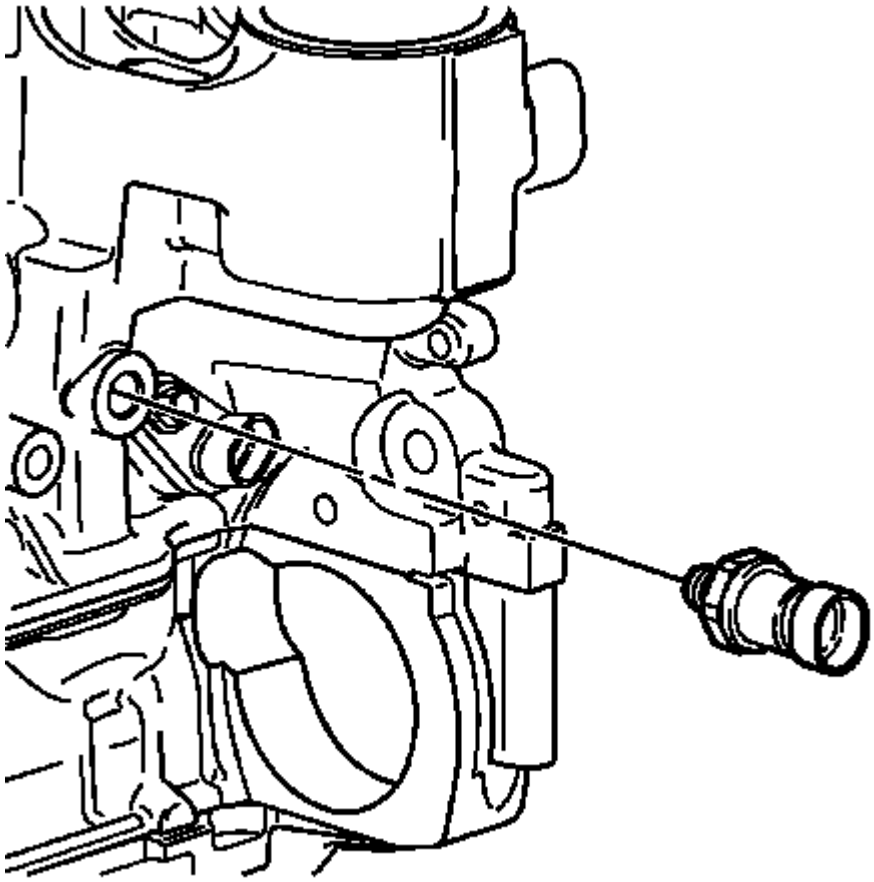

Fig. 34: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure sensor.

Installation Procedure

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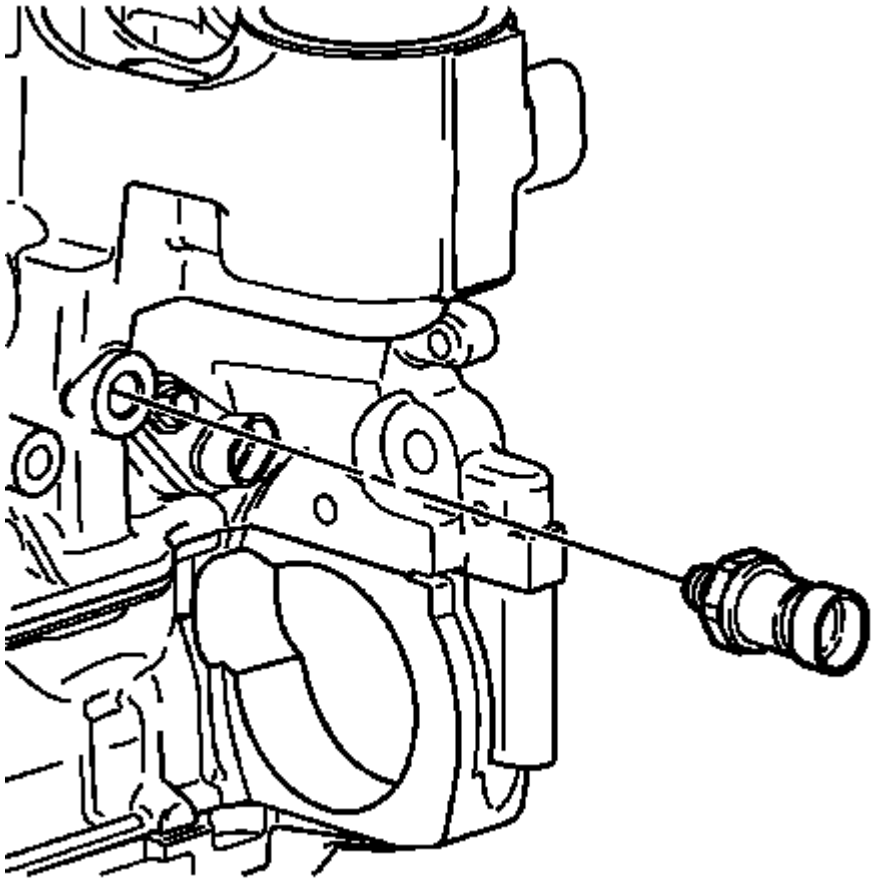

Fig. 35: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the engine oil pressure sensor.

   Tighten: Tighten the sensor to 22 N.m (16 lb ft).

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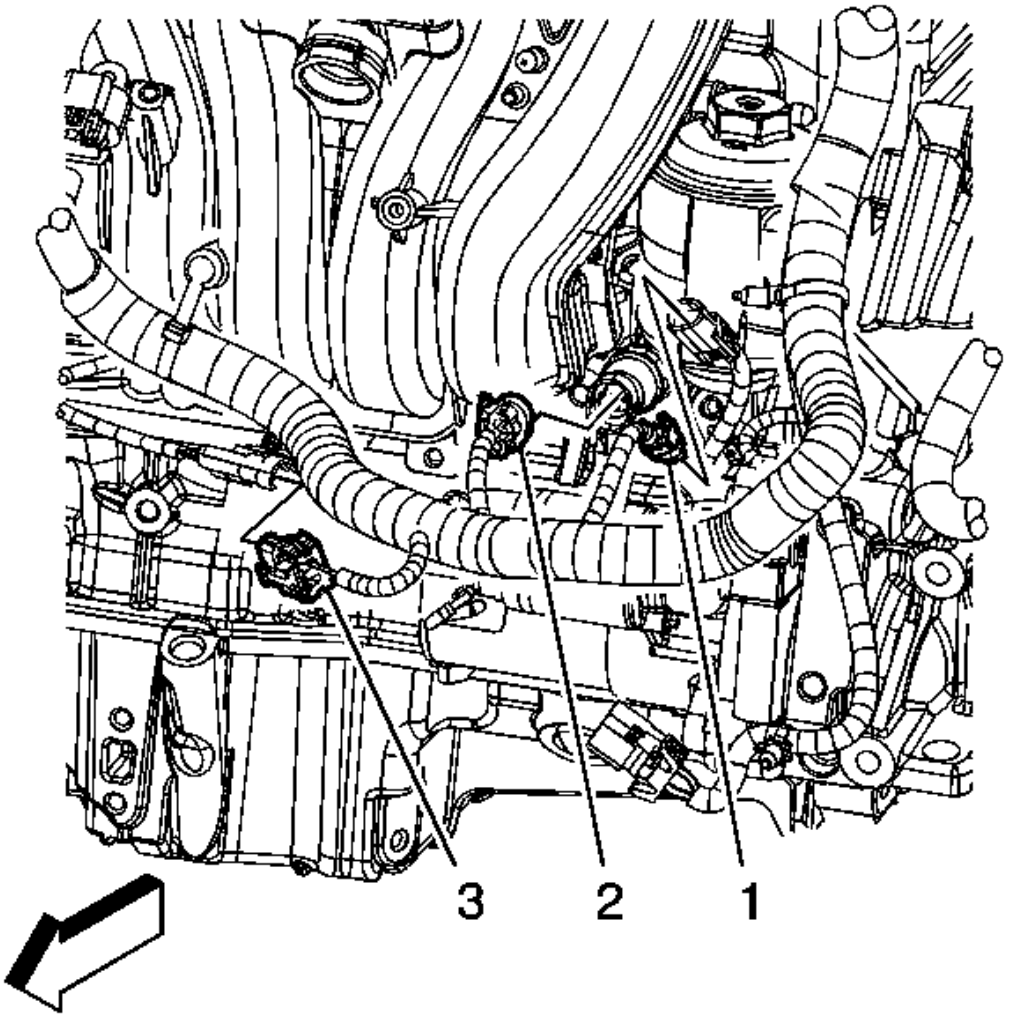

Fig. 36: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine harness electrical connector (2) to the oil pressure sensor.
3. Lower the vehicle.

Engine Mount Inspection

IMPORTANT: Before replacing any engine mount due to suspected fluid loss, verify that the source of the fluid is the engine mount, not the engine or accessories.

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1. Install the engine support fixture. Refer to **Engine Support Fixture**.
2. Raise the engine slightly and observe the engine mount. Raising the engine removes the weight from the engine mount and creates a slight tension on the rubber portion.
3. Replace the engine mount if the engine mount exhibits any of the following conditions:
   - The hard rubber is covered with heat check cracks.
   - The rubber is separated from the metal plate of the engine mount.
   - The rubber is split through the center of the engine mount.
   - The engine mount itself is leaking fluid.
4. For engine mount replacement. Refer to **Engine Mount Replacement**.

Powertrain Mount Balance - Total Mounts

IMPORTANT: Follow the balance procedure steps listed below. Powertrain mounts must be tightened in sequence.

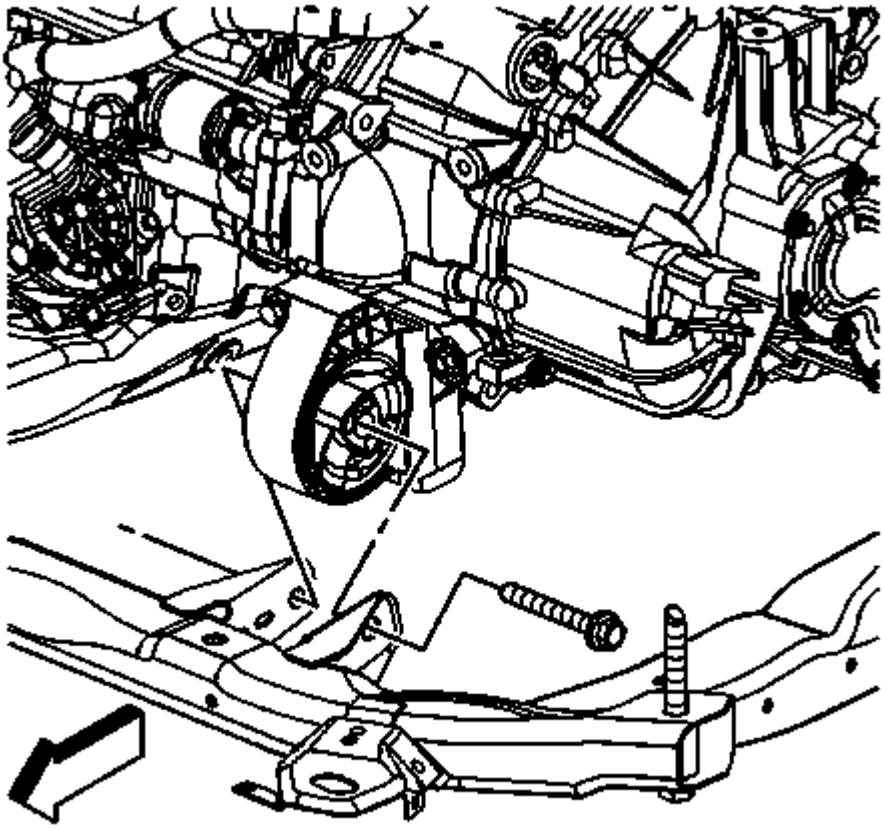

Fig. 37: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

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2. Loosen the front transaxle mount through bolt.

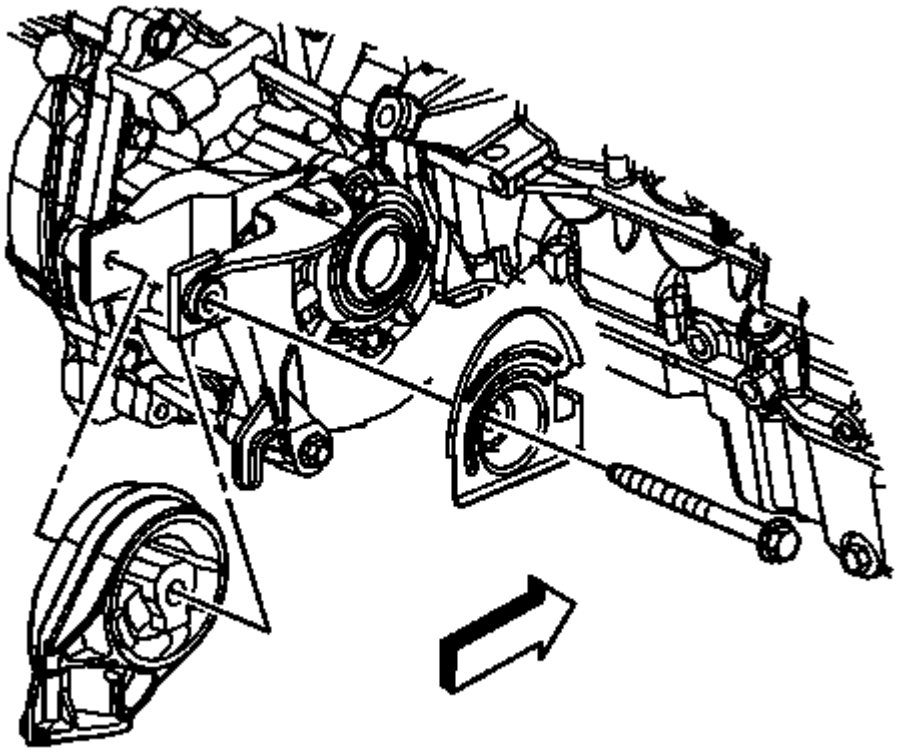

Fig. 38: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear transaxle mount through bolt.
4. Lower the vehicle.
5. Position two floor jacks with wood blocks under the engine and transaxle in order to support the powertrain assembly.

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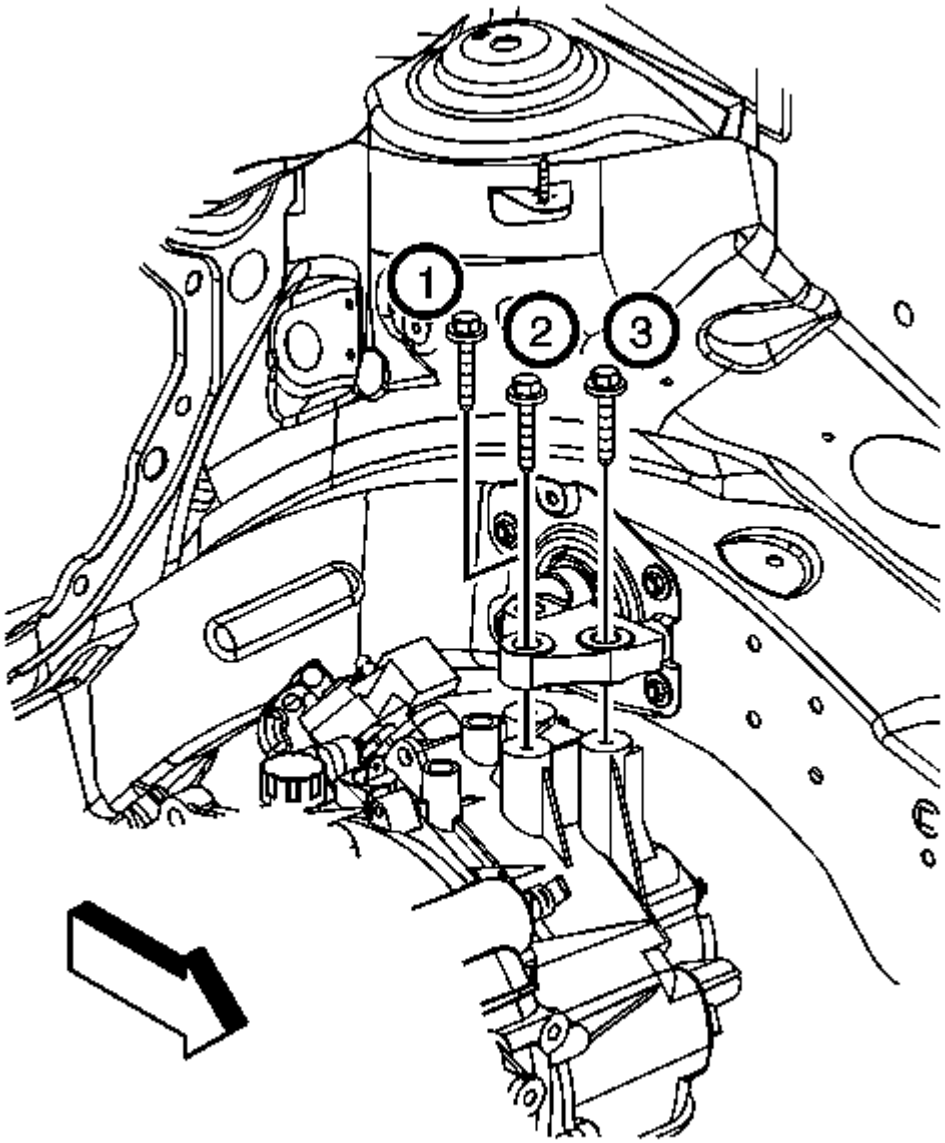

Fig. 39: Identifying Transaxle Mount to Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosen the transaxle mount to transaxle bolts.

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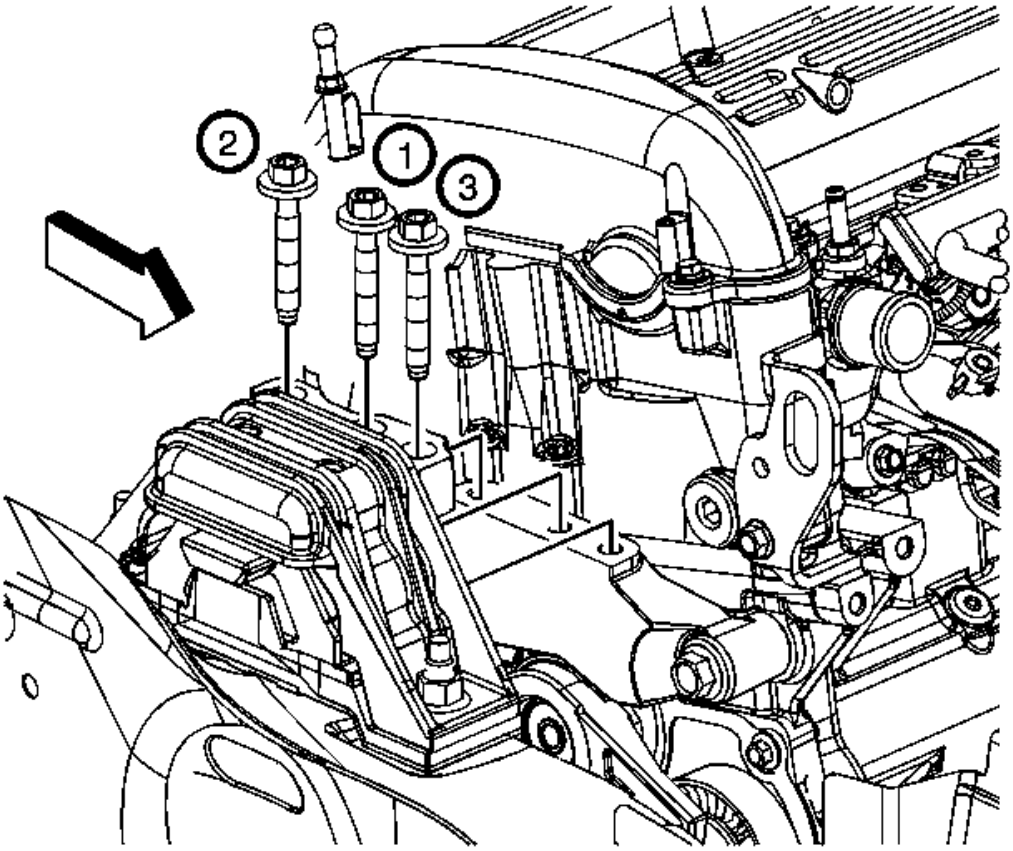

Fig. 40: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

7. Loosen the engine mount to bracket bolts.
8. Reposition both floor jacks in order to allow a 1/8 inch gap between the mount and bracket.

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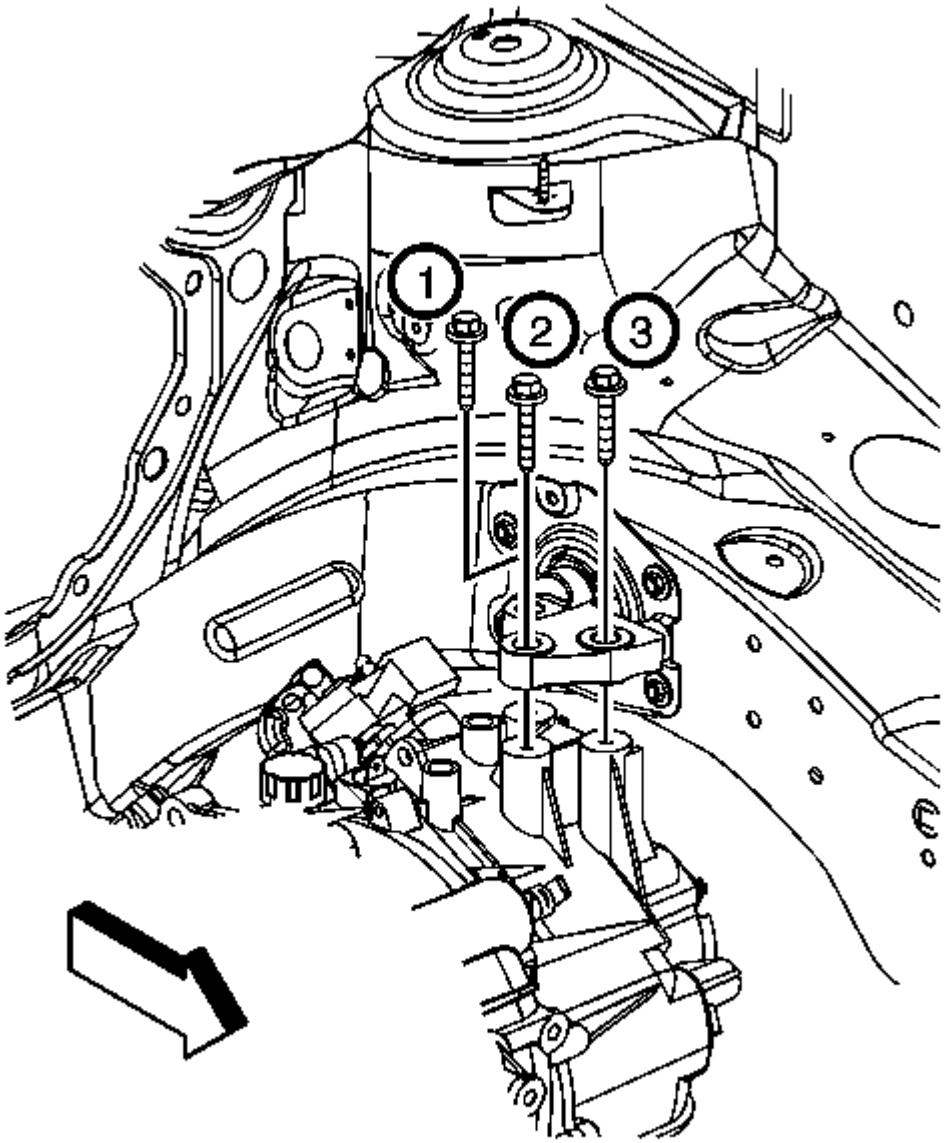

Fig. 41: Identifying Transaxle Mount to Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

9. Tighten the transaxle mount to transaxle bolts in the sequence shown.

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

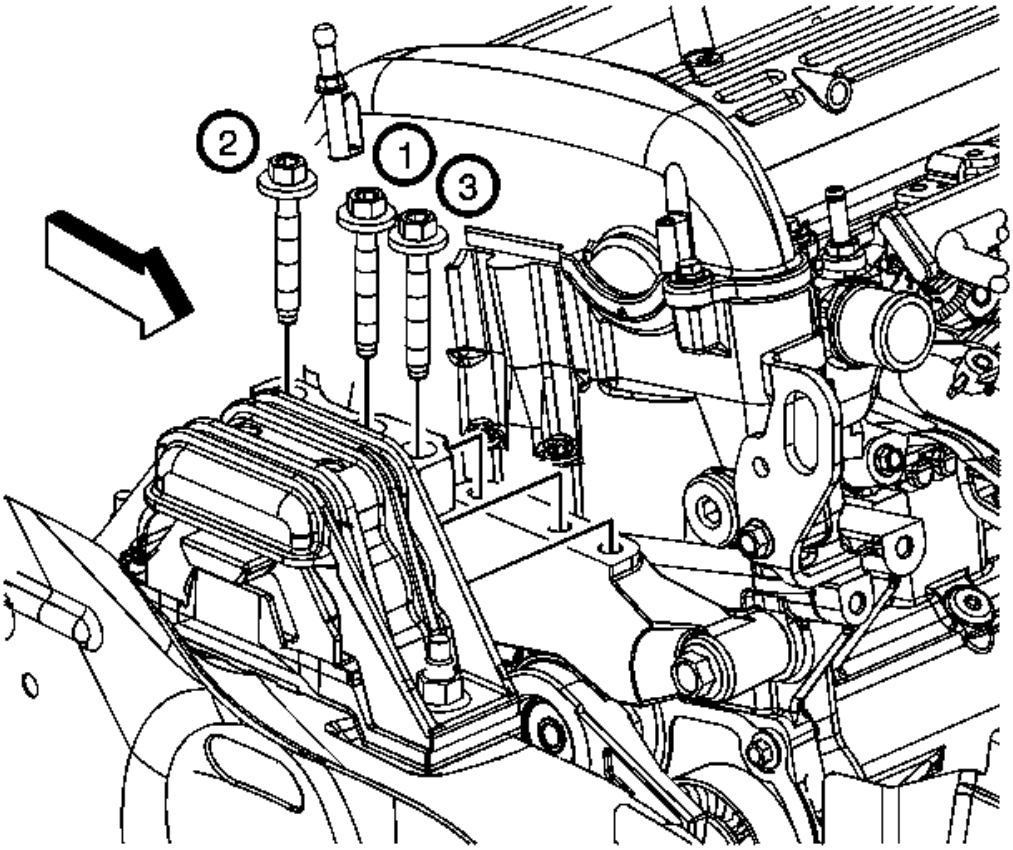

Fig. 42: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

10. Tighten the engine mount to bracket bolts in the sequence shown.

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

11. Remove the floor jacks from under the oil pan.
12. Shake the powertrain vigorously from front to rear and allow the powertrain to settle.
13. Raise the vehicle.

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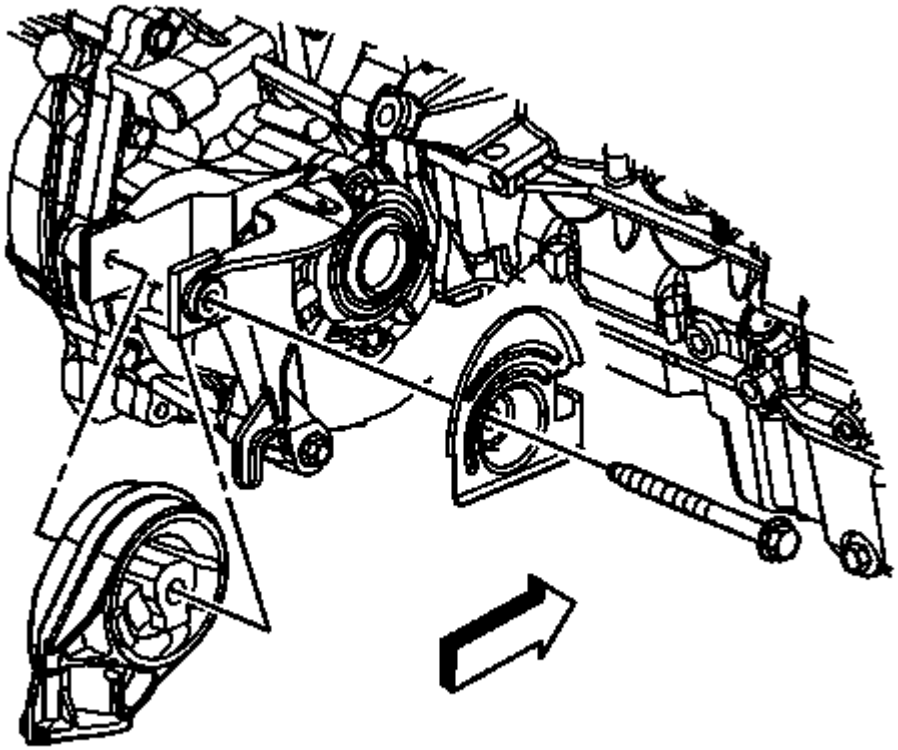

Fig. 43: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

14. Tighten the rear transaxle mount through bolt.

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

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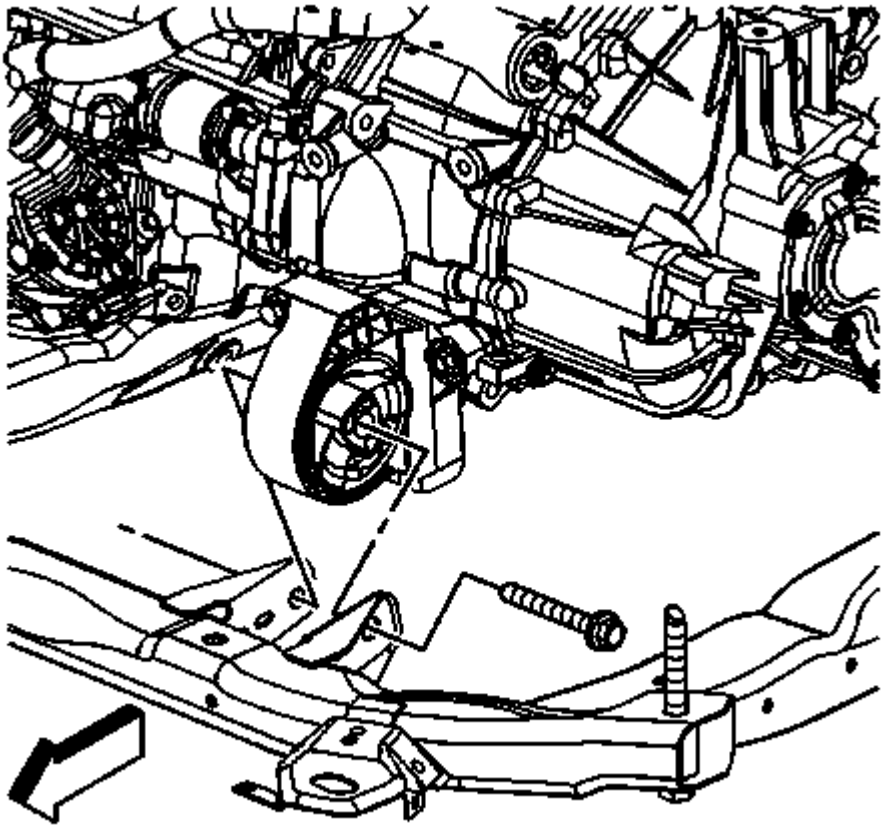

Fig. 44: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

15. Tighten the front transaxle mount through bolt.

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

16. Lower the vehicle.

Powertrain Mount Balance - Lower Mount

IMPORTANT: Follow the balance procedure steps listed below. Powertrain mounts must be tightened in sequence.

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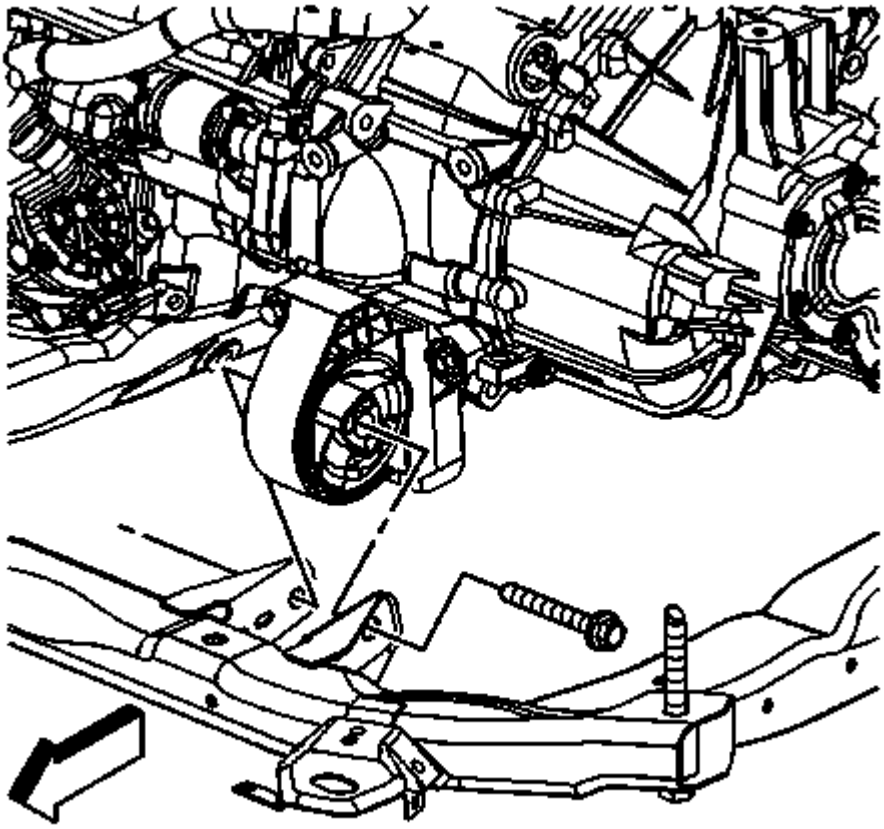

Fig. 45: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Loosen the front transaxle mount through bolt.

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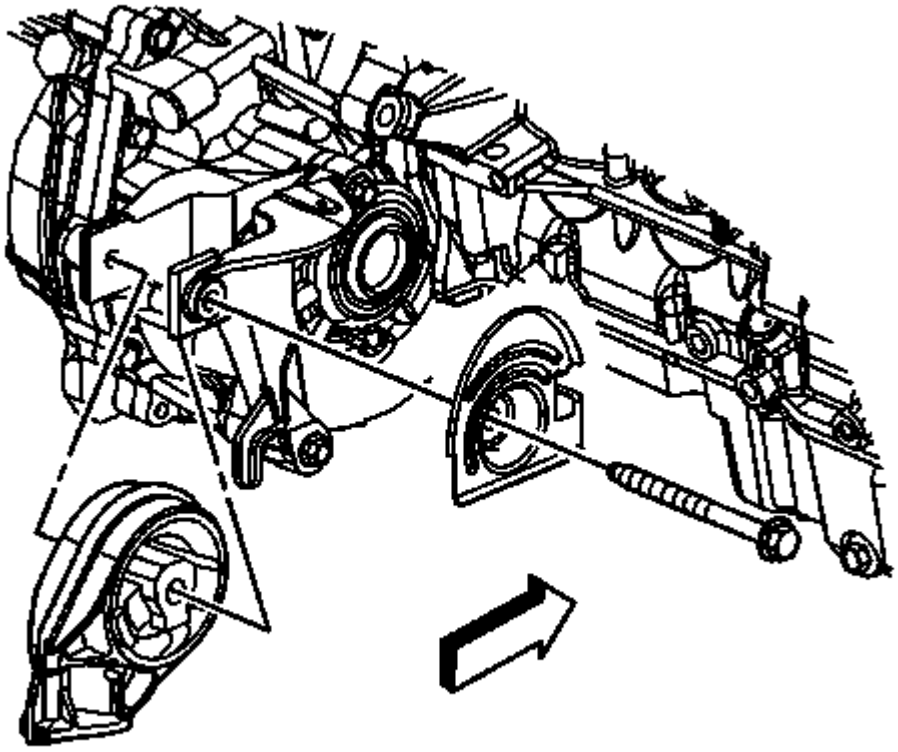

Fig. 46: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

3. Loosen the rear transaxle mount through bolt.
4. Shake the powertrain vigorously from front to rear and allow the powertrain to settle.

NOTE: **Refer to Fastener Notice .**

5. Tighten the rear transaxle mount through bolt.

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

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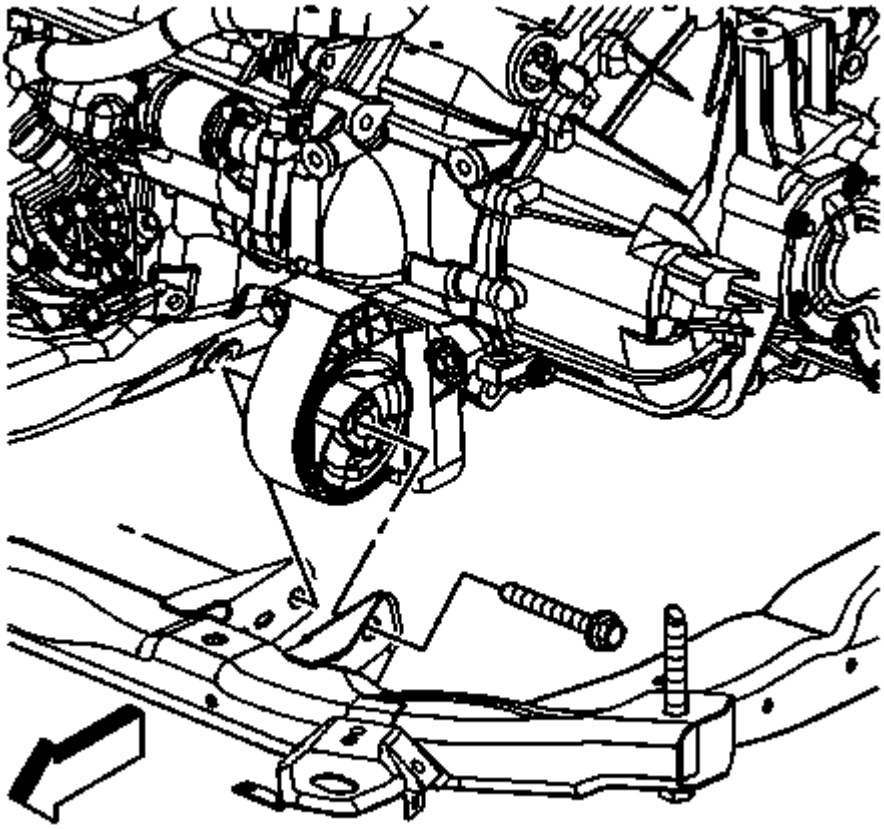

Fig. 47: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

6. Tighten the front transaxle mount through bolt.

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

7. Lower the vehicle.

Engine Mount Bracket Replacement

Removal Procedure

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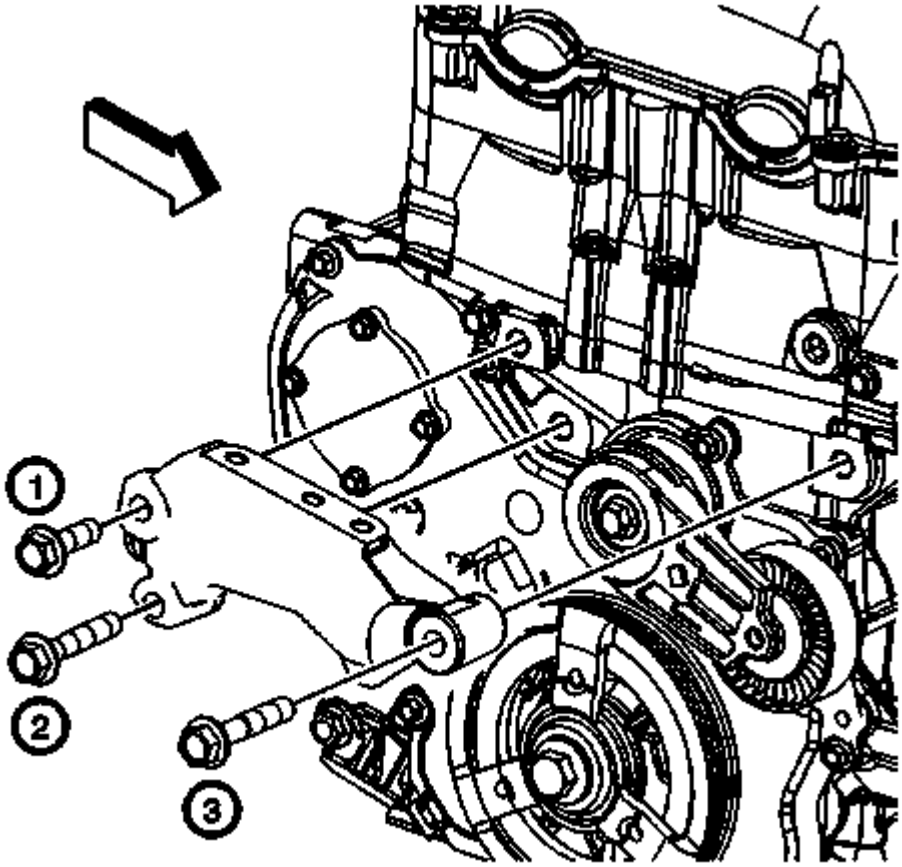

Fig. 48: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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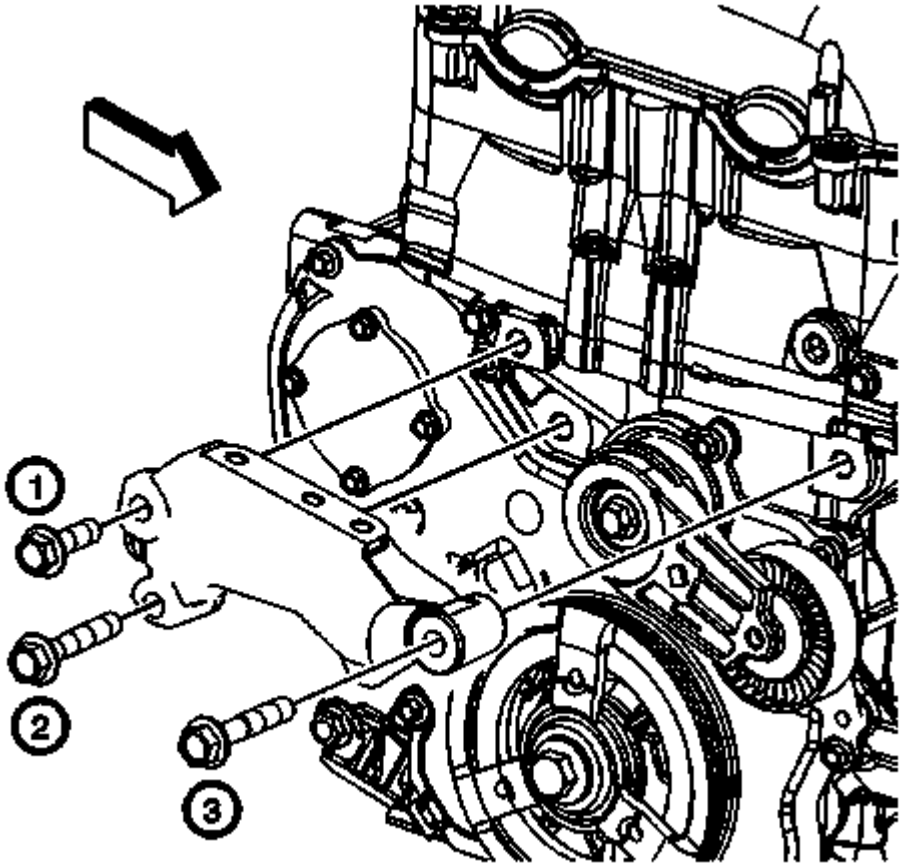

Fig. 49: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

1. Position the engine mount bracket to the engine.
2. Install the engine mount bracket bolts in the following locations:
   - The long bolts in the forward and lower front holes
   - The short bolt in the upper rear hole

NOTE: **Refer to Fastener Notice .**

3. Tighten the engine mount bracket bolts.

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

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

Engine Mount Replacement

Removal Procedure

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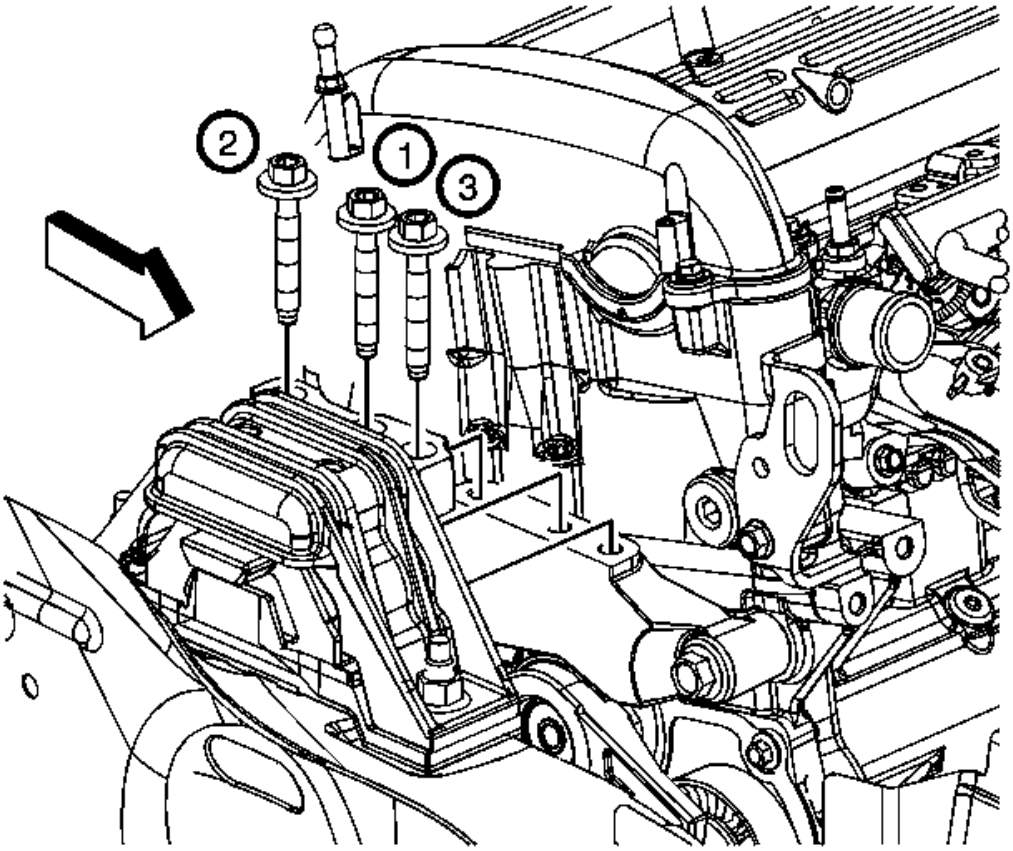

Fig. 50: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Support the engine with a hydraulic floor jack. Use a piece of wood between the floor jack and the oil pan.
3. Remove the engine mount to bracket bolts.

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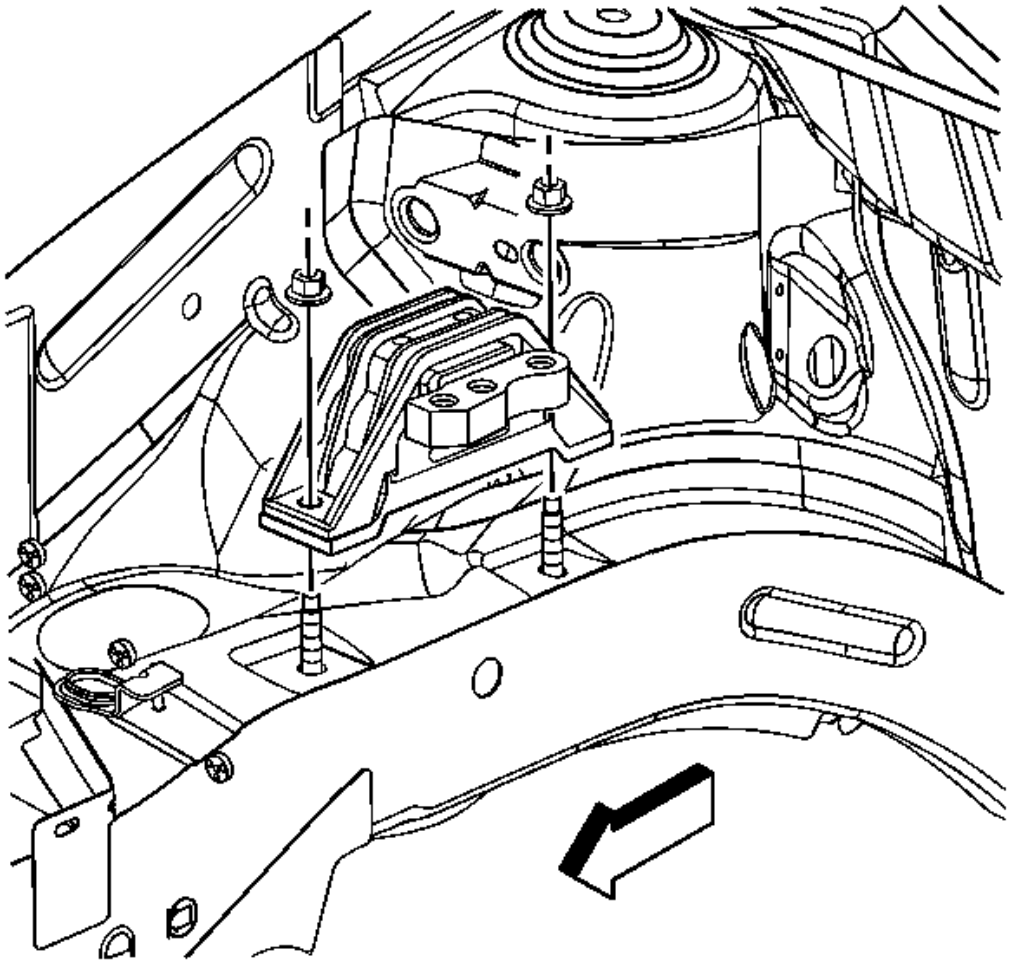

Fig. 51: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

4. Remove the engine mount to side rail nuts.
5. Remove the engine mount from the engine compartment.

Installation Procedure

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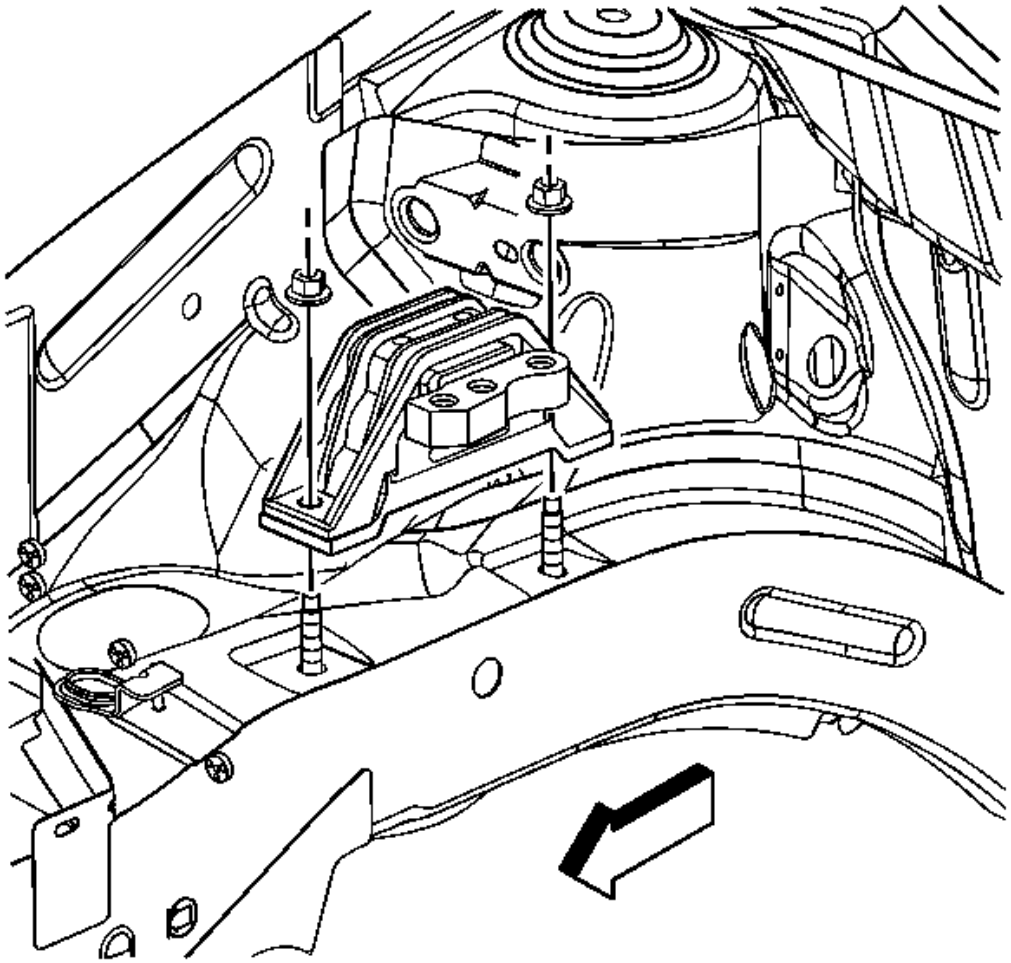

Fig. 52: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

1. Place the engine mount onto the side rail studs.

   NOTE: Refer to Fastener Notice .

2. Install the engine mount to side rail nuts.

   Tighten: Tighten the nuts in the sequence shown to 100 N.m (74 lb ft).

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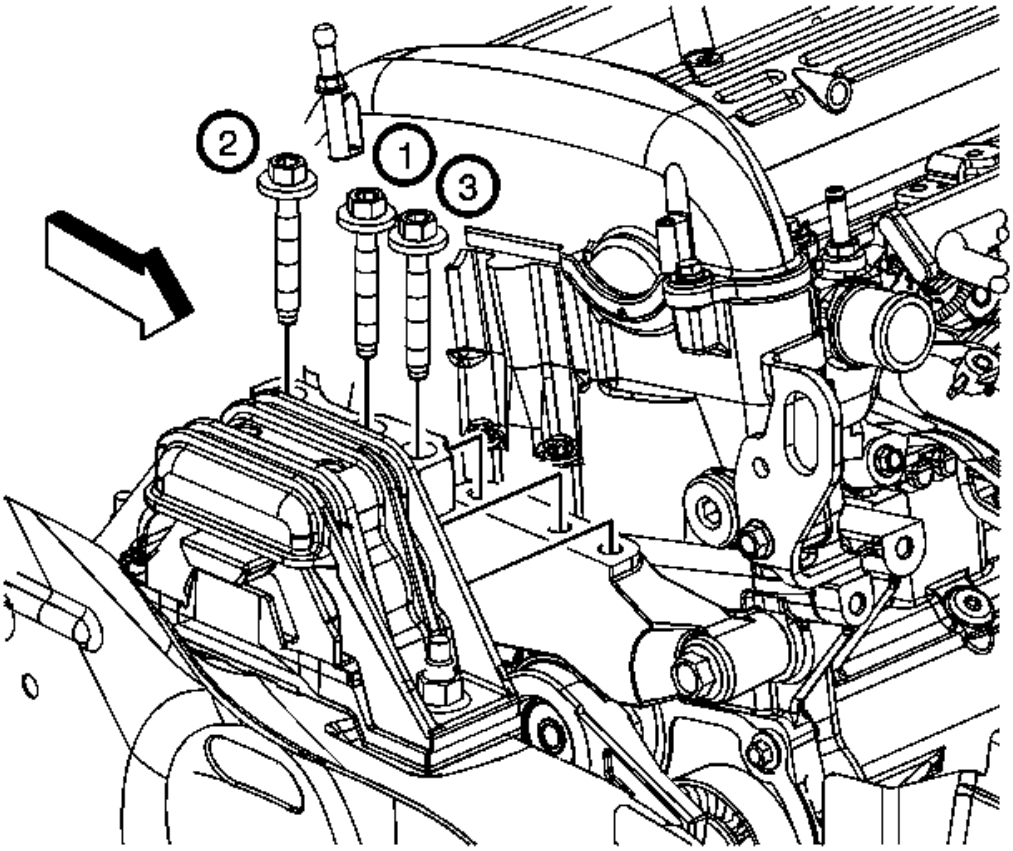

Fig. 53: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The engine mount to bracket bolts must be hand started. Do not pry the engine mount to align the holes.

3. Install the engine mount to bracket bolts.
4. Tighten the engine mount to bracket bolts.

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

5. Remove the hydraulic floor jack from under the oil pan.
6. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

Engine Support Fixture

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Tools Required

- **J 28467-B** Universal Engine Support Fixture
- **J 43405** Engine Support Fixture Adaptor

Installation Procedure

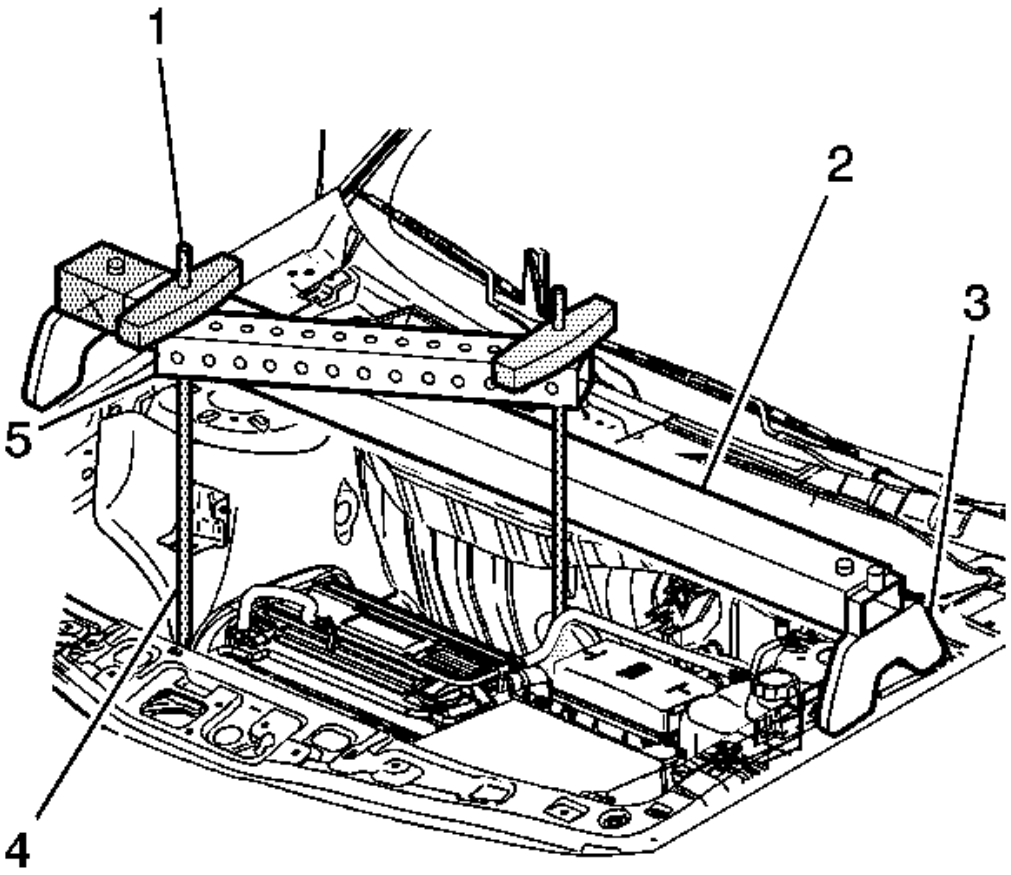

Fig. 54: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

1. Place the engine support fixture long bar (2), from the **J 28467-B** across the engine compartment.
2. Install the Engine support fixture legs (3) from the **J 43405** on the engine support fixture long bar and center above the engine.
3. Install the engine support fixture hooks (4) and engine support fixture handle to the engine support cross bar.

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4. Place the engine support cross bar over the engine support long bar and connect the hooks to the engine lift brackets.

Oil Level Indicator and Tube Replacement

Removal Procedure

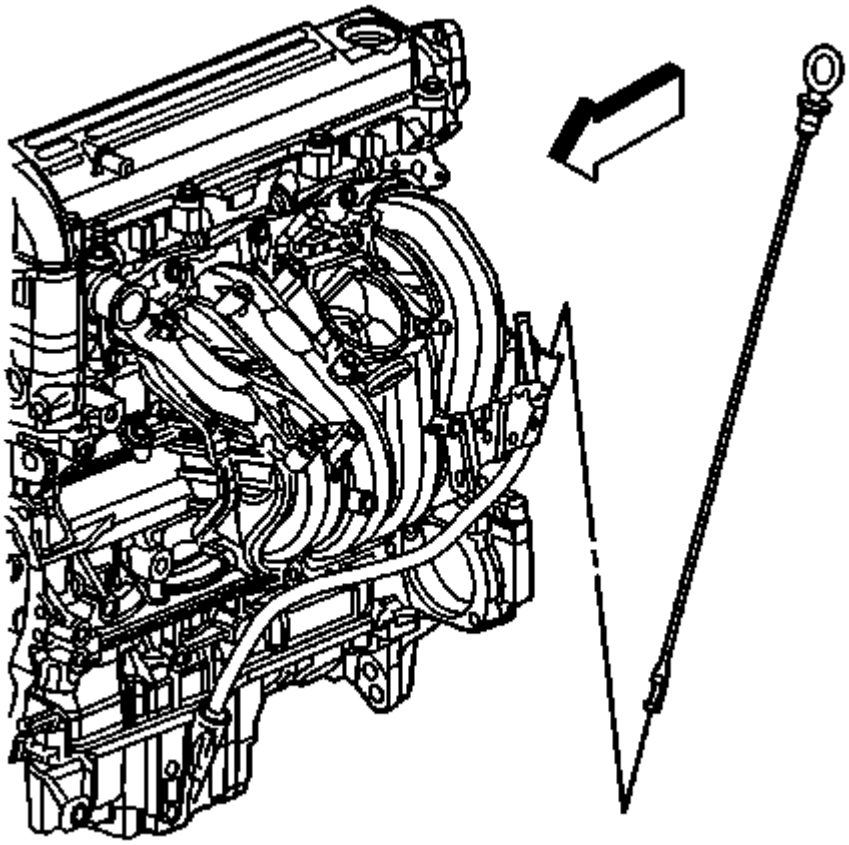

Fig. 55: Identifying Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the oil level indicator.

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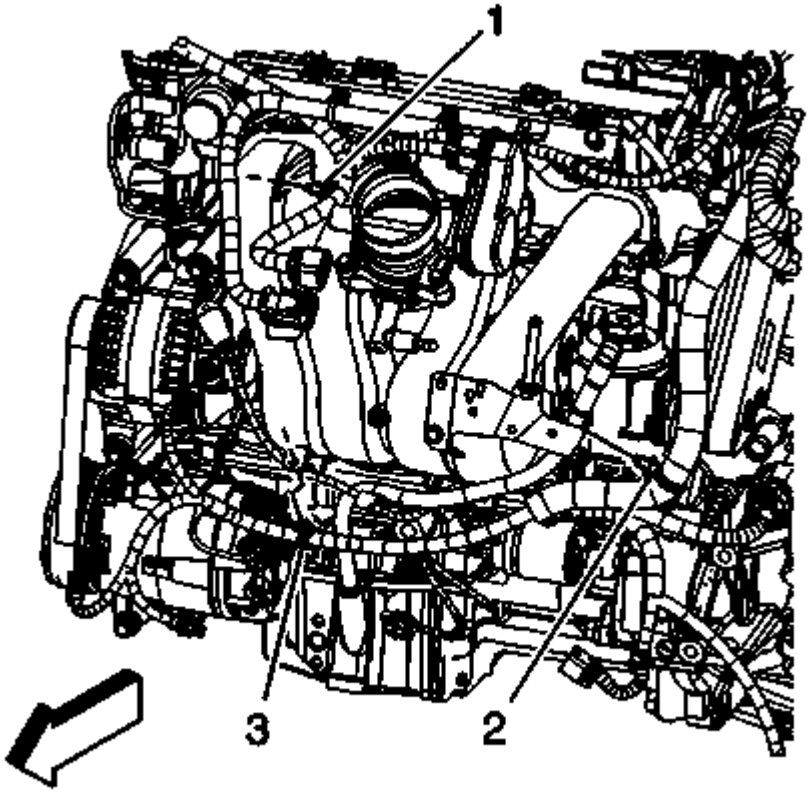

Fig. 56: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine harness clip (2) from the oil level indicator tube bracket.

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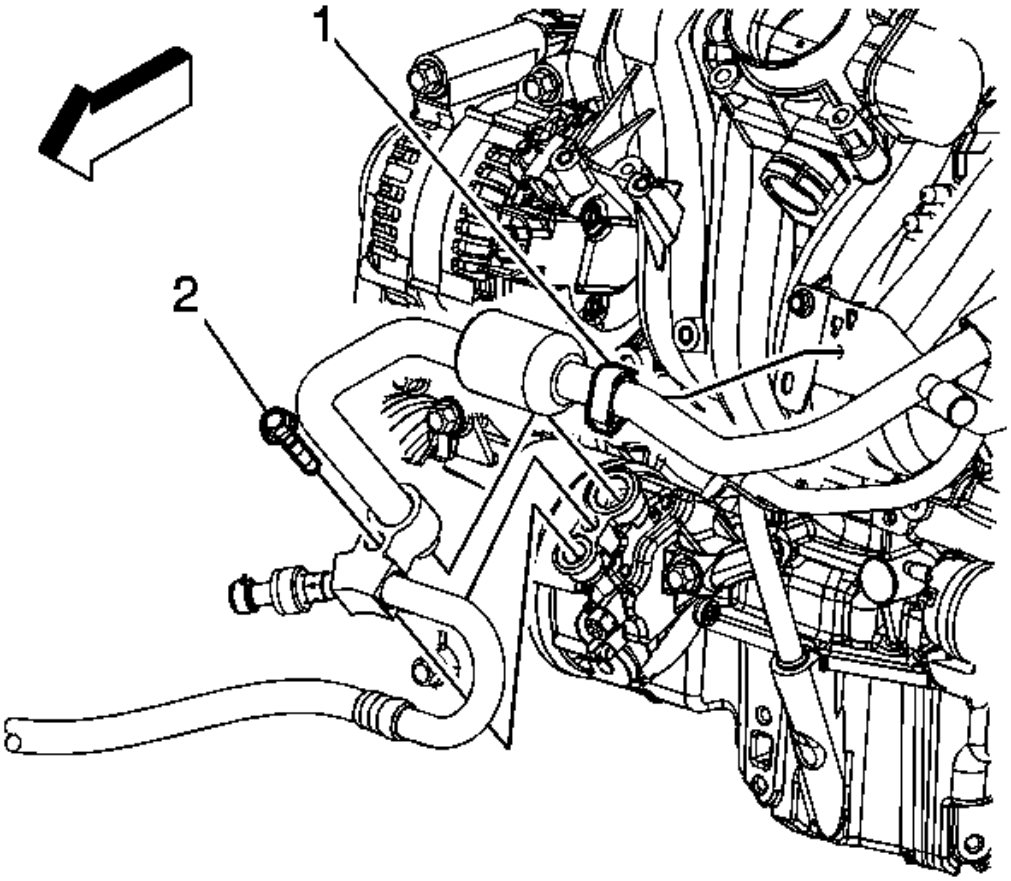

Fig. 57: View Of Air Conditioning (A/C) Compressor/Condenser Line Clip
Courtesy of GENERAL MOTORS CORP.

4. Remove the air conditioning (A/C) compressor/condenser line clip (1) from the oil level indicator tube bracket.

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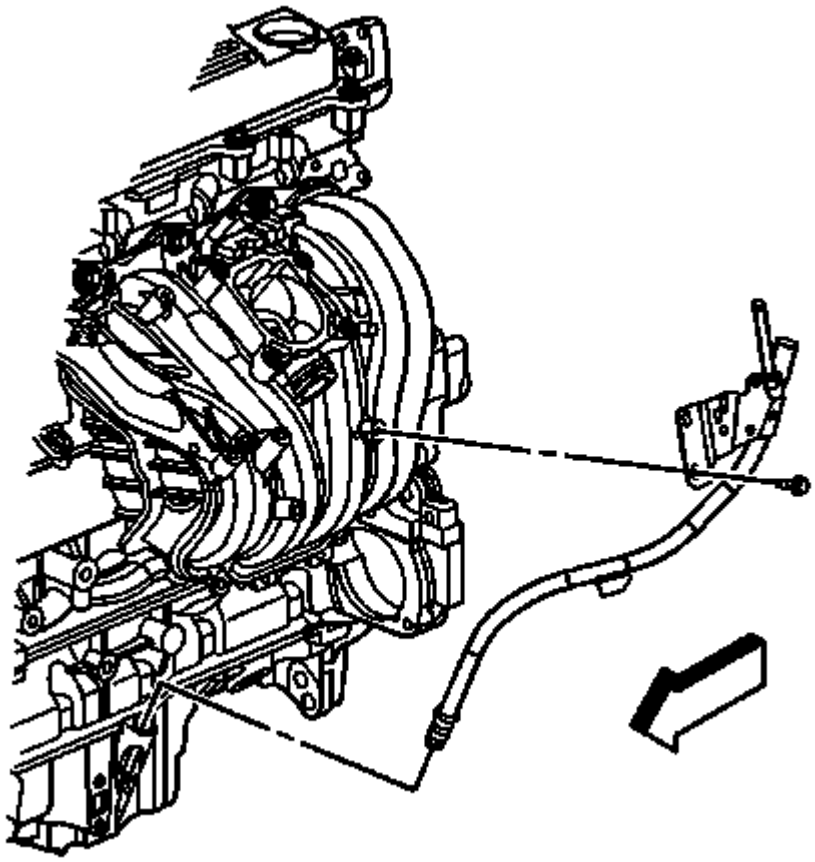

Fig. 58: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

5. Remove the oil level indicator tube bolt.
6. Remove the oil level indicator tube.
7. Remove the oil level indicator tube O-ring seals, if necessary.

Installation Procedure

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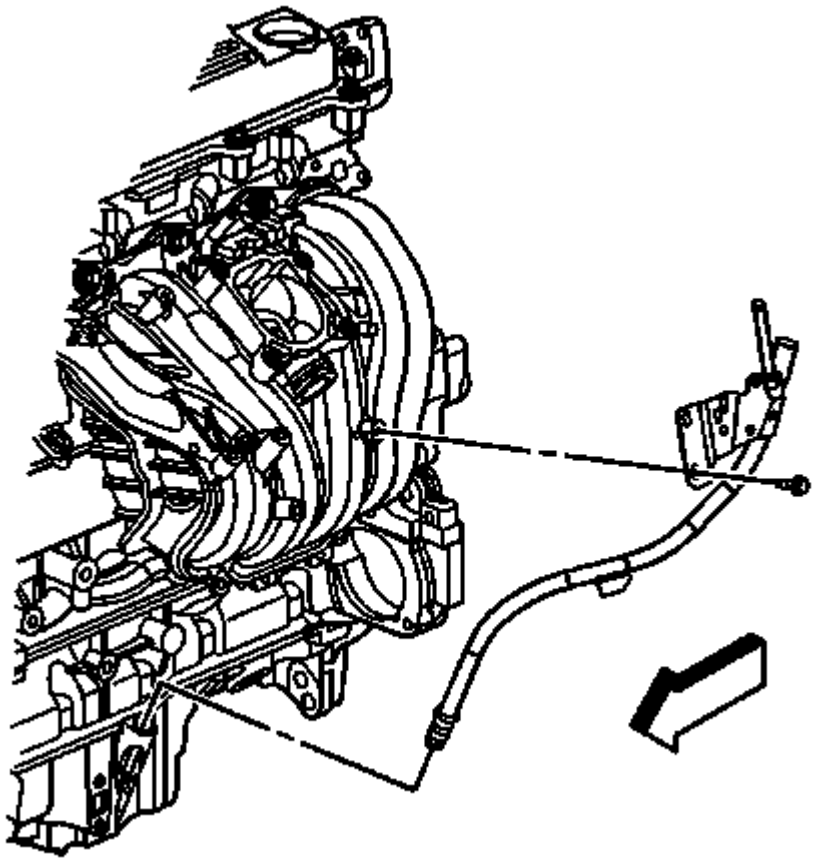

Fig. 59: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Install NEW oil level indicator tube O-ring seals, if necessary.
2. Install the oil level indicator tube.

NOTE: **Refer to Fastener Notice .**

3. Install the oil level indicator tube bolt.

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

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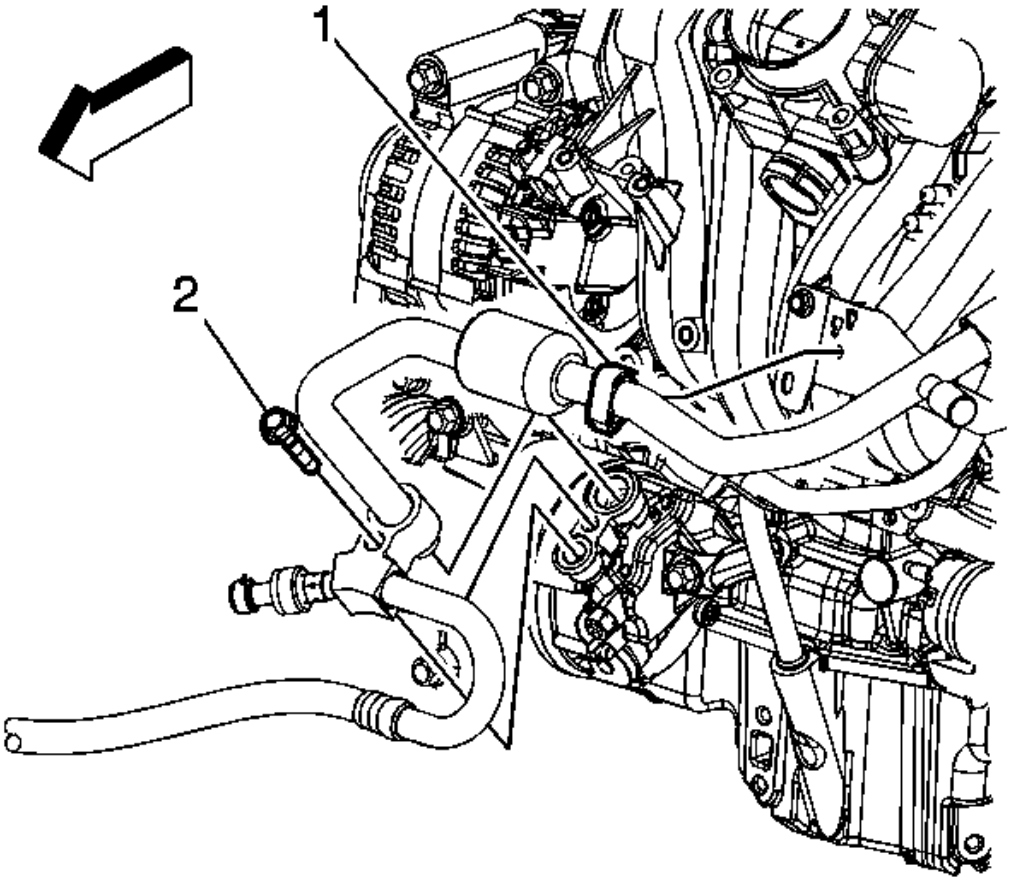

Fig. 60: View Of Air Conditioning (A/C) Compressor/Condenser Line Clip
Courtesy of GENERAL MOTORS CORP.

4. Install the A/C compressor/condenser line clip (1) to the oil level indicator tube bracket.

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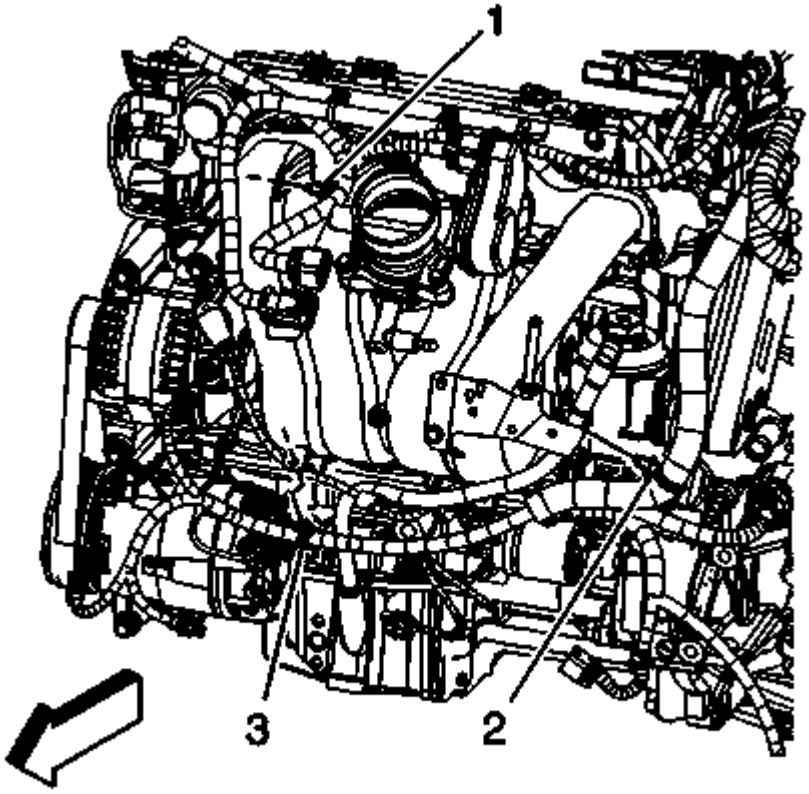

Fig. 61: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

5. Install the engine harness clip (1) to the oil level indicator tube bracket.

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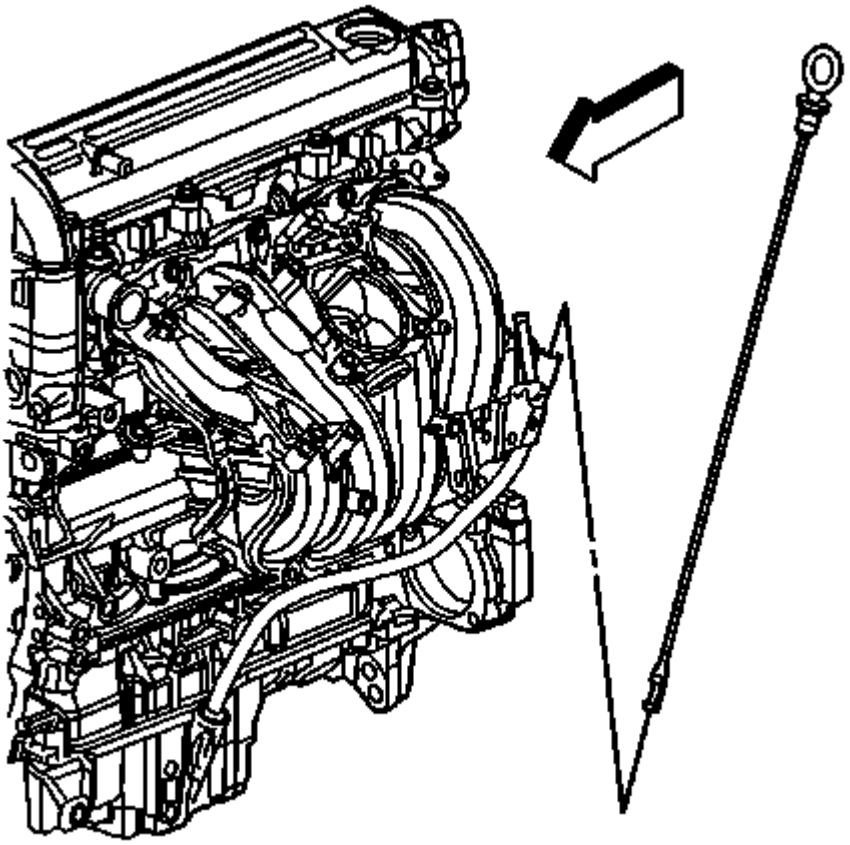

Fig. 62: Identifying Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

6. Install the oil level indicator.
7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Crankcase Ventilation Hoses/Pipes Replacement

Removal Procedure

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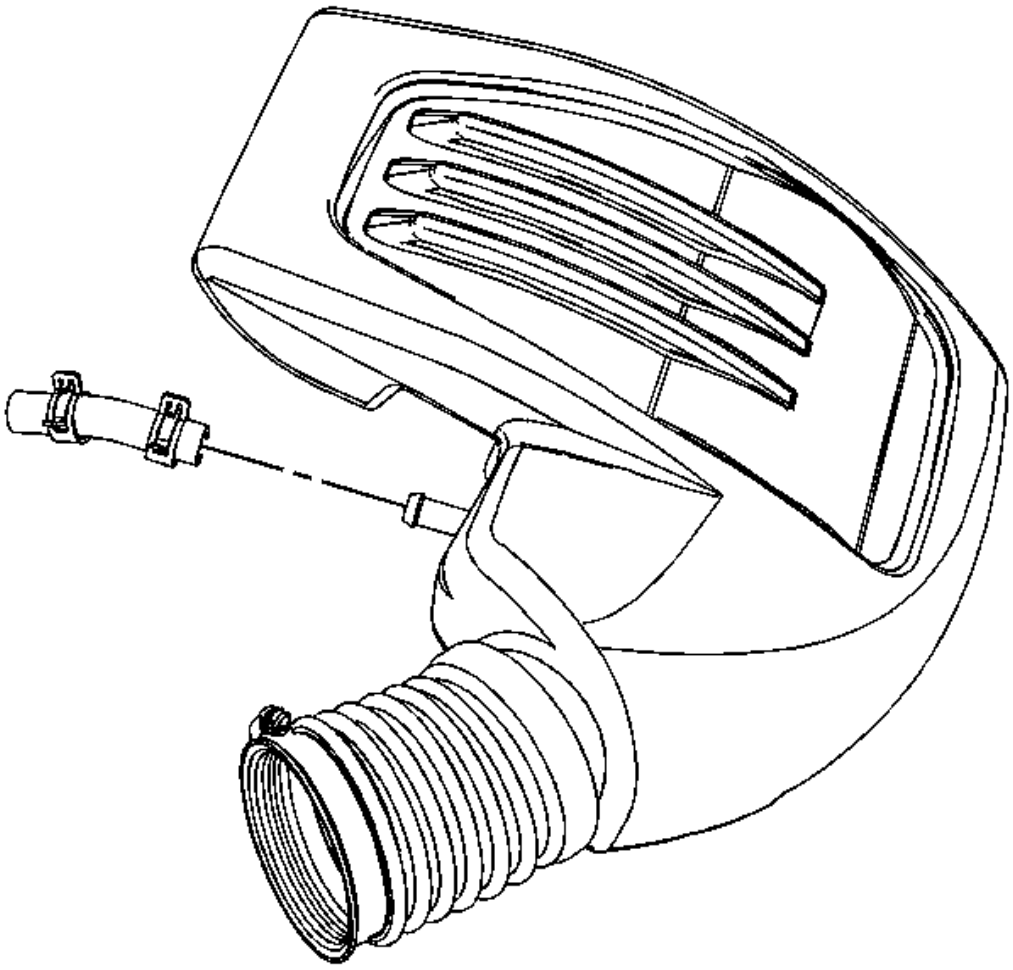

Fig. 63: Removing PCV Hose From Outlet Duct
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. Reposition the positive crankcase ventilation (PCV) hose clamp at the outlet duct.
4. Remove the PCV hose from the air cleaner outlet duct.

Installation Procedure

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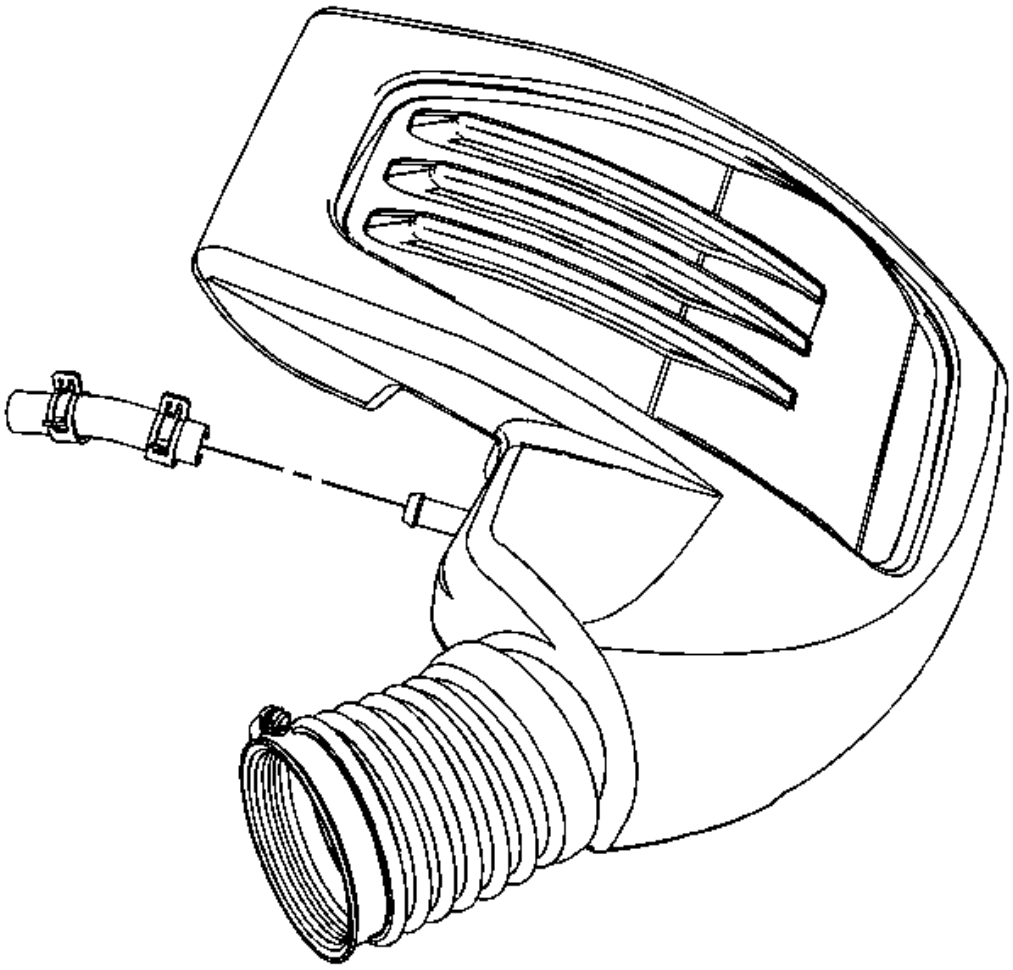

Fig. 64: Installing PCV Hose To Outlet Duct
Courtesy of GENERAL MOTORS CORP.

1. Install the PCV hose to the air cleaner outlet duct.
2. Reposition the PCV hose clamp at the outlet duct.
3. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
4. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Intake Manifold Replacement

Removal Procedure

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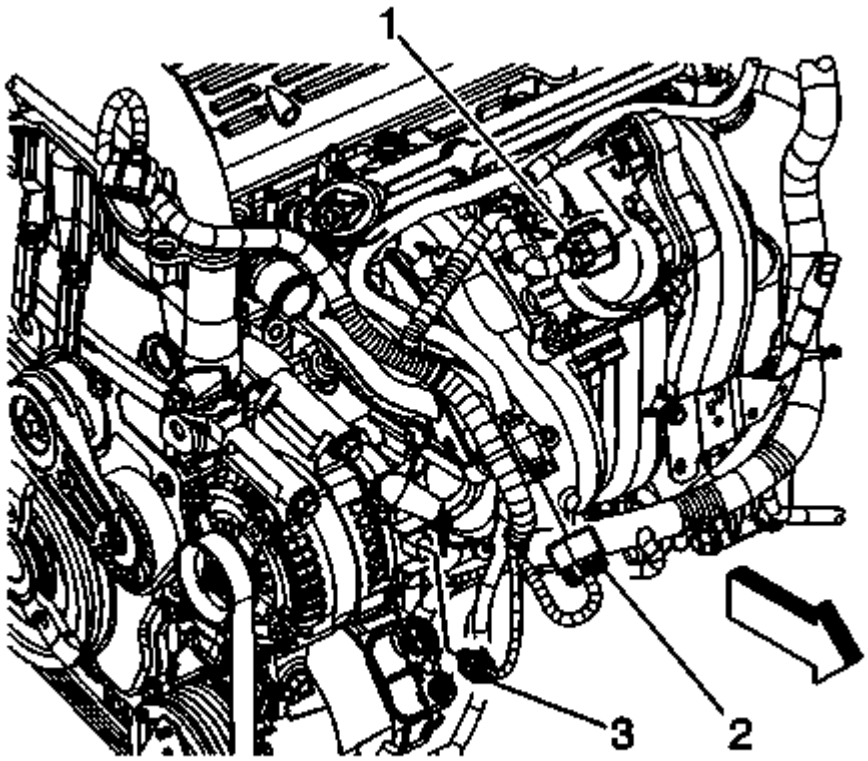

Fig. 65: Identifying Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. Disconnect the engine harness electrical connector (1) from the throttle actuator control (TAC).
4. Disconnect the engine harness electrical connector (2) from the fuel injector harness.
5. Disconnect the engine harness electrical connector from the manifold absolute pressure (MAP) sensor.

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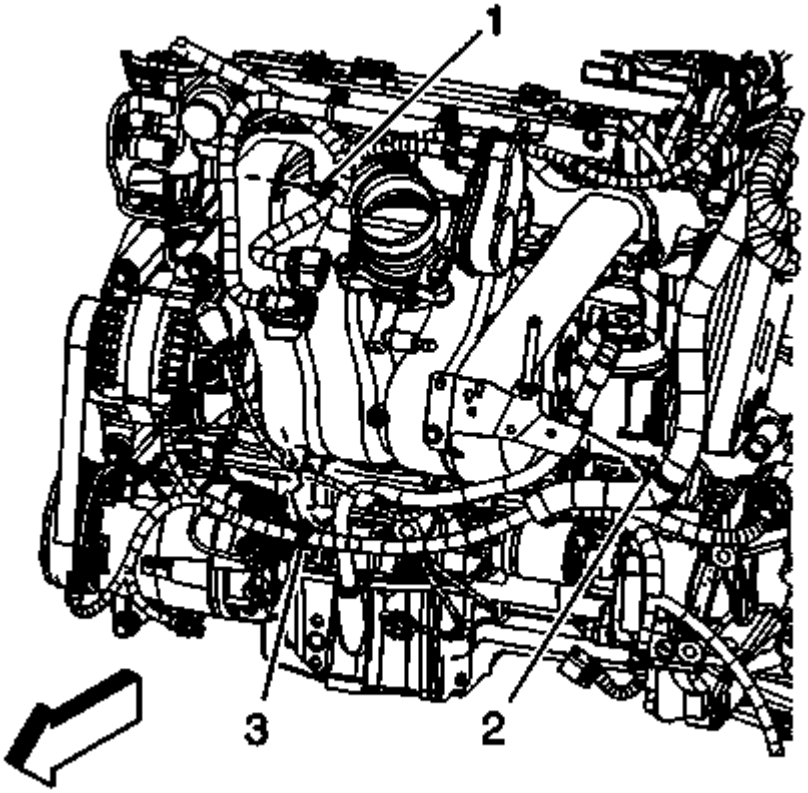

Fig. 66: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the engine harness clips (1 and 3) from the intake manifold.
7. Disconnect the engine harness clip (2) from the oil level indicator tube.
8. Disconnect the fuel injector electrical connector clip from the intake manifold.

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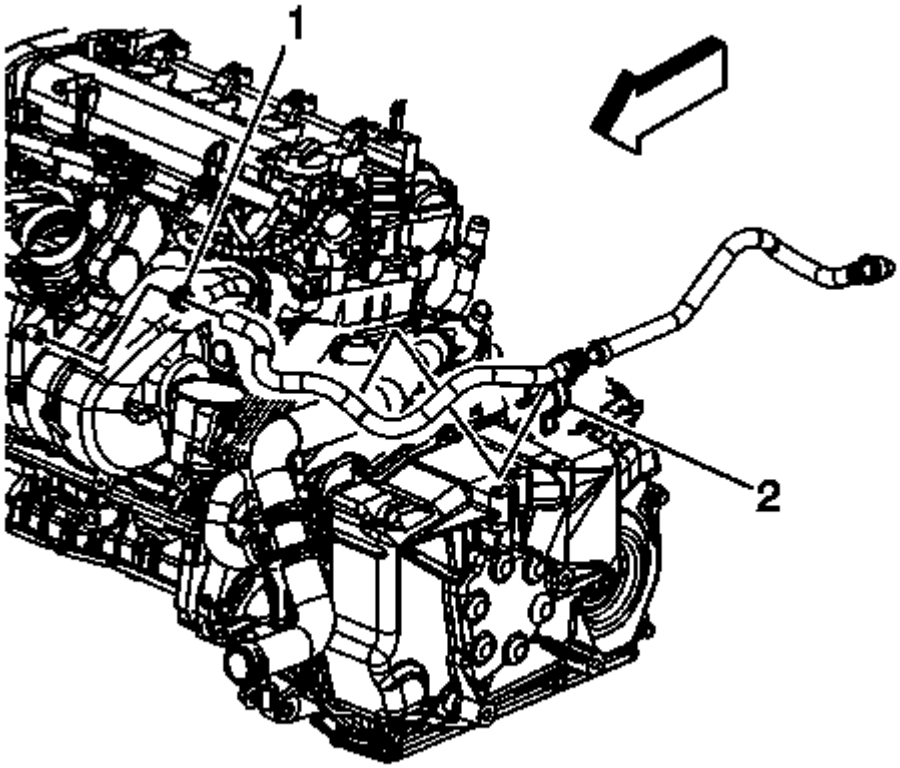

Fig. 67: View of Vacuum brake booster hose clamp
Courtesy of GENERAL MOTORS CORP.

9. Reposition the vacuum brake booster hose clamp (1) at the intake manifold.
10. Remove the vacuum brake booster hose from the intake manifold.

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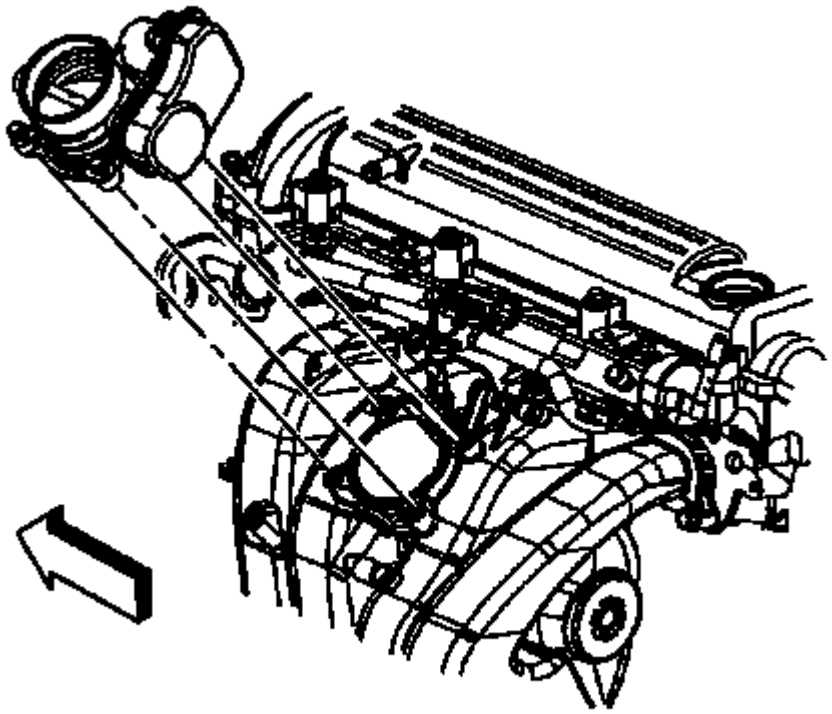

Fig. 68: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

11. Remove the throttle body bolts.

IMPORTANT: The throttle body seal is reusable, only replace the seal if damaged.

12. Remove the throttle body and seal.
13. Remove and inspect the throttle body seal.

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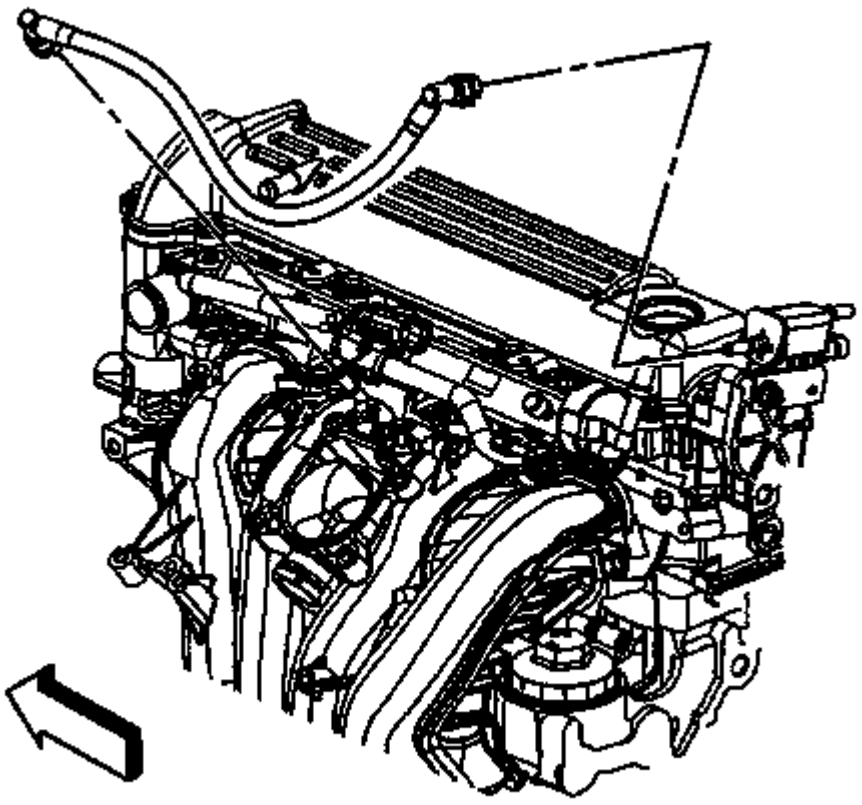

Fig. 69: Identifying EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

14. Disconnect the evaporative emission (EVAP) canister purge tube from the intake manifold and the EVAP solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
15. Remove the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
16. Remove the fuel rail. Refer to **Fuel Rail Assembly Replacement** .

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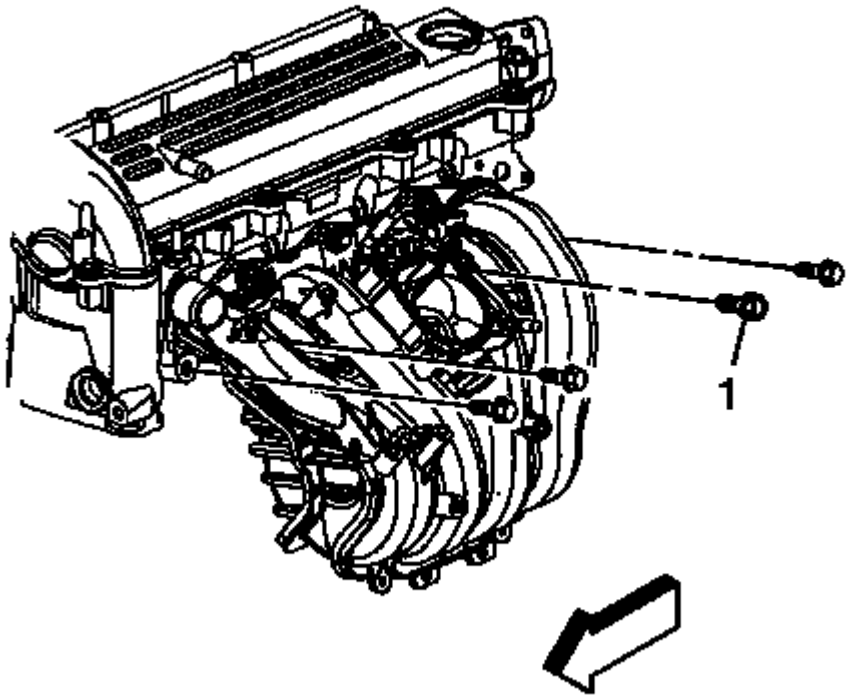

Fig. 70: Intake Manifold Lower Bolts
Courtesy of GENERAL MOTORS CORP.

17. Remove the intake manifold lower bolts.

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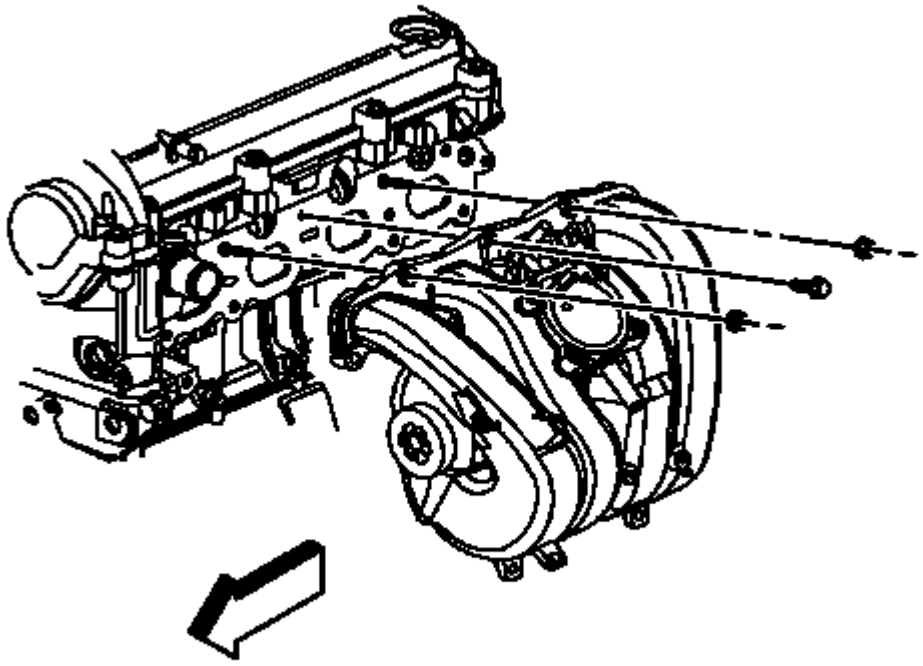

Fig. 71: View Of Intake Manifold, Upper Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

18. Remove the intake manifold upper bolt and nuts.
19. Remove the intake manifold.

IMPORTANT: The intake manifold gasket is reusable, only replace the gasket if damage has occurred.

20. Remove and inspect the intake manifold gasket.

Installation Procedure

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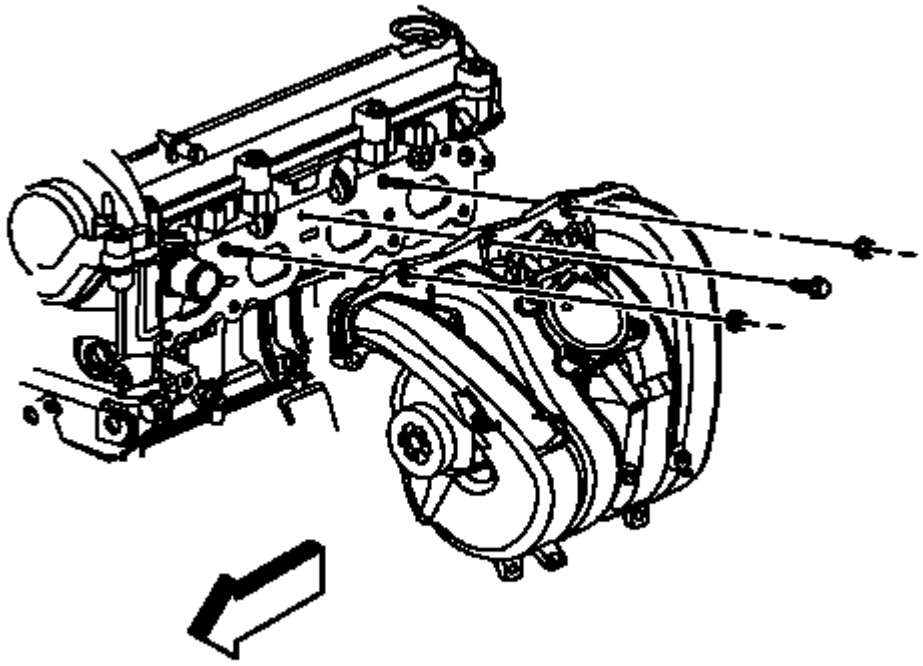

Fig. 72: View Of Intake Manifold, Upper Bolts And Nuts
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW intake manifold gasket if necessary, otherwise install the old gasket.
2. Install the intake manifold.
3. Install the intake manifold upper bolt and nuts.

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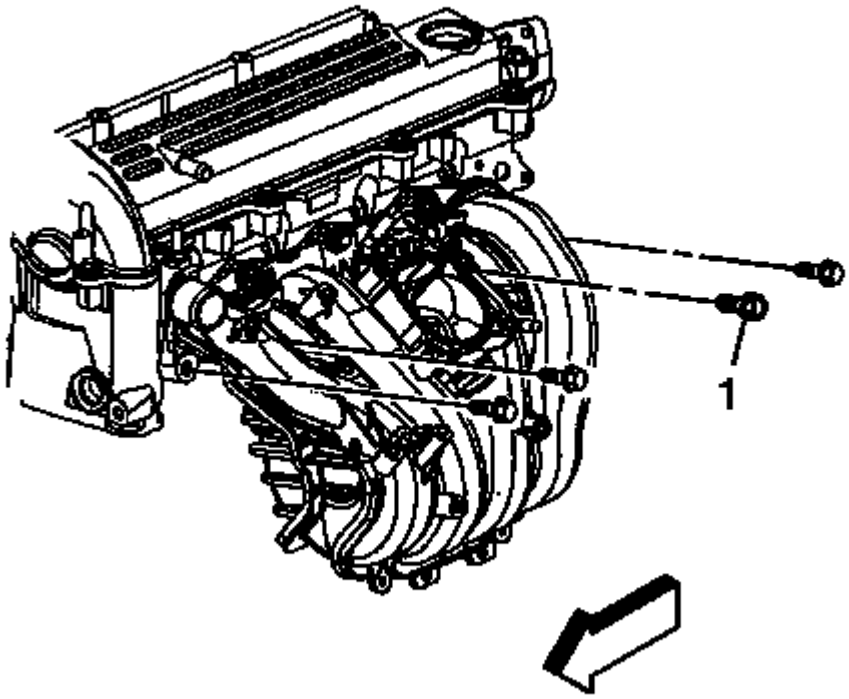

Fig. 73: Identifying Intake Manifold Lower Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the intake manifold lower bolts.

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

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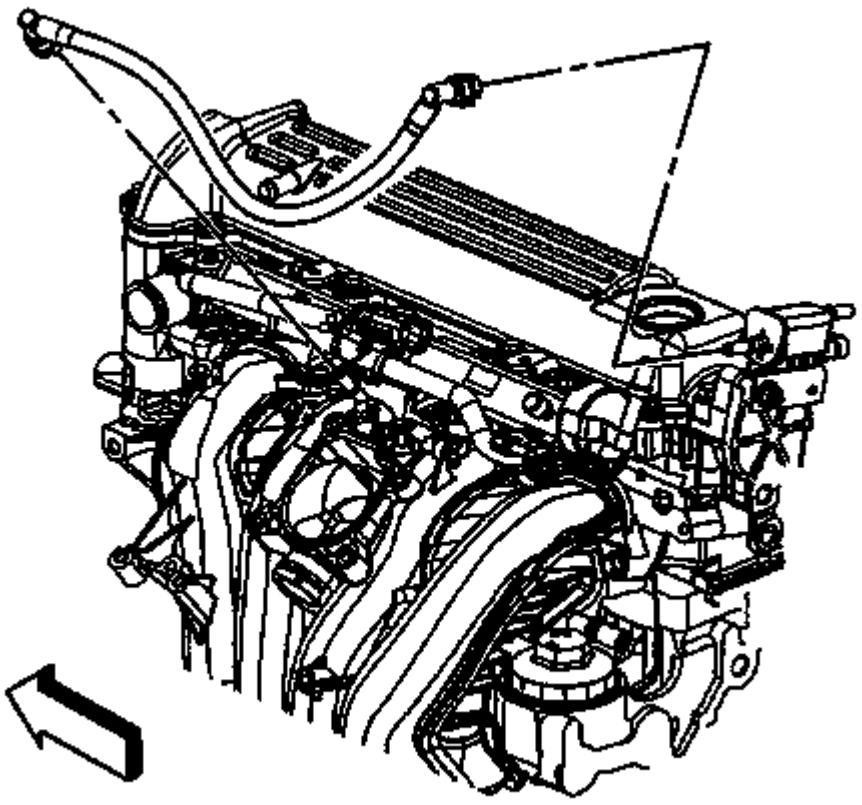

Fig. 74: Identifying EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail. Refer to **Fuel Rail Assembly Replacement** .
6. Install the oil level indicator tube. Refer to **Oil Level Indicator and Tube Replacement**.
7. Connect the EVAP canister purge tube to the intake manifold and the EVAP solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .

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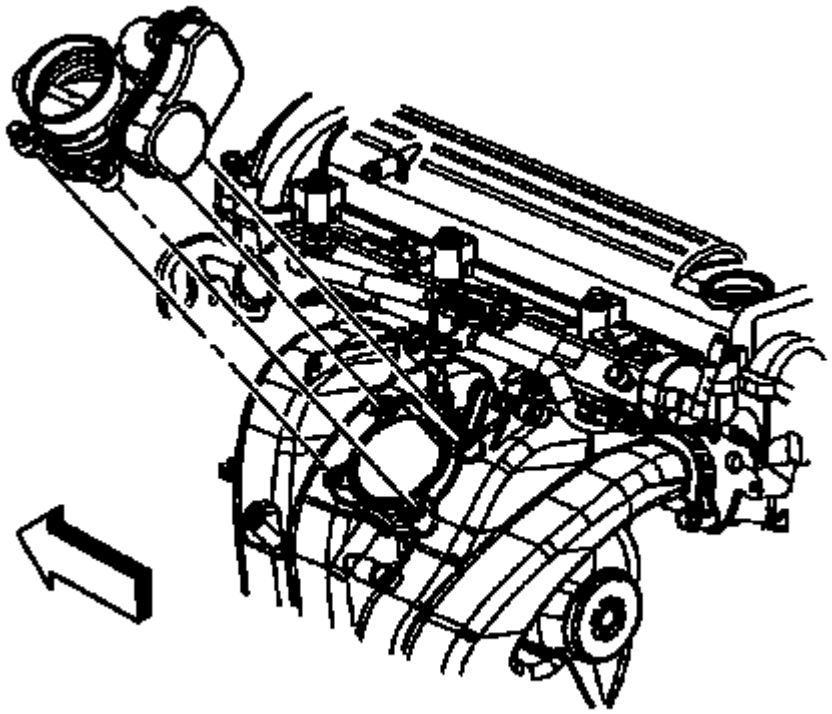

Fig. 75: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

8. Install a NEW throttle body seal if necessary, otherwise install the old seal.
9. Position the throttle body.
10. Install the throttle body bolts.

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

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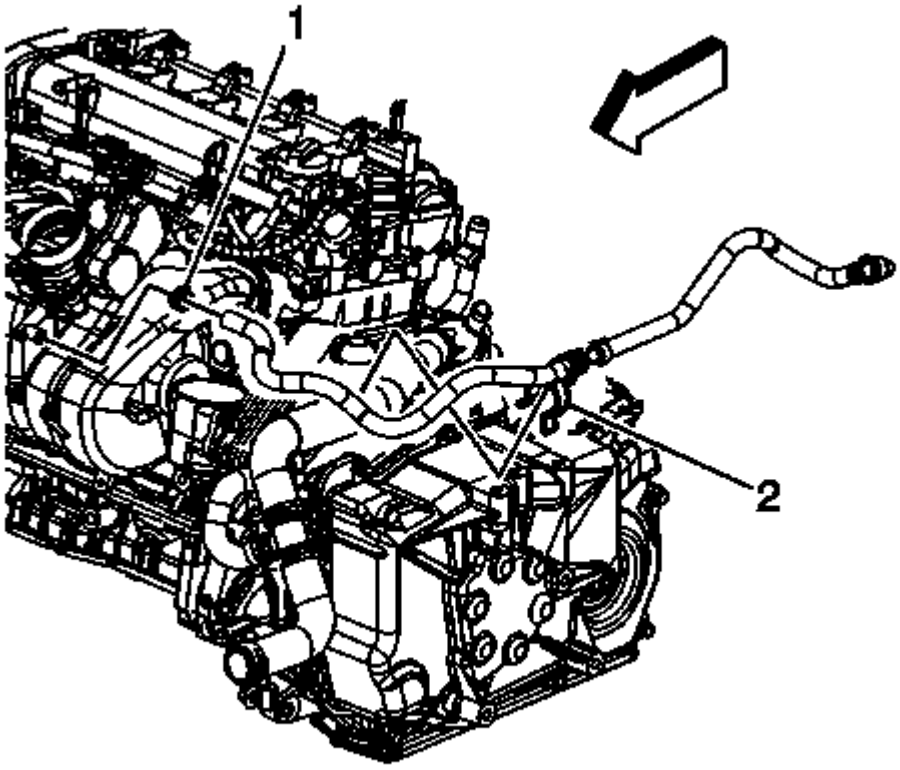

Fig. 76: View of Vacuum brake booster hose clamp
Courtesy of GENERAL MOTORS CORP.

11. Install the vacuum brake booster hose to the intake manifold.
12. Position the vacuum brake booster hose clamp (2) at the intake manifold.

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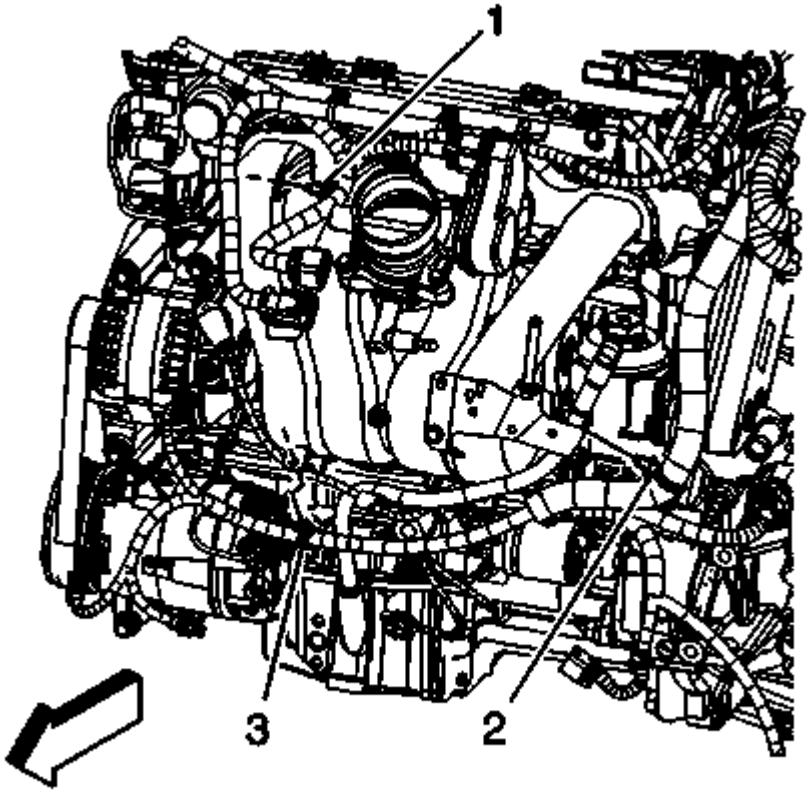

Fig. 77: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

13. Connect the engine harness clips (1 and 3) to the intake manifold.
14. Connect the engine harness clip (2) to the oil level indicator tube.
15. Connect the fuel injector electrical connector clip to the intake manifold.

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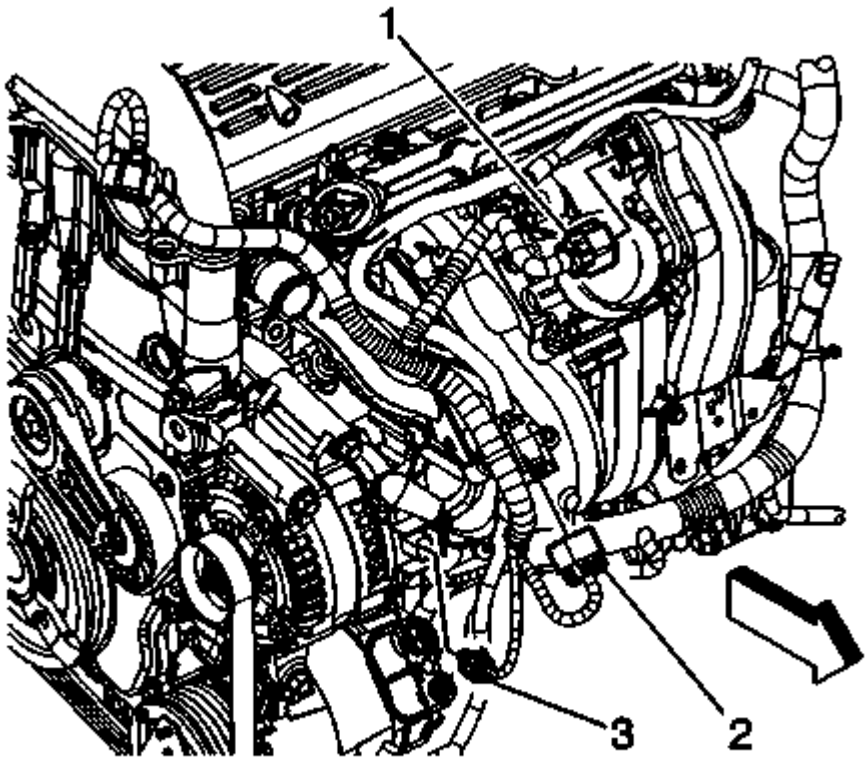

Fig. 78: Identifying Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

16. Connect the engine harness electrical connector (2) to the fuel injector harness.
17. Connect the engine harness electrical connector to the MAP sensor.
18. Connect the engine harness electrical connector (1) to the TAC.
19. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
20. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Crankshaft Balancer Replacement

Tools Required

- **J 38122-A** Harmonic Balancer Holder
- **J 45059** Angle Meter

Removal Procedure

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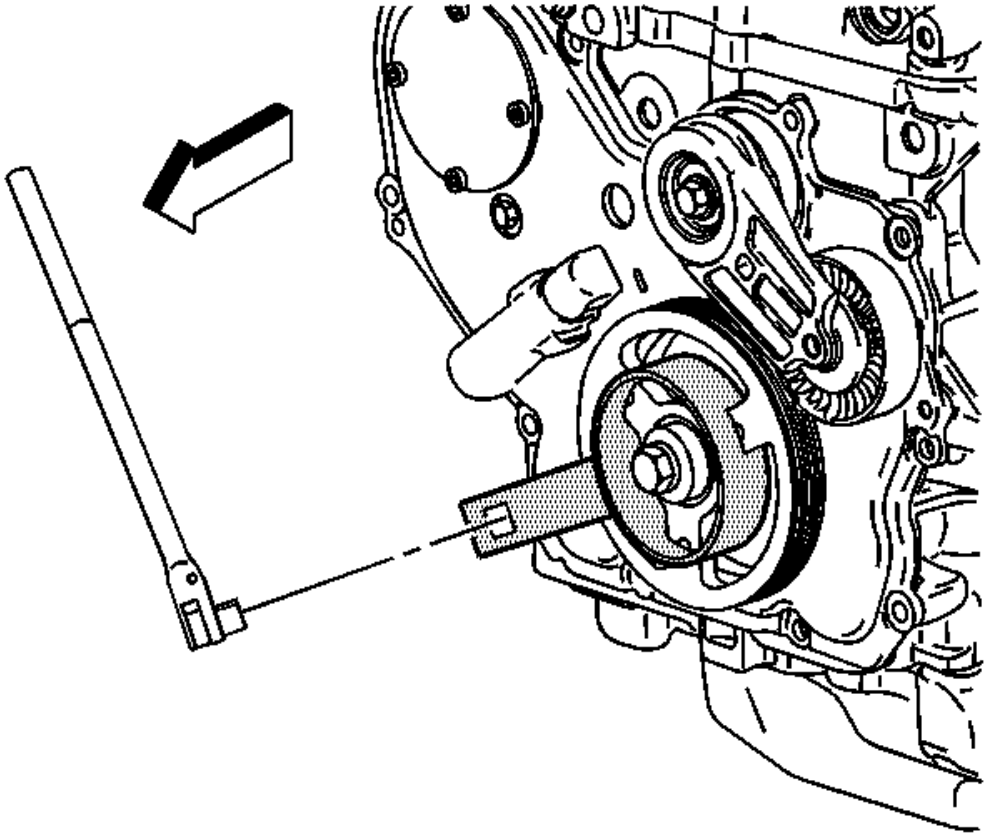

Fig. 79: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt. Refer to **Drive Belt Replacement**.
2. Use **J 38122-A** to prevent the crankshaft from rotating while loosening the crankshaft balancer bolt.
3. Remove and discard the crankshaft balancer bolt.

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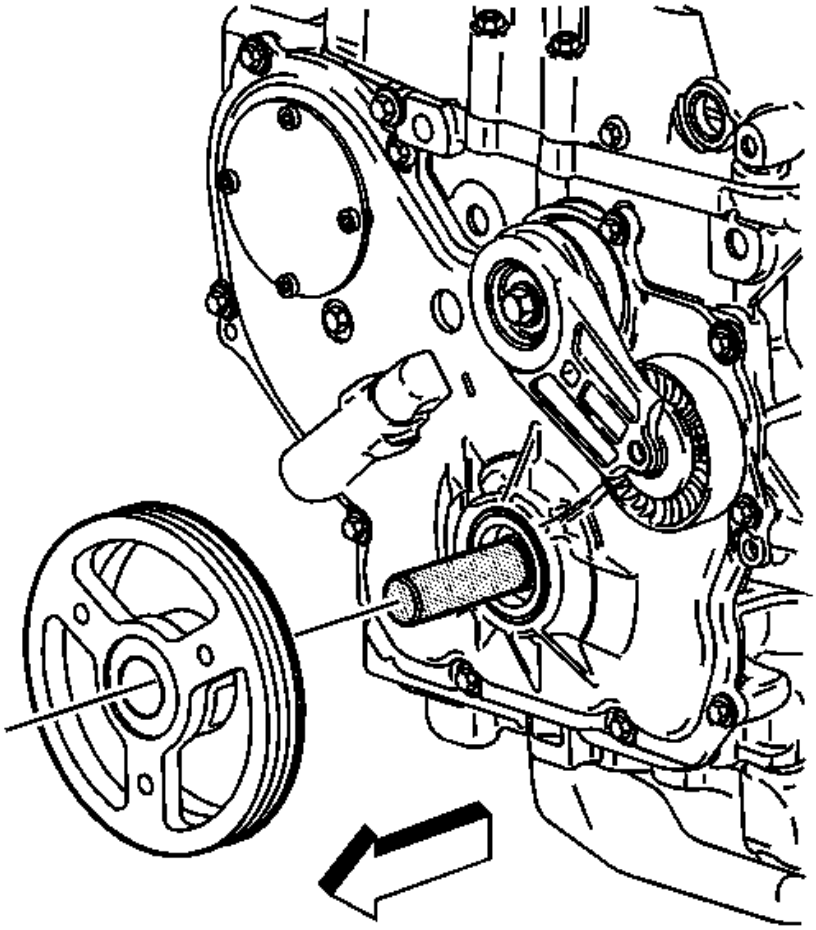

Fig. 80: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

Installation Procedure

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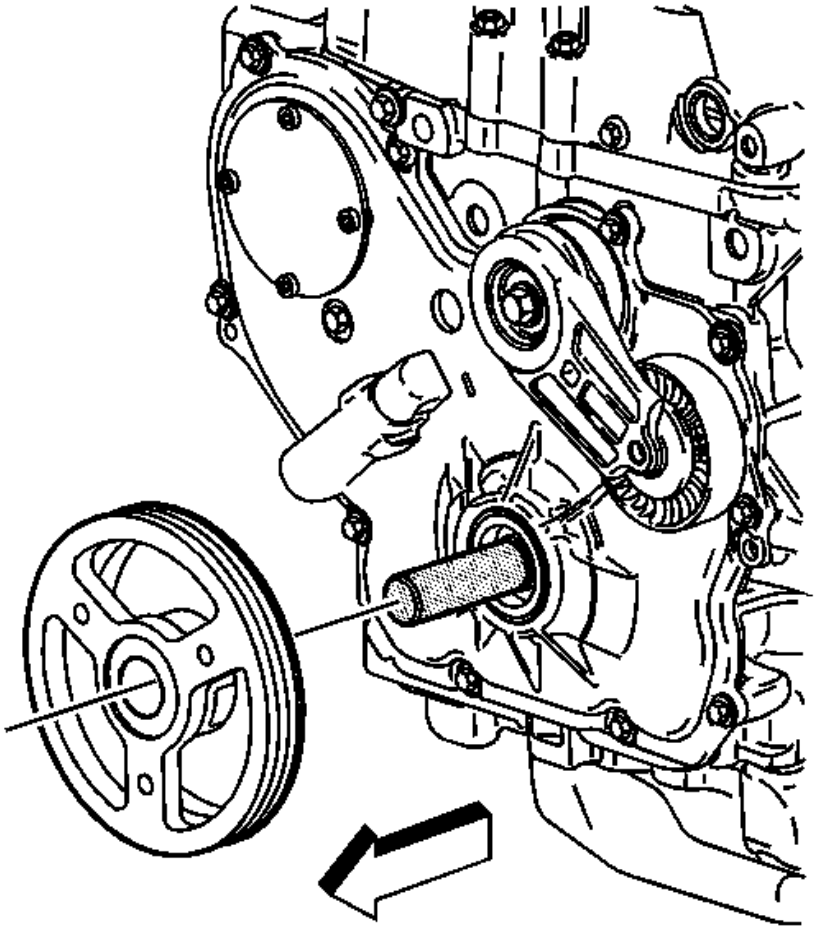

Fig. 81: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Position the crankshaft balancer.
2. Install a NEW crankshaft balancer bolt.

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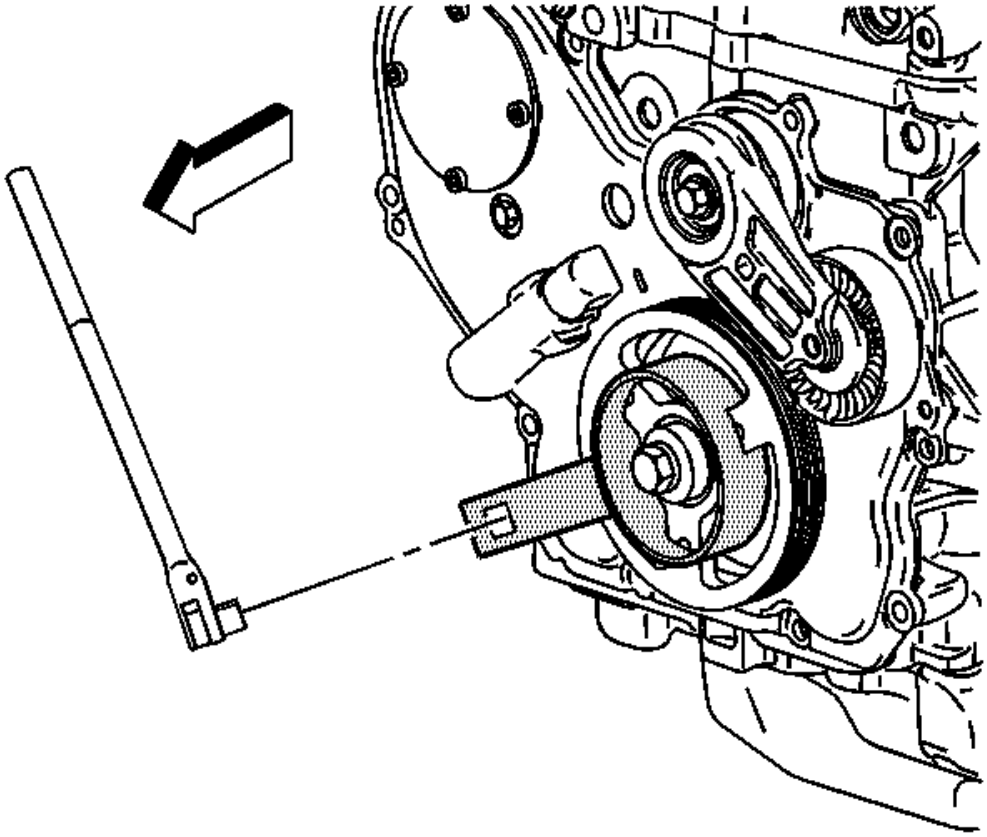

Fig. 82: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

3. Use the **J 38122-A** to hold the crankshaft balancer in order to prevent the balancer from rotating while tightening the bolt.

NOTE: **Refer to Fastener Notice .**

4. Tighten the crankshaft balancer bolt.

   Tighten: Tighten the bolt to 100 N.m (74 lb ft) plus an additional 125 degrees using the **J 45059** .

5. Install the drive belt. Refer to **Drive Belt Replacement**.

Crankshaft Front Oil Seal Replacement

Tools Required

J 35268-A Camshaft/Front Main Seal Installer. See **Special Tools**.

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Removal Procedure

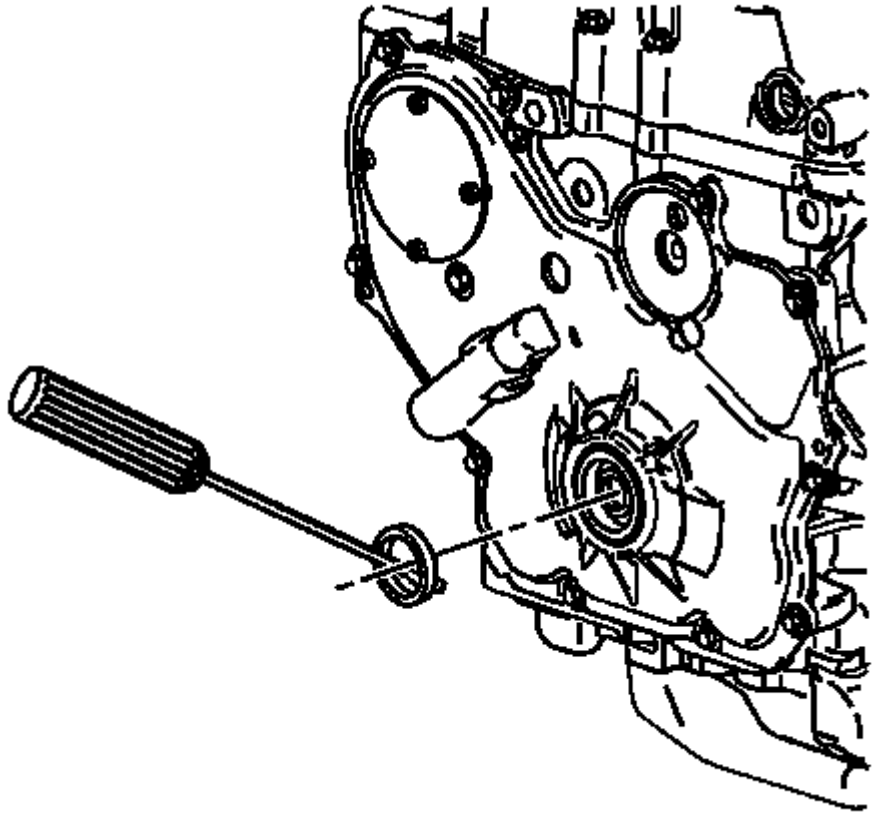

Fig. 83: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
2. Use a flat-bladed tool to remove the seal from the front cover.

Installation Procedure

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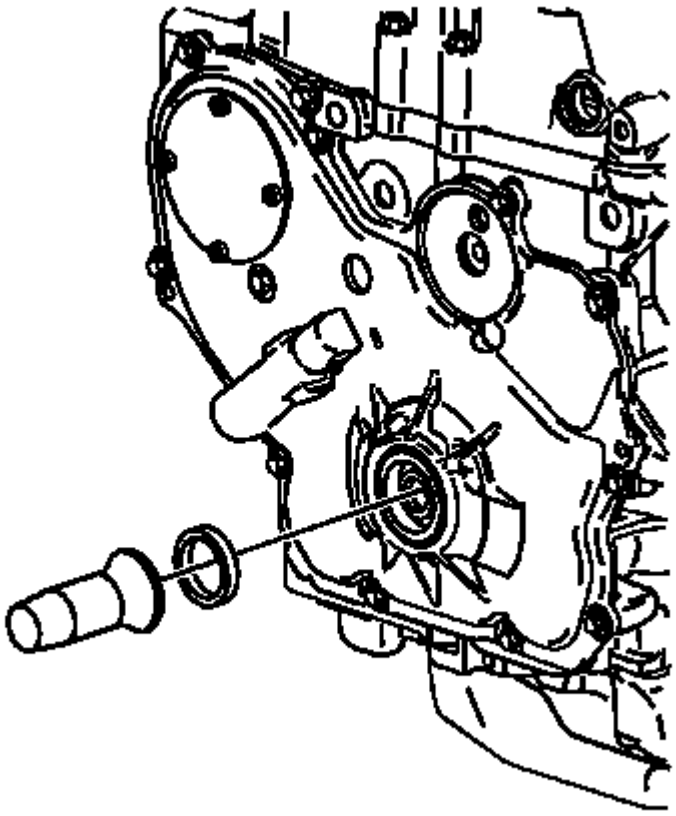

Fig. 84: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Use the **J 35268-A** in order to install the crankshaft front oil seal to the engine front cover. See **Special Tools**.
2. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Engine Front Cover Replacement

Removal Procedure

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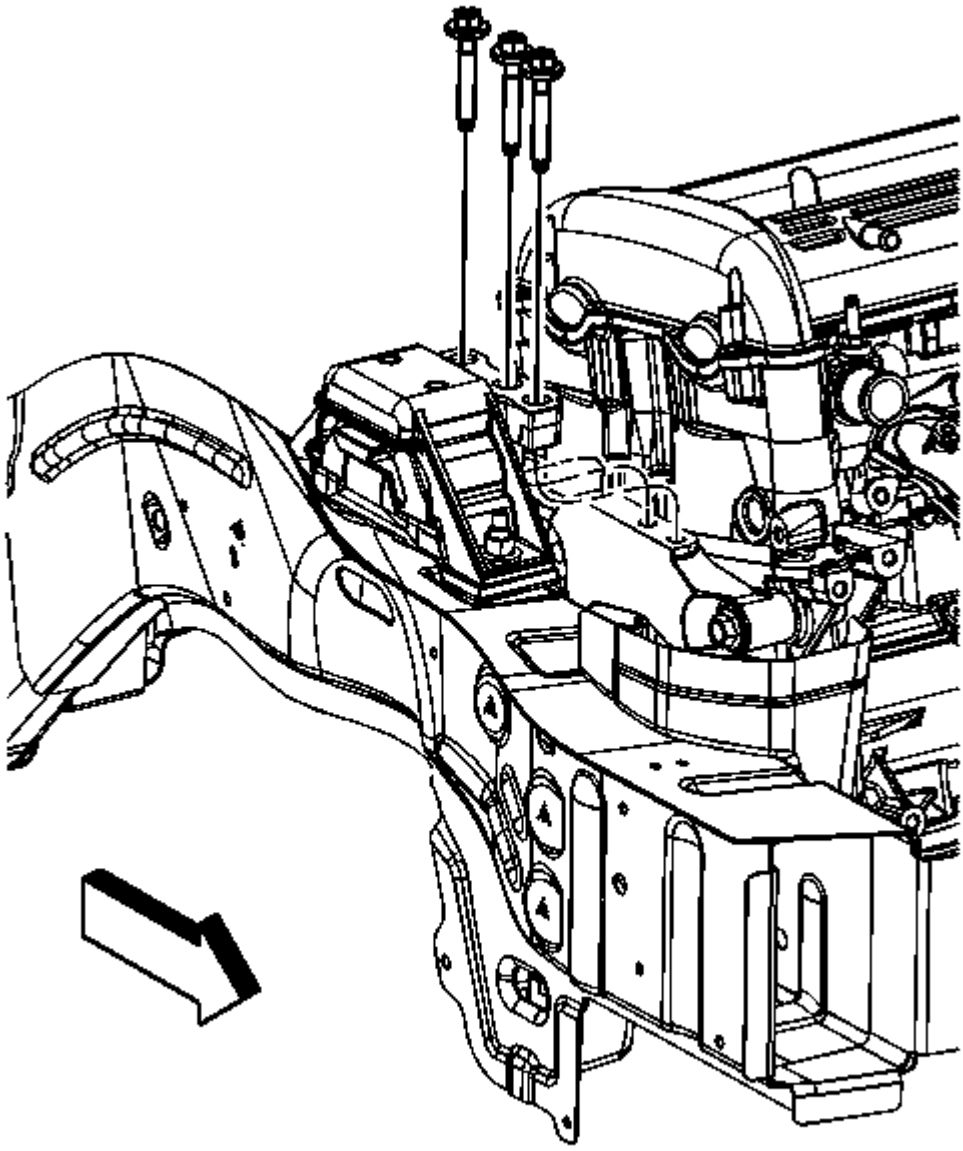

Fig. 85: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
4. Remove the windshield washer solvent reservoir. Refer to **Washer Solvent Container Replacement** .

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5. Install the engine support fixture. Refer to **Engine Support Fixture**.
6. Remove the engine mount to bracket bolts.

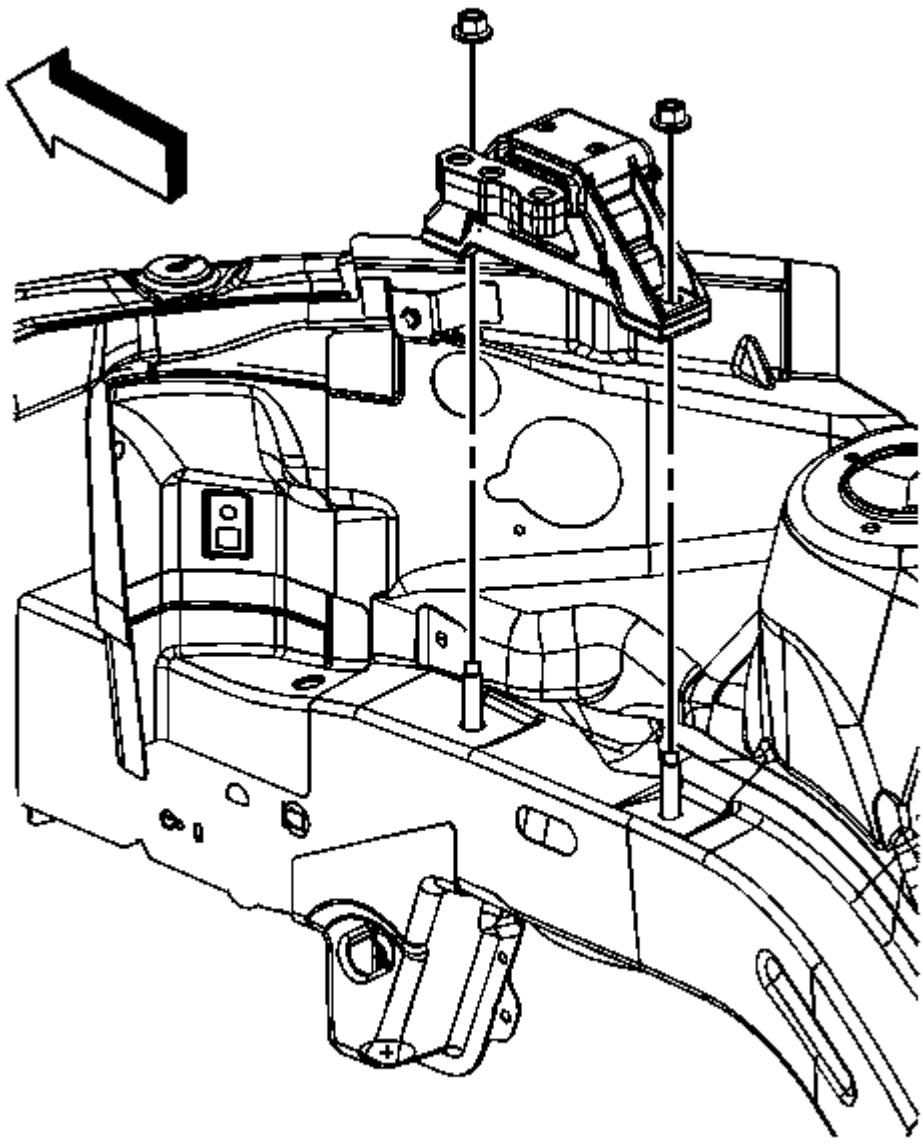

Fig. 86: Engine Mount To Side Rail Nuts
Courtesy of GENERAL MOTORS CORP.

7. Remove the engine mount to side rail nuts.

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8. Remove the engine mount from the engine compartment.

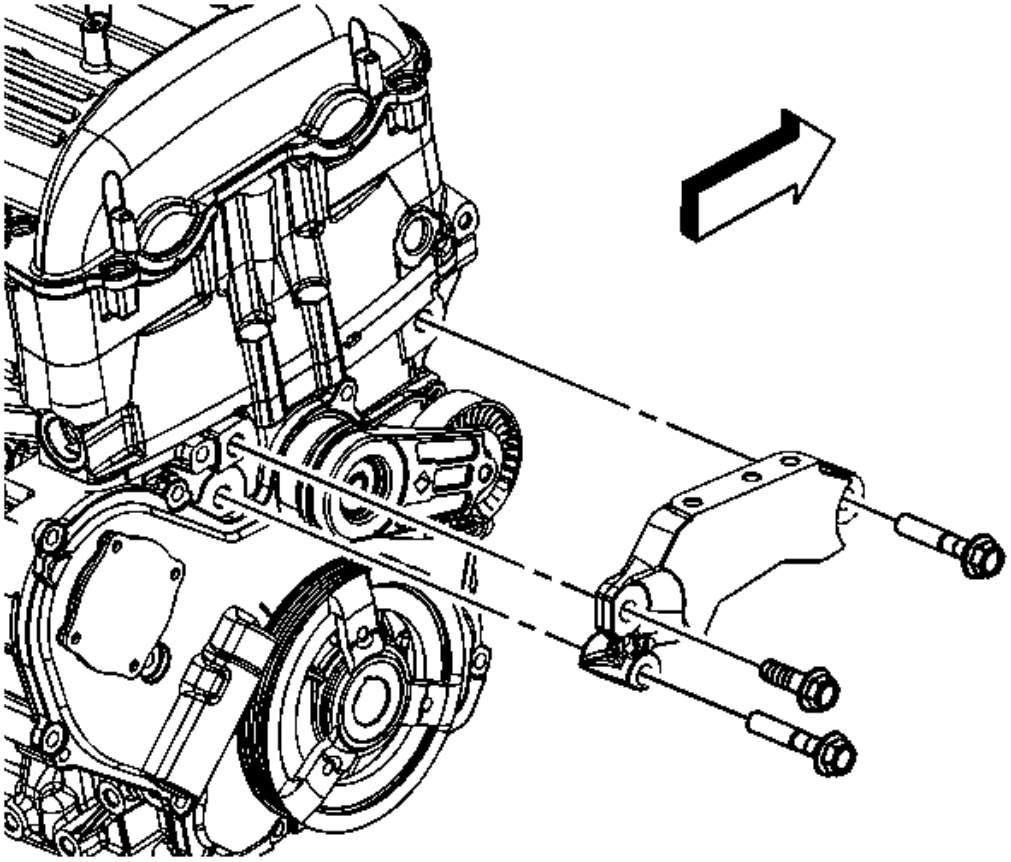

Fig. 87: Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

9. Remove the engine mount bracket to engine bolts.
10. Remove the engine mount bracket.

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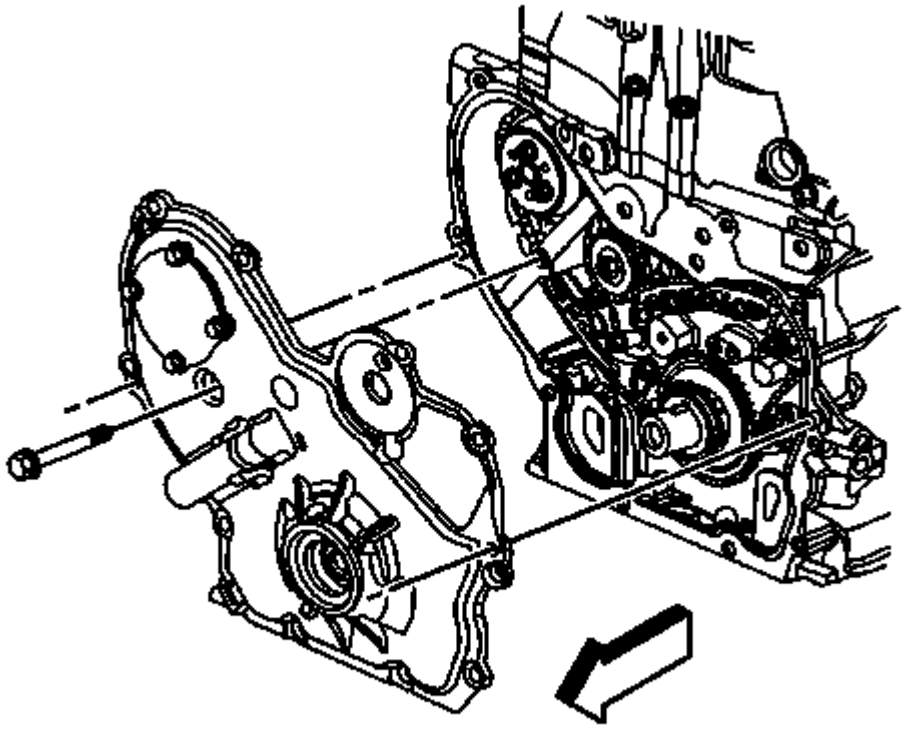

Fig. 88: View Of Engine Front Cover-To-Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine front cover to water pump bolt.

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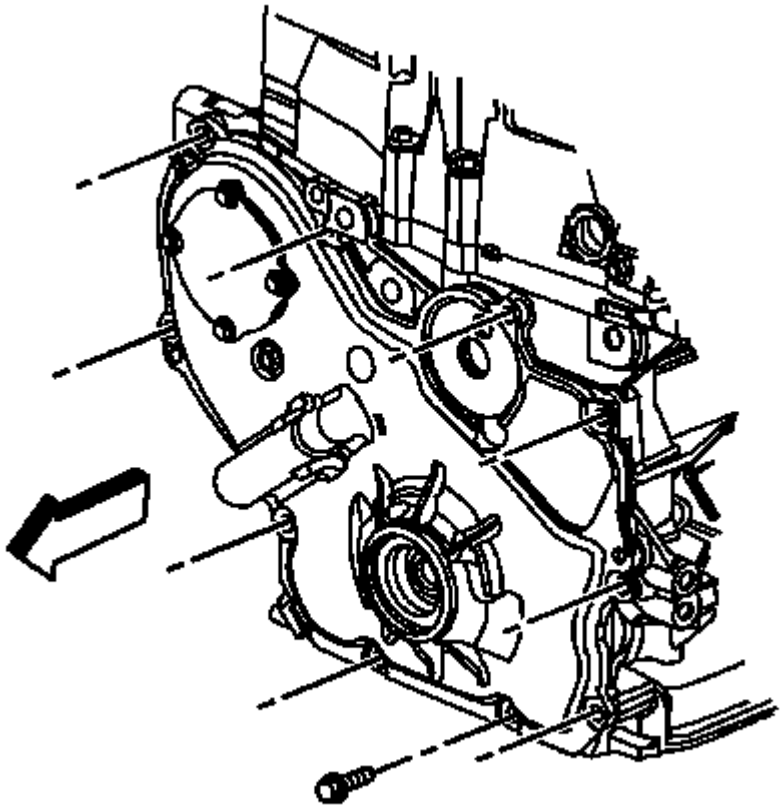

Fig. 89: Identifying Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

12. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
13. Remove the engine front cover bolts.
14. Remove the engine front cover.

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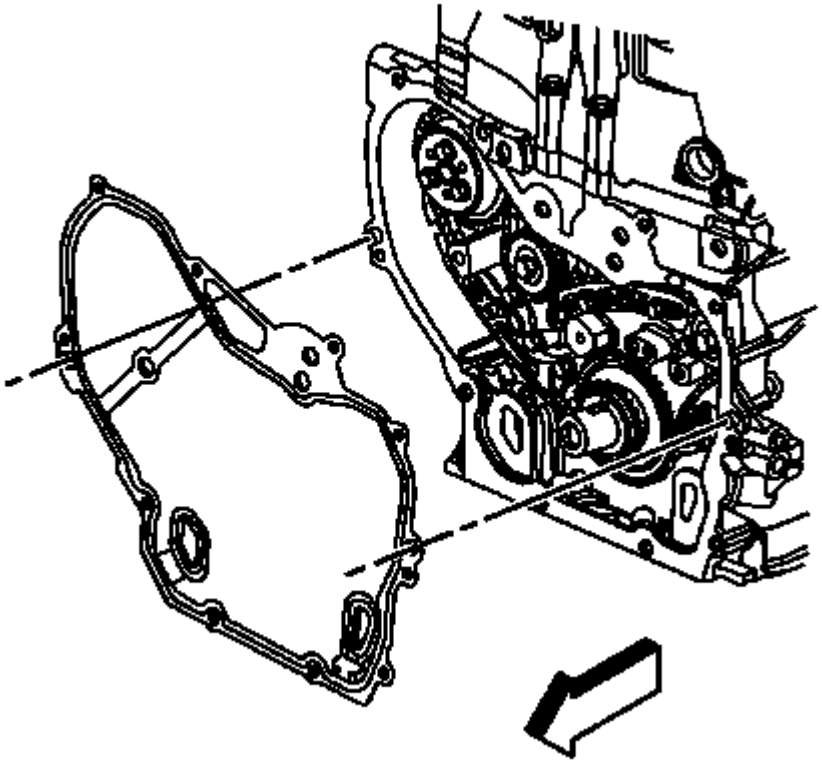

Fig. 90: Identifying Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

15. Remove and discard the engine front cover gasket.

Installation Procedure

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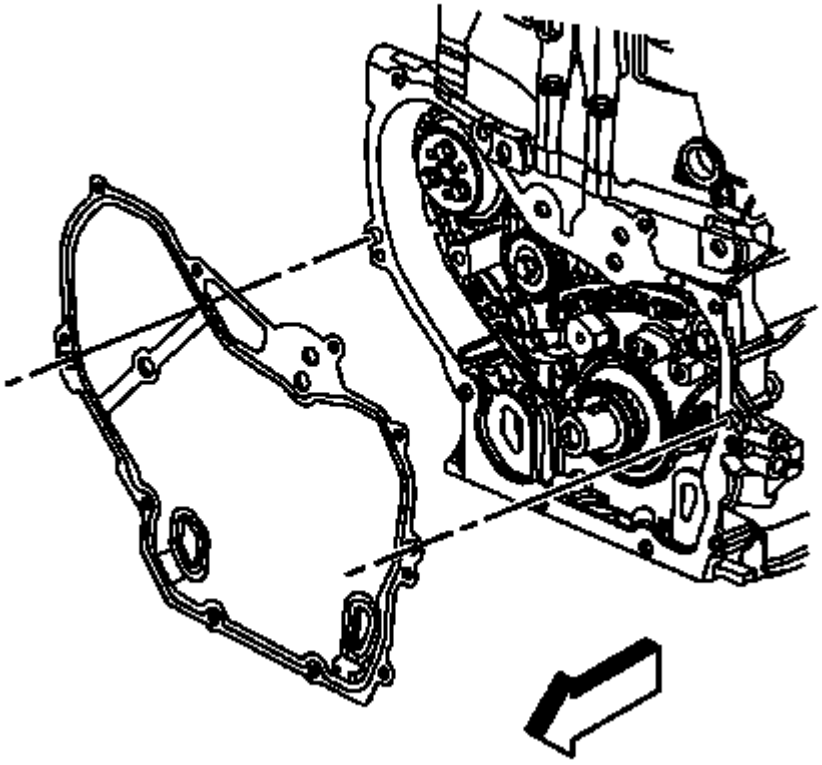

Fig. 91: Identifying Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install a NEW engine front cover gasket to the dowel pins.
2. Install the engine front cover.

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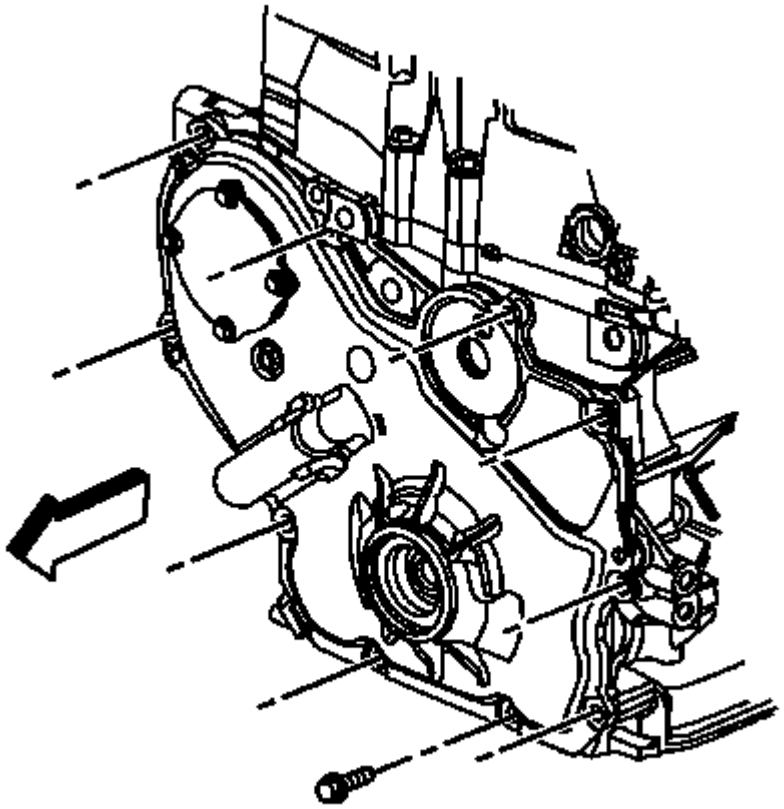

Fig. 92: Identifying Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

3. Install the engine front cover bolts.

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

4. Lower the vehicle.

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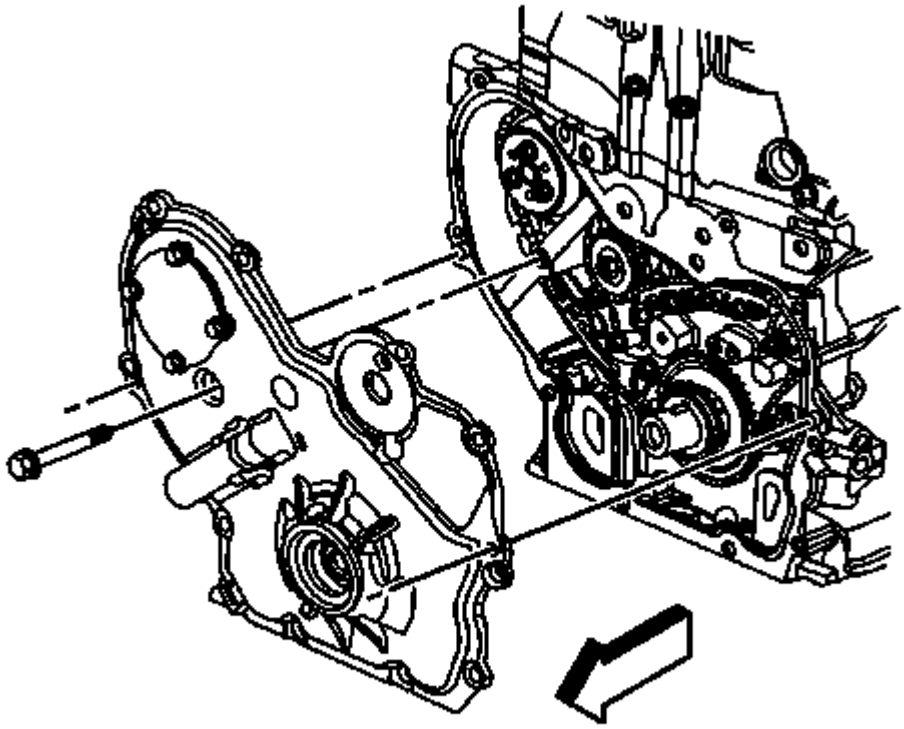

Fig. 93: View Of Engine Front Cover-To-Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

5. Install the engine front cover to water pump bolt.

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

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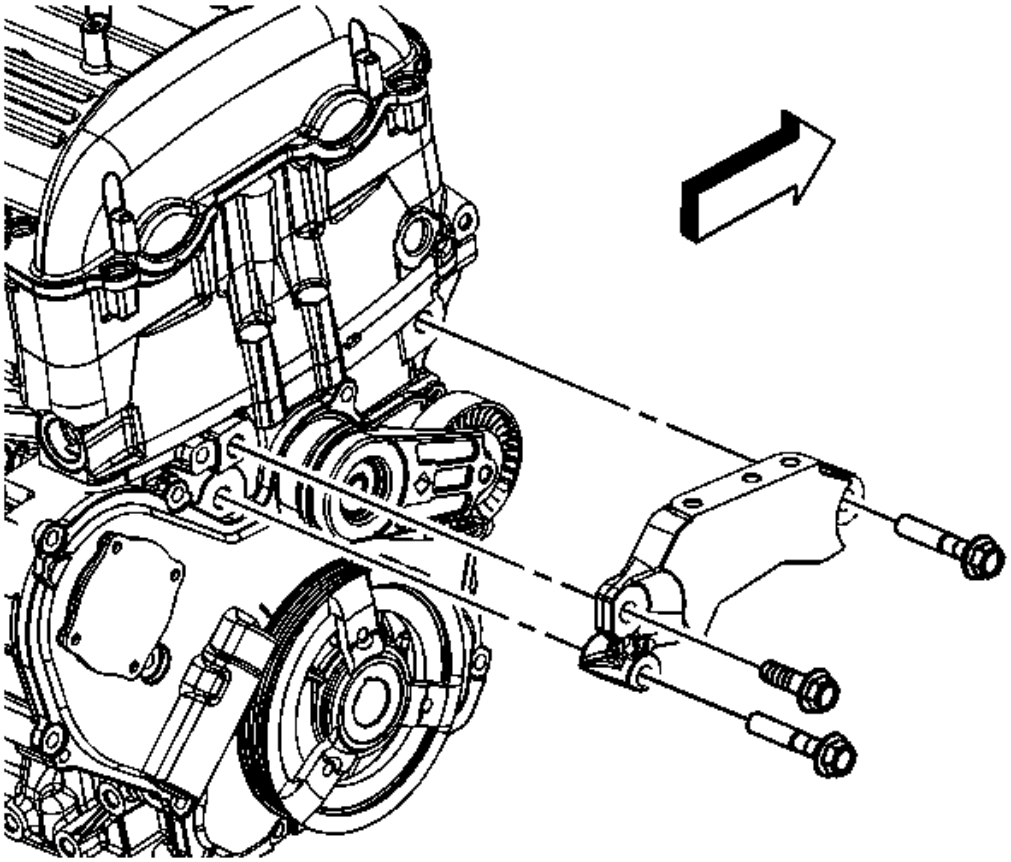

Fig. 94: Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

6. Position the engine mount bracket to the engine.
7. Install the engine mount bracket bolts in the following locations.
    - The long bolts in the forward and lower rear holes
    - The short bolt in the upper rear hole
8. Tighten the engine mount bracket bolts in the following sequence.
    1. Upper rear
    2. Lower rear
    3. Forward

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

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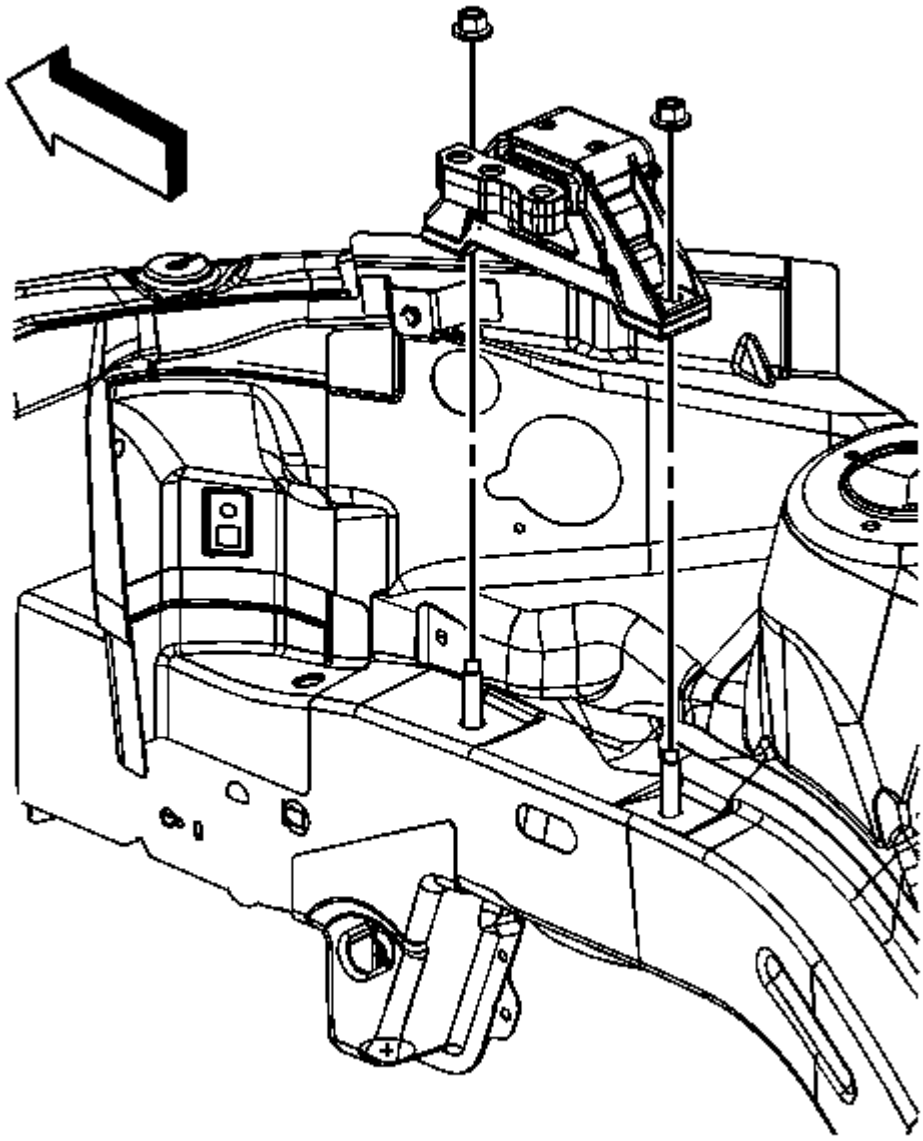

Fig. 95: Engine Mount To Side Rail Nuts
Courtesy of GENERAL MOTORS CORP.

9. Install the engine mount to the engine compartment.
10. Install the engine mount to side rail nuts.

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

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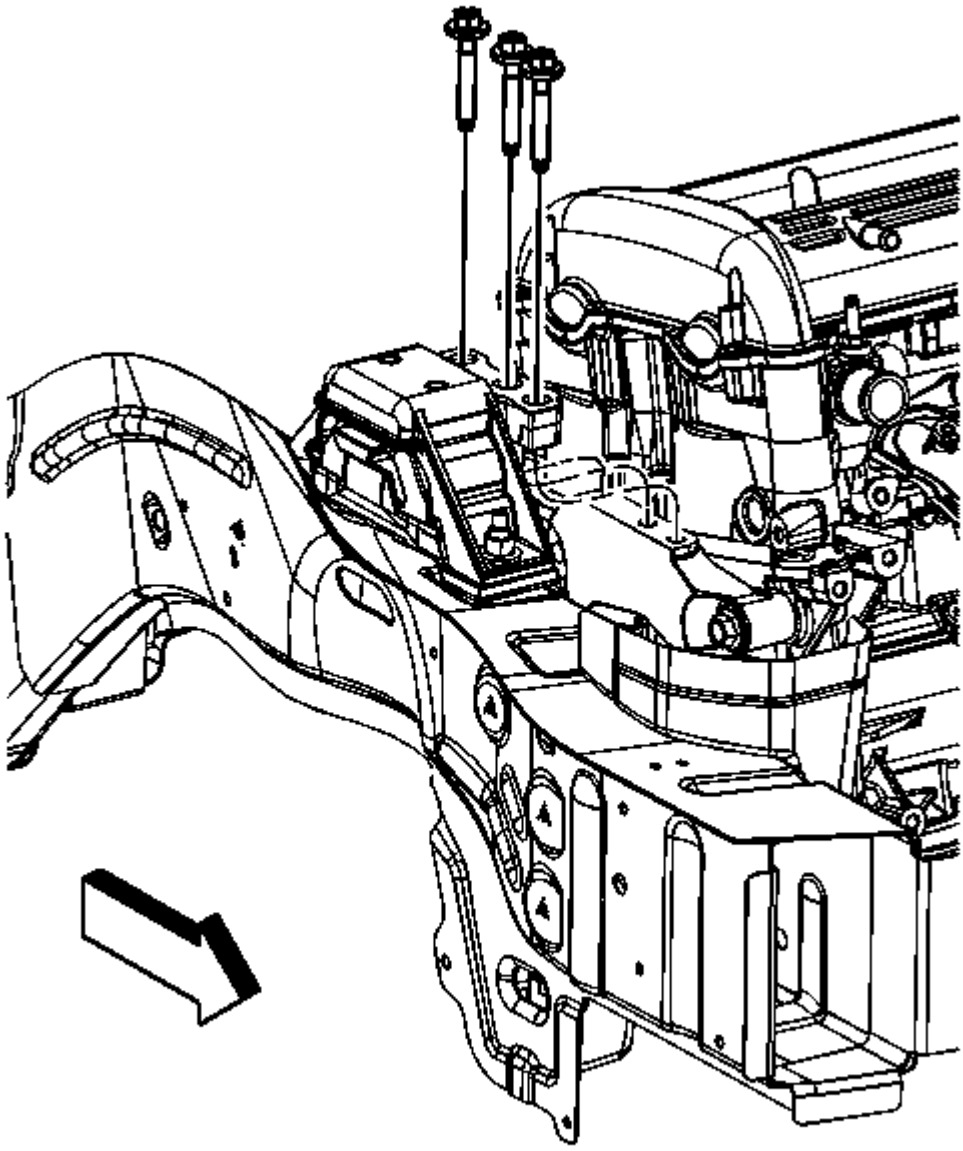

Fig. 96: Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

11. Install the engine mount to bracket bolts.
12. Tighten the engine mount to bracket bolts in the following sequence.
    1. Middle
    2. Rear

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3. Front

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

13. Remove the engine support fixture. Refer to **Engine Support Fixture**.
14. Install the windshield washer solvent reservoir. Refer to **Washer Solvent Container Replacement** .
15. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
16. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
17. Install the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement**.

Timing Chain, Sprockets, and/or Tensioner Replacement

Tools Required

- **J 45027** Tensioner Tool
- **J 45059** Angle Meter

Removal Procedure

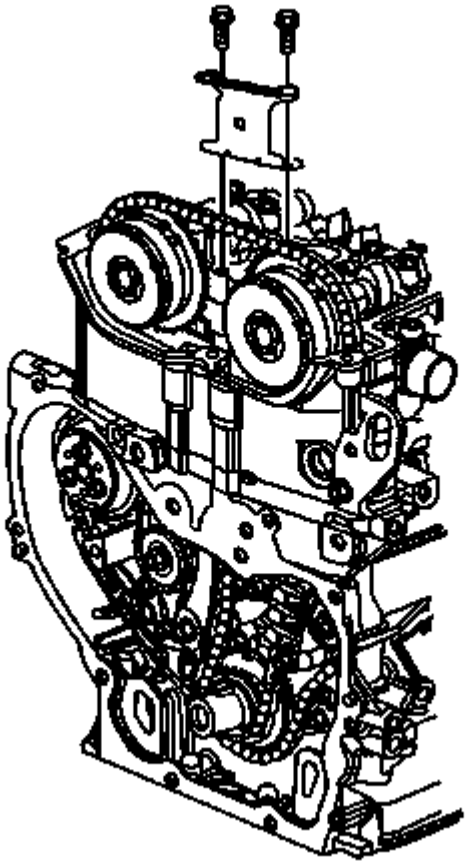

Fig. 97: View Of Upper Timing Chain Guide Bolts And Guide

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Courtesy of GENERAL MOTORS CORP.

1. Remove the #1 cylinder spark plug. Refer to **Spark Plug Replacement** .
2. Rotate the crankshaft in the engine rotational direction clockwise, until the #1 piston is at top dead center (TDC) on the exhaust stroke.
3. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
4. Remove the engine front cover. Refer to **Engine Front Cover Replacement**.
5. Remove the upper timing chain guide bolts and guide.

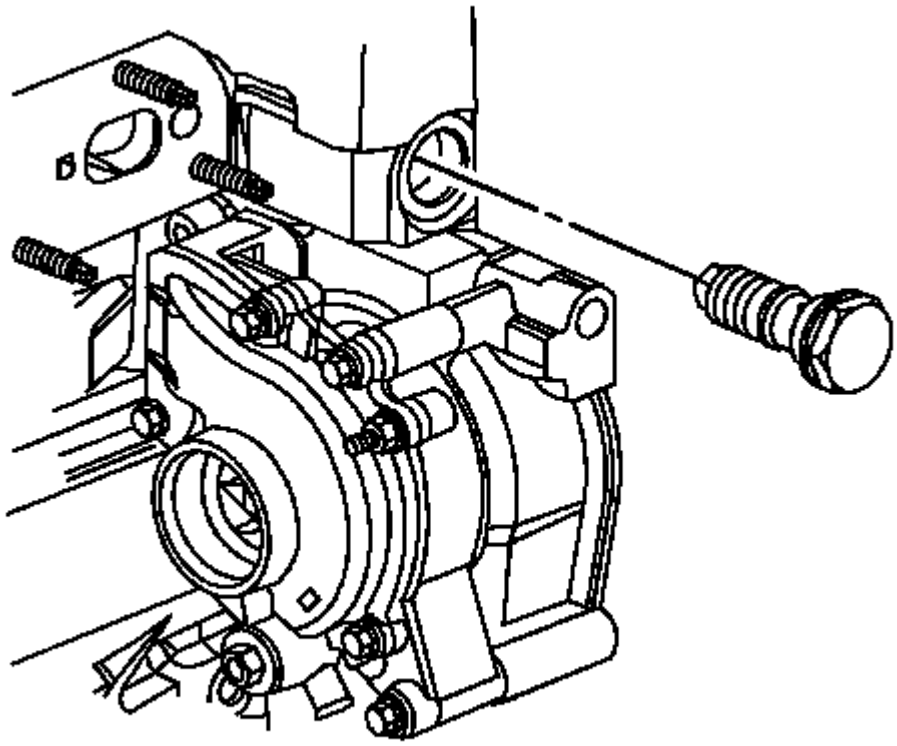

Fig. 98: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

6. Remove the timing chain tensioner.

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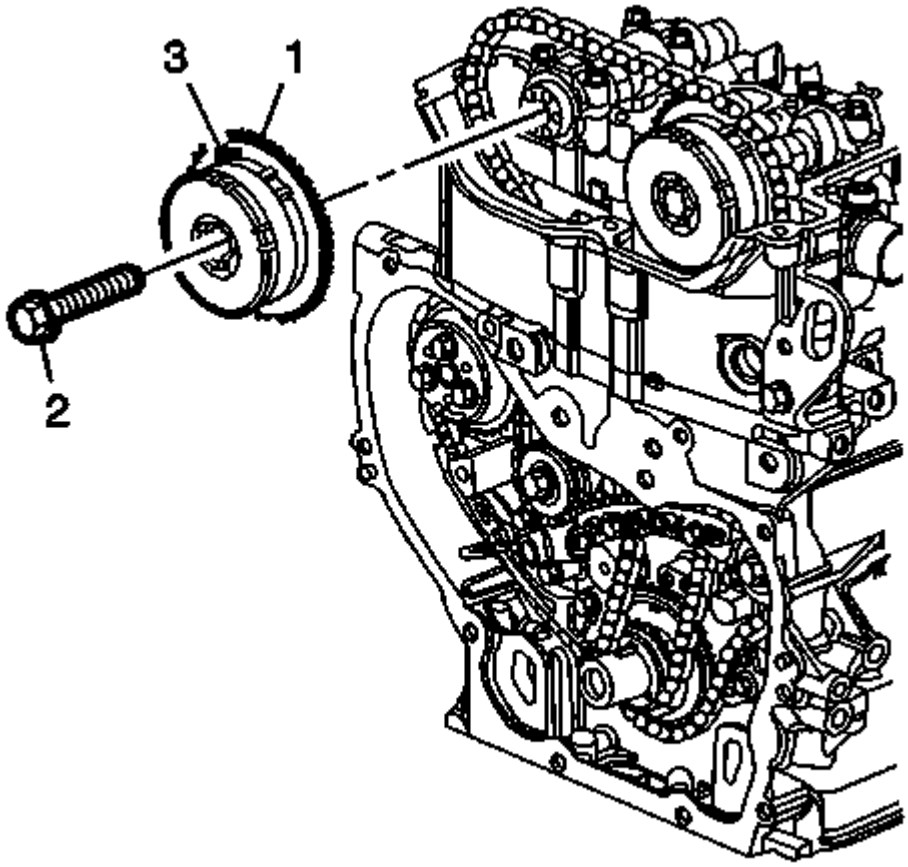

Fig. 99: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

7. Install a 24 mm wrench on the hex on the exhaust camshaft in order to hold the camshaft.
8. Remove and discard the exhaust camshaft actuator bolt (2).
9. Remove the exhaust camshaft actuator (1) from the camshaft and timing chain.

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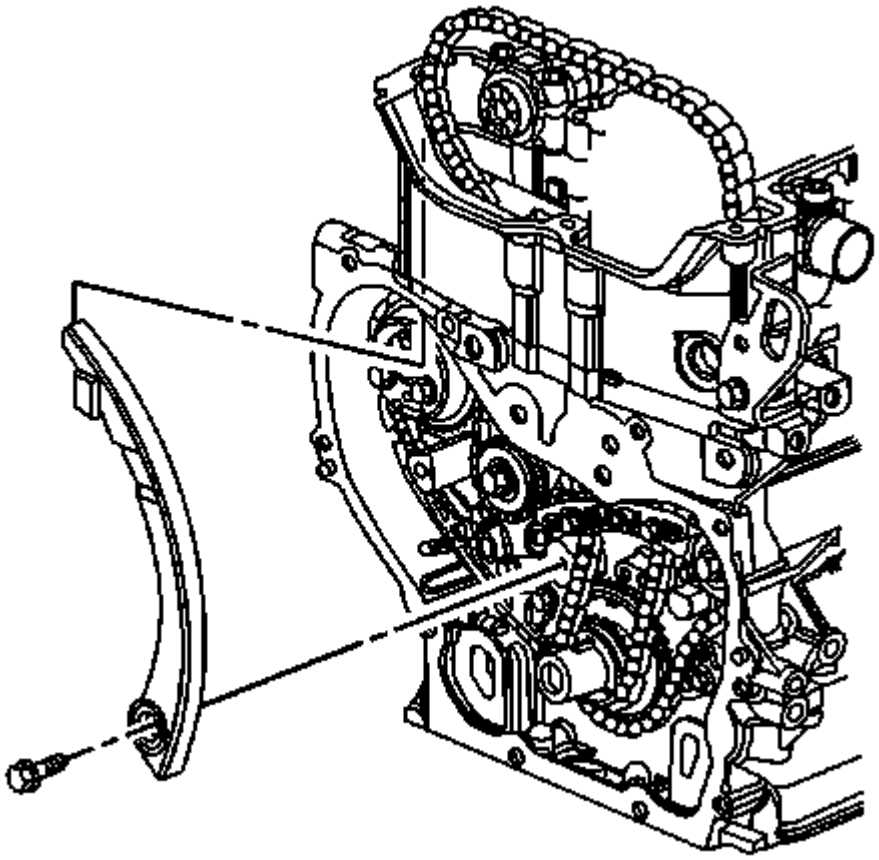

Fig. 100: Identifying Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner guide bolt and guide.

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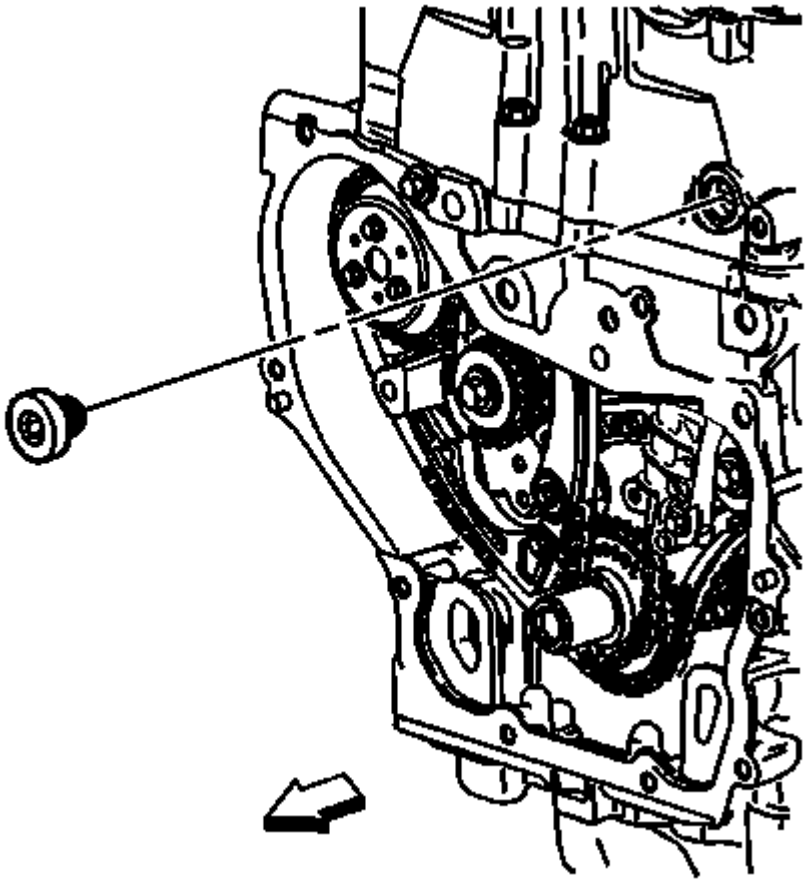

Fig. 101: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

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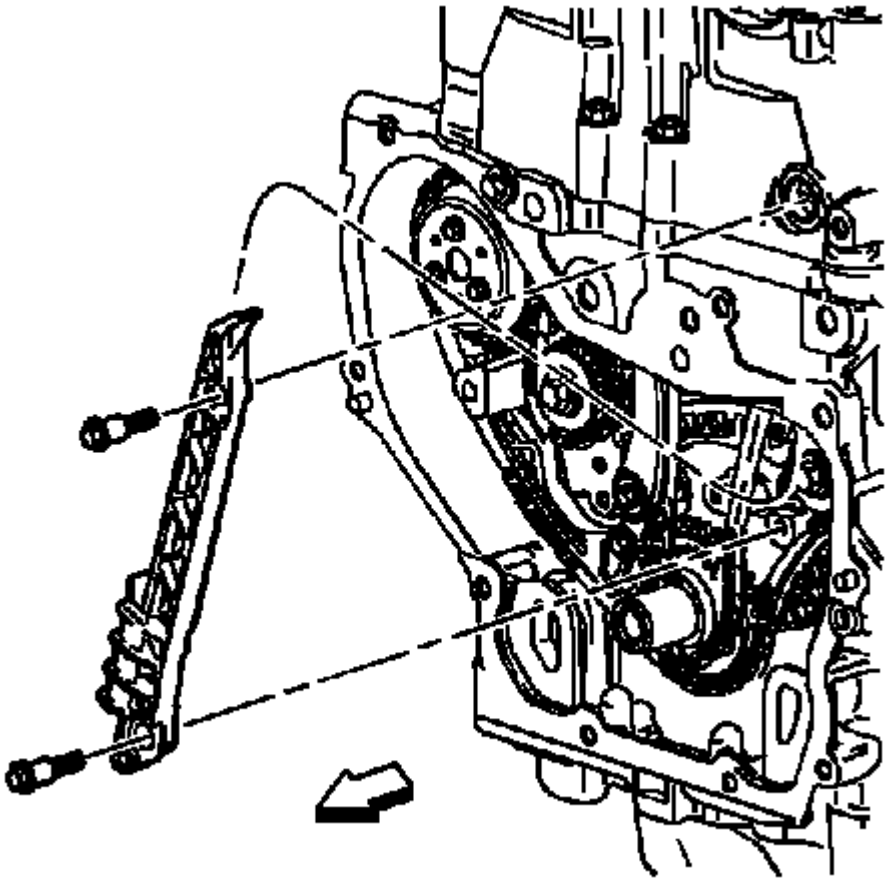

Fig. 102: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

12. Remove the fixed timing chain guide bolts and guide.

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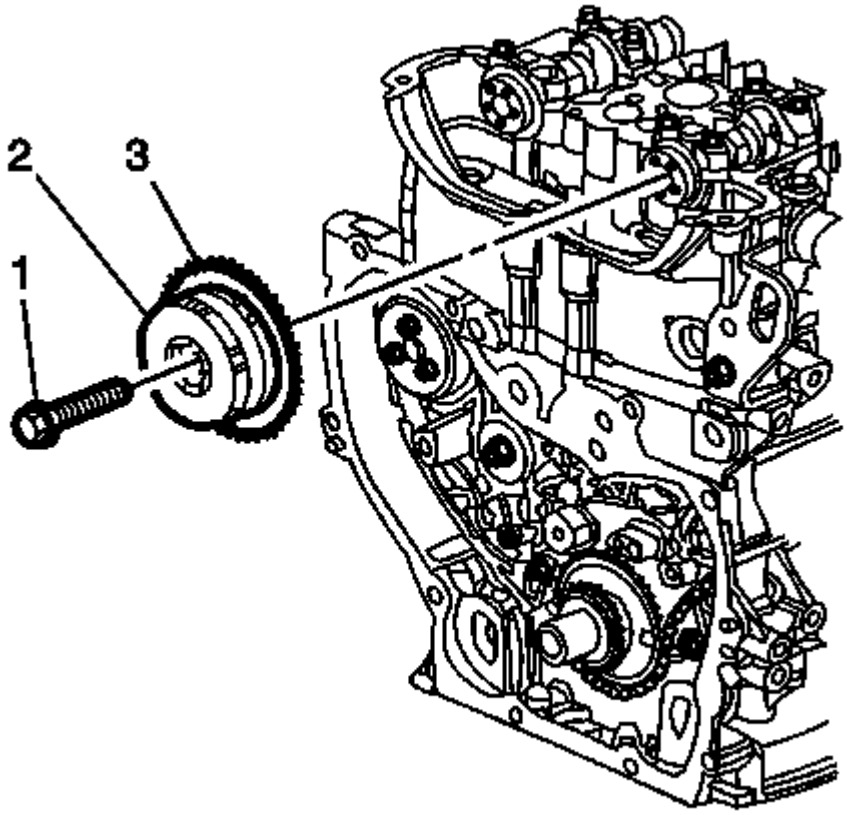

Fig. 103: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Install a 24 mm wrench on the hex on the intake camshaft in order to hold the camshaft.
14. Remove and discard the intake camshaft actuator bolt (2).
15. Remove the intake camshaft actuator (3), and the timing chain through the top of the cylinder head.

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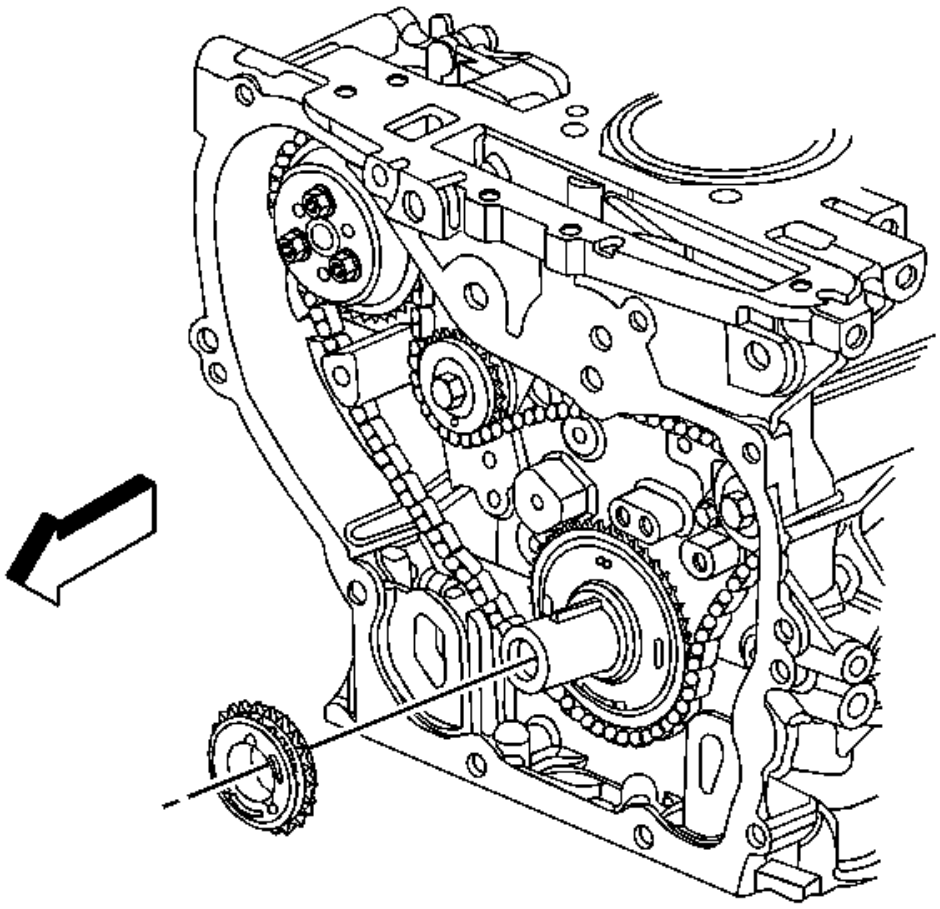

Fig. 104: Identifying Timing Chain Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Remove the timing chain crankshaft sprocket.

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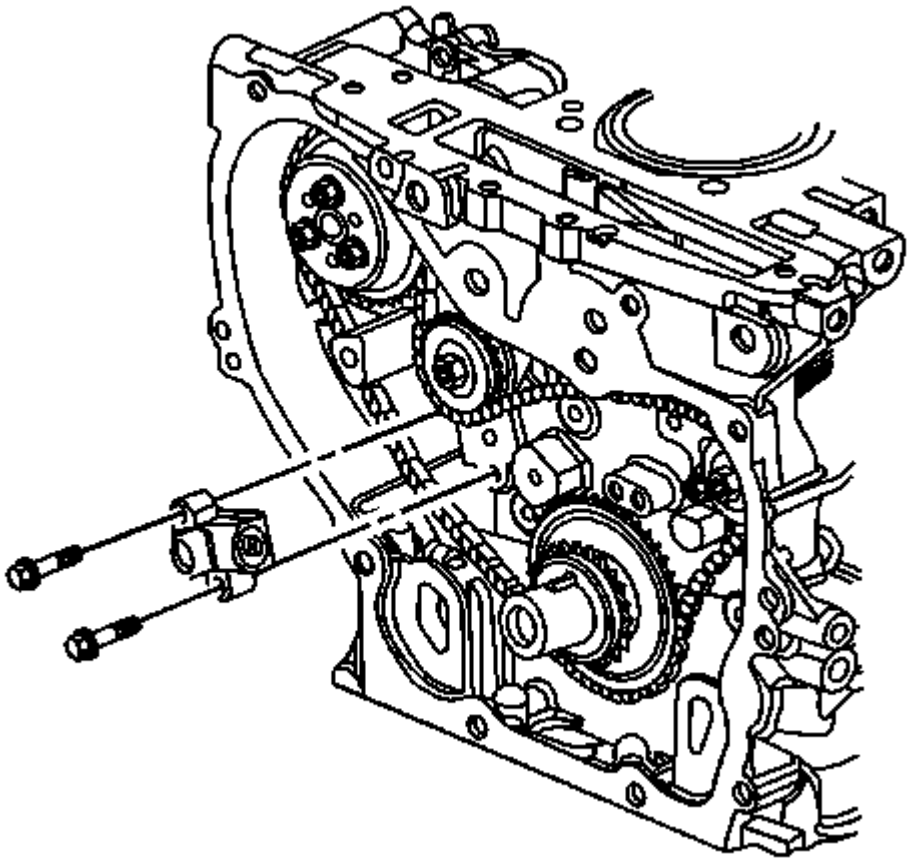

Fig. 105: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

17. If replacing the balance shaft timing chain and sprocket, perform the following steps. If not, proceed the step 10 in the installation procedure.
18. Remove the balance shaft drive chain tensioner bolts and tensioner.

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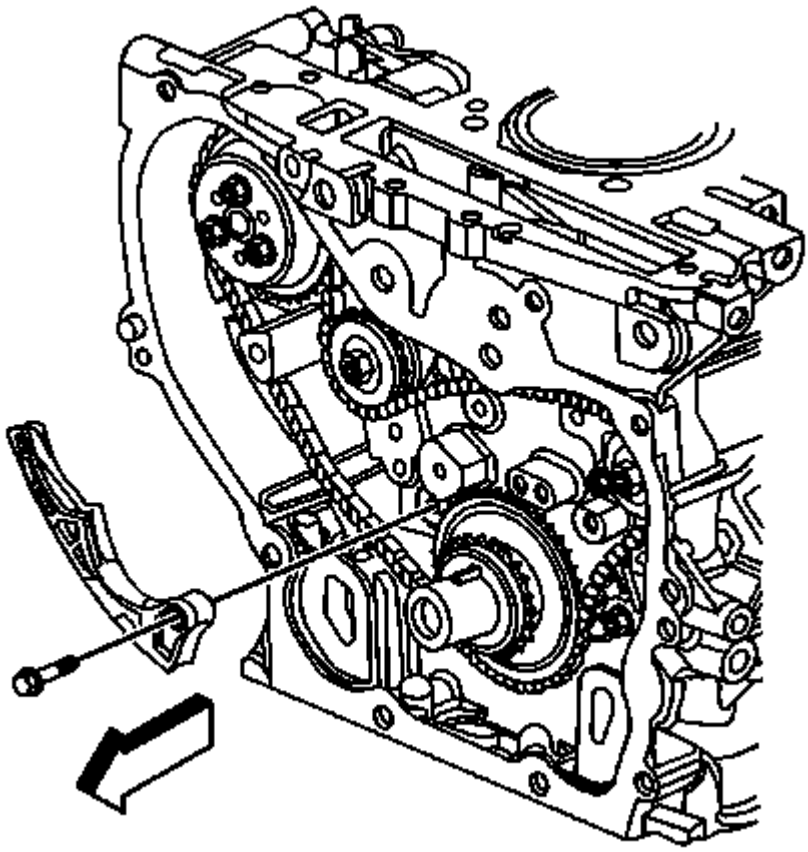

Fig. 106: Identifying Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

19. Remove the adjustable balance shaft chain guide bolt and guide.

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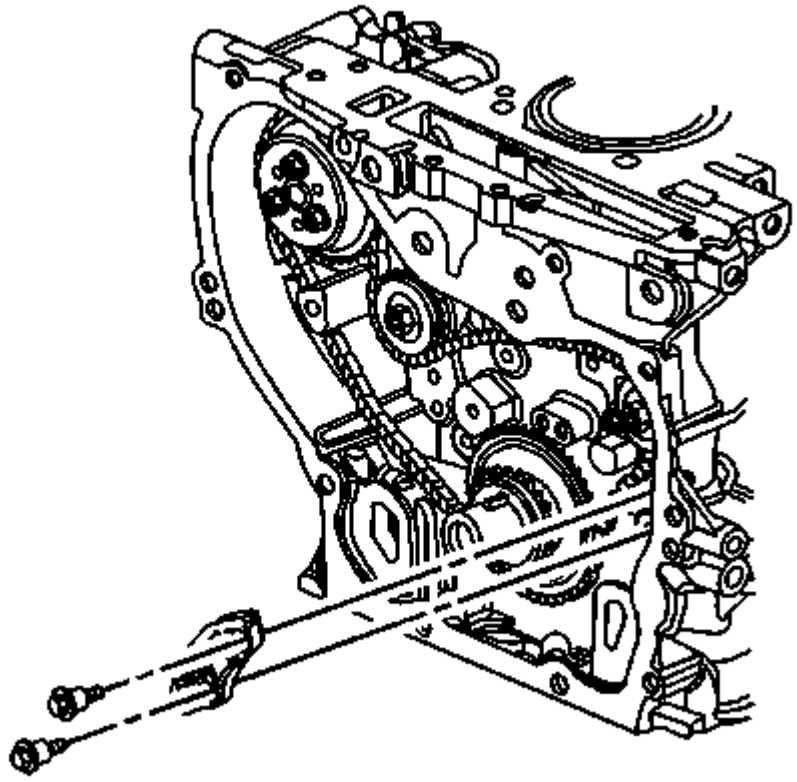

Fig. 107: Identifying Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Remove the small balance shaft drive chain guide bolts and guide.

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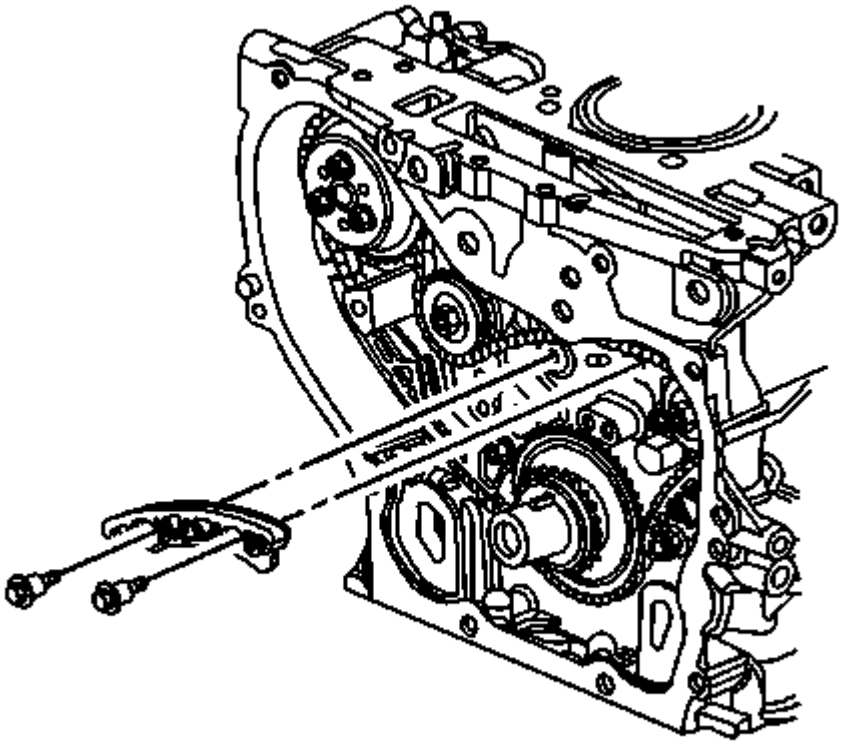

Fig. 108: Identifying Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

21. Remove the upper balance shaft drive chain guide bolts and guide.

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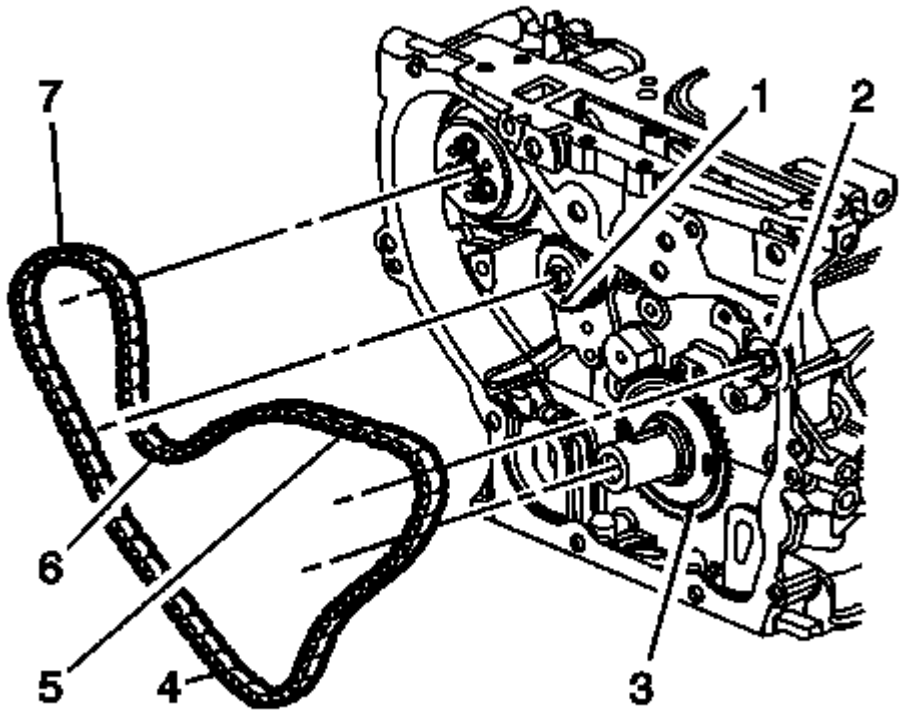

Fig. 109: Identifying Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may ease removal of the balance shaft drive chain to get all the slack in the chain between the crankshaft and water pump sprockets.

22. Remove the balance shaft drive chain (7).
23. Remove the balance shaft drive sprocket.

Installation Procedure

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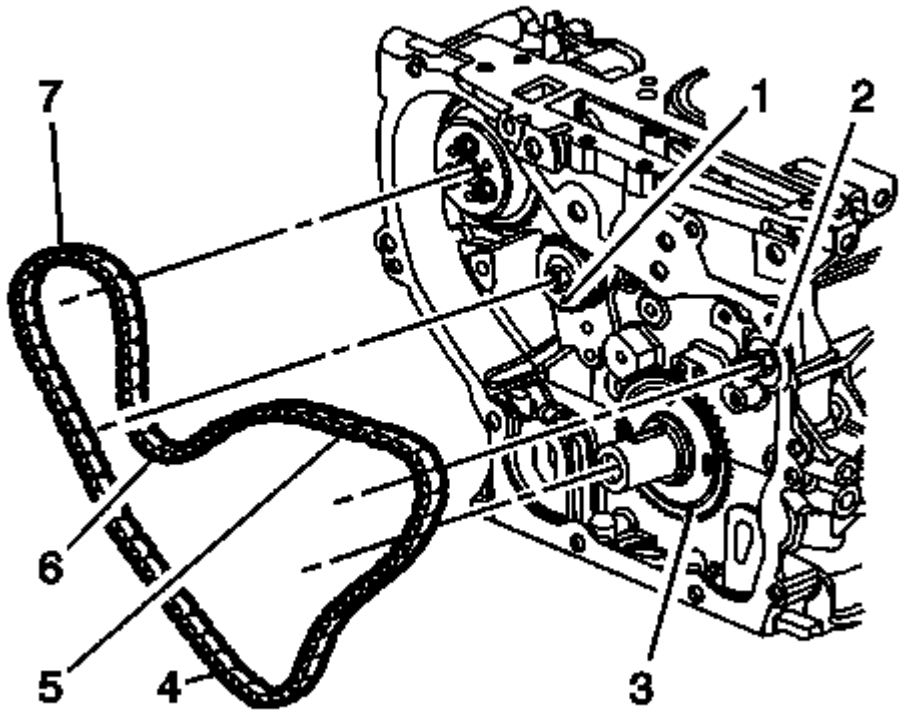

Fig. 110: Identifying Balance Shaft Drive Chain Components
Courtesy of GENERAL MOTORS CORP.

1. If replacing the balance shaft timing chain, perform the following steps. If not, proceed to step 10.
2. Install the balance shaft drive sprocket.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

3. Install the balance shaft drive chain (1) with the colored link lined up with the marks on the balance shaft sprockets and the balance shaft drive sprocket. There are 3 colored links on the chain. Two are chrome and one is copper. Use the following steps in order to line up the links with the sprockets.
   - Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft sprocket.
   - Working clockwise around the chain, place the chrome link (4) in line with the timing mark (3) on the balance shaft drive sprocket. (approximately 6 o'clock position on the sprocket)
   - Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
   - Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

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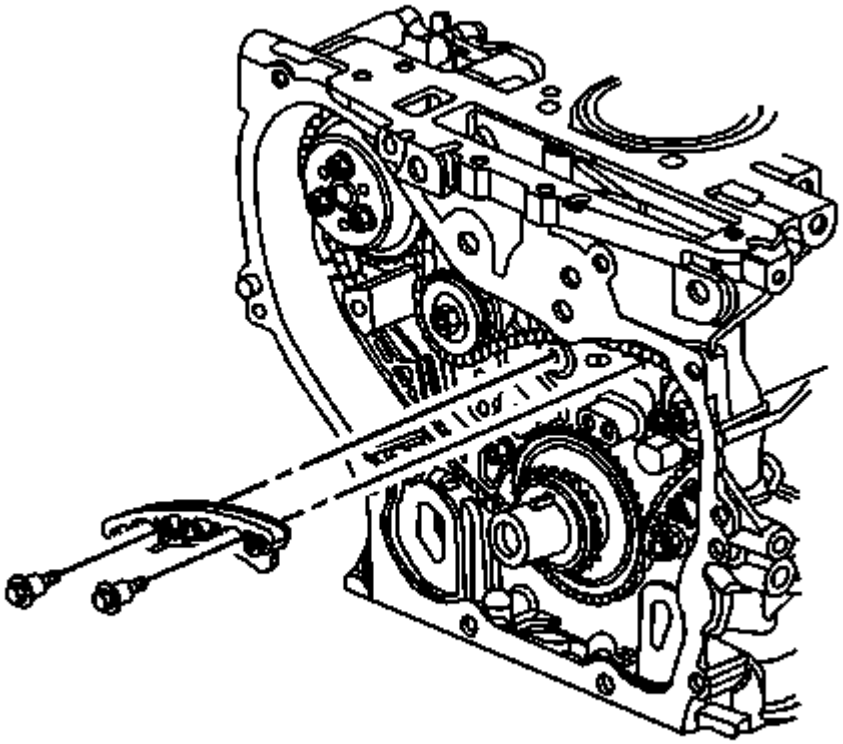

Fig. 111: Identifying Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

4. Install the upper balance shaft drive chain guide and bolts.

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

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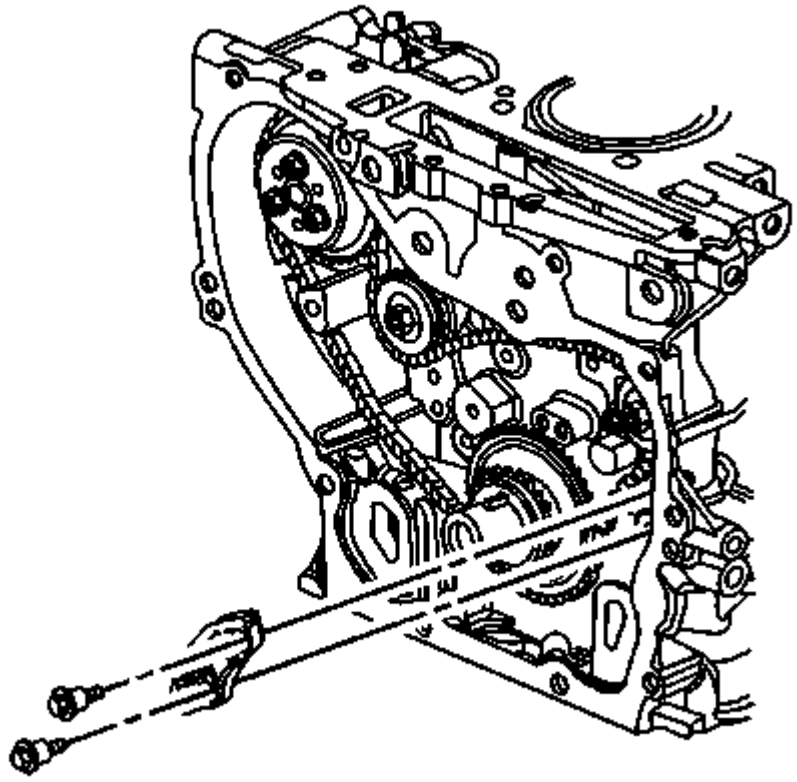

Fig. 112: Identifying Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts.

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

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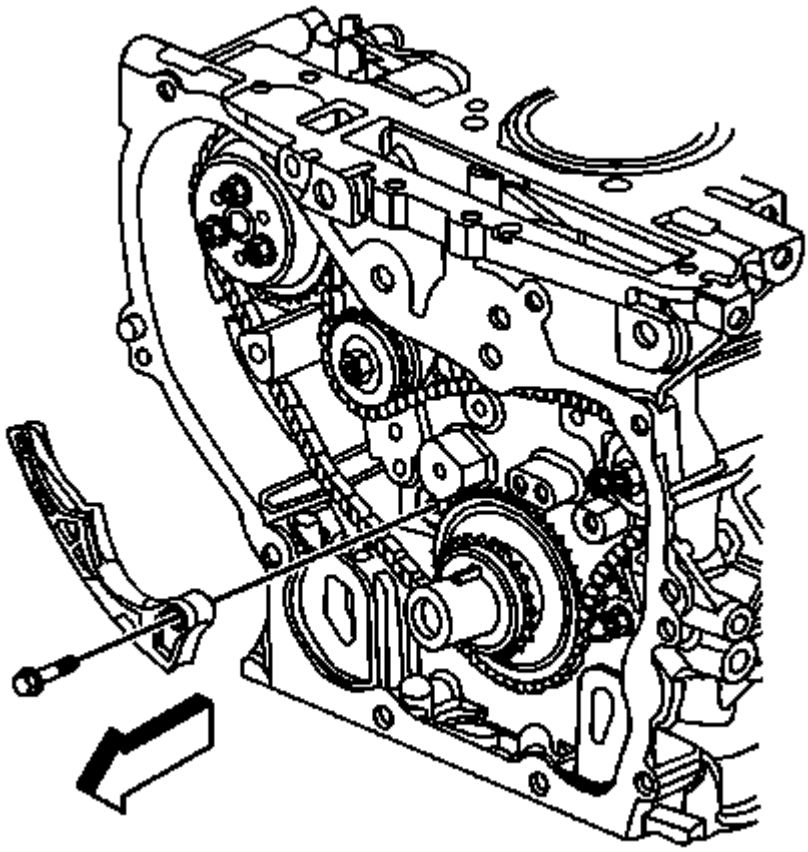

Fig. 113: Identifying Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt.

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

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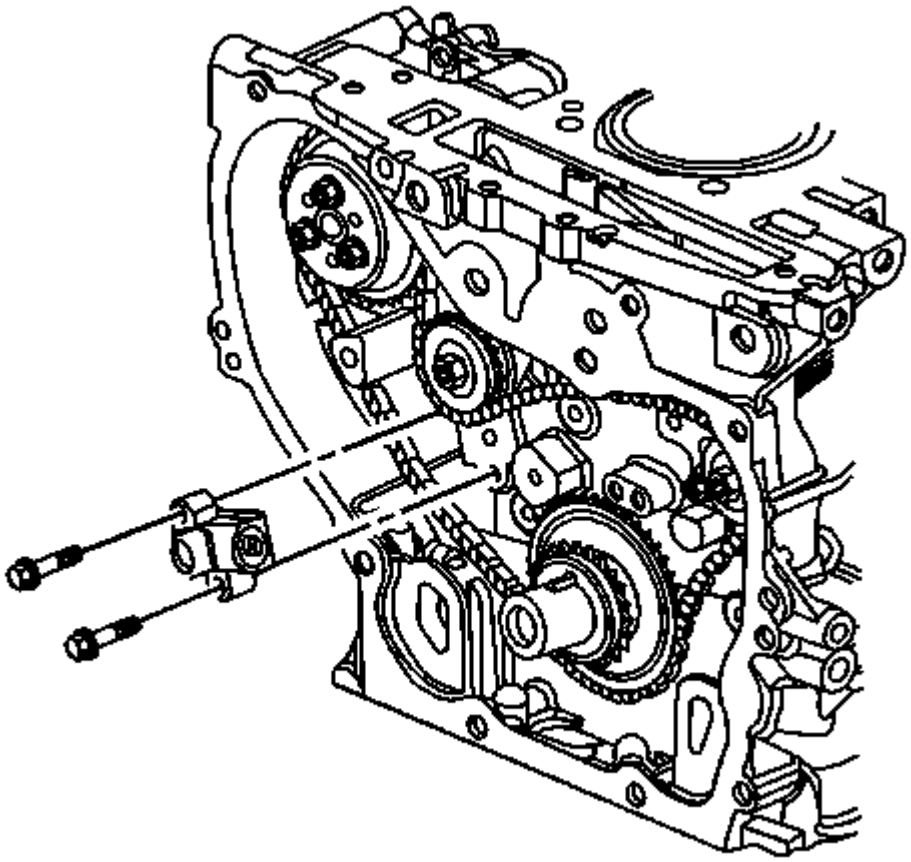

Fig. 114: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Reset the timing chain tensioner by performing the following steps:
   - Rotate the tensioner plunger 90 degrees in its bore and compress the plunger.
   - Rotate the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hose in the tensioner plunger.
8. Install the balance shaft drive chain tensioner and bolts.

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

9. Remove the paper clip from the balance shaft drive chain tensioner.

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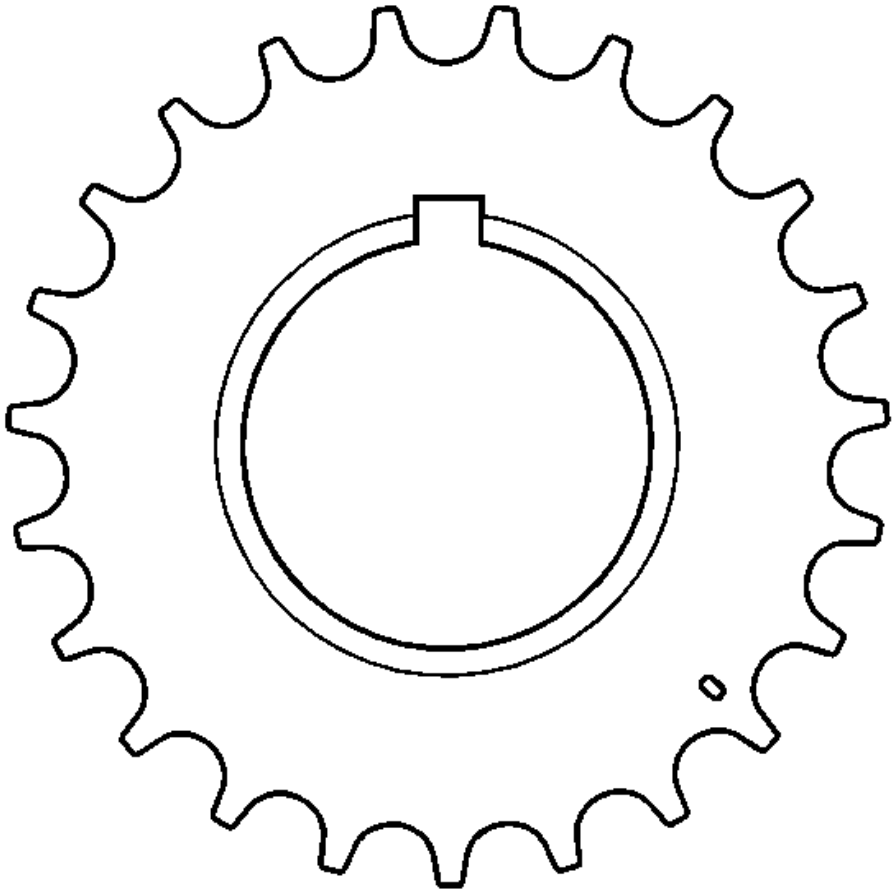

Fig. 115: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

10. Install the timing chain crankshaft sprocket to the crankshaft with the timing mark in the 5 o'clock position.

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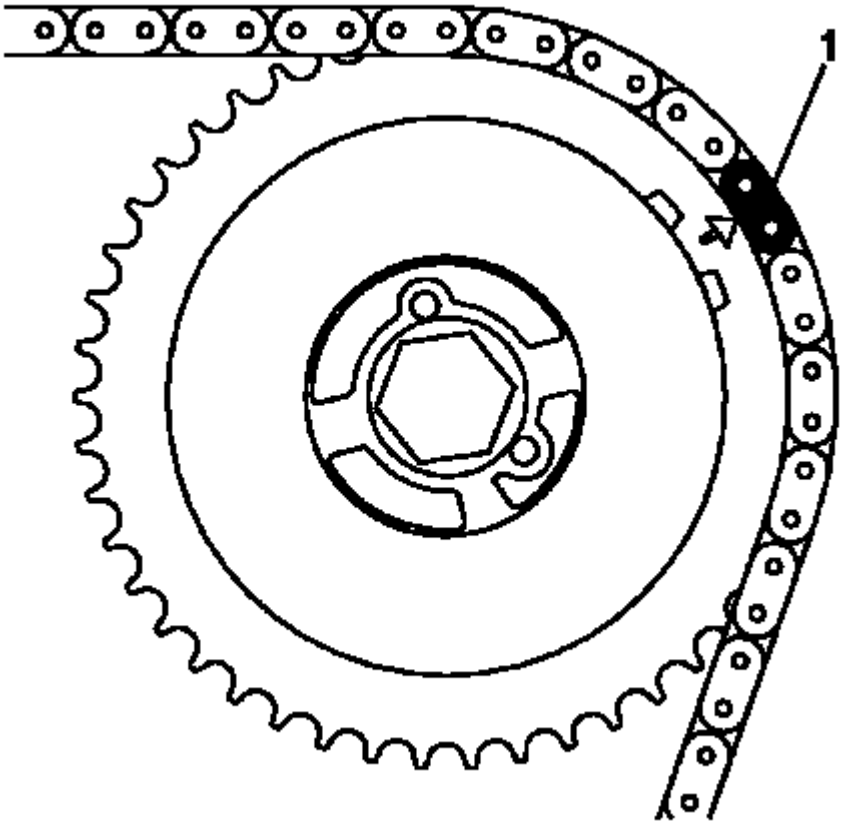

Fig. 116: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **There are 3 colored links on the timing chain. Two links are pink in color and one link is blue in color. Use the following procedure to line up the links with the sprockets. Orient the chain so that the colored links are visible.**
- **Always use NEW actuator bolts.**

11. Assemble the intake camshaft actuator to the timing chain with the timing mark lined up with the blue colored link (1). Install and hand tighten a NEW intake camshaft actuator bolt.

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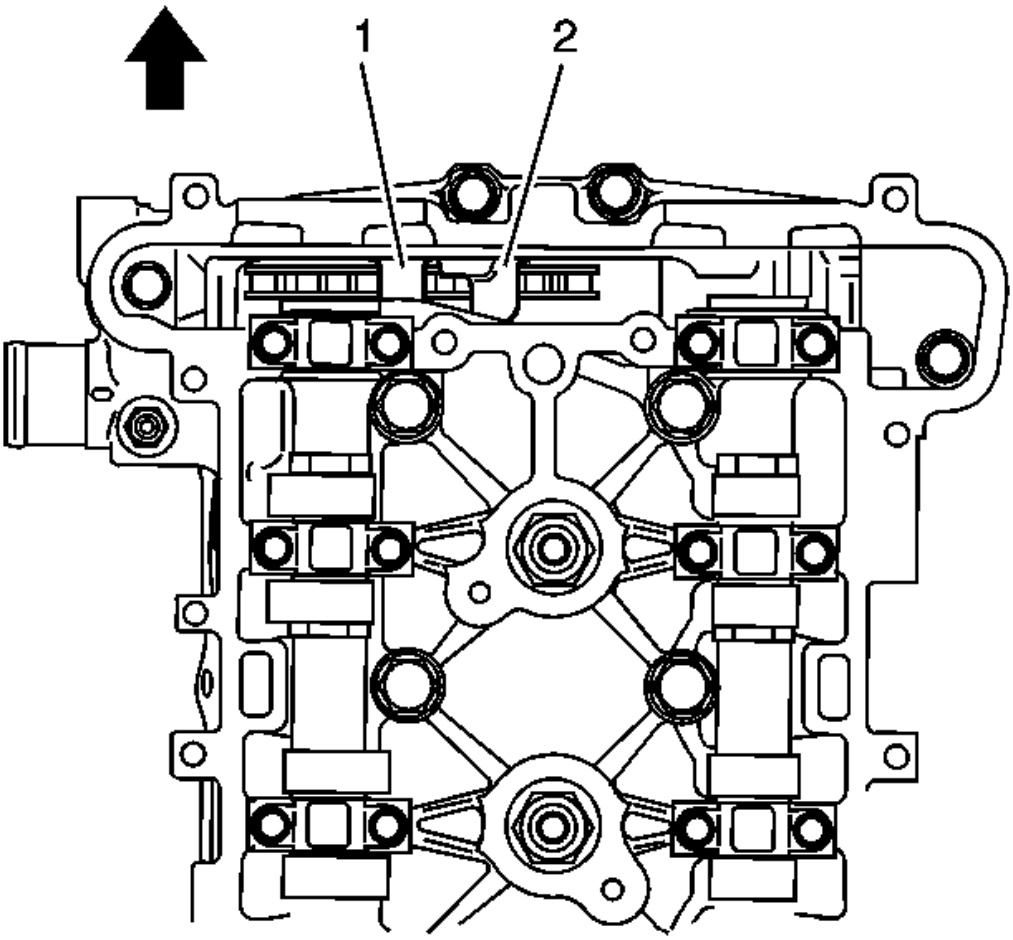

Fig. 117: Locating Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

12. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).

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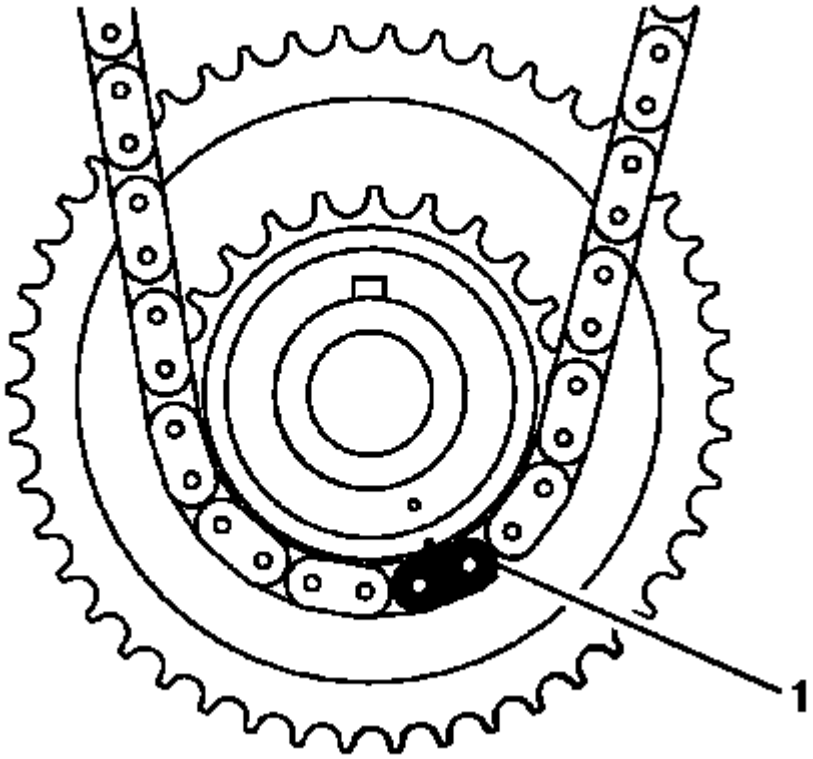

Fig. 118: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Route the timing chain around the crankshaft sprocket and line up the first pink link with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

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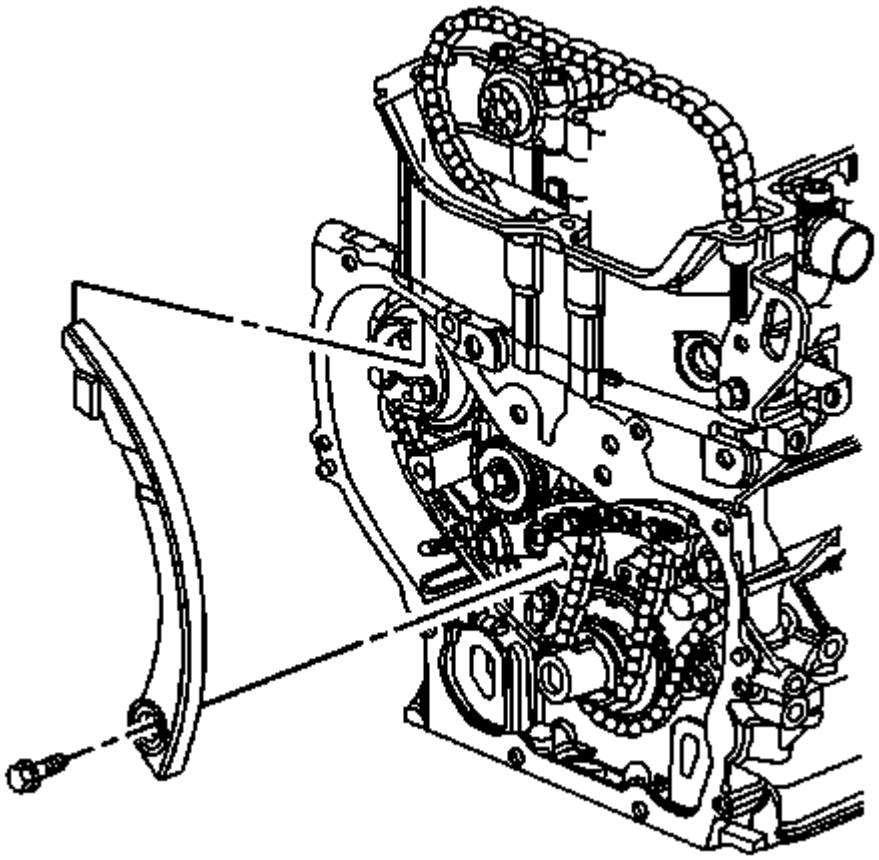

Fig. 119: Identifying Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

14. Install the adjustable timing chain guide through the opening in the cylinder head. Install the adjustable timing chain bolt.

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

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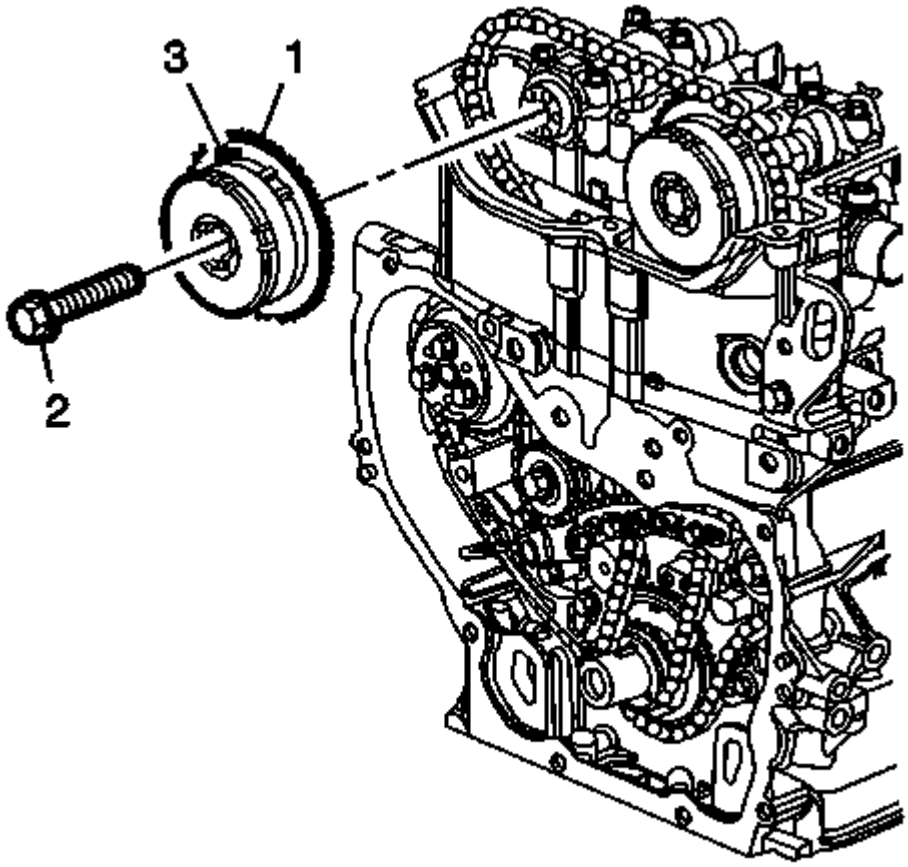

Fig. 120: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install NEW sprocket bolts.

15. Install the exhaust camshaft actuator (1) and a NEW bolt (2) loosely onto the exhaust camshaft.

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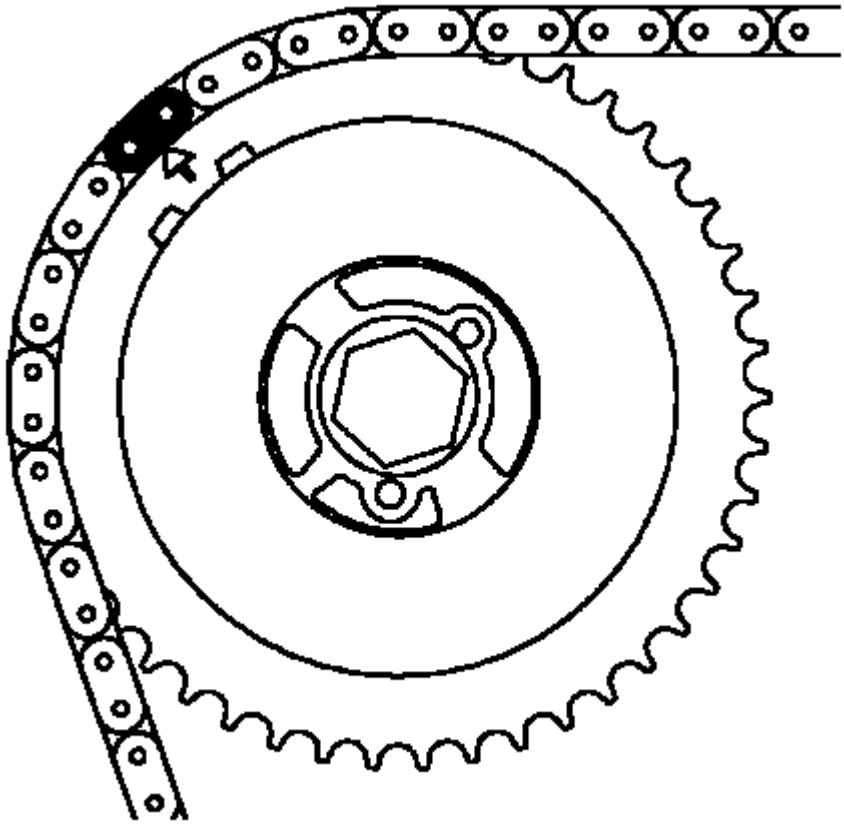

Fig. 121: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

16. Align the timing mark on the actuator with the last pink colored link. Tighten the bolt finger tight.

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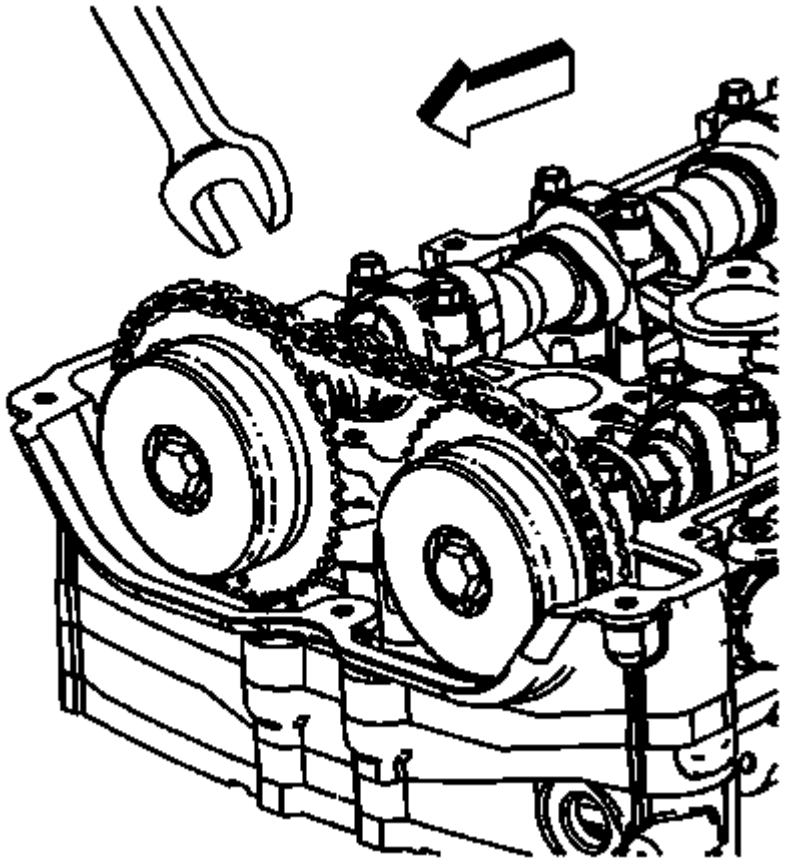

Fig. 122: Identifying Cam Actuator, Camshaft & Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not rotate either camshaft more than half turn in either direction with crankshaft at top dead center (TDC). To do so may cause valve to piston contact resulting in a damaged valve and/or a damaged piston.

17. If the camshaft is 180 degrees out of time, use the following procedure to re-align the camshaft. Using a 24 mm wrench, first turn the intake camshaft until the alignment feature on the back of the camshaft actuator seats in the notch in the front of the intake camshaft.
    1. Turn the crankshaft 45 degrees in either direction.
    2. Turn the intake cam to the appropriate location.
    3. Turn the crankshaft back to TDC.
18. When the actuator seats on the cam, tighten the actuator bolt hand tight.
19. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not, repeat the portion of the procedure necessary to align the timing marks.

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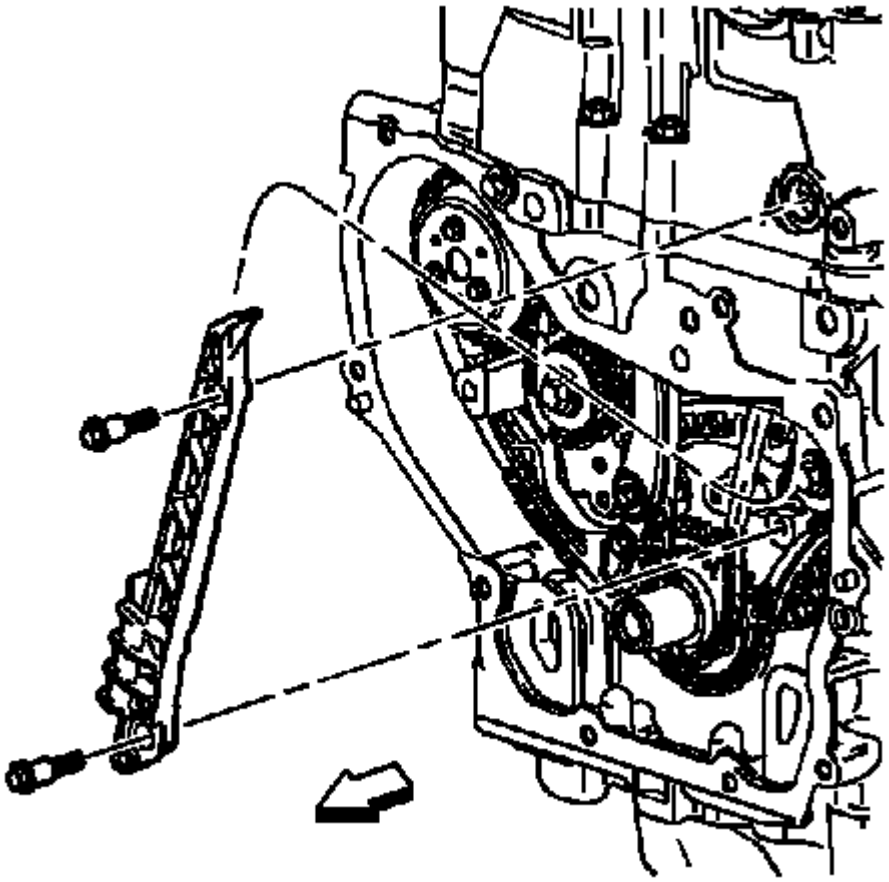

Fig. 123: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Install the fixed timing chain guide and bolts.

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

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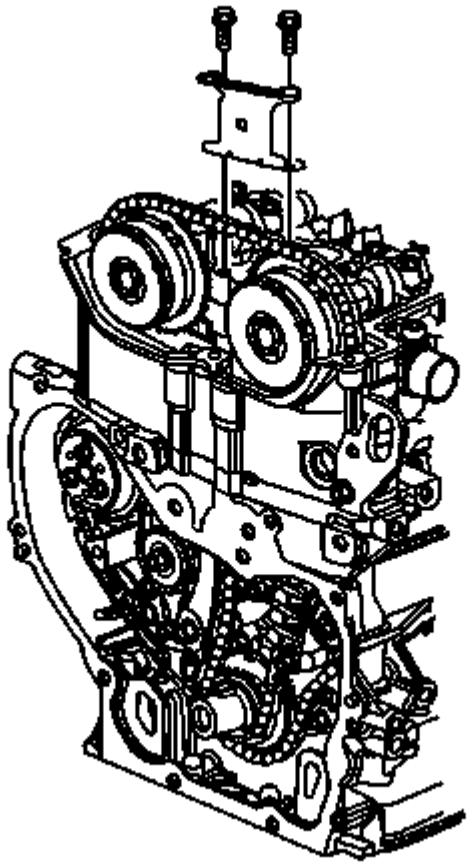

Fig. 124: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

21. Install the upper timing chain guide and bolts.

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

22. Install a 24 mm wrench onto the hex on the intake camshaft. Using a torque wrench, tighten the camshaft actuator bolt.

    Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus 30 degrees using the **J 45059** .

23. Install a 24 mm wrench onto the hex on the exhaust camshaft. Using a torque wrench, tighten the camshaft actuator bolt.

    Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus 30 degrees **J 45059** .

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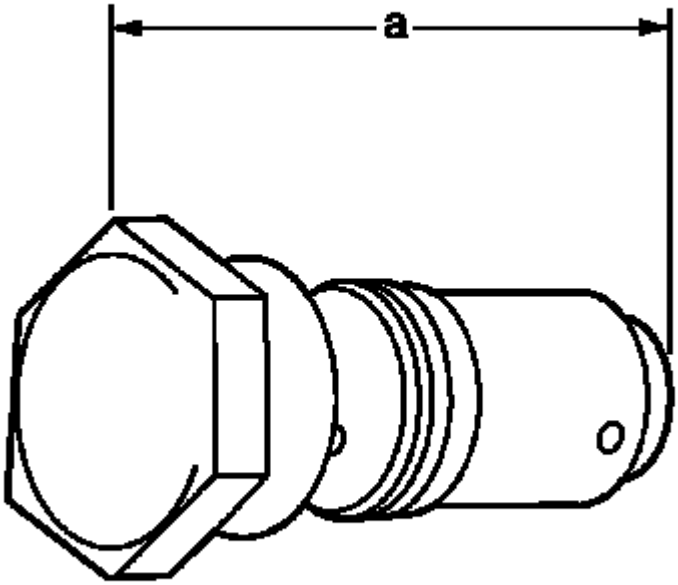

Fig. 125: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

24. Remove the old oil from the timing chain tensioner.
25. Inspect the timing chain tensioner. If the timing tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner.
26. Measure the timing chain tensioner assembly from end to end. A new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

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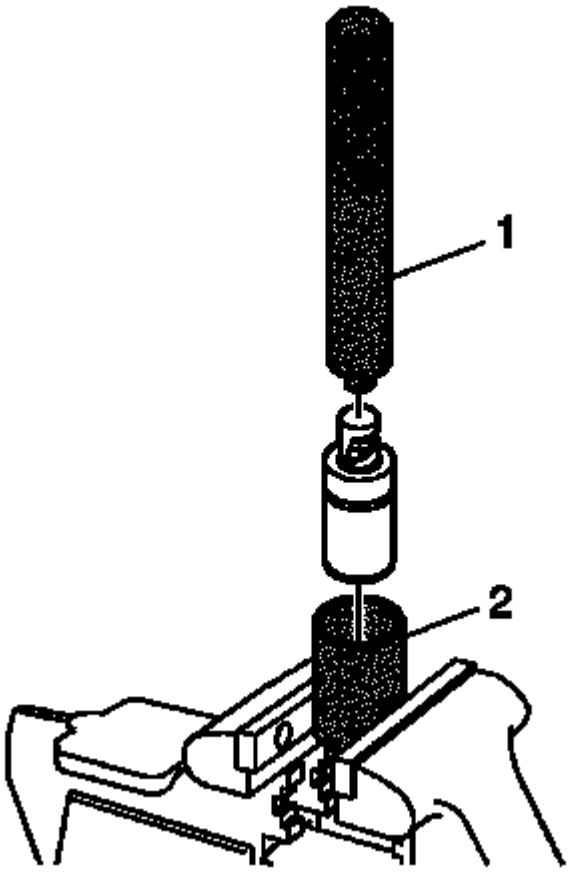

Fig. 126: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

27. If the timing chain tensioner is not in the compressed state, perform the following steps:
    1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
    2. Install the J 45027-2 (2) into a vise.
    3. Install the notch end of the piston assembly into the J 45027-2 (2).
    4. Using the J 45027-1 (1), turn the ratchet cylinder into the piston.

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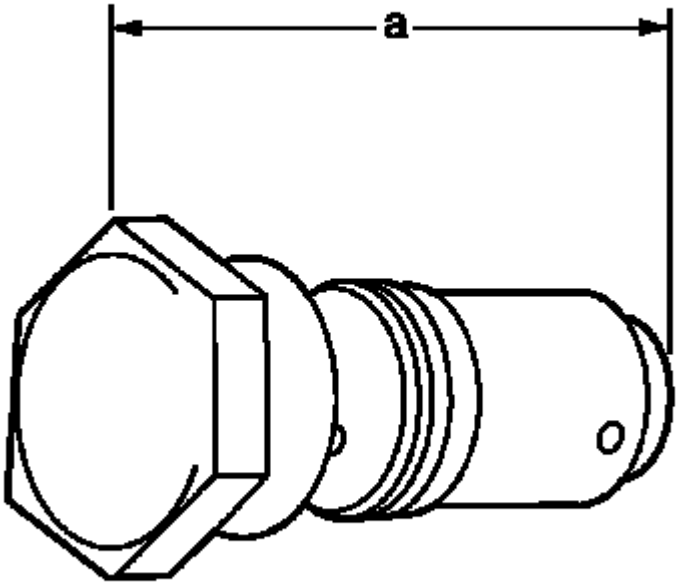

Fig. 127: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

28. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris with a lint free cloth.
29. Install the compressed piston assembly back into the timing chain tensioner body until the assembly stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, the assembly will activate the tensioner, which will then need to be reset again.
30. At this point the tensioner should measure approximately 72 mm (2.83 in) (a) from end to end. If the tensioner does not read 72 mm (2.83 in) (a) from end to end repeat steps 27.1 thorough 27.4.

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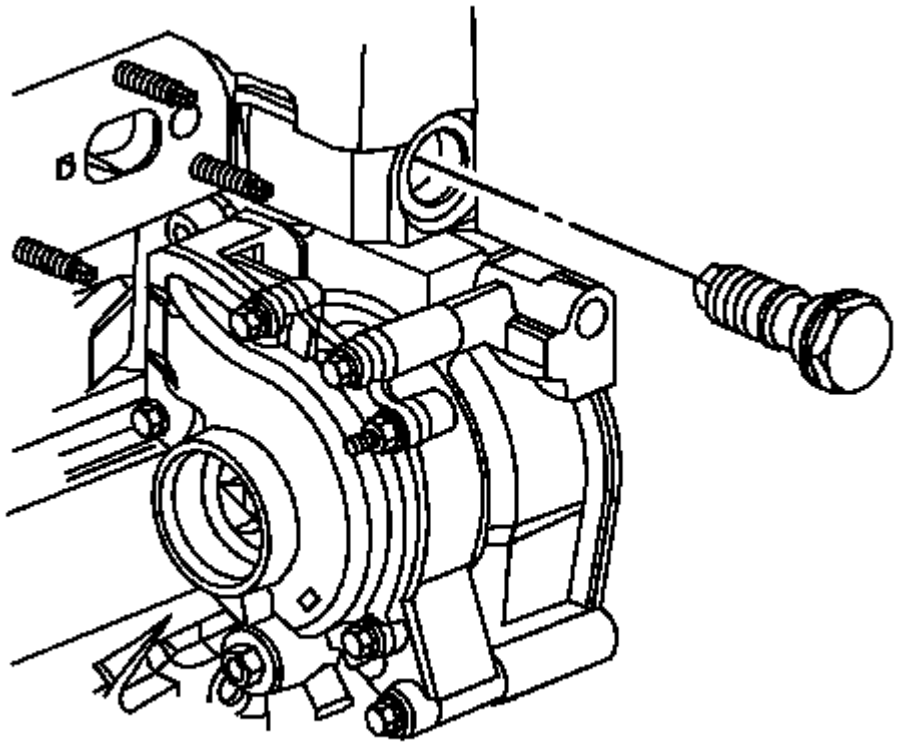

Fig. 128: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

31. Ensure that all dirt and debris are removed from the timing chain tensioner threaded hole in the cylinder head.
32. Install the timing chain tensioner.

    Tighten: Tighten the tensioner to 75 N.m (66 lb ft).

33. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.

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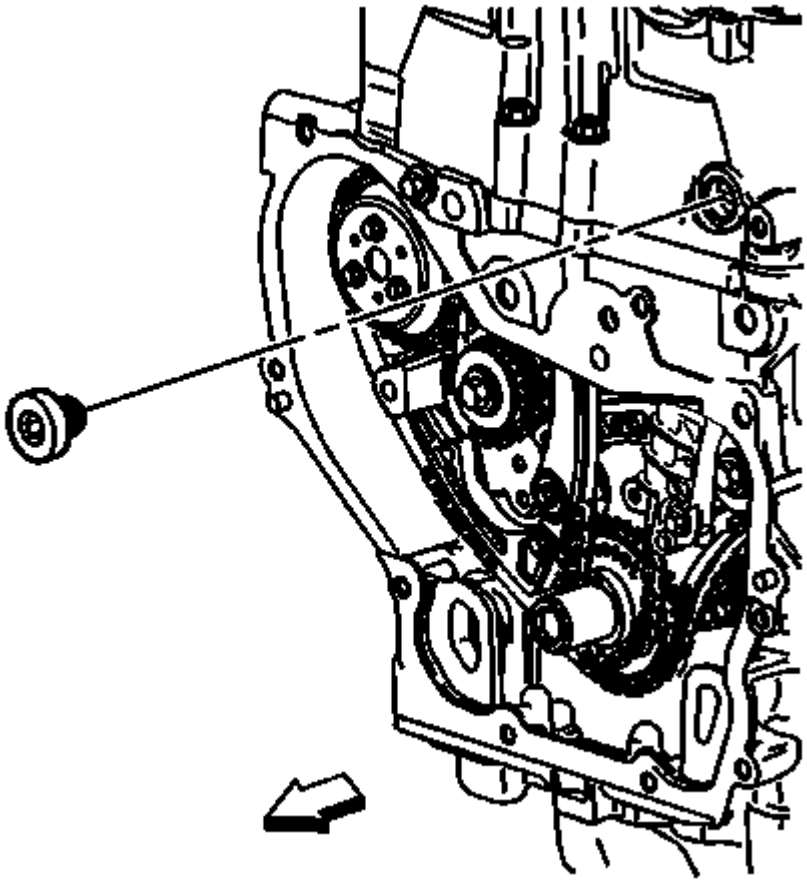

Fig. 129: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

34. Apply sealant GM PN 12345382 (Canadian PN 10953489) or equivalent, to the threads and install the timing chain guide bolt access hole plug.

    Tighten: Tighten the plug to 90 N.m (59 lb ft).

35. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
36. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
37. Install the #1 cylinder spark plug. Refer to **Spark Plug Replacement** .

Camshaft Cover Replacement

Removal Procedure

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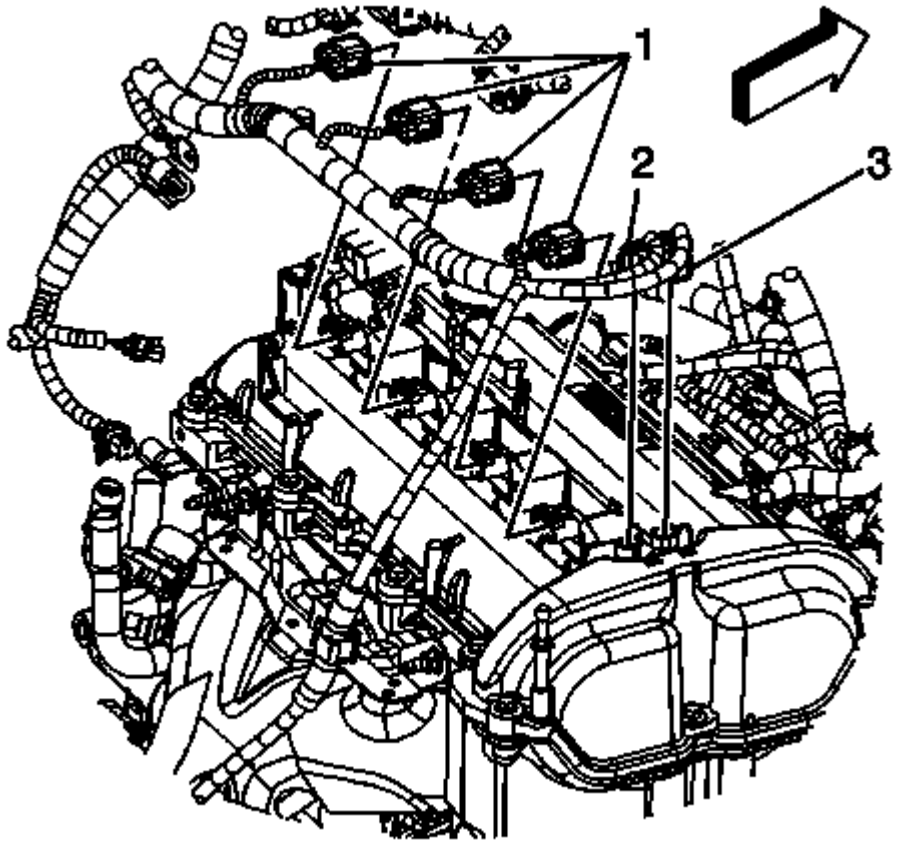

Fig. 130: Identifying Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
3. Disconnect the intake (3) and exhaust (2) camshaft position actuator solenoid valve electrical connectors.

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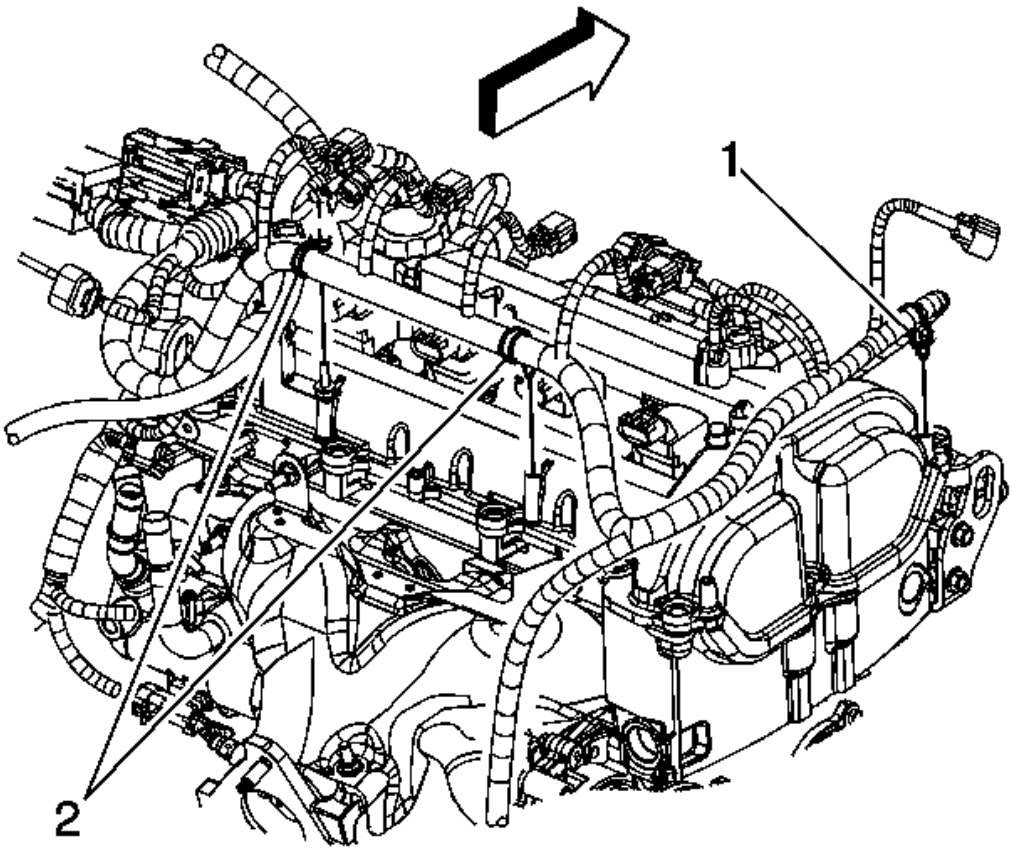

Fig. 131: View Of Engine Harness Clips To Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the ignition coils. Refer to **Ignition Coil Replacement** .
5. Remove the engine harness clips (1, 2) from the cover.

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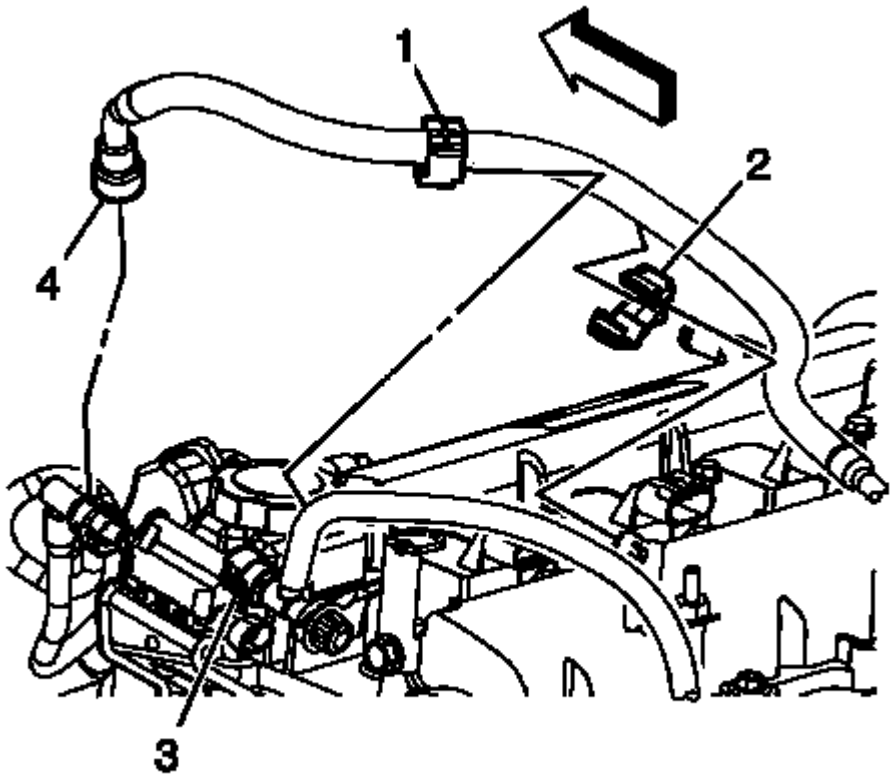

Fig. 132: View Of Caps Or Plugs, Fuel Line And Fuel Rail
Courtesy of GENERAL MOTORS CORP.

6. Remove the fuel feed line retainers (1, 2) from the engine brackets.

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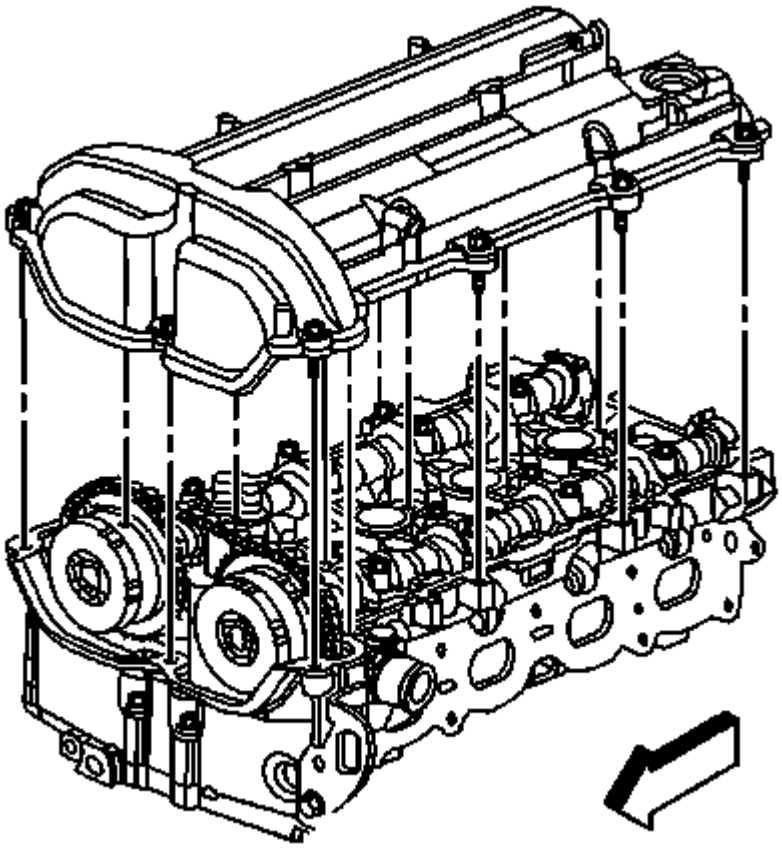

Fig. 133: Identifying Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft cover bolts.
8. Remove the camshaft cover.

Installation Procedure

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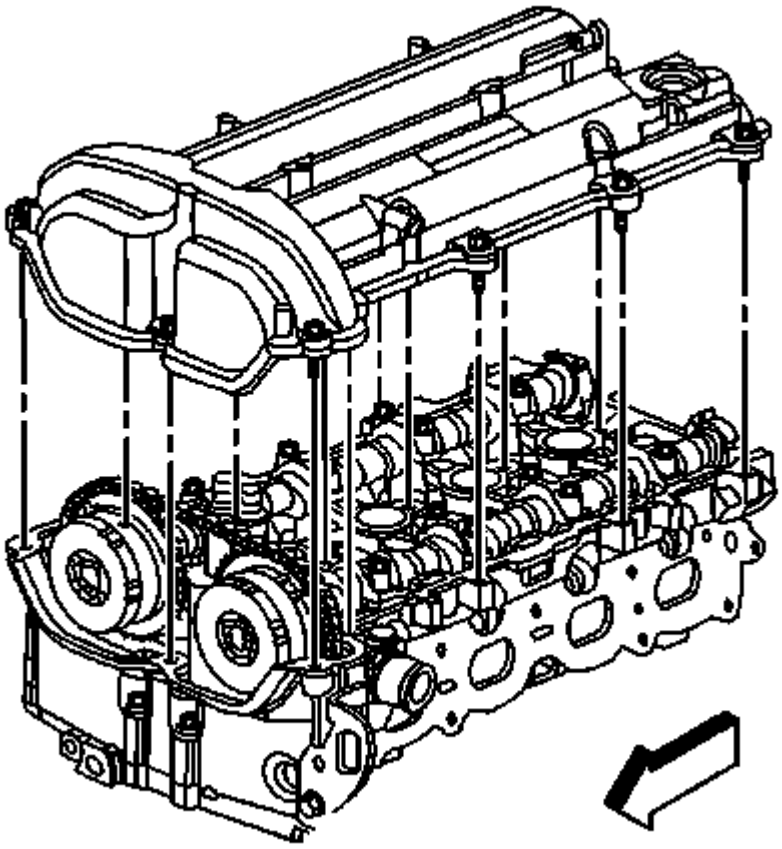

Fig. 134: Identifying Camshaft Cover & Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the camshaft cover and bolts.

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

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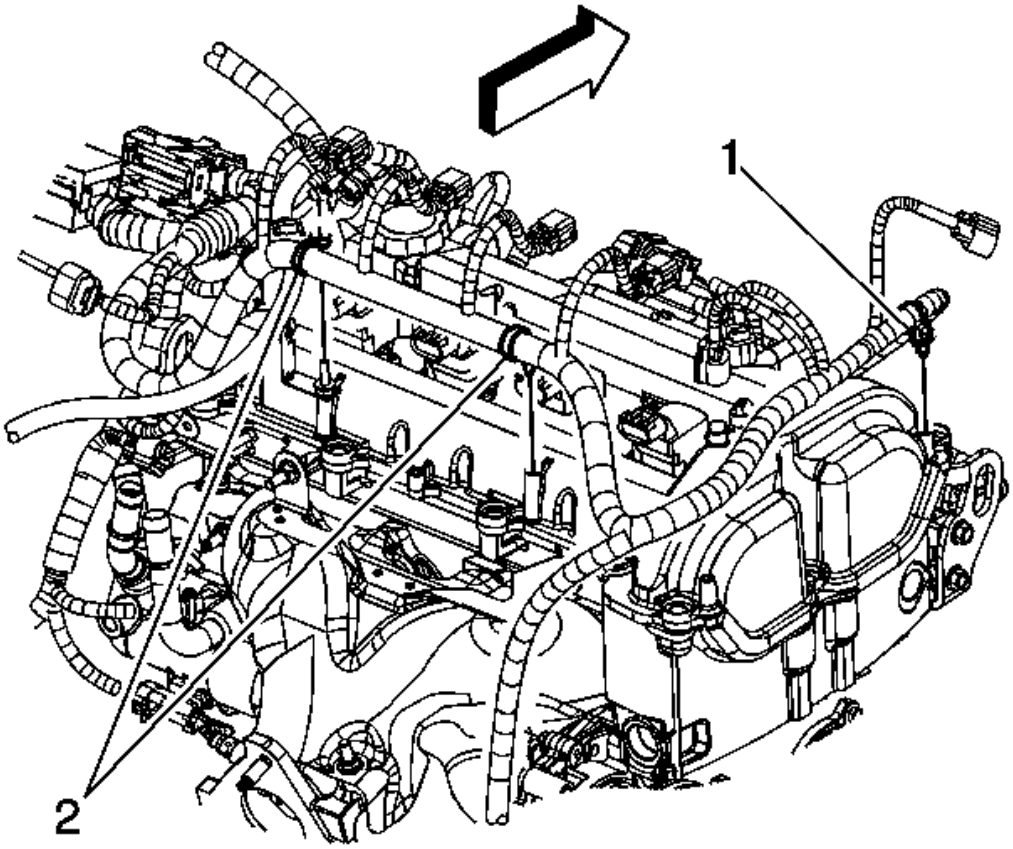

Fig. 135: View Of Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

2. Install the ignition coils. Refer to **Ignition Coil Replacement** .
3. Install the engine harness clips (1, 2) to the cover.

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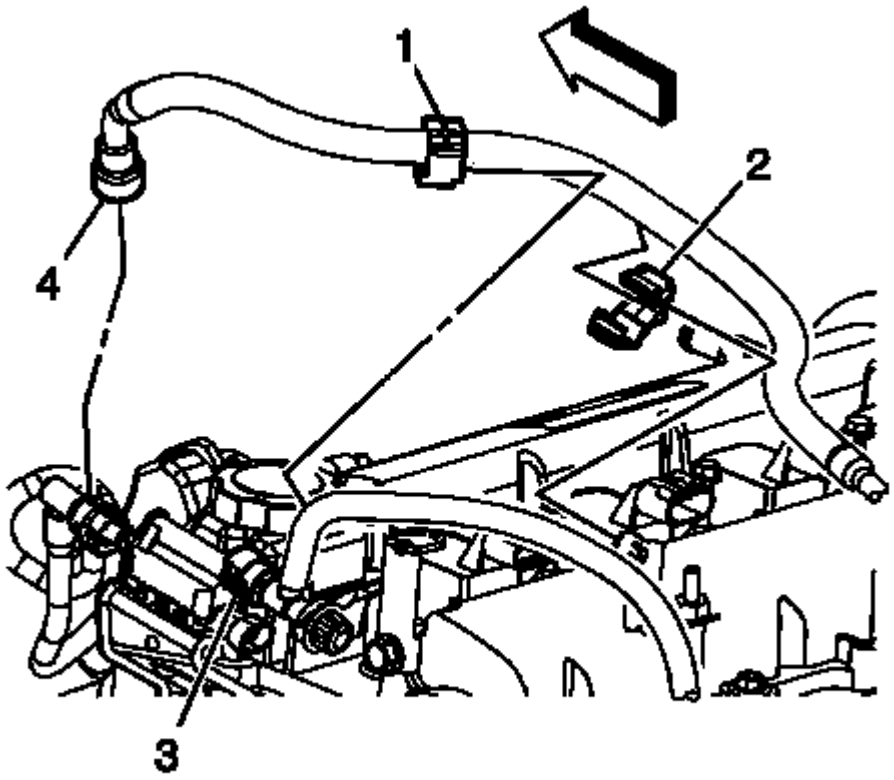

Fig. 136: View Of Caps Or Plugs, Fuel Line And Fuel Rail
Courtesy of GENERAL MOTORS CORP.

4. Install the feed line retainers (1, 2) to the engine brackets.

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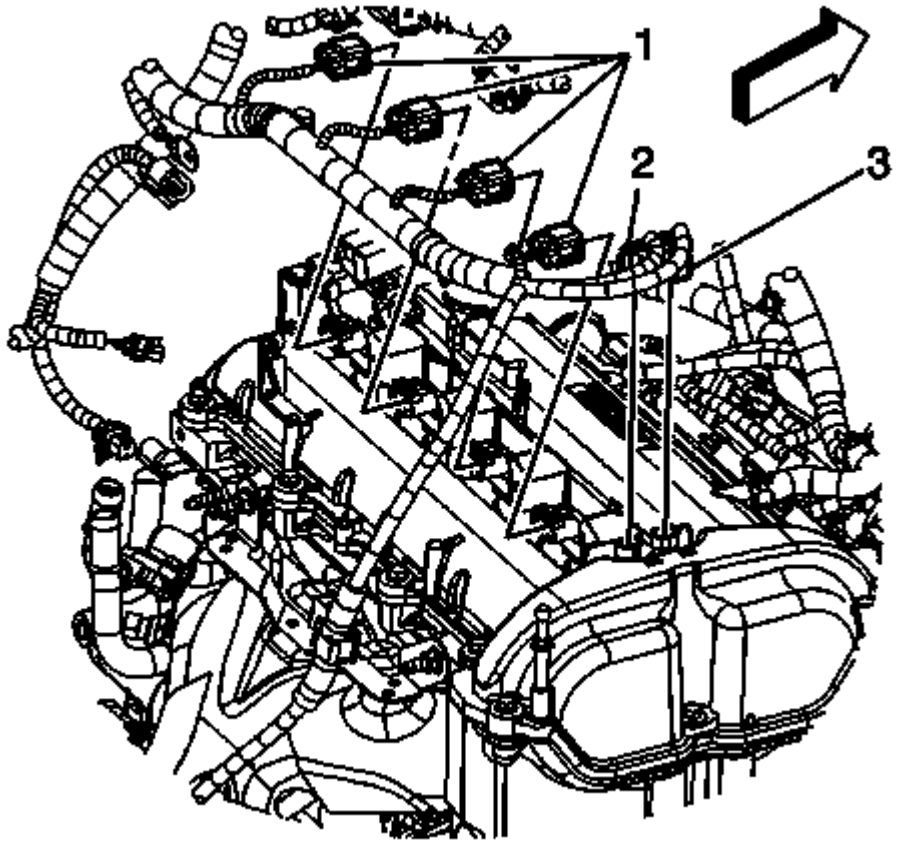

Fig. 137: Identifying Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

5. Connect the intake (2) and exhaust (2) camshaft position actuator solenoid valve electrical connectors.
6. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement** .
7. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement**.

Timing Chain Tensioner Replacement

Tools Required

J 45027 Tensioner Tool

Removal Procedure

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
2. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

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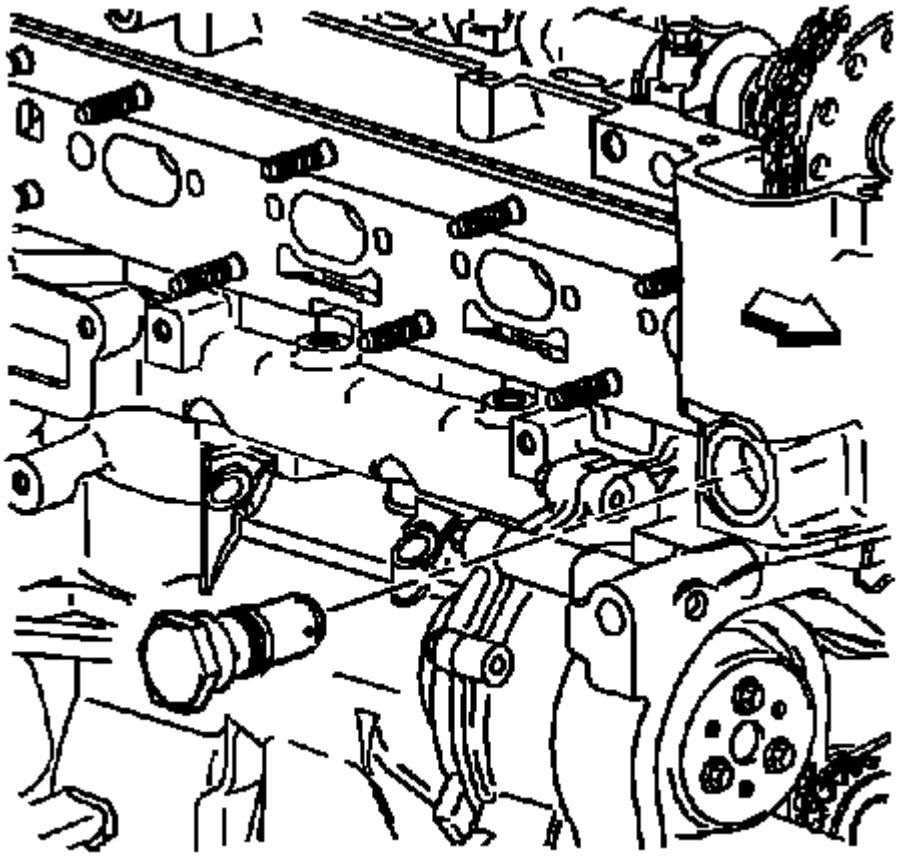

Fig. 138: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain tensioner.
4. Remove the seal from the tensioner.

Installation Procedure

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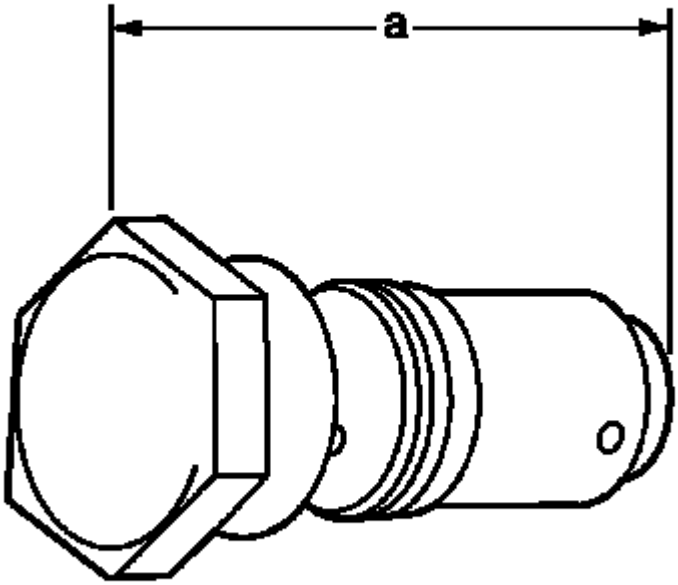

Fig. 139: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain tensioner. If the timing chain tensioner, O-ring seal, or washer is damaged, replace the timing chain tensioner or O-ring seal as applicable.
2. Measure the timing chain tensioner assembly from end to end. If the timing chain tensioner is to be replaced, a new tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) (a) from end to end. A tensioner in the active state will measure 85 mm (3.35 in) (a) from end to end.

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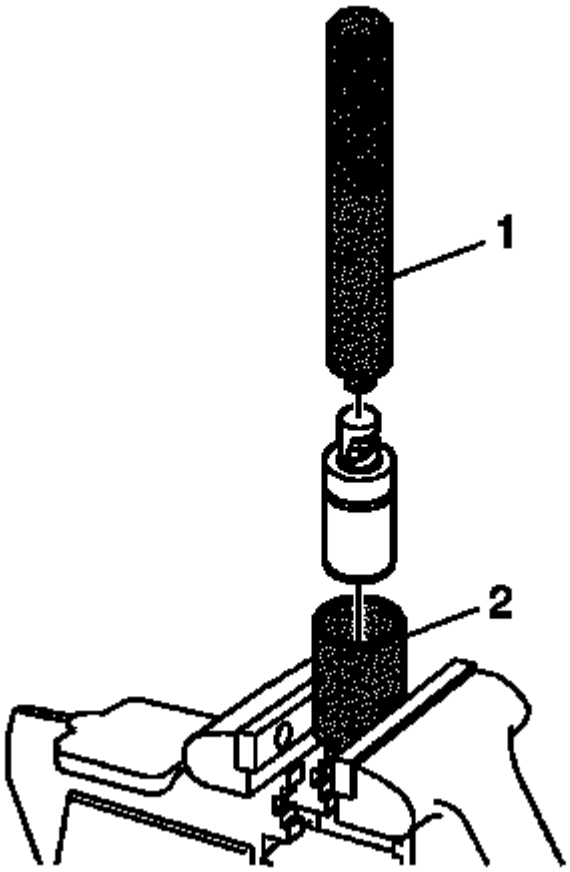

Fig. 140: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. If the timing chain tensioner is not in the compressed state, perform the following steps:
    1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
    2. Install the J 45027-2 (2) into a vise.
    3. Install the notch end of the piston assembly into the J 45027-2 (2).
    4. Using the J 45027-1 (1), turn the ratchet cylinder into the piston.

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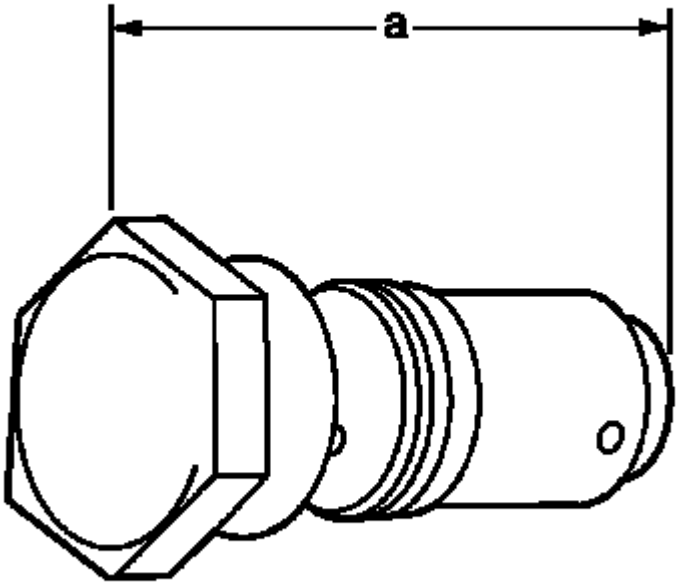

Fig. 141: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

4. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris out with a lint-free cloth.
5. Install the compressed piston assembly back into the timing chain tensioner body until it stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, it will activate the tensioner, which will then need to be reset again.
6. At this point the tensioner should measure approximately 72 mm (2.83 in) (a) from end to end. If the tensioner does not read 72 mm (2.83 in) (a) from end to end, repeat steps 3-5.

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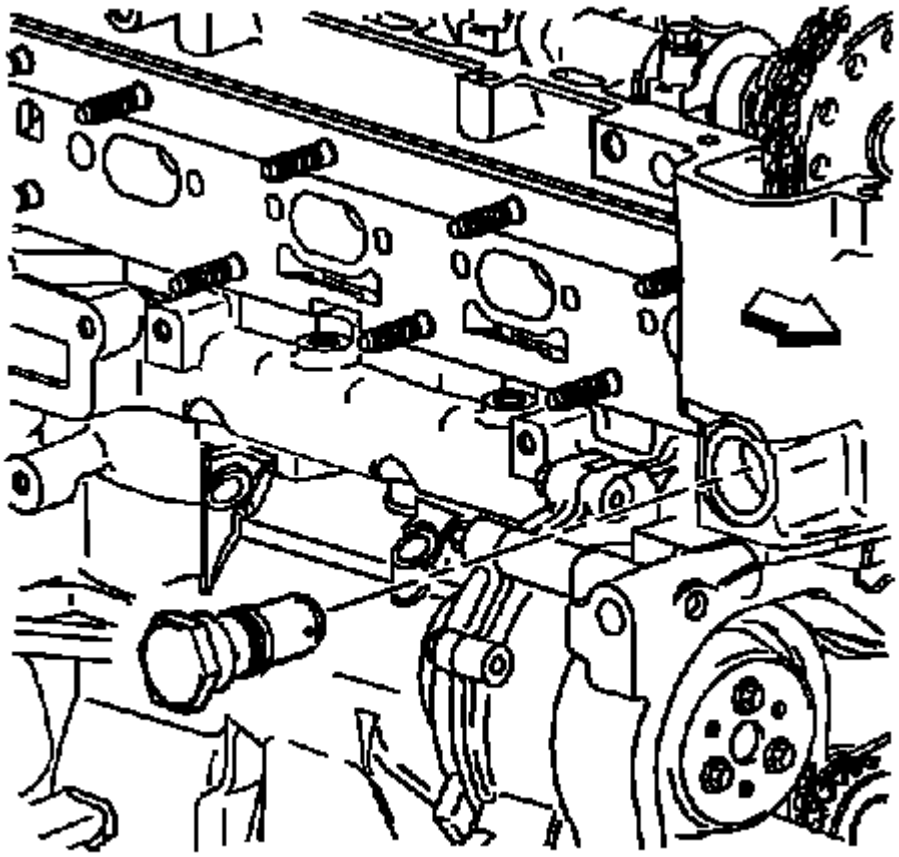

Fig. 142: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

NOTE: **Refer to Fastener Notice .**

IMPORTANT: Ensure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.

8. Install the timing chain tensioner assembly.

   Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

9. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.
10. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
11. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .

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Intake Camshaft and Lifter Replacement

Removal Procedure

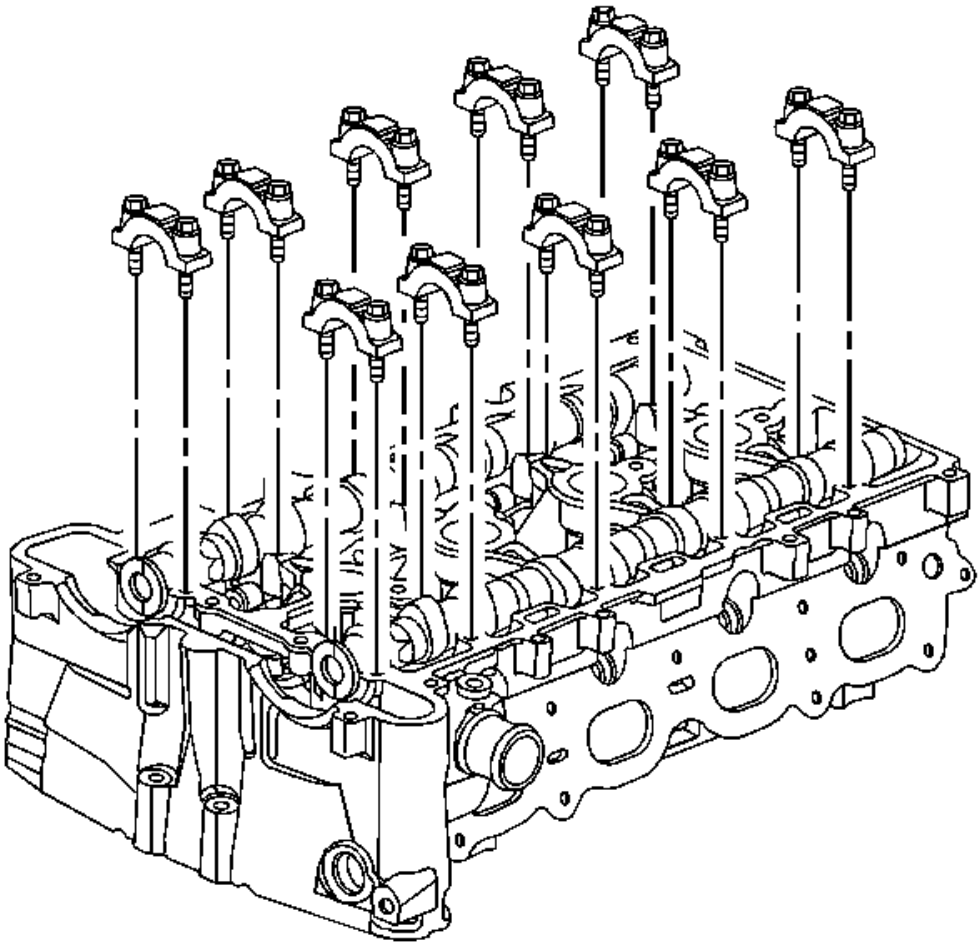

Fig. 143: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

IMPORTANT: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

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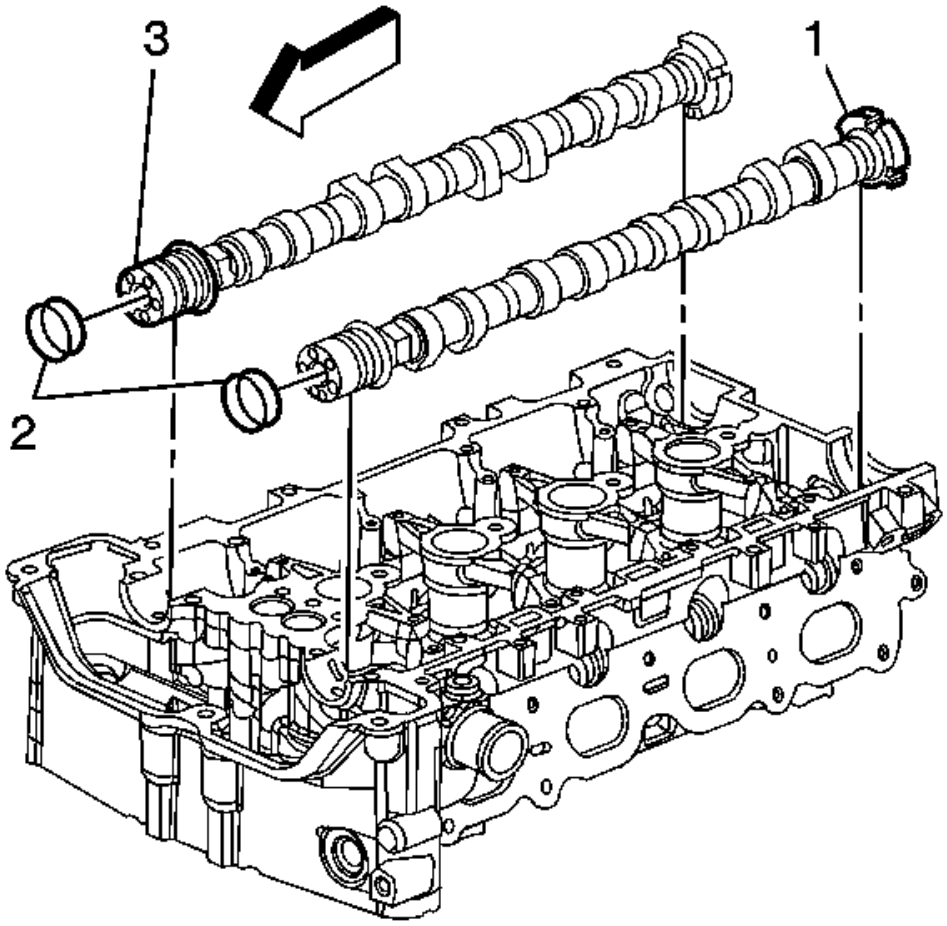

Fig. 144: Identifying Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake camshaft (1).

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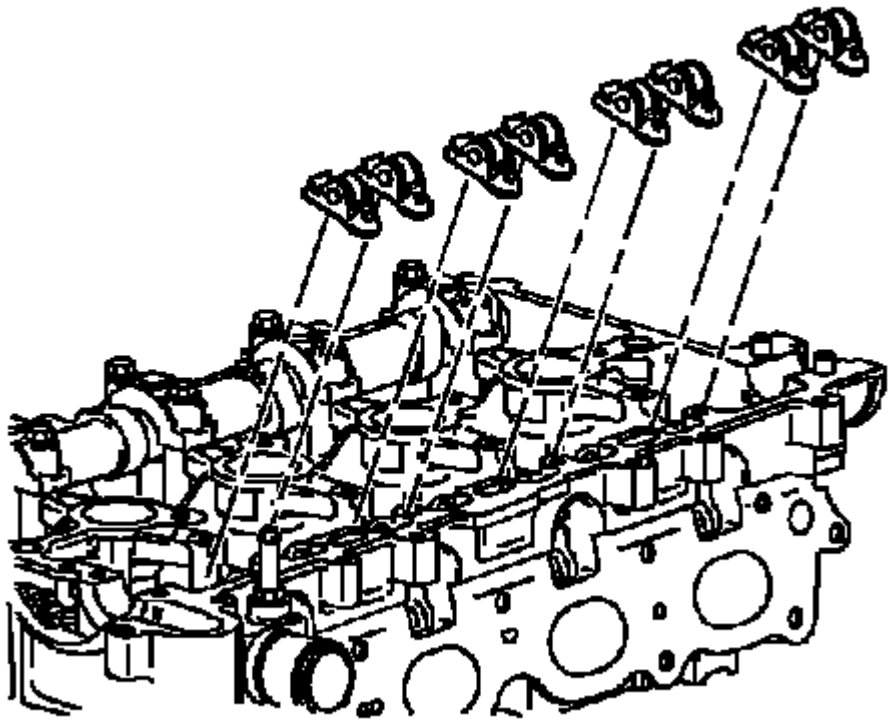

Fig. 145: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

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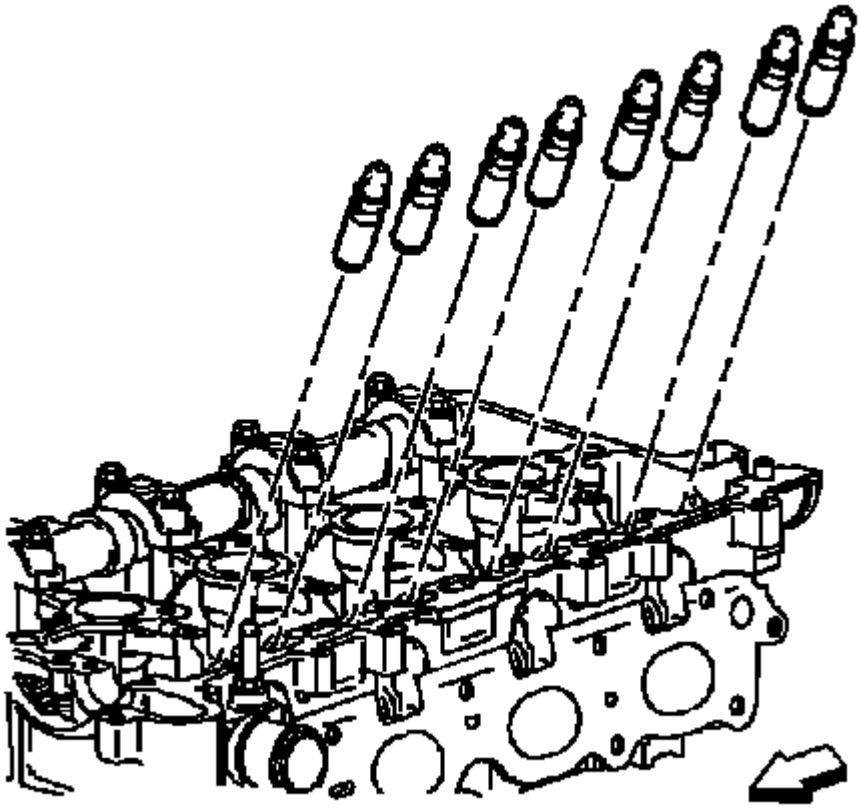

Fig. 146: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

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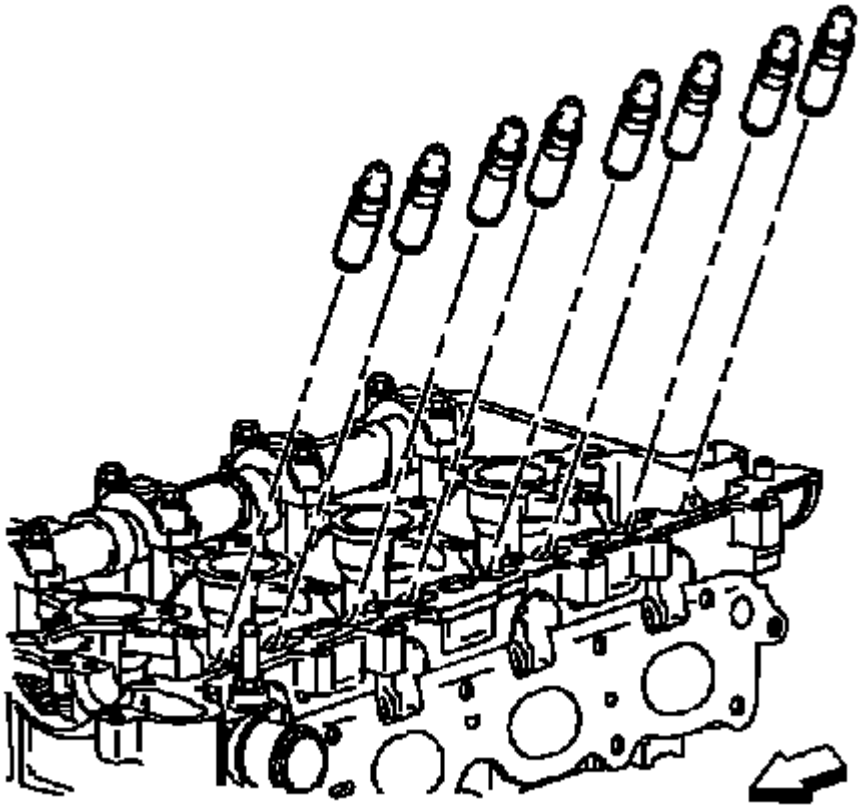

Fig. 147: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters with GM PN 12345501 (Canadian PN 992704) or equivalent.

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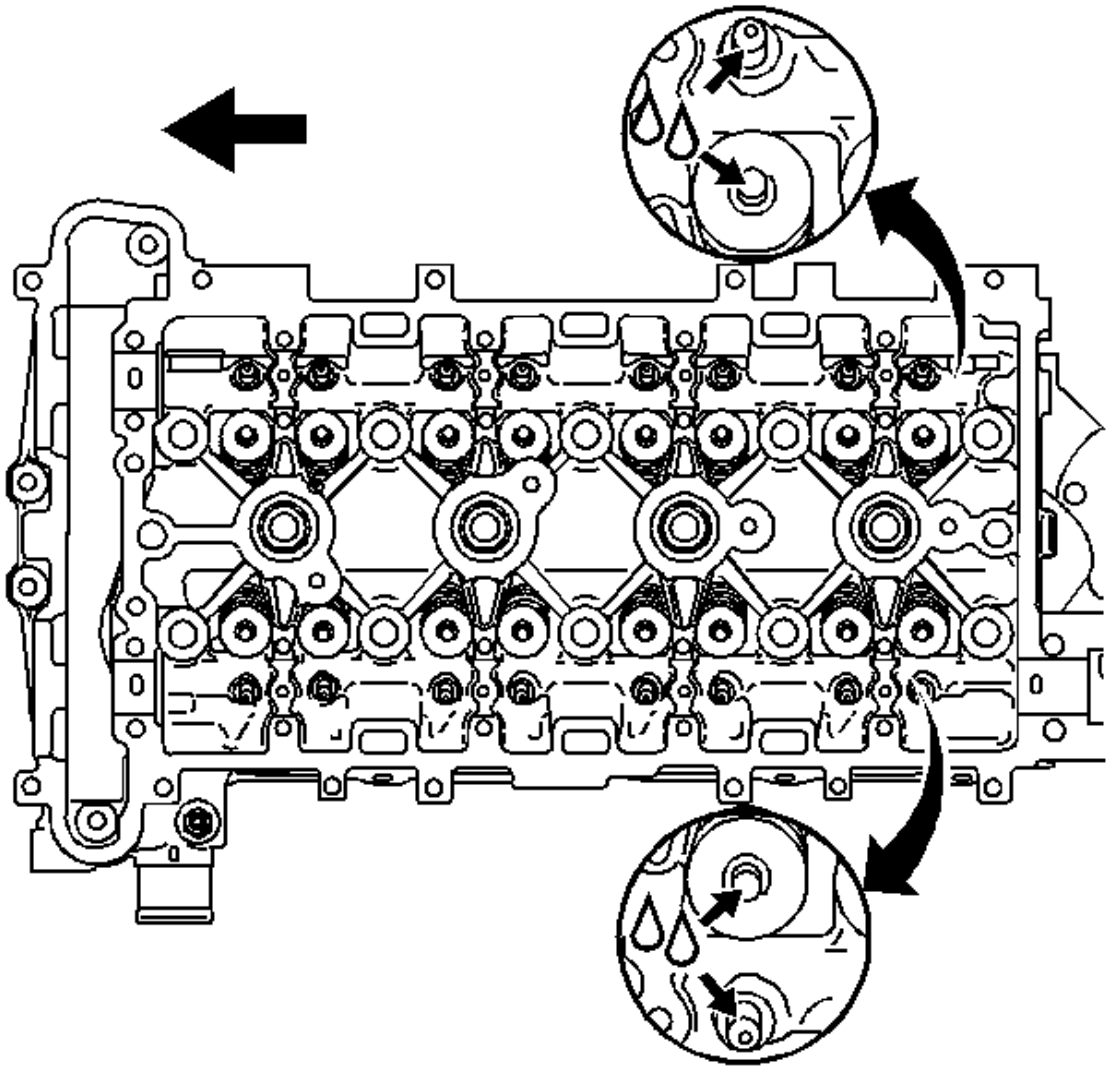

Fig. 148: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with GM PN 12345501 (Canadian PN 992704) or equivalent.

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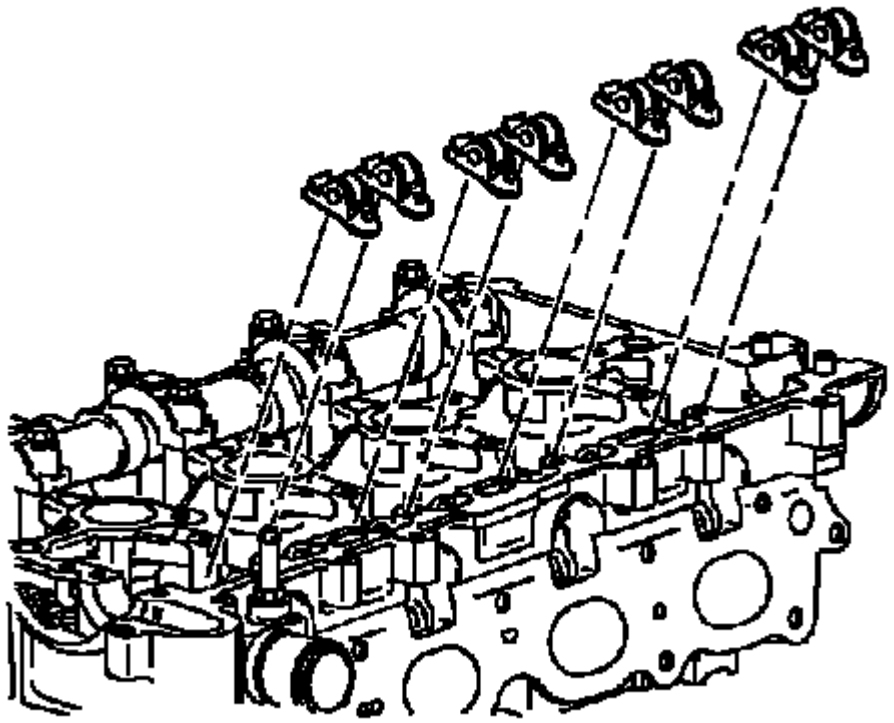

Fig. 149: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used roller followers MUST be returned to their original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the camshaft roller followers on the tip of the valve stem and on the lash adjuster. Lubricate the roller followers with GM PN 12345501 (Canadian PN 992704) or equivalent.

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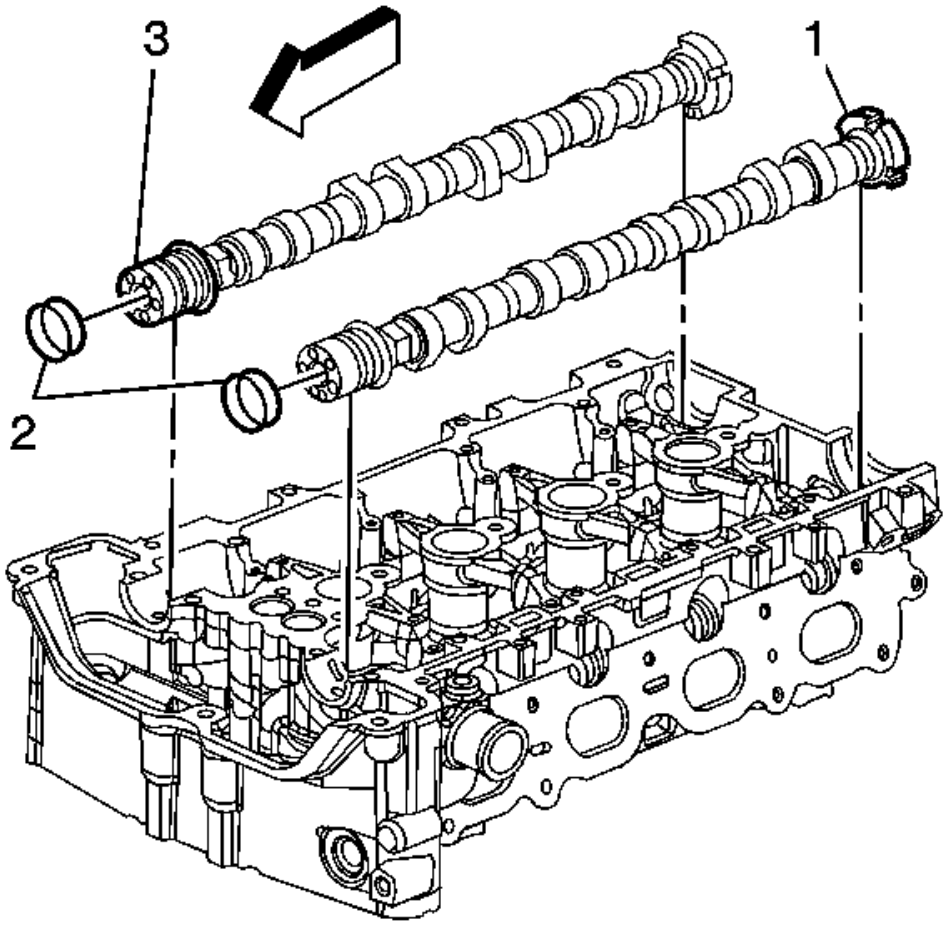

Fig. 150: Identifying Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft (1). Lubricate with GM PN 12345501 (Canadian PN 992704) or equivalent.

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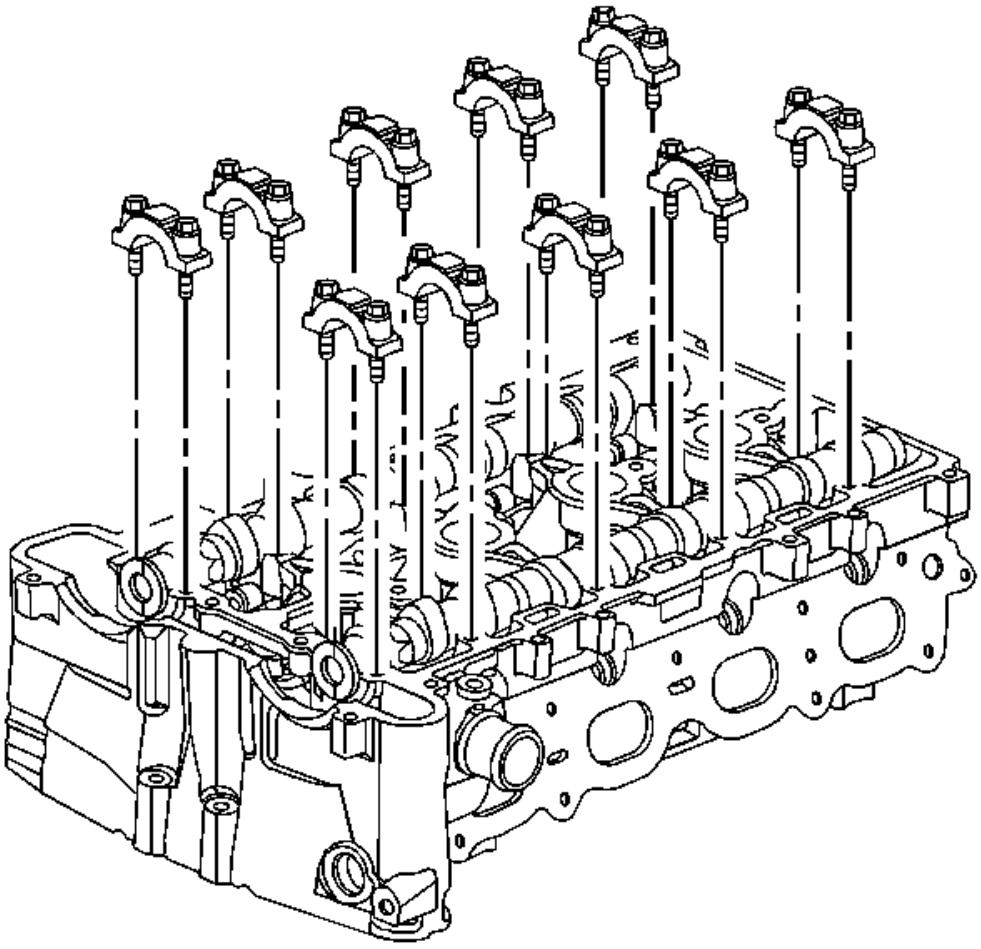

Fig. 151: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

NOTE: **Refer to Fastener Notice .**

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated.

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

8. Install the intake camshaft position actuator. Refer to **Camshaft Position Intake Actuator Replacement**.

Exhaust Camshaft and Lifter Replacement

Removal Procedure

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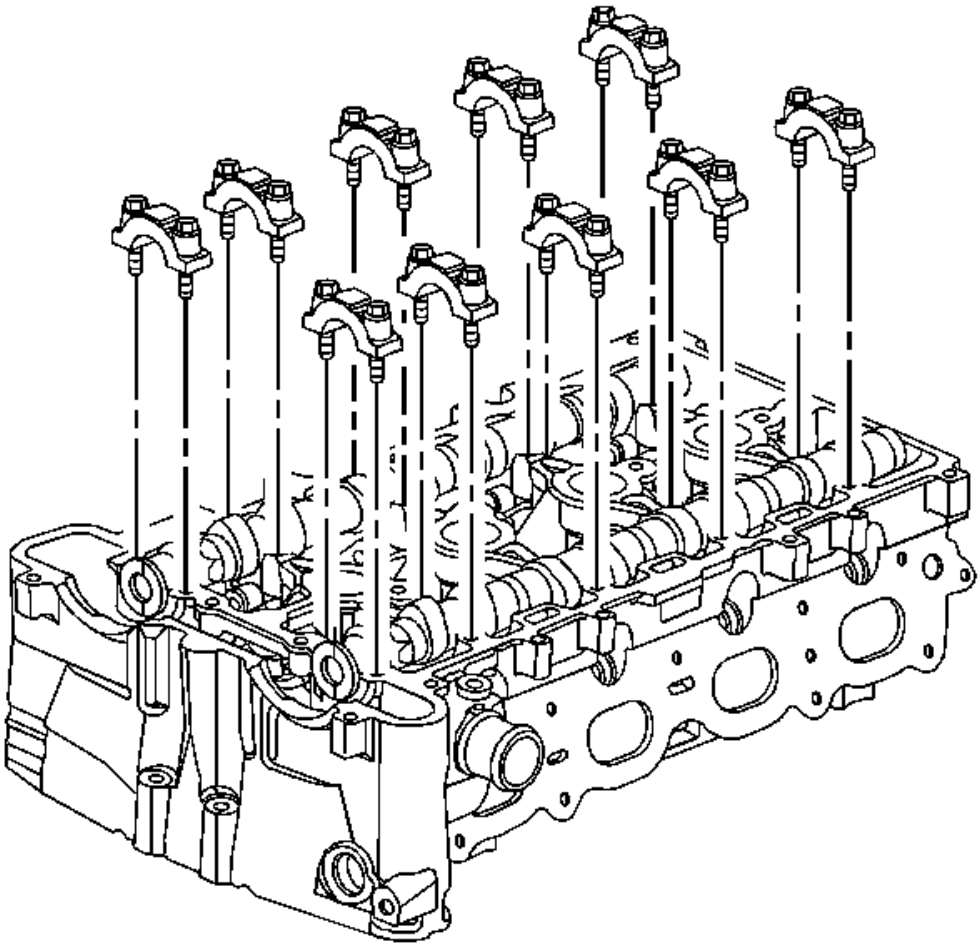

Fig. 152: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

IMPORTANT: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

2. Mark the bearing caps to ensure they are installed in the original position.
3. Remove the bearing cap bolts.
4. Remove the bearing caps.

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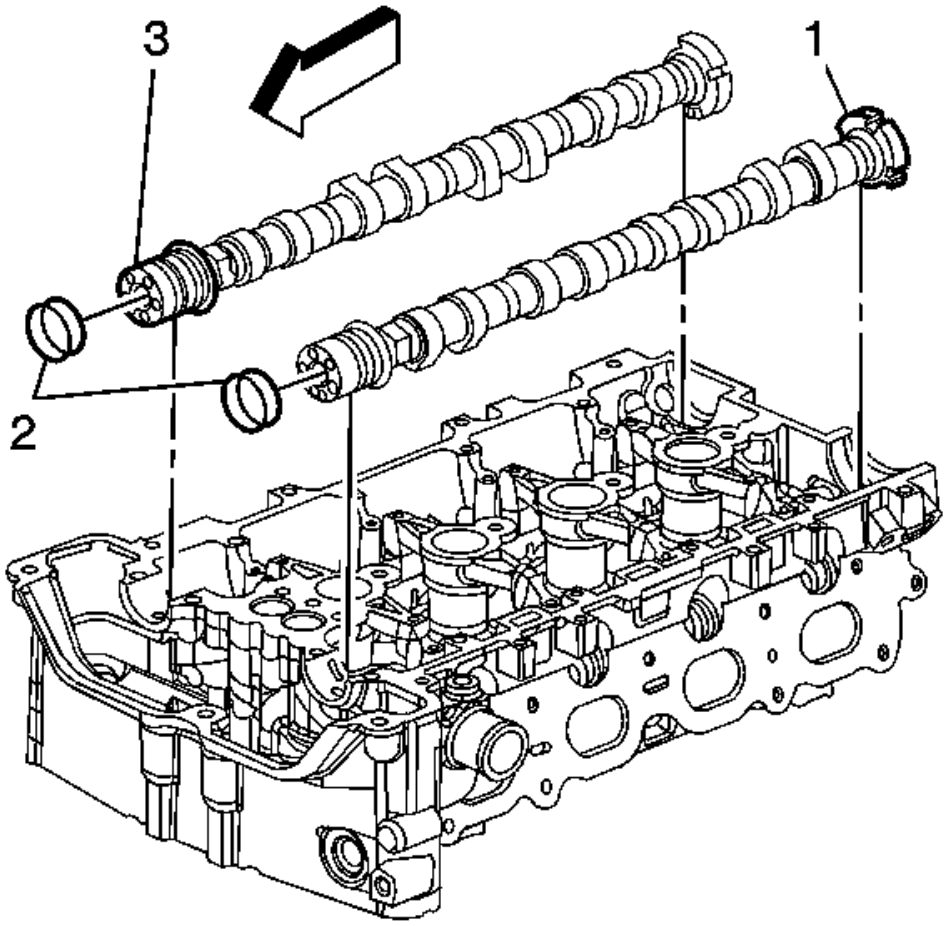

Fig. 153: Identifying Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft (3).

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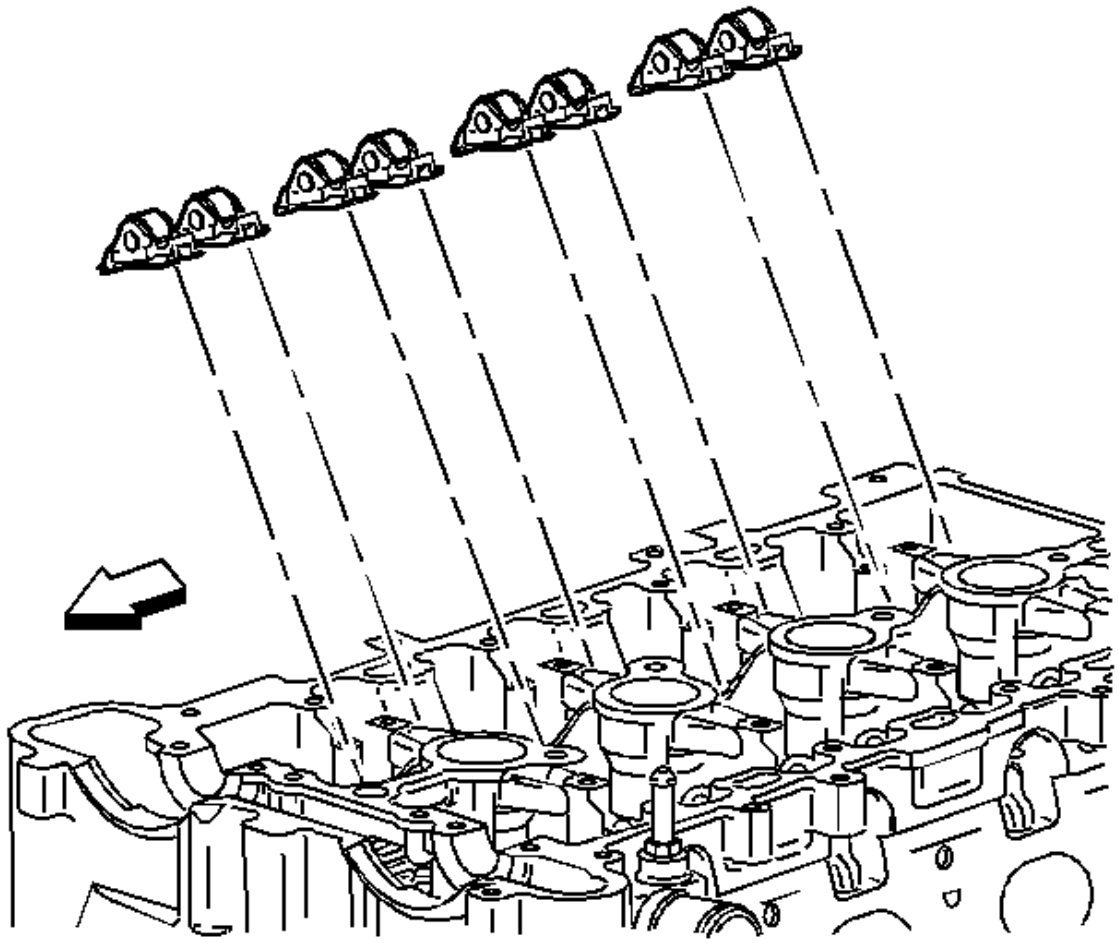

Fig. 154: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep all of the roller followers and hydraulic adjusters in order so that they can be reinstalled in their respective locations.

6. Remove the camshaft roller followers.

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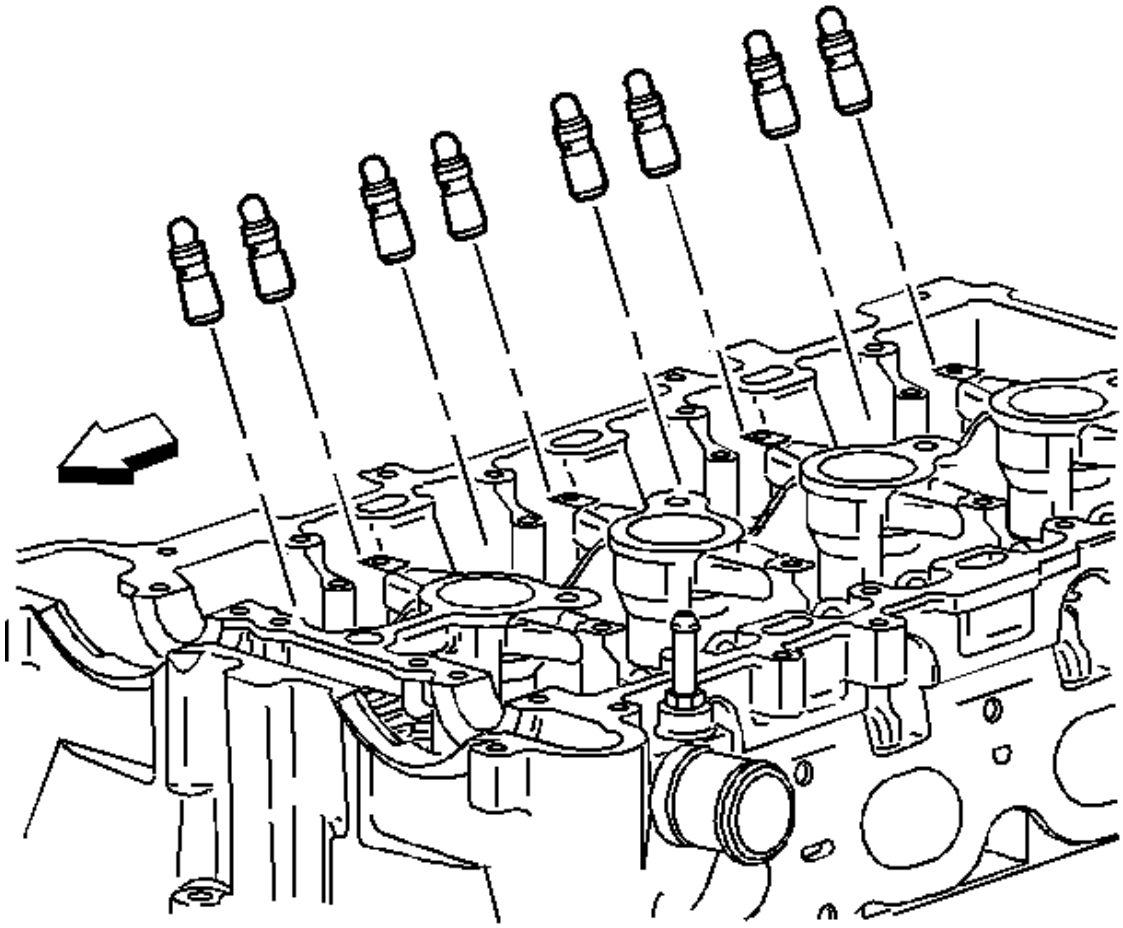

Fig. 155: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

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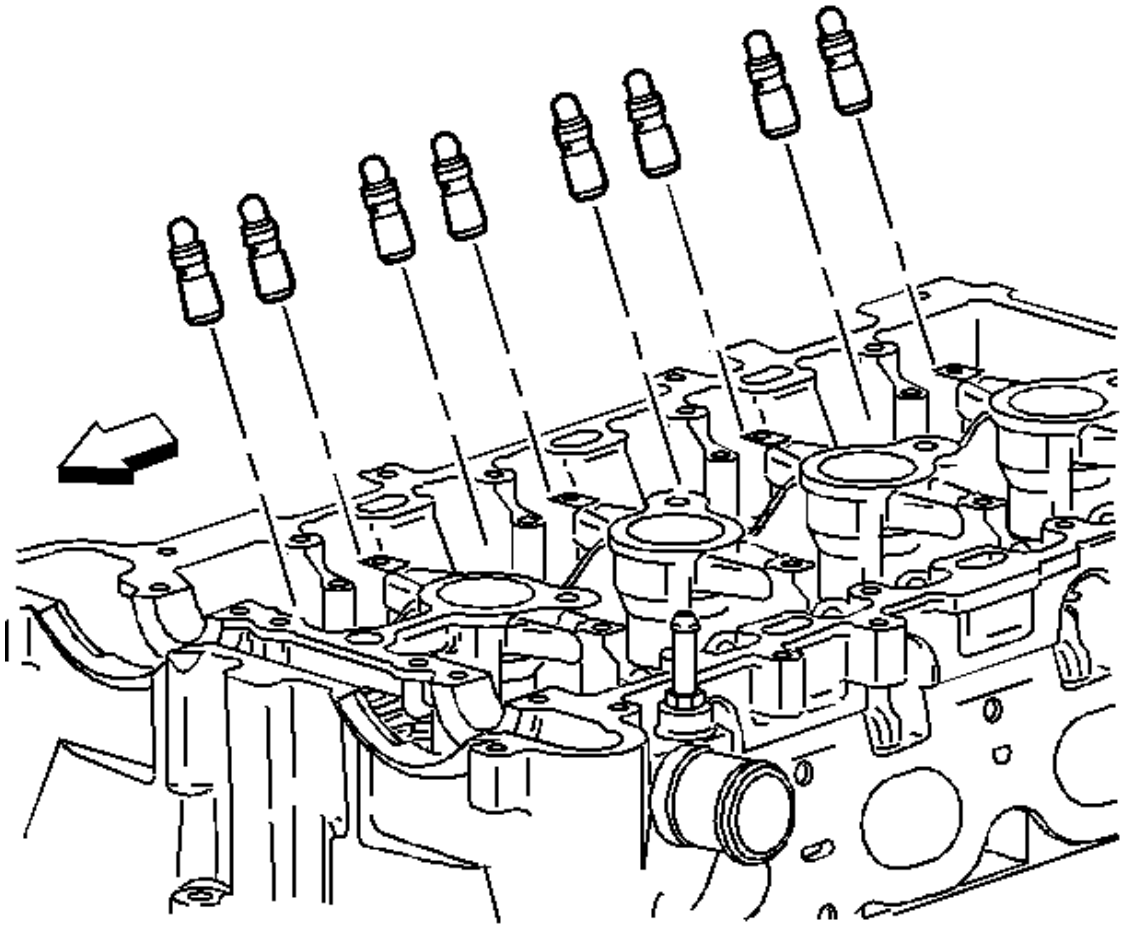

Fig. 156: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters with GM PN 12345501 (Canadian PN 992704) or equivalent.

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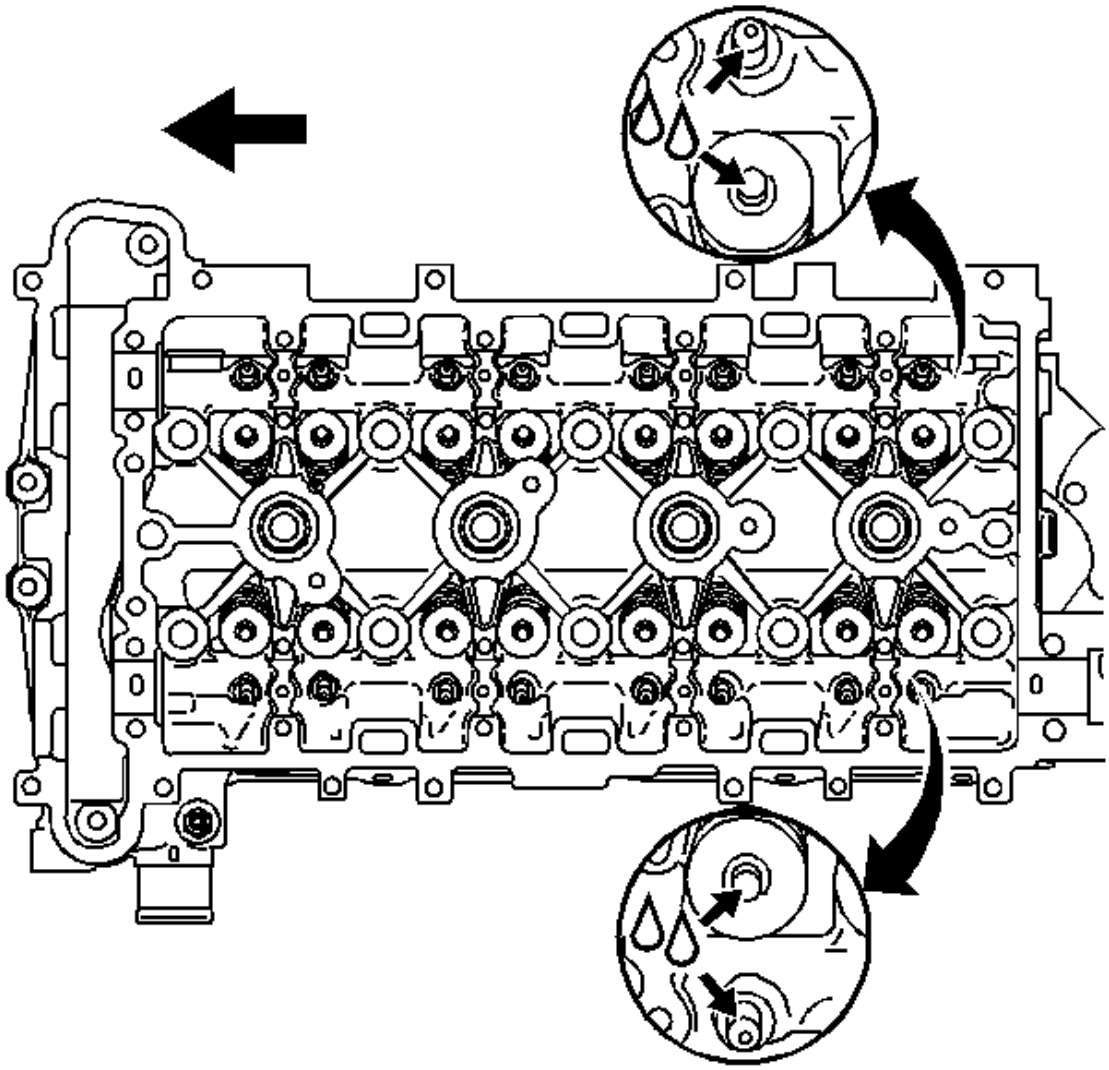

Fig. 157: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with GM PN 12345501 (Canadian PN 992704) or equivalent.

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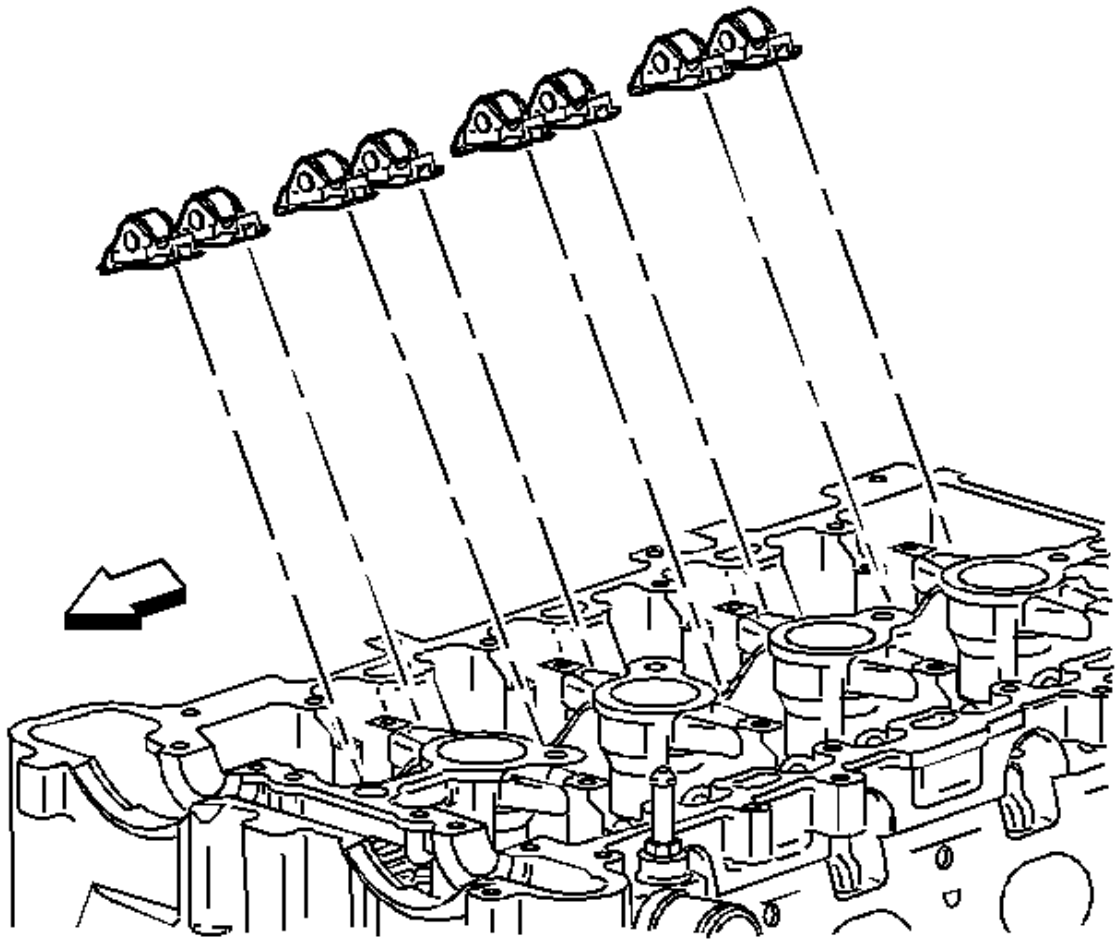

Fig. 158: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used roller followers MUST be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Apply lubricate GM PN 12345501 (Canadian PN 992704) or equivalent.

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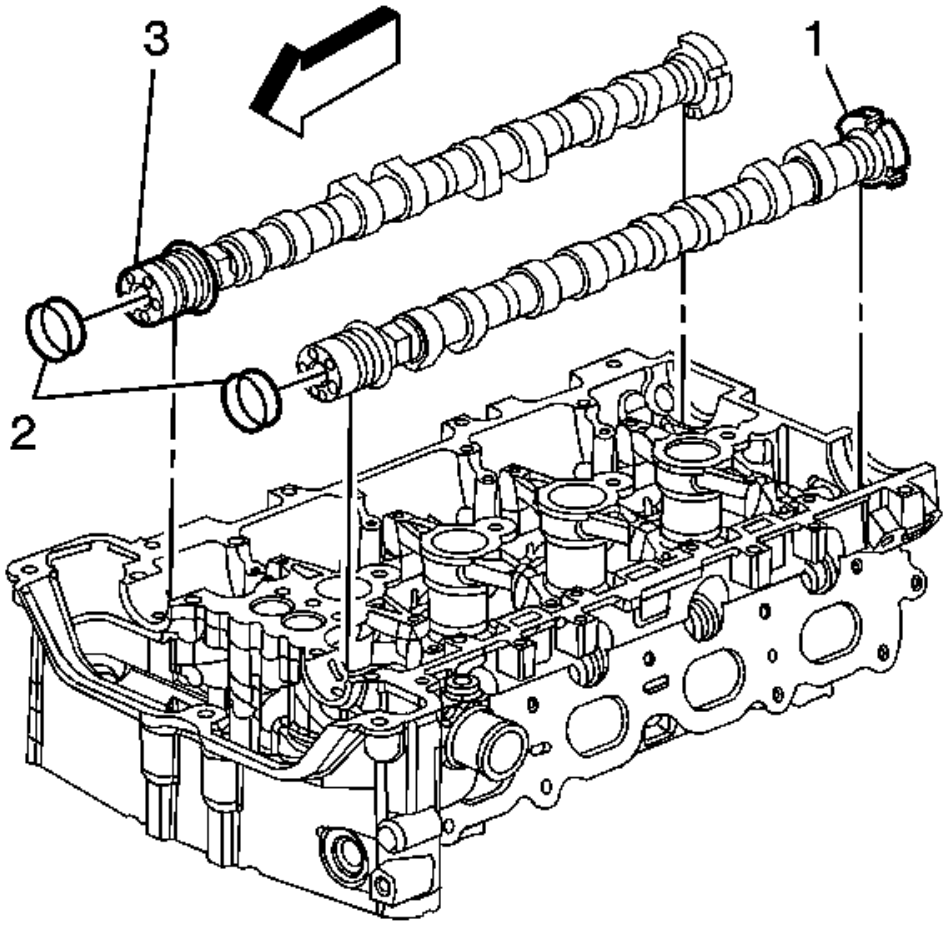

Fig. 159: Identifying Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft (3). Lubricate with GM PN 12345501 (Canadian PN 992704) or equivalent.

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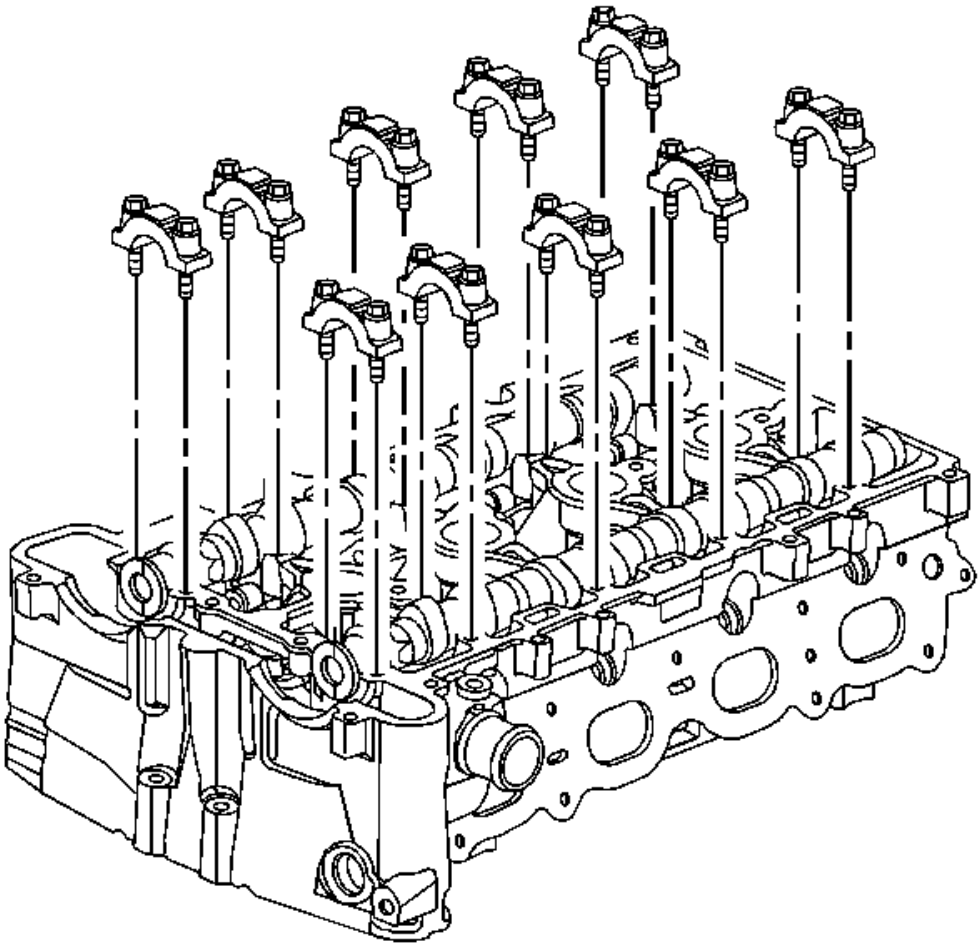

Fig. 160: View Of Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

6. Install the camshaft bearing caps. Hand tighten the cap bolts.

   NOTE: Refer to Fastener Notice .

7. Tighten the bearing cap bolts in increments of 3 turns until they are seated.

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

8. Install the exhaust camshaft position actuator. Refer to **Camshaft Position Exhaust Actuator Replacement**.

Camshaft Position Intake Actuator Replacement

Tools Required

- **J 44217** Timing Chain Tensioner Tool. See **Special Tools**.

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- **J 45059** Angle Meter

Removal Procedure

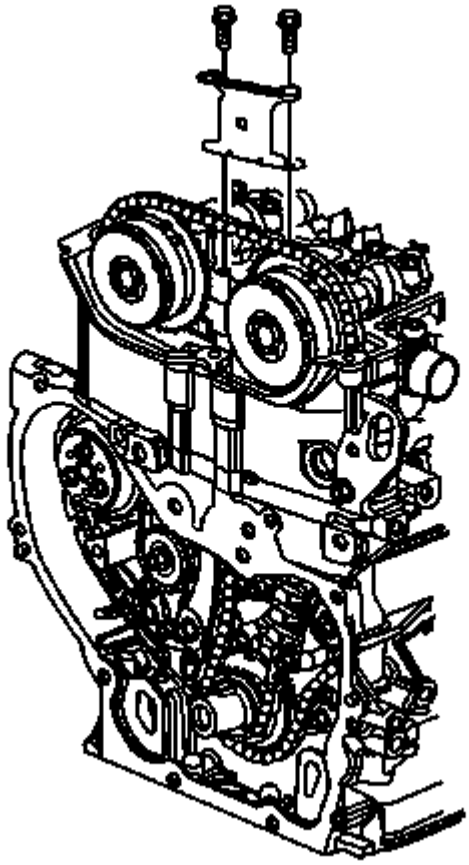

Fig. 161: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the upper timing chain guide bolts and guide.
3. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.
4. Loosen, but DO NOT remove the intake camshaft actuator bolt.

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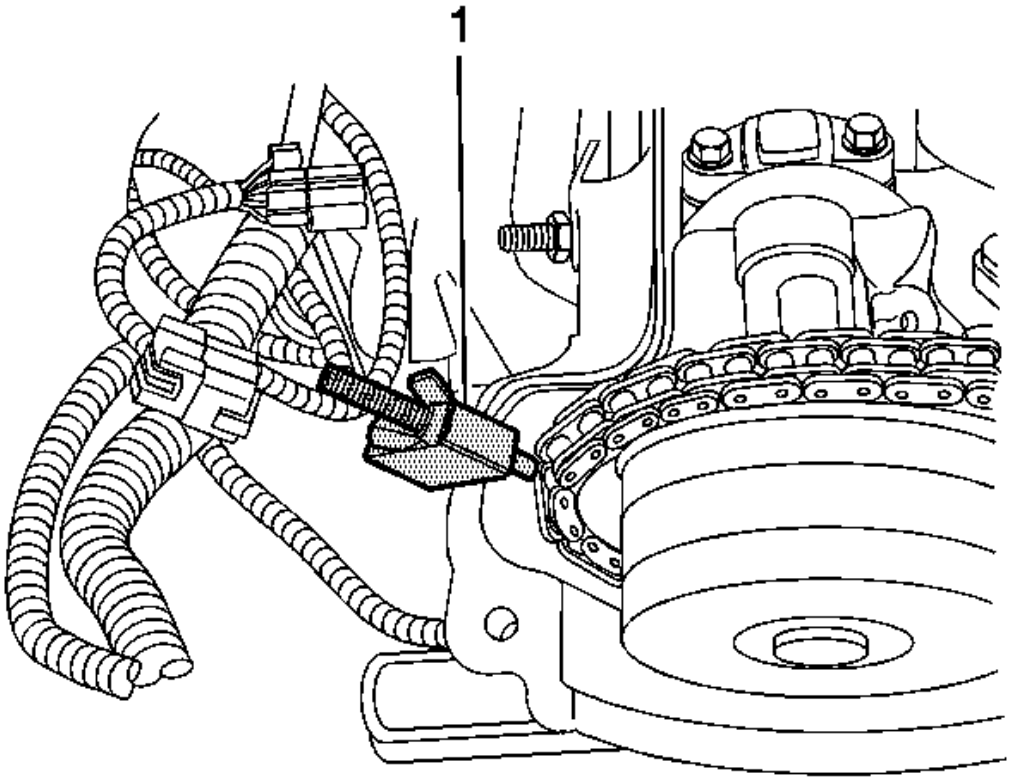

Fig. 162: Identifying J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the tips of the J 44217 are fully engaged into the timing chain. See Special Tools.

5. Install one of the tools (1) from the **J 44217** to the exhaust camshaft side of the timing chain assembly in order to retain the timing chain. See **Special Tools**. Firmly tighten the nuts.

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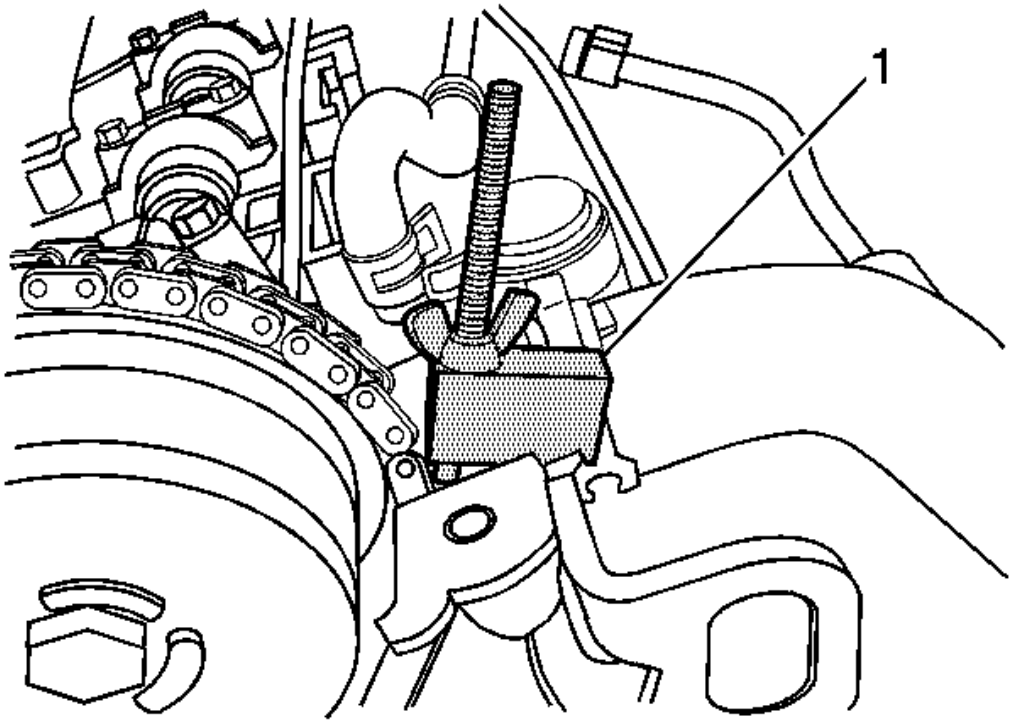

Fig. 163: View Of J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the tips of the J 44217 are fully engaged into the timing chain. See Special Tools.

6. Install one of the tools (1) from the **J 44217** to the intake camshaft side of the timing chain assembly in order to retain the timing chain. See **Special Tools**. Firmly tighten the nuts.

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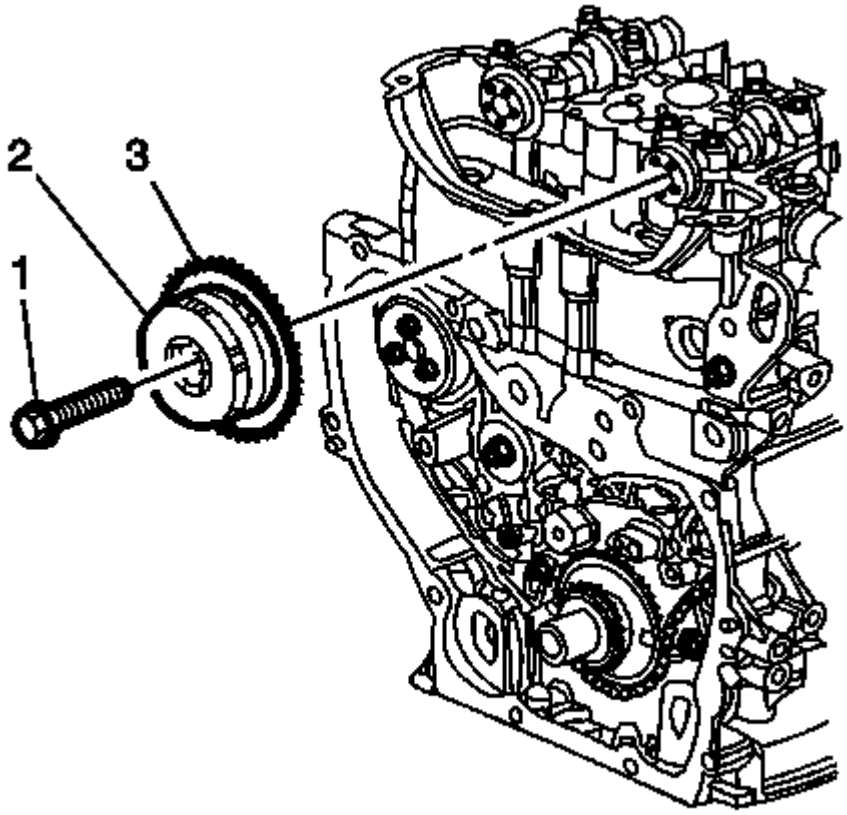

Fig. 164: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the timing chain and the camshaft position actuators are marked for proper assembly.

7. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.
8. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.
9. Remove and discard the intake camshaft actuator bolt (2).
10. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

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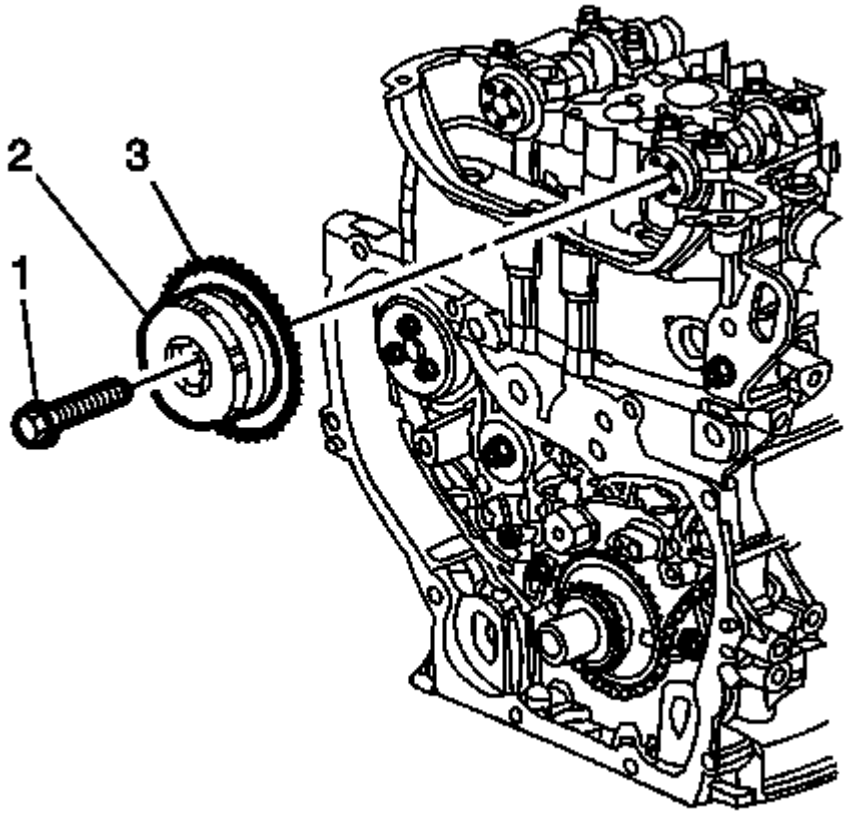

Fig. 165: Identifying Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the alignment mark made previously on the exhaust camshaft actuator is still aligned properly with the mark on the timing chain.

1. Install the timing chain onto the intake camshaft actuator.
2. Align the intake camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
3. Install a NEW intake camshaft actuator bolt (2) until snug.

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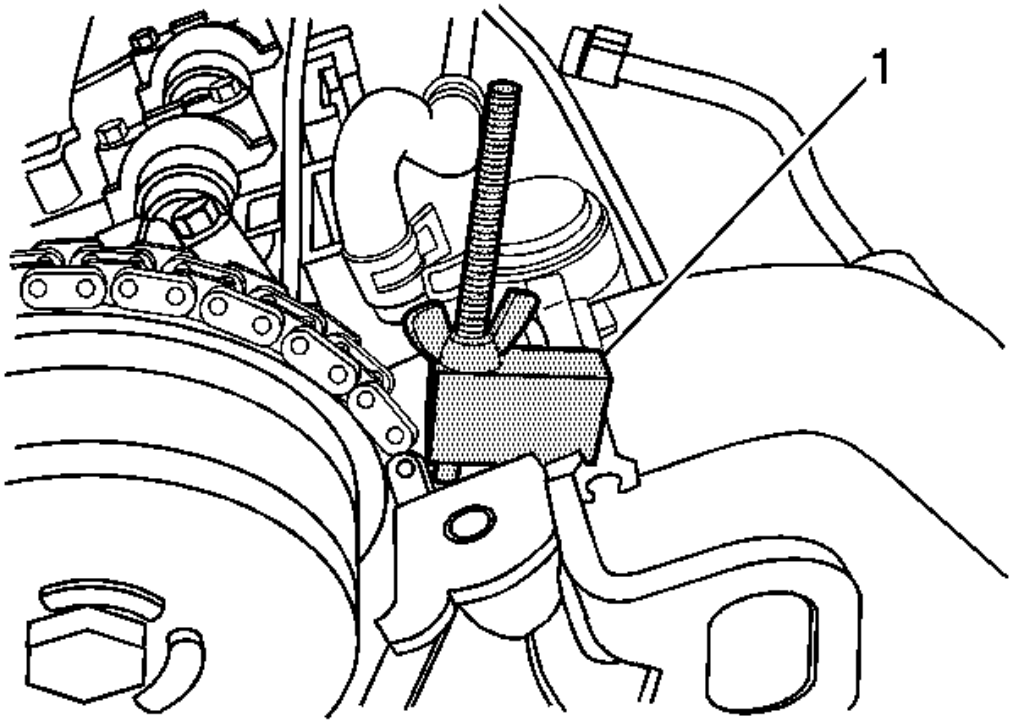

Fig. 166: View Of J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the tool (1) from the intake camshaft side of the timing chain assembly.

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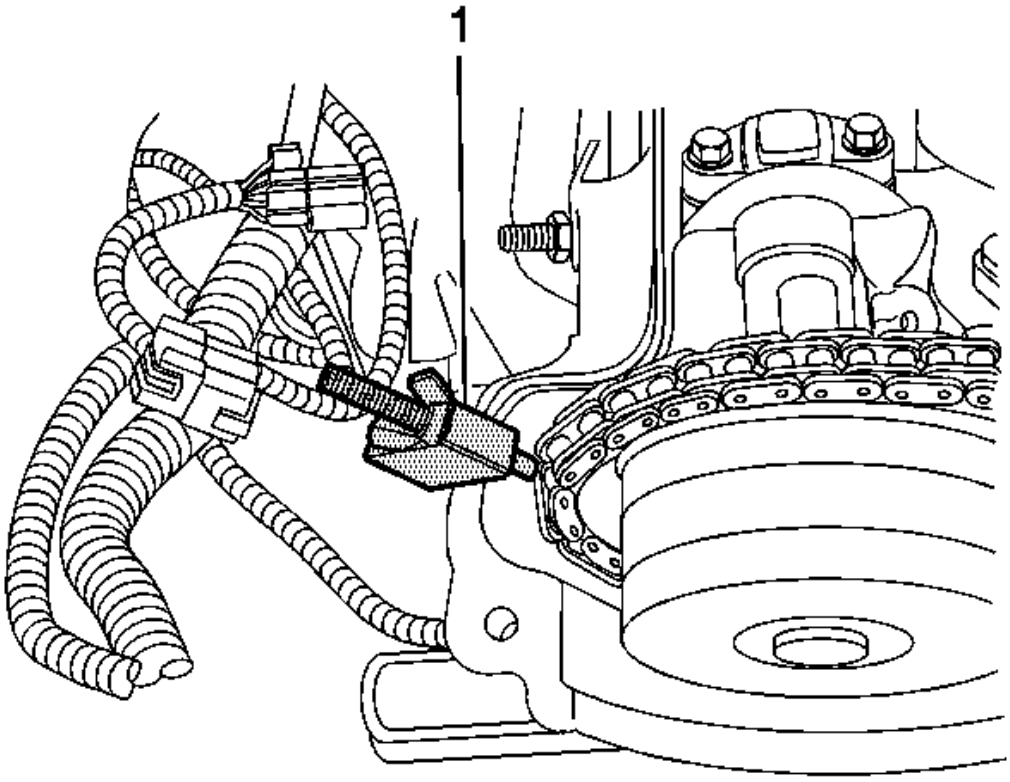

Fig. 167: Identifying J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the tool (1) from the exhaust camshaft side of the timing chain assembly.
6. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.

NOTE: Refer to Fastener Notice .

7. Tighten the NEW camshaft actuator bolt.

Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059** .

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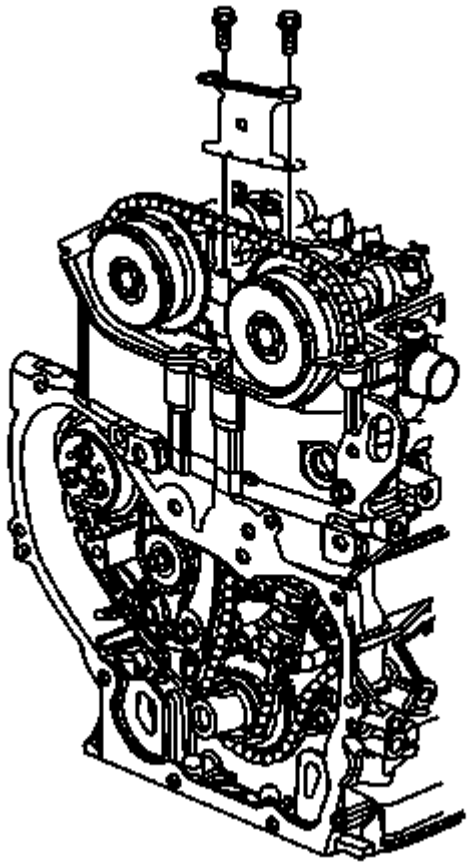

Fig. 168: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

8. Install the upper timing chain guide and bolts.

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

9. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

Camshaft Position Exhaust Actuator Replacement

Tools Required

- **J 44217** Timing Chain Tensioner Tool. See **Special Tools**.
- **J 45027** Tensioner Tool
- **J 45059** Angle Meter

Removal Procedure

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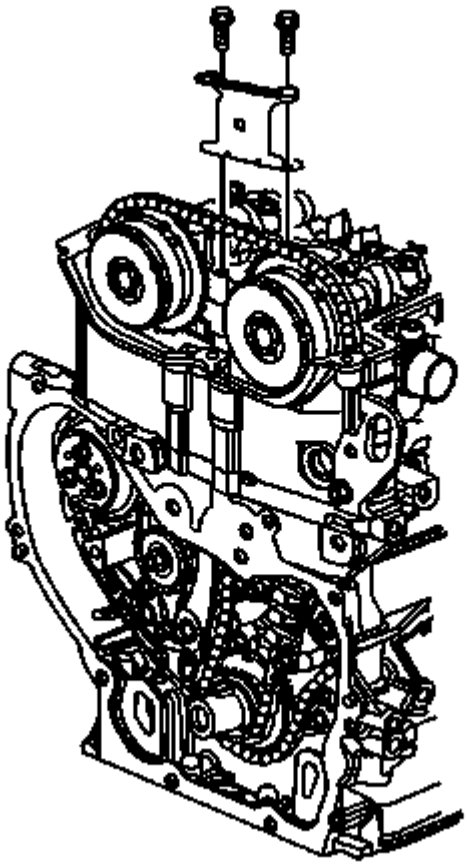

Fig. 169: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the upper timing chain guide bolts and guide.

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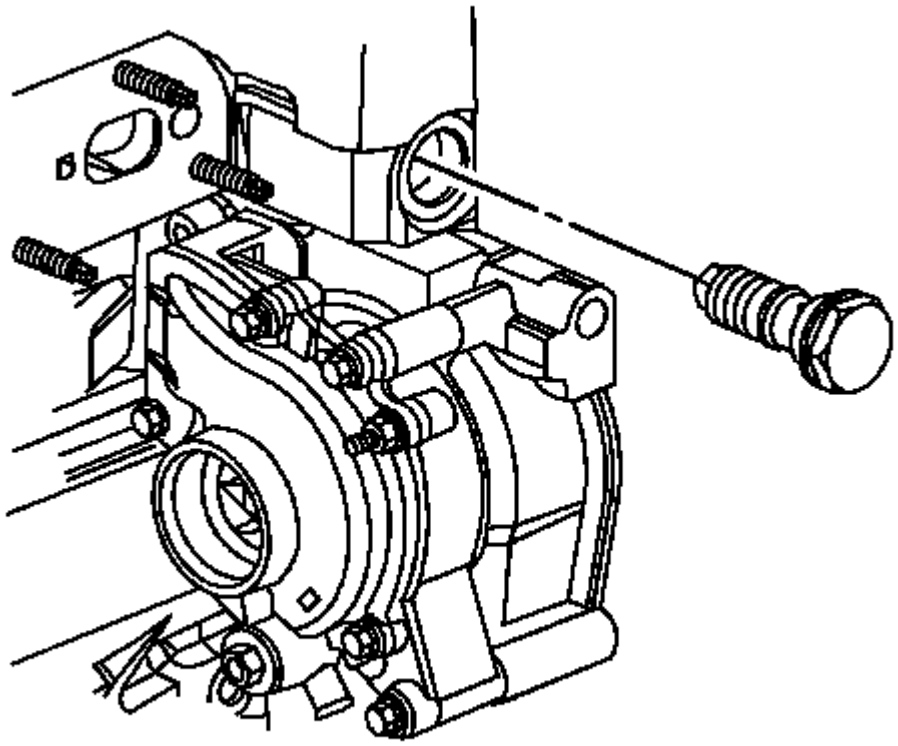

Fig. 170: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

3. Remove the timing chain tensioner.
4. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.
5. Loosen, but DO NOT remove the exhaust camshaft actuator bolt.

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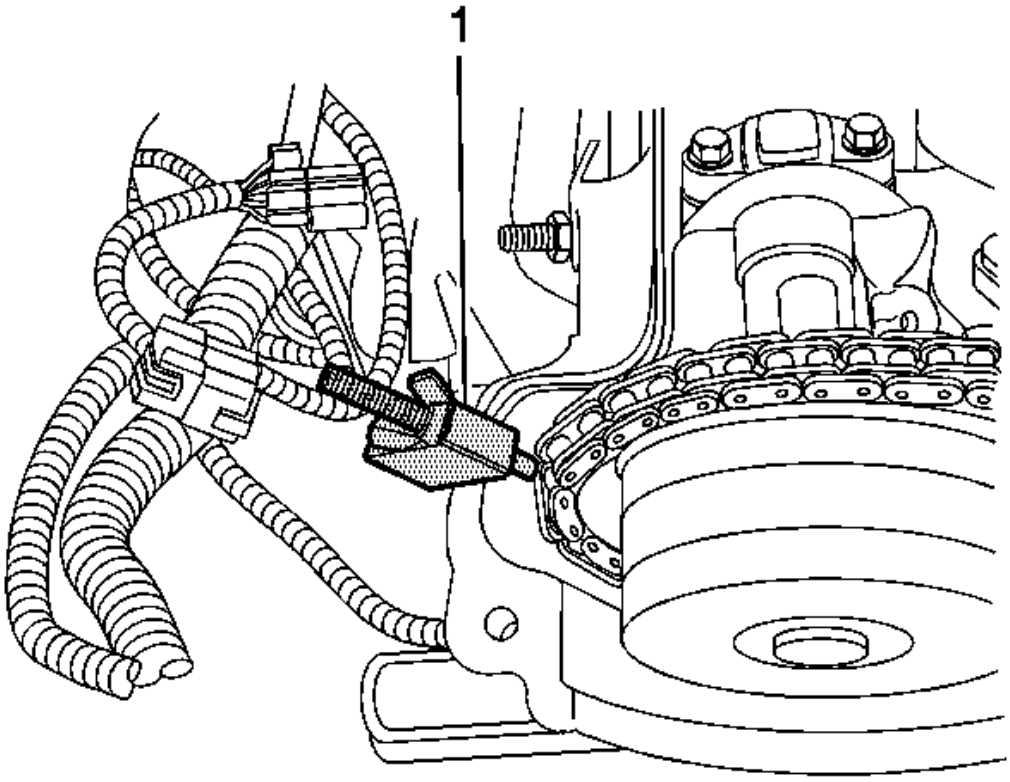

Fig. 171: Identifying J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the tips of the J 44217 are fully engaged into the timing chain. See Special Tools.

6. Install one of the tools (1) from the **J 44217** to the exhaust camshaft side of the timing chain assembly in order to retain the timing chain. See **Special Tools**. Firmly tighten the nuts.

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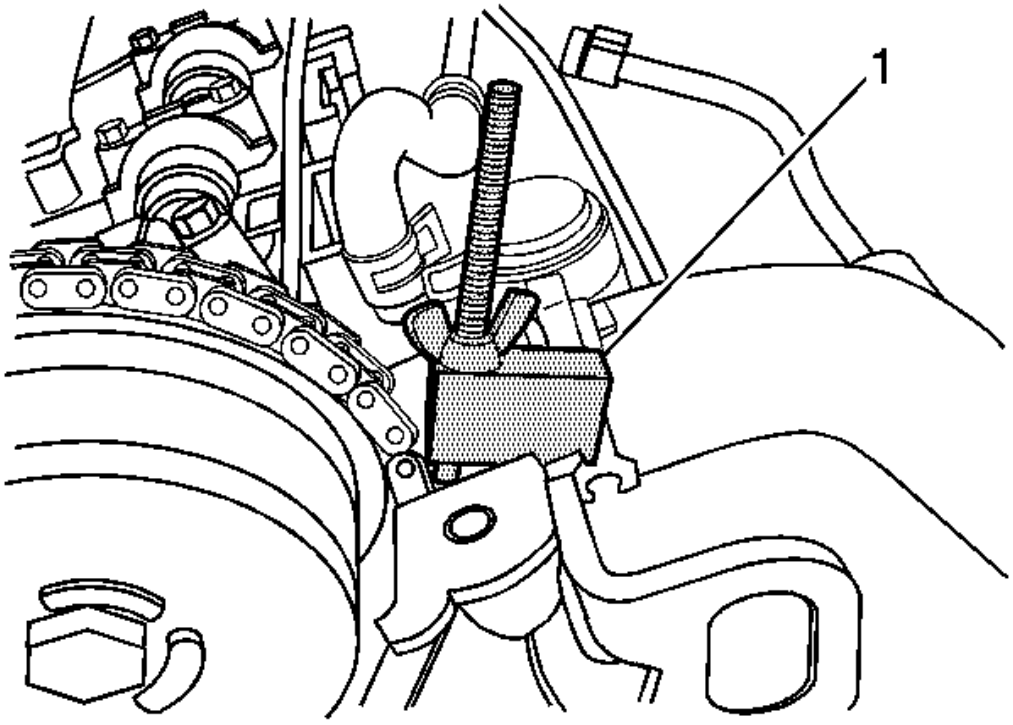

Fig. 172: View Of J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the tips of the J 44217 are fully engaged into the timing chain. See Special Tools.

7. Install one of the tools (1) from the **J 44217** to the intake camshaft side of the timing chain assembly in order to retain the timing chain. See **Special Tools**. Firmly tighten the nuts.

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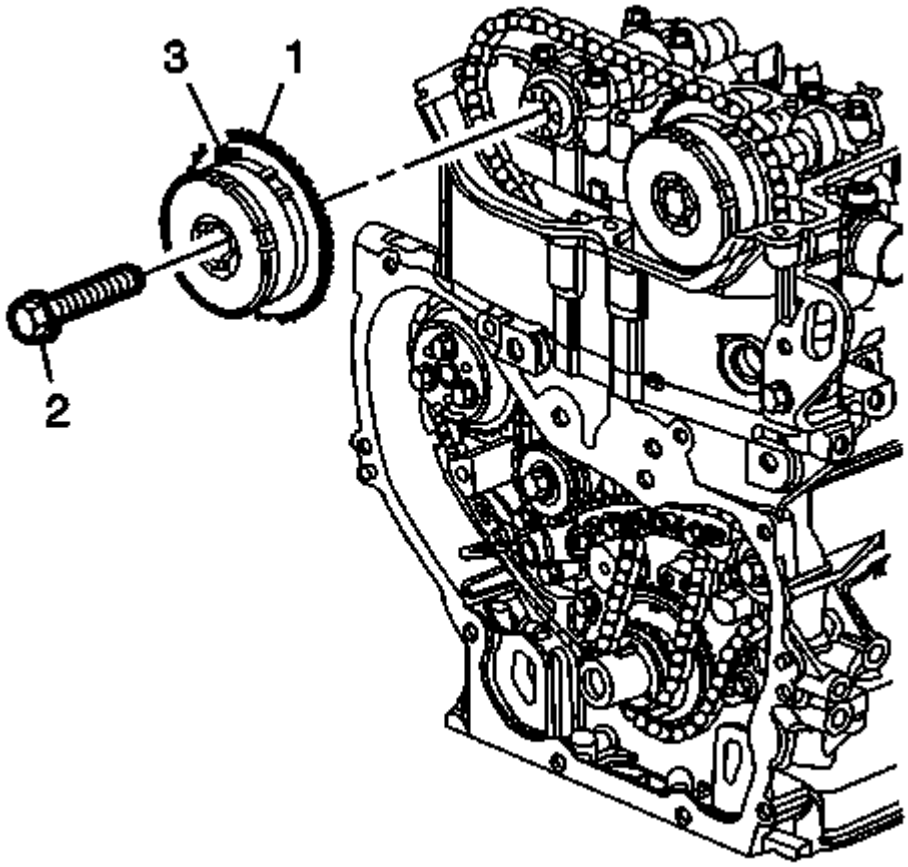

Fig. 173: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the timing chain and the camshaft position actuators are marked for proper assembly.

8. Mark the intake and exhaust camshaft actuators and the respective locations on the timing chain.
9. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.
10. Remove and discard the exhaust camshaft actuator bolt (2).
11. Remove the exhaust camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

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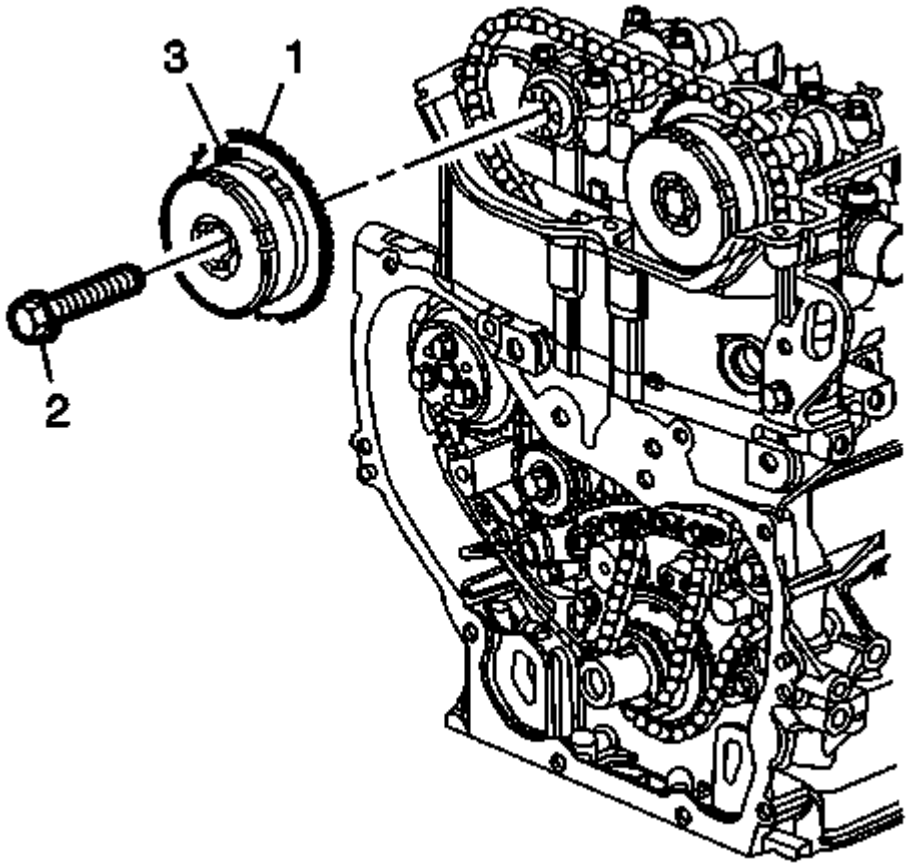

Fig. 174: Identifying Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.

1. Install the timing chain onto the exhaust camshaft actuator.
2. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
3. Install a NEW exhaust camshaft actuator bolt (2) until snug.

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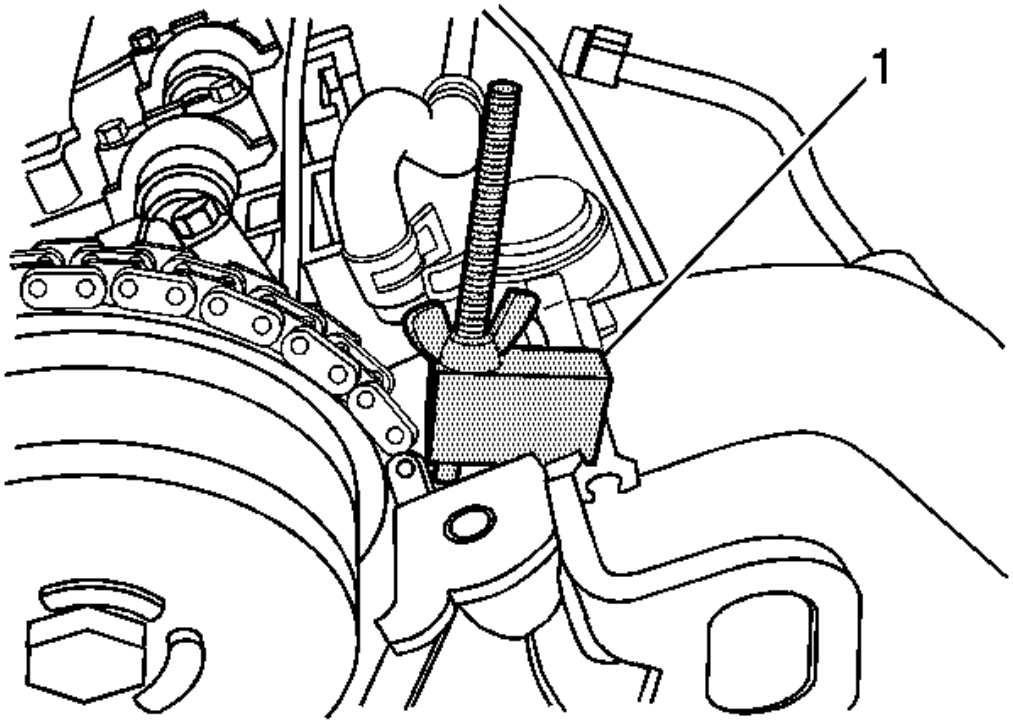

Fig. 175: View Of J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

4. Remove the tool (1) from the intake camshaft side of the timing chain assembly.

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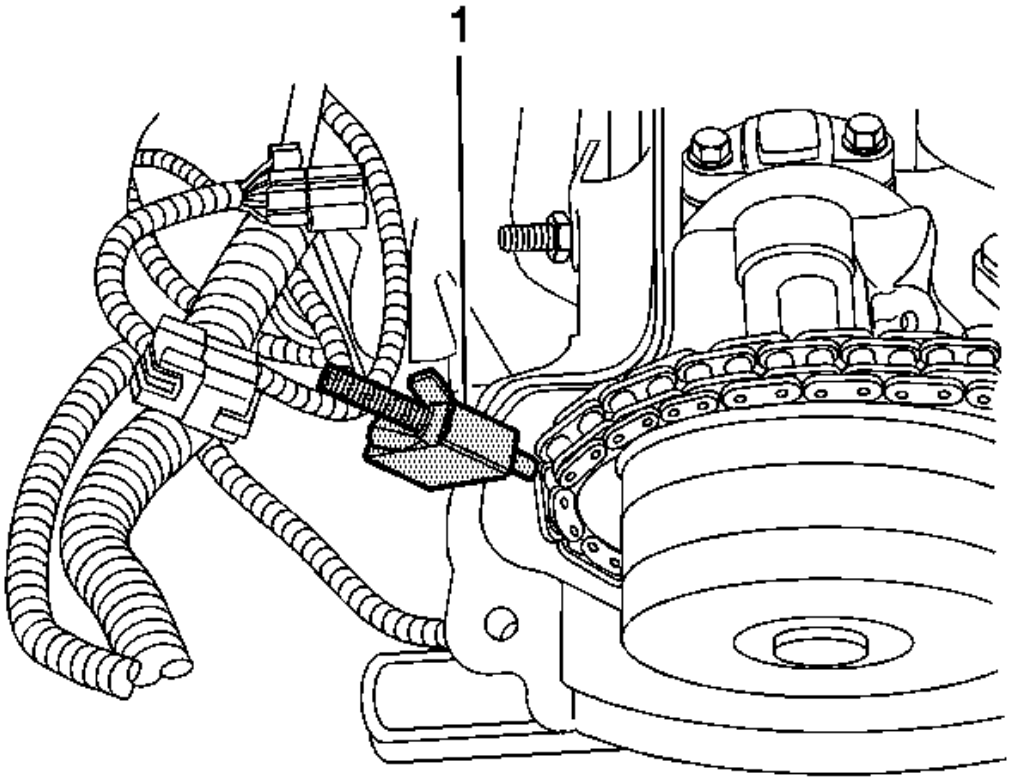

Fig. 176: Identifying J 44217 Timing Chain Tensioner Tool
Courtesy of GENERAL MOTORS CORP.

5. Remove the tool (1) from the exhaust camshaft side of the timing chain assembly.
6. Install a 24 mm wrench onto the hex on the camshaft in order to hold the camshaft.

NOTE: Refer to Fastener Notice .

7. Tighten the NEW camshaft actuator bolt.

Tighten: Tighten the bolt to 85 N.m (63 lb ft), plus an additional 30 degrees using the **J 45059** .

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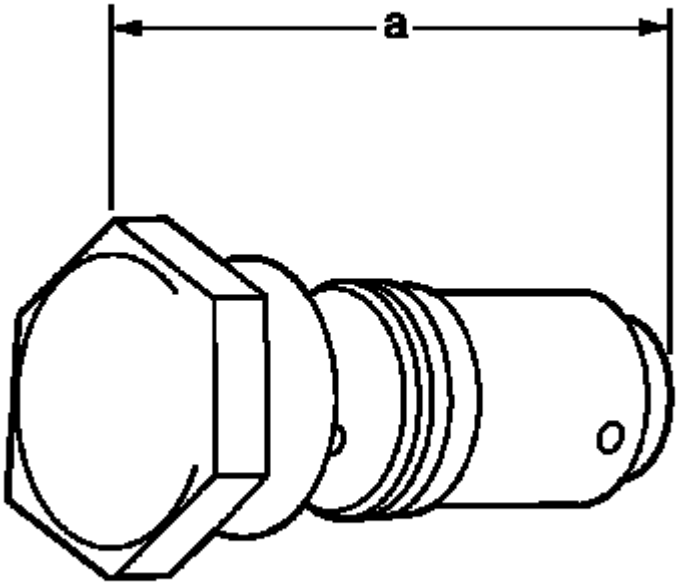

Fig. 177: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

8. Remove the old oil from the timing chain tensioner.
9. Inspect the timing chain tensioner for scoring or free movement.
10. Inspect the timing chain washer and O-ring for damage. If damaged, replace the timing chain tensioner.
11. Measure the timing chain tensioner assembly from end to end. A NEW tensioner should be supplied in the fully compressed non-active state. A tensioner in the compressed state will measure 72 mm (2.83 in) from end to end (a). A tensioner in the active state will measure 85 mm (3.35 in) from end to end (a).

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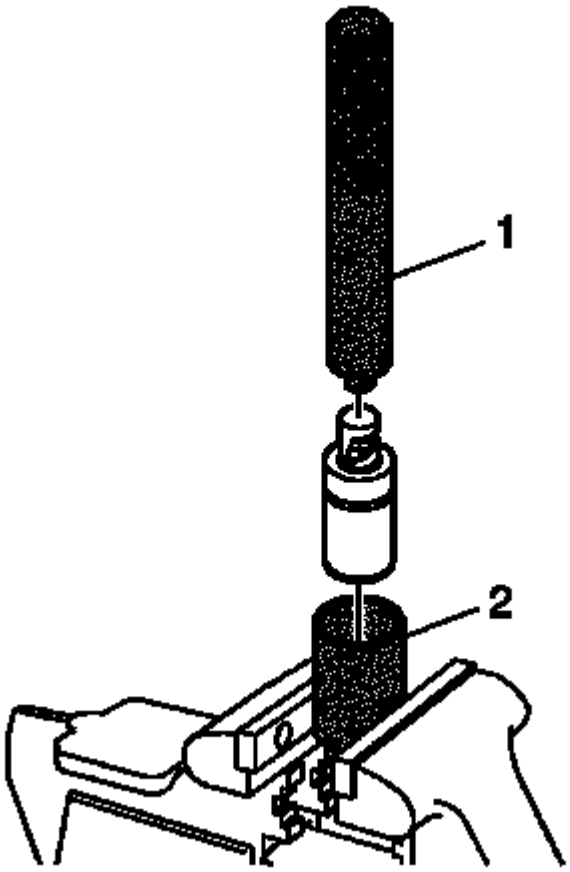

Fig. 178: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

12. If the timing chain tensioner is not in the compressed state, perform the following steps:
    1. Remove the piston assembly from the body of the timing chain tensioner by pulling it out.
    2. Install the J 45027-2 (2) into a vise.
    3. Install the notch end of the piston assembly into the J 45027-2 (2).
    4. Using the J 45027-1 (1), turn the ratchet cylinder into the piston.

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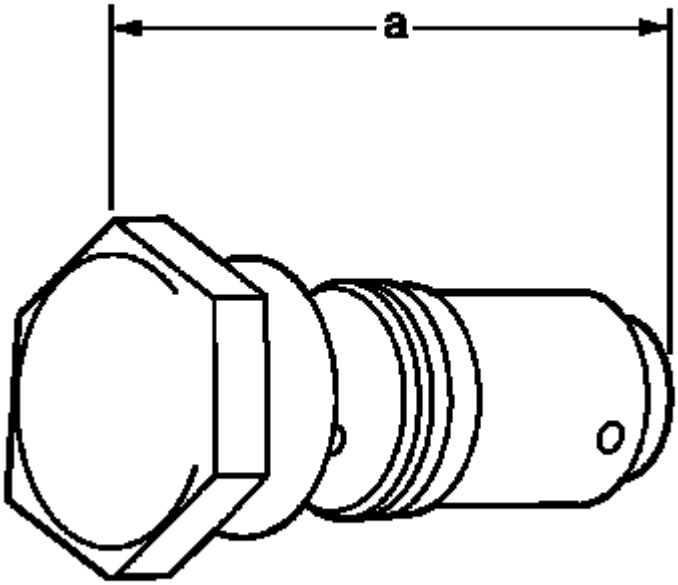

Fig. 179: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

13. Inspect the bore of the tensioner body for dirt, debris, and damage. If any damage appears, replace the tensioner. Clean dirt or debris with a lint free cloth.
14. Install the compressed piston assembly back into the timing chain tensioner body until the assembly stops at the bottom of the bore. Do not compress the piston assembly against the bottom of the bore. If the piston assembly is compressed against the bottom of the bore, the assembly will activate the tensioner, which will then need to be reset again.
15. At the point the tension should measure approximately 72 mm (2.83 mm) from end to end (a). If the tensioner does not measure 72 mm (2.83 mm) from end to end (a) repeat steps 8.1- 8.4.

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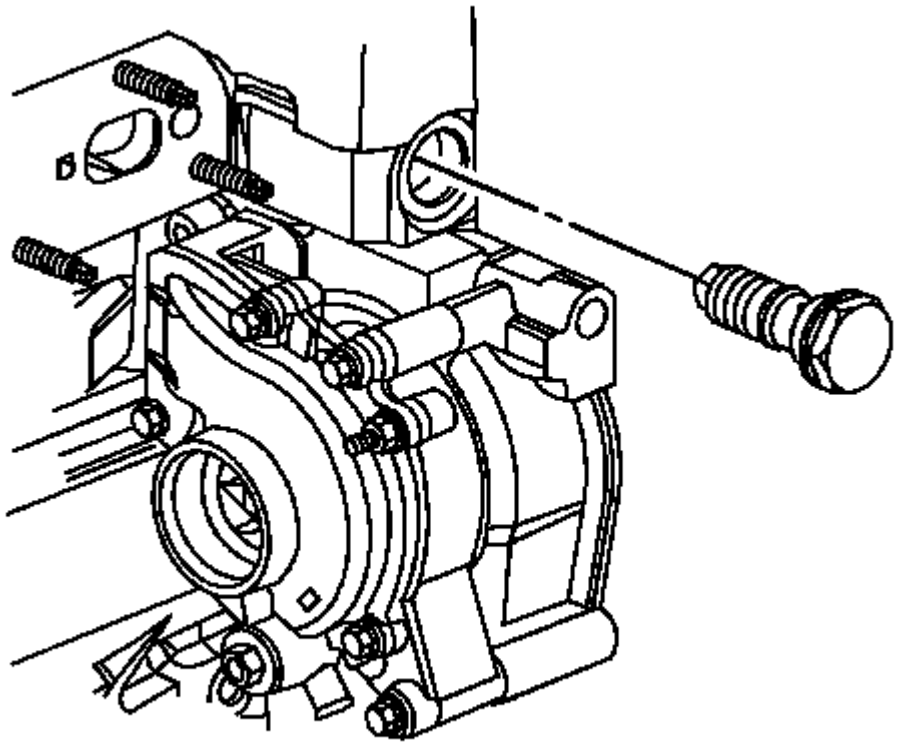

Fig. 180: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

16. Ensure that all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.
17. Install the timing chain tensioner.

    Tighten: Tighten the tensioner to 75 N.m (66 lb ft).

18. The timing chain tensioner is released by compressing the tensioner 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam chest to rest on the timing chain, then give a sharp jolt diagonally downwards to release the tensioner.

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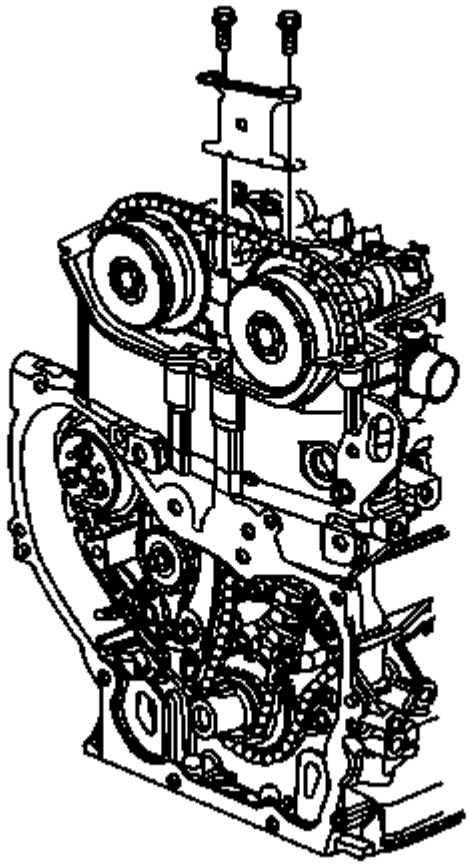

Fig. 181: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

19. Install the upper timing chain guide and bolts.

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

20. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

Valve Stem Oil Seal and Valve Spring Replacement

Tools Required

- **J 43649** Valve Spring Compressor
- **J 36017** Valve Guide Seal Remover
- **J 43653** Flywheel Holding Tool
- **J 43655** Sprocket Holding Tool

Removal Procedure

IMPORTANT: Prevent the crankshaft from rotating clockwise or counter-clockwise before

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using compressed air in the cylinder. Rotation of the crankshaft may cause damage to J 43655 .

1. If equipped, with a manual transmission leave the transmission in first gear with the vehicle on the ground and the parking brake set.
2. If equipped, with an automatic transmission, remove the starter. Refer to **Starter Motor Replacement (RPOs L61/LE5)** .
3. Install **J 43653** .

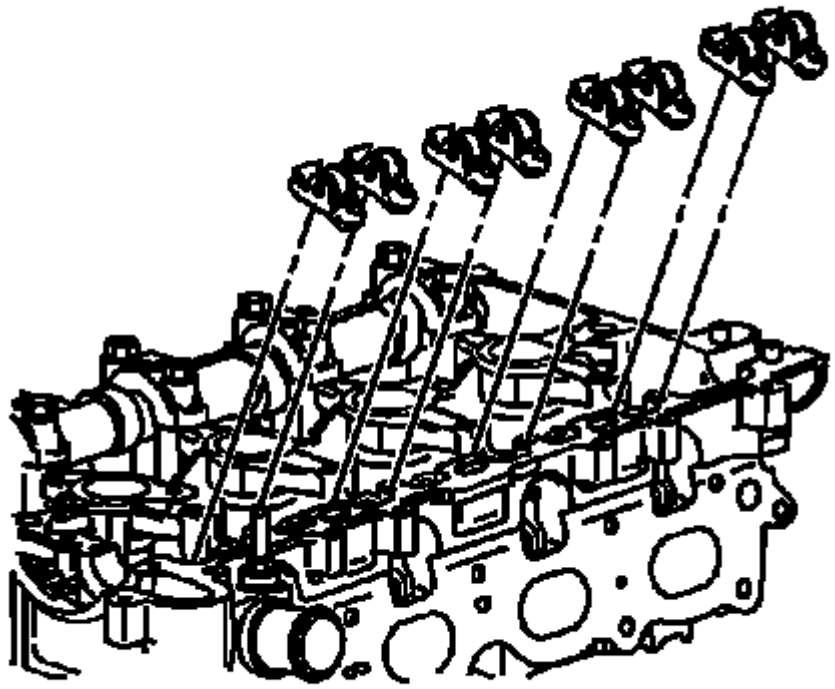

Fig. 182: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft. Refer to **Intake Camshaft and Lifter Replacement** or **Exhaust Camshaft and Lifter Replacement**.
5. Remove the camshaft roller followers.

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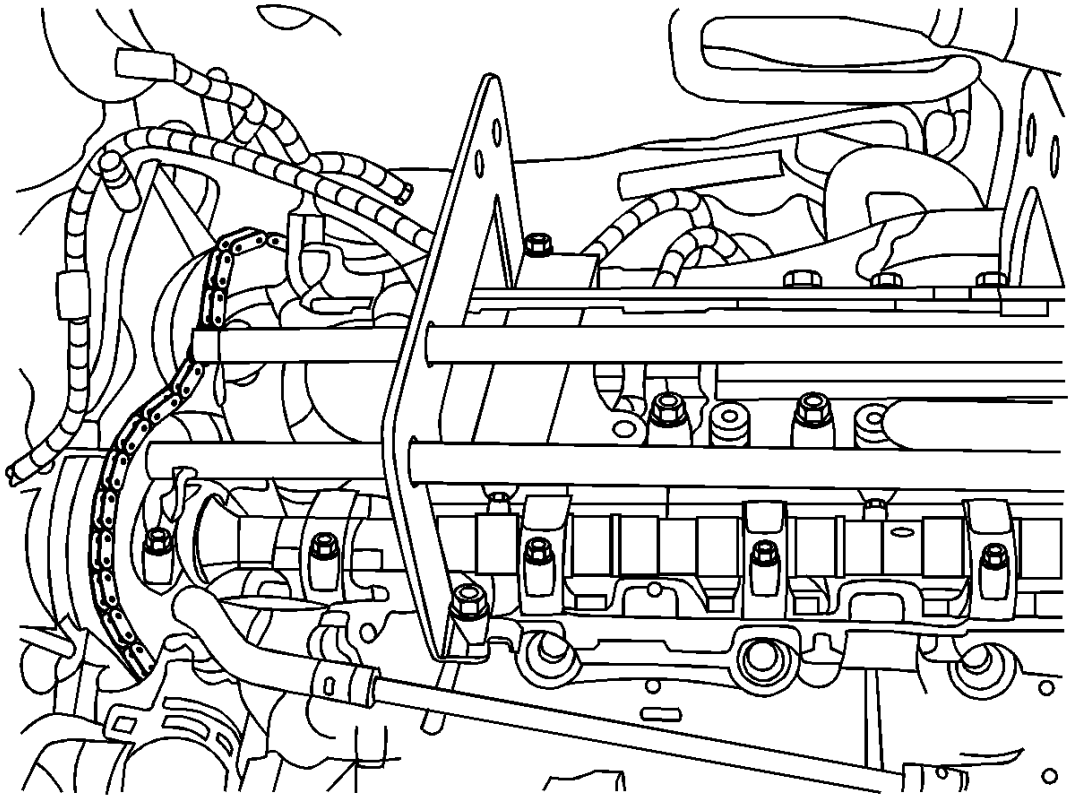

Fig. 183: View Of J 43649 Valve Spring Compressor
Courtesy of GENERAL MOTORS CORP.

6. Install the front section of the **J 43649** to the second camshaft cover bolt hole.

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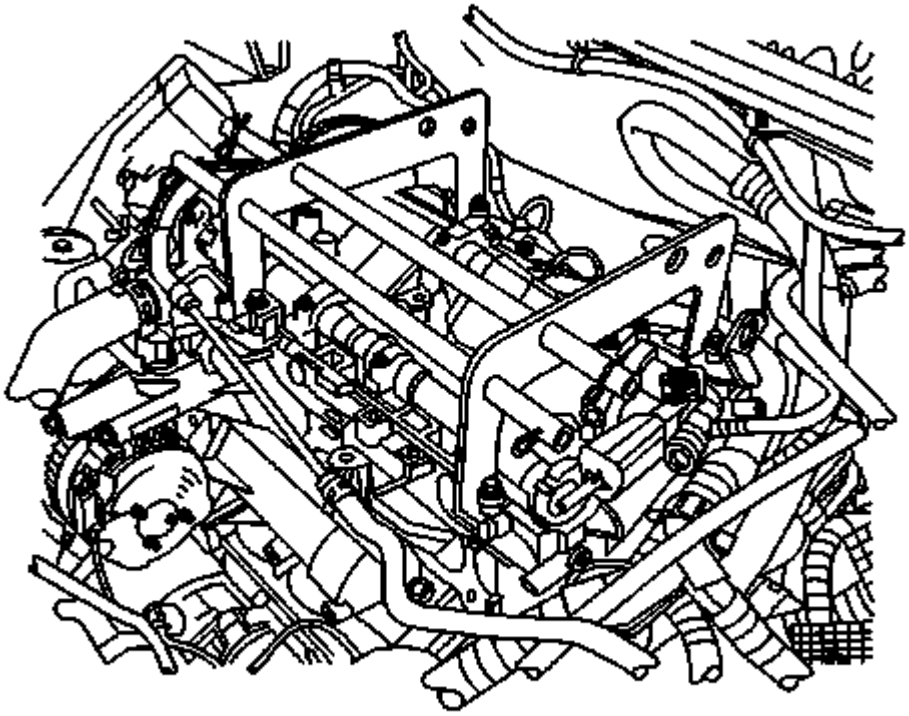

Fig. 184: View Of J 43649 Valve Spring Compressor (Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

7. Install the remaining parts of the **J 43649** to the cylinder head.
8. Remove the spark plugs. Refer to **Spark Plug Replacement** .

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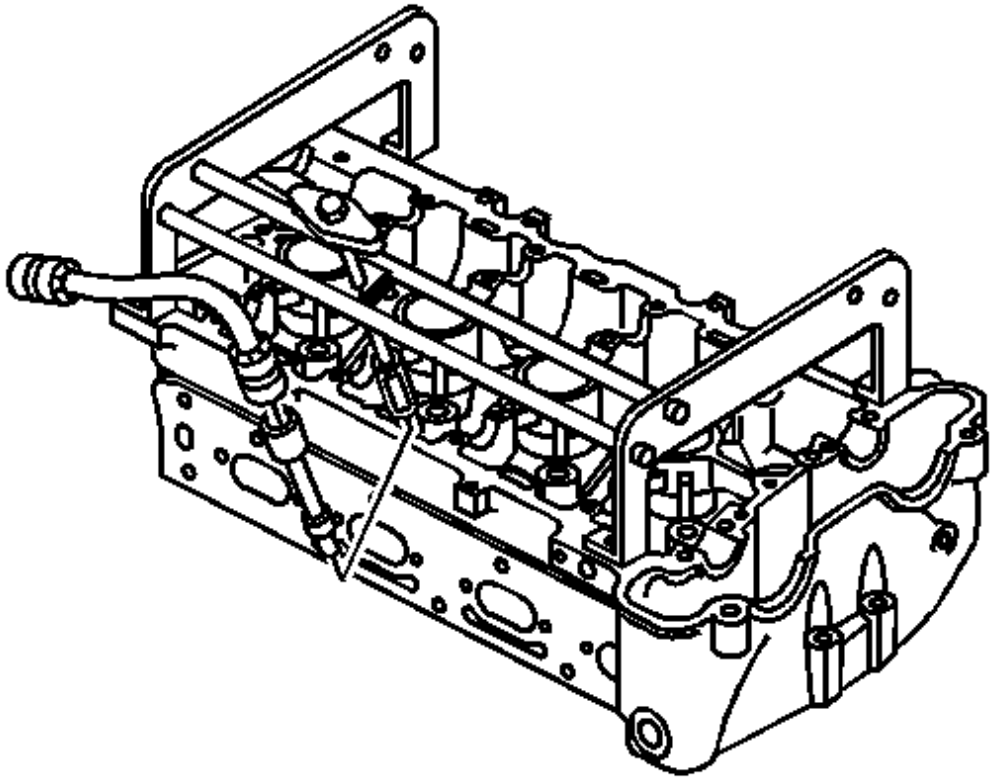

Fig. 185: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

9. Install an air hose adapter into the spark plug hole.
10. Attach an air hose to the adapter
11. Using the compressed air, pressurize the cylinder to 690 kPa (100 psi).
12. Compress the valve spring using the **J 43649** .

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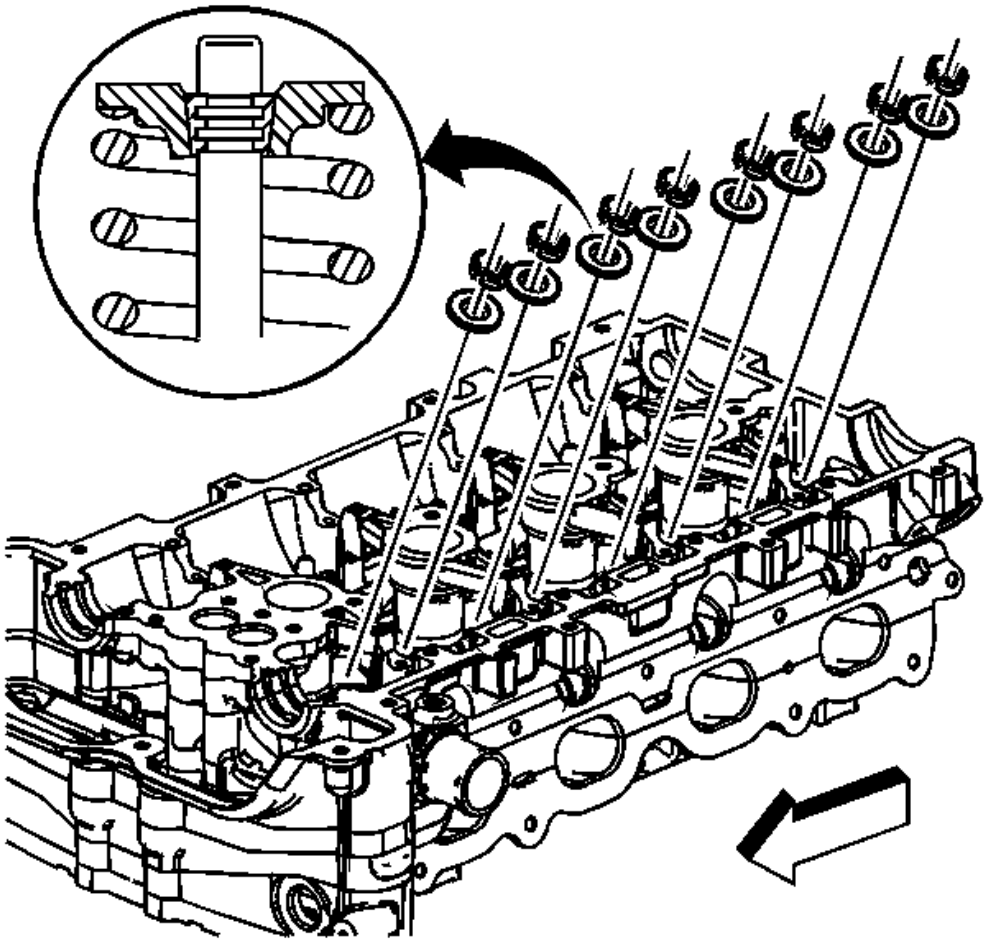

Fig. 186: Identifying Valve Spring Keepers
Courtesy of GENERAL MOTORS CORP.

13. Remove the valve spring keepers.
14. Remove the valve spring retainer.

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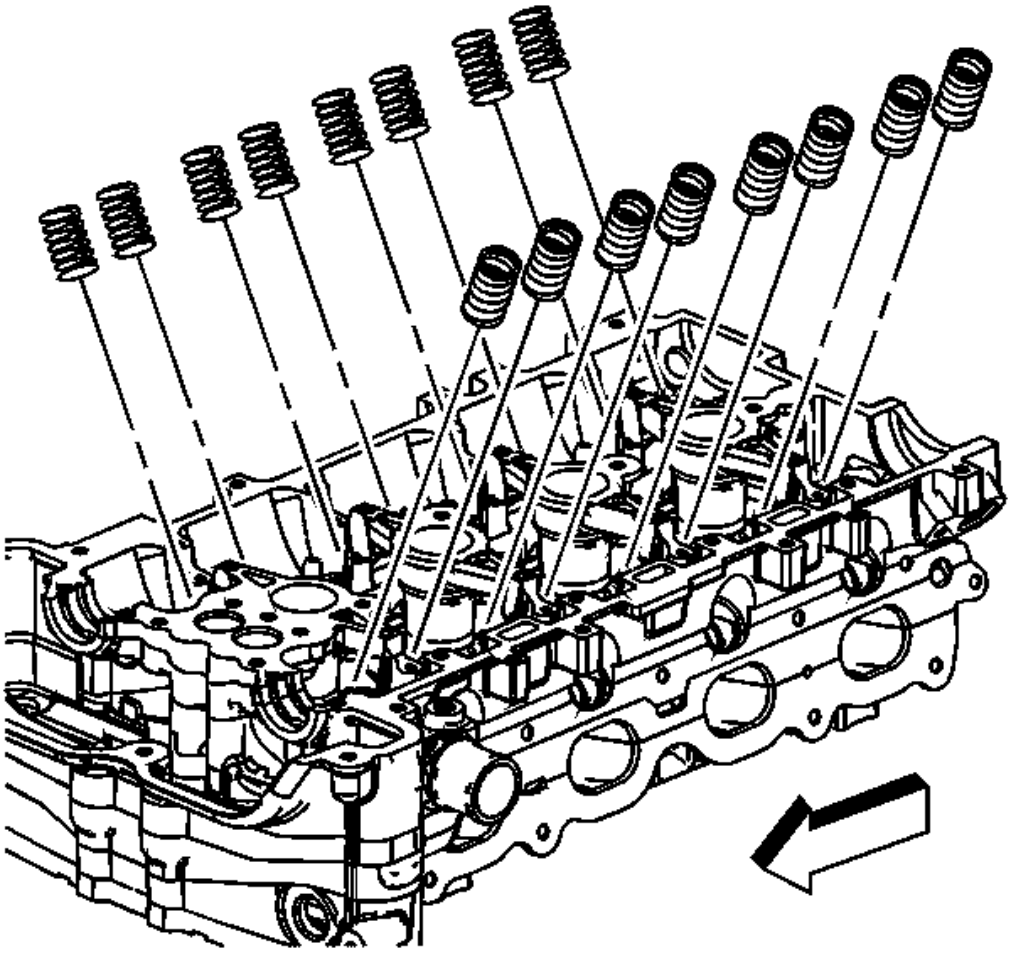

Fig. 187: Identifying Valve Springs
Courtesy of GENERAL MOTORS CORP.

15. Remove the valve spring.

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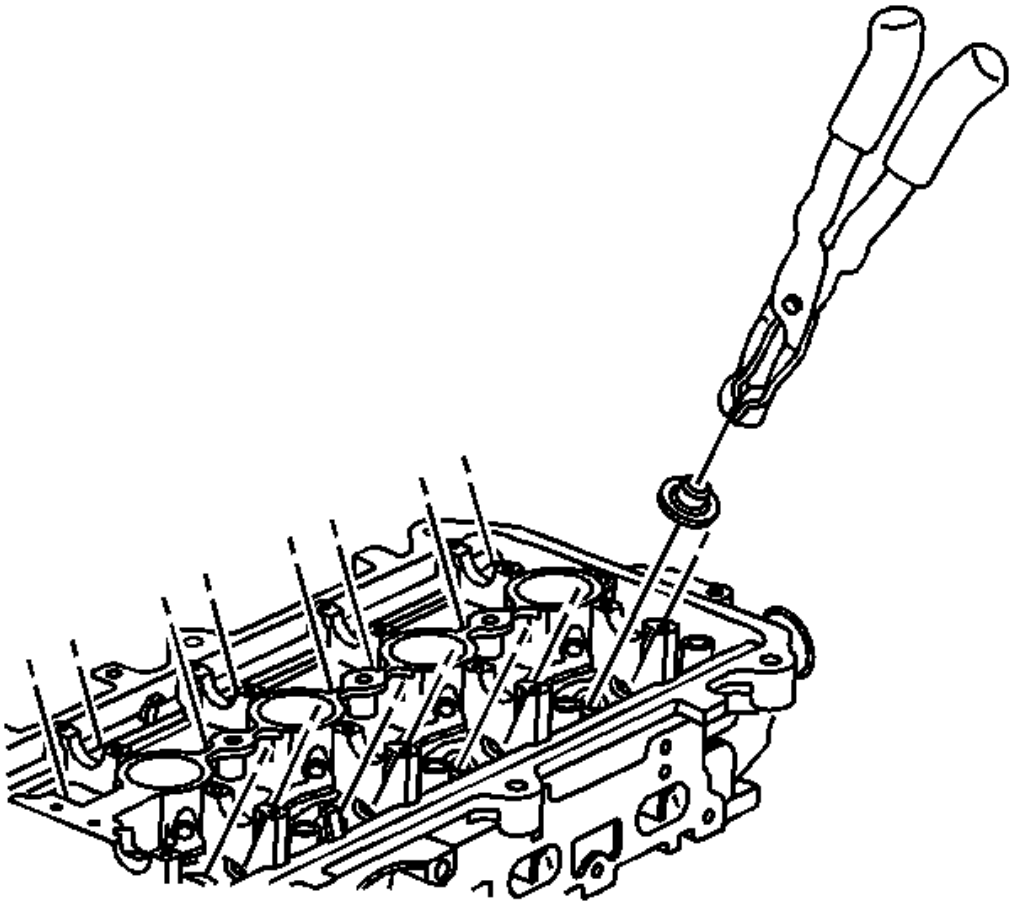

Fig. 188: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

16. Using the **J 36017** remove the valve seal.

Installation Procedure

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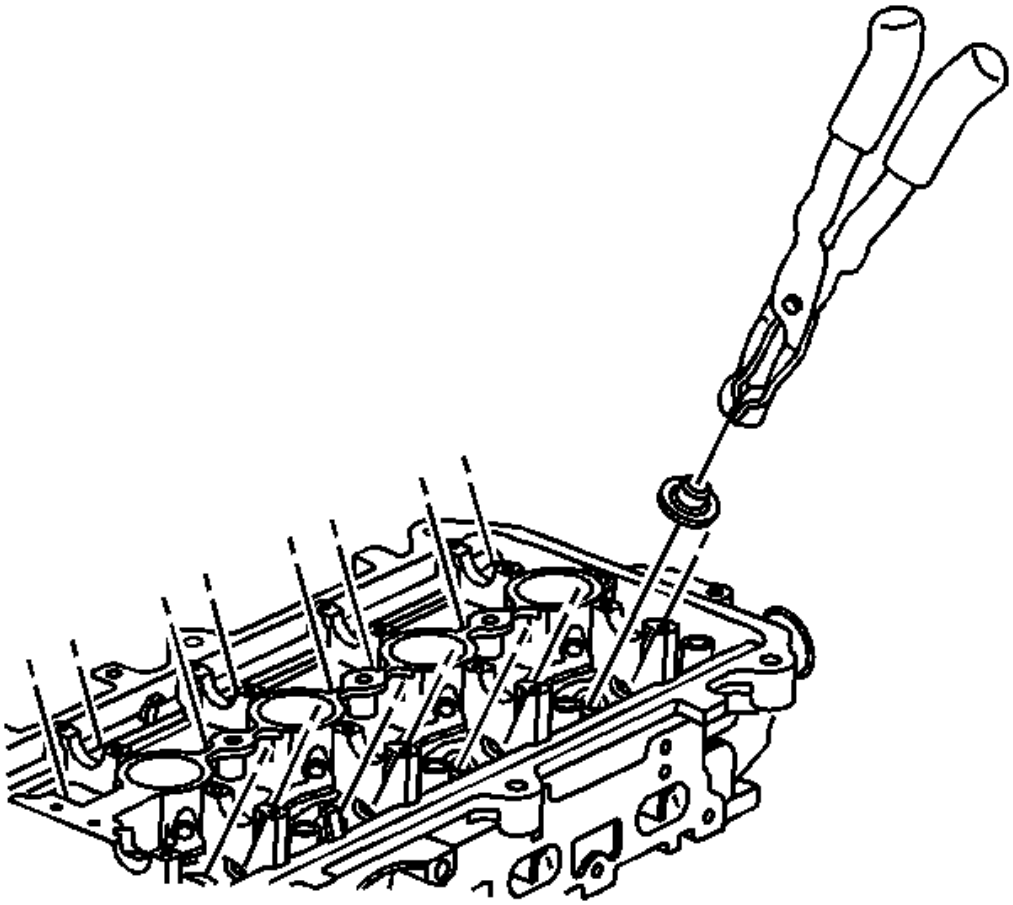

Fig. 189: View Of J 36017 & Valve Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 36017** install the NEW valve seal. Fully seat the seal onto the valve guide.

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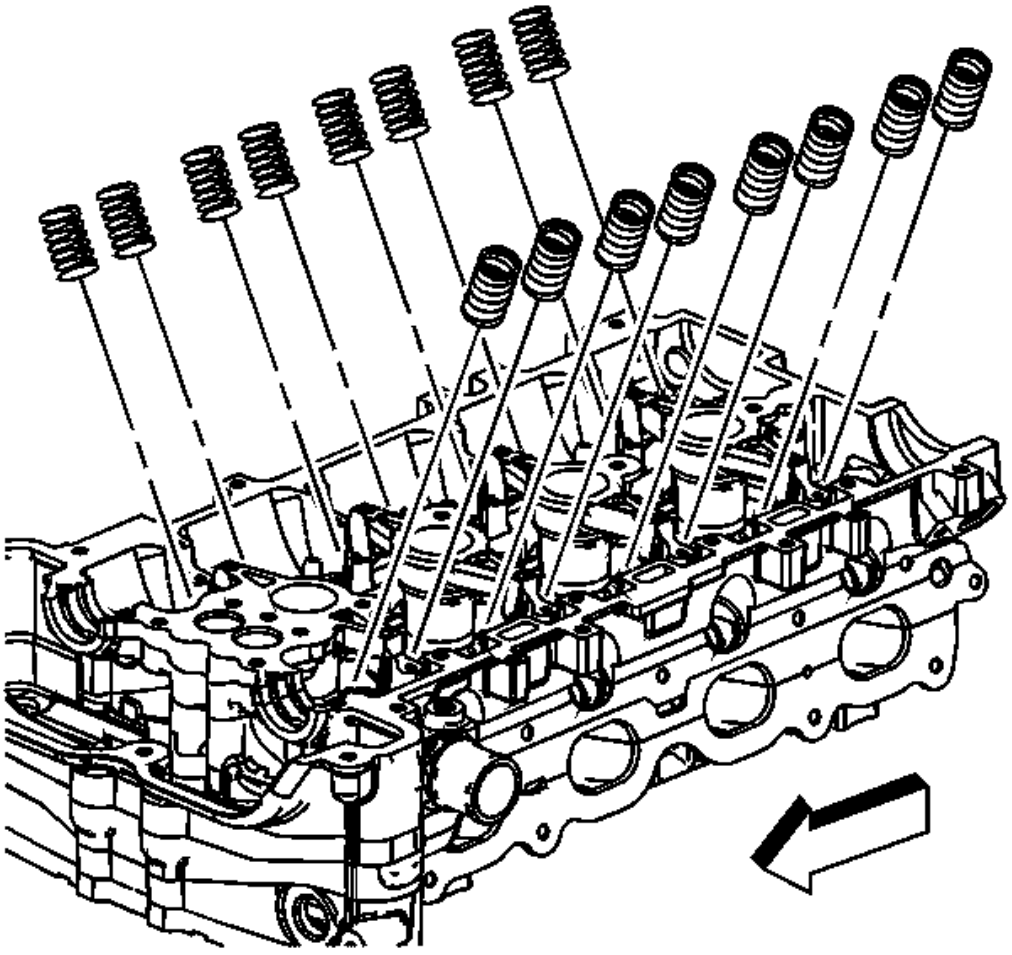

Fig. 190: Identifying Valve Springs
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring.

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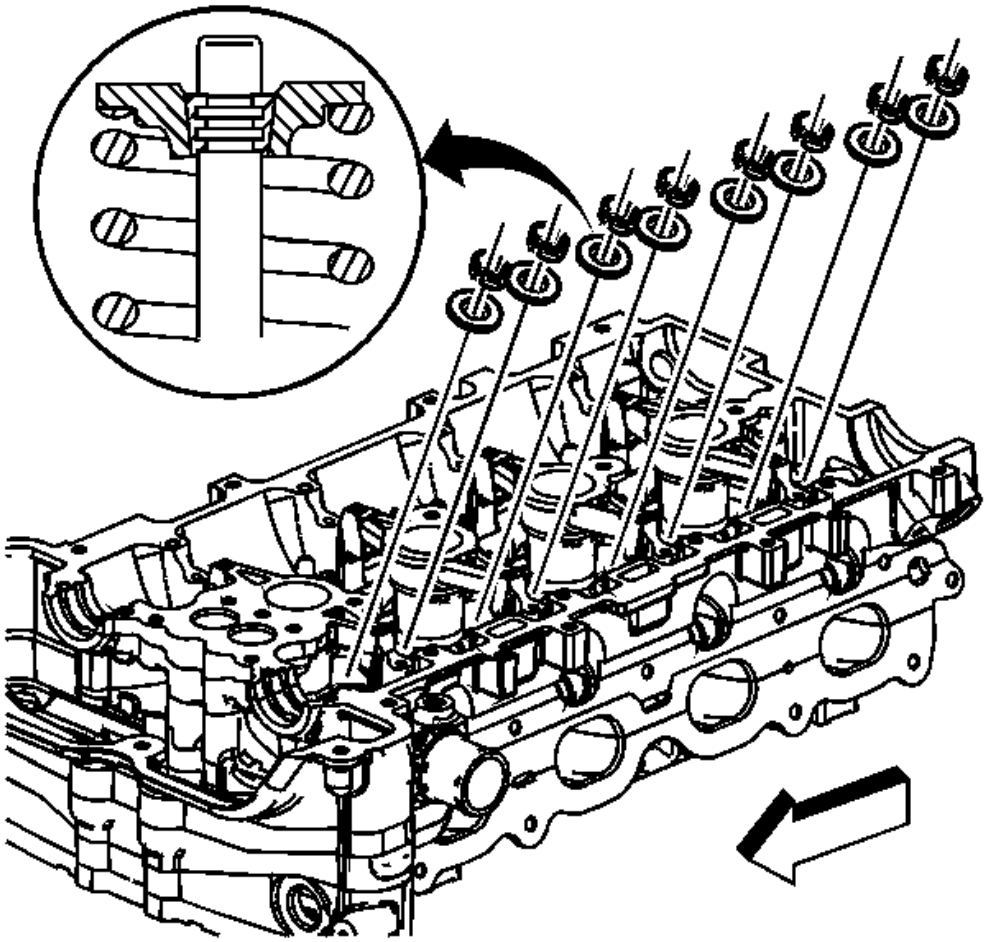

Fig. 191: Identifying Valve Spring Keepers
Courtesy of GENERAL MOTORS CORP.

3. Install the valve spring retainer.
4. Compress the valve spring using the **J 43649** .
5. Install the valve spring keepers.

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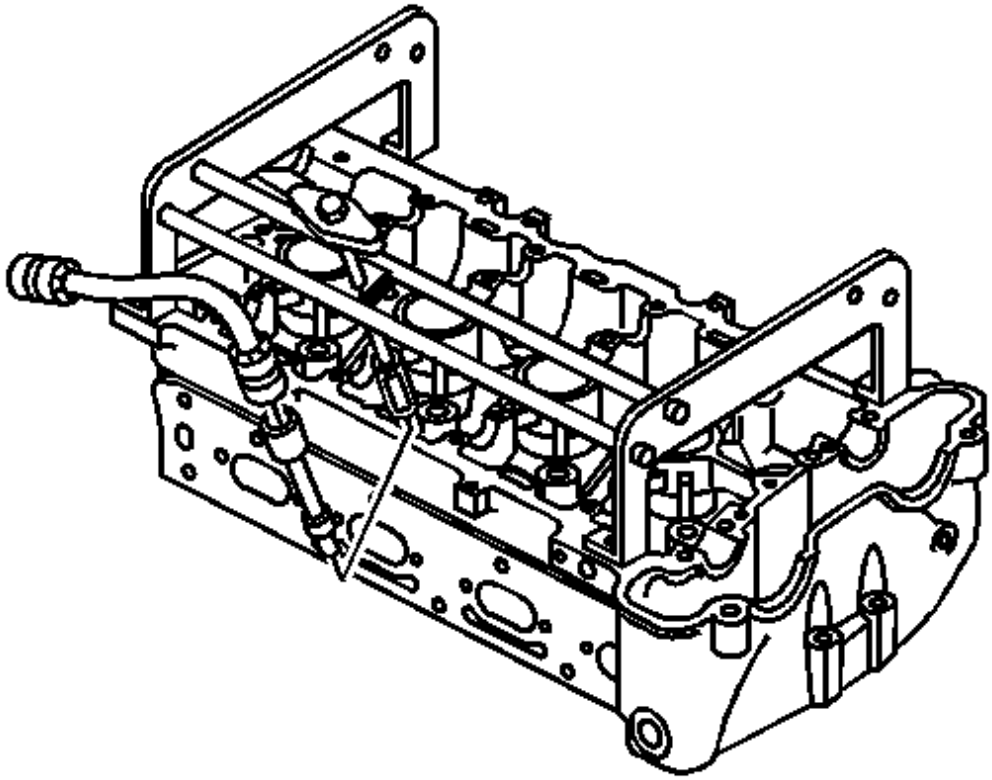

Fig. 192: View Of Air Hose Adaptor
Courtesy of GENERAL MOTORS CORP.

6. Disconnect the air hose from the adapter.
7. Remove the air hose adapter from the spark plug hole.

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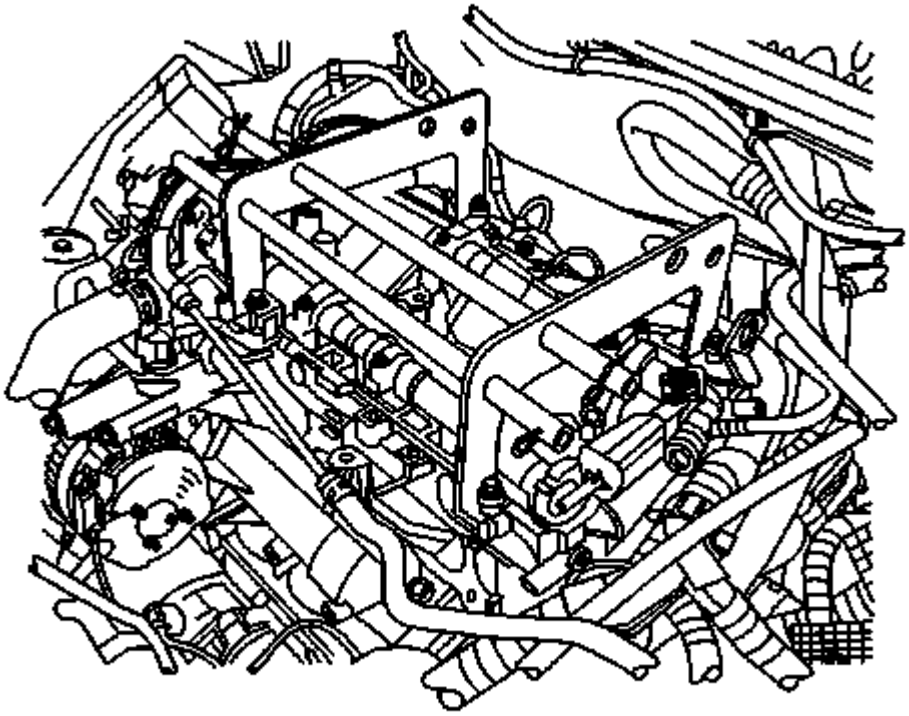

Fig. 193: View Of J 43649 Valve Spring Compressor (Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

8. Remove the **J 43649** from the cylinder head.
9. Install the spark plugs. Refer to **Spark Plug Replacement** .

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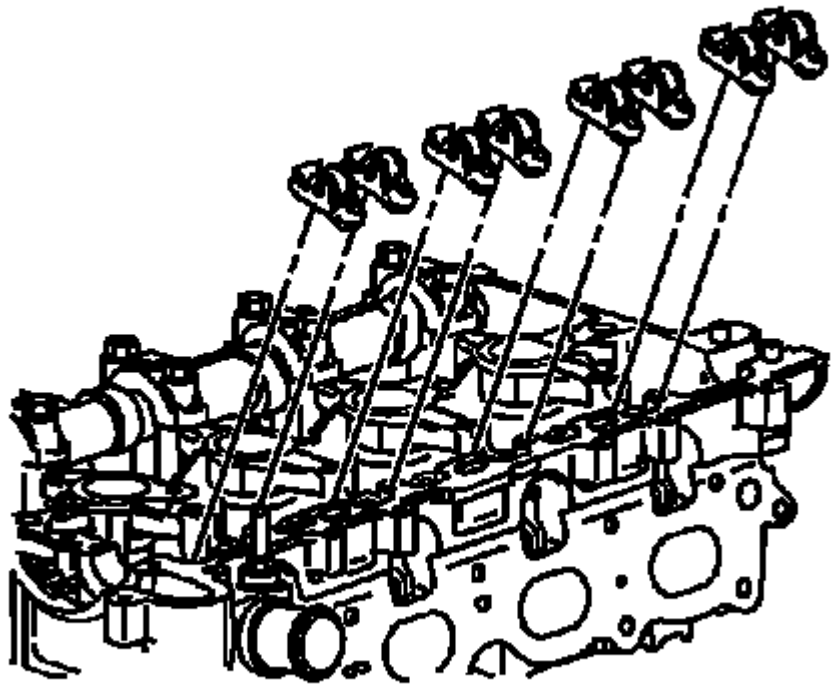

Fig. 194: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

10. Install the camshaft roller followers.
11. Install the camshaft. Refer to **Intake Camshaft and Lifter Replacement** or **Exhaust Camshaft and Lifter Replacement**.
12. If used, remove the **J 43653** .
13. If removed, install the starter. Refer to **Starter Motor Replacement (RPOs L61/LE5)** .

Cylinder Head Replacement

Tools Required

- **J 38185** Hose Clamp Pliers
- **J 45059** Angle Meter

Removal Procedure

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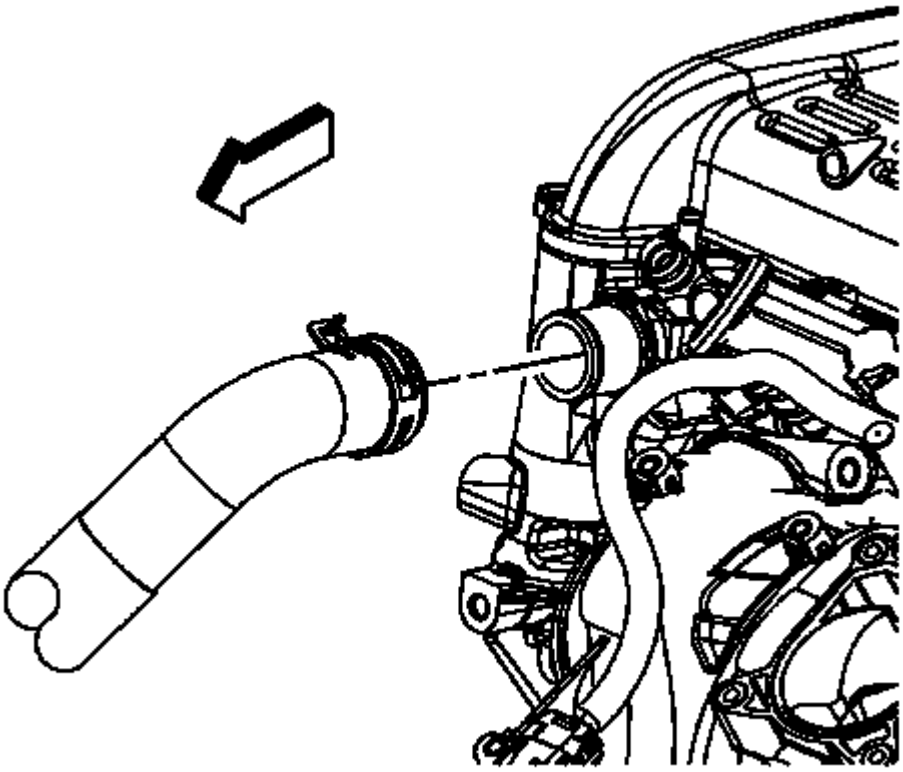

Fig. 195: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Draining and Filling Cooling System (2.2L (L61), 2.4L (LE5))** .
2. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement (RPO LE5)** .
3. Remove the intake manifold. Refer to **Intake Manifold Replacement**.
4. Reposition the radiator surge tank air bleed hose clamp.
5. Remove the radiator surge tank air bleed hose from the cylinder head.
6. Reposition the radiator inlet hose clamp using the **J 38185** .
7. Remove the radiator inlet hose from the cylinder head.
8. Remove the timing chain. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.

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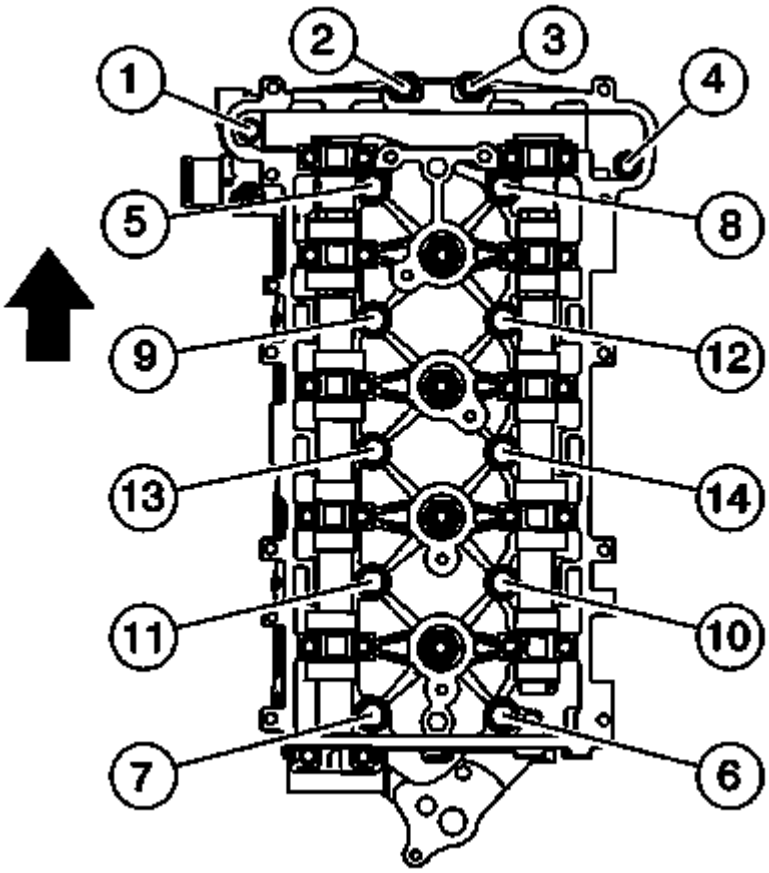

Fig. 196: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

9. Remove the cylinder head bolts in the sequence shown. Discard the bolts.

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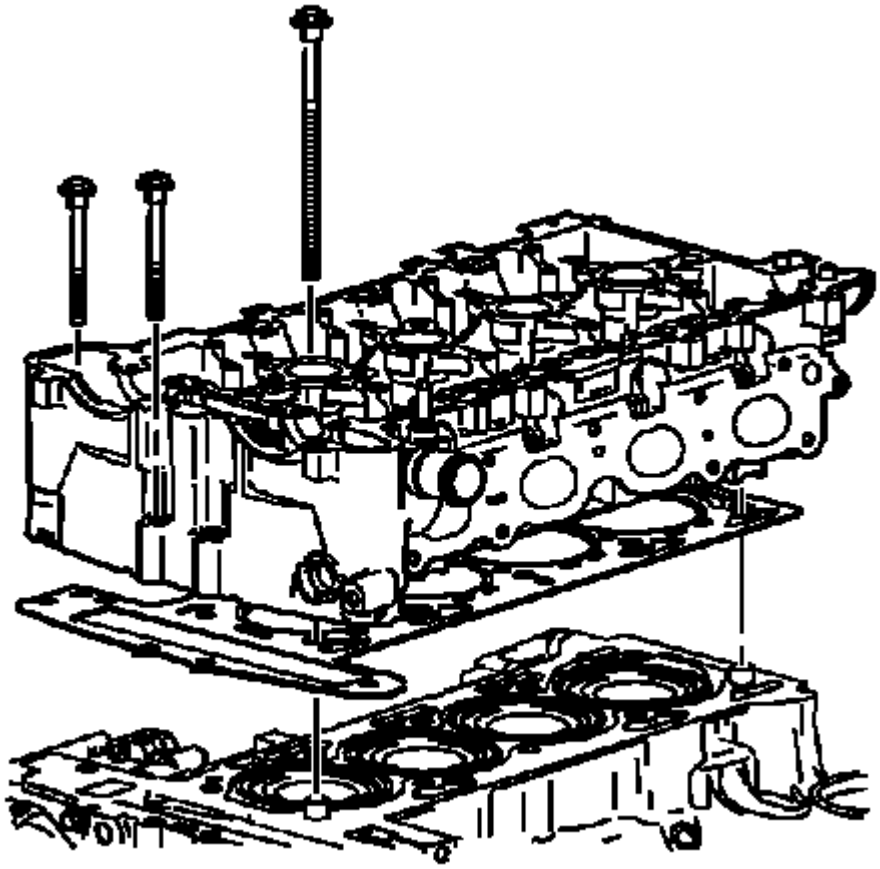

Fig. 197: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head.
11. Remove the cylinder head gasket.
12. Clean all of the gasket surfaces.
13. Use the following steps when cleaning the cylinder head and cylinder block surfaces:
    - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge either surface.

      IMPORTANT: DO NOT use any other method or technique to clean these gasket surfaces.

    - Use a NEW razor blade on the cylinder head and a NEW blade on the cylinder block.

      IMPORTANT: Be careful not to gouge or scratch the gasket surfaces. DO NOT gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in

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by the NEW gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

14. Clean the old sealer/lube and any dirt from around the bolt holes.

IMPORTANT: DO NOT use a tap to clean the cylinder head bolt holes.

15. Clean the bolts holes with a nylon bristle brush.
16. When cleaning the cylinder head bolt holes use suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun in order to reach the bottom of the holes.

Installation Procedure

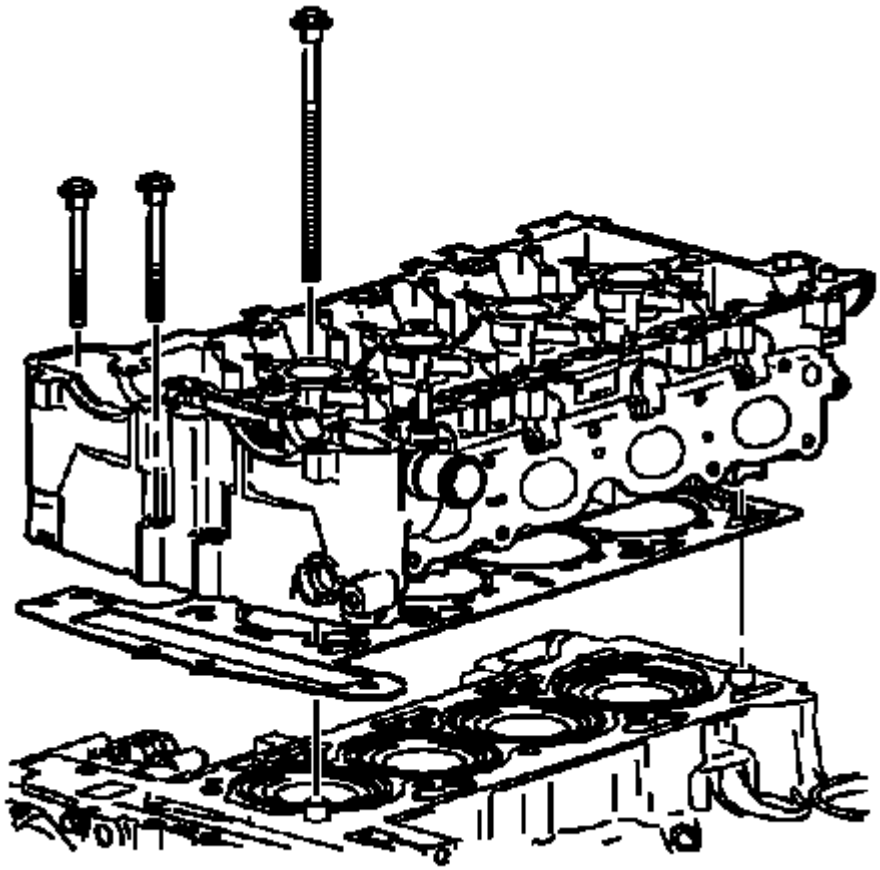

Fig. 198: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use any sealing material.

1. Install the cylinder head gasket.
2. Install the cylinder head.

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3. Install NEW cylinder head bolts.

NOTE: **Refer to Fastener Notice .**

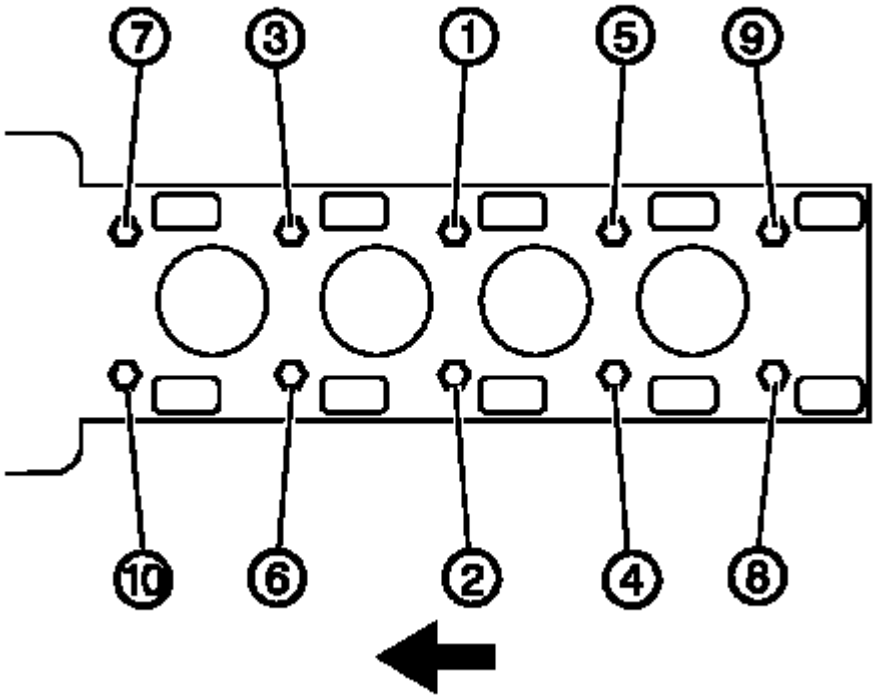

Fig. 199: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown.

Tighten: Tighten the bolts to 30 N.m (22 lb ft) plus an additional 155 degrees using the **J 45059** .

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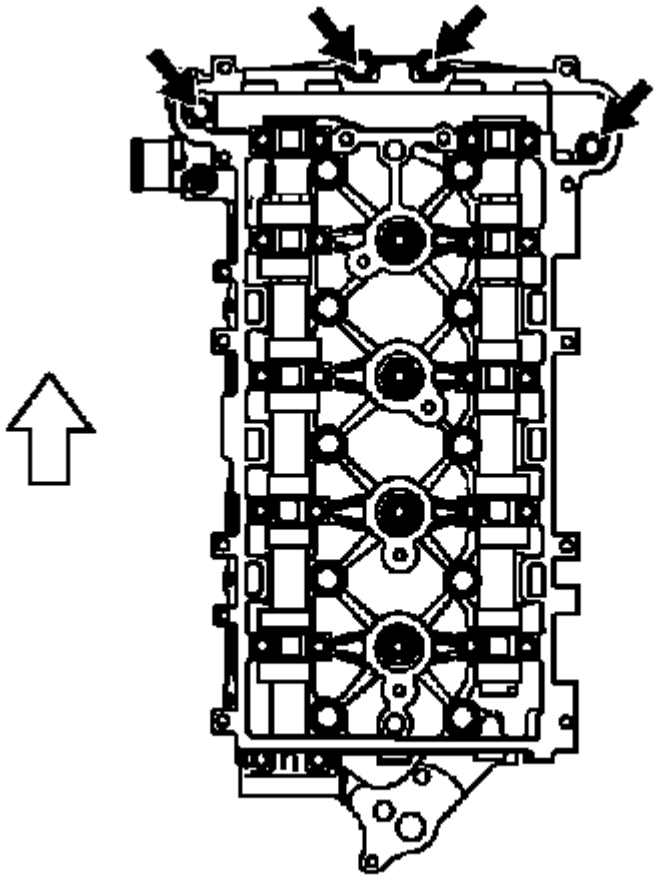

Fig. 200: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts.

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

6. Install the timing chain. Refer to **Timing Chain, Sprockets, and/or Tensioner Replacement**.

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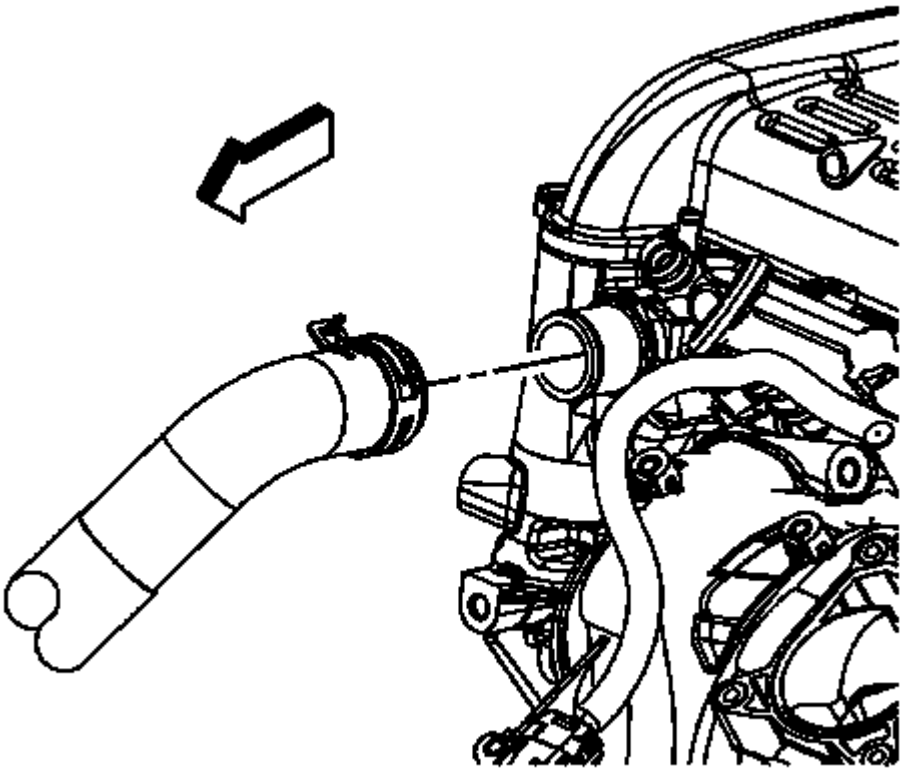

Fig. 201: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

7. Install the radiator inlet hose to the cylinder head.
8. Position the radiator inlet hose clamp using the **J 38185** .
9. Install the radiator surge tank air bleed hose to the cylinder head.
10. Position the radiator surge tank air bleed hose clamp.
11. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (RPO LE5)** .
12. Install the intake manifold. Refer to **Intake Manifold Replacement**.
13. Fill the cooling system. Refer to **Draining and Filling Cooling System (2.2L (L61), 2.4L (LE5))** or **Draining and Filling Cooling System (GE 47716 Fill)** .

Oil Pan Replacement

Removal Procedure

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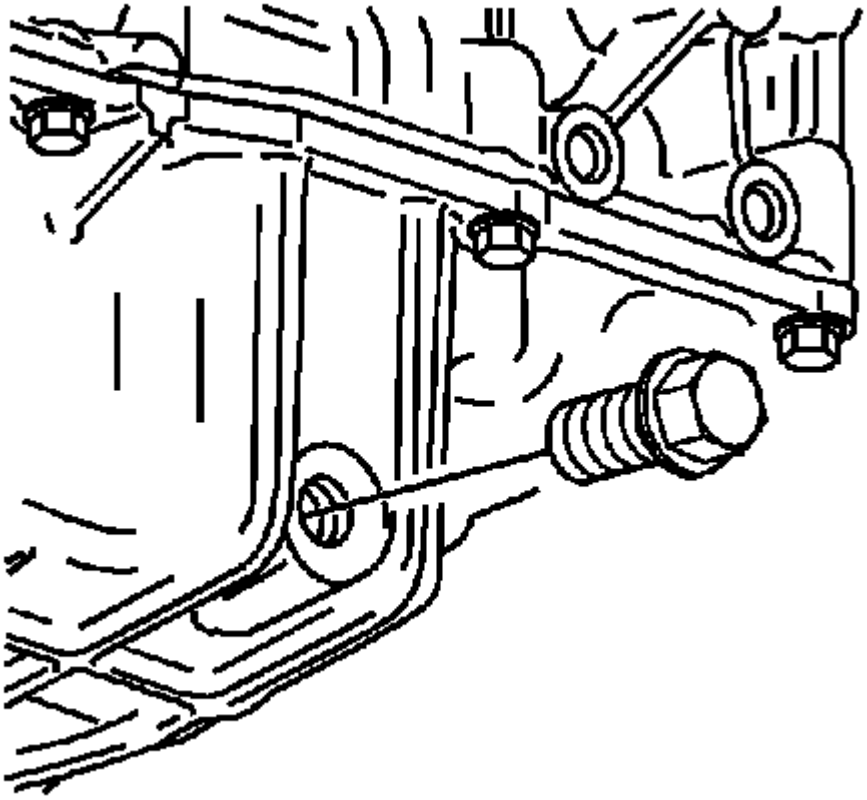

Fig. 202: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil pan drain plug.
3. Remove the oil pan drain plug.
4. Drain the engine oil.
5. Remove the engine drive belt. Refer to **Drive Belt Replacement**.
6. Remove the lower AC compressor bolt.

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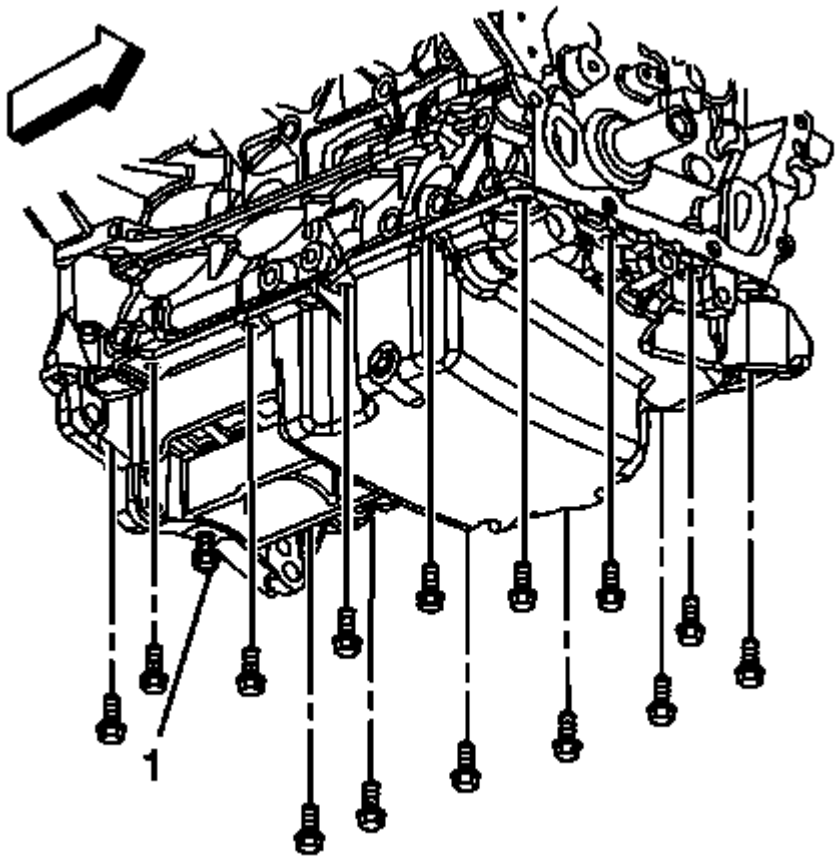

Fig. 203: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the 4 oil pan to transaxle bolts.
8. Remove the oil pan bolts.

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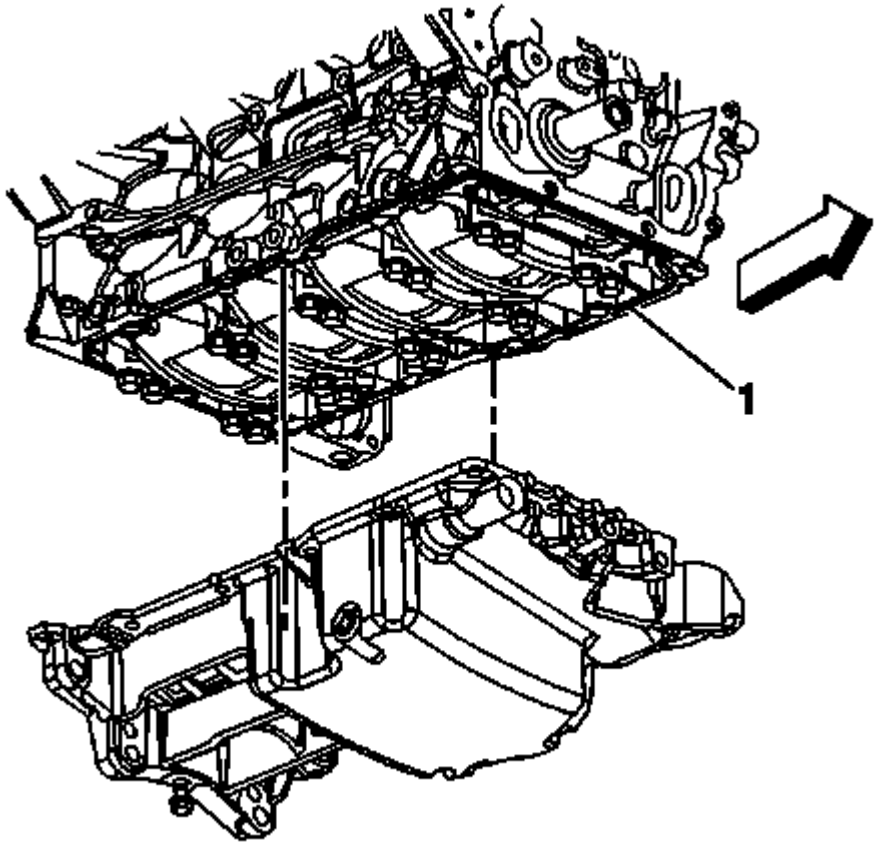

Fig. 204: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

9. Remove the oil pan
10. Remove any old oil pan sealant (1).

Installation Procedure

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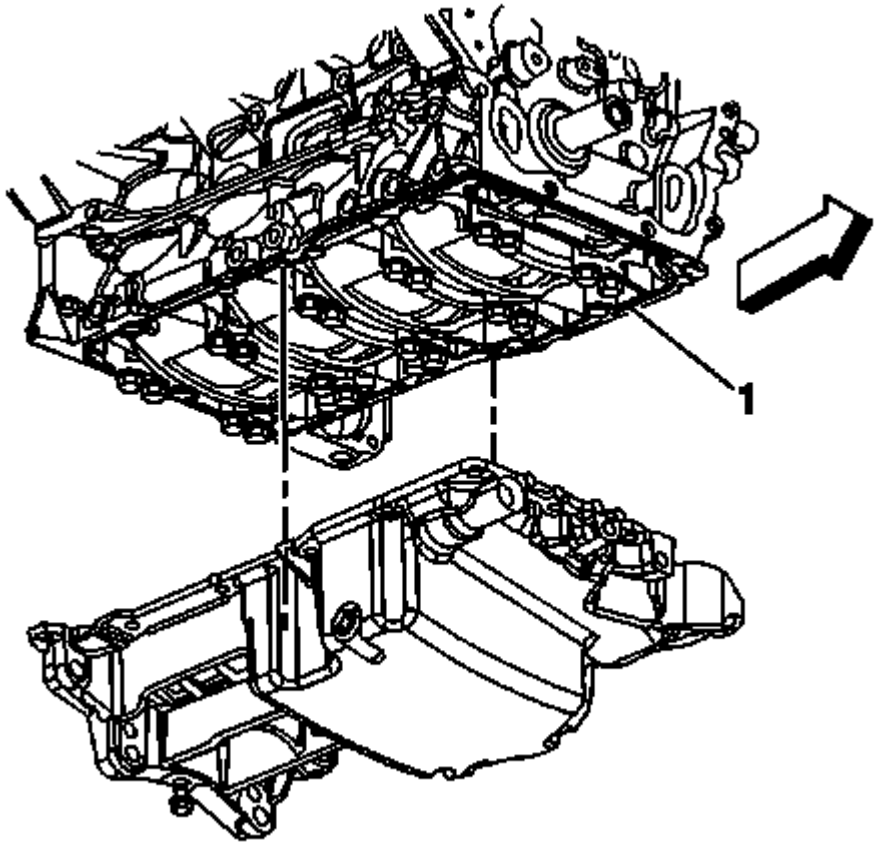

Fig. 205: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the oil pan and the sealing surface on the lower crankcase are free of all oil and debris.
2. Apply a 2 mm bead of sealant (1) around the perimeter of the oil pan and the oil suction port opening. DO NOT over apply the sealant. More than a 2 mm bead is not required. Refer to **Sealers, Adhesives, and Lubricants** for the correct part number.
3. Install the oil pan.

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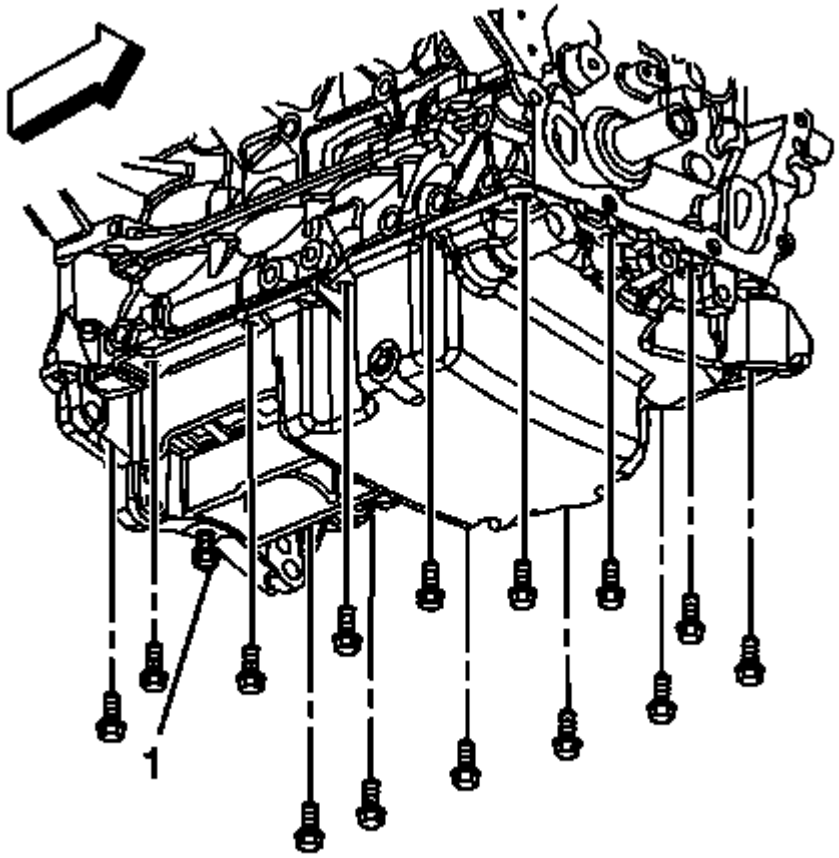

Fig. 206: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

   NOTE: Refer to Fastener Notice .

5. Install the 4 oil pan to transaxle bolts.

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

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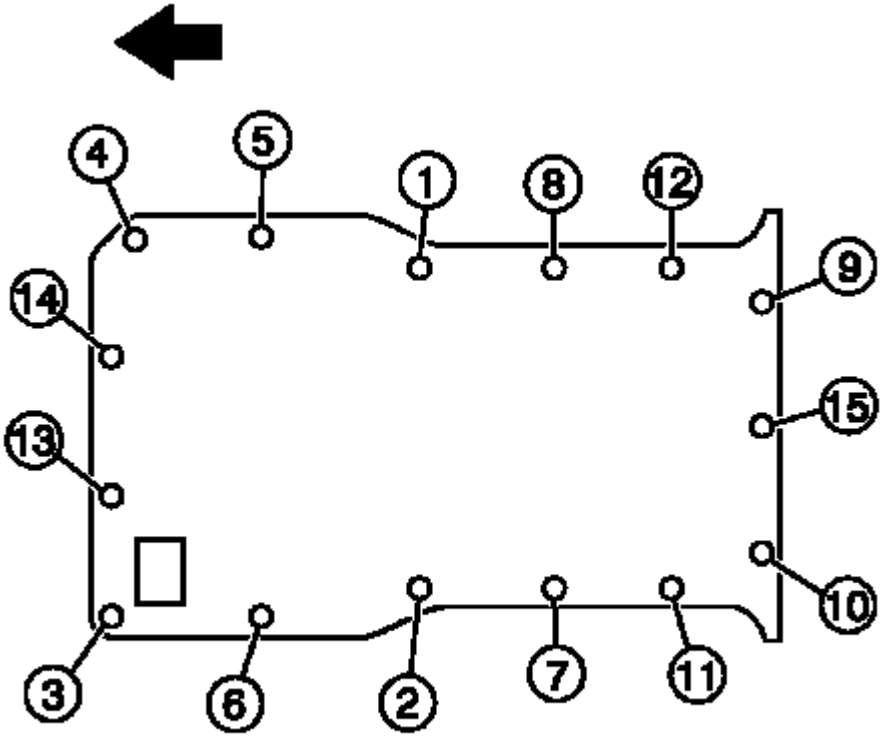

Fig. 207: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

6. Tighten the oil pan bolts in the sequence shown.

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

7. Install the lower AC compressor bolt.
8. Install the engine drive belt. Refer to **Drive Belt Replacement**.
9. Lower the vehicle.
10. Fill the engine oil to the proper level.

Crankshaft Rear Oil Seal Replacement

Tools Required

J 42067 Rear Main Seal Installer

Removal Procedure

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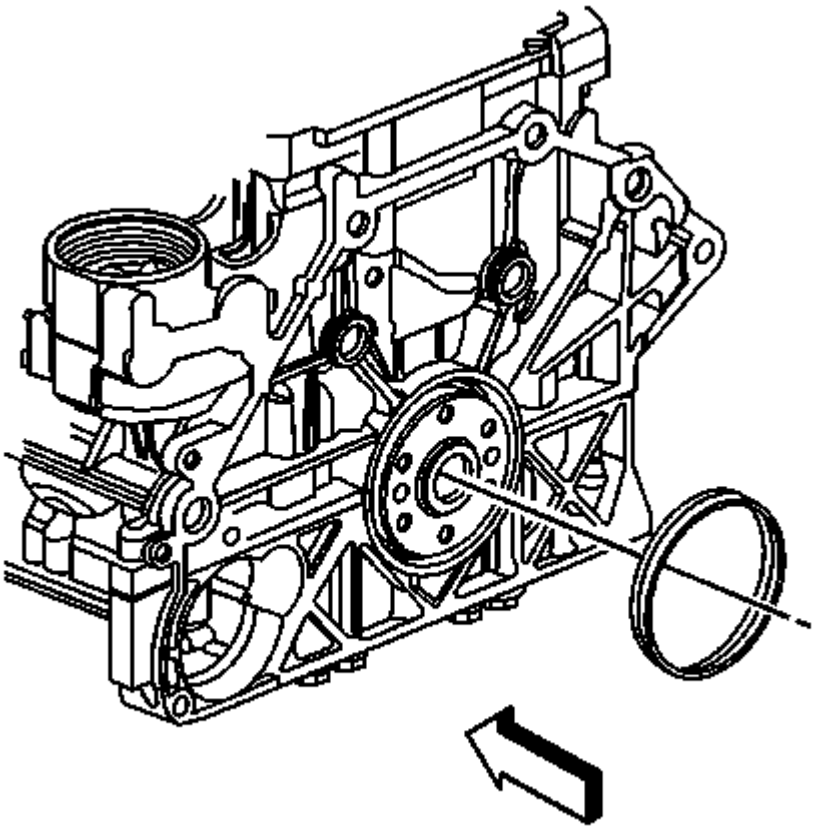

Fig. 208: Identifying Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

IMPORTANT: Do not damage the outside diameter of the crankshaft or chamber with any tool.

2. Pry out the crankshaft rear oil seal using a flat-bladed tool.

Installation Procedure

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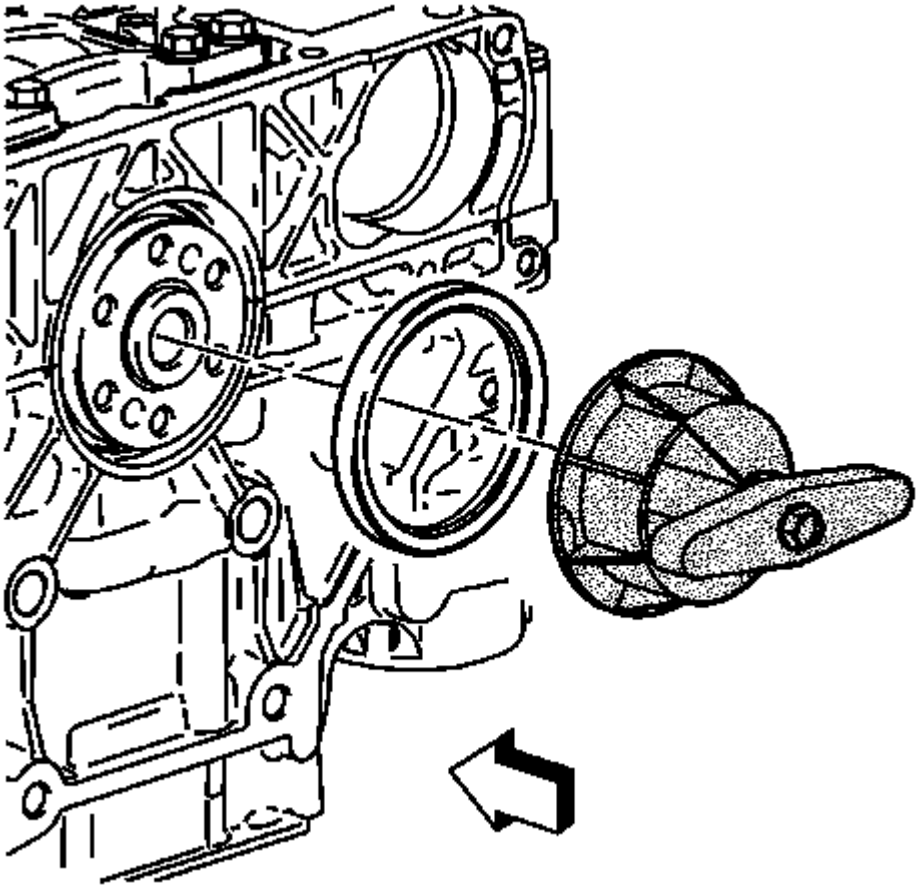

Fig. 209: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Using the **J 42067** , install a NEW crankshaft real oil seal.
2. Install the flywheel. Refer to **Engine Flywheel Replacement**.

Engine Flywheel Replacement

Tools Required

- **J 38122-A** Crankshaft Balancer Holder
- **J 45059** Angle Meter

Removal Procedure

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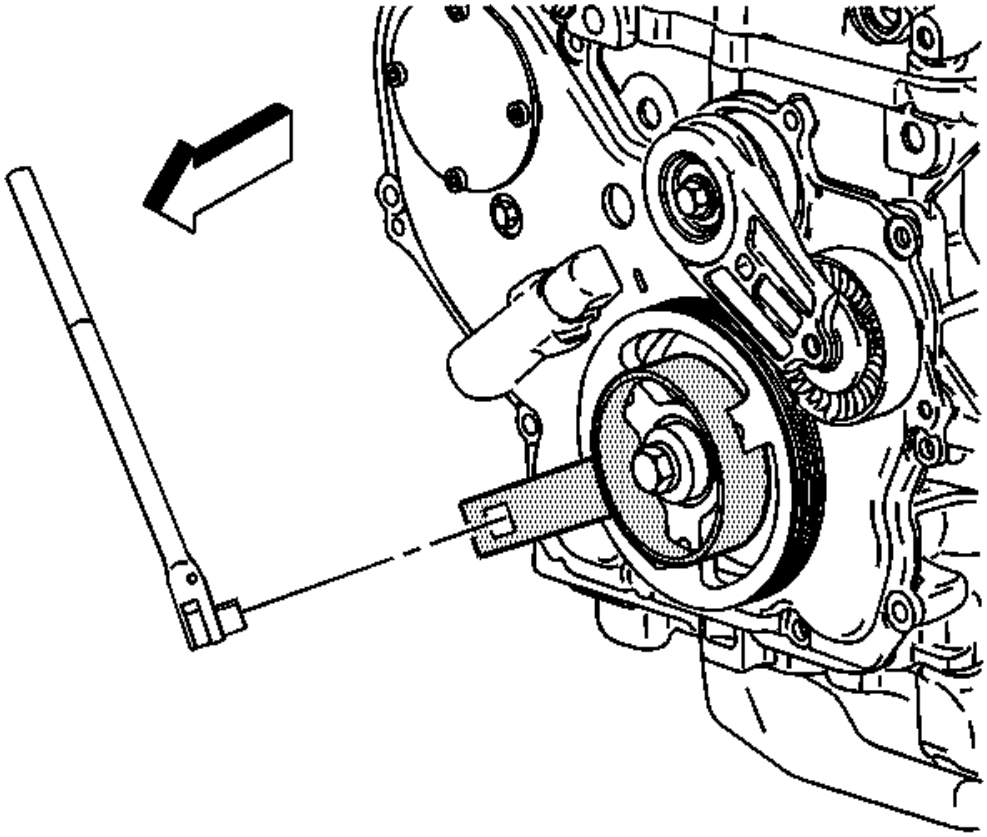

Fig. 210: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

1. If equipped with a automatic transaxle, remove the transaxle. Refer to **Transmission Replacement** .
2. If equipped with a manual transaxle, remove the clutch. Refer to **Clutch Drive Plate and Clutch Driven Plate (M86)** or **Clutch Drive Plate and Clutch Driven Plate (MU3)** .
3. Using the **J 38122-A** , hold the crankshaft balancer.

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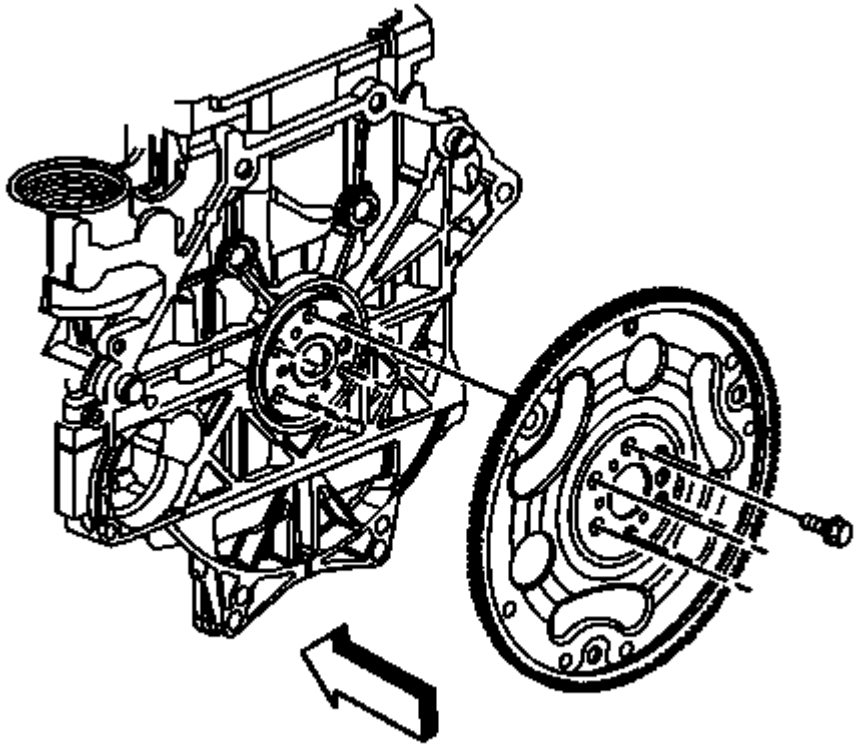

Fig. 211: View Of Flywheel (Manual Transaxle)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full engagement on the thin-headed flywheel bolts.

4. Remove and discard the automatic transaxle flywheel bolts, if equipped.

IMPORTANT: Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

5. Remove the automatic transaxle flywheel, if equipped.

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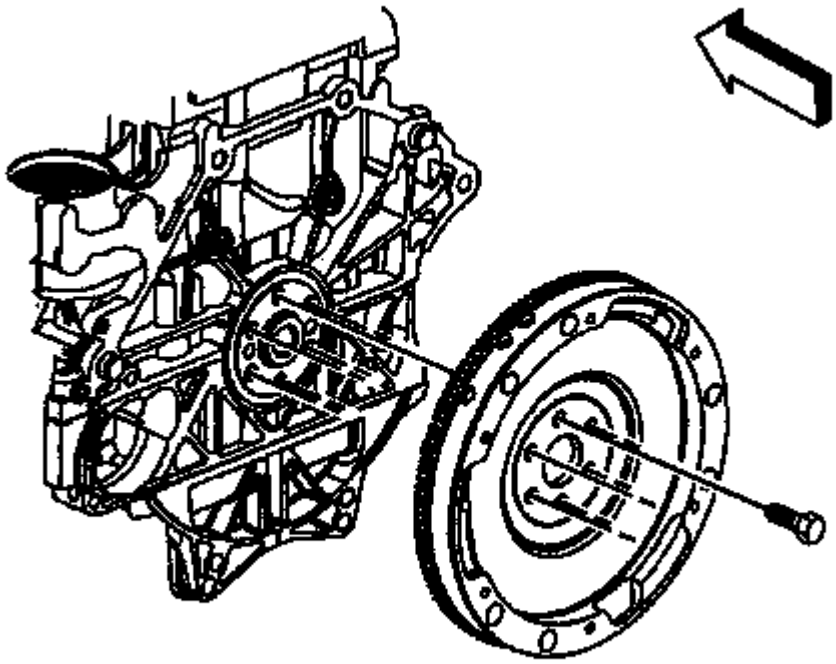

Fig. 212: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full engagement on the thin-headed flywheel bolts.

6. Remove and discard the manual transaxle flywheel bolts, if equipped.

IMPORTANT: Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

7. Remove the manual transaxle flywheel, if equipped.
8. Clean the thread adhesive from the flywheel bolt holes. Use a nylon bristle brush to clean the holes in the crankshaft.

Installation Procedure

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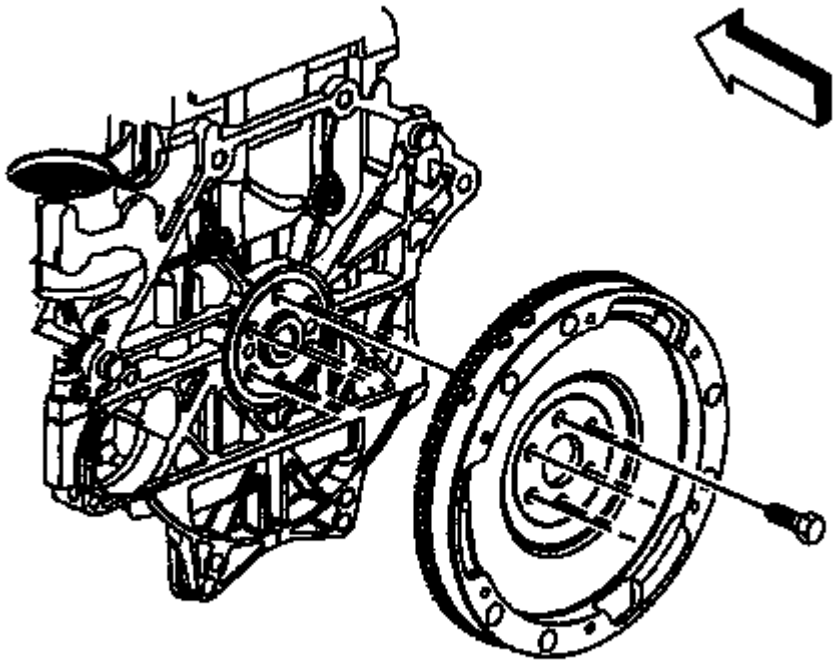

Fig. 213: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Install the manual transaxle flywheel, if equipped.

NOTE: **Refer to Fastener Notice .**

2. Install the NEW manual transaxle flywheel bolts, if equipped.

Tighten: Tighten the bolts to 53 N.m (39 lb ft) plus an additional 25 degrees using the **J 45059** .

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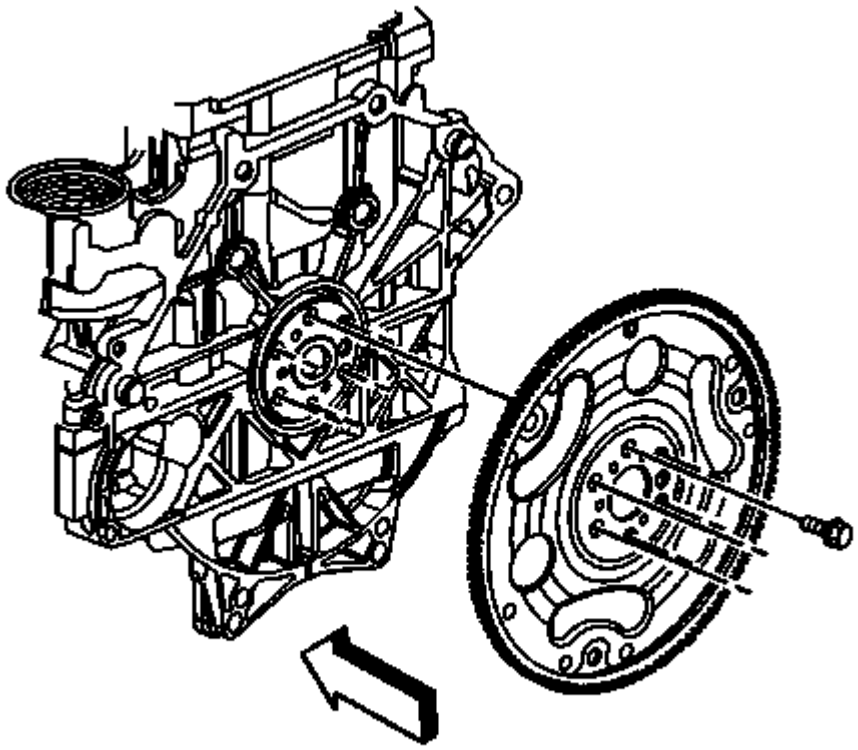

Fig. 214: View Of Flywheel (Manual Transaxle)
Courtesy of GENERAL MOTORS CORP.

3. Install the automatic transaxle flywheel, if equipped.
4. Install the NEW automatic transaxle flywheel bolts, if equipped.

   Tighten: Tighten the bolts to 53 N.m (39 lb ft) plus an additional 25 degrees using the **J 45059** .

5. Remove the **J 38122-A** .
6. If equipped with a manual transaxle, install the clutch. Refer to **Clutch Drive Plate and Clutch Driven Plate (M86)** or **Clutch Drive Plate and Clutch Driven Plate (MU3)** .
7. If equipped with a automatic transaxle, install the transaxle. Refer to **Transmission Replacement** .

Cylinder Sleeve Replacement

Tools Required

EN 45680-850 Cylinder Sleeve Removal and Installation Kit

Removal Procedure

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NOTE: **Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.**

NOTE: **Do not damage the crankshaft connecting rod journals or reluctor ring or engine damage will occur.**

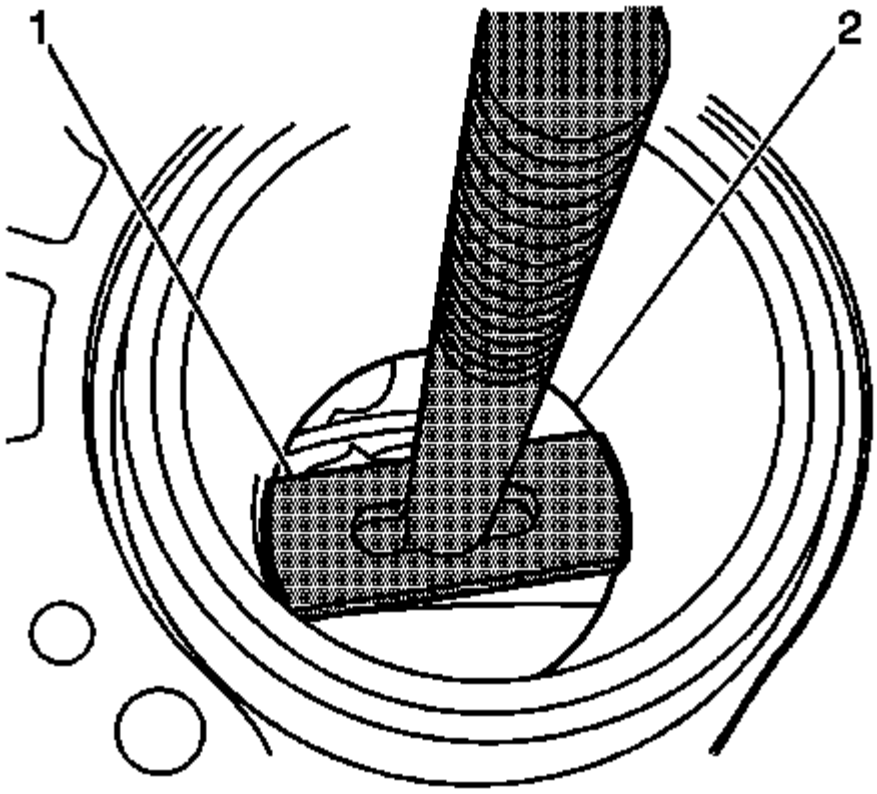

Fig. 215: View Of Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head. Refer to **Cylinder Head Replacement**.
2. Remove the oil pan. Refer to **Oil Pan Replacement**.
3. Remove the piston and connecting rod. Refer to **Piston, Connecting Rod, and Bearing Removal** .
4. Inspect the condition of the piston. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
5. Rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
6. Install the EN 45680-852 cylinder bore sleeve puller (1) through the cylinder bore.

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NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore liner or damage to the cylinder bore liner puller EN45680-852 will occur.

7. Align the shoe (1) of the EN 45680-852 cylinder bore sleeve puller to the bottom of the cylinder bore sleeve (2).

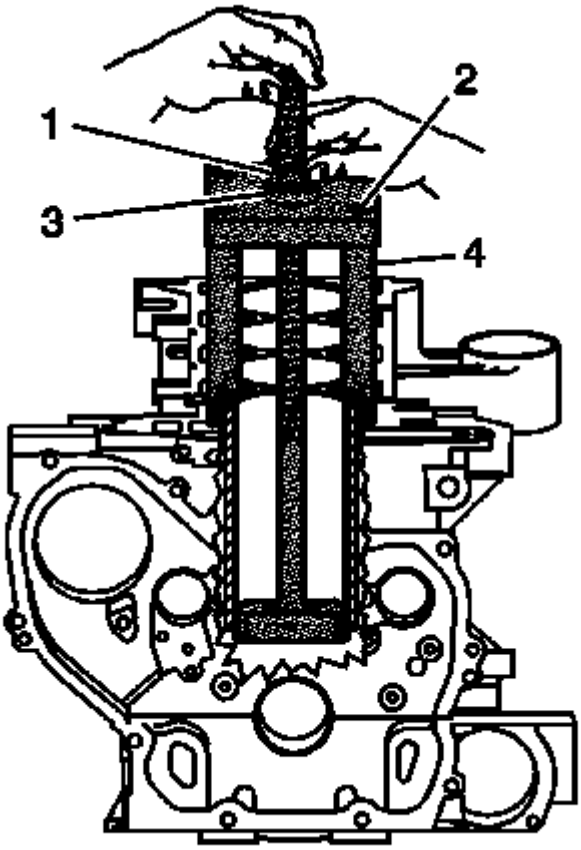

Fig. 216: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

8. Hold the threaded shaft of the EN 45680-852 cylinder bore sleeve puller upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.
9. Install the EN 456850-851 fixture (4) onto the threaded shaft of the EN 456850-852 cylinder bore sleeve puller and the engine block.
10. Install the bearing (3) and the nut (1).
11. Tighten the nut (1) to the bearing (3).

NOTE: Refer to Fastener Notice .

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

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12. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block.

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

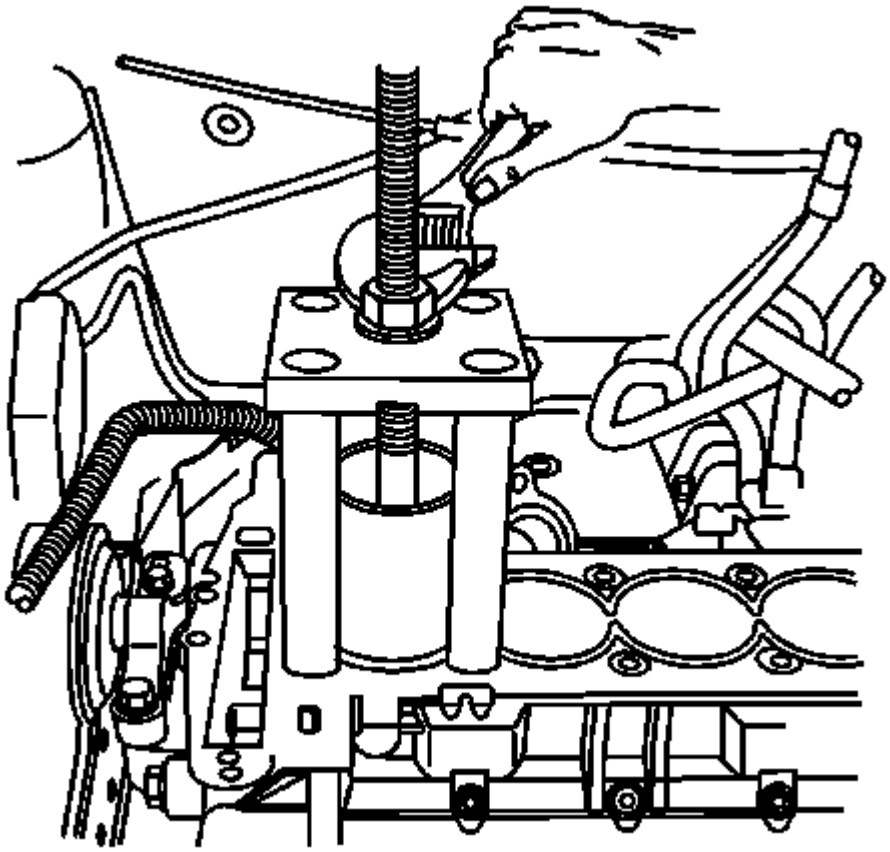

Fig. 217: Identifying Cylinder Bore Sleeve Puller Nut
Courtesy of GENERAL MOTORS CORP.

13. Rotate the nut clockwise in order to remove the cylinder bore liner.

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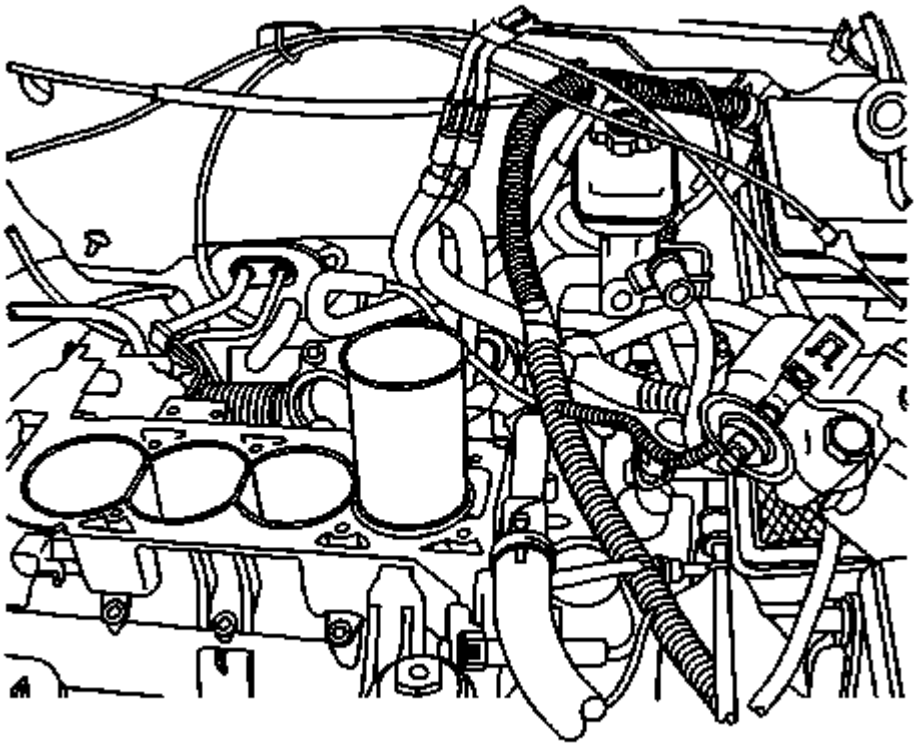

Fig. 218: Removing Cylinder Bore Liner From The Engine Block
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the cylinder block surface. Damage to the cylinder block surface can cause engine failure.

14. Remove EN 45680-851 fixture, EN 45680-852 cylinder bore sleeve puller, and the cylinder bore sleeve from the engine block.
15. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.

Installation Procedure

NOTE: Do not use assembly aids or lubricants on the cylinder bore sleeve or the cylinder bore block when installing a new cylinder bore sleeve, or engine damage will occur. These items will not aid in the installation of the new cylinder bore sleeve.

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and

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will not aid the removal or installation of the new cylinder bore sleeve.

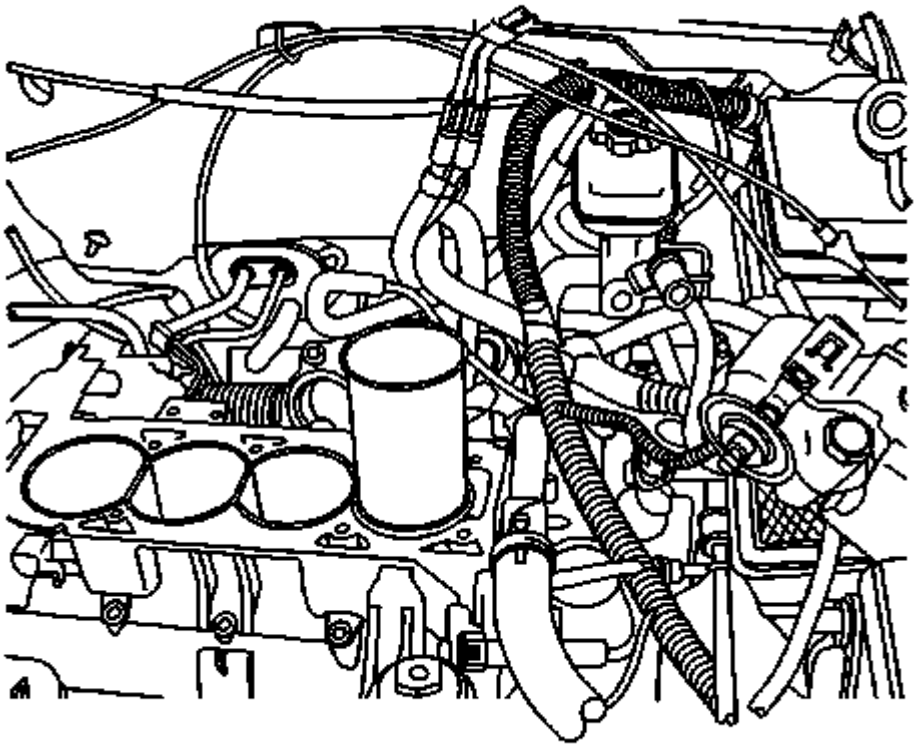

Fig. 219: Removing Cylinder Bore Liner From The Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve onto the cylinder block.
2. Install EN 45680-851 fixture and EN 45680-853 cylinder bore sleeve installer assembly over the cylinder bore sleeve and onto the cylinder block. Do not apply downward pressure to the cylinder bore sleeve.

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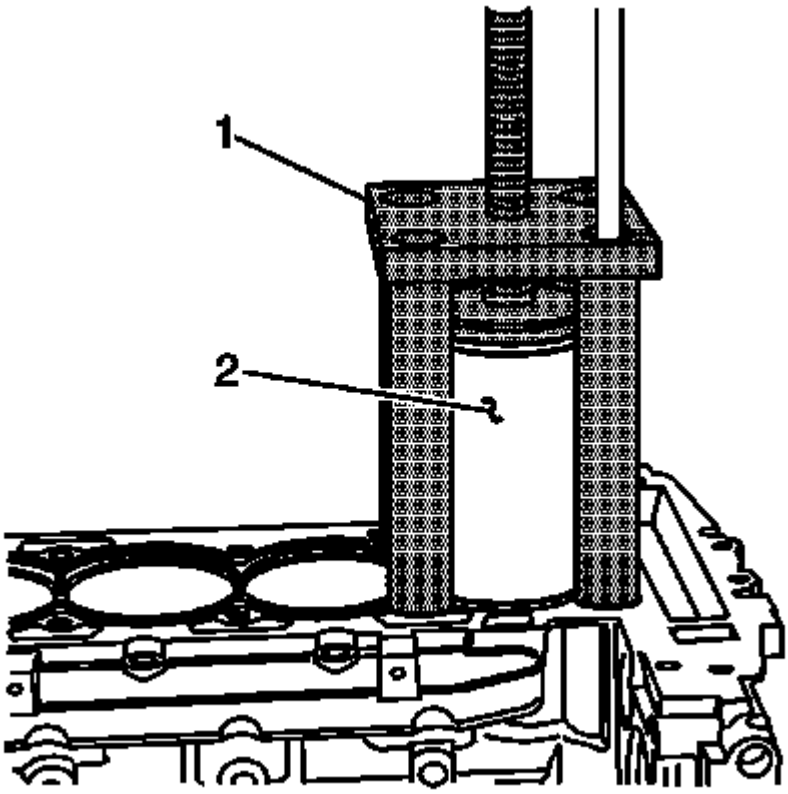

Fig. 220: View Of Cylinder Bore Sleeve Installer
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

3. Insert the 4 attachment bolts into the legs of the EN 45680-851 fixture (1). Do not apply downward pressure to the cylinder bore sleeve (2).

   Tighten: Tighten the 4 attachment bolts to 15 N.m (11 lb ft).

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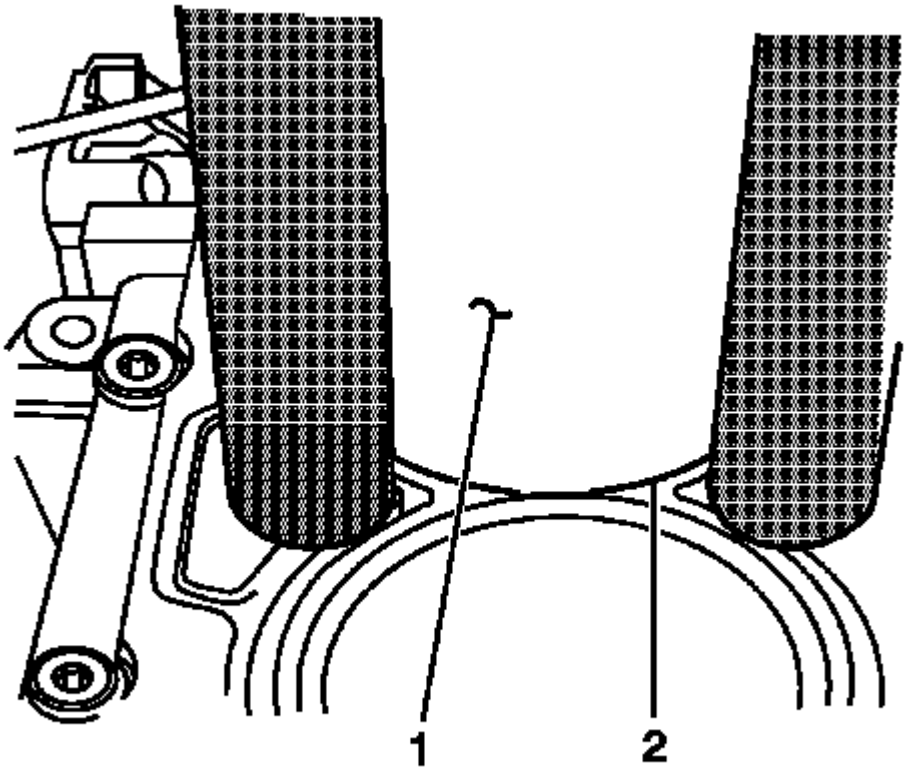

Fig. 221: Aligning Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

4. Align the bottom of the cylinder bore sleeve (1) with the cylinder bore of the block (2).

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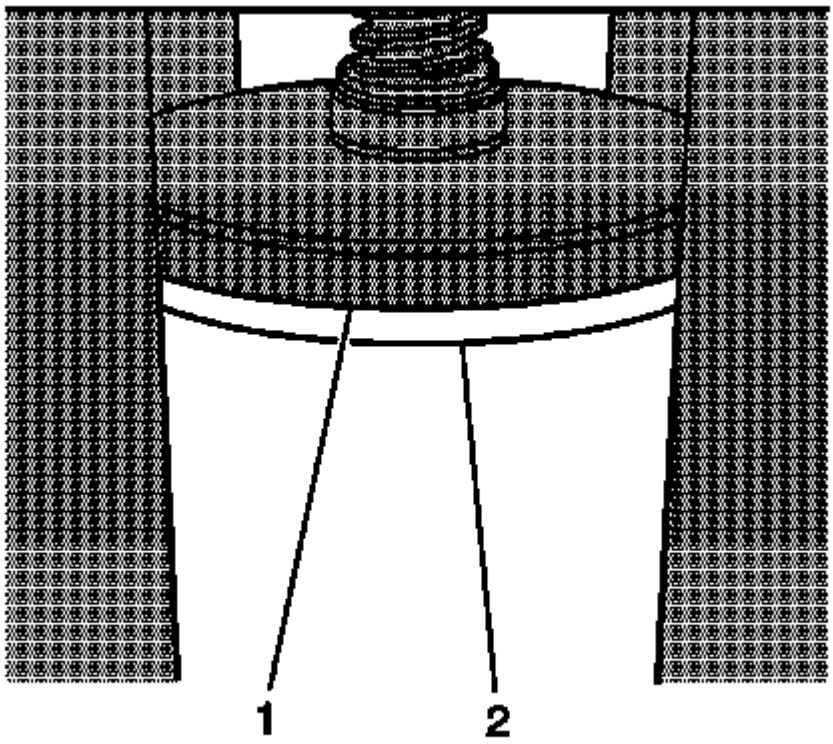

Fig. 222: Aligning Installation Arbor
Courtesy of GENERAL MOTORS CORP.

5. Align the installation arbor (1) onto the top of the cylinder bore sleeve (2).

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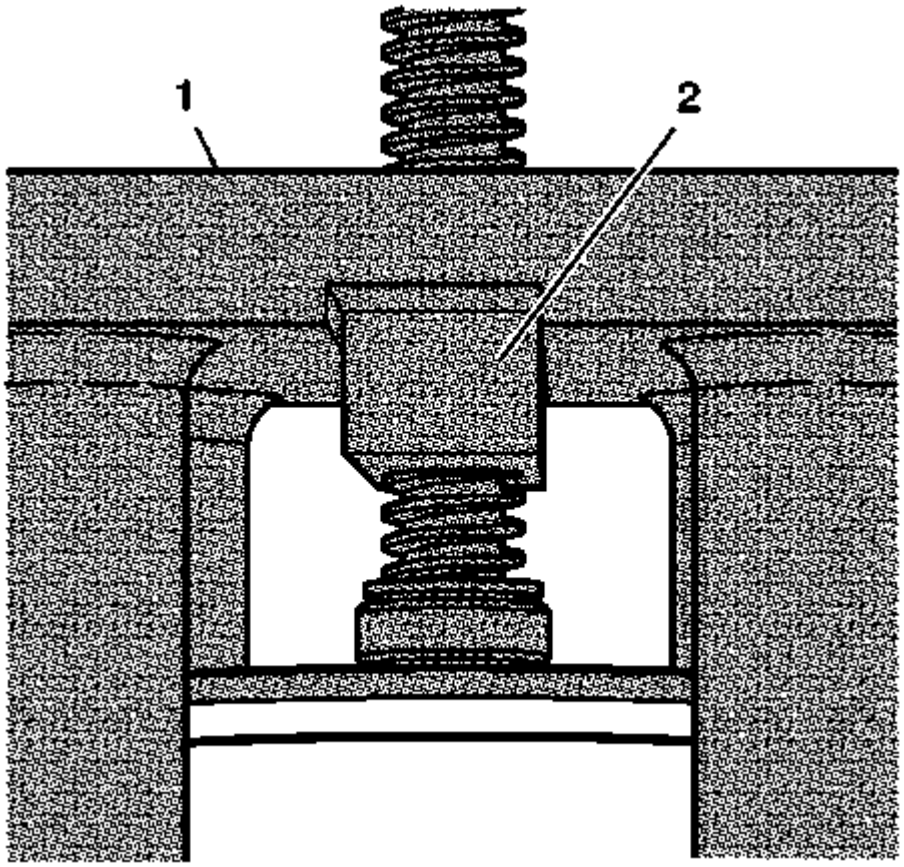

Fig. 223: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

6. Align the pusher block (2) of EN 45680-853 cylinder bore sleeve installer into the groove of EN 45680-851 fixture (1).

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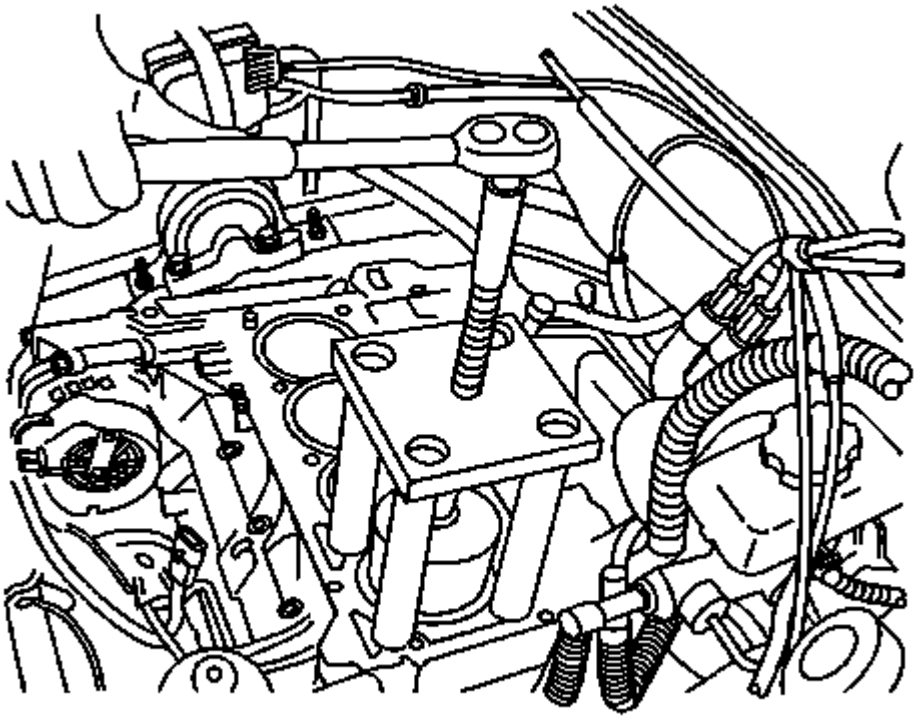

Fig. 224: View Of Cylinder Bore Sleeve Installer Assembly
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any air powered or electric tools to rotate the threaded shaft of the fixture EN 45680-851/cylinder bore liner installer EN 45680-853 assembly or damage to the cylinder bore liner will occur.

7. Using a ratchet, rotate the threaded shaft of EN 45680-85 fixture and EN 45680-853 cylinder bore sleeve installer assembly in order to install the cylinder bore sleeve into the engine block.
8. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

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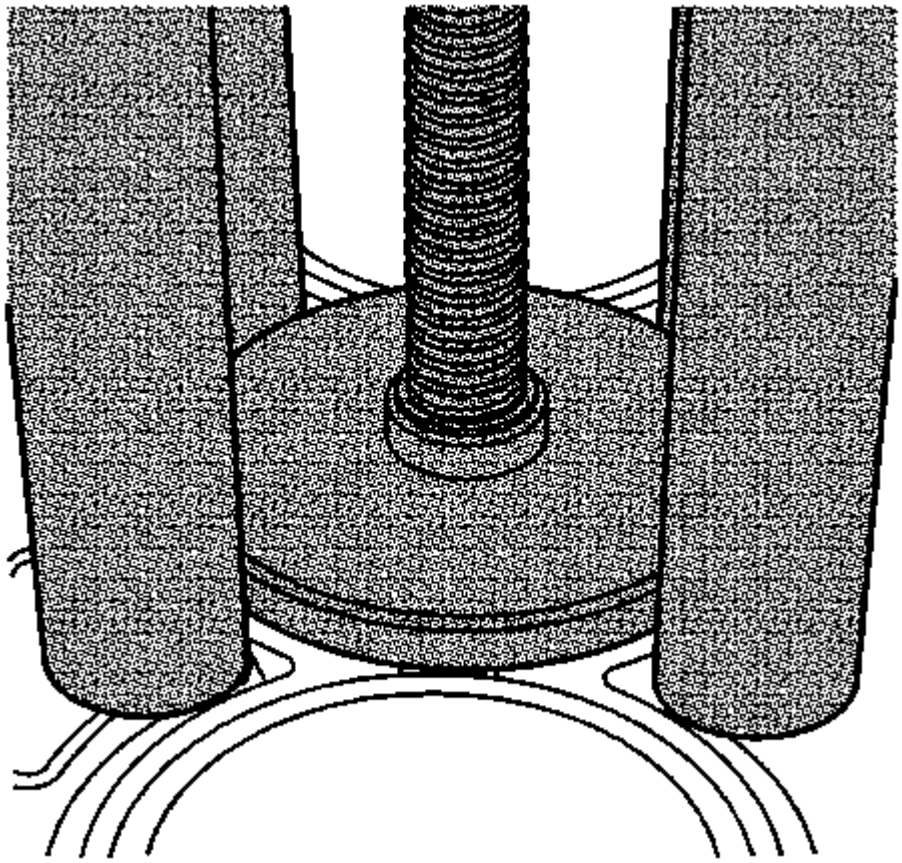

Fig. 225: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

9. Using a torque wrench, tighten the threaded shaft of the EN 45680-851 fixture and EN 45680-853 cylinder bore sleeve installer assembly to 102 N.m (75 lb ft) in order to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore liner flange will protrude above the block deck surface.

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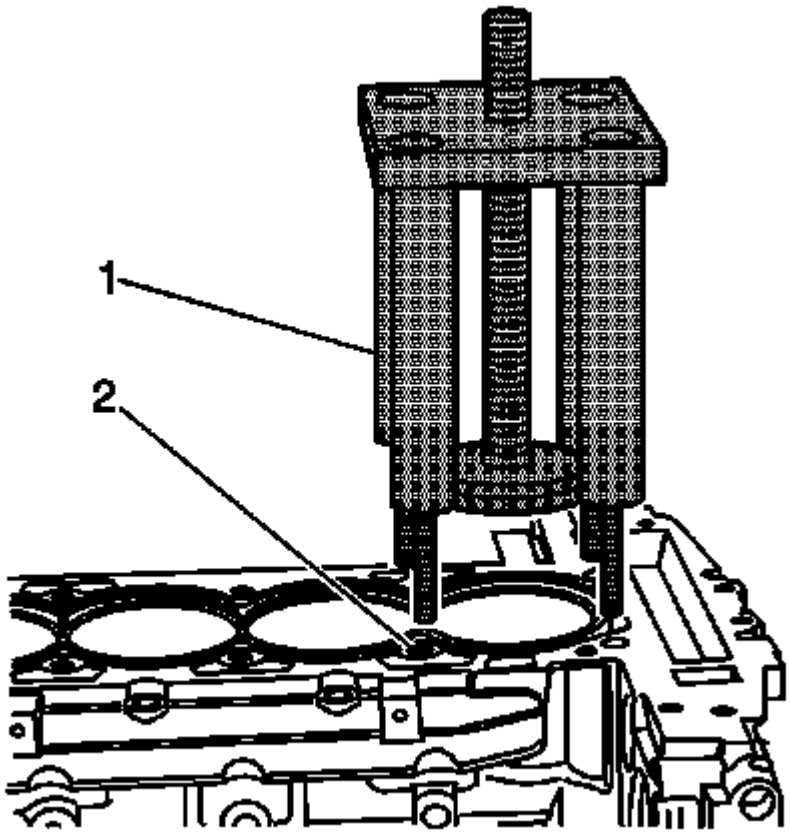

Fig. 226: Identifying Cylinder Bore Sleeve Installer Assembly
Courtesy of GENERAL MOTORS CORP.

10. Remove the EN 45680-851 fixture and EN 45680-853 cylinder bore sleeve installer assembly (1) from the cylinder block (2).

Cylinder Liner Trimming

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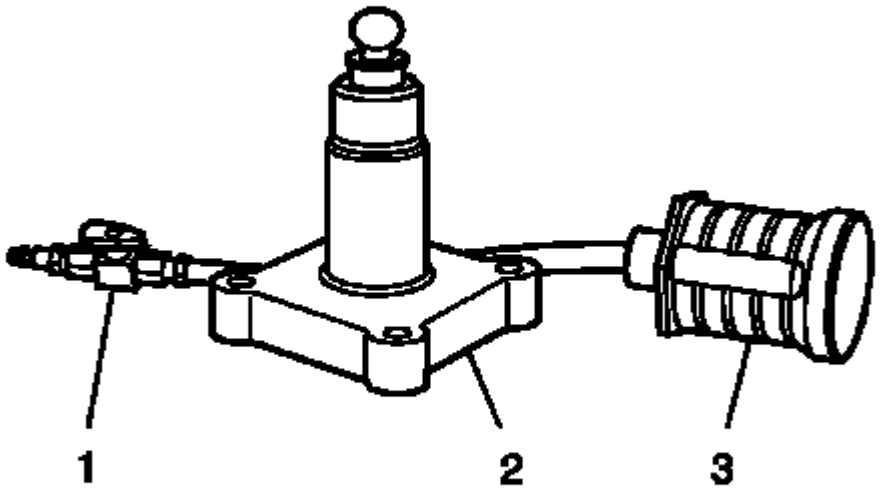

Fig. 227: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- EN 45680-865 Debris Collector (3)
- EN 45680-861 Trim Tool Assembly (2)
- Air Control Valve (1)
- Drill Motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction

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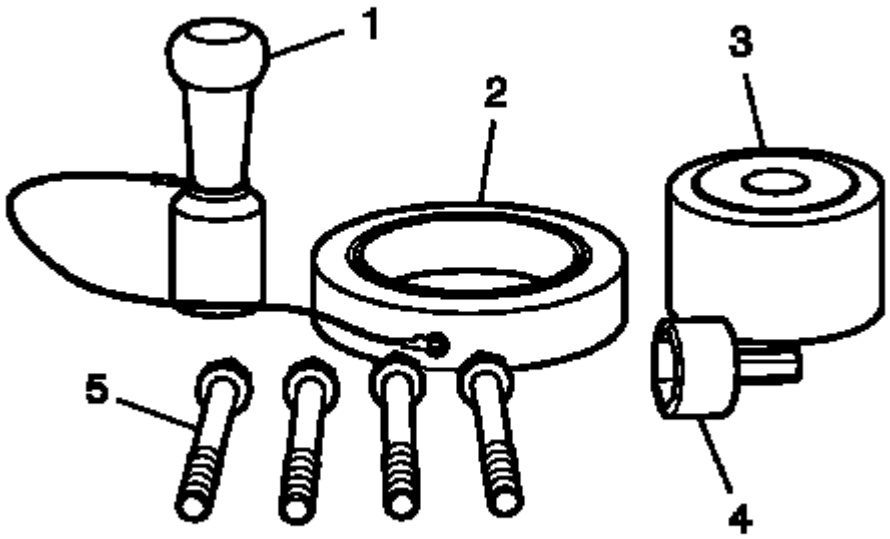

Fig. 228: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- Trim Tool Preloader (1)
- EN 45680-862 Set Gage Ring (2)
- EN 45680-863 Metal Shavings Catch Plug (3)
- EN 45680-866 Drive Adapter (4)
- EN 45680-864 Bolts (5)

NOTE: **Do not bore or hone the cylinder bore sleeve. The cylinder bore sleeve inside diameter (I.D) is fully machined and honed to size and is optimally finished as shipped. Any attempt to modify this factory-produced sizing and finish with additional boring and honing will lead to engine damage, excessive noise or abnormal oil consumption.**

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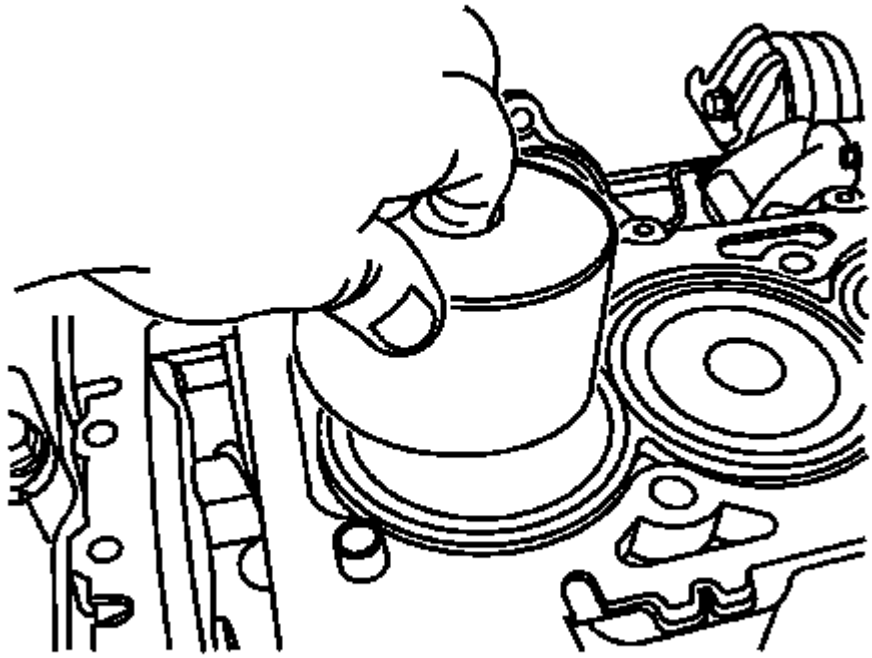

Fig. 229: View Of Metal Shaving Catch Plug
Courtesy of GENERAL MOTORS CORP.

1. After installing the NEW cylinder bore sleeve(s) into the engine block, trim the excess material from the cylinder bore sleeve flange.

NOTE: Ensure that all the metal particles are collected in order to prevent internal damage to the transaxle or bearings.

2. Place the EN 45680-863 metal shaving catch plug into the cylinder bore sleeve to be trimmed. Position the top of the EN 45680-863 approximately 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.
3. Place additional EN 45680-863 metal shaving catch plugs into all remaining cylinder bore sleeves.

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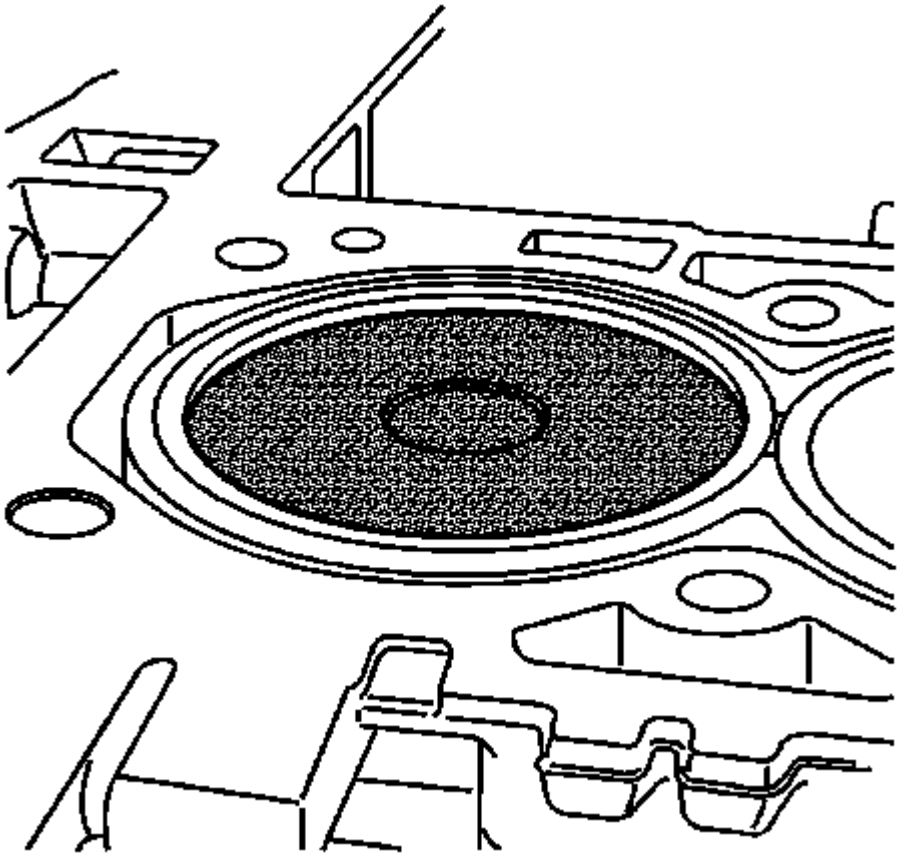

Fig. 230: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Installing the metal shaving catch plug EN 45680-863 deeper than the recommended depth will create a decrease in vacuum system performance. A decrease in vacuum system performance will cause metal shavings to enter the engine and cause engine failure.

NOTE: Installing the metal shaving catch plug EN 45680-863 above the recommended depth will cause damage to the metal shaving catch plug EN 45680-863.

4. Ensure that the EN 45680-863 metal shaving catch plug is 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.

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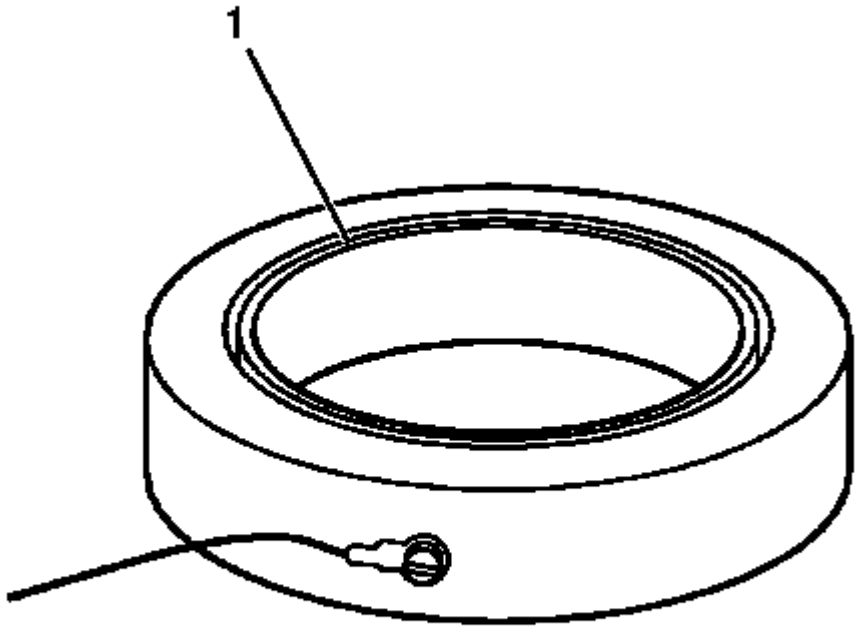

Fig. 231: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Before using EN 45680-861 trim tool assembly, the height of the cutting blades must be set to the proper specification. The proper specification is that the cylinder bore sleeve flange must be flush to +0.02 mm (0.0008 in) above the block deck surface.

5. The groove side of the EN 45680-862 set gage ring (1) should be positioned upward on a flat surface.

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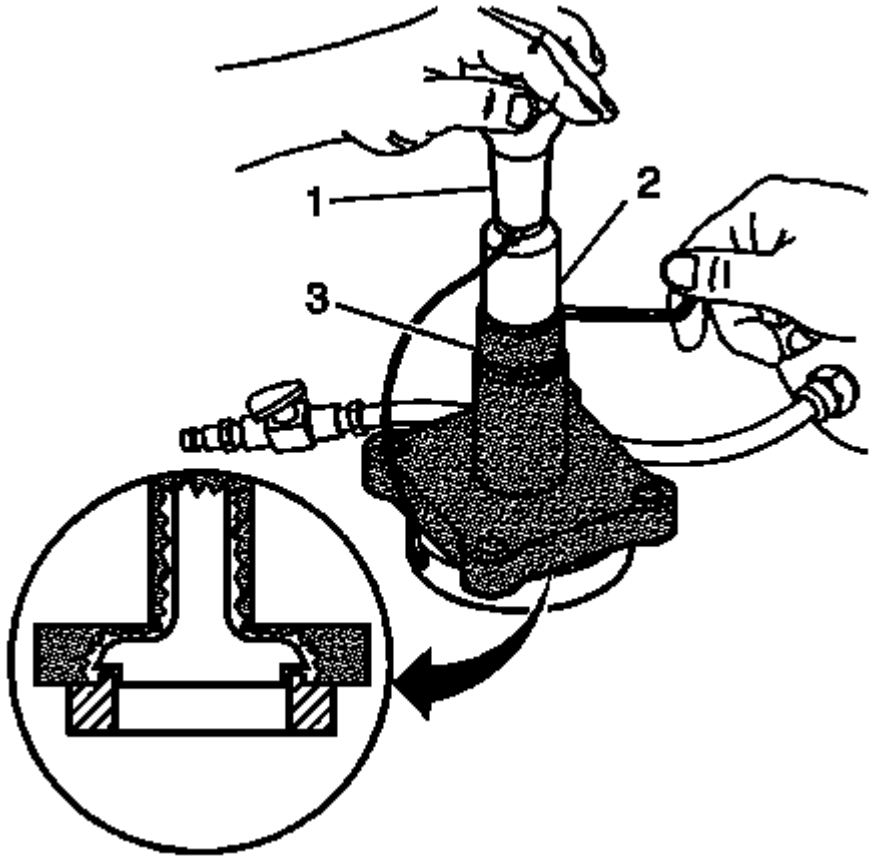

Fig. 232: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the EN 45680-862 set gage ring surfaces are clean.

6. Carefully position EN 45680-861 trim tool assembly onto the EN 45680-862 set gage ring.
7. Loosen the shaft collar screw (2).
8. Push the shaft collar (2) downward using the trim tool preloader (1) until the shaft collar is positioned against the top of the flange bearing (3).

IMPORTANT: Once this procedure is done, it is not necessary to reset the EN 45680-861trim tool assembly height until the blades are worn or damaged.

9. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw.

Tighten: Tighten the shaft collar screw to 19 N.m (14 lb ft).

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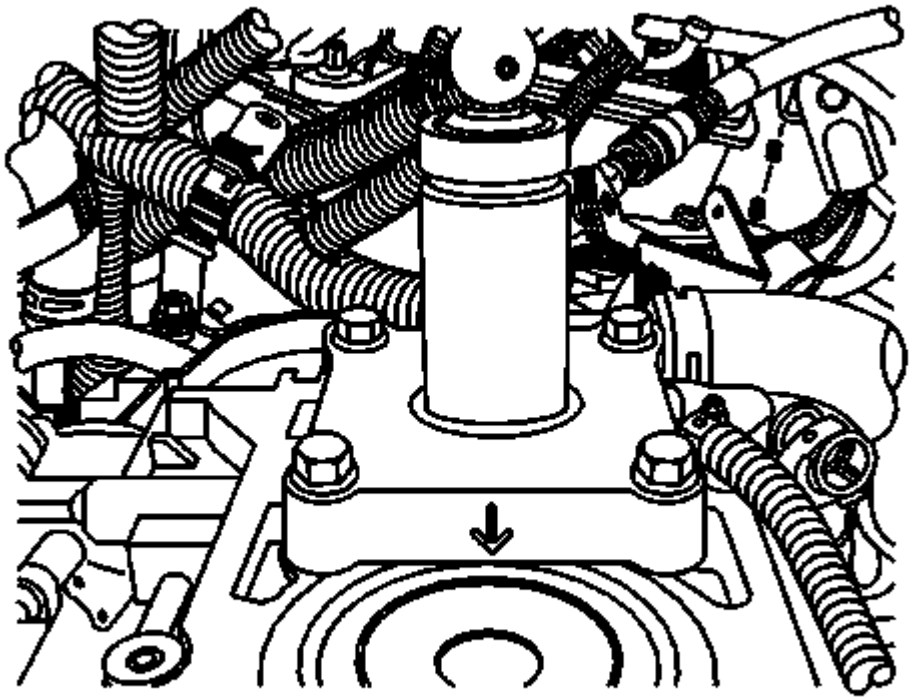

Fig. 233: Aligning Trim Tool Assembly
Courtesy of GENERAL MOTORS CORP.

10. Place the EN 45680-861 trim tool assembly onto the cylinder to be trimmed with the directional arrow pointing in line with the crankshaft centerline and the front of the block.
11. Install the EN 45680-864 4 bolts into the cylinder head bolt holes in the block.

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

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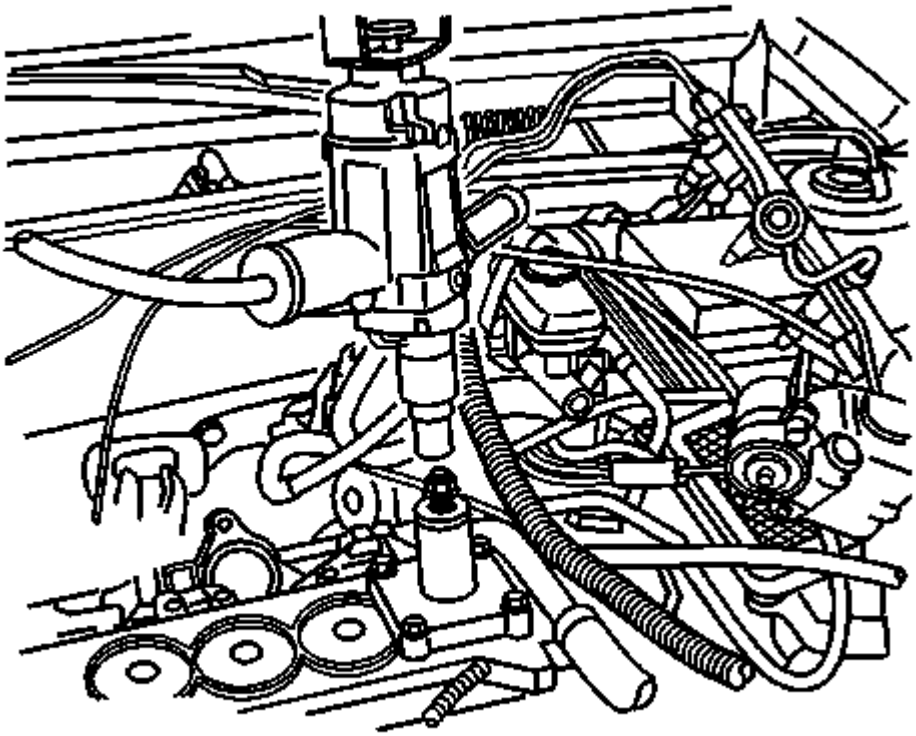

Fig. 234: Identifying EN 45680-866
Courtesy of GENERAL MOTORS CORP.

NOTE: For proper tool operation, a drill motor with a 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction must be used. If the proper drill motor is not used, damage to the cylinder bore sleeve will occur.

12. Fasten the drive adapter EN 45680-866 into the drill chuck.

NOTE: Ensure that there are no crimps in the air feed hose or the vacuum hose. Crimps in the hose may cause metal shavings to exit the cutting tool in any direction, causing engine damage.

13. Connect a compressed air supply (75-125 psi) to the male quick connect located on EN 45680-861 trim tool assembly. Turn the compressed air valve to the open position. This starts the venturi vacuum system that will catch the metal shavings.
14. Place the EN 45680-866 drive adapter and the drill assembly vertically onto the EN 45680-861 drive adapter end of trim tool assembly. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, gradually apply downward force until the cutting action is complete in approximately 5 seconds.

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15. Remove the EN 45680-866 drive adapter (1) and the drill assembly from the EN 45680-861 trim tool assembly.
16. Turn OFF the compressed air valve.
17. Remove the EN 45680-861 trim tool assembly from the engine block.
18. Wipe the cylinder bore sleeve and the surrounding areas of any powder residue. Remove the EN 45680-863 metal shaving catch plug.

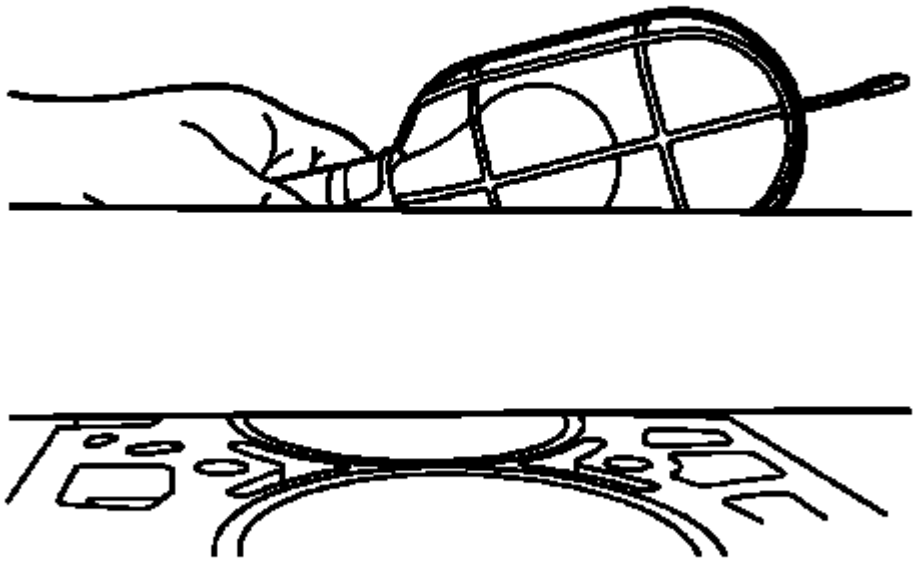

Fig. 235: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

19. Install a straight edge on the cylinder block perpendicular to the crankshaft centerline.
20. Using a light, illuminate the backside of the straight edge.

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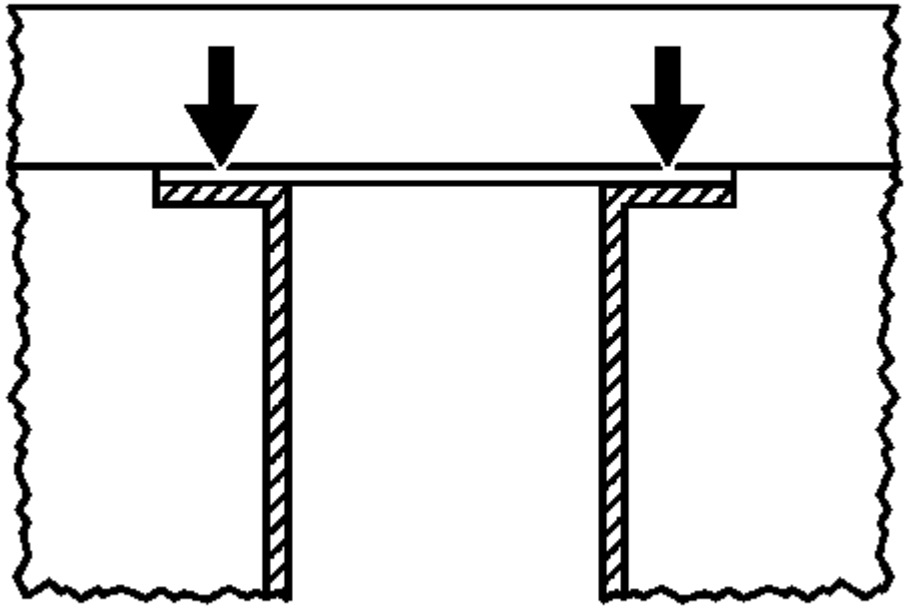

Fig. 236: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

21. Looking at the front of the straight edge, inspect to see if light is protruding through the bottom of the straight edge and the top of the cylinder bore sleeve flange. If light is present on either side of both sides of the cylinder bore sleeve, the cylinder bore sleeve is cut incorrectly and a new cylinder bore sleeve needs to be installed.

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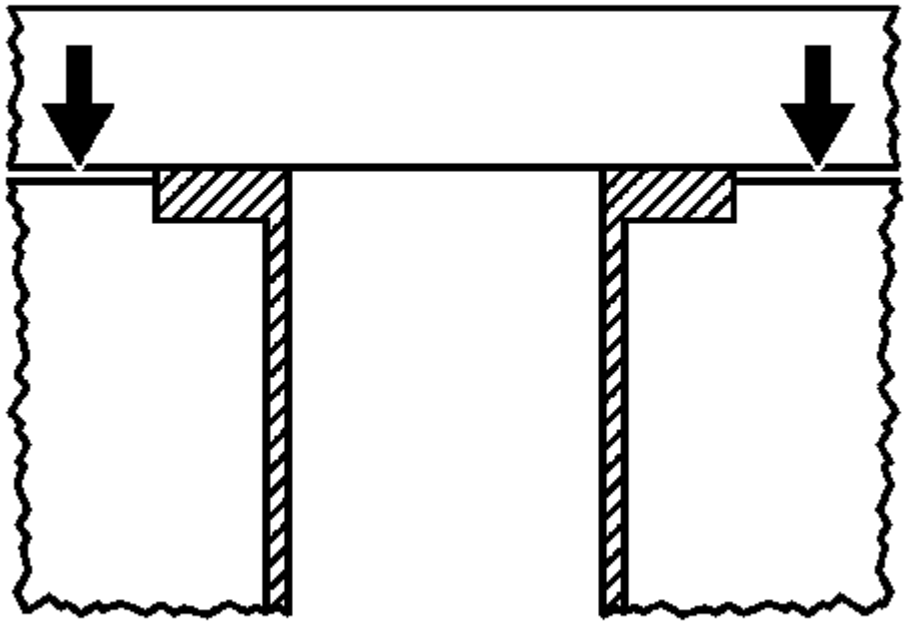

Fig. 237: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

22. Looking at the front of the straight edge, inspect to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.
23. Proceed to the next bore sleeve to be trimmed, repeating steps 10-19 if necessary.
24. Install the piston and the connecting rod. Refer to **Piston, Connecting Rod, and Bearing Installation**.
25. Install the oil pan. Refer to **Oil Pan Replacement**.
26. Install the cylinder head. Refer to **Cylinder Head Replacement**.

Engine Replacement

Removal Procedure

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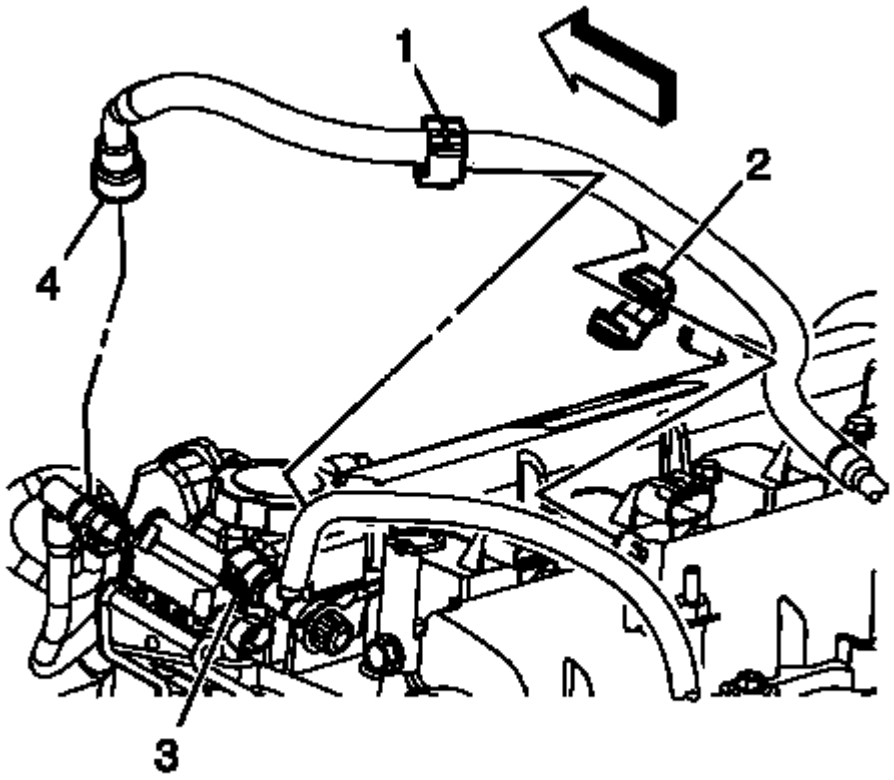

Fig. 238: View Of Caps Or Plugs, Fuel Line And Fuel Rail
Courtesy of GENERAL MOTORS CORP.

1. Ensure that the tires are in the straight forward position. Remove the key from the ignition.
2. Raise the hood.
3. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
4. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief** .
5. Disconnect the fuel feed line quick connect fitting (4) from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
6. Disconnect the evaporative emission (EVAP) line quick connect fitting (3) from the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
7. Remove the fuel line clips (1, 2) from the engine brackets.

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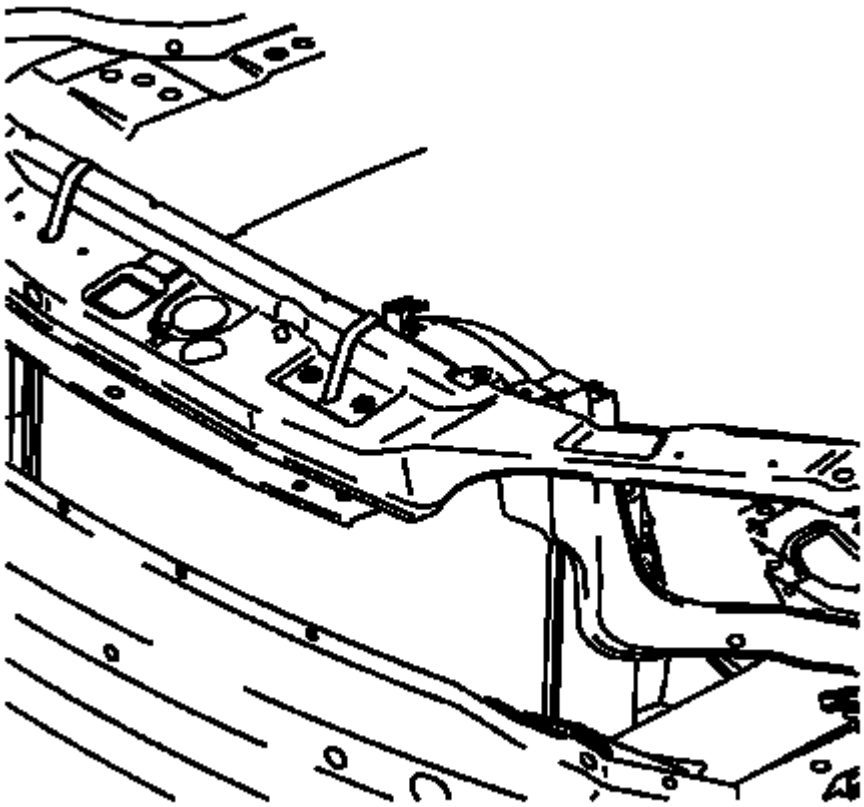

Fig. 239: Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

8. Drain the cooling system. Refer to **Draining and Filling Cooling System (2.2L (L61), 2.4L (LE5))** .
9. Secure the cooling module to the upper body structure.
10. Remove the engine drive belt. Refer to **Drive Belt Replacement**.

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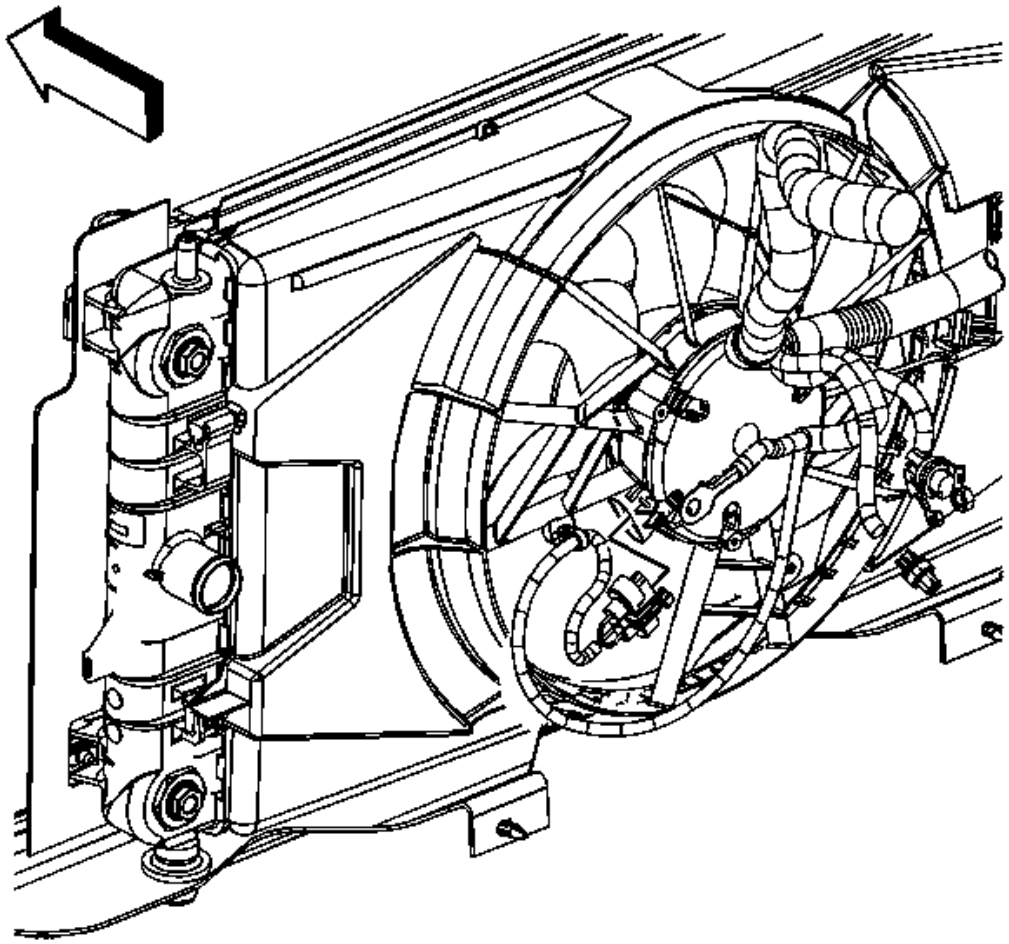

Fig. 240: Identifying Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the cooling fan electrical connector.

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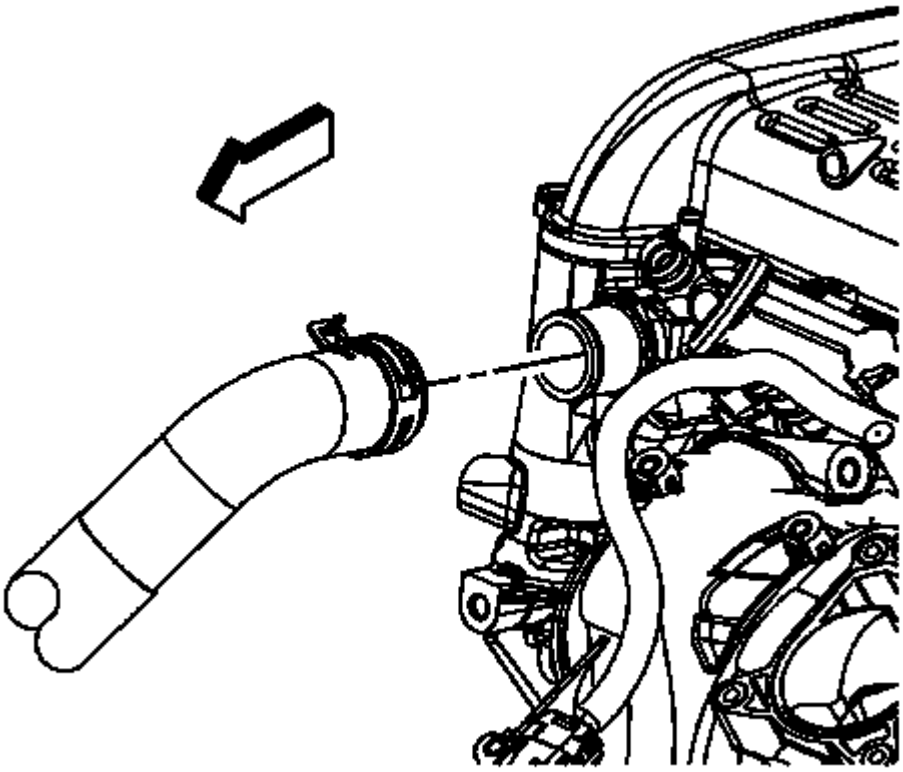

Fig. 241: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

12. Reposition the radiator inlet hose clamp at the engine.
13. Remove the radiator inlet hose from the engine.

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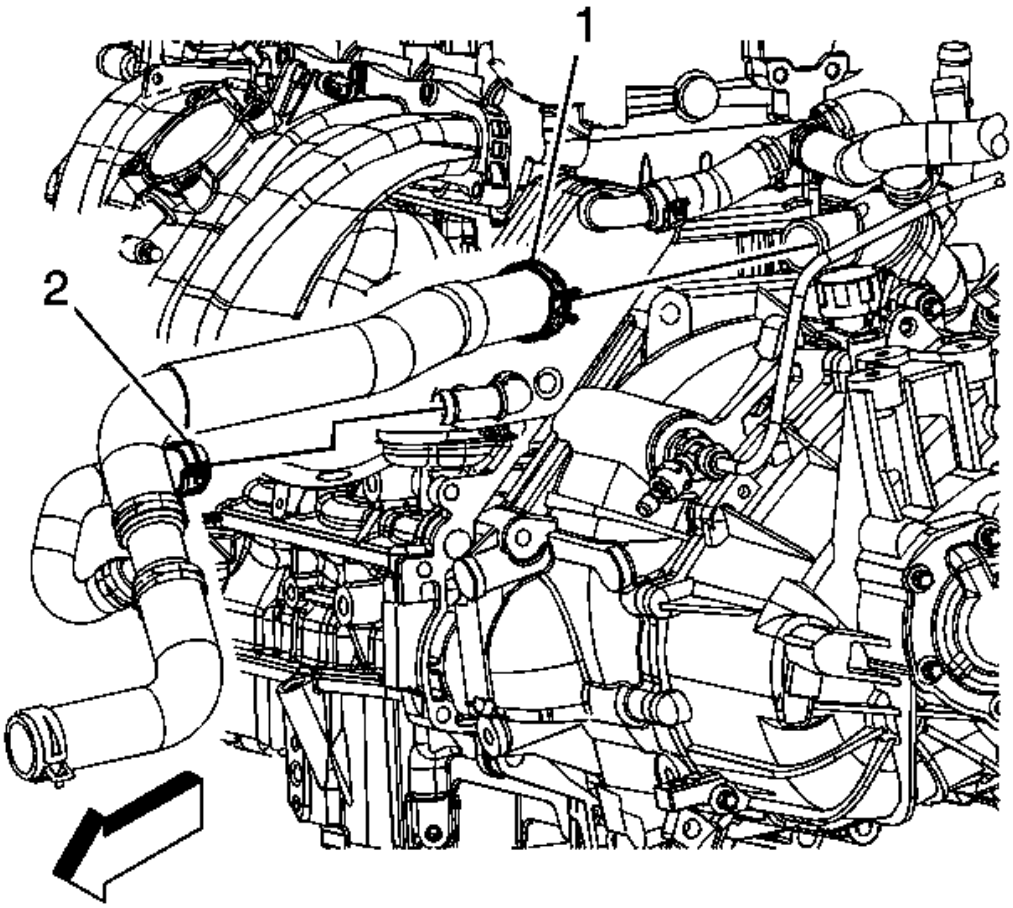

Fig. 242: View Of Radiator Outlet Hose To Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

14. If the vehicle is equipped with a engine oil cooler perform the following steps, otherwise proceed to step 19.
15. Reposition the radiator outlet hose clamp (1) at the water outlet.
16. Reposition the radiator outlet hose clamp (2) at the oil cooler.
17. Remove the radiator outlet hose from the water outlet.
18. Remove the radiator outlet hose from the oil cooler. Proceed to step 23.

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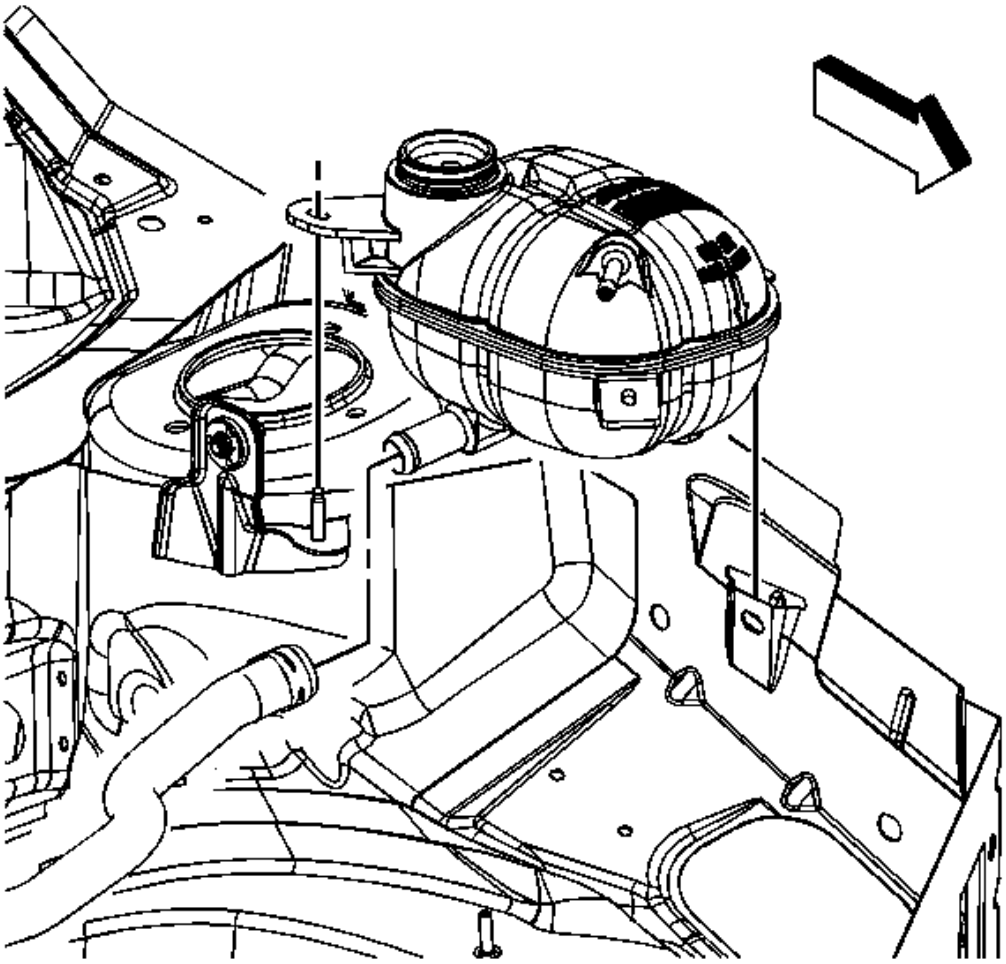

Fig. 243: View of surge tank outlet hose
Courtesy of GENERAL MOTORS CORP.

19. If the vehicle is not equipped with a engine oil cooler, reposition the surge tank outlet hose clamp at the surge tank.
20. Remove the surge tank outlet hose from the surge tank.

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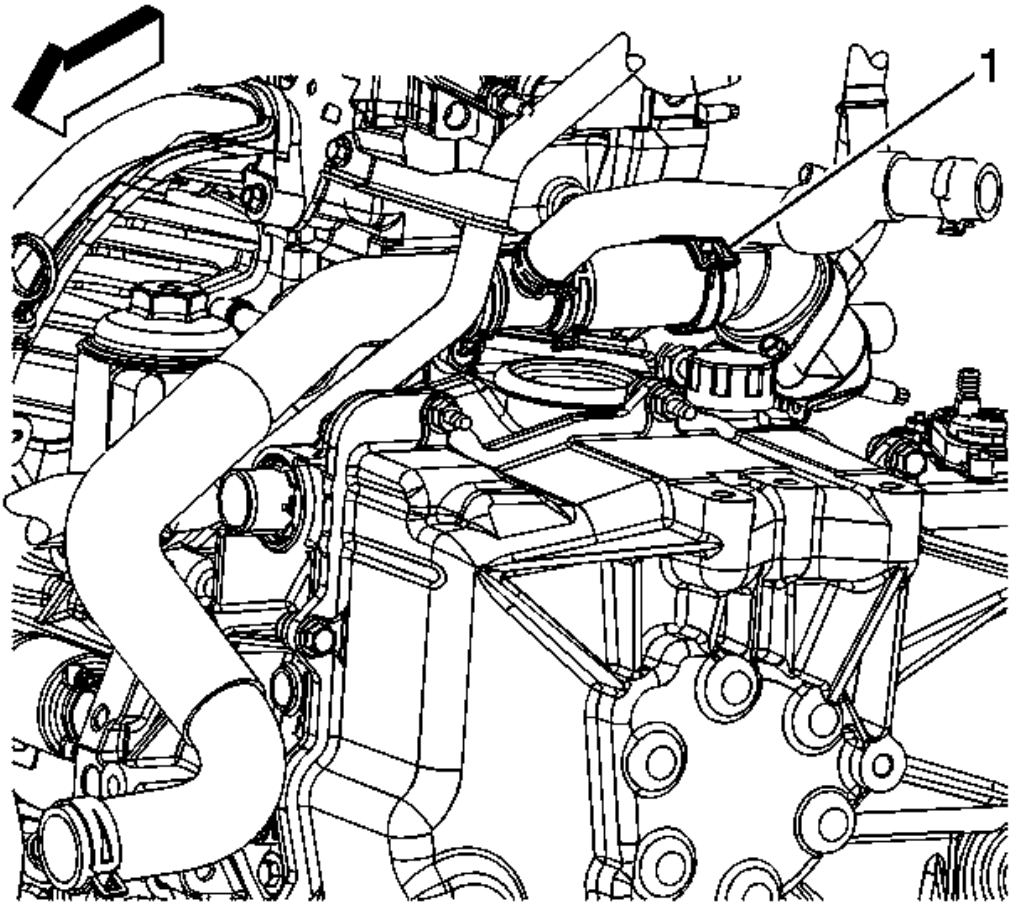

Fig. 244: Identifying Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

21. Reposition the radiator outlet hose clamp (1) at the thermostat cover.
22. Remove the radiator outlet hose from the thermostat cover.

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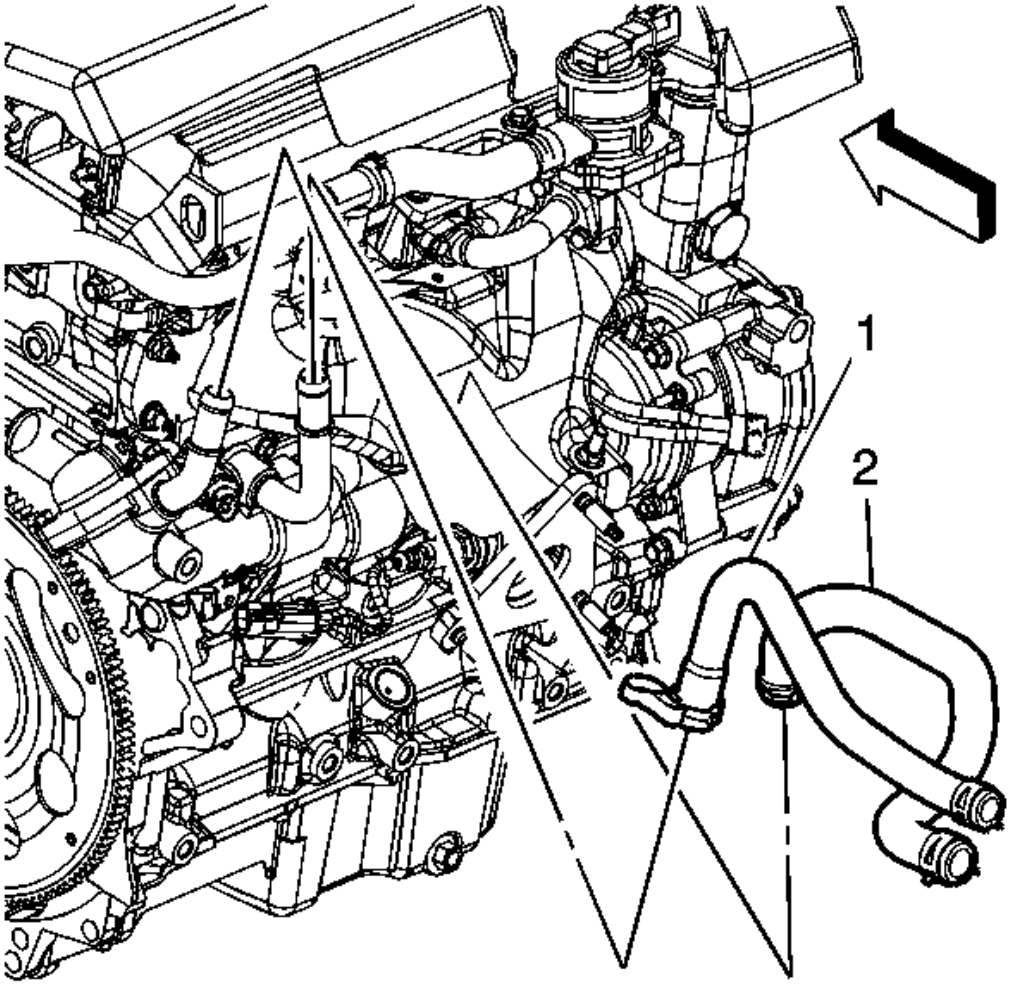

Fig. 245: View Of Heater Inlet And Outlet Hoses And Thermostat Housing Pipes
Courtesy of GENERAL MOTORS CORP.

23. Reposition the heater inlet and outlet hose clamps at the thermostat housing.
24. Remove the heater inlet (2) and outlet (1) hoses from the thermostat housing.

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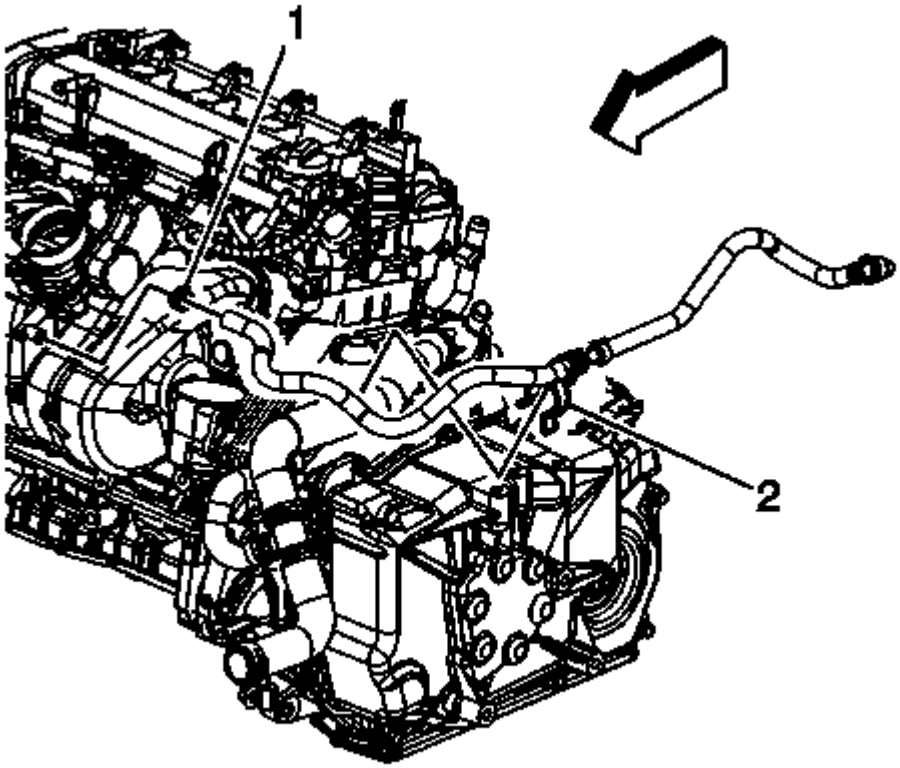

Fig. 246: View of Vacuum brake booster hose clamp
Courtesy of GENERAL MOTORS CORP.

25. Reposition the brake booster vacuum hose clamp (2) at the intake manifold.
26. Remove the brake booster vacuum hose from the intake manifold. Reposition the hose.

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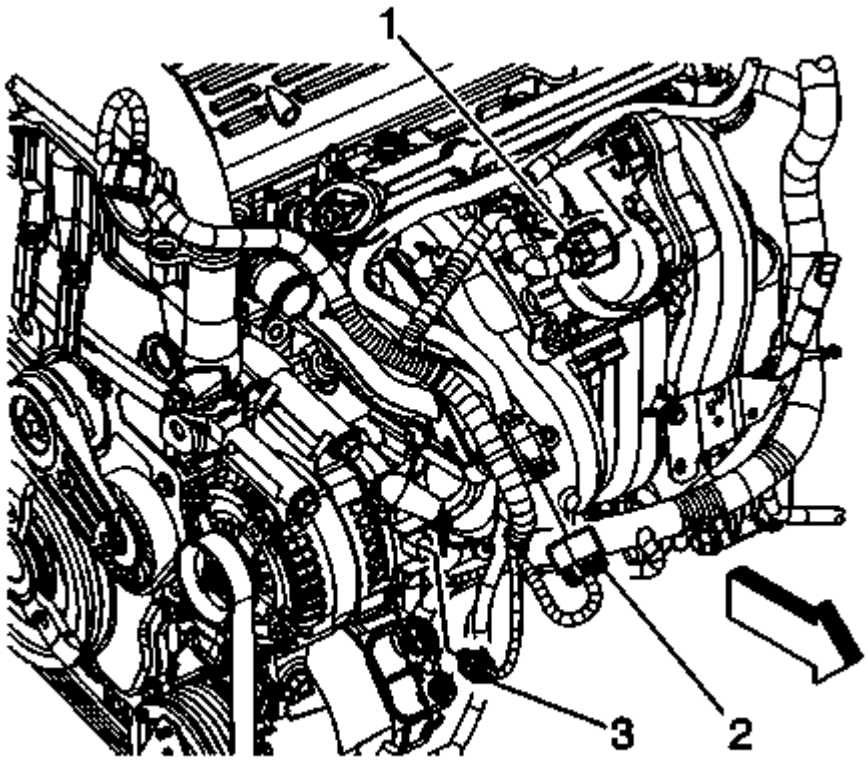

Fig. 247: Identifying Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

27. Disconnect the following electrical connectors:
    - Throttle actuator control (TAC) (1)
    - Manifold absolute pressure (MAP) sensor
    - Fuel injector harness (2)
    - Generator (3)

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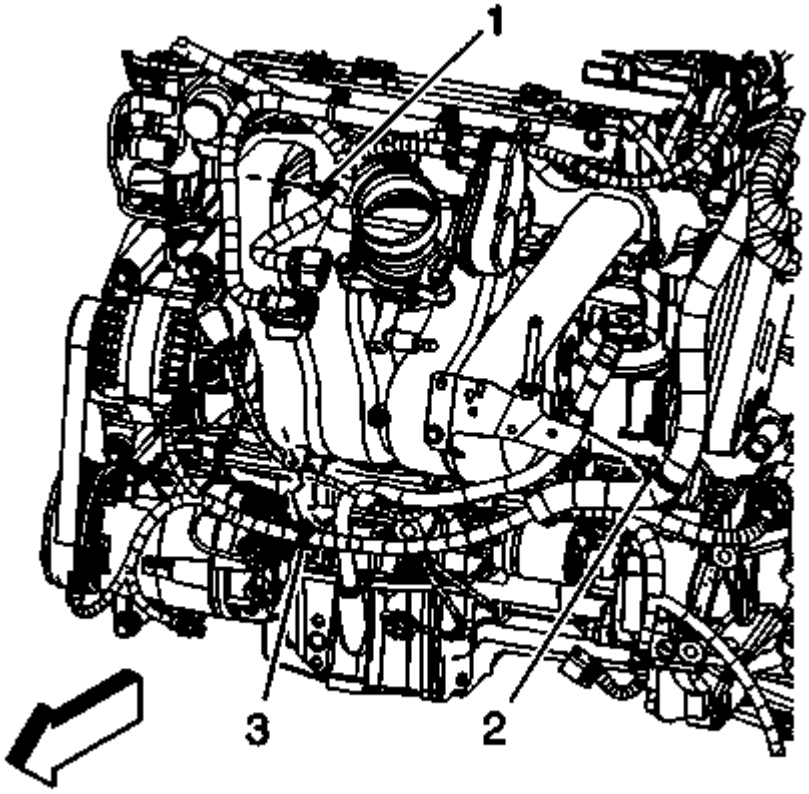

Fig. 248: View of engine harness clip
Courtesy of GENERAL MOTORS CORP.

28. Disconnect the engine harness clip (2) from the oil level indicator tube.
29. Disconnect the engine harness clips (1 and 3) from the intake manifold.

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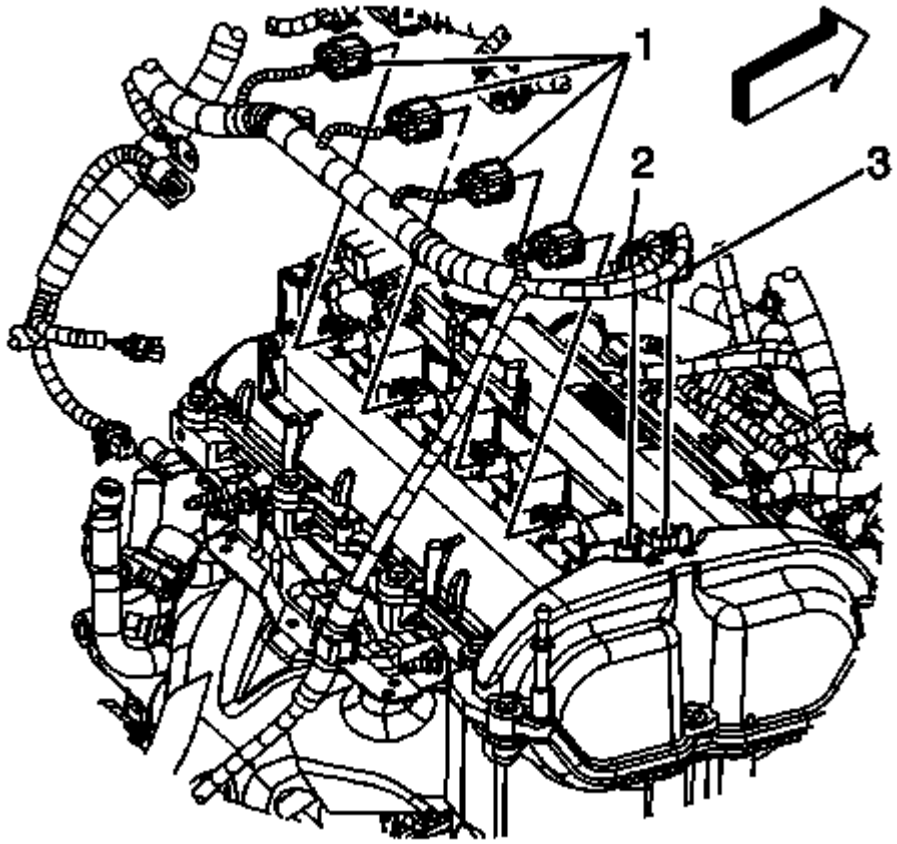

Fig. 249: Identifying Camshaft Position Actuator Solenoid Valve Electrical Connectors
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30. Disconnect the ignition coils electrical connectors (1).
31. Disconnect the intake (3) and exhaust (2) camshaft position actuator electrical connectors.

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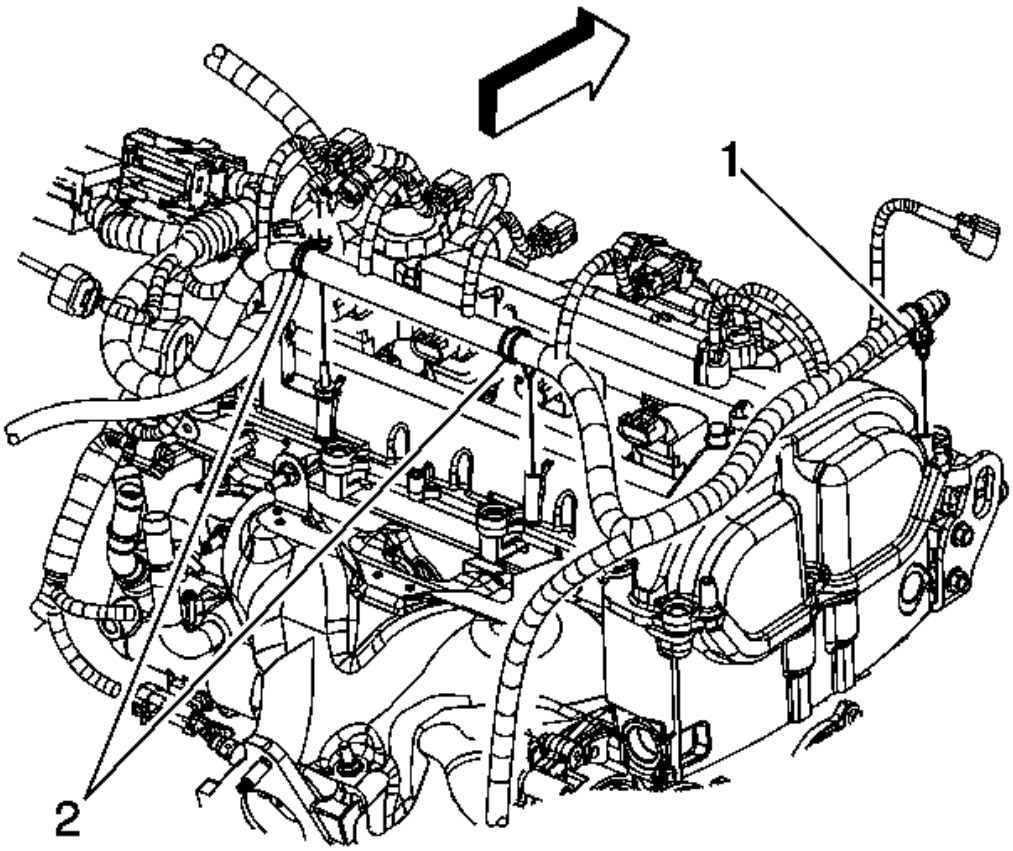

Fig. 250: View of engine harness clips
Courtesy of GENERAL MOTORS CORP.

32. Remove the engine harness clips (1 and 2) from the camshaft cover.

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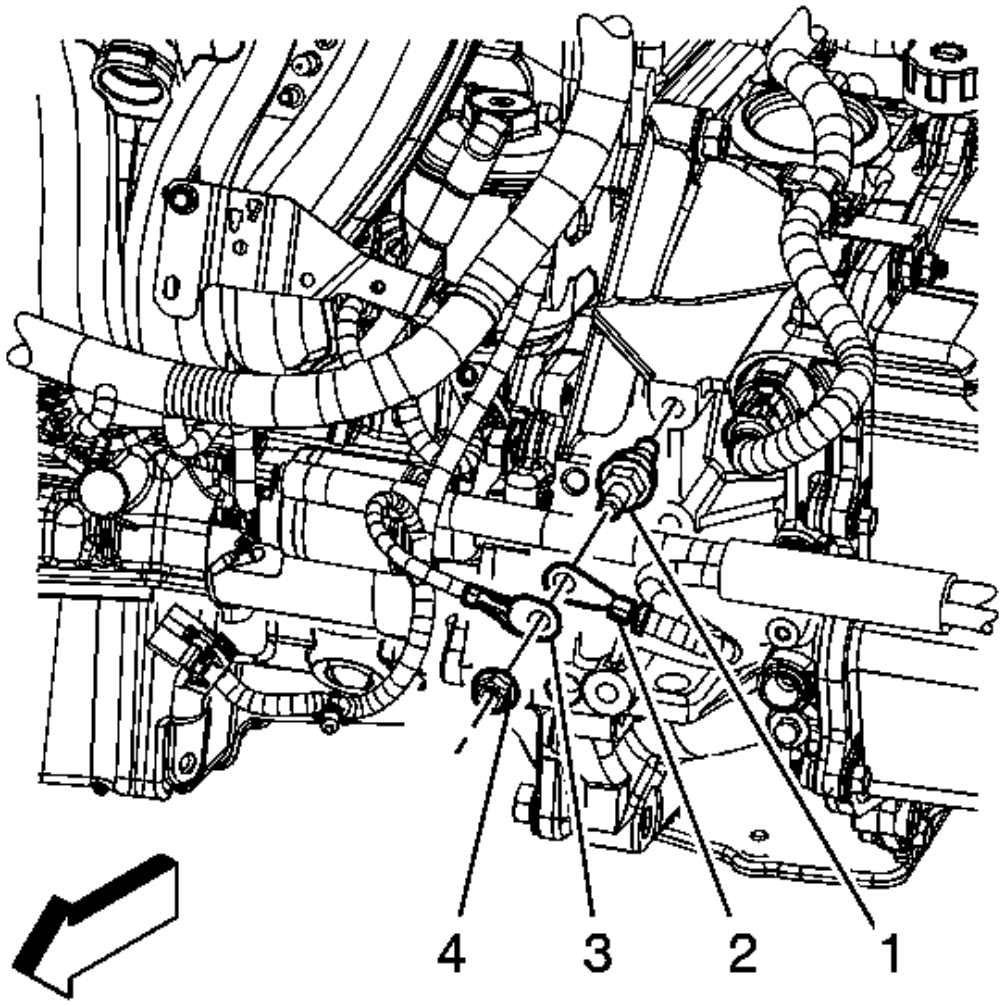

Fig. 251: View Of Battery Connections
Courtesy of GENERAL MOTORS CORP.

33. Remove the negative battery cable ground nut (4).
34. Remove the engine harness ground terminal (3) from the stud.
35. Remove the negative battery cable ground terminal (2) from the stud.

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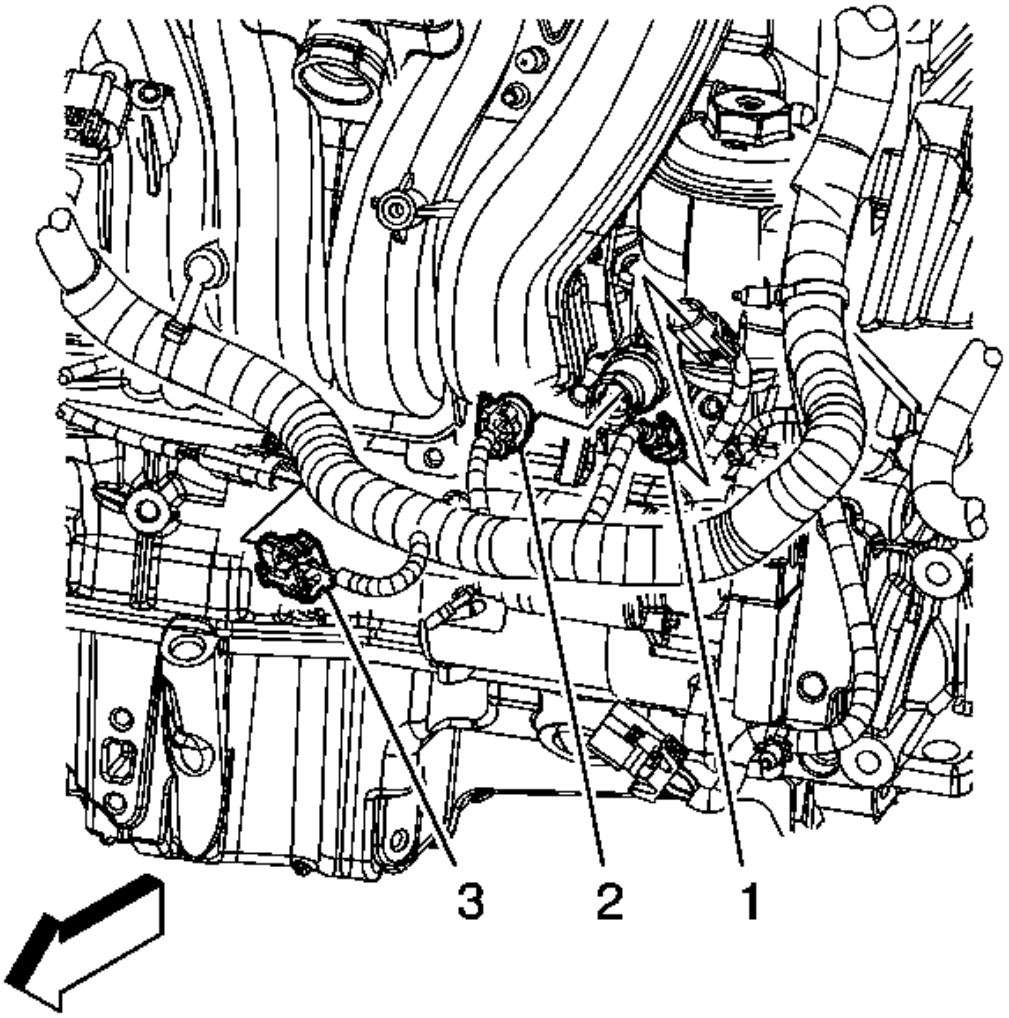

Fig. 252: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

36. Disconnect the following engine harness electrical connectors:
    - Oil pressure sensor (2)
    - Crankshaft position (CKP) sensor (1)
    - Knock sensor (3)

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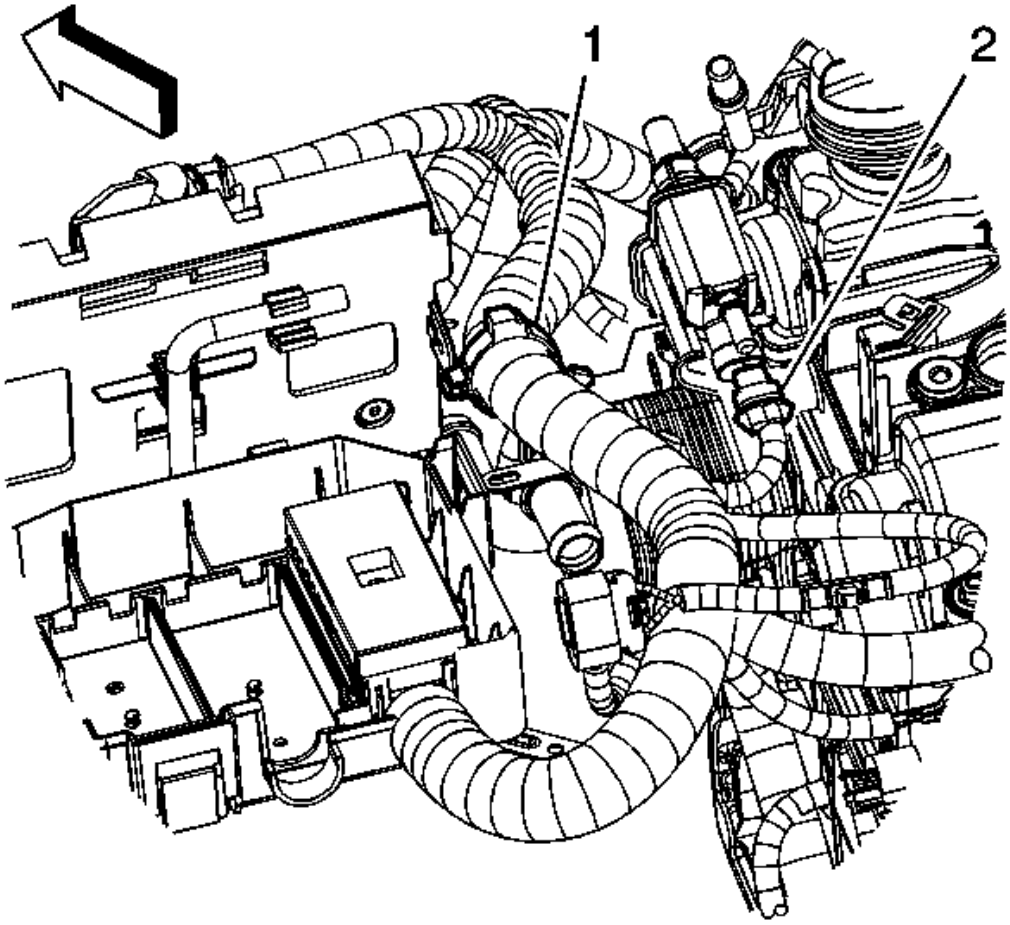

Fig. 253: Locating EVAP Purge Solenoid Electrical Connector
Courtesy of GENERAL MOTORS CORP.

37. Disconnect the EVAP purge solenoid electrical connector (2).
38. Remove the engine harness clip (1) from the purge solenoid bracket.

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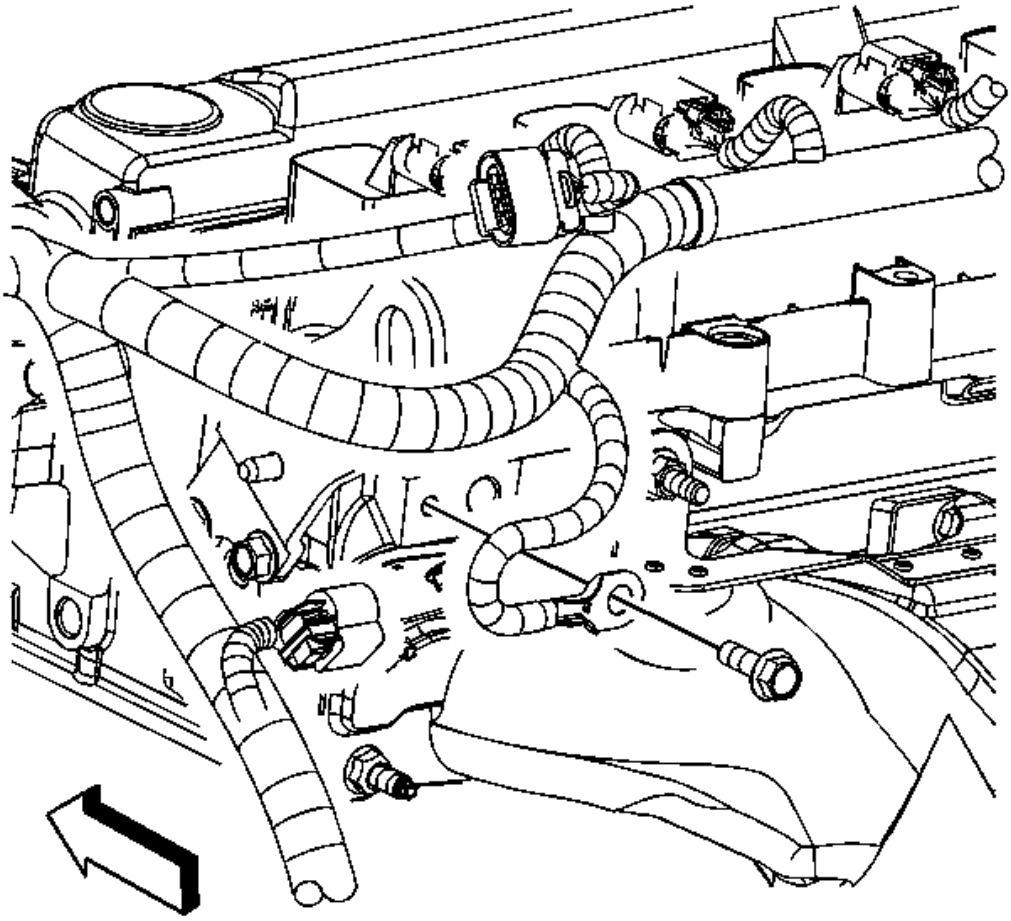

Fig. 254: Identifying Engine Harness Ground Terminal
Courtesy of GENERAL MOTORS CORP.

39. Remove the engine harness ground bolt.
40. Reposition the engine harness ground terminal.

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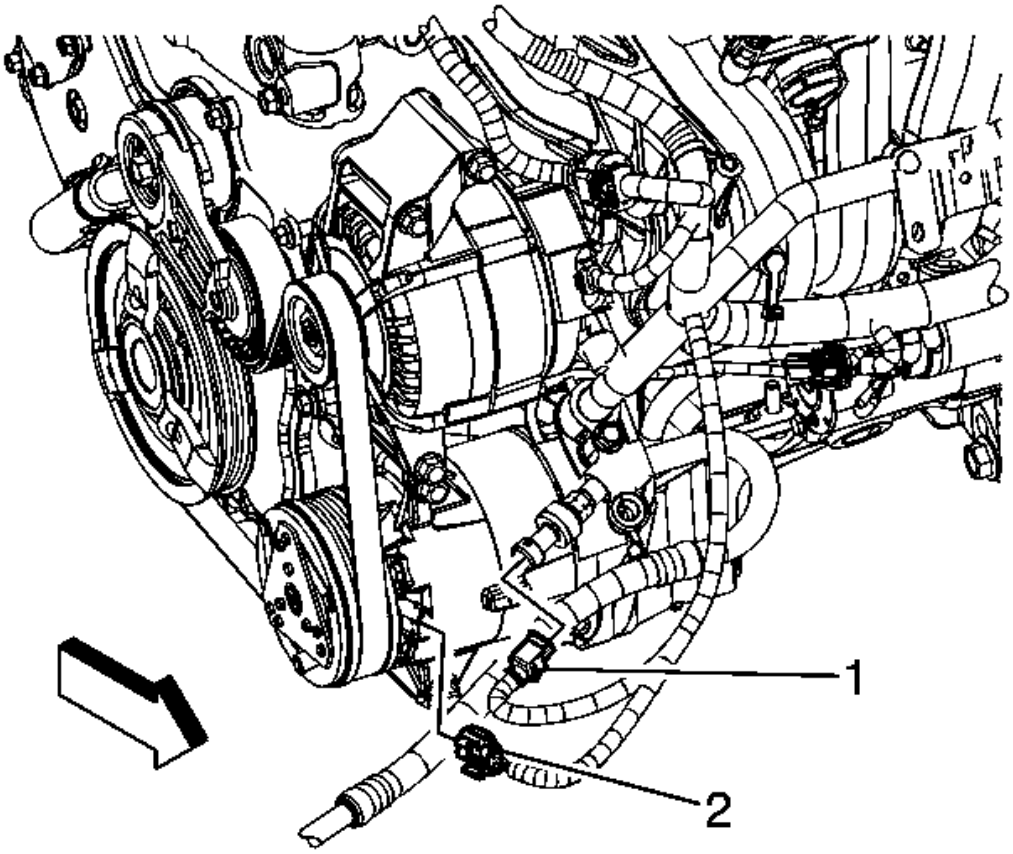

Fig. 255: View Of Engine Harness Electrical Connector To A/C Compressor And Pressure Switch
Courtesy of GENERAL MOTORS CORP.

41. Disconnect the engine harness electrical connector (1) from the air conditioning (A/C) pressure switch.
42. Disconnect the engine harness electrical connector (2) from A/C compressor.
43. Unbolt and reposition the AC compressor aside.
44. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
45. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.

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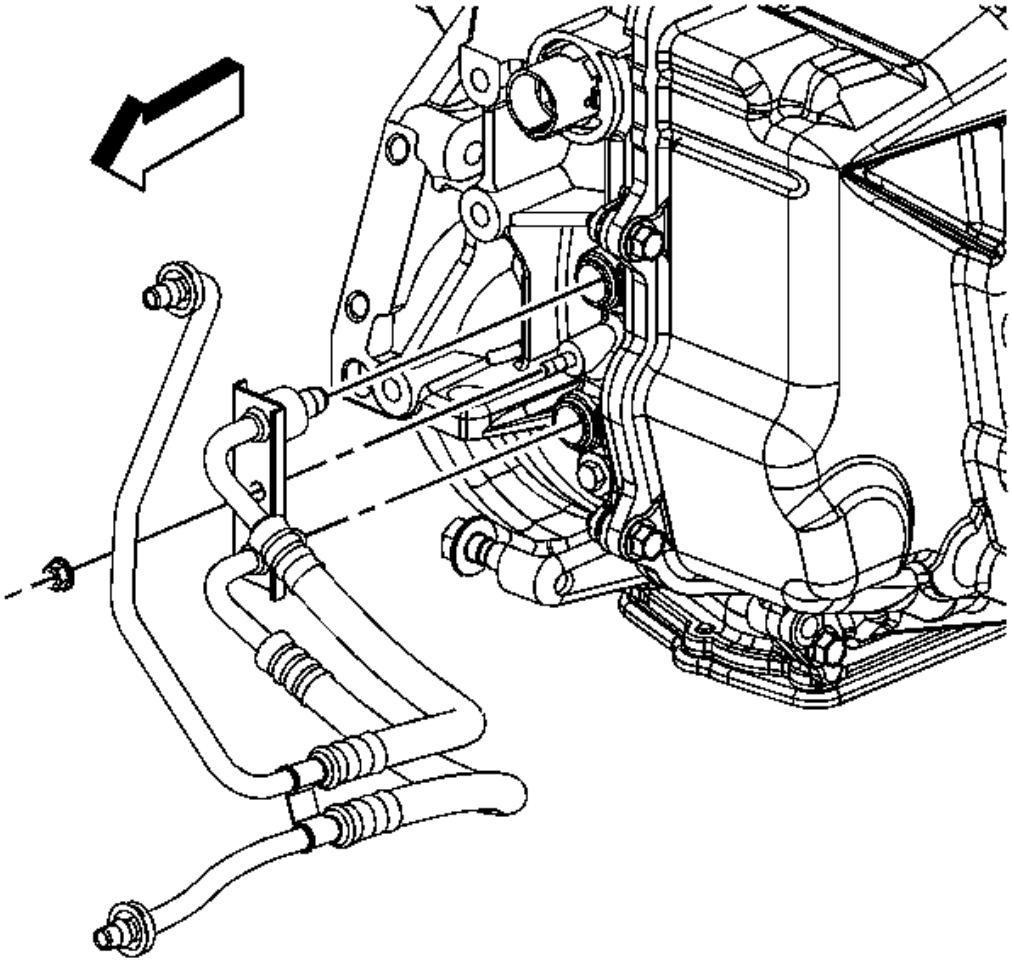

Fig. 256: Identifying Transaxle Fluid Cooler Lines & Bracket Nut
Courtesy of GENERAL MOTORS CORP.

46. Remove the transaxle fluid cooler bracket nut.
47. Remove the transaxle fluid cooler lines from the transaxle.

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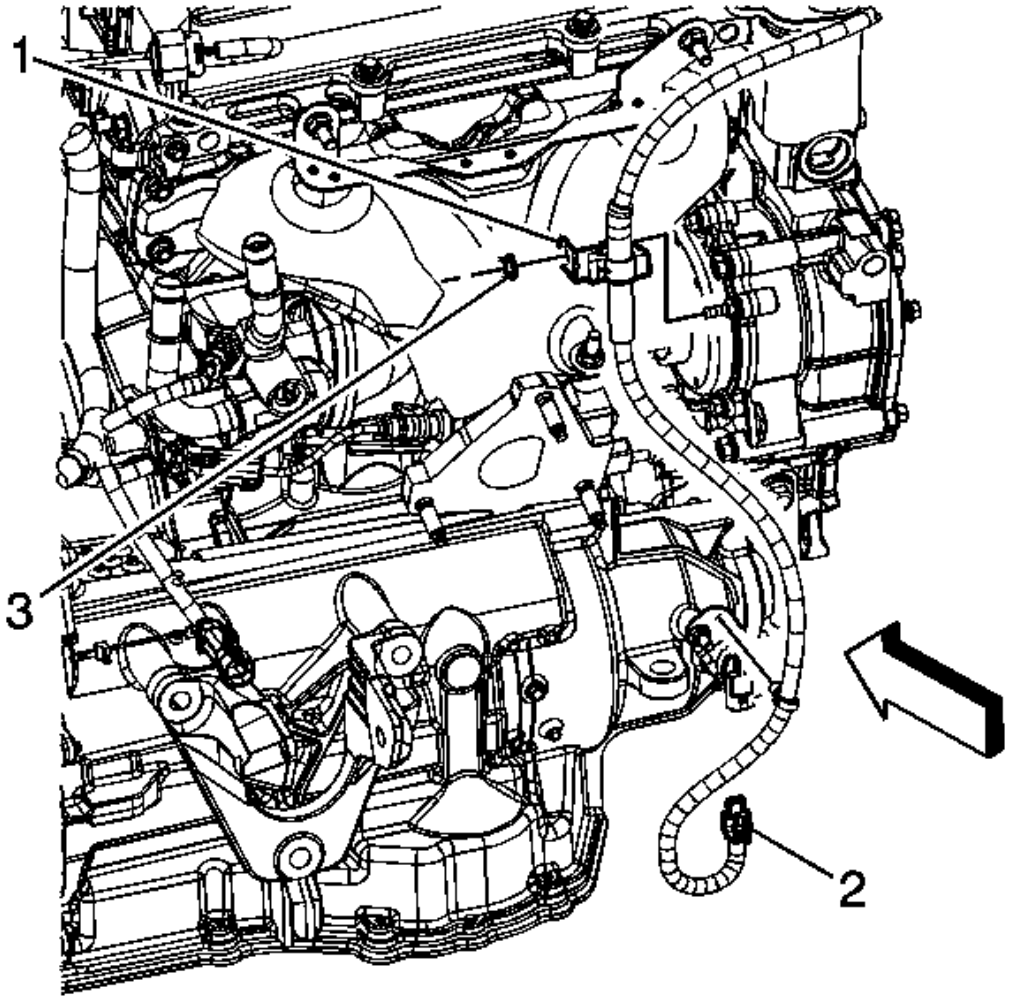

Fig. 257: Identifying Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

48. Remove the engine harness clip nut (3) from the engine stud.
49. Remove the engine harness clip (1) from the stud.
50. If equipped with a automatic transaxle, disconnect the engine harness electrical connector (2) from the vehicle speed sensor (VSS).
51. Remove the engine harness clip (3) from the speed sensor.

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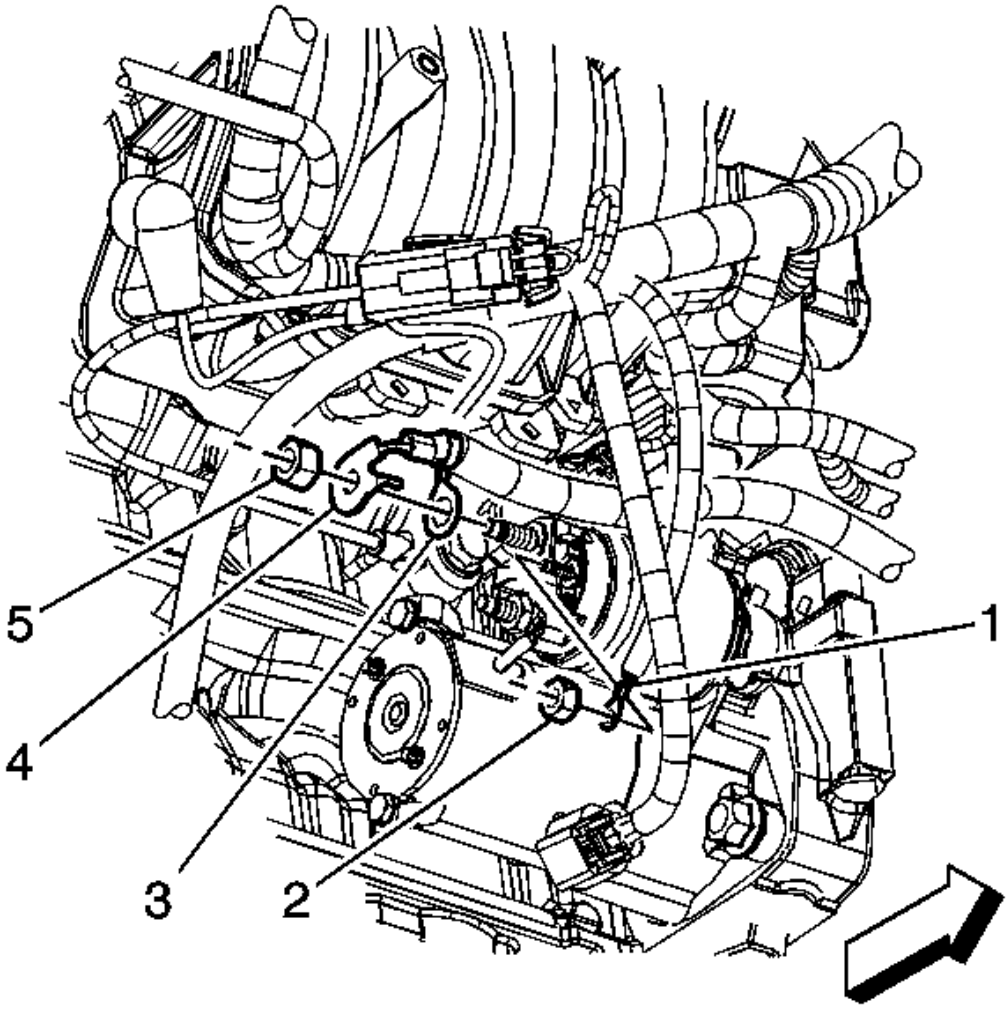

Fig. 258: View Of Negative Battery Cable
Courtesy of GENERAL MOTORS CORP.

52. Remove the positive battery cable lead nut (5) from the starter solenoid.
53. Remove the positive battery cable terminal (4) from the starter.
54. Remove the engine harness terminal (3) from the starter.
55. Remove the engine harness to starter solenoid "S" terminal nut (2).
56. Remove the engine harness lead terminals (1) from the starter solenoid.
57. Lower the vehicle.

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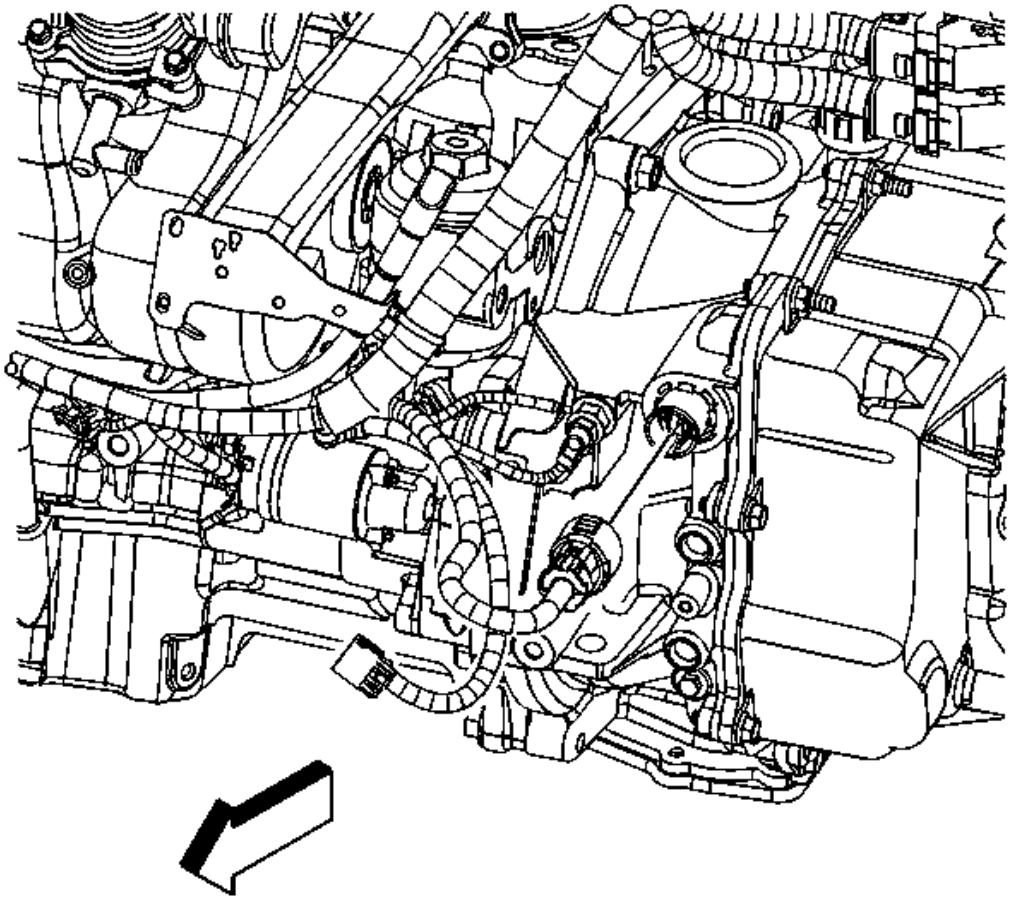

Fig. 259: Identifying Engine Harness
Courtesy of GENERAL MOTORS CORP.

58. If equipped with a automatic transaxle, disconnect the engine harness from the transaxle.

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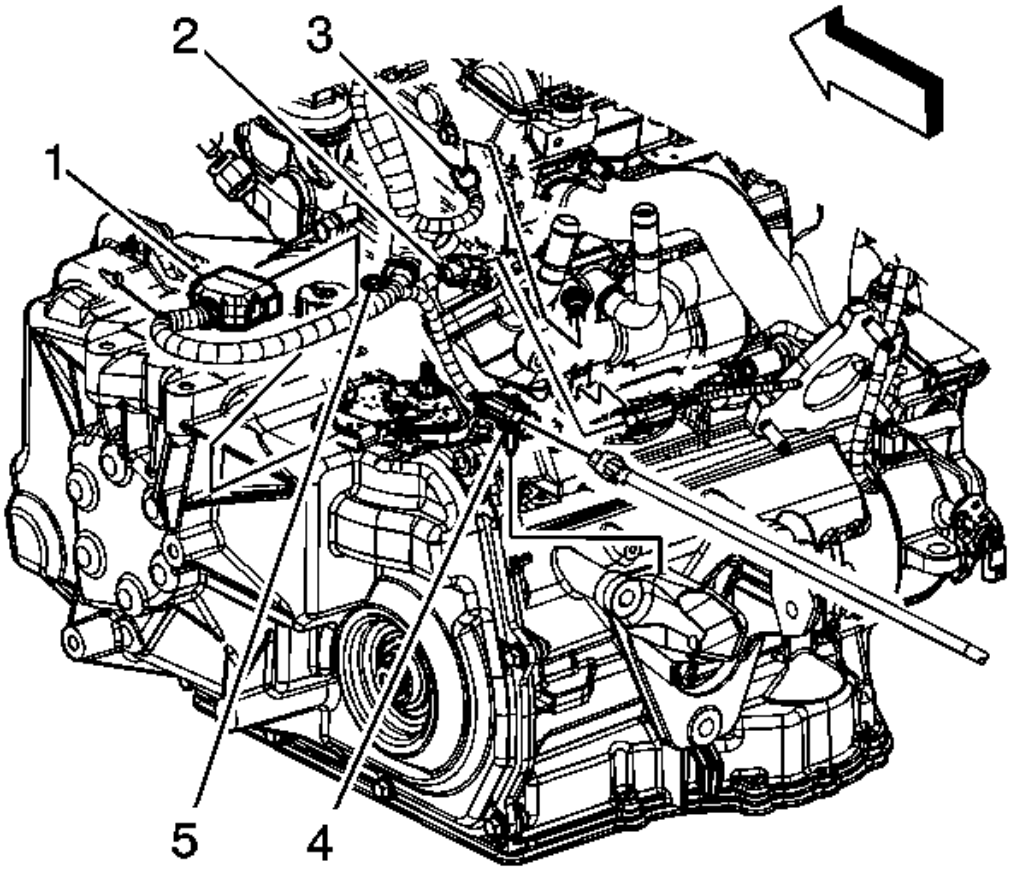

Fig. 260: Identifying Engine Harness Electrical Connectors - Top Of Engine
Courtesy of GENERAL MOTORS CORP.

59. If equipped with a automatic transaxle, perform the following steps. Disconnect the engine harness electrical connector (2) from the engine coolant temperature (ECT) sensor.
60. Remove the heated oxygen sensor (HO2S) connector position assurance (CPA) retainers.
61. Disconnect the engine harness electrical connectors (2, 4) from the HO2S.
62. Remove the HO2S connector clips from the thermostat housing and engine bracket.
63. Disconnect the engine harness electrical connector (1) from the park neutral position switch.

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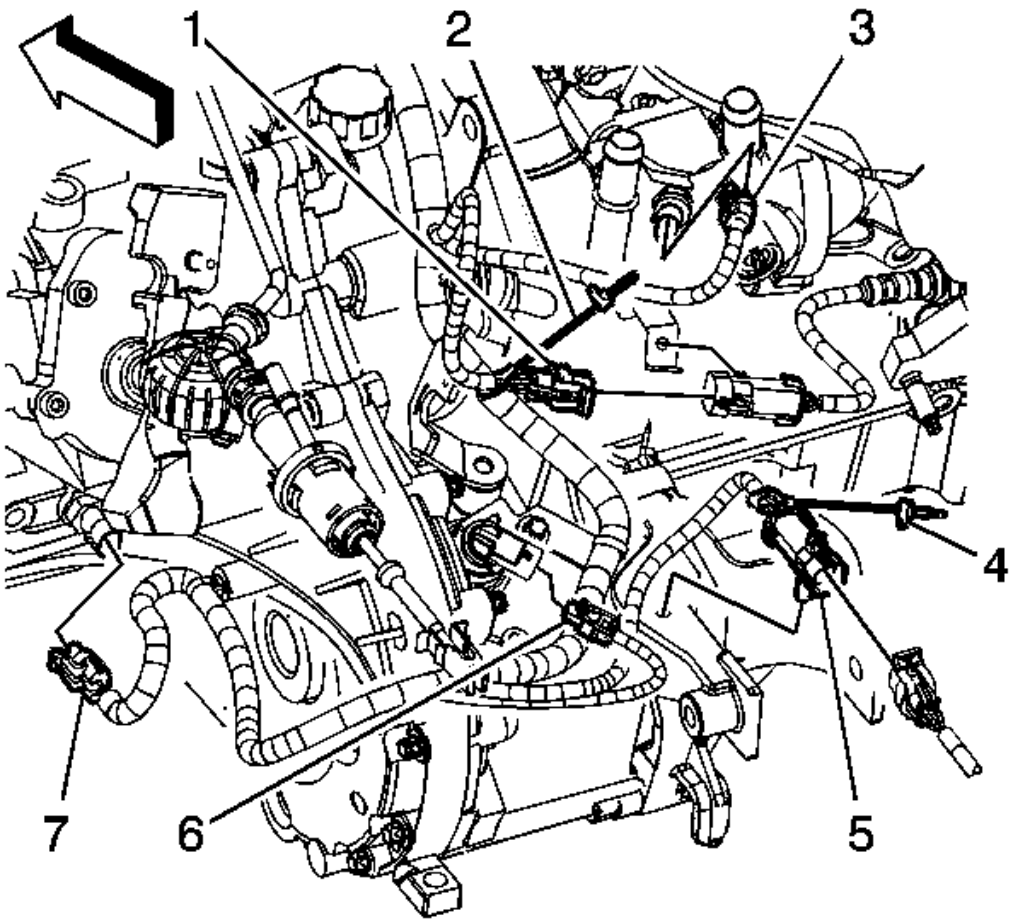

Fig. 261: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

64. If equipped with a manual transaxle, disconnect the engine harness electrical connector (6) from the VSS.
65. Disconnect the engine harness electrical connector (7) from the back up lamp switch.
66. Remove the HO2S CPA retainers (2, 4).
67. Disconnect the engine harness electrical connectors (1, 5) from the HO2S.
68. Remove the HO2S clips from the engine brackets.
69. Gather all engine harness branches are reposition the harness off to the side, out of the way.

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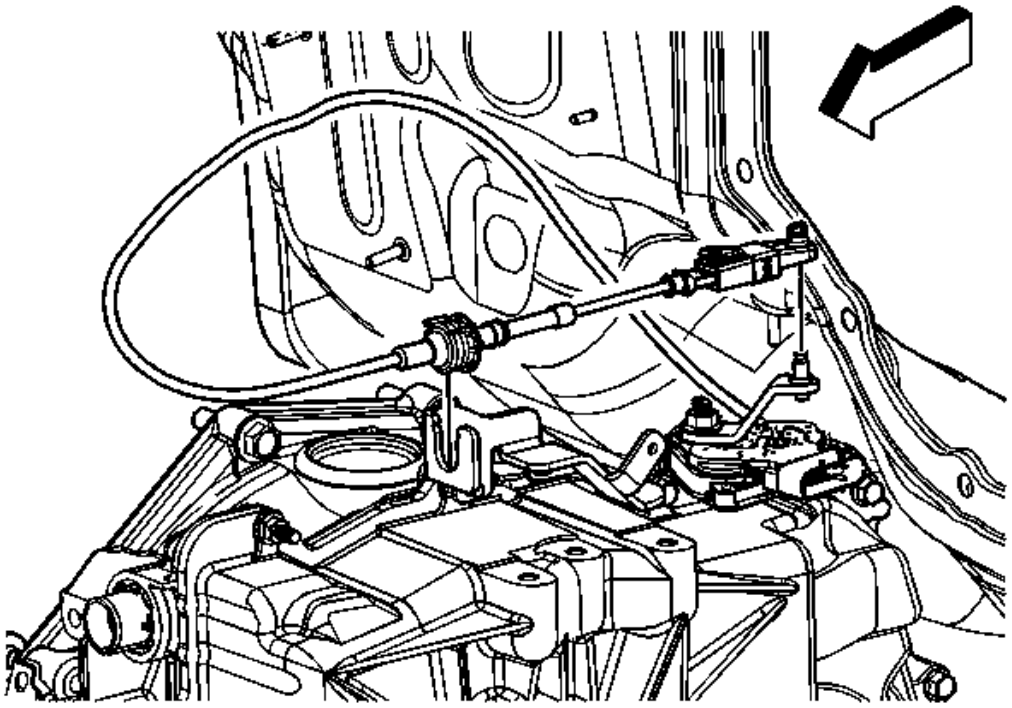

Fig. 262: Identifying Range Selector Level Cable
Courtesy of GENERAL MOTORS CORP.

70. If equipped with a automatic transaxle, disconnect the range selector lever cable from the transaxle lever.
71. Remove the range selector lever cable from the transaxle bracket.

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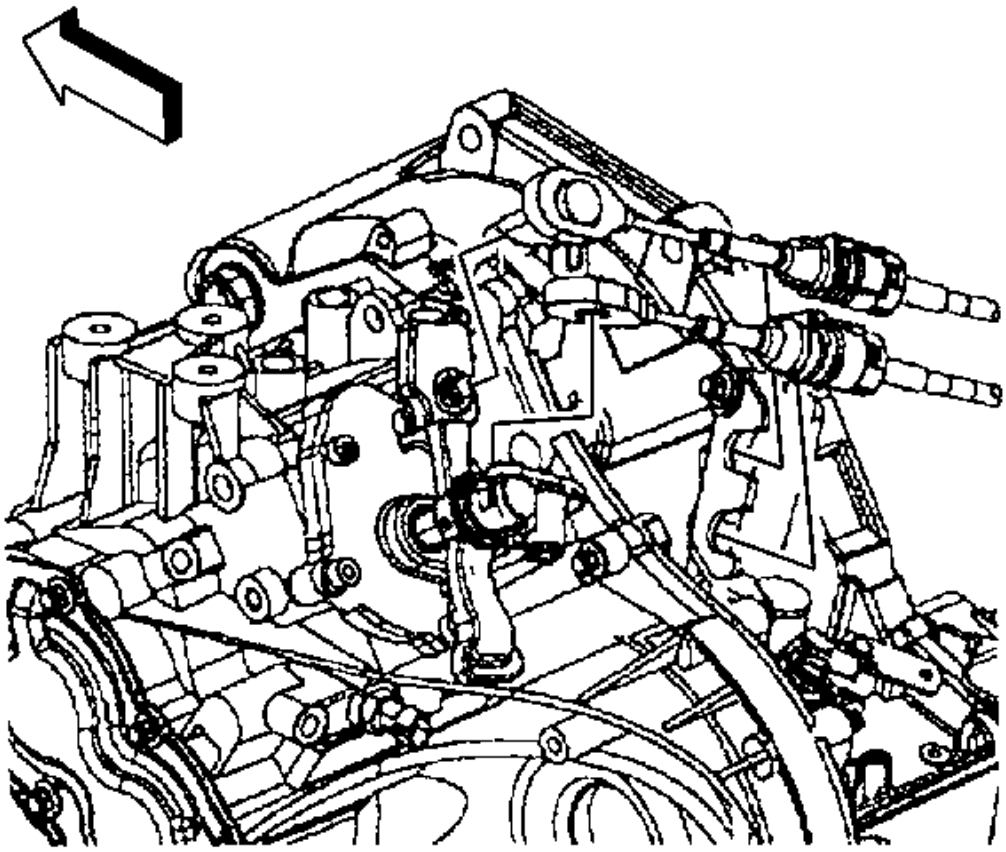

Fig. 263: Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

72. If equipped with a manual transaxle, disconnect the range selector and shift lever cables from the transaxle levers.
73. Remove the range selector and shift lever cables from the transaxle bracket.
74. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (RPO LE5)** .
75. Lower the vehicle.
76. Insert blocks of wood between the powertrain and the frame, in order to support the powertrain.
77. Remove the engine mount. Refer to **Engine Mount Replacement**.

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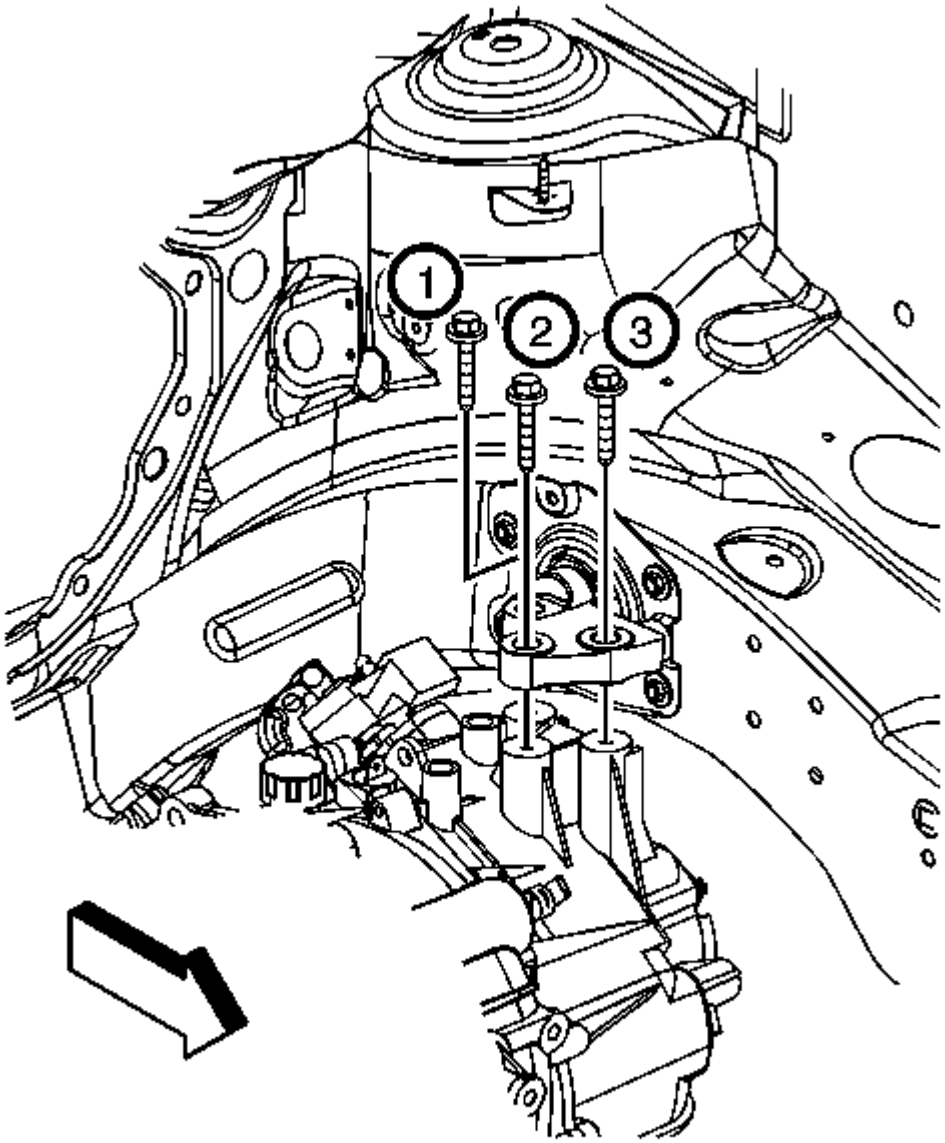

Fig. 264: Identifying Transaxle Mount to Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

78. Remove the transaxle mount to transaxle bolts.
79. Raise the vehicle.
80. Disconnect the stabilizer links from the stabilizer bar. Refer to **Stabilizer Shaft Link Replacement** .
81. Disconnect the outer tie rod ends from the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod**

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End Replacement .

82. Disconnect the intermediate shaft from the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
83. Disconnect the lower control arms from the steering knuckles. Refer to **Lower Control Arm Replacement** .

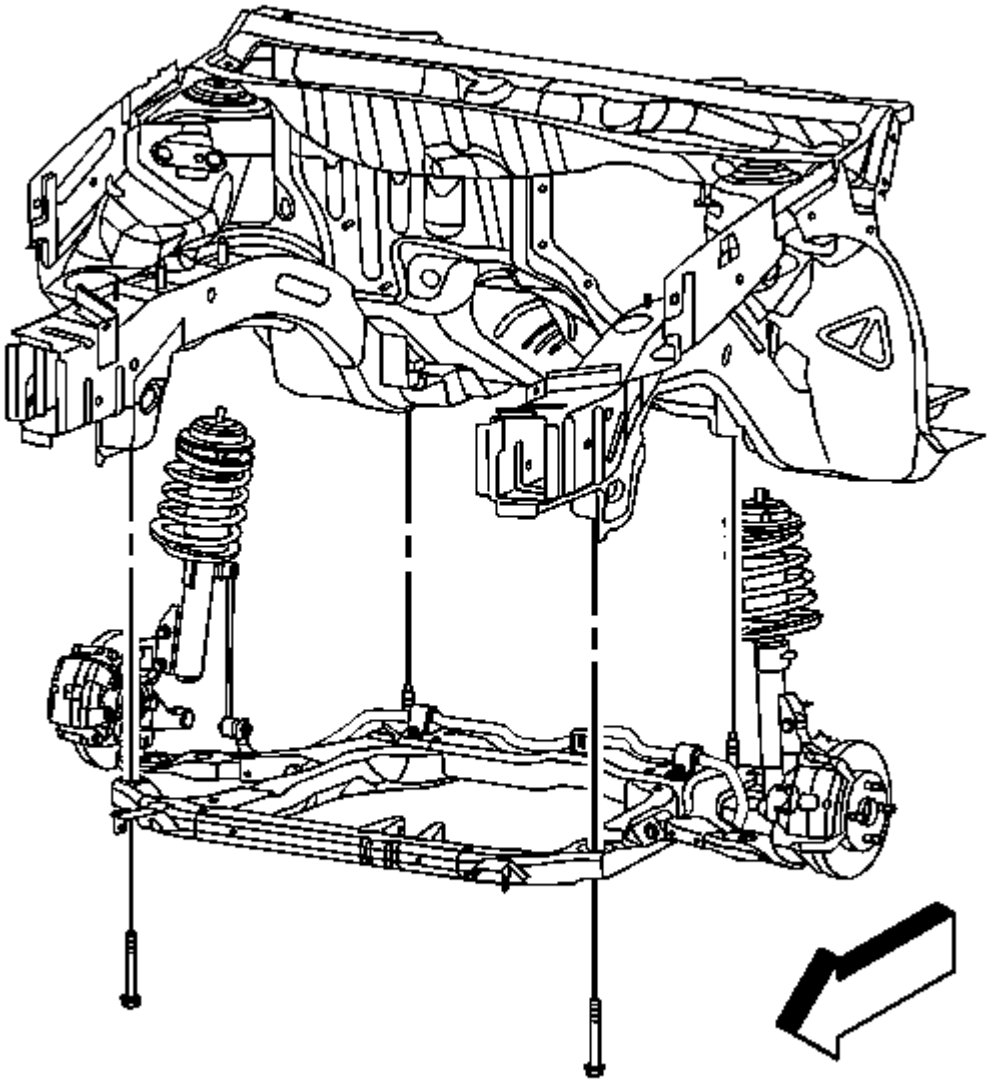

Fig. 265: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

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84. Using a paint pen or magic marker, mark the frame to body position.
85. Lower the vehicle to about 3 feet off the ground.
86. Position a engine lift table under the frame.
87. Place wood blocks on top of the lift table between the table and the frame.
88. Lower the vehicle until the frame is resting on the blocks of wood.
89. Slowly loosen/remove the frame bolts using the following sequence:
    1. Loosen/remove the front frame bolts.
    2. Loosen/remove the rear frame bolts.
90. Slowly raise the vehicle away from the powertrain assembly.
91. Slide the lift table out from under the vehicle.
92. Attach the engine lift hoist to the engine lift hooks.

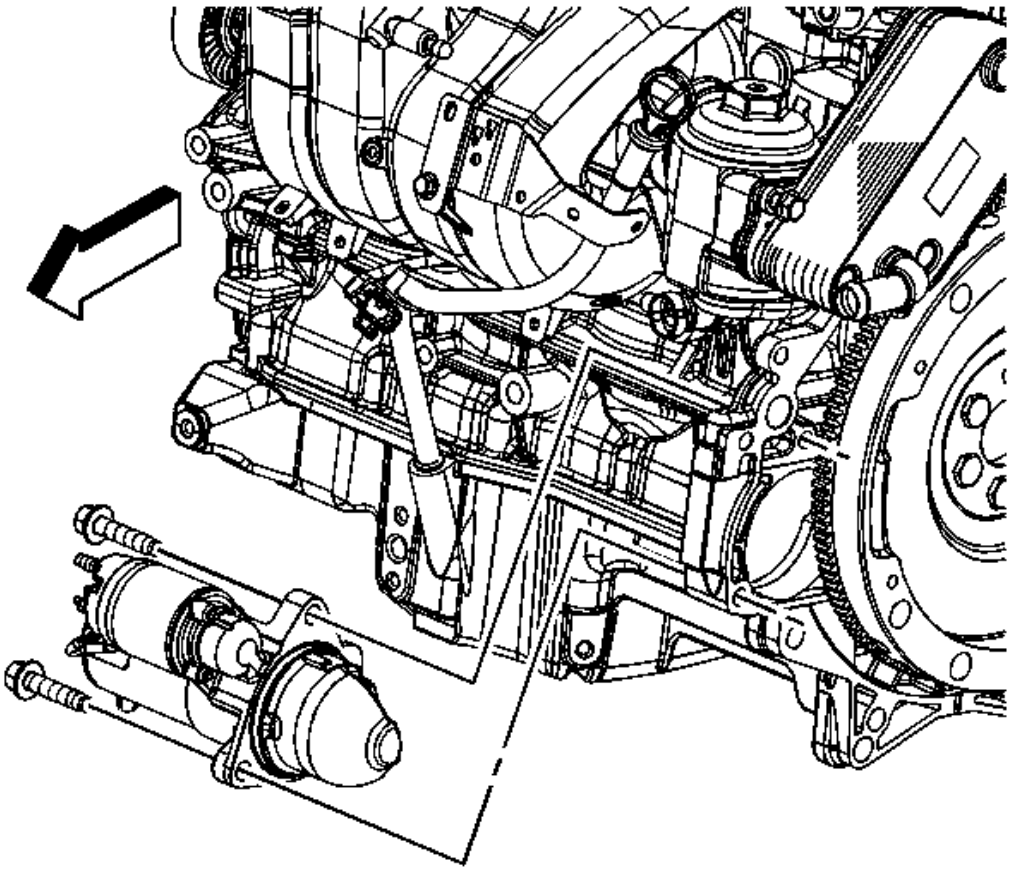

Fig. 266: Identifying Starter Bolts & Starter

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Courtesy of GENERAL MOTORS CORP.

93. Remove the starter bolts and starter.

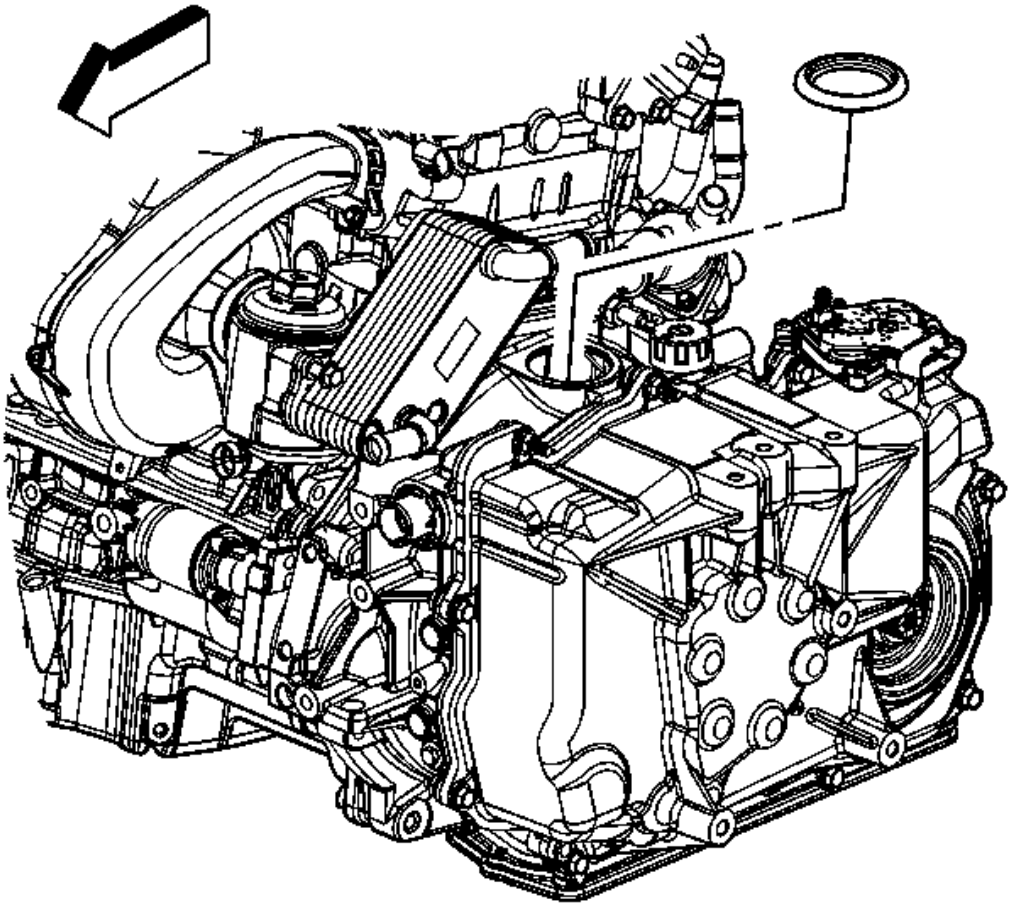

Fig. 267: Identifying Torque Converter Housing Access Plug
Courtesy of GENERAL MOTORS CORP.

94. If equipped with a automatic transaxle, remove the torque converter housing access plug.

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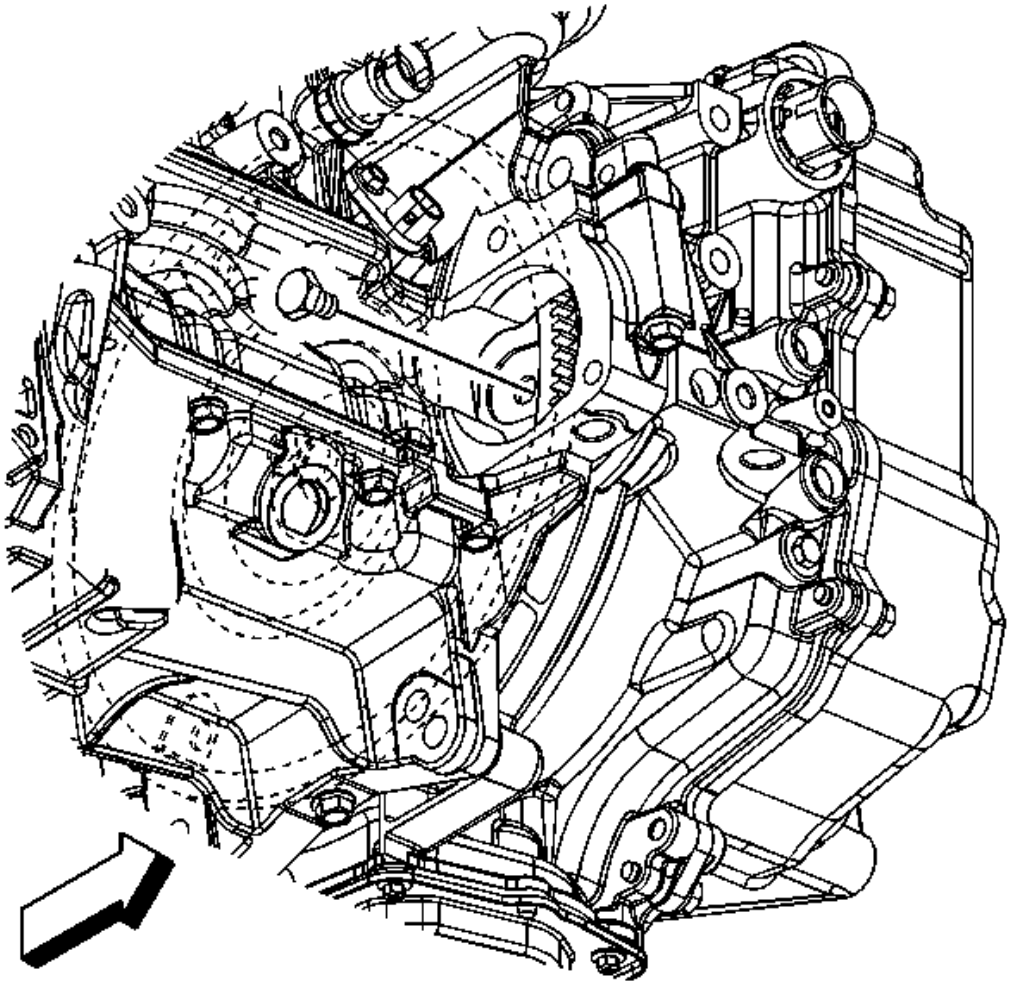

Fig. 268: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

95. If equipped with a automatic transaxle, remove the torque converter bolts.

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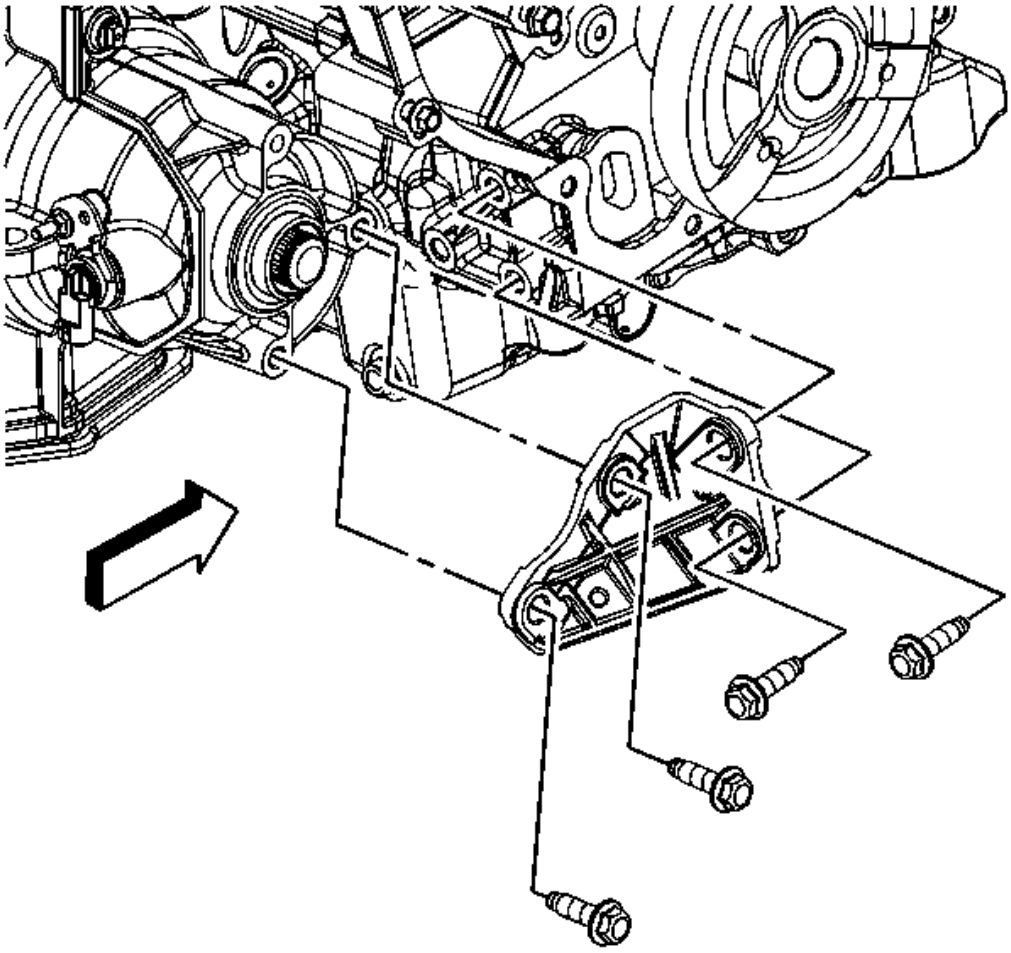

Fig. 269: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

96. Remove the transaxle brace bolts and brace.

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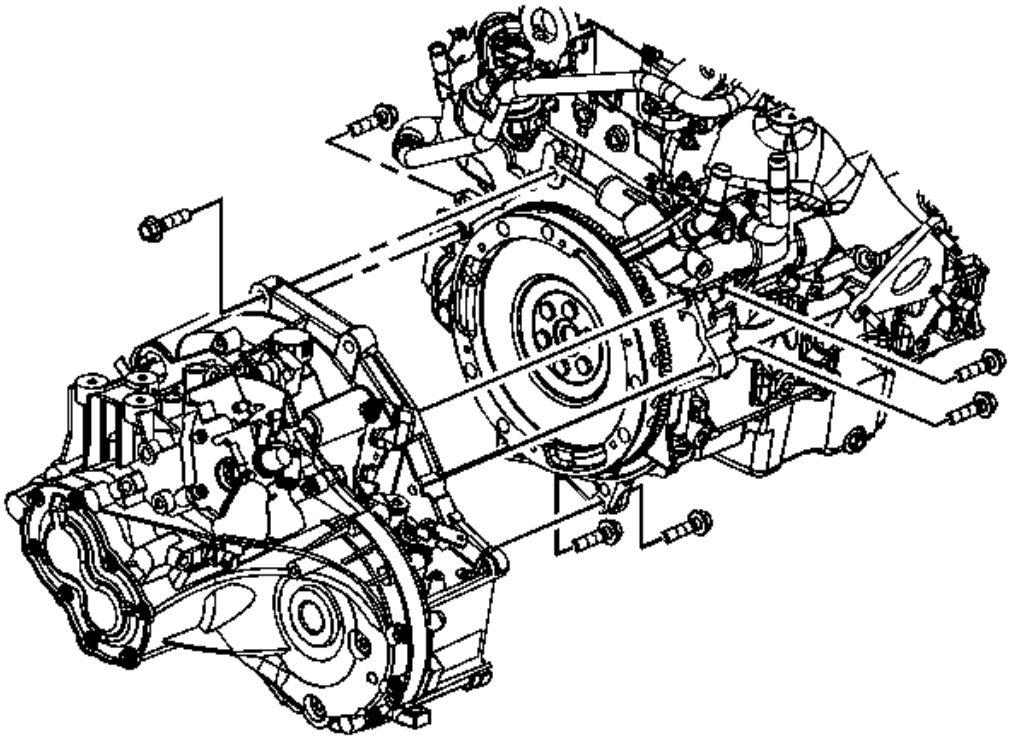

Fig. 270: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

97. If equipped with a manual transaxle, remove the transaxle to engine bolts/stud.

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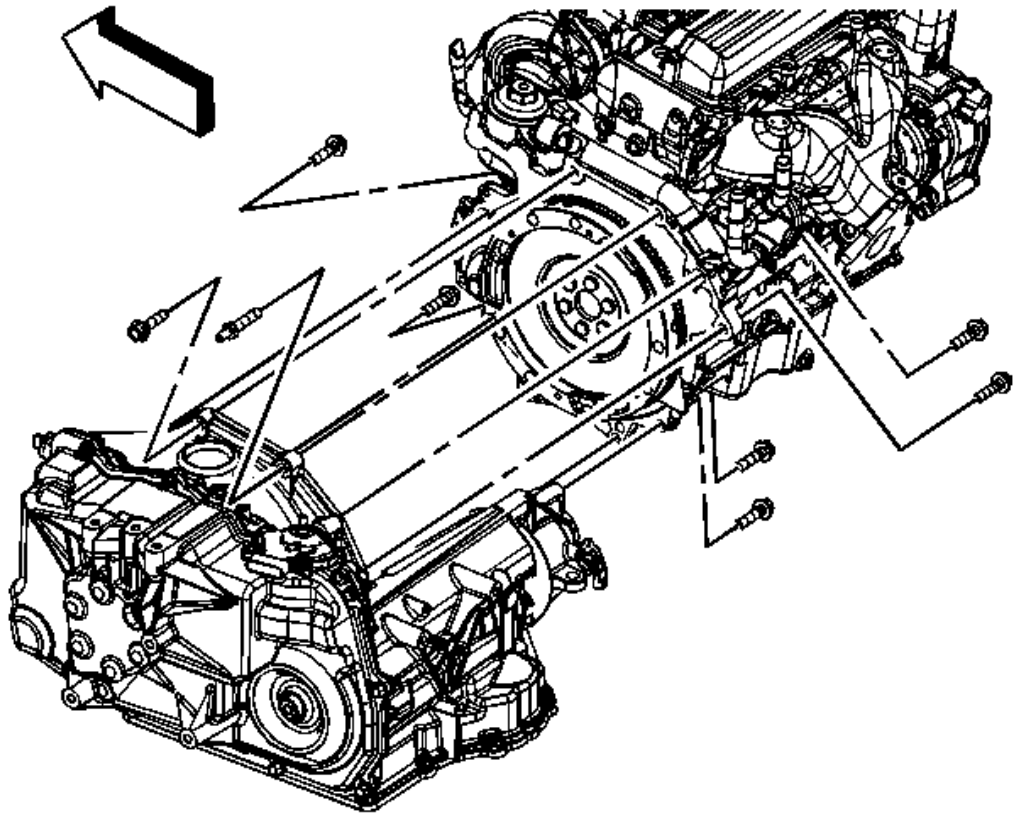

Fig. 271: Identifying Engine To/From Transaxle
Courtesy of GENERAL MOTORS CORP.

98. If equipped with a automatic transaxle, remove the transaxle to engine bolts/stud.
99. Separate the engine from the transaxle.
100. If equipped with a manual transaxle, remove the clutch pressure plate and disc. Refer to **Clutch Drive Plate and Clutch Driven Plate (M86)** or **Clutch Drive Plate and Clutch Driven Plate (MU3)** .
101. Remove the following components:
    - The engine mount bracket
    - The engine block heater
    - The generator
102. Using a engine hoist, install the engine to a engine stand.

Installation Procedure

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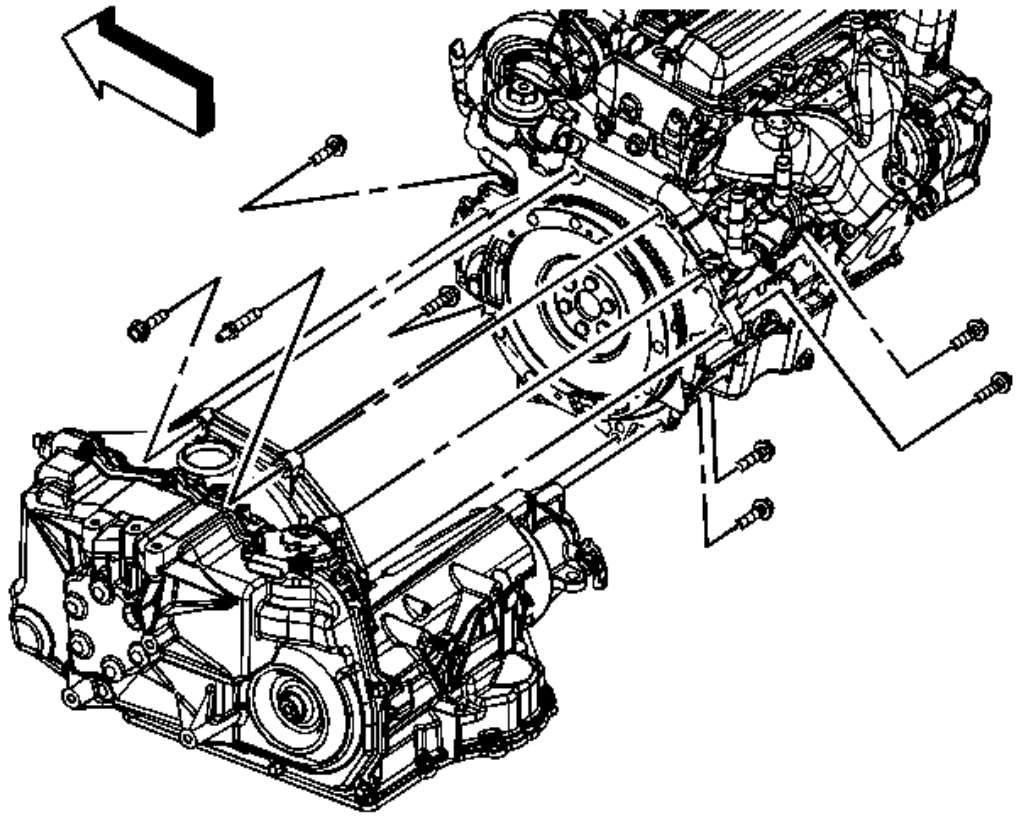

Fig. 272: Identifying Engine/Transaxle Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

1. Using a engine hoist, remove the engine from the engine stand.
2. Install the following components:
   - The engine mount bracket
   - The engine block heater
   - The generator
3. If equipped with a manual transaxle, install the clutch pressure plate and disc. Refer to **Clutch Drive Plate and Clutch Driven Plate (M86)** or **Clutch Drive Plate and Clutch Driven Plate (MU3)** .
4. Install the engine to the transaxle.

   NOTE: Refer to Fastener Notice .

5. If equipped with a automatic transaxle, install the transaxle to engine bolts/stud.

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Tighten: Tighten the bolts/stud to 75 N.m (55 lb ft).

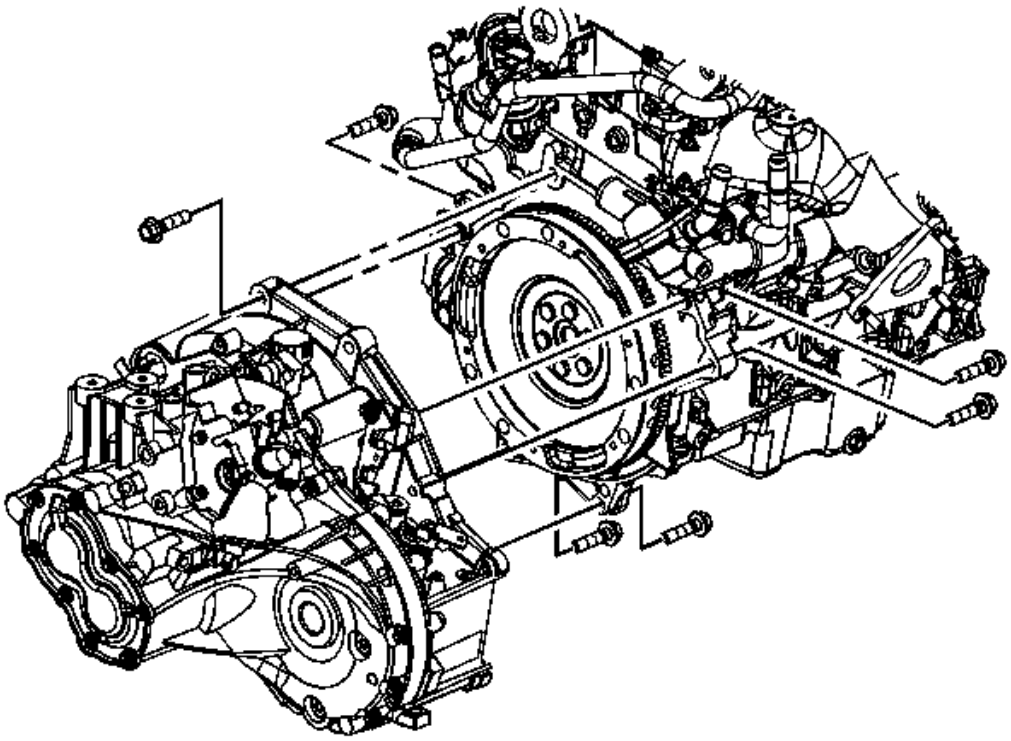

Fig. 273: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

6. If equipped with a manual transaxle, install the transaxle to engine bolts/stud.

   Tighten: Tighten the bolts/stud to 75 N.m (55 lb ft).

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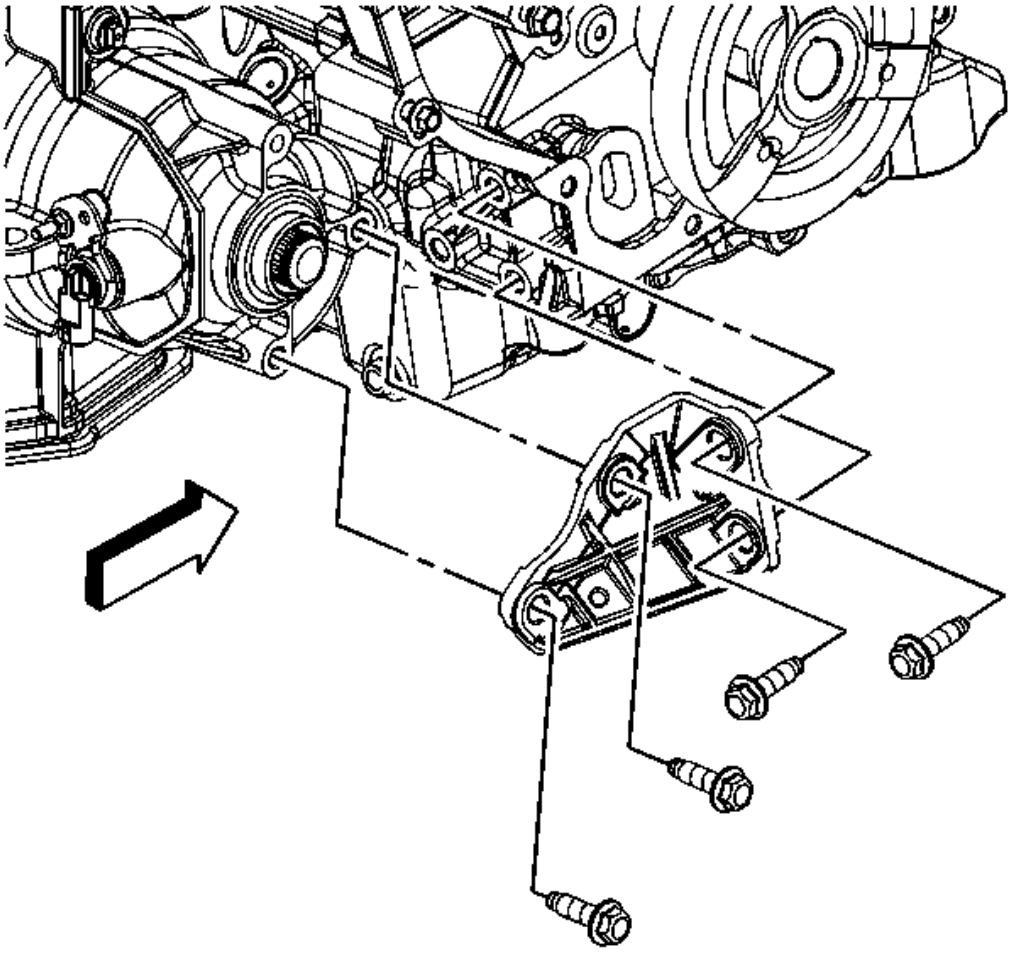

Fig. 274: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the transaxle brace and bolts.

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

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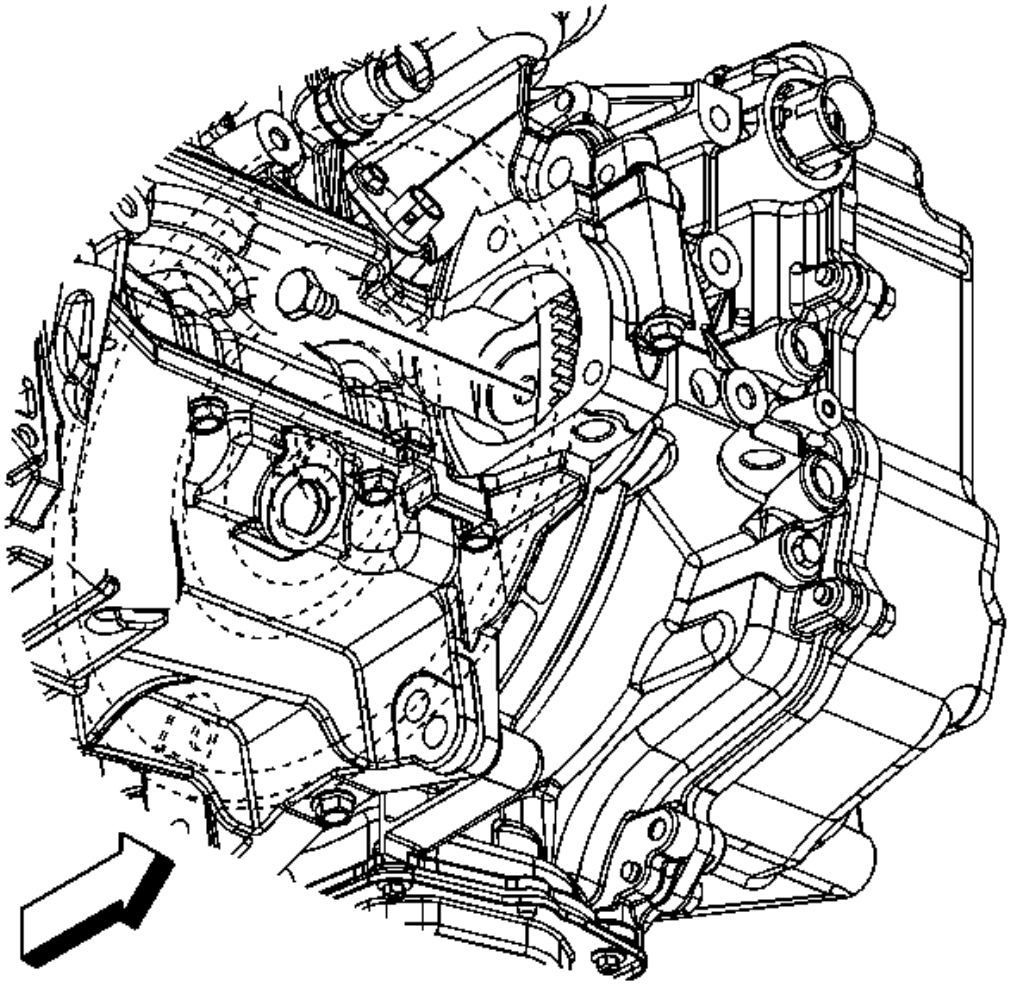

Fig. 275: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

8. If equipped with a automatic transaxle, install the torque converter bolts.

   Tighten: Tighten the bolts to 62 N.m (46 lb ft).

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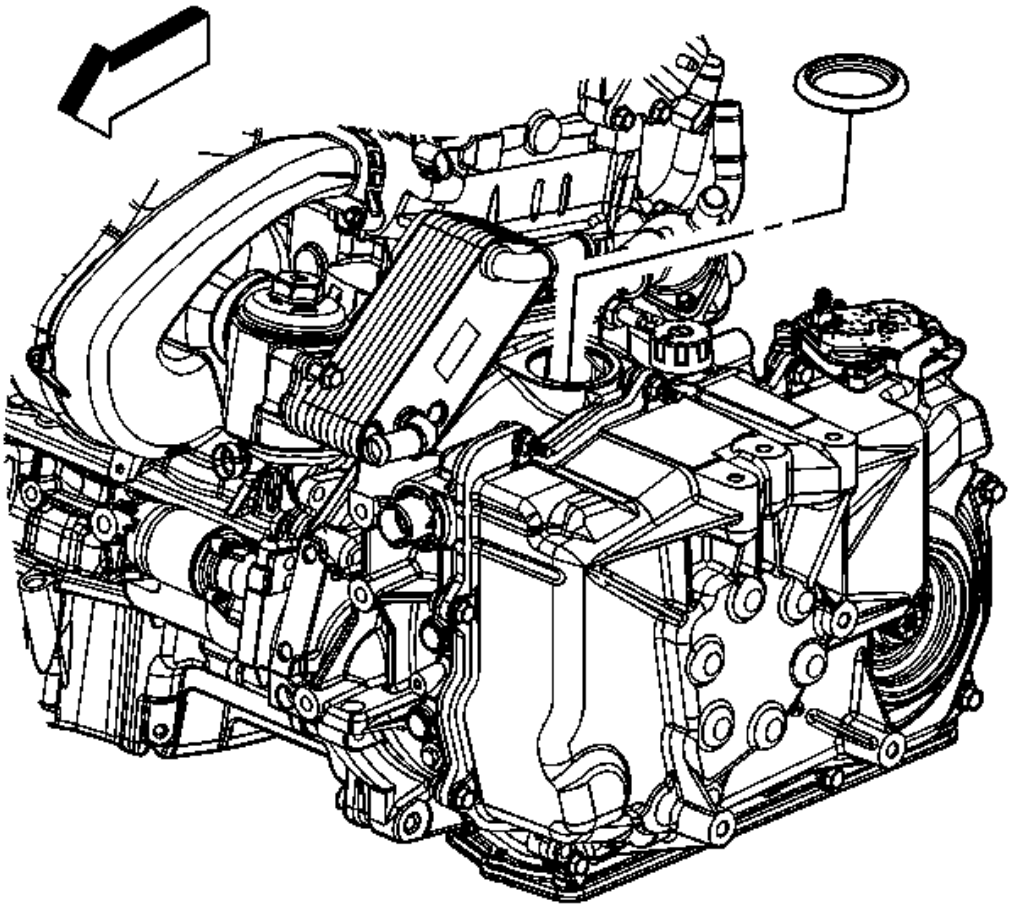

Fig. 276: Identifying Torque Converter Housing Access Plug
Courtesy of GENERAL MOTORS CORP.

9. If equipped with a automatic transaxle, install the torque converter housing access plug.

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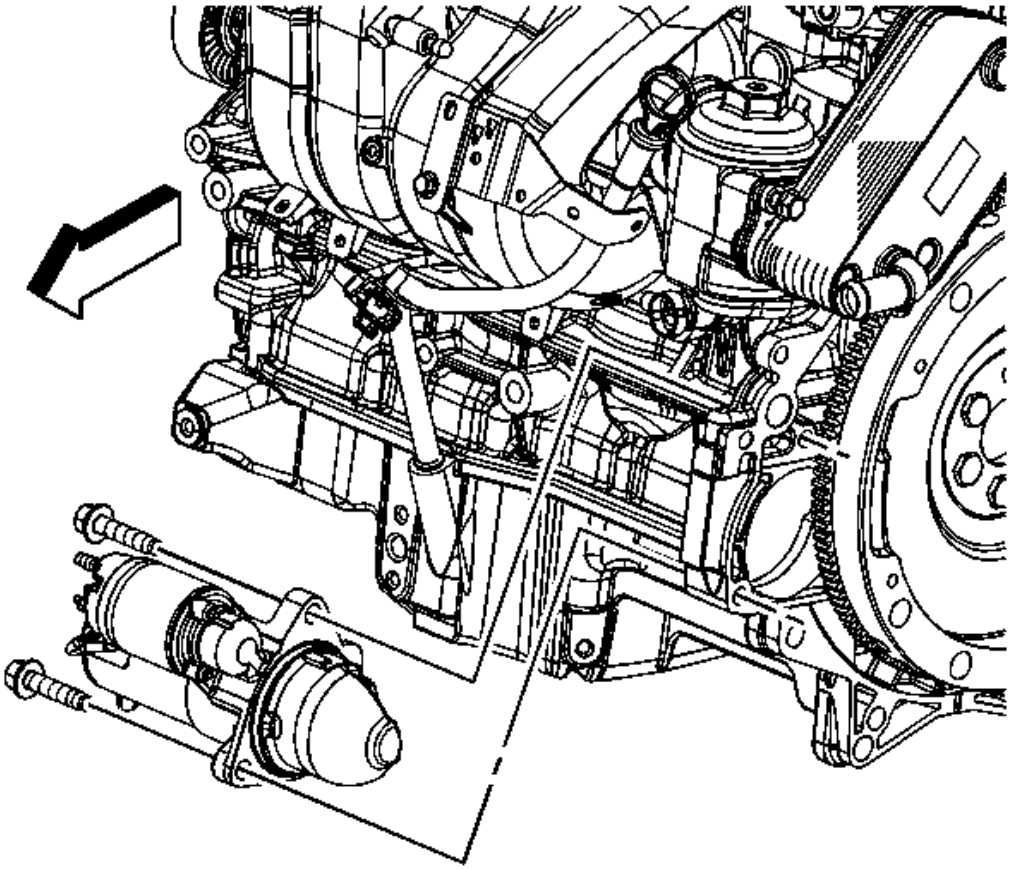

Fig. 277: Identifying Starter Bolts & Starter
Courtesy of GENERAL MOTORS CORP.

10. Install the starter and bolts.

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

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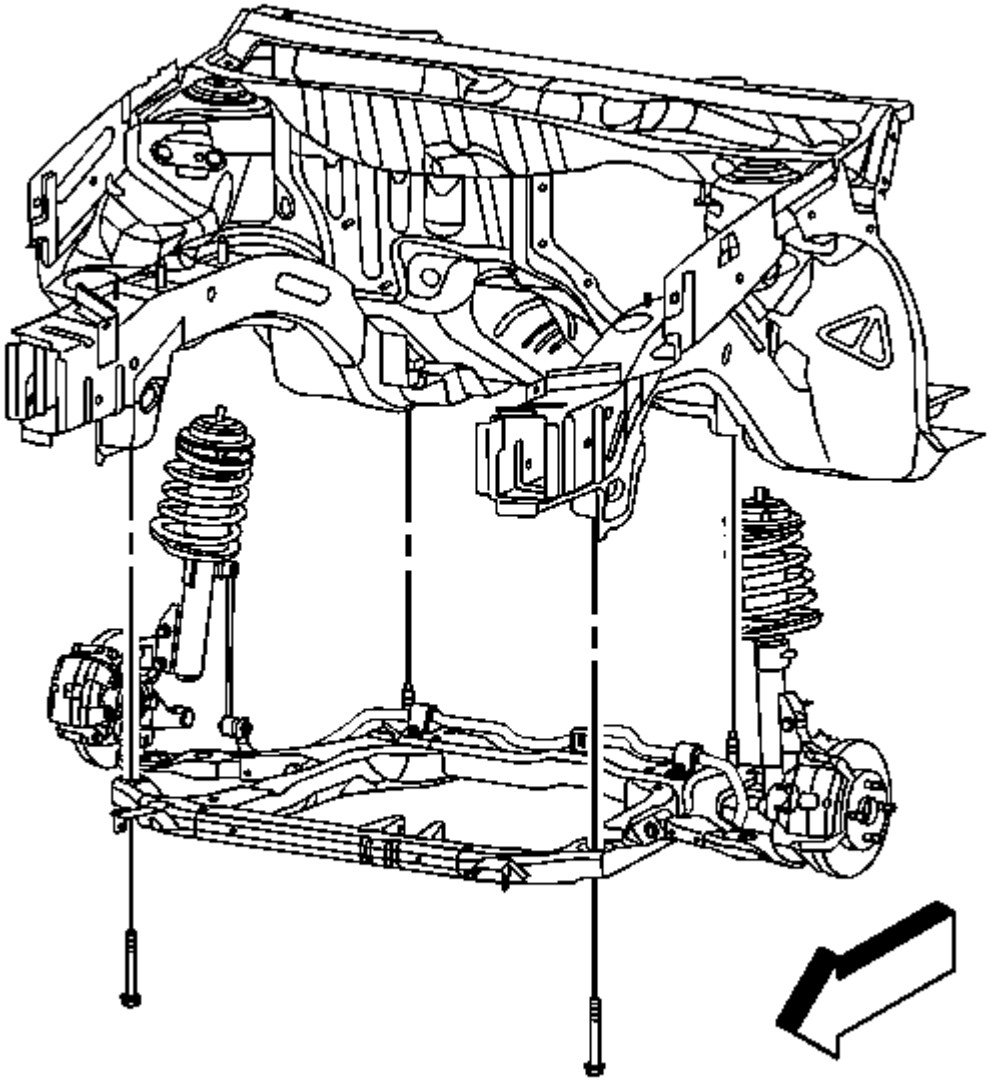

Fig. 278: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

11. Remove the engine lift hoist from the engine lift hooks.
12. Slide the lift table under the vehicle.
13. Slowly lower the vehicle until it aligns with the alignment marks made during the removal.
14. Tighten/install the frame bolts.

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Tighten: Tighten the bolts to 100 N.m (74 lb ft) plus and additional 180 degrees.

15. Raise the vehicle until the lift table can be removed from under the vehicle.
16. Remove the lift table.

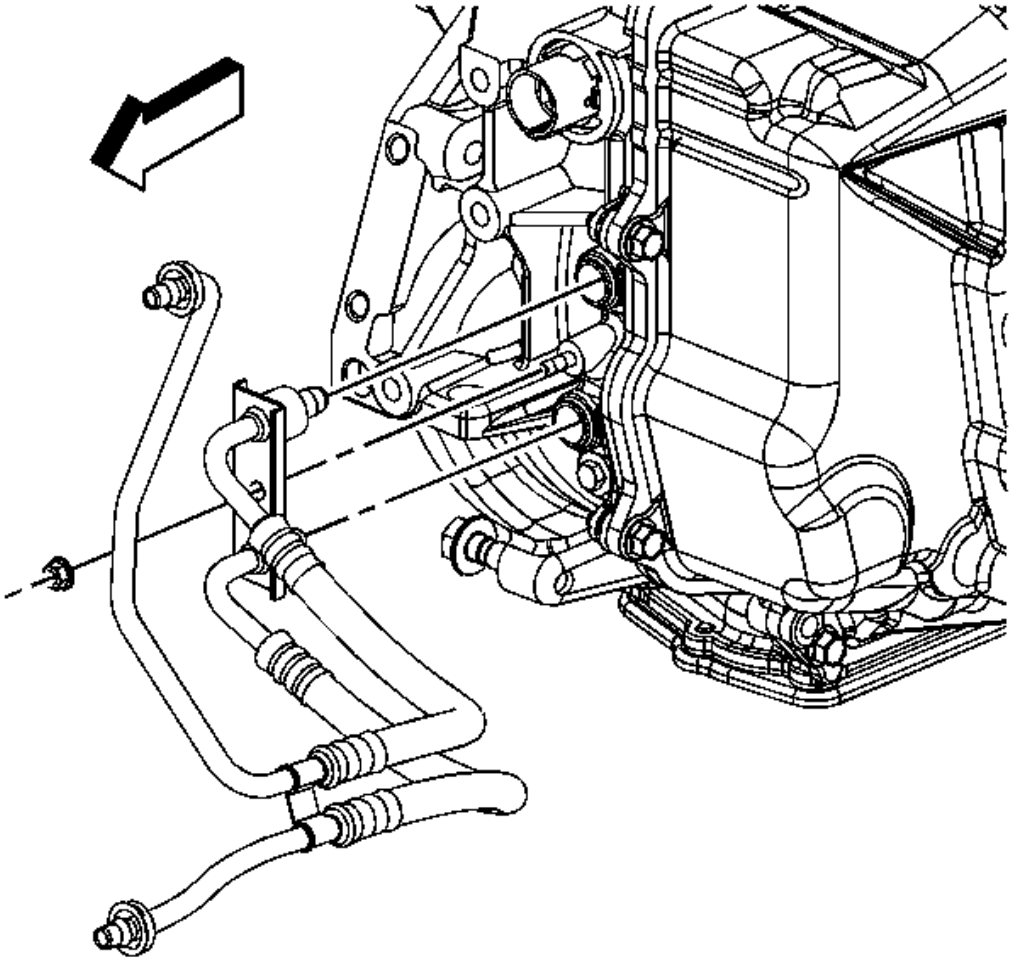

Fig. 279: Identifying Transaxle Fluid Cooler Lines & Bracket Nut
Courtesy of GENERAL MOTORS CORP.

17. Install the transaxle fluid cooler lines to the transaxle.
18. Install the transaxle fluid cooler bracket nut.

Tighten: Tighten the nut to 7 N.m (62 lb in).

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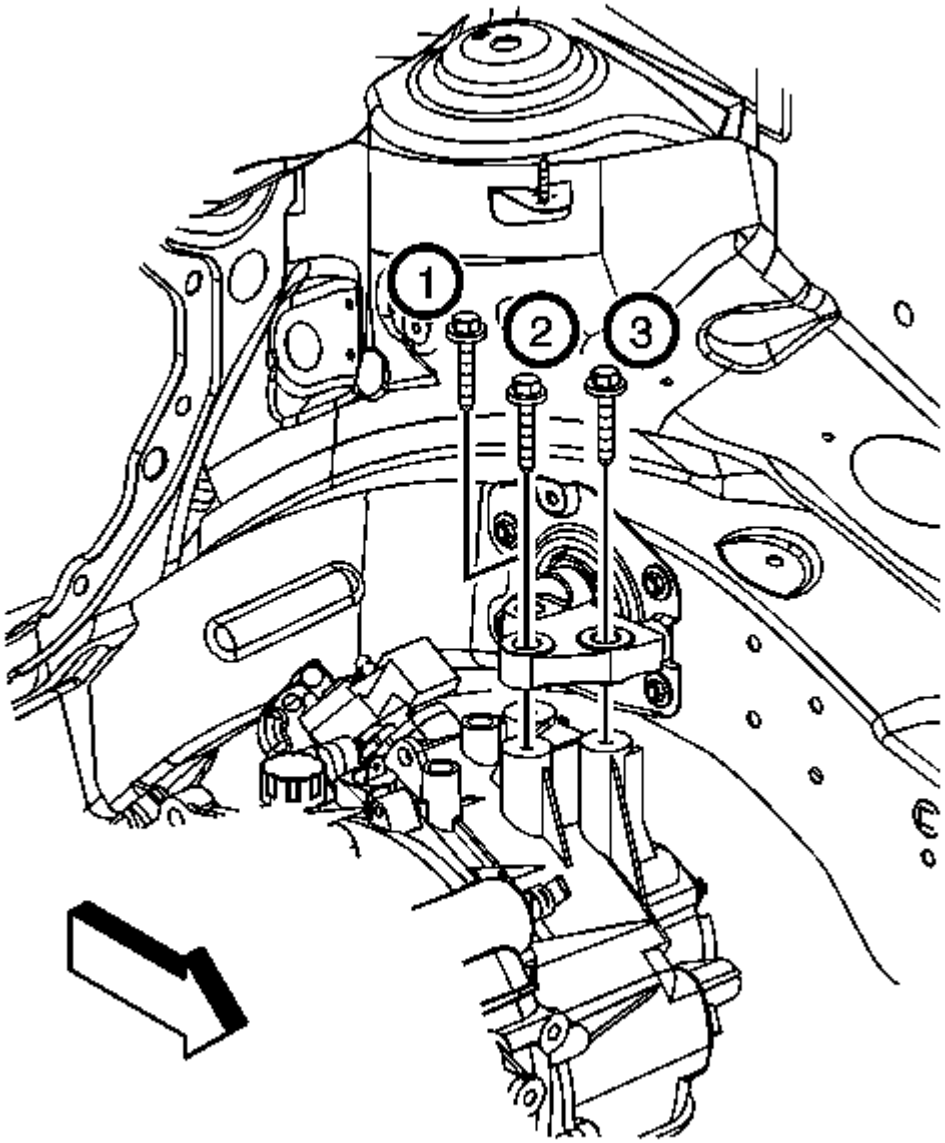

Fig. 280: Identifying Transaxle Mount to Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

19. Connect the lower control arms to the steering knuckles. Refer to **Lower Control Arm Replacement** .
20. Connect the intermediate shaft to the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
21. Connect the outer tie rod ends to the steering knuckles. Refer to **Rack and Pinion Outer Tie Rod End Replacement** .

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22. Connect the stabilizer links to the stabilizer bar. Refer to **Stabilizer Shaft Link Replacement** .
23. Lower the vehicle.
24. Install the transaxle mount to transaxle bolts.

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

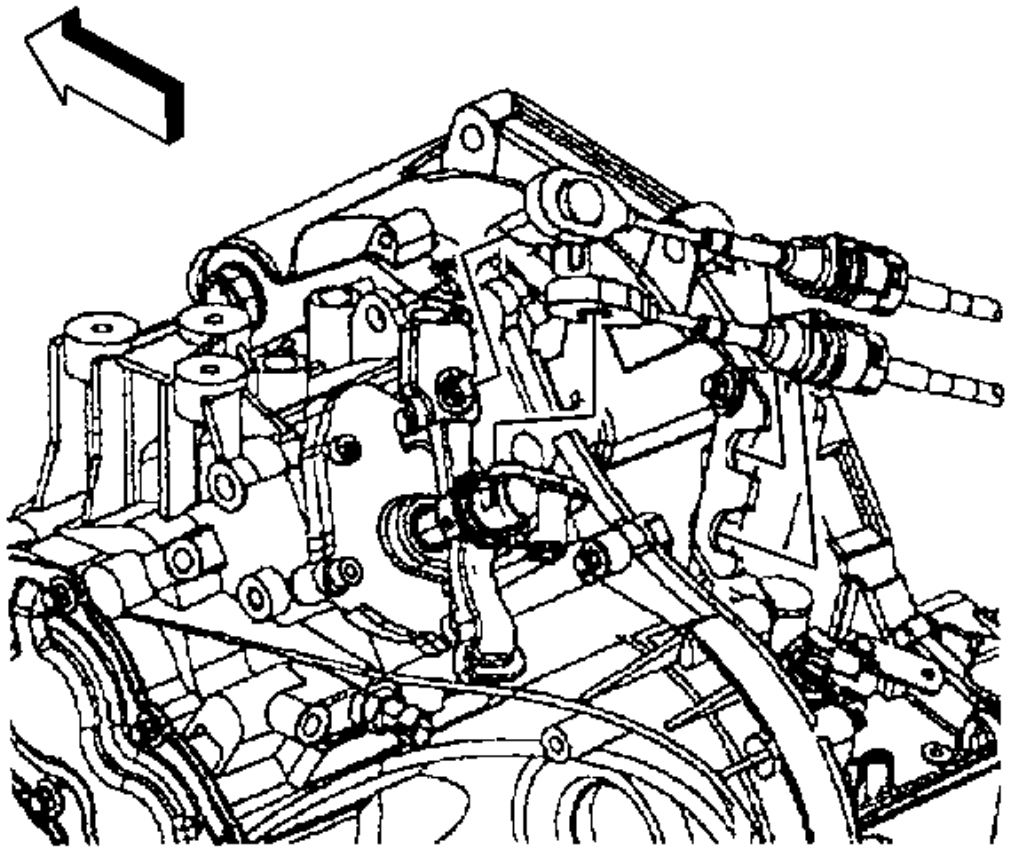

Fig. 281: Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

25. Install the engine mount. Refer to **Engine Mount Replacement**.
26. Remove the blocks of wood from between the powertrain and the frame.
27. Install the catalytic converter. Refer to **Catalytic Converter Replacement (RPO LE5)** .
28. Lower the vehicle.

IMPORTANT: Ensure that the black cable is installed in the top notch of the transaxle

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bracket and the white cable in installed in the bottom notch of the transaxle bracket.

29. If equipped with a manual transaxle, install the range selector and shift lever cables to the transaxle bracket.
30. Connect the range selector and shift lever cables to the transaxle levers.

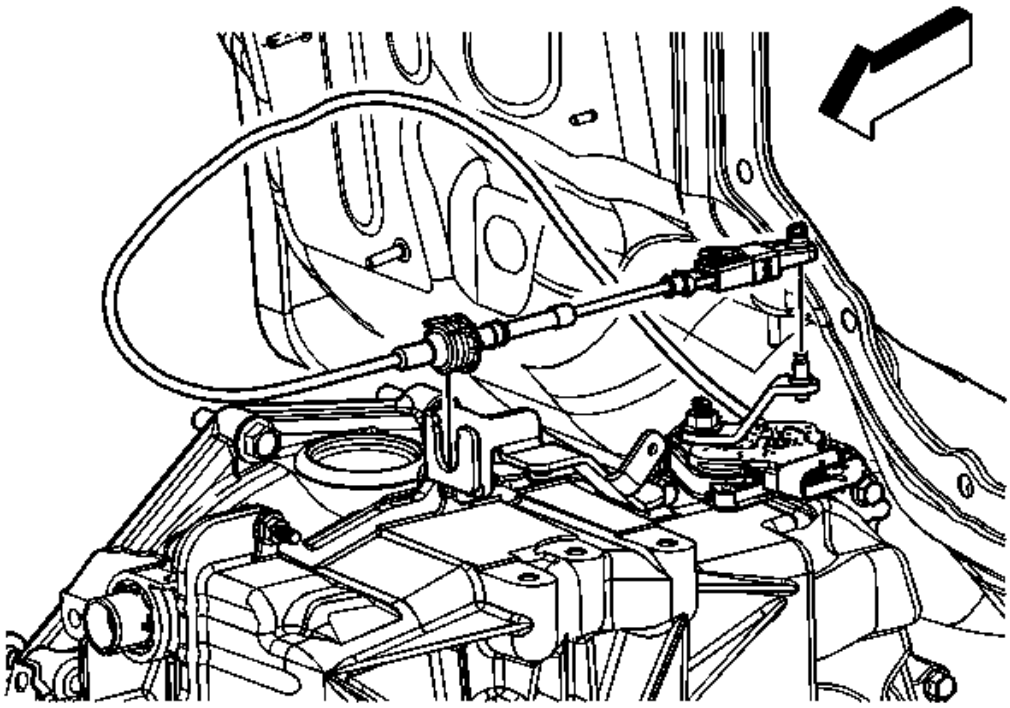

Fig. 282: Identifying Range Selector Level Cable
Courtesy of GENERAL MOTORS CORP.

31. If equipped with a automatic transaxle, install the range selector lever cable to the transaxle bracket.
32. Connect the range selector lever cable to the transaxle lever.

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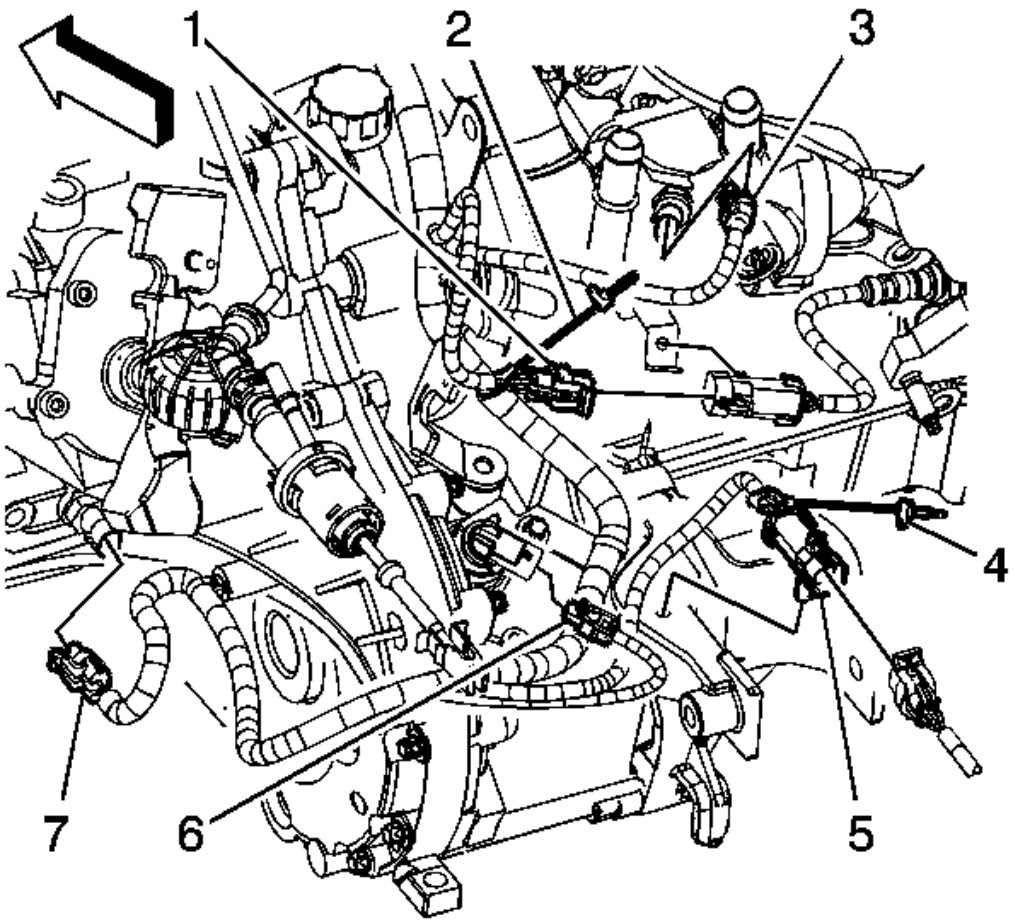

Fig. 283: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

33. Gather all engine harness branches and position the harness over the engine.
34. If equipped with a manual transaxle, perform the following steps. Install the HO2S clips to the engine brackets.
35. Connect the engine harness electrical connectors (1, 5) to the HO2S.
36. Install the HO2S CPA retainers (2, 4).
37. Connect the engine harness electrical connector (7) to the back up lamp switch.
38. Connect the engine harness electrical connector (1) to the VSS.

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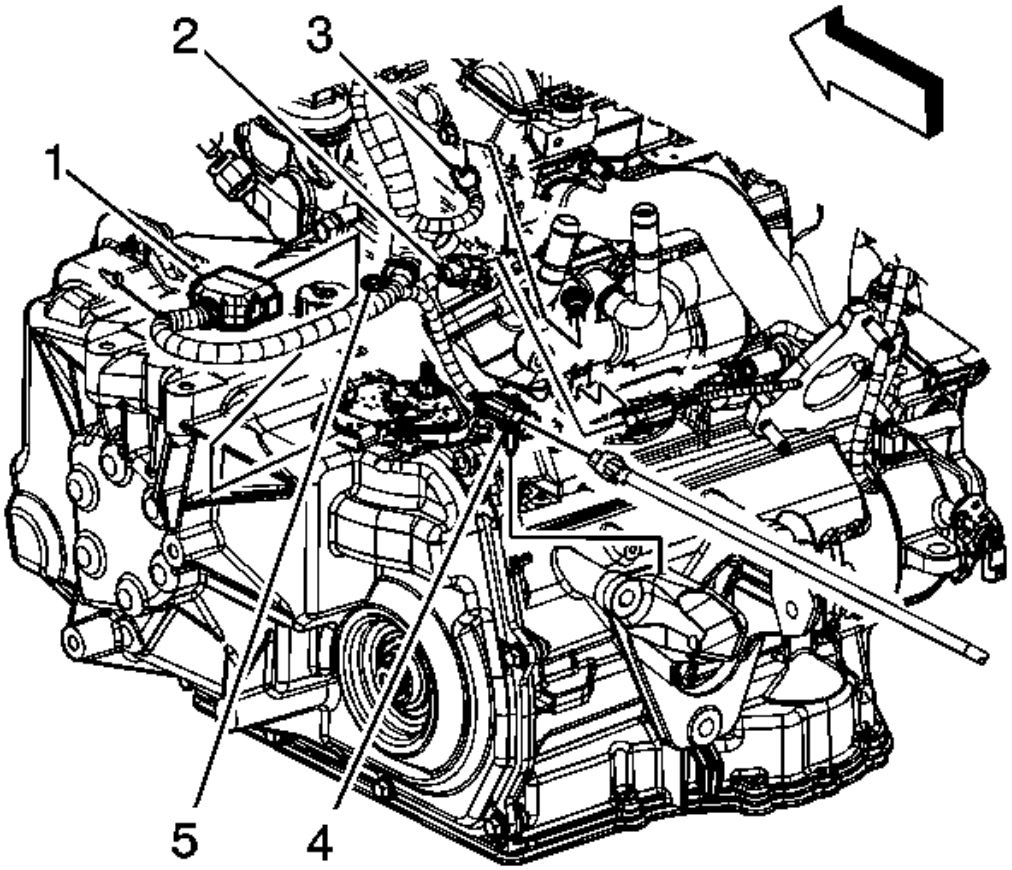

Fig. 284: Identifying Engine Harness Electrical Connectors - Top Of Engine
Courtesy of GENERAL MOTORS CORP.

39. If equipped with a automatic transaxle, perform the following steps. Connect the engine harness electrical connector (1) to the park neutral position switch.
40. Install the engine harness clips to the thermostat housing and engine brackets.
41. Connect the engine harness electrical connectors (2, 4) to the HO2S.
42. Install the HO2S CPA retainers.
43. Connect the ECT sensor electrical connector (1).

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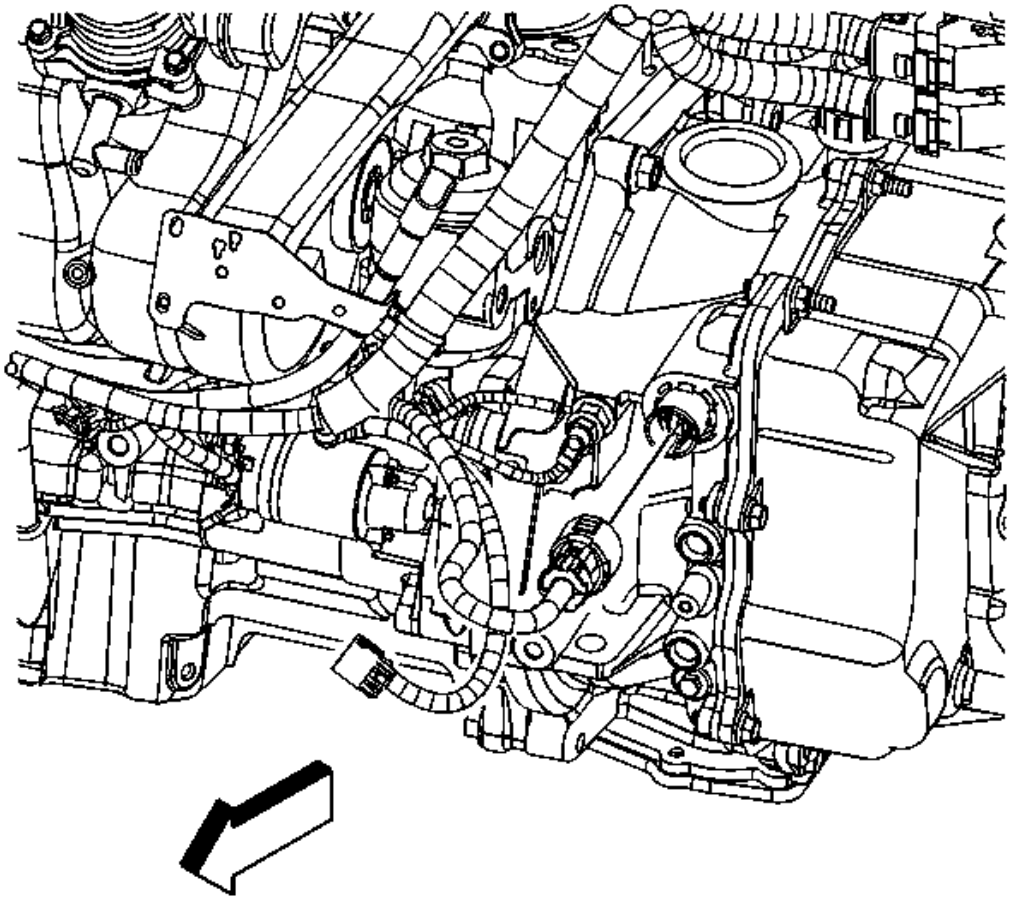

Fig. 285: Identifying Engine Harness
Courtesy of GENERAL MOTORS CORP.

44. If equipped with a automatic transaxle, connect the engine harness to the transaxle.
45. Raise the vehicle.

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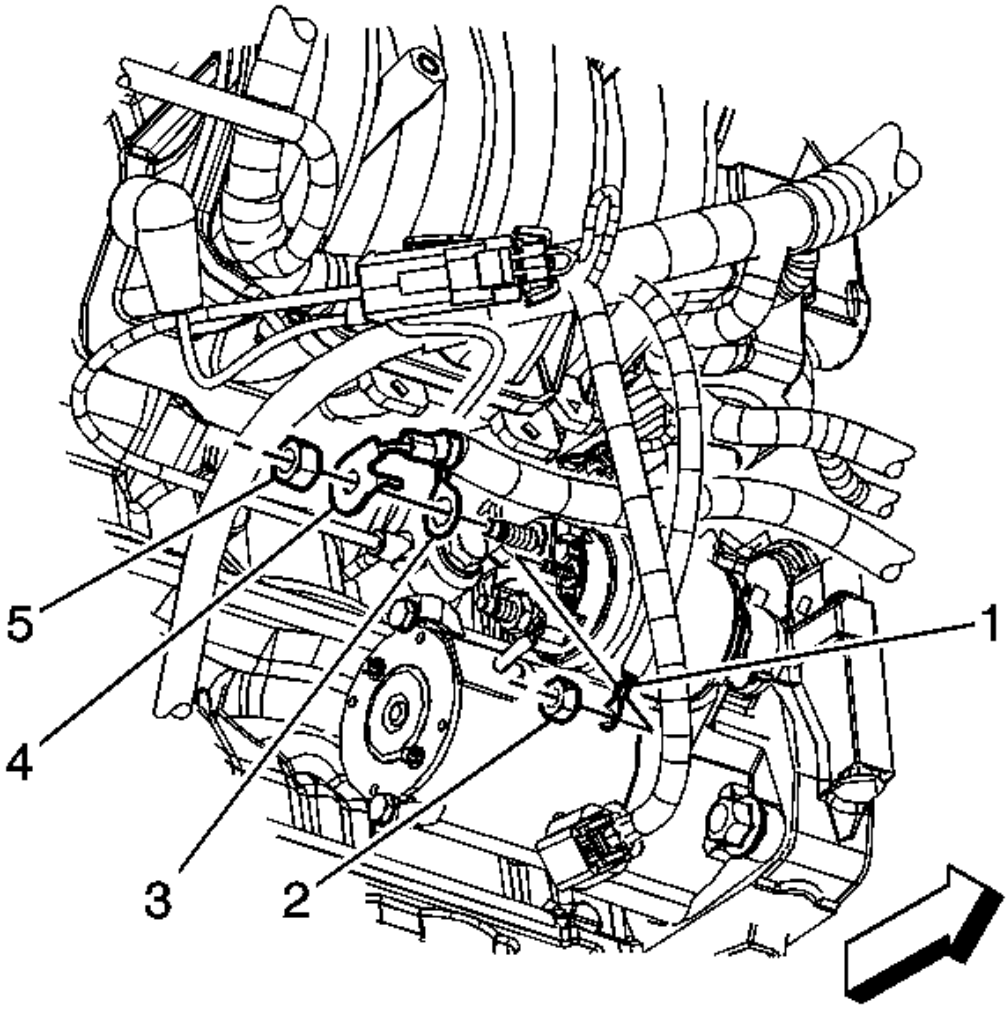

Fig. 286: View Of Negative Battery Cable
Courtesy of GENERAL MOTORS CORP.

46. Install the engine harness lead terminal (1) to the starter solenoid.
47. Install the engine harness to starter solenoid "S" terminal nut (2).

    Tighten: Tighten the nut to 3 N.m (27 lb in).

48. Install the engine harness terminal (3) to the starter.
49. Install the positive battery cable terminal (4) to the starter.
50. Install the positive/negative battery cable lead nut (5) to the starter solenoid.

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Tighten: Tighten the nut to 17 N.m (13 lb ft).

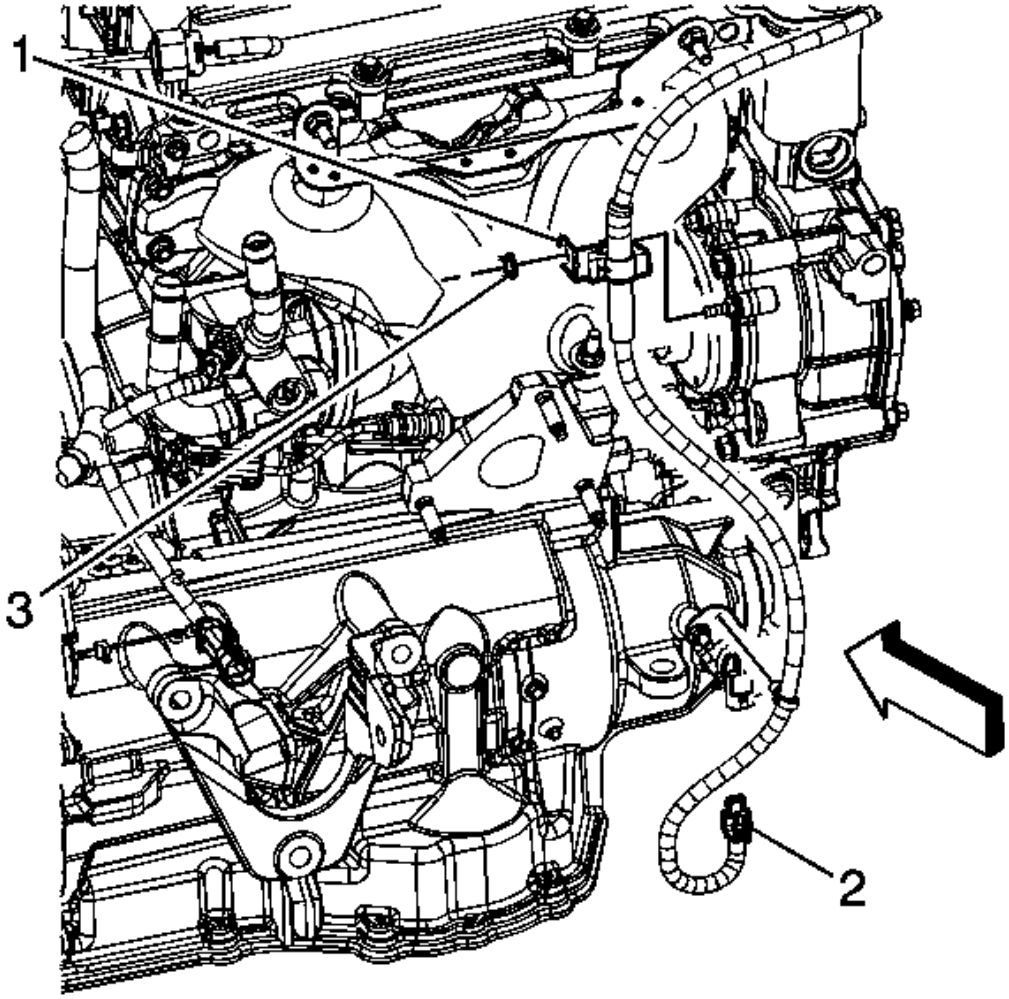

Fig. 287: Identifying Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

51. Install the engine harness clip (3) to the speed sensor.
52. Connect the engine harness electrical connector (2) to the VSS.
53. Install the engine harness clip (1) to the stud.
54. Install the engine harness clip nut (3) to the engine stud.

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

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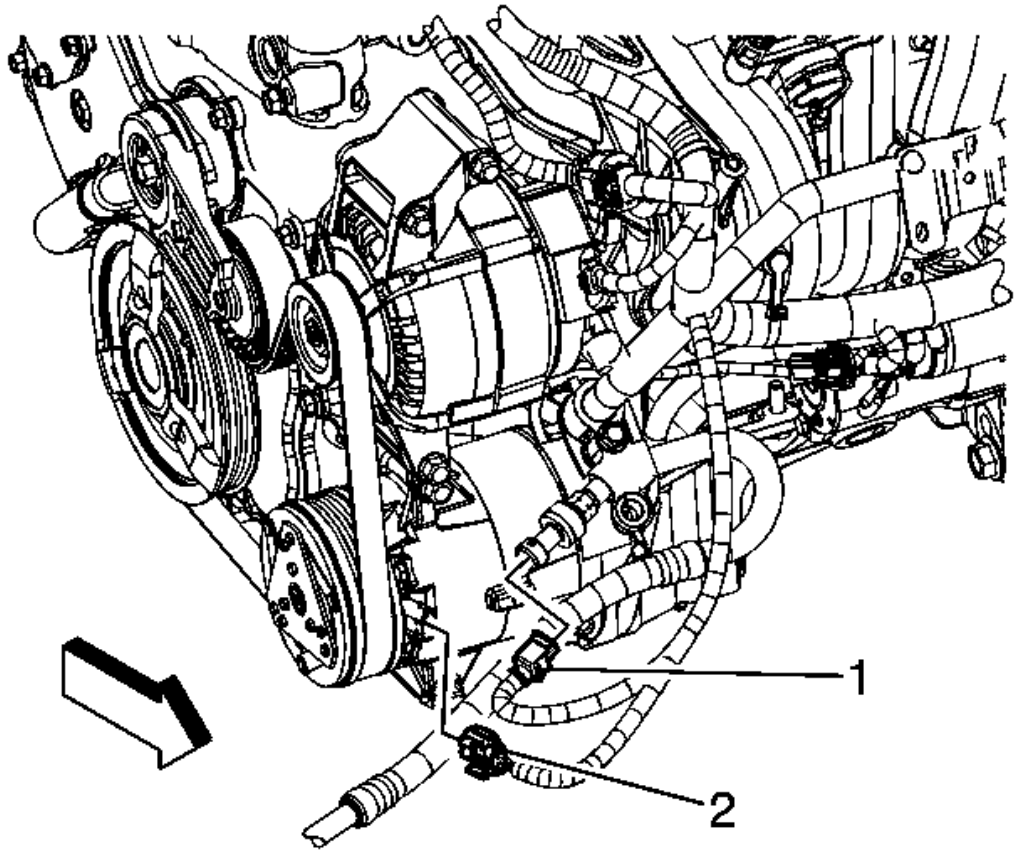

Fig. 288: View Of engine harness electrical connector to A/C compressor and pressure switch
Courtesy of GENERAL MOTORS CORP.

55. Lower the vehicle.
56. Reposition and install the AC compressor.

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

57. Connect the engine harness electrical connector (2) to the A/C compressor.
58. Connect the engine harness electrical connector (1) to the A/C pressure switch.

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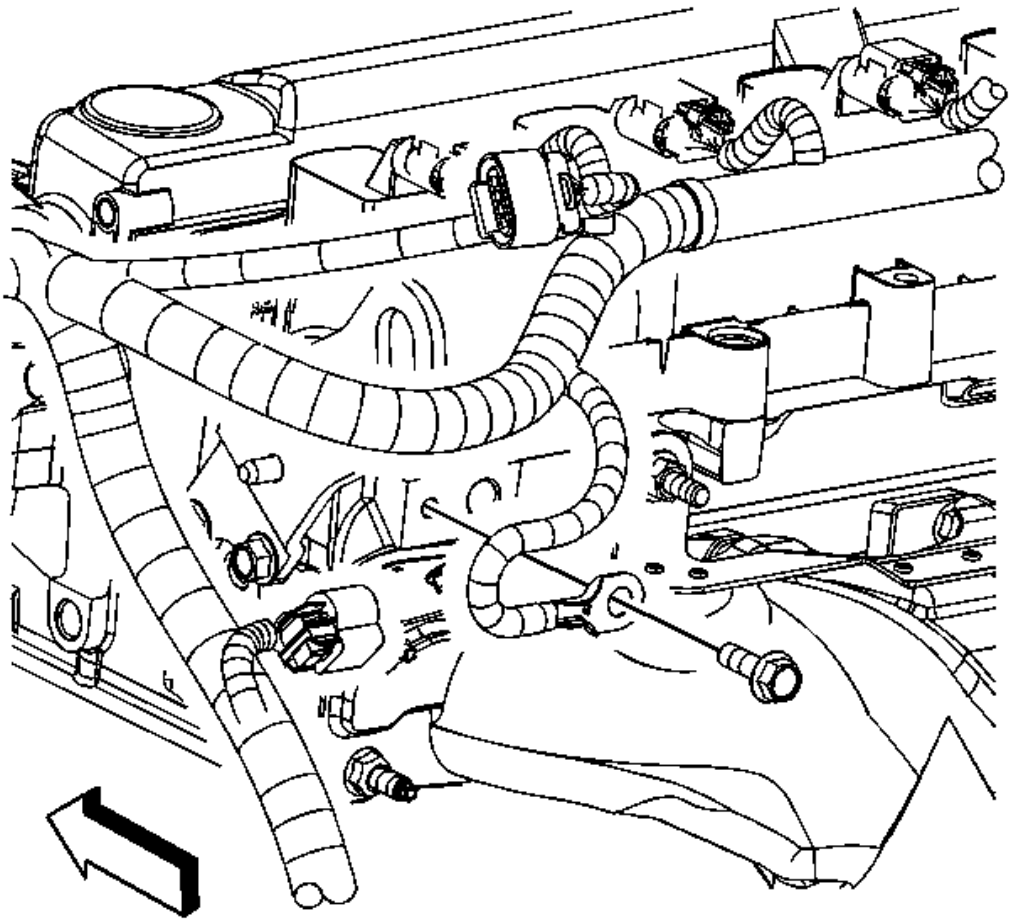

Fig. 289: Identifying Engine Harness Ground Terminal
Courtesy of GENERAL MOTORS CORP.

59. Position the engine harness ground terminal to the engine block.
60. Install the engine harness ground bolt.

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

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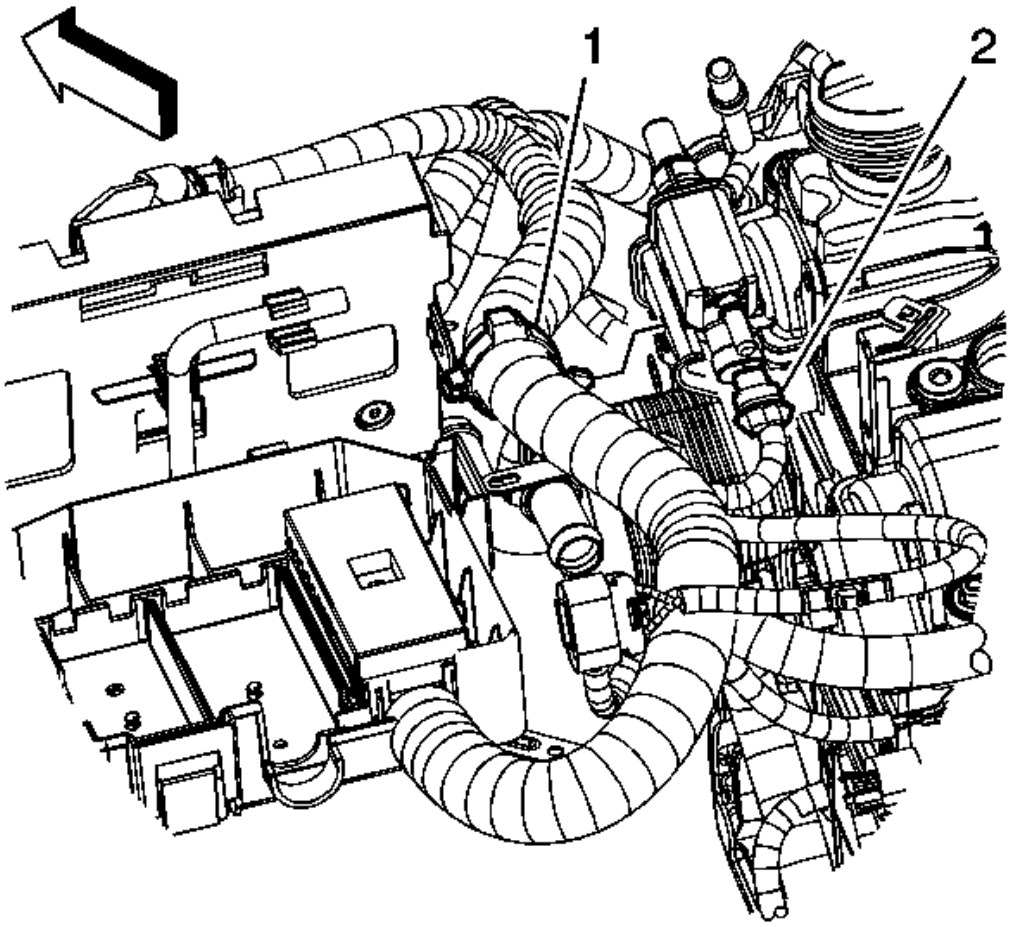

Fig. 290: Locating EVAP Purge Solenoid Electrical Connector
Courtesy of GENERAL MOTORS CORP.

61. Connect the EVAP purge solenoid electrical connector (2).
62. Install the engine harness clip (1) to the EVAP purge solenoid bracket.

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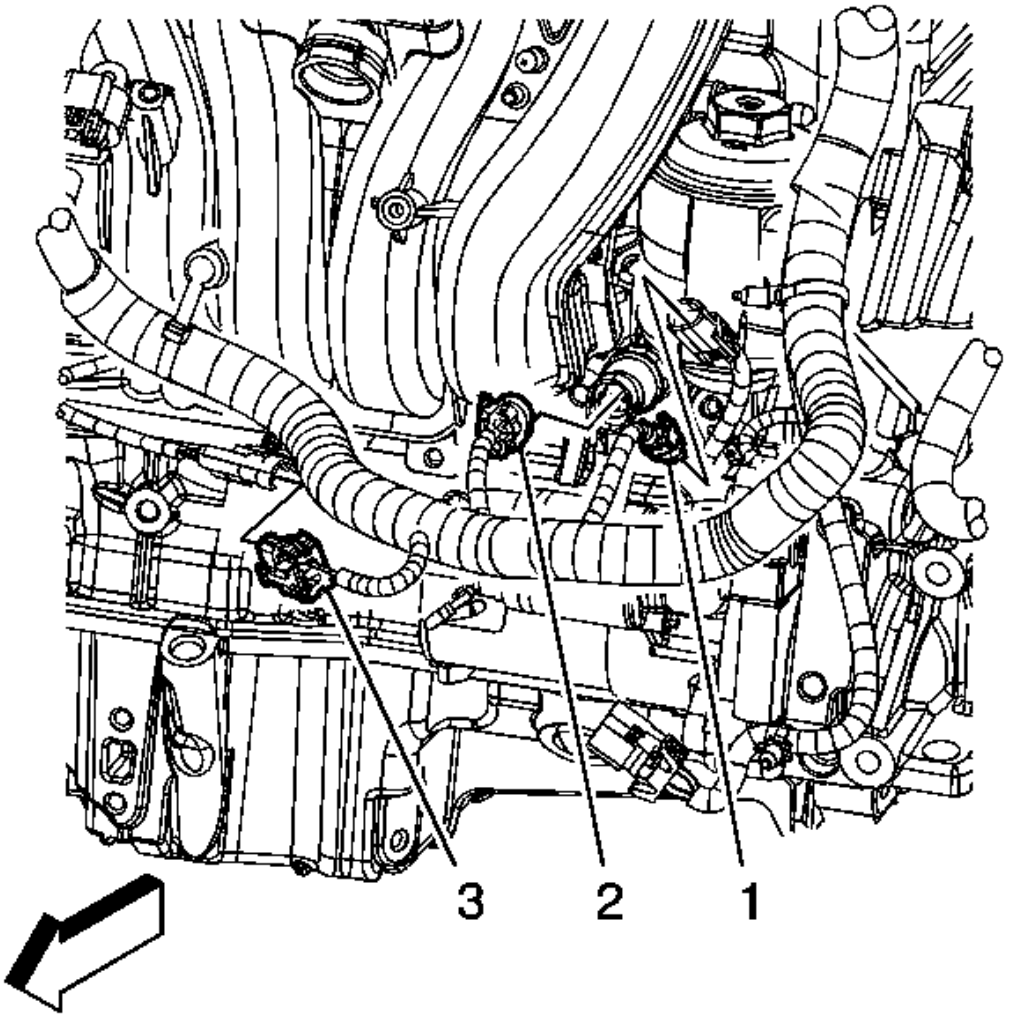

Fig. 291: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

63. Connect the following electrical connectors:
    - Knock sensor (3)
    - CKP sensor (1)
    - Oil pressure sensor (2)

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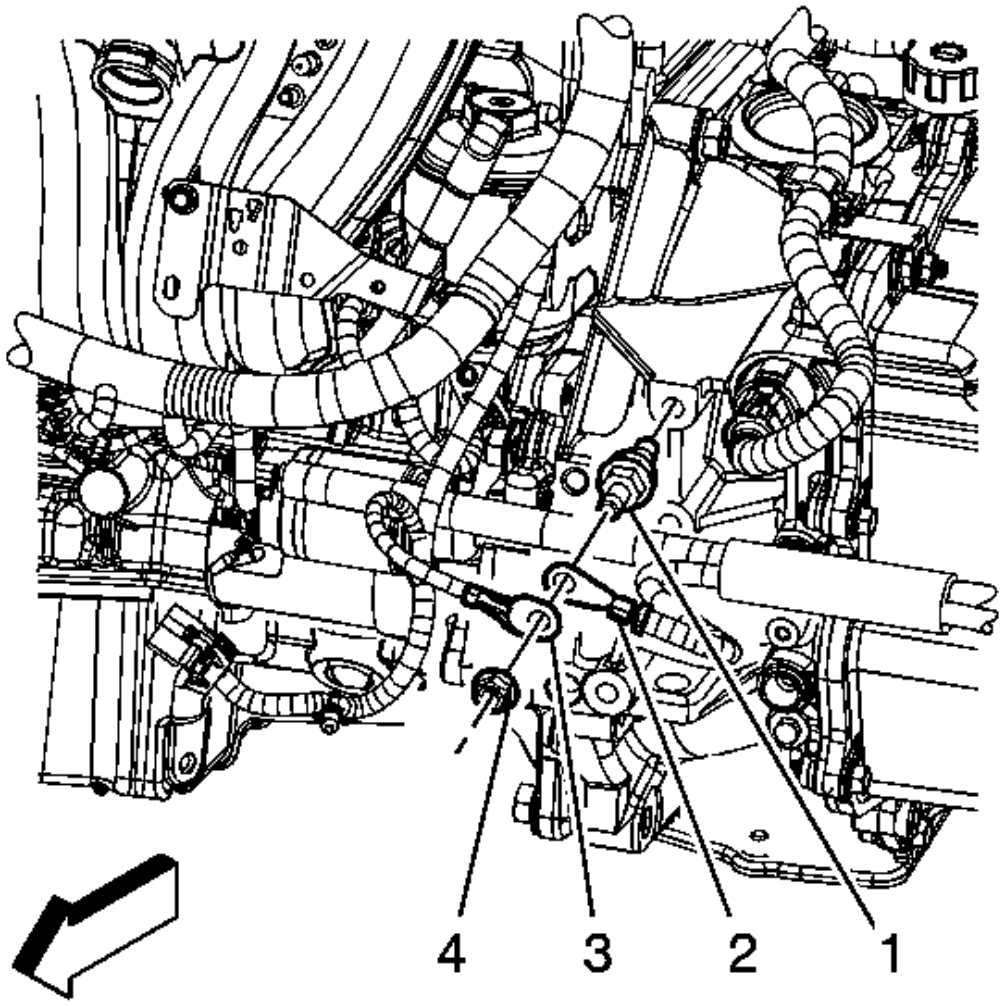

Fig. 292: View Of Battery Connections
Courtesy of GENERAL MOTORS CORP.

64. Install the negative battery cable ground terminal (2) to the stud.
65. Install the engine harness ground terminal (3) to the stud.
66. Install the negative battery cable ground nut (4).

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

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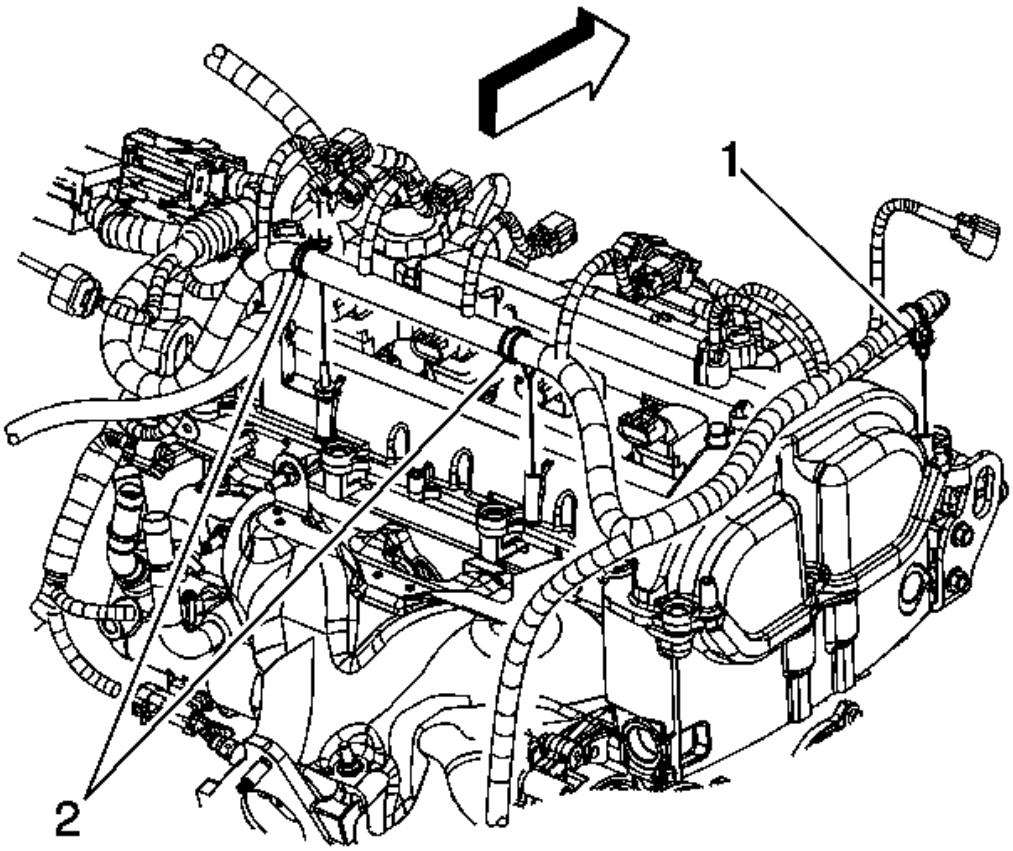

Fig. 293: View of engine harness clips
Courtesy of GENERAL MOTORS CORP.

67. Install the engine harness clips (1 and 2) to the camshaft cover.

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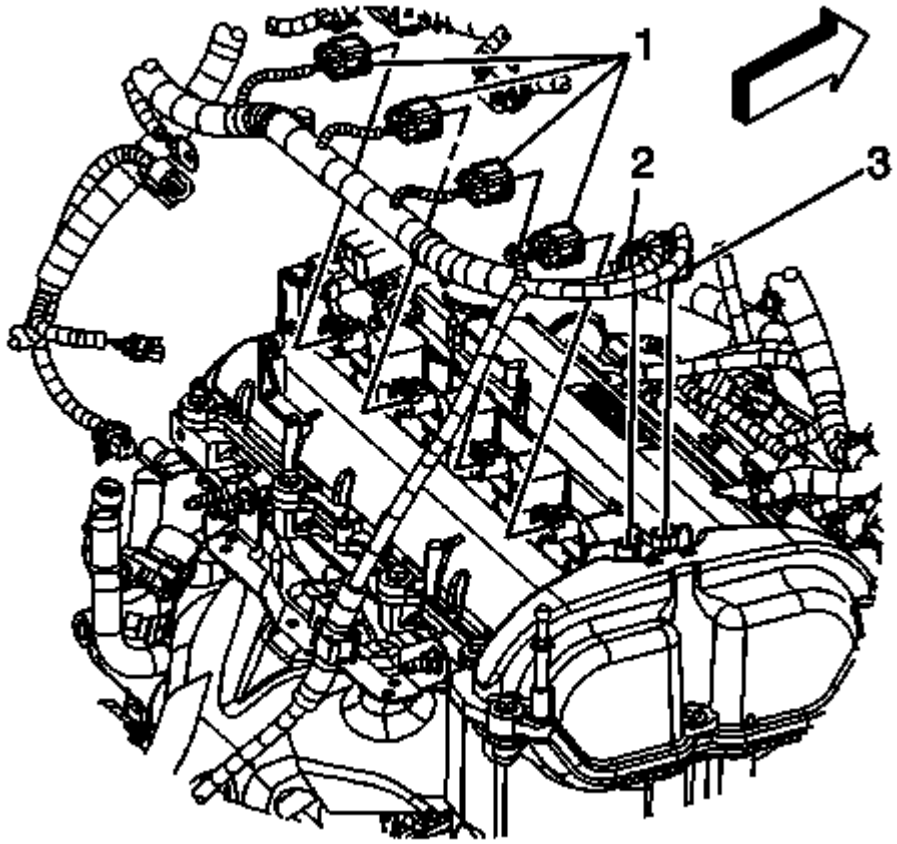

Fig. 294: Identifying Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

68. Connect the intake (3) and exhaust (2) camshaft position actuator electrical connectors.
69. Connect the ignition coils electrical connectors (1).

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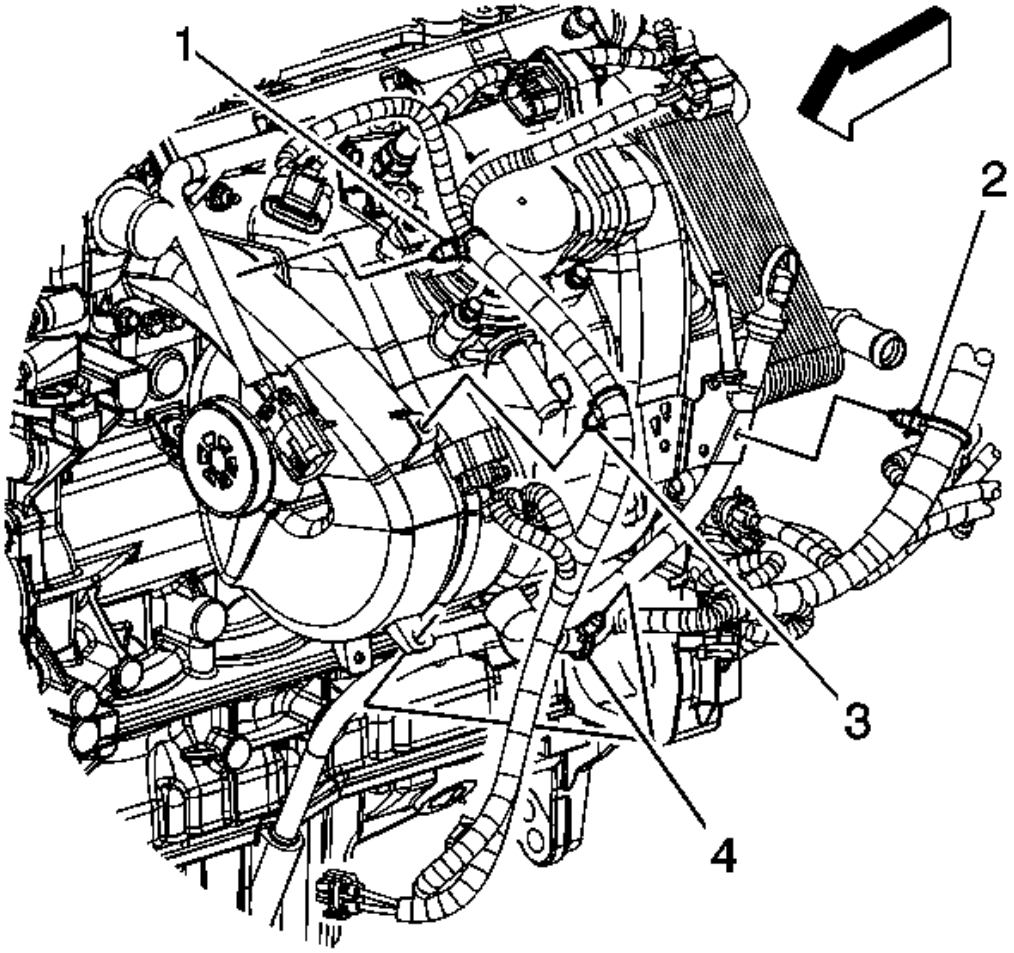

Fig. 295: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

70. Connect the engine harness clips (1, 3 and 4) to the intake manifold.
71. Connect the engine harness clip (2) to the oil level indicator tube.

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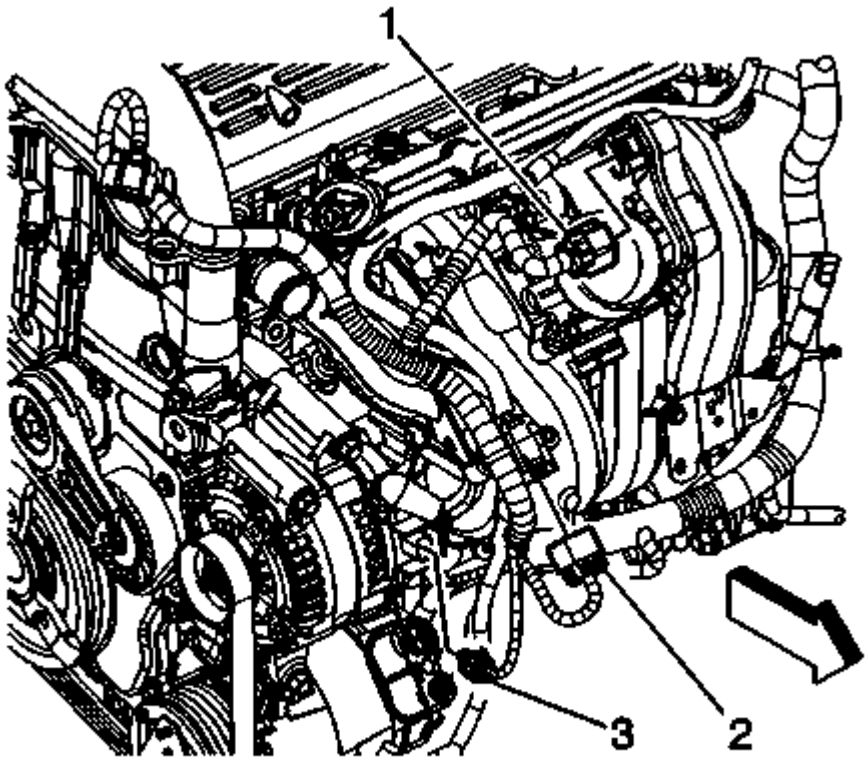

Fig. 296: Identifying Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS CORP.

72. Connect the following electrical connectors:
    - TAC (1)
    - MAP sensor
    - Fuel injector harness (2)
    - Generator (3)

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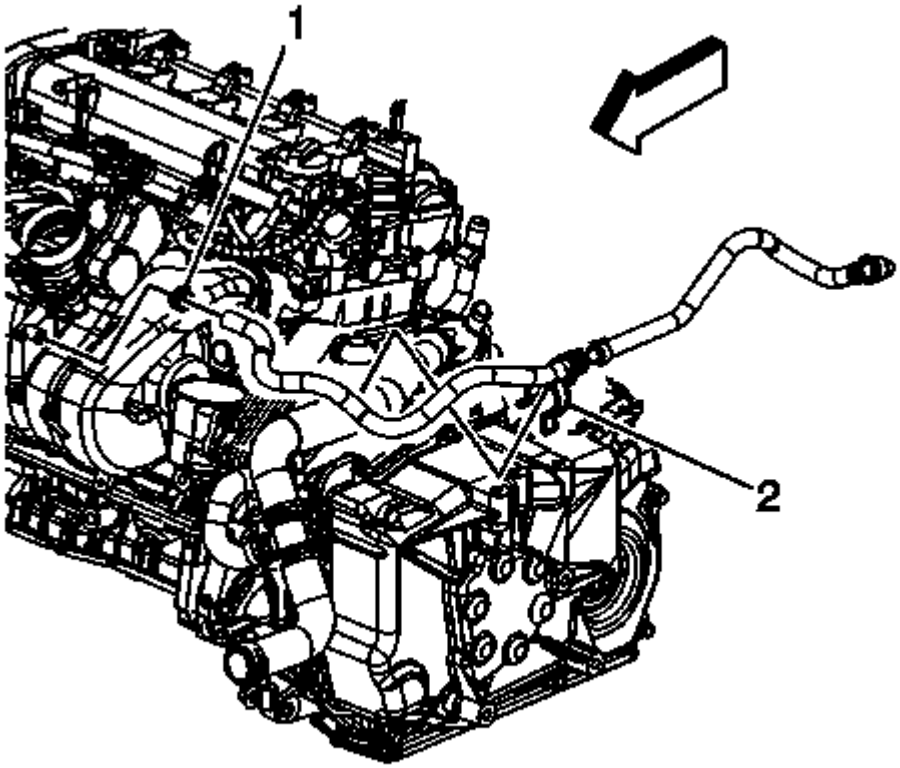

Fig. 297: View of Vacuum brake booster hose clamp
Courtesy of GENERAL MOTORS CORP.

73. Install the brake booster vacuum hose to the intake manifold.
74. Position the brake booster vacuum hose clamp (1) at the intake manifold.

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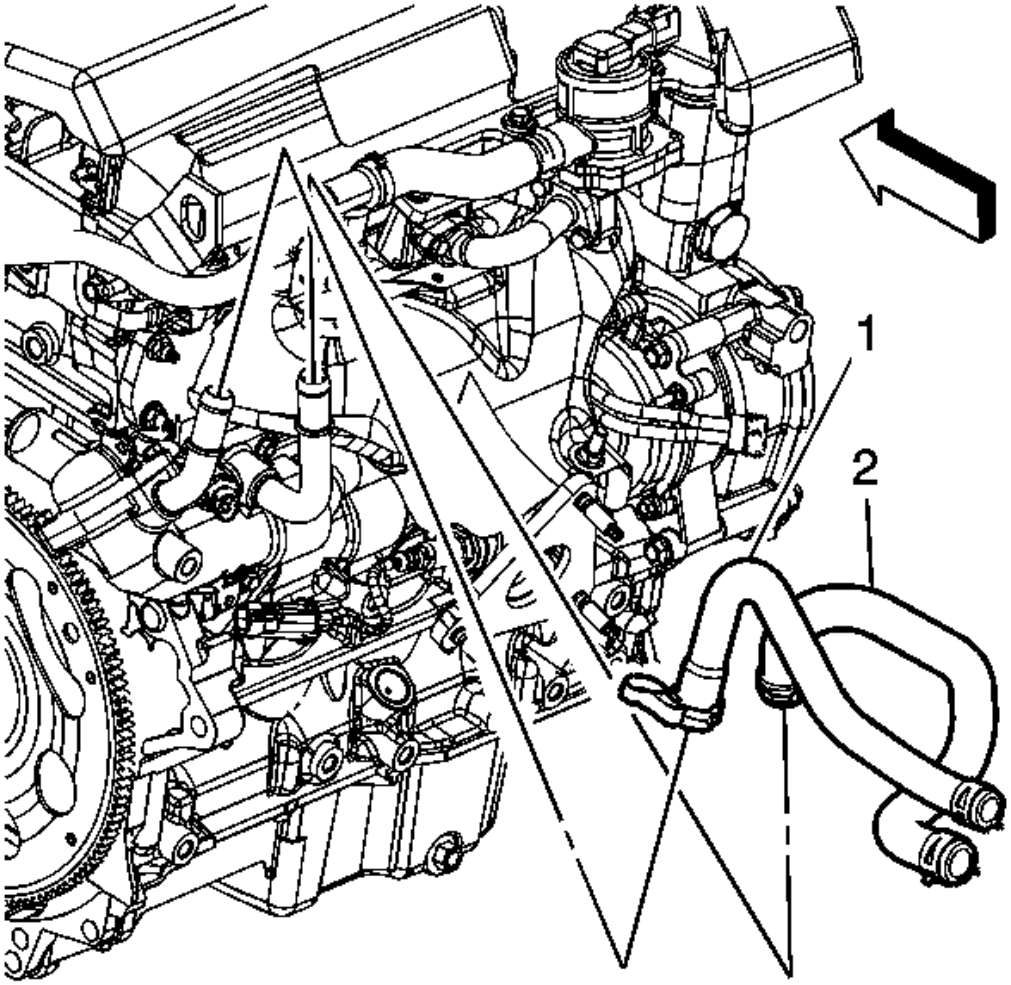

Fig. 298: View Of Heater Inlet And Outlet Hoses And Thermostat Housing Pipes
Courtesy of GENERAL MOTORS CORP.

75. Install the heater inlet and outlet hoses to the thermostat housing.
76. Position the heater inlet (2) and outlet hose (1) clamps at the thermostat housing.

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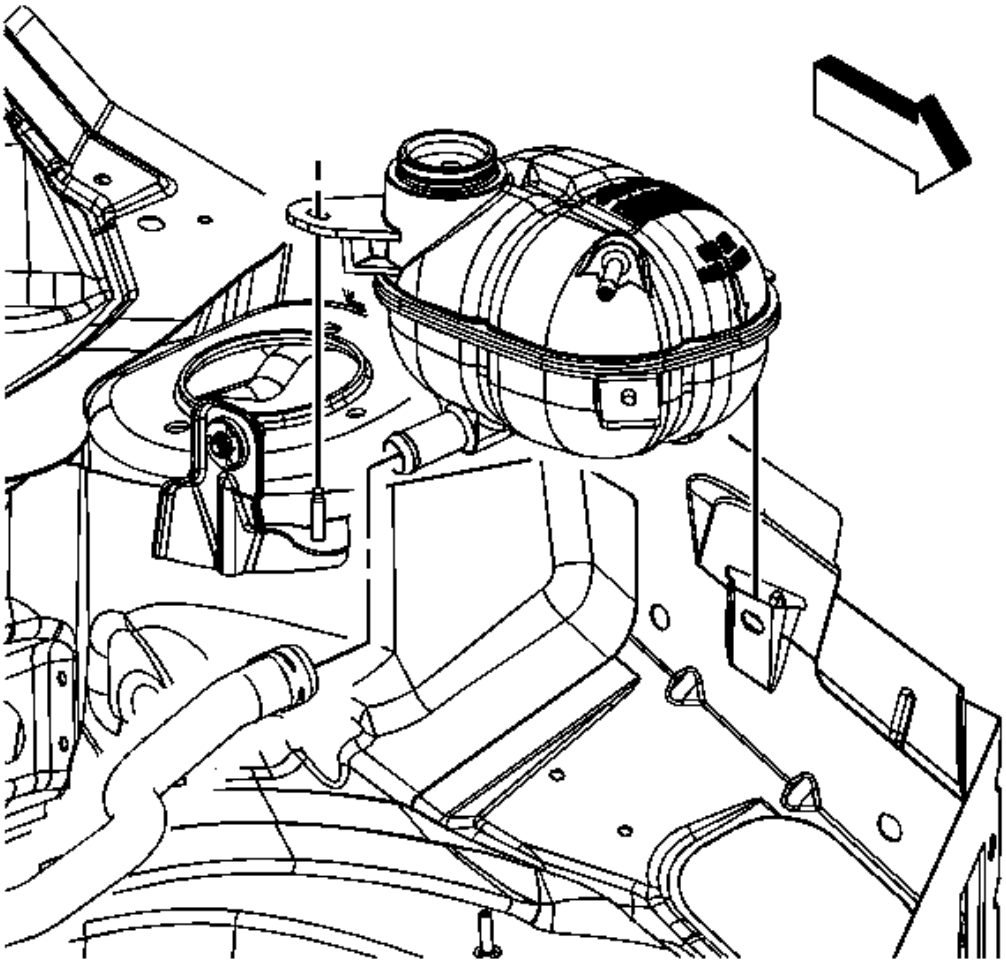

Fig. 299: View of surge tank outlet hose
Courtesy of GENERAL MOTORS CORP.

77. If the vehicle is not equipped with a engine oil cooler perform the following steps, otherwise proceed to step 82.
78. Install the surge tank outlet hose to the surge tank.
79. Position the surge tank outlet hose clamp at the surge tank.

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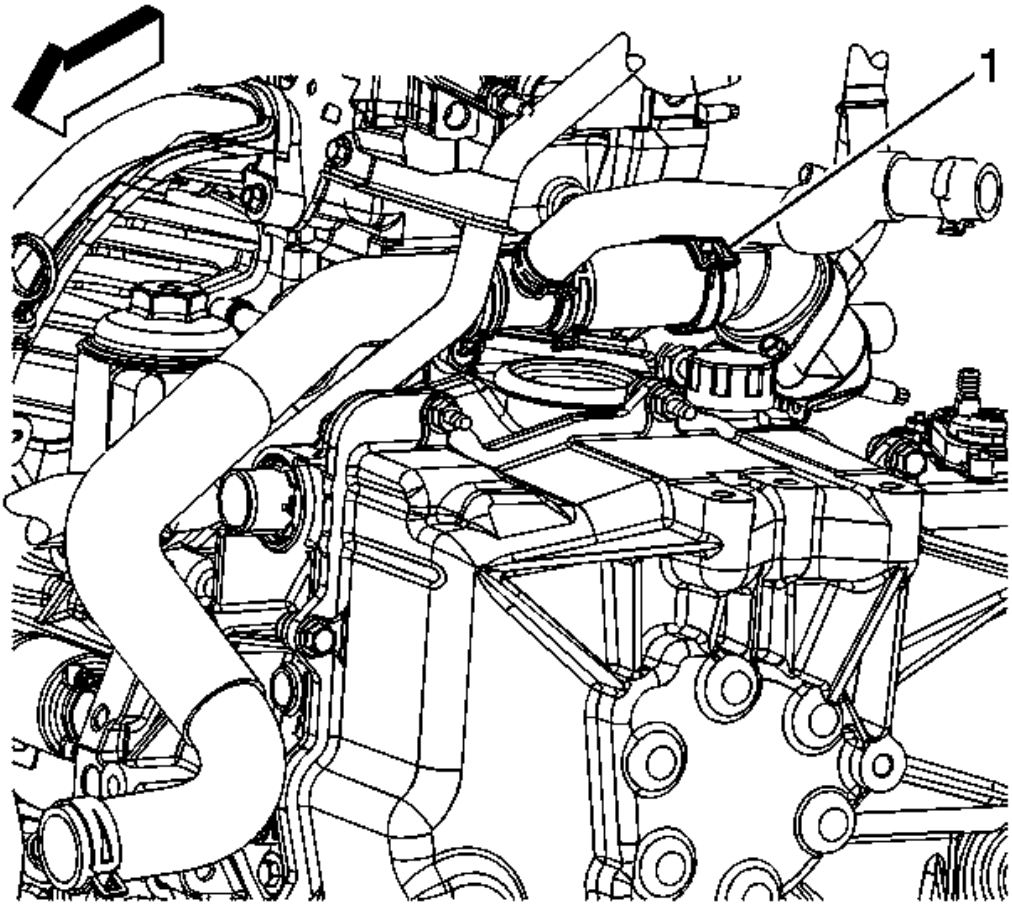

Fig. 300: Identifying Radiator Outlet Hose
Courtesy of GENERAL MOTORS CORP.

80. Install the radiator outlet hose to the thermostat cover.
81. Position the radiator outlet hose clamp (1) at the thermostat cover. Proceed to step 86.

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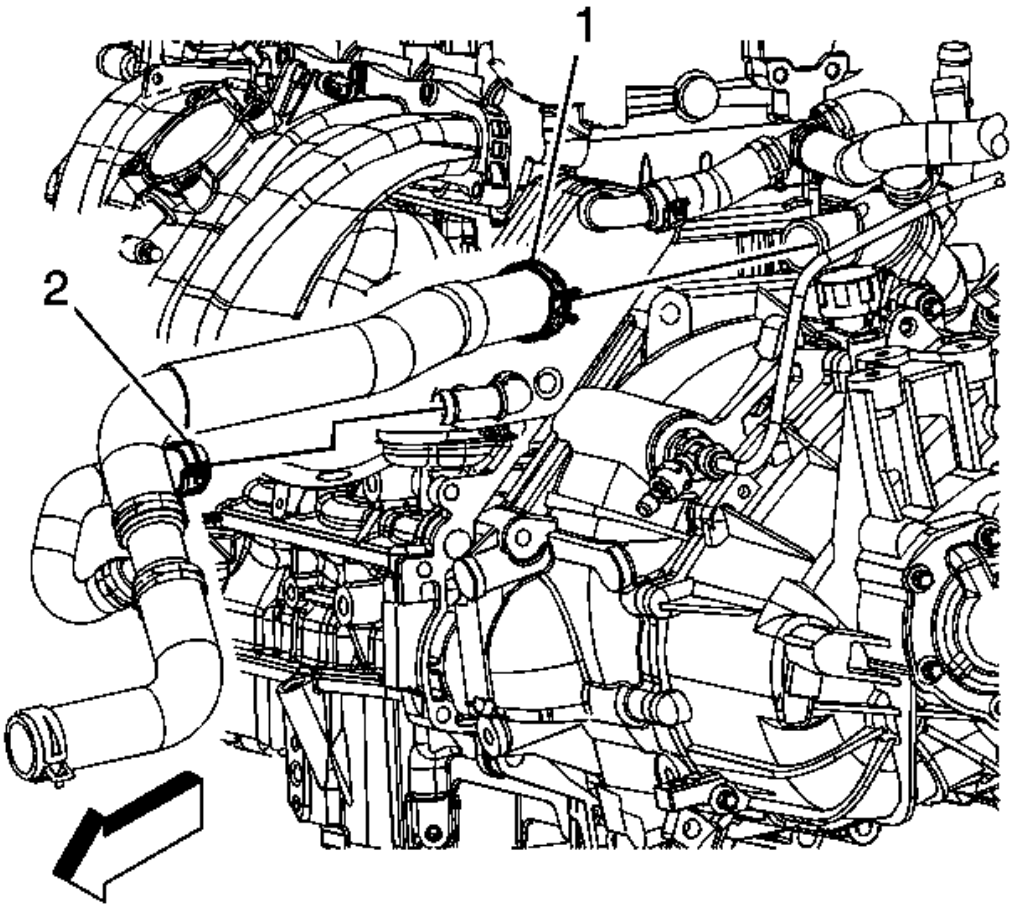

Fig. 301: View Of Radiator Outlet Hose To Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

82. If the vehicle is equipped with a engine oil cooler perform the following steps, install the radiator outlet hose to the oil cooler.
83. Install the radiator outlet hose to the water outlet.
84. Position the radiator outlet hose clamp (2) at the oil cooler.
85. Position the radiator outlet hose clamp (1) at the water outlet.

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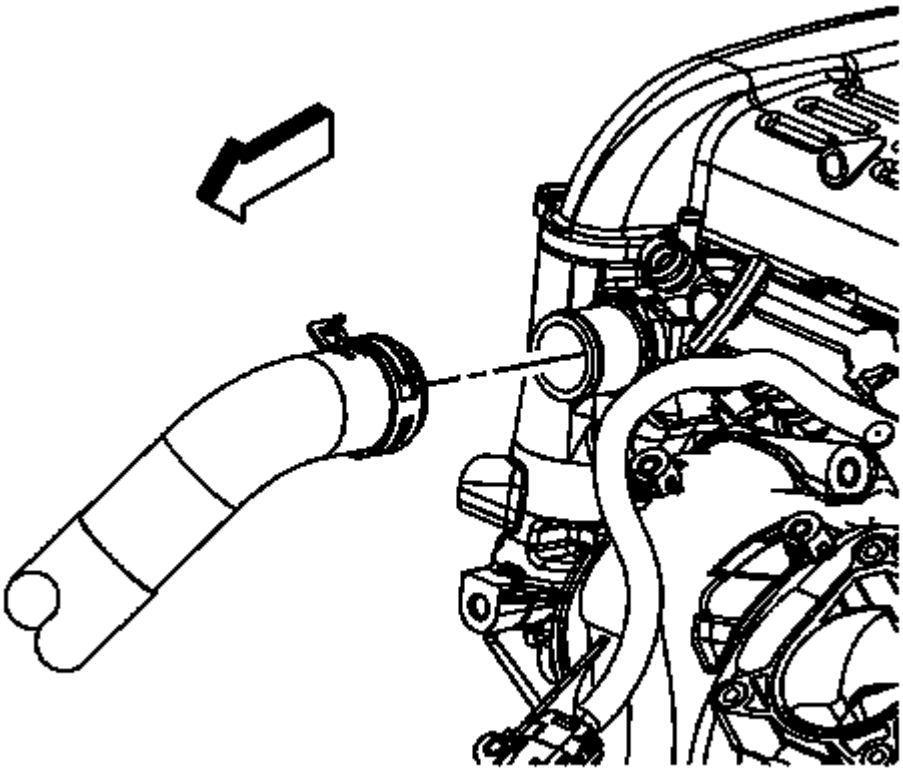

Fig. 302: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

86. Install the radiator inlet hose to the engine.
87. Position the radiator inlet hose clamp at the engine.

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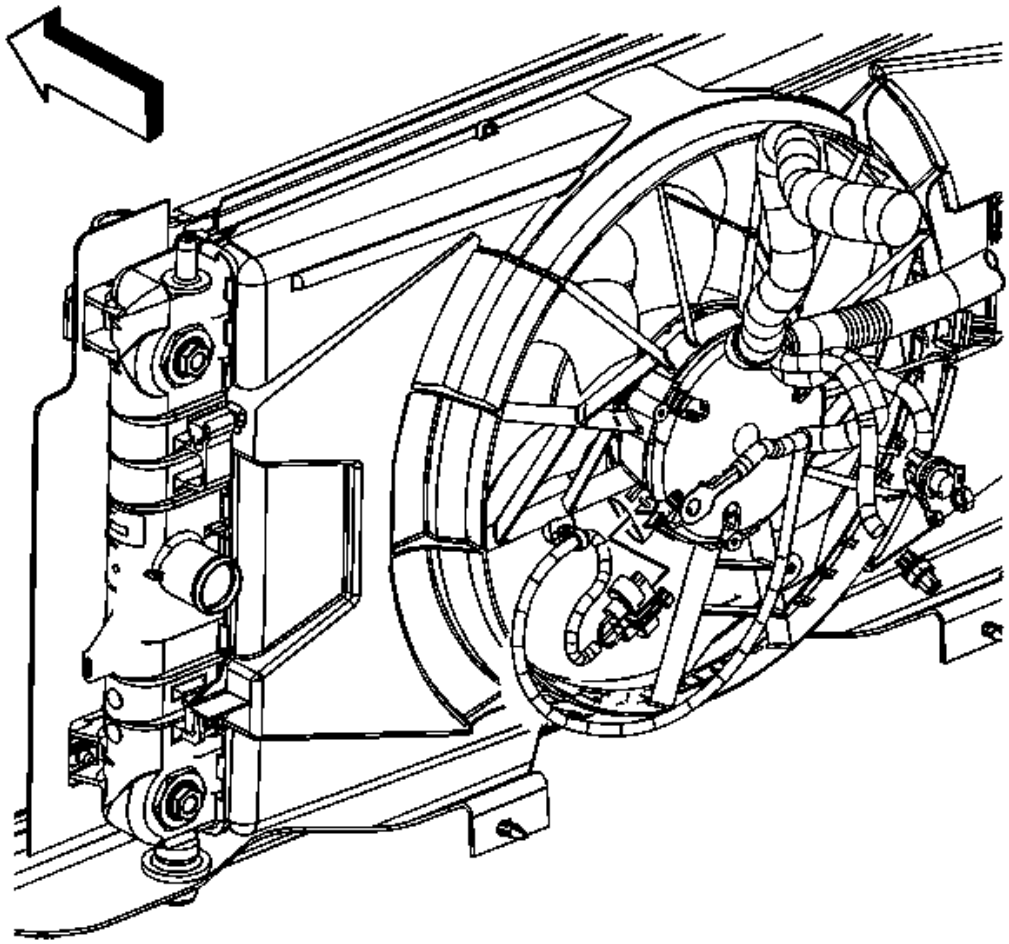

Fig. 303: Identifying Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

88. Connect the cooling fan electrical connector.

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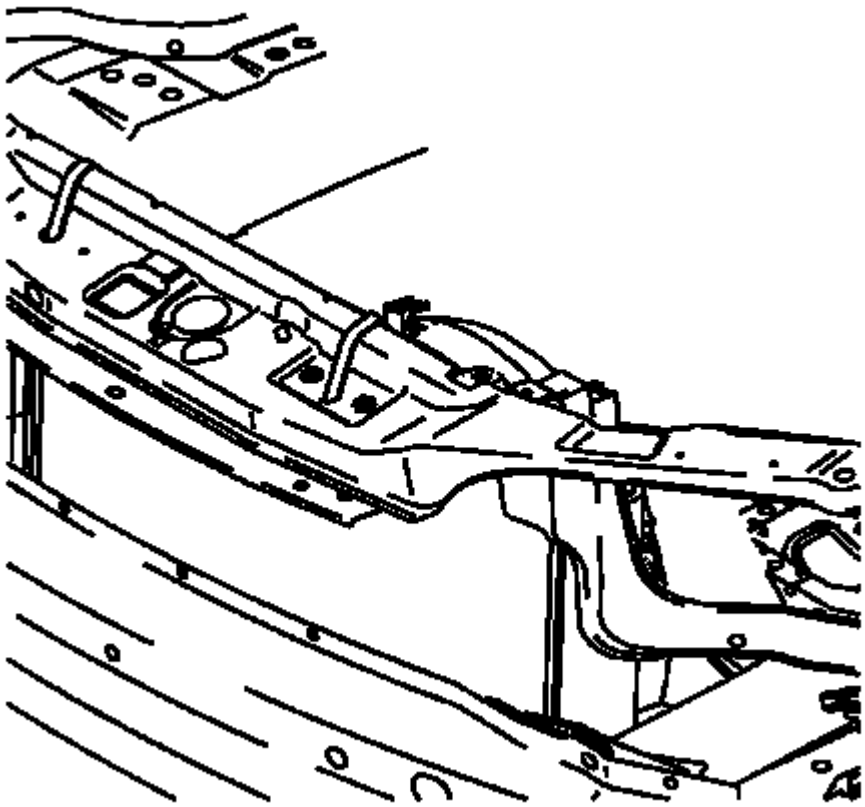

Fig. 304: Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

89. Install the engine drive belt. Refer to **Drive Belt Replacement**.
90. Unsecure the cooling module from the upper body structure.
91. Fill the cooling system. Refer to **Draining and Filling Cooling System (2.2L (L61), 2.4L (LE5))** or **Draining and Filling Cooling System (GE 47716 Fill)** .
92. Check and fill the transaxle fluid as needed.

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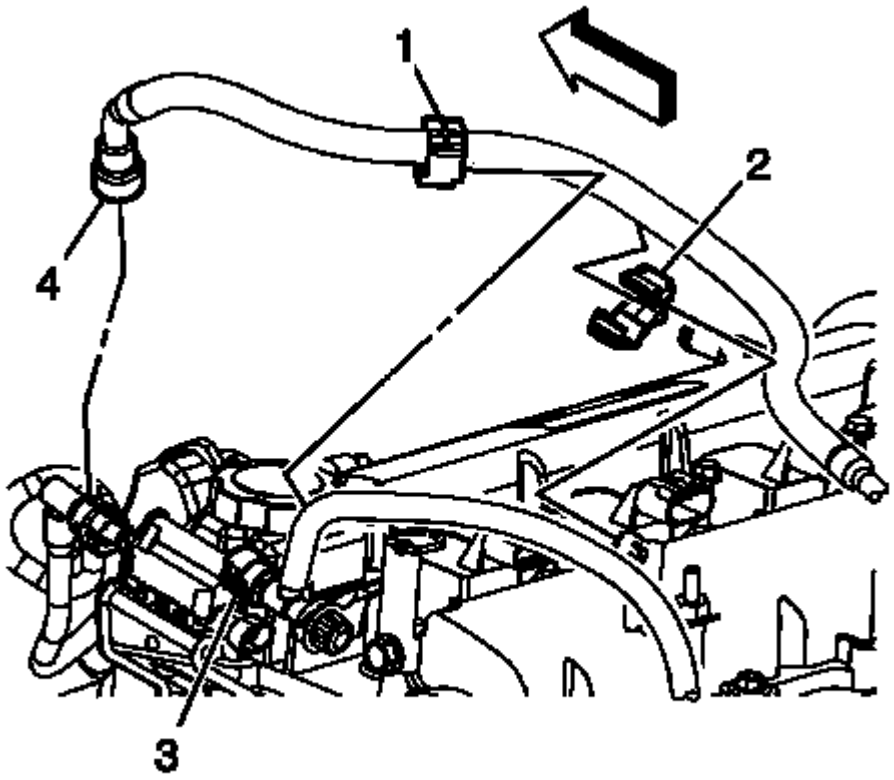

Fig. 305: View Of Caps Or Plugs, Fuel Line And Fuel Rail
Courtesy of GENERAL MOTORS CORP.

93. Connect the EVAP line quick connect fitting (3) to the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
94. Connect the fuel feed line quick connect fitting (4) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
95. Install the fuel line clips (1, 2) to the engine brackets.
96. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement**.
97. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
98. Close the hood.
99. Road test the vehicle.

Engine Oil and Oil Filter Replacement

Removal Procedure

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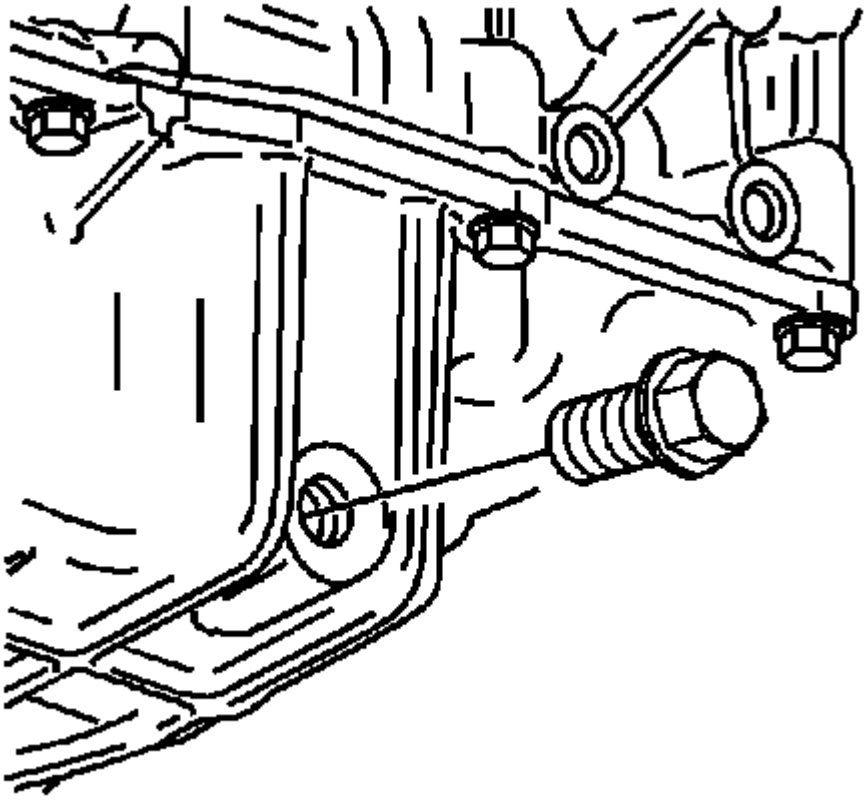

Fig. 306: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Place a drain pan under the oil drain plug.
3. Remove the oil pan drain plug.
4. Allow the oil to drain completely.

NOTE: Refer to Fastener Notice .

5. Install the oil pan drain plug.

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

6. Lower the vehicle.

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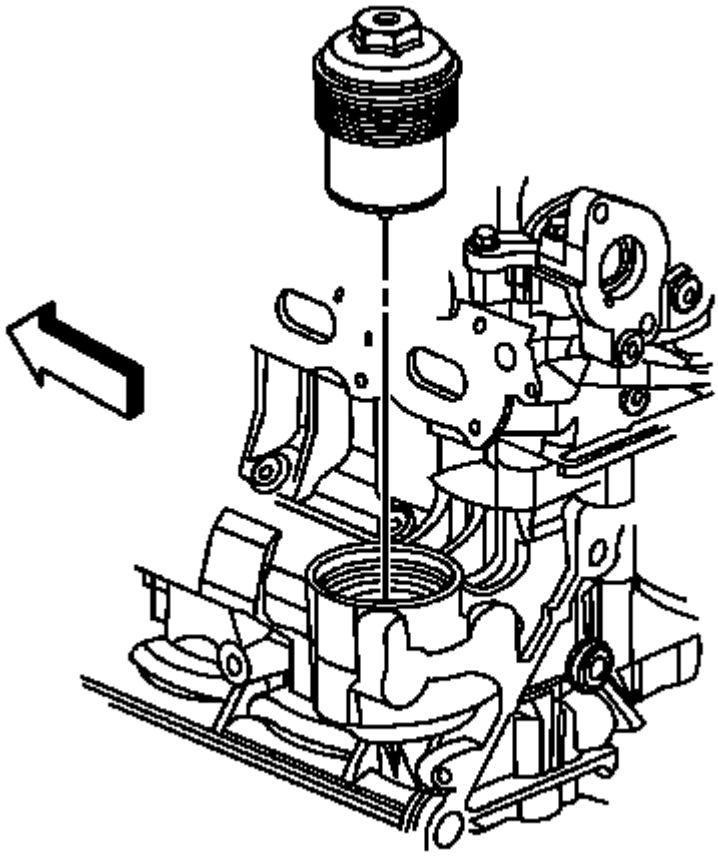

Fig. 307: Locating Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: DO NOT use an open end wrench on the hex on top of the oil filter cap.

7. Use a 32 mm (1 1/4 in) socket on the hex on top of the oil filter cap, or an oil filter wrench on the outside diameter of the oil filter cap.
8. Remove the oil filter cap and filter.
9. Remove the filter from the cap.

Installation Procedure

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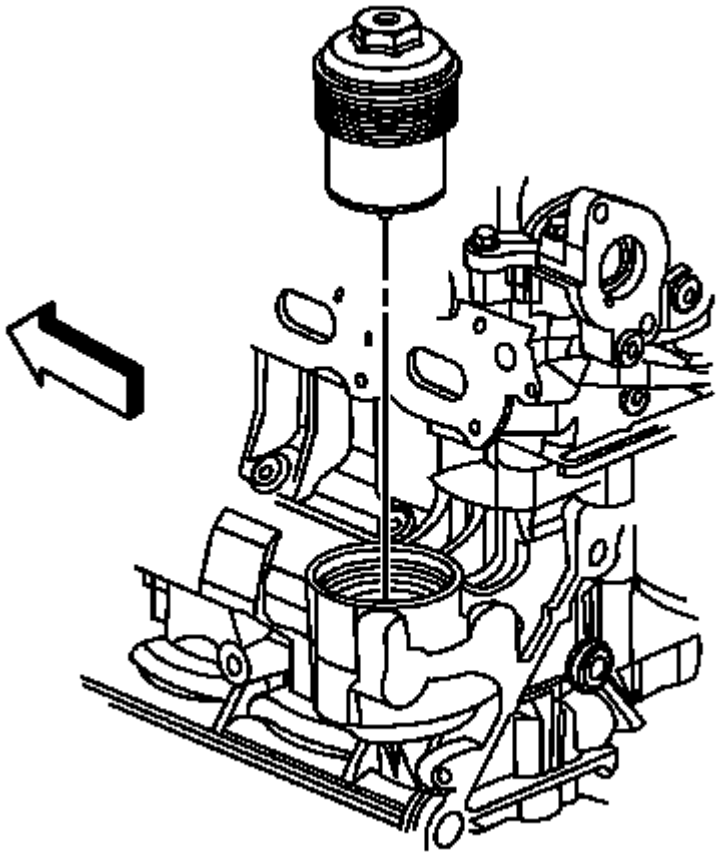

Fig. 308: Locating Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter to the cap.
2. Install the oil filter cap and filter.

NOTE: Over torquing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak.

IMPORTANT: DO NOT use an open end wrench on the hex on top of the oil filter cap.

3. Use a 32 mm (1 1/4 in) socket on the hex on the top of the oil filter cap, or an oil filter wrench on the outside diameter of the oil filter cap.

   Tighten: Tighten the oil filter cap until fully seated. DO NOT exceed 25 N.m (18 lb ft).

4. Fill the engine with oil. Refer to **Fluid and Lubricant Recommendations** .

OFF-VEHICLE REPAIR INSTRUCTIONS

Draining Fluids and Oil Filter Removal

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Tools Required

J 44887 Oil Filter Wrench

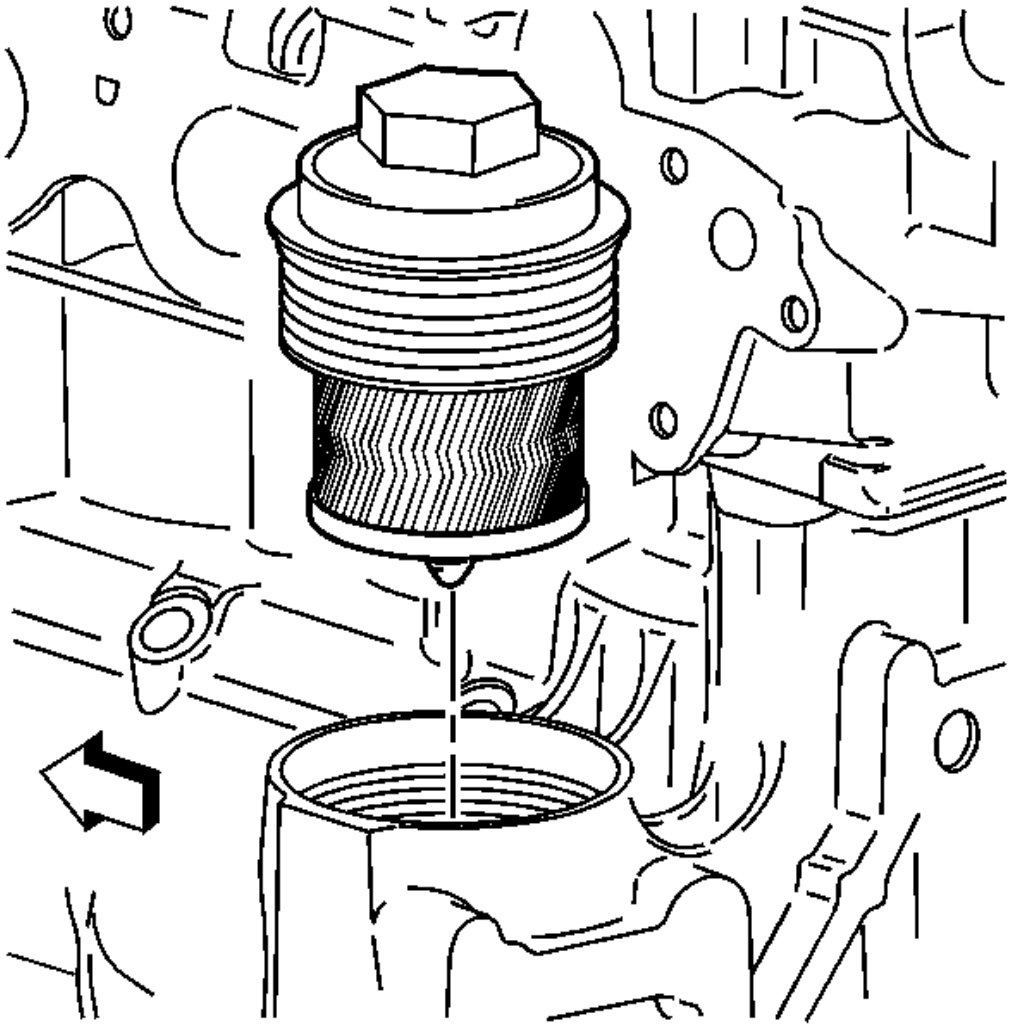

Fig. 309: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

1. Use **J 44887** to remove the oil filter cap. Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter from the cap and discard.
3. Clean the oil filter housing in the engine block.

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NOTE: Refer to FASTENER NOTICE .

4. Install the oil pan drain plug.

   Tighten: Tighten the oil pan drain plug to 25 N.m (18 lb ft).

5. Remove the water pump drain plug from the water pump and allow the coolant to drain from the water jacket.
6. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the water pump drain plug.
7. Install the water pump drain plug.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

8. If cleaning or repairing the engine block, it is not necessary to reinstall the plugs.

Crankshaft Balancer Removal

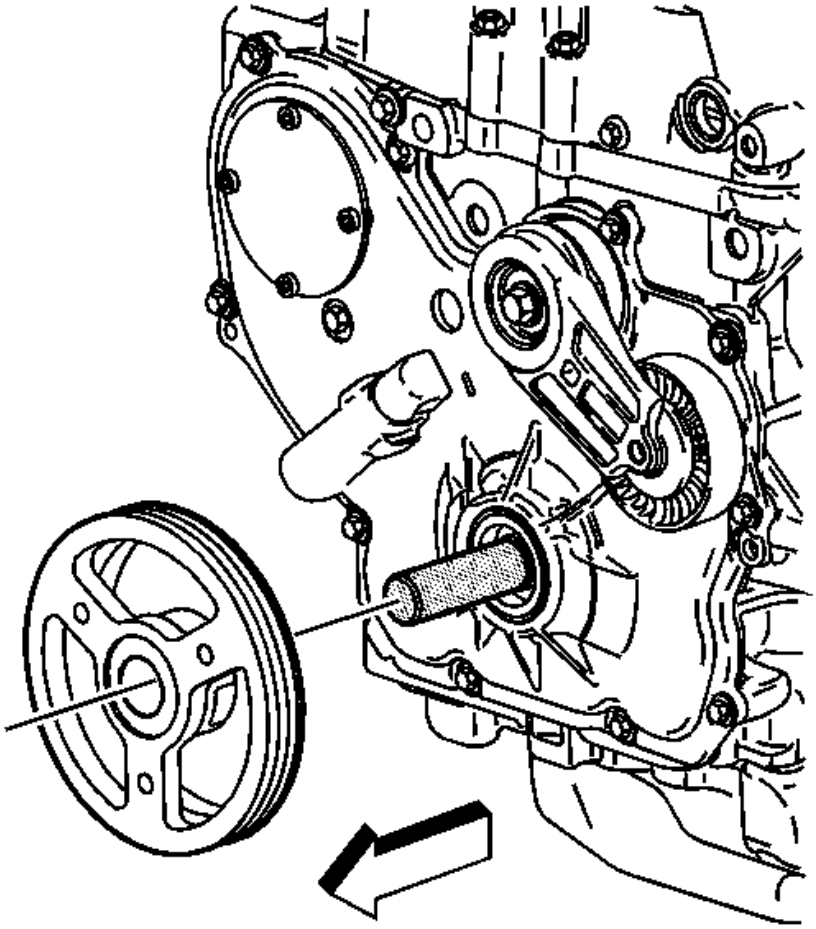

Fig. 310: View Of Crankshaft Balancer

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Courtesy of GENERAL MOTORS CORP.

1. Remove the balancer retaining bolt and washer.

   Discard the bolt.

2. Remove the balancer using a universal removal tool.

Engine Flywheel Removal

Tools Required

J 38122-A Harmonic Balancer Holder. See **Special Tools**.

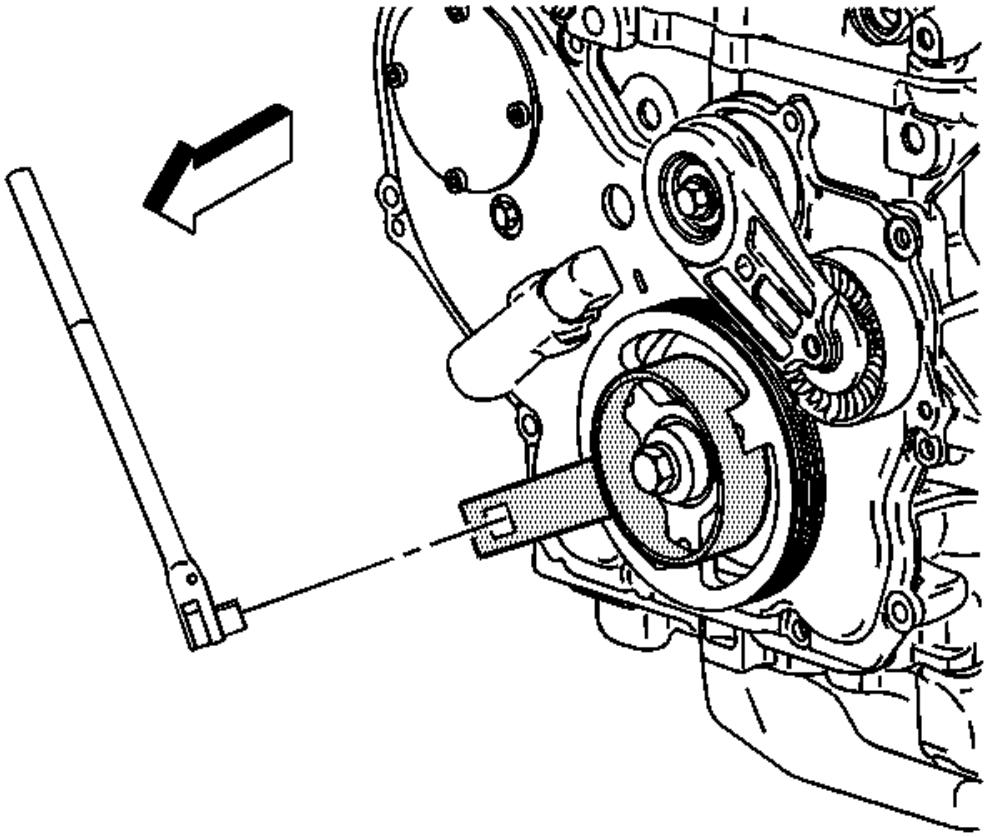

Fig. 311: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may be necessary to remove the chamfer (bevel) from the edge of an 18 mm socket in order to get full socket engagement on the thin headed

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flywheel bolts.
Do not orientate the flywheel to the crankshaft. It is balanced separately from the engine.

1. Remove the flywheel attaching bolt. Use the **J 38122-A** to prevent crankshaft rotation. See **Special Tools**.

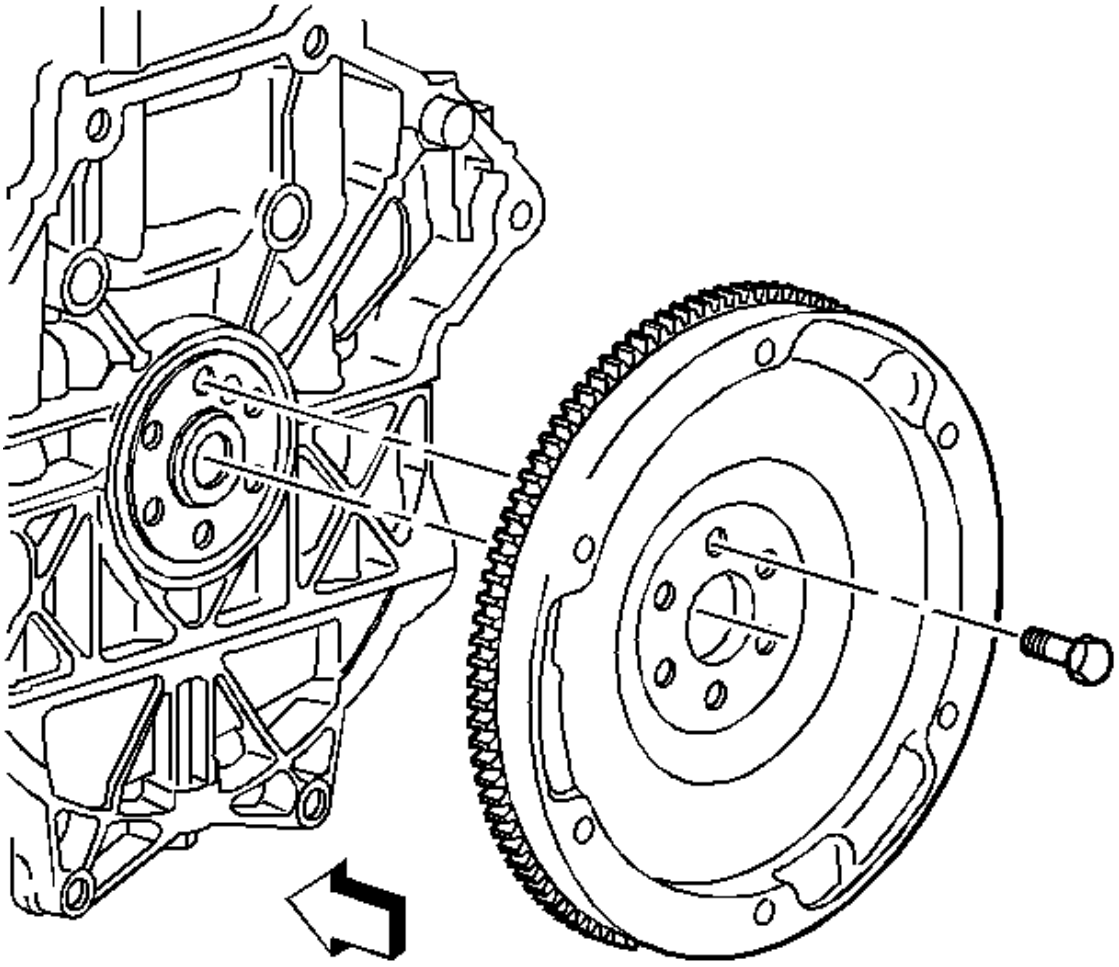

Fig. 312: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel, if the vehicle has a manual transmission.

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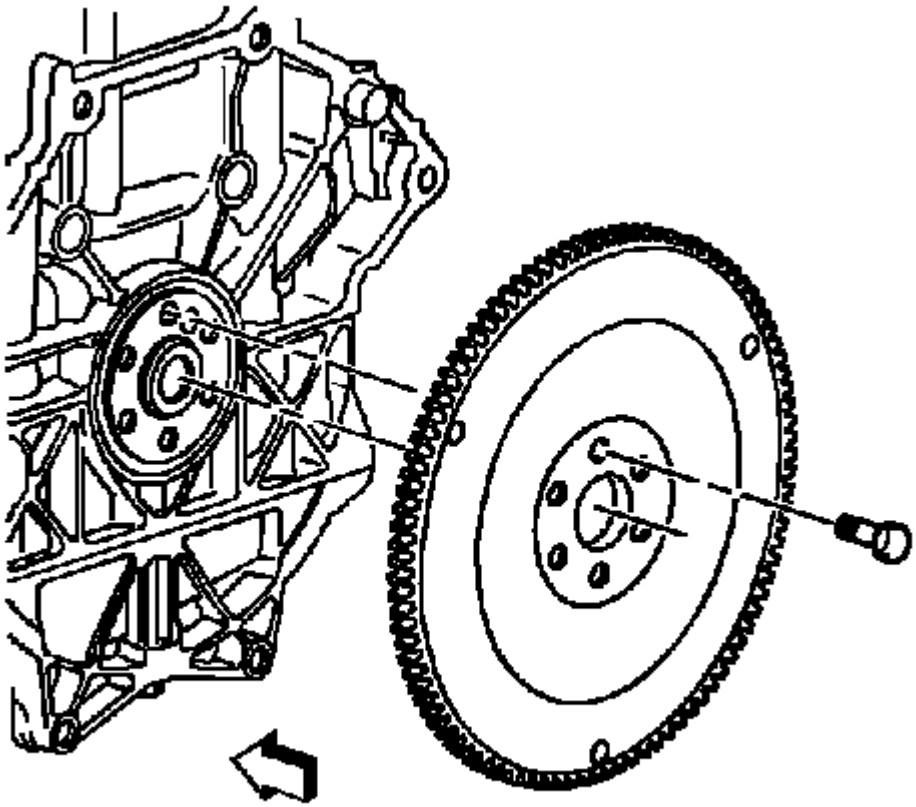

Fig. 313: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

3. Remove the flywheel retainer for vehicles with automatic transmission.
4. Remove the flywheel, if the vehicle has an automatic transmission.
5. Clean the thread adhesive from the flywheel bolt holes. Use a nylon bristle brush to clean the holes in the crankshaft.

Oil Level Indicator and Tube Removal

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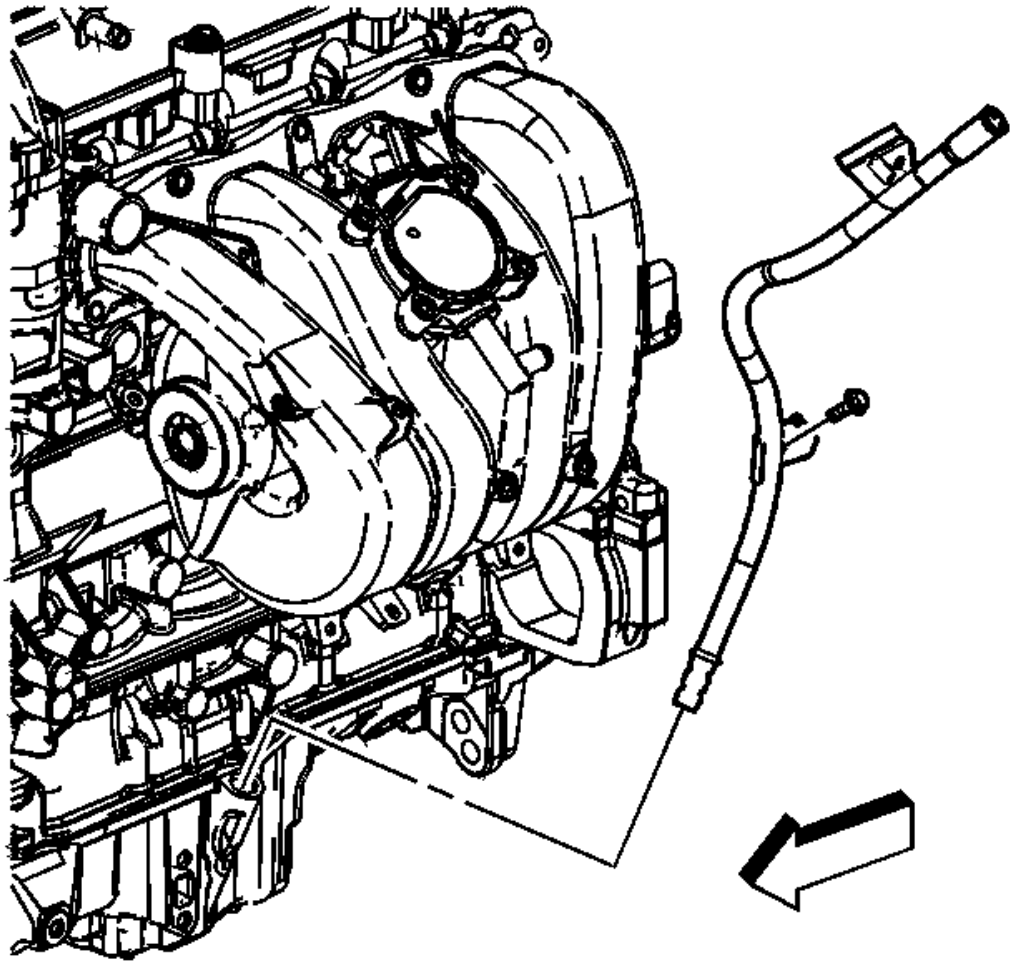

Fig. 314: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove knock sensor connector from the oil level indicator tube.
2. Remove the electrical wiring harness from the oil level indicator tube.
3. Remove the oil level indicator tube bracket to the intake manifold bolt.
4. Remove the oil level indicator and the oil level indicator tube from the oil pan.

Engine Oil Cooler Removal

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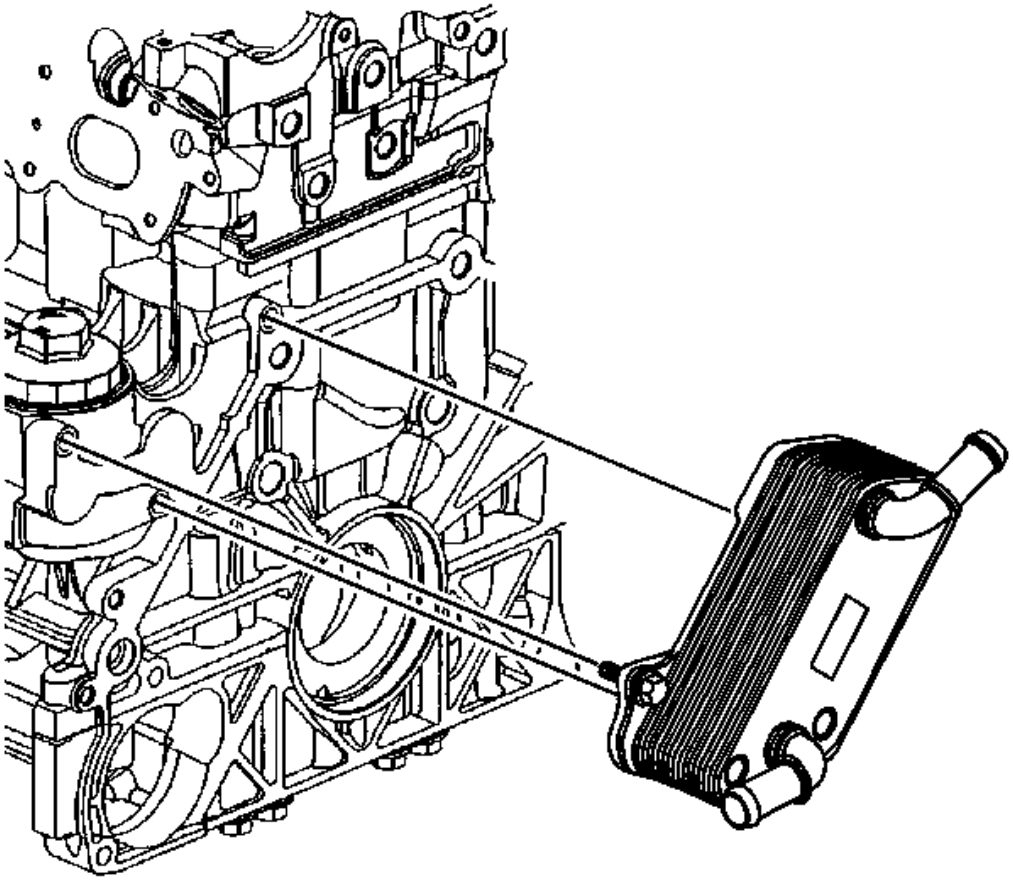

Fig. 315: Identifying Oil Cooler
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil cooler bolt.
2. Remove the oil cooler.

Exhaust Manifold Removal

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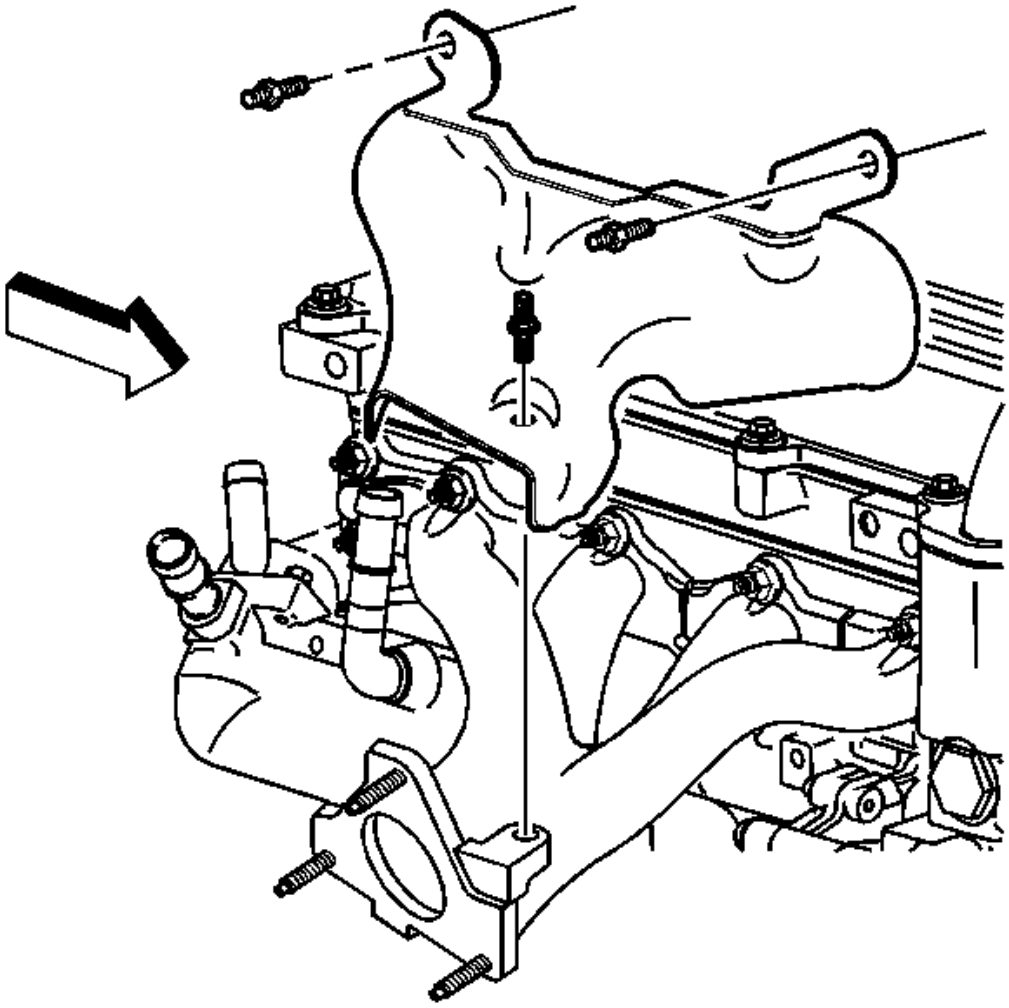

Fig. 316: View Of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

1. Remove the exhaust manifold heat shield.

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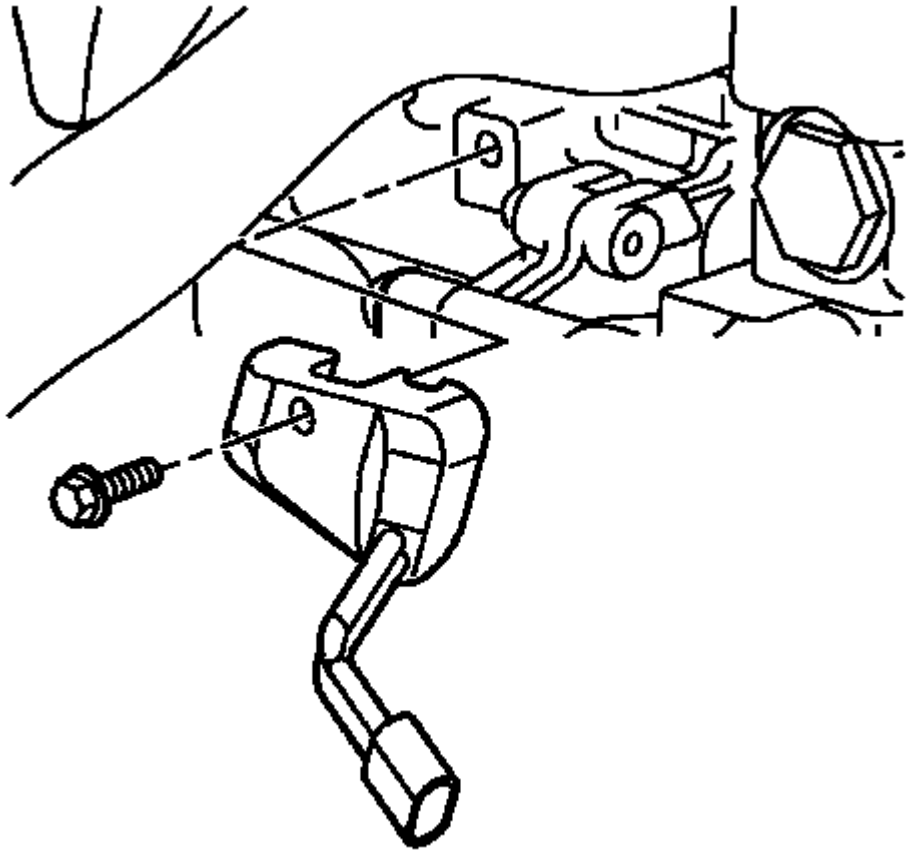

Fig. 317: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

2. Remove the block heater if equipped.

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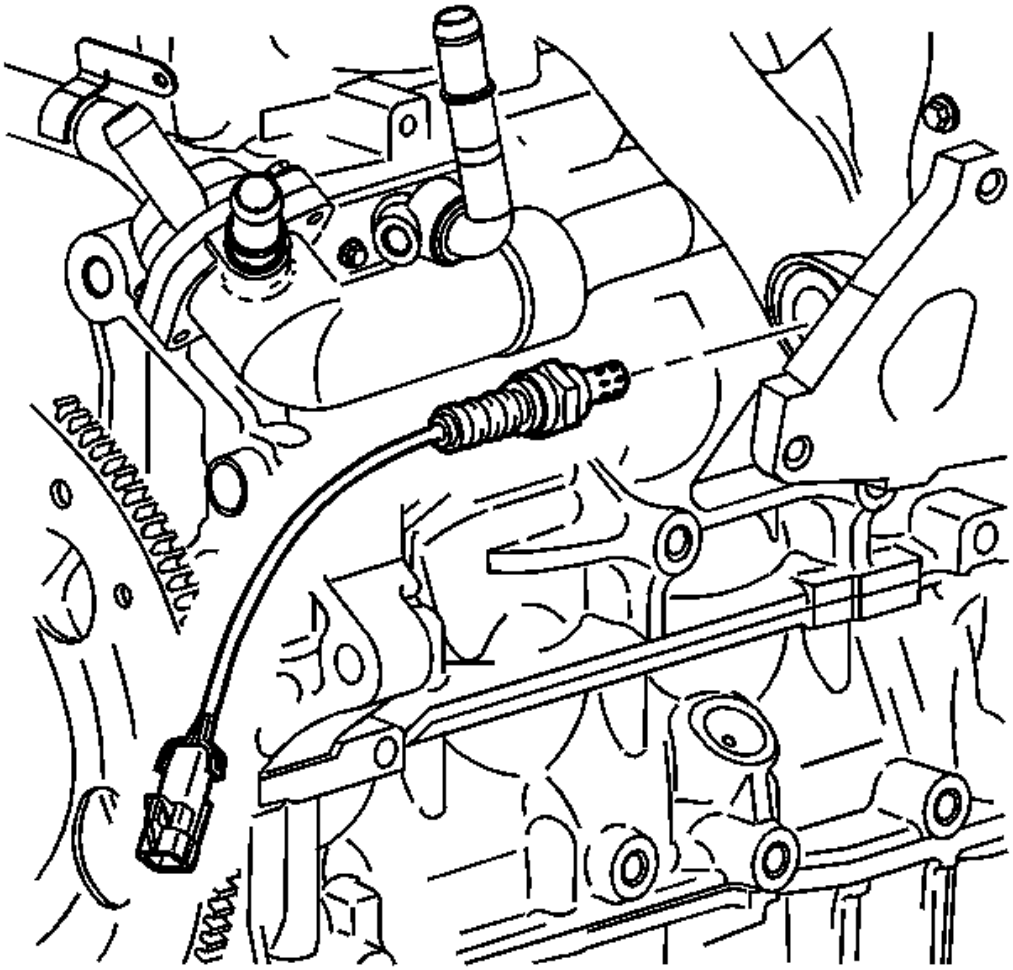

Fig. 318: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the oxygen sensor.

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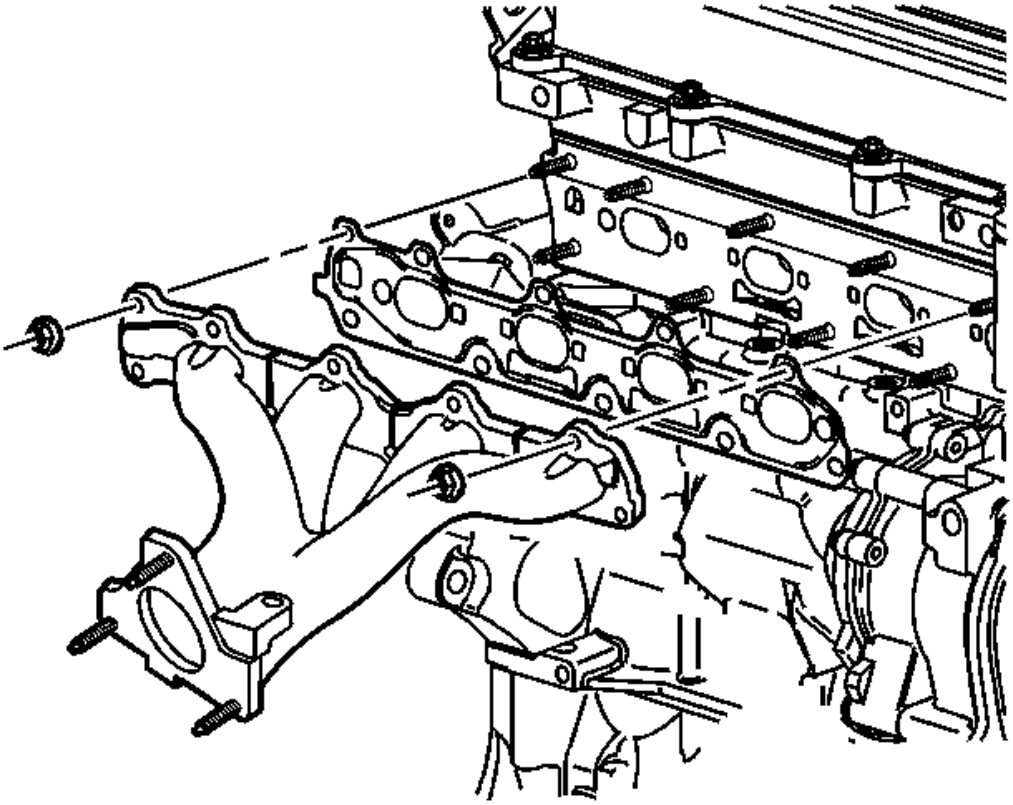

Fig. 319: View Of Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

4. Remove and discard the exhaust manifold to cylinder head retaining nuts.
5. Remove the exhaust manifold.
6. Clean all of the sealing surfaces.
7. If the exhaust manifold is being replaced, transfer the following parts:
    - The exhaust manifold heat shield
    - The oxygen sensor

Intake Manifold Removal

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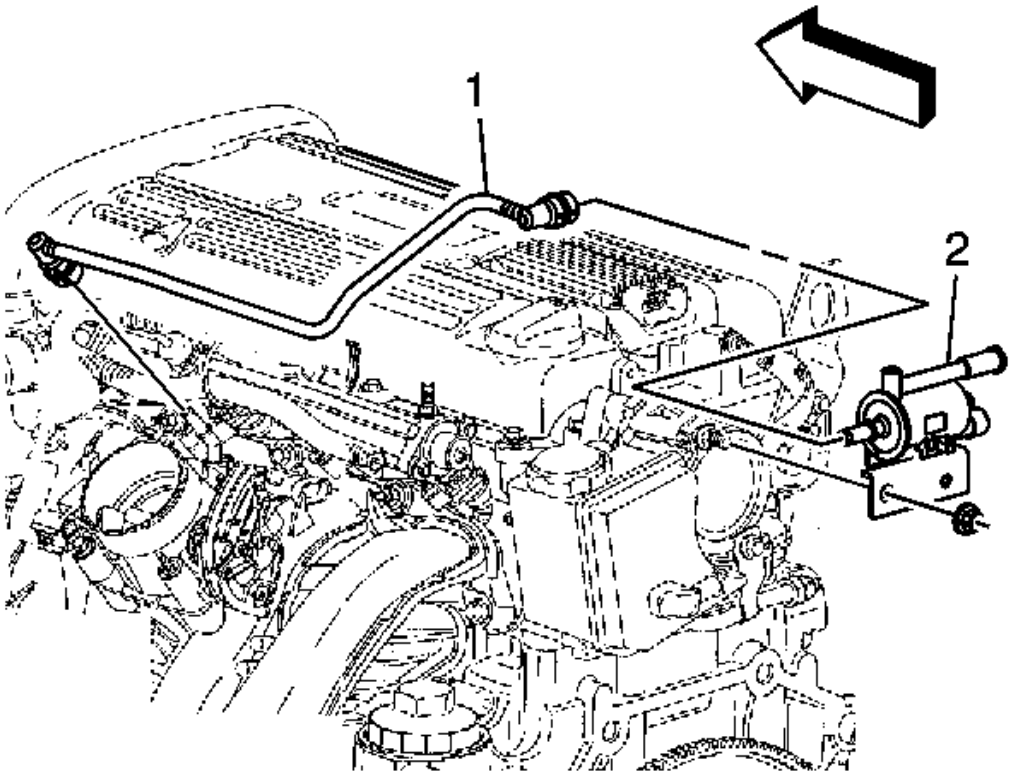

Fig. 320: View Of EVAP Emission Canister Valve Tube
Courtesy of GENERAL MOTORS CORP.

NOTE: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold is made of a composite plastic and can be damaged if it is removed when the engine is hot.

1. Remove the evaporative emission (EVAP) canister valve tube (1).
2. Remove the EVAP canister valve (2).

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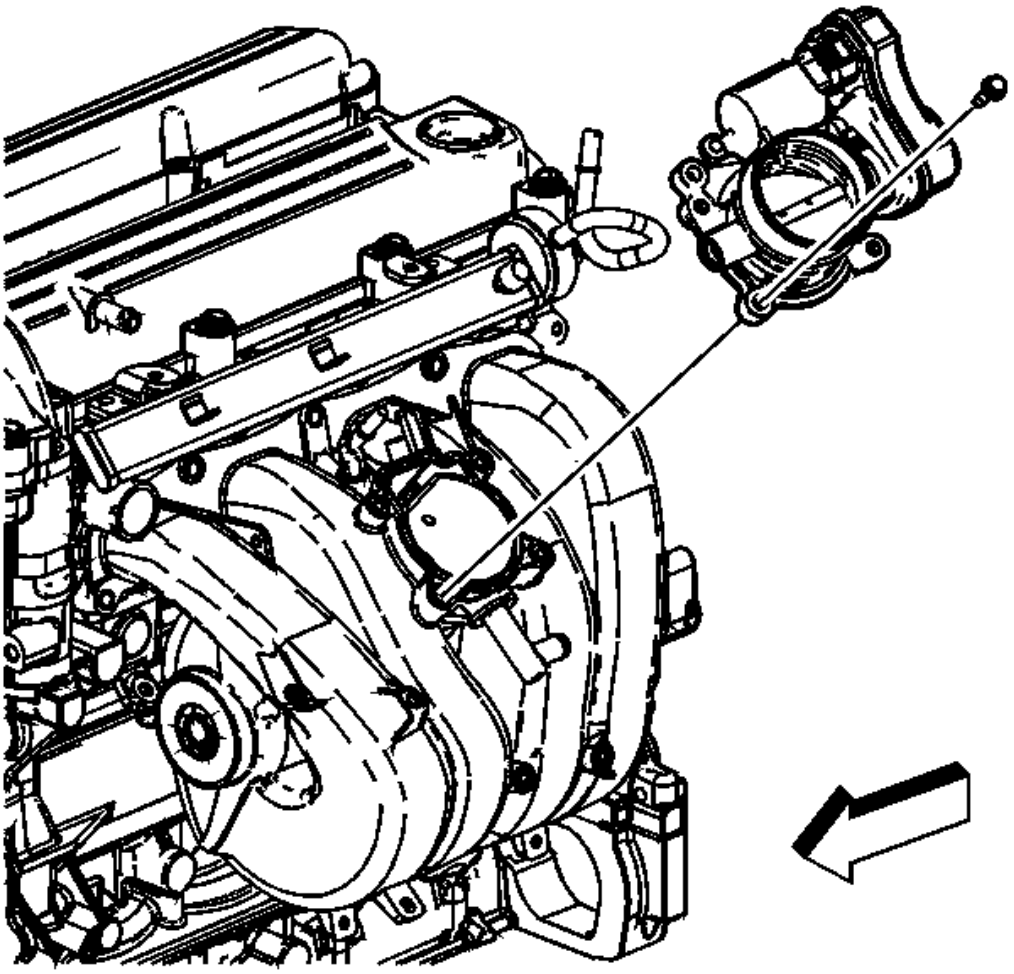

Fig. 321: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body bolts.
4. Remove the throttle body.

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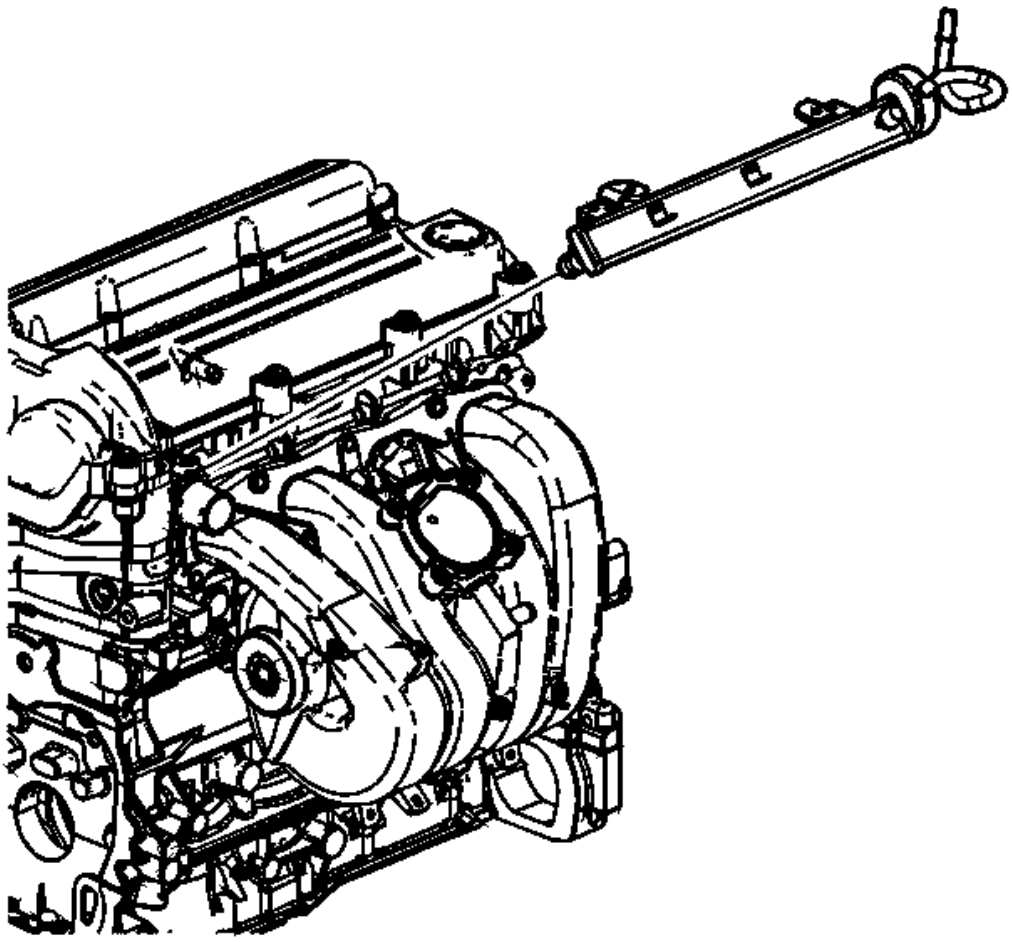

Fig. 322: Identifying Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

5. Remove fuel pipes and clip. Remove the fuel rail assembly.

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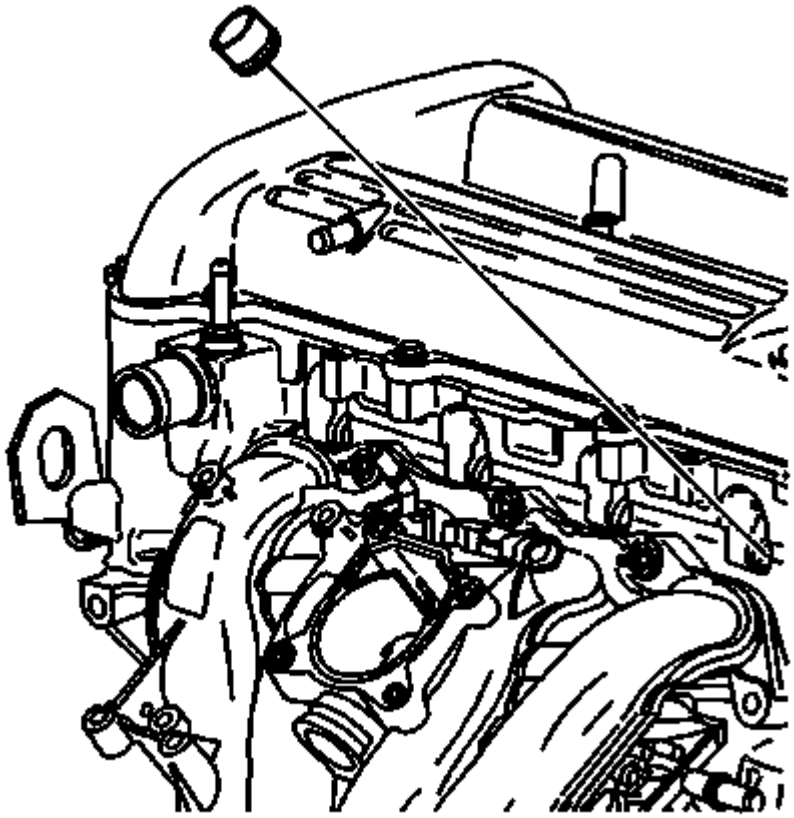

Fig. 323: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

6. Remove the fuel injector tip insulators and discard.

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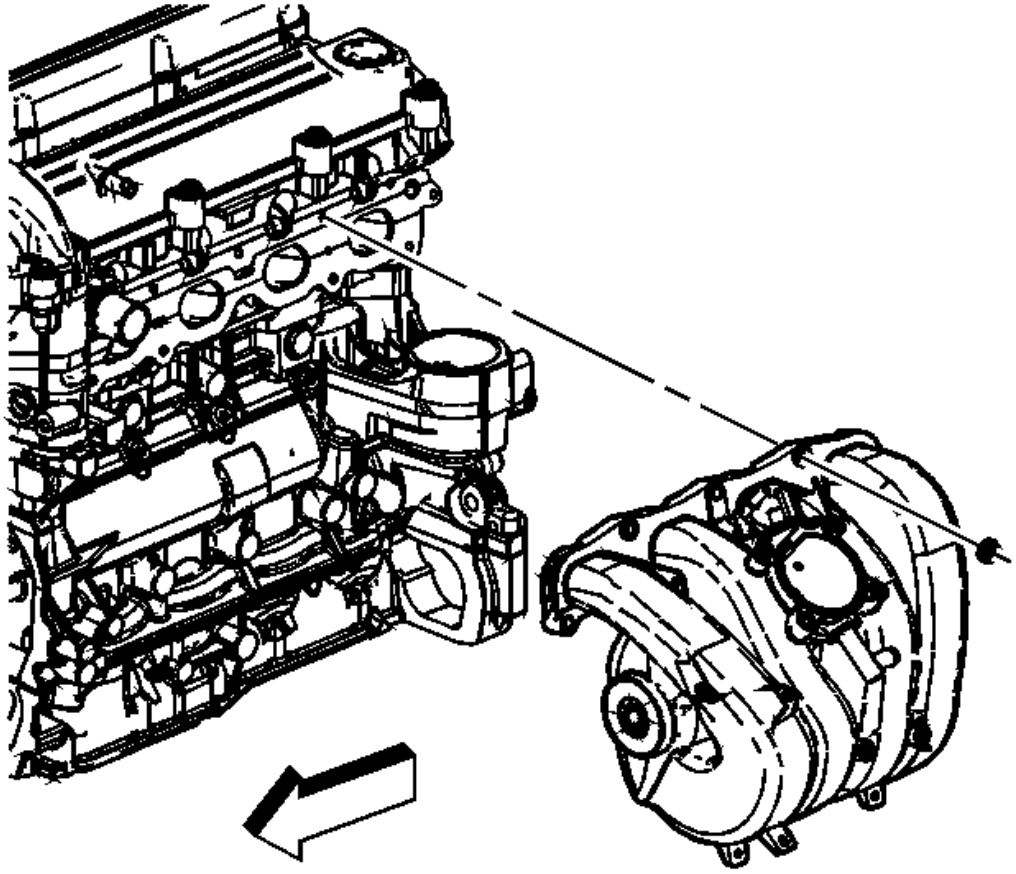

Fig. 324: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

7. Remove the intake manifold retaining nuts and bolts.
8. Remove the intake manifold.
9. Remove the intake manifold gasket, if necessary. The gasket can be used again if it is not damaged.
10. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

Camshaft Cover Removal

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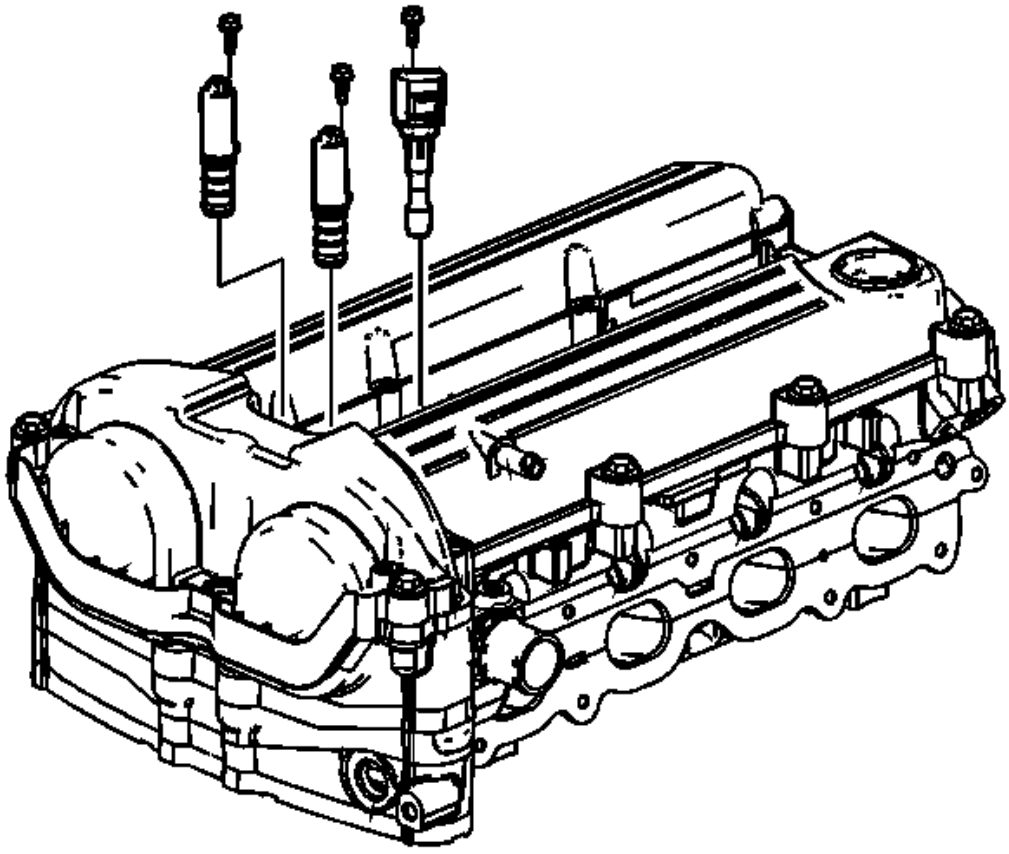

Fig. 325: Identifying Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

1. Remove the bolt and coil.
2. Remove the camshaft position actuator solenoid valve bolts.
3. Remove the camshaft position actuator solenoid valves.

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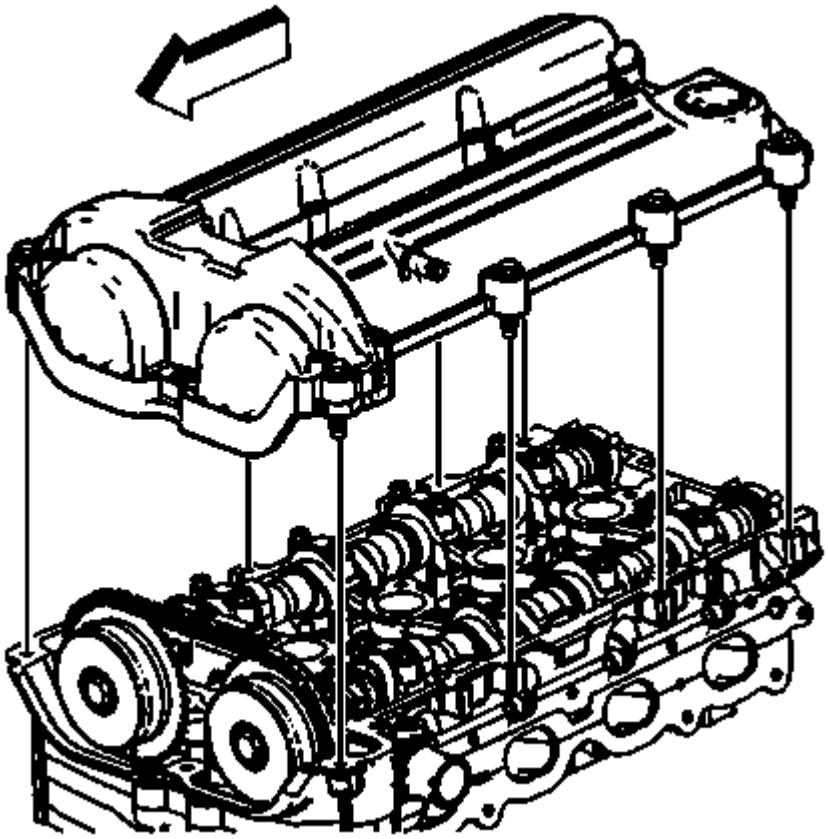

Fig. 326: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the camshaft cover assembly.

Engine Front Cover and Oil Pump Removal

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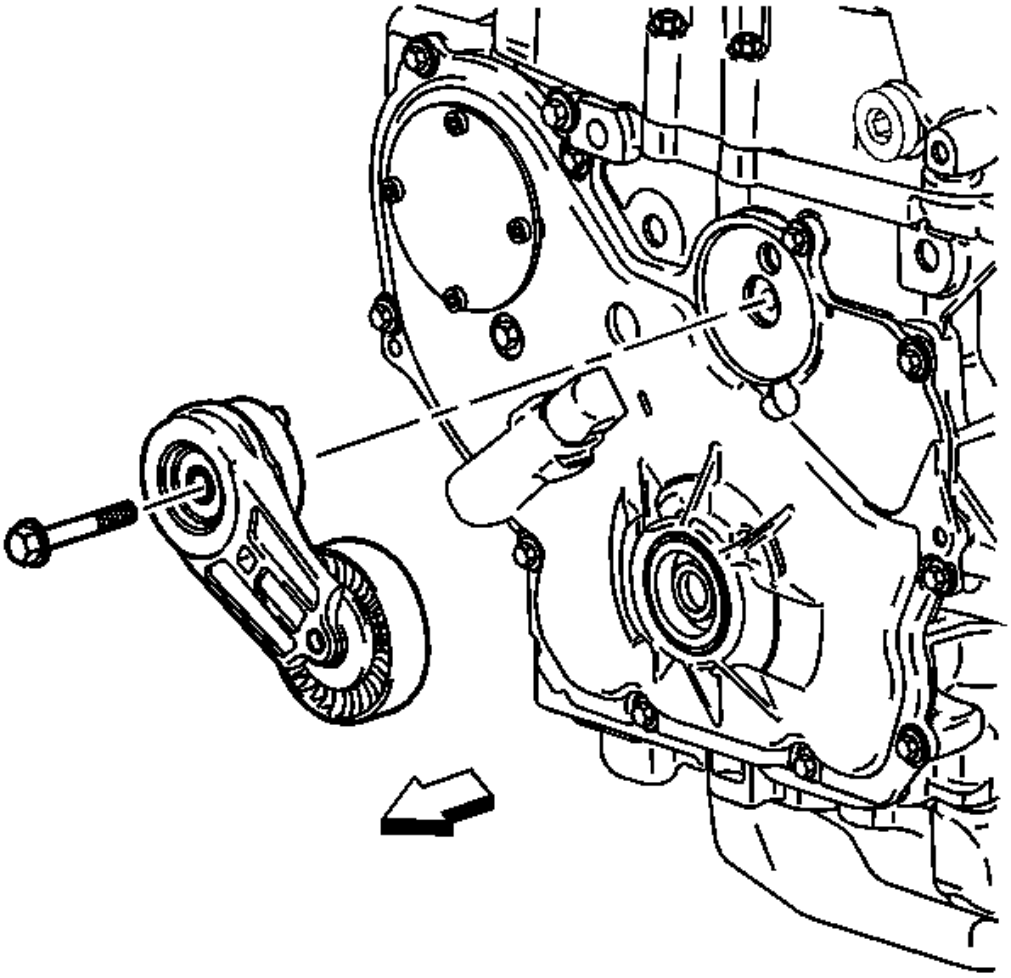

Fig. 327: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt tensioner bolt.
2. Remove the accessory drive belt tensioner.

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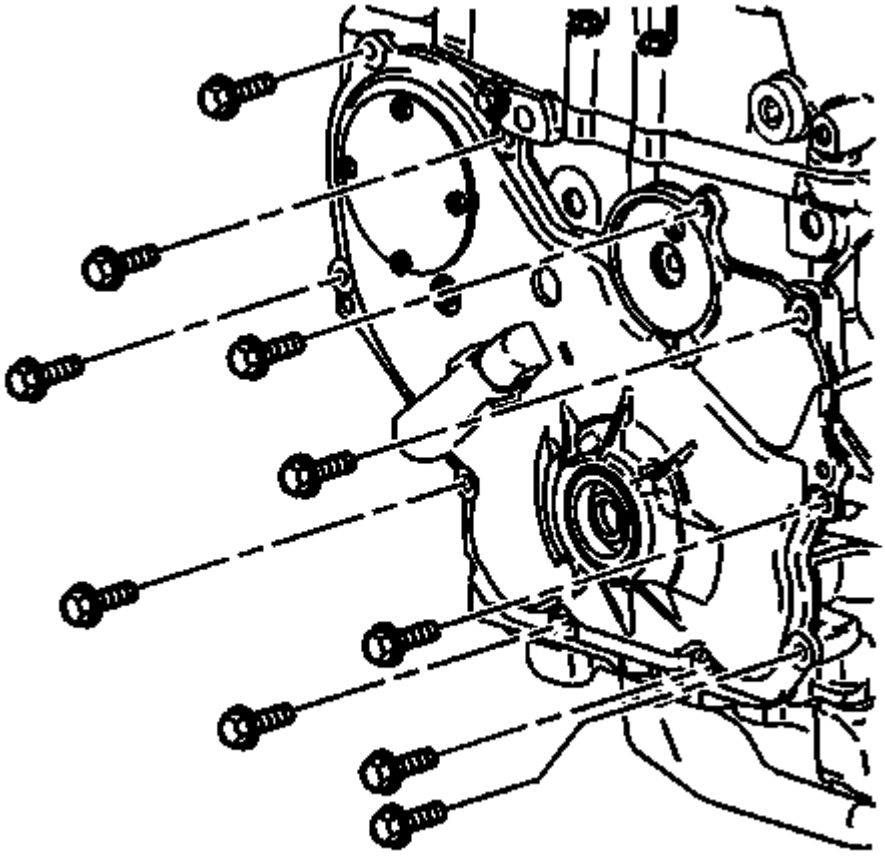

Fig. 328: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

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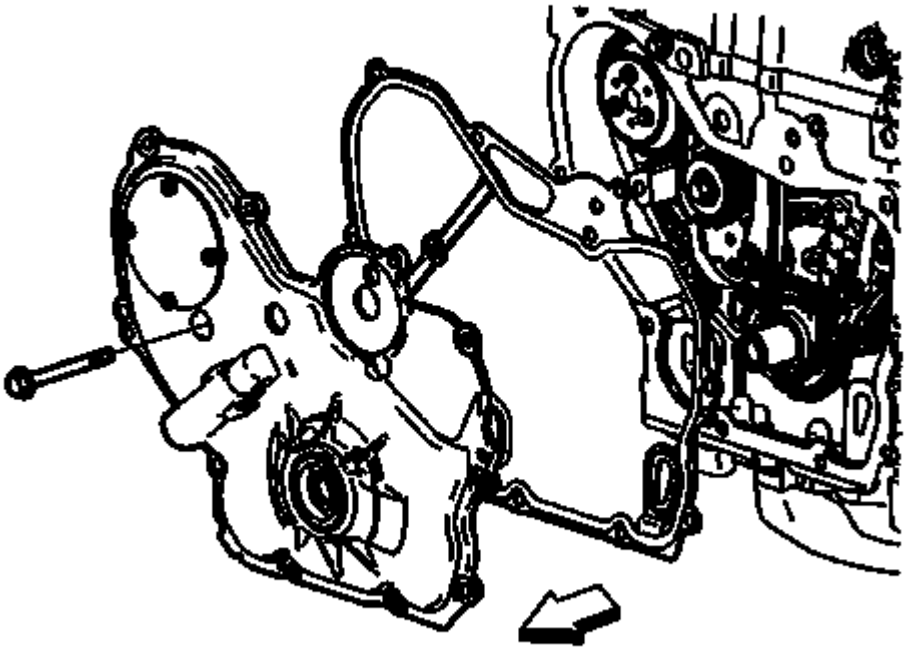

Fig. 329: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

4. Remove the long water pump bolt.
5. Remove the engine front cover and gaskets.
6. Remove the crankshaft front cover oil seal with an appropriate tool.

Timing Chain and Tensioner Removal

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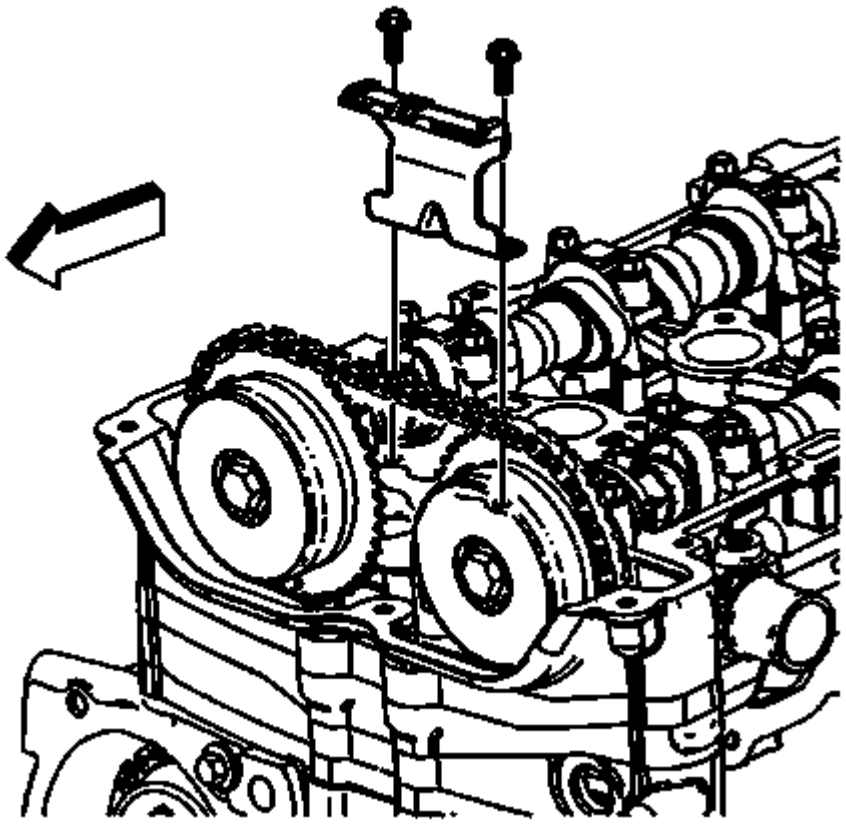

Fig. 330: Locating Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the upper timing chain guide bolts.
2. Remove the upper timing chain guide.

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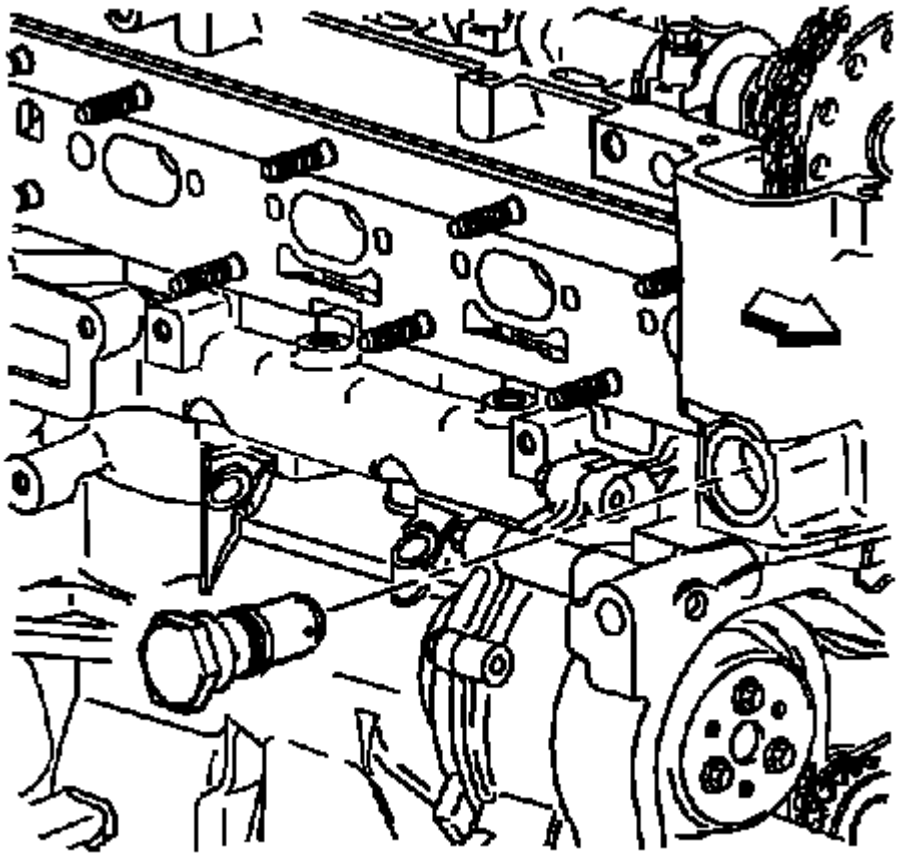

Fig. 331: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed. If it is not, the timing chain will become cocked and it will be difficult to remove.

3. Remove the timing chain tensioner plunger.

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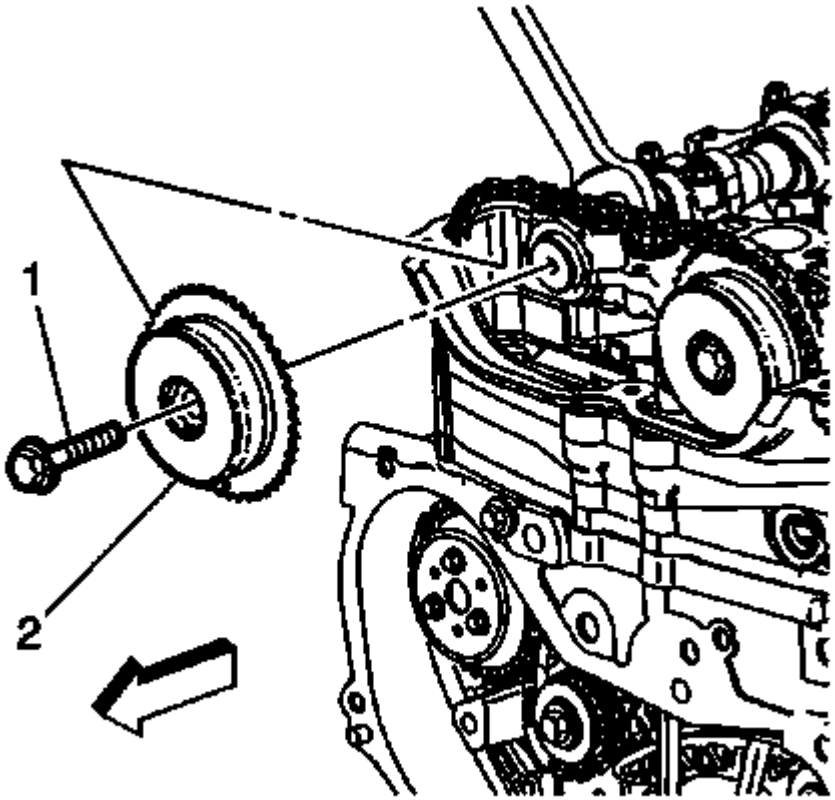

Fig. 332: Locating Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

4. Locate hex on the exhaust camshaft and hold with a wrench.
5. Remove the exhaust cam bolt and the exhaust cam actuator.

   Discard the bolt.

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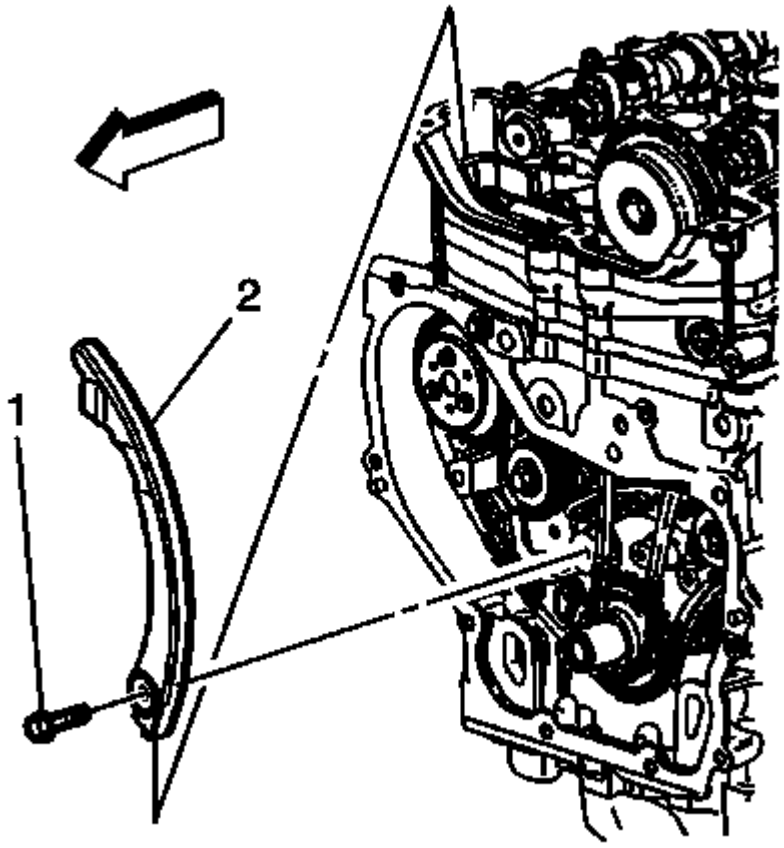

Fig. 333: Identifying Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the adjustable timing chain guide bolt.
7. Remove the adjustable timing chain guide.

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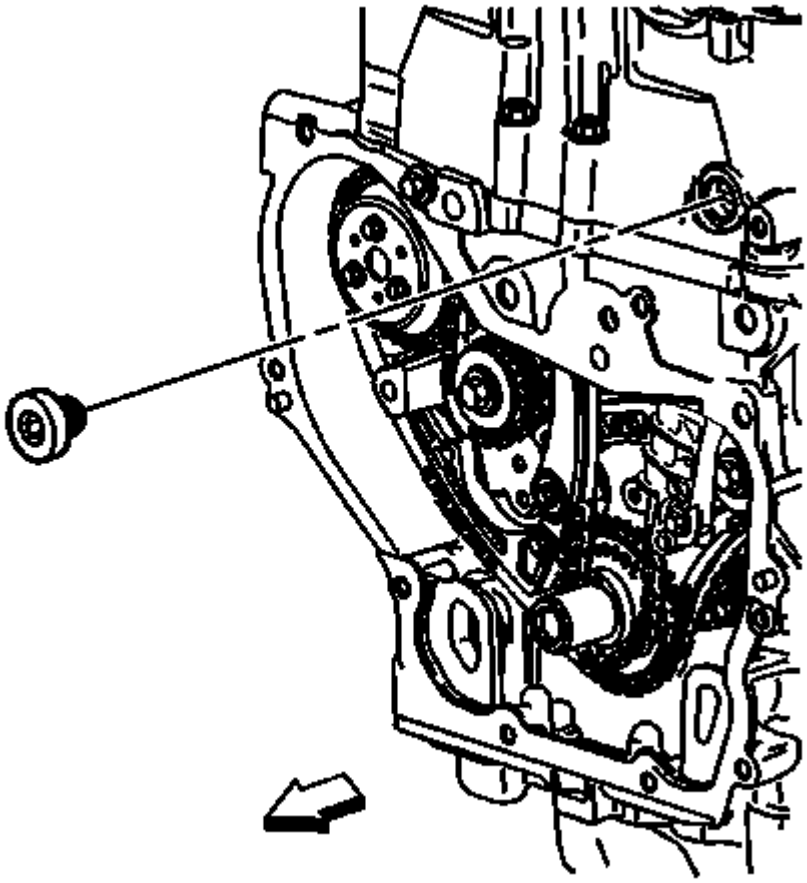

Fig. 334: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the plug to gain access to the fixed timing chain guide bolt.

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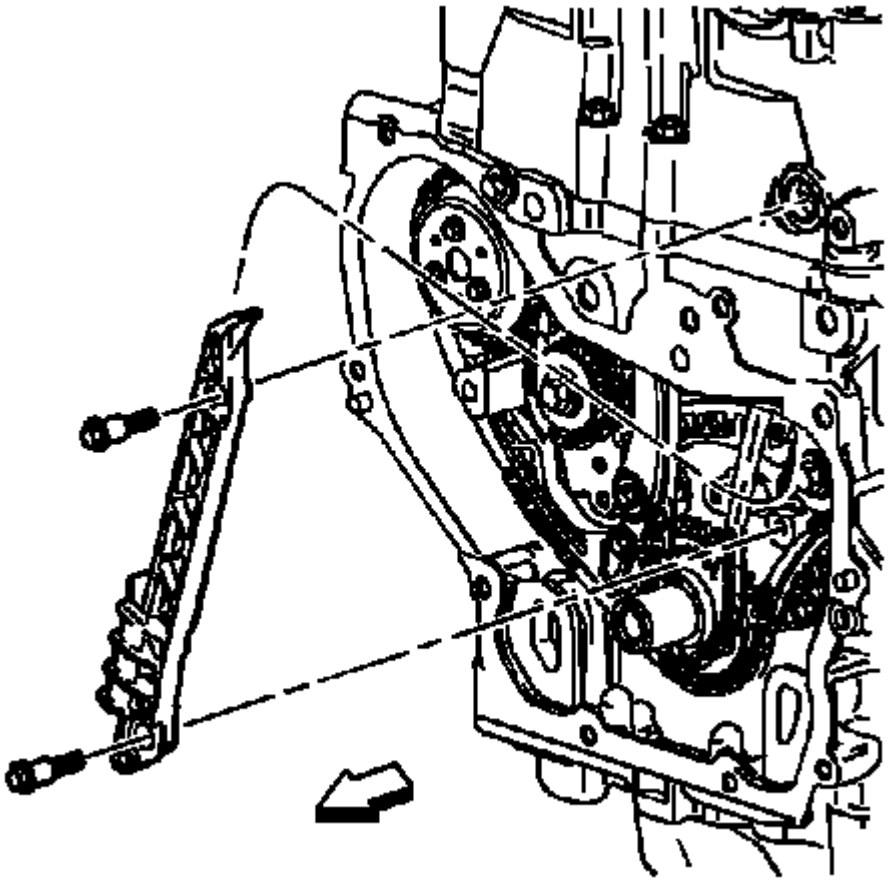

Fig. 335: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the fixed timing chain guide bolts.
10. Remove the fixed timing chain guide.

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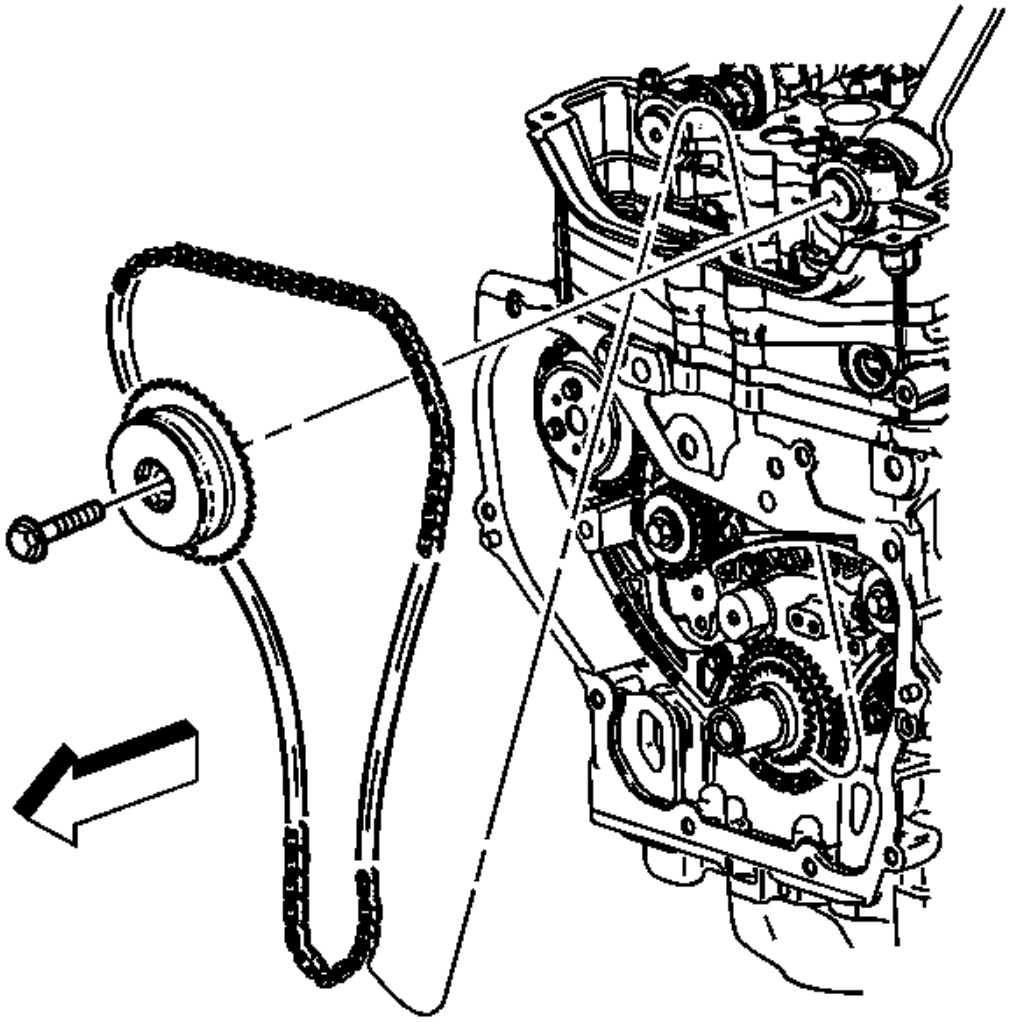

Fig. 336: Identifying Intake Cam Sprocket & The Timing Chain
Courtesy of GENERAL MOTORS CORP.

11. Locate hex on the intake camshaft and hold with a wrench.
12. Remove the intake cam sprocket bolt, the intake cam sprocket and the timing chain through the top of the cylinder head.

    Discard the bolt.

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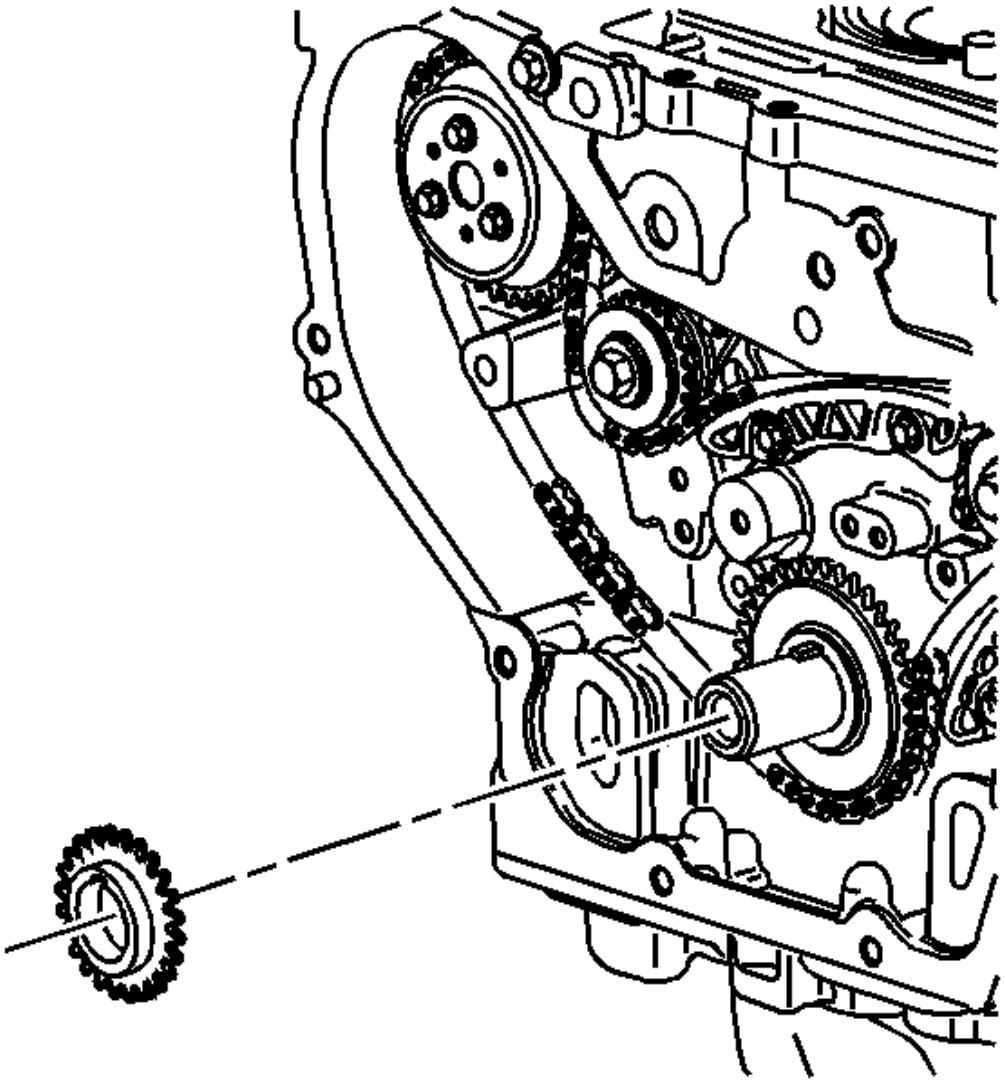

Fig. 337: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Remove the crankshaft sprocket.

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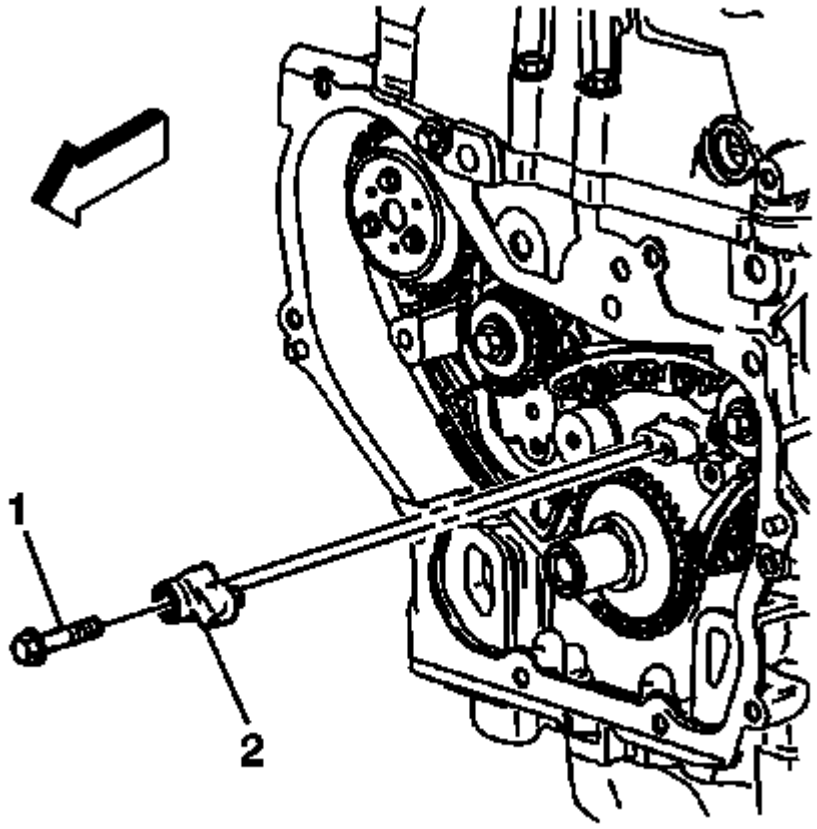

Fig. 338: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the timing chain oil nozzle bolt.
15. Remove the timing chain oil nozzle.

Intake Camshaft, Follower, and Adjuster Removal

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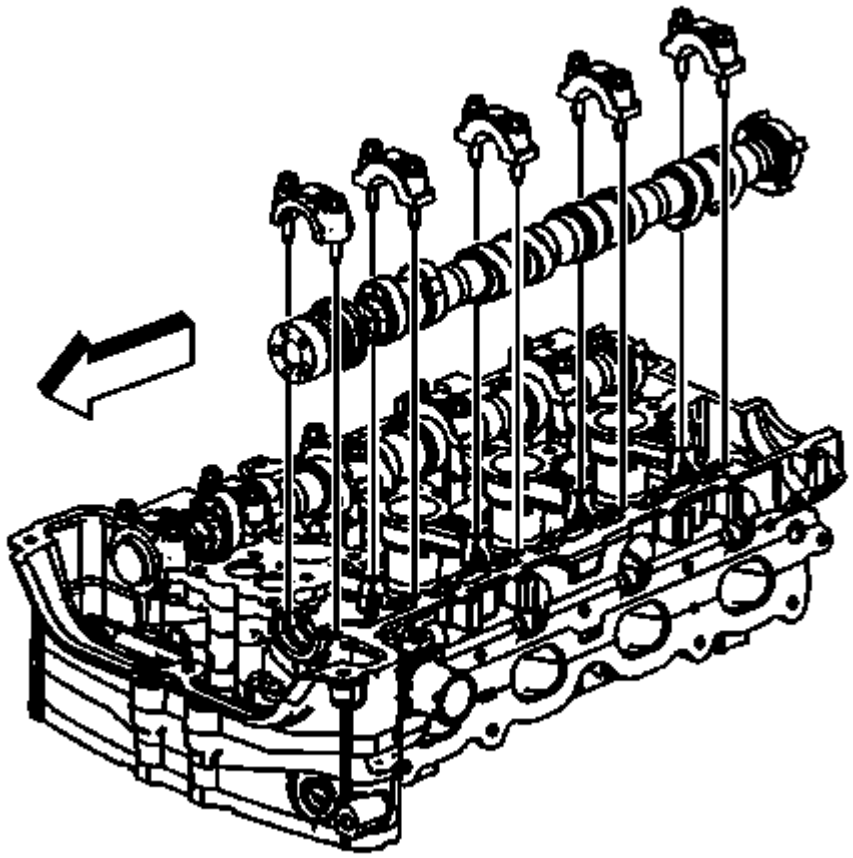

Fig. 339: Identifying Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

1. Mark camshaft caps to ensure they are installed in the same position.
2. Remove the intake camshaft cap bolts.
3. Remove the camshaft caps.
4. Remove the intake camshaft.

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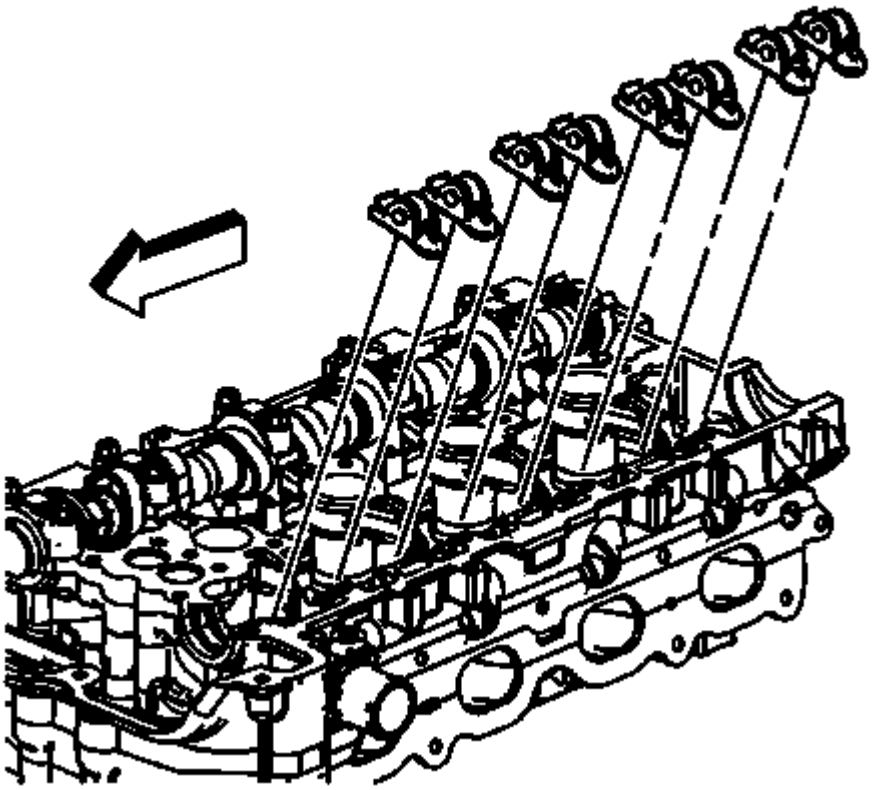

Fig. 340: Identifying Camshaft Roller Finger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

5. Remove the intake camshaft roller finger followers.

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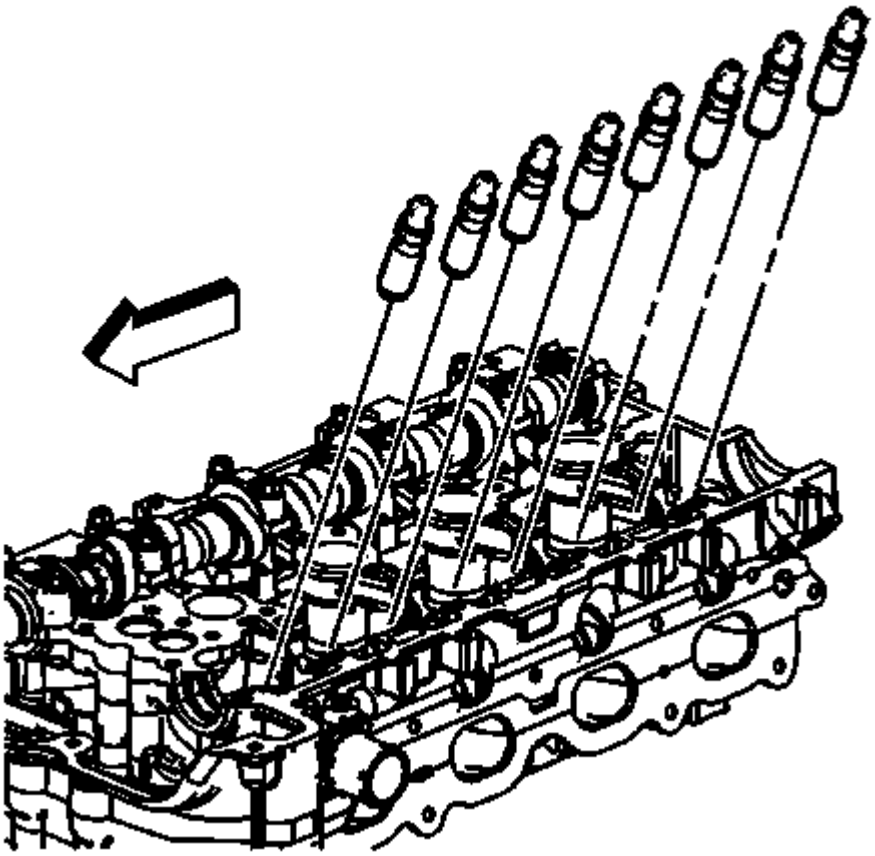

Fig. 341: Identifying Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

Exhaust Camshaft, Follower, and Adjuster Removal

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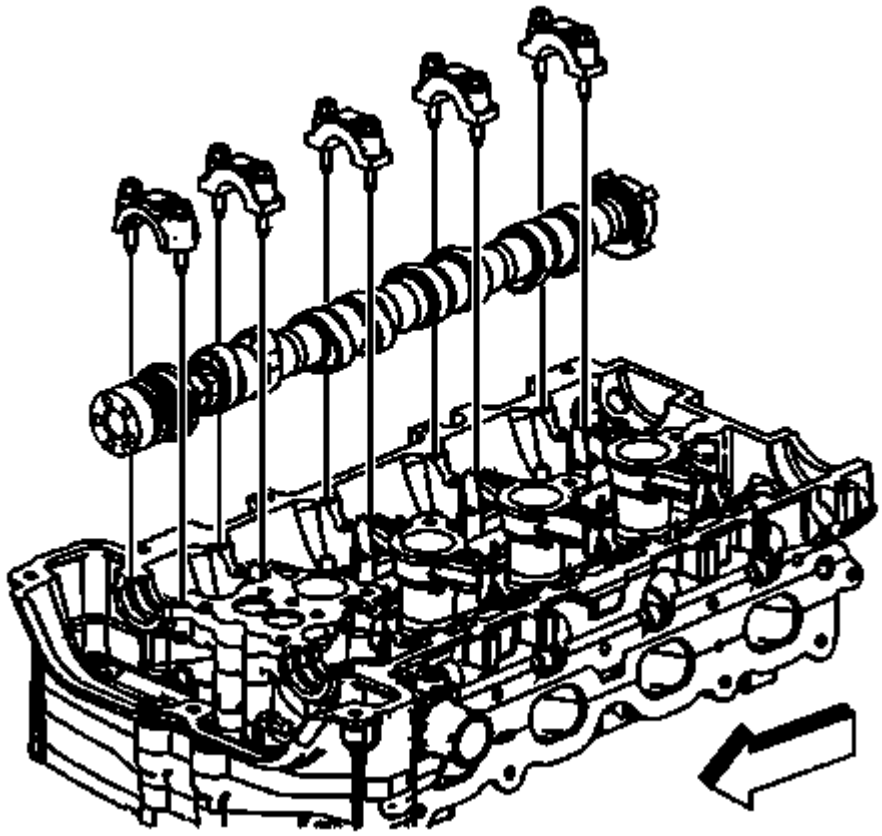

Fig. 342: Identifying Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Remove each bolt on each cap one turn at a time until there is no spring tension pushing on the camshaft.

1. Mark camshaft caps to ensure they are installed in the same position.
2. Remove the exhaust camshaft cap bolts.
3. Remove the camshaft caps ensuring they are marked and refitted in same position on assembly.
4. Remove the exhaust camshaft.

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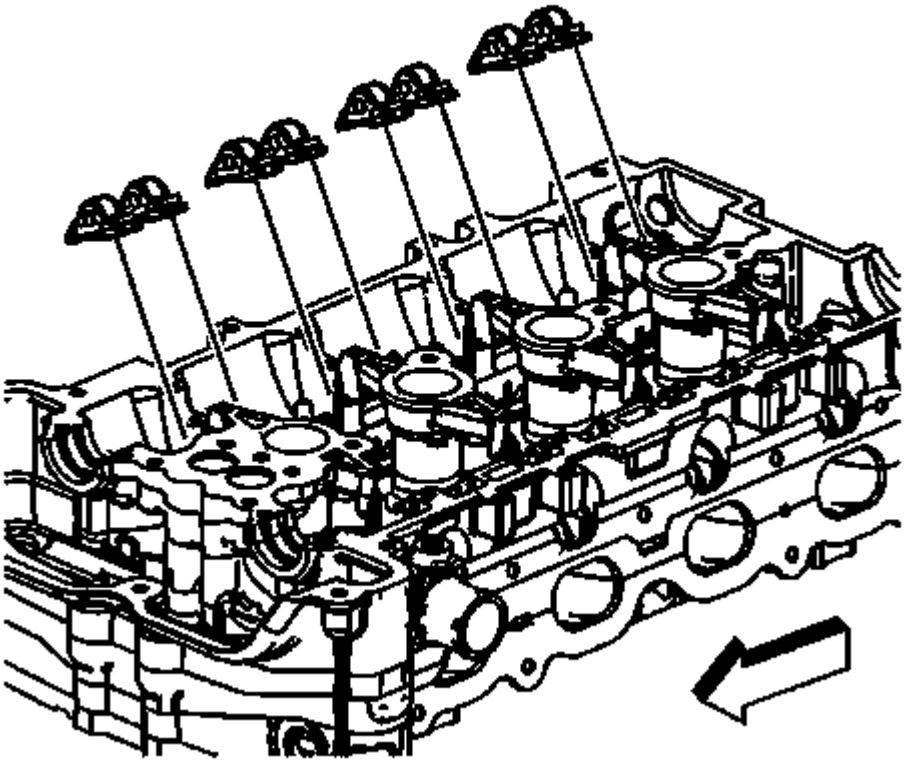

Fig. 343: Identifying Camshaft Roller Finger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Keep all of the roller finger followers and hydraulic lash adjusters in order so that they can be reinstalled in their respective locations.

5. Remove the exhaust camshaft roller finger followers.

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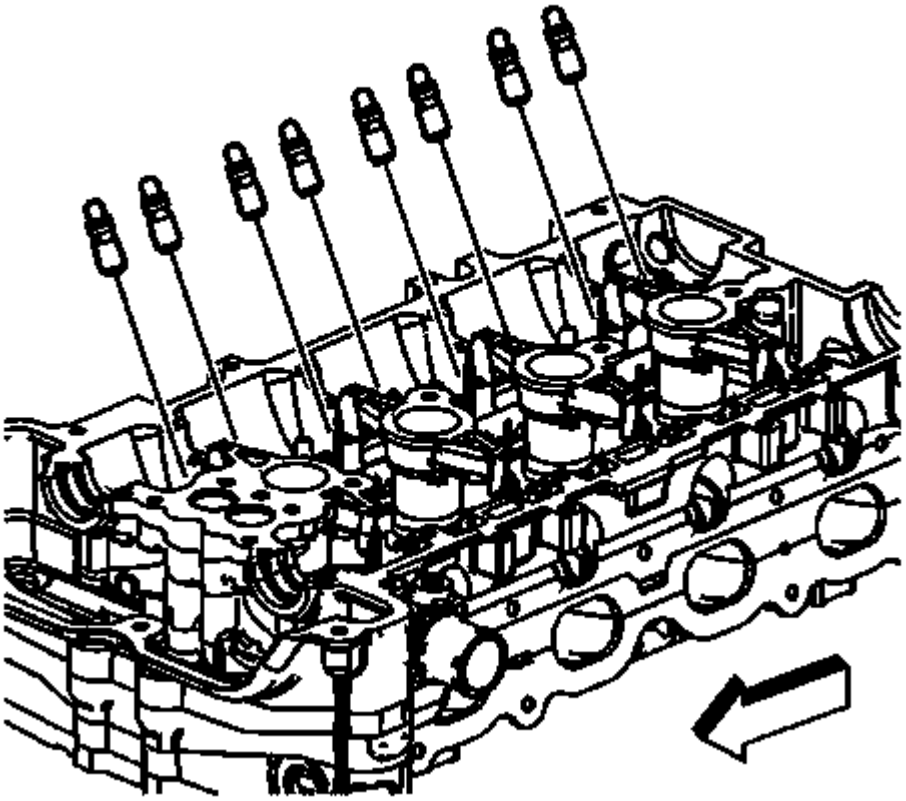

Fig. 344: Identifying Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

Balance Shaft Drive Chain and Tensioner Removal

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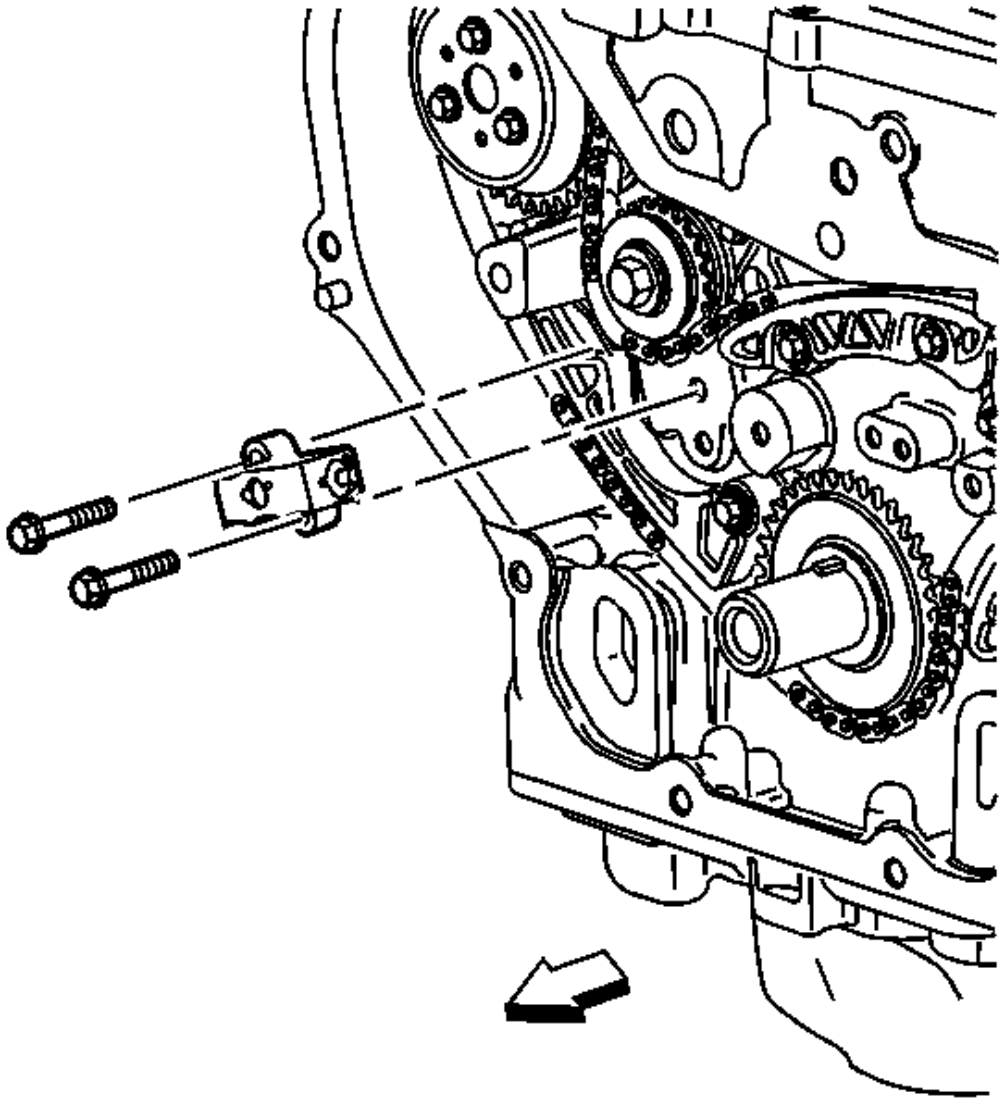

Fig. 345: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft drive chain tensioner bolts.
2. Remove the balance shaft drive chain tensioner.

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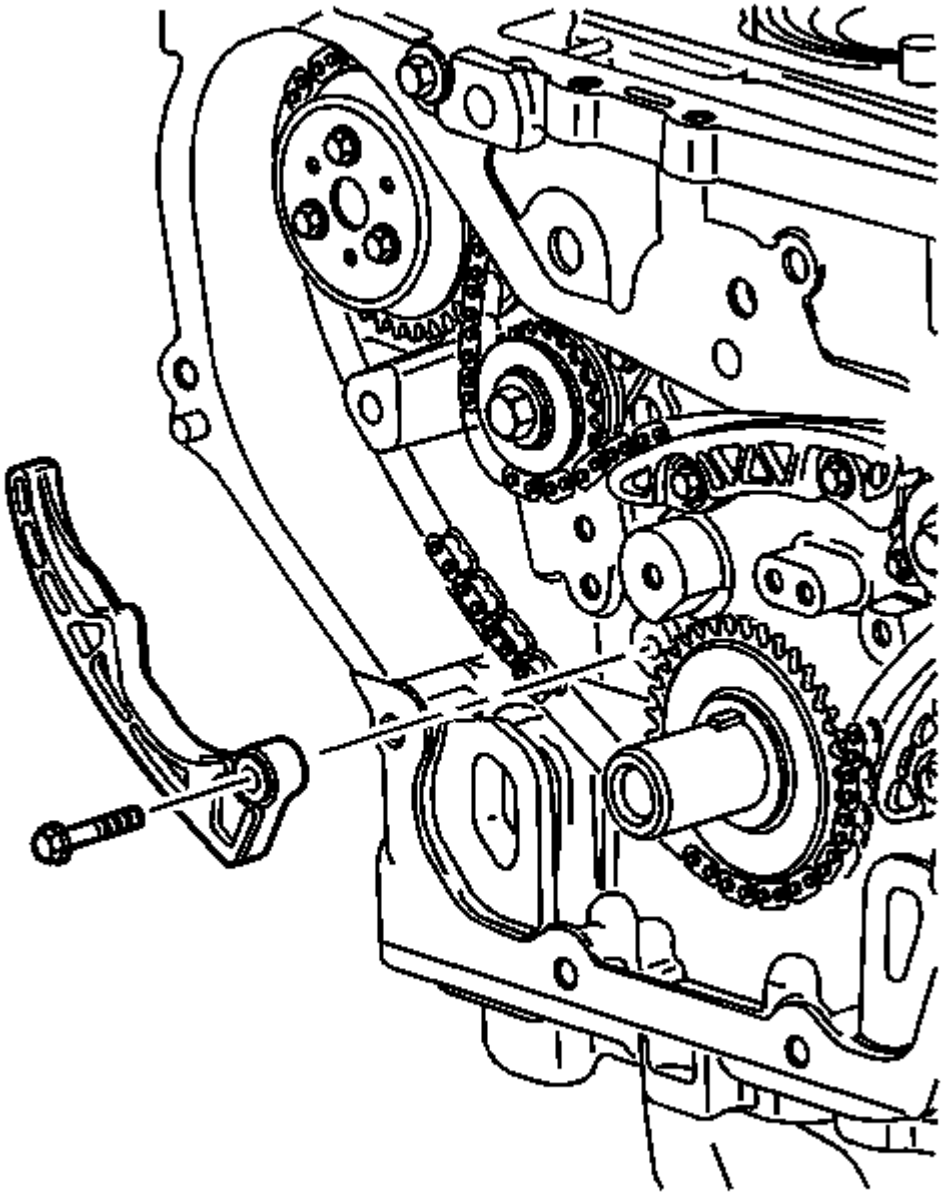

Fig. 346: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide.

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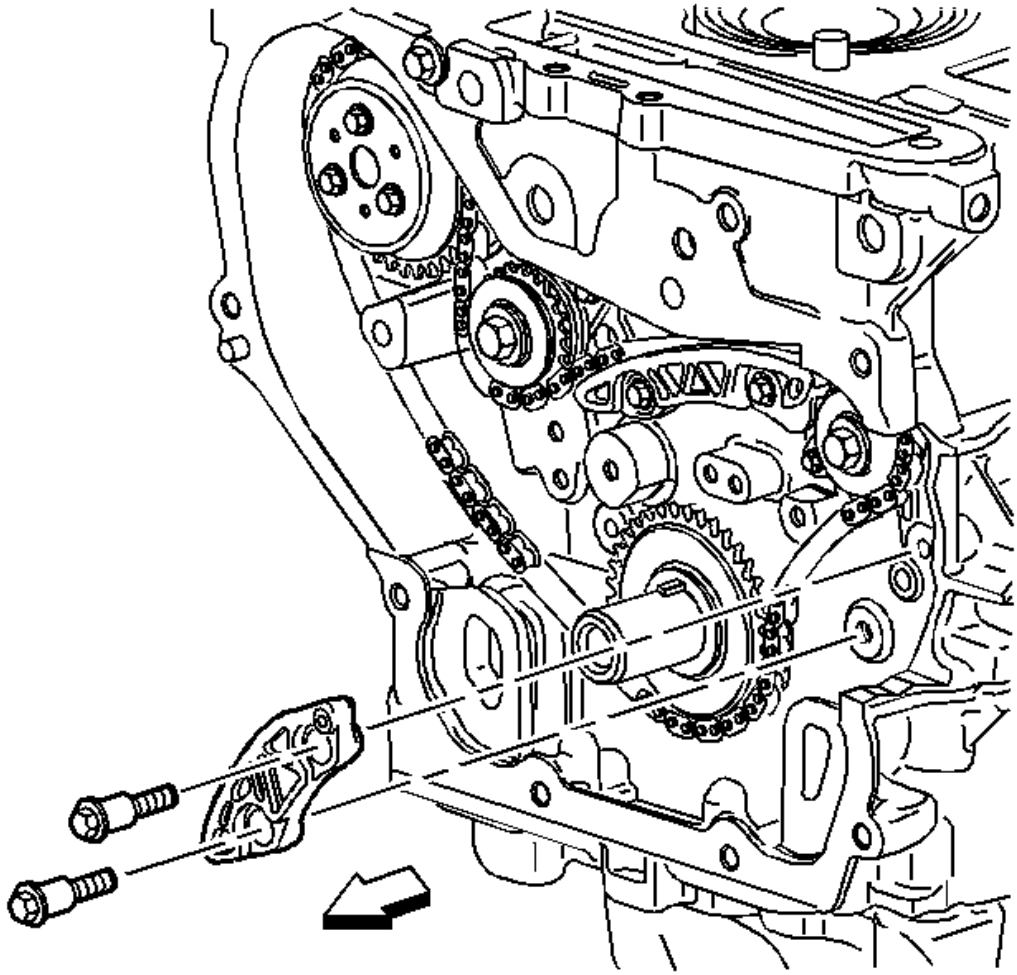

Fig. 347: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide.

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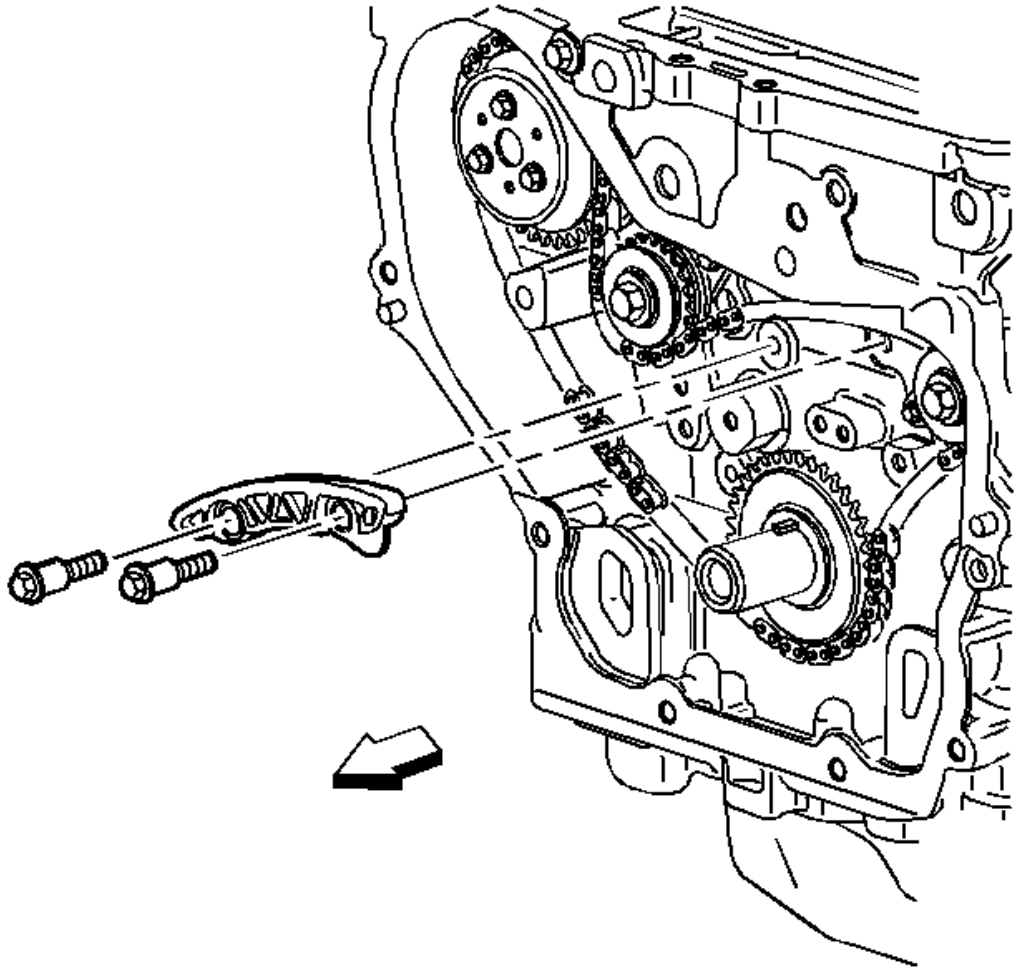

Fig. 348: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide.

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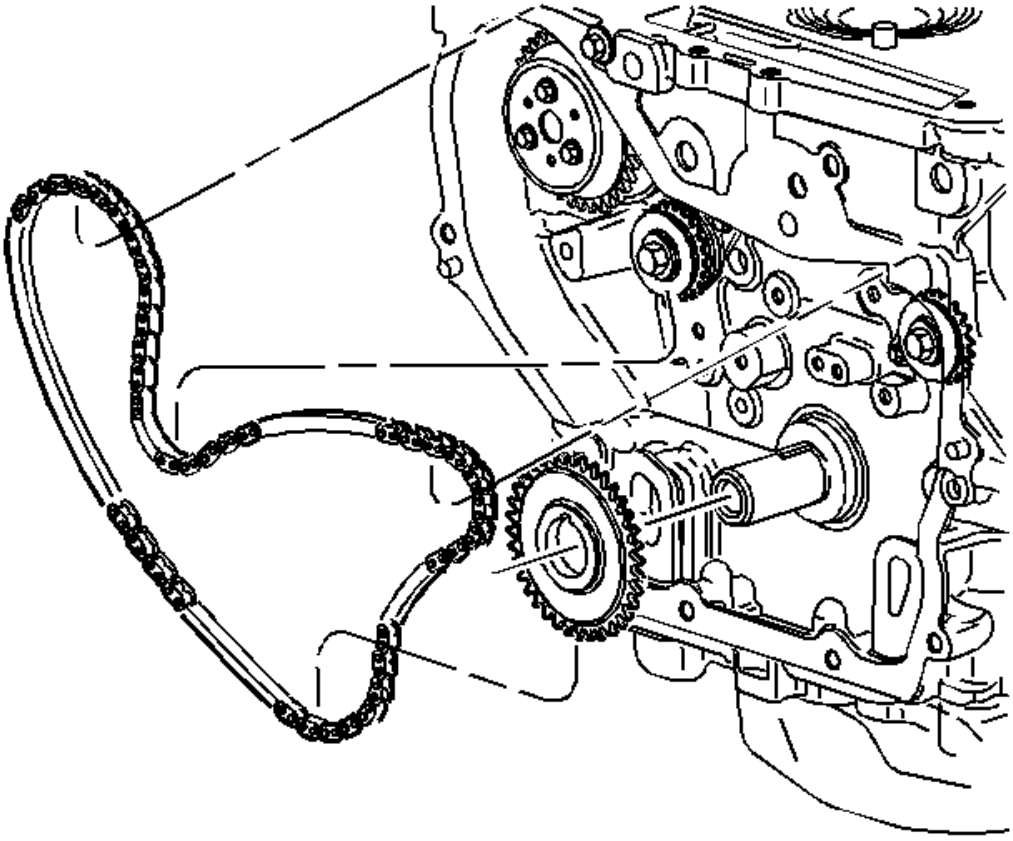

Fig. 349: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: It may ease removal of the balance shaft drive chain to get all of the slack in the chain between the crankshaft and water pump sprockets.

9. Remove the balance shaft drive chain.
10. Remove the balance shaft drive sprocket.

Balance Shaft Removal

Tools Required

J 43650 Balancer Shaft Bearing Remover and Installer

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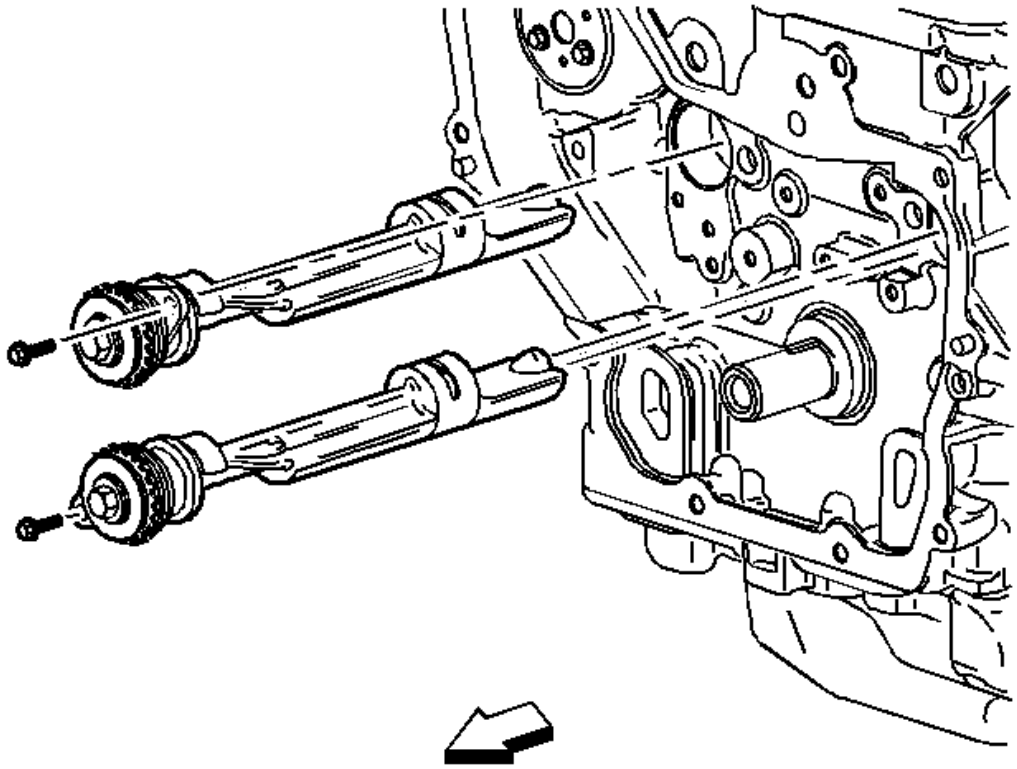

Fig. 350: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

IMPORTANT:

- **It is possible to install the intake side balance shaft into the exhaust side and vice versa. Please use care not to install the balance shafts into the wrong bores. Engine vibration will result.**
- **Do not remove the bolt holding the sprocket.**

2. Remove the balance shaft assemblies.

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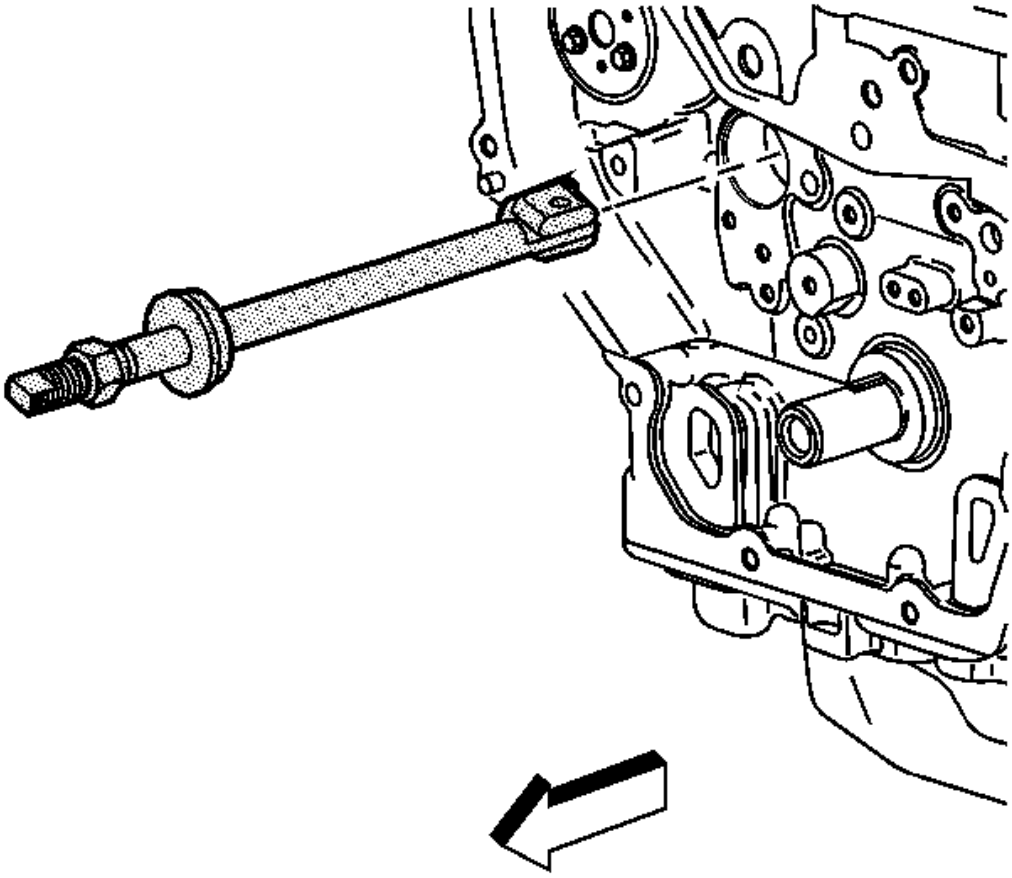

Fig. 351: Identifying J 43650
Courtesy of GENERAL MOTORS CORP.

NOTE: Proper centering of the tool is required on the balance shaft bushing. If the tool is not properly centered then damage to the bearing bore and block will occur.

3. Install the **J 43650** into the balance shaft hole. Insert the tool with the foot parallel to the shaft.

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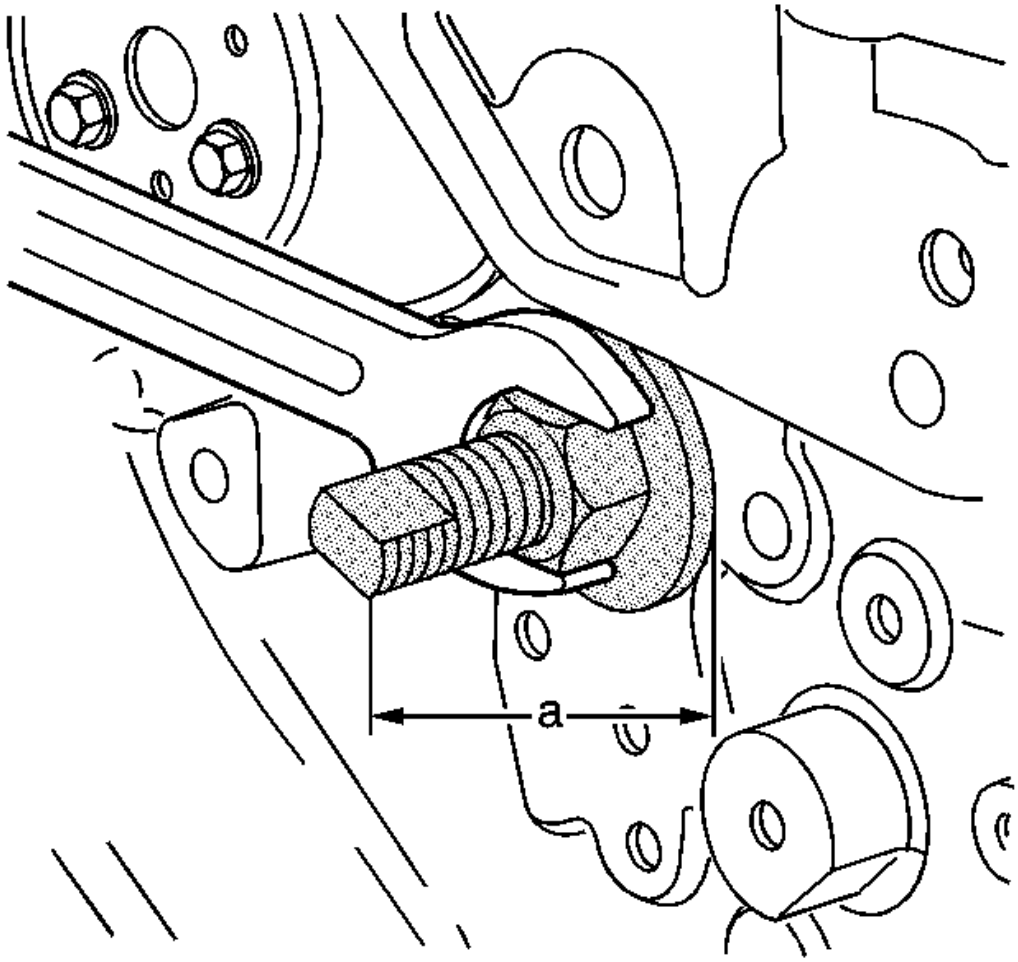

Fig. 352: Using J 43650
Courtesy of GENERAL MOTORS CORP.

4. When the **J 43650** is inserted in the block turn the **J 43650** so that the foot becomes perpendicular to the shaft.
5. Center the foot of the **J 43650** on the balance shaft bushing.
6. Once the **J 43650** is centered on the balance shaft bushing, then insert the centering guide into the front balance shaft bore and tighten the nut with an appropriate wrench.

   When the **J 43650** is properly installed, before removing the bushing, the end of the tool should be 116 mm (4.6 in) (a) from the block face.

   If the **J 43650** is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.

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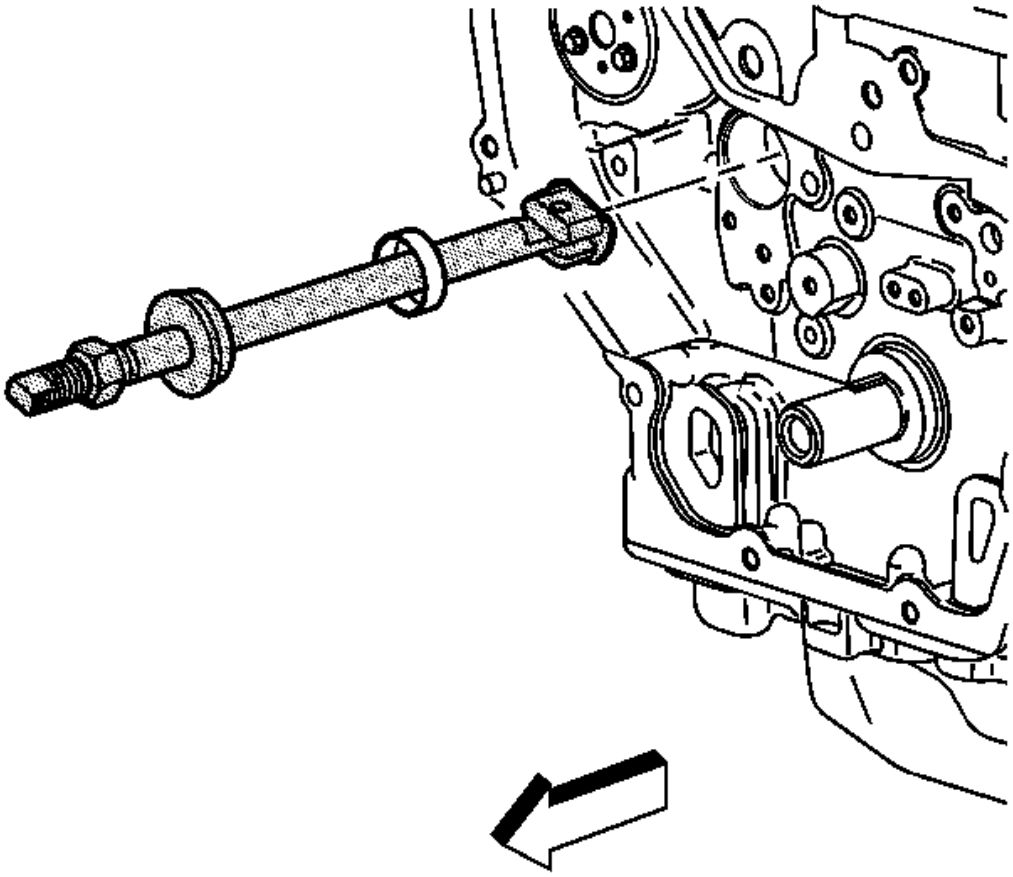

Fig. 353: View of J 43650
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **J 43650** until the tension releases. When the tension releases, remove the **J 43650** and the balance shaft bushing.

Water Pump Removal

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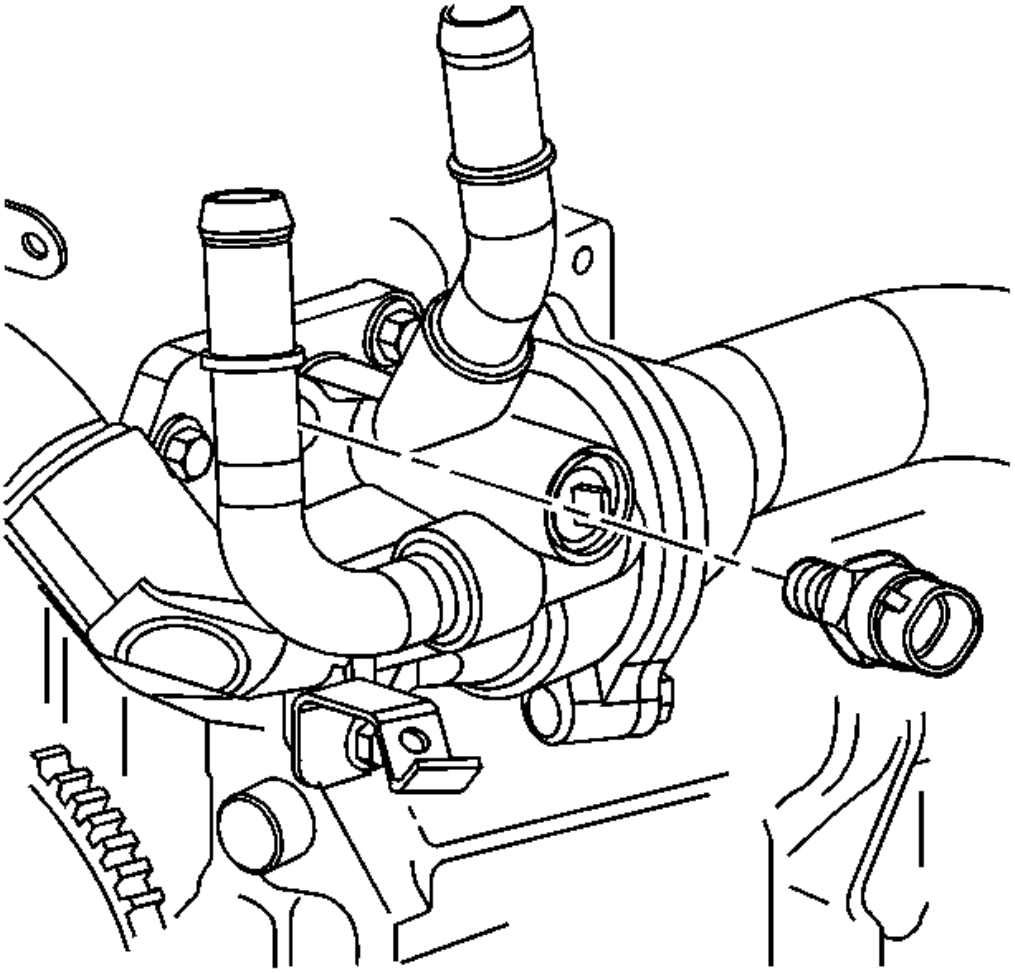

Fig. 354: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

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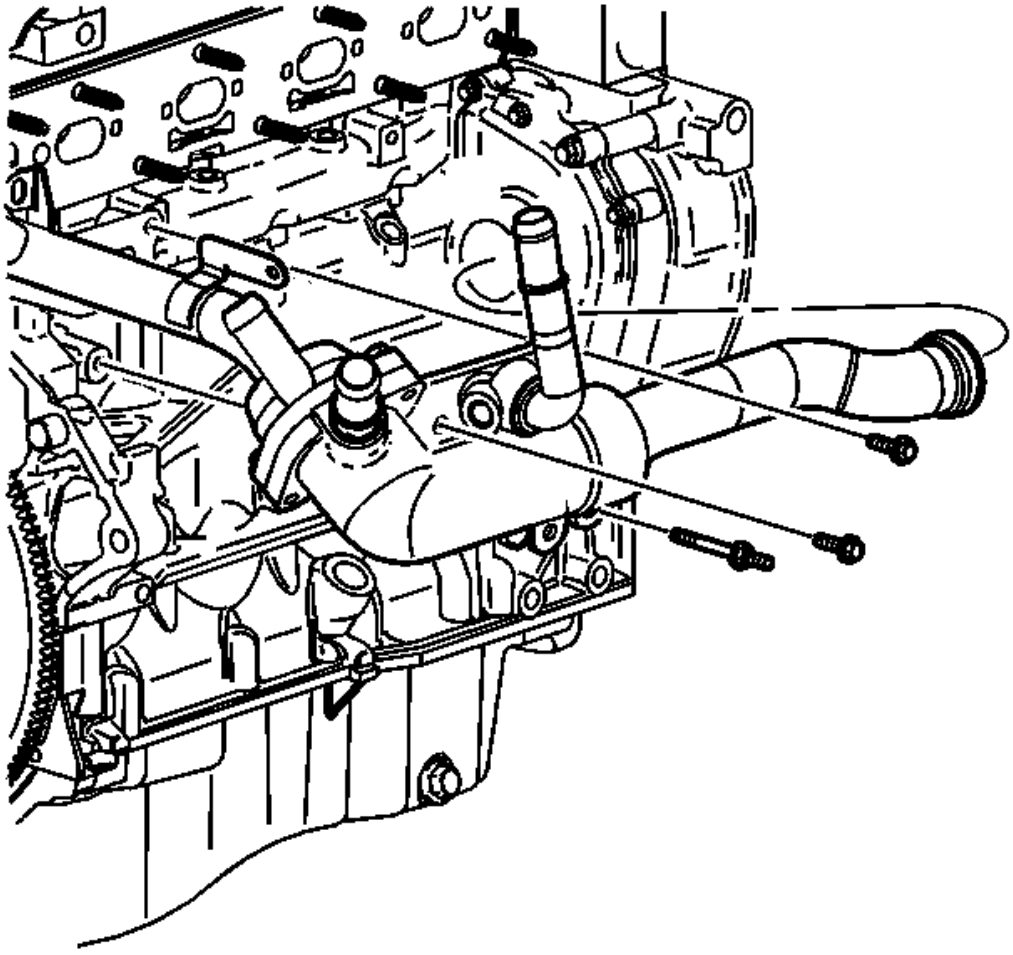

Fig. 355: View Of Water Feed Pipe
Courtesy of GENERAL MOTORS CORP.

2. Remove the thermostat and water feed pipe retaining bolts.

IMPORTANT: Twist the water feed pipe while pulling to remove it from the water pump cover.

3. Remove the thermostat housing and water feed pipe from the water pump cover.

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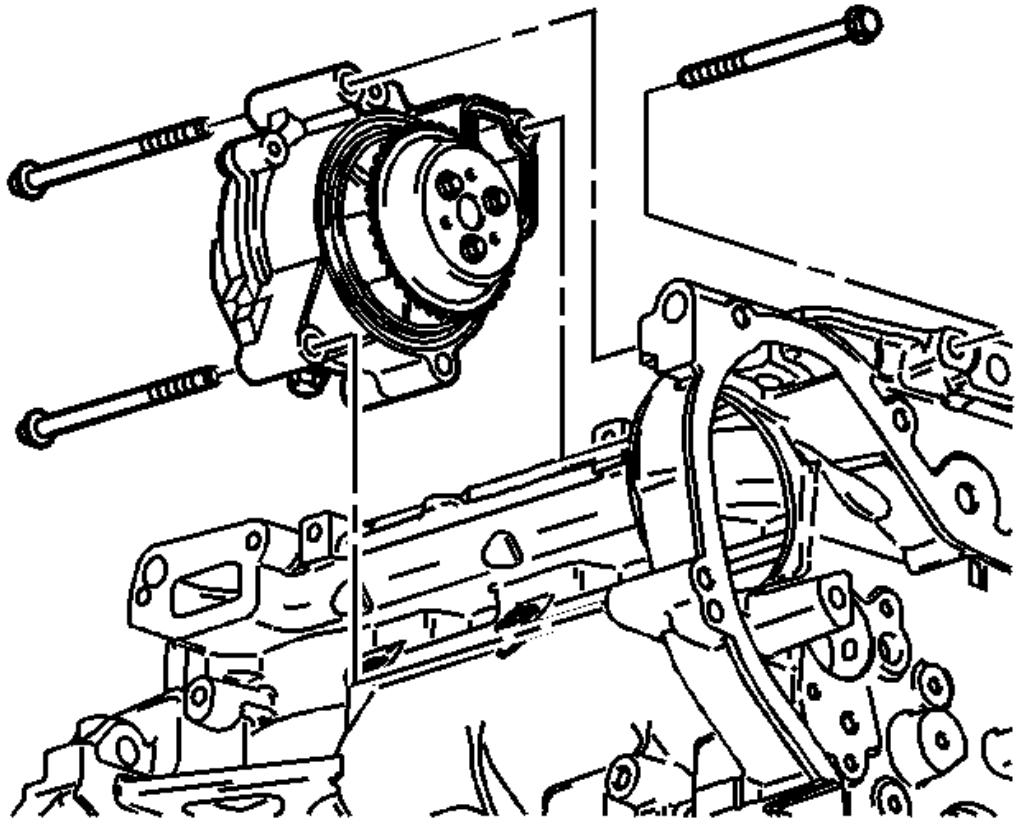

Fig. 356: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

4. Remove the water pump retaining bolts. Be sure to remove the bolt that goes through the front of the engine block.
5. Remove the water pump assembly.

Cylinder Head Removal

Tools Required

J 38188 Cylinder Head Broken Bolt Extractor Kit

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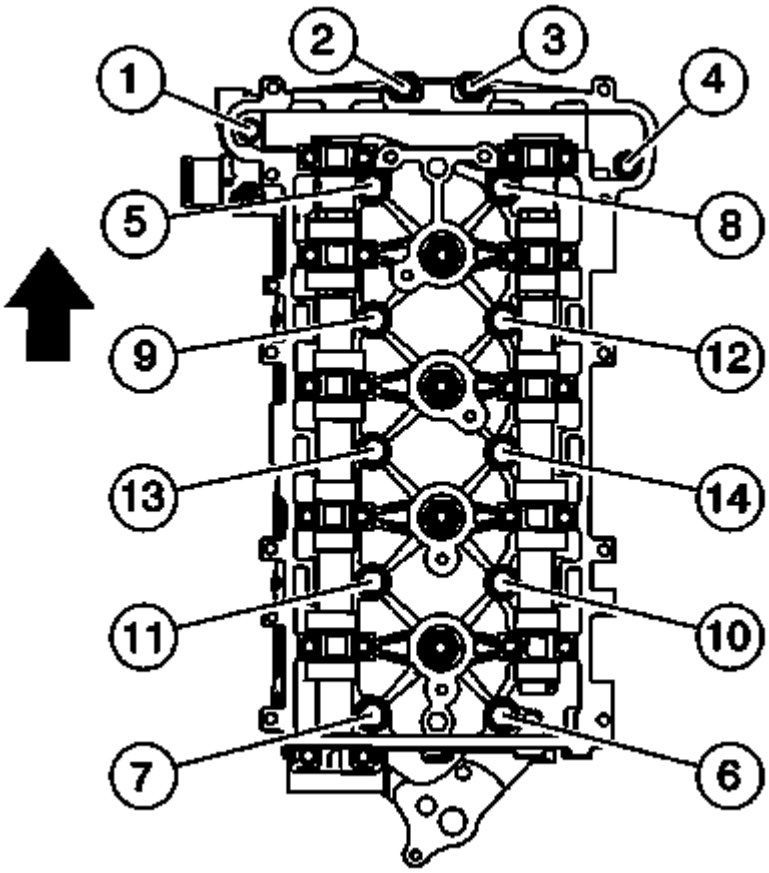

Fig. 357: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head to the block bolts in sequence.

   Discard the bolts.

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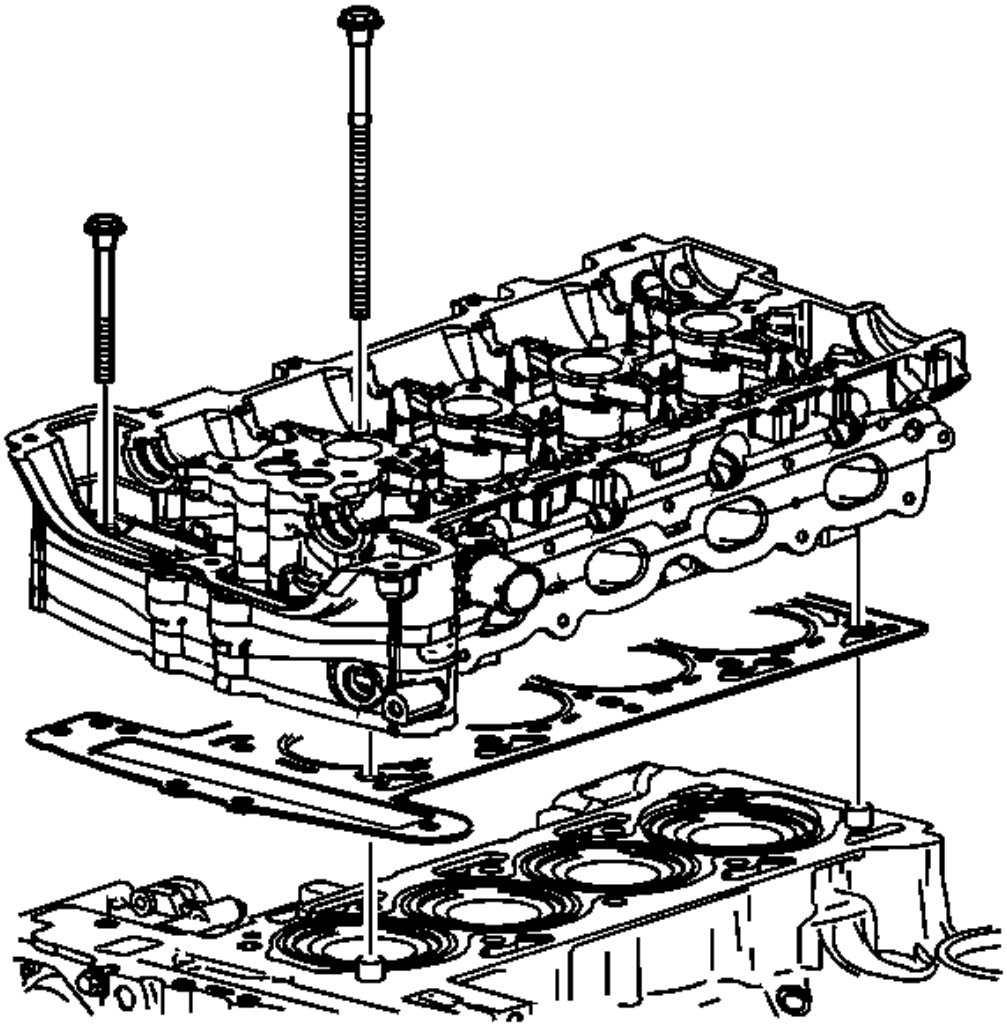

Fig. 358: View Of Cylinder Head, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Remove the cylinder head.
3. Remove the cylinder head gasket.
4. Clean all of the gasket surfaces.
5. Use the following procedures when cleaning the cylinder head and cylinder block surfaces:
    - Use a razor blade gasket scraper to clean the cylinder head and cylinder block gasket surfaces. Do not scratch or gouge any surface.

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IMPORTANT: Do not use any other method or technique to clean these gasket surfaces.

- Use a new razor blade for each cylinder head and cylinder block.

IMPORTANT: Be careful not to gouge or scratch the gasket surfaces. Do not gouge or scrape the combustion chamber surfaces. The feel of the gasket surface is important, not the appearance. There will be indentations from the gasket left in the cylinder head after all of the gasket material is removed. These small indentations will be filled in by the new gasket.

- Hold the razor blade as parallel to the gasket surface as possible.

IMPORTANT: Do not use a tap to clean the cylinder head bolt holes.

6. Clean the old sealer/lube and dirt from the bolt holes.
7. Clean the bolt holes with a nylon bristle brush.

CAUTION: Wear safety glasses to avoid injury when using compressed air or any cleaning solvent. Bodily injury may occur if fumes are inhaled or if skin is exposed to chemicals.

8. When cleaning the cylinder head bolt holes use a suitable commercial spray liquid solvent and compressed air from an extended-tip blow gun to reach the bottom of the holes.
9. Remove any broken long cylinder head bolts using the **J 38188** .

Oil Pan Removal

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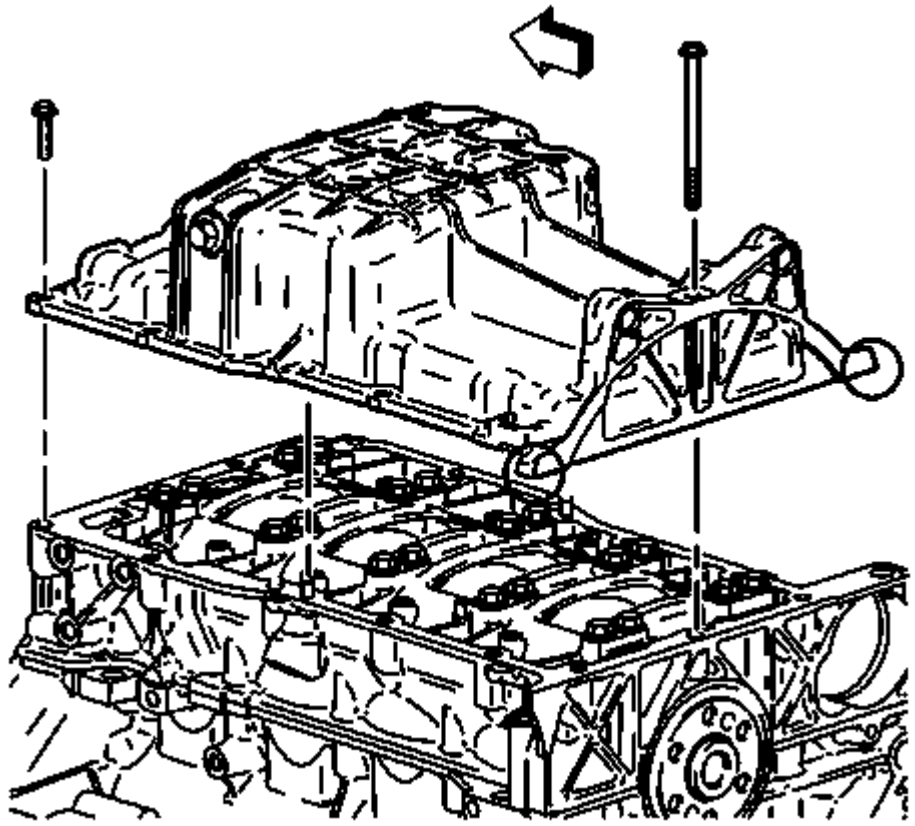

Fig. 359: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Remove the oil pan bolts.
2. Remove the oil pan at pry points.

Piston, Connecting Rod, and Bearing Removal

Tools Required

J-43966-1 Connecting Rod Guides. See **Special Tools**.

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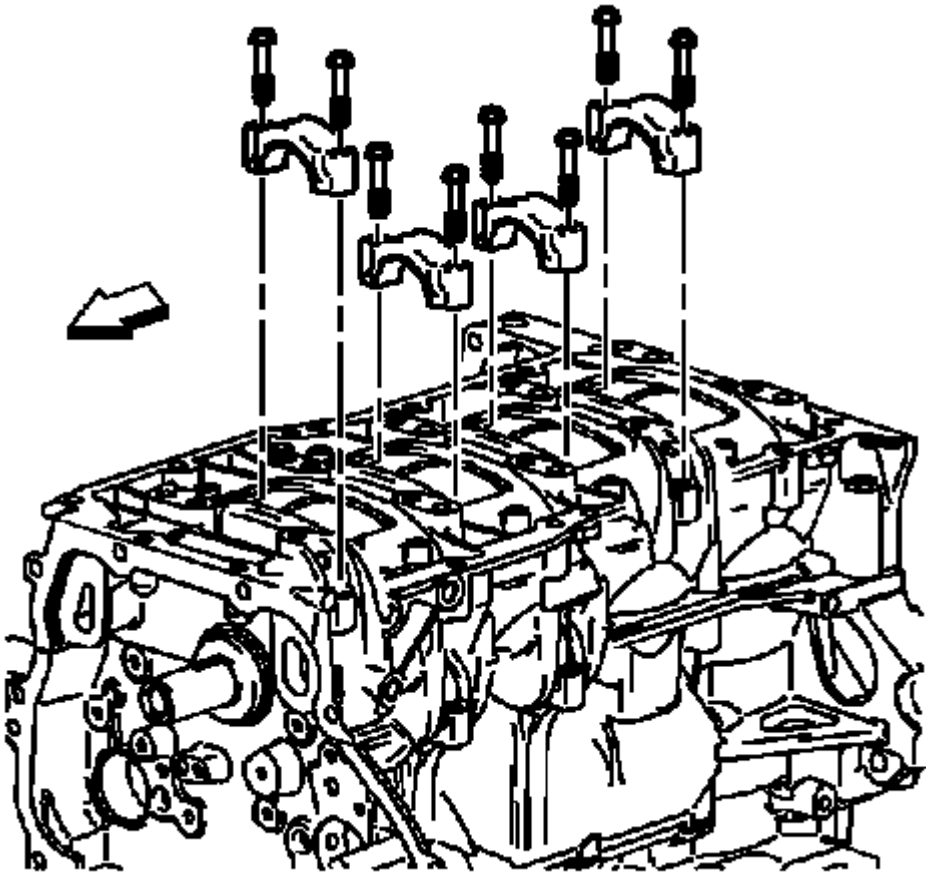

Fig. 360: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

1. Rotate the crankshaft to a position where the connecting rod bolts are the most accessible.
2. Mark the connecting rod and cap with the cylinder position. Also mark their orientation. This will ensure the caps and connecting rods are re-assembled properly.
3. Remove any ridge at the top of the cylinder bore to avoid damage to the piston ring lands.
4. Remove the connecting rod bolts.
5. Remove the connecting rod cap.

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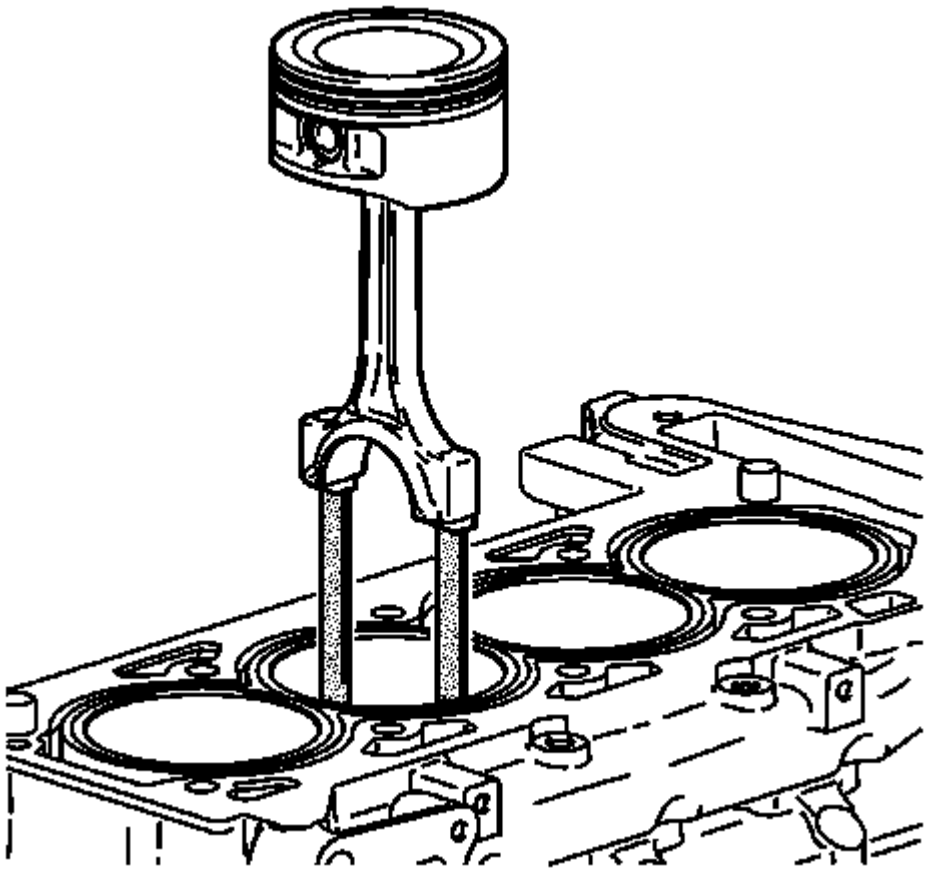

Fig. 361: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

6. Install **J-43966-1** on the connecting rod bolts before removing the piston and connecting rod assembly. See **Special Tools**.
7. Remove the piston and connecting rod assembly.

Lower Crankcase Removal

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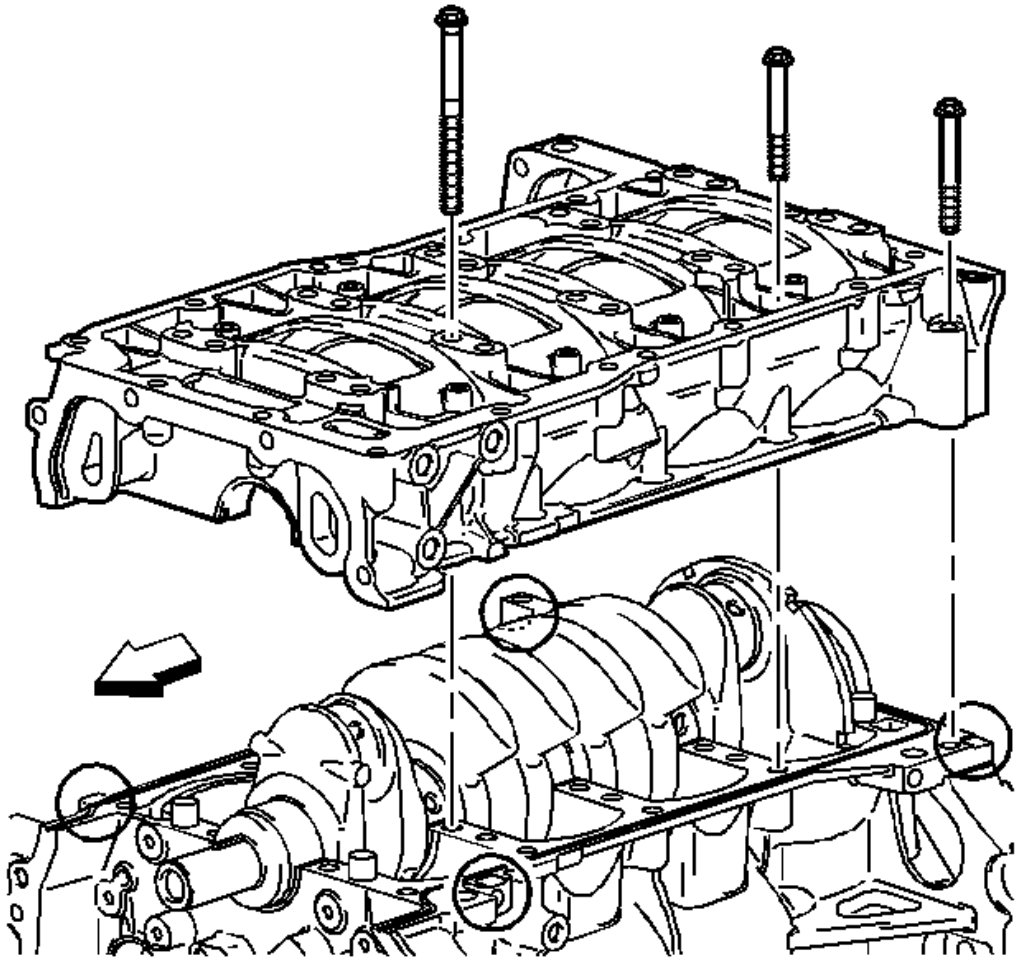

Fig. 362: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft position sensor.
2. Inspect the crankshaft position sensor for damage and replace, if necessary.
3. Remove the bedplate perimeter bolts.

IMPORTANT: Do not forget the 2 outside rear bolts.

4. Remove and discard the crankshaft bearing bolts.
5. Using the pry-points and an appropriate prying tool, gently separate the upper and lower crankcase.

Crankshaft and Bearings Removal

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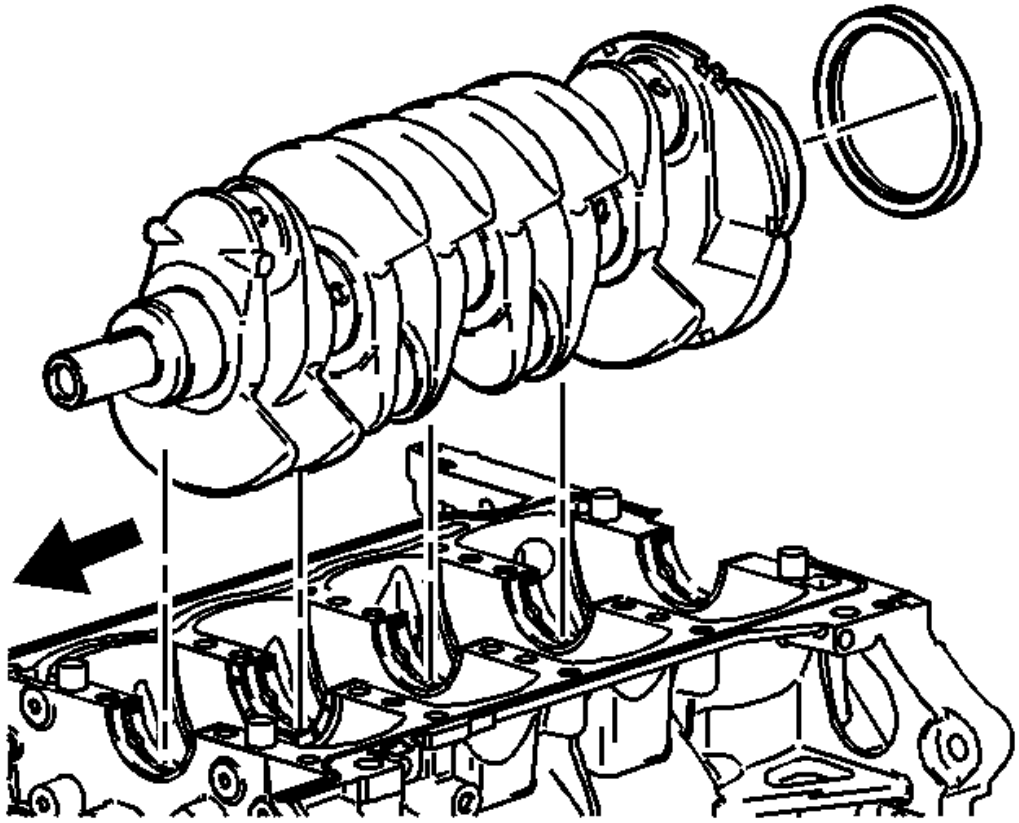

Fig. 363: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft from the block.
2. Remove the crankshaft rear oil seal from the block.

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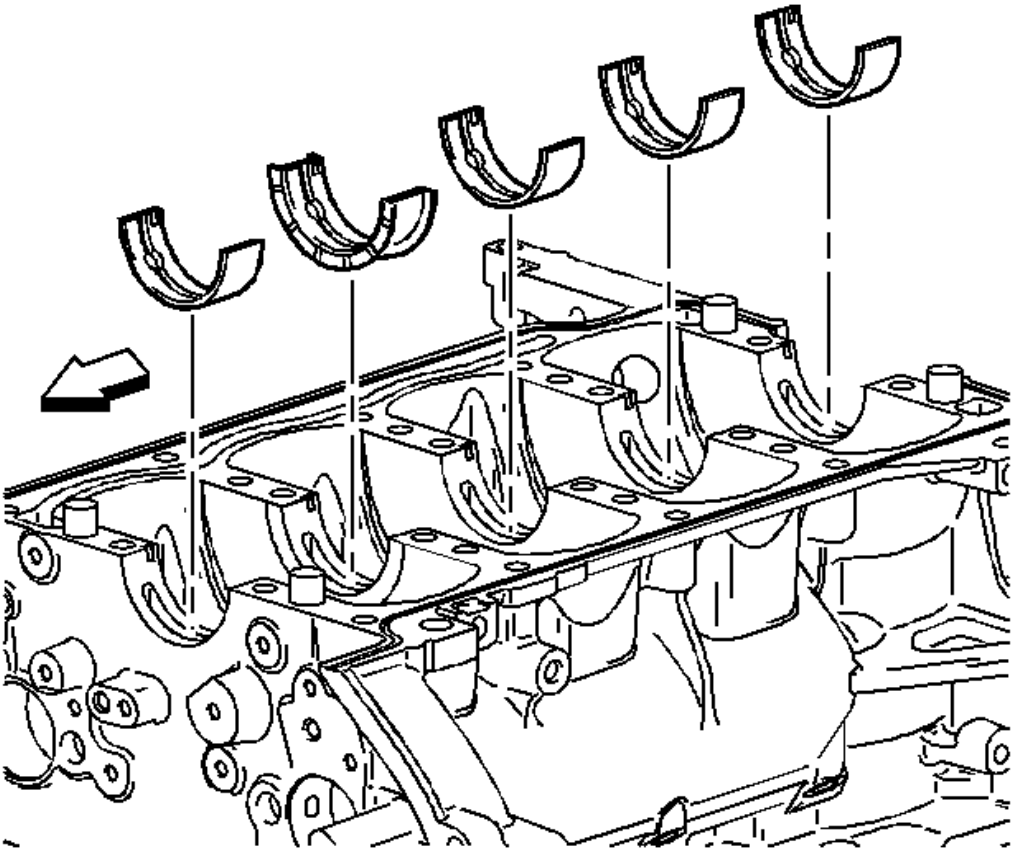

Fig. 364: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

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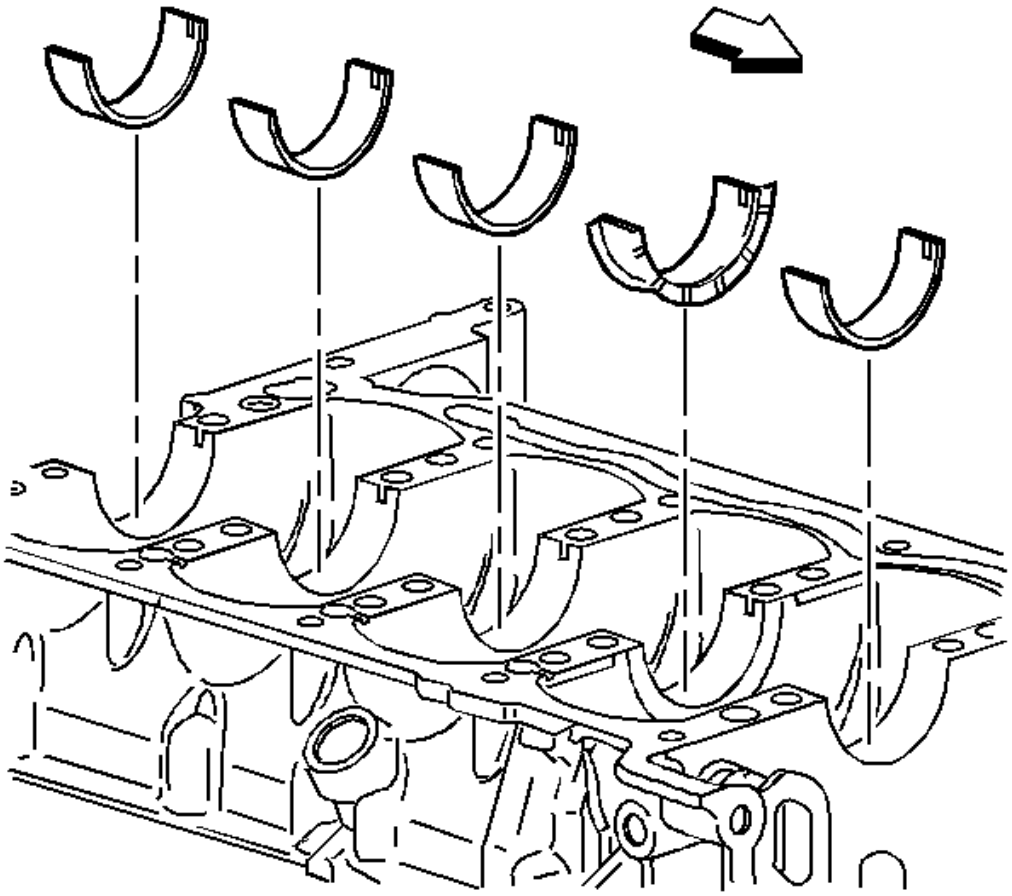

Fig. 365: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

4. Remove the bearing inserts from the bed plate.
5. Clean the oil, sludge, and carbon.
6. Inspect the oil passages for obstructions.
7. Inspect the threads.
8. Inspect the bearing journals and the thrust surfaces for the following conditions:
    - Cracks
    - Chips
    - Gouges
    - Roughness
    - Grooves

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- Overheating (discoloration)

9. Inspect the corresponding bearing inserts for imbedded foreign material. If foreign material exists find the cause and repair it.

IMPORTANT: Replace the crankshaft if cracks, severe gouges or burned spots are found. Slight roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

10. Measure the crankshaft journals. Use a micrometer or dial indicator to measure the taper and runout. Note the result for the later selection of bearing inserts. If not within limits the crankshaft must be replaced.

    Note the location of the main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

Engine Block Disassemble

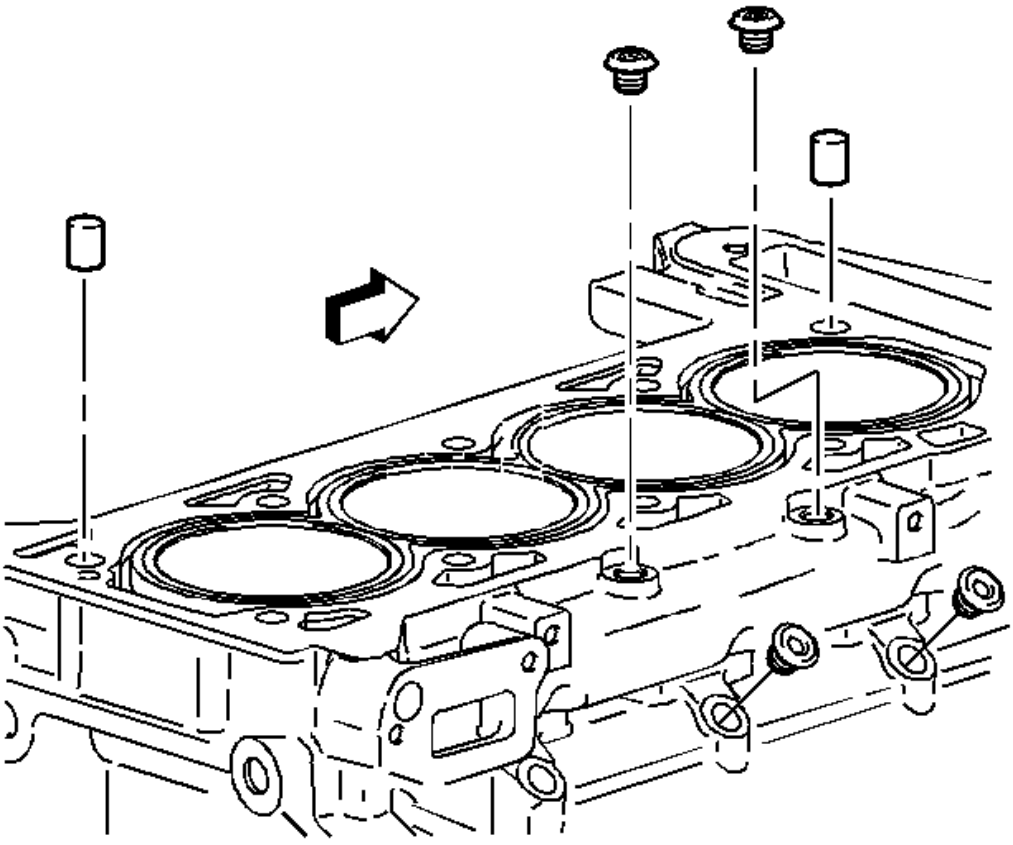

Fig. 366: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug

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Courtesy of GENERAL MOTORS CORP.

1. Remove the water jacket drain plug.
2. Remove the oil flow check valve.
3. Remove the rear oil passage plug.
4. Remove the 6 oil passage plugs on the sides of the block.
5. Remove the 2 water passage plugs on the top of the block.
6. Remove the 2 front oil passage plugs.

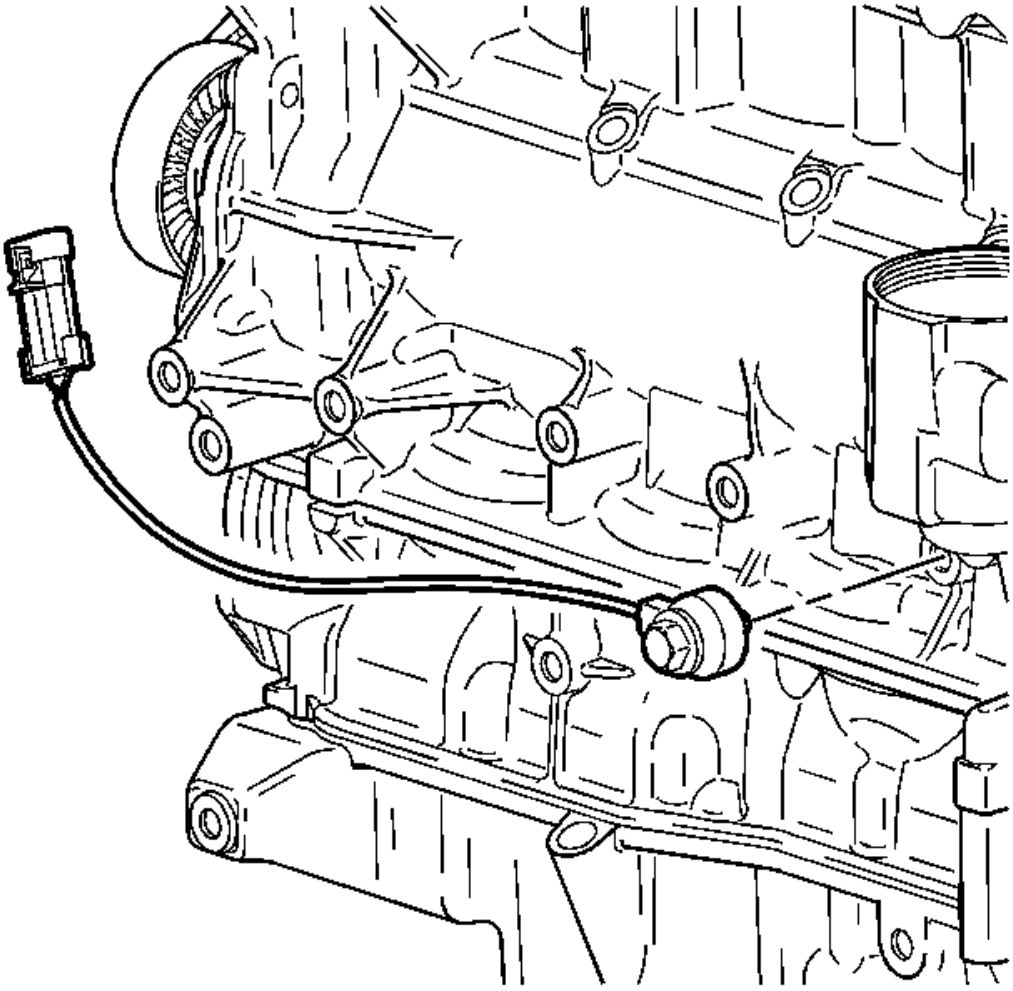

Fig. 367: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

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7. Remove the knock sensor and bolt.

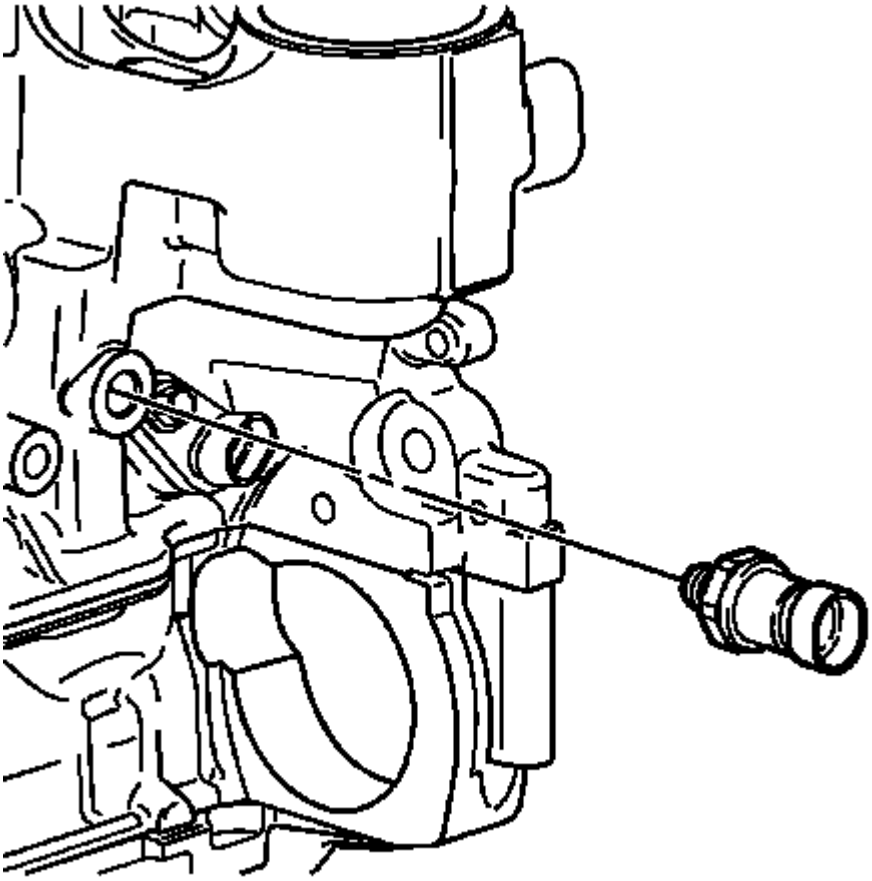

Fig. 368: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the oil pressure switch.

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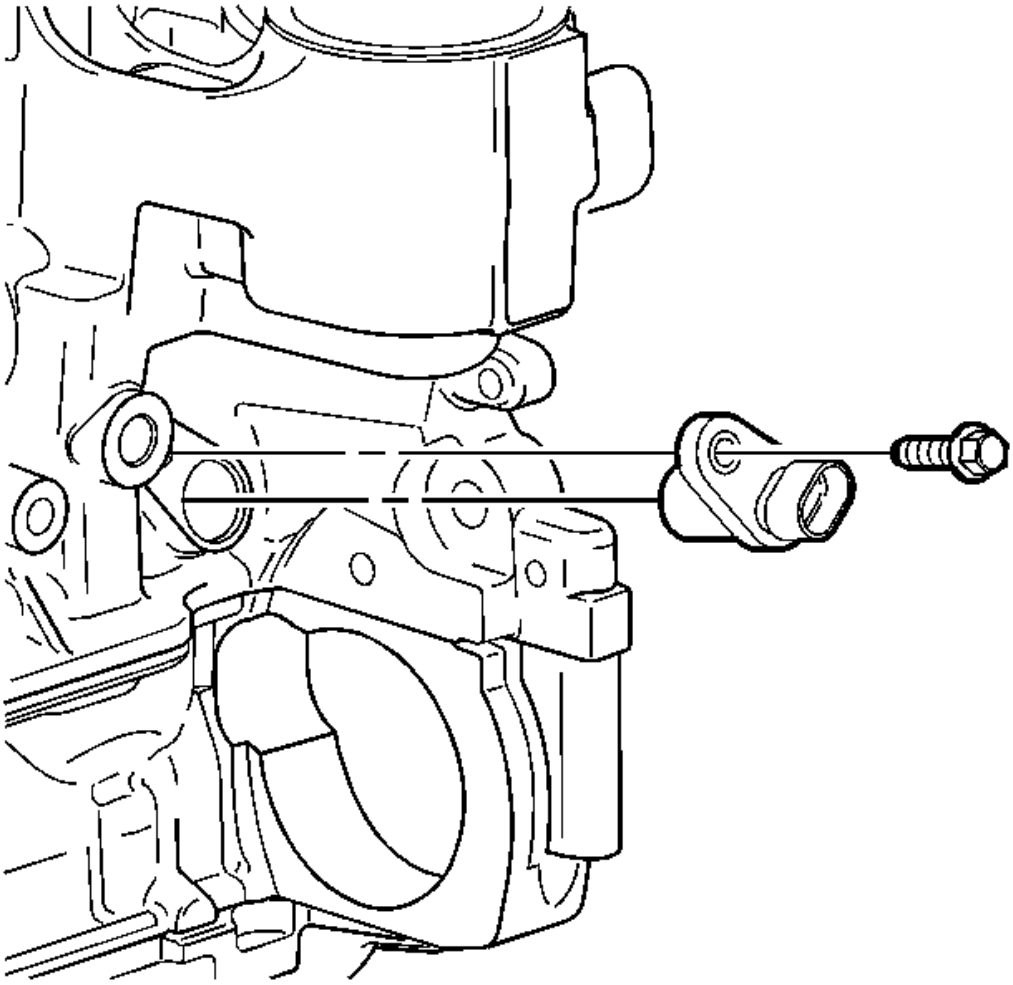

Fig. 369: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

9. Remove the crankshaft position (CKP) sensor and bolt.

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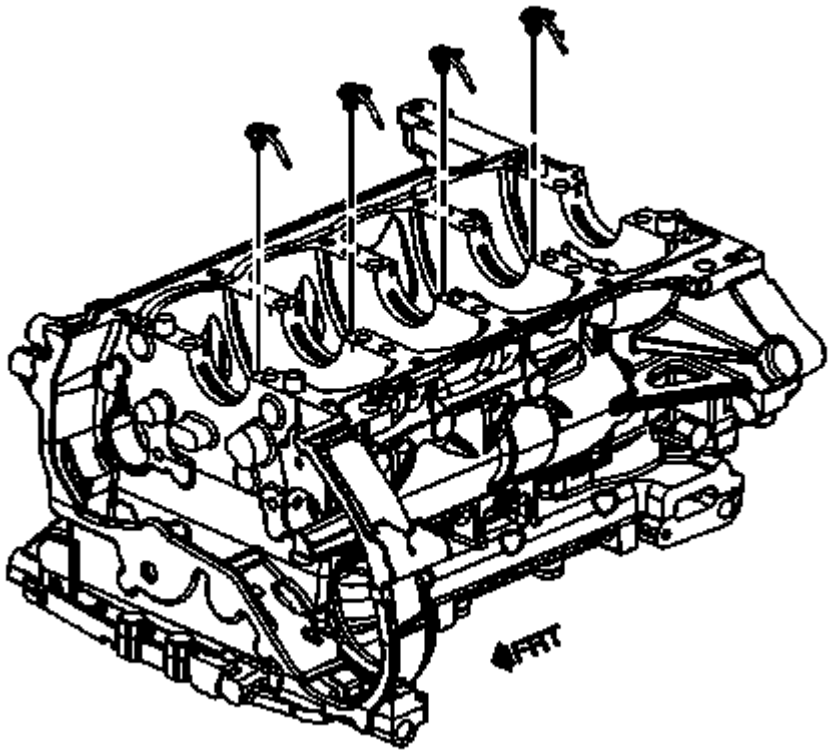

Fig. 370: Identifying Piston Oil Squirters
Courtesy of GENERAL MOTORS CORP.

10. Remove the piston oil squirter bolt.
11. Remove the piston oil squirter.

Engine Block Cleaning and Inspection

Tools Required

- **J 7872** Magnetic Base Dial Indicator
- **J 8087** Cylinder Bore Gage

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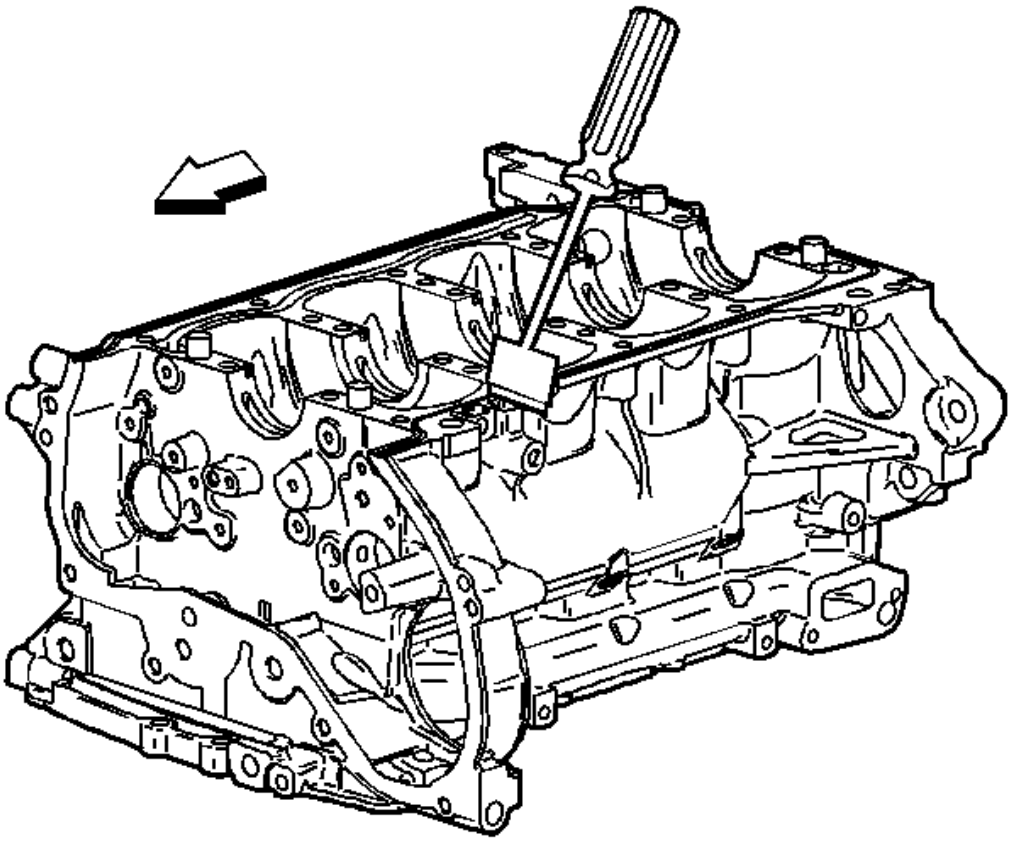

Fig. 371: Cleaning Gasket Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces.
2. Clean the engine block and lower crankcase in a cleaning tank with solvent appropriate for aluminum.
3. Flush the engine block with clean water or steam.
4. Clean the oil passages.
5. Clean the blind holes.
6. Spray the cylinder bores and the machined surfaces with engine oil.
7. Inspect the threaded holes. Clean the threaded holes with a rifle brush. If necessary, drill out the holes and install thread inserts. Refer to **Thread Repair** .

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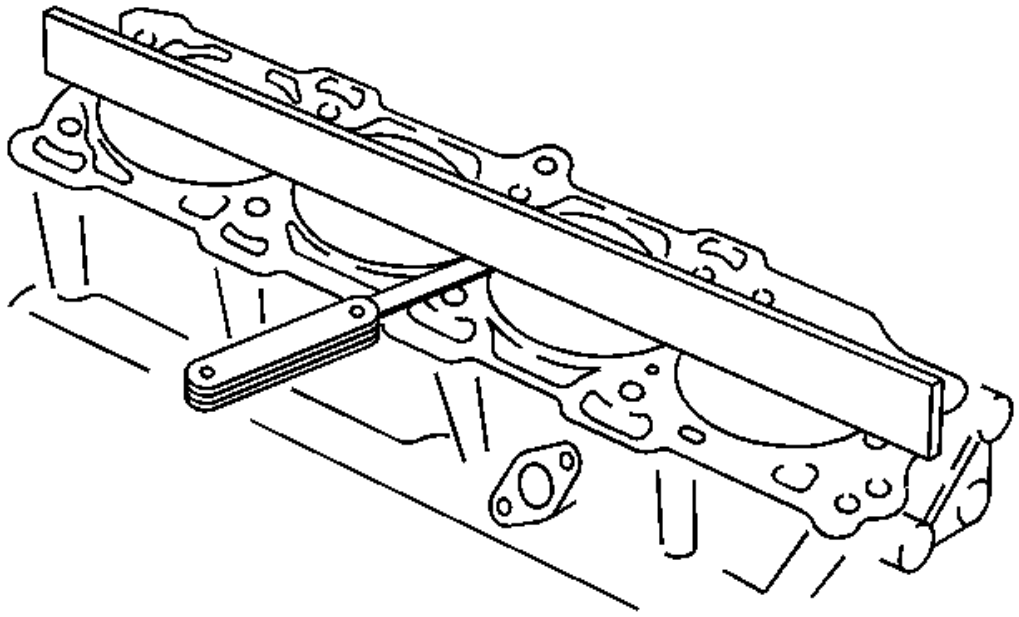

Fig. 372: Checking Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not attempt to machine the lower crankcase to engine block surfaces.

8. Use a straight edge and a feeler gage to check the deck surface for flatness. Carefully machine minor irregularities. Replace the block if more than 0.254 mm (0.010 in) must be removed.
9. Inspect the oil pan rail for nicks. Inspect the front cover attaching area for nicks. Use a flat mill file to remove any nicks.

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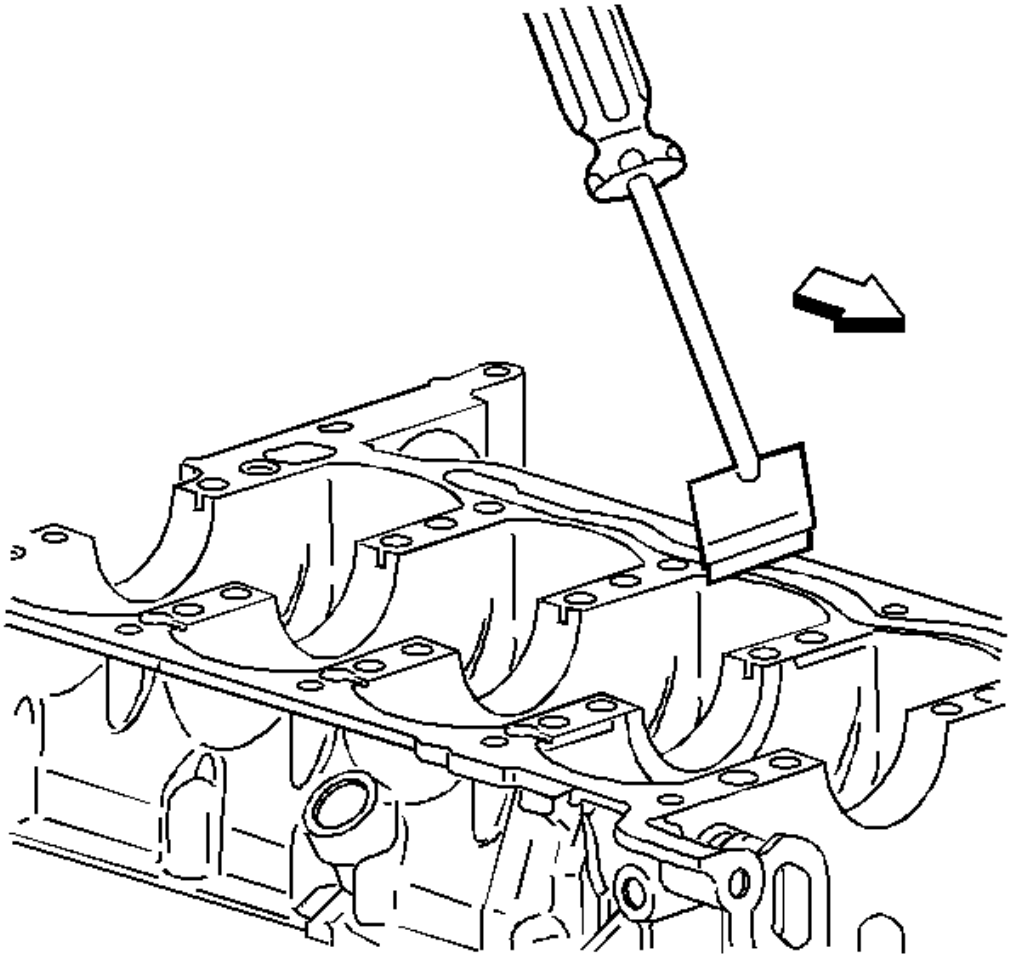

Fig. 373: Cleaning Sealing Material From Gasket Mating Surfaces - Engine Block Side
Courtesy of GENERAL MOTORS CORP.

10. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side.

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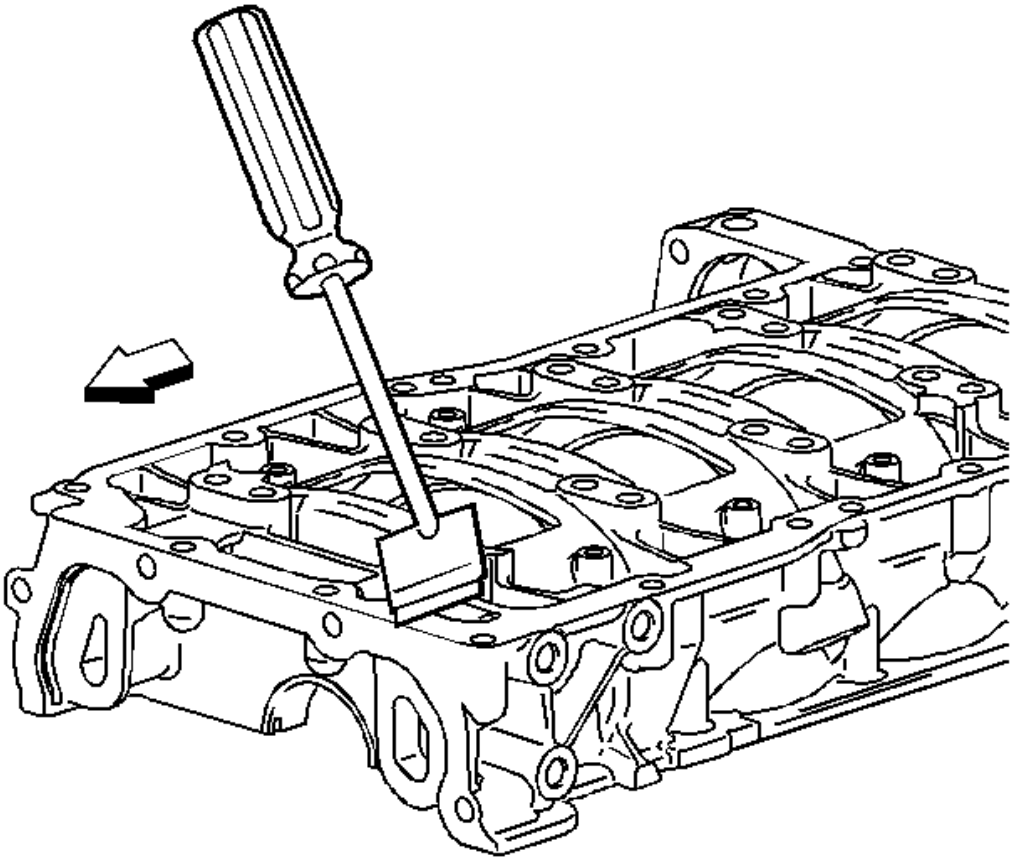

Fig. 374: Cleaning Sealing Material From Gasket Mating Surfaces - Oil Pan Side
Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side.

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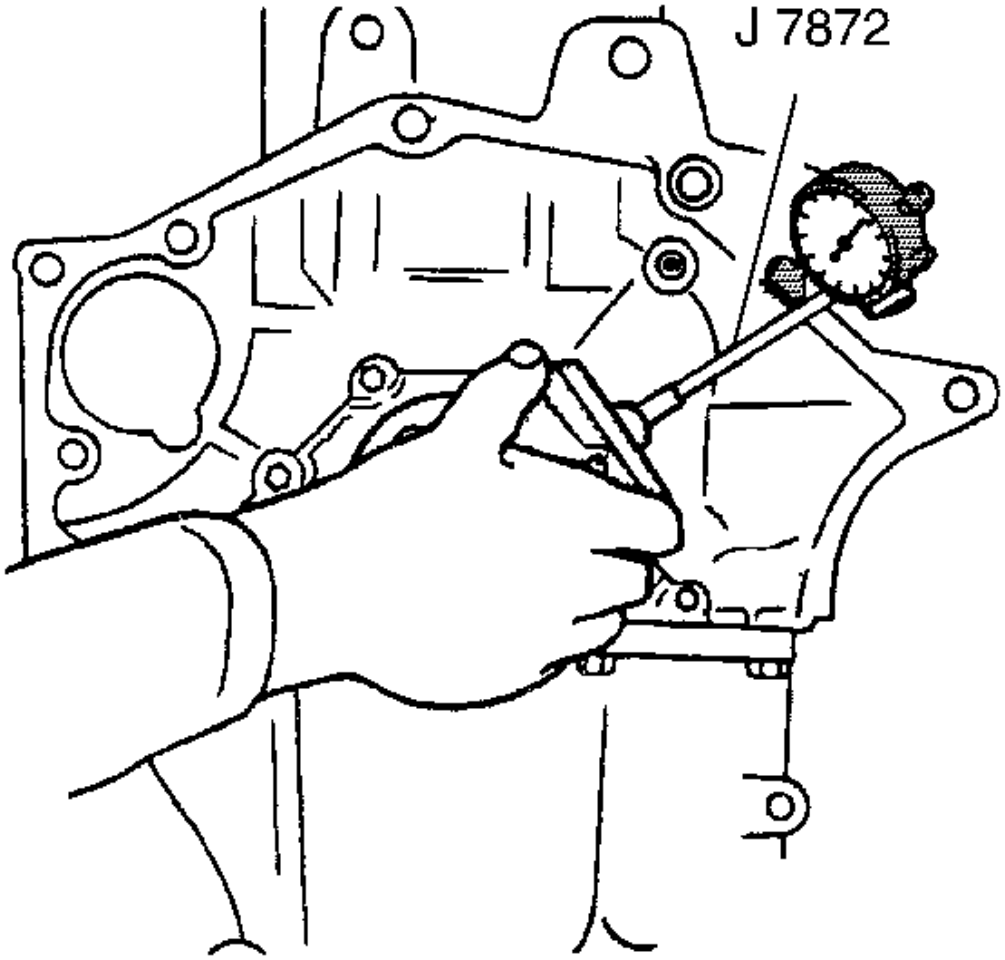

Fig. 375: Measuring Engine Block Flange Runout
Courtesy of GENERAL MOTORS CORP.

12. Inspect the mating surfaces of the transmission face.

NOTE: A broken flywheel may result if the transmission case mating surface is not flat.

13. Use the following procedure in order to measure the engine block flange runout at the mounting bolt hole bosses:
    1. Temporarily install the crankshaft and upper bearings. Measure the crankshaft flange runout using the **J 7872** .
    2. Hold the gage plate flat against the crankshaft flange.

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3. Place the dial indicator stem on the transmission mounting bolt hole boss. Set the indicator to 0.
4. Record the readings obtained from all of the bolt hole bosses. The measurements should not vary more than 0.203 mm (0.008 in).
5. Recheck the crankshaft flange runout if the readings vary more than 0.203 mm (0.008 in).
6. Remove the crankshaft and bearings.

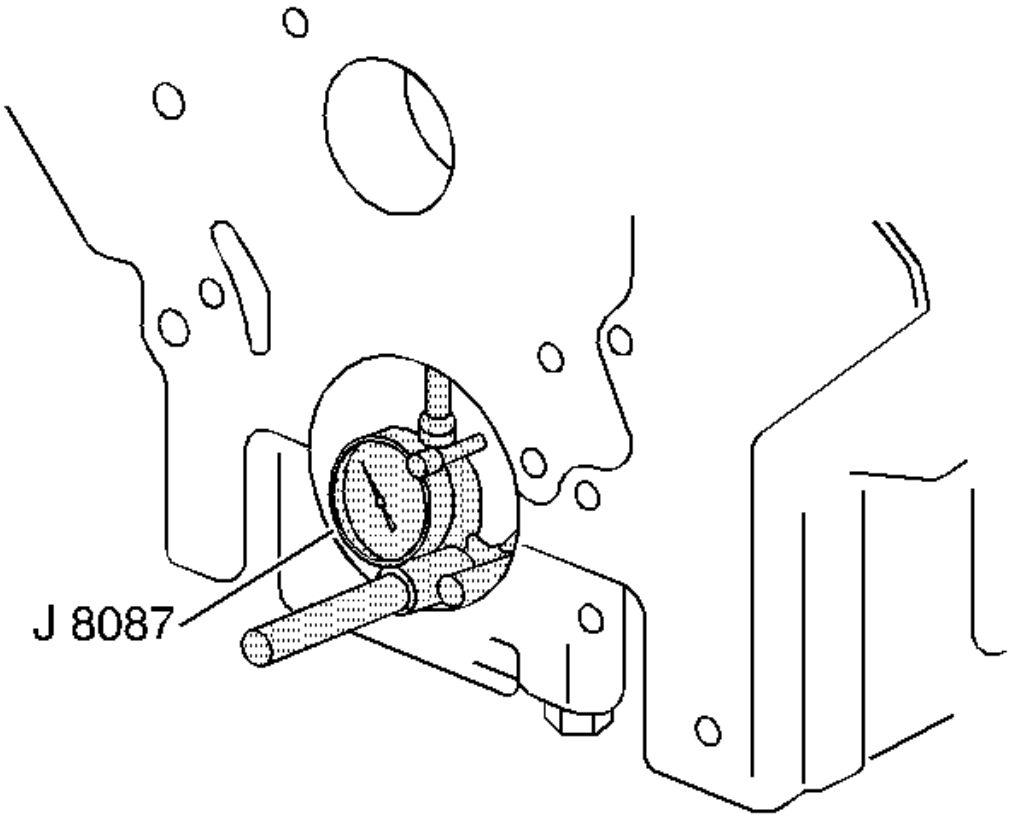

Fig. 376: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

14. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
15. Inspect the crankshaft main bearing bores. Use the **J 8087** to measure the bearing bore concentricity and alignment. Refer to **Engine Mechanical Specifications**.
16. Replace the engine block and bed plate if the crankshaft bearing bores are out of specification.
17. Remove the bed plate.

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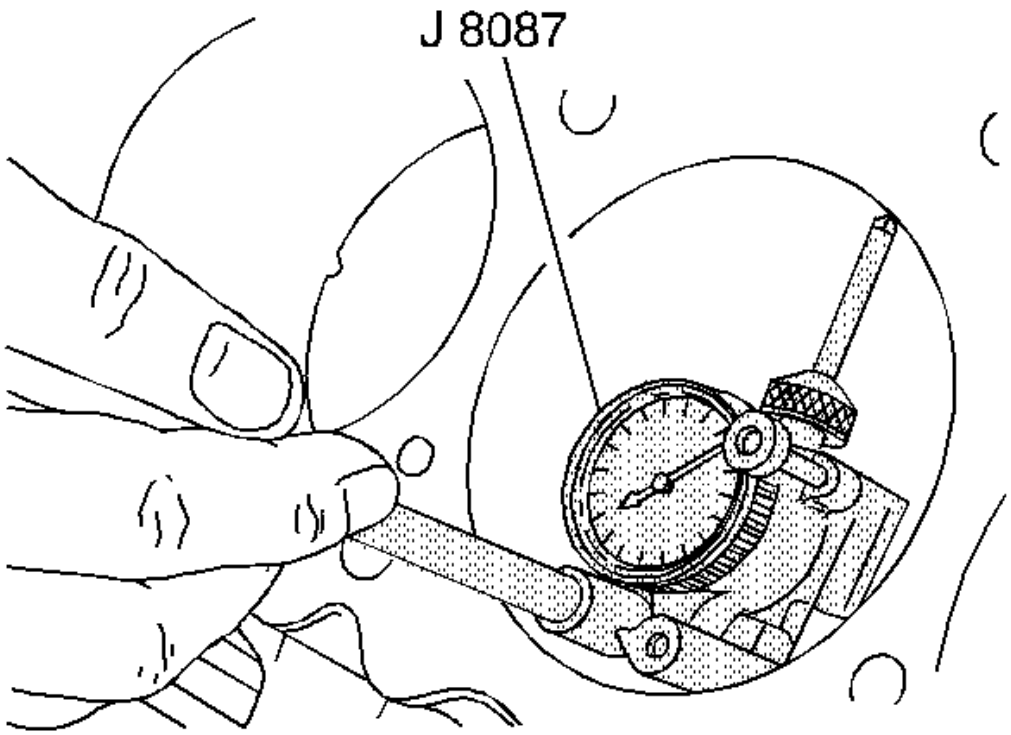

Fig. 377: Inspecting Cylinder Bores Using J 8087
Courtesy of GENERAL MOTORS CORP.

18. Inspect the cylinder bores using the **J 8087** . Inspect for the following items:
    - Wear
    - Taper
    - Runout
    - Ridging
19. If the cylinder bores are out of specification, install a NEW cylinder bore sleeve. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.

Cylinder Honing

Tools Required

J 8087 Cylinder Bore Gage

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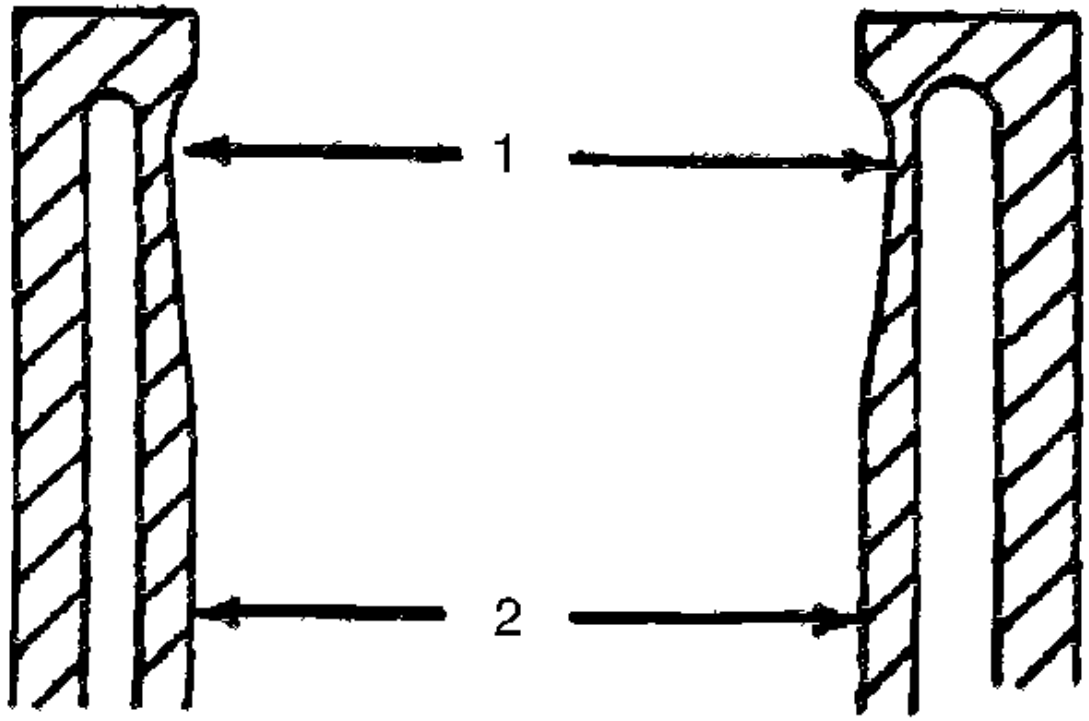

Fig. 378: Measuring Head Gasket Dimensions
Courtesy of GENERAL MOTORS CORP.

1. Measure the cylinder bore for out-of-round and taper.
2. Measure dimension (1) at 13 mm (1/2 in) below the head gasket surface. Measure dimension (2) at 100 mm (4 in) below the head gasket surface.

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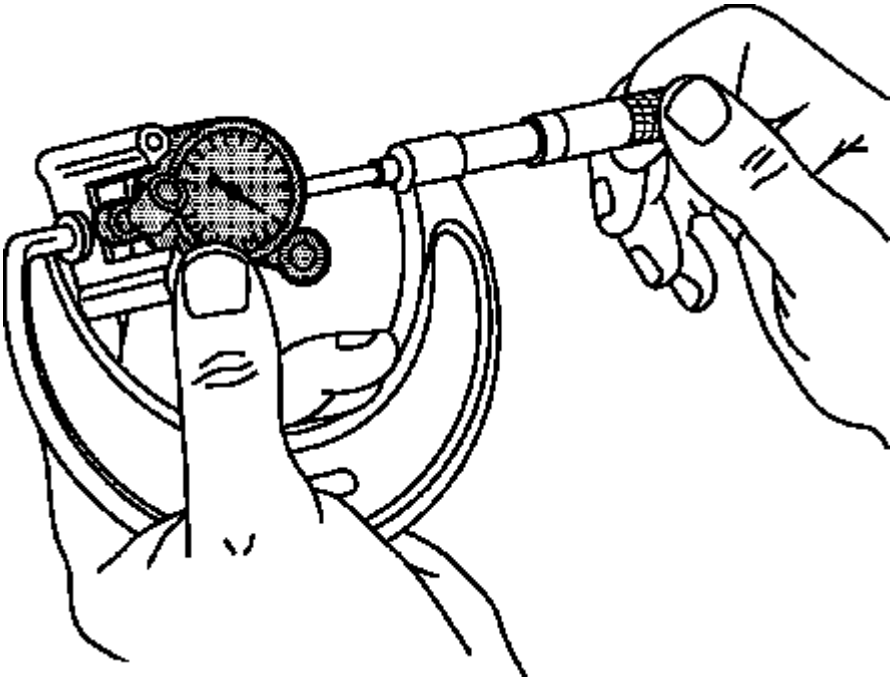

Fig. 379: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

3. Measure the cylinder bores by setting the **J 8087** dial at zero in the cylinder at the point of the desired measurement. Lock the dial indicator at zero before removing the dial from the cylinder. Measure across the gage contact points with an outside micrometer, with the gage at the same zero setting as when the gage was removed from the cylinder.
4. Fine vertical scratches made by the ring ends do not, by themselves, cause excessive oil consumption. Do not hone the cylinder in order to remove these scratches.
5. If the bore is glazed but otherwise serviceable, lightly break the glaze with a hone. Replace the piston rings. Refer to **Piston, Connecting Rod, and Bearing Installation**.
    1. The honing stones must be clean, sharp, and straight.
    2. Move the hone slowly up and down to produce a 45 degree cross-hatch pattern.
    3. Clean the bore thoroughly with soap and water.
    4. Dry the bore.
    5. Rub clean engine oil in the bore.
    6. Re-measure the bore.
6. If the cylinder bore is out of specification, install a new cylinder bore sleeve. Refer to **Cylinder Sleeve Removal** and **Cylinder Sleeve Installation**.
7. If honing is not required, clean the cylinder bores with hot water and detergent. Apply clean engine oil to the bore after washing and drying the bore.

Cylinder Sleeve Removal

Tools Required

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EN-45680-880 Cylinder Sleeve Removal and Installation Kit. See **Special Tools**.

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

NOTE: Do not damage the crankshaft connecting rod journals or reluctor ring or engine damage will occur.

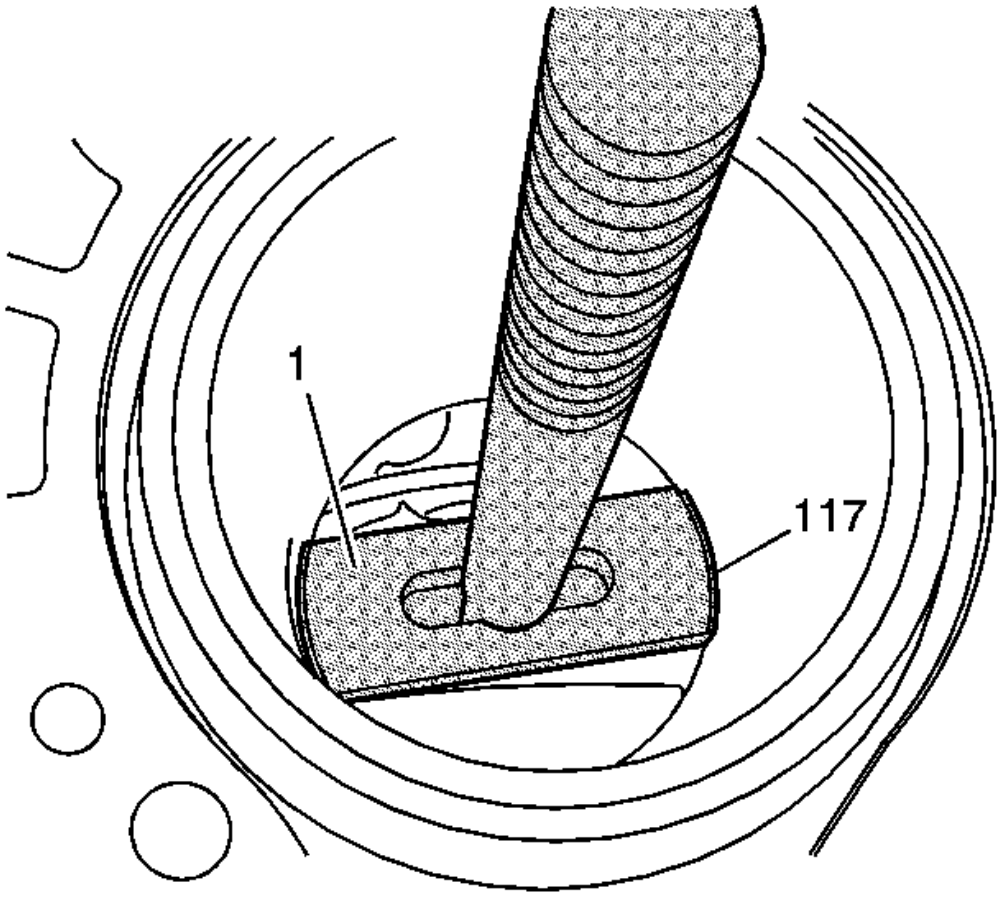

Fig. 380: View Of Cylinder Bore Liner Puller
Courtesy of GENERAL MOTORS CORP.

1. If the crankshaft is still installed, rotate the crankshaft so that the counterweight is to the right side and the connecting rod journal is to the left side and not in alignment with the cylinder bore.
2. Install the cylinder bore sleeve puller EN 45680-402 (1), which is part of EN 45680-880, through the cylinder bore.

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NOTE: Ensure that the shoe is flat against the bottom of the cylinder bore sleeve or damage to the cylinder bore sleeve puller will occur.

3. Align the shoe (1) of the cylinder bore sleeve puller EN 45680-402 to the bottom of the cylinder bore sleeve (117).

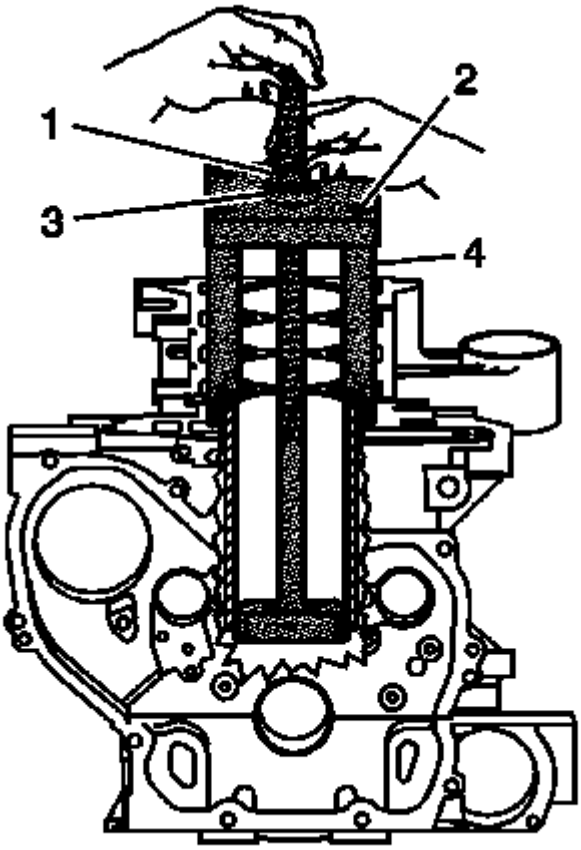

Fig. 381: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

4. Hold the threaded shaft of the cylinder bore sleeve puller EN 45680-402 upward in order to retain the shoe alignment to the bottom of the cylinder bore sleeve.
5. Install the fixture EN 456850-401 (4) onto the threaded shaft of the cylinder bore sleeve puller EN 456850-402 and the engine block.
6. Install the bearing (3) and the nut (1).
7. Tighten the nut (1) to the bearing (3).

NOTE: Refer to Fastener Notice .

IMPORTANT: Use four old cylinder head bolts for the attaching bolts.

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8. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block.

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

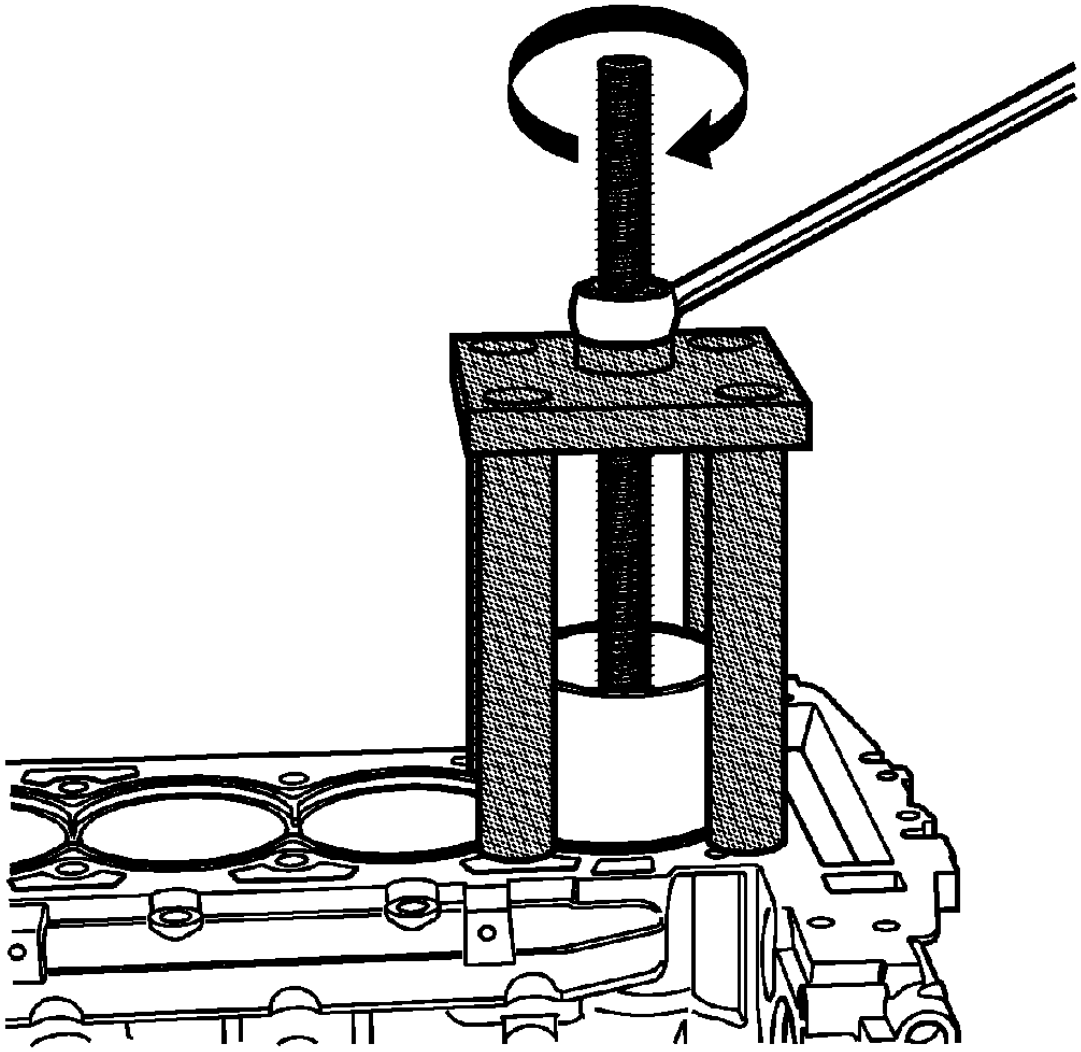

Fig. 382: Removing Cylinder Bore Sleeve By Rotating Nut
Courtesy of GENERAL MOTORS CORP.

9. Rotate the nut clockwise in order to remove the cylinder bore sleeve.

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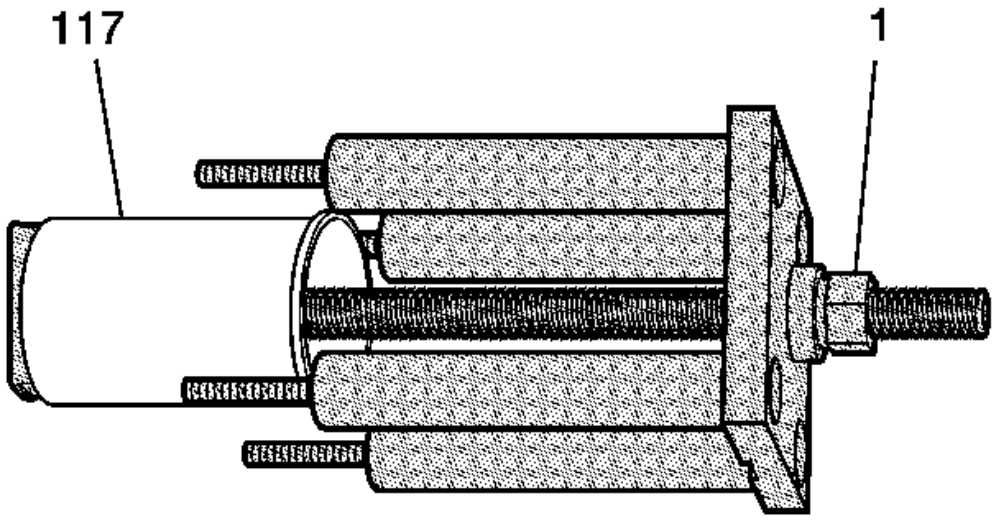

Fig. 383: Removing Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the cylinder block surface. Damage to the cylinder block surface can cause engine failure.

10. Remove fixture EN 45680-401, cylinder bore sleeve puller EN 45680-402, and the cylinder bore sleeve (117) from the engine block.
11. Loosen the nut (1) in order to remove the cylinder bore sleeve (117).
12. Inspect the cylinder bore in the cylinder block for cracks or damage. If cracked or damaged, replace the cylinder block.
13. Inspect the piston, piston rings, and connecting rod for damage. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.

Cylinder Sleeve Installation

Tools Required

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EN-45680-880 Cylinder Sleeve Removal and Installation Kit. See **Special Tools**.

NOTE: Do not use assembly aids or lubricants on the cylinder bore sleeve or the cylinder bore block when installing a new cylinder bore sleeve, or engine damage will occur. These items will not aid in the installation of the new cylinder bore sleeve.

NOTE: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or heating the cylinder bore sleeve or the cylinder block will cause engine damage and will not aid the removal or installation of the new cylinder bore sleeve.

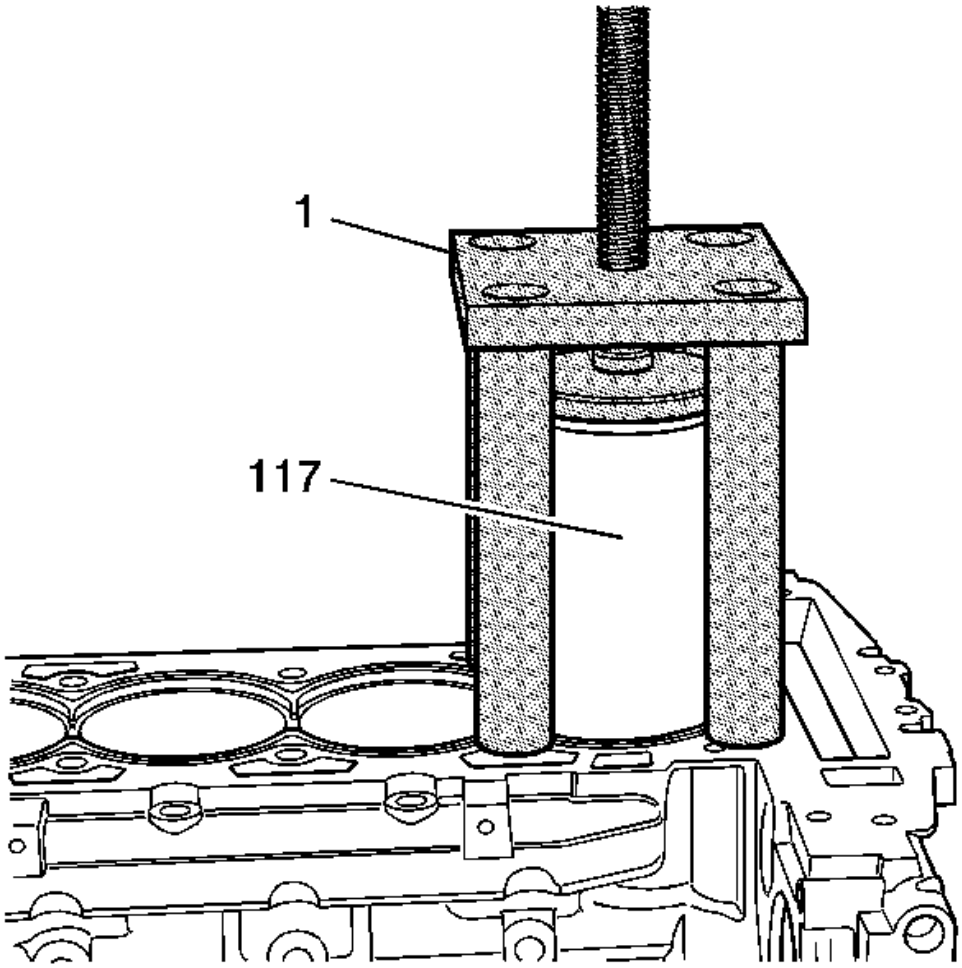

Fig. 384: View Of Cylinder Bore Sleeve Fixture
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install the fixture (1) over the cylinder bore sleeve (117) and onto the cylinder block. Do not apply downward pressure to the cylinder bore sleeve (117).

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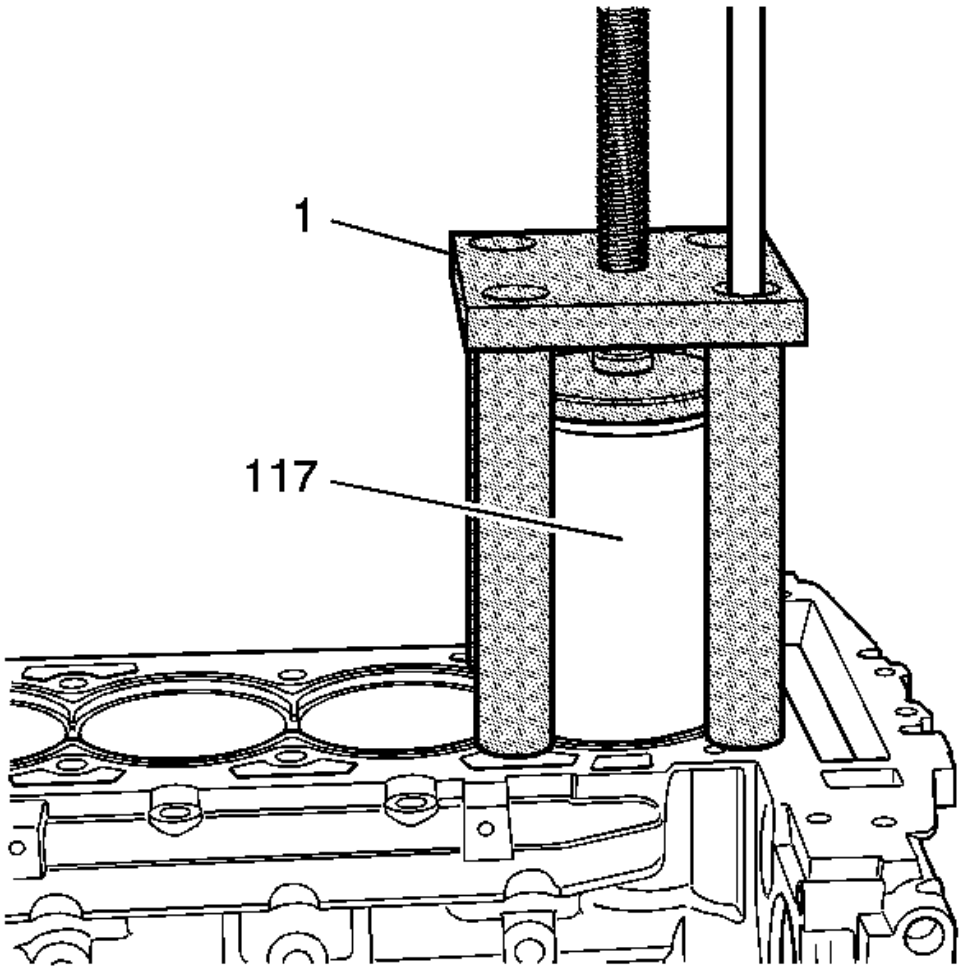

Fig. 385: Installing Cylinder Bore Sleeve Puller Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use 4 old cylinder head bolts for the attaching bolts.

3. Insert the 4 attachment bolts into the legs of the fixture (1).

NOTE: Refer to Fastener Notice .

4. Tighten the 4 attachment bolts. Do not apply downward pressure to the cylinder bore sleeve (117).

Tighten: Tighten the 4 attachment bolts to 15 N.m (11 lb ft).

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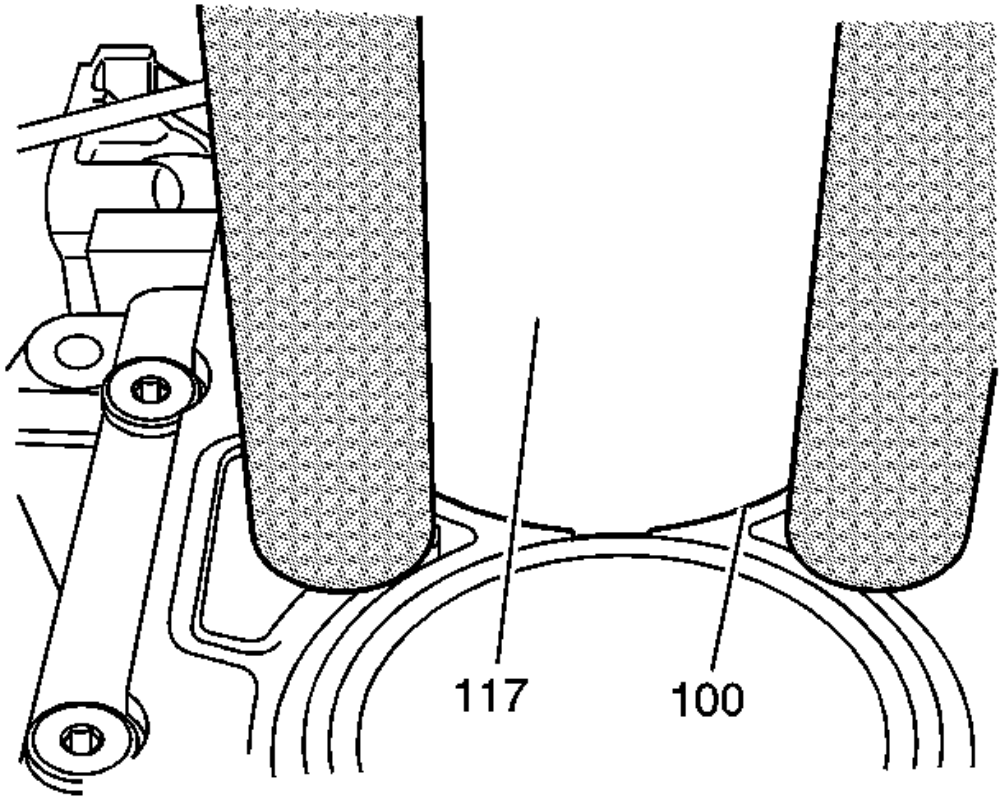

Fig. 386: View Of Proper Liner Alignment
Courtesy of GENERAL MOTORS CORP.

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).

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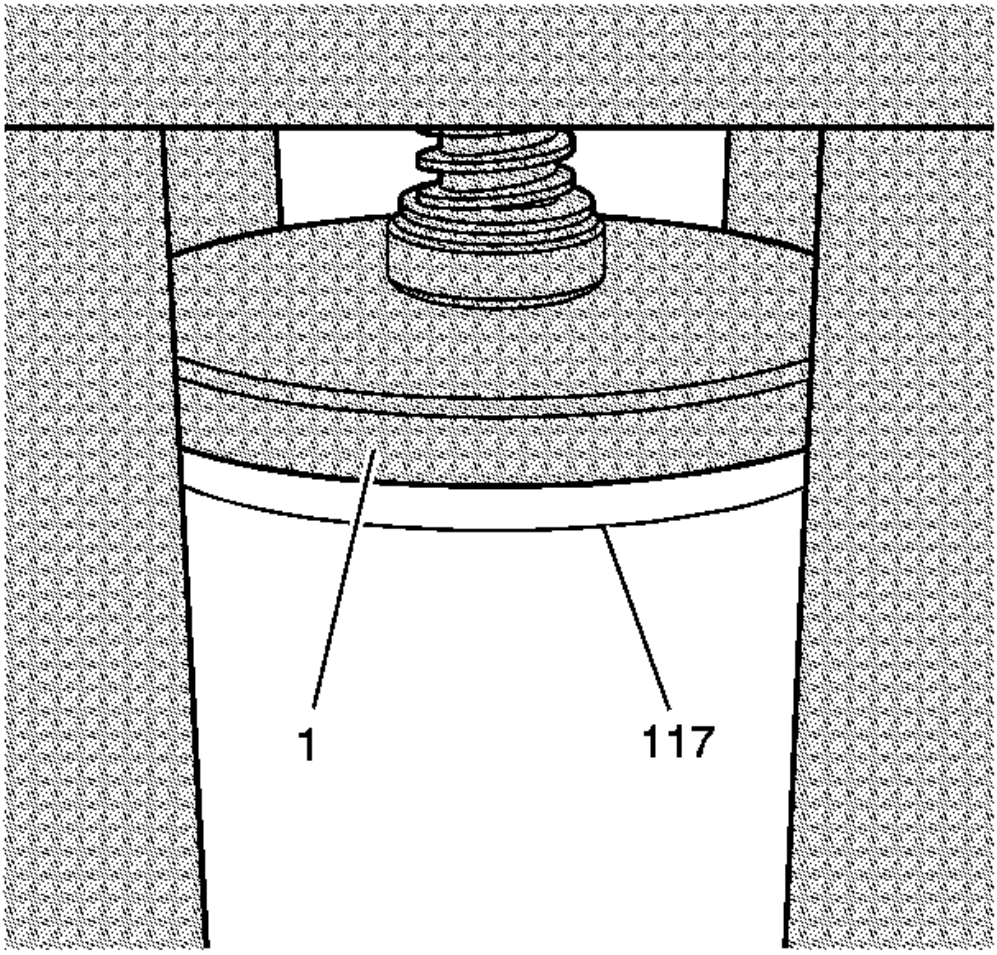

Fig. 387: View Of Installation Arbor
Courtesy of GENERAL MOTORS CORP.

6. Align the installation arbor (1) onto the top of the cylinder bore sleeve (117).

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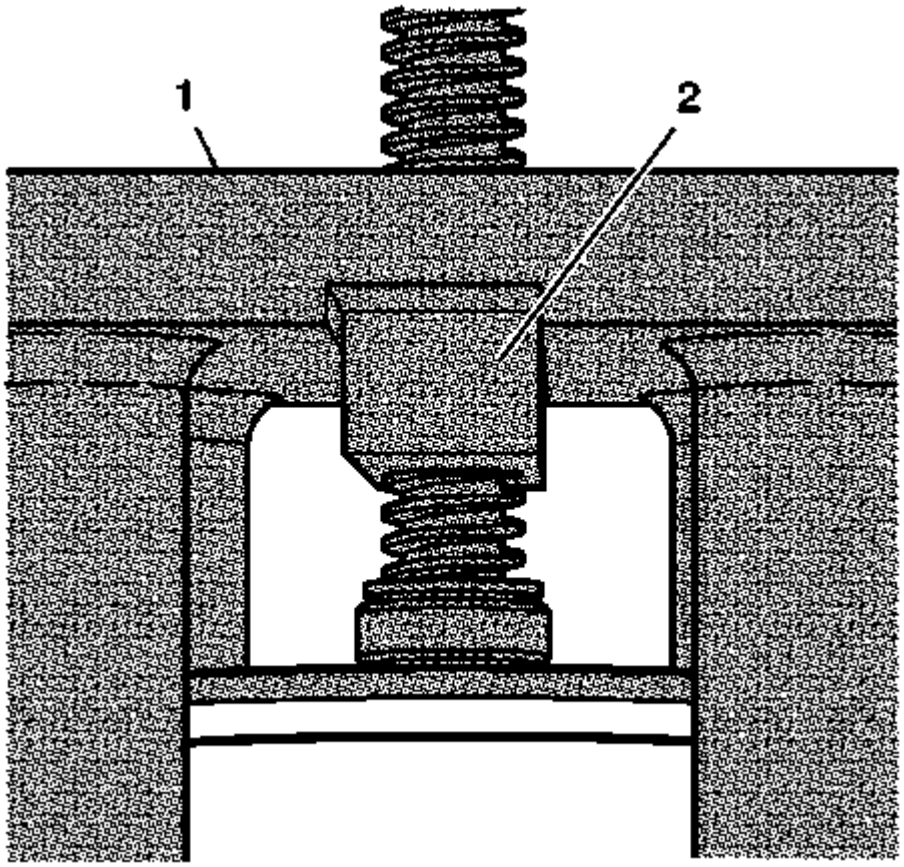

Fig. 388: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

7. Align the pusher block (2) into the groove of fixture (1).

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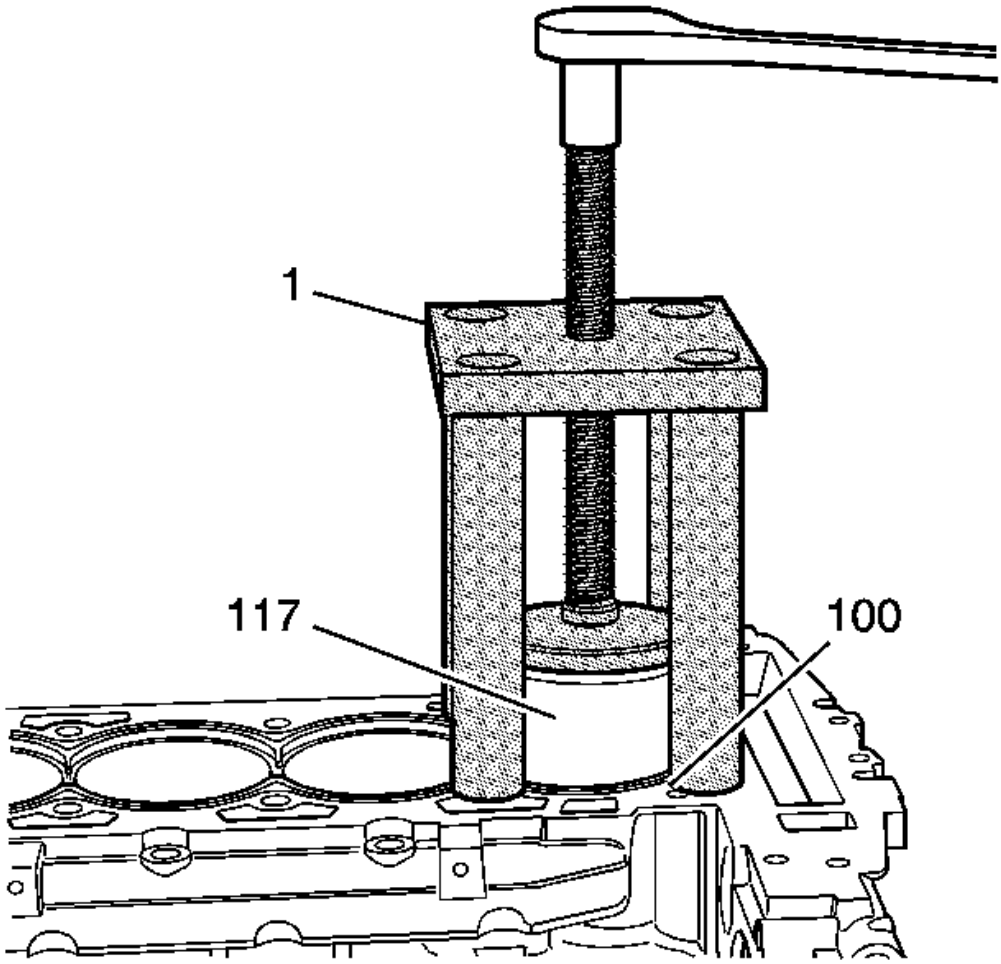

Fig. 389: Installing Cylinder Bore Sleeve Into Engine Block Using Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any air powered or electric tools to rotate the threaded shaft of the fixture EN 45680-401/cylinder bore sleeve installer EN 45680-403 assembly or damage to the cylinder bore sleeve will occur.

8. Using a ratchet, rotate the threaded shaft of fixture (1) in order to install the cylinder bore sleeve (117) into the engine block (100).
9. Do not completely seat the cylinder bore sleeve in the block. Leave approximately 1/16 inch of the cylinder bore sleeve above the surface of the cylinder block.

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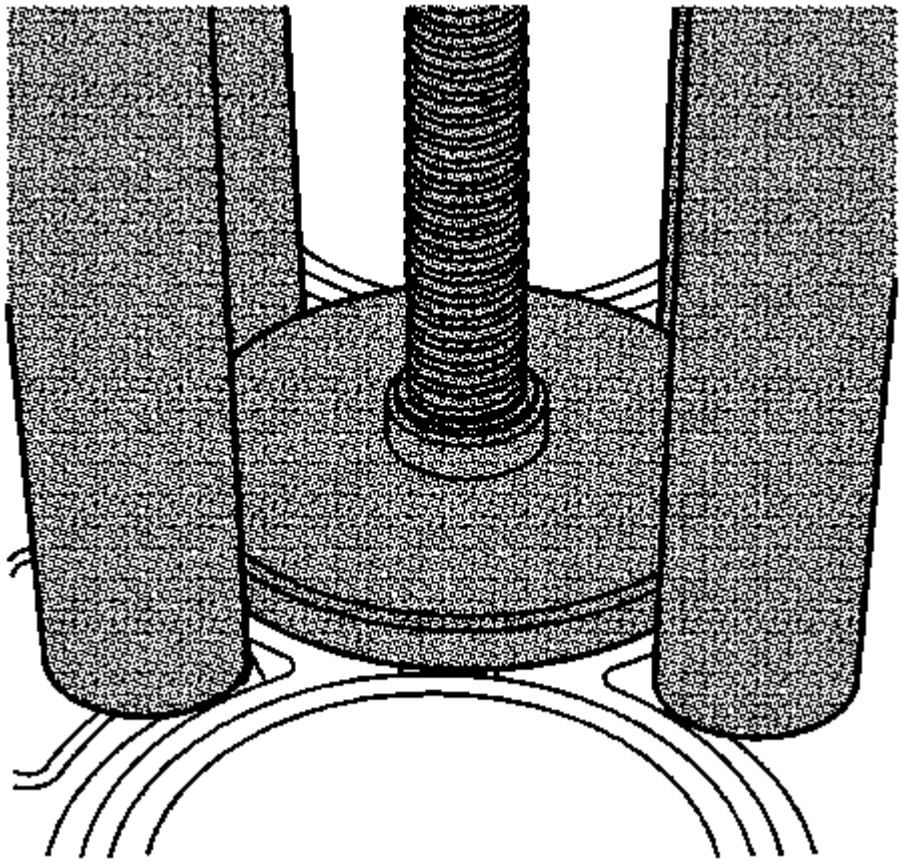

Fig. 390: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

10. Using a torque wrench, torque the threaded shaft to 102 N.m (75 lb ft) to completely seat the cylinder bore sleeve in the cylinder block. With the cylinder bore sleeve properly installed, a minimal portion of the cylinder bore sleeve flange will protrude above the block deck surface.

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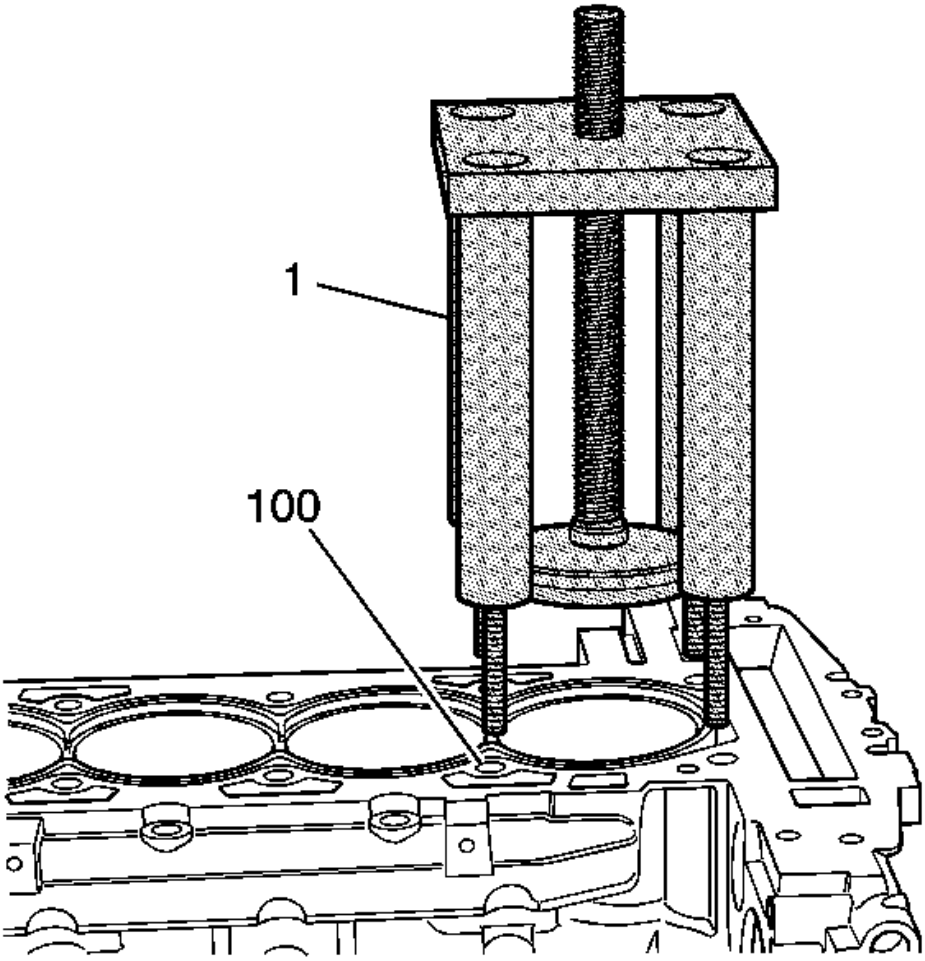

Fig. 391: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixture (1) from the cylinder block (100).

Cylinder Sleeve Trimming

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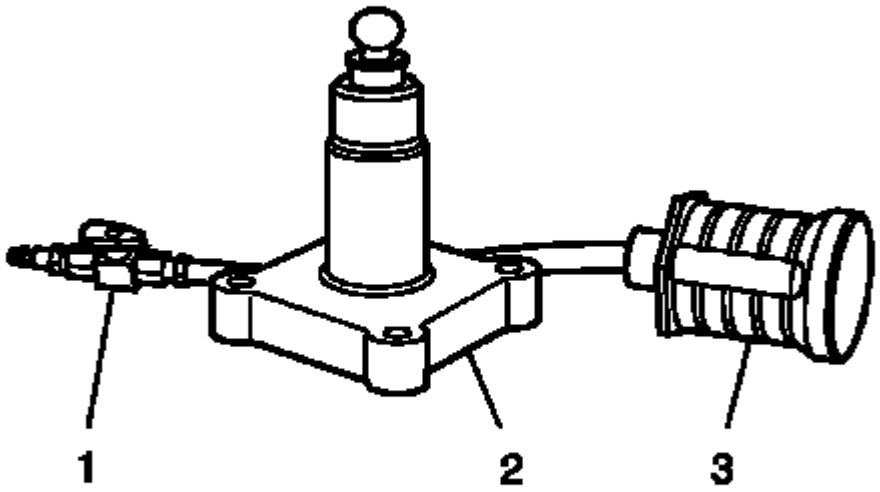

Fig. 392: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- EN 45680-865 Debris Collector (3)
- EN 45680-861 Trim Tool Assembly (2)
- Air Control Valve (1)
- Drill Motor with 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction
- EN 45680-881 Bore Chamfer Bit
- EN 45680-885 Bore Trimmer Pilot

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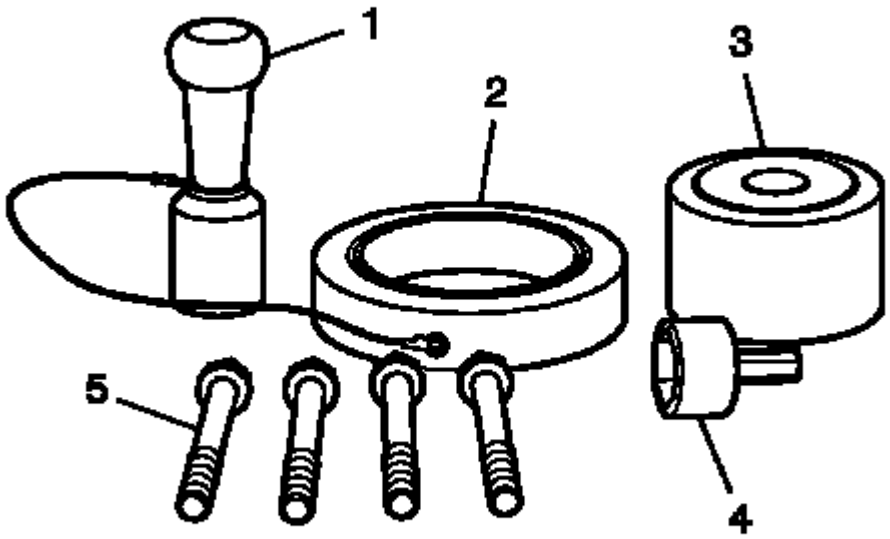

Fig. 393: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- Trim Tool Preloader (1)
- EN 45680-412 Set Gage Ring (2)
- EN 45680-413 Metal Shavings Catch Plug (3)
- EN 45680-866 Drive Adapter (4)
- EN 45680-414 Bolts (5)

NOTE: **Do not bore or hone the cylinder bore sleeve. The cylinder bore sleeve inside diameter (I.D) is fully machined and honed to size and is optimally finished as shipped. Any attempt to modify this factory-produced sizing and finish with additional boring and honing will lead to engine damage, excessive noise or abnormal oil consumption.**

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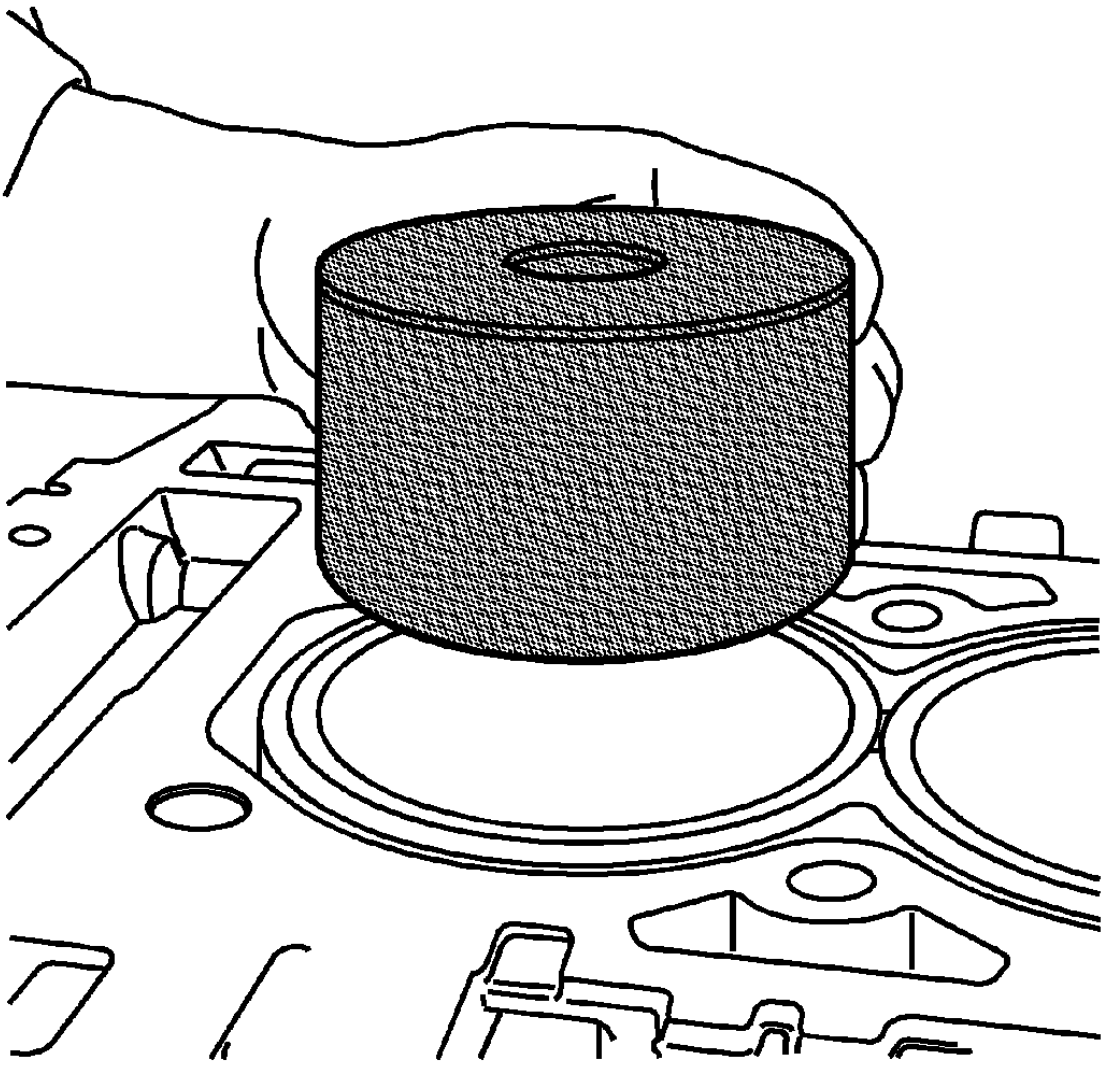

Fig. 394: Placing Metal Shaving Catch Plug Into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

1. After installing the NEW cylinder bore sleeve(s) into the engine block, trim the excess material from the cylinder bore sleeve flange.

NOTE: Ensure that all the metal particles are collected in order to prevent internal damage to the transaxle or bearings.

2. Place the metal shaving catch plug into the cylinder bore sleeve to be trimmed. Position the top approximately 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.
3. Place additional metal shaving catch plugs into all remaining cylinder bore sleeves.

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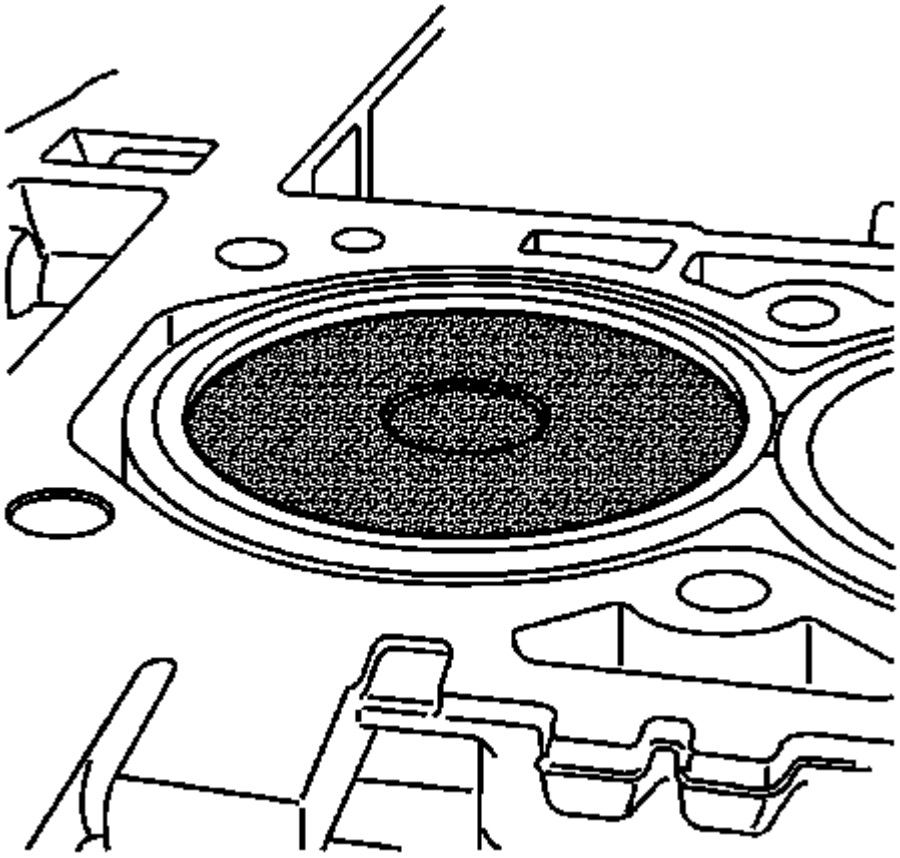

Fig. 395: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Installing the metal shaving catch plug deeper than the recommended depth will create a decrease in vacuum system performance. A decrease in vacuum system performance will cause metal shavings to enter the engine and cause engine failure.

NOTE: Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.

4. Ensure that the metal shaving catch plug is 3.0 mm (0.12 in) below the top surface of the cylinder bore sleeve.

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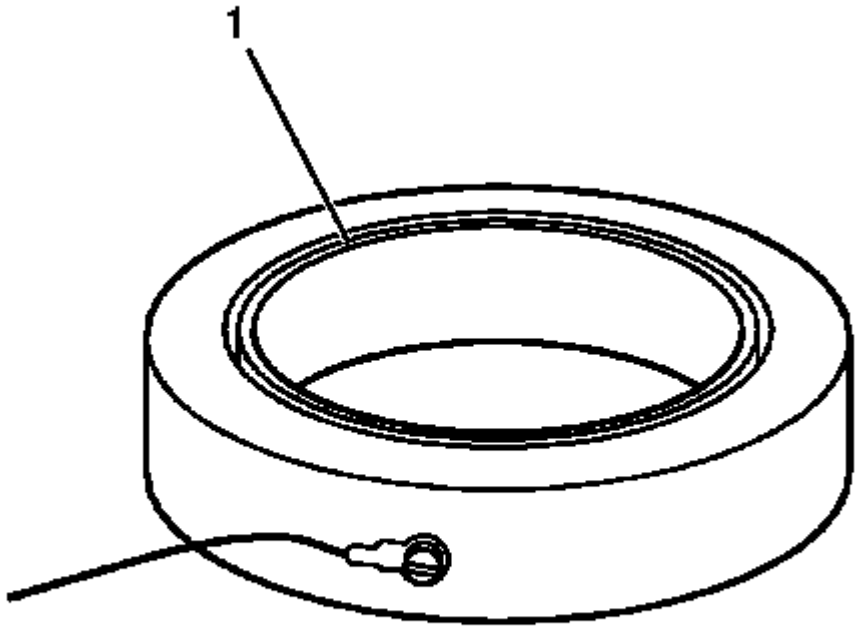

Fig. 396: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Before using the trim tool assembly, the height of the cutting blades must be set to the proper specification. The proper specification is that the cylinder bore sleeve flange must be flush to +0.02 mm (0.0008 in) above the block deck surface.

5. The groove side of the set gage ring (1) should be positioned upward on a flat surface.

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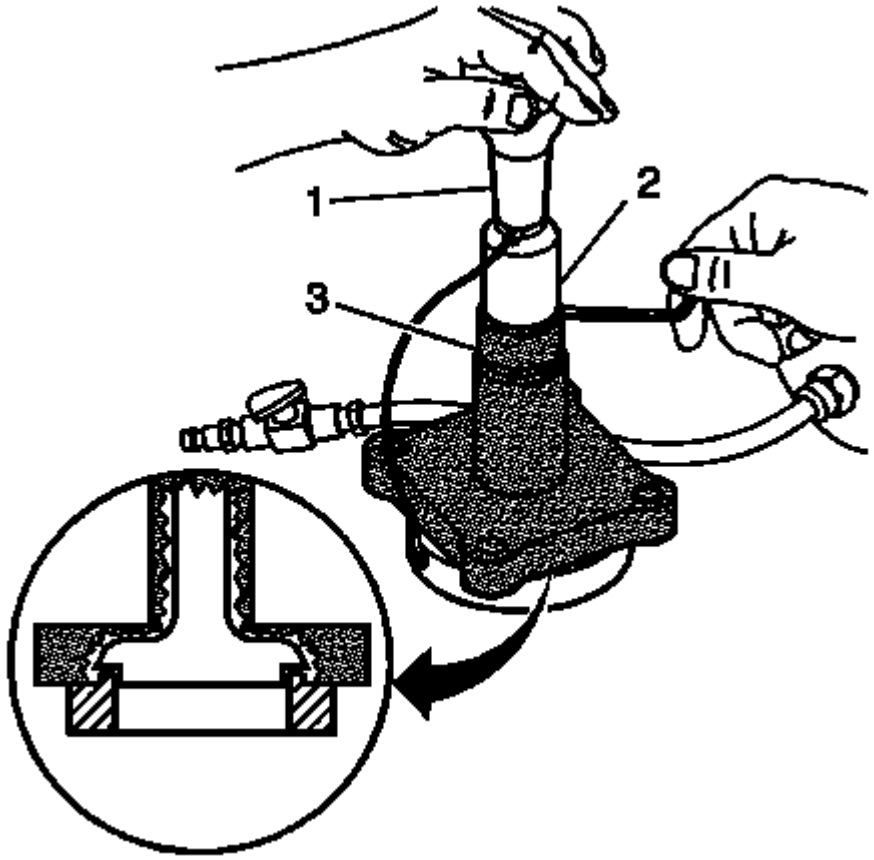

Fig. 397: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the set gage ring surfaces are clean.

6. Carefully position the trim tool assembly onto the set gage ring.
7. Loosen the shaft collar screw (2).
8. Push the shaft collar (2) downward using the trim tool preloader (1) until the shaft collar is positioned against the top of the flange bearing (3).

IMPORTANT: Once this procedure is done, it is not necessary to reset the trim tool assembly height until the blades are worn or damaged.

9. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw.

Tighten: Tighten the shaft collar screw to 19 N.m (14 lb ft).

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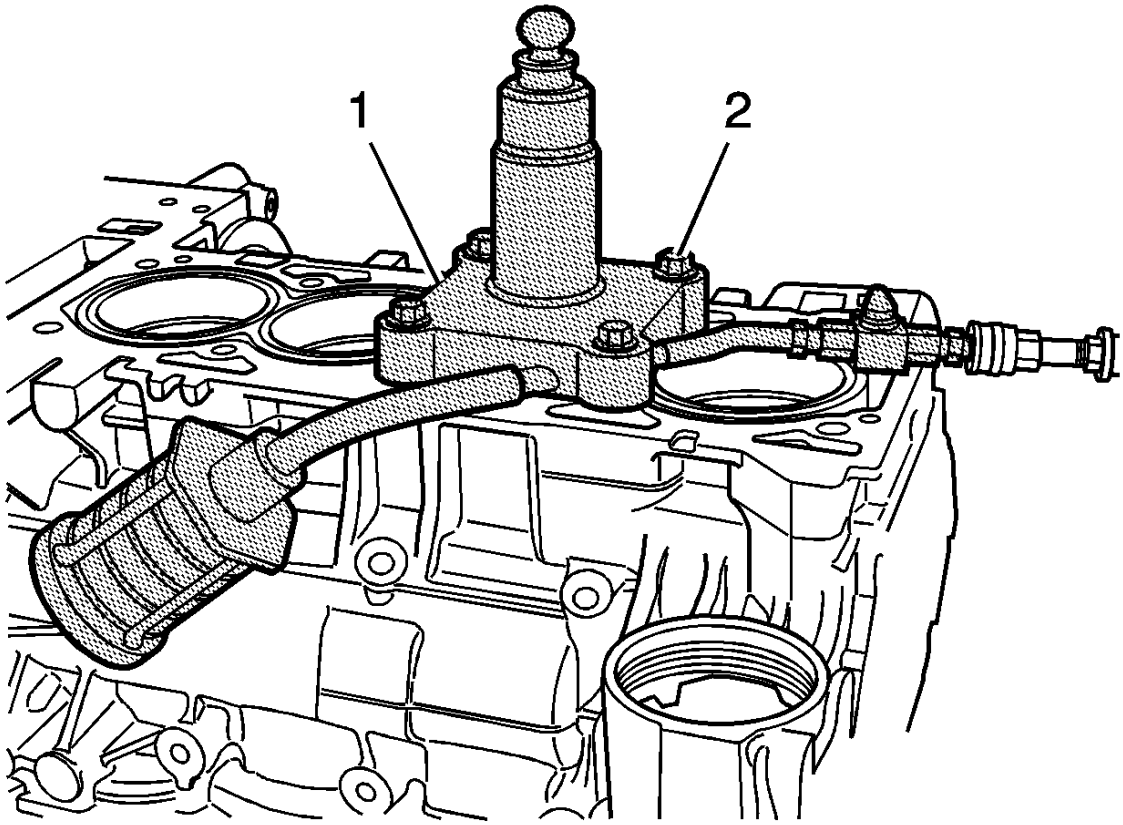

Fig. 398: Aligning Trim Tool Assembly
Courtesy of GENERAL MOTORS CORP.

10. Place the trim tool assembly onto the cylinder to be trimmed with the directional arrow (1) pointing in line with the crankshaft centerline and the front of the block.
11. Install the 4 bolts (2) into the cylinder head bolt holes in the block.

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

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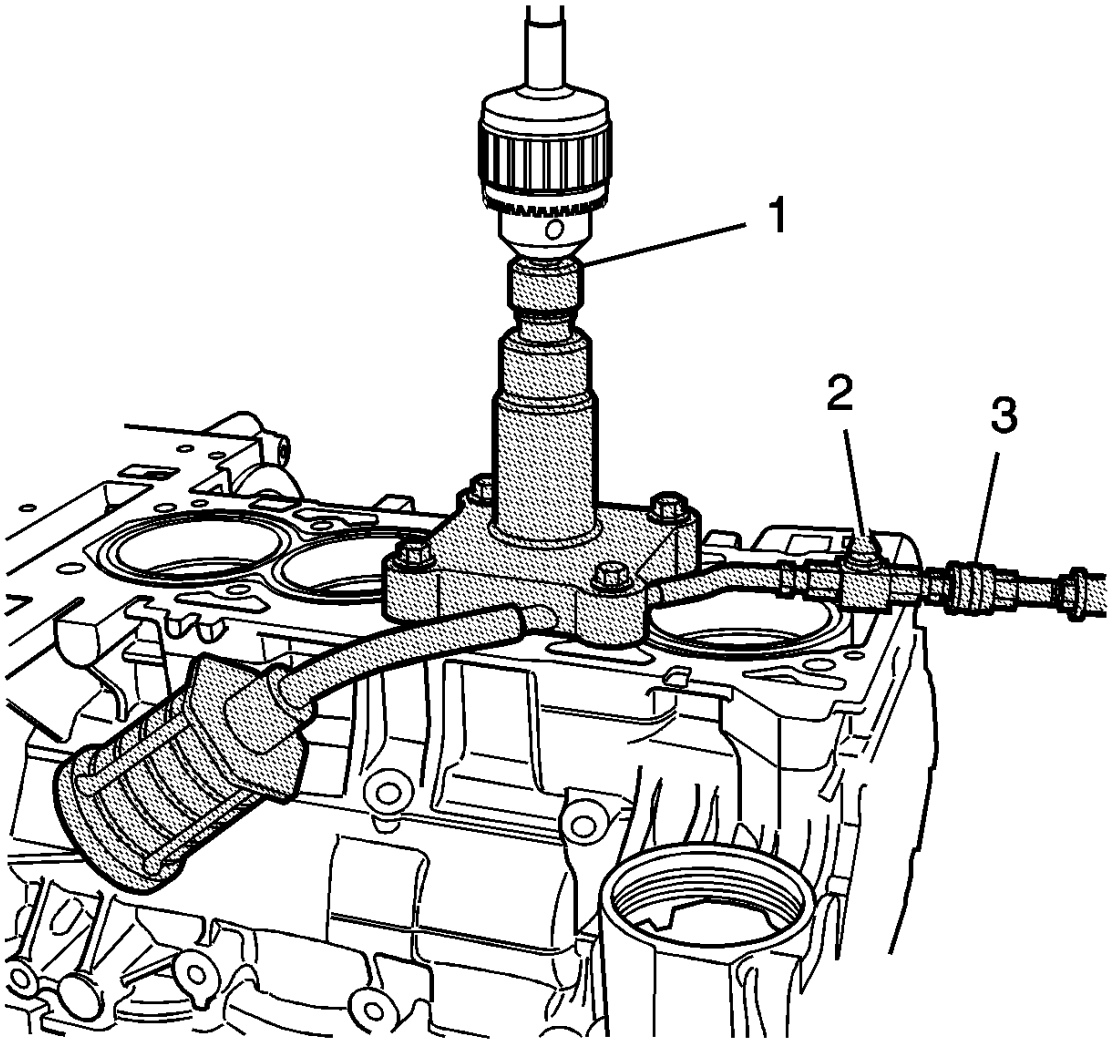

Fig. 399: View Of Drive Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: For proper tool operation, a drill motor with a 1/2 inch chuck, 1 1/8 hp, 7 amps, triple gear reduction, and a 450-600 RPM rotational speed in a clockwise direction must be used. If the proper drill motor is not used, damage to the cylinder bore sleeve will occur.

12. Fasten drive adapter (1) into the drill chuck.

NOTE: Ensure that there are no crimps in the air feed hose or the vacuum hose. Crimps in the hose may cause metal shavings to exit the cutting tool in any direction, causing engine damage.

13. Connect a compressed air supply (75-125 psi) to the male quick connect (3) located on trim tool assembly. Turn the compressed air valve (2) to the open position. This starts the venturi vacuum system that will catch the metal shavings.

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14. Place the drive adapter and drill assembly (1) vertically onto the drive adapter end of trim tool assembly. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, gradually apply downward force until the cutting action is complete in approximately 5 seconds.
15. Remove the drive adapter (1) and drill assembly from the trim tool assembly.
16. Turn off the compressed air valve (2).
17. Remove the trim tool assembly from the engine block.
18. Remove any material shavings that may be found on the metal shaving catch plug.
19. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug.

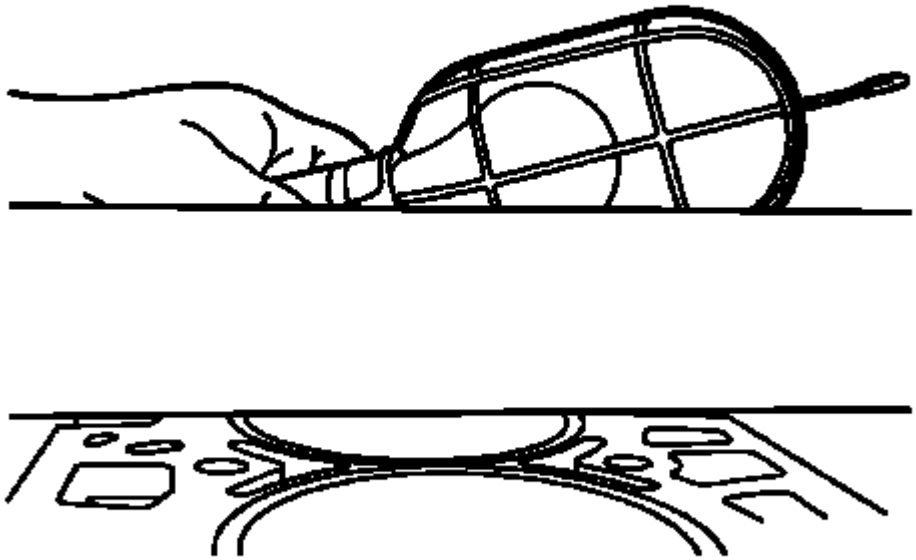

Fig. 400: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

20. Install a straight edge on the cylinder block perpendicular to the crankshaft center line.
21. Using a light, illuminate the backside of the straight edge.

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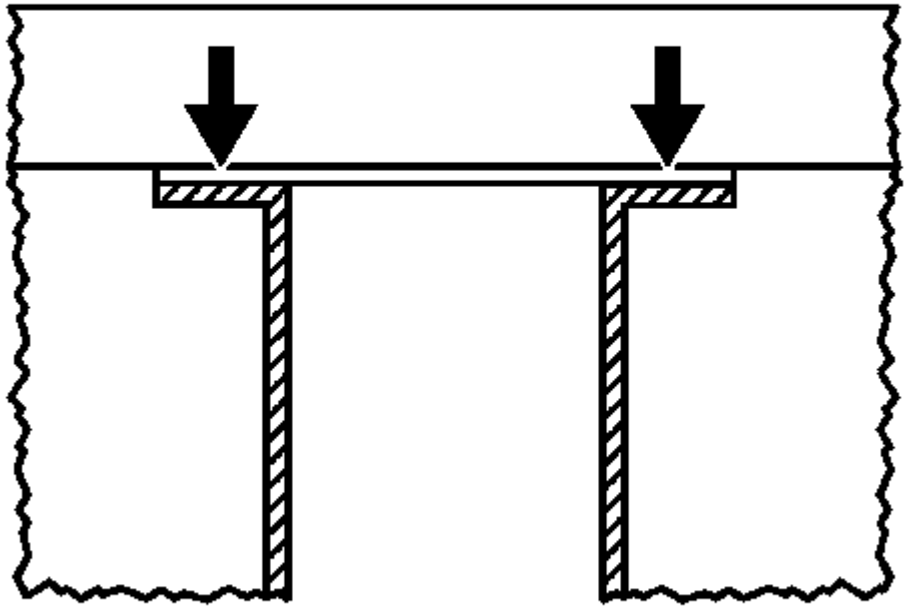

Fig. 401: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

22. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder bore sleeve flange. If light is present on either side or both sides of the cylinder bore sleeve, the cylinder bore sleeve is cut incorrectly and a new cylinder bore sleeve needs to be installed.

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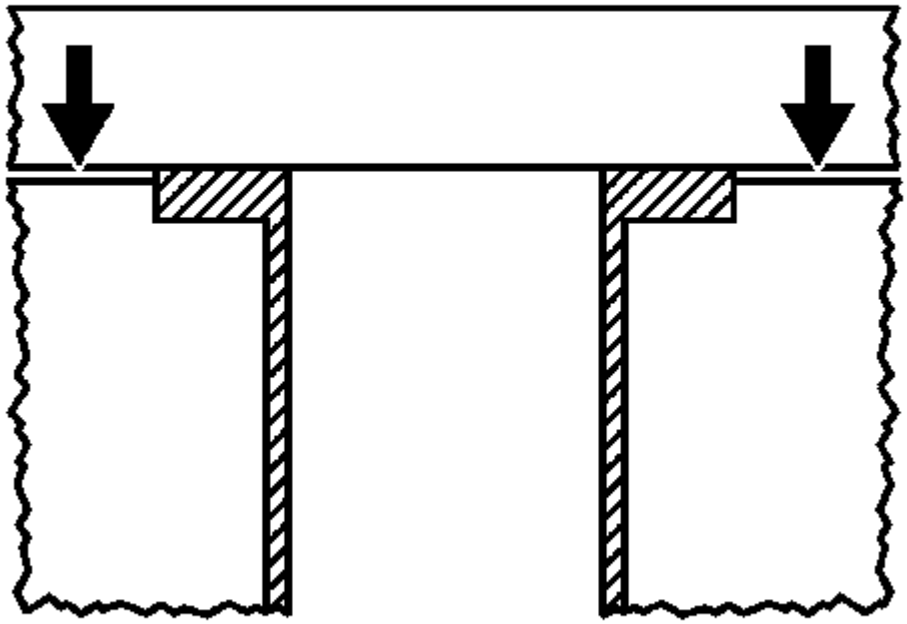

Fig. 402: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

23. Looking at the front of the straight edge, check to see if light is protruding through the bottom of the straight edge and the top of the cylinder block deck surface. If light is present on both sides of the cylinder block, the cylinder bore sleeve is cut correctly.
24. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

Crankshaft Balancer Cleaning and Inspection

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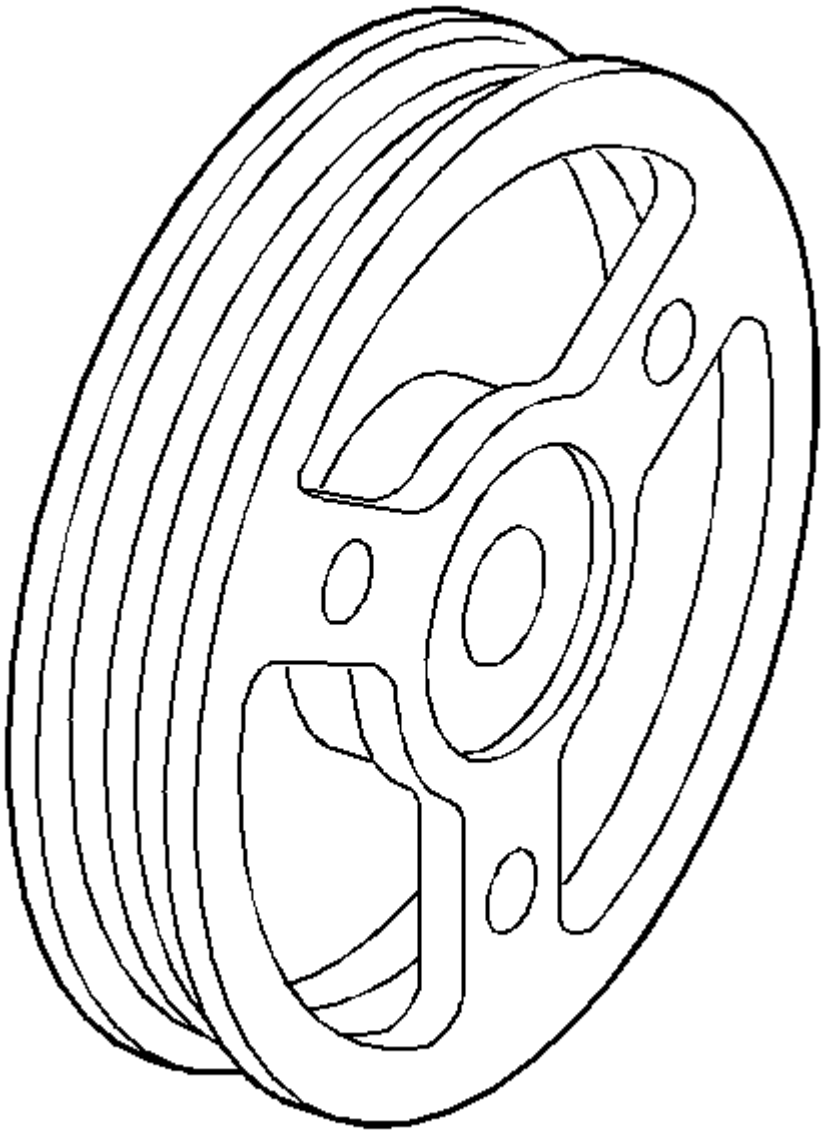

Fig. 403: Inspecting Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer.
2. Clean the belt grooves of all dirt or debris with a wire brush.

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

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3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following:
    - Worn, grooved, or damaged hub seal surface

      A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

      IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

    - Dirty or damaged belt grooves

      The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

      Minor imperfections may be removed with a fine file.

    - Worn, chunking or deteriorated rubber between the hub and pulley

Engine Flywheel Cleaning and Inspection

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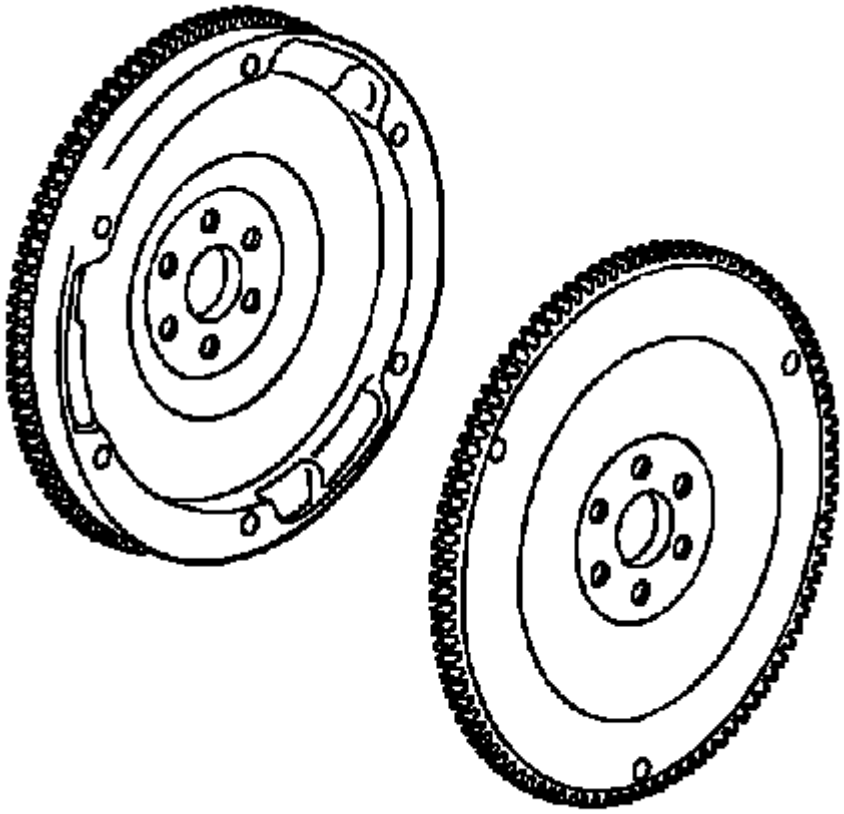

Fig. 404: Identifying Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

1. Clean the flywheel in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

2. Dry the flywheel with compressed air.

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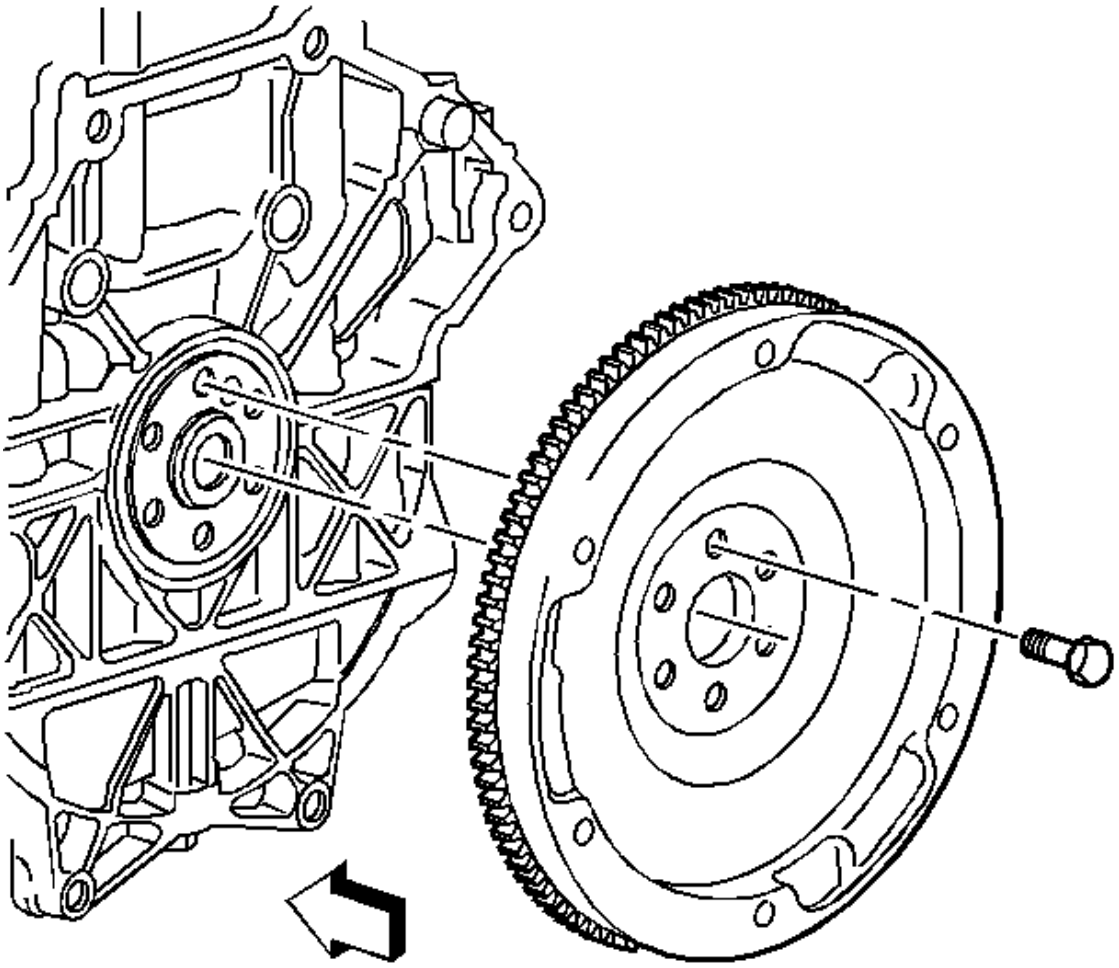

Fig. 405: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

3. Inspect the manual transmission flywheel for the following:
   - Damaged ring gear teeth
   - Loose or improperly positioned ring gear

     The ring gear has an interference fit onto the flywheel and should be positioned completely against the flange of the flywheel.

   - A scored, grooved or damaged friction surface

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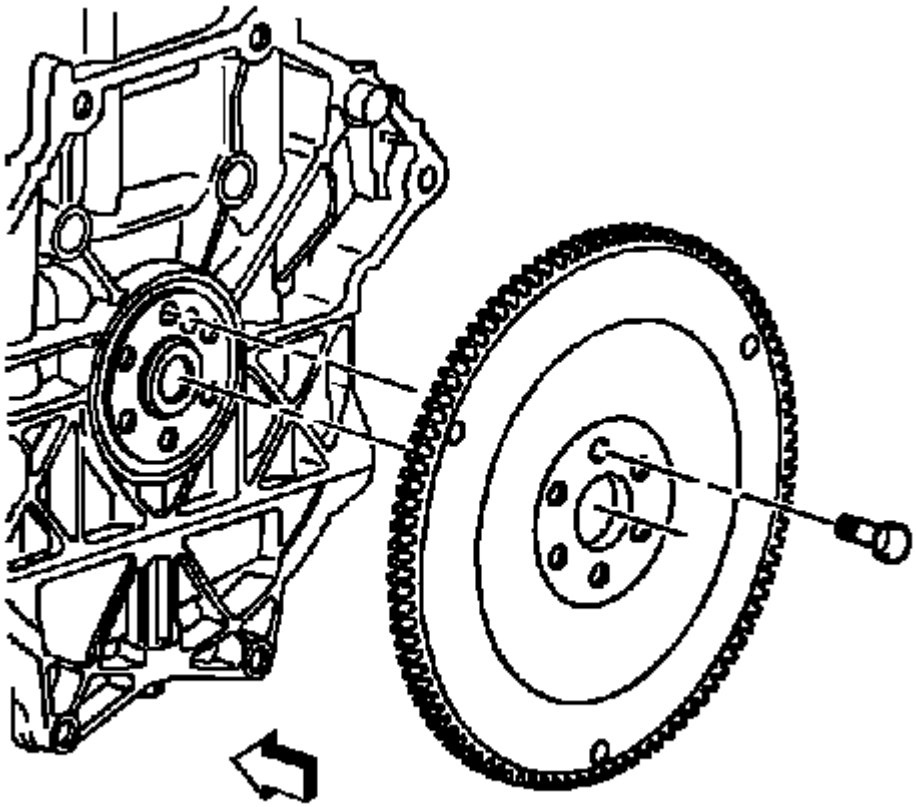

Fig. 406: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

4. Inspect the automatic transmission flywheel for the following:
    - Damaged ring gear teeth
    - Stress cracks around the flywheel-to-crankshaft bolt hole locations
    - Weight saving holes

Crankshaft and Bearings Cleaning and Inspection

Tools Required

J 7872 Magnetic Base Dial Indicator Set

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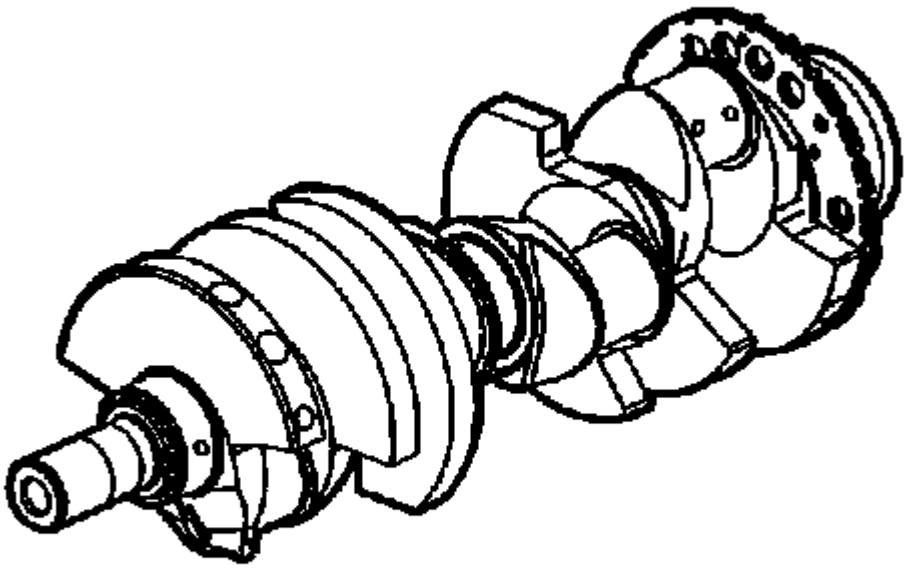

Fig. 407: View Of Crankshaft
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position reluctor ring. Damage to the teeth of the crankshaft position reluctor ring may affect on-board diagnostic (OBD) II system performance.

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

CAUTION: Refer to Safety Glasses Caution .

3. Dry the crankshaft with compressed air.

IMPORTANT: Reluctor ring teeth should not have imperfections on the rising or falling edges.
Imperfections of the reluctor ring teeth may effect OBD II system

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performance.

4. Perform a visual inspection of the crankshaft for damage.

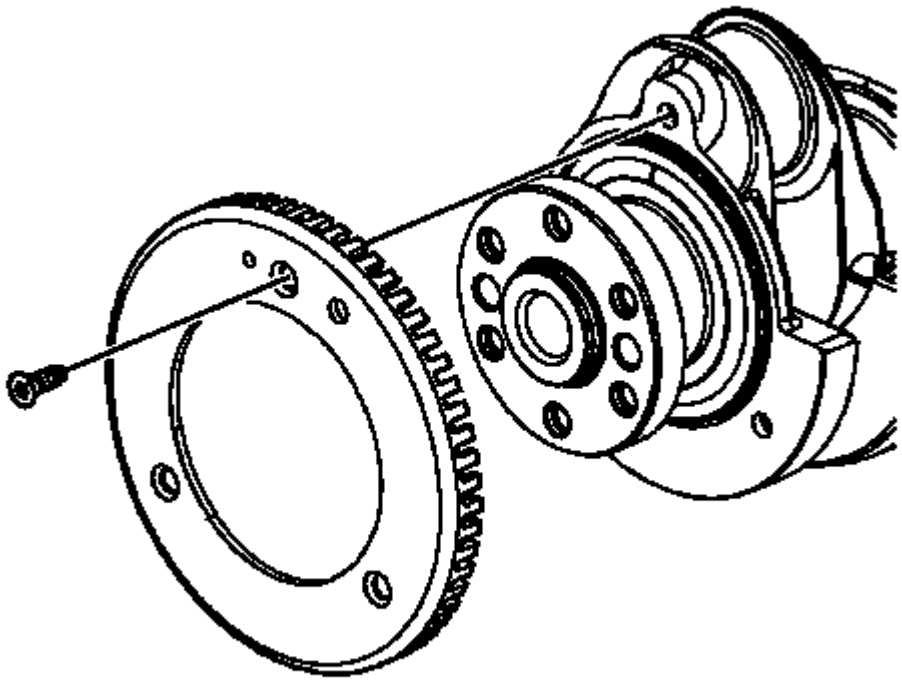

Fig. 408: View Of Crankshaft Position Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft position reluctor ring may be replaced if damaged.

   Tighten: Tighten the crankshaft position reluctor ring bolts to 15 N.m (11 lb ft).

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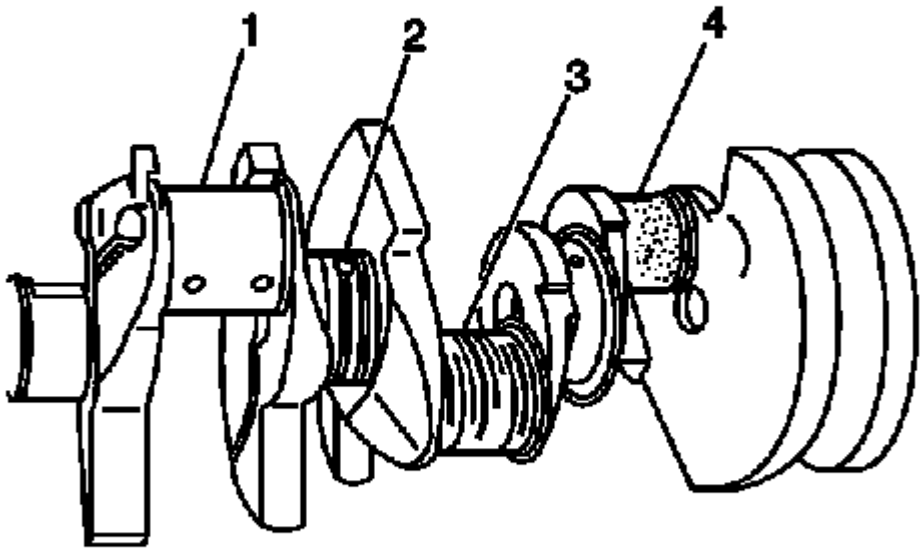

Fig. 409: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

6. Inspect the crankshaft journals for wear (1). The journals should be smooth, with no signs of scoring, wear, or damage.
7. Inspect the crankshaft journals for grooves or scoring (2).
8. Inspect the crankshaft journals for scratches or wear (3).
9. Inspect the crankshaft journals for pitting or imbedded bearing material (4).

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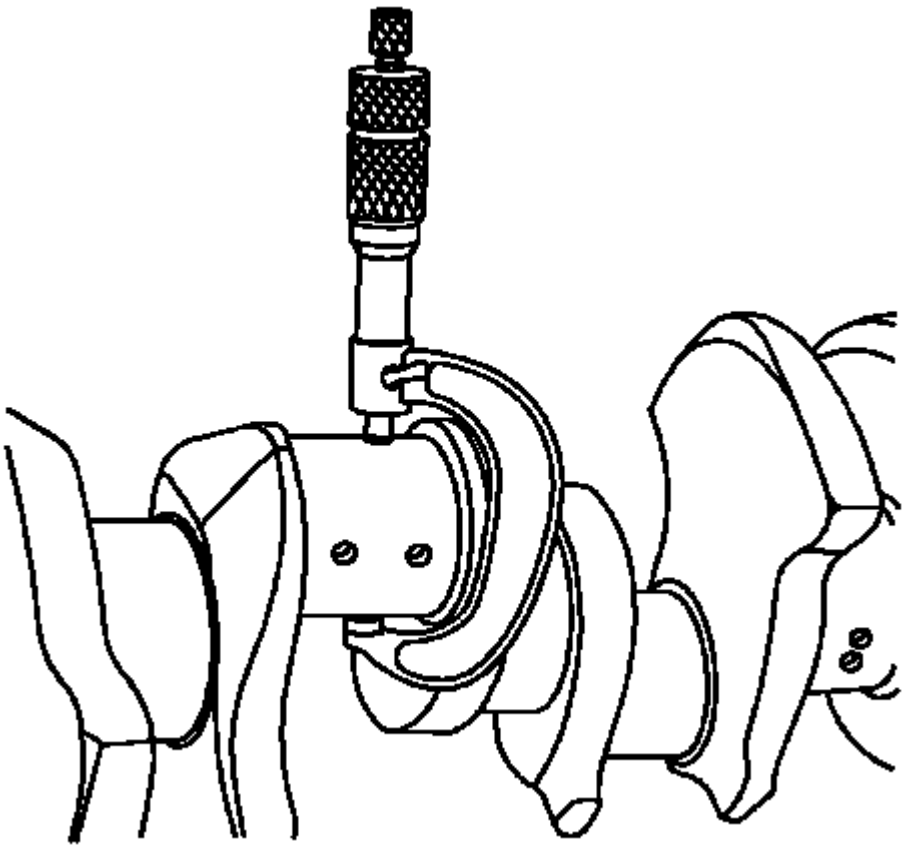

Fig. 410: Measuring Crankshaft Journals
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft journals for out-of-round.
11. Measure the crankshaft journals for taper.

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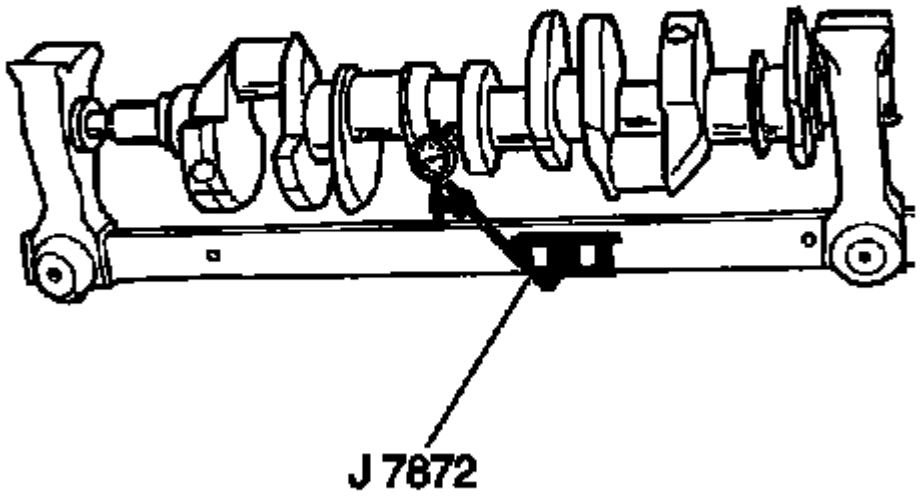

Fig. 411: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

    Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **J 7872** in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **J 7872** in order to measure the runout of the crankshaft rear flange.
15. Replace the crankshaft if the measurements are not within specifications.

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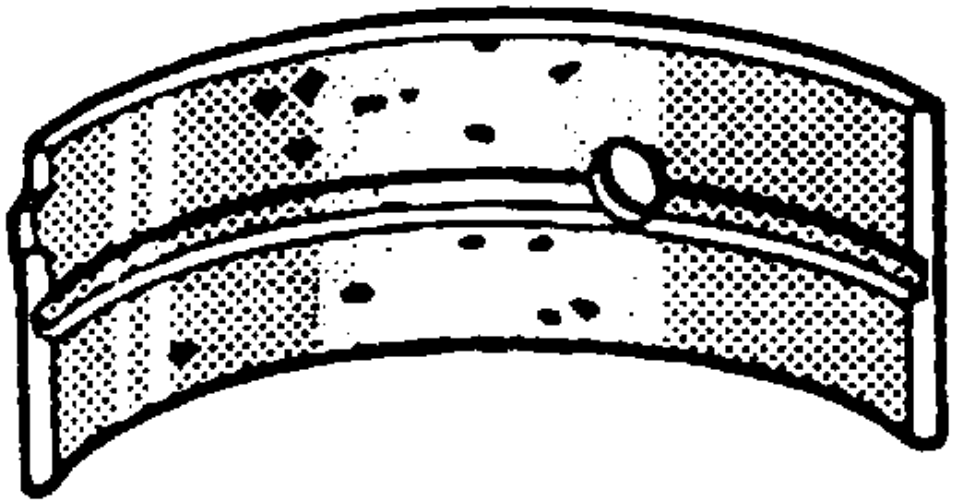

Fig. 412: Identifying Crankshaft Bearing Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

16. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

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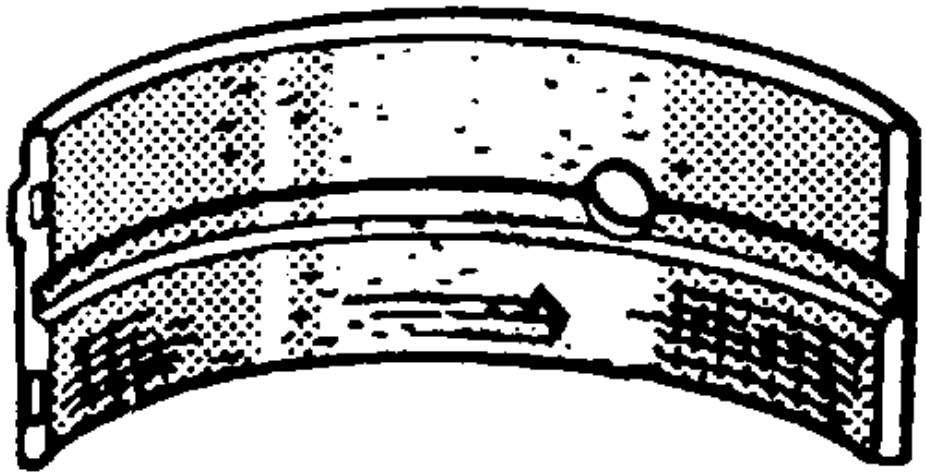

Fig. 413: Identifying Connecting Rod Bearing Scoring Or Discoloration
Courtesy of GENERAL MOTORS CORP.

17. Inspect the crankshaft bearings for excessive scoring or discoloration.
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

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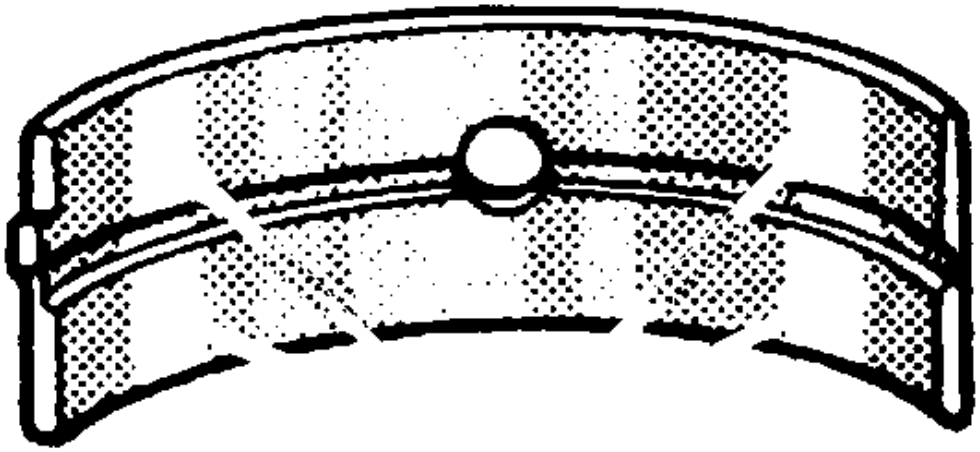

Fig. 414: Crankshaft Bearing Polished Sections (Improper Seating)
Courtesy of GENERAL MOTORS CORP.

19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.

    If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

    Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Piston and Connecting Rod Disassemble

Tools Required

EN-46745 Piston Pin Retainer Remover and Installer. See **Special Tools**.

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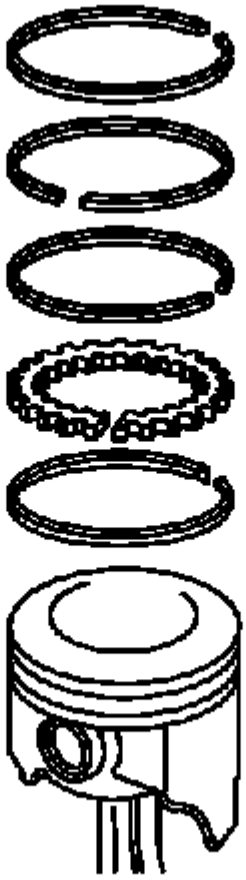

Fig. 415: Exploded View Of Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings. Use a suitable tool to expand the rings. The piston rings must not be reused.

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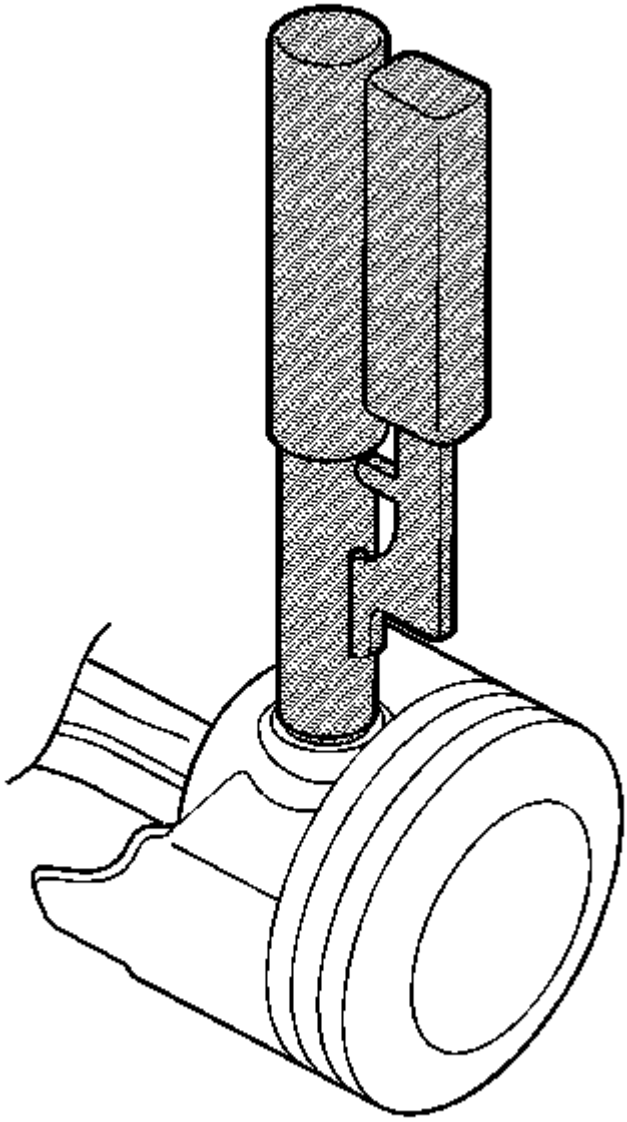

Fig. 416: Identifying Piston Pin Retainer Installation Tool
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Two retainers hold the piston pins in place. No special tools are required to remove the piston pins. Ensure that the piston pin is not damaged. Do not reuse the retainers.

2. Remove the piston pin retainers using the **EN-46745** . See **Special Tools**.

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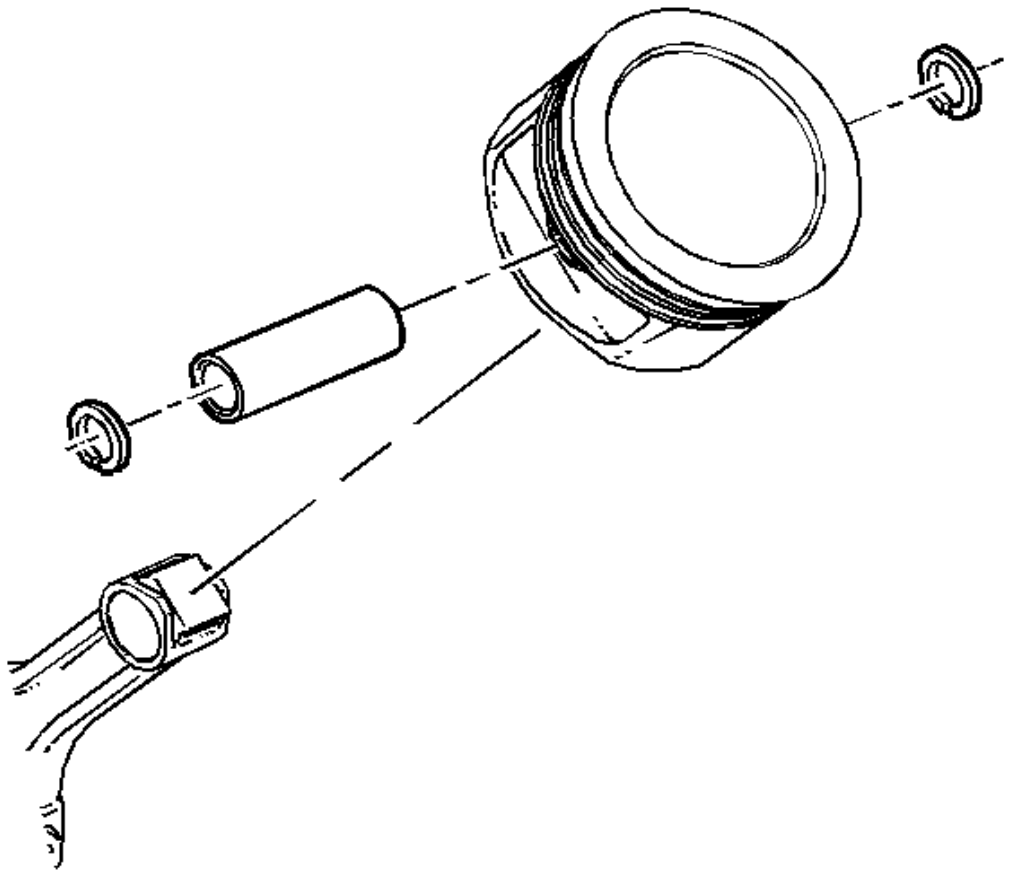

Fig. 417: View Of Piston Pin, Piston, Clips & Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin.

Piston, Connecting Rod, and Bearings Cleaning and Inspection

Connecting Rod Measurement

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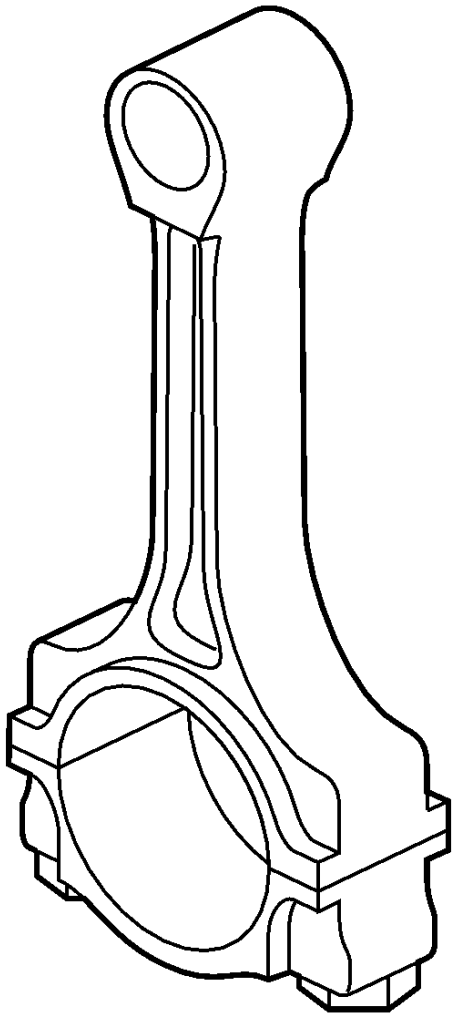

Fig. 418: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

1. Clean the connecting rods in solvent and dry with compressed air.
2. Inspect the connecting rods for the following:
   - Signs of being twisted, bent, nicked, or cracked
   - Scratches or abrasion on the rod bearing seating surface
3. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper. DO NOT scrape the rod or rod cap.
4. If the beam of the rod is scratched or has other damage replace the connecting rod.
5. Measure the piston pin to connecting rod bore using the following procedure:
   1. Using an outside micrometer, take two measurements of the piston pin in the area of the connecting rod contact.
   2. Using an inside micrometer, measure the connecting rod piston pin bore.
   3. Subtract the piston pin diameter from the piston pin bore diameter.

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4. The clearance should not be more than 0.021 mm (0.0008 in).
6. If there is excessive clearance, replace the piston pin.
7. If there is still excessive clearance, replace the connecting rod.

Piston Measurement

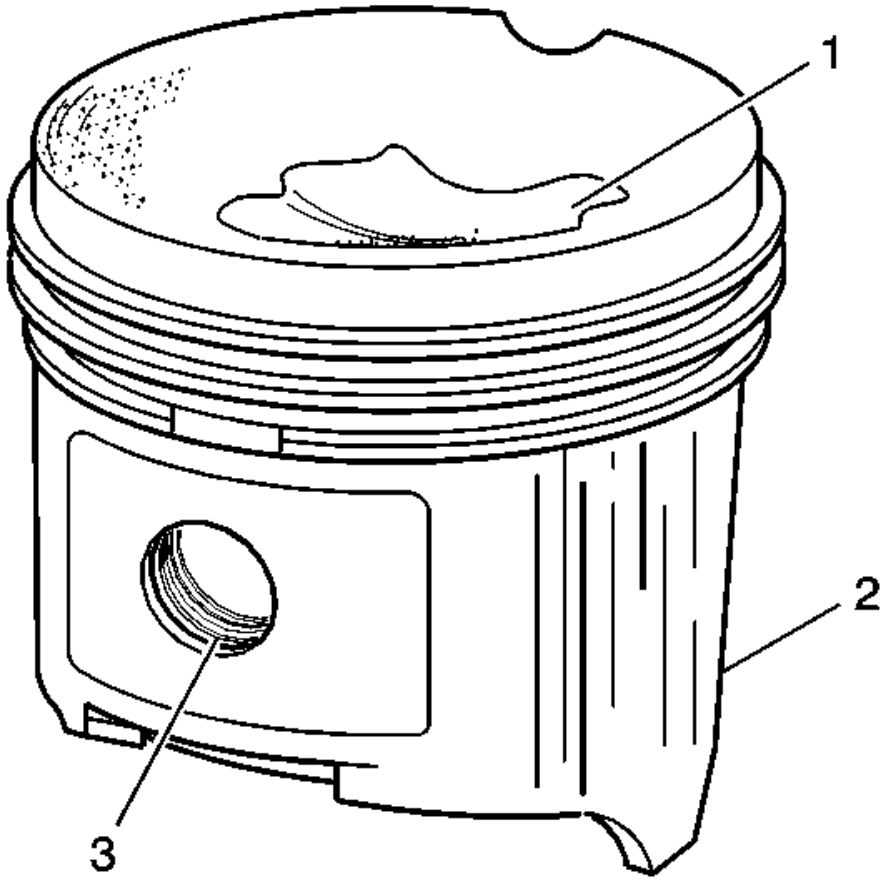

Fig. 419: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

1. Clean the piston skirts and the pins with a cleaning solvent. DO NOT wire brush any part of the piston.
2. Clean the piston ring grooves with a groove cleaner. Make sure oil ring holes and slots are clean.
3. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts, or pin bosses
   - Ring grooves for nicks, burrs that may cause binding
   - Warped or worn ring lands
   - Eroded areas at the top of the piston (1)

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- Scuffed or damaged skirts (2)
- Worn piston pin bores (3)

4. Replace pistons that show any signs or damage or excessive wear.
5. Measure the piston pin bore to piston pin clearances using the following procedure:
    1. Piston pin bores and pins must be free of varnish or scuffing.
    2. Use an outside micrometer to measure the piston pin in the piston contact areas.
    3. Using an inside micrometer, measure the piston pin bore.
    4. Subtract the measurement of the piston pin bore from the piston pin. The clearance should be within 0.002-0.012 mm (0.00007-0.00047 in).
    5. If the clearance is excessive, determine which component is out of specification.

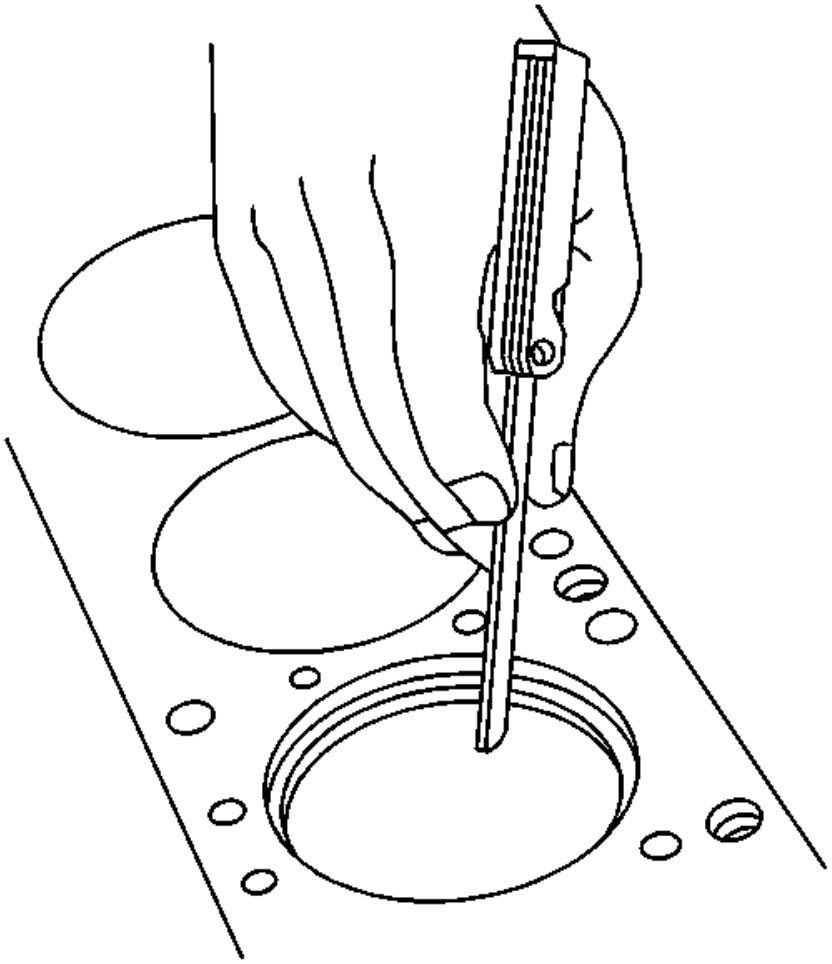

Fig. 420: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

6. Measure the piston ring end gap using the following procedure:

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1. Place the piston ring in the area of the bore where the piston ring will travel (approximately 25 mm or 1 inch down from the deck surface). Be sure the ring is square with the cylinder bore by positioning the ring with the piston head.
2. Measure the end gap of the piston ring with feeler gages. Compare the measurements with those provided below:
    - The top compression ring end gap should be 0.20-0.40 mm (0.0060-0.015 in).
    - The second compression ring end gap should be 0.35-0.55 mm (0.0137-0.0216 in).
    - The oil ring end gap should be 0.25-0.76 mm (0.0098-0.029 in).
3. If the clearance exceeds the provided specifications, the piston rings must be replaced.
4. Repeat the procedure for all the piston rings.

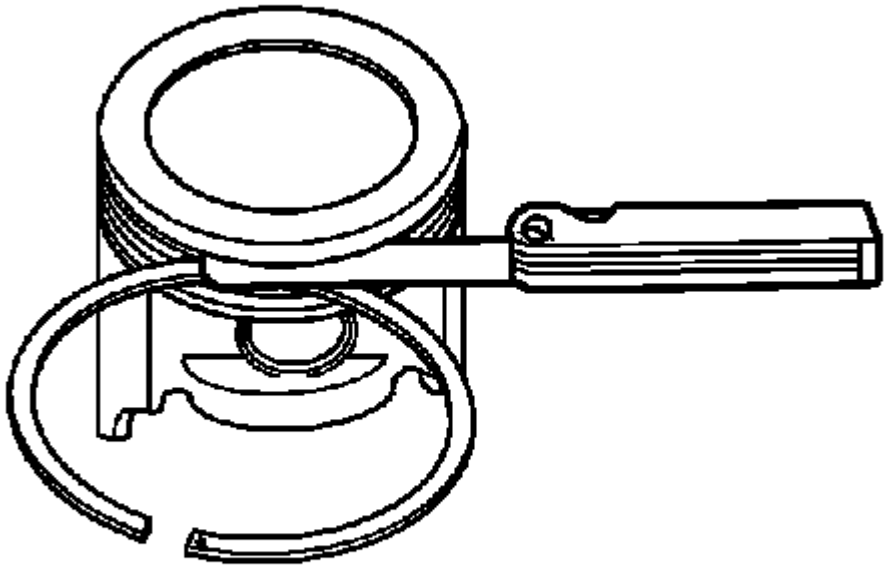

Fig. 421: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the piston ring side clearance using the following procedure:
    1. Roll the piston ring entirely around the piston ring groove. If any binding is caused by a distorted piston ring, replace the ring.
    2. With the piston ring on the piston, use feeler gages to check clearance at multiple locations.

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3. The clearance between the surface of the top piston ring and the ring land should be no greater than 0.075 mm (0.0030 in).
4. If the clearance is greater than specifications, replace the piston ring.
5. If the new ring does not reduce the top ring side clearance to 0.075 mm (0.0030 in) or less, install a new piston.

8. The top compression ring may be installed with either side up. There is a locating dimple on the 2nd compression ring near the end for identification of the top side. Install the 2nd compression ring with the dimple facing up.
9. The clearance between the surface of the second piston ring and the ring land should be no greater than 0.069 mm (0.0026 in).
10. If the new ring does not reduce the clearance to 0.069 mm (0.0026 in) or less, install a new piston.

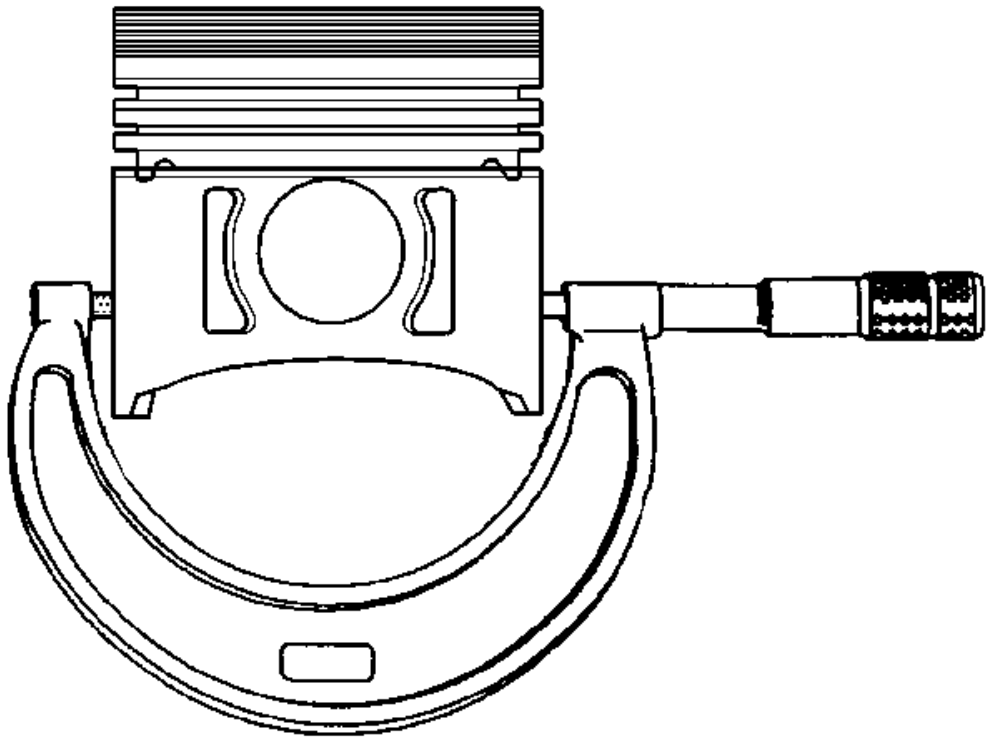

Fig. 422: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

11. Measure piston width using the following procedure:

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1. Using an outside micrometer, measure the width of the piston 14.5 mm (0.570 in) above the bottom of the piston skirt at the thrust surface perpendicular to the centerline of the piston pin.
2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
3. The proper clearance specification for the piston is 0.010-0.041 mm (0.0006-0.0016 in).

12. If the clearance obtained through measurement is greater than these specifications and the cylinder bores are within specification, replace the piston.

Piston Selection

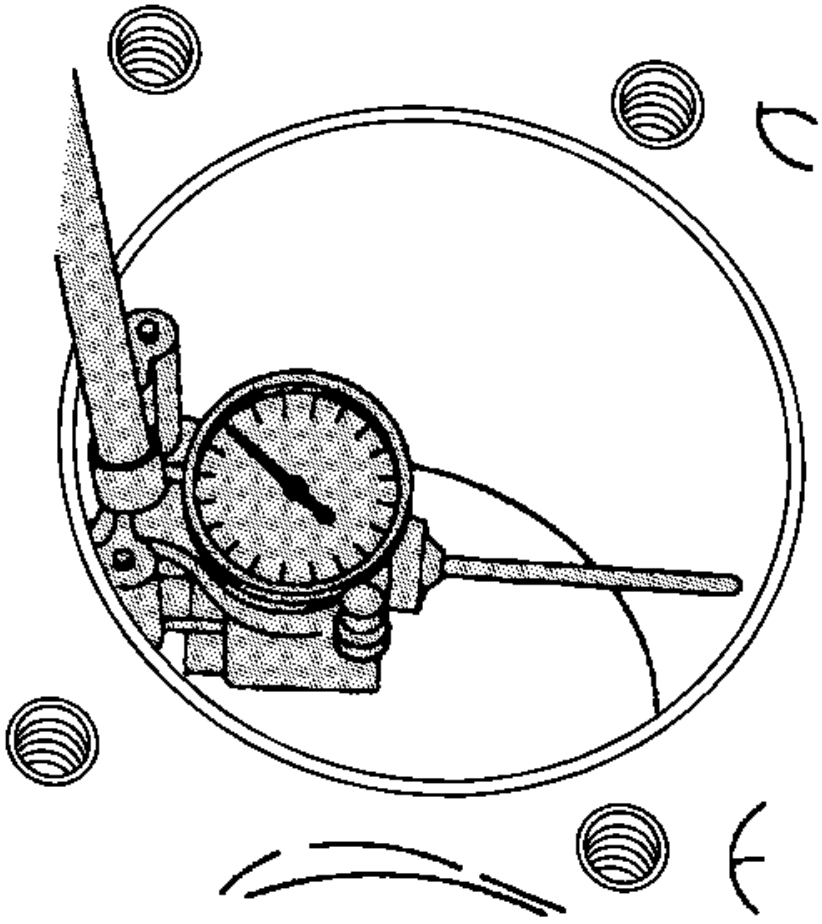

Fig. 423: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Measurements of all components should be taken with the components at normal room temperature.
For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.
A used piston and pin set may be reinstalled if, after cleaning and

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inspection, they are within specifications.

1. Inspect the engine block cylinder bore. Refer to **Engine Block Cleaning and Inspection** .
2. Inspect the piston and the piston pin. Refer to **Piston, Connecting Rod, and Bearings Cleaning and Inspection**.
3. Use a bore gauge and measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore.

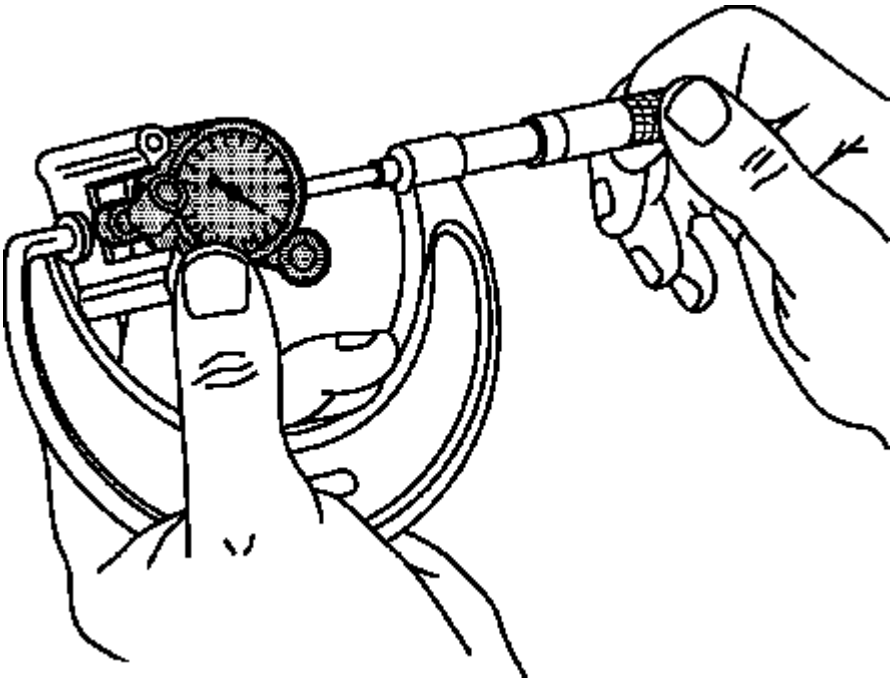

Fig. 424: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gauge with a micrometer and record the reading.

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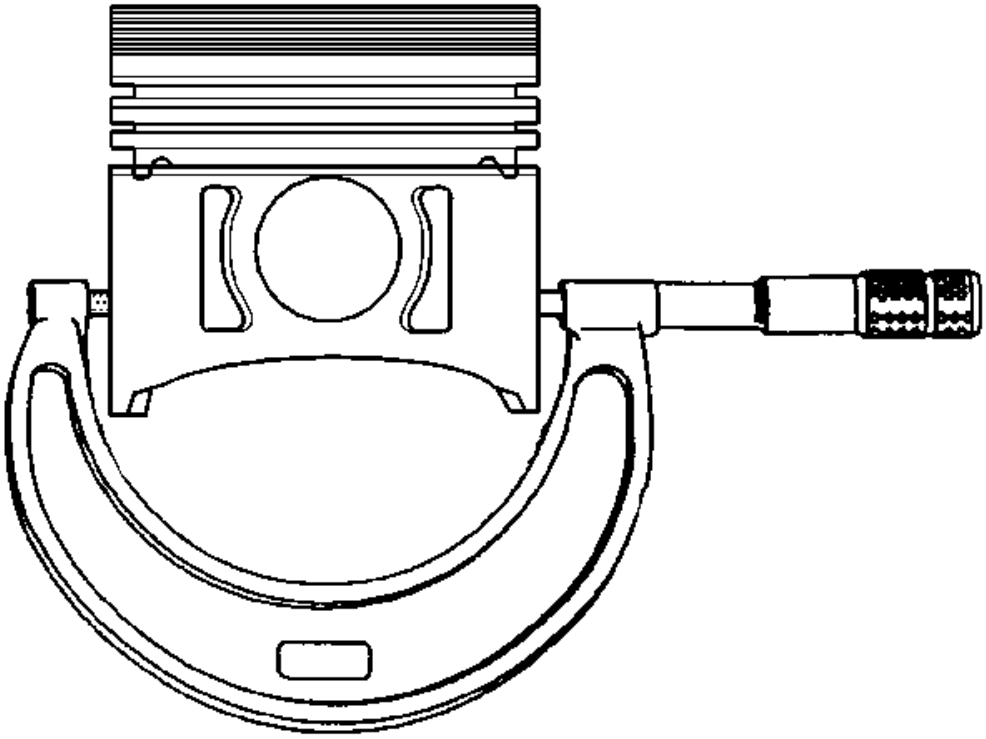

Fig. 425: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

5. With a micrometer or caliper at a right angle to the piston, measure the piston 14 mm (0.570 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance. Refer to **Engine Mechanical Specifications**.
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances.
9. If the proper fit cannot be obtained, hone the cylinder bore or replace the cylinder block.
10. When the piston-to-cylinder bore clearance is within specifications, mark the top of the piston using a permanent marker for installation to the proper cylinder. Refer to **Separating Parts** .

Piston and Connecting Rod Assemble

Tools Required

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EN-46745 Piston Pin Retainer Remover and Installer. See **Special Tools**.

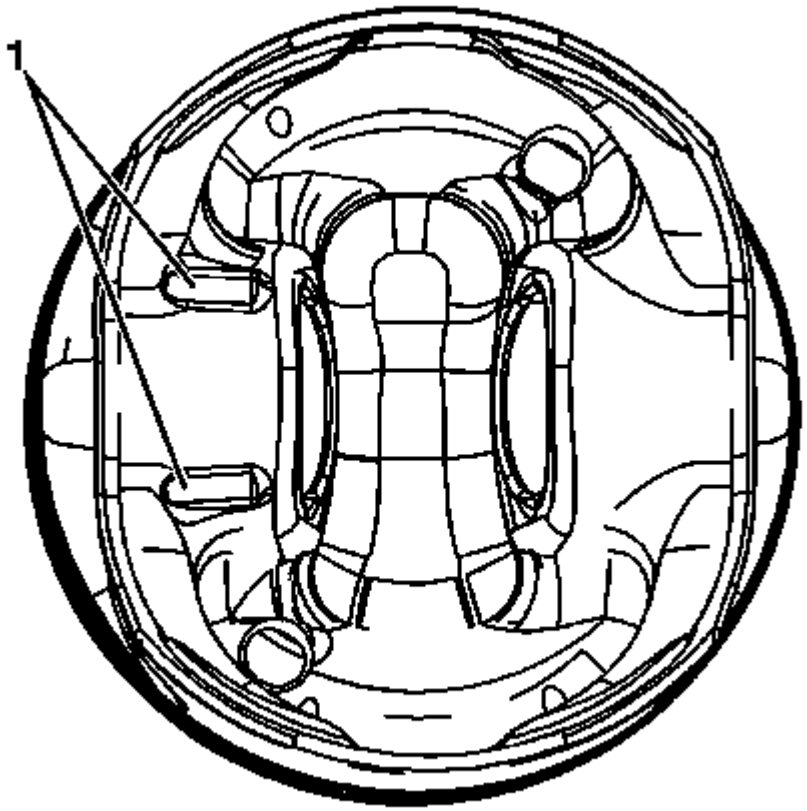

Fig. 426: Locating "Cast Boss" On Underside of Piston
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Install the piston onto the connecting rod with the arrow oriented toward the front of the engine.

1. The cast boss (1), on the underside of the piston, must go to the rear of the block.

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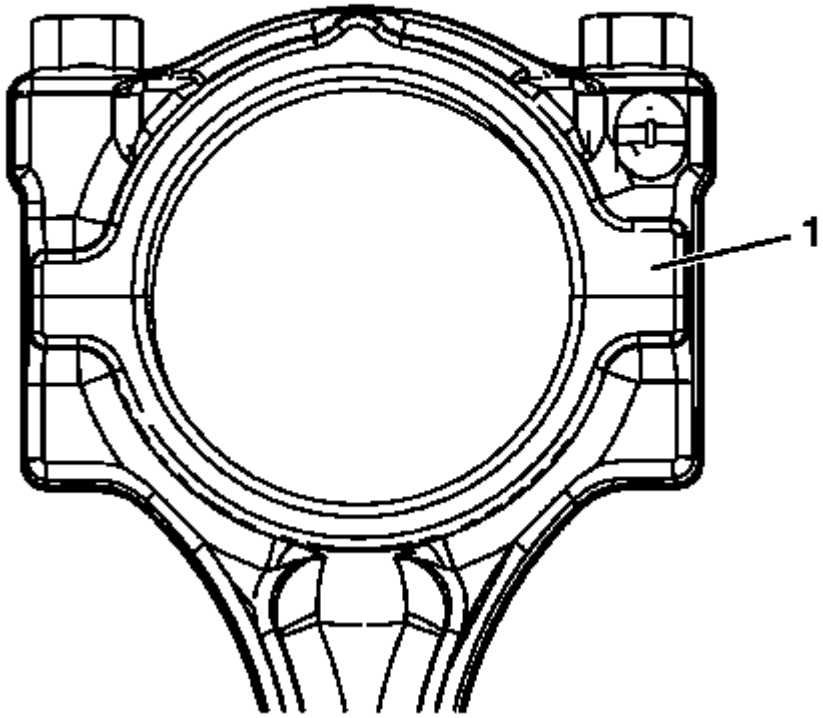

Fig. 427: Identifying Cast Mark
Courtesy of GENERAL MOTORS CORP.

2. The cast mark (1), on the connecting rod, must go to the front of the block.

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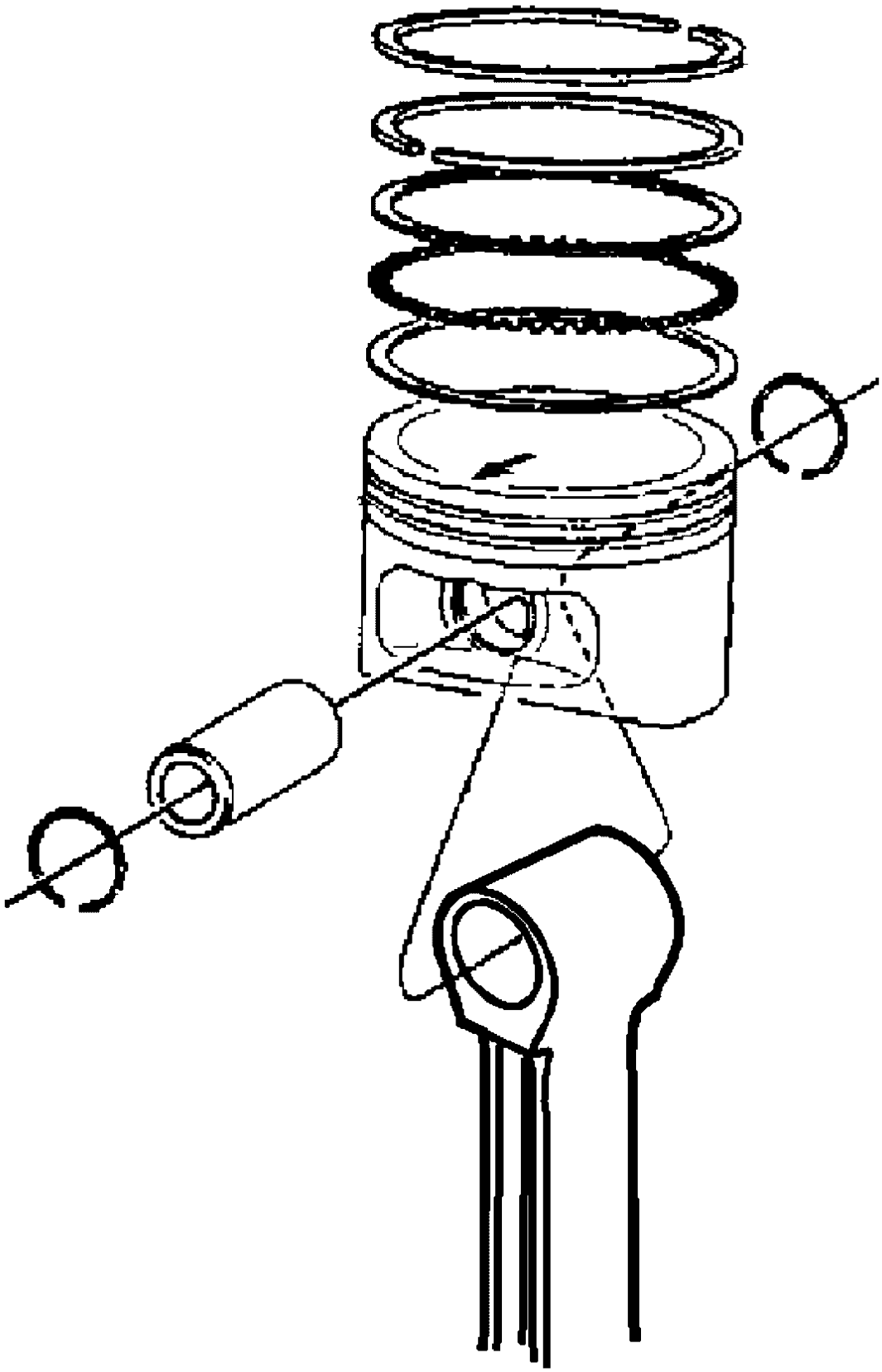

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Fig. 428: Assembling Connecting Rod & Piston
Courtesy of GENERAL MOTORS CORP.

3. Assemble the connecting rod and the piston.

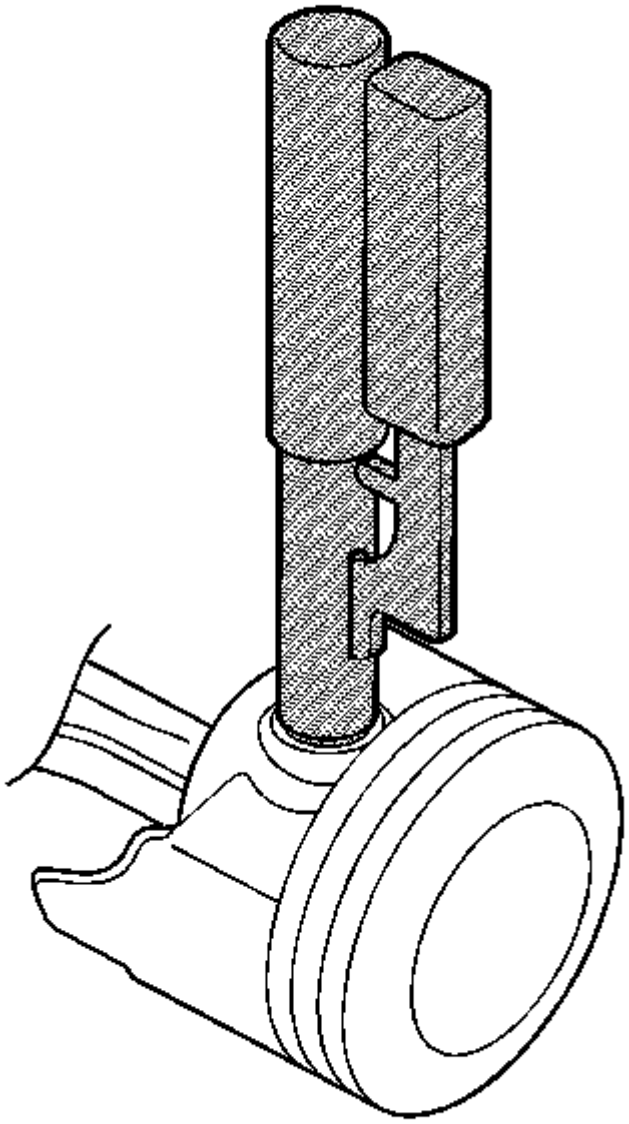

Fig. 429: Identifying Piston Pin Retainer Installation Tool
Courtesy of GENERAL MOTORS CORP.

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NOTE: Install the piston pin retainers correctly in the retaining groove during assembly in order to avoid engine damage.

4. Use the following procedure to assemble the piston pin and the retainer:
    1. Coat the piston pin with oil.
    2. Install one side of one piston pin retainer into the retaining groove using **EN-46745** . See **Special Tools**. Rotate the retainer until it is fully seated in the groove.
    3. Install the connecting rod and the piston pin.

       Push the piston pin until it bottoms in the previously installed retainer.

    4. Install the second piston pin retainer, using **EN-46745** . See **Special Tools**.
    5. Ensure that the piston moves freely.

Fig. 430: Exploded View Of Piston Rings
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.

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5. Install the following components of the oil control ring assembly (bottom ring):
    1. The expander
    2. The lower oil control ring
    3. The upper control ring
6. Install the lower compression ring (second ring). Place the manufacturer's mark facing up.
7. Install the upper compression ring (top ring).

Camshaft Cleaning and Inspection

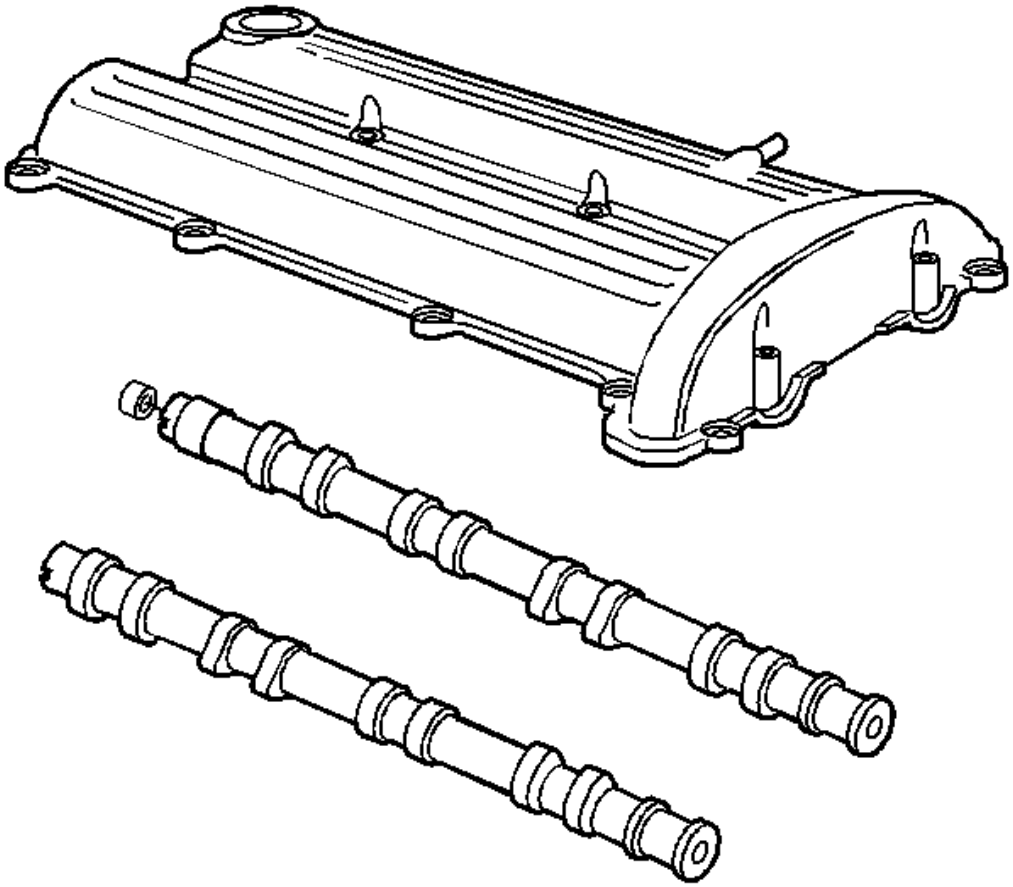

Fig. 431: View Of Camshaft Cover & Journals
Courtesy of GENERAL MOTORS CORP.

- Inspect the camshaft journals and lobes for wear or scoring.
- Inspect the camshaft sprocket alignment notch for damage.

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- Inspect the camshaft cover for damage or loose oil control baffles.
- Clean the camshaft cover.
- Wash the camshaft in solvent.
- Oil the camshaft.
- Inspect the camshaft cover for cracks or other signs of damage.

Timing Chain and Sprockets Cleaning and Inspection

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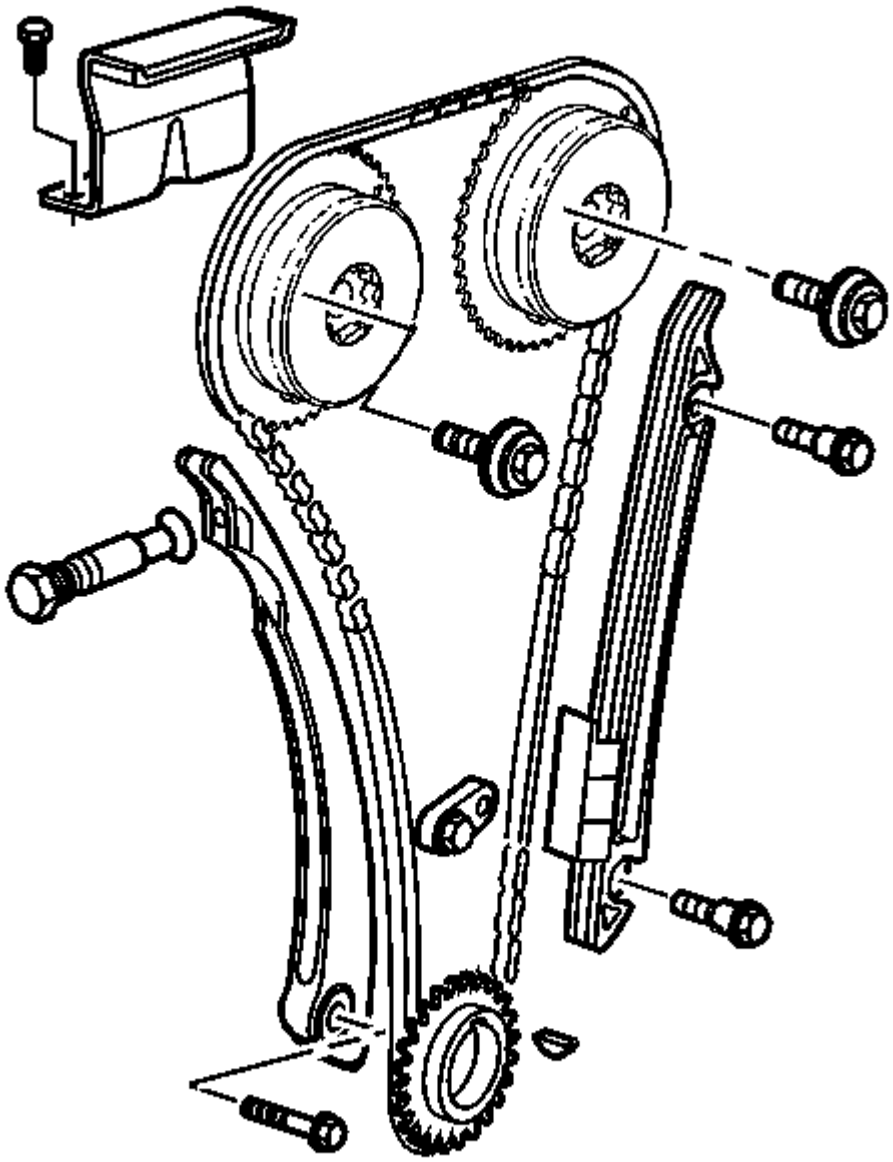

Fig. 432: View Of Timing Chain & Guides
Courtesy of GENERAL MOTORS CORP.

1. Inspect the timing chain guides for cracking or wear.
2. Replace the timing chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the timing chain tensioner shoe for wear.

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4. Replace the timing chain tensioner shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
5. Inspect the timing chain and actuators for wear.
6. Inspect the camshaft actuator faces for signs of movement.
7. Inspect the camshaft actuator teeth and chain for signs of excessive wear, chipping, or seizure of the timing chain links.
8. Inspect the oil nozzle body for collapse or cracks at the bolt boss. Discard and replace the oil nozzle body if it is damaged.
9. Inspect the timing chain tensioner for the scoring or free movement.
10. Inspect the timing chain washer and O-ring for damage. If damaged, replace the timing chain tensioner.

Balance Shaft Cleaning and Inspection

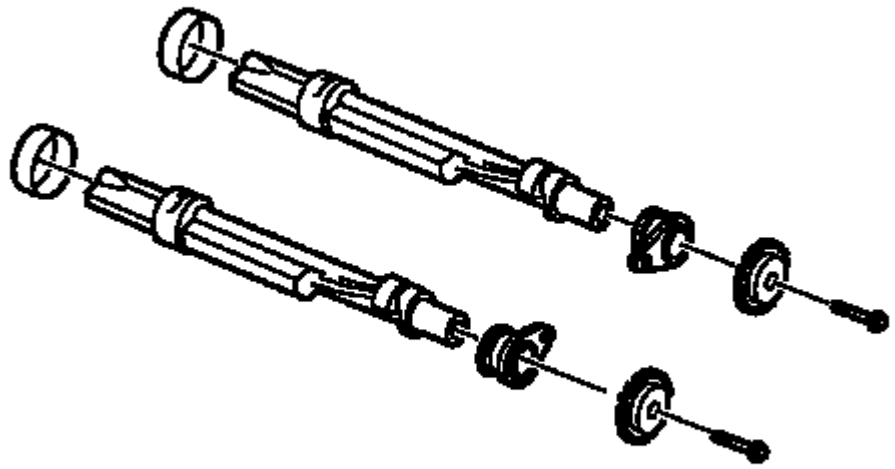

Fig. 433: Identifying Balance Shafts
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shafts in solvent.
2. Remove the balance shaft front bearing carriers from the balance shafts.
3. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.
4. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth. When installing new balance shaft drive sprockets tighten to 55 N.m (41 lb ft).

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5. Measure the rear bearing journals on the balance shafts, the journals should be 36.723-36.743 mm (1.4458-1.4466 in) in diameter.
6. Measure the front bearing journals on the balance shafts, the front bearing journals should be 20.020-20.000 mm (0.7881-0.7874 in) in diameter.
7. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

Balance Shaft Drive Chain and Sprockets Cleaning and Inspection

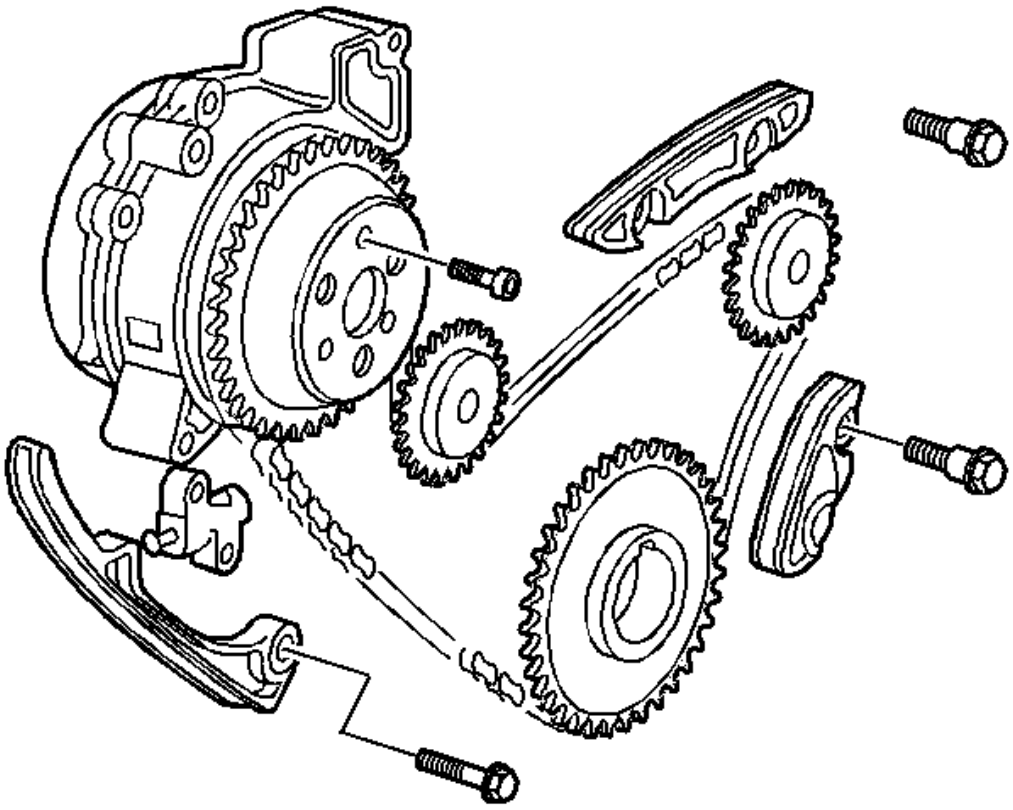

Fig. 434: Inspecting Balance Shaft Drive Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

1. Inspect the balance shaft drive chain guides for cracking or wear.
2. Replace the balance shaft drive chain guides if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.
3. Inspect the balance shaft drive chain tensioner guide shoe for wear.

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Replace the balance shaft drive chain tensioner guide shoe if wear exceeds 1.12 mm (0.045 in) depth on the chain guide surface.

4. Inspect the balance shaft drive chain and sprockets for wear.
5. Inspect the crankshaft sprocket faces for signs of movement.
6. Inspect the alignment notch in the balance shaft for cracking or damage.
7. Inspect the water pump, crankshaft, and balance shaft sprocket teeth and chain for signs of excessive wear, chipping, or seizure of the balance shaft drive chain links.
8. Inspect the timing chain tensioner for damage or wear.

Cylinder Head Disassemble

Tools Required

- **J 8062** Valve Spring Compressor
- **J 36017** Valve Seal Remover
- **J 43963** Valve Spring Compressor (off car)

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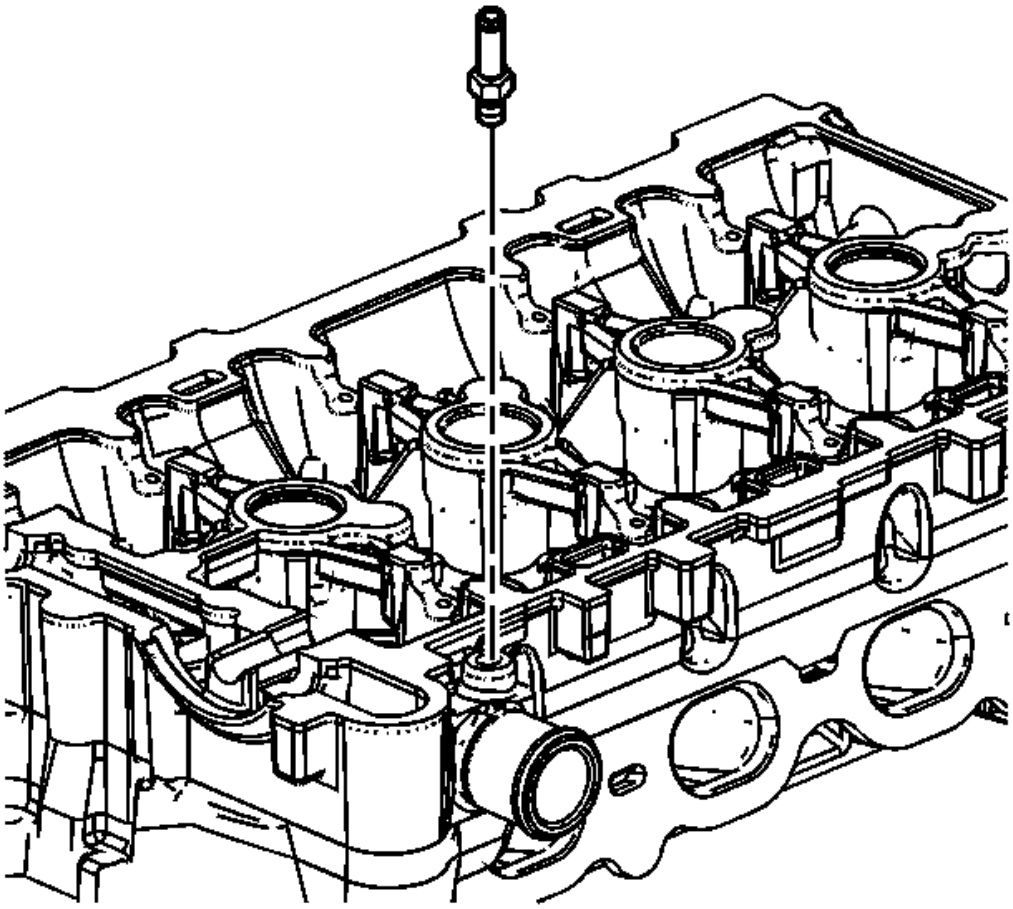

Fig. 435: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant air bleed hose fitting.

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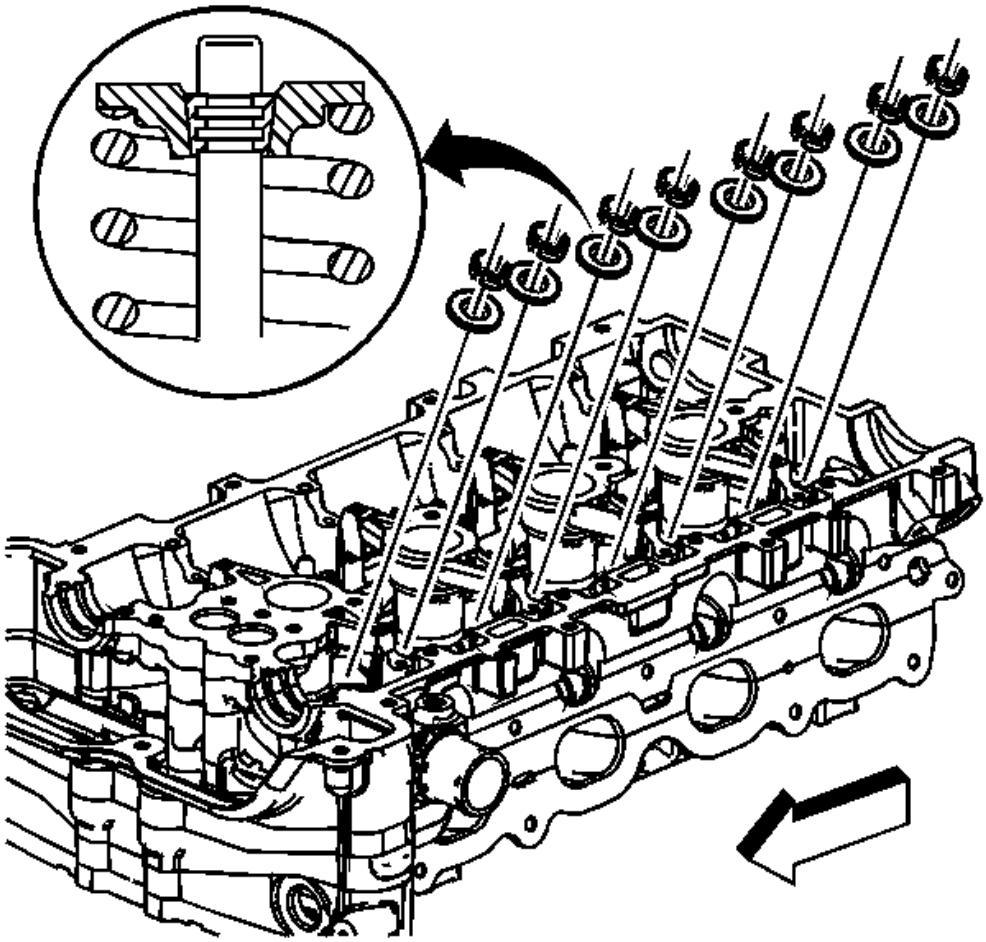

Fig. 436: Identifying Valve Spring Keepers
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the valve train components are kept together and identified in order for proper re-installation in their original position.

2. Using the **J 8062** and the **J 43963** , compress the valve spring.
3. Remove the valve keys.
4. Slowly release the **J 8062** and the **J 43963** from the valve spring assembly.
5. Remove the retainer.

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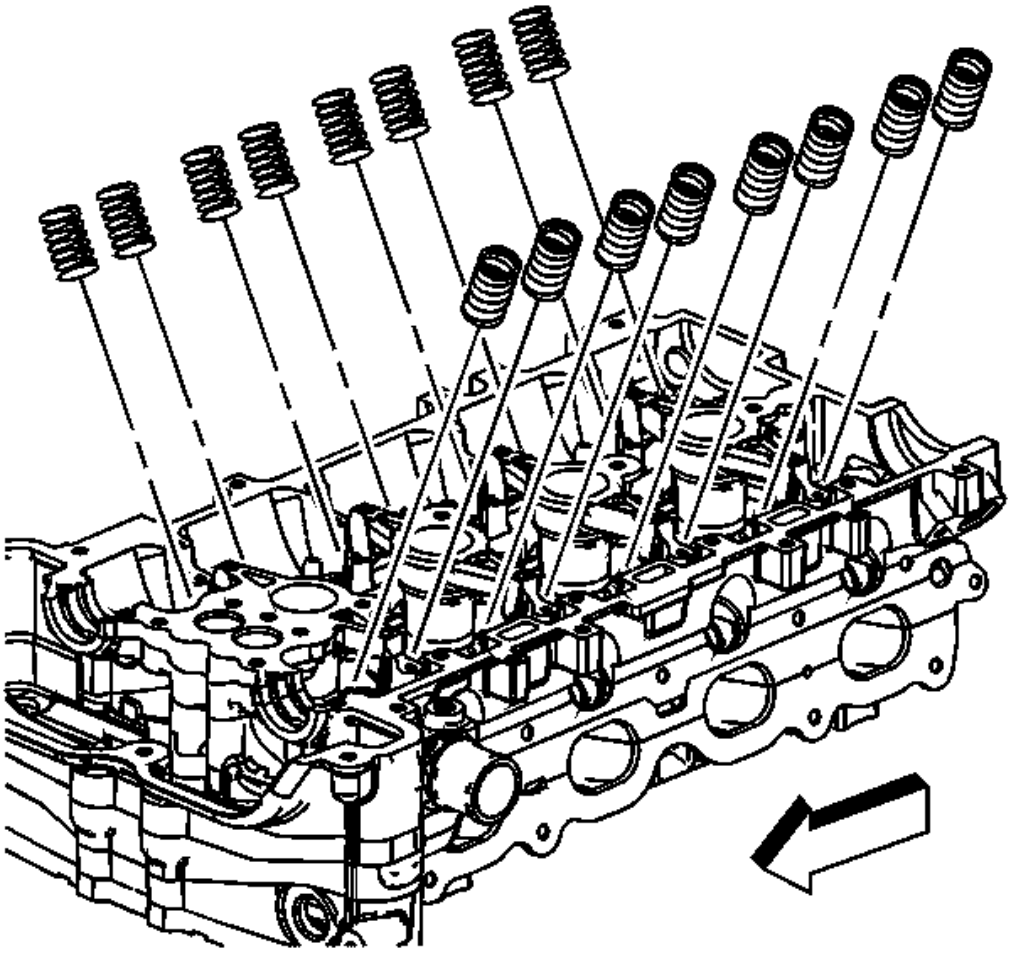

Fig. 437: Identifying Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Remove the spring.

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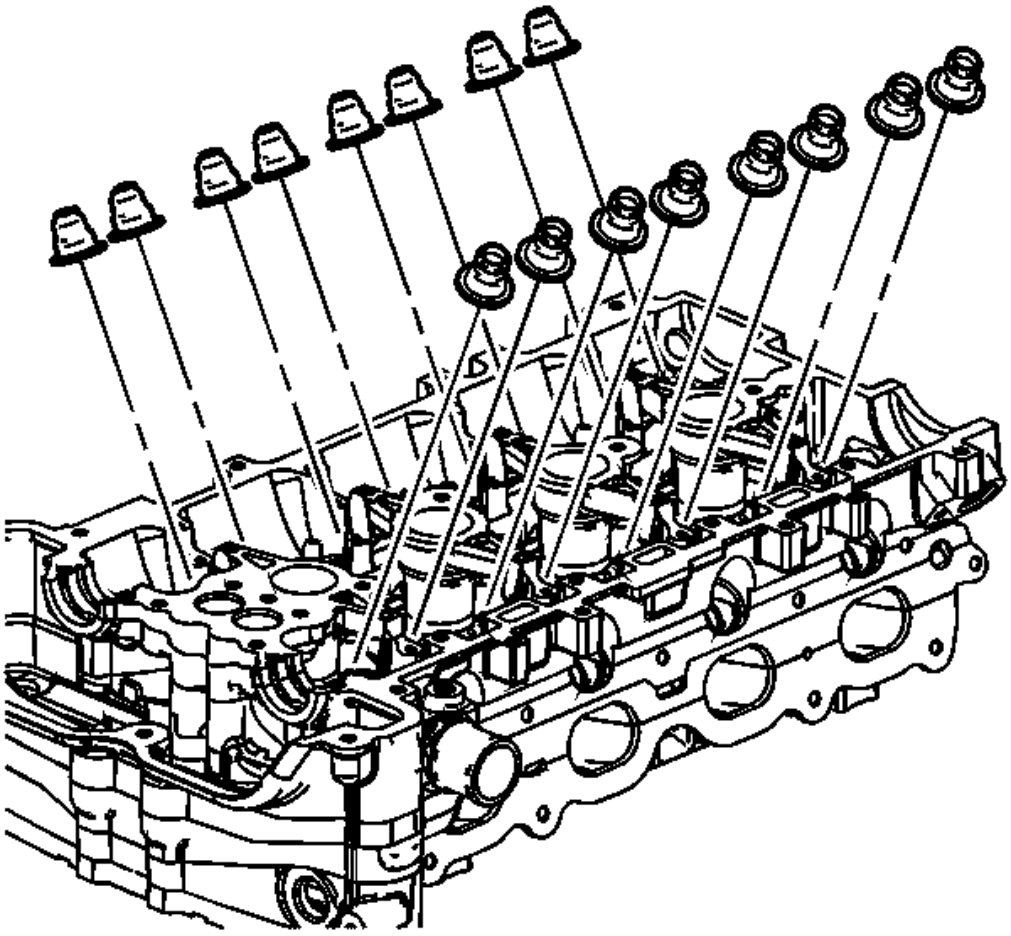

Fig. 438: Identifying Valve Seals
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not damage the valve guide. Remove any burrs that have formed at the key groove by chamfering the valve stem with an oil stone or a file.

7. Remove the valve seal. Use the **J 36017** . Do not reuse.

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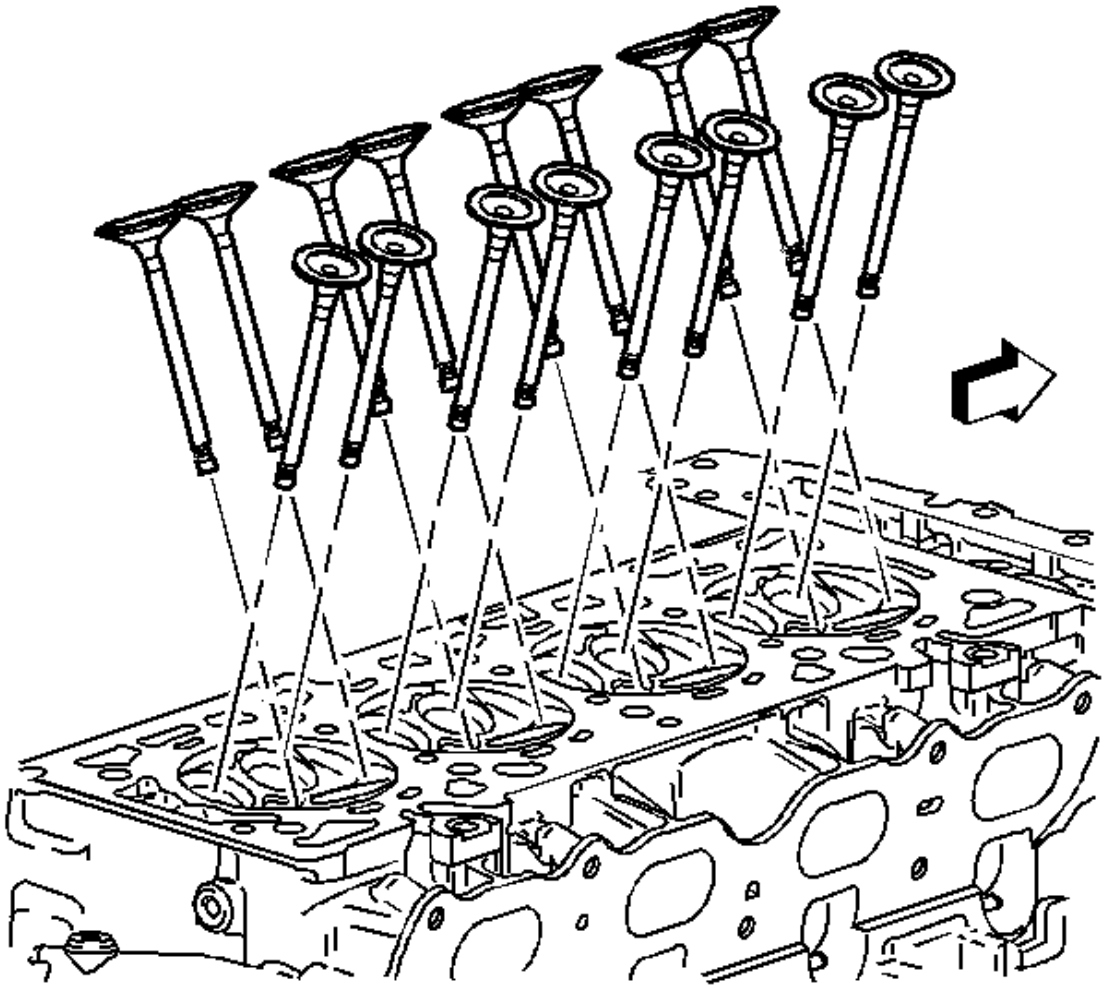

Fig. 439: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

8. Remove the valve.
9. Remove the remaining valves.

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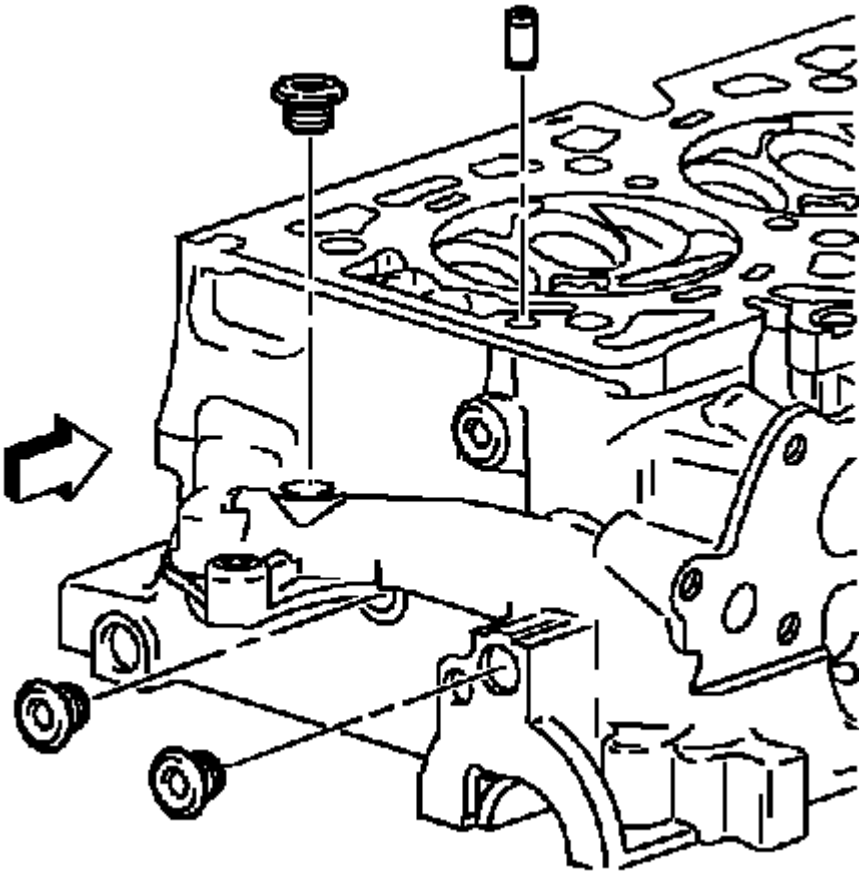

Fig. 440: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

10. Remove the cylinder head plugs.

Cylinder Head Cleaning and Inspection

Valve Cleaning and Inspection

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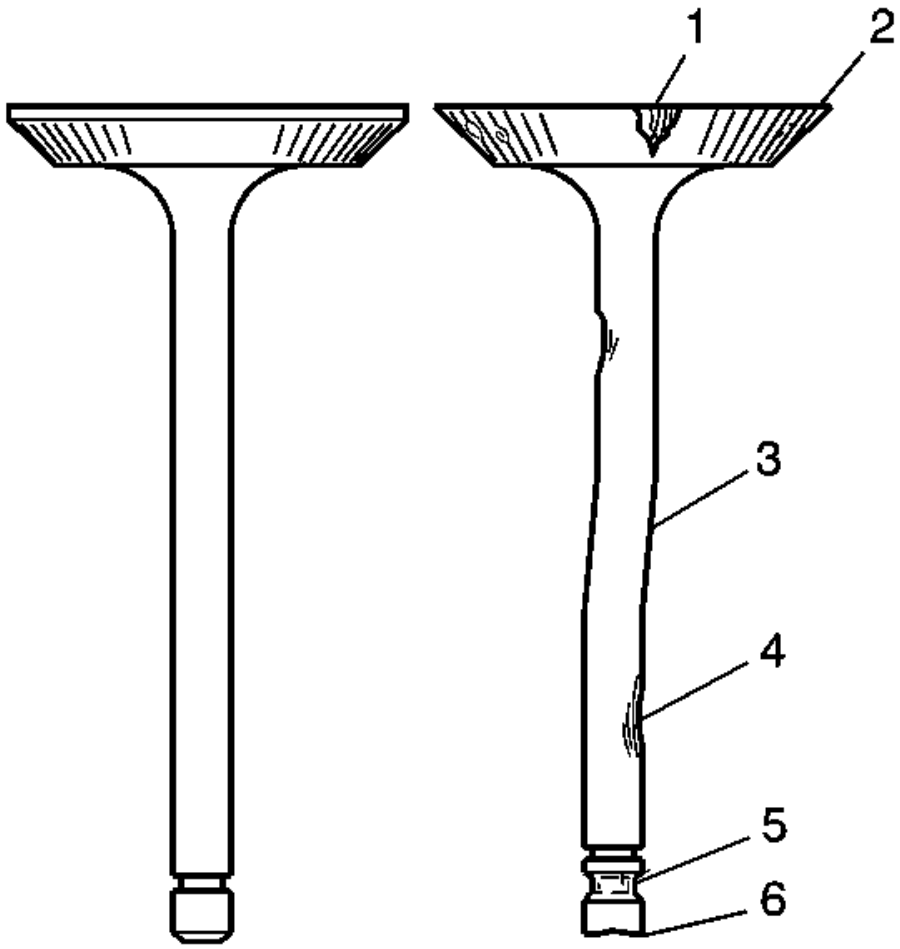

Fig. 441: Identifying Inspection Points For Valves Damage
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not scratch the valve stem with the wire brush.

1. Clean the valves of carbon, oil and varnish. Carbon can be removed with a wire brush. Varnish can be removed by soaking in Parts Immersion Solvent GM P/N 12345368 (Canadian P/N 10953514) or equivalent.
2. Clean the valve guides.
3. Inspect the valve stem for wear (4).
4. Inspect the valve keeper groove for chipping or wear (5). Replace the valve if chipped or worn.
5. Inspect the valve face for burning or cracking (1). If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
6. Inspect the valve stem for burrs and scratches. Burrs and minor scratches may be removed with an oil stone.
7. Inspect the valve stem for straightness and the valve head for bending or distortion (3) using V blocks.

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Bent or distorted valves must be replaced.

8. Clean the deposits from the valve face. Inspect the valve face for grooving.
9. Replace the valve if the face is grooved. Valve faces cannot be machined. If worn, or damaged, the valves must be replaced.
10. The valves may be lightly lapped to the valve seats.

Cylinder Head and Gasket Surface Cleaning and Inspection

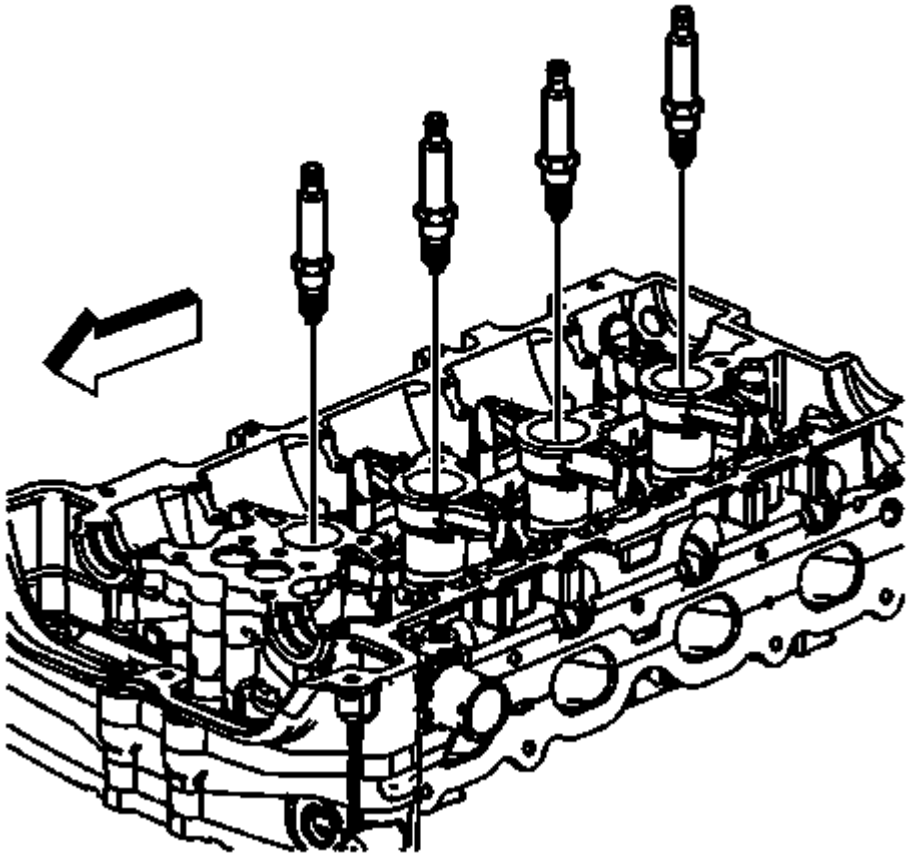

Fig. 442: Identifying Spark Plugs
Courtesy of GENERAL MOTORS CORP.

1. Remove the spark plugs.
2. Inspect the cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, use the following faults to determine the cause:
    1. Improper installation
    2. Loose or warped cylinder head
    3. Missing, off location or not fully seated dowel pins
    4. Corrosion in the seal area around the coolant passages
    5. Chips or debris in the cylinder head bolt holes

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6. Bolt holes in the cylinder block not drilled or tapped deep enough

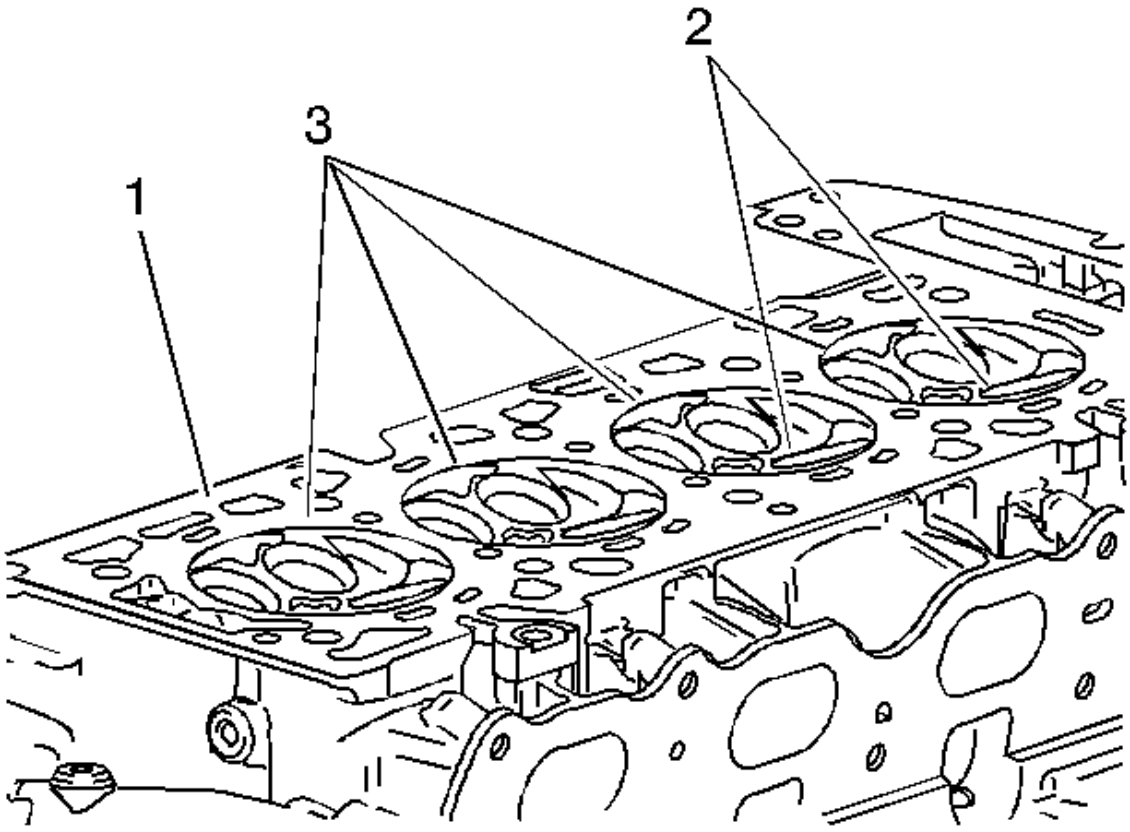

Fig. 443: Locating Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

3. Inspect the cylinder head gasket surface.
   - Cylinder head may be reused if corrosion is found only outside a 4 mm (0.375 in) band around each combustion chamber (1).
   - Replace the cylinder head if the area between the valve seats is cracked (2).
   - Replace the cylinder head if corrosion has been found inside a 4 mm (0.375 in) band around each combustion chamber (3).
4. Clean the cylinder head bolts.

IMPORTANT: Do not use a wire brush on any gasket sealing surface.

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5. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.
6. Clean the valve guides.
7. Clean the threaded holes. Use a nylon bristle brush.
8. Clean the remains of the sealer from the plug holes.
9. Inspect the cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.
10. Replace all suspect bolts.
11. Inspect the cylinder head for cracks. Check between the valve seats and in the exhaust ports.

IMPORTANT: Do not attempt to weld the cylinder head, replace it.

12. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

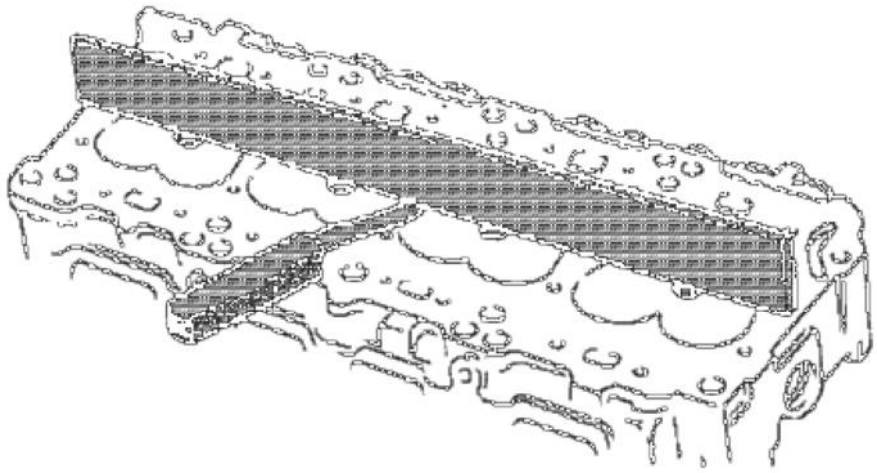

Fig. 444: Inspecting Cylinder Head Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

13. Inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications**.

    If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.

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14. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.
15. Inspect the sealing surfaces.

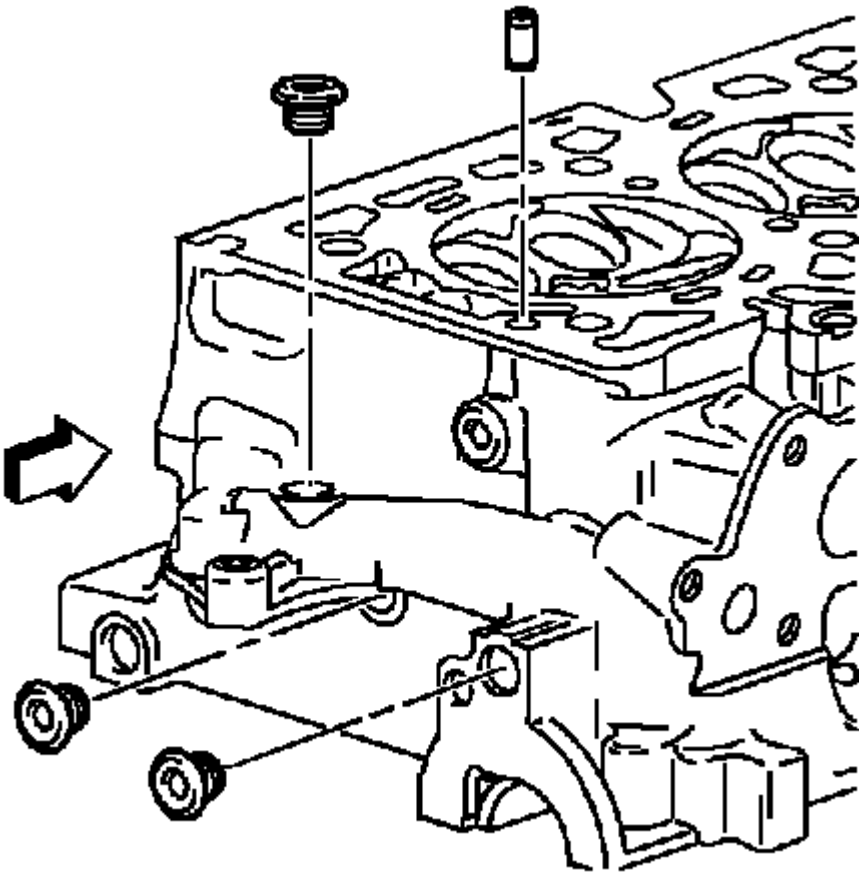

Fig. 445: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder head plugs.

Cylinder Head Assemble

Tools Required

- **J 8062** Valve Spring Compressor
- **J 9666** Valve Spring Tester
- **J 43963** Valve Spring Compressor (off car)

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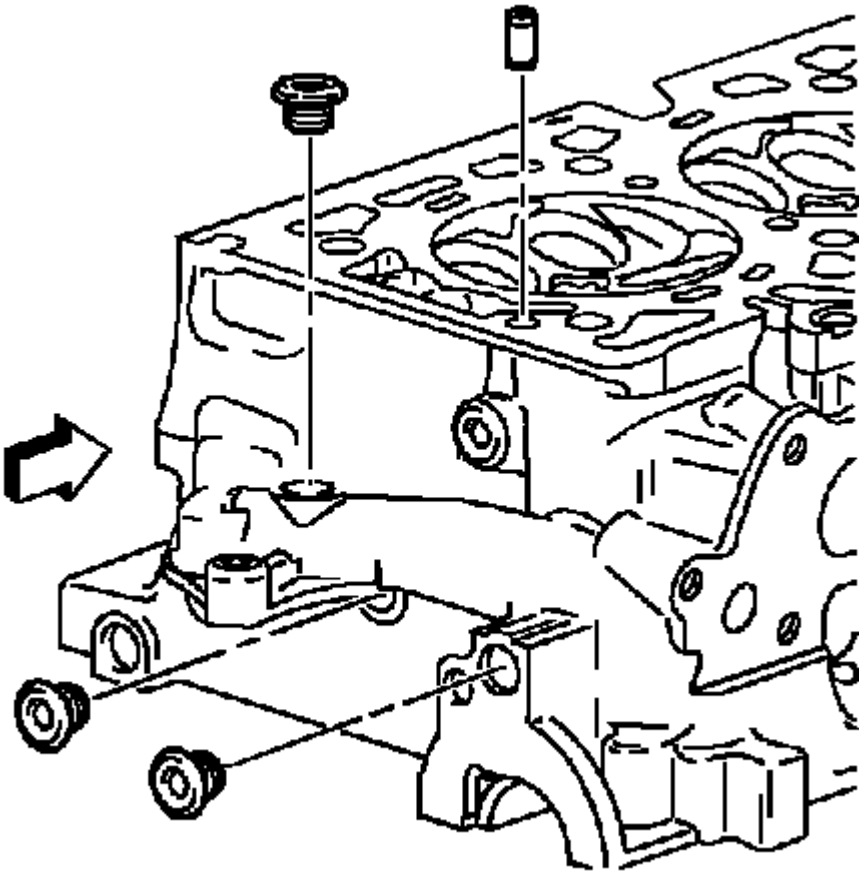

Fig. 446: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to avoid damage, install the spark plugs after the cylinder head has been installed on the engine.

1. Install NEW cylinder head plugs. Coat the plugs with sealer GM P/N 12345382 (Canadian P/N 10953489) or equivalent.

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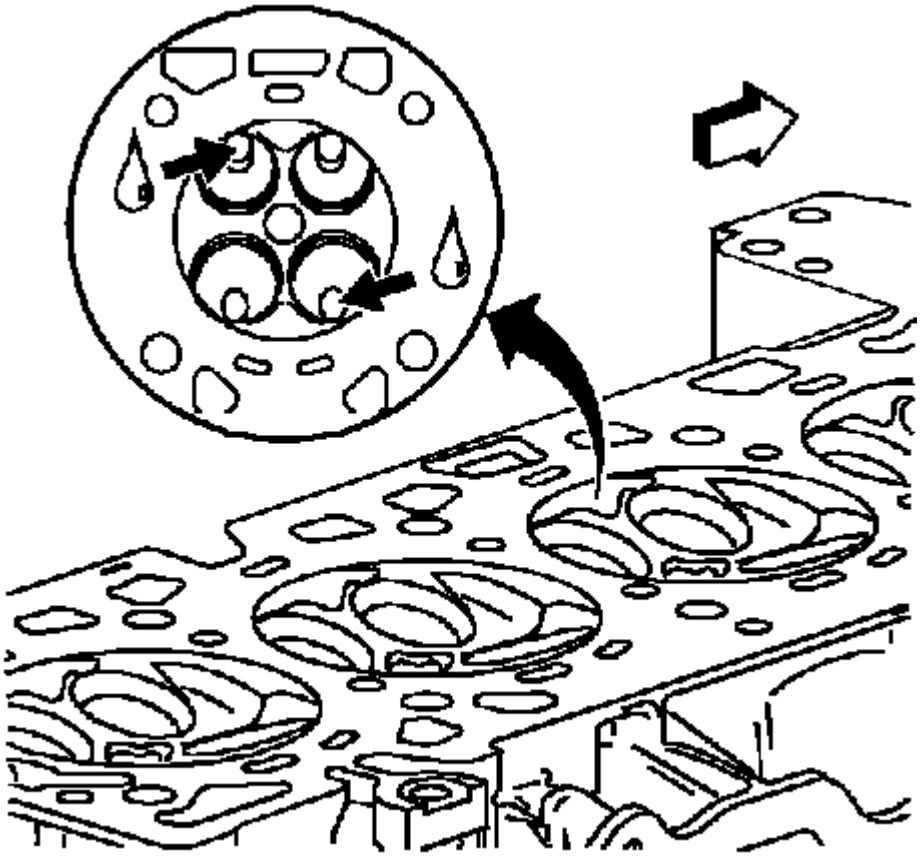

Fig. 447: Applying Prussian Blue
Courtesy of GENERAL MOTORS CORP.

2. Assemble the valves.
3. Use the following steps to measure valve runout:
    1. Apply a dab of Prussian blue on the entire valve face. Seat the valve but do not rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.
    2. Clean all traces of Prussian blue.
    3. Apply a dab of Prussian blue on the valve seat and repeat the check. The traces of Prussian blue transferred to the valve face indicates valve face concentricity.

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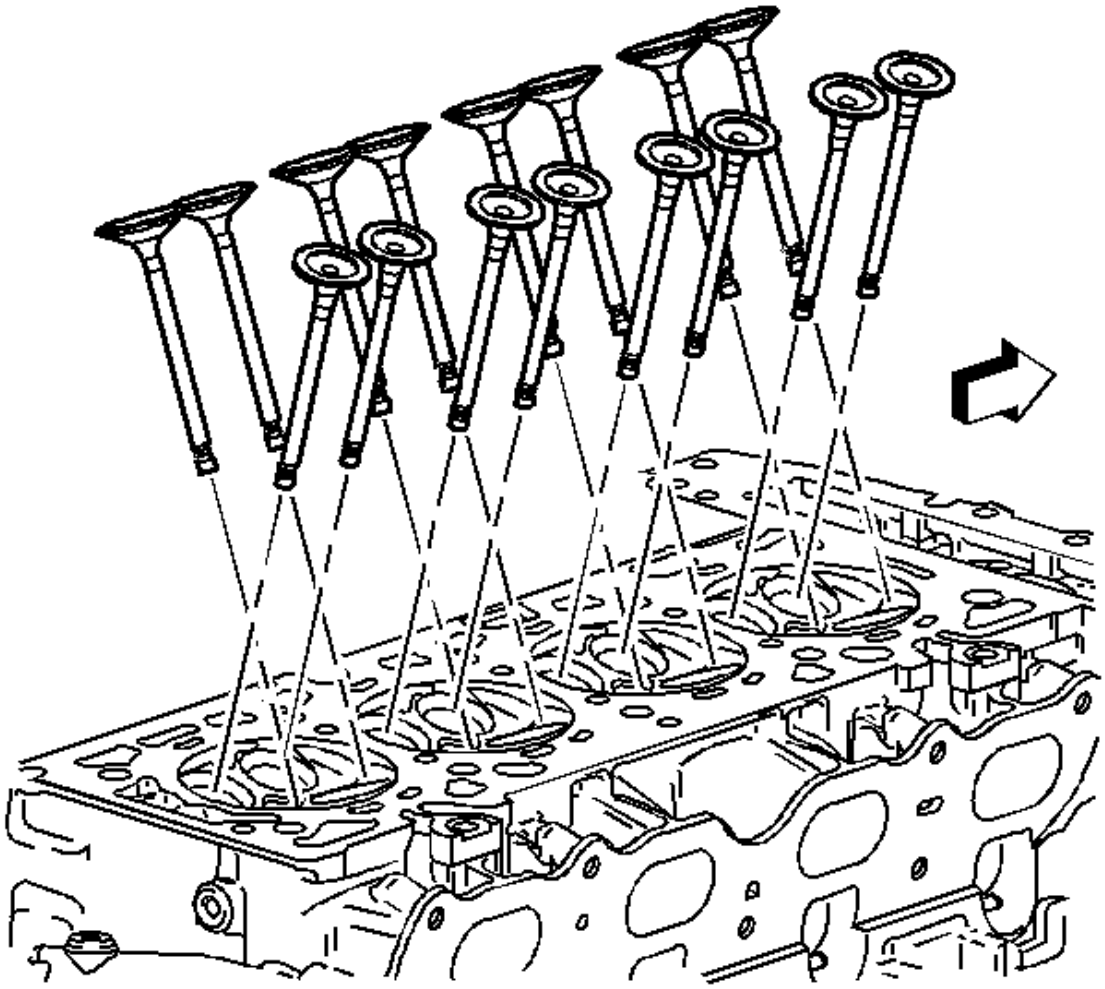

Fig. 448: Identifying Engine Valves
Courtesy of GENERAL MOTORS CORP.

4. Replace the valves, if required.

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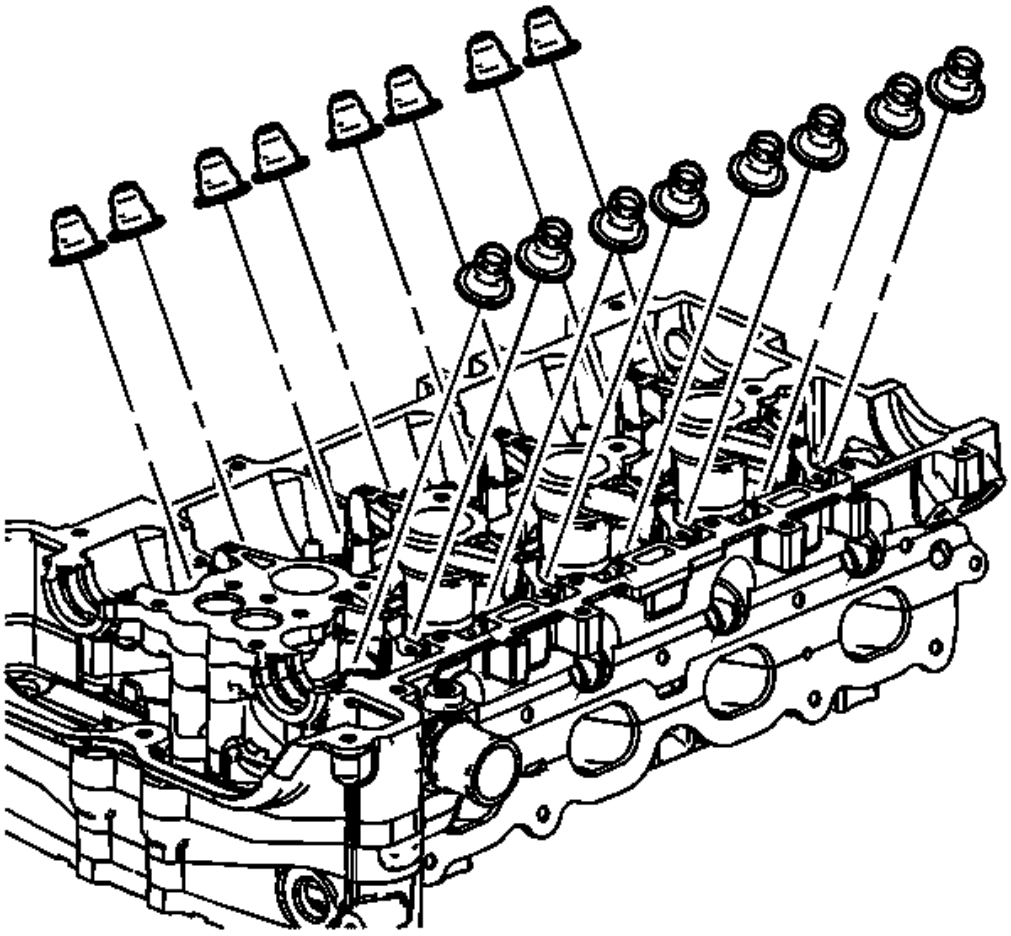

Fig. 449: Identifying Valve Seals
Courtesy of GENERAL MOTORS CORP.

5. Install the new valve seals. Fully seat the seals on the valve guides.

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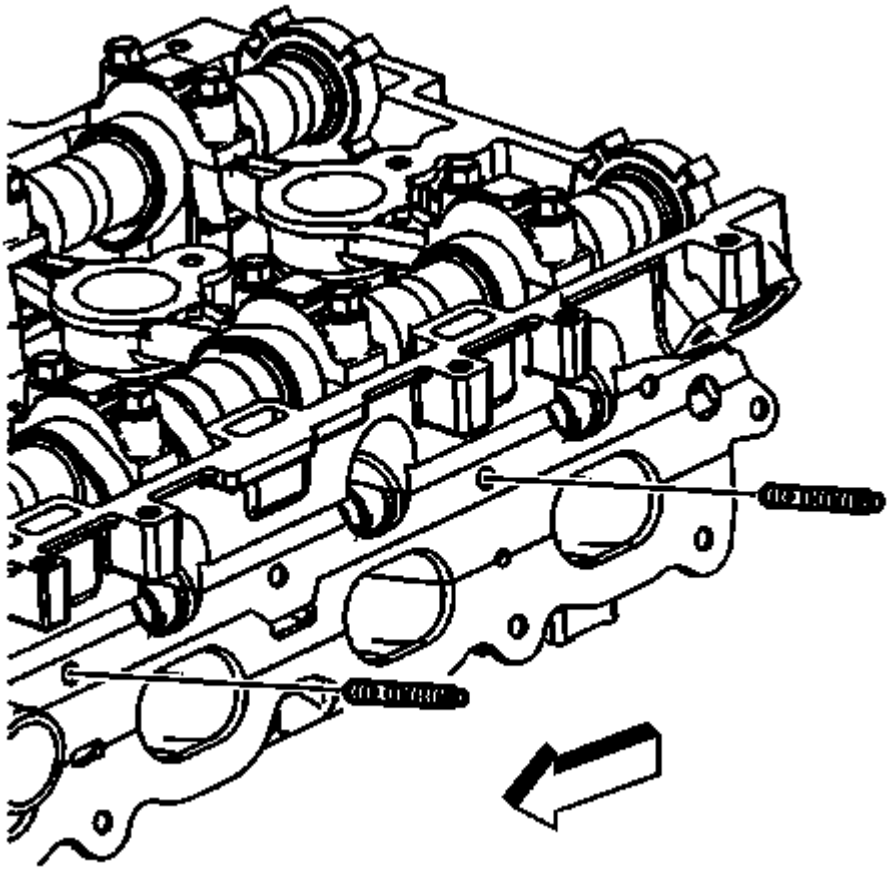

Fig. 450: Identifying Intake Manifold Studs
Courtesy of GENERAL MOTORS CORP.

6. Install the spring.

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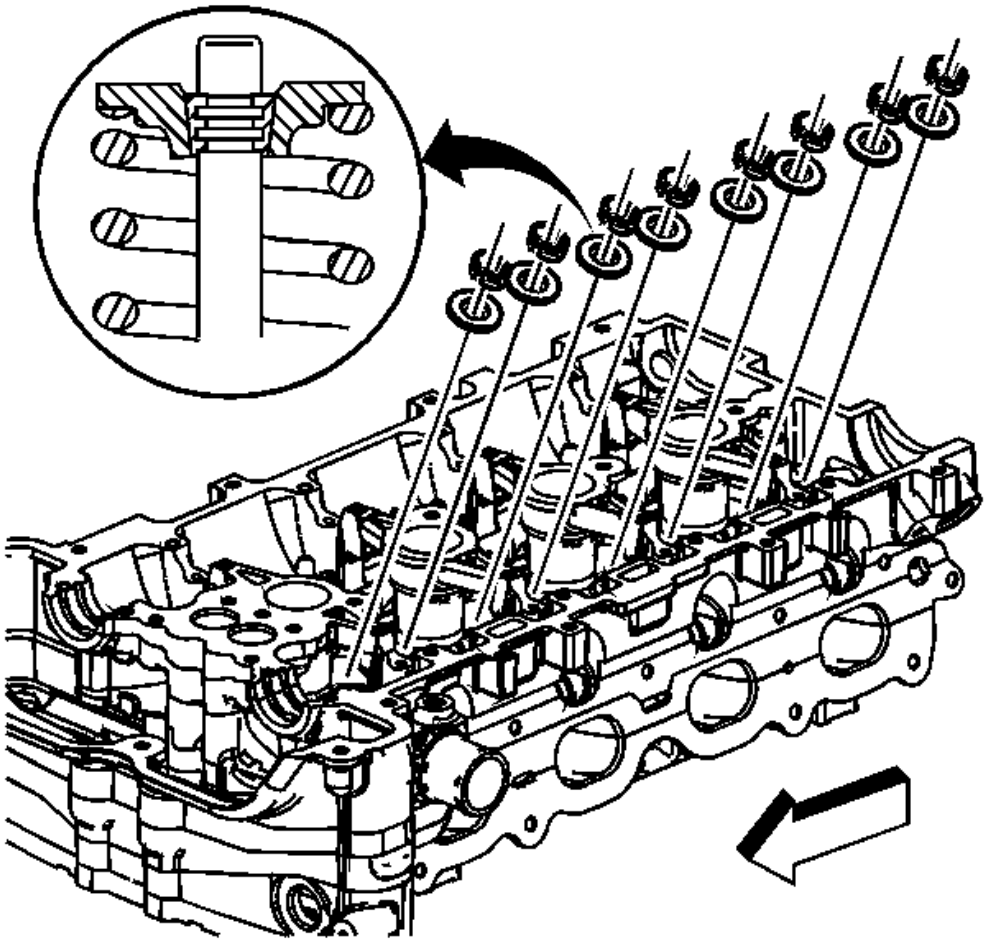

Fig. 451: Identifying Valve Spring Keepers
Courtesy of GENERAL MOTORS CORP.

7. Install the retainer.
8. Using the **J 8062** and the **J 43963** , compress the valve spring.
9. Install the valve keys.
10. Slowly release the **J 8062** and the **J 43963** from the valve/spring assembly.
11. Inspect for proper valve key seating.
12. Install the remaining valves, springs, and other components.

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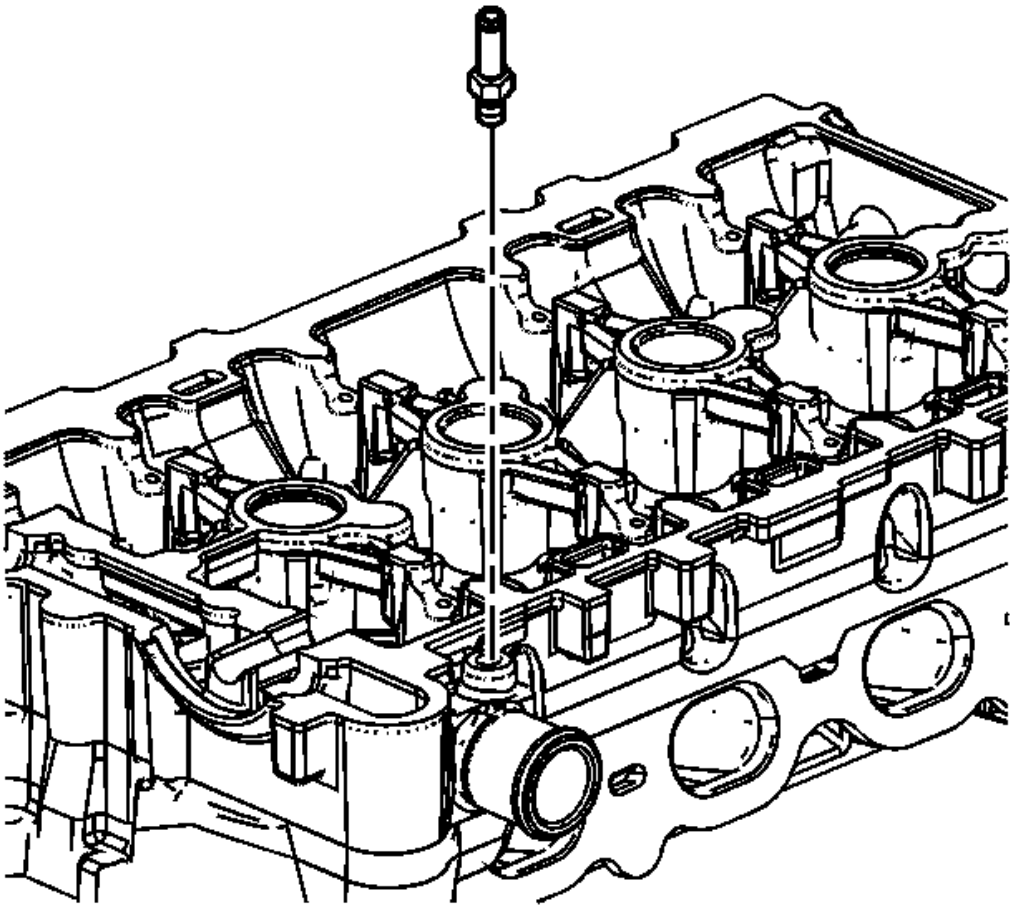

Fig. 452: Identifying Cylinder Head Air Bleed Tube
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

13. Install the cylinder head air bleed tube.

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

Oil Pump Disassemble

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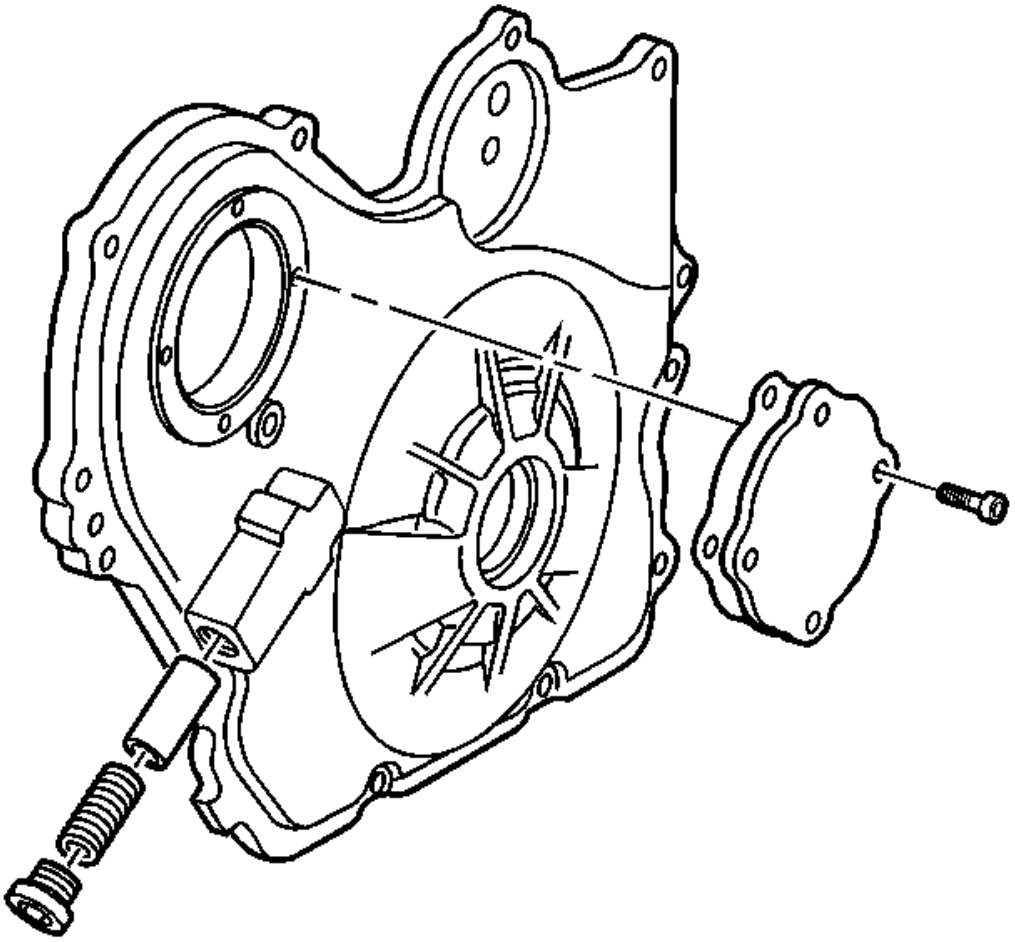

Fig. 453: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

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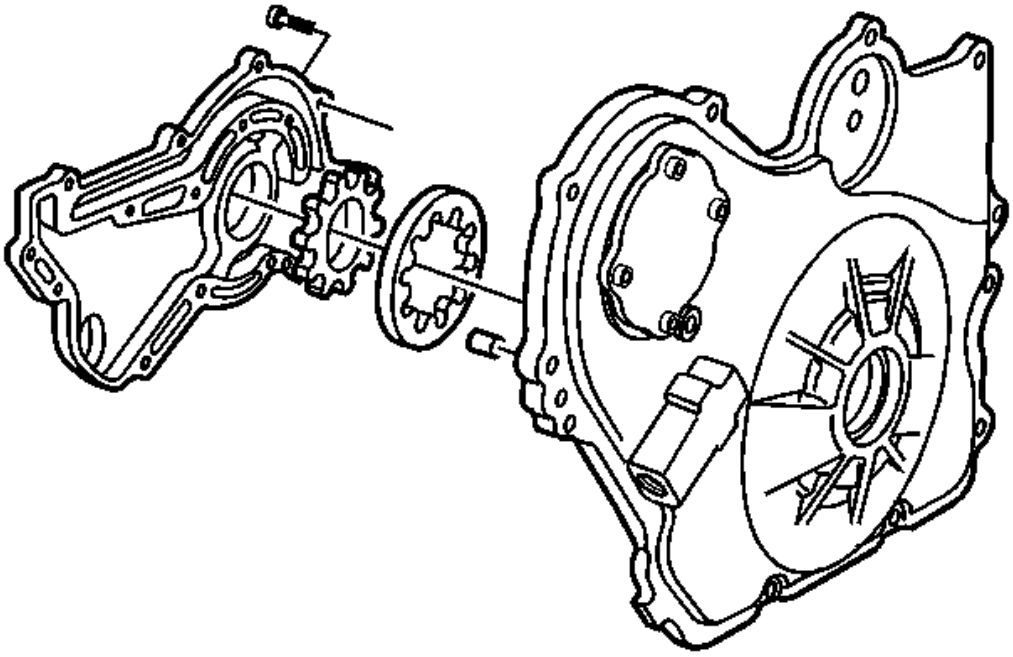

Fig. 454: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

2. Remove the oil pump gerotor cover and bolts.
3. Clean all of the parts in cleaning solvent. Remove varnish, sludge and dirt.
4. Inspect the oil pump for wear and scoring. Insure that all components are within specifications. Refer to **Engine Mechanical Specifications**.

   Replace the front cover and oil pump assembly if it is out of specification or damaged.

Oil Pump Assemble

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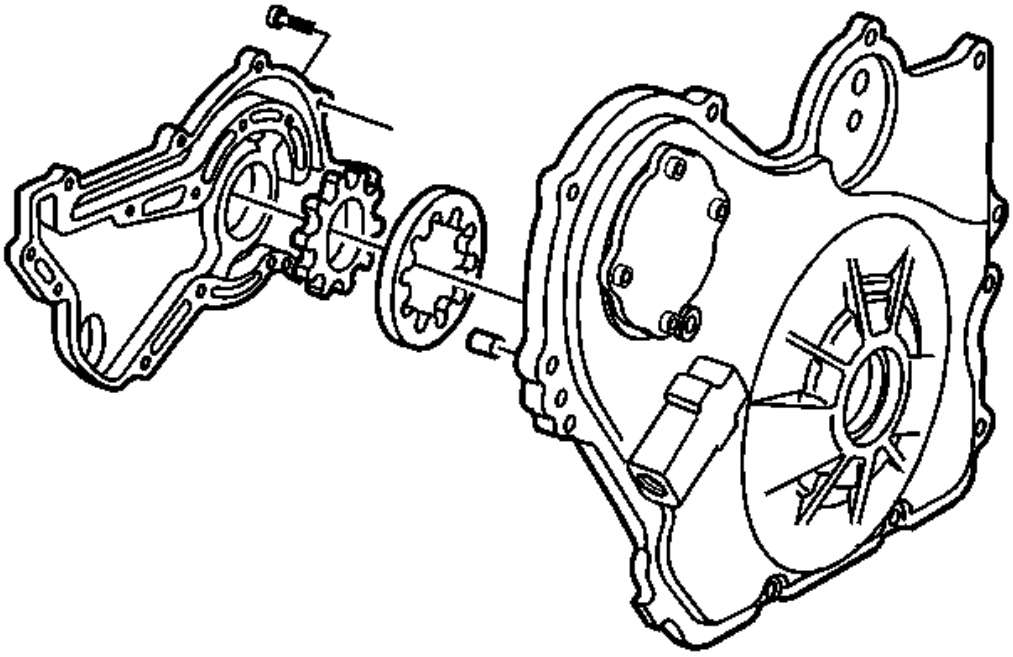

Fig. 455: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

IMPORTANT: If gears are improperly installed in the front cover, the gerotor cover will not bolt on.

3. Install the gears together into the front cover with the hub of the center gear facing the front cover.

NOTE: Refer to Fastener Notice .

4. Install the oil pump gerotor cover and bolts.

Tighten: Tighten the oil pump gerotor bolts to 6 N.m (53 lb in).

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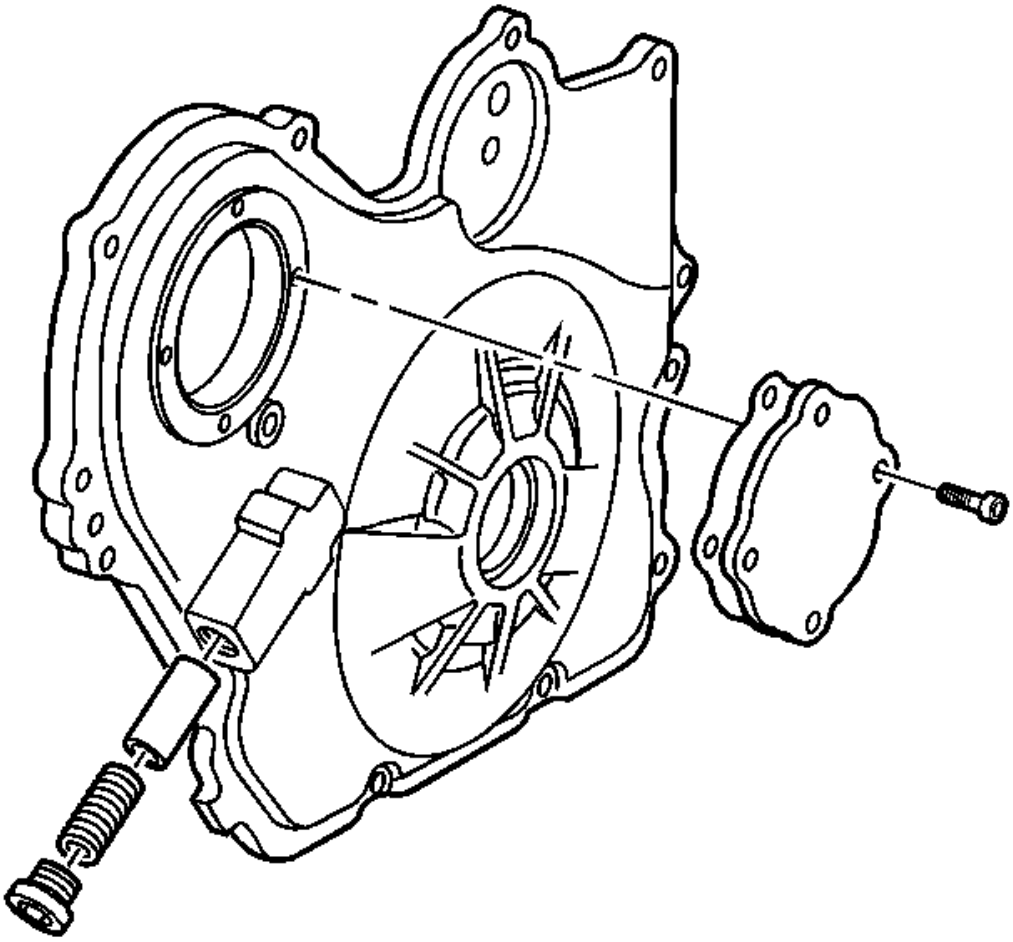

Fig. 456: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure relief valve piston.
6. Install the pressure relief valve spring.

Tighten: Tighten the pressure relief valve plug to 40 N.m (30 lb ft).

Intake Manifold Cleaning and Inspection

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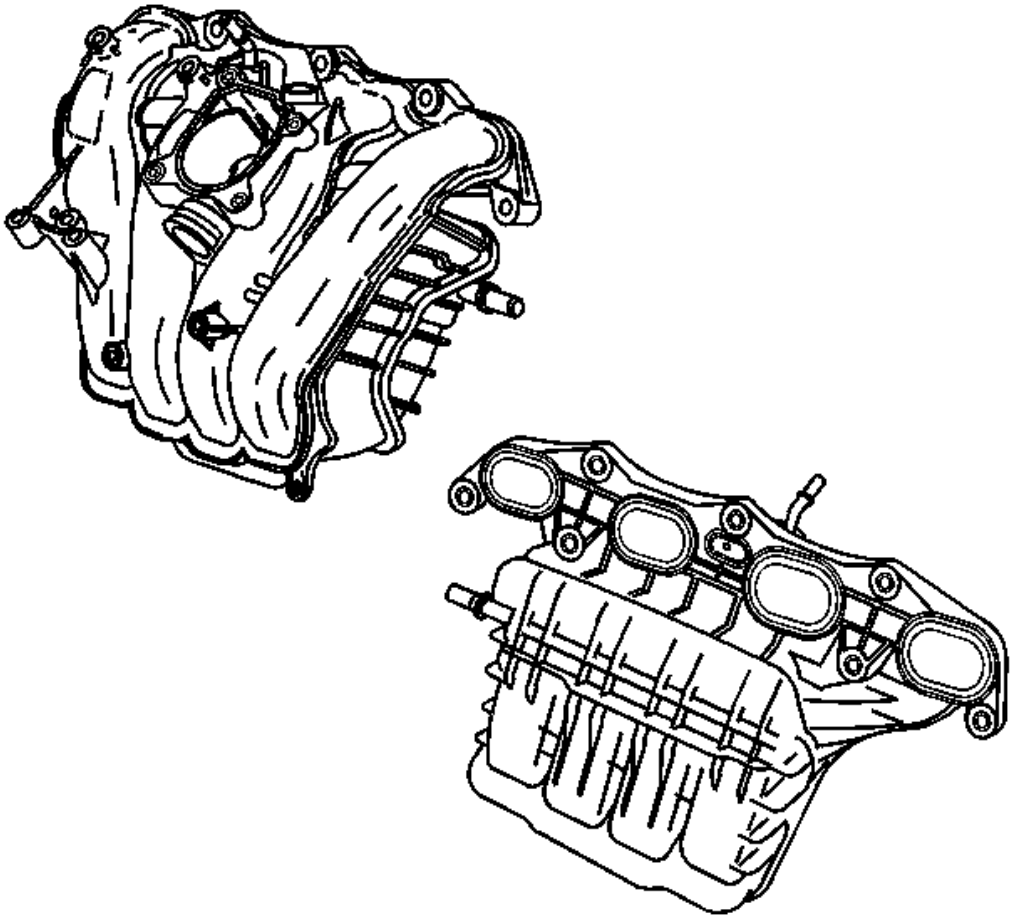

Fig. 457: Inspecting Intake Manifold
Courtesy of GENERAL MOTORS CORP.

1. Clean the intake manifold mating surfaces.
2. Inspect the intake manifold for damage.
3. Inspect the intake manifold for cracks near metallic inserts.
4. Inspect the crankcase ventilation passages in the intake manifold face for blockage.

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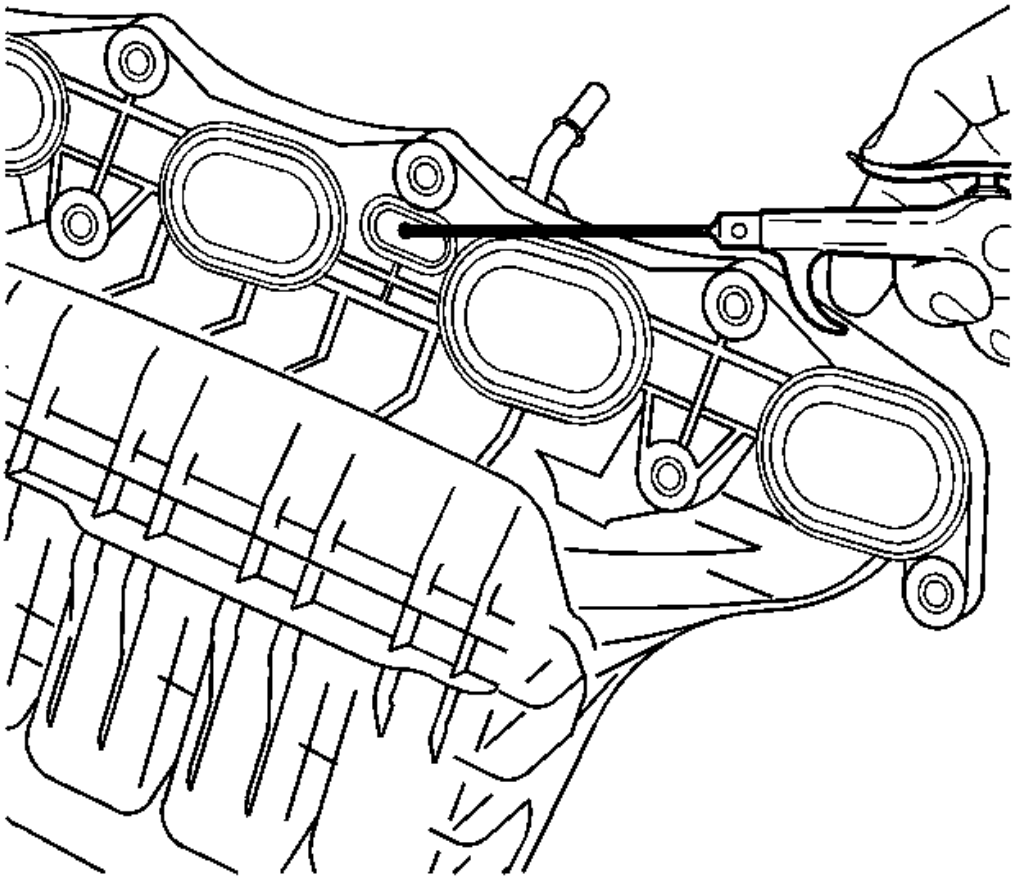

Fig. 458: Cleaning Crankcase Ventilation Passages
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

5. Clean the crankcase ventilation passages with compressed air if necessary. Use a maximum of 172 kPa (25 psi) of air pressure.
6. Replace the intake manifold as necessary.

Exhaust Manifold Cleaning and Inspection

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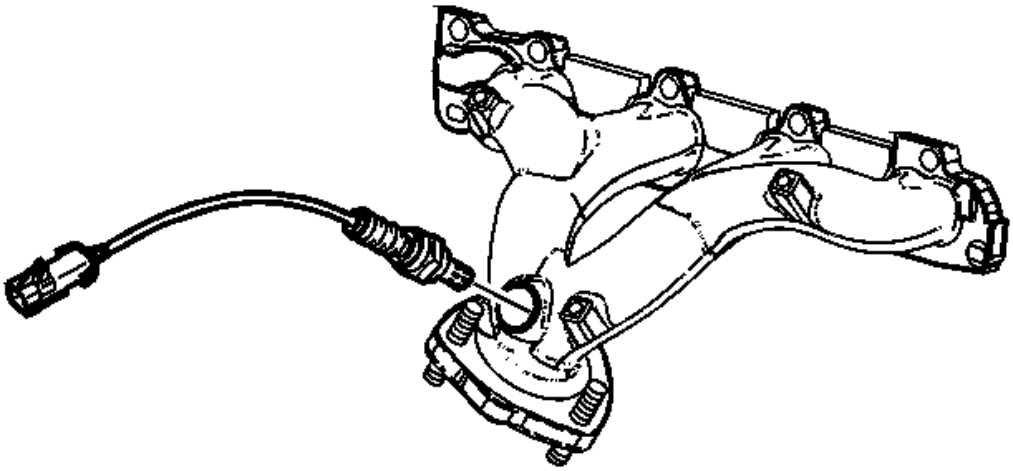

Fig. 459: View Of Exhaust Manifold & Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **Do not reuse the exhaust manifold-to-cylinder head gaskets. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may effect On-Board Diagnostics (OBD) II system performance.**
- **Remove the oxygen sensor prior to cleaning the manifold. Do not submerge the oxygen sensor in cleaning solvent.**

1. Remove the oxygen sensor from the manifold.
2. Clean the exhaust manifold in solvent.

CAUTION: Refer to SAFETY GLASSES CAUTION .

3. Dry the exhaust manifold with compressed air.
4. Inspect the heat shield for damage.

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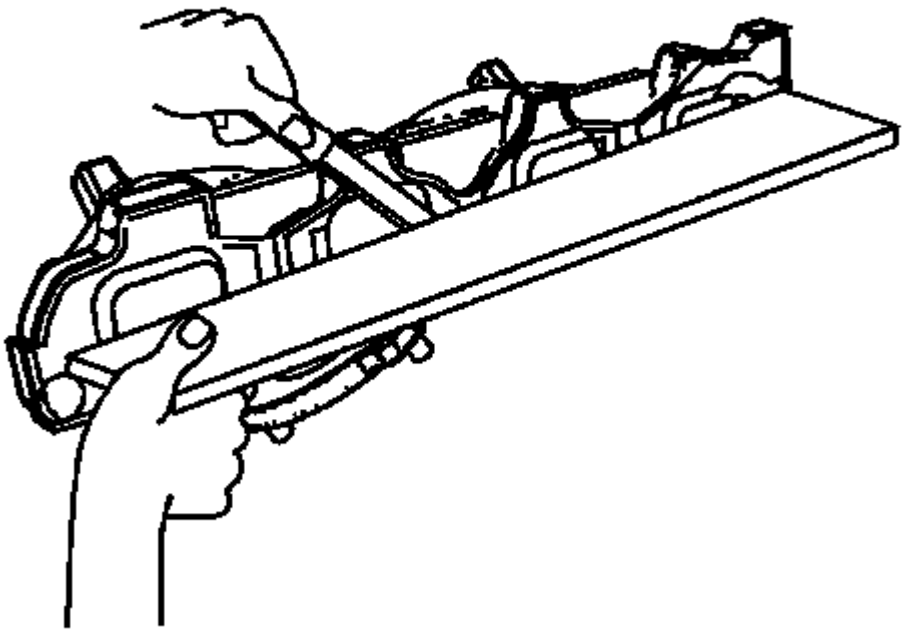

Fig. 460: Checking Exhaust Manifold Mounting Face For Warpage
Courtesy of GENERAL MOTORS CORP.

5. Use a straight edge and a feeler gage and measure the exhaust manifold mounting face for warpage.

   An exhaust manifold face with warpage in excess of 0.25 mm (0.0100 in) may cause an exhaust leak and may effect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

Oil Pan Cleaning and Inspection

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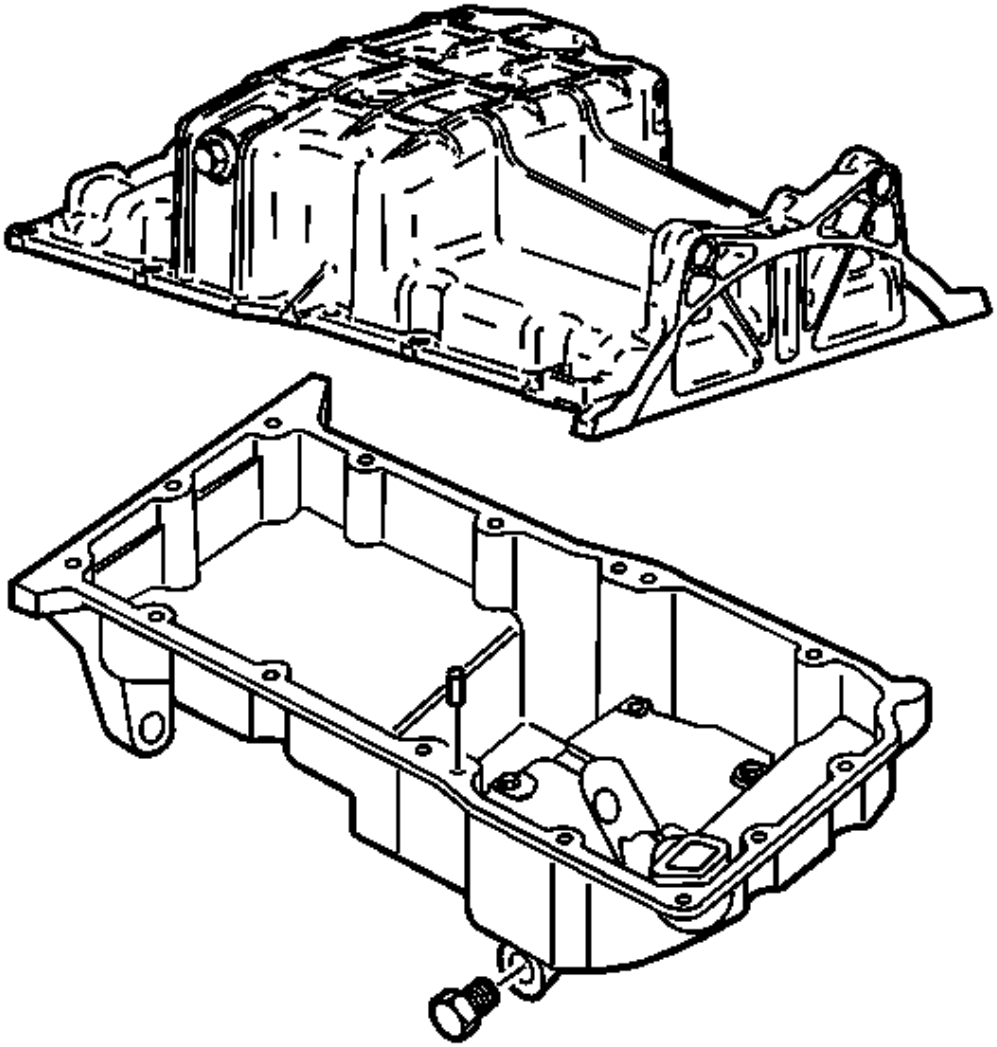

Fig. 461: Inspecting Oil Pan
Courtesy of GENERAL MOTORS CORP.

1. Clean the oil pan mating surface.
2. Clean the oil pan. Remove all the sludge and the oil deposits.
3. Inspect the threads for the engine oil drain plug.
4. Inspect the oil pan for cracking near the pan rail and the transmission mounting points.
5. Inspect the oil pan for cracking resulting from impact or flying road debris.

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IMPORTANT: The oil pan baffle and pickup screen are not removable from the oil pan.

6. Inspect the oil pan baffle and pickup screen.
7. Repair or replace the oil pan as necessary.

Thread Repair

General Thread Repair

Tools Required

J 42385-850 Thread Repair Kit

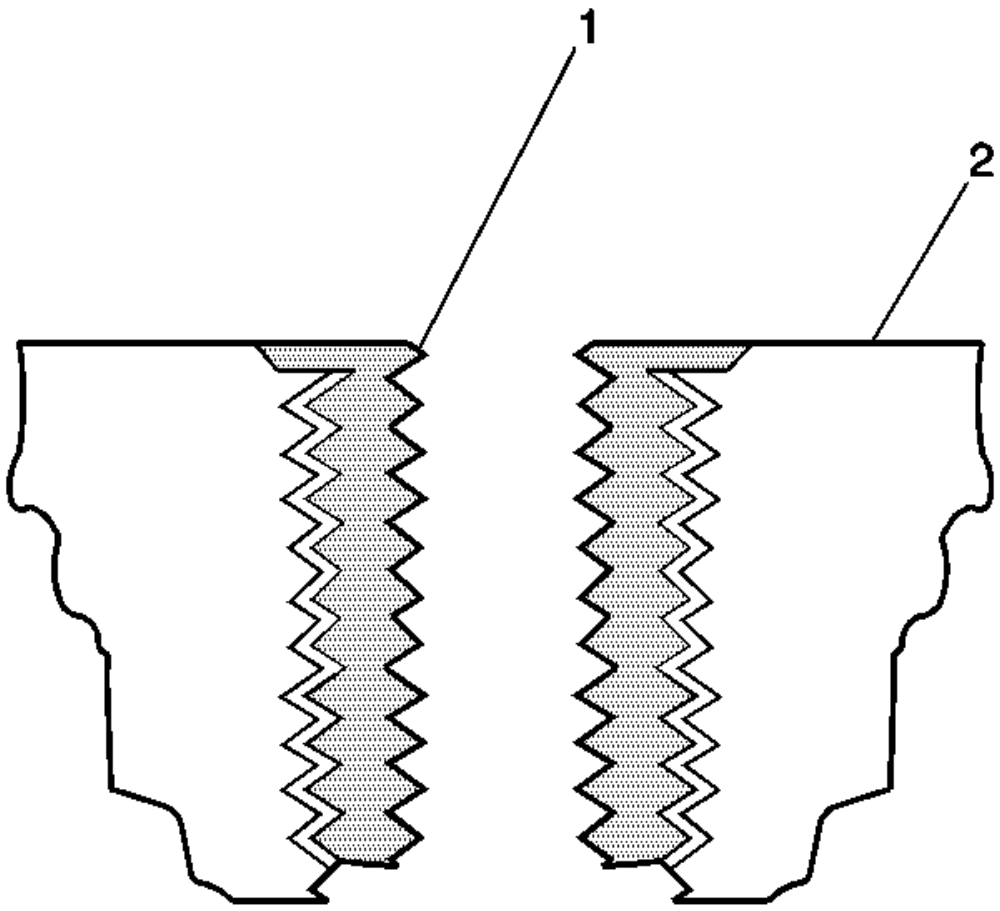

Fig. 462: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1).

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During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

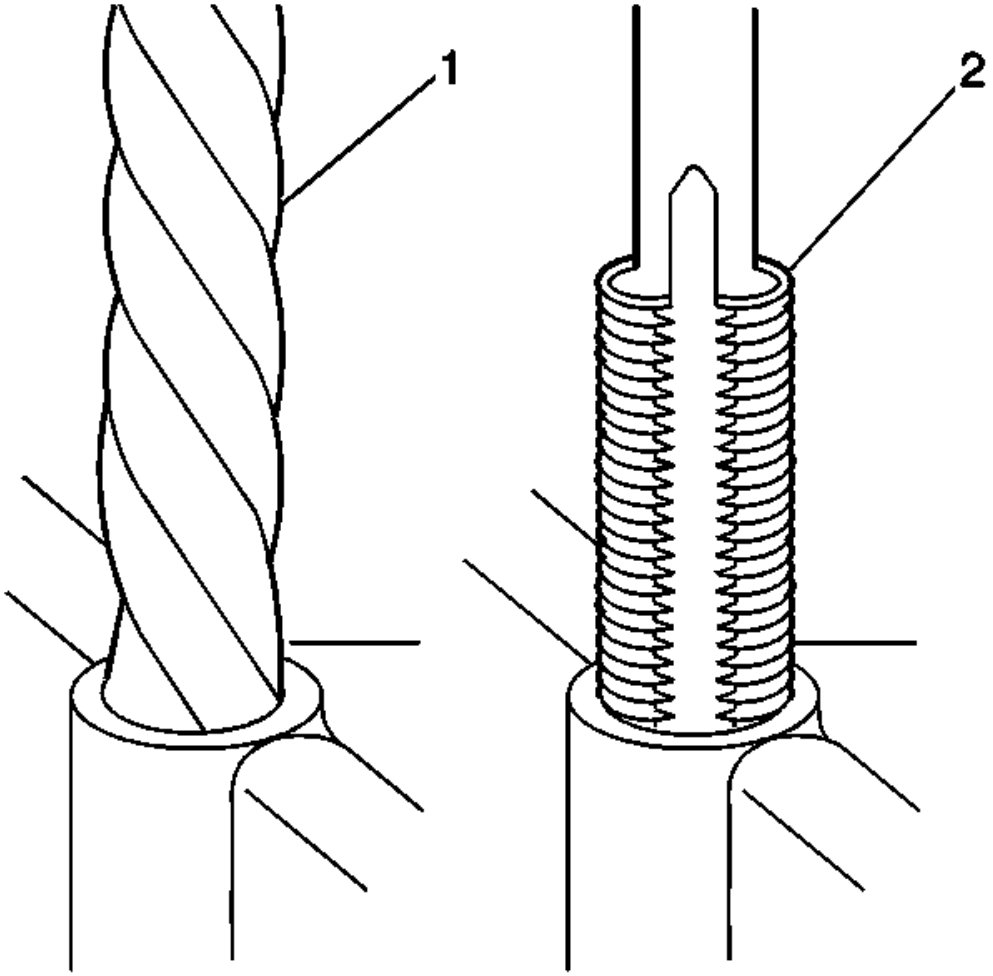

Fig. 463: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

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1. Drill out the threads of the damaged hole (1).
    - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
    - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
    - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

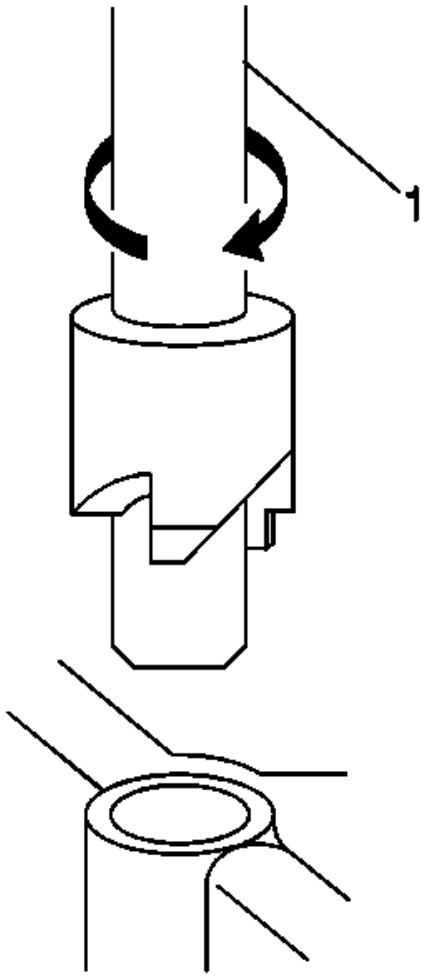

Fig. 464: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

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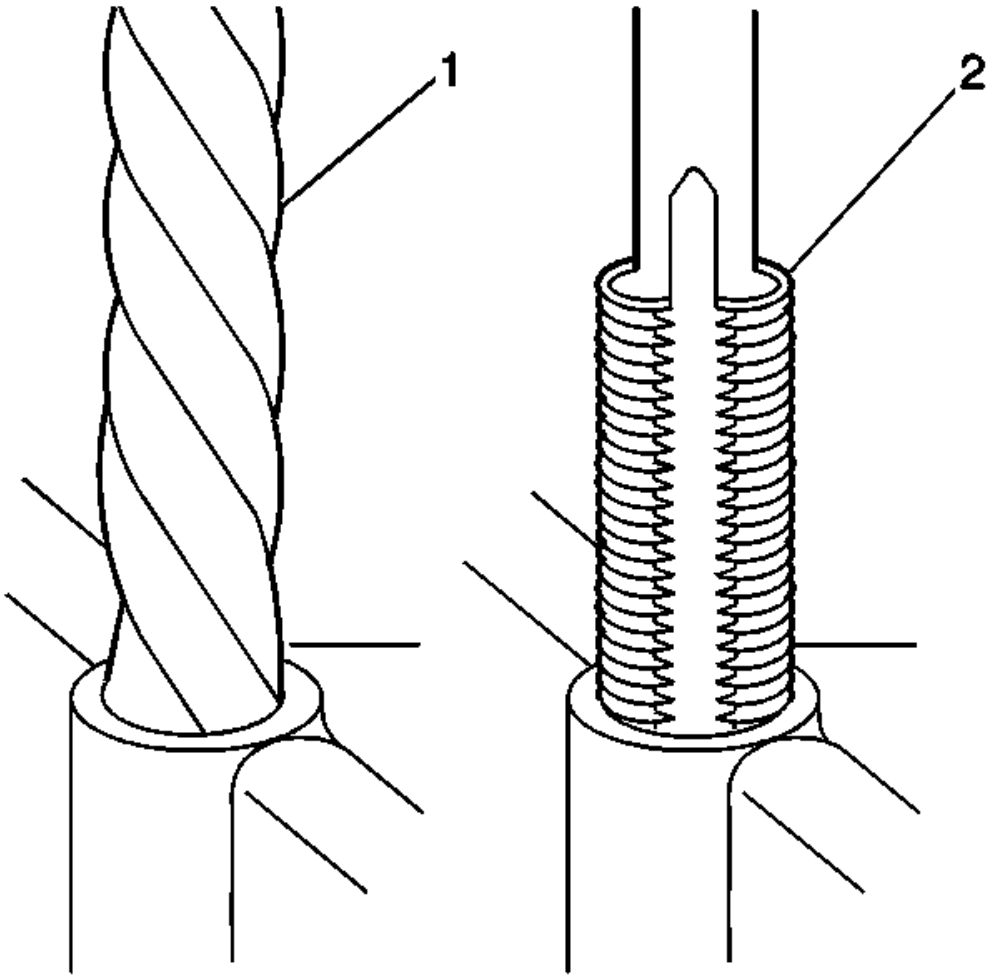

Fig. 465: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

5. Using a tap wrench (2), tap the threads of the drilled hole.
    - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
    - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
    - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).
6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463) or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

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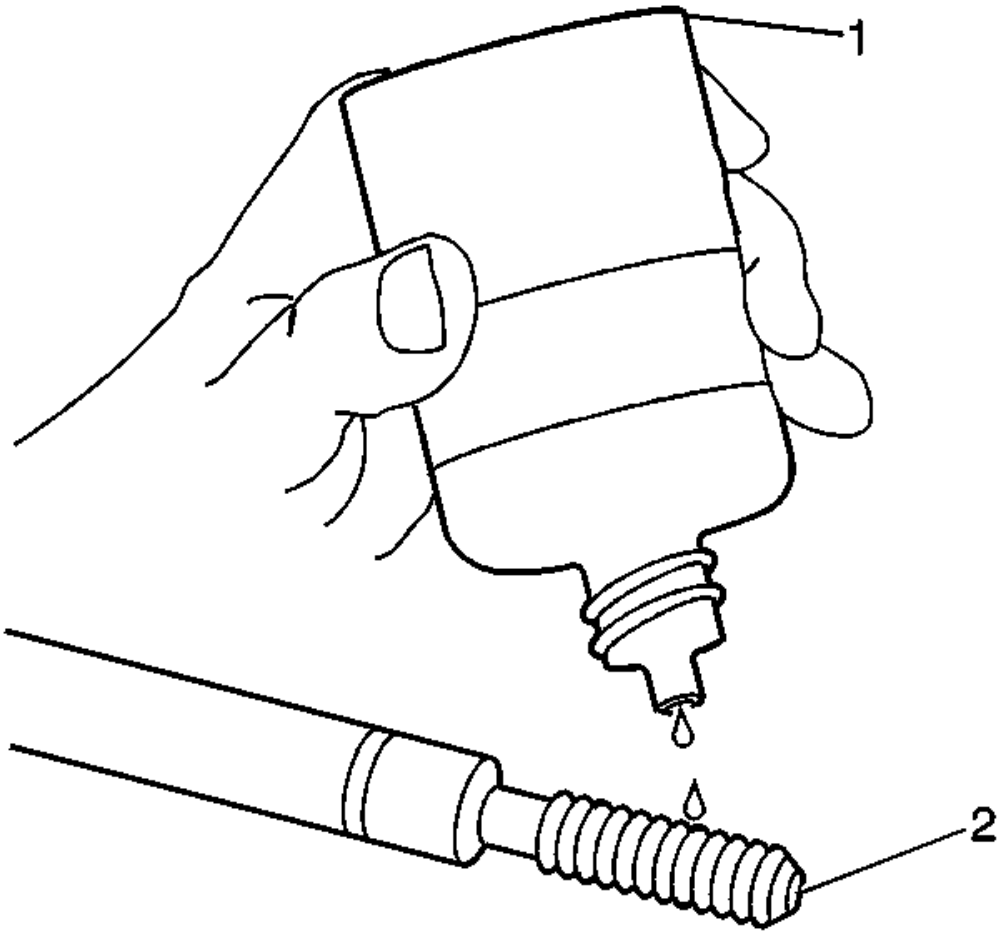

Fig. 466: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

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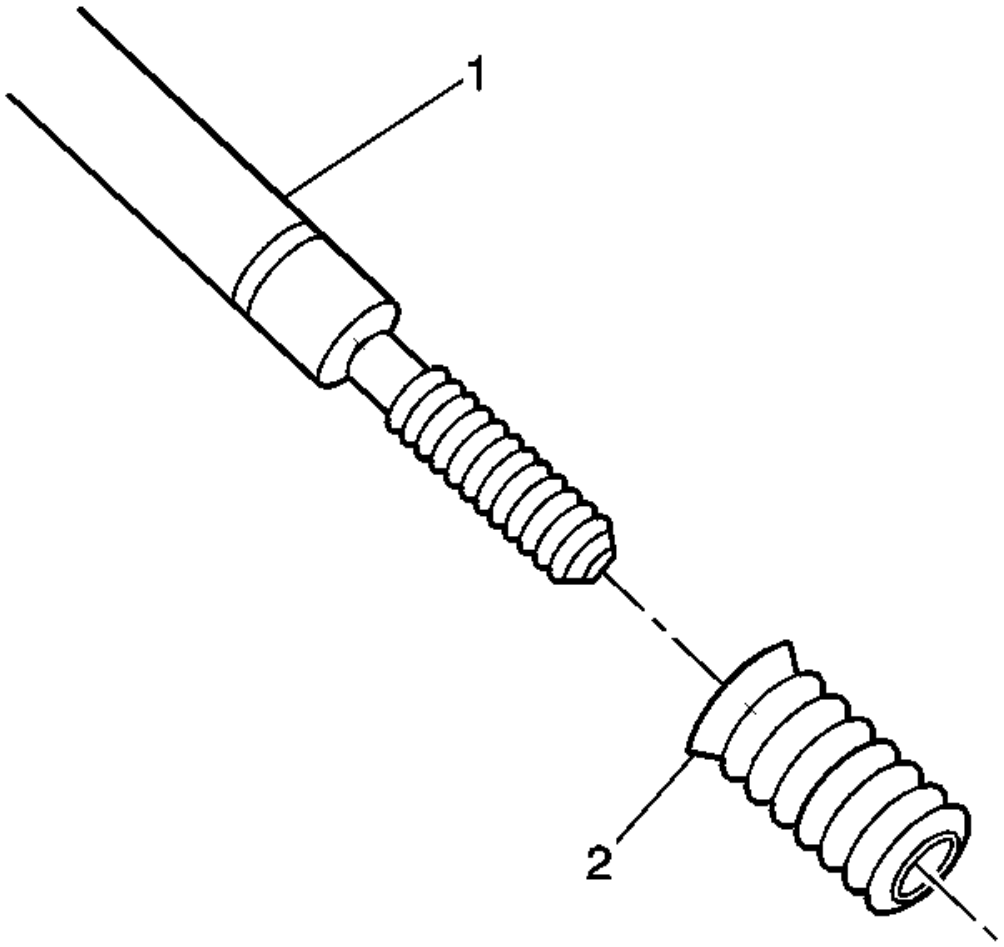

Fig. 467: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

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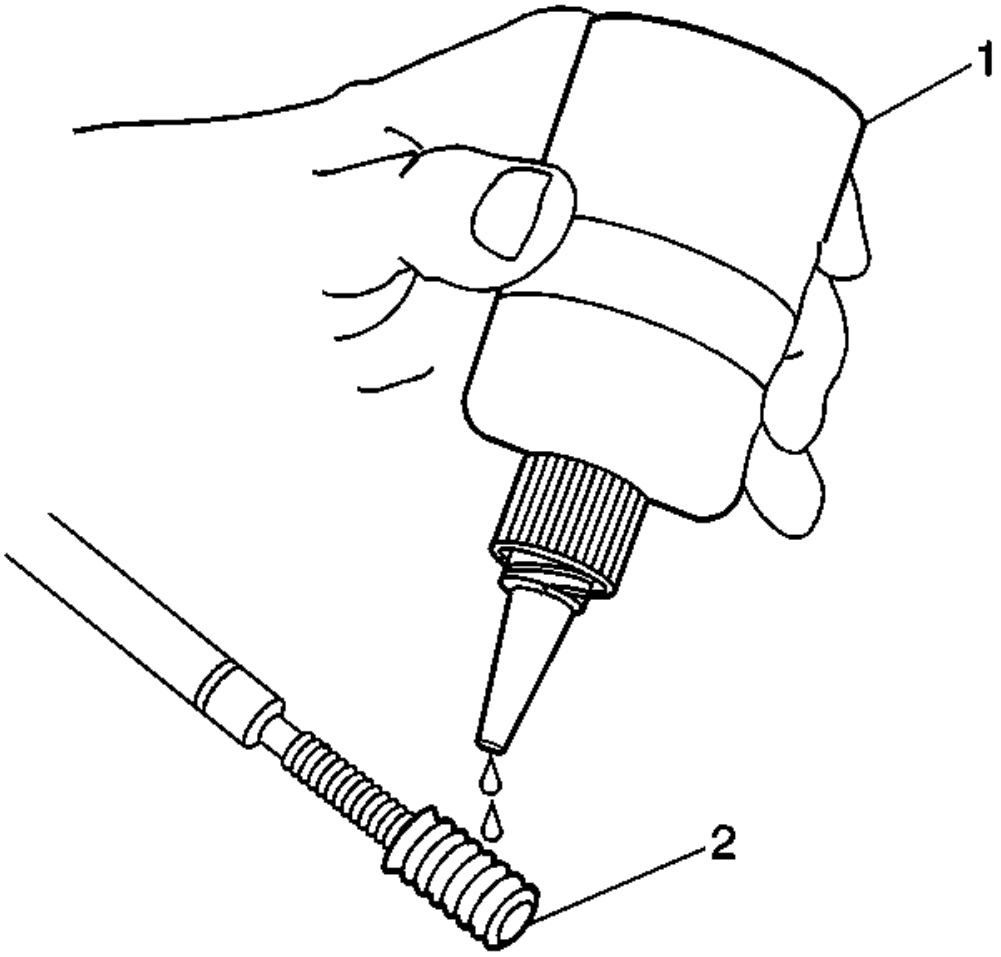

Fig. 468: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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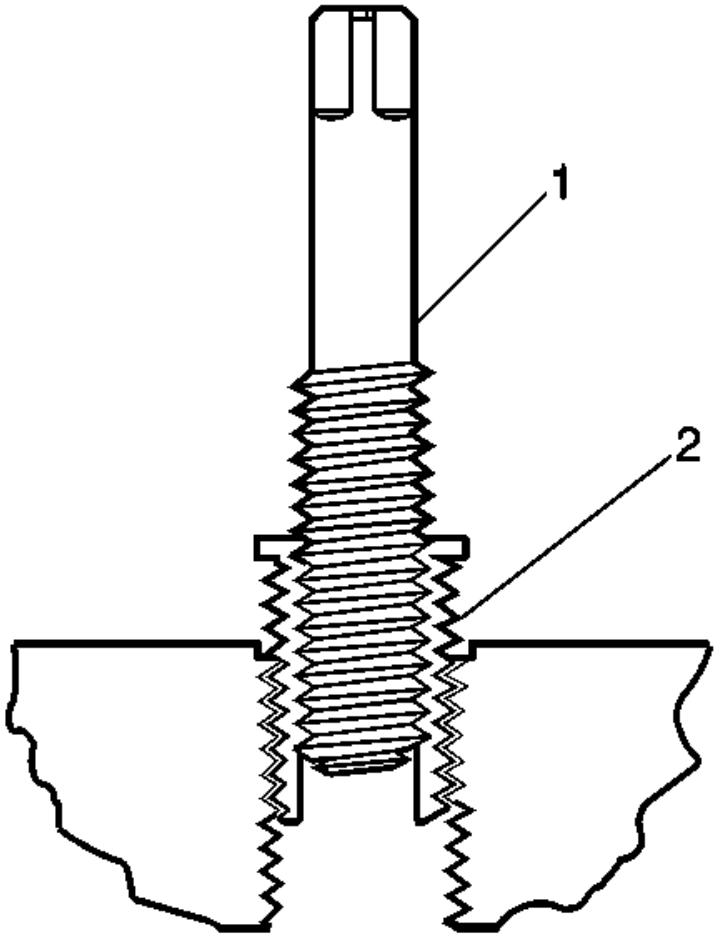

Fig. 469: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) into the hole.

    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

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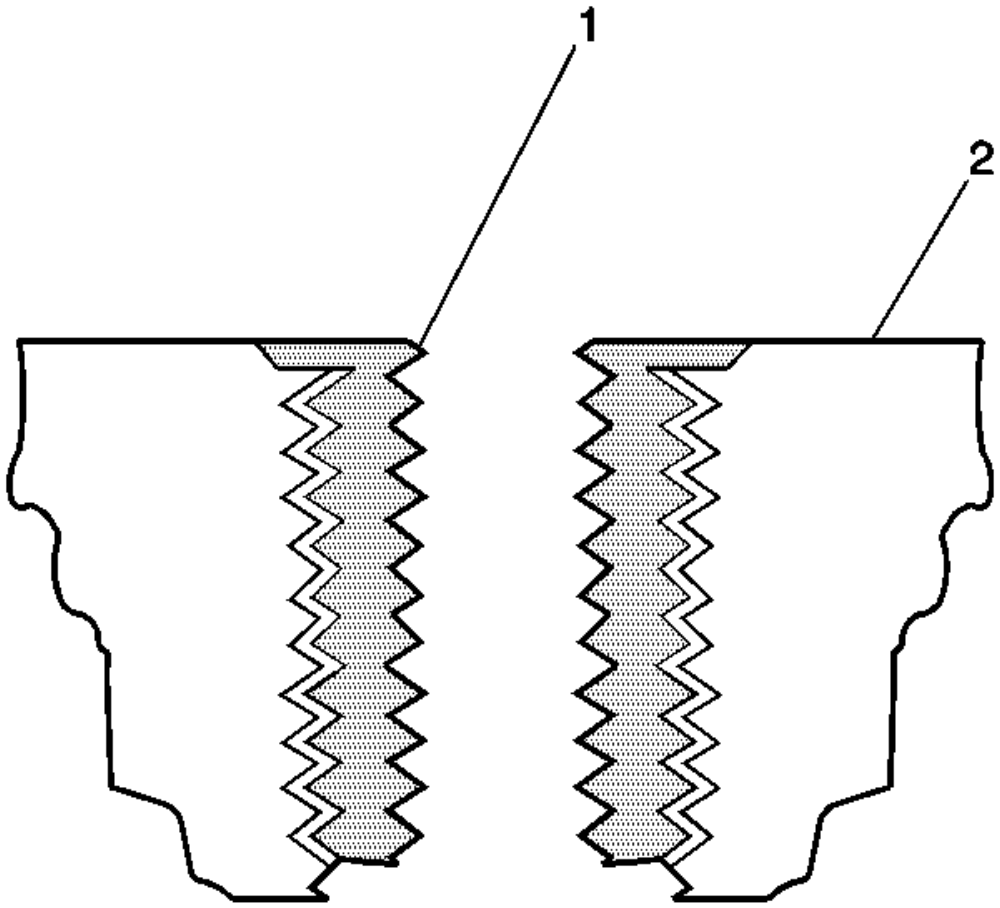

Fig. 470: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

13. Inspect the insert for proper installation into the hole.

    A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

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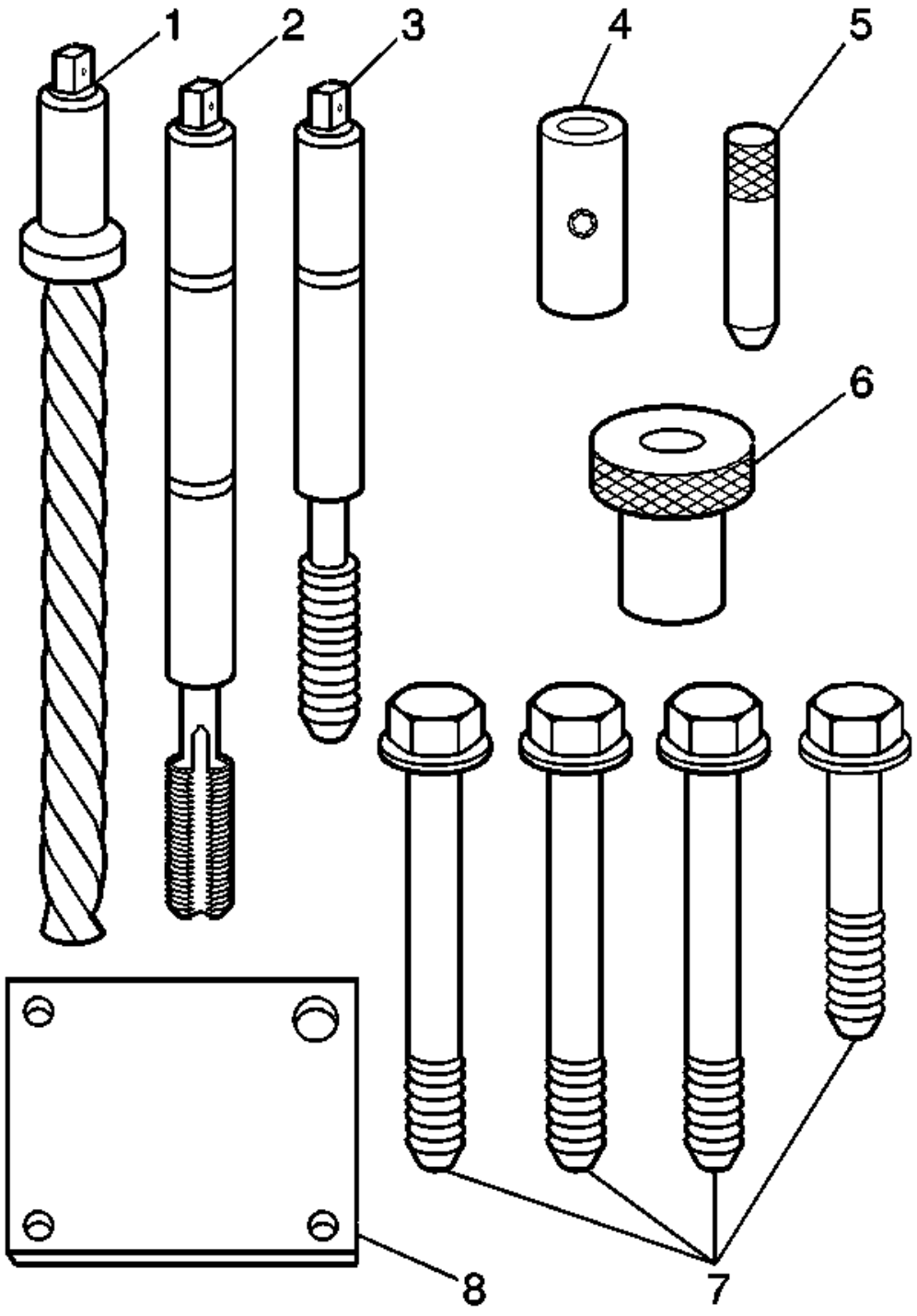

Fig. 471: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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1. The cylinder head bolt hole thread repair kit consists of the following items:
   - Drill (1)
   - Tap (2)
   - Installer (3)
   - Sleeve (4)
   - Alignment Pin (5)
   - Bushing (6)
   - Bolts (7)
   - Fixture Plate (8)

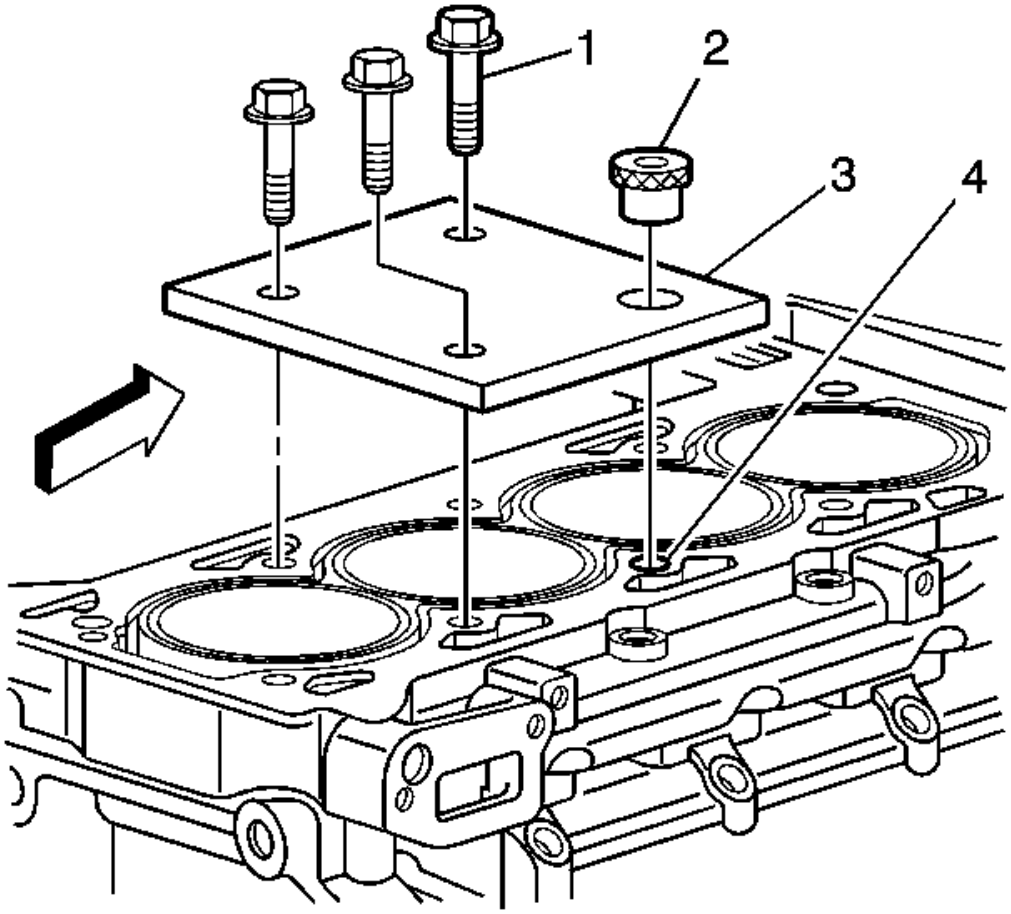

Fig. 472: Installing Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to SAFETY GLASSES CAUTION in Cautions and Notices.

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IMPORTANT: The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

   Position the fixture plate and bushing over the hole that is to be repaired (4).

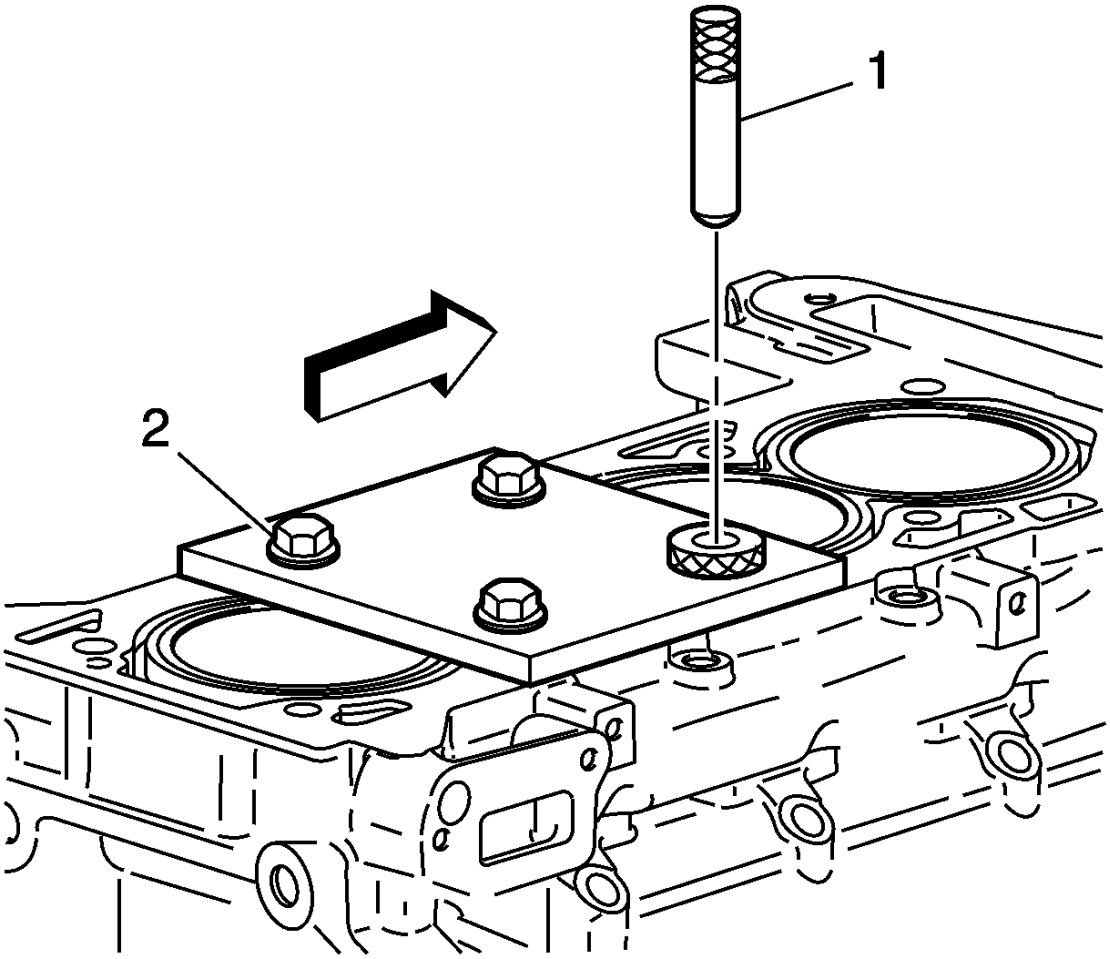

Fig. 473: Identifying Alignment Pin
Courtesy of GENERAL MOTORS CORP.

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

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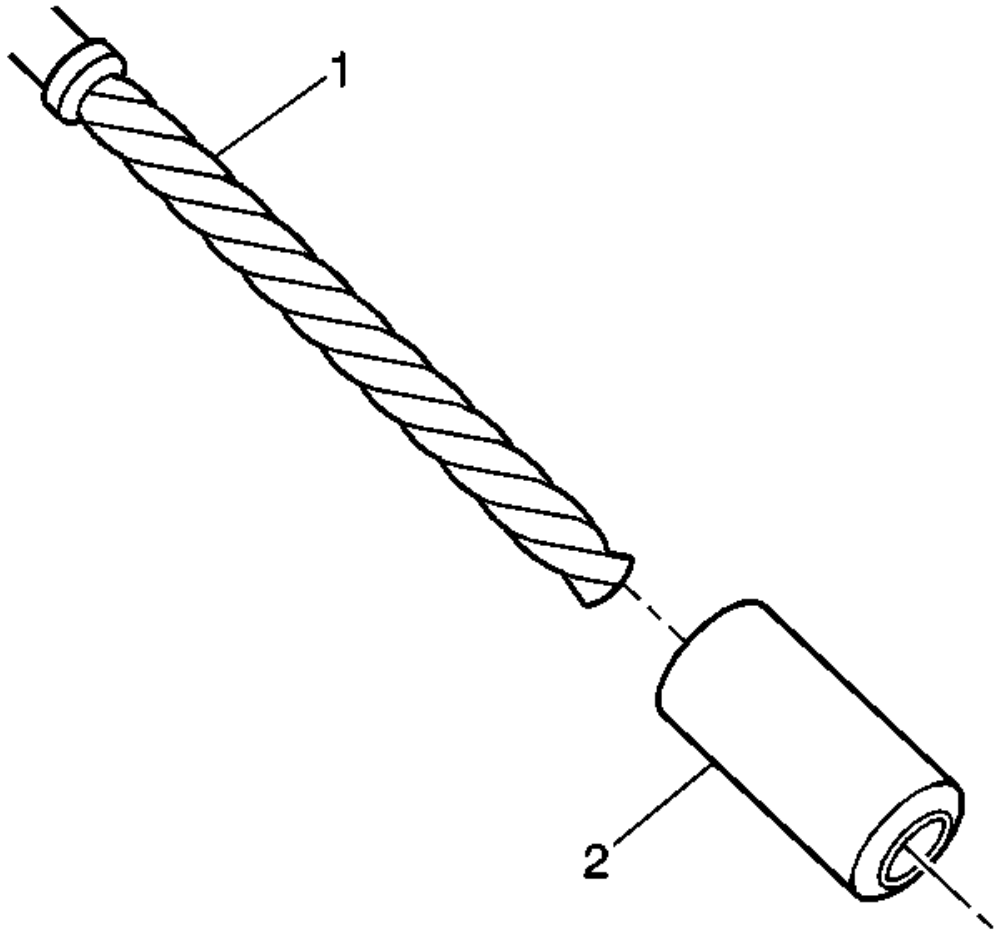

Fig. 474: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

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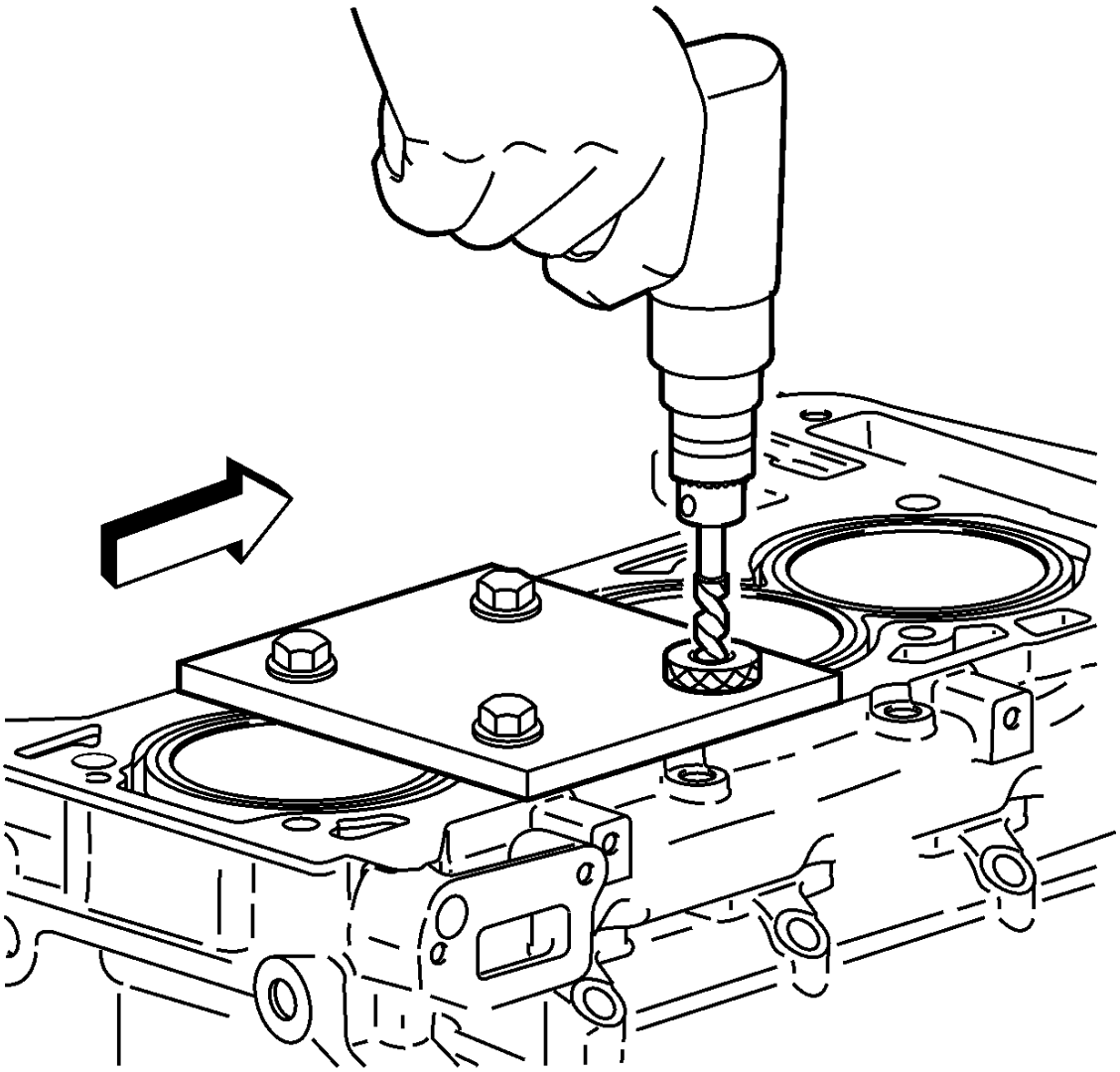

Fig. 475: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

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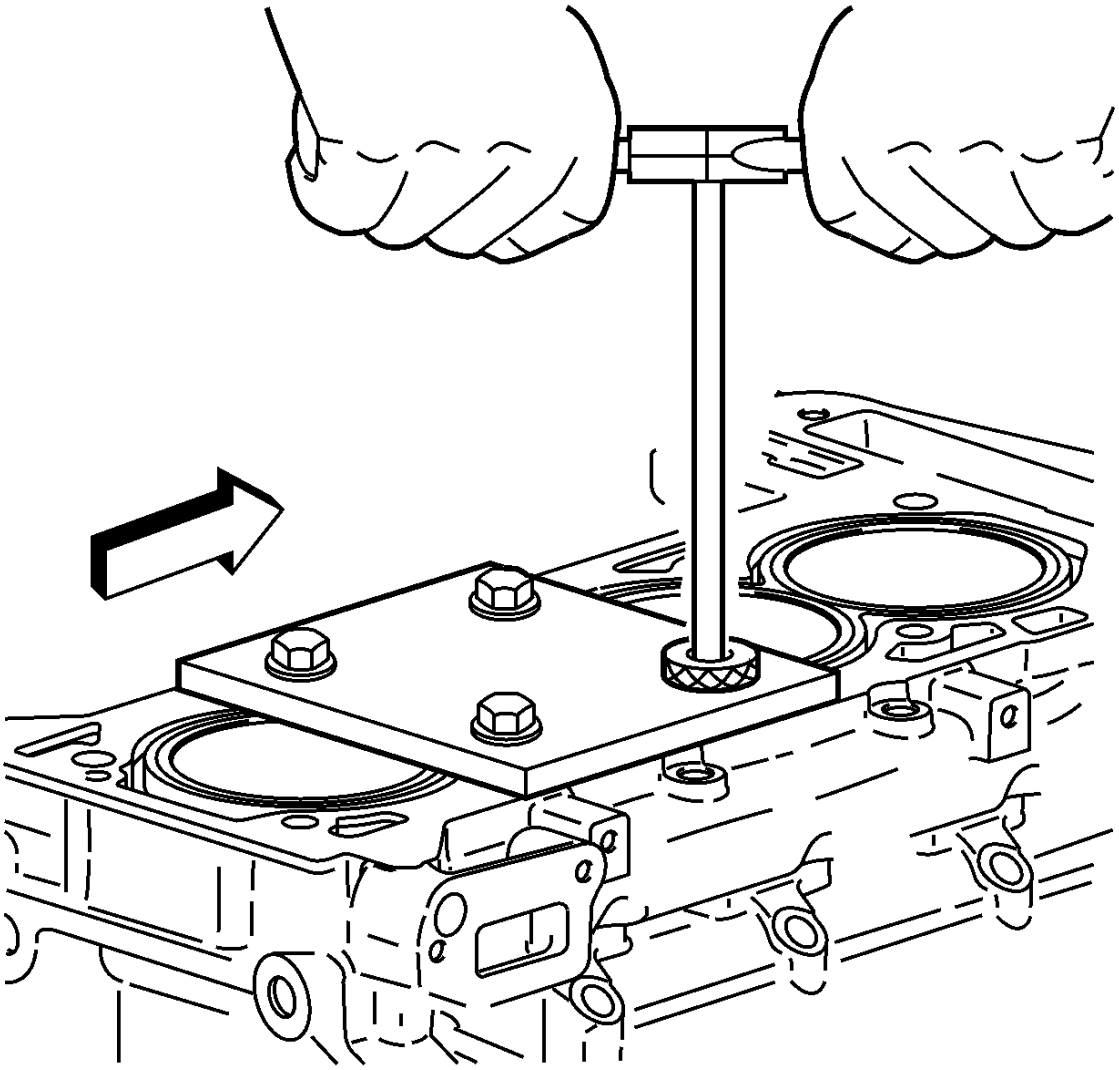

Fig. 476: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

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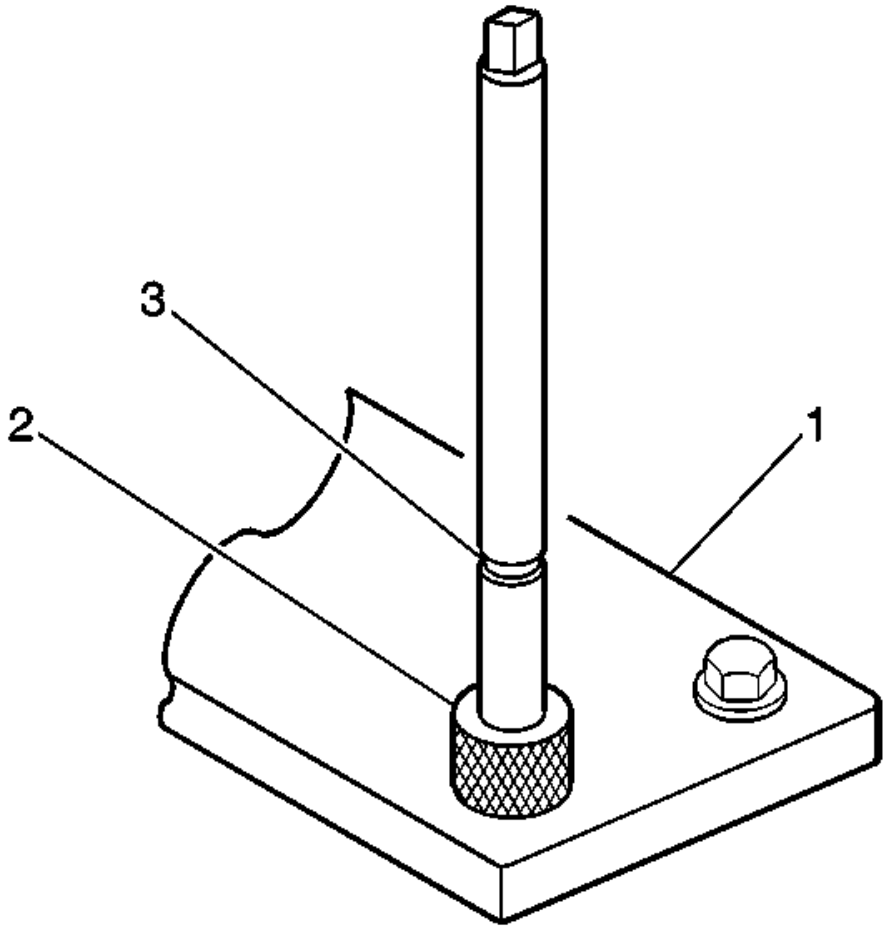

Fig. 477: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

10. Using a TAP wrench, tap the threads of the drilled hole.

    In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap align with the top of the drill bushing (2).

11. Remove the fixture plate (1), bushing (2), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139 or GM P/N 1237798 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

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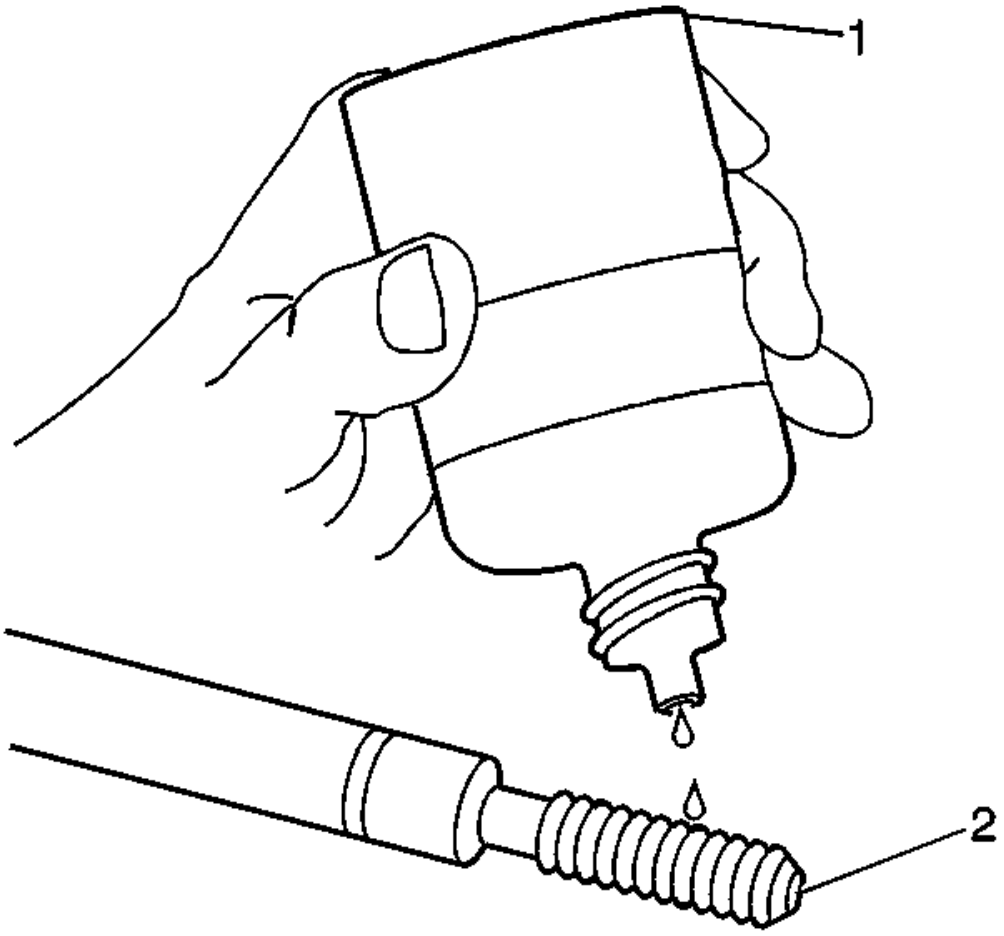

Fig. 478: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

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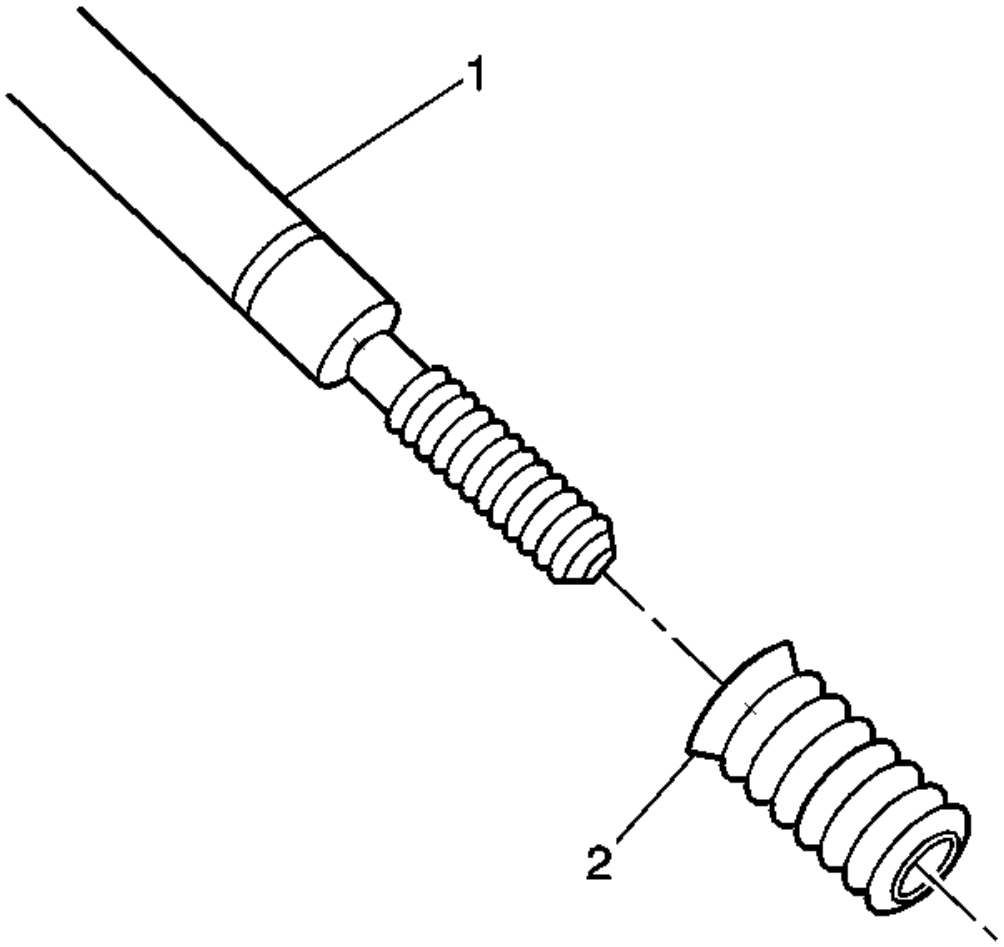

Fig. 479: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

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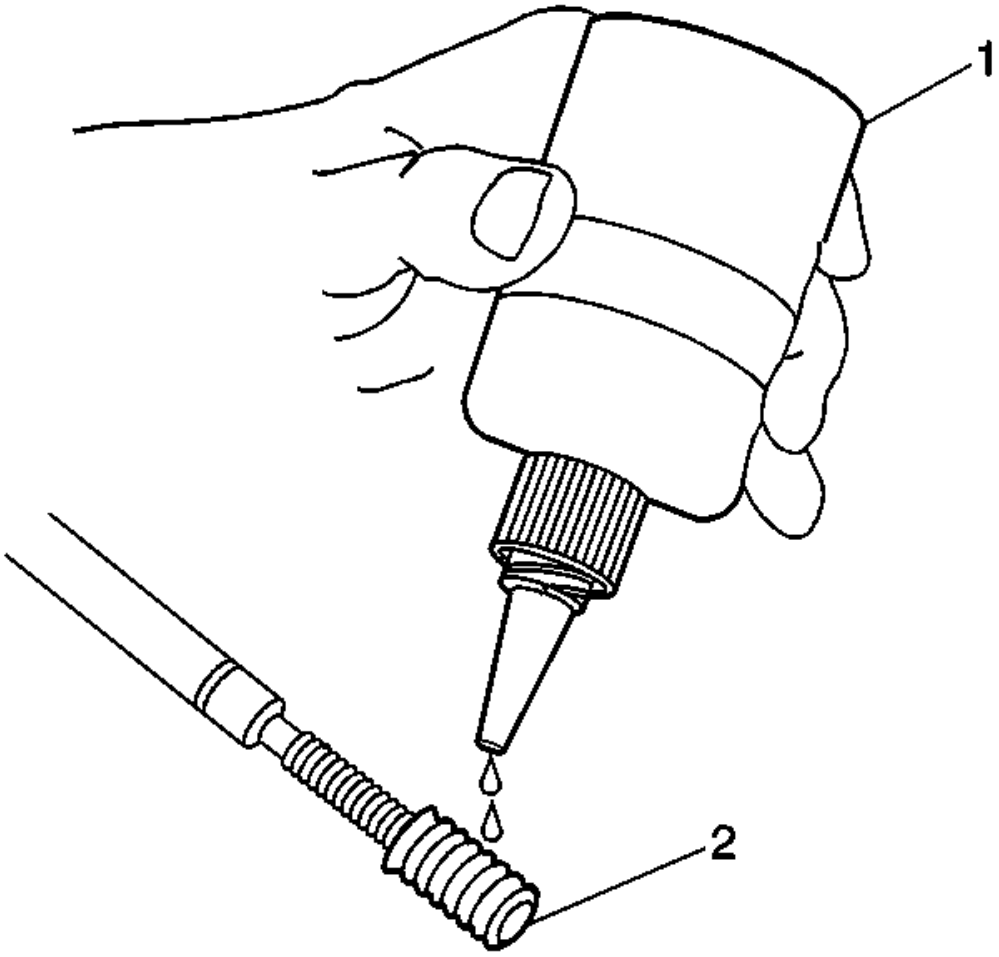

Fig. 480: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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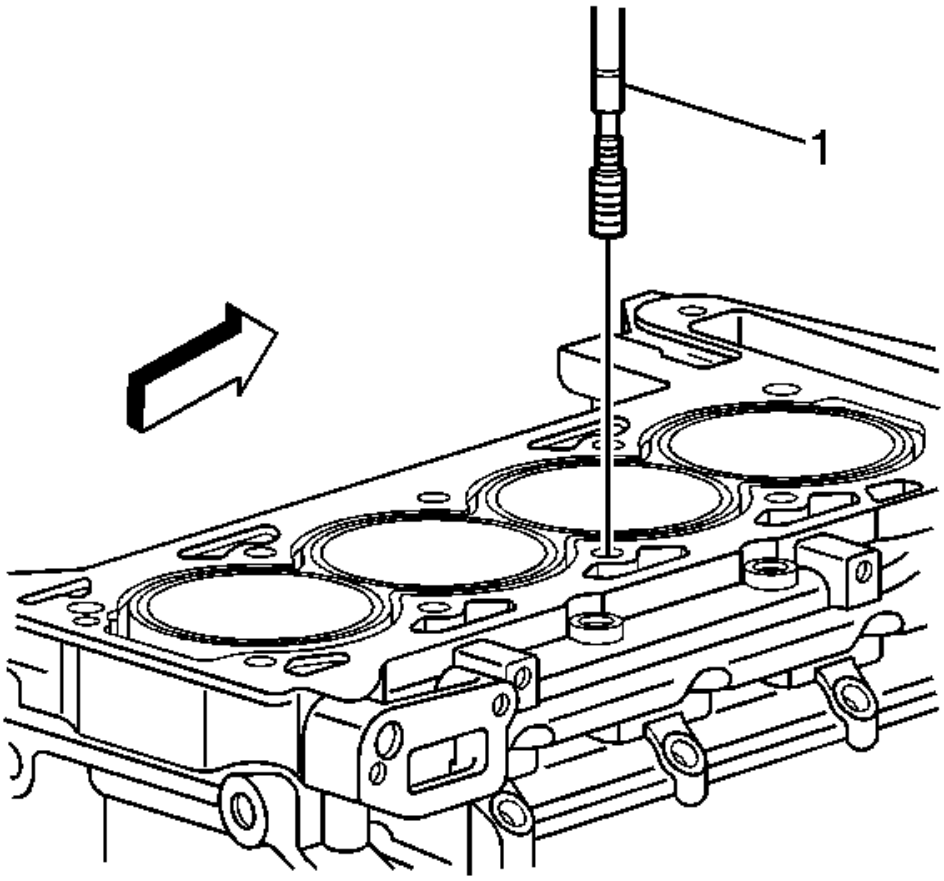

Fig. 481: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS CORP.

18. Install the insert and driver (1) into the hole.

    Rotate the driver tool until the mark on the tool aligns with the deck surface of the engine block.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

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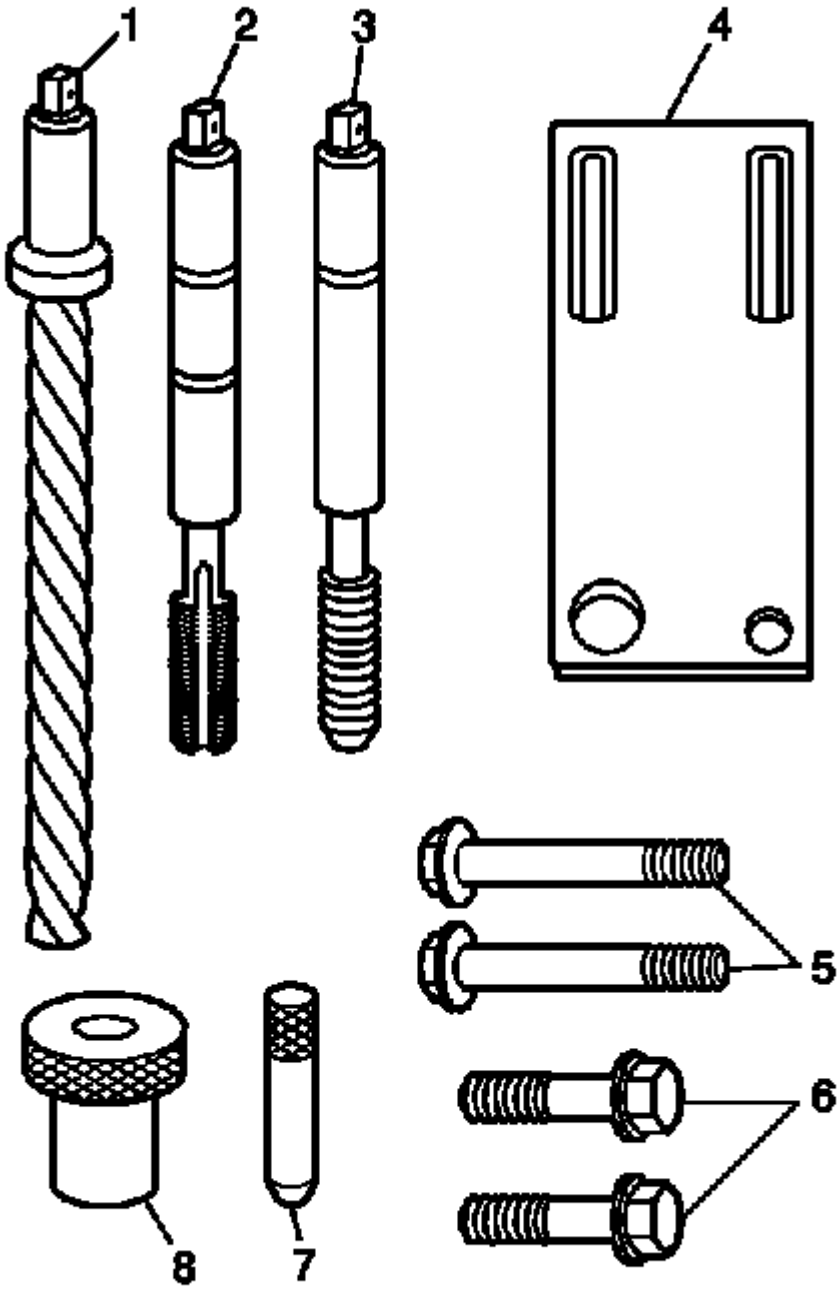

Fig. 482: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

1. The main cap bolt hole thread repair kit consists of the following items:
    - Drill (1)
    - Tap (2)
    - Installer (3)

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- Fixture Plate (4)
- Long Bolts (5)
- Short Bolts (6)
- Alignment Pin (7)
- Bushing (8)

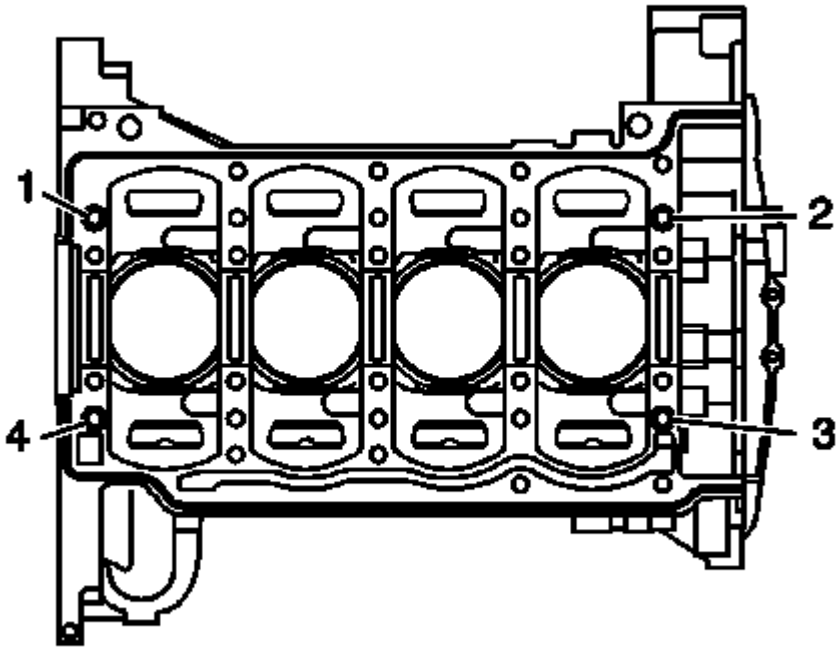

Fig. 483: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment dowel pins from the holes (1-4), if necessary.

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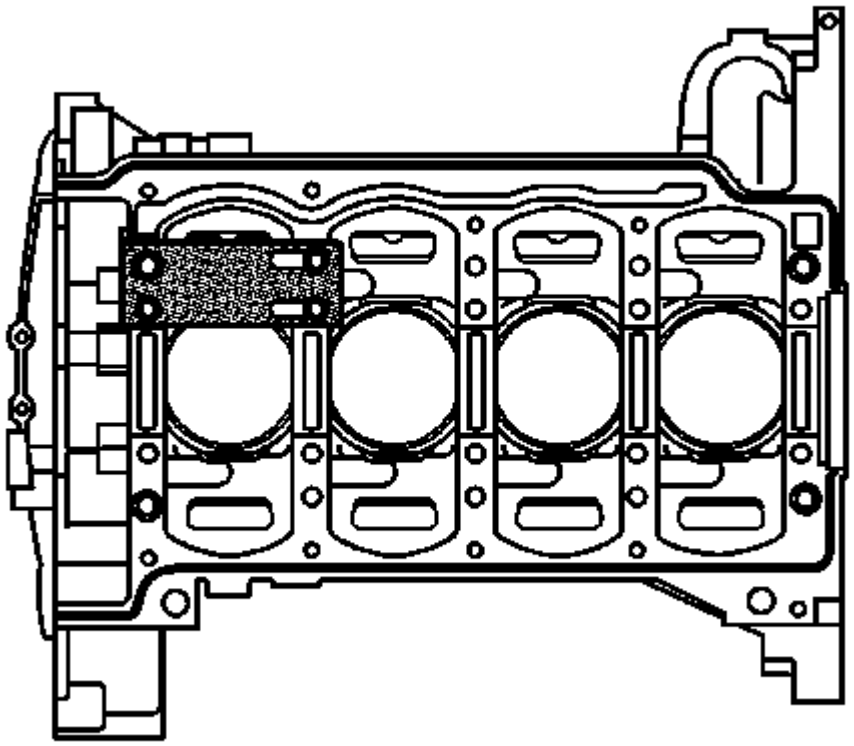

Fig. 484: Installing Fixture Plate, Bolt, & Bushing Onto Engine Block
Courtesy of GENERAL MOTORS CORP.

3. Install the fixture plate, bolt, and bushing, onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

4. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.
5. Drill out the damaged hole.
6. Using compressed air, clean out any chips.

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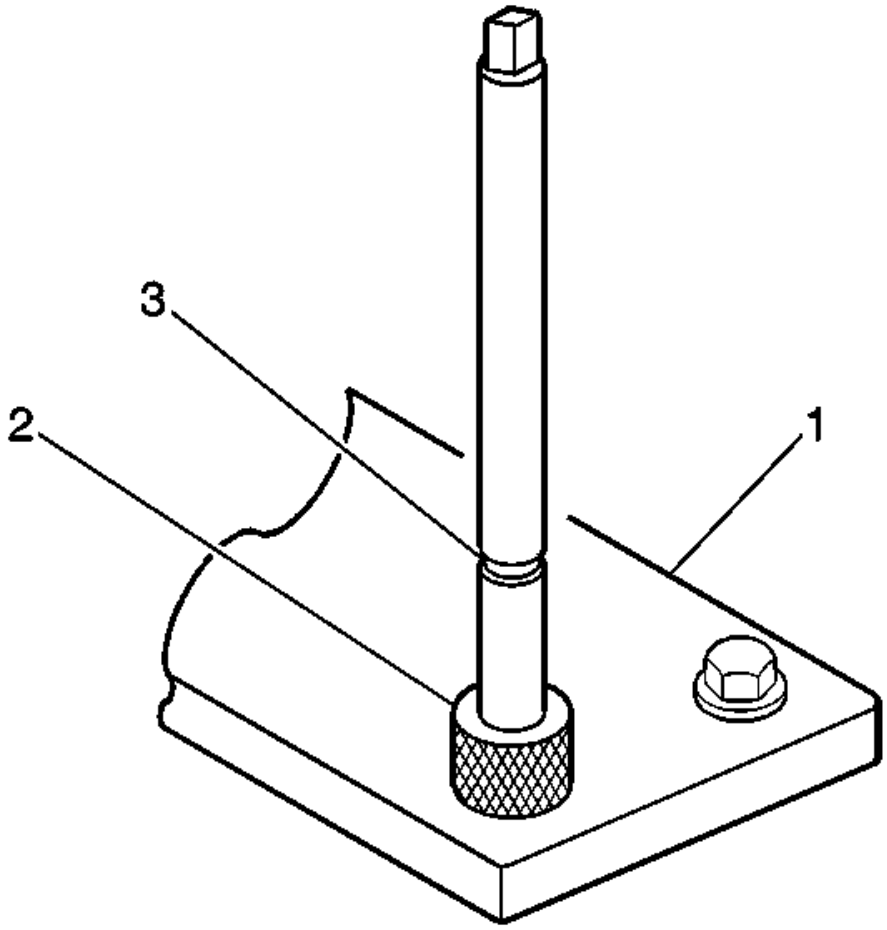

Fig. 485: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

7. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark (3) on the tap aligns with the top of the bushing (2).

8. Using compressed air, clean out any chips.
9. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463) or equivalent, into the hole.
10. Using compressed air, clean any cutting oil and chips out of the hole.

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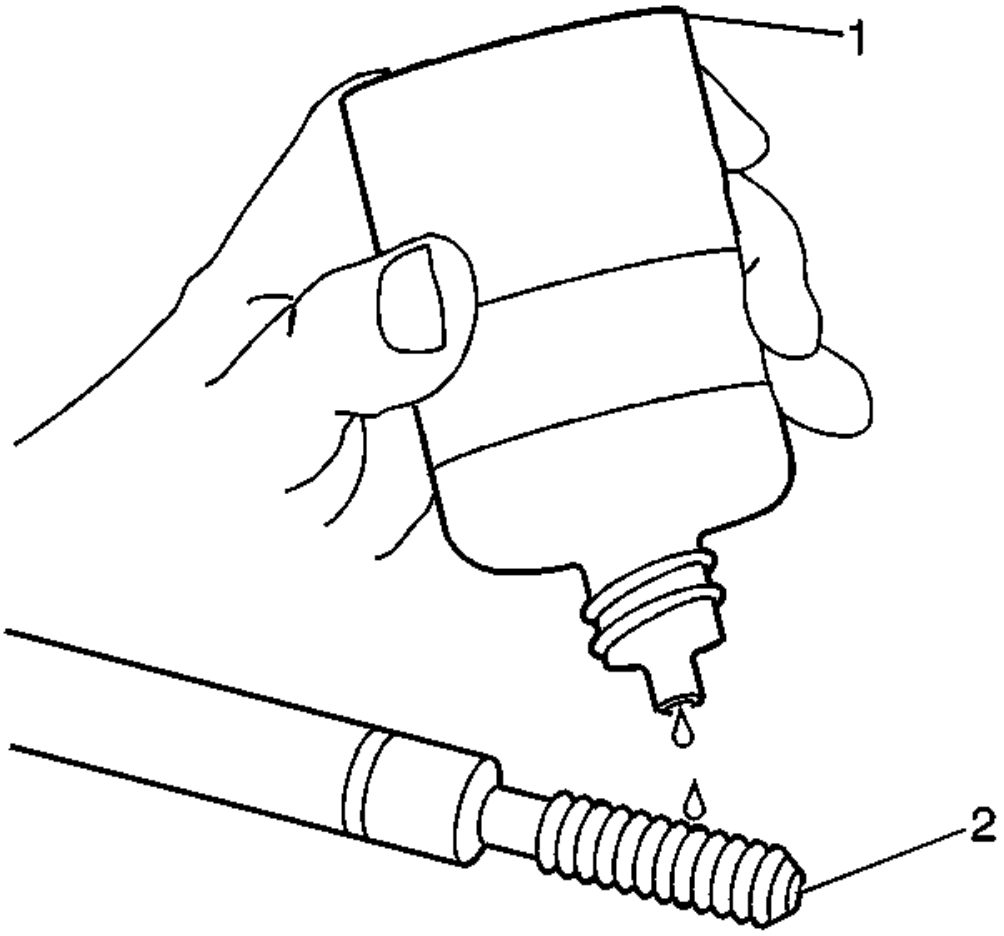

Fig. 486: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

11. Lubricate the threads of the installer tool (2) with the driver oil (1).

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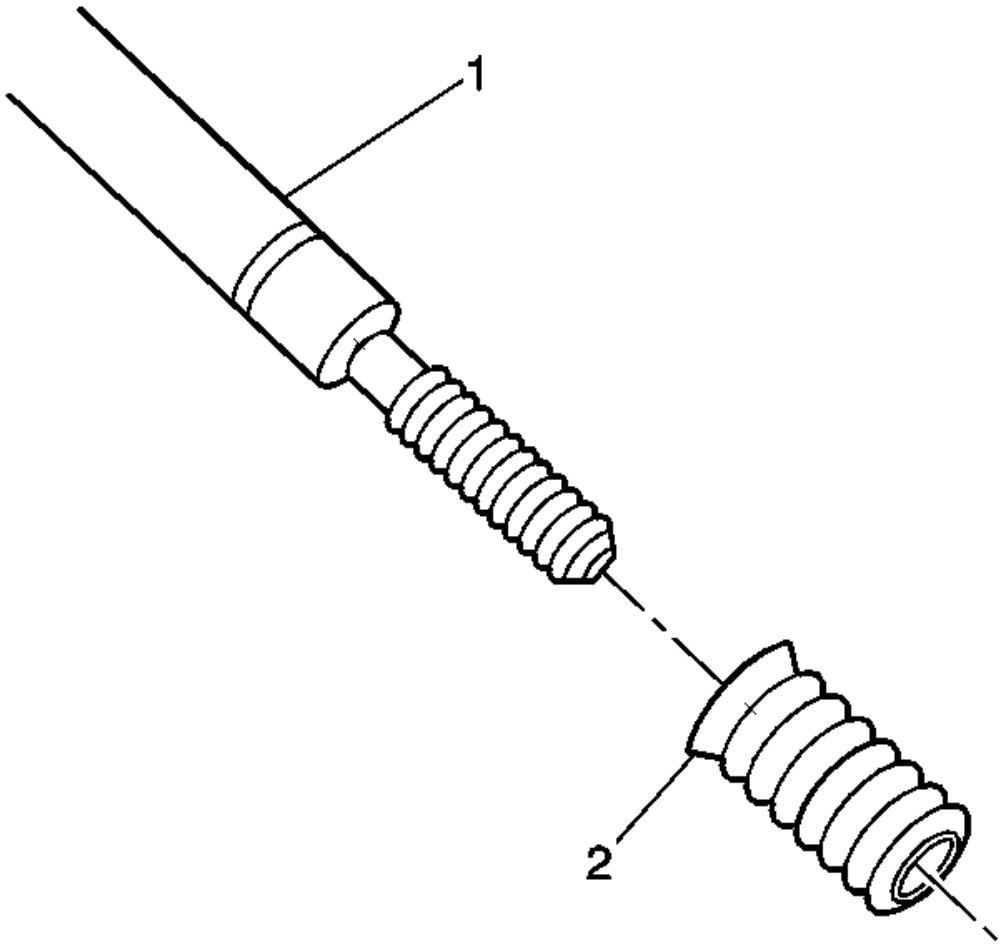

Fig. 487: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

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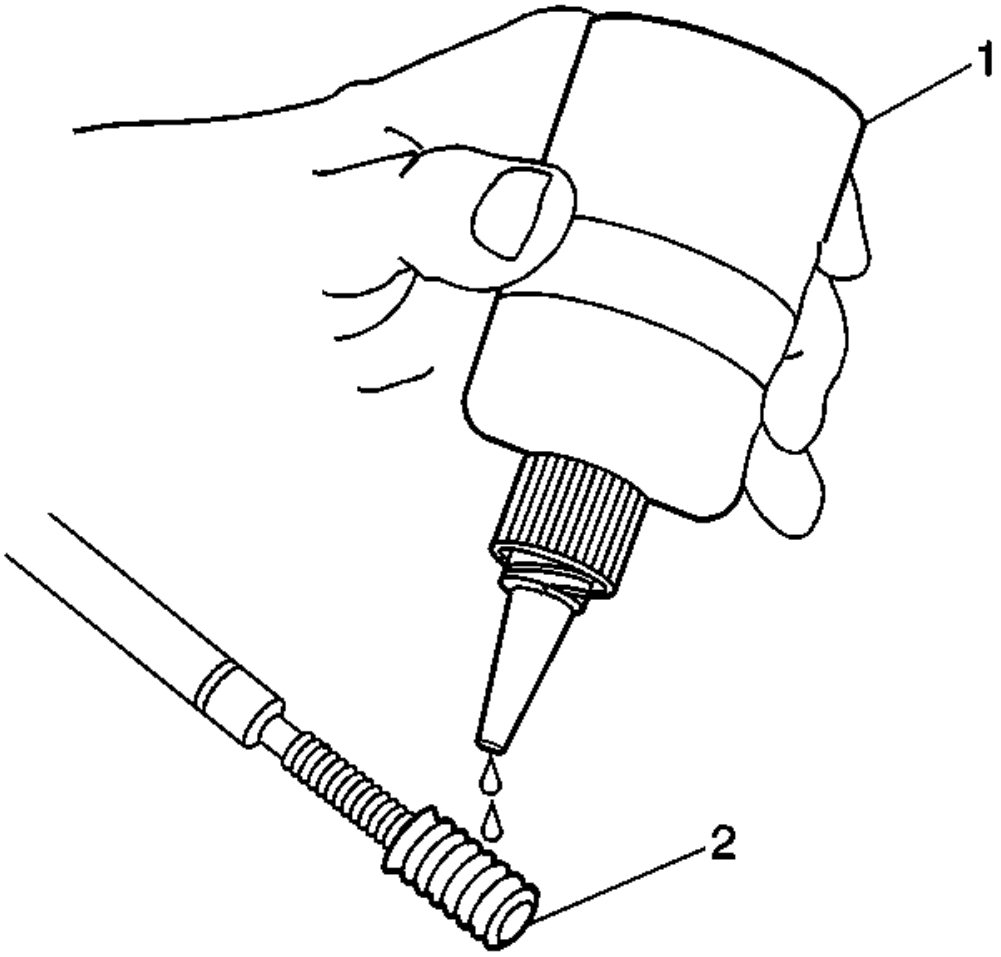

Fig. 488: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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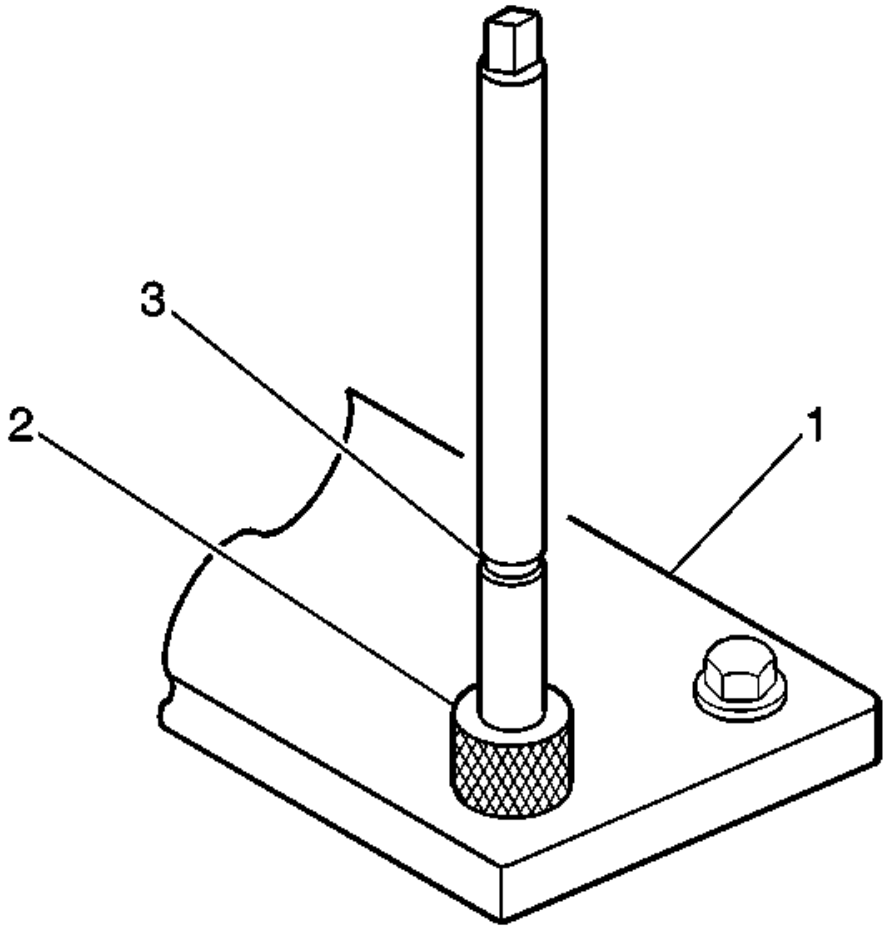

Fig. 489: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

14. Install the insert and driver through the bushing (2), fixture plate (1) and into the hole.

    Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

15. Remove the driver, bushing (2), fixture plate (1), and bolts.

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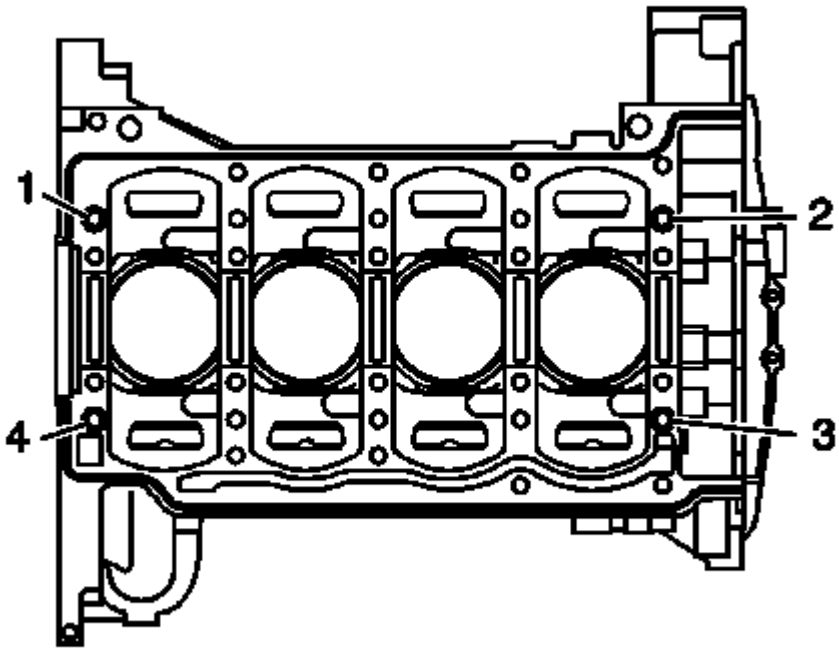

Fig. 490: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

16. Install the alignment dowel pins in holes (1-4), if necessary.

Service Prior to Assembly

The importance of cleanliness during assembly cannot be overstated. Dirt or debris will cause engine damage. An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Lubricate all moving parts with engine oil or a specified assembly lubricant. This will provide lubrication for initial start up.

Engine Block Assemble

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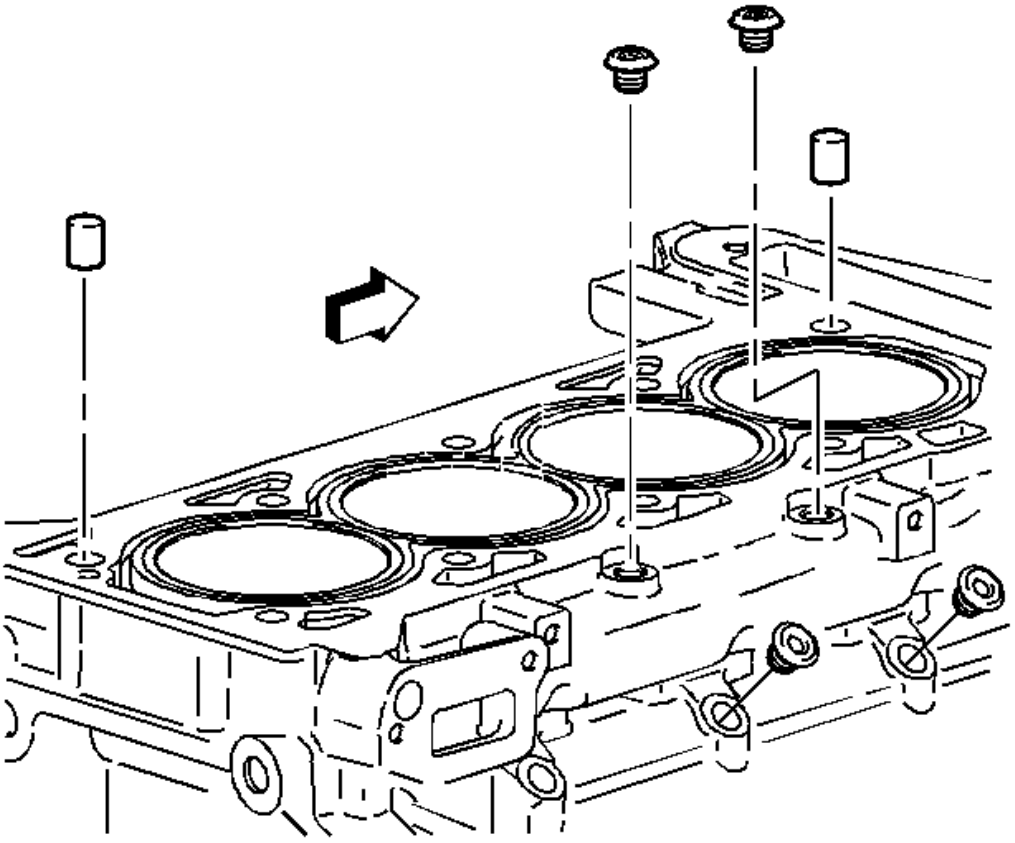

Fig. 491: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the drain plug in the water pump.
2. Apply GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the plug before installation.

NOTE: **Refer to Fastener Notice .**

3. Install the coolant jacket plugs.

   Tighten: Tighten the coolant jacket plug to 35 N.m (26 lb ft).

4. Install the rear oil passage plugs.
5. Apply GM P/N 12346004 (Canadian P/N 10953480)) or equivalent to the plugs before installation.

   Tighten: Tighten the oil passage plug to 60 N.m (44 lb ft).

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6. Install the other oil passage plugs.
7. Apply GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the plug before installation.

   Tighten: Tighten the oil passage plugs to 35 N.m (26 lb ft).

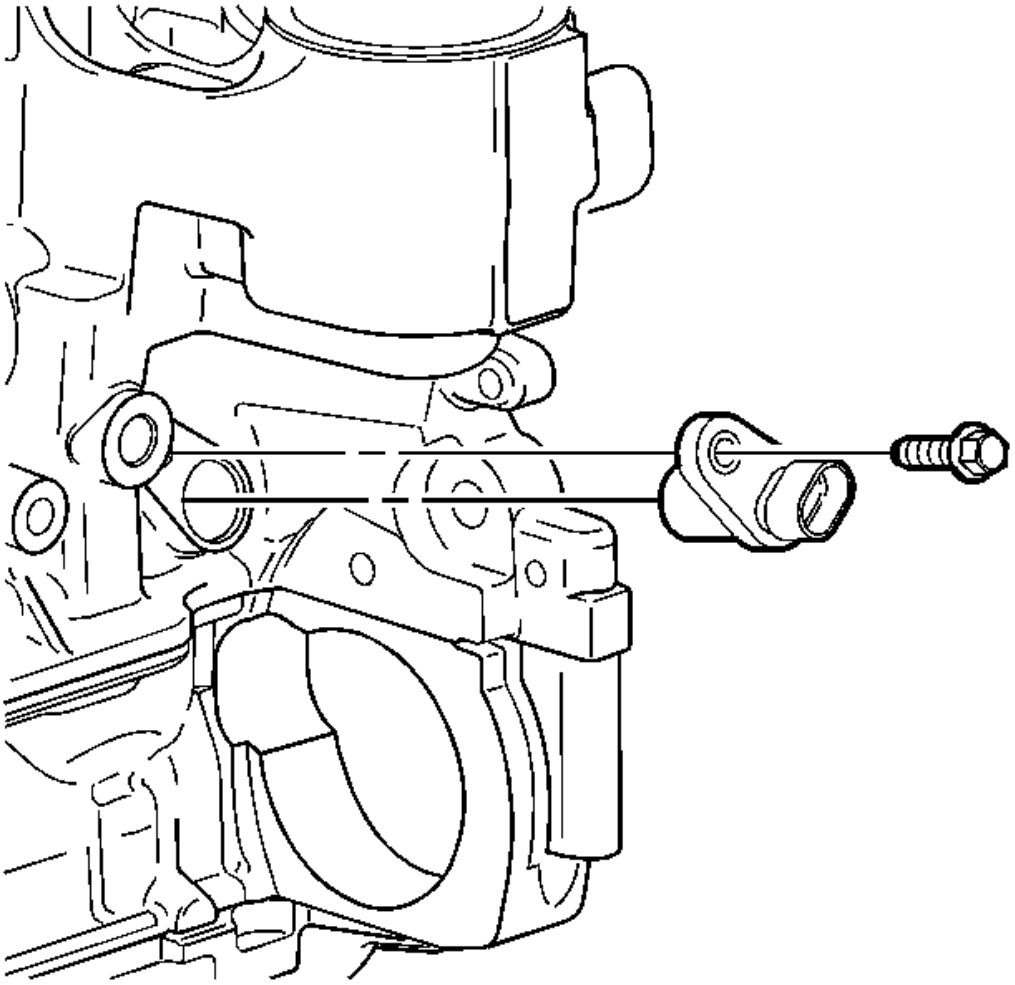

Fig. 492: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the crankshaft position sensor O-ring with engine oil.
9. Install the crankshaft position sensor and bolt.

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

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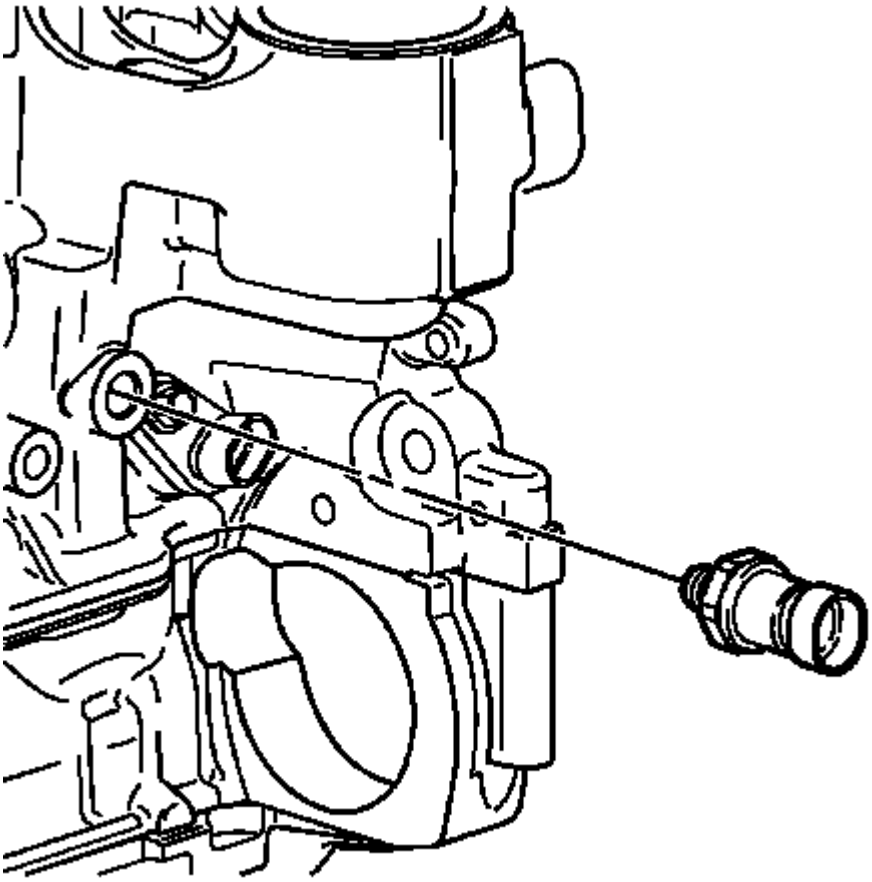

Fig. 493: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the oil pressure switch.

    Tighten: Tighten the oil pressure switch to 22 N.m (16 lb ft).

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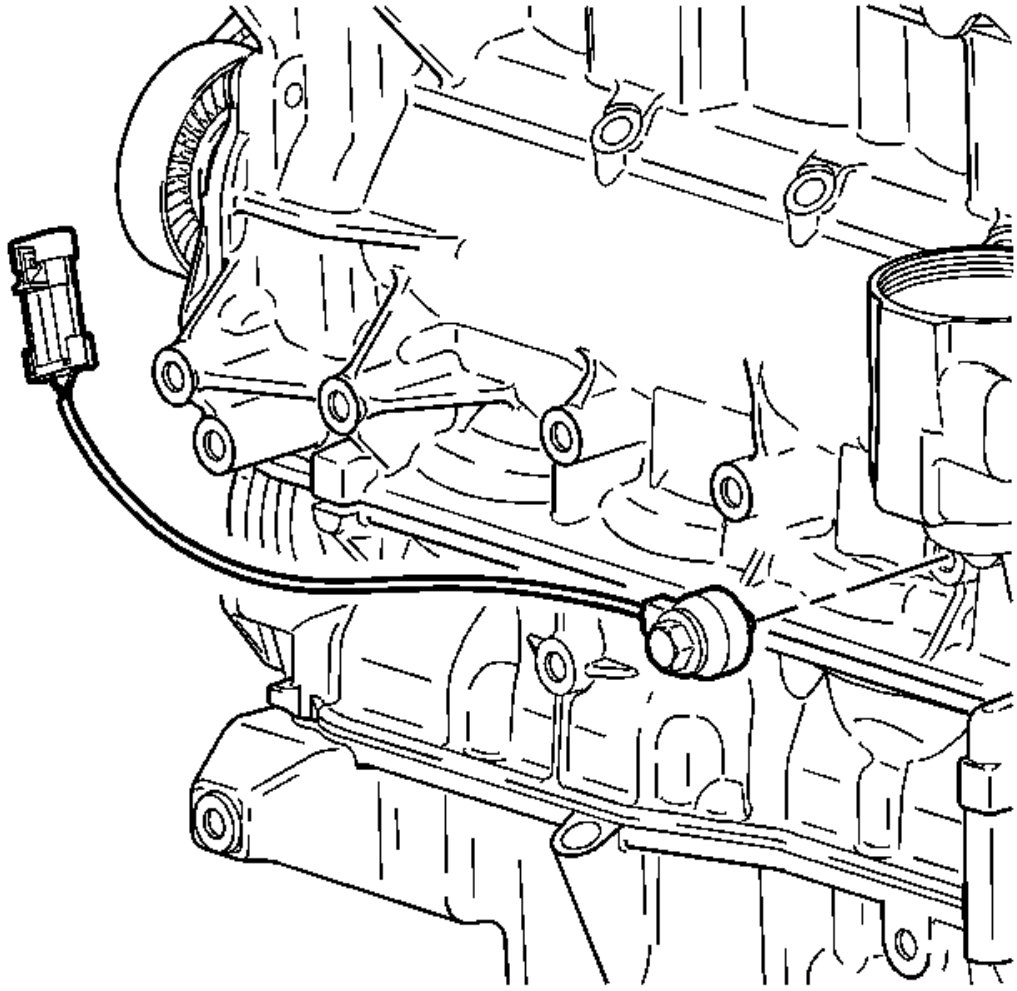

Fig. 494: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

11. Install the knock sensor and bolt.

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

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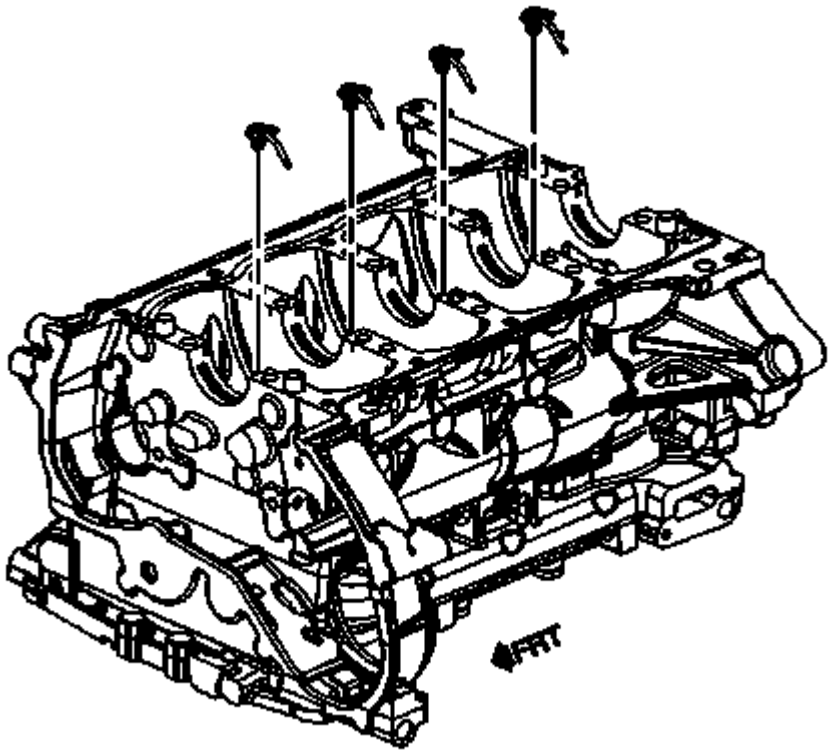

Fig. 495: Identifying Piston Oil Squirters
Courtesy of GENERAL MOTORS CORP.

12. Install the piston oil squirters.
13. Install the piston oil squirter bolts.

Tighten: Tighten the piston oil squirter bolts to 15 N.m (11 lb ft).

Crankshaft and Bearings Installation

Tools Required

- **J 8087** Cylinder Bore Checking Gage
- **J 45059** Angle Meter

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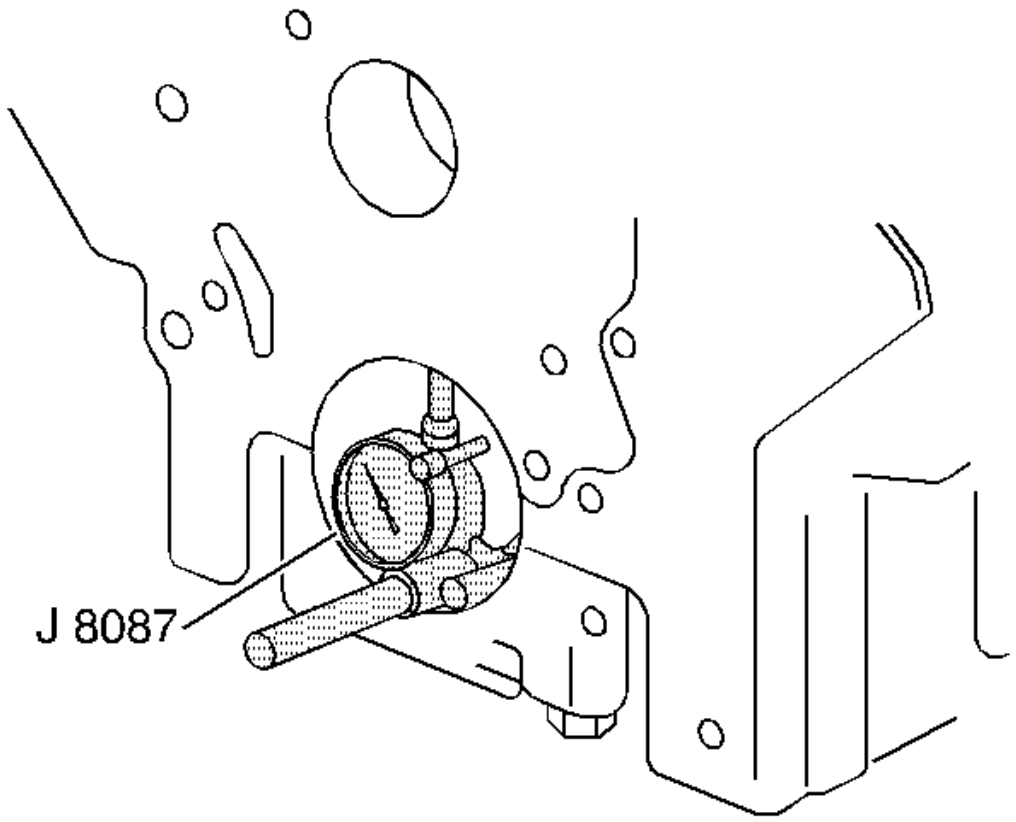

Fig. 496: Inspecting Crankshaft Main Bearing Bores
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If crankshaft bearing failure is due to other than normal wear, investigate the cause. Inspect the crankshaft or connecting rod bearing bores.

Inspect the connecting rod bearing bores or crankshaft main bearing bores using the following procedure:

- Tighten the bedplate to specification using the **J 45059** .
- Measure the bearing bore for taper and out-of-round using the **J 8087** .
- No taper or out-of-round should exist.

Bearing Selection

1. Measure the bearing clearance to determine the correct replacement bearing insert size. There are 2 methods to measure bearing clearance. Method A gives more reliable results and is preferred.
    - Method A yields measurement from which the bearing clearance can be computed.

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- Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

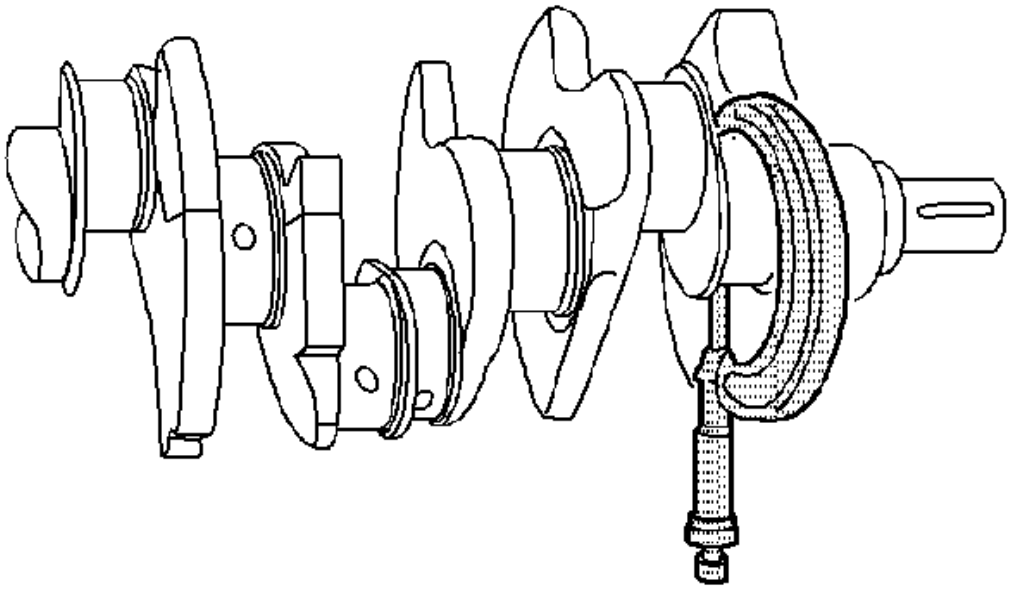

Fig. 497: Measuring Crankshaft Bearing Journal Diameter
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not mix inserts of different nominal size in the same bearing bore.

2. To measure bearing clearance using Method A, use the following procedure:
    1. Measure the crankshaft bearing journal diameter with a micrometer in several places, 90 degrees apart. Average the measurements.
    2. Measure the crankshaft bearing journal taper and runout.
    3. Install the lower crankcase and tighten the bearing cap bolts to specification.
    4. Measure bearing inside diameter (ID) in several places 90 degrees apart, average measurements.
    5. Subtract journal measurement from bearing ID measurement to determine clearance.
    6. Determine whether clearance is within specification.
    7. If out of specification, choose different inserts.
    8. Measure the connecting rod inside diameter in the same direction as the length of the rod with an inside micrometer.
    9. Measure the crankshaft main bearing inside diameter with an inside micrometer.

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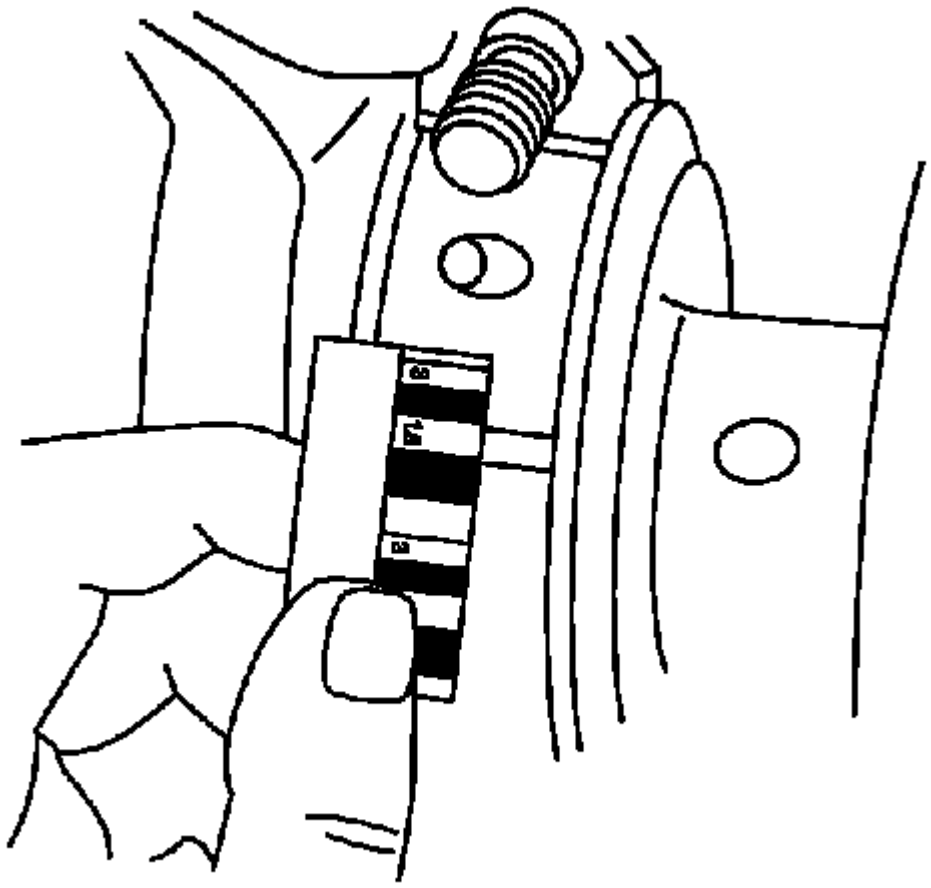

Fig. 498: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS CORP.

3. To measure bearing clearance using Method B, use the following procedure:
    1. Clean the used bearing inserts.
    2. Install the used bearing inserts.
    3. Place a piece of gaging plastic across the entire bearing width.
    4. Install the bearing caps.

    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.

    5. Install the bearing cap bolts to specification.

    IMPORTANT: Do not rotate the crankshaft.

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6. Remove the bearing cap, leaving the gaging plastic in place. It does not matter whether the gaging plastic adheres to the journal or to the bearing cap.
7. Measure the gaging plastic at its widest point with the scale printed on the gaging plastic package.
8. Remove the gaging plastic.

Lower Crankcase Installation

Tools Required

J 45059 Angle Meter

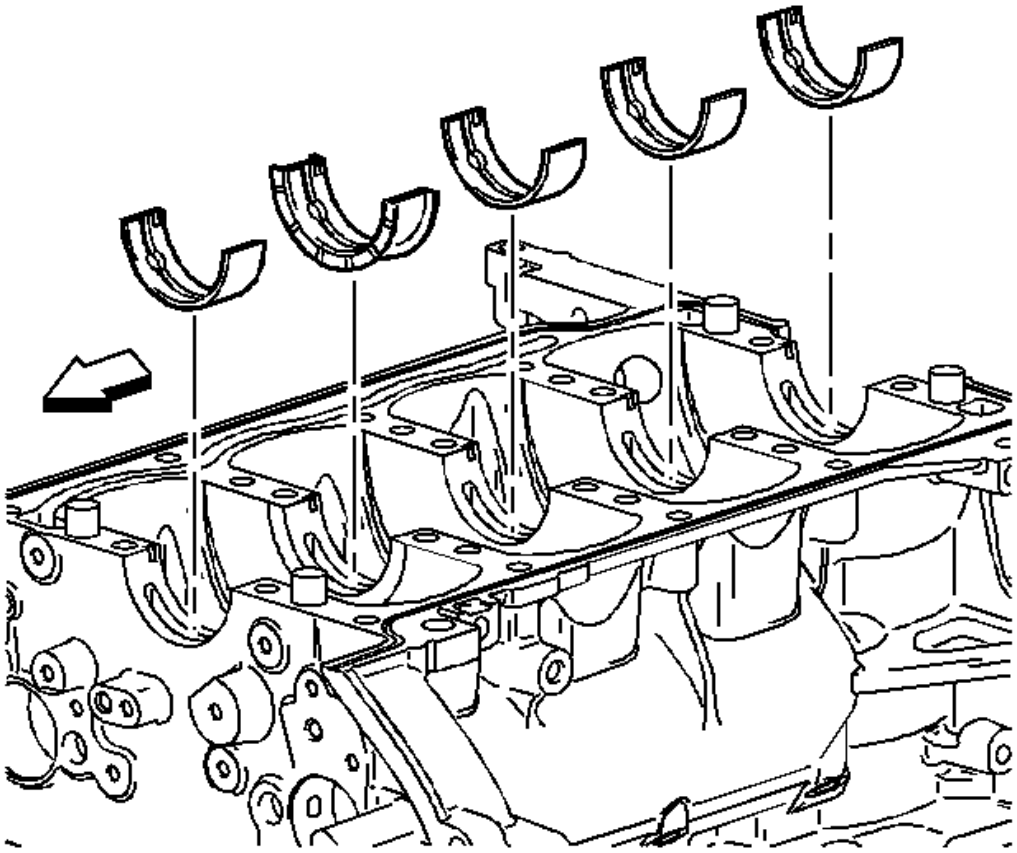

Fig. 499: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

1. Install the upper crankshaft bearings and lubricate bearing surfaces with engine oil.

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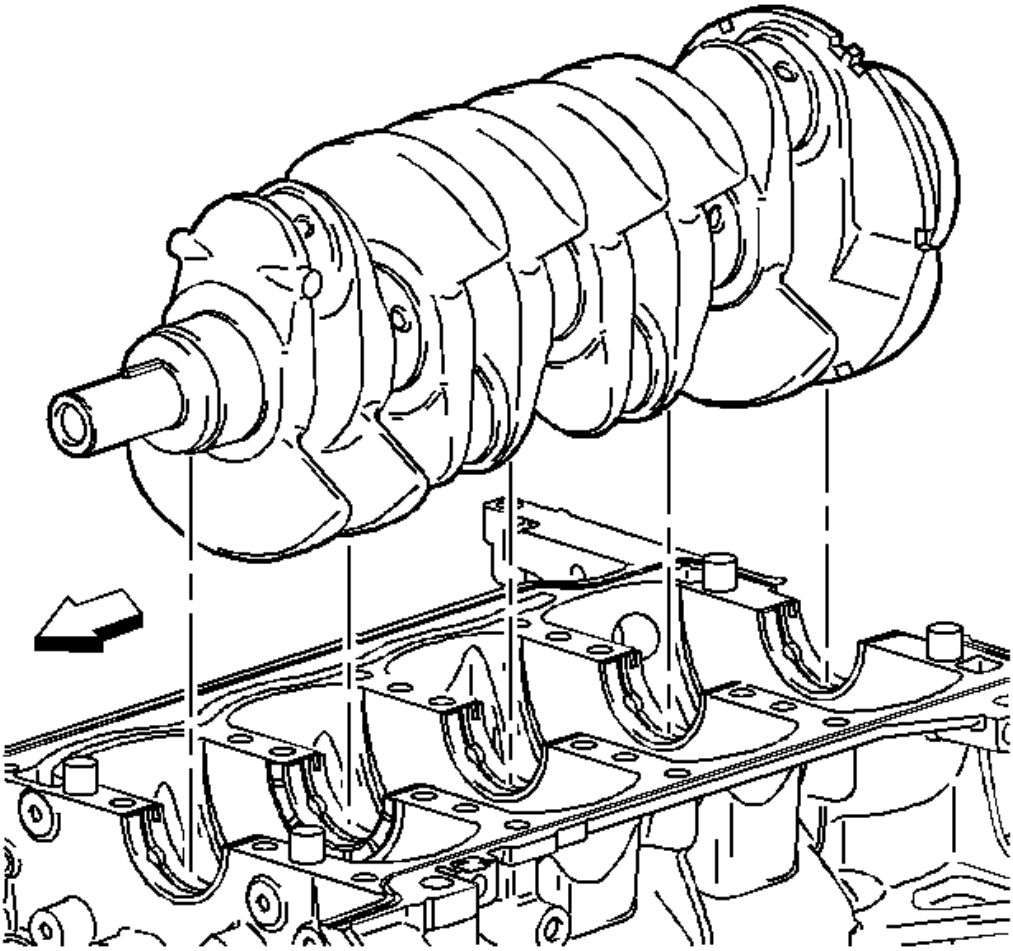

Fig. 500: View Of Crankshaft & Journals
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft on the journals.

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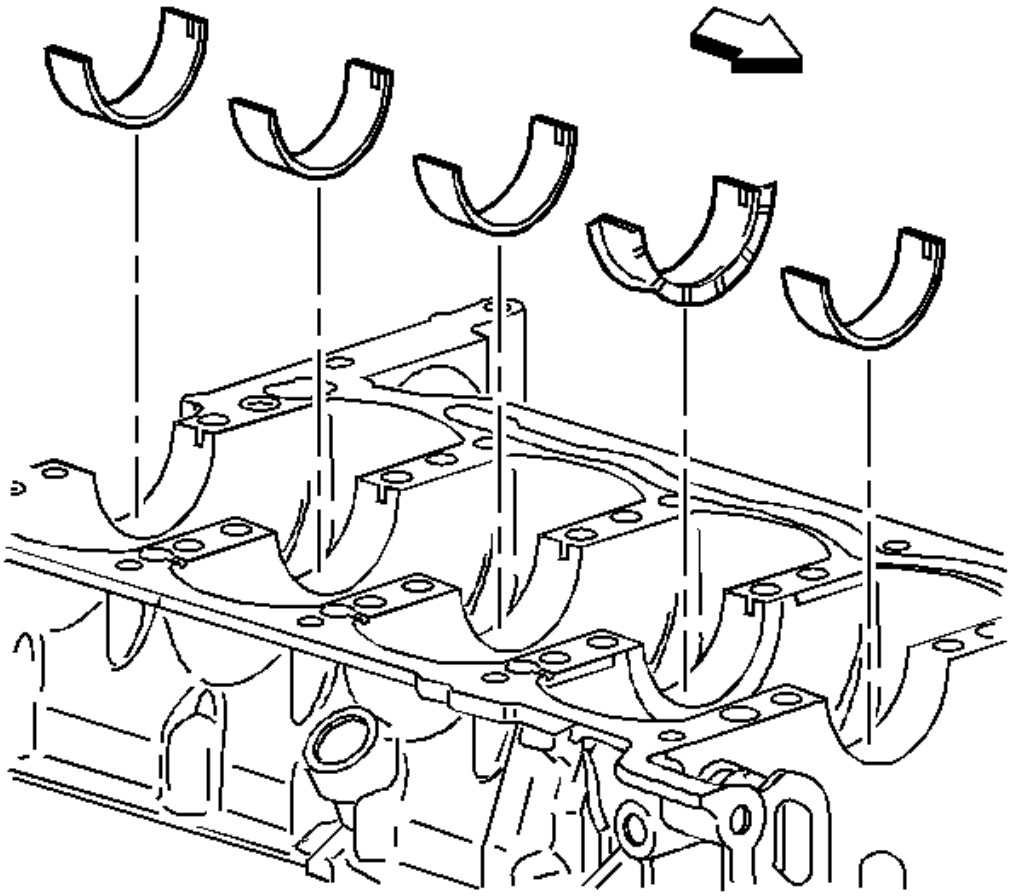

Fig. 501: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Install the lower bearing halves, without grooves, into the lower crankcase. Apply oil to bearing surfaces.

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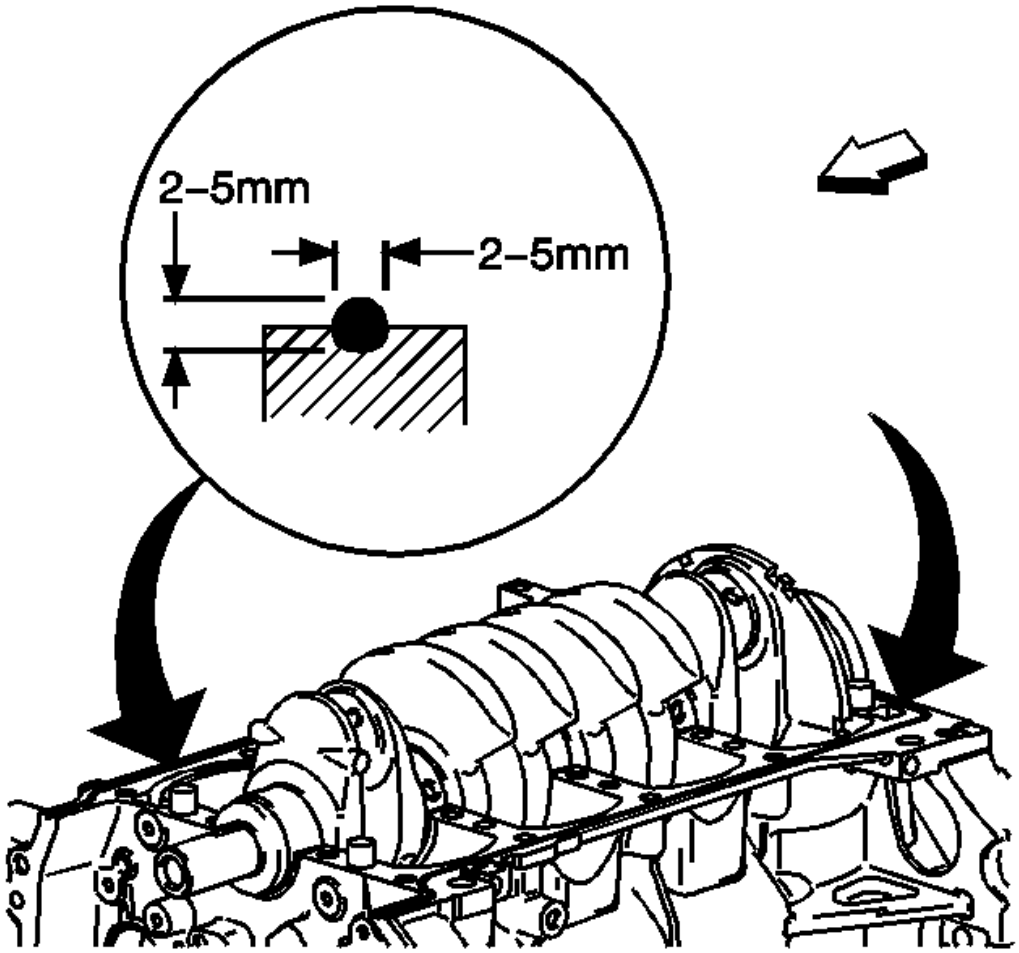

Fig. 502: Applying Sealer To Surfaces Of Engine Block To Bedplate Mating Surfaces
Courtesy of GENERAL MOTORS CORP.

4. Apply sealer GM P/N 12378521 (Canadian P/N 88901148) to the surfaces of the engine block to bedplate mating surfaces.

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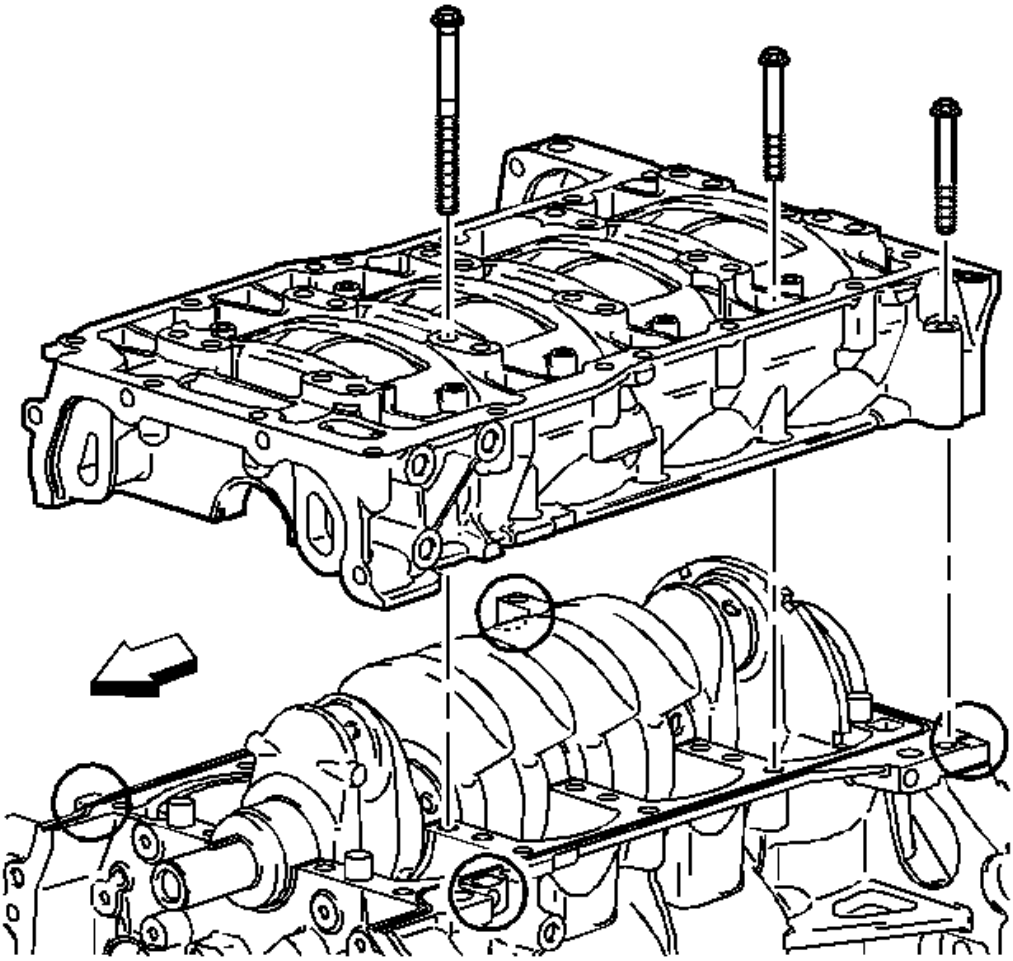

Fig. 503: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase. Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

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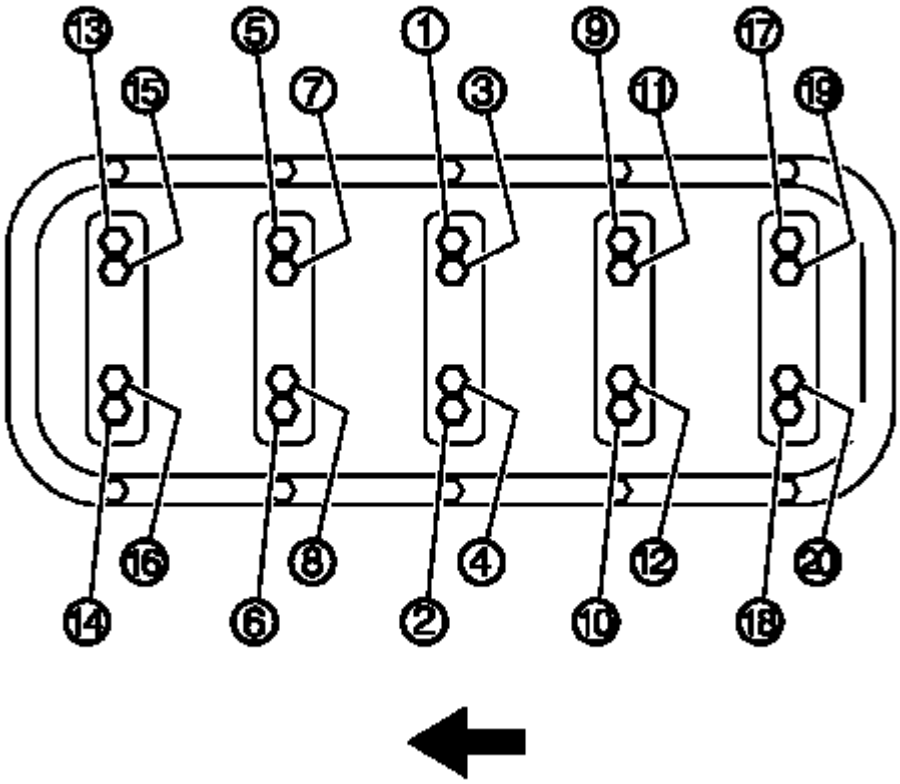

Fig. 504: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to FASTENER NOTICE e.

6. Install the NEW crankshaft bearing bolts in sequence finger tight.
    1. Tighten the crankshaft bearing bolts in sequence.

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

    2. Tighten the crankshaft bearing bolts in sequence using the **J 45059** .

       Tighten: Tighten the crankshaft bearing bolts 70 degrees using the torque angle meter.

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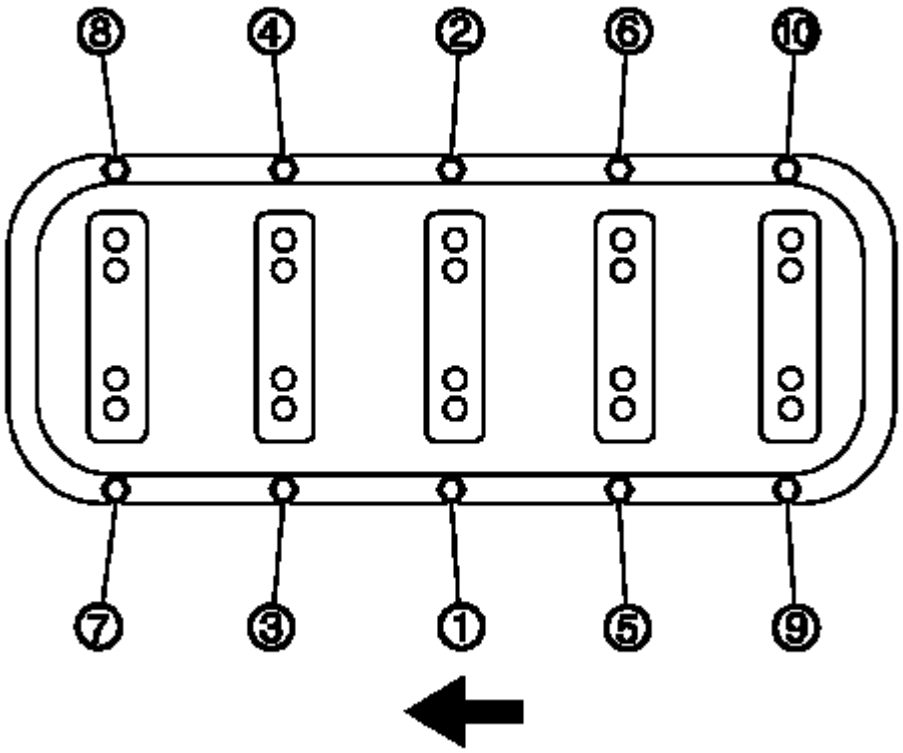

Fig. 505: Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

7. Tighten the lower crankcase perimeter bolts in sequence.

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

Crankshaft Rear Oil Seal Installation

Tools Required

J 42067 Rear Main Seal Installer

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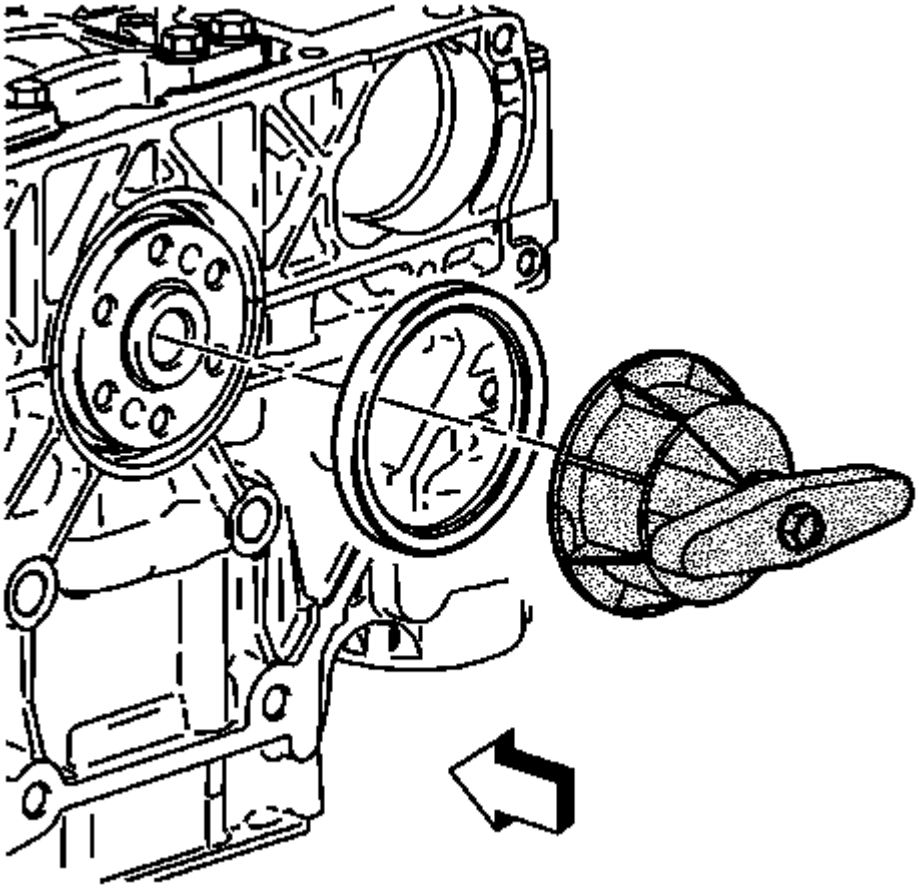

Fig. 506: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove excess sealer from seal recess.
2. Lubricate the outside diameter of the new crankshaft seal with clean engine oil.
3. Using the **J 42067** , press the new crankshaft seal into the housing. The **J 42067** also establishes the depth of the seal in the crankshaft seal bore.

Piston, Connecting Rod, and Bearing Installation

Tools Required

- **EN-47836** Piston Ring Compressor. See **Special Tools**.
- **J 45059** Angle Meter
- **J-43966-1** Connecting Rod Guides. See **Special Tools**.

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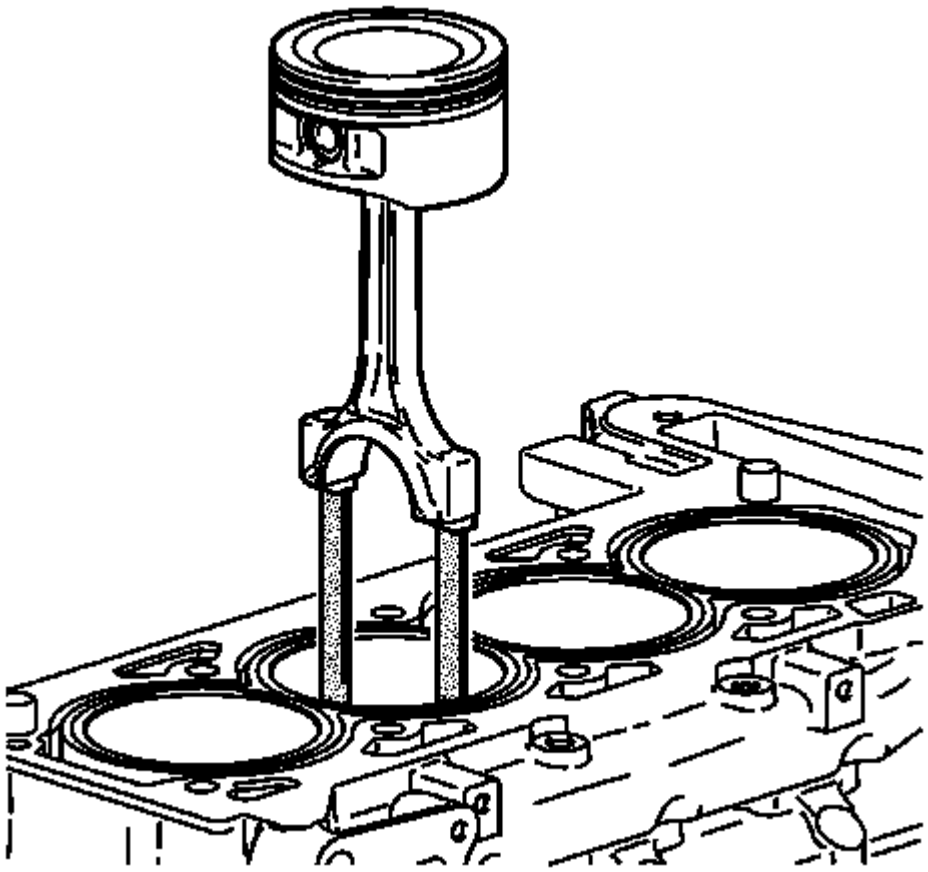

Fig. 507: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod bearings. Use NEW bearings.
    1. Install the bearing inserts into the connecting rod and the connecting rod cap.
    2. Lubricate the connecting rod bearings with engine oil.
2. Install the **J-43966-1** into the connecting rod bolt holes. See **Special Tools**. This protects the crankshaft journal during piston and connecting rod installation.
3. Install **EN-47836** , piston, and the connecting rod to the correct bore. See **Special Tools**.
    1. Stagger each piston ring end gap equally around the piston.
    2. Lubricate the piston and the piston rings with engine oil.
    3. Do not disturb the piston ring end gap location.
    4. The piston must be installed so that the mark on the top of the piston faces the front of the engine.
    5. Place the piston in its matching bore.
    6. Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal while tapping the piston into place.
    7. Hold the **EN-47836** against the engine block until all the rings have entered the cylinder bore. See **Special Tools**.
    8. Remove the connecting rod guides from the connecting rod bolt holes.

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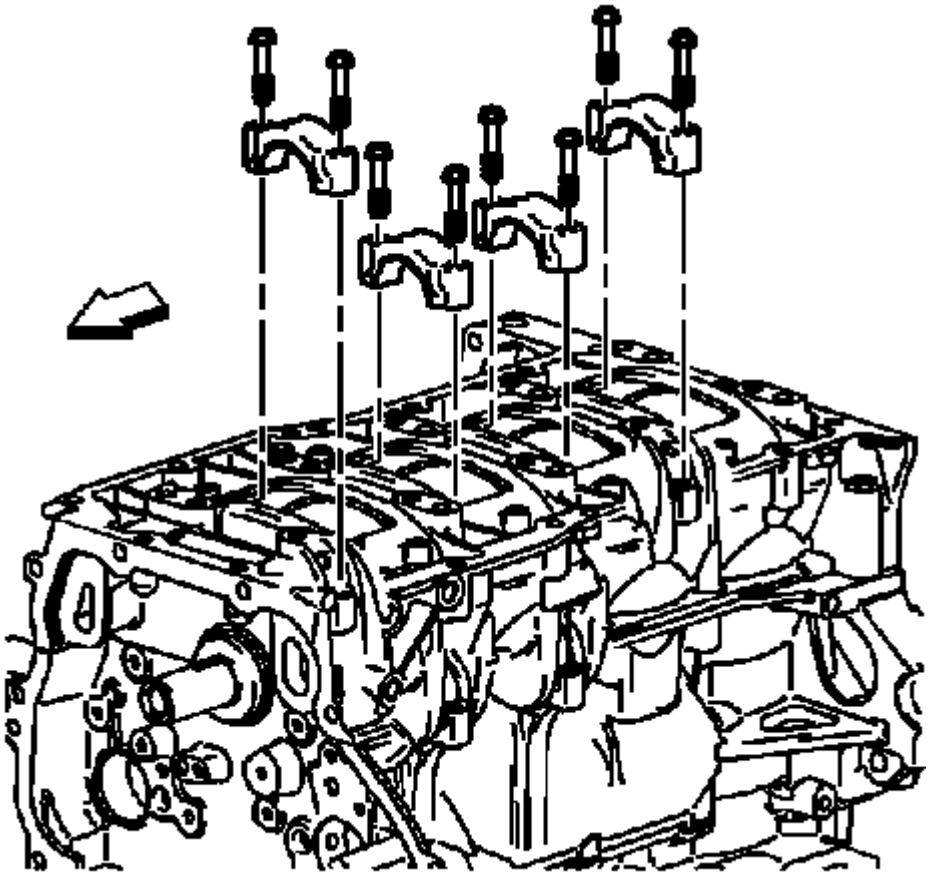

Fig. 508: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap.

   NOTE: Refer to FASTENER NOTICE .

5. Install the connecting rod bolts. Always use new bolts.

   Tighten: Tighten the connecting rod bolts to 25 N.m (18 lb ft), plus 100 degrees using the **J 45059** .

6. Install the remaining connecting rods and piston assemblies.

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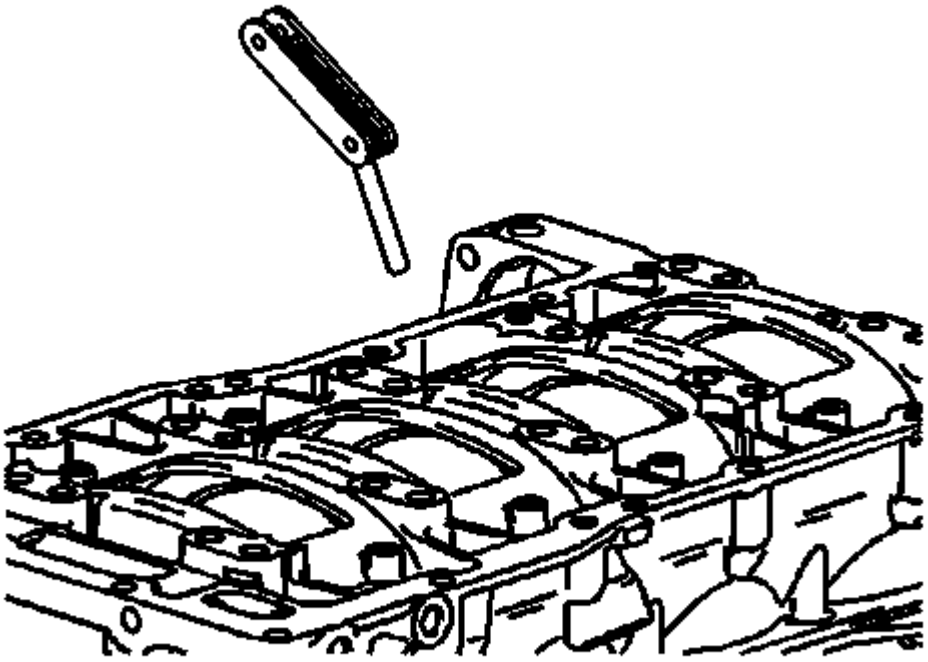

Fig. 509: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the connecting rod side clearance with a feeler gage.

   The correct clearance is 0.07-0.37 mm (0.0027-0.0145 in).

Cylinder Head Installation

Tools Required

J 45059 Angle Meter

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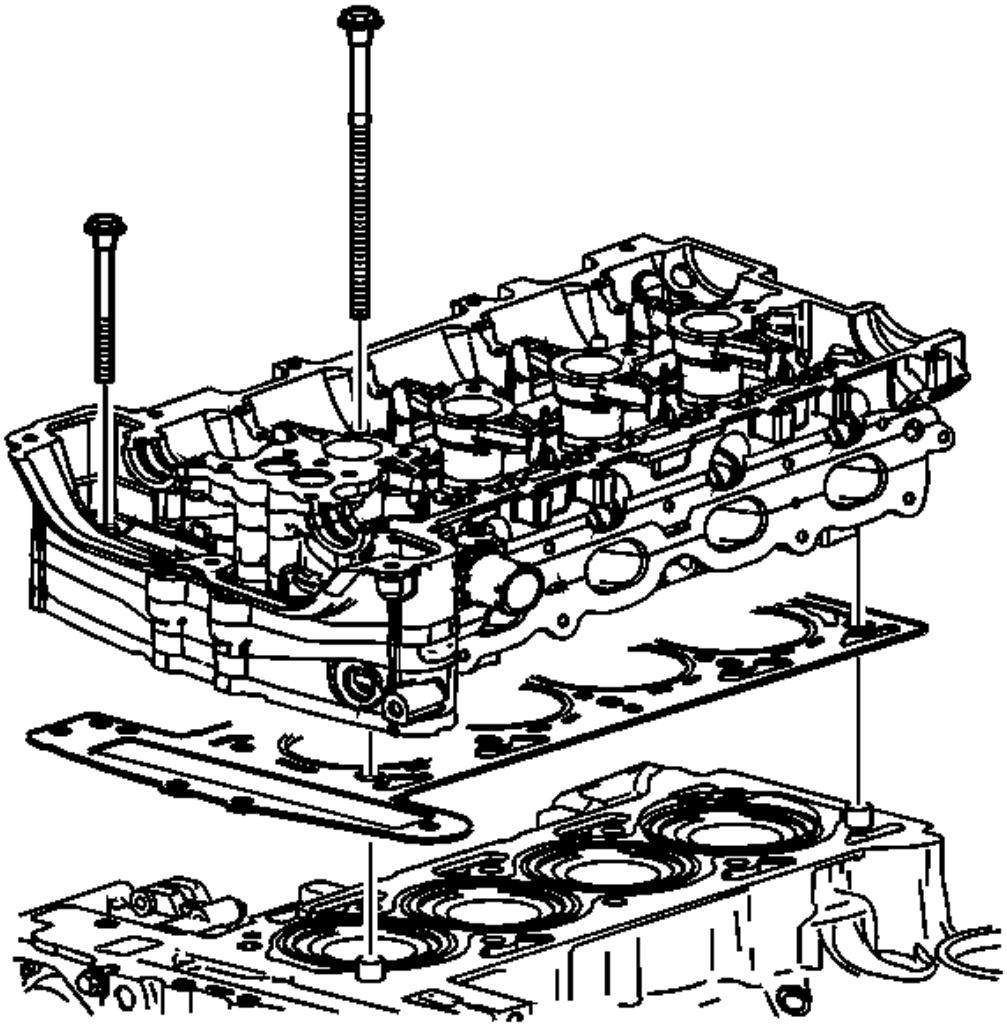

Fig. 510: View Of Cylinder Head, Bolts & Gasket
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Do not use any sealing material.

1. Install the cylinder head gasket to the block.
2. Install the cylinder head.

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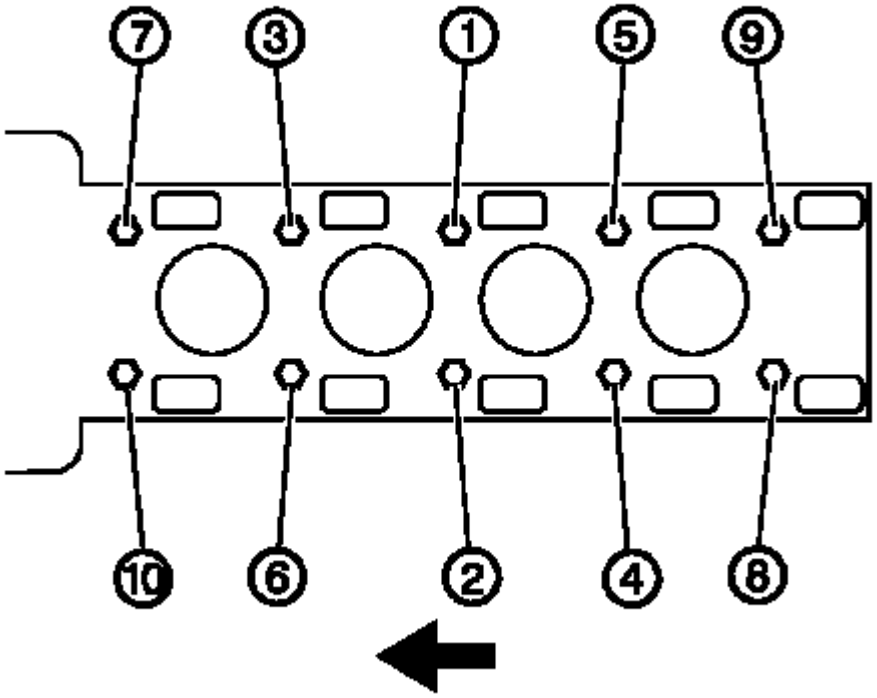

Fig. 511: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always use new cylinder head bolts.

NOTE: Refer to Fastener Notice .

3. Install and tighten the cylinder head bolts in sequence.

Tighten:

- Tighten the bolts to 30 N.m (22 lb ft).
- Tighten the bolts an additional 155 degrees in sequence. Use the **J 45059** .

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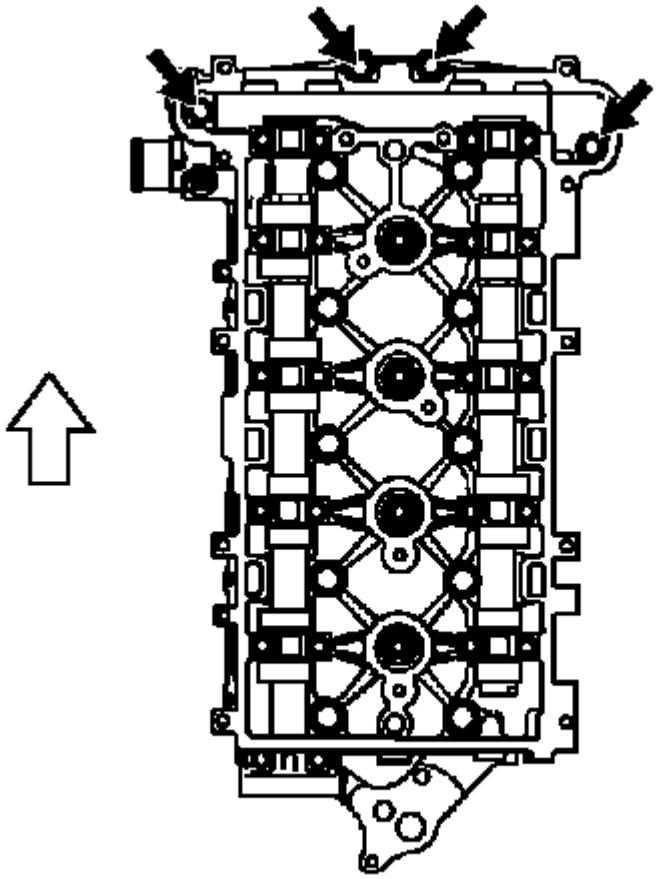

Fig. 512: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the front cylinder head bolts.

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

Intake Camshaft, Follower, and Adjuster Install

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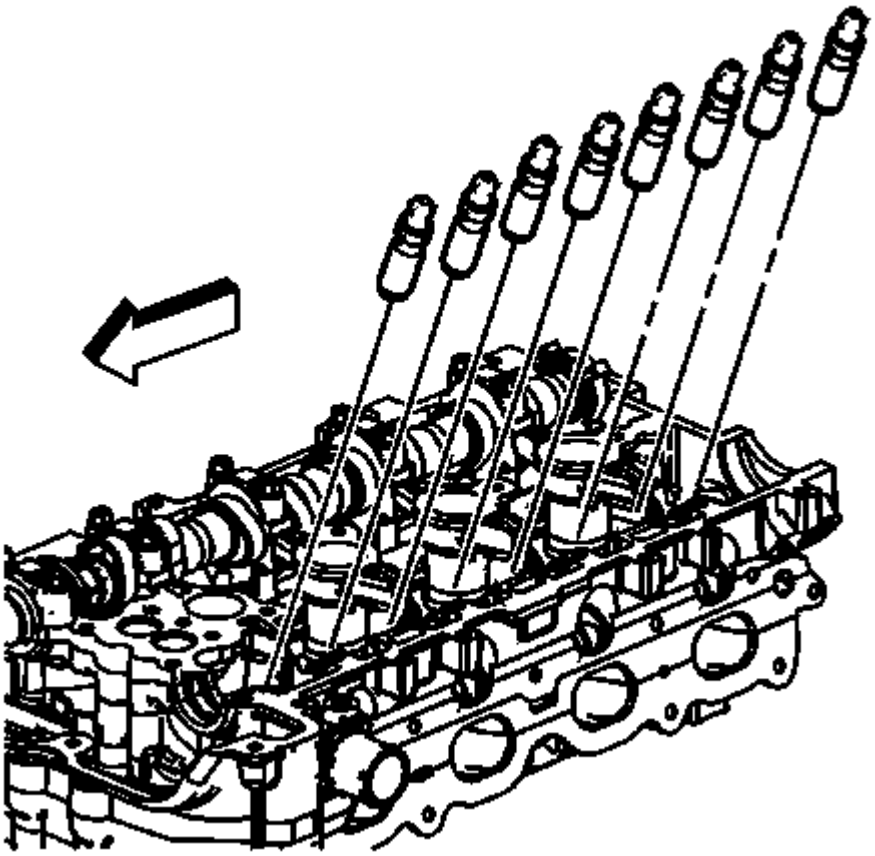

Fig. 513: Identifying Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters with GM P/N 1234550 (Canadian P/N 992704) or equivalent.

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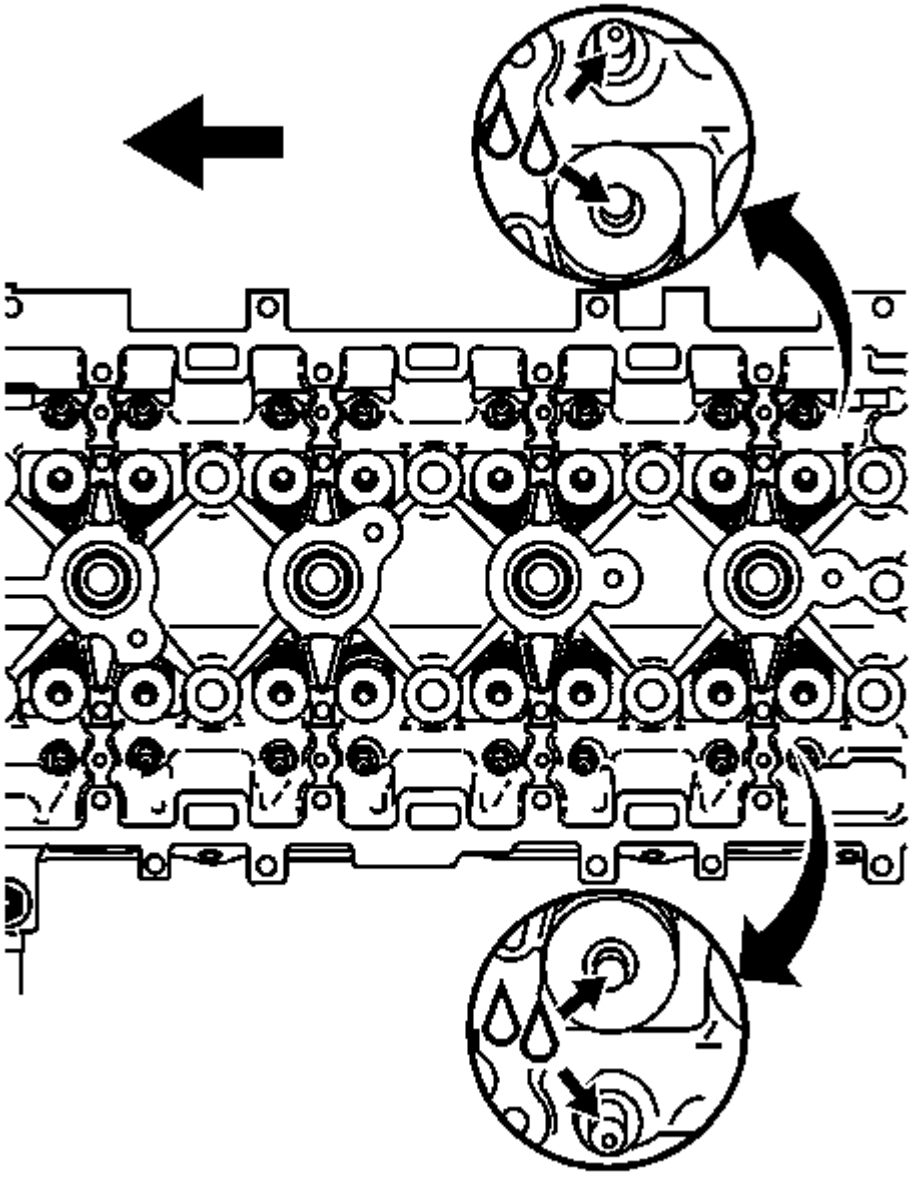

Fig. 514: Identifying Tip Of Valve Stem
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips.

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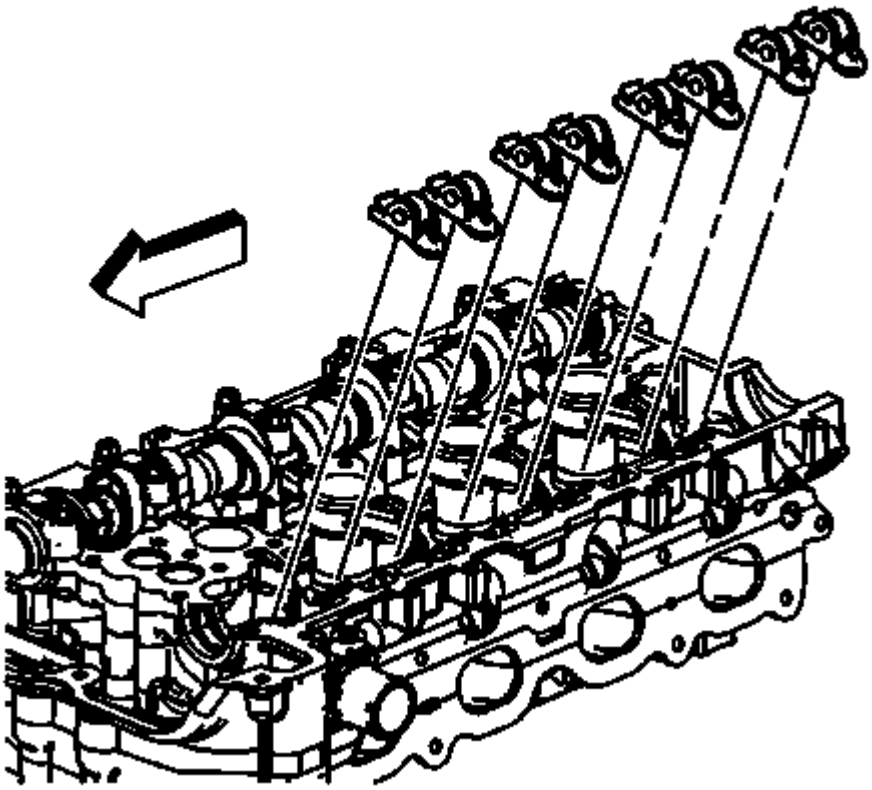

Fig. 515: Identifying Camshaft Roller Finger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used roller followers must be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

4. Position the roller followers on the tip of the valve stem and on the lash adjuster. Lubricate roller followers with GM P/N 12345501 (Canadian P/N 992704) or equivalent.

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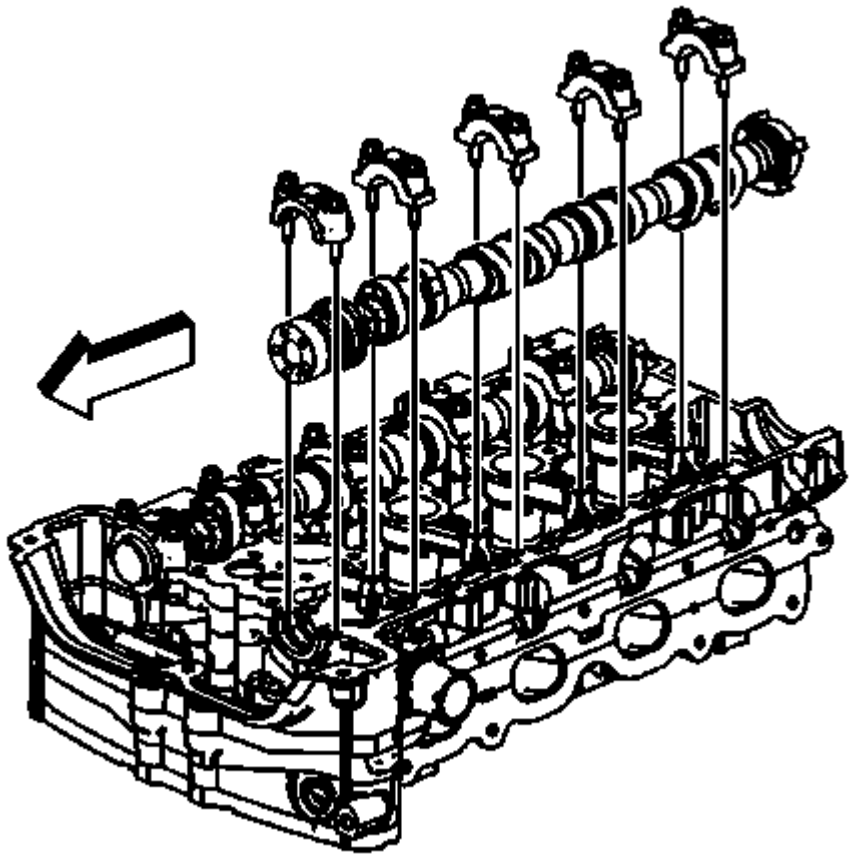

Fig. 516: Identifying Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the intake camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
6. Install the camshaft caps and hand start the camshaft cap bolts.

NOTE: **Refer to Fastener Notice .**

7. Tighten the camshaft cap bolts in increments of 3 turns until they are seated.

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

Exhaust Camshaft, Follower, and Adjuster Install

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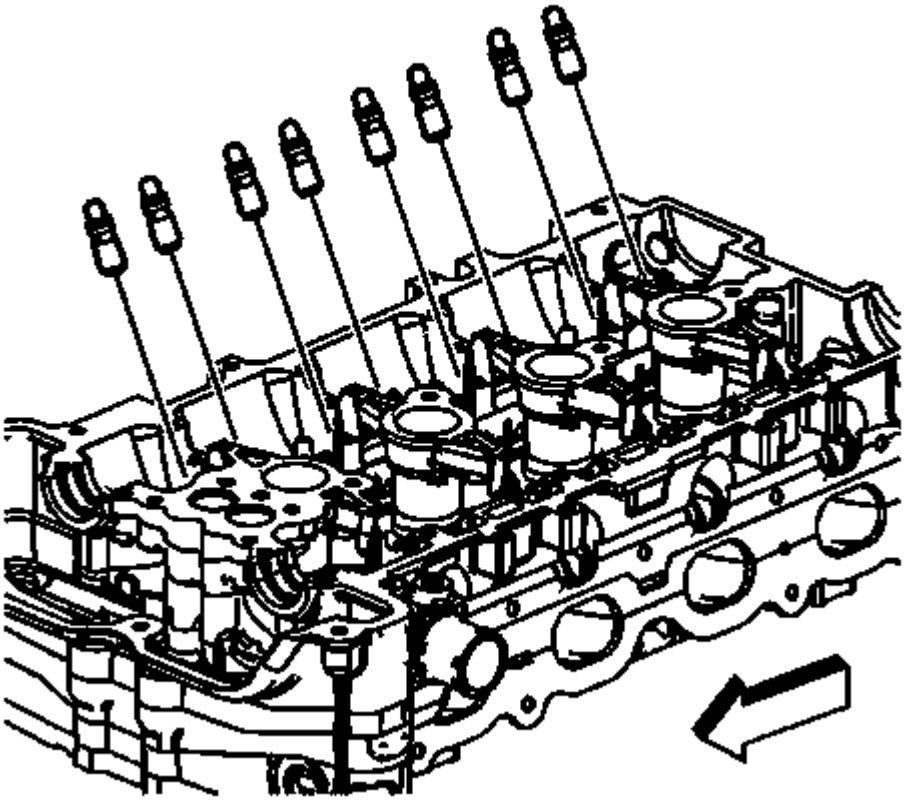

Fig. 517: Identifying Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head. Apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent.

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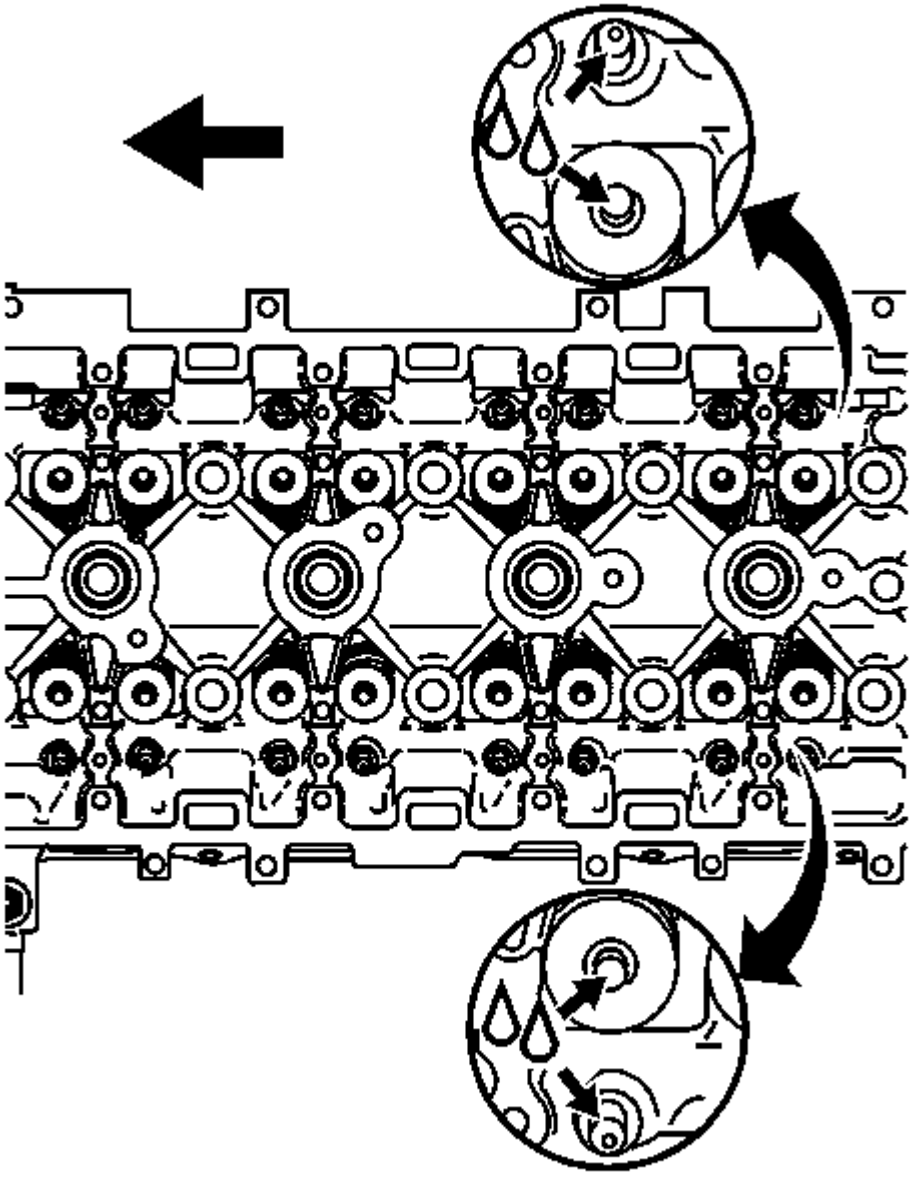

Fig. 518: Identifying Tip Of Valve Stem
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the valve tips with GM P/N 12345501 (Canadian P/N 992704) or equivalent.

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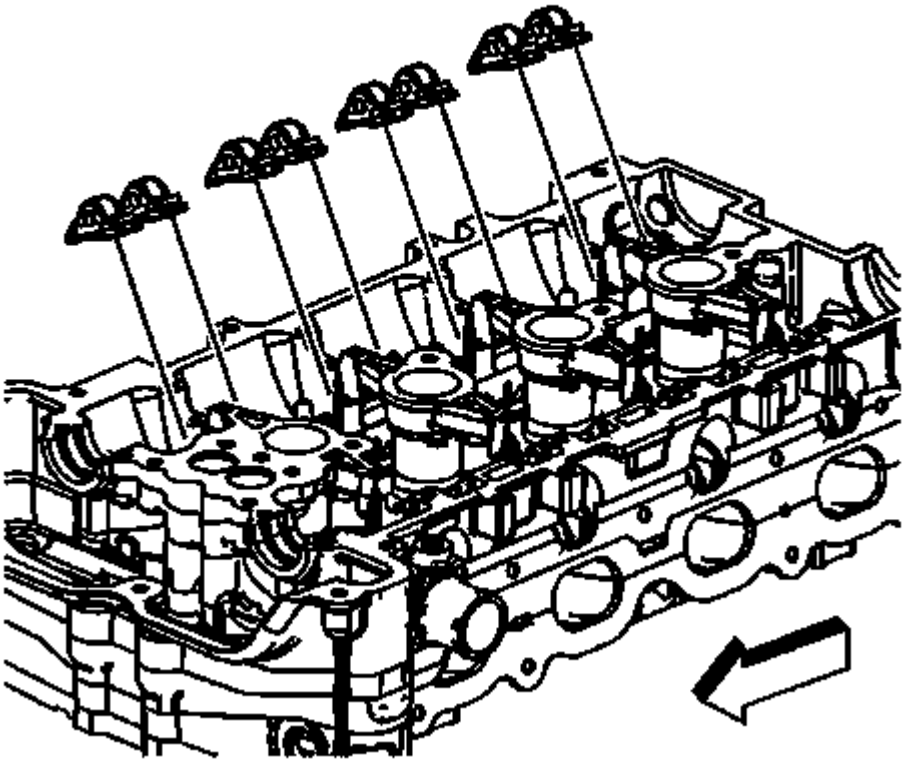

Fig. 519: Identifying Camshaft Roller Finger
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Used roller followers must be returned to the original position on the camshaft. If the camshaft is being replaced, the roller followers actuated by the camshaft must also be replaced.

3. Position the roller followers on the tip of the valve stem and on the lash adjuster. Apply lubricant GM P/N 12345501 (Canadian P/N 992704) or equivalent.

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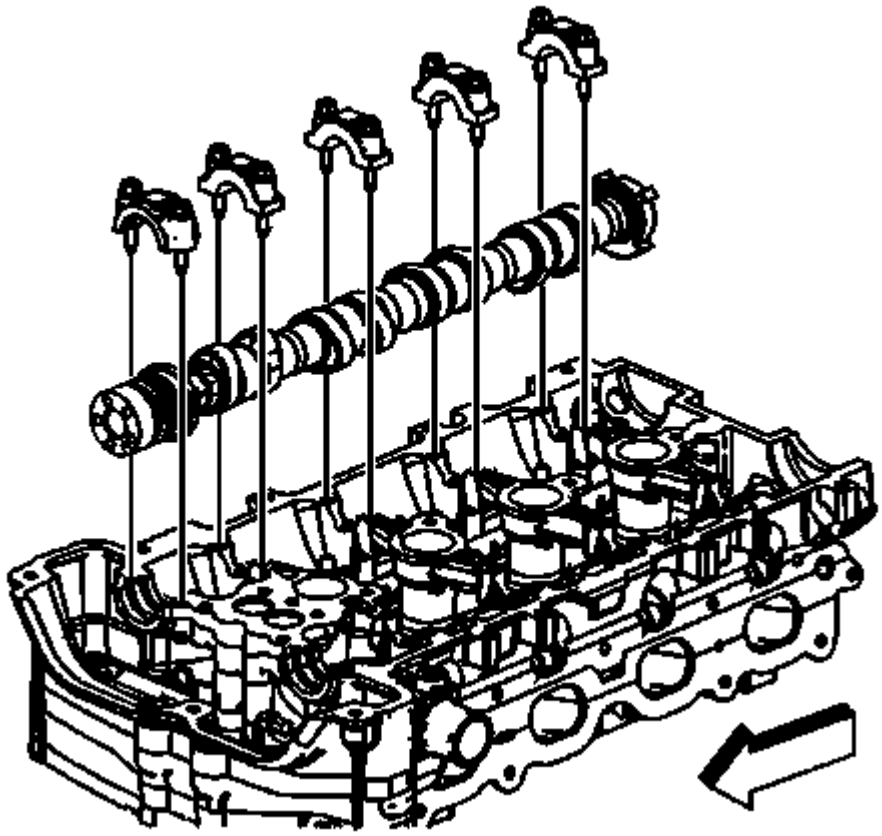

Fig. 520: Identifying Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

4. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals. Lubricate with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
5. Install the camshaft caps and hand start the camshaft cap bolts.

NOTE: Refer to Fastener Notice .

6. Tighten the camshaft cap bolts in increments of 3 turns until they are seated, lubricate.

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

Balance Shaft Installation

Tools Required

J 43650 Balance Shaft Bushing Remover/Installer

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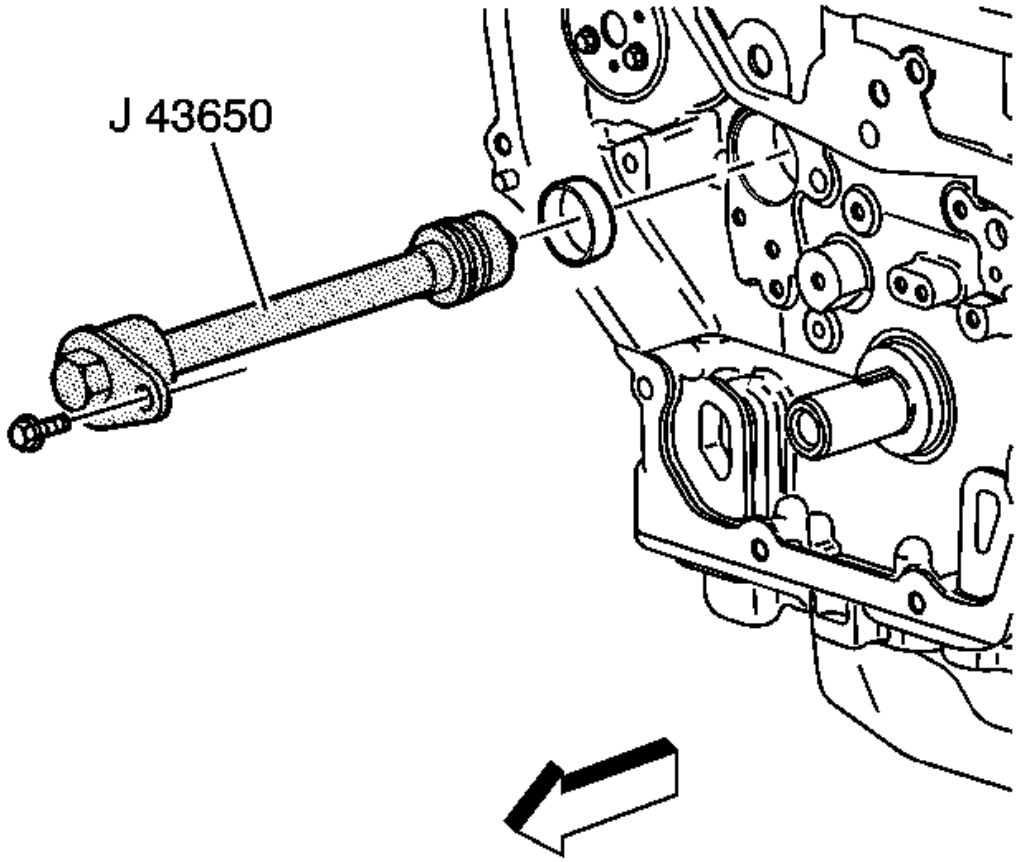

Fig. 521: Installing Balance Shaft Using J 43650
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft bushing using the **J 43650** .

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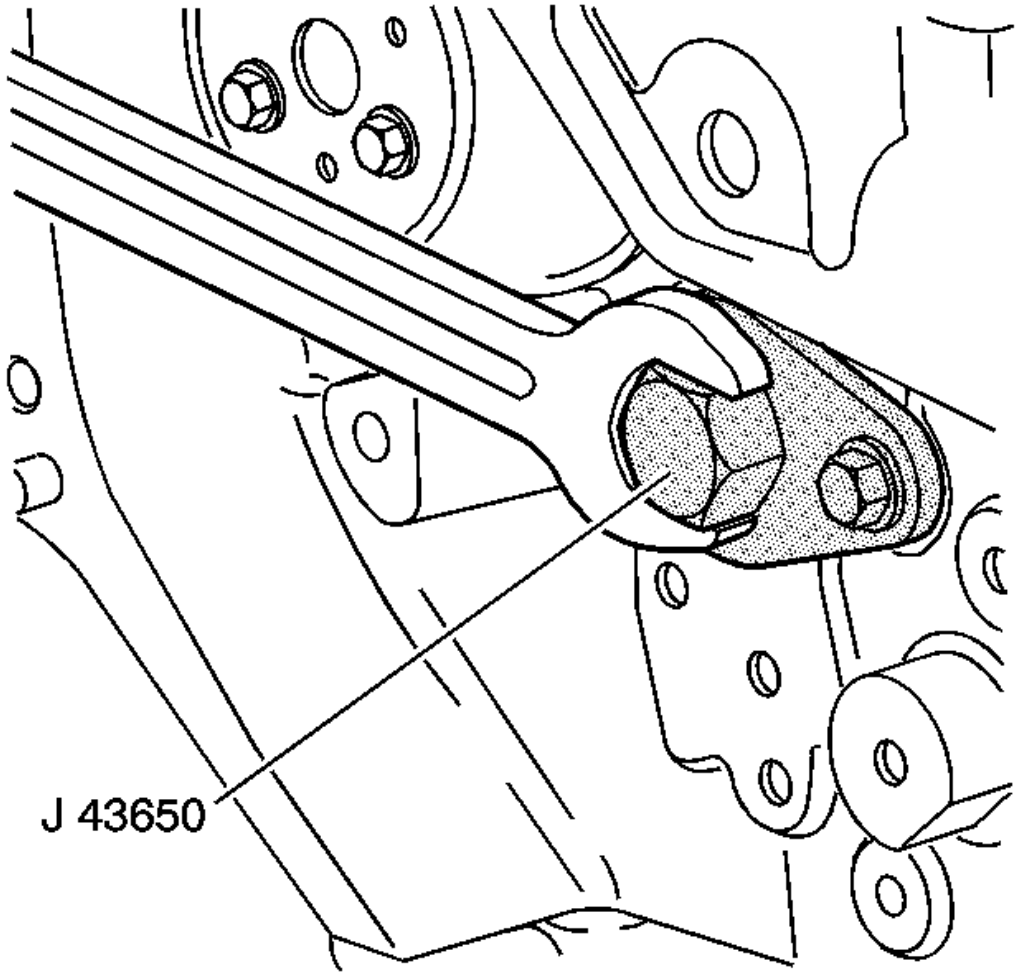

Fig. 522: Seating Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

2. Seat the balance shaft bushing into the bore using the **J 43650** and a wrench.
3. When the **J 43650** is fully seated in the engine block, remove it with a wrench.

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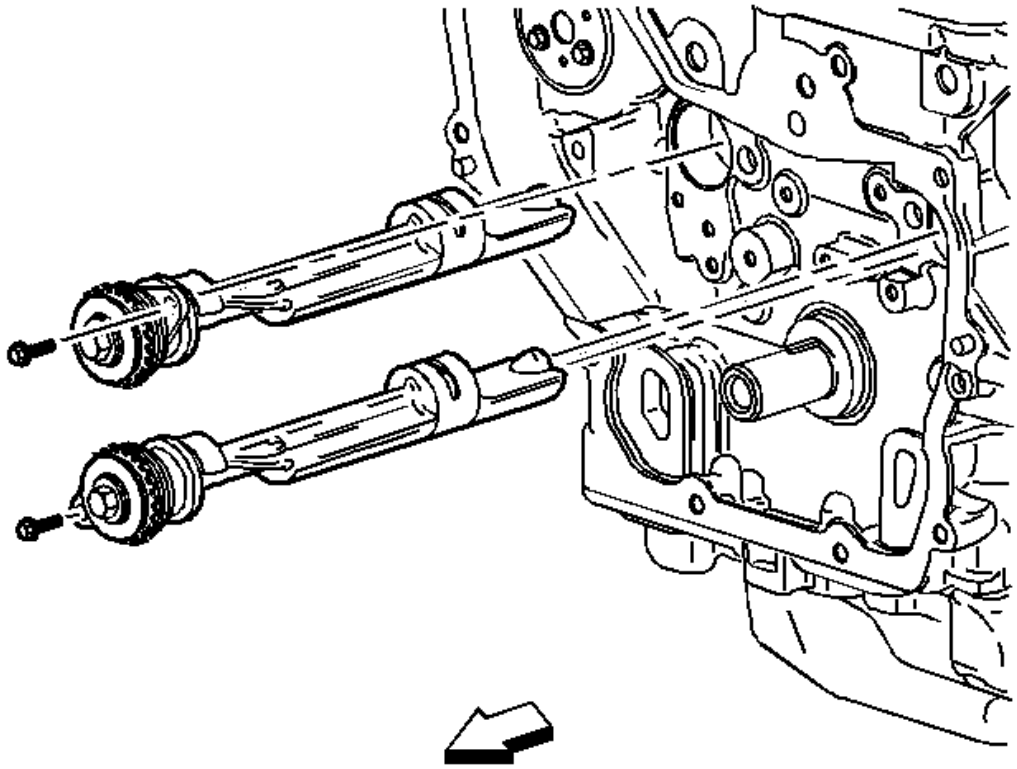

Fig. 523: View Of Balance Shafts assemblies
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.
Install the balance shaft assemblies to the engine using the following steps:

4. Place the number one piston at top dead center (TDC).
5. Lubricate the balance shaft lobes with engine oil.
6. Install the balance shafts into their bores.

NOTE: Refer to FASTENER NOTICE .

7. Install the balance shaft retaining bolts.

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

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Water Pump Installation

Prior to installing the water pump, read the entire procedure. Pay special attention to avoid part damage and to ensure proper sealing.

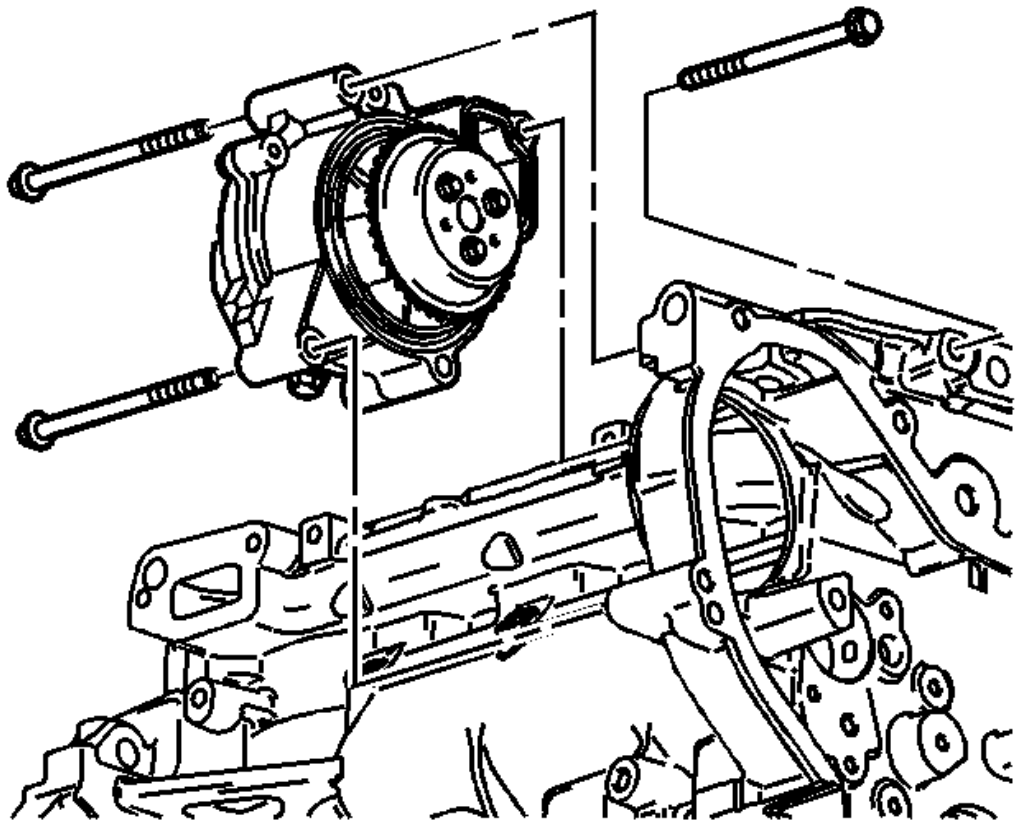

Fig. 524: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump assembly.
2. Install the water pump bolts. Finger tighten the bolts.

NOTE: **Refer to Fastener Notice .**

3. Tighten the water pump bolts.

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

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4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) or equivalent to the water pump drain plug.
5. Install the water pump drain plug, if necessary.

   Tighten: Tighten the water pump drain plug to 20 N.m (15 lb ft).

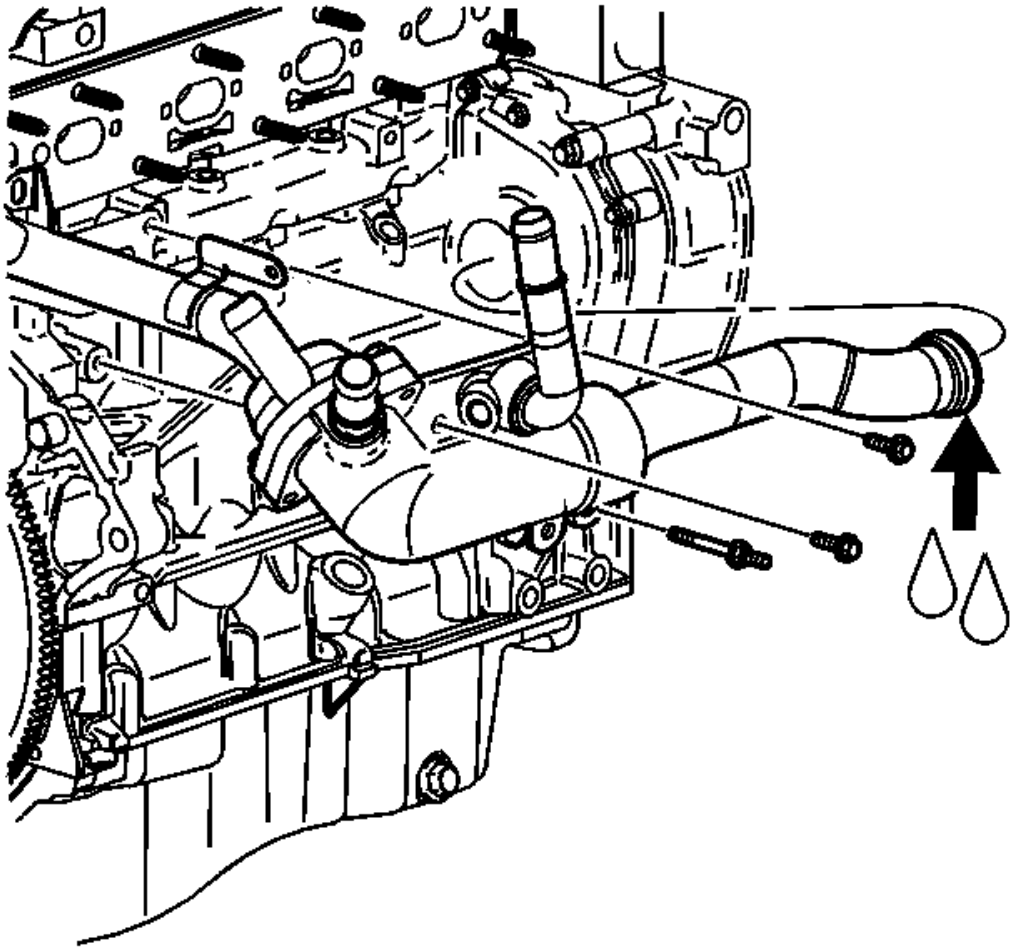

Fig. 525: View Of Water Feed Tube
Courtesy of GENERAL MOTORS CORP.

6. Install the water feed tube.
7. Lubricate the feed tube O-ring with antifreeze.
8. Install the water feed tube by twisting and pushing toward the water pump. Take care not to tear or damage the O-ring.
9. Install the thermostat housing to block bolts and stud.

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

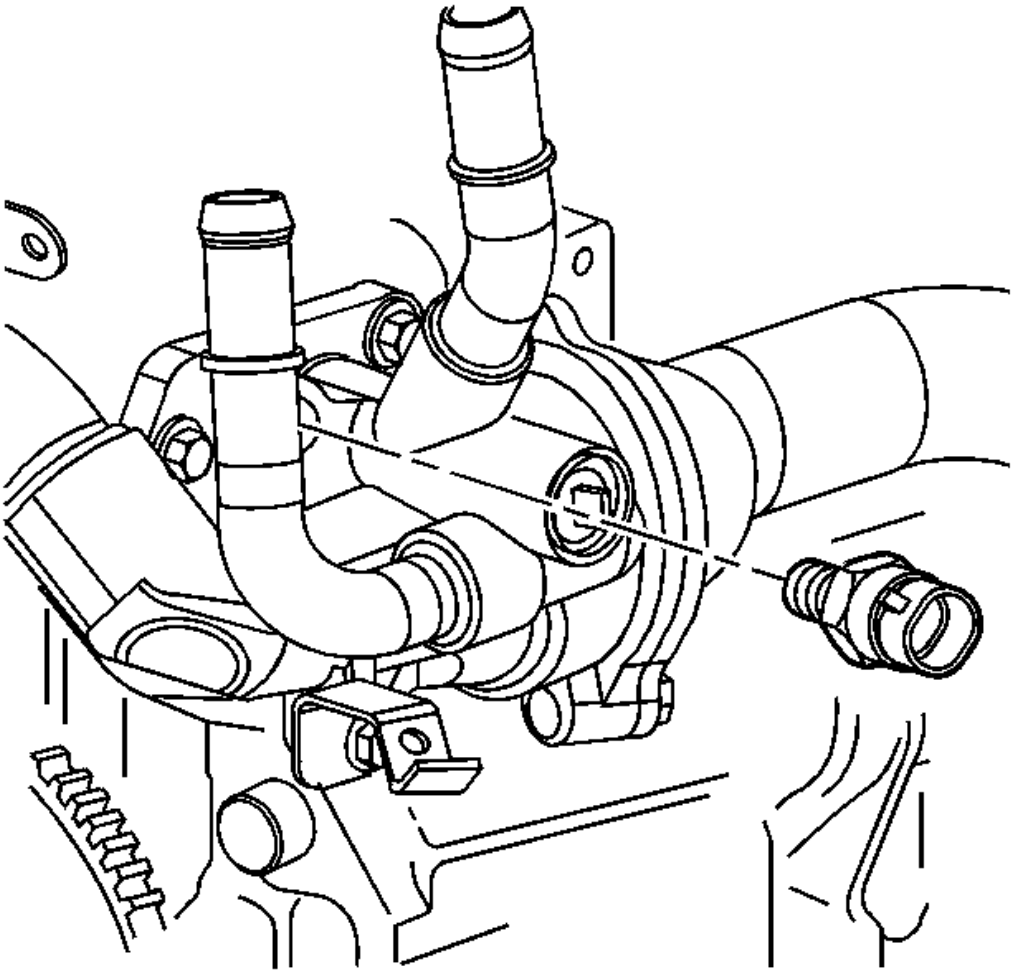

Fig. 526: View Of Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the engine coolant temperature sensor by hand.
11. Tighten the engine coolant temperature sensor.

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

Balance Shaft to Engine Timing

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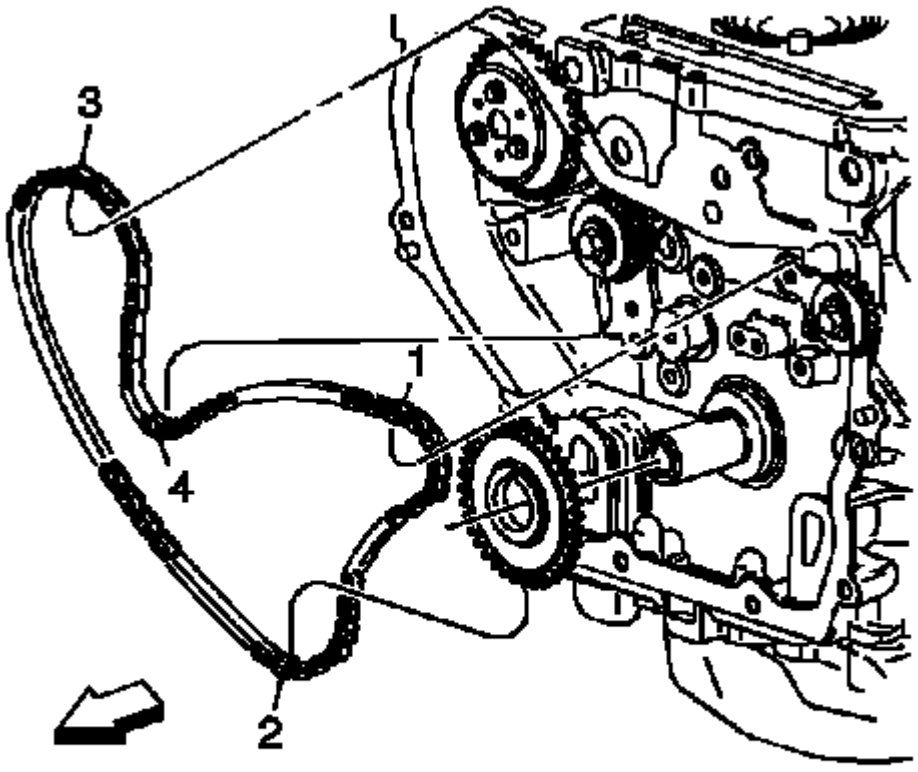

Fig. 527: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft drive sprocket.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate or make noise.

2. Install the balance shaft drive chain with the colored links lined up on with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three colored links on the chain. Two links are of matching colors, and one link is of a unique color. Use the following procedure to line up the links with the sprockets:

   Orient the chain so that the colored links are visible.

3. Place the uniquely colored link (1) so that it lines up with the timing mark on the intake side balance shaft sprocket.
4. Working clockwise around the chain, place the first matching colored link (2) in line with the timing mark on the crankshaft drive sprocket. (approximately 6 o'clock position on the crank sprocket)
5. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
6. Align the last matching colored link (4) with the timing mark on the exhaust side balance shaft drive

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sprocket.

Balance Shaft Drive Chain and Tensioner Install

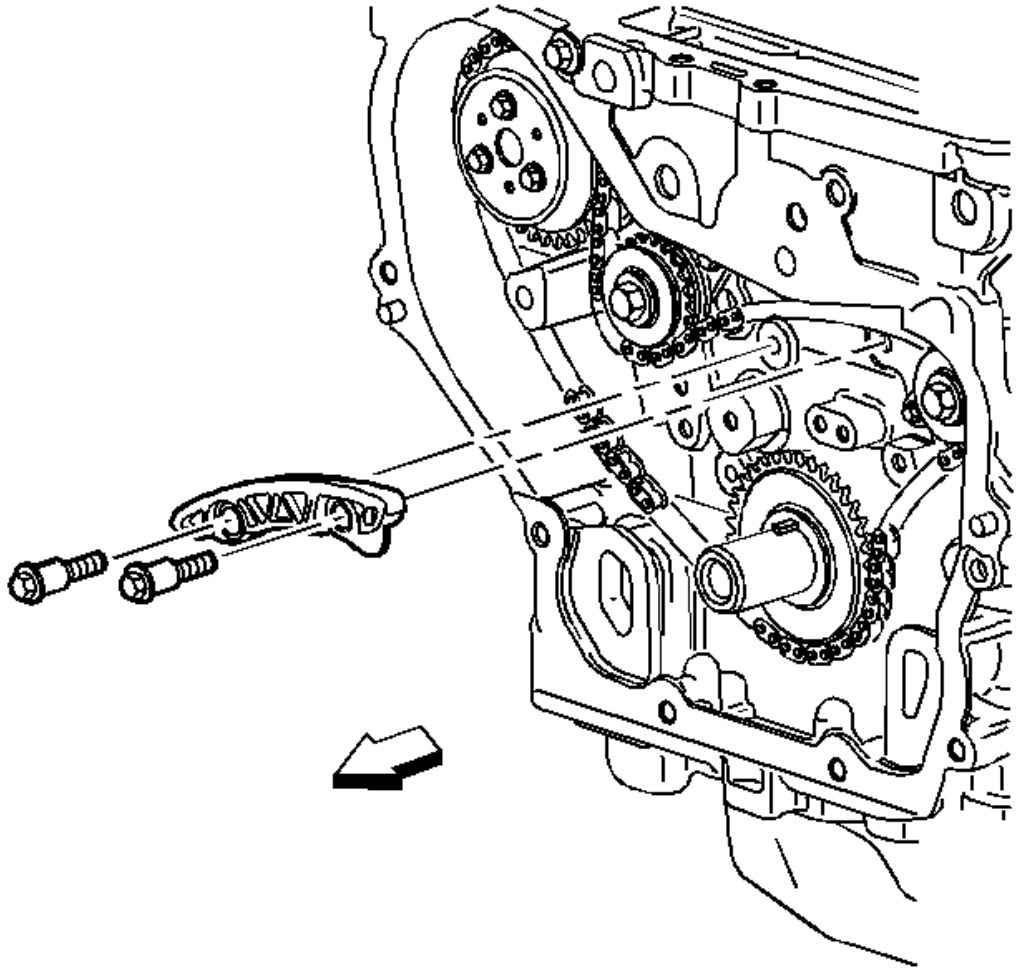

Fig. 528: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to FASTENER NOTICE in Cautions and Notices.

IMPORTANT: If the balance shafts are not properly timed to the engine, the engine may vibrate and make noise.

1. Install the upper balance shaft chain guide and bolts.

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Tighten: Tighten the upper balance shaft chain guide bolts to 15 N.m (11 lb ft).

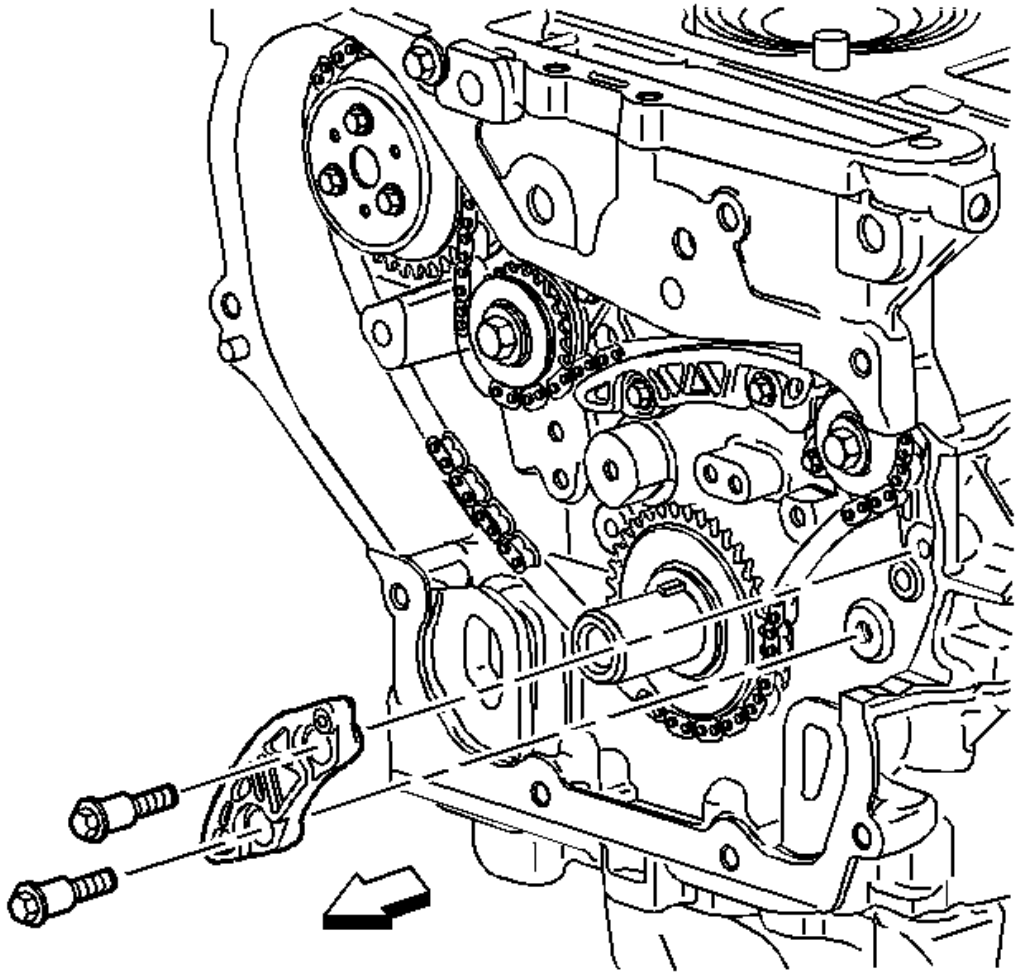

Fig. 529: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts.

Tighten: Tighten the chain guide bolts to 15 N.m (11 lb ft).

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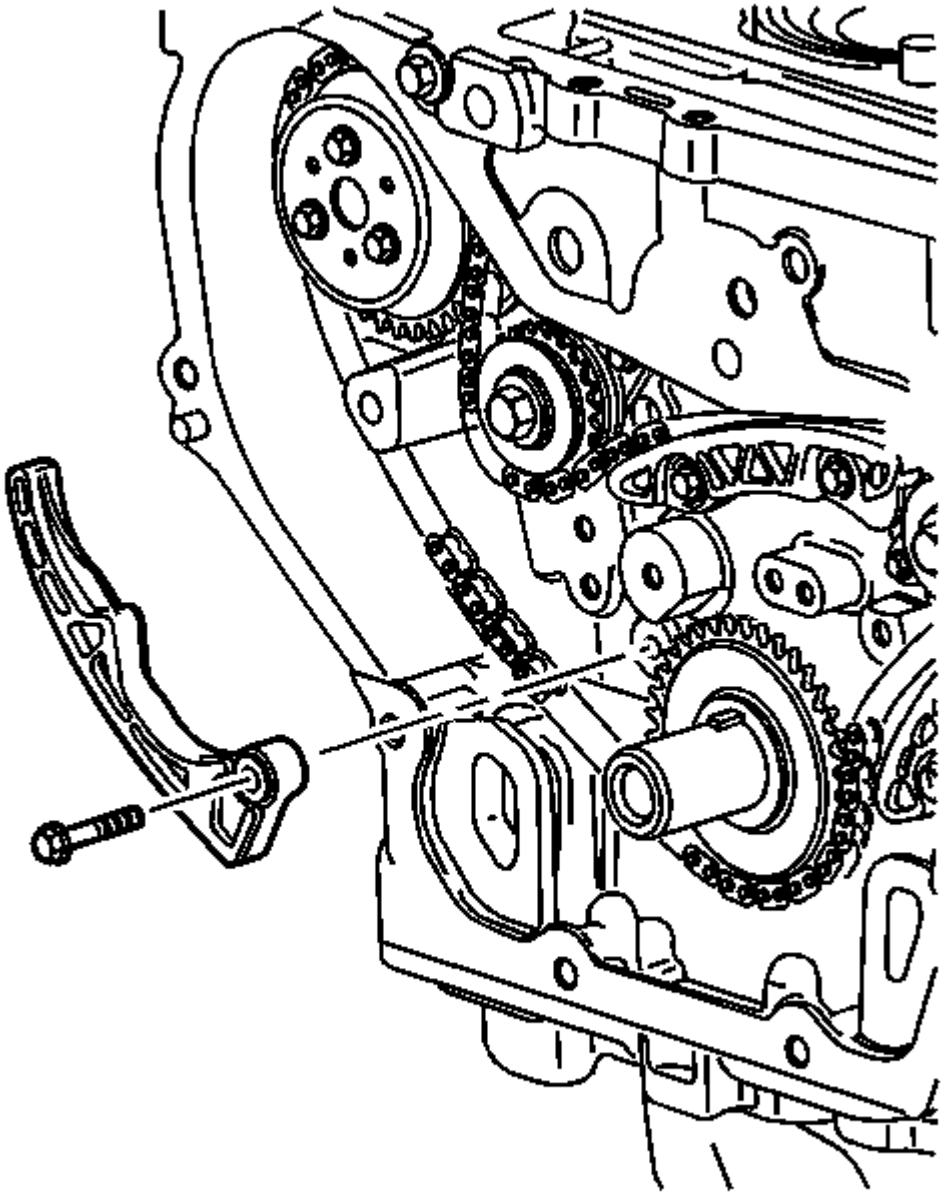

Fig. 530: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the adjustable balance shaft drive chain guide.
5. Install the adjustable balance shaft drive chain guide bolts.

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

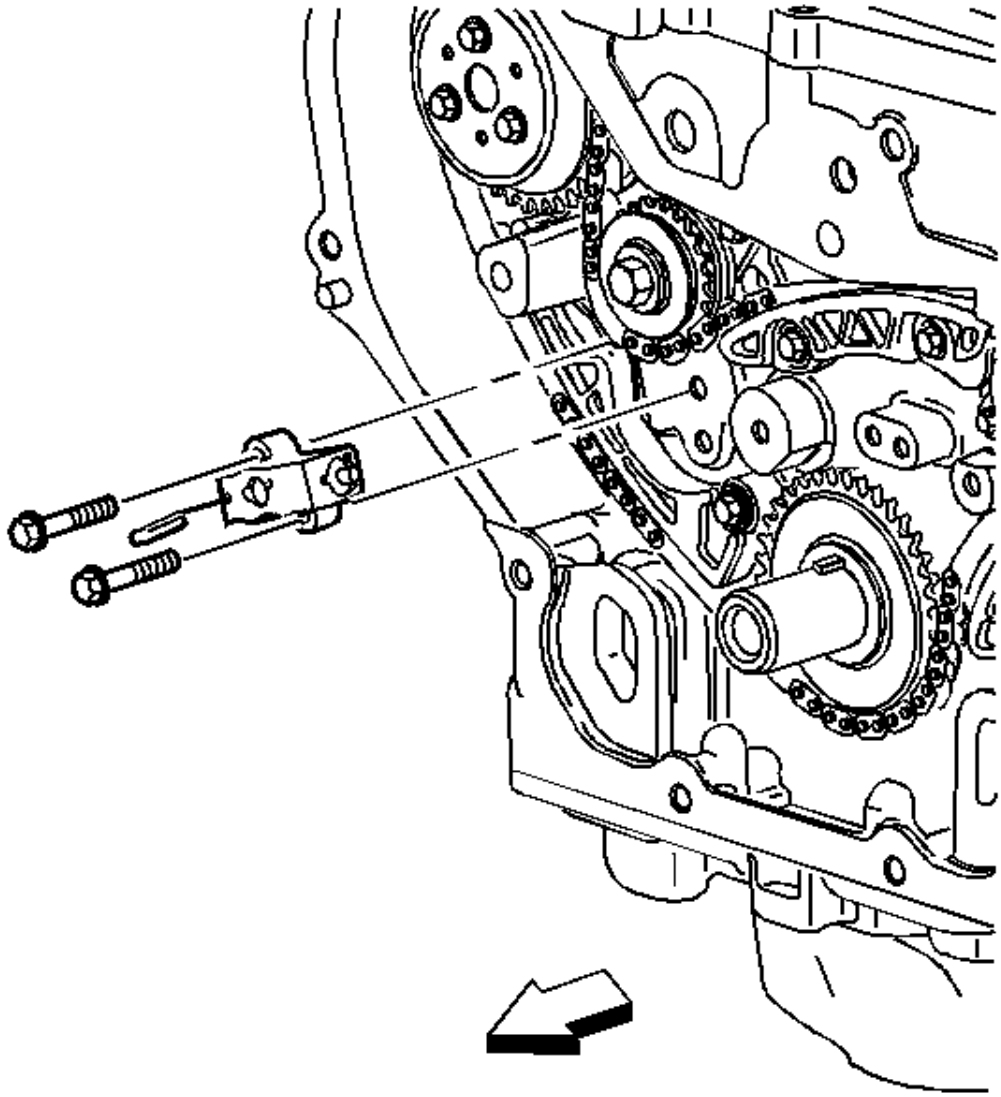

Fig. 531: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

6. Reset the timing chain tensioner by performing the following steps:
    1. Turn the tensioner plunger 90 degrees in its bore and compress the plunger.
    2. Turn the tensioner back to the original 12 o'clock position and insert a paper clip through the hole in the plunger body and into the hole in the tensioner plunger.

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7. Install the timing chain tensioner.
8. Install the chain tensioner bolts.

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

9. Remove the paper clip from the balance shaft drive chain tensioner.

Timing Chain, Sprockets, Tensioner Installation

Tools Required

J 45059 Angle Meter

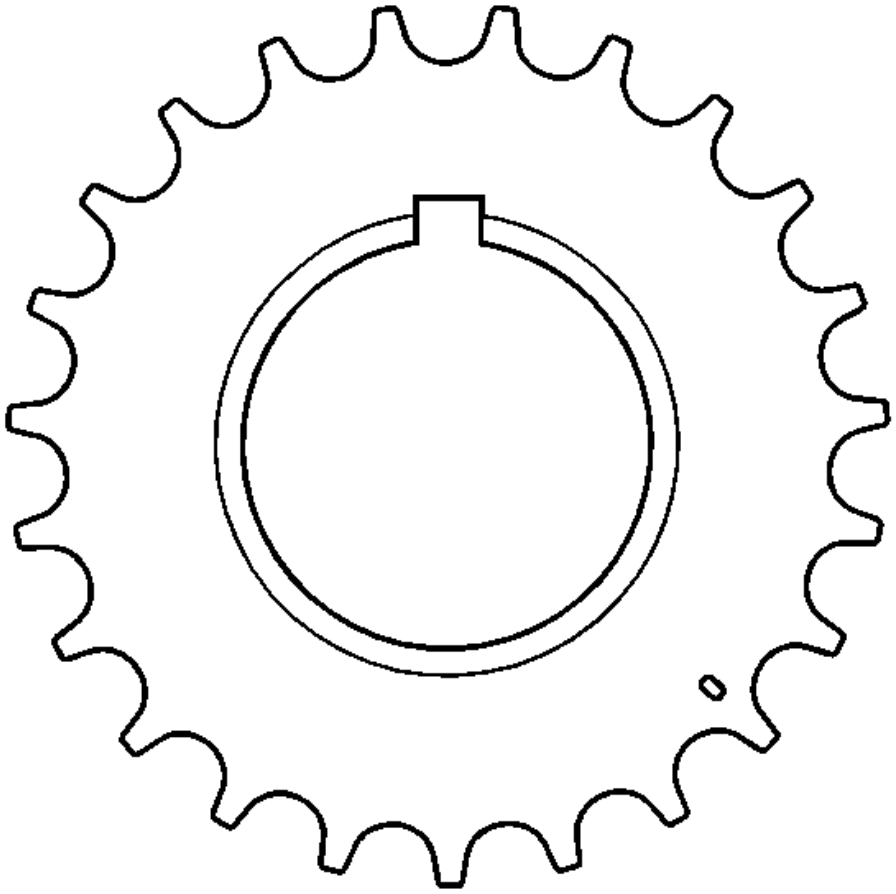

Fig. 532: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

1. Install the timing chain drive sprocket to the crankshaft with the timing mark in the 5 o'clock position.

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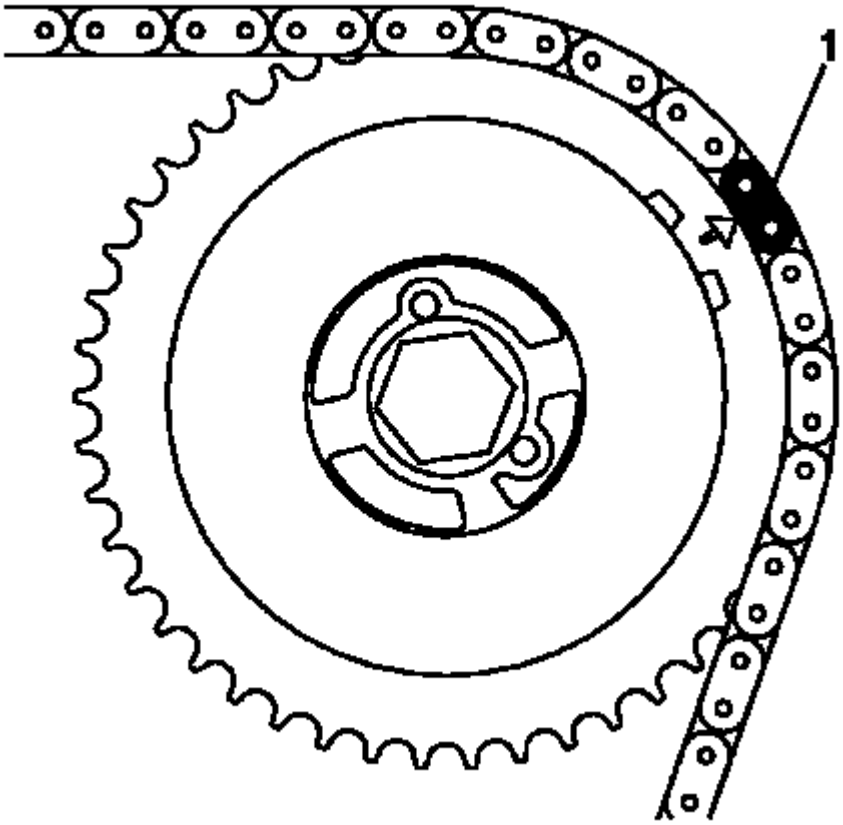

Fig. 533: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

IMPORTANT:

- **There are 3 colored links on the timing chain. Two links are of matching color, and one link is of a unique color. Use the following procedure to line up the links with the actuators. Orient the chain so that the colored links are visible.**
- **Always use new actuator bolts.**

2. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1). Hand tighten a new intake camshaft actuator bolt.

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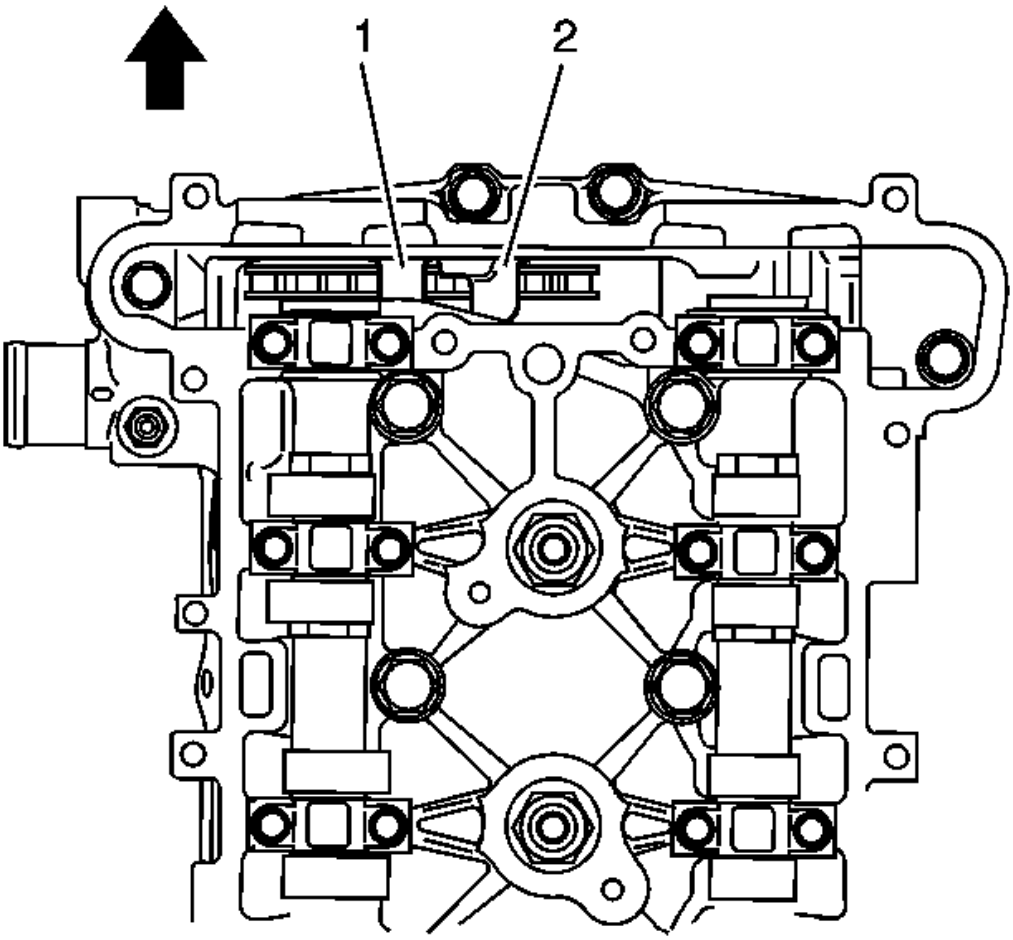

Fig. 534: Locating Cylinder Block Bosses
Courtesy of GENERAL MOTORS CORP.

3. Lower the timing chain through the opening in the cylinder head. Use care to ensure that the chain goes around both sides of the cylinder block bosses (1, 2).

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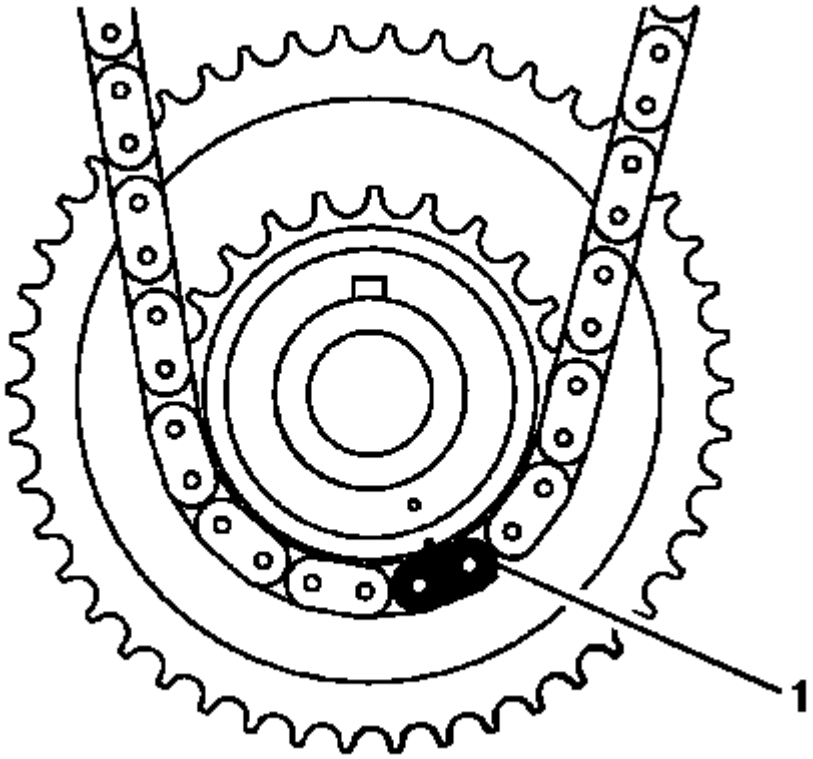

Fig. 535: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

4. Route the timing chain around the crankshaft sprocket and line up the first matching colored link (2) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

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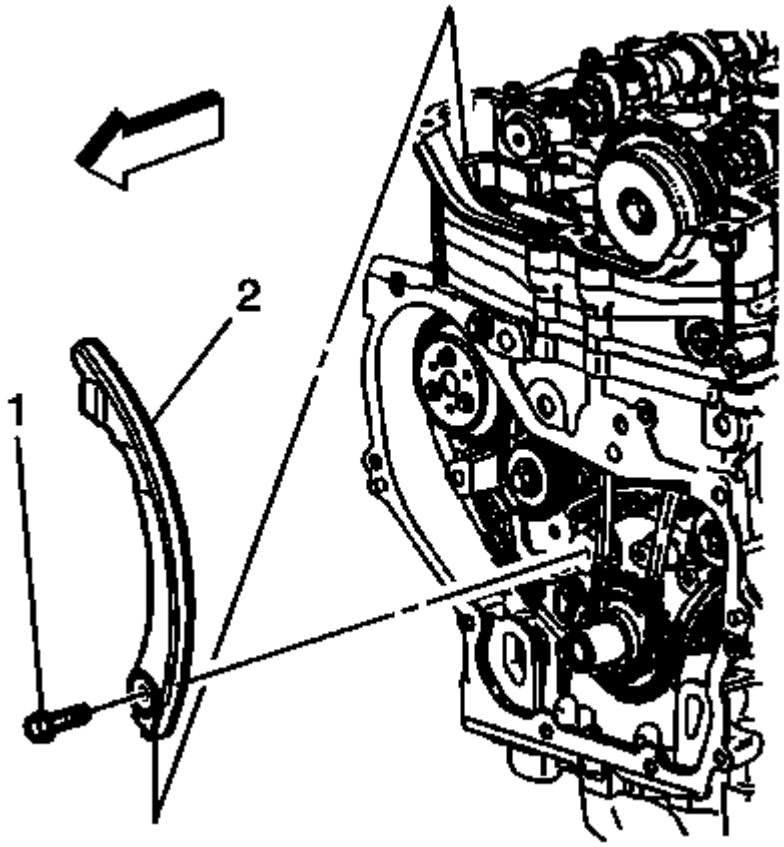

Fig. 536: Identifying Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

5. Install the adjustable timing chain guide through the opening in the cylinder head and install the adjustable timing chain bolt.

   Tighten: Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

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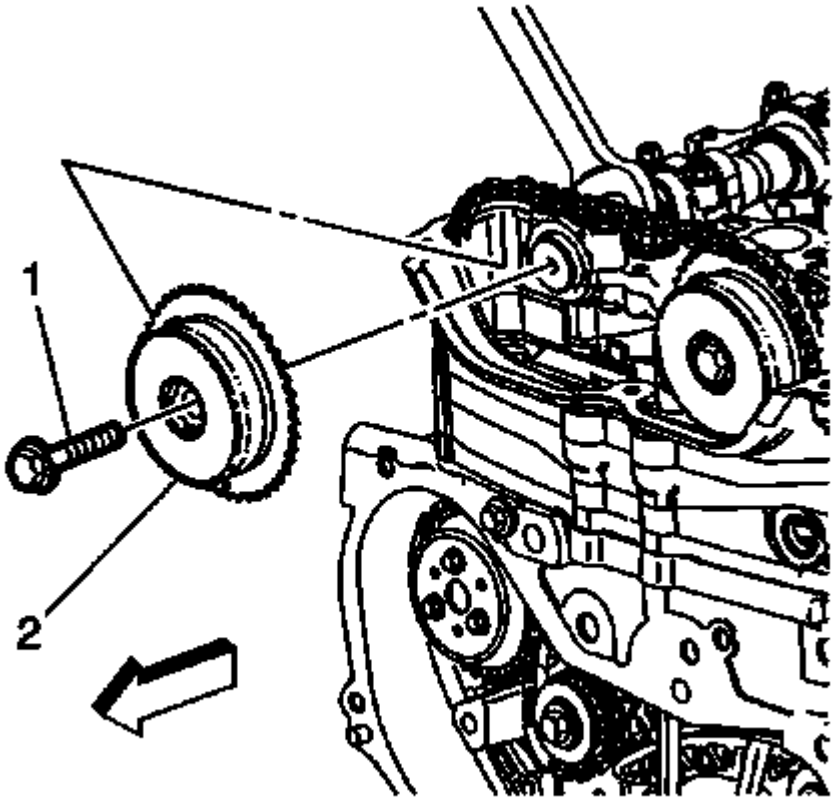

Fig. 537: Locating Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Always install NEW actuator bolts.

6. Install the exhaust camshaft actuator and a NEW bolt loosely onto the exhaust camshaft.

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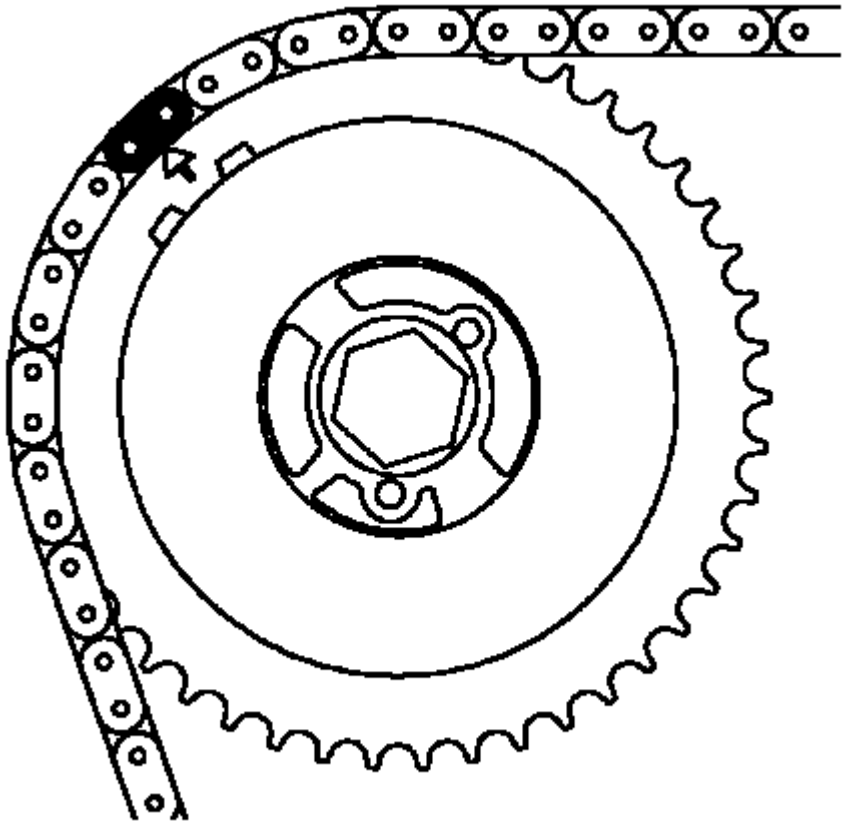

Fig. 538: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

7. Align the timing mark on the actuator with the last matching colored link (3). Install the bolt finger tight.

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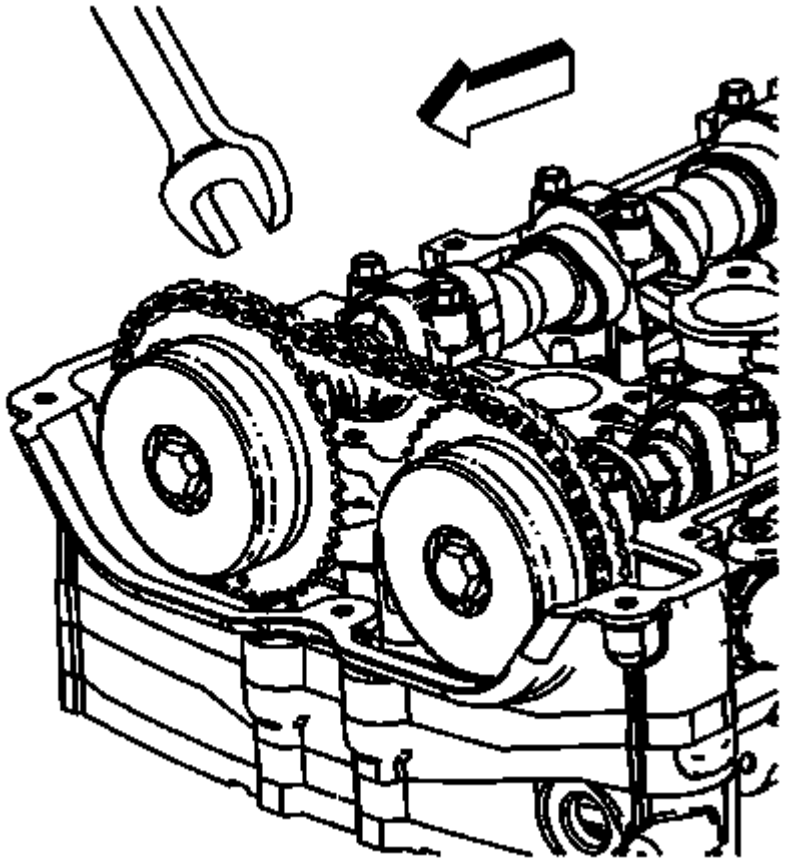

Fig. 539: Identifying Cam Actuator, Camshaft & Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not rotate either camshaft more than half turn in either direction with crankshaft at top dead center (TDC). To do so may cause valve to piston contact resulting in a damaged valve and/or a damaged piston.

8. If the camshaft is 180 degrees out of time, use the following procedure to re-align the cam.

   Using a 24 mm wrench, first turn the intake camshaft until the alignment feature on the back of the camshaft actuator seats in the notch in the front of the intake camshaft.

   1. Turn the crankshaft 45 degrees in either direction.
   2. Turn the intake cam to the appropriate location.
   3. Turn the crankshaft back to top dead center.
9. When the actuator seats on the cam, tighten the sprocket bolt hand tight.
10. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not, repeat the portion of the procedure necessary to align the timing marks.

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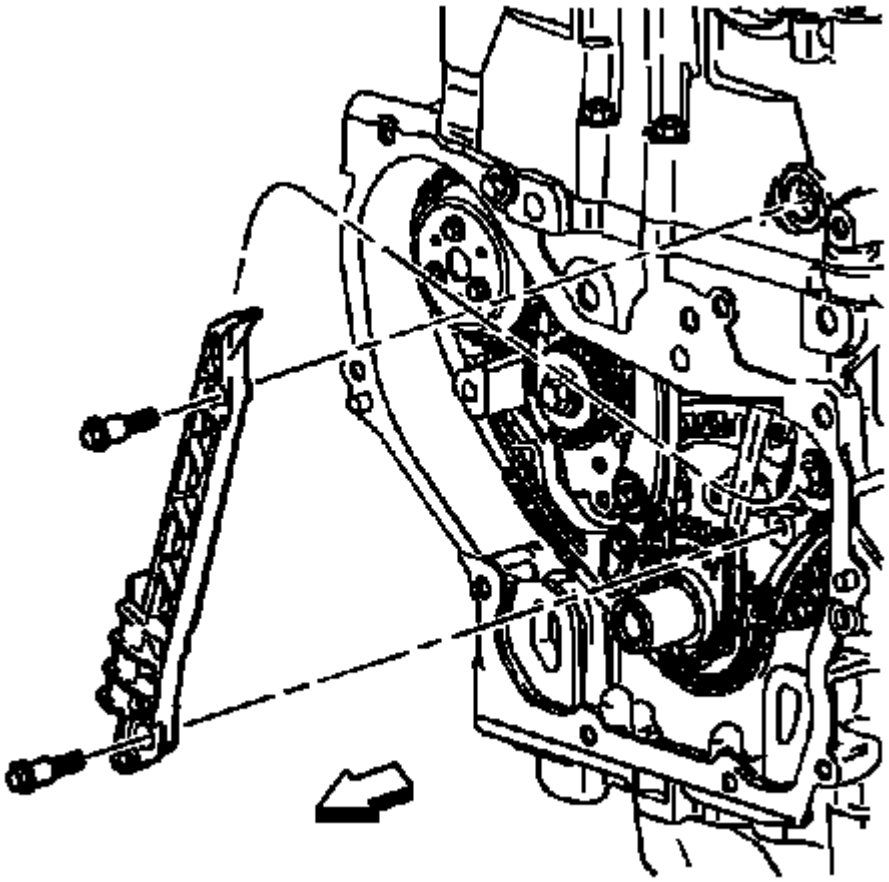

Fig. 540: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the fixed timing chain guide and bolts.

    Tighten: Tighten the fixed timing chain guide bolts to 15 N.m (11 lb ft).

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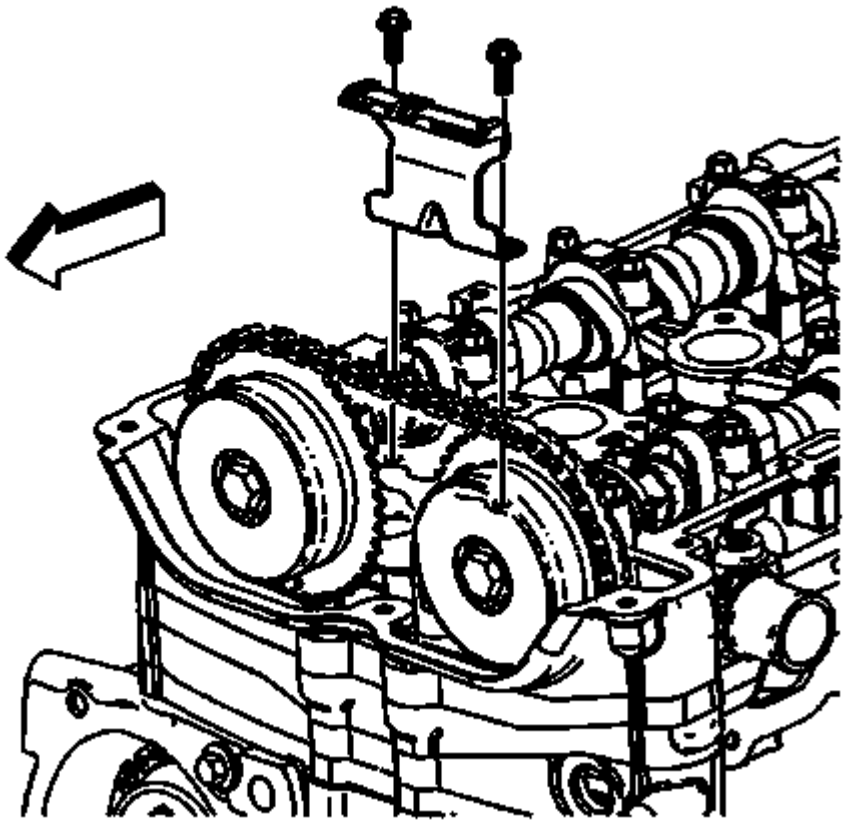

Fig. 541: Locating Upper Timing Chain Guide Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide and bolts.

    Tighten: Tighten the upper timing chain guide bolts to 10 N.m (89 lb in).

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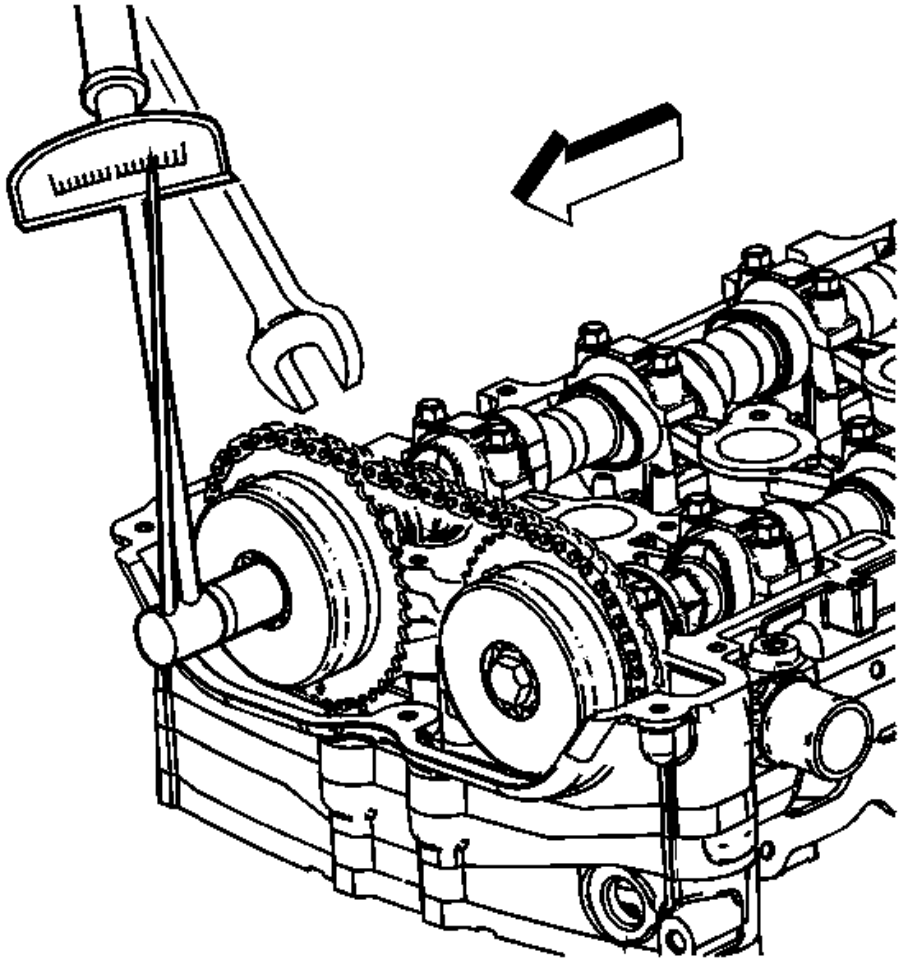

Fig. 542: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

13. Using a 24 mm wrench, engage the hex on the intake camshaft and using a torque wrench, tighten the camshaft actuator bolt.

    Tighten: Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** .

14. Using a 24 mm wrench, engage the hex on the exhaust camshaft and using a torque wrench, tighten the camshaft actuator bolt.

    Tighten: Tighten the exhaust camshaft position actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059** .

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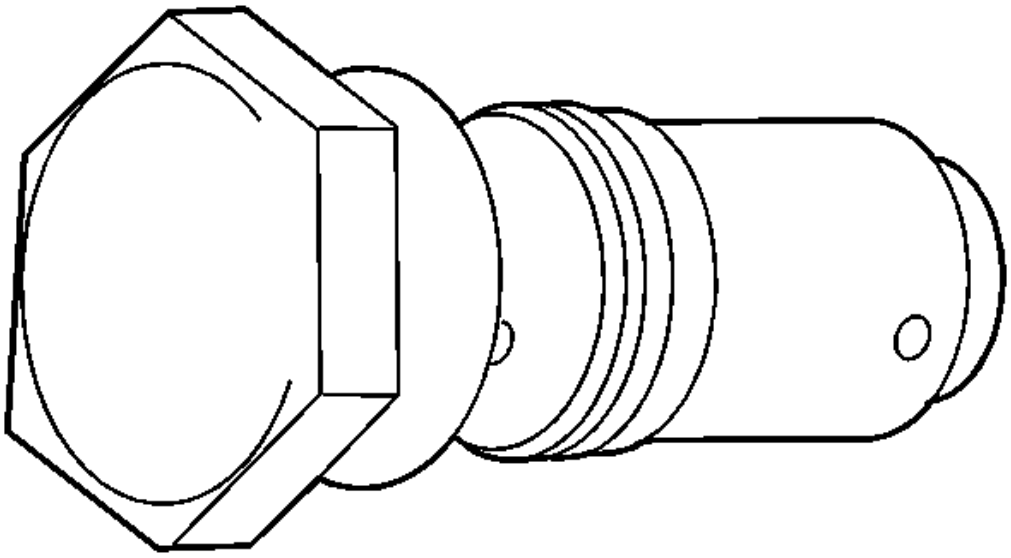

Fig. 543: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

15. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.

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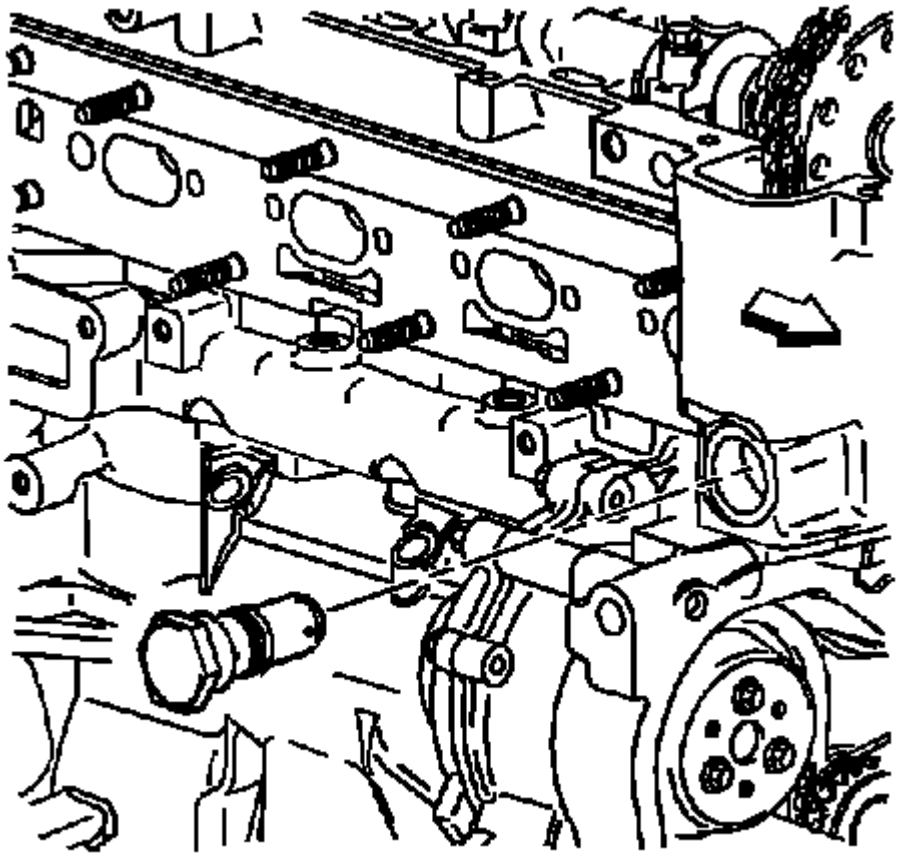

Fig. 544: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

16. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

IMPORTANT: Make sure the timing chain tensioner seal is centered throughout the torque procedure to eliminate the possibility of an oil leak.

17. Install the new timing chain tensioner assembly.

    Tighten: Tighten the timing chain tensioner to 75 N.m (55 lb ft).

18. The timing chain tensioner is released by compressing it 2 mm (0.079 in) which will release the locking mechanism in the ratchet. To release the timing chain tensioner, use a suitable tool with a rubber tip on the end. Feed the tool down through the cam drive chest to rest on the cam chain. Then give a sharp jolt diagonally downwards to release the tensioner.

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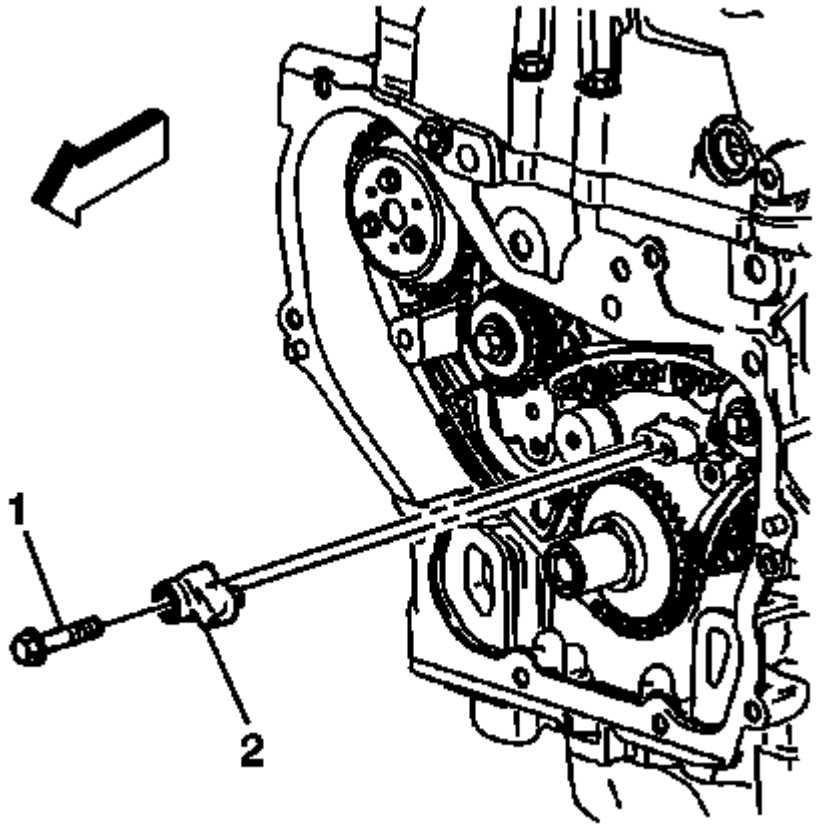

Fig. 545: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

19. Install the timing chain oiling nozzle.

    Tighten: Tighten the timing chain oiling nozzle bolt to 10 N.m (89 lb in).

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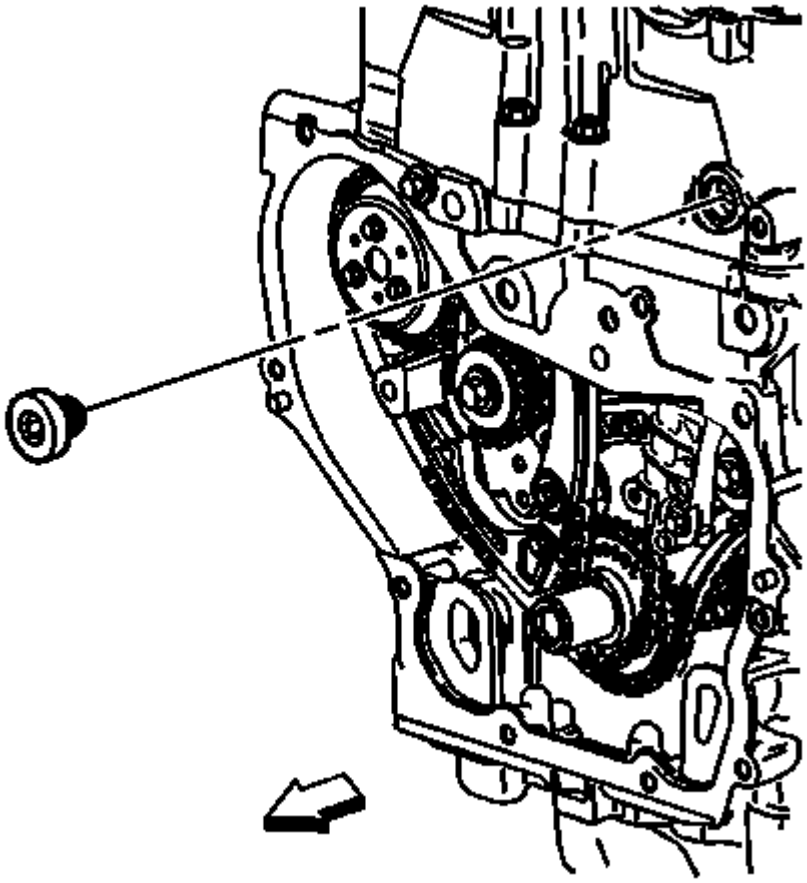

Fig. 546: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

20. Apply sealant GM P/N 12345382 (Canadian P/N 10953489) compound to the thread, and install the timing chain guide bolt access hole plug.

    Tighten: Tighten the access hole plug to 90 N.m (66 lb ft).

Crankshaft Front Oil Seal Installation

Tools Required

J 35268-A Camshaft/Front Main Seal Installer

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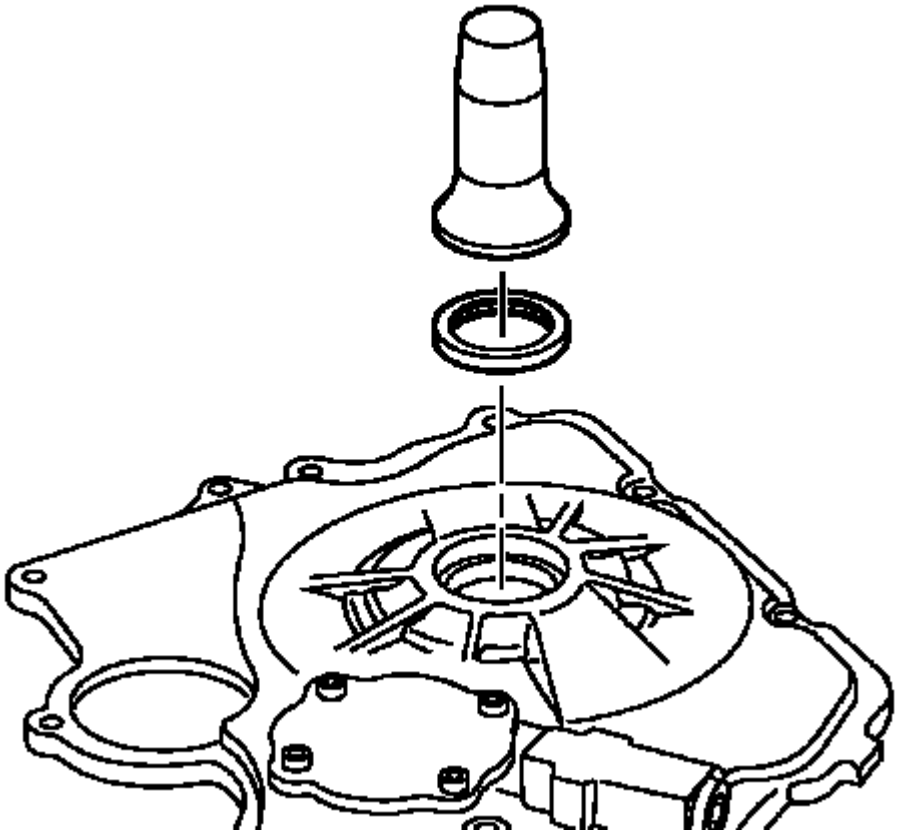

Fig. 547: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Install the seal into the front cover using the **J 35268-A** .
2. Ensure that the engine front cover is properly supported when installing the seal.

Engine Front Cover and Oil Pump Installation

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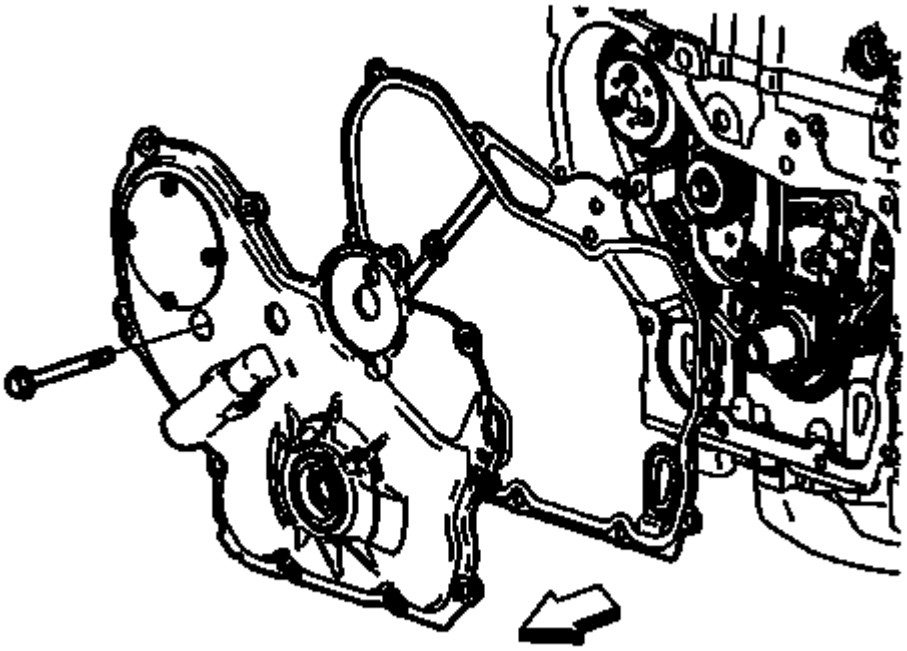

Fig. 548: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover with a new gasket.

NOTE: Refer to FASTENER NOTICE in Cautions and Notices.

2. Install the long water pump bolt.

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

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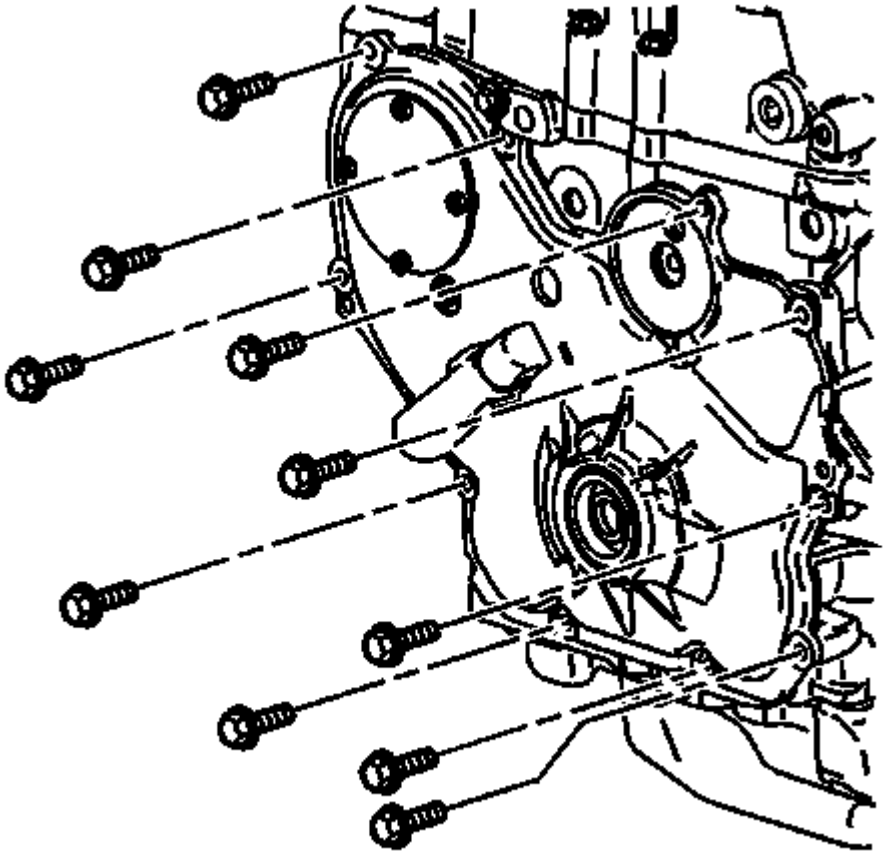

Fig. 549: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Install the engine front cover bolts.

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

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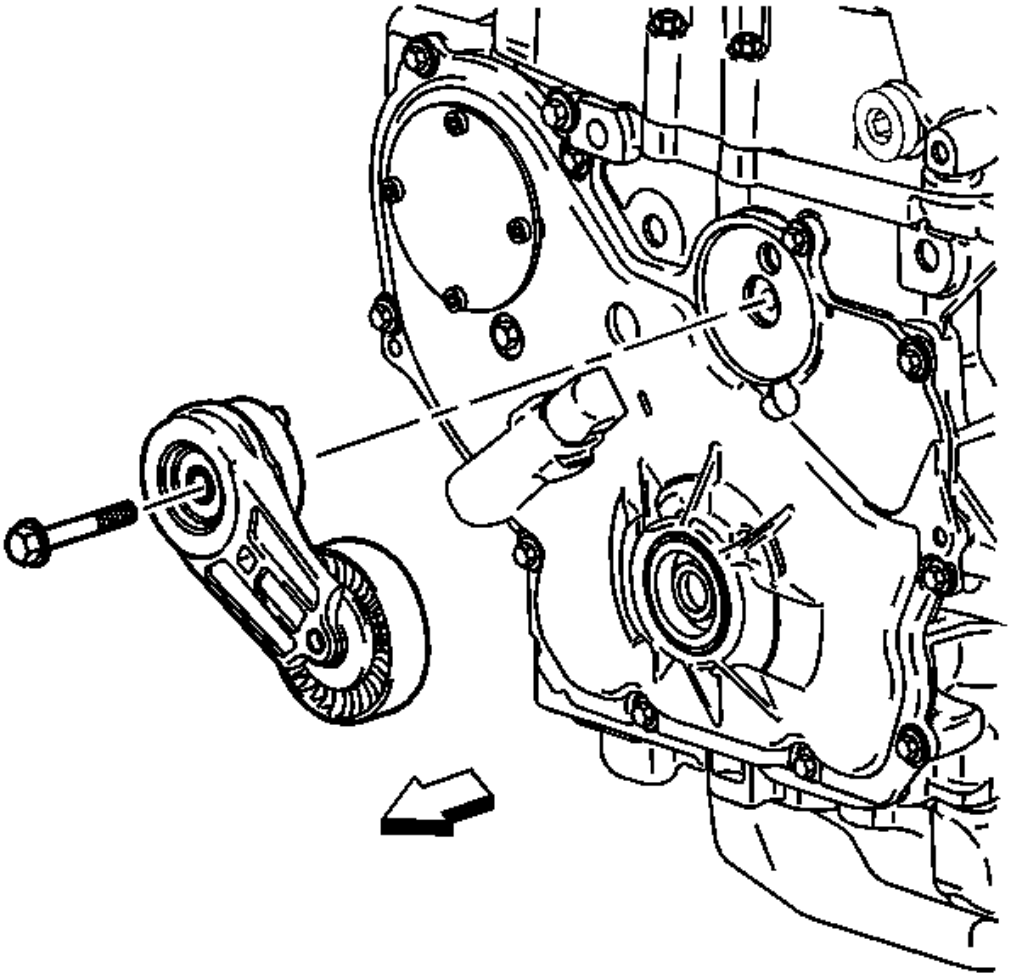

Fig. 550: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install the accessory drive belt tensioner.
5. Install the accessory drive belt tensioner bolt.

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

Camshaft Cover Installation

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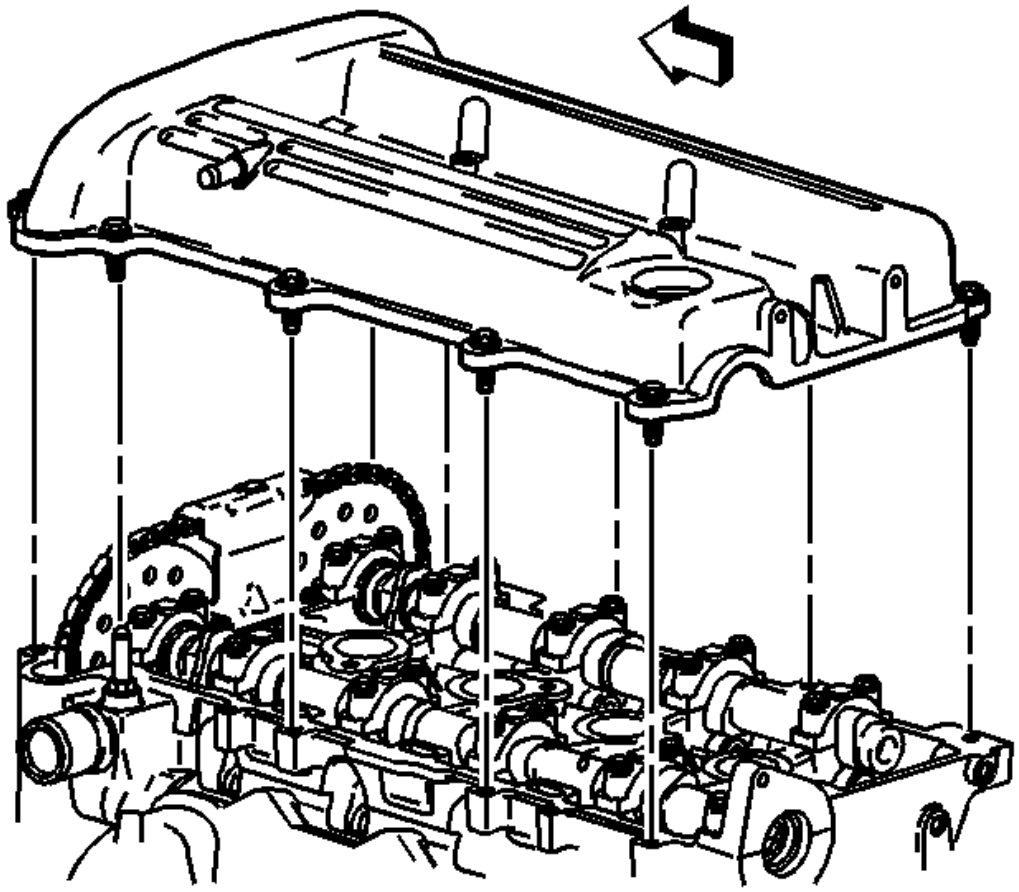

Fig. 551: View Of Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

1. Assemble the camshaft cover and gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

   NOTE: Refer to Fastener Notice .

2. Install the cover on the cylinder head and hand start the bolts.

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

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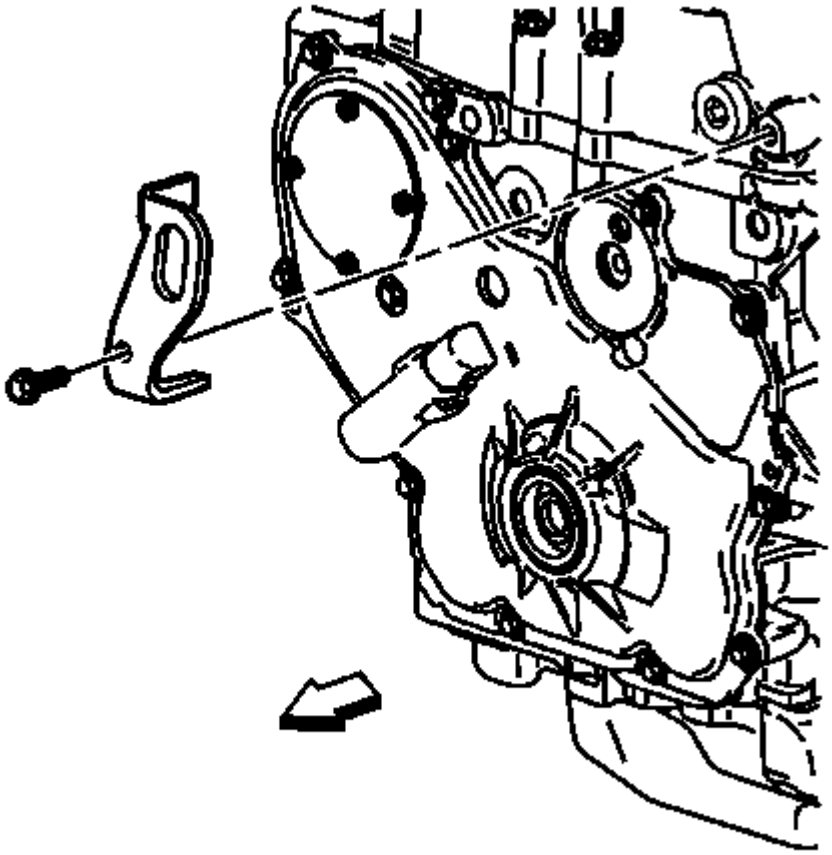

Fig. 552: View Of Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Install the front lift bracket.
4. Install the front lift bracket bolt.

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

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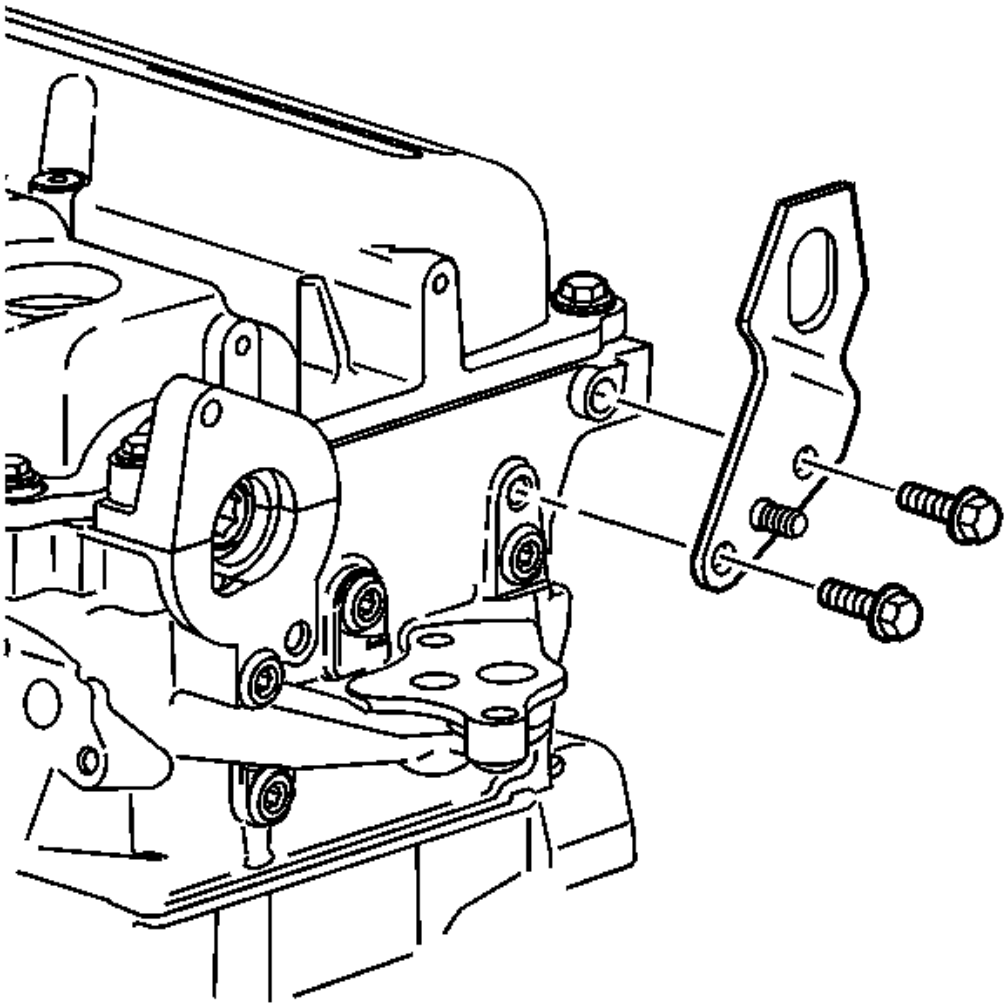

Fig. 553: View Of Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

5. Install the rear lift bracket.
6. Install the rear lift bracket bolts.

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

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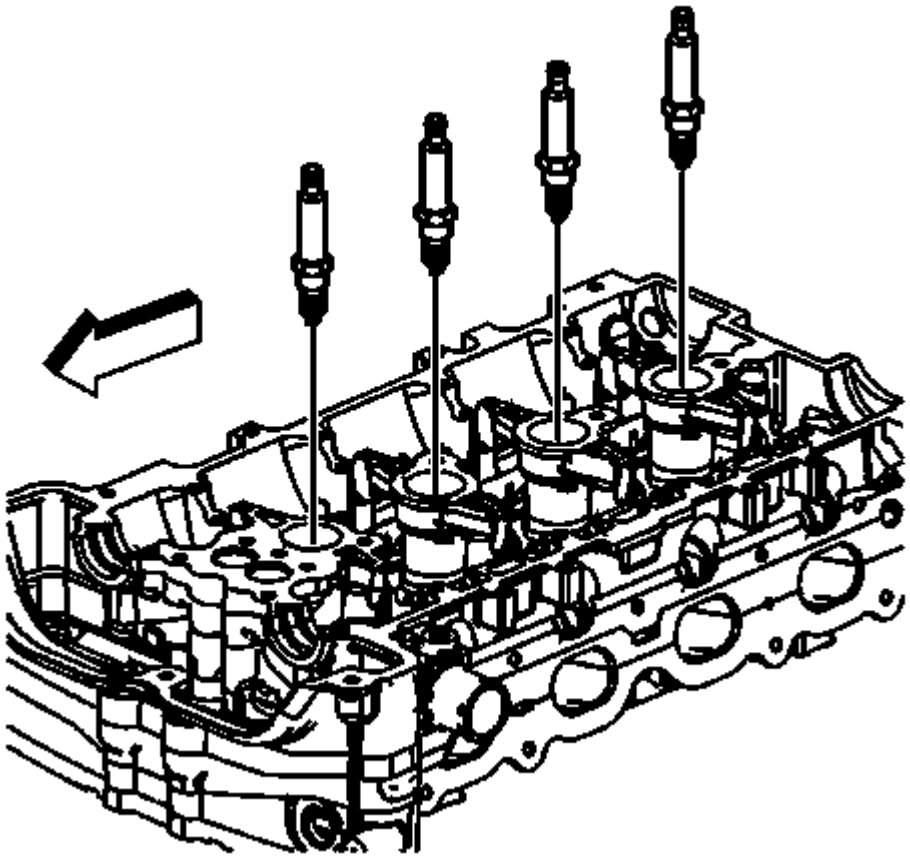

Fig. 554: Identifying Spark Plugs
Courtesy of GENERAL MOTORS CORP.

7. Install the spark plugs.

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

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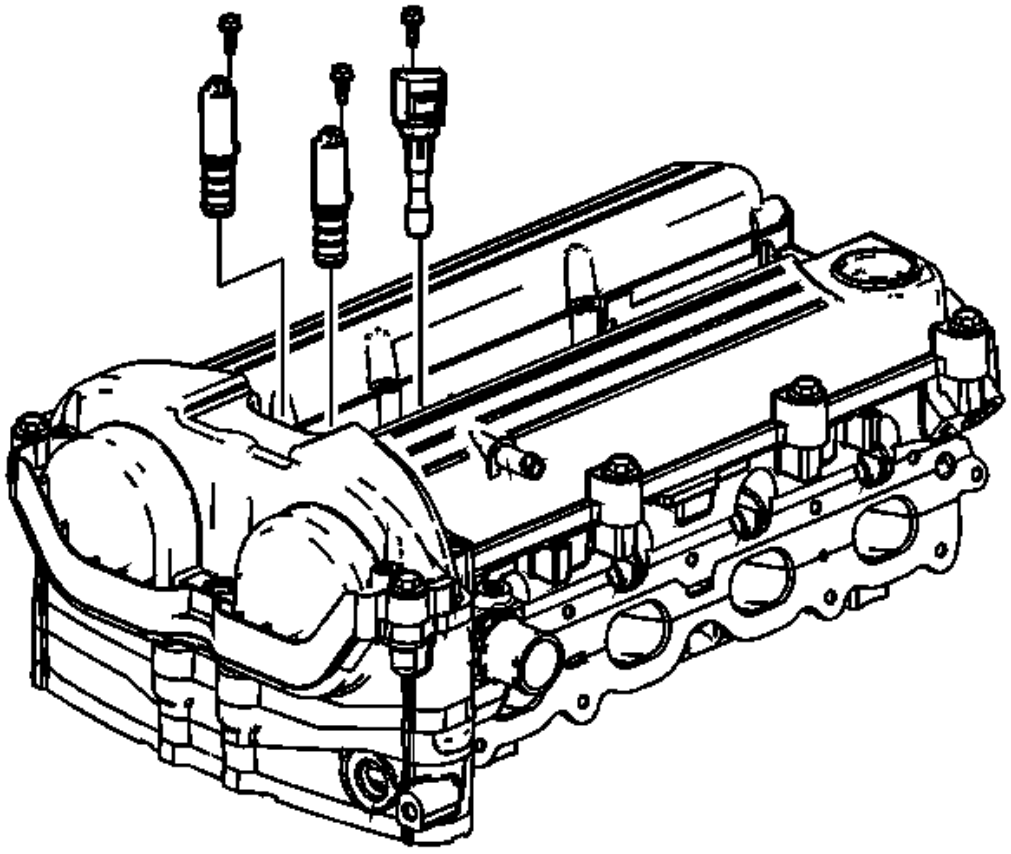

Fig. 555: Identifying Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

8. Install the ignition coil.

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

9. Install the camshaft position actuator solenoid valves.
10. Install the camshaft position actuator solenoid valve bolts.

Oil Pan Installation

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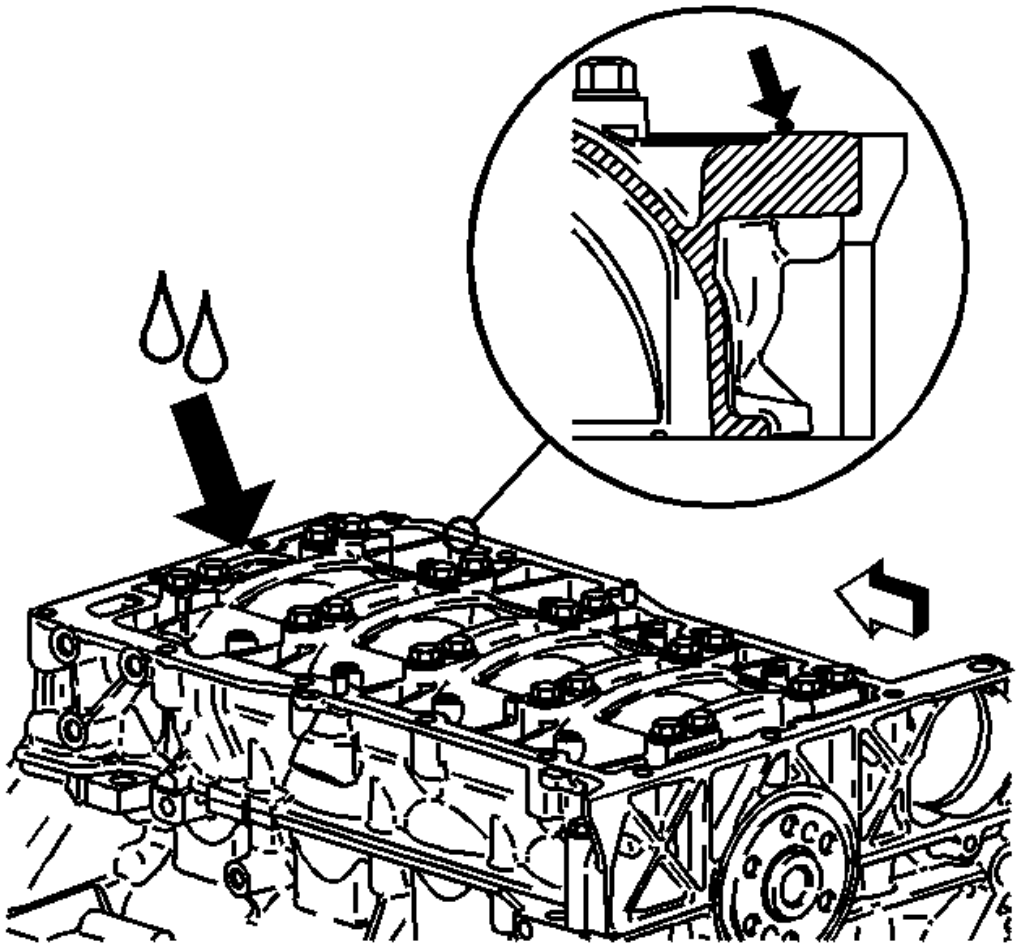

Fig. 556: Applying RTV Around Perimeter Of Oil Pan & Oil Suction Port Opening
Courtesy of GENERAL MOTORS CORP.

1. Make sure that the oil pan and mounting surface on the lower crankcase are free of all oil and debris.
2. Apply a 3.5 mm bead of GM P/N 12378521 (Canadian P/N 88901148) or equivalent around the perimeter of the oil pan and the oil suction port opening.

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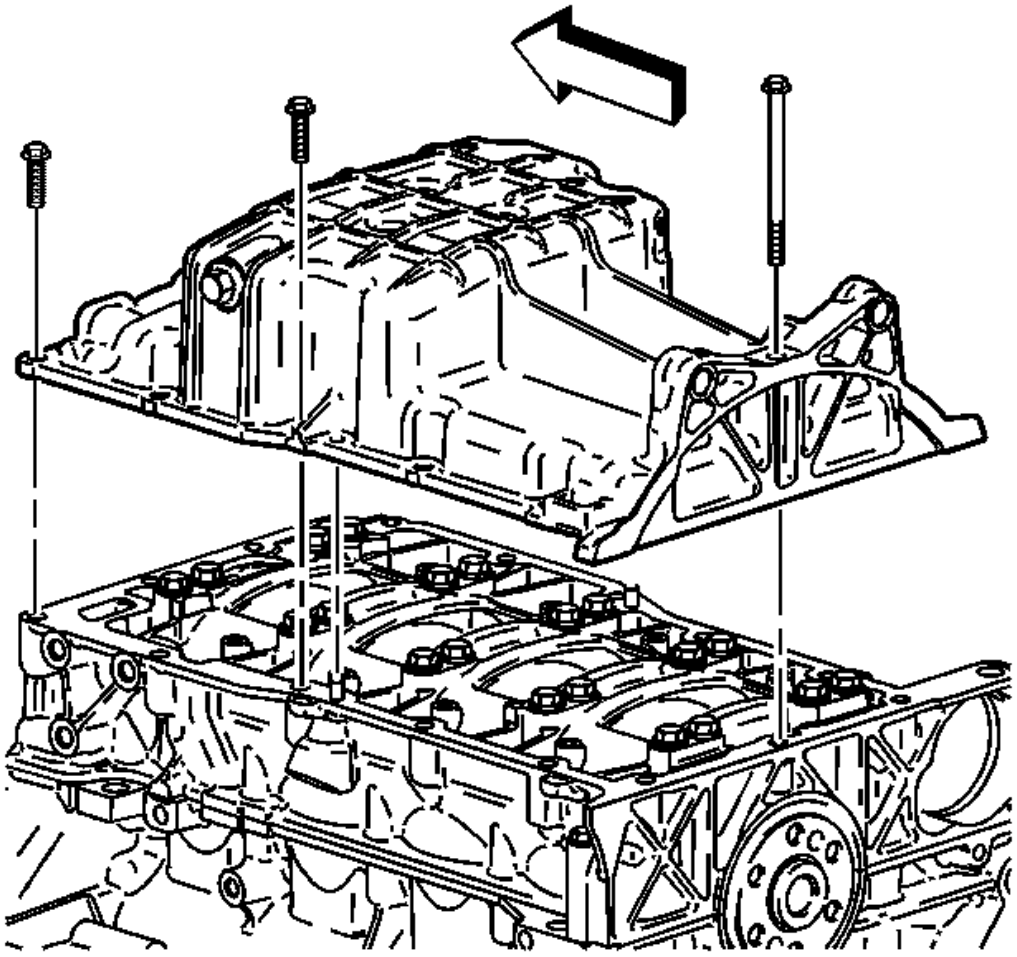

Fig. 557: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

3. Install the oil pan.

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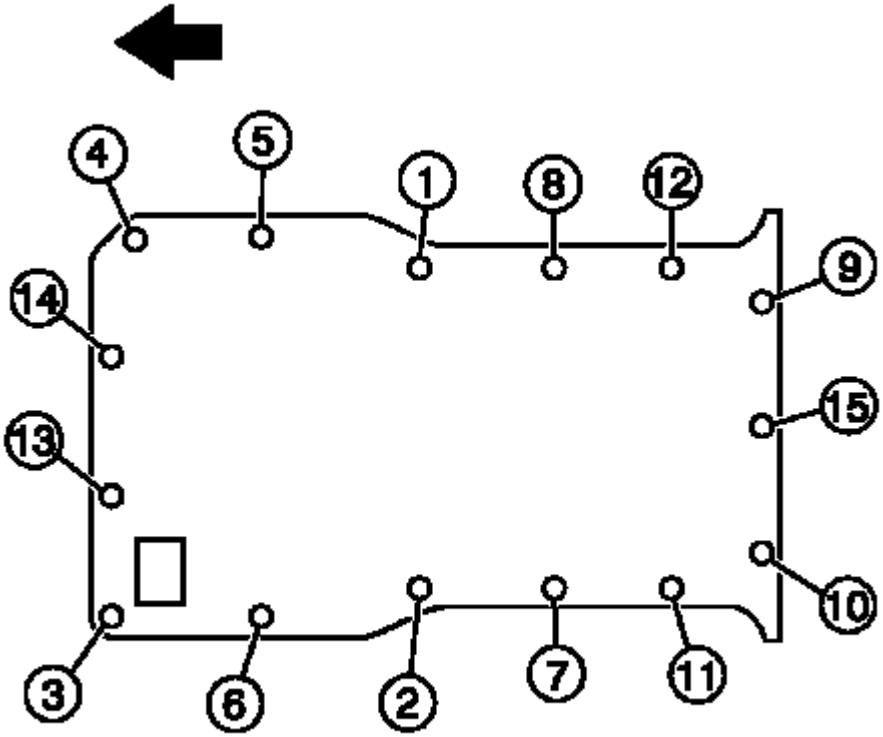

Fig. 558: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to FASTENER NOTICE .

4. Install the oil pan bolts.

   Tighten: Tighten the oil pan bolts to 25 N.m (18 lb ft) in sequence.

Crankshaft Balancer Installation

Tools Required

- **J 38122-A** Crankshaft Balancer Holder
- **J 45059** Angle Meter

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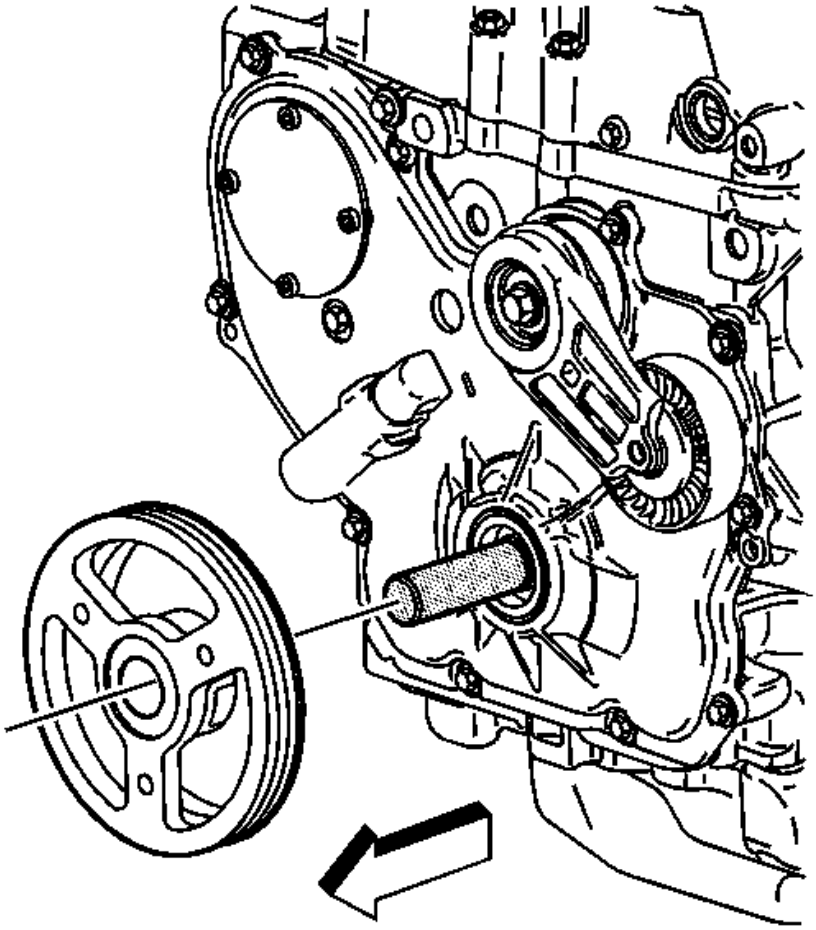

Fig. 559: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the balancer onto the crankshaft indexing keyway. Use care to properly align the keyway and flats on the balancer with the oil pump drive.

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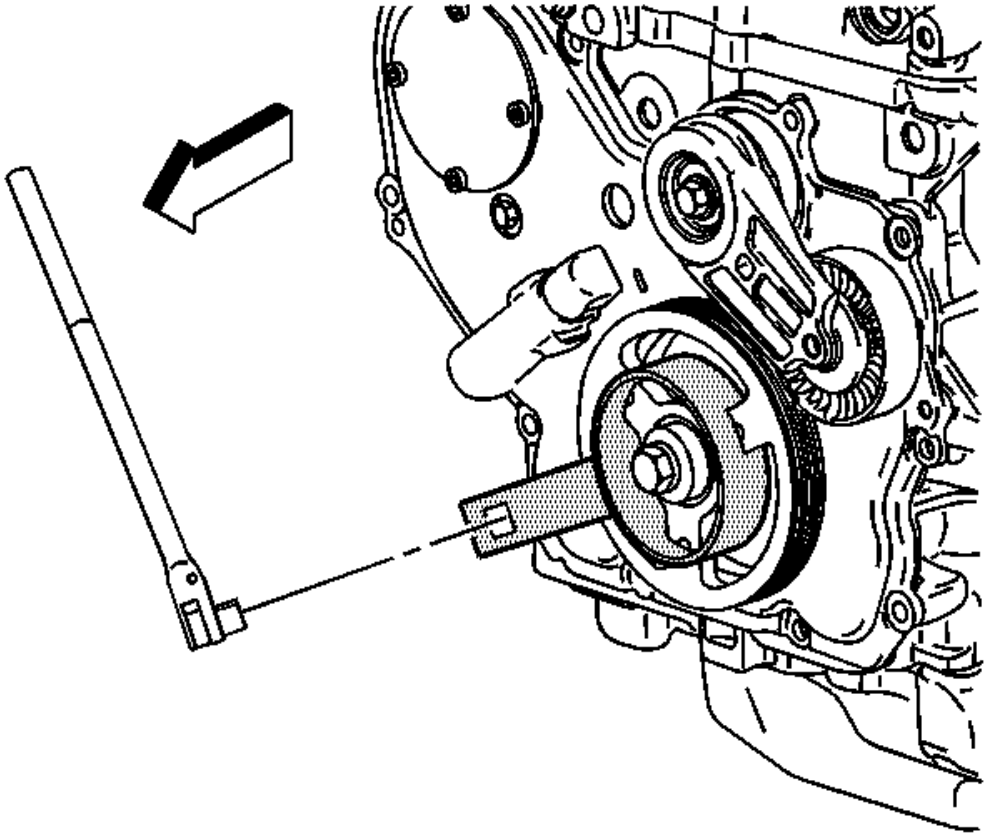

Fig. 560: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

2. Install the **J 38122-A** .

NOTE: Refer to FASTENER NOTICE .

IMPORTANT: Always install a new crankshaft balancer retaining bolt and washer.

3. Install a new retaining bolt and washer. Use the **J 38122-A** and a breaker bar to prevent the crankshaft from rotating when tightening the bolt.

Tighten: Tighten the bolt to 100 N.m (74 lb ft) plus 125 degrees using the **J 45059** .

Oil Filter Adapter Installation

Tools Required

J 44887 Oil Filter Wrench

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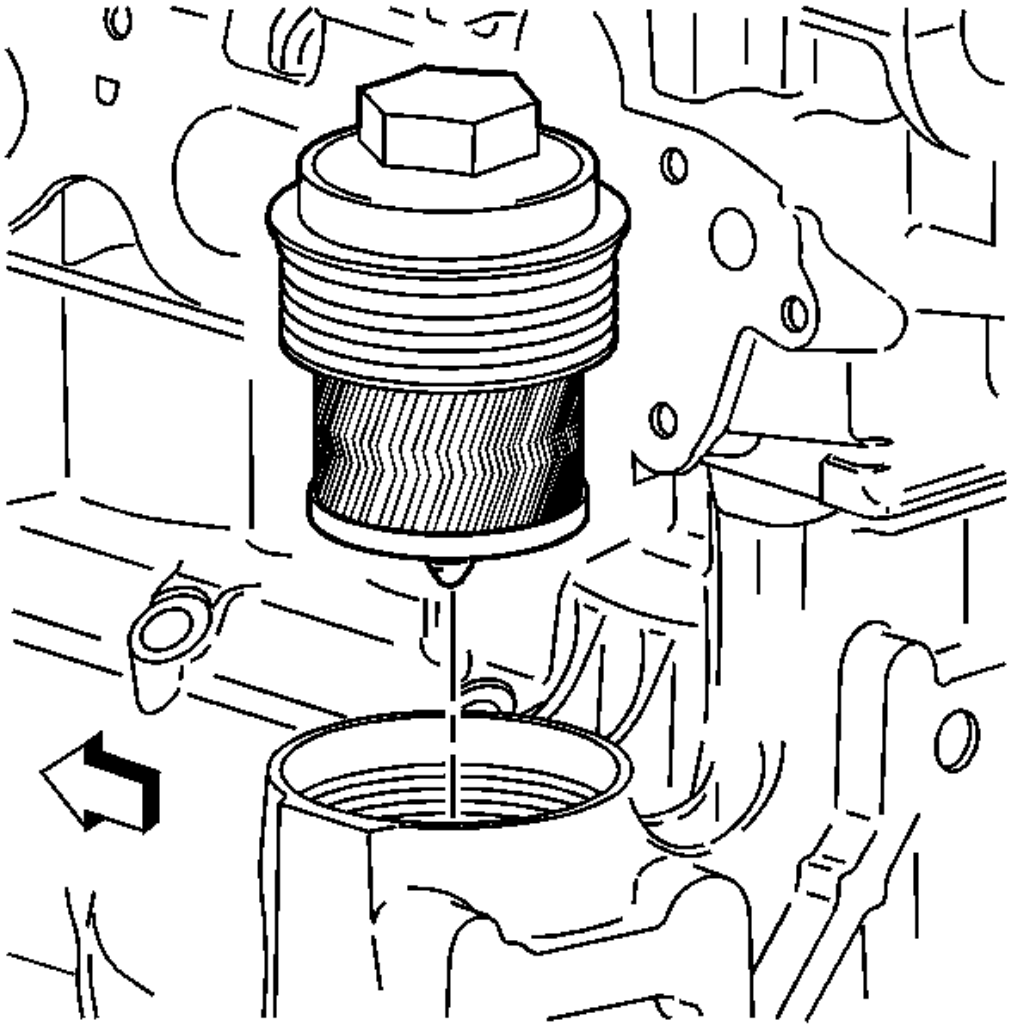

Fig. 561: Identifying Oil Filter Housing
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter on the oil filter cap.
2. Lubricate the O-ring on the oil filter cap with 5W30 engine oil.

NOTE: Refer to FASTENER NOTICE in Cautions and Notices.

3. Use **J 44887** to install the oil filter adapter.

   Tighten: Tighten the oil filter adapter to 22 N.m (16 lb ft).

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Intake Manifold Installation

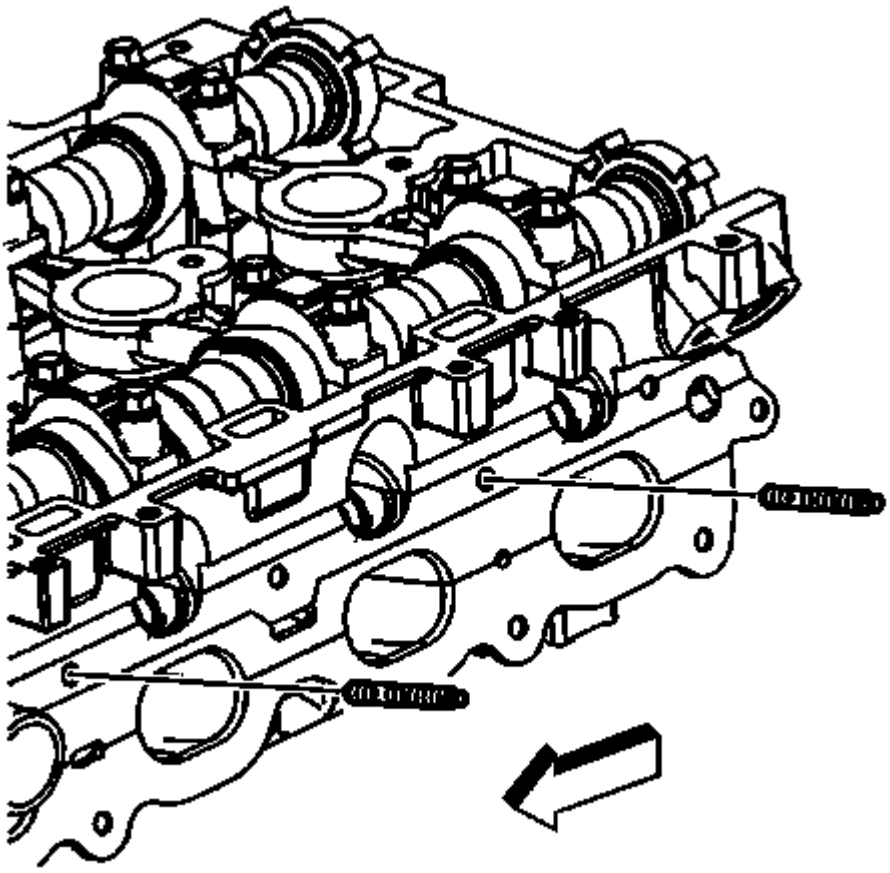

Fig. 562: Identifying Intake Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice .

1. Install the intake manifold studs in the manifold face.

   Tighten: Tighten the intake manifold studs to 5 N.m (44 lb in).

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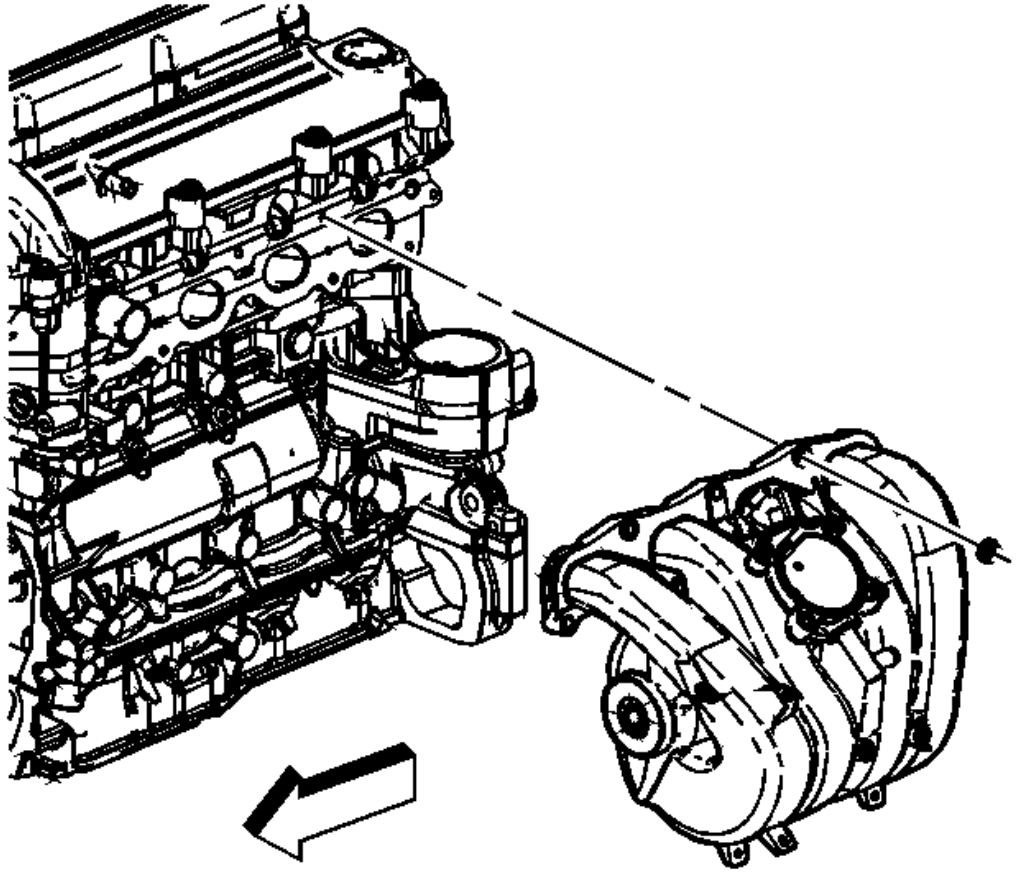

Fig. 563: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install a new intake manifold gasket on the intake manifold.
3. Install the intake manifold.
4. Install the intake manifold bolts and nuts. Follow the tightening sequence.

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

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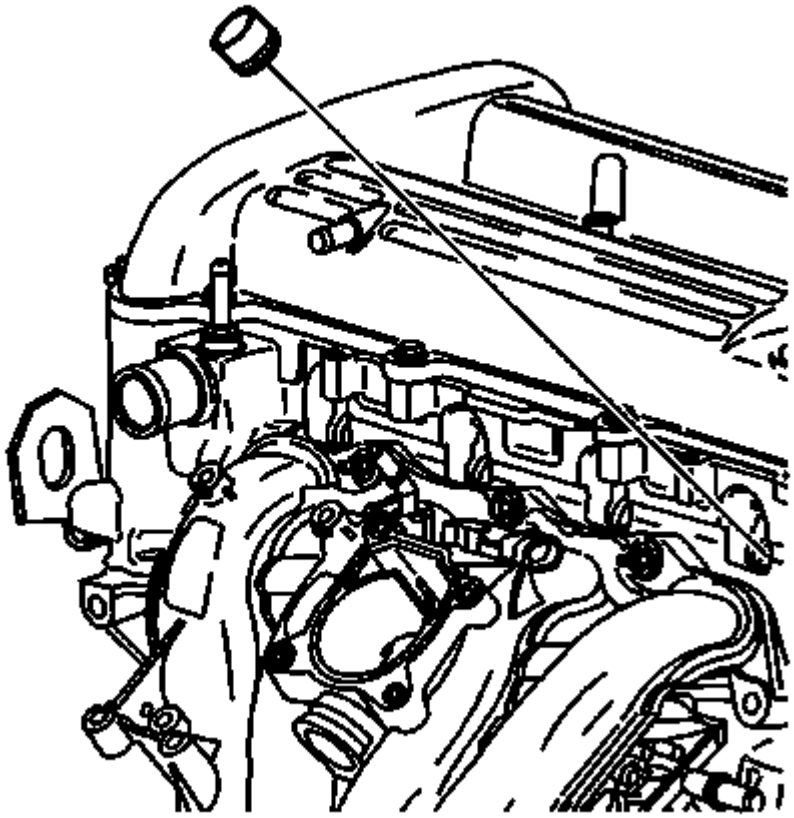

Fig. 564: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

5. Lubricate the fuel injector tip insulators with engine oil.
6. Install new fuel injector tip insulators.

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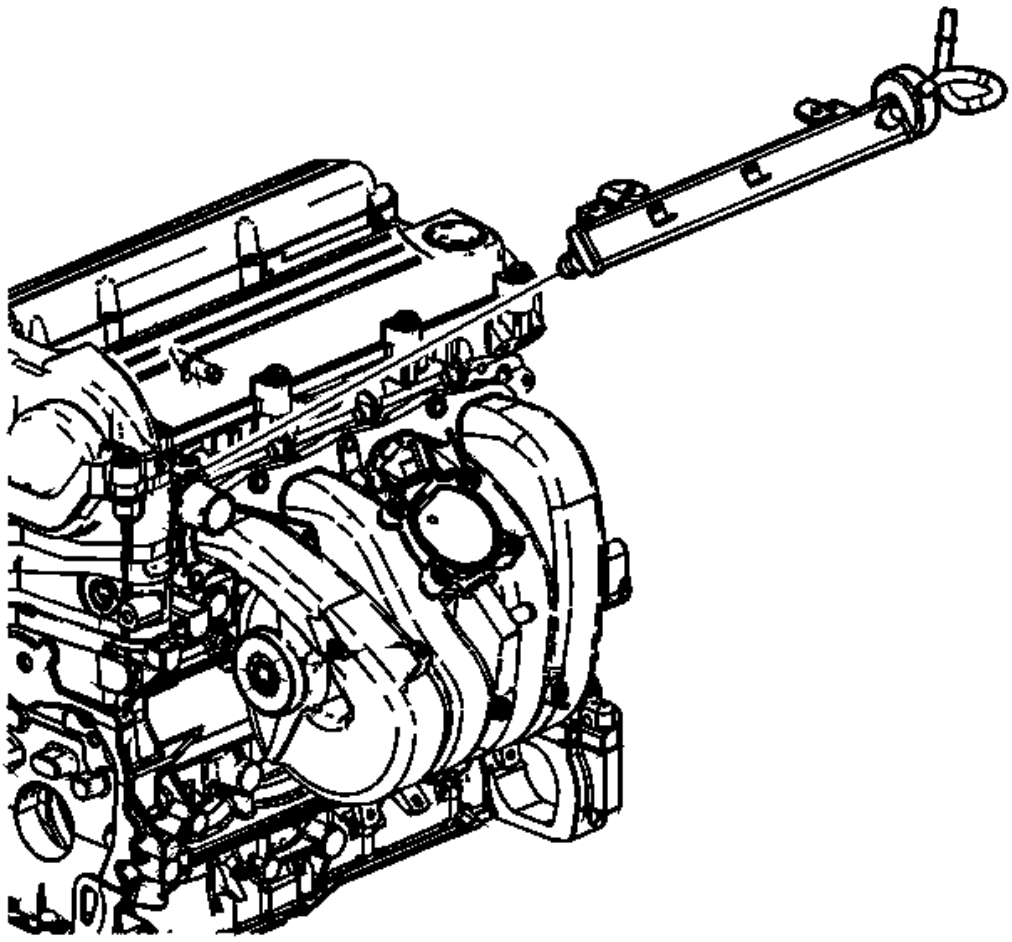

Fig. 565: Identifying Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

7. Lubricate the fuel injector oil rings with engine oil.
8. Install the fuel rail assembly.
9. Install the fuel rail stud.

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

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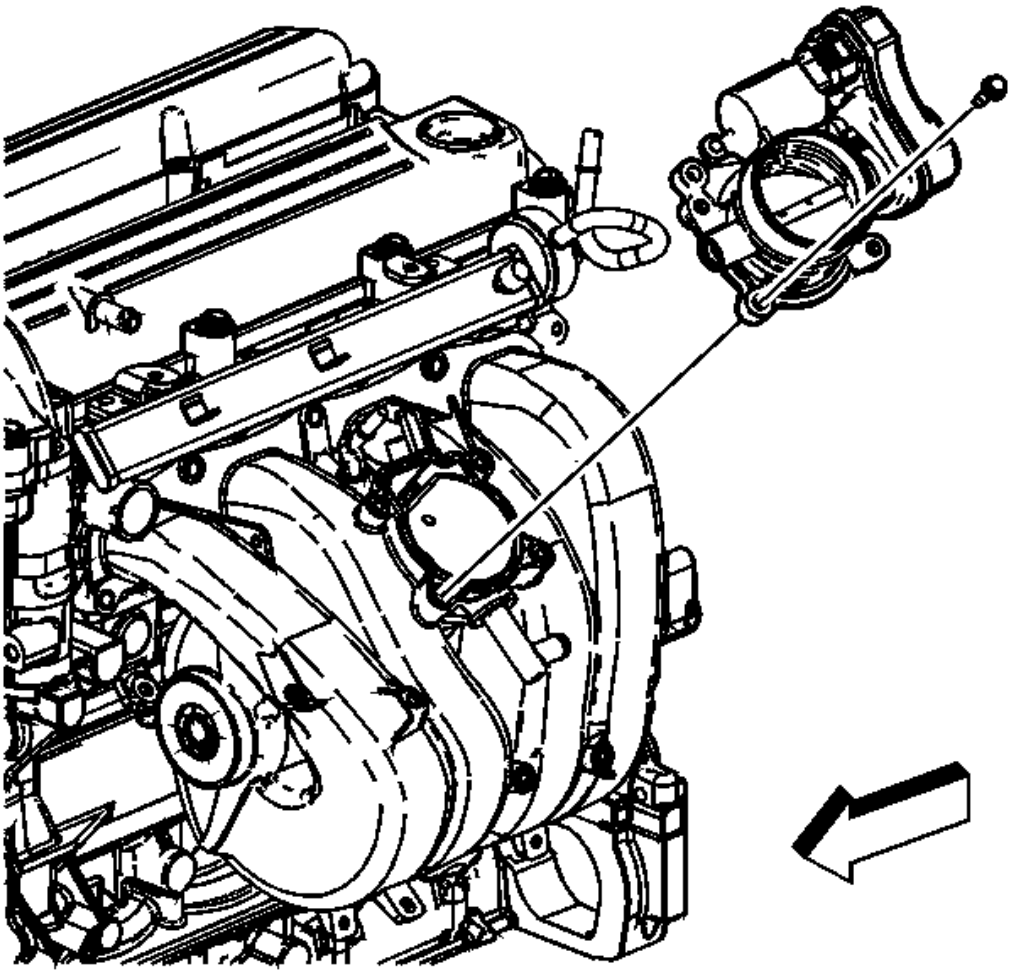

Fig. 566: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

10. Install a new throttle body gasket.
11. Install the throttle body.
12. Install the throttle body bolts.

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

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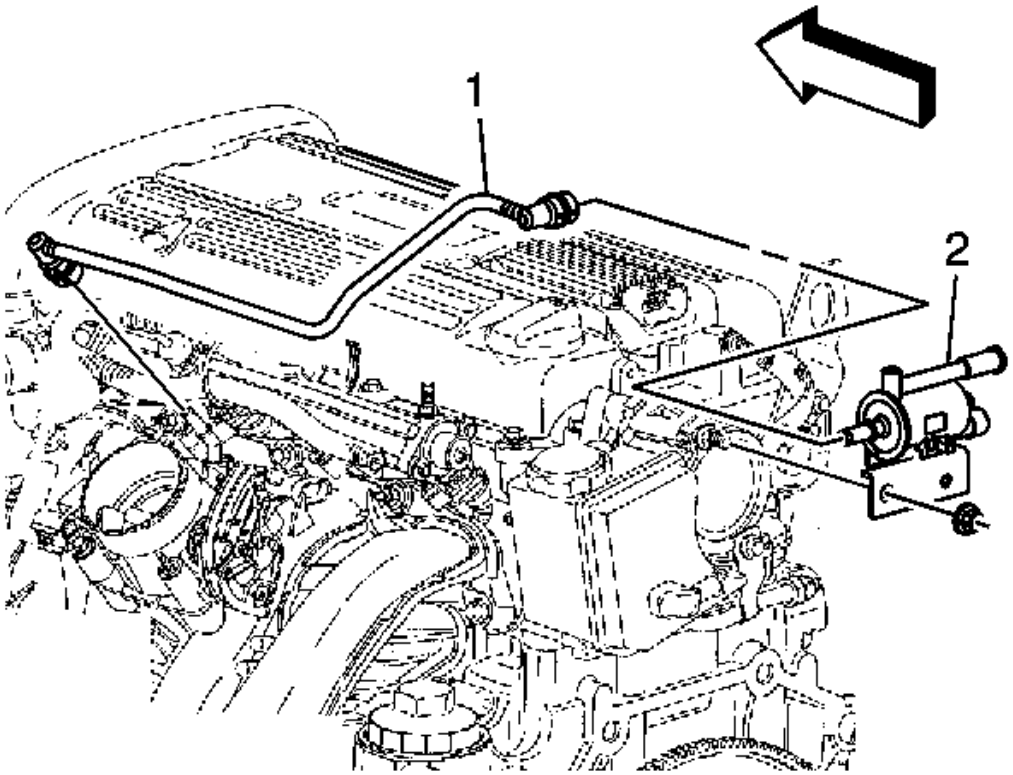

Fig. 567: View Of EVAP Emission Canister Valve Tube
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: Ensure that the rear metal tab of the EVAP canister valve is resting on the power steering pump metal body.

13. Install the EVAP canister valve (2).

    Tighten: Tighten the EVAP canister valve to 22 N.m (16 lb ft).

14. Install the EVAP canister valve tube (1).

Exhaust Manifold Installation

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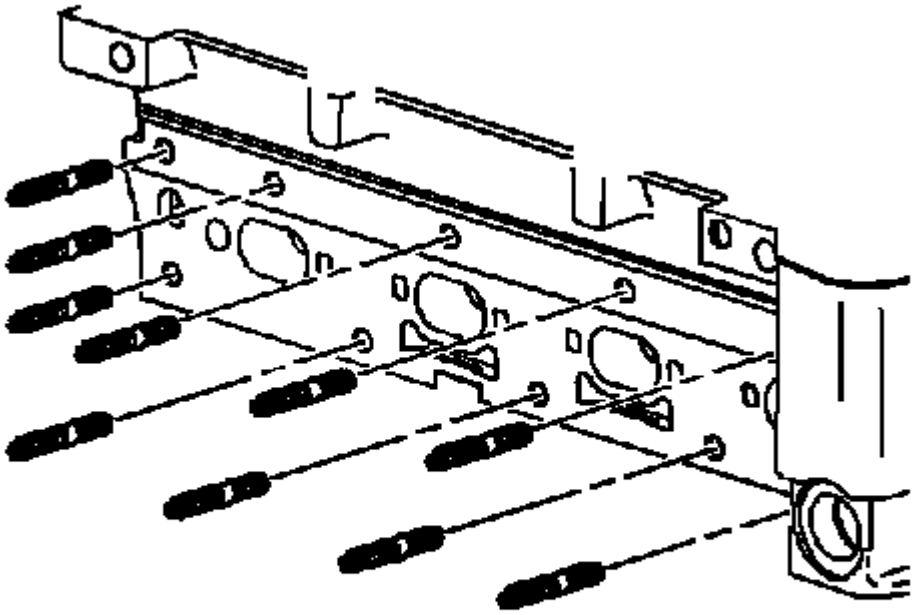

Fig. 568: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

NOTE: Refer to Fastener Notice in Cautions and Notices.

1. Install new exhaust manifold studs.

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

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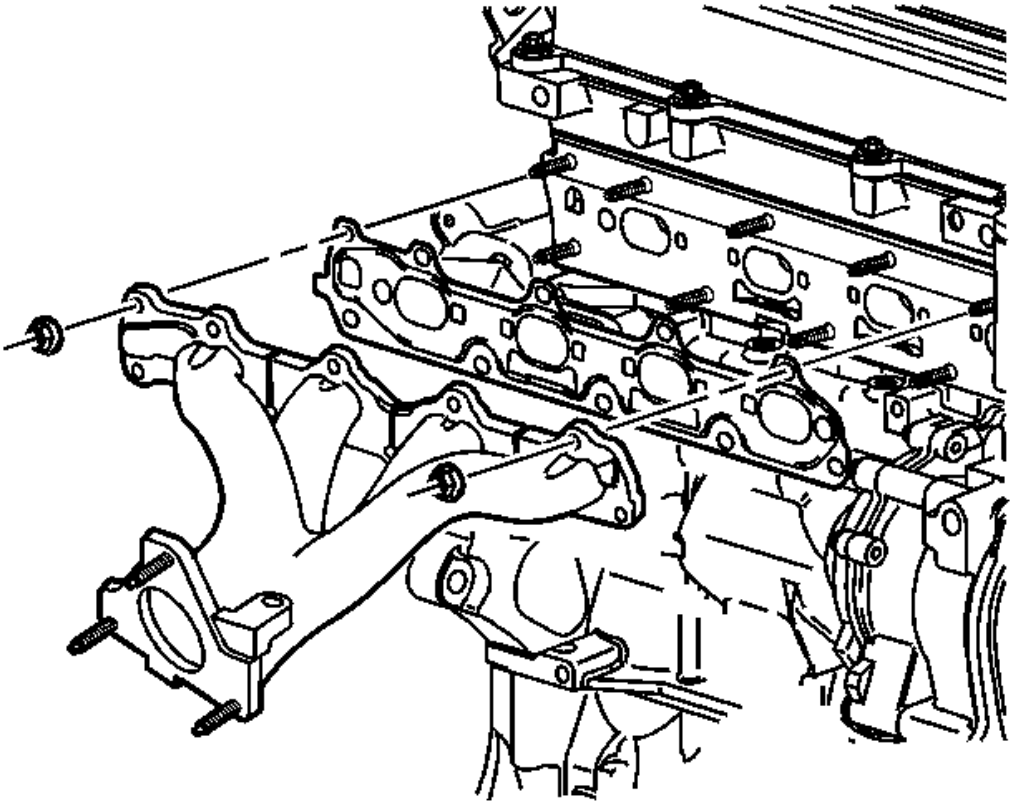

Fig. 569: View Of Exhaust Manifold & Gasket
Courtesy of GENERAL MOTORS CORP.

2. Install the exhaust manifold gasket.
3. Install the exhaust manifold to the cylinder head.
4. Install NEW exhaust manifold to cylinder head retaining nuts finger tight.

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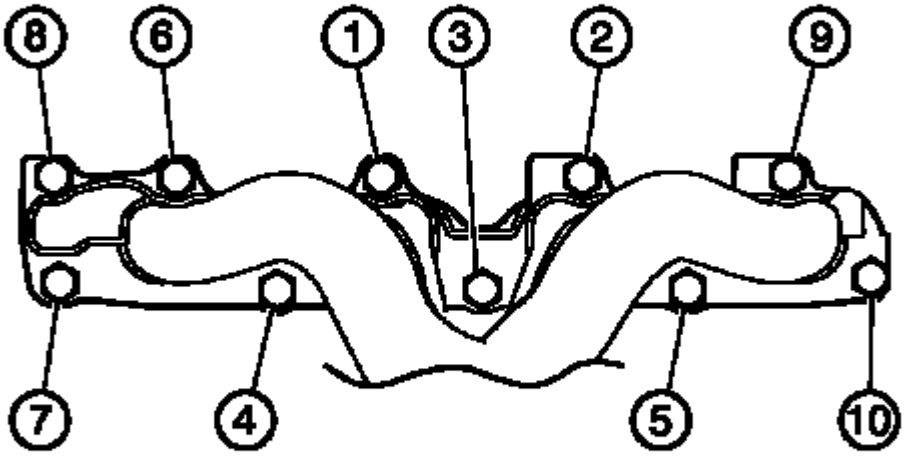

Fig. 570: Exhaust Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the NEW exhaust manifold to cylinder head retaining nuts in sequence.

   Tighten: Tighten the nuts a second time to 14 N.m (124 lb in).

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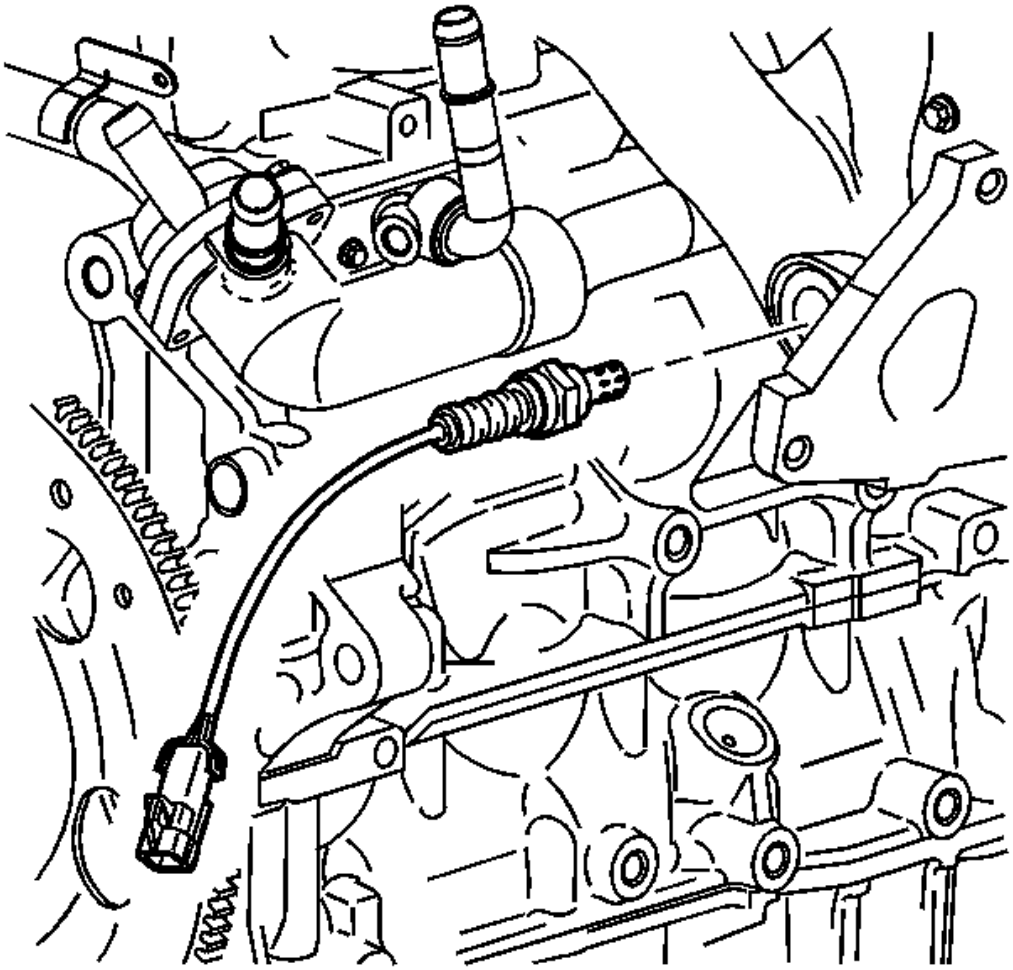

Fig. 571: Identifying Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

6. Coat the threads of the oxygen sensor with antiseize P/N 12397953 or equivalent.
7. Install the oxygen sensor.

Tighten: Tighten the oxygen sensor to 42 N.m (31 lb ft).

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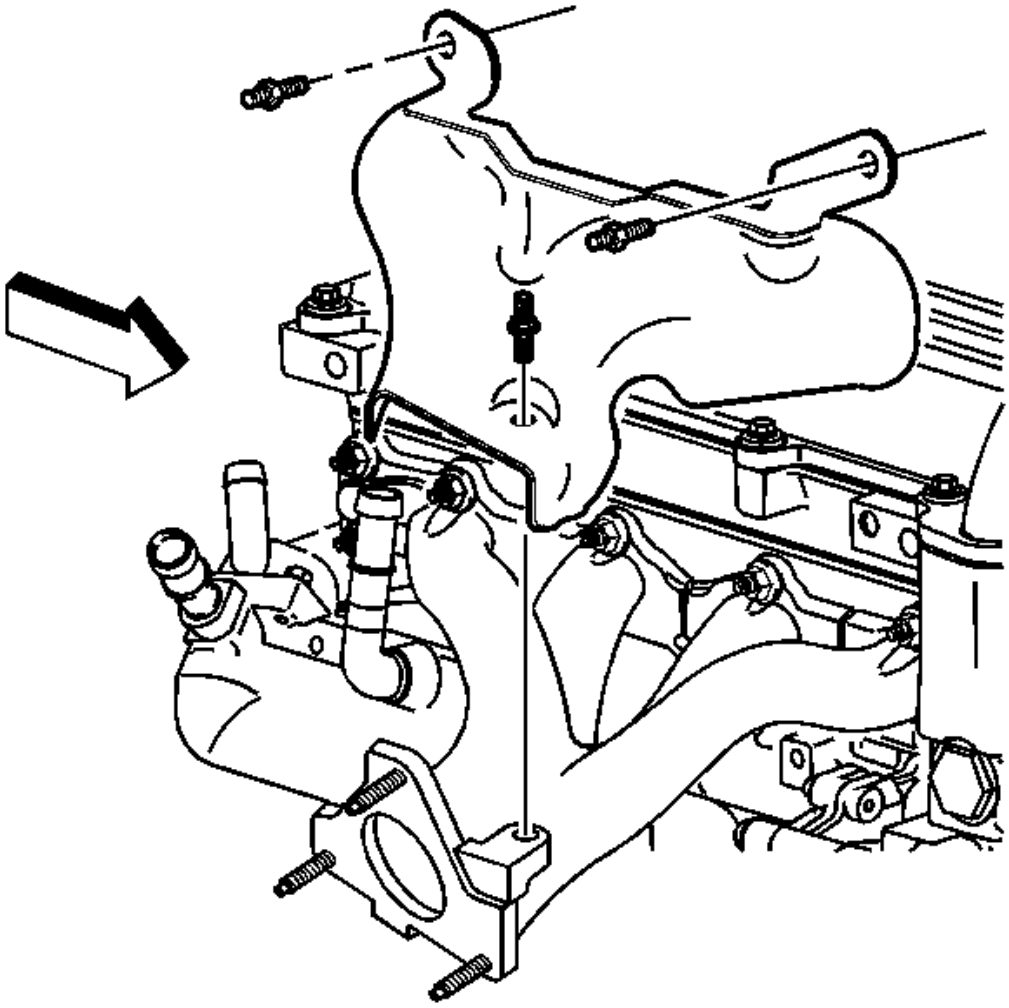

Fig. 572: View Of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

8. Install the exhaust manifold heat shield.
9. Install the exhaust manifold heat shield bolts.

Tighten: Tighten the bolts to 22 N.m (16 lb ft).

Engine Oil Cooler Installation

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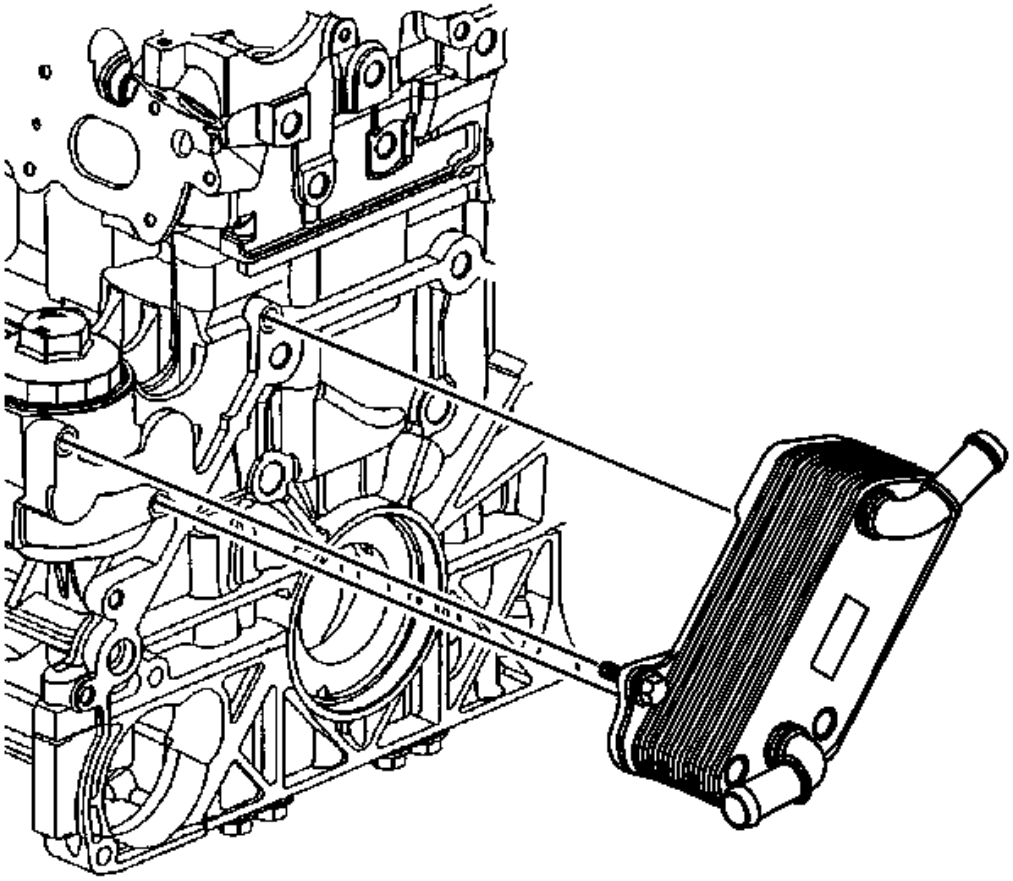

Fig. 573: Identifying Oil Cooler
Courtesy of GENERAL MOTORS CORP.

1. Install the oil cooler.

NOTE: Refer to Fastener Notice .

2. Install the oil cooler bolt and studs.

Tighten: Tighten the bolts and studs to 22 N.m (16 lb ft).

Oil Level Indicator and Tube Installation

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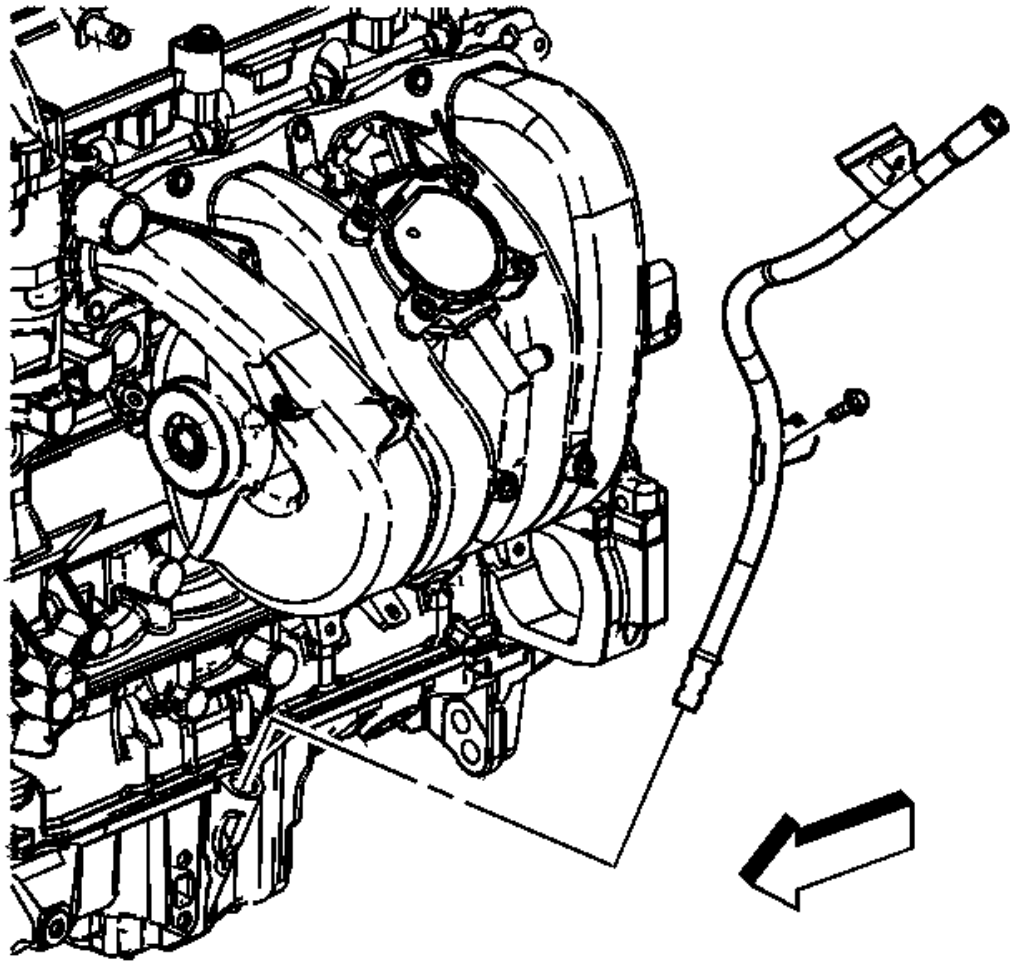

Fig. 574: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring with GM P/N 12345501 (Canadian P/N 992704) or equivalent.
2. Install the oil level indicator and the oil level indicator tube into the oil pan.

NOTE: **Refer to Fastener Notice .**

3. Install the oil level indicator tube bracket to the intake manifold bolt.

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

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4. Install the electrical wiring harness to the oil level indicator tube.
5. Install the knock sensor wiring clip into the oil level indicator tube.

Engine Flywheel Installation

Tools Required

- **J 38122-A** Crankshaft Balancer Holder
- **J 45059** Angle Meter

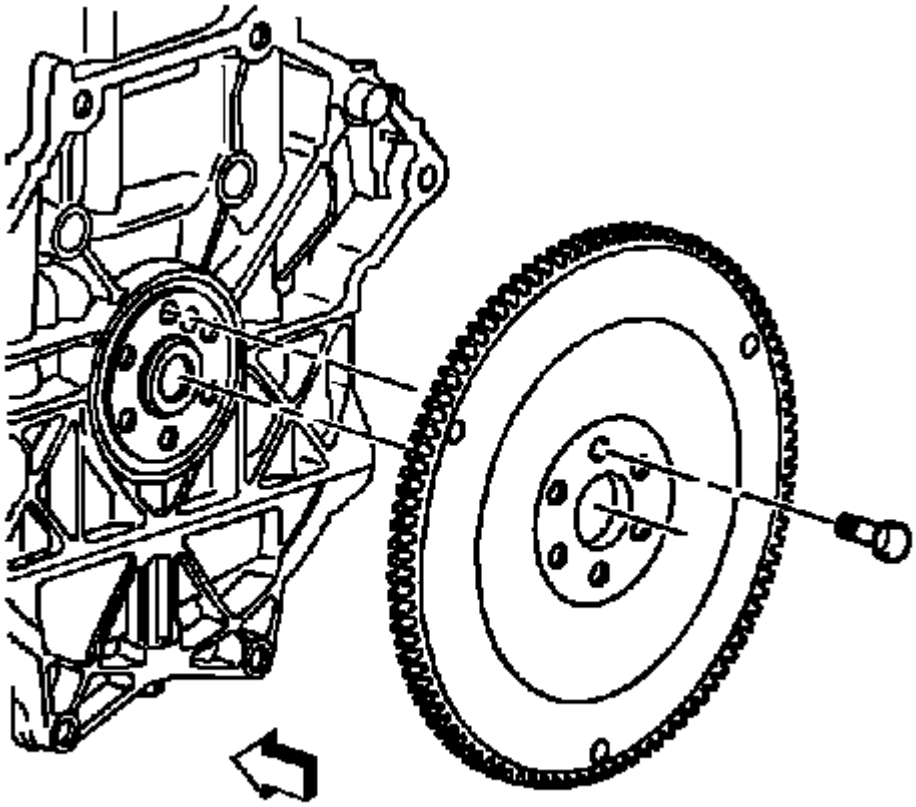

Fig. 575: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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

NOTE: Refer to FASTENER NOTICE .

3. Holding the crankshaft balancer with **J 38122-A** , tighten the bolts evenly.

Tighten: Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the **J 45059** .

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Engine Prelubing

Tools Required

J 45299 Engine Preluber

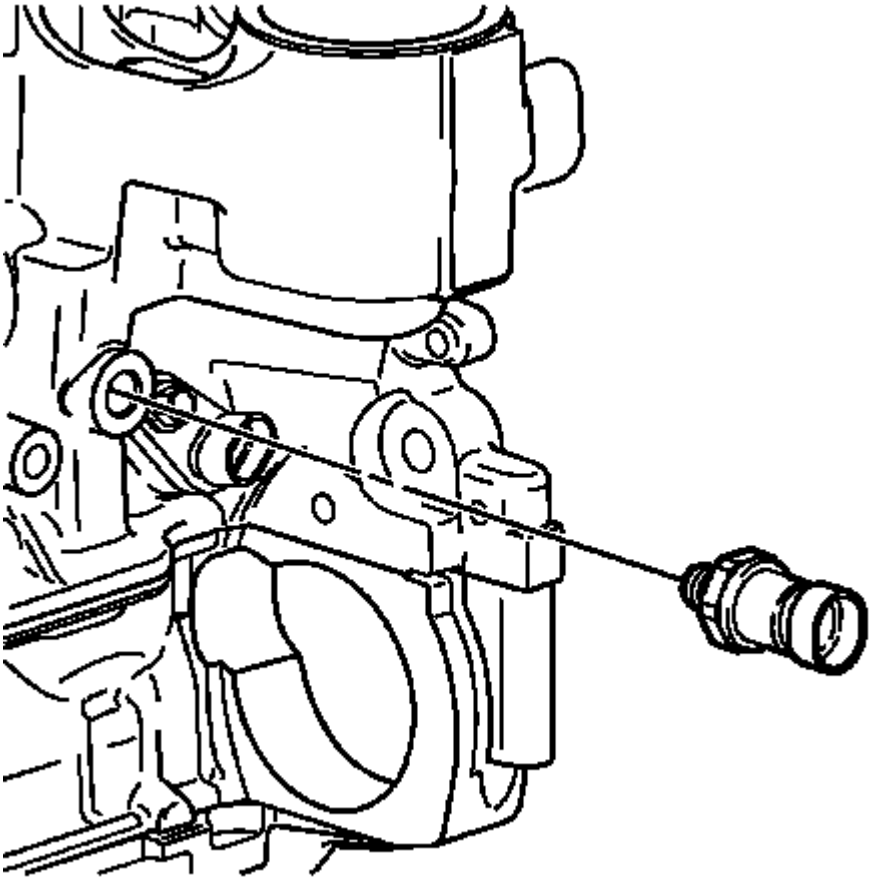

Fig. 576: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Ensure an approved engine oil is used, as specified in the owners manual.

1. Remove the oil pressure switch.
2. Install the M12 x 1.75 adapter P/N 509376.

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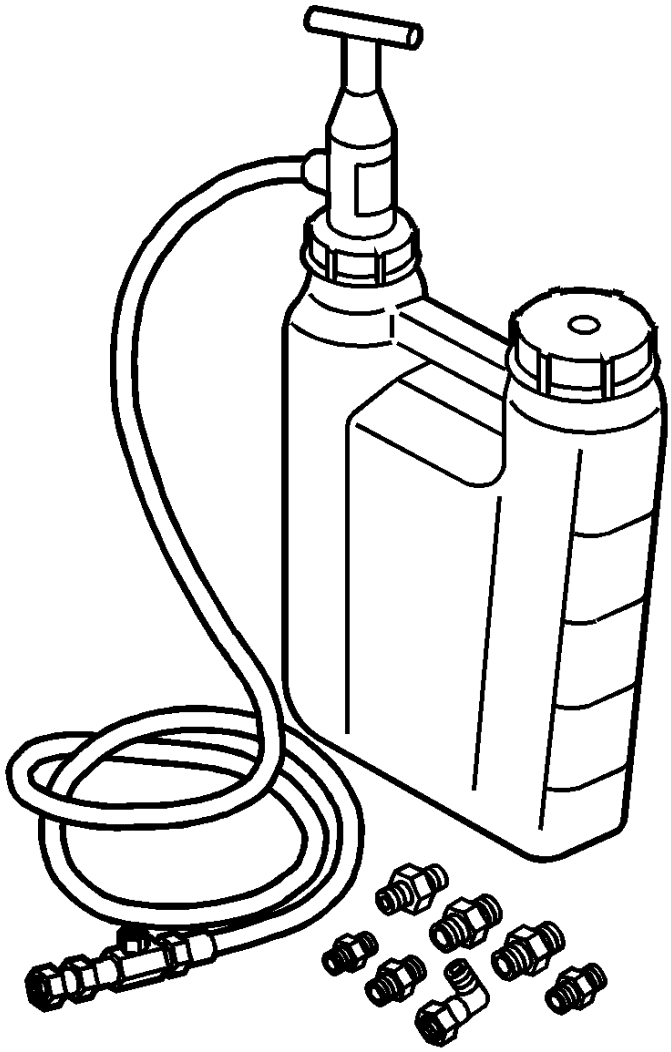

Fig. 577: Identifying Engine Preluber J 45299
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. 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.
5. Close the valve and remove the flexible hose and adapter from the engine.

NOTE: **Refer to Fastener Notice .**

6. Install the oil pressure switch to the engine.

   Tighten: Tighten the oil pressure switch to 22 N.m (16 lb ft).

7. Top-off the engine oil to the proper level.

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DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

General Description

A crankcase ventilation system is used to consume crankcase vapors in the combustion process instead of venting them to atmosphere. Fresh air from the intake system is supplied to the crankcase, mixed with blow by gases and then passed through a calibrated orifice into the intake manifold.

Operation

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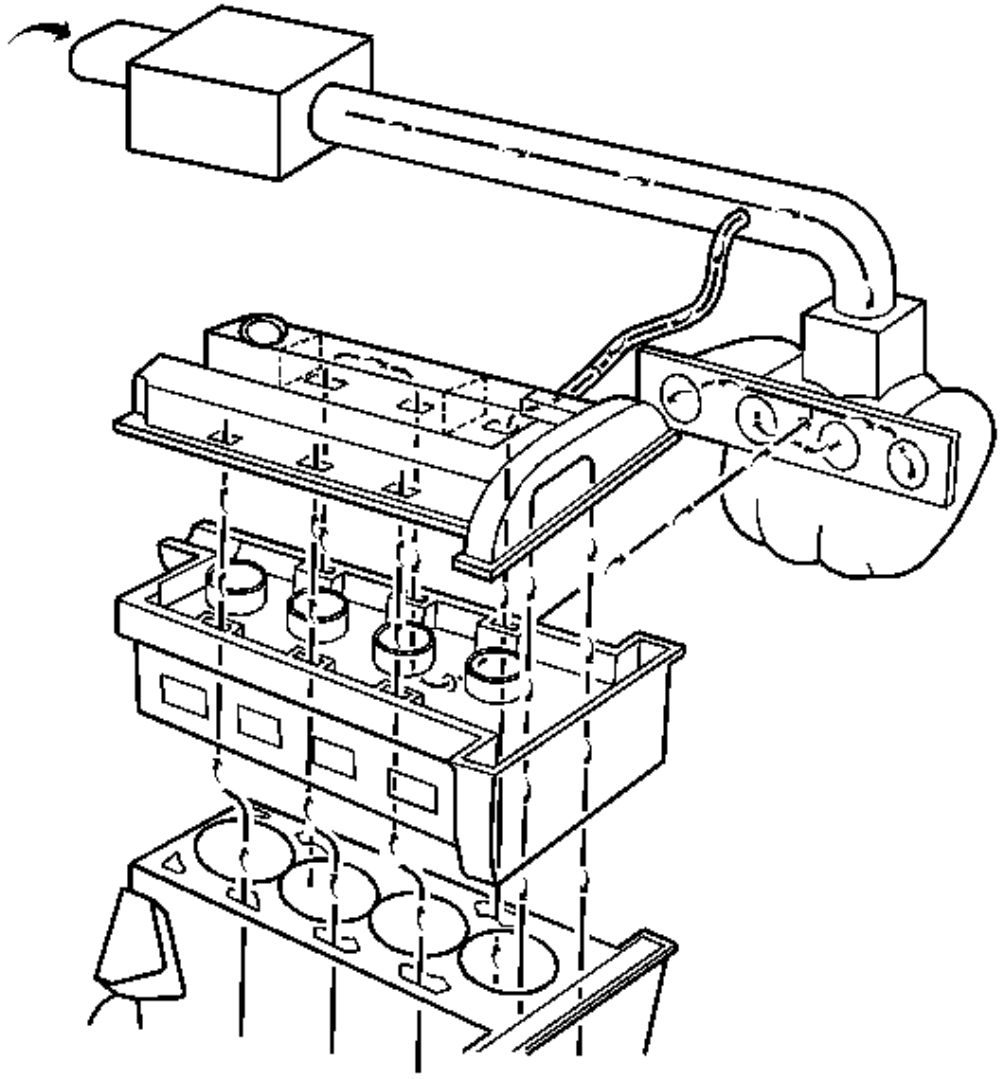

Fig. 578: Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

The primary control is through the positive crankcase ventilation (PCV) orifice which meters the flow at a rate depending on inlet vacuum. The PCV orifice is an integral part of the camshaft cover. If abnormal operating conditions occur, the system is designed to allow excessive amounts of blow by gases to back flow through the crankcase vent into the intake system to be consumed by normal combustion.

Results of Incorrect Operation

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A plugged orifice may cause the following conditions:

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

A leaking orifice may cause the following conditions:

- Rough idle
- Stalling
- High idle speed

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 one belt or two belts. The drive belt is thin so that it can bend backward 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 rubber (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.

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The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

ENGINE COMPONENT DESCRIPTION

Engine Description

Cylinder Block

The cylinder block is lost foam cast aluminum with 4 cylinders arranged in-line. The cylinders have pressed in place iron liners. The block has 5 crankshaft bearings with the thrust bearing located on the second bearing from the front of the engine. The cylinder block incorporates a bedplate design that forms an upper and lower crankcase. This design promotes cylinder block rigidity and reduced noise and vibration.

Crankshaft

The crankshaft is cast nodular iron with 8 counterweights. The number 8 counterweight is also the ignition system reluctor wheel. The main bearing journals are cross-drilled, and the upper bearings are grooved. The crankshaft has a slip fit balance shaft drove sprocket. Number 2 main bearing is the thrust bearing. A harmonic damper is used to control torsional vibration.

Connecting Rod and Piston

The connecting rods are powdered metal. The connecting rod incorporates the floating piston pin. The pistons are cast aluminum. The piston rings are of a low tension type to reduce friction. The top compression ring is ductile iron with a molybdenum facing and phosphate coated sides. The second compression ring is gray iron. The oil ring is a 3-piece spring construction with chromium plating.

Oil Pan

The oil pan is die cast aluminum. The oil pan includes an attachment to the transmission to provide additional structural support.

Balance Shaft Assembly

There are 2 block mounted balance shafts located on each side of the crankcase at the bottom of the cylinder bores. The balance shafts are driven by a single roller chain that also drives the water pump. The chain is tensioned by a hydraulic tensioner that is supplied pressure by the engine oil pump. This design promotes the maximum effectiveness of the balance shaft system and reduces noise and vibration.

Cylinder Head

The cylinder head is a lost foam aluminum casting. Pressed-in powdered metal valve guides and valve seat insets are used. The fuel injection nozzle is located in the intake port. The cylinder head incorporates camshaft journals and camshaft caps.

Valves

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There are 2 intake and 2 exhaust valves per cylinder. Rotators are used on all of the intake valves. The rotators are located at the bottom of the valve spring to reduce valve train reciprocating mass. Positive valve stem seals are used on all valves.

Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron. The intake camshaft had a pressed-in hex insert. The hex inset is used to drive the direct drive power steering pump.

Valve Lifters

The valve train uses a roller finger follower acted on by a hydraulic lash adjuster. The roller finger follower reduces friction and noise.

Camshaft Cover

The camshaft cover has a steel crankcase ventilation baffling incorporated. The camshaft cover has mounting locations for the ignition system.

Camshaft Drive

A single row roller chain is used for camshaft drive. There is a tensioner and active guide used on the slack side of the chain to control chain motion and noise. The chain drive promotes long valve train life and low maintenance.

Intake and Exhaust Manifold

The intake manifold is made of composite plastic. The exhaust manifold is cast iron. The intake manifold incorporates a distribution and control system for positive crankcase ventilation (PCV) gases. The exhaust manifold is a dual plane design that promotes good low end torque and performance.

LUBRICATION DESCRIPTION

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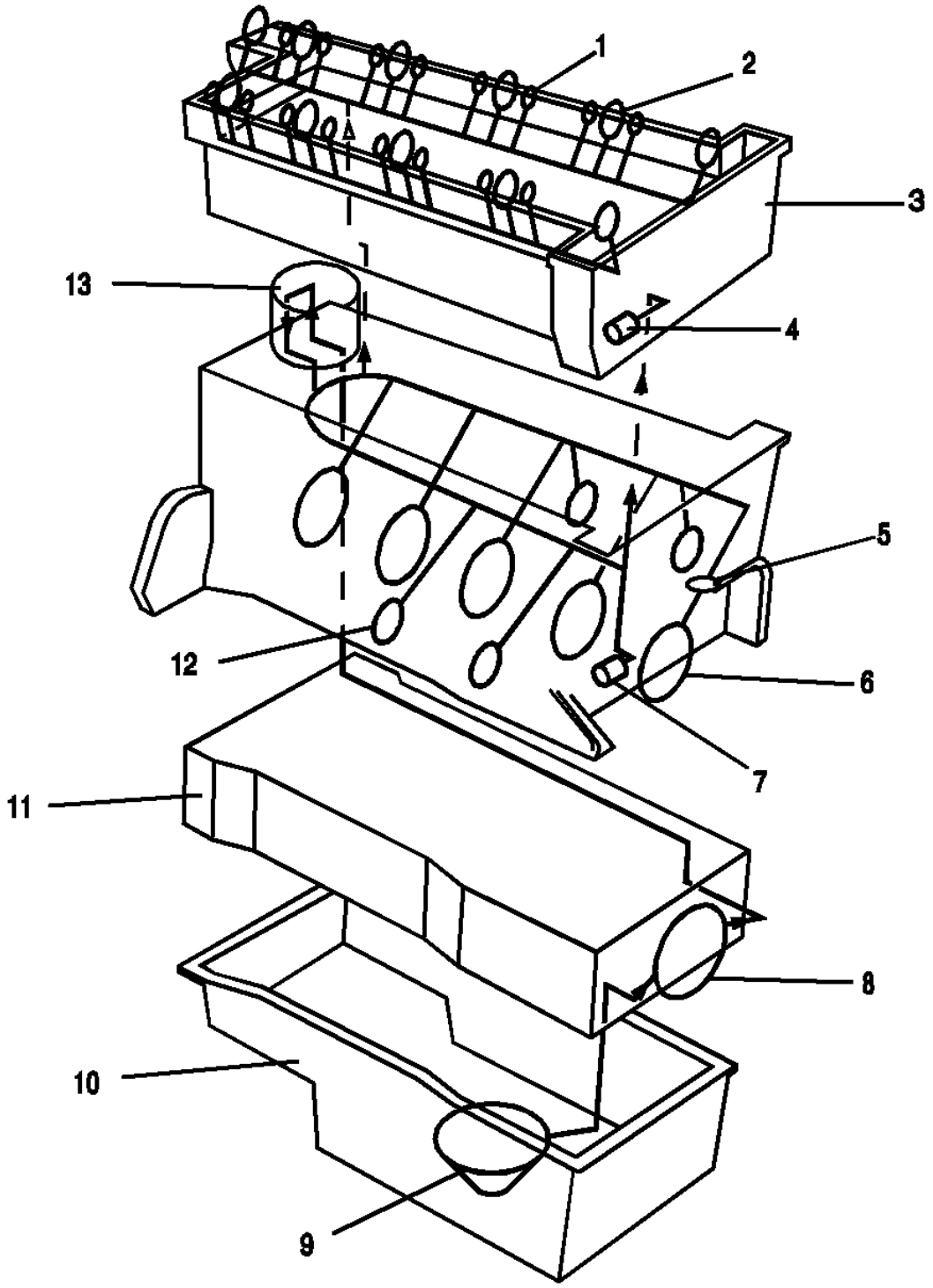

Fig. 579: Lubrication System
Courtesy of GENERAL MOTORS CORP.

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Callout	Component Name
1	Hydraulic Lash Adjuster
2	Cam Journal
3	Cylinder Head
4	Timing Chain Tensioner
5	Cam Drive Chain Oil Nozzle
6	Crankshaft Bearing
7	Balance Shaft Chain Tensioner
8	Oil Pump
9	Oil Pick Up
10	Oil Pan
11	Bedplate
12	Balance Shaft Bearings
13	Oil Filter

Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, valve lifters and timing chain hydraulic tensioner. All other moving parts are lubricated by gravity flow or splash. Oil enters the gerotor type oil pump through a fixed inlet screen. The oil pump is driven by the crankshaft. The oil pump body is within the engine front cover. The pressurized oil from the pump passes through the oil filter. The oil filter is located on the right (front) side of the engine block. The oil filter is housed in a casting that is integrated with the engine block. The oil filter is a disposable cartridge type. A by-pass valve in the filter cap allows continuous oil flow in case the oil filter should become restricted. Oil then enters the gallery where it is distributed to the balance shafts, crankshaft, camshafts and camshaft timing chain oiler nozzle. The connecting rod bearings are oiled by constant oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. The pressurized oil passes through the cylinder head restrictor orifice into the cylinder head and then into each camshaft feed gallery. Cast passages feed each hydraulic element adjuster and drilled passages feed each camshaft bearing surface. An engine oil pressure switch or sensor is installed at the end. Oil returns to the oil pan through passages cast into the cylinder head. The timing chain lubrication drains directly into the oil pan.

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished, and lapped surfaces with tolerances that are measured in ten thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces during initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas are part of the repair procedure. This is considered standard shop practice even if not specifically stated.

When valve train components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

SEPARATING PARTS

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IMPORTANT:

- **Disassembly of the piston, press fit design piston pin, and connecting rod may create scoring or damage to the piston pin and piston pin bore. If the piston, pin, and connecting rod have been disassembled, replace the components as an assembly.**
- **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 installation to their original location and position.**

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Tools Required

J 28410 Gasket Remover

Gasket Reuse and Applying Sealants

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

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- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
    - These methods of cleaning can cause damage to the component sealing surfaces.
    - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
    - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Pipe Joint Compound

IMPORTANT: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the 3 types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where 2 non-rigid parts, such as the oil pan and the engine block, are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

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- Apply the pipe joint compound to a clean surface. Use a bead size or quantity as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when the bolt is tightened.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- Room temperature vulcanizing (RTV) sealant hardens when exposed to air. This type sealer is used where 2 rigid parts, such as the lower crankcase and the engine block, are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifold, head gasket, or other surfaces where a gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

- Apply RTV to a clean surface. Use a bead size as specified in the procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet, within 3 minutes. Do not wait for RTV to skin over.
- Tighten bolts to specifications. Do not overtighten.

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

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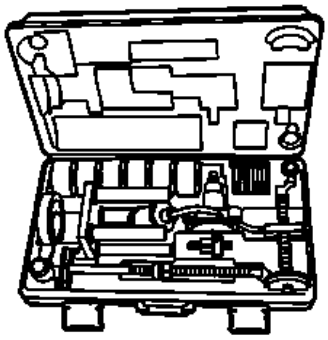
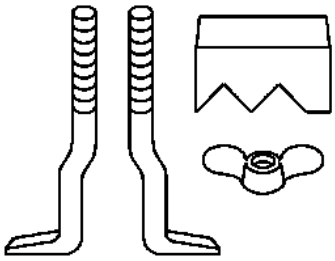
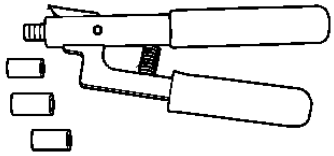
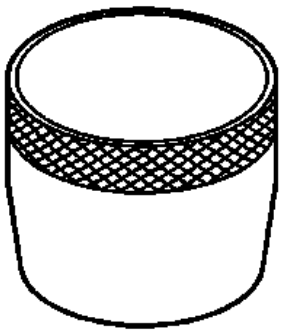
SPECIAL TOOLS

Special Tools

Illustration	Tool Number/Description
	EN 45680-880 Cylinder Sleeve Removal and Installation Kit
	EN 46327 Timing Chain Retention Tool
	EN 46745 Piston Pin Retainer Remover and Installer
	EN 47836 Piston Ring Compressor

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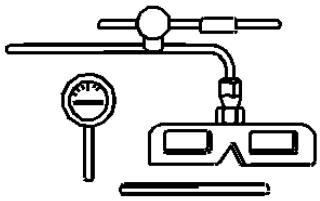
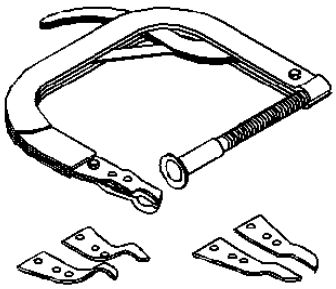
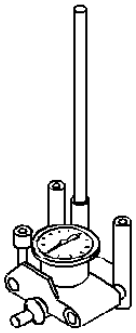
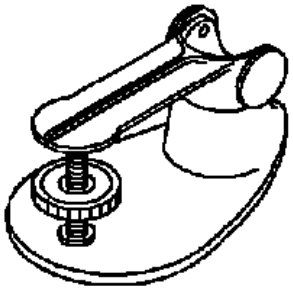
	J 7872 Magnetic Base Dial Indicator
	J 8062 Valve Spring Compressor - Head Off
	J 8087 Cylinder Bore Gage
	J 9666 Valve Spring Tester
	J 28410

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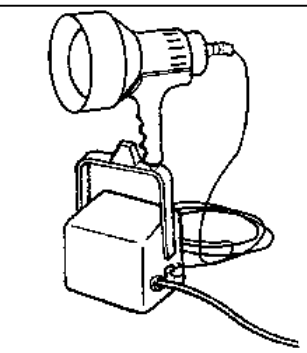
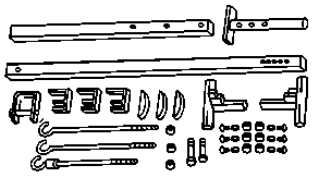
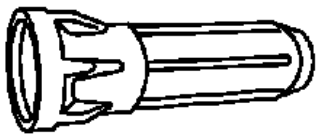
	Gasket Remover
	J 28428-E High-Intensity Black Light Kit
	J 28467-B Universal Engine Support Fixture
	J 35268-A Camshaft/Front Main Seal Installer
	J 35667-A Cylinder Head Leakdown Tester

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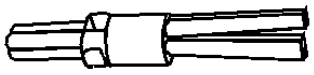
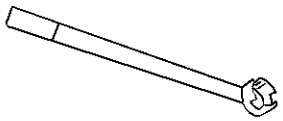
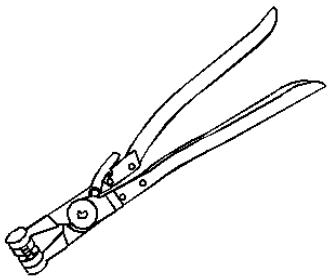
	J 36017 Valve Guide Seal Remover
	J 38122-A Harmonic Balancer Holder
	J 38185 Hose Clamp Pliers
	J 38188 Cylinder Head Broken Bolt Extractor Kit

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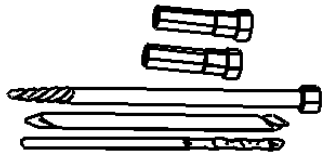
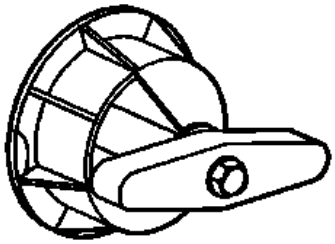
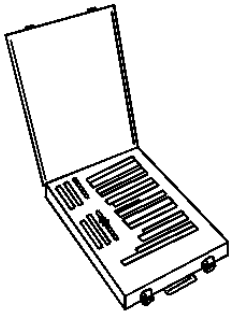
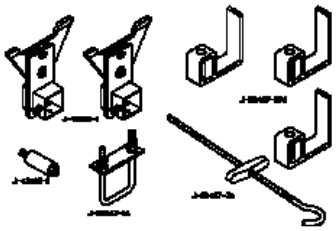
	
	J 42067 Rear Main Seal Installer
	J 42385-850 Thread Repair Kit
	J 43405 Engine Support Fixture Adapter
	J 43649 Valve Spring Compressor

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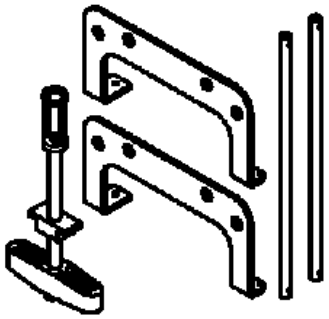
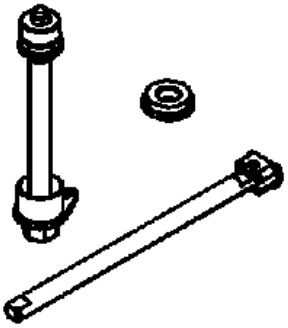
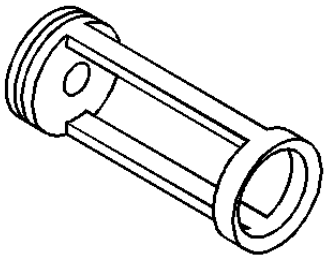
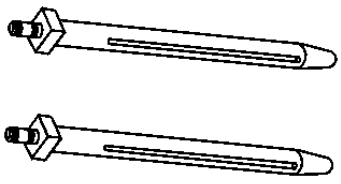
	
	J 43650 Balancer Shaft Bearing Remover and Installer
	J 43963 Valve Spring Compressor (off car)
	J 43966-1 Connecting Rod Guides 2000 2.2L (L61)
	J 44811 Accessory Belt Tensioner Unloader

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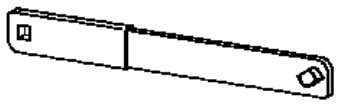
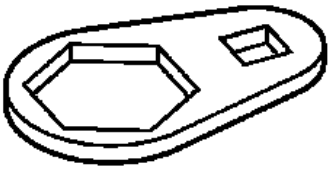
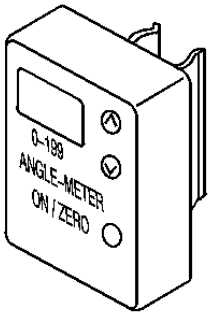
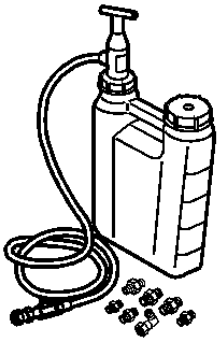
	
	J 44887 Oil Filter Wrench
	J 45059 Angle Meter
	J 45299 Engine Pre-Luber

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