2010 ENGINE

Engine Mechanical - 2.2L or 2.4L - Cobalt & G5 (Canadian)

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Application	Specification	
	Metric	English
A/C Compressor to Block Bolt	20 N.m	15 lb ft
Air Pump Assembly Bolt	22 N.m	16 lb ft
Balance Shaft Bearing Carrier to Block Bolt	10 N.m	89 lb in
Balance Shaft Chain Guide Bolt, Adjustable	10 N.m	89 lb in
Balance Shaft Chain Guide Bolt, Fixed	12 N.m	106 lb in
Balance Shaft Sprocket Bolt		
• First Pass	8 N.m	71 lb in
• Final Pass	30 degrees	
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 Bolt		
• First Pass	30 N.m	22 lb ft
• Final Pass	100 degrees	
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
Connecting Rod Bolt		
• First Pass	25 N.m	18 lb ft
• Final Pass	100 degrees	
Crankshaft Bearings - Lower Crankcase to Block - Bedplate		
• First Pass	20 N.m	15 lb ft
• Final Pass	70 degrees	
Crankshaft Balancer Bolt		
• First Pass	100 N.m	74 lb ft
• Final Pass	125 degrees	
Crankshaft Position Reluctor Ring	15 N.m	11 lb ft

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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	
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
Engine Block Coolant Drain Plug	15 N.m	11 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 Purge Solenoid Valve Nut	25 N.m	18 lb ft
Exhaust Manifold Brace Bolt	58 N.m	43 lb ft
Exhaust Manifold to Cylinder Head Nut	14 N.m	124 lb in
Exhaust Manifold to Cylinder Head Stud - 2 passes	10 N.m	89 lb in
Exhaust Manifold Pipe Flange Stud	16 N.m	12 lb ft
Flexplate (AMT) Bolt		
• First Pass	53 N.m	39 lb ft
• Final Pass	25 degrees	
Flywheel (SMT) Bolt		
• 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 Bolt	10 N.m	89 lb in
Generator to Block Bolt	23 N.m	17 lb ft
Heat Shield to Exhaust Manifold Bolt	25 N.m	18 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
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 Filter Cap	22 N.m	16 lb ft
Oil Gallery Gerotor Cover - Rear Bolt	6 N.m	53 lb in
Oil Gallery Block Plug - Rear	60 N.m	44 lb ft
Oil Gallery Plug	35 N.m	26 lb ft
Oil Level Indicator Tube to Intake Manifold Bolt	10 N.m	89 lb in
Oil Pan Baffle	14 N.m	124 lb in

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Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan to Block Bolts	25 N.m	18 lb ft
Oil Pressure Switch	26 N.m	19 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
Secondary Air Injection Assembly to Secondary Air Injection Pipe Assembly Bolt	10 N.m	89 lb in
Secondary Air Injection Pipe Assembly to Cylinder Head Bolt	10 N.m	89 lb in
Secondary Air Injection Assembly and Exhaust Manifold Heat Shield Bolt	22 N.m	16 lb ft
Secondary Air Injection Assembly Stud	10 N.m	89 lb in
Secondary Air Injection Assembly Nut	22 N.m	16 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
Timing Chain Guide Bolt, Adjustable	10 N.m	89 lb in
Timing Chain Guide Bolt, Fixed	12 N.m	106 lb in
Timing Chain Guide Bolt, Upper	10 N.m	89 lb in
Timing Chain Guide Plug	75 N.m	55 lb ft
Timing Chain Oil Nozzle Bolt	10 N.m	89 lb in
Vent Tube to Cylinder Head	15 N.m	11 lb ft
Water Pump Access Cover Bolt	10 N.m	89 lb in
Water Pump/Balance Shaft Chain Tensioner Bolt	10 N.m	89 lb in
Water Pump Bolt	25 N.m	18 lb ft
Water Pump Cover Stud	10 N.m	89 lb in
Water Pump Sprocket Bolt	10 N.m	89 lb in

ENGINE MECHANICAL SPECIFICATIONS (LAP, LE8)

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General Data		
• Engine Type	Inline 4 Cylinder	
• Displacement	2.2 L	134 CID
• RPO	LAP, LE8	
• Liter (VIN)	F	
• Bore	85.992-86.008 mm	3.3855-3.3861 in

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• Stroke	94.6 mm	3.727 in
• Compression Ratio	10.0:1	
Balance Shaft		
• Bearing Clearance	0.030-0.060 mm	0.0012-0.0024 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	0.050-0.300 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	85.992-86.008 mm	3.3855-3.3861 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 - Transverse	0.030 mm	0.0012 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
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	0.029-0.073 mm	0.0011-0.0029 in
• Connecting Rod Bore Diameter - Bearing End	52.118-52.134 mm	2.0519-2.05252 in
• Connecting Rod Bore Diameter - Pin End	20.007-20.017 mm	0.7877-0.7881 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		
• Overall Height, Minimum	128.9 mm	5.07 in
• Surface Flatness - Block Deck - Transverse	0.030 mm	0.0012 in
• Surface Flatness - Block Deck - Longitude	0.050 mm	0.002 in
• Surface Flatness - Block Deck - Overall	0.1 mm	0.004 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
• Valve Seat Angle - Relief Surface	30 Degrees	
• Valve Seat Angle - Seating Surface	45 Degrees	
• Valve Seat Angle - Undercut Surface	60 Degrees	
• Valve Seat Roundness - Maximum	0.025 mm	0.0010 in
• Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valve Seat Width - Exhaust Seating Surface	1.600 mm	0.0630 in
• Valve Seat Width - Intake Seating Surface	1.200 mm	0.0472 in
Lubrication System		
• Oil Pressure - Minimum - @1000 RPM @ 90°C (194° F)	206.84-482.63 kPa	30-70 psi
• Oil Capacity	4.8L	5.0 quarts
Piston Rings		
• Piston Ring End Gap - First Compression Ring	0.20-0.35 mm	0.008-0.014 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	0.25-0.75 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	0.058-0.207 mm	0.0023-0.0081 in
• Piston Ring Thickness - Upper First Compression Ring	1.170-1.190 mm	0.0461-0.0469 in
• Piston Ring Thickness - Upper Second Compression	1.471-1.490 mm	0.0579-0.0587 in

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Ring		
• Piston Ring Thickness - Oil Control Ring - Rail - Maximum	0.473 mm	0.0186 in
• Piston Ring Thickness - Oil Control Ring - Spacer	0.929-1.006 mm	0.0366-0.0396 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Connecting Rod Bore	0.007-0.020 mm	0.0003-0.0008 in
• Pin - Piston Pin Clearance to Piston Pin Bore	0.004-0.012 mm	0.0002-0.0005 in
• Pin - Piston Pin Diameter	19.997-20.000 mm	0.7873-0.7874 in
• Pin - Piston Pin End Play	0.210-1.266 mm	0.0083-0.0498 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
• Piston - Piston Ring Groove Width - Top	1.23-1.25 mm	0.0484-0.0492 in
• Piston - Piston Ring Groove Width - Second	1.52-1.54 mm	0.0598-0.0606 in
• Piston - Piston Ring Groove Width - Oil Control	2.01-2.03 mm	0.0791-0.0799 in
• Piston - Piston To Bore Clearance, without polymer	0.010-0.041 mm	0.0004-0.0016 in
Valve System		
• Valves - Valve Face Angle	45 Degrees	
• Valves - Valve Face Runout - Maximum	0.04 mm	0.0016 in
• Valves - Valve Seat Runout - Maximum	0.080 mm	0.0031 in
• Valves - Valve Face Seat Width - Exhaust	1.6000 mm	0.06299 in
• Valves - Valve Face Seat Width - Intake	1.2000 mm	0.04724 in
• Valves - Valve Head Diameter - Exhaust	29.950-30.250 mm	1.1791-1.1909 in
• Valves - Valve Head Diameter - Intake	34.950-35.250 mm	1.3760-1.4154 in
• Valves - Valve Head O.D. and Chamfer Height - Exhaust	1.1174 mm	0.04399 in
• Valves - Valve Head O.D. and Chamfer Height - Intake	1.0526 mm	0.04144 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 Height - Closed	32.500 mm	1.2795 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 -	0.013-0.051 mm	3.2210-3.2299 in

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Stationary Lash Adjuster		
• Valve Rocker Arms - Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arms - Rocker Arm Roller Diameter	17.740-17.800 mm	0.6987-0.7008 in
• Valve Springs - Valve Spring Free Length	41.400-44.200 mm	1.6299-1.7402 in
• Valve Springs - Valve Spring Installed Height - Closed	32.500 mm	1.2795 in
• Valve Springs - Valve Spring Installed Height - Open	22.500 mm	0.8858 in
• Valve Springs - Valve Spring Load - Closed - @32.5 mm	245.0-271.0 N	55-61 lb
• Valve Springs - Valve Spring Load - Open - @22.5 mm	525.0-575.0 N	118-129 lb

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

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	Engine Oil	12345610	993193
Fuel Injector O-rings	Engine Oil	12345610	993193
Fuel Injector Tip Insulators	Engine Oil	12345610	993193
Hydraulic Lash Adjusters	Lubricant	12345501	992704
Intake and Exhaust Valve Stems	Lubricant	12345501	992704
Main Bearings	Lubricant	12345501	992704
Oil Filter Cap - Threads and O-ring Lead-in Chamfers	Engine Oil	12345610	993193
Oil Level Indicator Tube O-ring	Lubricant	12345501	992704
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
	Cutting Fluid	1052864	992881

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Thread Repair	Cleaner	12346139 12377981	10953463
Timing Chain Guide Bolt Access Hole Plug	Sealant	12345382	10953489
Valves	Parts Immersion Solvent	12345368	10953514
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

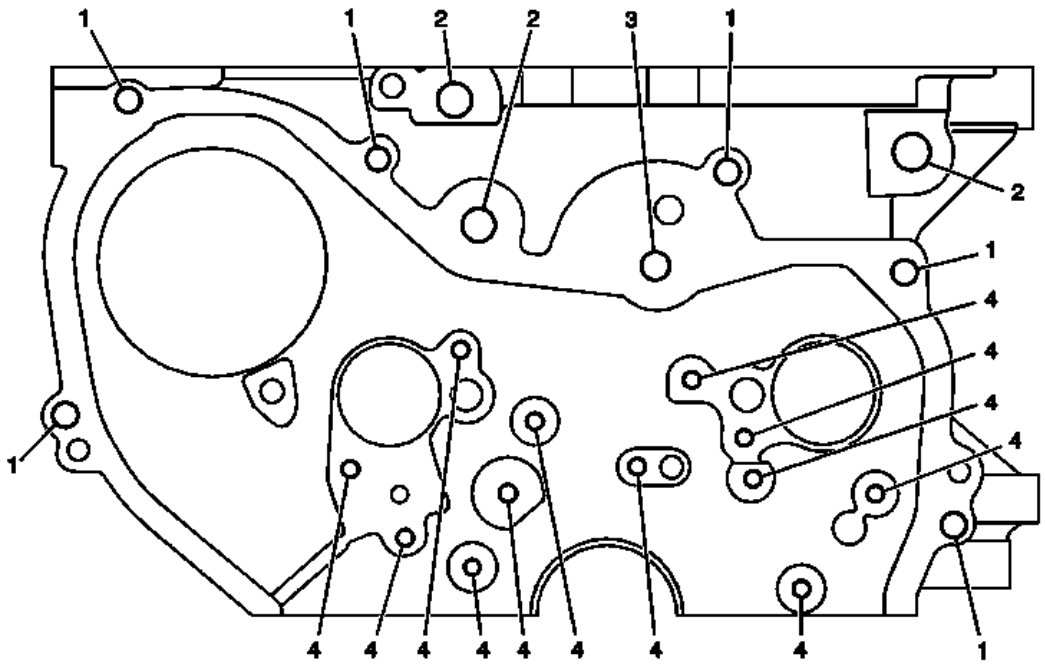

Fig. 1: Identifying Bolt Size & Locations On Engine Block - Front View
Courtesy of GENERAL MOTORS CORP.

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)
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

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4	M6 x 1	205	201	202	203	204	20	0.787	16	0.63

Engine Block - Back View

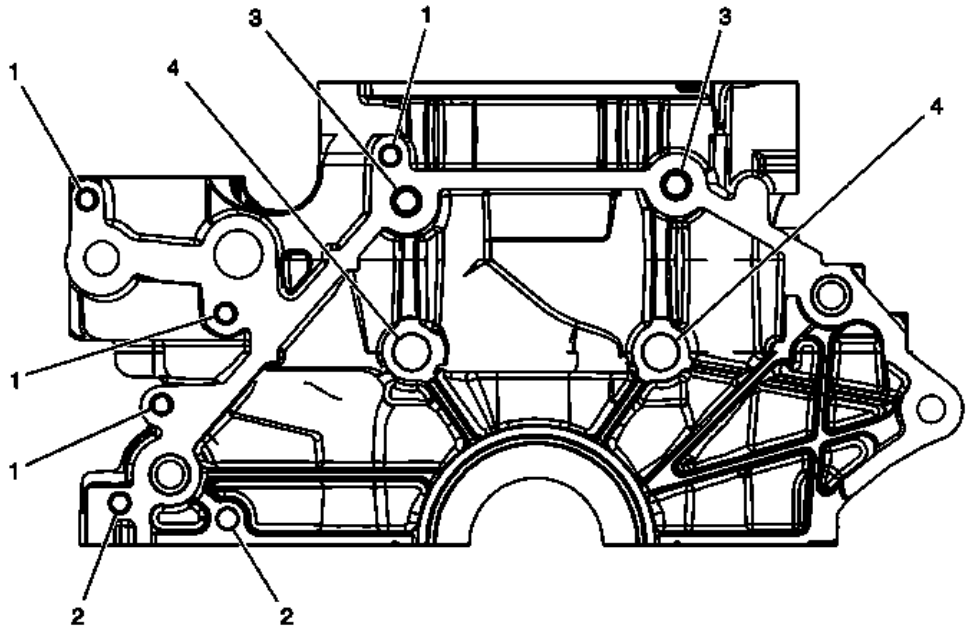

Fig. 2: Identifying Bolt Size & Locations On Engine Block - Back View
Courtesy of GENERAL MOTORS CORP.

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 - Right Side View

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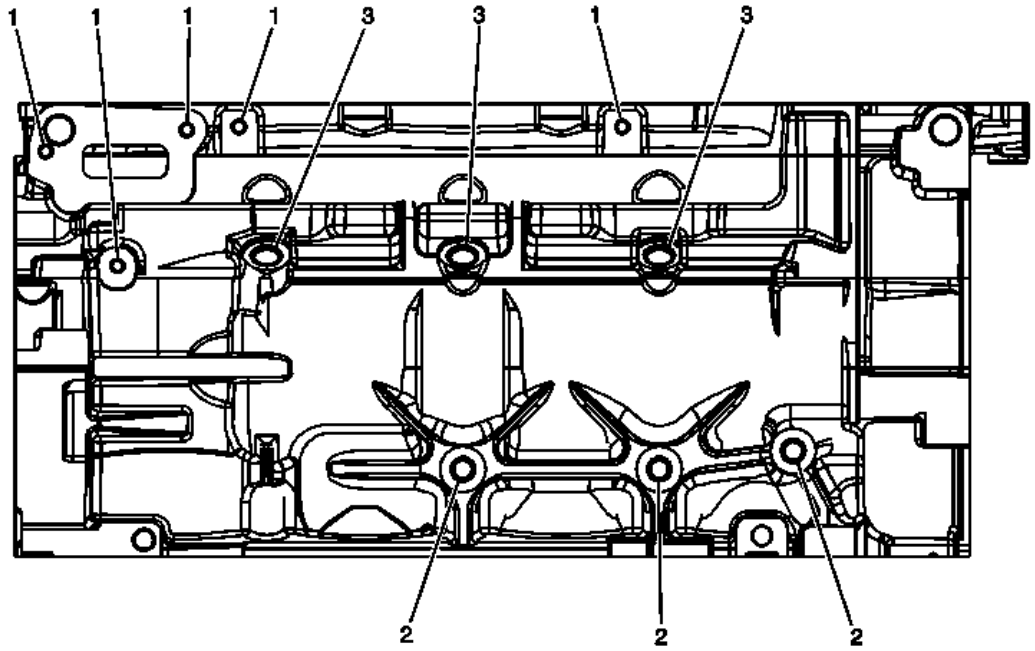

Fig. 3: Identifying Bolt Size & Locations On Engine Block - Back View
Courtesy of GENERAL MOTORS CORP.

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	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 - Left Side View

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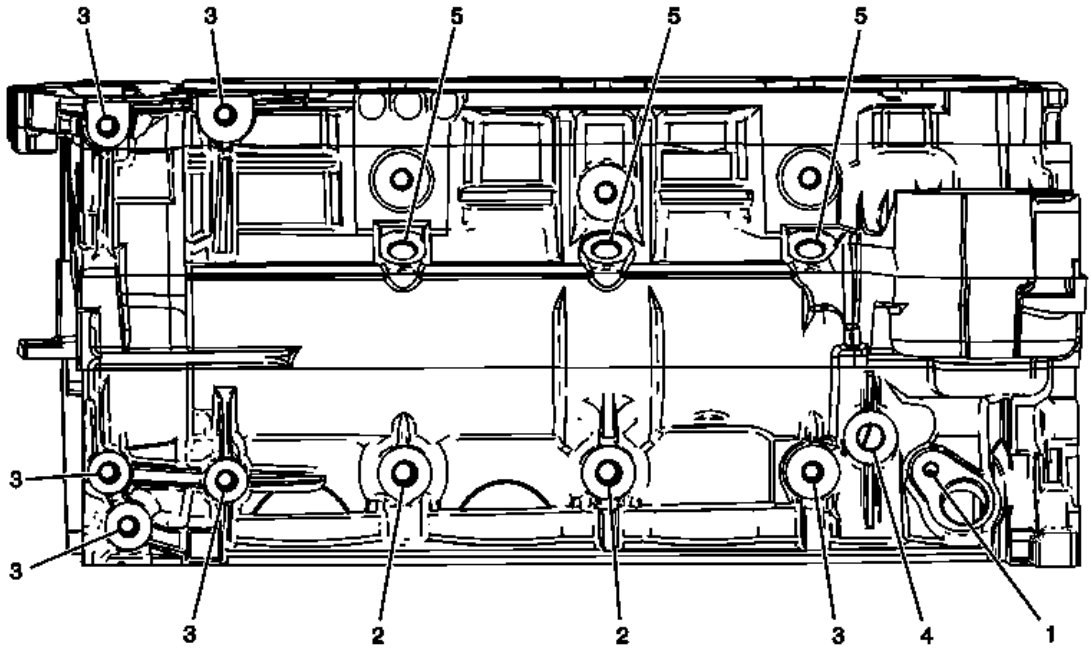

Fig. 4: Identifying Bolt Size & Locations On Engine Block - Left Side View
Courtesy of GENERAL MOTORS CORP.

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	16.5	0.65
2	M10 x 1.5	215	211	212	213	214	23.5	0.925	18	0.71
3	M8 x 1.25	210	206	2047	208	209	30.5	1.201	22.5	0.89
4	M12 x 1.75	865	856	857	858	859	15.5	.061	12.5	0.49
5	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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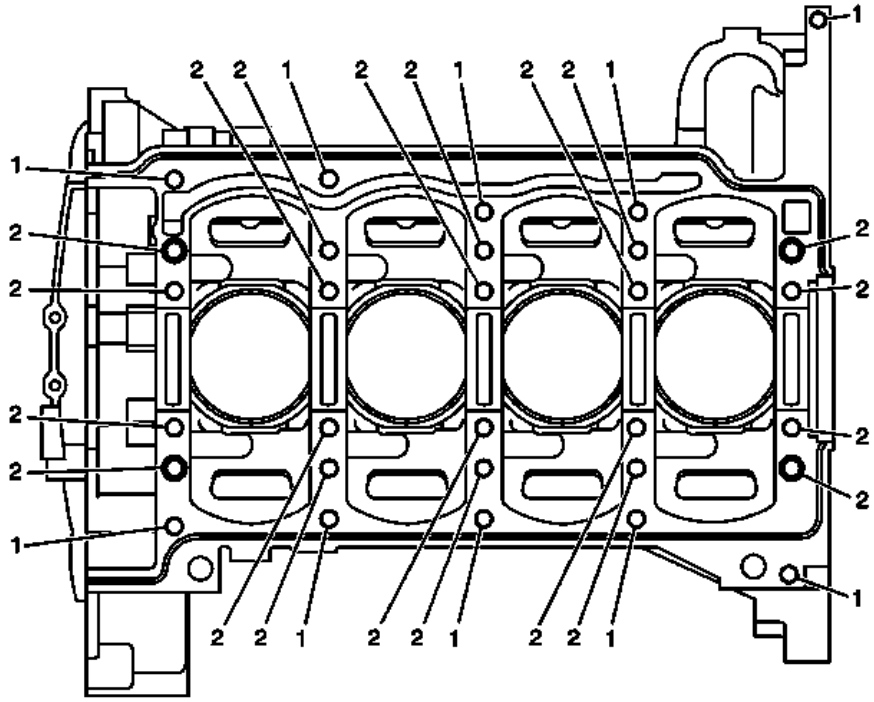

Fig. 5: Identifying Bolt Size & Locations On Engine Block - Bottom
Courtesy of GENERAL MOTORS CORP.

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 - Top View

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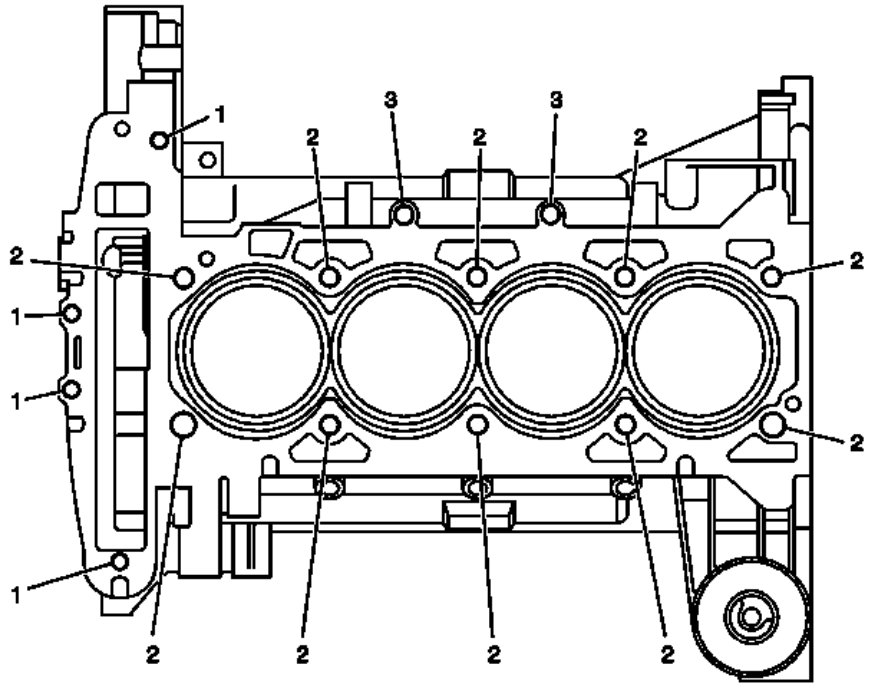

Fig. 6: Identifying Bolt Size & Locations On Engine Block - Top
Courtesy of GENERAL MOTORS CORP.

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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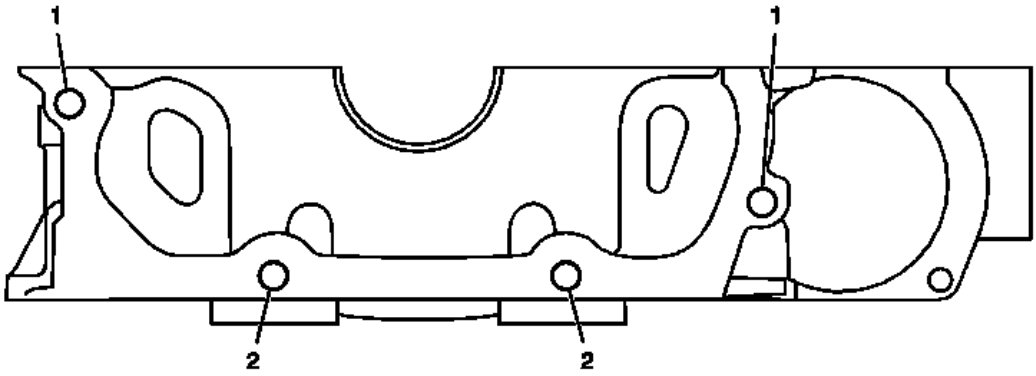

Fig. 7: Identifying Bolt Size & Locations On Engine Block - Top
Courtesy of GENERAL MOTORS CORP.

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

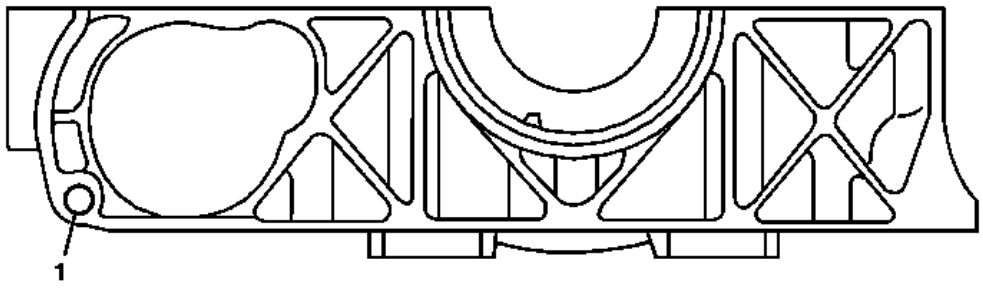

Fig. 8: Identifying Bolt Size & Locations On Lower Crankcase - Back
Courtesy of GENERAL MOTORS CORP.

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

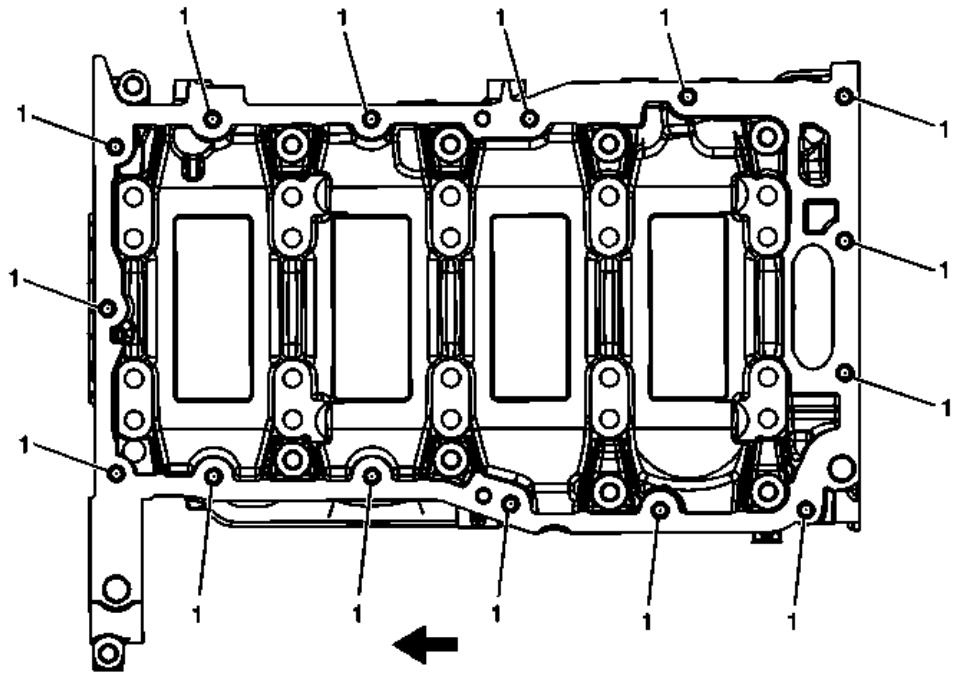

Fig. 9: Lower Crankcase - Bottom View
Courtesy of GENERAL MOTORS CORP.

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 - Right View

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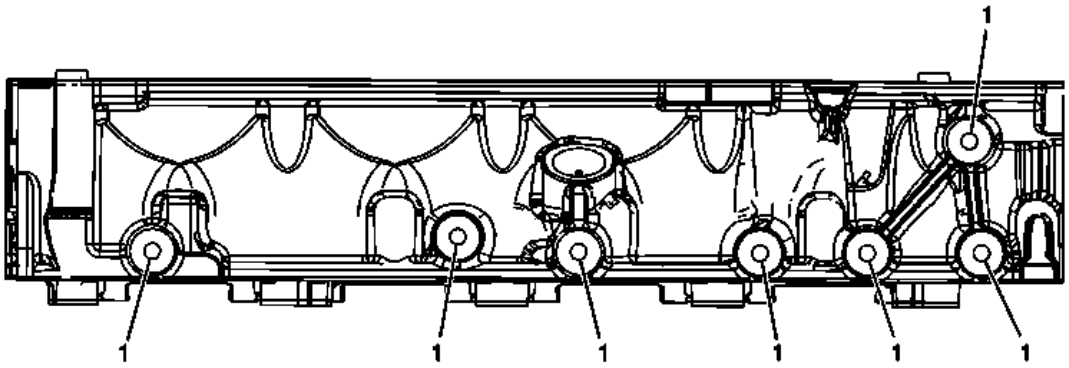

Fig. 10: Identifying Bolt Size & Locations On Lower Crankcase - Right
Courtesy of GENERAL MOTORS CORP.

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	M10 x 1.5	215	211	212	213	214	34	1.339	27	1.063

Lower Crankcase - Left View

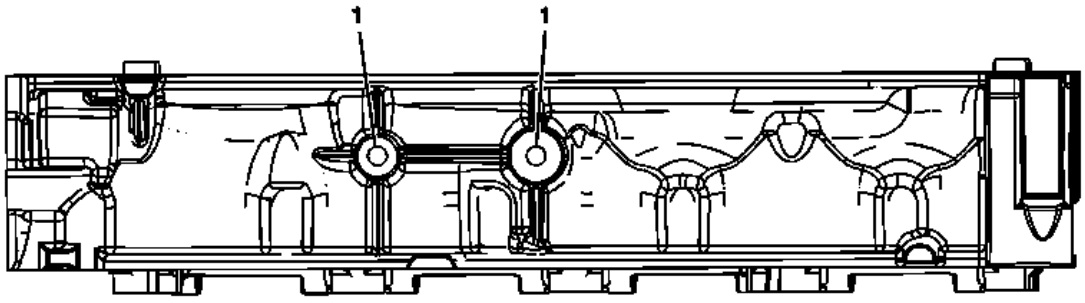

Fig. 11: Identifying Bolt Size & Locations On Lower Crankcase - Left
Courtesy of GENERAL MOTORS CORP.

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)

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1	M8 x 1.25	210	211	212	213	214	34	1.339	27	1.063

Cylinder Head - Top View

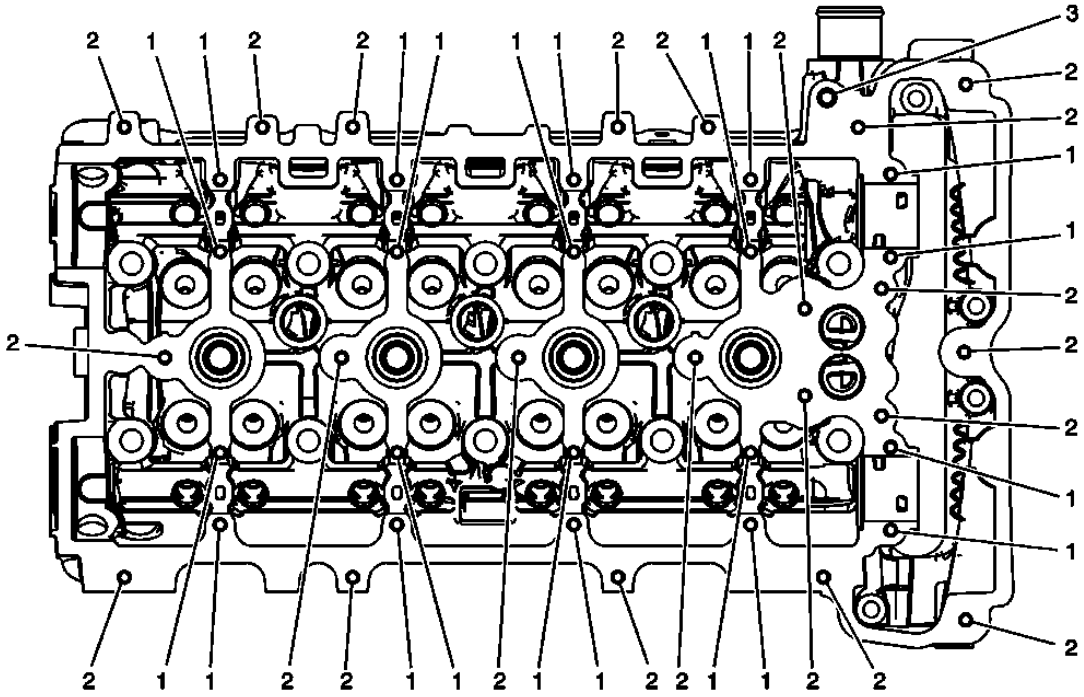

Fig. 12: Cylinder Head - Top View
Courtesy of GENERAL MOTORS CORP.

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	

Cylinder Head - Intake Manifold Deck View

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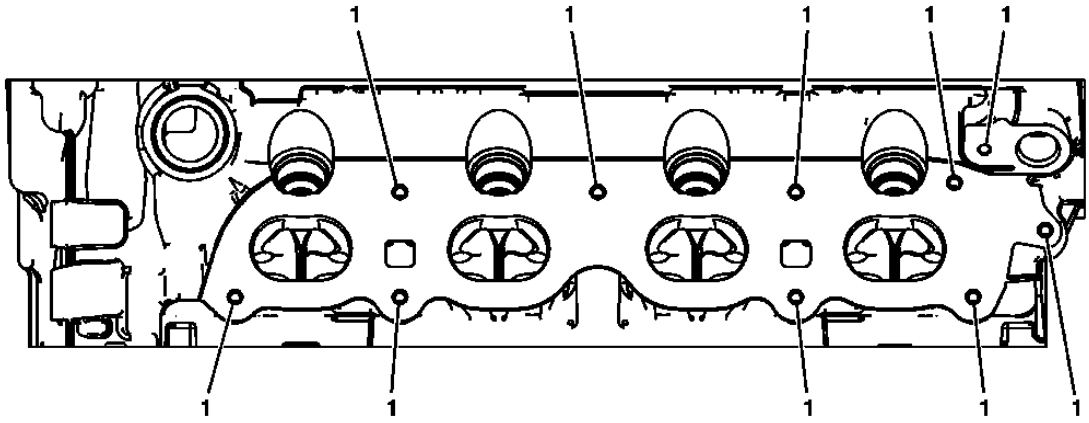

Fig. 13: Cylinder Head - Intake Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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

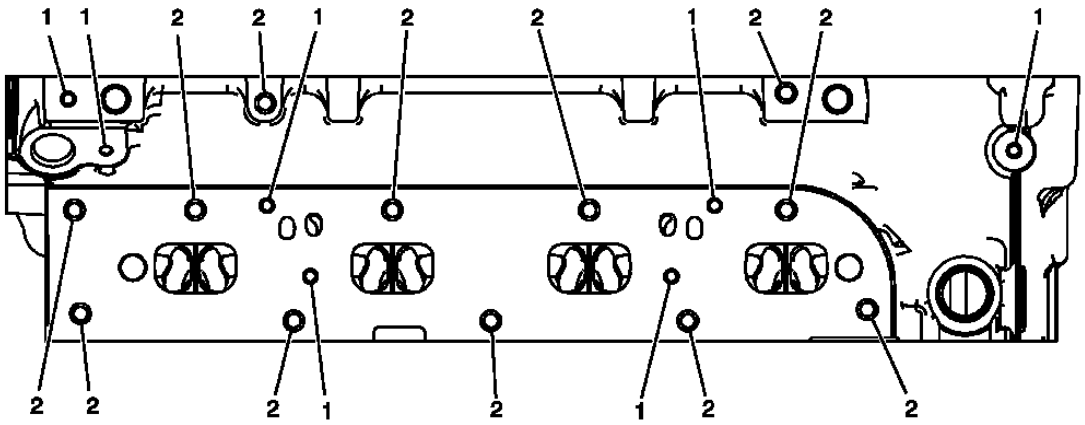

Fig. 14: Cylinder Head - Exhaust Manifold Deck View
Courtesy of GENERAL MOTORS CORP.

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

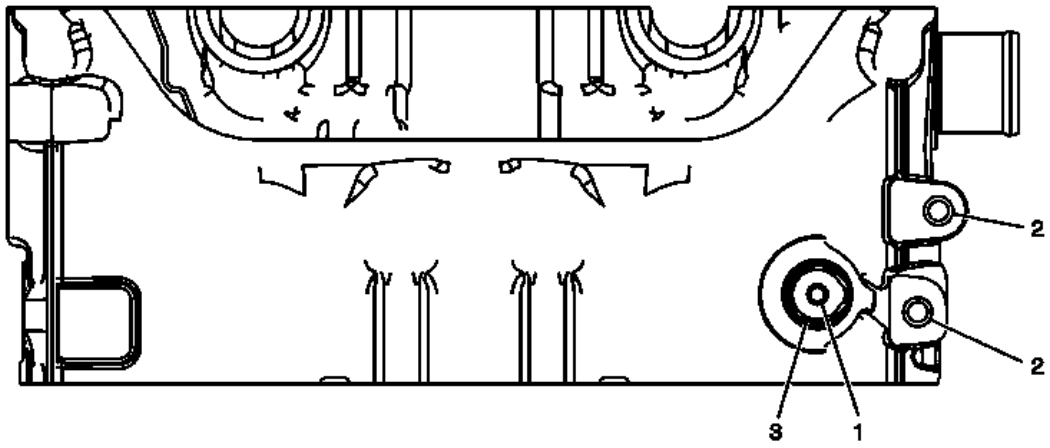

Fig. 15: Cylinder Head - Front View
Courtesy of GENERAL MOTORS CORP.

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
3	M22 x 1.5	No Service Tools Available					THRU		THRU	

Cylinder Head - Back View

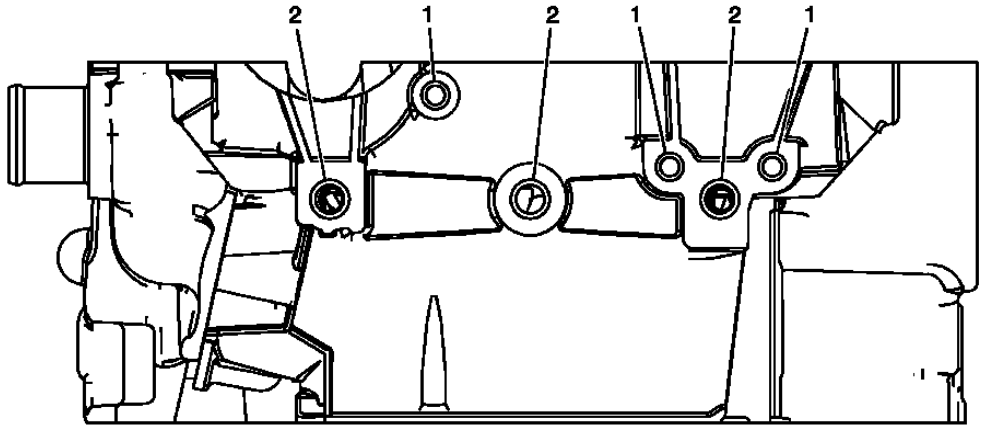

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Fig. 16: Cylinder Head - Back View
Courtesy of GENERAL MOTORS CORP.

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

COMPONENT LOCATOR

DISASSEMBLED VIEWS

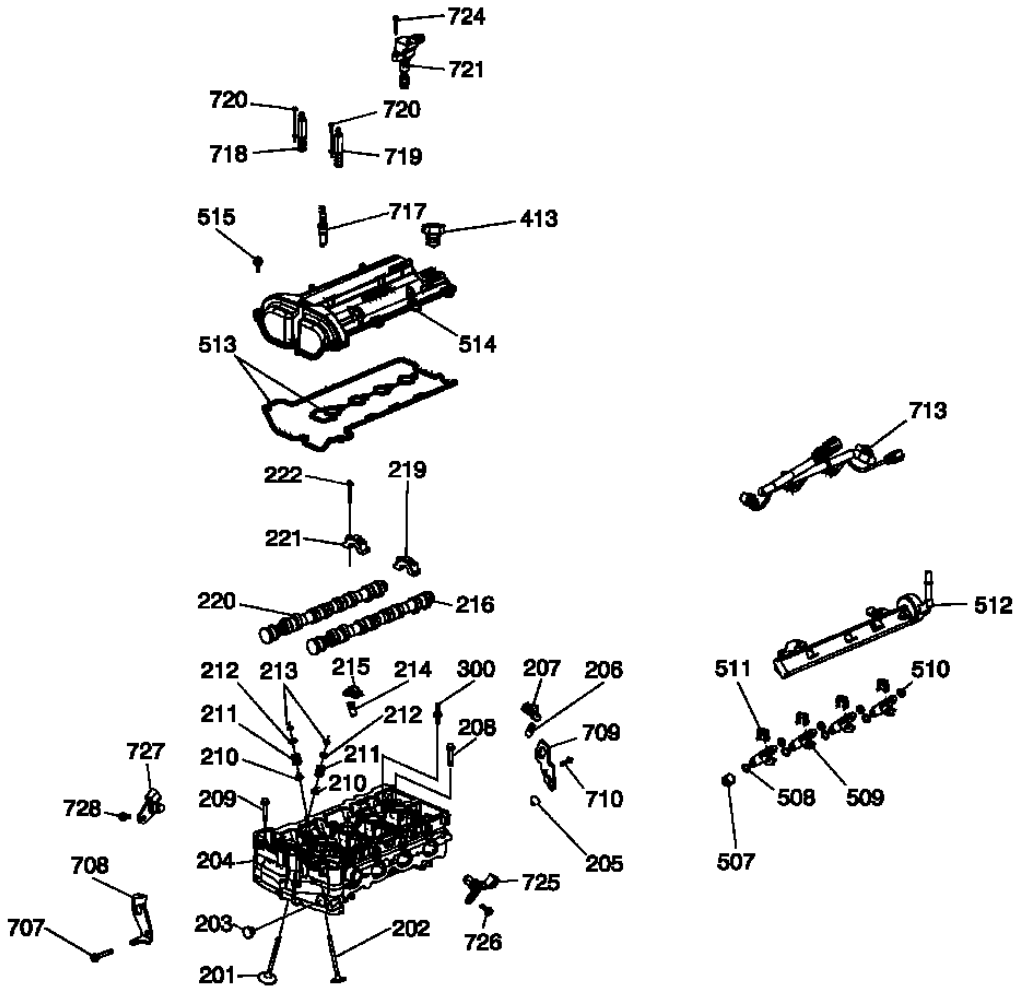

Fig. 17: Cylinder Head and Components
Courtesy of GENERAL MOTORS CORP.

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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
211	Valve Spring
212	Valve Spring Retainer
213	Valve Keys
214	Hydraulic Lash Adjuster
215	Roller Finger Follower
216	lntake Camshaft
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
707	Front Lift Bracket Bolt
708	Front Lift Bracket
709	Rear Lift Bracket
710	Rear Lift Bracket Bolt
713	Fuel Injector Wiring Harness
717	Spark Plug
718	Camshaft Position Actuator Solenoid Valve - Exhaust
719	Camshaft Position Actuator Solenoid Valve - Intake
720	Camshaft Position Actuator Solenoid Valve Bolt

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	Ignition Coil
724	Ignition Coil Bolt
725	Camshaft Position Sensor
726	Camshaft Position Sensor Bolt
727	Camshaft Position Sensor
728	Camshaft Position Sensor Bolt

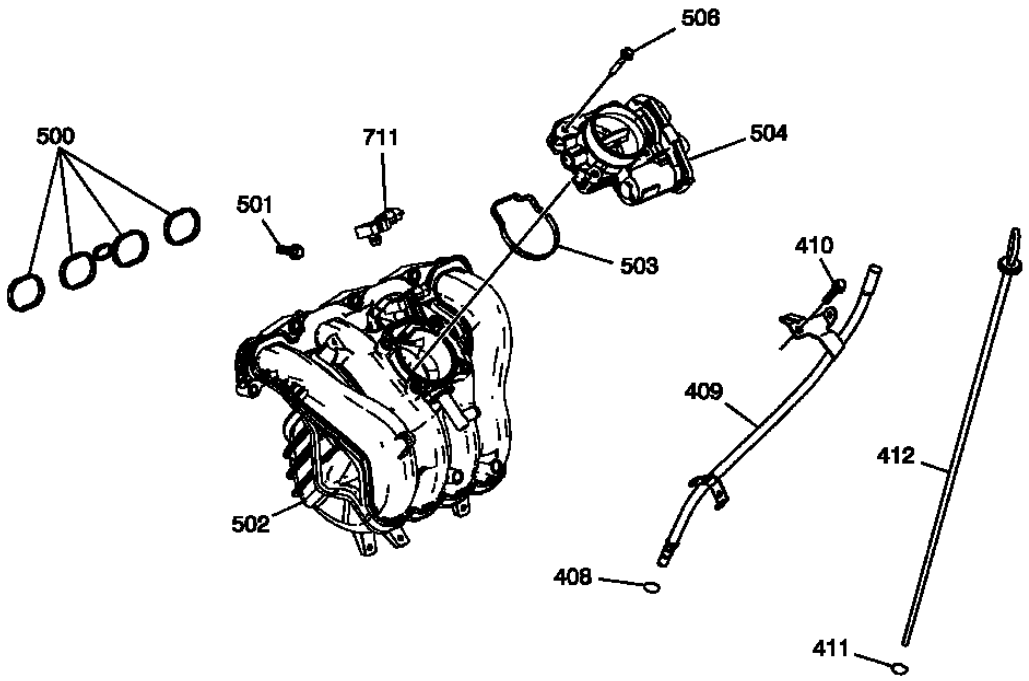

Fig. 18: Intake Manifold and Components
Courtesy of GENERAL MOTORS CORP.

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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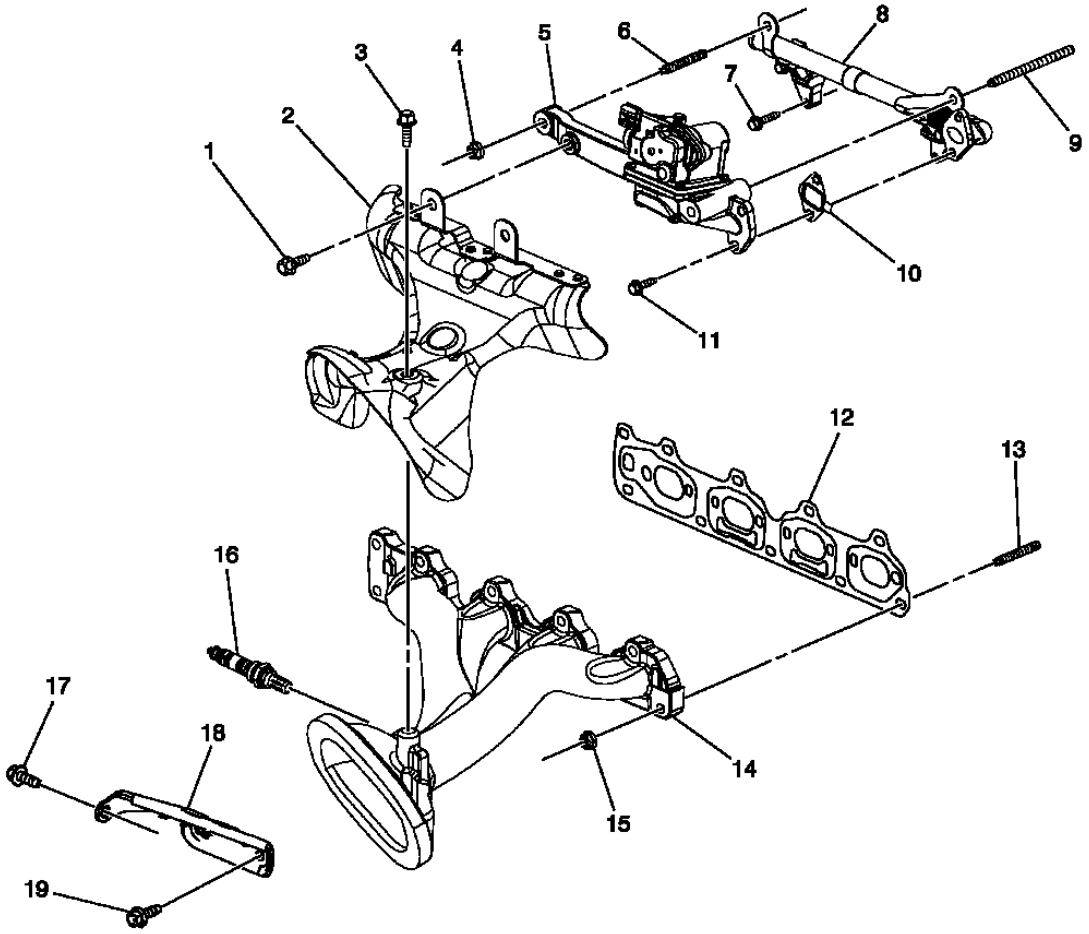

Fig. 19: Exhaust Manifold and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Exhaust Manifold Heat Shield Bolt
2	Exhaust Manifold Heat Shield
3	Exhaust Manifold Heat Shield Bolt
4	Secondary Air Injection Assembly Nut
5	Secondary Air Injection Assembly
6	Secondary Air Injection Check Stud
7	Secondary Air Injection Bolt
8	Secondary Air Injection Pipe Assembly
9	Secondary Air Injection Stud
10	Secondary Air Injection Check Valve Gasket
11	Secondary Air Injection Bolt
12	Exhaust Manifold Gasket
13	Exhaust Manifold Stud

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14	Exhaust Manifold
15	Exhaust Manifold Nut
16	Oxygen Sensor
17	Exhaust Manifold Brace Bolt
18	Exhaust Manifold Brace
19	Exhaust Manifold Brace Bolt

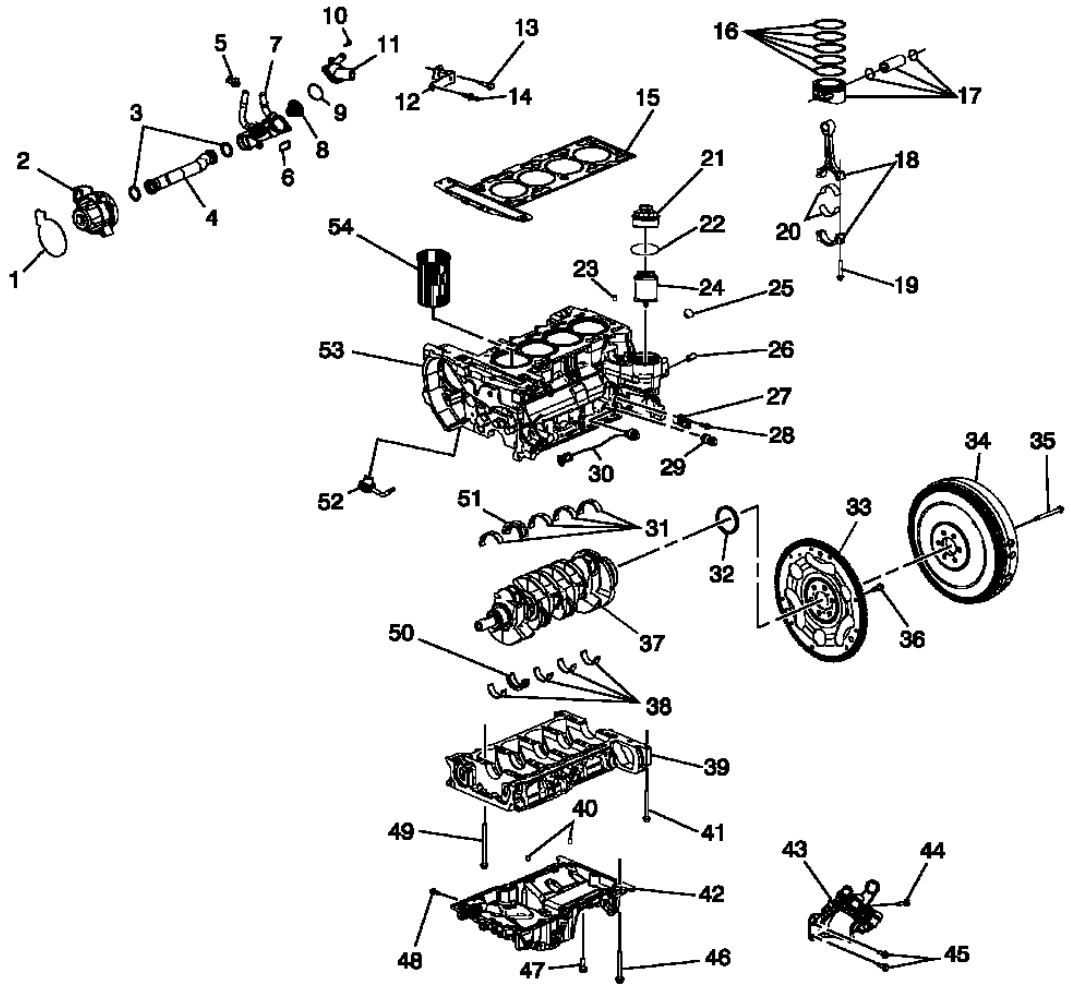

Fig. 20: Engine Block and Components
Courtesy of GENERAL MOTORS CORP.

Callout	Component Name
1	Water Pump to Engine Block Seal
2	Water Pump
3	Water Transfer Pipe O-ring Seals
4	Water Transfer Pipe
5	Coolant Temperature Sensor
6	Thermostat Housing to Block Gasket

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7	Thermostat Housing
8	Thermostat
9	Thermostat Gasket
10	Thermostat Housing Cap Bolt
11	Thermostat Housing Cap
12	Water Pipe Support Bracket
13	Water Pipe Support Bracket Bolt
14	Water Pipe Support Bracket Bolt Stud
15	Cylinder Head Gasket
16	Piston Ring Assembly
17	Piston Assembly
18	Connecting Rod
19	Connecting Rod Cap Bolt
20	Connecting Rod Bearing
21	Oil Filter Cap
22	Oil Filter Cap O-ring
23	Cylinder Head Alignment Pin
24	Oil Filter
25	Engine Block Gallery Plug
26	Engine Block to Transaxle Alignment Pin
27	Crankshaft Position Sensor
28	Crankshaft Position Sensor Bolt
29	Oil Pressure Switch
30	Knock Sensor
31	Crankshaft Bearing - Upper
32	Crankshaft Rear Seal
33	Flywheel - Automatic Transmission
34	Manual Transaxle Flywheel
35	Manual Transaxle Flywheel Bolt
36	Automatic Transaxle Flywheel to Crankshaft Bolt
37	Crankshaft
38	Crankshaft Bearing - Lower
39	Lower Crankcase
40	Engine Oil Pan Alignment Pins
41	Lower Crankcase Perimeter Bolt
42	Engine Oil Pan
43	Air Pump Assembly
44	Air Pump Assembly Bolt
45	Air Pump Assembly Bolt
46	Engine Oil Pan Long Bolt
47	Engine Oil Pan Bolt

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	Engine Oil Pan Drain Plug
49	Lower Crankcase Main Bearing Bolt
50	Crankshaft Thrust Bearing - Lower
51	Crankshaft Thrust Bearing - Upper
52	Piston Oil Nozzle Assembly
53	Engine Block
54	Cylinder Bore Sleeve

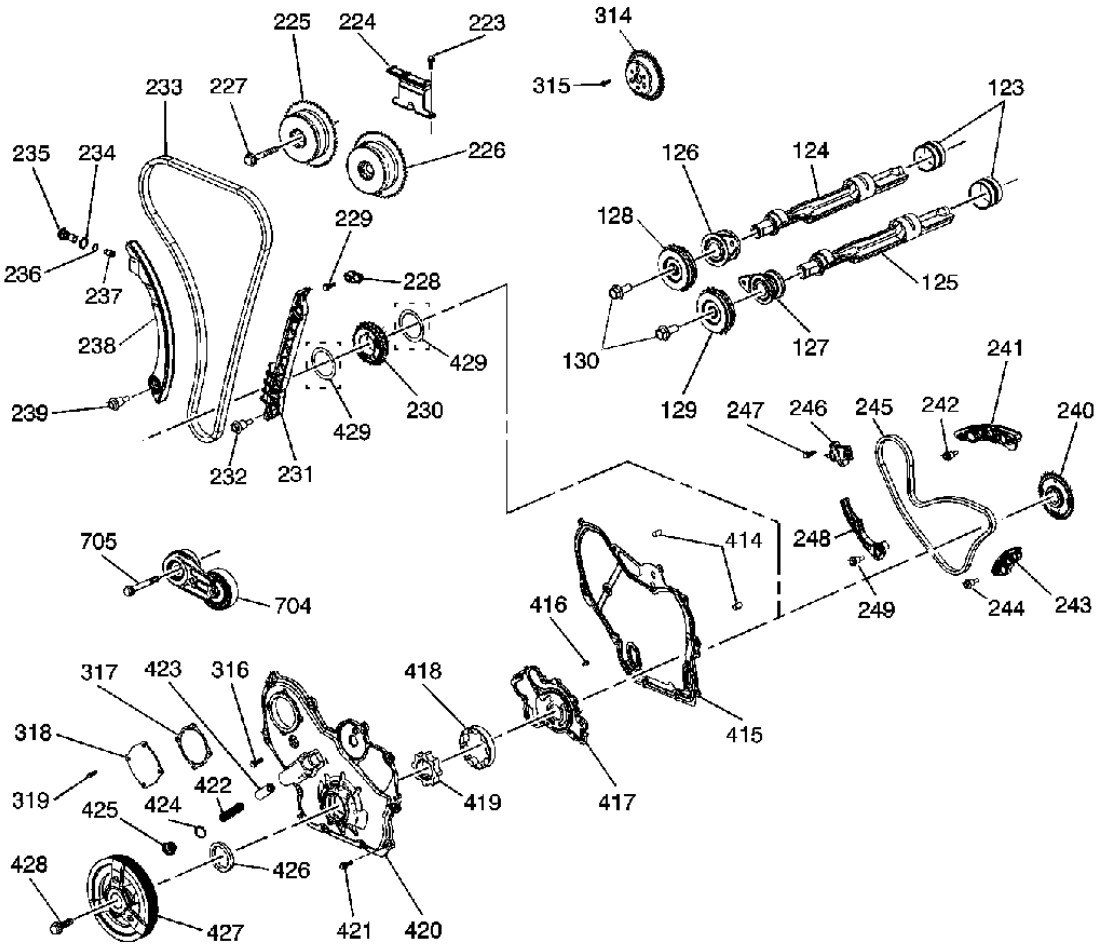

Fig. 21: Timing Chain and Components
Courtesy of GENERAL MOTORS CORP.

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

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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
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

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	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
427	Crankshaft Damper
428	Crankshaft Damper Bolt
429	Friction Washer, some models
704	Belt Tensioner
705	Belt Tensioner Bolt

ENGINE IDENTIFICATION

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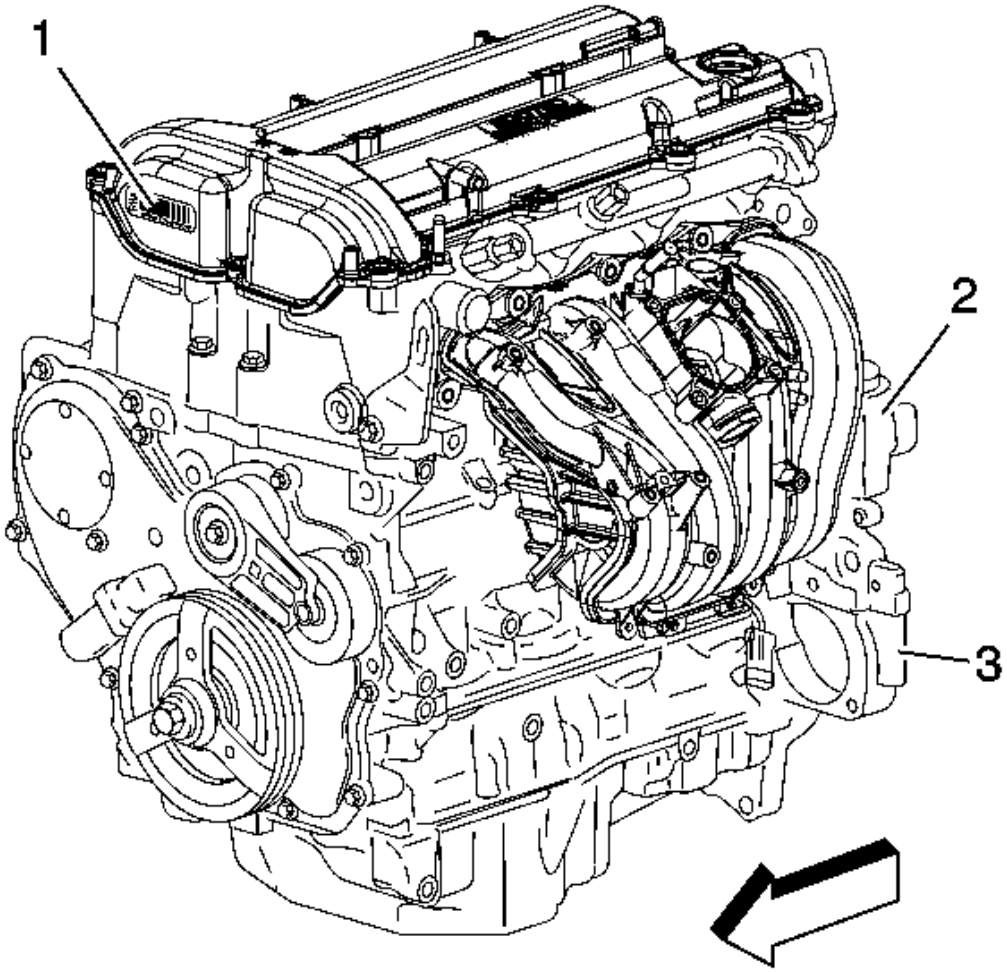

Fig. 22: Locating Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

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 in one of two places - the primary location is on the starter motor flange (3). The secondary location is the oil filter bowl (2).

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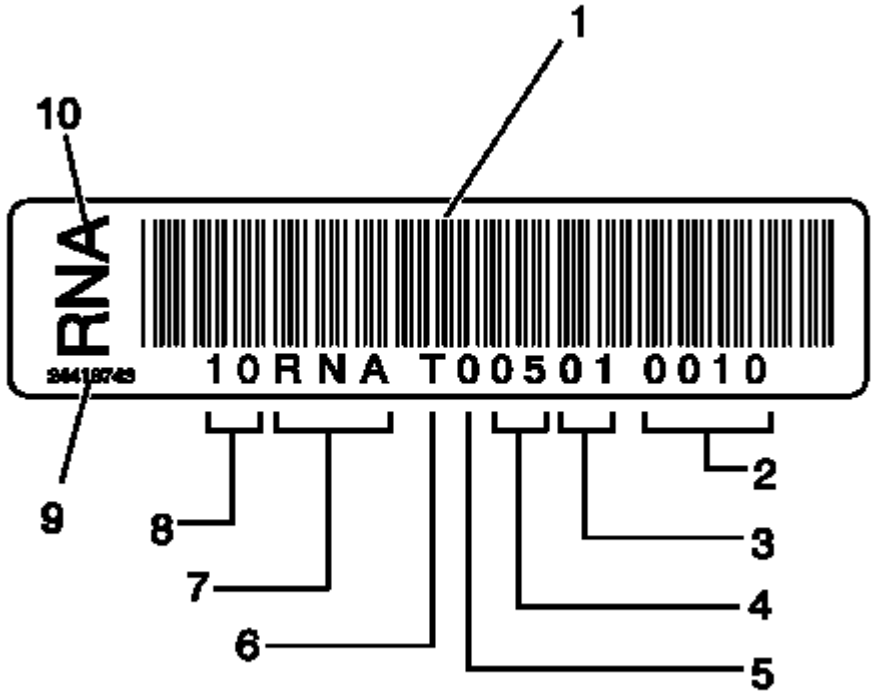

Fig. 23: View Of Broadcast Code Label
Courtesy of GENERAL MOTORS CORP.

- 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

SYMPTOMS - ENGINE MECHANICAL

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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**
- **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**

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- **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

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 The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor as required.
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.

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Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
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 effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	Replace the sensor and/or crankshaft as required.

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,	Replace the drive belt.

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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.	
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

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 valve to not close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets as required.
Worn camshaft lobes	Replace the camshaft and valve lash adjusters.
Sticking lifters	Replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to **Oil Pressure Diagnosis and Testing**. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator

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	solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to **Camshaft Position Intake Actuator Replacement** or **Camshaft Position Exhaust Actuator Replacement**.

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

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

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 operation.

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	2. Repair or replace as required.
Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	1. Verify correct oil pressure. If low, inspect the bottom of the oil filter for oil filter drain back feature. Refer to **Oil Pressure Diagnosis and Testing**. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to **Camshaft Position Intake Actuator Replacement** or **Camshaft Position Exhaust Actuator Replacement**.

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 lash adjusters	Replace the valve lash adjusters.
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 lash adjusters as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required:

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	• 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

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:

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	• The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin, and connecting rod installation - pistons must be installed with the mark or dimple on the top of the piston, facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition. 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
	1. Verify correct oil pressure. If low, inspect the

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Malfunctioning camshaft position actuators - improper oil viscosity or contamination.	bottom of the oil filter for oil filter drain back feature. Refer to **Oil Pressure Diagnosis and Testing**. 2. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator. Refer to **Camshaft Position Intake Actuator Replacement** or **Camshaft Position Exhaust Actuator Replacement**.

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 • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 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	1. Inspect timing chain and gears. 2. Repair as required.
Seized balance shaft	1. Inspect balance shaft. 2. Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material • Cracked cylinder wall	1. Inspect cylinder for damaged components and/or foreign materials. 2. Inspect for fallen cylinder wall. 3. Repair or replace as required.

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Seized crankshaft or connecting rod bearings	1. Inspect crankshaft and connecting rod bearings. 2. Inspect for fallen cylinder wall. 3. Repair as required.
Bent or broken connecting rod	1. Inspect connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect crankshaft. 2. Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate** . 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. 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

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	

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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

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gauge at zero and crank the engine through 4 compression strokes, 4 puffs.
8. Measure the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Measure the compression again and record the reading.
10. The minimum compression in any 1 cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1 035 x 70% = 725) (150 x 70% = 105).
    - Normal - Compression builds up quickly and evenly to the specified compression for each cylinder.
    - Piston Rings Leaking - Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
    - Valves Leaking - Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
    - If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

CYLINDER LEAKAGE TEST

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Special Tools

J 35667-A: Cylinder Head Leakdown Tester

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

NOTE: 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 lash adjusters
- 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

WARNING: Unless directed otherwise, the ignition and start switch must be in the OFF or LOCK position, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components.
For Vehicles equipped with OnStar® (UE1) with Back Up Battery: The Back Up Battery is a redundant power supply to allow limited OnStar® functionality in the event of a main vehicle battery power disruption to the VCIM (OnStar®module). Do not disconnect the main vehicle battery or remove the OnStar® fuse with the ignition key in any position other than OFF. Retained accessory power (RAP) should be allowed to time out or be disabled (simply opening the driver door should disable RAP) before disconnecting power. Disconnecting power to the OnStar® module in any way while the ignition is On or with RAP activated may cause activation of the OnStar® Back-Up Battery (BUB) system and will discharge and permanently damage the back-up battery. Once the Back-Up Battery is activated it will stay on until it has completely discharged. The BUB is not rechargeable and once activated the BUB must be replaced.

1. Disconnect the battery ground negative cable.

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

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

5. Apply shop air pressure to the **J 35667-A:** tester and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage 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.

- 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.

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- 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

Tools Required

J-21867-850 Oil Pressure Gauge Adapter. See **Special Tools**.

1. 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.

2. Run the engine, and verify low, or no oil pressure on the vehicle gauge or light.

   Listen for a noisy valve train or a knocking noise.

3. Inspect for the following:
   - Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
   - 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 gauge
   - Plugged oil filter
   - Malfunctioning oil bypass valve
4. Remove the oil pressure sender or another engine block oil gallery plug.
5. Install **J-21867-850** and an oil pressure gauge and measure the engine oil pressure. See **Special Tools**.
6. Compare the readings to specifications. Refer to **Engine Mechanical Specifications (LAP, LE8)**.
7. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
   - Correct oil filter with anti-drain back feature and O-ring on the cylinder block side of the filter
   - Oil pump worn or dirty

     Refer to **Oil Pump Disassemble** .

   - Oil pump-to-engine front cover bolts loose

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

   - Oil pump screen loose, plugged, or damaged

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

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

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

  Refer to **Engine Block Assemble (LAP)** .

- Broken lash adjusters

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 (LAP, LE8)**. 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**
	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several miles at normal		

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4	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**
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		

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	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 (WITHOUT TURBOCHARGER)

Special Tools

J 23951 Valve Manometer

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1. Remove the oil level indicator. Install a **J 23951** or equivalent.
2. Start the engine.
3. Check for slight vacuum. The vacuum level should be less than 3.377 kPa (1 in Hg).
4. If vacuum is higher, inspect and verify that the clean air hose from cam cover to air intake is not blocked or kinked.
5. If vacuum is in the normal range, block or pinch off the clean air hose. The clean air hose is the hose between the cam cover and air intake system. Vacuum should increase on the manometer. If held too long, vacuum will be drawn through the crankshaft seals creating a sucking sound.
6. If vacuum does not increase, the orifice in the intake manifold could be plugged.
7. If there is zero vacuum or pressure, verify compression of the engine.
8. If compression is normal, check for a blocked orifice at the intake manifold. Clean the orifice.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

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

Test Description

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

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

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

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

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

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

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

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

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

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

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

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

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

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	perform the necessary inspections?	Go to **Step 2**	**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	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Tightening Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 19**
	Inspect for an accessory drive component seized		

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

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

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one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

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

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

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

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

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

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: o Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove o The separation of the drive belt o A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • 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. If the engine has multiple drive belts, remove the belts one at a time and perform the test below		

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3	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	**CAUTION:** **Refer to Fastener Caution .** 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 (LNF)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

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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 snapping the throttle.

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

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	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

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

INTAKE MANIFOLD COVER REPLACEMENT

Removal Procedure

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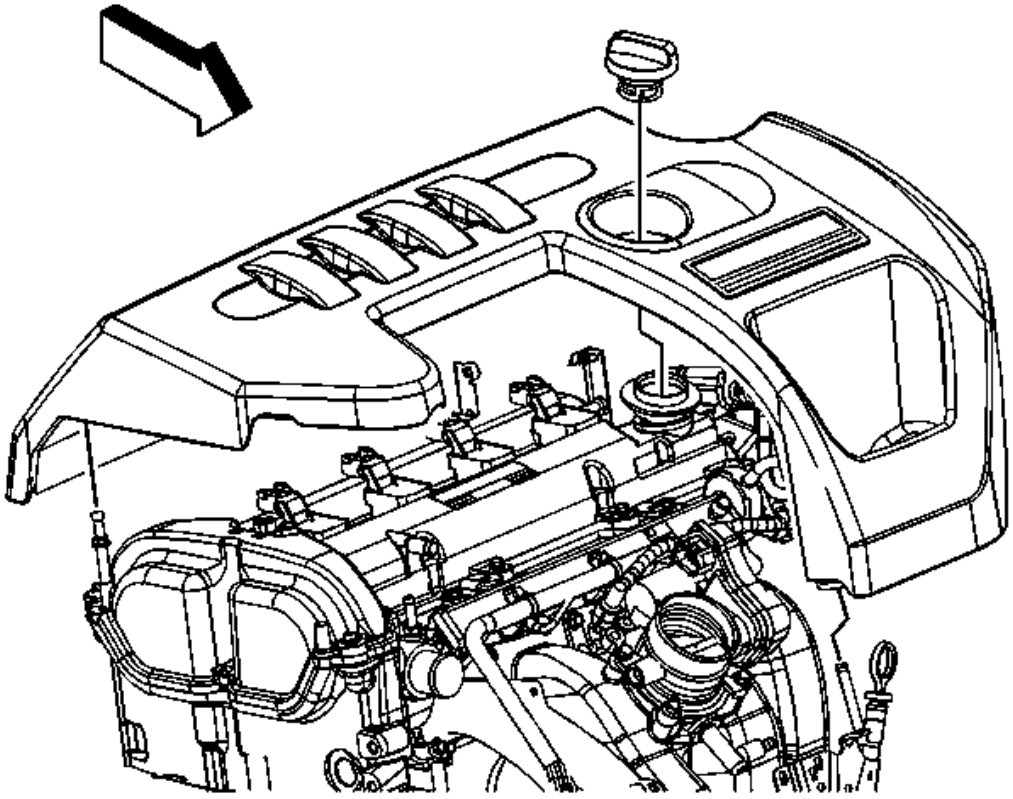

Fig. 24: View Of Intake Manifold Cover
Courtesy of GENERAL MOTORS CORP.

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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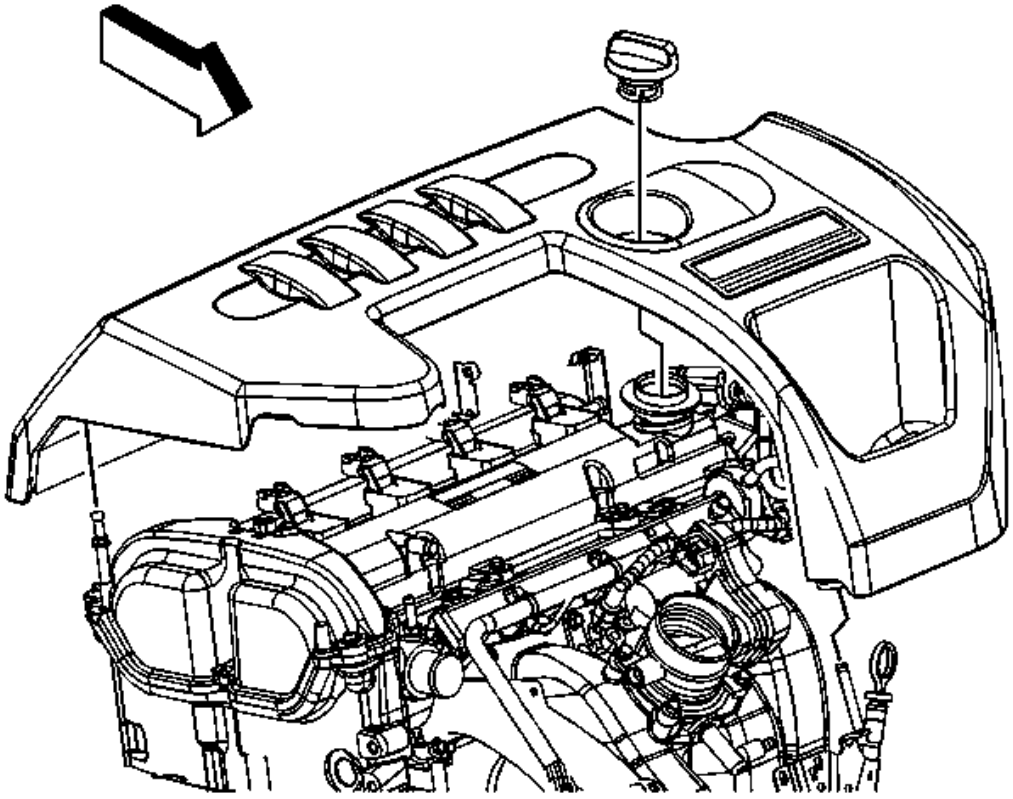

Fig. 25: View Of Intake Manifold Cover
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

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

Removal Procedure

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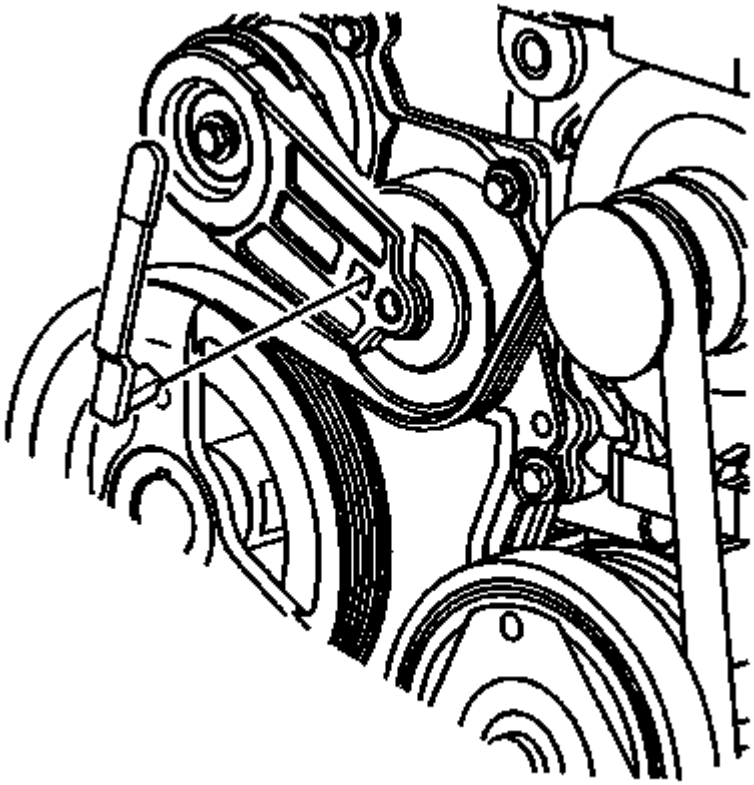

Fig. 26: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine splash shield. Refer to **Engine Splash Shield Replacement - Right Side** .
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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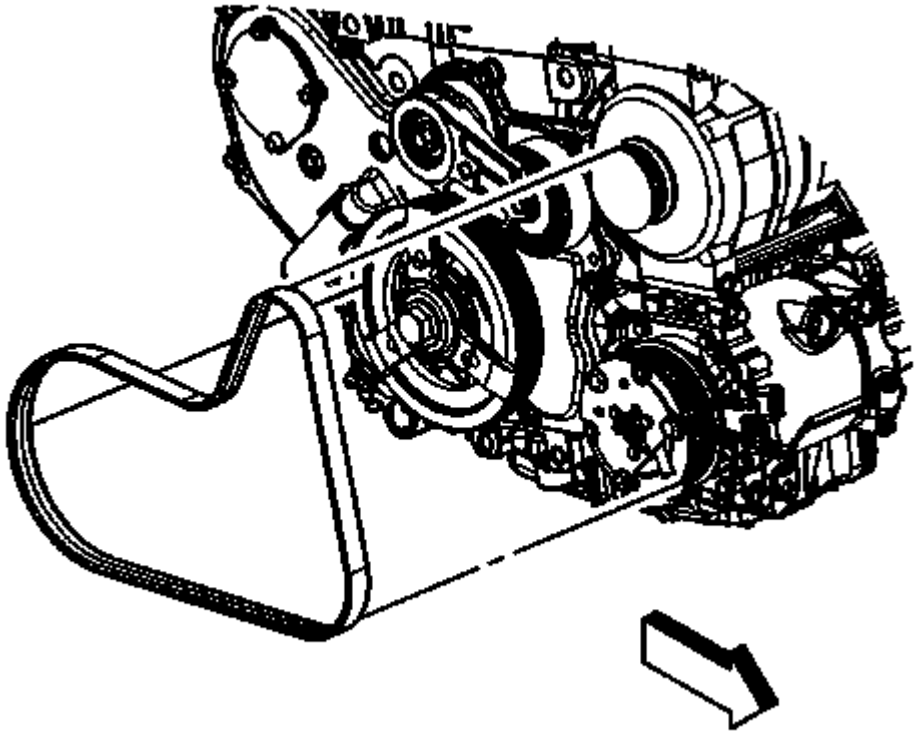

Fig. 27: Drive Belt
Courtesy of GENERAL MOTORS CORP.

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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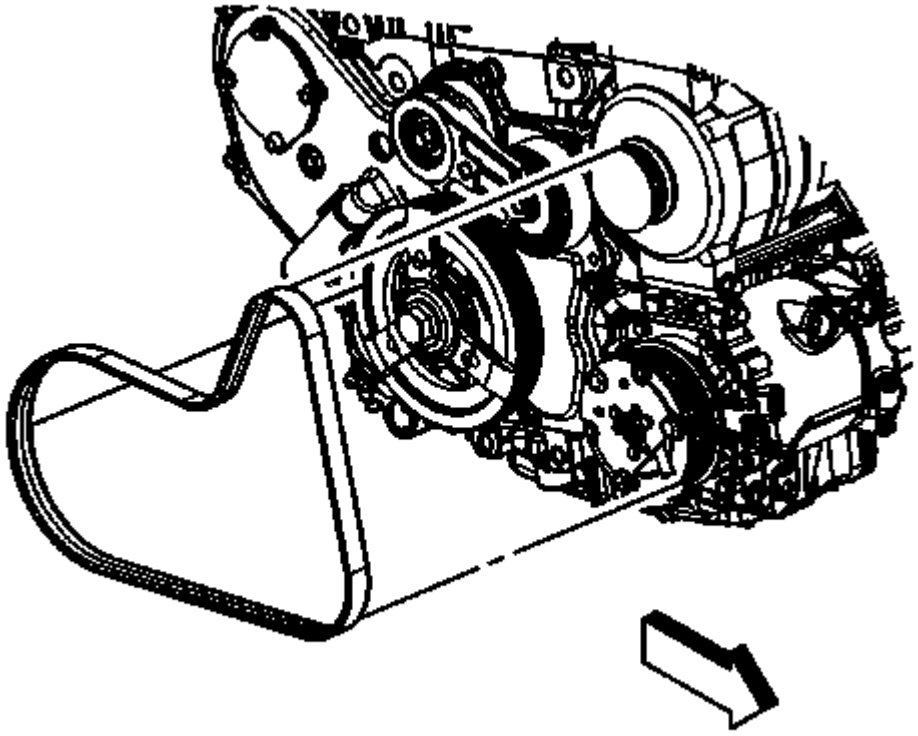

Fig. 28: Drive Belt
Courtesy of GENERAL MOTORS CORP.

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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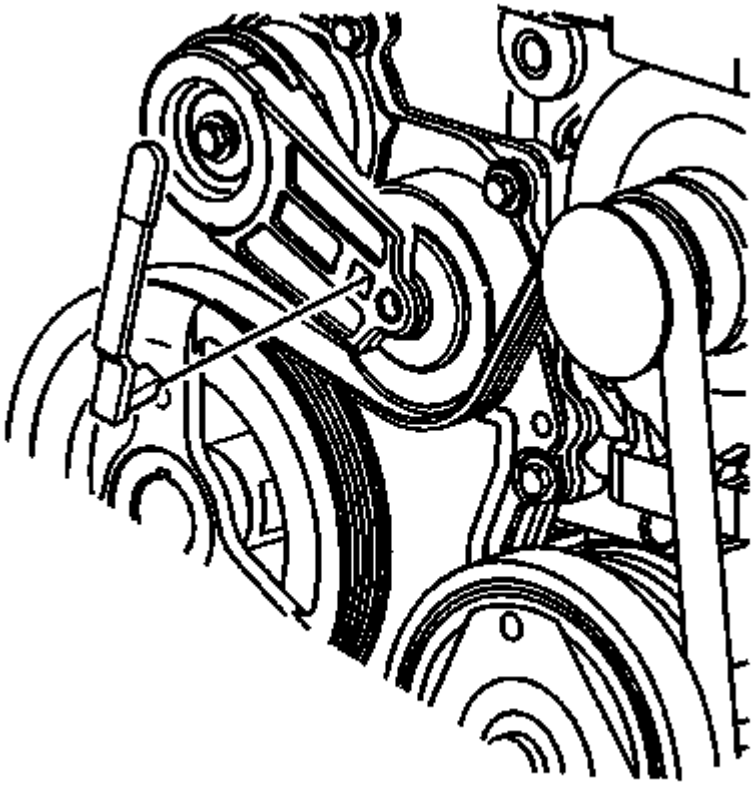

Fig. 29: View Of Drive Belt Tensioner And Special Tool
Courtesy of GENERAL MOTORS CORP.

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 **Engine Splash Shield Replacement - Right Side** .

DRIVE BELT TENSIONER REPLACEMENT

Removal Procedure

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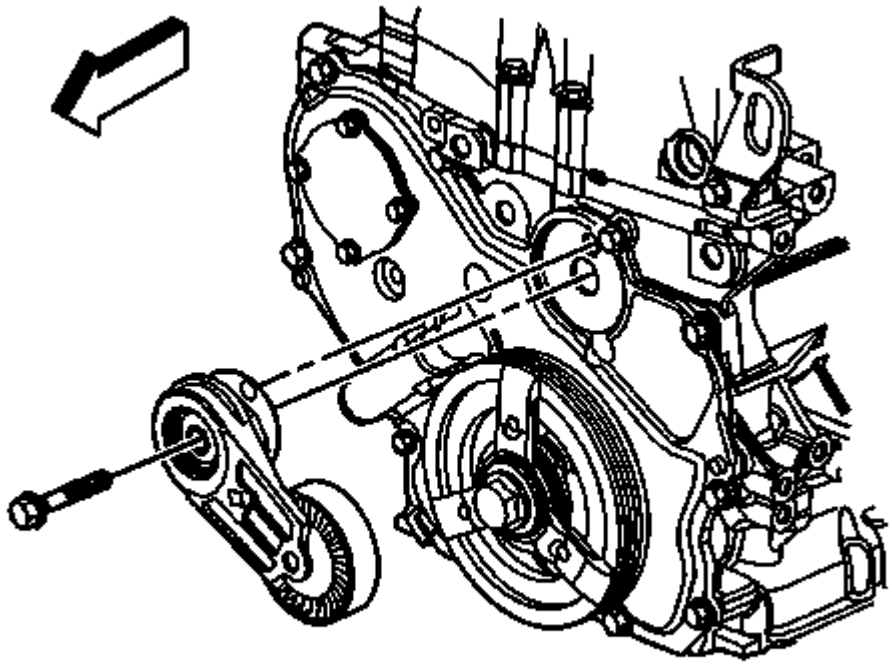

Fig. 30: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

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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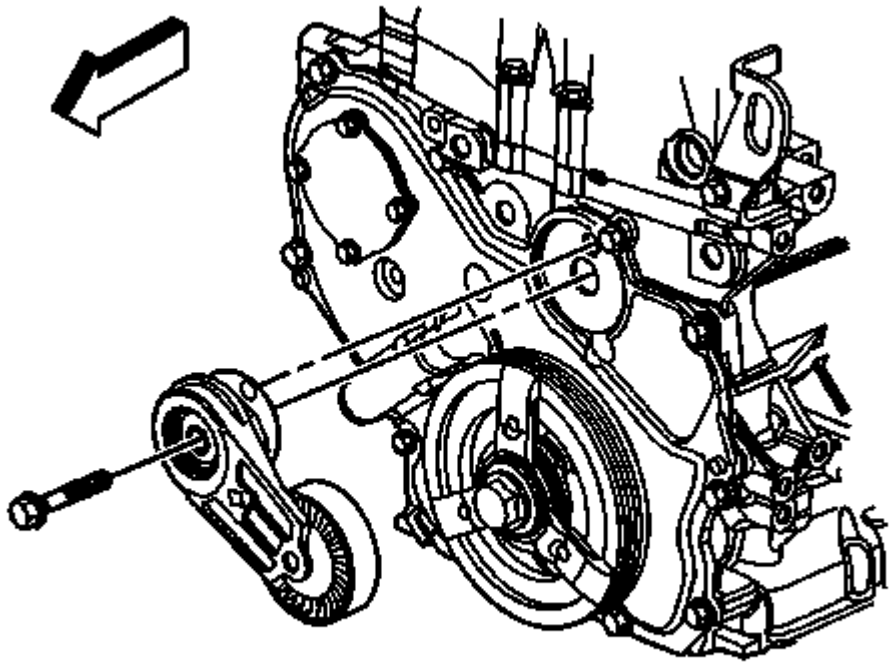

Fig. 31: Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Position the drive belt tensioner.

CAUTION: Refer to Fastener Caution .

2. Install the drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).
3. Install the drive belt. Refer to **Drive Belt Replacement**.

ENGINE OIL PRESSURE SWITCH REPLACEMENT

Removal Procedure

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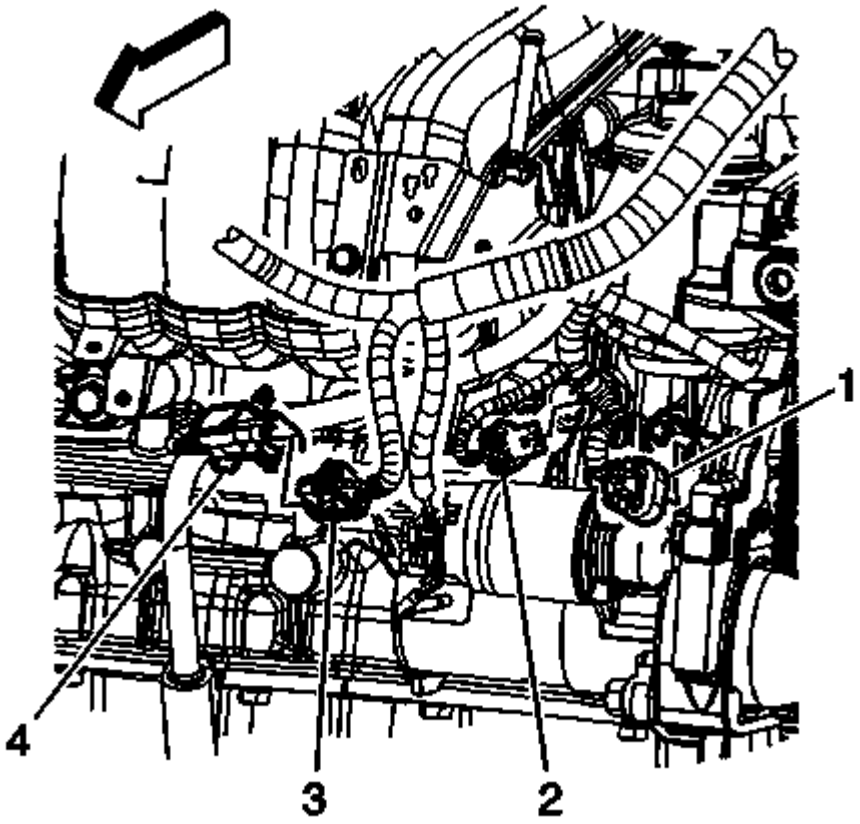

Fig. 32: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

1. Remove the starter. Refer to **Starter Replacement** .
2. Disconnect the engine wiring harness electrical connector (2) from the oil pressure switch.

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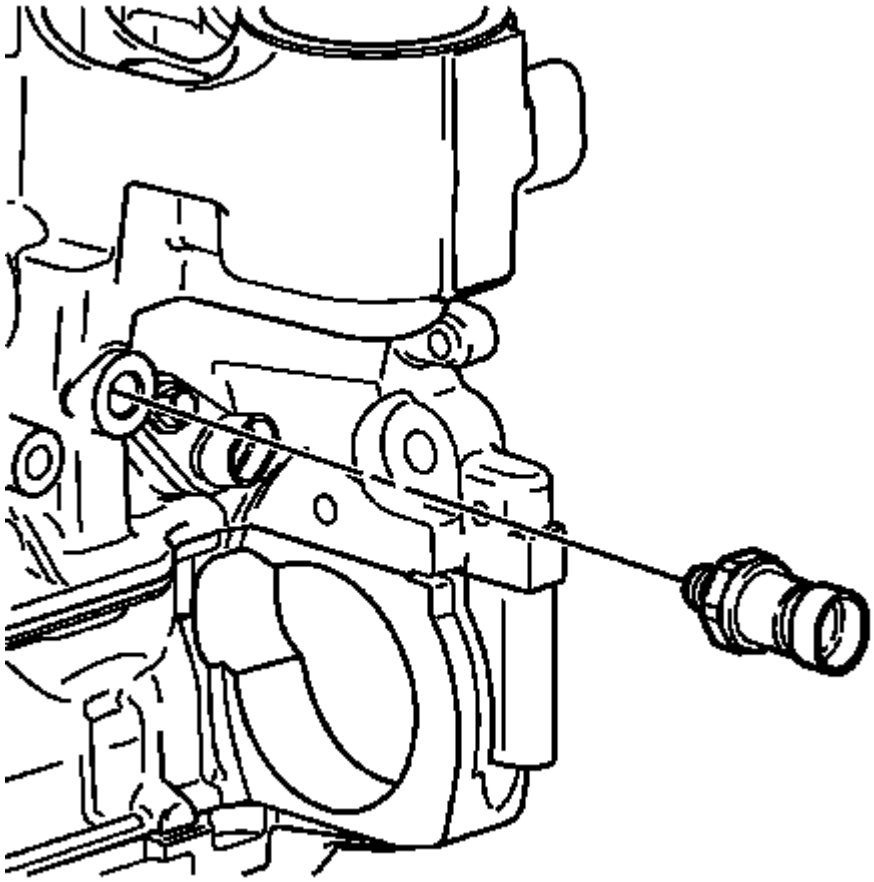

Fig. 33: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine oil pressure switch.

Installation Procedure

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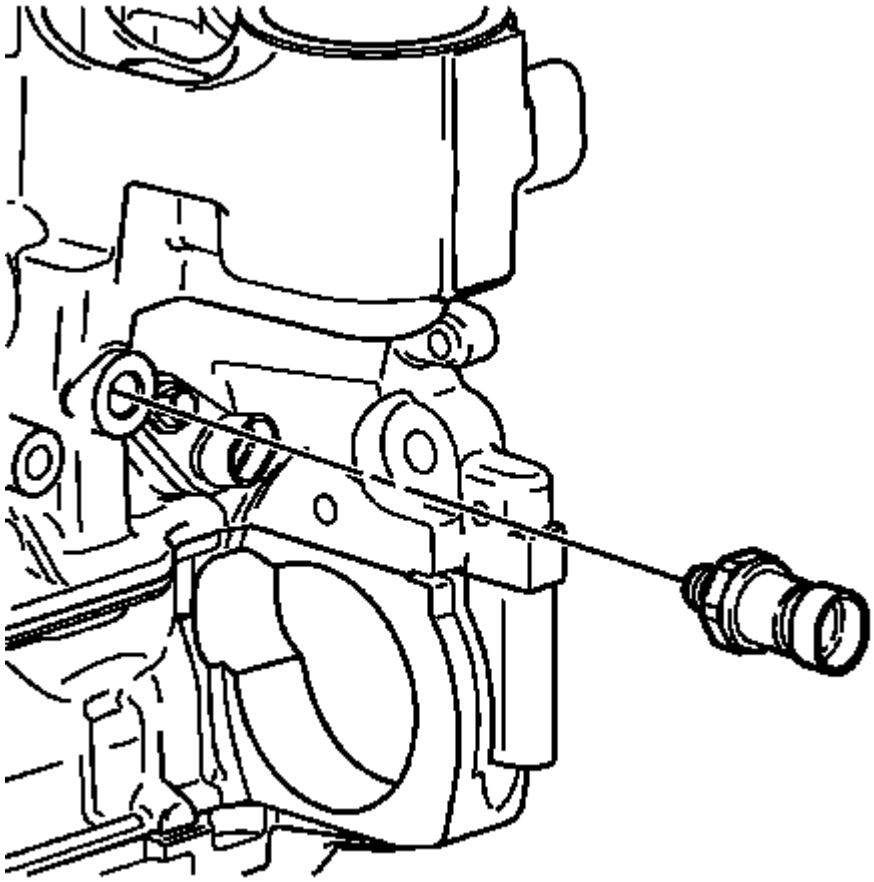

Fig. 34: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the engine oil pressure switch. Tighten the switch to 22 N.m (16 lb ft).

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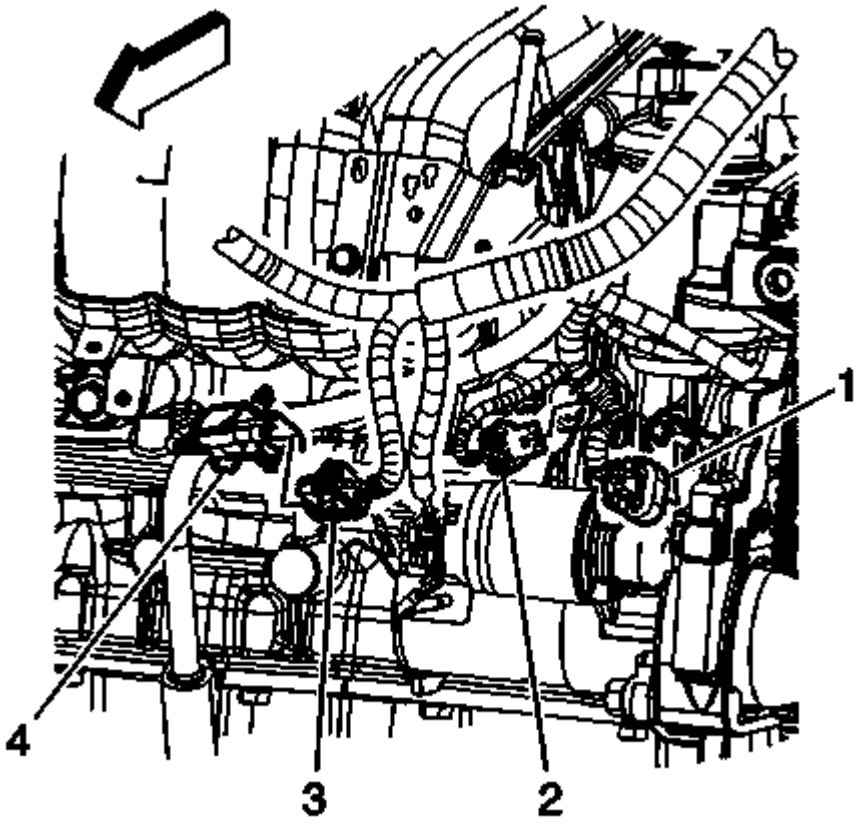

Fig. 35: View Of Starter And Engine Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

2. Connect the engine wiring harness electrical connector (2) to the oil pressure switch.
3. Install the starter. Refer to **Starter Replacement** .

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.

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.

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4. For engine mount replacement. Refer to **Engine Mount Replacement**.

ENGINE MOUNT BRACKET REPLACEMENT

Removal Procedure

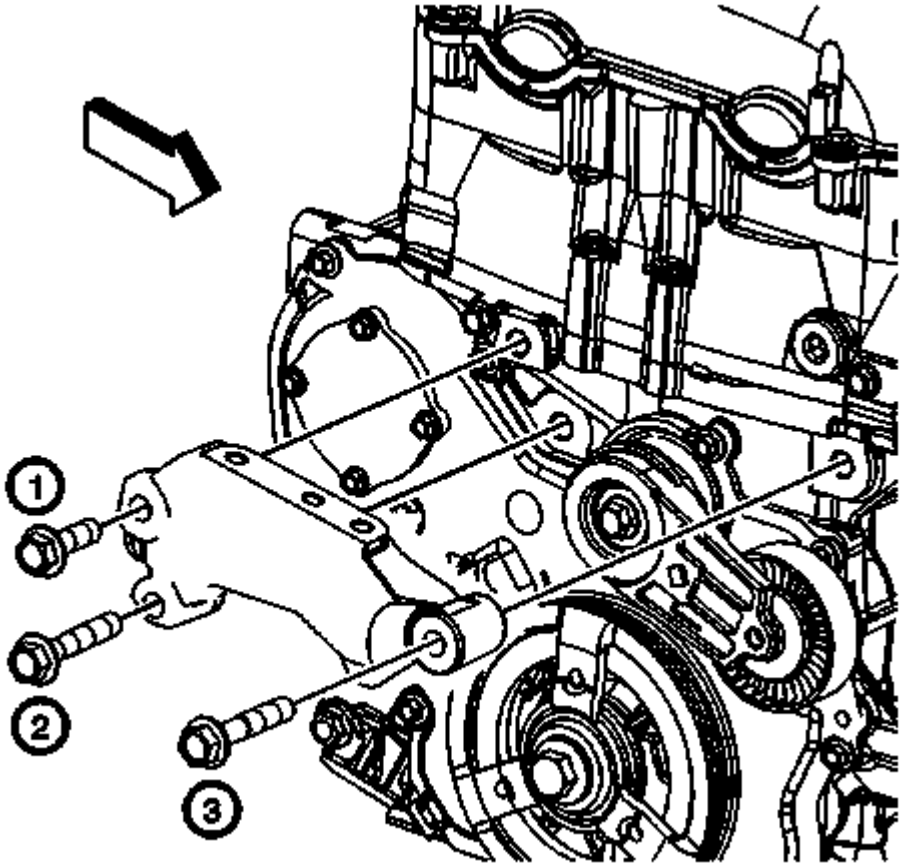

Fig. 36: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

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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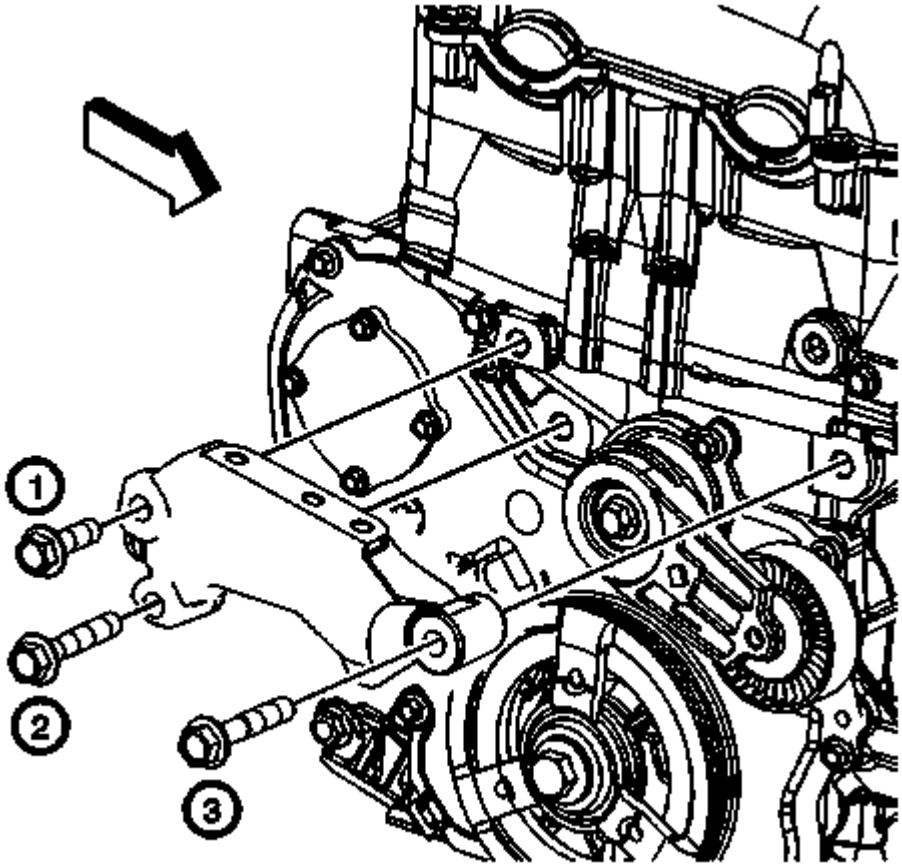

Fig. 37: View Of Engine Mount Bracket To Engine Bolts
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

3. Tighten the engine mount bracket bolts in the sequence shown to 100 N.m (74 lb ft).
4. Install the engine mount. Refer to **Engine Mount Replacement**.

POWERTRAIN MOUNT BALANCING

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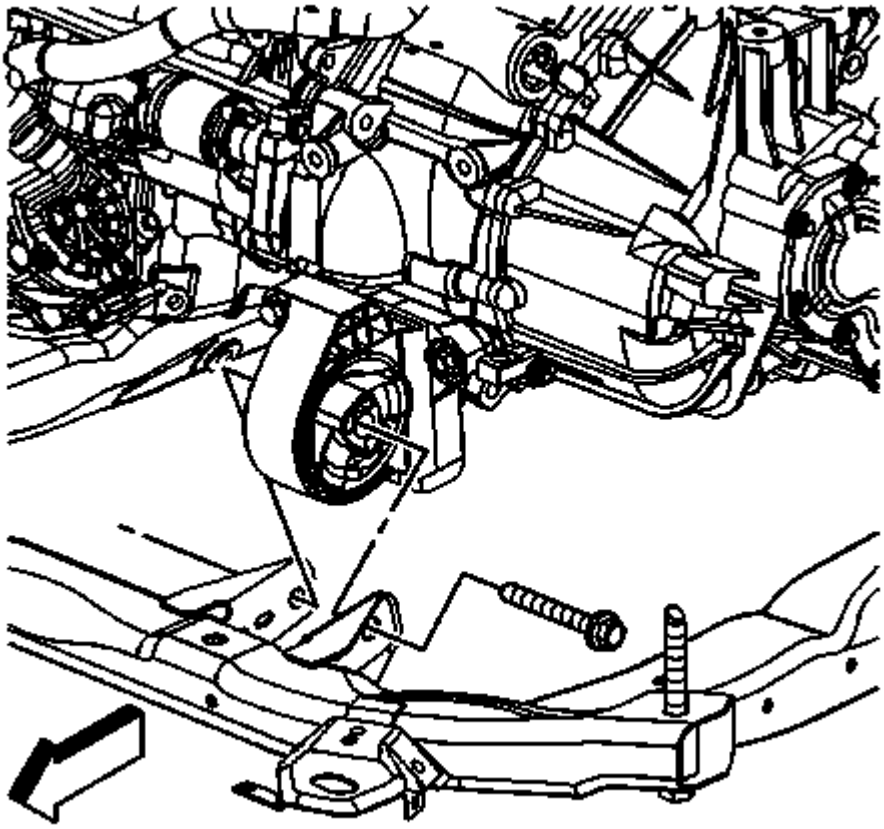

Fig. 38: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

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

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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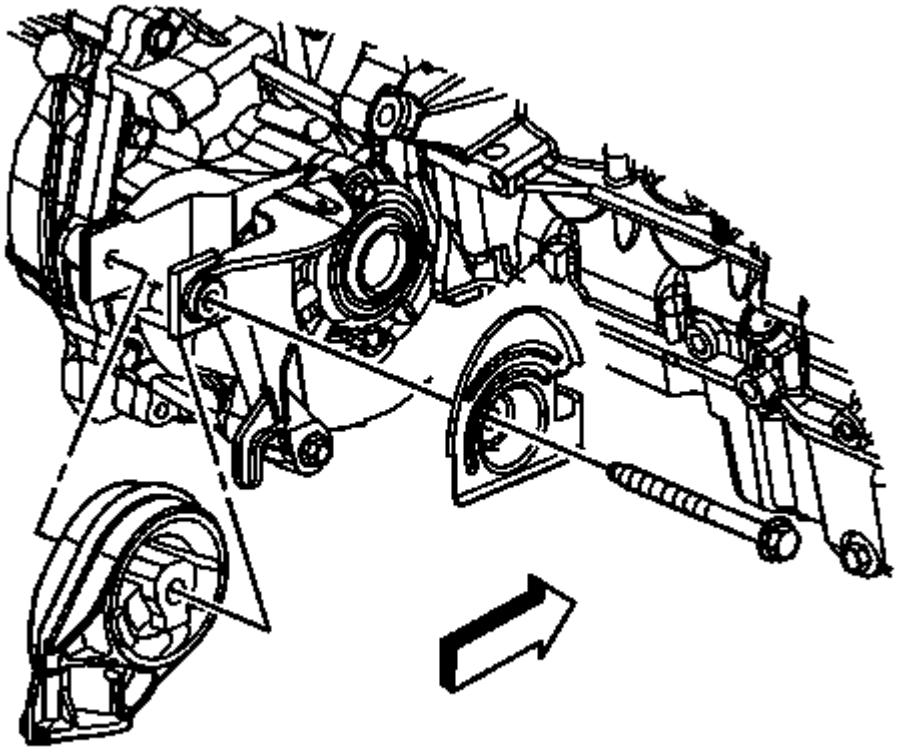

Fig. 39: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

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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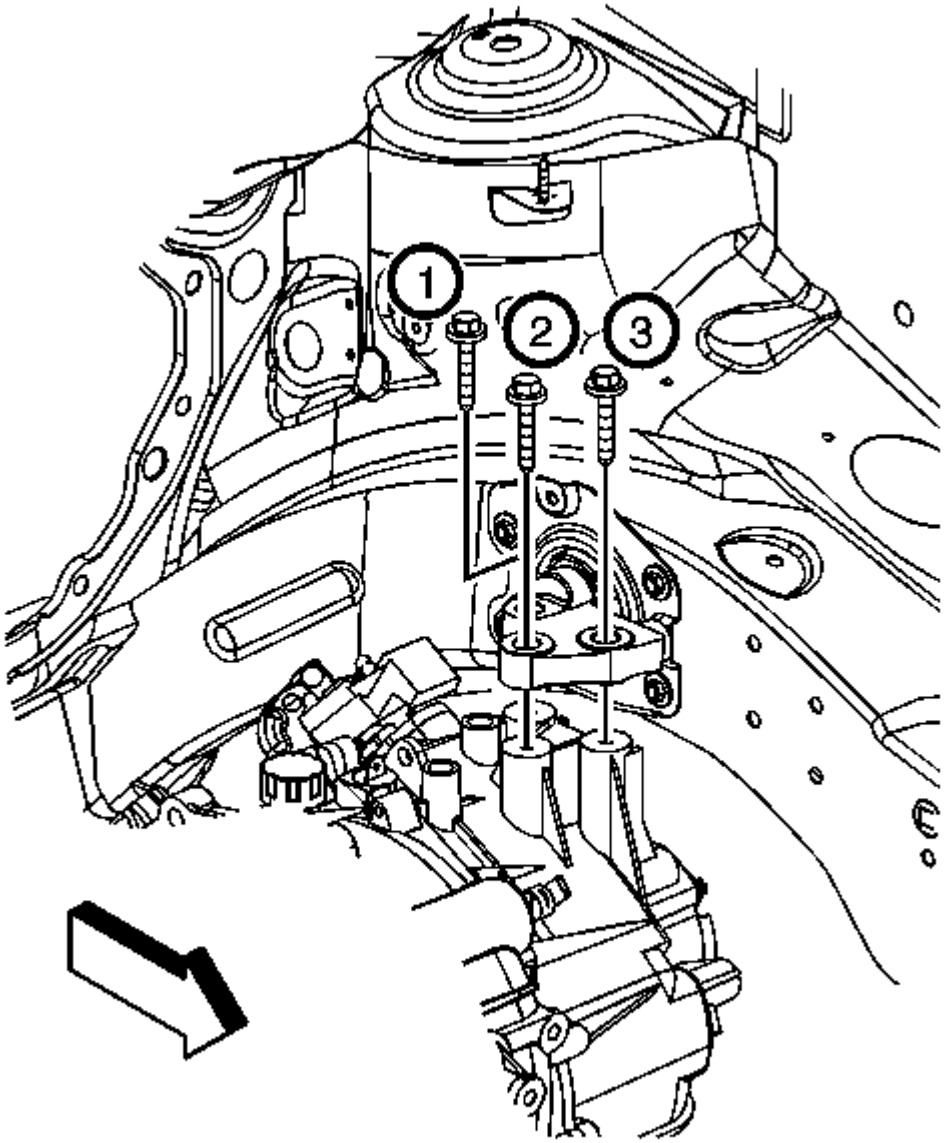

Fig. 40: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

6. Loosen the transaxle mount to transaxle bolts.

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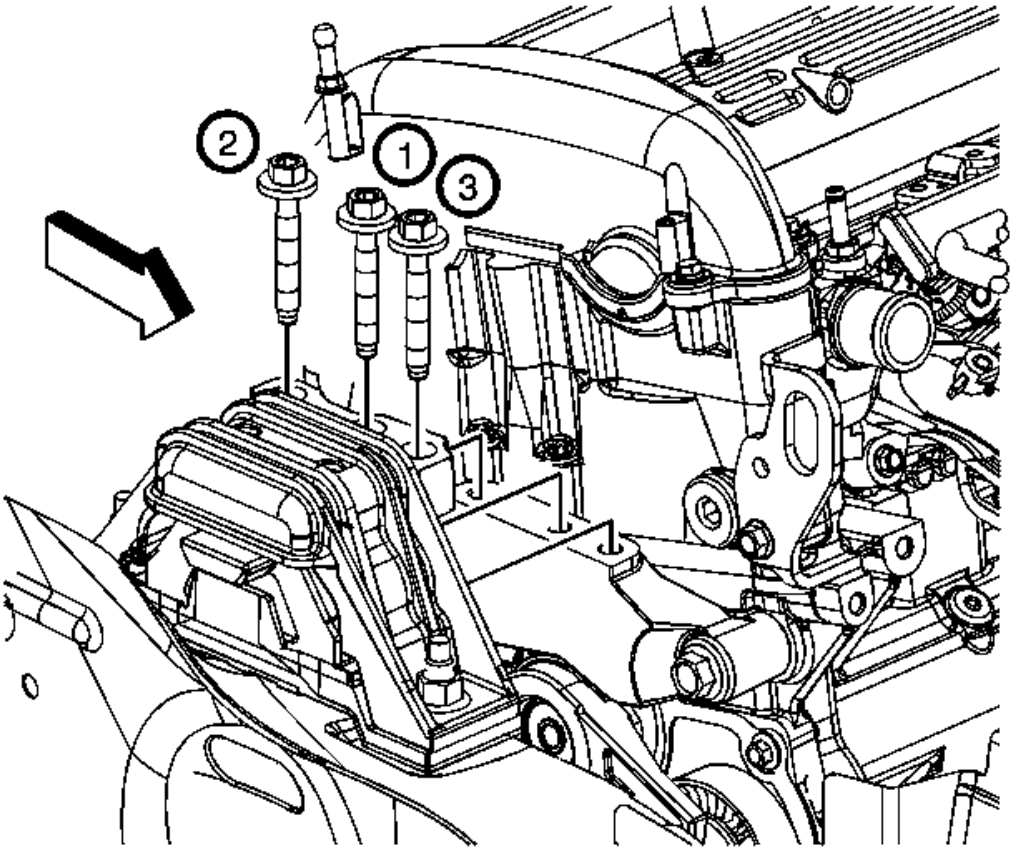

Fig. 41: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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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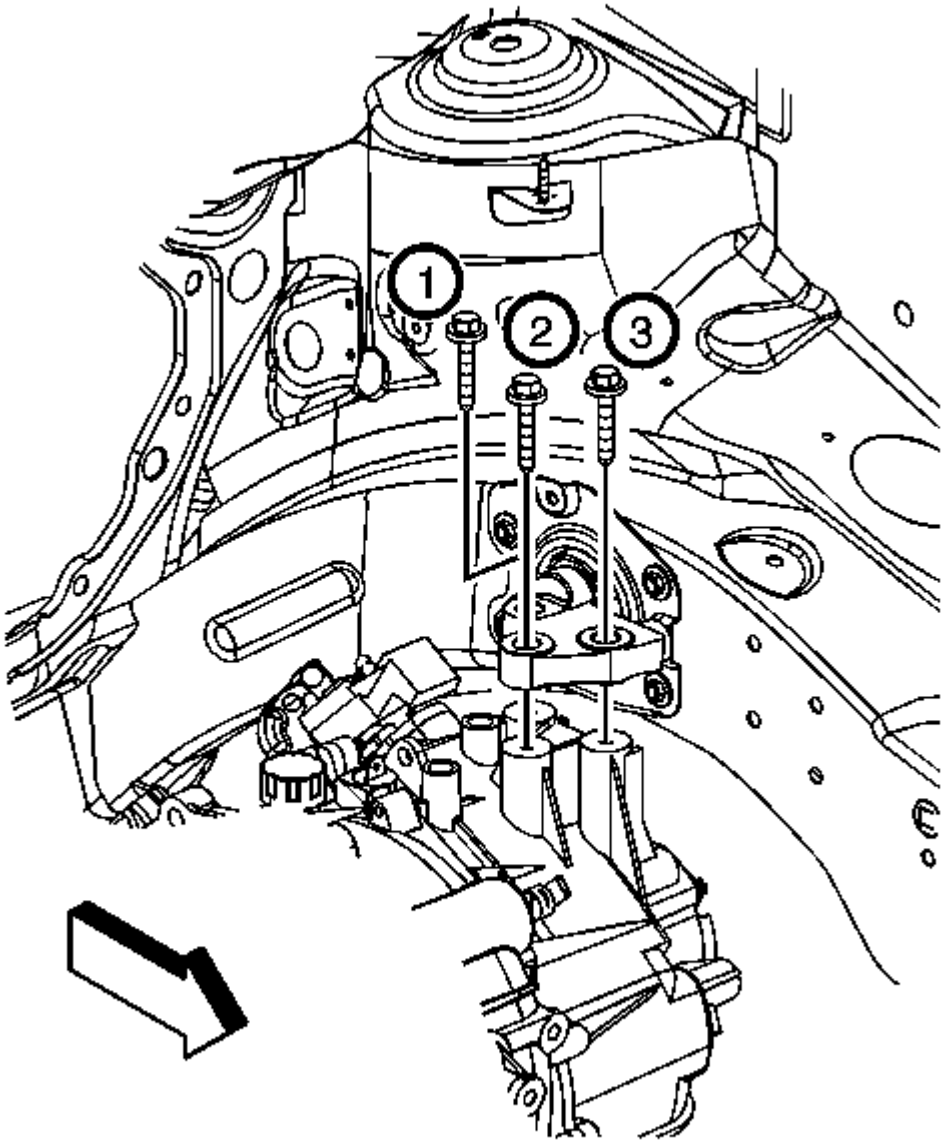

Fig. 42: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

9. Tighten the transaxle mount to transaxle bolts in the sequence shown to 45 N.m (33 lb ft).

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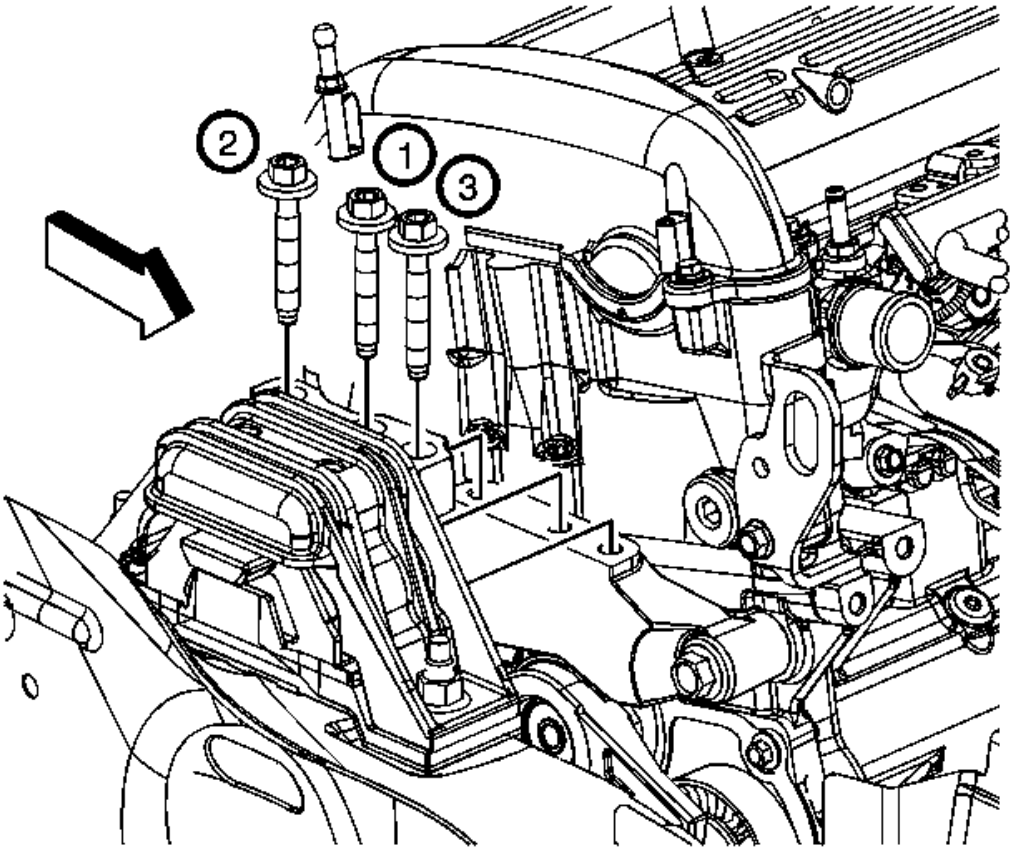

Fig. 43: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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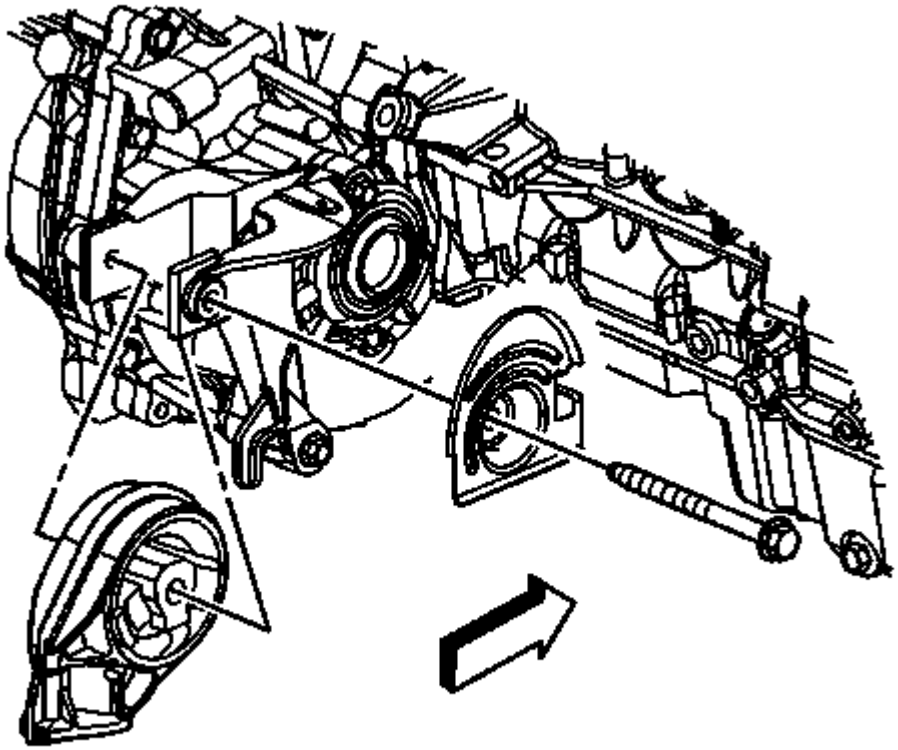

Fig. 44: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

14. Tighten the rear transaxle mount through bolt to 100 N.m (74 lb ft).

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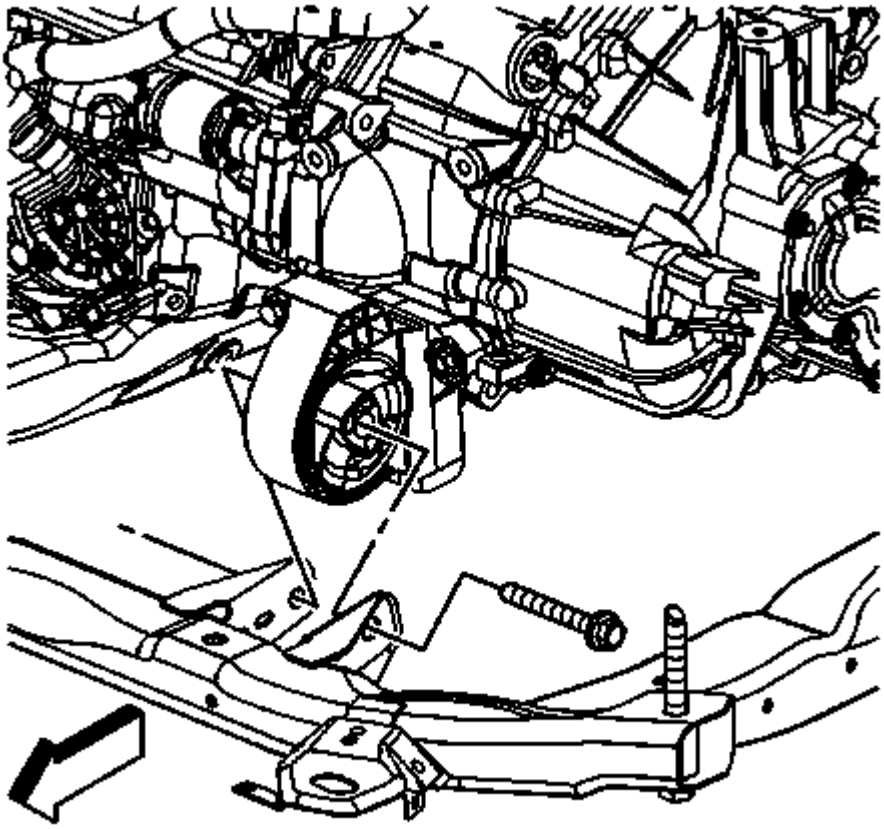

Fig. 45: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

15. Tighten the front transaxle mount through bolt to 100 N.m (74 lb ft).
16. Lower the vehicle.

POWERTRAIN MOUNT BALANCING - LOWER

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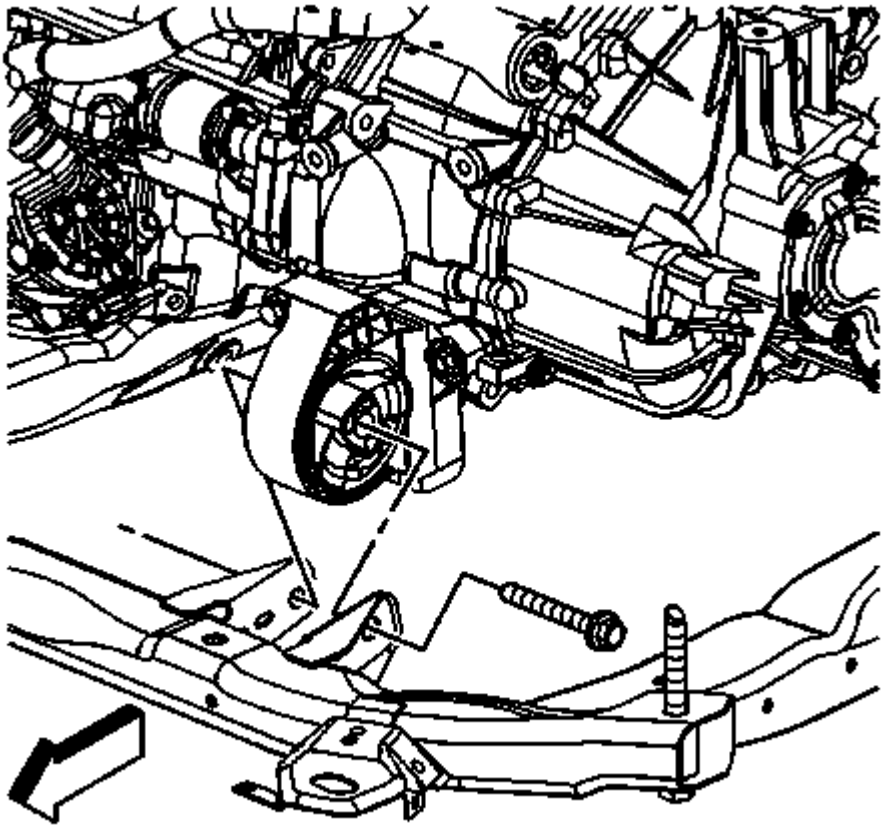

Fig. 46: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

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

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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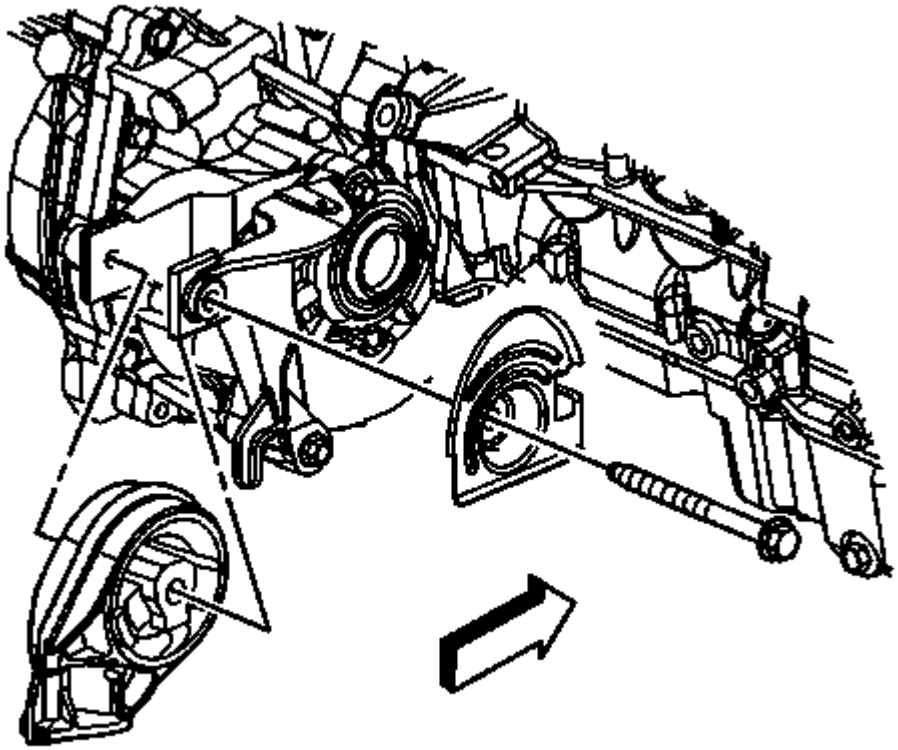

Fig. 47: Identifying Rear Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

5. Tighten the rear transaxle mount through bolt to 100 N.m (74 lb ft).

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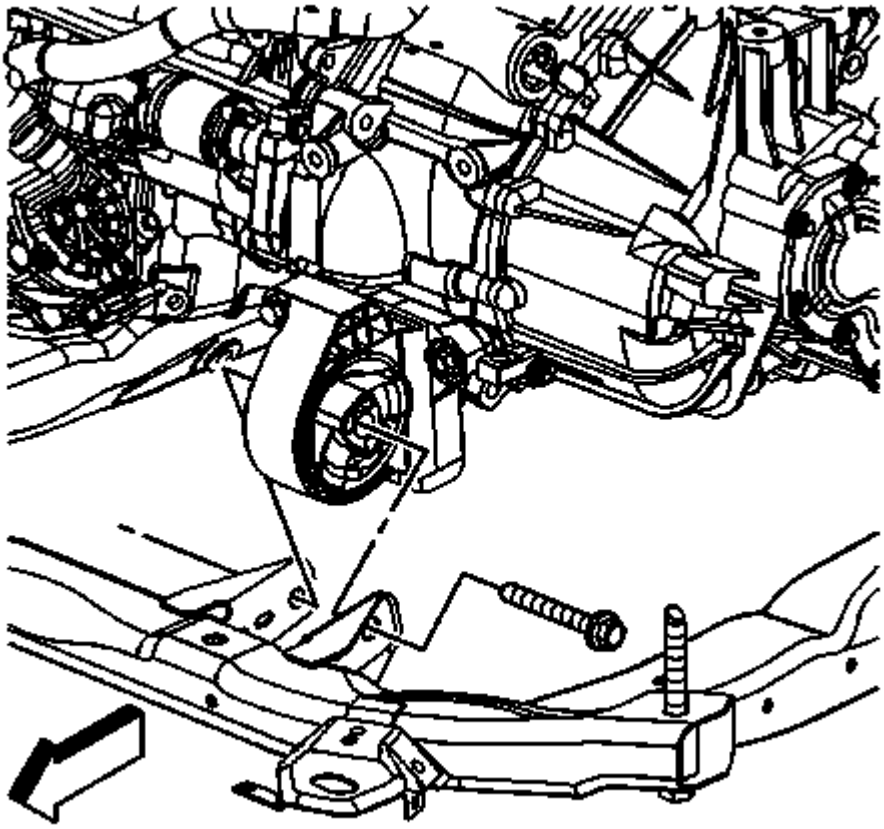

Fig. 48: Identifying Front Transaxle Mount Through Bolt
Courtesy of GENERAL MOTORS CORP.

6. Tighten the front transaxle mount through bolt to 100 N.m (74 lb ft).
7. Lower the vehicle.

ENGINE MOUNT REPLACEMENT

Removal Procedure

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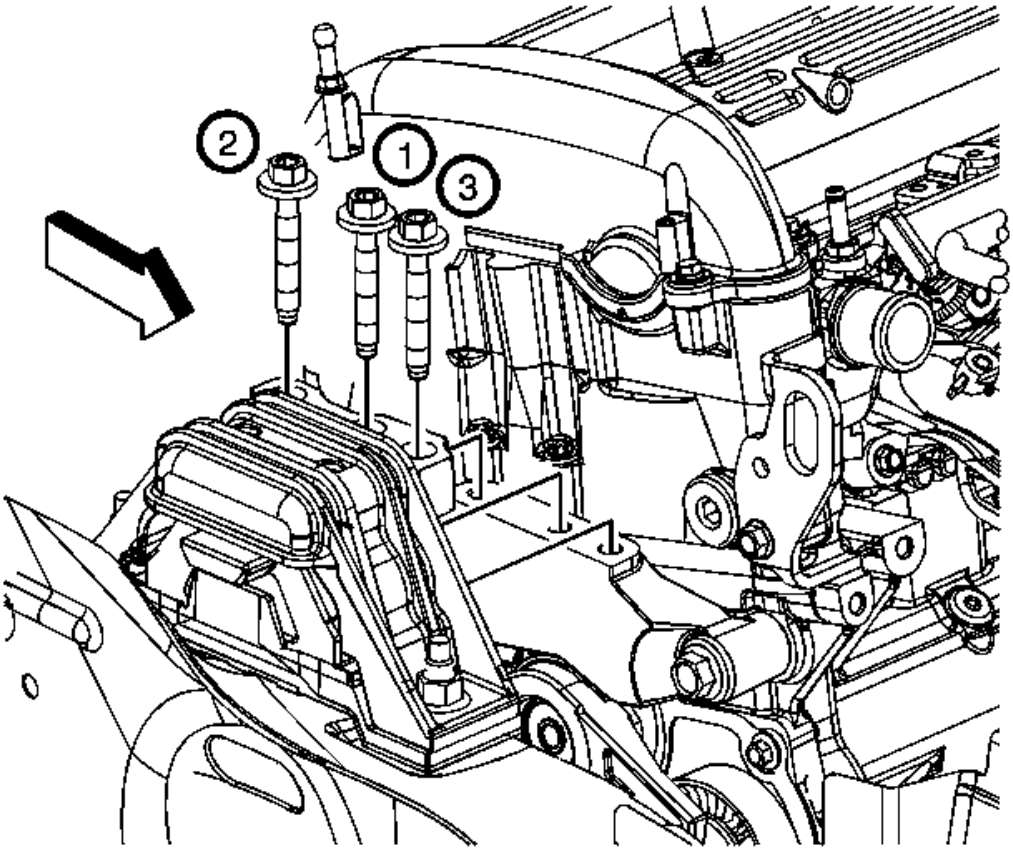

Fig. 49: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

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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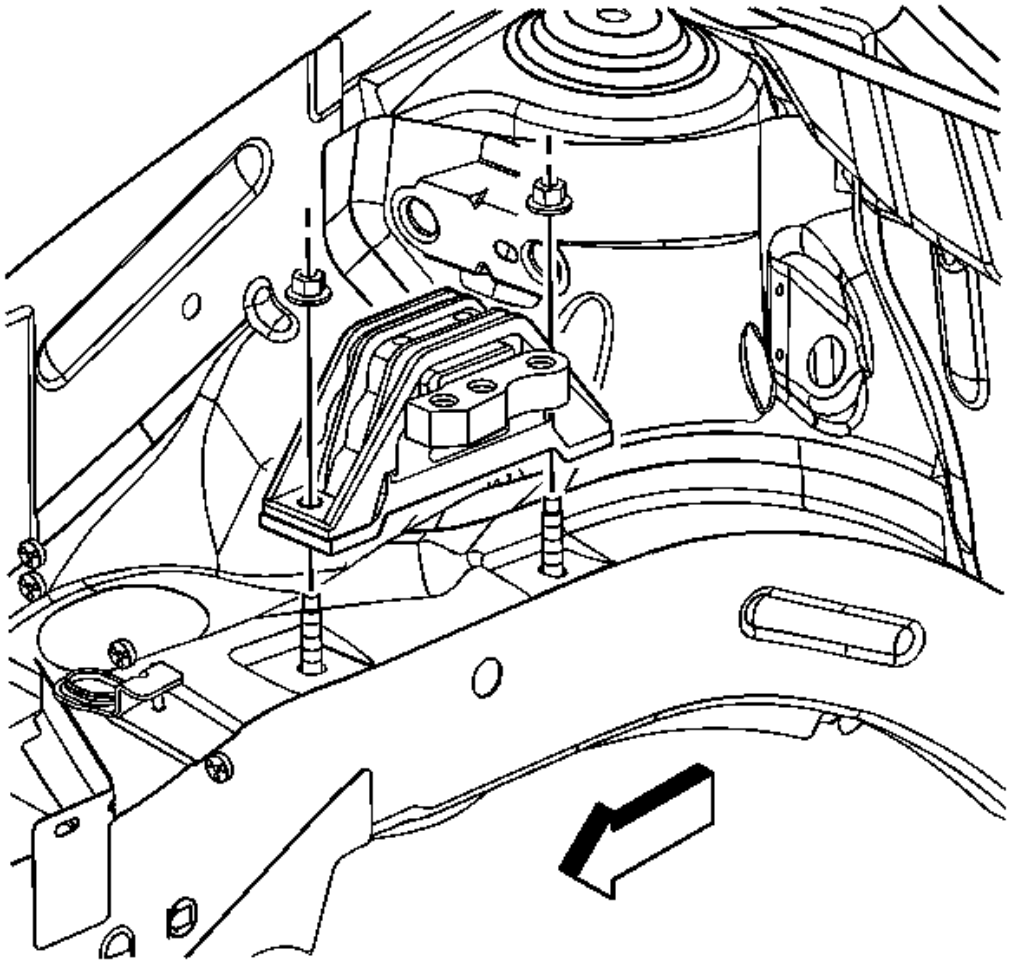

Fig. 50: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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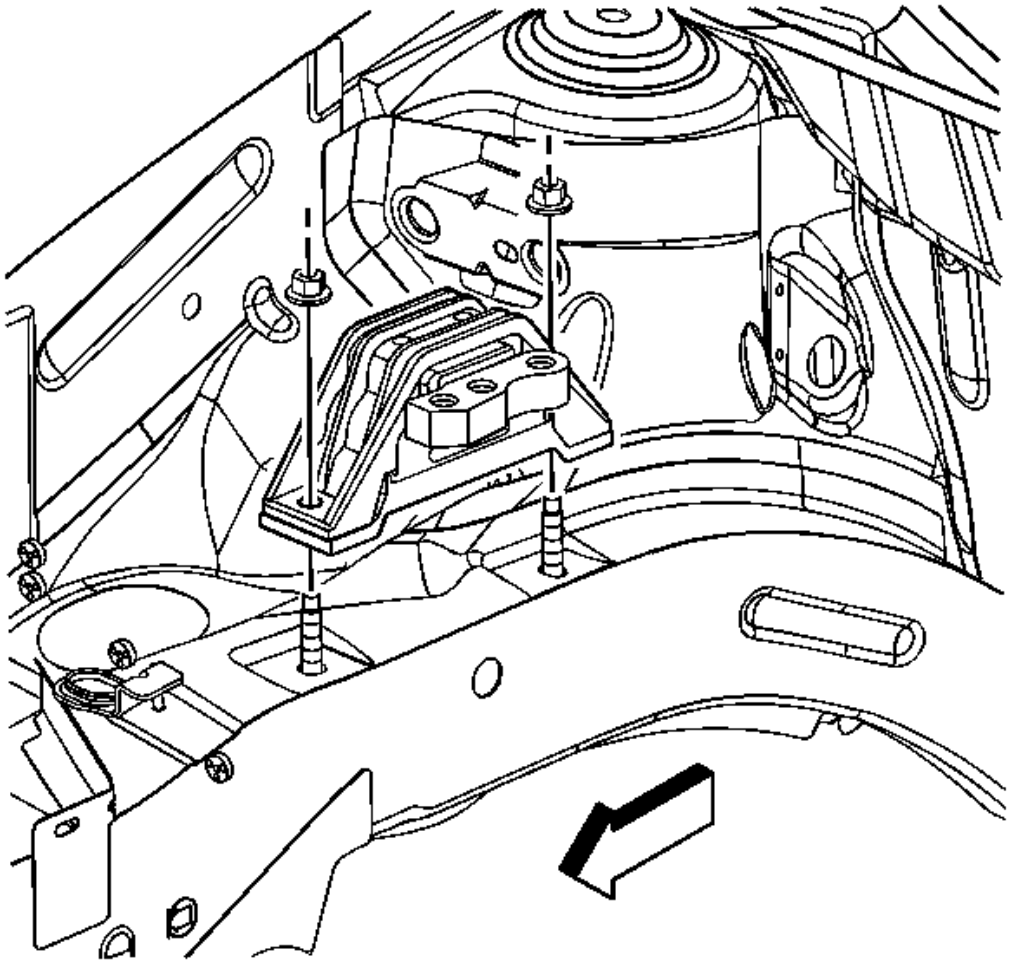

Fig. 51: View Of Engine Mount
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

2. Install the engine mount to side rail nuts and tighten the nuts in the sequence shown to 100 N.m (74 lb ft).

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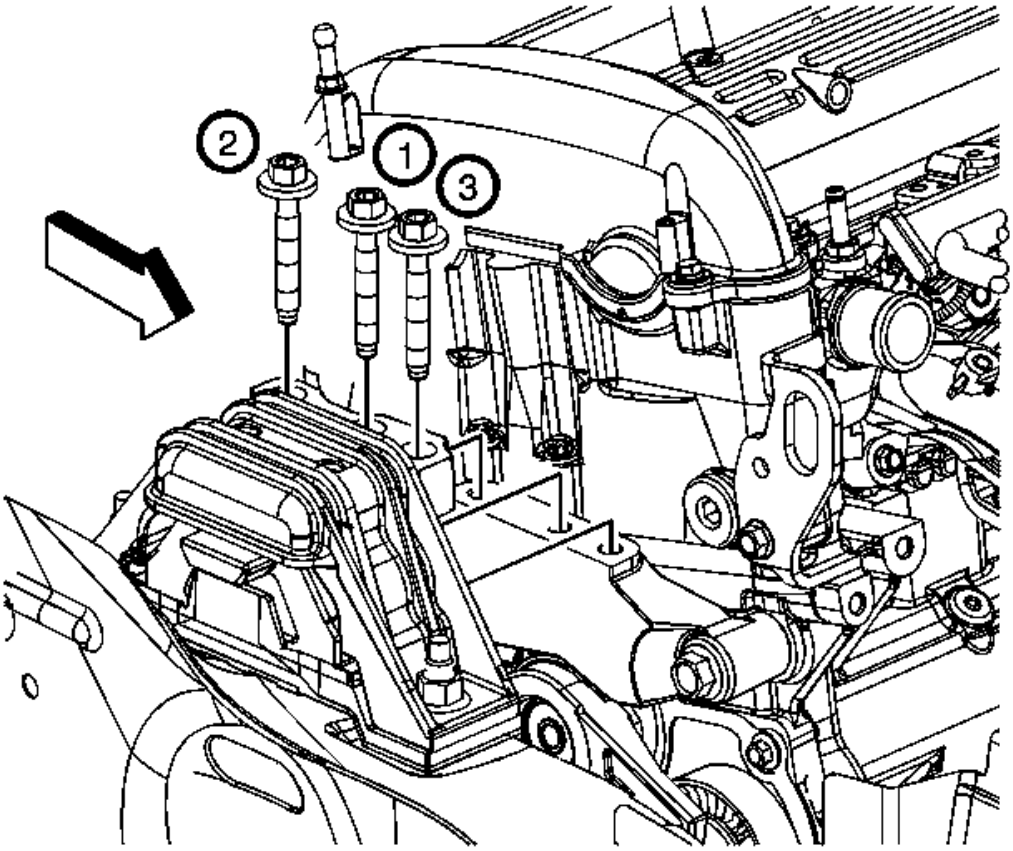

Fig. 52: View Of Engine Mount To Bracket Bolts
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 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

Tools Required

- **J 28467-B** Universal Engine Support Fixture. See **Special Tools**.

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- **J 28467-500** Engine Support Fixture

Installation Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .
2. Place the engine support fixture legs (1) from the **J 28467-B** across the engine compartment. See **Special Tools**.
3. Install the engine support fixture legs (1) from the **J 28467-500** on the engine support fixture long bar (2).

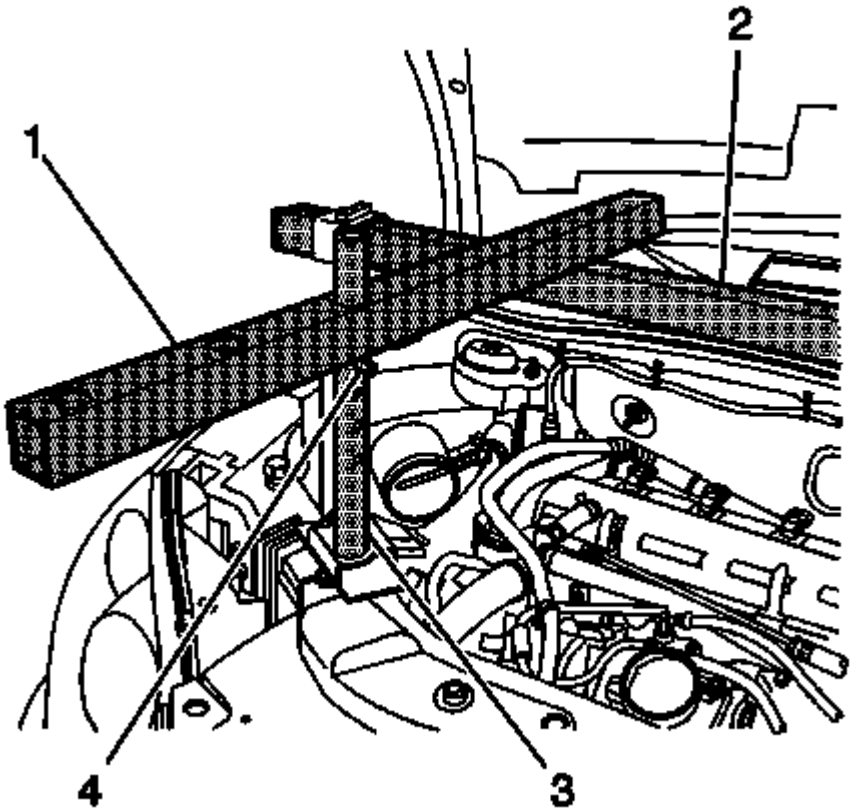

Fig. 53: View Of Engine Support Fixture
Courtesy of GENERAL MOTORS CORP.

4. Install the radiator shelf tube J-28467-2A (1) on top of the strut tower tube J-28467-3 (2) above the engine front (right back) lift hook bracket.
5. Install the round tube of the front support assembly J-28467-4A (3) through the large hole in the radiator shelf tube J-28467-2A.
6. Locate the J-28467-4A front support assembly to the upper tie bar.
7. Install the J-28467-9 7/16 inch x 2.0 inch quick-release pin (4) through the top hole in the J-28467-4A front support assembly.

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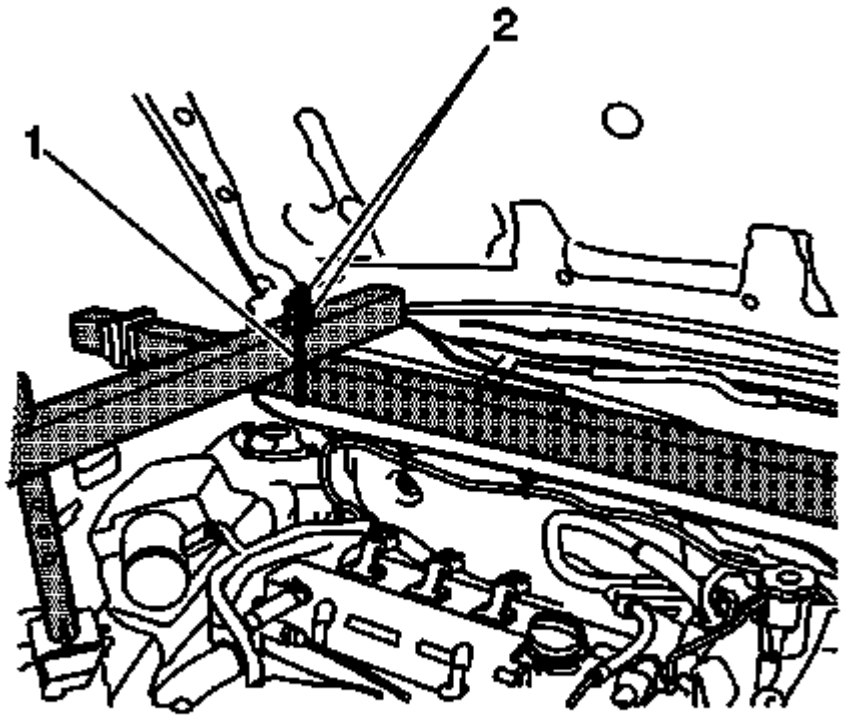

Fig. 54: View Of Engine Support Fixture & Cross Bracket
Courtesy of GENERAL MOTORS CORP.

8. Install the J-28467-1A cross bracket assembly (1).
9. Hand tighten the J-28467-1A cross bracket wing nuts (2).

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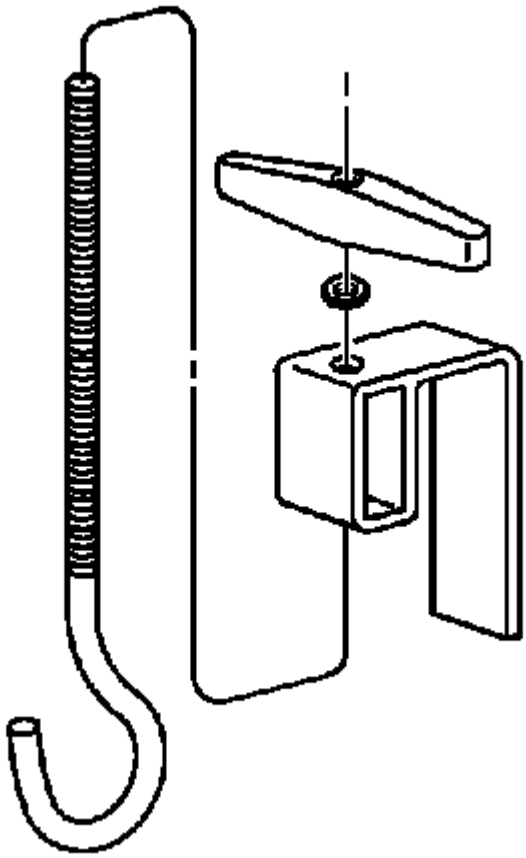

Fig. 55: View Of Lift Hook Assembly
Courtesy of GENERAL MOTORS CORP.

10. Install the J-28467-7A bolt hook through the J-28467-6A bracket.
11. Install the J-28467-34 lift hook wing nut and washer to the J-28467-7A lift hook.
12. Repeat the previous 2 steps in order to assemble 2 lift hooks and brackets.

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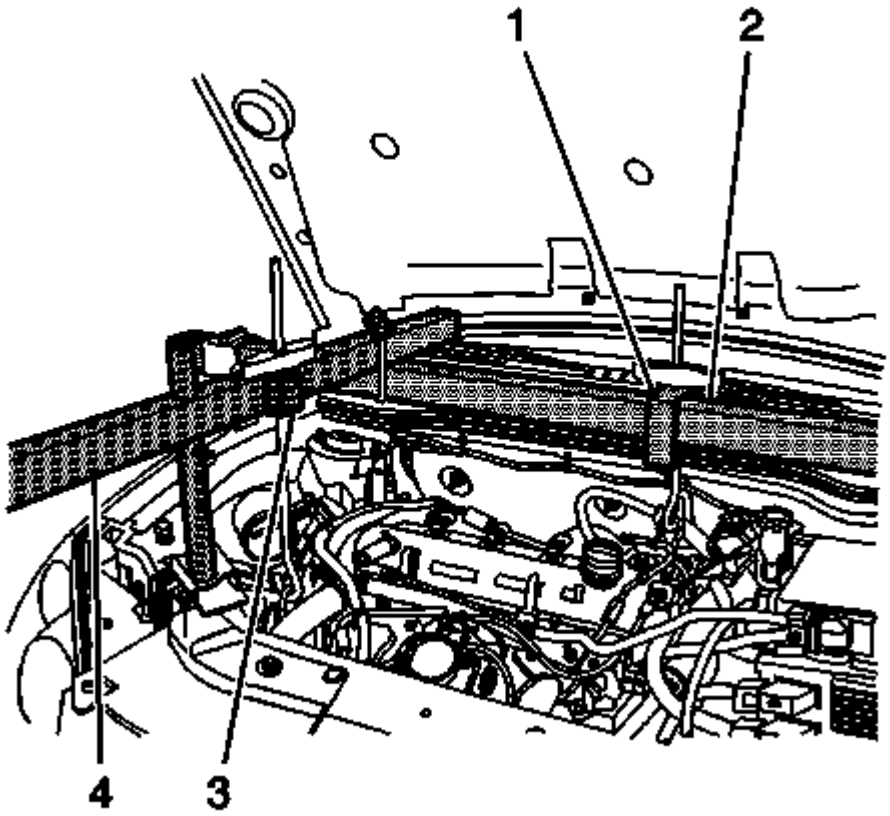

Fig. 56: Identifying Engine Support Fixture & Cross Bracket
Courtesy of GENERAL MOTORS CORP.

13. Install one of the lift hook and bracket assemblies (1) to the engine support fixture long bar (2).
14. Install the other lift hook and bracket assembly (3) to the J-28467-2A radiator shelf tube (4) above the engine front lift bracket.

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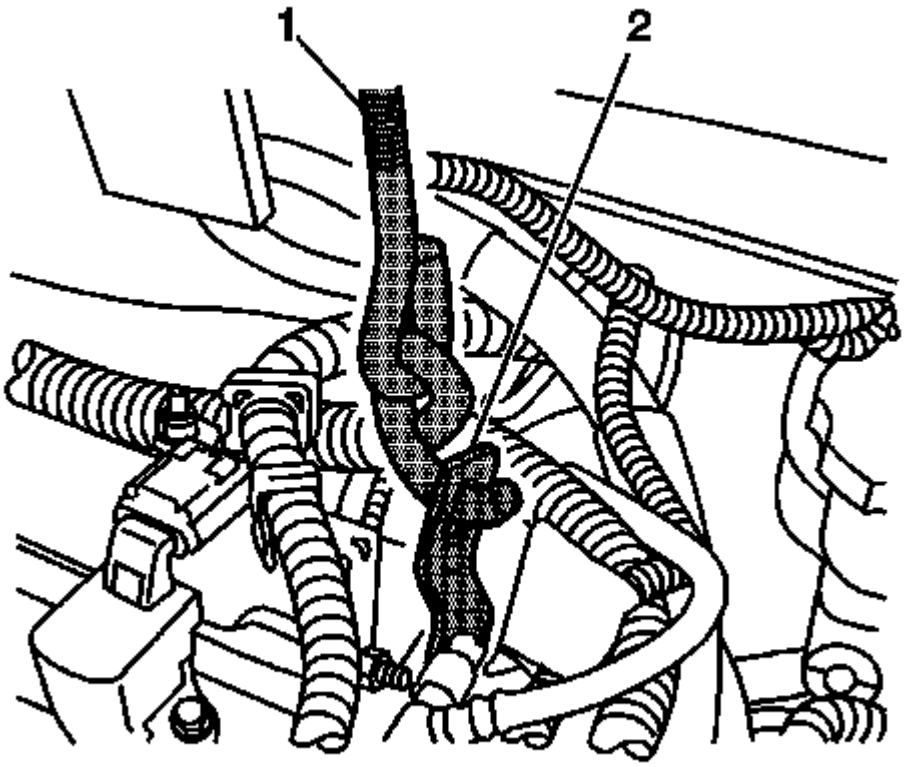

Fig. 57: Inserting Lift Hook Through Engine Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

15. Install the lift hook J-28467-7A through the engine rear lift bracket (2).

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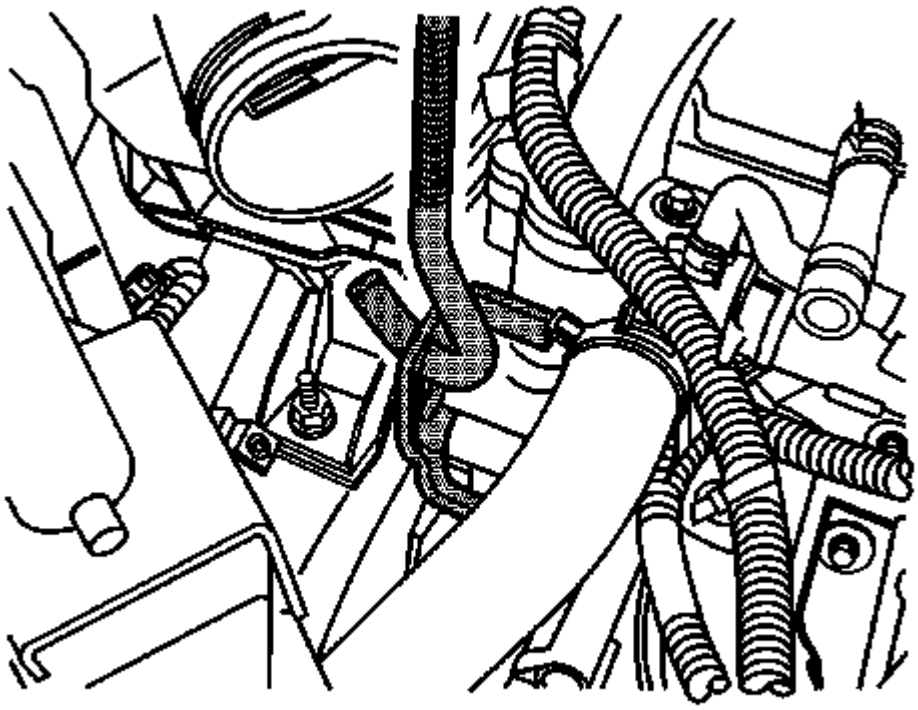

Fig. 58: Inserting Lift Hook Through Engine Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

16. Install the lift hook J-28467-7A (3) through the engine front lift bracket (4).
17. Hand tighten the lift hook wing nuts J-28467-34 (5) in order to remove all slack from the engine support fixture assembly.

OIL LEVEL INDICATOR TUBE REPLACEMENT

Removal Procedure

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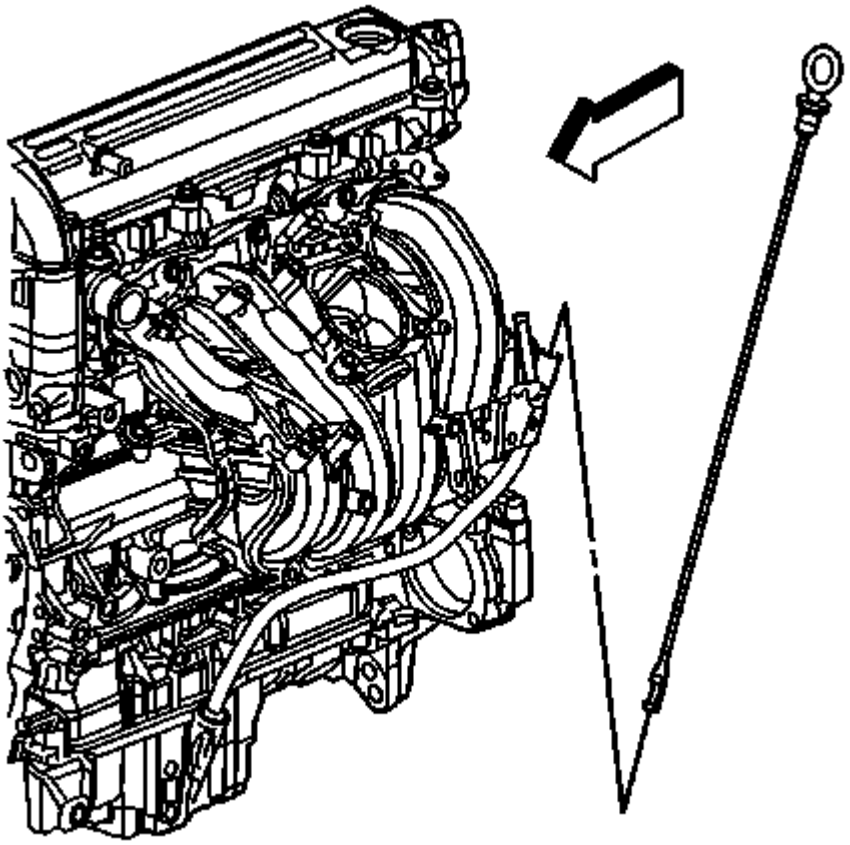

Fig. 59: Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

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

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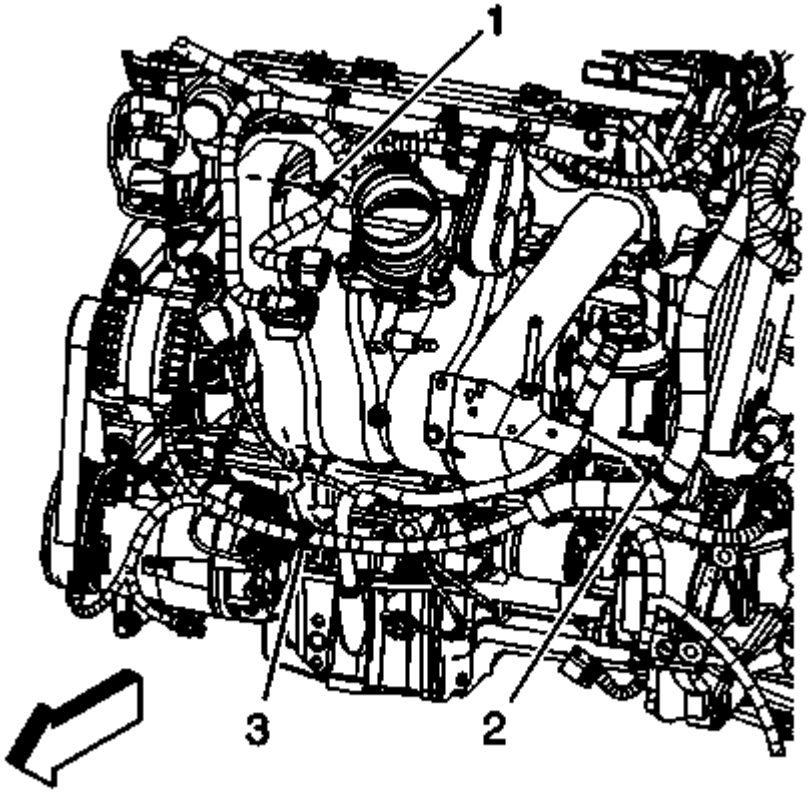

Fig. 60: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

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

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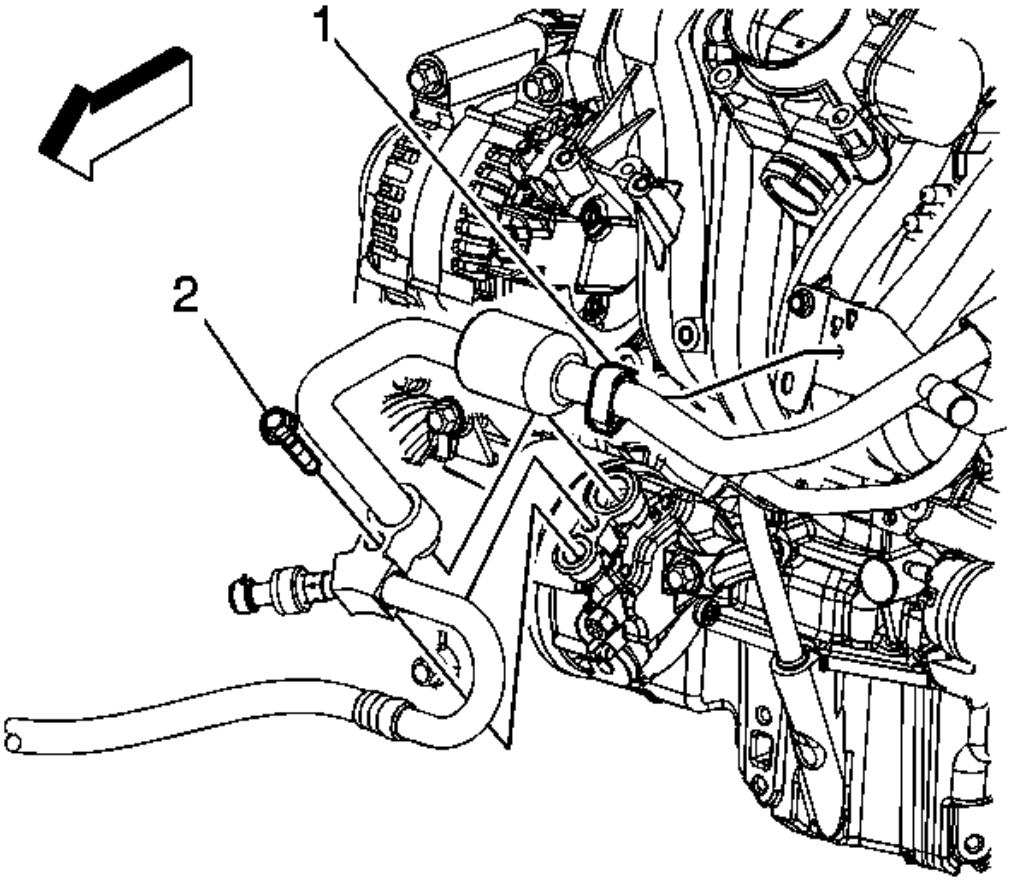

Fig. 61: View Of Air Conditioning (A/C) Compressor/Condenser Line Clip
Courtesy of GENERAL MOTORS CORP.

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

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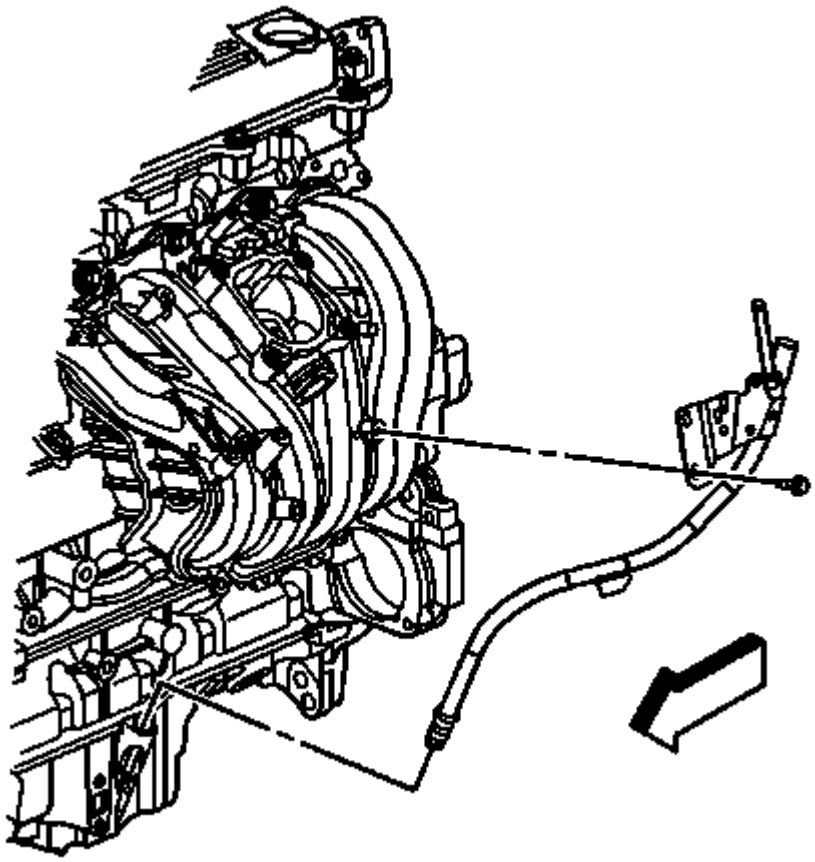

Fig. 62: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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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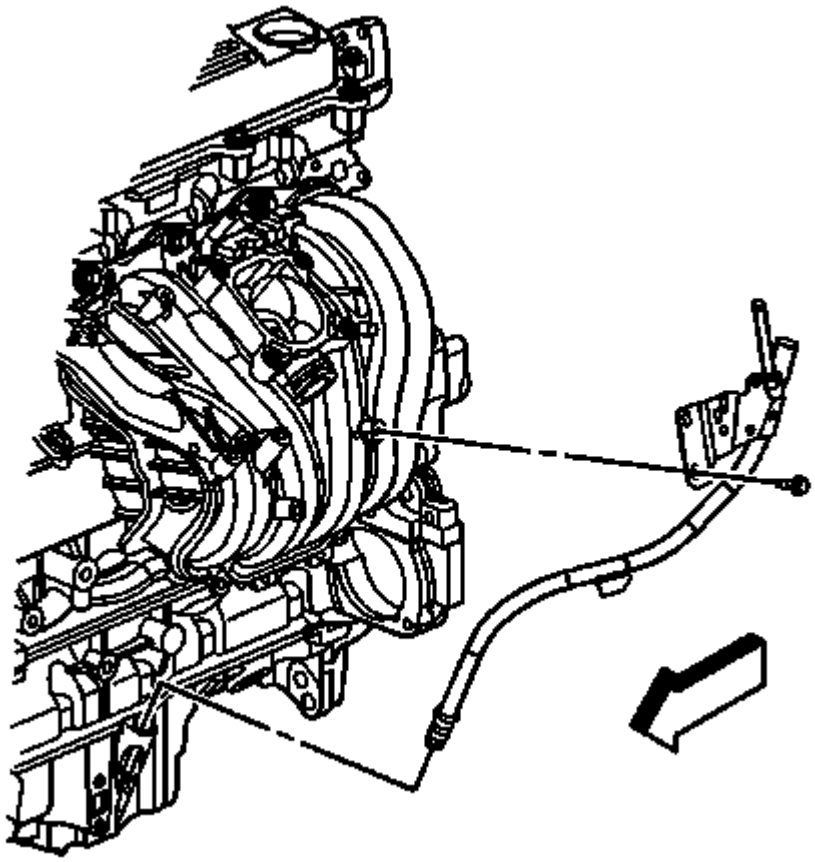

Fig. 63: Identifying Oil Level Indicator Tube
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bolt and tighten to 10 N.m (89 lb in).

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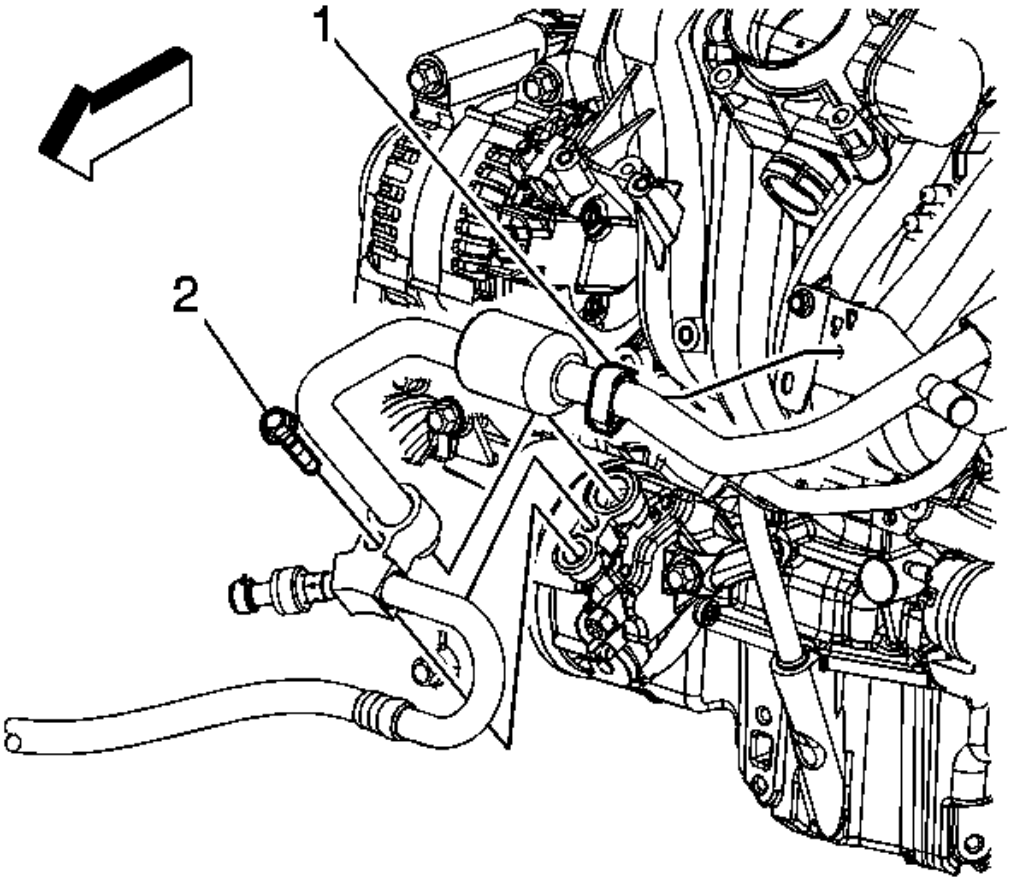

Fig. 64: View Of Air Conditioning (A/C) Compressor/Condenser Line Clip
Courtesy of GENERAL MOTORS CORP.

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

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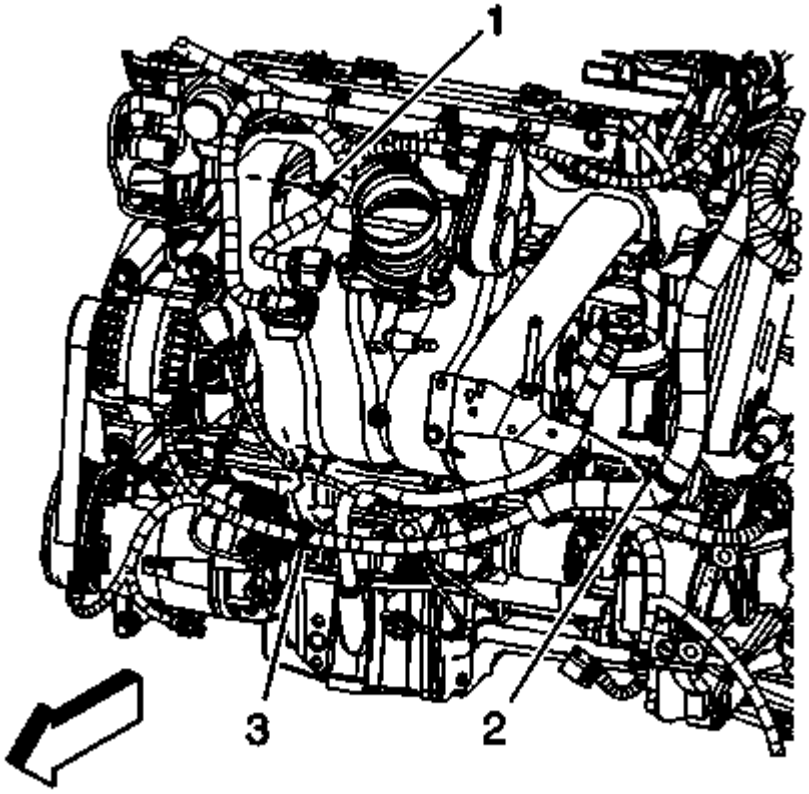

Fig. 65: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

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

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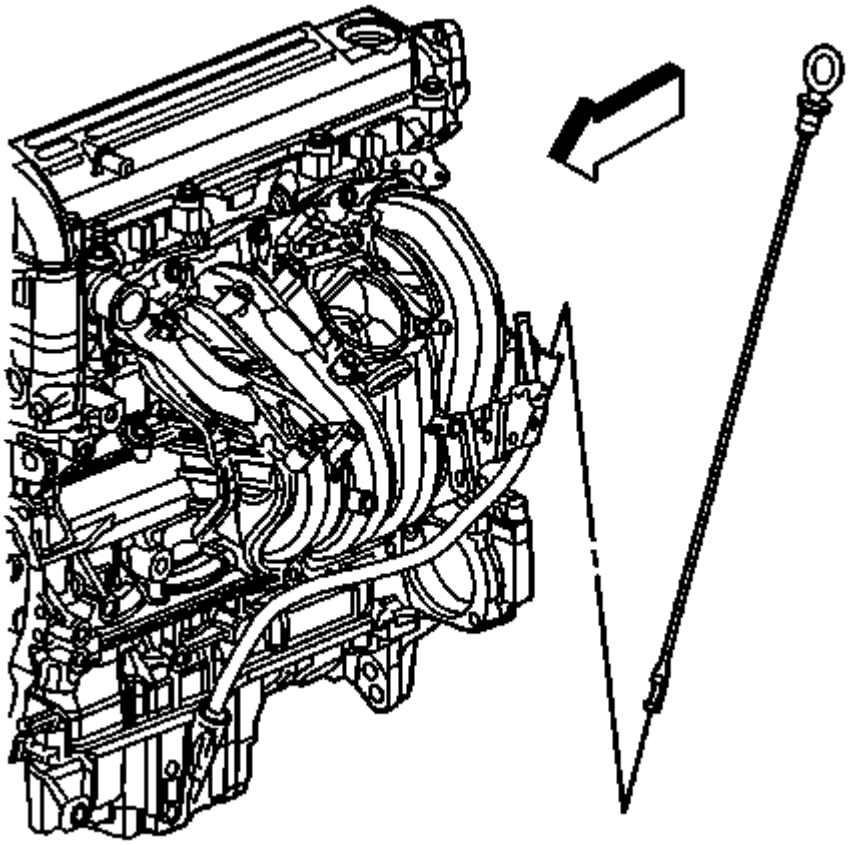

Fig. 66: Oil Level Indicator
Courtesy of GENERAL MOTORS CORP.

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

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT

Removal Procedure

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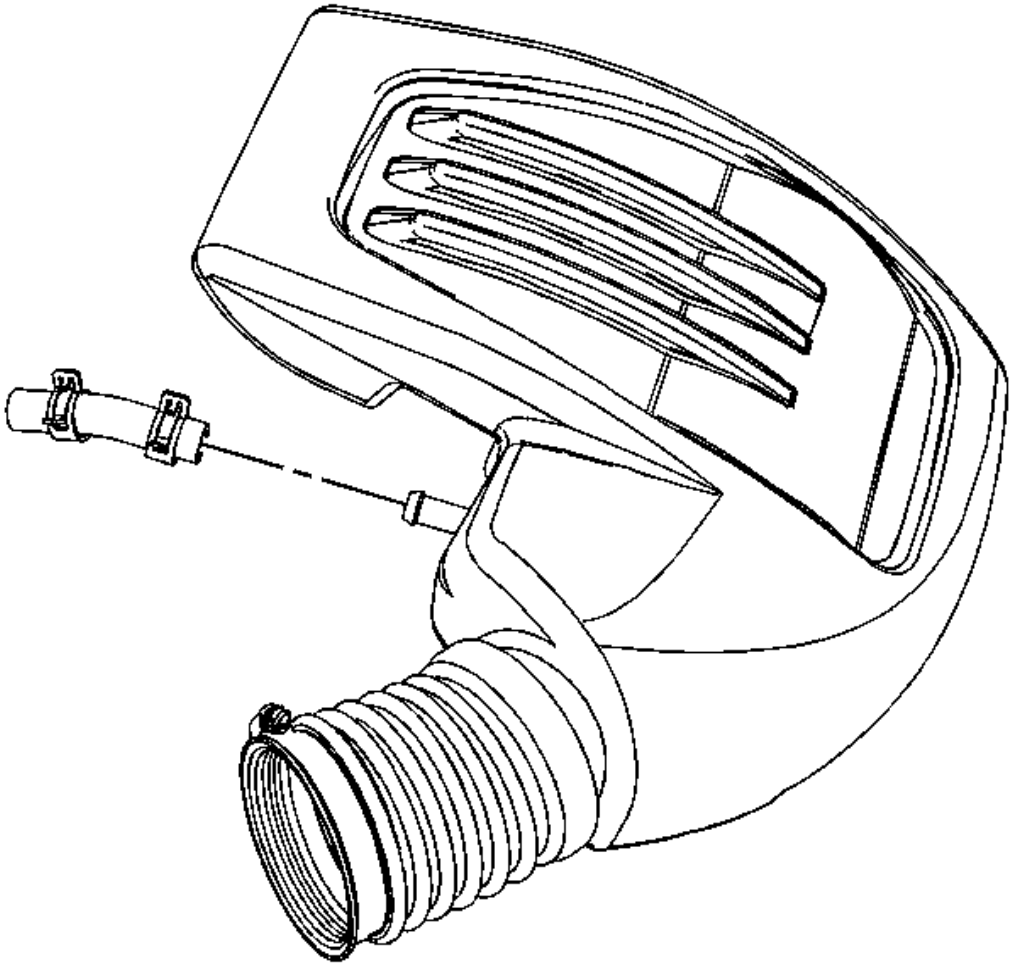

Fig. 67: View Of PCV Hose From Outlet Duct
Courtesy of GENERAL MOTORS CORP.

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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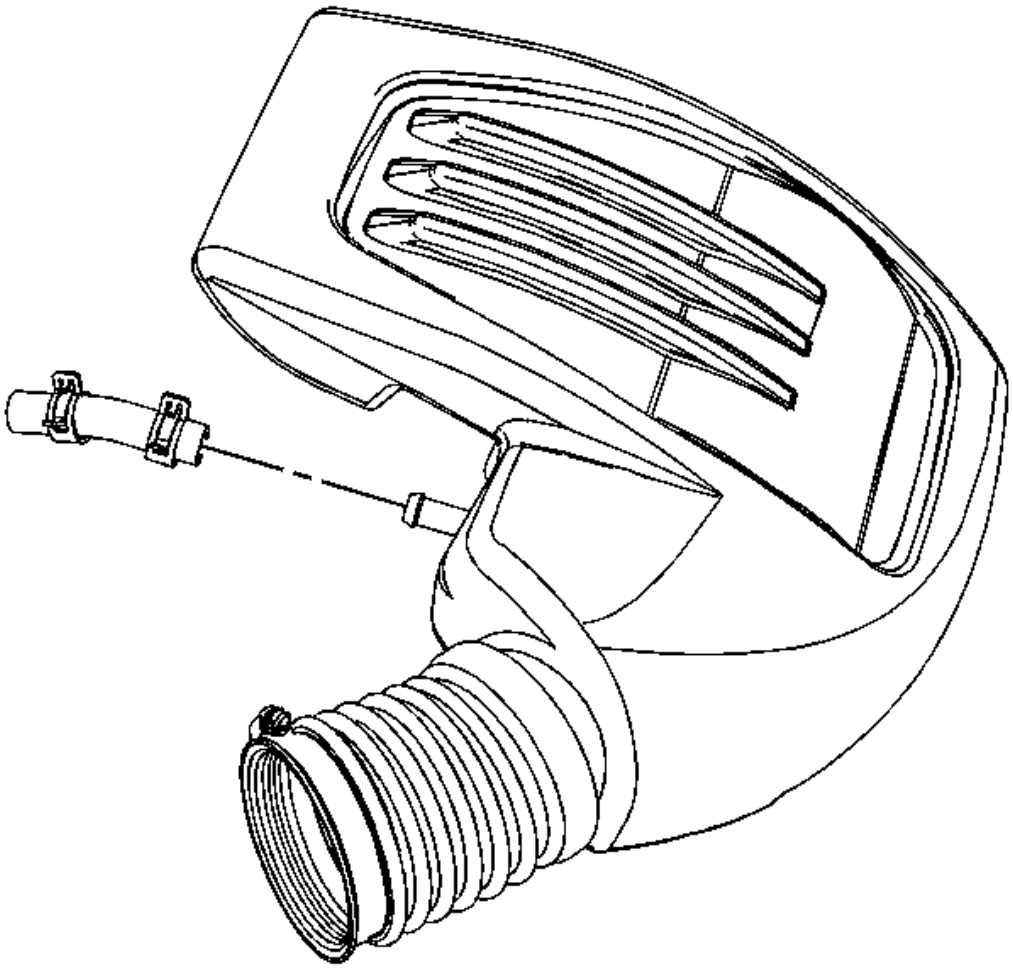

Fig. 68: View Of PCV Hose From Outlet Duct
Courtesy of GENERAL MOTORS CORP.

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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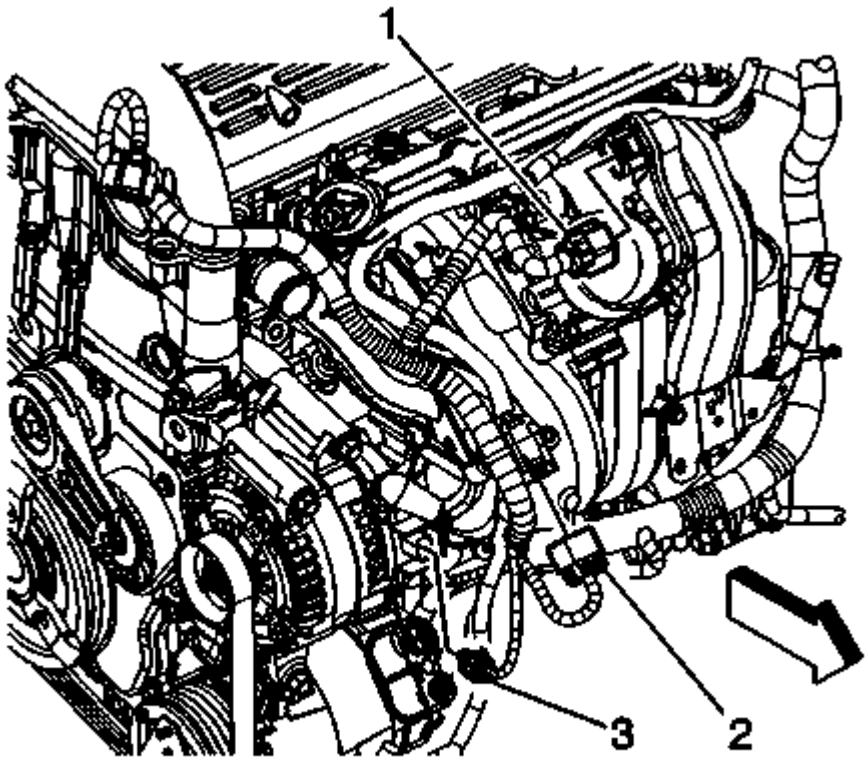

Fig. 69: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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 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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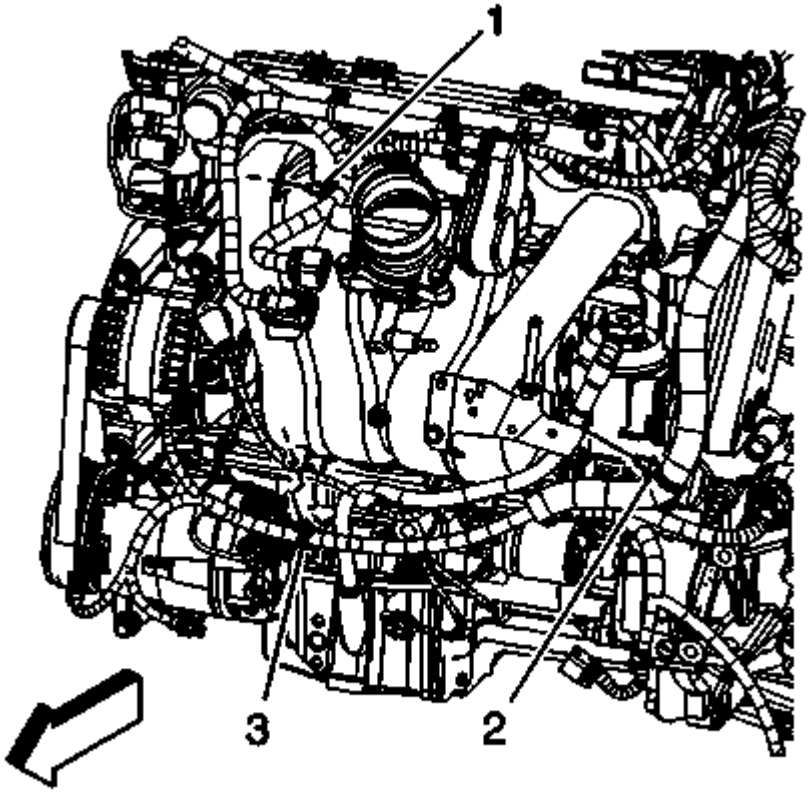

Fig. 70: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

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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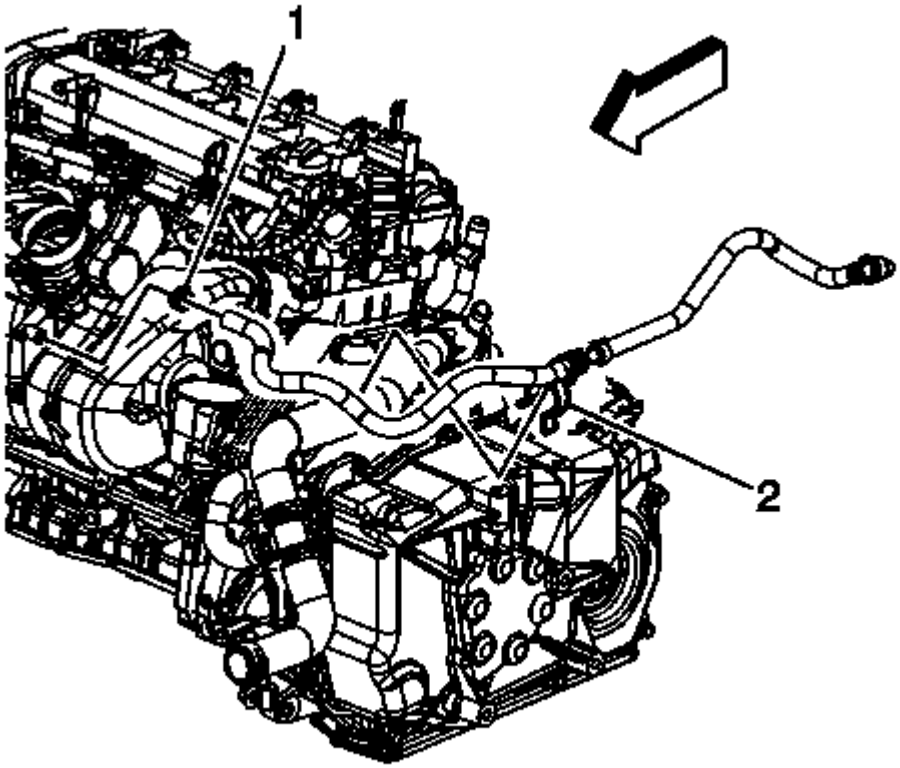

Fig. 71: Positioning Brake Booster Vacuum Hose Clamp At Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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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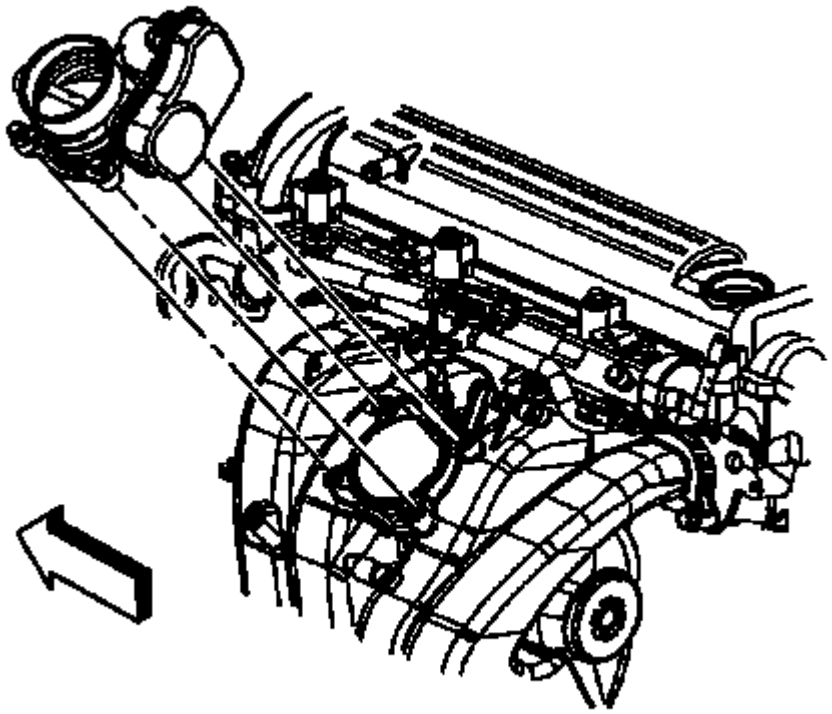

Fig. 72: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

11. Remove the throttle body bolts.

NOTE: 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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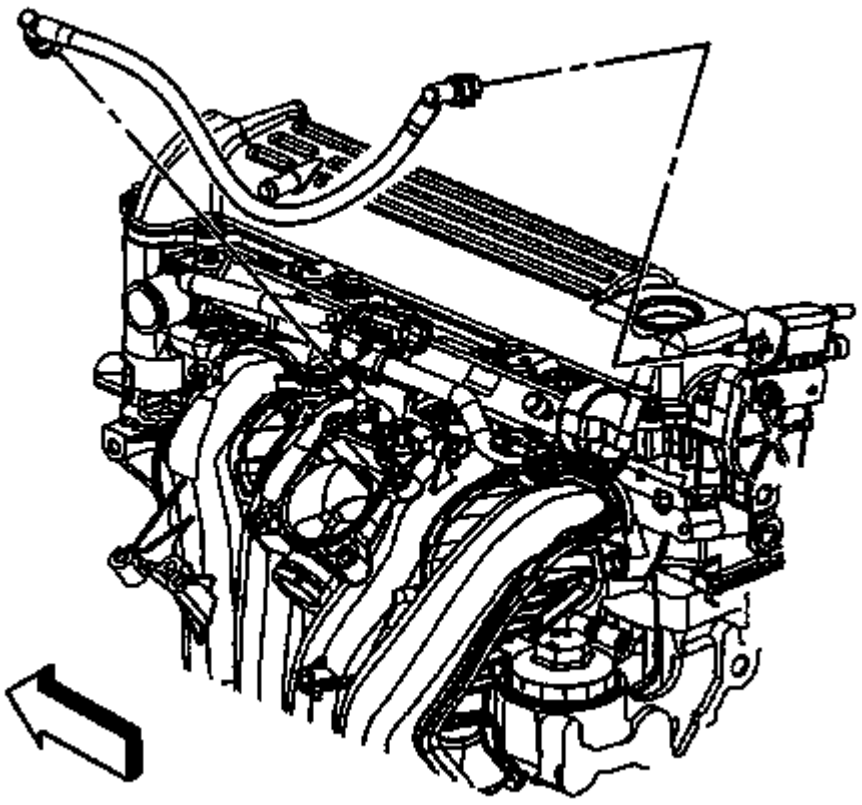

Fig. 73: EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

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 Tube Replacement**.
16. Remove the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .

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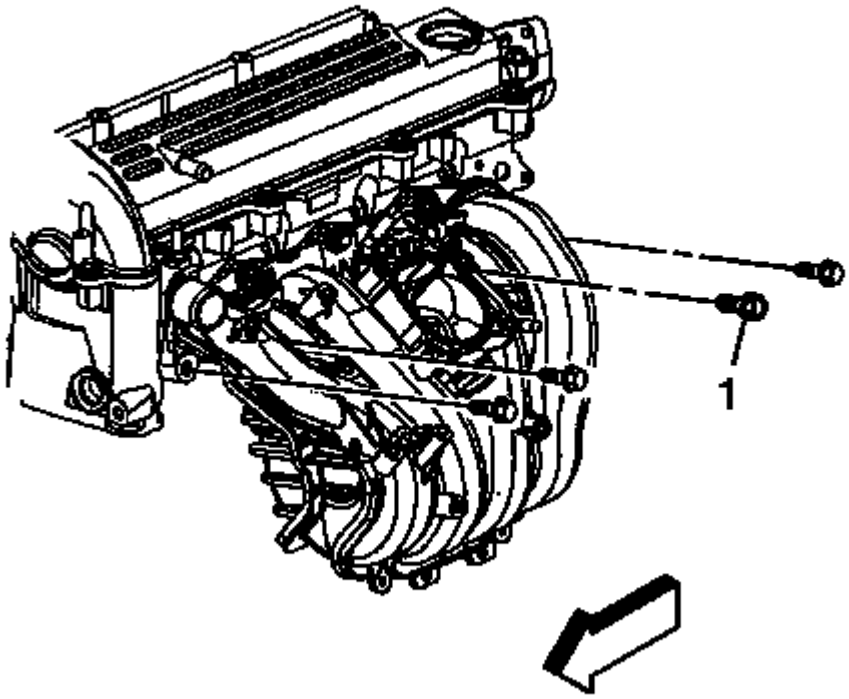

Fig. 74: Intake Manifold Lower Bolts
Courtesy of GENERAL MOTORS CORP.

17. Remove the intake manifold lower bolts (1).

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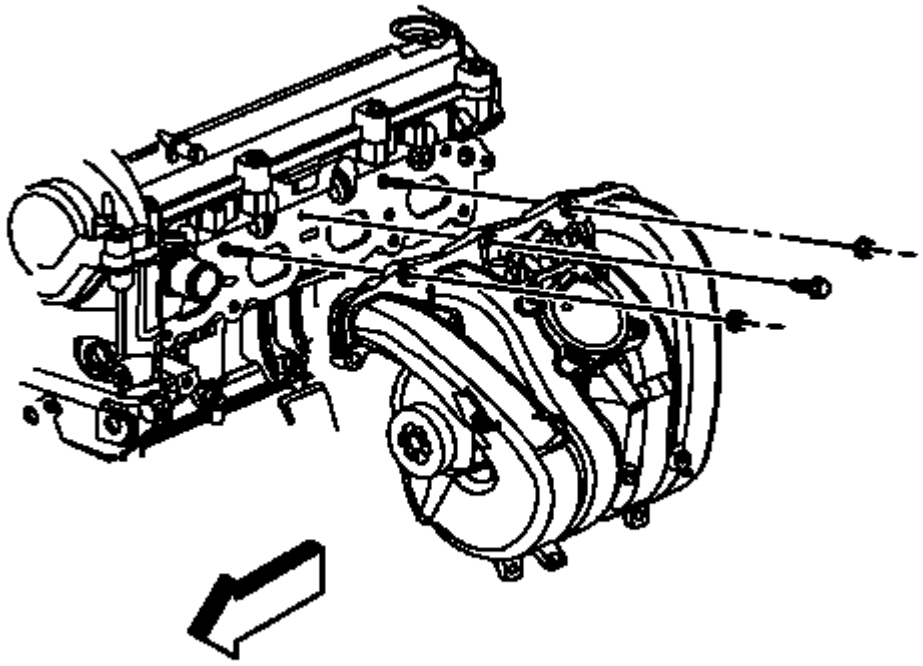

Fig. 75: Intake Manifold Upper Bolt And Nuts
Courtesy of GENERAL MOTORS CORP.

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

NOTE: 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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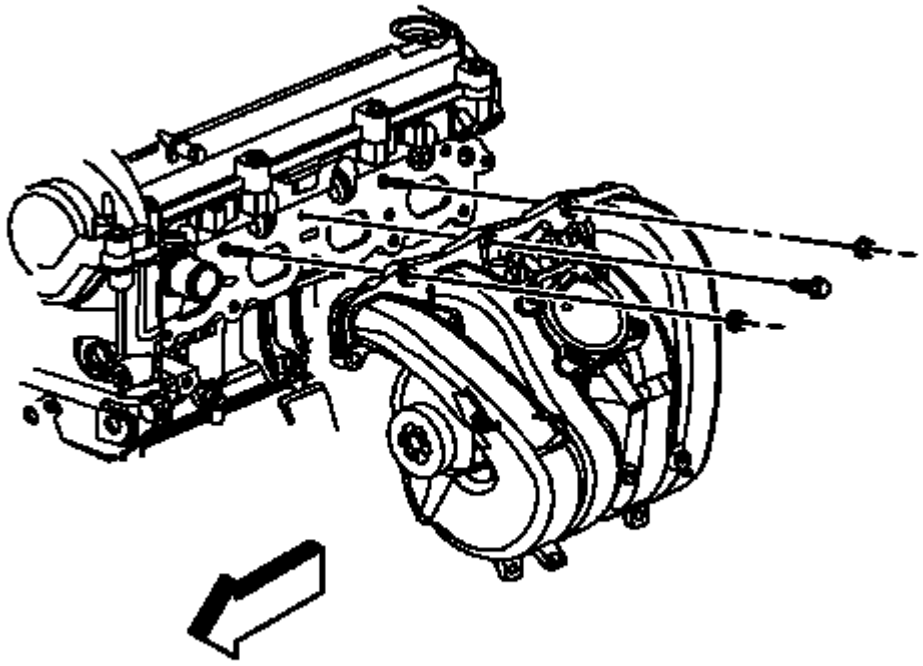

Fig. 76: Intake Manifold Upper Bolt And Nuts
Courtesy of GENERAL MOTORS CORP.

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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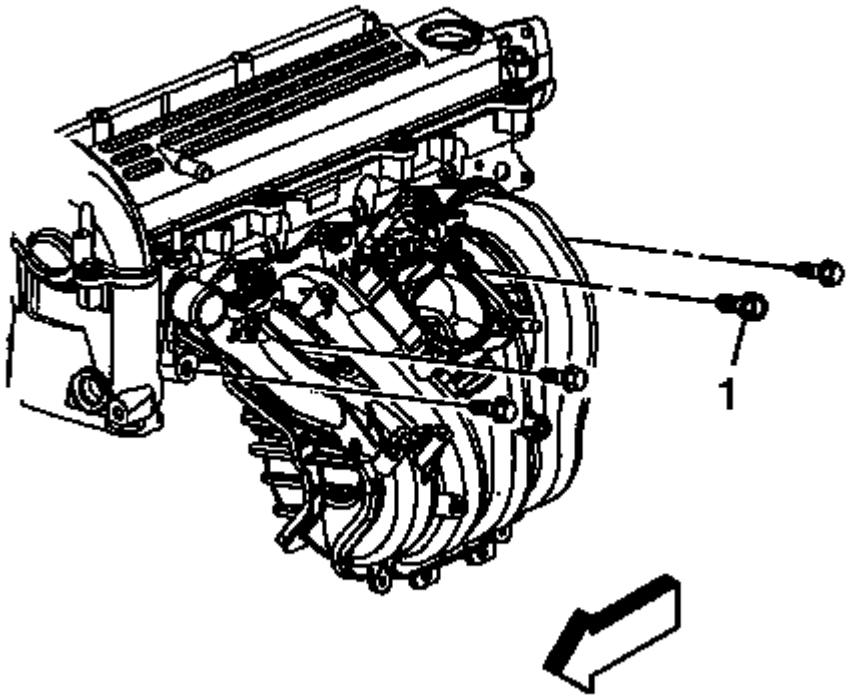

Fig. 77: Intake Manifold Lower Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the intake manifold lower bolts (1) and tighten to 10 N.m (89 lb in).

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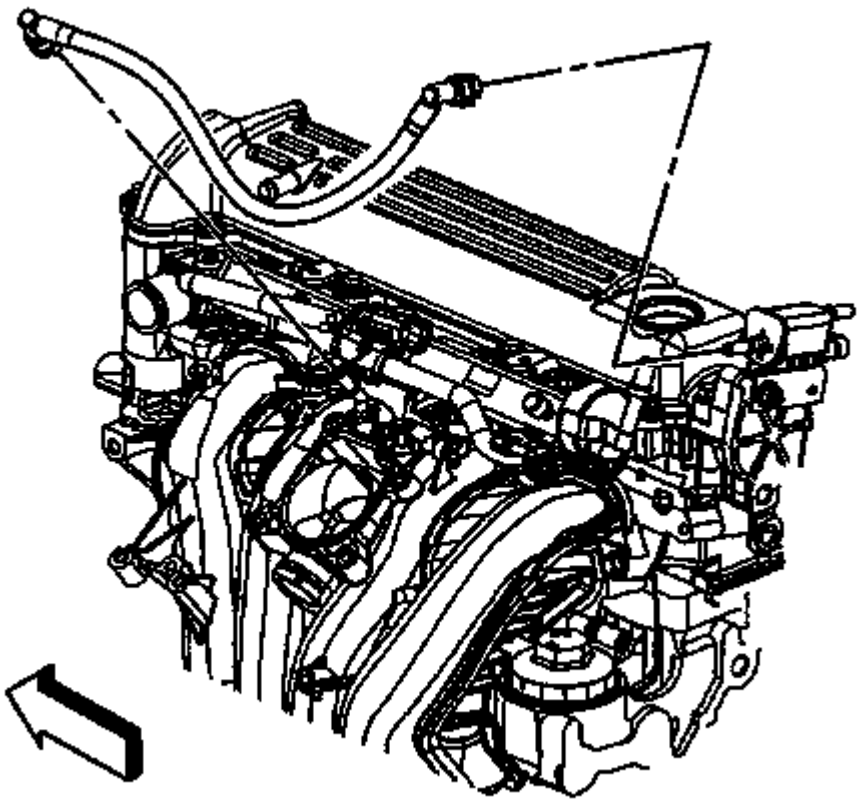

Fig. 78: EVAP Canister Purge Valve Tube
Courtesy of GENERAL MOTORS CORP.

5. Install the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .
6. Install the oil level indicator tube. Refer to **Oil Level Indicator 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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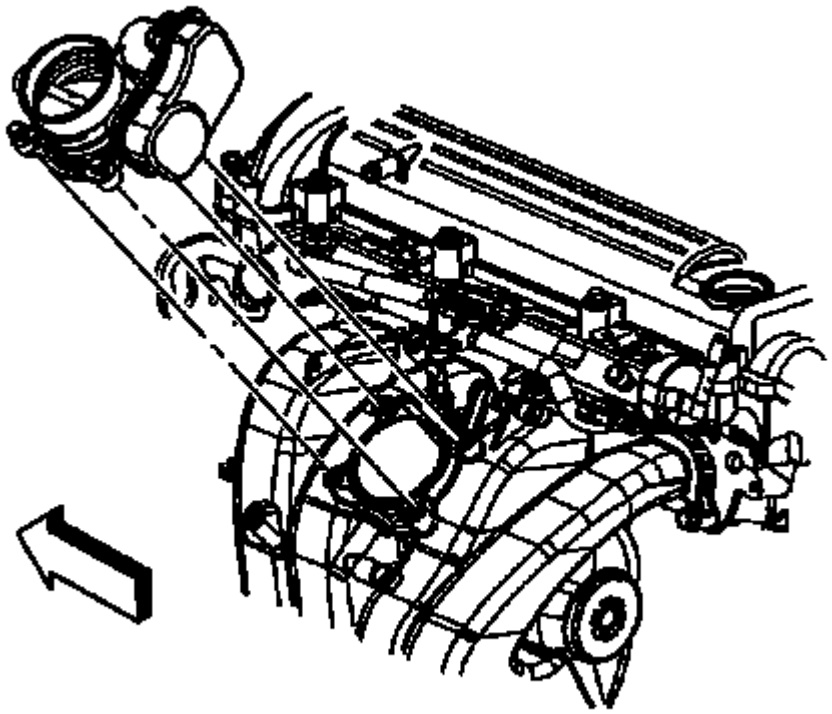

Fig. 79: Identifying Throttle Body
Courtesy of GENERAL MOTORS CORP.

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 and tighten to 10 N.m (89 lb in).

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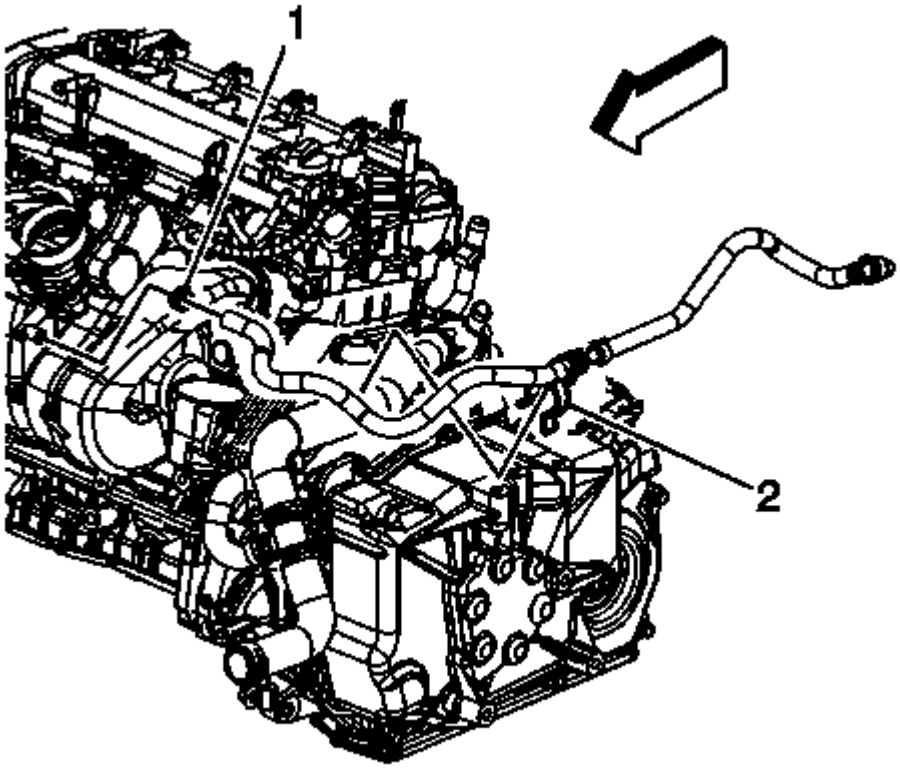

Fig. 80: Positioning Brake Booster Vacuum Hose Clamp At Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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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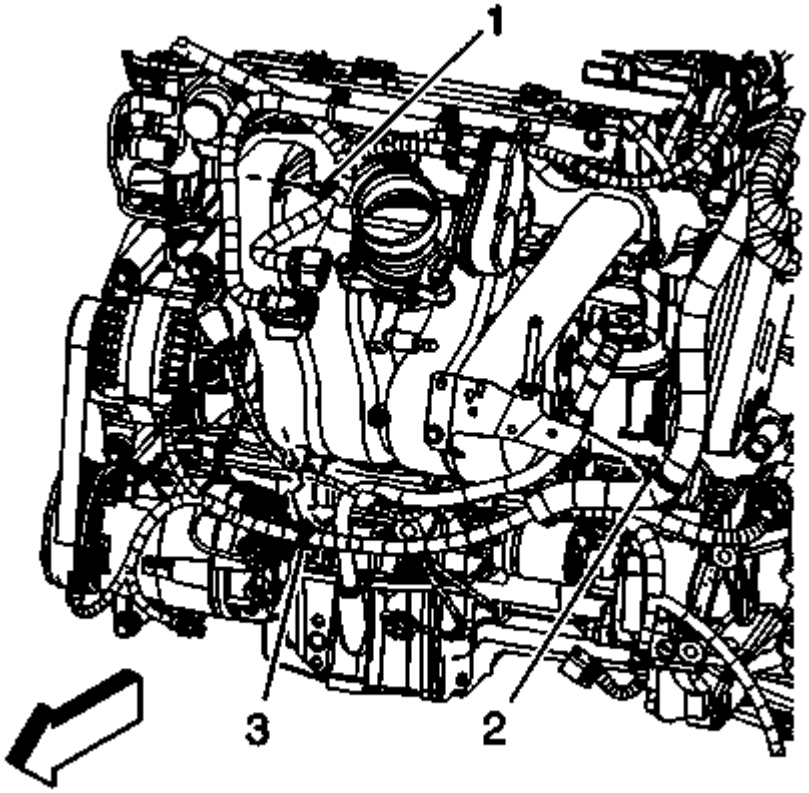

Fig. 81: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

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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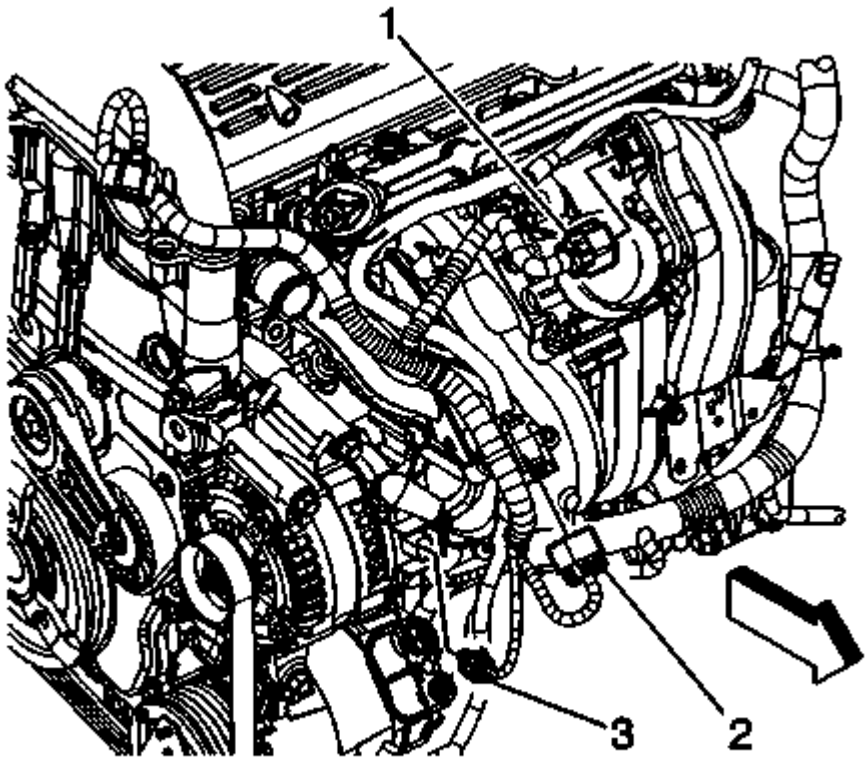

Fig. 82: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

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

Removal Procedure

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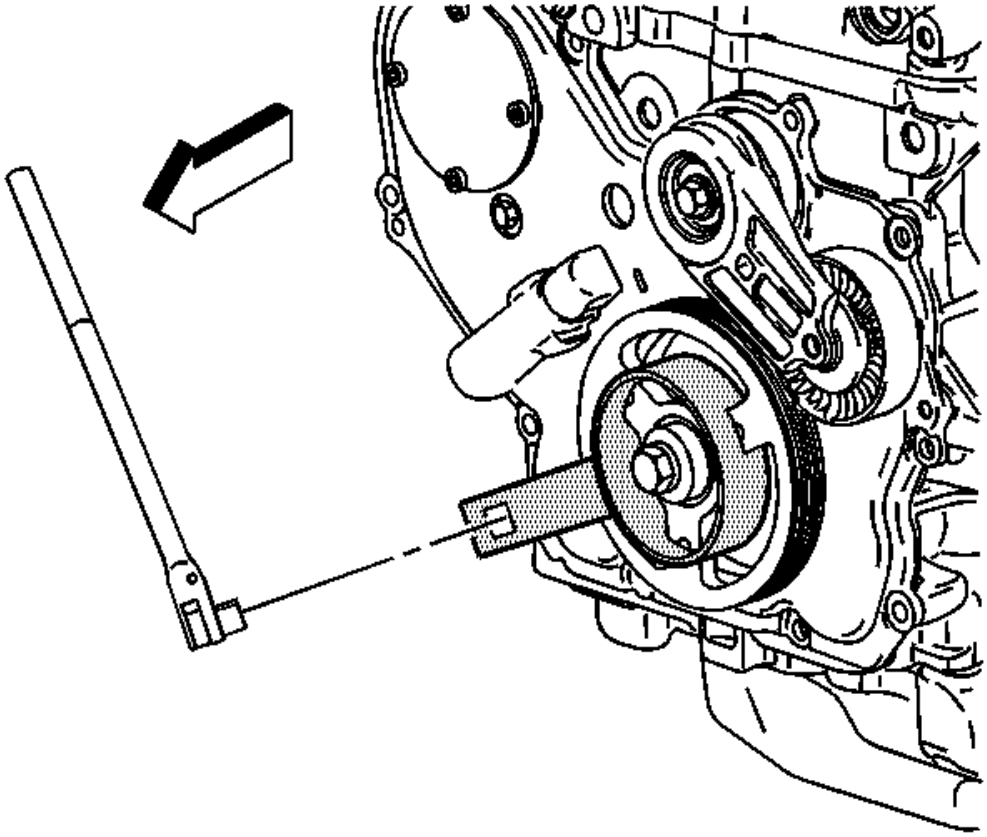

Fig. 83: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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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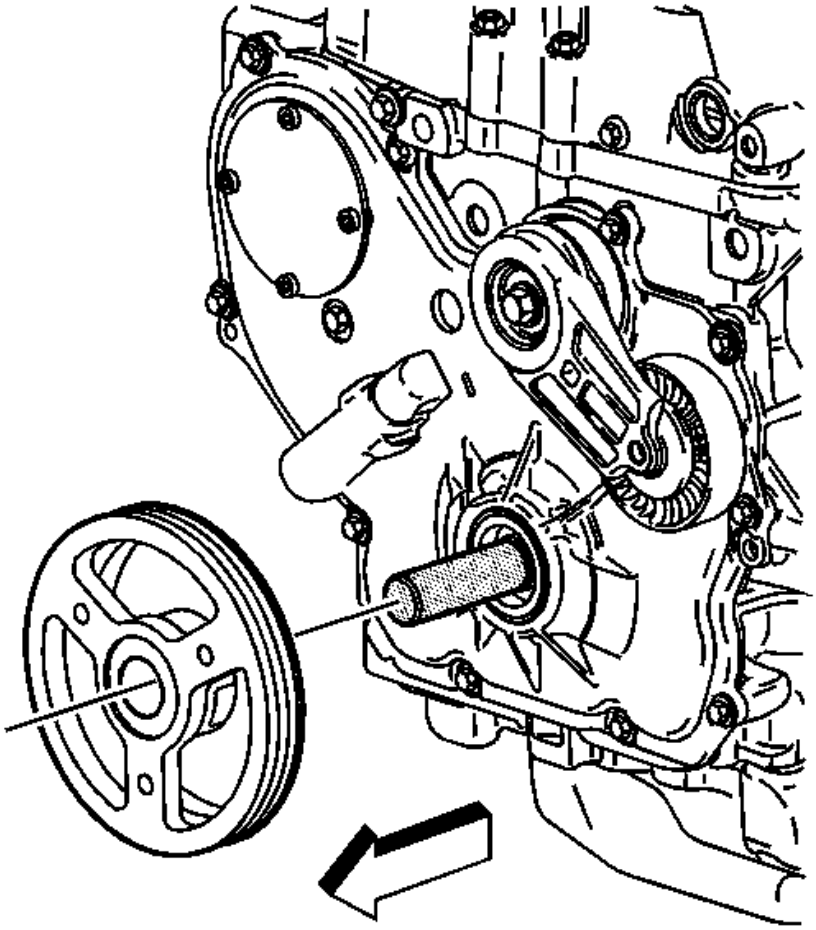

Fig. 84: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

4. Remove the crankshaft balancer.

Installation Procedure

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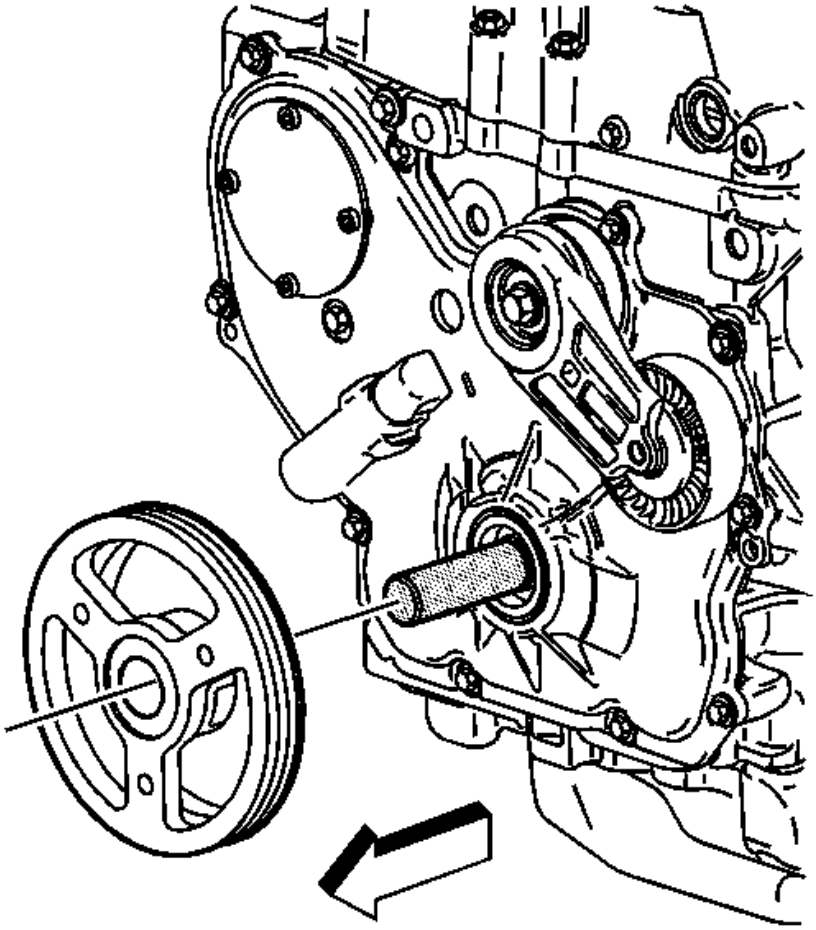

Fig. 85: View Of Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

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

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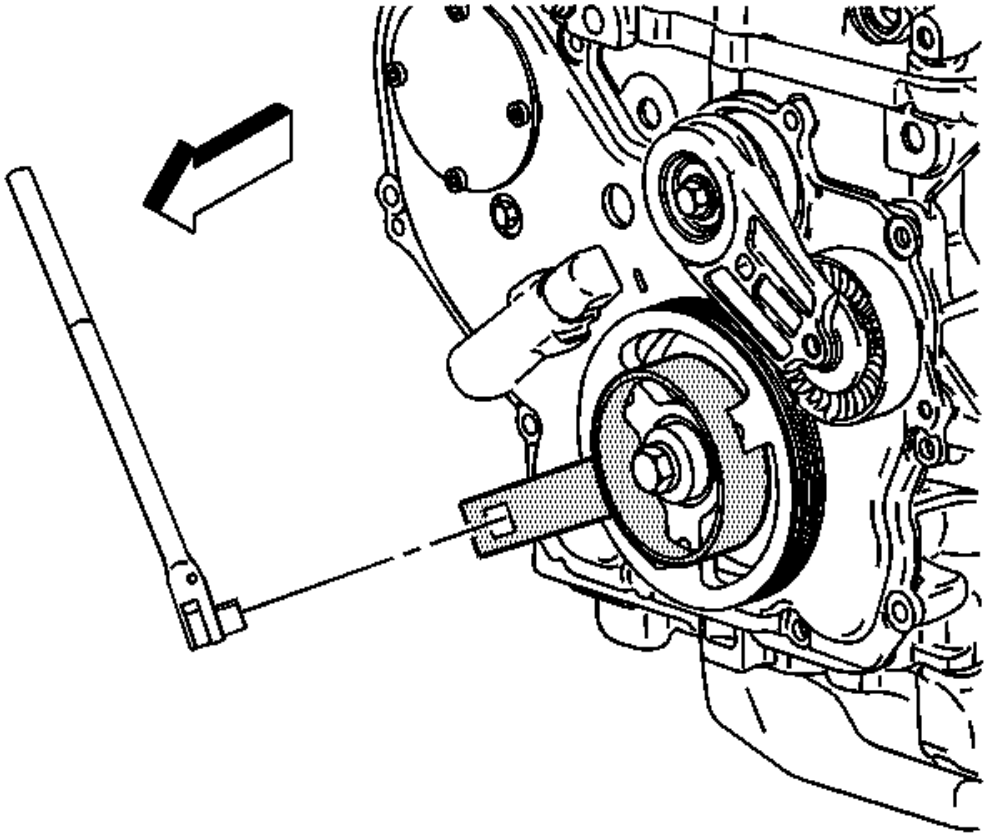

Fig. 86: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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

   CAUTION: Refer to Fastener Caution .

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

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

Removal Procedure

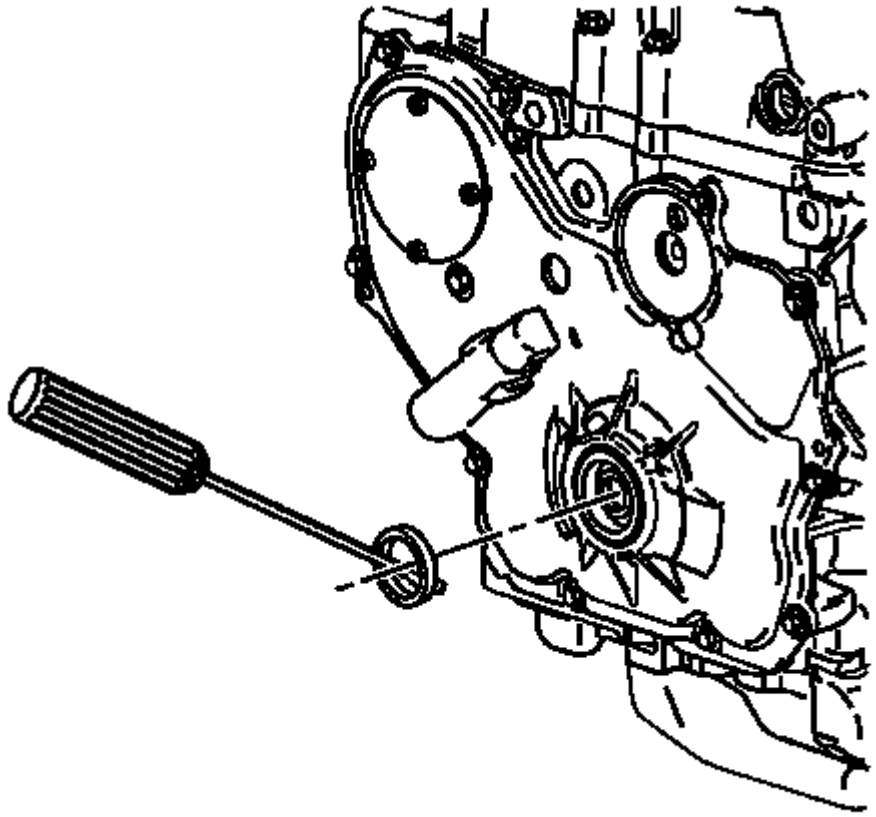

Fig. 87: Removing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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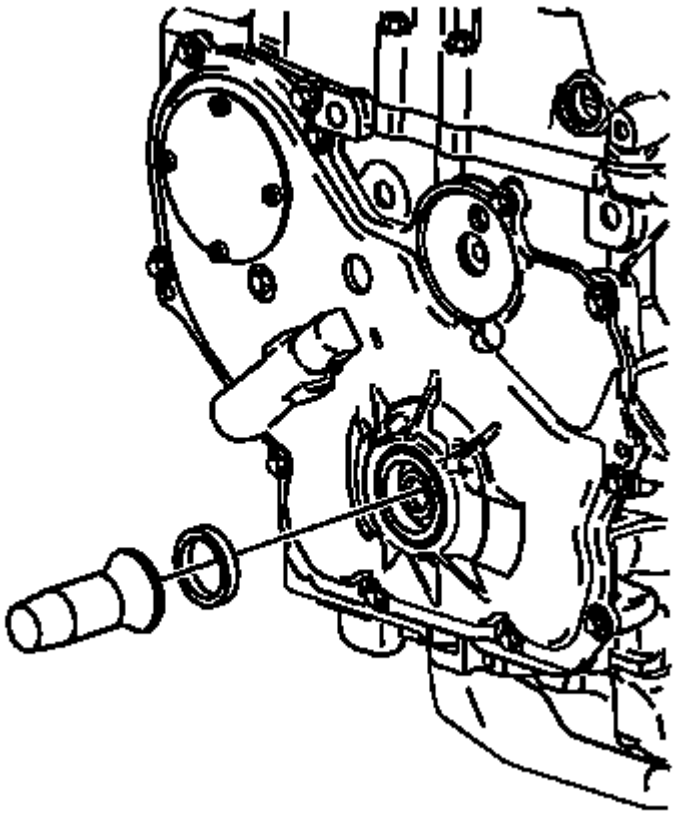

Fig. 88: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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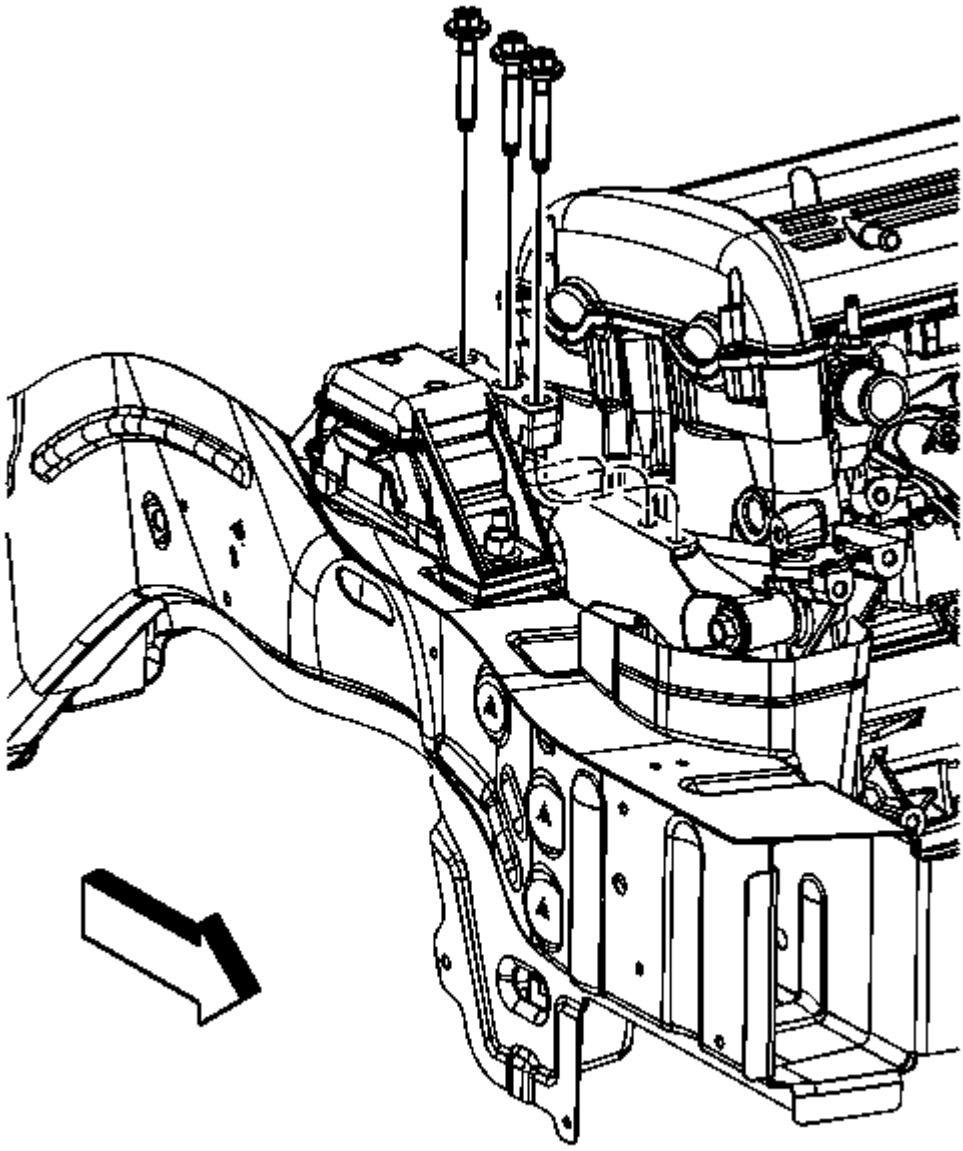

Fig. 89: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

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 **Windshield Washer Solvent Container**

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Replacement (Pontiac) or **Windshield Washer Solvent Container Replacement (Chevrolet)** .

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

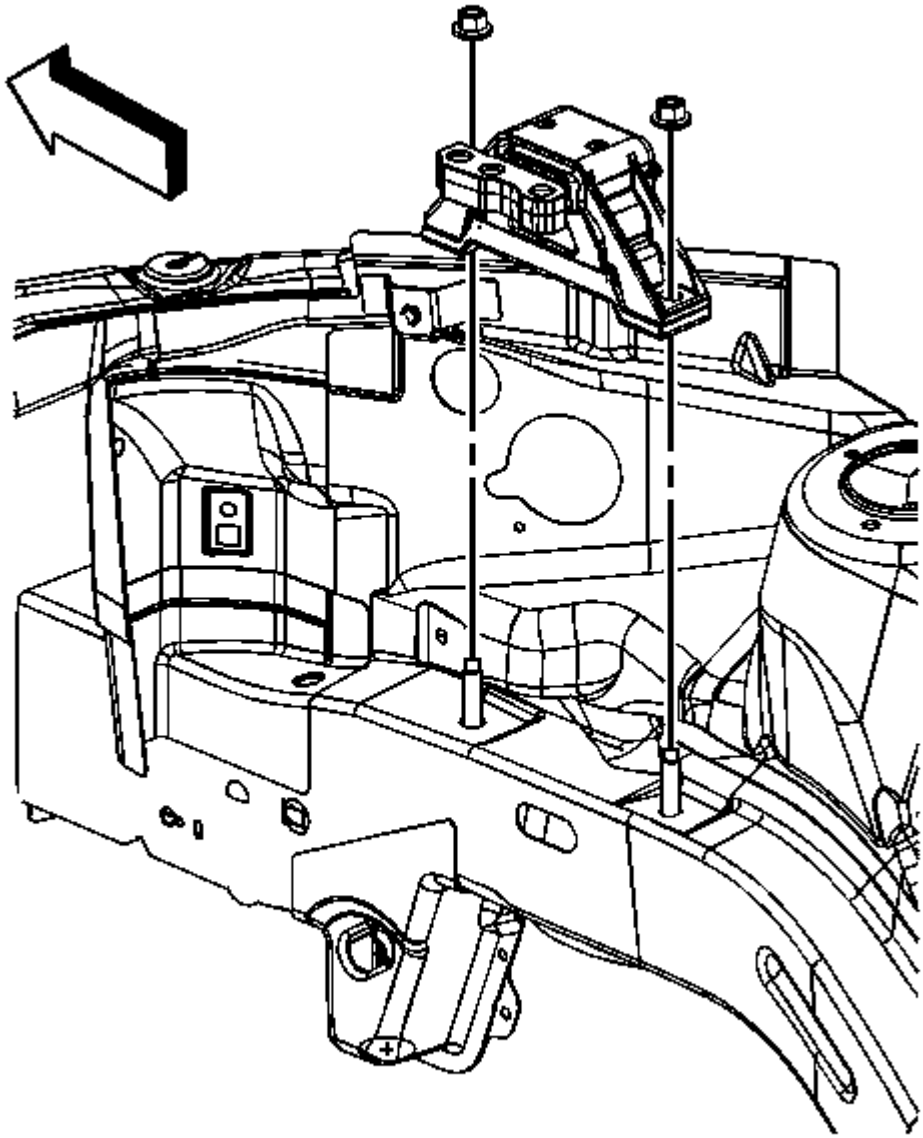

Fig. 90: Engine Mount To Side Rail Nuts
Courtesy of GENERAL MOTORS CORP.

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7. Remove the engine mount to side rail nuts.
8. Remove the engine mount from the engine compartment.

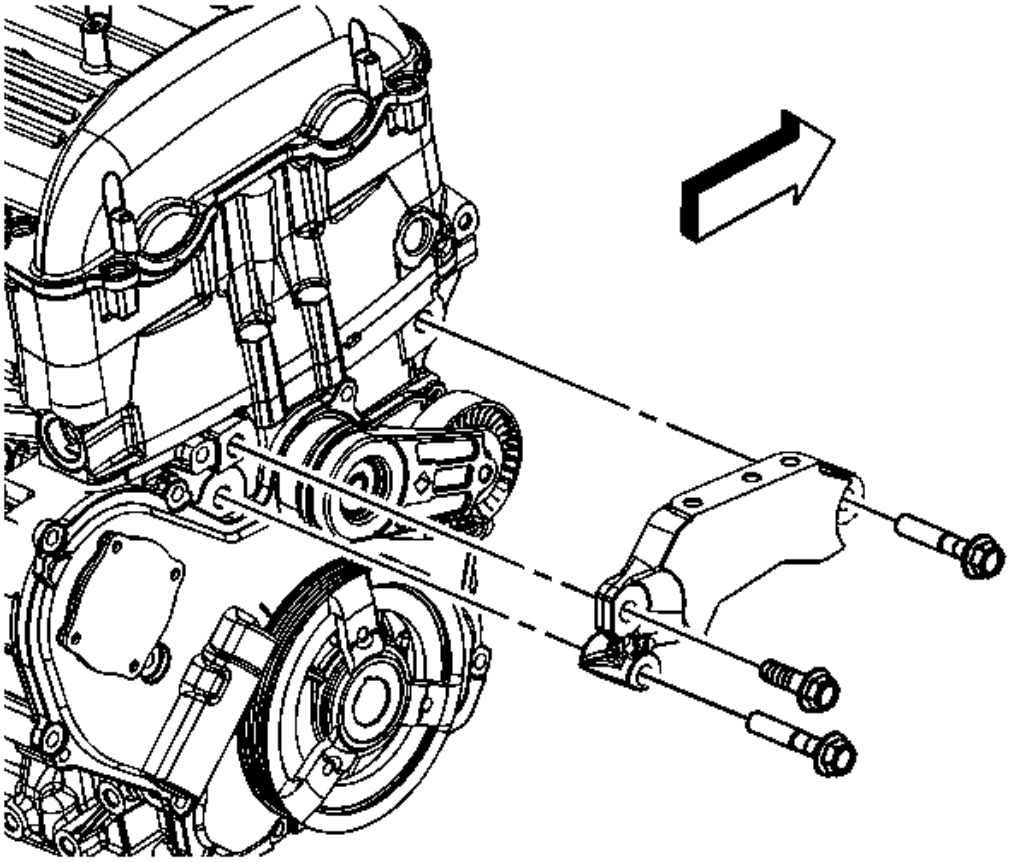

Fig. 91: Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

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

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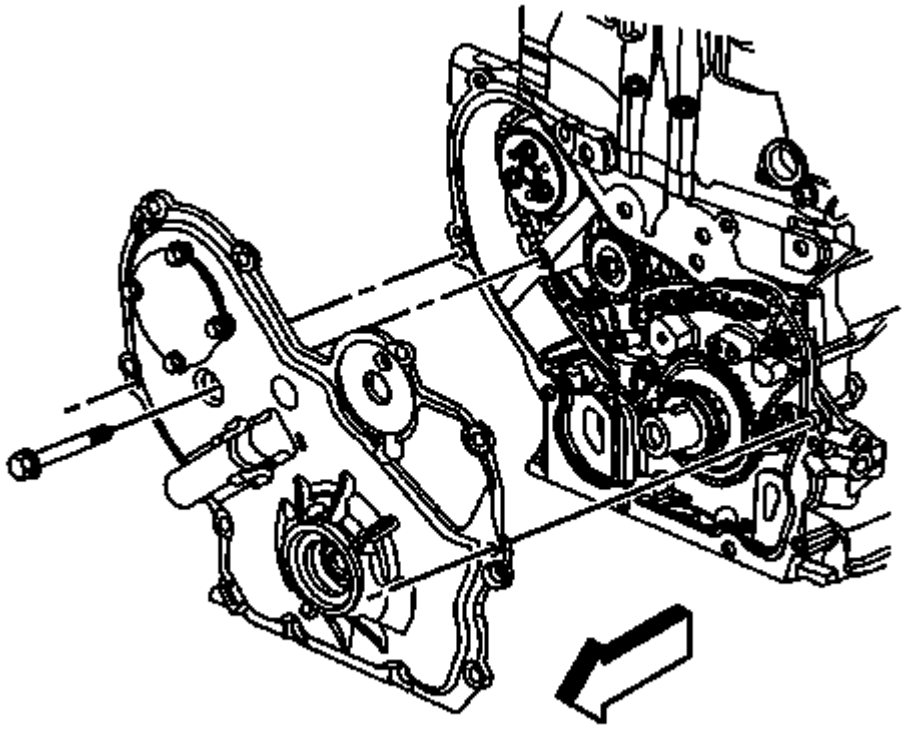

Fig. 92: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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

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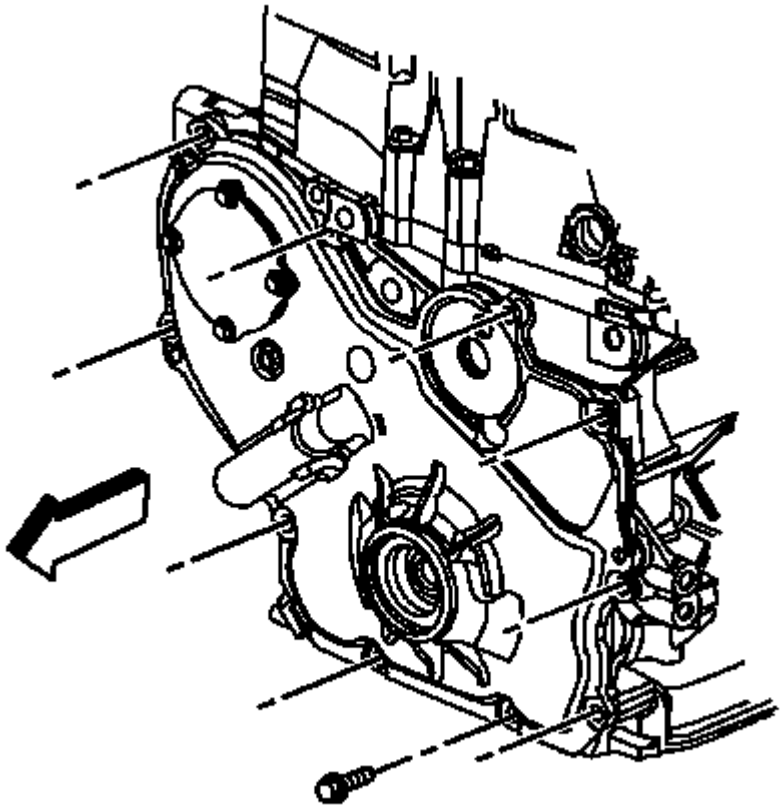

Fig. 93: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

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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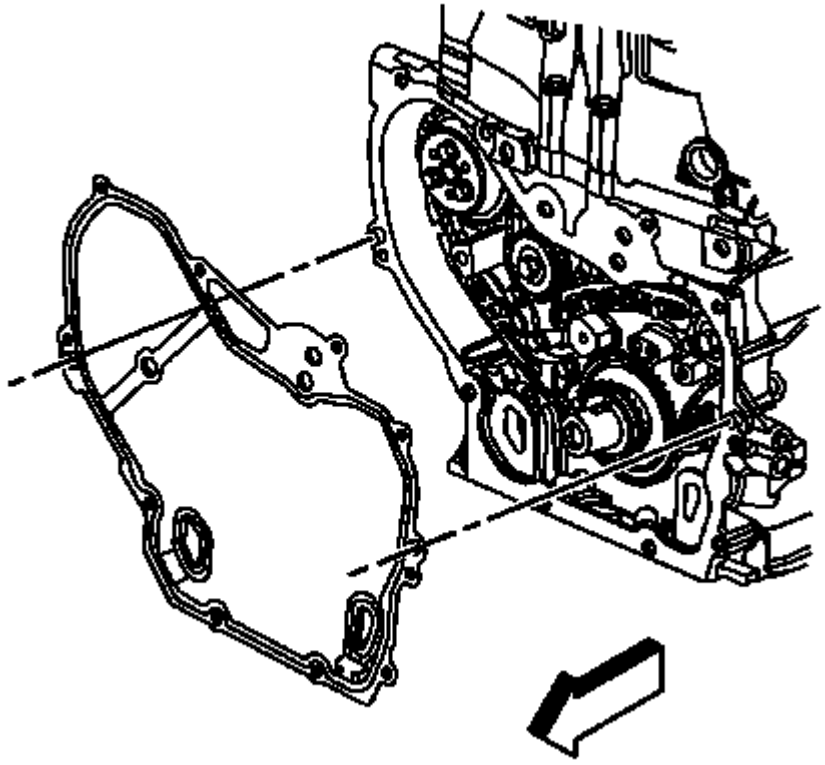

Fig. 94: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

15. Remove and discard the engine front cover gasket.

Installation Procedure

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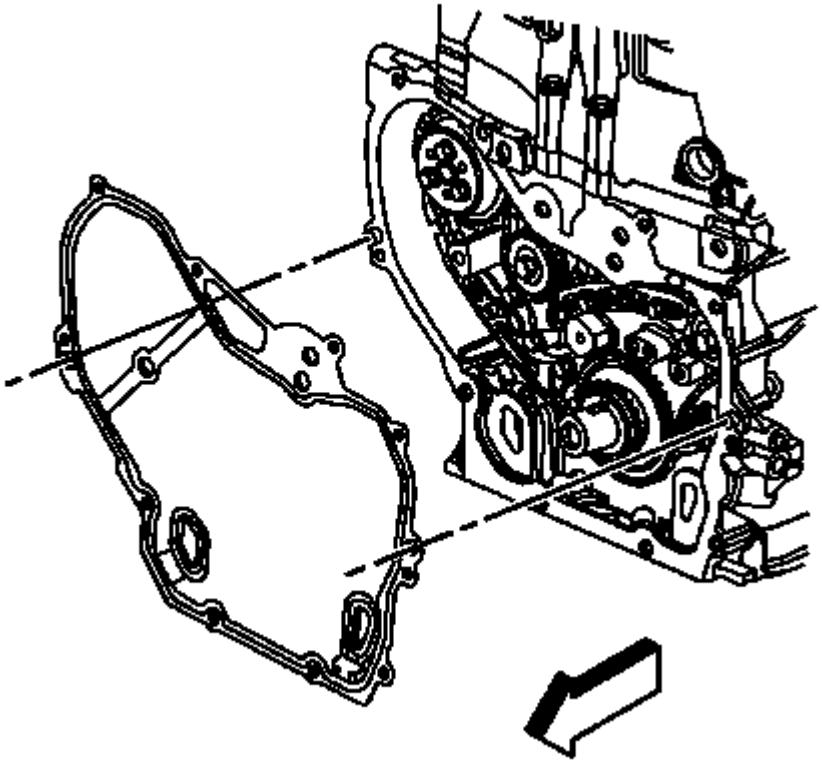

Fig. 95: Engine Front Cover Gasket
Courtesy of GENERAL MOTORS CORP.

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

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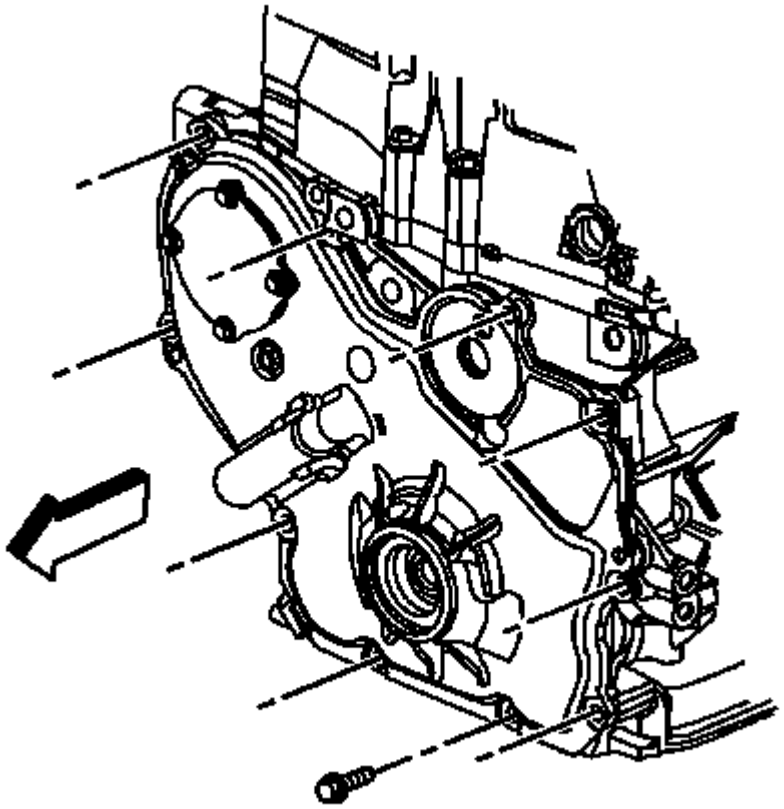

Fig. 96: Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

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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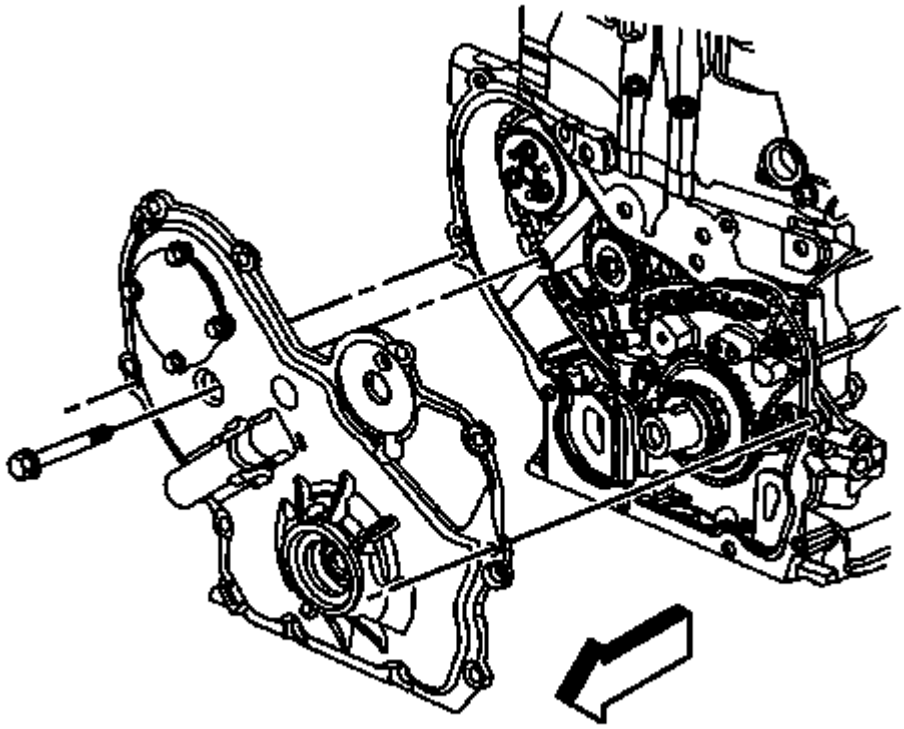

Fig. 97: Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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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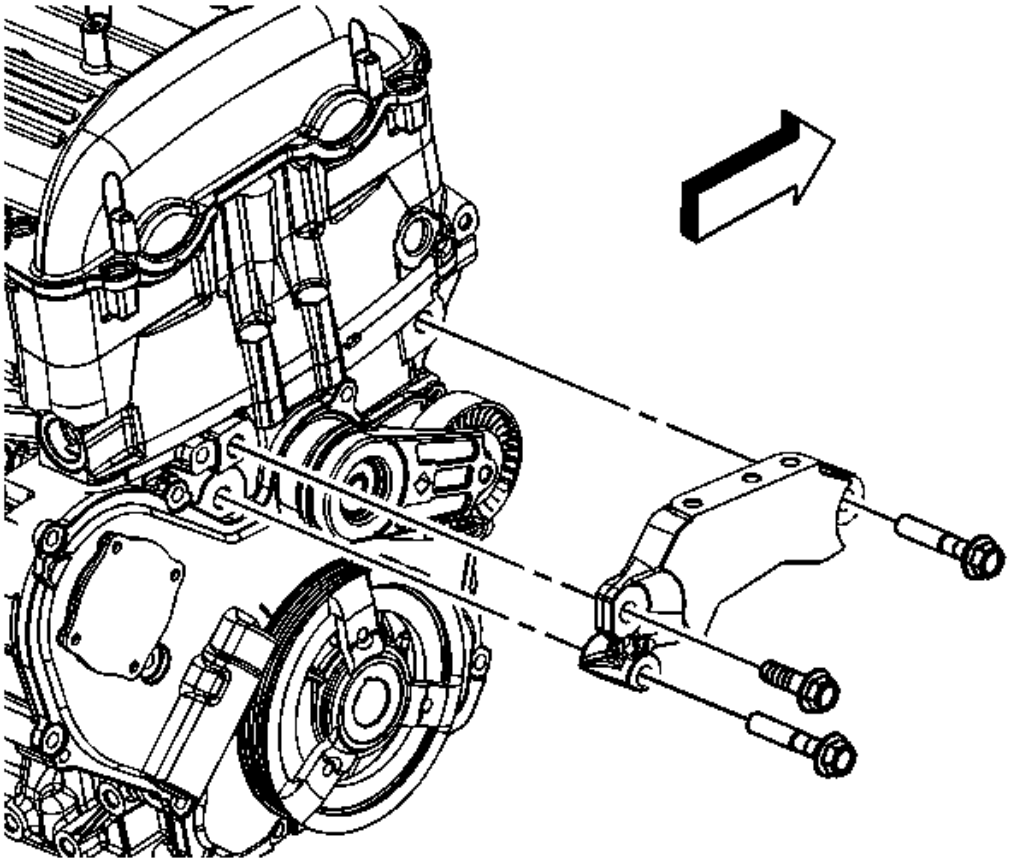

Fig. 98: Engine Mount Bracket
Courtesy of GENERAL MOTORS CORP.

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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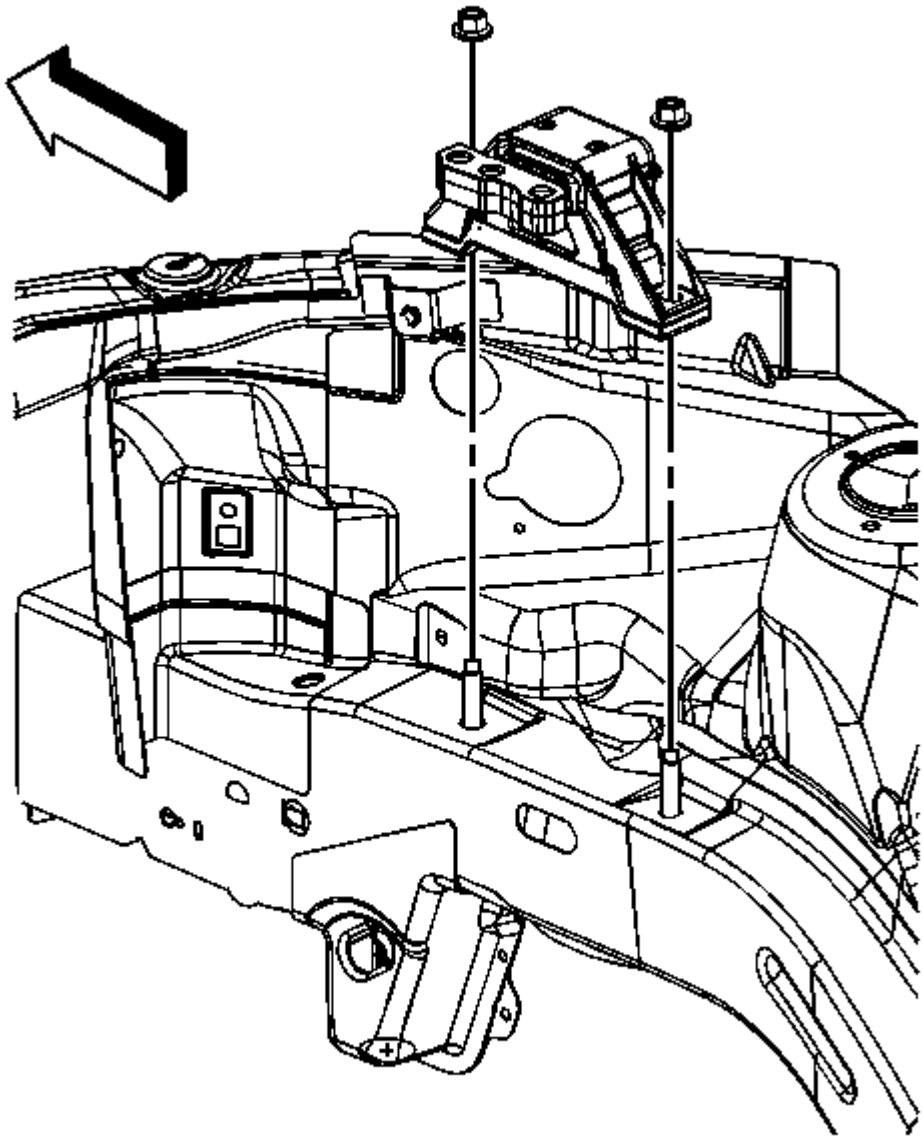

Fig. 99: Engine Mount To Side Rail Nuts
Courtesy of GENERAL MOTORS CORP.

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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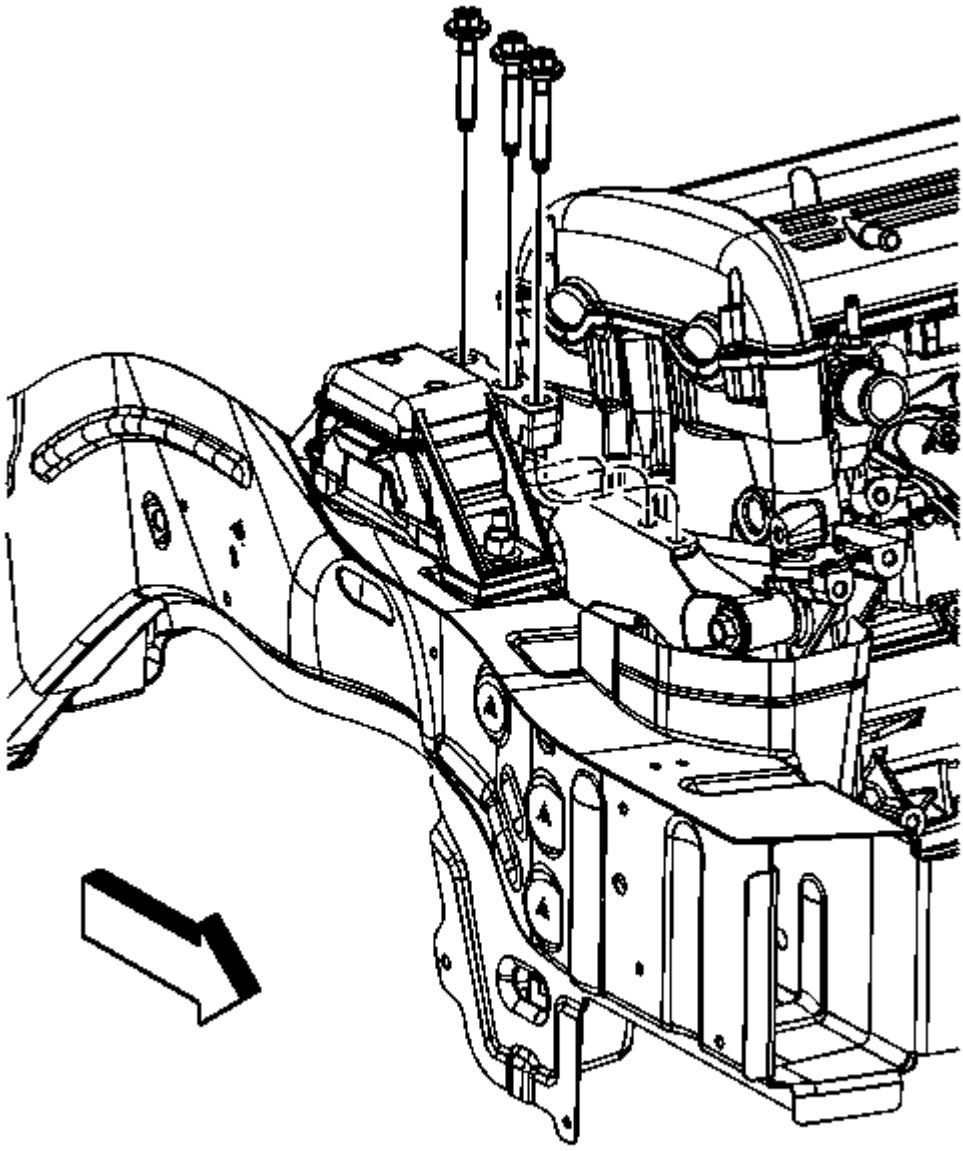

Fig. 100: Engine Mount Bolts
Courtesy of GENERAL MOTORS CORP.

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 **Windshield Washer Solvent Container Replacement (Pontiac)** or **Windshield Washer Solvent Container Replacement (Chevrolet)** .
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**.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER REPLACEMENT

Special Tools

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

Removal Procedure

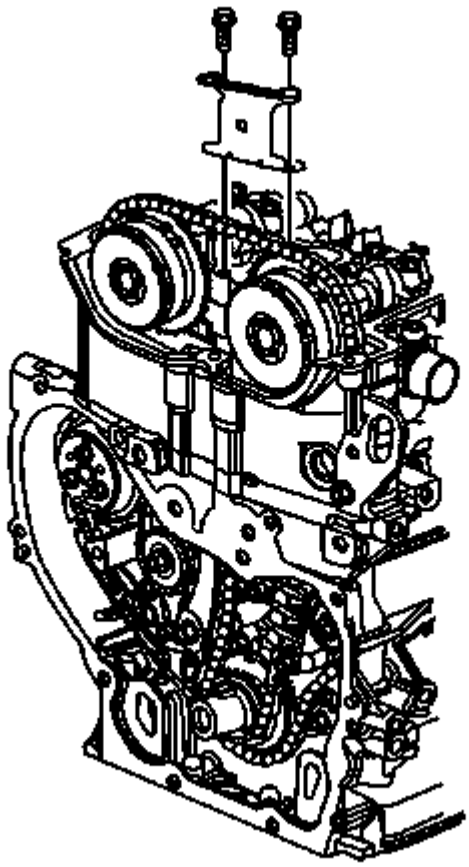

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Fig. 101: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the number 1 cylinder spark plug. Refer to **Spark Plug Replacement** .
2. Rotate the crankshaft in the engine rotational direction clockwise, until the number 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.

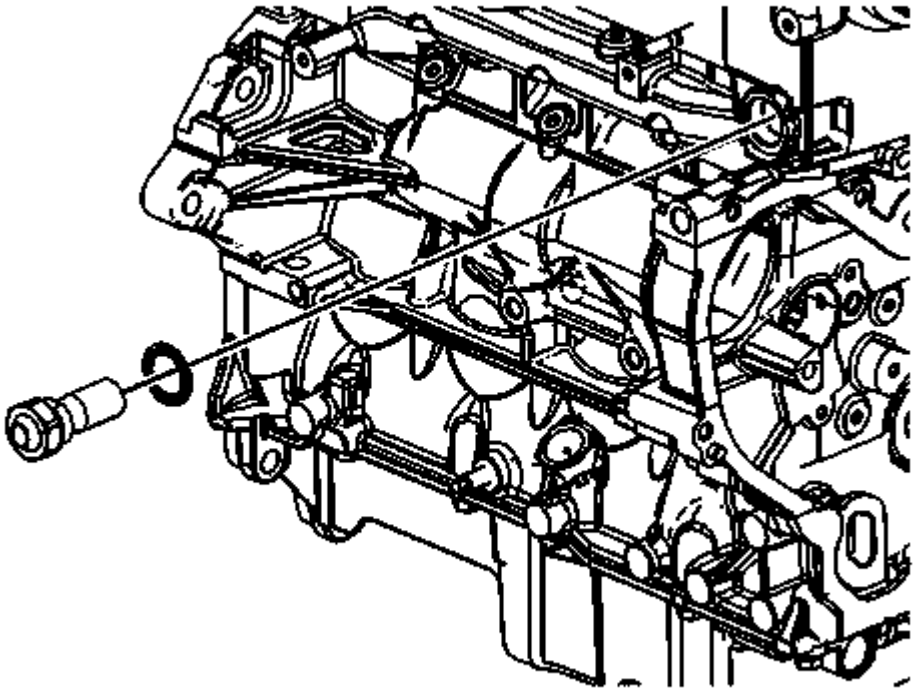

Fig. 102: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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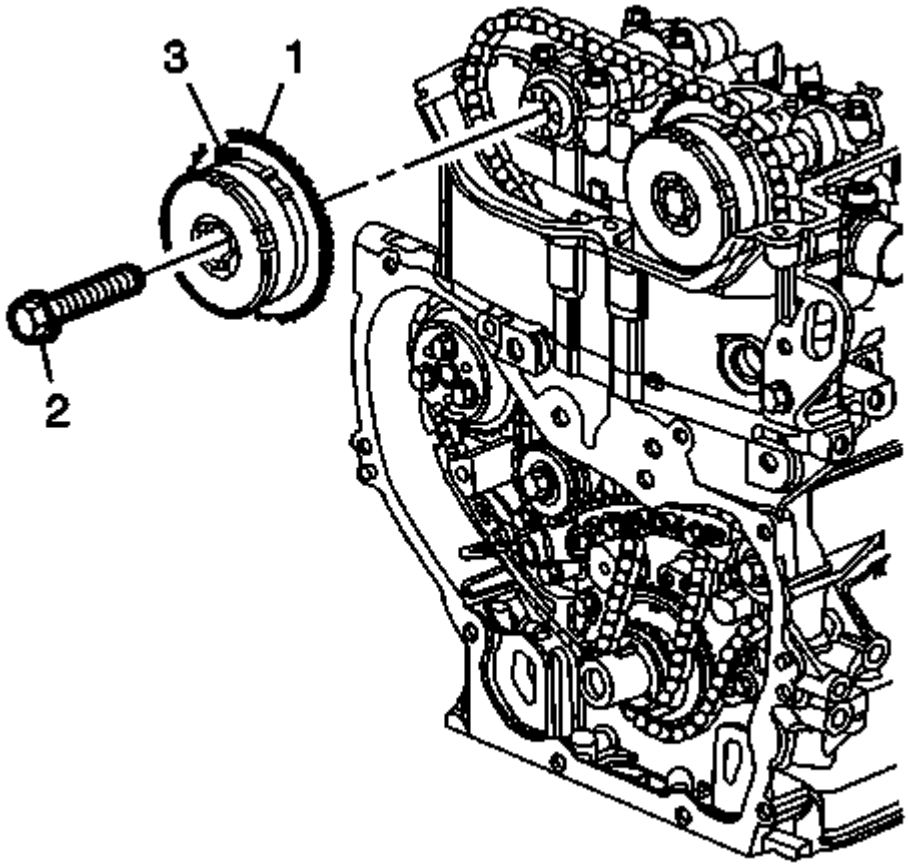

Fig. 103: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

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, 3) from the camshaft and timing chain.

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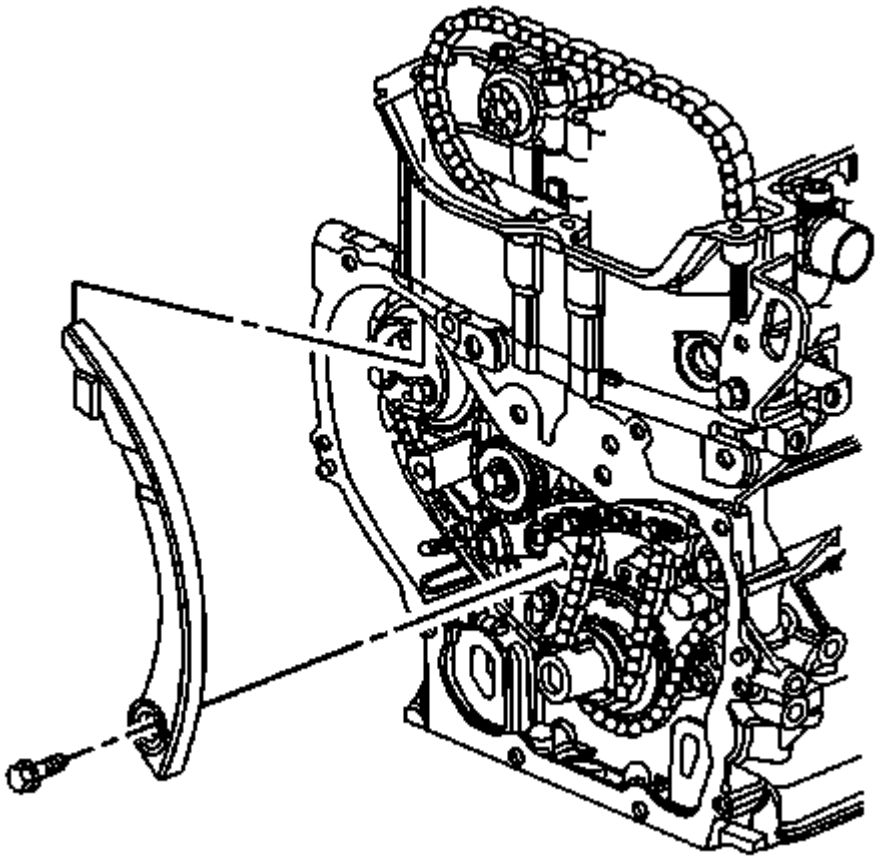

Fig. 104: Timing Chain Tensioner Guide
Courtesy of GENERAL MOTORS CORP.

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

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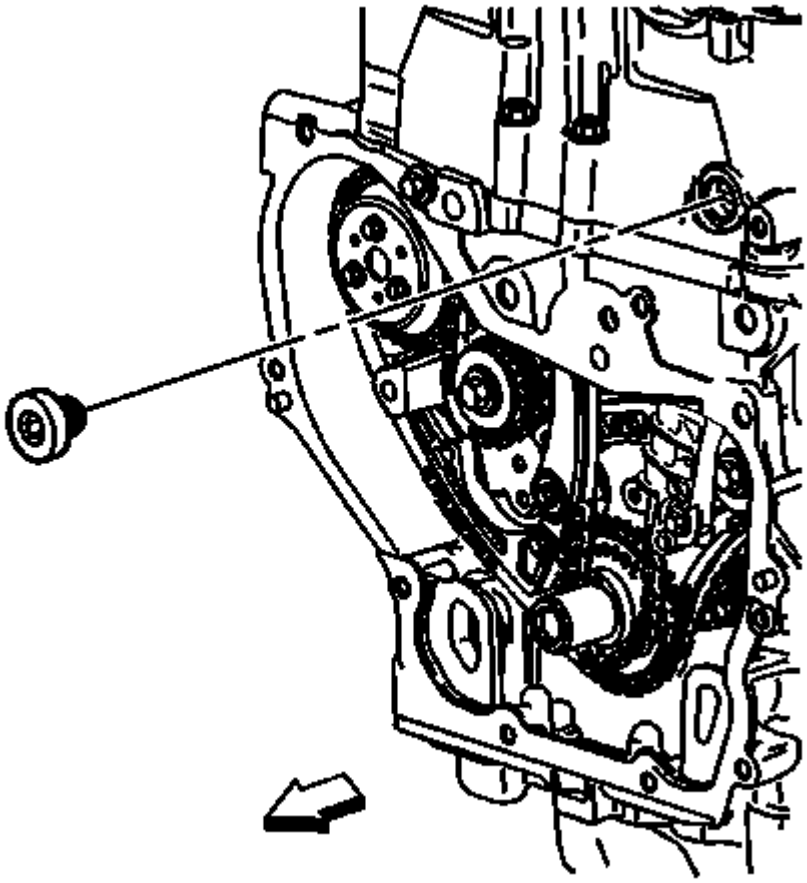

Fig. 105: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

11. Remove the fixed timing chain guide access plug.

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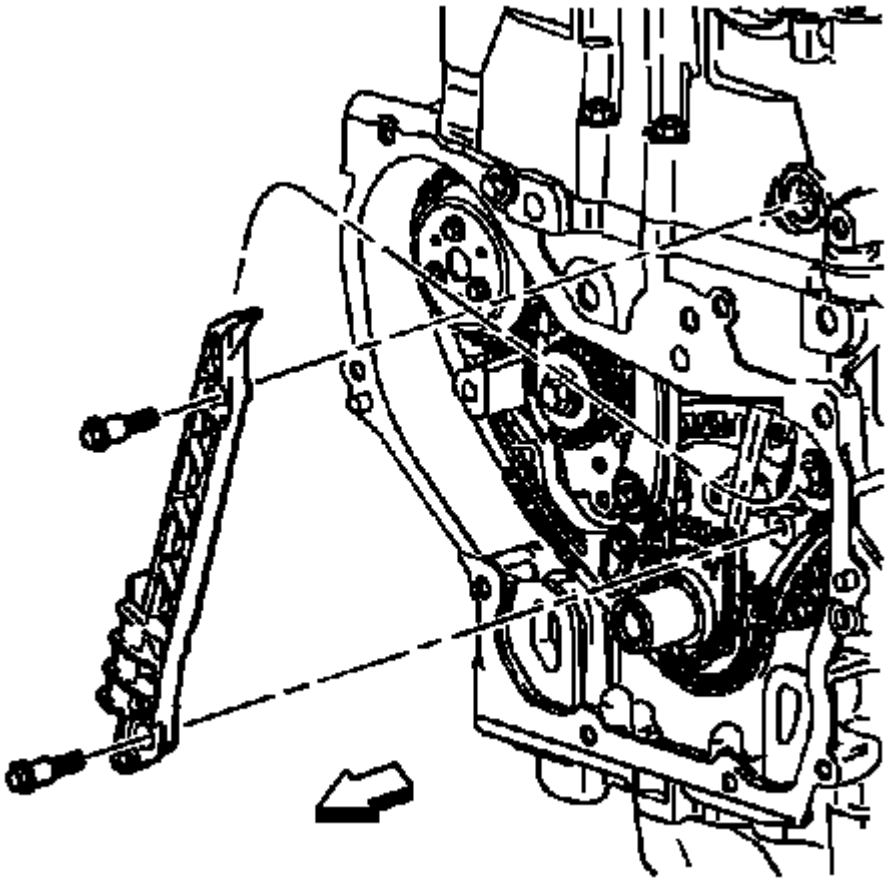

Fig. 106: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

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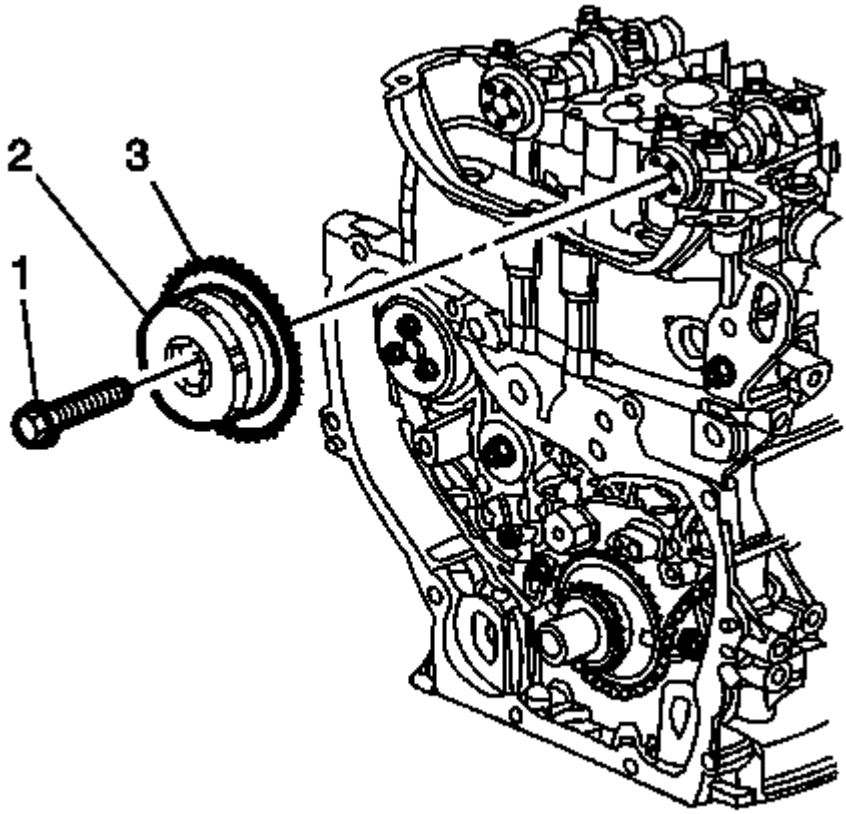

Fig. 107: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

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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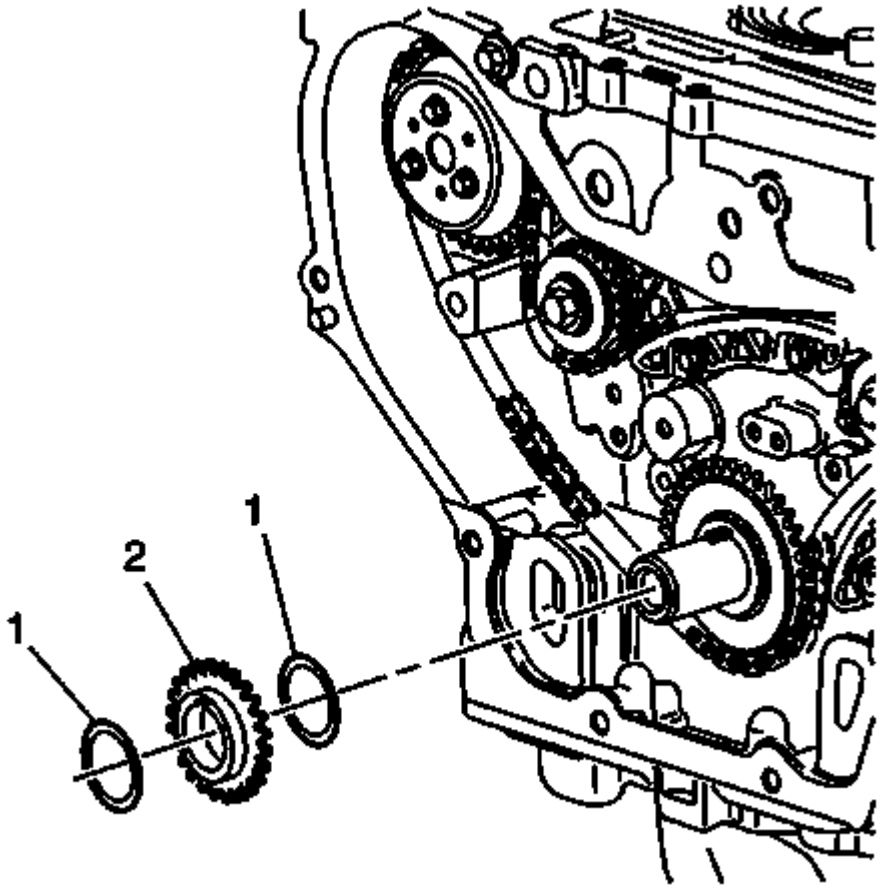

Fig. 108: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

16. Remove the crankshaft sprocket (2) and friction washers (1), if equipped.

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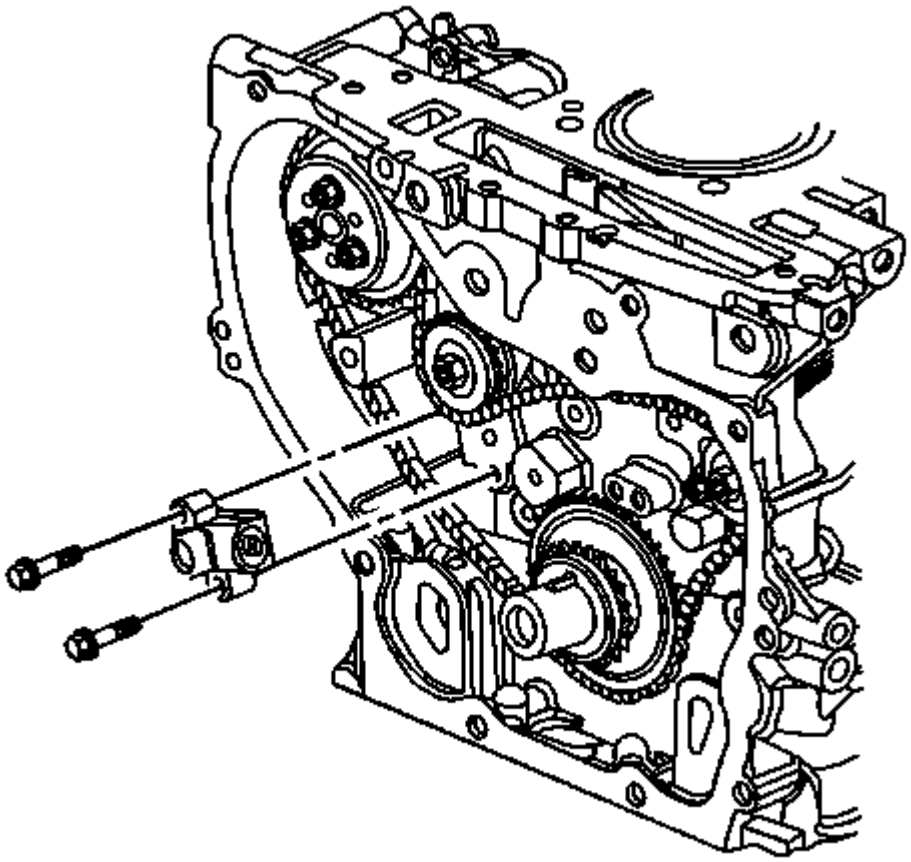

Fig. 109: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

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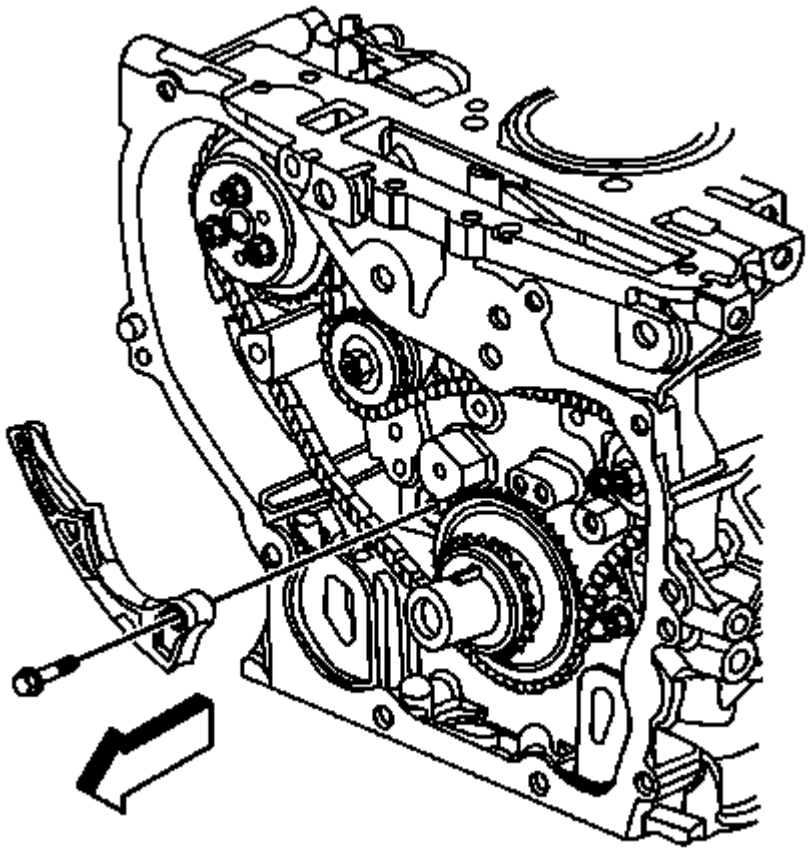

Fig. 110: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

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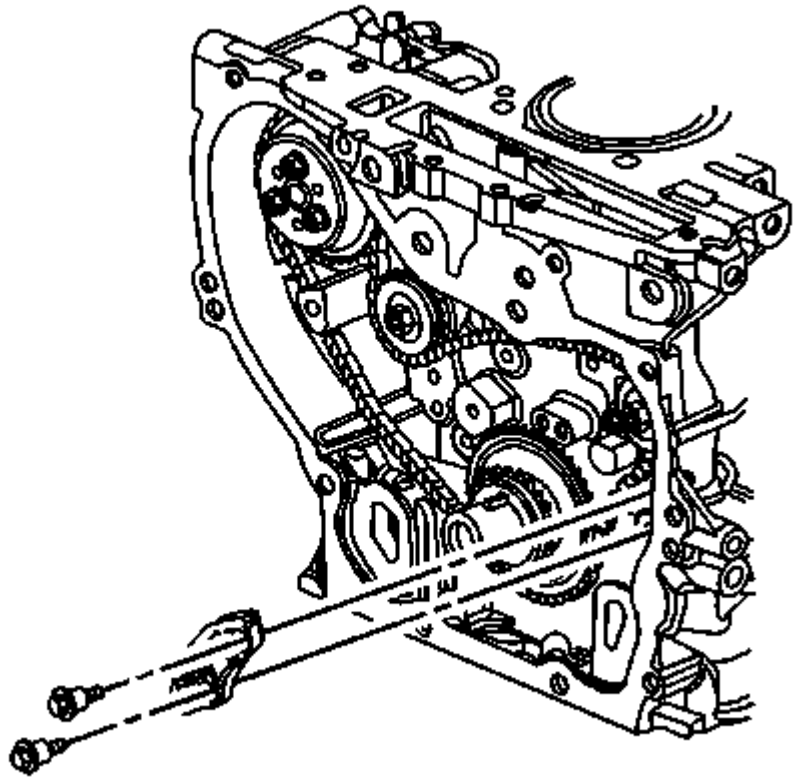

Fig. 111: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

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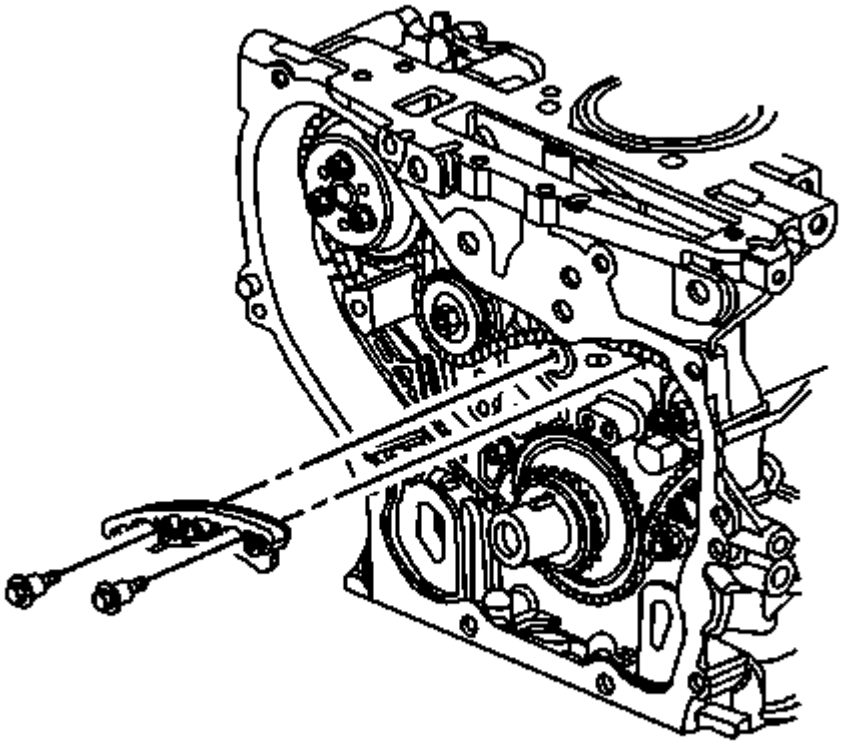

Fig. 112: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

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

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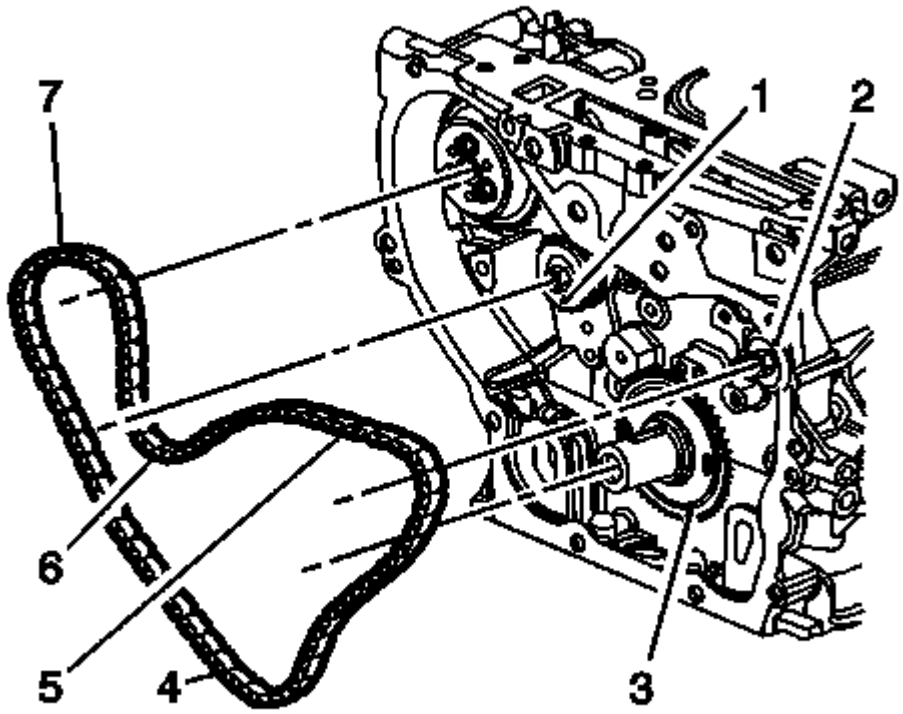

Fig. 113: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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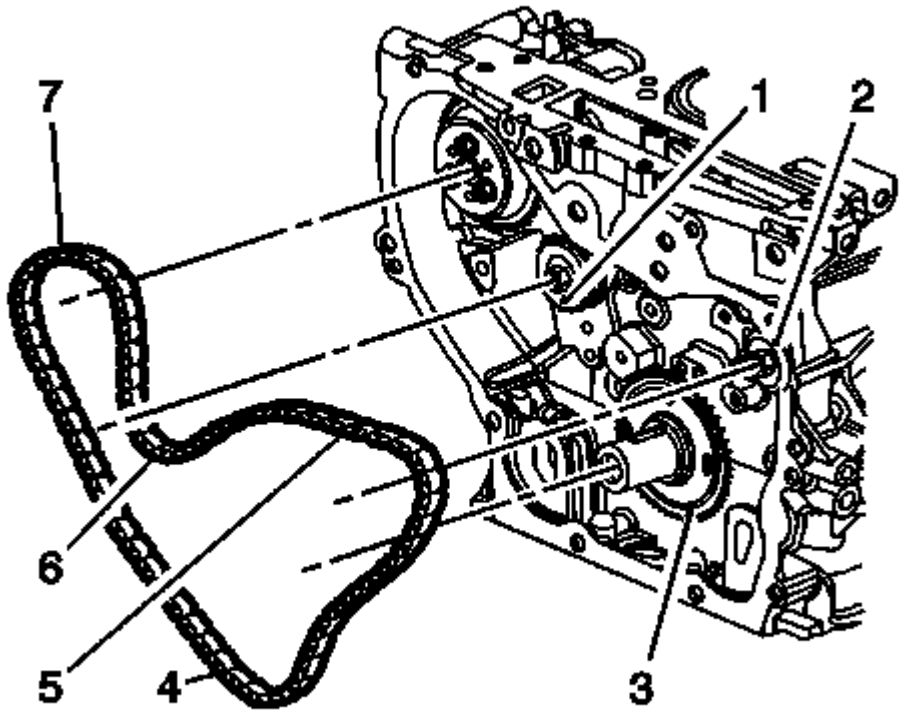

Fig. 114: Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: 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 1 is copper. Use the following steps in order to line up the links with the sprockets.
    1. Place the copper link (5) so that it lines up with the timing mark (2) on the intake side balance shaft sprocket.
    2. 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).
    3. Place the chain (7) on the water pump drive sprocket. The alignment is not critical.
    4. Align the last chrome link (6) with the timing mark (1) on the exhaust side balance shaft drive sprocket.

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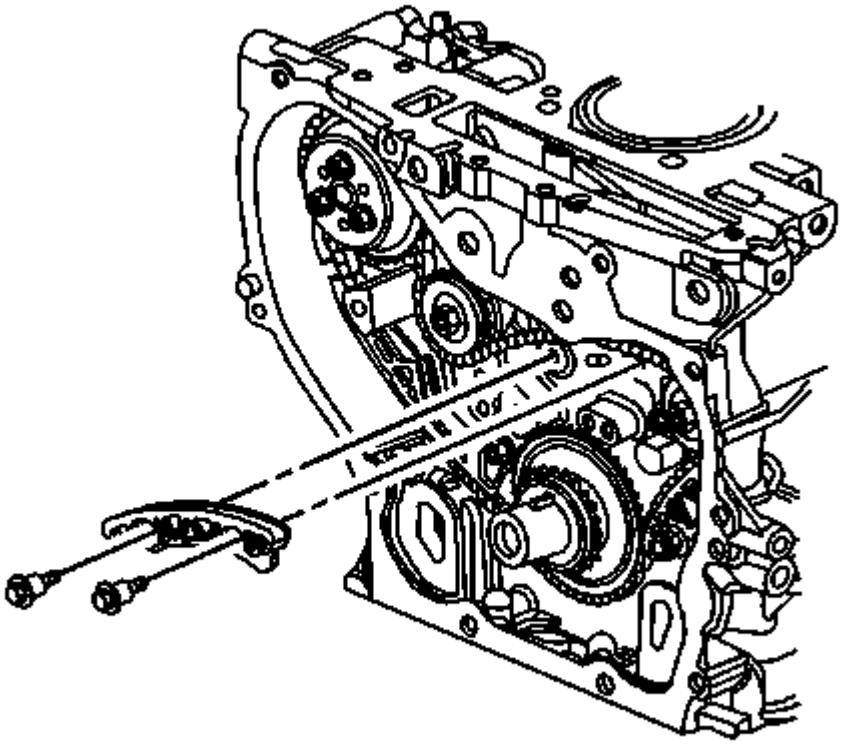

Fig. 115: Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

4. Install the upper balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

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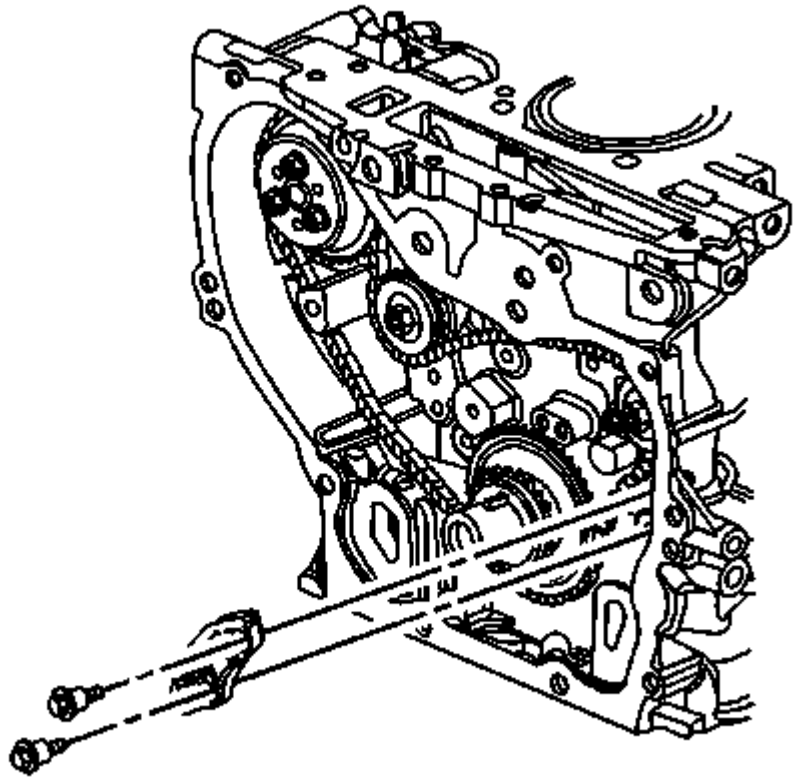

Fig. 116: Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Install the small balance shaft drive chain guide and bolts and tighten to 15 N.m (11 lb ft).

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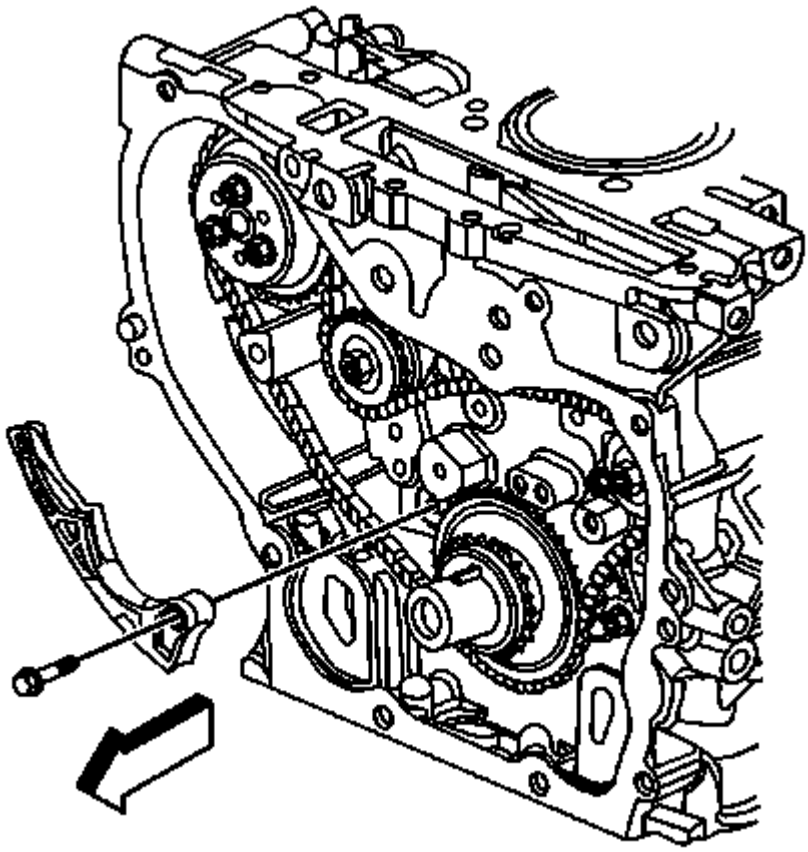

Fig. 117: Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Install the adjustable balance shaft chain guide and bolt and tighten to 10 N.m (89 lb in).

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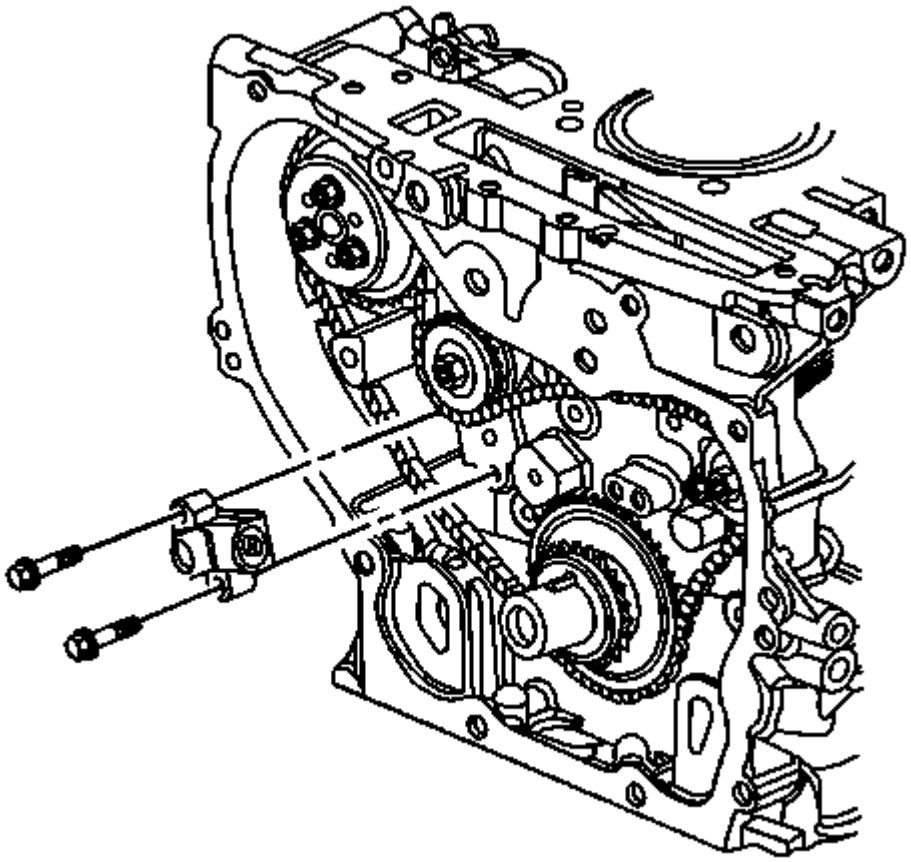

Fig. 118: Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

7. Reset the timing chain tensioner by performing the following steps:
    1. Rotate the tensioner plunger 90 degrees in its bore and compress the plunger.
    2. 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 and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

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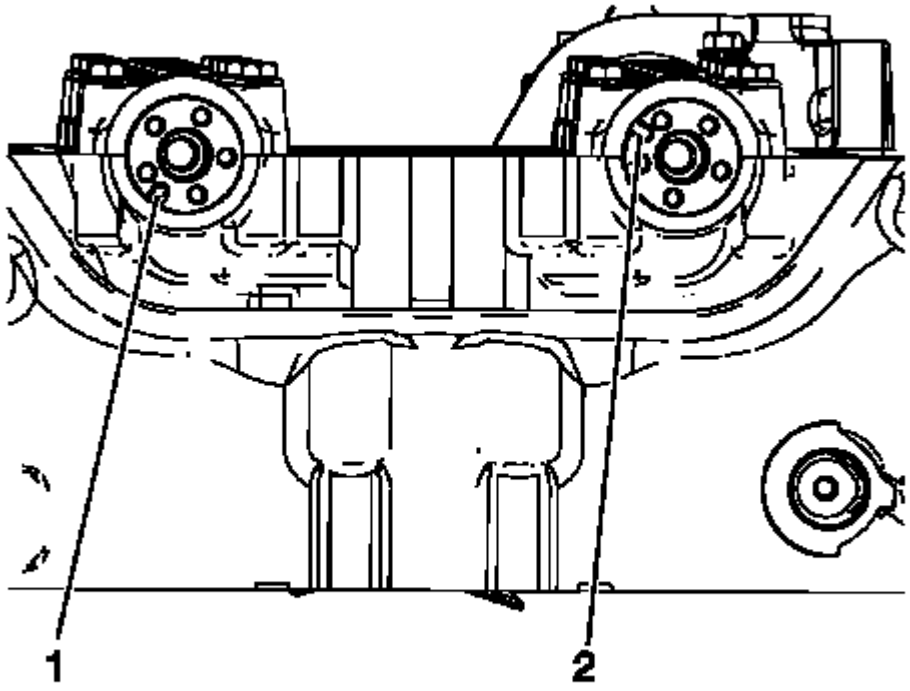

Fig. 119: Camshaft Notches (2.2L)
Courtesy of GENERAL MOTORS CORP.

10. On 2.2L engines, ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

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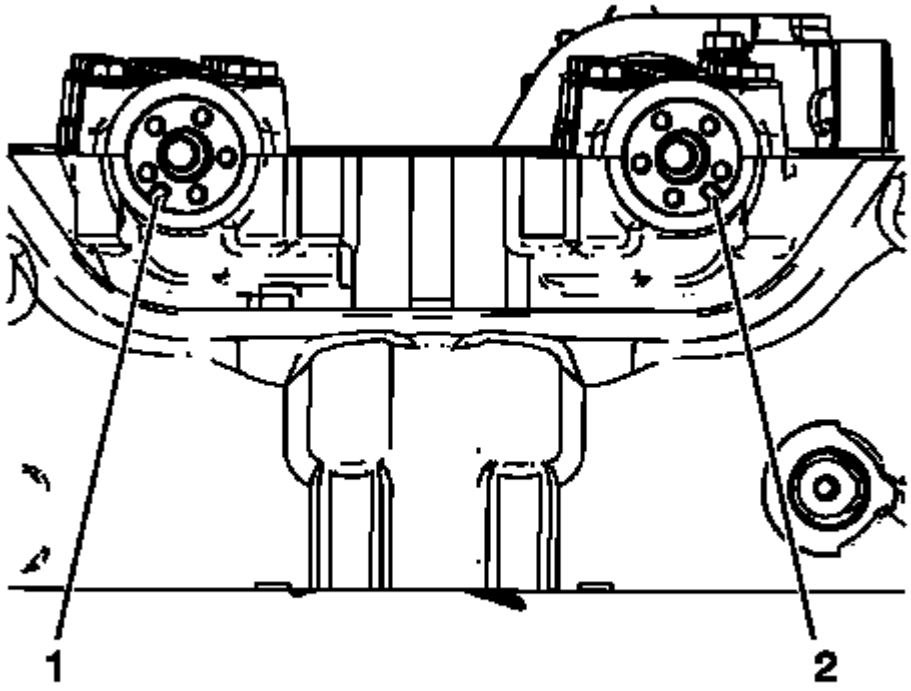

Fig. 120: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

11. On 2.4L engines, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at TDC, crankshaft key at 12 o'clock.

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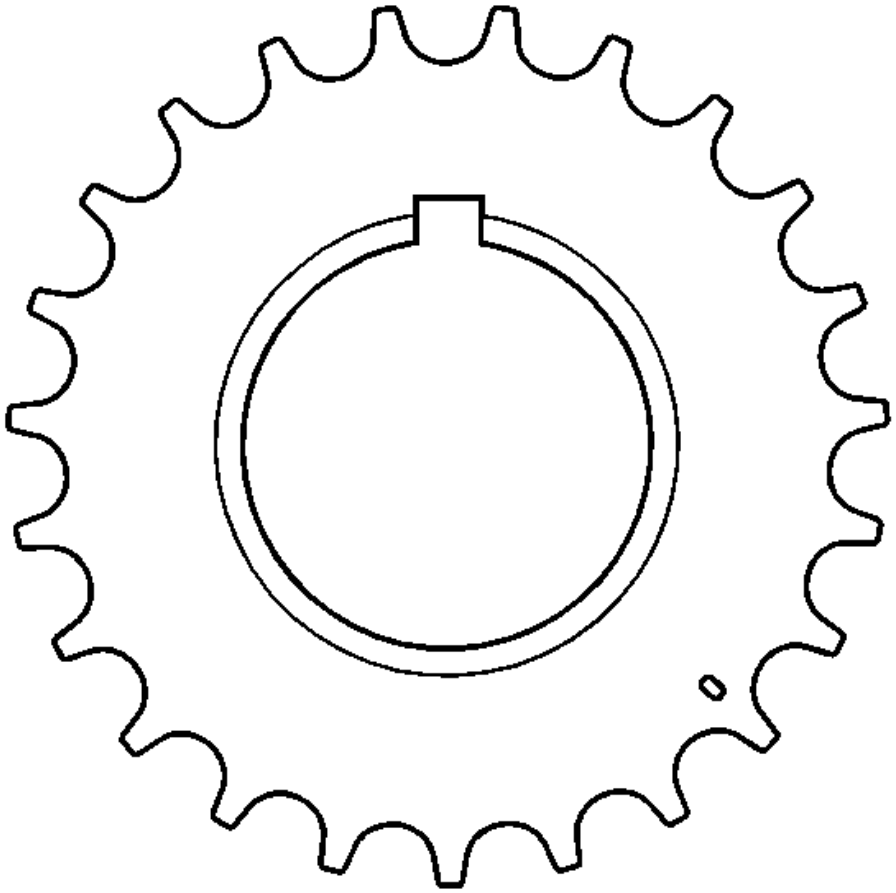

Fig. 121: View Of Crankshaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

12. Install the friction washer, if applicable.
13. Install the timing chain drive sprocket to the crankshaft with the timing mark in the 5 o'clock position and the front of the sprocket facing.

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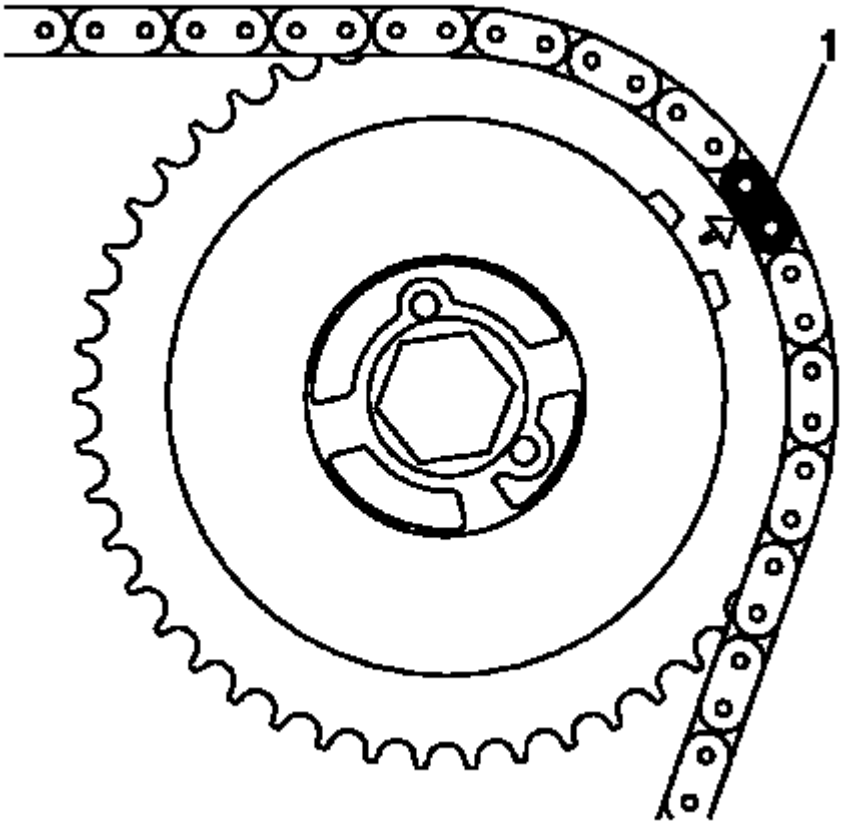

Fig. 122: Identifying Colored Links On Timing Chain
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **There are 3 colored links on the timing chain. Two links are of matching color, and 1 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.**

14. Assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).

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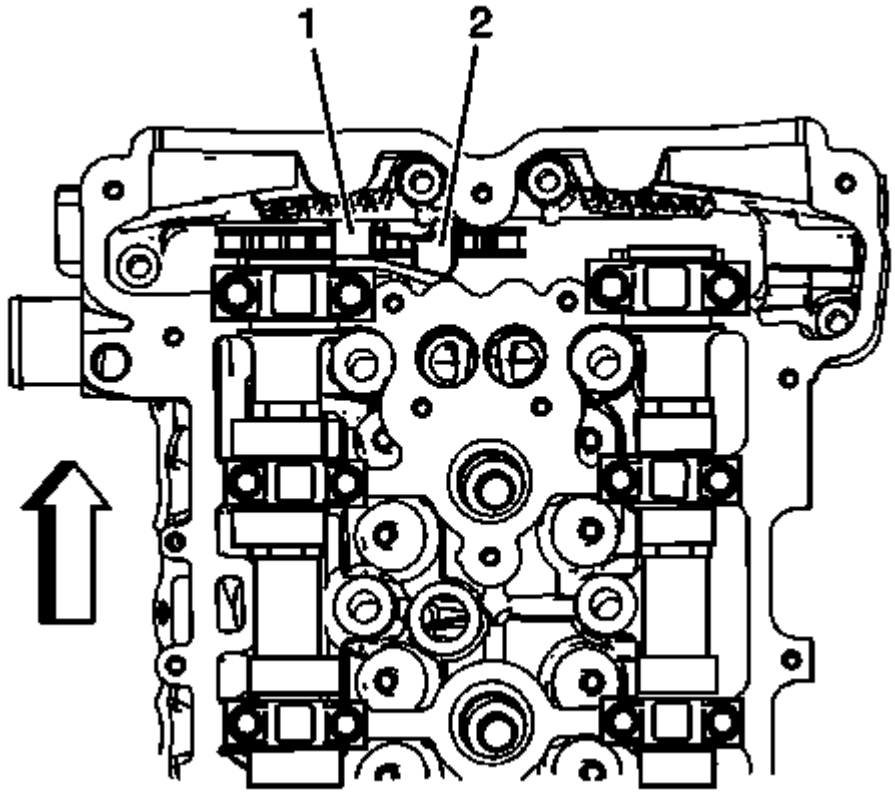

Fig. 123: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

15. 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).
16. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.
17. Hand tighten the new intake camshaft actuator bolt.

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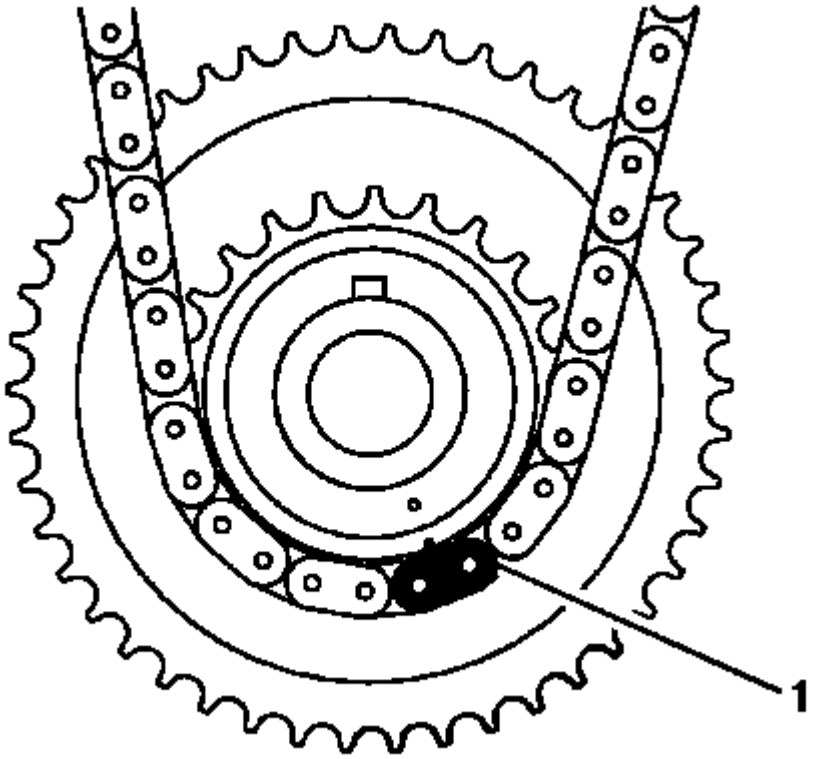

Fig. 124: Lining Up First Pink Link With Timing Mark On Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

18. Route the timing chain around the crankshaft sprocket and line up the first matching colored link with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.
19. Install the friction washer, if applicable.

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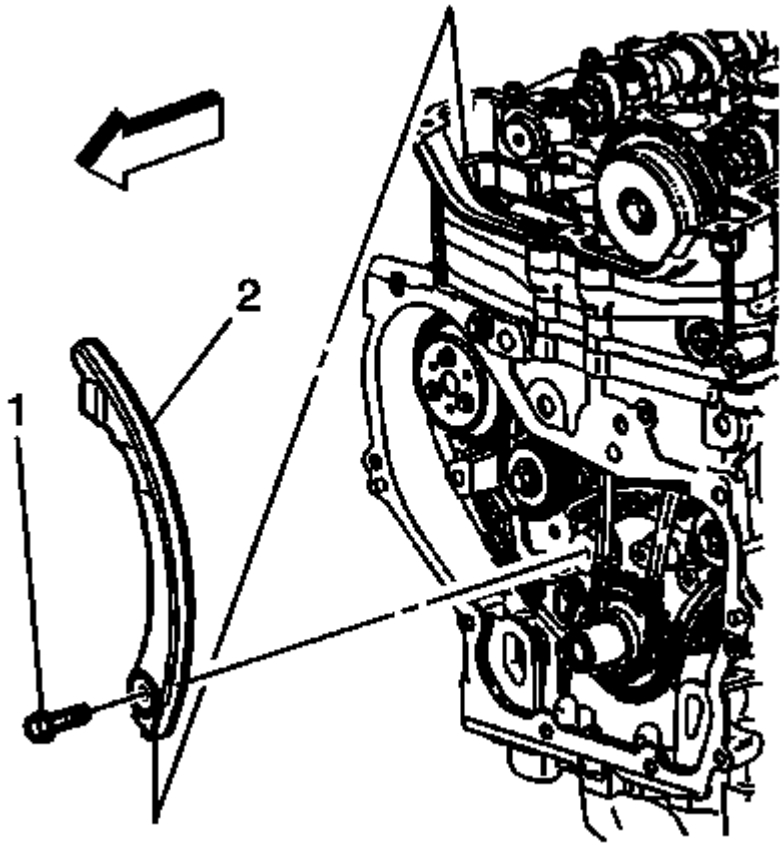

Fig. 125: Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.
21. Install the adjustable timing chain guide down through the opening in the cylinder head and install the adjustable timing chain bolt. Tighten the adjustable timing chain guide bolt to 10 N.m (89 lb in).

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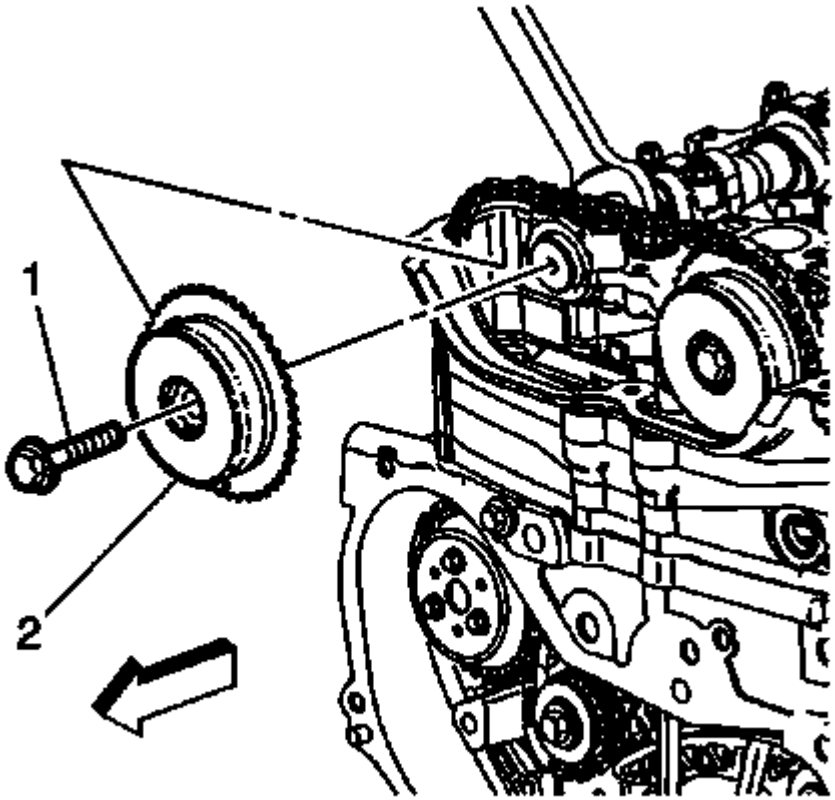

Fig. 126: Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install NEW actuator bolts.

22. Install the exhaust camshaft actuator into the timing chain with the timing mark lined up with the second matching colored link.

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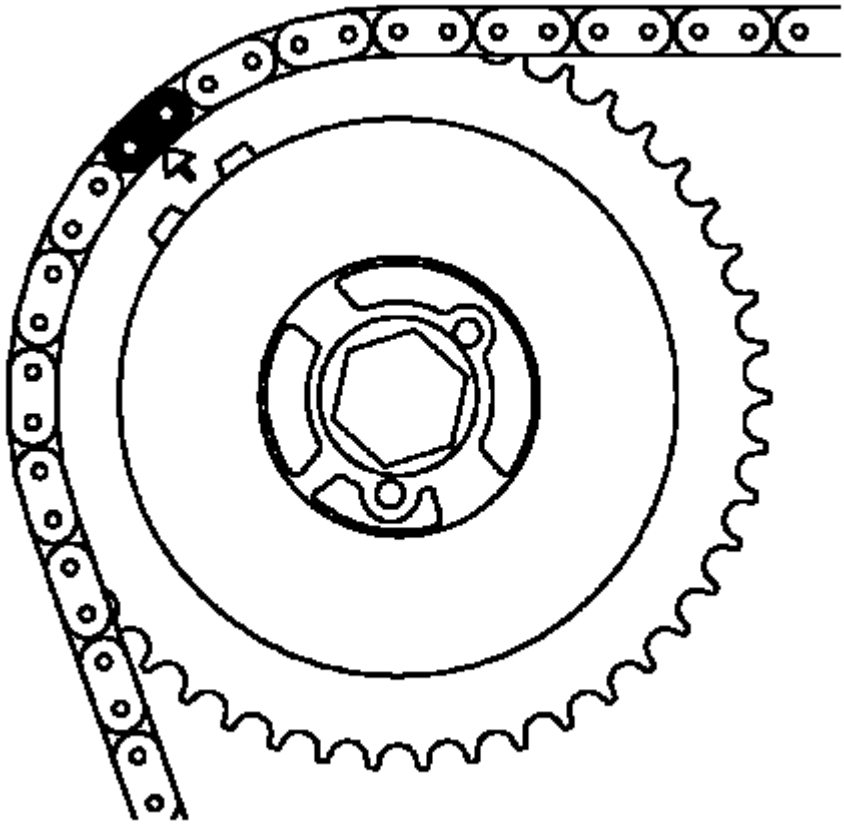

Fig. 127: Aligning Timing Mark On Actuator With Last Pink Colored Link
Courtesy of GENERAL MOTORS CORP.

23. Install the exhaust camshaft actuator onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
24. use 24 mm open ended wrench, rotate the exhaust camshaft approximately 45 degrees until the dowel pin in the camshaft actuator goes into the camshaft slot.

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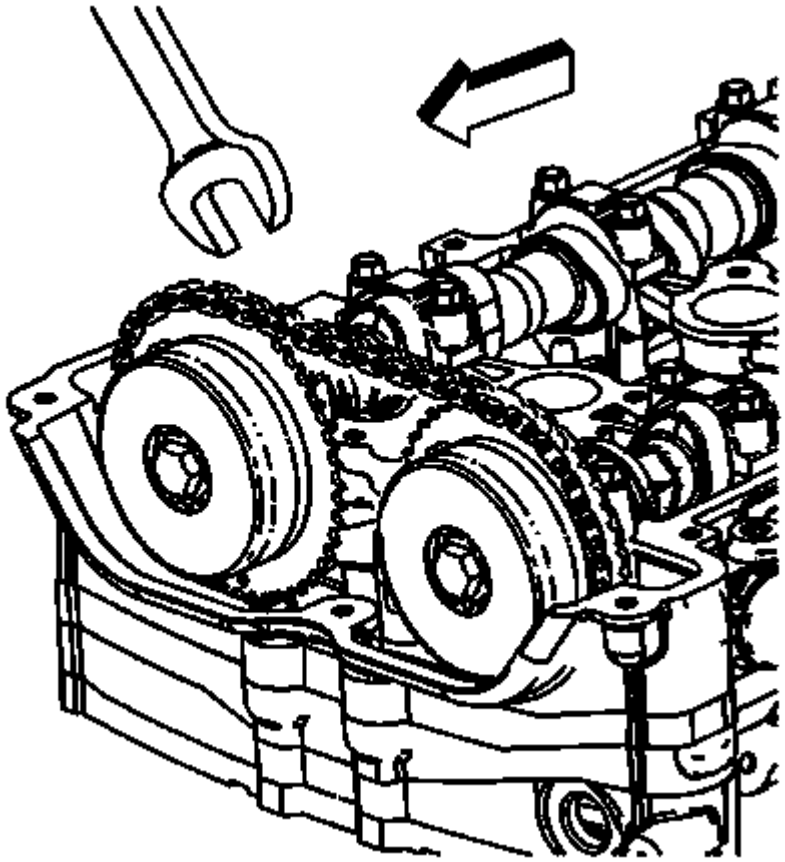

Fig. 128: Identifying Cam Actuator, Camshaft & Chain
Courtesy of GENERAL MOTORS CORP.

25. When the actuator seats on the cam, tighten the new exhaust camshaft actuator bolt hand tight.

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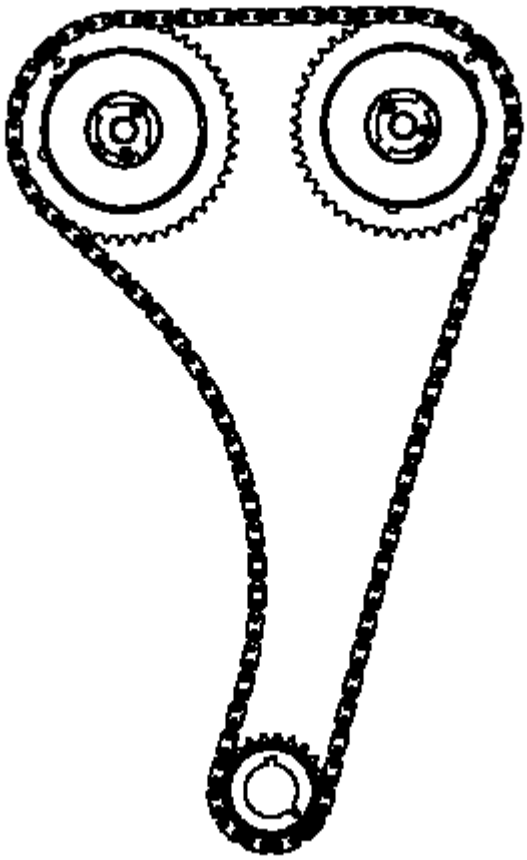

Fig. 129: Identifying Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

26. Verify that all of the colored links and the appropriate timing marks are still aligned. If they are not aligned, repeat the portion of the procedure necessary to align the timing marks.

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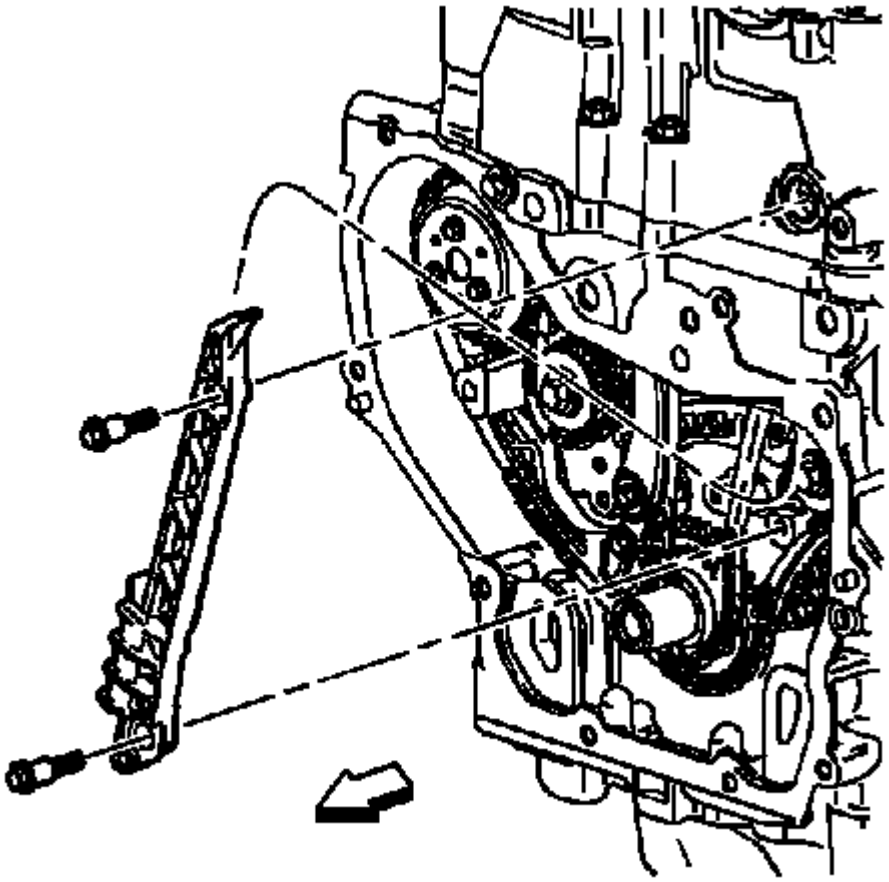

Fig. 130: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

27. Install the fixed timing chain guide and bolts. Tighten the fixed timing chain guide bolts to 12 N.m (106 lb in).

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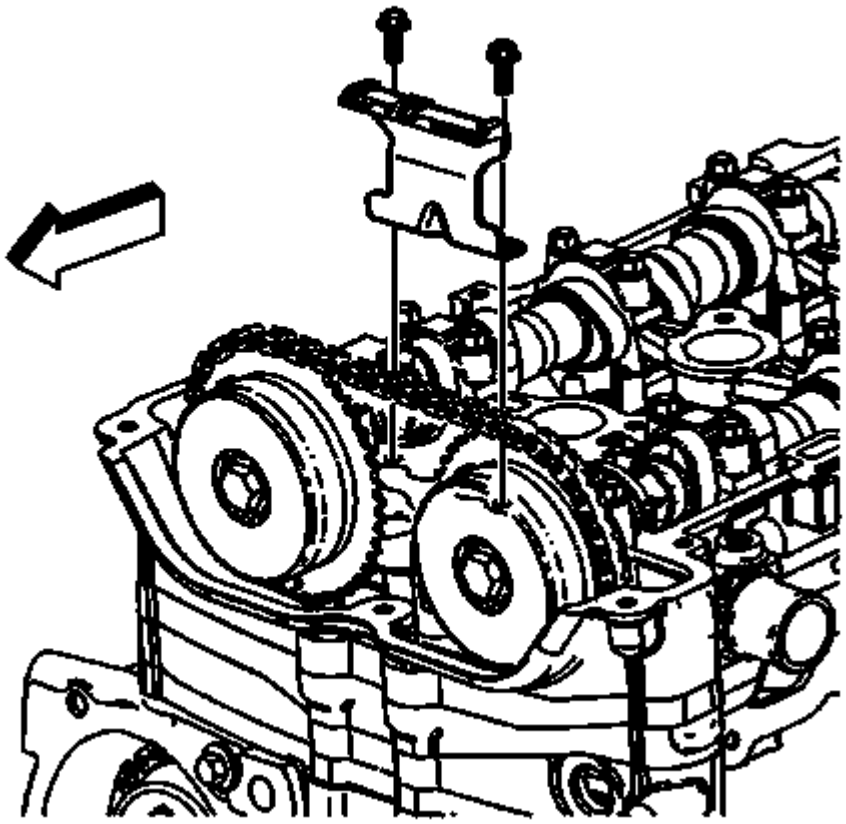

Fig. 131: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

28. Install the upper timing chain guide and bolts. Tighten the upper timing chain guide bolts to 10 N.m (89 lb in).

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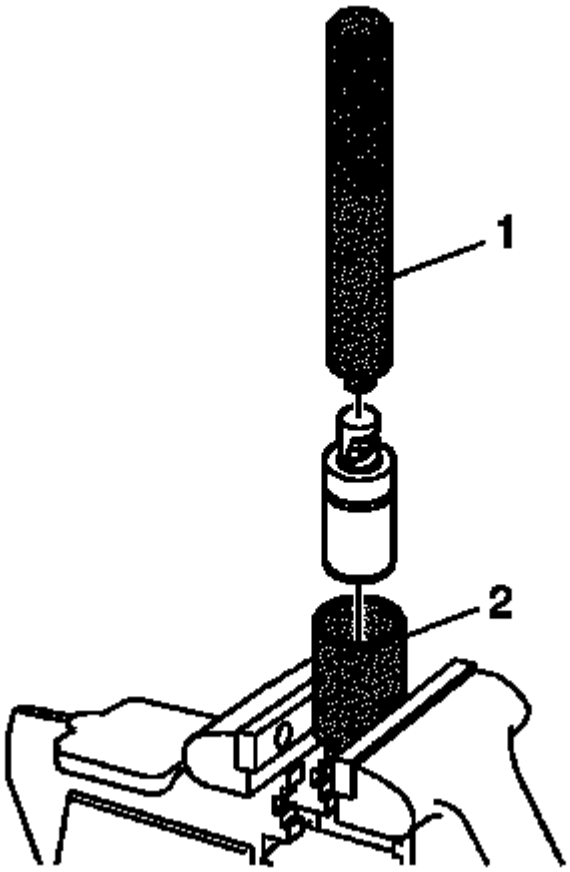

Fig. 132: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

29. Reset the timing chain tensioner by performing the following steps:
    1. Remove the snap ring.
    2. Remove the piston assembly from the body of the timing chain tensioner.
    3. Install the J 45027-2 (2) into a vise.
    4. Install the notch end of the piston assembly into the J 45027-2 (2).
    5. Using the J 45027-1 (1), turn the ratchet cylinder into the piston.
    6. Reinstall the piston assembly into the body of the tensioner.
    7. Install the snap ring.

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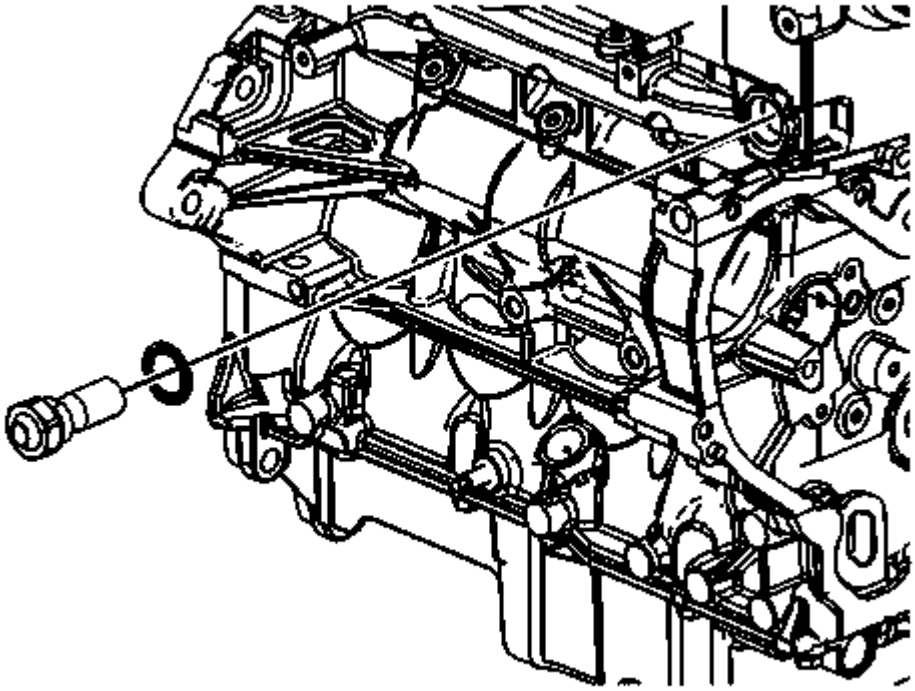

Fig. 133: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

30. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
31. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

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

32. Install the timing chain tensioner assembly. Tighten the timing chain tensioner to 75 N.m (55 lb ft).
33. 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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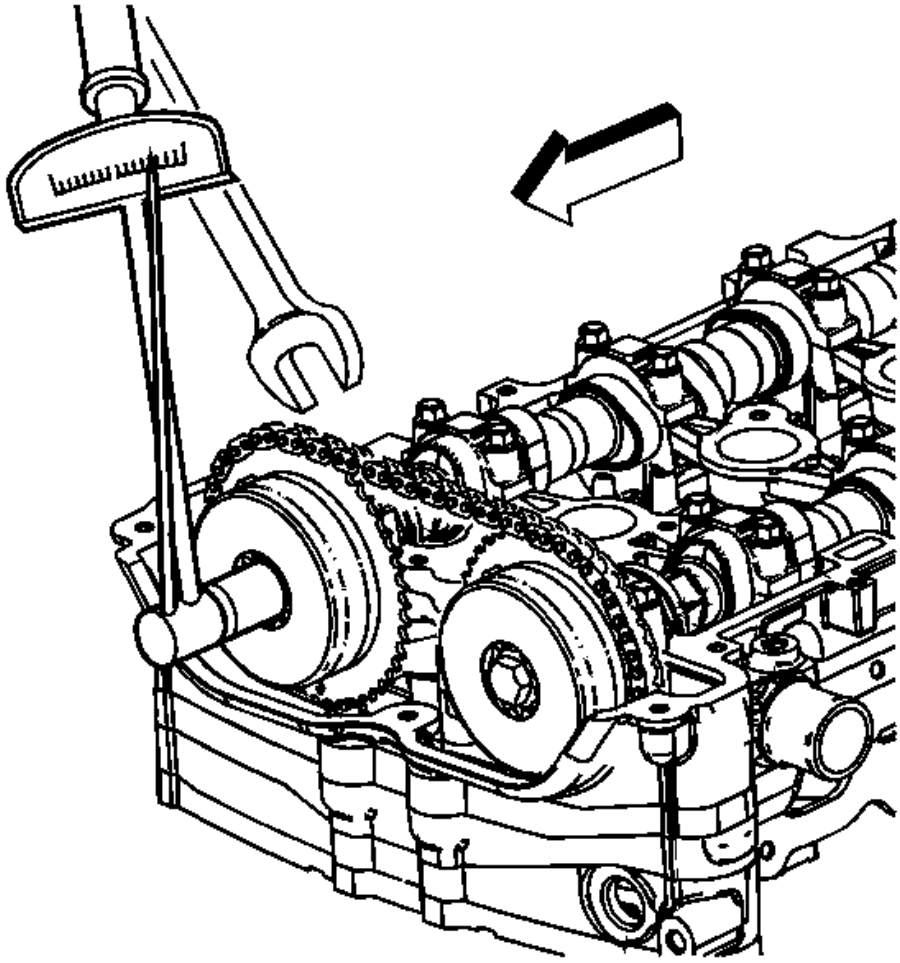

Fig. 134: Tightening Camshaft Actuator Bolt
Courtesy of GENERAL MOTORS CORP.

34. Using a 24 mm wrench, engage the hex on the intake camshaft, and using a torque wrench, tighten the camshaft actuator bolt. Tighten the intake camshaft position actuator bolt to 30 N.m (22 lb ft) plus 100 degrees using the **J 45059** .
35. Using a 24 mm wrench, engage the hex on the exhaust camshaft, and using a torque wrench, tighten the camshaft actuator bolt. 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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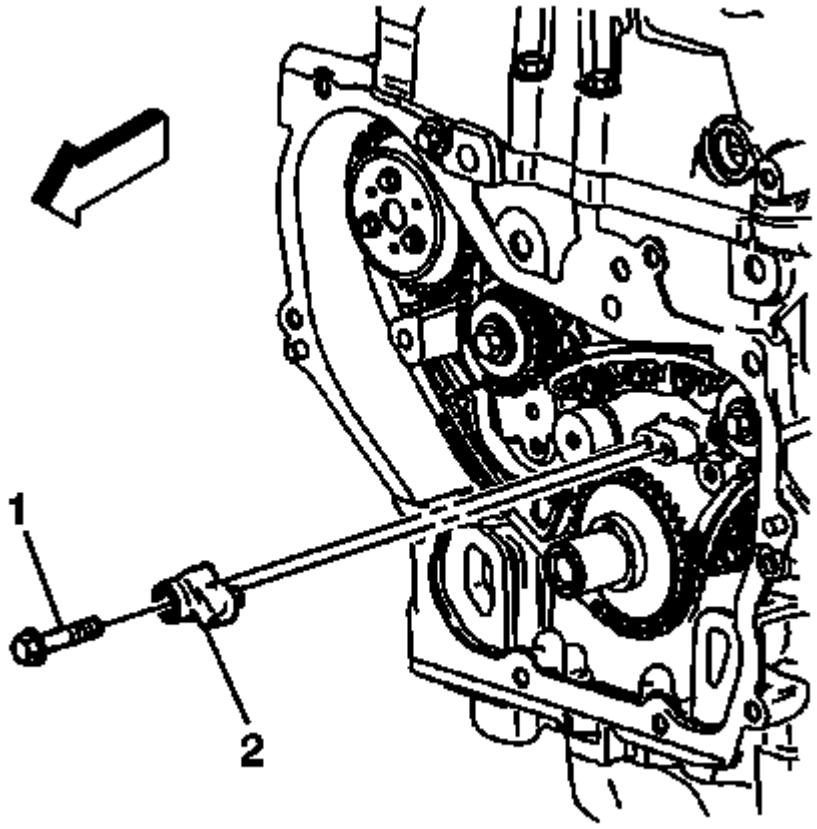

Fig. 135: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

36. Install the timing chain oiling nozzle. Tighten the timing chain oiling nozzle bolt to 10 N.m (89 lb in).

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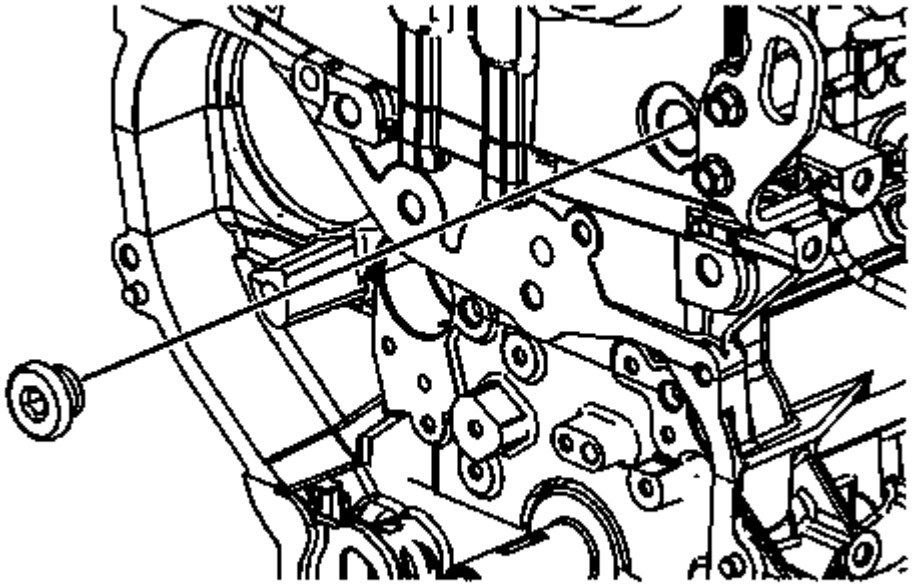

Fig. 136: View Of Timing Chain Guide Bolt Access Hole & Plug
Courtesy of GENERAL MOTORS CORP.

37. Apply sealant compound to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended sealant.
38. Install the timing chain guide bolt access hole plug. Tighten the access hole plug to 90 N.m (66 lb ft).
39. Install the engine front cover. Refer to **Engine Front Cover Replacement**.
40. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
41. Install the number 1 cylinder spark plug. Refer to **Spark Plug Replacement** .

CAMSHAFT COVER REPLACEMENT

Removal Procedure

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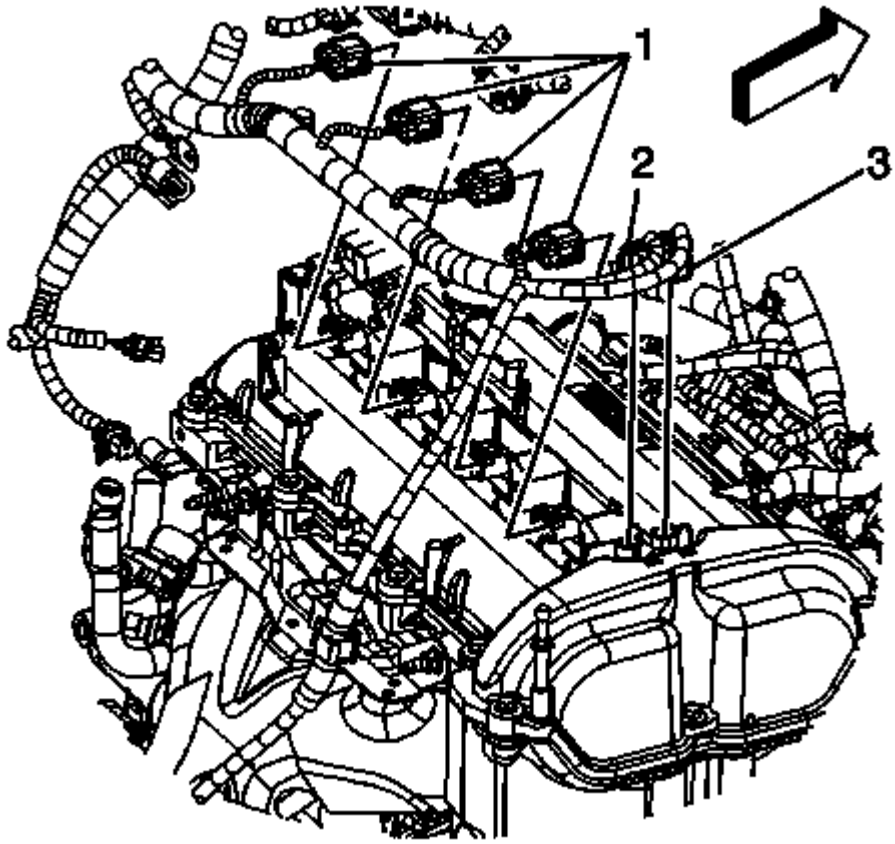

Fig. 137: Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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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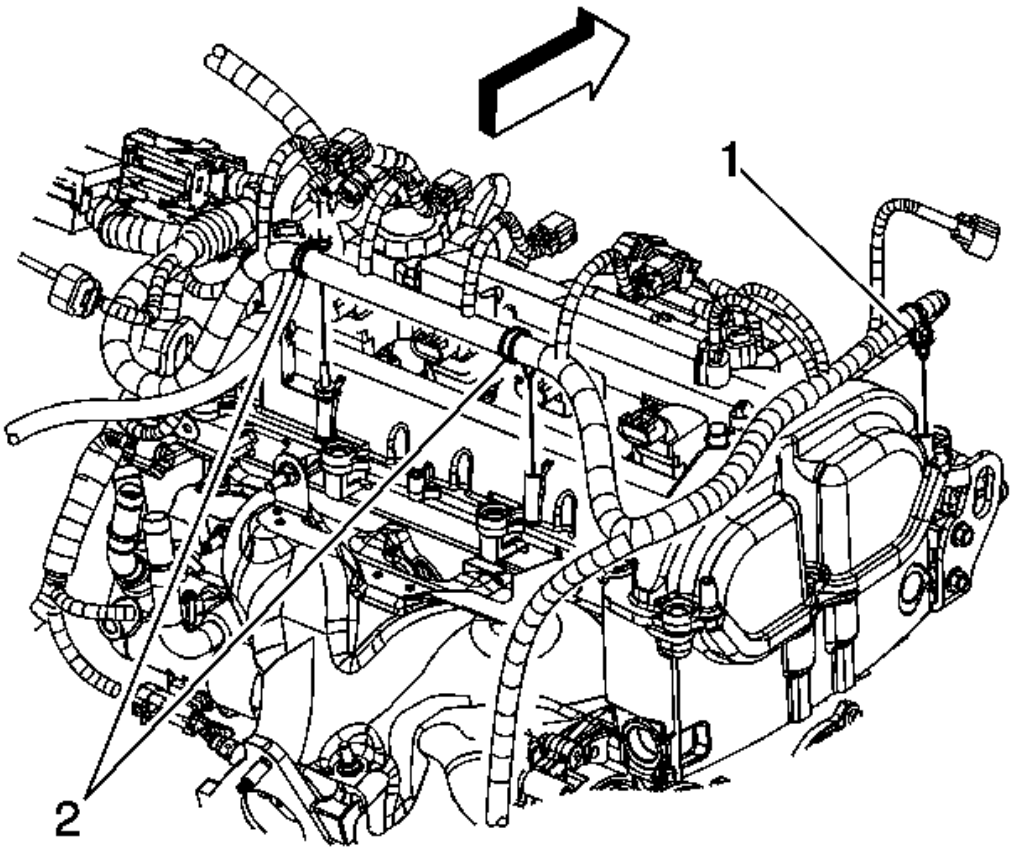

Fig. 138: View Of Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

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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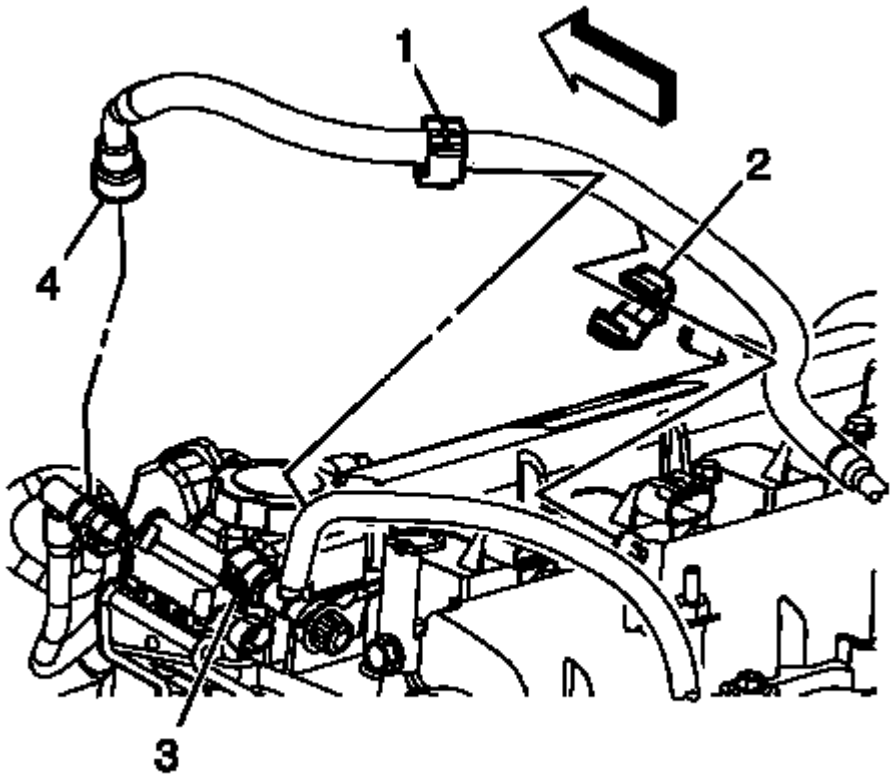

Fig. 139: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

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

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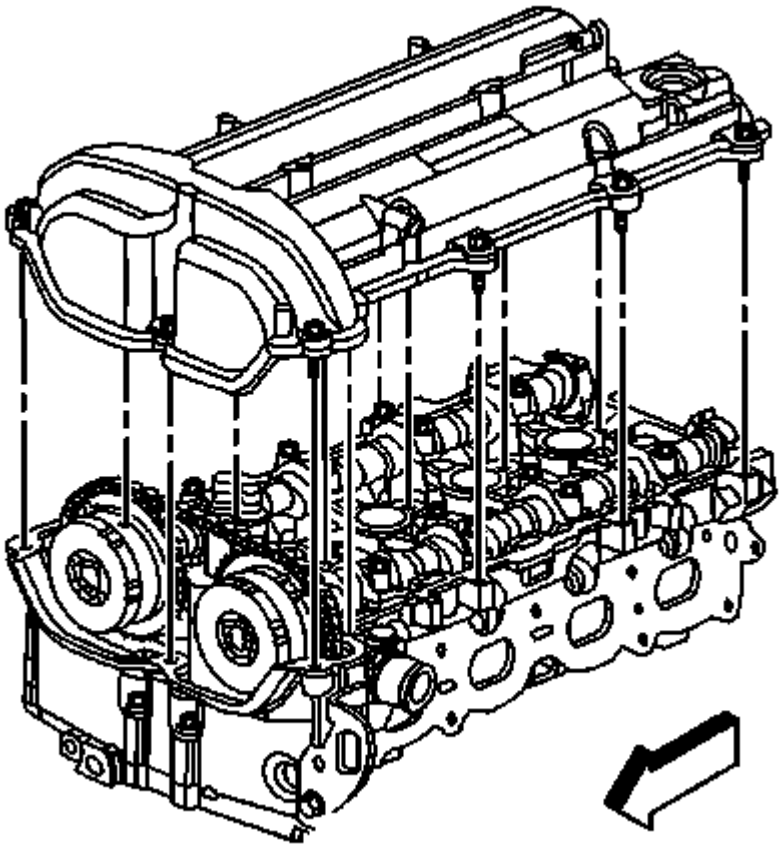

Fig. 140: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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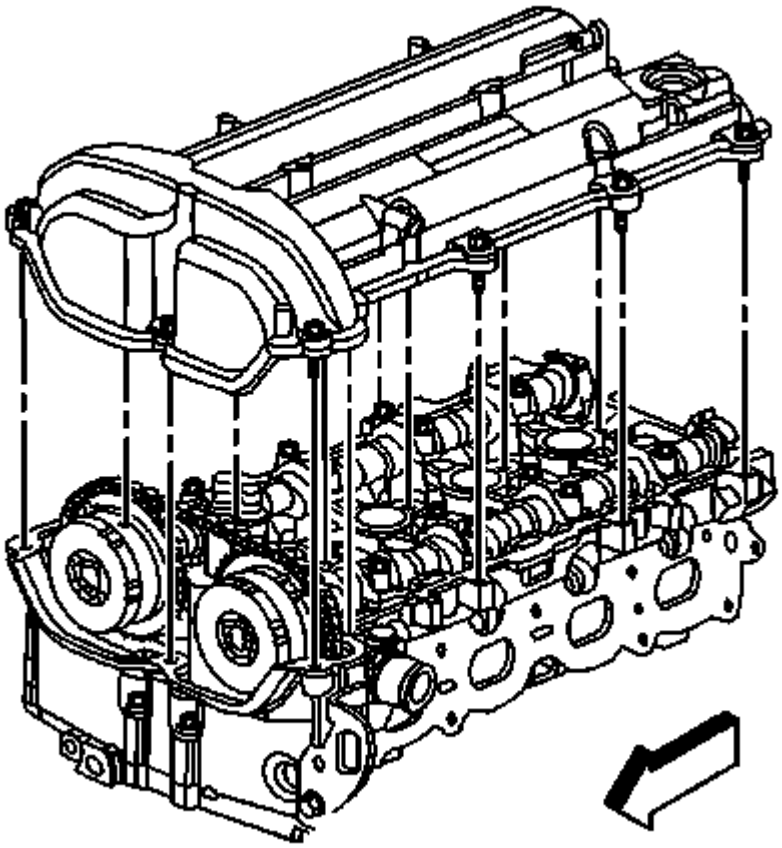

Fig. 141: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the camshaft cover and bolts and tighten to 10 N.m (89 lb in).

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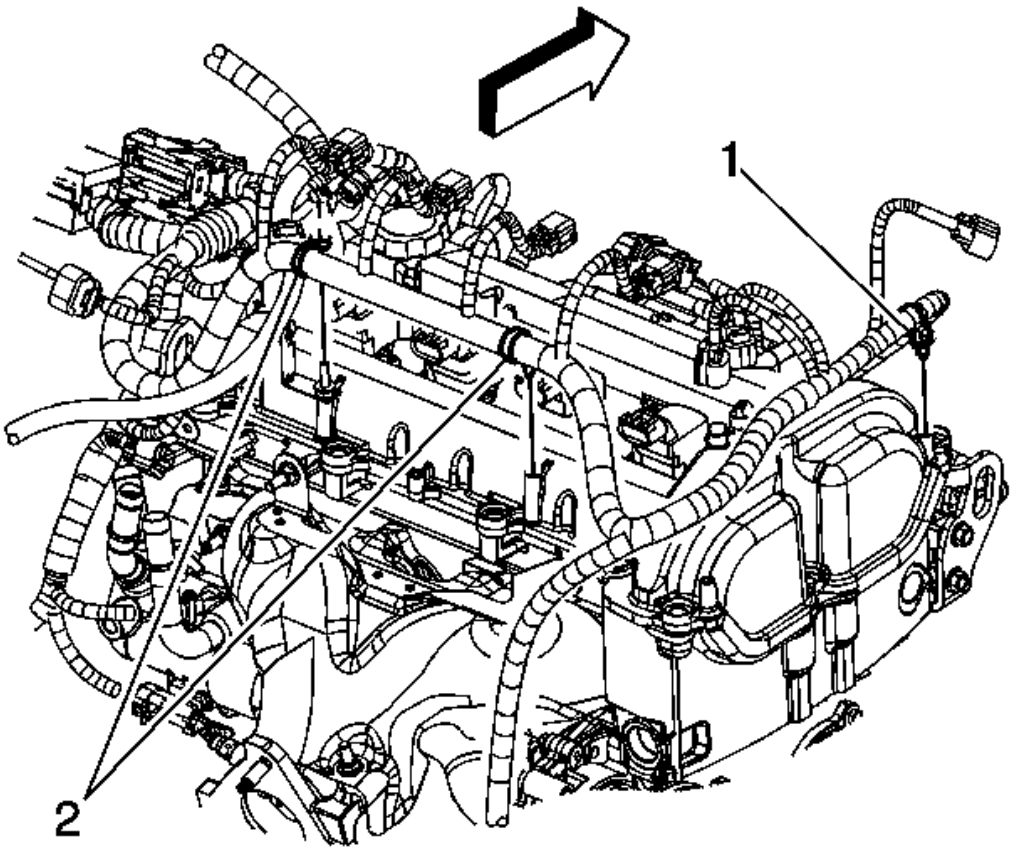

Fig. 142: View Of Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

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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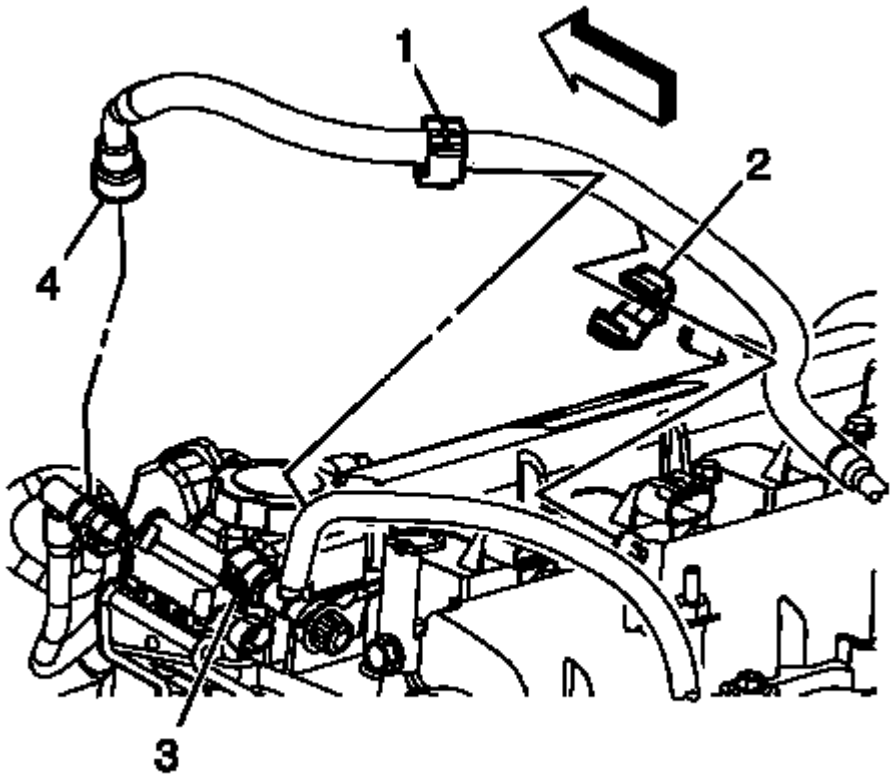

Fig. 143: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

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

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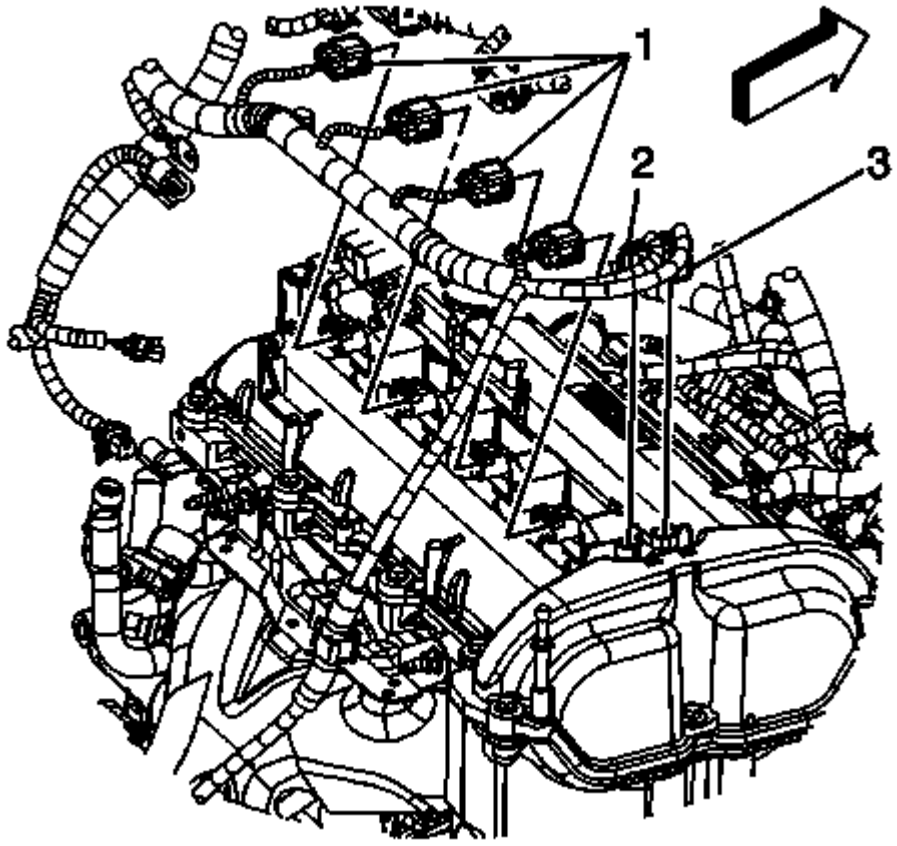

Fig. 144: Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

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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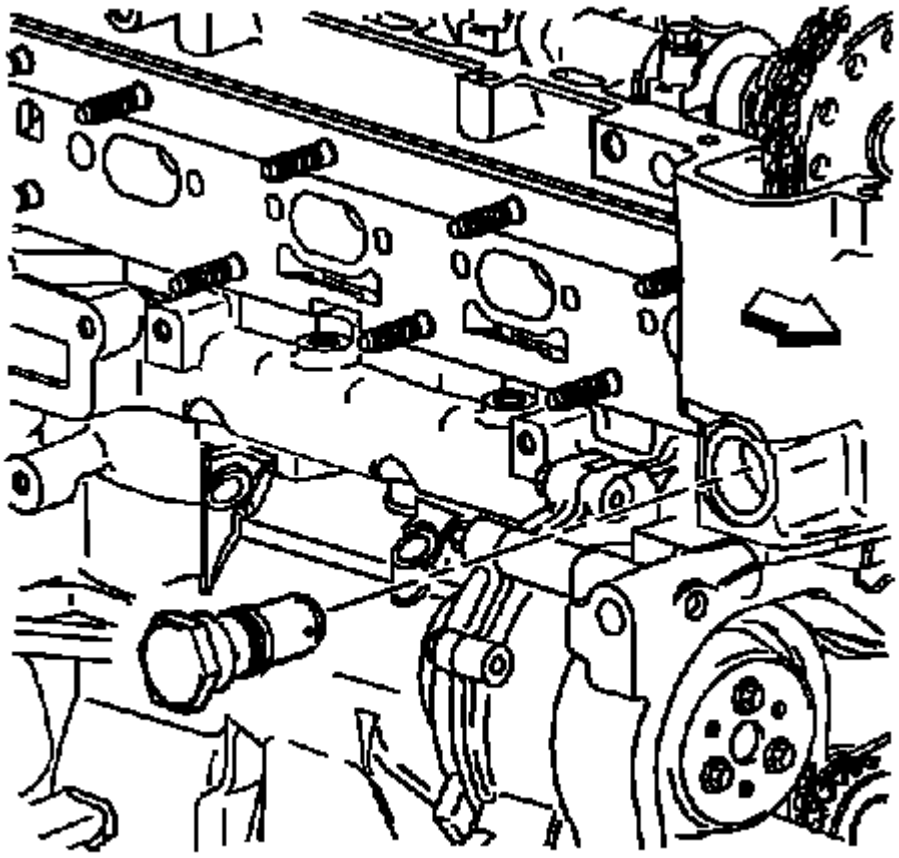

Fig. 145: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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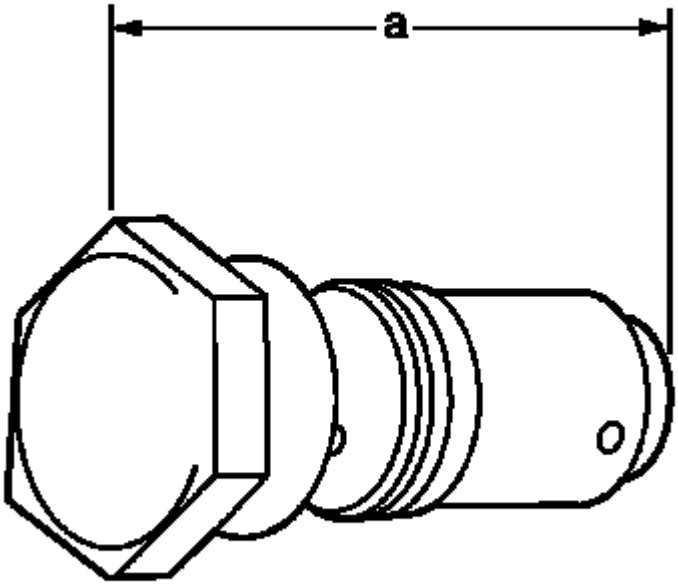

Fig. 146: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

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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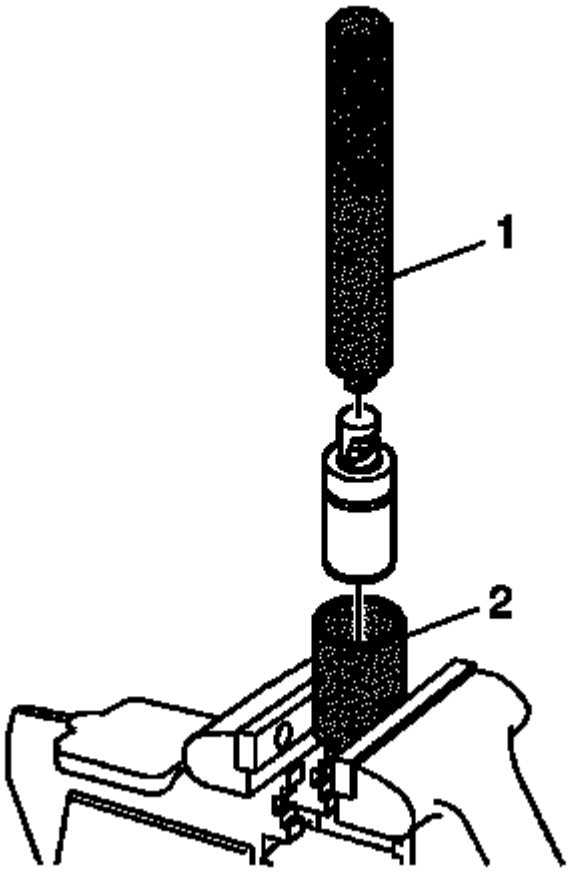

Fig. 147: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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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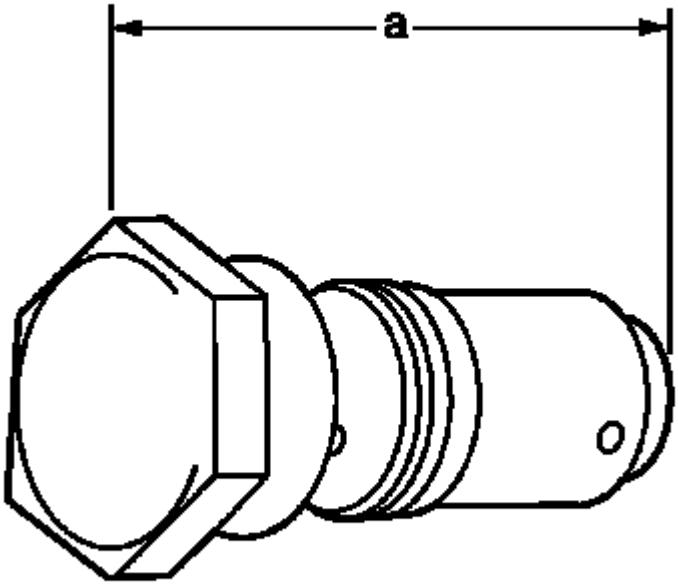

Fig. 148: Measuring Timing Chain Tensioner Assembly
Courtesy of GENERAL MOTORS CORP.

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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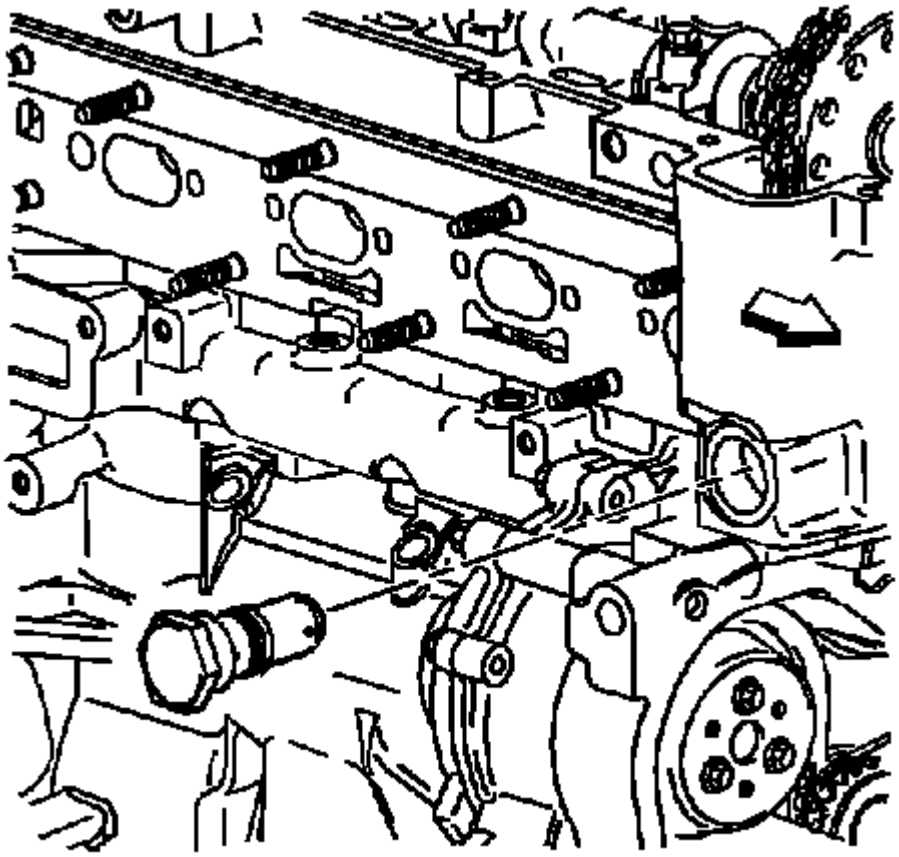

Fig. 149: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

NOTE: 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 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 VALVE LIFTER REPLACEMENT

Removal Procedure

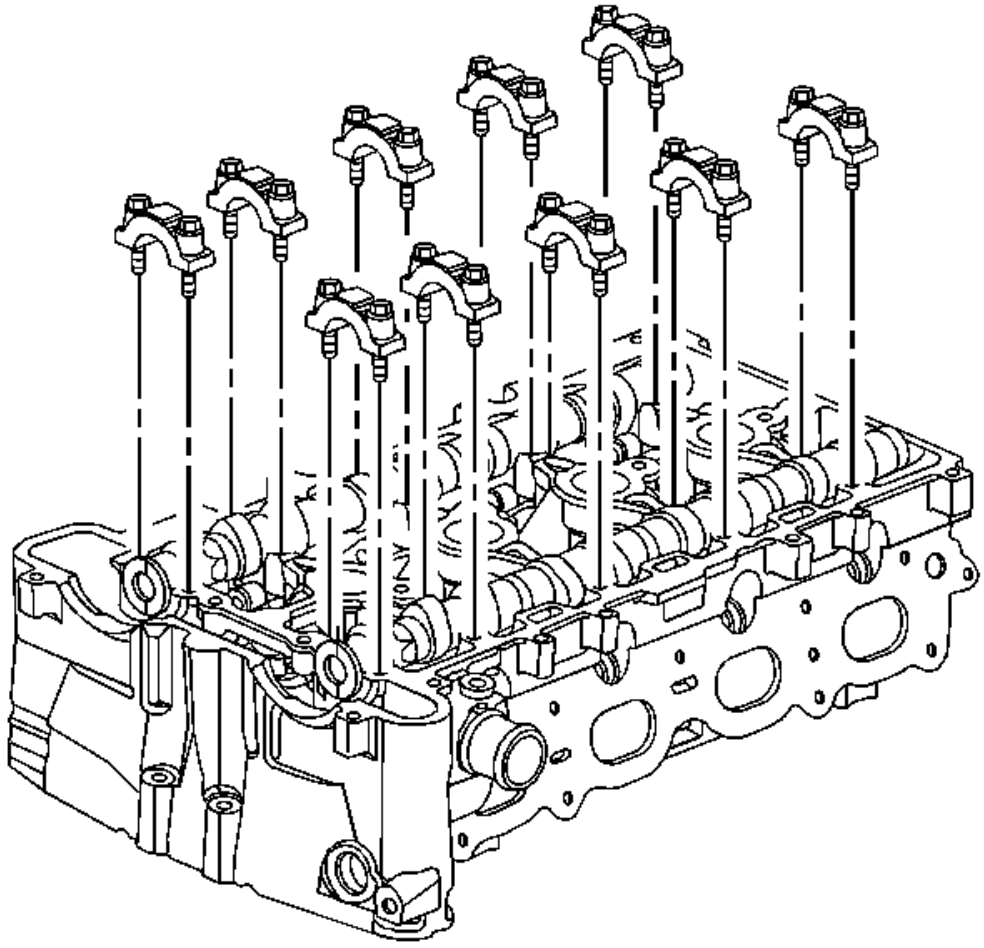

Fig. 150: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

NOTE: 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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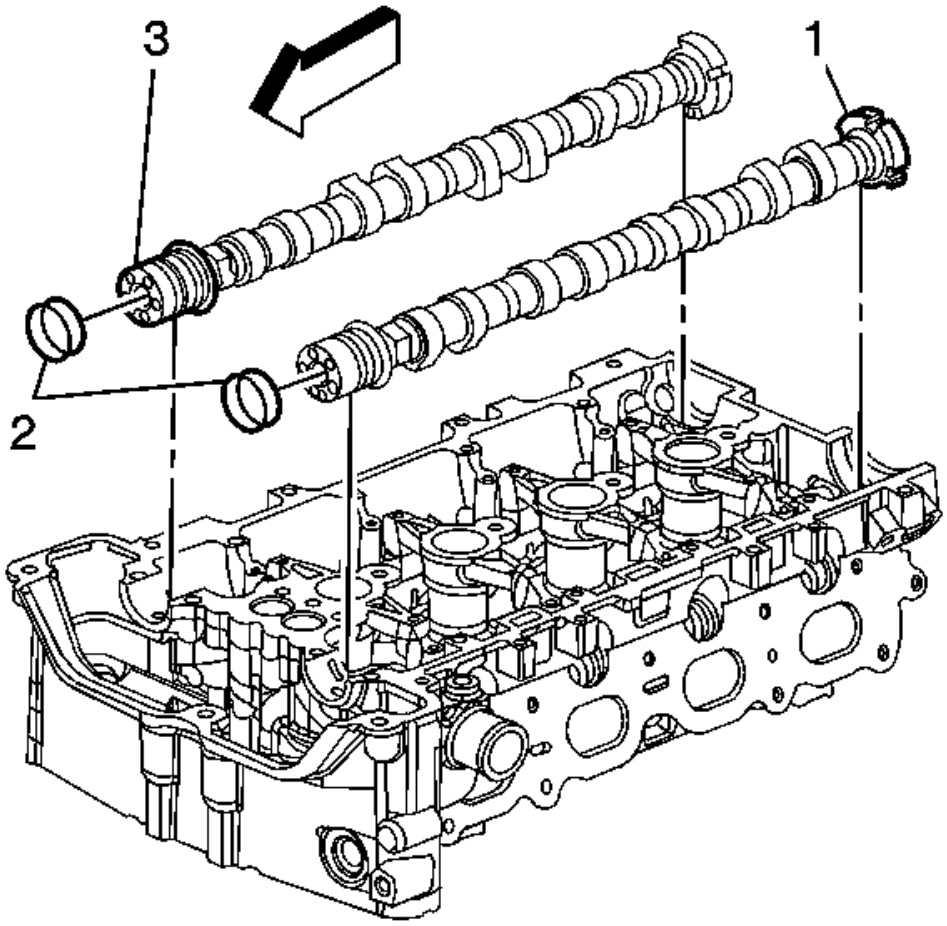

Fig. 151: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the intake camshaft (1).

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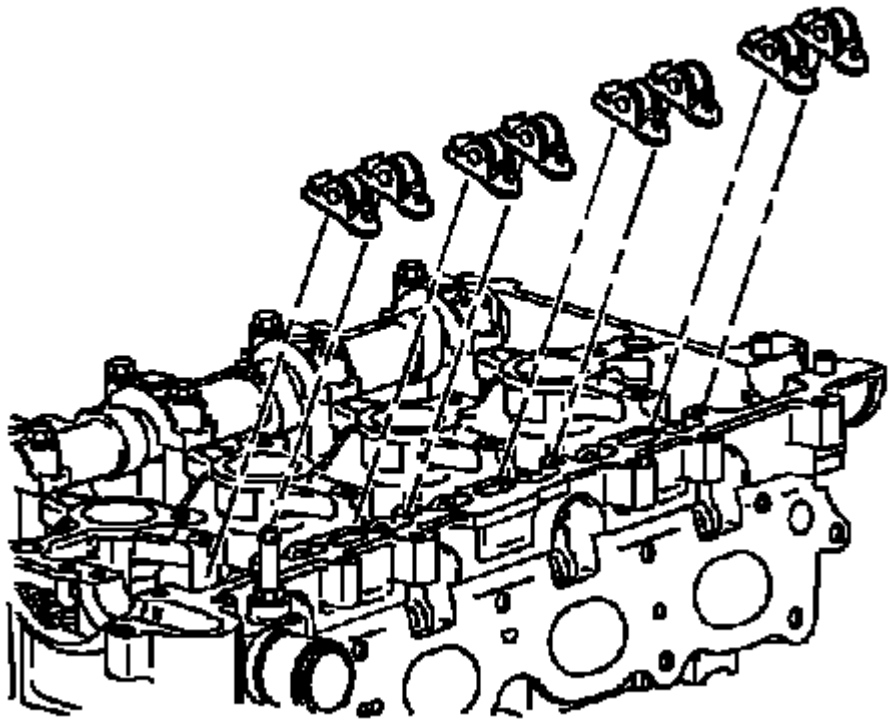

Fig. 152: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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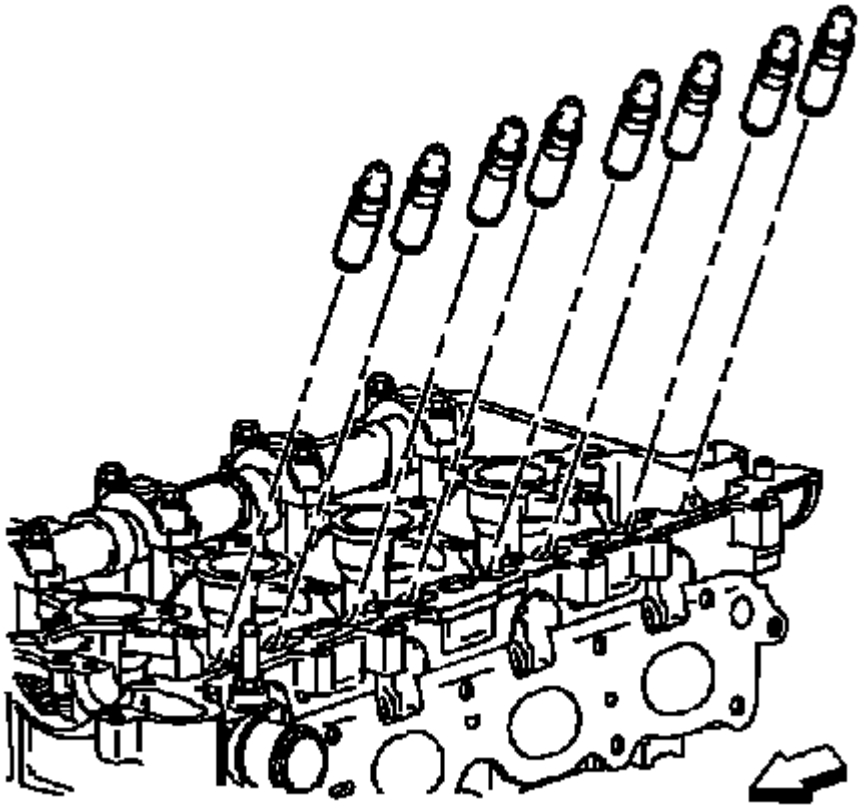

Fig. 153: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

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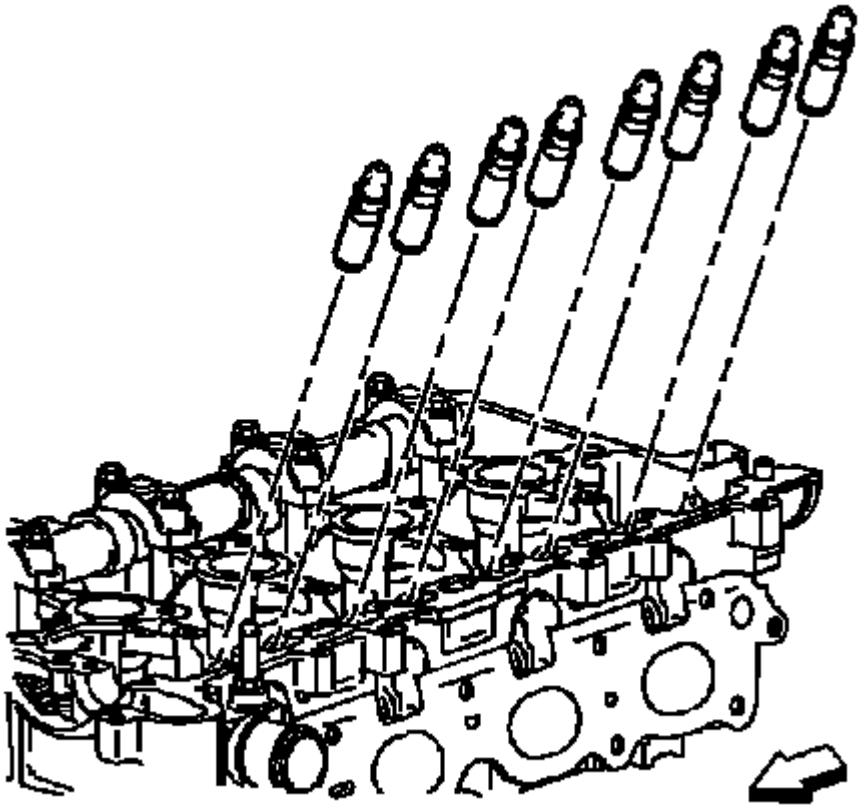

Fig. 154: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

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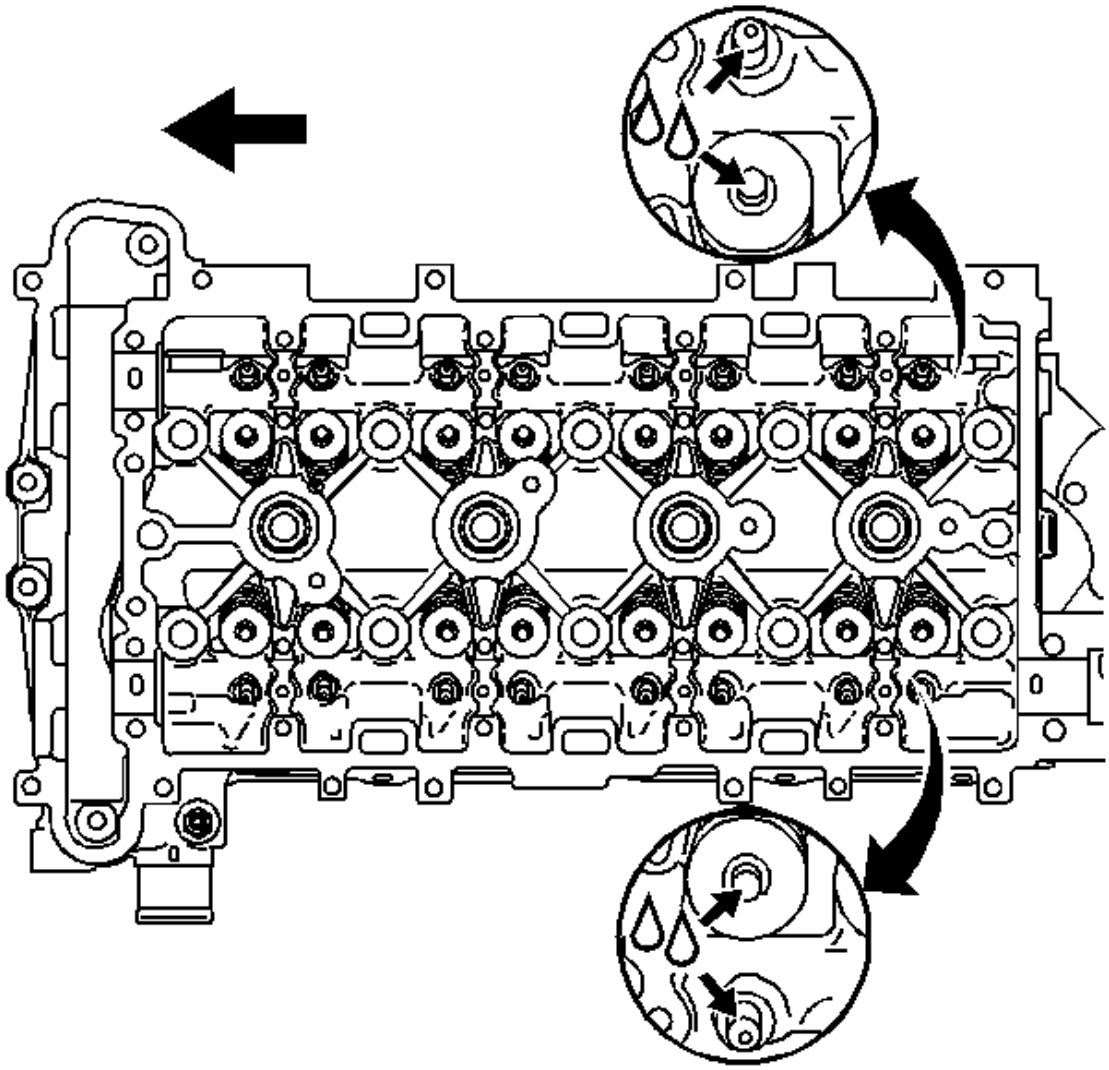

Fig. 155: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

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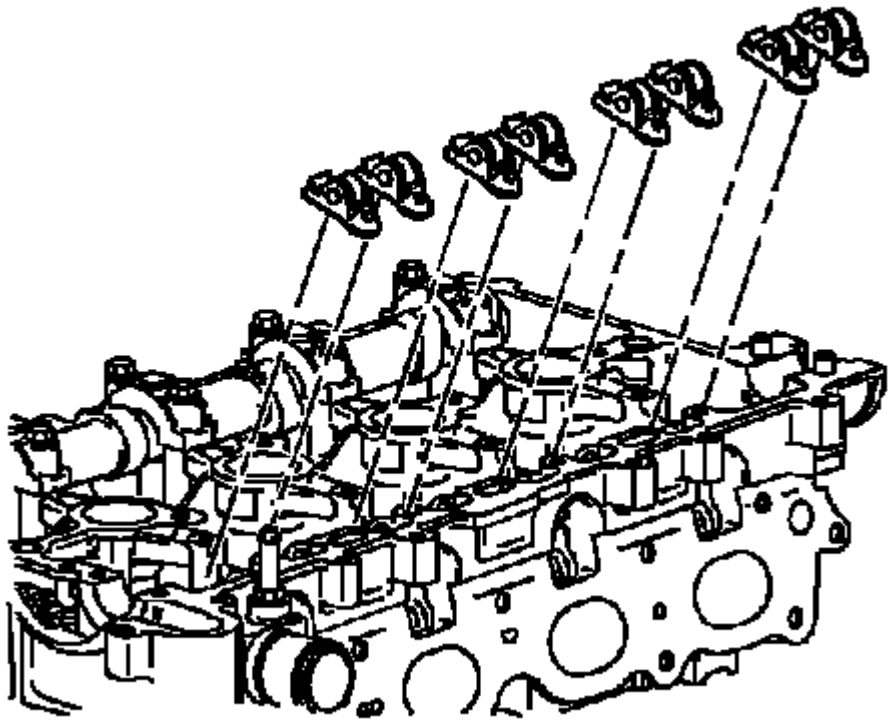

Fig. 156: View Of Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

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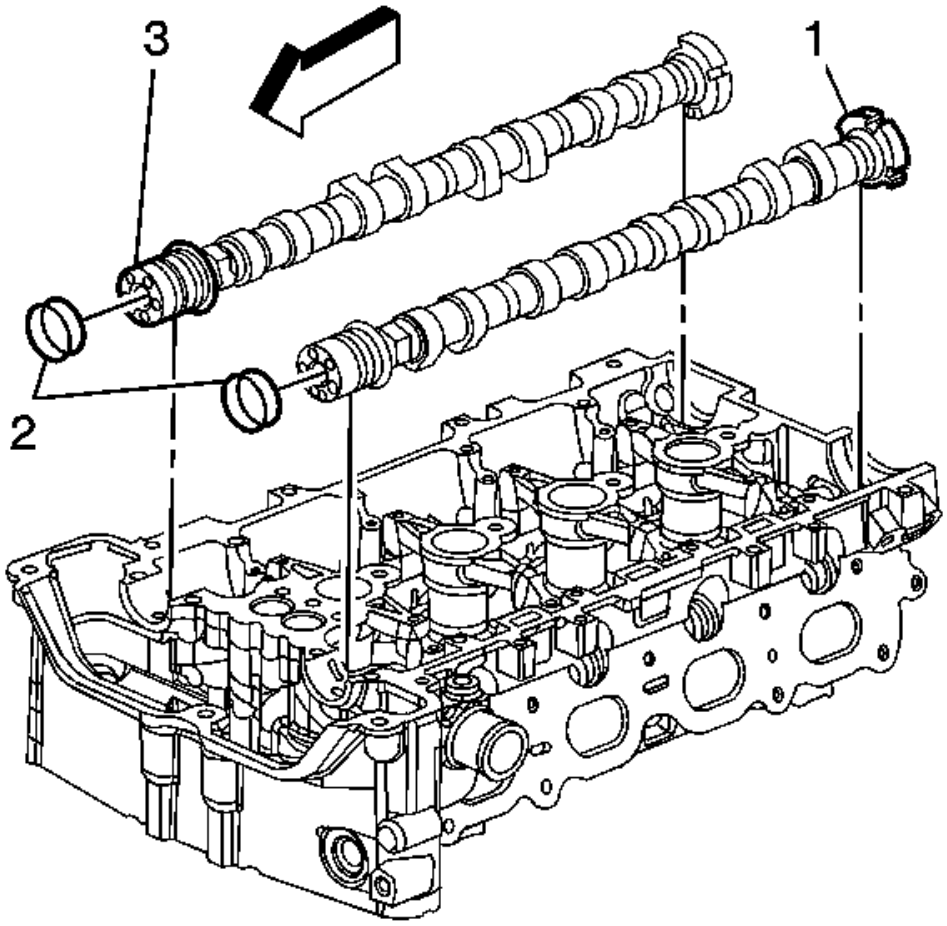

Fig. 157: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the intake camshaft (1) and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the recommended lubricant.

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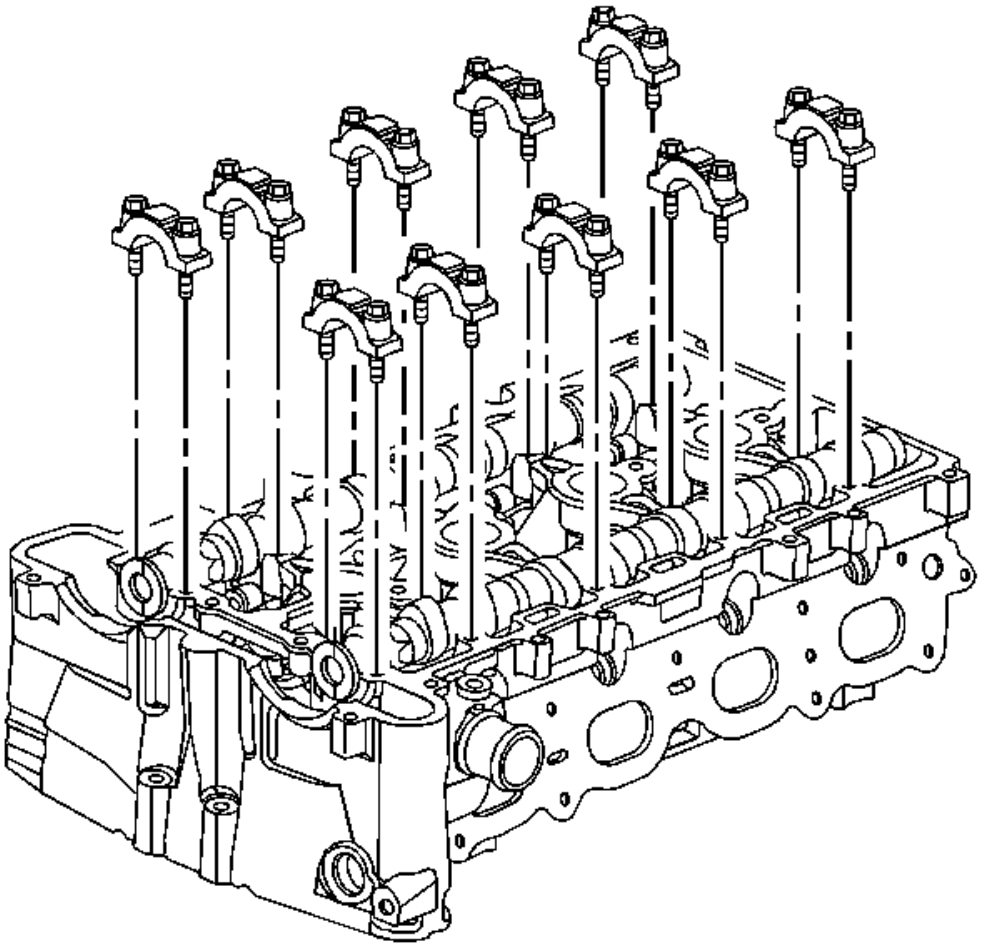

Fig. 158: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

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

Removal Procedure

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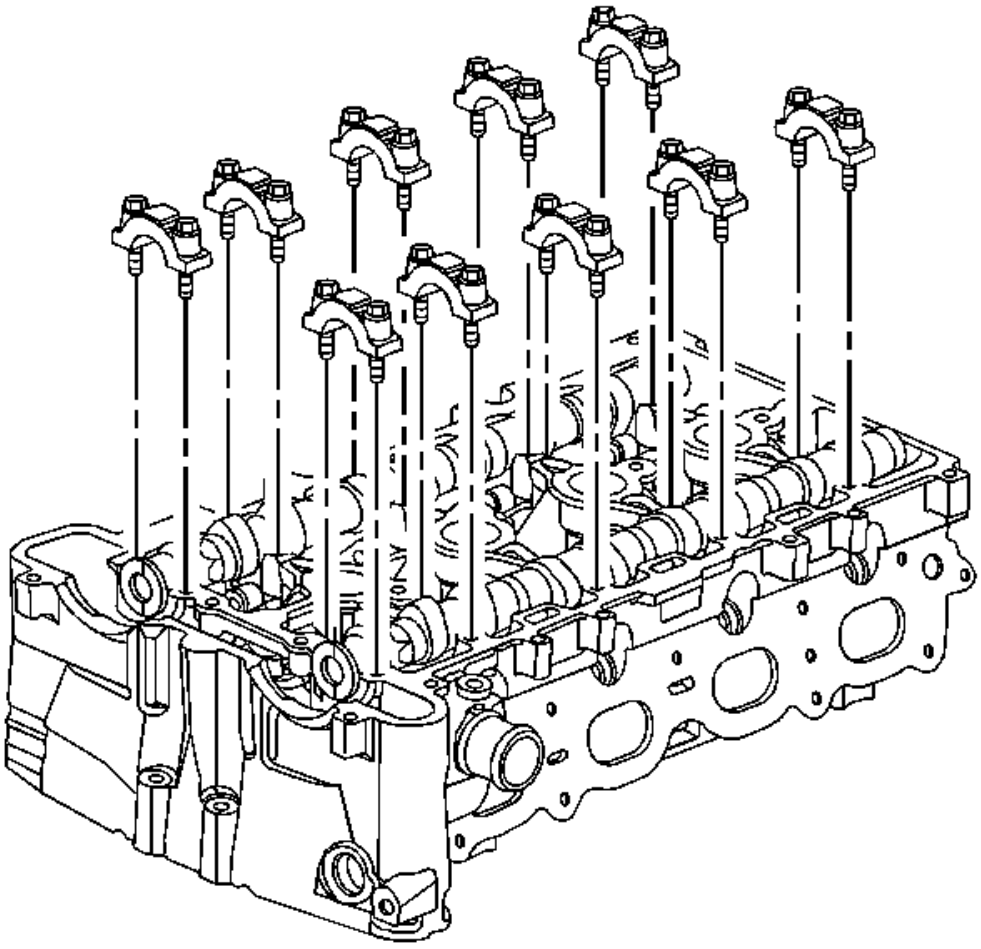

Fig. 159: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

NOTE: 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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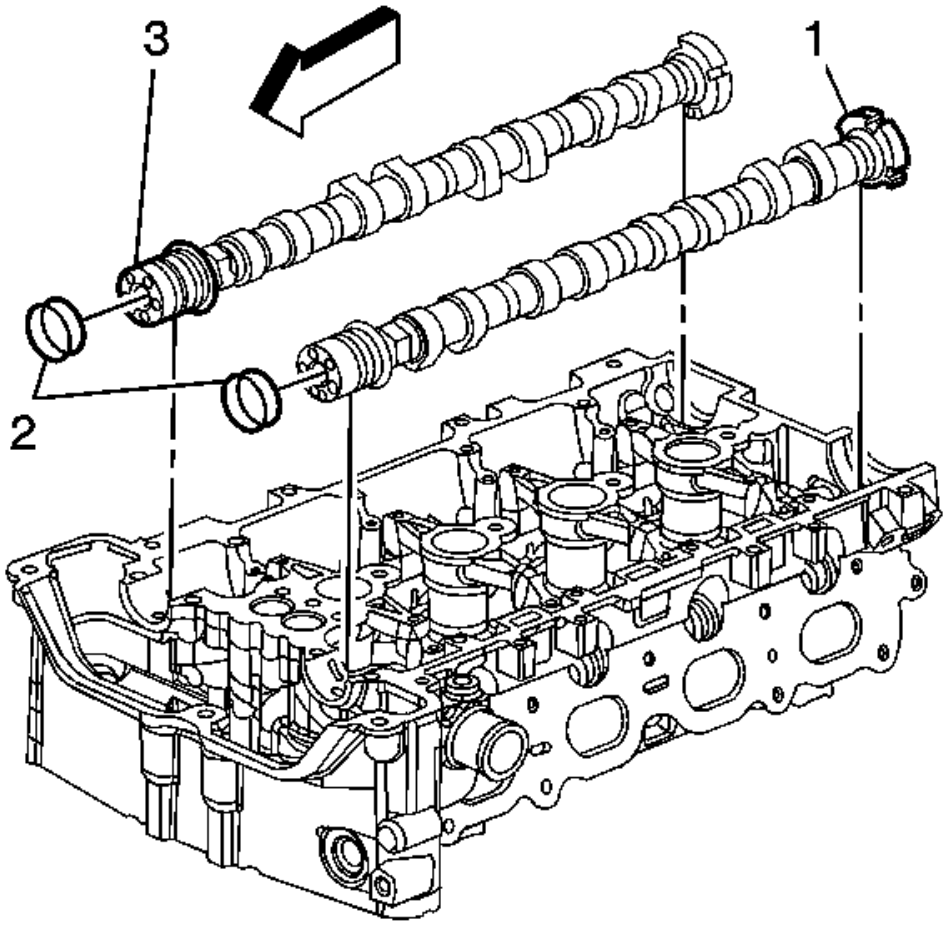

Fig. 160: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust camshaft (3).

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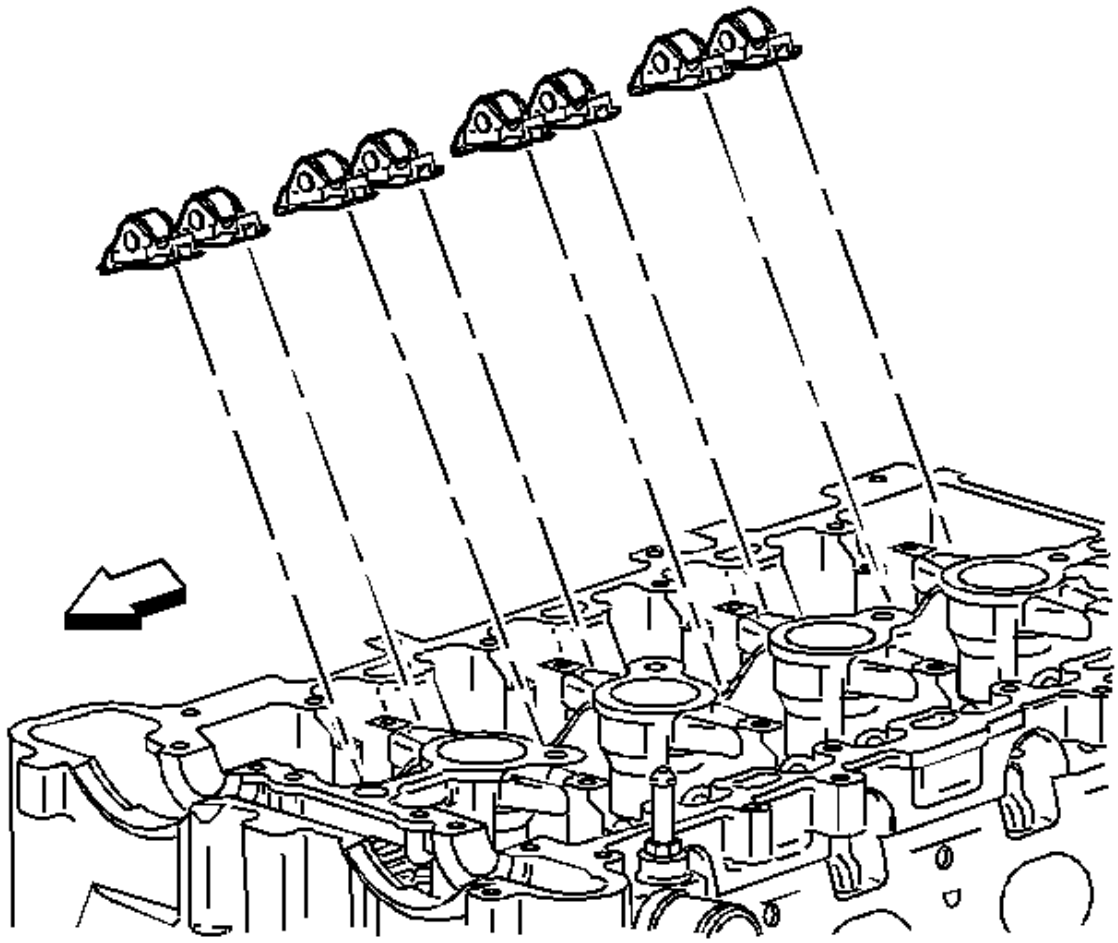

Fig. 161: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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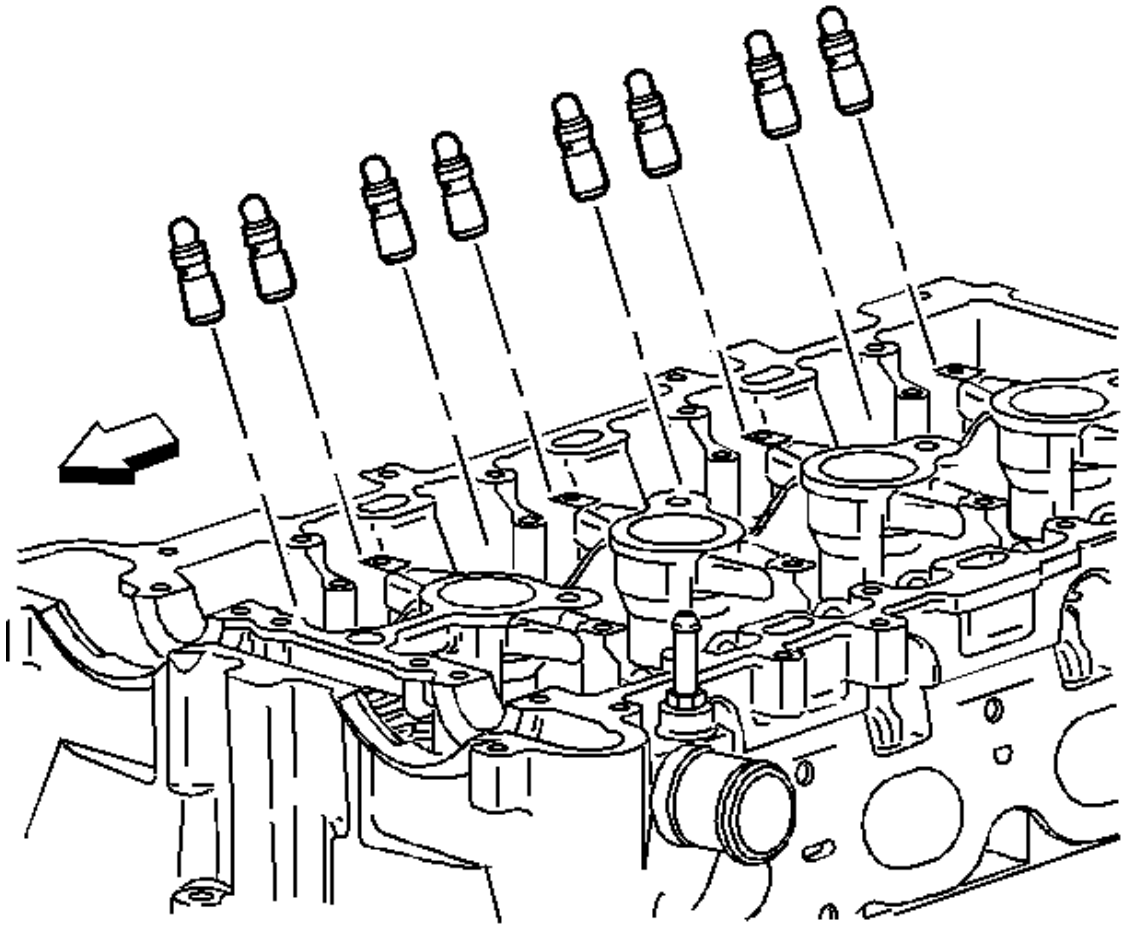

Fig. 162: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

7. Remove the hydraulic element lash adjusters.

Installation Procedure

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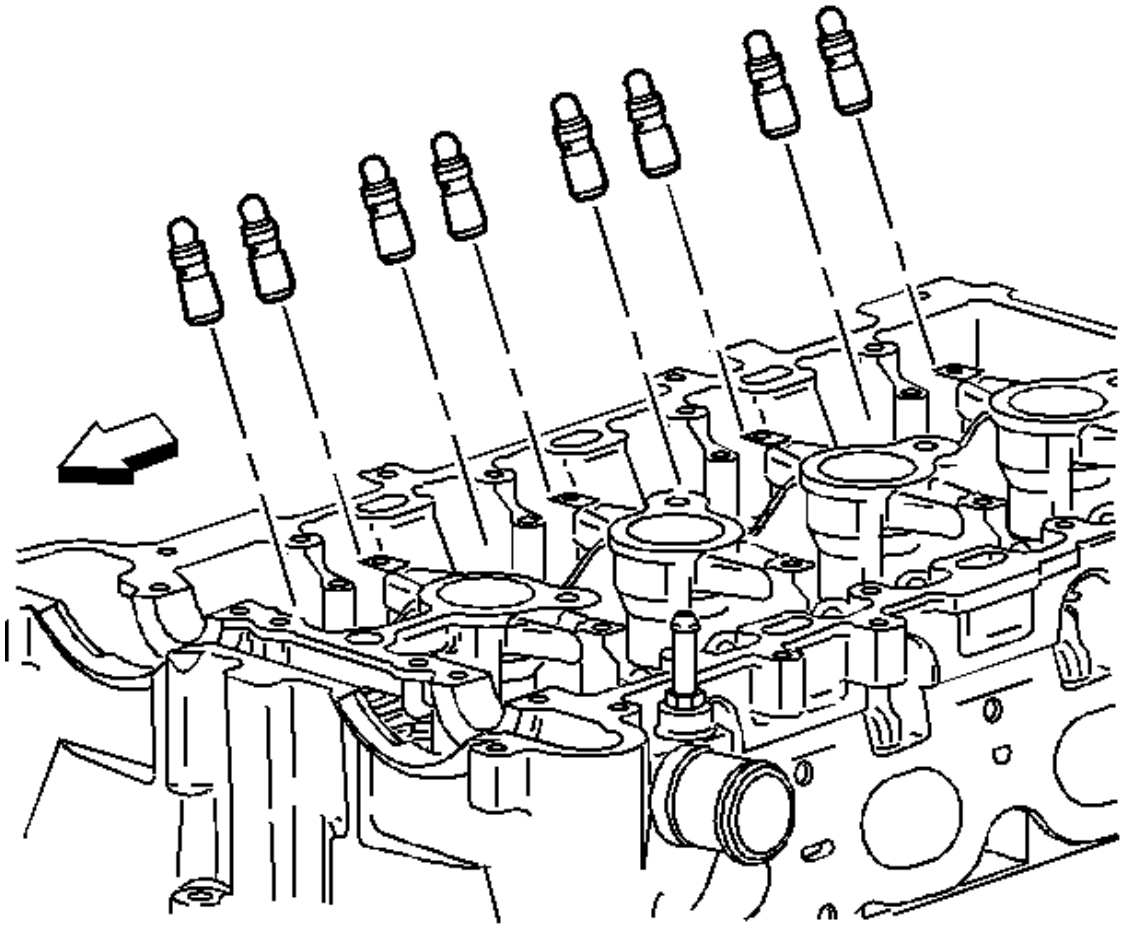

Fig. 163: View Of Hydraulic Element Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic element lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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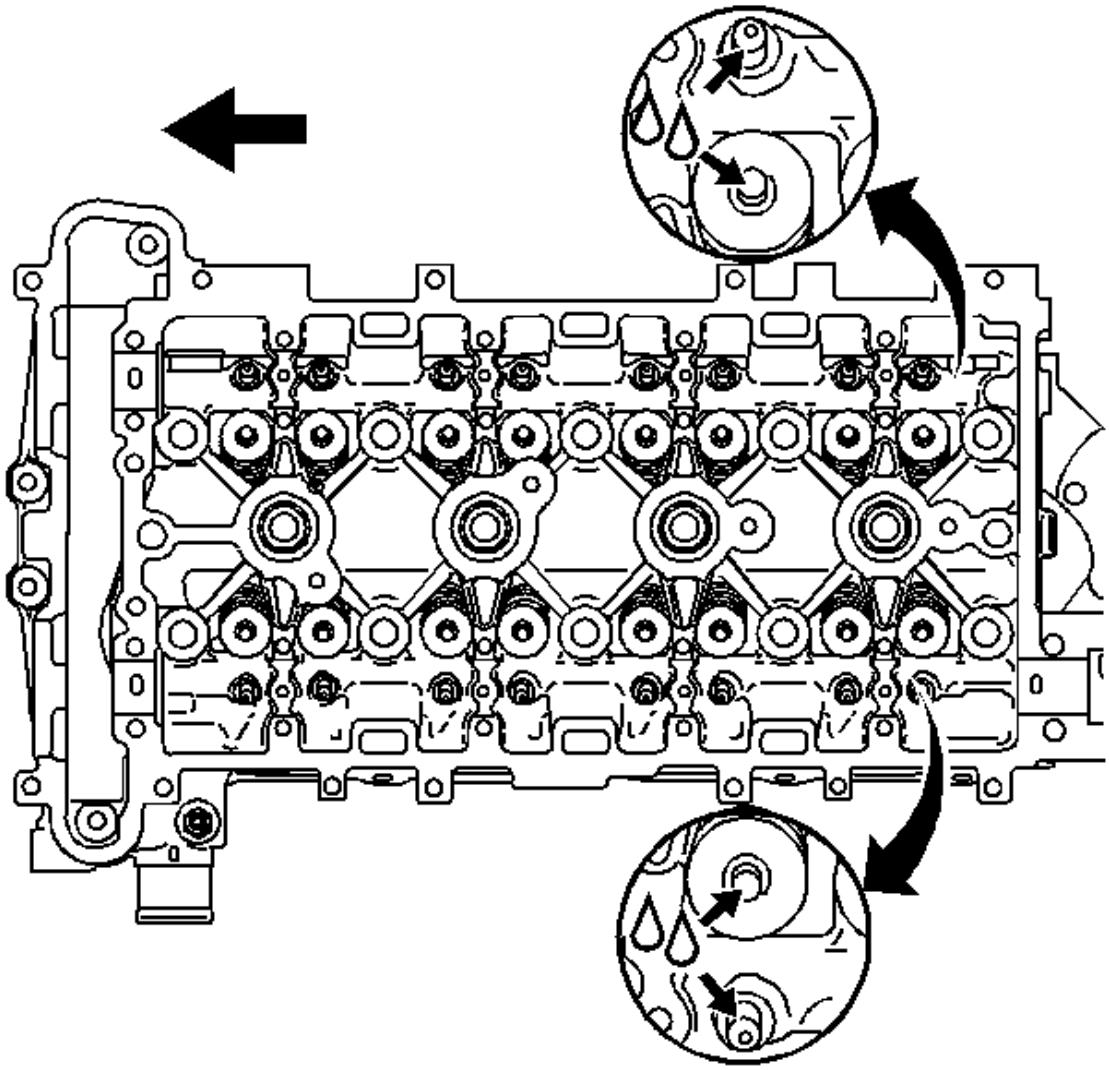

Fig. 164: Lubricating Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips with **Adhesives, Fluids, Lubricants, and Sealers**.

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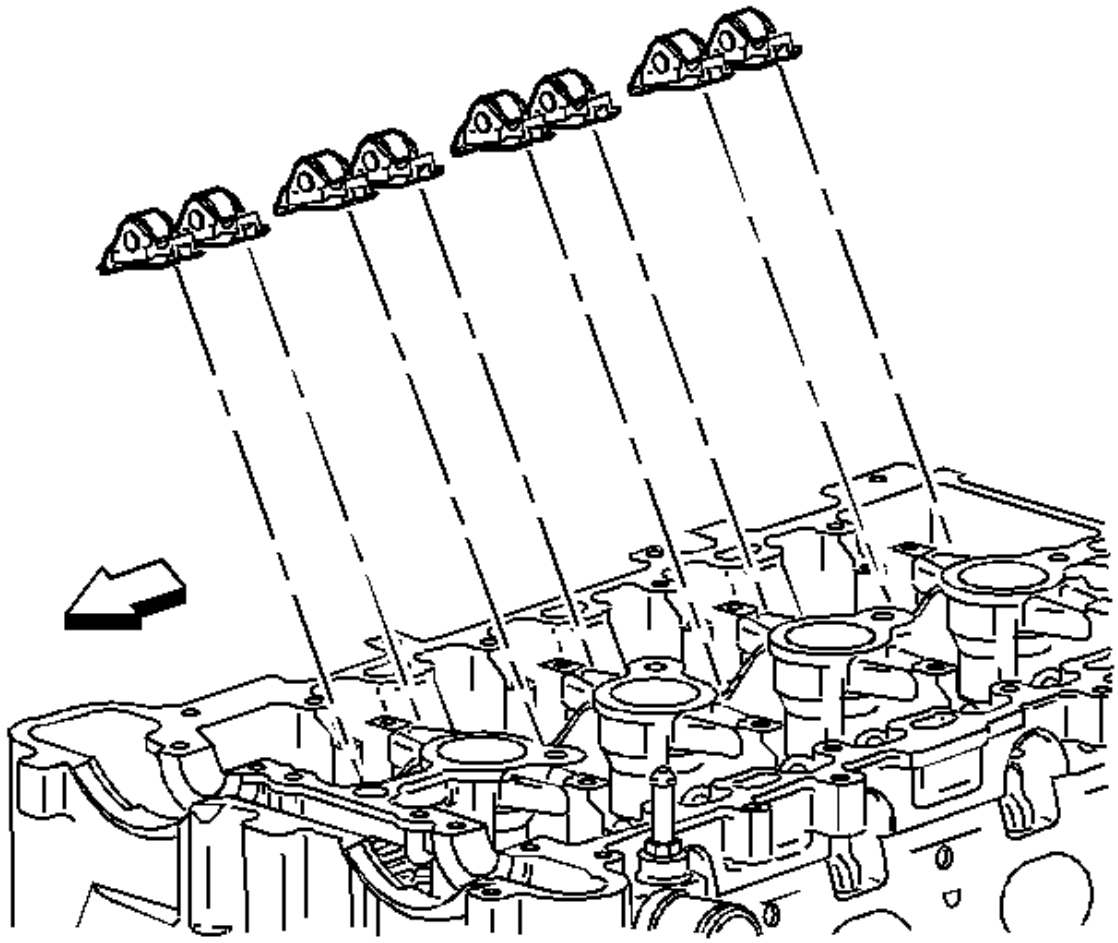

Fig. 165: Identifying Exhaust Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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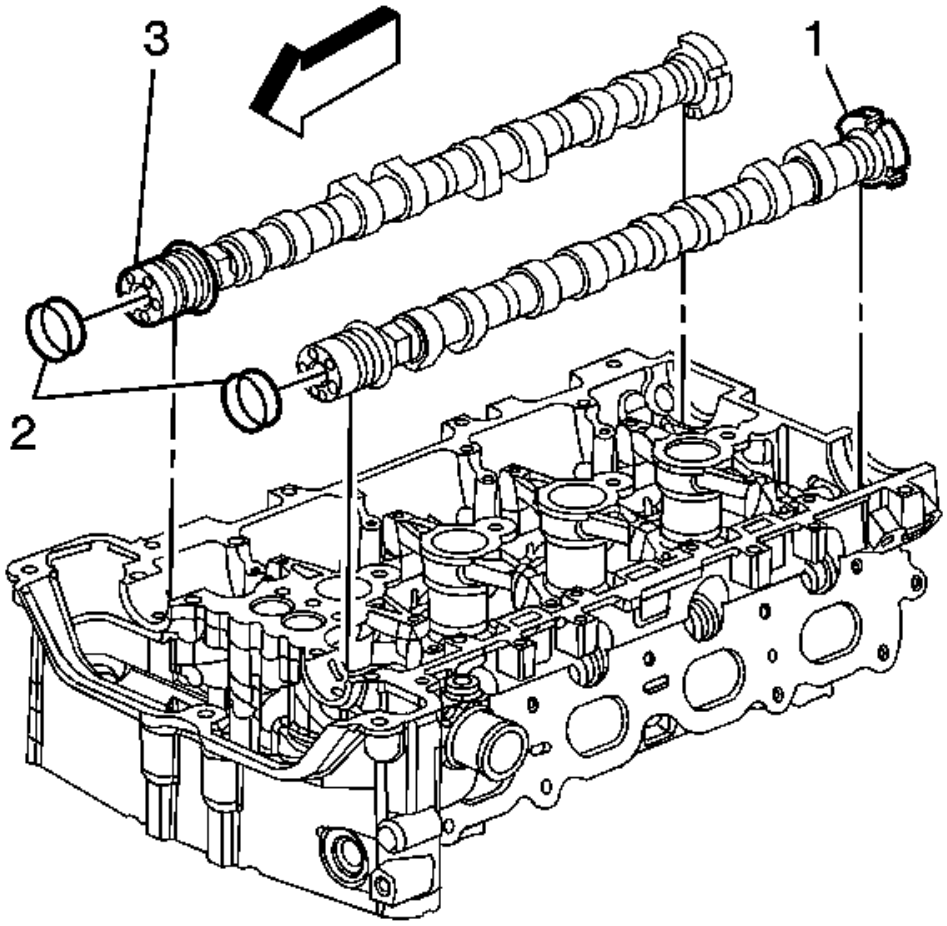

Fig. 166: Intake/Exhaust Camshaft
Courtesy of GENERAL MOTORS CORP.

5. Install the exhaust camshaft (3). Lubricate with **Adhesives, Fluids, Lubricants, and Sealers**.

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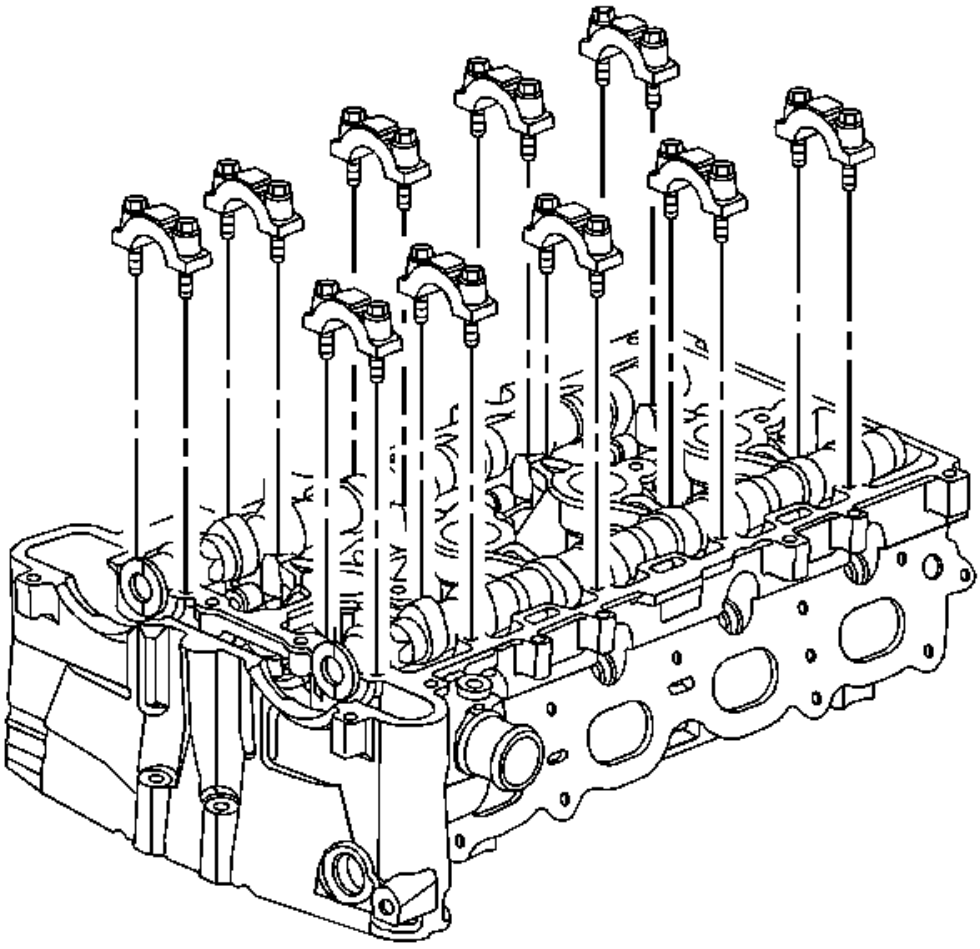

Fig. 167: Camshaft Bearing Caps
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

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

Special Tools

- **EN-48749** Timing Chain Retention Tool Kit. See **Special Tools**.

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- **EN-48953** Camshaft Actuator Locking Tool. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

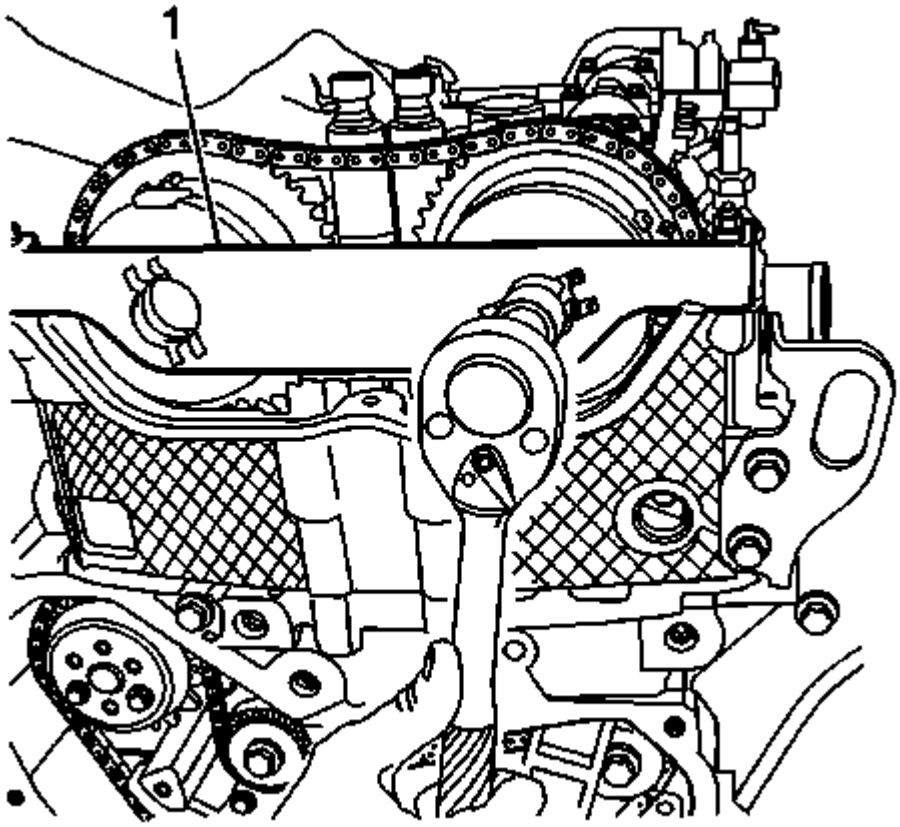

Fig. 168: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the camshaft actuator retainer **EN-48953** (1). See **Special Tools**.

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but DO NOT remove the intake camshaft actuator bolt.
6. Remove the camshaft actuator locking tool, **EN-48953** (1). See **Special Tools**.

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7. Clean the timing chain and gears with solvent.

NOTE: Ensure 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.

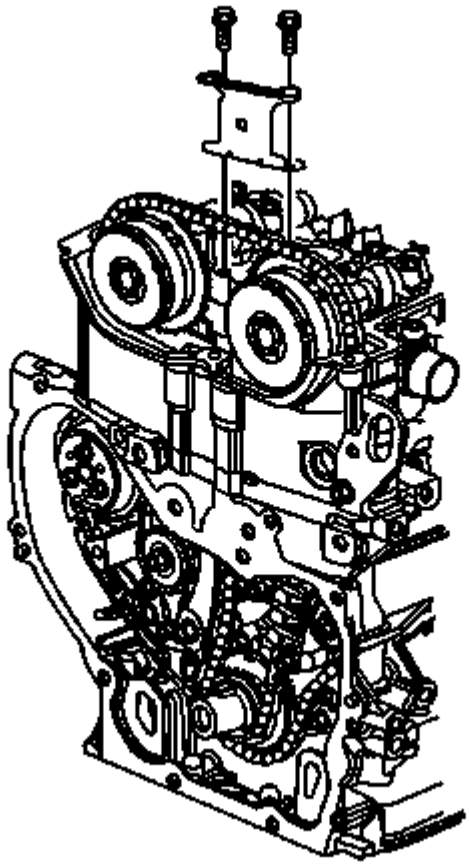

Fig. 169: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the upper timing chain guide bolts and guide.

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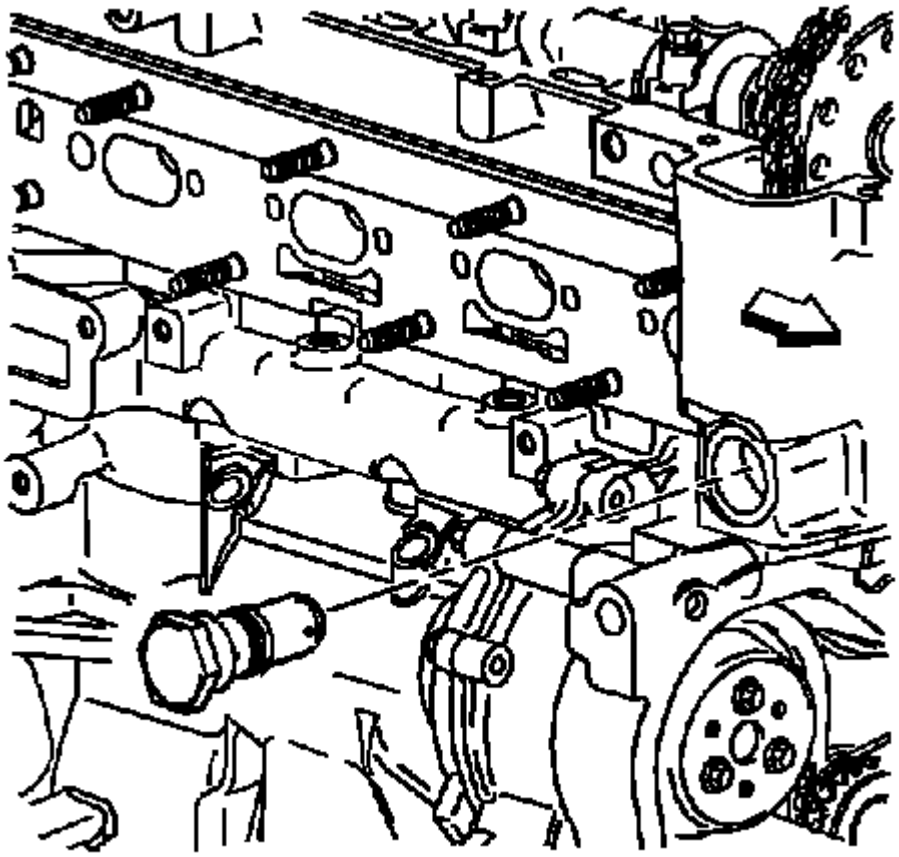

Fig. 170: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

10. Remove the timing chain tensioner.

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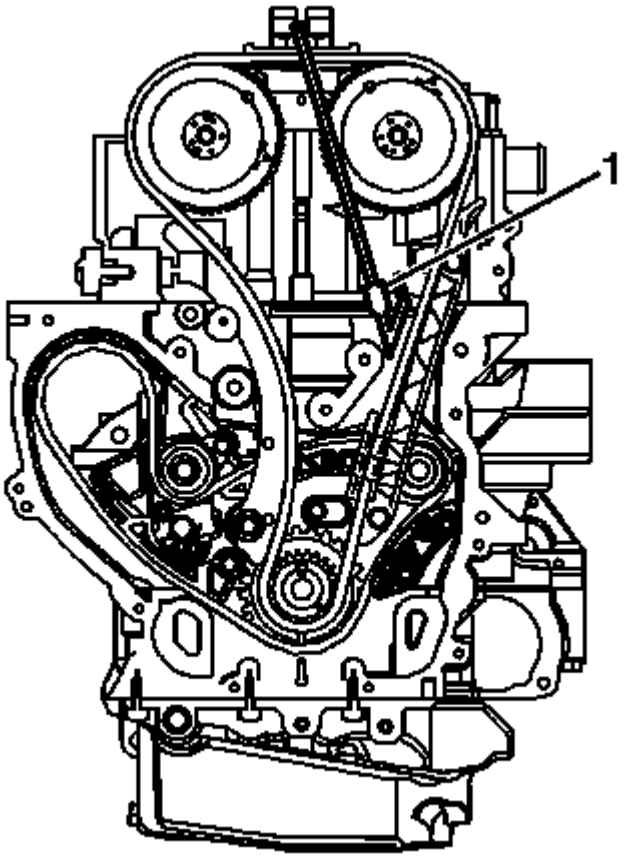

Fig. 171: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The intake camshaft actuator should not rotate during the removal or installation.**
- **Ensure the tips of the are fully engaged into the timing chain. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.**

11. Install the timing chain retention tool **EN-48749** (1) to the intake side of the timing chain. See **Special Tools**.

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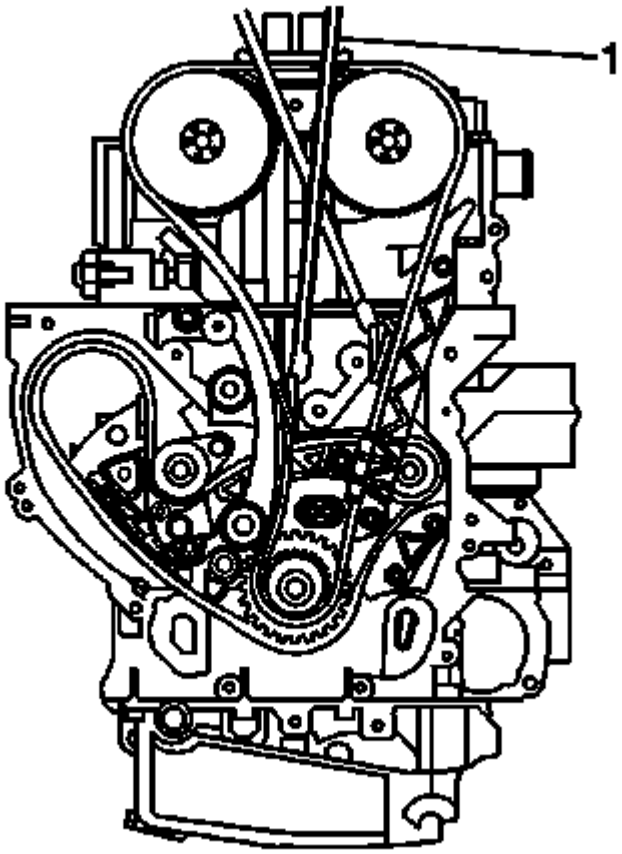

Fig. 172: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

12. Install the timing chain retention tool **EN-48749** (1) to the exhaust side of the timing chain. See **Special Tools**.

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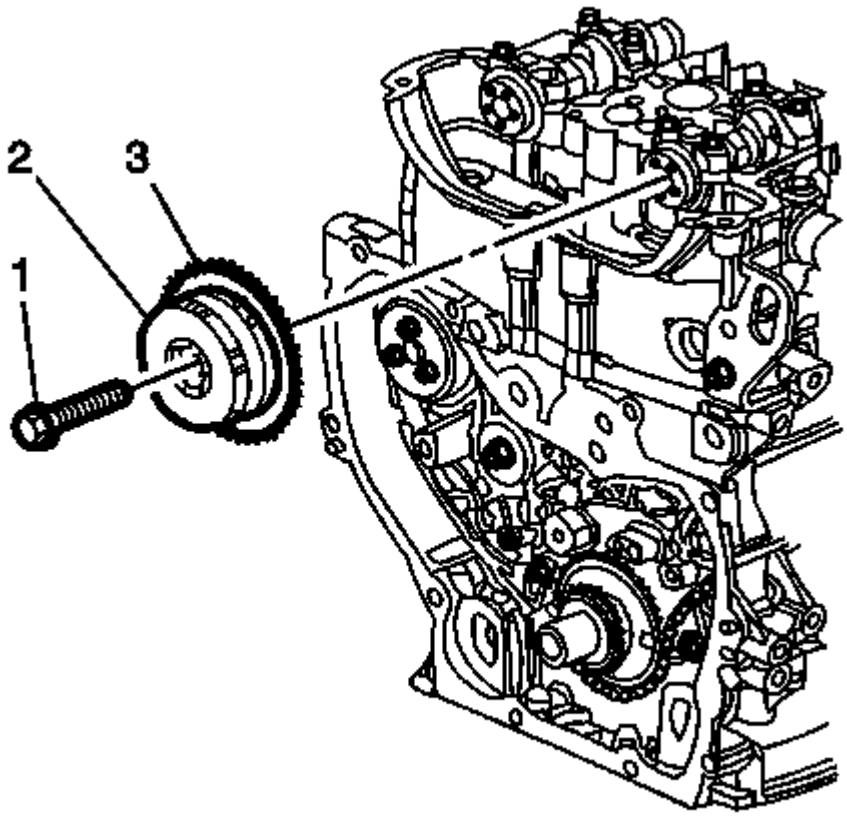

Fig. 173: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

13. Remove and discard the intake camshaft actuator bolt (2).
14. Rotate the exhaust camshaft clockwise slightly to take the tension off of the timing chain on the intake actuator.
15. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

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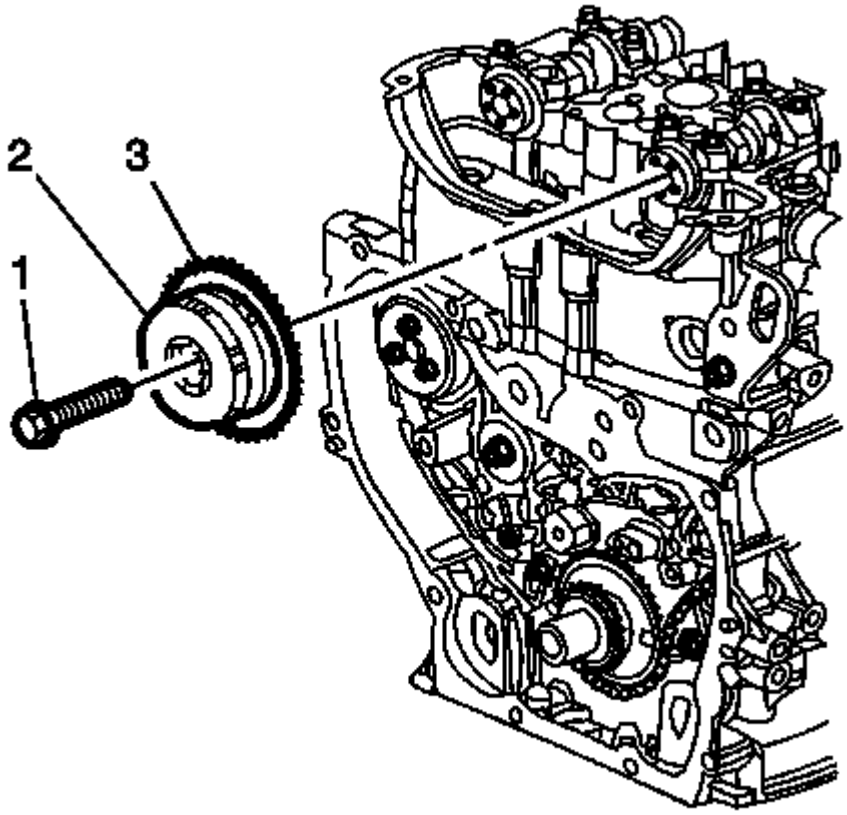

Fig. 174: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 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 rotating the exhaust camshaft clockwise, if required.
3. Install a NEW intake camshaft actuator bolt (2) until snug.

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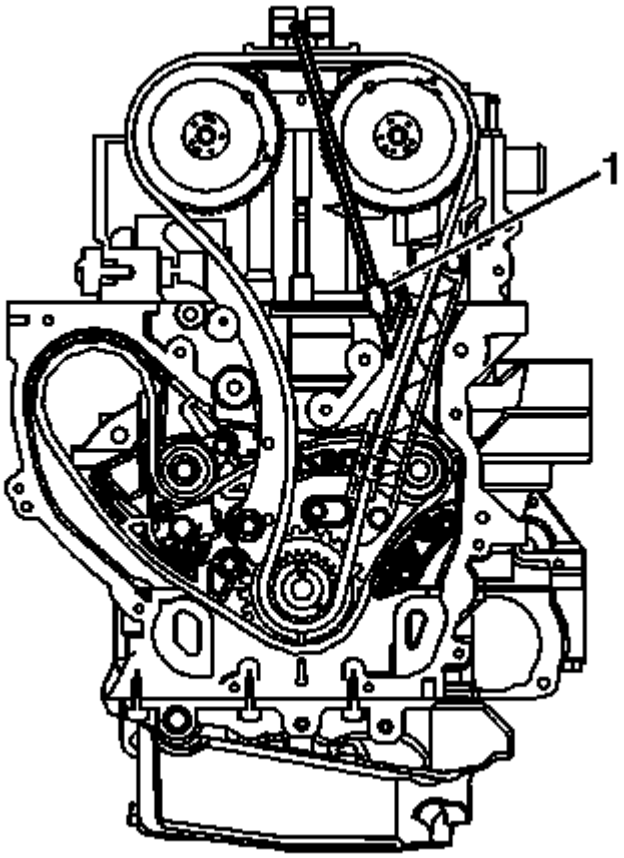

Fig. 175: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

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

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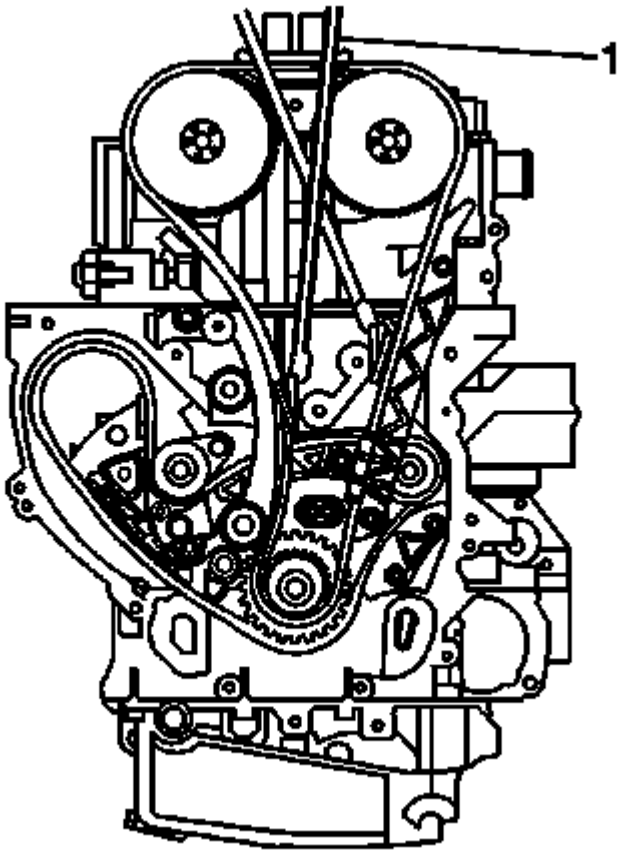

Fig. 176: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the intake camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

5. Remove the timing chain retention tool (1) from the exhaust side of the timing chain.

NOTE: Failure to reset the tensioner will allow the tensioner to over estend. limiting the timing chain life.

6. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**

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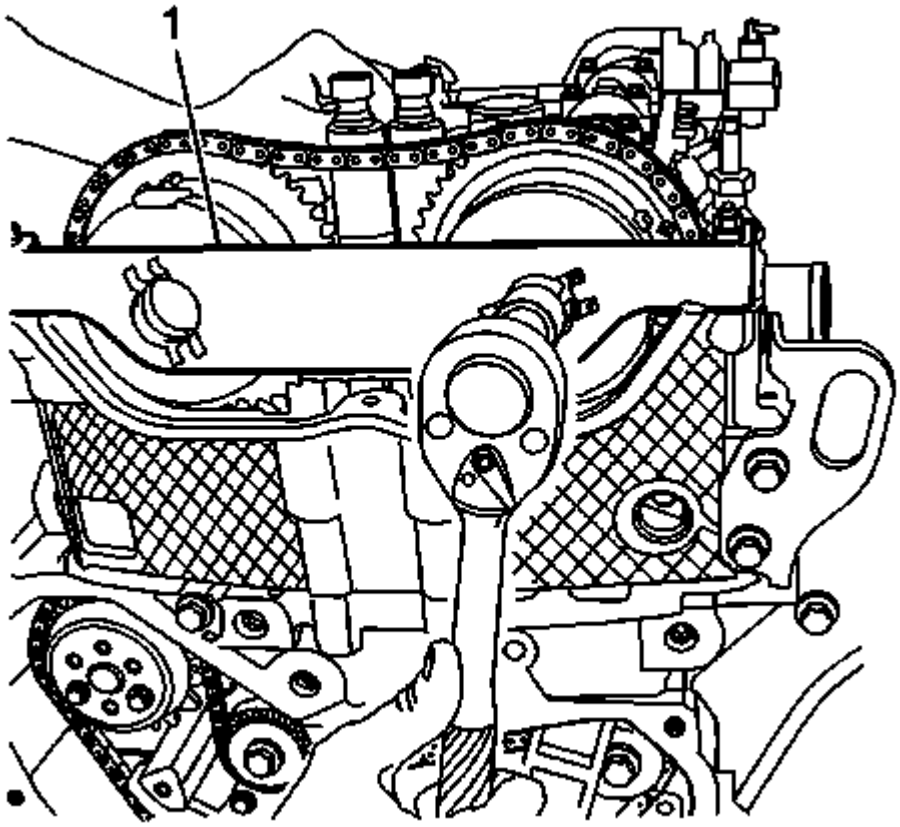

Fig. 177: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the camshaft actuator retainer (1) **EN-48953:** Camshaft Actuator Locking Tool.
8. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
9. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **J 45059** .

NOTE: **You must have the EN-48953 installed to perform this procedure. See Special Tools.**

10. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).
11. Remove the camshaft actuator retainer **EN-48953** (1). See **Special Tools**.

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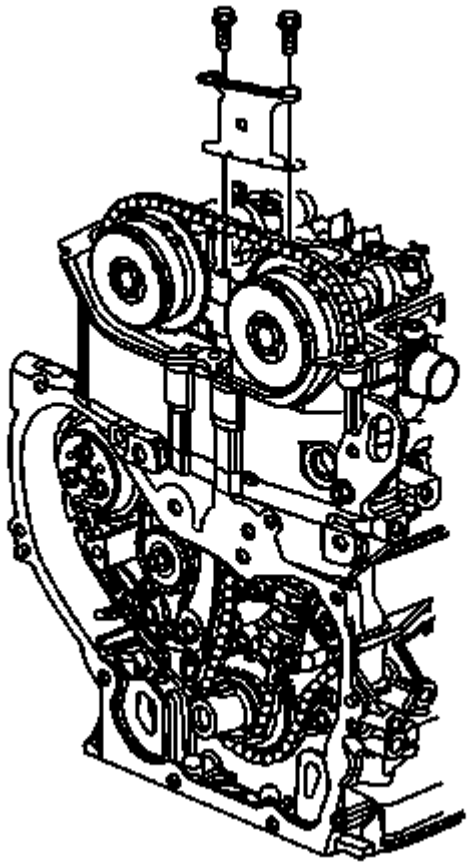

Fig. 178: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

12. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
13. Install the spark plugs. Refer to **Spark Plug Replacement** .
14. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

CAMSHAFT POSITION EXHAUST ACTUATOR REPLACEMENT

Special Tools

- **EN-48749** Timing Chain Retention Tool Kit. See **Special Tools**.
- **EN-48953** Camshaft Actuator Locking Tool. See **Special Tools**.
- **J 45059** Angle Meter

Removal Procedure

1. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .

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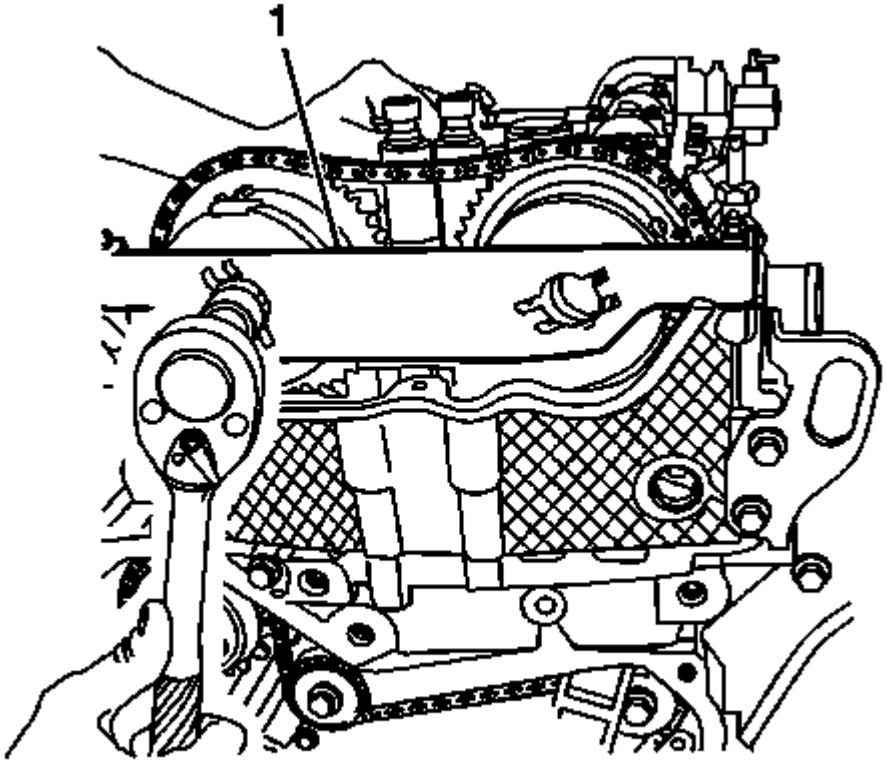

Fig. 179: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

3. Rotate the crankshaft clockwise and install the camshaft actuator retainer **EN-48953** (1). See **Special Tools**.

CAUTION: Refer to Fastener Caution .

4. Install the camshaft actuator retainer bolts and tighten to 10 N.m (89 lb in).
5. Loosen, but do not remove the exhaust camshaft actuator bolt.
6. Clean the timing chain and gears with solvent.

NOTE: Ensure 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.

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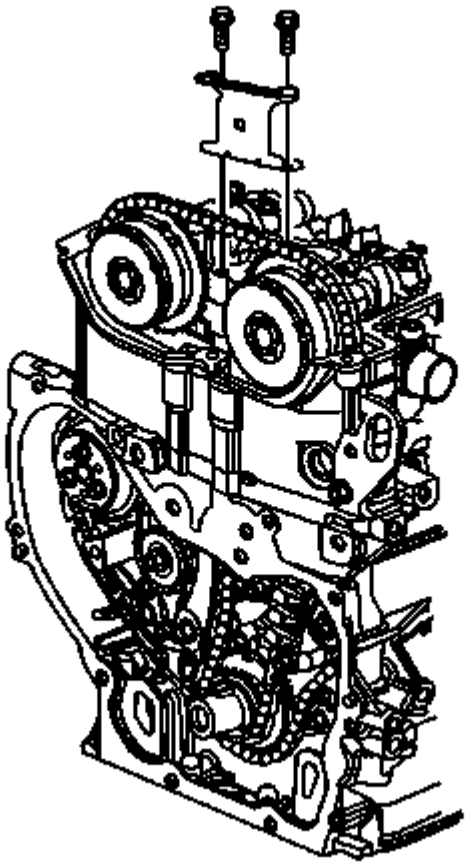

Fig. 180: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

8. Remove the upper timing chain guide bolts and guide.

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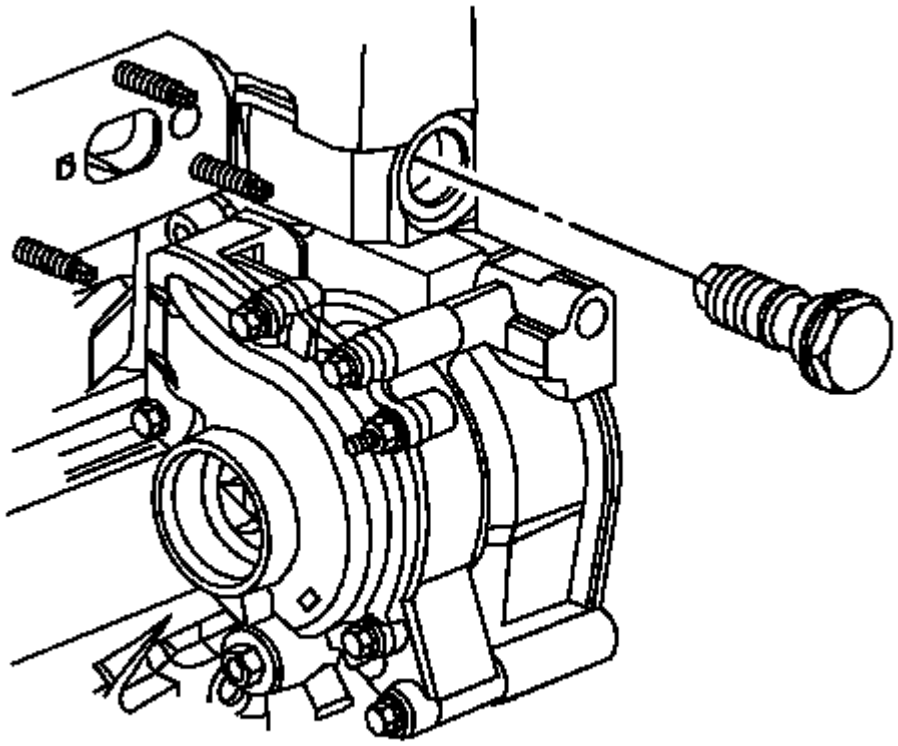

Fig. 181: Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

9. Remove the timing chain tensioner.

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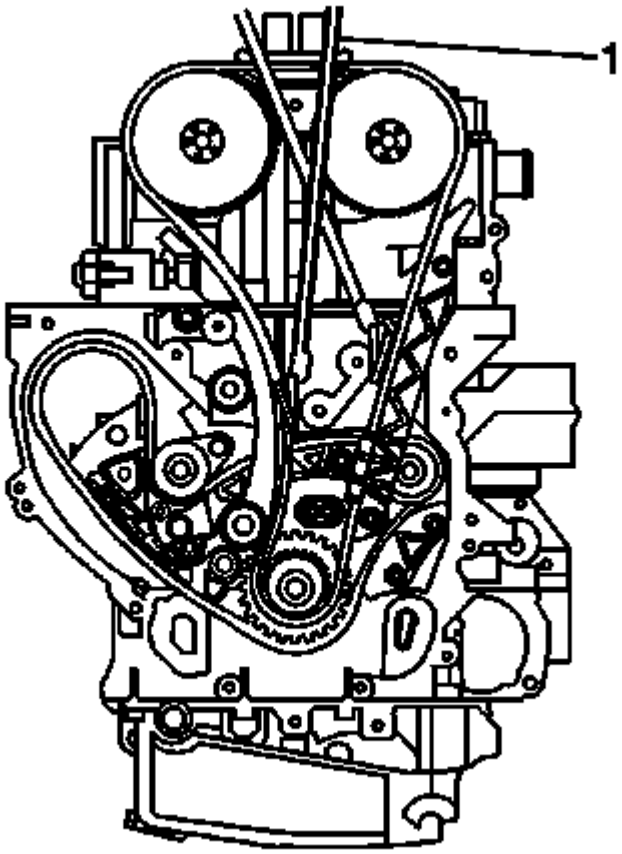

Fig. 182: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The camshaft actuators should not rotate during the removal or installation.**
- **Ensure the tips of the EN-48749 are fully engaged into the timing chain. See Special Tools. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.**

10. Install the timing chain retention tool **EN-48749** (1) to the exhaust side of the timing chain. See **Special Tools**.

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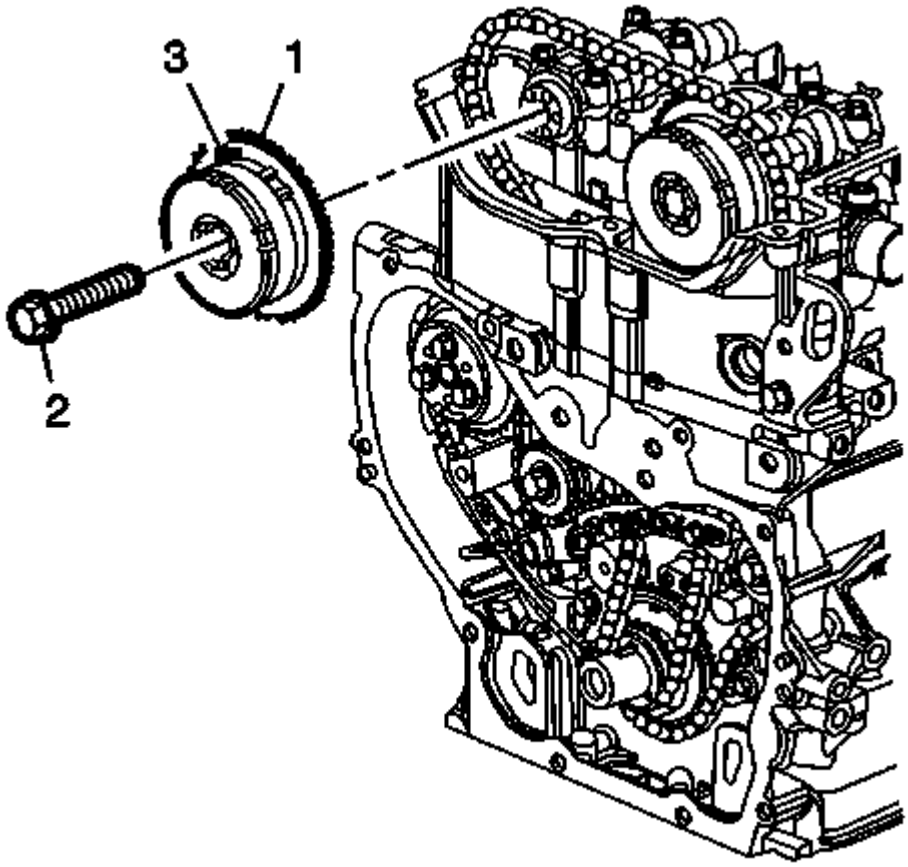

Fig. 183: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

11. Remove and discard the exhaust camshaft actuator bolt (2).
12. Remove the exhaust camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

Installation Procedure

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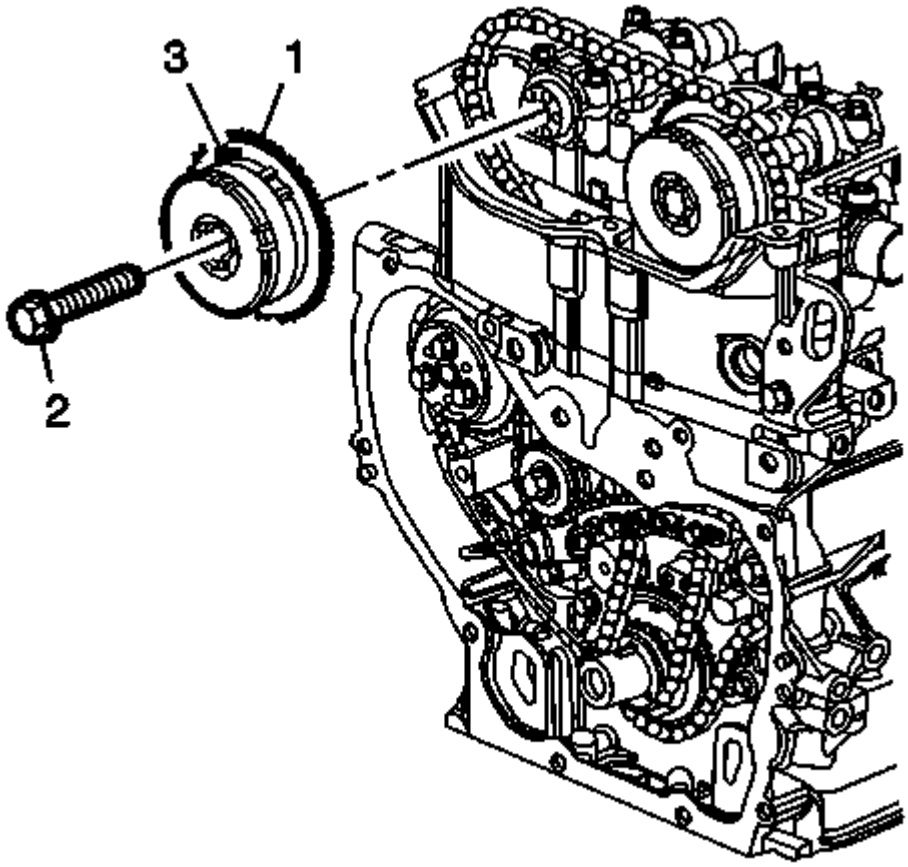

Fig. 184: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **Ensure that the alignment mark made previously on the intake camshaft actuator is still aligned properly with the mark on the timing chain.**
- **The exhaust camshaft may need to be rotated clockwise to fully set the camshaft actuator.**

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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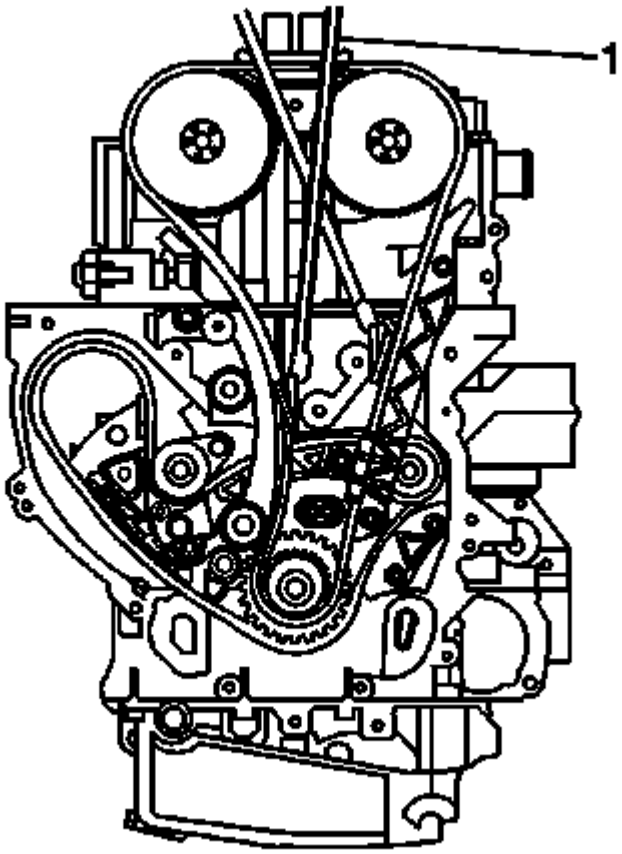

Fig. 185: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark previously on the exhaust camshaft actuator is still aligned properly with the timing chain. If the mark made previously on the intake camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

4. Remove the timing chain retention tool **EN-48749** (1) from the exhaust side of the timing chain. See **Special Tools**.

NOTE: Failure to reset the tensioner will allow the tensioner to over extend. limiting the timing chain life.

5. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

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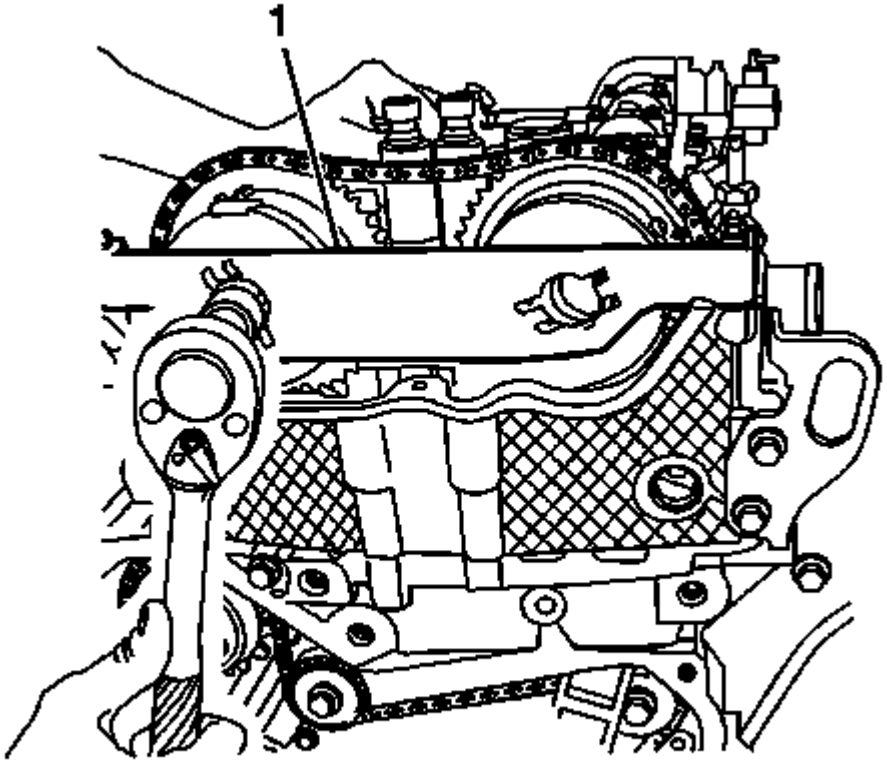

Fig. 186: View of Camshaft Actuator Retainer
Courtesy of GENERAL MOTORS CORP.

6. Install the intake camshaft actuator retainer (1).
7. Install the camshaft actuator retainer bolts and tighten 10 N.m (89 lb in).
8. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft) plus an additional 100 degrees using the **J 45059** .

NOTE: **You must have the EN-48953 installed to perform this procedure. See Special Tools.**

9. To release the tensioner apply a counterclockwise rotational torque to the crankshaft balancer bolt of 45 N.m (33 lb ft).

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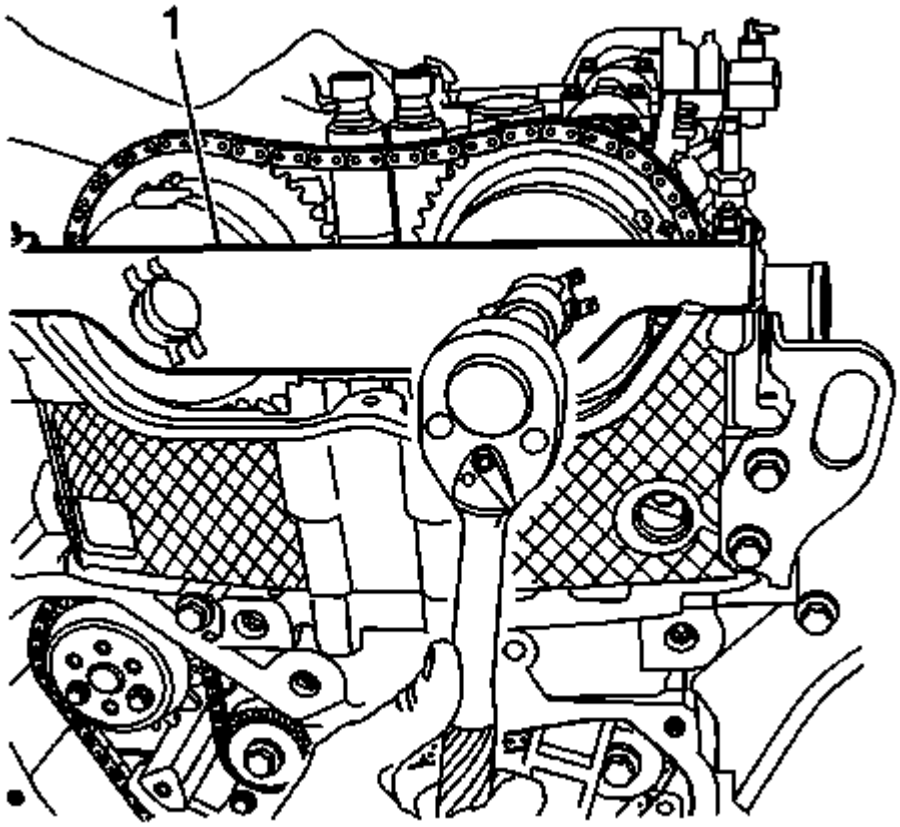

Fig. 187: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

10. Remove the camshaft actuator retainer **EN-48953** (1). See **Special Tools**.

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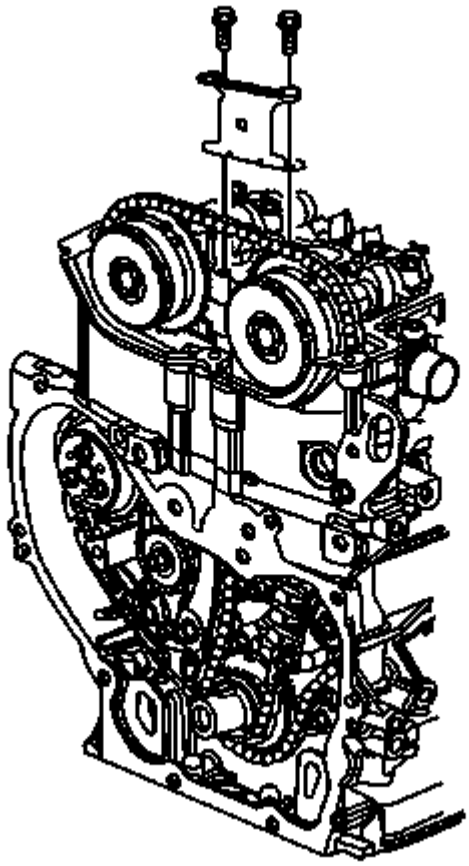

Fig. 188: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

11. Install the upper timing chain guide and bolts and tighten to 10 N.m (89 lb in).
12. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.
13. Install the spark plugs. Refer to **Spark Plug Replacement** .

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Tools Required

- **EN-36017:** Valve Guide Seal Remover
- **EN-43649:** Valve Spring Compressor
- **EN-43649-10:** Valve Spring Compressor Adaptor Set
- **EN-43653:** Flywheel Holding Tool

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

Removal Procedure

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IMPORTANT: Prevent the crankshaft from rotating clockwise or counter-clockwise before using compressed air in the cylinder. Rotation of the crankshaft may cause damage to EN-43653: Flywheel Holding Tool.

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 Replacement** .
3. Install **EN-43653:** flywheel holding tool.
4. Remove the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.

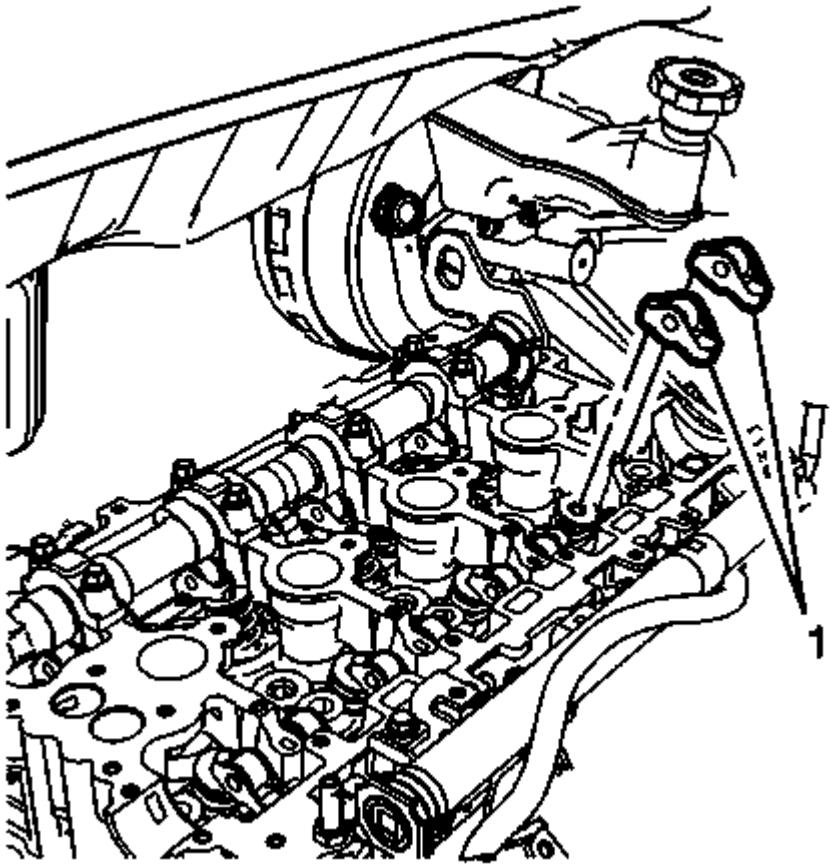

Fig. 189: Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

5. Remove the camshaft roller followers (1).

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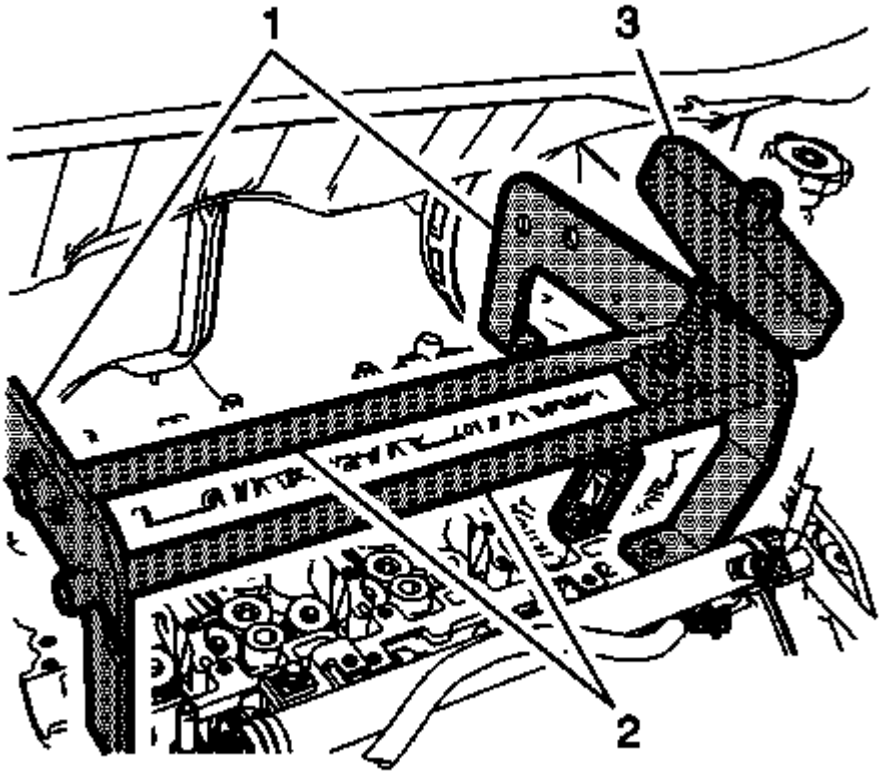

Fig. 190: Valve Spring Compressor Adaptor Set
Courtesy of GENERAL MOTORS CORP.

6. Install the **EN-43649-10:** valve spring compressor adaptor set (1) to the front and rear of the cylinder head.
7. Install the cross bars and locks (2) of the **EN-43649:** valve spring compressor to the valve spring compressor adaptors.
8. Remove the spark plugs. Refer to **Spark Plug Replacement** .
9. Install an air hose adapter into the spark plug hole.
10. Attach an air hose to the adapter and pressurize the cylinder to 690 kPa (100 psi)
11. Compress the valve spring using the valve spring compressor (3).

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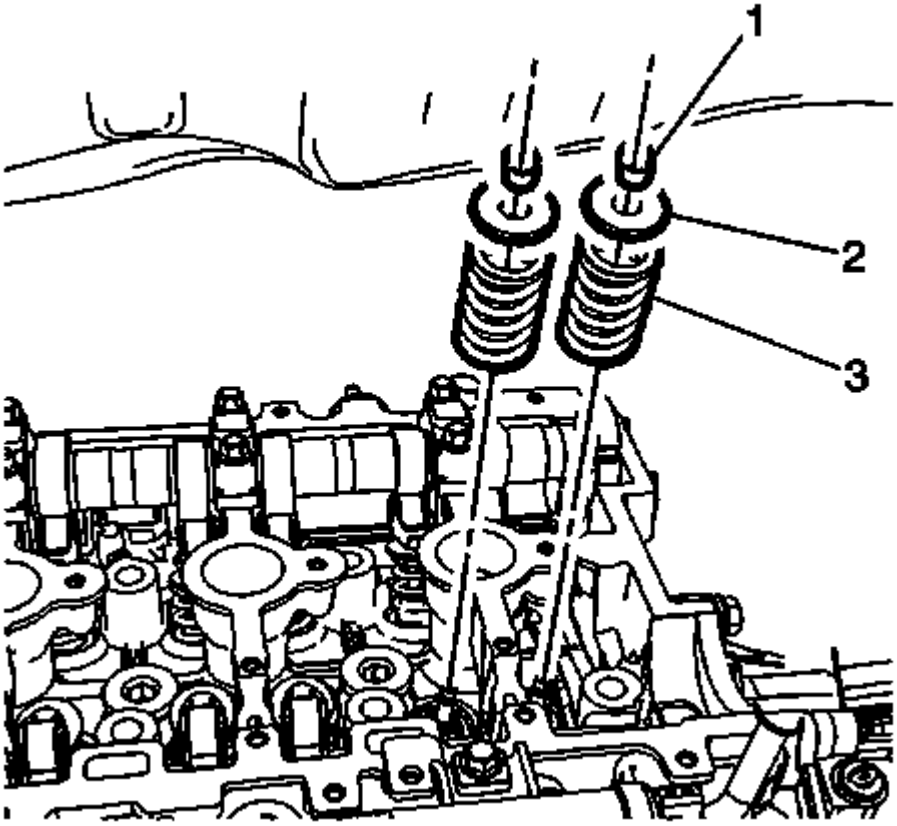

Fig. 191: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

12. Remove the valve spring keepers (1).
13. Remove the valve spring (3) and retainer (2).

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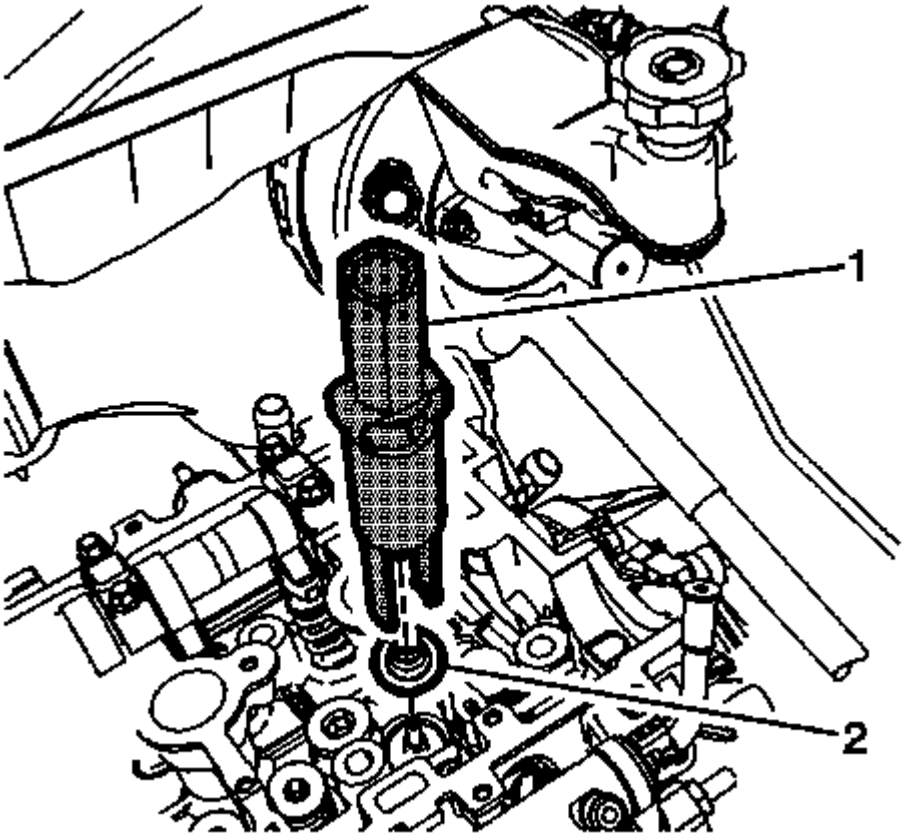

Fig. 192: Valve Guide Seal Remover
Courtesy of GENERAL MOTORS CORP.

14. Use the **EN-36017:** valve guide seal remover (1) to remove the valve seal.

Installation Procedure

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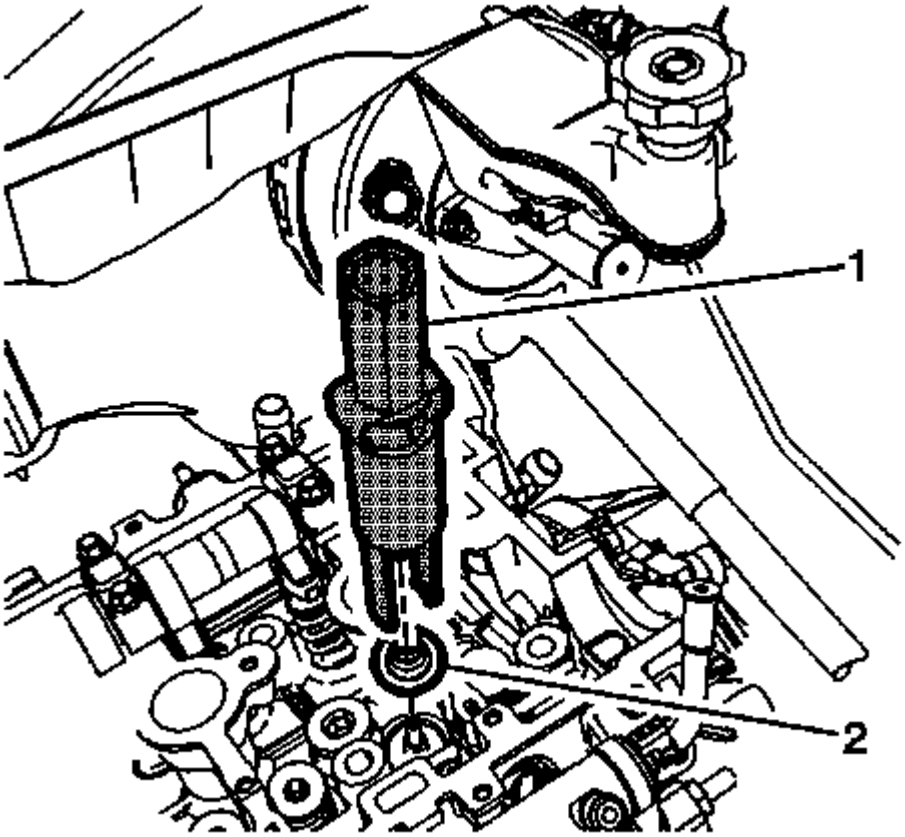

Fig. 193: Valve Guide Seal Remover
Courtesy of GENERAL MOTORS CORP.

1. Using the **EN-36017:** valve guide seal remover (1) install the NEW valve seal. Fully seat the seal onto the valve guide.

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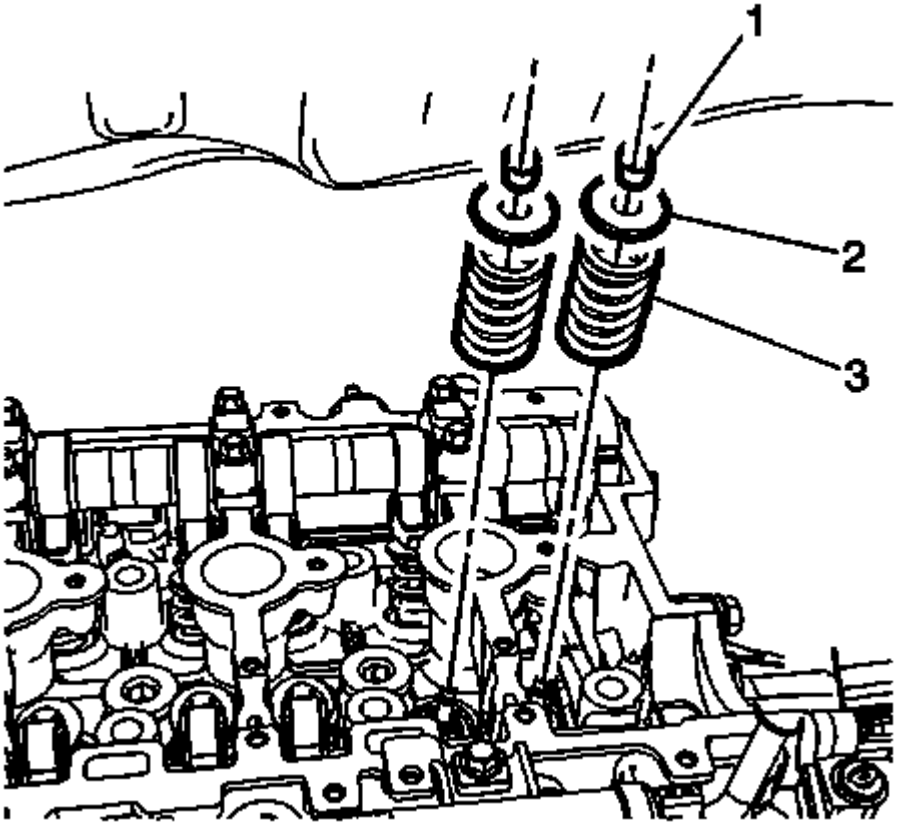

Fig. 194: Valve Spring, Keepers & Retainer
Courtesy of GENERAL MOTORS CORP.

2. Install the valve spring (3) and Retainer (2).
3. Compress the valve spring using the valve spring compressor.
4. Install the valve spring keepers (1).
5. Disconnect the air hose and air hose adapter.

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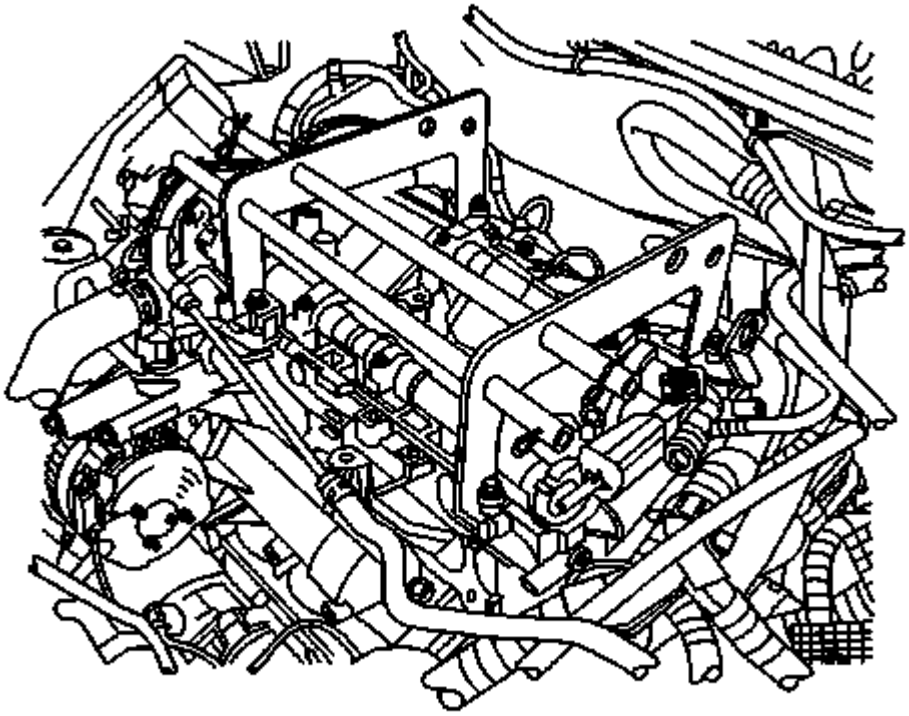

Fig. 195: View Of J 43649 Valve Spring Compressor (Cylinder Head)
Courtesy of GENERAL MOTORS CORP.

6. Remove the **EN-43649:** valve spring compressor and **EN-43649-10:** valve spring compressor adaptor set from the cylinder head.
7. Install the spark plugs. Refer to **Spark Plug Replacement** .

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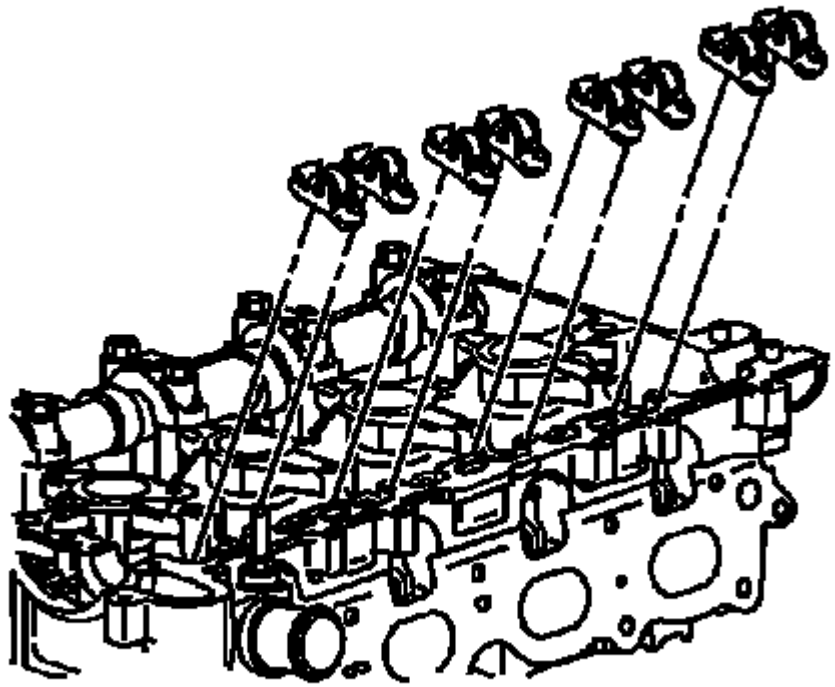

Fig. 196: Identifying Camshaft Roller Followers
Courtesy of GENERAL MOTORS CORP.

8. Install the camshaft roller followers (1).
9. Install the camshaft. Refer to **Intake Camshaft and Valve Lifter Replacement** or **Exhaust Camshaft and Valve Lifter Replacement**.
10. If used, remove the **EN-43653:** flywheel holding tool.
11. If removed, install the starter. Refer to **Starter Replacement** .

CYLINDER HEAD REPLACEMENT

Special Tools

- **J 38185:** Hose Clamp Pliers
- **J 45059:** Angle Meter
- **EN-46101:** Spark Plug Tube Seal Guide
- **EN-48749:** Timing Chain Retention Tool Kit
- **EN-48953:** EGR Cooler Pressure Tester Adapter Set

Removal Procedure

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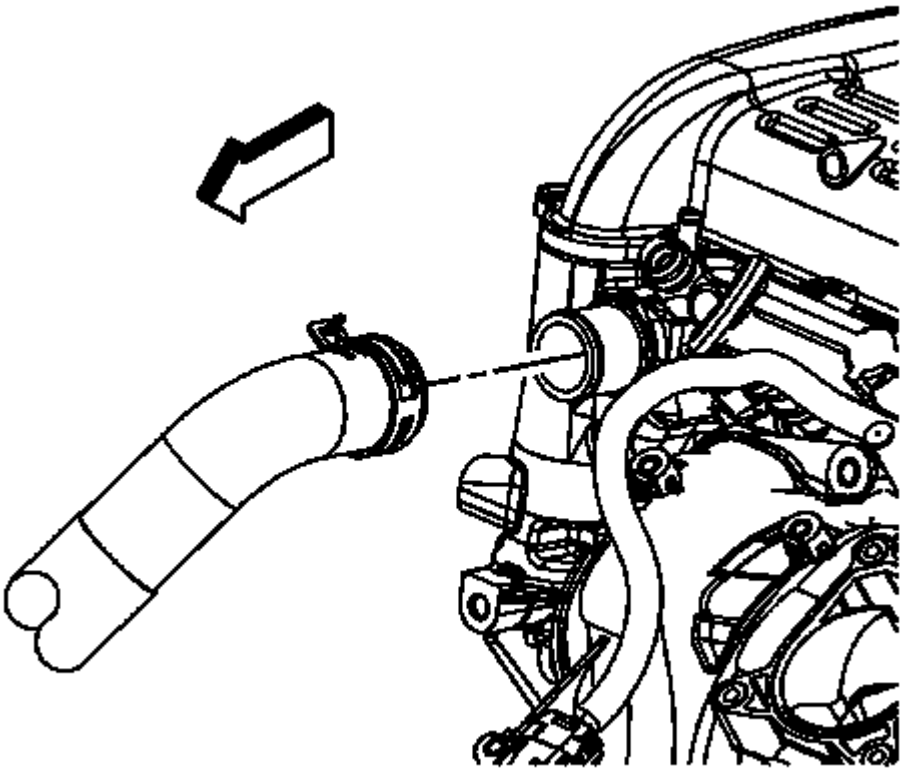

Fig. 197: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LE5, L61)** or **Cooling System Draining and Filling (GE 47716 Fill)** .
2. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement (LAP)** .
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. Disconnect all electrical connectors as necessary.
9. Remove the spark plugs. Refer to **Spark Plug Replacement** .
10. Remove the camshaft cover. Refer to **Camshaft Cover Replacement**.

NOTE: If the intake camshaft actuator is moving independently of the camshaft, this means the camshaft is not locked to the actuator. Rotate the camshaft counter-clockwise while the holding tool is installed and this will lock the camshaft to the actuator.

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11. Rotate the crankshaft clockwise to install the camshaft actuator locking the tool **EN-48953:** EGR Cooler Pressure Tester Adapter Set.

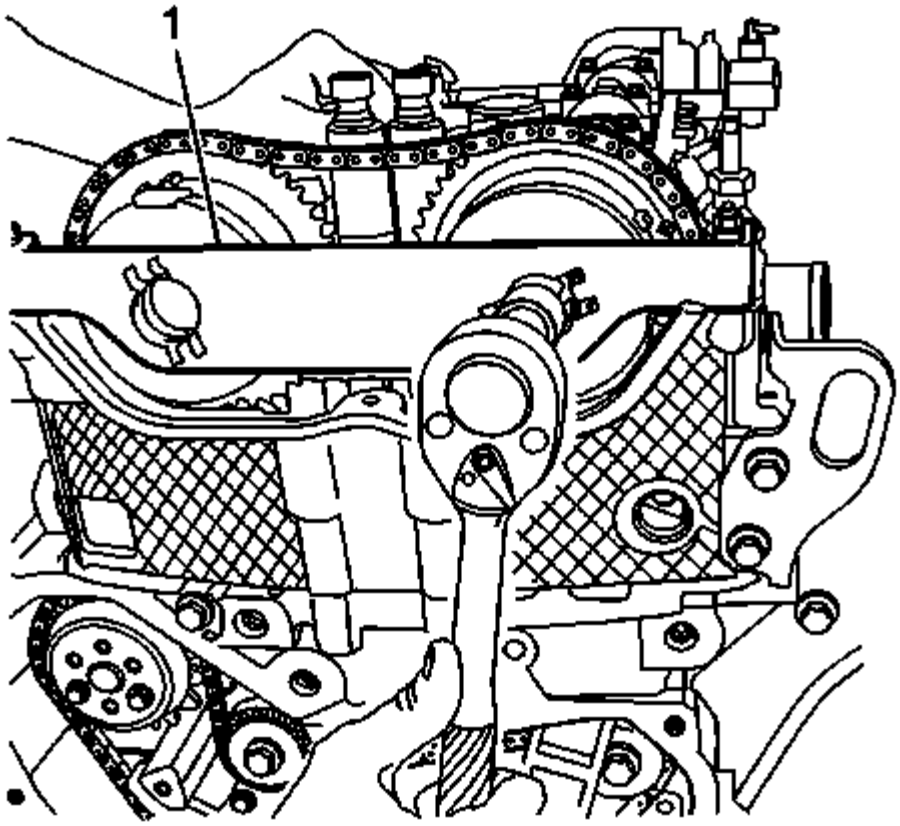

Fig. 198: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

12. Install the **EN-48953** (1). See **Special Tools**.

CAUTION: Refer to Fastener Caution .

13. Install the camshaft actuator locking tool tightening the bolt to 10 N.m (89 lb in).

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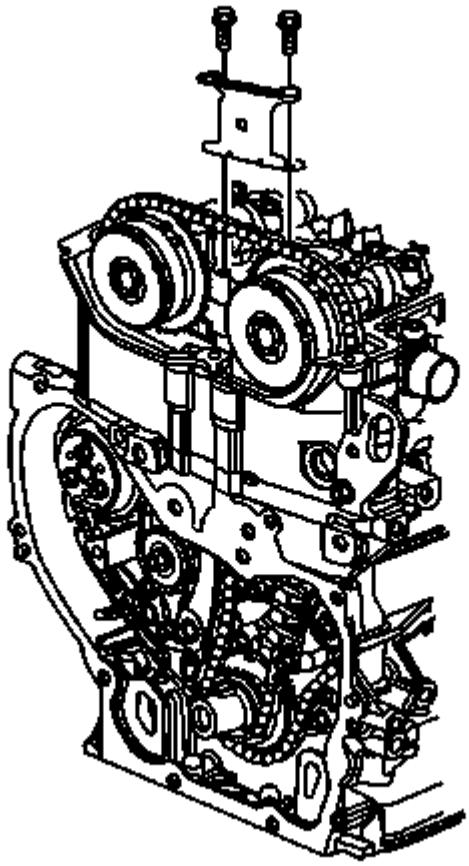

Fig. 199: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

14. Remove the upper timing chain guide bolts and guide.
15. Clean the timing chain and gears with solvent.

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

16. Mark the timing gear sprockets and the timing chain. It is recommended that the paint marks are located in the 12 o'clock position.
17. Loosen, but do not remove the intake and exhaust camshaft actuator bolts.
18. Remove the camshaft actuator locking tool, **EN-48953** . See **Special Tools**.

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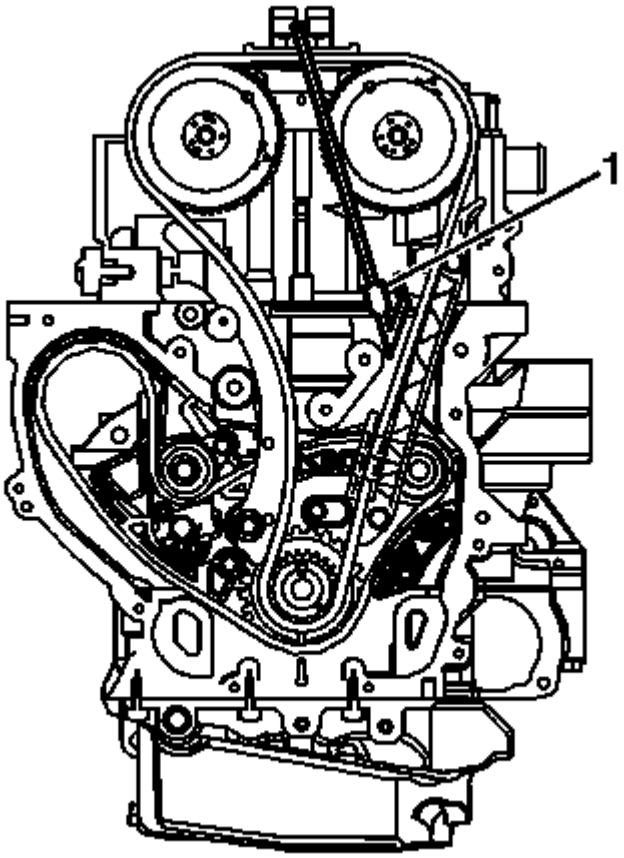

Fig. 200: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure the tips of the EN-48749 are fully engaged into the timing chain. See Special Tools. The retention tool rod can be used on the back side of the chain to ensure the teeth from the retention tool are engaged.

19. Install the timing chain retention tool **EN-48749** (1) to the intake side of the timing chain. See **Special Tools**.

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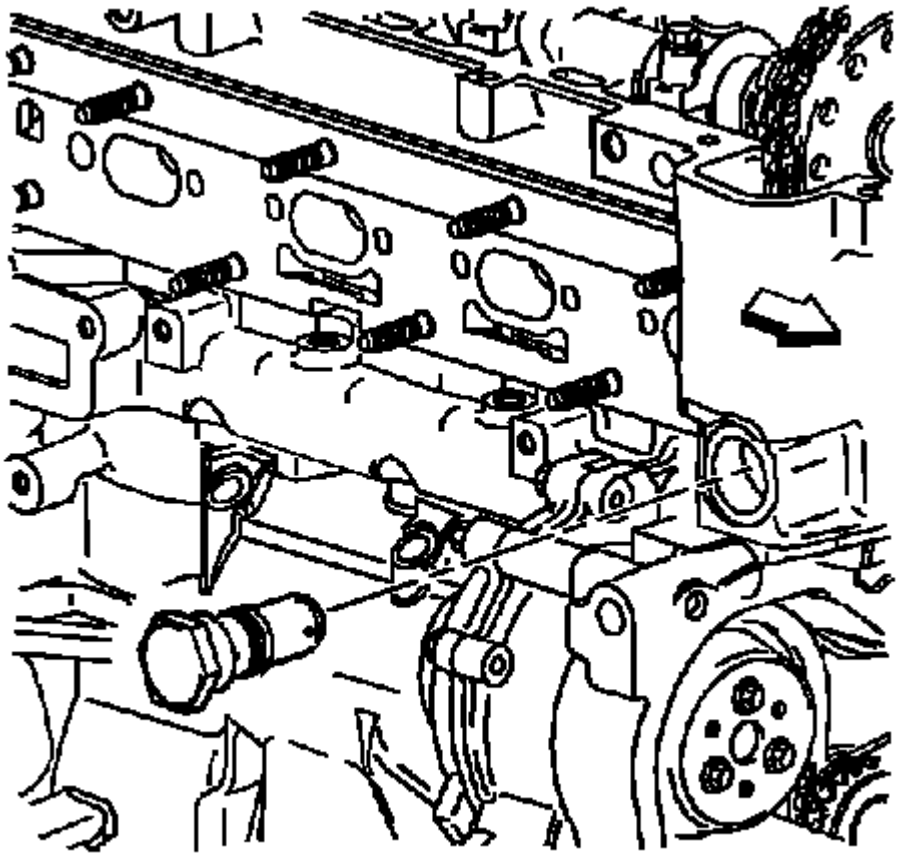

Fig. 201: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

20. Remove the timing chain tensioner.

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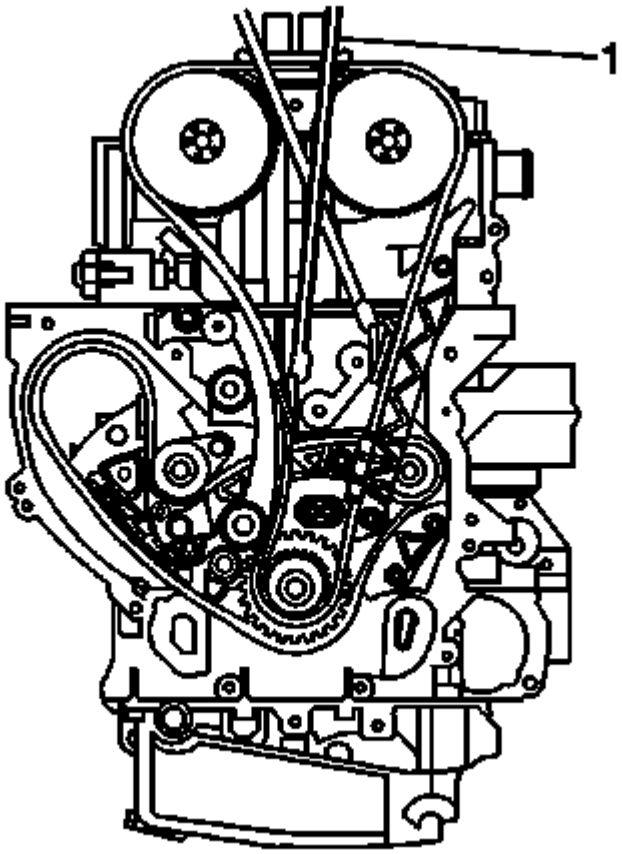

Fig. 202: Identifying Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

NOTE: The Intake camshaft and actuator should not rotate during the removal or installation.

21. Install the timing chain retention tool **EN-48749** (1) to the exhaust side of the timing chain. See **Special Tools**.

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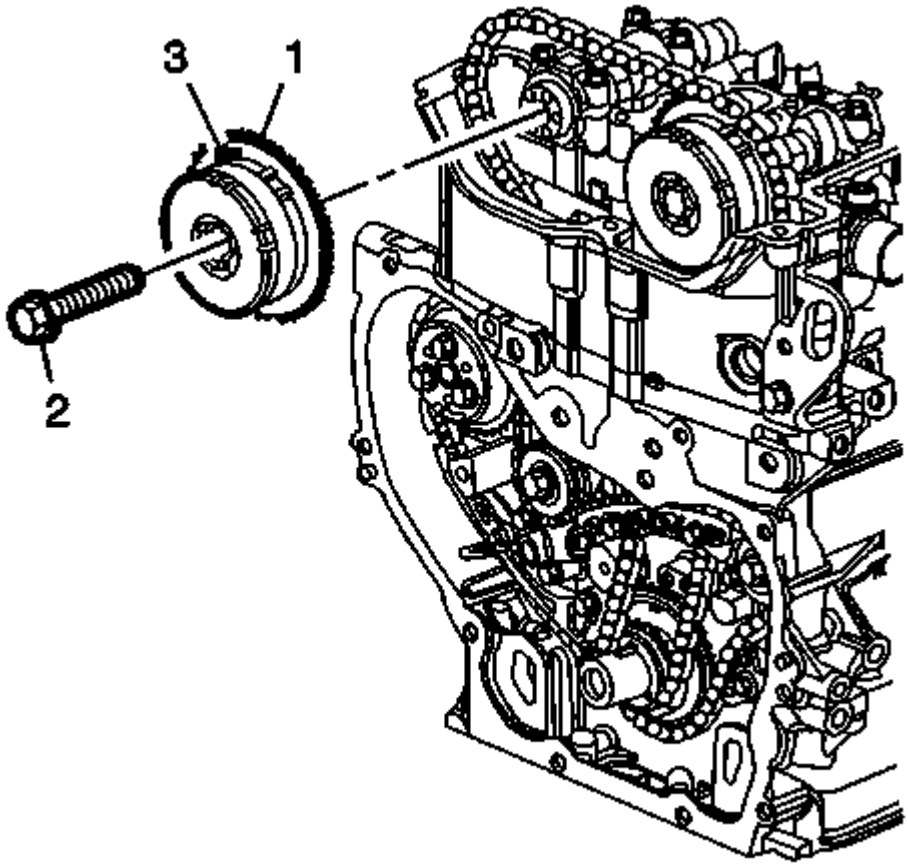

Fig. 203: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

22. Remove and discard the exhaust camshaft actuator bolt (2).
23. Remove the exhaust cam actuator (3) from the exhaust camshaft while also removing the actuator from the chain.

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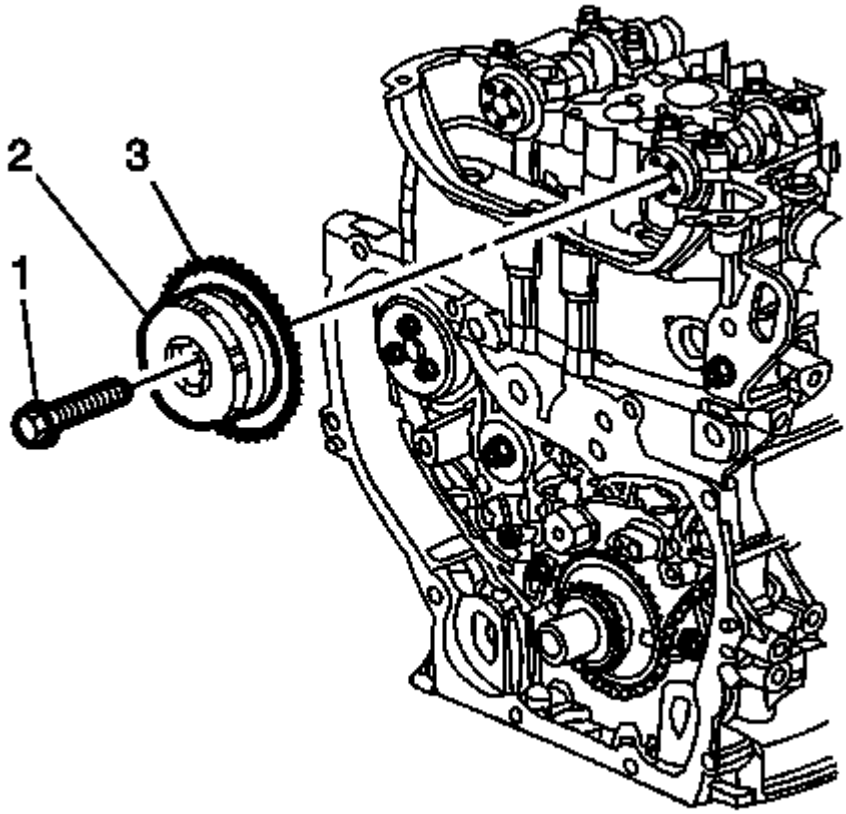

Fig. 204: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

24. Remove and discard the intake camshaft actuator bolt (2).
25. Remove the intake camshaft actuator (3) from the camshaft while also removing the actuator from the timing chain.

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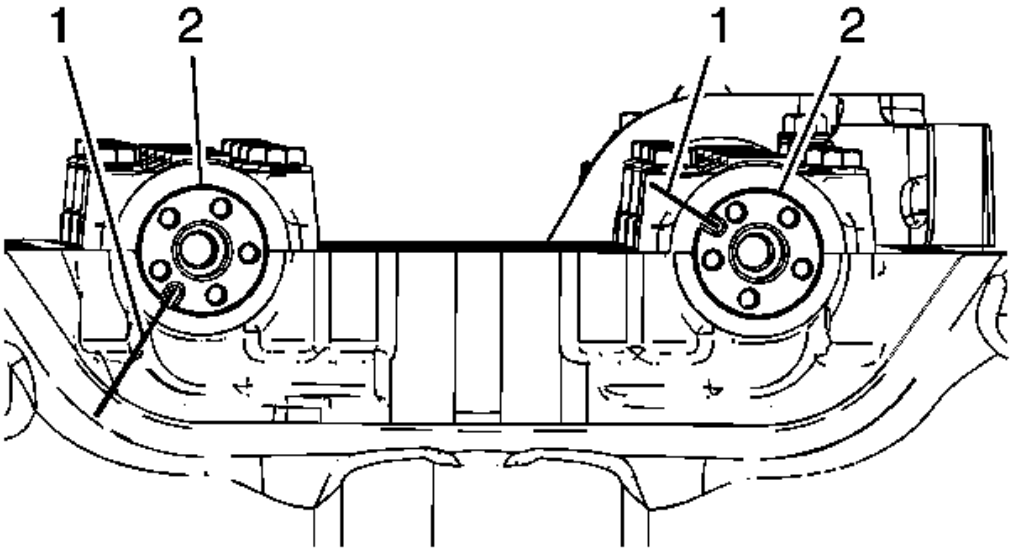

Fig. 205: Aligning Cylinder Head Marks And Camshaft Notches Correctly
Courtesy of GENERAL MOTORS CORP.

26. On 2.2L engines, mark the cylinder head (1) in relationship to the camshaft actuator notch on the camshaft (2).

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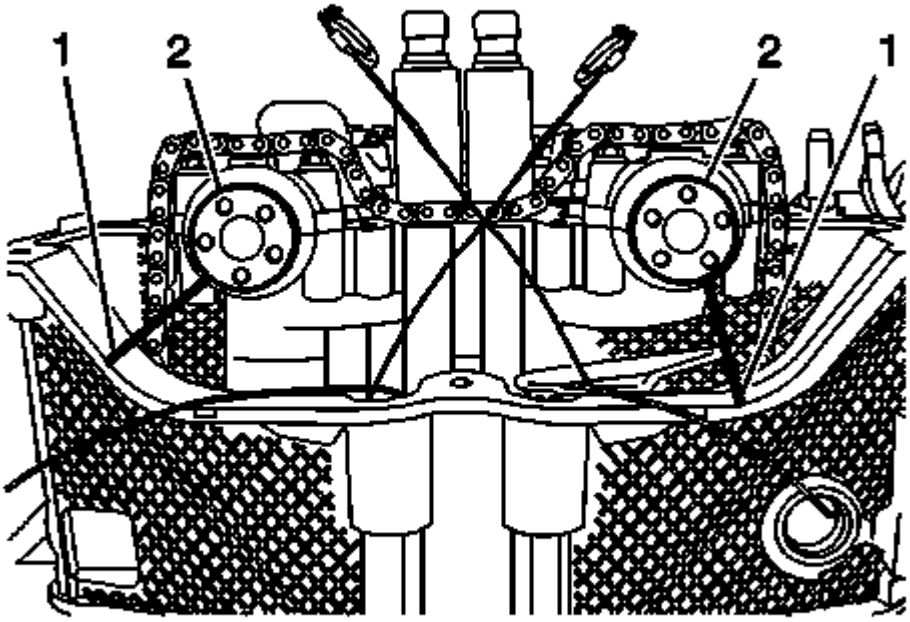

Fig. 206: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

27. On 2.4L engines, mark the cylinder head (1) in relationship to the camshaft actuator notch on the camshaft (2).

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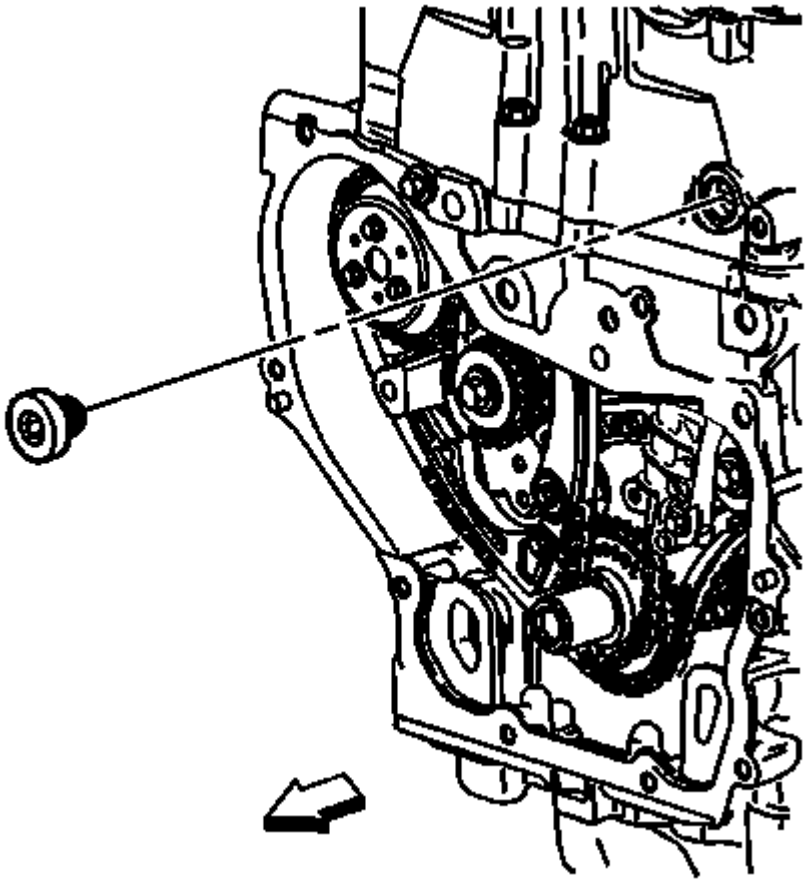

Fig. 207: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

28. Remove the fixed timing chain guide access plug.
29. Remove the upper fixed timing chain guide bolt.

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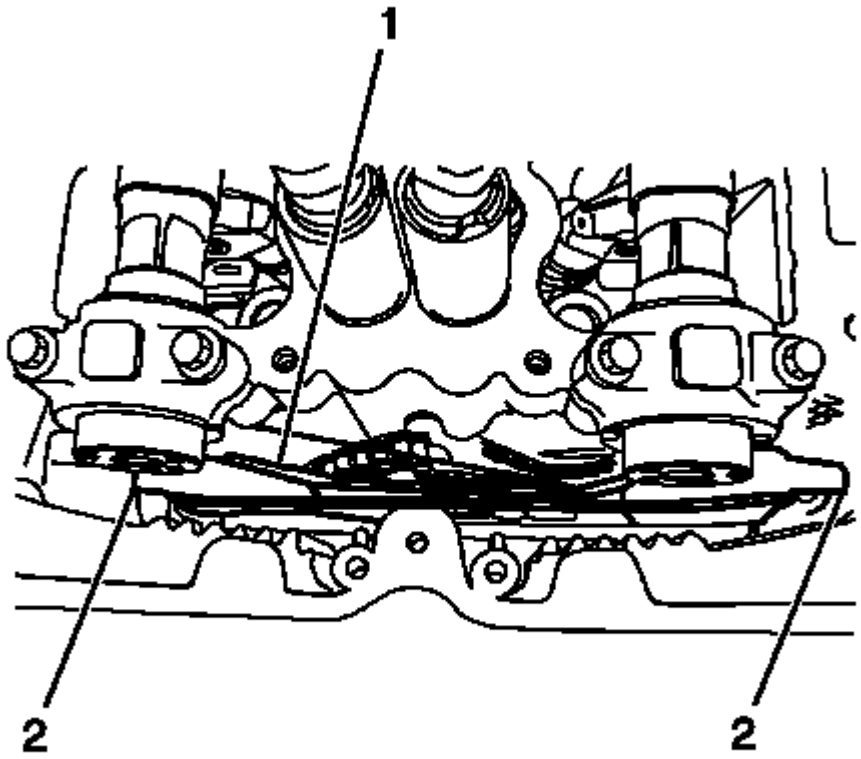

Fig. 208: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

NOTE: The threaded rod from the timing chain retention tool can be used to help feed the rubber band around the chain guides.

30. Install a rubber band (1) around the top of the upper timing chain guides (2) in order to pull the guides together.

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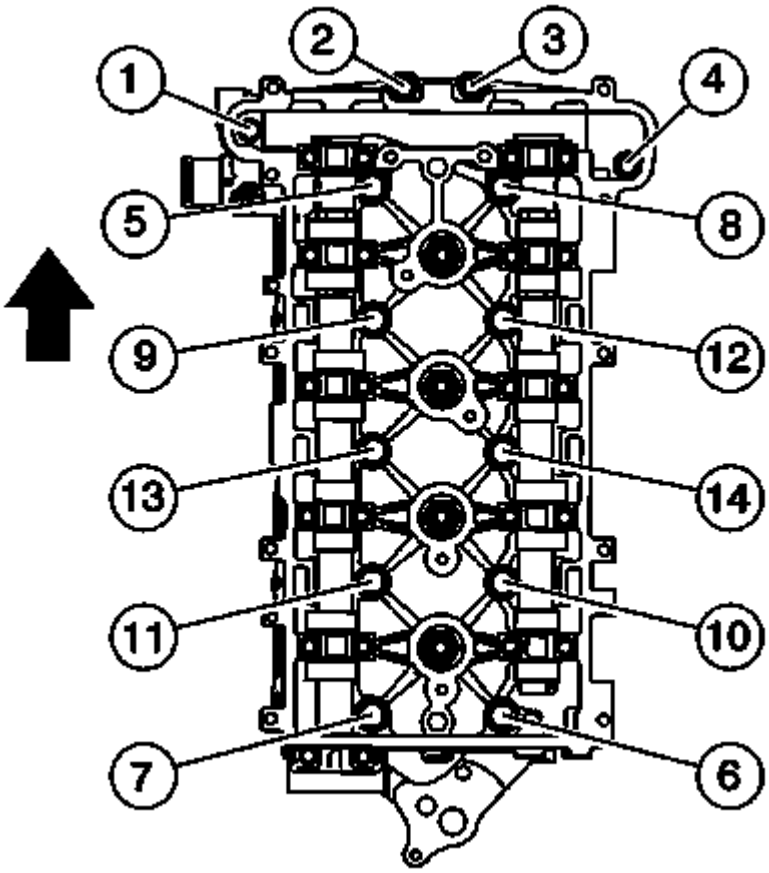

Fig. 209: Cylinder Head Bolt Removal Sequence
Courtesy of GENERAL MOTORS CORP.

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

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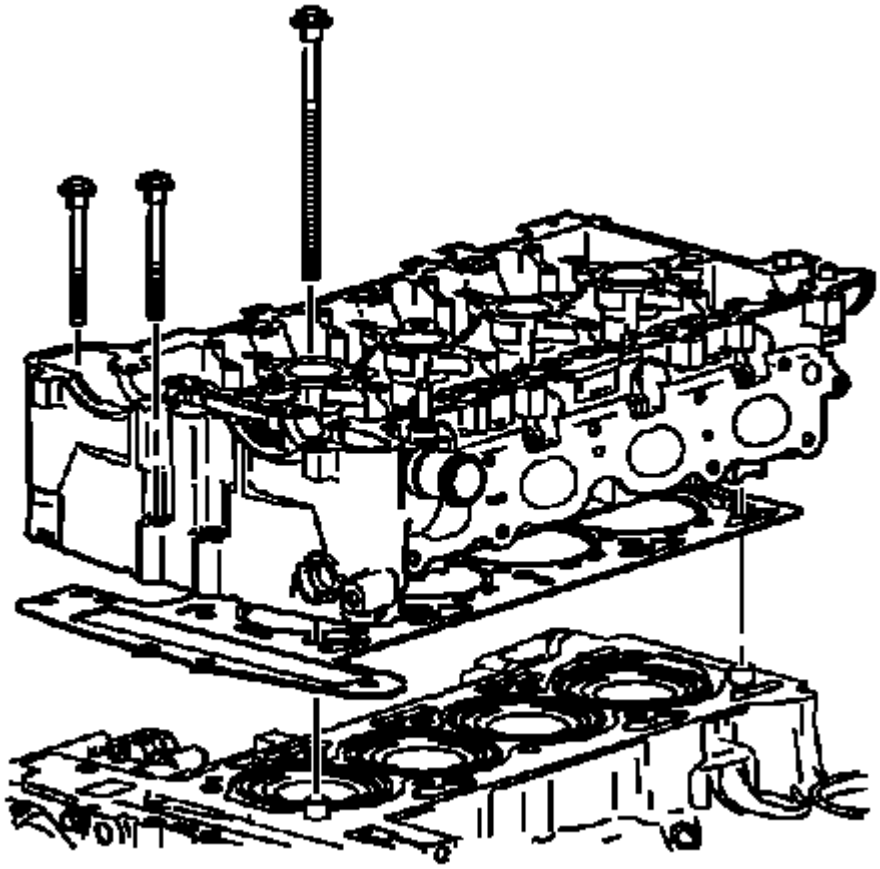

Fig. 210: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

32. Remove the cylinder head.
33. Remove the cylinder head gasket.
34. Clean all of the gasket surfaces.
35. 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.

      NOTE: 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.

      NOTE: 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.

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

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

37. Clean the bolts holes with a nylon bristle brush.
38. 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.
39. If replacing the cylinder head, transfer all parts as necessary.

Installation Procedure

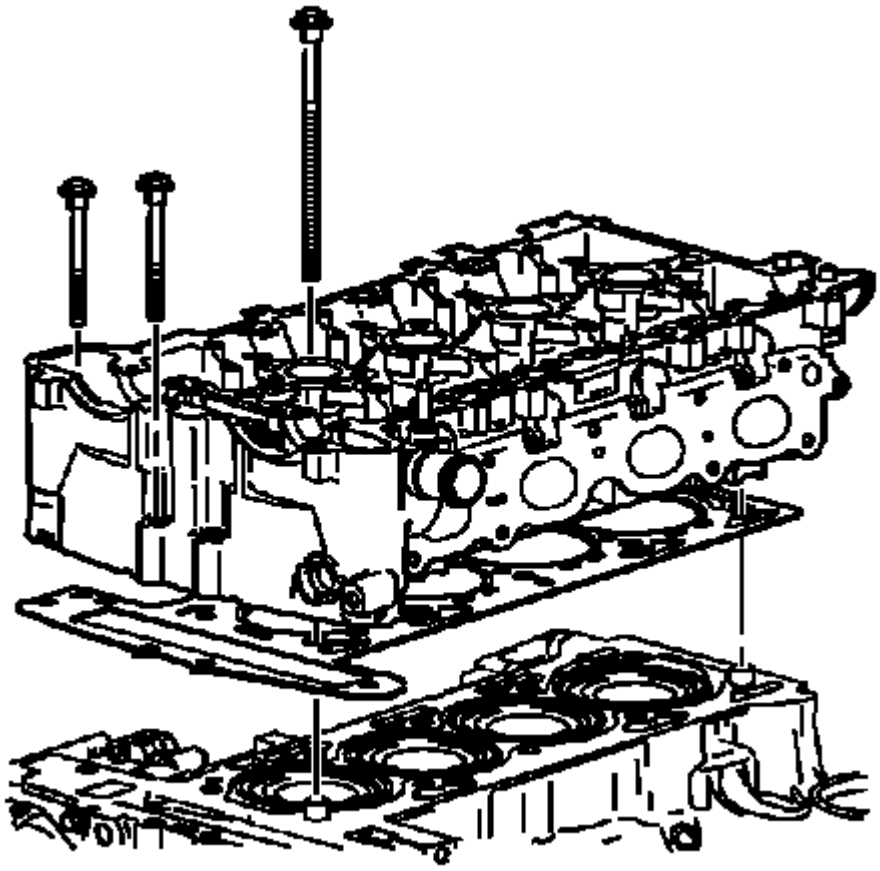

Fig. 211: View Of Cylinder Head And Gasket
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use any sealing material.

1. Install the cylinder head gasket.

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2. Install the cylinder head.
3. Install NEW cylinder head bolts.

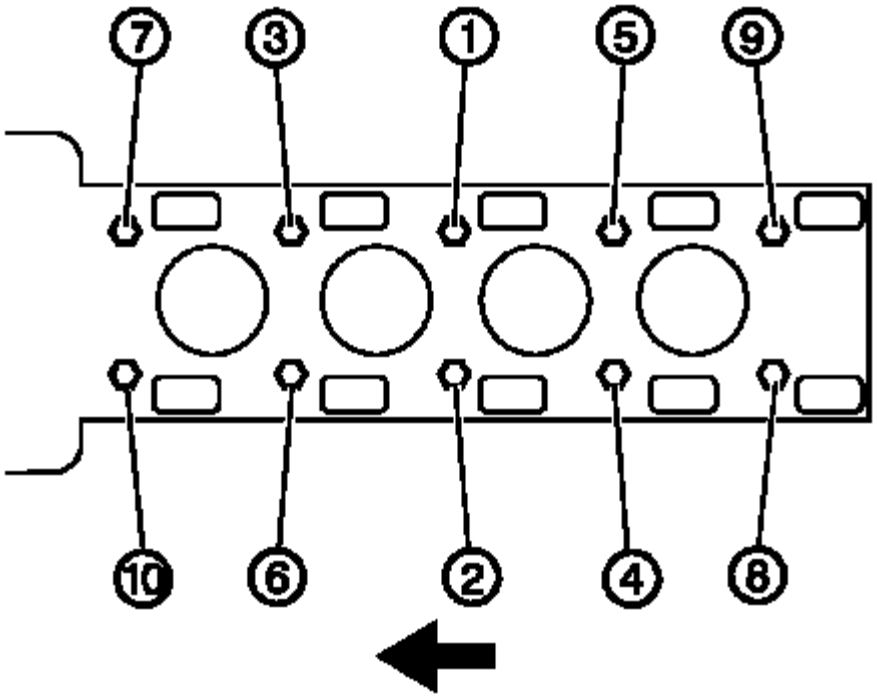

Fig. 212: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

4. Install and tighten the cylinder head bolts in the sequence shown to 30 N.m (22 lb ft) plus an additional 155 degrees using the **J 45059** .

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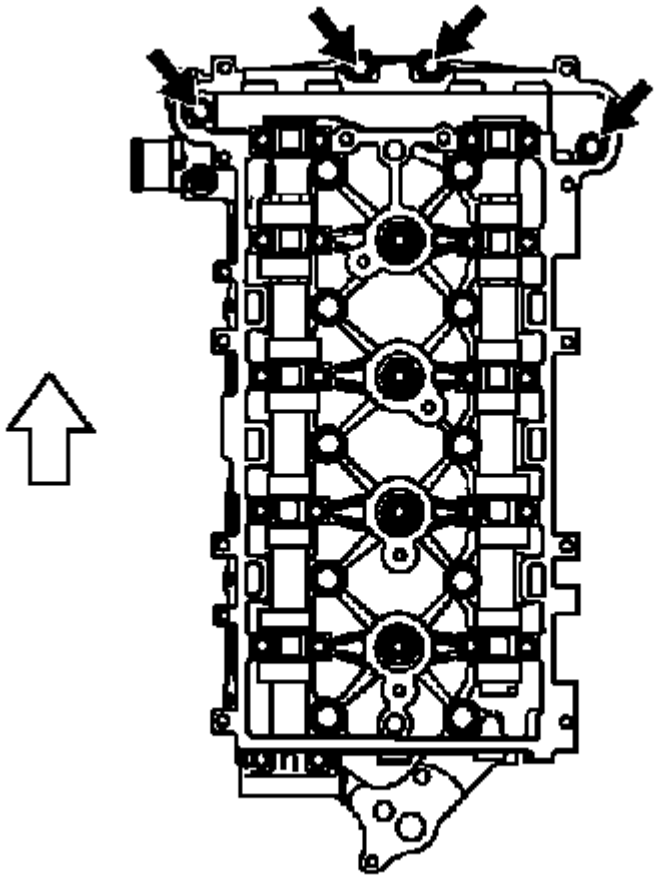

Fig. 213: Locating Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

5. Install the NEW front cylinder head bolts and tighten the bolts to 35 N.m (26 lb ft).

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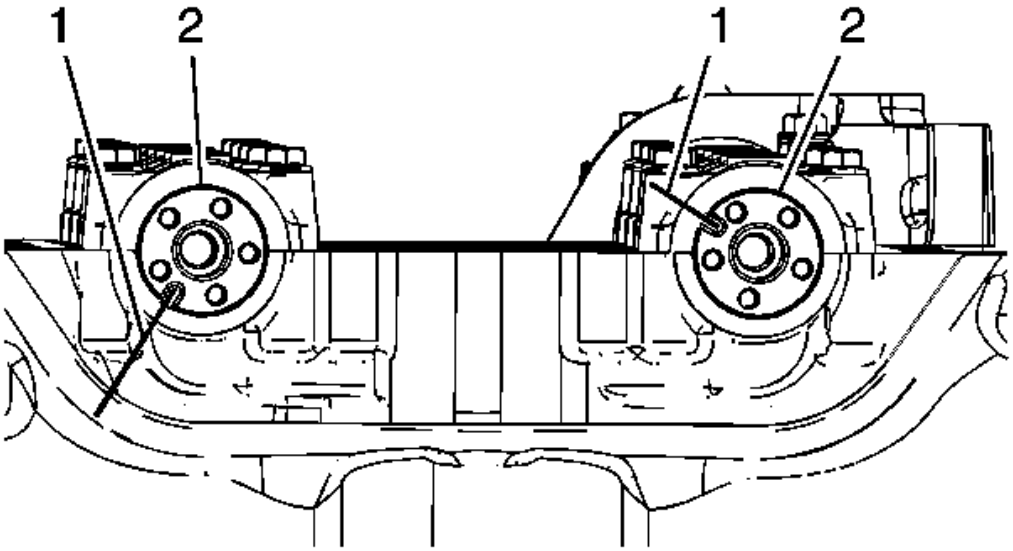

Fig. 214: Aligning Cylinder Head Marks And Camshaft Notches Correctly
Courtesy of GENERAL MOTORS CORP.

6. On 2.2L engines, ensure the cylinder head marks (1) and the camshaft notches (2) are correctly aligned.

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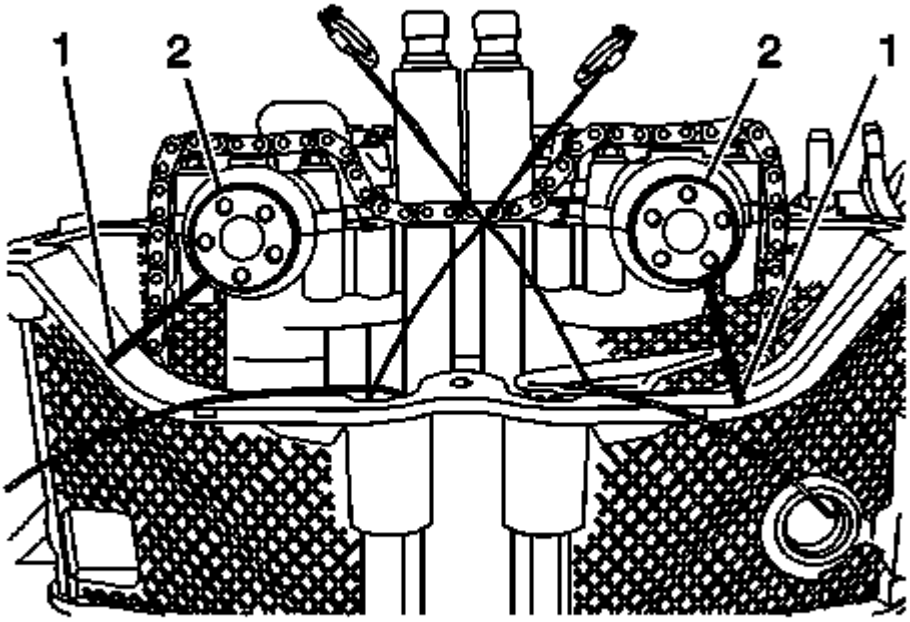

Fig. 215: Aligning Marks On Cylinder Head In Relationship To Camshaft Actuator Notches
Courtesy of GENERAL MOTORS CORP.

7. On 2.4L engines, ensure the cylinder head marks (1) and the camshaft notches (2) are correctly aligned.

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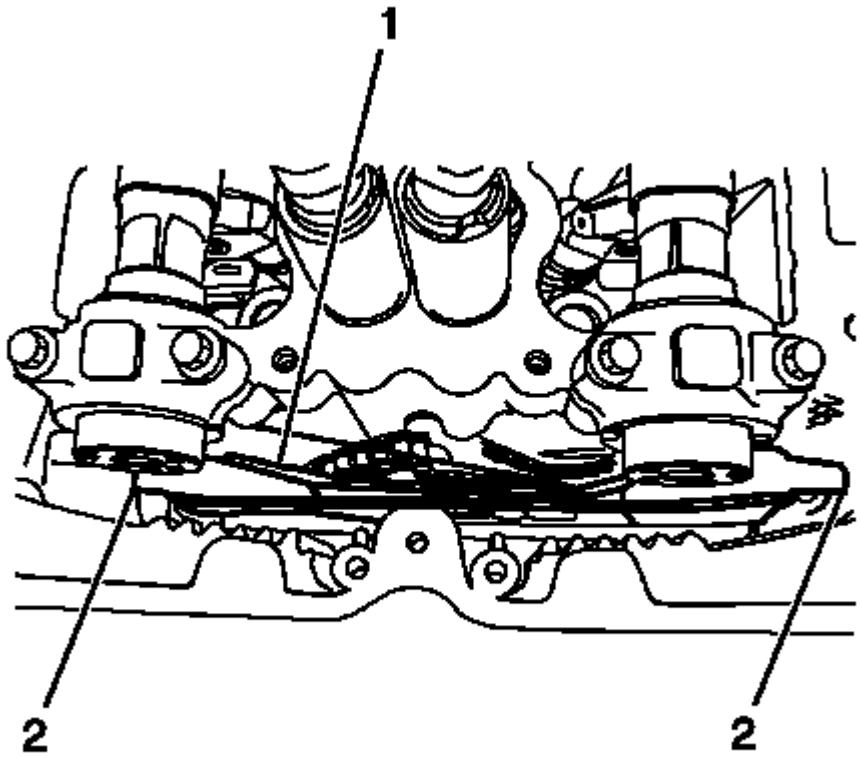

Fig. 216: View Of Rubber Band To Pull Guides Together
Courtesy of GENERAL MOTORS CORP.

8. Remove the rubber band (1) from around the top of the upper timing chain guides (2).
9. Install the fixed guide bolt into the cylinder head and tighten to 12 N.m (106 lb in).

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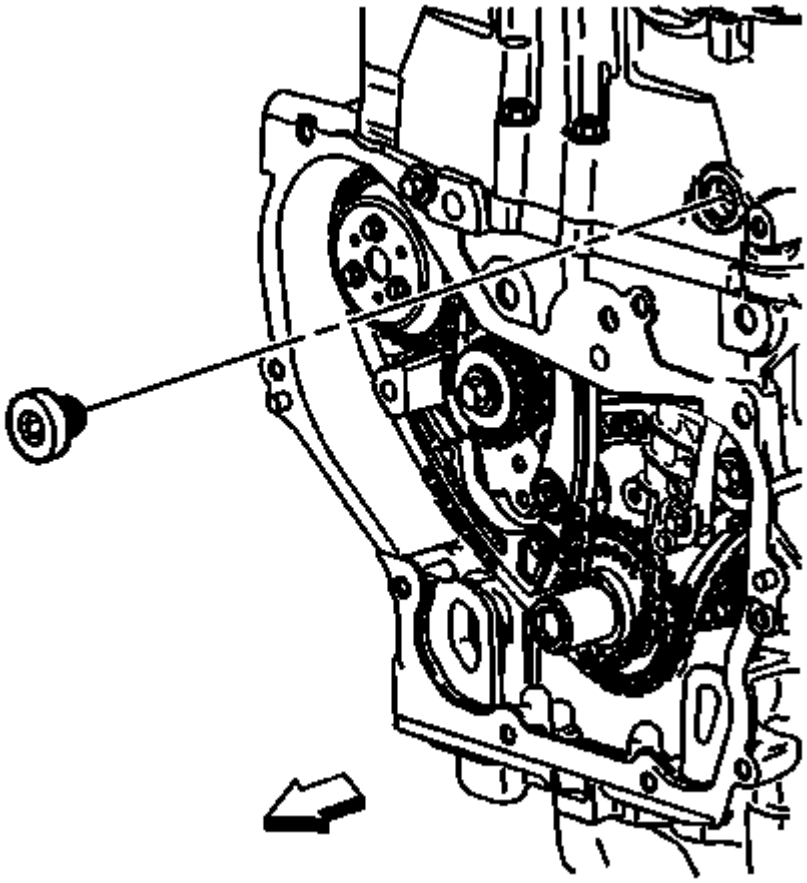

Fig. 217: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

10. Apply sealant compound to thread and install the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
11. Install the fixed timing chain guide access plug and tighten the plug to 90 N.m (59 lb ft).

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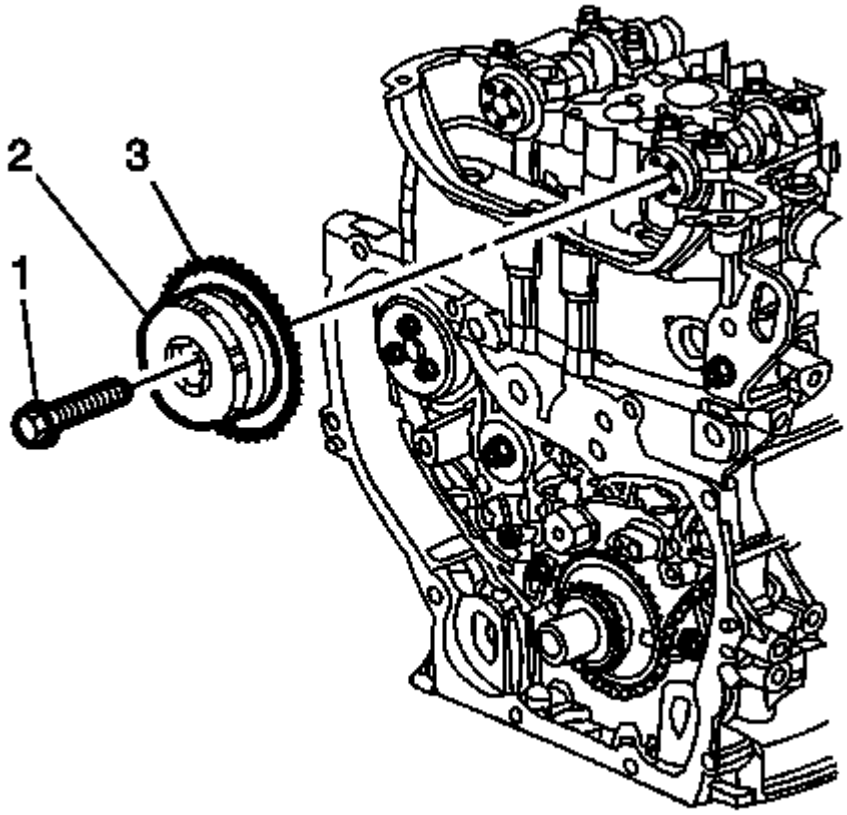

Fig. 218: Timing Chain & Camshaft Position Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the intaket camshaft actuator is still aligned properly with the mark on the timing chain. If the mark made previously on the intaket camshaft actuator is not aligned properly, refer to Camshaft Timing Chain, Sprocket, and Tensioner Replacement.

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

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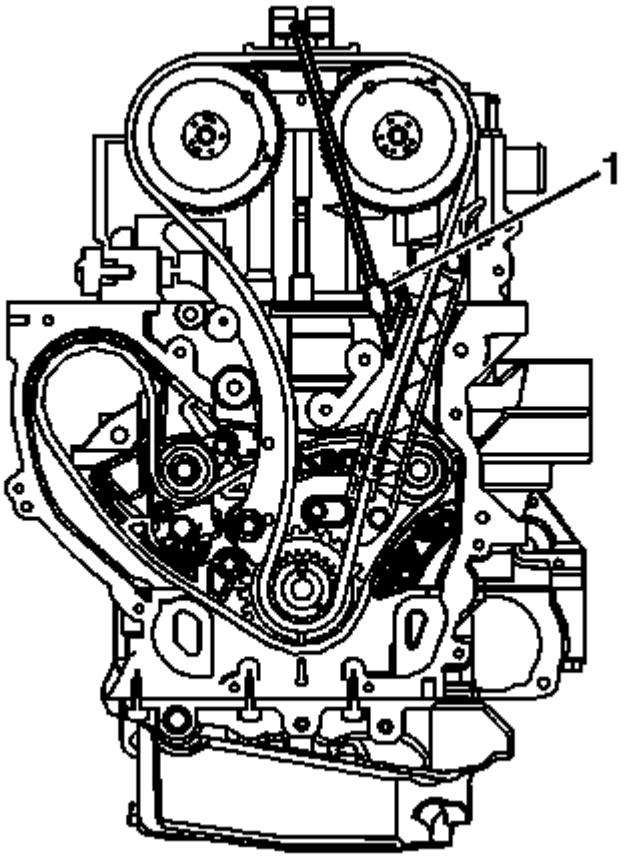

Fig. 219: View Of Timing Chain & Chain Retention Tool
Courtesy of GENERAL MOTORS CORP.

15. Remove the timing chain retention tool **EN-48749** (1) from the intake side of the timing chain. See **Special Tools**.

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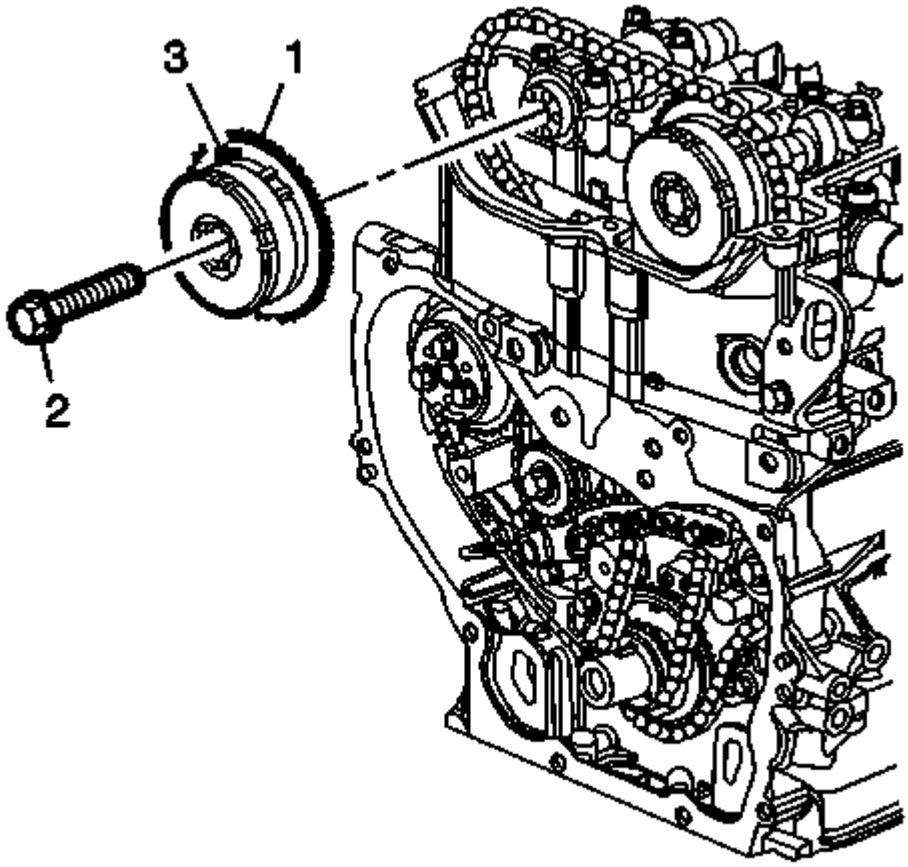

Fig. 220: Exhaust Camshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the alignment mark made previously on the exhaust camshaft actuator is still aligned properly with the mark on the timing chain. The exhaust cam may have to be rotated clockwise to install the exhaust actuator.

16. Install the timing chain onto the exhaust camshaft actuator.
17. Align the exhaust camshaft actuator alignment mark made previously with the timing chain mark and install the actuator onto the camshaft.
18. Install a NEW exhaust camshaft actuator bolt (2) until snug.
19. Remove the timing chain retention tool **EN-48749** (1) from the exhaust side of the timing chain. See **Special Tools**.

NOTE: Failure to reset the chain tensioner will put excess tension on the chain, limiting the chains life.

20. Reset and install the timing chain tensioner. Refer to **Timing Chain Tensioner Replacement**.

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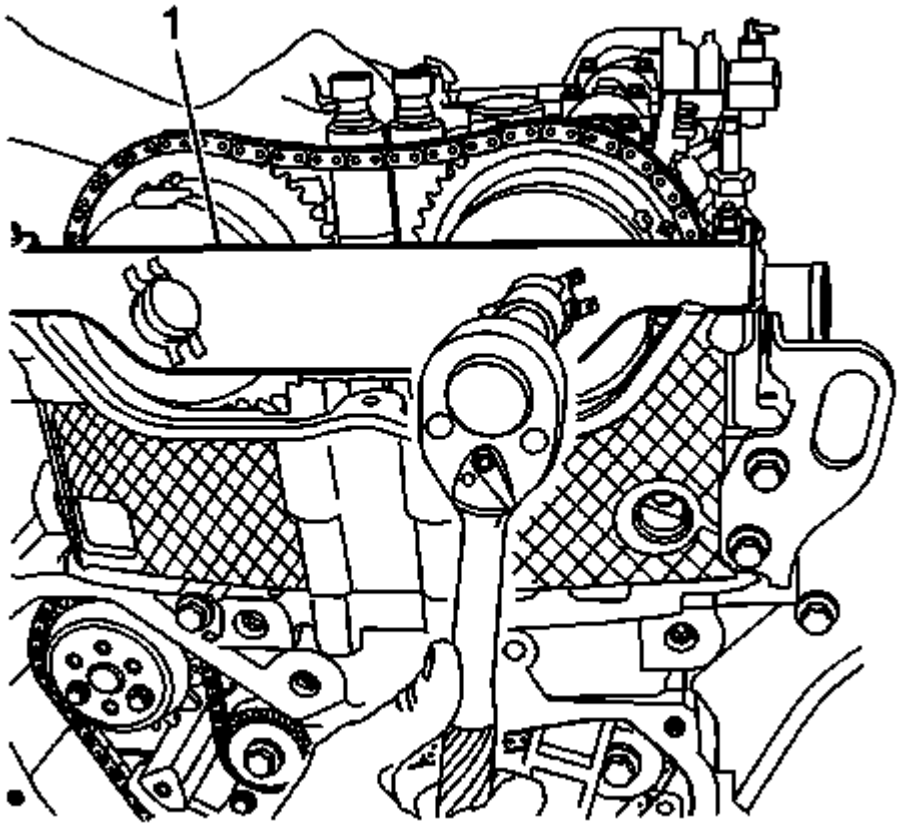

Fig. 221: Loosening/Tightening Camshaft Actuator Retainer Bolts
Courtesy of GENERAL MOTORS CORP.

21. Install the **EN-48953** (1) to the actuators. See **Special Tools**.
22. Install the camshaft actuator locking tool bolts and tighten to 10 N.m (89 lb in).
23. Tighten the NEW camshaft actuator bolt to 30 N.m (22 lb ft), plus an additional 100 degrees using the **J 45059** .
24. Release the tensioner by applying a counterclockwise rotational torque of 45 N.m (33 lb ft) to the harmonic balancer bolt.
25. Remove the camshaft actuator locking tool, **EN-48953** . See **Special Tools**.

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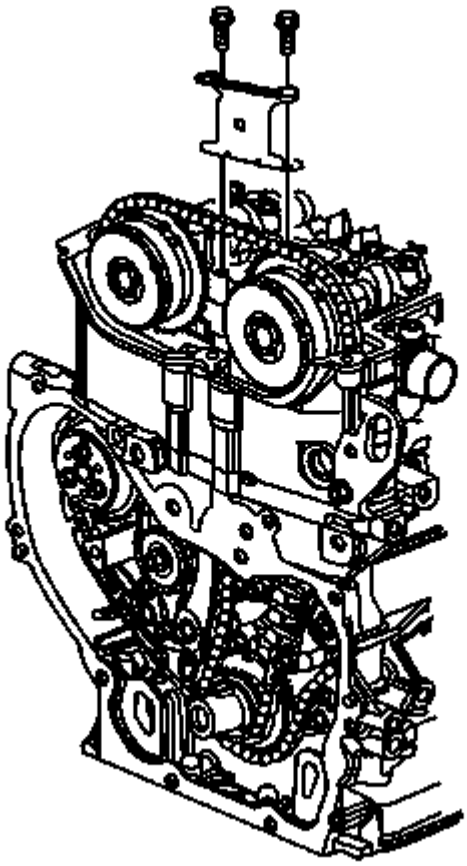

Fig. 222: View Of Upper Timing Chain Guide Bolts And Guide
Courtesy of GENERAL MOTORS CORP.

26. Install the upper timing chain guide bolts and guide and tighten the bolts to 10 N.m (89 lb in).
27. Install the camshaft cover. Refer to **Camshaft Cover Replacement**.

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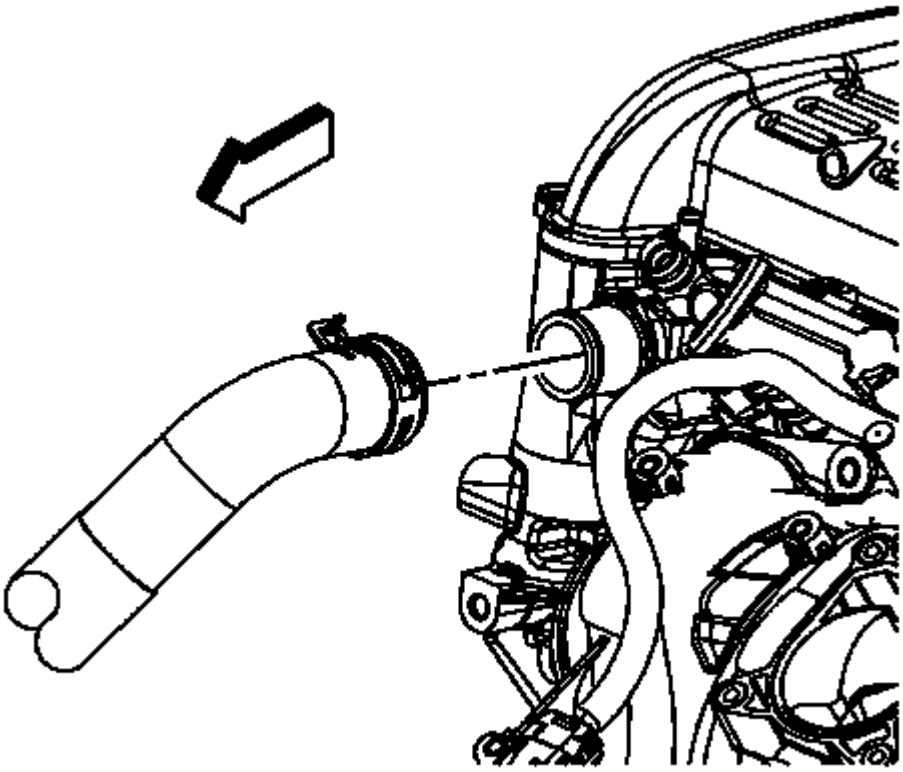

Fig. 223: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

28. Install the spark plugs. Refer to **Spark Plug Replacement** .
29. Connect all electrical connectors as necessary.
30. Install the radiator inlet hose to the cylinder head.
31. Position the radiator inlet hose clamp using the **J 38185** .
32. Install the radiator surge tank air bleed hose to the cylinder head.
33. Position the radiator surge tank air bleed hose clamp.
34. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement (LAP)** .
35. Install the intake manifold. Refer to **Intake Manifold Replacement**.
36. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LE5, L61)** or **Cooling System Draining and Filling (GE 47716 Fill)** .

OIL PAN REPLACEMENT

Removal Procedure

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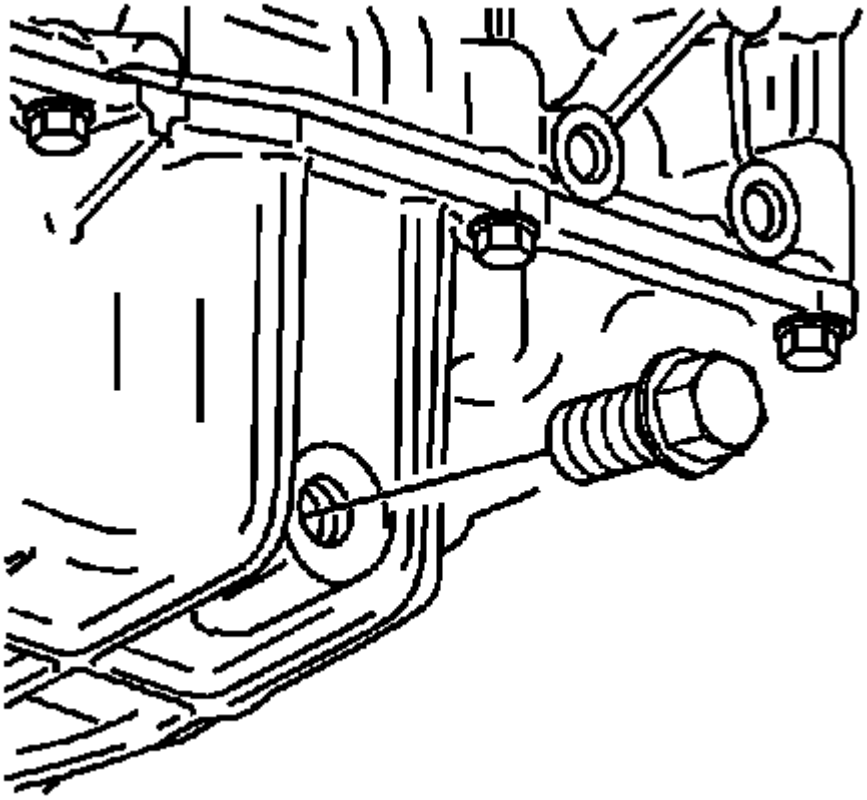

Fig. 224: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

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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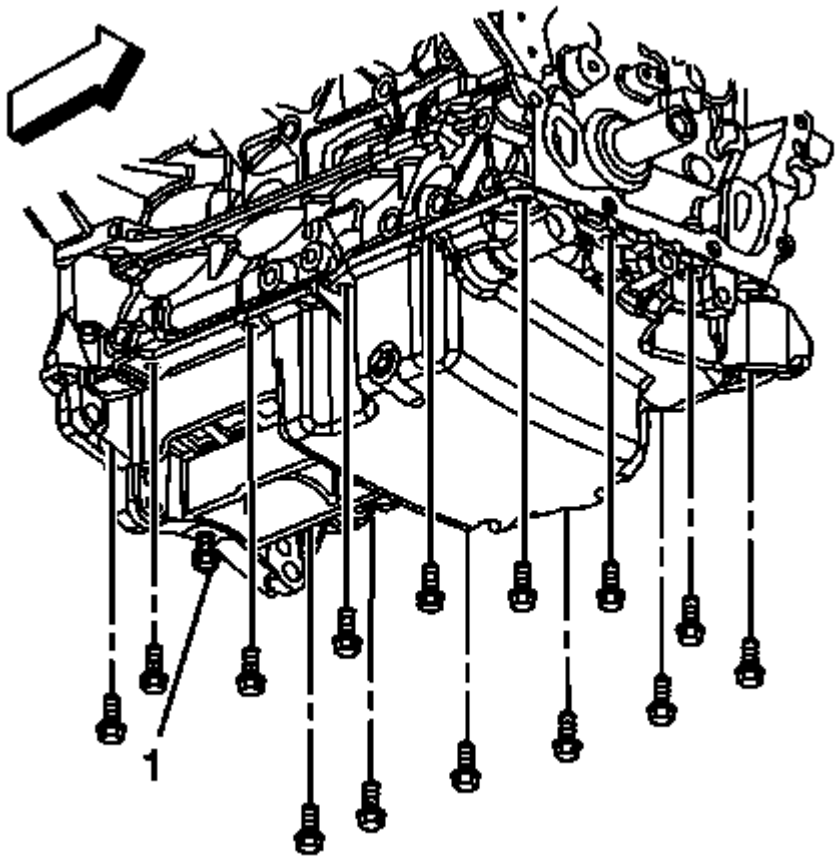

Fig. 225: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

7. Remove the 4 oil pan to transaxle bolts (1).
8. Remove the oil pan bolts.

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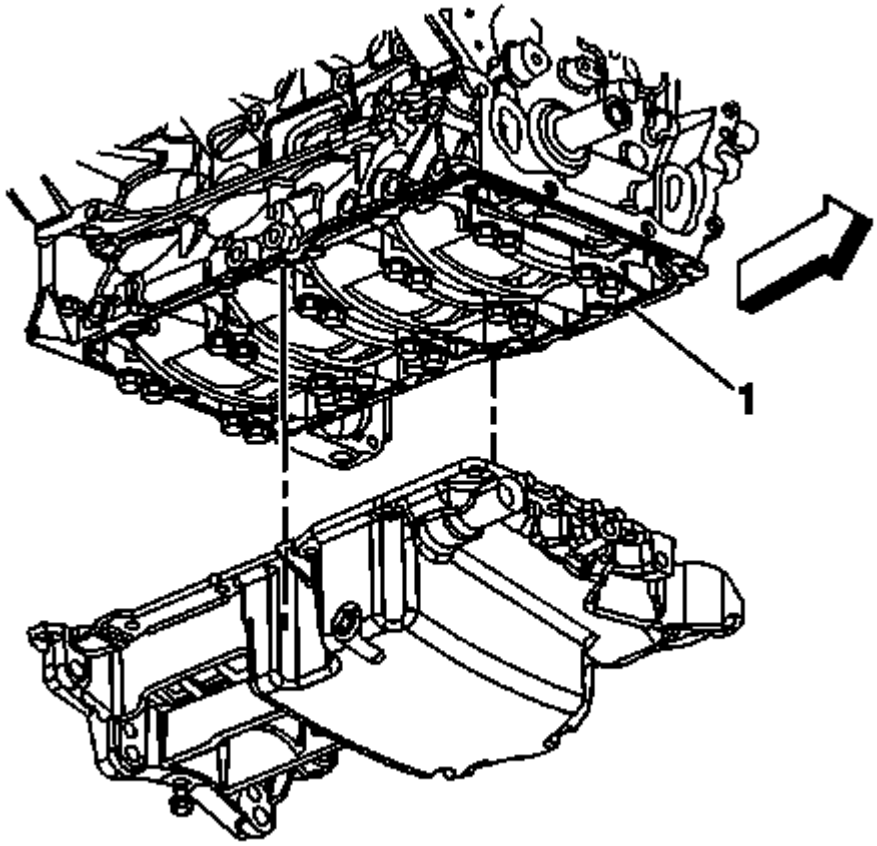

Fig. 226: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

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

Installation Procedure

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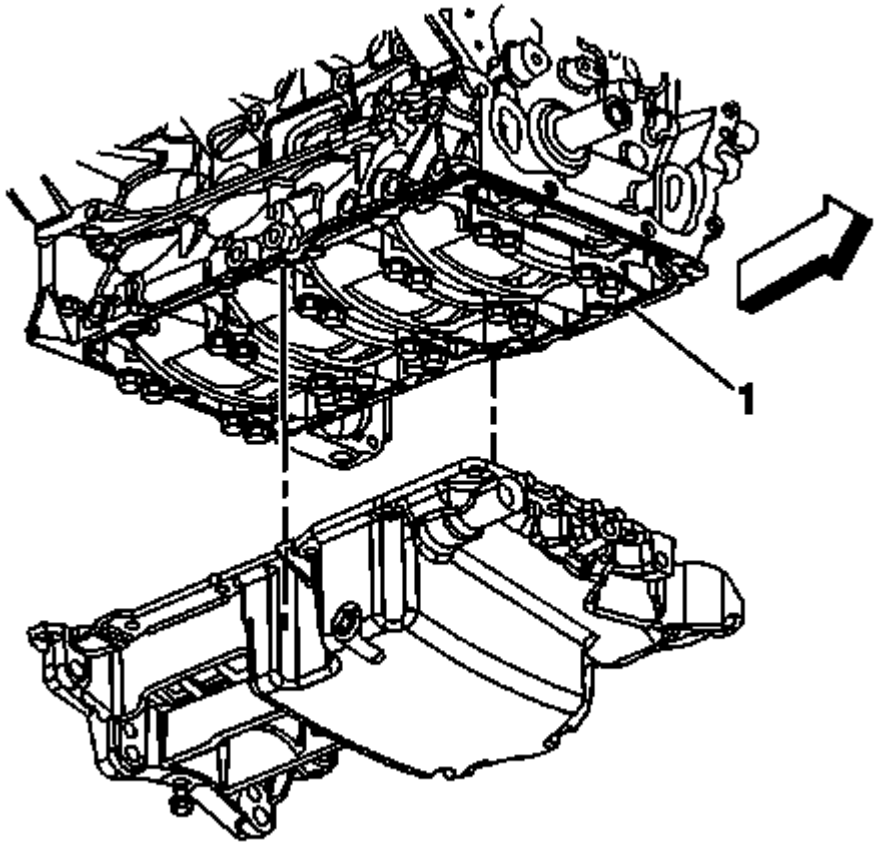

Fig. 227: Identifying Oil Pan
Courtesy of GENERAL MOTORS CORP.

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 **Adhesives, Fluids, Lubricants, and Sealers** for the correct part number.
3. Install the oil pan.

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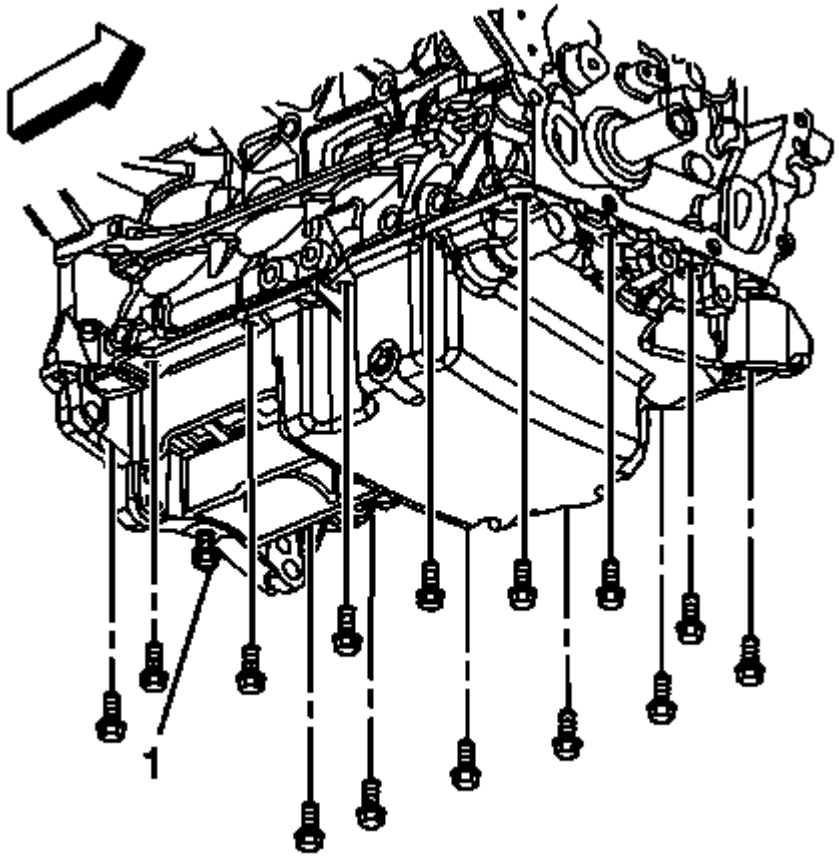

Fig. 228: Identifying Oil Pan Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the oil pan bolts.

   CAUTION: Refer to Fastener Caution .

5. Install the 4 oil pan to transaxle bolts (1).

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

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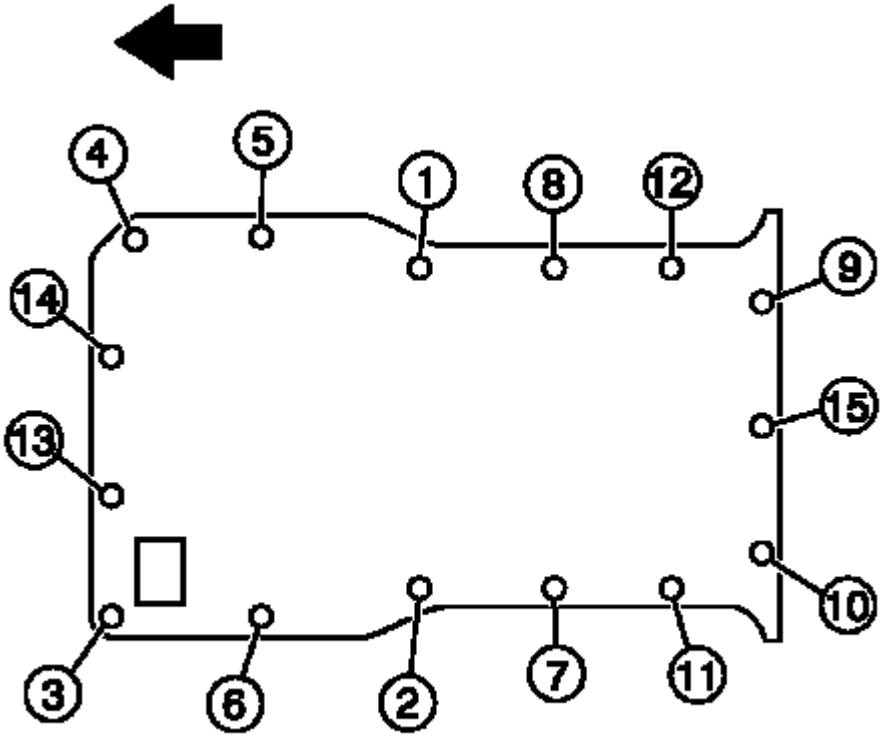

Fig. 229: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

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.

PISTON, CONNECTING ROD, AND BEARING REPLACEMENT

Special Tools

- **J 41742:** Connecting Rod Guide Pin
- **J 43953:** Piston Ring Compressor
- **J 43966-1:** Connecting Rod Guides
- **J 45059:** Angle Meter

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Removal Procedure

1. Remove the oil pan. Refer to **Oil Pan Replacement**.
2. Remove the cylinder head. Refer to **Cylinder Head Replacement**.

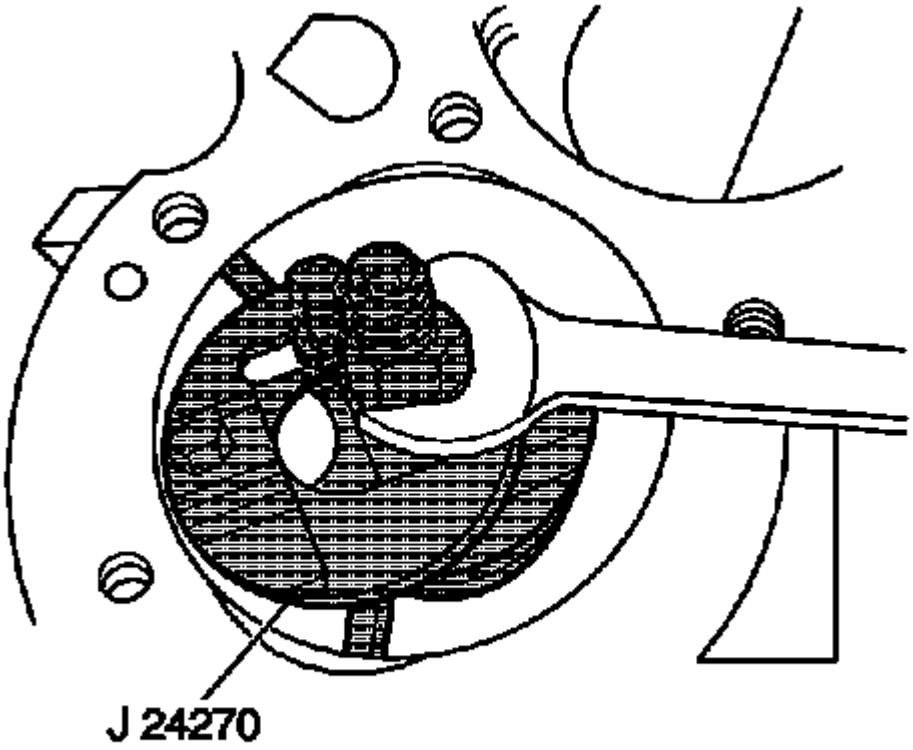

Fig. 230: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS CORP.

3. If a ring ridge is present, remove the ring ridge as follows:
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Place a cloth on top of the piston.
    3. Use a ridge reamer to remove the ring ridge.
    4. Turn the crankshaft so the piston is at top of the stroke.
    5. Remove the cloth and cutting debris.

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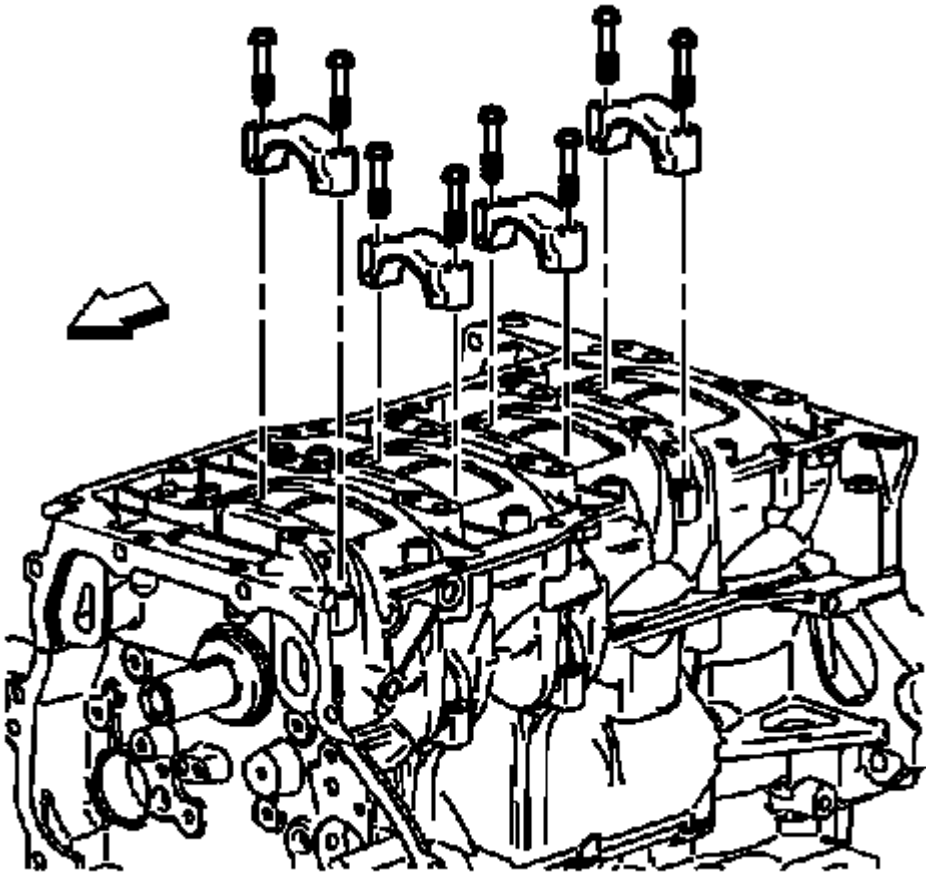

Fig. 231: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Place the numbers on connecting rods and the connecting rod caps. The connecting rod caps must be assembled to their original connecting rods.

4. Remove the connecting rod nuts and the connecting rod cap.

   Discard the bolts and nuts.

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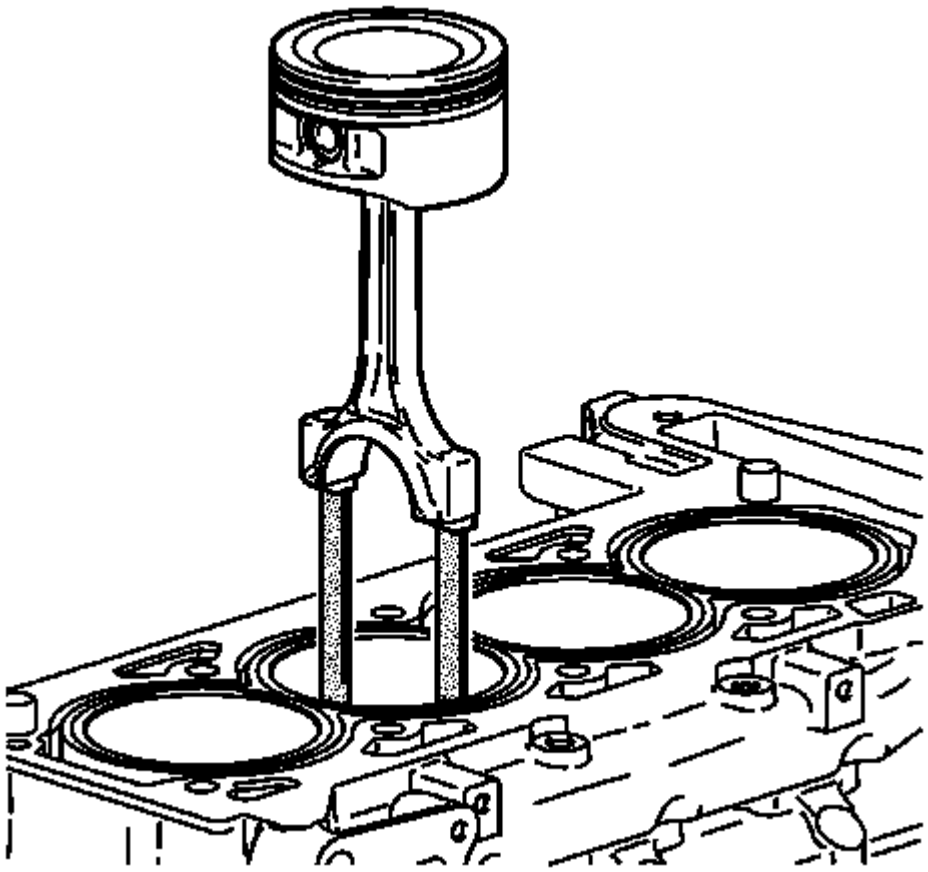

Fig. 232: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

5. Remove the connecting rod and the piston out of the top of the engine block using the **J 41742** and **J-43966-1** . See **Special Tools**.
6. Clean the cylinder bores with hot water and detergent or with a light honing.
7. Swab the bores with the engine oil and a clean, dry cloth.

Installation Procedure

1. Coat the following parts with engine oil:
   - The piston
   - The piston rings
   - The cylinder bore
   - The bearing surfaces

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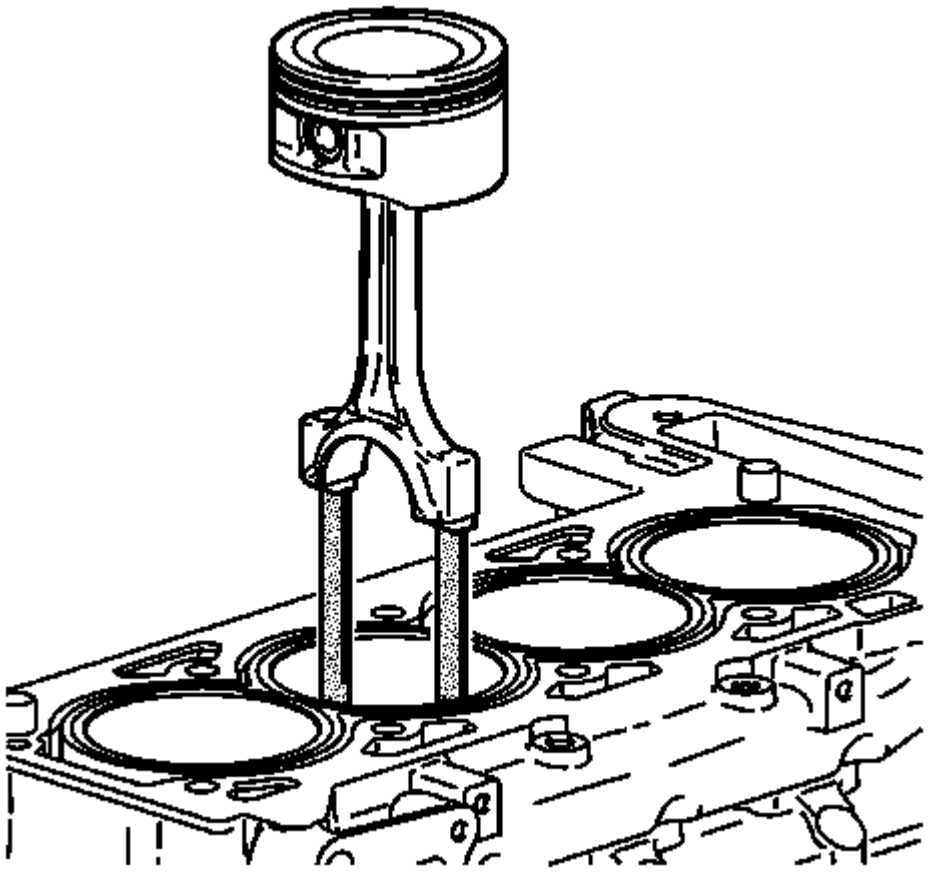

Fig. 233: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

2. Install the piston into its original bore using the **J-43966-1** , **J 43953** and **J 41742** . See **Special Tools**.
3. Lightly tap the top of the piston with a wooden hammer handle.
4. When installing the piston and the connecting rod, the stamped mark on the piston must point to the front of the engine.
5. Hold the **J 43953** firmly against the engine block until all the piston rings have entered the cylinder bore. See **Special Tools**.
6. Install the connecting rod caps onto their original connecting rods.
7. Align the numbers placed on the connecting rod and the connecting rod cap during removal.
8. Install the new connecting rod bolts and nuts and tighten.

CAUTION: Refer to Fastener Caution .

9. On the first pass, tighten the nuts evenly to 25 N.m (18 lb ft).
10. On the final pass, use the **J 45059** in order to tighten the nuts an additional 100 degrees.

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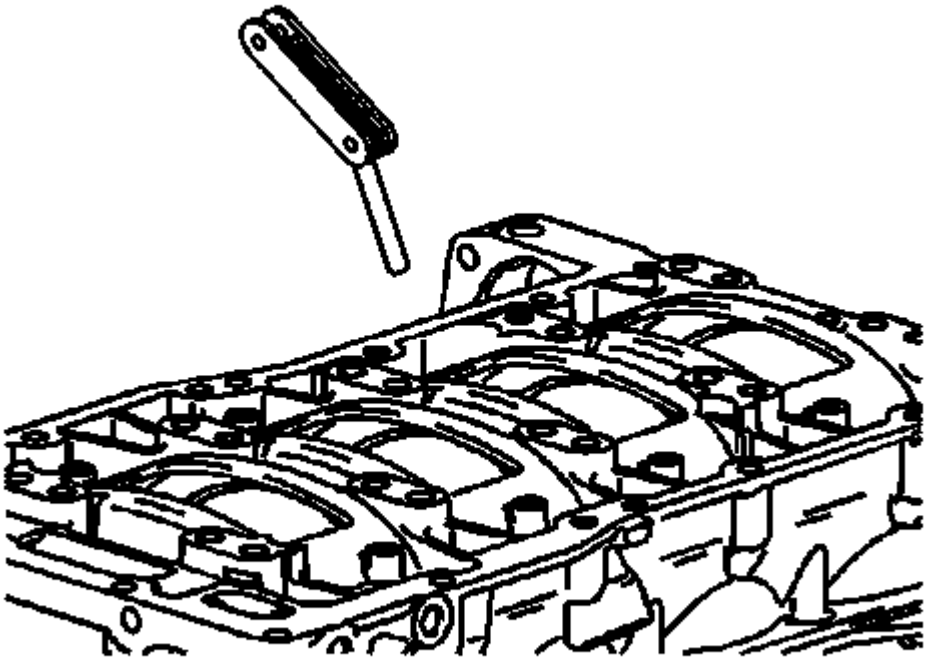

Fig. 234: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

11. Measure the connecting rod side clearance with a feeler gauge.

    The correct clearance is 0.070-0.370 mm (0.0027-0.0145 in).

12. Install the cylinder head. Refer to **Cylinder Head Replacement**.
13. Install the oil pan. Refer to **Oil Pan Replacement**.

CYLINDER SLEEVE REPLACEMENT

Special Tools

EN 45680-850 Cylinder Sleeve Removal and Installation Kit

Removal Procedure

1. Remove the piston and connecting rod. Refer to **Piston, Connecting Rod, and Bearing Replacement**.
2. Inspect the condition of the piston. Refer to **Piston, Connecting Rod, and Bearing Cleaning and Inspection**.

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CAUTION: 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.

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

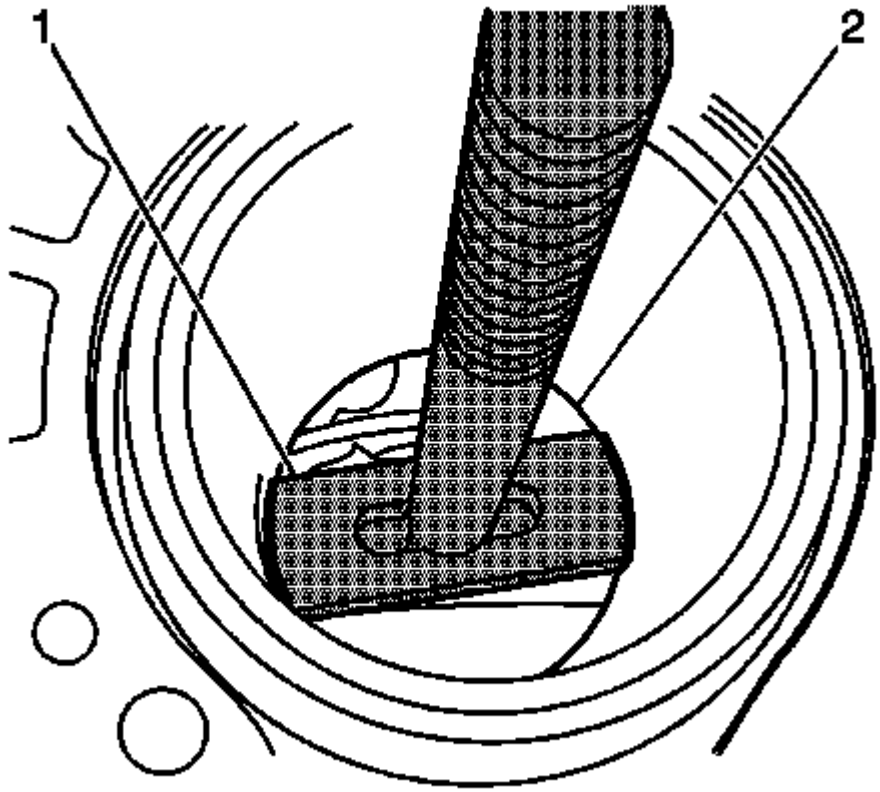

Fig. 235: View Of Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

3. 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.
4. Install the cylinder bore sleeve puller EN 45680-852 (1) through the cylinder bore.

CAUTION: 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.

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

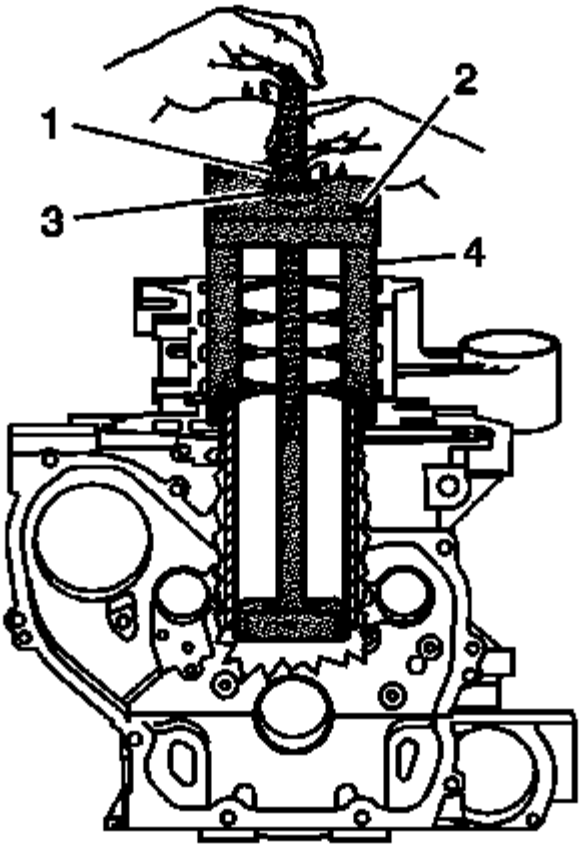

Fig. 236: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: Refer to Fastener Caution .

NOTE: Use four old cylinder head bolts for the attaching bolts.

10. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block to 15 N.m (11 lb ft).

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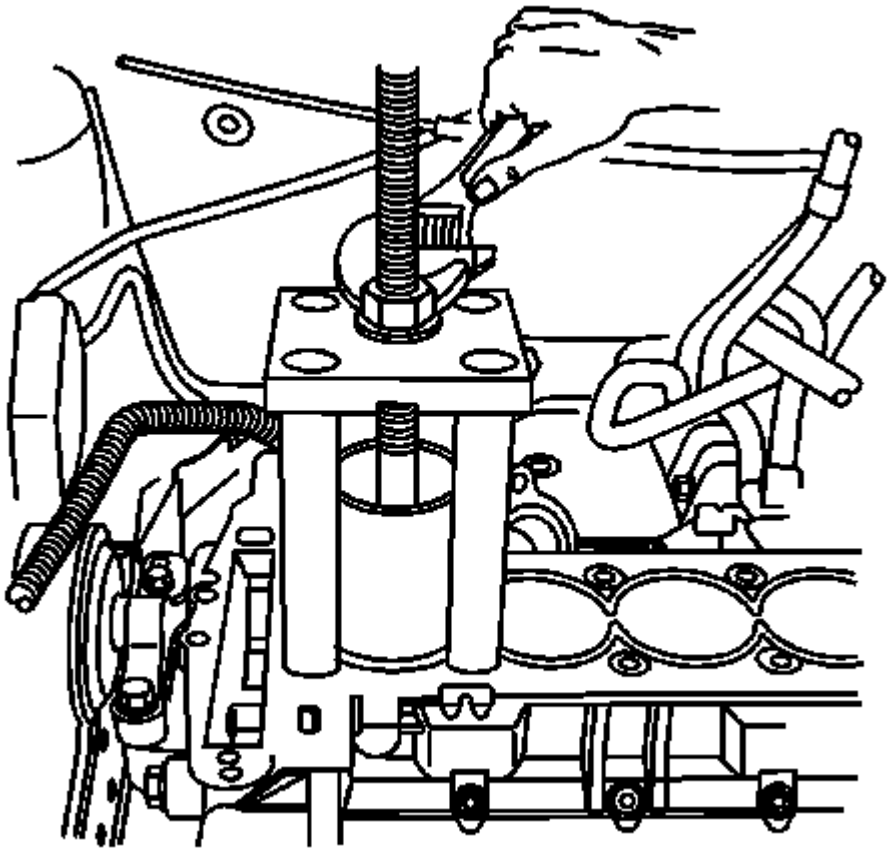

Fig. 237: Identifying Cylinder Bore Sleeve Puller Nut
Courtesy of GENERAL MOTORS CORP.

11. Rotate the nut clockwise in order to remove the cylinder bore sleeve.

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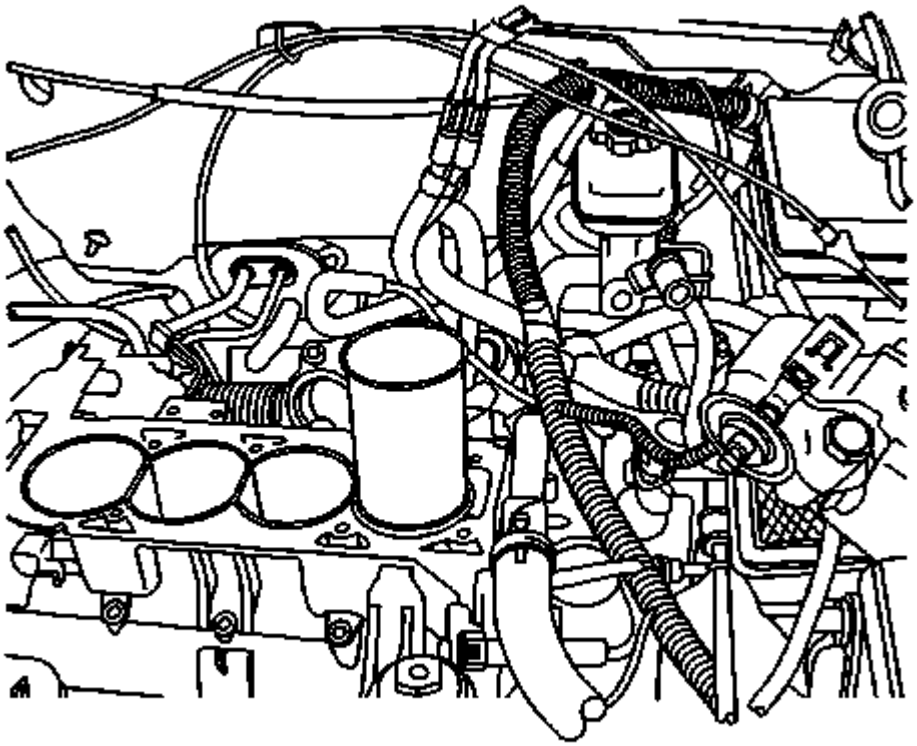

Fig. 238: Removing Cylinder Bore Liner From The Engine Block
Courtesy of GENERAL MOTORS CORP.

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

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

Installation Procedure

CAUTION: 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.

CAUTION: Do not chill or heat the cylinder bore sleeve or the cylinder block when removing or installing a new cylinder bore sleeve. Chilling or

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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.

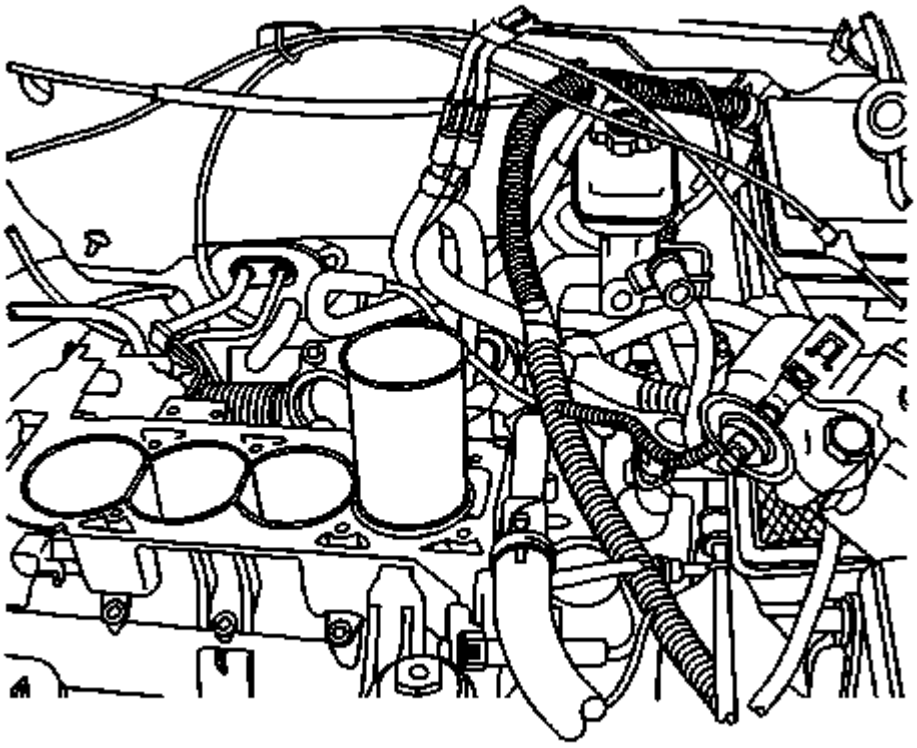

Fig. 239: Removing Cylinder Bore Liner From The Engine Block
Courtesy of GENERAL MOTORS CORP.

1. Place the NEW cylinder bore sleeve onto the cylinder block.
2. Install fixture EN 45680-851/cylinder bore sleeve installer EN 45680-853 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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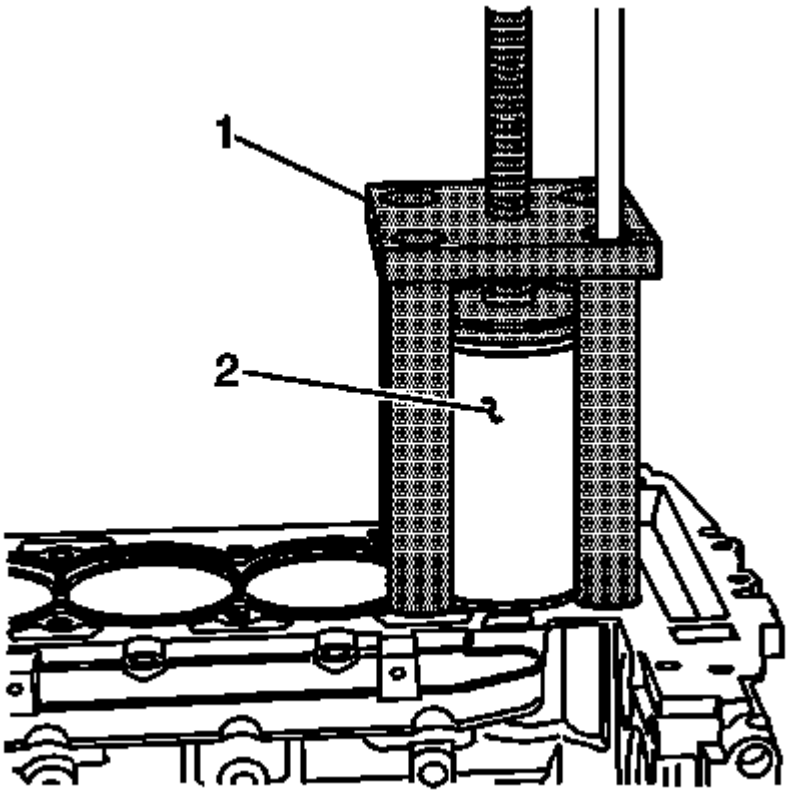

Fig. 240: View Of Cylinder Bore Sleeve Installer
Courtesy of GENERAL MOTORS CORP.

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

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

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

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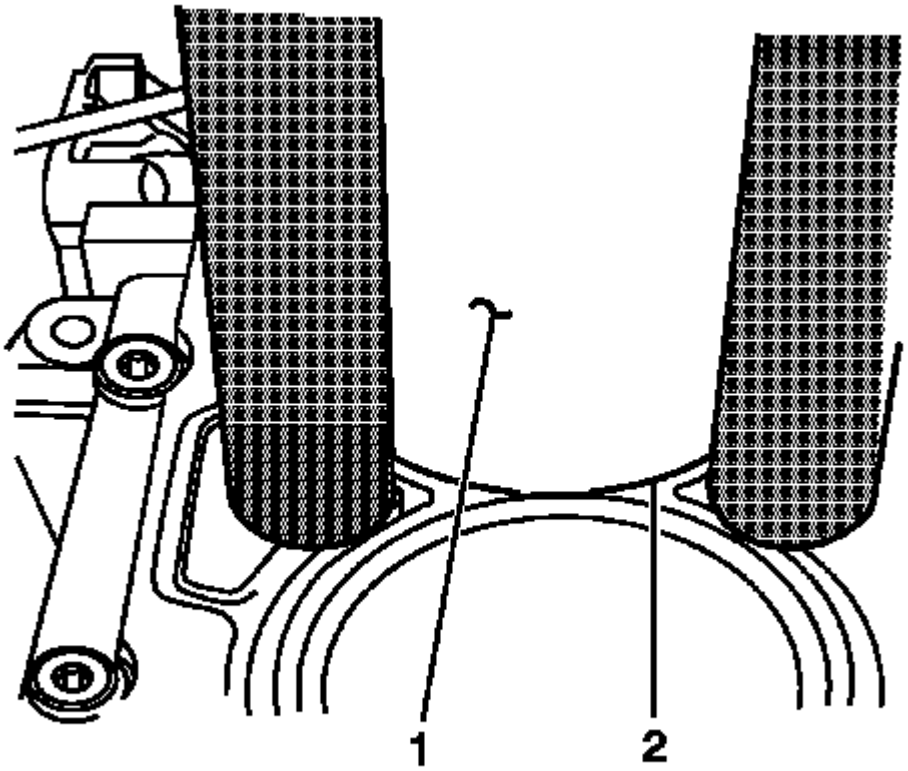

Fig. 241: Aligning Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

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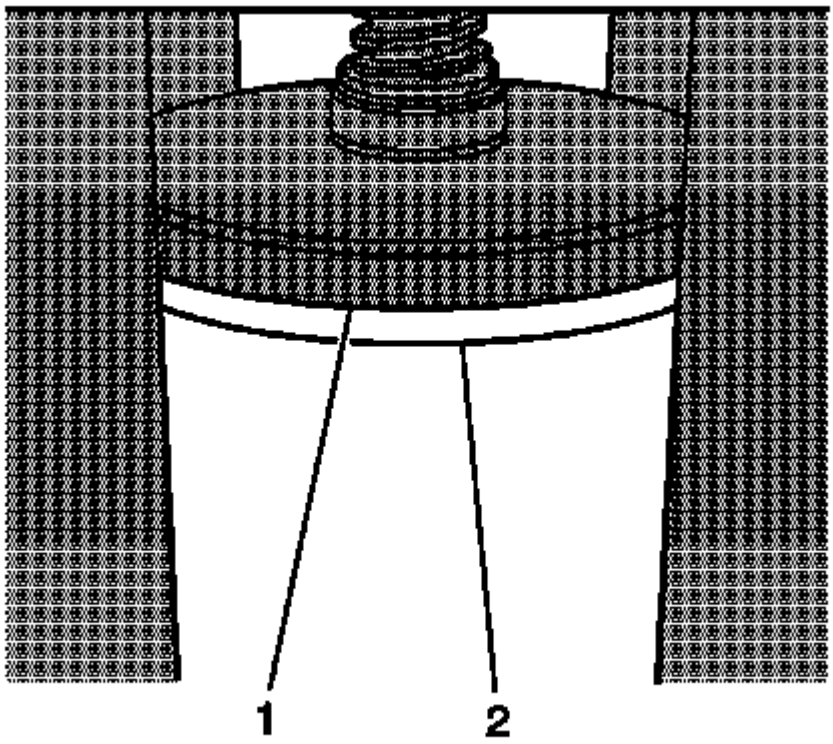

Fig. 242: Aligning Installation Arbor
Courtesy of GENERAL MOTORS CORP.

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

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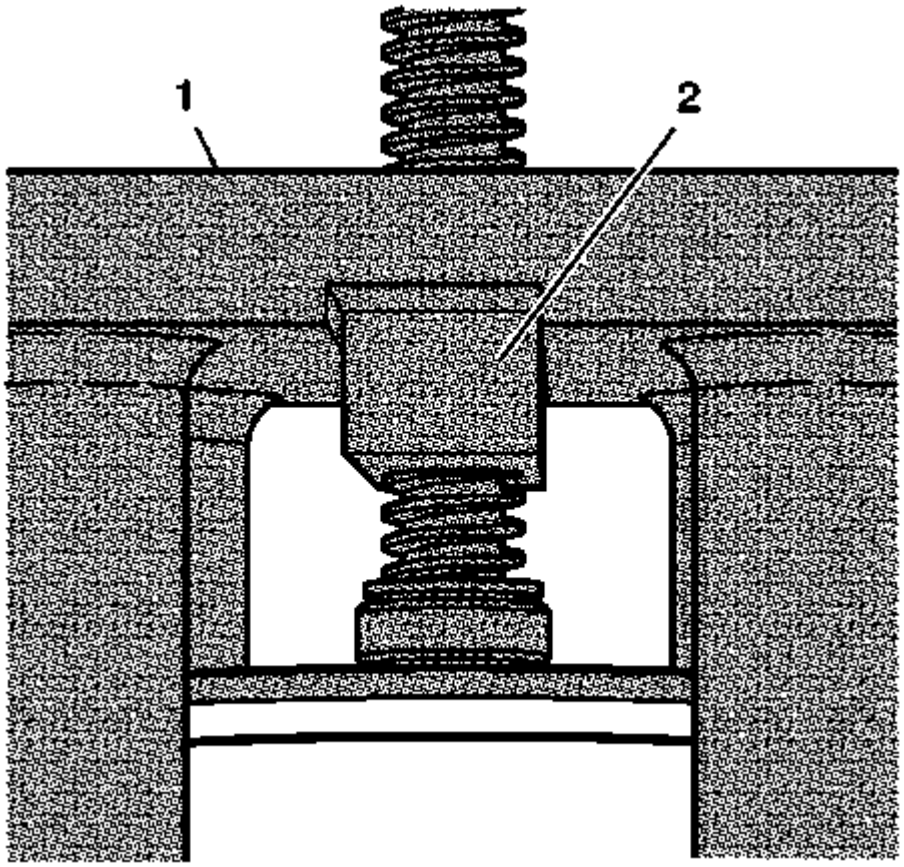

Fig. 243: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

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

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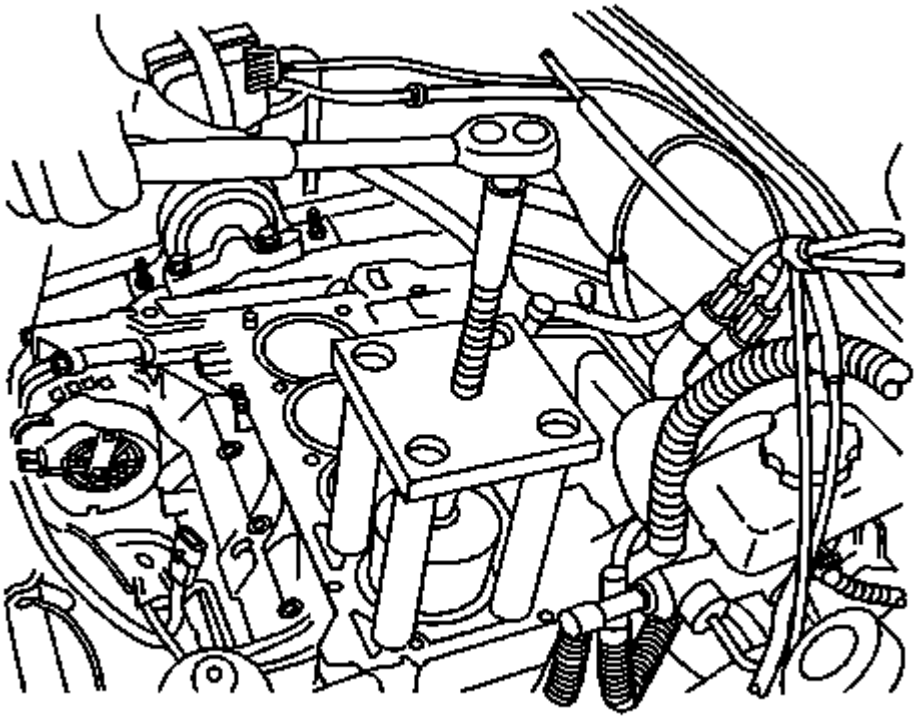

Fig. 244: View Of Cylinder Bore Sleeve Installer Assembly
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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 fixture EN 45680-851/cylinder bore sleeve installer EN 45680-853 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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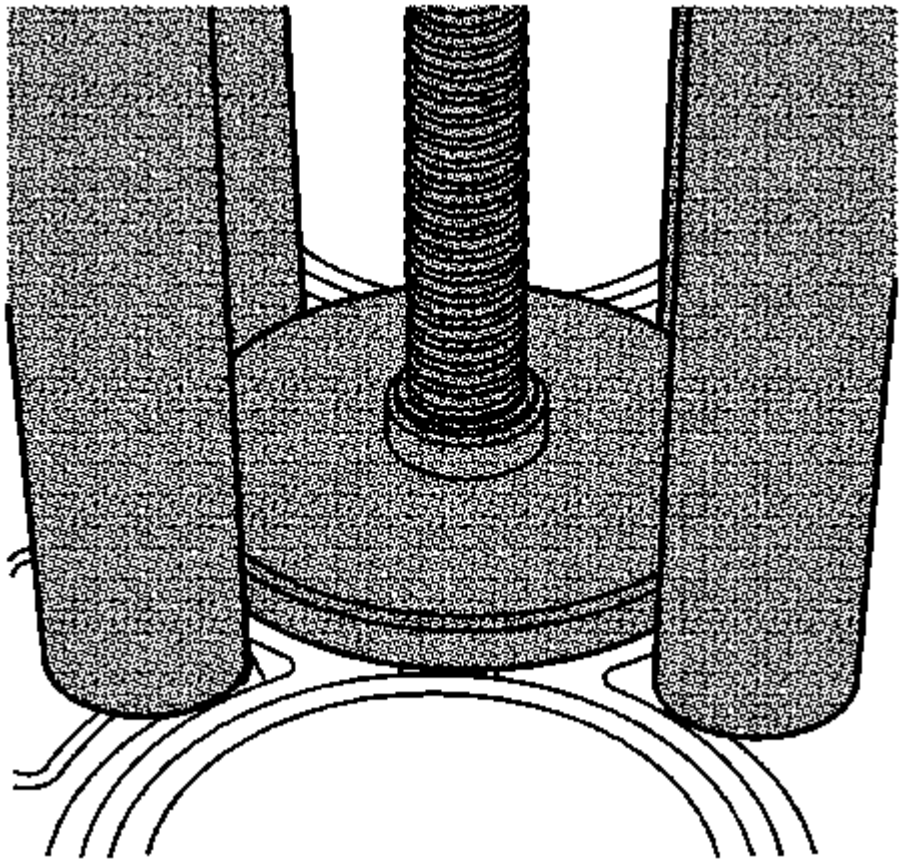

Fig. 245: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

9. Using a torque wrench, torque the threaded shaft of the fixture EN 45680-851/cylinder bore sleeve installer EN 45680-853 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 sleeve flange will protrude above the block deck surface.

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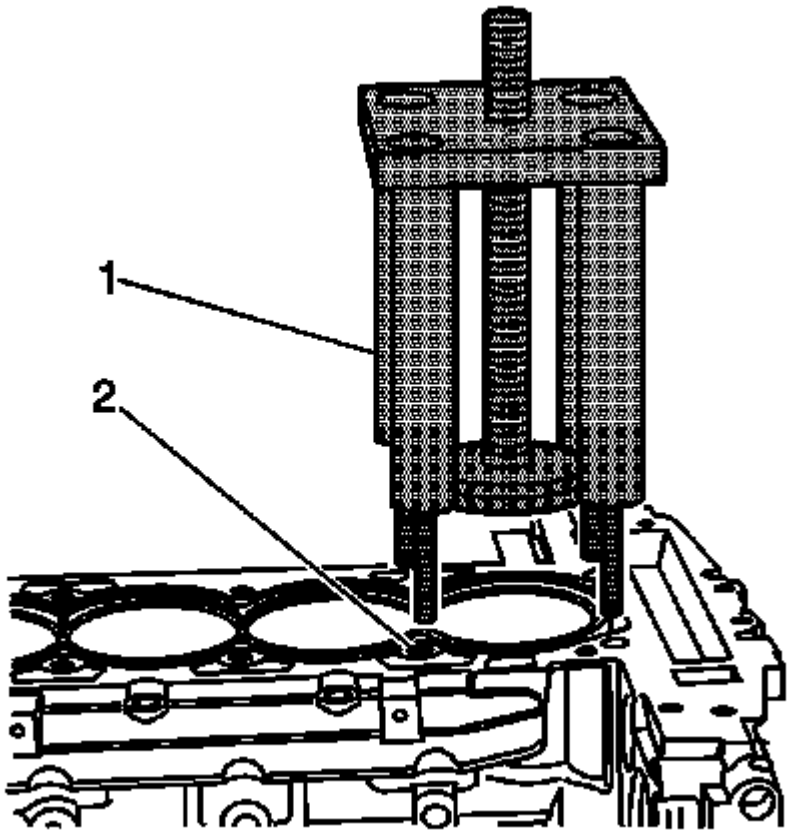

Fig. 246: Identifying Cylinder Bore Sleeve Installer Assembly
Courtesy of GENERAL MOTORS CORP.

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

Cylinder Liner Trimming

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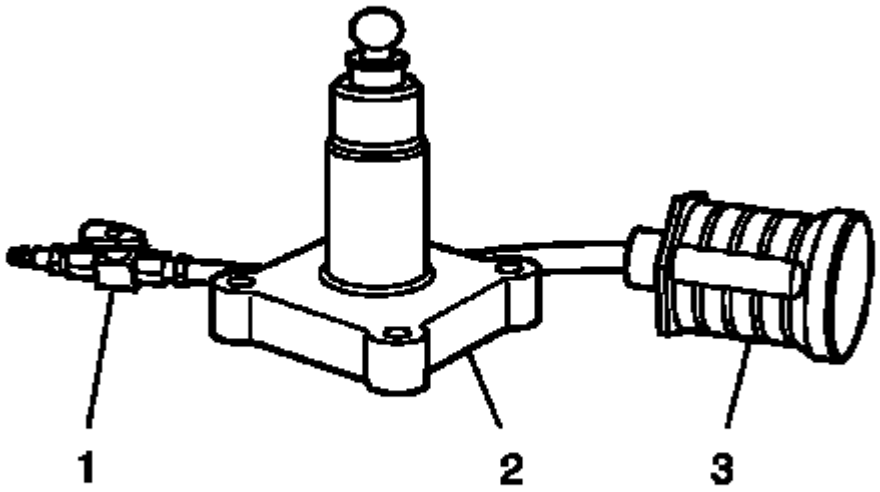

Fig. 247: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

- 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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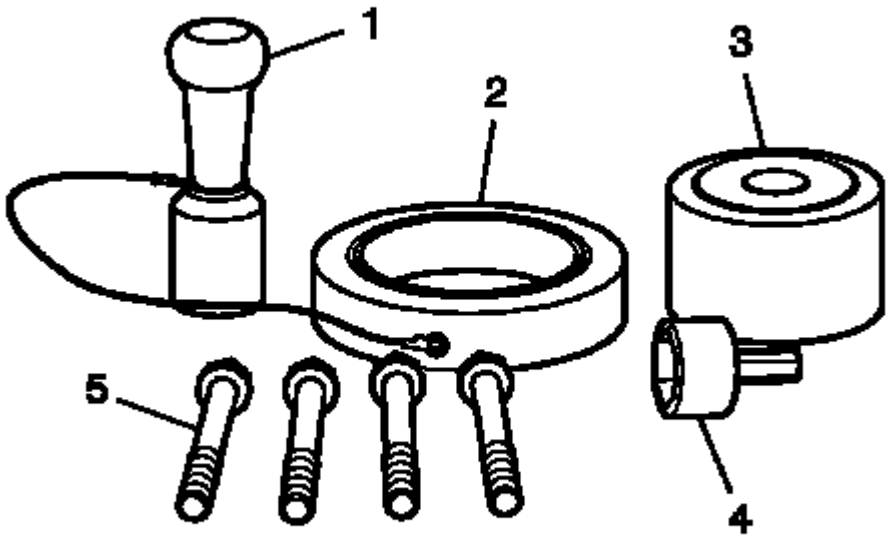

Fig. 248: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

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

CAUTION: 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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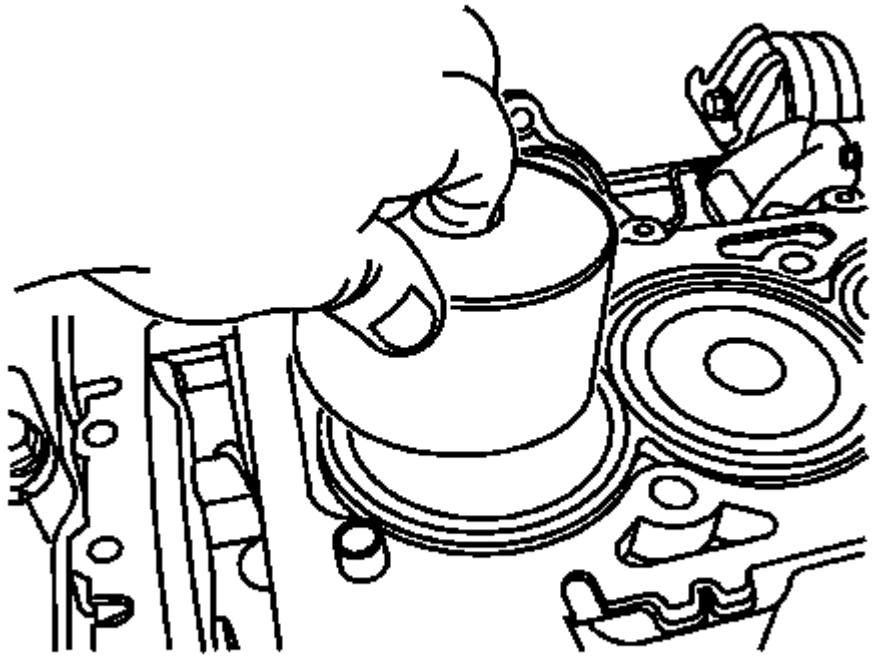

Fig. 249: View Of Metal Shaving Catch Plug
Courtesy of GENERAL MOTORS CORP.

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

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

2. Place metal shaving catch plug EN 45680-863 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 metal shaving catch plugs EN 45680-863 into all remaining cylinder bore sleeves.

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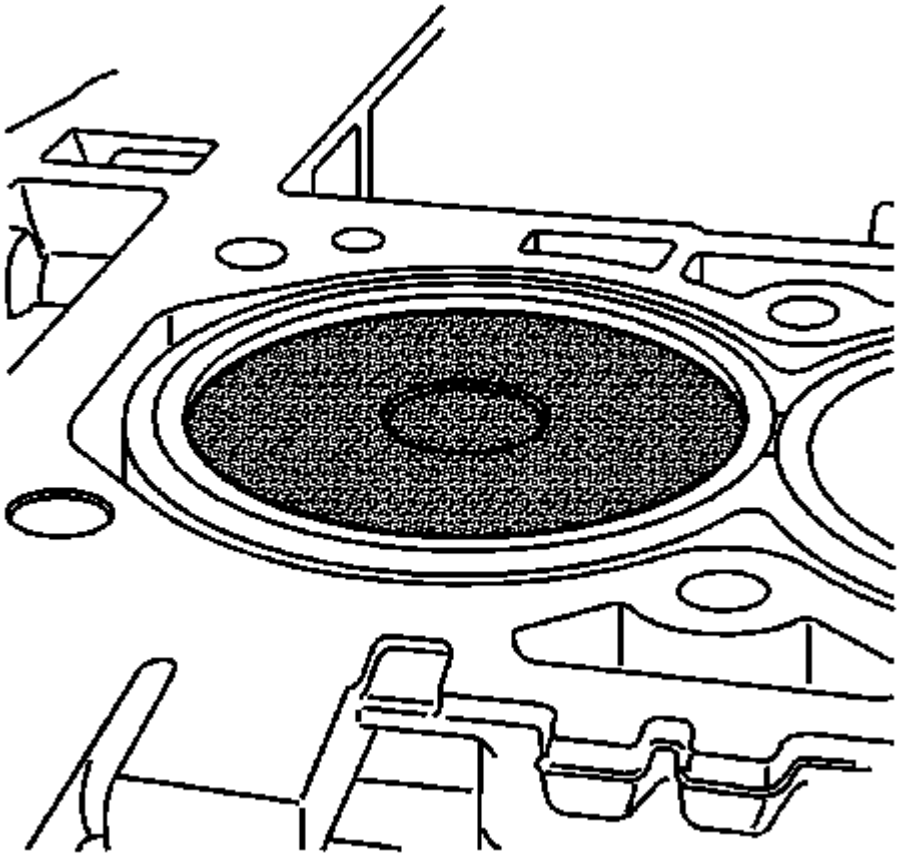

Fig. 250: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

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

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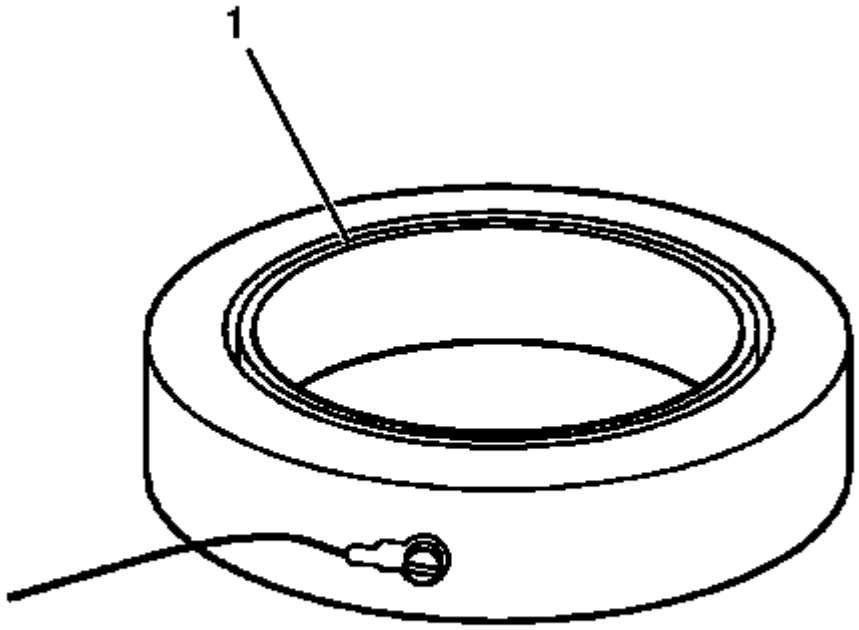

Fig. 251: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

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

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

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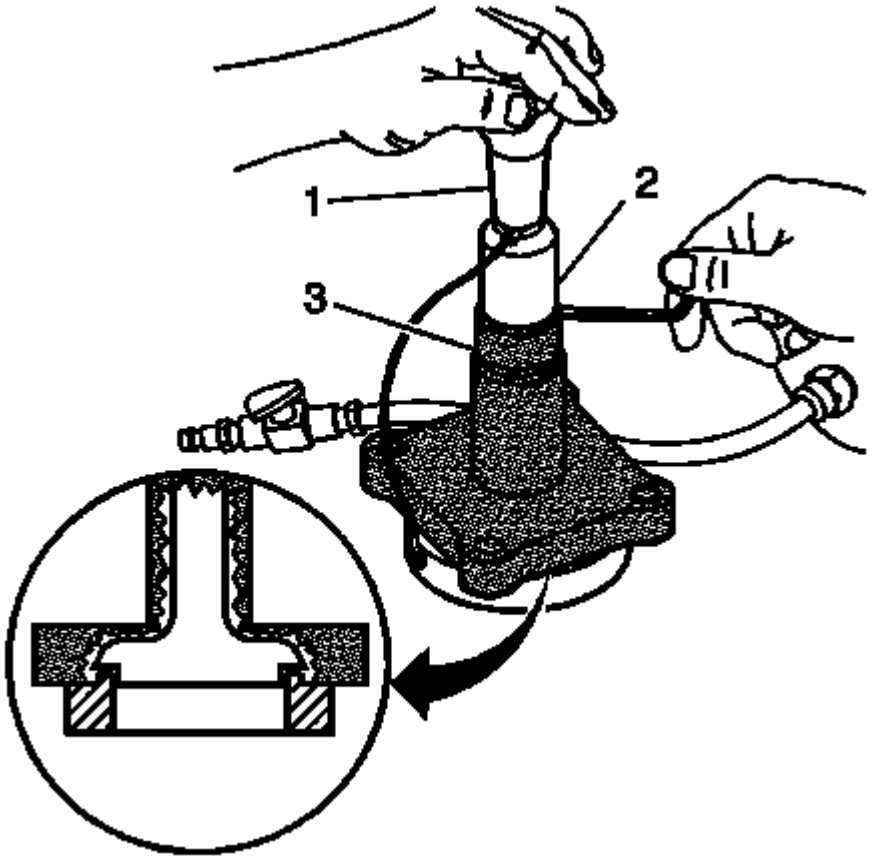

Fig. 252: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the set gauge ring EN 45680-862 surfaces are clean.

6. Carefully position trim tool assembly EN 45680-861 onto the set gauge ring EN 45680-862.
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).

NOTE: Once this procedure is done, it is not necessary to reset the trim tool assembly EN 45680-861 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 to 19 N.m (14 lb ft).

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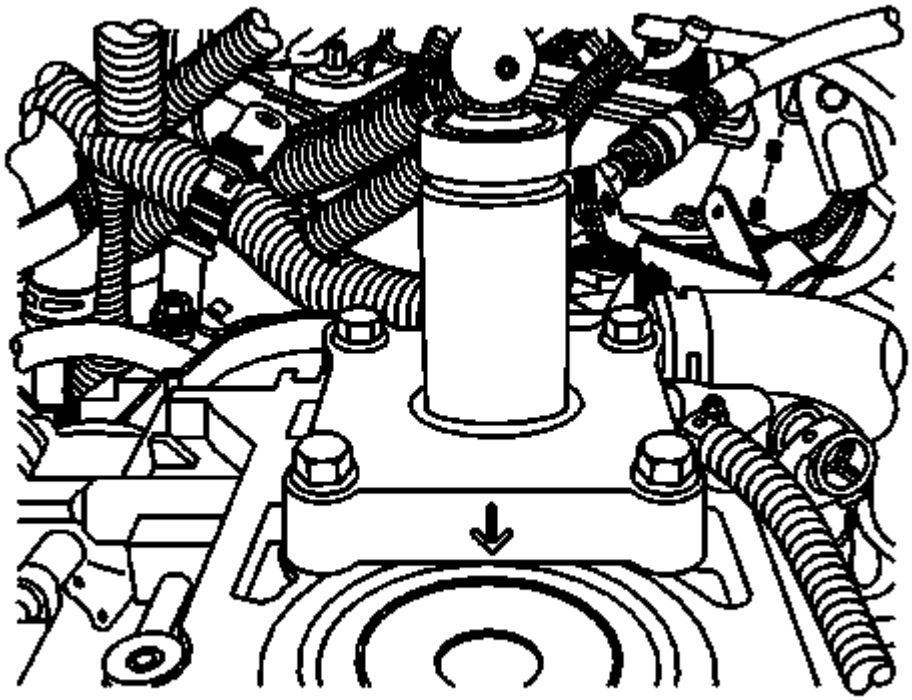

Fig. 253: Aligning Trim Tool Assembly
Courtesy of GENERAL MOTORS CORP.

10. Place trim tool assembly EN 45680-861 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 4 bolts EN 45680-864 into the cylinder head bolt holes in the block and tighten the bolts to 20 N.m (15 lb ft).

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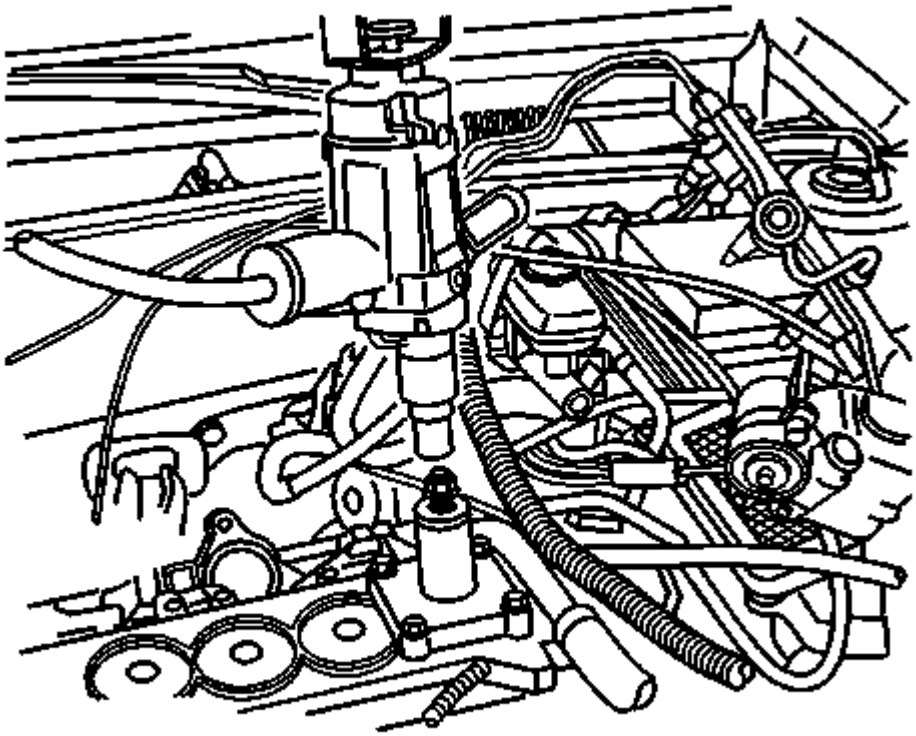

Fig. 254: Identifying EN 45680-866
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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 EN 45680-866 into the drill chuck.

CAUTION: 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 trim tool assembly EN 45680-861. Turn the compressed air valve to the open position. This starts the venturi vacuum system that will catch the metal shavings.
14. Place drive adapter EN 45680-866 and drill assembly vertically onto the drive adapter end of trim tool assembly EN 45680-861. 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 drive adapter EN 45680-866 and drill assembly from the trim tool assembly EN 45680-861.
16. Turn OFF the compressed air valve.
17. Remove trim tool assembly EN 45680-861 from the engine block.
18. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the metal shaving catch plug EN 45680-863.

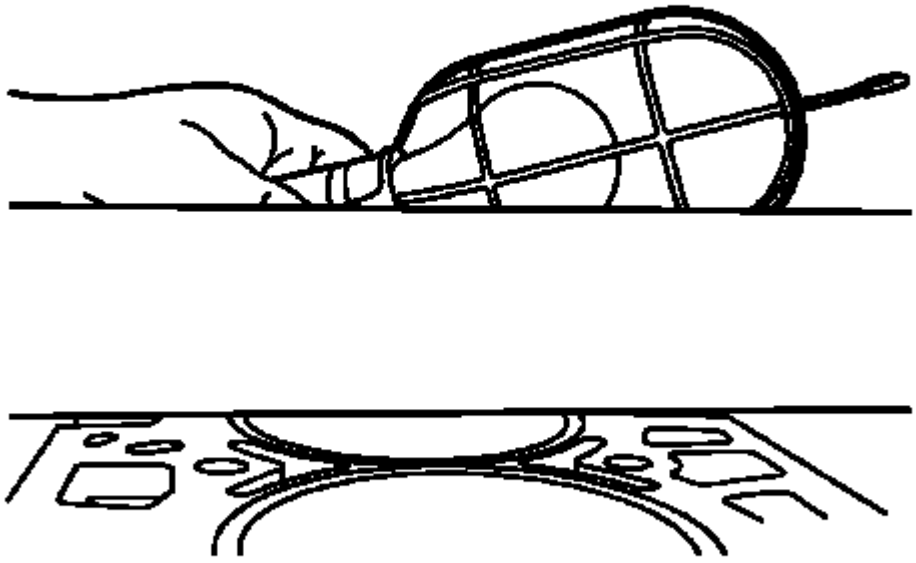

Fig. 255: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

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

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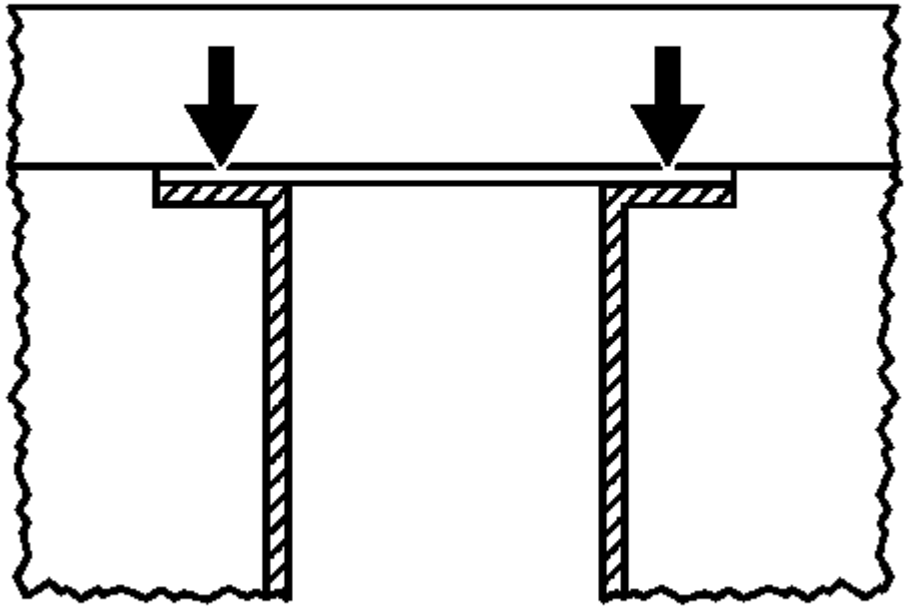

Fig. 256: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

21. 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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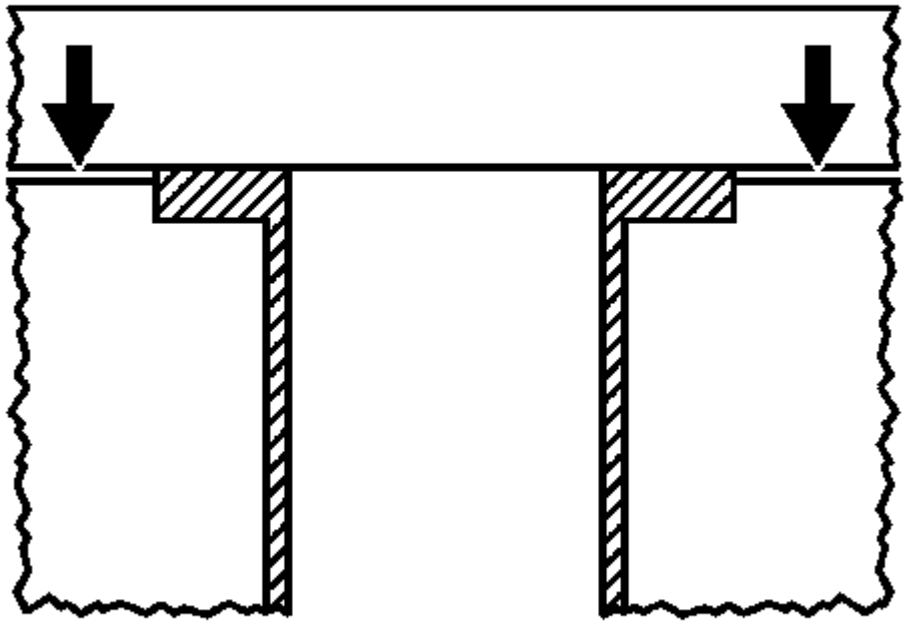

Fig. 257: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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 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 connecting rod. Refer to **Piston, Connecting Rod, and Bearing Replacement**.

ENGINE FLYWHEEL REPLACEMENT

Special Tools

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

Removal Procedure

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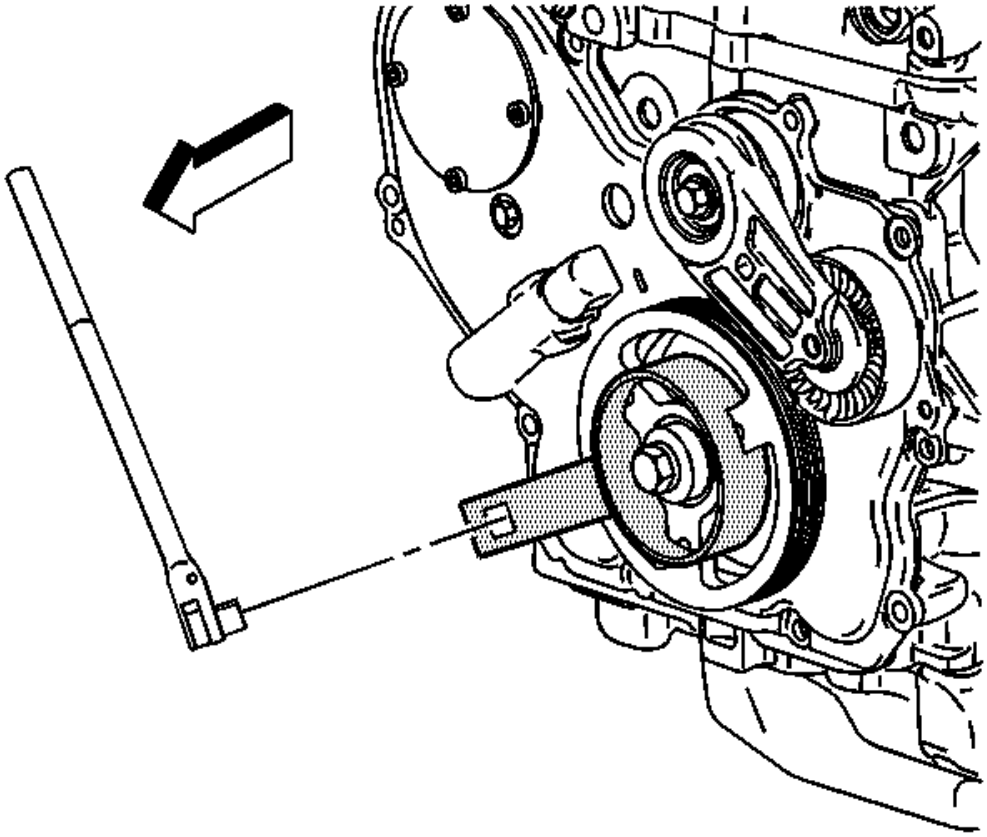

Fig. 258: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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 Pressure and Driven Plate Replacement** .
3. Using the **J 38122-A** , hold the crankshaft balancer.

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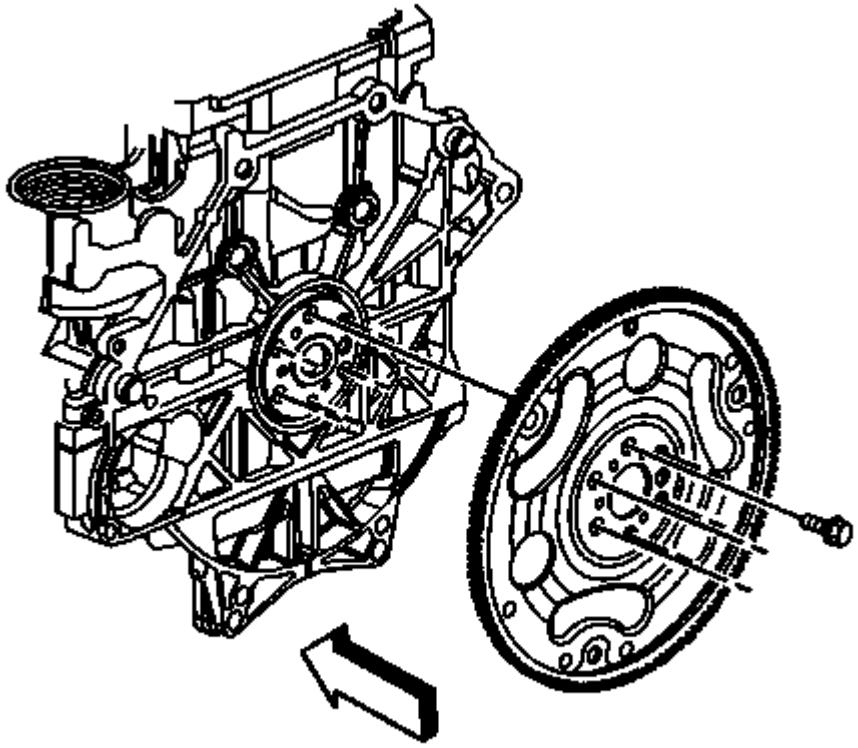

Fig. 259: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

NOTE: 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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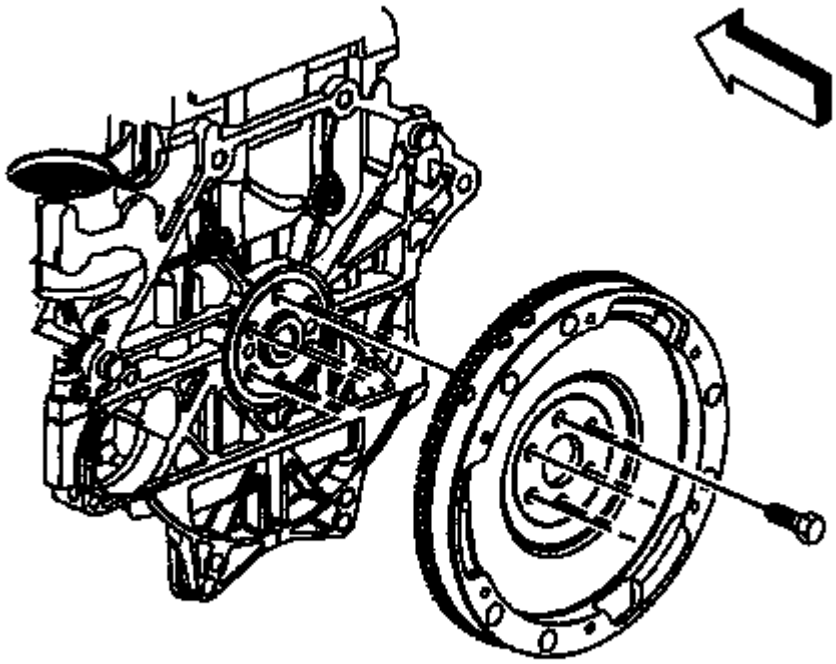

Fig. 260: View Of Flywheel (Manual Transaxle)
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

NOTE: 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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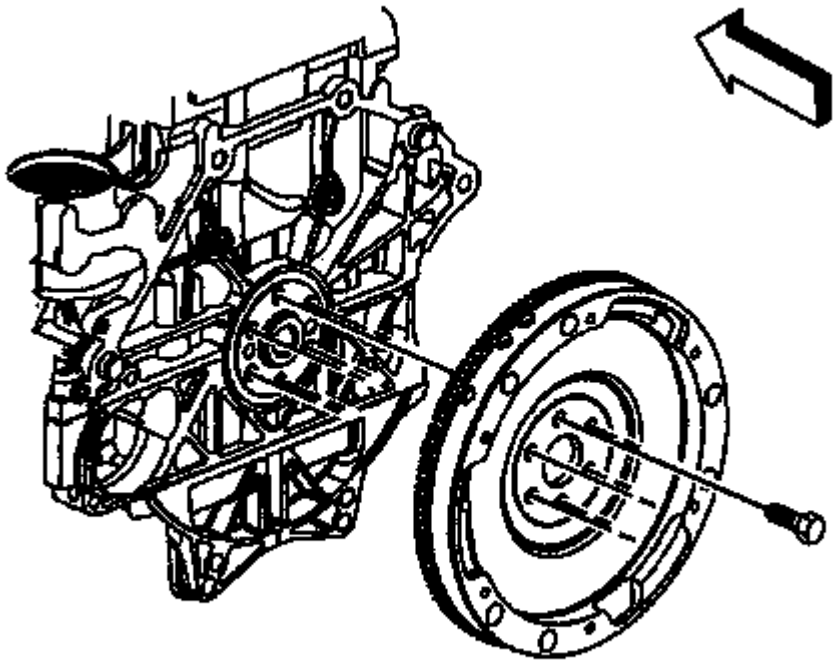

Fig. 261: View Of Flywheel (Manual Transaxle)
Courtesy of GENERAL MOTORS CORP.

1. Install the manual transaxle flywheel, if equipped.

   CAUTION: Refer to Fastener Caution .

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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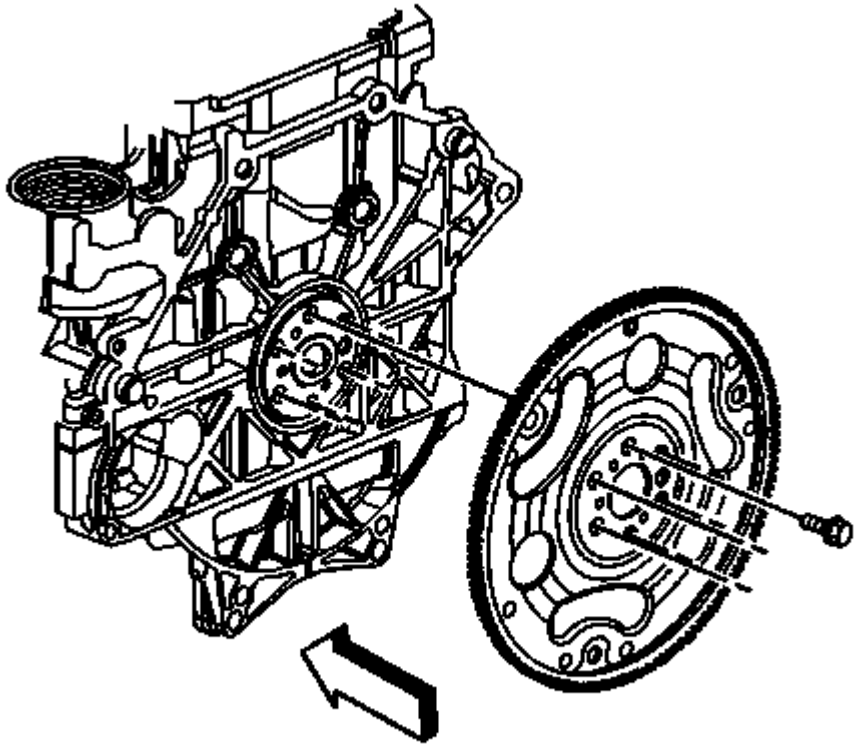

Fig. 262: View Of Flywheel (Automatic Transaxle)
Courtesy of GENERAL MOTORS CORP.

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 Pressure and Driven Plate Replacement** .
7. If equipped with a automatic transaxle, install the transaxle. Refer to **Transmission Replacement** .

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Tools Required

J 42067 Rear Main Seal Installer

Removal Procedure

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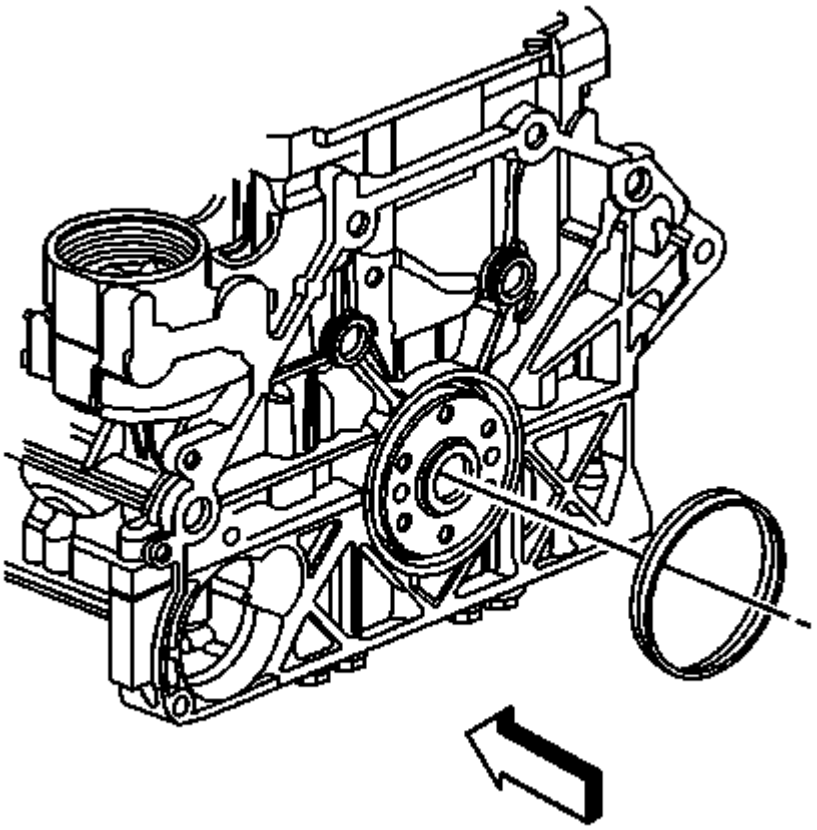

Fig. 263: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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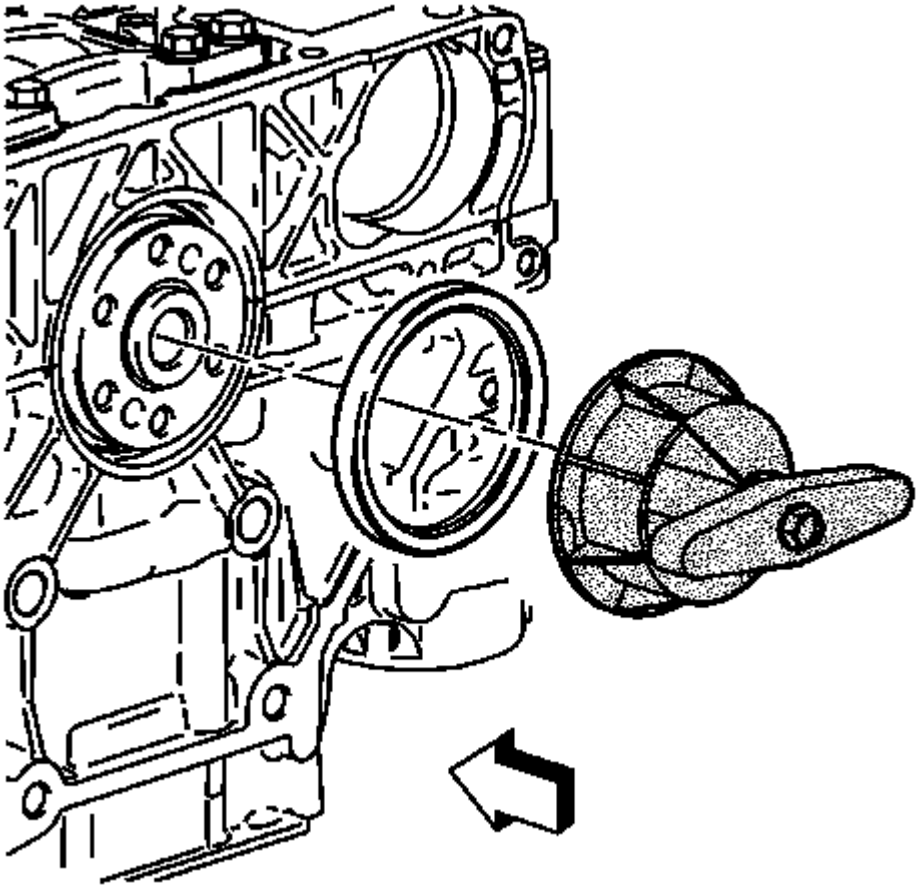

Fig. 264: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

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

ENGINE REPLACEMENT

Removal Procedure

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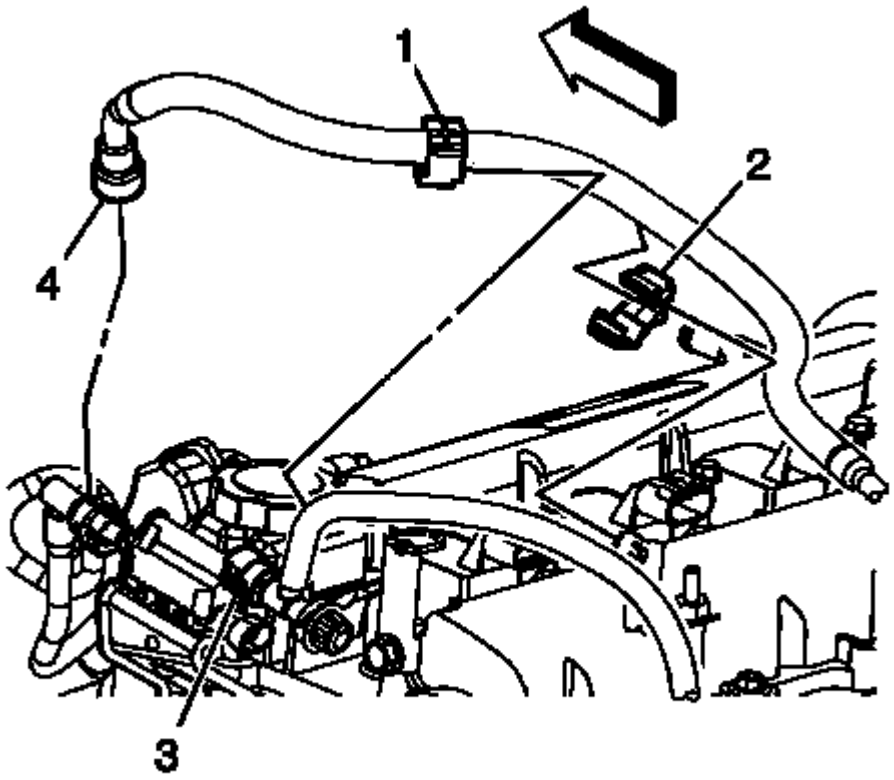

Fig. 265: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

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 (With CH 48027)** or **Fuel Pressure Relief (Without CH 48027)** .
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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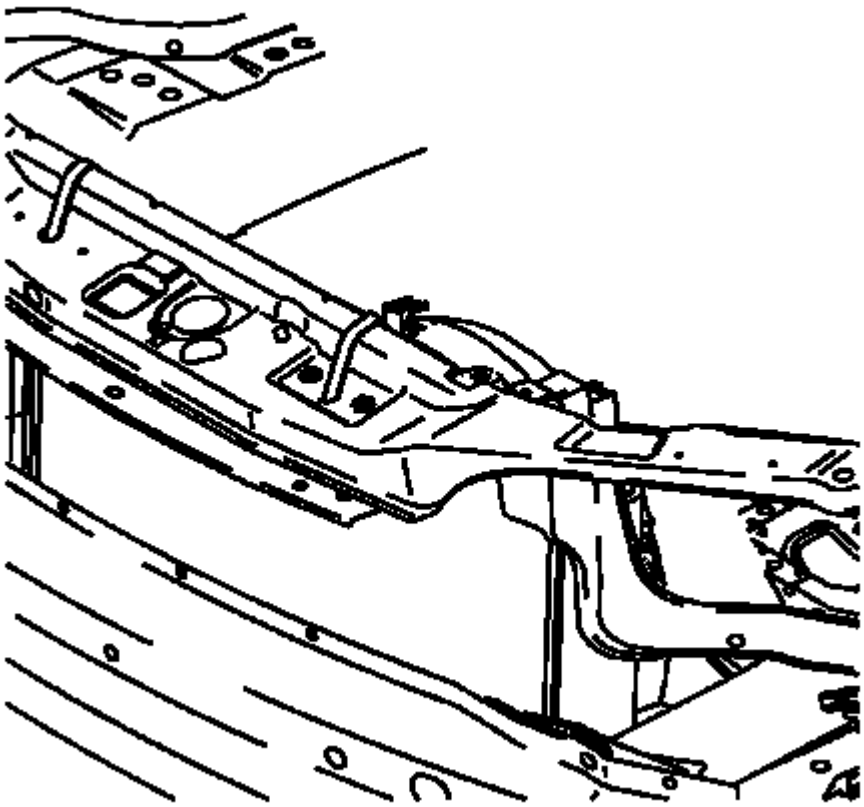

Fig. 266: View Of Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

8. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LE5, L61)** or **Cooling System Draining and Filling (Static Fill LNF)** or **Cooling System Draining and Filling (GE 47716 Fill)** .
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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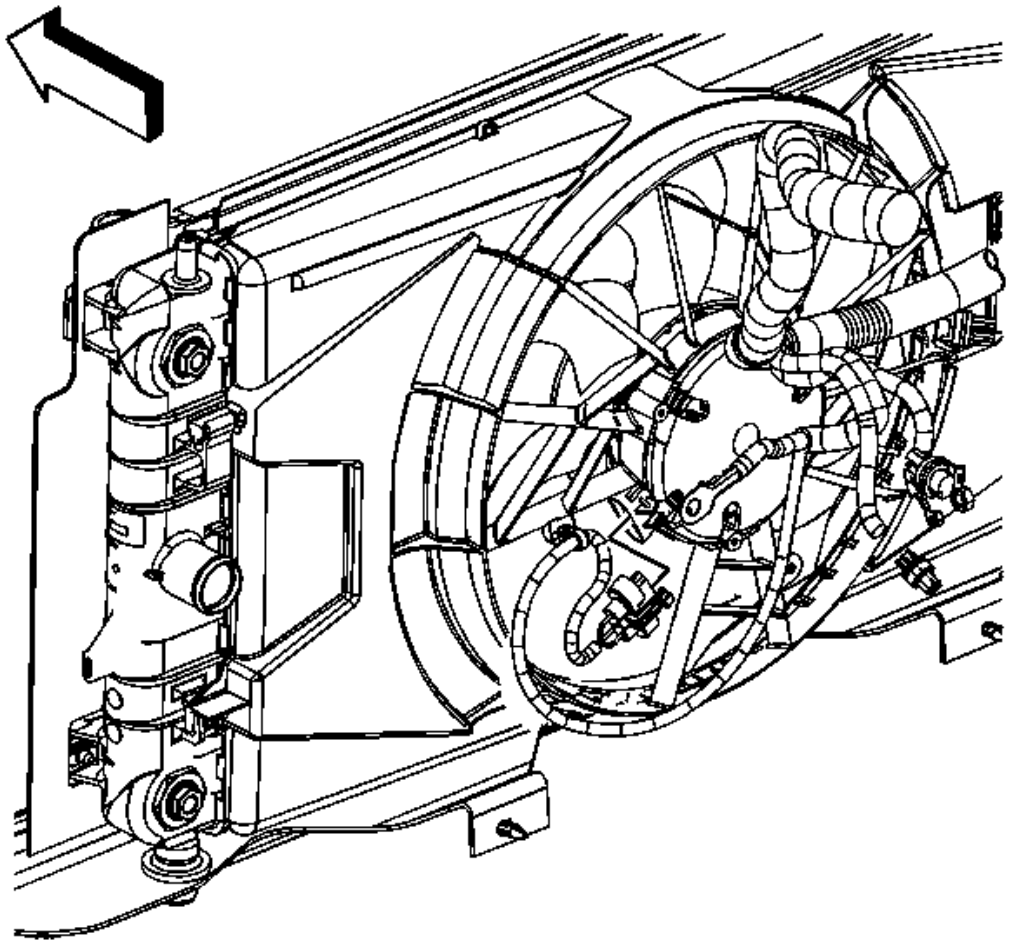

Fig. 267: Identifying Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

11. Disconnect the cooling fan electrical connector.

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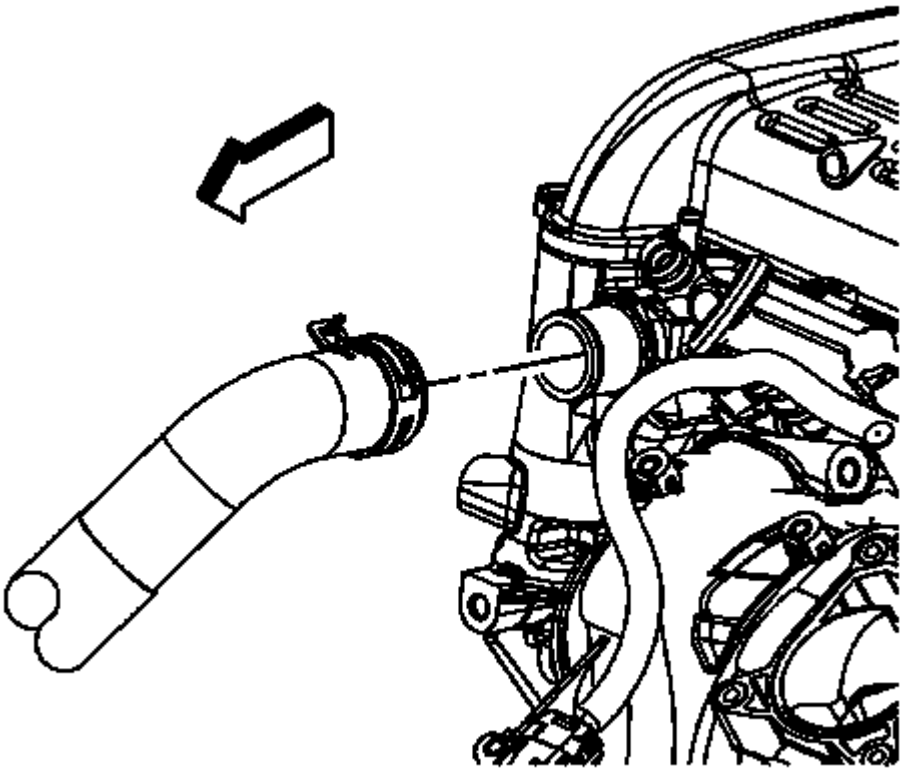

Fig. 268: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

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

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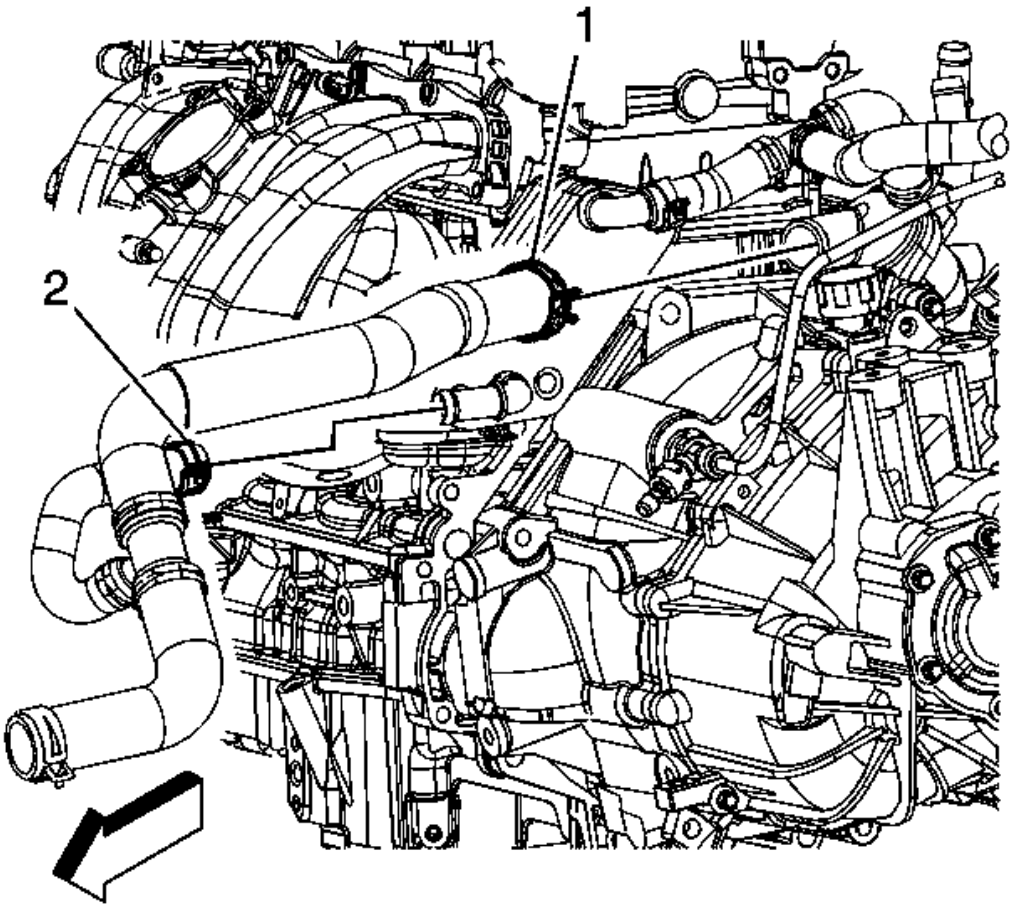

Fig. 269: View Of Radiator Outlet Hose To Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

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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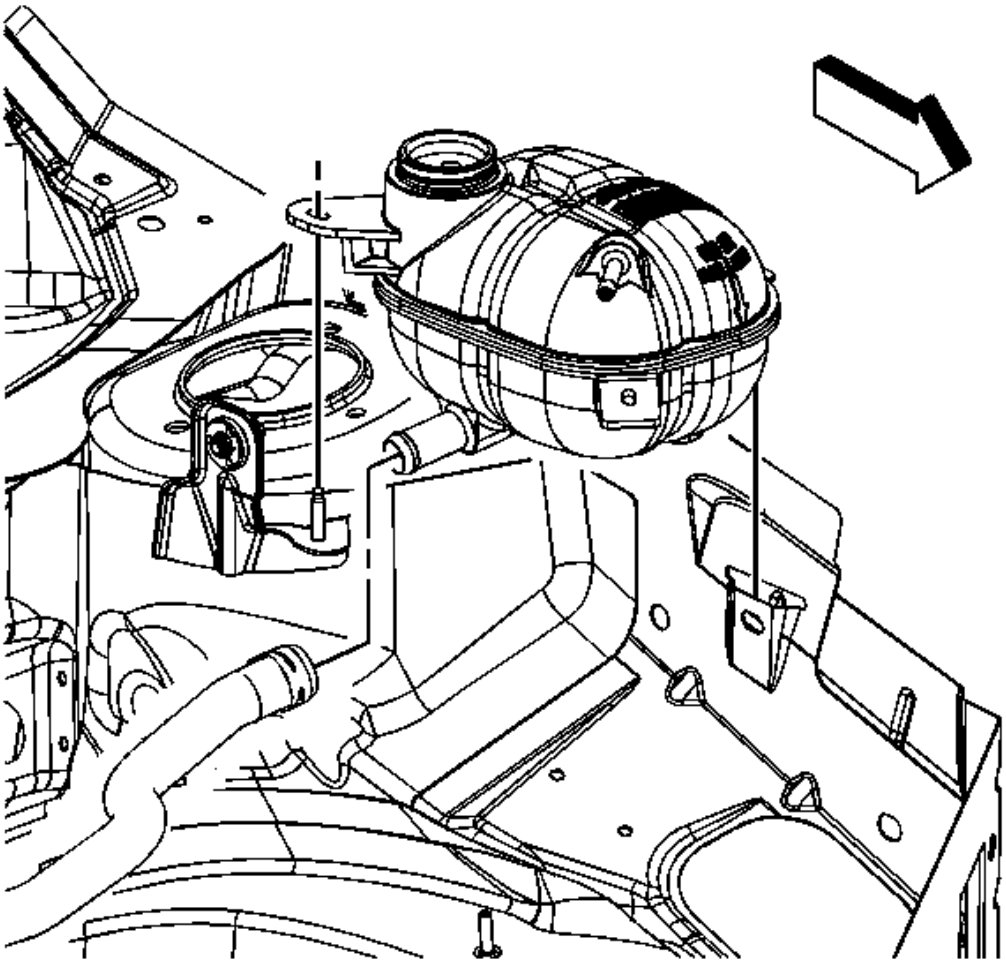

Fig. 270: View Of Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

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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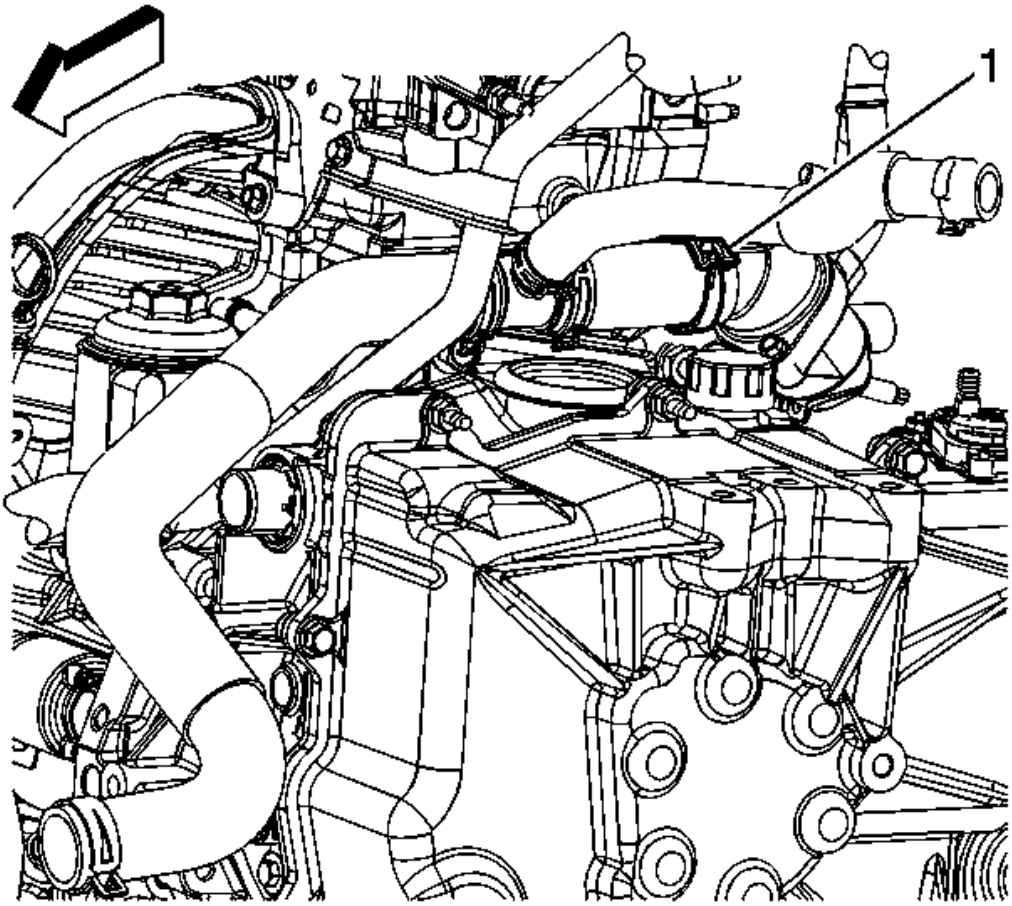

Fig. 271: Identifying Radiator Outlet Hose Clamp
Courtesy of GENERAL MOTORS CORP.

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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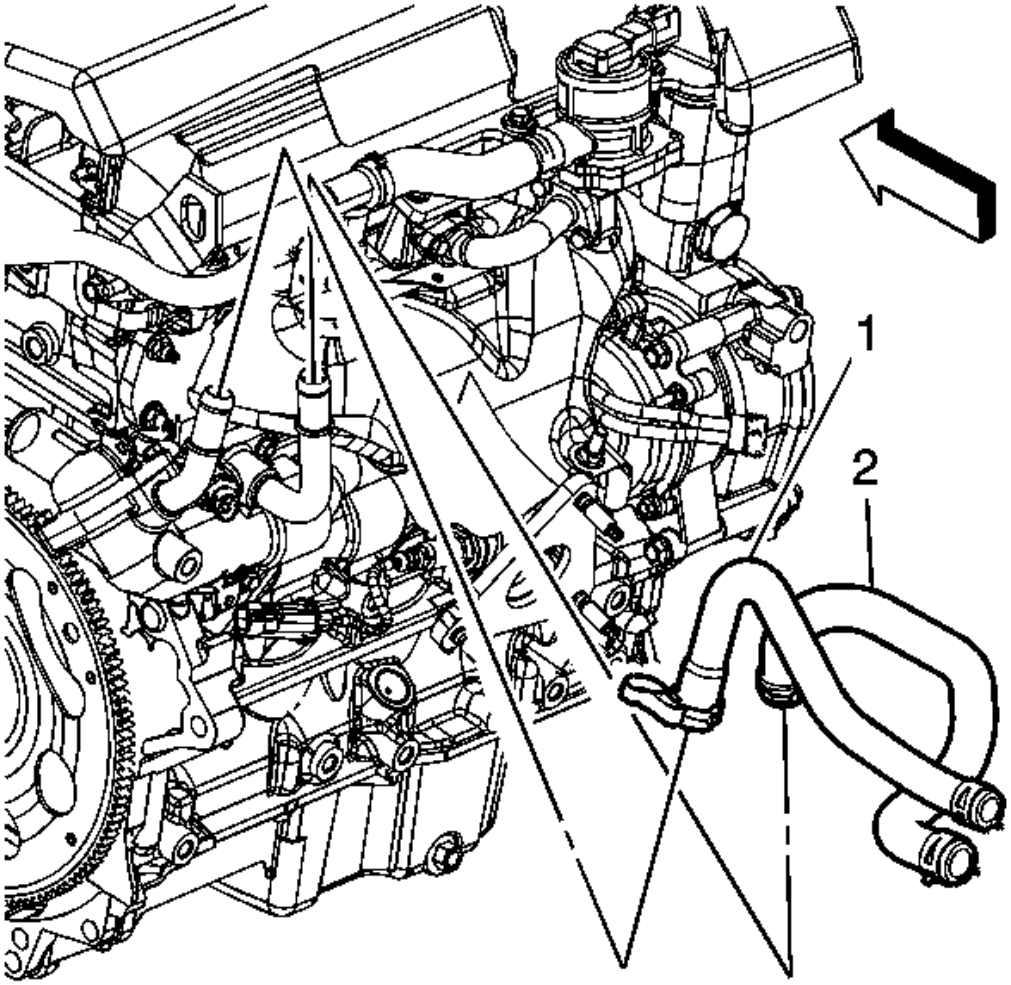

Fig. 272: View Of Heater Inlet And Outlet Hoses And Thermostat Housing Pipes
Courtesy of GENERAL MOTORS CORP.

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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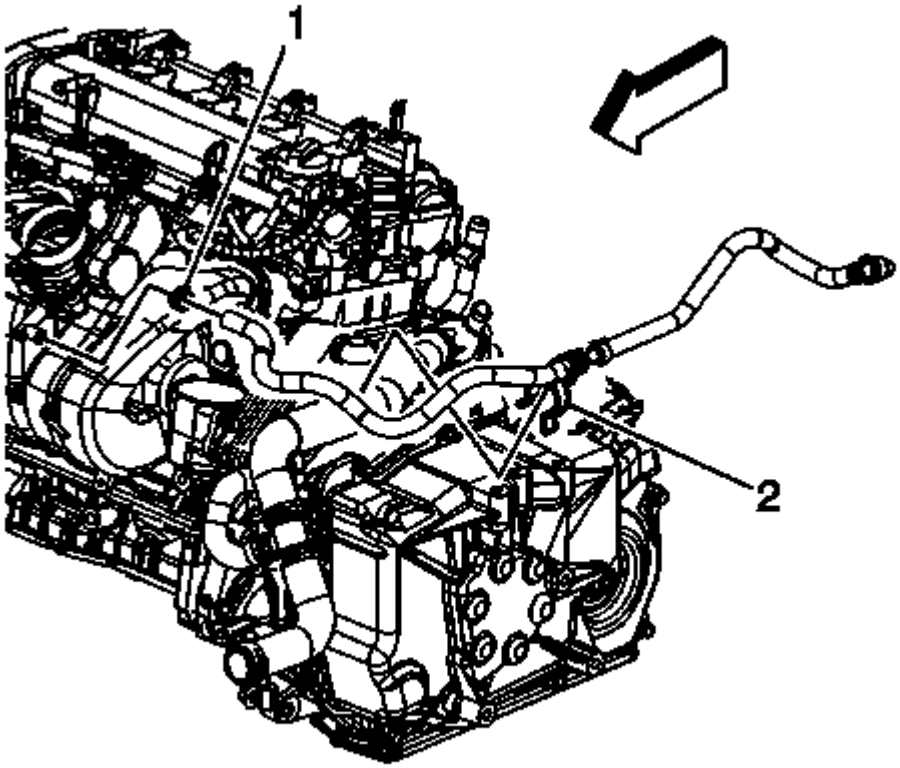

Fig. 273: Positioning Brake Booster Vacuum Hose Clamp At Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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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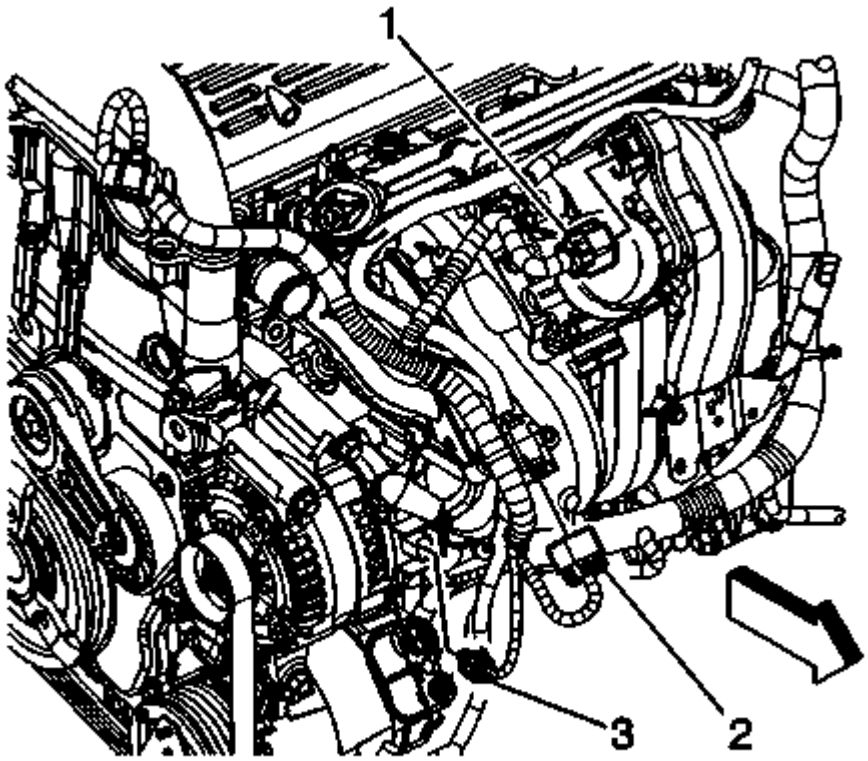

Fig. 274: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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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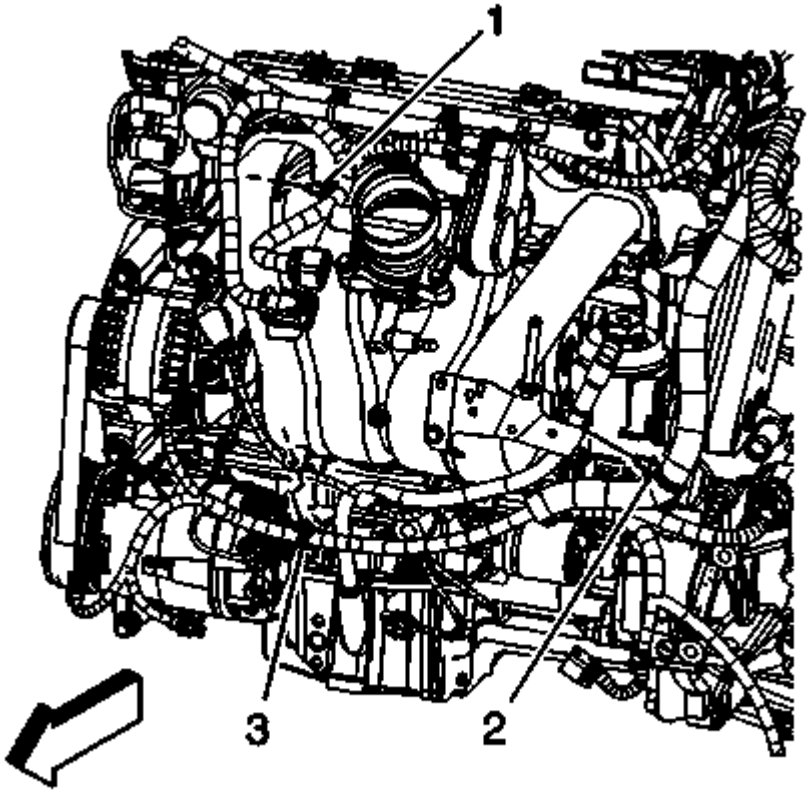

Fig. 275: View Of Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

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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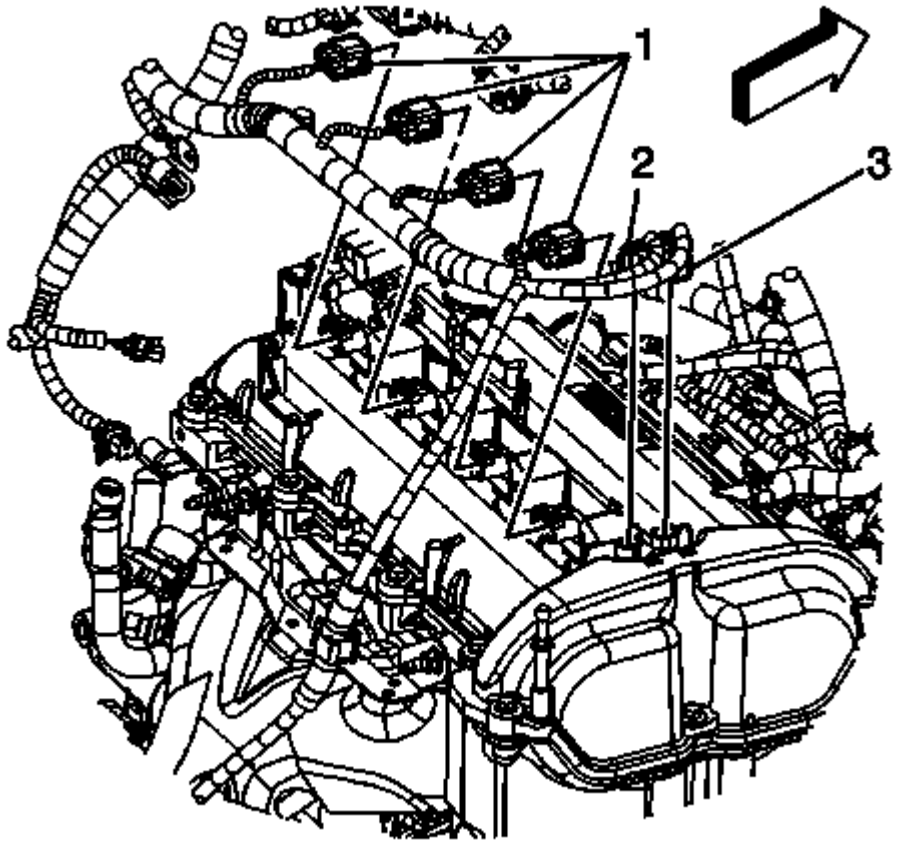

Fig. 276: Camshaft Position Actuator Solenoid Valve Electrical Connectors
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30. Disconnect the ignition coils electrical connectors (1).
31. Disconnect the intake (3) and exhaust (2) camshaft position actuator electrical connectors.

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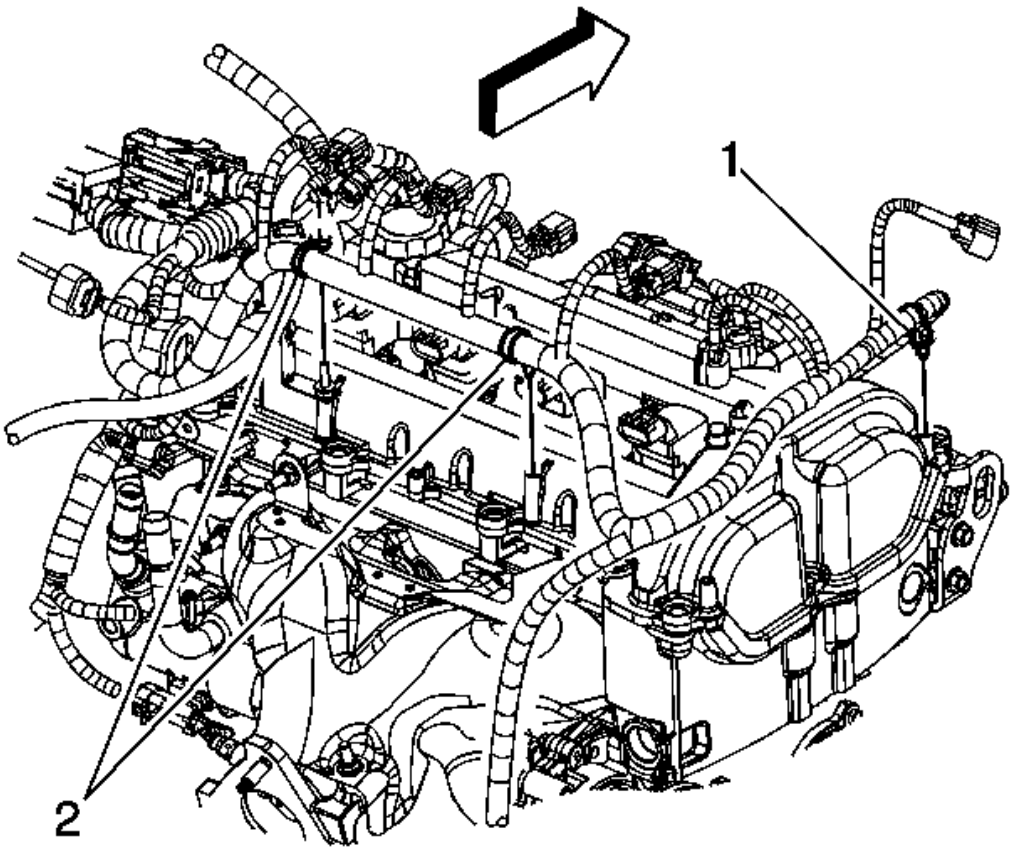

Fig. 277: View Of Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

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

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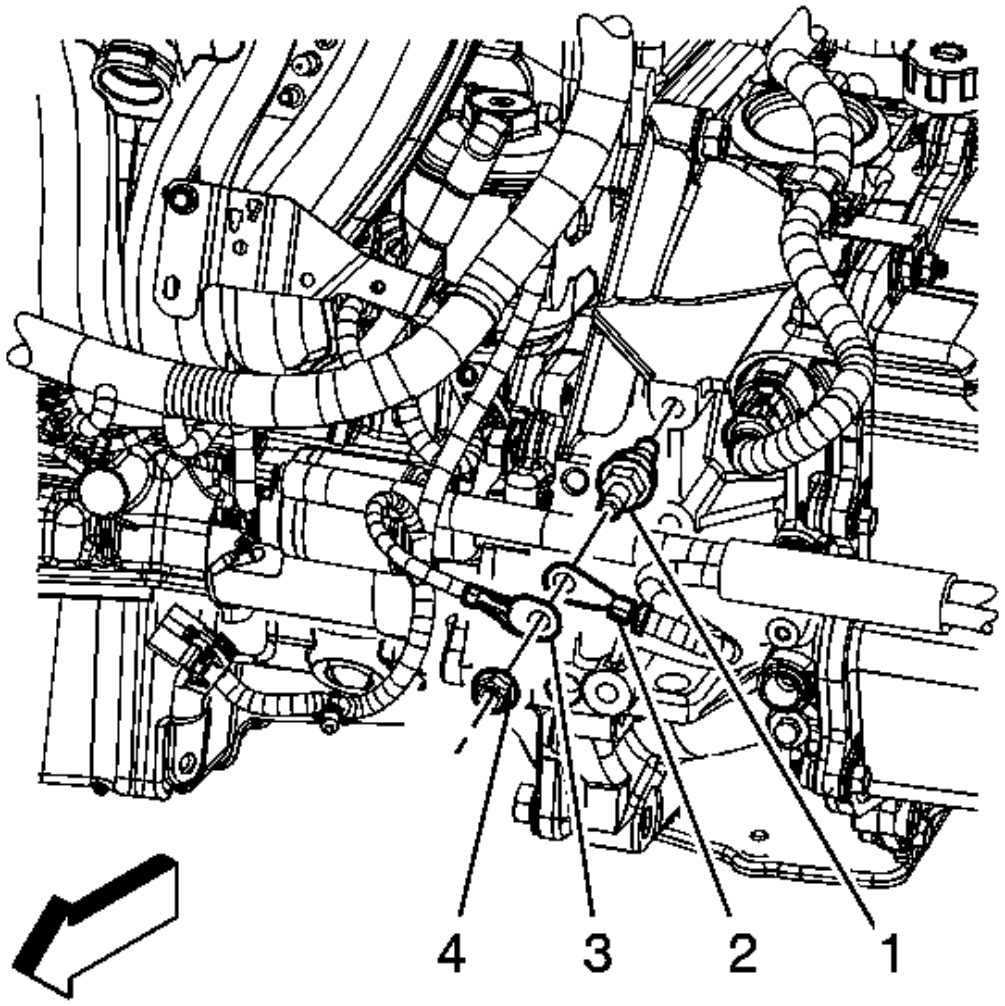

Fig. 278: View Of Battery Connections
Courtesy of GENERAL MOTORS CORP.

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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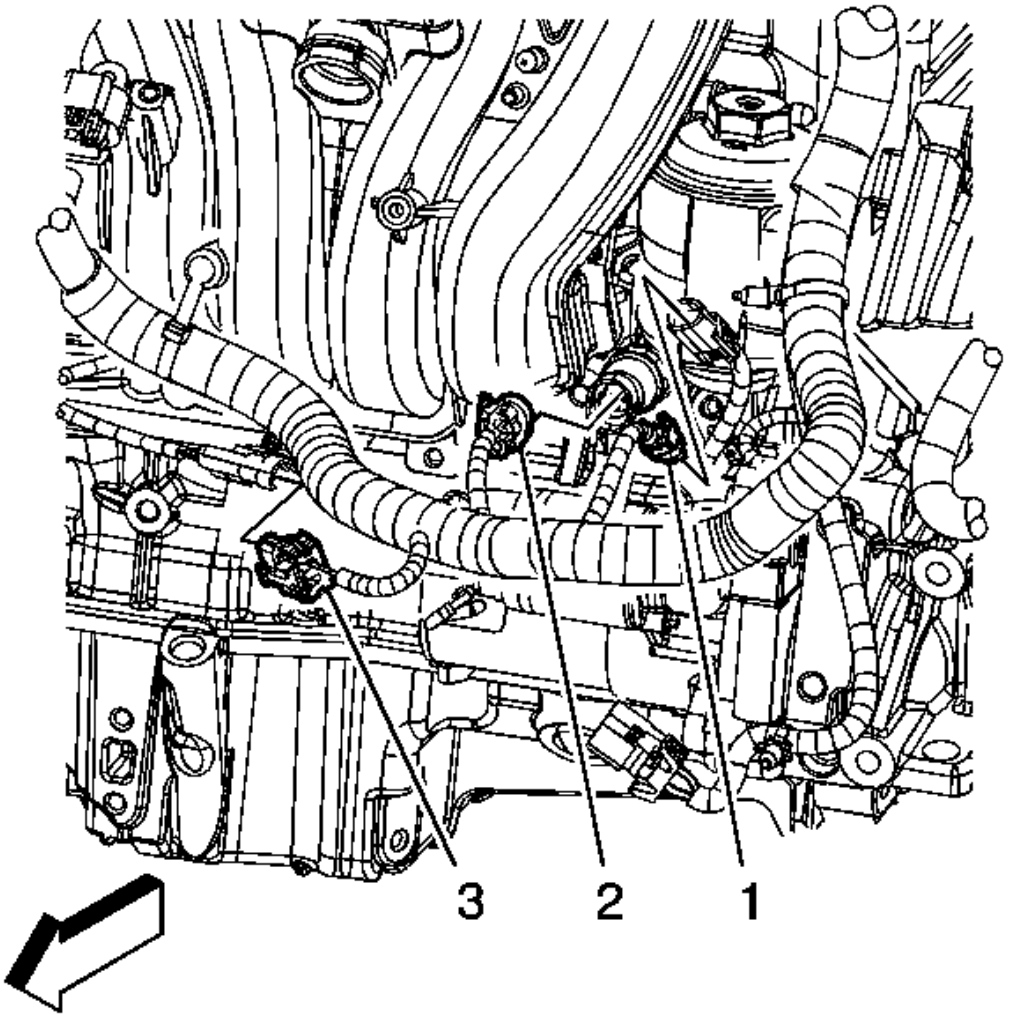

Fig. 279: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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

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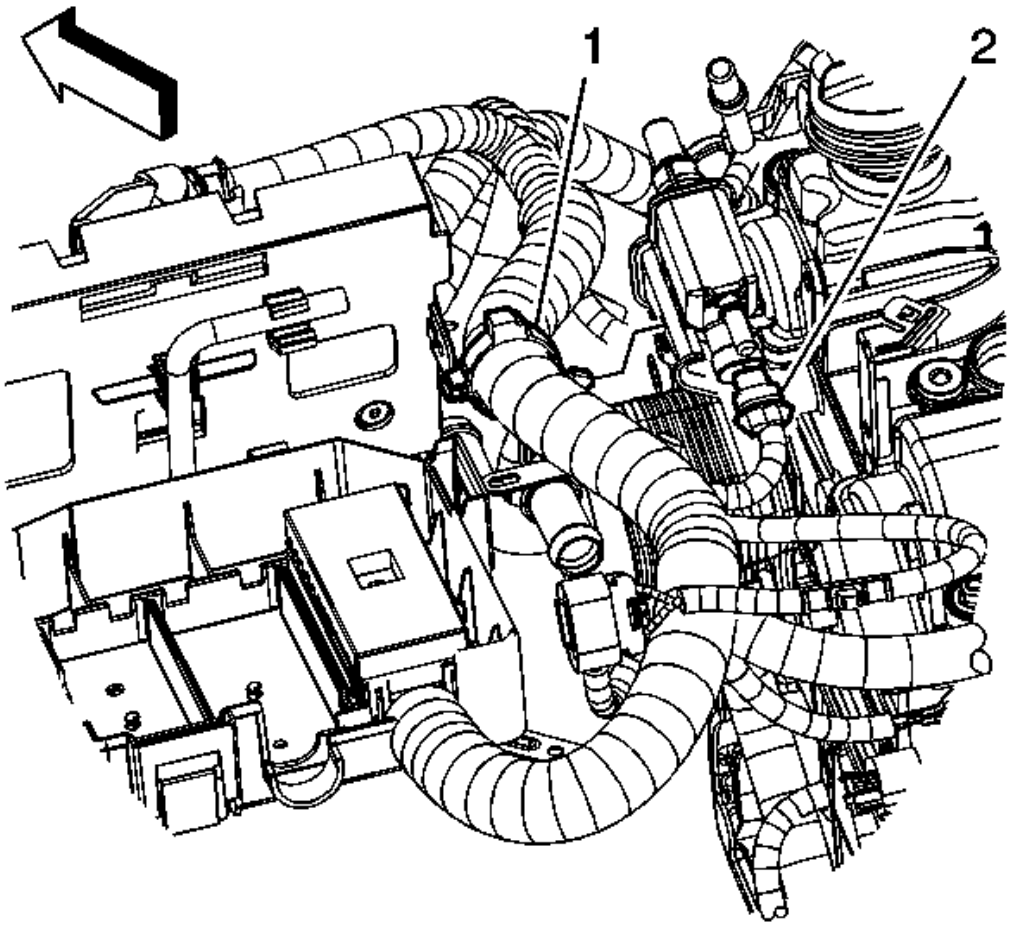

Fig. 280: Locating EVAP Purge Solenoid Electrical Connector
Courtesy of GENERAL MOTORS CORP.

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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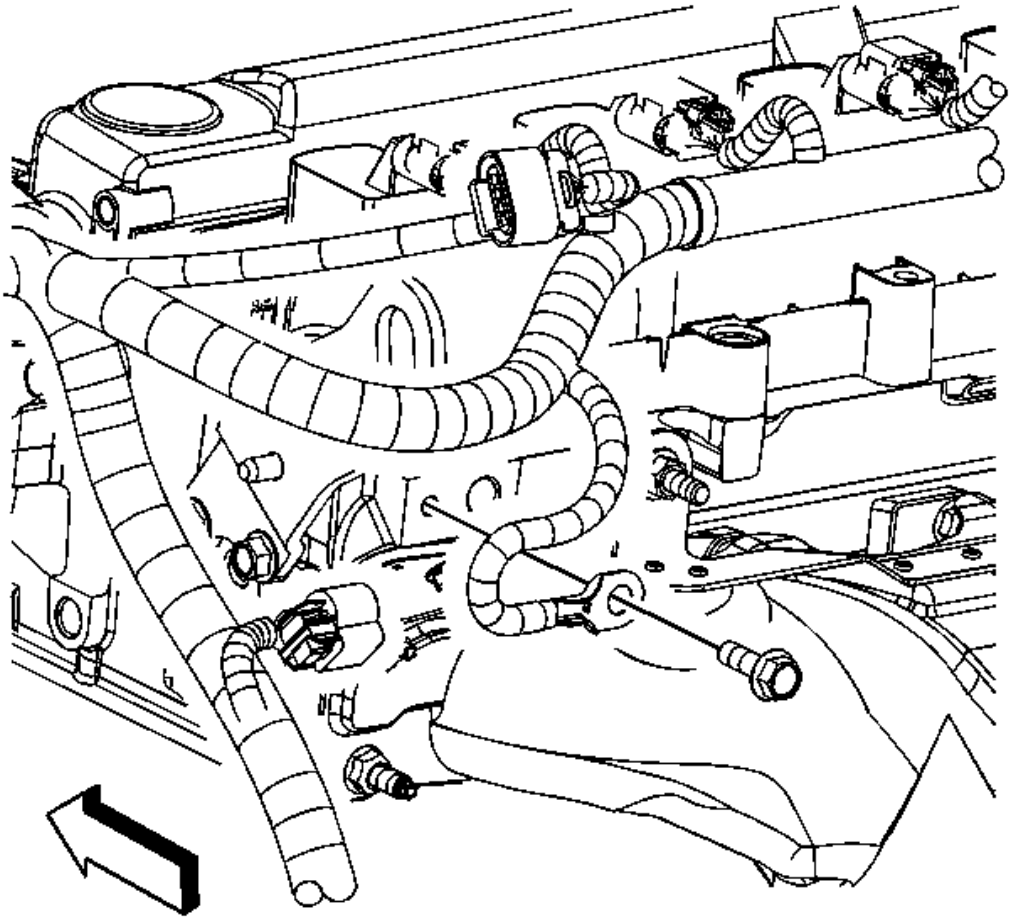

Fig. 281: Identifying Engine Harness Ground Terminal
Courtesy of GENERAL MOTORS CORP.

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

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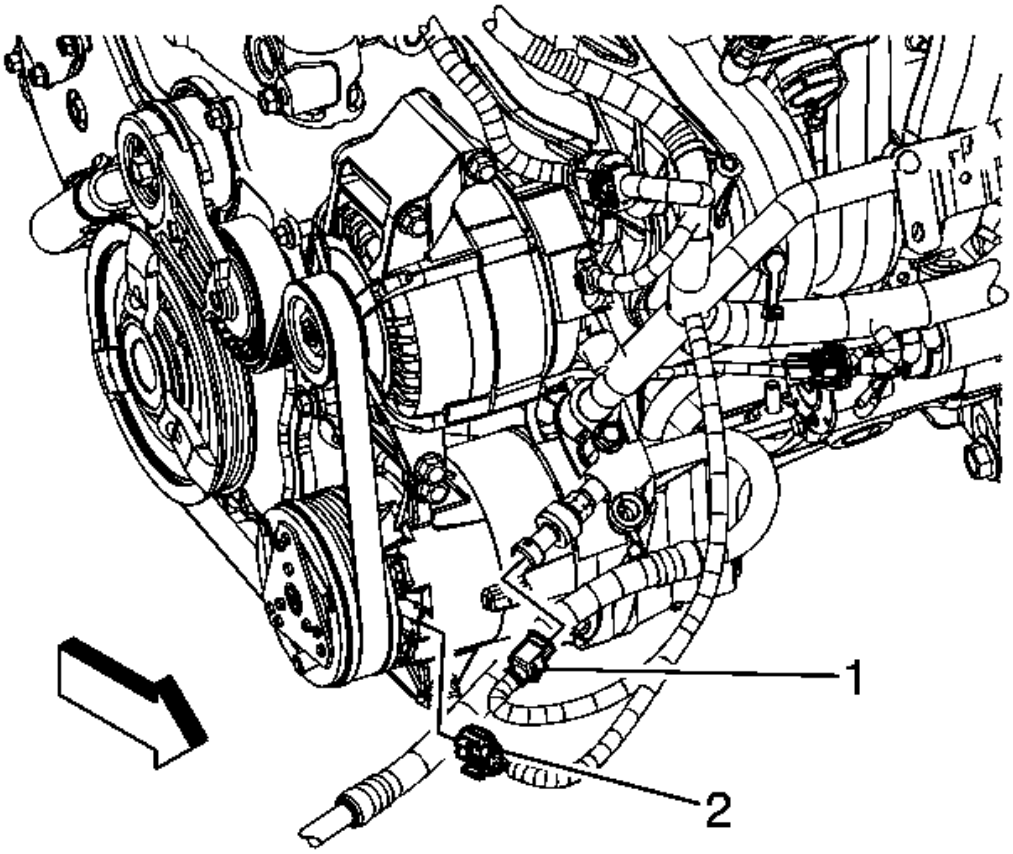

Fig. 282: View Of Engine Harness Electrical Connector To A/C Compressor And Pressure Switch
Courtesy of GENERAL MOTORS CORP.

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 (LAF)**.

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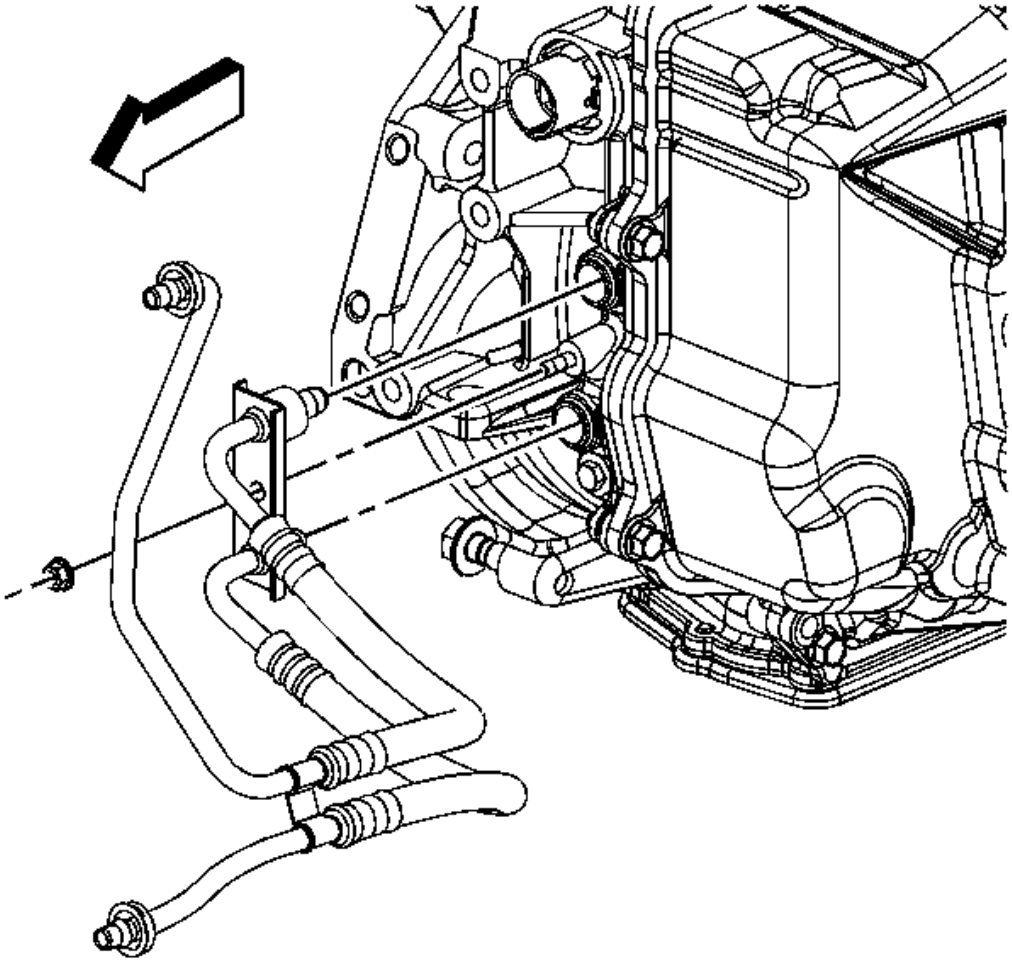

Fig. 283: Identifying Transaxle Fluid Cooler Lines & Bracket Nut
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46. Remove the transaxle fluid cooler bracket nut.
47. Remove the transaxle fluid cooler lines from the transaxle.

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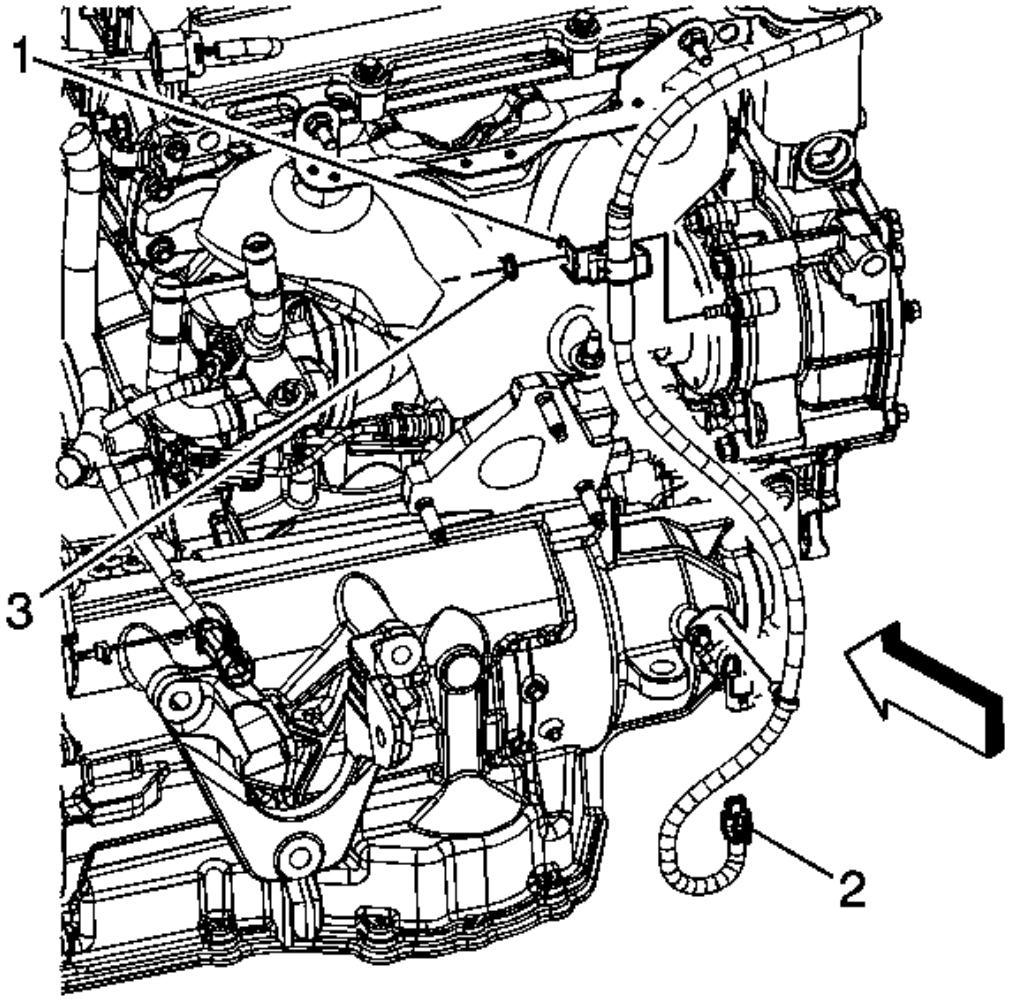

Fig. 284: Identifying Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

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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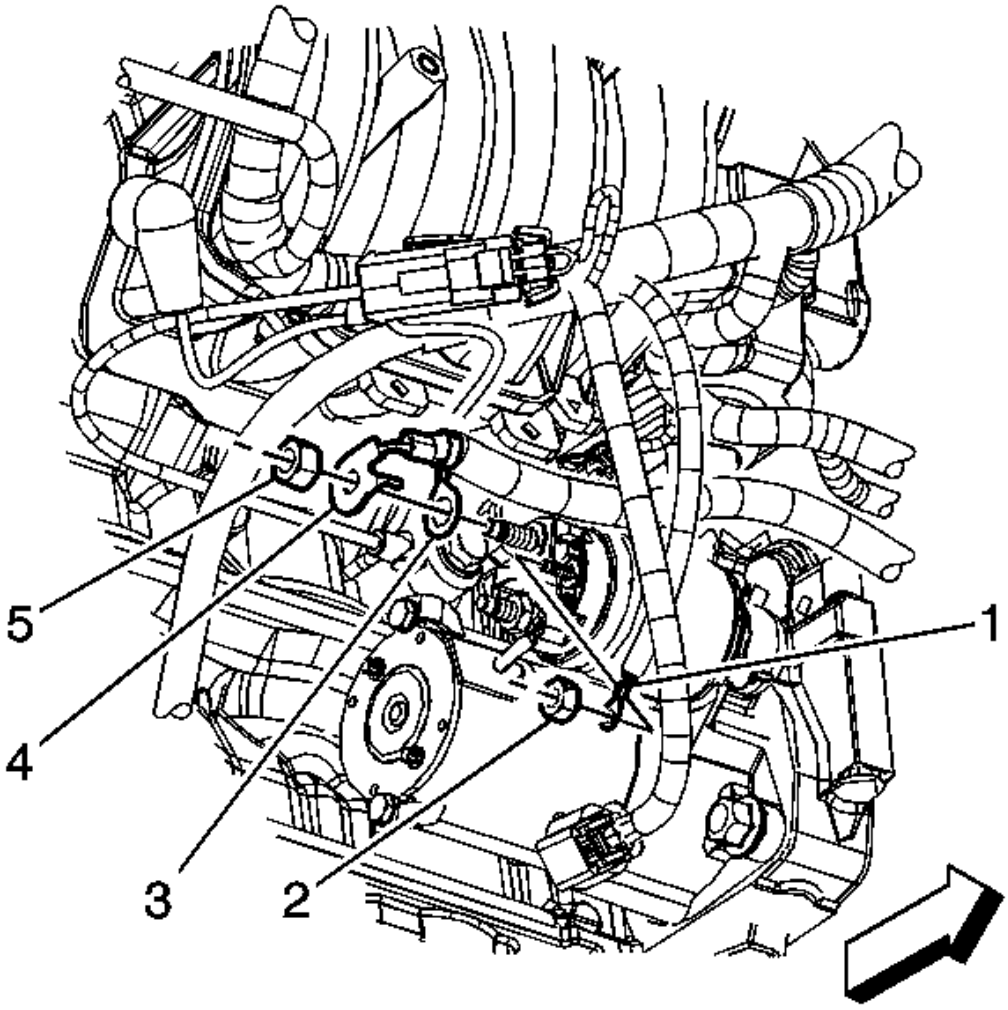

Fig. 285: View Of Engine Harness Terminal To Starter
Courtesy of GENERAL MOTORS CORP.

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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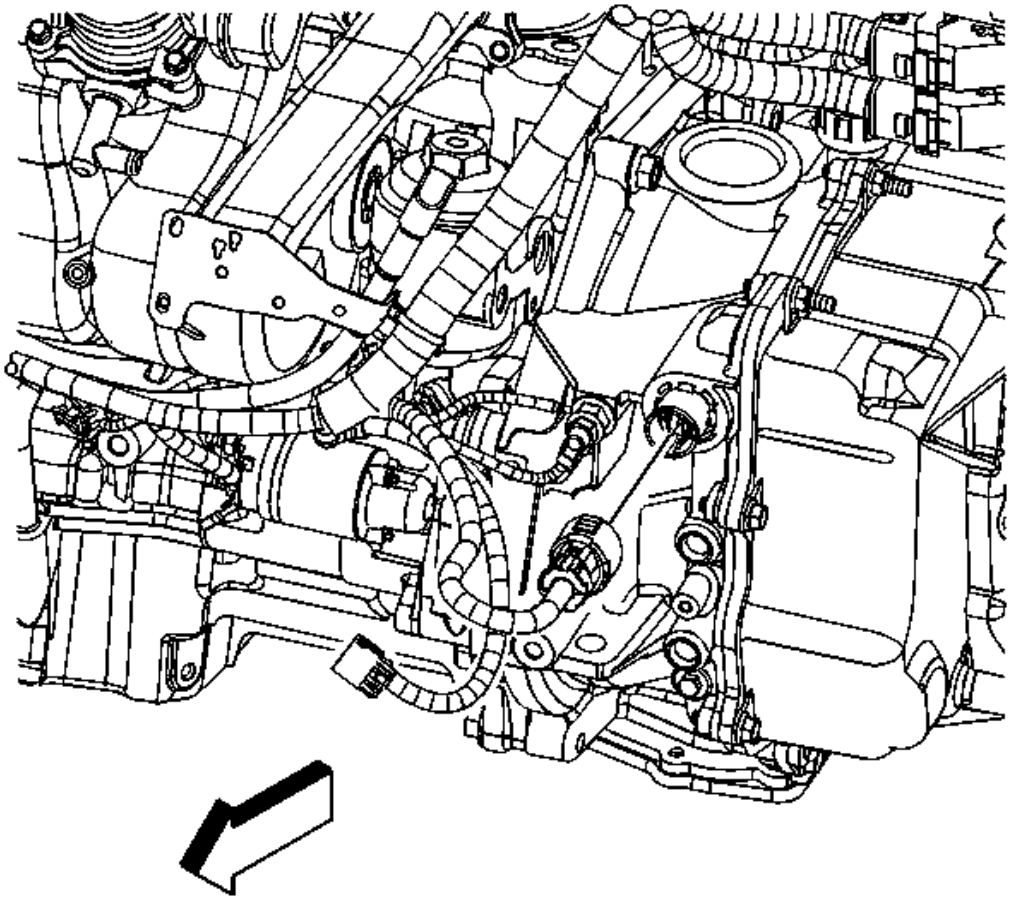

Fig. 286: Identifying Engine Harness
Courtesy of GENERAL MOTORS CORP.

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

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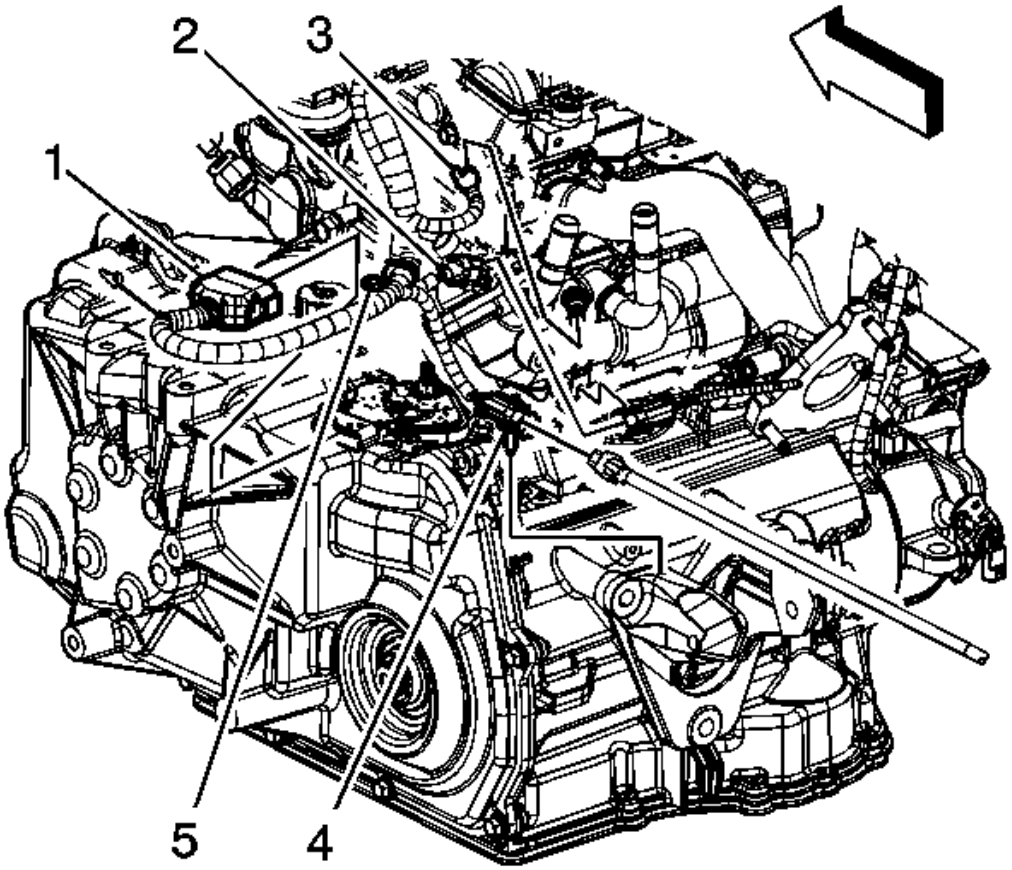

Fig. 287: Identifying Engine Harness Electrical Connectors - Top Of Engine
Courtesy of GENERAL MOTORS CORP.

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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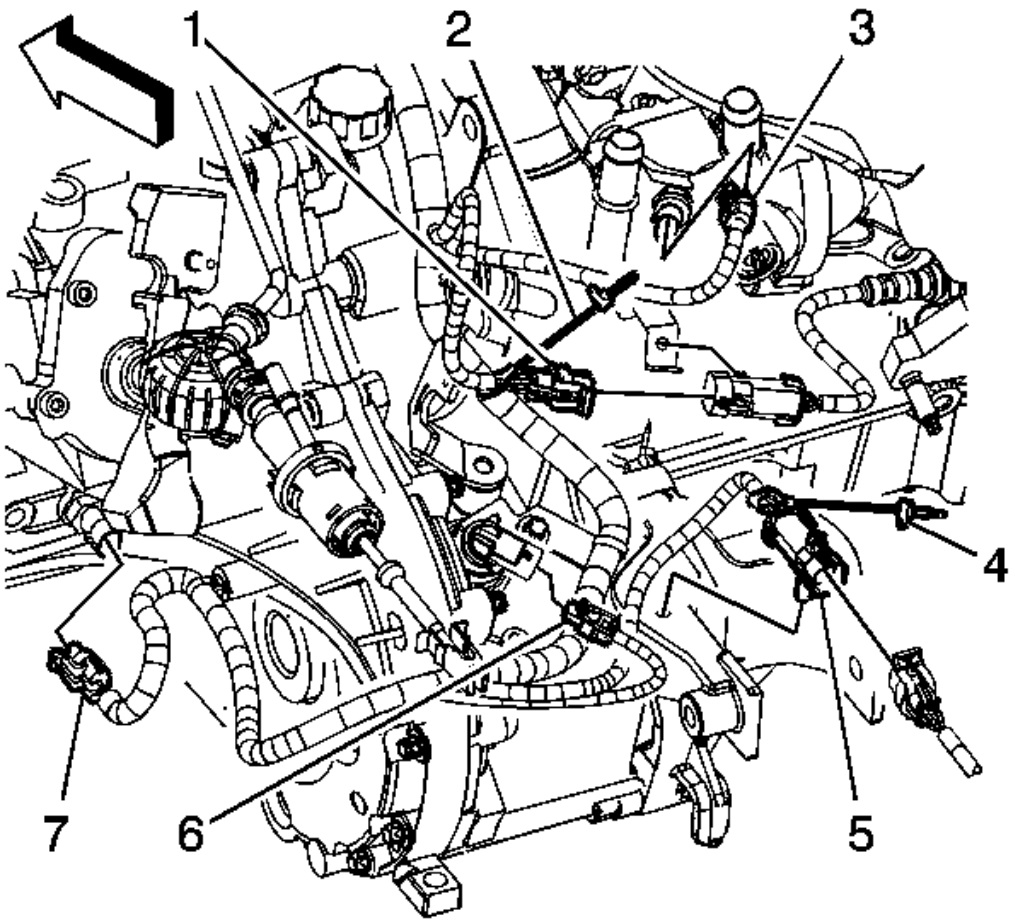

Fig. 288: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

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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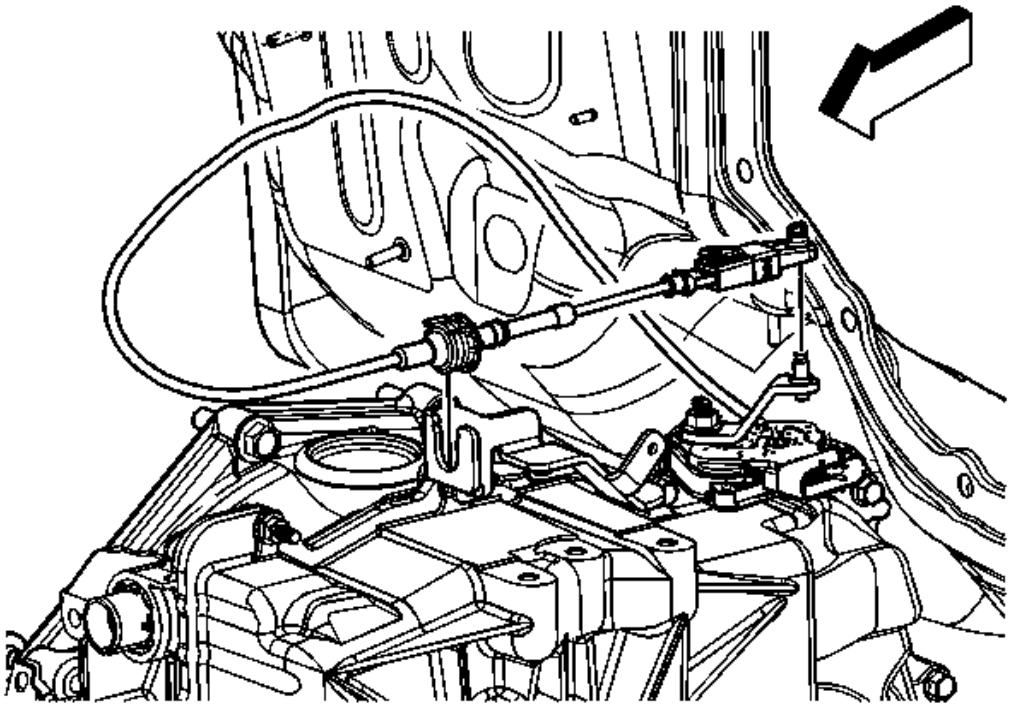

Fig. 289: Identifying Range Selector Level Cable
Courtesy of GENERAL MOTORS CORP.

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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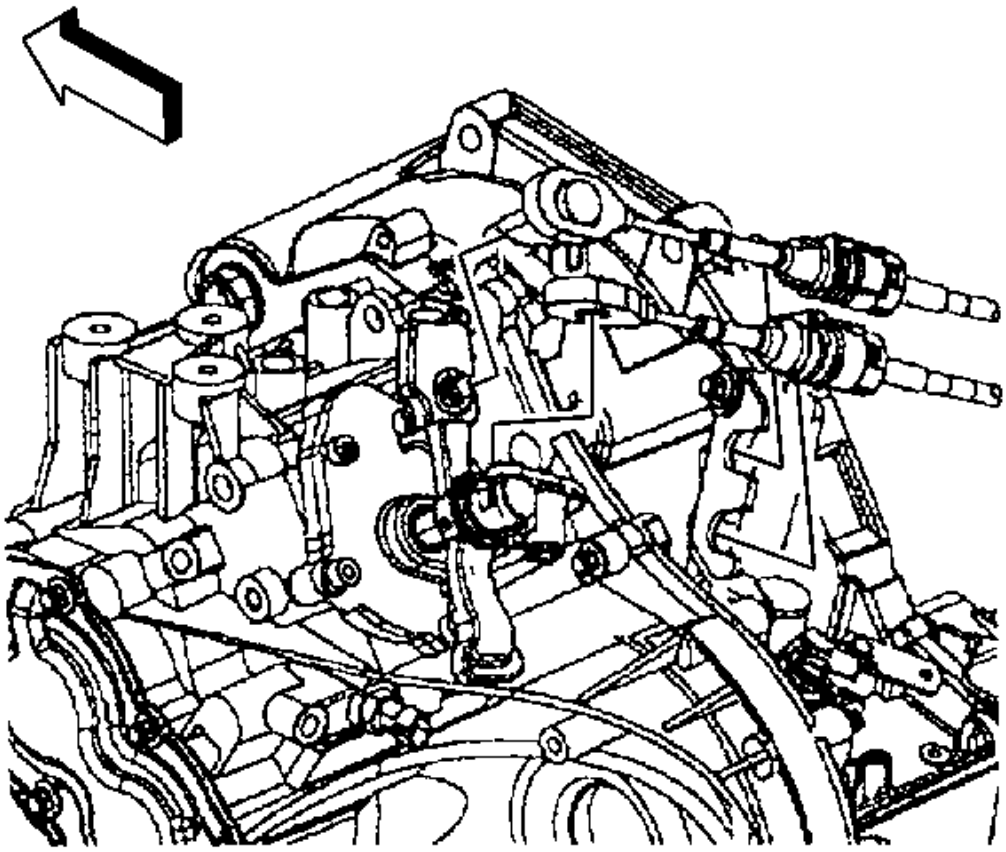

Fig. 290: Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

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 (LAP)** .
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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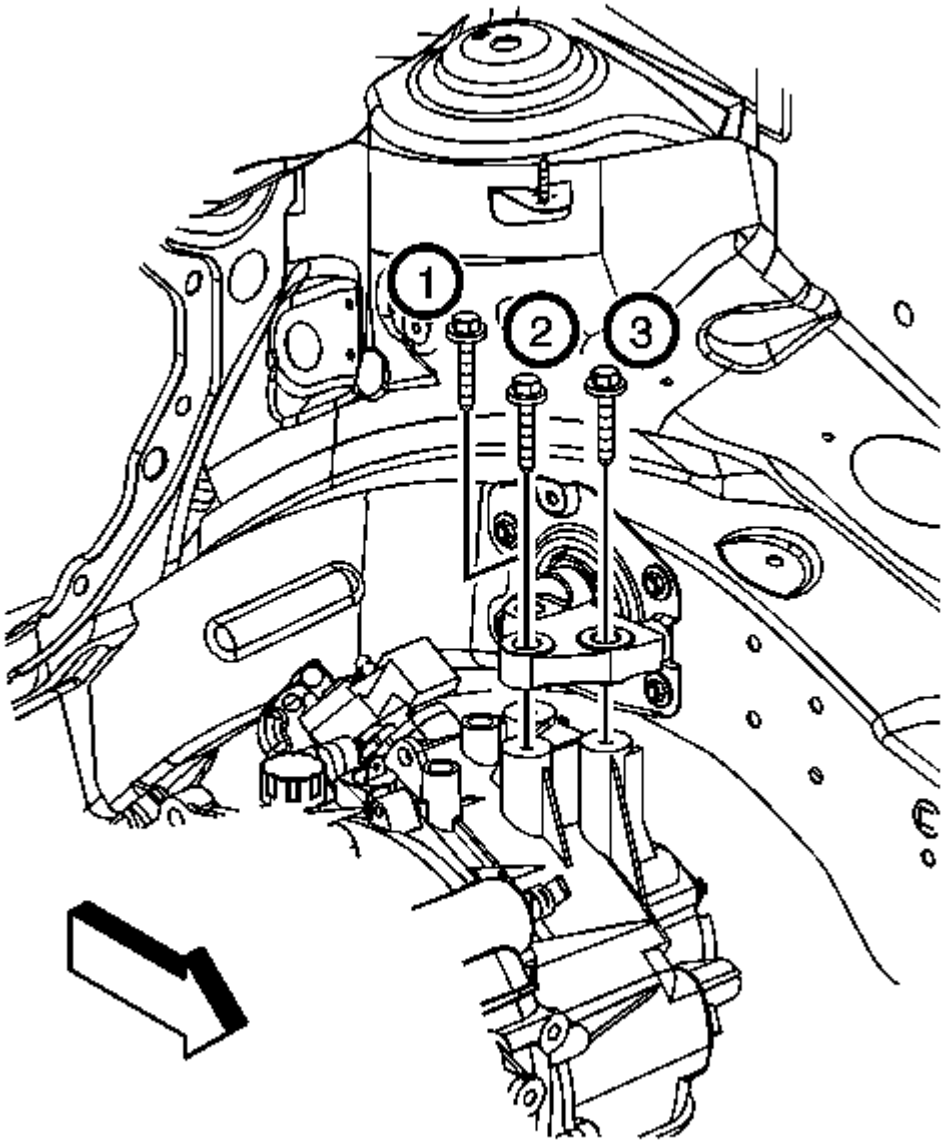

Fig. 291: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

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 **Steering Linkage Outer Tie Rod**

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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** .

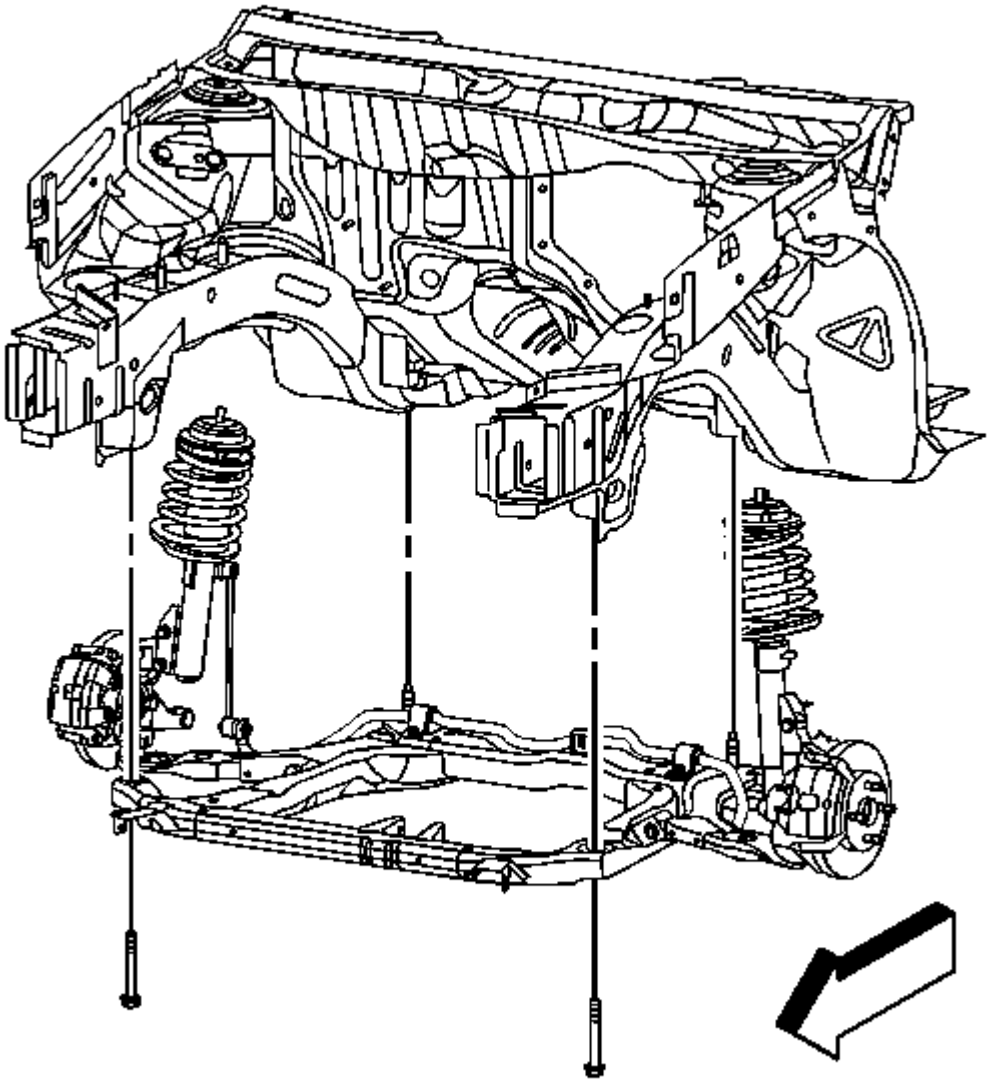

Fig. 292: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

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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.

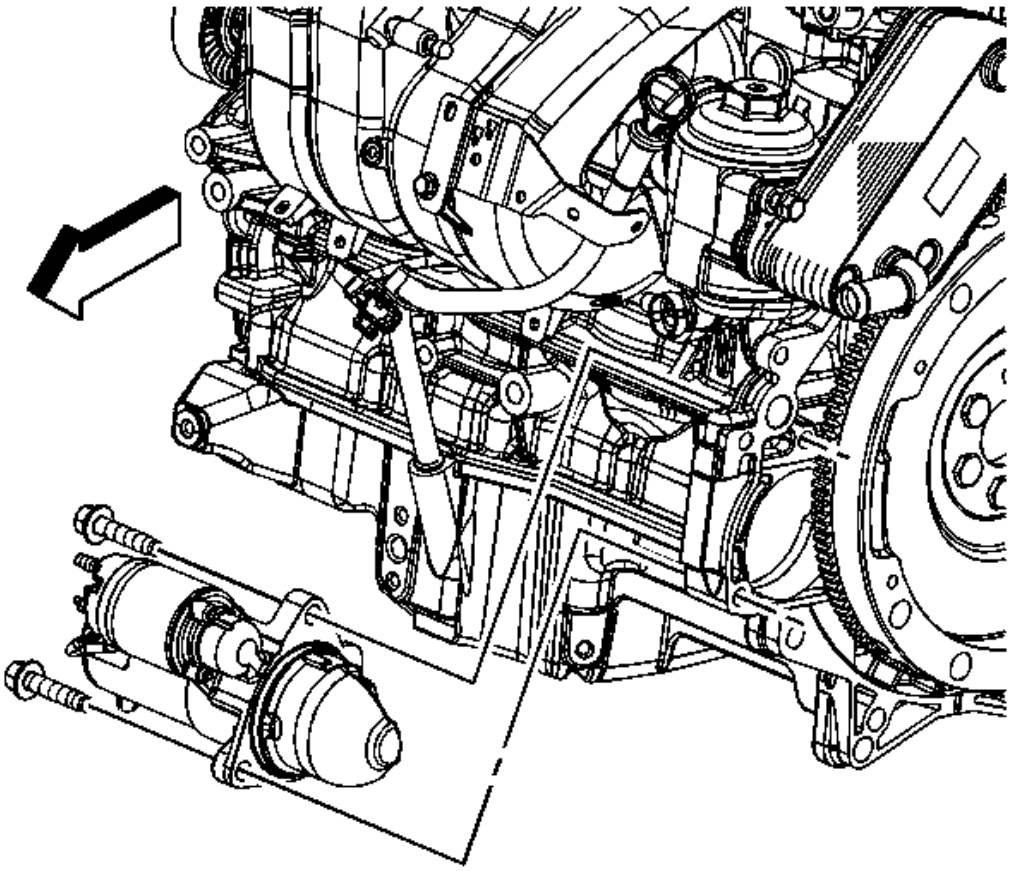

Fig. 293: Identifying Starter Bolts & Starter

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Courtesy of GENERAL MOTORS CORP.

93. Remove the starter bolts and starter.

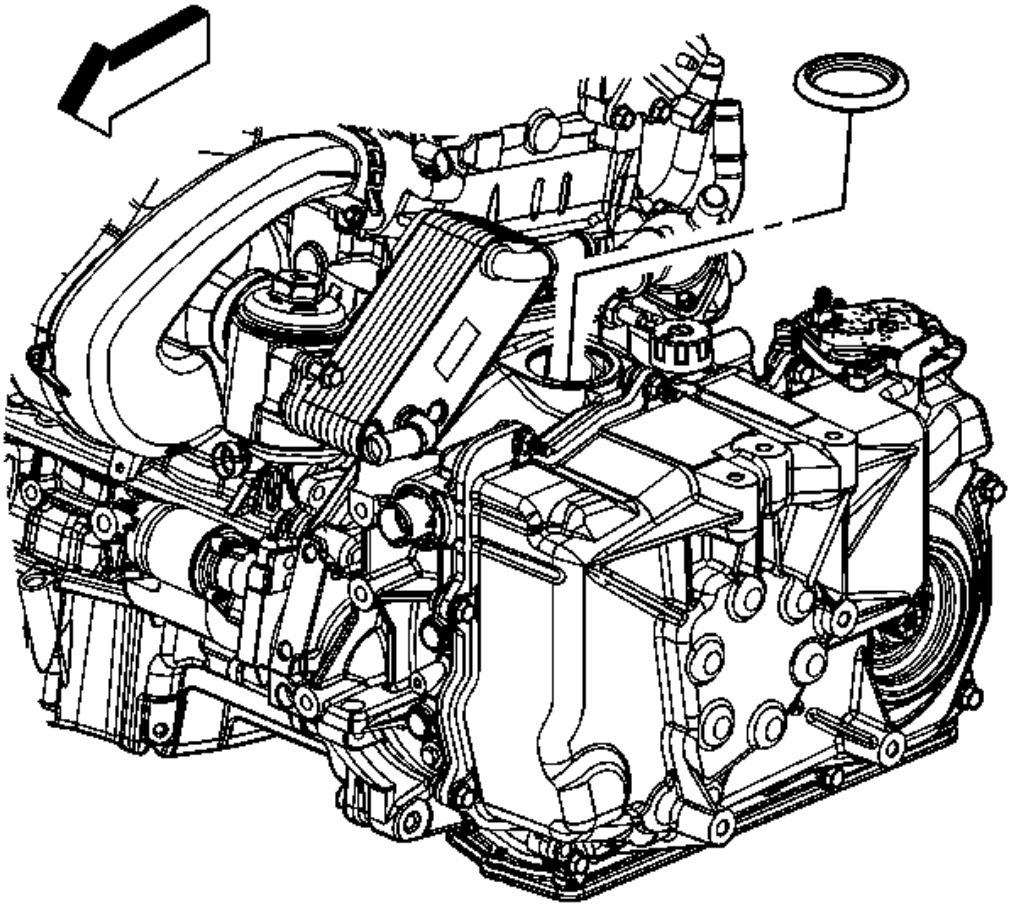

Fig. 294: Identifying Torque Converter Housing Access Plug
Courtesy of GENERAL MOTORS CORP.

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

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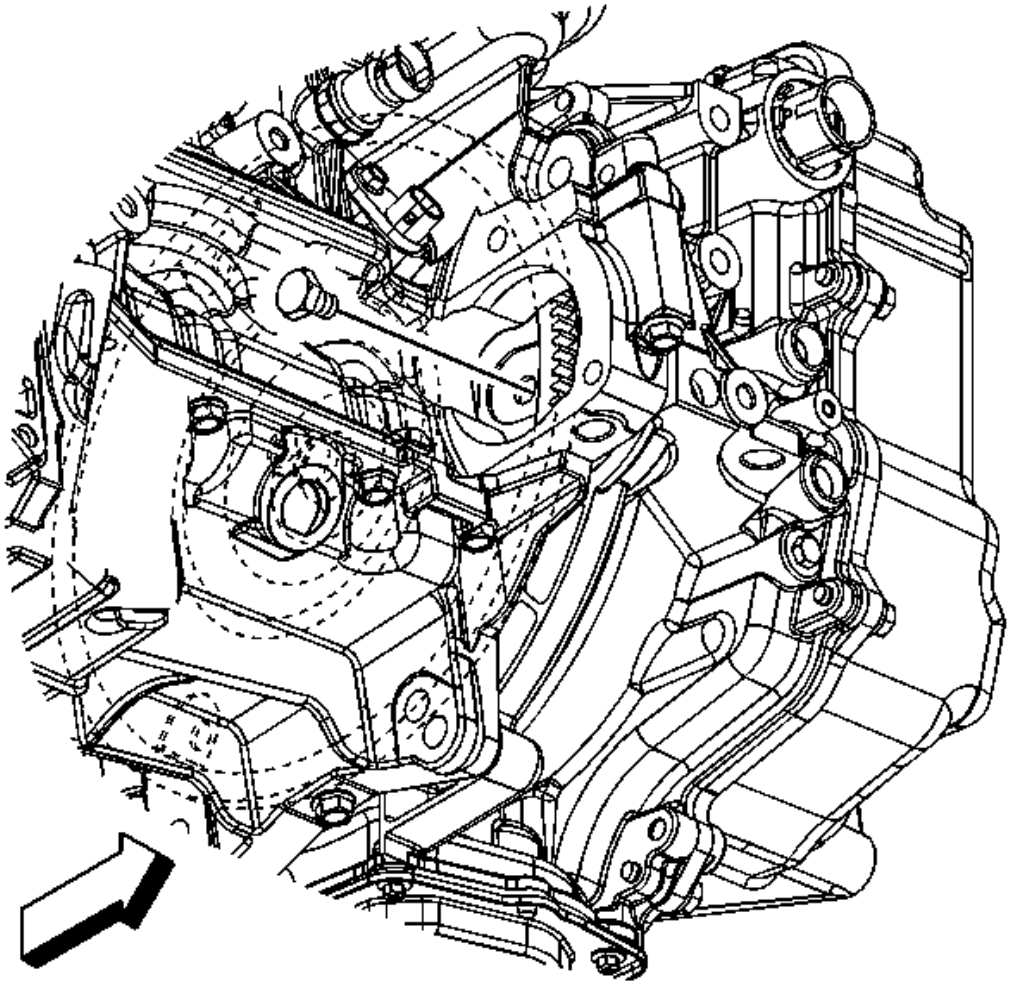

Fig. 295: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

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

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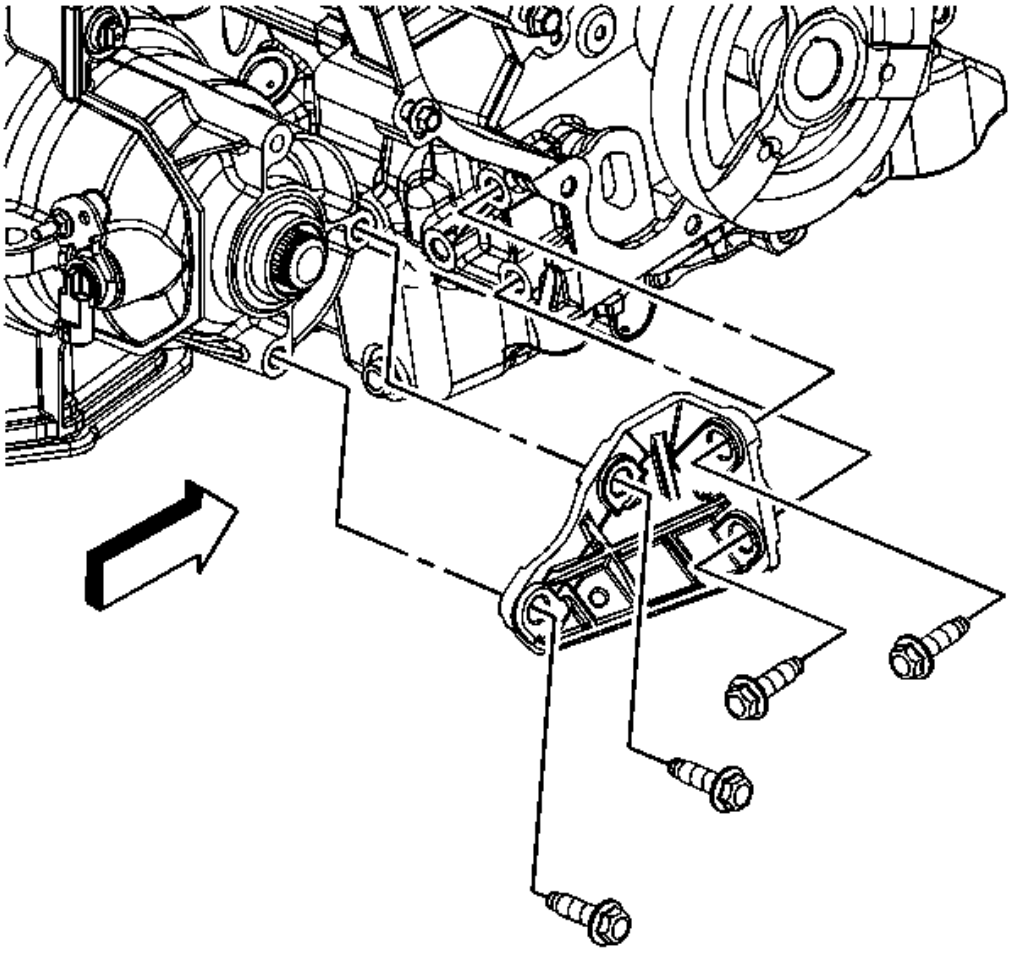

Fig. 296: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

96. Remove the transaxle brace bolts and brace.

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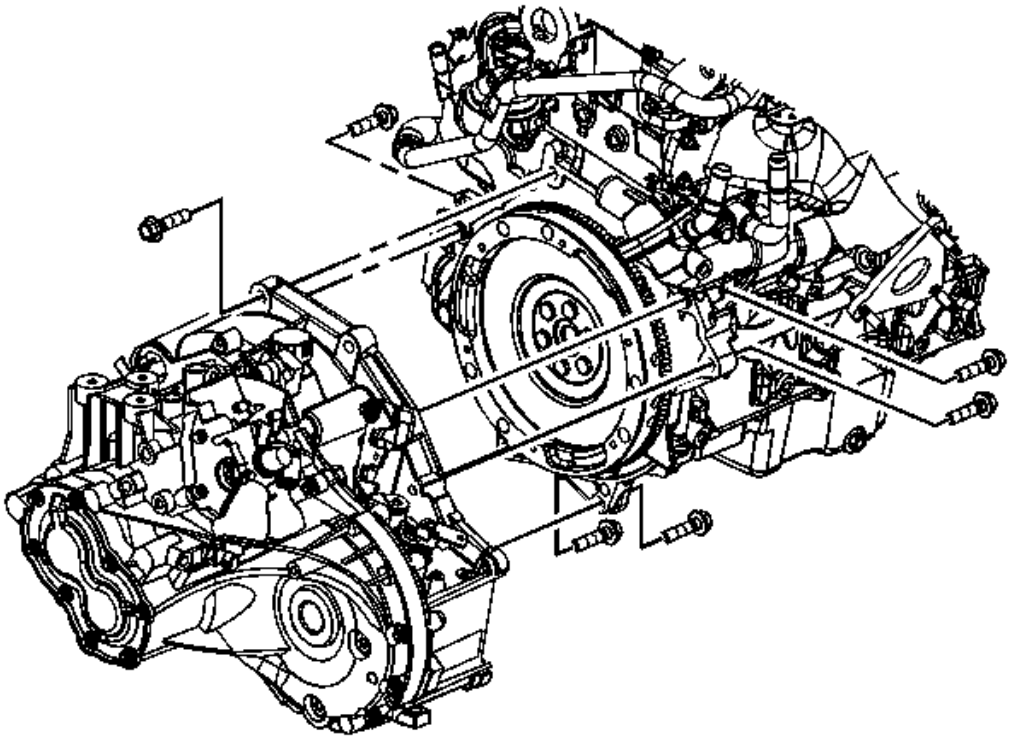

Fig. 297: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

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

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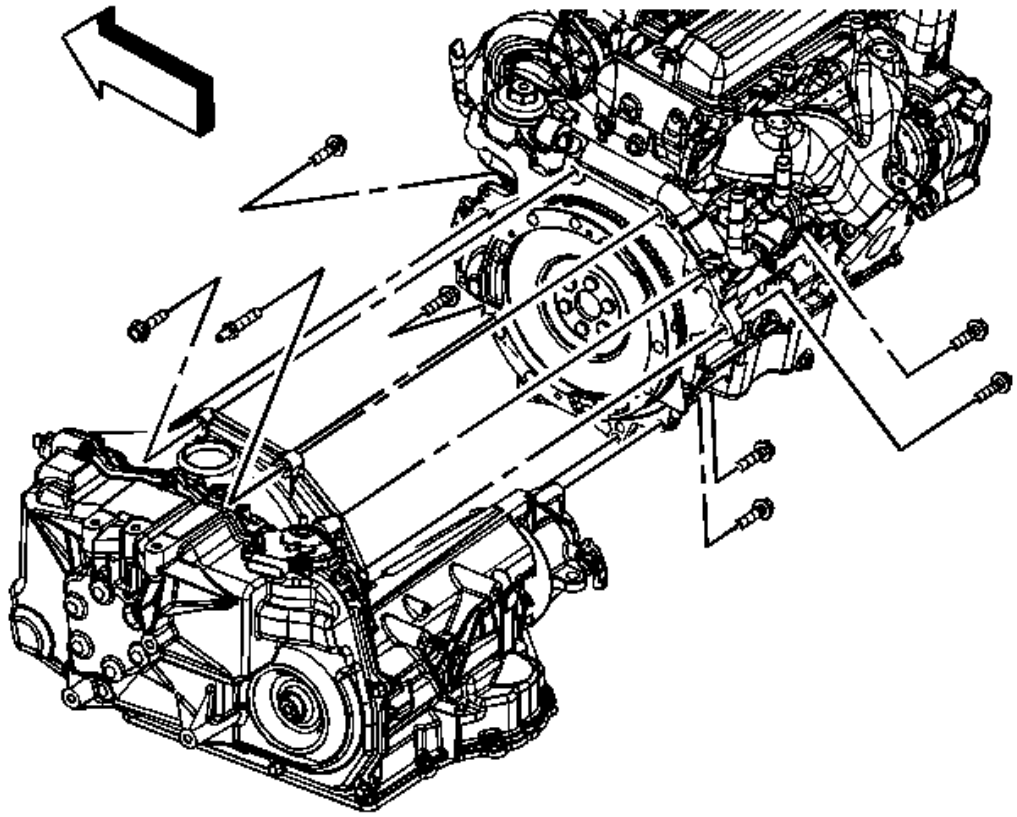

Fig. 298: Identifying Engine/Transaxle Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

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 Pressure and Driven Plate Replacement** .
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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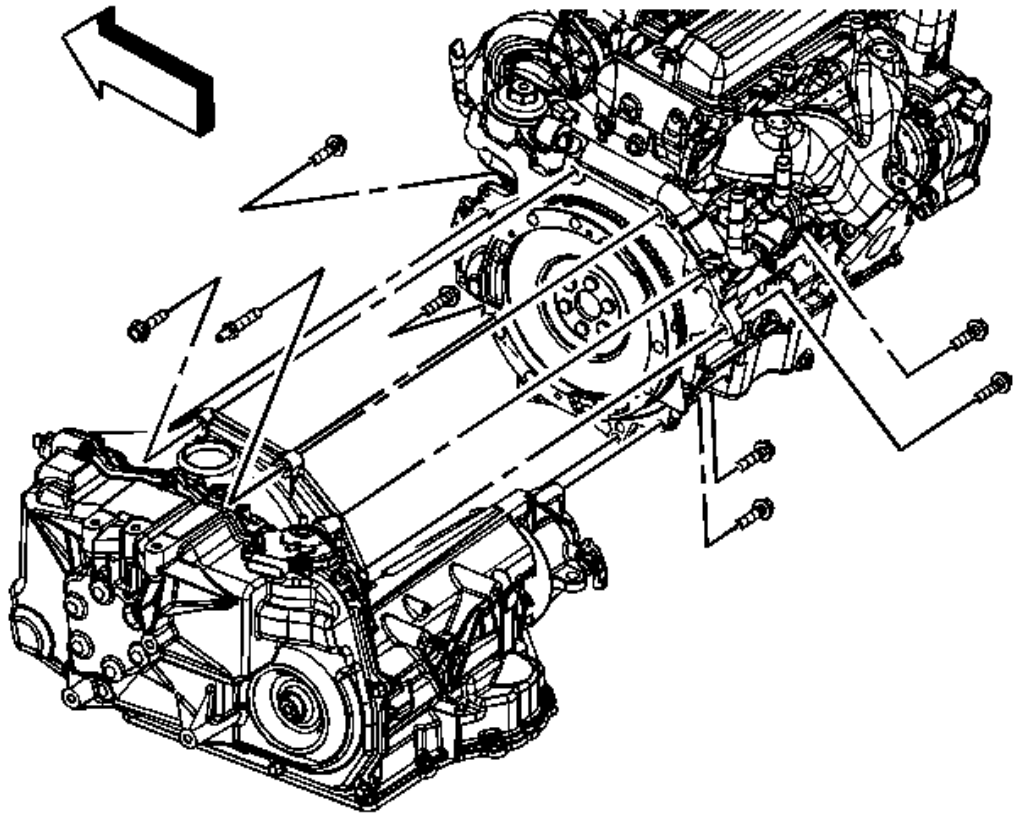

Fig. 299: Identifying Engine/Transaxle Mounting Bolts
Courtesy of GENERAL MOTORS CORP.

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 Pressure and Driven Plate Replacement** .
4. Install the engine to the transaxle.
5. Clean bolts and apply LOCTITE.

CAUTION: Refer to Fastener Caution .

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6. If equipped with a automatic transaxle, install the transaxle to engine bolts/stud and tighten to 75 N.m (55 lb ft).

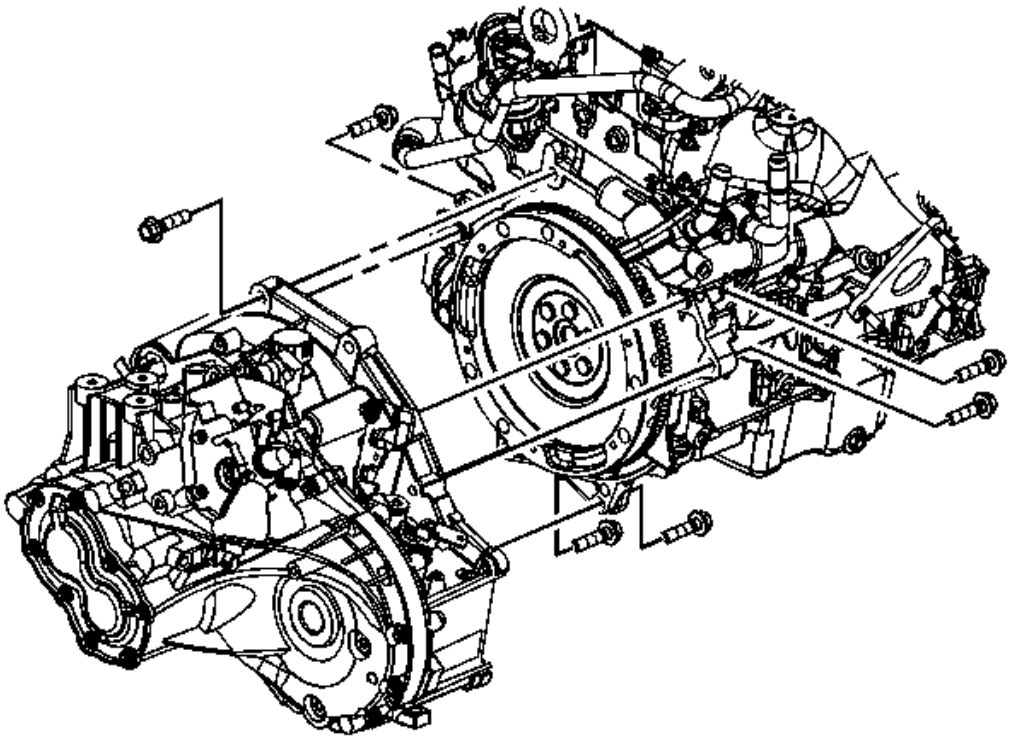

Fig. 300: Identifying Engine Bolts/Stud
Courtesy of GENERAL MOTORS CORP.

7. If equipped with a manual transaxle, install the transaxle to engine bolts/stud and tighten to 75 N.m (55 lb ft).

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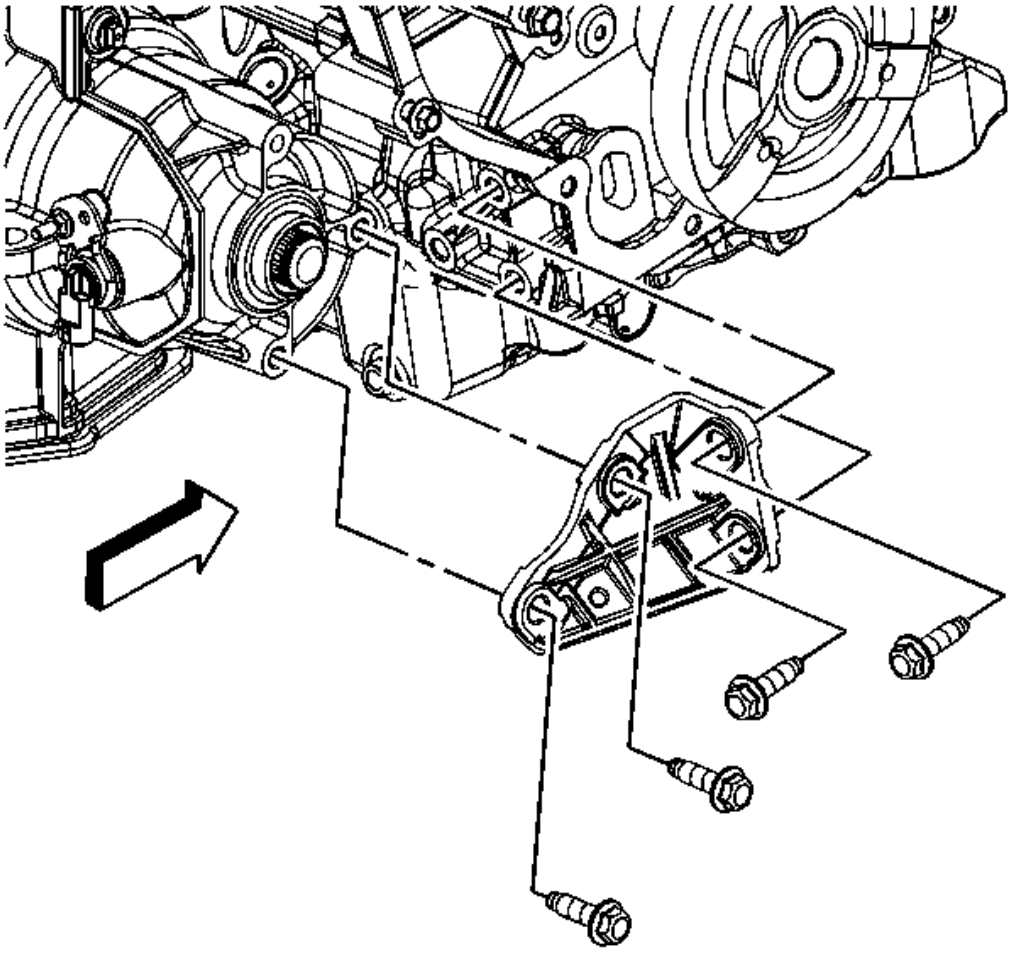

Fig. 301: View Of Transaxle Brace & Bolts
Courtesy of GENERAL MOTORS CORP.

8. Install the transaxle brace and bolts and tighten to 50 N.m (37 lb ft).

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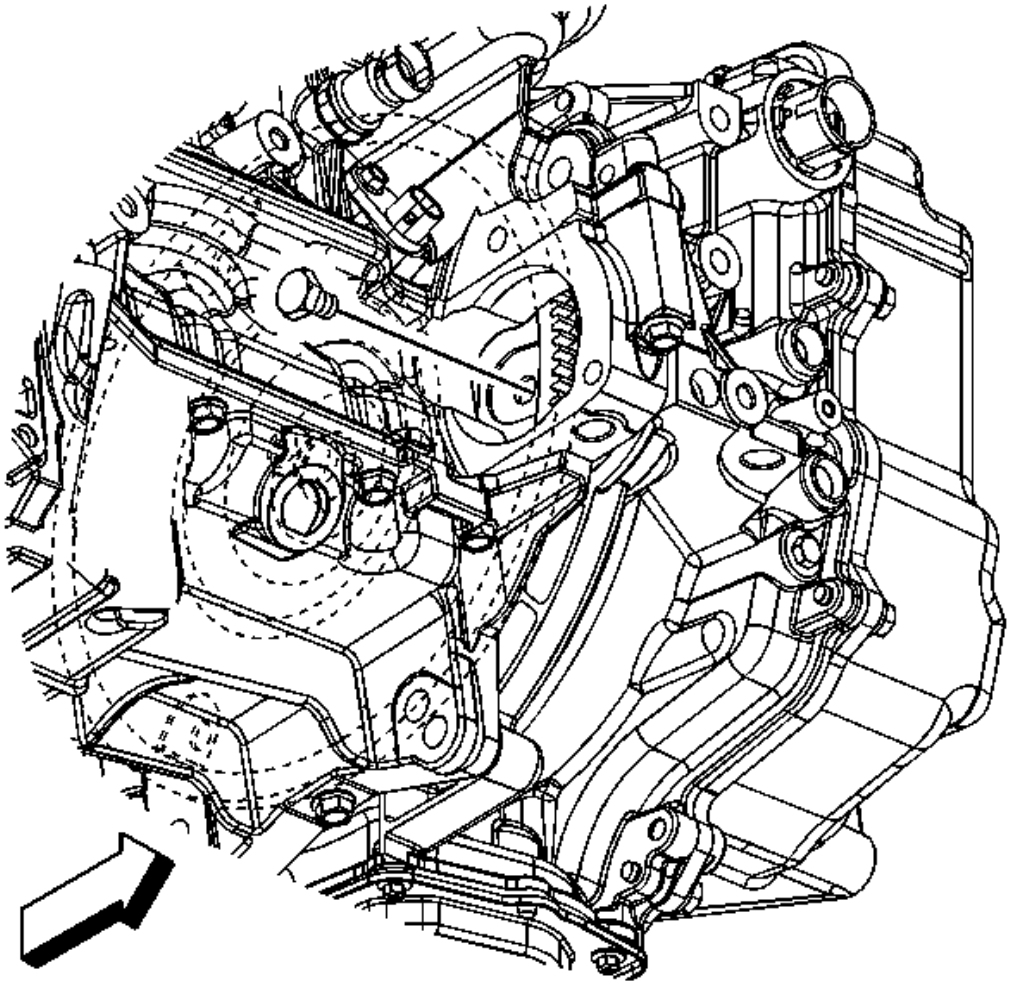

Fig. 302: Identifying Torque Converter Bolts
Courtesy of GENERAL MOTORS CORP.

9. If equipped with a automatic transaxle, install the torque converter bolts and tighten to 62 N.m (46 lb ft).

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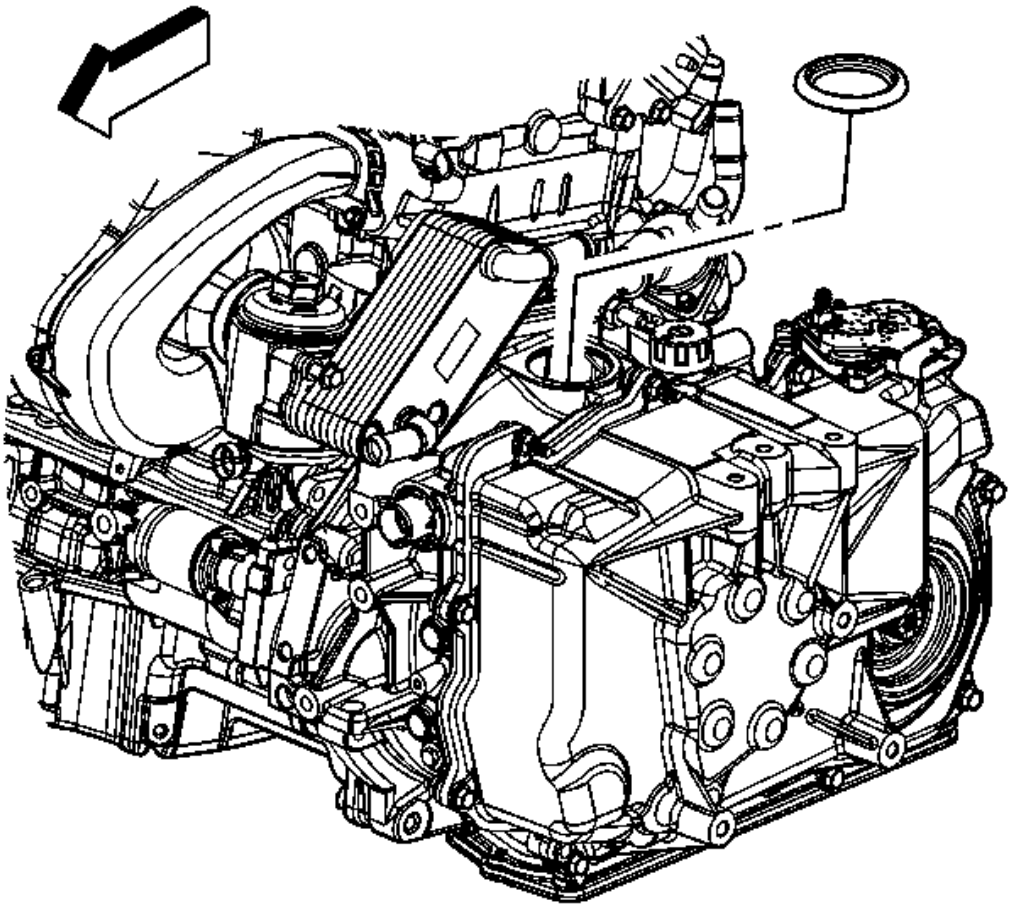

Fig. 303: Identifying Torque Converter Housing Access Plug
Courtesy of GENERAL MOTORS CORP.

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

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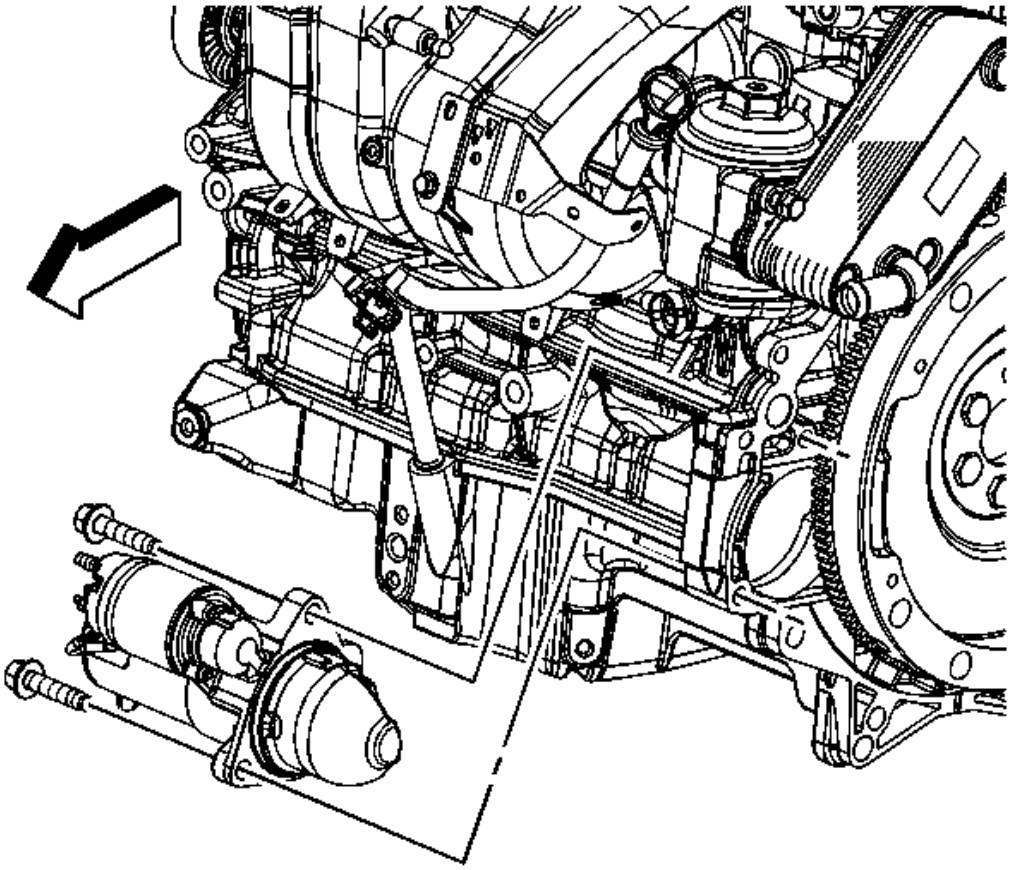

Fig. 304: Identifying Starter Bolts & Starter
Courtesy of GENERAL MOTORS CORP.

11. Install the starter and bolts and tighten to 40 N.m (30 lb ft).

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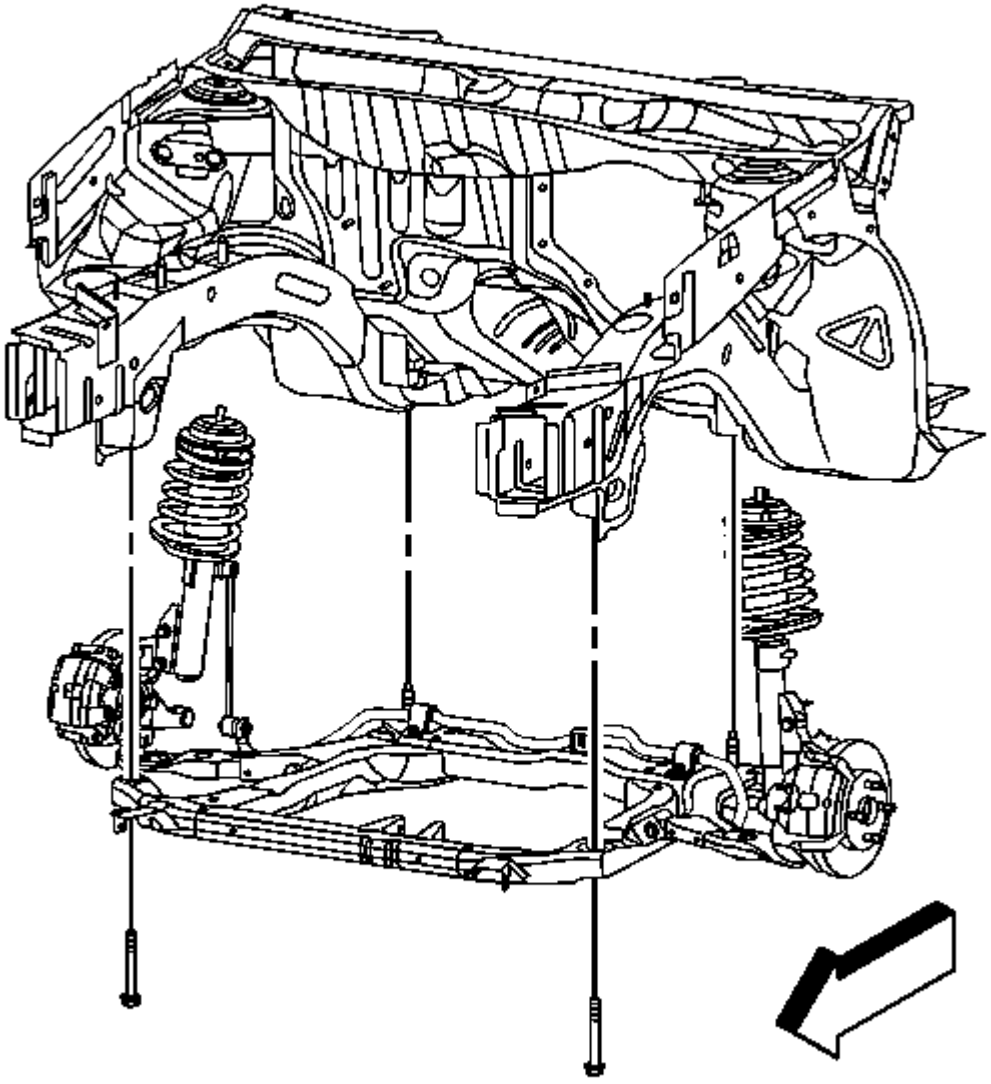

Fig. 305: Identifying Engine Lift Hoist-To-Engine Lift Hooks
Courtesy of GENERAL MOTORS CORP.

12. Remove the engine lift hoist from the engine lift hooks.
13. Slide the lift table under the vehicle.
14. Slowly lower the vehicle until it aligns with the alignment marks made during the removal.
15. Install and tighten the frame bolts to 100 N.m (74 lb ft) plus and additional 180 degrees.
16. Raise the vehicle until the lift table can be removed from under the vehicle.

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17. Remove the lift table.

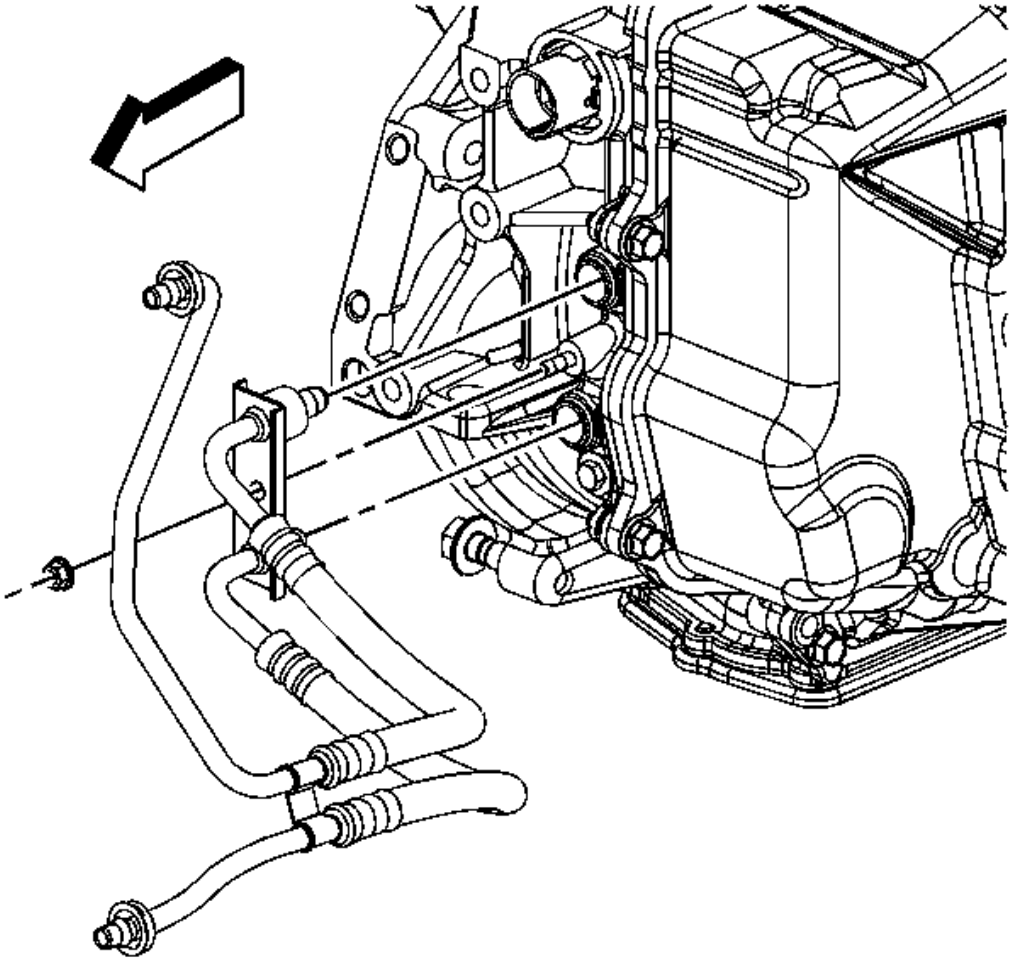

Fig. 306: Identifying Transaxle Fluid Cooler Lines & Bracket Nut
Courtesy of GENERAL MOTORS CORP.

18. Install the transaxle fluid cooler lines to the transaxle.
19. Install the transaxle fluid cooler bracket nut and tighten to 7 N.m (62 lb in).

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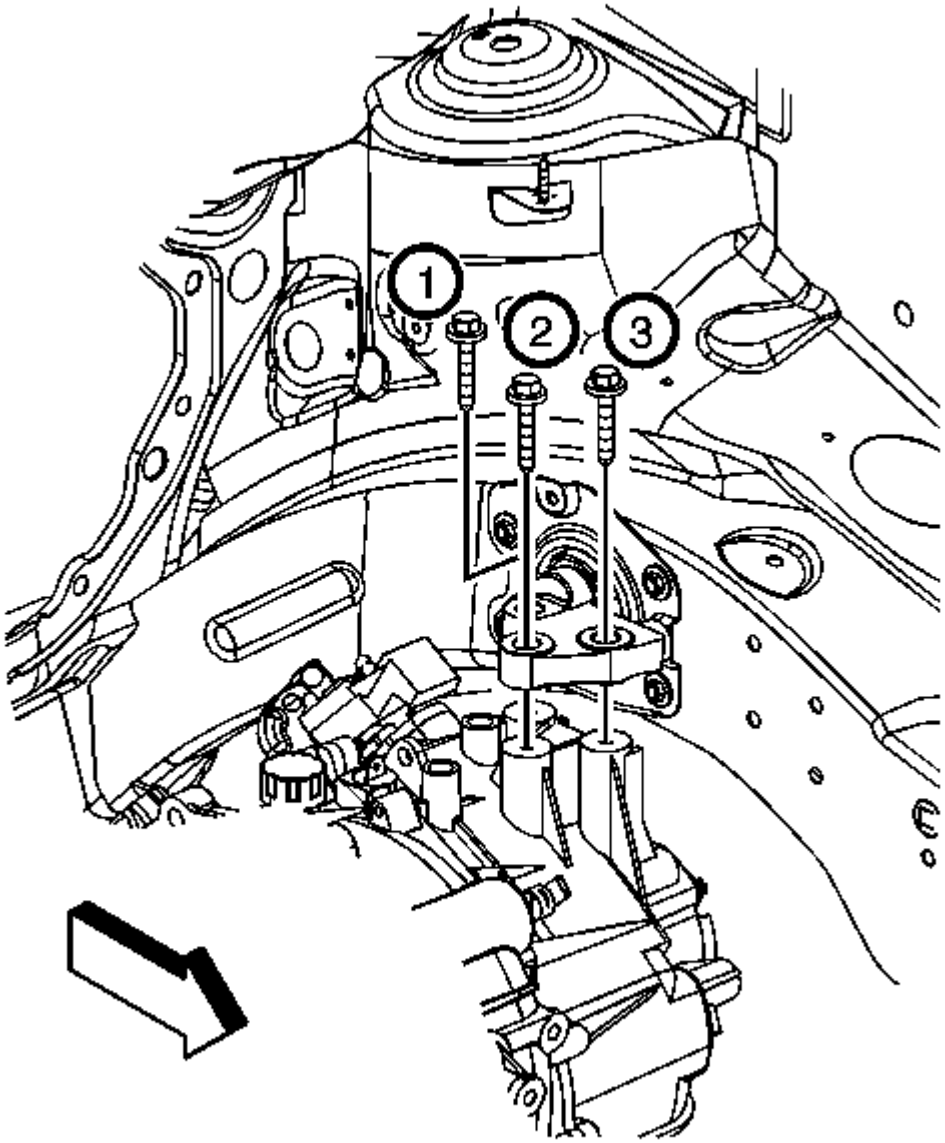

Fig. 307: Identifying Transaxle Mount To Transaxle Bolts
Courtesy of GENERAL MOTORS CORP.

20. Connect the lower control arms to the steering knuckles. Refer to **Lower Control Arm Replacement** .
21. Connect the intermediate shaft to the steering gear. Refer to **Intermediate Steering Shaft Replacement** .
22. Connect the outer tie rod ends to the steering knuckles. Refer to **Steering Linkage Outer Tie Rod Replacement** .

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23. Connect the stabilizer links to the stabilizer bar. Refer to **Stabilizer Shaft Link Replacement** .
24. Lower the vehicle.
25. Install the transaxle mount to transaxle bolts and tighten to 45 N.m (33 lb ft).

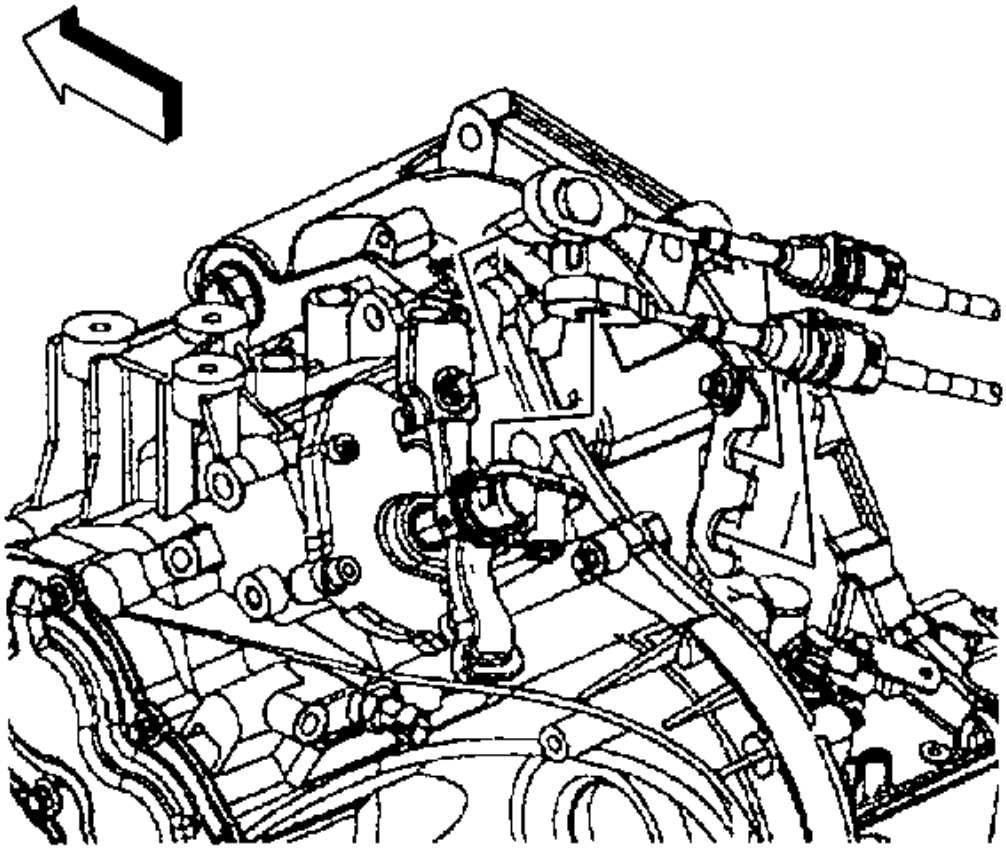

Fig. 308: Range Selector And Shift Lever Cables
Courtesy of GENERAL MOTORS CORP.

26. Install the engine mount. Refer to **Engine Mount Replacement**.
27. Remove the blocks of wood from between the powertrain and the frame.
28. Install the catalytic converter. Refer to **Catalytic Converter Replacement (LAP)** .
29. Lower the vehicle.

NOTE: **Ensure that the black cable is installed in the top notch of the transaxle bracket and the white cable in installed in the bottom notch of the transaxle bracket.**

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30. If equipped with a manual transaxle, install the range selector and shift lever cables to the transaxle bracket.
31. Connect the range selector and shift lever cables to the transaxle levers.

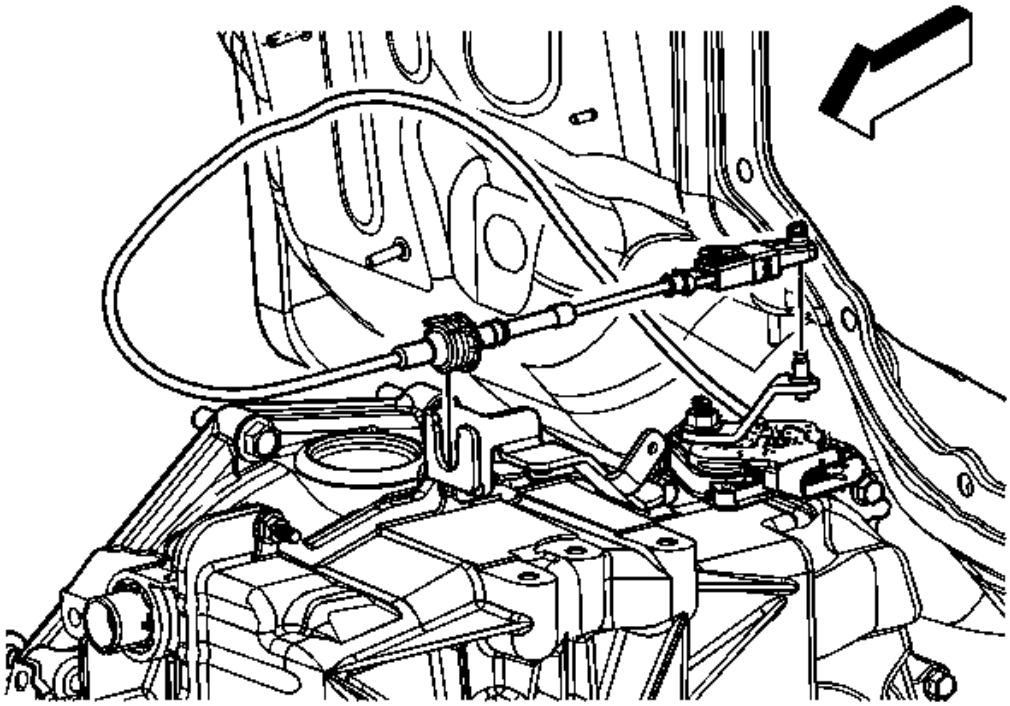

Fig. 309: Identifying Range Selector Level Cable
Courtesy of GENERAL MOTORS CORP.

32. If equipped with a automatic transaxle, install the range selector lever cable to the transaxle bracket.
33. Connect the range selector lever cable to the transaxle lever.

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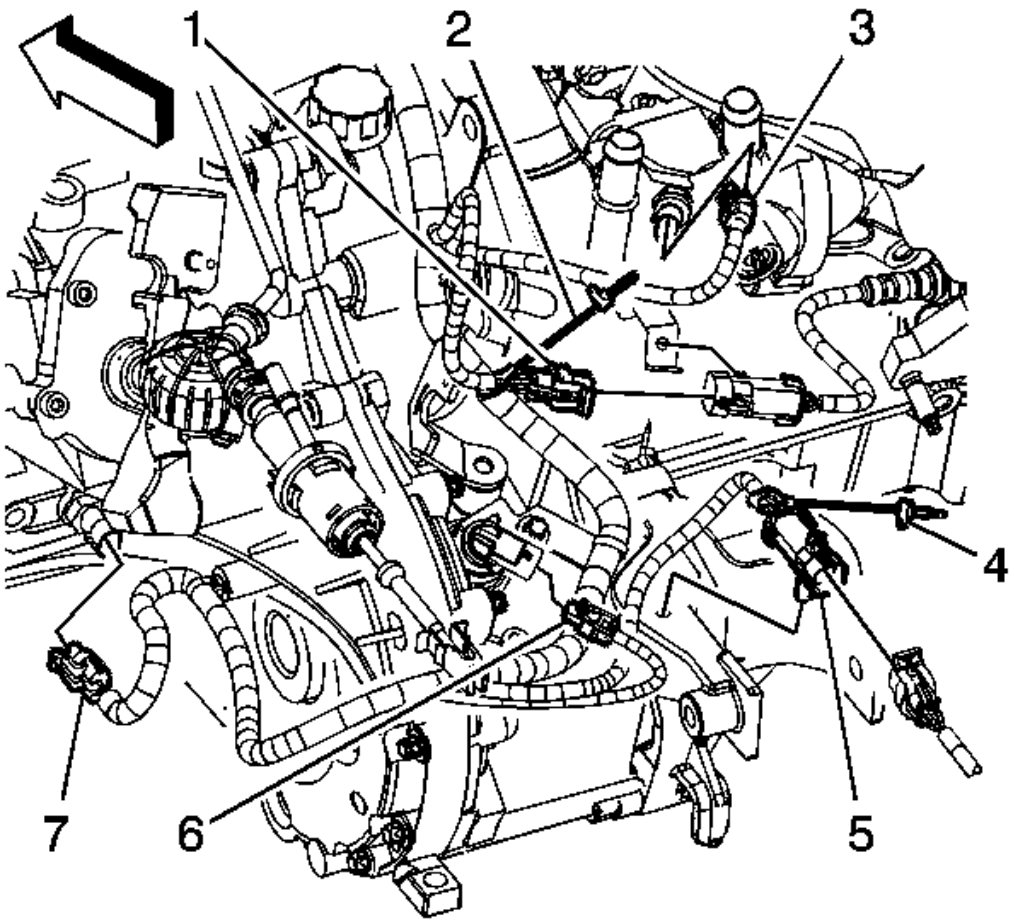

Fig. 310: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

34. Gather all engine harness branches and position the harness over the engine.
35. If equipped with a manual transaxle, perform the following steps. Install the HO2S clips to the engine brackets.
36. Connect the engine harness electrical connectors (1, 5) to the HO2S.
37. Install the HO2S CPA retainers (2, 4).
38. Connect the engine harness electrical connector (7) to the back up lamp switch.
39. Connect the engine harness electrical connector (1) to the VSS.

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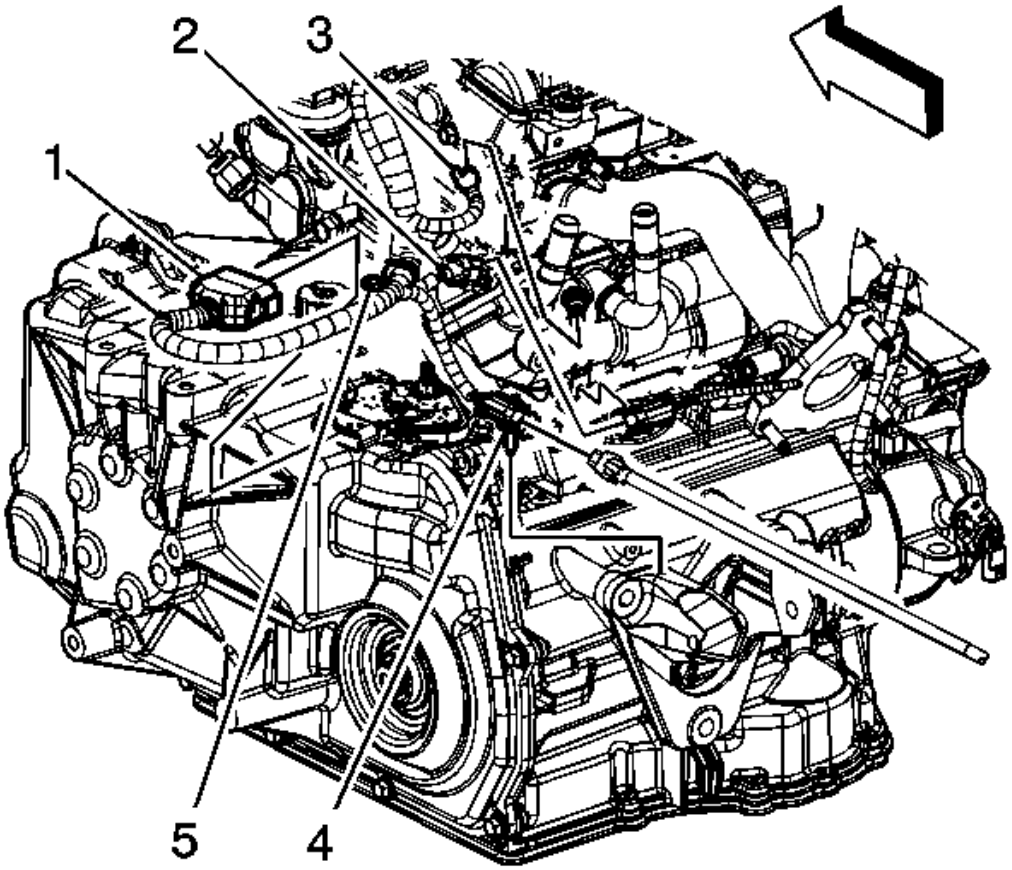

Fig. 311: Identifying Engine Harness Electrical Connectors - Top Of Engine
Courtesy of GENERAL MOTORS CORP.

40. If equipped with a automatic transaxle, perform the following steps. Connect the engine harness electrical connector (1) to the park neutral position switch.
41. Install the engine harness clips to the thermostat housing and engine brackets.
42. Connect the engine harness electrical connectors (2, 4) to the HO2S.
43. Install the HO2S CPA retainers.
44. Connect the ECT sensor electrical connector (1).

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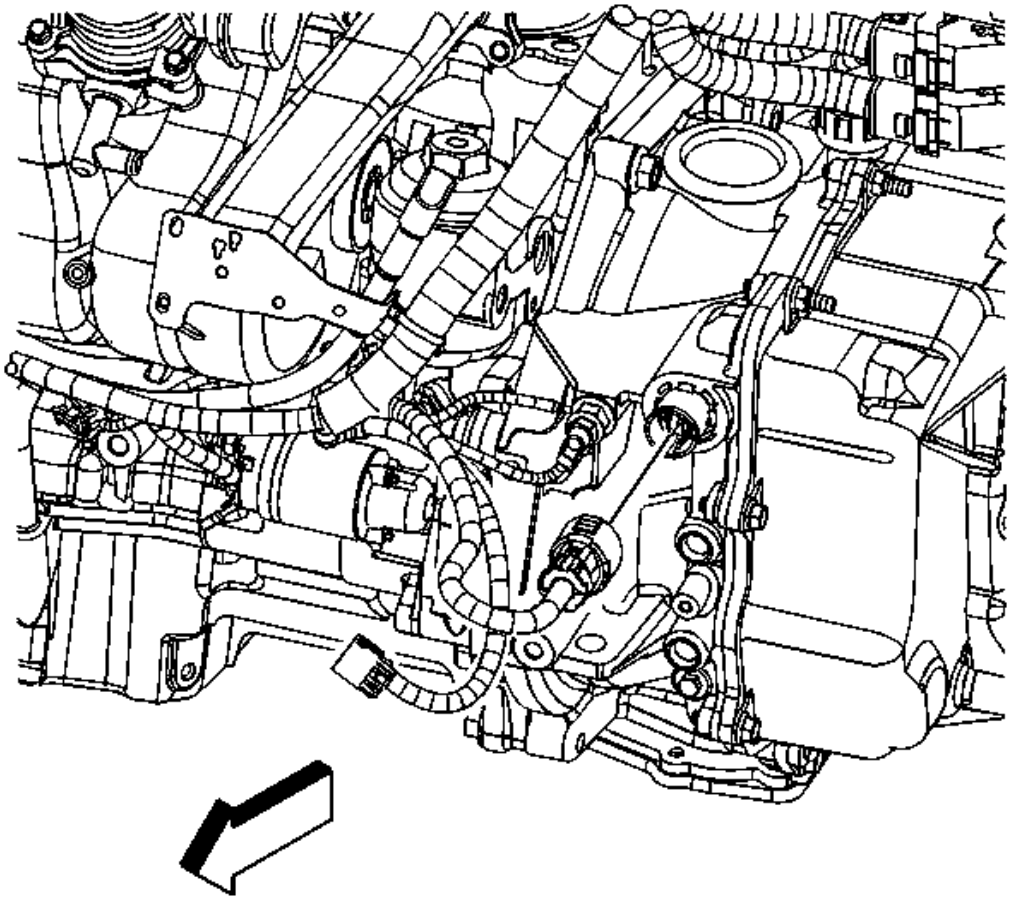

Fig. 312: Identifying Engine Harness
Courtesy of GENERAL MOTORS CORP.

45. If equipped with a automatic transaxle, connect the engine harness to the transaxle.
46. Raise the vehicle.

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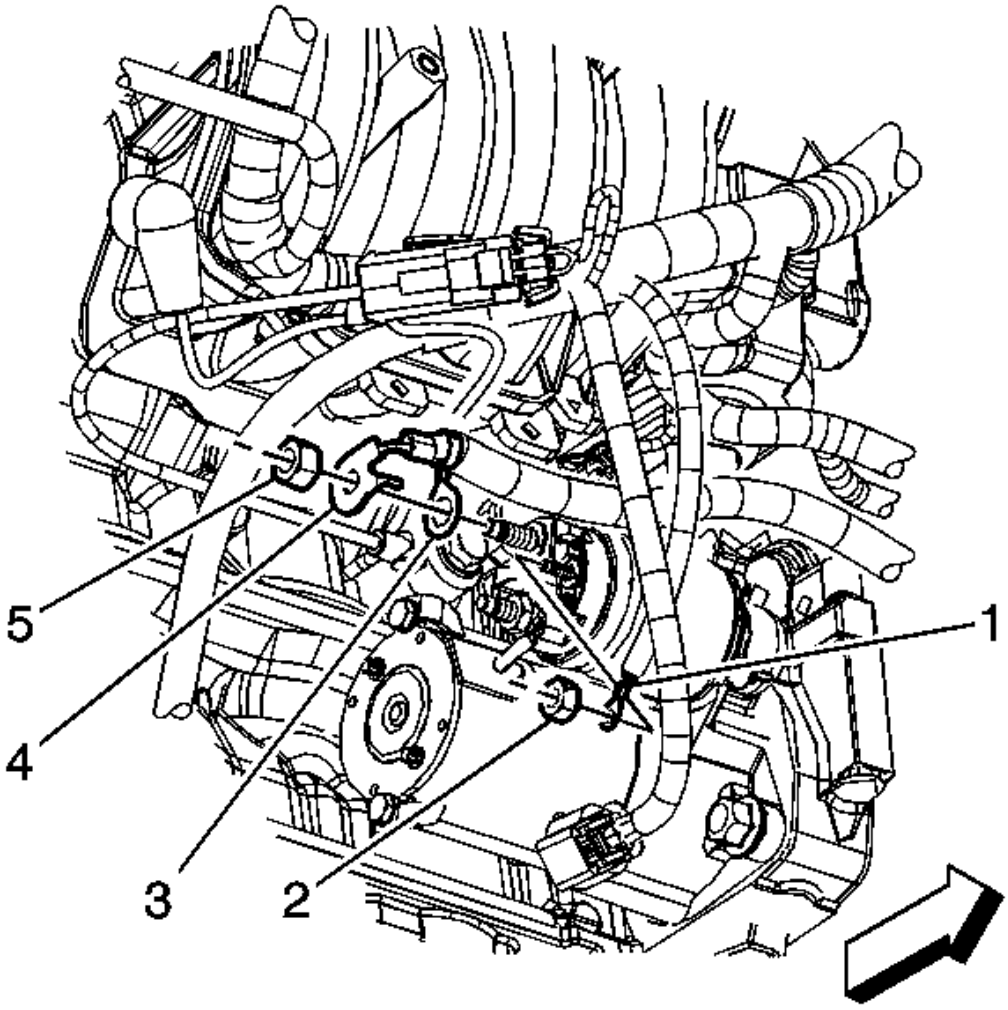

Fig. 313: View Of Engine Harness Terminal To Starter
Courtesy of GENERAL MOTORS CORP.

47. Install the engine harness lead terminal (1) to the starter solenoid.
48. Install the engine harness to starter solenoid "S" terminal nut (2) and tighten to 3 N.m (27 lb in).
49. Install the engine harness terminal (3) to the starter.
50. Install the positive battery cable terminal (4) to the starter.
51. Install the positive/negative battery cable lead nut (5) to the starter solenoid and tighten the nut to 17 N.m (13 lb ft).

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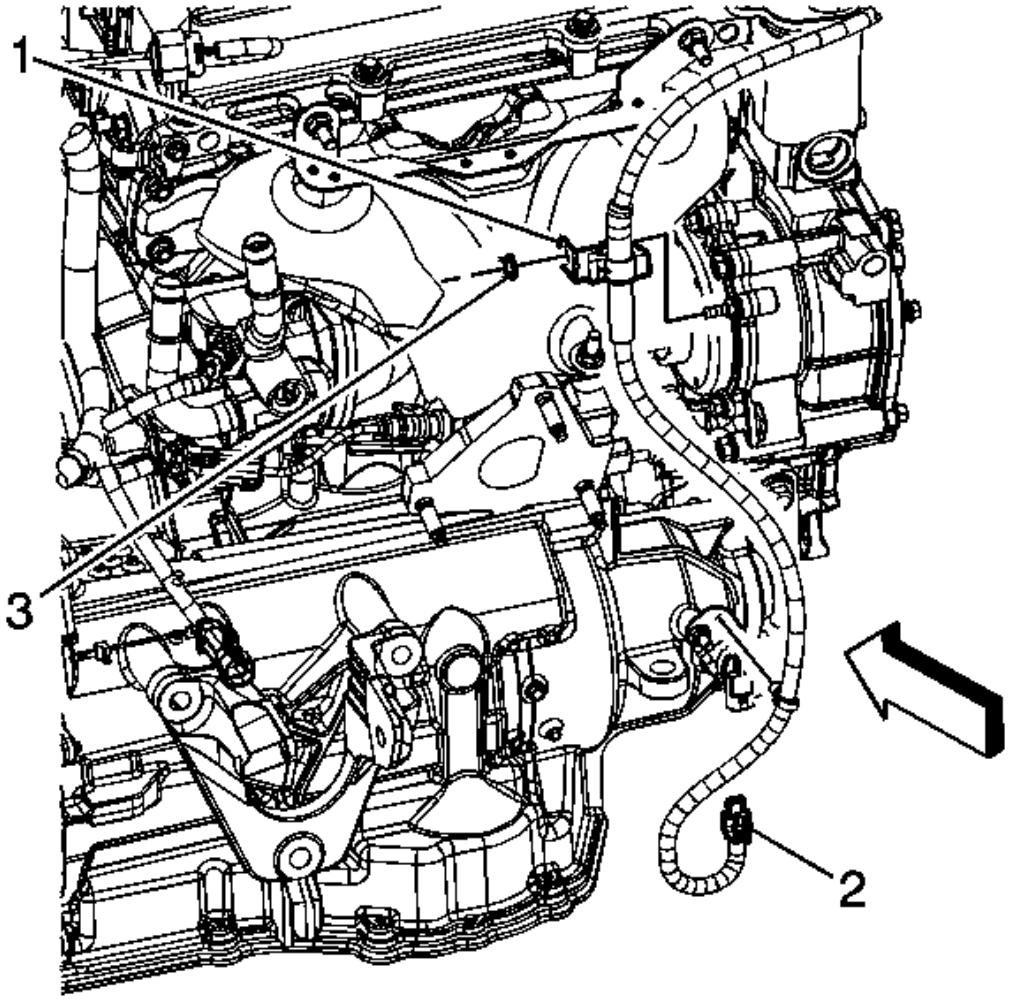

Fig. 314: Identifying Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

52. Install the engine harness clip (3) to the speed sensor.
53. Connect the engine harness electrical connector (2) to the VSS.
54. Install the engine harness clip (1) to the stud.
55. Install the engine harness clip nut (3) to the engine stud and tighten the nut to 50 N.m (37 lb ft).

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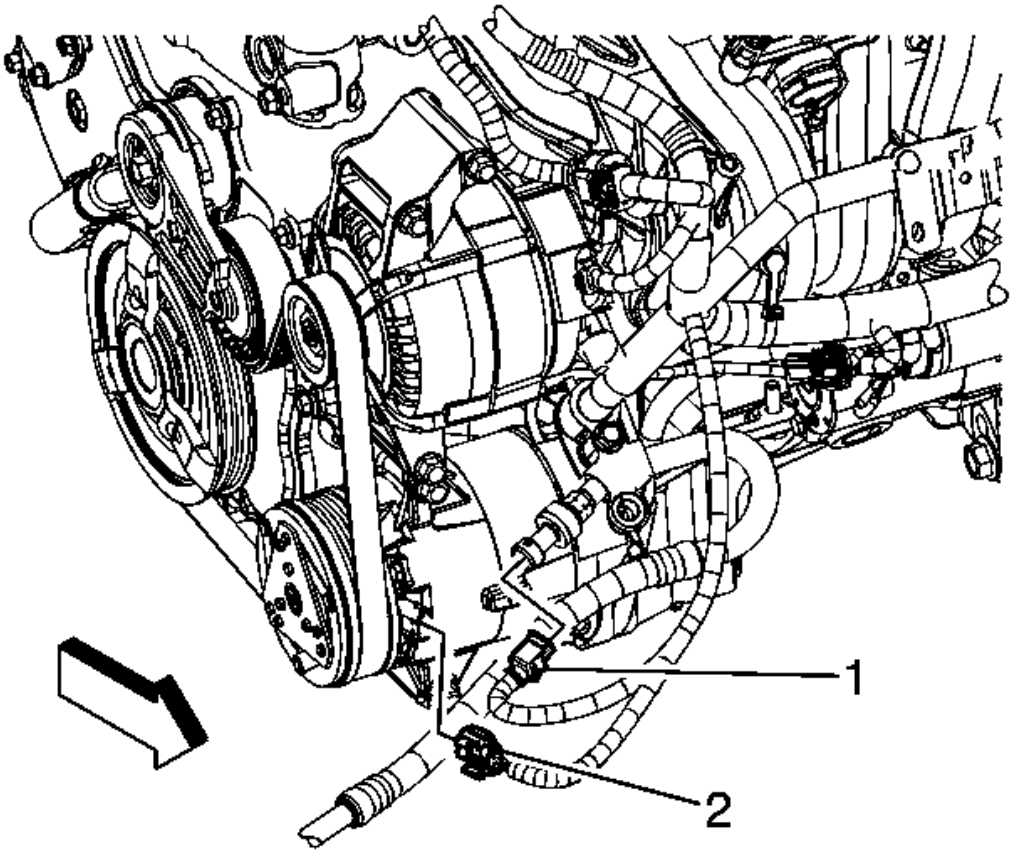

Fig. 315: View Of Engine Harness Electrical Connector To A/C Compressor And Pressure Switch
Courtesy of GENERAL MOTORS CORP.

56. Lower the vehicle.
57. Reposition and install the AC compressor and tighten the bolts to 50 N.m (37 lb ft).
58. Connect the engine harness electrical connector (2) to the A/C compressor.
59. Connect the engine harness electrical connector (1) to the A/C pressure switch.

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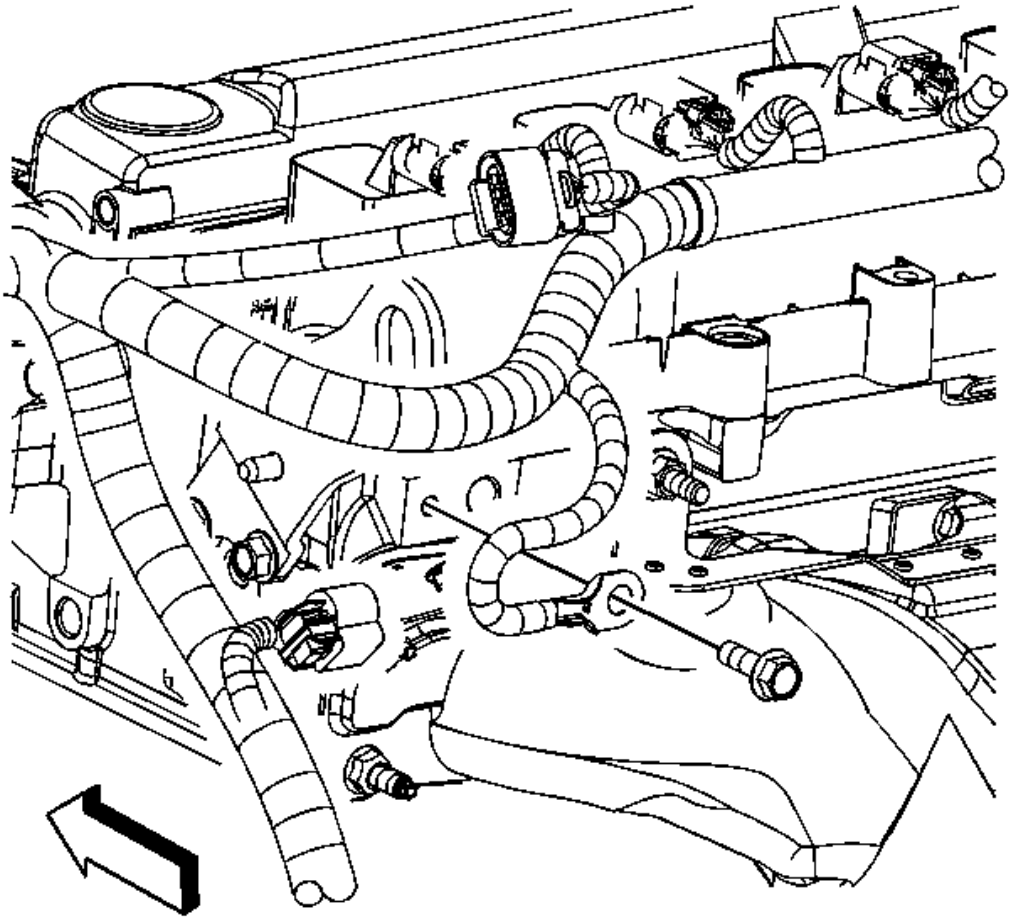

Fig. 316: Identifying Engine Harness Ground Terminal
Courtesy of GENERAL MOTORS CORP.

60. Position the engine harness ground terminal to the engine block.
61. Install the engine harness ground bolt and tighten to 25 N.m (18 lb ft).

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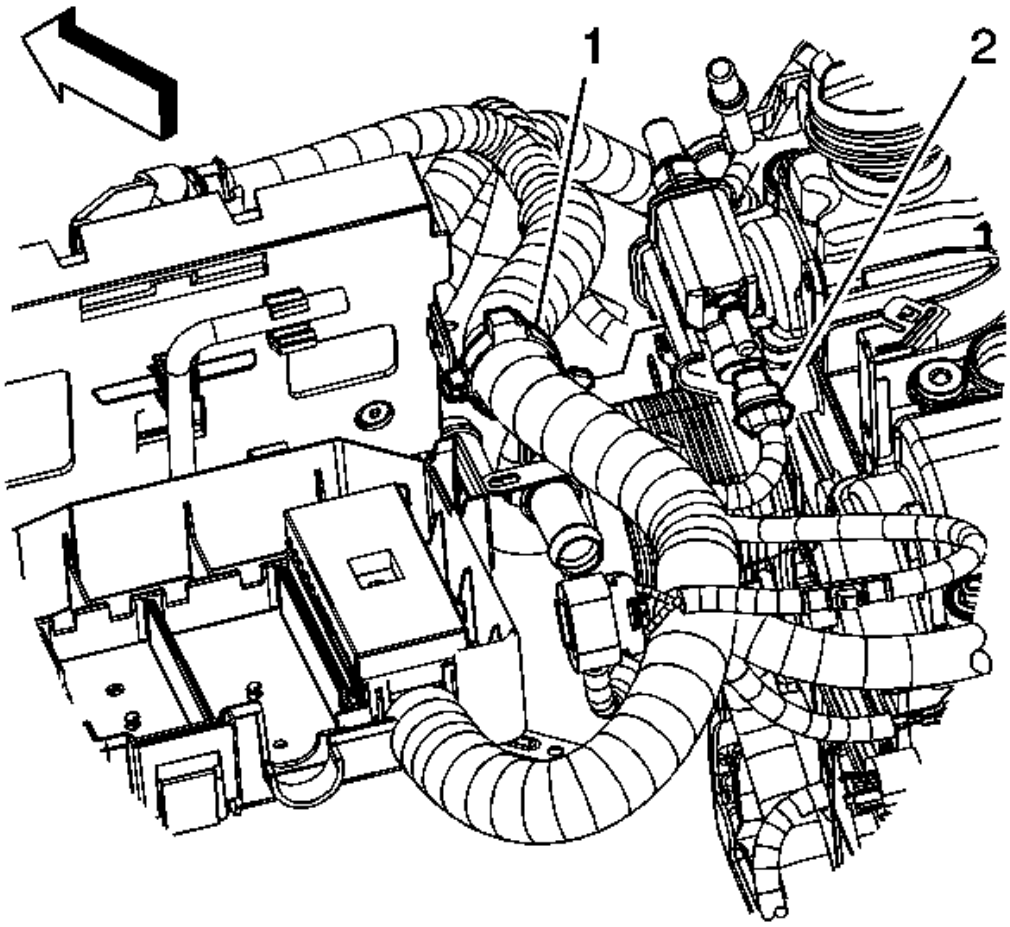

Fig. 317: Locating EVAP Purge Solenoid Electrical Connector
Courtesy of GENERAL MOTORS CORP.

62. Connect the EVAP purge solenoid electrical connector (2).
63. Install the engine harness clip (1) to the EVAP purge solenoid bracket.

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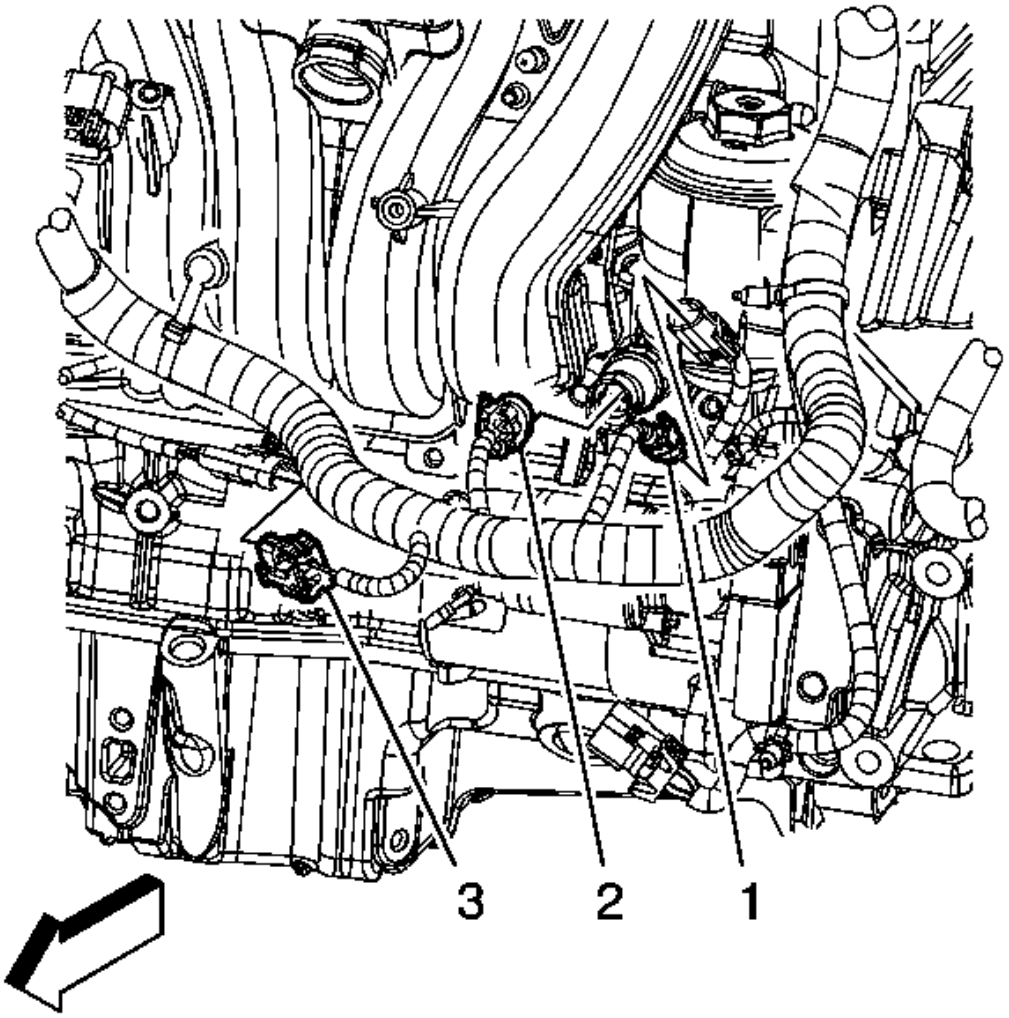

Fig. 318: View Of Knock Sensor (KS) Electrical Connector
Courtesy of GENERAL MOTORS CORP.

64. Connect the following electrical connectors:
    - Knock sensor (3)
    - CKP sensor (1)
    - Oil pressure sensor (2)

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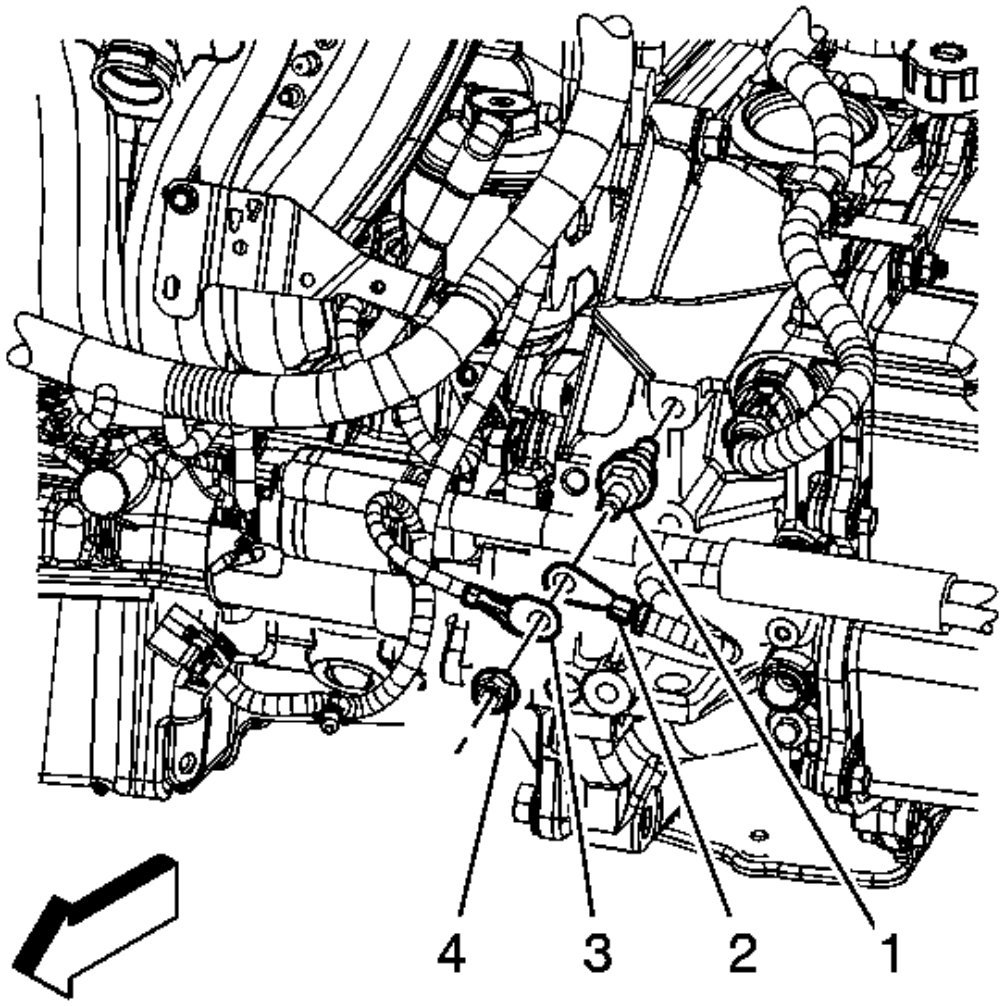

Fig. 319: View Of Battery Connections
Courtesy of GENERAL MOTORS CORP.

65. Install the negative battery cable ground terminal (2) to the stud.
66. Install the engine harness ground terminal (3) to the stud.
67. Install the negative battery cable ground nut (4) and tighten to 10 N.m (89 lb in).

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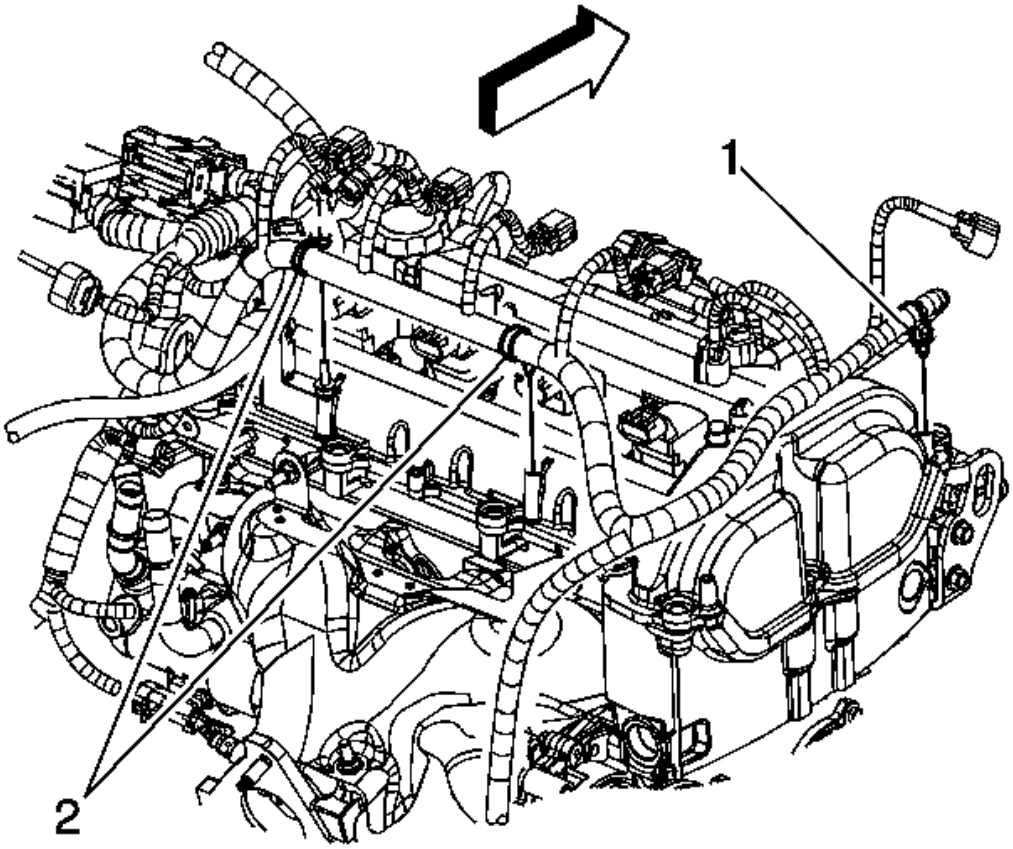

Fig. 320: View Of Engine Harness Clips
Courtesy of GENERAL MOTORS CORP.

68. Install the engine harness clips (1 and 2) to the camshaft cover.

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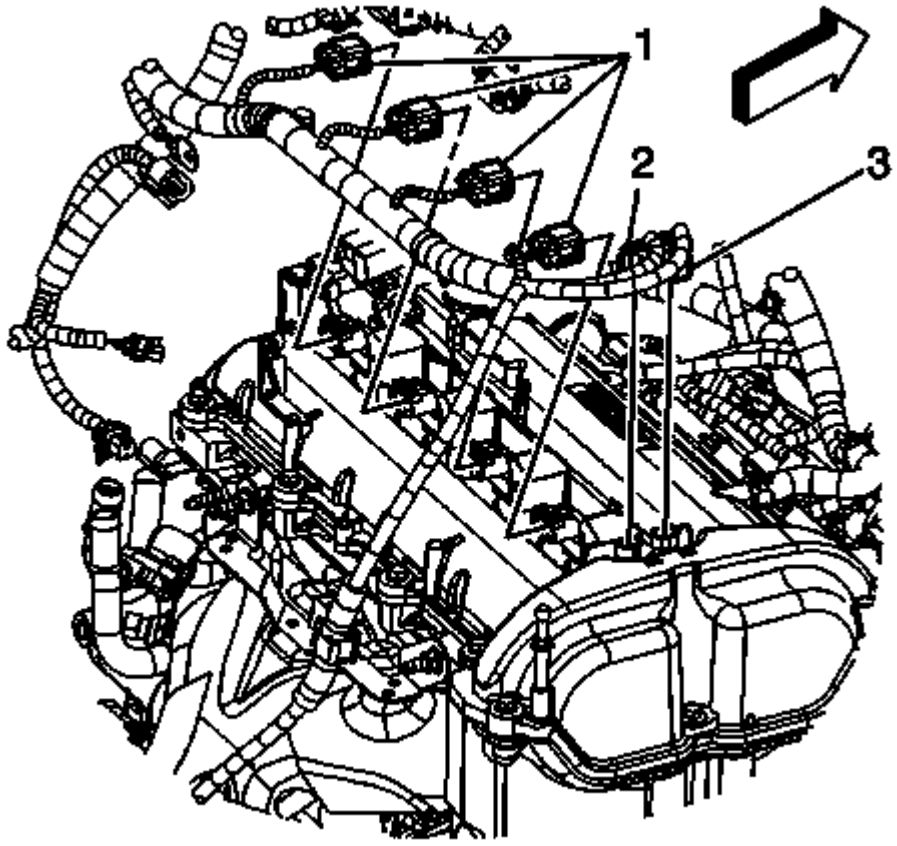

Fig. 321: Camshaft Position Actuator Solenoid Valve Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

69. Connect the intake (3) and exhaust (2) camshaft position actuator electrical connectors.
70. Connect the ignition coils electrical connectors (1).

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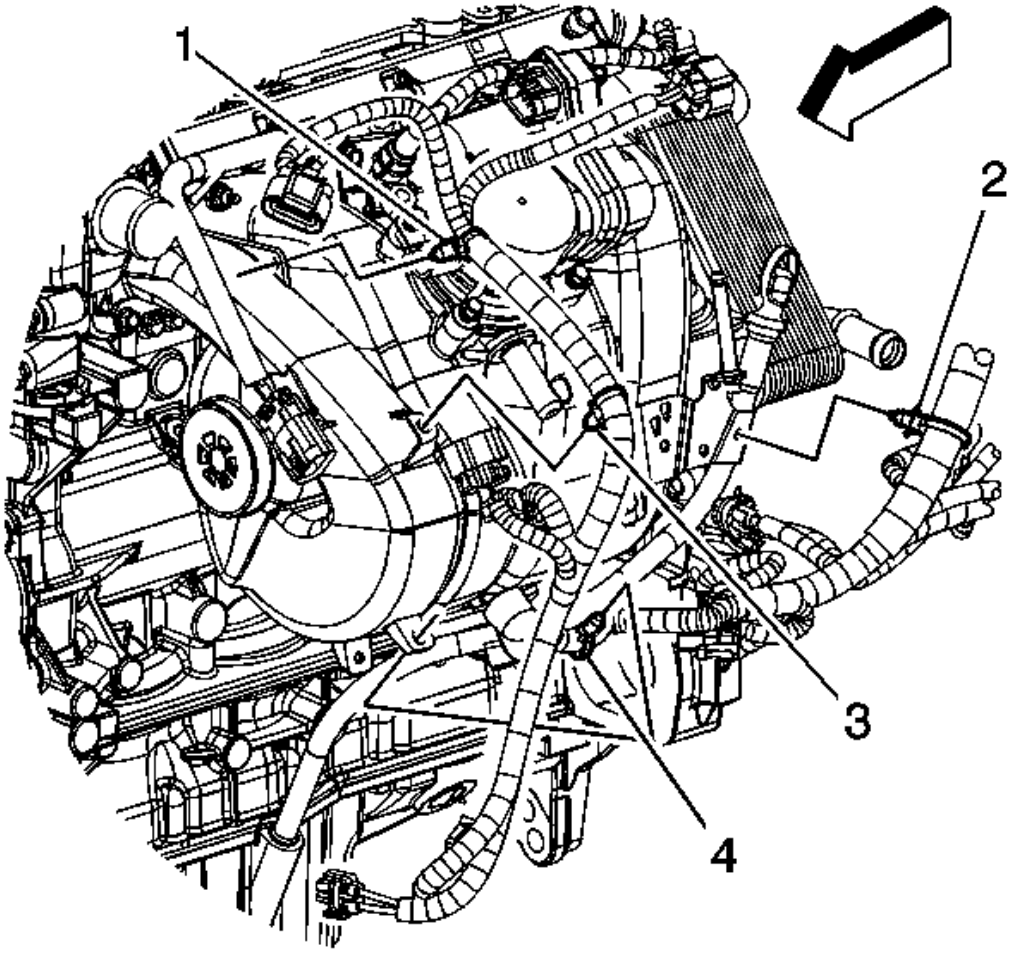

Fig. 322: Identifying Engine Harness Clip
Courtesy of GENERAL MOTORS CORP.

71. Connect the engine harness clips (1, 3 and 4) to the intake manifold.
72. Connect the engine harness clip (2) to the oil level indicator tube.

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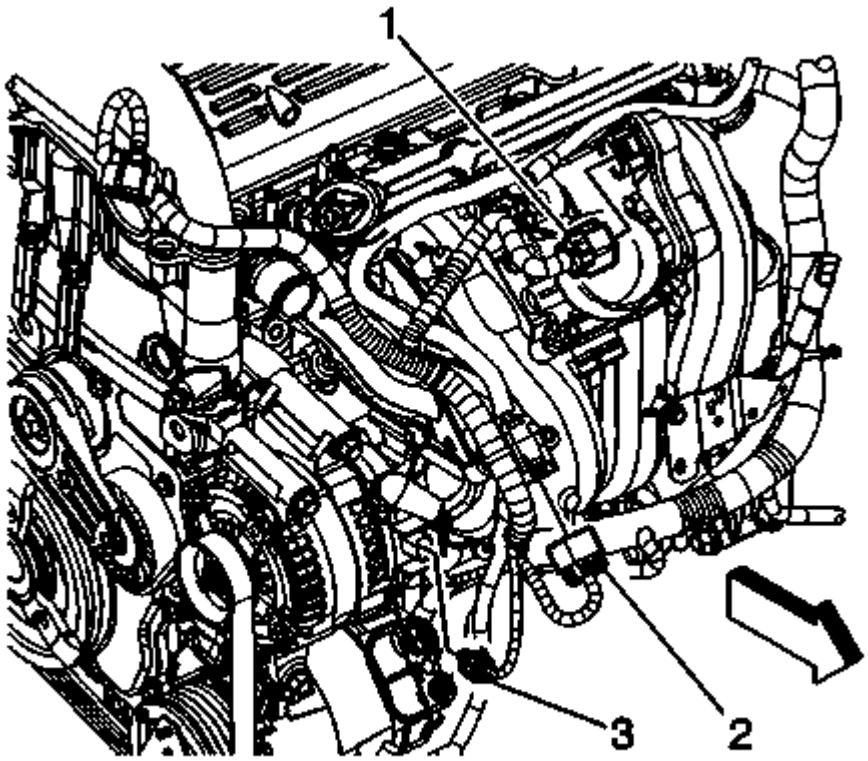

Fig. 323: Identifying Engine Harness Electrical Connectors
Courtesy of GENERAL MOTORS CORP.

73. Connect the following electrical connectors:
    - TAC (1)
    - MAP sensor
    - Fuel injector harness (2)
    - Generator (3)

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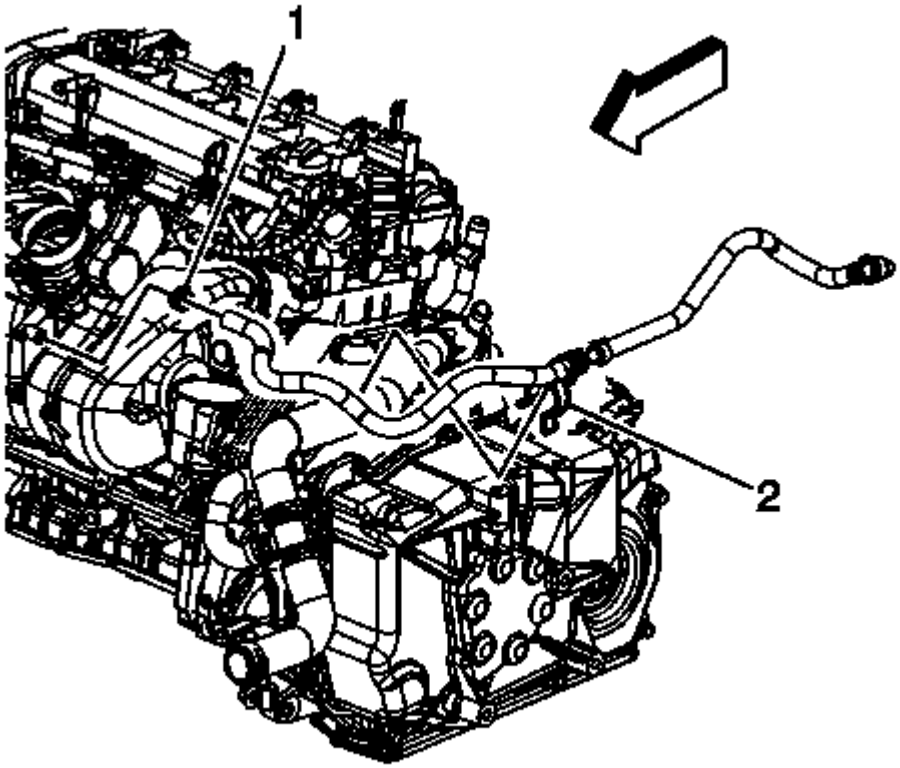

Fig. 324: Positioning Brake Booster Vacuum Hose Clamp At Intake Manifold
Courtesy of GENERAL MOTORS CORP.

74. Install the brake booster vacuum hose to the intake manifold.
75. Position the brake booster vacuum hose clamp (1) at the intake manifold.

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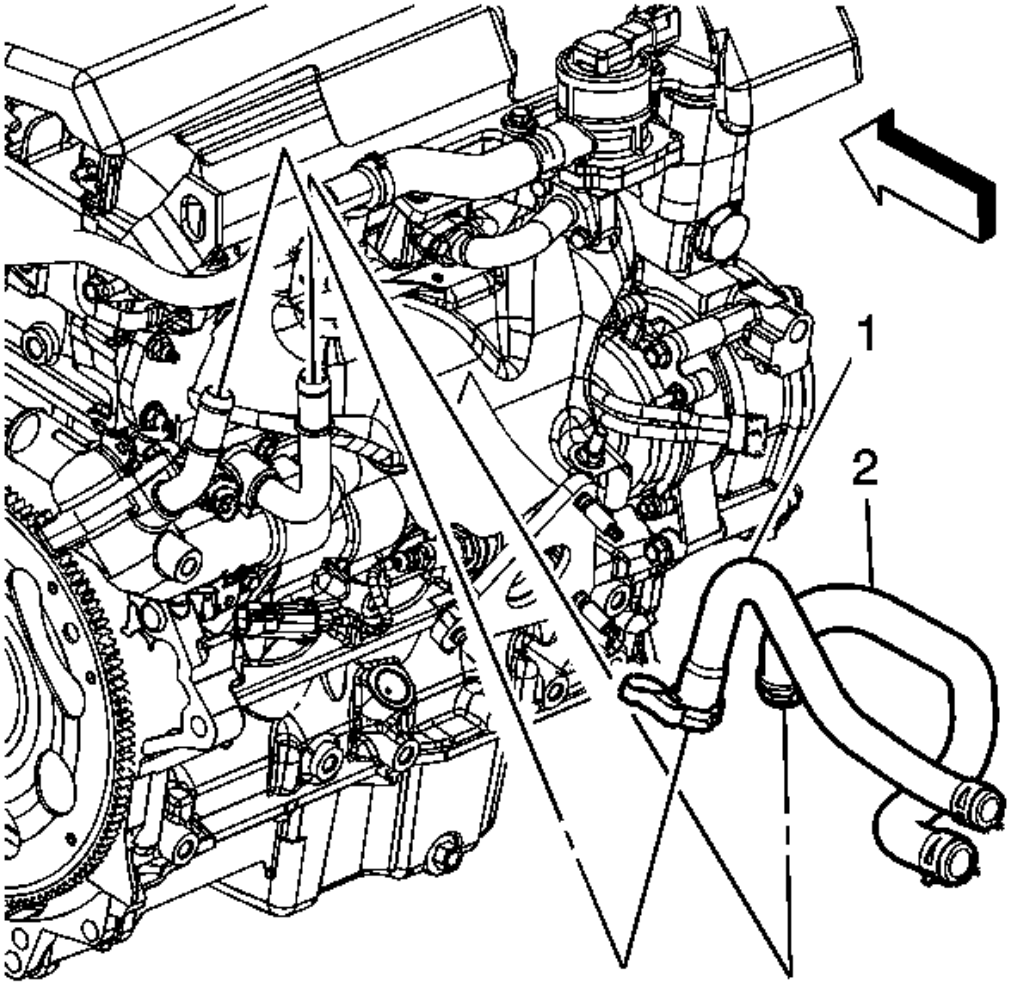

Fig. 325: View Of Heater Inlet And Outlet Hoses And Thermostat Housing Pipes
Courtesy of GENERAL MOTORS CORP.

76. Install the heater inlet and outlet hoses to the thermostat housing.
77. Position the heater inlet (2) and outlet hose (1) clamps at the thermostat housing.

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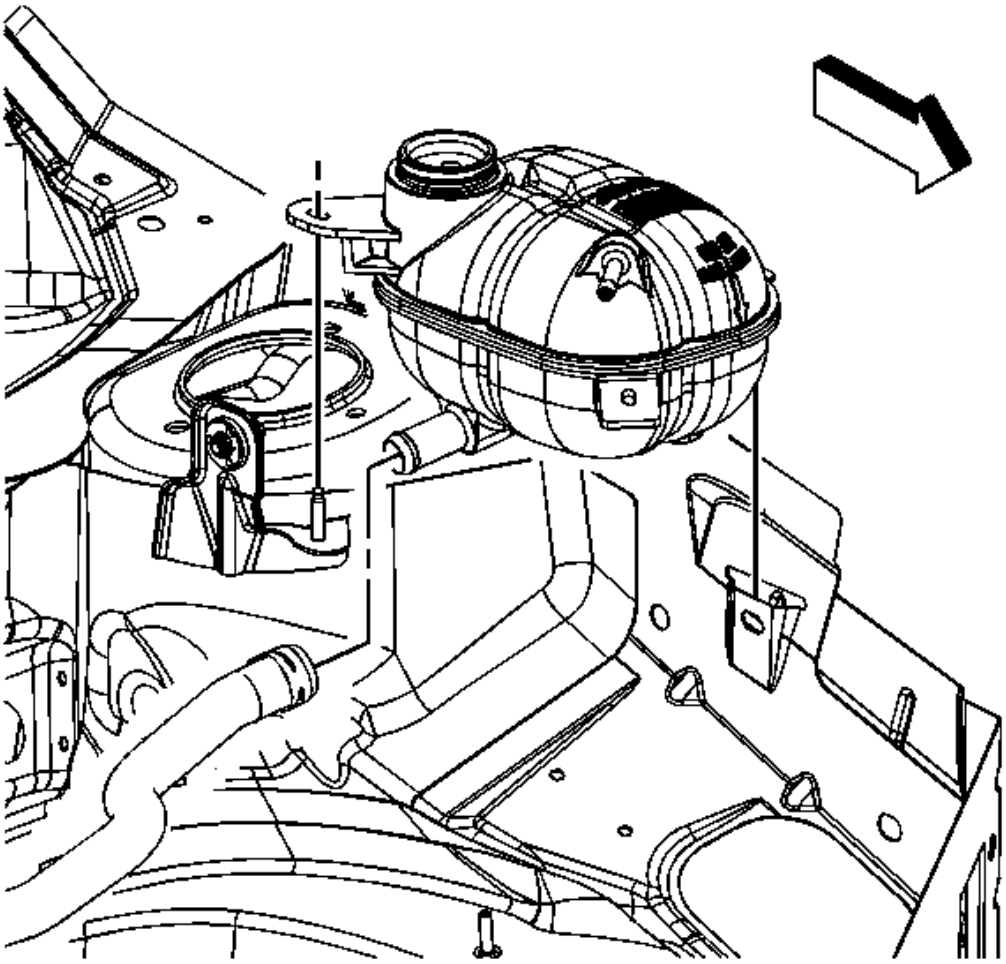

Fig. 326: View Of Surge Tank Outlet Hose
Courtesy of GENERAL MOTORS CORP.

78. If the vehicle is not equipped with a engine oil cooler perform the following steps, otherwise proceed to step 82.
79. Install the surge tank outlet hose to the surge tank.
80. Position the surge tank outlet hose clamp at the surge tank.

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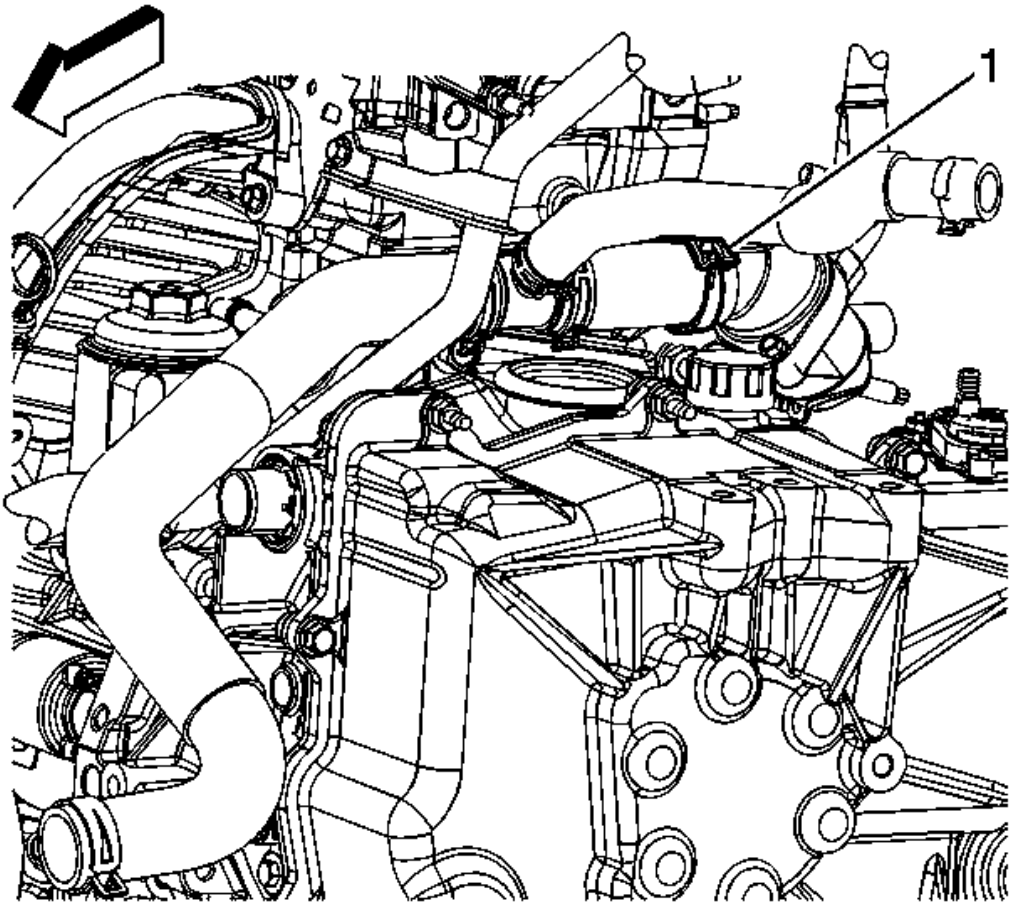

Fig. 327: Identifying Radiator Outlet Hose Clamp
Courtesy of GENERAL MOTORS CORP.

81. Install the radiator outlet hose to the thermostat cover.
82. Position the radiator outlet hose clamp (1) at the thermostat cover. Proceed to step 86.

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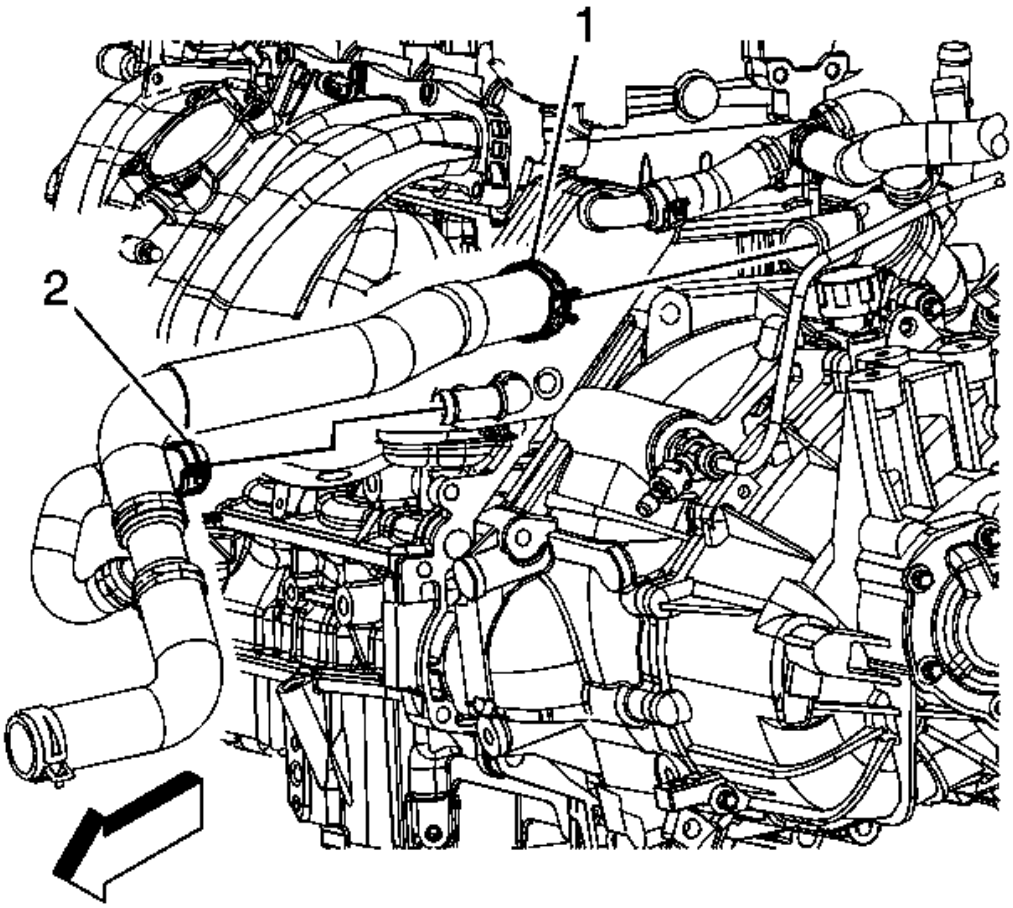

Fig. 328: View Of Radiator Outlet Hose To Thermostat Housing
Courtesy of GENERAL MOTORS CORP.

83. If the vehicle is equipped with a engine oil cooler perform the following steps, install the radiator outlet hose to the oil cooler.
84. Install the radiator outlet hose to the water outlet.
85. Position the radiator outlet hose clamp (2) at the oil cooler.
86. Position the radiator outlet hose clamp (1) at the water outlet.

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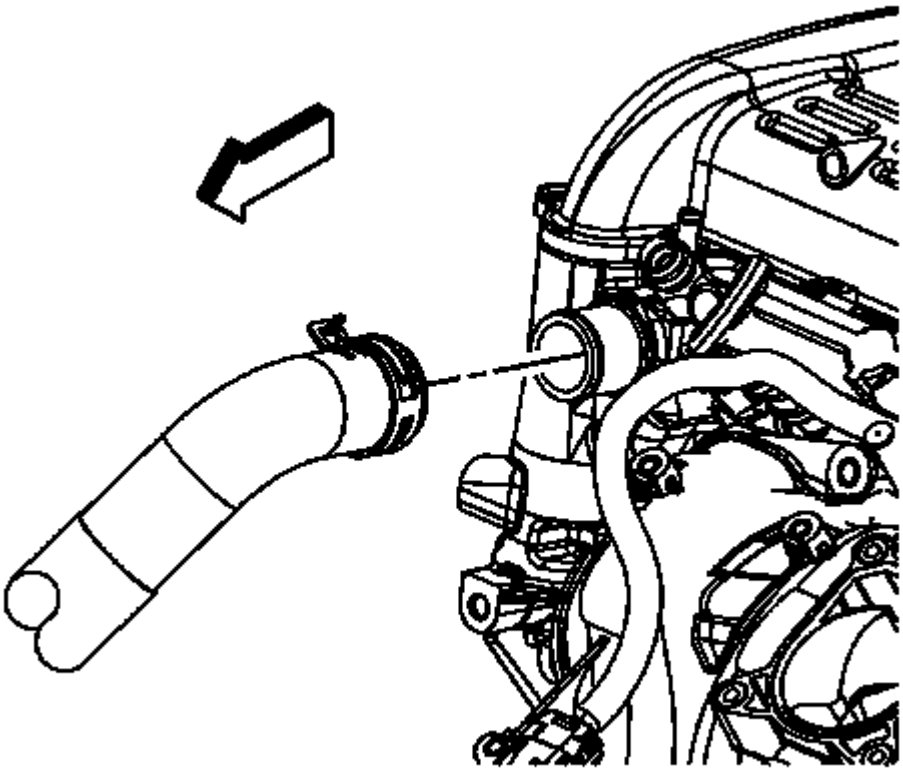

Fig. 329: View Of Radiator Inlet Hose To Engine
Courtesy of GENERAL MOTORS CORP.

87. Install the radiator inlet hose to the engine.
88. Position the radiator inlet hose clamp at the engine.

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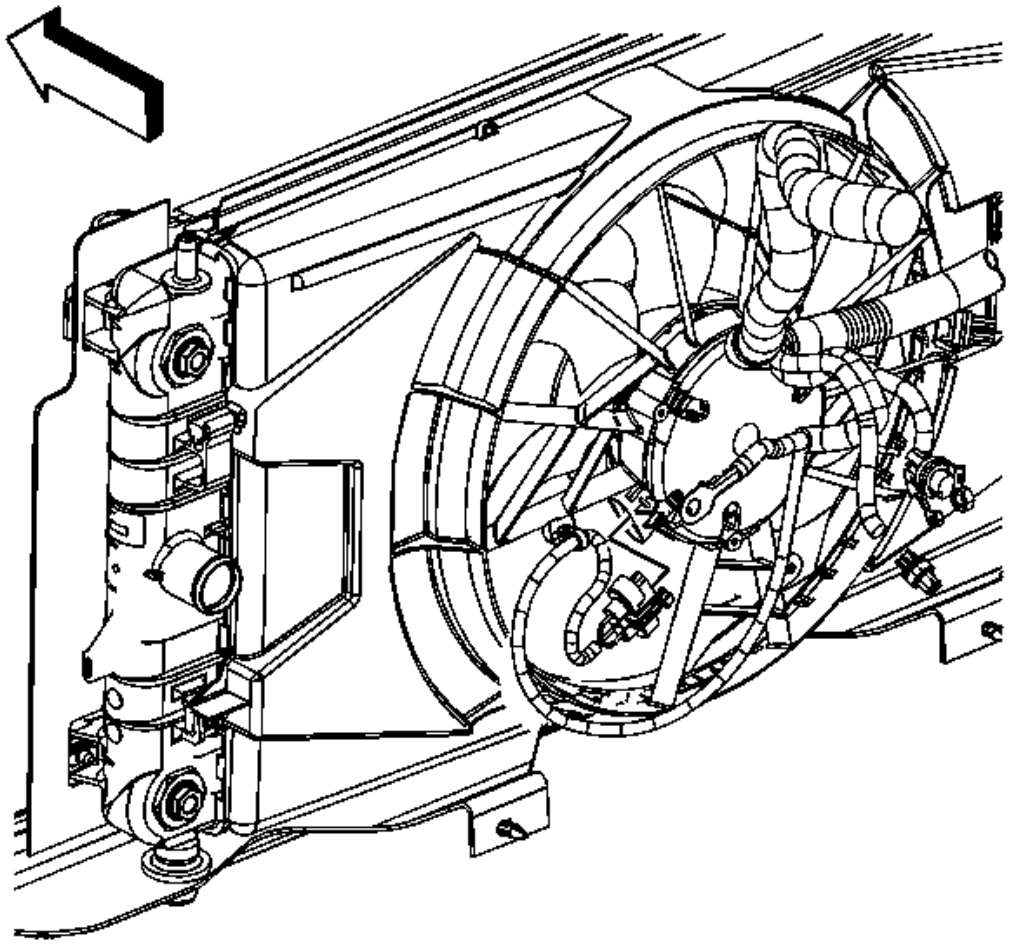

Fig. 330: Identifying Cooling Fan Electrical Connector
Courtesy of GENERAL MOTORS CORP.

89. Connect the cooling fan electrical connector.

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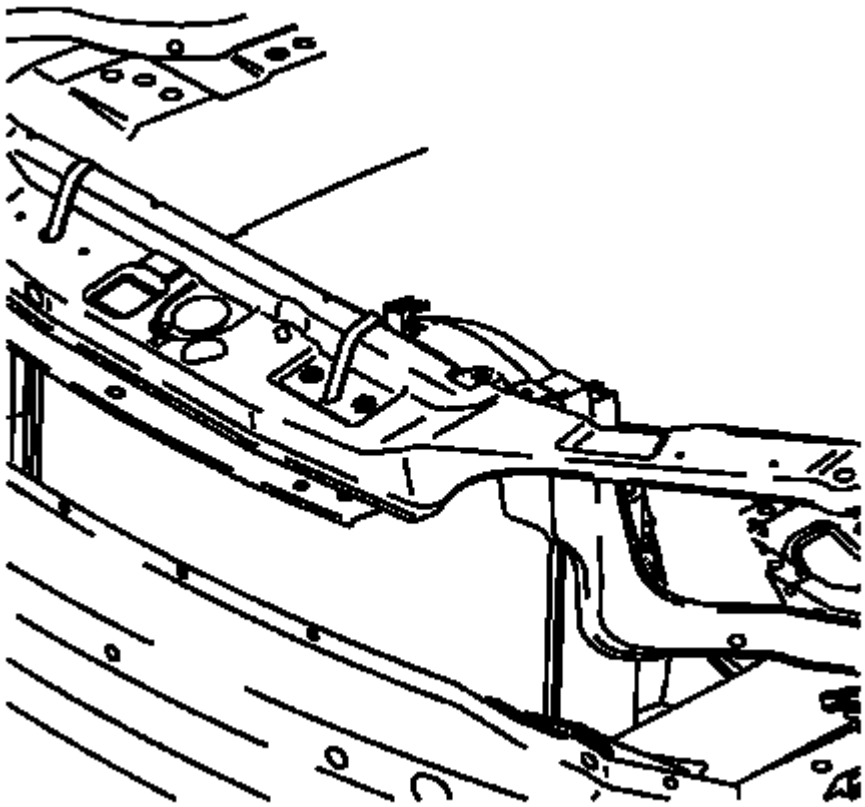

Fig. 331: View Of Cooling Module Secured To Upper Body Structure
Courtesy of GENERAL MOTORS CORP.

90. Install the engine drive belt. Refer to **Drive Belt Replacement**.
91. Unsecure the cooling module from the upper body structure.
92. Fill the cooling system. Refer to **Cooling System Draining and Filling (Static Fill LE5, L61)** or **Cooling System Draining and Filling (GE 47716 Fill)** .
93. Check and fill the transaxle fluid as needed.

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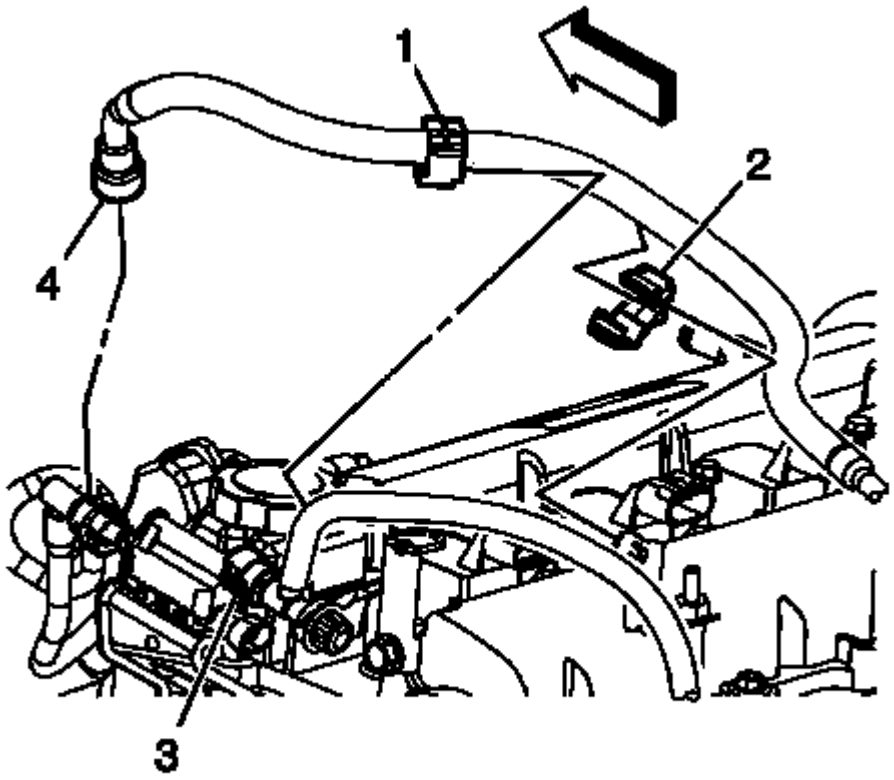

Fig. 332: Identifying Fuel Line
Courtesy of GENERAL MOTORS CORP.

94. Connect the EVAP line quick connect fitting (3) to the EVAP purge solenoid. Refer to **Plastic Collar Quick Connect Fitting Service** .
95. Connect the fuel feed line quick connect fitting (4) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service** .
96. Install the fuel line clips (1, 2) to the engine brackets.
97. Fill the engine with oil. Refer to **Engine Oil and Oil Filter Replacement (LAF)**.
98. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .
99. Close the hood.
100. Road test the vehicle.

ENGINE OIL AND OIL FILTER REPLACEMENT (LAF)

Removal Procedure

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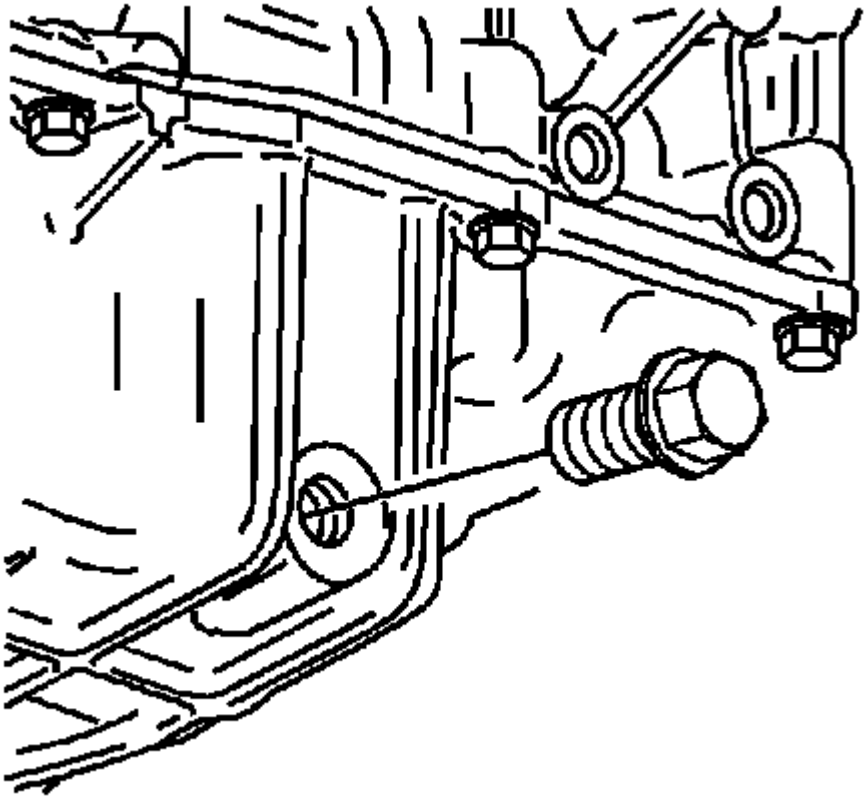

Fig. 333: View Of Oil Pan Drain Bolt
Courtesy of GENERAL MOTORS CORP.

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.

CAUTION: Refer to Fastener Caution .

5. Install the oil pan drain plug and tighten to 25 N.m (18 lb ft).
6. Lower the vehicle.

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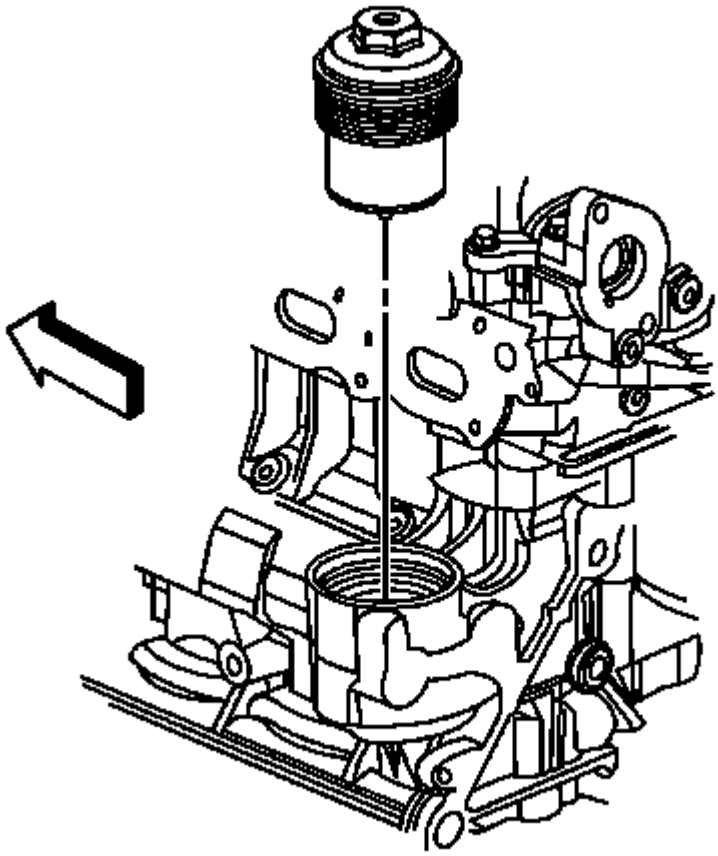

Fig. 334: Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

7. use 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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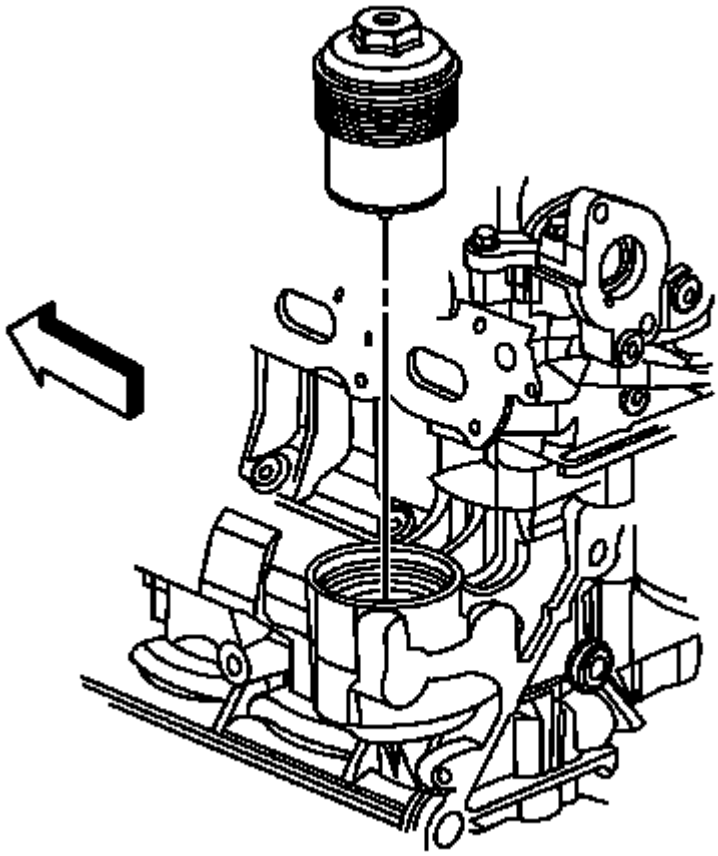

Fig. 335: Oil Filter Cap
Courtesy of GENERAL MOTORS CORP.

1. Install the NEW oil filter to the cap.
2. Install the oil filter cap and filter.

CAUTION: Over torquing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak.

NOTE: DO NOT use an open end wrench on the hex on top of the oil filter cap.

3. use an oil filter wrench on the outside diameter of the oil filter cap. 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 (USA and Canada)** .

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

Special Tools

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EN-44887: Oil Filter Wrench

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

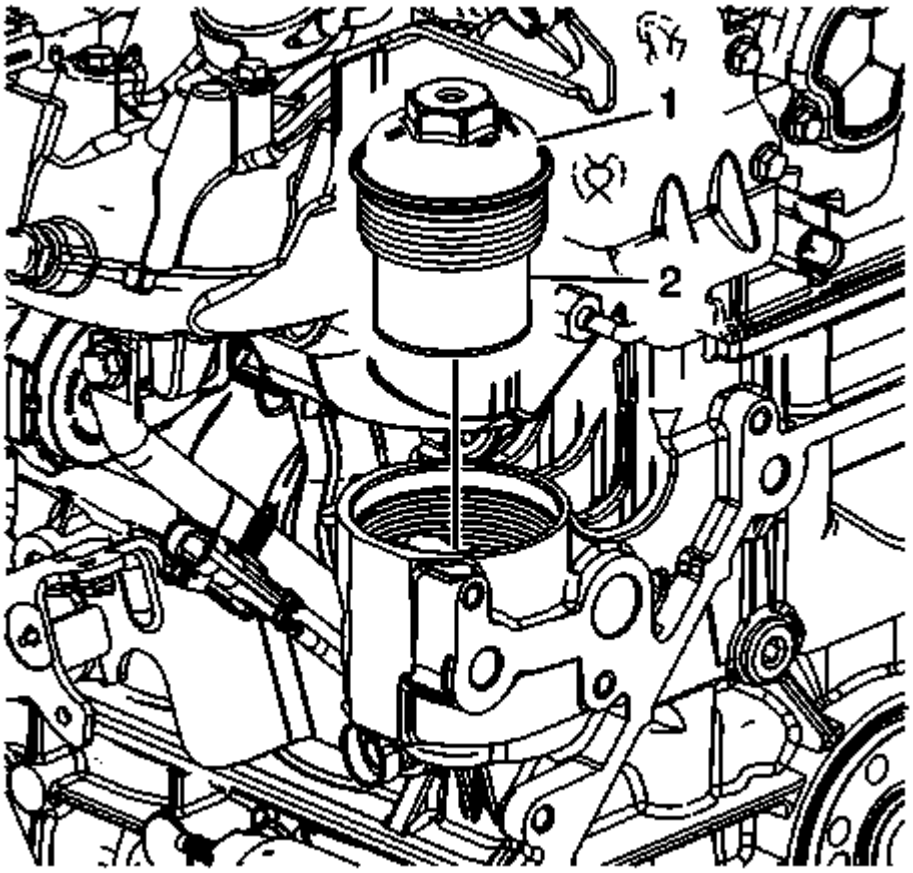

Fig. 336: View of Draining Fluids and Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Use **EN-44887:** wrench to remove the oil filter cap (1). Remove the oil pan drain plug and allow the oil to drain out.
2. Remove the oil filter (2) from the cap and discard.
3. Clean the oil filter housing in the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the oil pan drain plug and tighten 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 to the water pump drain plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. Install the water pump drain plug and tighten to 20 N.m (15 lb ft).

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8. If cleaning or repairing the engine block, it is not necessary to reinstall the plugs.

CRANKSHAFT BALANCER REMOVAL

Special Tools

- **EN-38122-A:** Crankshaft Balancer Holder
- **EN-43653:** Flywheel Holding Tool

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

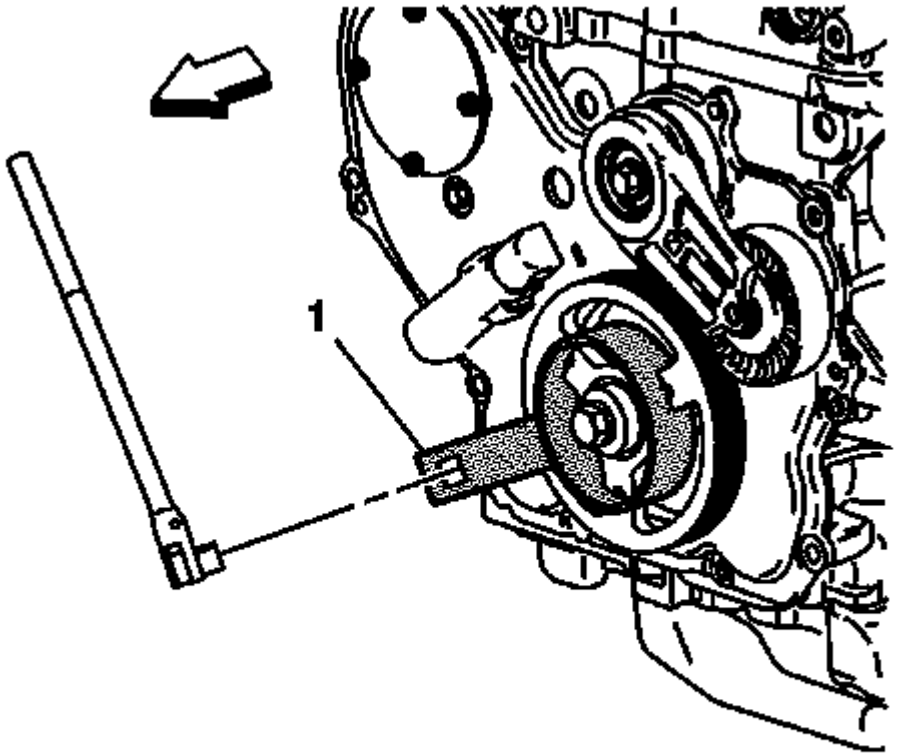

Fig. 337: Identifying J 38122-A
Courtesy of GENERAL MOTORS CORP.

NOTE: EN-43653: flywheel holding tool may be used instead of EN-38122-A: crankshaft balancer holder to prevent crankshaft rotation.

1. Install **EN-38122-A:** holder (1).
2. Remove the balancer retaining bolt and washer. Use **EN-38122-A:** holder and a breaker bar to prevent the crankshaft from rotating when loosening the bolt. Discard the bolt.

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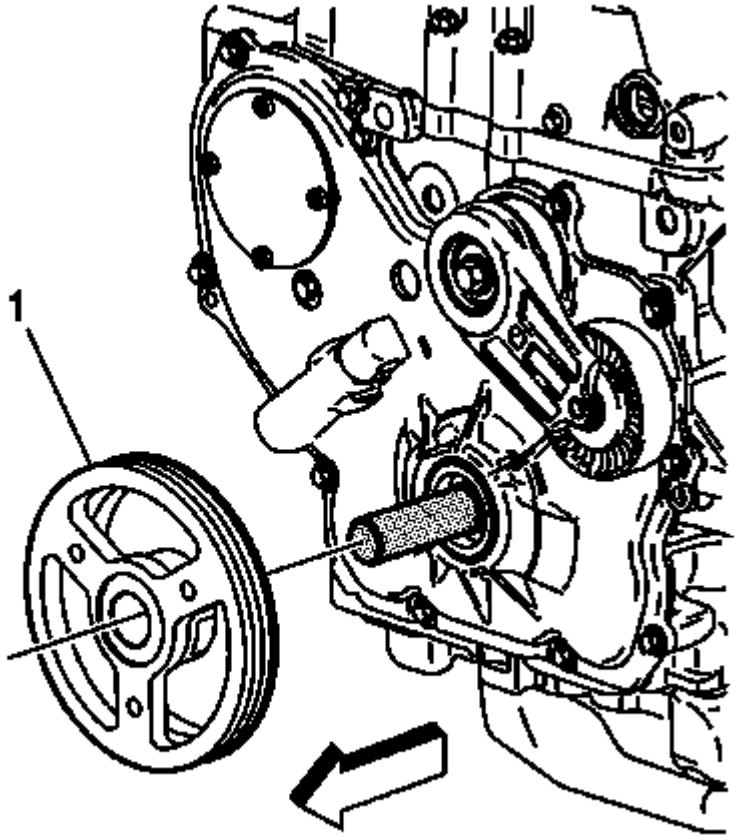

Fig. 338: Identifying Balancer
Courtesy of GENERAL MOTORS CORP.

3. Remove the crankshaft balancer assembly (1) using a universal removal tool.

ENGINE FLYWHEEL REMOVAL

Tools Required

J 38122-A Harmonic Balancer Holder. See **Special Tools**.

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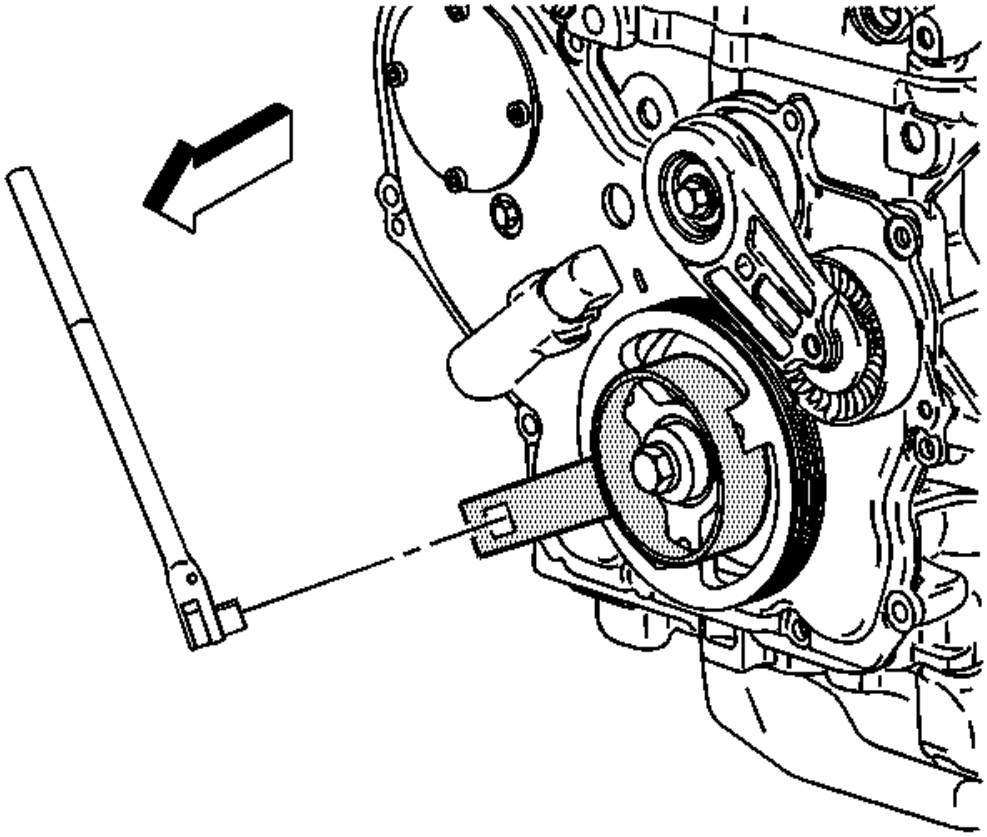

Fig. 339: View Of Harmonic Balancer Holder J38122-A
Courtesy of GENERAL MOTORS CORP.

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 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**.

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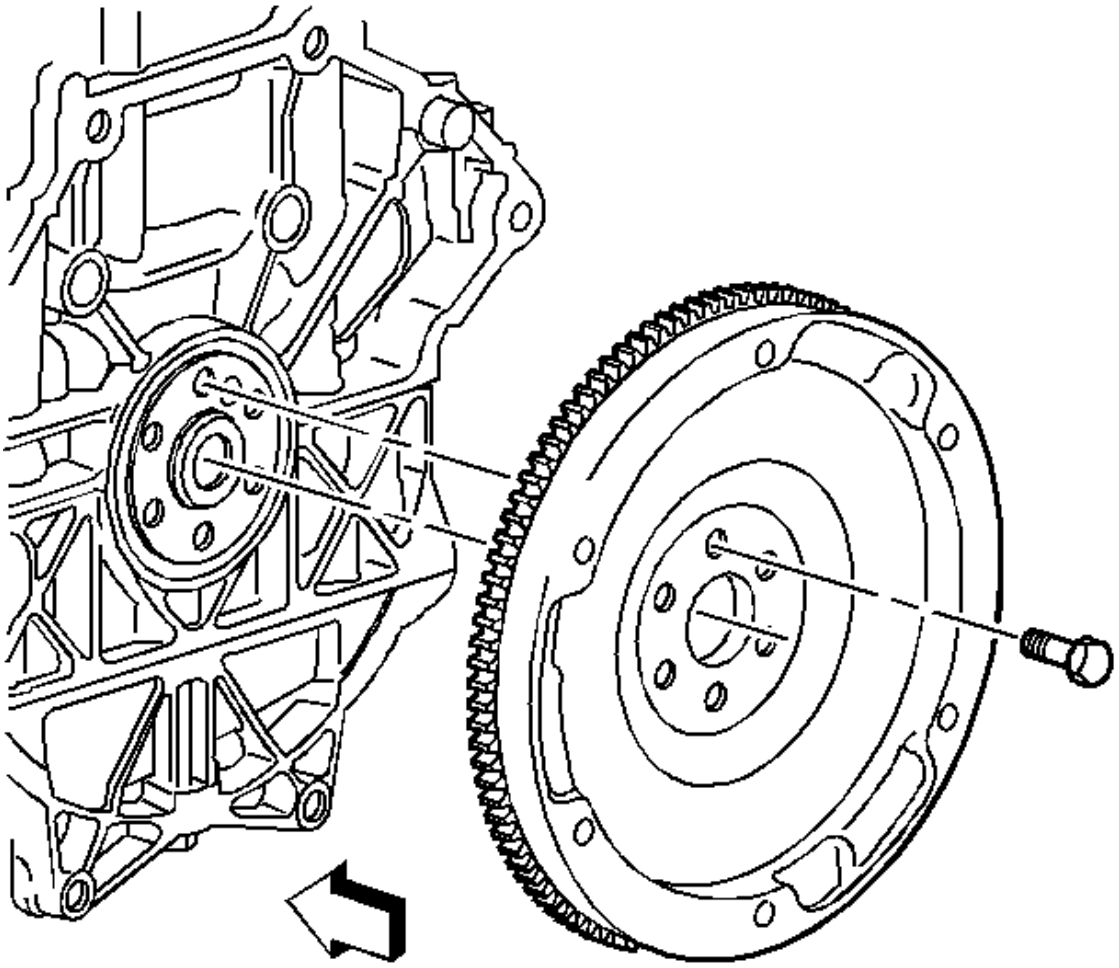

Fig. 340: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

2. Remove the flywheel, if the vehicle has a manual transmission.

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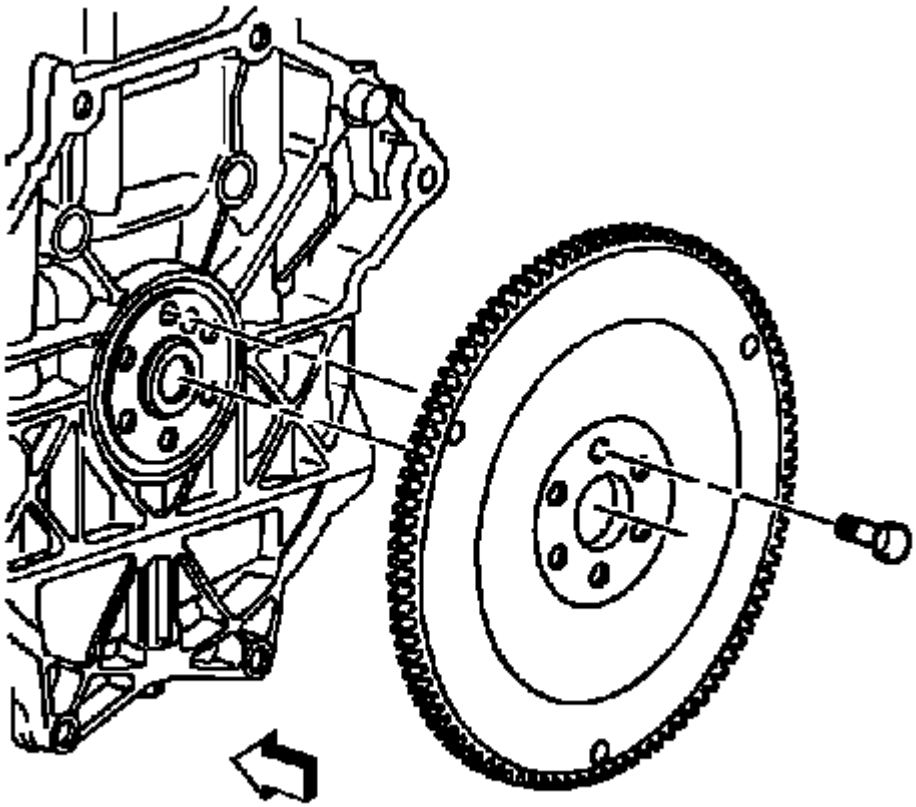

Fig. 341: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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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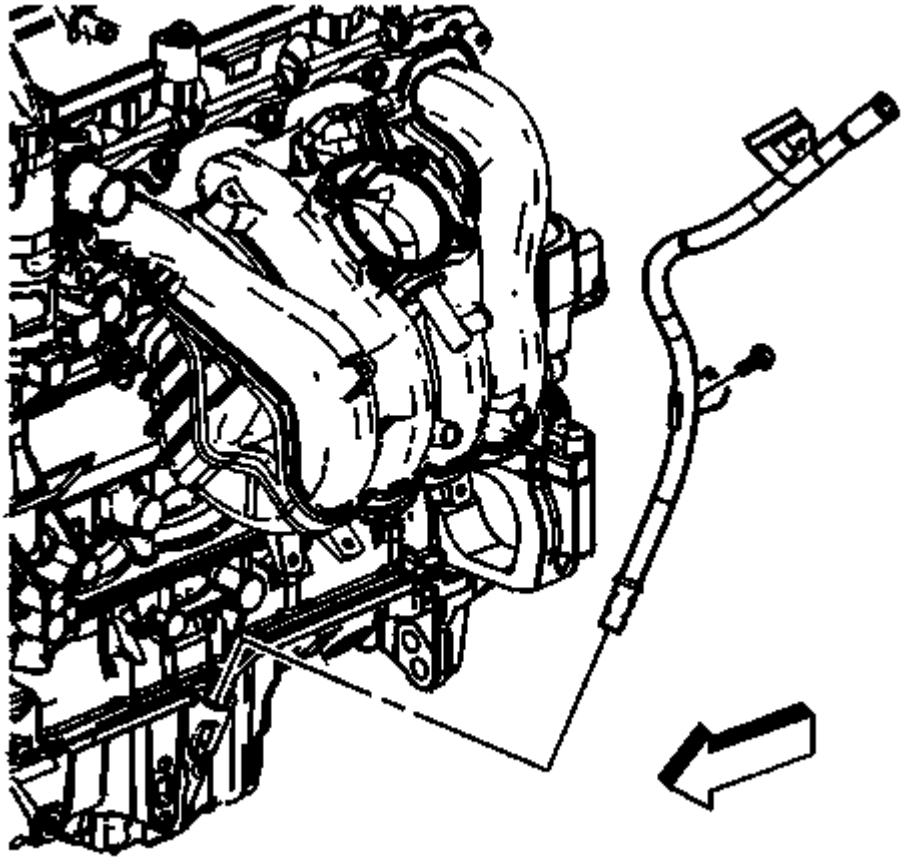

Fig. 342: Locating Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

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.

EXHAUST MANIFOLD REMOVAL (WITH SECONDARY AIR INJECTION)

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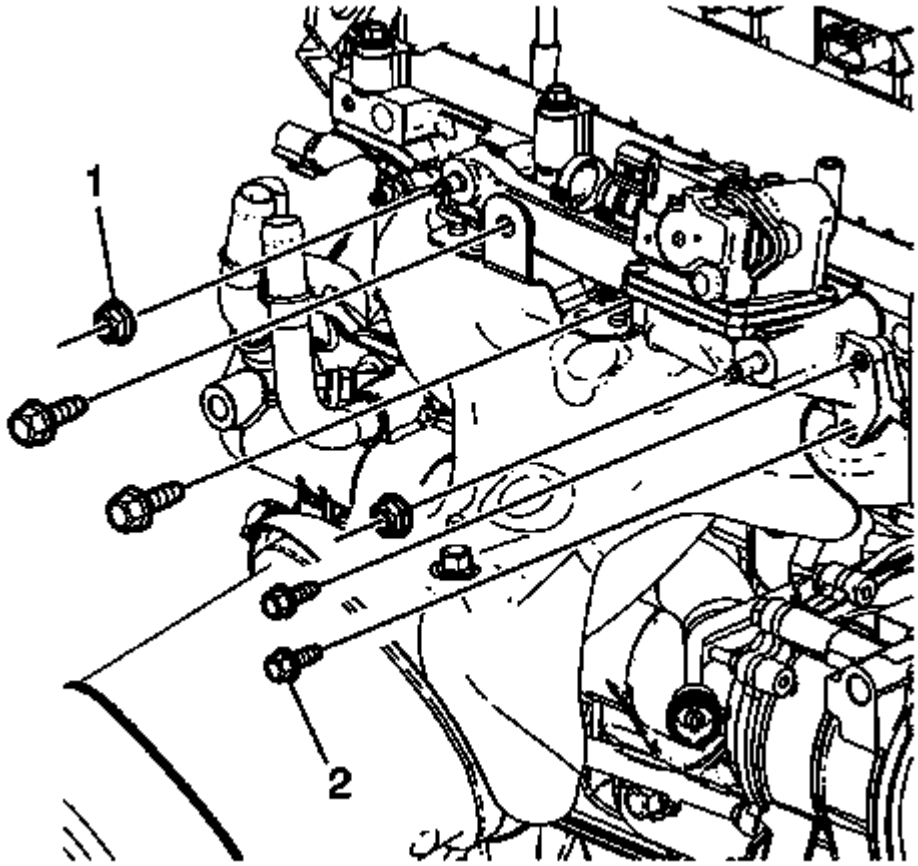

Fig. 343: View of Exhaust Manifold and Secondary Air Injection Bolts and Nuts
Courtesy of GENERAL MOTORS CORP.

1. Remove the secondary air injection bolts (2) and nuts (1).

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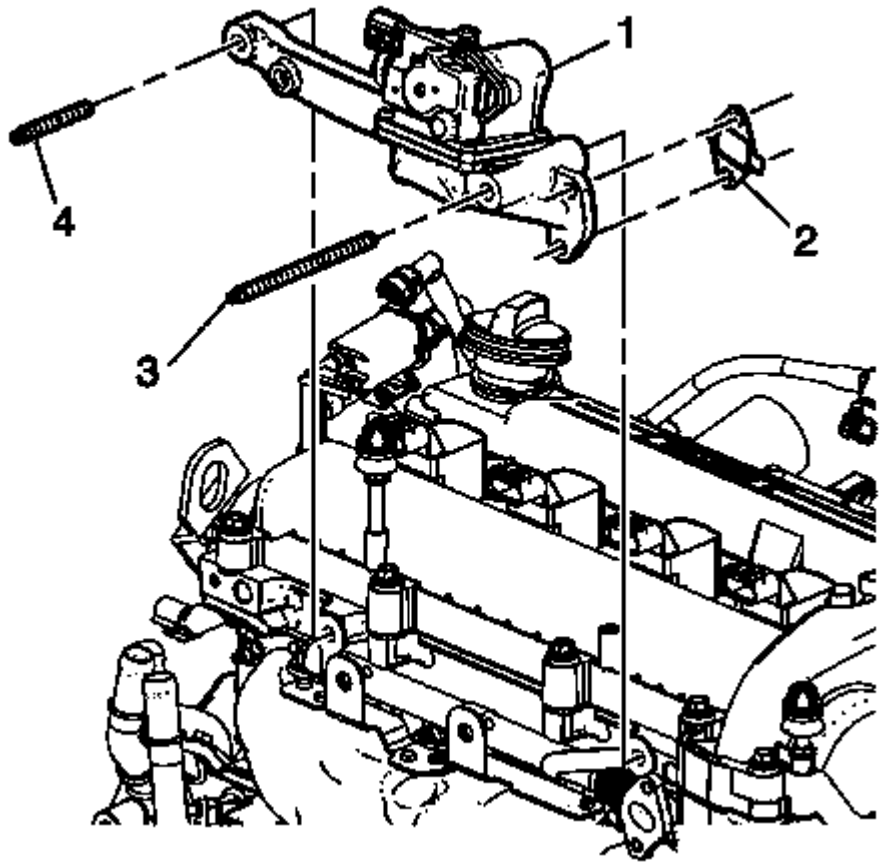

Fig. 344: View of Secondary Air Injection Studs
Courtesy of GENERAL MOTORS CORP.

2. Remove the secondary air injection studs (3 and 4).
3. Remove the secondary air injection valve assembly (1)
4. Remove the secondary air injection gasket (2) and discard.

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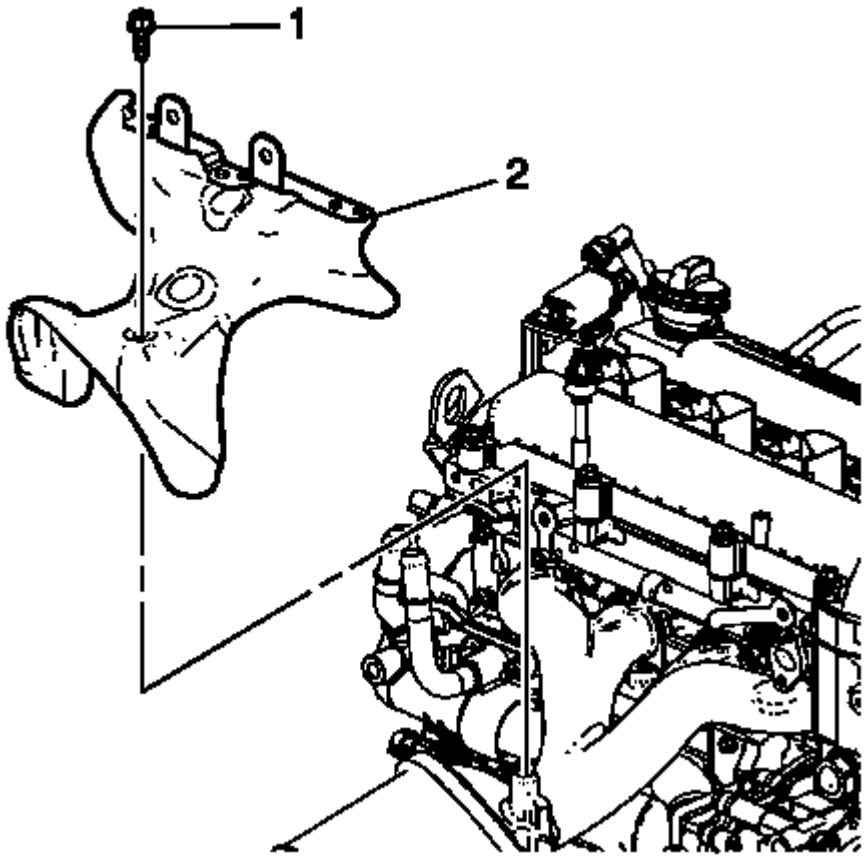

Fig. 345: View of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

5. Remove the exhaust manifold heat shield bolt (1).
6. Remove the exhaust manifold heat shield (2).

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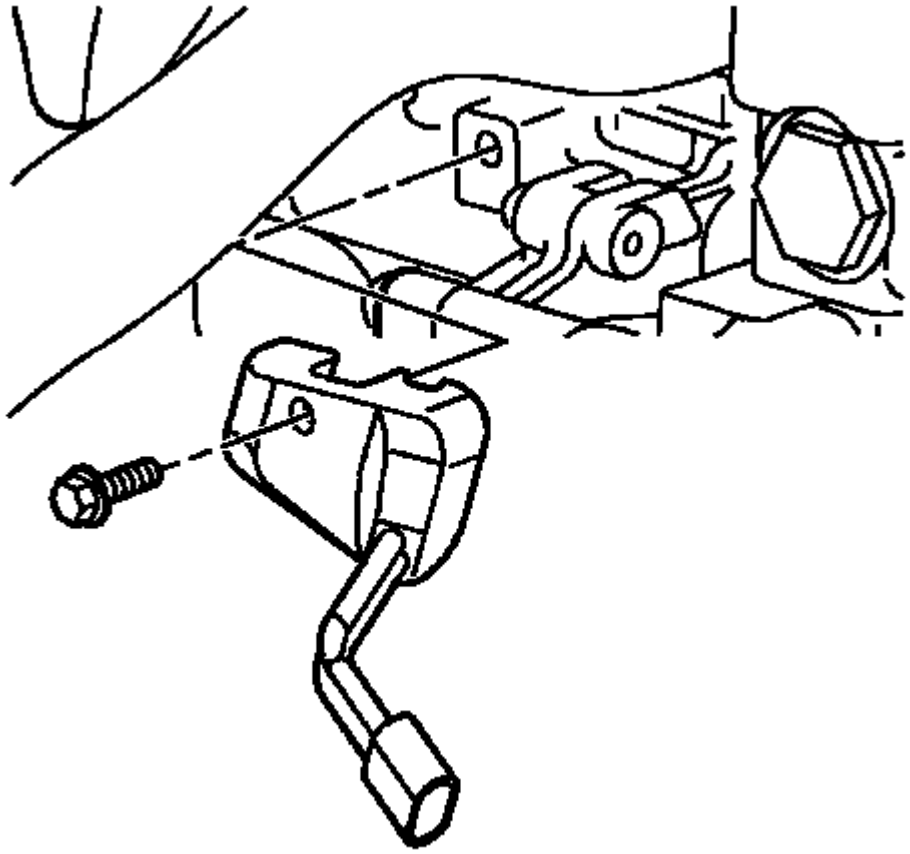

Fig. 346: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

7. Remove the block heater if equipped.

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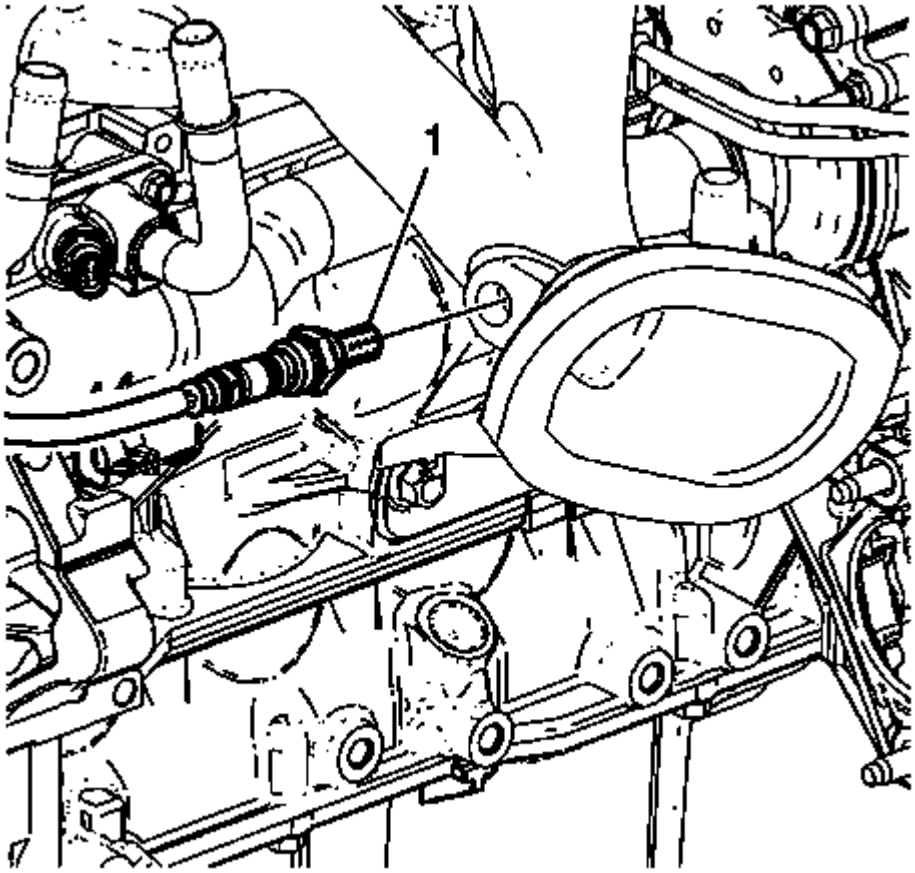

Fig. 347: View of Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the oxygen sensor (1).

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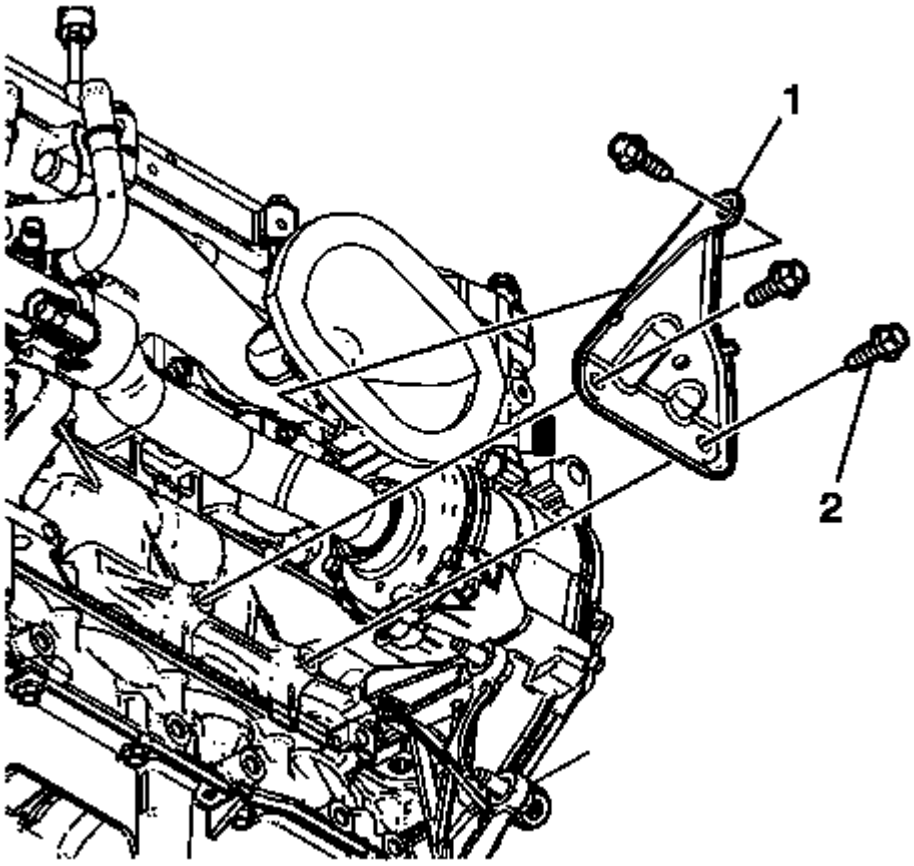

Fig. 348: Exhaust Manifold Brace And Bolts
Courtesy of GENERAL MOTORS CORP.

9. Remove the exhaust manifold brace bolts (2) and brace (1).

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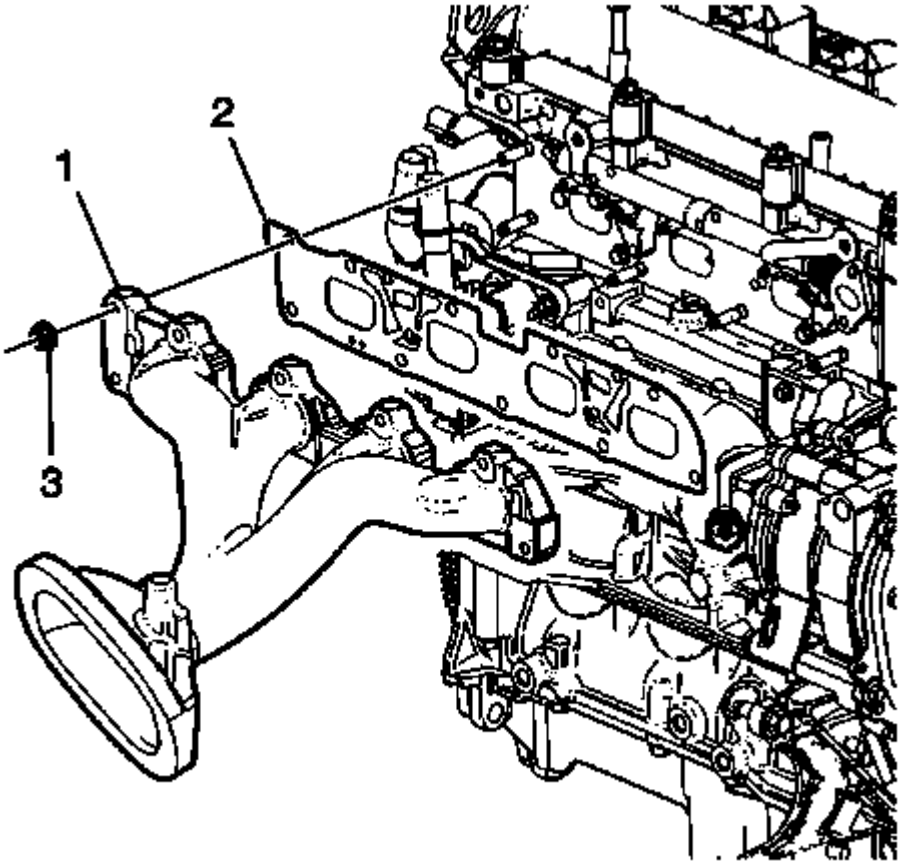

Fig. 349: View of Exhaust Manifold to Cylinder Head Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

10. Remove and discard the exhaust manifold to cylinder head retaining nuts (3).
11. Remove the exhaust manifold (1).
12. Remove the exhaust manifold gasket (2).
13. Clean all of the sealing surfaces.
14. If the exhaust manifold is being replaced, transfer the following parts:
    - The exhaust manifold heat shield
    - The oxygen sensor

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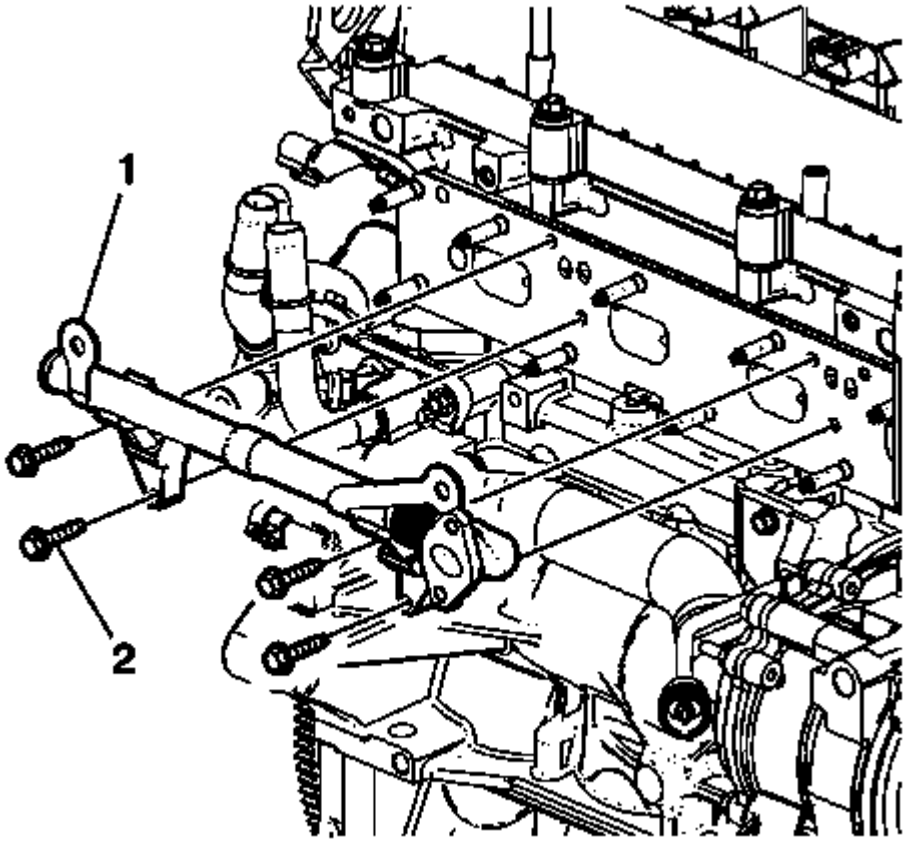

Fig. 350: View of Secondary Air Injection Pipe Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

15. Remove the secondary air injection pipe assembly bolts (2).
16. Remove the secondary air injection pipe assembly (1).

INTAKE MANIFOLD REMOVAL

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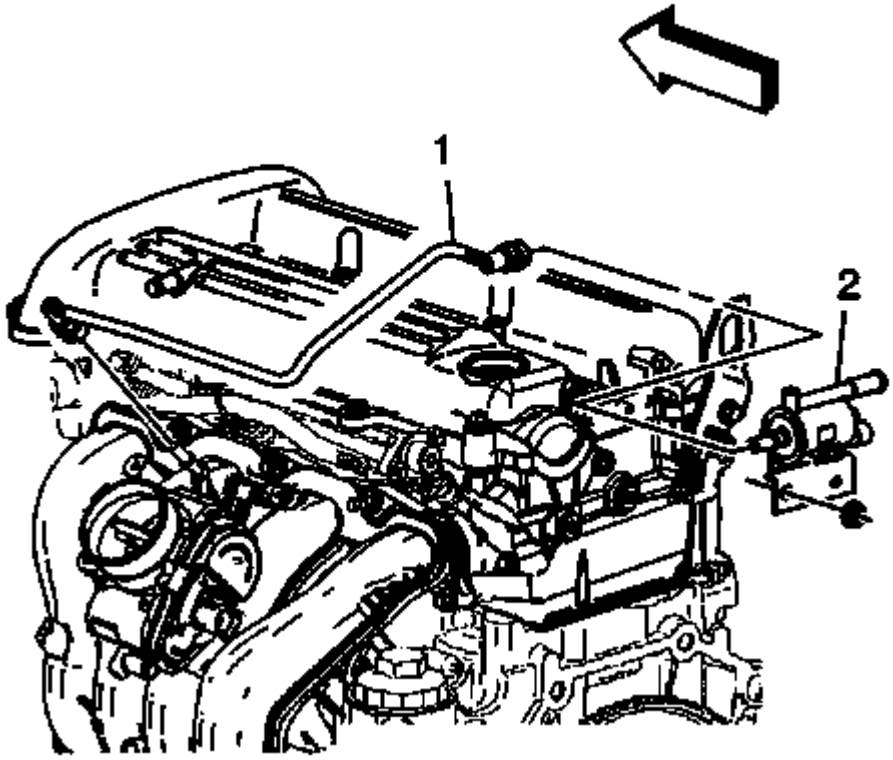

Fig. 351: View of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

CAUTION: Never attempt to remove the intake manifold from a hot engine, allow the engine to cool to ambient temperature. The intake manifold 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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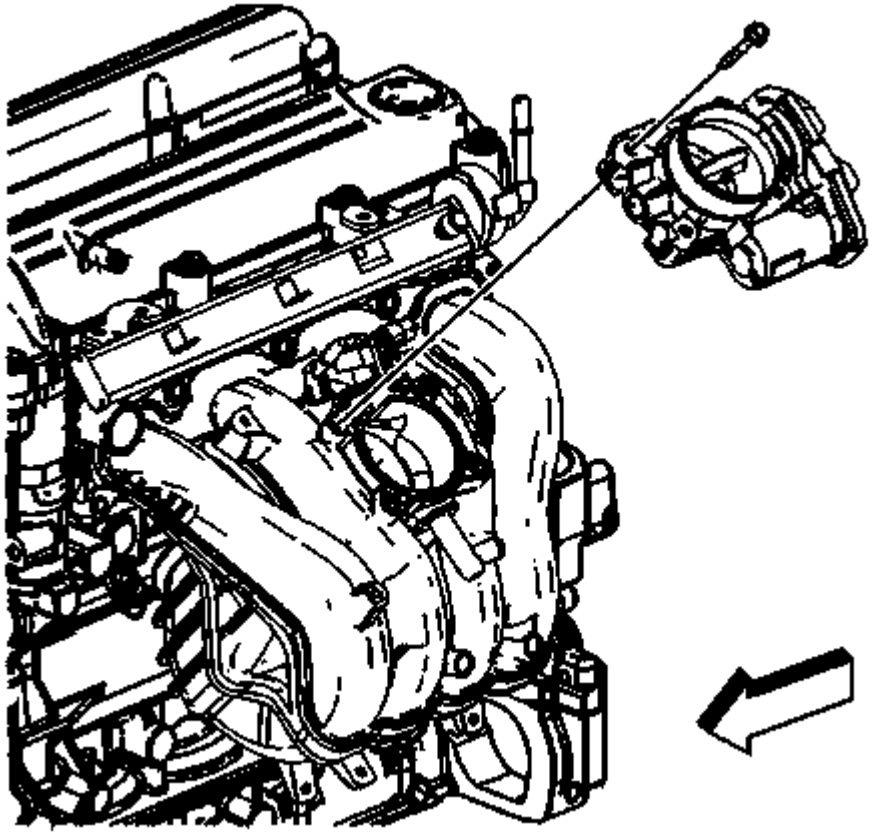

Fig. 352: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

3. Remove the throttle body bolts.
4. Remove the throttle body.

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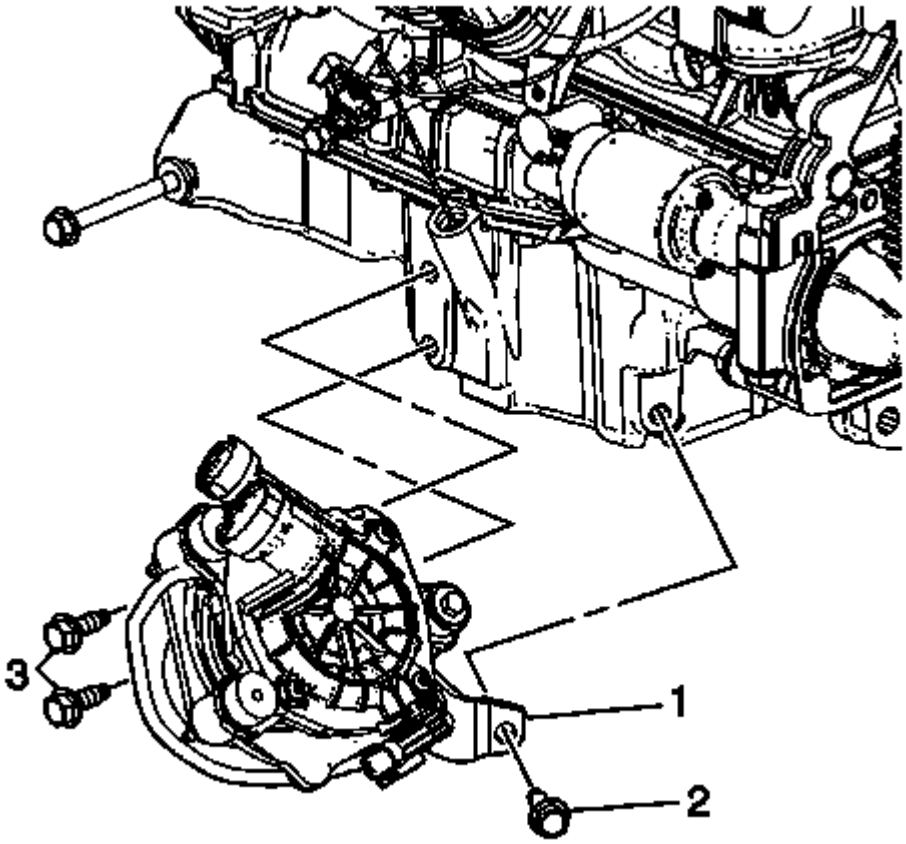

Fig. 353: View of Air Pump Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

5. Remove the air pump assembly bolts (2, 3).
6. Remove the air pump assembly (1).

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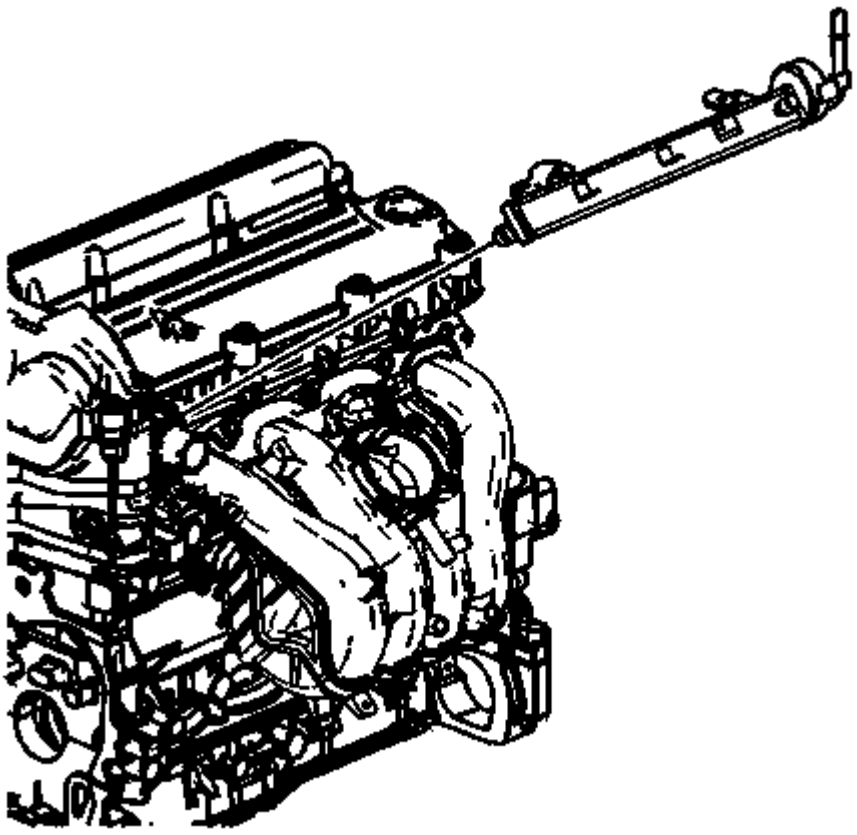

Fig. 354: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

7. Remove fuel pipes and clip. Remove the fuel rail assembly.
8. Disassemble the fuel rail assembly. Refer to **Fuel Injector Replacement** .

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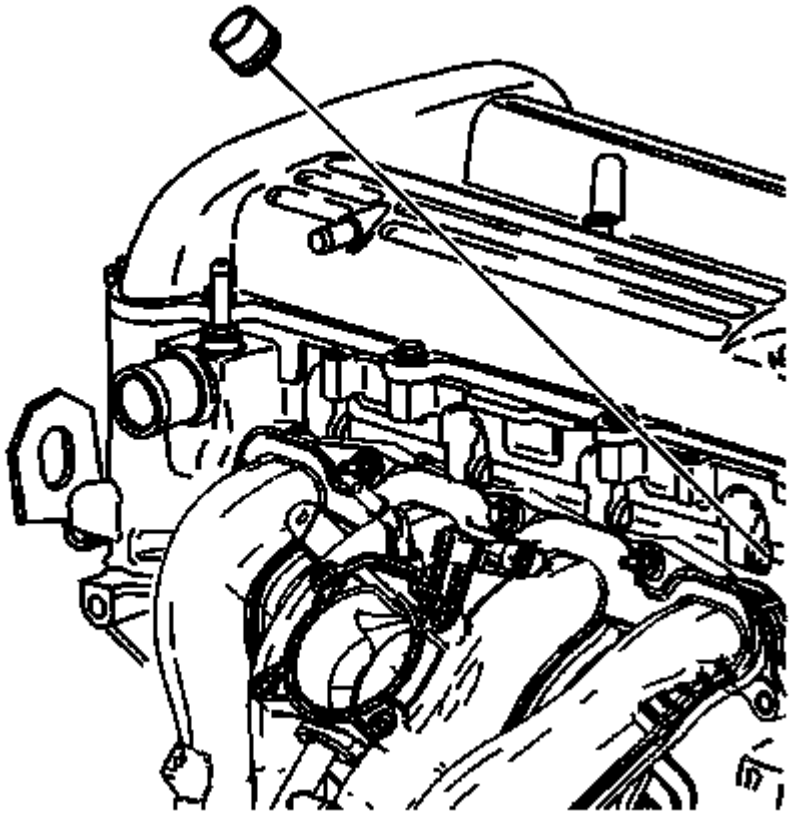

Fig. 355: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

9. Remove the fuel injector tip insulators and discard.

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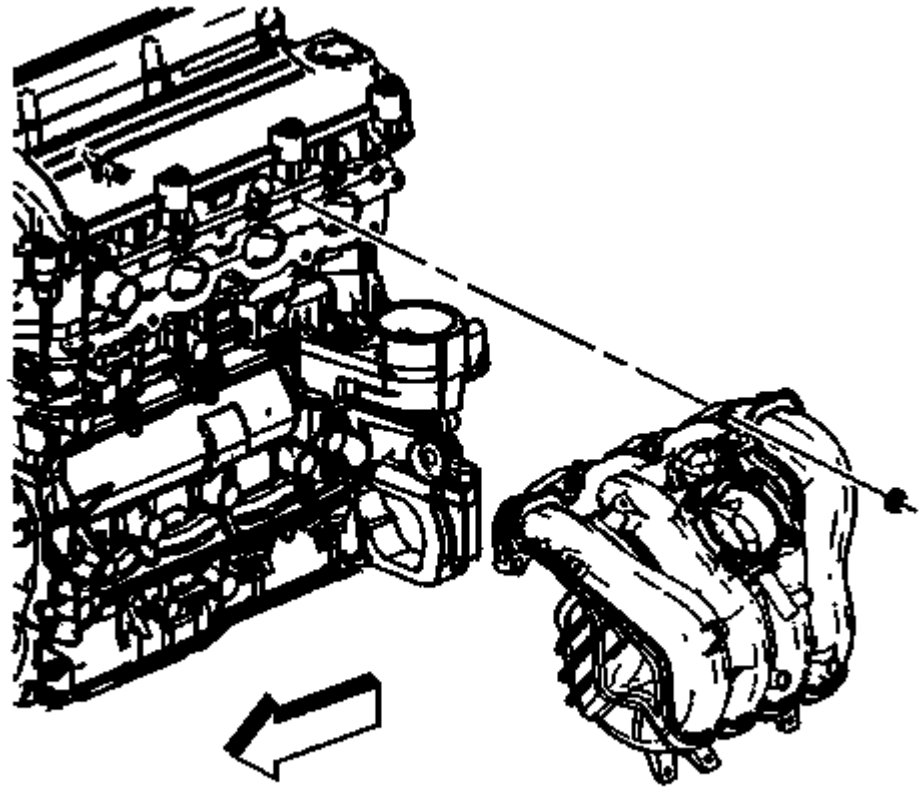

Fig. 356: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

10. Remove the intake manifold retaining nuts and bolts.
11. Remove the intake manifold.
12. Remove the intake manifold gasket, if necessary. The gasket can be used again if it is not damaged.
13. If the intake manifold needs to be replaced, transfer the throttle body to the new intake manifold.

CAMSHAFT COVER REMOVAL

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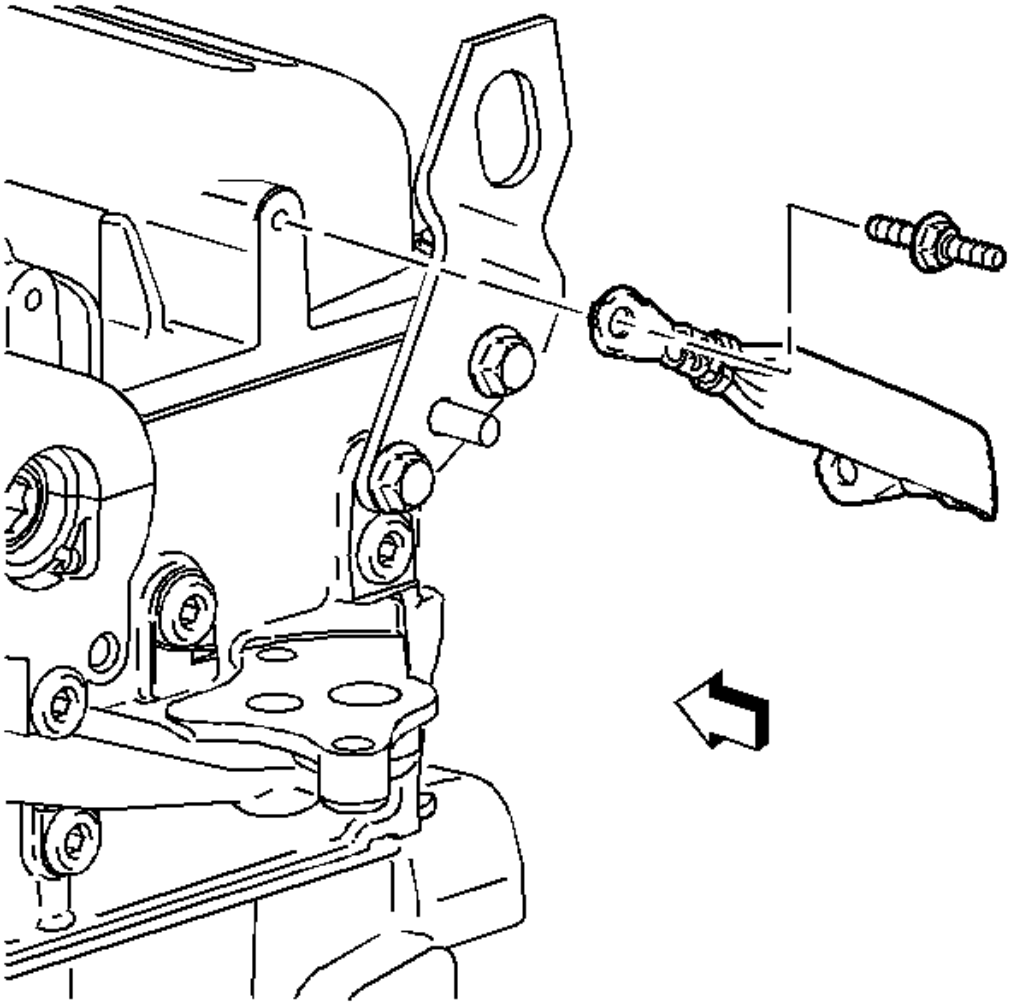

Fig. 357: View Of Camshaft Cover Ground Strap
Courtesy of GENERAL MOTORS CORP.

1. Remove the camshaft cover ground strap.

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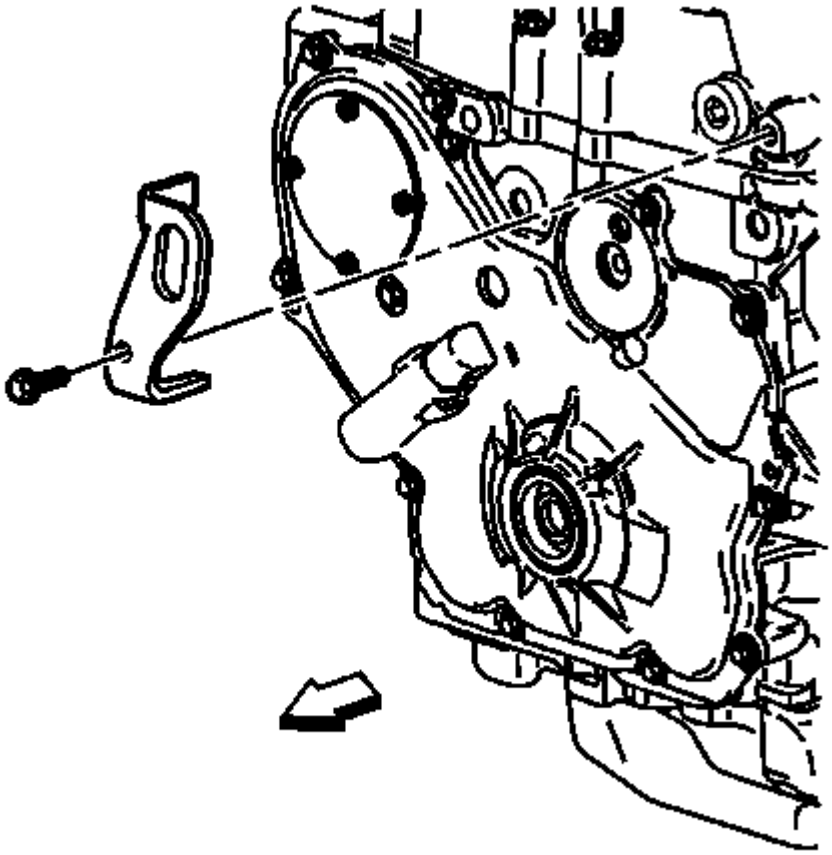

Fig. 358: View Of Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

2. Remove the front lift bracket.

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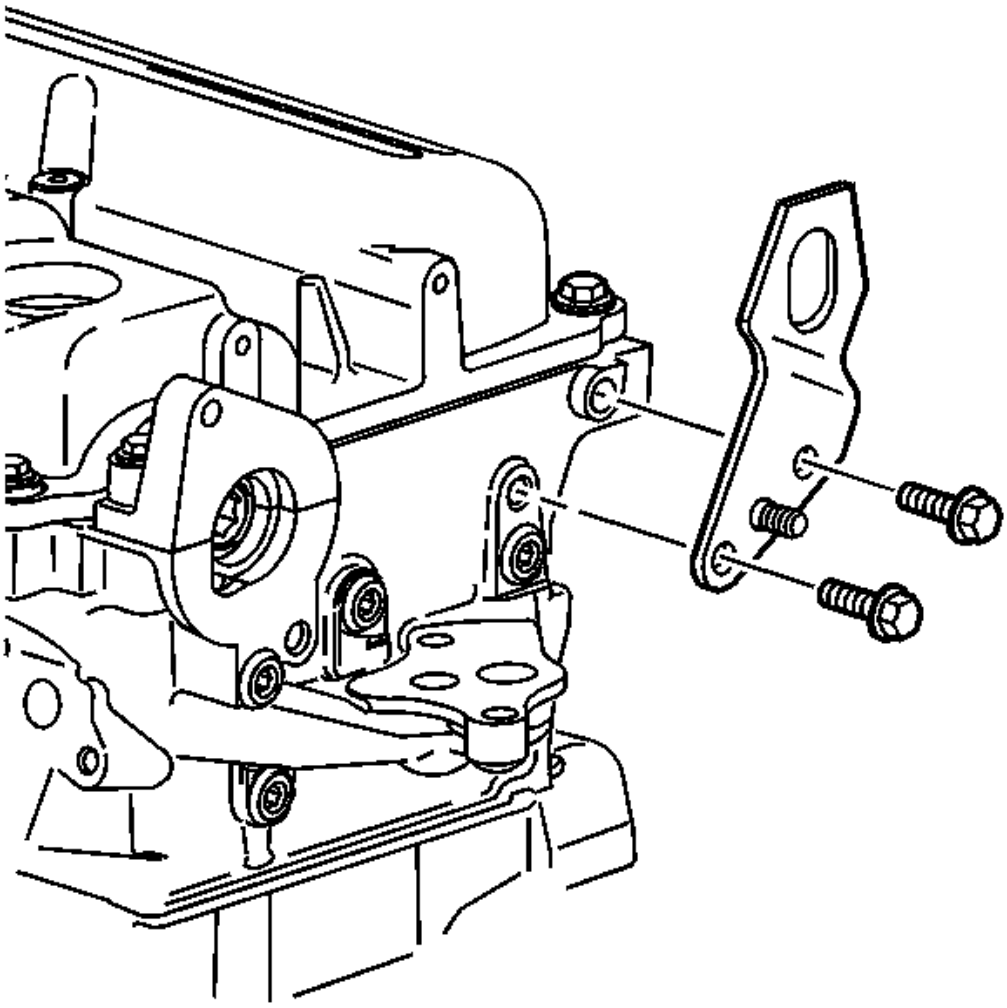

Fig. 359: View Of Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

3. Remove the rear lift bracket.

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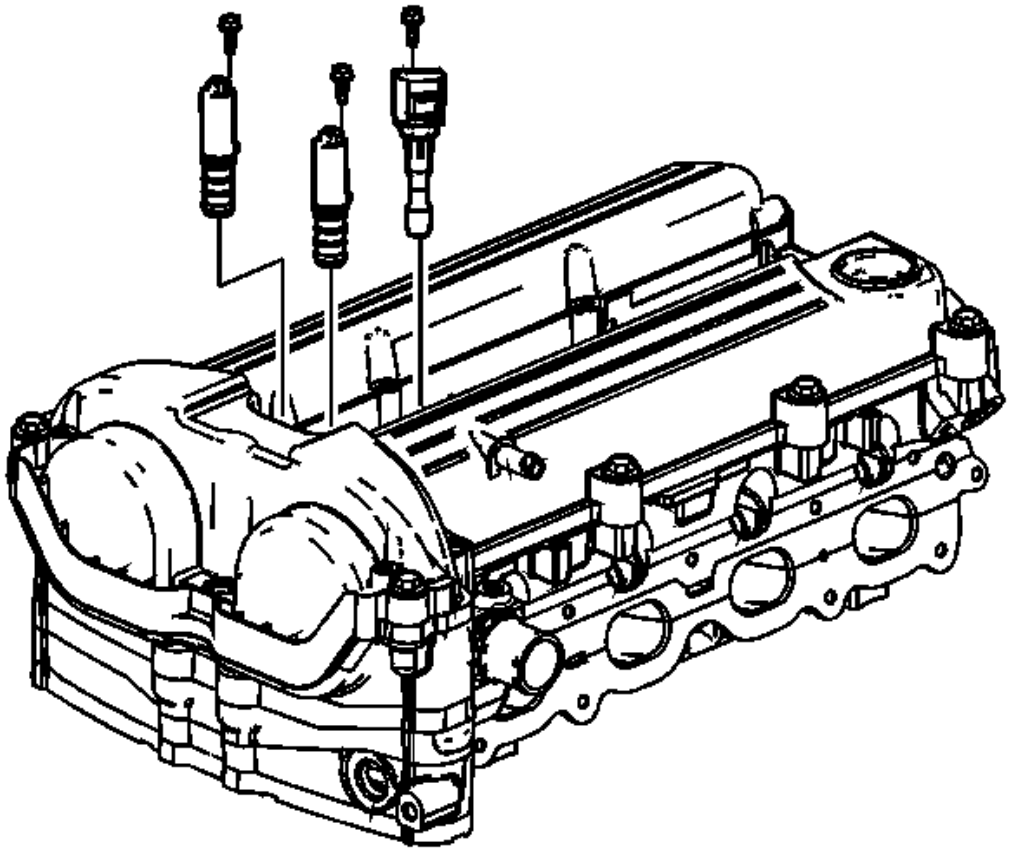

Fig. 360: Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS CORP.

4. Remove the bolt and coil.
5. Remove the camshaft position actuator solenoid valve bolts.
6. Remove the camshaft position actuator solenoid valves.

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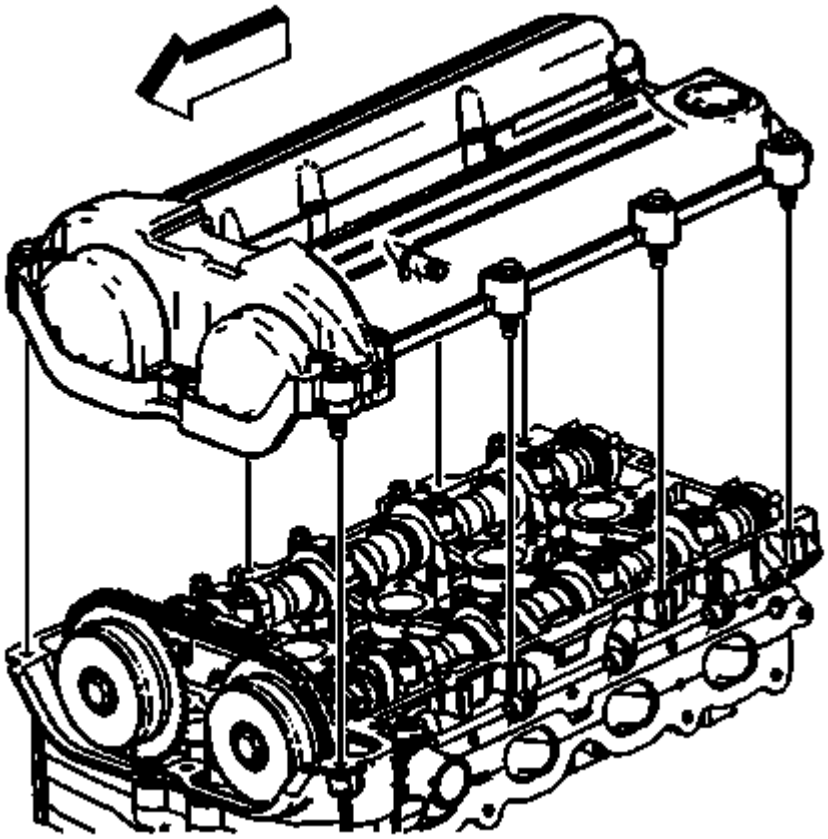

Fig. 361: Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

7. Remove the camshaft cover assembly.
8. Remove and discard the camshaft cover gasket, camshaft cover grommets, and camshaft cover bolts if they are serviced with the grommet.

ENGINE FRONT COVER AND OIL PUMP REMOVAL

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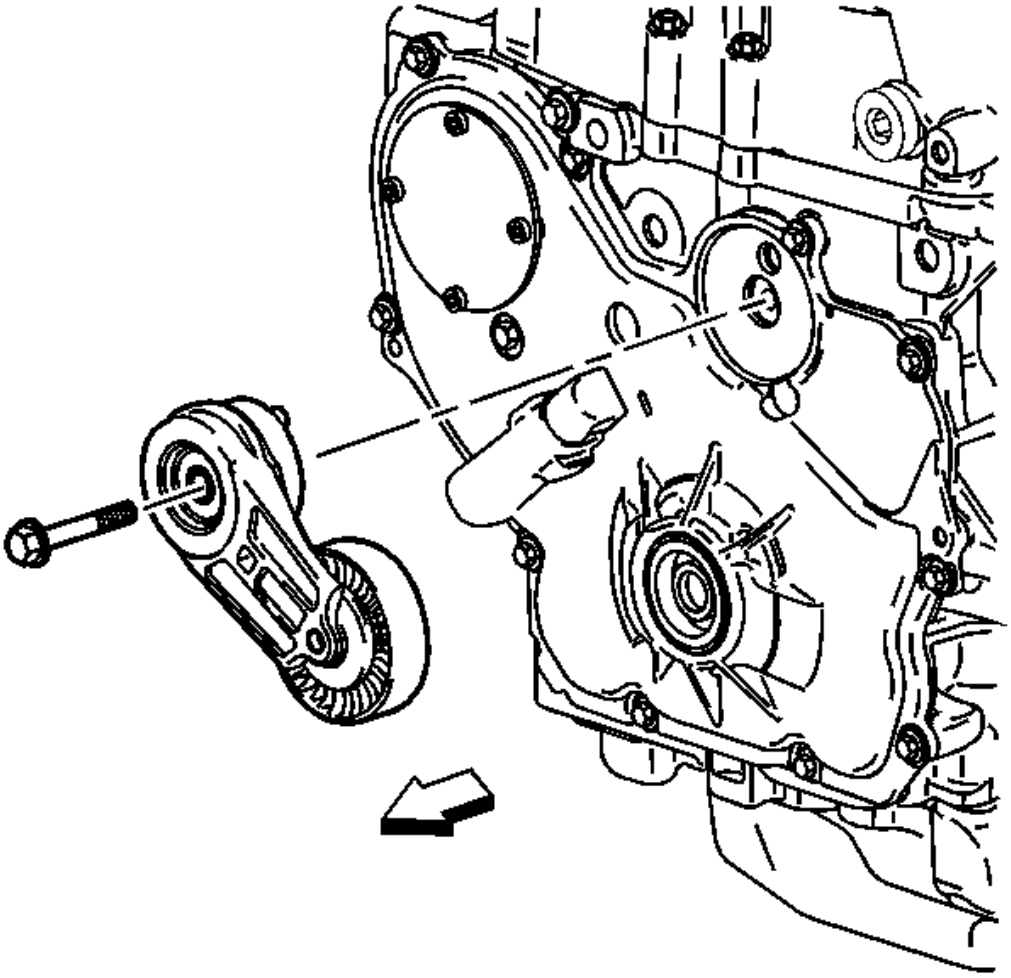

Fig. 362: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the accessory drive belt tensioner bolt.
2. Remove the accessory drive belt tensioner.

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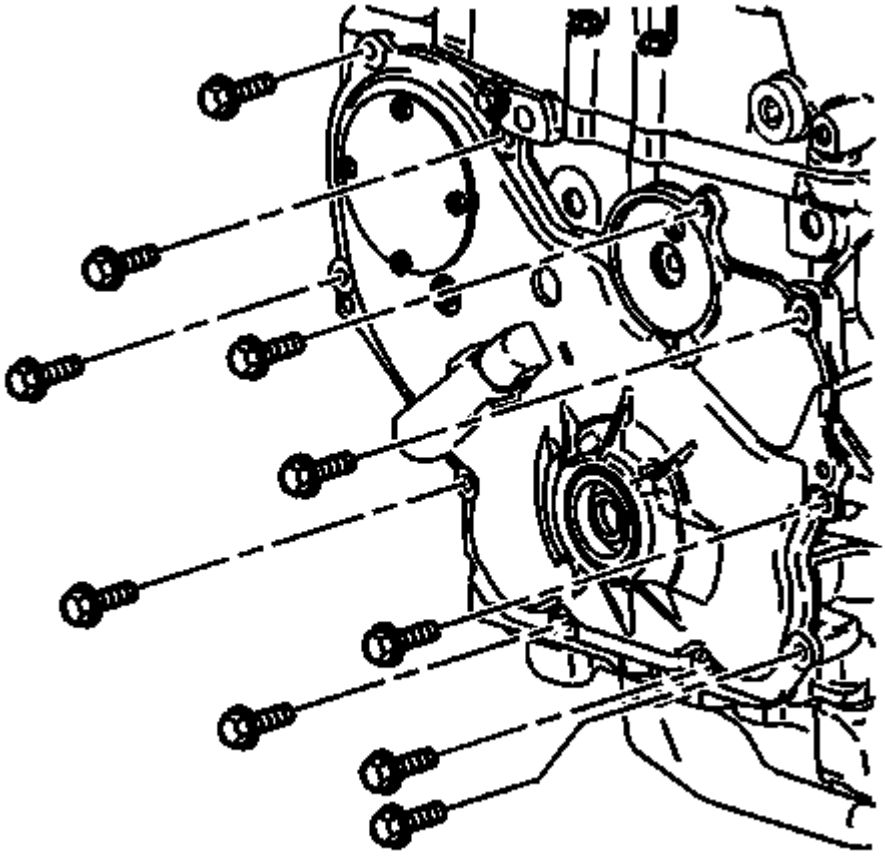

Fig. 363: View Of Engine Front Cover Bolts
Courtesy of GENERAL MOTORS CORP.

3. Remove the engine front cover bolts.

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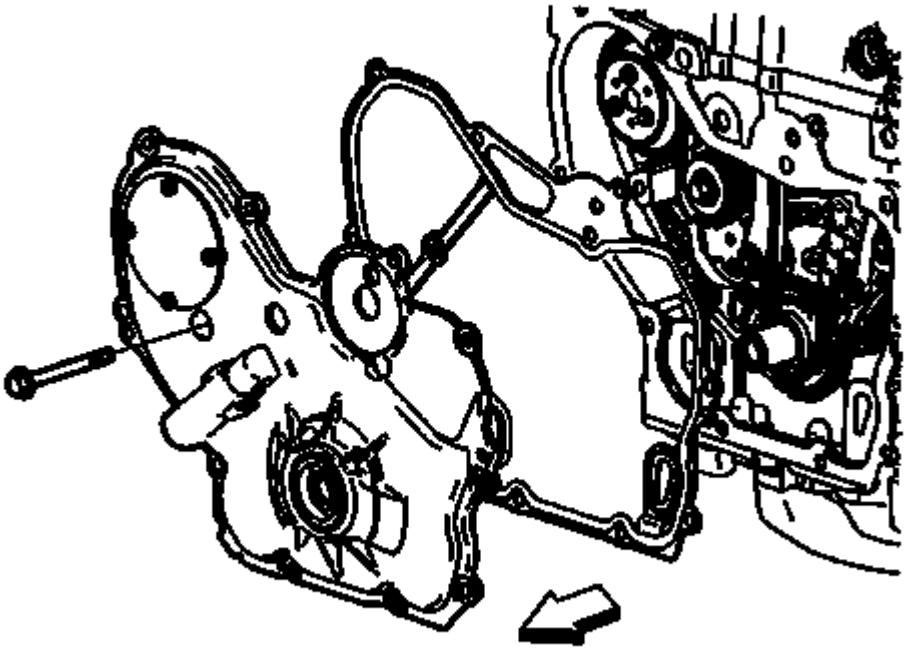

Fig. 364: View Of Engine Front Cover
Courtesy of GENERAL MOTORS CORP.

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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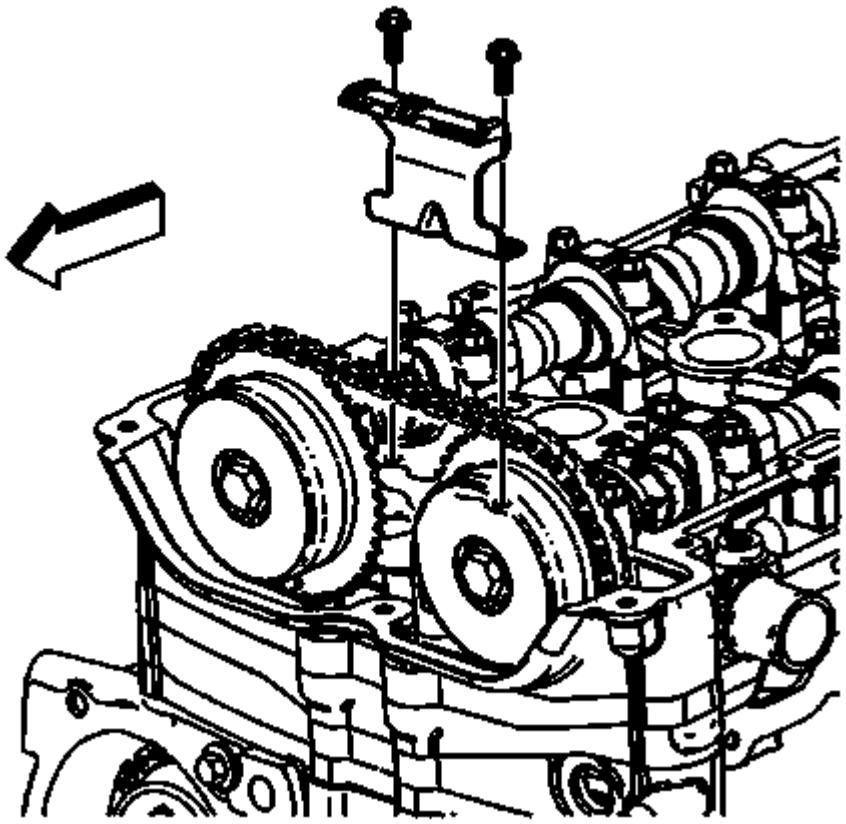

Fig. 365: Upper Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

1. Remove the upper timing chain guide bolts.
2. Remove the upper timing chain guide.

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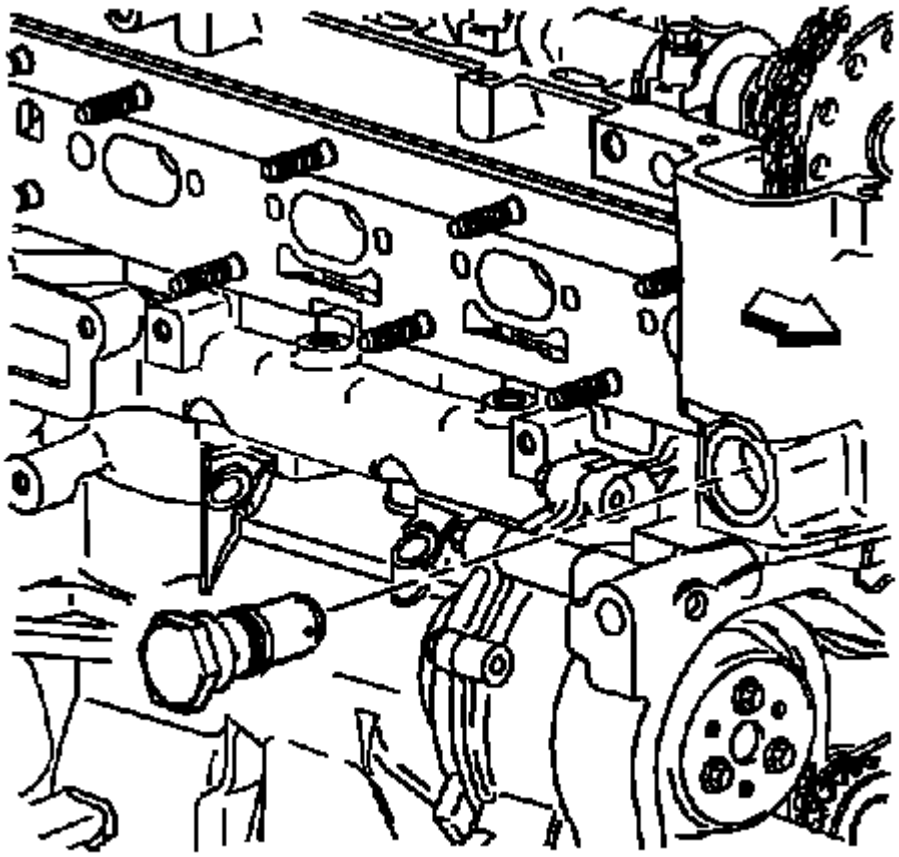

Fig. 366: Identifying Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

IMPORTANT: The timing chain tensioner must be removed to unload chain tension before the timing chain is removed.

3. Remove the timing chain tensioner plunger.

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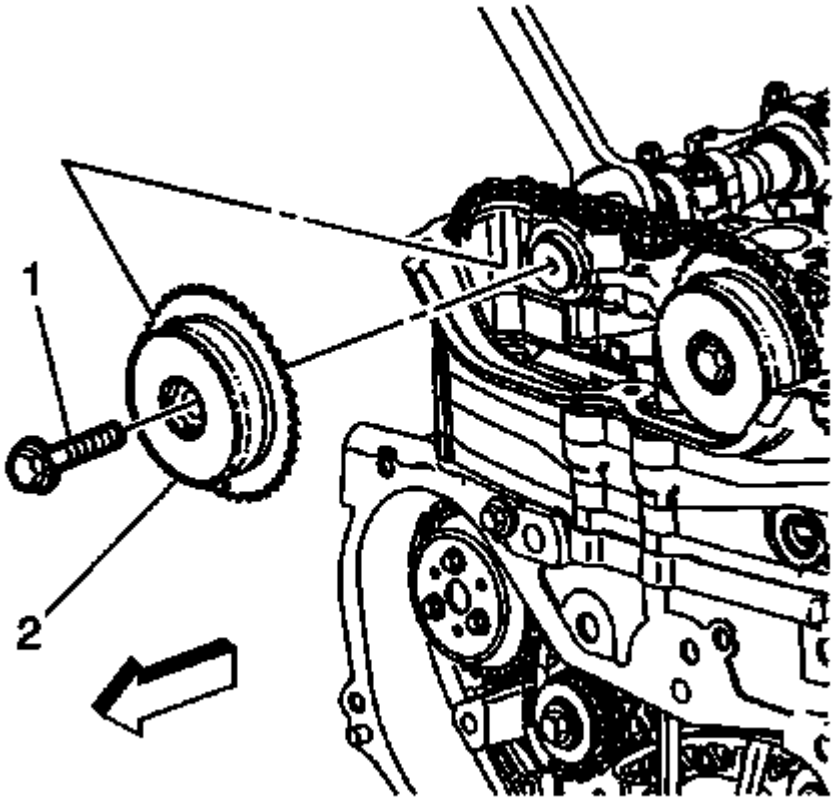

Fig. 367: Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

4. Locate hex on the exhaust camshaft and hold with a wrench.
5. Remove the exhaust camshaft bolt and the exhaust camshaft actuator.

   Discard the bolt.

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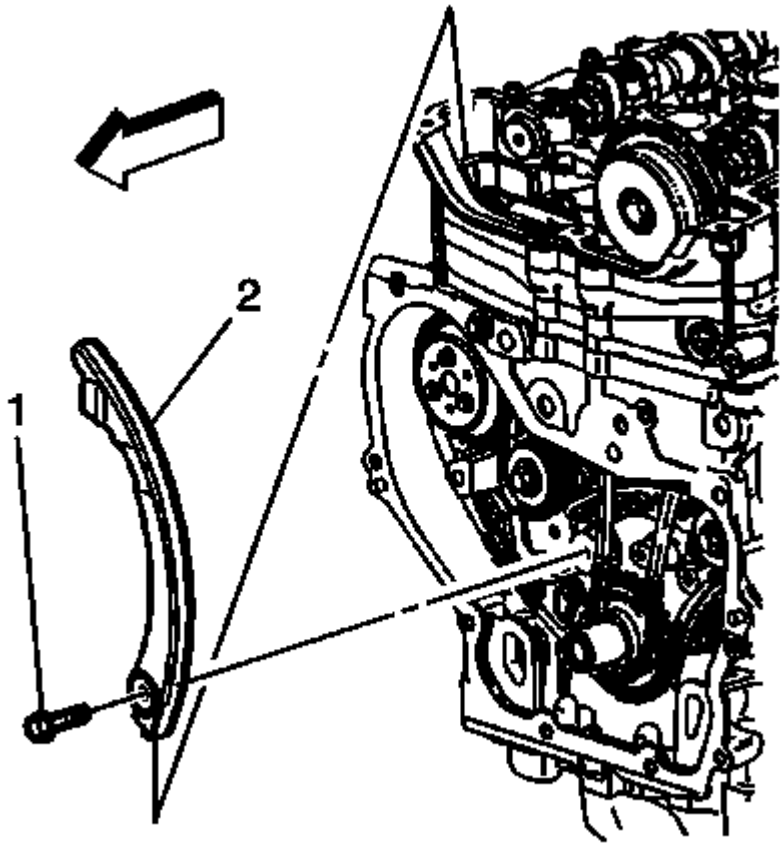

Fig. 368: Adjustable Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

6. Remove the adjustable timing chain guide bolt.
7. Remove the adjustable timing chain guide.

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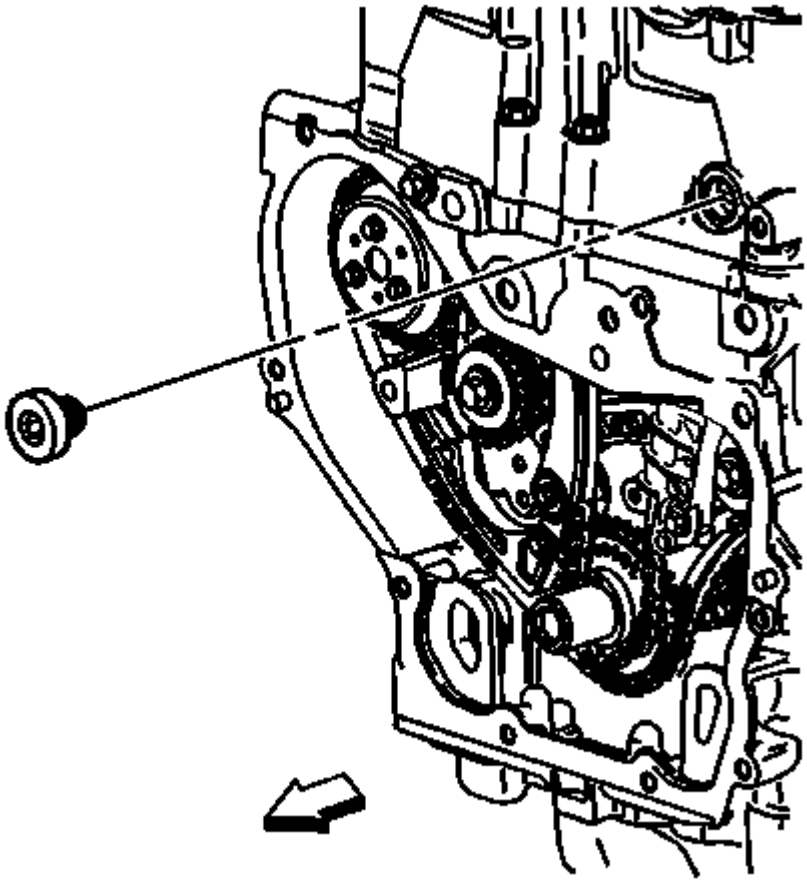

Fig. 369: View Of Fixed Timing Chain Guide Access Plug
Courtesy of GENERAL MOTORS CORP.

8. Remove the plug to gain access to the fixed timing chain guide bolt.

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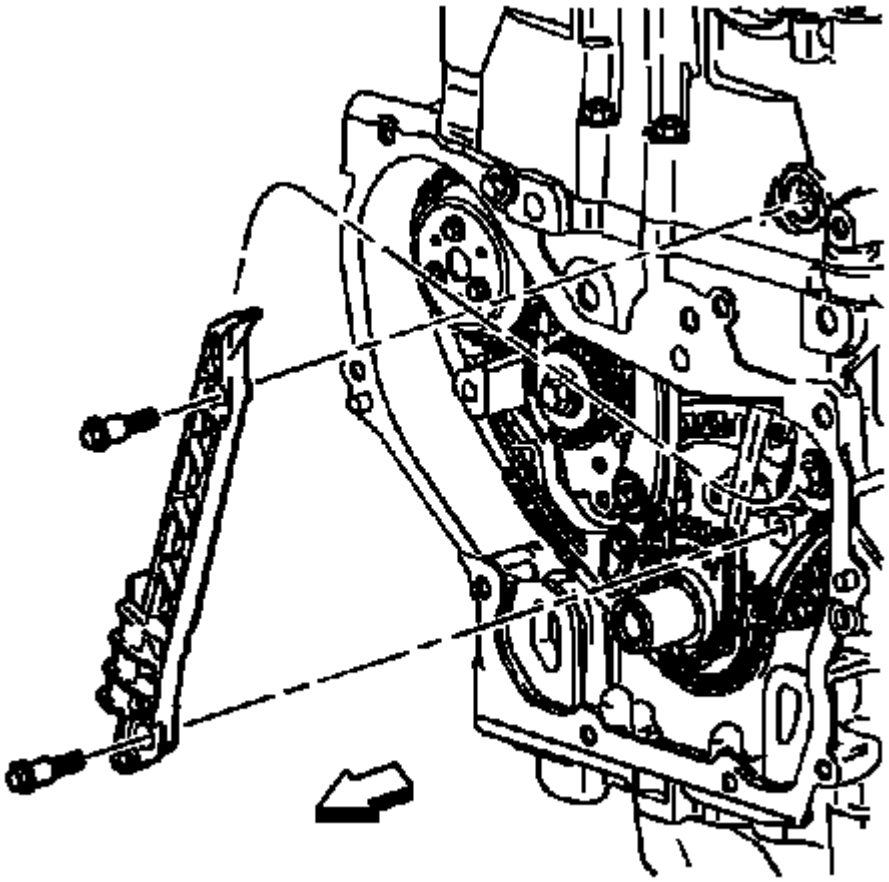

Fig. 370: View Of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

9. Remove the fixed timing chain guide bolts.
10. Remove the fixed timing chain guide.

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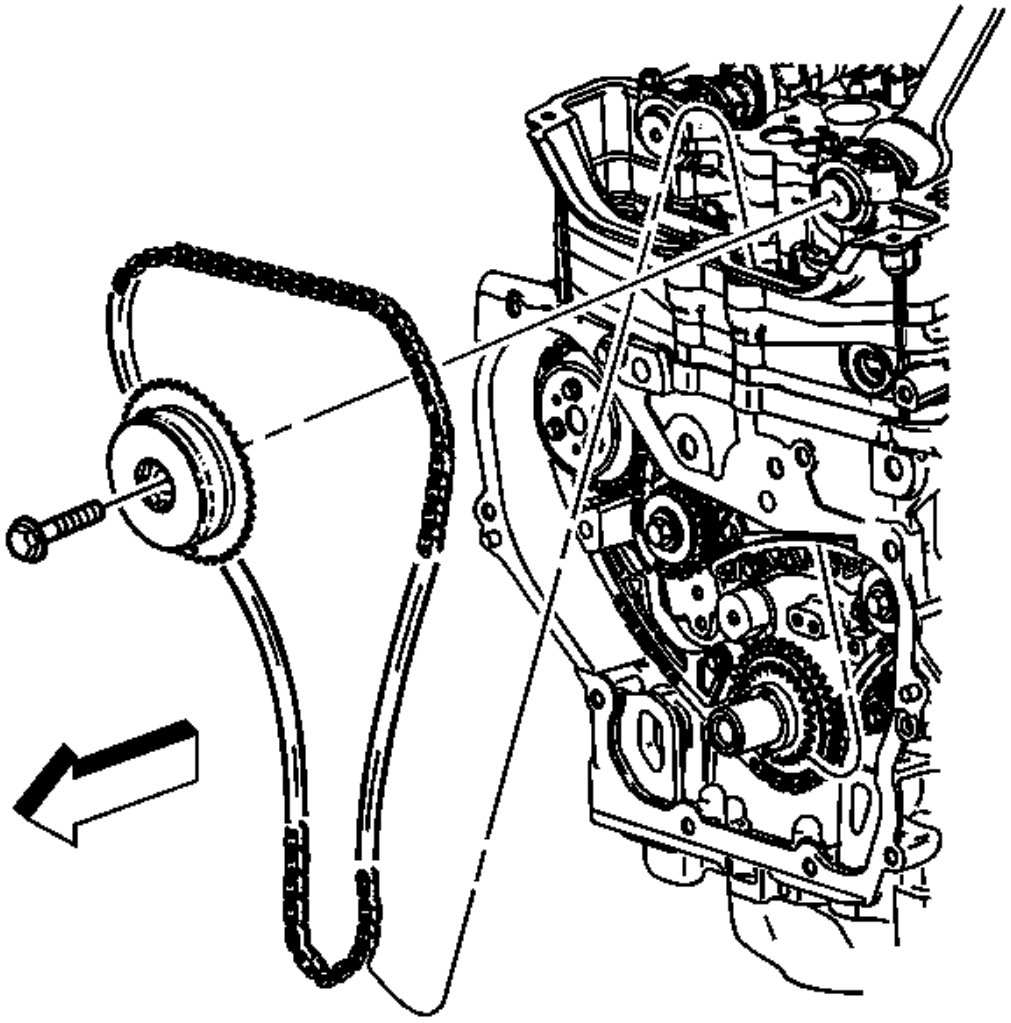

Fig. 371: Identifying Intake Cam Sprocket & The Timing Chain
Courtesy of GENERAL MOTORS CORP.

11. Locate hex on the intake camshaft and hold with a wrench.
12. Remove the intake camshaft actuator bolt, the intake camshaft actuator and the timing chain through the top of the cylinder head.

    Discard the bolt.

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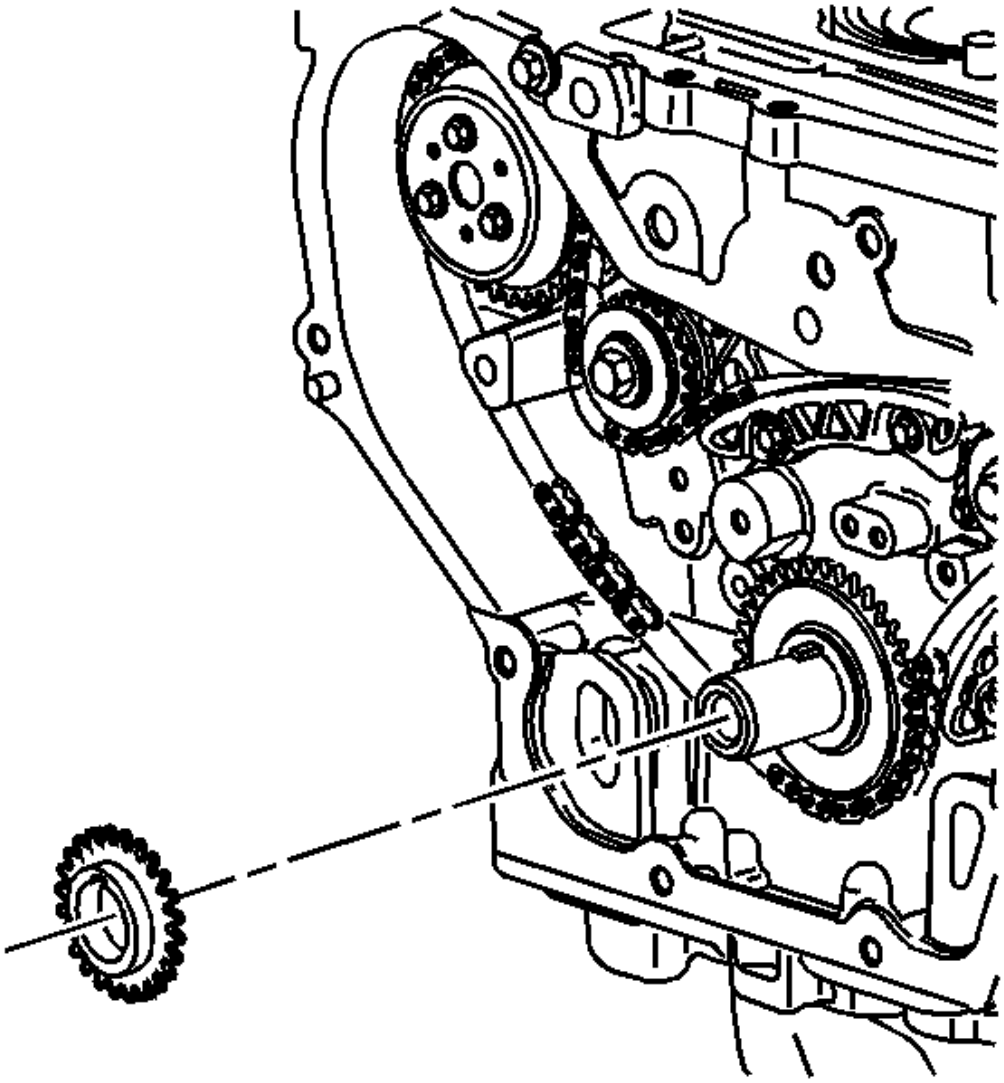

Fig. 372: View Of Crankshaft Sprocket
Courtesy of GENERAL MOTORS CORP.

13. Remove the crankshaft sprocket.

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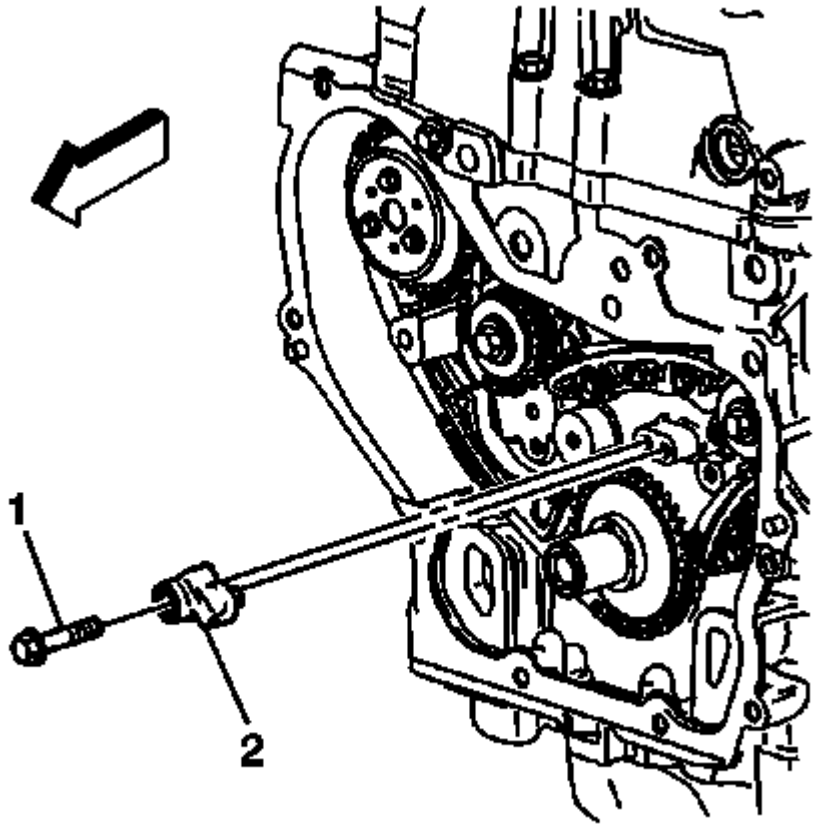

Fig. 373: View Of Oil Nozzle & Bolt
Courtesy of GENERAL MOTORS CORP.

14. Remove the timing chain oil nozzle bolt.
15. Remove the timing chain oil nozzle.

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER REMOVAL

Intake Camshaft Removal

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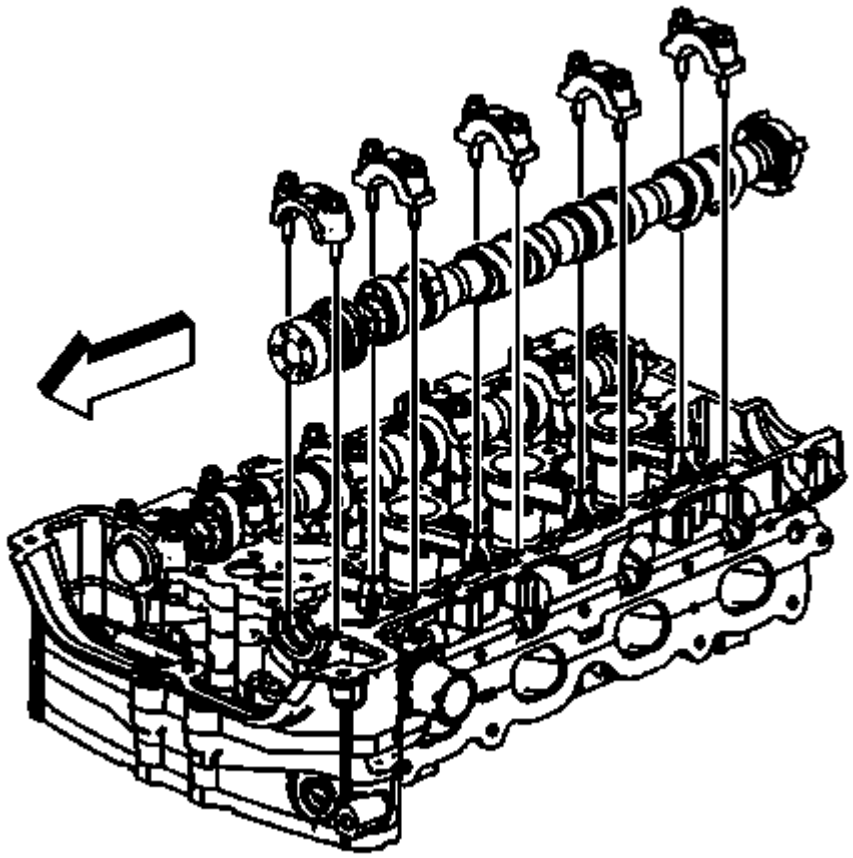

Fig. 374: Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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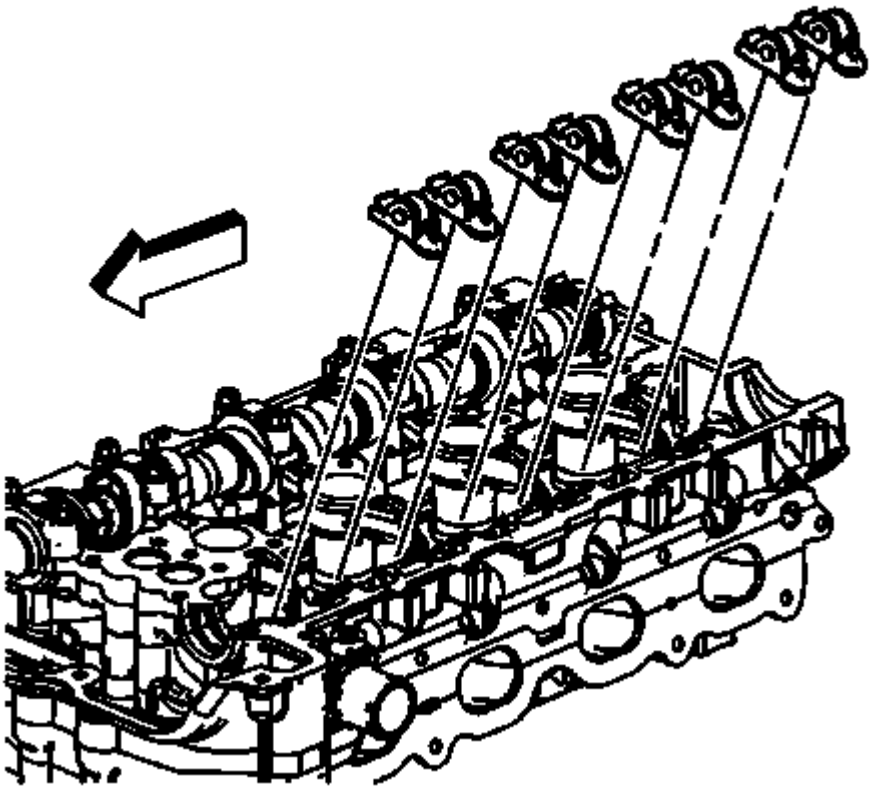

Fig. 375: Identifying Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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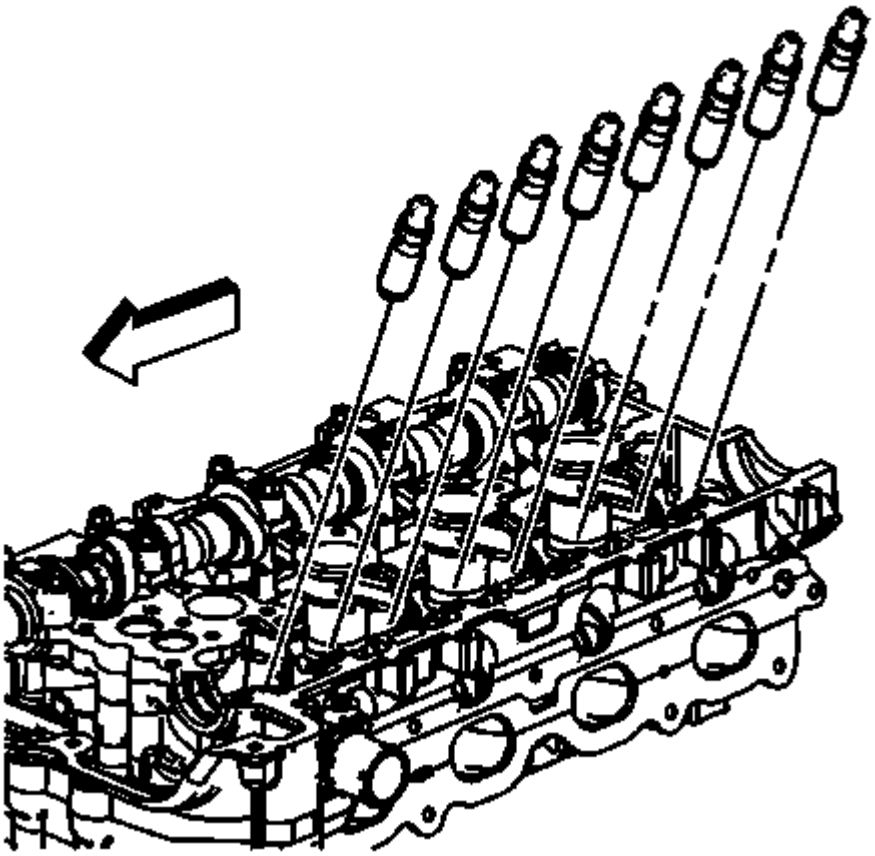

Fig. 376: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

Exhaust Camshaft Removal

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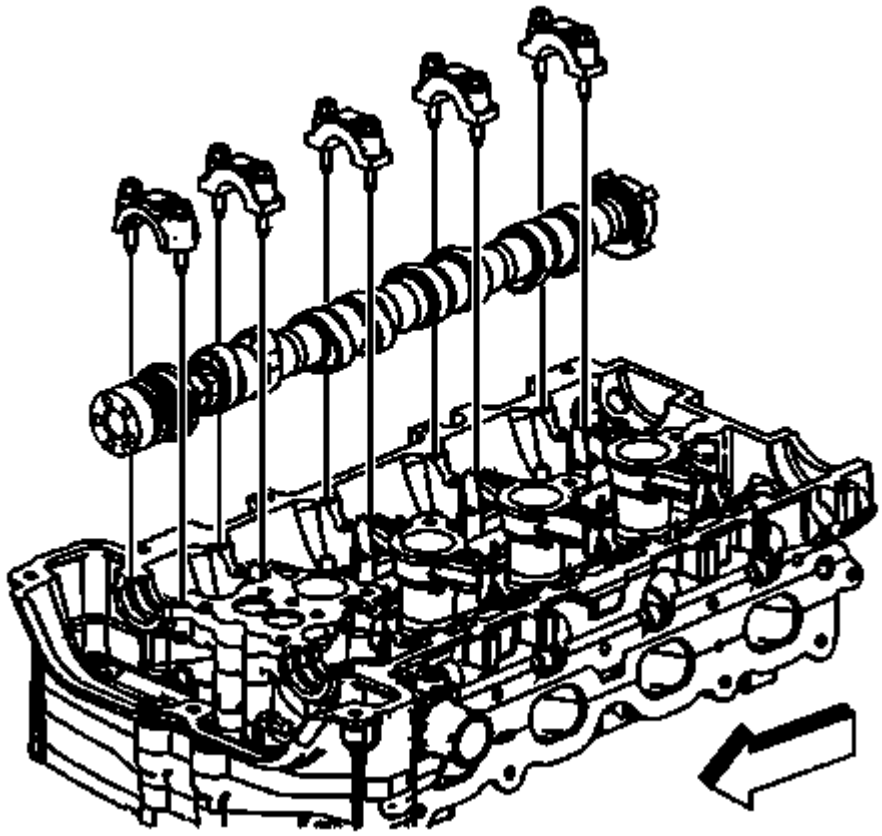

Fig. 377: Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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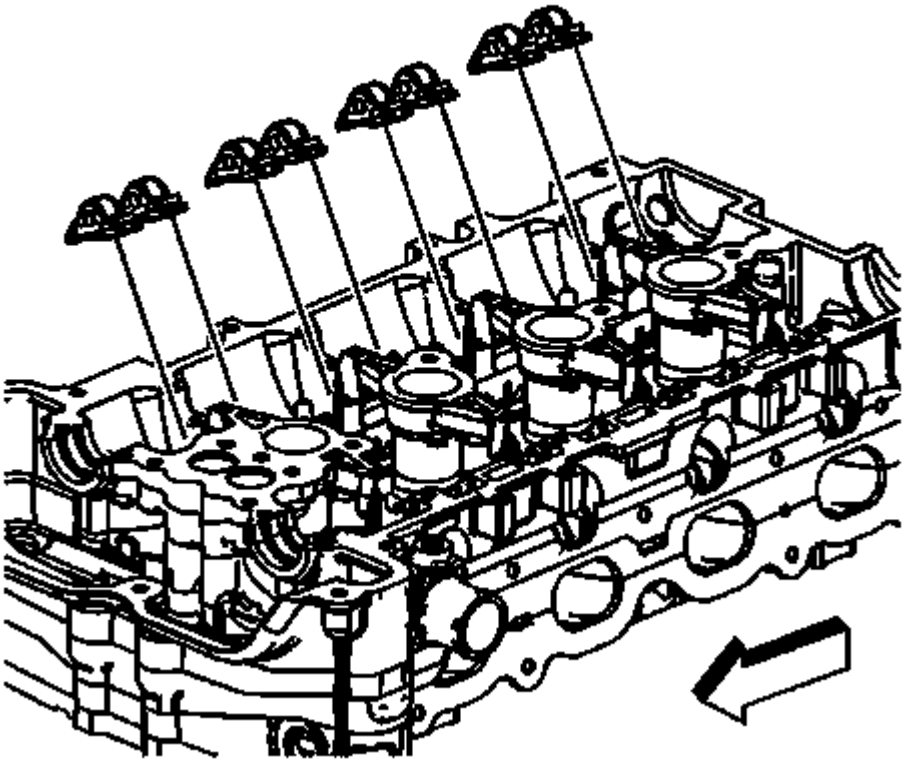

Fig. 378: Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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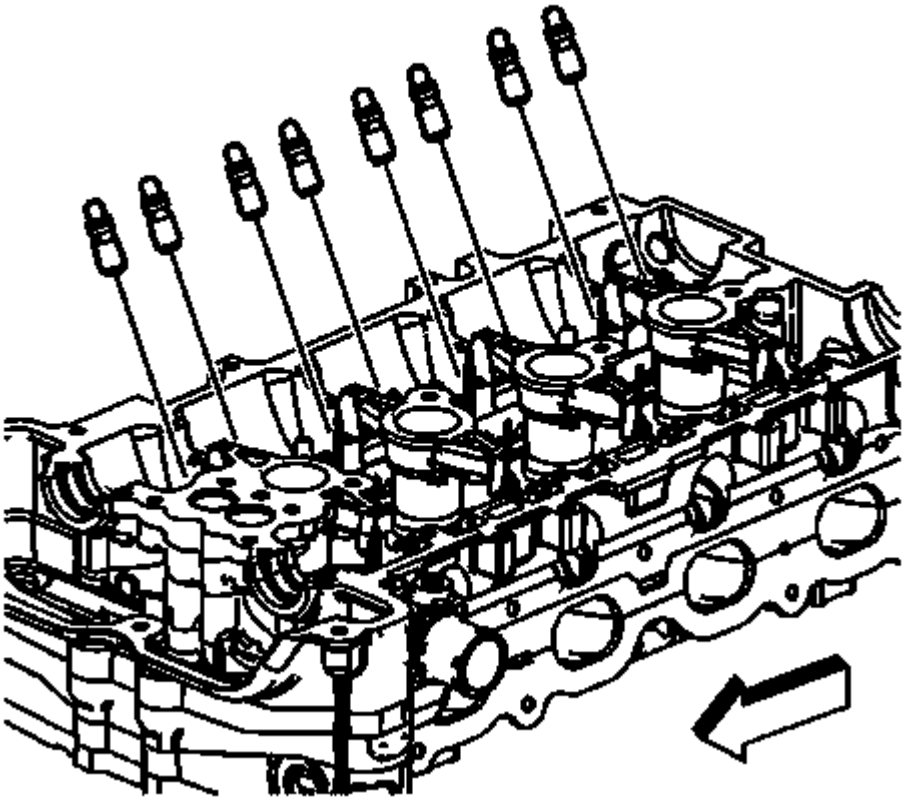

Fig. 379: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

6. Remove the hydraulic lash adjusters.

WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER REMOVAL

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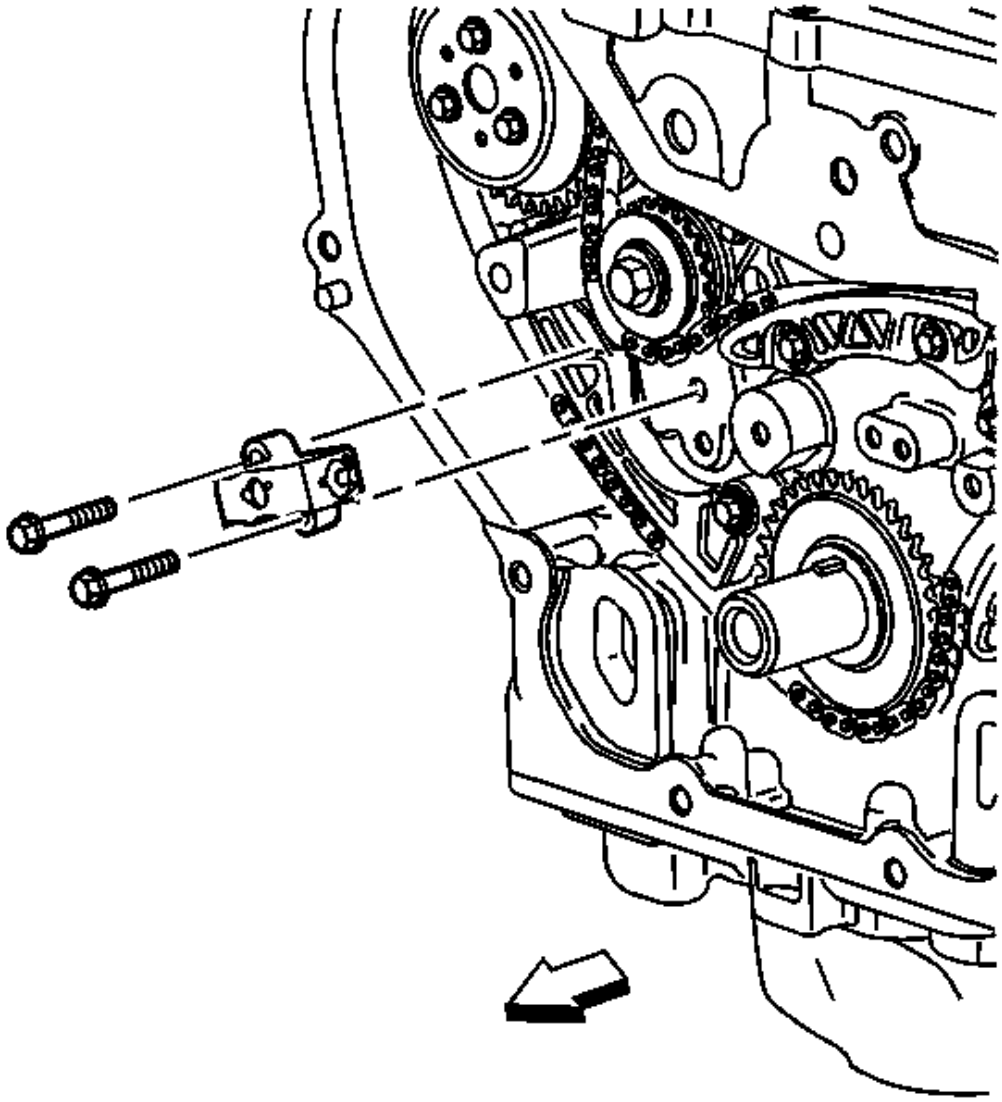

Fig. 380: Identifying Balance Shaft Drive Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft drive chain tensioner bolts.
2. Remove the balance shaft drive chain tensioner.

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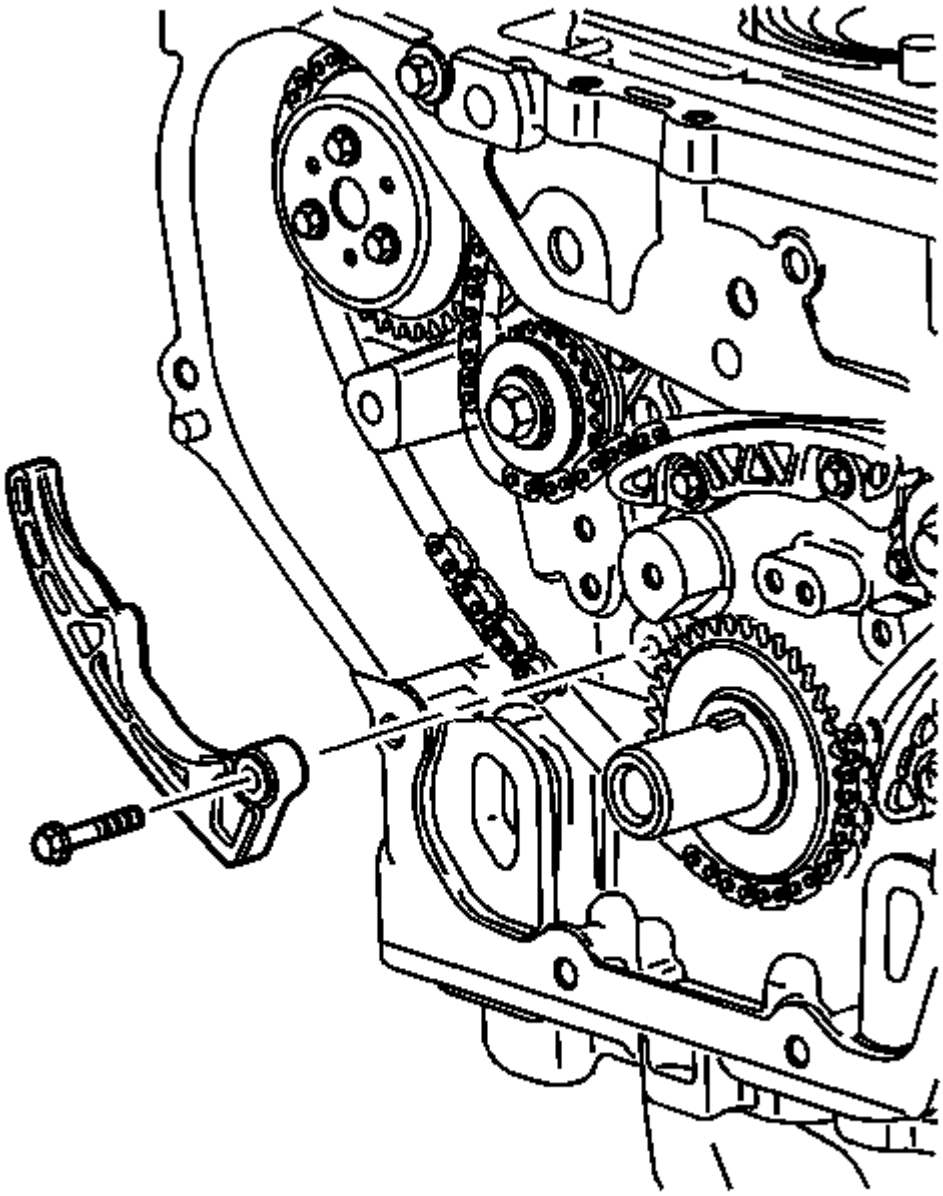

Fig. 381: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

3. Remove the adjustable balance shaft chain guide bolt.
4. Remove the adjustable balance shaft chain guide.

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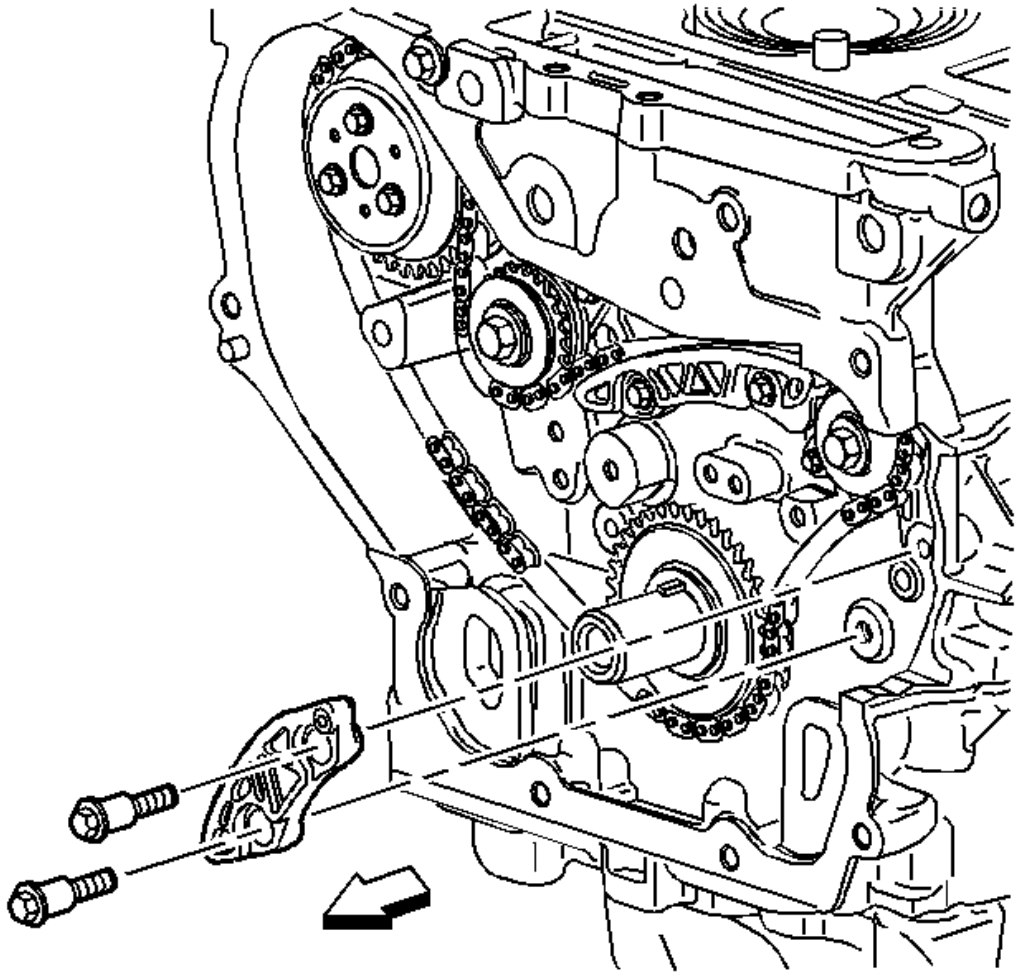

Fig. 382: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

5. Remove the small balance shaft drive chain guide bolts.
6. Remove the small balance shaft drive chain guide.

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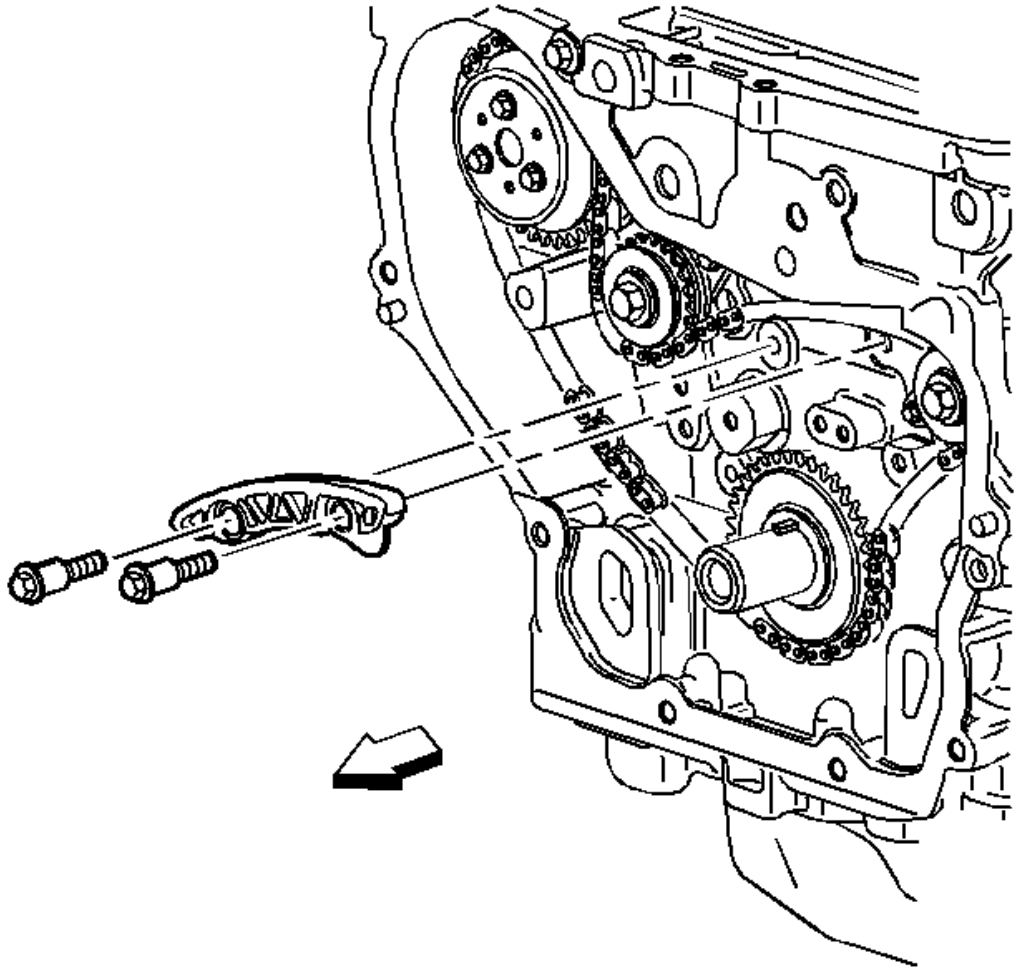

Fig. 383: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

7. Remove the upper balance shaft drive chain guide bolts.
8. Remove the upper balance shaft drive chain guide.

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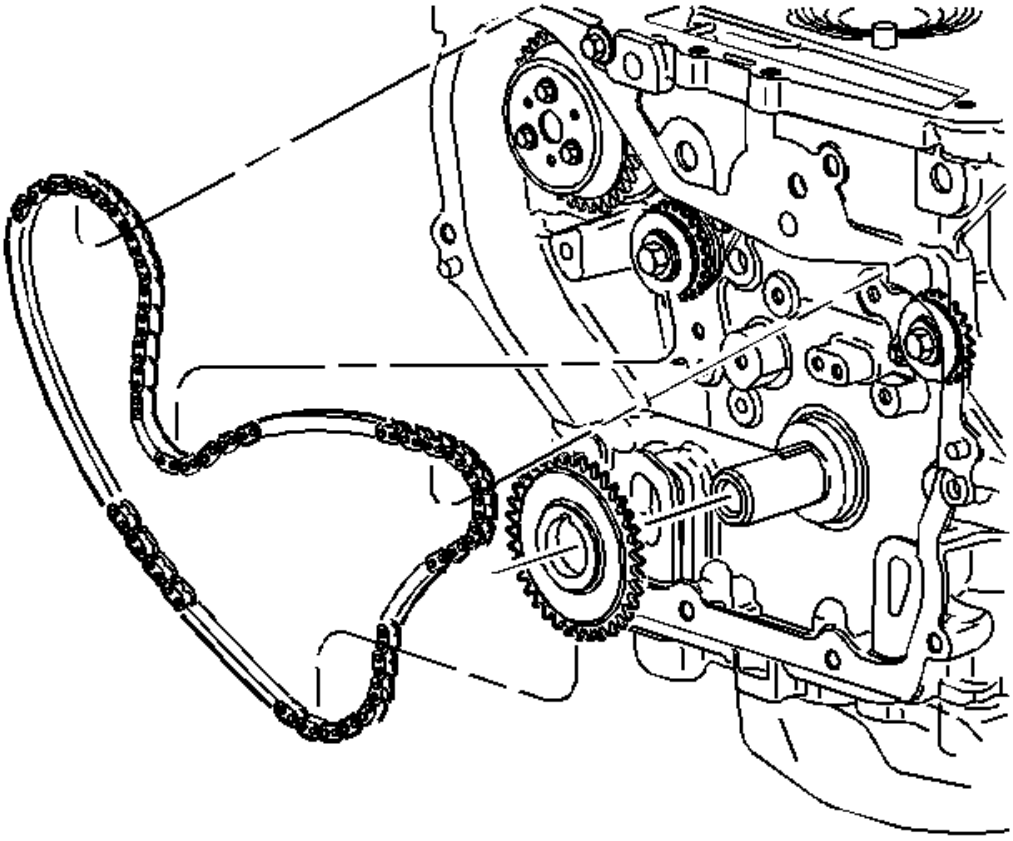

Fig. 384: Identifying Upper Balance Shaft Drive Chain/Sprocket
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

EN-43650: Balancer Shaft Bearing Remover and Installer

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

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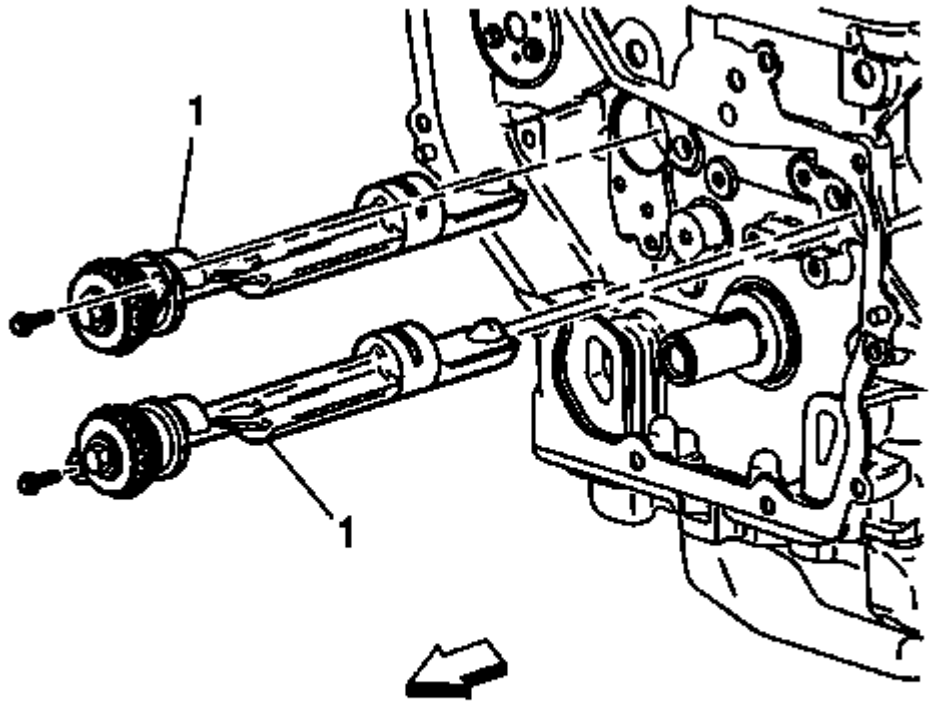

Fig. 385: View of Balance Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

1. Remove the balance shaft bearing carrier bolts.

NOTE:

- **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 (1).

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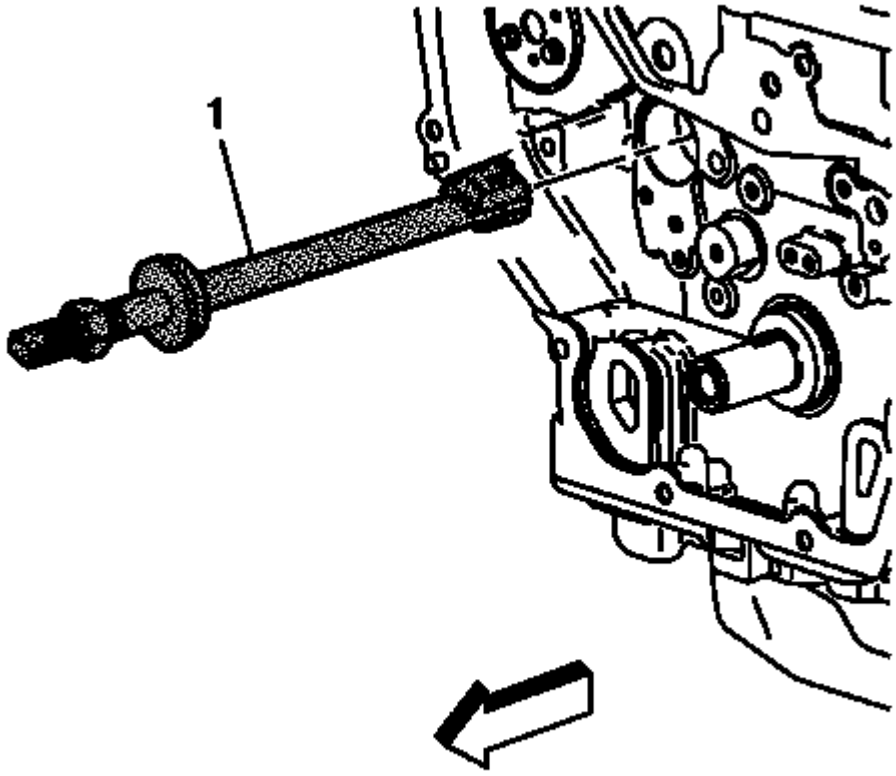

Fig. 386: View of Special Tool EN-43650 on the Balance Shaft Bushing
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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 **EN-43650:** remover (1) into the balance shaft hole. Insert the tool with the foot parallel to the shaft.

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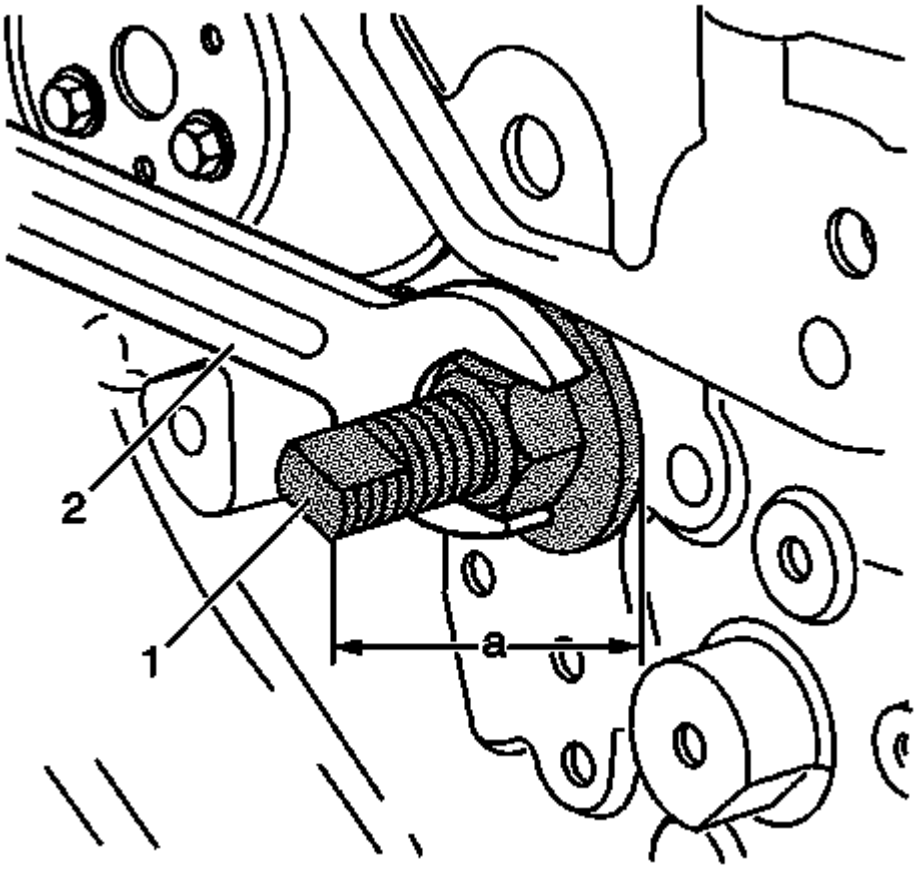

Fig. 387: Turn Special Tool EN-43650 Remover So Foot Becomes Perpendicular To Shaft
Courtesy of GENERAL MOTORS CORP.

4. When the **EN-43650:** remover (1) is inserted in the block turn the **EN-43650:** remover so that the foot becomes perpendicular to the shaft.
5. Center the foot of the **EN-43650:** remover on the balance shaft bushing.
6. Once the **EN-43650:** remover 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 (2).

   When the **EN-43650:** remover 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 **EN-43650:** remover is less than approximately 114 mm (4.5 in) (a), recheck the tool alignment.

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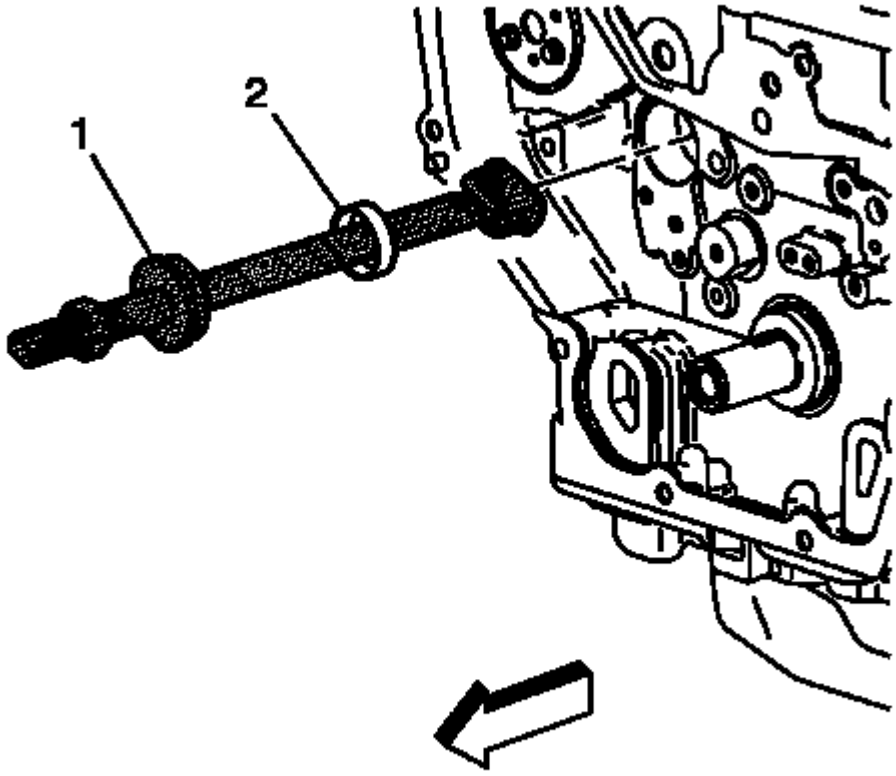

Fig. 388: View of Special Tool EN-43650
Courtesy of GENERAL MOTORS CORP.

7. Tighten the nut on the **EN-43650:** remover (1) until the tension releases. When the tension releases, remove the **EN-43650:** remover and the balance shaft bushing (2).

WATER PUMP REMOVAL

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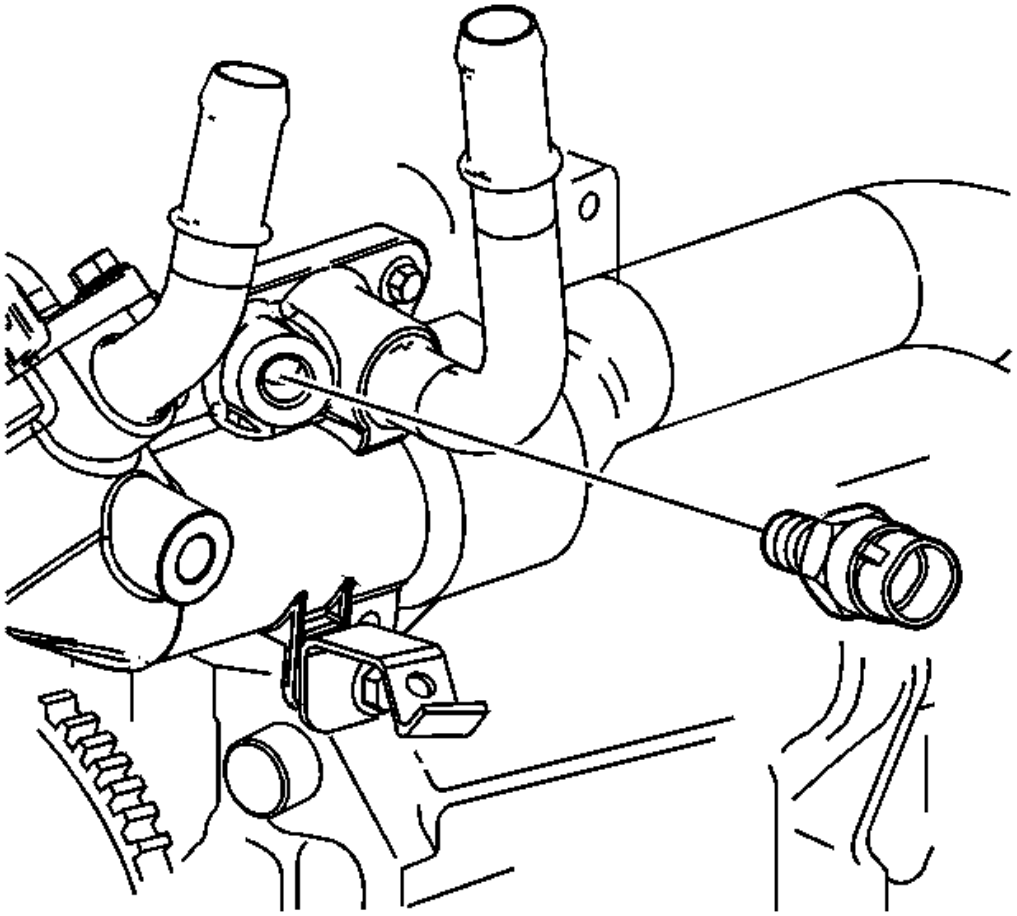

Fig. 389: Locating Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine coolant temperature sensor.

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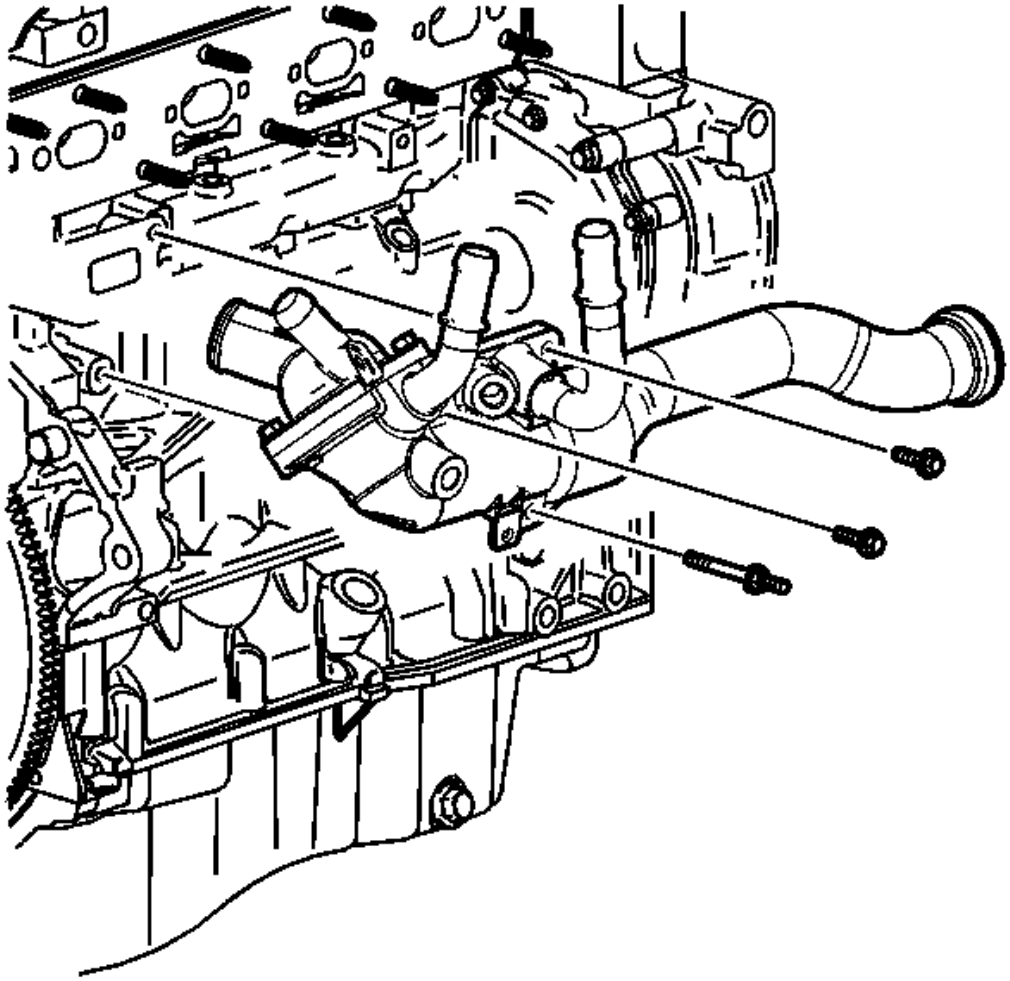

Fig. 390: View Of Thermostat & Water Feed Pipe Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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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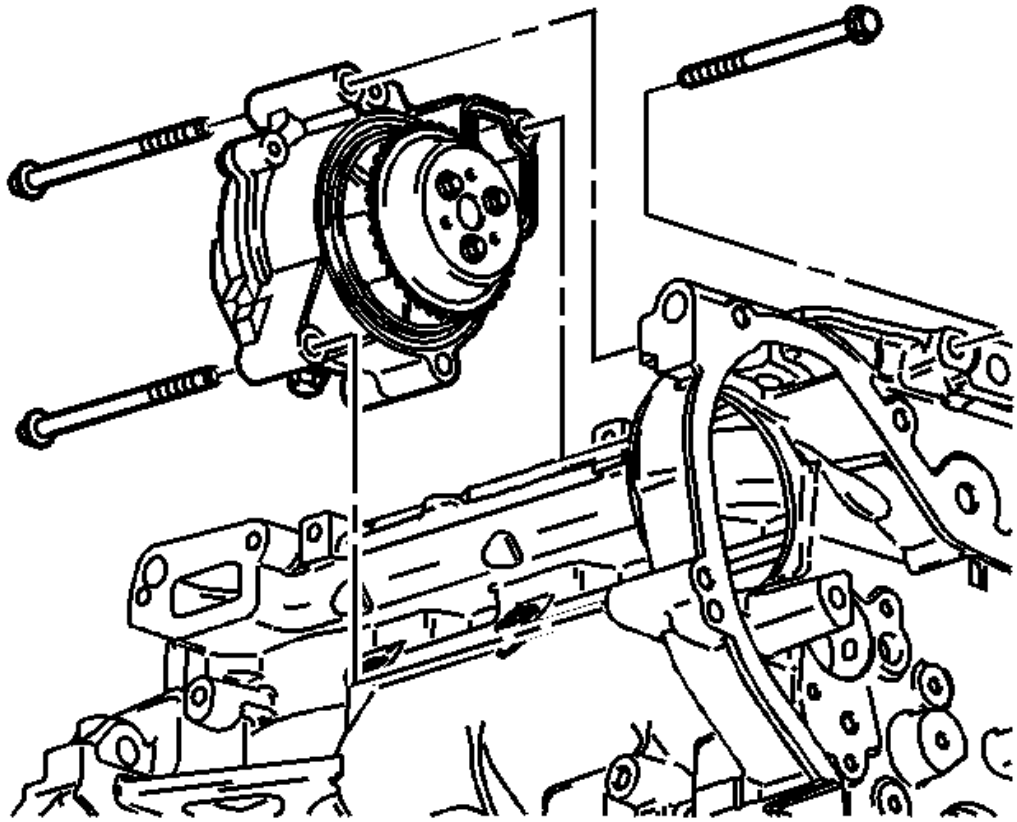

Fig. 391: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

EN-38188: Cylinder Head Broken Bolt Extractor Kit

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

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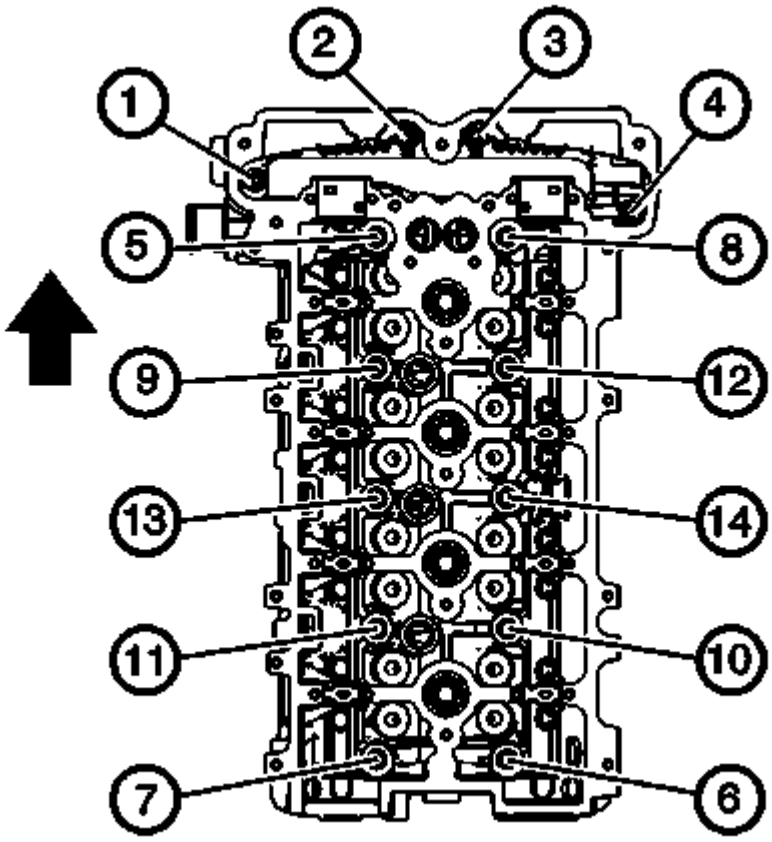

Fig. 392: Cylinder Head To Block Bolts Sequence
Courtesy of GENERAL MOTORS CORP.

1. Remove the cylinder head to the block bolts in sequence.

   Discard the bolts.

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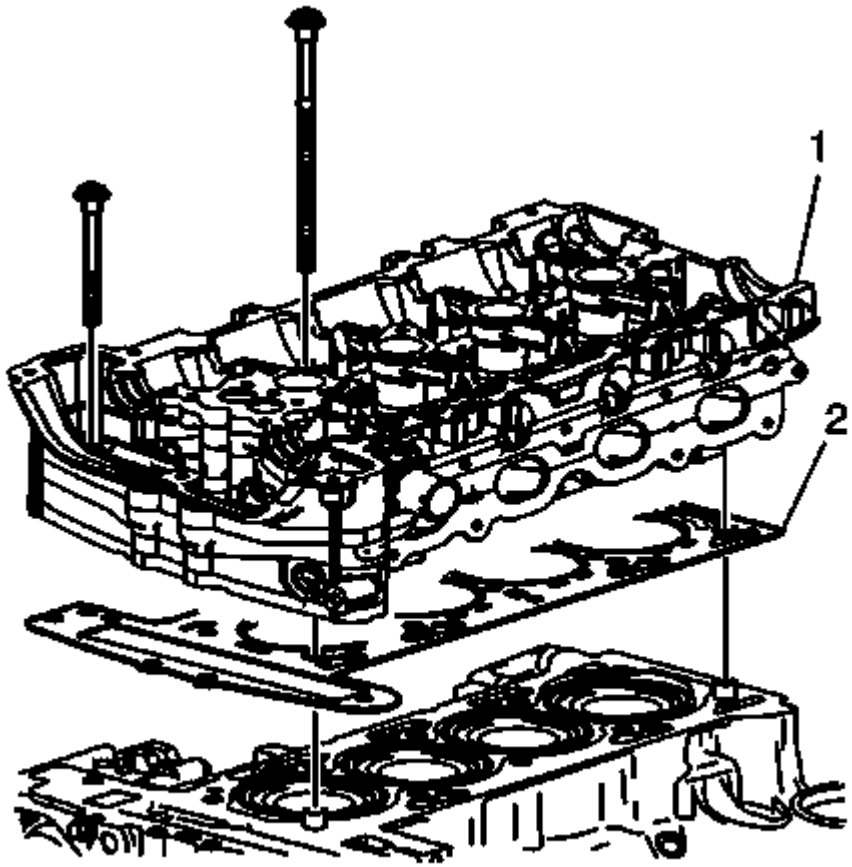

Fig. 393: View of Cylinder Head Gasket and Cylinder Head
Courtesy of GENERAL MOTORS CORP.

CAUTION: In order to prevent damage to the valves and injectors during cylinder head removal, set the cylinder head on blocks.

2. Remove the cylinder head (1).
3. Remove the cylinder head gasket (2).
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.

     NOTE: 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.

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NOTE: 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.

NOTE: 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.

WARNING: 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 **EN-38188:** extractor kit.

OIL PAN REMOVAL

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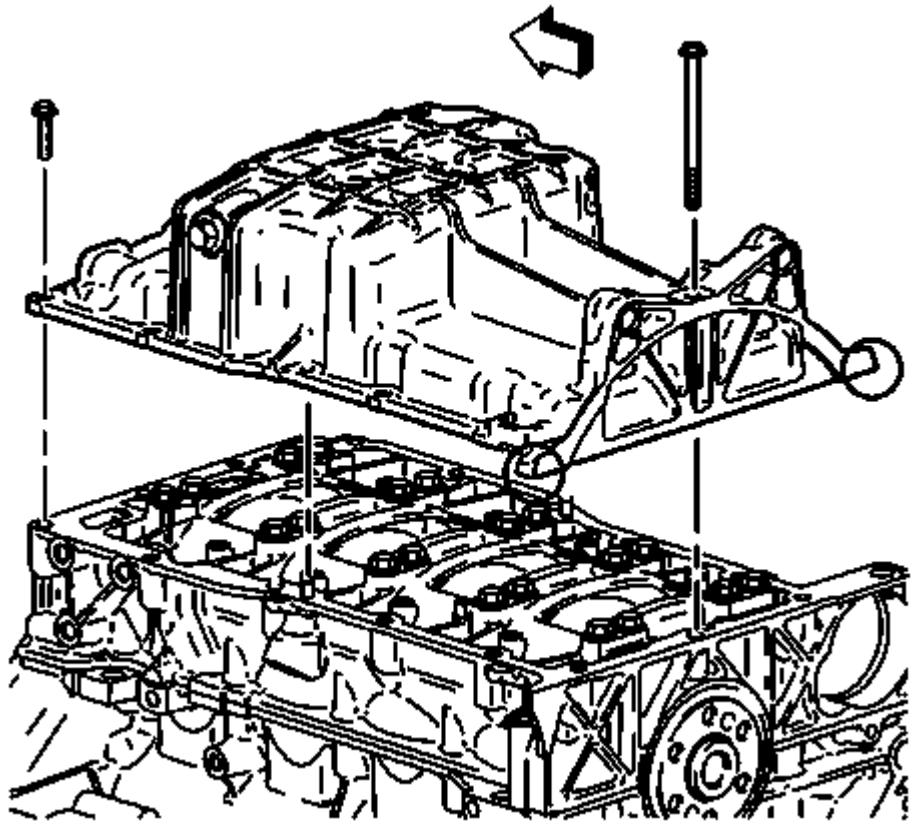

Fig. 394: View Of Oil Pan
Courtesy of GENERAL MOTORS CORP.

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

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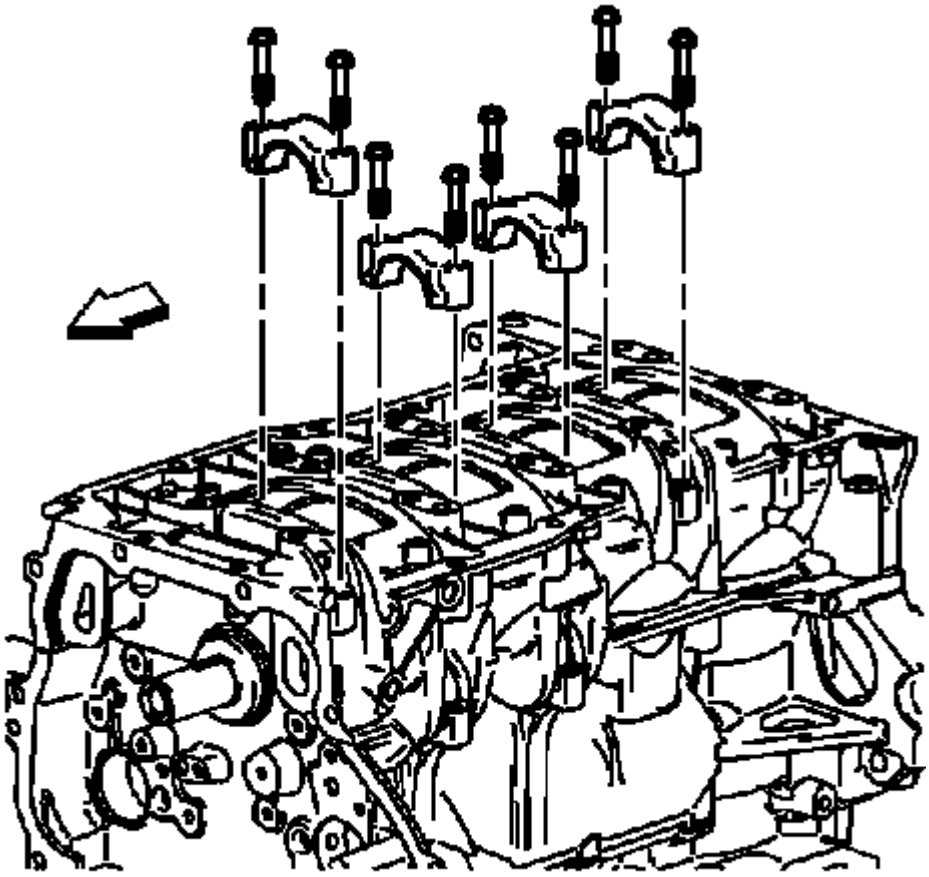

Fig. 395: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

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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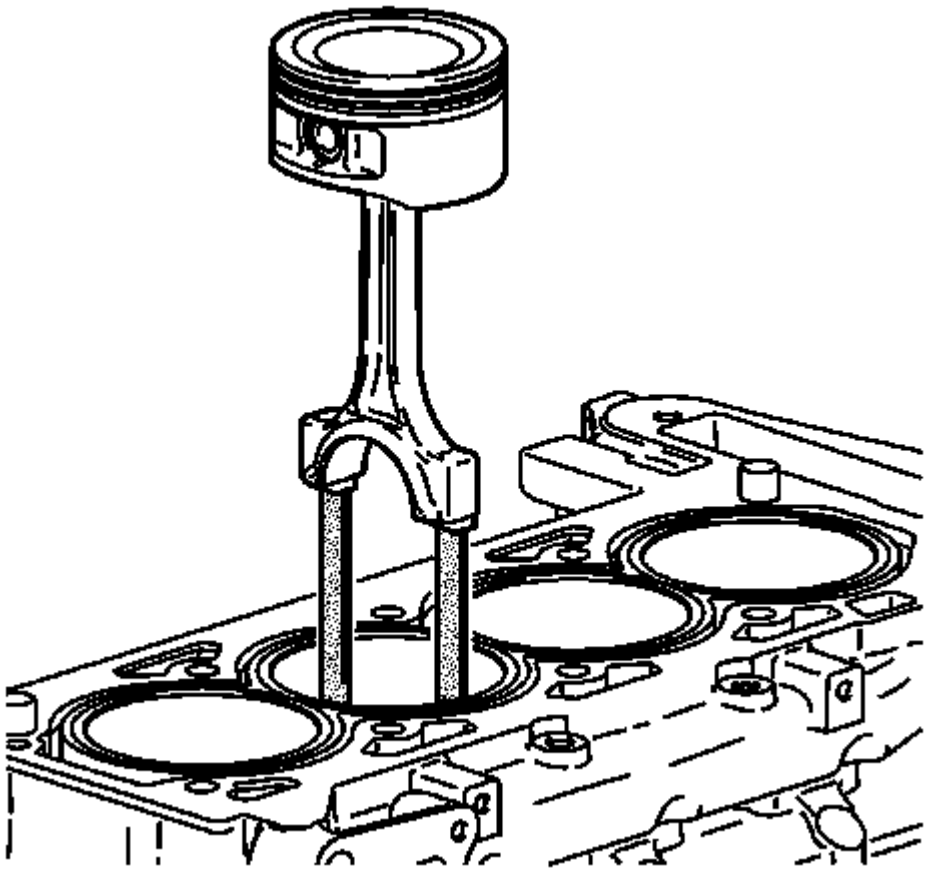

Fig. 396: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

6. Install **J-43966-1** on the connecting rod bolts before removing the piston and connecting rod assembly.
7. Remove the piston and connecting rod assembly.

LOWER CRANKCASE REMOVAL

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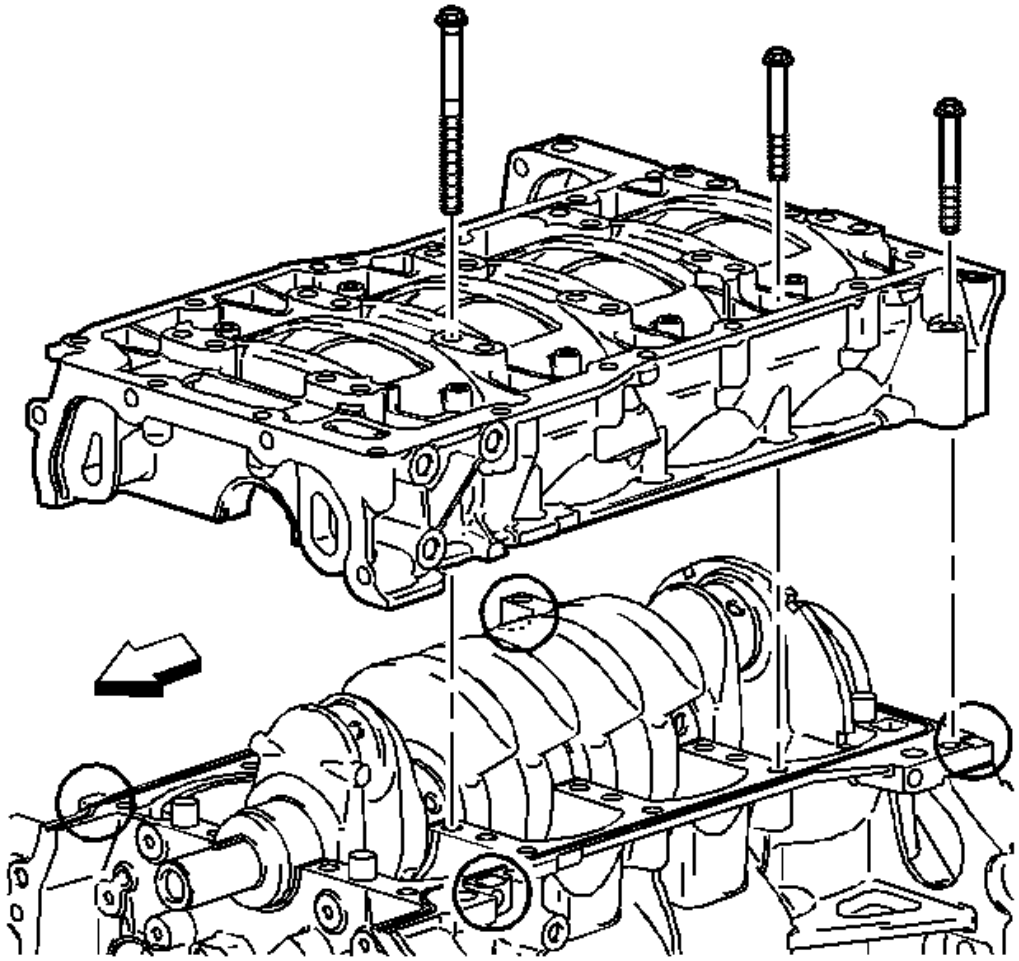

Fig. 397: View Of Upper & Lower Crankcase W/Bolts
Courtesy of GENERAL MOTORS CORP.

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 BEARING REMOVAL

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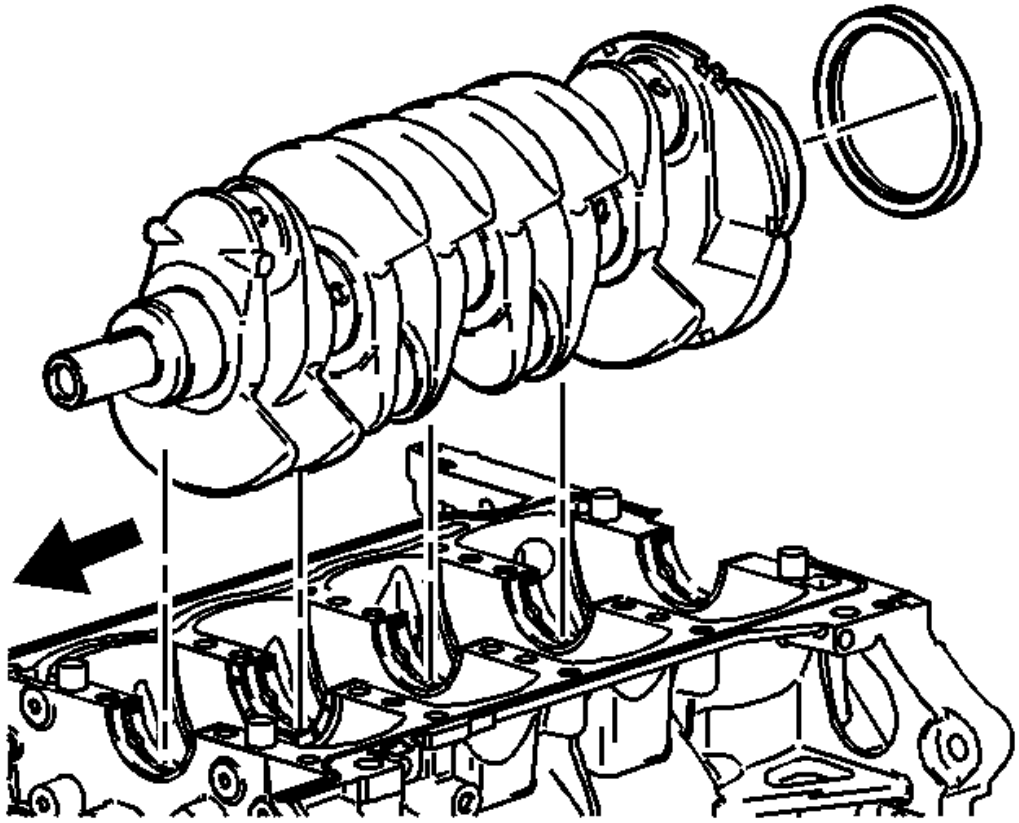

Fig. 398: View Of Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove the crankshaft from the block.
2. Remove the crankshaft rear oil seal from the block.

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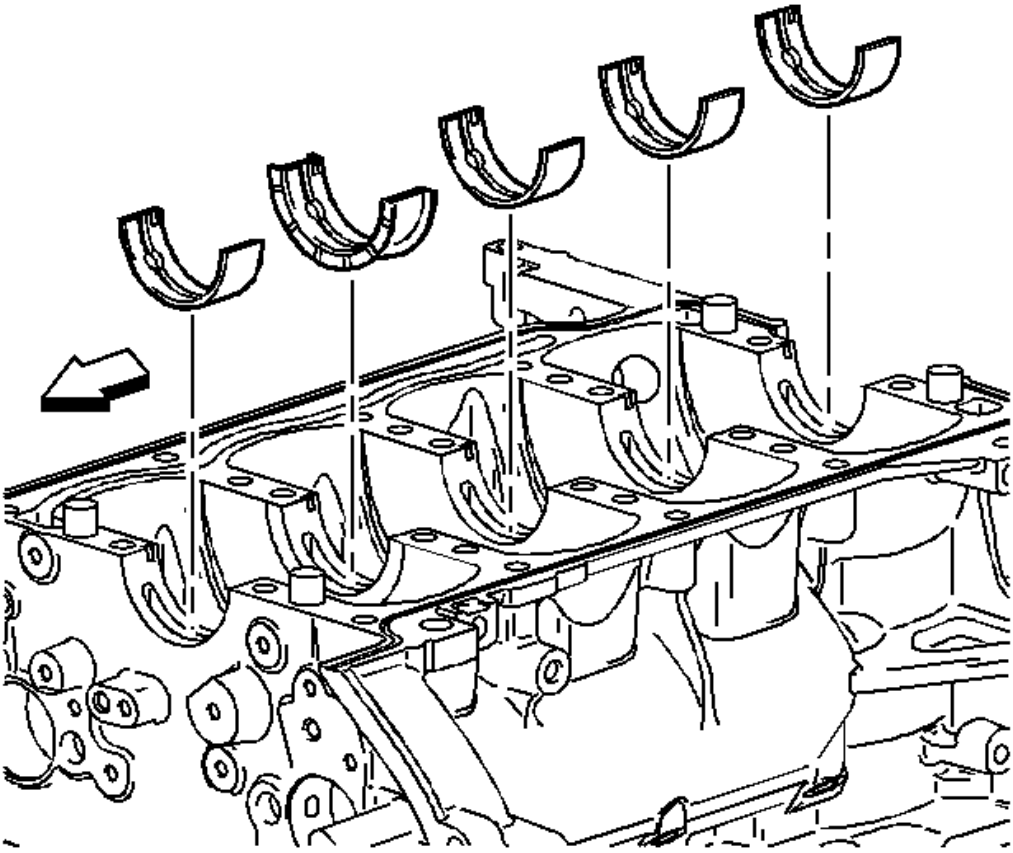

Fig. 399: View Of Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

3. Remove the bearing inserts from the block.

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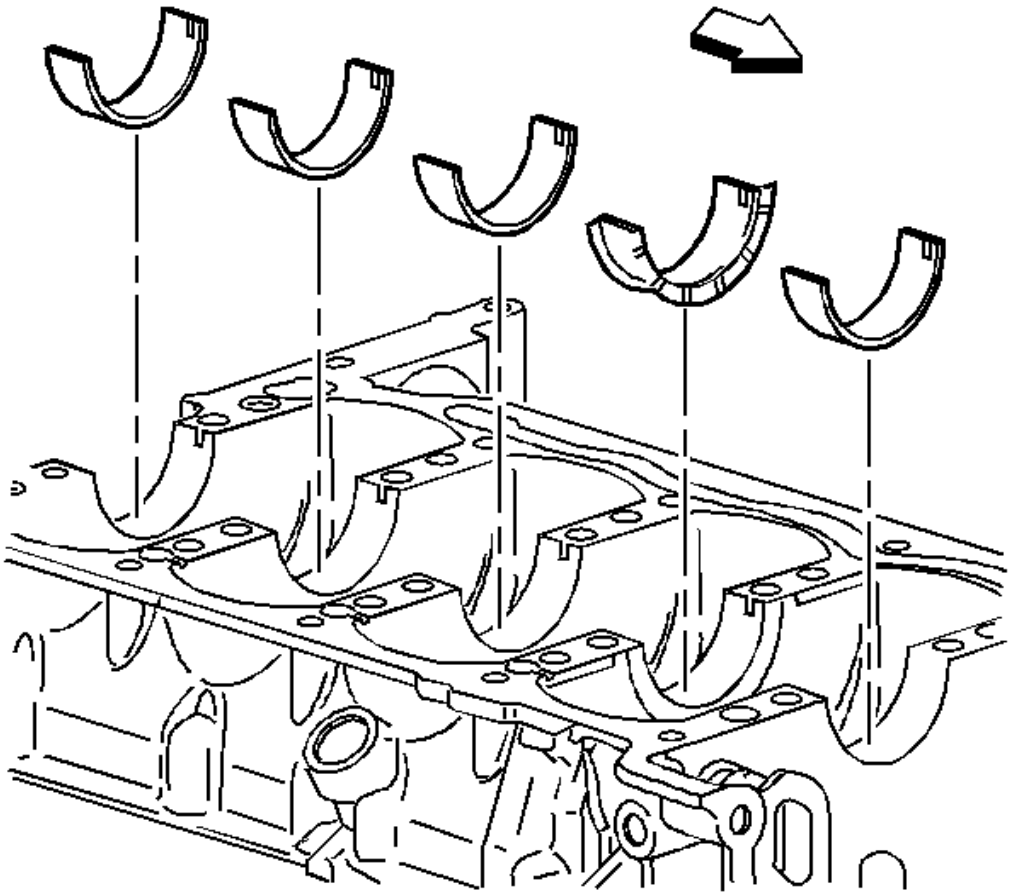

Fig. 400: Identifying Crankshaft Bearing Inserts
Courtesy of GENERAL MOTORS CORP.

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

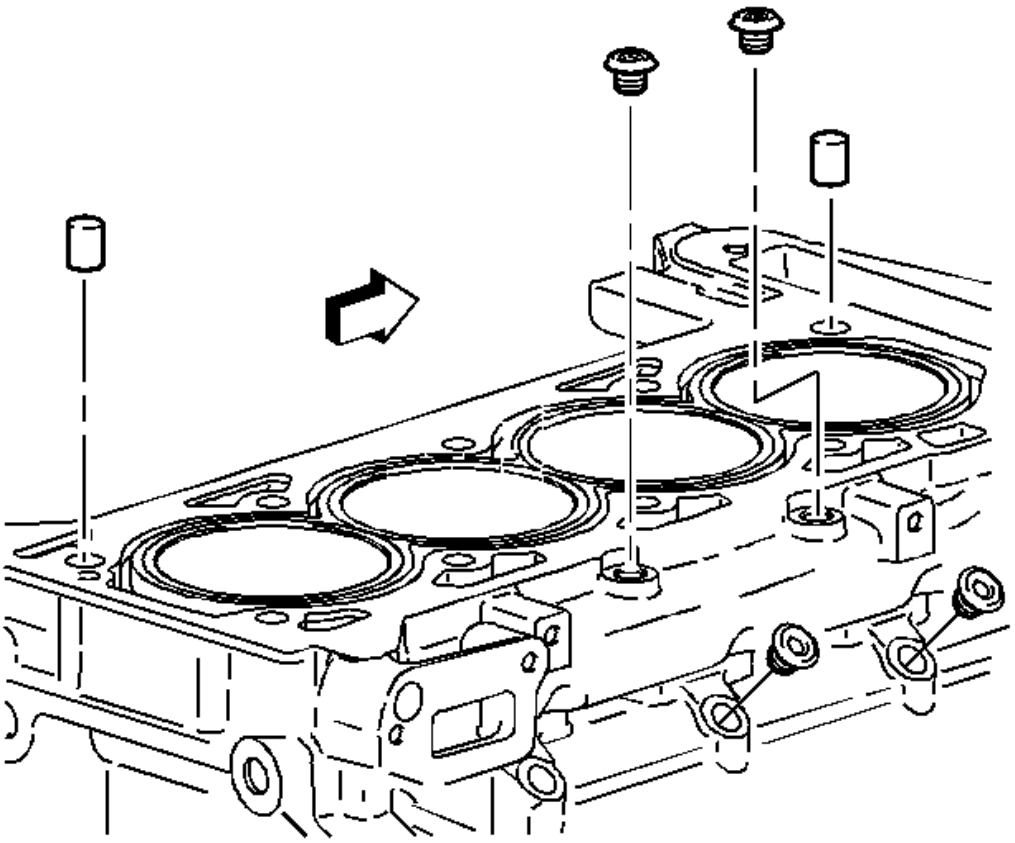

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Fig. 401: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Remove the engine block coolant drain plug.
2. Remove the rear oil passage plug.
3. Remove the 6 oil passage plugs on the sides of the block.
4. Remove the 2 water passage plugs on the top of the block.
5. Remove the 2 front oil passage plugs.

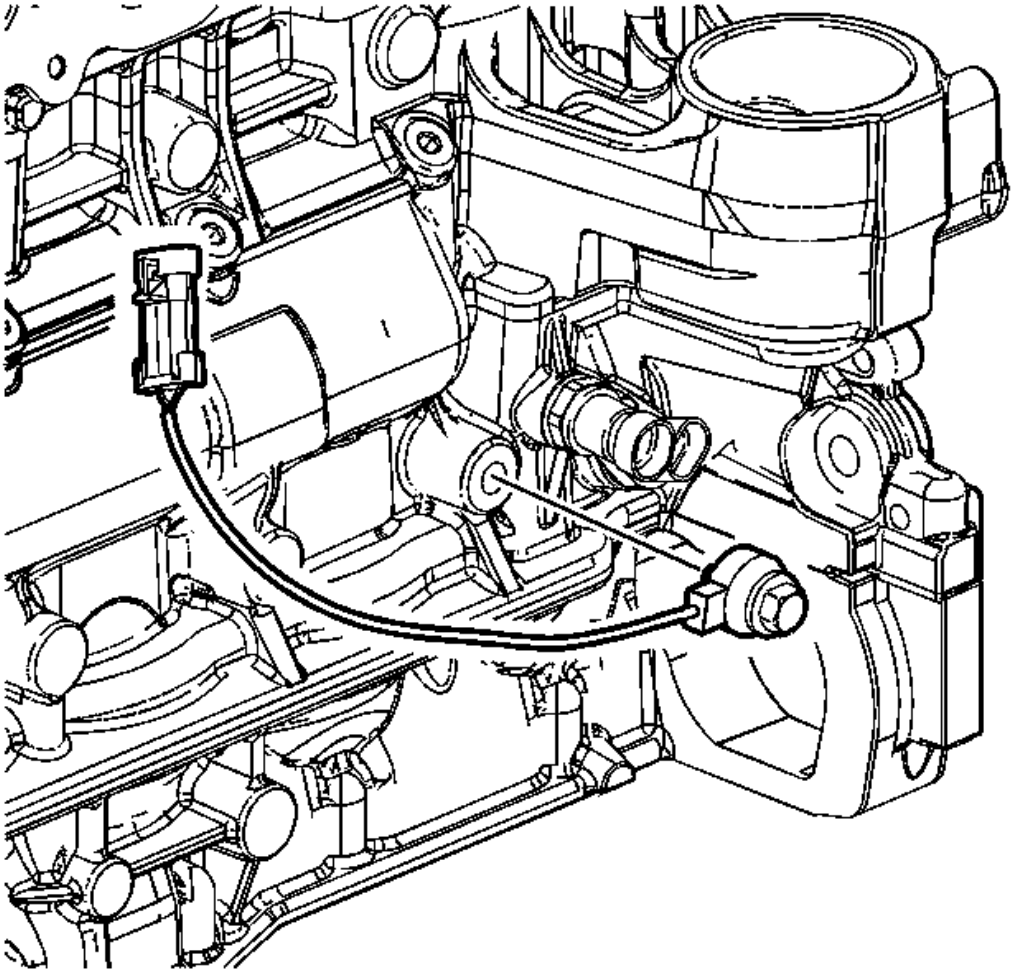

Fig. 402: View Of Knock Sensor & Bolt
Courtesy of GENERAL MOTORS CORP.

6. Remove the knock sensor and bolt.

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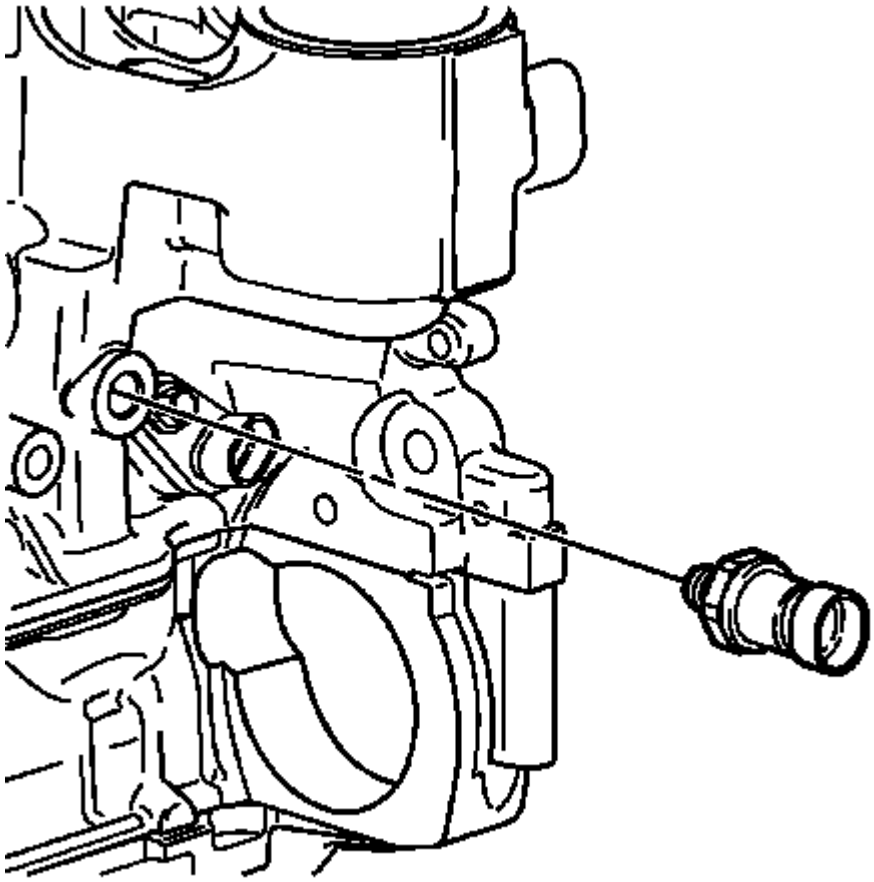

Fig. 403: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

7. Remove the oil pressure switch.

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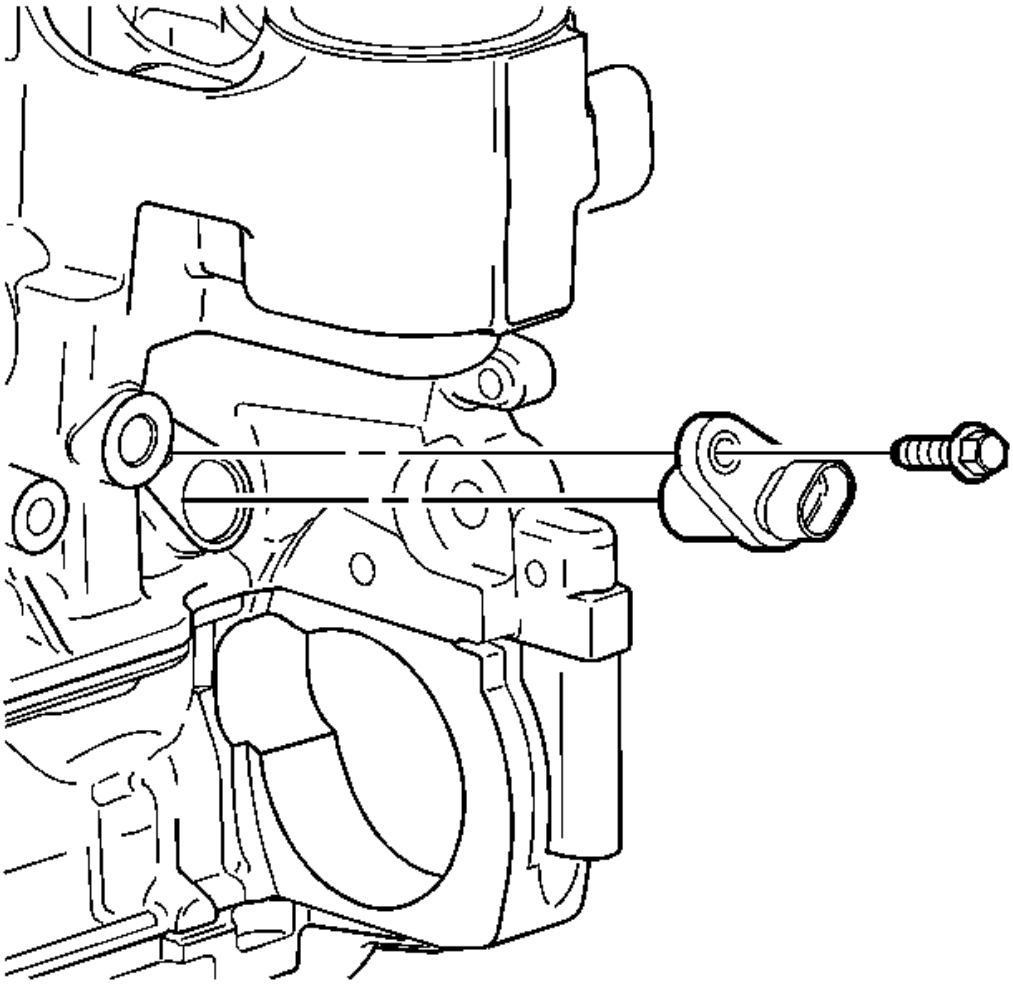

Fig. 404: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

8. Remove the crankshaft position (CKP) sensor and bolt.

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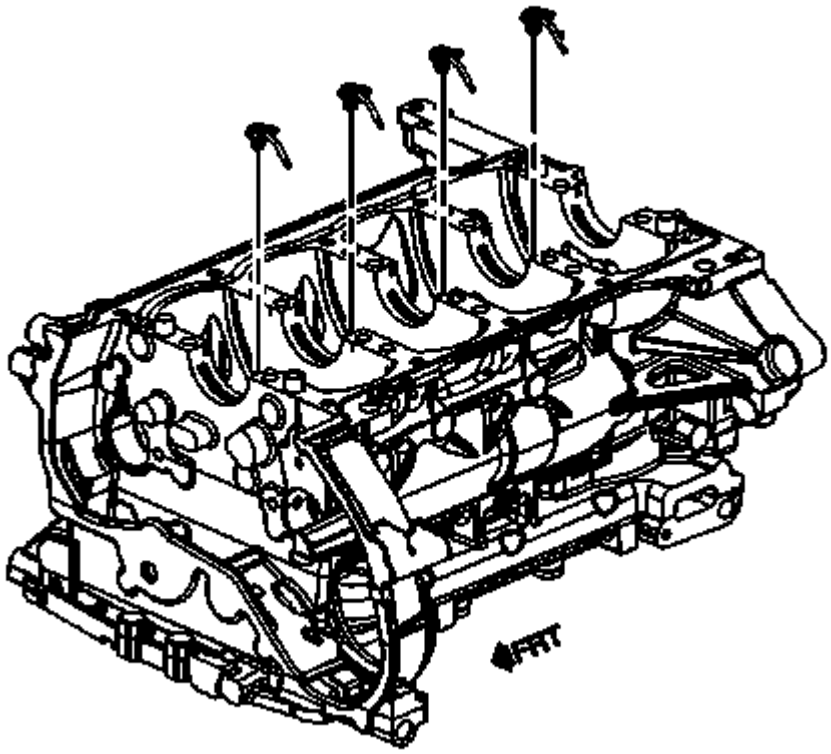

Fig. 405: Piston Oil Squirter
Courtesy of GENERAL MOTORS CORP.

9. If equipped, loosen the piston oil nozzle assembly bolt and remove the piston oil nozzle assembly.

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

- **EN-7872:** Magnetic Base Dial Indicator
- **EN-8087:** Cylinder Bore Gauge

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

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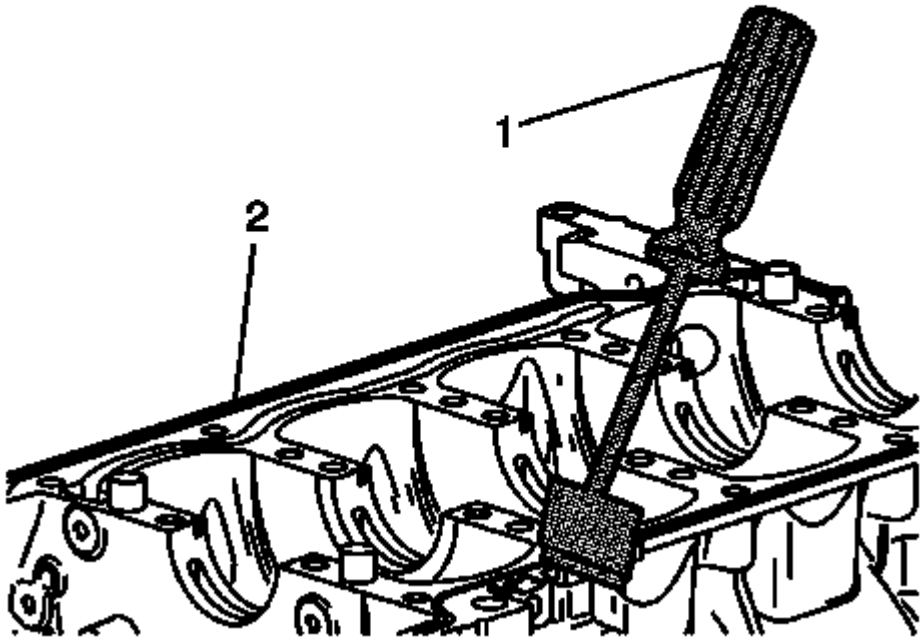

Fig. 406: Clean Sealing Material From Gasket Mating Surfaces With A Suitable Tool
Courtesy of GENERAL MOTORS CORP.

1. Clean the sealing material from the gasket mating surfaces (2) with a suitable tool (1).
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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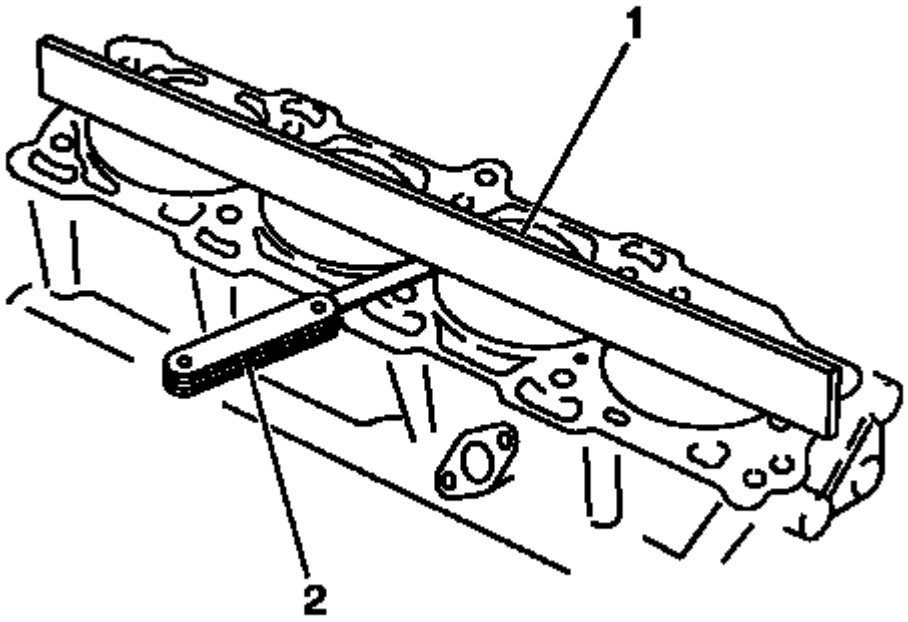

Fig. 407: Use A Straight Edge And Feeler Gage To Check Deck Surface For Flatness
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not attempt to machine the lower crankcase to engine block surfaces.

8. Use a straight edge (1) and a feeler gauge (2) 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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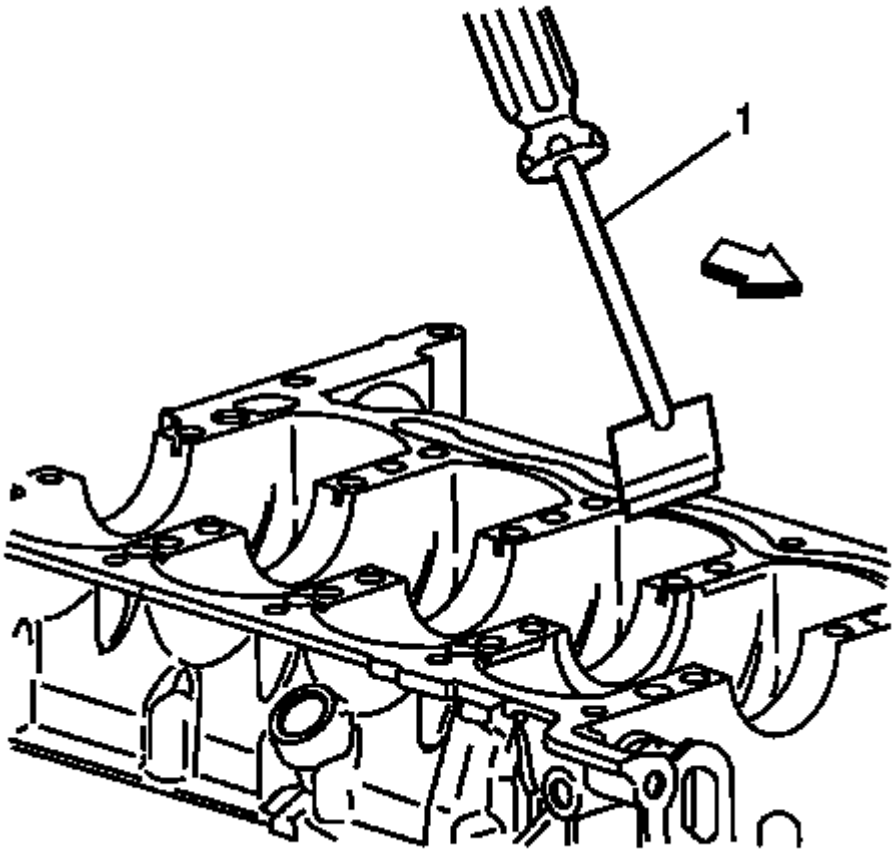

Fig. 408: Clean Sealing Material From Gasket Mating Surfaces On Lower Crankcase Engine Block Side With Suitable Tool
Courtesy of GENERAL MOTORS CORP.

10. Clean the sealing material from the gasket mating surfaces on the lower crankcase engine block side with a suitable tool (1).

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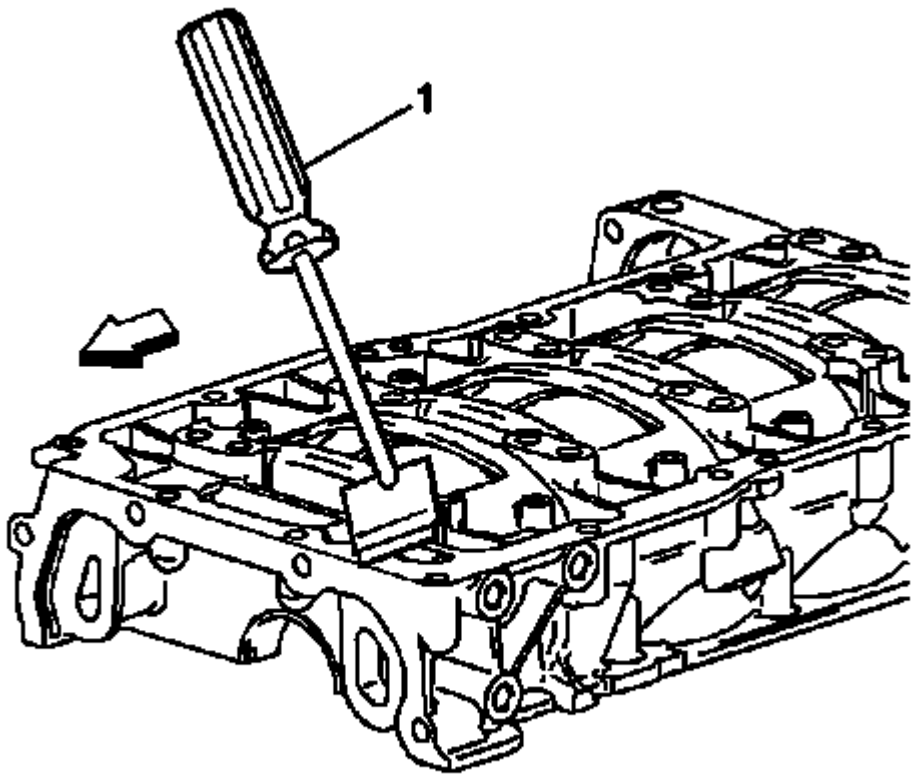

Fig. 409: Clean Sealing Material From Gasket Mating Surfaces On Lower Crankcase Oil Pan Side With Suitable Tool
Courtesy of GENERAL MOTORS CORP.

11. Clean the sealing material from the gasket mating surfaces on the lower crankcase oil pan side with a suitable tool (1).

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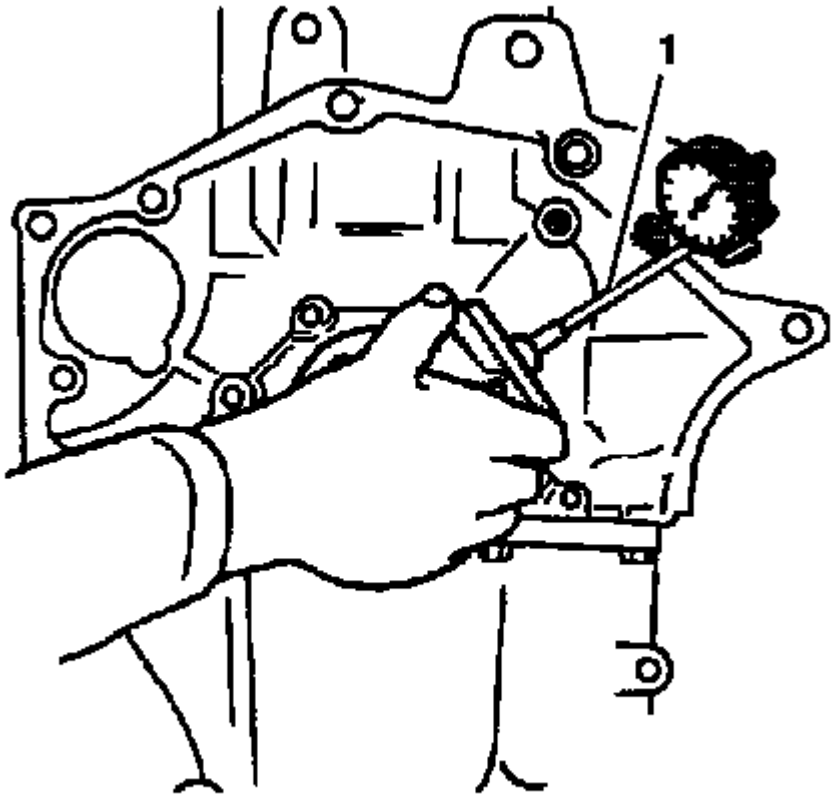

Fig. 410: Inspect The Mating Surfaces Of The Transmission Face
Courtesy of GENERAL MOTORS CORP.

12. Inspect the mating surfaces of the transmission face.

CAUTION: 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 **EN-7872:** dial indicator (1)
    2. Hold the gauge plate flat against the crankshaft flange.
    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.

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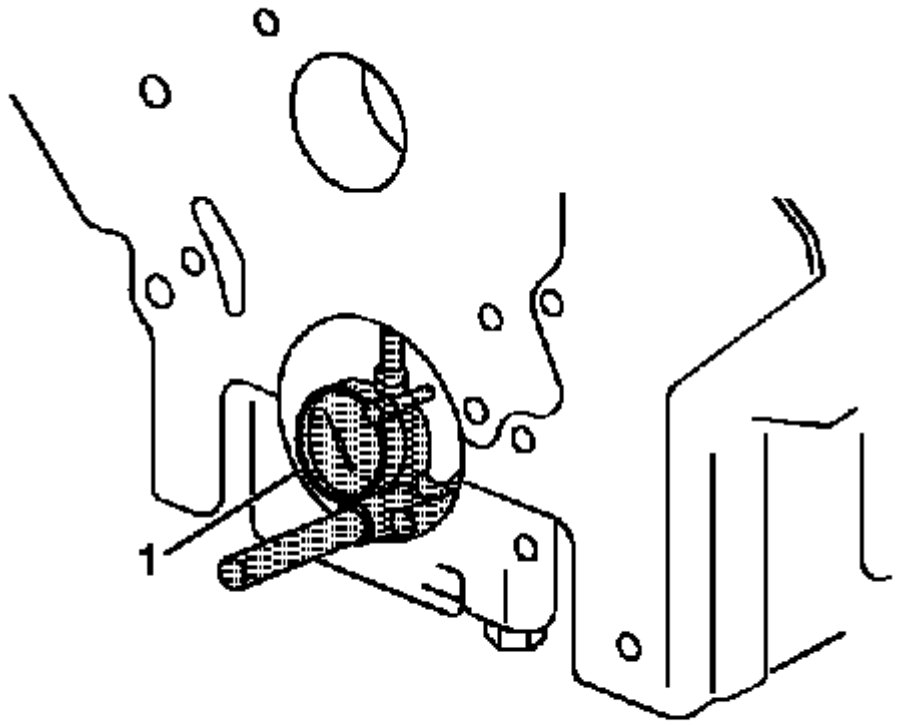

Fig. 411: View of EN-8087 Gage To Measure Bearing Bore
Courtesy of GENERAL MOTORS CORP.

14. Install the bed plate and bolts. Tighten the bed plate bolts to specification.
15. Inspect the crankshaft main bearing bores. Use the **EN-8087:** gauge (1) to measure the bearing bore concentricity and alignment. Refer to **Engine Mechanical Specifications (LAP, LE8)**.
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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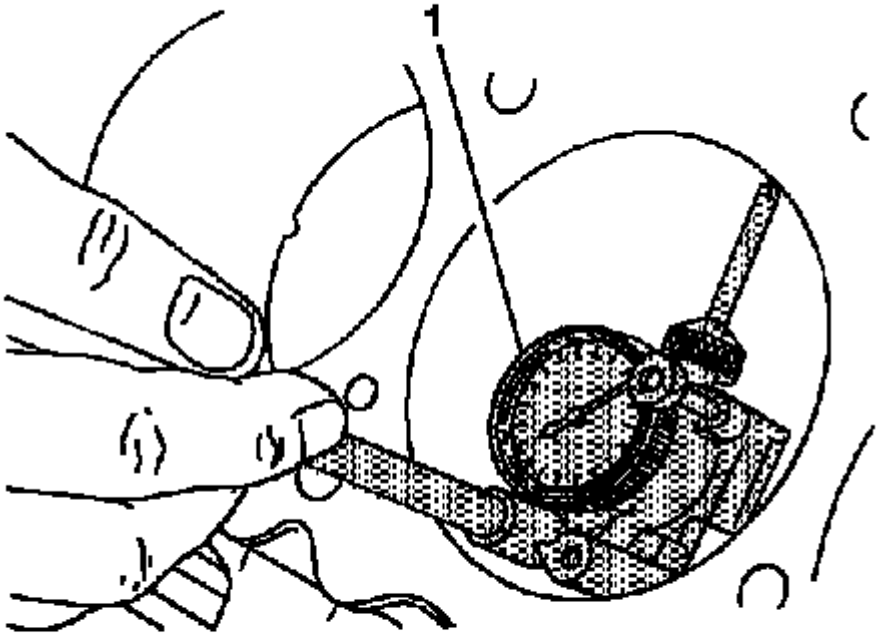

Fig. 412: Inspect Cylinder Bores Using EN-8087 Gage
Courtesy of GENERAL MOTORS CORP.

18. Inspect the cylinder bores using the **EN-8087:** gauge (1). 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 (LAP, LE8)** and **Cylinder Sleeve Installation (LAP, LE8)**.

CYLINDER HONING

Tools Required

J 8087 Cylinder Bore Gauge

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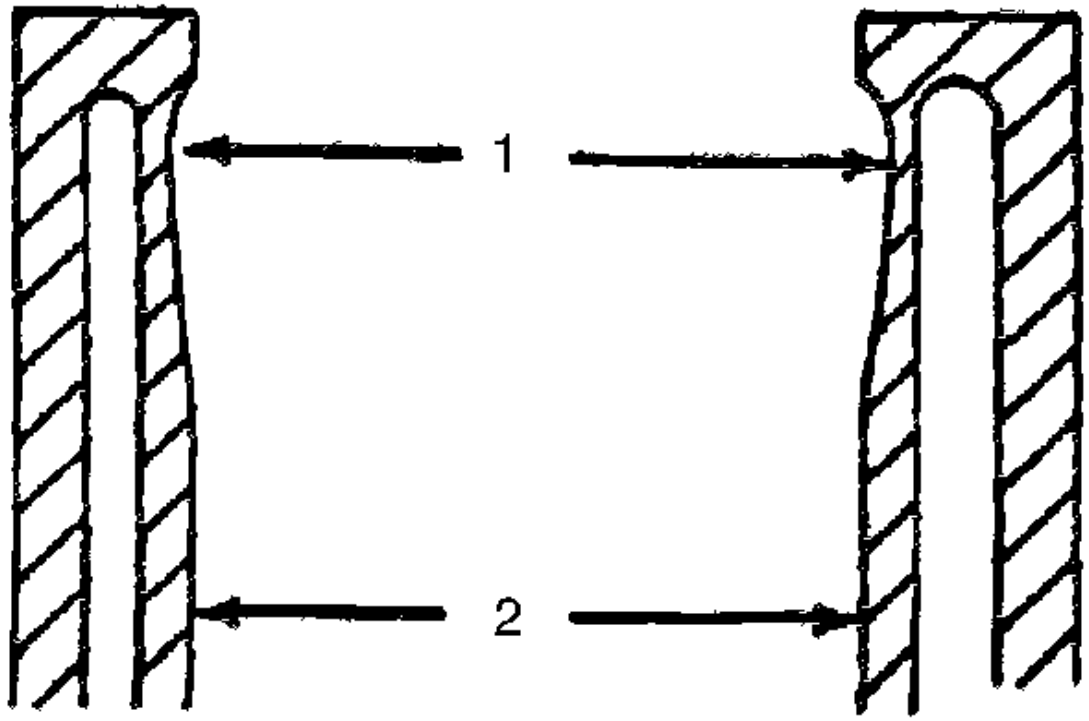

Fig. 413: Measuring Head Gasket Dimensions
Courtesy of GENERAL MOTORS CORP.

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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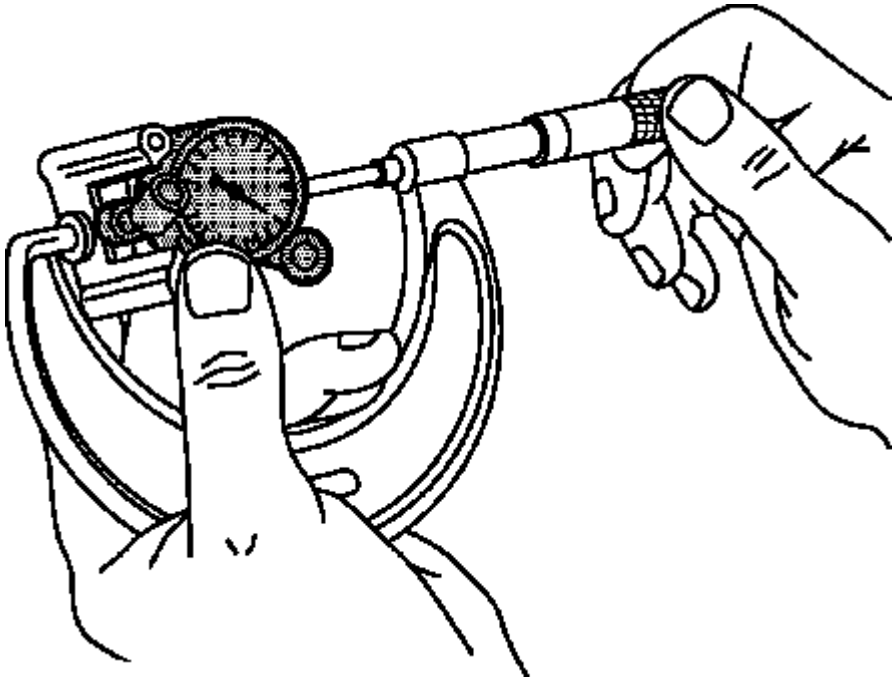

Fig. 414: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

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 gauge contact points with an outside micrometer, with the gauge at the same zero setting as when the gauge 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 (LAP, LE8)**.
    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 (LAP, LE8)** and **Cylinder Sleeve Installation (LAP, LE8)**.
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 (LAP, LE8)

Special Tools

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EN 45680-850: Cylinder Sleeve Removal and Installation Kit

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

CAUTION: 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.

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

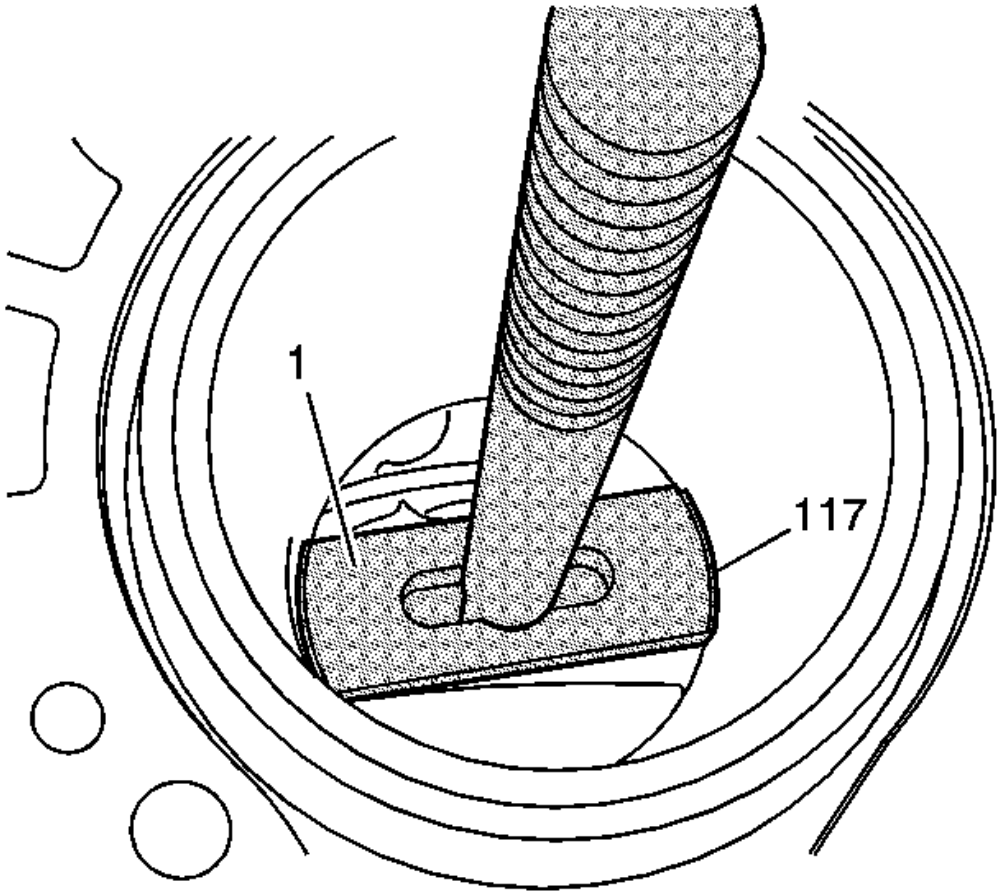

Fig. 415: View Of Cylinder Bore Liner Puller
Courtesy of GENERAL MOTORS CORP.

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.

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2. Install the **EN-45680-852:** cylinder bore sleeve puller (1) through the cylinder bore.

CAUTION: 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 **EN-45680-852:** cylinder bore sleeve puller to the bottom of the cylinder bore sleeve (117).

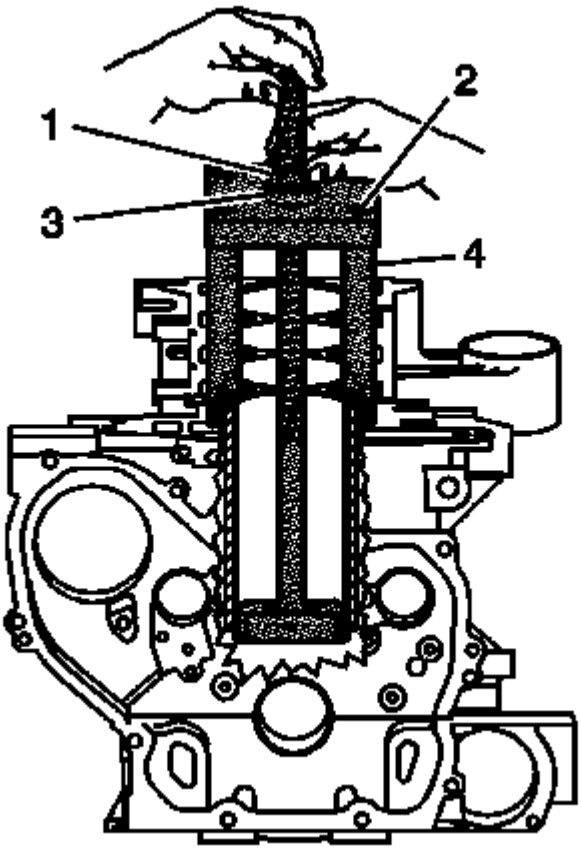

Fig. 416: Aligning Cylinder Bore Sleeve Puller
Courtesy of GENERAL MOTORS CORP.

4. 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.
5. Install the **EN-45680-851 (4):** fixture onto the threaded shaft of the **EN-45680-852:** cylinder bore sleeve puller and the engine block.
6. Install the bearing (3) and the nut (1).
7. Tighten the nut (1) to the bearing (3).

CAUTION: Refer to Fastener Caution .

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NOTE: Use four old cylinder head bolts for the attaching bolts.

8. Install and tighten the 4 attaching bolts (2) into the cylinder head bolt holes of the block and tighten the bolts to 15 N.m (11 lb ft).

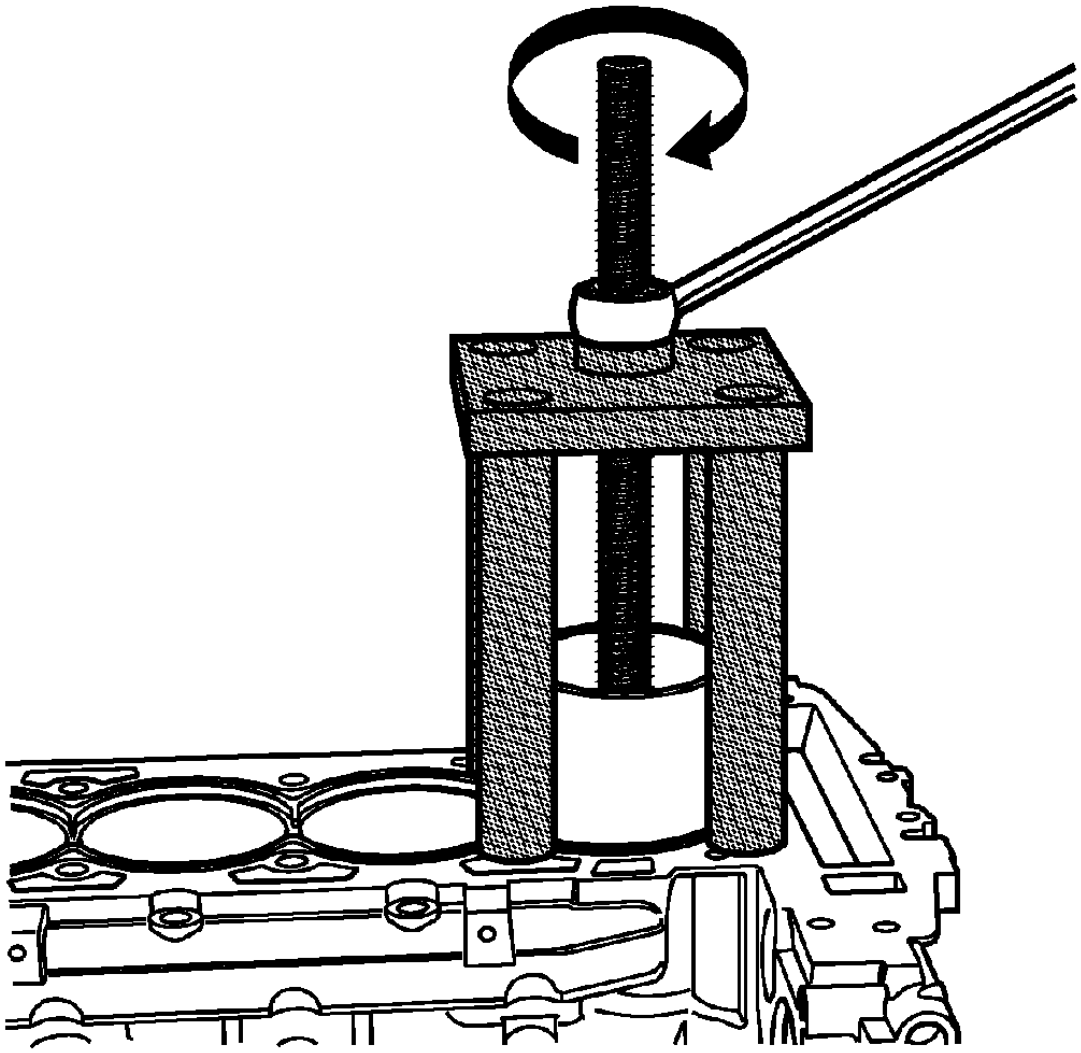

Fig. 417: Removing Cylinder Bore Sleeve By Rotating Nut
Courtesy of GENERAL MOTORS CORP.

9. Rotate the nut clockwise in order to remove the cylinder bore sleeve.

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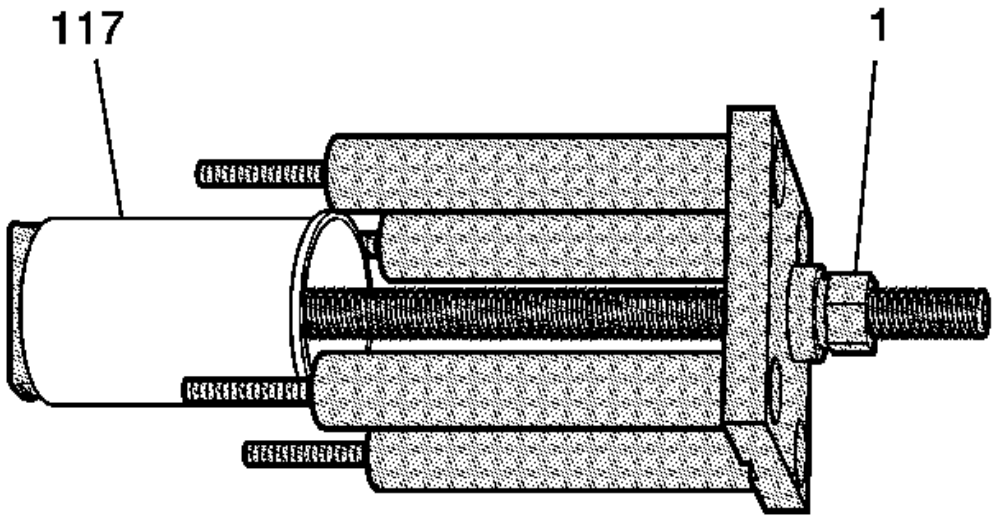

Fig. 418: Removing Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

10. Remove the **EN-45680-851:** fixture, **EN-45680-852:** cylinder bore sleeve puller, and the cylinder bore sleeve (117) from the engine block.
11. Loosen the nut (1) 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 Bearing Cleaning and Inspection**.

CYLINDER SLEEVE INSTALLATION (LAP, LE8)

Special Tools

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EN 45680-850: Cylinder Sleeve Removal and Installation Kit

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

CAUTION: 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.

CAUTION: 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.

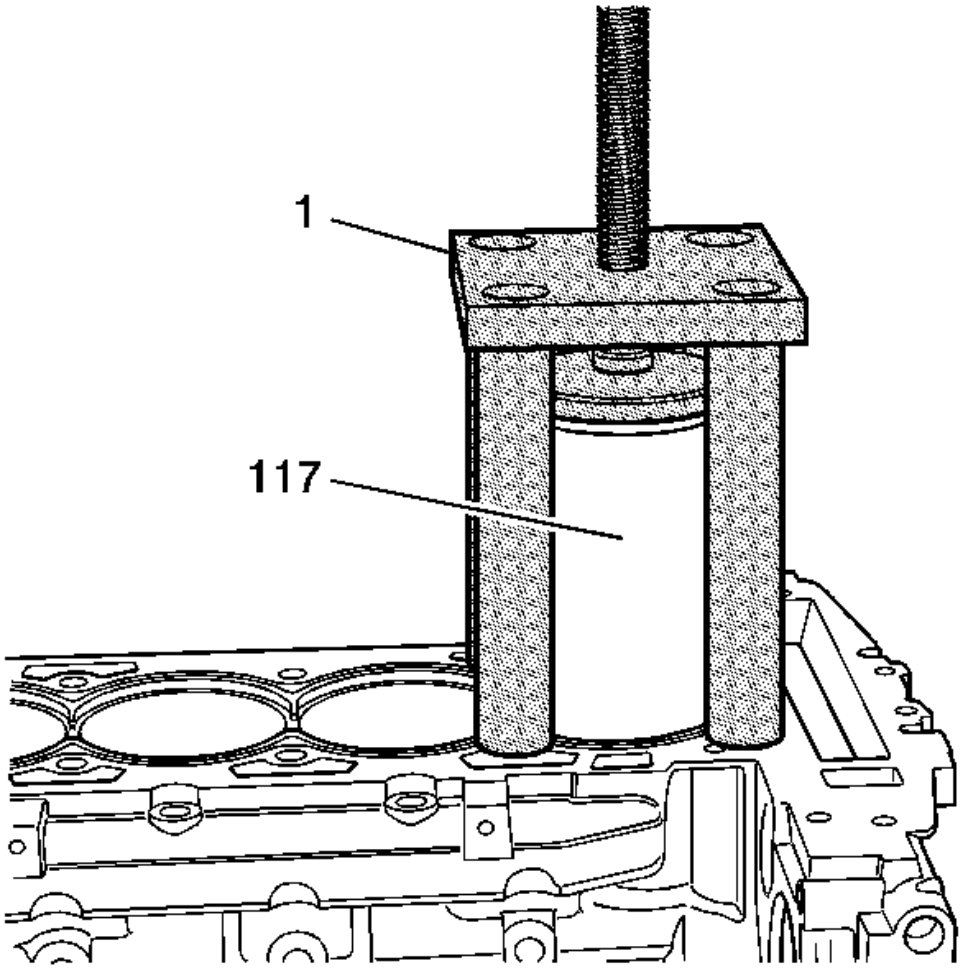

Fig. 419: View Of Cylinder Bore Sleeve Fixture
Courtesy of GENERAL MOTORS CORP.

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1. Place the NEW cylinder bore sleeve (117) onto the cylinder block.
2. Install the fixture **EN-45680-851:** fixture and the **EN-45680-853:** cylinder bore sleeve installer (1) over the cylinder bore sleeve (117) and onto the cylinder block. Do not apply downward pressure to the cylinder bore sleeve (117).

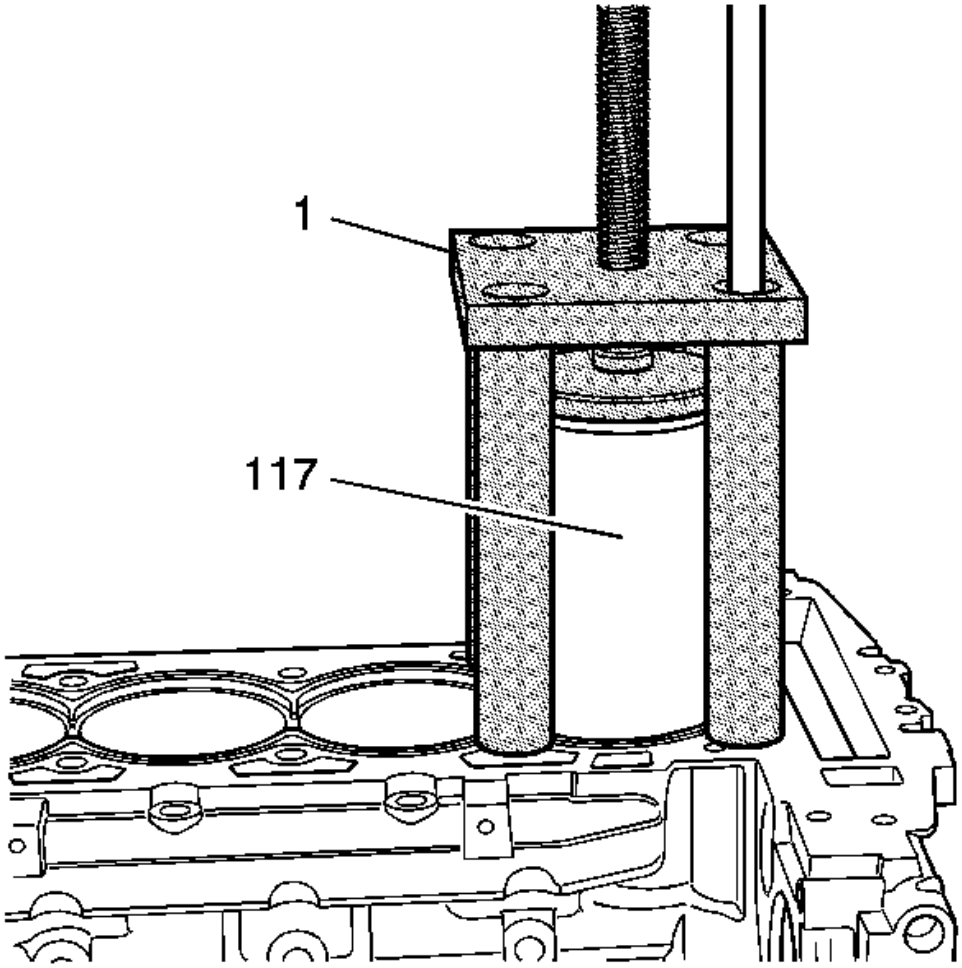

Fig. 420: Installing Cylinder Bore Sleeve Puller Attachment Bolts
Courtesy of GENERAL MOTORS CORP.

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

3. Insert the 4 attachment bolts into the legs of the fixture EN-45680-851 (1).

CAUTION: Refer to Fastener Caution .

NOTE: Do not apply downward pressure to the cylinder bore sleeve (117).

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

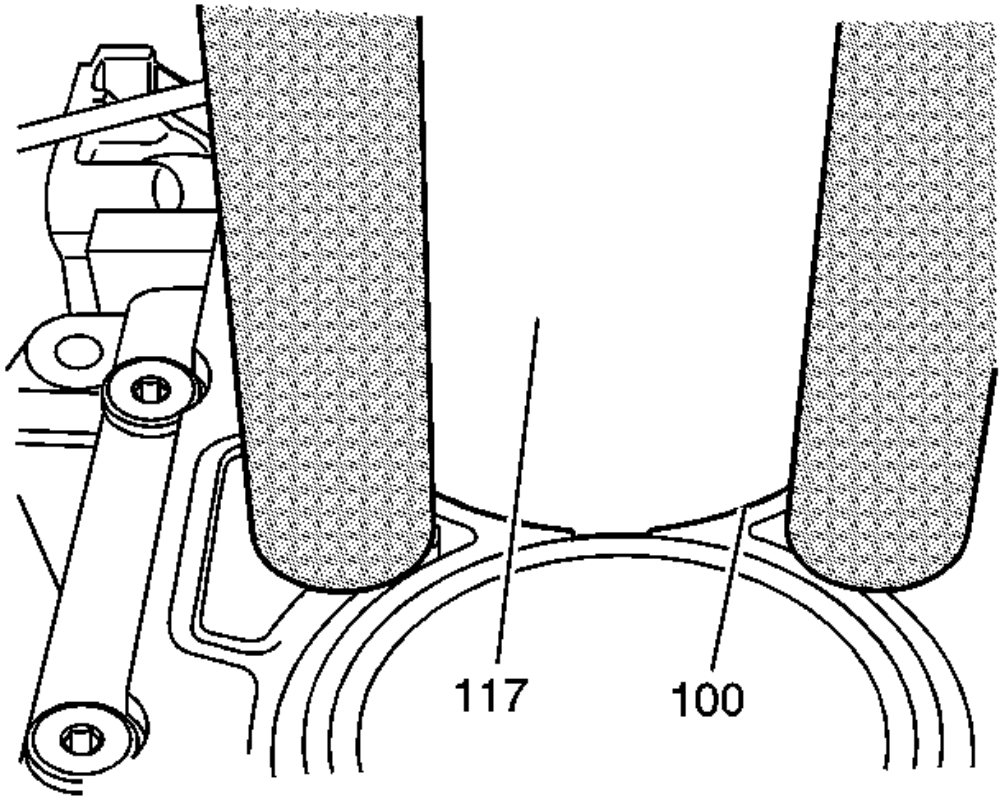

Fig. 421: View Of Proper Liner Alignment
Courtesy of GENERAL MOTORS CORP.

5. Align the bottom of the cylinder bore sleeve (117) with the cylinder bore of the block (100).

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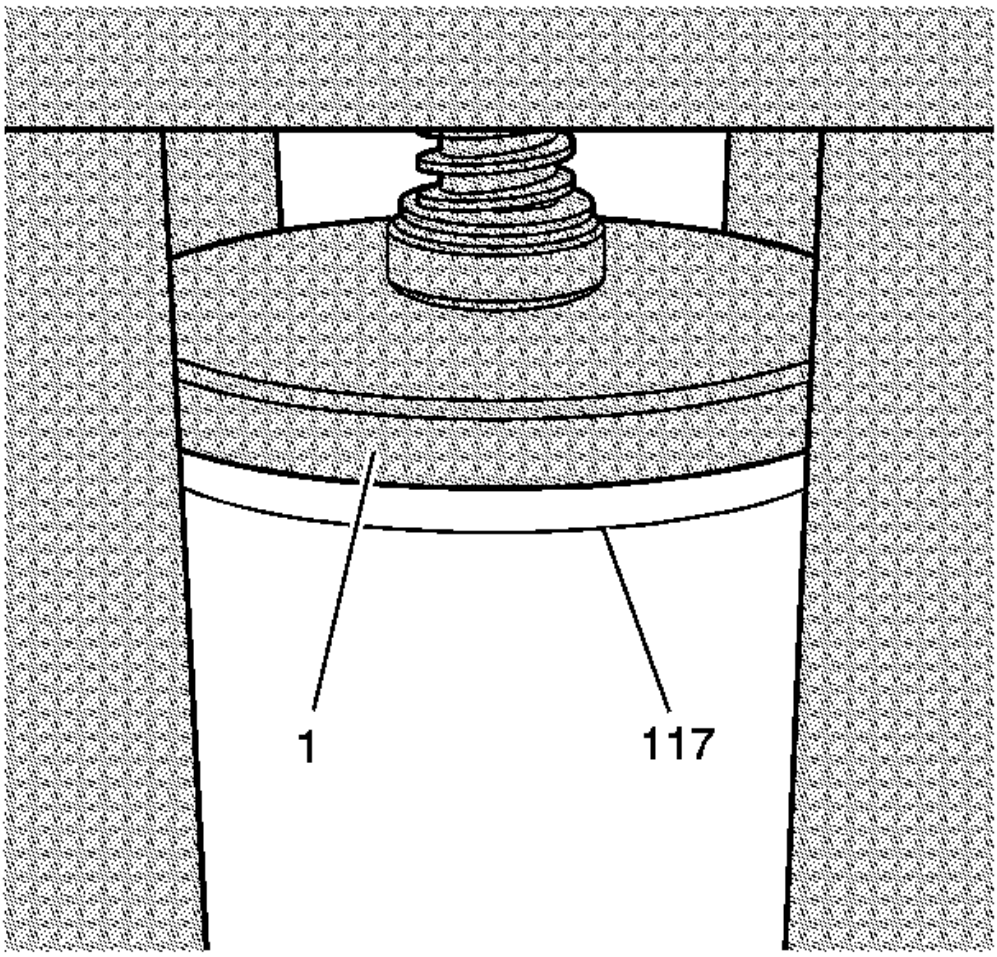

Fig. 422: View Of Installation Arbor
Courtesy of GENERAL MOTORS CORP.

6. Align the installation arbor (1) of the **EN-45680-853:** cylinder bore sleeve installer onto the top of the cylinder bore sleeve (117).

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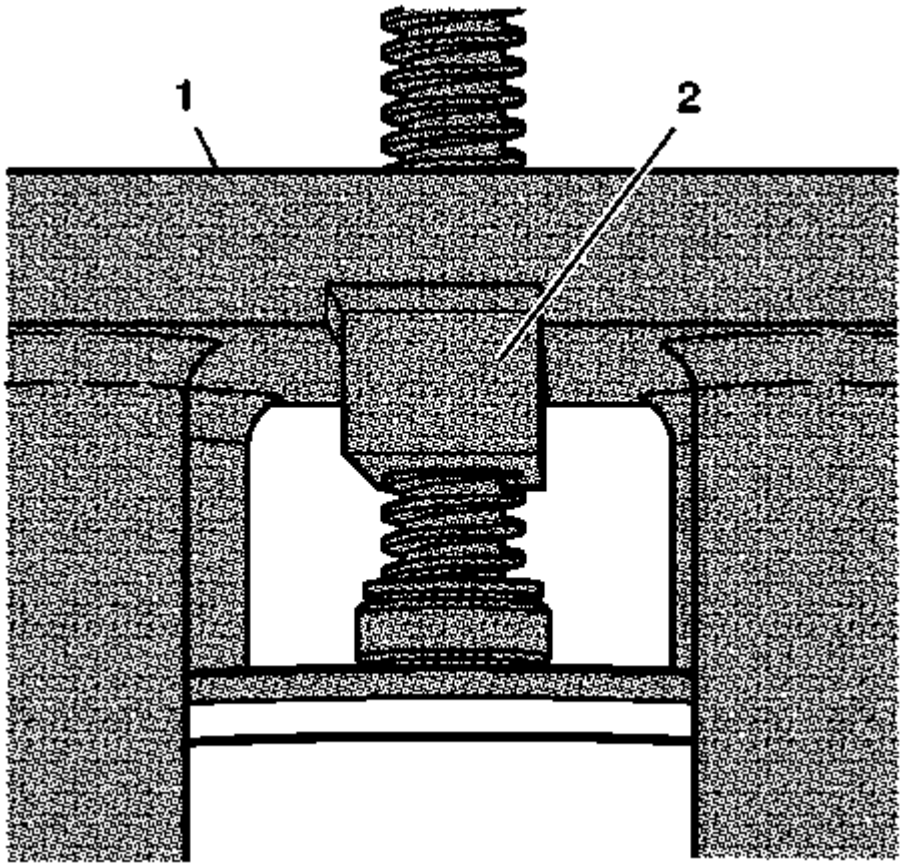

Fig. 423: View Of Pusher Block
Courtesy of GENERAL MOTORS CORP.

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

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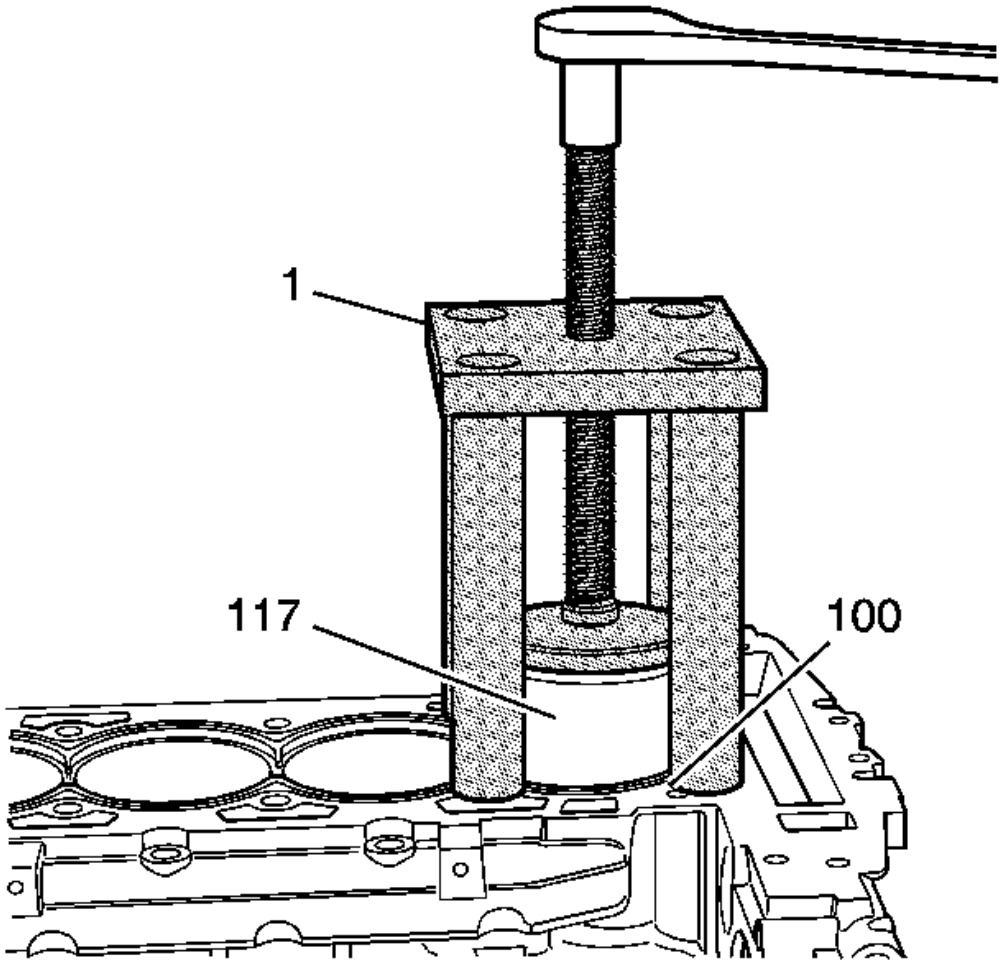

Fig. 424: Installing Cylinder Bore Sleeve Into Engine Block Using Tool
Courtesy of GENERAL MOTORS CORP.

CAUTION: Do not use any air powered or electric tools to rotate the threaded shaft of the cylinder bore sleeve installer in the fixture assembly or damage to the cylinder bore sleeve will occur.

8. Using a ratchet, rotate the threaded shaft of the **EN 45680-853 (1):** cylinder bore sleeve installer 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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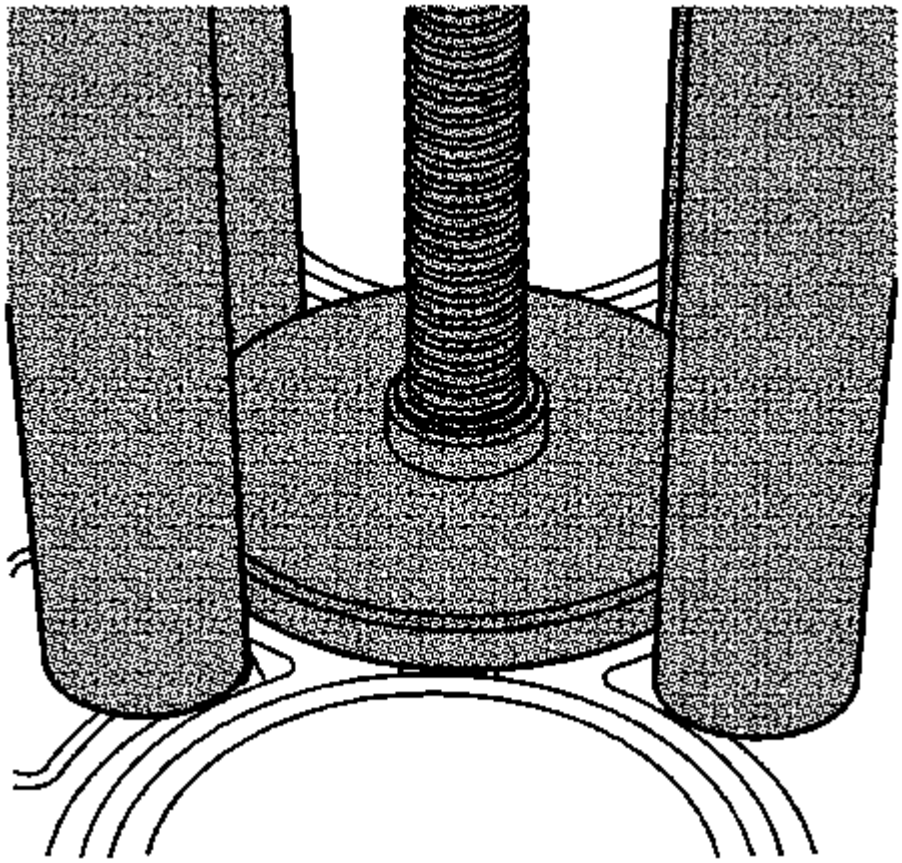

Fig. 425: Seating Cylinder Bore Sleeve Completely Using Tool
Courtesy of GENERAL MOTORS CORP.

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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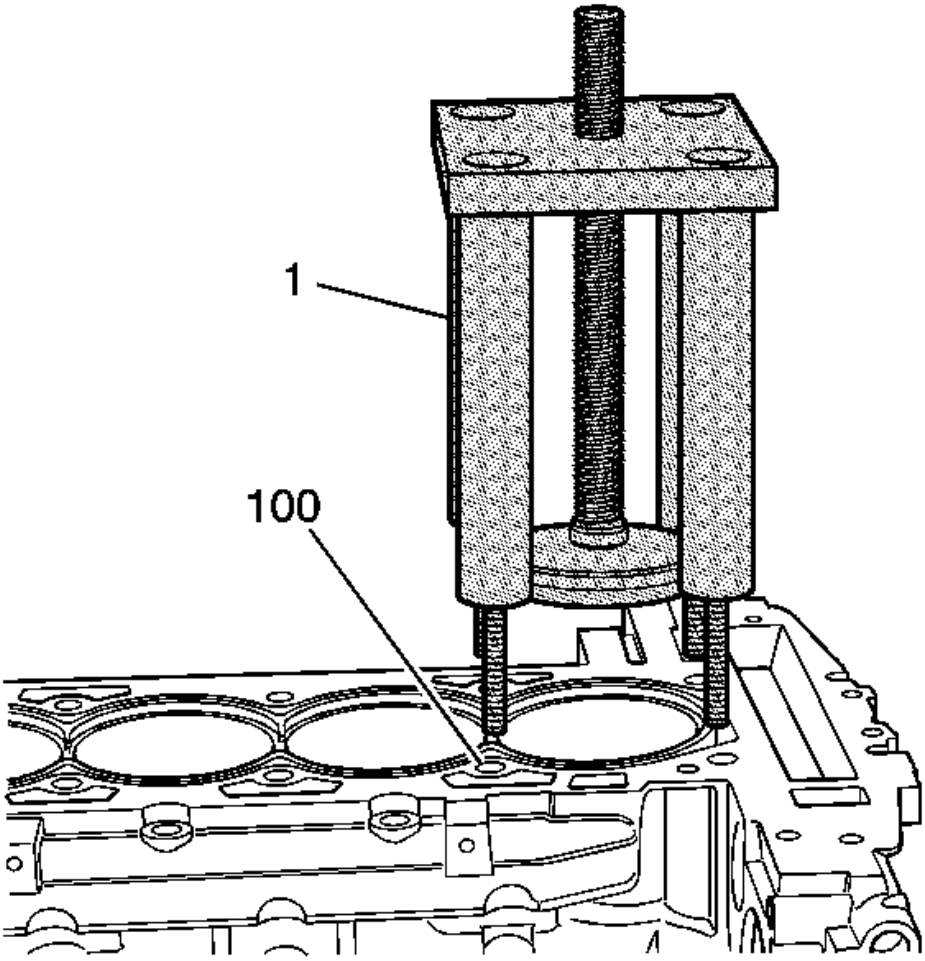

Fig. 426: View Of Service Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Remove the **EN 45680-851:** fixture assembly with the **EN 45680-853 (1):** cylinder bore sleeve installer from the cylinder block (100).

Cylinder Sleeve Trimming

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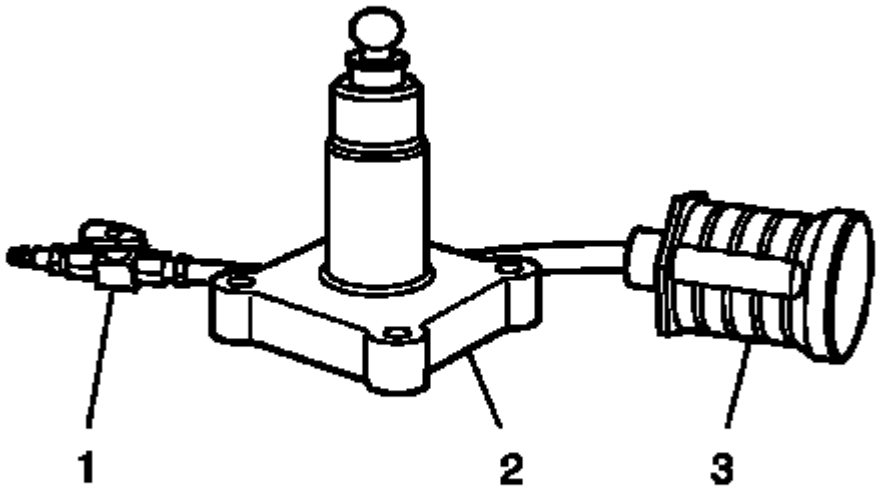

Fig. 427: Cylinder Liner Trimming Tools View (1 Of 2)
Courtesy of GENERAL MOTORS CORP.

The **EN 45680-861:** trim tool assembly (2) contains or requires the following components to complete 2.2L, 86 mm cylinder sleeve trimming:

- Debris collector (3) with **EN-45680-865:** filter.
- 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 45680-869:** bore cutter bit and screw.
- **EN 45680-899:** Bore trimmer pilot, white in color

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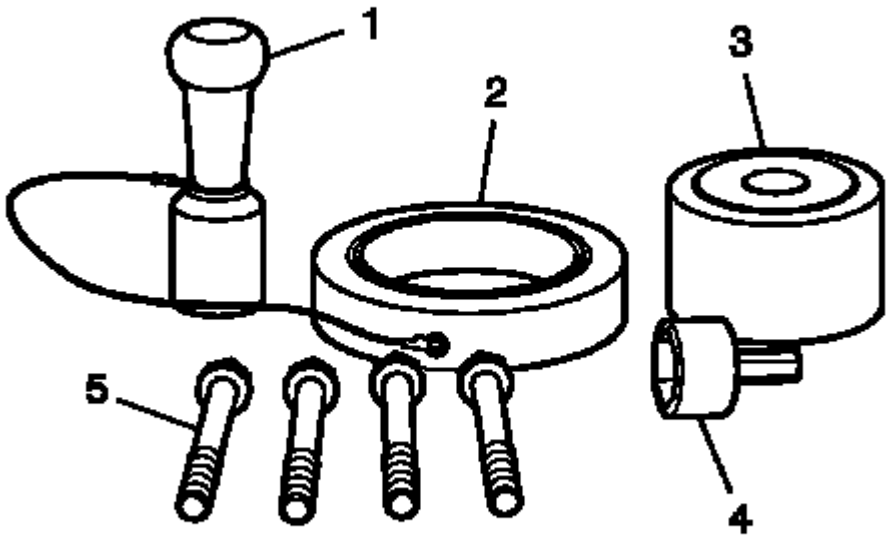

Fig. 428: Cylinder Liner Trimming Tools View (2 Of 2)
Courtesy of GENERAL MOTORS CORP.

- **EN-45680-862:** Gauge ring assembly.
  - Trim tool preloader (1)
  - Set gauge ring (2)
- **EN 45680-412:** Set Gauge Ring (2)
- **EN 45680-863:** metal shavings catch plug (3)
- **EN 45680-866:** drive adapter (4)
- **EN 45680-864:** bolts (5)

CAUTION: 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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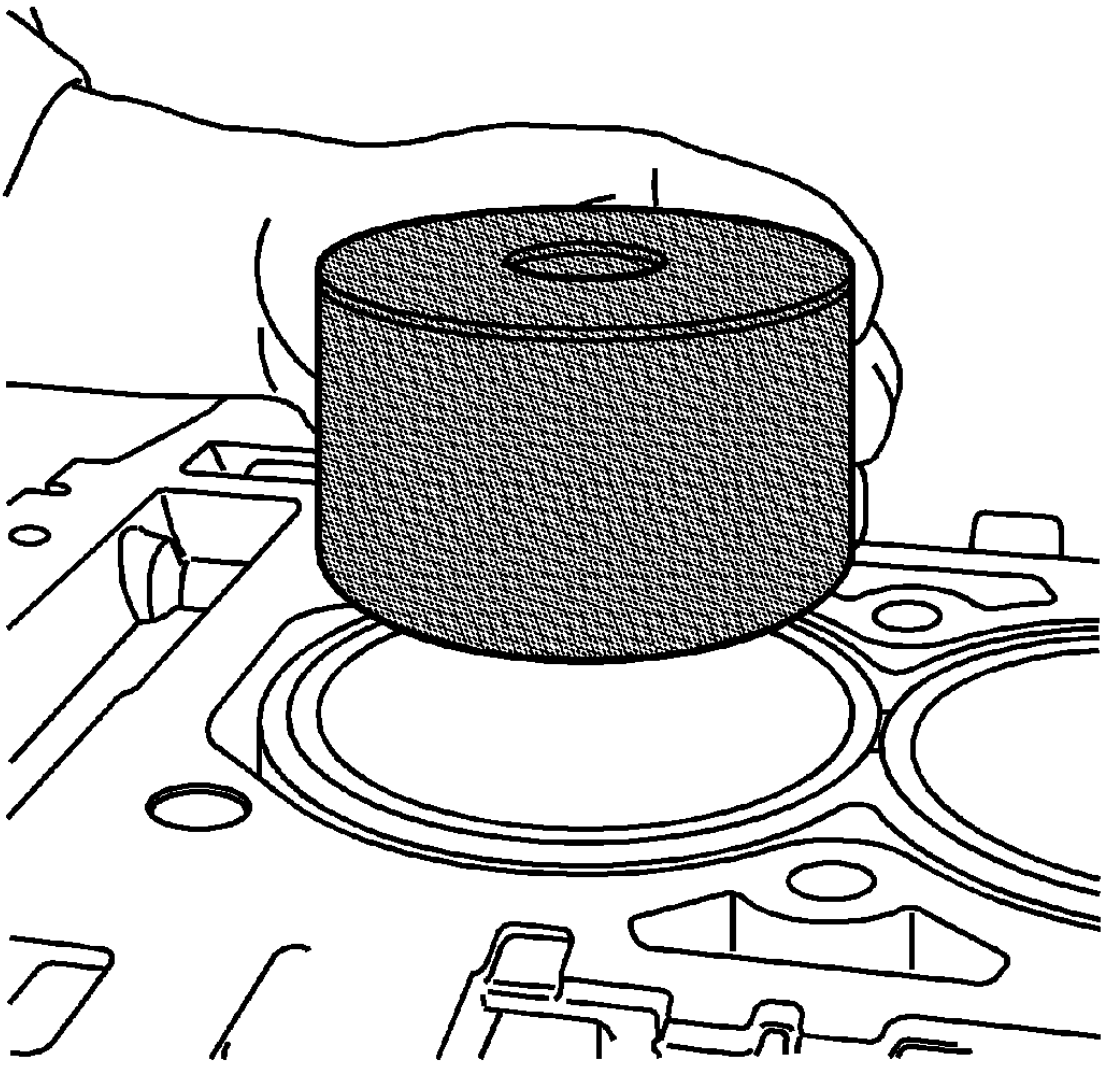

Fig. 429: Placing Metal Shaving Catch Plug Into Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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

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

2. Place **EN 45680-863:** 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 an additional **EN 45680-863:** metal shaving catch plug into all remaining cylinder bore sleeves.

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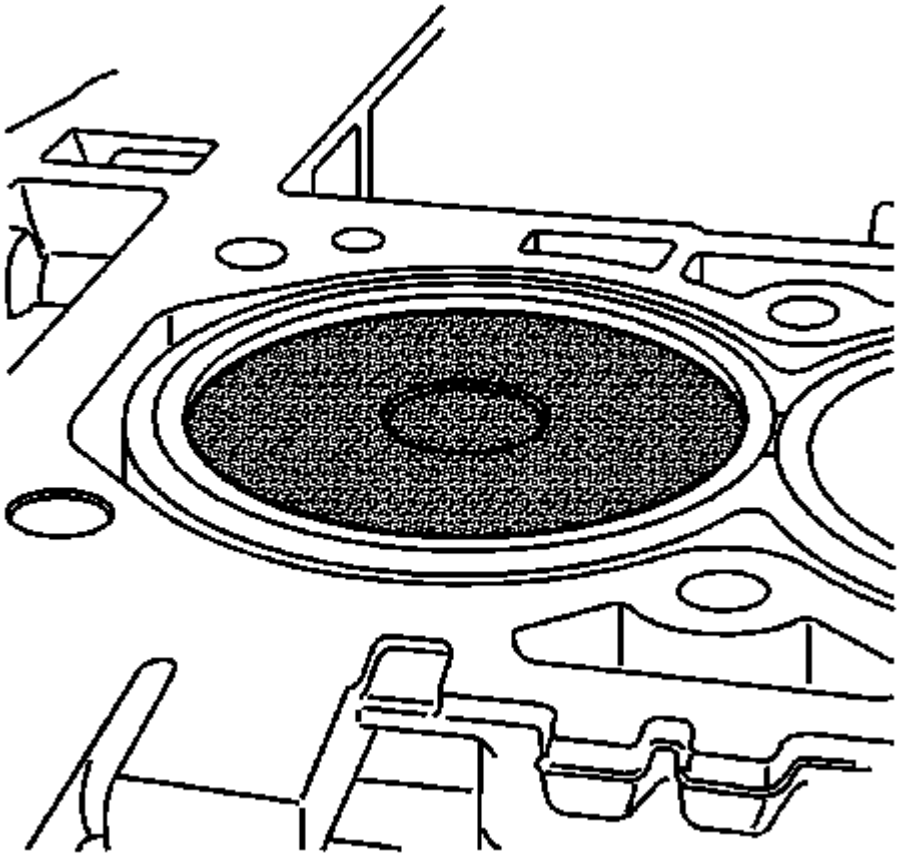

Fig. 430: Identifying Catch Plug Positioning
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

CAUTION: Installing the metal shaving catch plug above the recommended depth will cause damage to the metal shaving catch plug.

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.
5. Ensure that the correct bore trimmer pilot and cutter bit are installed on the **EN 45680-861:** trimmer base assembly :
   - **EN 45680-869:** cutter bit and screw
   - **EN 45680-899:** trimmer pilot, 86 mm sleeve

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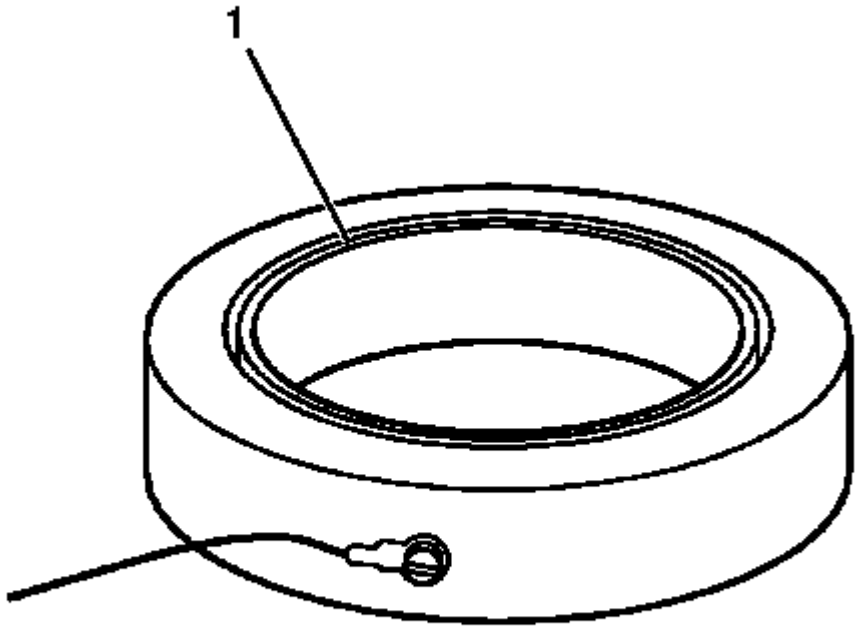

Fig. 431: Identifying Set Gauge Ring Groove
Courtesy of GENERAL MOTORS CORP.

NOTE: 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.

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

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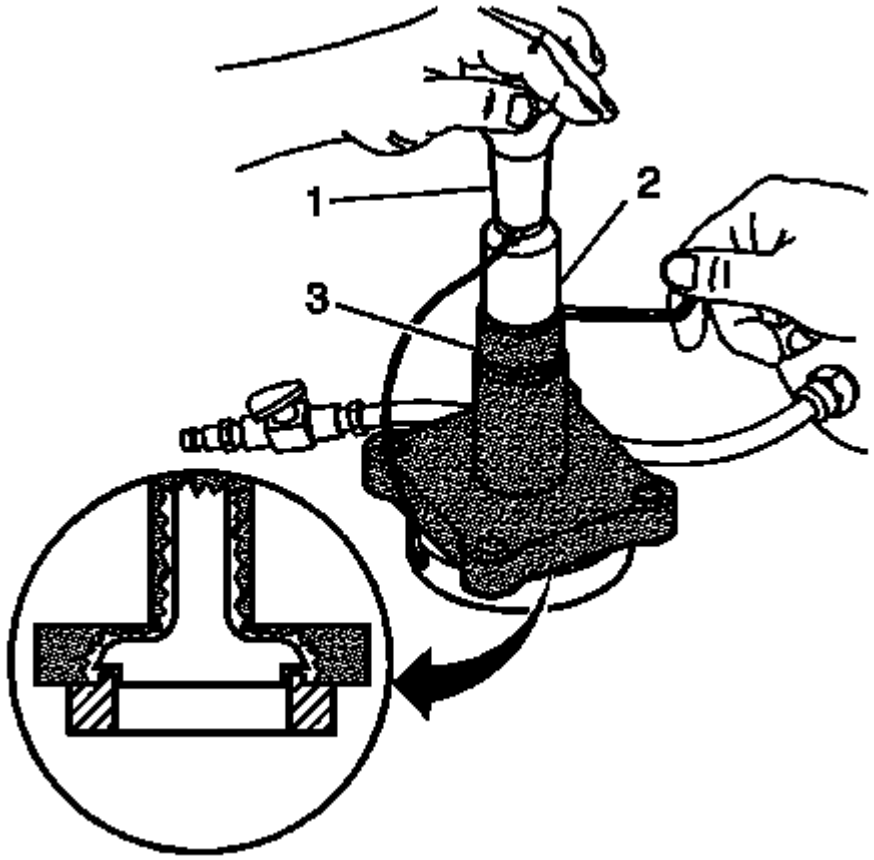

Fig. 432: View Of Trim Tool Assembly Components And Positioning
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the set gauge ring surfaces are clean.

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

NOTE: Once this procedure is done, it is not necessary to reset the trim tool assembly height until the blades are worn, damaged, or replaced.

10. Apply downward pressure on the collar and inner drive shaft using the trim tool preloader (1), then tighten the shaft collar screw to 19 N.m (14 lb ft).

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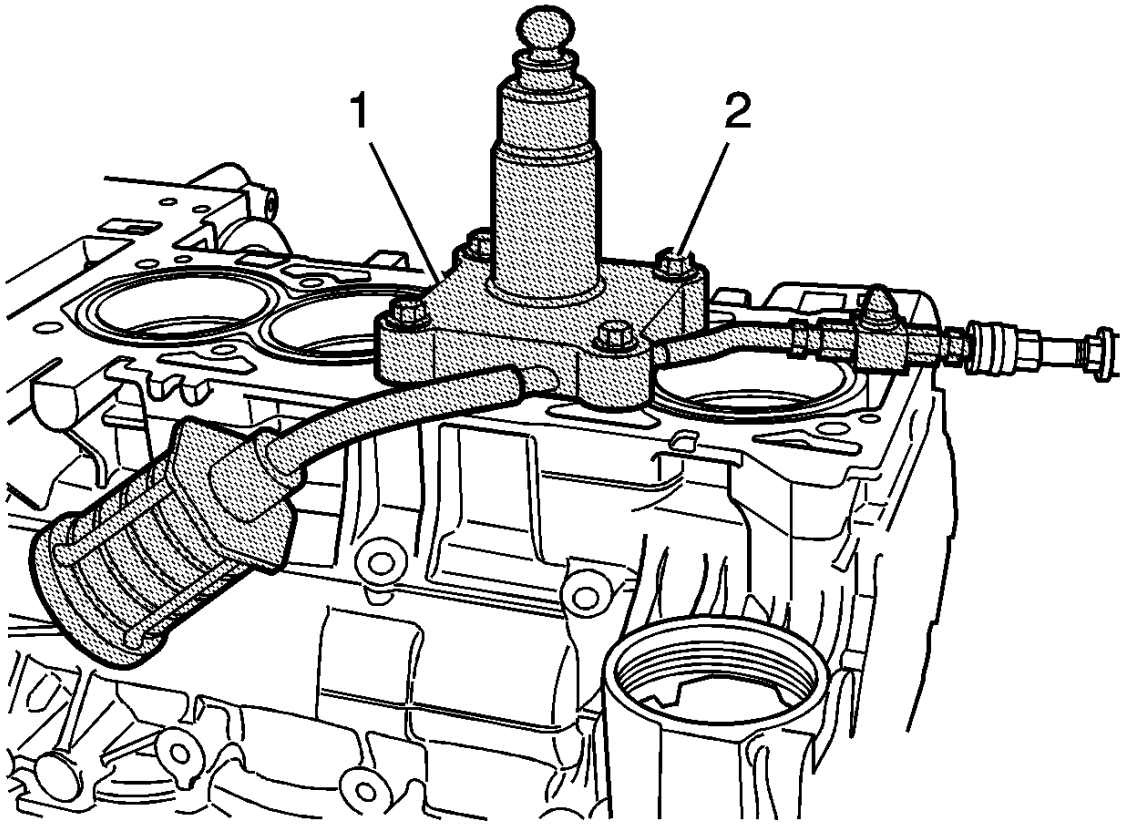

Fig. 433: Aligning Trim Tool Assembly
Courtesy of GENERAL MOTORS CORP.

11. Place the **EN 45680-861:** 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.
12. Install the **EN 45680-864 (2):** 4 bolts into the cylinder head bolt holes in the block and tighten to 20 N.m (15 lb ft).

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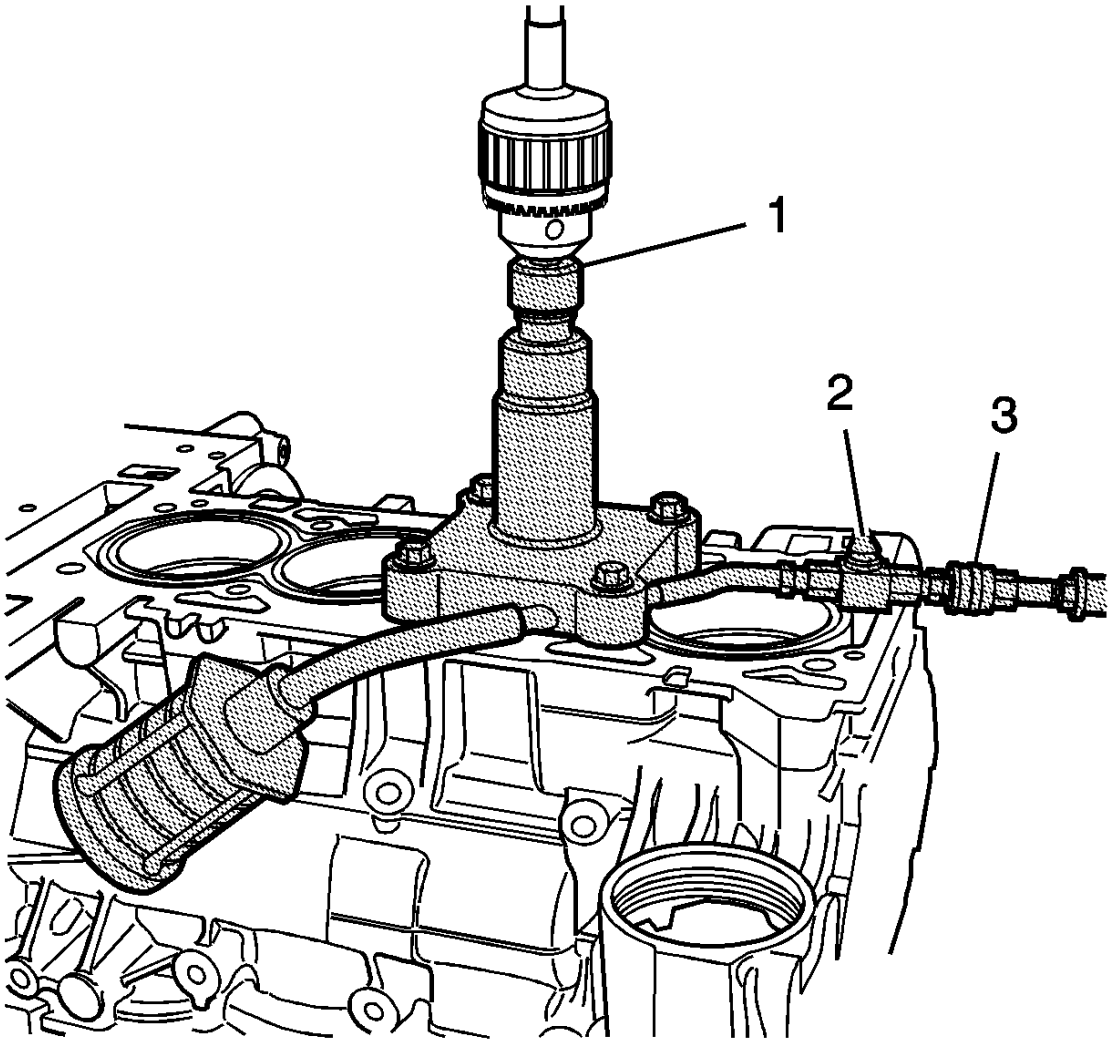

Fig. 434: View Of Drive Adapter
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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.

13. Fasten the drive adapter EN 45680-866 (1) into the drill chuck.

CAUTION: 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.

14. Connect a compressed air supply 517.10-861.84 kPa (75-125 psi) to the male quick connect (3) located on **EN 45680-861:** 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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NOTE: It should not take longer than 15 seconds to complete the trimming procedure. If it does, the trimming bits must be repositioned to a new cutting surface.

15. Place the **EN 45680-866:** drive adapter and drill assembly (1) vertically onto the drive adapter end of **EN 45680-861:** trim tool assembly. Do not apply downward force on the drill until full rotational speed has been reached. After reaching full rotational speed, apply firm downward force until the cutting action is complete.
16. Remove the **EN 45680-866 (1):** drive adapter and drill assembly from the **EN 45680-861:** trim tool assembly.
17. Turn off the compressed air valve (2).
18. Remove the **EN 45680-861:** trim tool assembly from the engine block.
19. Remove any material shavings that may be found on the **EN 45680-863:** metal shaving catch plug.
20. Wipe the cylinder bore sleeve and surrounding areas free of any powder residue and then remove the **EN 45680-863:** metal shaving catch plug.

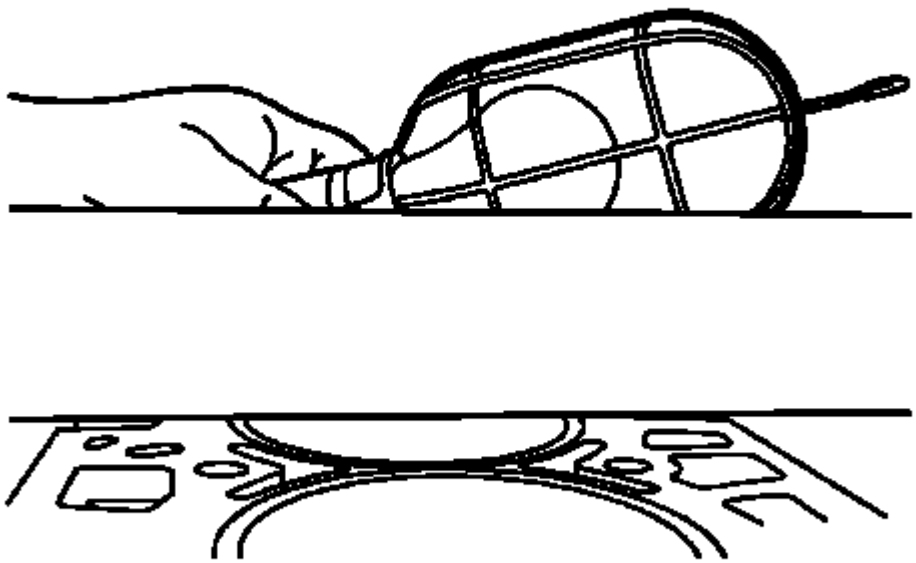

Fig. 435: Checking Cylinder Block Deck Surface With Straight Edge
Courtesy of GENERAL MOTORS CORP.

21. Install a straight edge on the cylinder block perpendicular to the crankshaft center line.

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22. Using a light, illuminate the backside of the straight edge.

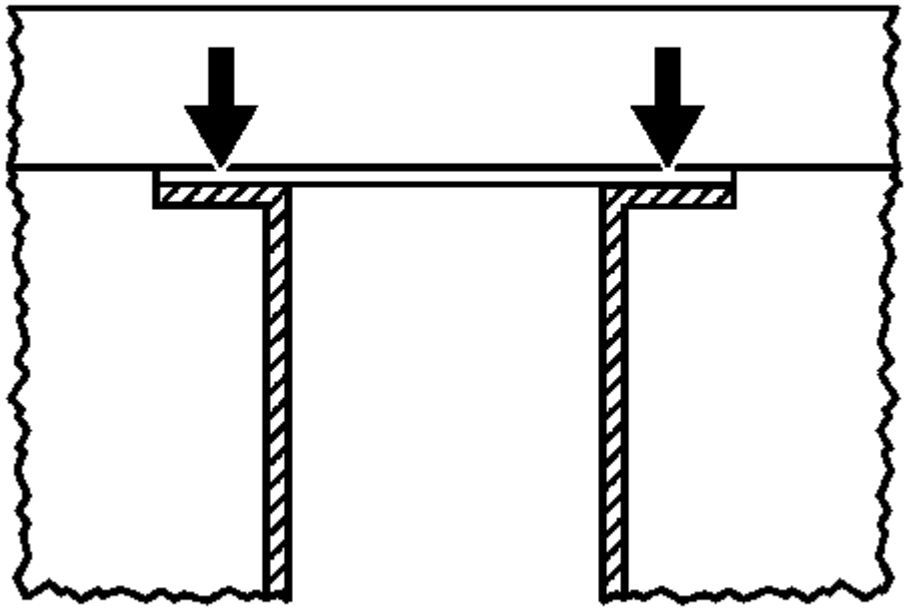

Fig. 436: View Of Improperly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

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 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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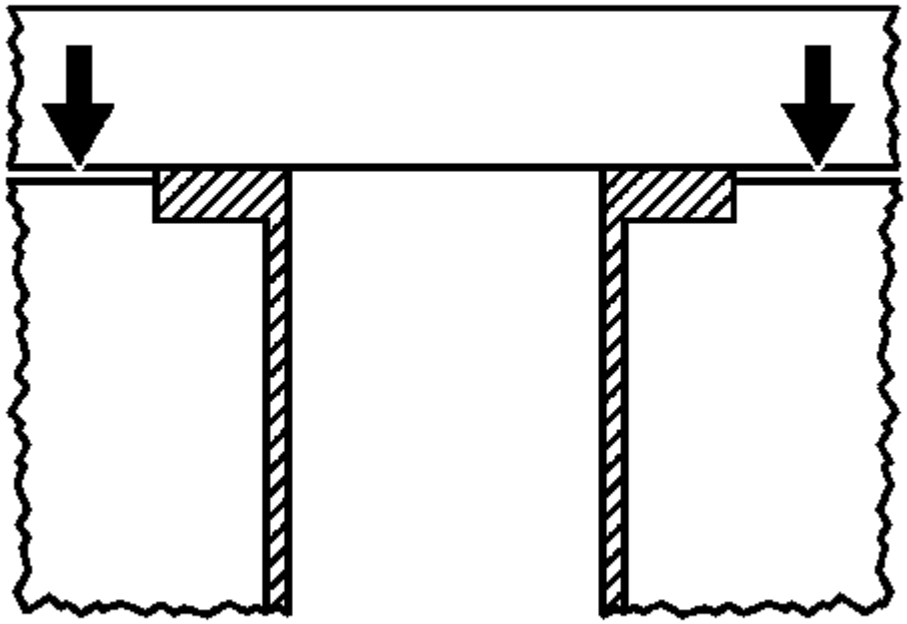

Fig. 437: View Of For Properly Cut Cylinder Bore Sleeve
Courtesy of GENERAL MOTORS CORP.

24. 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.
25. Proceed to the next bore sleeve to be trimmed repeating steps 10-23 if necessary.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

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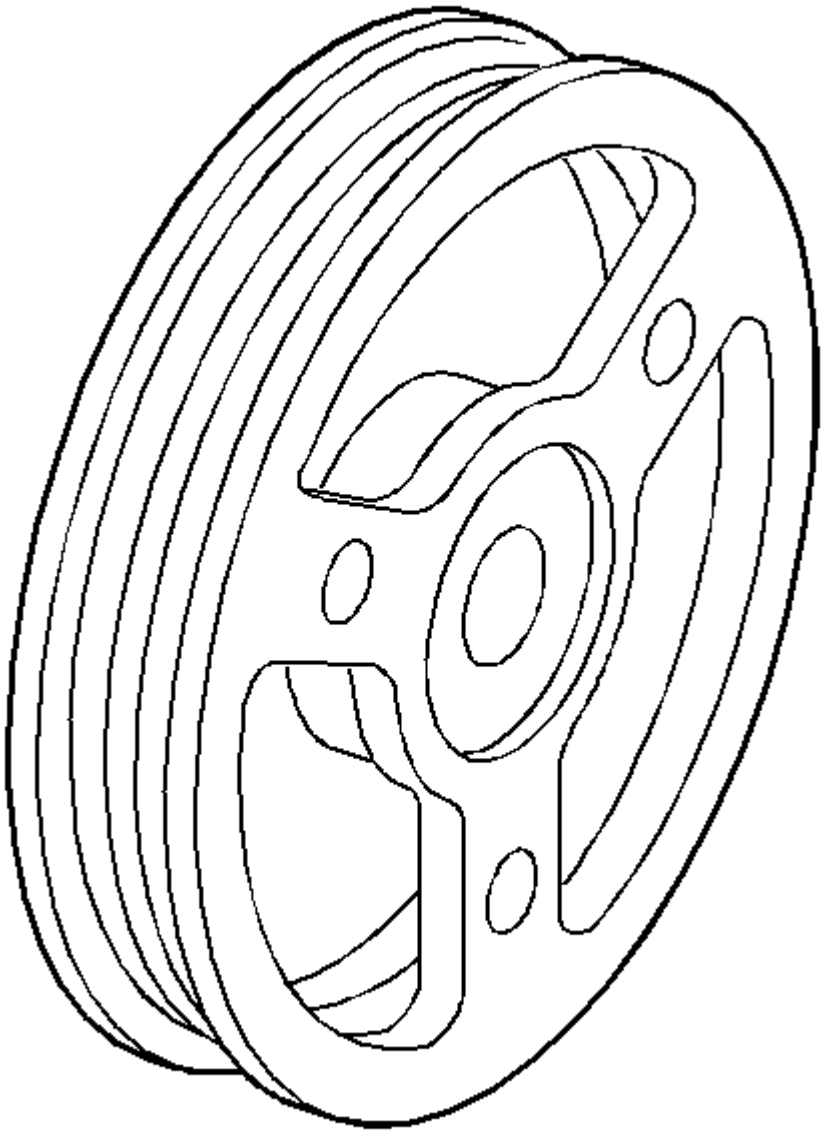

Fig. 438: Inspecting Crankshaft Balancer
Courtesy of GENERAL MOTORS CORP.

1. Clean the crankshaft balancer.
2. Clean the belt grooves of all dirt or debris with a wire brush.

WARNING: Refer to Safety Glasses Warning .

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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.

      NOTE: 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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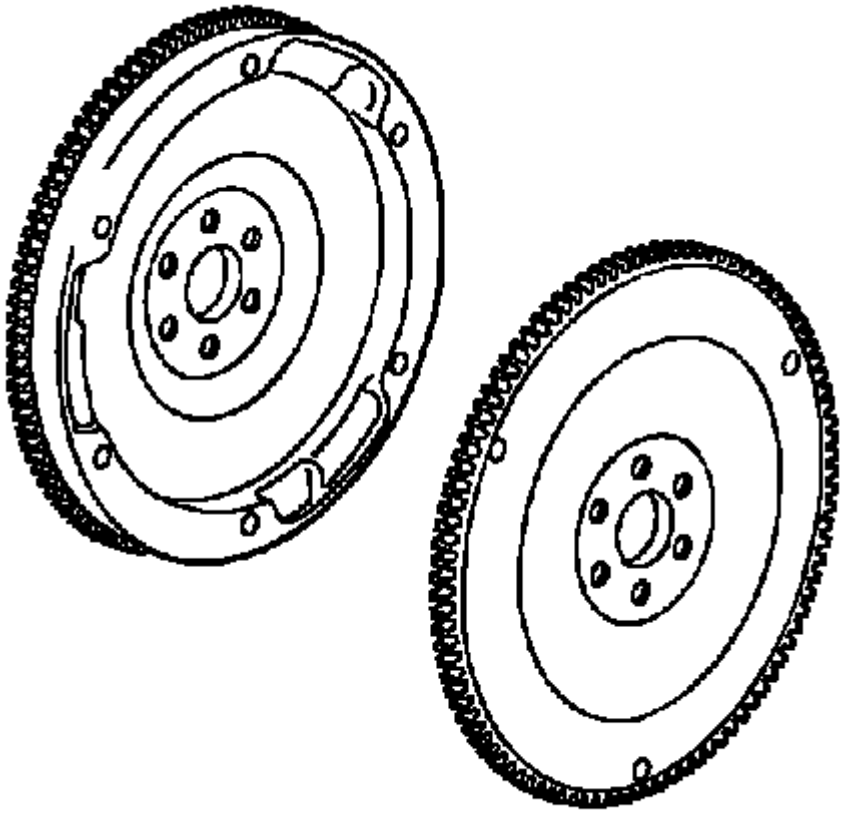

Fig. 439: Identifying Engine Flywheel
Courtesy of GENERAL MOTORS CORP.

NOTE: In order to maintain the proper component balance, contact surface taper, and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the flywheel in solvent.

   WARNING: Refer to Safety Glasses Warning .

2. Dry the flywheel with compressed air.

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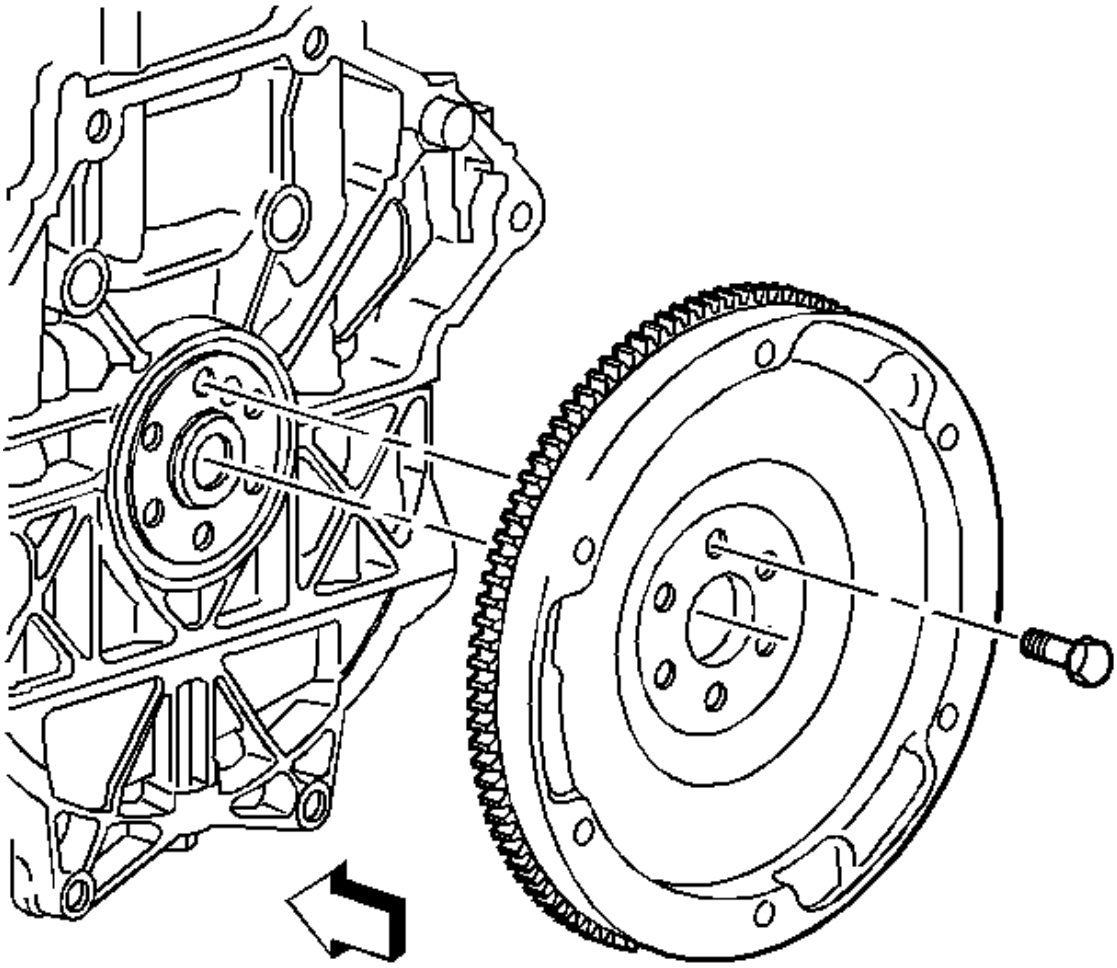

Fig. 440: Identifying Flywheel & Retaining Bolts
Courtesy of GENERAL MOTORS CORP.

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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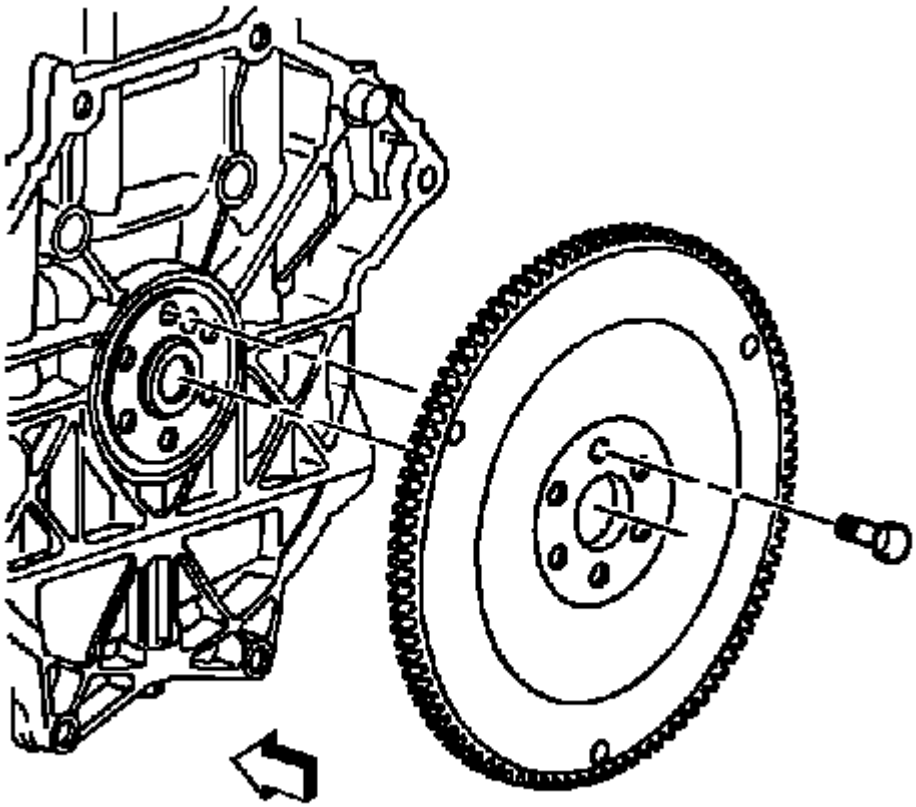

Fig. 441: View Of Flywheel
Courtesy of GENERAL MOTORS CORP.

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 BEARING CLEANING AND INSPECTION

Special Tools

EN-7872: Magnetic Base Dial Indicator Set

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

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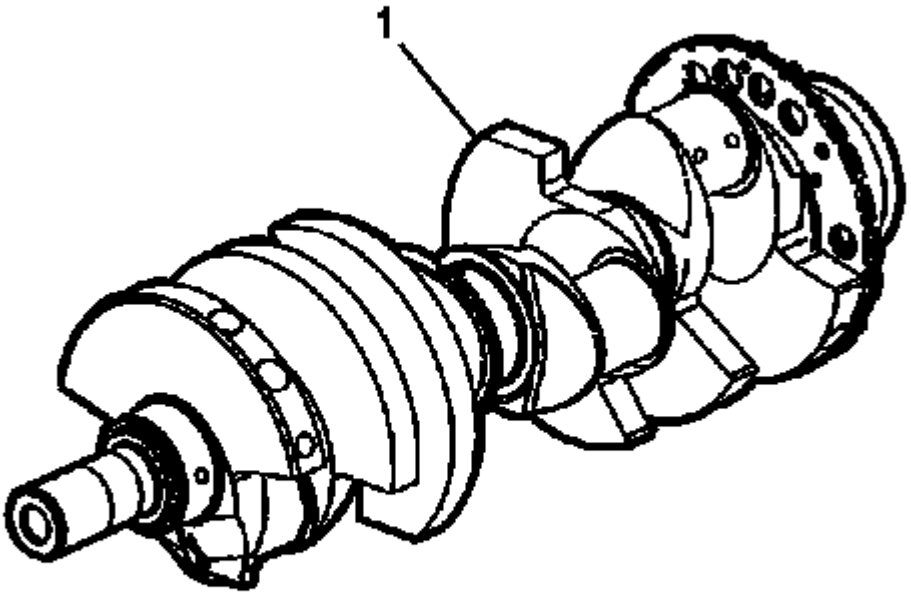

Fig. 442: Clean Crankshaft With Solvent
Courtesy of GENERAL MOTORS CORP.

NOTE: Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position 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 (1) with solvent.
2. Thoroughly clean all oil passages and inspect for restrictions or burrs.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

NOTE: Reluctor ring teeth should not have imperfections on the rising or falling edges.

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Imperfections of the reluctor ring teeth may effect OBD II system performance.

4. Perform a visual inspection of the crankshaft for damage.

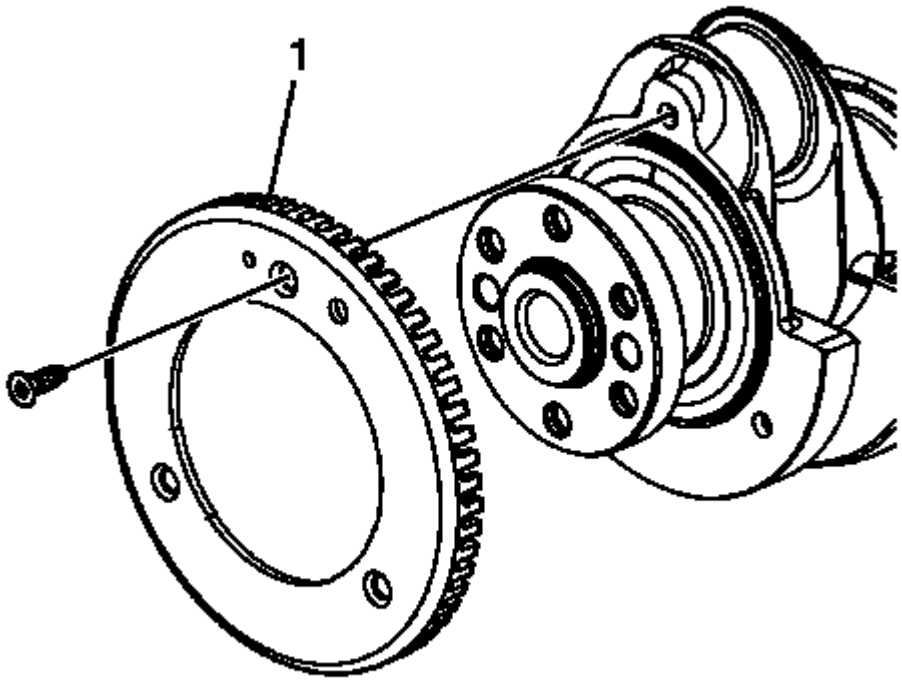

Fig. 443: View of Crankshaft Position Reluctor Ring
Courtesy of GENERAL MOTORS CORP.

5. The crankshaft position reluctor ring (1) may be replaced if damaged. Tighten the crankshaft position reluctor ring bolts to 15 N.m (11 lb ft).

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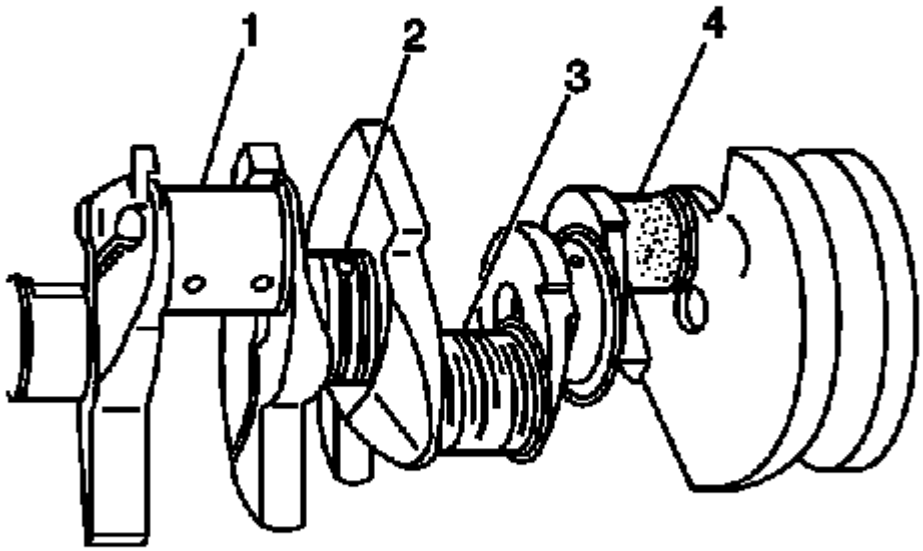

Fig. 444: Identifying Different Crankshaft Journal Wear Patterns
Courtesy of GENERAL MOTORS CORP.

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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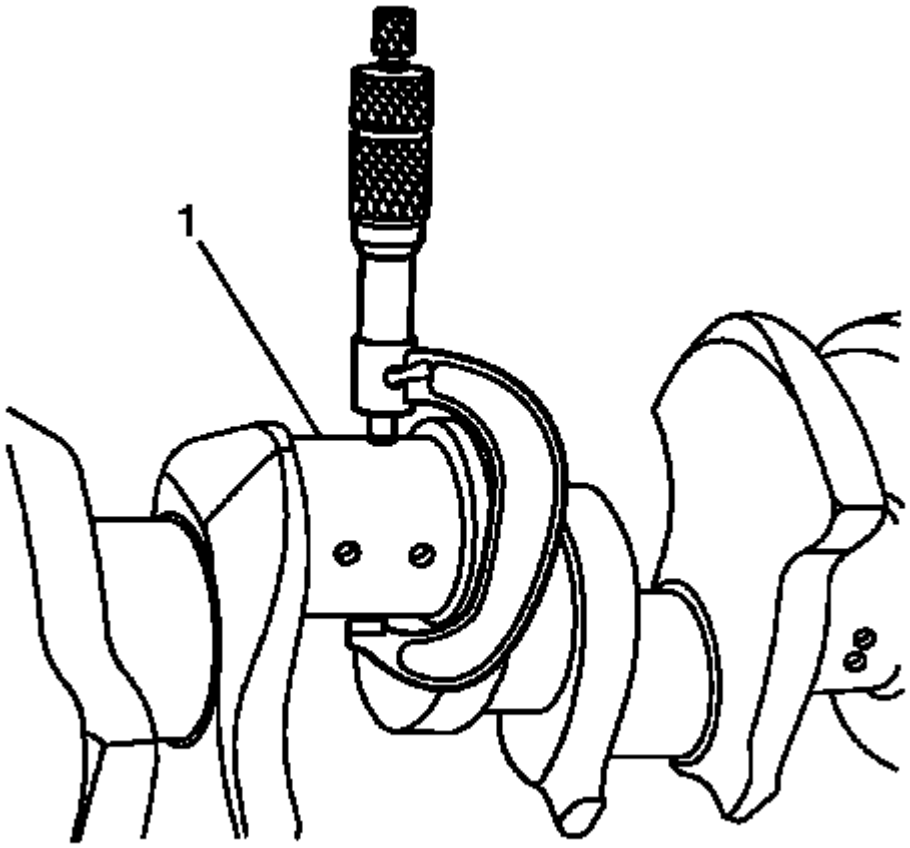

Fig. 445: Measure Crankshaft Journals For Out-Of-Round
Courtesy of GENERAL MOTORS CORP.

10. Measure the crankshaft journals (1) for out-of-round.
11. Measure the crankshaft journals for taper.

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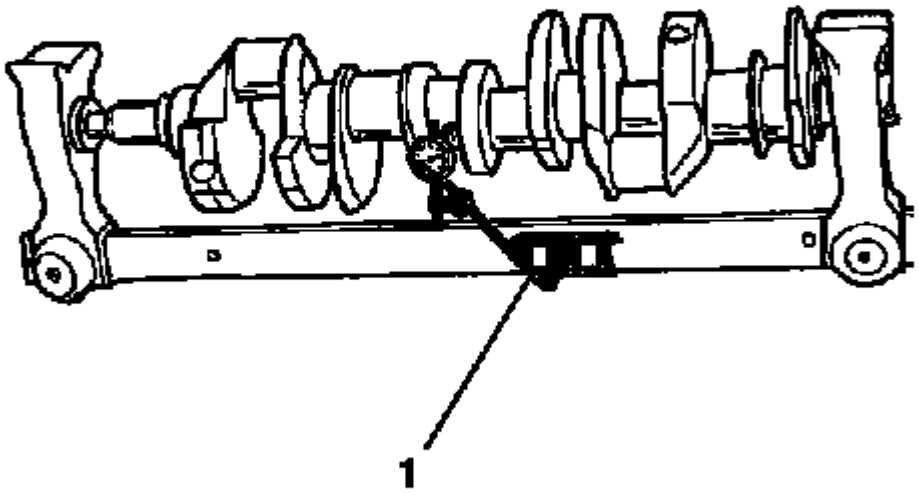

Fig. 446: Measuring The Crankshaft Runout
Courtesy of GENERAL MOTORS CORP.

12. Measure the crankshaft runout.

    Using wooden V-blocks, support the crankshaft on the front and rear journals.

13. Use the **EN-7872:** indicator (1) in order to measure the crankshaft runout at the front and rear intermediate journals.
14. Use the **EN-7872:** indicator 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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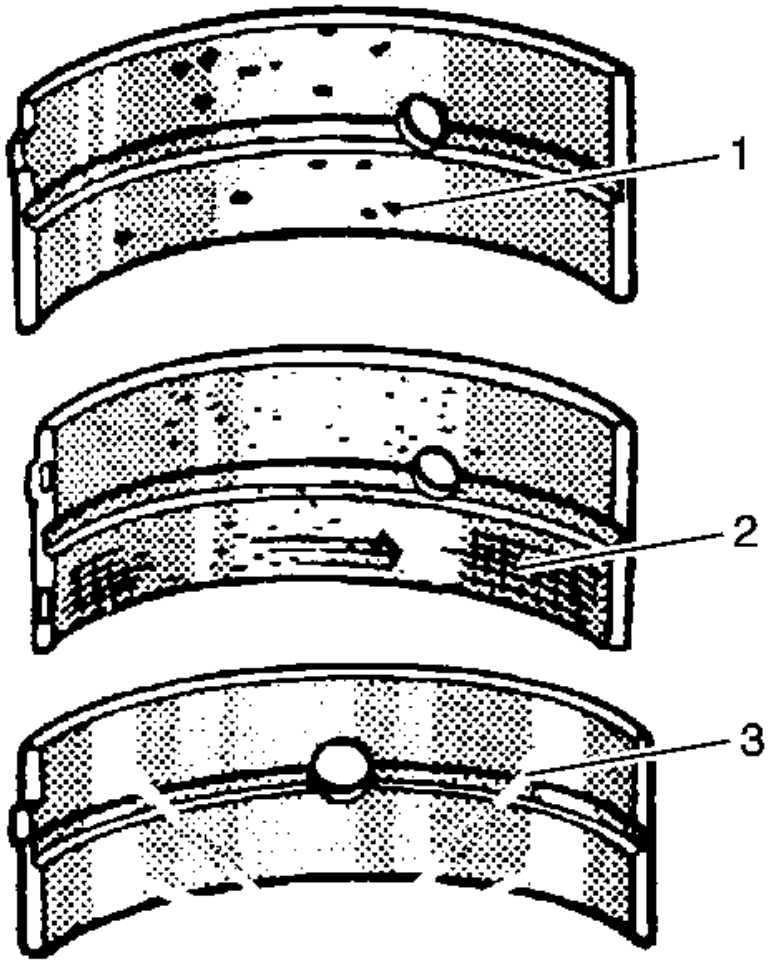

Fig. 447: Identifying Crankshaft Bearings For Craters Or Pockets
Courtesy of GENERAL MOTORS CORP.

16. Inspect crankshaft bearings for craters or pockets (1). Flattened sections on the bearing halves also indicate fatigue.
17. Inspect the crankshaft bearings for excessive scoring or discoloration (2).
18. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.
19. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing (3).

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

Special Tools

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EN-46745: Piston Pin Retainer Remover and Installer

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

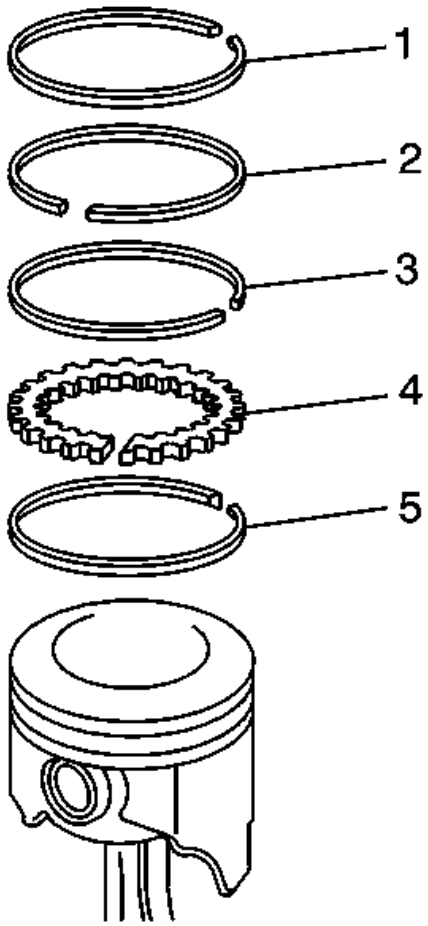

Fig. 448: Identifying Piston Rings
Courtesy of GENERAL MOTORS CORP.

WARNING: Handle the piston carefully. Worn piston rings are sharp and may cause bodily injury.

1. Disassemble the piston rings (1, 2, 3, 4, 5). Use a suitable tool to expand the rings. The piston rings must not be reused.

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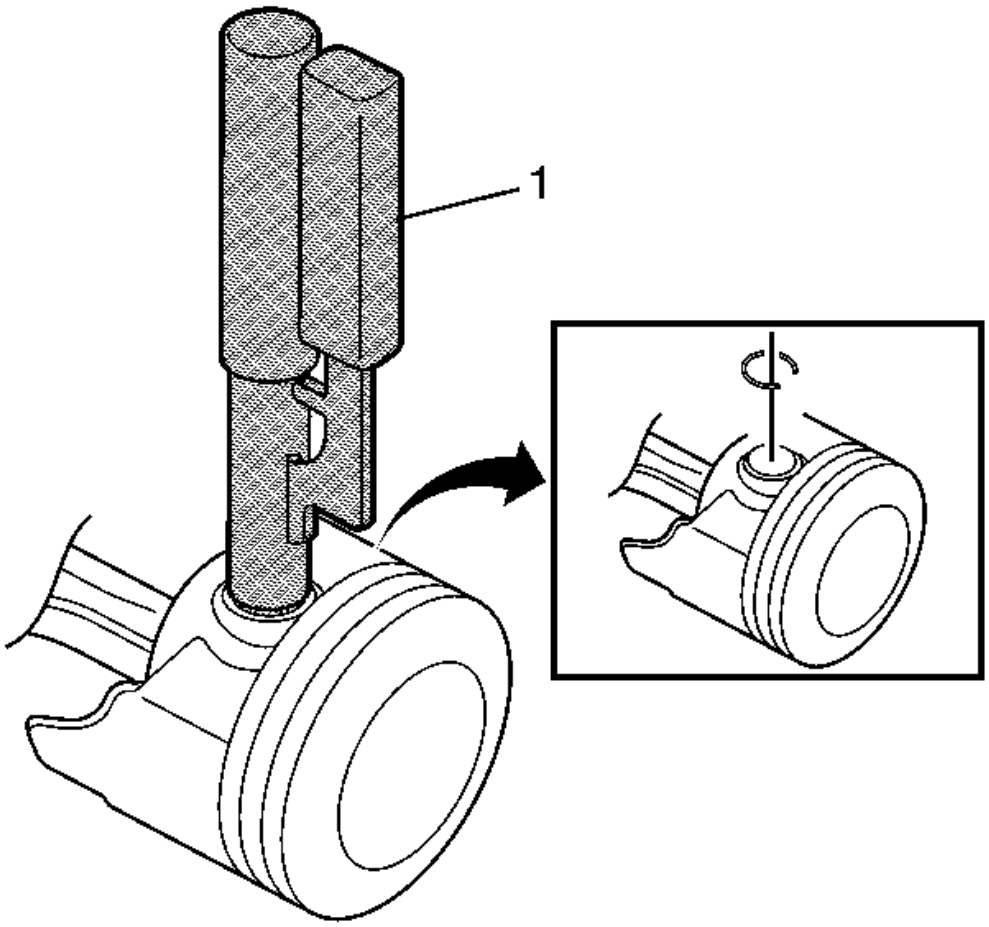

Fig. 449: View of Piston Pin Retainers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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:** remover (1).

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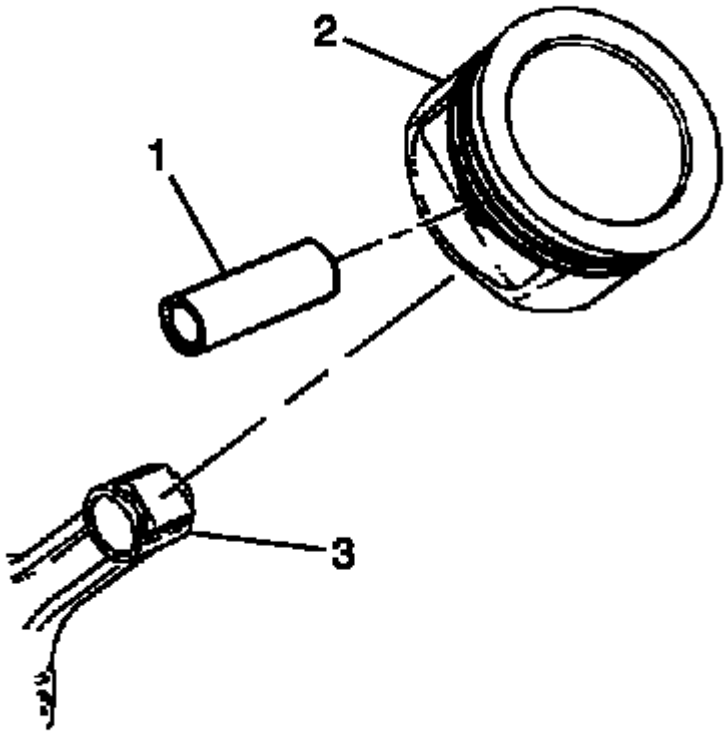

Fig. 450: Identifying Piston Pin And Connecting Rod
Courtesy of GENERAL MOTORS CORP.

3. Remove the piston pin (1) and the connecting rod (3) from the piston (2).

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Connecting Rod Measurement

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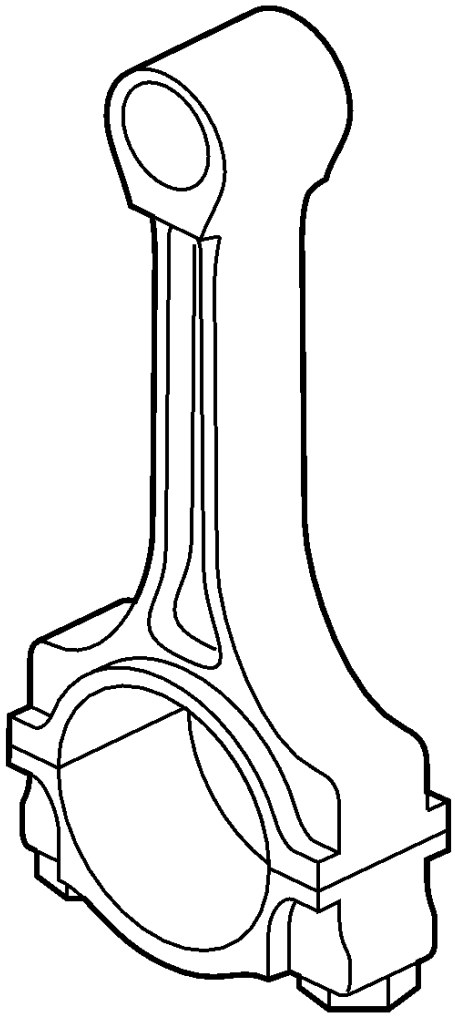

Fig. 451: View Of Connecting Rod
Courtesy of GENERAL MOTORS CORP.

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

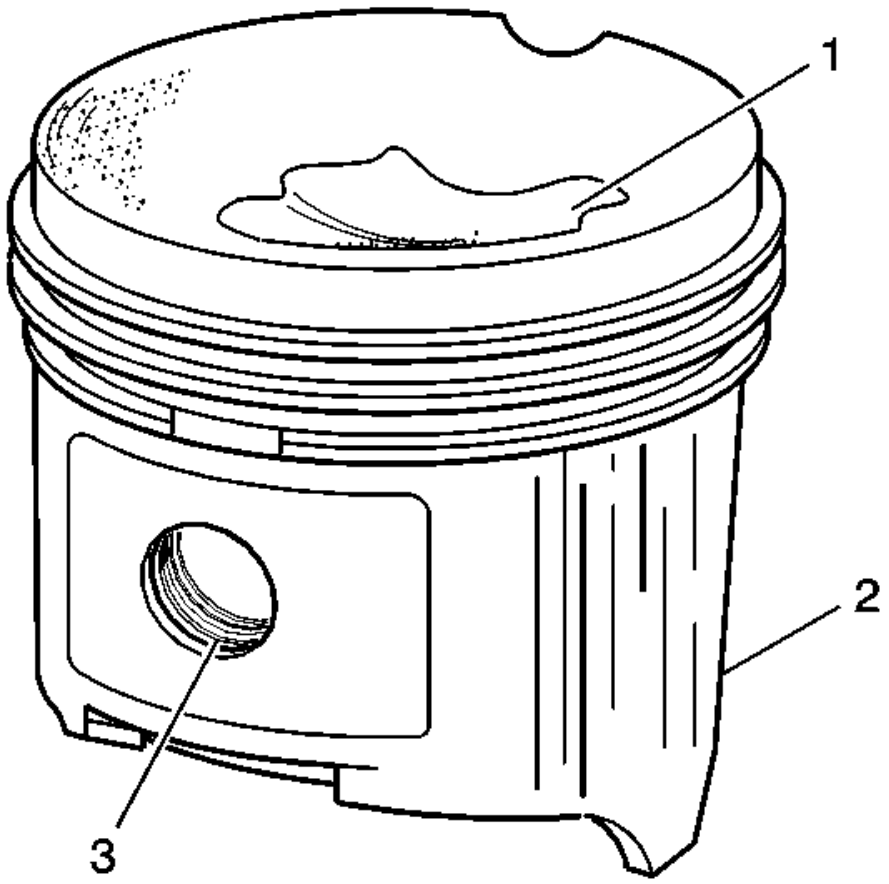

Fig. 452: Identifying Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS CORP.

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.

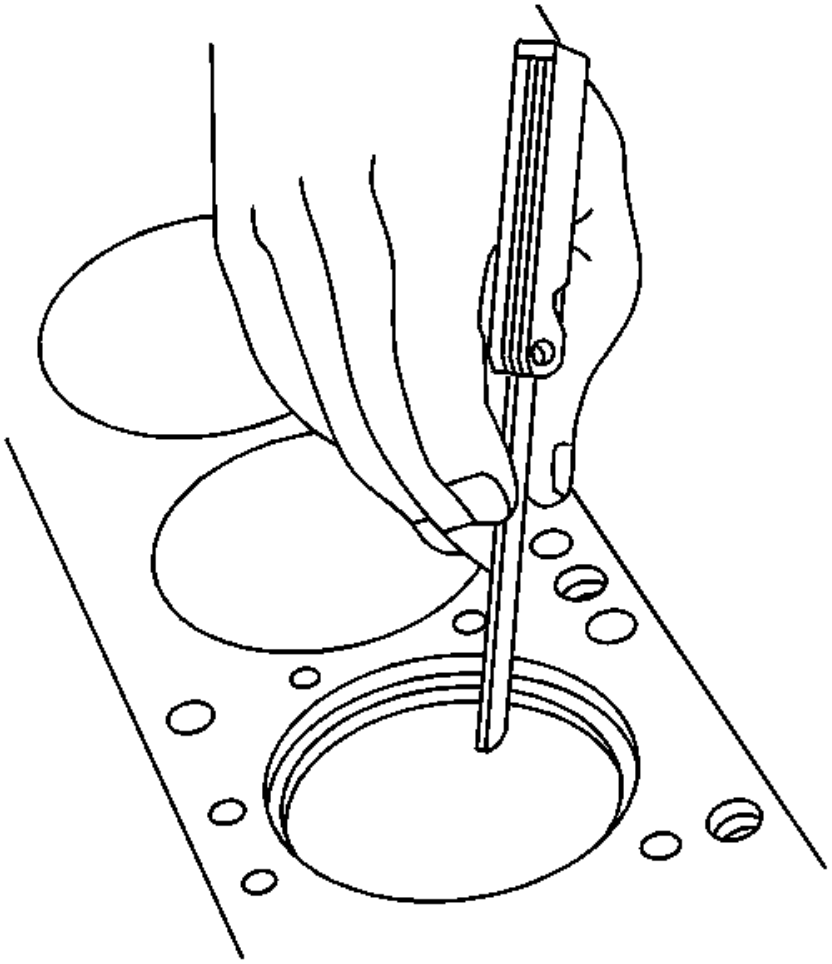

Fig. 453: Measuring Piston Ring End Gap
Courtesy of GENERAL MOTORS CORP.

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 gauges. 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.

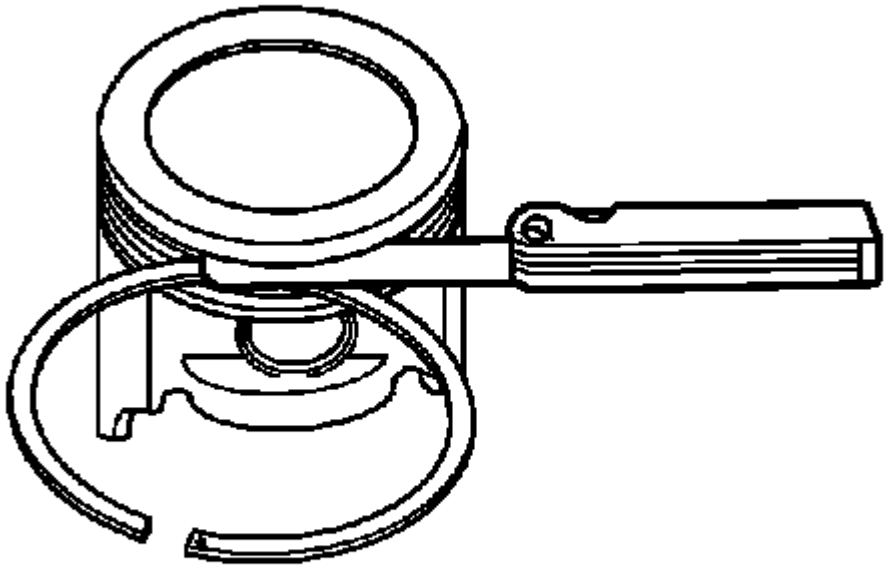

Fig. 454: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS CORP.

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 gauges 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.

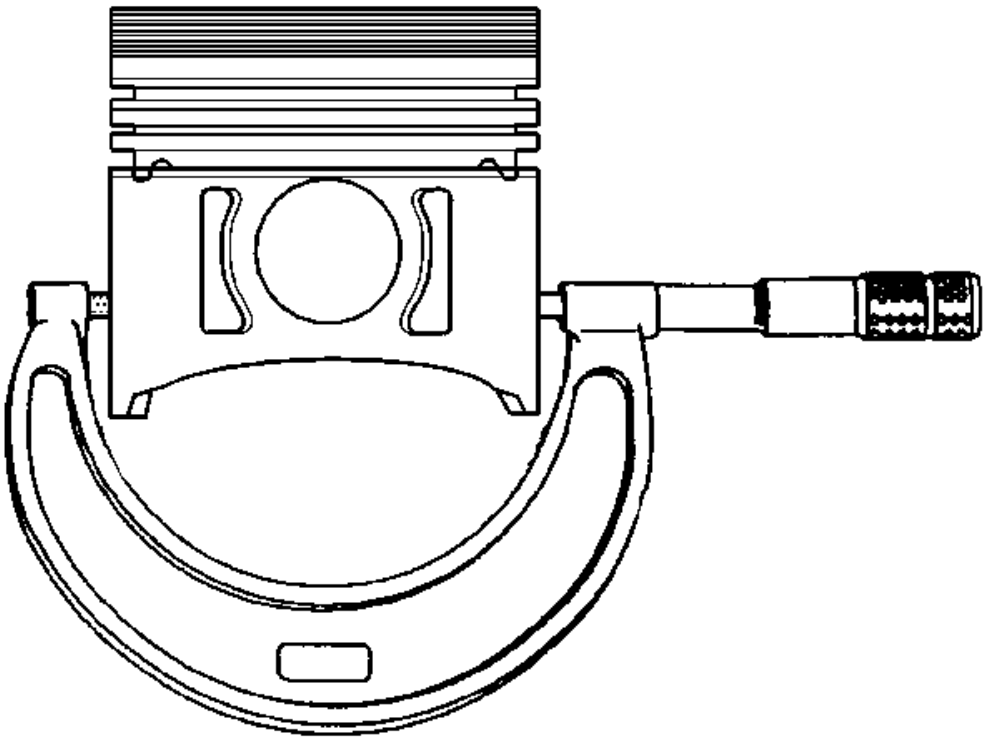

Fig. 455: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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

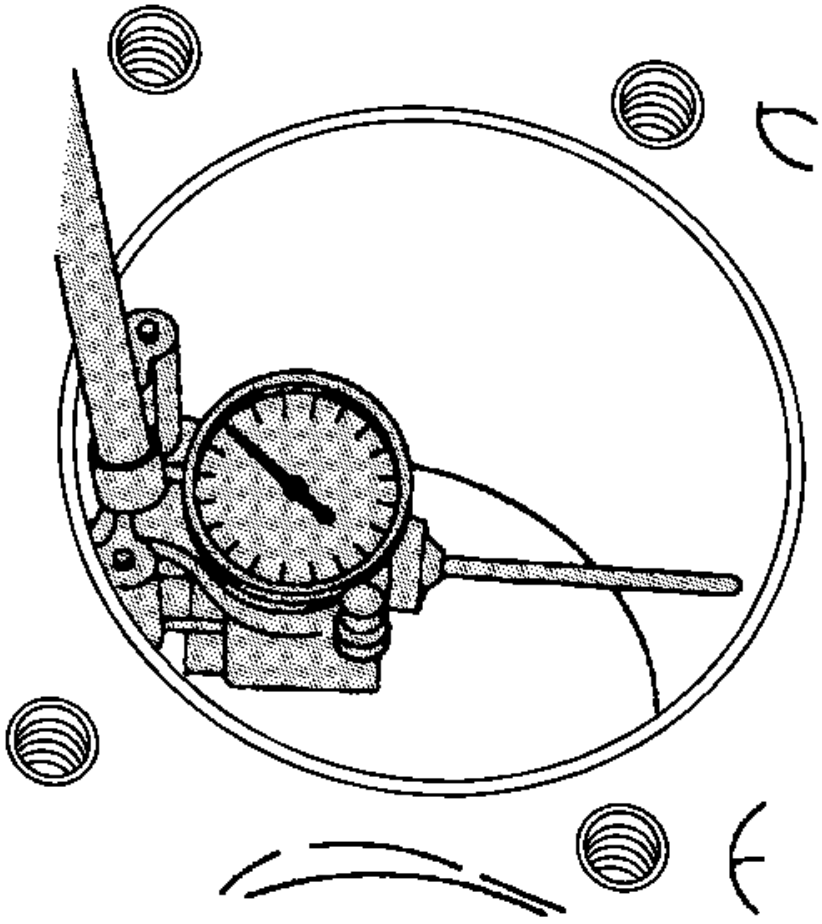

Fig. 456: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS CORP.

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 Bearing 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.

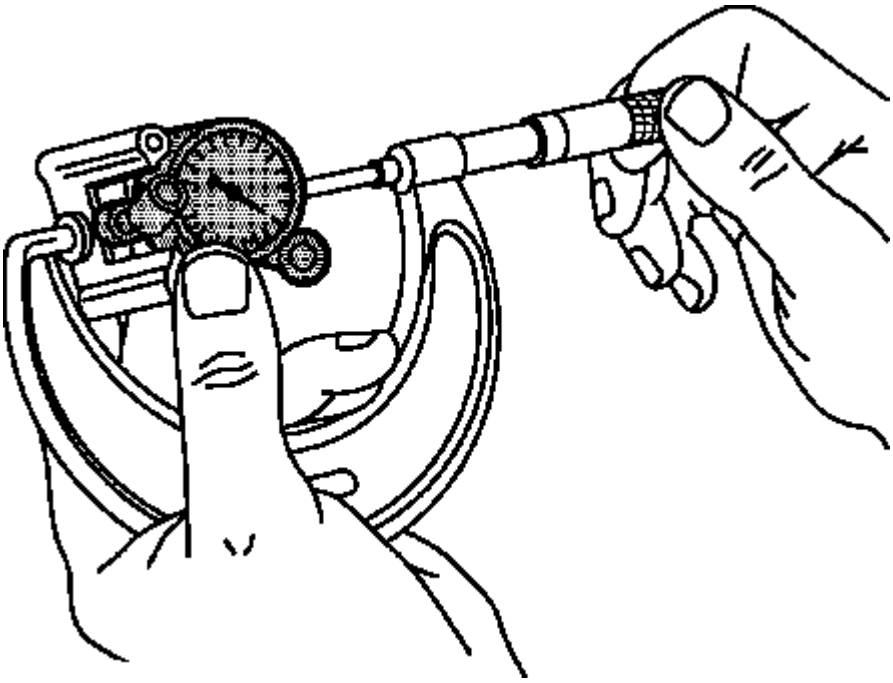

Fig. 457: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS CORP.

4. Measure the bore gauge with a micrometer and record the reading.

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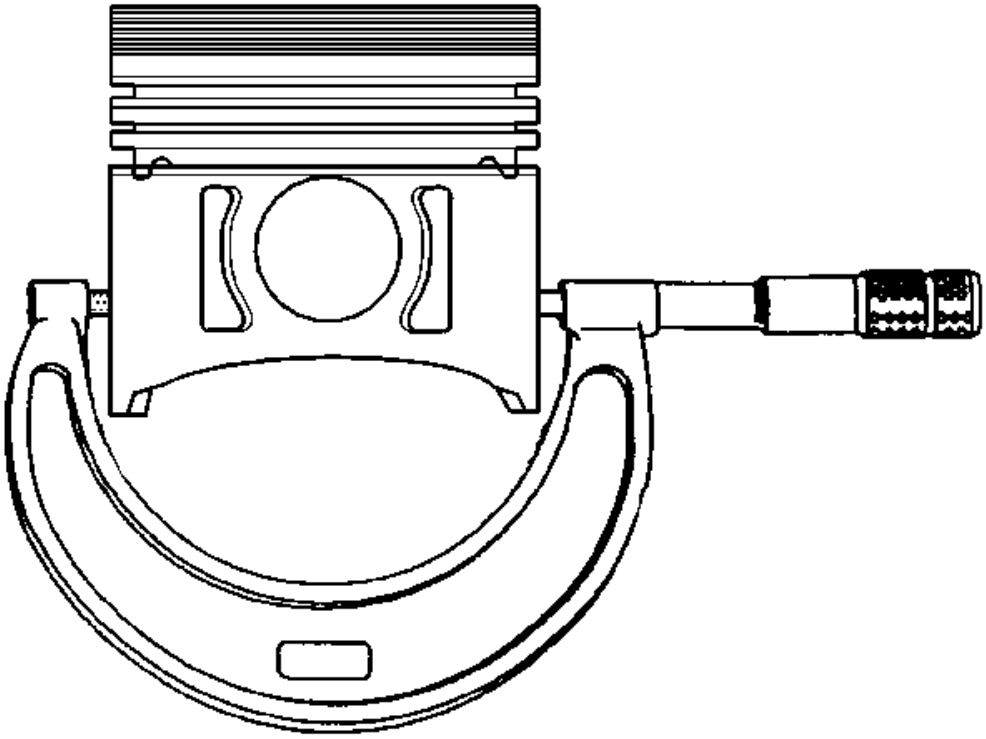

Fig. 458: Measuring Piston Diameter
Courtesy of GENERAL MOTORS CORP.

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 (LAP, LE8)**.
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

Special Tools

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EN-46745: Piston Pin Retainer Remover and Installer

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

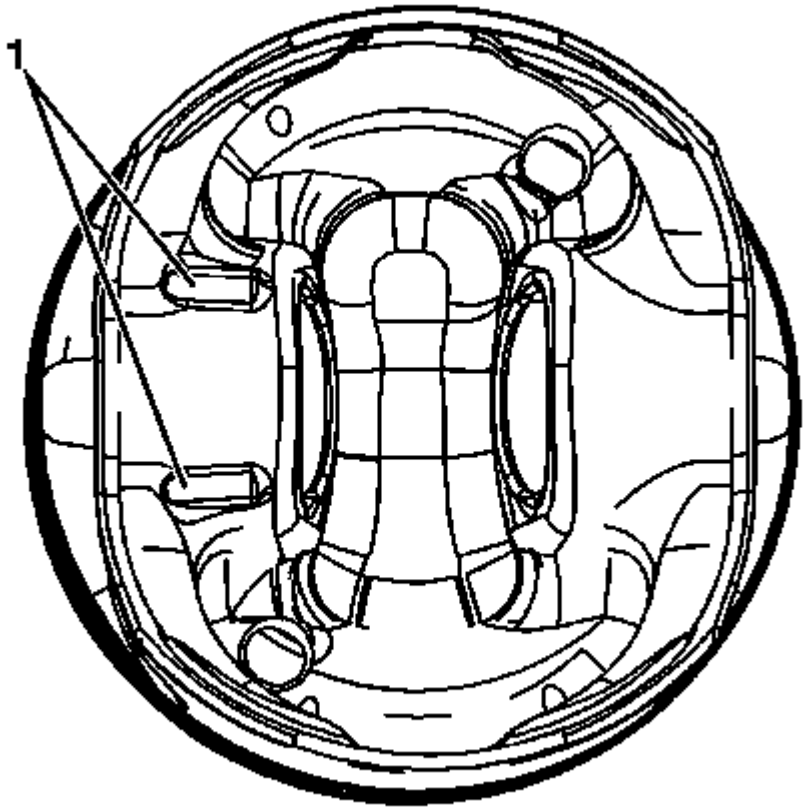

Fig. 459: Locating "Cast Boss" On Underside of Piston
Courtesy of GENERAL MOTORS CORP.

NOTE: Install the piston onto the connecting rod with the arrow on top of the piston toward the front oriented toward the front of the engine.

NOTE: The cast boss (1) can be in either or both locations depending on displacement.

1. The cast boss (1), on the underside of the piston, must go to the rear of the block.

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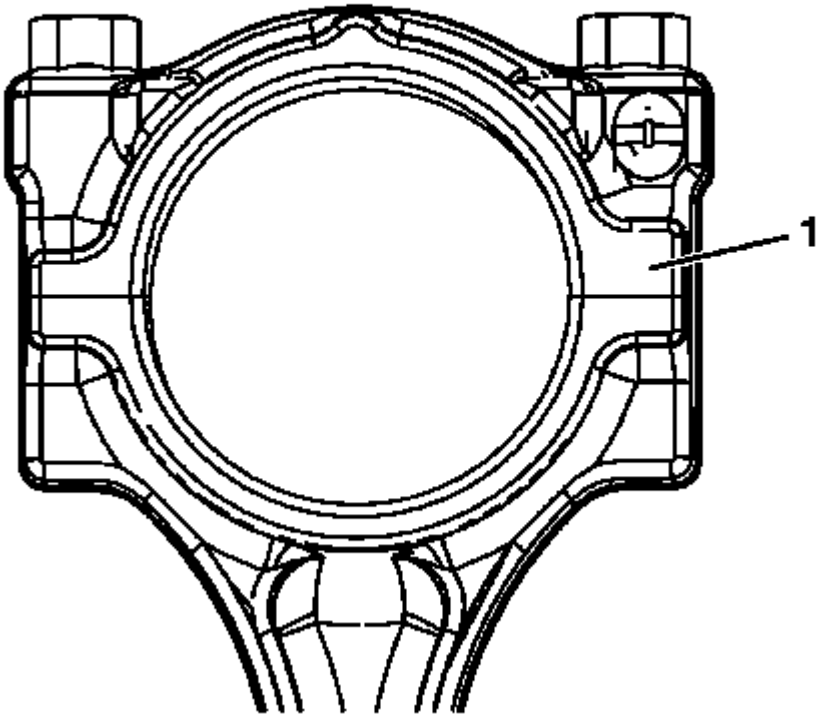

Fig. 460: Identifying Cast Mark
Courtesy of GENERAL MOTORS CORP.

2. The larger feature (1), at the split line located on one side of the connecting rod, must go to the front of the block.

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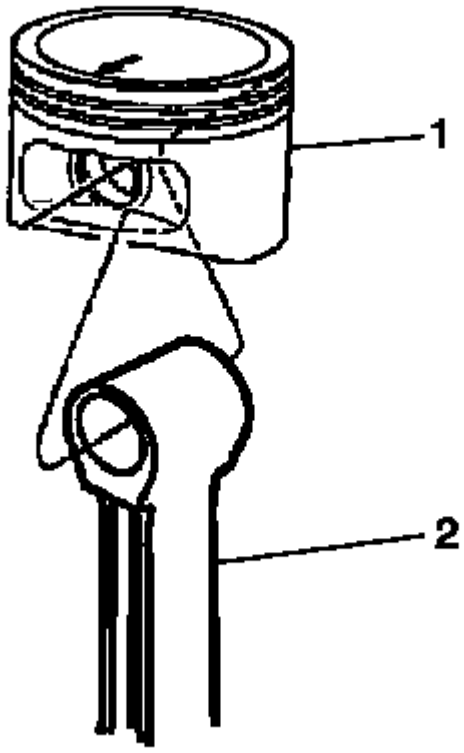

Fig. 461: View of Connecting Rod and Piston
Courtesy of GENERAL MOTORS CORP.

3. Assemble the connecting rod (2) and the piston (1).

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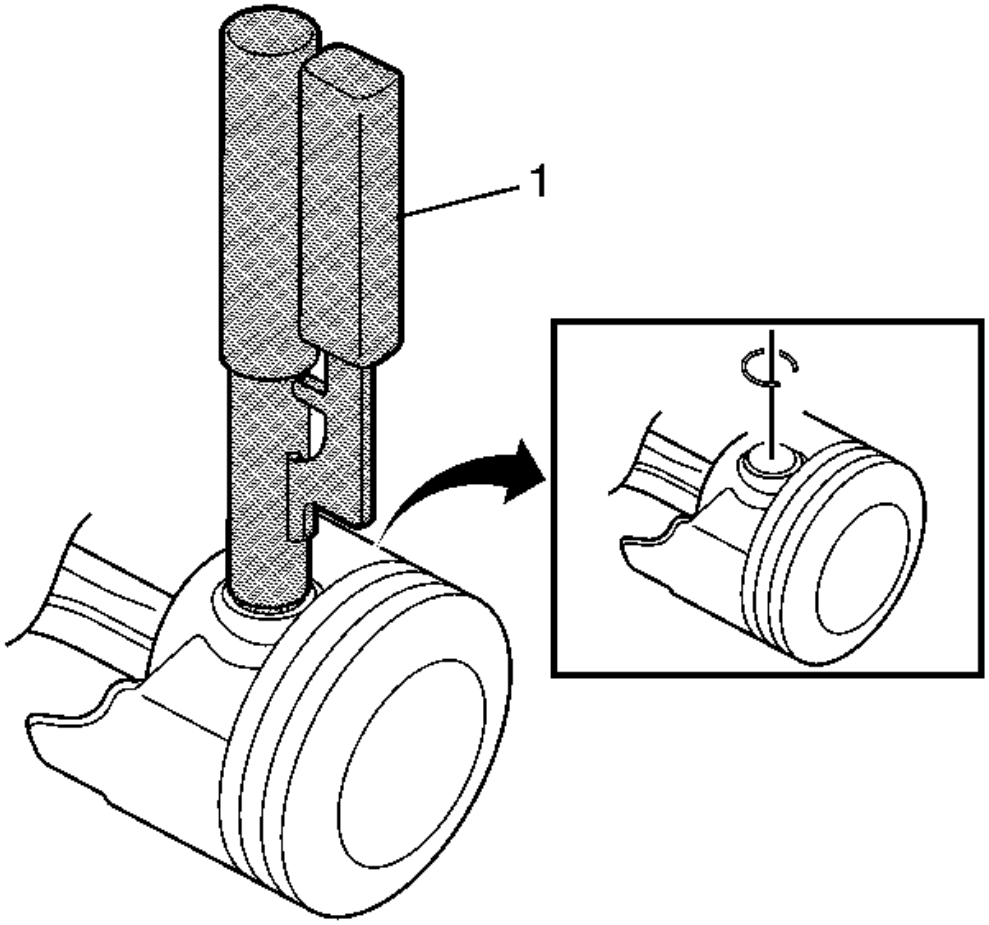

Fig. 462: View of Piston Pin Retainers
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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:** installer. 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:** installer (1) .
    5. Ensure that the piston moves freely.

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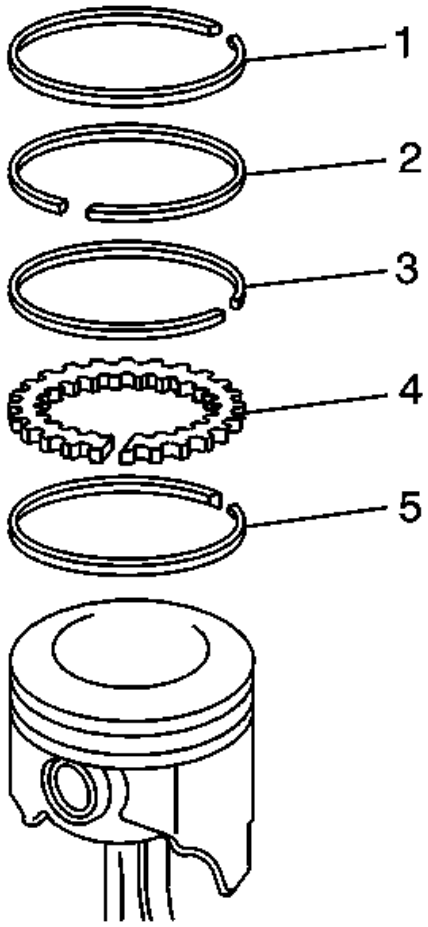

Fig. 463: Identifying Piston Rings
Courtesy of GENERAL MOTORS CORP.

CAUTION: Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.

5. Install the following components of the oil control ring assembly (bottom ring):
    1. The expander (5)
    2. The lower oil control ring (4)
    3. The upper control ring (3)
6. Install the lower compression ring (2). Place the manufacturer's mark facing up.
7. Install the upper compression ring (1).

CAMSHAFT CLEANING AND INSPECTION

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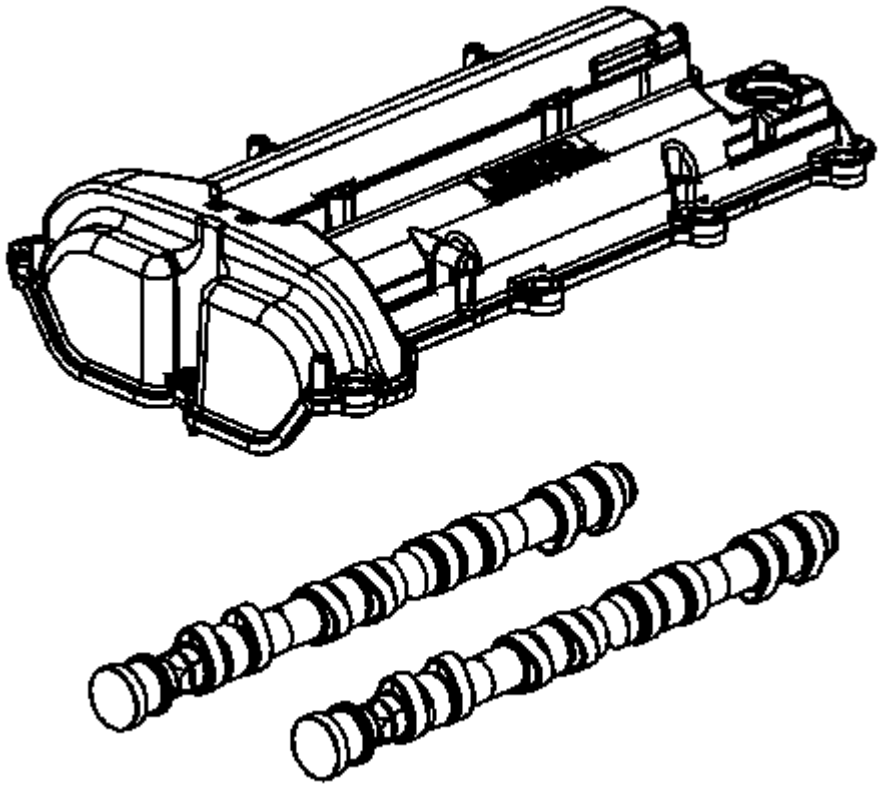

Fig. 464: View Of Camshaft And Camshaft Cover
Courtesy of GENERAL MOTORS CORP.

- Inspect the camshaft journals and lobes for wear or scoring.
- Inspect the camshaft sprocket alignment notch for damage.
- 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.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

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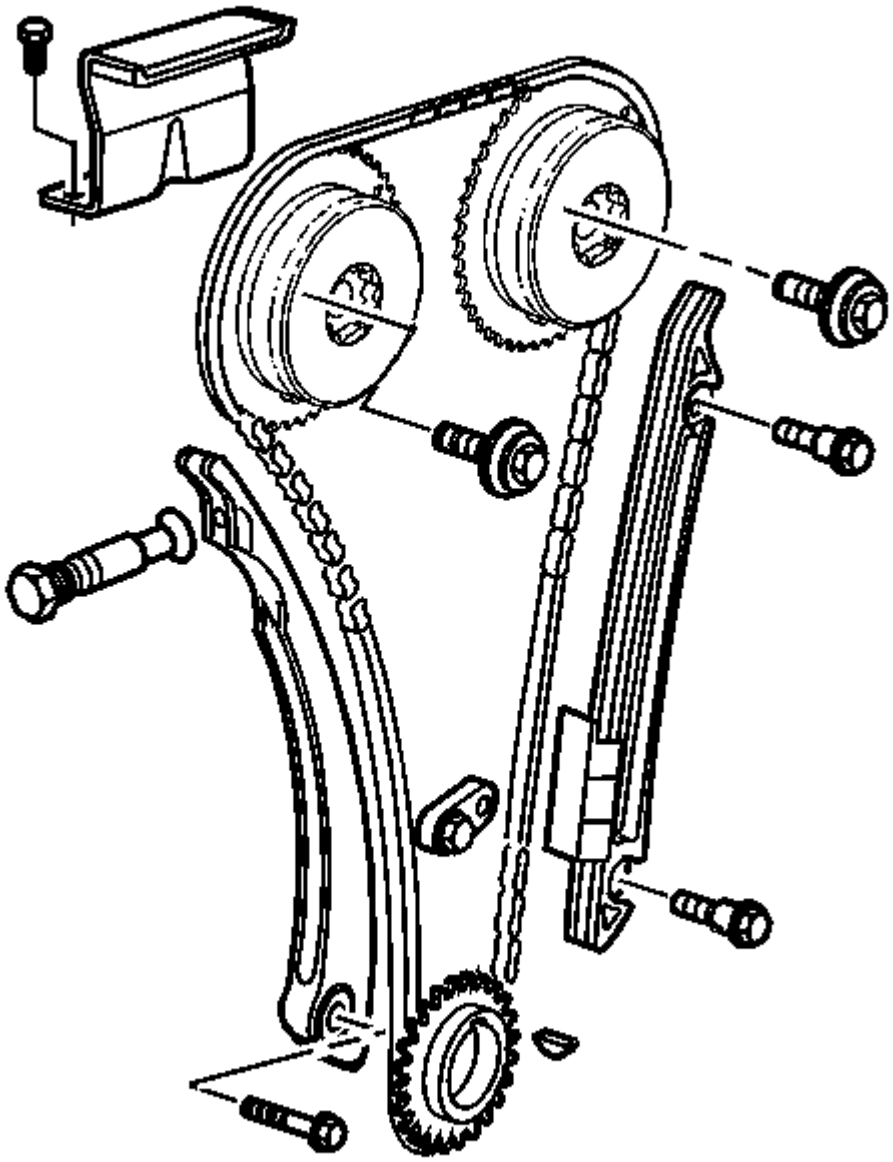

Fig. 465: Timing Chain Guides
Courtesy of GENERAL MOTORS CORP.

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. Verify oil nozzle oil flow with compressed air.
10. Inspect the timing chain tensioner for the scoring or free movement.
11. Inspect the timing chain tensioner washer and O-ring for damage. If damaged, replace the timing chain tensioner.

BALANCE SHAFT CLEANING AND INSPECTION

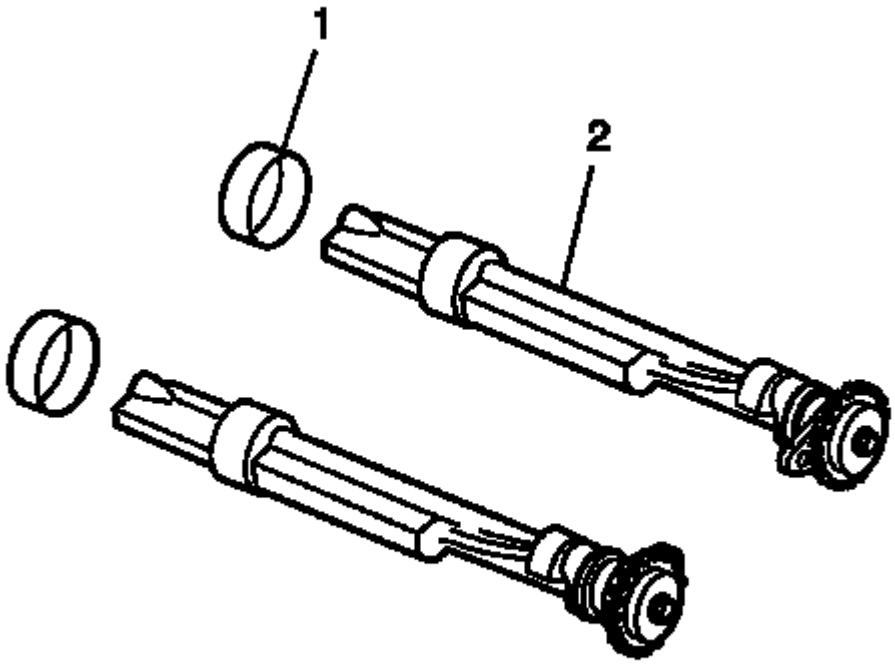

Fig. 466: Balance Shafts
Courtesy of GENERAL MOTORS CORP.

1. Clean the balance shafts (1) in solvent.

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2. Inspect the bearing surfaces on the balance shafts for scoring or unusual wear.

NOTE: Do not remove the balance shaft drive sprockets.

3. Inspect the balance shaft drive sprockets for wear, damage, or missing teeth.
4. 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.
5. 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.
6. When the balance shafts have been installed in the engine block, check for smooth rotation, sticking, binding, or roughness.

WATER PUMP AND BALANCE SHAFT CHAIN AND SPROCKET CLEANING AND INSPECTION

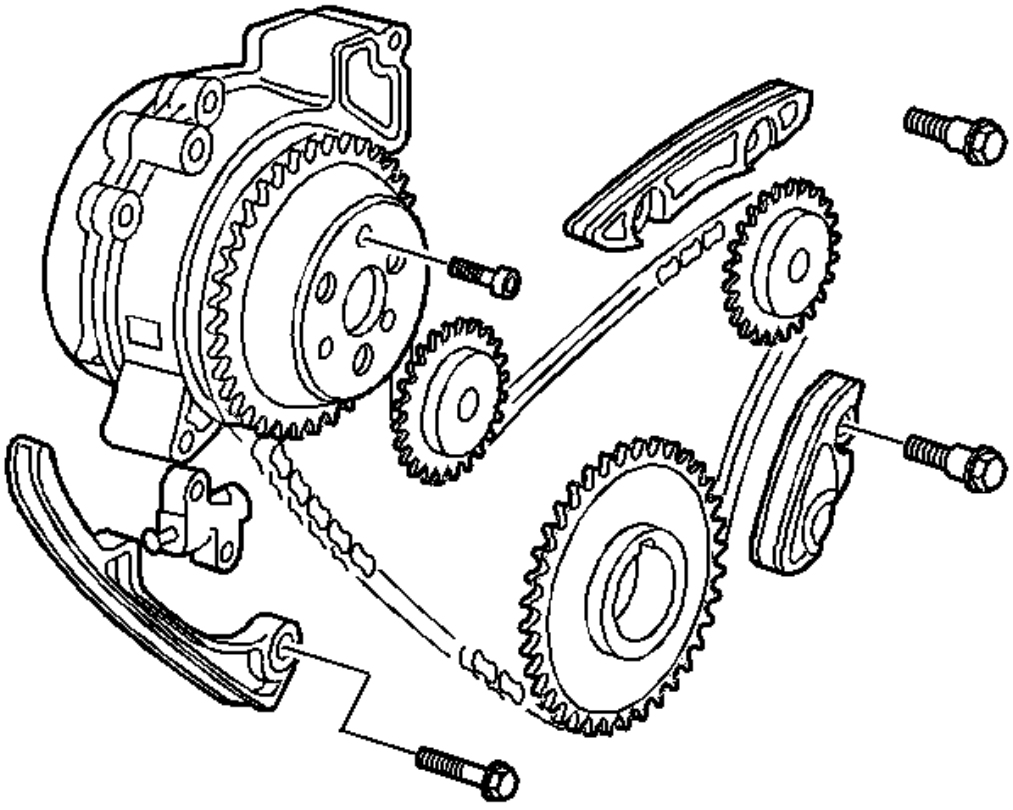

Fig. 467: Inspecting Balance Shaft Drive Chain & Sprockets
Courtesy of GENERAL MOTORS CORP.

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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.

   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

Special Tools

- **EN-8062:** Valve Spring Compressor
- **EN-36017:** Valve Seal Remover
- **EN-43963:** Valve Spring Compressor (off car)

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

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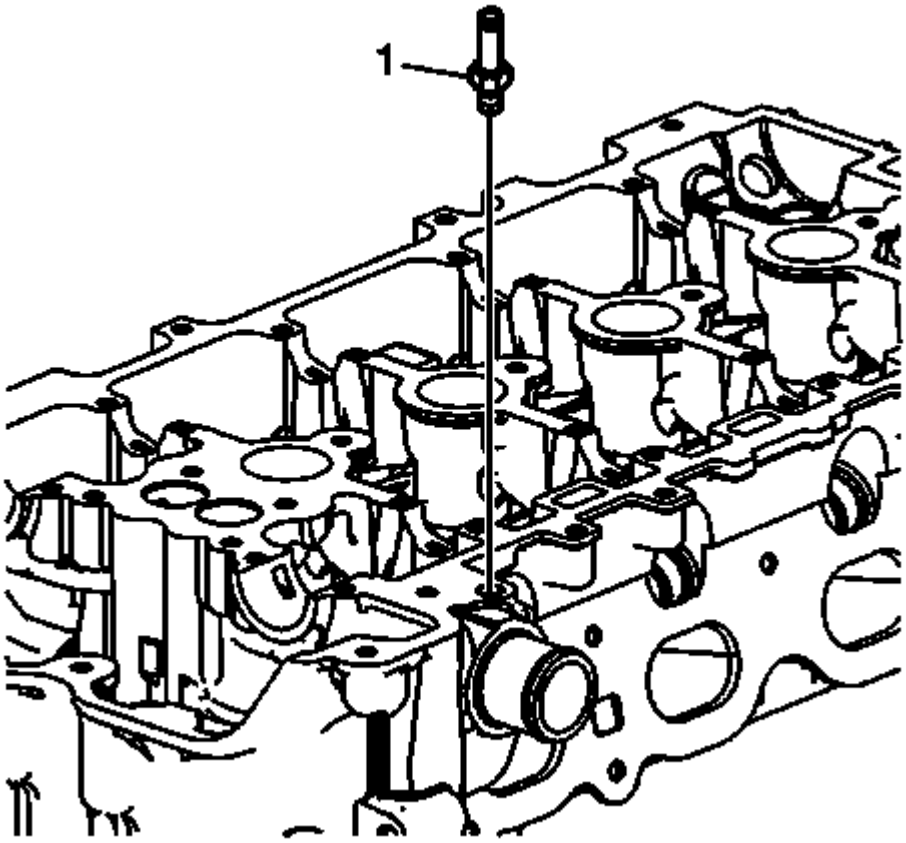

Fig. 468: Identifying the Coolant Air Bleed Hose Fitting
Courtesy of GENERAL MOTORS CORP.

1. Remove the coolant air bleed hose fitting (1).

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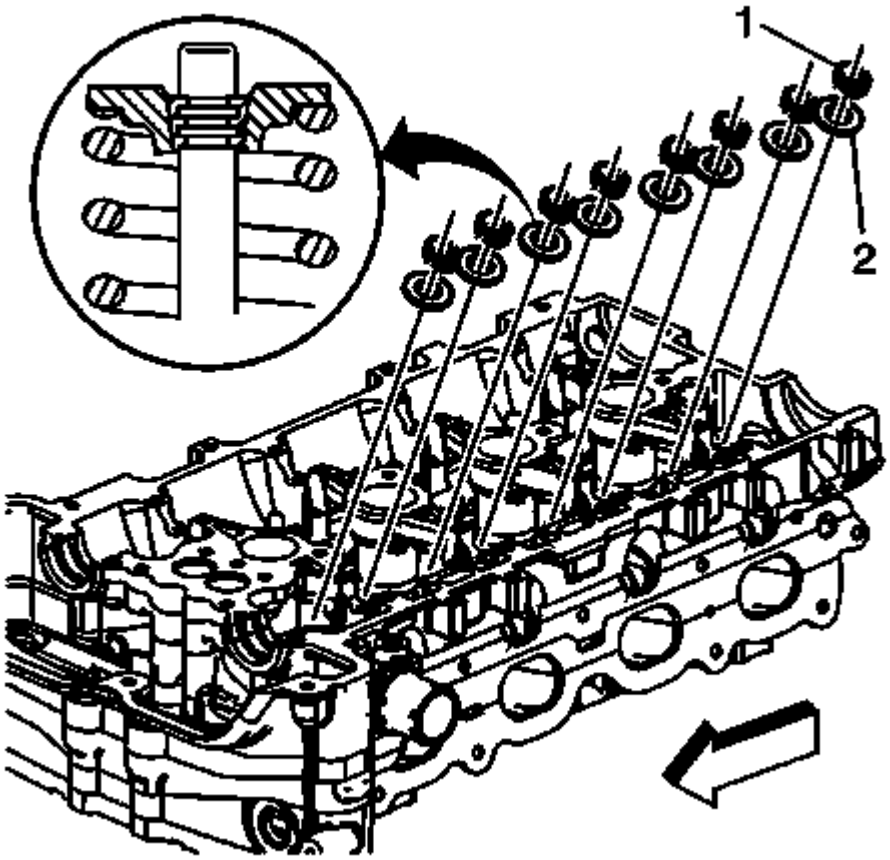

Fig. 469: View of Valve Keys and Retainer
Courtesy of GENERAL MOTORS CORP.

WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

NOTE: Ensure that the valve train components are kept together and identified in order for proper re-installation in their original position.

2. Using the **EN-8062:** compressor and the **EN-43963:** compressor (off car), compress the valve spring.
3. Remove the valve keys (1).

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4. Slowly release the **EN-8062:** compressor and the **EN-43963:** compressor (off car) from the valve spring assembly.
5. Remove the retainers (2).

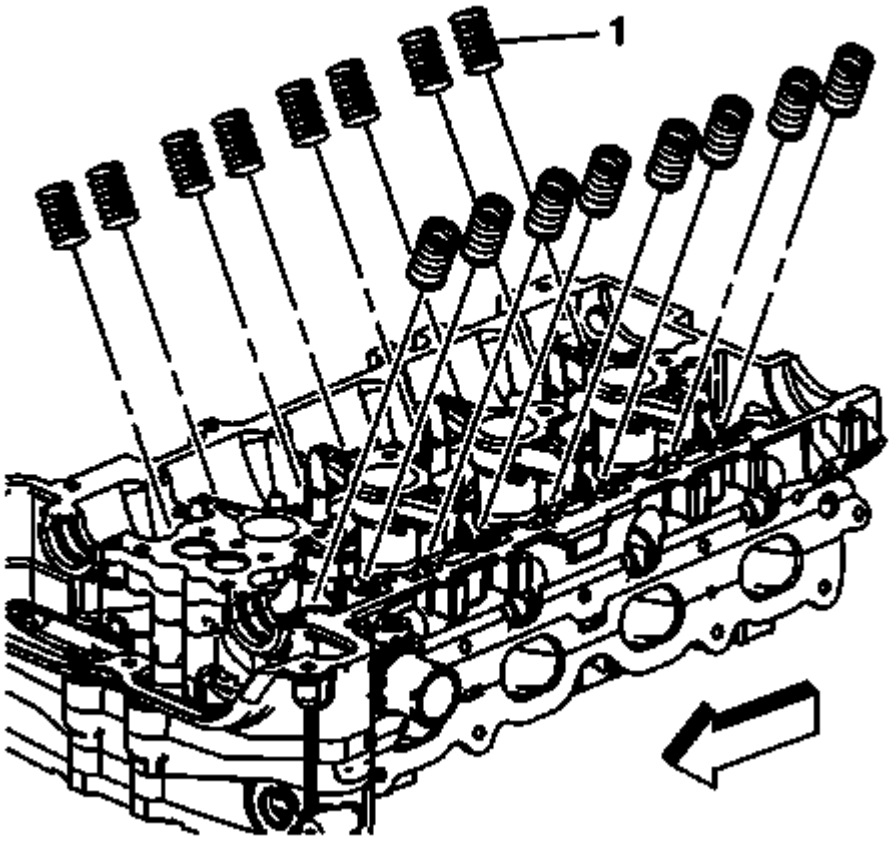

Fig. 470: View of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Remove the springs (1).

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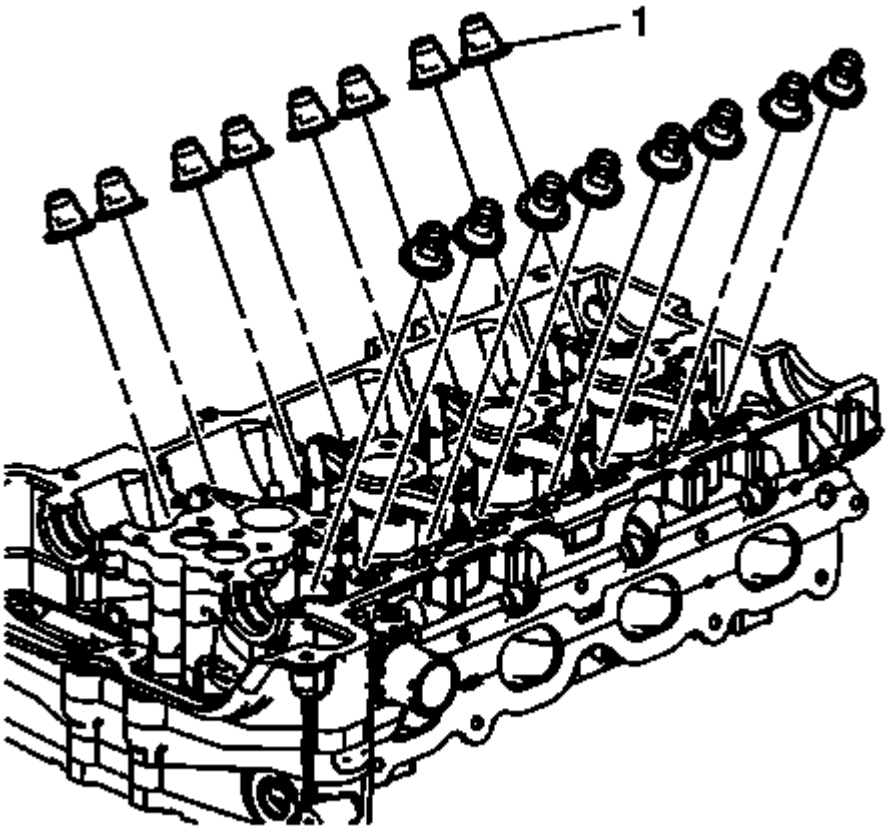

Fig. 471: View of Valve Seals
Courtesy of GENERAL MOTORS CORP.

CAUTION: 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. Using the **EN-36017:** remover, remove the valve seals (1). Do not reuse the valve seals.

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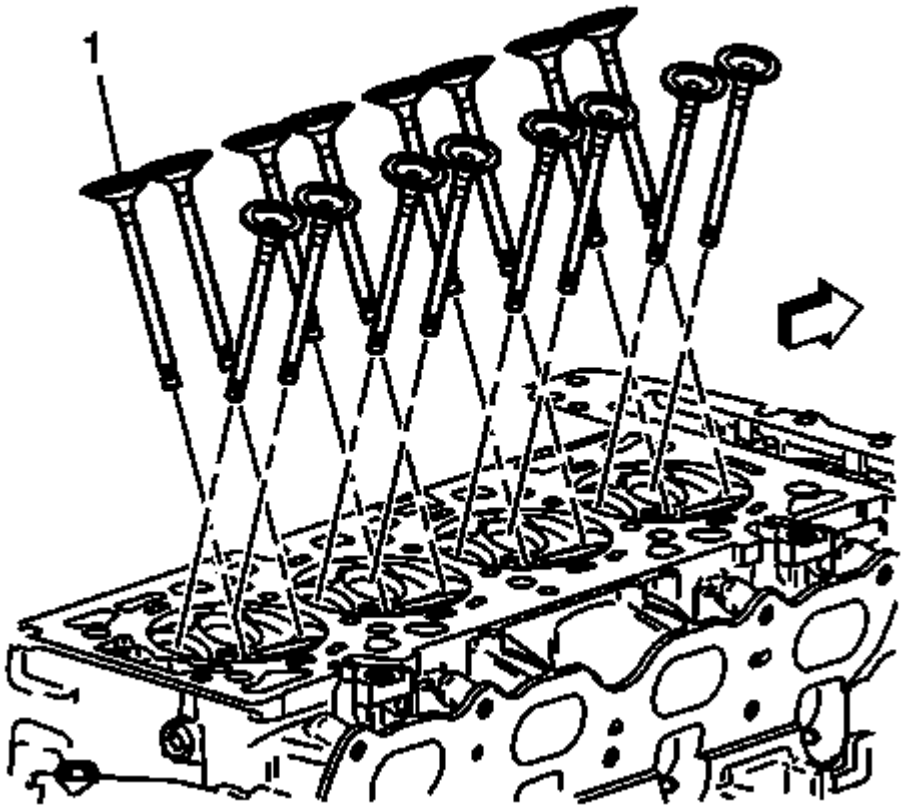

Fig. 472: View of Valves
Courtesy of GENERAL MOTORS CORP.

8. Remove the valves (1).

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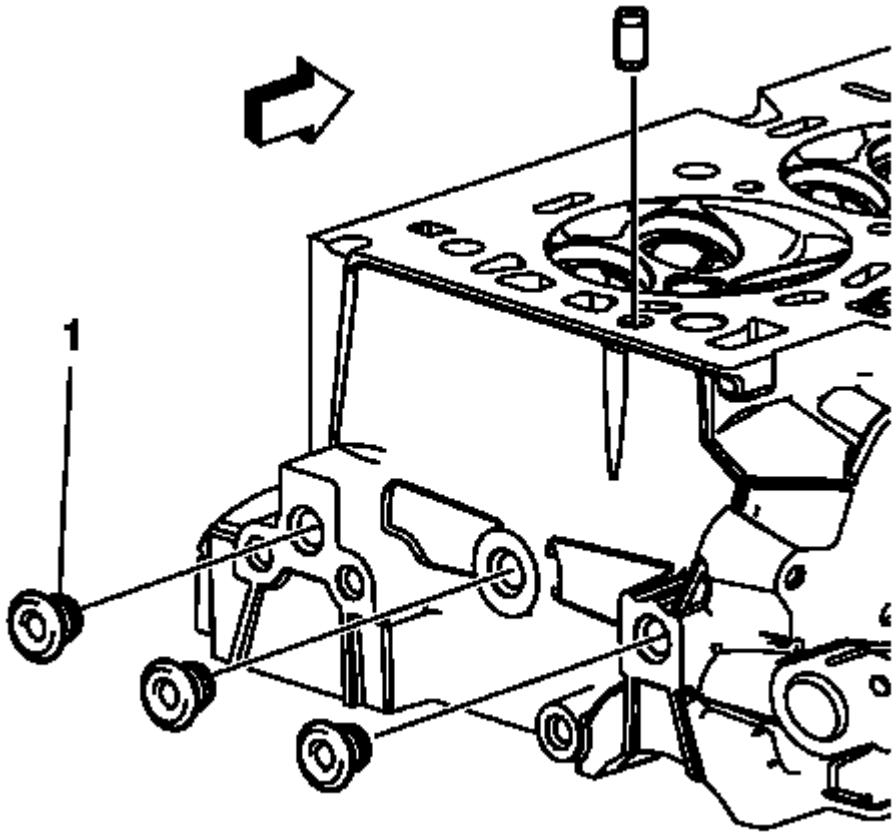

Fig. 473: Identifying Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

9. Remove the cylinder head plugs (1) and oil restrictor.

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **J 7872:** Magnetic Base Dial Indicator
- **J 22738-B:** Valve Spring Tester

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

Valve Cleaning and Inspection

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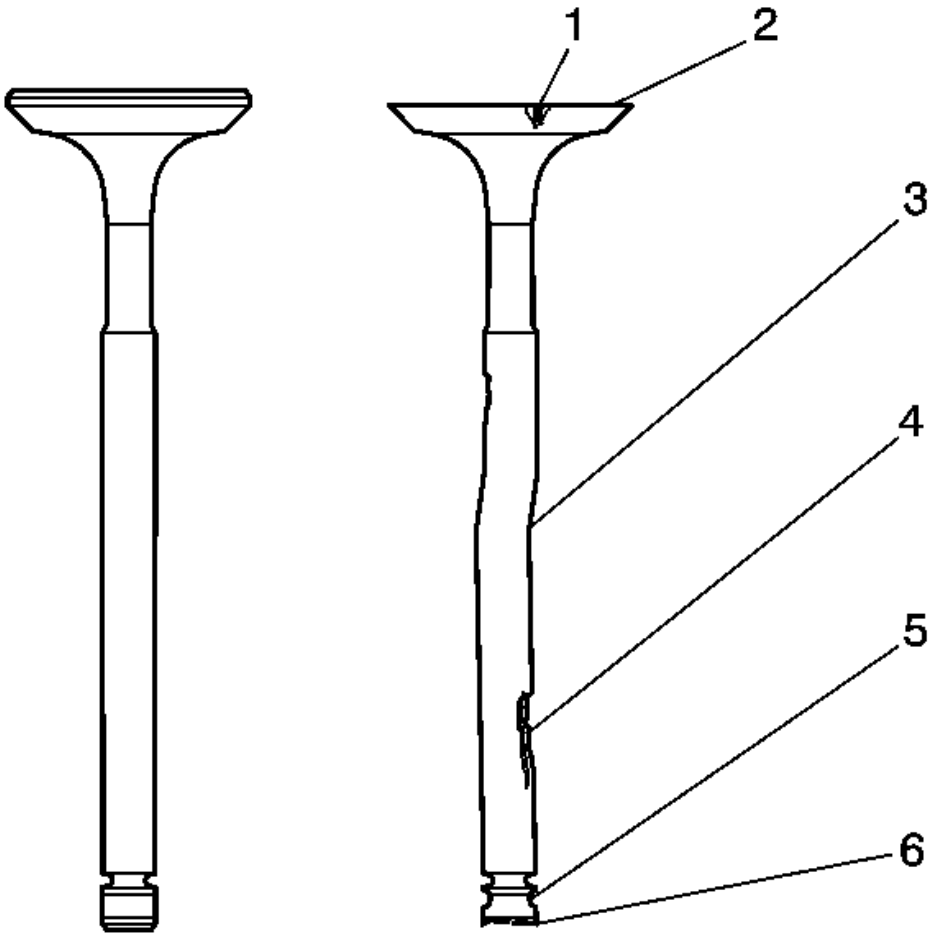

Fig. 474: Identifying Valve Flaws
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use a wire brush on any part of the valve stem.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

1. Clean the valves of carbon, oil and varnish. Use a soft bristle wire brush to clean any carbon build-up from the valve head. Varnish can be removed by soaking in Parts Immersion Solvent or equivalent. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Clean the valve guides.
3. Inspect the valve stem for pitting or wear (4).
4. Inspect the valve key 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

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stone.

7. Inspect the valve stem for straightness (3) and the valve head for bending or distortion using V blocks. 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. Replace the valve if the valve head O.D. and chamfer (2) is worn or out of specification. Refer to **Valve and Seat Grinding**.
11. The valves may be lightly lapped to the valve seats.
12. Replace the valve if the valve tip (6) is worn.
13. If no apparent wear, pitting, grooving, or distortion is present, perform the valve measurement and reconditioning procedure to verify valve specification. Refer to **Valve and Seat Grinding**.

Valve Guide Measurement

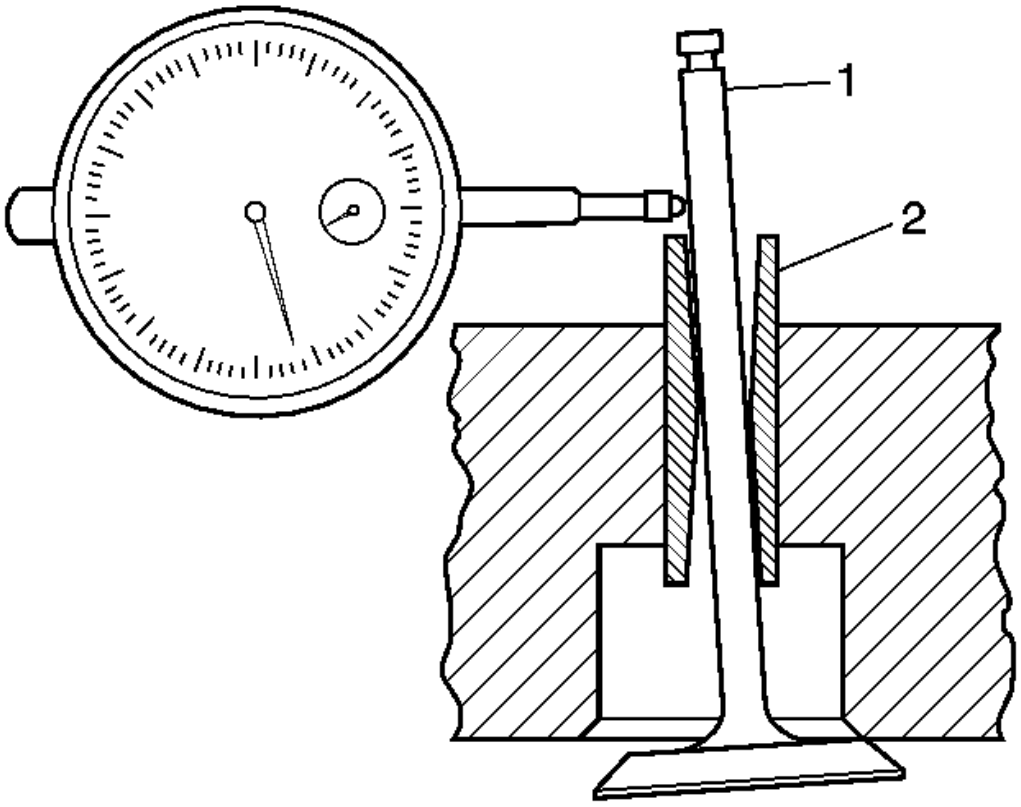

Fig. 475: Inspecting For Excessive Valve Stem To Guide Clearance
Courtesy of GENERAL MOTORS CORP.

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1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the **J 7872:** indicator to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to **Engine Mechanical Specifications (LAP, LE8)** for proper clearance.

NOTE: Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.

6. If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, replace the cylinder head.

Valve Spring Cleaning and Inspection

1. Clean the valve springs in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

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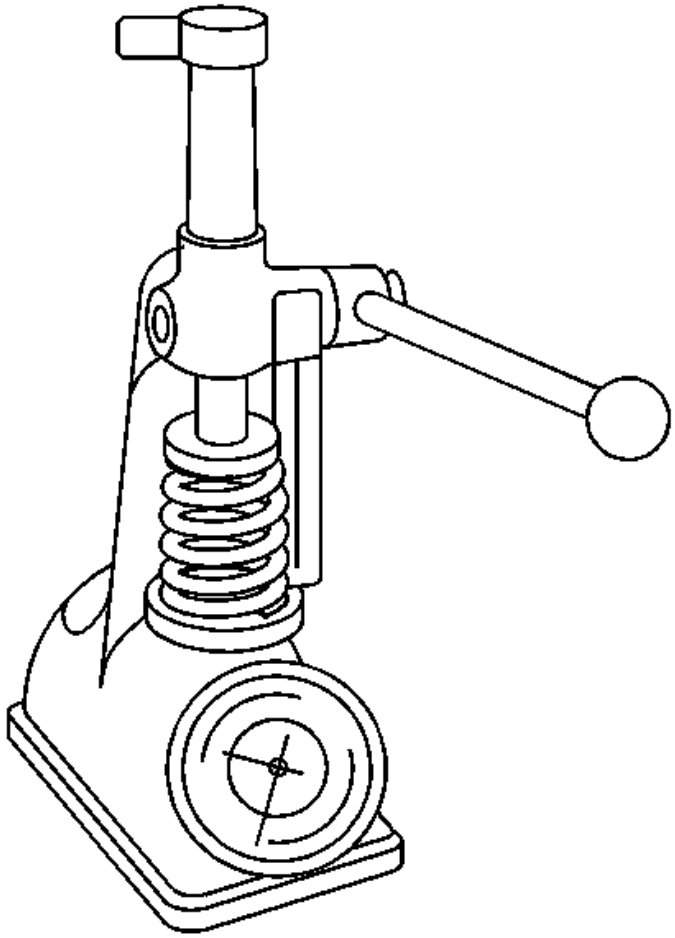

Fig. 476: View Of J 22738-B
Courtesy of GENERAL MOTORS CORP.

4. Measure the valve spring tension using the **J 22738-B:** tester. Refer to **Engine Mechanical Specifications (LAP, LE8)**
5. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

Valve Rocker Arm Cleaning and Inspection

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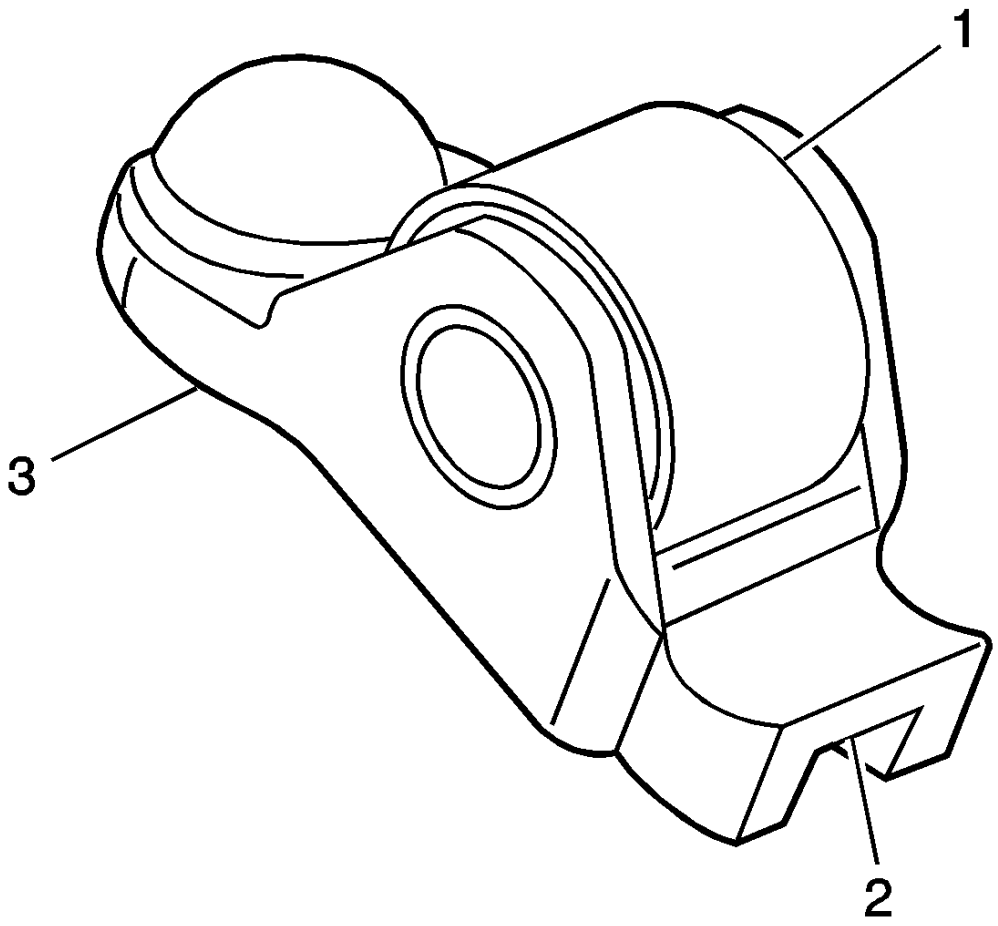

Fig. 477: Inspecting Valve Rocker Arms
Courtesy of GENERAL MOTORS CORP.

1. Inspect the camshaft follower roller (1) for the following:
   - Flat spots
   - Excessive scoring and pitting
   - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

Cylinder Head and Gasket Surface Cleaning and Inspection

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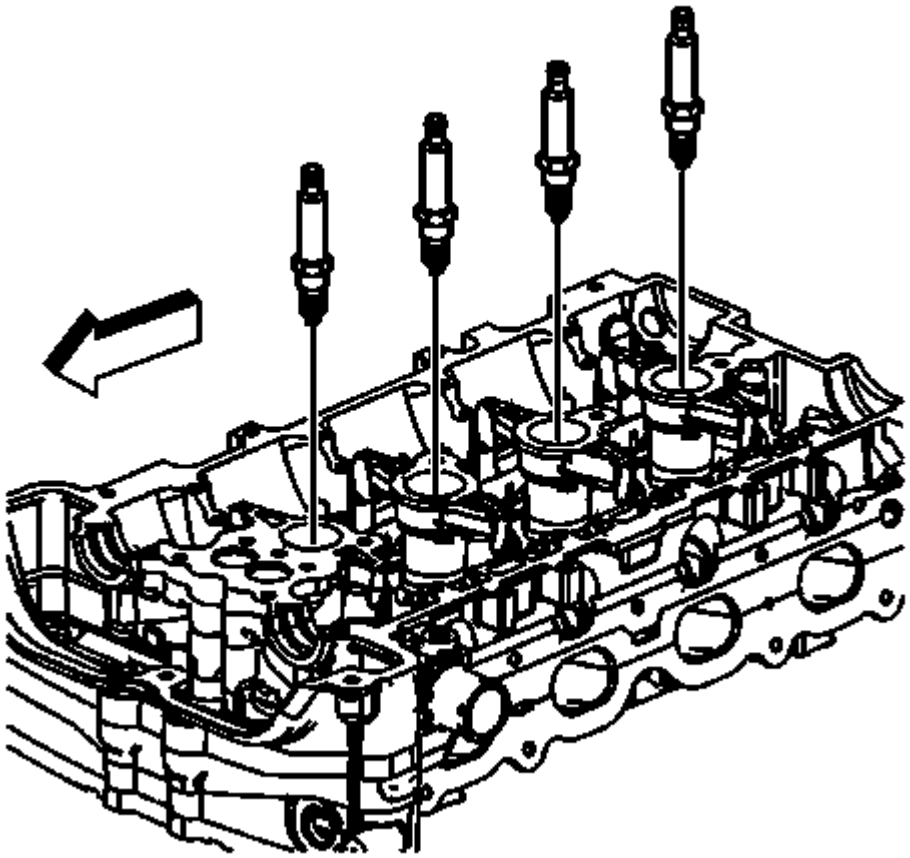

Fig. 478: Spark Plugs
Courtesy of GENERAL MOTORS CORP.

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
    6. Bolt holes in the cylinder block not drilled or tapped deep enough

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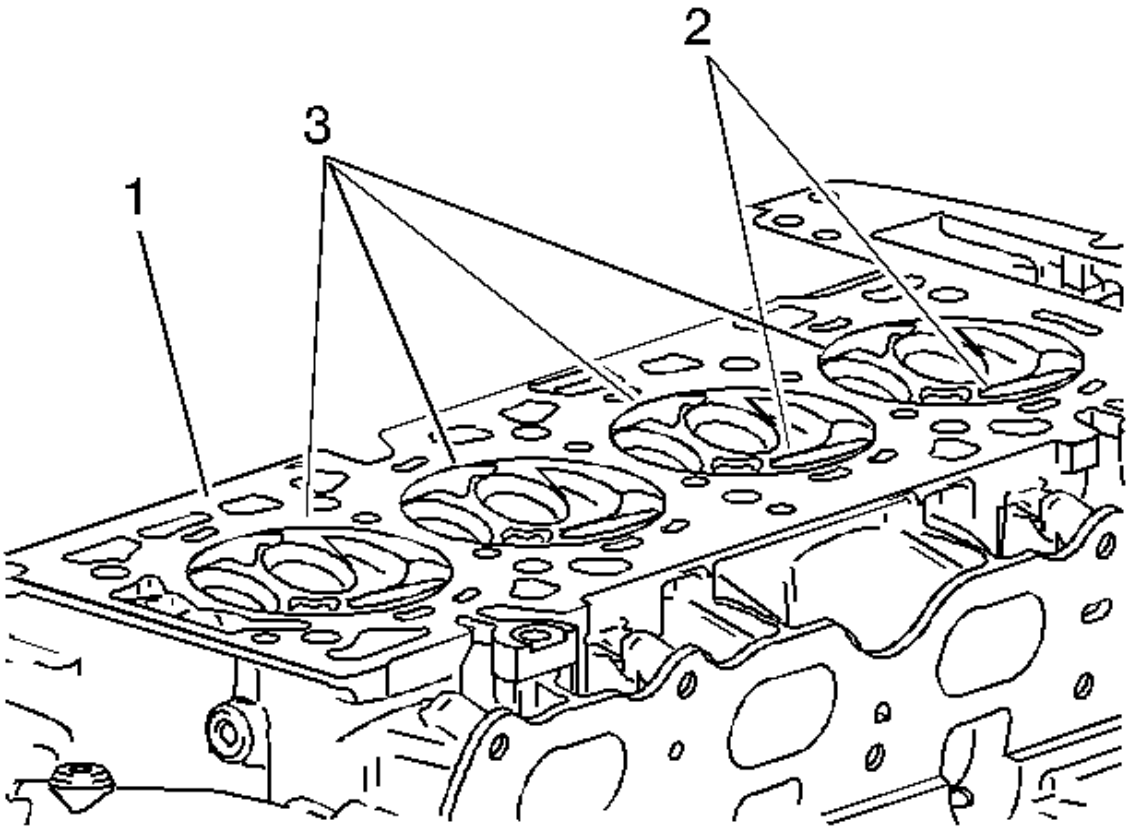

Fig. 479: Locating Combustion Chambers
Courtesy of GENERAL MOTORS CORP.

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.

NOTE: Do not use a wire brush on any gasket sealing surface.

5. Clean the cylinder head. Remove all varnish, soot and carbon to the bare metal.

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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.

NOTE: Do not attempt to weld the cylinder head, replace it.

12. Inspect the cylinder head deck for corrosion, sand inclusions and blow holes.

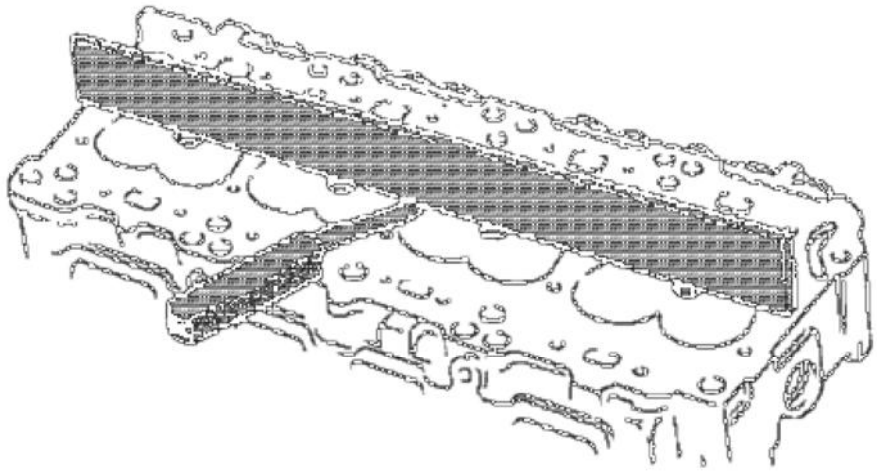

Fig. 480: Inspecting Cylinder Head Surfaces For Flatness
Courtesy of GENERAL MOTORS CORP.

13. Inspect the cylinder head deck surface for flatness. Refer to **Engine Mechanical Specifications (LAP, LE8)**. If the cylinder head is out of specification, replace the cylinder head. Do not machine the cylinder head.
14. Inspect all the threaded holes for damage. Threads may be reconditioned with thread inserts.

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15. Inspect the sealing surfaces.

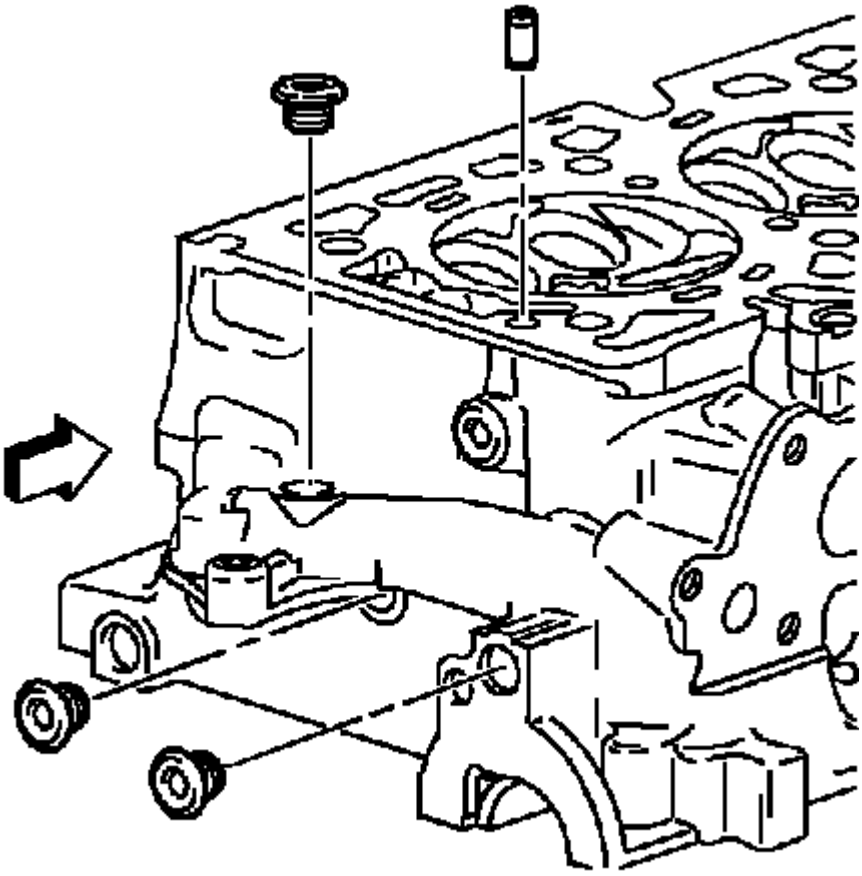

Fig. 481: View Of Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

16. Inspect the cylinder head plugs and verify the oil orifice is clear and free of debris.

VALVE AND SEAT GRINDING

Valve Measurement and Reconditioning Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- If the measurement procedures reveal that the valve or valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning.

Valve Seat Width Measurement Procedure

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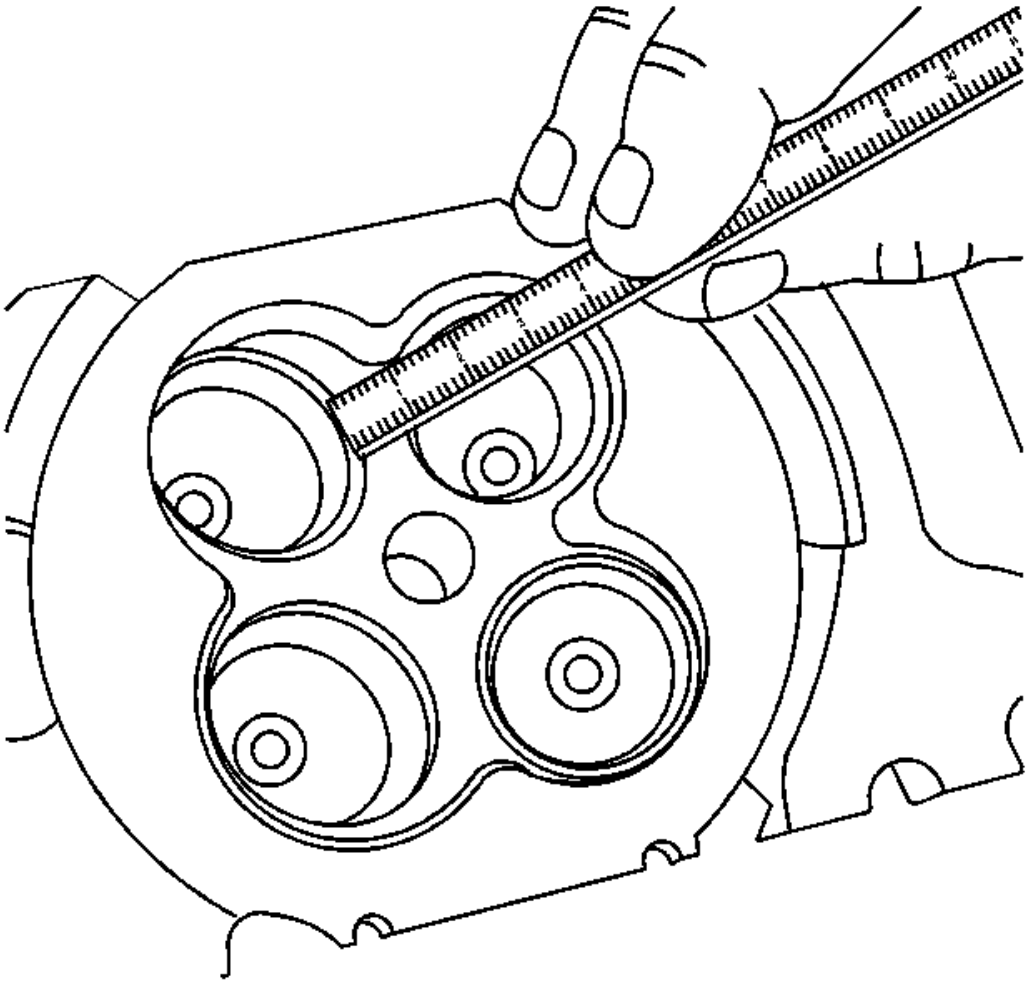

Fig. 482: Checking Valve Seat Width
Courtesy of GENERAL MOTORS CORP.

1. Measure the valve seat width in the cylinder head using a proper scale.

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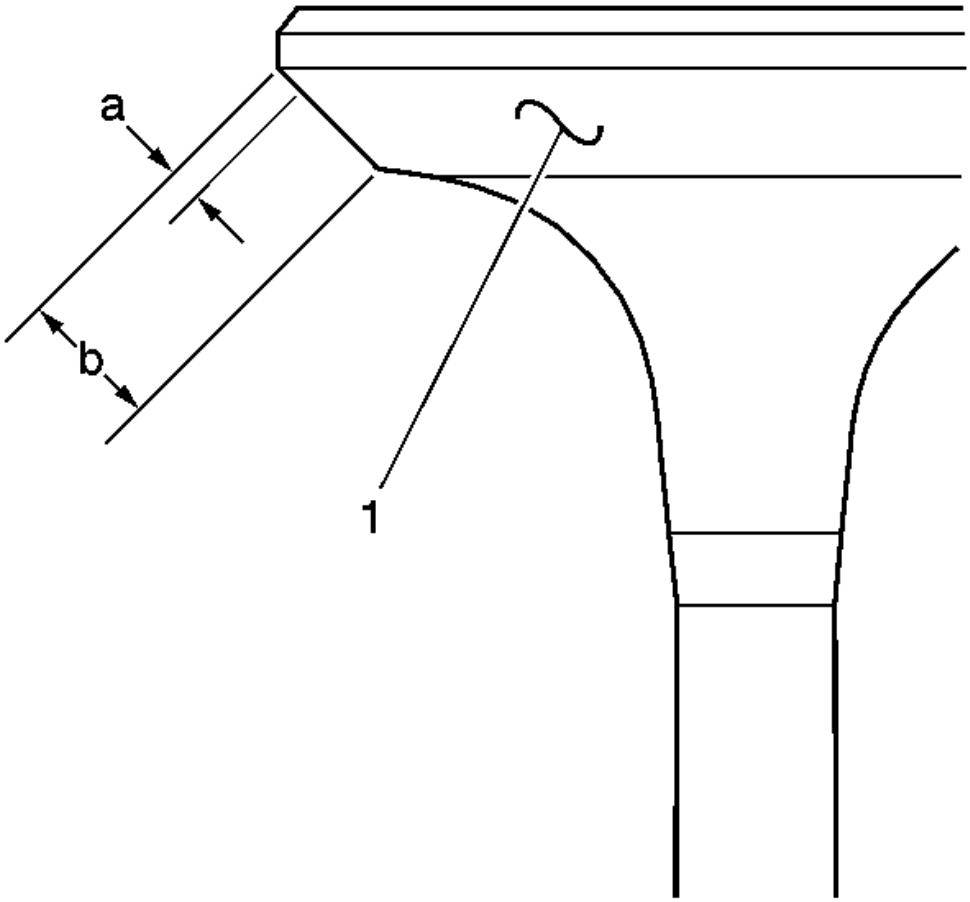

Fig. 483: Valve Face Seat Width
Courtesy of GENERAL MOTORS CORP.

2. Measure the seat width (b) on the valve face (1) using a proper scale.

NOTE: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter, margin (a), of the valve. If the contact area is too close to the margins, the seat must be reconditioned to move the contact area away from the margin.

3. Compare your measurements with the specifications listed in **Engine Mechanical Specifications (LAP, LE8)**.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must grind the valve seat using the Valve and Seat Reconditioning Procedure to bring the width back into specification. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

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Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

CAUTION: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.

2. Compare your measurements with the specifications listed in **Engine Mechanical Specifications (LAP, LE8)**.
3. If the valve seat exceeds the roundness specification, you must grind the valve and valve seat using the Valve and Seat Reconditioning Procedure.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Head O.D. and Chamfer Measurement Procedure

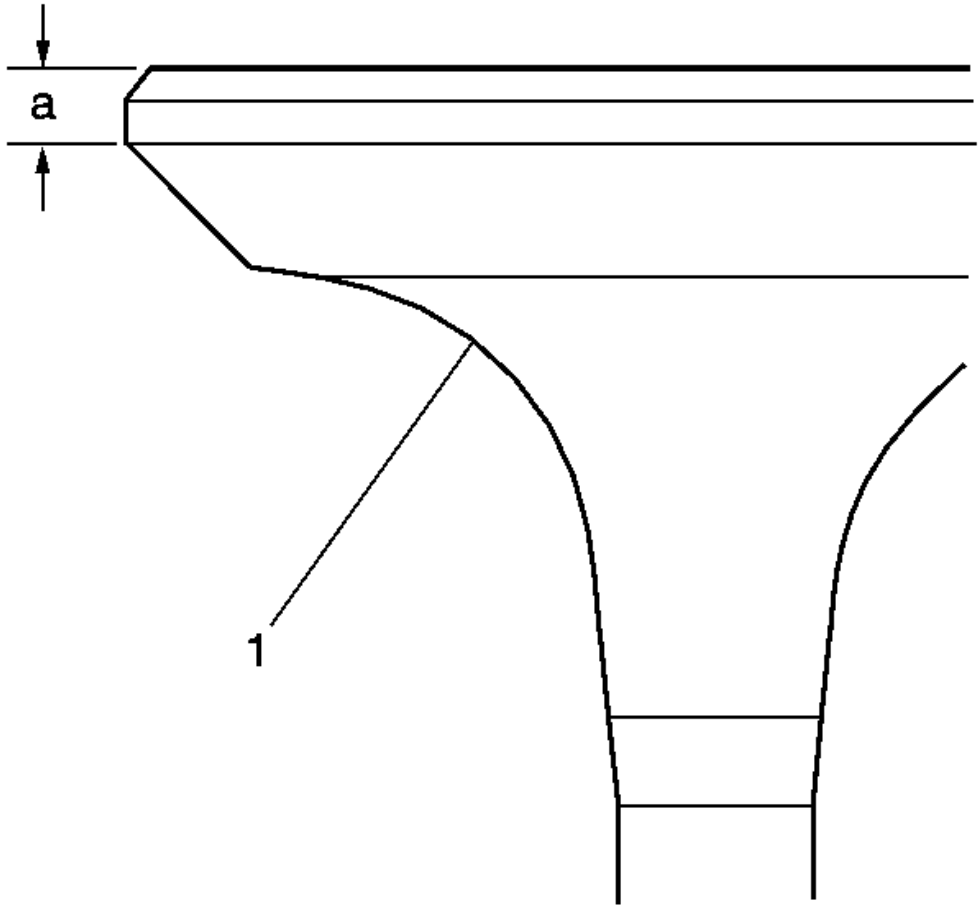

Fig. 484: Valve Head O.D. & Chamfer
Courtesy of GENERAL MOTORS CORP.

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1. Measure the valve head O.D. and chamfer (a) using an appropriate scale. Refer to **Engine Mechanical Specifications (LAP, LE8)**.
2. If the valve head O.D. and chamfer is within specification, test the valve (1) for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure. Reinspect the valve head O.D. and chamfer after completing the concentricity measurement if valve seat reconditioning is performed.

Valve-to-Seat Concentricity Measurement Procedure

NOTE:

- **Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.**
- **You must measure the valve face and the valve seat to ensure proper valve sealing.**

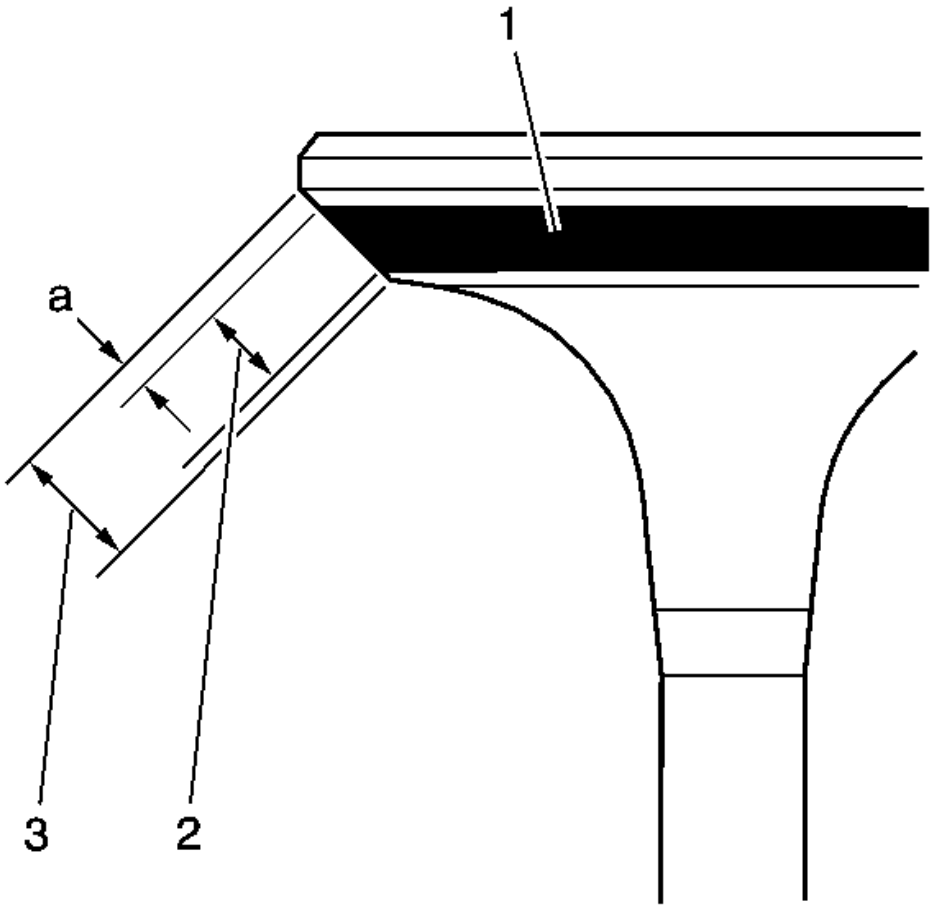

Fig. 485: Inspecting Valve Face
Courtesy of GENERAL MOTORS CORP.

1. Coat the valve face (3) lightly with blue dye (1).
2. Install the valve in the cylinder head.

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3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.
    - If the valve face is concentric, providing a proper seal, with the valve stem, a continuous mark (2) will be made around the entire face.

NOTE: The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin (a), of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

NOTE: Do not grind or condition the intake valve. If the intake valve is out of specification, replace the valve.

    - If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be refaced or replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure

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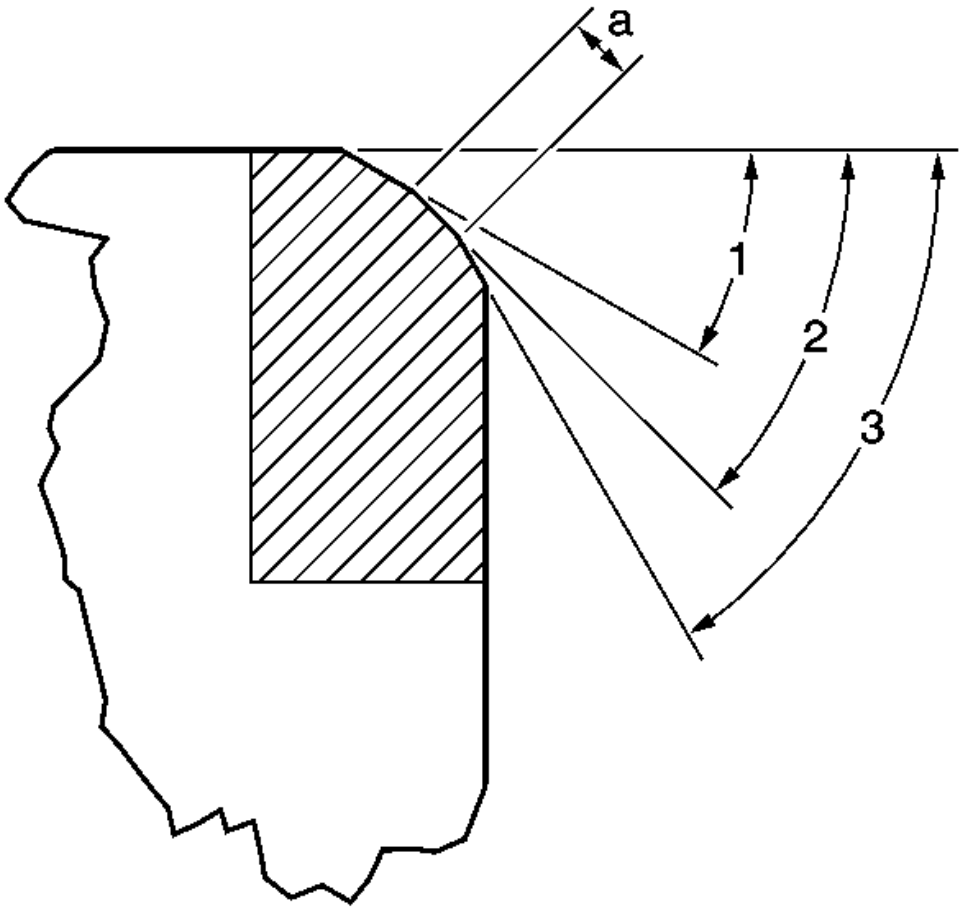

Fig. 486: Valve Seating Surface
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the build up of carbon on the seats.**
- **It is necessary to reface the valve if seat reconditioning is required unless a new valve is used.**

1. Grind the valve seating surface (a) to the proper angle specification (2) listed in **Engine Mechanical Specifications (LAP, LE8)**.
2. Grind the valve relief surface to the proper angle specification (1) listed in **Engine Mechanical Specifications (LAP, LE8)**, to correctly position the valve seating surface (a) to the valve.
3. Grind the valve undercut surface to the proper angle specification (3) listed in **Engine Mechanical Specifications (LAP, LE8)**, to narrow the valve seating surface width (a) to the specifications listed in**Engine Mechanical Specifications (LAP, LE8)**.

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NOTE: Do not grind or condition the intake valve. If the intake valve seat has been reconditioned, replace the corresponding intake valve.

4. Replace the intake valve if it is out of specification. Refer to **Engine Mechanical Specifications (LAP, LE8)**.
5. If the original exhaust valve is being used, grind the valve to the specifications listed in **Engine Mechanical Specifications (LAP, LE8)**. Measure the valve head O.D. and chamfer again after grinding using the Valve Head O.D. and Chamfer Measurement Procedure. Replace the exhaust valve if it is out of specification. New valves do not require grinding.
6. When grinding the valves and seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
7. Install the valve in the cylinder head.
   - If you are using refaced exhaust valves, lap the valves into the seats with a fine grinding compound. The refacing and reseating operations should leave the refinished surfaces smooth and true so that minimal lapping is required. Excessive lapping will groove the valve face and prevent a good seat when hot.
   - Be sure to clean any remaining lapping compound from the valve and seat with solvent and compressed air prior to final assembly.
8. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
9. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

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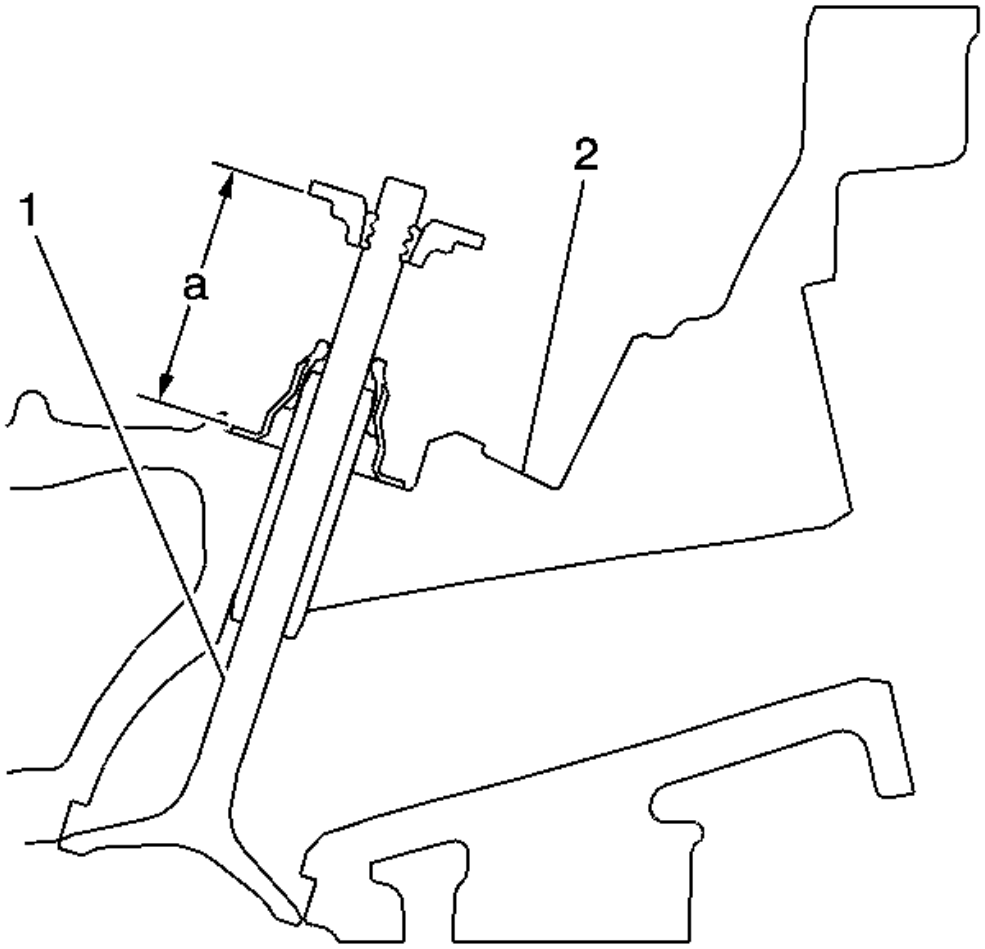

Fig. 487: Valve Stem Height Measurement
Courtesy of GENERAL MOTORS CORP.

NOTE: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve (1) into the valve guide in the cylinder head (2).
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (a) between the valve seal lip to the bottom of the valve spring retainer. Refer to **Engine Mechanical Specifications (LAP, LE8)**.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

CAUTION: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing

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premature wear and possible engine damage.

CAUTION: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.

7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

CYLINDER HEAD ASSEMBLE

Special Tools

- **EN-8062:** Valve Spring Compressor
- **EN-9666:** Valve Spring Tester
- **EN-43963:** Valve Spring Compressor (off car)

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

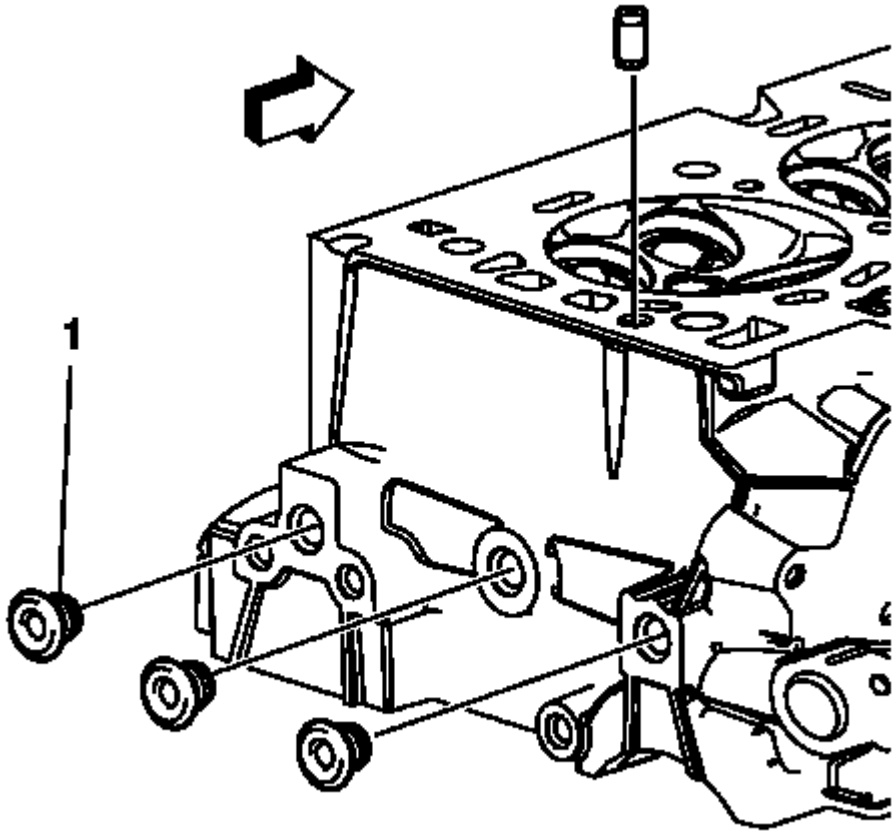

Fig. 488: Identifying Cylinder Head Plugs
Courtesy of GENERAL MOTORS CORP.

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CAUTION: 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 (1). Coat the plugs with sealer. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Inspect the valve springs for the following conditions:
   - Expanded height
   - Unparallel spring ends
   - Spring tension using **EN-9666:** tester
   - Any distorted springs should be replaced

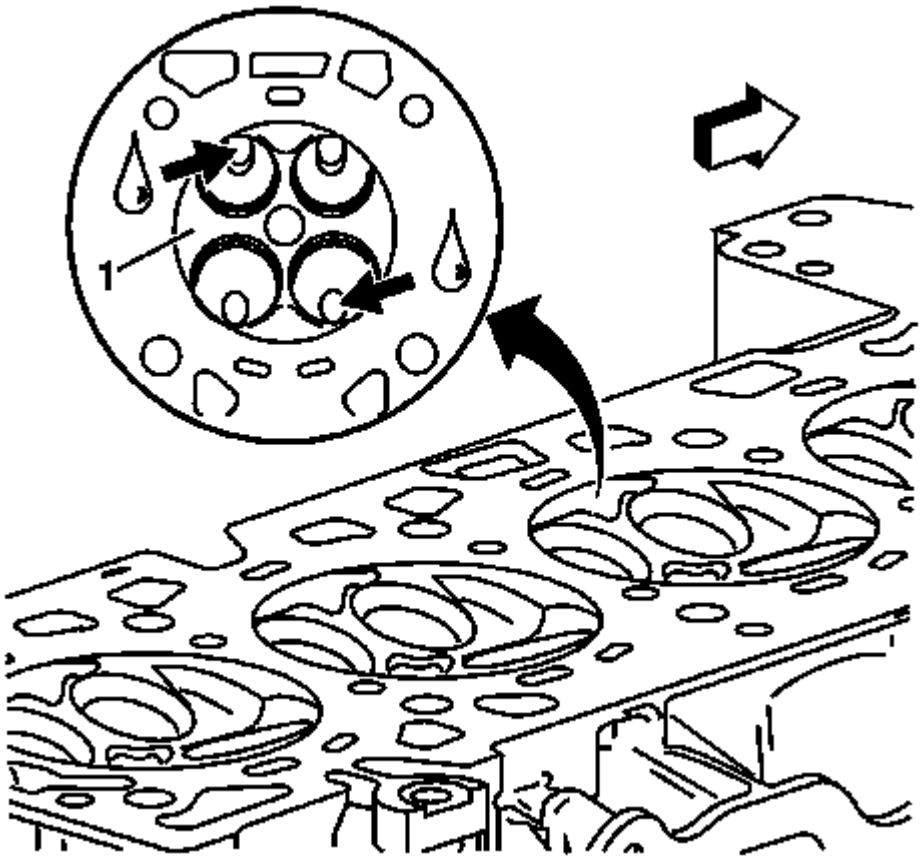

Fig. 489: View of Valve Runout
Courtesy of GENERAL MOTORS CORP.

3. Inspect the valves and the valve seats. Refer to **Valve and Seat Grinding**.

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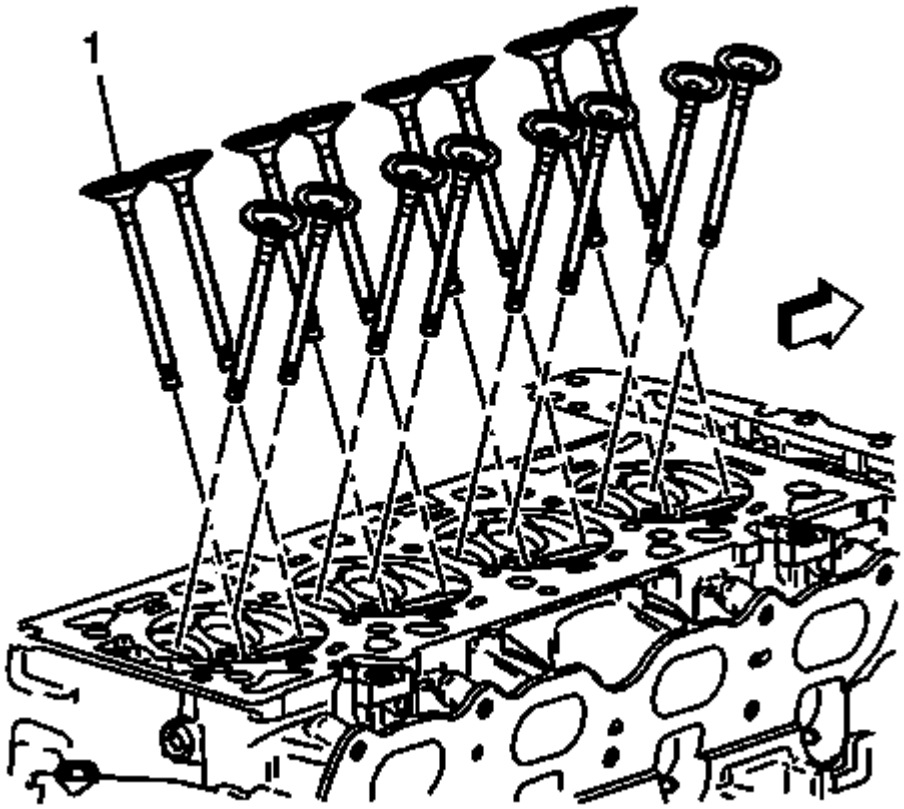

Fig. 490: View of Valves
Courtesy of GENERAL MOTORS CORP.

4. Install the valves (1). Replace any valves, if required.

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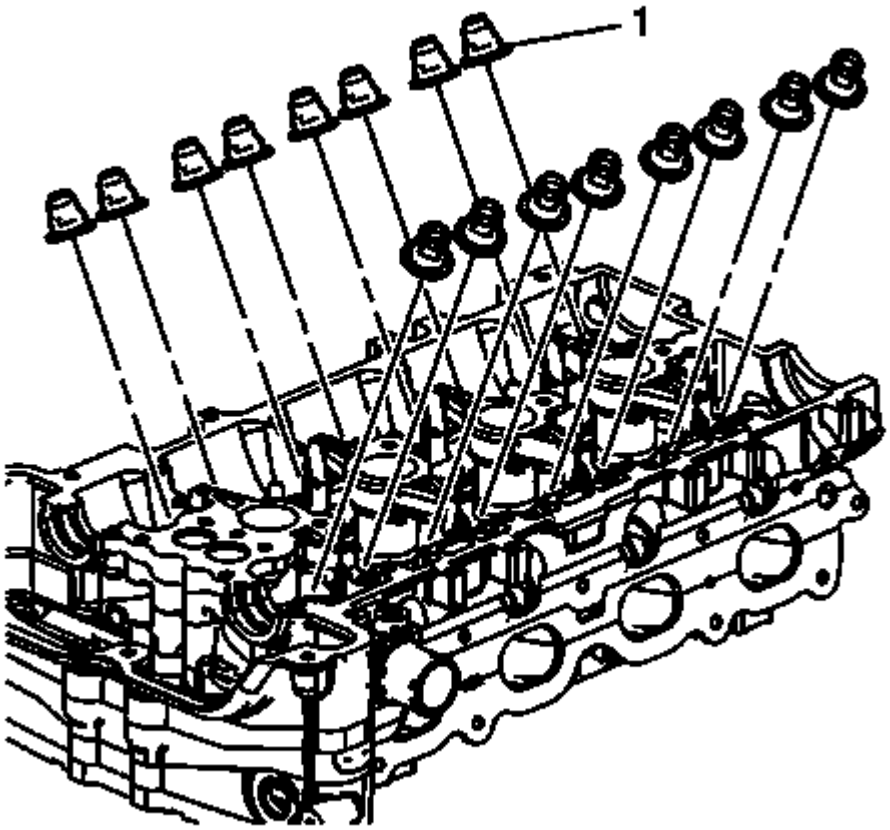

Fig. 491: View of Valve Seals
Courtesy of GENERAL MOTORS CORP.

NOTE: Always use NEW valve stem oil seals when assembling the cylinder head.

5. Install the new valve seals (1). Fully seat the seals on the valve guides.

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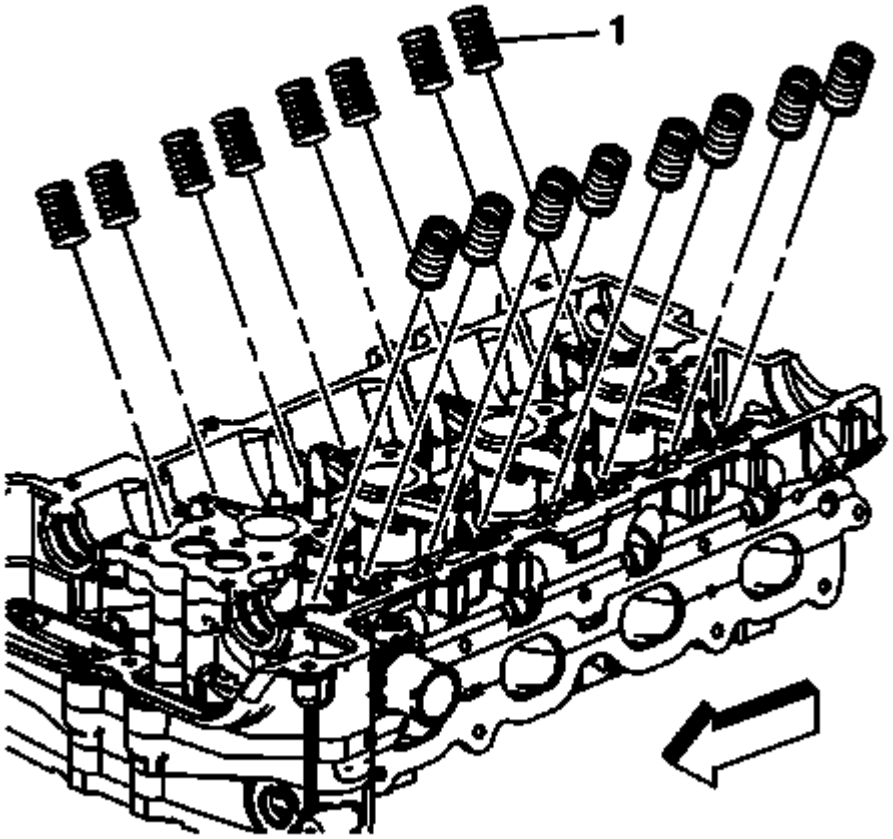

Fig. 492: View of Valve Springs
Courtesy of GENERAL MOTORS CORP.

6. Install the springs (1).

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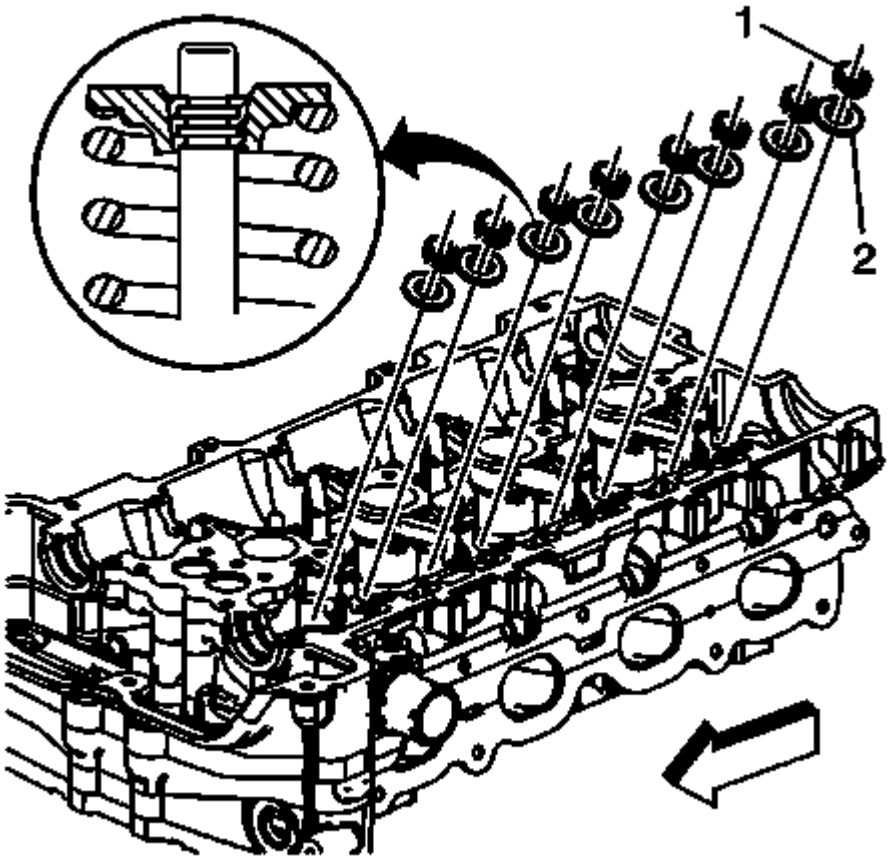

Fig. 493: View of Valve Keys and Retainer
Courtesy of GENERAL MOTORS CORP.

WARNING: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

CAUTION: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

7. Install the retainers (1).
8. Using the **EN-8062:** compressor and the **EN-43963:** compressor (off car), compress the valve spring.
9. Install the valve keys.
10. Slowly release the **EN-8062:** compressor and the **EN-43963:** compressor (off car) from the valve/spring

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assembly.

11. Inspect for proper valve key seating.
12. Install the remaining valves, springs, and other components.

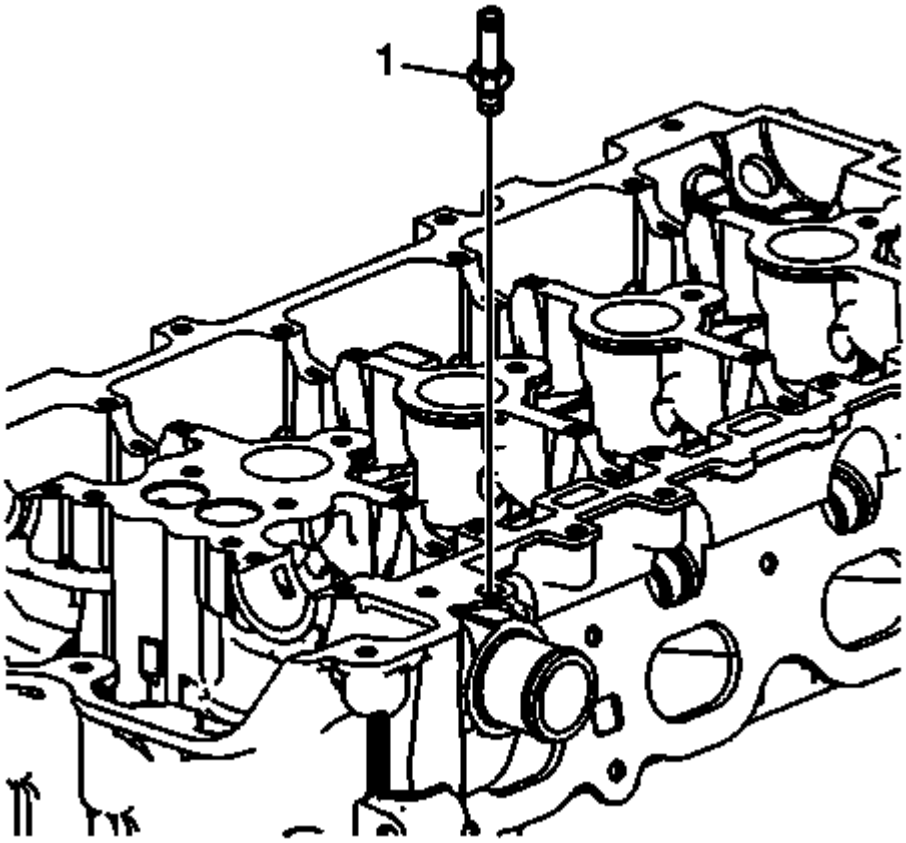

Fig. 494: Identifying the Coolant Air Bleed Hose Fitting
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

13. Install the cylinder head air bleed tube (1) and tighten the tube to 15 N.m (11 lb ft).

OIL PUMP DISASSEMBLE

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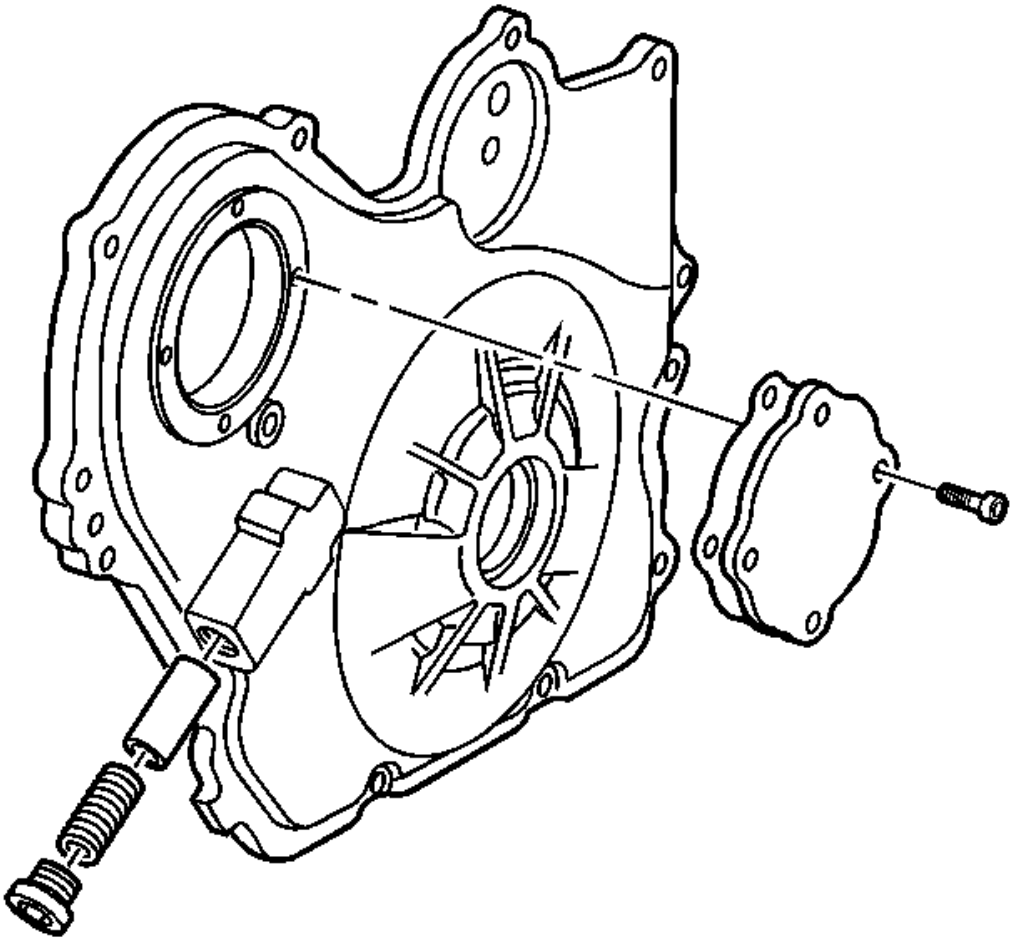

Fig. 495: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

1. Disassemble the pressure relief valve.

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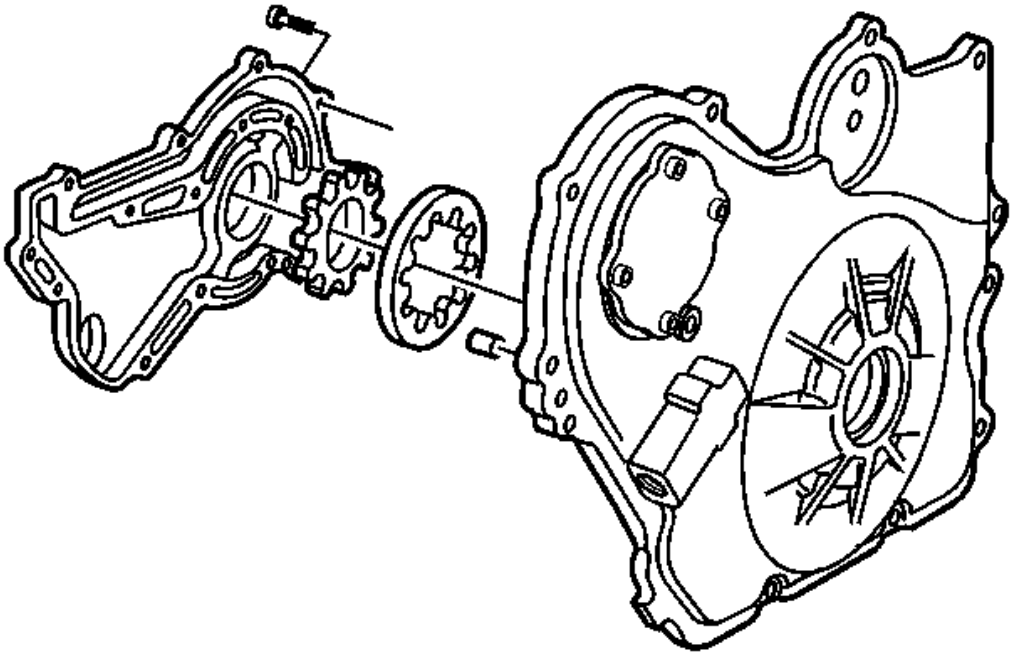

Fig. 496: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

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 (LAP, LE8)**.

   Replace the front cover and oil pump assembly if it is out of specification or damaged.

OIL PUMP ASSEMBLE

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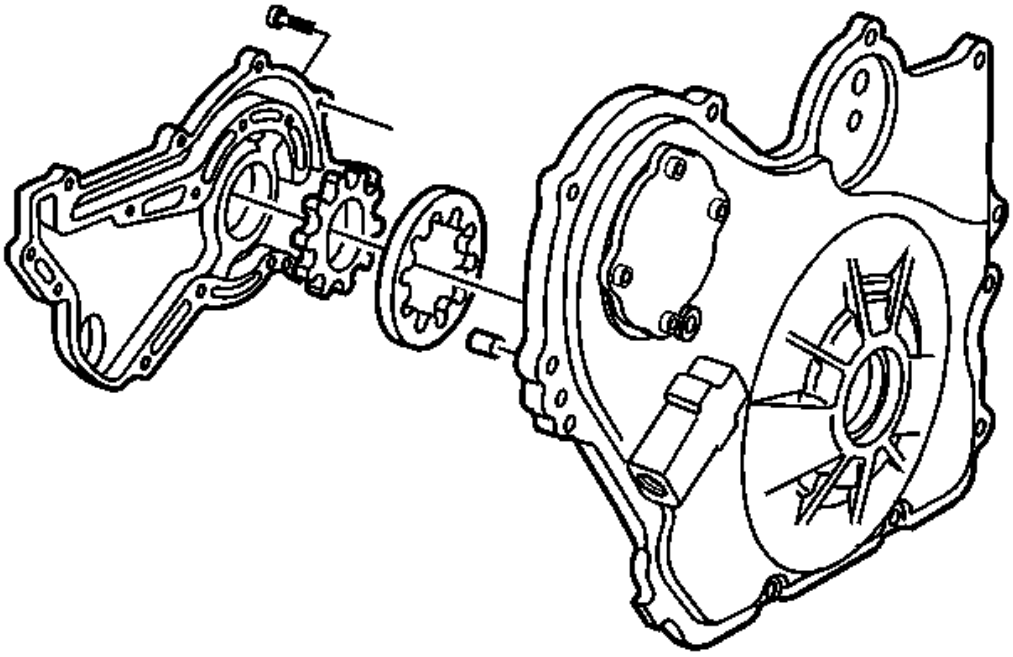

Fig. 497: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Lubricate all oil pump parts with engine oil.
2. Install the inner gear into the outer gear.

NOTE: 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.

CAUTION: Refer to Fastener Caution .

4. Install the oil pump gerotor cover and bolts and tighten to 6 N.m (53 lb in).

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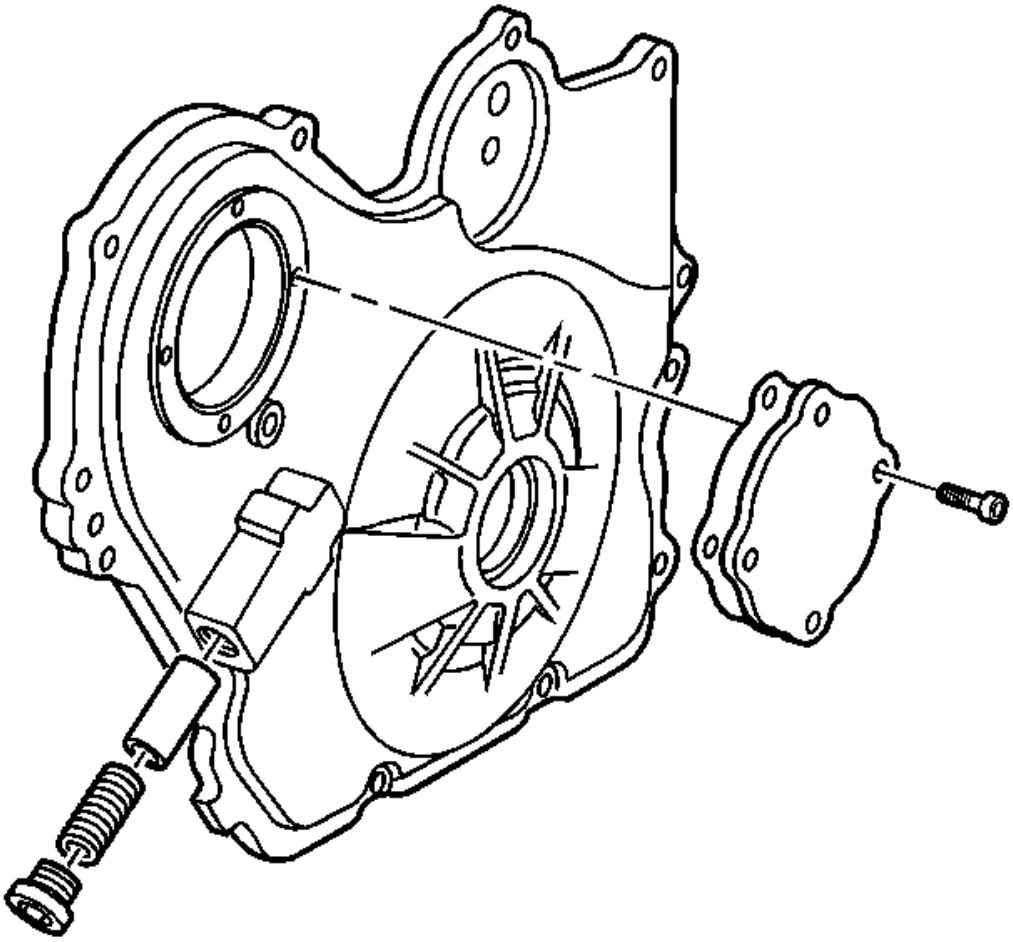

Fig. 498: View Of Pressure Relief Valve
Courtesy of GENERAL MOTORS CORP.

5. Install the pressure relief valve piston.
6. Install the pressure relief valve spring.
7. Install and tighten the pressure relief valve plug to 40 N.m (30 lb ft).

INTAKE MANIFOLD CLEANING AND INSPECTION

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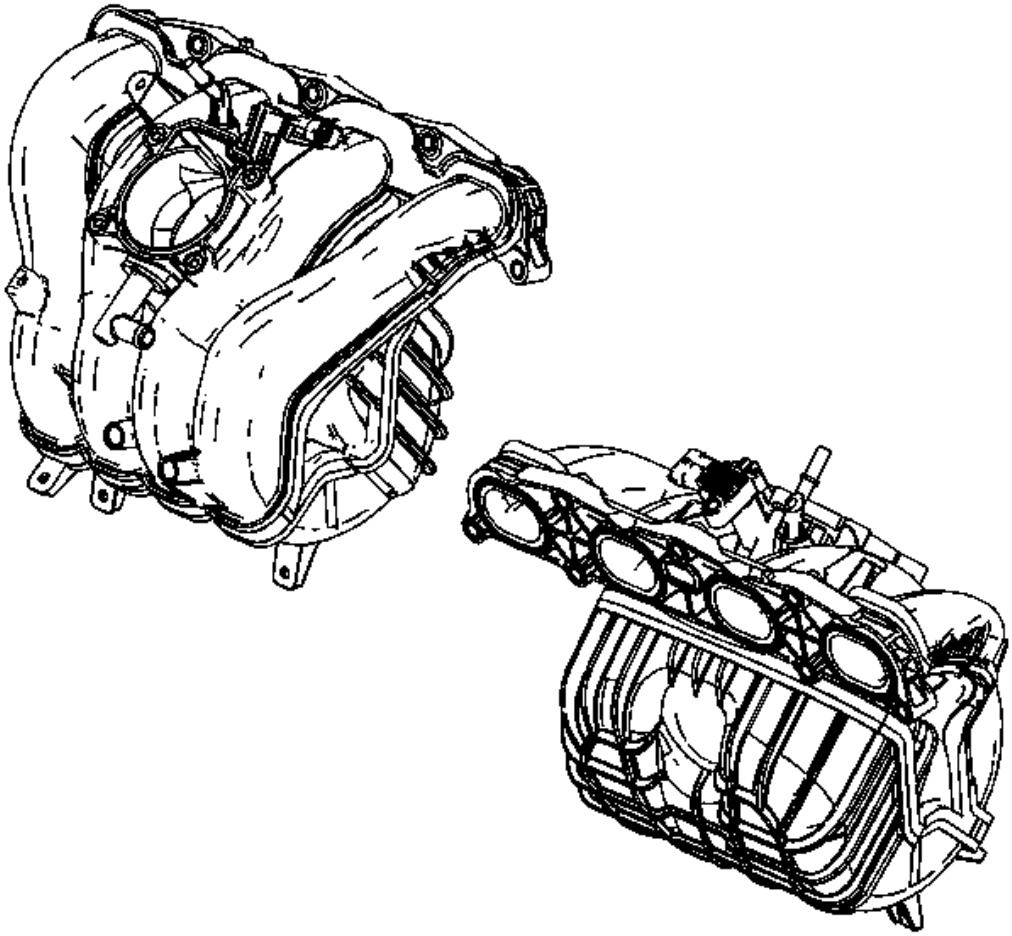

Fig. 499: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

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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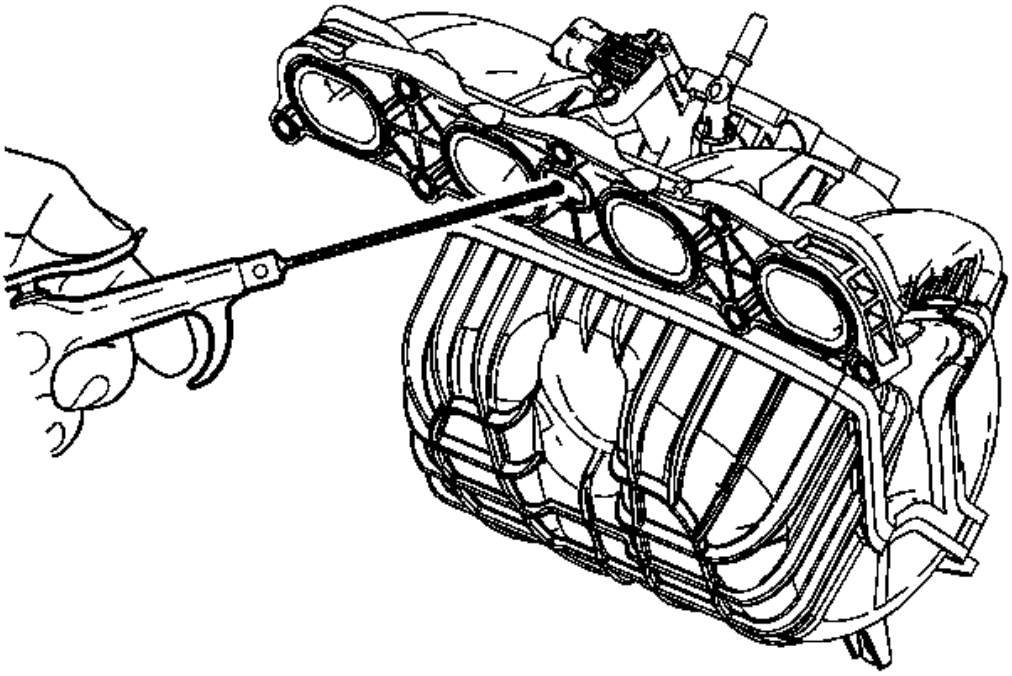

Fig. 500: Cleaning Crankcase Ventilation Passages With Compressed Air
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses Warning .

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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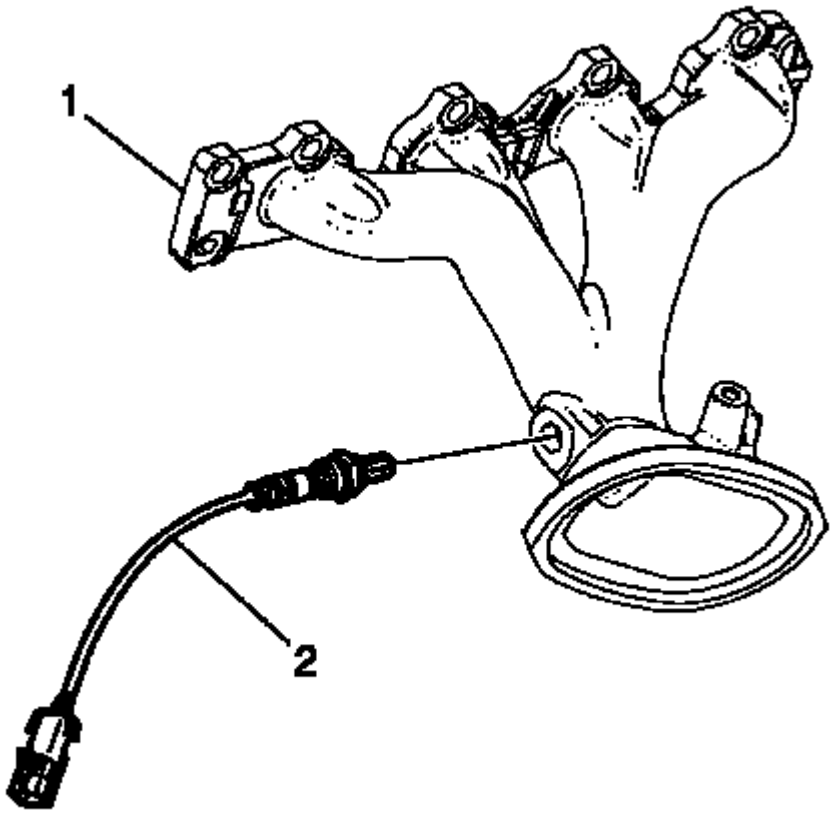

Fig. 501: View of Exhaust Manifold and Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **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 (2) from the manifold.
2. Clean the exhaust manifold (1) in solvent.

WARNING: Refer to Safety Glasses Warning .

3. Dry the exhaust manifold with compressed air.
4. Inspect the heat shield for damage.

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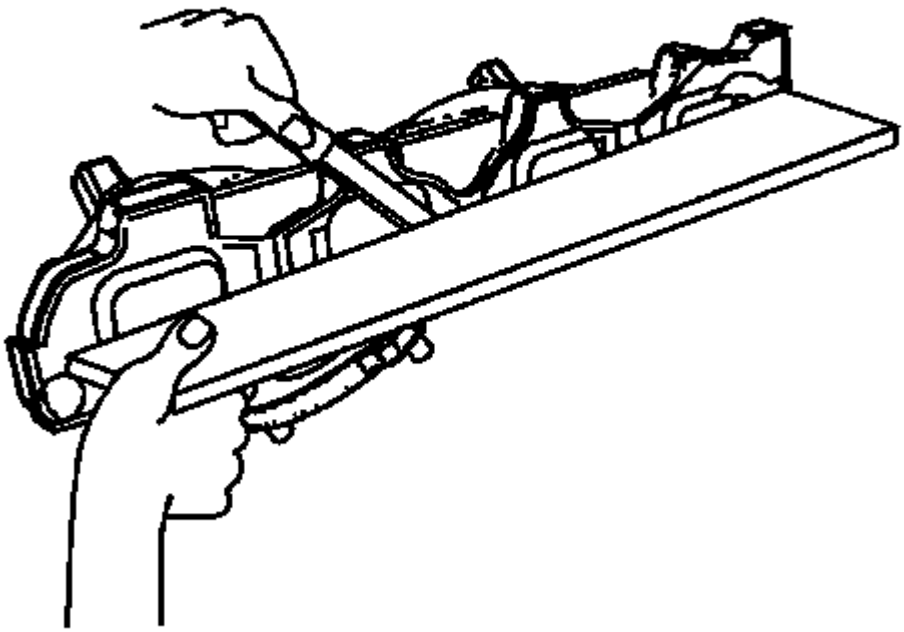

Fig. 502: Checking Exhaust Manifold Mounting Face For Warpage
Courtesy of GENERAL MOTORS CORP.

5. Use a straight edge and a feeler gauge 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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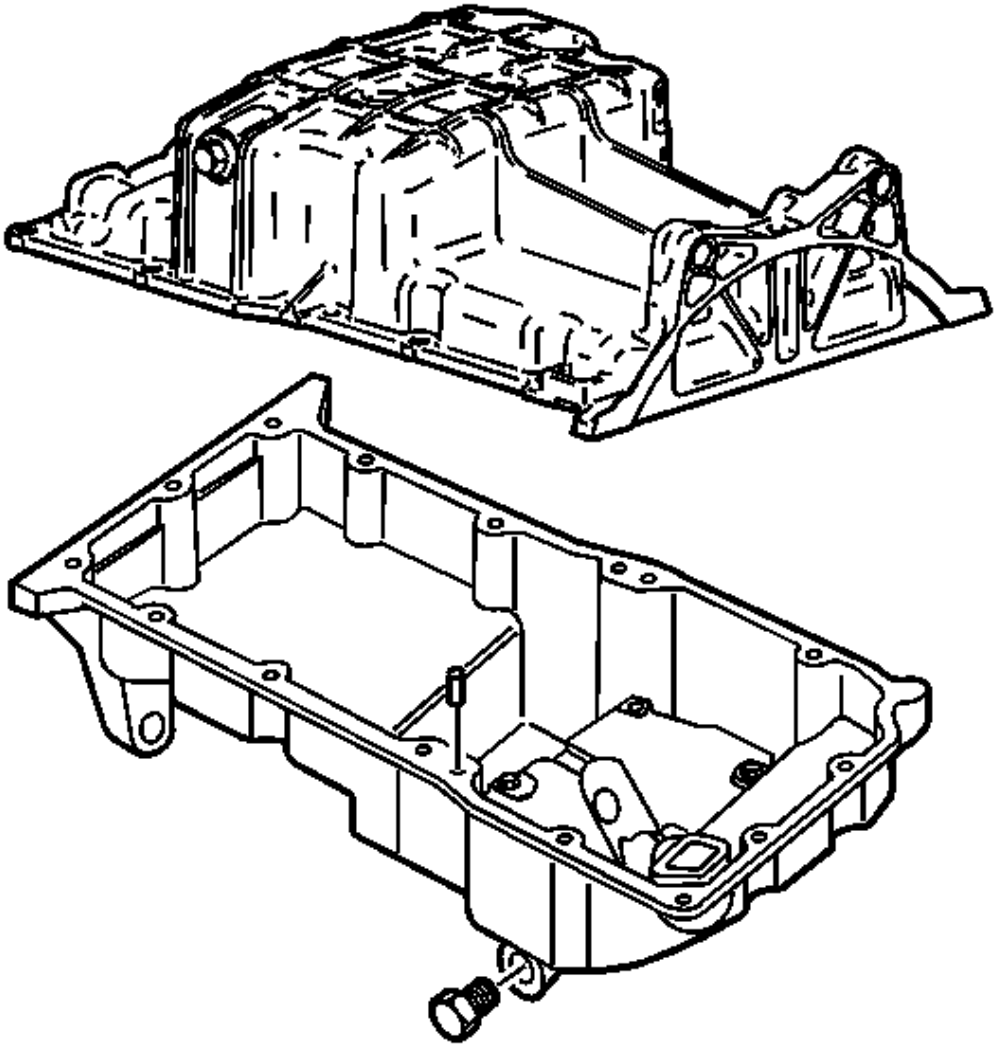

Fig. 503: Inspecting Oil Pan
Courtesy of GENERAL MOTORS CORP.

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

Special Tools

J 42385-850: Thread Repair Kit

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

General Thread Repair

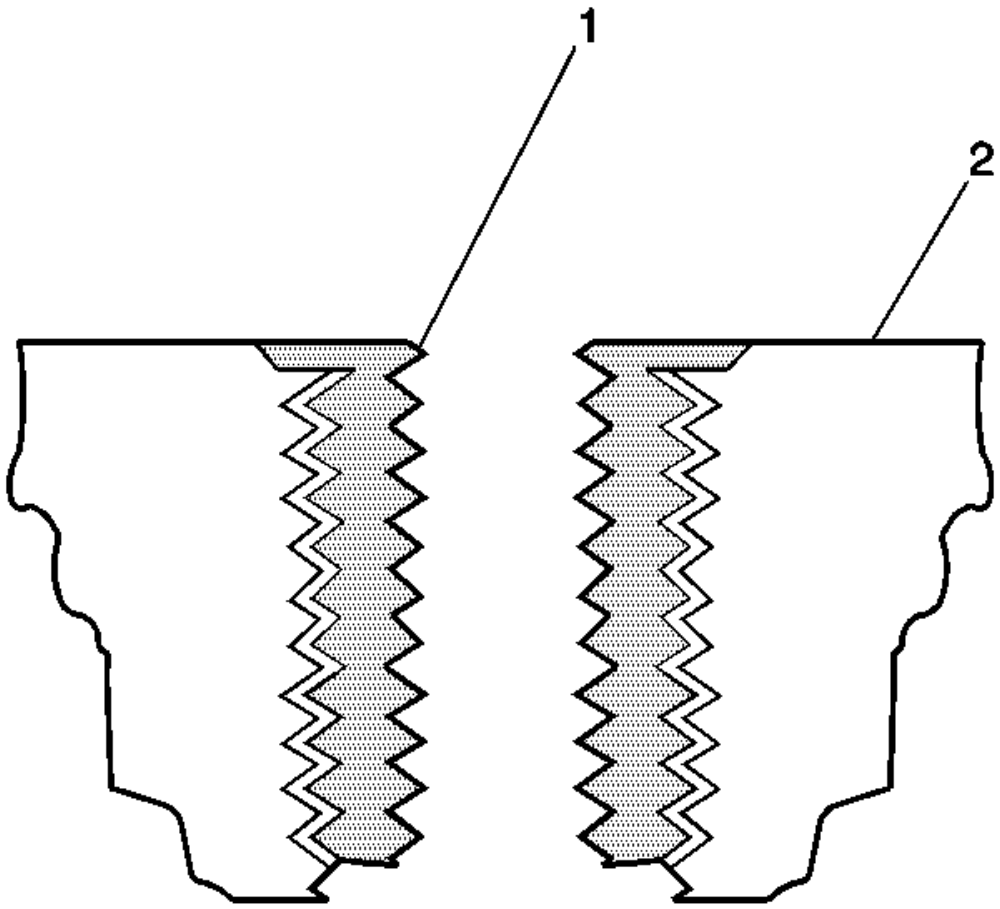

Fig. 504: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

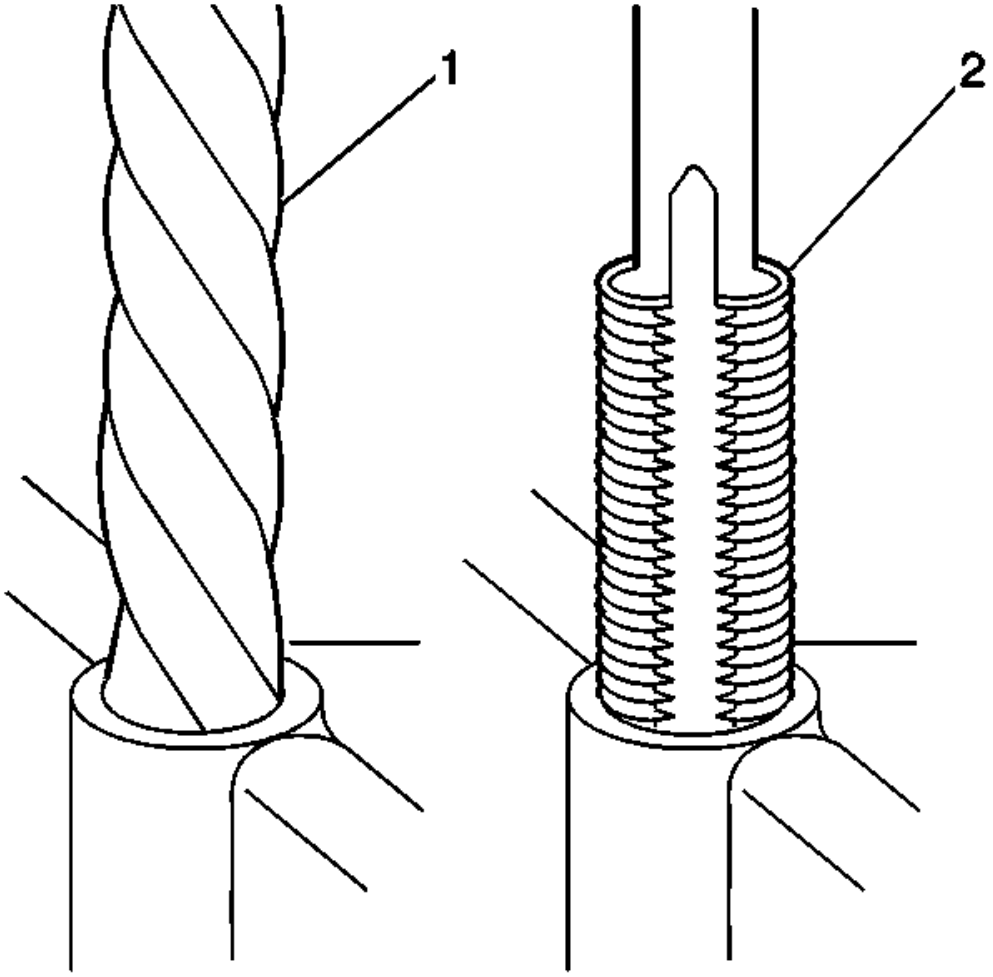

Fig. 505: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

NOTE: The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling, counterboring, and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.
Driver oil MUST be used on the installer driver tool.
The tool kits are designed for use with either a suitable tap wrench or drill motor.

1. Drill out the threads of the damaged hole (1).
    - M6 inserts require a minimum drill depth of 15 mm (0.59 in).

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- M8 inserts require a minimum drill depth of 20 mm (0.79 in).
- M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Using compressed air, clean out any chips.

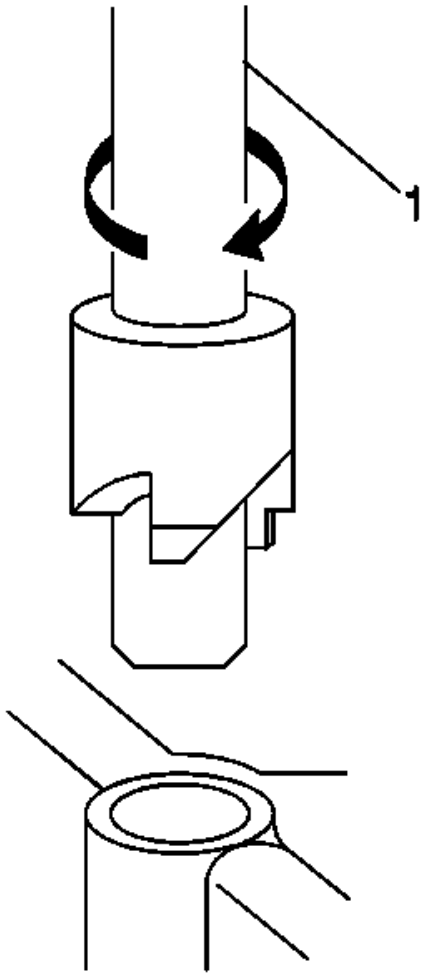

Fig. 506: View Of Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

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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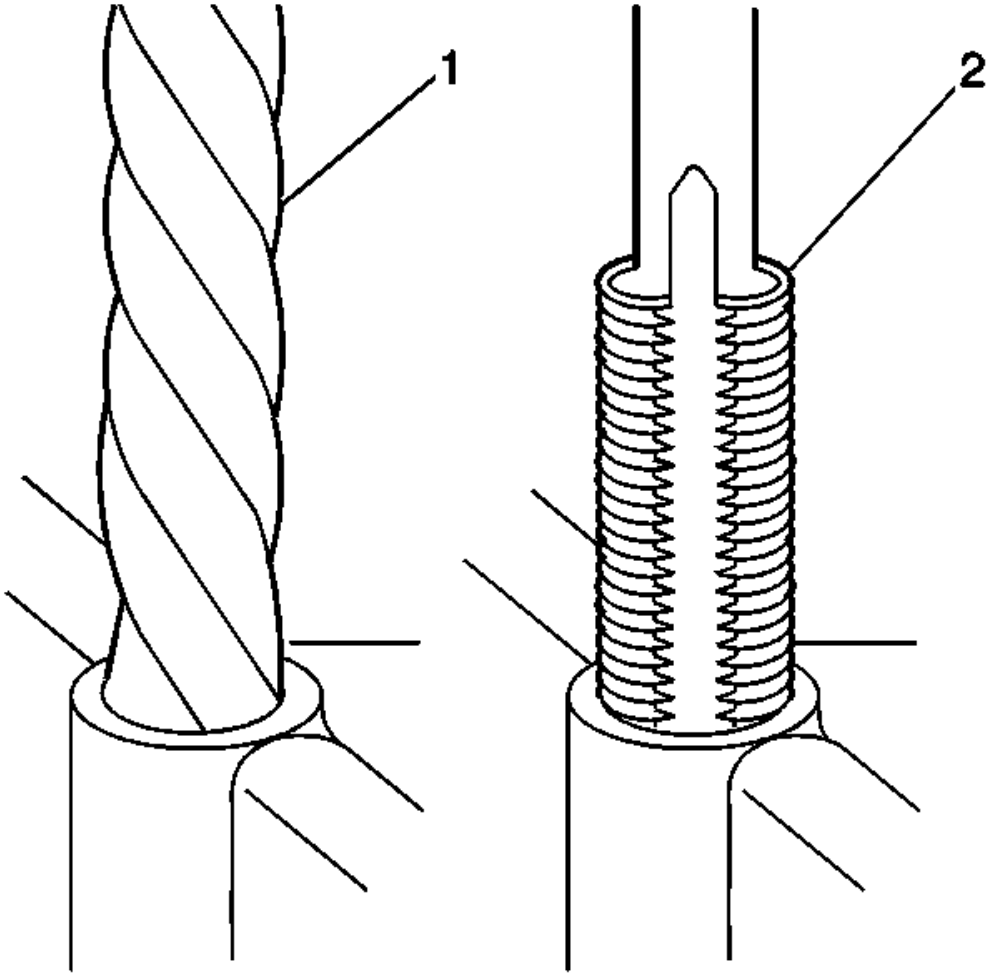

Fig. 507: Drilling & Tapping Threads
Courtesy of GENERAL MOTORS CORP.

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).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

6. Using compressed air, clean out any chips.

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7. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
8. Using compressed air, clean any cutting oil and chips out of the hole.

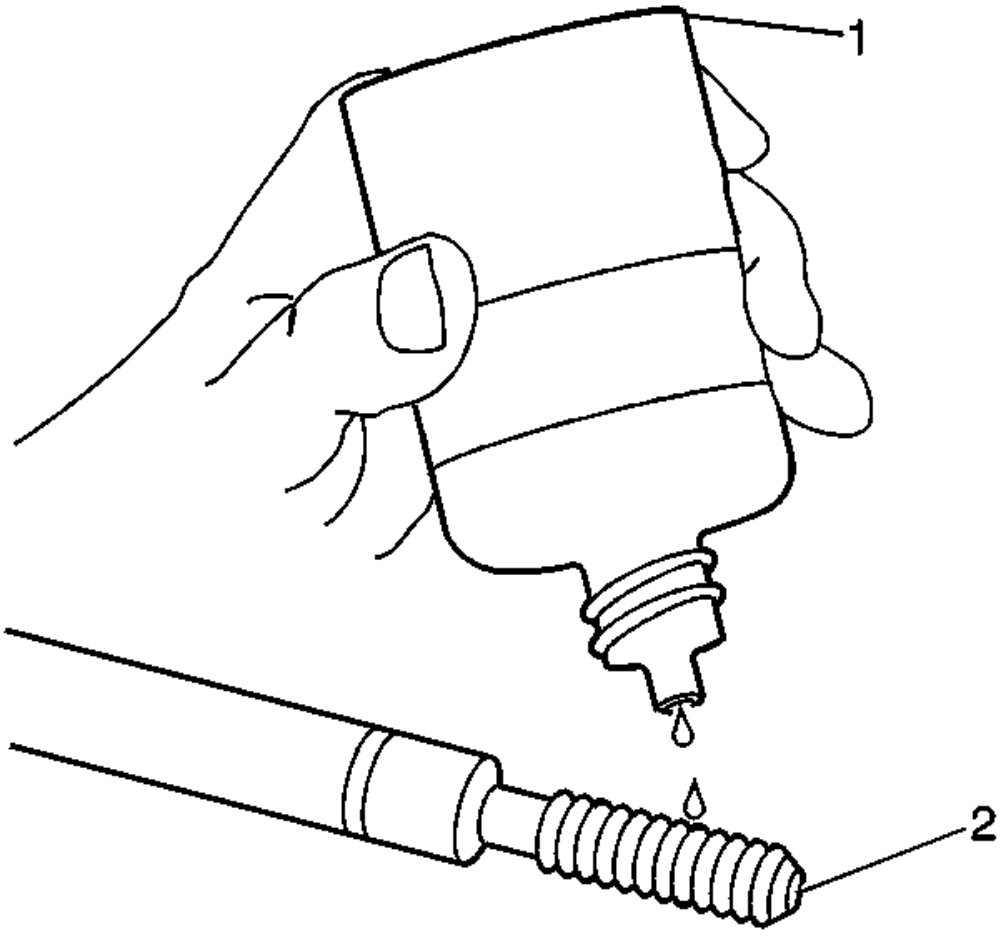

Fig. 508: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

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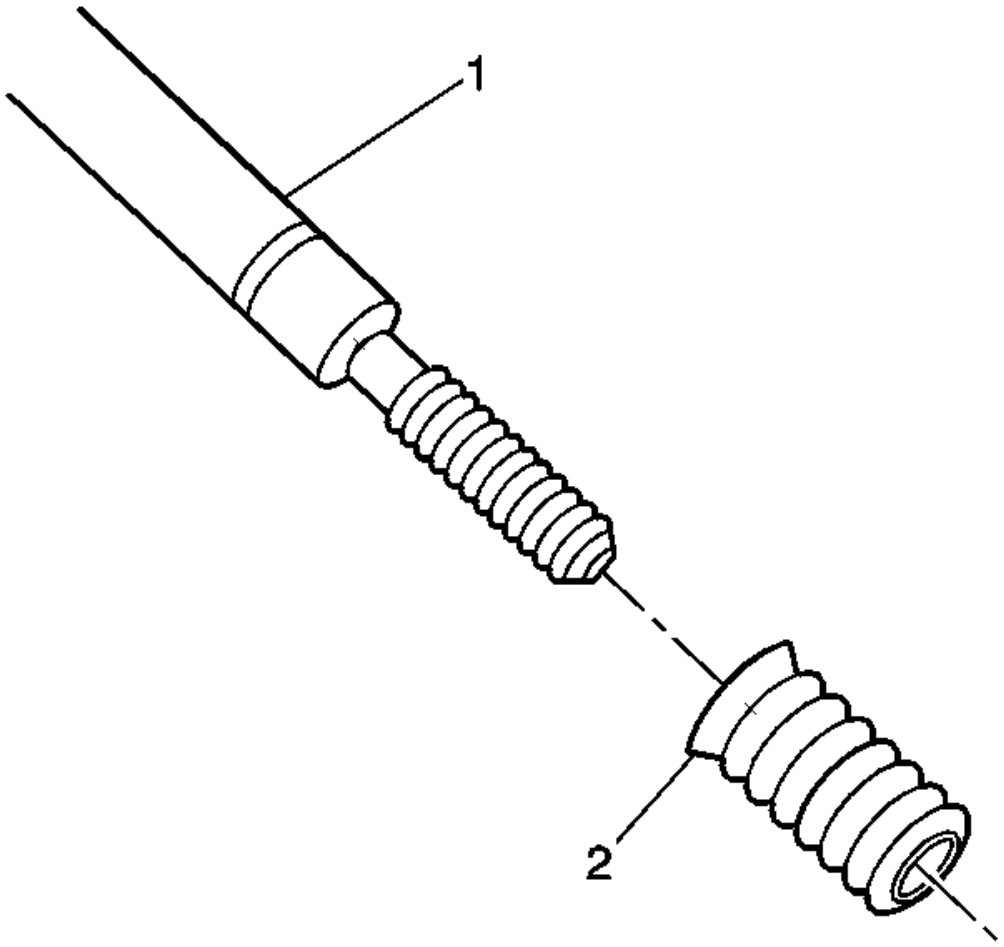

Fig. 509: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

10. Install the insert (2) onto the driver tool (1).

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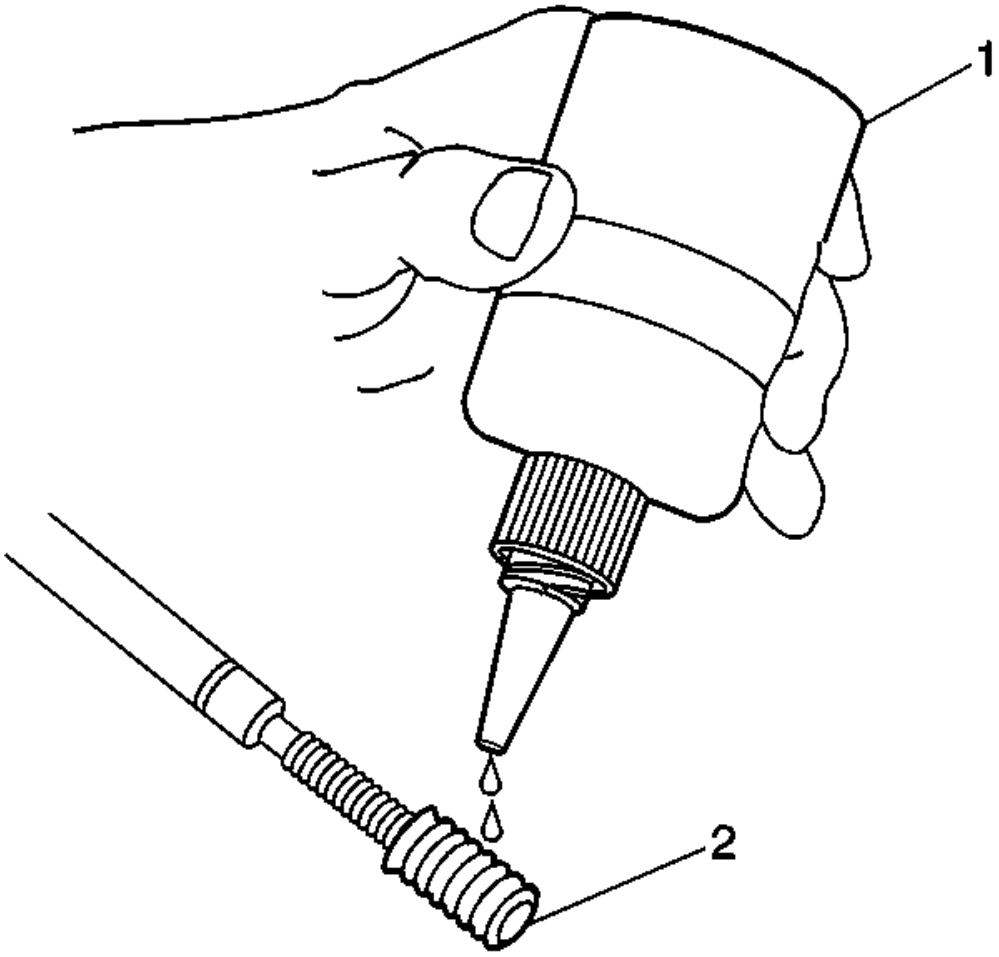

Fig. 510: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

11. Apply threadlock LOCTITE™ 277, **J 42385-109 (1):** loctite, or equivalent to the insert OD threads (2).

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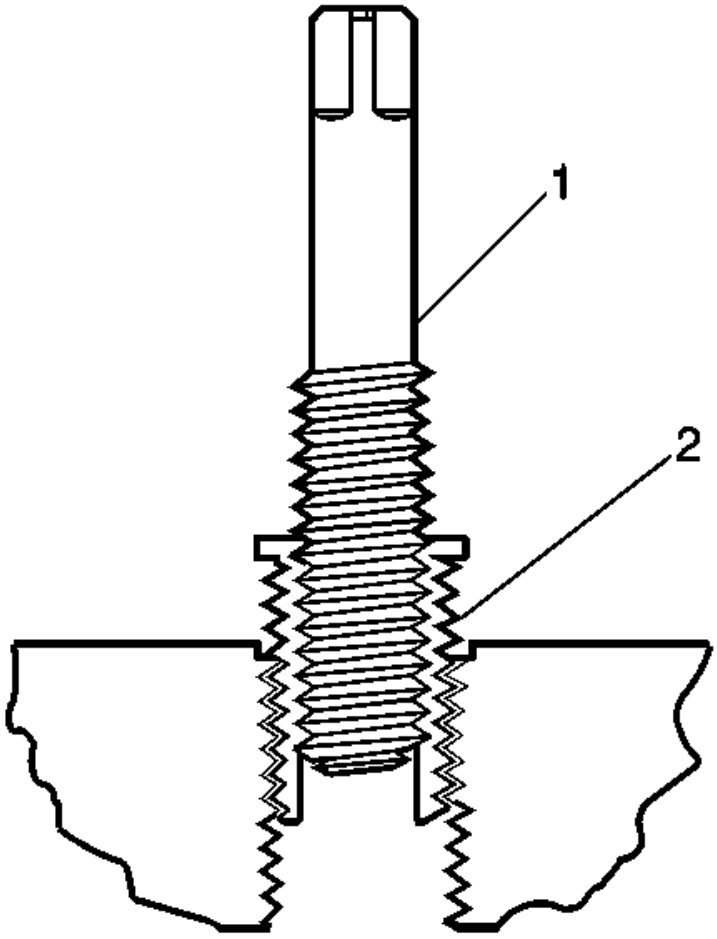

Fig. 511: Installing Insert Into Tapped Bolt Hole
Courtesy of GENERAL MOTORS CORP.

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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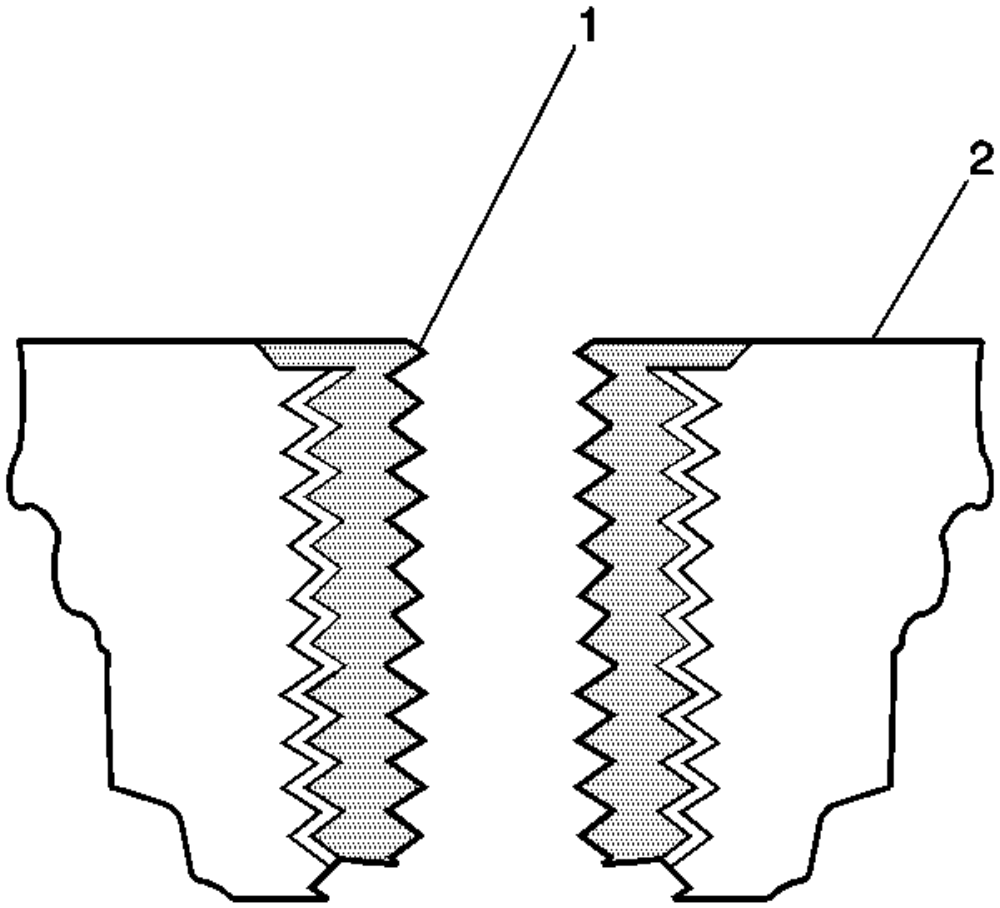

Fig. 512: View Of Bushing Type Insert & Base Material
Courtesy of GENERAL MOTORS CORP.

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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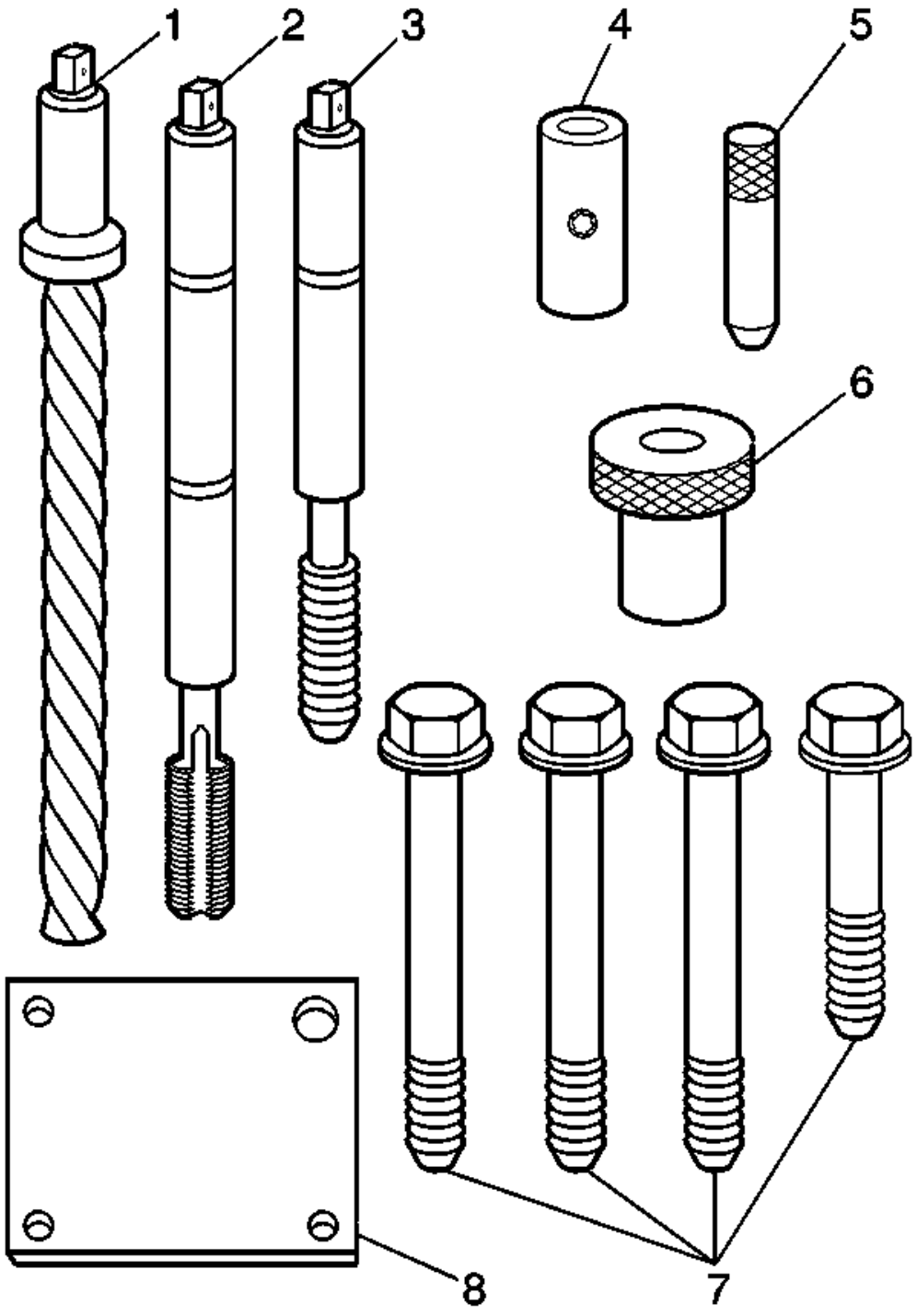

Fig. 513: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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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)

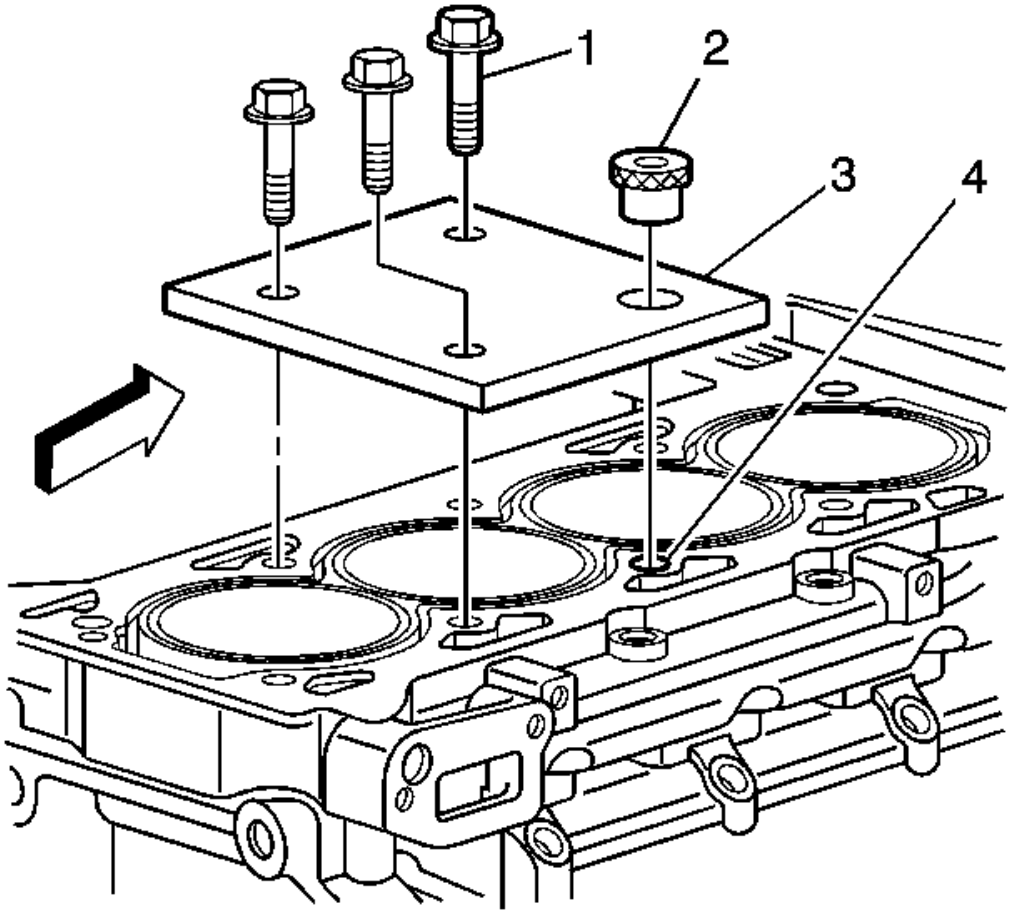

Fig. 514: Installing Fixture Plate, Bolts, & Bushing
Courtesy of GENERAL MOTORS CORP.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

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NOTE: **The use of a cutting fluid, WD 40®, or equivalent, is recommended when performing the drilling and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.**
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).

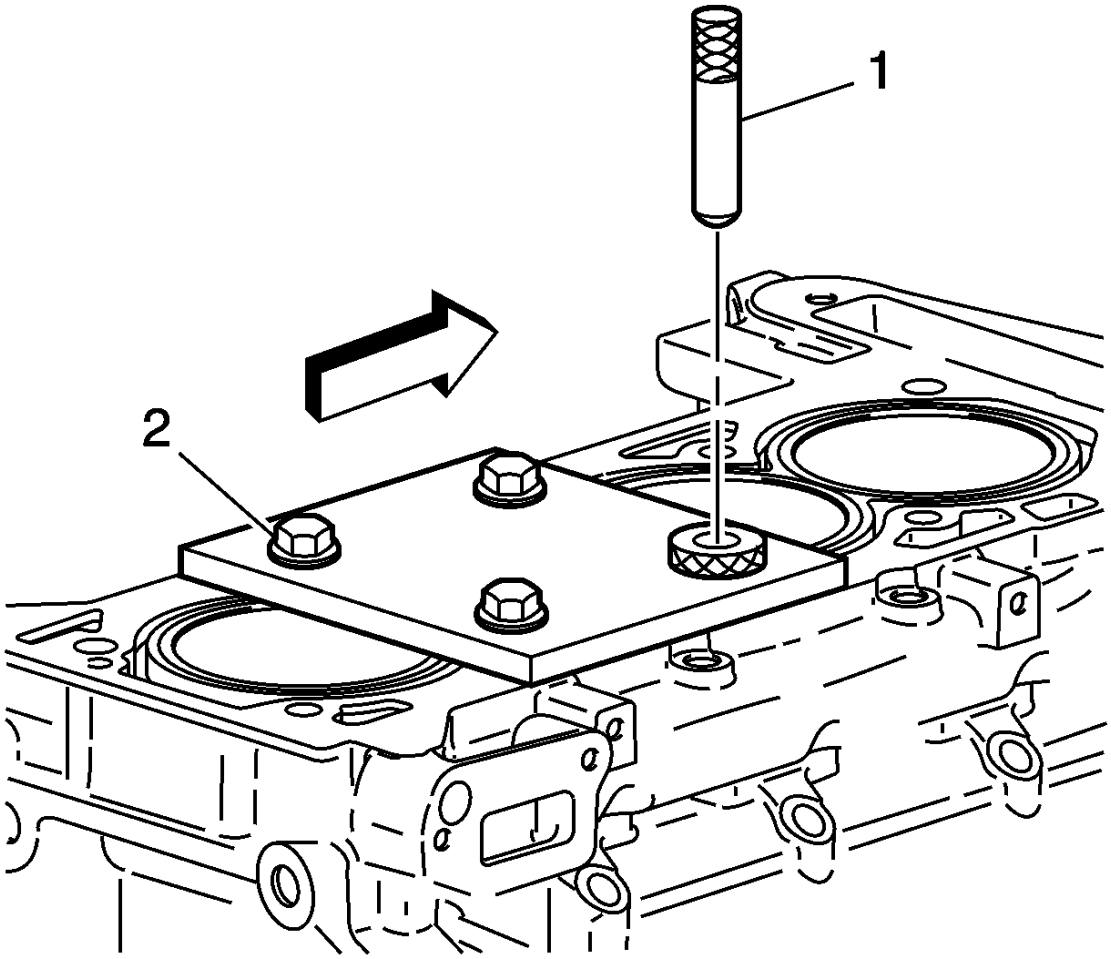

Fig. 515: Identifying Alignment Pin
Courtesy of GENERAL MOTORS CORP.

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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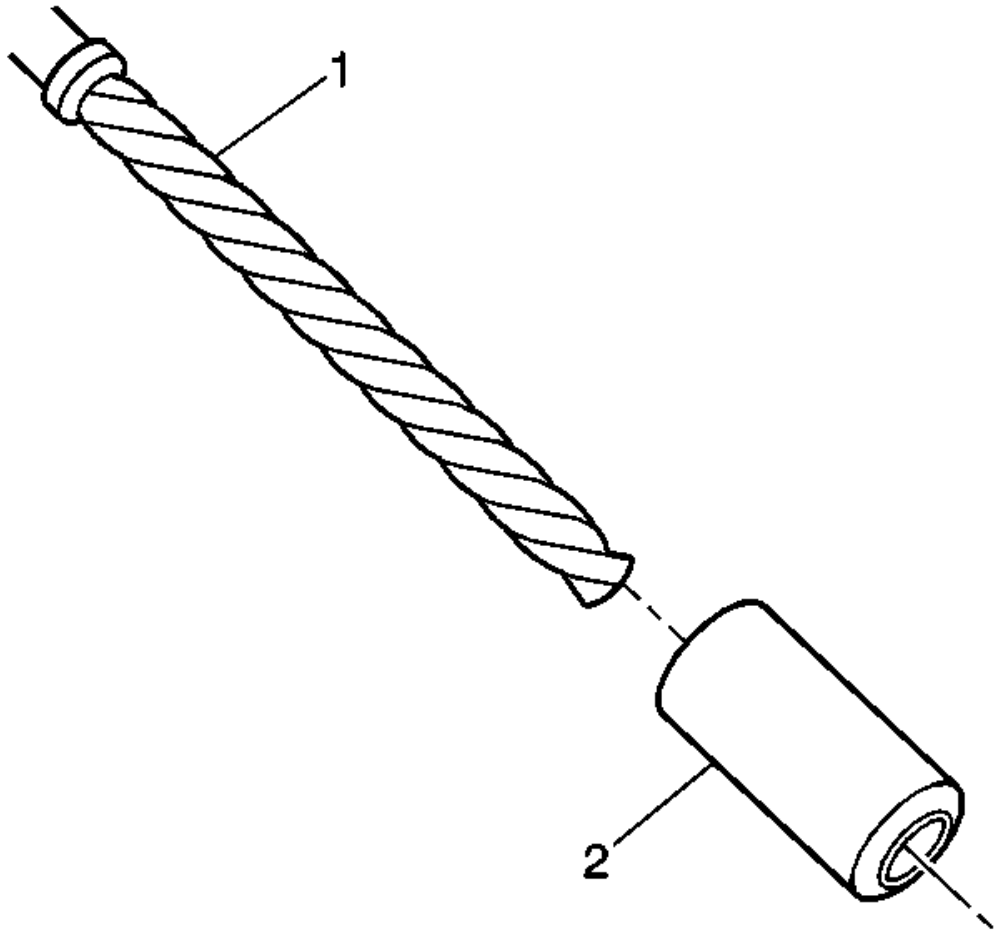

Fig. 516: View Of Stop Collar & Counterbore Drill
Courtesy of GENERAL MOTORS CORP.

6. Install the sleeve (2) onto the drill (1), if required.

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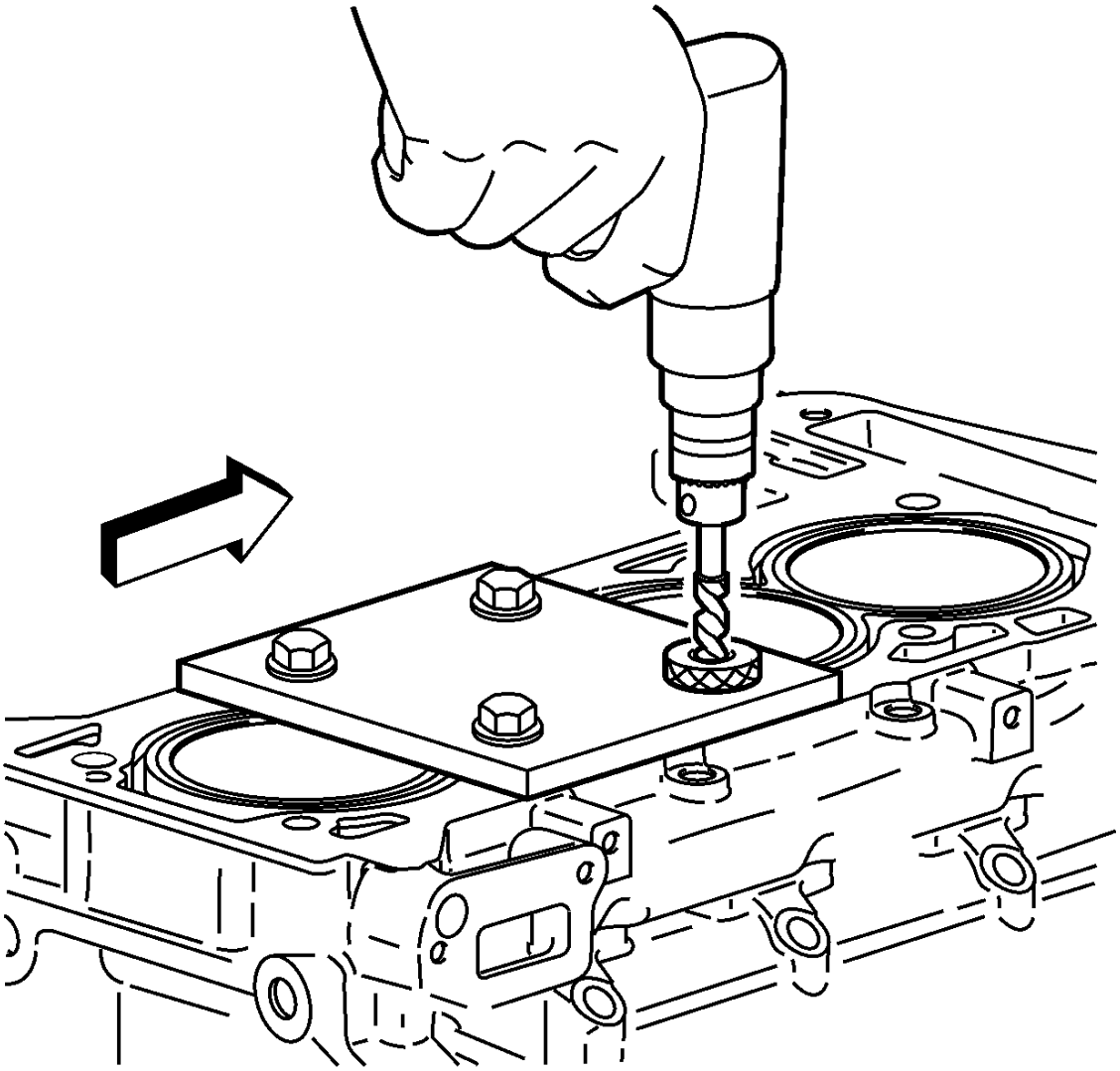

Fig. 517: Drilling Out Threads Of Damaged Hole
Courtesy of GENERAL MOTORS CORP.

NOTE: During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

   WARNING: Refer to Safety Glasses and Compressed Air Warning .

8. Using compressed air, clean out any chips.

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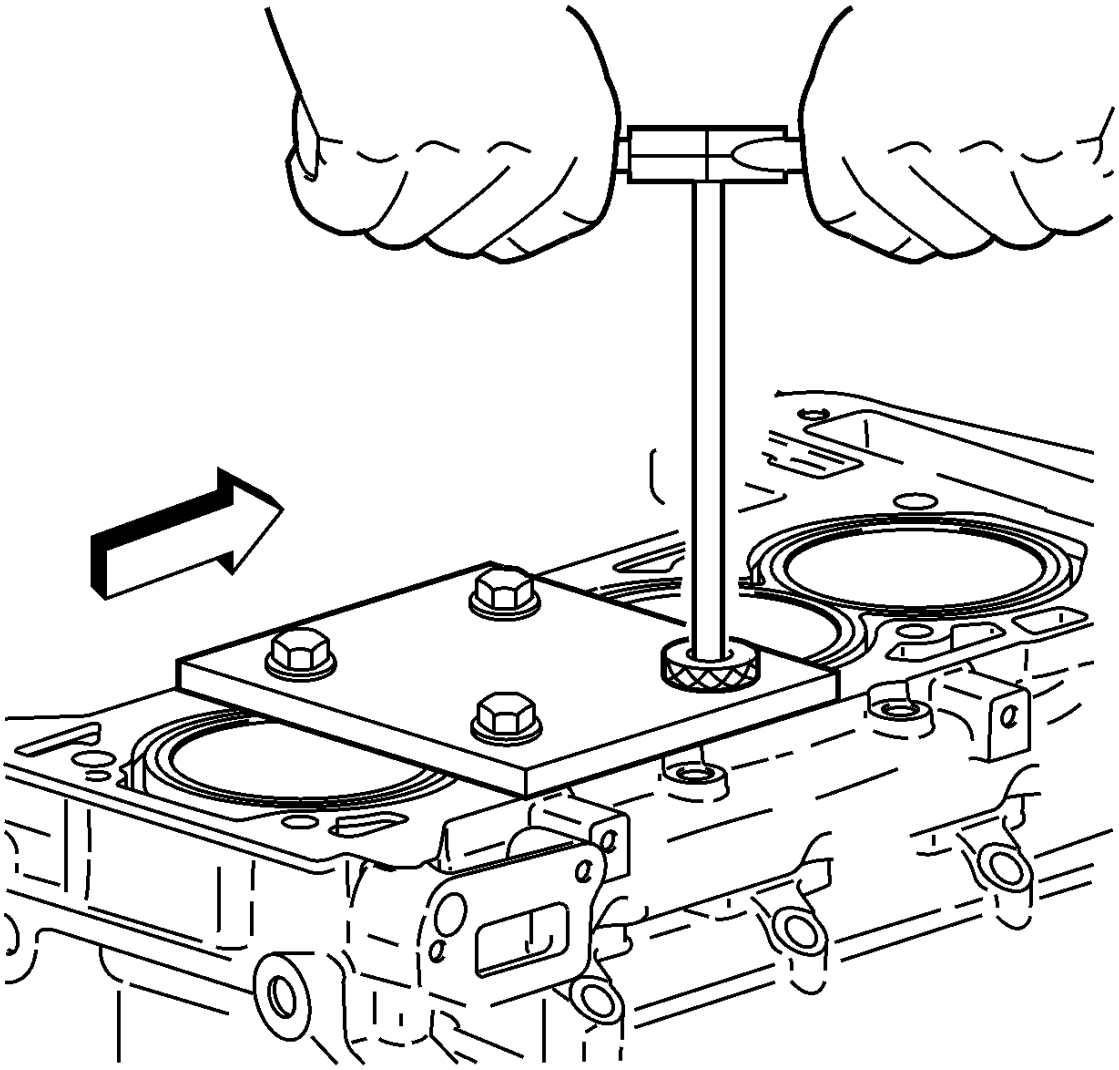

Fig. 518: Tapping Threads Of Drilled Hole With Tap Wrench
Courtesy of GENERAL MOTORS CORP.

9. Using a tap wrench, tap the threads of the drilled hole.

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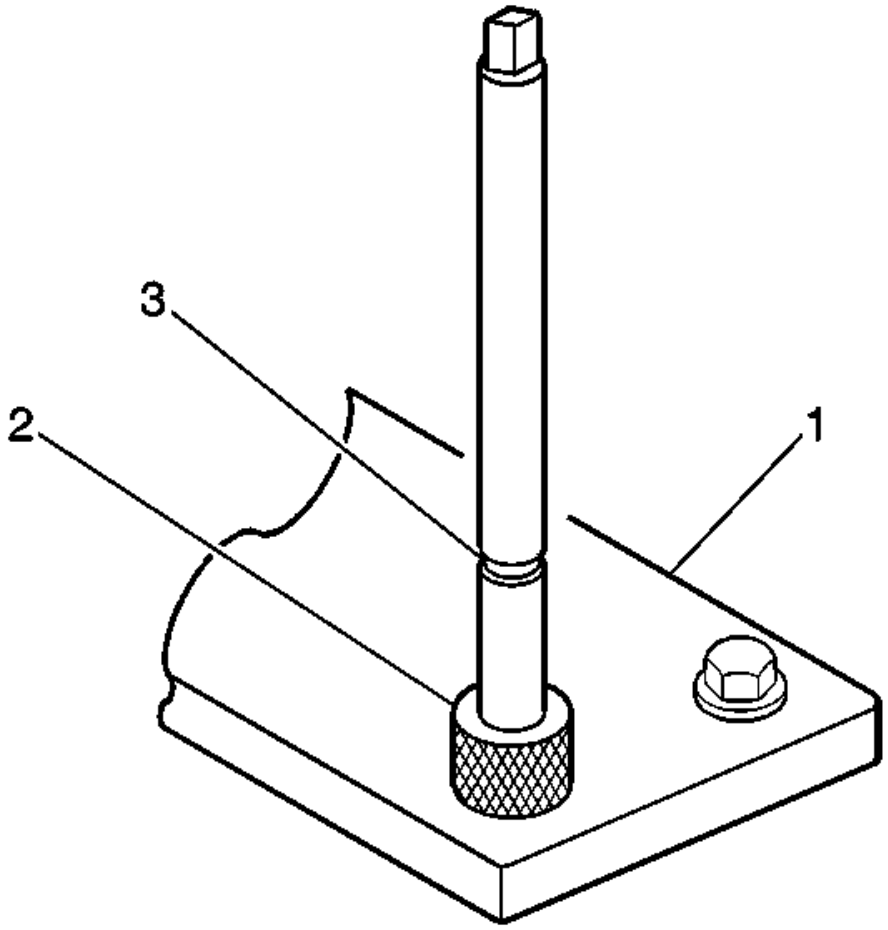

Fig. 519: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

WARNING: Refer to Cleaning Solvent Warning .

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12. Using compressed air, clean out any chips.
13. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
14. Using compressed air, clean any cutting oil and chips out of the hole.

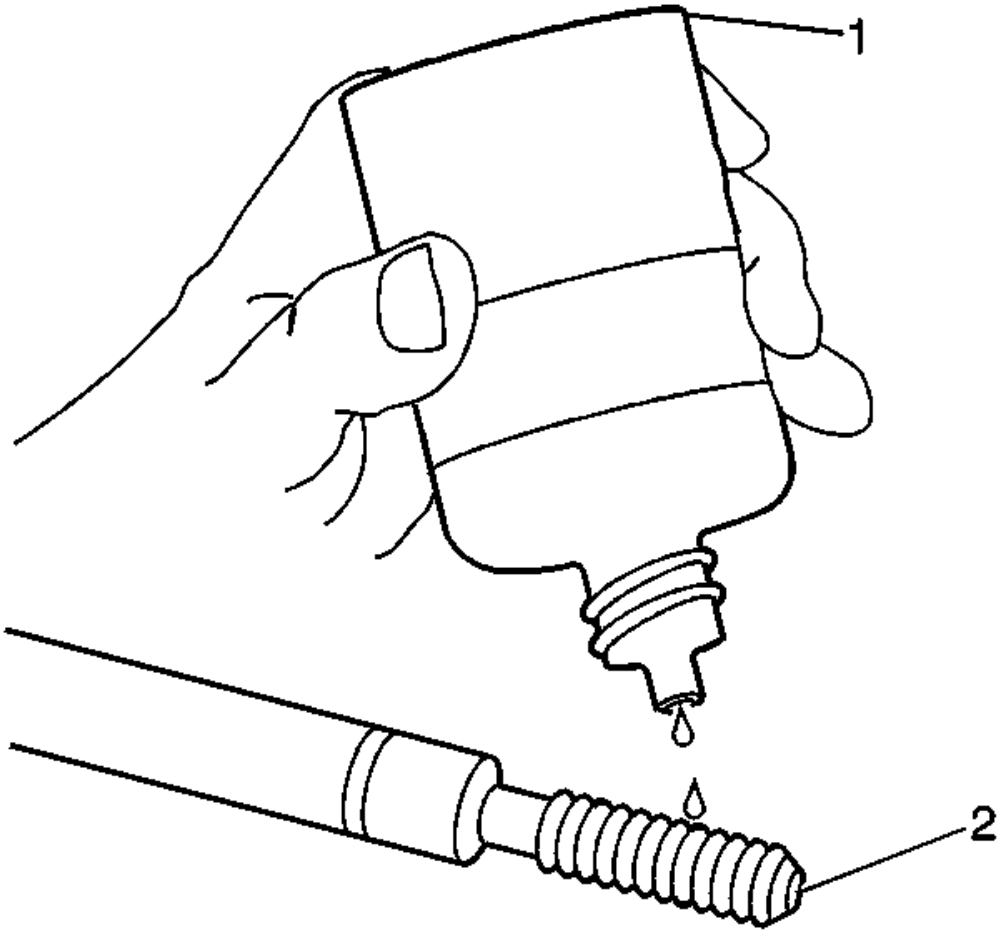

Fig. 520: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

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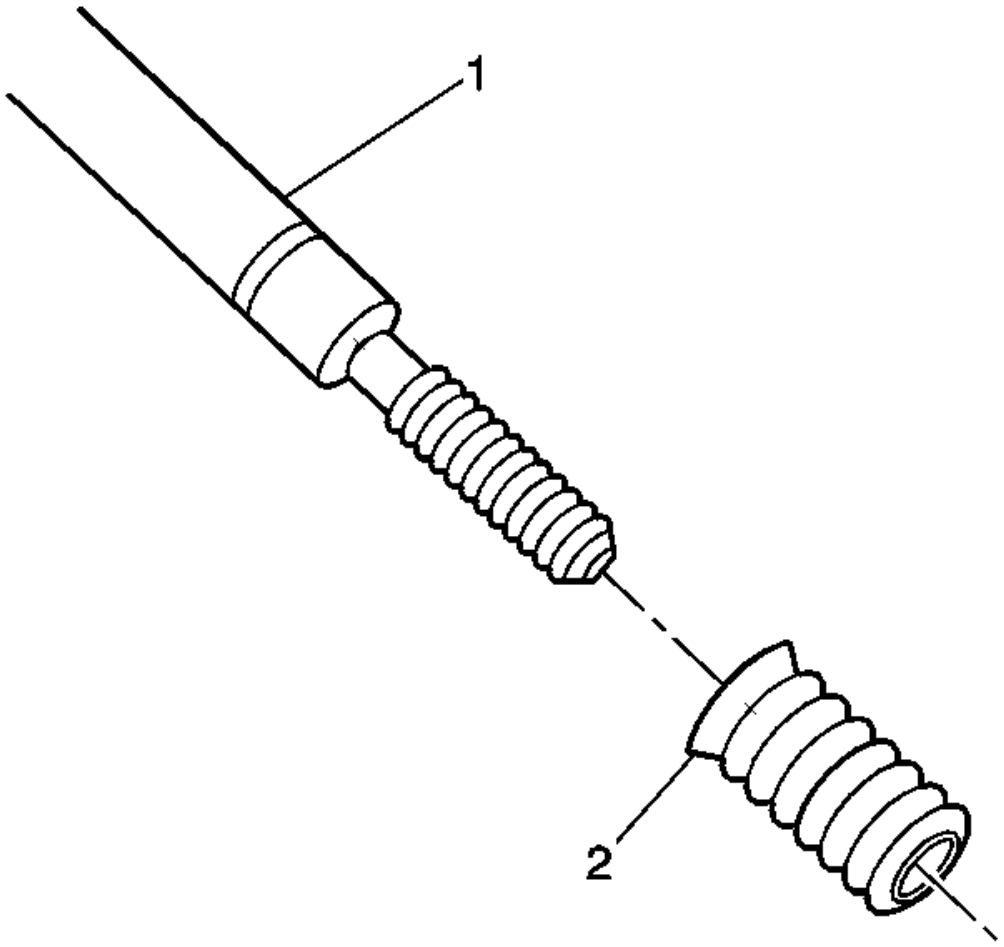

Fig. 521: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

16. Install the insert (2) onto the driver tool (1).

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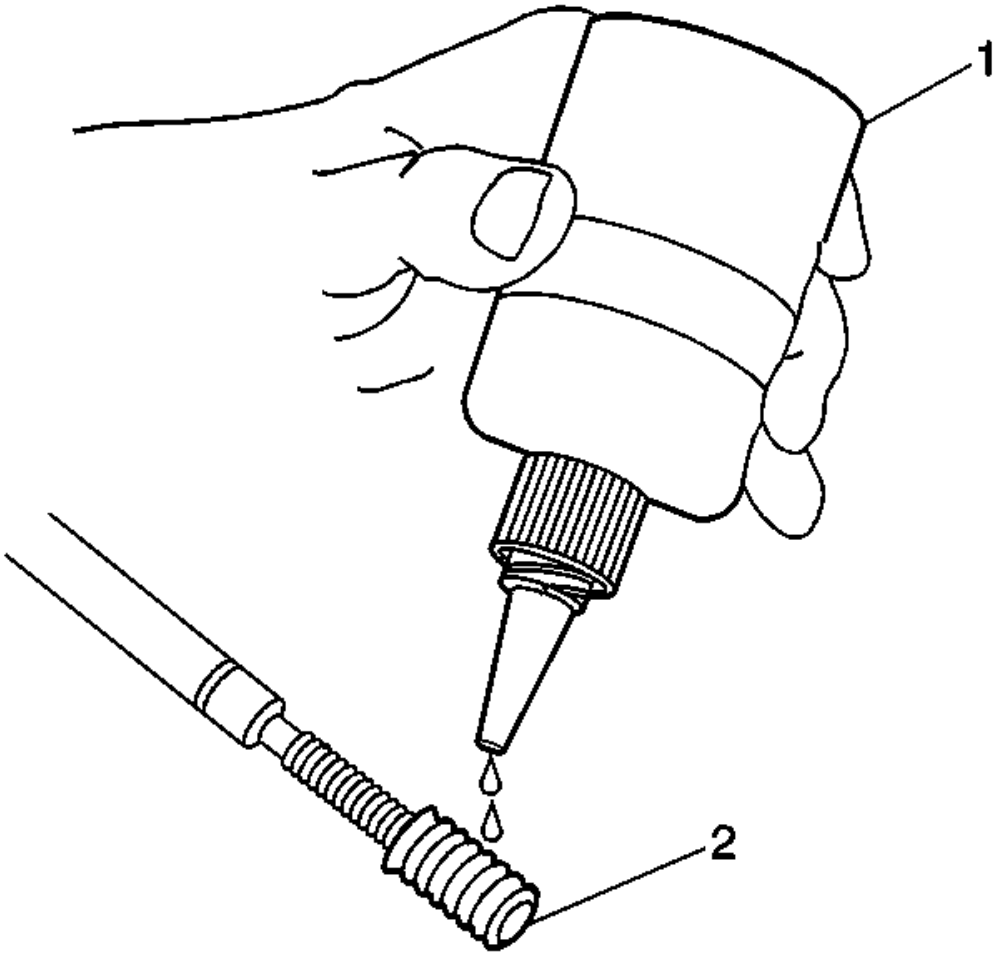

Fig. 522: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

17. Apply threadlock LOCTITE™ 277, **J 42385-109:** loctite (1), or equivalent to the insert OD threads (2).

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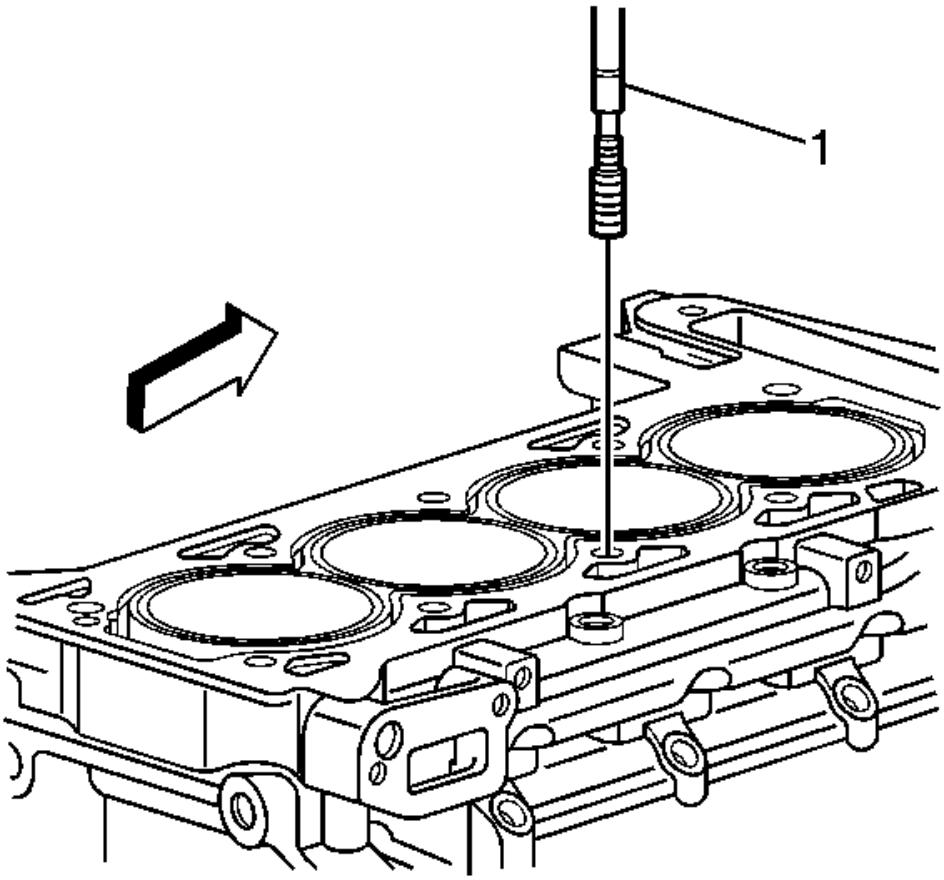

Fig. 523: Installing & Inserting Driver Into Hole
Courtesy of GENERAL MOTORS CORP.

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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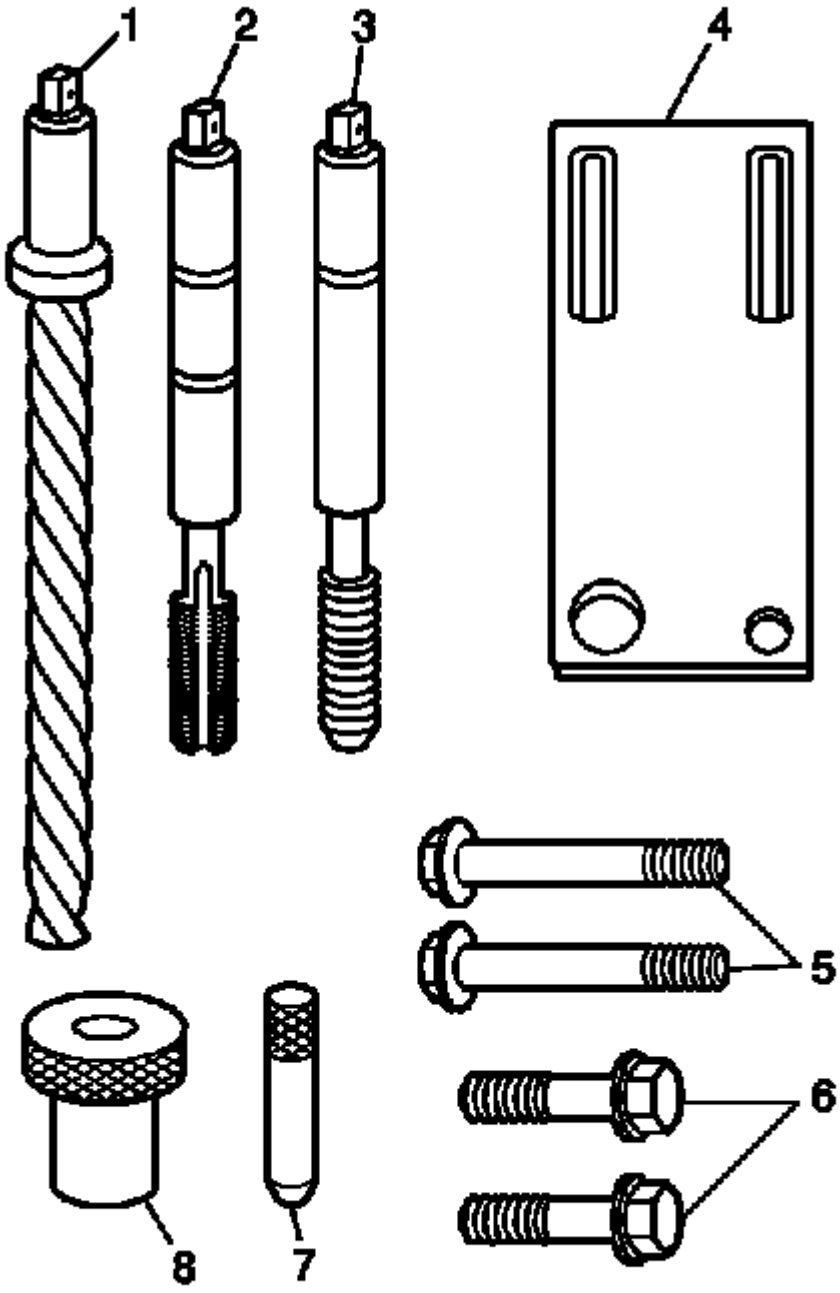

Fig. 524: Identifying Thread Repair Kit Components
Courtesy of GENERAL MOTORS CORP.

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)

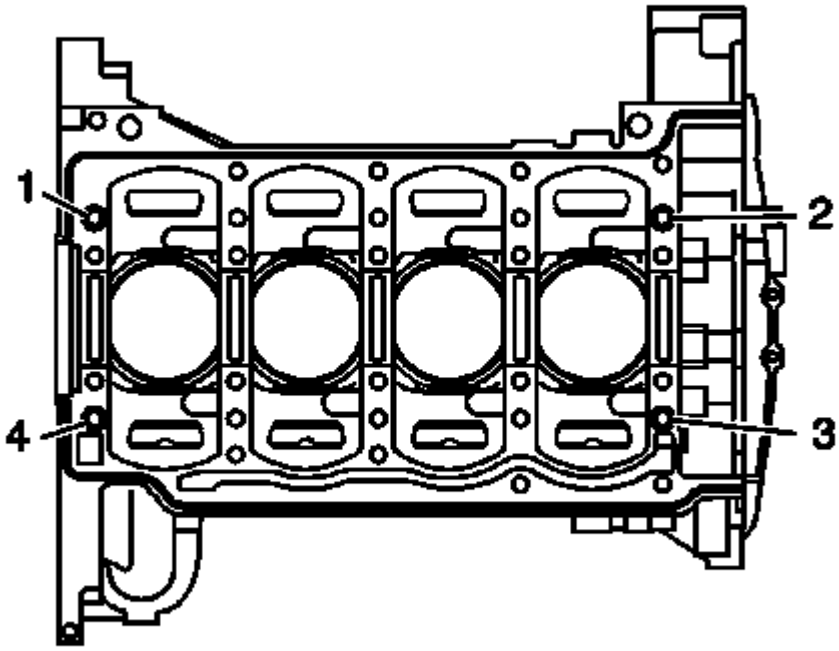

Fig. 525: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

2. Remove the alignment dowel pins from the holes (1-4), if necessary.

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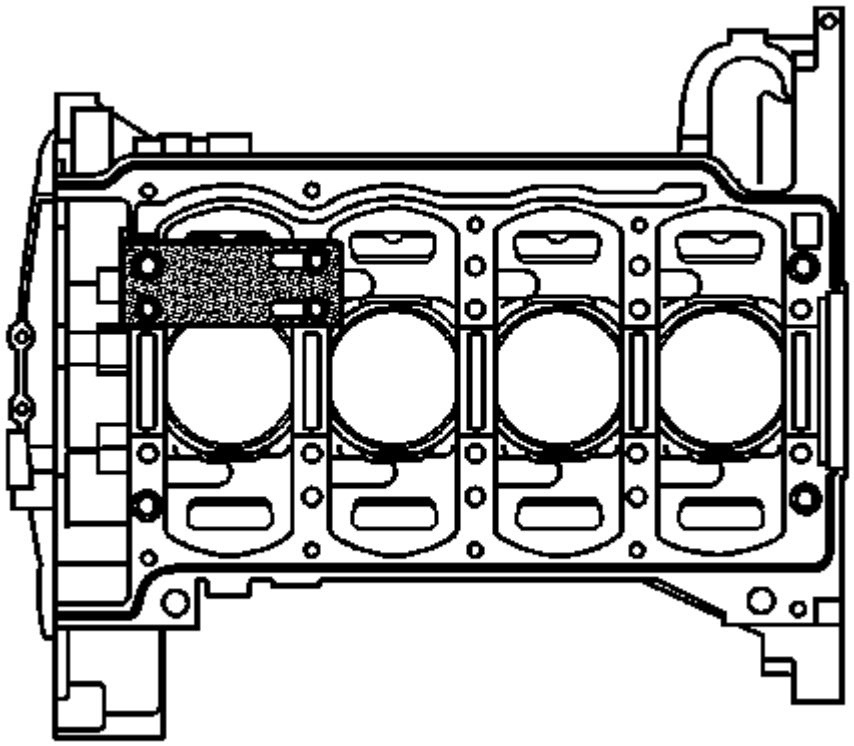

Fig. 526: Installing Fixture Plate, Bolt, & Bushing Onto Engine Block
Courtesy of GENERAL MOTORS CORP.

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.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

6. Using compressed air, clean out any chips.

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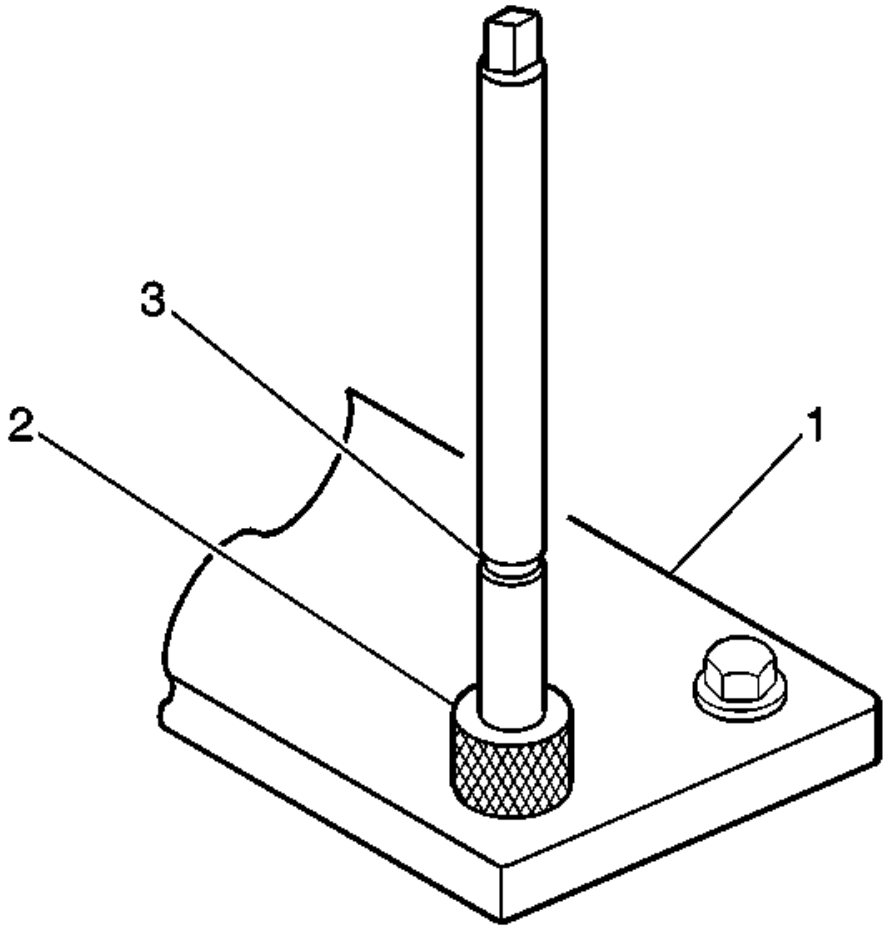

Fig. 527: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

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).

   WARNING: Refer to Safety Glasses and Compressed Air Warning .

   WARNING: Refer to Cleaning Solvent Warning .

8. Using compressed air, clean out any chips.
9. Spray cleaner into the hole. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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10. Using compressed air, clean any cutting oil and chips out of the hole.

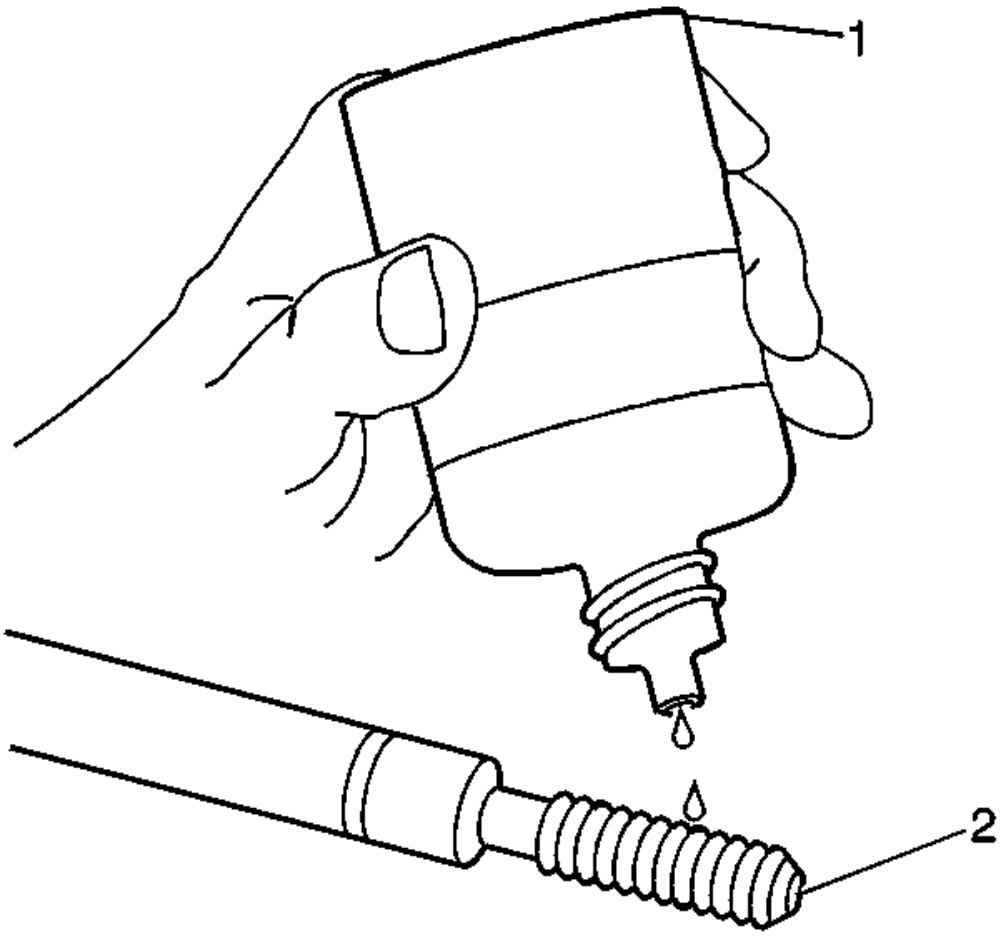

Fig. 528: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS CORP.

NOTE: 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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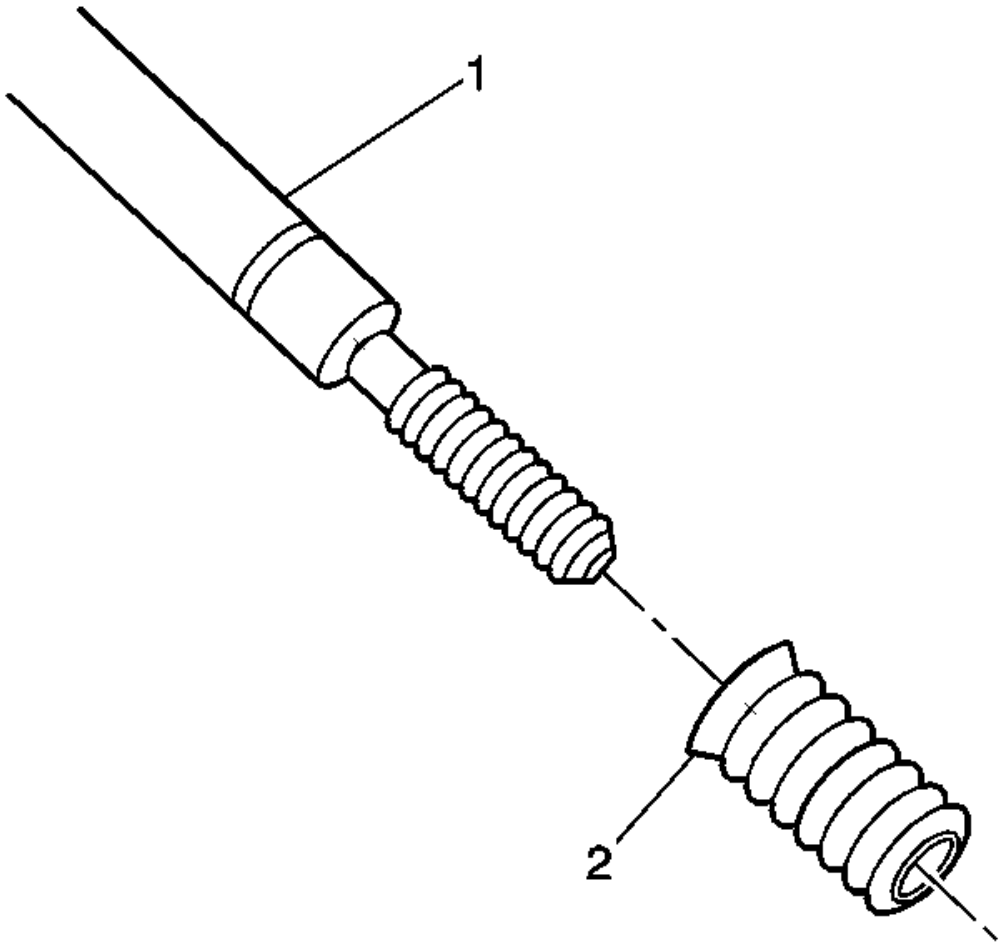

Fig. 529: View of Bushing Type Insert
Courtesy of GENERAL MOTORS CORP.

12. Install the insert (2) onto the driver tool (1).

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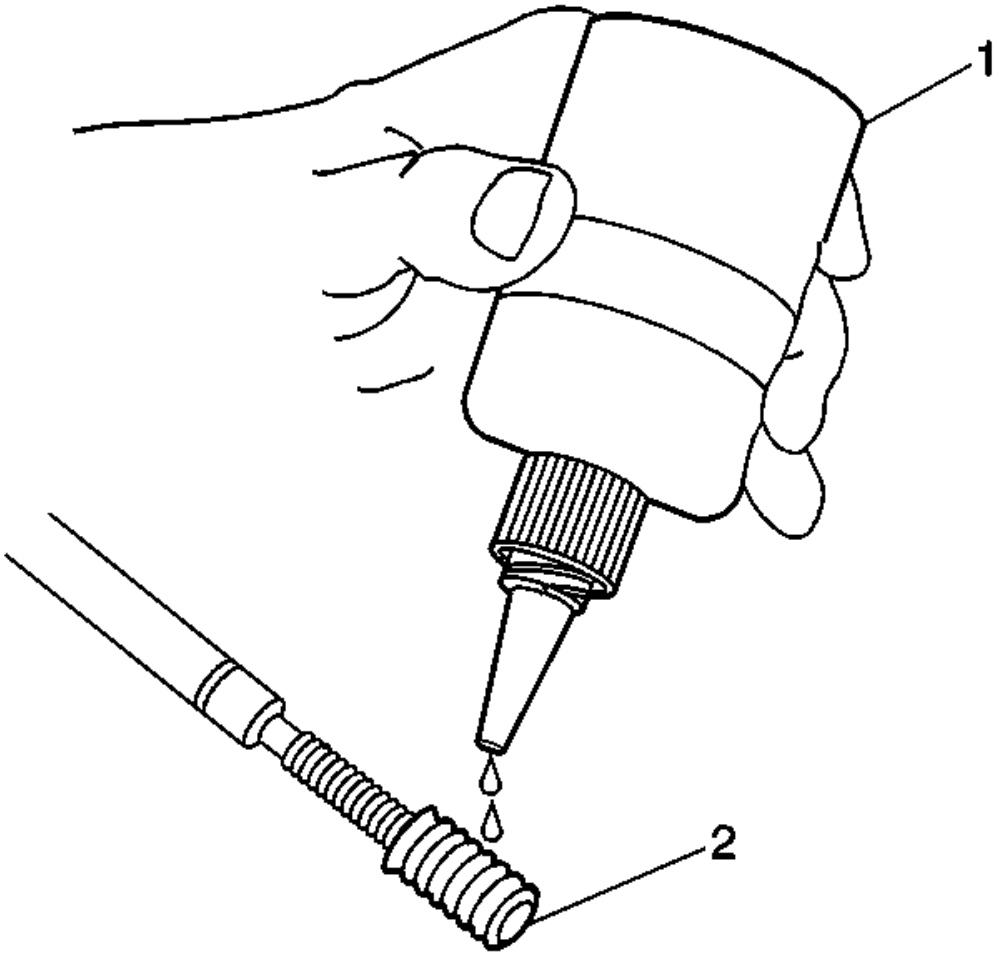

Fig. 530: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS CORP.

13. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent to the insert OD threads (2).

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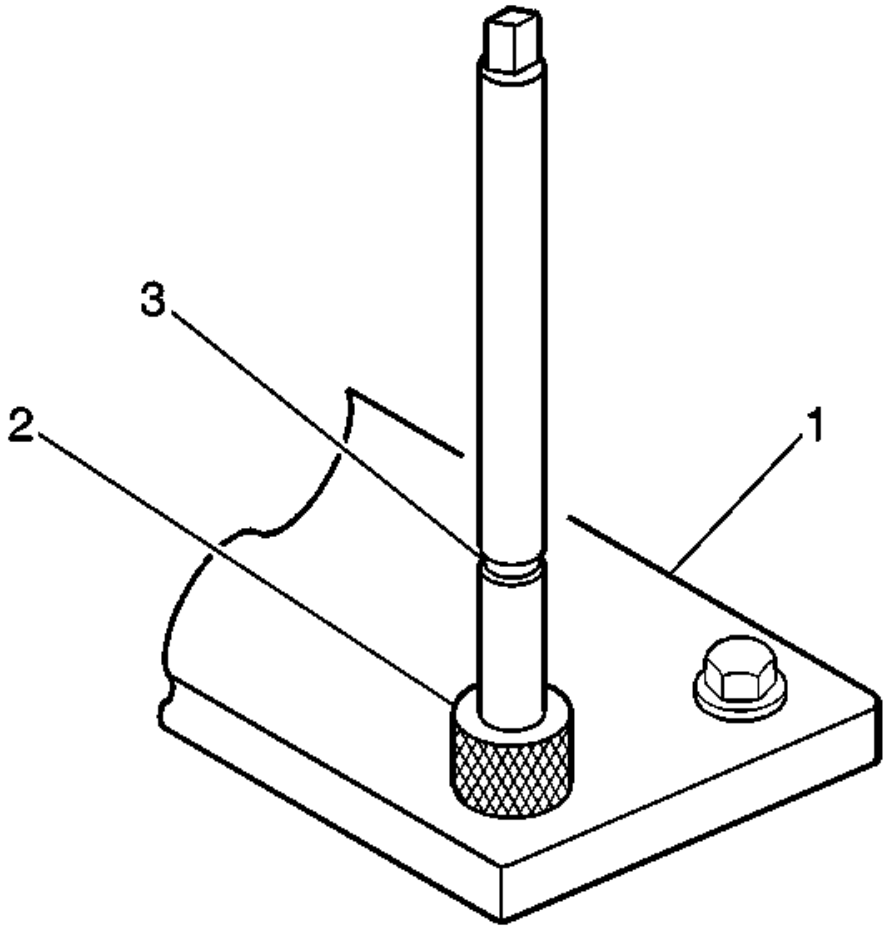

Fig. 531: View Of Fixture Plate, Drill Bushing & Tool Marking
Courtesy of GENERAL MOTORS CORP.

NOTE: The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.

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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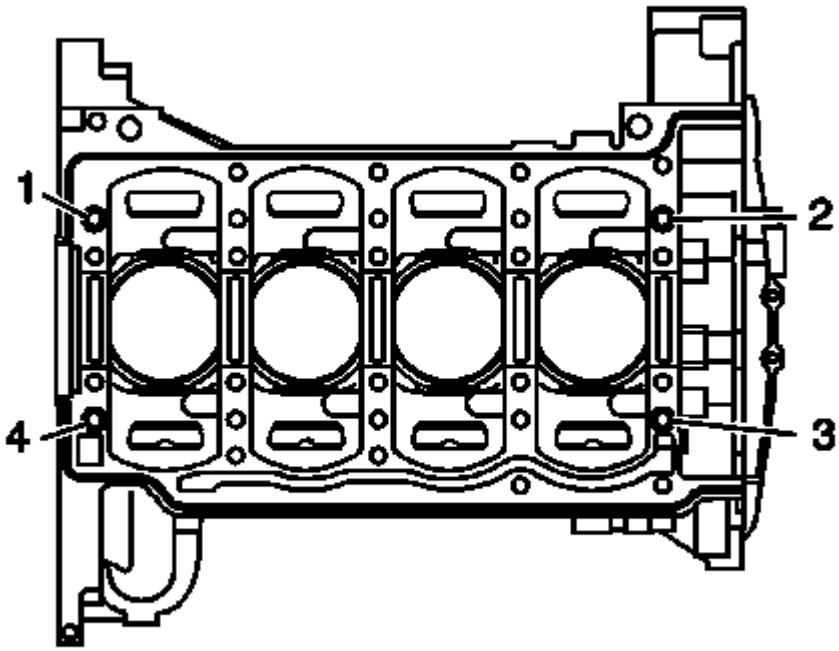

Fig. 532: Identifying Alignment Dowel Pins
Courtesy of GENERAL MOTORS CORP.

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 (LAP)

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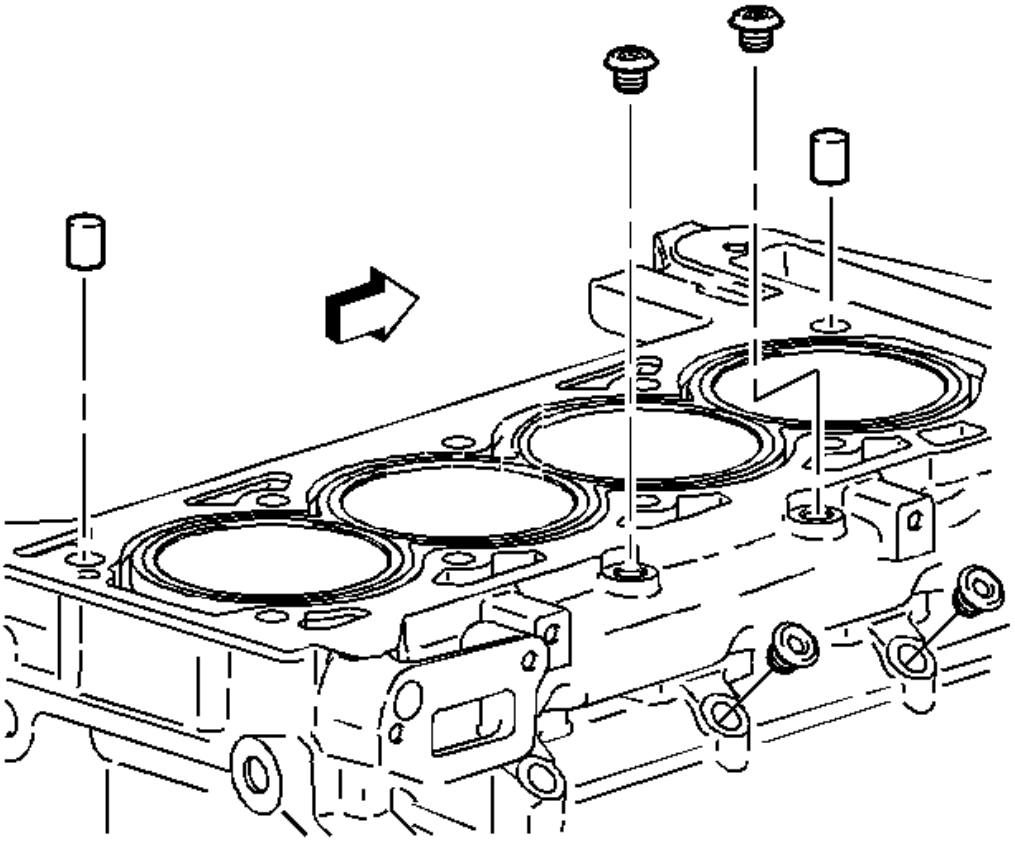

Fig. 533: View Of Oil Passage Plug, Oil Flow Check Valve & Water Jacket Drain Plug
Courtesy of GENERAL MOTORS CORP.

1. Install the drain plug in the water pump.
2. Apply sealer GM P/N 12346004 (Canadian P/N 10953480) to the plug before installation.

CAUTION: Refer to Fastener Caution .

3. Install the coolant jacket plugs and tighten to 35 N.m (26 lb ft).
4. Apply sealer GM P/N 12346004 (Canadian P/N 10953480 to the plugs before installation.
5. Install the rear oil passage plugs and tighten to 60 N.m (44 lb ft).
6. Install the other oil passage plugs and tighten to 35 N.m (26 lb ft).

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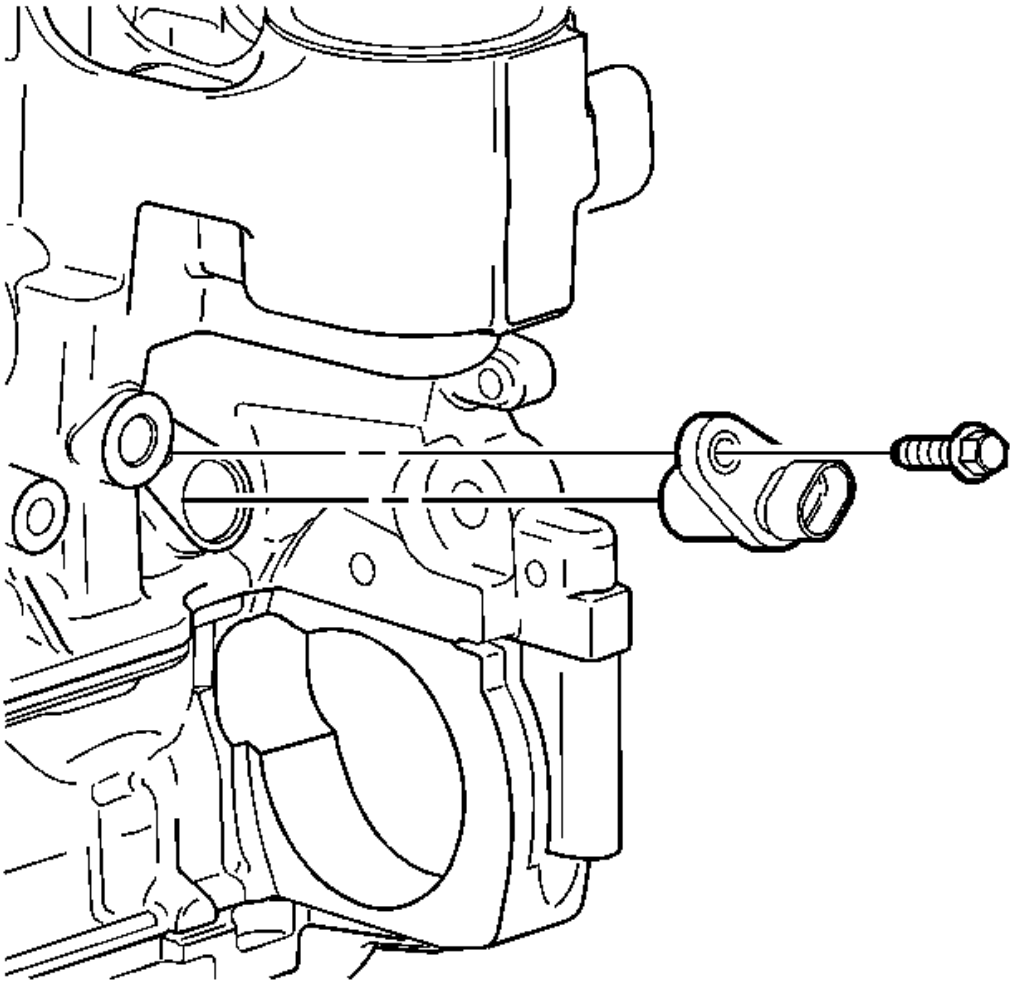

Fig. 534: View Of Crankshaft Position Sensor
Courtesy of GENERAL MOTORS CORP.

7. Lubricate the crankshaft position sensor O-ring with engine oil.
8. Install the crankshaft position sensor and bolt and tighten to 10 N.m (89 lb in).

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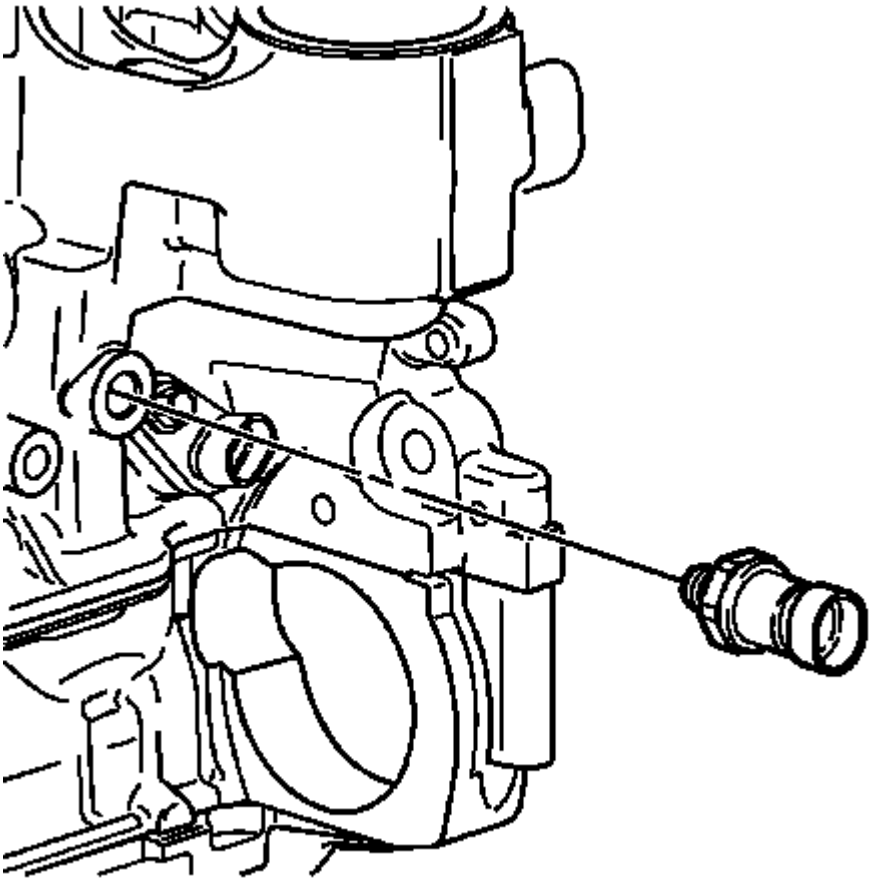

Fig. 535: View Of Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS CORP.

9. Install the oil pressure switch and tighten to 26 N.m (19 lb in).

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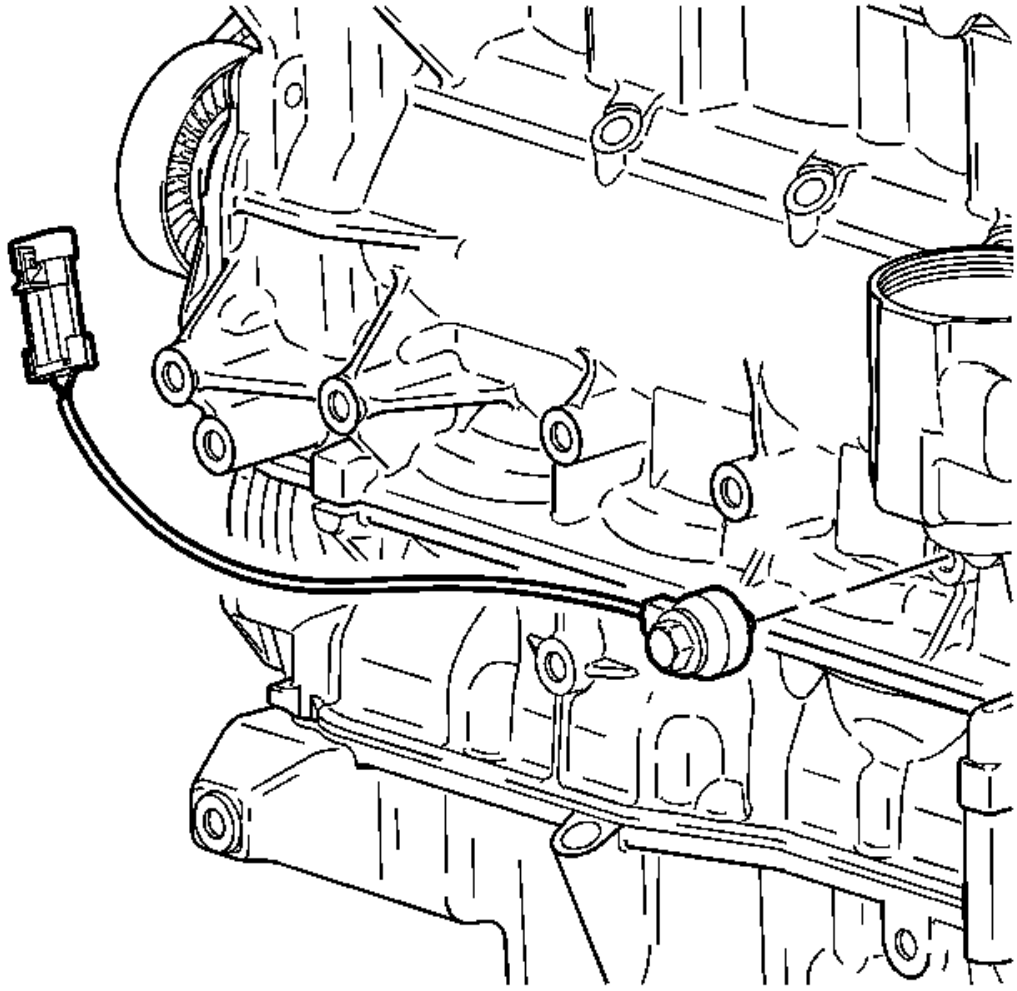

Fig. 536: View of Knock Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the knock sensor and bolt and tighten to 25 N.m (18 lb ft).

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

- **EN-8087:** Cylinder Bore Checking Gauge
- **J 45059:** Angle Meter

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

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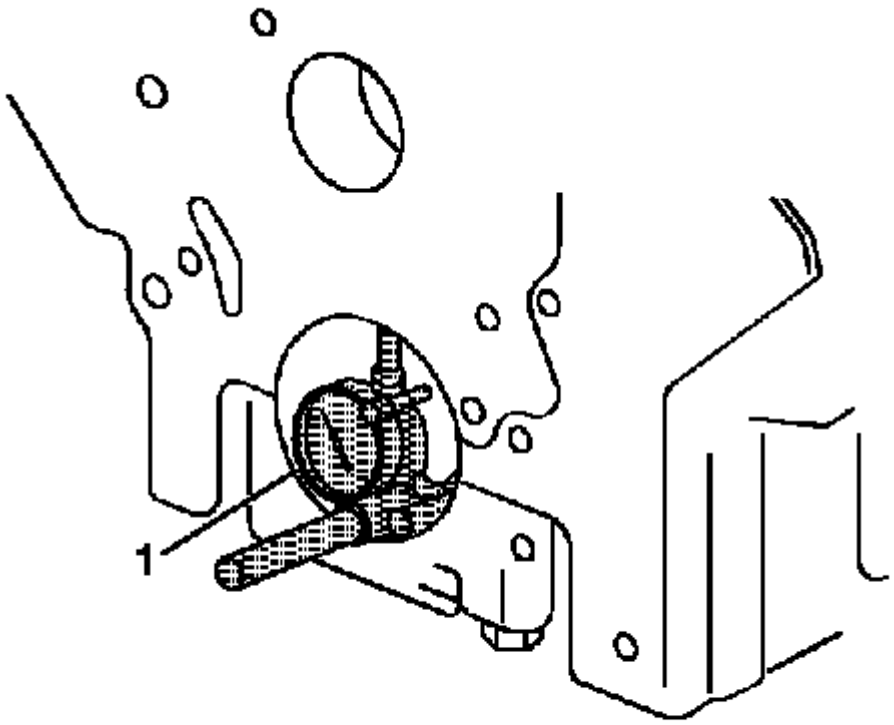

Fig. 537: View of EN-8087 Gage To Measure Bearing Bore
Courtesy of GENERAL MOTORS CORP.

NOTE: 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:** meter.
- Measure the bearing bore for taper and out-of-round using the **EN-8087:** gauge (1).
- 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.
    - Method B yields the bearing clearance directly. Method B does not give any indication of bearing run-out.

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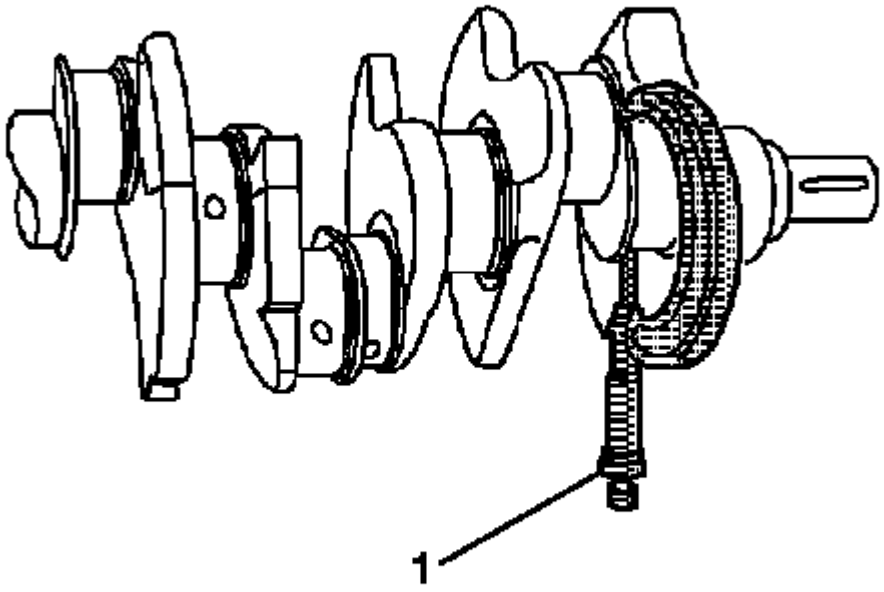

Fig. 538: View of Measuring Crankshaft Bearing Journal Using Method A
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 (1) 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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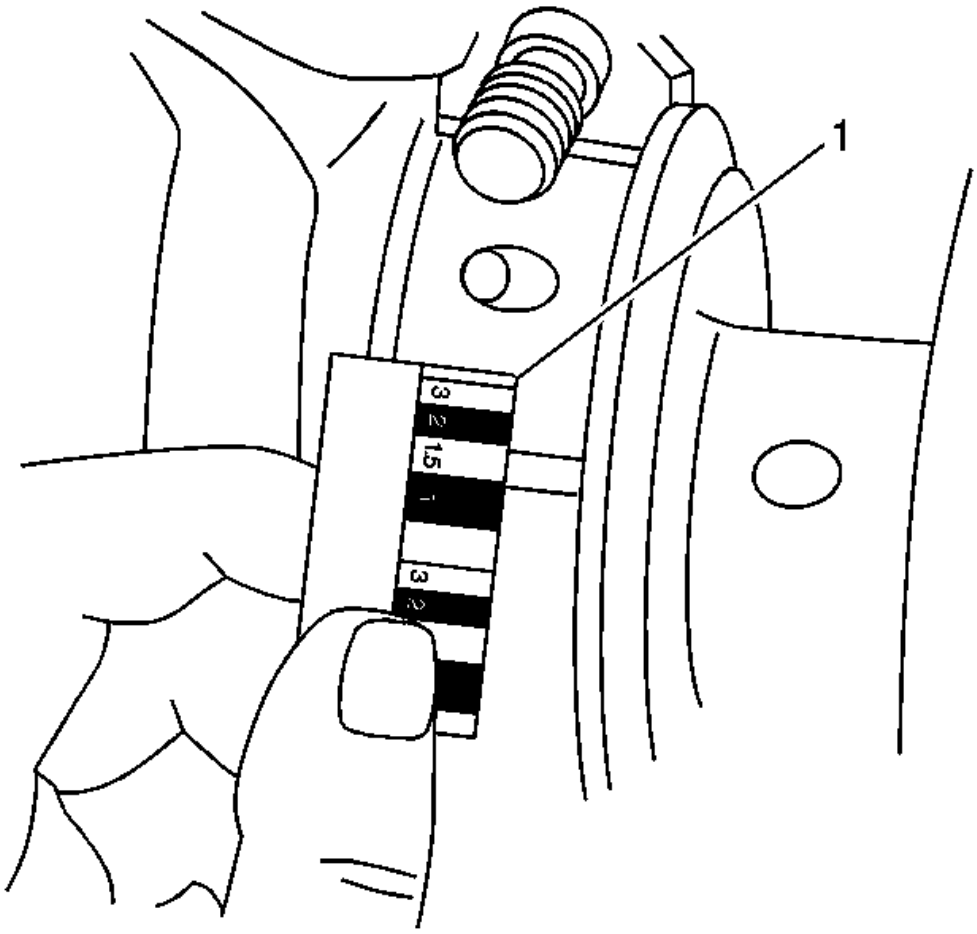

Fig. 539: Measuring Bearing Clearance Using Method B
Courtesy of GENERAL MOTORS CORP.

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.

CAUTION: 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.

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5. Install the bearing cap bolts to specification.

NOTE: Do not rotate the crankshaft.

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 (1) printed on the gaging plastic package.
8. Remove the gaging plastic.

LOWER CRANKCASE INSTALLATION

Special Tools

J 45059: Angle Meter

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

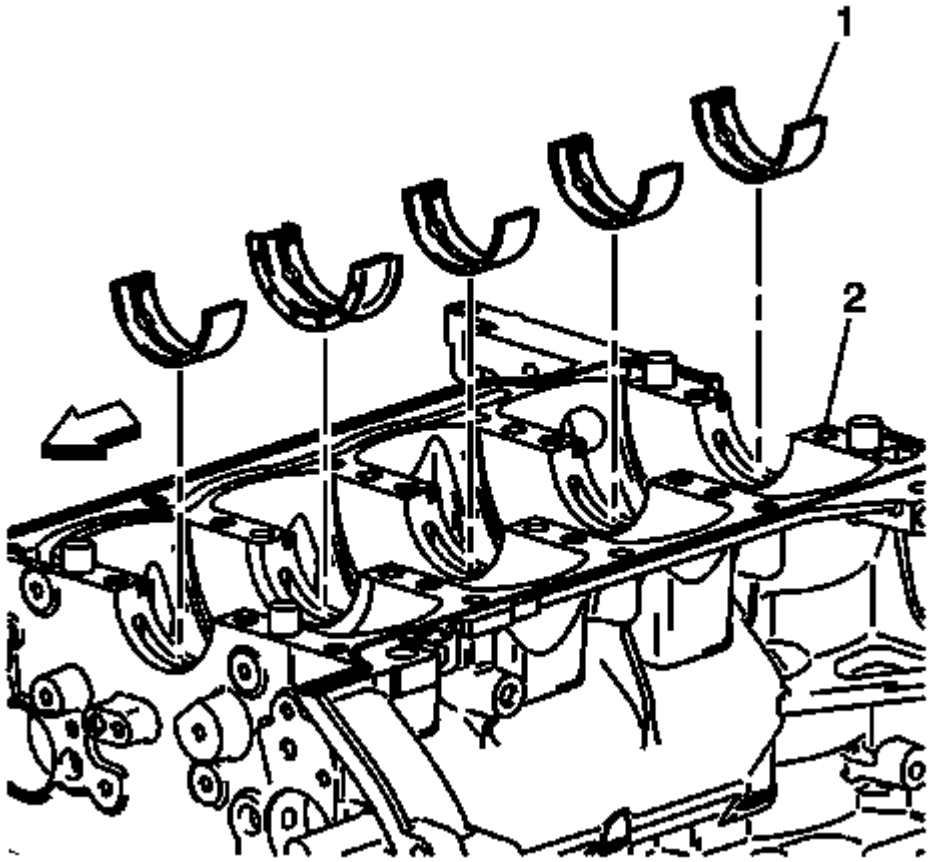

Fig. 540: View of Upper Crankshaft Bearings
Courtesy of GENERAL MOTORS CORP.

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1. Install the upper crankshaft bearings (1) and lubricate bearing surfaces with engine oil.

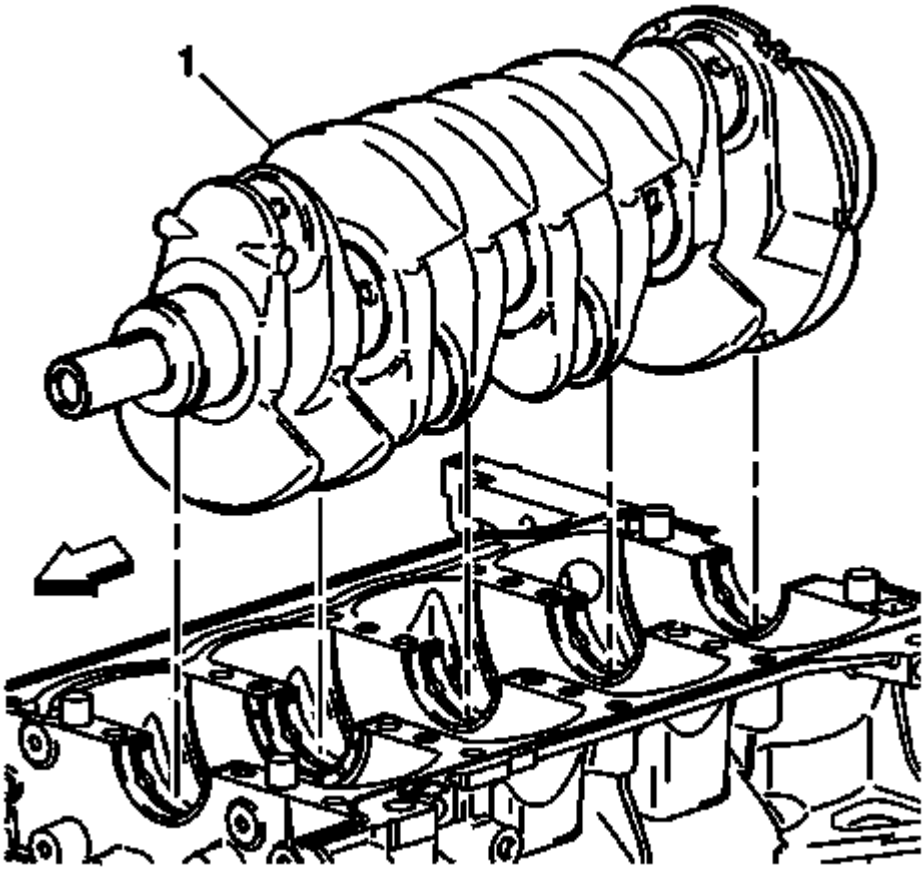

Fig. 541: View of Crankshaft
Courtesy of GENERAL MOTORS CORP.

2. Install the crankshaft (1) on the journals.

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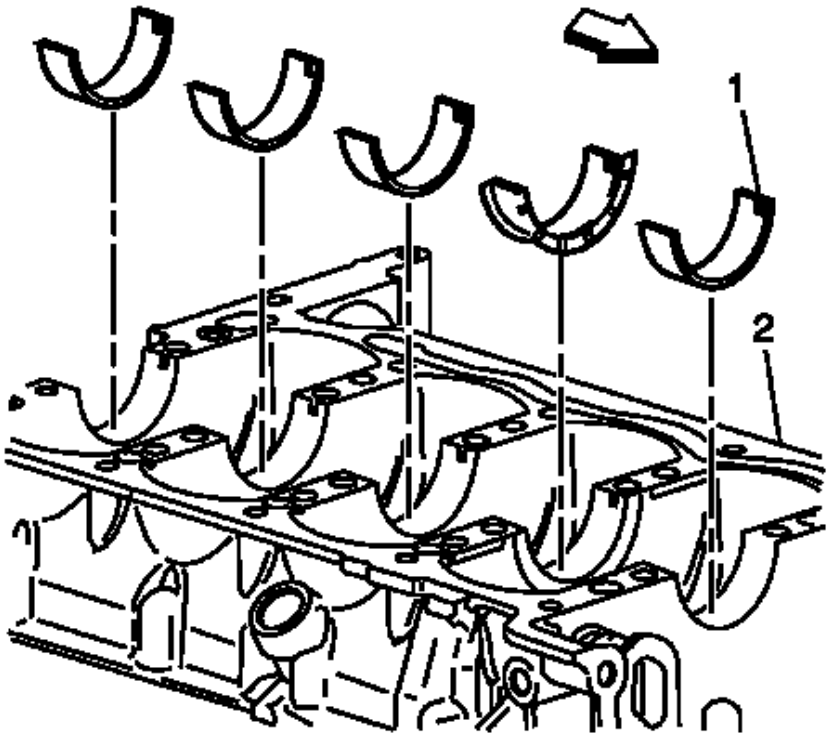

Fig. 542: View of Lower Bearing Halves
Courtesy of GENERAL MOTORS CORP.

3. Install the lower bearing halves (1), without grooves, into the lower crankcase. Apply oil to bearing surfaces.

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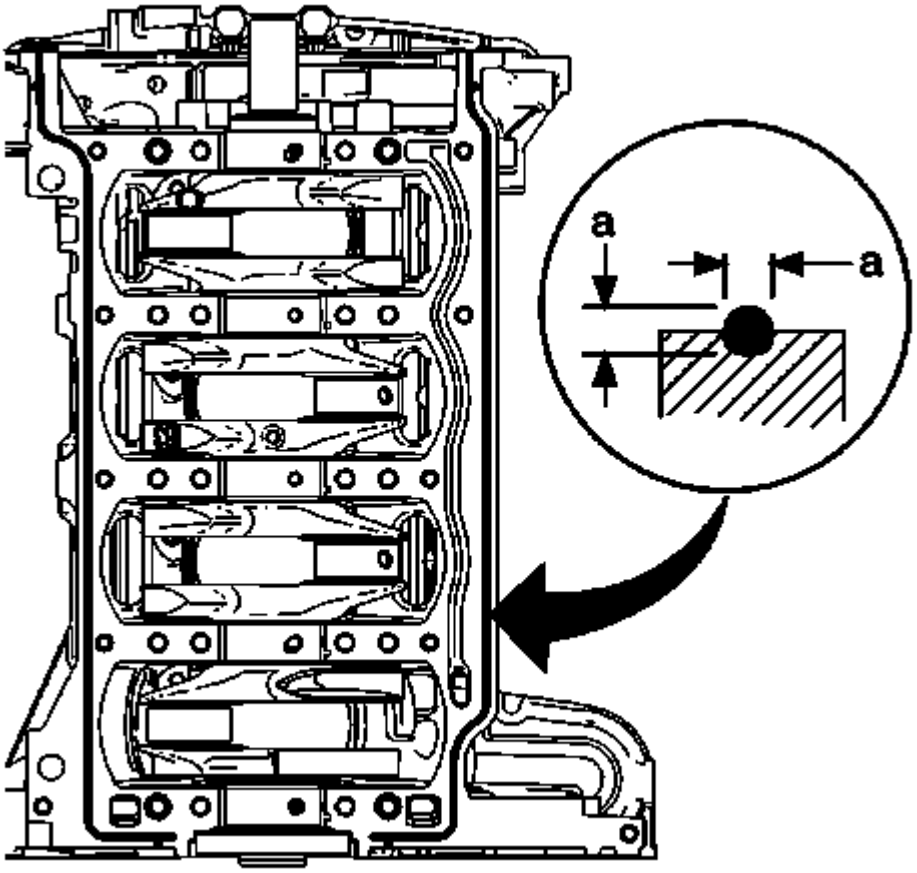

Fig. 543: View of Bead of Sealer on Bedplate Mating Surface
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The block assembly surface must be free of contamination prior to applying the sealer.**
- **Install and align the bedplate to block within 20 minutes of applying the sealer.**
- **The bedplate must be fastened to final torque specification within 60 minutes of applying the sealer.**

4. Apply a 4.25 mm bead of sealer, dimension (a), directly in the groove of the block to bedplate mating surfaces. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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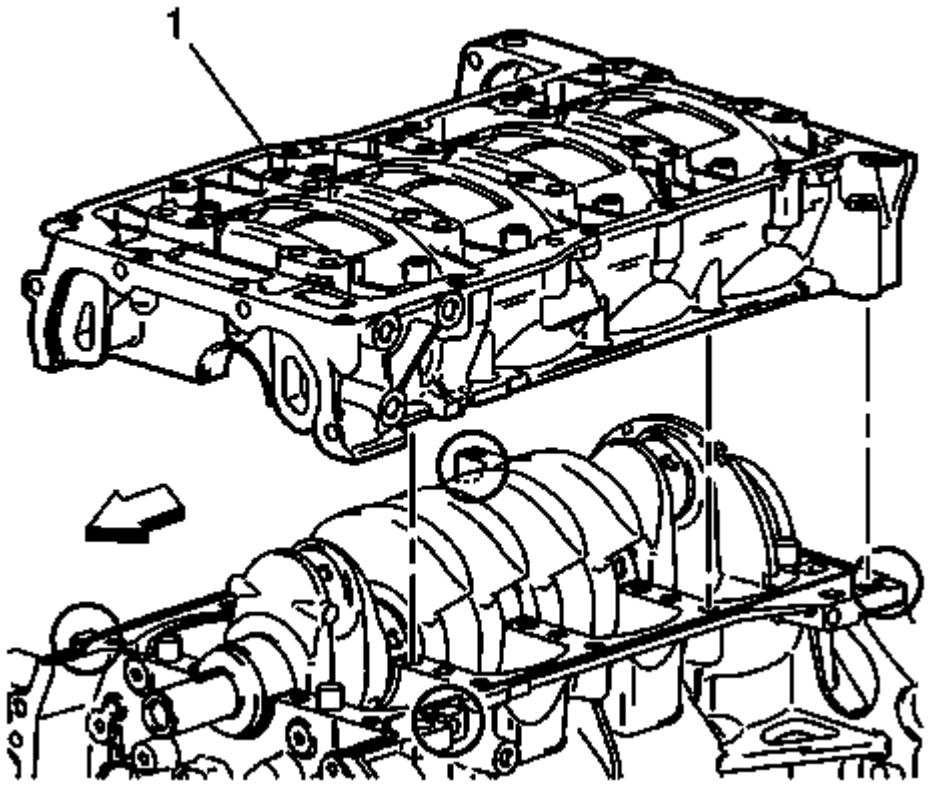

Fig. 544: View of Lower Crankcase
Courtesy of GENERAL MOTORS CORP.

5. Install the lower crankcase (1). Tap gently into place with a suitable tool if necessary. Ensure it is aligned properly on the dowels.

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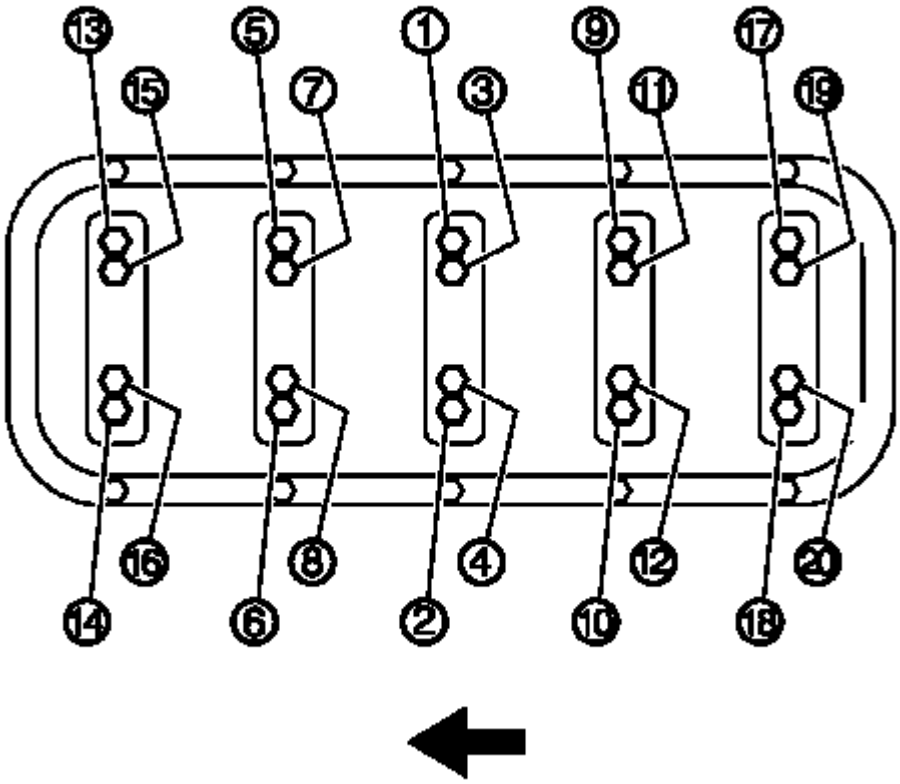

Fig. 545: Identifying Crankshaft Bearing Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

6. Install the NEW crankshaft bearing bolts in sequence finger tight.
    1. Tighten the crankshaft bearing bolts in sequence to 20 N.m (15 lb ft) .
    2. Tighten the crankshaft bearing bolts in sequence using the **J 45059:** meter an additional 70 degrees.

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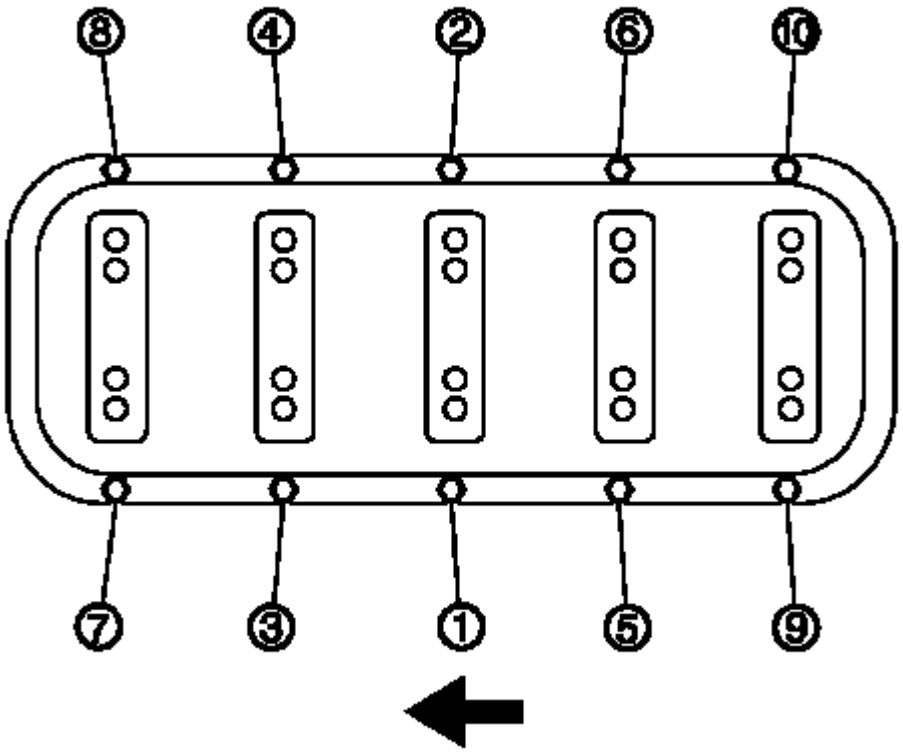

Fig. 546: Lower Crankcase Perimeter Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

7. Tighten the lower crankcase perimeter bolts in sequence to 25 N.m (18 lb ft).

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

J 42067 Rear Main Seal Installer

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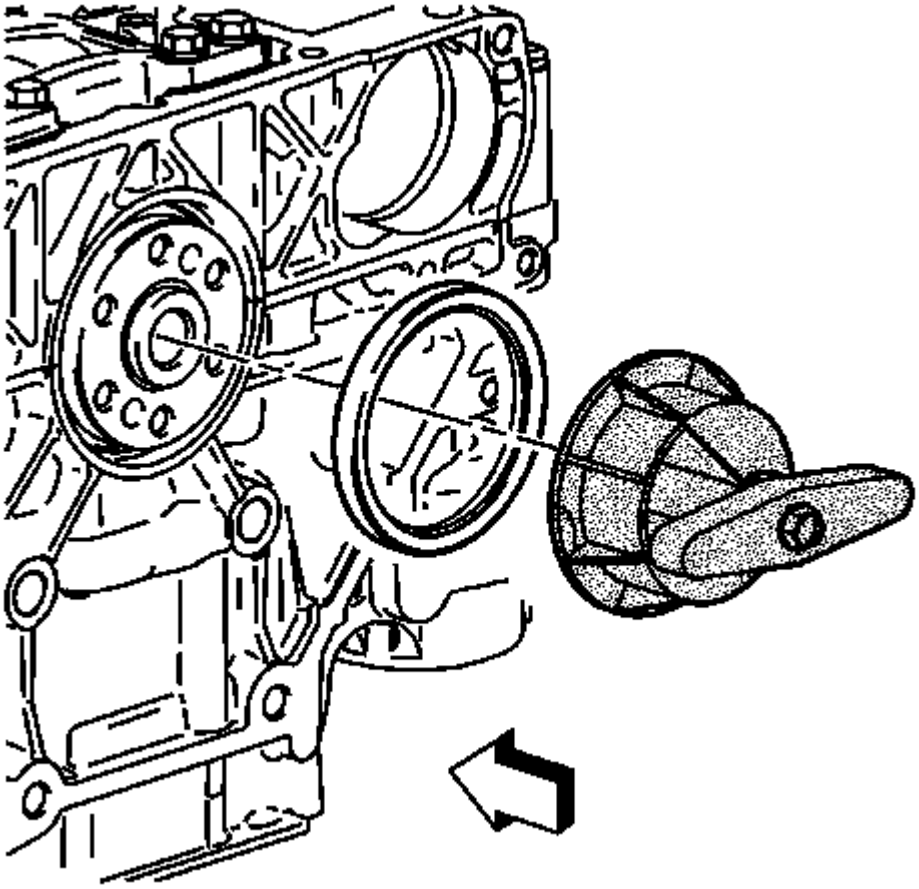

Fig. 547: Installing Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS CORP.

1. Remove excess sealer from seal recess.
2. Make sure the crankshaft rear chamfer is free of grit, loose rust, and burrs. Correct as needed.
3. Apply a very light film of oil onto the crankshaft sealing surface. DO NOT apply oil to the sealing surface of the engine block.
4. 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 (LAP, LE8)

Special Tools

- **J 43953:** Piston Ring Compressor
- **J 45059:** Angle Meter
- **J-43966-1 / J 41742:** Connecting Rod Guides

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

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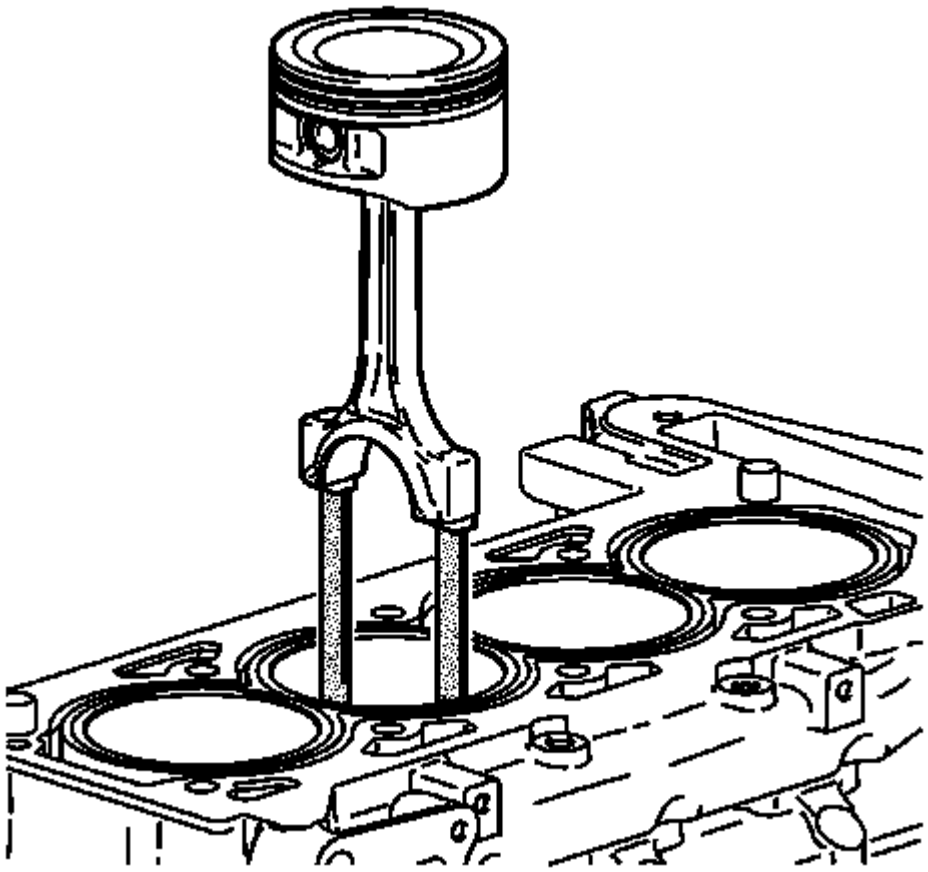

Fig. 548: J-43966-1 Installed Into Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS CORP.

1. Install the connecting rod bearings. Use the proper size 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:** guide / **J 41742:** guide into the connecting rod bolt holes. This protects the crankshaft journal during piston and connecting rod installation.
3. Install the piston and the connecting rod to the correct bore.
    1. Stagger each piston ring end gap equally around the piston.
    2. Lubricate the piston and the piston rings with engine oil.
    3. Install **J 43953:** piston over the piston. 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 **J 43953:** piston against the engine block until all the rings have entered the cylinder bore.
    8. Remove the connecting rod guides from the connecting rod bolt holes.

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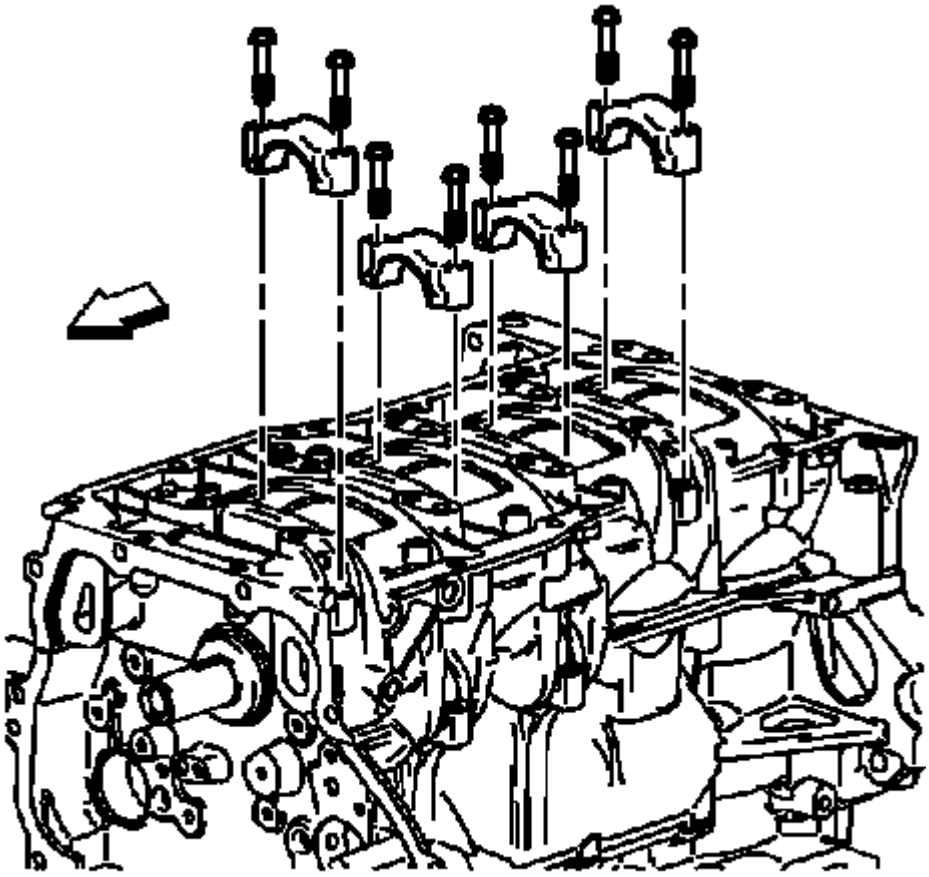

Fig. 549: View Of Connecting Rod Nuts And Caps
Courtesy of GENERAL MOTORS CORP.

NOTE: Ensure that the connecting rod cap is properly oriented on the connecting rod.

4. Install the connecting rod cap.

CAUTION: Refer to Fastener Caution .

5. Install the connecting rod bolts. Always use new bolts. Tighten the connecting rod bolt nuts to 25 N.m (18 lb ft), plus 100 degrees using **J 45059:** meter
6. Install the remaining connecting rods and piston assemblies.

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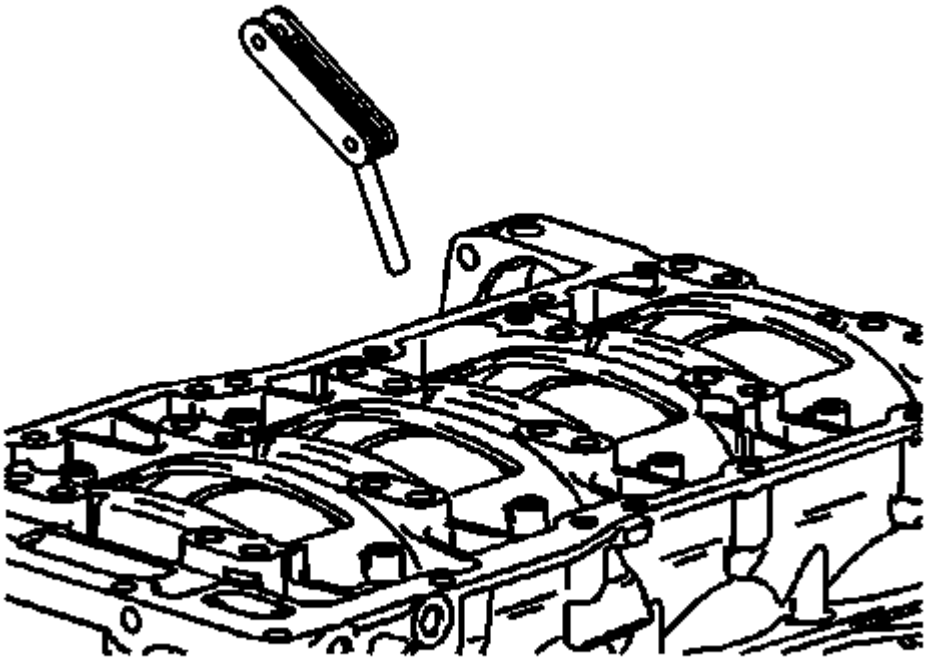

Fig. 550: Measuring Connecting Rod Side Clearance
Courtesy of GENERAL MOTORS CORP.

7. Measure the connecting rod side clearance with a feeler gauge.

   The correct clearance is 0.070-0.370 mm (0.0027-0.0145 in).

CYLINDER HEAD INSTALLATION

Special Tools

J 45059: Angle Meter

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

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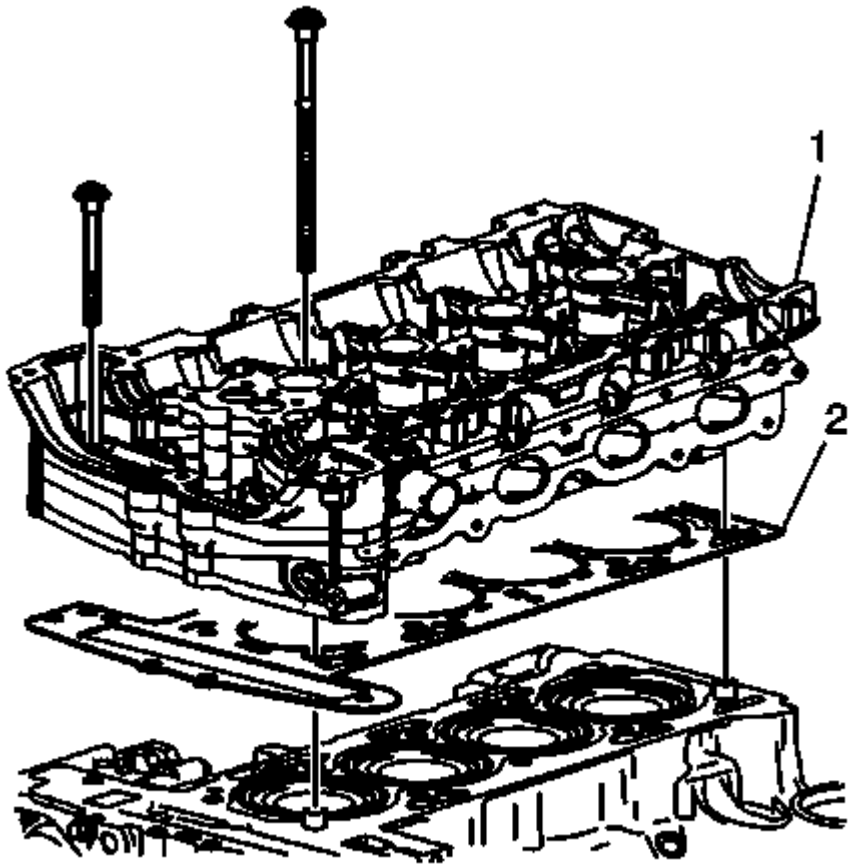

Fig. 551: View of Cylinder Head Gasket and Cylinder Head
Courtesy of GENERAL MOTORS CORP.

NOTE: Do not use any sealing material.

1. Install the cylinder head gasket (2) to the block.
2. Install the cylinder head (1).

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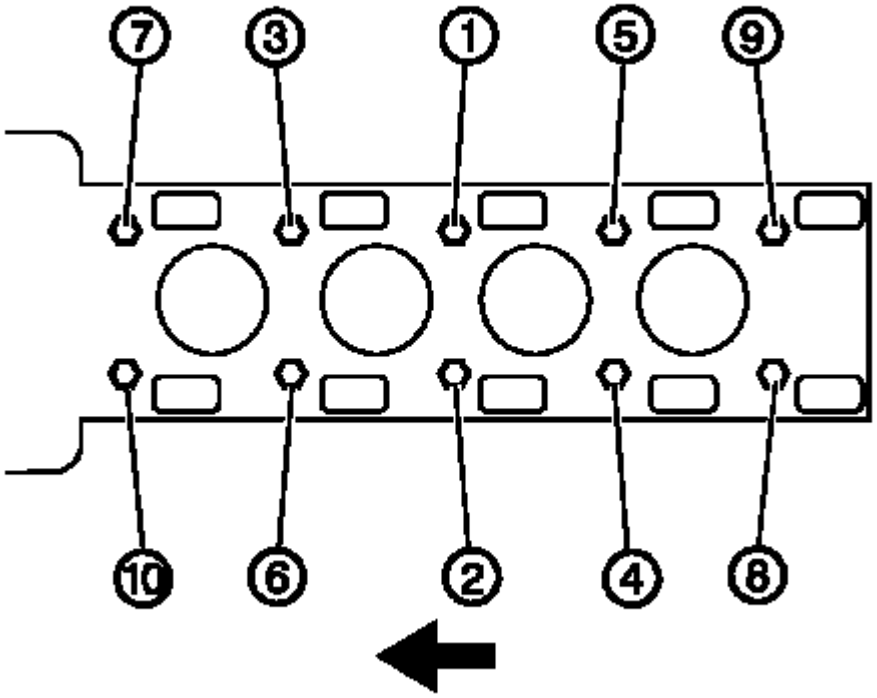

Fig. 552: Identifying Cylinder Head Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: Always use new cylinder head bolts.

3. Install and tighten the cylinder head bolts in sequence.
   - Tighten the bolts to 30 N.m (22 lb ft) .
   - Using the **J 45059:** meter , tighten the bolts an additional 155 degrees in sequence.

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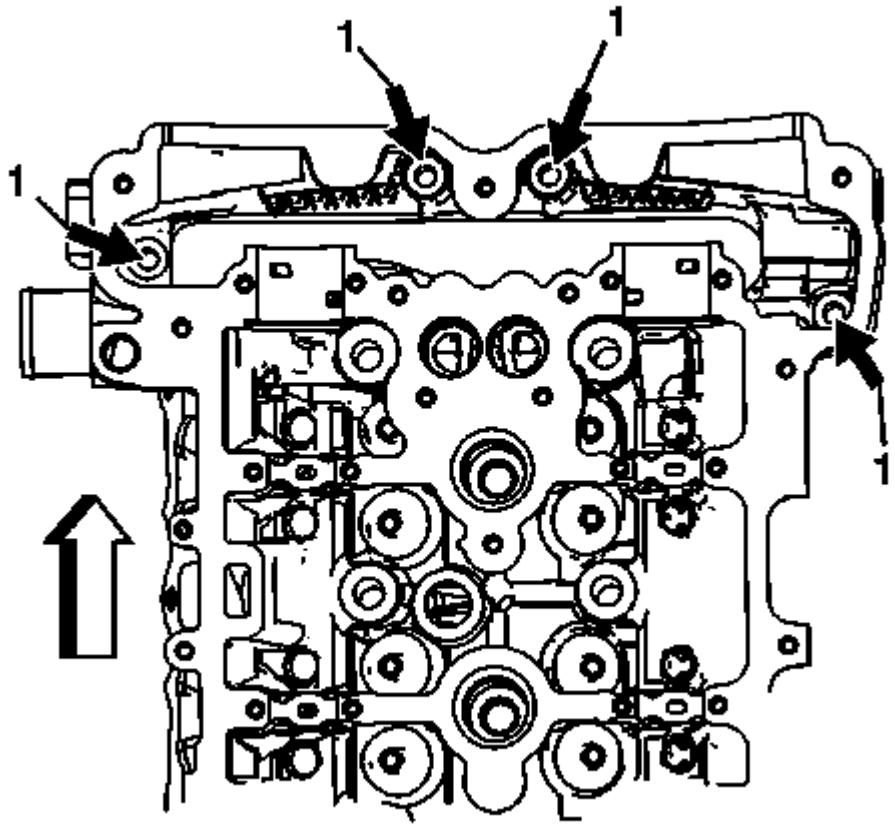

Fig. 553: Identifying Front Cylinder Head Bolts
Courtesy of GENERAL MOTORS CORP.

4. Install the front cylinder head bolts (1) and tighten to 35 N.m (26 lb ft).

INTAKE AND EXHAUST CAMSHAFT, BEARING CAP, AND LASH ADJUSTER INSTALLATION

Exhaust Camshaft Installation

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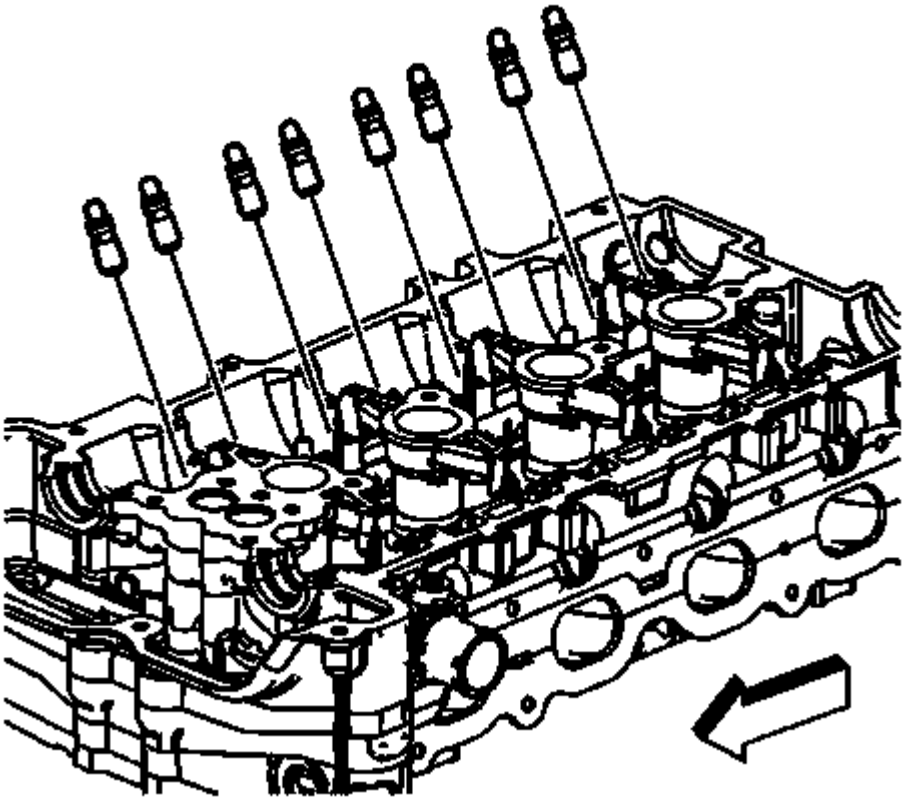

Fig. 554: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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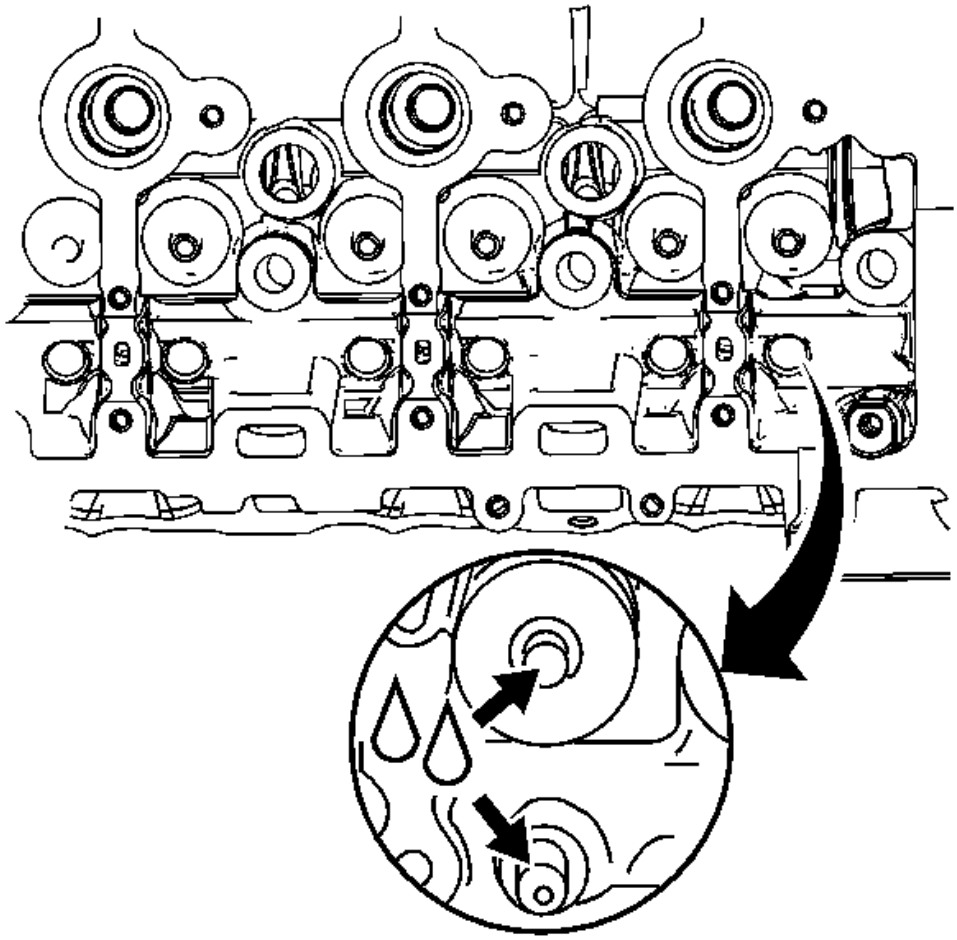

Fig. 555: Valve Tips
Courtesy of GENERAL MOTORS CORP.

2. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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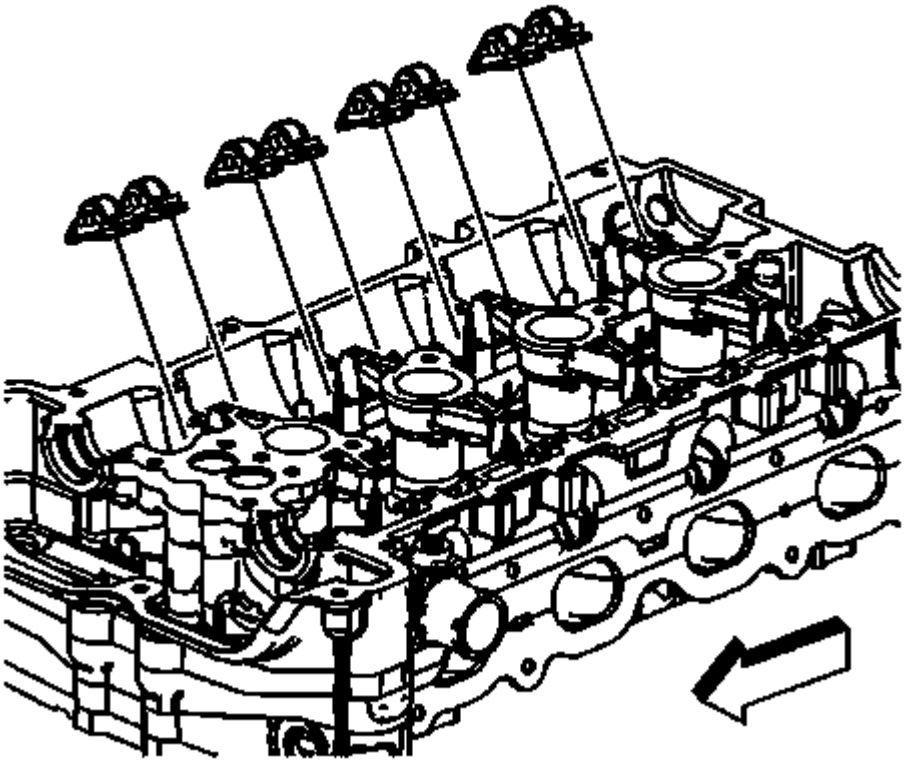

Fig. 556: Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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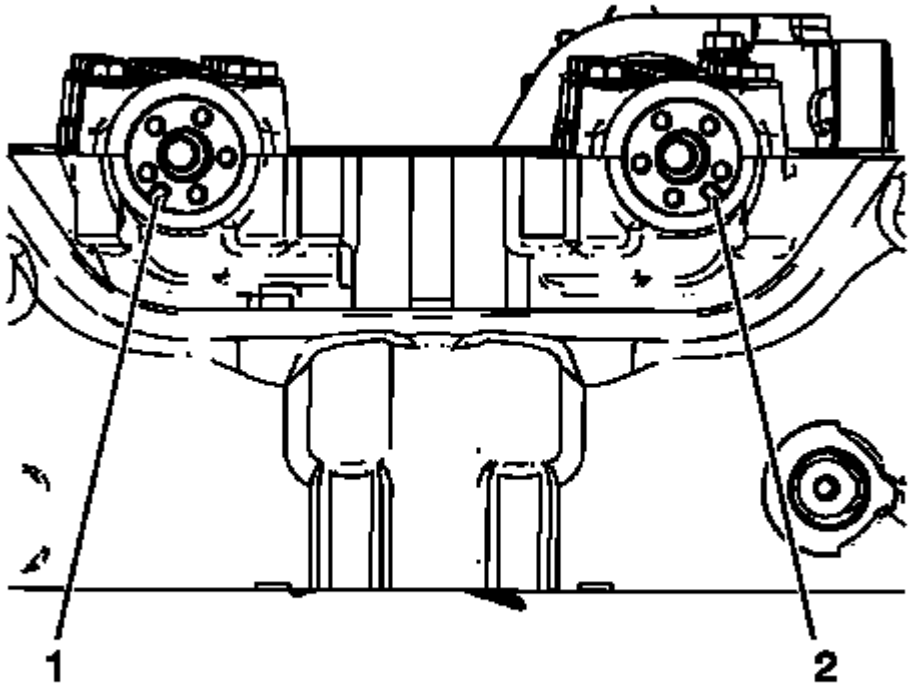

Fig. 557: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

4. When installing the camshafts, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

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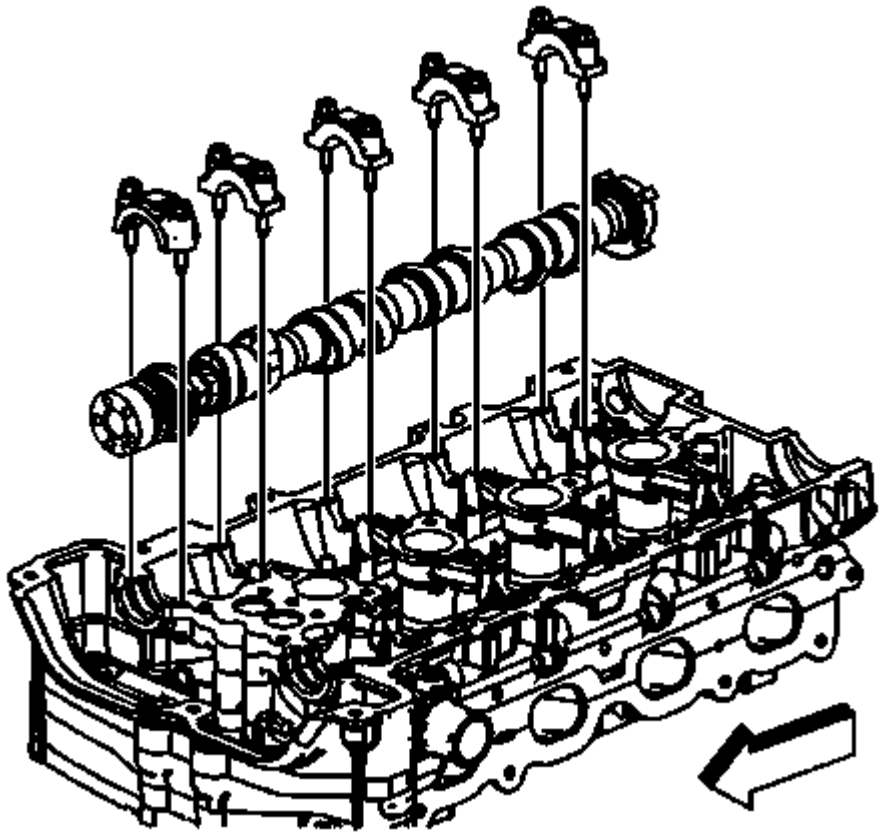

Fig. 558: Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

5. Set the exhaust camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
6. Install the camshaft caps and hand start the camshaft cap bolts.

CAUTION: Refer to Fastener Caution .

7. Tighten the camshaft cap bolts in increments of 3 turns until they are seated, lubricate. Tighten the camshaft caps to 10 N.m (89 lb in).

Intake Camshaft Installation

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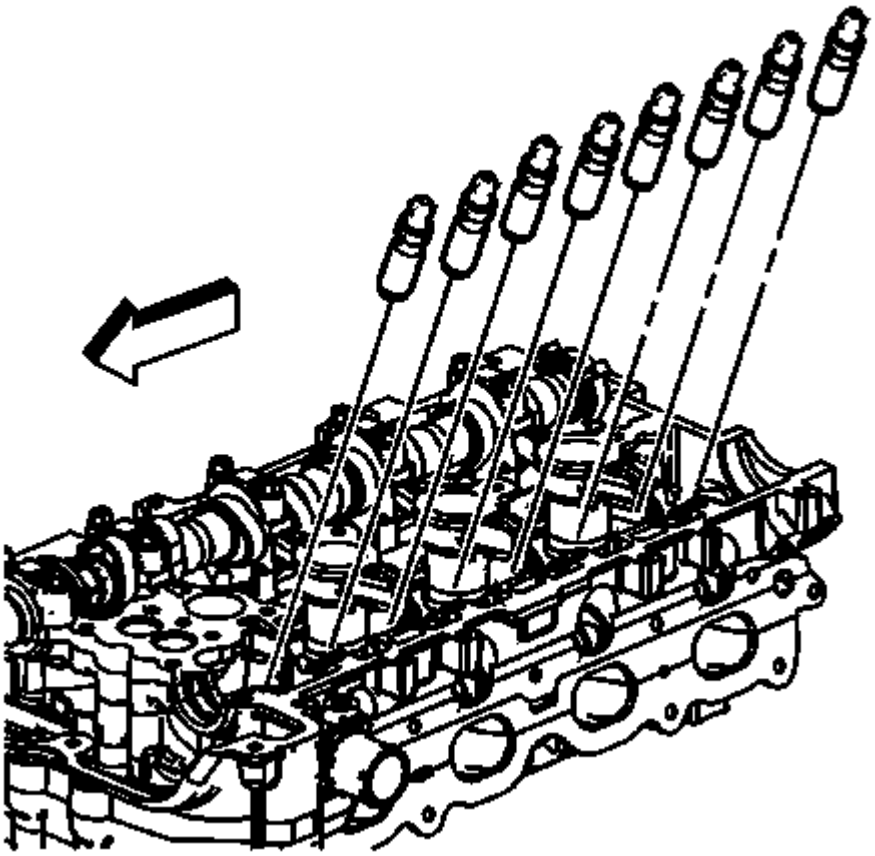

Fig. 559: Hydraulic Lash Adjusters
Courtesy of GENERAL MOTORS CORP.

1. Install the hydraulic lash adjusters into their bores in the cylinder head.
2. Lubricate the hydraulic lash adjusters. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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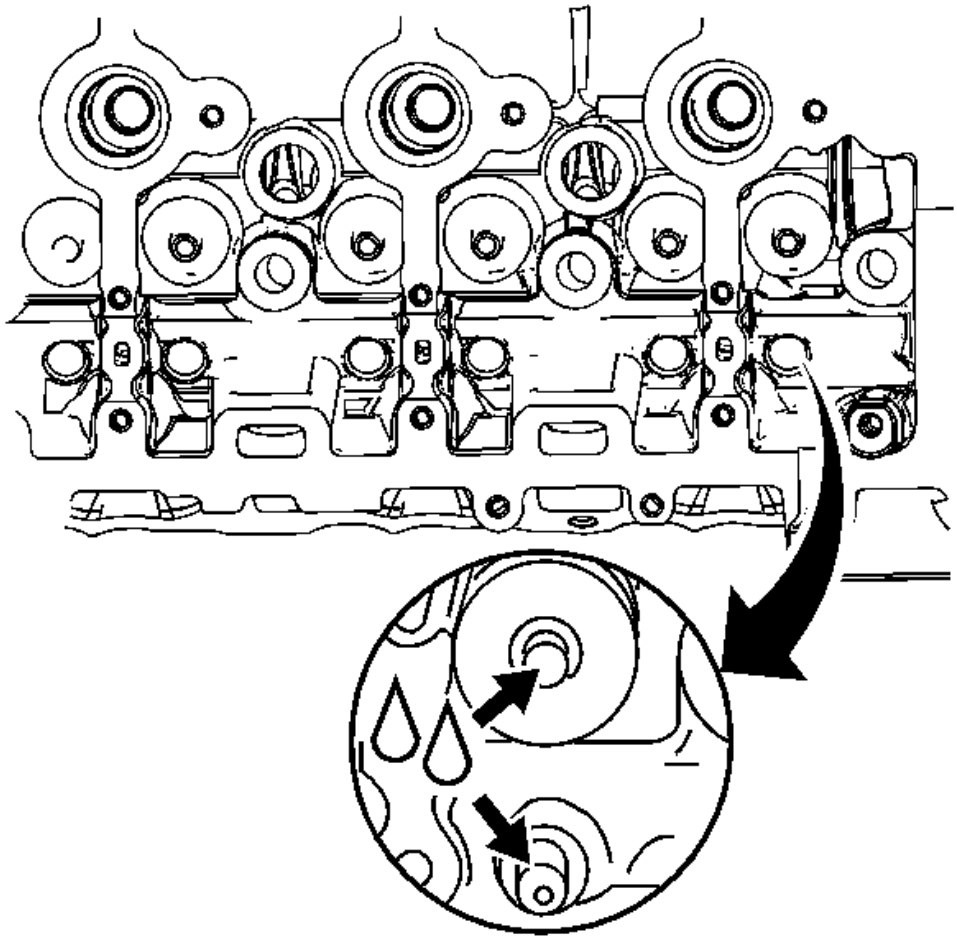

Fig. 560: Valve Tips
Courtesy of GENERAL MOTORS CORP.

3. Lubricate the valve tips. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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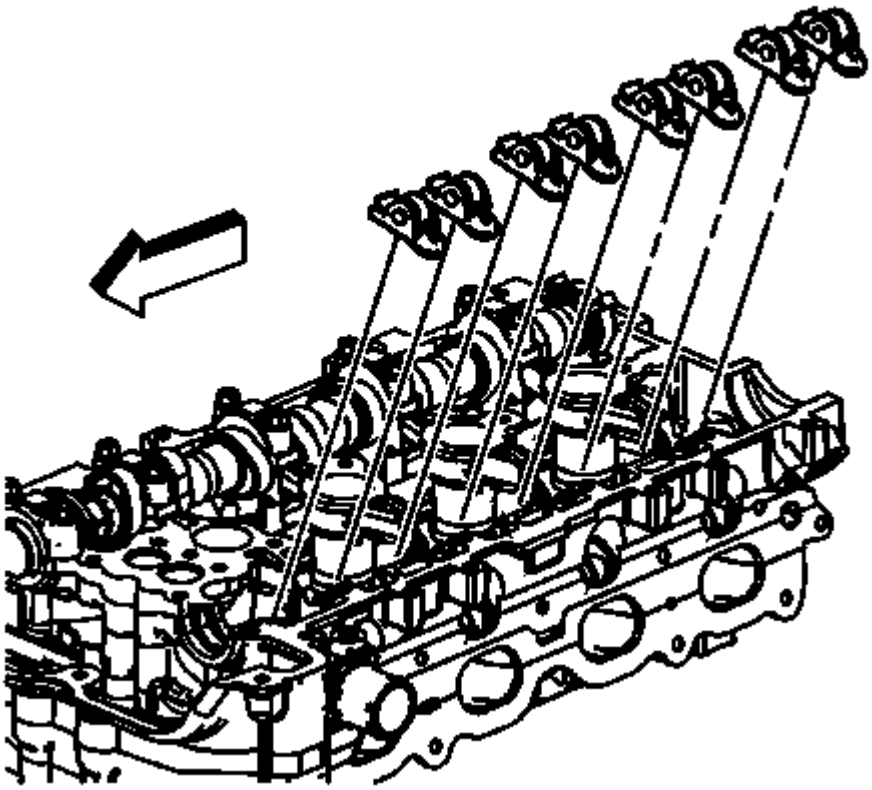

Fig. 561: Identifying Camshaft Roller Finger Followers
Courtesy of GENERAL MOTORS CORP.

NOTE: 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. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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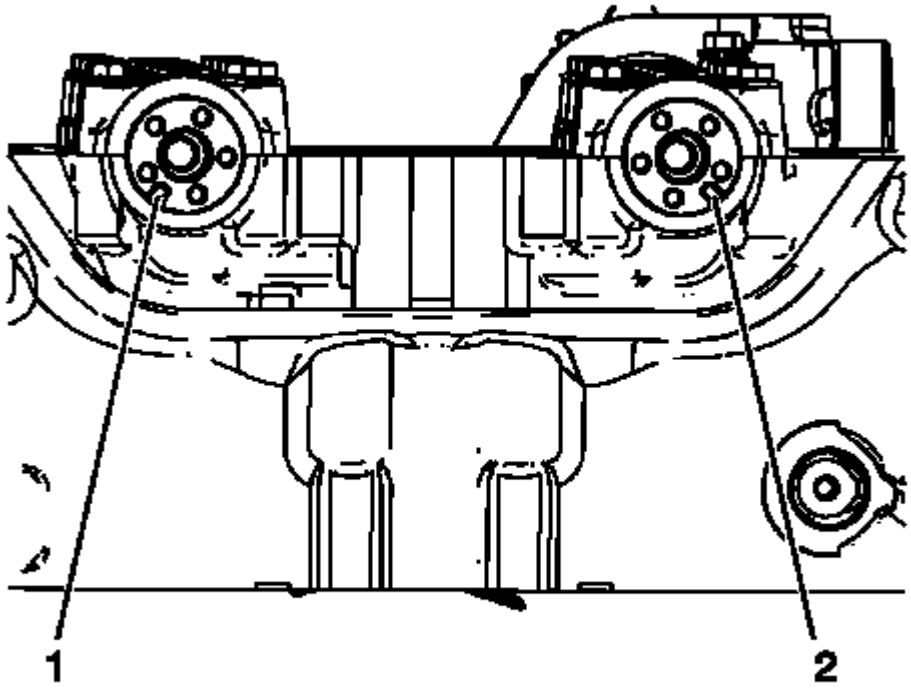

Fig. 562: Identifying Proper Exhaust/Intake Camshaft Alignment positions
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

5. When installing the camshafts, ensure the intake camshaft notch is in the 5 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12 o'clock.

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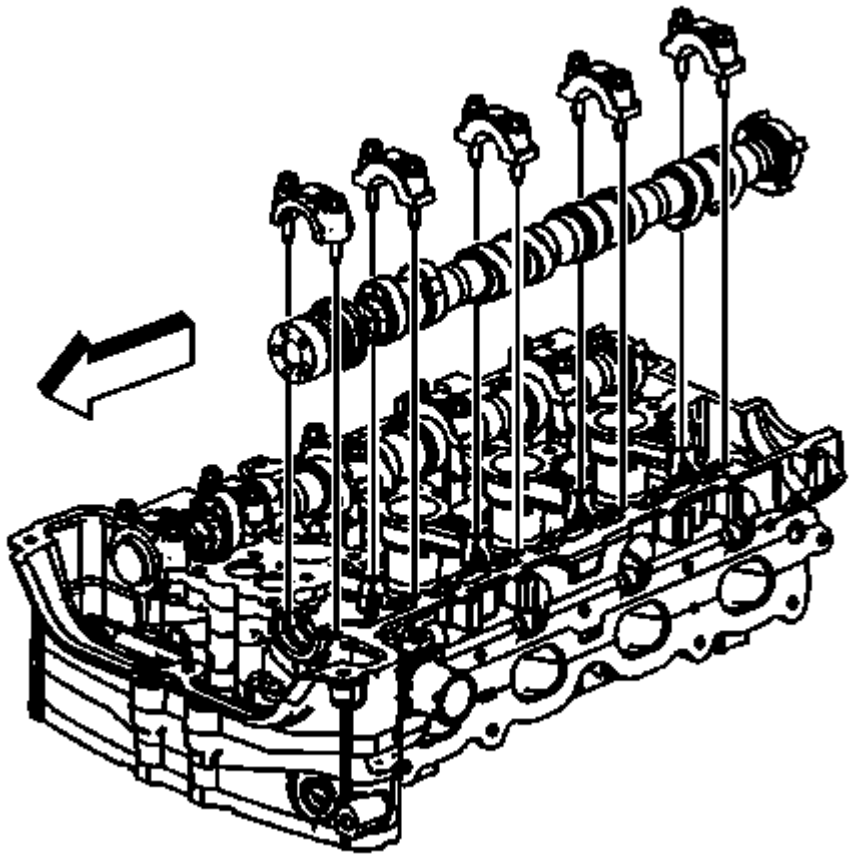

Fig. 563: Camshaft Caps
Courtesy of GENERAL MOTORS CORP.

6. Set the intake camshaft on top of the roller followers in the camshaft bearing journals and lubricate. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
7. Install the camshaft caps and hand start the camshaft cap bolts.
8. Tighten the camshaft cap bolts in increments of 3 turns until they are seated. Tighten the camshaft caps to 10 N.m (89 lb in).

BALANCE SHAFT INSTALLATION

Special Tools

EN-43650: Balance Shaft Bushing Remover/Installer

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

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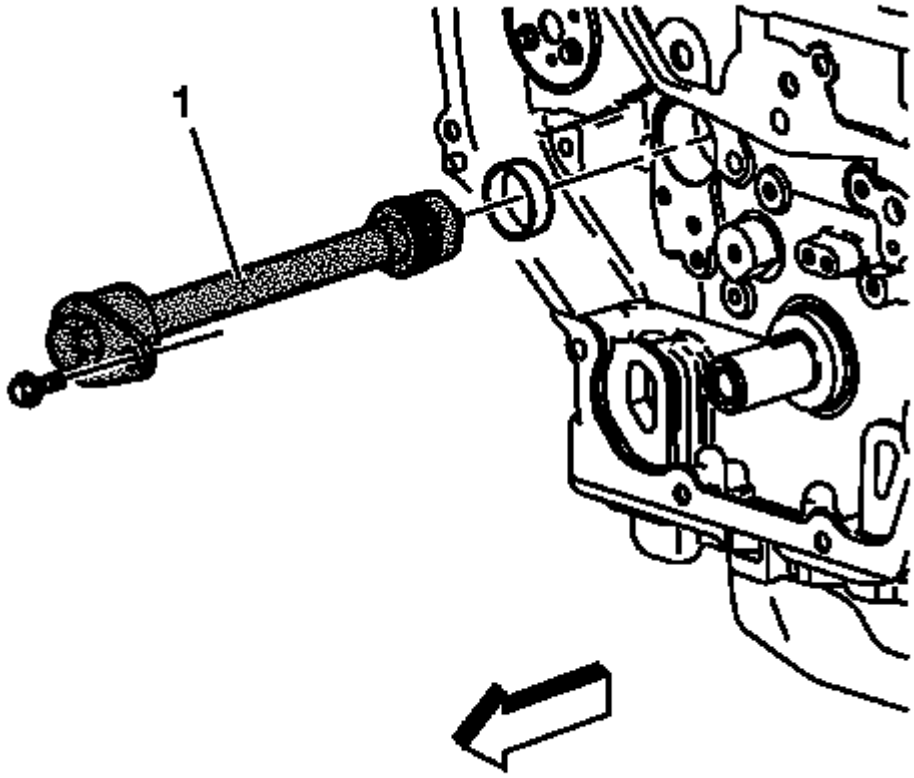

Fig. 564: View of Balance Shaft Bushing and EN-43650 Installer
Courtesy of GENERAL MOTORS CORP.

1. Install the balance shaft bushing using the **EN-43650:** installer (1).

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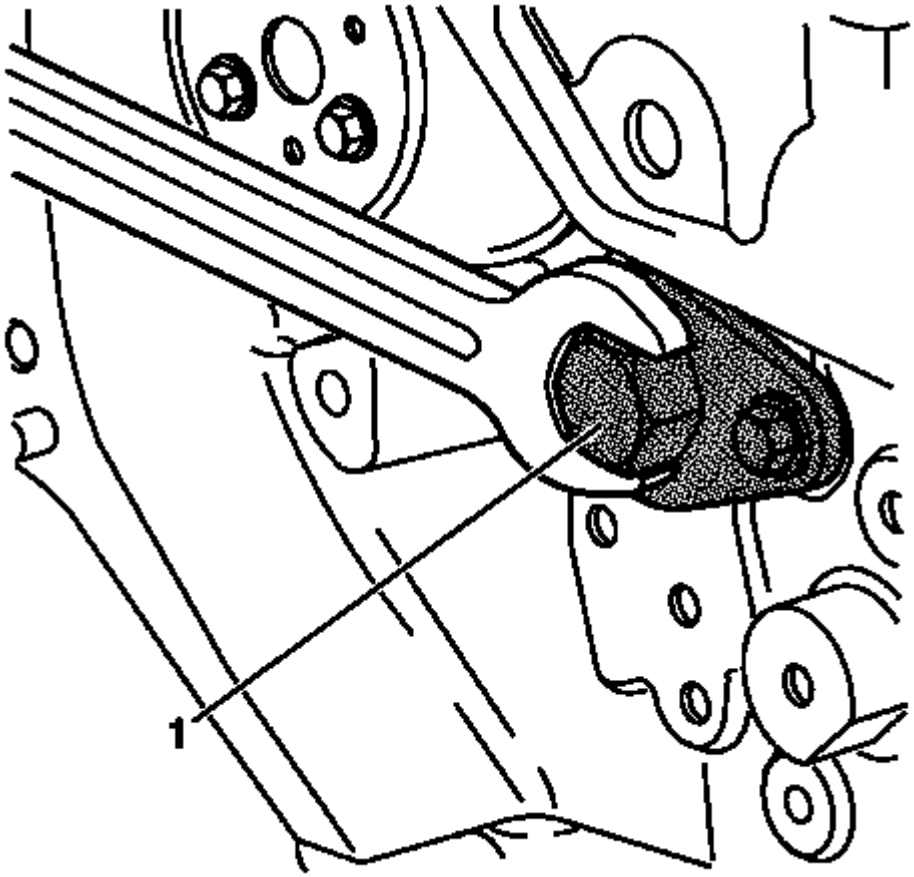

Fig. 565: Seat Balance Shaft Bushing Into Bore Using EN-43650
Courtesy of GENERAL MOTORS CORP.

2. Seat the balance shaft bushing into the bore using the **EN-43650:** installer (1) and a wrench.
3. When the **EN-43650:** installer is fully seated in the engine block, remove it with a wrench.

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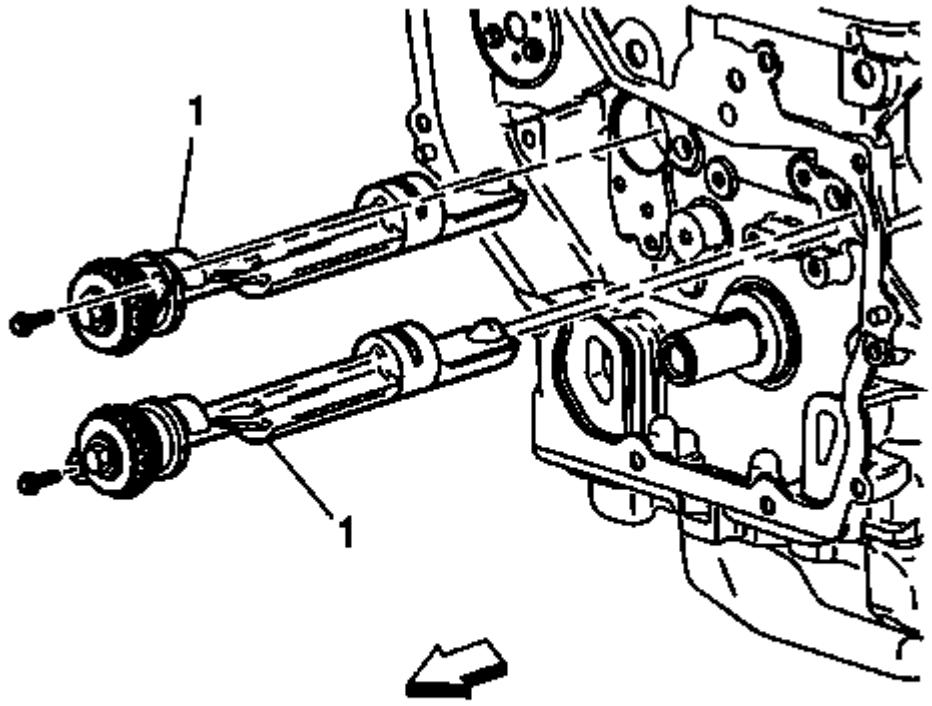

Fig. 566: View of Balance Shaft Bolts
Courtesy of GENERAL MOTORS CORP.

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

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 (1) into their bores.

CAUTION: Refer to Fastener Caution .

7. Install the balance shaft retaining bolts and tighten to 10 N.m (89 lb in).

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.

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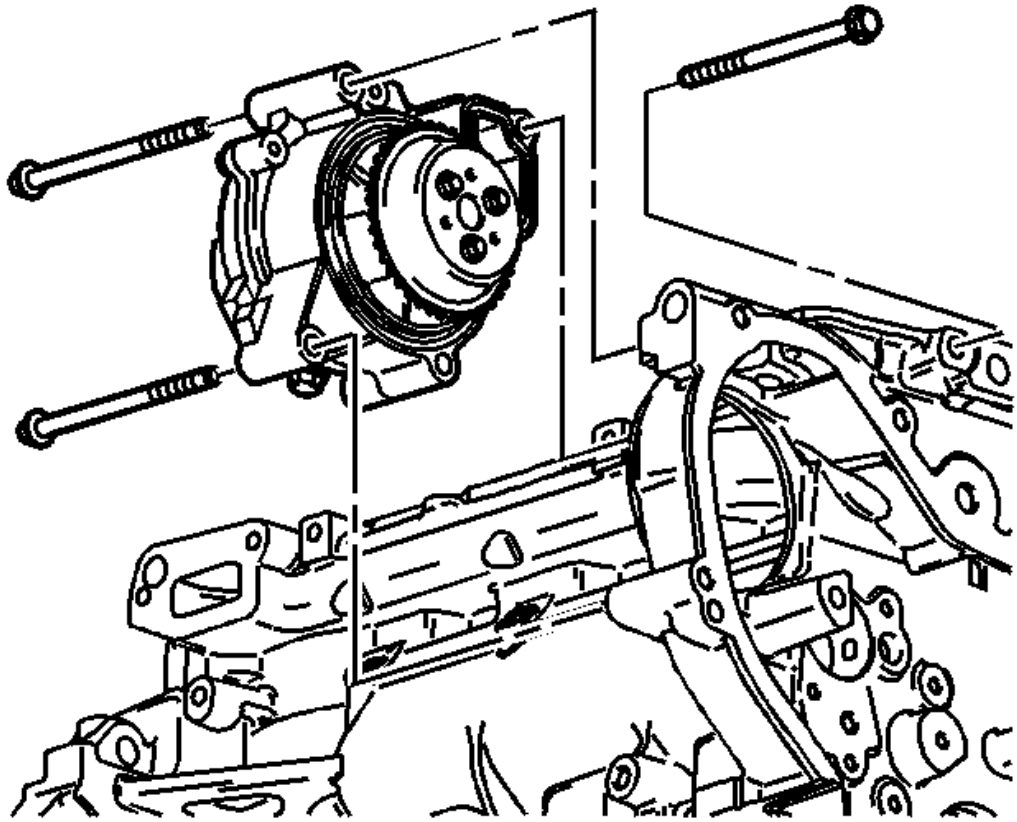

Fig. 567: View Of Water Pump Assembly
Courtesy of GENERAL MOTORS CORP.

1. Install the water pump assembly.
2. Install the water pump bolts. Finger tighten the bolts.

CAUTION: Refer to Fastener Caution .

3. Tighten the water pump bolts to 25 N.m (18 lb ft).
4. Apply sealant to the water pump drain plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
5. Install the water pump drain plug, if necessary. Tighten to 20 N.m (15 lb ft).

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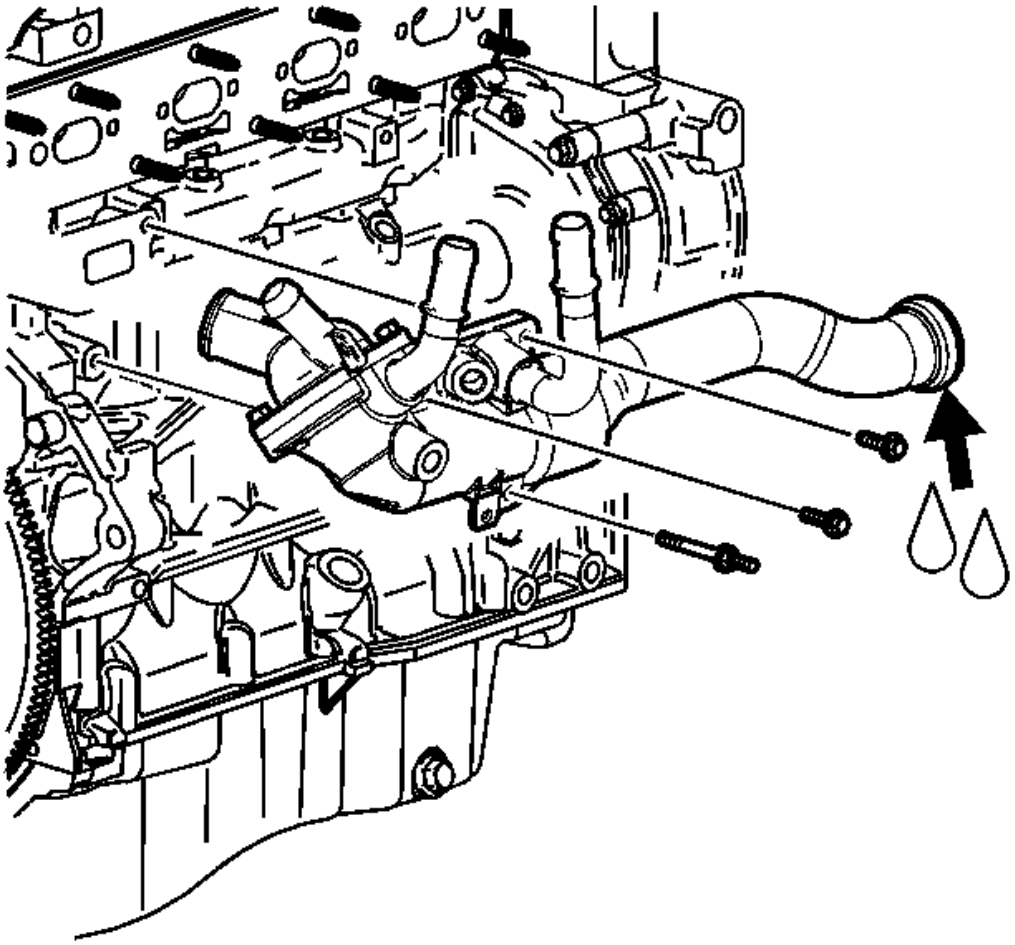

Fig. 568: View Of Water Feed Tube
Courtesy of GENERAL MOTORS CORP.

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 and tighten to 10 N.m (89 lb in).

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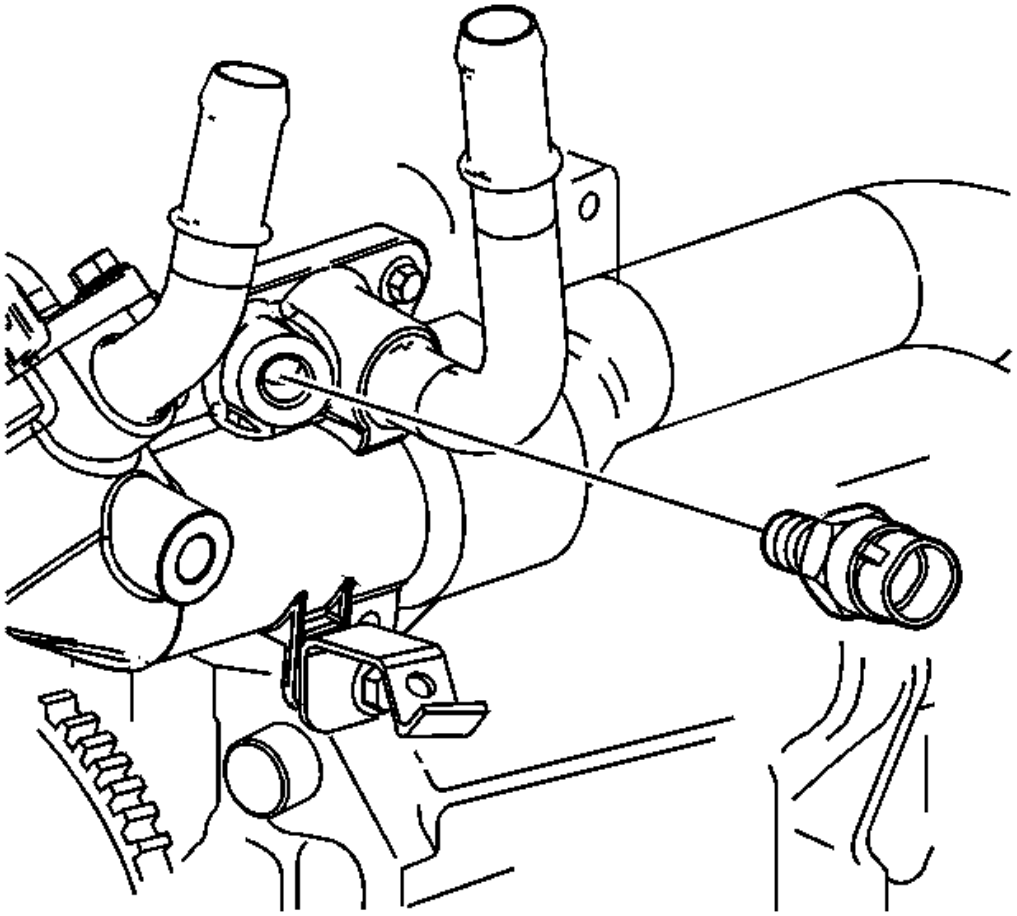

Fig. 569: Locating Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS CORP.

10. Install the engine coolant temperature sensor by hand.
11. Tighten the engine coolant temperature sensor and tighten to 20 N.m (15 lb ft).

BALANCE SHAFT TO ENGINE TIMING

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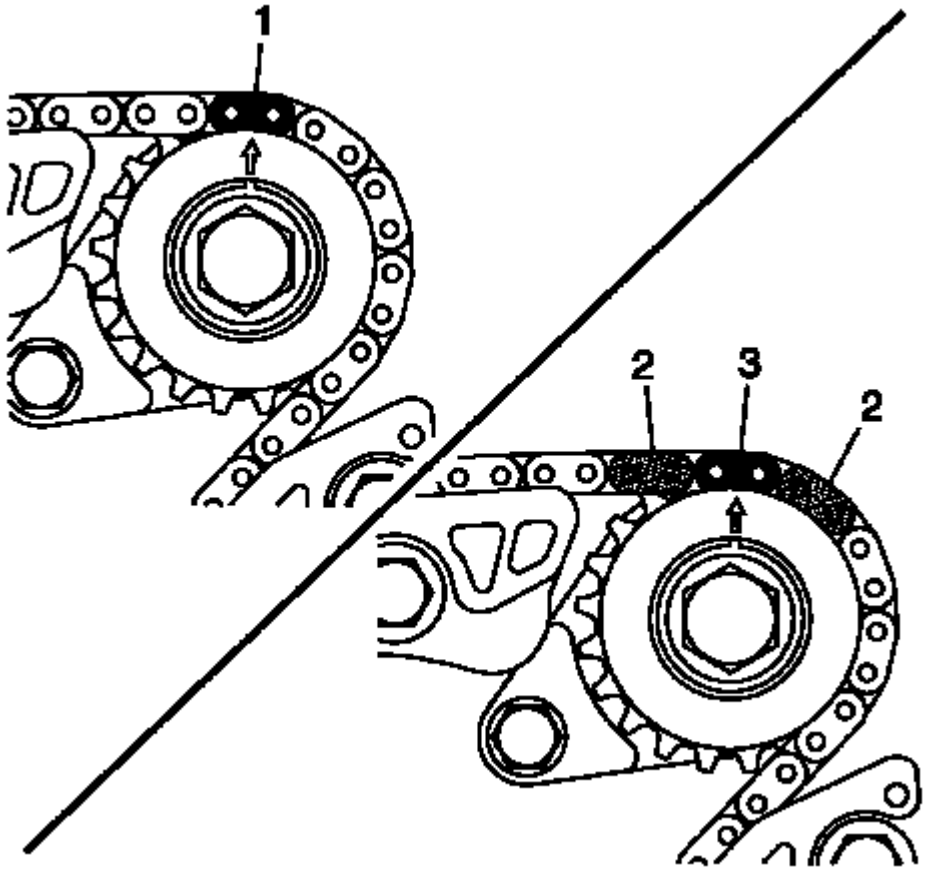

Fig. 570: Using Unique Chain Link to Line Up With The Intake Side Balance Shaft Sprocket Timing Mark
Courtesy of GENERAL MOTORS CORP.

NOTE: There are two possible chain configurations for the engine. Both configurations use a unique chain link to line up with the intake side balance shaft sprocket timing mark. The first design uses a unique link color (1). The second design uses a black anodized link (3) with uniquely colored links on either side (2).

1. Determine the configuration of the balance chain.

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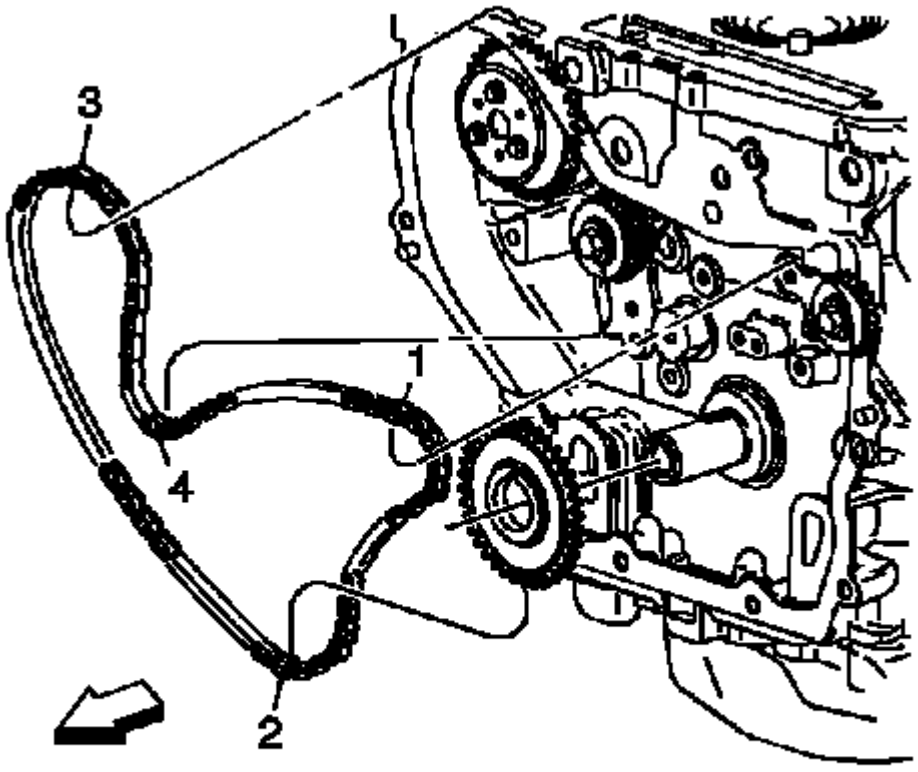

Fig. 571: Aligning Balance Shaft Drive Chain
Courtesy of GENERAL MOTORS CORP.

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

2. Install the balance shaft drive sprocket.
3. For the 1st design balance chain, install the balance shaft drive chain with the colored links lined up 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:
    1. Orient the chain so that the colored links are visible.
    2. Place the uniquely colored link (1) so that it lines up with the timing mark on the intake side balance shaft sprocket.
    3. 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.
    4. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
    5. Align the last matching colored link (4) with the timing mark on the exhaust side balance shaft drive sprocket.

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4. For the 2nd design balance chain, install the balance shaft drive chain with the black anodized links lined up with the marks on the balance shaft drive sprockets and the crankshaft sprocket. There are three timing links with a black anodized finish on the chain. One black anodized link has uniquely colored links on either side. Use the following procedure to line up the links with the sprockets:
    1. Orient the chain so that the colored links are visible.
    2. Place the black anodized link (1), with uniquely colored links on either side, so that it lines up with the timing mark on the intake side balance shaft sprocket.
    3. Working clockwise around the chain, place the next black anodized link (2) in line with the timing mark on the crankshaft drive sprocket, approximately 6 o'clock position on the crank sprocket.
    4. Place the chain (3) on the water pump drive sprocket. The alignment is not critical.
    5. Align the last black anodized link (4) with the timing mark on the exhaust side balance shaft drive sprocket.

WATER PUMP AND BALANCE SHAFT CHAIN AND TENSIONER INSTALLATION

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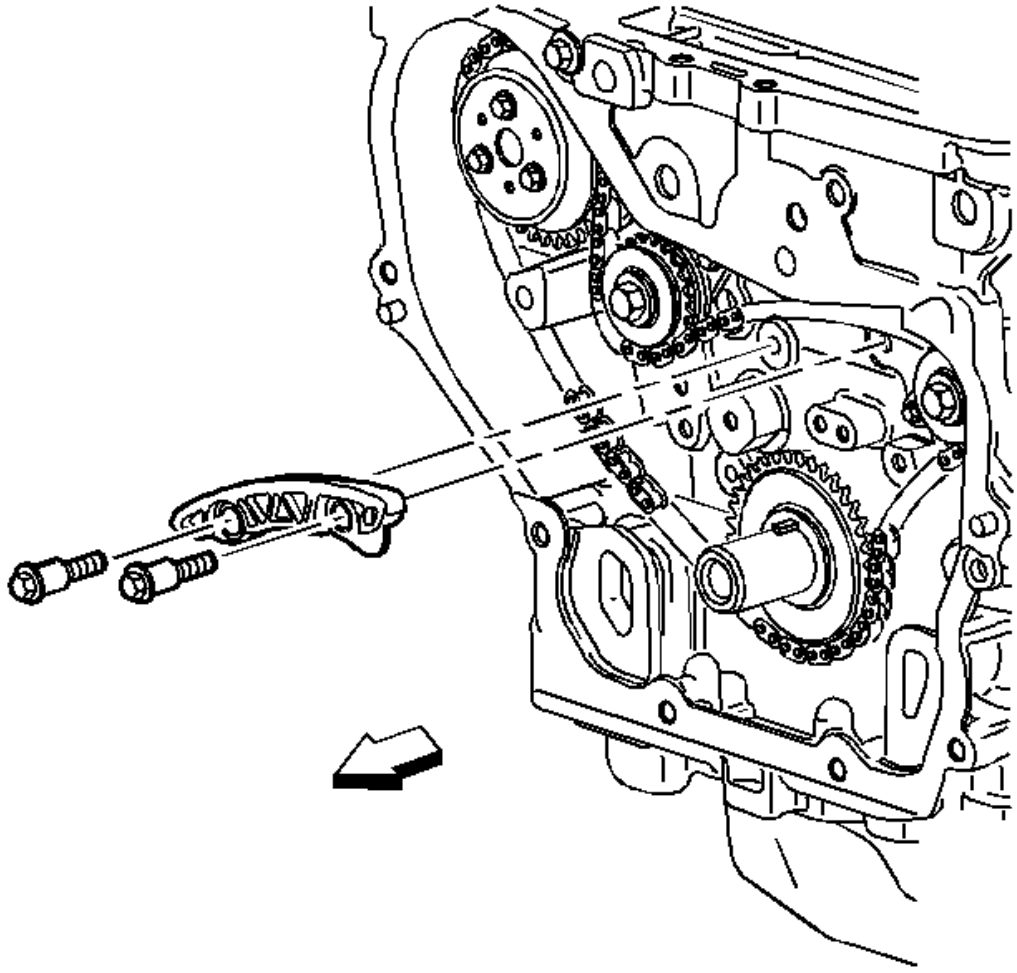

Fig. 572: View Of Upper Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: 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 and tighten to 15 N.m (11 lb ft).

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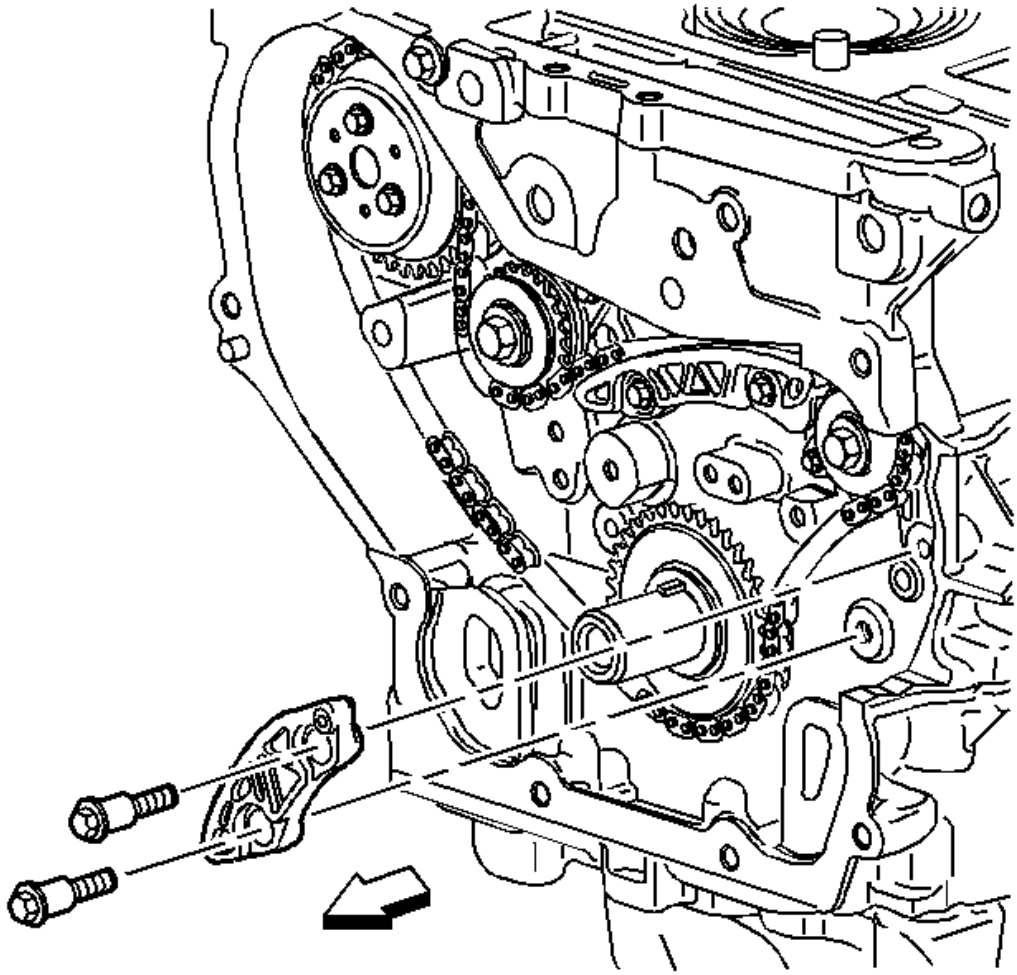

Fig. 573: Exploded View Of Small Balance Shaft Drive Chain Guide
Courtesy of GENERAL MOTORS CORP.

2. Install the small balance shaft chain guide.
3. Install the balance shaft chain guide bolts and tighten to 15 N.m (11 lb ft).

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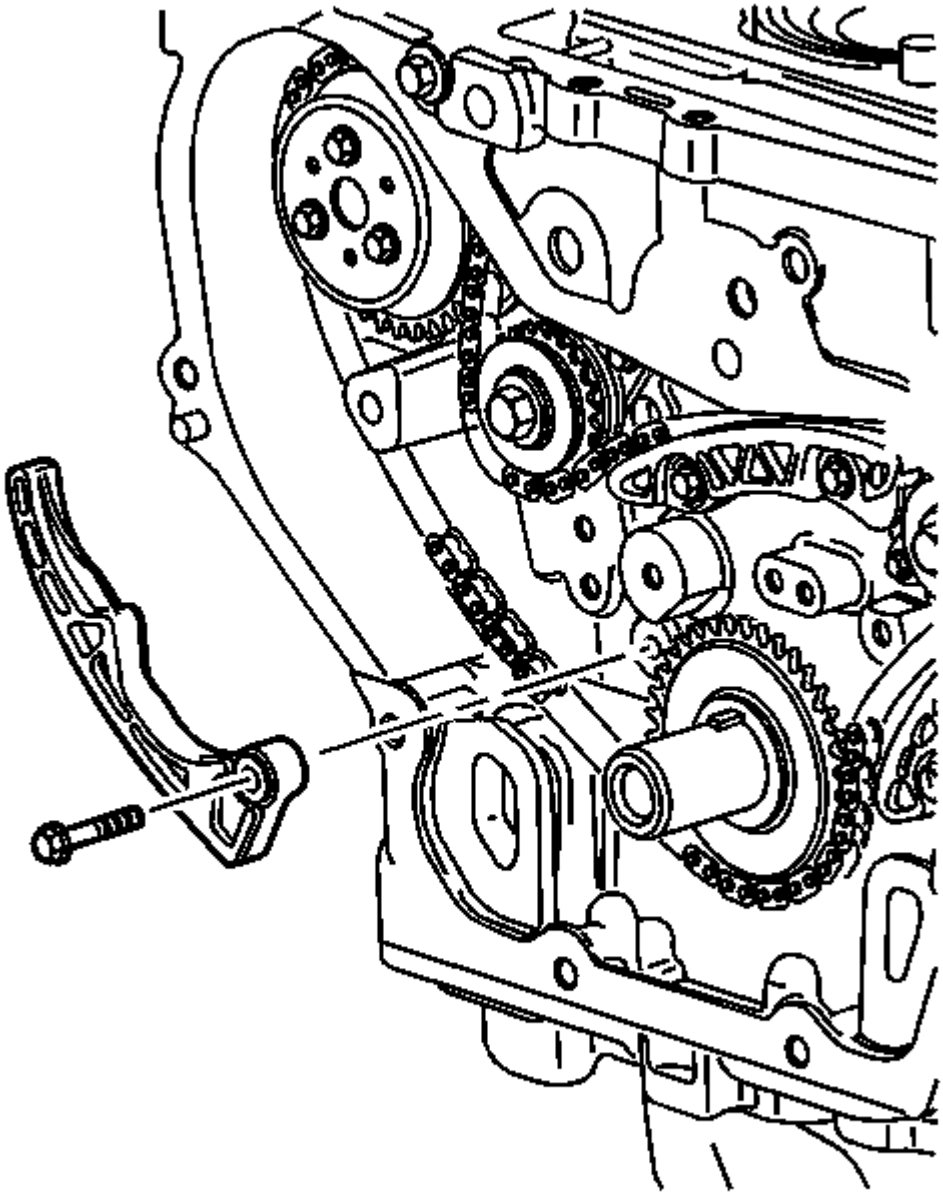

Fig. 574: View Of Adjustable Balance Shaft Chain Guide
Courtesy of GENERAL MOTORS CORP.

4. Install the adjustable balance shaft drive chain guide.
5. Install the adjustable balance shaft drive chain guide bolts and tighten to 10 N.m (89 lb in).

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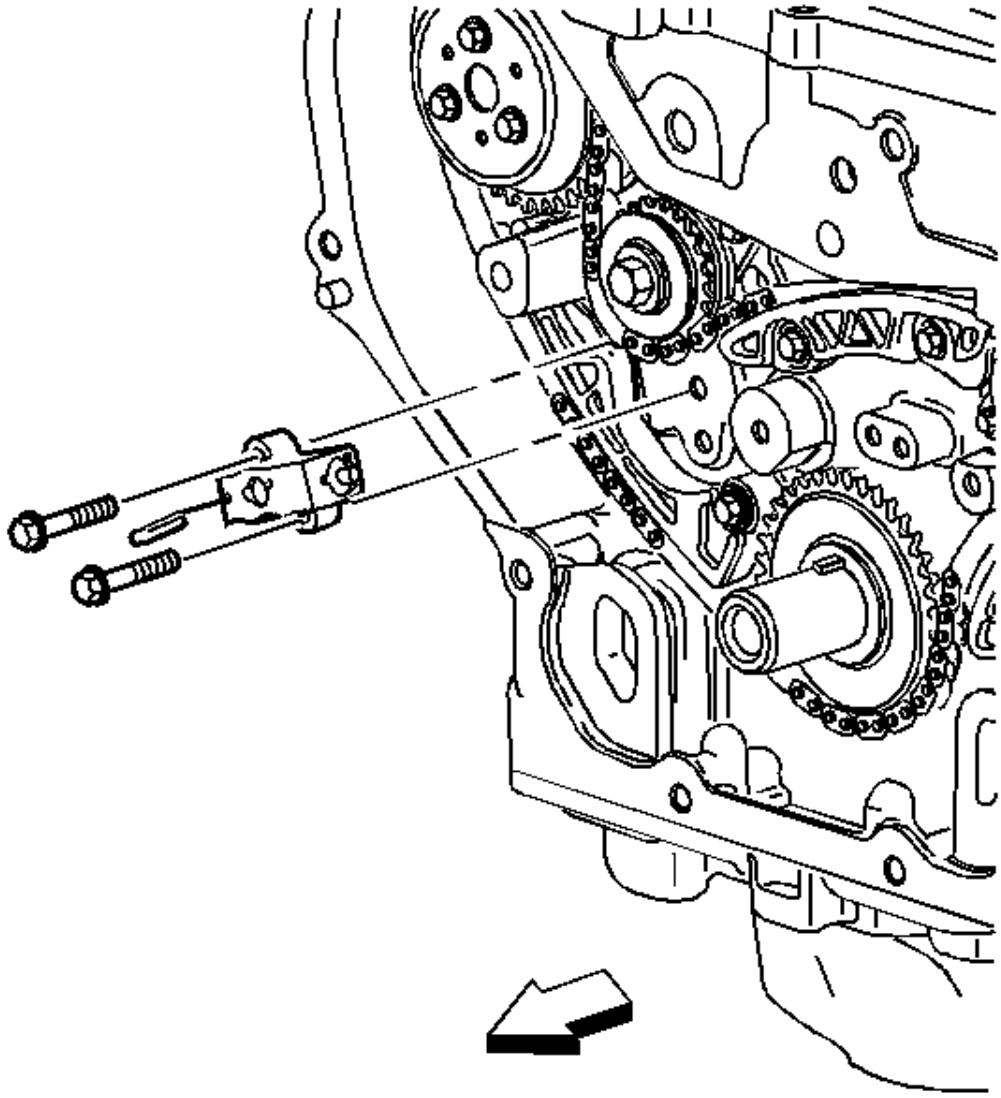

Fig. 575: View Of Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

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.
7. Install the timing chain tensioner.

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8. Install the chain tensioner bolts and tighten to 10 N.m (89 lb in).
9. Remove the paper clip from the balance shaft drive chain tensioner.

CAMSHAFT TIMING CHAIN, SPROCKET, AND TENSIONER INSTALLATION (LAP, LE8)

Special Tools

- **EN-45027:** Tensioner Tool
- **EN-48953:** Camshaft Actuator Locking Tool
- **J 45059:** Angle Meter

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

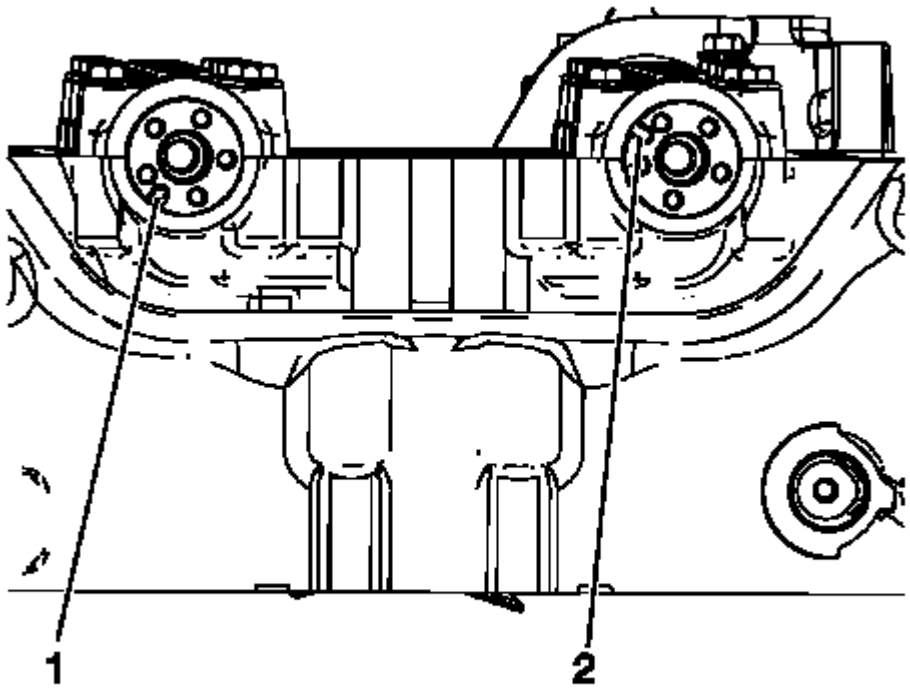

Fig. 576: Camshaft Notches (2.2L)
Courtesy of GENERAL MOTORS CORP.

NOTE: The engine is timed top-dead center exhaust stroke.

1. Ensure the intake camshaft notch is in the 10 o'clock position (2) and the exhaust camshaft notch is in the 7 o'clock position (1). The number 1 piston should be at top dead center (TDC), crankshaft key at 12

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o'clock.

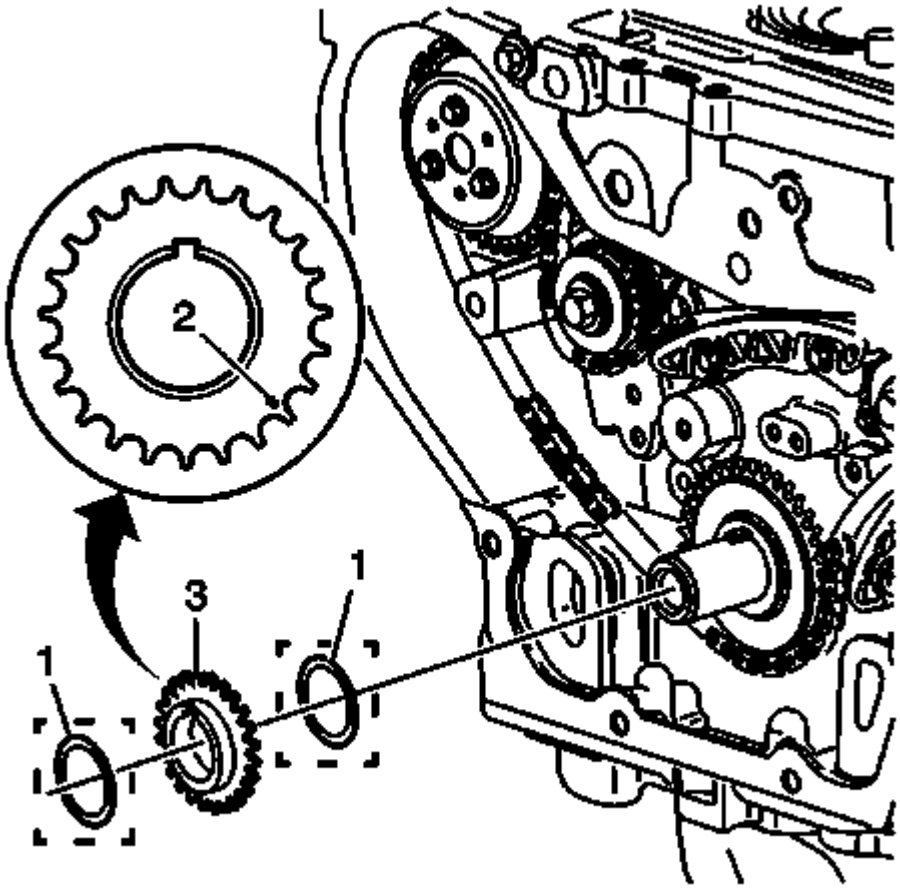

Fig. 577: View of Friction Washer and Timing Chain Drive Sprocket
Courtesy of GENERAL MOTORS CORP.

2. Install a friction washer (1), if equipped.
3. Install the timing chain drive sprocket (3) to the crankshaft with the timing mark (2) in the 5 o'clock position and the front of the sprocket facing out.
4. Install a second friction washer (1), if equipped.

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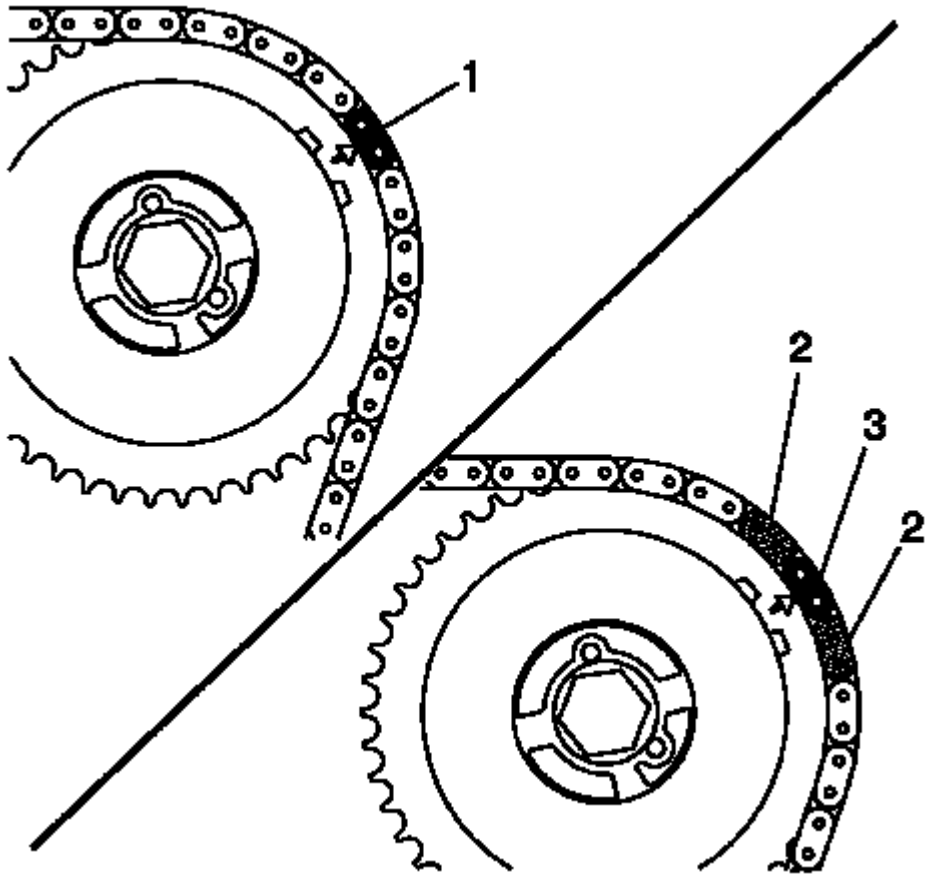

Fig. 578: Using Two Possible Chain Configurations For The Engine
Courtesy of GENERAL MOTORS CORP.

NOTE: There are two possible chain configurations for the engine. Both configurations use a unique chain link to line up with the intake camshaft actuator timing mark. The first design uses a unique link color (1). The second design uses a black anodized link (3) with uniquely colored links on either side (2).

5. Orient the chain so that the colored links are visible.
6. Determine the configuration of the timing chain.
7. For the 1st design timing chain, assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the uniquely colored link (1).
8. For the 2nd design timing chain, assemble the intake camshaft actuator into the timing chain with the timing mark lined up with the black anodized timing link (3) that has uniquely colored links on either side (2).

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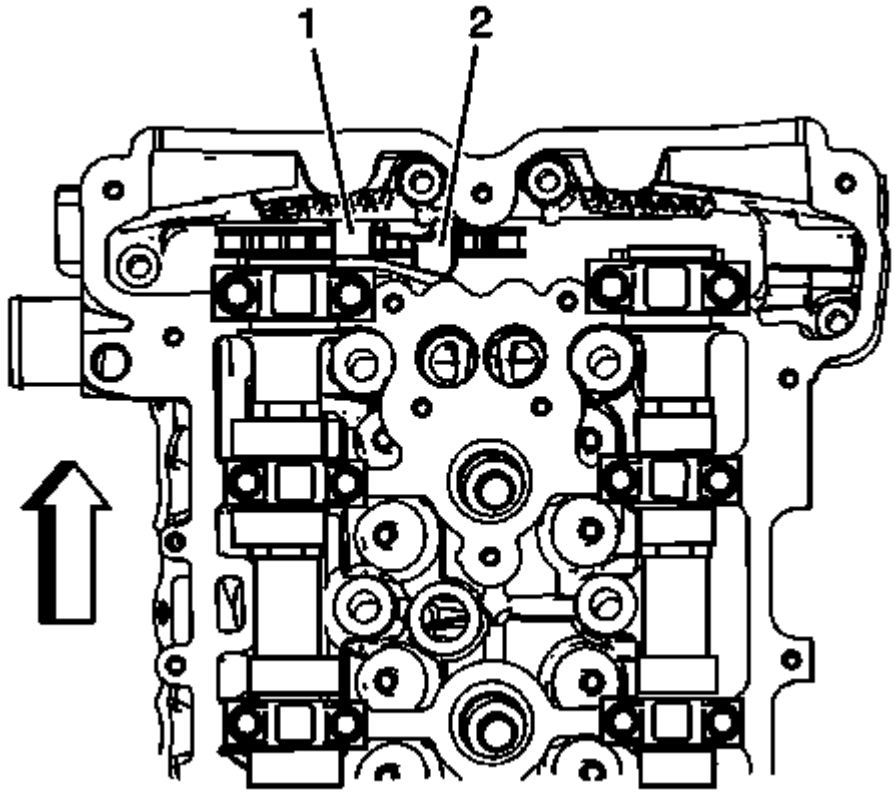

Fig. 579: Identifying Cylinder Head Opening
Courtesy of GENERAL MOTORS CORP.

9. 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).
10. Install the intake camshaft actuator onto the intake camshaft while aligning the dowel pin into the camshaft slot.

NOTE: Always use NEW actuator bolts.

11. Hand tighten the new intake camshaft actuator bolt.

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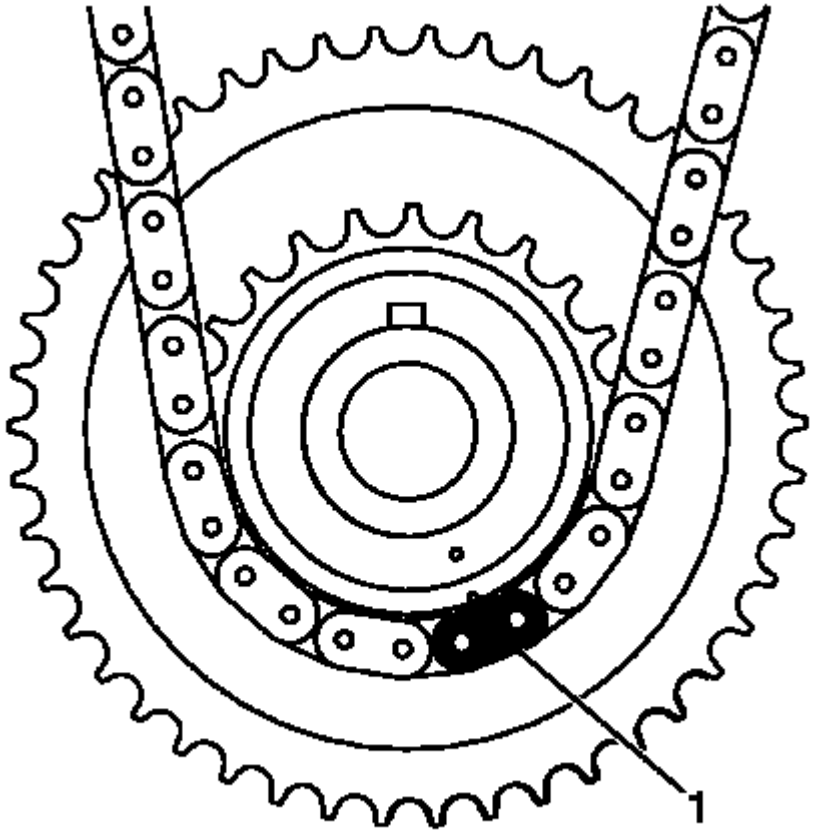

Fig. 580: Identifying Timing Mark on Crankshaft Sprocket and Lining Up With First Matching Colored Link
Courtesy of GENERAL MOTORS CORP.

12. Route the timing chain around the crankshaft sprocket and line up the colored link (1) with the timing mark on the crankshaft sprocket, in approximately the 5 o'clock position.

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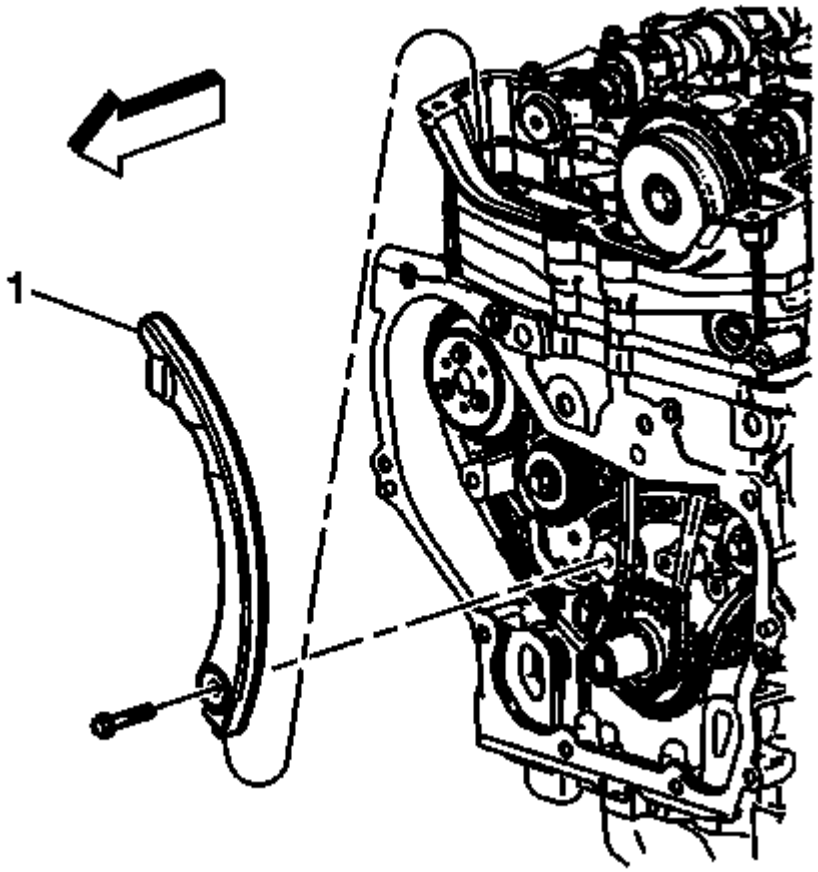

Fig. 581: View of Adjustable Timing Chain Guide Bolt.
Courtesy of GENERAL MOTORS CORP.

13. Rotate the crankshaft clockwise to remove all chain slack. Do not rotate the intake camshaft.

CAUTION: Refer to Fastener Caution .

14. Install the adjustable timing chain guide (1) down through the opening in the cylinder head and install the adjustable timing chain bolt and tighten to 10 N.m (89 lb in).

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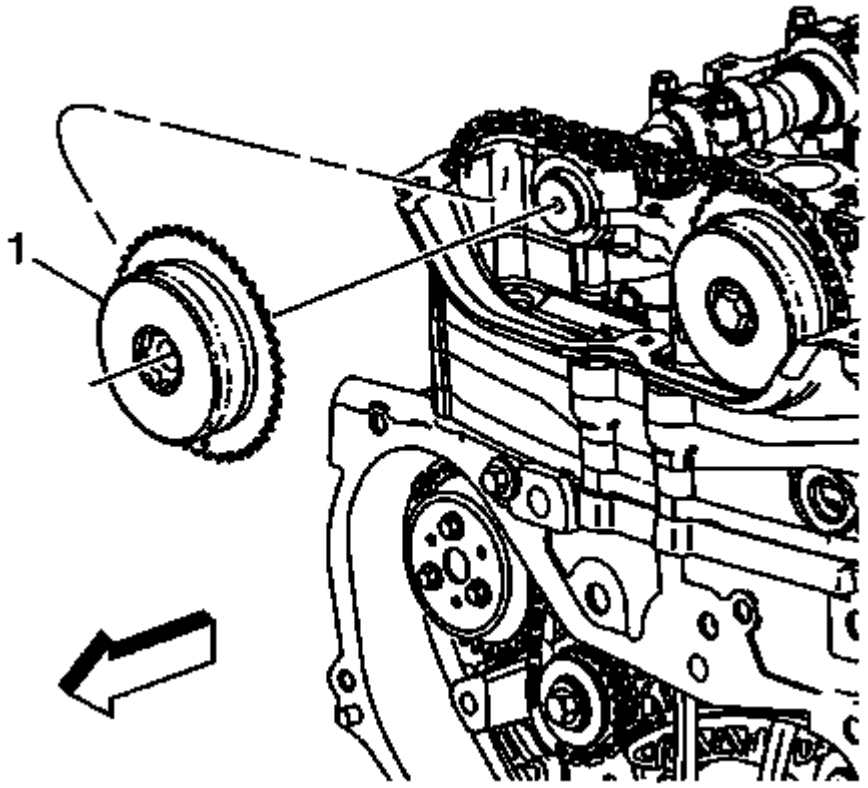

Fig. 582: View of Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

15. Install the exhaust camshaft actuator (1) into the timing chain with the timing mark lined up with the colored link.

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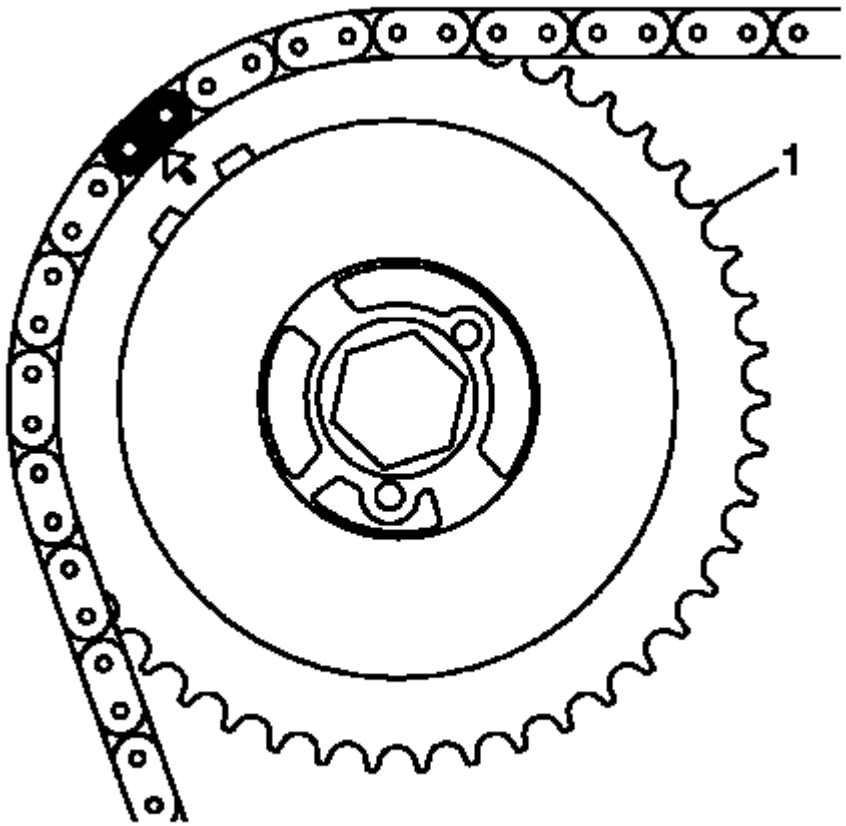

Fig. 583: Exploded View of Exhaust Camshaft Actuator
Courtesy of GENERAL MOTORS CORP.

NOTE: Always install NEW actuator bolts.

16. Install the exhaust camshaft actuator (1) onto the exhaust camshaft, aligning the dowel pin into the camshaft slot.
17. Using a 23-24 mm open end wrench, rotate the exhaust camshaft clockwise until the dowel pin in the camshaft actuator goes into the camshaft slot.

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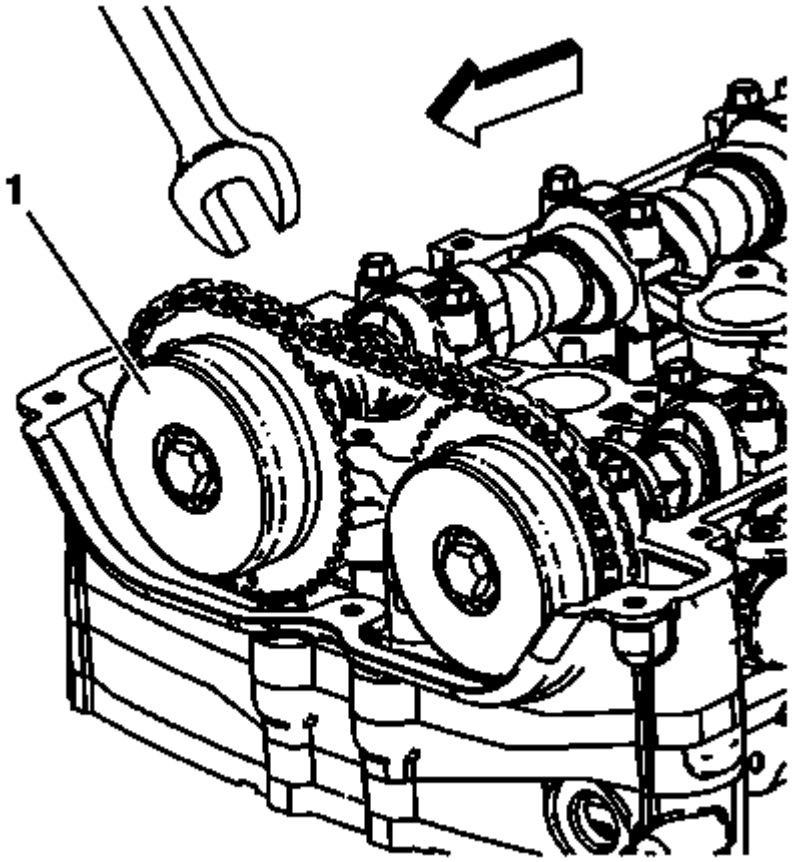

Fig. 584: View of Actuator
Courtesy of GENERAL MOTORS CORP.

18. When the actuator (1) seats on the cam, tighten the new exhaust camshaft 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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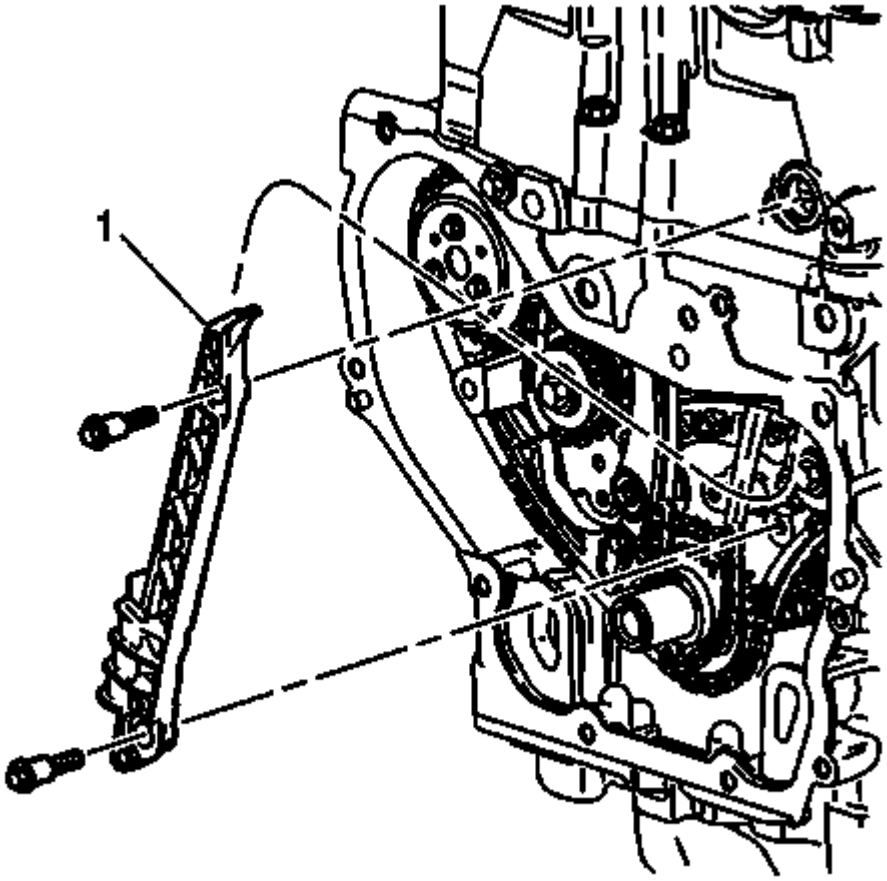

Fig. 585: View of Fixed Timing Chain Guide
Courtesy of GENERAL MOTORS CORP.

20. Install the fixed timing chain guide (1) and bolts and tighten to 12 N.m (106 lb in).

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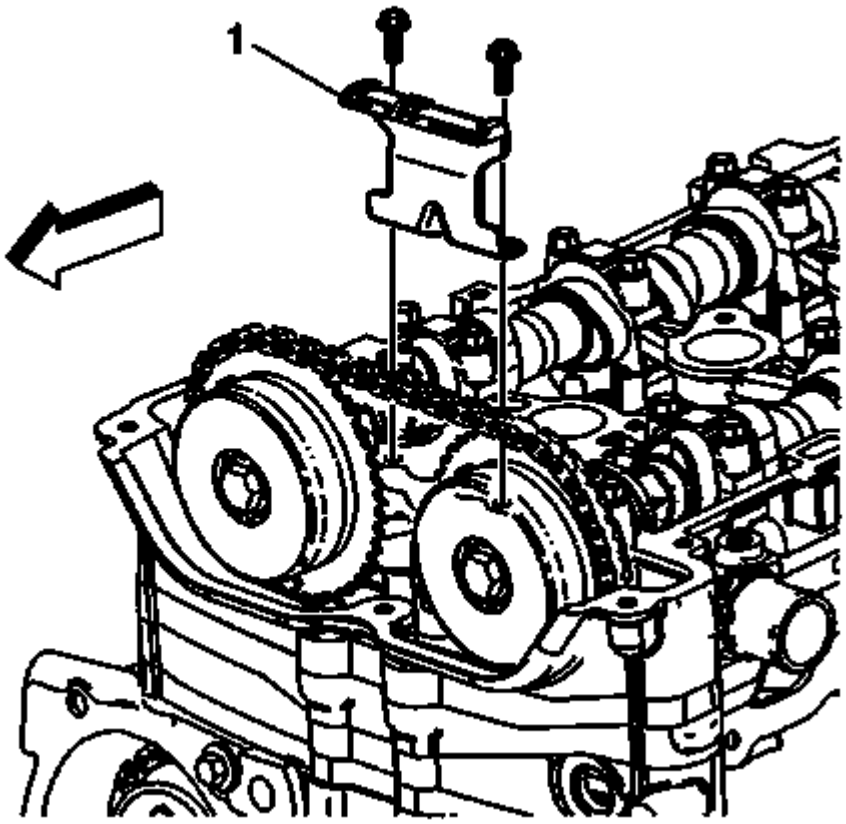

Fig. 586: View of Timing Chain and Tensioner
Courtesy of GENERAL MOTORS CORP.

21. Install the upper timing chain guide (1) and bolts and tighten to 10 N.m (89 lb in).

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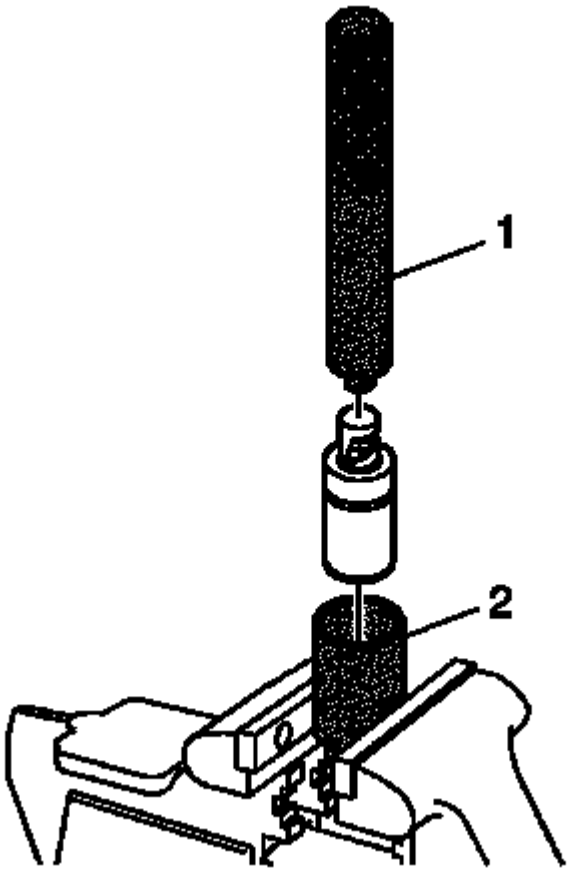

Fig. 587: Compressing Timing Chain Tensioner
Courtesy of GENERAL MOTORS CORP.

22. Reset the timing chain tensioner by performing the following steps:
    1. Remove the snap ring.
    2. Remove the piston assembly from the body of the timing chain tensioner.
    3. Install the **EN-45027-2 (2):** tensioner into a vise.
    4. Install the notch end of the piston assembly into the **EN-45027-2 (2):** tensioner .
    5. Using the **EN-45027-1 (1):** tensioner , turn the ratchet cylinder into the piston.
    6. Reinstall the piston assembly into the body of the tensioner.
    7. Install the snap ring.

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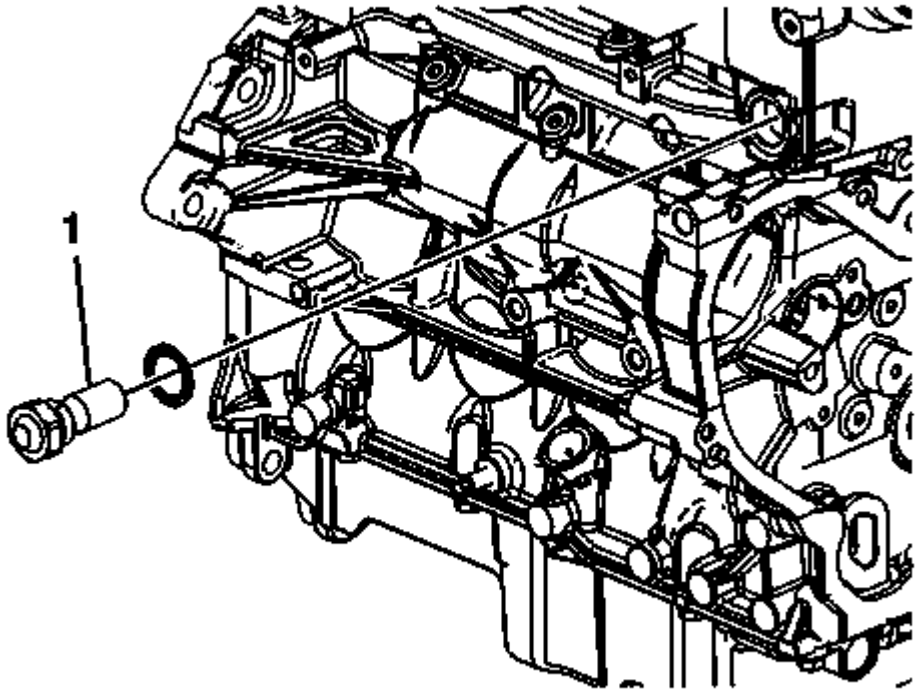

Fig. 588: View of Timing Chain Tensioner Seal
Courtesy of GENERAL MOTORS CORP.

23. Inspect the timing chain tensioner seal for damage. If damaged, replace the seal.
24. Inspect to ensure all dirt and debris is removed from the timing chain tensioner threaded hole in the cylinder head.

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

25. Install the timing chain tensioner assembly (1) and tighten to 75 N.m (55 lb ft).

NOTE: The timing chain tensioner is released by compressing it 2 mm (0.079 in), which will release the locking mechanism in the ratchet.

26. The crankshaft balancer must be installed in order to release the tensioner. Refer to **Crankshaft Balancer Installation**.

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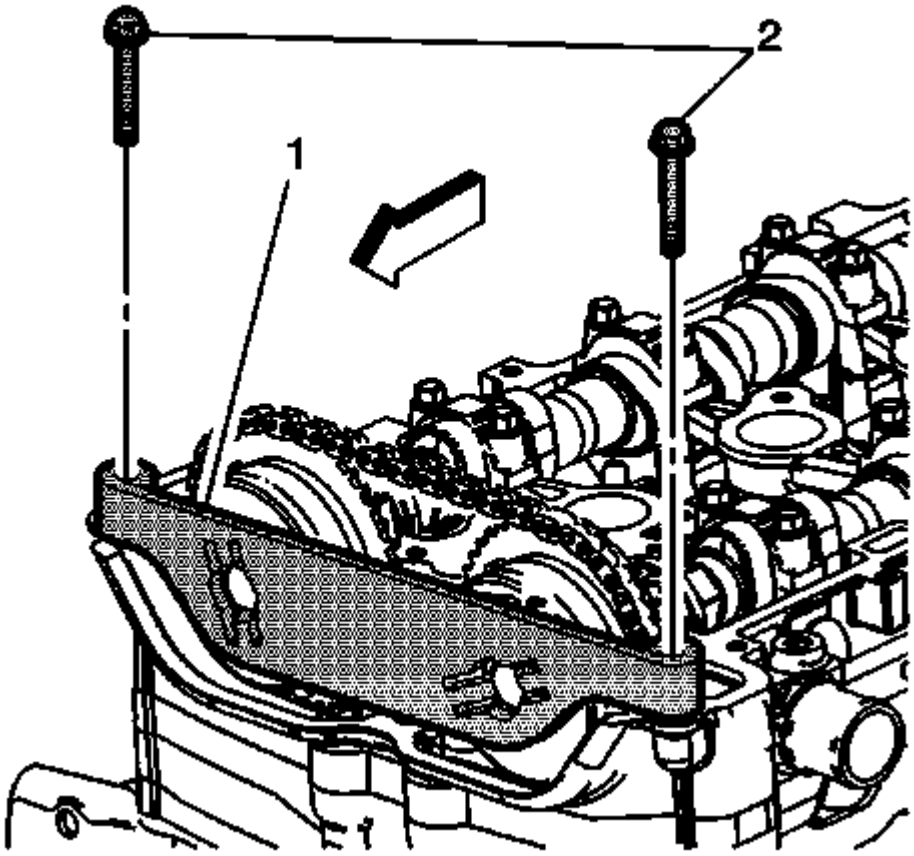

Fig. 589: View Locking Tool
Courtesy of GENERAL MOTORS CORP.

27. Install **EN-48953:** locking tool (1) and tighten the bolts into the cylinder head to 10 N.m (89 lb in).
28. Using a torque wrench, tighten the camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059:** meter.
29. Using a torque wrench, tighten the camshaft actuator bolt to 30 N.m (22 lb ft), plus 100 degrees using the **J 45059:** meter.
30. Remove **EN-48953:** locking tool.

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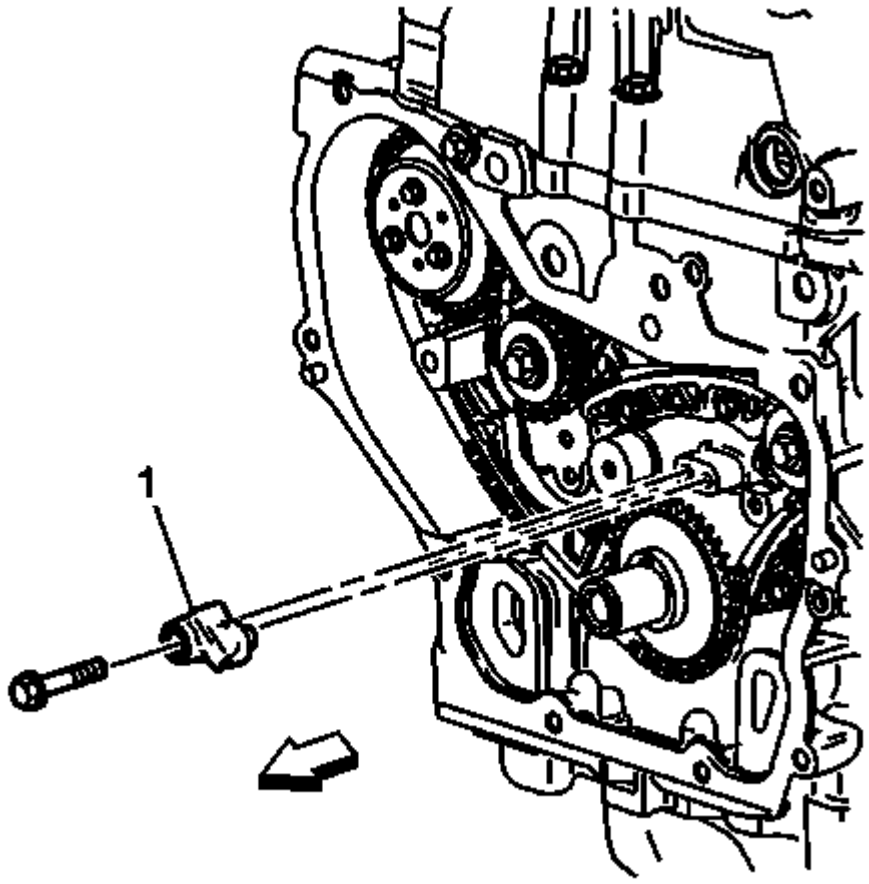

Fig. 590: View of Timing Chain Oil Nozzle
Courtesy of GENERAL MOTORS CORP.

31. Install the timing chain oiling nozzle (1) and tighten the bolt to 10 N.m (89 lb in).

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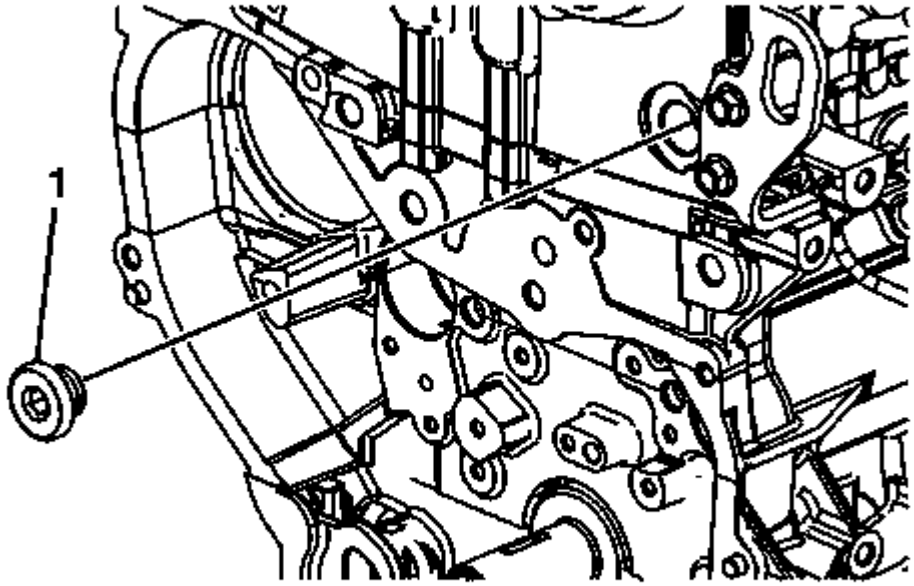

Fig. 591: View of timing Chain Guide Bolt Access Hole Plug
Courtesy of GENERAL MOTORS CORP.

32. Apply sealant to the thread of the timing chain guide bolt access hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
33. Install the timing chain guide bolt access hole plug (1) and tighten 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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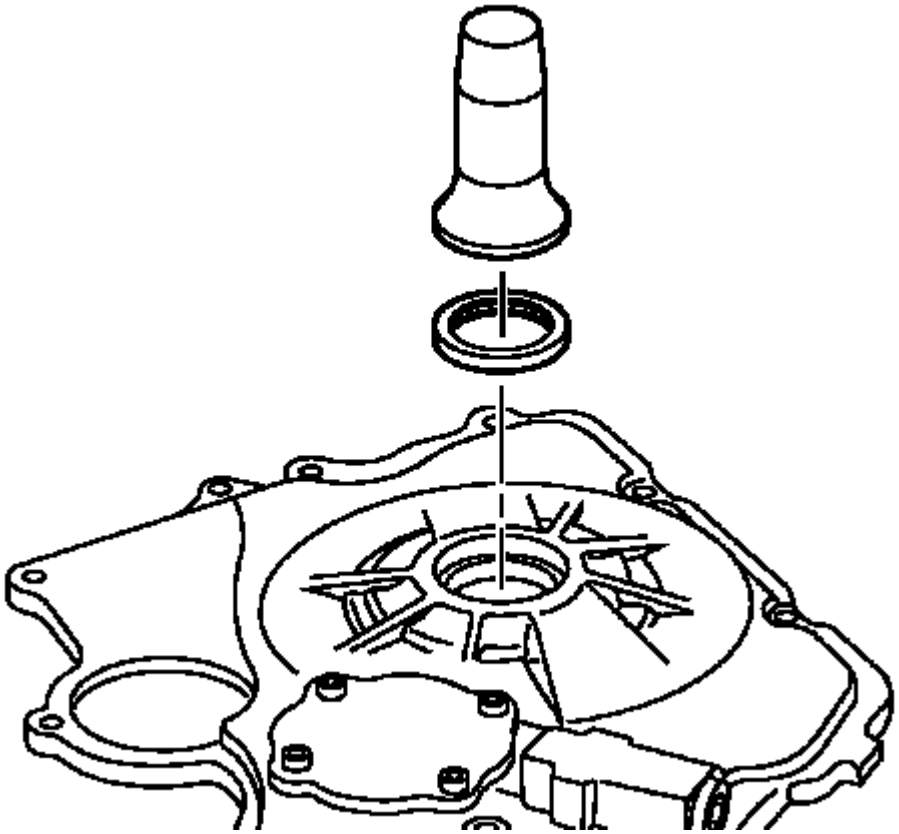

Fig. 592: Installing Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS CORP.

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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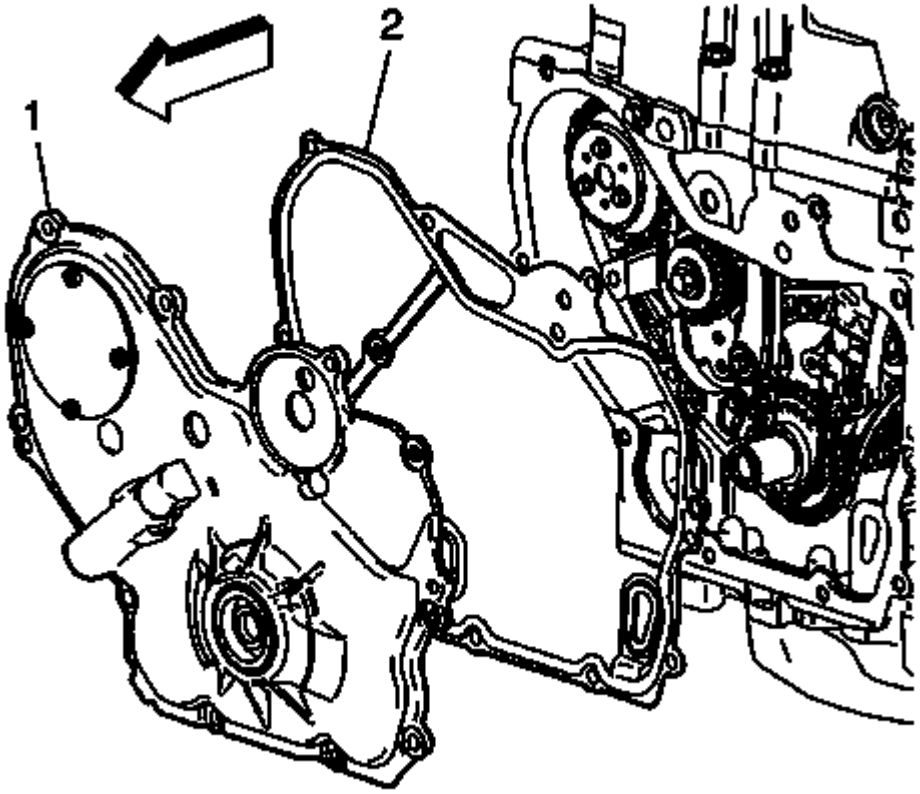

Fig. 593: Engine Front Cover & Gasket
Courtesy of GENERAL MOTORS CORP.

1. Install the engine front cover (1) with a new gasket (2).

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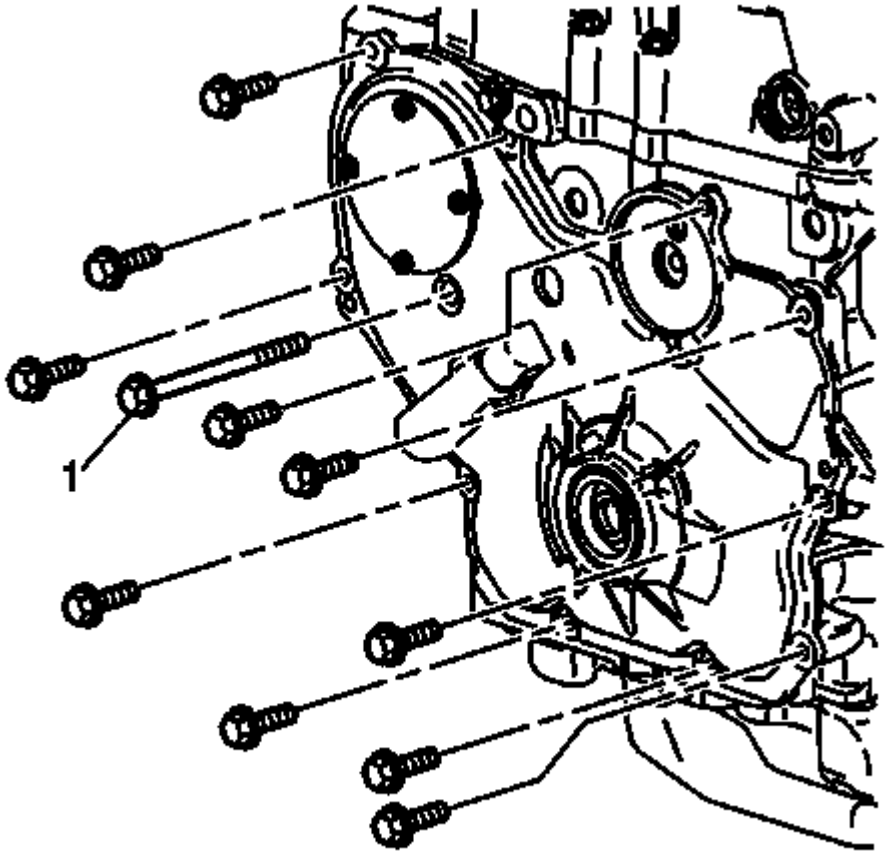

Fig. 594: Engine Front Cover Bolts & Long Water Pump Bolt
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

NOTE: The center bolt (1) should be tightened last.

2. Install the engine front cover bolts and tighten to 25 N.m (18 lb ft).
3. Install the long water pump bolt (1) and tighten to 25 N.m (18 lb ft).

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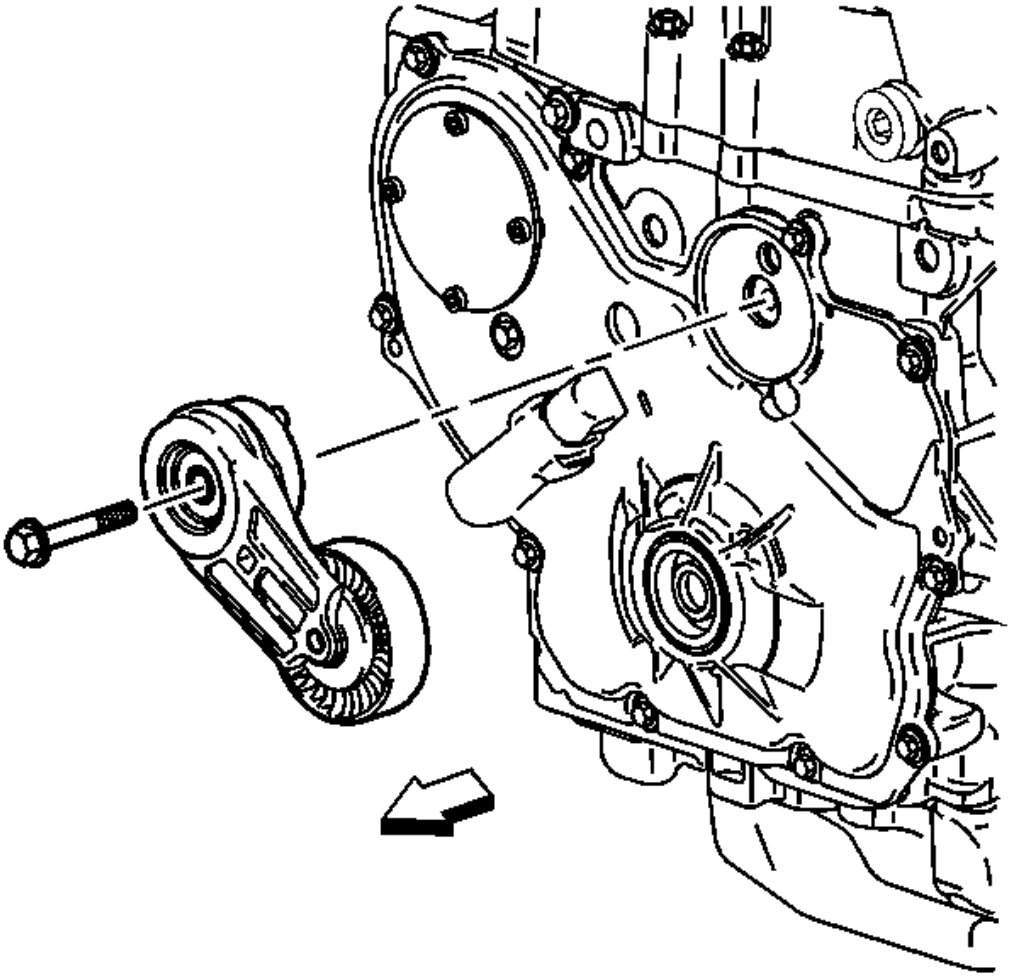

Fig. 595: View Of Drive Belt Tensioner
Courtesy of GENERAL MOTORS CORP.

4. Install the accessory drive belt tensioner.
5. Install the accessory drive belt tensioner bolt and tighten to 45 N.m (33 lb ft).

OIL PAN INSTALLATION

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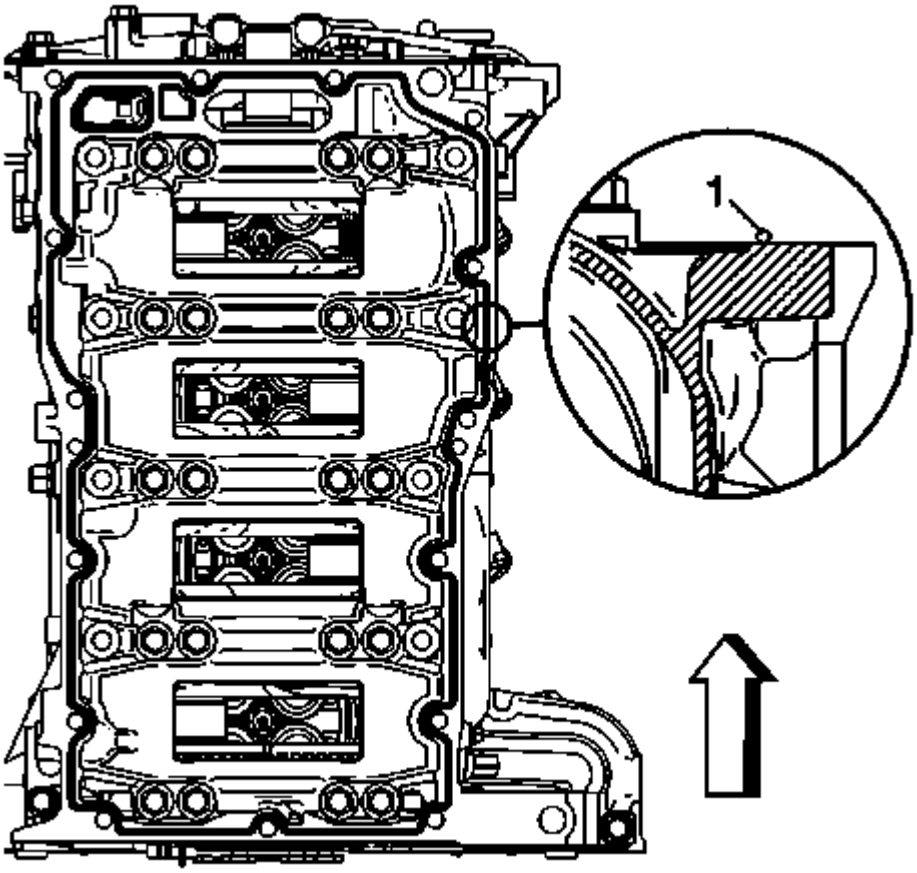

Fig. 596: Identifying Bead of Sealer on Oil Pan
Courtesy of GENERAL MOTORS CORP.

NOTE:

- **The lower crankcase surface must be free of contamination prior to applying the sealer.**
- **Install and align the oil pan to block within 20 minutes of applying the sealer.**
- **The oil pan must be fastened to final torque specification within 60 minutes of applying the sealer.**

1. Apply a 2.25 mm bead of sealer (1) on the level part of the flange next to the chamfer around the perimeter of the oil pan and the oil suction port opening. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

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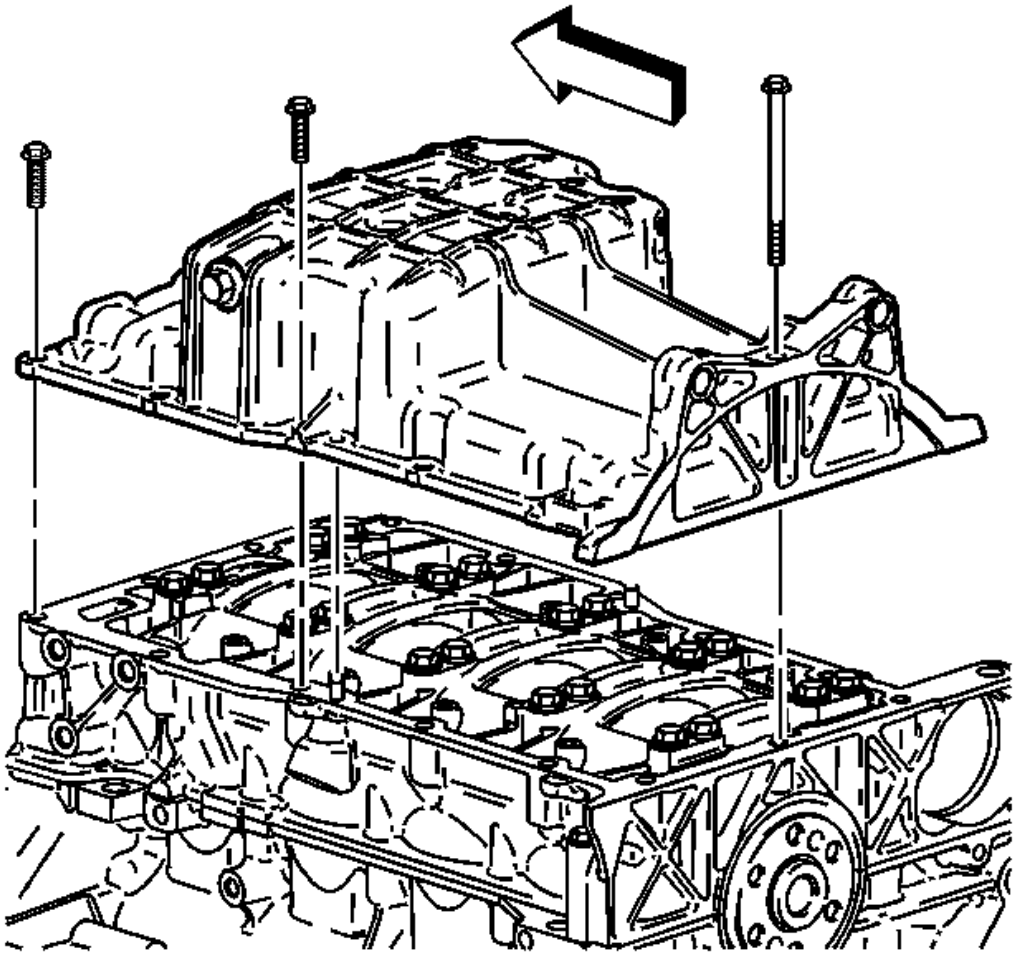

Fig. 597: Installing Oil Pan
Courtesy of GENERAL MOTORS CORP.

2. Install the oil pan.

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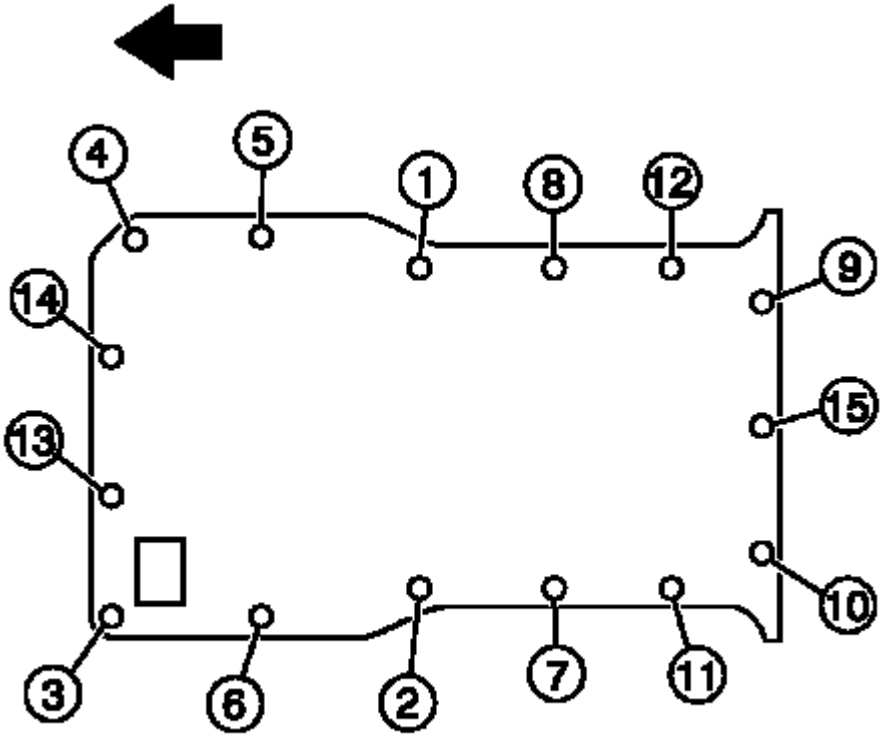

Fig. 598: Identifying Oil Pan Bolts Removal & Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

3. Install the oil pan bolts and tighten to 25 N.m (18 lb ft) in sequence.

CRANKSHAFT BALANCER INSTALLATION

Special Tools

- **EN-48585:** Crankshaft Balancer Guide
- **EN-48953:** Camshaft Actuator Locking Tool
- **J 38112-A:** Crankshaft Balancer Holder
- **J 43653:** Flywheel Holding Tool
- **J 45059:** Angle Meter

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

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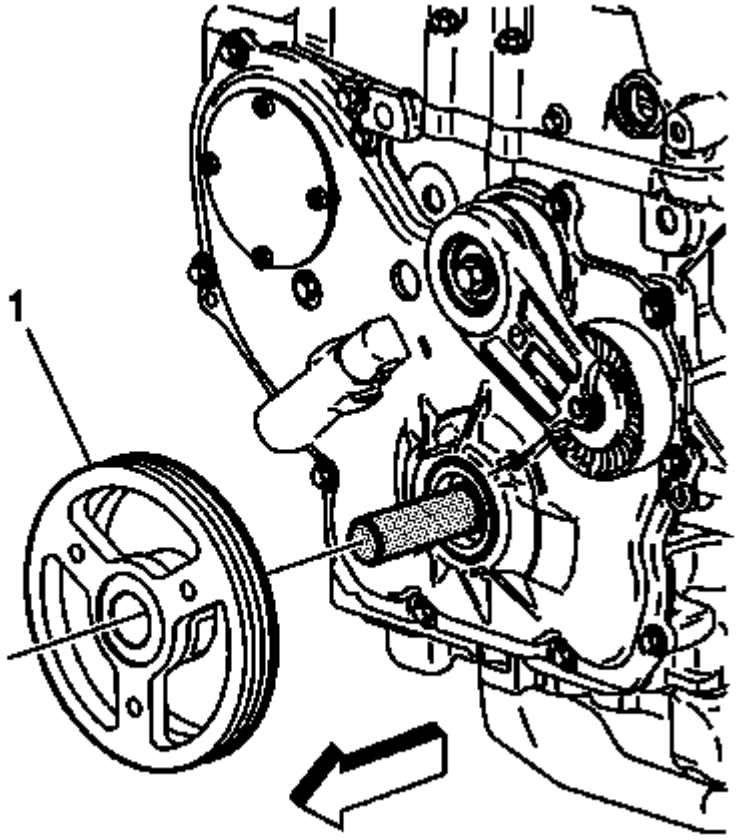

Fig. 599: Identifying Balancer
Courtesy of GENERAL MOTORS CORP.

CAUTION: Ensure both components are aligned correctly or serious engine damage will occur.

1. Install the **J 38112-A:** holder into the end of the crankshaft.
2. Install the balancer (1) onto the **EN-48585:** guide. Use care to properly align the keyway and flats on the balancer with the oil pump drive.

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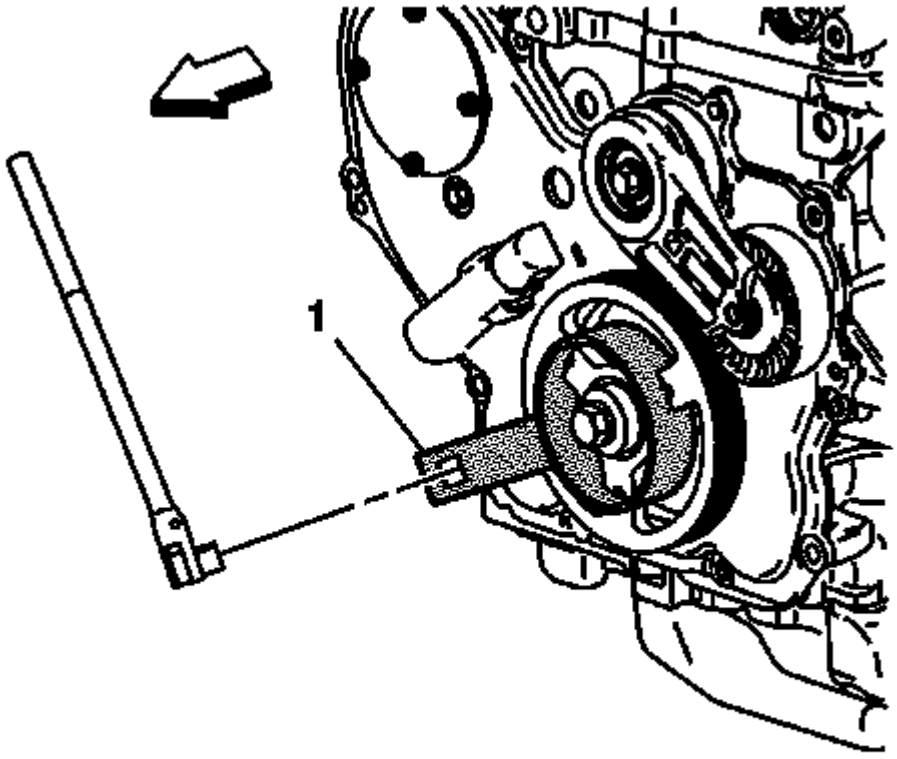

Fig. 600: Identifying J 38122-A
Courtesy of GENERAL MOTORS CORP.

NOTE: J 43653: locking tool may be used instead of J 38112-A: holder to prevent crankshaft rotation.

3. Install the **J 38122-A:** holder (1).

CAUTION: Refer to Fastener Caution .

NOTE: Always install a new crankshaft balancer retaining bolt and washer.

4. Install a new retaining bolt and washer. Use the **J 38122-A:** holder and a breaker bar to prevent the crankshaft from rotating when tightening the bolt. Tighten the bolt to 100 N.m (74 lb ft) plus 125 degrees using the **J 45059:** meter.

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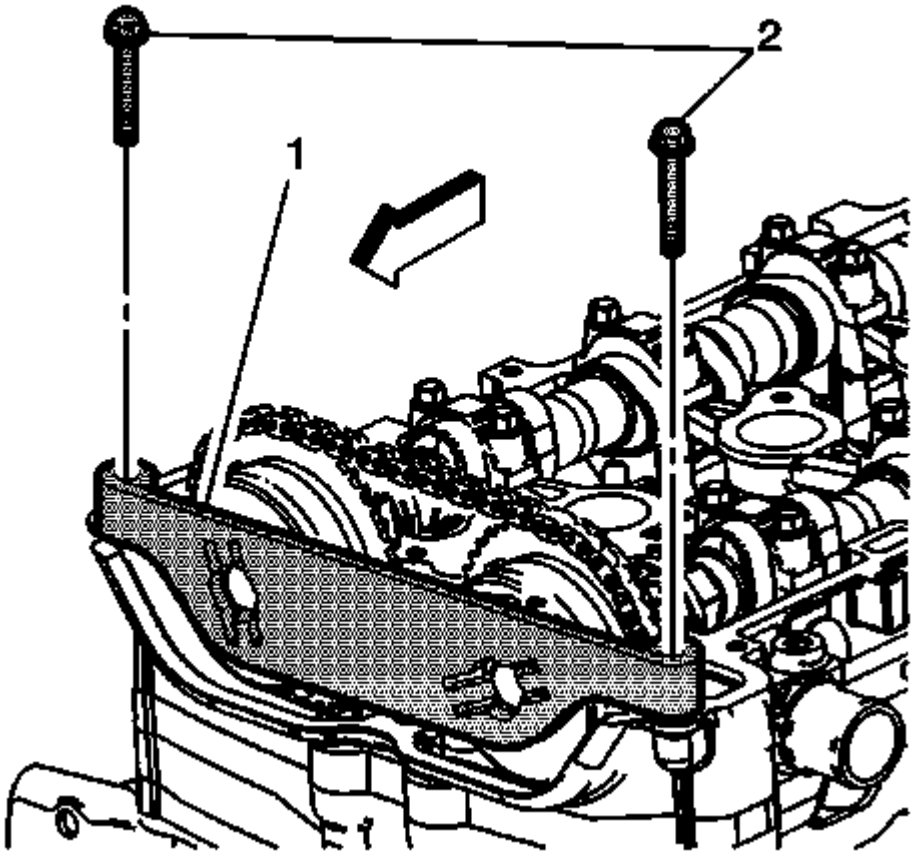

Fig. 601: View Locking Tool
Courtesy of GENERAL MOTORS CORP.

5. Install the **EN-48953:** locking tool (1) and tighten the bolts into the cylinder head. Tighten the **EN-48953:** locking tool retaining bolts to 10 N.m (89 lb in).
6. Release the timing chain tensioner by applying 45 N.m (33 lb ft) counterclockwise torque to the crankshaft balancer bolt.
7. Remove the **EN-48953:** locking tool.

CAMSHAFT COVER INSTALLATION

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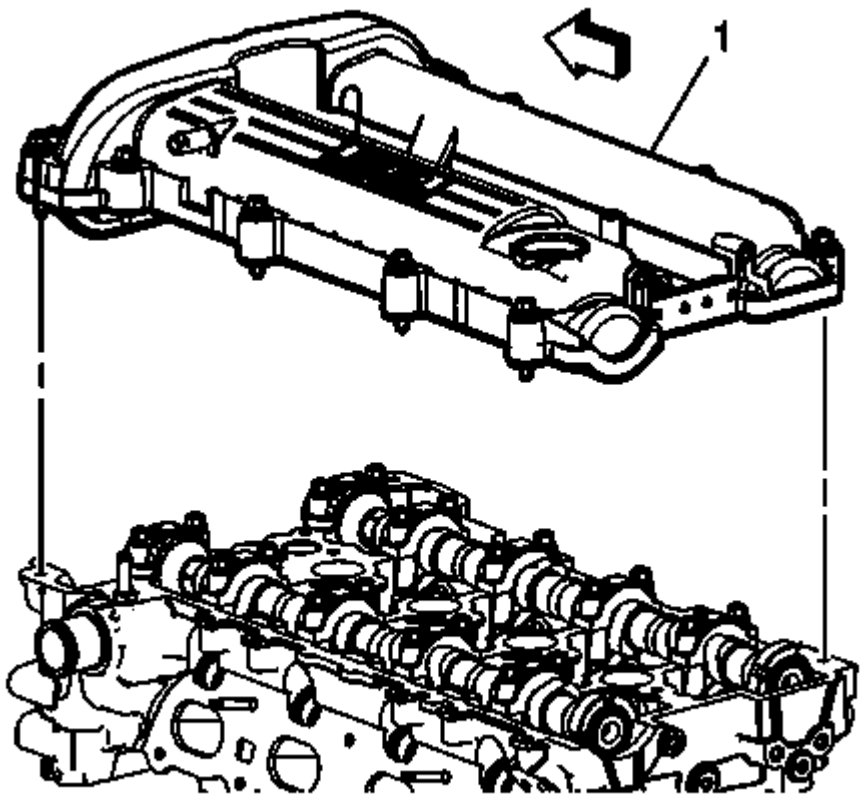

Fig. 602: View of Camshaft Cover and Cylinder Head
Courtesy of GENERAL MOTORS CORP.

1. Install NEW camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.
2. Assemble the camshaft cover (1) and a NEW gasket. Ensure that the gasket is located in the retaining groove in the camshaft cover.

CAUTION: Refer to Fastener Caution .

3. Install the cover on the cylinder head and hand start the bolts. Tighten the bolts to 10 N.m (89 lb in).

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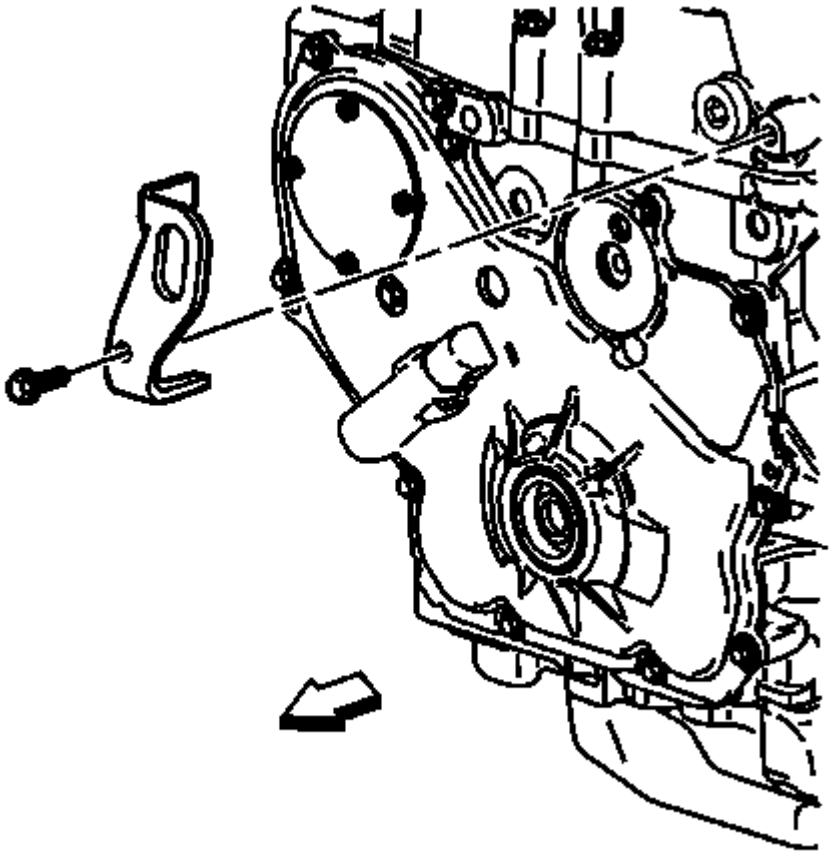

Fig. 603: View Of Front Lift Bracket
Courtesy of GENERAL MOTORS CORP.

4. Install the front lift bracket.
5. Install the front lift bracket bolt and tighten to 25 N.m (18 lb ft).

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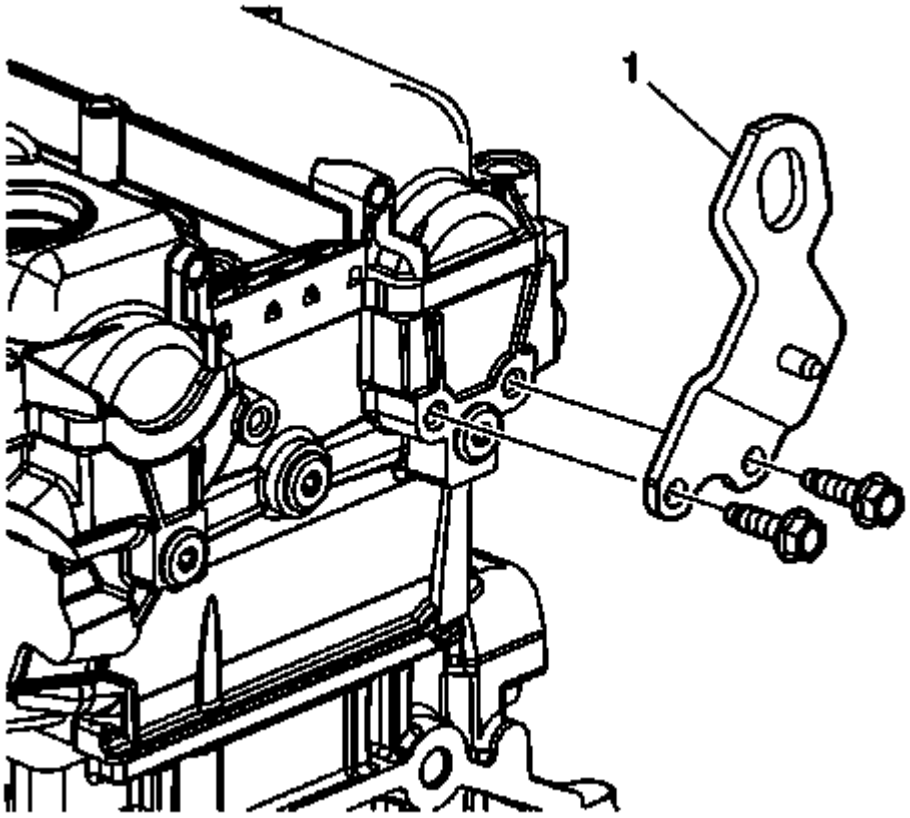

Fig. 604: View of Rear Lift Bracket
Courtesy of GENERAL MOTORS CORP.

6. Install the rear lift bracket (1).
7. Install the rear lift bracket bolts and tighten to 25 N.m (18 lb ft).

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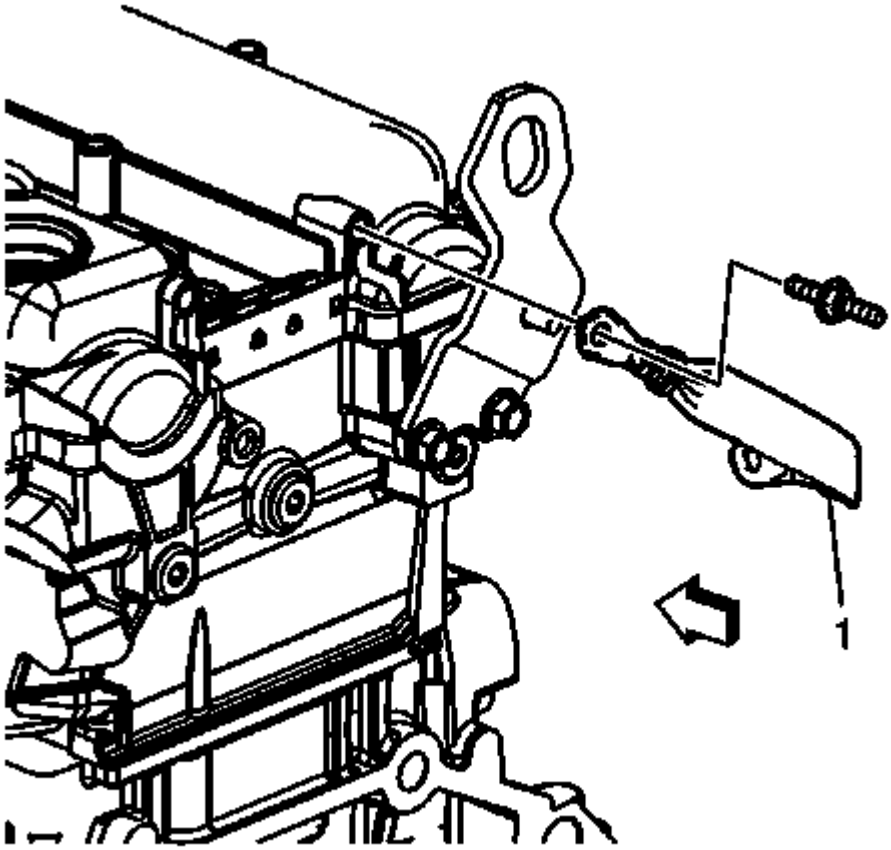

Fig. 605: View of Ground Strap
Courtesy of GENERAL MOTORS CORP.

8. Install the ground strap (1) and tighten the bolts to 10 N.m (89 lb in).

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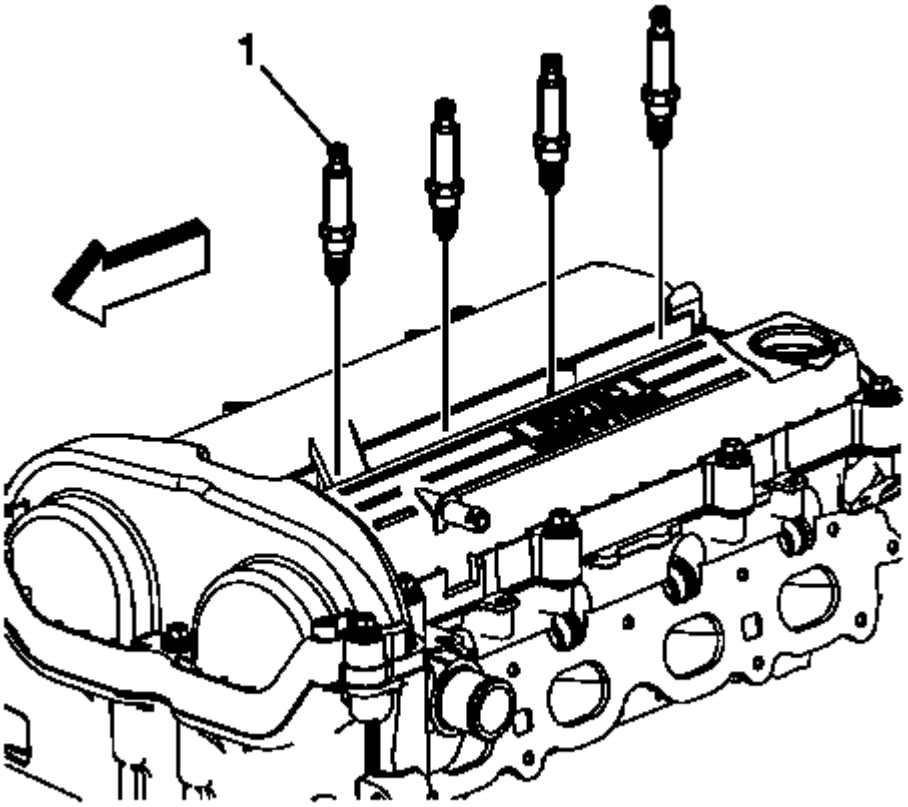

Fig. 606: View of Spark Plugs
Courtesy of GENERAL MOTORS CORP.

9. Install the spark plugs (1) and tighten to 20 N.m (15 lb ft).

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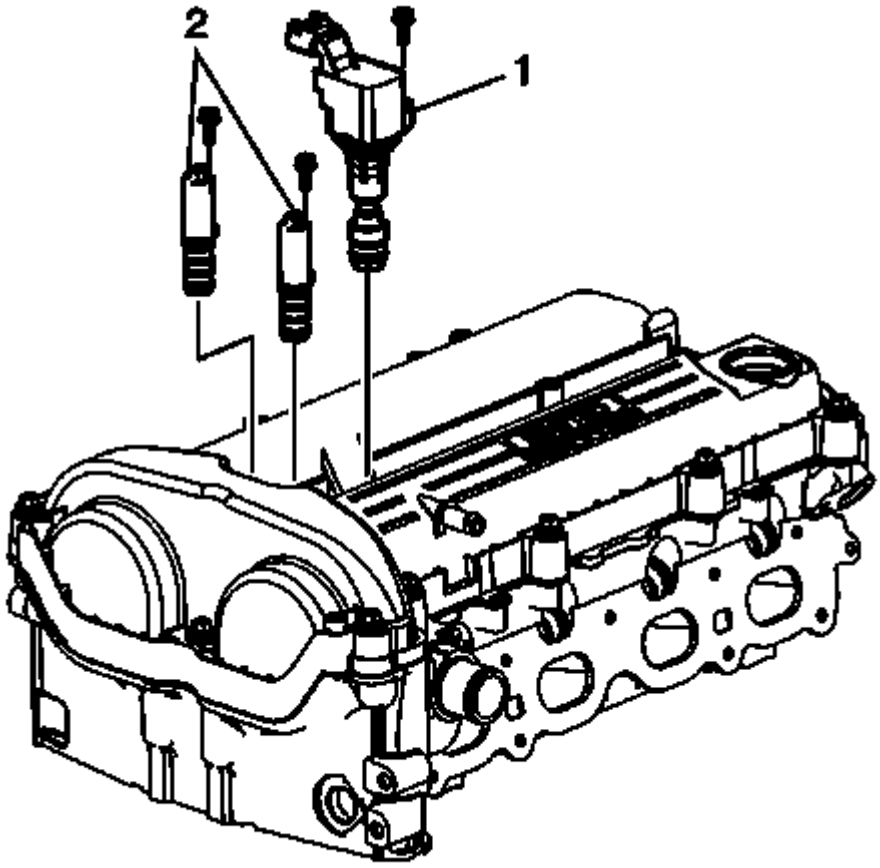

Fig. 607: View Of Ignition Coil And Camshaft Position Actuator Solenoid Valves
Courtesy of GENERAL MOTORS CORP.

10. Install the ignition coil (1) and tighten the bolt to 10 N.m (89 lb in).
11. Install the camshaft position actuator solenoid valves (2).
12. Install the camshaft position actuator solenoid valve bolts and tighten to 10 N.m (89 lb in).

OIL FILTER WITH CAP AND SEAL INSTALLATION

Special Tools

EN-44887: Oil Filter Wrench

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

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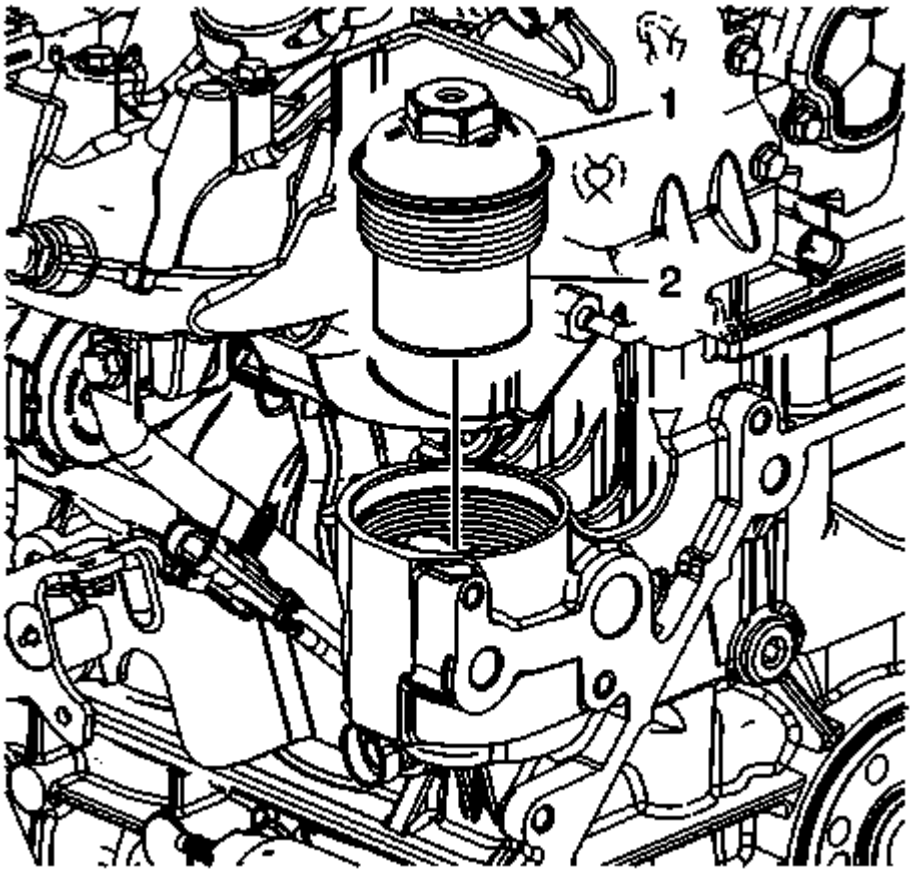

Fig. 608: View of Draining Fluids and Oil Filter
Courtesy of GENERAL MOTORS CORP.

1. Install a new oil filter (2) on the oil filter cap (1).
2. Lubricate the O-ring on the oil filter cap with 5W30 engine oil.

CAUTION: Refer to Fastener Caution .

3. Use **EN-44887:** wrench to install the oil filter cap. Tighten the oil filter cap to 22 N.m (16 lb ft).

INTAKE MANIFOLD INSTALLATION

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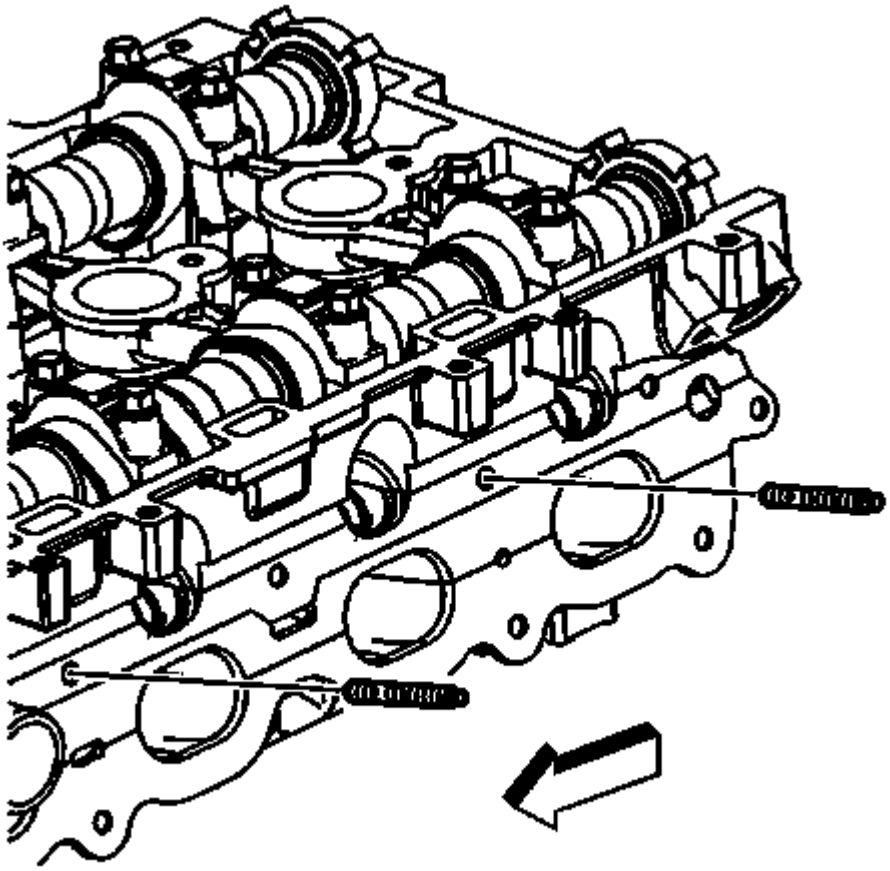

Fig. 609: Intake Manifold Studs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install the intake manifold studs in the manifold face and tighten to 6 N.m (53 lb in).

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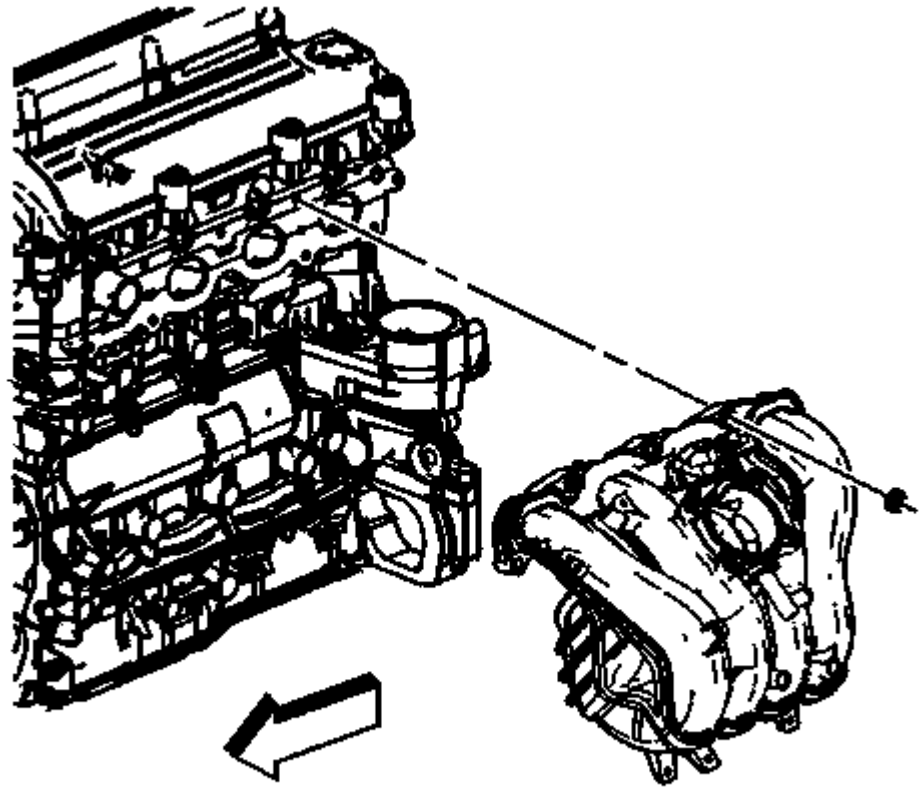

Fig. 610: View Of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

2. Install a new intake manifold gasket on the intake manifold.
3. Install the intake manifold.
4. Install the intake manifold bolts and nuts finger tight.

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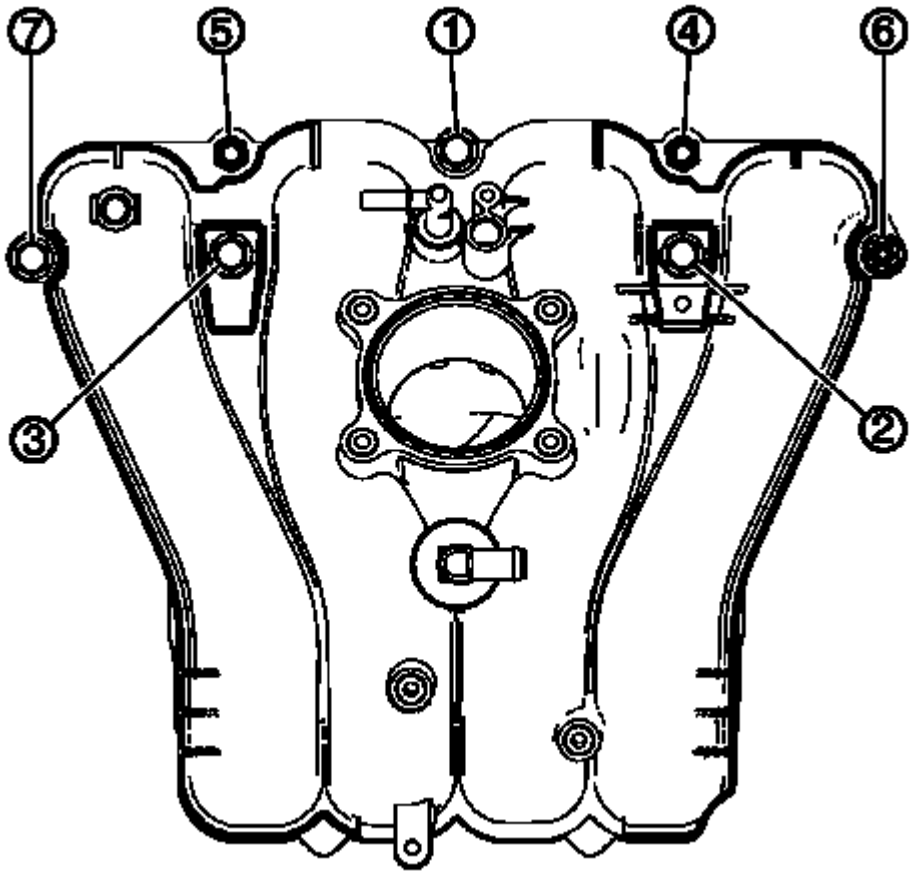

Fig. 611: Intake Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

5. Tighten the intake manifold bolts and nuts in sequence to 10 N.m (89 lb in).

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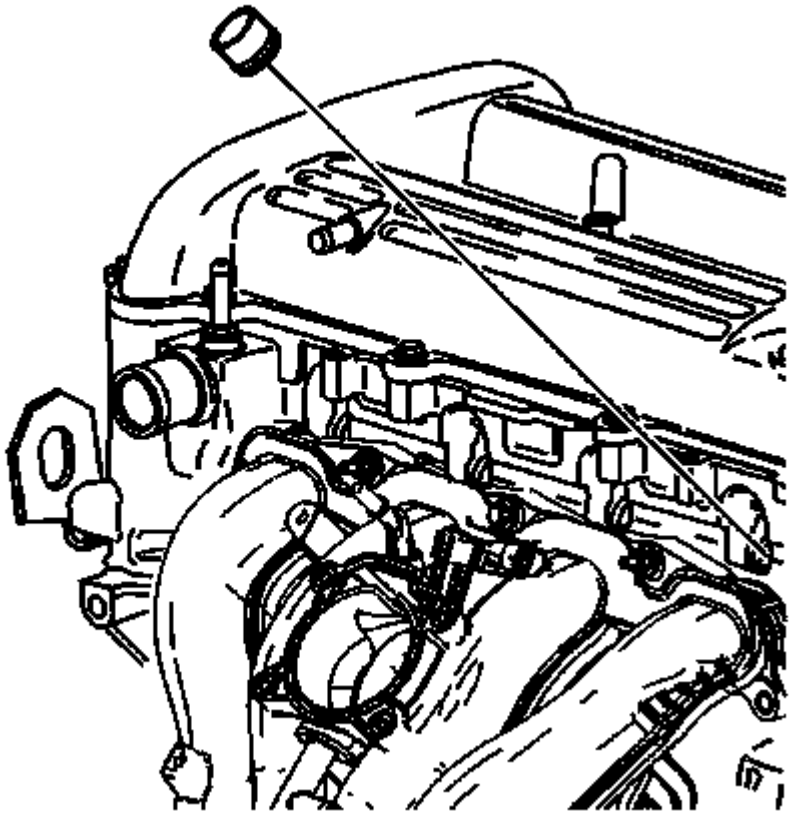

Fig. 612: View Of Fuel Injector Tip Insulators
Courtesy of GENERAL MOTORS CORP.

6. Lubricate NEW fuel injector tip insulators with engine oil.
7. Install NEW fuel injector tip insulators.

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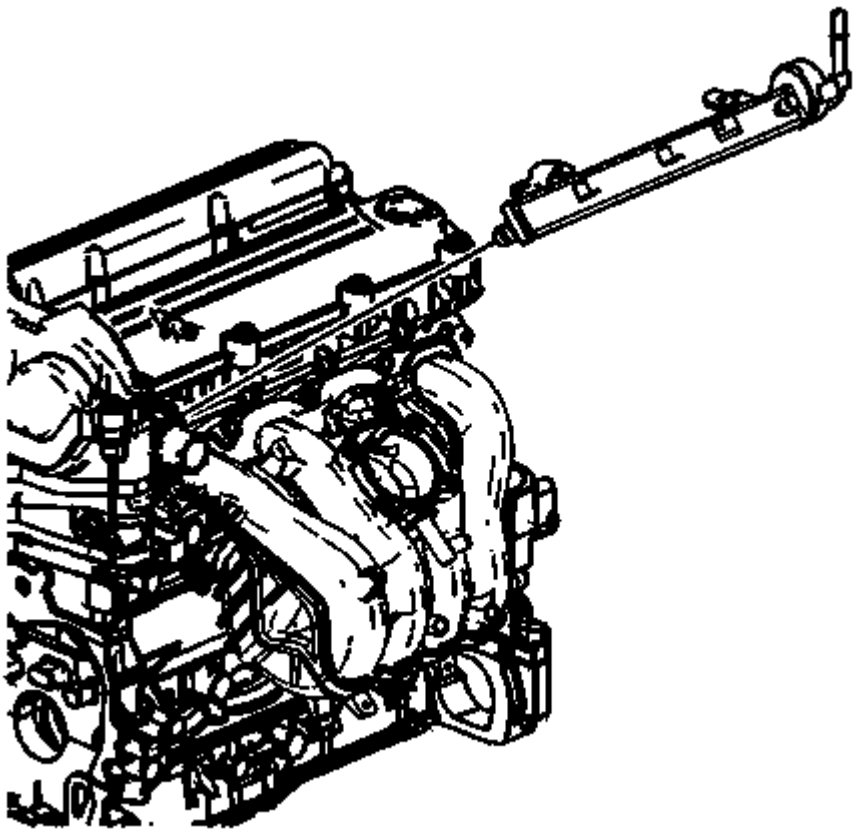

Fig. 613: View Of Fuel Rail Assembly
Courtesy of GENERAL MOTORS CORP.

8. Lubricate the fuel injector oil rings with engine oil.
9. Install the fuel rail assembly.
10. Install the fuel rail fastener and tighten to 10 N.m (89 lb in).

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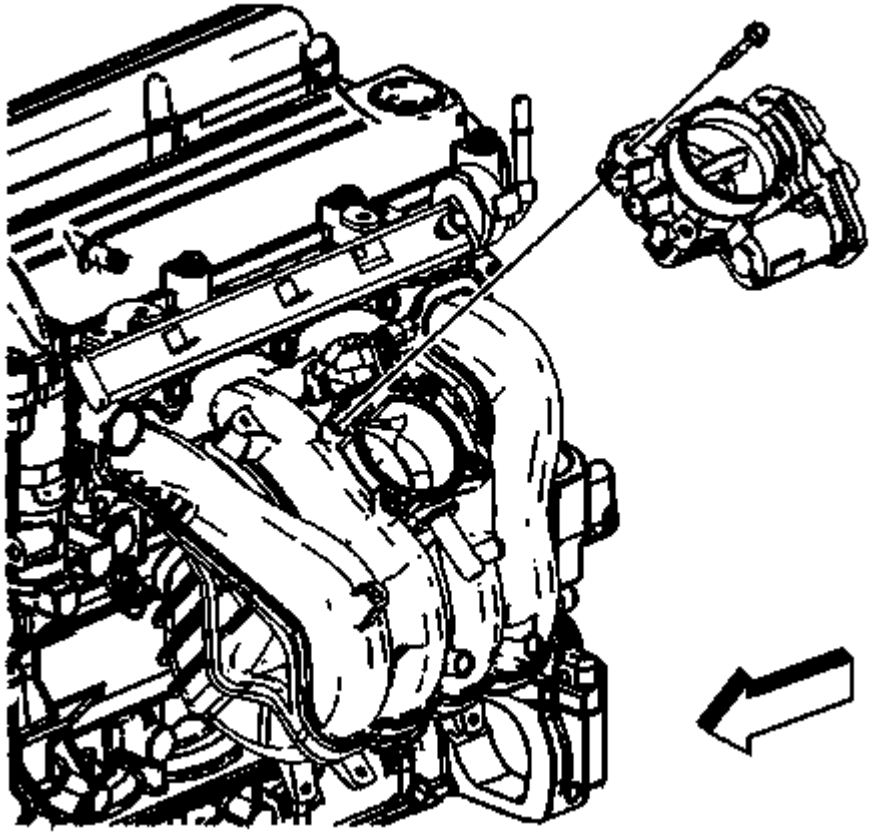

Fig. 614: View Of Throttle Body
Courtesy of GENERAL MOTORS CORP.

11. Install a new throttle body gasket.
12. Install the throttle body.
13. Install the throttle body bolts and tighten to 10 N.m (89 lb in).

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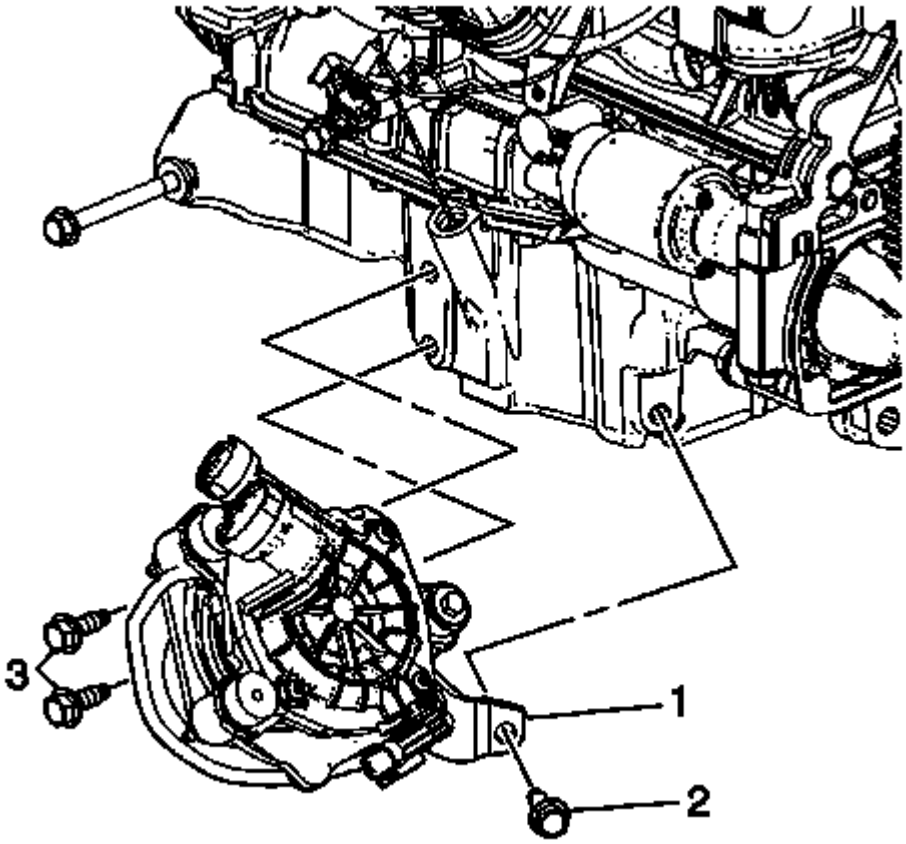

Fig. 615: View of Air Pump Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

14. Install the air pump assembly (1).
15. Install the air pump assembly bolts (2, 3) and tighten to 22 N.m (16 lb ft).

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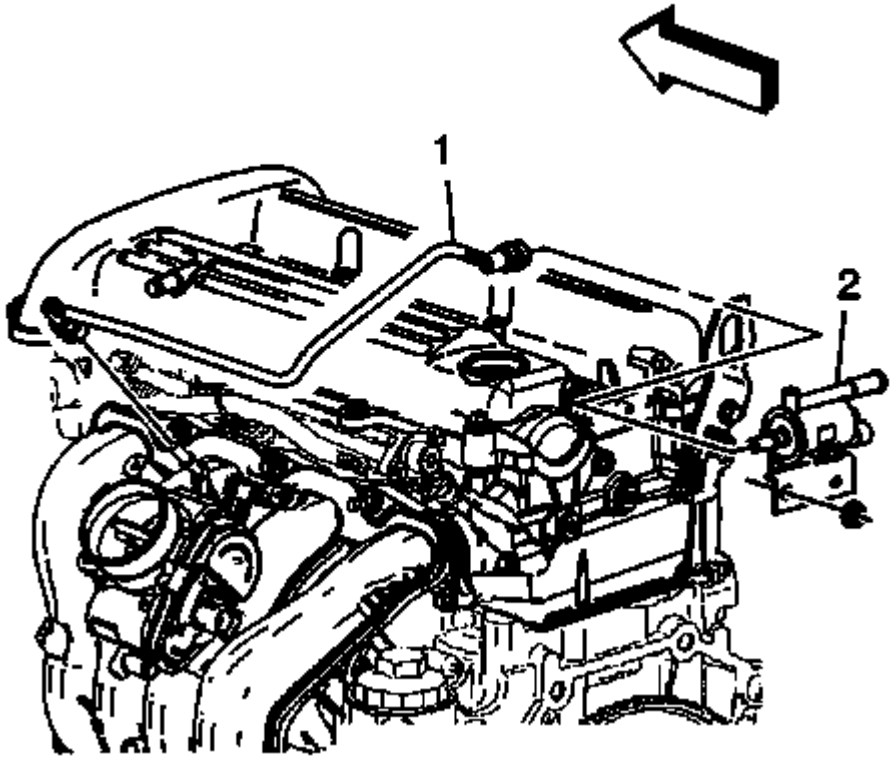

Fig. 616: View of Intake Manifold
Courtesy of GENERAL MOTORS CORP.

16. Install the EVAP canister valve (2) and tighten to 25 N.m (18 lb ft).
17. Install the EVAP canister valve tube (1).

EXHAUST MANIFOLD INSTALLATION (WITH SECONDARY AIR INJECTION)

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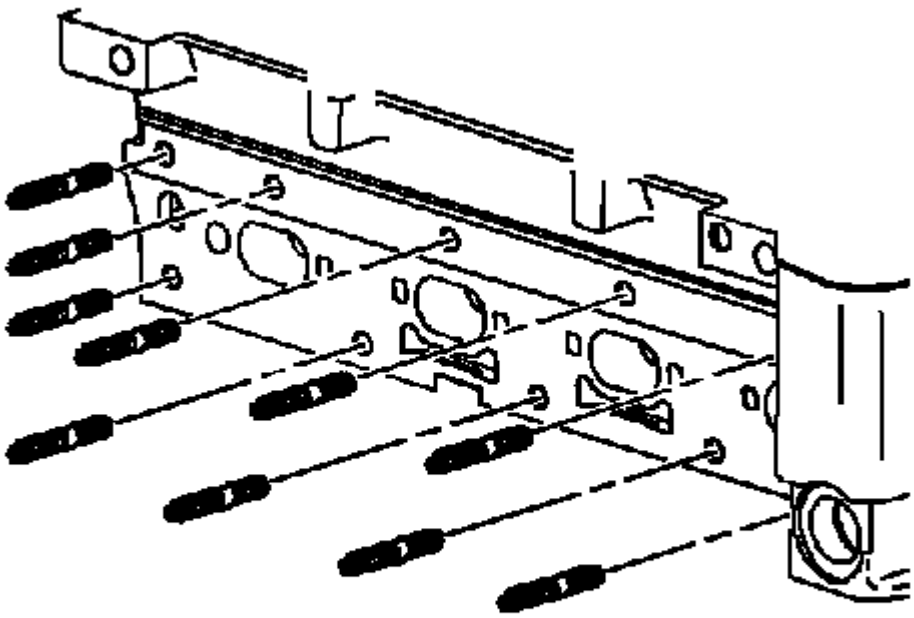

Fig. 617: View Of Exhaust Manifold Studs
Courtesy of GENERAL MOTORS CORP.

CAUTION: Refer to Fastener Caution .

1. Install new exhaust manifold studs and tighten to 10 N.m (89 lb in).

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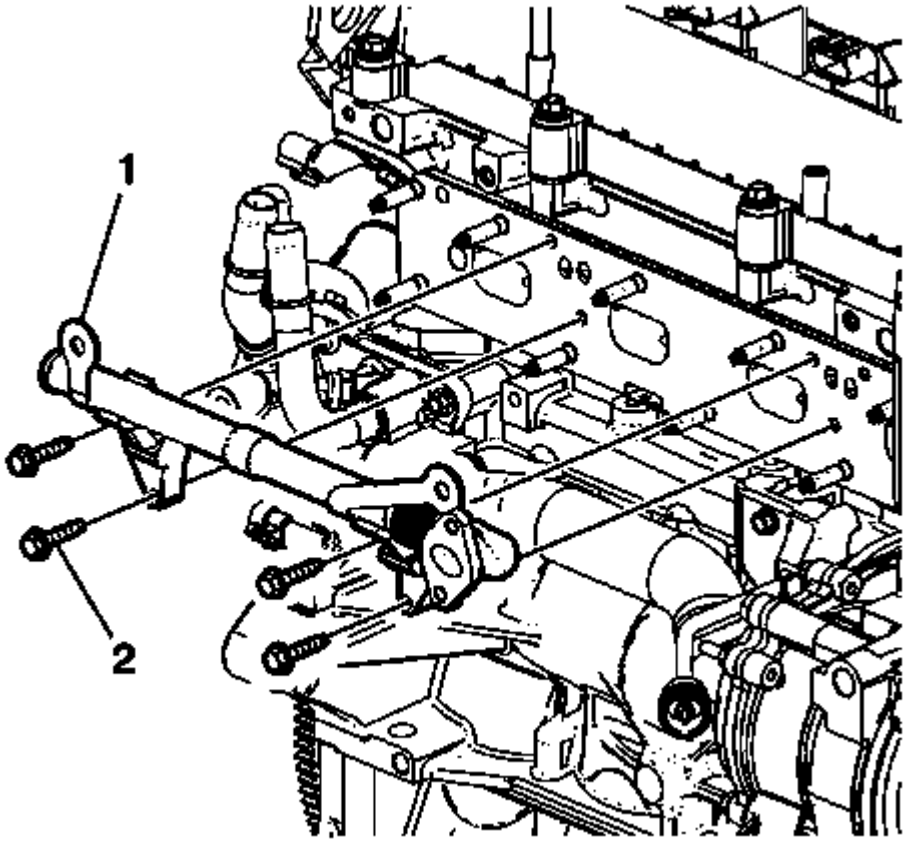

Fig. 618: View of Secondary Air Injection Pipe Assembly Bolts
Courtesy of GENERAL MOTORS CORP.

2. Install the secondary air injection pipe assembly (1).
3. Install the secondary air injection pipe assembly bolts (2) and tighten to 10 N.m (89 lb in).

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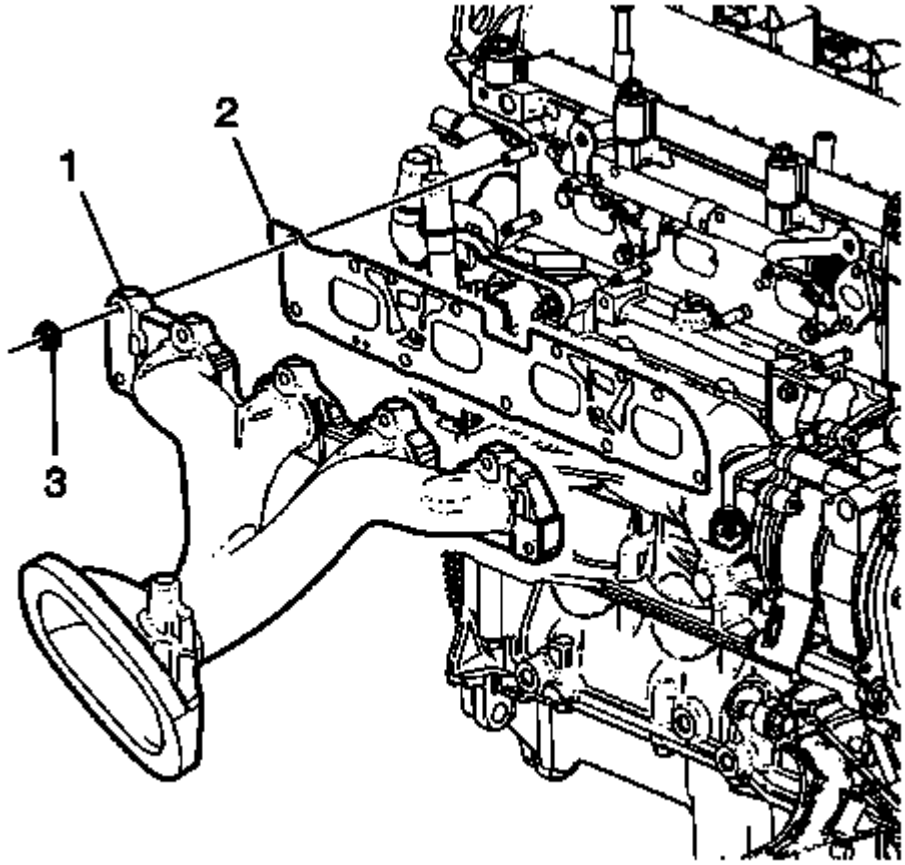

Fig. 619: View of Exhaust Manifold to Cylinder Head Retaining Nuts
Courtesy of GENERAL MOTORS CORP.

4. Install the exhaust manifold gasket (2).
5. Install the exhaust manifold (1) to the cylinder head.
6. Install NEW exhaust manifold to cylinder head retaining nuts (3) finger tight.

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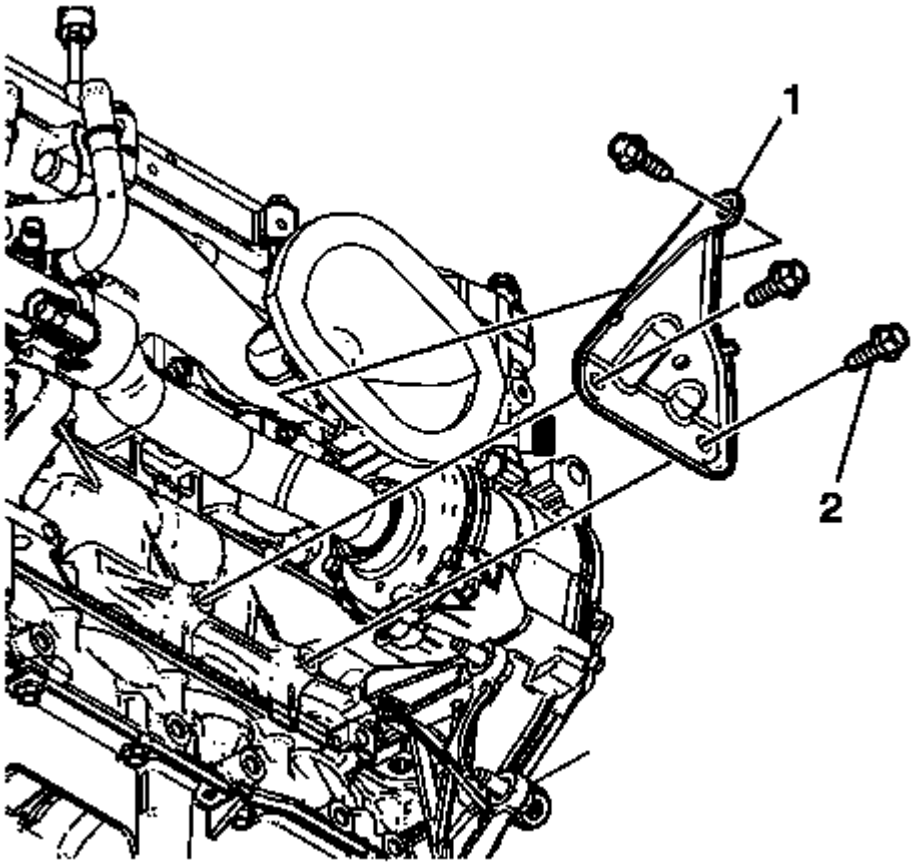

Fig. 620: Exhaust Manifold Brace And Bolts
Courtesy of GENERAL MOTORS CORP.

7. Install the exhaust manifold brace (1) and bolts (2). Tighten the bolts to 58 N.m (43 lb ft).

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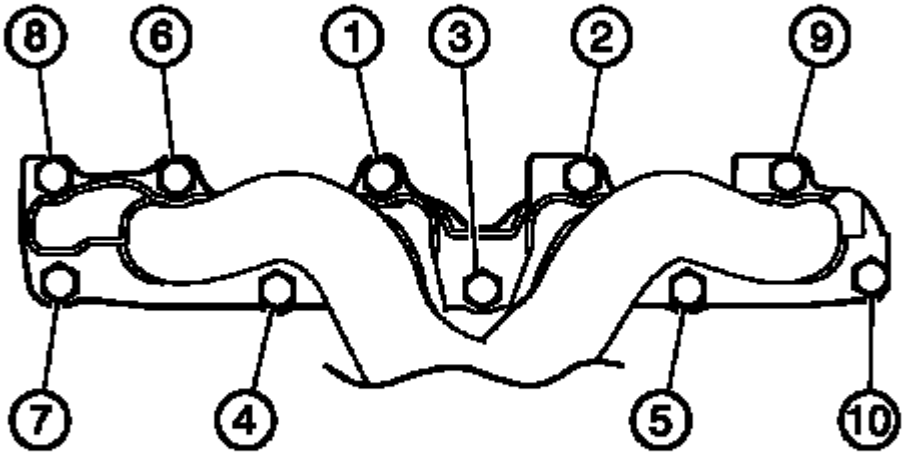

Fig. 621: Exhaust Manifold Bolt Tightening Sequence
Courtesy of GENERAL MOTORS CORP.

8. Tighten the NEW exhaust manifold to cylinder head retaining nuts two passes in sequence. Tighten the nuts to 14 N.m (124 lb in).

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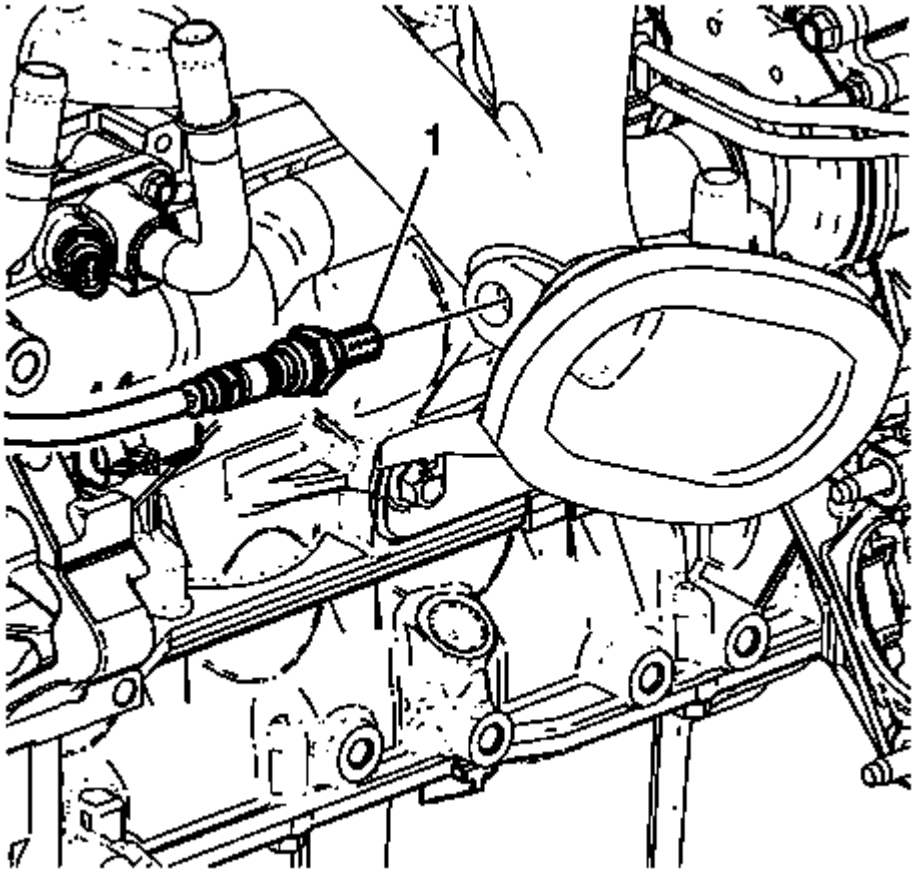

Fig. 622: View of Oxygen Sensor
Courtesy of GENERAL MOTORS CORP.

9. Coat the threads of the oxygen sensor (1) with antiseize. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
10. Install the oxygen sensor and tighten to 42 N.m (31 lb ft).

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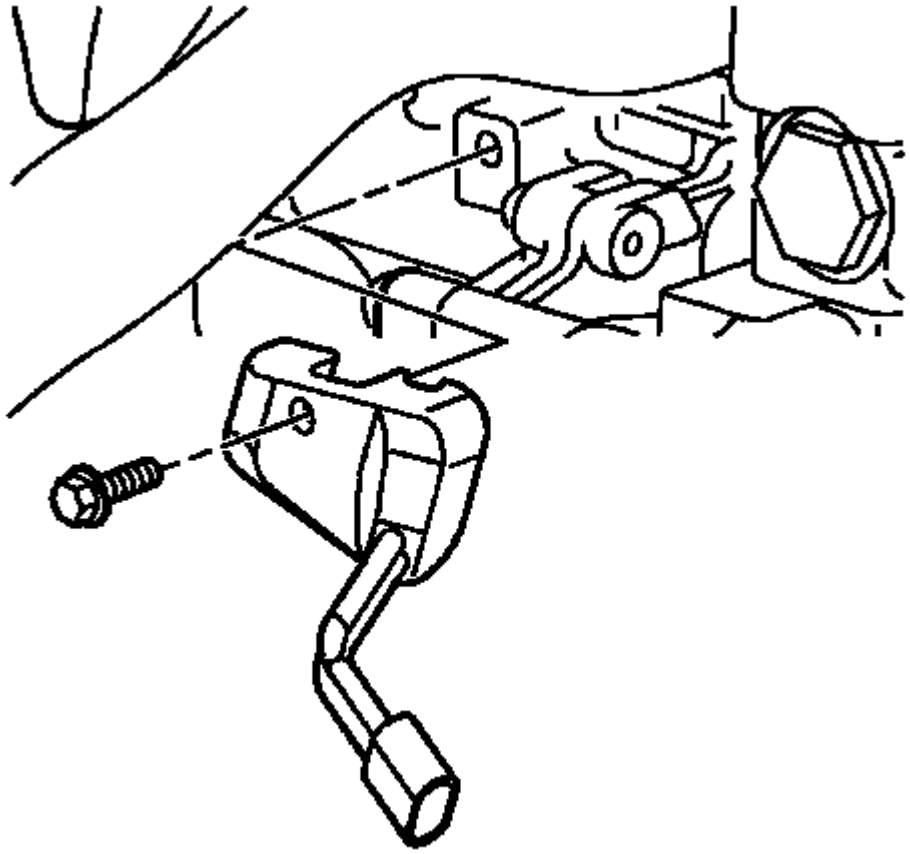

Fig. 623: View Of Block Heater
Courtesy of GENERAL MOTORS CORP.

11. Install the block heater, if equipped. Tighten the block heater to 10 N.m (89 lb in).

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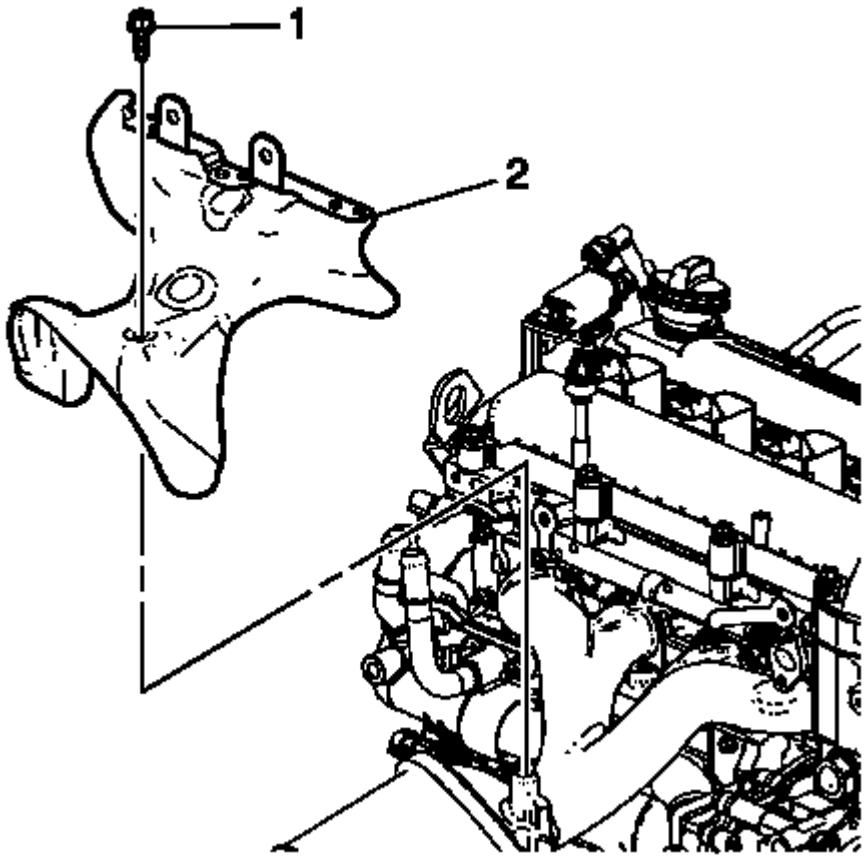

Fig. 624: View of Exhaust Manifold Heat Shield
Courtesy of GENERAL MOTORS CORP.

12. Install the exhaust manifold heat shield (2).
13. Install the exhaust manifold heat shield bolt (1) and tighten to 25 N.m (18 lb ft).

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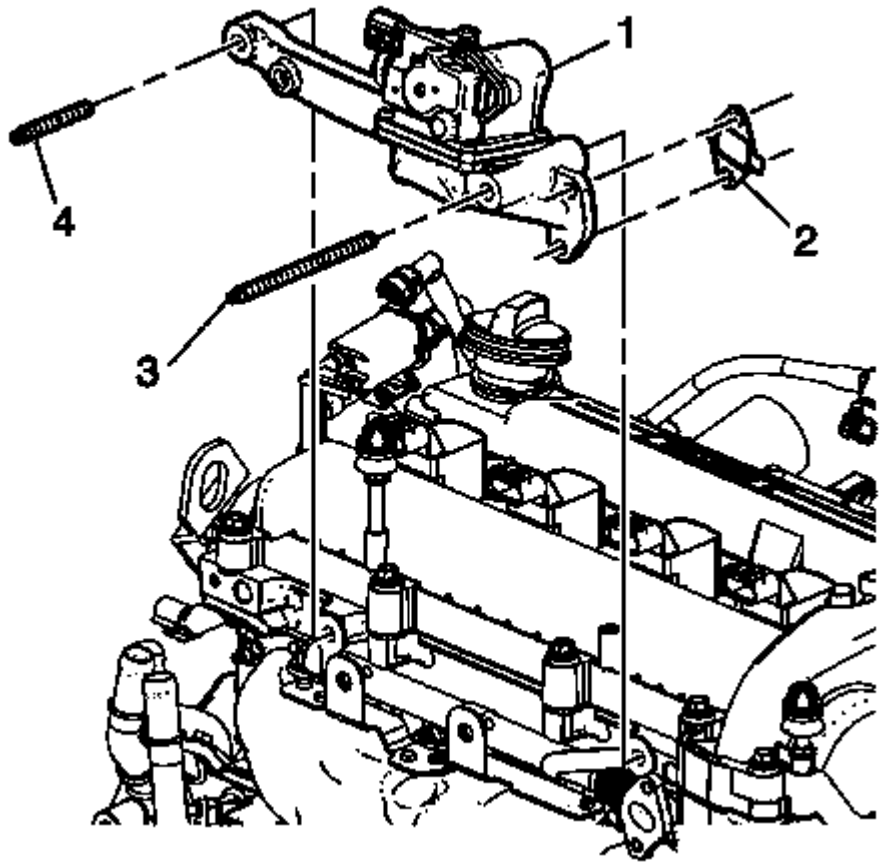

Fig. 625: View of Secondary Air Injection Studs
Courtesy of GENERAL MOTORS CORP.

14. Install the secondary air injection studs (3 and 4) and tighten to 10 N.m (89 lb in).
15. Install the secondary air injection valve assembly (1) with a NEW gasket (2).

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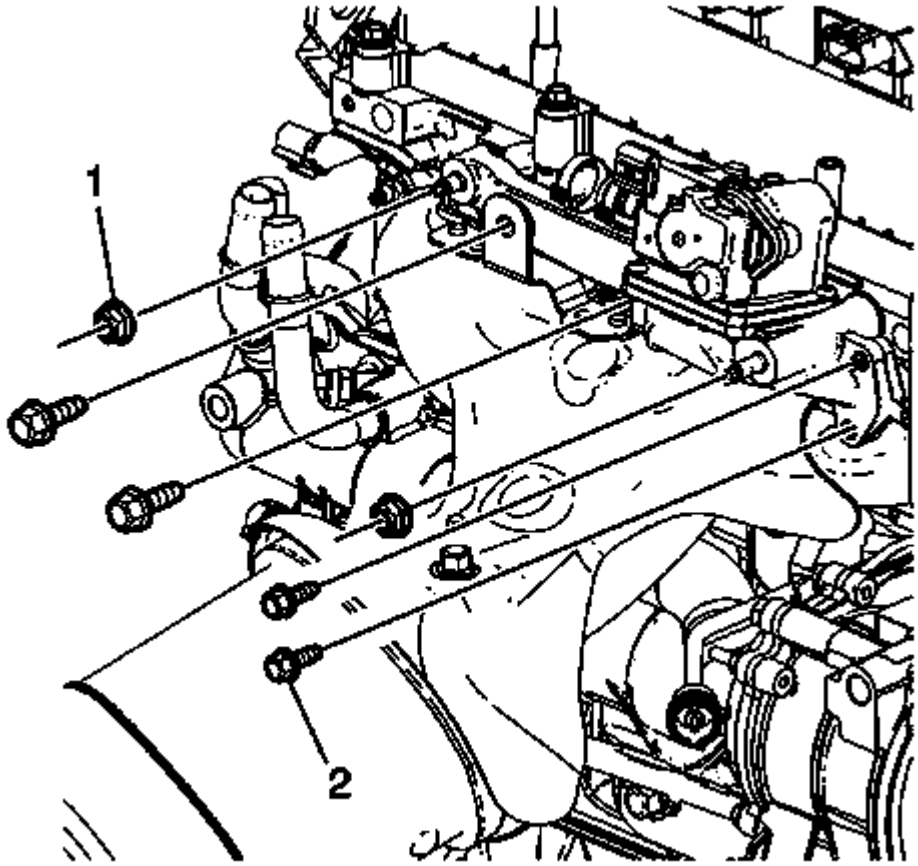

Fig. 626: View of Exhaust Manifold and Secondary Air Injection Bolts and Nuts
Courtesy of GENERAL MOTORS CORP.

16. Install the secondary air injection bolts (2) and nuts (1).
    1. Tighten the secondary air injection assembly and exhaust manifold heat shield bolts to 22 N.m (16 lb ft)
    2. Tighten the secondary air injection assembly to pipe assembly bolts to 10 N.m (89 lb in)
    3. Tighten the secondary air injection assembly nuts to 22 N.m (16 lb ft)

OIL LEVEL INDICATOR AND TUBE INSTALLATION

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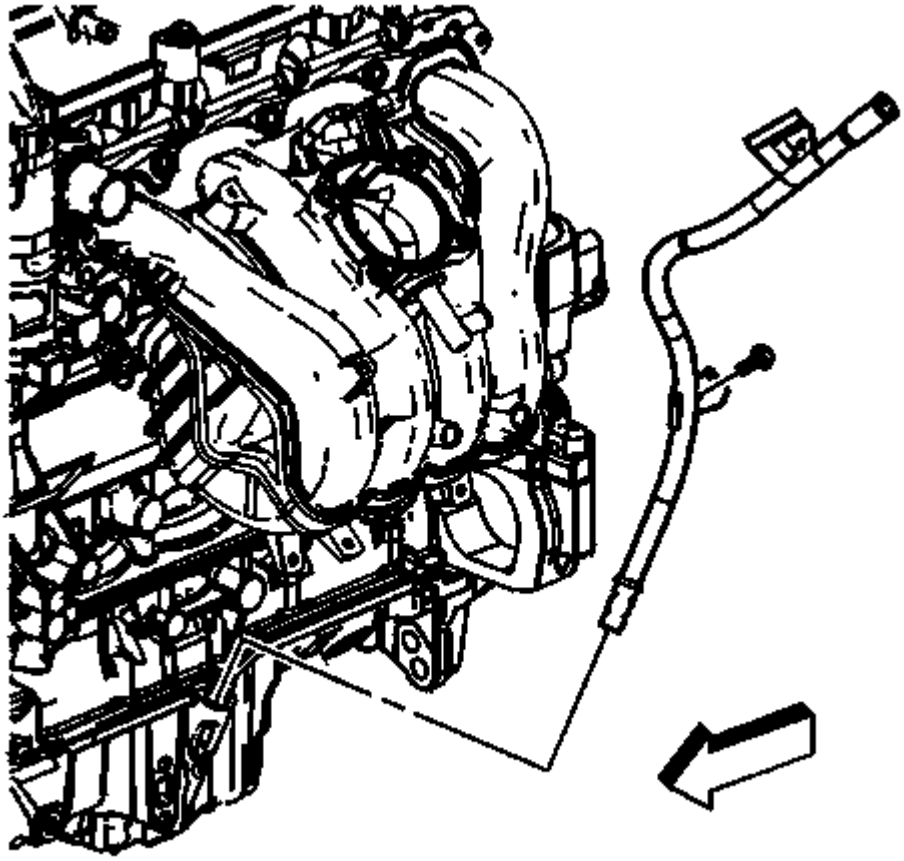

Fig. 627: Locating Oil Level Indicator & Tube
Courtesy of GENERAL MOTORS CORP.

1. Lubricate the oil level indicator tube O-ring. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2. Install the oil level indicator and the oil level indicator tube into the oil pan.

CAUTION: Refer to Fastener Caution .

3. Install the oil level indicator tube bracket to the intake manifold bolt and tighten to 10 N.m (89 lb in).
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

Special Tools

- **EN-38122-A:** Crankshaft Balancer Holder
- **EN-43653:** Flywheel Holding Tool
- **EN-45059:** Angle Meter

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

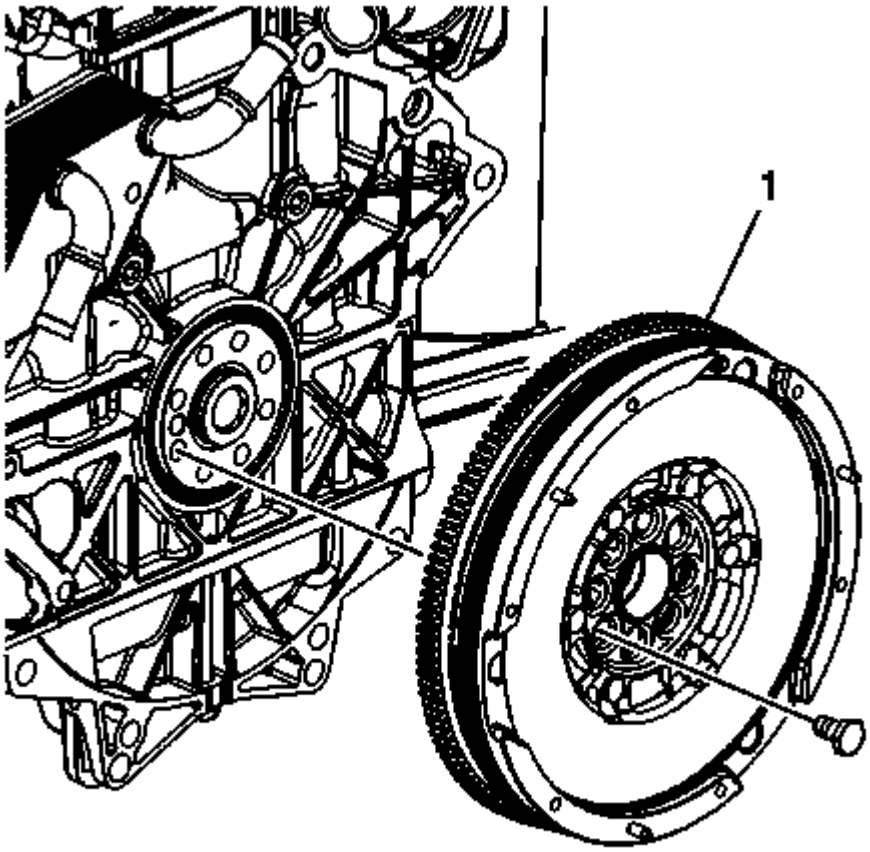

Fig. 628: View Of Flywheel With Manual Transmission
Courtesy of GENERAL MOTORS CORP.

1. Install the flywheel (1) for vehicles with manual transmission.
2. Install the NEW bolts.

CAUTION: Refer to Fastener Caution .

NOTE: EN-43653: flywheel holding tool may be used instead of EN-38122-A: holder in order to prevent crankshaft rotation.

3. Holding the crankshaft balancer with **EN-38122-A:** holder, tighten the bolts evenly. Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the **EN-45059:** meter

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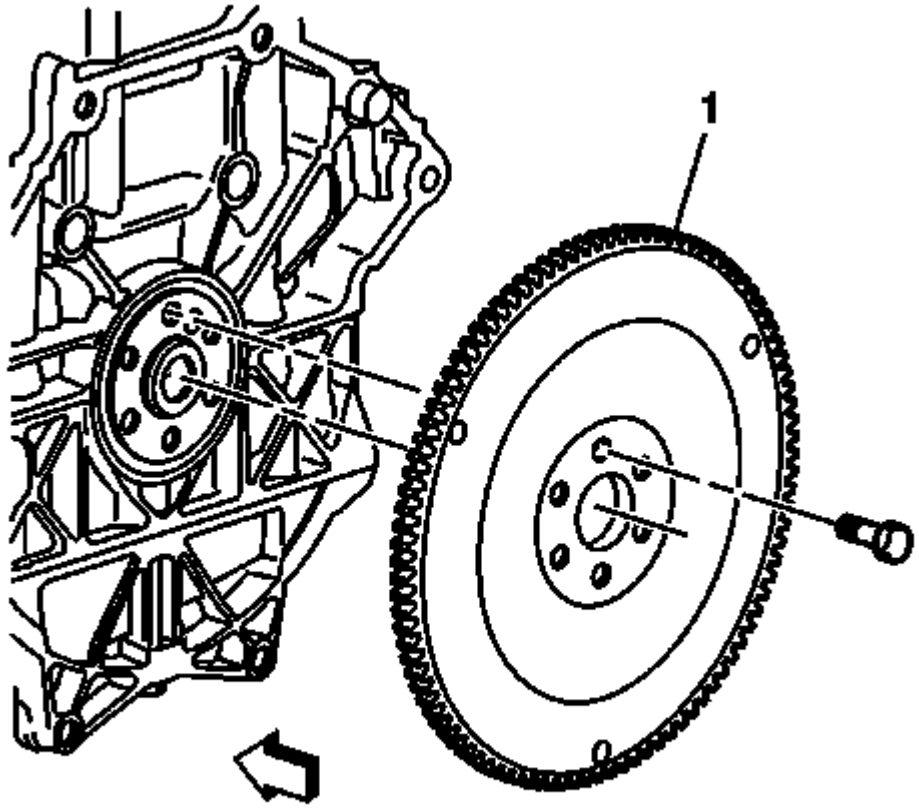

Fig. 629: View of The Flywheel With Automatic Transmission
Courtesy of GENERAL MOTORS CORP.

4. Install the flywheel (1) for vehicles with automatic transmission.
5. Install the NEW bolts.

CAUTION: Refer to Fastener Caution .

NOTE: EN-43653: flywheel holding tool may be used instead of EN-38122-A: holder in order to prevent crankshaft rotation.

6. Holding the crankshaft balancer with **EN-38122-A:** holder, tighten the bolts evenly. Tighten the bolts to 53 N.m (39 lb ft), plus 25 degrees using the **EN-45059:** meter

ENGINE PRELUBING

Special Tools

EN-45299: Engine Preluber

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

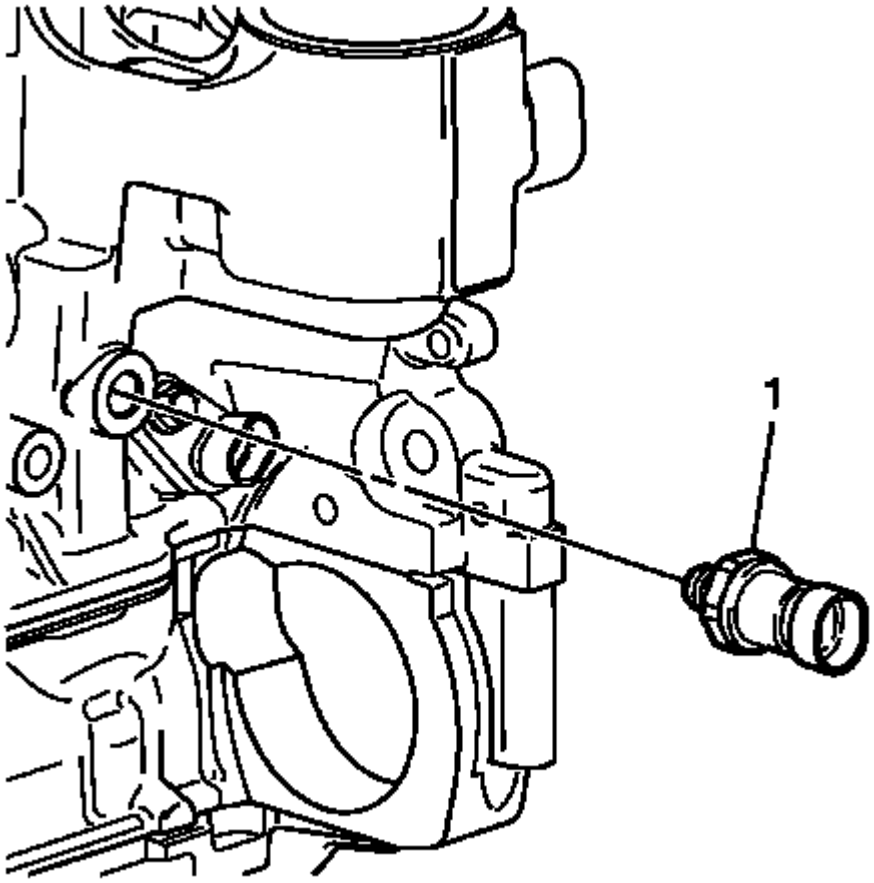

Fig. 630: Identifying the M12 x 1.75 Adapter
Courtesy of GENERAL MOTORS CORP.

NOTE: 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 (1) P/N 509376.

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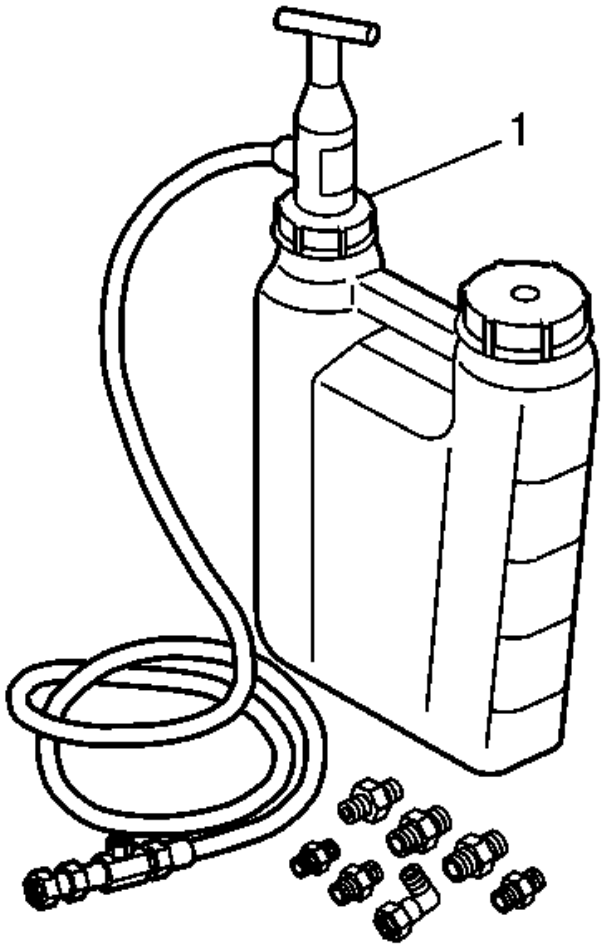

Fig. 631: View of Flexible Hose, Adapter and Preluber
Courtesy of GENERAL MOTORS CORP.

3. Install the flexible hose to the adapter and open the valve.
4. Pump the handle on the **EN-45299:** preluber (1) 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.

CAUTION: Refer to Fastener Caution .

6. Install the oil pressure switch to the engine and tighten to 22 N.m (16 lb ft).
7. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

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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

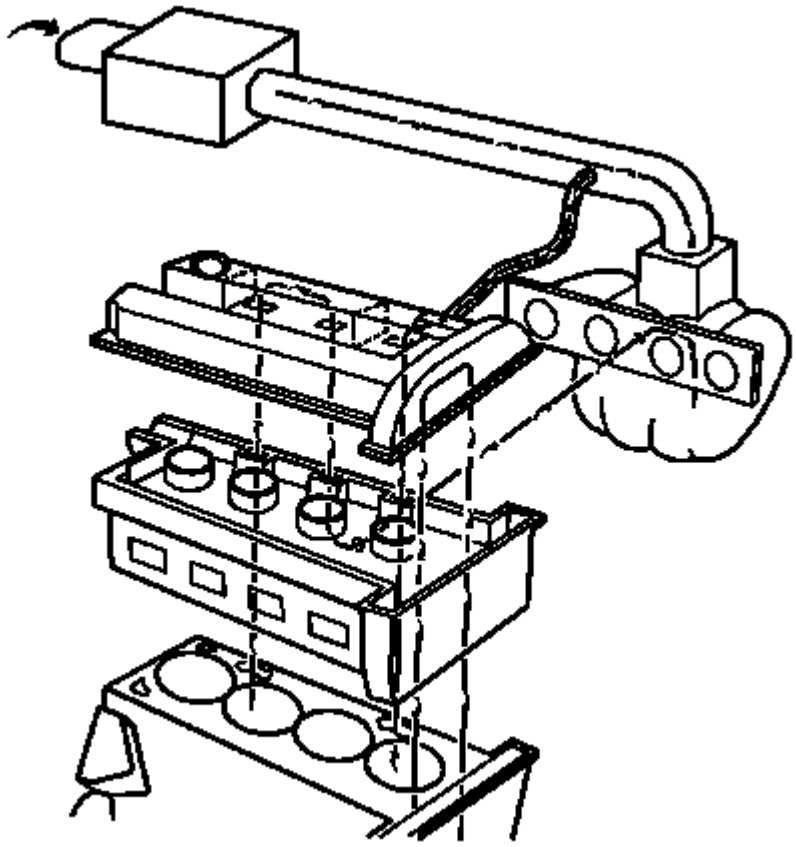

Fig. 632: Identifying Crankcase Ventilation System
Courtesy of GENERAL MOTORS CORP.

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

A plugged orifice may cause the following conditions:

- Rough idle
- Stalling or slow idle speed

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- 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.

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.

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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

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.

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Camshaft

Two camshafts are used, one for all intake valves, the other for all exhaust valves. The camshafts are cast iron.

Valve Lash Adjusters

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 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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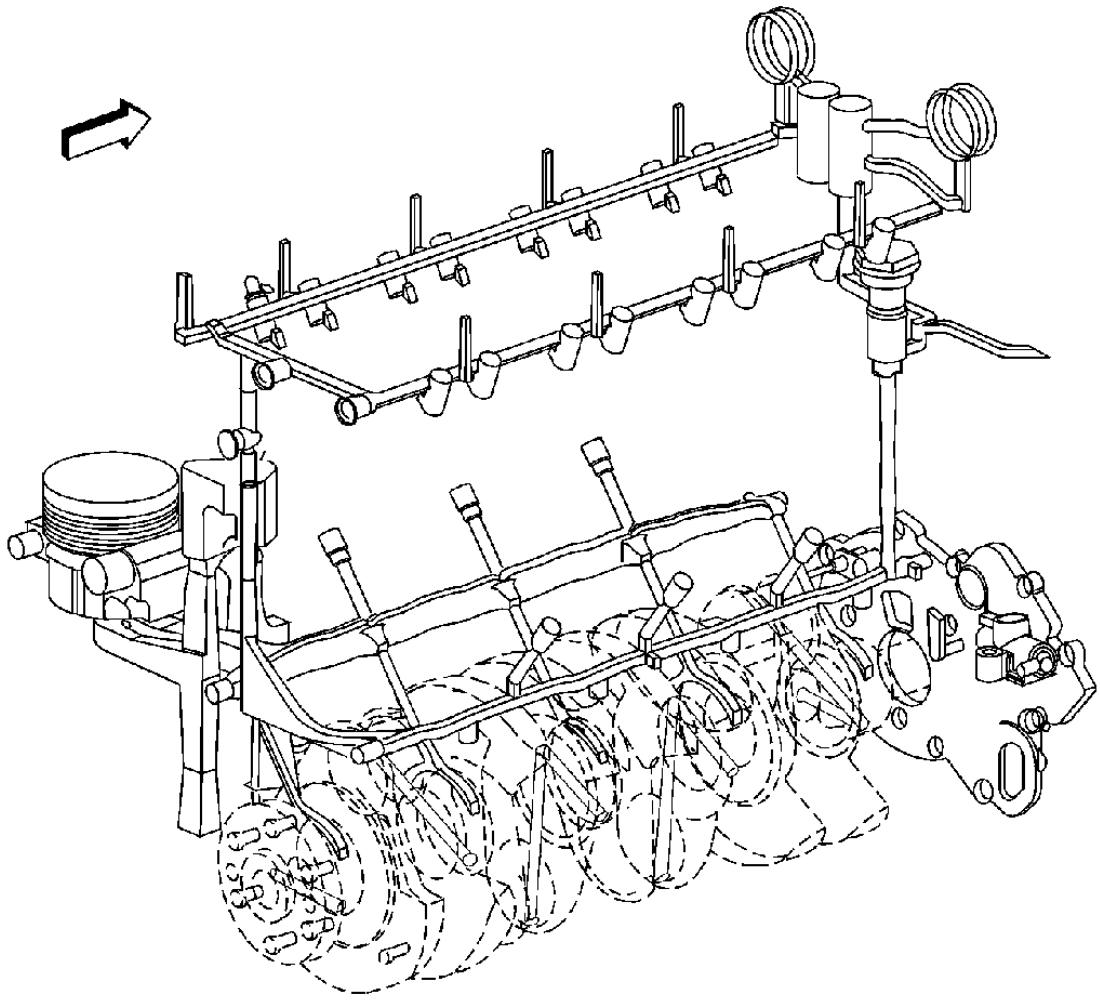

Fig. 633: Lubrication System
Courtesy of GENERAL MOTORS CORP.

Oil is applied under pressure to the crankshaft, connecting rods, balance shaft assembly, camshaft bearing surfaces, valve lash adjusters 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.

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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

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 lash adjusters
- Valve lash adjusters, lash adjuster 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

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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

- 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 SEALANT

Pipe Joint Compound

NOTE: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer, and pipe joint compound. The correct sealer

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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** .

- 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.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled together. When two rigid parts are disassembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.

  To remove the sealant or the gasket material, refer to **Replacing Engine Gaskets** .

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- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.
- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface.
- Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when tightened.

NOTE: Anaerobic sealed joints that are partially torqued and allowed to cure more than five minutes may result in incorrect shimming and sealing of the joint.
Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from seating properly or cause damage when the bolt is tightened.

- Tighten bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand
- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	EN 45680-850

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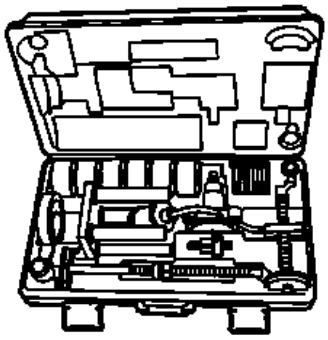
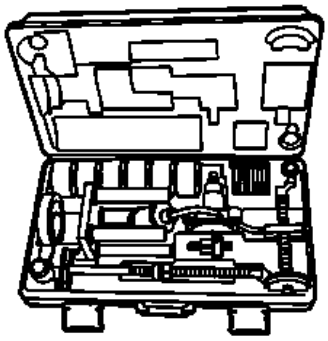
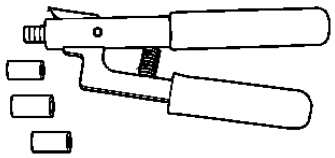
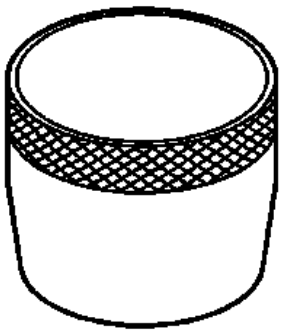
	Cylinder Sleeve Removal and Installation Kit 2.2L and 2.4L
	EN 45680-880 Cylinder Sleeve Removal and Installation Kit 2.4L only
	EN 46745 Piston Pin Retainer Remover and Installer
	EN 47836 Piston Ring Compressor 2.4L only
	EN 48585 Crankshaft Balancer Guide

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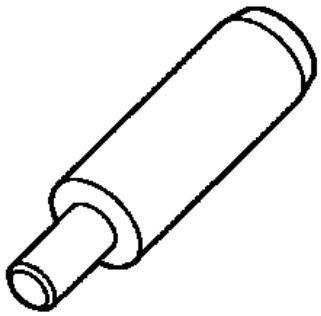
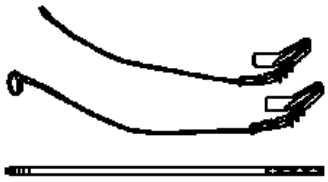
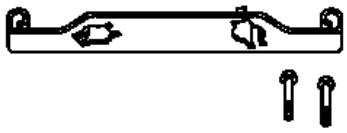
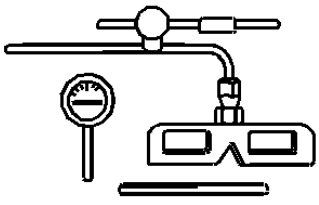
	
	EN 48749 Timing Chain Retention Tool Kit
	EN 48953 Camshaft Actuator Locking Tool
	J 7872 Magnetic Base Dial Indicator
	J 8062 Valve Spring Compressor - Head Off

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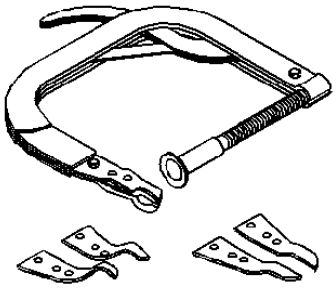
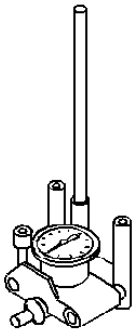
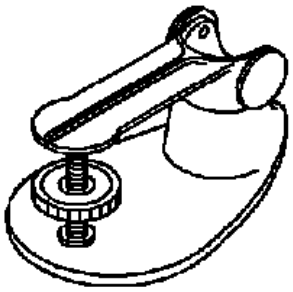
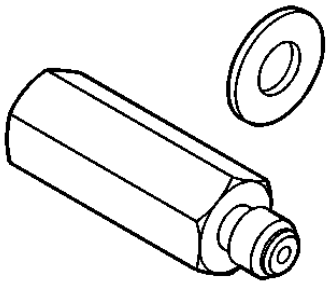
	
	J 8087 Cylinder Bore Gauge
	J 9666 Valve Spring Tester
	J 21867-850 Oil Pressure Gauge Adapter
	J 22738-B Valve Spring Tester

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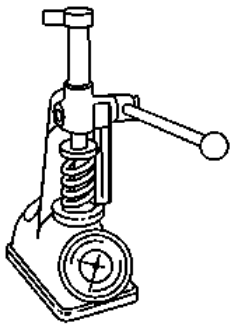
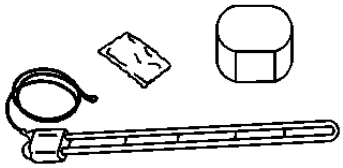
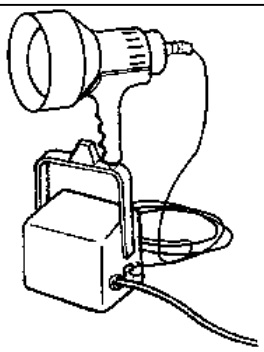
	
	J 23951 Valve Manometer
	J 28410 Gasket Remover
	J 28428-E High-Intensity Black Light Kit
	J 28467-B Universal Engine Support Fixture

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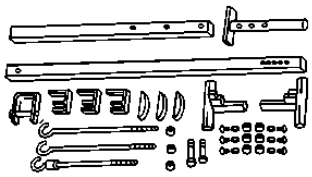
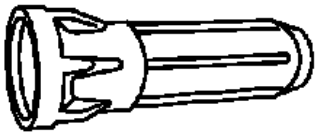
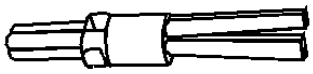
	
	J 35268-A Camshaft/Front Main Seal Installer
	J 35667-A Cylinder Head Leakdown Tester
	J 36017 Valve Guide Seal Remover
	J 38122-A Harmonic Balancer Holder

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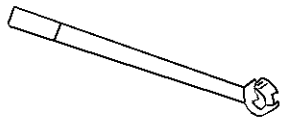
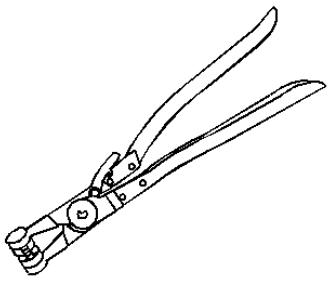
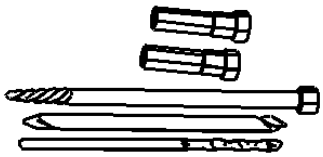
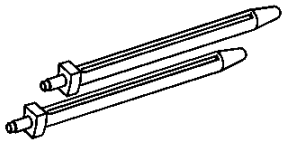
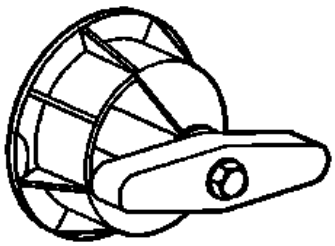
	
	J 38185 Hose Clamp Pliers
	J 38188 Cylinder Head Broken Bolt Extractor Kit
	J 41742 Connecting Rod Guide Pin
	J 42067 Rear Main Seal Installer

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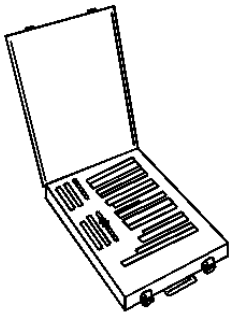
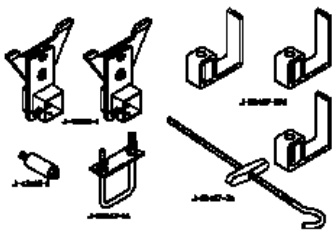
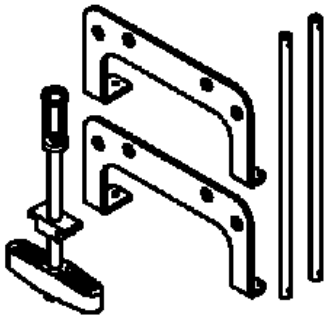
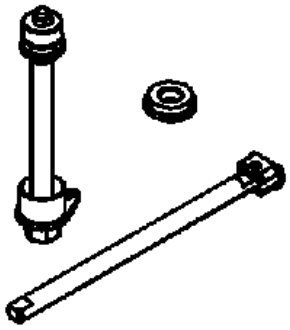
	J 42385-850 Thread Repair Kit
	J 43405 Engine Support Fixture Adapter
	J 43649 Valve Spring Compressor
	J 43650 Balancer Shaft Bearing Remover and Installer
	J 43653 Flywheel Holding Tool

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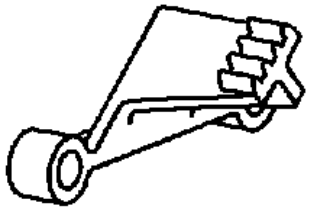
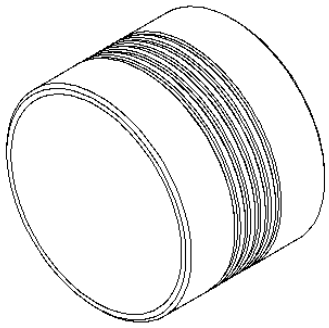
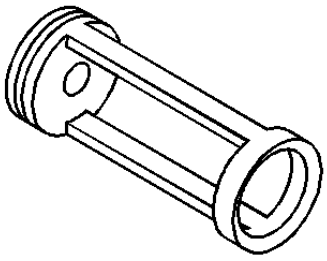
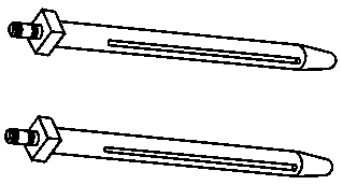
	
	J 43953 Ring Compressor 2.2L only
	J 43963 Valve Spring Compressor (off car)
	J 43966-1 Connecting Rod Guides
	J 44811 Accessory Belt Tensioner Unloader

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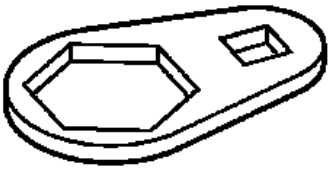
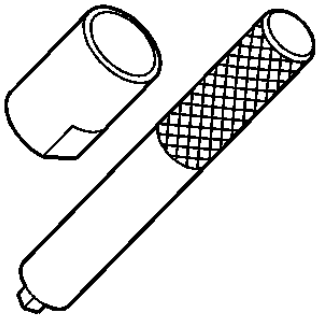
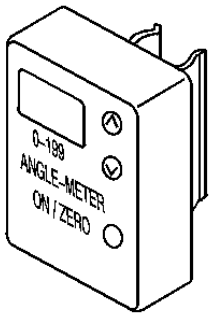
	J 44887 Oil Filter Wrench
	J 45027 Tensioner Tool
	J 45059 Angle Meter
	J 45299 Engine Pre-Luber

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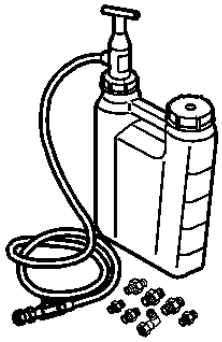	

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